Contents

The Windows Online Help of FluidSIM ties up with the handbook within large parts; it describes both the full version of FluidSIM and the restricted student version. The topics listed below can be chosen by mouse click. If you click on a word that is underlined normally, a jump to the topic's page will be performed.

FluidSIM-H is the result of a joint research venture between the Measuring and Control Technology Department of Duisburg University and the Knowledge-based Systems Department of the University of Paderborn.

Concept and development of FluidSIM-H is based on research work carried out by Dr. Daniel Curatolo, Dr. Marcus Hoffmann, and Dr. habil. Benno Stein. Mechanical Engineering contributions by Dr. Ralf Lemmen.

Welcome!

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Advanced Concepts in Simulating and Creating Circuits

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Welcome!

Welcome to FluidSIM!

Thank you for purchasing the FluidSIM-H training software. This handbook functions both as an introduction to FluidSIM and as a reference manual outlining the possibilities, concepts, and operation of the software package. This handbook, however, is not intended to help in defining special aspects of hydraulics. Concerns of this nature can be found in the Festo Didactic GmbH & **Co. KG** textbook series.

Users of this software are encouraged to contribute tips, criticism, and suggestions for improvement of the program via email at

info@fluidsim.com

did@de.festo.com

Moreover, the newest updates can be found at our Internet site at

www.fluidsim.com

www.festo-didactic.com

August 2007 The Authors

About FluidSIM

Layout of the Handbook

Conventions







About FluidSIM

FluidSIM-H is a teaching tool for simulating hydraulics basics and runs using Microsoft Windows ©. It can be used in combination with the **Festo Didactic GmbH & Co. KG** training hardware, but also independently. FluidSIM was developed as a joint venture between the University of Paderborn, **Festo Didactic GmbH & Co. KG**, and Art Systems Software GmbH, Paderborn.

A major feature of FluidSIM is its close connection with CAD functionality and simulation. FluidSIM allows DIN-compliant drawing of electro-hydraulic circuit diagrams and can perform realistic simulations of the drawing based on physical models of the components. Simply stated, this eliminates the gap between the drawing of a circuit diagram and the simulation of the related hydraulic system.

The CAD functionality of FluidSIM has been specially tailored for fluidics. For example, *while drawing*, the program will check whether or not certain connections between components are permissible.

Another feature of FluidSIM results from its well thought-out didactic concept: FluidSIM supports learning, educating, and visualizing hydraulic knowledge. Hydraulic components are explained with textual descriptions, figures, and animations that illustrate underlying working principles; exercises and educational films mediate knowledge about both important circuits and the usage of hydraulic components.

The development of FluidSIM included special emphasis on both an intuitive and easy-to-learn user interface. The user will quickly learn to draw and simulate electro-hydraulic circuit diagrams.





Layout of the Handbook

The Handbook from FluidSIM has been divided into two parts. The first part serves as a user's guide, and the second part functions as a reference book. The user's guide contains chapters that introduce the user to FluidSIM. By following the chapters in order, the user will understand how to operate FluidSIM. The reference part contains a complete listing of the FluidSIM functions, the component library, the didactics material, and the FluidSIM messages.

User's Guide

Reference





User's Guide

Chapter Getting Started describes the computer requirements for FluidSIM, the installation process, and the meaning of the supplied files.

Chapter Introduction to Simulating and Creating Circuits contains small examples of circuit diagrams, showing how they can be simulated and how new circuit diagrams can be created.

Chapter Advanced Concepts in Simulating and Creating Circuits introduces advanced concepts of FluidSIM. Examples include the linking of hydraulic and electric components, the possible settings for simulation, and the testing of a circuit diagram.

Chapter <u>Learning</u>, <u>Teaching</u>, and <u>Visualizing Hydraulics</u> shows additional educational concepts. In particular, FluidSIM enables a user to pop-up a component's technical description, to start animations, or to play a film with related information.

Chapter Special Functions describes special functions of FluidSIM including how to print and export circuit diagrams, along with the rearrangement of the component library.

Chapter Help and Advanced Tips deals specifically with help for questions concerning the use of FluidSIM. It also includes tips for the advanced user.







Reference

Appendix <u>FluidSIM Menus</u> contains a complete listing of FluidSIM menus and is intended to be used as a quick reference for all FluidSIM functions.

Appendix <u>The Component Library</u> contains the library of all FluidSIM components.

Appendix <u>Didactics Material Survey</u> contains the component illustrations, the animations, the exercises, and the educational films.

Appendix <u>Messages</u> contains a listing of messages that may occur while using FluidSIM along with a brief explanation for each.





Conventions

User instructions are indented and marked with the passages begin with the symbol.

The symbols found on the FluidSIM toolbar are represented in this manual with the appropriate icon; menu entries are shown framed; function keys are represented with their appropriate key symbol. For example is the icon used to start a simulation; File- Open... indicates the "Open..." entry under the "File" menu; **F9** stands for function key "9".

In this manual the term "clicking" with a mouse means using the left mouse button. It is explicitly stated when the right button is to be used.

Values for quantities calculated and displayed in FluidSIM are expressed in the following units:

Quantities in FluidSIM

Quantity	Unit of measure
Pressure (p)	bar, MPa, psi
Flow (q)	l/min, gal/min
Velocity (v)	m/s
Force (F)	N, kN
Opening level (%)	-
Voltage (U)	V





Getting Started

This Chapter describes how FluidSIM is installed on your computer.

<u>Technical</u> <u>Requirements</u>

Installation

Supplied Files

<u>De-installation of a Single-Position License</u>







Technical Requirements

You need a computer with a Pentium processor or higher that runs using Microsoft Windows 95©, Microsoft Windows 98©, Microsoft Windows ME©, Microsoft Windows NT©, Microsoft Windows 2000©, Microsoft Windows XP© or Microsoft Windows Vista©.

If you intend to draw simple circuit diagrams or to simulate the existing circuit diagrams, 128 MB RAM is adequate. However, minimum 256 MB RAM is recommended to simulate complex circuit diagrams.

In order to play the educational films, you will need a CD-ROM drive that runs at double speed along with hardware for sound.

Related Topic

Playback of Educational Films





Installation

Having purchased the full version of FluidSIM, you received two CD-ROMs and possibly a license connector. One CD-ROM contains both full version and student version of FluidSIM. The other provides educational films providing the Video-CD format that may also be viewed on common DVD-players.

The installation procedure is described in the following sections.

The full version of FluidSIM is available in two versions: A version that supports the automatic <u>online activation</u> and the license connector version.

Installation and Online Activation

Import Online Activation Notes

Installation with license connector

FluidSIM Full Version: Installation from CD

How to Install the Student Version of FluidSIM





Installation and Online Activation

dialog box of the installation PC.

For the online activation you will need a computer with internet access. During the installation you will be prompted to activate FluidSIM . There are three ways of doing so:

- Automatic Online ActivationThis variant requires Internet access from the computer where FluidSIM is to be activated and realizes a completely automated procedure.
- Indirect Activation
 In this variant an activation dialog box is opened that shows an Internet address (url) and your individual license ID. With this information you can generate your individual activation key at an arbitrary computer with Internet access. Then, the activation key has to be entered in the activation
- Call Festo to receive your individual activation key
 If you don't have Internet access or if the Internet activation fails, you can
 call a service employee at weekday office hours who will provide you with
 your activation code. Please note: The displayed phone number in Germany
 is available at European office times only. Depending on the geographical
 position of your site, you will find different telephone numbers for the
 software activation on the shipping box.





Import Online Activation Notes

During the activation of FluidSIM several features of your PC and the product ID are used to generate an individual activation key. This string is valid for your PC only. I.e., if your PC is substantially modified or if you want to use another PC, your FluidSIM license has to be transferred to the new hardware. Such a transfer requires the deactivation of the license of the original PC, which is accomplished by uninstalling FluidSIM. The respective uninstallation program can be found in the menu Start under "Deinstallation" or in the control panel under "Software".

If a deactivation of FluidSIM is not possible because of technical problems, as an exception your license can be transferred without deactivation.

Note that a license transfer without a preceding deactivation is possible only a few times. Also note that if your license has been transferred to another PC, it cannot be re-activated for the initial PC without deactivating it before.





Installation with license connector

Depending on the license model (single-position systems or network), the license connector is needed only during the *Installation* of FluidSIM or must be attached to the so-called *license server*.

The network license connector defines how many instances of FluidSIM can be running at the same time in the network. If you attempt to start more instances than the allowed number, an error message is displayed. If the license server is down or if the license connector has been removed from the system, all circuits that are already open and modified can be saved before FluidSIM terminates. If the license server is up again FluidSIM starts as usual.

Details for a network installation of FluidSIM is given in an addendum of the FluidSIM package and can also be found as pdf-file "net_inst.pdf" in the "Doc"-Folder of the installation CD.





FluidSIM Full Version: Installation from CD

If your software needs a license connector, connect the key not until you are requested by the installation program.

- Switch on your PC and login with administrator permissions.
- Insert the CD.

Usually the installation program starts automatically. Please start it manually if it doesn't:

Click Run... in the Start Menu.

A dialog box opens.

Enter the following string in the space provided: **d:setup.exe**.

Then click "OK". If your CD-ROM drive is configured differently, then be sure to use the appropriate letter in place of **d:**.

After a few seconds the startup screen of the installation program appears. Here you can choose whether to install the student version or the full version of FluidSIM. When installing the full version, please select the appropriate license connector (single-position systems or network). If you got a FluidSIM version for online activation no license connector is necessary but only your individual product ID is required, which is printed on the back of the CD cover. Note that the student version does neither require a license connector nor a product ID.

Follow the directions as they appear on the screen. If you are unsure how to answer or are unsure of a question, simply click "Next>>".





How to Install the Student Version of FluidSIM

- Turn the computer on and start Microsoft Windows ©.
- ·····

 Insert the CD.

Usually the installation program starts automatically. Please start it manually if it doesn't:

Click Run... in the Start Menu.

A dialog box opens.

Enter the following string in the space provided: **d:setup.exe**.

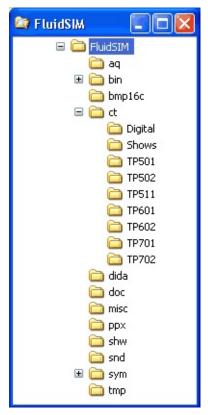
Then click "OK". If your CD-ROM drive is configured differently, then be sure to use the appropriate letter in place of **d:**.





Supplied Files

The directory structure of FluidSIM is demonstrated in the following figure.



In case you installed FluidSIM for several users, you should not make any changes to the installation directory. New files and changes of the existing circuits, symbols and didactic material should be performed in the directory **My Documents**.

The directory **ct** contains the supplied circuits for FluidSIM. This is also the default directory in which all new circuits diagrams are saved. In its subdirectories the following circuit diagrams have been included:

- **digital**: Circuits including sample circuits regarding digital technology.
- **shows**: Circuits that can be opened as a bitmap via the Didactics menu (see section <u>Learning</u>, <u>Teaching</u>, and <u>Visualizing Hydraulics</u>).
- **tp501**: Circuits in the workbook "Hydraulics Basic Level TP 501".

- **tp502**: Circuits in the workbook "Hydraulics Advanced Level TP 502".
- **tp511**: Circuits in the workbook "Closed-loop Hydraulics TP 511".
- **tp601**: Circuits in the workbook "Electrohydraulics Basic Level TP 601".
- **tp602**: Circuits in the workbook "Electrohydraulics Advanced Level TP 602".
- **tp701**: Circuits in the workbook "Proportional Hydraulics Basic Level TP 701".
- **tp702**: Circuits in the workbook "Proportional Hydraulics Advanced Level TP 701".

The directory **ppx** contains extended PowerPoint presentations.





De-installation of a Single-Position License

The following steps are necessary to de-install FluidSIM from your computer.

Click on the program icon **Remove FluidSIM-H** in the Start Menu **Program Files/Festo Didactic**. If the program icon cannot be found, start the program **unwise.exe** in the **bin-**subdirectory of the FluidSIM directory.



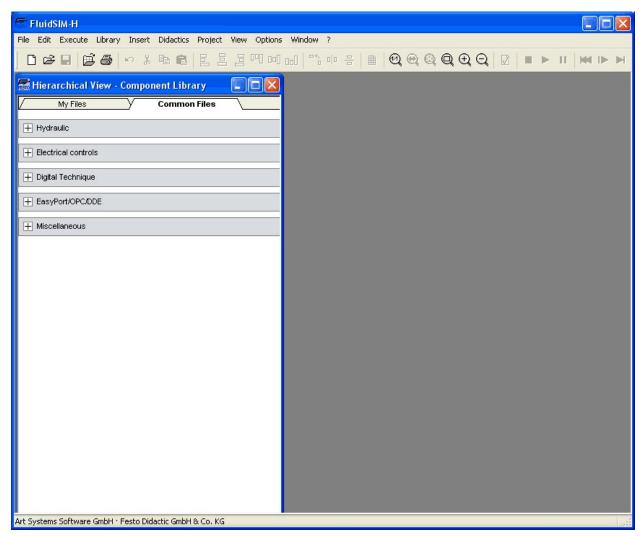


Introduction to Simulating and Creating Circuits

The following chapter is set up in the form of a tutorial to introduce the user to important FluidSIM functions. At the end the user should be comfortable designing and simulating circuit diagrams.

Start FluidSIM via the Start Menu under **Program Files/Festo Didactic.**

After a few seconds the main window from FluidSIM should appear on your screen:



The left-hand side shows the component library of FluidSIM in its hierarchical

view; it contains hydraulic, electrical and digital components for the designing new circuit diagrams. Using the menu bar at the top of the window, you may access all functions provided for designing and simulating circuit diagrams. The toolbar below allows convenient access to frequently used menu functions.

The toolbar contains the following ten groups of functions:

- 2. printing the contents of the window, for example circuit diagrams and component photos
- 3. editing circuit diagrams
- 4. **昌昌吧吧 alignment of components**
- 5. solution in the second seco
- 6. using a grid
- 8. superficial circuit checking

9. simulating circuit diagrams, directing animation (basic level)

10. simulating circuit diagrams, directing animation (additional functions)

Only a certain number of the above listed functions will apply to a specific circuit diagram. FluidSIM recognizes which functions apply according to the contents of the window, component functions and context (circuit diagram design, animation, circuit diagram simulation, etc.), and disables the operations on the toolbar that do not apply.

In many new Microsoft Windows © programs "context menus" are available. A <u>context menuappears</u> when the user clicks the *right* button on the mouse within the program window. In FluidSIM, context menus apply to the contents and situations in the window; the context menus contain a useful subset of functions from the main menu bar.

Located at the bottom of the window is a status bar that displays information on the current calculations and activities during the operation of FluidSIM. In Edit Mode, FluidSIM displays the designation of the component found under the mouse cursor.

Buttons, scrollbars, and the menu bar in FluidSIM operate in the same way as in most other programs that utilize Microsoft Windows ©.

Simulating Existing Circuit Diagrams

The Different Simulation Modes

Creating new Circuit Diagrams





Simulating Existing Circuit Diagrams

Included with the FluidSIM installation disks are a number of working circuit diagrams.

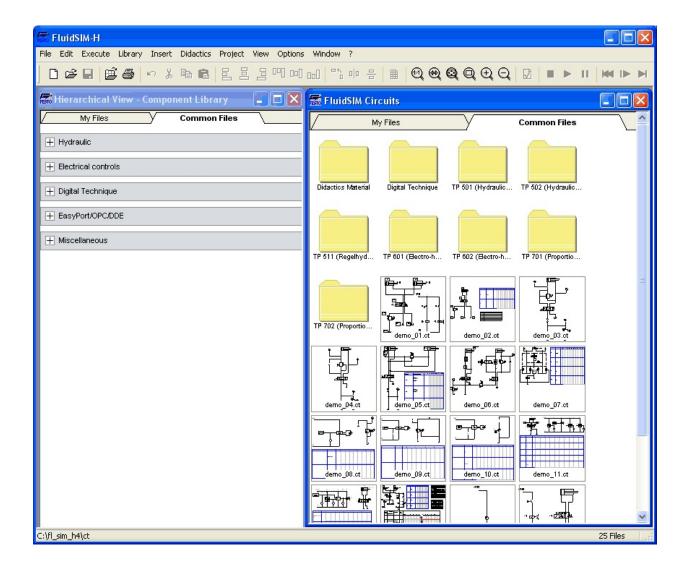
Among others, these are circuit diagrams as part of the learning material and will be discussed in the following workbooks "Hydraulics Basic Level TP 501", "Hydraulics Advanced Level TP 502", "Electrohydraulics Basic Level TP 601" and "Electrohydraulics Advanced Level TP 602".

The circuit library of the FluidSIM student version contains only circuits of the basic levels.

These circuit diagrams can be opened and simulated with FluidSIM as follows:

Click on or choose <u>Circuit Preview</u> in the File menu.

Preview windows containing overviews of existing circuit diagrams should appear:



A <u>preview window</u> displays the circuit diagrams of a specific directory in alphabetical order accompanied by a miniature representation. The name of the current directory is shown in the title bar of the preview window; the files of the FluidSIM circuit diagrams contain the extension **ct**.

By double clicking a directory icon you go down to the respective subdirectory.

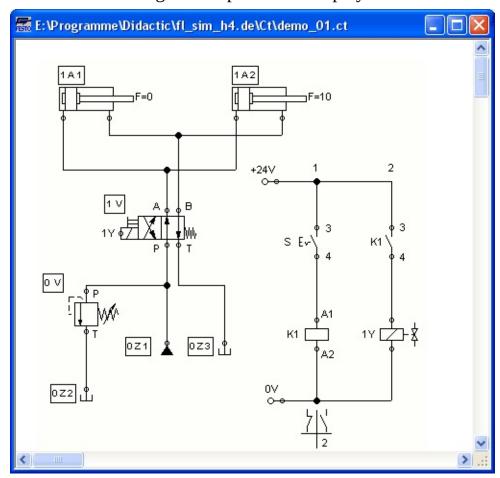
In the **ct** subdirectory of the **fl_sim_h** installation additional subdirectories for diagrams can be created. These subdirectories are automatically found by FluidSIM, and extra directory icons are created for them.

Open the circuit diagram **demo1.ct** by double clicking on its miniature representation.

Circuit diagrams can also be opened using the File Selector dialog box. By

clicking on or choosing Open... under the File menu, the File Selector dialog box will appear, in which a circuit diagram can be opened by double clicking on its filename.

In either case the circuit diagram is opened and displayed in a new window:



Click on or on Execute- Start, or press the key **F9**.

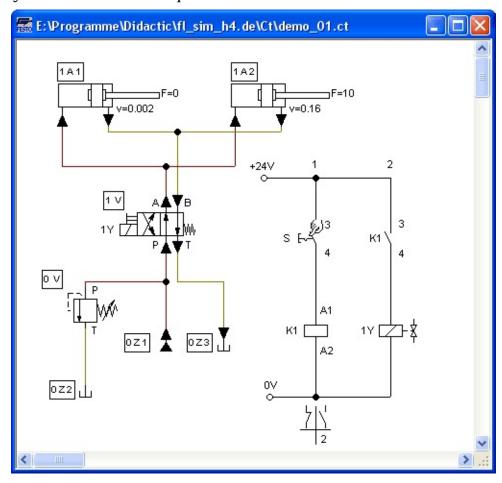
FluidSIM switches to the *simulation mode* and starts the simulation of the circuit diagram. When in the simulation mode, the mouse cursor changes to a hand . During the simulation FluidSIM first calculates all electrical parameters. pressure is calculated.

This step is followed by formulating a model of the hydraulic circuit and, based on this model, a continuous distribution for flow and pressure will be calculated for the circuit.

Formulating models is demanding. Depending on a circuit's complexity and the computer's power, a circuit's simulation may take considerable time. Likewise,

the real-time completion of the following dynamic simulation cannot always be guaranteed. The percentage of real-time achieved is shown in FluidSIM in the status bar at the lower edge of the main window.

As soon as the results are available, the connection lines will be shown in color and the cylinders extend in sequence:



The colors of the connection lines have the following meaning:

Colors of the electrical and hydraulic lines

Color	Meaning
Dark red	Hydraulic line: pressure ≥ 50% of maximum
Ocher	Hydraulic line: pressure < 50% of maximum

You can define your own mapping between colors and state values under Options- Simulation.... The varying thicknesses of the *dark red* connection lines corresponds to the pressure as related to the maximum pressure. FluidSIM distinguishes between three thicknesses of line:

Thickness of the dark red hydraulic connection lines

Thickness	Meaning
_	Pressure ≥ 50% and < 75% of maximum
_	Pressure ≥ 75% and < 90% of maximum
_	Pressure ≥ 90% of maximum

The exact numeric values for pressures, flow rates, voltages, and currents are displayed on the attached measuring instruments. Section <u>Displaying Quantity Values</u> describes how you may go about getting values for all or only selected variables on the circuit diagram, even when measuring instruments are not present.

Simulation in FluidSIM is based on physical models whose components match those components found in the **Festo Didactic GmbH & Co. KG** equipment set. Therefore, calculated values should closely match measured values. When comparing results, please acknowledge the fact that in practice, measurements can be subject to large fluctuations. The reasons for differences range from component tolerances to oil temperature.

The calculation of variables forms the basis for an exact, *real-time proportional* animation of the cylinder.

<u>Real-time-proportionality</u> guarantees the following property: If in reality a cylinder moves twice as fast as another one, the relationship between these two components is shown in the animation. In other words, the real-time relationship remains unaltered.

Manually operated valves and switches, found in the circuit diagram, can be switched by clicking on them with the mouse:

Move the mouse cursor to the left switch.

Click on the switch.

When you click on a manually operated switch, its real behavior is simulated. In this example the clicked switch becomes closed and recalculation begins automatically. Following the calculation, the new pressure and flow values are indicated and the cylinders retract.

The switching of a component is only possible when a simulation is running or when a simulation has been set to pause ().

In the event that you would like to simulate another circuit diagram, it is not necessary to close the open one. FluidSIM allows you to have several circuits open at one time. Furthermore, FluidSIM is able to simulate multiple circuits simultaneously.

- Click on or Execute- Stop to switch the current circuit from Simulation Mode to Edit Mode.
- By switching a circuit from Simulation Mode to Edit Mode, all components will automatically be set back to their "normal status". In particular, switches are set to their original position, valves switch to their normal position, cylinder pistons are set to their *previous* position, and all values calculated are deleted.

By clicking on (alternative: Execute- Pause or **F8**) you can switch from Edit Mode to Simulation Mode without starting the simulation. This feature is useful, if components shall be set *before* the simulation is started.

Related Topic

Additional Simulation Functions





The Different Simulation Modes

In addition to the functions of the preceding section (, ,), there exist also the following additional functions:

- reset and restart of the simulation
- simulation in single step mode
- simulation to a certain point where a state change happens

Reset and Restart of the Simulation

Single Step Mode

Simulation to a State Change





Reset and Restart of the Simulation

By clicking on or under Execute- Reset, an already running simulation or paused simulation can be reset. Immediately following this, the simulation will be restarted.

Related Topics

Single Step Mode
Simulation to a State Change





Single Step Mode

During single step mode, the simulation will stop after a small step. More exactly, by clicking on or Execute- Single Step, the simulation will begin for just a short time period (approximately 0.01 - 0.1 seconds in the real system); the system then pauses (1).

A running simulation can, at any time, be set into single step mode. It is then possible to focus on key moments during the simulation.

Related Topics

Reset and Restart of the Simulation
Simulation to a State Change





Simulation to a State Change

By clicking on or under Execute- Simulate until State Change the simulation begins and runs up until a certain point where a state change happens; the simulation then pauses (III). The following situations describe the point at which the simulation pauses:

- 1. a cylinder's piston moves at a stop
- 2. a valve switches or is operated
- 3. a relay switches
- 4. a switch is operated

It is possible to switch from a running simulation into this state change mode.

Related Topics

Reset and Restart of the Simulation
Single Step Mode

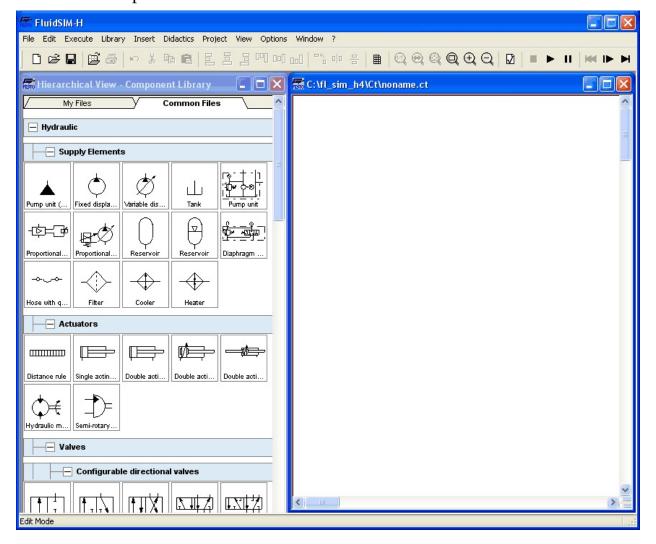




Creating new Circuit Diagrams

This section contains an introduction to creating and simulating circuit diagrams using FluidSIM.

Create an empty drawing area by clicking on or under File-New to open a new window:



Circuit diagrams can only be created or altered in the Edit Mode. The Edit Mode is indicated with the following mouse cursor .

Each and every newly opened drawing area automatically contains a name, with

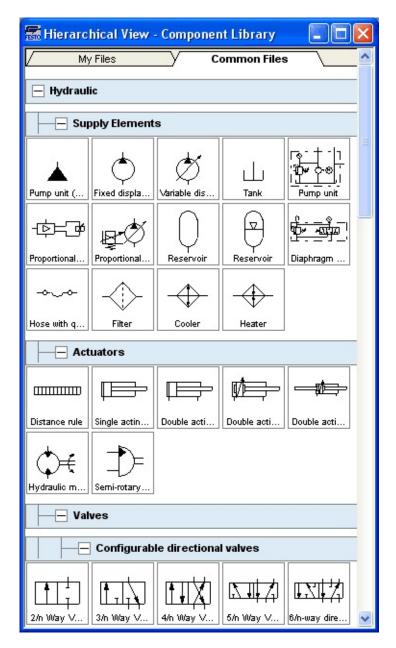
which it can be saved. This name is found in the title bar of the new window.

While in basic mode, you will see the available component groups in the hierarchical view of the component library. To list the components of a group, you may list off the group by clicking it. For a better overview you may also hide non-required elements and subgroups by once more clicking and hence closing the hierarchy. Component groups may often contain further subgroups that may also be listed off or closed.

To list off a group including all of its subgroups, you may hold the Shift-Key while clicking. This will reduce your efforts to list off each subgroup. You may similarly use the Shift-Key to close all subgroups of a superordinate group.

press the Shift-Key, hold it and click "Hydraulic".

The entire group of hydraulic components will be listed off. Using the scrollbars, you may browse through the component library to the left and right or up and down.



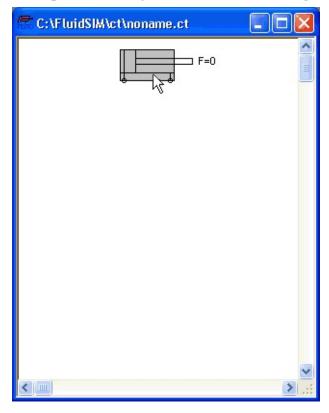
Using the mouse and "drag-and-drop" you may drag components from the component library to the drawing area:

- Move the mouse cursor to a component in the library, more specifically to the cylinder.
- Press the left mouse button. While continuing to hold down the button, move the cursor.

The cylinder is then *highlighted* (selected) and the mouse cursor changes to a four way directional cross . The component's outline moves with the mouse

cursor.

Move the cursor to the drawing area and release the button on the mouse. This action places the cylinder in the drawing area:



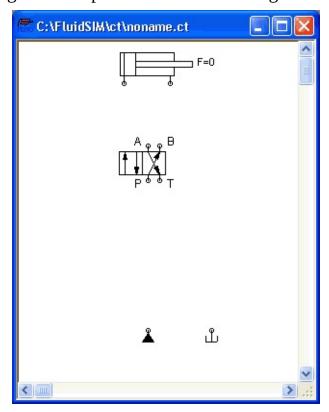
In this way it is possible to "drag" each component from the component library and place it in the desired position in the drawing area. In the same way it is possible to rearrange components already in the drawing area.

- Drag the cylinder to the bottom right hand corner.
- In order to simplify the creation of circuit diagrams, the components automatically snap to grid in the drawing area.
 - Try to move the cylinder onto a non-permissible area, for example outside the window.

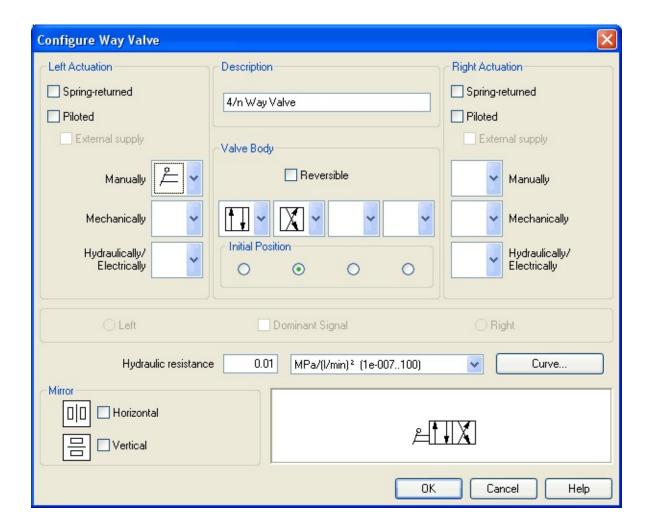
Outside a permissible area the mouse cursor changes to the prohibited sign \circ ; the component cannot be dropped.

- Drag a second cylinder onto the drawing area and notice that the second cylinder is now highlighted.
- Highlight, say, select the first cylinder by clicking on it.

- Delete the cylinder by clicking on (cut) or under Edit- Delete or by pressing the **Del** key.
- The commands in the Edit menu correspond only to the selected components.
 - Drag onto the drawing area a configurable 4/n-way valve, a pump unit, and a tank.
 - Arrange the components in the following manner:



Double click the valve to assign an operation mode to it. A dialog box appears:



• **Left/Right Actuation**For both sides the actuation modes of the valve can be defined individually; it can be one or more of the categories "Manually", "Mechanically", or "Hydraulically/Electrically". An operation mode is set by clicking on the down-arrow at the right-hand side of the list and selecting a symbol. If for a category no operation mode is desired, simply choose the blank symbol from the list. Moreover, for each side of the valve the attributes "Spring-returned" and "Piloted" can be set.

• Description

Enter here a name for the valve. This name is used in the <u>state diagram</u> and in the <u>parts list</u>.

• Valve Body

A configurable valve has at most four positions. For each of the positions a valve body element can be chosen individually. Such an element is set by

clicking on the down-arrow at the right-hand side of the list and selecting a symbol. If for a position no element is desired, simply choose the blank symbol from the list. The valve may be marked "Reversible" to indicate that there is no particular direction of flow.

• Initial Position

This button defines the valve's initial position (sometimes also called normal position or neutral position), which is the position without having any operation applied to the valve. Note that this setting is only exploited if it physically does not contradict a spring-returned setting, possibly defined above.

Dominant Signal

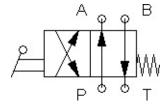
A "Dominant signal" on the left or right-hand side defines the overriding signal, in case the valve is addressed from both sides simultaneously.

• Hydraulic Resistance

This is where you define the hydraulic resistance of the valve.

Choose from the left-hand side in the topmost list a manual operation with snap in, and select the "Spring-returned" option in the right field. Close the dialog box via OK.

Now the valve should look as follows:



Move the mouse cursor over the left cylinder *connection* .

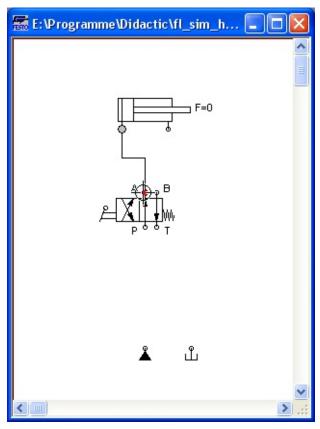
In Edit Mode, the mouse cursor changes to a cross-wires pointer \diamondsuit , when it is above a component *connection* .

- Press the left mouse button while the mouse cursor is above the cylinder connection. Move the mouse cursor and notice how the crosswires pointer gains arrows.
- Keep pressing the mouse button, and move the cross-wires pointer to the upper left valve connection. Notice how the arrows on the cross-

wires pointer turn inward .

Release the mouse button.

Immediately a line appears between the two chosen connections:



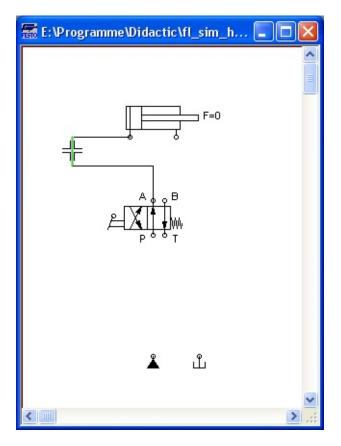
FluidSIM automatically draws a line between the two chosen connections. The mouse cursor changes to the prohibited sign \circ when it is not possible to draw a line between two connections.

Move the mouse cursor to a line.

In the Edit Mode, the mouse cursor changes to a line-selection symbol $\exists \Gamma$, when it is positioned over a line.

Press the left mouse button and move the line-selection symbol to the left. Release the mouse button.

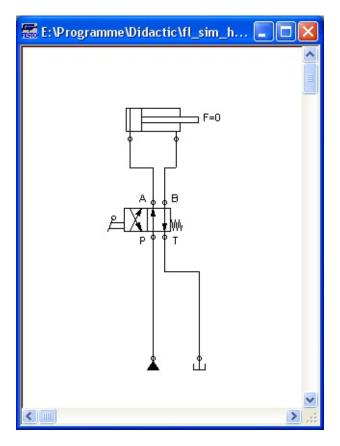
Immediately, the line is redrawn:



In the Edit Mode the components and lines can be selected, moved, or deleted by clicking on Edit- Deleteor by pressing the **Del** key.

Connect the remaining components.

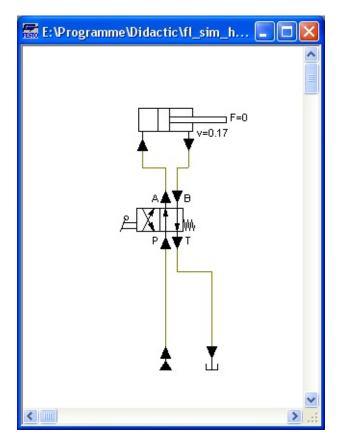
The circuit diagram should look somewhat like the following one:



The circuit diagram has been completely drawn and connected. Attempt to simulate this circuit.

Start the simulation by clicking on (or under Execute- Start or with the **F9** key).

During simulation all pressures and flow rates are calculated, all lines are colored, and the cylinder's piston extends.



After the cylinder has been extended, the pressure in the cylinder supply line must inevitably increase. This situation is recognized by FluidSIM and the parameters are recalculated; the pressure downstream of the pump unit increases to the value, as defined by the pump unit safety guard.

In order to keep the value of the maximum pressure low, the pump unit must be equipped with a pressure relief valve.

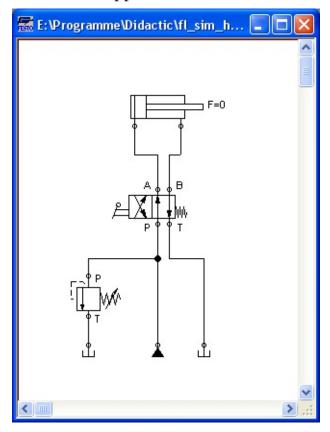
- Activate the Edit Mode by clicking on (or under Execute- Stop or with the **F5** key).
- Drag a pressure relief valve and a second tank into the window.
- In reality, to connect a component to an existing line requires a T-connection . FluidSIM automatically creates a T-connection when you draw a line from a connection to an existing line.
 - Using the cross-wires cursor draw a line between the input connection of the pressure relief valve to the line connecting the pump unit and the valve. Notice how the arrows in the cross-wires turn inwards.

Release the mouse button.

The T-connection appears on the line at the point where the mouse button was released.

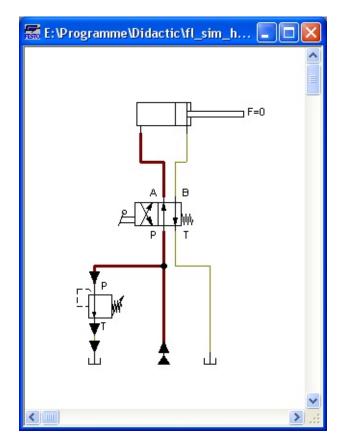
- Connect the tank to the pressure relief valve.
- If necessary, draw the line so that the wiring diagram is arranged clearly.

The circuit diagram should now appear somewhat like the following diagram:



- Save the circuit by clicking on or File- Save. FluidSIM automatically opens the File Selector dialog box, if the title is new; here you must give the circuit a name.
- Start the <u>simulation</u> by clicking **L**.

The cylinder's piston extends. As soon as the piston fully extends, a new situation arises. This situation is recognized by FluidSIM and is recalculated. The pressure relief valve opens and the distribution of pressure is shown:



FluidSIM not only animates manually operated components during changeover, but nearly all components with multiple states.

The following figure shows a pressure relief valve in closed and open position:



Recall that in the Simulation Mode, manually operated valves and switches can be switched with a mouse click:

Move the mouse cursor over the left-hand side of the valve.

Click on the left side of the valve and hold the mouse button down.

When you click on a valve, the real behavior of the valve is simulated. In our example the valve is switched to crossover position and a recalculation is initiated automatically. As a result, the pressure relief valve closes and the

cylinder retracts. As soon as the cylinder reaches its left stop, the pressure relief valve opens again.

Components whose switching status is not locked remain activated as long as the mouse button is held down.

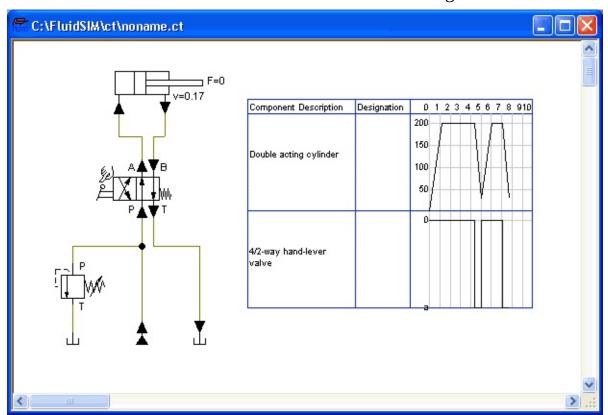
Stop the simulation, which also brings you to Edit Mode. Select from the component library the state diagram component, and place it onto the drawing area.

The <u>state diagram</u> records the state quantities of important components and depicts them graphically.

Move the state diagram to a free place in the drawing. Drag the cylinder and drop it onto the state diagram.

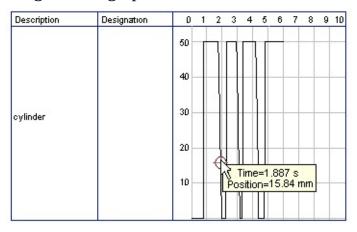
A dialog opens where you may choose the desired status variables. In this particular case only the position is of interest, so you may confirm the default selection by choosing OK.

Start the simulation and observe the state diagram.



Set the simulation to "Pause"-mode and move the mouse curser to the graph in the diagram.

When resting on the diagram for approximately one second, the mouse curser will call a window indicating the exact values of time and of the applicable status variable. The display will move along and update the values when you move the mouse alongside the graph.



You may use several status diagrams in one window as well as you may display several components in the same diagram. By dragging a component onto the diagram you will add the component to the status diagram. A selection dialog will appear where you may choose the applicable status variables and different colors. A repeated drag onto the diagram will open the dialog again, so you may change your choice. In case no status variable of a component is selected, the component will be removed from the diagram. The following components and the applicable status variables may be displayed in the status variable diagram:

Recording state quantities in the state diagram

Component	State
cylinder	position, velocity
	acceleration, force
way valve	position

pressure meter, accumulator pressure

shutoff valve and throttle valve opening level

pump, motor rpm

semi-rotary actuator position

pressure valve and switching valves state, pressure

flow control valves flow

flow meter flow, volume

pressure or switching valve state

switch state

relay, valve solenoid state

indicator light, buzzer, pressure indicator state

counter state, counter value

function generator, voltmeter voltage

status controller, PID-controller voltage

The example is now finished. Further editing and simulation concepts are described in the next chapter.

Related Topic

Advanced Concepts in Simulating and Creating Circuits





Advanced Concepts in Simulating and Creating Circuits

This chapter contains advanced concepts and functions, which can be used when simulating and creating circuits with FluidSIM.

Configurable Symbols

Additional Editing Functions

Additional Simulation Functions

Linking Components Automatically

Current Path Numbering and Switching Elements Table

Terminal Assignment Diagrams

Displaying Quantity Values

Displaying State Diagrams

Functional diagram editor

Superficial Circuit Checking

Coupling Hydraulics, Electrics and Mechanics

Operating Switches

Adjustable Components

Settings for Simulation

Use of the EasyPort-Hardware

OPC and DDE communication with Other Applications

Settings for the EasyPort/OPC/DDE communication

Open-loop and Closed-loop Control by using Continuous Valves

Related Topic

Introduction to Simulating and Creating Circuits





Configurable Symbols

FluidSIM is capable of simulating a vast number of different cylinders and valves. The combination of all part designs and functional types would lead to displaying many thousands of symbols. Therefore you will find, alongside some common part designs in the component library, configurable and representative components. In order to adapt a cylinder or a way valve, drag one of these representatives in the circuit and open the status dialog. Here you will find settings helping you to define layout and function of the component.

Configure Cylinders

Configuring Way Valves





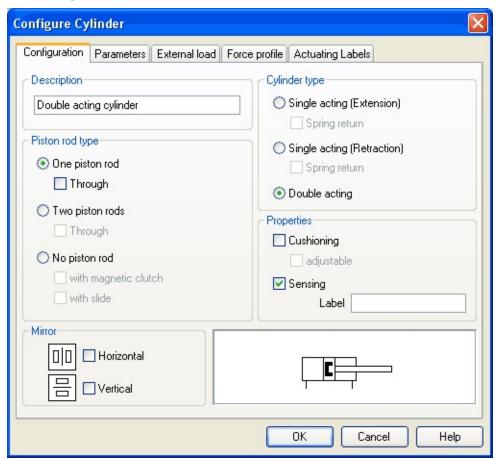
Configure Cylinders

Double-click the cylinder to define part design, parameter and external influence of a cylinder. The status dialog of the cylinder will open.

The dialog consists of several registers, providing a convenient overview despite the vast number of settings.

Find descriptions of the dialog boxes of individual registers below.

Register "Configuration"



- **Component Description**You may enter a description for the cylinder into the text field, it will show in the <u>state diagram</u> and in the <u>parts list</u>.
- **Cylinder Type** cylinder type (single-acting, double-acting, spring return)
- Piston Rod Type

piston rod type (quantity, part design, magnet coupling, slide unit)

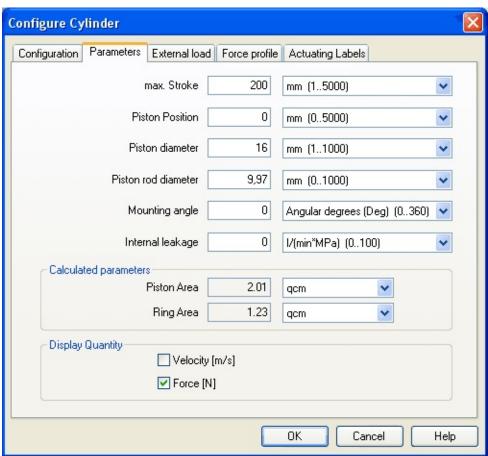
Properties

More properties of the cylinder (end position cushioning, sensing)
The label you may define at "sensing" serves as an interconnection with the displacement encoder. This is how, e.g. in combination with proportional valves, controlled systems can be constructed. Please find more reference to proportional technology in section Open-loop and Closed-loop Control by using Continuous Valves.

Mirror

This is where you may define whether the cylinder will be mirrored horizontally or vertically. The effect will be the same as when mirrored as in Edit- Mirror.

Register "Parameter"



Max. Stroke

Maximum cylinder stroke

• Piston Position

Piston position at the start of the simulation

• Piston Diameter

Diameter of the Piston

Piston Rod Diameter

Diameter of the piston rod of the cylinder

Mounting Angle

The bracket affects the friction force of the moved load. You may define the mass as well as the friction coefficients in the register "external load".

• Internal Leakage

This is where you may define the inner leakage of a cylinder. In reality there is never an ideal cylinder, since the piston never seals the chassis perfectly. Thus and despite the cut off cylinder port, the piston gradually slides under the load.

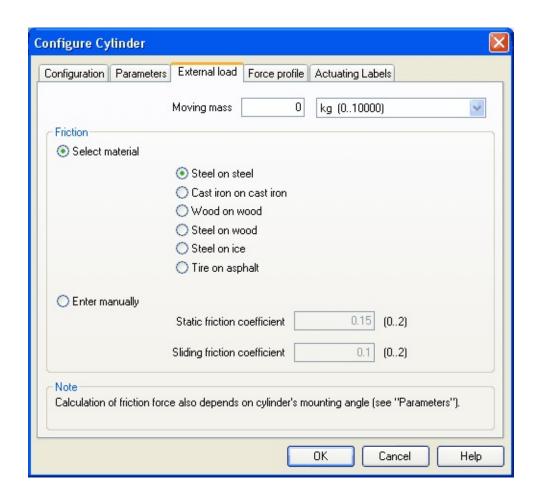
• Calculated Parameters

Piston surface and annular surface will be automatically calculated from piston diameter and piston rod diameter.

• Display Quantities

In the field "Display Quantities" you may tick state variables that are to be displayed alongside the cylinder when the "selected"-option is switched on for these state variables in the state variable box. In case in the state variable dialog box "no"-option is switched on, the particular cylinder related state variables will not be displayed.

Register "External Load"



Moving Mass

Please enter the mass of the load here that is supposed to move cylinder. The mass of the cylinder piston and of the piston rod will be automatically and appropriately calculated by FluidSIM from the entered cylinder dimensions; thus the mass in this case refers only to the external load. Particularly, entering "0" does not conclude in the moving parts being massless.

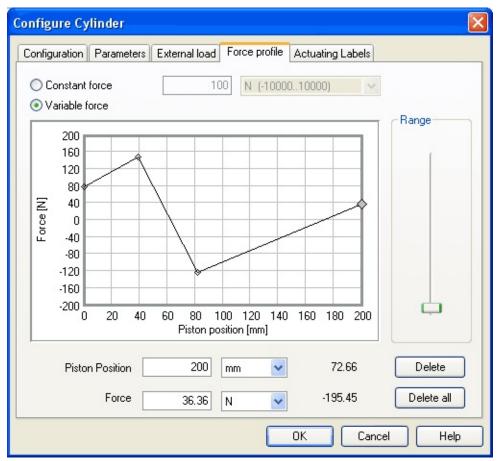
Friction

Static friction and sliding friction determine the friction of the moving load on a surface. The internal friction inside the cylinder will be automatically and appropriately calculated by FluidSIM from the entered cylinder dimensions. Please enter "0" for both values if the load is lifted or pulled without touching a surface. In reality it is very difficult to achieve reliable values for friction. Therefore FluidSIM offers set friction coefficients for

some combinations of material, providing a roundabout orientation. When comparing other tables of friction values you will notice that the (often experimentally measured) specifications differ in major ways. Please interpret these carefully and concurrently take into account the results of simulations generated by friction. Nevertheless, the variation of the friction values allows you to distinctly notice the physical influence of static and sliding friction.

Please note also that the mounting angle influences the friction force through the moved load. You may define the mounting angle in the register "parameter".

Register "Force Profile"



Constant Force

Please choose this option and enter a force if a constant force is meant to

take effect for the entire distance of the cylinder movement.

Variable Force

Please choose this option if the force changes depending on the position of the cylinder rod. You may interactively define applicable points in the chart field by clicking the mouse, these applicable points will be linked to be one lineament. Alternatively, you may mark an existing applicable point and enter the two values numerically for piston position and applicable force using the input field.

• Range

Using this slider you may define the range of values to be displayed for the force.

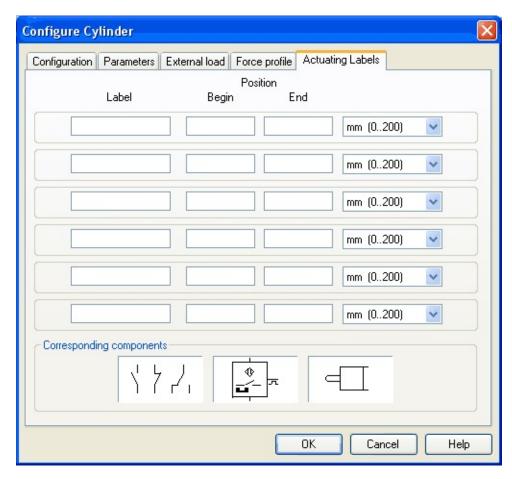
Delete

Deletes the marked applicable point and links the two adjoining points with one straight line.

• Delete all

Deletes all applicable points and defines a constant force. Use this option to delete an existing lineament without having to delete each single applicable point.

Register "Actuating Labels"



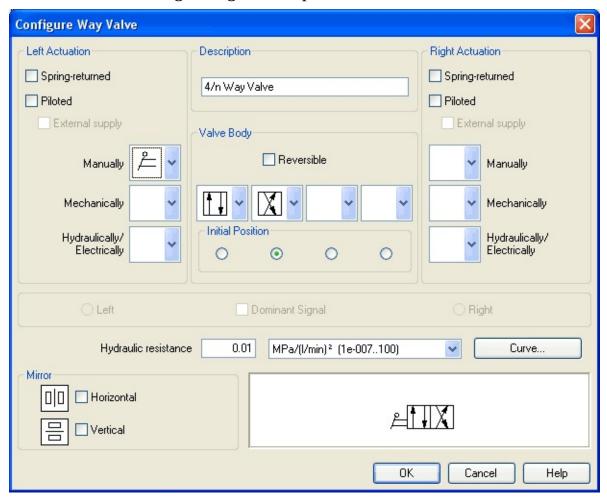
This is where you may define new actuating labels or change existing ones. This dialog box is identical to the one that is opened when you double-click on a <u>distance rule</u>.





Configuring Way Valves

The body of a valve or its operation concept can be changed by double-clicking the valve. The following dialog box is opened.



- **Left/Right Actuation**For both sides the actuation modes of the valve can be defined individually; it can be one or more of the categories "Manually", "Mechanically", or "Hydraulically/Electrically". An operation mode is set by clicking on the down-arrow at the right-hand side of the list and selecting a symbol. If for a category no operation mode is desired, simply choose the blank symbol from the list. Moreover, for each side of the valve the attributes "Spring-returned" and "Piloted" can be set.
- Description

Enter here a name for the valve. This name is used in the <u>state diagram</u> and in the <u>parts list</u>.

• Valve Body

A configurable valve has at most four positions. For each of the positions a valve body element can be chosen individually. Such an element is set by clicking on the down-arrow at the right-hand side of the list and selecting a symbol. If for a position no element is desired, simply choose the blank symbol from the list. The valve may be marked as "Reversible" to display that it has no particular direction of flow.

• Initial Position

This button defines the valve's initial position (sometimes also called normal position or neutral position), which is the position without having any operation applied to the valve. Note that this setting is only exploited if it physically does not contradict a spring-returned setting, possibly defined above.

• Dominant Signal

A "Dominant signal" to the left-hand or right-hand side defines which signal will be overriding when the valve is addressed from both sides simultaneously.

• Hydraulic Resistance

This is where you may define the hydraulic resistance of the valve. In reality the hydraulic resistance is often assigned by a characteristic line resp. by pairs of values (pressure drop/flow). Using the button **Curve...** you may access a dialog by interactively clicking on the chart field or by entering a pair of values and thus defining the process of the parabola.

Mirror

This is where you may define whether the valve be mirrored horizontally or vertically. The effect is the same as when mirrored using Edit- Mirror.





Additional Editing Functions

In addition to the commands that were introduced in section **Creating new** Circuit Diagrams, the Edit Mode in FluidSIM provides you with a higher level of important editing functions:

Setting the Paper Size

Undoing Editing Steps

Multiple Selection

Right Mouse Button

Double Clicking with the Mouse

Copying

Copying between Windows

Aligning Objects

Rotate and Mirror

Deleting Lines

Setting Line Type

Setting Blind Plugs

Zoom Features

Background Grid

Grouping Objects

Ungrouping Objects

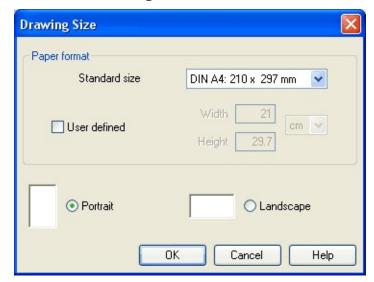






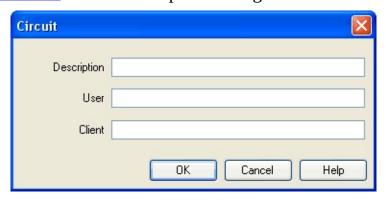
Setting the Paper Size

In Edit Mode the size of the paper is indicated by a red rectangle. The default setting of the paper size is "DIN A4, portrait". The default setting can be changed in the menu File- Drawing Size....



The size and the orientation of the paper can be set here. If the drawing size exceeds the paper size of your printer, the total area of several smaller papers can be tiled with the drawing.

For orientation purposes, under File- Properties... additional information can be stored along with each drawing. The text that is entered in **description** is shown in the <u>preview window</u> below the respective diagram.







Undoing Editing Steps

By clicking on or Edit- Undo and with Edit- Redo, each step given in the Edit Mode can be undone in the following manner:

By clicking on (Edit- Undo), the last editing step that was taken is undone. FluidSIM recalls the last 128 editing steps, which can be undone.

The function Edit- Redoserves as a way to "withdraw the last undone step". When using to undo an editing step, you may go to far. By clicking under Edit- Redo, the circuit is returned to its original state before undo was initiated. The function Edit- Redo can be invoked until there are no more undo steps to be redone.

The function Edit- Undoapplies to all possible editing steps in the Edit Mode.





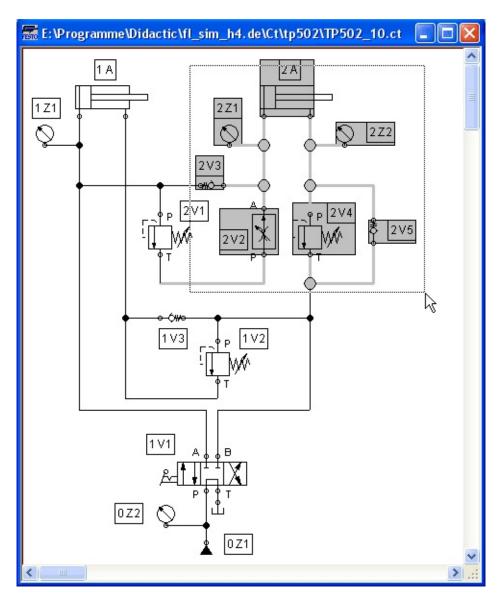
Multiple Selection

A component can be highlighted, that is to say selected, by clicking on it with the left mouse button. However, by clicking on another component with the left mouse button, the first component is no longer selected, but the second component is. Only *one* component at a time may be selected when clicking with the left mouse button.

If, while you are clicking on components, you hold down the **Ctrl** key, the components that are already selected will remain so. In addition, the component underneath the mouse cursor will also be selected, if not already selected, or deselected, if already selected. In this sense, the component's state of selection is reversed.

Another efficient concept for selecting multiple components is by using the *rubber band*. The rubber band is opened by pressing and holding down the left mouse button, and then moving the mouse cursor. The mouse cursor cannot be located directly over a component if the rubber band shall be opened.

All components enclosed, either partially or fully, by the rubber band, are selected.



All components and lines of the current circuit diagram can be selected by clicking under Edit- Select All or typing **Ctrl A**.

Editing functions such as dragging or moving, copying and, deleting apply to all selected components.





Right Mouse Button

When you click the mouse button on the right in a FluidSIM window, the appropriate context menu is opened. If the mouse cursor is located above a component or component connection, the item will become selected. If this component was not yet selected, then a possibly existing selection of other components will be de-selected.

Clicking the right mouse button on a component (connection) is actually a short cut for the following two actions: Clicking the left mouse button on the component (connection) and opening a menu.





Double Clicking with the Mouse

Double clicking the left mouse button on a component (connection) is a short cut for the following two actions: Selecting the component (connection) and clicking on Edit- Properties....





Copying

Selected components can be copied to the clipboard by clicking on Edit-Copy; the component can then be inserted in the circuit diagram by clicking on or Edit-Paste. In the same way it is possible to paste the contents of the clipboard into another graphic or word processing program.

Within a circuit diagram selected components can also be copied by holding down the **Shift** key and moving them. The mouse cursor changes then to the copy symbol $\stackrel{\clubsuit}{\longleftarrow}$.





Copying between Windows

Components can simply be copied between windows by selecting the desired components and dragging them in the other window.





Aligning Objects

To align objects, firstly select these objects and then click on the icon or on the appropriate entry in the Edit- Align menu. Reference object is always the object which lies furthermost in the desired direction. If, for instance, several components shall become aligned left, all but one objects are moved to the left so that they align with the left-most object. Note that hydraulic and electrical components obey the constraint that their connections must lie on the grid. As a consequence, an alignment may not always coincide with the symbol bounding.





Rotate and Mirror

Selected components may be rotated by 90°, 180° or 270° by using Edit- Rotate. If you wish only *one* component to be rotated you may alternatively perform a double-click on the component while holding the **Ctrl**-key, the component will then be rotated counterclockwise in 90°-steps. If you also hold the **Shift**-key in doing so, the component will be rotated *clockwise*.

In order to mirror marked objects, please select Edit- Mirror. The applicable objects will be mirrored at its own axis, provided they are not part of a group. Grouped objects will be mirrored at the central shaft of the applicable group. Instead of using the menu entries, you may also rotate or mirror through the applicable symbols





Deleting Lines

If only one component *connection* is selected, its connected (but de-selected) lines can be deleted using Edit- Deleteor by pressing the **Del** key. This concept provides an alternative way to delete lines.





Setting Line Type

The type of each fluidic line can be changed from the standard line type, "Main Line", to the special line type "Control Line". Being in Edit Mode, double clicking on a fluidic line or selecting the line and choosing the menu entry Edit-Properties... brings up a dialog box in which you can set the line type. A control line is shown dashed. Note that—aside from a different appearance—changing line type has no impact respecting simulation.

Related Topic

Line (hydraulic)

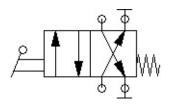




Setting Blind Plugs

Before starting a simulation, FluidSIM checks for open connections and, on request, will fit a blind plug. You can set or delete such blind plugs in the Edit Mode by double clicking on the desired hydraulic connection. A dialog box appears, in which you can either set or remove a blind plug for the selected connection. Another way to go about changing blind plugs is to select the desired connection and then click under Edit- Properties..., which will open the desired dialog box.

Hydraulic connections that are fitted with a blind plug are indicated clearly with a crossbar.







Zoom Features

The content of windows can be enlarged by clicking on or View- Zoom In or reduced by using or View- Zoom Out. The short cut keys for this function are > and < respectively. If your mouse device is equipped with a mouse wheel you can roll the wheel while holding down the **Ctrl** key to zoom in and out, respectively

If you click on or View- Zoom by Rubber Band and then draw a rectangle with the rubber band, the selected area will be shown enlarged. You can also switch between the current and previous view of a window by clicking on or View- Previous View.

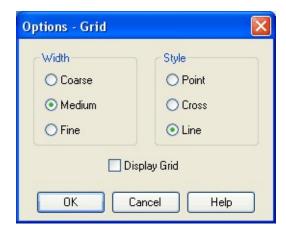
or View- Fit to Window fits the entire circuit to the window; or View-Standard Size shows the circuit diagram without enlargement or reduction.





Background Grid

By clicking on , the background grid is shown. By clicking under Options-Grid..., a dialog box appears that allows you to select between grid types and line resolution.



- **Width** The grid width defines how close together the lines of the grid should be. You can choose between "Coarse", "Medium", or "Fine".
- **Style**There are three types of grid to choose from "Point", "Cross", or "Line".
- **Display Grid**This selection displays or hides the background grid.





Grouping Objects

If objects shall be subsumed under a single group, select them and click Edit-Group. Groups can be nested. The objects of a group can be selected, moved, deleted, or copied only all at once. However, component properties can be edited individually, as usual, by either double clicking the object or choosing the respective entry in the component's context menu.





Ungrouping Objects

To ungroup a collection of objects, click Edit- Ungroup. Note that only the outermost group is resolved; repeated ungrouping will resolve nested groups.







Additional Simulation Functions

This section describes in detail additional functions that apply to the simulation of circuit diagrams.

Simultaneous Actuation of Several Components

Switching to the Edit Mode

Editing and Simulating in Parallel





Simultaneous Actuation of Several Components

During the Simulation Mode, it is sometimes necessary to actuate more switches or valves simultaneously. It is possible in FluidSIM to simulate just such an actuation by means of setting a component in a permanently actuated state. A button (or a manually operated valve) will become permanently actuated when clicking on it while holding down the **Shift** key. This permanent actuation will be released by a simple click on the component.

At times it may be necessary to release several actuated objects at once. In this case, while clicking the object, hold the **Ctrl**-key instead of the **Shift**-key. The reversed components will remain actuated until the **Ctrl**-key is released again; this is how all applicable objects will simultaneously switch back to their original position.





Switching to the Edit Mode

If a component is dragged from the component library to the circuit in the drawing area, and the simulation has been paused , FluidSIM automatically switches to the Edit Mode.

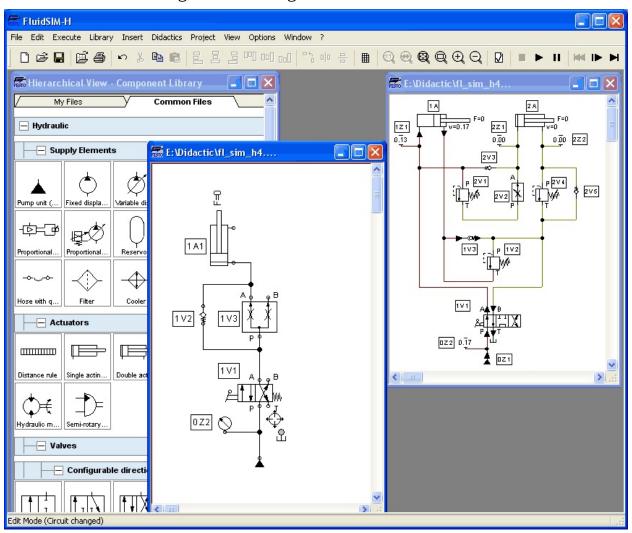




Editing and Simulating in Parallel

In FluidSIM it is possible to open more than one circuit diagram at a time. Each circuit can either be simulated or edited. This fact means that the Simulation Mode and the Edit Mode are applied uniquely and independently to each window containing a circuit diagram.

This concept means that it is possible to edit one circuit diagram, while other circuits are in the background running in simulation:



It's in the nature of hydraulics that the simulation of circuits is a demanding problem. Therefore, when using a lower-performance computer, the editing of

new circuit diagrams often appears jerky when simulations of other circuits are simultaneously running in the background. So that working in the Edit Mode goes more smoothly, all simulations performed in the background should be stopped.

Related Topic

Settings for Simulation





Linking Components Automatically

In order to make circuit design efficient, FluidSIM provides more functions to facilitate component linking.

Insertion of T-connections

Connecting Components in Series





Insertion of T-connections

FluidSIM automatically inserts a T-connection when a line is drawn from a component *connection* . to an already existing line. This functionality applies to hydraulic as well as electrical and digital lines.





Connecting Components in Series

In major circuits several components are often connected in series. To reduce the effort of connection in such a serial connection you may place components without a distance and on the same level in such way one after another that neighboring in or outputs will meet; this is how FluidSIM automatically establishes the connections of these inputs and outputs.

These connections will be visible by displaying lines when you move the components away from each other.

FluidSIM will only establish the connections of components once a simulation is started or when a circuit is checked graphically (see Section Superficial Circuit Checking).





Current Path Numbering and Switching Elements Table

The automatic generation of current paths simplifies the identification of switches and relays when constructing electrical circuits. Along with the generated switching element tables FluidSIM makes it easy to understand which switches are controlled by which relays. To make the automatic labeling feature a satisfactorily working concept, the following points should be obeyed.

- The +24V current path should form the top horizontal line.
- The 0V current path should form the bottom horizontal line.
- The electric make/break/changeover switches should be placed above the relays.
- The relays should be placed closed to the bottom 0V current path.
- All connections of a vertical current path should align.
- The horizontal distances between the paths should be equal and of reasonable distance.

If the automatic numbering or the label positions are not entirely satisfying, a manual adjustment of a few lines or components will yield the desired layout quality in most cases. If two separated electrical circuits cause an unfavorable numbering, try to increase the distance between these circuits.

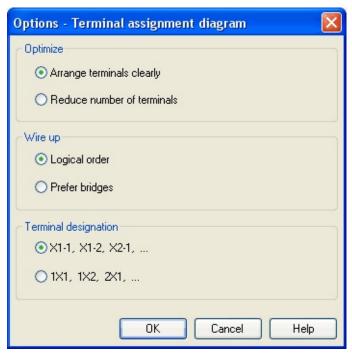
The automatic current path numbering can enabled or disabled via View / Display current path numbering and switching elements table.





Terminal Assignment Diagrams

The automatic establishment of terminal assignment diagrams will help you with the clear wiring of external switches, sensors and state indicators outside the control cabinet with the relays and switches inside. FluidSIM automatically and appropriately numbers the terminals in the electrical part of the circuit as soon as you place the component "terminal assignment diagram" in the circuit. Using Options- Terminal Assignment Diagram... you may define several presettings:



• Optimize

You may choose either a better overview or a reduced number of terminals for an optimization goal.

• Wire up

Please choose whether FluidSIM is to commit to the logical order when numbering the terminals or, if possible, whether it is to privilege bridges, even if this causes to disturb the strict order of numbering.

• Terminal Designation

Defines which convention will rule the designation of the terminals in the

electrical circuit.

Please leave plenty of space in the electrical circuit between the components and towards the voltage supply paths to give enough room for the automatically inserted terminal connections as well as their designation to be seen.

FluidSIM starts a new terminal strip for each partial circuit that provides no connection with other electrical circuits. These are numbered by "X1", "X2", "X3", etc. Each terminal allocation list may either show all terminal strips or a single one. In order to do this please open the status dialog of the terminal allocation list by double-clicking it:



Selection

Defines for which electrical partial circuit the allocation will be listed in this table.

• Layer

In this selection list you will select the <u>drawing layer</u> of the diagram. The <u>drawing layer</u> may be set by clicking on the downward arrow on the right-hand side of the list and choosing a layer.

Depending on the setting of the <u>drawing layers</u>, the rectangle may happen to be non-displayed or to be non-editable. To make the object visible or to change the settings, you need to temporarily activate the <u>drawing layer</u> in the menu View- Layers....

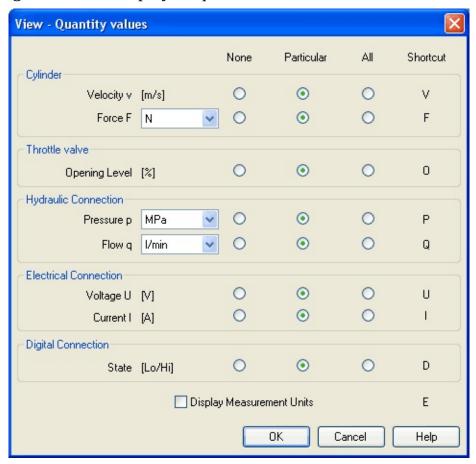




Displaying Quantity Values

The values for all or only selected quantities of a circuit can also be displayed without measuring instruments.

Click under the View menu on Quantity Values... to open the dialog box for the display of quantities:



For each of the listed quantities ("Velocity", "Pressure", ...) a display mode can be chosen.

The display of pressure, flows and force values allows the choice of different units. This settings influence the display of state variables of connections, components and state diagrams.

• **None** No values are displayed for this quantity.

Particular

Values are displayed at those connections that the user has previously chosen.

All

Values are displayed at all connections for this quantity.

• Display Measurement Units

Enable this option if both state values and the related units shall be displayed.

For each quantity there is a key short cut for toggling between the three display modes. The "Shortcut" column of the dialog box for the quantity display shows the appropriate keys.

Selecting connections for the display of single parameters is explained here:

- Open a circuit diagram.
- Change into the Edit Mode and double click on a component connection, or click under the Edit menu on Properties....

A dialog box with the connection settings opens. The field "Show Values" defines the state values to be displayed when the "selected"-option in the state values dialog box is chosen. However, if the "no"-option in the state values dialog box is chosen, even the checked state values are not displayed.

The settings for the display behavior for state values belong to the current circuit diagram only. Hence, for several open circuit diagrams, different view options can be defined. By clicking on Options- Save Settings Now, the view option settings of the current circuit are saved and serve as default for newly opened circuit diagrams.

Special Features of the Quantity Display





Special Features of the Quantity Display

Vector quantities are characterized by an absolute value along with a direction. To indicate the direction within a circuit diagram the signs "+" (into or toward a component) and "-" (out of or away from a component) are used. An arrow may also be used to display direction. FluidSIM uses both representations:

Direction indicators in FluidSIM

Quantity	Direction indicator
Flow	Sign, arrow
Velocity	Sign
Force	Sign
Current	Sign

The arrow as a direction of flow indicator can be turned on or off by clicking under View- Display Flow Direction. The arrow for the direction of flow will be shown clear the component connection, that is, as long as the flow is other than zero.

If the total value of a quantity is extremely near to zero (< 0.0001), no numerical value will be displayed. Rather, the symbol "> 0" for a small positive value or "< 0" for a small negative value is shown.





Displaying State Diagrams

The <u>state diagram</u> records the state quantities of important components and depicts them graphically.

You may use several state diagrams in one window as well as to display several components in the same diagram. By dragging a component on the diagram you will add the component to the state diagram. A selection dialog will open where you may select the state variables to be logged as well as to define different colors. Dragging on the diagram again will reopen the dialog, allowing you to change your choice. In case no state variable of a component is selected, the component will be removed from the diagram.

When in edit mode please double-click the state diagram or select the menu option Edit- Properties....

The following dialog box opens:



Description of the dialog box:

• **Display Interval**This is where you may enter starting point and terminal point of the interval, defining how the state variables be logged. Prior to the simulation, you don't need to necessarily know when the interesting events are going to happen; the display interval may also be changed after the simulation, since FluidSIM internally logs all values all the time of the simulation.

If you select the field "adjust automatically", the defined limits will be ignored and the time axis will be scaled in such way that the entire period of the simulation can be displayed.

Activate the field "run automatically", if the diagram is to the last n seconds. In this case, the time axis will be displaced to the left-hand side once the simulation period exceeds the defined time window. In the input field you may define how many seconds are to be displayed in the applicable time window.

• Log File

The state values be written to a file. To enable this option enter the complete path of a file and set a reasonable step width.

Note that a large amount of data can be written the step width is very small. Hence, if necessary, shorten the simulation interval or increase the step width.

If the option "Record state changes only" is enabled, FluidSIM lists only values if at least one state variable incurred a state change. This option simplifies the detection of interesting simulation points-

Color

Defines the color of the diagram. It is set by clicking on the down-arrow at the right-hand side of the list and selecting a color.

• Fill Area

Defines whether the entire diagram or only its frame is filled with specified the color.

• Line Thickness

This is where you define whether curves in the diagram are to be thick or thin. Thin lines are appropriate for exact reading of the values, thick lines are appropriate for spotting the curve from a distance.

• Diagram Columns

This is where you select the columns to be displayed at the left-hand side of the diagram. The columns "Description", "Designation" and "Quantity value" can be combined to your choice.

• Layer

Sets the <u>drawing layer</u> of the diagram. It is set by clicking on the downarrow at the right-hand side of the list and selecting a layer. Depending on <u>drawing layer</u> the diagram may be invisible or not selectable. In such a case the <u>drawing layer</u> must be activated via View- Layers... before the diagram can be modified.

State quantities of the following components can be recorded and displayed in the state diagram:

Recording state quantities in the state diagram

Component	State
Cylinder	Position
Way valve	Position
Pressure Meter, Accumulator	Pressure
Shutoff Valve and Flow Control Valve	Opening Level
Pump, Engine	Speed
Swivel Cylinder	Position
Pressure and Switching Valves	Status, Pressure

Flow Control Valves Flow

Flow meter Flow, Volume

Switch Status

Relay, Valve Solenoid Status

Indicator Light, Buzzer, Pressure Indicator Status

Counter Status, Counter Value

Function Generator, Voltmeter Voltage

Status Controller, PID-Controller Voltage





Functional diagram editor

Using the functional diagram editor, you may easily generate function diagrams, such as e.g. distance-step diagrams.

By dragging the window edges, the window can be resized. It is also possible to maximize the window.

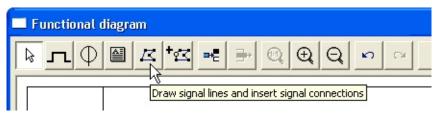
The tool bar buttons are used to edit a functional diagram. With the following six buttons you can chose an operation mode.

- Edit mode
- Draw diagram curves
- Insert signal elements
- Insert text boxes
- Draw signal lines and insert signal connections
- Insert additional nodes into signal lines

The chosen mode is pointed out in white.

for example indicates that signal lines are drawn by clicking into the diagram area.

If the mouse pointer remains for more than one second on a button, a short description appears on the screen.



Edit mode

Set up diagram properties

Table text boxes

Adjust the representation of the diagrams

Draw diagram curve

<u>Insert signal elements</u>

<u>Insert text boxes</u>

Draw signal lines and insert signal connections

Insert additional nodes into signal lines

Add row

Delete row

Additional functions







Edit mode

This mode is used to adjust the objects in the functional diagram. You can move elements in the diagram. The size of text boxes can be changed in this mode only.

Move- and resize operations can be aborted with the **Esc** button.

If you move the mouse pointer out of the window area by keeping the left mouse button pressed, the view is scrolled automatically.

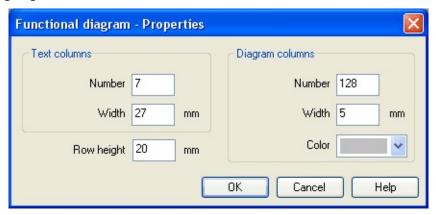
A double-click on a diagram element (diagram row, text, signal element, etc.) opens a dialog box where the requested adjustments can be made.





Set up diagram properties

A click on the button opens a dialog box in which you can set up the diagram properties.



- **Text columns Number**If the number of the text columns is changed, all table's text boxes are distributed equally in a horizontal direction.
- Text columns Width

If the width of the text columns is changed, all table-text boxes are distributed equally in a horizontal direction.

• Diagram columns – Number

The diagram columns are located on the right side of the functional diagram. In this area the diagram curves can be drawn. The number of diagram columns can also be changed by moving the mouse on the right margin of the diagram.

• Diagram columns – Width

Color

Color used for drawing the grid lines in the diagram area.

• Row height

Determines the height of all rows.



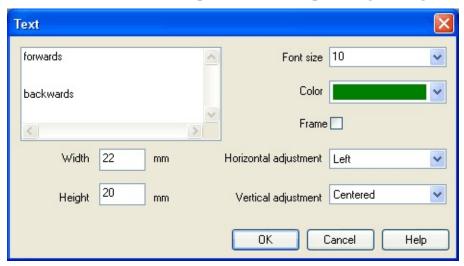


Table text boxes

On the left side of the functional diagram the table's text boxes are located.

Description	Designation	Function	State	
				Sc
	(2)		3	
			1	

A double-click on a table text box opens the corresponding dialog box.



- **Font size**Font size of the text to be represented.
- Color

Choice between sixteen standard colors for the text to be represented.

• Width

The width of the table column you have chosen can also be changed by moving the mouse.

• Height

The height of the table column you have chosen can also be changed by moving the mouse.

• Horizontal adjustment

Following adjustments are available: "Left", "Centered" and "Right".

• Vertical adjustment

Following adjustments are available: "Top", "Centered" and "Bottom".

• Table-like adjustment within a table cell

In order to get a table-like adjustment of text within a text box, tabulators are inserted between the separate parts of the text. The text is represented in the text box according to the number of tabulators and the defined horizontal and vertical adjustments. In order to set tabulators within a text field of a dialog box it is necessary to keep the **Ctrl** button pressed.

Examples: Text 3TK1 3TK3 Font size 9 Color 3TK2 3TK4 Frame ___ < 33 Width Horizontal adjustment mm Centered Height Vertical adjustment mm 0K Cancel Help 1. 3TK1 3ТК3 3TK2 3TK4 Text 3TK1 3TK3 Font size 9 3TK2 Color 3TK4 Frame ___ < Width mm Horizontal adjustment Bottom Height Vertical adjustment mm 0K Cancel Help 2.

	l .	
	3TK1	зткз
	3TK2	3TK4
_		

Related Topic

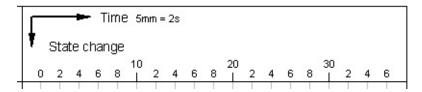
<u>Insert text boxes</u>



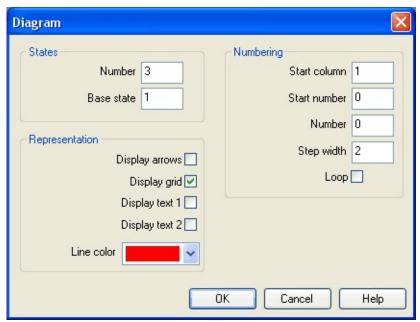


Adjust the representation of the diagrams

On the right side of a diagram row you can find the area in which the curves can be drawn.



A double-click on this area opens a corresponding dialog box. You can determine the appearance of the drawing area with it. Please make sure that there is no diagram element under the mouse like e.g. a signal element.



- **States Number**The entry defines the number of states and by that the number of horizontal lines in the diagram row.
- States Base state

 Horizontal lines through the base state are drawn with a thin pen.
- **Numbering Start column**The start column indicates at which column the numbering is to begin.
- Numbering Start number

 The start number indicates with which number the numbering is to begin.

Numbering – Number

The number indicates how many steps are to be numbered.

• Numbering – Step width

Defines the step width between two numbers.

• Numbering – Loop

If this field is marked, an equals sign and the start number display additionally after the last number.

• Representation – Display arrows

If this field is marked, two arrows display.

• Representation – Display grid

If this field is marked, the background grid displays.

• Representation – Display text 1

If this field is marked, a text box displays. It can be used for marking purposes. This text box belongs to the row you have chosen and cannot be shifted into another row.

• Representation – Display text 2

If this field is marked, an additional text box displays. It can be used for marking purposes. This text box belongs to the row you have chosen and cannot be shifted into another row.

• Representation – Line color

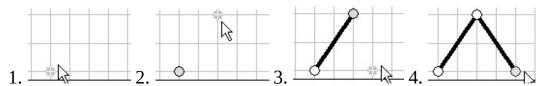
Defines the color of the diagram lines.





Draw diagram curve

In this mode you can draw the diagram curves. Nodes can only be inserted on the grid. Every left mouse click creates a new node.



If you keep the left mouse button pressed, nodes can be moved like in the edit mode.

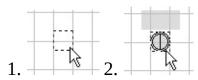
Marked nodes are shown in gray color. With the **Del** button a marked node is deleted.





Insert signal elements

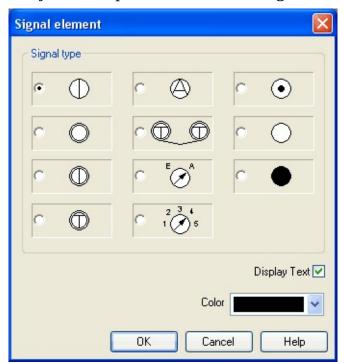
 \Box In this mode you can insert signal elements with a left-click.



If you keep the left mouse button pressed, signal elements can be moved like in the edit mode.

Marked signal elements are shown in gray color. With the **Del** button a marked signal element is deleted.

A double-click on a signal element in the edit mode opens a corresponding dialog box. You can adjust the representation of the signal element with it.



- Signal type
- Display text

If this field is marked, a text which can be used to mark the signal element displays.

• Color

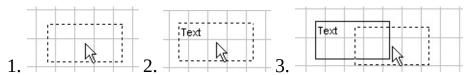
This is the color showing the signal element.





Insert text boxes

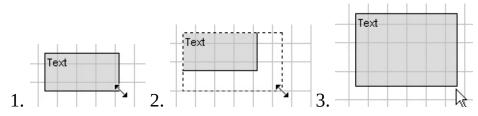
In this mode you can insert text boxes by a left mouse button click.



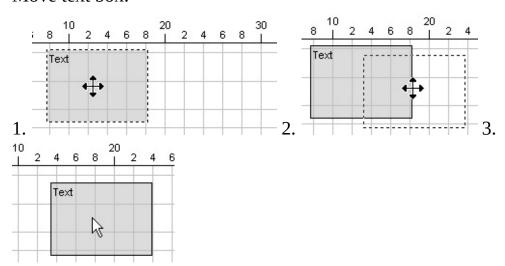
Marked text boxes are shown in gray color. With the **Del** button a marked text box is deleted.

In the **edit mode** the size and position of a text box can be changed with the mouse.

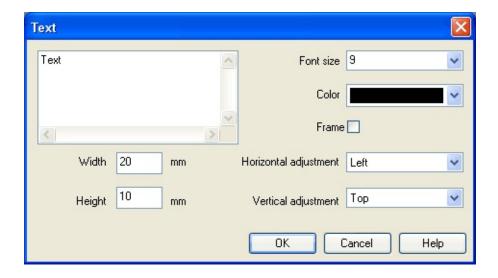
Adjust size:



Move text box:



A double-click on a text box in the edit mode opens a corresponding dialog box. You can adjust the representation of the text box with it.



- **Font size**Font size of the text to be represented.
- Color

Choice between sixteen standard colors for the text which can be represented.

• Frame

If this field is marked, the text box is drawn with a frame.

• Width

The width of the text box.

• Height

The height of the text box.

• Horizontal adjustment

Following adjustments are available: "Left", "Centered" and "Right".

• Vertical adjustment

Following adjustments are available: "Top", "Centered" and "Bottom".

Related Topic

Edit mode





Draw signal lines and insert signal connections

In this mode signal lines can be drawn arbitrarily or can be transferred automatically by signal elements.

Draw signal lines arbitrarily

Every left-click creates an additional node. You can stop this operation by clicking on the present line and keeping the **Ctrl** button pressed, by pressing the **Esc** button or by changing the operation mode. With the **Del** button a marked signal line is deleted. If only one node is marked, just this node is removed from the line.

In the **edit mode** you can move the nodes of the signal lines. If you keep the **Shift** button pressed when you place or move nodes, the corresponding node is adjusted vertically and horizontally, respectively.

Change the representation of the lines in the edit mode with a double-click.



• **Display description**A framed description on the line and a description next to the framed description displays.

The framed description can be moved freely on the line. The additional description can be moved freely.

• Start with arrow

An arrow displays at the beginning of the line. The arrow can be moved freely on the line.

End with arrow

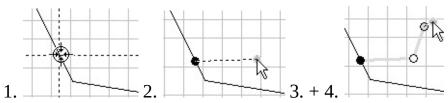
An arrow displays at the end of the line. The arrow can be moved freely on

the line.

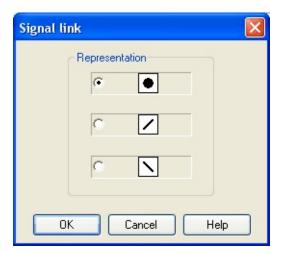
Color

Line color.

If you click on a finished signal line in the mode draw signal lines , a signal connection is inserted. This connection node can be moved freely on the line.

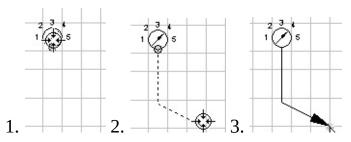


In the edit mode the representation of the signal connection can be changed by a double-click:



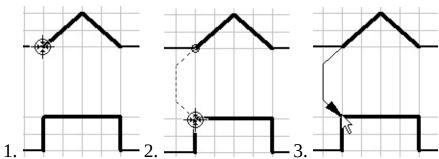
Draw signal lines from signals onwards

In the mode draw signal lines [45], signal lines can be drawn from signals onwards. Click with the left mouse button on a signal and keep the mouse button pressed. Move the mouse to a position which you have chosen as the end point of a signal line. After having released the mouse button, the signal line is being drawn.



Draw signal lines from diagram-nodes onwards

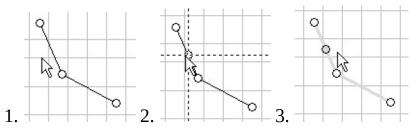
In the mode draw signal lines [45], signal lines can be drawn from curve nodes onwards. Click with the left mouse button on a node and keep the mouse button pressed. Move the mouse on a second node. After having released the mouse button on top of the second node, the signal line is being drawn.





Insert additional nodes into signal lines

In the mode insert additional nodes into signal lines time, additional nodes can be inserted into existing signal lines.







Add row

By clicking on the button **Add row**, a new diagram row is inserted on top of the current selection. If there is no selection on a cell, a new line is added to the end of the diagram.





Delete row

By clicking on the button **Delete row**, a selected diagram row is deleted. If nothing is selected, the button is disabled.





Additional functions

Zoom

With the button 1:1 view the view is reset to the standard zoom level.

With the button the view is enlarged in size.

With the button the view is reduced in size.

Undo actions

With the button undo Line, you can undo the last 50 actions.

With the button redo , the actions you have undone before can be redone.

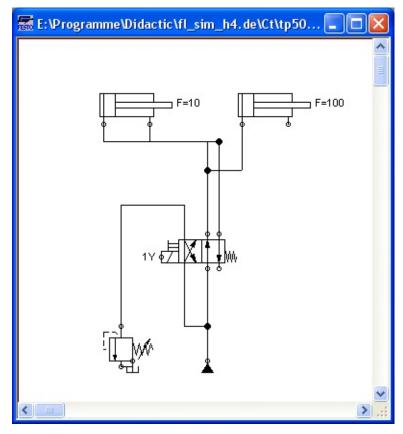




Superficial Circuit Checking

Before a simulation is started, the circuit diagram can be checked to see if there are any *graphic* drawing mistakes present. The mistakes that lead to errors include the following:

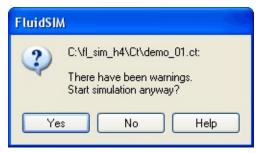
- 1. objects outside of the drawing area
- 2. lines that cross through components
- 3. superimposed lines
- 4. superimposed components
- 5. superimposed connections or connections that do not go together
- 6. open hydraulic connections
- 7. components that have the same identification assigned
- 8. mismatched labels (see section <u>Coupling Hydraulics</u>, <u>Electrics and Mechanics</u>)
- 9. lines that cross through connections to which they are not connected The following circuit diagram contains mistakes of type 2, 3, 4, and 6:



Click on or Execute- Check Superficially.

Message boxes should now appear, which inform the user of the graphic mistakes.

After the instructions, you may decide if the circuit should be simulated anyway:



In the case that you start a circuit with open hydraulic connections FluidSIM automatically closes these connection with blind plugs.

Related Topic

Simulating Existing Circuit Diagrams

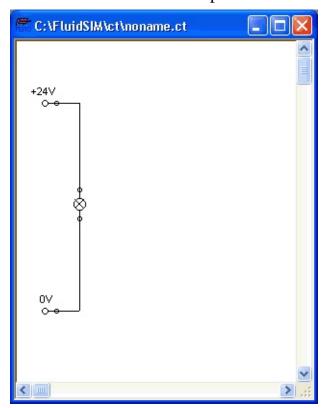




Coupling Hydraulics, Electrics and Mechanics

In the same way FluidSIM allows you to create hydraulic circuit diagrams, the software also allows you to design electrical circuits. The components for the electrical circuits can be found in the component library and dragged from there to be inserted on the drawing area. Electrical components are connected in the same way that fluidic components are.

The following illustration shows a small example:



- Create this circuit diagram on your computer.
- Start the simulation and observe that the indicator light is illuminated.

There are also electrical components that link electrical circuits with hydraulic circuits. These linking components include switches that are hydraulically operated and solenoids that control directional valves.

Electrical circuits are drawn independently of hydraulic circuits. Therefore, there needs to be a way to create definite links between electrical components (such as

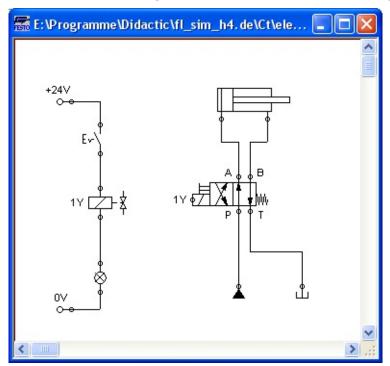
a control solenoid) and hydraulic components (such as a directional valve). So-called *labels* bridge the difference and link both circuit diagrams together.

A label has a specific name and can be assigned to a component. If two components have the same label name they are linked together, although no apparent line is visible between them.

Entering a label takes place in a dialog box, which can be opened by either double clicking on the desired component or selecting the component and then clicking Edit- Properties.... Labels can be established on the left and right sides of an electrically operated valve by double clicking on the appropriate side, as opposed to clicking in the middle of the component.

The following example explains how labels can be used in FluidSIM.

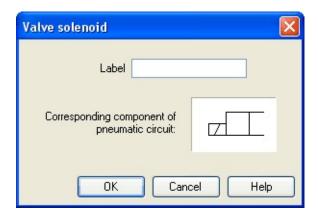
- Activate the Edit Mode by clicking on 🔳 or Execute- Stop.
- Create the circuit diagram as shown in the following figure:



So that the valve can be controlled by the solenoid, you have to link the components with a label.

Double click on the control solenoid or simply select the control solenoid and click under Edit- Properties....

The following dialog box appears:



Description of the dialog box:

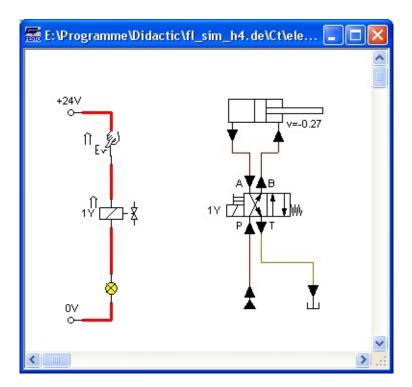
- **Label** This text field gives the label its name. A label can be up to 32 characters in length consisting of letters, numbers, and symbols.
- Enter a name for this label, for example "Y1".
 - Double click on the outside of the valve solenoid to open the dialog box for the label name.
- Input the same label name as for the solenoid, for example "Y1". The solenoid is now linked to the valve.
- In practice the valve solenoid would not be directly controlled by the switch, rather via an intermediate relay. This component has been neglected here for the sake of simplicity.
 - Start the simulation.

The electrical current as well as the pressure and flow distribution are computed; the pressures are shown in color.

If you want to see the exact values of the quantities at hand, you can mark them by clicking under View- Quantity Values.... The marked quantities are displayed next to the components' connections. Section <u>Displaying Quantity Values</u> applies here.

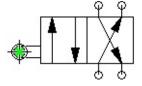
Operate the electrical switch.

As a result the valve switches and the cylinder's piston extends:



Aside from a manual or electrical operation, valves can be controlled *mechanically*, either through a cylinder piston or a magnet mounted at the piston. Such a coupling is realized in the same way an electrical coupling is established: By means of labels, which are assigned to the cylinder's distance rule and the mechanical valve connection.

Draw a configurable valve on the drawing area and furnish it with a mechanical actuator.



Double click the mechanical actuator.

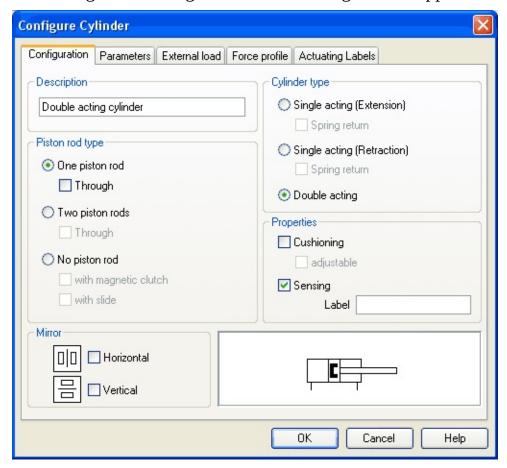
A dialog opens where a string for the related label can be entered. If the same label is assigned to the cylinder's distance rule, the valve will become actuated mechanically if the cylinder piston reaches its predefined position.

A particular form of interconnection is presented by the connection of a cylinder with a <u>displacement encoder</u>. This is how, e.g. in combination with <u>proportional valves</u>, you may create controlled systems. You will find further advice on proportional technology in section <u>Open-loop and Closed-loop Control by using</u>

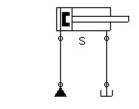
Continuous Valves .

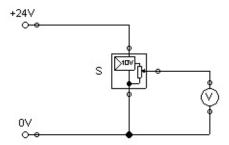
Double-click a cylinder.

A dialog box opens where you may define the cylinder properties. Please make sure to have the register "Configuration" in the foreground if applicable.



- Activate the box "Sensing" and add a label.
- Insert the displacement encoder from the component library in the circuit and double-click to open the properties dialog. Please enter the same label here as for the cylinder.





At the output the displacement encoder system provides a voltage proportional to the piston position of the interconnected cylinder. This voltage will be at its defined minimum when the cylinder is retracted completely; the voltage will be at its defined maximum when the cylinder is advanced completely.

Display Styles for Labels

Related Topics

Simulating Existing Circuit Diagrams

Switches at Cylinders

Open-loop and Closed-loop Control by using Continuous Valves





Display Styles for Labels

If a label shall be displayed framed, similar to the display of component descriptions, click onto View- Labels....

The following dialog box opens:



In the dialog box for each label of the circuit its style, framed or not framed, can be defined.

FluidSIM will place the labels automatically in such order that they will usually be at an appropriate position near the component resp. near the connection. Instead, you may also move the labels using the mouse or the keyboard. To do this, please click the label and move it to the desired position. To change the position using the keyboard, please mark the label (or the applicable connection) and move it with the curser keys.

FluidSIM keeps you from moving the label too far away from the applicable component or the connection. Once a particular distance is exceeded, you won't be able to move the label any further away in that particular direction.

Related Topic

Switches at Cylinders





Operating Switches

This section describes how to operate switches by means of cylinders, relays, pressure, or other switches.

Switches at Cylinders

Relays

Coupling Mechanical Switches

Automatic Switch Altering





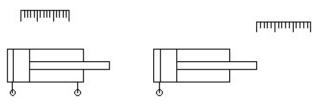
Switches at Cylinders

Limit switches, proximity switches, and mechanically operated valves can be activated by the piston of the cylinder. Therefore, it is necessary to use a distance rule at the cylinder to position the switches correctly:

- Drag a cylinder and a distance rule **IIIIIIIIII** to the drawing area.
- Drag the distance rule near to the cylinder.

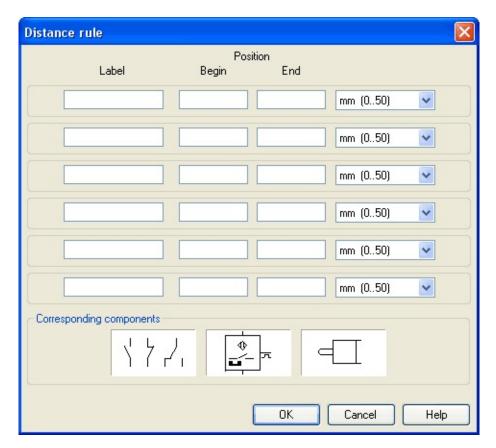
When the distance rule is dropped near the cylinder, it automatically snaps in the right position. Move the cylinder just slightly and the distance rule moves with it. If you move the cylinder more than a centimeter in distance, the connection between distance rule and cylinder is broken, and the distance rule does not travel with.

The correct position for a distance rule depends on the type of cylinder. Distance rules can be set *above* the cylinder, *before* the cylinder (on the moving piston), or at both positions at the same time:



Double click on the distance rule.

The following dialog box appears:



Description of the dialog box:

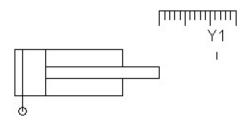
• **Label** The text insertion fields on the left are for naming labels from proximity switches or limit switches in electrical circuits, which are actuated by the movement of the cylinder's piston.

Position

The description fields on the right-hand column define the precise begin and end positions of the switches and of the limit switch at the cylinder.

At the first line, please enter 35 for both labels "Y1" and for begin and end position, then please close the dialog box by clicking "OK".

Immediately following, a mark with the appropriate label appears beneath the distance rule:



I.e., this cylinder activates the switch or the valve with the label "Y1", when its piston has moved 35 mm, provided the switch in the electrical part of the circuit resp. the mechanical "connection" of the valve was given the same label.

Once the cylinder in the above example has exceeded the position 35 mm, the switch will be put to off. If you wish the activation of the switch to last over a longer distance, please enter the applicable begin and end positions in the dialog.

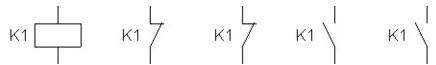
To place labels for electrical switches, please double-click the component; valves with mechanical actuation come with a particularly designed "connection", e.g. at the end of the stem, or at the center of the roller. If the component or the connection has already got a label you may double-click the label straight away instead of the connection in order to change the designation.



Relays

By using relays, more than one switch can be actuated simultaneously. It is therefore necessary to couple the relay with the appropriate switches. Thus in FluidSIM also relays possess labels, which can be used to couple relays and switches in the previously described way. By double clicking on a relay, the dialog box for a label name appears.

The following illustration shows an electrical circuit in which a relay operates two break switches and two make switches at the same time:



Besides simple relays, relays with switch-on delay, relays with switch-off delay, and relay counter exist. These relays are used when the linked switch should be actuated after a preset time interval or a number of pulses received. By double clicking on these relays, a dialog box appears where the appropriate values can be entered.





Coupling Mechanical Switches

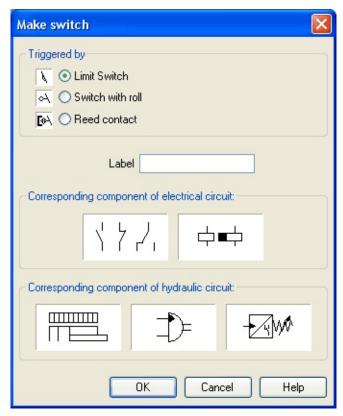
To mechanically couple mechanical (manually operated) switches in FluidSIM, you have to use labels. When more than one mechanical switch has the same label, all these switches operate with the switching of only one.





Automatic Switch Altering

FluidSIM recognizes delay switches, limit switches, and pressure switches by the nature of their usage and by their labels and supplies the corresponding symbol for the switch in the electrical circuit: \leftarrow for switch-on delayed, \rightarrow for switch-off delayed, \rightarrow for mechanical operated switches, and pressure operated switches. The representation of switches that are actuated by cylinders can be determined by selecting the corresponding switch type in the component's properties dialog:



This means that there do not exist special symbols for these switches in the FluidSIM component library. Instead the symbols for simple switches can be utilized:







Adjustable Components

Certain components contain parameters that can be set in the Edit Mode. A number of these components have been discussed in earlier sections.

The dialog box for setting these parameters can be opened with a double click or Edit- Properties....

During the simulation, some components may be adjusted in the same way as in reality. Thus e.g. the delivery rate of the pump or the opening level of the throttle allow to be continuously changed. To do so, it is not necessary to open the properties dialog and to subsequently close it using OK; instead a simple click on the component is enough to open a window providing slide controllers. Changes will effect the simulation immediately. Once you click another component or a blank area in the window, the properties dialog will disappear automatically.

When in simulation mode and moving the mouse across a component, the mouse curser will change to the slider symbol if the applicable "real-time settings" are available.



To help with precision adjustment some controllers provide an optional control range. You may alternatively enter the numeric value using the input field.





Settings for Simulation

By clicking Simulation... or Sound...under the Options menu, parameters and options can be set for simulation.

Simulation Parameters

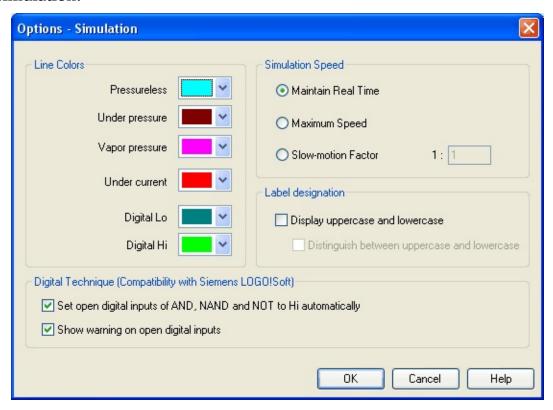
Sound Parameters





Simulation Parameters

By clicking under Options- Simulation... a dialog box appears with parameters for simulation:



Description of the dialog box:

• **Line Colors**During simulation the electrical, the hydraulic and the digital lines get colored, depending on their state. The mapping from a state to a color is set by clicking on the down-arrow at the right-hand side of the list and selecting a color.

Maintain Real Time

Using the option "Maintain Real Time" will attempt the cylinder movement to move as fast as in reality. Please note that real time movement requires a computer with sufficient computing power.

Maximum Speed

The option "maximum speed" utilizes the entire computing power. The aim

is to run the simulation as fast as possible. The actual acceleration of the simulation depends on the performance of the computer. If your computer does not at least achieve "real-time", the simulation cannot be accelerated to any higher speed.

• Slow-motion Factor

The slow-motion factor controls whether the simulation should go more slowly then it would in reality. With a slow-motion factor of 1:1, the simulation should proceed in real-time.

Label designation

By default, FluidSIM does not distinguish between uppercase and lowercase characters in label identifiers of mechanical or electrical connections. I.e., label identifiers are automatically converted to uppercase. Now, using the option "Display uppercase and lowercase", label identifiers are treated case sensitively. Case sensitivity can be enabled for both display purposes and a more strict label identity checking. In the former case, upper- and lowercase characters, say, for instance "a" and "A", are displayed as such, but treated as the same character. In the latter case, which is enabled by the option "Distinguish between uppercase and lowercase", "a" and "A" are treated as different labels.

• Digital Technique (Compatibility with Siemens LOGO!Soft)

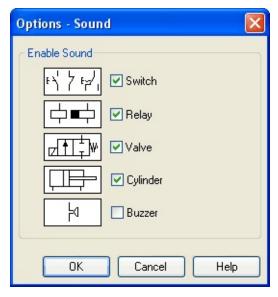
It is a useful convention in the field of digital technology setting open input ports of AND, NAND, and NOT components to Hi. Otherwise, e.g. an AND gate with three input ports would not function as expected if only two of its input ports were connected. Many *constant* Hi connections may clutter up a circuit unnecessarily, and hence FluidSIM can be configured to set open input ports of the respective components always to Hi. This option can be disabled of course. If open input ports have been detected at the start of the simulation, FluidSIM issues a warning message. The display of this message can also be disabled.





Sound Parameters

By clicking under Options- Sound...a dialog box appears with parameters for sound settings:



Description of the dialog box:

- **Enable Sound**An acoustic signal can be activated or deactivated for each of the following four component types: switch, relay, valve, cylinder, and buzzer.
- If there is no sound hardware, the settings can be set but not applied.





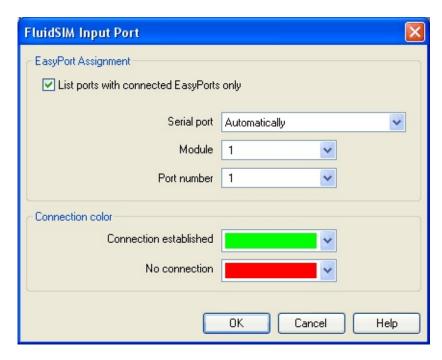
Use of the EasyPort-Hardware

FluidSIM can directly address the EasyPort that is connected to the serial port your computer. No other drivers or software tools are required. The interconnection is effected by implementing special electrical in/out components that provide both eight inputs and outputs. The components are the same as the ones used for the interconnection via OPC or DDE. The operation mode of these input and output components is defined by the use of the menu option Options-EasyPort/OPC/DDE Connection....

The EasyPort-hardware may also be addressed by using OPC-communication. This is how you may also address remote EasyPort-modules that are not connected locally (e.g. using a LAN-connection). Provided the EasyPort-modules are connected locally to the simulating computer, you are recommended to define a direct connection.

- Initially, please select the option "direct EasyPort-connection" in the menu Options- EasyPort/OPC/DDE Connection....
- Please drag an input or output component from the component library in the circuit diagram window and open the properties dialog by double-clicking or by accessing menu Edit- Properties....

The following dialog box will open:



Description of the dialog box:

• **EasyPort Assignment**This is where you may define which serial port the hardware uses to connect to your computer, which EasyPort-module and which port number is assigned to the i/o module. If you don't know exactly which number is used by the serial interface, please use "automatically" setting, FluidSIM will scan all COM-ports for connected EasyPorts.

By standard the EasyPort-hardware comes with a serial interface, which has proved to work well for years in the world of computers as well as in the world of industrial use. Modern computers and most of all mobile ones tend to leave out this interface more and more. Still, you may inexpensively and simply add a serial interface by using a USB-serial converter, enabling you to use the EasyPort. The converter's own software defines a virtual COM-port that will be assigned a number higher than the existing physical interfaces (usually COM 5). This virtual port will enable you to address the hardware as usual.

Connection Color

Defines the color of the connection indicator for the i/o component when either the EasyPort-connection is active or when the connection is not available or out of order.

The color may be defined by clicking the downward arrow on the righthand side of the list and then select a color.

If FluidSIM doesn't find the EasyPort hardware on starting the simulation, a related warning will be shown. The simulation can still be started, but until the end or until restarting the simulation FluidSIM will not attempt to detect any EasyPorts. If the connection fails during the simulation, (e.g. due to unintentionally removing connecting cable), the simulation will continue without EasyPort-interconnection, but FluidSIM will attempt to reestablish the connection. Once the hardware is again available at the defined interface, the connection will once again be established and the simulation will continue including the EasyPort-communication.



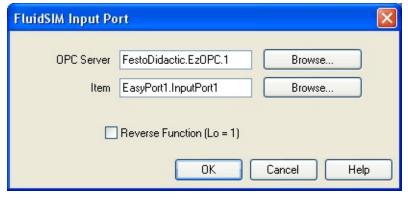


OPC and DDE communication with Other Applications

FluidSIM can exchange data with other applications; thus it may coupled with programmable logic controllers, PLC, for instance. Prerequisite for such a coupling is the ability of the partner application to provide an "OPC interface" and to act as a so-called "DDE client", respectively. From within a FluidSIM circuit the DDE coupling is realized by means of two electrical DDE components, each of which providing eight inputs and outputs respectively.

- Further information and examples regarding the DDE communication can be found on the FluidSIM-CD in the **DDE** directory.
 - Firstly, enable the option "OPC mode" in the Options-EasyPort/OPC/DDE Connection....
 - Drag an input (or output) component from the component library and open the property dialog box by double clicking the component or by clicking on Edit- Properties....

The following dialog box opens:



Description of the dialog box:

- **OPC Server**Enter the OPC server here or click on **Select ...** and select a server from the list.
- Item

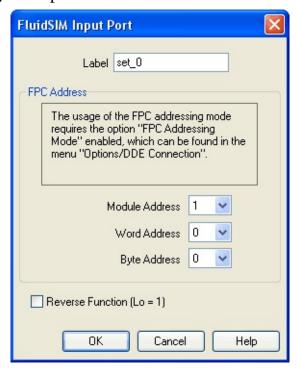
Enter the data item here or click on **Select ...** and select an item from the list.

Reverse Function

Inverts the logical values of the DDE components. Normally, current flow corresponds to a logical 1.

- Select the option "Use DDE" by clicking Options-EasyPort/OPC/DDE Connection....
 - Select a DDE component from the library, place it onto the drawing area, and open its property dialog box by either double clicking or via Edit- Properties....

The following dialog box opens:



Description of the dialog box:

Label

Label of the DDE component. This label is used from within the partner application to request or to set values in FluidSIM via DDE.

FPC Address

If FluidSIM is coupled with an application that also provides FPC addressing support, the addresses of assembly, word, and byte can be entered here. These settings are necessary only if the option <u>FPC mode</u> is

active.

• Reverse Function

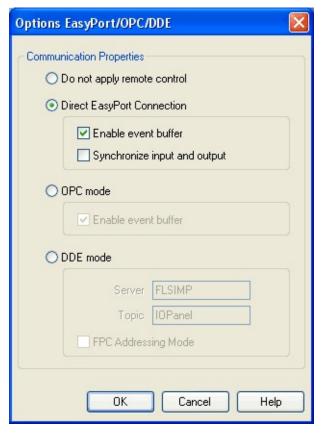
Inverts the logical values of the DDE components. Normally, current flow corresponds to a logical 1.





Settings for the EasyPort/OPC/DDE communication

Clicking on Options- EasyPort/OPC/DDE Connection... opens the following dialog box with settings for the EasyPort, OPC, and DDE communication:



- Do not apply remote controlPlease click this field if you don't wish
 FluidSIM to communicate with connected EasyPorts or other applications.
 If this option is activated, FluidSIM may ignore any connected EasyPortmodule and may neither respond to other applications trying to establish an OPC or DDE connection.
- **Direct EasyPort-Connection**Select this option if you wish to interconnect FluidSIM with other locally connected EasyPort-modules.
- Enable event buffer
 Enable this field, if FluidSIM shall buffer all events and process them in a

first-in-first-out manner. If this option is disabled, events that occur during high computational load may go lost.

• Synchronize input and output

Using this option you will define whether FluidSIM is to check, with every change of bit pattern at an output, for the status of the inputs. This may be useful if the output values, by means of a circuit that involves the EasyPortmodule, influence the status of the inputs. Please note that the operation mode may massively reduce the simulation speed, since FluidSIM may occasionally need to wait, with every step, for an answer of the connected EasyPorts.

OPC mode

Choose this option, if FluidSIM shall be coupled with other applications via OPC.

DDE mode

Choose this option, if FluidSIM shall be coupled with other applications via DDE.

Server

Defines the name under which name FluidSIM logs on the partner application. As the case may be, this name must be told the partner application as the *server* name.

Topic

A topic is necessary to agree upon a common label for the data exchange. As the case may be, the topic must be told the partner application.

• FPC Addressing Mode

This option must be checked if FluidSIM is coupled with an application that also provides FPC addressing support.

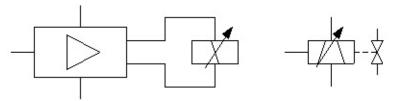
You will find notes on interconnecting FluidSIM with EasyPort hardware in chapter <u>Use of the EasyPort-Hardware</u>, handling the OPC or DDE interface is described in chapter <u>OPC and DDE communication with Other Applications</u>.





Open-loop and Closed-loop Control by using Continuous Valves

Among simple way valves with only discrete switching positions, FluidSIM also provides a number of continuous valves. These are particularly interesting because they may represent continuous intermediate positions. These components are addressed - in the same way as electrically operated way valves - by using a proportional amplifier or a valve solenoid. These are represented by specific symbols:



The individual proportional valve solenoid is used with position controlled continuous valves that integrate the controller and amplifier part in their valve.

If you unintentionally link a way valve with a proportional valve solenoid or vice versa a proportional valve with a simple valve solenoid by using a label, FluidSIM will show a warning.

The following two sections will introduce you to the possibilities of *open-loop control* and *closed-loop control* with FluidSIM. The term "open-loop control" means here that an *output variable* changes depending on an *input variable*. In detail the voltage represents the input variable at the proportional valve solenoid or at the amplifier. Depending on the value (and on the direction) of the electrical current caused by the voltage (assisted by an amplifier), the valve piston of the proportional valve will more or less be deflected to one direction. This is the output variable. In the case of a constant pressure at the valve port you may therefore manage the flow. Instead, in the case of a constant flow, the pressure drop will change depending on the opening level that is defined by the valve position. We speak of "closed-loop control" when the output variable or a state variable influenced by this output variable itself serves as an input variable. In the course of this several output variables as well as pending state variables may well be combined with further input variables when a calculation rule is

used. A classical example is represented by a *position control* that defines a particular position to be reached by a cylinder. In this case the valve will be electrically addressed in such a way that the cylinder travels. The position of the cylinder (in consequence of the travel depending on the valve position) will again be used as an input value while the deviation from the desired position of the cylinder is considered. Once the cylinder has reached its target position, the deviation is 0 and the valve returns to mid-position (closed position). Thus the cylinder stops. Should the cylinder, by inertia or because of outside malfunction or interference, pass the target position, the valve will switch to the opposite side and will reverse the direction of flow; the cylinder travels back. This already represents the simplest form of controlling, the so-called "P-control".

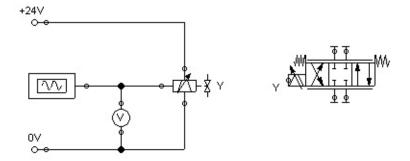
Open-loop Control
Closed-loop Control





Open-loop Control

In order to understand the mode of operation of the continuous components, please reconstruct the following circuit (voltage supply, function generator, voltmeter, proportional valve solenoid, continuous valve):

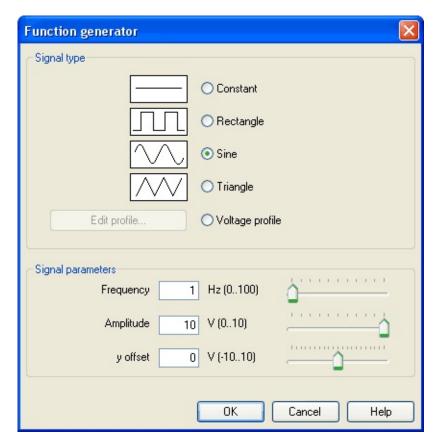


In the case of the four hydraulic connections of the valve, please don't forget to seal them by using blind plugs, to avoid warnings issued by FluidSIM.

Please launch the simulation and observe the continuous valve.

The function generator generates a signal between -10 and 10 volts. This varying voltage is converted in the valve by using a proportional amplifier to assign an applicable current to activate the proportional valve solenoid; converted in such way that the linked valve can be deflected to a maximum to both sides according to the applied signal voltage.

In order to be deflected less, the valve needs to have less maximum voltage. We may achieve this by double-clicking and therefore opening the properties dialog of the function generator.



Please define 4 for an "amplitude", close the dialog and launch the simulation again.

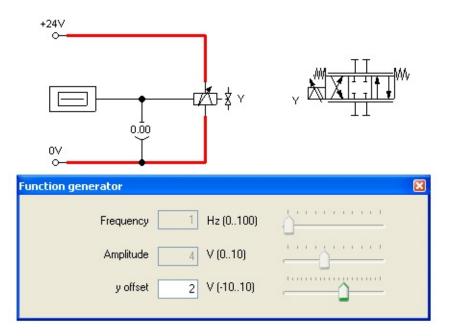
Now the voltage will alternate between -4 and 4 volt. This will still cause the valve to swing symmetrically, but it will show less deflection around the midposition.

Please open the properties of the function generator again and define 2 for the y-offset.

The function generator now supplies a voltage between -2 and 6 volts, causing the valve to deflect more to the left-hand side than to the right-hand side.

- Please open the properties of the function generator and define "Constant" for a type of signal.
- The slider of the function generator for "Frequency" and "Amplitude" provide no function for the type of signal "Constant". Therefore we may model a manually adjustable potentiometer.
 - Please launch the simulation and click (by a *single* click) on the function generator.

A window will open showing the slider of the function generator.



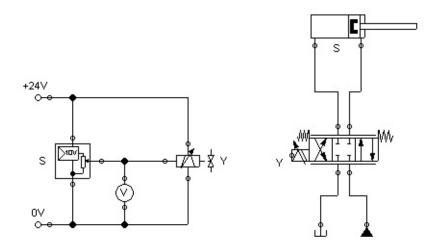
Gradually change the y-offset and observe how the valve moves subject to the controller setting.





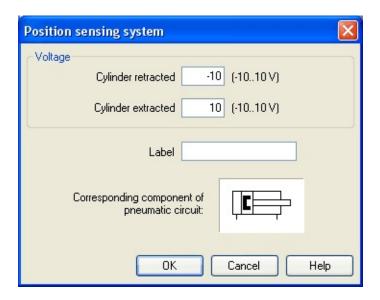
Closed-loop Control

Now a simple position control is to be put into practice. Please change the circuit according to the following illustration. Please note that you need to remove the blind plug from the valve connection before you may define connections. Instead of the function generator, the <u>displacement encoder</u> now supplies the input voltage for the proportional valve solenoid. To define the label for the cylinder, please choose the option "Sensing" in the register "Configuration" of the properties dialog.



Please launch the simulation and observe how the cylinder retracts and how the valve moves further in the closed position.

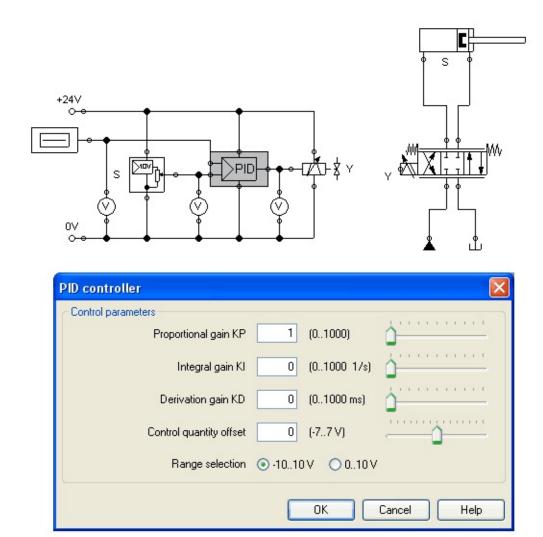
This is how the cylinder gradually becomes slower until the moment it finally and entirely retracted. Strictly speaking this does not exactly represent a position control because the cylinder would have ended its movement at the at the stop anyhow. Now we will therefore change the correlation between piston position of the cylinder and output voltage in the displacement encoder. If the cylinder is e.g. to stop in the middle, the valve needs to be exactly in closed position when the cylinder has reached this position. Since the output voltage changes proportionally to the piston position, it will be easy to calculate how the voltages at the two limits (cylinder retracted / cylinder advanced) are to be defined so that 0 volts are about at the moment of half of the cylinder stroke:



Please launch the simulation and observe that the cylinder stops when it reaches half of the distance.

Now we wish to expand the circuit in such way that the cylinder may arrive, as rapidly as possible and still exactly, at any desired position that we define during the simulation by adjusting a controller. For this we will use a <u>PID-controller</u>.

- Please construct the following circuit and adjust the parameter values of the PID-controller as indicated.
- Please note that the pump unit and the tank, according to the above example, are situated in reversed positions.



Launch the simulation and gradually change the y-offset of the function generator between -10 and 10.

The cylinder will travel until it has found its desired position and will stop there. The target position of the cylinder acts proportionally to the defined voltage at the function generator: -10 volts correspond to "entirely retracted", 10 volts correspond to "entirely advanced". The value 0 is therefore the mid-position of the cylinder piston. In the course of this the position from which the cylinder begins to travel is irrelevant, it will still stop at the desired target position.

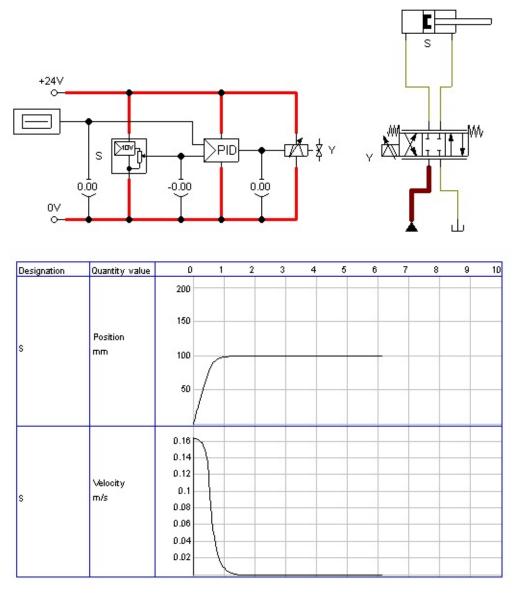
Change the initial piston position and observe how accurately the cylinder reaches its target position each time.

To achieve a more precise analysis of the control procedure we will observe the travel and the speed of the cylinder until it reaches its desired position. Therefore we include a state diagram, scale it to an adequate size and drag the cylinder on

the diagram. A dialog will open where we choose the two state variables "Position" and "Velocity".

Please adjust the y-offset of the function generator to 0 and the start position of the cylinder's piston rod to 0 and then launch the simulation.

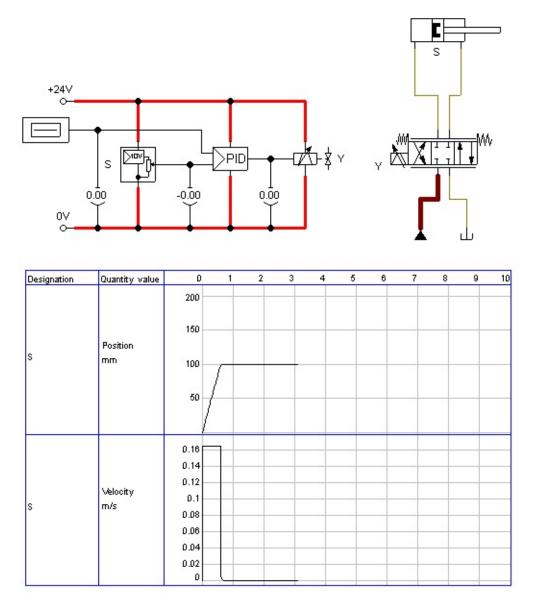
The cylinder travels as far as the middle and gradually decreases its speed until it stops.



It often may be desirably to make a cylinder travel by maximum speed until it reaches its desired position, and to make it stop most spontaneously. To achieve this we can amplify the position signal of the displacement encoder and therefore

accelerate the reversing of the control valve. In doing so we make use of the fact that the PID-controller limits the output voltage of the proportional valve magnet to 10 volts.

Please adjust the "proportional coefficient" of the PID-controller to 10 and launch the simulation.



It is clear that cylinder now travels at a constant speed over a long distance. It will then be firmly slowed down and will quickly stop completely.

If instead the cylinder had to actuate a load, it would, because of its inertia, slightly pass the target and would need to travel back and forth a few times until

it came to rest. These vibrations around the desired position are typical for such a basic control. In reality one would attempt, by trimming the additional parameter of the PID-controller or the <u>status controller</u>, to cushion the vibrations. At this point we wish to stay with the basics and would like to draw your attention to the advanced literature on proportional technology and control technology.





Learning, Teaching, and Visualizing Hydraulics

Beside the creation and simulation of electro-hydraulic circuit diagrams, FluidSIM also supports teaching basic hydraulic knowledge. This knowledge is presented in the form of texts, overview pictures, sectional views, exercises, and educational films. Functions that realize the selection of this instruction material are found under the Didactics menu.

One group of these functions refers to information about single, selected components. Another group of functions refers to ordered overviews of the didactics material, allowing the selection of an interesting topic. Finally, it is also possible to select and link together arbitrary topics into so-called "presentations".

Appendix The Component Library and Didactics Material Survey offer a complete and concise summary of the instructional material in FluidSIM.

The following sections contain a description of the functions found under the Didactics menu.

Information about Single Components

Selecting Didactics Material from a List

Presentations: Combining Instructional Material

Extended Presentations in the Microsoft PowerPoint Format

Playback of Educational Films

Settings for Didactics







Information about Single Components

The first three entries under the Didactics menu refer to selected components and are context sensitive. More precisely:

When a component in the current circuit diagram window is selected, or all selected components are of the same type, the menu entry Component Description will be enabled.

Component Descriptions

Component Illustrations





Component Descriptions

All components possess a page with a technical description. This page contains the diagram symbol for the component according to the DIN standard ("Deutsche Industrienorm"), a textual description of the component's function, the designations of the connections, and a listing of the adjustable parameters along with their value ranges.

You will find a photograph of the real-life part provided for most components. In the case that a component cannot exist singularly in a real system, FluidSIM displays a photo of the assembly group that this component belongs to. Examples for such components include the indicator light, relays, switches, and the electrical power supply.

Components, that do not exist in reality, simply have no photo. Examples include the text component and the distance rule.

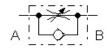
Select the throttle check valve, and click on the menu item Component Description under the Didactics menu.

The following page opens:



Component library < Hydraulic Components < Flow Control Valves < One-way flow control valve

One-way flow control valve





The setting of the One-way flow control valve is set by means of a rotary knob. A check valve (see check valve) is located parallel to the throttle valve. Please note that by the rotary knob no *absolute* resistance value can be set This means that, in reality, different throttle valves can generate different resistance values despite identical settings.

Adjustable parameters

Opening level: 0 ... 100 % (100)

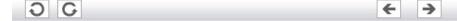
Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Throttle valve

Check valve

[144] One-way flow control valve (1)



Under the heading "Related Topics", but also when appropriate in the component description, cross references for related instruction material and components are defined. By clicking on a cross reference, the related page will automatically be displayed.



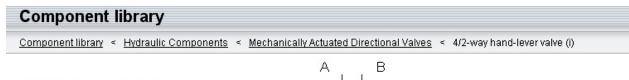


Component Illustrations

Component illustrations provide useful information relating a component's function. This may include a sectional view of the component, but also illustrations of the component's usage within a circuit diagram. For several components, their sectional view can be animated like a cartoon.

Select a 4/2-way hand-lever valve and click on Component Descriptionunder the Didactics menu.

The following dialog box appears:



4/2-way hand-lever valve (i)



In normal position the connection P is open to B and A to T. When manually actuated the valve is set to parallel position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the **Library** menu

Related Topics

Configurable 4/n way valve

4/2-way hand-lever valve (ii)

[104] 4/2-way valve, two pistons (1)



Please click the line with the relevant topic **[104] 4/2-way valve**,

two pistons (1). The following picture appears:

Didactics material

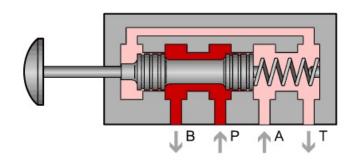
Didactics material < Basics and working principles < Way Valves < 4/2-way valve, two pistons (1)

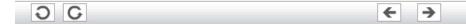
[104] 4/2-way valve, two pistons (1)



The 4/2-way valve has two working ports A and B, a supply port P and a tank port T. The supply port is always connected to one of the working ports, while the second working port is routed to the tank. In the normal position, there is flow from P to B and from A to T.

→ In contrast to valves with three pistons, 4/2-way valves with two pistons do not require a leakage-oil port (see topic 106).





Often it is easier to understand the functional nature of a component, when its behavior is visualized through the use of animation. For this reason, several components possess different sectional views showing the component at different states. These sectional views can be animated in much the same way as a flip book.

Please mark a 3-way pressure reducing valve and click the menu option Didactics- Component Description to open the window with the component description. Now click the link with the function illustration [84] 3-way pressure reducing valve

This function illustration can be animated.

Click on or Execute- Start to start the animation.

An animation can be "frozen" with or by clicking on Pause in the Execute menu. or Execute- Stop stops an animation, whereas or Execute- Reset restarts an animation.





Selecting Didactics Material from a List

The entries Tutorial, Component Library, and Didactics Material under the Didactics menu present the didactics material of FluidSIM organized in the form of overview pages. From these pages topics can be chosen and viewed independently of the current window and possibly selected components.

Tutorial

Component Library

Didactics Material

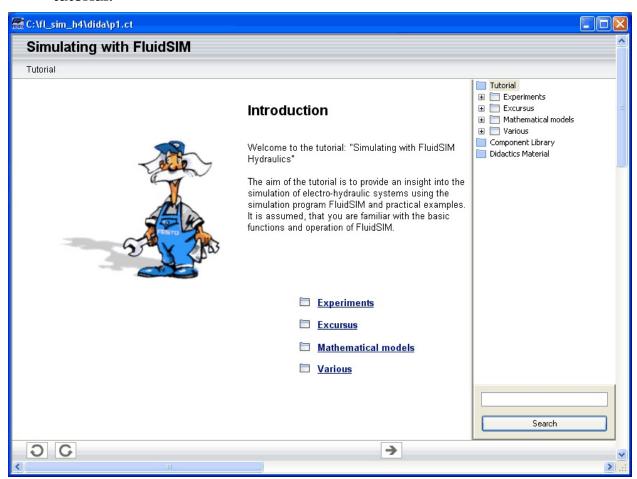




Tutorial

Below this menu option you can launch the tutorial "Simulating with FluidSIM", which contains a variety of interesting experiments and an excursus. By means of these useful examples you will get to know the possibilities of simulating with FluidSIM. Furthermore, for the most important components the mathematic models used in FluidSIM are also described.

Please click the menu option Didactics- Tutorial to open the tutorial.



On the right-hand side the hierarchical directory is displayed. By double-clicking the directory symbols you may list off or close the applicable subsections. Clicking a page symbol will display the contents of the page in the open window.

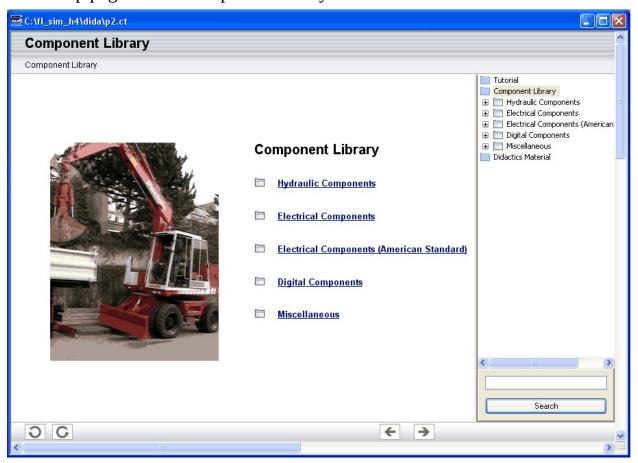




Component Library

Below the menu option Component Library you will find descriptions and photos of all FluidSIM-components.

Click a menu option Didactics- Component Library to open the help pages of the component library.



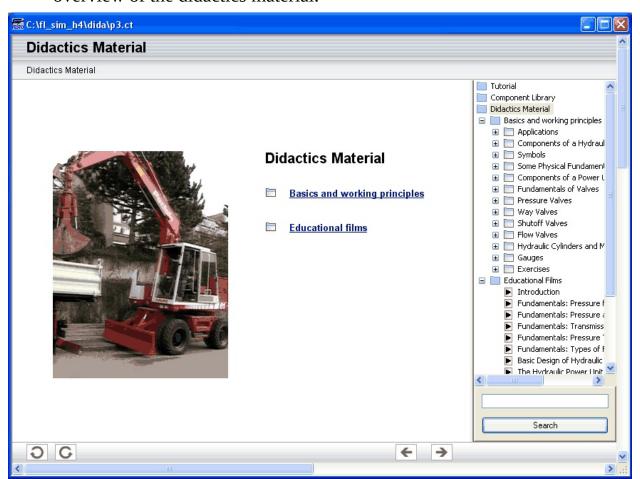




Didactics Material

FluidSIM, alongside the tutorial and the component reference, contains further didactics material particularly useful for group work. Moreover, here you will find educational films, provided you have copied them onto the hard disk during the installation. If you haven't installed the film files, you may choose a chapter via the menu option Didactics- Educational Film... to view the applicable film from the included video-CD.

Click the menu option Didactics- Didactics Material to open the overview of the didactics material.







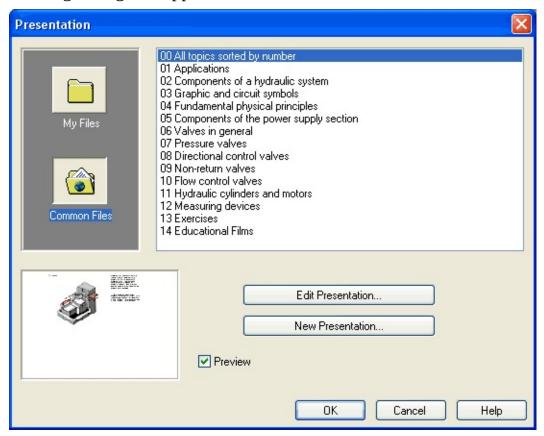
Presentations: Combining Instructional Material

Sometimes you may want to examine a topic from different angles or combine individual topics into a lesson. For this purpose FluidSIM offers the concept entitled "presentation".

There are a number of already prepared presentations, which can be found on the FluidSIM installation disks. However, editing presentations or creating new presentations is also possible with FluidSIM. All presentations can be found under Presentation... in the Didactics menu.

Click on Didactics- Presentation....

The following dialog box appears:



Description of the dialog box:

Available Presentations This field contains a list of already created presentations.

New Presentation...

Clicking on "New Presentation..." opens a second dialog box for the creation of a new presentation.

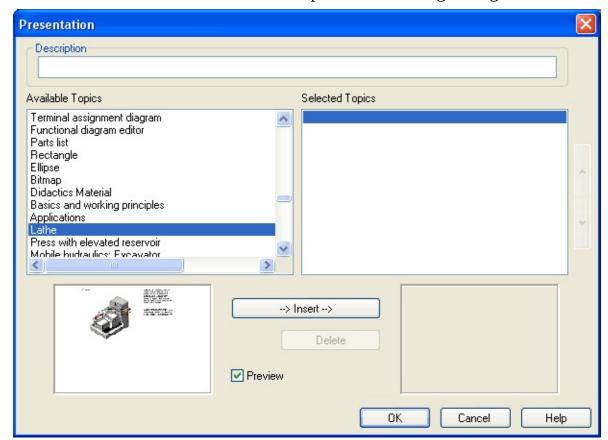
• Edit Presentation...

Clicking on "Edit Presentation..." opens a second dialog box to begin editing a presentation.

Preview

When the "Preview" setting is activated, the picture that pertains to the selected presentation appears underneath the topics list.

Click on "New Presentation" to open the following dialog box.



Description of the dialog box:

• Description

In this text field a short description of the presentation can be entered. This text may consist of up to 128 characters and will appear with the other

presentations, the next time the presentation dialog box is opened.

• Available Topics

This field contains a list of all available topics dealing with "Hydraulic Basics", "Working Principles", and "Exercises". Moreover, there exist two pictures that can be used to announce a refreshment and a lunch break respectively. A double click on a line in the "Available Topics" list inserts this line in the "Selected Topics" list above the highlighted bar. In this way a presentation can be created or altered.

Moreover, a user can integrate his own circuit diagrams, DXF files, BMP-and WMF-picture files, or even multimedia files such as sounds or video clips. To do so, click on "User File...": A dialog box opens that allows for the selection of the desired data source on the file system.

• Selected Topics

This field contains a list of topics chosen for the current presentation.

• Insert

Clicking on "Insert" is the same as double clicking a line in the "Available Topics" list: The selected line in "Available Topics" will be inserted in the "Selected Topics" list.

• Delete

Clicking on "Delete" deletes the selected line of the "Selected Topics" list.

Preview

When the "Preview" setting is activated, the picture that pertains to the selected topic appears underneath the respective list.

Within both topics lists the highlighted bar can be moved using the arrow keys. Maybe it will be necessary to click and select the list you want to work with.

After creating a new presentation and closing the dialog box by clicking on "OK", FluidSIM asks you to name the presentation *file*. Presentation files have the extension **.shw** and are located in the subdirectory **shw** under the **fl_sim_h** directory.

The structure of a presentation file is described more thoroughly in section <u>Tips</u> for the Advanced <u>User</u> .

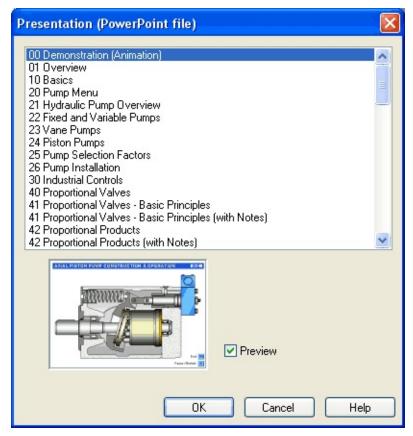




Extended Presentations in the Microsoft PowerPoint Format

FluidSIM 3 contains an additional large set of presentations written in the Microsoft PowerPoint Format. To use these presentations, PowerPoint must not be installed on your PC since FluidSIM installs the necessary viewer at its installation time.

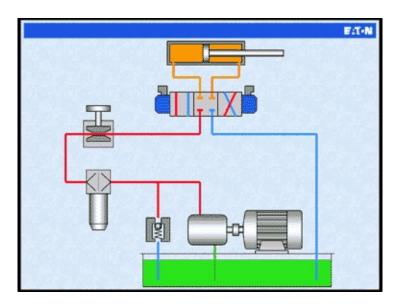
Click on Extended Presentation... to open the dialog box of a presentation.



Select the item "Actuators" to open the related presentation in full screen mode.

Most of the topics form a picture sequence, which can be viewed in a single-step manner using the left mouse button or the spacebar.

Move two single steps forward in the current presentation.



When clicking the right mouse button, a context menu is opened by which, among others, the presentation can be closed or particular pictures picked out.

The files of the extended presentations are in the subdirectory **ppx** of the FluidSIM installation. You can add new PowerPoint presentations on your own by copying the related files (format: "ppt" or "pps") into the **ppx**-directory.

Like the other didactics material (illustrations of function, component photos, circuit drawings, educational films, etc.), the PowerPoint presentations can linked and used within presentations (cf. Section <u>Presentations: Combining Instructional Material</u>).



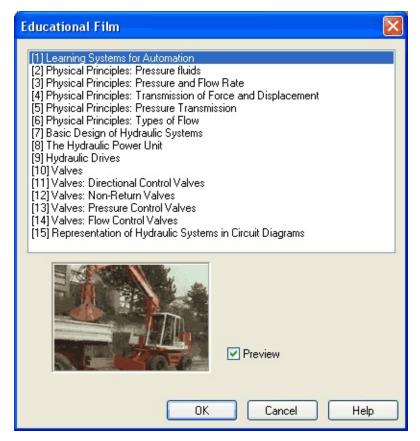


Playback of Educational Films

The FluidSIM CD-ROM contains <u>15 educational films</u>, which last between 1 to 10 minutes in length and cover a specific area of electro-hydraulics.

Provided you have copied the film files onto the hard disk during the installation, this menu option will not appear; in this case the films are not available directly at Didactics- Didactics Material.

Click on Didactics- Educational Film... to open the dialog box that contains a list of the educational films.

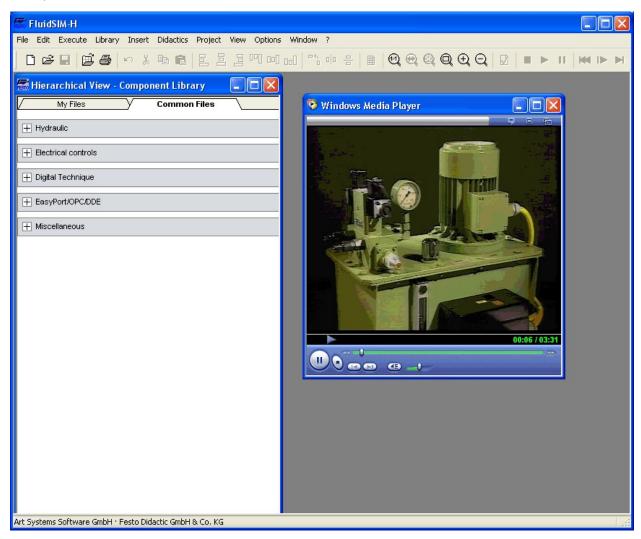


Description of the dialog box:

- **Available Educational Films**This field contains a list of <u>available</u> <u>educational films</u>. By double clicking on a line in the list, the dialog box closes and the media playback starts playing the selected film.
- Preview

When the "Preview" setting is activated, a typical scene from the film appears underneath the list of titles.

Click on **The Hydraulic Power Unit** to start the playback of the selected film:



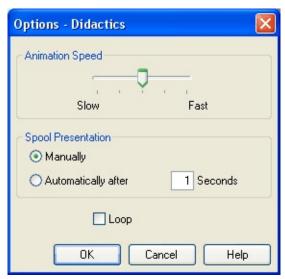
Underneath the window for the media playback, you will the find the control elements to start, stop, and wind the film. A detailed description of the media playback is available under the standard Microsoft Windows © help.





Settings for Didactics

By clicking on Didactics...- Options, a dialog box appears that contains the settings for didactics:



Description of the dialog box:

• **Animation Speed**This setting defines the speed at which the animations should run.

• Spool Presentation

A presentation in FluidSIM can be set to automatically run. For this the setting "Automatically after ... Seconds" must be activated. The time span that can be entered defines how long FluidSIM waits before switching to the next topic of the presentation. By clicking on , the presentation will immediately change to the next topic in the presentation. With the setting set to "Manually", no automatic switching will take place during the presentation.

• Loop

Defines whether a running presentation is reset and started over again after all topics have been displayed. This is known as loop mode.





Special Functions

This chapter develops further concepts and functions of FluidSIM.

Drawing Layers

Graphic Primitives

Text Components and Identifications

Embedding Pictures

Parts Lists

Printing a Window's Contents

TIFF Export

DXF Export

DXF Import

Using and Organizing Component Libraries

Managing Projects

Saving Settings

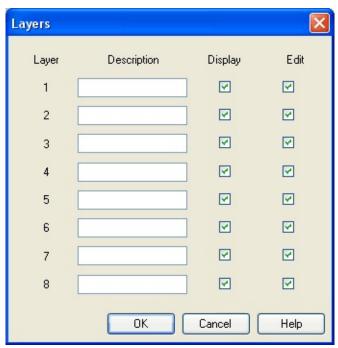






Drawing Layers

Components in FluidSIM that cannot be simulated, such as texts, DXF import data, rectangles, circles, state diagrams, and parts lists, can be assigned to one of eight drawing layers. Each layer can be shown or hidden as well as set locked or unlocked. These properties are defined under View- Layers...; here also a layer can be given a name. Components of FluidSIM that can be simulated are always on layer 1.



 Description The layer name is displayed in the dialog box of an object's properties instead of the layer number.

Display

If the option "Show" is disabled, the respective drawing layer is invisible, and, of course, can not be edited.

• Edit

If the option "Edit" is disabled, the respective drawing layer is still visible but cannot be edited. I.e., the objects that belong to such a locked layer can neither be selected, nor moved or deleted. By this concept e.g. a drawing frame can be protected. To edit objects on a locked layer, first unlock the

layer.

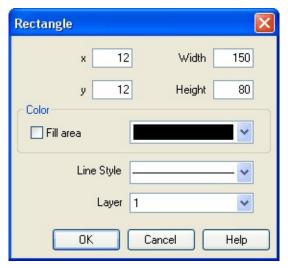
The identifiers of components and connections in FluidSIM's standard circuit library stand on drawing layer two. By disabling the "Show"-option for this layer, the identifiers are made invisible.





Rectangles

By selecting a rectangle and clicking on Edit- Properties..., or by simply double clicking it, its property dialog box is opened.



Description of the dialog box:

- **x**Defines the x-coordinate of the rectangle. Instead of providing a number, the rectangle can also be moved with the mouse.
- y
 Defines the y-coordinate of the rectangle. Instead of providing a number,
 the rectangle can also be moved with the mouse.

Width

Defines the width of the rectangle. Instead of providing a number, the rectangle can also be resized by dragging the mouse: If the mouse pointer is moved onto the rectangle's border, the mouse pointers becomes a resize indicator, \leftrightarrow , \updownarrow , or \nwarrow . Now the rectangle can be resized as indicated by holding down the left mouse button.

• Height

Defines the height of the rectangle. Instead of providing a number, the rectangle can also be resized by dragging the mouse: If the mouse pointer is moved onto the rectangle's border, the mouse pointers becomes a resize

indicator, \leftrightarrow , \updownarrow , or \searrow . Now the rectangle can be resized as indicated by holding down the left mouse button.

Color

Defines the color of the rectangle's border. A color is set by clicking on the down-arrow at the right-hand side of the list and selecting a color.

• Fill Area

Defines whether the entire area or only the border of the rectangle is colored.

• Line Style

Defines the line style of the rectangle. A line style is set by clicking on the down-arrow at the right-hand side of the list and selecting a style.

• Layer

Defines the <u>drawing layer</u> of the rectangle. The drawing layer is set by clicking on the down-arrow at the right-hand side of the list and selecting a layer.

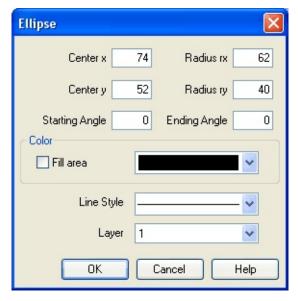
Depending on the settings of <u>drawing layer</u>, the rectangle may not be visible or may not be selectable. To display an invisible rectangle or to change its properties in such a case, the <u>drawing layer</u> must be activated via the menu View- Layers....





Ellipses

By selecting an ellipse and clicking on Edit- Properties..., or by simply double clicking it, its property dialog box is opened.



Description of the dialog box:

• **Center x**Defines the x-coordinate of the ellipse center. Instead of providing a number, the ellipse can also be moved with the mouse.

• Center y

Defines the y-coordinate of the ellipse center. Instead of providing a number, the ellipse can also be moved with the mouse.

• Radius rx

Defines the x-radius of the ellipse. Instead of providing a number, the ellipse can also be resized by dragging the mouse: If the mouse pointer is moved onto the ellipse's border, the mouse pointers becomes a resize indicator, \leftrightarrow , \uparrow , or \searrow . Now the ellipse can be resized as indicated by holding down the left mouse button.

• Radius ry

Defines the y-radius of the ellipse. Instead of providing a number, the ellipse can also be resized by dragging the mouse: If the mouse pointer is

moved onto the ellipse's border, the mouse pointers becomes a resize indicator, \longleftrightarrow , \updownarrow , or \nwarrow . Now the ellipse can be resized as indicated by holding down the left mouse button.

• Starting Angle

Defines the ellipse's start angle, specified in degree. A value of zero degree corresponds to the three o'clock watch hands position.

• Ending Angle

Defines the ellipse's end angle, specified in degree. A value of zero degree corresponds to the three o'clock watch hands position.

Color

Defines the color of the ellipse's border. A color is set by clicking on the down-arrow at the right-hand side of the list and selecting a color.

• Fill Area

Defines whether the entire area or only the border of the ellipse is colored.

• Line Style

Defines the line style of the ellipse. A line style is set by clicking on the down-arrow at the right-hand side of the list and selecting a style.

• Layer

Defines the <u>drawing layer</u> of the ellipse. The drawing layer is set by clicking on the down-arrow at the right-hand side of the list and selecting a layer.

Depending on the settings of <u>drawing layer</u>, the ellipse may not be visible or may not be selectable. To display an invisible ellipse or to change its properties in such a case, the <u>drawing layer</u> must be activated via the menu View- Layers....





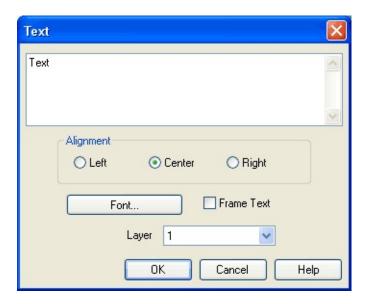
Text Components and Identifications

The concept of text components in FluidSIM gives the user a way in which to describe components in diagrams, assign identification texts, or to provide commentary on the diagram. The text and the appearance of text components can be customized to the user's liking.

Text components function in much the same as other fluidic or electrical components in FluidSIM. The dummy text component *Text* can be found in the component library, and it can be dragged onto the drawing area. However, text components contain no connections.

As long as the setting Options- Protect Text Components remains switched off, the text components can be marked, dragged, deleted, and rotated in the same way that other components are handled. When this setting is activated, the text components can neither be marked nor moved or deleted. This concept allows the text components to be anchored in the background. They are out of the way and cannot interfere with changes or manipulations made to the circuit diagram while in the Edit Mode.

- Drag the text component from the component library to the drawing area.
- Make sure that Options- Protect Text Components is switched off.
- Properties... to open the dialog box for entering new text.



Description of the dialog box:

• **Text** In this field the text to be displayed is entered. A new line is entered by holding down the Ctrl-key while hitting the **Return** key.

• Alignment

Activates horizontal text alignment.

• Font...

By clicking on "Font...", a Microsoft Windows © common dialog box opens, which allows you to set the font attributes for the given text.

• Frame Text

Draws a border around the text.

Layer

Defines the <u>drawing layer</u> of the text component. The drawing layer is set by clicking on the down-arrow at the right-hand side of the list and selecting a layer.

Depending on the settings of <u>drawing layer</u>, the text component may not be visible or may not be selectable. To display an invisible text component or to change its properties in such a case, the <u>drawing layer</u> must be activated via the menu View- Layers....

The dialog box can be closed by clicking on "OK". As a result the text along with its font attributes is inserted into the drawing area.

Click on Options- Protect Text Components to protect the text. The protected text can no longer be selected. Therefore, components can be placed over the text.





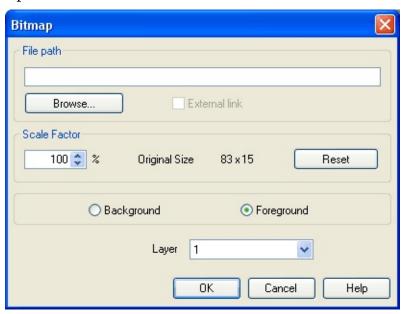
Embedding Pictures

Alongside denominating texts and comments you may furthermore include picture files in circuits. This way you may conveniently complement your circuits by using your own visual material. This may be a photo of a real construction, an illustrating sectional drawing or even a small company logo in the drawing corner.

Pictures in FluidSIM, like all other components and objects, may be included and placed, dragged, rotated and mirrored. Furthermore, in the same way as rectangles and ellipses, pictures may also be freely scaled.

Since picture files are not vector graphics, a <u>DXF-export</u> will only show a frame instead of the picture.

Double-clicking a picture or using Edit- Properties... will open the properties dialog for bitmaps.



Description of the dialog box:

- **File Path**Defines the path to the picture file. Please enter the path of an existing picture file here or choose one by using the file selection dialog.
- External Link

Bitmaps may be assigned as an external reference or may be stored with circuit file. The advantage of the latter is that of a transported circuit automatically containing the pictures. When you only work within your own environment, the reference to a file path is convenient because the circuit files remain compact and changes of the pictures also take effect in FluidSIM.

Scale Factor

Defines the scale factor of a picture file. Instead of entering the value, you may also change the picture's size by using the mouse. When moving the mouse pointer across the border of an object, the pointer will change to the size modification symbol \longleftrightarrow , \updownarrow or \nwarrow . Keeping the left mouse button pressed, you may magnify or downsize it in the displayed direction. Pictures in FluidSIM are always scaled according to the aspect ratio. You cannot change just one side by narrowing or stretching.

Reset

Changes back the scaling factor to 100 %.

Background/Foreground

Defines whether the picture is to be positioned in front of all other circuit objects or behind them. The option "in the foreground" is favorable with small logos, while big pictures should be assigned the option "in the background" because a large part of the circuit could be concealed.

• Layer

In this selection list you may define the <u>drawing layer</u> of the picture file. The <u>drawing layer</u> may be set by clicking the downward arrow on the right-hand side of the list, you may then choose a layer.

Depending on the setting of the <u>drawing layers</u>, the picture file may not be displayed or you may not be able to change it. To make the object visible or to change the settings, you need to temporarily activate the <u>drawing layer</u> in the menu View- Layers....

Large background pictures may massively reduce edit speed and simulation speed, since dragging or animating symbols always forces parts of the picture in the layer below to be re-drawn.





Parts Lists

With FluidSIM parts lists can be generated automatically. A parts list is represented by a "parts list component", which can be inserted, moved, or deleted like every other component. The parts list is updated automatically while a drawing is edited. The automated update may slow down the drawing process of large circuits and thus, a parts list component should be inserted in the end of a drawing process.

Inserting a Parts List

Properties of Parts Lists

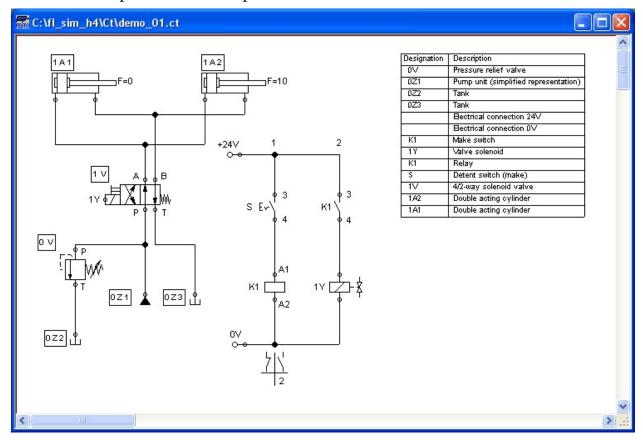
Exporting Parts Lists





Inserting a Parts List

- Open the circuit **demo1.ct**.
- Select the <u>parts list component</u> from either the Insert menu or the component library and add it to the drawing. Move the parts list such that it overlaps no other component.



The <u>parts list component</u> analyzes all components of the diagram and generates table with columns for the component identifications and the component designations. In this connection, FluidSIM uses existing labels and texts as component identifications.

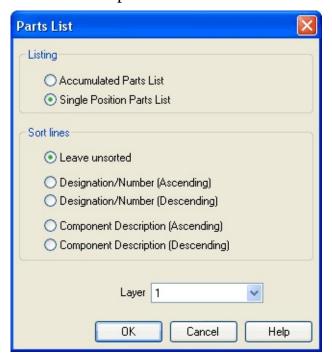
The sorting of the table can be customized to the user's liking; moreover, the parts list can be exported as a text file. Also note that more than one <u>parts list component</u> can be inserted in a diagram.





Properties of Parts Lists

Double-click on a <u>parts list component</u> or select a parts list component and click on Properties... in the Edit menu.



Description of the dialog box:

• **Listing** With the "Accumulated Parts List" option enabled, all components of the same type become comprised into a single row. As a consequence, the first column of the <u>parts list component</u> shows the number of the comprised components.

With the "Single Position Parts List" option enabled, each component gets its own row within the parts list. The first column of the <u>parts list</u> <u>component</u> then shows a possible existing identification.

Sort Lines

The lines of a parts list can be sorted in "ascending" order, in "descending" order, by the "component description", by the "component number", or by the "component designation".

Layer

Defines the <u>drawing layer</u> of the <u>parts list component</u>. The drawing layer is set by clicking on the down-arrow at the right-hand side of the list and selecting a layer.

Depending on the settings of <u>drawing layer</u>, the parts list component may not be visible or may not be selectable. To display an invisible <u>parts list</u> component or to change its properties in such a case, the <u>drawing layer</u> must be activated via the menu View- Layers....





Exporting Parts Lists

Aside from printing a <u>parts list component</u>, it can also be exported in the form of a text file.

Select a parts list component click on File- Parts list Export....

A file selector box opens where an existing file can be selected or a new file name can be entered. After a file has been specified and the file selector box been closed, a dialog box opens where a column separator can be defined.



Description of the dialog box:

- **Tabulator** The tab-character is used as column separator.
- Semicolon

The semicolon is used as column separator.

• Other

The entered character is used as column separator.



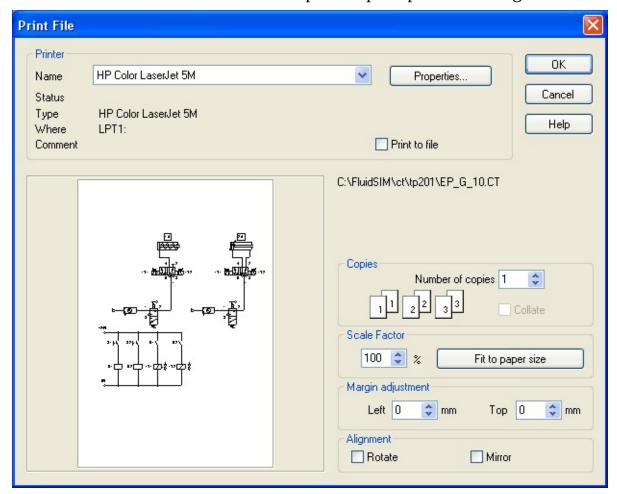


Printing a Window's Contents

FluidSIM contains a practical printing function that is always available, whether you are in the Edit Mode or the Simulation Mode. The contents of any window in FluidSIM can be printed.

The student version of FluidSIM does not provide the printing facility.

Click on File- Print... to open the print preview dialog box:



Description of the dialog box:

• **Printer** This list contains all available local as well as network printers. A printer is set by clicking on the down-arrow at the right-hand side of the list and selecting a printer.

• Properties...

Opens a dialog box with available printer options.

Copies

In the number field "Number of copies" the desired number of copies is typed in. If the printout consists of several pages you can check the "Collate" to have the pages sorted automatically.

Scale factor

In the number field "Scale factor" enlargement or reduction of the circuit diagram is typed in as a percentage. The print preview window then rescales the circuit diagram according to the size proportion that was given.

If the <u>paper size</u> in combination with the chosen scaling factor exceeds the printer's printing area, the diagram is printed in a tiled fashion. The expected number of pages is indicated in the printer preview dialog box. Pressing the "Fit to paper size" button sets the scale factor so that the circuit diagram fills out the entire paper area.

• Margin adjustment

In order to take the printable regions of different output devices into account, or enlarge the margin of a printout, an offset in **mm** can be defined for the left as well as the upper margin. Positive values move the drawing to the right or down, negative values move the drawing to the left or up.

• Alignment

In some cases it could be useful to rotate or to mirror the drawing. E. g. some printer drivers do not support rotating by themselves.

Printing begins by clicking on "OK".





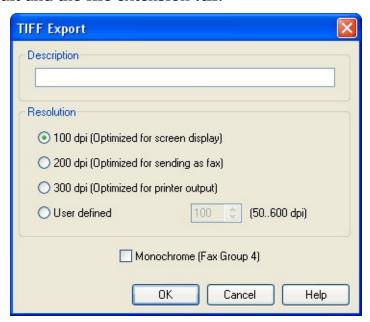
TIFF Export

FluidSIM-circuits may be exported as TIFF e.g. to process them using a non-vector oriented software.

The student version of FluidSIM doesn't provide this function.

Please click TIFF Export... un the File-menu to export the current circuit.

If you do not define a new name for the TIFF file, the file will be saved using the name of the circuit and the file extension .tif.



Description of the dialog box:

• **Description** Please enter an optional description here. By default, the description you've defined at <u>circuit properties</u> will be used. In case nothing is entered there, the circuit description will be used.

Resolution

Please choose an adequate resolution for the picture file here. Please note that a high resolution may particularly increase the file size and that it may cause the export to take a lot more time. You may stop the export at any time if it takes too long.

• Monochrome

This export option will save the entire drawing black and white. This will help the files to become compact ones, but naturally all other colors will be lost.





DXF Export

FluidSIM contains a filter module to export circuit diagram in the DXF format. Hence circuit diagrams from FluidSIM can be imported into a CAD program, where they can still be edited.

In the student version of FluidSIM, this function is not at your disposal.

Click on DXF Export... under the File menu to export the actual circuit diagram.

If no new name is given for the DXF file, the exported circuit diagram file is saved with the extension **.dxf**.

The exported drawings in the DXF format differ from those in FluidSIM in the following manner:

- 1. Component connections are shown without circles.
- 2. The DIN symbol is inserted for the cylinder.
- 3. The text font is set to **STANDARD** for the text components.

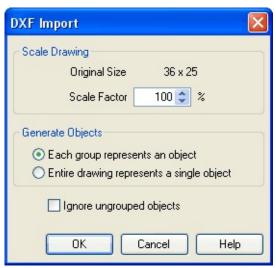




DXF Import

Files that are of the DXF format type can be imported, retaining most of the DXF element attributes. Clearly, imported circuit diagrams or symbols cannot be simulated since the DXF standard does provide for a definition language of physical behavior models. However, the import functionality is useful if a circuit diagram shall contain elements that cannot be realized from within FluidSIM. For example, CAD drawing frames or terminal strip plans, which have been created by means of another CAD program, can be inserted into a FluidSIM drawing. Depending on whether a single symbol or a complex drawing is to be imported, particular conventions relating the grouping should be obeyed.

Having selected a DXF file via File- Open..., the dialog box for the DXF import opens.



Description of the dialog box:

- **Scale Drawing**The scaling factor defines scaling in percent that is applied to DXF file.
- Each group represents an object

Enable this option if the DXF file contains several symbols. Note that symbol elements that belong together can only be identified as such, if they have been grouped within the CAD program in such a way, that the outermost group of the symbol occurs in the **ENTITIES** section. This

means among others that no two symbols can belong to the same group. However, different symbols are allowed to share blocks; the import filter of FluidSIM creates copies for shared blocks.

• Entire drawing represents a single object

If this option is enabled, the entire drawing is treated as a single object.

• Ignore ungrouped objects

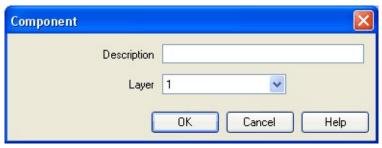
Enable this option if only for the grouped elements objects shall be generated. The elements mentioned in section **ENTITIES** are not considered.

If this option is disabled, FluidSIM comprises all ungrouped elements within a single object.

Elements that have been imported can be placed on each of the eight <u>drawing</u> <u>layers</u>. Moreover, they can be equipped with a designation, which is displayed in the <u>parts list</u>.

If you have imported a CAD frame, it makes sense to place this frame on a drawing layer whose "Edit"-option is disabled: This way the frame is anchored and will not interfere when placing components.

By double clicking on an imported DXF symbol, the following dialog box is opened:



Description of the dialog box:

• Description

In this field a designation can be entered, which is also displayed in the parts list.

• Layer

Defines the <u>drawing layer</u> of the symbol. The drawing layer is set by

clicking on the down-arrow at the right-hand side of the list and selecting a layer.

Depending on the settings of <u>drawing layer</u>, the symbol may not be visible or may not be selectable. To display an invisible symbol or to change its properties in such a case, the <u>drawing layer</u> must be activated via the menu View- Layers....



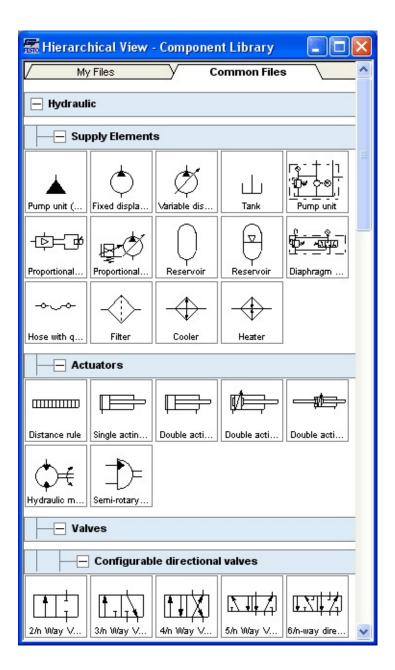


Displaying the Component Library

FluidSIM offers two ways of displaying the component libraries:

• Tree ViewThis will display the entire structure tree-like. Subgroups, as opposed to their superordinate groups, are indented to the right-hand side. Below the applicable group designation you will find the symbols. To keep track of the overview despite the large number of component symbols, you may display or hide entire branches by clicking the group designation. By holding the Shift-key you can display or hide a group including all subgroups (see Creating new Circuit Diagrams). This way of displaying is similar to the one on the left-hand side of the

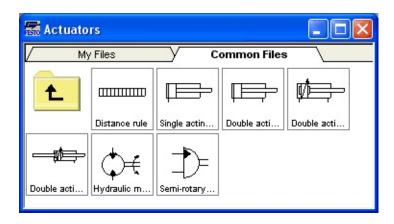
This way of displaying is similar to the one on the left-hand side of the Windows Explorer.



• Folder View

The folder view only shows the symbols of a single level in its hierarchy at a time. Subgroups are represented by folder symbols. To access a subordinate level please open the folder by double-clicking it. You may access a superordinate level by double-clicking the "upwards"-folder (see Simulating Existing Circuit Diagrams).

This way of displaying is similar to the symbol view on the right-hand side of the Windows Explorer.





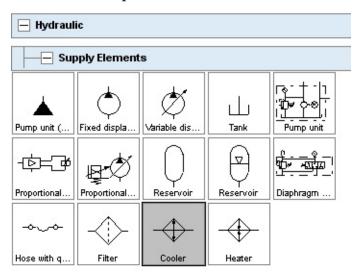


Rearranging a Component Library

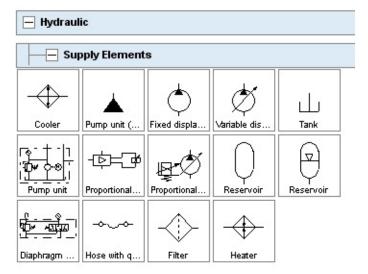
The components in the component library can be rearranged according to their usefulness and the desire of the user.

In the tree view you may drag separate symbols or also entire groups of one level to another position.

Please mark a component in the lower section of the group:



Drag the marked component to the top left:



FluidSIM adds the symbol to the applicable position. The order of the other symbols will be maintained. FluidSIM keeps the symbols from being on top of

each other or from creating "gaps".

You may also relocate an entire group including all subgroups.

Close all component groups:

+ Hydraulic
+ Electrical controls
Digital Technique
+ EasyPort/OPC/DDE
H Miscellaneous

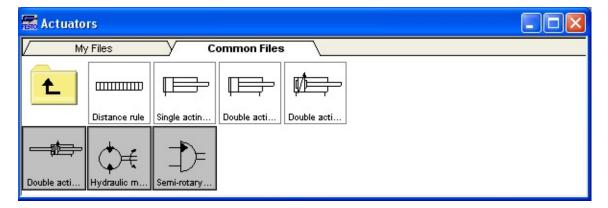
Move the group "Electrical controls" up:

+ Electrical controls
Hydraulic
⊞ Digital Technique
⊞ EasyPort/OPC/DDE
H Miscellaneous

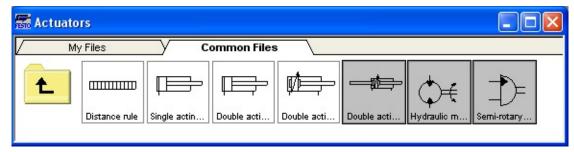
You cannot change the hierarchy's layer structure this way. You may only relocate symbols and groups within the same level. Relocating a group will automatically relocate the entire branch below the group.

In the folder view you may freely relocate and rearrange the symbols. Particularly, "gaps" are allowed to exist between the symbols; FluidSIM does not relocate them next to each other like in the tree view.

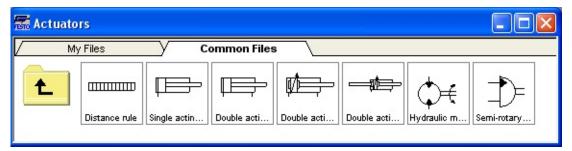
- Select the folder view at View and open the group "Hydraulic" and then "Actuators".
- Enlarge the window of the component library.
- Using the rubber band, select for example the bottom row:



Drag the selected components, for example up and to the right:



It is also possible to rearrange the components in the library horizontally, in just a few steps:



It is not possible for the user to add components to or delete components from the *standard* component libraries. However, own libraries can be constructed at the user's will.





Building New Component Libraries

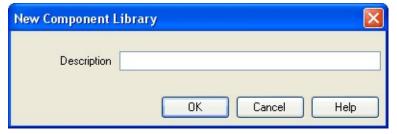
In addition to the standard component library, where the available FluidSIM-components are located, you may assemble additional libraries.

In contrast to the FluidSIM standard libraries both the arrangement and the contents of such user-defined libraries can defined, by means of operations that add and delete components.

To display available libraries, to create a new one, or to rename an existing one, choose the respective entry from the Library menu.

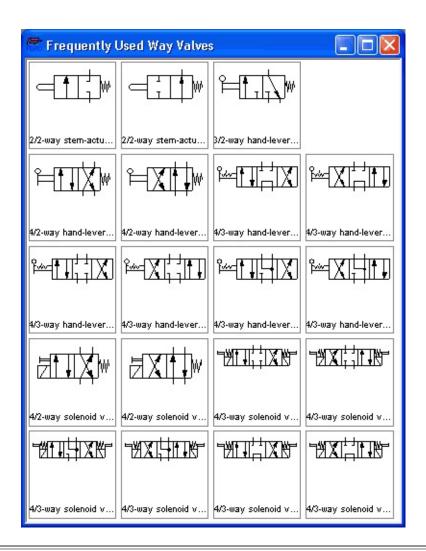
The first entry in this menu opens the standard library. Below you will find entries for the user defined libraries. When these entries are selected, the applicable library windows will open. At the end of the Library-menu you will find functions for creating a new library (New...), for renaming a user defined library (Rename...) and for deleting a created library (Delete). The menu entries for renaming and for deleting always refer to the active library window.

When clicking on Library- New...a dialog box opens, where a description of the new library can be entered:



The text that has been entered here is shown as a menu entry in the Library menu. The text can be modified anytime, by opening the library and clicking on Library- Rename....

Enter an appropriate name for new library and drag a few symbols from the standard library or from a circuit window in the empty window of the created library. You may also add symbols using the Insert-menu.







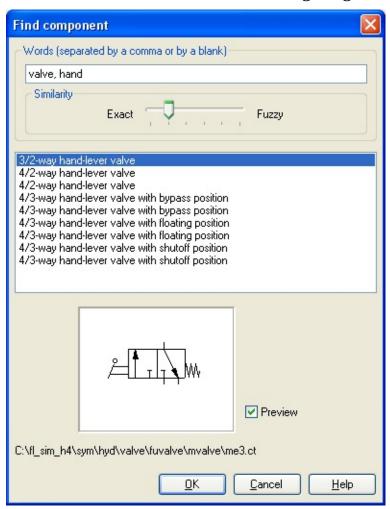


Inserting Components Via Menu

In FluidSIM, several alternative concepts exist to insert a component into a circuit diagram. One concept is "Drag-and-Drop", which has been used in the preceding examples.

Alternatively, components can be selected through the Insert menu, either by navigating along the hierarchical menu structure or by entering one or more search strings. While mousing a component description in the menu, the related symbol is shown either in the preview window of the search dialog or in the upper left corner of the FluidSIM main window.

Open a new circuit window, select the menu item Insert/Find Component... and enter one or more search strings; e.g., **valve, hand**.



• **Words** In this field one or more search items can be entered in order to find a particular component. The order of the search items does not play a role, they are combined by a logical "AND". Also note that partial matches are allowed. I.e., if you are unsure respecting the correct spelling of a component name, simply partition this name into several comma-separated search strings.

• Similarity

Determines the accuracy of the match between "Exact" and "Fuzzy". This setting can be used to allow a tolerance respecting different spelling variants or typing errors.

Results

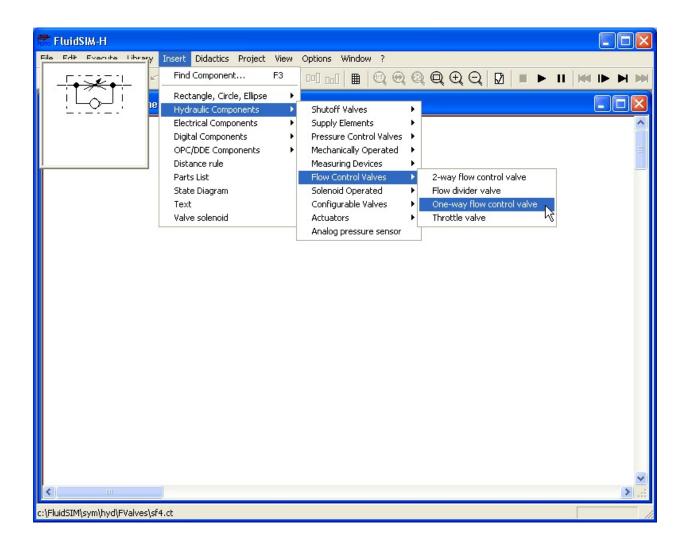
Contains a list of component descriptions, which contain the provided search strings. This list is ordered with respect to the accuracy of the match. By double-clicking onto a line in the list the dialog box is closed and the related component is inserted in the circuit diagram. The selection marker in the list can be moved by simply clicking the mouse, but also by using the arrow keys. Note that the selection marker does not follow the scroll bars.

• Preview

If the "preview" option is enabled, the component symbol of the selected entry is shown below the list.

Recall that a component can also be searched by navigating along the hierarchical menu structure.

Open a new diagram window and navigate through the menu hierarchy until you have reached the component "throttle check valve". Observe the preview window in the left corner while navigating.



After a symbol has been chosen, it is inserted in the current diagram and gets selected. It then can be moved and connected as usual.





Managing Projects

FluidSIM allows of including various settings and files in a project file with a unique name, thereby facilitating project management. When opening a project, the previously saved project settings are used as default. The project menu realizes a quick access of all files that belong to a particular project.

Creating a New Project

Entering Project Properties

Adding Files to a Project

Removing Files from a Project

Opening Project Files





Creating a New Project

Before a new project is created some preparatory actions to facilitate project management and to save several process steps at a later stage must be undertaken.

Open all files to be added to the new project. This may include, for example, preview windows for often used symbols, libraries as well as circuit files.

All files that are open when creating a new project will be automatically added to the project.

Select Project- New... and enter a file name for the new project.

Project files have the extension **prj** and should, for best results, reside in the same **ct** subdirectory as the circuit files of the project.

After having entered the file name in the dialog box, the system creates the project file with all open files.

Close all windows which you don't need right now, and arrange the remaining windows according to your preferences.

Any closed windows that belong to the project can be opened at any time by clicking Files or Overviewsin the project menu.

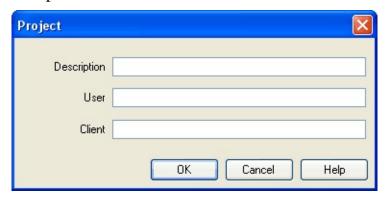
Save the settings and the window arrangement as default for this project by clicking Options- Save Settings Now.





Entering Project Properties

To enter project data, select Properties... from the Project menu. The text entered in the **description** field will be displayed in the status line of the main window while the project is open.







Adding Files to a Project

To add a new symbol, a library, or a circuit file to a project, open or activate the appropriate window, then click Add Current Window in the Project menu. Depending on whether the window is a circuit file or a preview window, it is automatically added to Files, Overviews, and Presentations respectively.





Removing Files from a Project

To remove a symbol, a library, or a circuit file from a project, open or activate the appropriate window. Then click Delete Current Window in the Project menu.





Opening Project Files

To open the files and previews (overviews) of a project, go to the Project menu and click Files, Overviews, or Presentations, whatever is appropriate. Alternatively, you may open the files by selecting Open... from the file menu or by selecting them from the list of files that were last opened, by selecting them from preview windows, or by using "Drag-and-Drop" in the Windows Explorer.





Saving Settings

FluidSIM distinguishes between three types of settings: global settings, circuit diagram specific settings, and window specific settings. Although most of these settings have already been in discussed in preceding sections, this section comprises the possible settings from FluidSIM and their relationship to one another.

Global Settings

Circuit Diagram-Specific Settings

Window-Specific Settings





Global Settings

The global settings are found under the Options and the View menu and belong to the following groups.

Global settings for various display features:

- 1. View- Large Mouse Cursor Activates or deactivates the large mouse cursor.
- 2. View- Toolbar Displays or hides the toolbar.
- 3. View- Status Bar Displays or hides the status bar.

Global settings in the dialog boxes:

- 1. Options- Simulation...
- 2. Options- Sound...
- 3. Options- Didactics...
- 4. Options- Grid...

Other global settings:

- 1. Options- Protect Text Components
 Switches the protection for the text components on or off.
- 2. Options- Create Backup Files
 Enables or disables the automatic creation of a backup file for circuit
 diagrams. Backup files have the file name extension **bak**. The backup files
 are created when the circuit diagram is saved and are updated each time the
 circuit diagram is saved.
- 3. Options- Default Directory on Network
 Defines the default directory for circuit diagrams and presentation files. If
 this option is enabled the default directory for the mentioned files is on the
 network file server. Otherwise, the default directory is on the local PC. This

menu entry is available only in the network version.

4. Options- Save Settings on Exit

Determines whether the global settings and the circuit diagram specific settings of each open circuit diagram should be saved before exiting FluidSIM.

All global settings can be saved with Options- Save Settings Now.

By clicking on Save Settings Now under the Options menu, the circuit diagram specific settings of the current circuit will also be saved. These settings then become the default for all new circuit diagrams that are created. The following settings belong in the circuit diagram specific category: display of quantity values, the flow direction indicator, and the background grid (see next section).





Circuit Diagram-Specific Settings

The following belong to the circuit diagram specific settings:

- 1. View- Quantity Values...
- 2. View- Display Flow Direction
- 3. View- Display Grid

These settings can be adjusted for each open circuit diagram individually, although they cannot be saved as such. Instead, the user has a way to define a default setting for the creation of new circuit diagrams: By clicking on Save Settings Nowunder Options, the display settings of the current circuit diagram are saved as the default. These default settings apply to the display of quantities, the flow direction indicator, and the background grid of each newly opened circuit diagram.

The term "current circuit" refers to the selected circuit diagram window. A selected window will always be fully visible and its title bar will be highlighted.





Window-Specific Settings

The following settings are window specific:

- 1. zoom factor
- 2. window size
- 3. window position

Window-specific settings can be saved by clicking on Save Settings Now under the Options menu.





GRAFCET

This chapter provides an introduction to creating and simulating GRAFCET plans with FluidSIM. See norm DIN EN 60848 for the complete specification of the GRAFCET description language. Festo Didactic provides a range of training documentation for more detailed introductions to GRAFCET.

Unlike an SPS programming language, such as Sequential Function Chart (SFC), GRAFCET is a graphic description language that describes the logical behaviour and operation of a control system or a process - regardless of the technical software and hardware implementation. FluidSIM can be used to both create and simulate GRAFCET plans. The term GRAFCET is also used as a synonym for a GRAFCET plan. It should be obvious from the context whether the word GRAFCET refers to the plan or the language.

A GRAFCET essentially describes two aspects of a control system, according to specified rules: the actions (commands) to be carried out and the sequence of execution. The elementary components of a GRAFCET are steps, actions and transitions and can be used in the same way as pneumatic or electrical components. To achieve a uniform operating concept, the GRAFCET elements feature connections that can be used to link them to each other (as with all other FluidSIM components).

<u>Steps</u>

Actions

Transitions

Stored effective actions (allocations)

Linking GRAFCET variables with the electrical part of FluidSIM

Quick reference for the FluidSIM-relevant GRAFCET concepts





Steps

Steps are either active or inactive and can be linked by actions. The actions of active steps are executed. The sequence of a GRAFCET is described by the transitions from a previous to a subsequent step. Steps and transitions have to alternate in the plan.

The creation and simulation of GRAFCETs in FluidSIM is illustrated in the following using simple examples.

Drag a step into a newly created circuit diagram.



Each step has to be assigned a name. If a step is to be active at the start of the sequence control, it is marked as the initial step.

Open the step's dialogue box by double-clicking on it or via the menu (Edit- Properties...), enter "1" as the name and select the type "initial step".



Start simulation with or via the menu (Execute- Start).



Active steps are marked with a point. Additionally, active steps are framed in green.

Related Topic

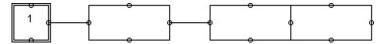
<u>Step</u>





Actions

To execute commands, you can link any number of actions to a step. Actions do not have to be directly linked to a step; you can also link them to each other. To make it easier to create the drawing, it is enough to place actions next to each other, without having to draw connecting lines. If the connections for the elements overlap each other, they are automatically connected.



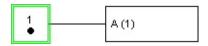
Actions can be defined by a textual description or by setting (or changing) variable values. If you want to simulate a GRAFCET with FluidSIM, the variable values are taken into account in the simulation. When displaying a GRAFCET graphically, you can decide whether the variable name or the descriptive text is shown in an action. If you want to display the description, you can set the checkmark next to "Display description instead of formula" in the action's properties dialogue (see example: **Grafcet/Grafcet18.ct**). At View-GRAFCET..., you can specify whether the descriptions are displayed instead of the formulae for all GRAFCET components.

There are two types of action: continuously effective and stored effective actions. For a continuously effective action, its associated variable is set to the Boolean value (logical value) "TRUE" (1), provided that the step connected to the action is active. If the step is inactive, the value is set to "FALSE" (0). This way of setting a variable is referred to as "assignation" in the GRAFCET specifications.

For a stored effective action, the set value of the variable remains unchanged until it is changed by another action. This way of setting a variable is referred to as "allocation" in the GRAFCET specifications.

At the start of a sequence, all the variable values are initialised with "0".

create the following GRAFCET. Select the action "Simple action" in the properties dialogue and enter "A" under "Variable/output". Then start the simulation.



Step "1" is active and the action connected to the step is executed. Variable "A" is set to "1". The value of an action variable is shown during simulation in brackets after the variable's name.

Related Topic

Action





Transitions

Transitions are used to describe the sequence of a control system. To do this, add the following information to GRAFCET:

Select "2" as the name of the second (simple) step. The transition conditions that specify when the system moves from one step to the next are still missing. A transition is considered released once all the immediately preceding steps are active. A transition is triggered once it has been released and its condition has the value "1". A transition with the value "1" is displayed in green in FluidSIM. You can show a descriptive text instead of the formula, as with the actions.

A Boolean value is automatically generated for each step. The name begins with an "X", followed by the name of the step. In the example here, the variables "X1" and "X2" are generated. The value of a step variable is "1" if the step is active; otherwise it is "0".

Transition conditions can be time-dependent. These have the following form: $t1\ s\ /\ "term"\ /\ t2\ s$

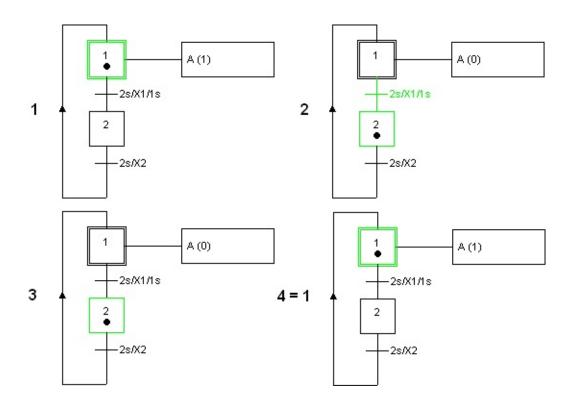
Where t1 and t2 have to be replaced by numbers and "term" by a Boolean term.

The transition condition becomes true ("1") t1 seconds after "term" has changed its value from "0" to "1". This is called a "rising edge". The transition condition becomes false again ("0") t2 seconds after "term" has changed its value from "1" to "0". This is called a "falling edge".

The short form t1 s / "term" is also allowed. The system then assumes that t2 is 0 seconds.

Enter the transition conditions into the transitions' properties dialogue as shown and then start the simulation.

The following cycle runs through:



Related Topics

Transition

<u>Delays / time limits</u>



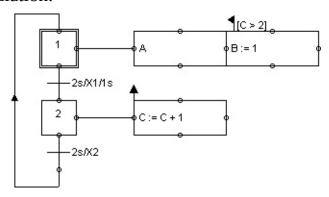


Stored effective actions (allocations)

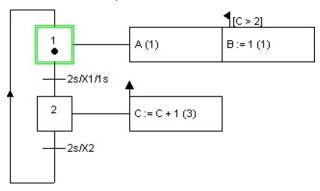
In the next example, a counter is to be implemented. This works using a stored effective action (allocation) and an action on an event.

To do this, add the following information to GRAFCET:

Select "Action on activation" for the action of the second step, "C" as the variable and "C + 1" as the allocation. "C" will work as a counter. For the second action of the first step, select "Action on event", "B" as the variable with the allocation. "1" and "[C>2]" as the condition/event. Then start the simulation.



Each time step "2" is activated, "C" is raised by one. As soon as "C" has the value "3" and step "1" is activated, "B" receives value "1".



Related Topics

Action

Boolean value of an assertion

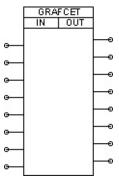




Linking GRAFCET variables with the electrical part of FluidSIM

The GRAFCET I/O component is used to link the GRAFCET variables with the electrical part of FluidSIM.

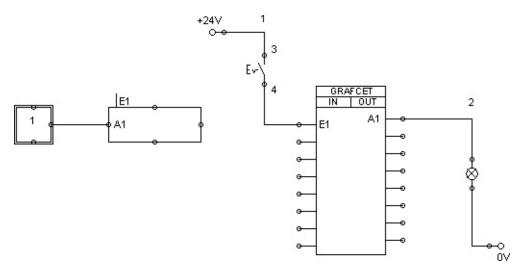
The access to labels associated with FluidSIM components is explained in section Access to labels of fluidic and electrical components .



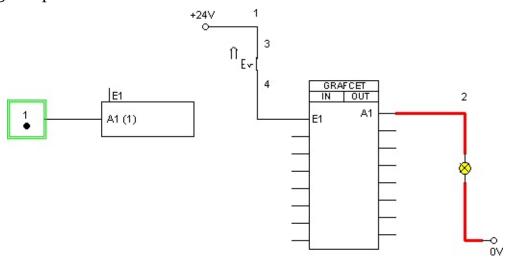
In the GRAFCET I/O component, you can specify GRAFCET variables to be used as inputs or outputs. The actions' variables serve as outputs. The inputs can be the conditions of actions and transitions.

If a potential is created as the input of the GRAFCET I/O component, the corresponding variable is set to "1". If an output variable has a value other than "0", an electric potential (24V) is present at the corresponding output of the GRAFCET I/O component.

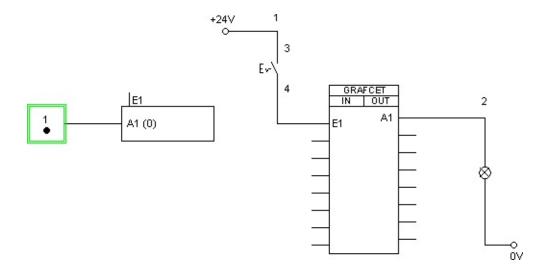
The following simple example illustrates the use of the GRAFCET I/O component.



In the GRAFCET I/O component's properties dialogue, "E1" is specified as the input and "A1" as the output. As soon as the electrical switch is closed, there is a potential at the input of "E1"; this potential causes the GRAFCET variable "E1" to change its value from "0" to "1". As a consequence of this, the condition in the action becomes true ("1") and the value of variable "A1" is set to "1". This in turn leads to a potential being created at the output of "A1" and the indicator light lights up.



As soon as the switch is opened again, the following situation arises:



Related Topics

Access to labels of fluidic and electrical components GRAFCET-I/O





Quick reference for the FluidSIM-relevant GRAFCET concepts

The next sections introduce all GRAFCET concepts that are related to FluidSIM.

Initialization

Sequence rules

Sequence selection

Synchronization

Transient sequence / unstable step / virtual triggering

Determining the values of GRAFCET variables

Checking the entries

Admissible characters for steps and variables

Variable names

Access to labels of fluidic and electrical components

Functions and formula entry

Delays / time limits

Boolean value of an assertion

Target information

Partial GRAFCETs

Macro-steps

Compulsory commands

Enclosing step

Action when a transition is triggered







Initialization

All the variables in a GRAFCET are preset with the value "0" at the start of the simulation.





Sequence rules

- A transition is considered released once all the immediately preceding steps are active. A transition is triggered once it has been released and its condition has the value "1". A transition with the value "1" is shown in green in FluidSIM, regardless of whether the step linked to it is active or inactive.
- The relevant transition is triggered at the same time and does not take any time.
- Since triggering a transition does not take any time, a step can be activated and deactivated at the same time (even across various intermediate steps). An active step remains active in this situation. A loop of steps is only run through once at one point in time (see example: **Grafcet/Grafcet06.ct**).

Related Topics

Step

Transition





Sequence selection

A step can branch off into various partial sequences. In the GRAFCET specifications, these partial sequences have to be exclusive. Since this can generally only be checked during the sequence, this exclusivity is not required in FluidSIM (see example: **Grafcet/Grafcet07.ct**).





Synchronization

The GRAFCET synchronization component can be used to implement synchronizations (see example: **Grafcet/Grafcet08.ct**).

Related Topic

Synchronization





Transient sequence / unstable step / virtual triggering

As described in Sequence rules, triggering a transition does not take any time. As a consequence of this, multiple consecutive steps can be activated at the same point in time one after the other. This sequence is called transient (continuous).

The intermediate steps in the sequence chain are referred to as unstable. The continuously effective actions connected to them are not displayed in the simulation. The allocations in the stored effective actions are carried out. Triggering the intermediate steps and their associated transitions is called virtual triggering (see example: **Grafcet/Grafcet06.ct**).

Related Topics

Step

Transition







Determining the values of GRAFCET variables

Variables of continuously effective actions (allocations) receive the value "1" if the corresponding action is linked to an active step and any action condition present has the value "1".

Variables of stored effective actions (assignation) are changed if the corresponding action is linked to an active step and the relevant action event occurs (e.g. action on event or on activation).

FluidSIM does not check whether the two types of variable identification contradict each other for a variable. If this case occurs, the variable value is determined by an internal calculation, which the user cannot predict (see example: **Grafcet/Grafcet09.ct**).

Related Topic

Action





Checking the entries

FluidSIM checks the validity of entries for conditions and assignations. If this kind of term does not match the specifications, the term in question is displayed in red. The simulation is only released once all the terms are valid.

Related Topics

Transition







Admissible characters for steps and variables

Only the following characters may be used for steps and variables:

- Numbers from "0" to "9"
- Lower-case letters from "a" to "z"
- Upper-case letters from "A" to "Z"
- The underscore "_"

There are no limitations for the descriptions that can be shown for conditions and actions, because these are only displayed and are not used for simulation.

Labels of fluidic or electrical components that are intended to be used from GRAFCETs (see <u>Access to labels of fluidic and electrical components</u>) are allowed to contain only the characters mentioned above.

Related Topics

Step

Transition

Action

Partial GRAFCET

GRAFCET-I/O





Variable names

There are four different types of variables. All variables can be used in conditions and assignations.

• **Action variables**Action variables are available throughout GRAFCET and can be set in actions (see example: **Grafcet/Grafcet10.ct**).

Step variables

Step variables are inserted automatically for each step and have the value "1" when and only when the corresponding step is active. Step variables have the form X + "step name". If, for example, the step name is "12", then the associated variable is "X12".

Step names are only ever valid within a partial GRAFCET or within the global GRAFCET. This means that the same step name can be used in different partial GRAFCETs. In order to be able to address step variables across partial GRAFCETs in FluidSIM, the step variable has to be preceded by the partial GRAFCET name.

Example:

Partial GRAFCET "1" contains step "2" and is meant to be addressed in the global GRAFCET. Within the global GRAFCET, the step variable name "G1.X2" has to be used. Within partial GRAFCET "1", "X2" is enough (see example: **Grafcet/Grafcet11.ct**).

Variables of macro-steps have the form XM + "step name", macro inputs have XE + "step name" and macro outputs have XS + "step name" (see example: **Grafcet/Grafcet15.ct**).

Partial GRAFCET variables

Partial GRAFCET variables are automatically inserted for each partial GRAFCET and have the value "1" when and only when at least one step in the corresponding partial GRAFCET is active. Partial GRAFCET variables have the form XG + "partial GRAFCET name". If, for example, the partial GRAFCET name is "1", the associated variable is "XG1" (see example: **Grafcet/Grafcet12.ct**).

• Labels of fluidic or electrical components

These labels can be used as GRAFCET input variables (see <u>Access to labels of fluidic and electrical components</u>).

Related Topics

Step

Transition

Action

Partial GRAFCET





Access to labels of fluidic and electrical components

GRAFCET-I/O components are the standard means to access electrical components in FluidSIM. In addition, certain labels of a circuit can be used as Boolean input variables in GRAFCET directly, without using a GRAFCET-I/O component (see example **Grafcet/TP201_09gc2.ct**). Such a direct access pertains to labels of the following components:

- Distance rule
- Semi-rotary actuator
- Pressure switch
- Manually actuated switch
- Relay
- Valve solenoid





Functions and formula entry

A range of functions can be used in conditions and assignations. These functions are displayed according to the GRAFCET specifications (e.g. upwards arrow for rising edge). Entering GRAFCET-specific functions is supported by the buttons in the dialogues with the relevant labels:

- "+" (logical OR)
- "*" (logical AND)
- "NOT" (logical NOT)
- "RE" (rising edge)
- "FE" (falling edge)
- "s / / s" (delay)
- "s /" (delay, short form)
- "NOT(s /)" (time limit)

If the functions "NOT", "RE" or "FE" refer to a term, the term has to be placed in brackets.

Examples:

NOT a

NOT(a + b)

RE X1

RE (X1 * X2)

The following additional mathematical functions are available:

- abs (absolute amount)
- sign (algebraic sign: +1, 0, -2)
- max (maximum of two numbers)
- min (minimum of two numbers)
- \land (to the power of, e.g. $a \land 3$)
- sqrt (square root)
- exp (to the power of constant "e")

- log (natural logarithm)
- sin (sine)
- cos (cosine)

Related Topics

Transition





Delays / time limits

Delays have the following form (see example: **Grafcet/Grafcet03.ct**):

"Time in seconds" s / "Boolean term" / "time in seconds"

or

"Time in seconds" s / "Boolean term"

Examples:

1 s / X1 / 2s 3s/X3

Time limits have the following form:

NOT ("time in seconds" s / "Boolean term")

Example:

NOT(6s/X28)

Related Topics

Transition





Boolean value of an assertion

In GRAFCET, you can use Boolean values to calculate an assertion, for example: a counter "C" should be larger than 6 and step "X1" should be activated. "C" is larger than "6" can be calculated as with a variable. To do this, the assertion has to be set in square brackets. So in this example:

$$[C > 6] * X1$$

If a Boolean assertion is positioned on its own in a condition, then you can omit the square brackets in FluidSIM, for example C > 6 instead of [C > 6]. (See example: **Grafcet/Grafcet13.ct**)

Related Topics

Transition





Target information

If you want to interrupt an operative connection from a transition to a step, you can enter the name of the target step in the transition's properties dialogue (see example: **Grafcet/Grafcet14.ct**).

Related Topics

Step

Transition





Partial GRAFCETs

Partial GRAFCETs can be used to separate a GRAFCET into different hierarchy levels. This function is most often used for enclosing steps and compulsory commands. The name of a partial GRAFCET is always preceded by a "G".

In order to determine partial GRAFCETs in FluidSIM, the partial GRAFCET frame has to be placed over the relevant GRAFCET part and you have to assign a name in the properties dialogue. The preceding "G" is not part of the name that you have to enter; it is added automatically by FluidSIM and shown at the bottom left of the partial GRAFCET frame. You can alter the size of the partial GRAFCET frame by dragging its edges with the mouse (see example: **Grafcet/Grafcet11.ct**). It is important that all the elements of the partial GRAFCET are located entirely within the relevant frame and that there are no "foreign" elements overlapping the frame.

Related Topics

Step

Action

Partial GRAFCET







Macro-steps

Macro-steps can be specified using a step's properties dialogue. The preceding "M" is not a part of the name that you have to enter; it is added automatically by FluidSIM. You can specify macro inputs and macro outputs in the same way. The preceding "E" and "S" in these cases are not part of the name either and are automatically added by FluidSIM (see example: **Grafcet/Grafcet15.ct**).

Related Topic

Step





Compulsory commands

Compulsory commands can be used to control partial GRAFCETs regardless of their normal sequence. There is an entry mask to help you enter these commands in FluidSIM. There are four types of compulsory command. They are shown here using four examples (see example: **Grafcet/Grafcet16.ct**).

- **G12 {8, 9, 11}**Setting a specific situation. This example activates steps 8, 9 and 11 of partial GRAFCET 12.
- G12 {*}

Freezing a partial GRAFCET. In this example, the current situation for partial GRAFCET 12 is maintained as it is. No further transitions are triggered.

• G12 {}

Setting a blank situation. All steps in partial GRAFCET 12 are deactivated in this example.

• G12 {INIT}

Setting the initial situation. In this example, the steps in partial GRAFCET 12 that are marked as initial steps are activated.

Related Topics

Action

Partial GRAFCET





Enclosing step

Enclosing steps can be specified using a step's properties dialogue. You can either enter the enclosed partial GRAFCETs directly or select them from a list. You have to separate individual partial GRAFCETs with a comma or a blank space.

During simulation, the name of the enclosing step is shown at the top left of the partial GRAFCET frame, as soon as the step is activated (see example: **Grafcet/Grafcet17.ct**).

You have to set the "Activation link" field in the properties dialogue for steps within the enclosed partial GRAFCET that you wish to activate when the enclosing step is activated.

Related Topics

Step

Partial GRAFCET





Action when a transition is triggered

FluidSIM does not support the execution of an action when a transition is triggered.





Help and Advanced Tips

This chapter serves as the first place to find help, when dealing with questions that come from working with FluidSIM. The second section of this chapter provides background information for advanced users.

The Most Frequently Occurring Problems

Tips for the Advanced User





The Most Frequently Occurring Problems

When attempting to perform certain actions, you are prompted to insert the FluidSIM CD.

FluidSIM cannot find certain installation directories on the hard disk. Probably not all of the software components were loaded at the time of installation. Either insert the CD or reinstall the missing software components.

Component cannot be moved or deleted.

Make sure that you are in the Edit Mode (); components can only be moved or deleted in the Edit Mode.

Components cannot be dragged onto the drawing area.

Make sure that you are in the Edit Mode.

Components cannot be moved or deleted in the Edit Mode.

Make sure that you have selected a component and not a *component connection*.

②A line cannot be drawn between two connections.

Make sure to check the following points:

- 1. FluidSIM is in the Edit Mode.
- 2. No other connections are selected.
- 3. Both connections do not have a blind plug.
- 4. Both connections are of the same type.

The parameters of a component cannot be changed.

Make sure that FluidSIM is in the Edit Mode or that the simulation has been paused (III).

The hard disk is running non-stop and the simulation is going slowly.

There is not enough memory available. A workaround is to quit other running applications or to quit Microsoft Windows © and restart the computer.

Already drawn lines, which are reported to be superimposed, cannot be found.

Press the **Del** key immediately after accepting the message; then draw a new line.

FluidSIM does not behave normally.

Exit both FluidSIM and Microsoft Windows ©, and then restart Microsoft Windows © and FluidSIM.

You are getting negative values for pressure.

Negative values for pressure mean that from a physical standpoint, the power supply unit is not providing the necessary output. Often, the reason is that there is a too high tensile load on a cylinder. In reality this situation can lead to different reactions, depending on apparent loads and the power supply unit involved. For this reason FluidSIM simply indicates a negative pressure value.

The pressure drop on a pressure relief valve is higher than its preset targeted nominal value.

There is really no mistake here: A pressure relief valve has a preset nominal pressure threshold, which is related to a certain pressure flow. If the flow should increase beyond this value, a larger pressure drop will occur, according to the resistance characteristics of the valve. The pressure relief valve is also not in the position to guarantee a certain pressure in all circumstances.

Components cannot be marked.

Please ensure that the option Protect Text Componentsis not activated and that the edit mode for the applicable <u>drawing layer</u> is activated.

Certain editing functions are not available in the context menu.

The context menu contains a practical subset of possible editing functions. Probably the operation that you would like to utilize applies only to one component at a time; if this is the case check to see that only one component is selected.

There is no pressure drop in the circuit, although a T-connection is apparently open.

T-connections are considered to be different from other connections: As an aid in drawing, they must not be provided with blind plugs because they are automatically closed if no line is connected.

The simulation time runs irregularly, although the slow-motion factor has been set to 1:1, and "Keep real-time" has been activated.

Both a complex circuit diagram and a slow computer could be reasons for the inability of FluidSIM to guarantee adherence to real-time.

At certain connections arrows for the flow direction are not displayed. The option Display Flow Direction has been activated.

The arrows only appear when a connection actual has a flow passing through it. This situation is not to be confused with a high pressure at a connection.

The animation is not repeated, although the "Loop" option has been activated.

The "Loop" option only applies to an animation that is not contained in part of a presentation.

FluidSIM is not behaving as expected, and you have already exited Microsoft Windows © and started FluidSIM new again many times.

Please uninstall FluidSIM and run a new installation.

Paste is not available from the menu, although a Copy operation has already taken place.

Only selected objects can be copied to the clipboard. If no objects are selected, only the picture will be copied to the clipboard.

No educational film will start playing.

Video playback requires appropriate hardware and software. Furthermore,

FluidSIM needs to access the movie files. To ensure this, the FluidSIM-CD-ROM needs to be present in the drive or the video files need to have been copied to the hard disk during the installation.

The student version of FluidSIM is being loaded each time you start, although you have purchased the full version.

The FluidSIM CD contains both the student version and the full version of FluidSIM. During the installation procedure you are asked whether the full version or the student version shall be installed.

The mouse cursor is not switching as described, especially on top of connections.

Make sure that the option Large Mouse Cursor has not been activated. The large mouse cursor is designed to be used with a projector; here the switching of the mouse cursor is undesirable.

②DXF Export... is not available from the menu.

Make sure that you are in the Edit Mode and that the window is not empty.

The text that was exported using the DXF filter does not appear as it did in FluidSIM.

The DXF format does not sufficiently support textual objects. I.e., CAD programs may not possess the ability to translate all fonts, font attributes, font colors, and special symbols.





Tips for the Advanced User

This section contains some technical information about different concepts in FluidSIM.

Data Formats of the Clipboard

Media Playback

Opening FluidSIM files via the Explorer

Opening FluidSIM Files by Command Line Entry

Reorganization of the Internal Memory

Changing the Sound Files

File Operations via Preview Windows

Creating Presentation Files

Network Installation of FluidSIM





Data Formats of the Clipboard

When information from a FluidSIM window is copied to the clipboard, both a meta file and a bitmap are generated. When pasting into another application (a word processing program or a drawing program), the program automatically finds the format that will contain the most information. However, it could be intended to insert a circuit diagram, for example into Word, as a bitmap as opposed to the meta file representation. In this case you simply paste the contents of the clipboard into bitmap editor such as Paintbrush, and then recopy it back to the clipboard. Following this action, Word then will find the bitmap when pasting from the clipboard.





Media Playback

Provided the video files have been copied to the hard disk during the installation, they will played within the FluidSIM window.Launching playback of the FluidSIM-educational films manually from the video-CD will open the "Media Player". Further hints are described in the Microsoft Windows © Help under the media playback topic.





Opening FluidSIM files via the Explorer

Normally, to open a file from within FluidSIM, you would click on Open... under the File menu. It is also possible to open files via the Explorer. There are two possible ways to go about doing this:

- 1. You can connect files with FluidSIM that have the same extension, for example **ct**. By double clicking on a file with this extension, it will be opened by FluidSIM. If FluidSIM is not running at this time, it will be started by the File Manager.
- 2. Select the files that are to be opened in the usual way in the Explorer. Here the window of the Explorer with the selected files should either appear next to an open FluidSIM window or next to the FluidSIM program icon on the desktop. You can open the files by dragging them over FluidSIM.





Opening FluidSIM Files by Command Line Entry

Besides the possibilities listed above for opening FluidSIM files, you can also open files by entering an appropriate command line. Once in the Start menu, click on Run... and enter the file name after the program name.





Reorganization of the Internal Memory

While working with FluidSIM, particular information is cached in the memory for performance purposes. In some cases it is desirable to free up memory or to force a window refresh. By pressing the **ESC** key, FluidSIM reorganizes its memory, removes the cached data, rebuilds the internal data structures, and refreshes all windows. If the topmost window is a circuit diagram preview window, the contents of the corresponding directory will also be read as new.





Changing the Sound Files

Provided your computer has an audio-interface capable of playing back audio, sounds will optionally play while actuating relays, switches, valves and while activating the buzzer. You may use your own sound files instead of the preset ones by replacing the sound files in the **snd**-folder. The sound for switch/pushbutton and for relays is **switch.wav**, the sound for valves is **valve.wav**, the buzzer activates the sound **horn.wav** and the cylinder end position stop triggers **cylinder.wav**.





File Operations via Preview Windows

Aside from opening circuit diagrams by double clicking on a circuit's miniature representation, a preview window does also provide some File Manager functionality. Analogous to the Edit Mode for objects in a circuit diagram, the miniaturized circuit diagrams can be selected, deleted, copied between overview windows (or moved by holding down the **Shift** key), copied to the clipboard, or dragged into the a circuit diagram window.

Please remember, that delete operations and move operations take place on the file system. Therefore, if a miniaturized circuit diagram is deleted, its related file will also be deleted in the file system.





Creating Presentation Files

This section describes how presentations can be created using a common text editor: more specifically, not using FluidSIM.

The file names of presentation files have the extension **.shw**. A **shw** file has the following structure:

The first line shows the description of the presentation which will also be represented in the selection box. In the following lines, in the applicable order, you will find file names with respect to the installation path. User files will simply be represented by their absolute path.

The **shw**-file of the presentation applications will be as follows:

01 Applications \dida\p3_1_1_1_1.ct \dida\p3_1_1_2.ct \dida\p3_1_1_3.ct





Network Installation of FluidSIM

If several PCs are running in a network, a complete installation of FluidSIM must only be performed once, on the network file system. Then on the local PCs merely the license information and a few configuration files are required. This concept serves several purposes: the saving of disk space on the local hard disks, the simplification of software maintenance, the quick distribution of circuit diagrams, or the installation of new releases of FluidSIM.

The installation of the network version happens within the following steps:

- Perform a standard installation of FluidSIM on the network file system. Note that the local PCs must be authorized to read the FluidSIM files on the network file system.
 - Use the network option when installing FluidSIM on the other local PCs by calling the installation program as follows: **setup.exe -N**

During a local installation, the installation program asks for the network path of the FluidSIM **bin**-directory. Thus FluidSIM must have been installed on the network file system *before* any local installation can be performed.

User-specifically, FluidSIM stores user files and settings in those file locations that are defined by the operation system. In the case of a standard-Microsoft Windows ©-installation these are **My Documents** and **Application Data** of the particular user account.

An aside: The PC used during the FluidSIM standard installation on the network file system also reads and writes the FluidSIM configuration files on the network. Moreover, a FluidSIM de-installation from this PC will delete the FluidSIM program files, and, consequently, FluidSIM is no longer available on the network.

If local PCs are not equipped with a CD-ROM drive, and if these PCs have no access to a CD-ROM drive of some other PC, the educational films may also be played from the network file system: If sufficient disk space is left on the network file system, the movie files can be copied to the installation folder during the setup procedure.





FluidSIM Menus

This chapter contains a complete listing of the menus in FluidSIM and can be utilized as a quick-reference guide. The term "current circuit" refers to the selected circuit diagram window. A selected window will always be fully visible and its title bar will be highlighted.

<u>File</u>

Edit

Execute

Library

Insert

Didactics

Project

View

Options

Window

?





File

New

Ctrl+N

Opens a new window to create a circuit diagram. The default name for the new circuit diagram is **noname.ct**. If a circuit with this name already exists, a number is appended to the title **noname** to create a unique file name.

Open...

Ctrl+O



Opens the File Selector dialog box, which allows you to select and open a circuit diagram.

Close

Ctrl+W

Closes the active window. Provided the window content has not been saved, a corresponding request will be prompted.

Save

Ctrl+S



Saves the current circuit diagram. The circuit diagram window remains open.

Save As...

Opens the File Selector dialog box, and you can save the current circuit under a different name. This name appears in the title bar of the circuit diagram window and becomes the new name for the circuit.

Circuit Preview

Ctrl+U



Opens the circuit diagram preview windows. Double clicking on a miniature circuit diagram will load the circuit. Circuit diagrams can be selected and deleted in the preview window. When saving circuit diagrams, the preview window is automatically updated.

In the **fluidsim** directory, subdirectories can be created for the saving of circuit

diagrams. FluidSIM recognizes all circuit diagram directories and generates appropriate circuit diagram preview windows.

TIFF Export...

The file selection box will open; the graphic information of the present circuit can be converted and saved to the TIFF format. If no new name is entered for the TIFF file, it will be saved using the circuit description and the file extension .tif.

The TIFF export filter is useful to provide the graphic circuit information as a picture file for the use in other applications.

DXF Export...

Opens the File Selector dialog box, and you can then export the current circuit diagram in the DXF format. If no new name is given for the DXF file, then it is saved under the circuit diagram name with the file extension .dxf.

The DXF export filter allows the graphic information from the circuit diagram to be exported to other CAD systems.

Parts list Export...

The file selector box is opened; the contents of the selected parts list is saved as a text file.

When file name has been specified, another dialog box opens where a character can be declared as column separator.

Properties...

Opens a dialog box where the circuit properties can be defined.

Drawing Size...

Opens a dialog box where the paper size can be defined.

Print... Ctrl+P

Opens the Print Preview dialog box, which allows you to print the current circuit diagram with an optional scaling factor.

Previously Opened Files

Displays a list with the eight previously opened files. When selecting one entry of this list the associated file is opened. The list is sorted: The most recently opened file forms the topmost entry.

Exit Alt+F4

Quits FluidSIM.





Edit

Undo

Alt+Backspace

N

Undoes the last edit step. Up to 128 previous editing steps, which have been stored, can be made undone.

Redo

Alt+Shift+Backspace

Withdraws the last action performed by Edit- Undo. The function can be used up until there are no more undo steps to be redone.

Cut

Shift+Del

X

Cuts the selected components and saves them to the clipboard.

Copy

Ctrl+Ins



Copies the selected components to the clipboard. In this way circuit diagrams and parts of diagrams can be inserted easily as vector graphics, for example into word-processing applications.

Paste

Shift+Ins



Inserts components from the clipboard onto the drawing area of the current circuit diagram.

Delete

Del

Deletes the selected components from the circuit diagram.

If a *connection* is selected and deleted, a possibly connected line or fitted blind plug is deleted. However, the component is not deleted.

Select All

Ctrl+A

Selects all components and lines of the current circuit diagram.

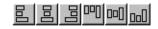
Group Ctrl+G

Groups the selected objects. Groups can be nested by applying the grouping operation recursively on already existing groups.

Ungroup

Ungroups the selected groups. Each ungroup operation removes only the outermost group when applied to a selection that contains nested groups.

Align



Aligns the selected objects.

Rotate

Rotates the marked components by 90°, 180° or 270°.

If only one component is to be rotated (counterclockwise), this action is accomplished by holding down the **Ctrl** key and double clicking on the component. If additionally the **Shift** key is held down, rotation happens in a clockwise fashion.

Mirror



Mirrors the marked components horizontally or vertically.

Properties...

Opens a dialog box that contains the parameters for a single, selected component. This dialog box will also contain an input field for a label name, as long as a label can be assigned to the component.

If a *fluidic line* is selected, a dialog box will appear in which you can change the line type from the standard line type, "Main Line", to the special line type "Control Line". Note that—aside from a different appearance—changing line type has no impact respecting simulation.

If a *fluidic connection* is selected, a dialog box will appear containing input

fields for the selected connection. The input fields define which of the quantities are to be displayed and, in the case of a hydraulic connection, if the connection is fitted with a blind plug or a muffler.





Execute

Check Superficially F6

Checks the current circuit diagram for mistakes in drawing.

Stop F5

Switches the current circuit diagram in the Edit Mode.

Start F9

Starts the simulation or, as the case may be, animation in the current circuit diagram.

Pause F8

Pauses the current circuit diagram during simulation without leaving the Simulation Mode. The simulation can then be re-animated from this point and continue as if it had not been halted.

If Pauseis clicked while being in the *Edit Mode*, the circuit diagram switches to the Simulation Mode without starting the simulation. In this manner, the components' states can be set before the simulation is started.

Reset

Sets an already running or paused simulation back to the initial state. The simulation is immediately restarted.

Single Step

Stops the simulation after it has run only a little bit. The simulation will run for a short time period and is then paused (). The single step mode can be applied at any time to an already running simulation.

Simulate until State Change

H

Starts the simulation until a state change happens; the simulation is then paused (

. A state change occurs when a cylinder piston travels a stop, a valve switches, a relay or a switch is actuated. The state change mode can be applied at any time to an already running simulation.

Next Topic



Switches to the next topic in a presentation.





Library

Hierarchical View

Opens a library window where the FluidSIM components are organized hierarchically, i.e. within a tree.

New...

Opens a dialog box for the creation of a user-defined component library.

User-defined component libraries can be rearranged according to the user's will—and, in contrast to the FluidSIM standard libraries, components can be added or deleted from them.

Rename...

Opens a dialog box to rename a user-defined component library.

Delete

Deletes that user-defined component library whose overview window is currently active.





Insert

A hierarchically organized menu from which an object can be selected and inserted in the current circuit diagram.

Find Component...

F3

Opens the dialog for the string-based search of components.





Didactics

Component Description

Opens the page with the technical description for the selected component. This page contains the DIN symbol of the component, a textual description of the component's function, the connection designations, and a listing of the adjustable parameters including their value ranges.

Tutorial

Opens the Tutorial "Simulating with FluidSIM".

Component Library

Opens the reference of the component library.

Didactics Material

Opens the overview of the didactics material. Provided you've copied the movie files on your hard disk during the installation, the educational film chapters will appear here.

Presentation...

Opens a dialog box that can be utilized to recall available presentations along with creating new presentations. Presentations allow for the combination of individual topics into a lesson, ideal for teaching hydraulics.

Extended Presentation...

Opens a dialog box that can be utilized to recall available Microsoft PowerPoint presentations. The files of the extended presentations are located in the **ppx** subdirectory of your FluidSIM installation. You can add PowerPoint presentations on your own by copying the respective "ppt"-files or "pps"-files to the **ppx** subdirectory.

Educational Film...

Opens a dialog box with educational films related to electro-hydraulics. By double clicking on a topic in the list, the dialog box closes, and the media playback starts playing the selected film. This menu option only appears if the movie files have not been copied on your hard disk during the installation. Otherwise you will find the educational films in the menu option Didactics Material.





Project

New...

The file selector box is opened, and a new project can be created. Project files get the file extension **prj**.

Open...

The file selector box is opened, and a project can selected and opened.

Close

The current project is closed and the standard settings are loaded.

Add Current Window

Adds the current window to the list of project files.

Delete Current Window

Removes the current window from the list of project files.

Properties...

Opens a dialog box where the project properties can be defined.

Files

Shows the list of files that belong to the current project.

Overviews

Shows the list of preview windows that belong to the current project.

Presentations

Shows the list of presentations that belong to the current project.





View

The functions of the View menu are circuit diagram specific, that is, they only apply to the current circuit diagram. Thus it is possible to apply individually different display options to each circuit diagram, which is loaded.

Folder View

Shows the content of the active <u>component library</u> or of the active <u>circuit</u> <u>diagram overview</u> using the folder view instead of the tree view.

Sort Symbols Alphabetically

Sorts the symbols of the current preview window with respect to their description and extension respectively.

Standard Size



Displays the circuit diagram without enlargement or reduction.

Previous View



Switches between the last view and the current enlargement of the current circuit diagram.

Fit to Window



Sets the scale factor so that the entire circuit diagram can be displayed in the window. The proportion between height and width remains unaltered.

Zoom by Rubber Band



Changes the mouse cursor to a rubber band, allowing a section of a window to be selected and then enlarged.

Zoom In >

Enlarges the diagram at a factor of 1.4 ($\sqrt{2}$). To repeat this action twice means a doubling in the diagram's size.

Zoom Out <

Reduces the diagram at a factor of 1.4 ($\sqrt{2}$). To repeat this action twice means a cutting in half of the diagram's size.

Quantity Values... A

Opens a dialog box for the display of quantities. For each of the quantities "Velocity", "Pressure", ..., different types of display options can be defined ("None", "Particular", "All").

GRAFCET...

Opens a dialog box with settings for the display of formulas and descriptions in GRAFCET components. If the option "Use settings of individual elements" is chosen, all formulas and descriptions are shown as transitions and actions according to the individual component settings, which is defined under "Display description instead of formula". If the option "Description, if available" is chosen, descriptions are shown in place of their related formulas. If the option "Always show formula" is chosen, formulas are shown even if a description exists as well.

Display Flow Direction D

Turns on or off the arrow as a direction of flow indicator. The arrow for the direction of flow will be shown near the component connection, that is, as long as the flow is other than zero.

Display counter values and delay times T

Displays or hides the current values of components with counting and delay behavior.

Display current path numbering and switching elements table N

Displays or hides the current path numbering and the switching elements table in electrical circuits.

Show Connection Descriptors C

Enables or disables the display of the component's connection descriptors.

Labels...

Opens a dialog box for the label display style. It can be defined whether or not the labels are drawn framed.

Display Grid G

Activates the background grid, according to the set style. The style of the grid can be chosen under Options- Grid....

Layers...

Opens a dialog box for renaming and activating the FluidSIM drawing layers. For drawing object that cannot be simulated, such as texts, DXF imports, rectangles, circles, state diagrams, or parts lists, up to eight drawing layers are provided. The FluidSIM components that can be simulated live always on the drawing layer number one.

Large Mouse Cursor M

Activates or deactivates the large mouse cursor.

Toolbar

Displays or hides the toolbar.

Status Bar

Displays or hides the status bar.





Options

Simulation...

Opens a dialog box with settings for the simulation. Here, parameters such as the maximum recording time, the slow-motion factor, and the priority are defined.

EasyPort/OPC/DDE Connection...

Opens a dialog box with options for the EasyPort/OPC/DDE connection. This is where you may define various options for interconnecting FluidSIM with the EasyPort hardware or with other applications.

Sound...

Opens a dialog box in which the acoustic signal is switched on for the following component types: switch, relay, valve, and buzzer.

Didactics...

Opens a dialog box with settings for the didactics. These settings include factors that apply to animation speed and repeat mode.

Grid...

Opens a dialog box allowing you to activate the background grid and select its style ("Point", "Cross", "Line") and its resolution ("Coarse", "Medium", "Fine").

Terminal Assignment Diagram...

Opens a dialog box where you may define the options for the terminal assignment diagrams.

Protect Text Components

Enables or disables the protection of text components. Protected text

components can neither be marked nor moved or deleted.

Create Backup Files

Enables or disables the automatic creation of a backup file for circuit diagrams. Backup file names have the extension **bak**. The backup files are created when the circuit diagram is saved and are updated each time the circuit diagram is saved.

Default Directory on Network

Defines the default directory for circuit diagrams and presentation files. If this option is enabled the default directory for the mentioned files is on the network file server. Otherwise, the default directory is on the local PC. This menu entry is available only in the network version.

Save Settings Now

Saves the current global and window specific settings. Defines the circuit diagram specific settings of the current circuit diagram as the default settings.

Global settings pertain to the toolbar and the status bar, to the simulation, sound, didactic, and grid options, to the creation of backup files, as well as quitting FluidSIM. Window specific settings pertain to zoom levels, window size, and window position. The quantity display, as well as the flow direction indicator and the background grid are considered circuit diagram specific.

Save Settings on Exit

Defines as to whether or not the current global and window specific settings should be saved upon quitting FluidSIM.





Window

Cascade

Shift+F5

Arranges the circuit diagram windows in an overlapping format.

Tile Horizontally

Arranges the circuit diagram windows next to each other.

Tile Vertically

Shift+F4

Arranges the circuit diagram windows below to each other.

Arrange Icons

Arranges the iconified windows on the desktop.

Window list

Opens a dialog box with all currently opened windows. The windows can be activated, minimized or closed by clicking the appropriate buttons.



?

Contents...

F1

Opens a help window pertaining to a list of contents from the FluidSIM online help.

How to Use Help

Describes how help can be used.

Addendum to the User Manual

Opens a help window pertaining to the additions to the handbook for FluidSIM. Note that this menu entry must not be available.

Looking up FluidSIM Updates on the Internet...

Connects to an update server to check for available FluidSIM-updates. To use this function you need to be connected to the internet. If an update is available for your software version, you will be prompted and may download the installation file directly. Following the download the update will be launched automatically.

About FluidSIM...

Opens the Program Information box about FluidSIM. Among others, the FluidSIM serial number (including the number of the license connector, if applicable) looked up.





The Component Library

In FluidSIM each component in the component library is assigned a physical model. Using these models, FluidSIM first creates a global behavior model of the circuit which is then processed during simulation.

This chapter provides for a short description of the components in FluidSIM's component library. If the component has adjustable parameters, their value ranges are given. A number in brackets after the value range indicates the default setting for the parameter.

Hydraulic Components

Electrical Components

Electrical Components (American Standard)

Digital Components

GRAFCET Elements

Miscellaneous







Hydraulic Components

Service Components

Pump unit

Pump unit (simplified)

Fixed displacement pump

Variable displacement pump

Proportional pump

Tank

Hose with quick-action coupling

Hydraulic reservoir

Hydraulic reservoir

Diaphragm accumulator with shutoff block

Filter

Cooler

Heater

Connection (hydraulic)

Line (hydraulic)

T-junction (hydraulic)

Configurable Way Valves

Configurable 2/n way valve

Configurable 3/n way valve

Configurable 4/n way valve

Configurable 5/n way valve

Configurable 6/n way valve

Configurable 8/n way valve

Mechanically Actuated Directional Valves

- 2/2-way stem-Actuated valve (i)
- 2/2-way stem-Actuated valve (ii)
- 3/2-way hand-lever valve
- 4/2-way hand-lever valve (i)
- 4/2-way hand-lever valve (ii)
- 4/3-way hand-lever valve with shutoff position (i)
- 4/3-way hand-lever valve with shutoff position (ii)
- 4/3-way hand-lever valve with floating position (i)
- 4/3-way hand-lever valve with floating position (ii)
- 4/3-way hand-lever valve with bypass position (i)
- 4/3-way hand-lever valve with bypass position (ii)

Solenoid-actuated Directional Valves

- 4/2-way solenoid valve (i)
- 4/2-way solenoid valve (ii)
- 4/3-way solenoid valve with shutoff position (i)
- 4/3-way solenoid valve with shutoff position (ii)
- 4/3-way solenoid valve with floating position (i)
- 4/3-way solenoid valve with floating position (ii)
- 4/3-way solenoid valve with bypass position (i)
- 4/3-way solenoid valve with bypass position (ii)

Shutoff Valves

Shutoff valve

Check valve

Check valve, spring loaded

Check valve with pilot control

Check valve with pilot control, spring loaded

Pilot to close check valve

Pilot to close check valve, spring loaded

Shuttle valve

Two-pressure valve

Pressure Control Valves

Pressure relief valve

Pressure relief valve with pilot control

Pressure relief valve with pilot control

Shutoff/counteracting valve

2-way pressure reducing valve

2-way pressure reducing valve, adjustable

3-way pressure reducing valve

Closing pressure compensator

Closing pressure compensator, adjustable

Opening pressure compensator

Opening pressure compensator, adjustable

Opening cartridge valve

Closing cartridge valve

Pressure Switches

Analog pressure sensor

Flow Control Valves

Nozzle

Throttle valve

Orifice

Orifice, adjustable

One-way flow control valve

2-way flow control valve

3-way flow control valve

Flow divider valve

Continuous valves

4/3-way regulating valve

4/3-way proportional valve

Proportional throttle valve

Proportional pressure relief valve

Proportional pressure relief valve, piloted

Proportional pressure reducing valve, piloted

Actuators

Configurable cylinder

Double acting cylinder

Double acting cylinder with shock adsorber at stroke end

Double acting cylinder with in and out piston rod and shock adsorber at stroke end

Single acting cylinder

Hydraulic motor

Semi-rotary actuator

Measuring Devices

Manometer

Differential pressure gauge

Pressure indicator

Pressure sensor, analog

Flow meter

Flow meter

Flow meter, analog







Electrical Components

Power Supply

Electrical connection 0V

Electrical connection 24V

Function generator

Setpoint value card

Connection (electrical)

Line (electrical)

T-junction (electrical)

Actuators / Signal Devices

DC motor

Indicator light

Buzzer

Measuring Instruments / Sensors

Voltmeter

Ammeter

<u>Displacement encoder</u>

Pressure sensor, analog

Flow meter, analog

General Switches

Break switch

Make switch

Changeover switch

Delay Switches

Break switch (switch-on delayed)

Make switch (switch-on delayed)

Changeover switch (switch-on delayed)

Break switch (switch-off delayed)

Make switch (switch-off delayed)

Changeover switch (switch-off delayed)

Limit Switches

Limit switch (break)

Switch with roll (break)

Reed contact (break)

Limit switch (make)

Switch with roll (make)

Reed contact (make)

Limit switch (changeover)

Switch with roll (changeover)

Reed contact (changeover)

Manually Operated Switches

Pushbutton (break)

Pushbutton (make)

Pushbutton (changeover)

Detent switch (break)

Detent switch (make)

Detent switch (changeover)

Pressure Switches

Pressure switch (break)

Pressure switch (make)

Pressure switch (changeover)

Pressure switch

Proximity Switches

Magnetic proximity switch

Inductive proximity switch

Capacitive proximity switch

Optical proximity switch

Relays

Relay

Relay with switch-on delay

Relay with switch-off delay

Relay counter

Starting current limiter

Controller

Comparator

PID controller

Status controller

EasyPort/OPC/DDE Components

FluidSIM Output Port

FluidSIM Input Port





Electrical Components (American Standard)

Power Supply

Electrical connection 0V (ladder)

Electrical connection 24V (ladder)

General Switches

Break switch (ladder)

Make switch (ladder)

Delay Switches

Break switch (switch-on delayed, ladder)

Make switch (switch-on delayed, ladder)

Break switch (switch-off delayed, ladder)

Make switch (switch-off delayed, ladder)

Limit Switches

Limit switch (break, ladder)

Limit switch (make, ladder)

Manually Operated Switches

Pushbutton (break, ladder)

Pushbutton (make, ladder)

Pushbutton (changeover, ladder)

Pressure Switches

Pressure switch (break, ladder)

Pressure switch (make, ladder)

Relays

Relay (ladder)

Relay with switch-on delay (ladder)

Relay with switch-off delay (ladder)





Digital Components

Constants and Connectors

Digital input

Digital output

Memory bits

Logic level HI

Logic level LO

Connection (digital)

Line (digital)

T-junction (digital)

Basic Functions

AND

Edge-triggered AND

NAND (AND not)

NAND With Edge Evaluation

<u>OR</u>

NOR (OR not)

XOR (exclusive OR)

NOT (Negation, Inverter)

Special Functions

Digital module

On delay

Off delay

On/Off delay

Retentive On delay

Latching Relay

Pulse Relay

Wiping Relay - Pulse Output

Edge-triggered Wiping Relay

Timer Switch

<u>Up/Down Counter</u>

Symmetric Clock Generator

Asynchronous Pulse Generator

Frequency Threshold Trigger







GRAFCET Elements

GRAFCET

<u>Step</u>

Transition

Action

Synchronization

Partial GRAFCET

GRAFCET-I/O







Miscellaneous

Miscellaneous

Connection (mechanical)

Valve solenoid

Proportional valve solenoid, position controlled

Proportional amplifier, 1-channel

Proportional amplifier, 2-channel

Valve solenoid (ladder)

Distance rule

Status indicator

Cam switch

Text

State diagram

Terminal assignment diagram

Functional diagram editor

Parts list

Rectangle

Ellipse

Bitmap







Didactics Material Survey

This chapter provides a comprehensive listing of those parts of the didactics material in FluidSIM that are not covered by chapter The Component Library. Basically, this material consists of the components' behavior illustrations, the animations, the exercises, and the educational films, which all can be activated under the Didactics menu.

The subsequent sections are arranged thematically. The icon indicates that an animation exists for the related topic. The last section gives an overview of the educational films.

Applications

Components of a Hydraulic Plant

Symbols

Some Physical Fundamentals

Components of a Power Unit

Fundamentals of Valves

Pressure Valves

Way Valves

Shutoff Valves

Flow Valves

Hydraulic Cylinders and Motors

Gauges

Exercises

Educational Films

Standard Presentations







Applications

- [1] Lathe
- [2] Press with elevated reservoir
- [3] Mobile hydraulics: Excavator





Components of a Hydraulic Plant

- [4] Structure of a hydraulic system
- [5] Hydraulic power section
- [6] Block diagram of a control system
- [7] Interaction of components
- [8] Action related numbering
- [9] Numbering in accordance with DIN ISO 1219-2
- [10] Numbering in accordance with parts list





Symbols

- [11] Circuit symbols for energy transfer (1)
- [12] Circuit symbols for energy transfer (2)
- [13] Circuit symbols for energy conversion
- [14] Circuit symbols for hydraulic motors
- [15] Circuit symbols for single acting cylinders
- [16] Circuit symbols for double acting cylinders
- [17] Circuit symbols for directional control valves (1)
- [18] Circuit symbols for directional control valves (2)
- [19] Circuit symbols for directional control valves (3)
- [20] Circuit symbols for manual operation
- [21] Circuit symbols for mechanical actuation
- [22] Circuit symbol for pressure valves
- [23] Circuit symbols for flow control valves
- [24] Circuit symbols for non-return valves
- [25] Circuit symbols for measuring devices







Some Physical Fundamentals

- [26] Hydrostatic pressure
- [27] Pressure propagation
- [28] Power transmission
- [29] Displacement transmission (1)
- [30] Displacement transmission (2)
- [31] Pressure transfer (1)
- [32] Pressure transfer (2)
- [33] Types of flow
- [34] Diesel effect
- [35] Cavitation
- [36] Cavitation
- [37] Input and output power







Components of a Power Unit

- [38] Hydraulic power unit
- [39] Hydraulic power unit: Reservoir
- [40] Externally toothed gear pump
- [41] Internally toothed gear pump
- [42] Circuit diagram: Return flow filter
- [43] Circuit diagram: Pump inlet filter
- [44] Circuit diagram: Pressure line filter
- [45] Circuit diagram: Contamination indicator
- [46] Water cooler
- [47] Air cooler
- [48] Heating element
- [49] Circuit diagram: Hydraulic power unit







Fundamentals of Valves

- [50] Actuating force
- [51] Poppet principle
- [52] Slide principle
- [53] Poppet valves
- [54] Piston overlap
- [55] Negative switching overlap
- [56] Positive switching overlap
- [57] Control edges
- [58] Vertical interconnection system







Pressure Valves

- [59] Pressure relief valve (1)
- [60] Pressure relief valve (2)
- [61] PRV used to limit system pressure
- [62] Circuit diagram: PRV used to limit system pressure
- [63] Circuit without brake valve
- [64] Circuit diagram: Brake valve
- [65] Circuit with brake valve
- [66] Circuit diagram: PRV as back-pressure valve
- [67] PRV, internally controlled, cushioned
- [68] PRV, externally controlled (1)
- [69] PRV, externally controlled (2)
- [70] Sequence valve
- [71] Circuit diagram: Sequence valve
- [72] Pressure relief valve
- [73] 2-way pressure regulator (1)
- [74] 2-way pressure regulator (2)
- [75] 2-way pressure regulator (3)
- [76] 2-way pressure regulator (4)
- [77] 2-way pressure regulator (5)
- [78] Circuit diagram: 2-way pressure regulator
- [79] Circuit diagram: 2-way pressure regulator
- [80] 3-way pressure regulator (1)
- [81] 3-way pressure regulator (2)
- [82] 3-way pressure regulator (3)
- [83] 3-way pressure regulator (4)
- [84] 3-way pressure regulator

- [85] 3-way pressure regulator (5)
- [86] 3-way pressure regulator (6)
- [87] Circuit diagram: 3-way pressure regulator





Way Valves

- [88] 2/2-way valve (1)
- [89] 2/2-way valve (2)
- [90] 2/2-way valve as by-pass valve
- [91] Circuit diagram: 2/2-way valve as by-pass valve
- [92] Circuit diagram: 2/2-way valve as final control element
- [93] 2/2-way valve as final control element
- [94] Circuit diagram for pressure-less pump recirculation
- [95] Circuit diagram: Pressure stage circuit
- [96] 3/2-way valve (poppet principle) (1)
- [97] 3/2-way valve (poppet principle) (2)
- [98] 3/2-way valve as final control element
- [99] Circuit diagram: 3/2-way valve as final control element
- [100] 3/2-way valve
- [101] 3/2-way valve (slide principle) (1)
- [102] 3/2-way valve (slide principle) (2)
- [103] 3/2-way valves as diverter
- [104] 4/2-way valve, two pistons (1)
- [105] 4/2-way valve, two pistons (2)
- [106] 4/2-way valve, three pistons (1)
- [107] 4/2-way valve, three pistons (2)
- [108] 4/2-way valve, three pistons (3)
- [109] Circuit diagram: 4/2-way valve
- [110] 4/3-way valve with pump bypass (1)
- [111] 4/3-way valve with pump bypass (2)
- [112] 4/3-way valve with pump bypass (3)
- [113] 4/3-way valve with pump bypass (4)

- [114] Circuit diagram: 4/3-way valve with pump bypass
- [115] 4/3-way valve with pump bypass
- [116] 4/3-way valve with closed mid-position (1)
- [117] 4/3-way valve with closed mid-position (2)
- [118] 4/3-way valve with closed mid-position (3)
- [119] 4/3-way valve with closed mid-position (4)
- [120] Circuit diagram: 4/3-way valve with closed mid-position
- [121] 4/3-way valve: overlap positions (1)
- [122] 4/3-way valve: overlap positions (2)
- [123] Directional control valve
- [124] 4/3-way module





Shutoff Valves

- [125] Non-return valve (1)
- [126] Non-return valve (2)
- [127] Circuit diagram: Pump protection
- [128] Graetz block (1)
- [129] Graetz block (2)
- [130] Graetz block
- [131] Delockable non-return valve (1)
- [132] Delockable non-return valve (2)
- [133] Delockable non-return valve (3)
- [134] Circuit diagram: Delockable non-return valve
- [135] Delockable non-return valve
- [136] Delockable double non-return valve (1)
- [137] Delockable double non-return valve (2)
- [138] Delockable double non-return valve (3)
- [139] Circuit diagram: Delockable double non-return valve





Flow Valves

- [140] Needle restrictor
- [141] Gap restrictor with helix
- [142] Circuit diagram: Flow division using restrictor
- [143] Flow control valve
- [144] One-way flow control valve (1)
- [145] One-way flow control valve (2)
- [146] 2-way flow control valve (1)
- [147] 2-way flow control valve (2)
- [148] 2-way flow control valve (3)
- [149] Circuit diagram: 2-way flow control valve
- [150] 2-way flow control valve







Hydraulic Cylinders and Motors

- [151] Single acting cylinder
- [152] Plunger cylinder
- [153] Double acting cylinder
- [154] Double acting cylinder with end position cushioning
- [155] End position cushioning (1)
- [156] End position cushioning (2)
- [157] End position cushioning
- [158] Double acting cylinder
- [159] Automatic bleed valve





Gauges

[160] Piston pressure gauge

[161] Bourdon-tube pressure gauge

[162] Flow meter





Exercises

- [163] Exercise: Horizontal grinding machine (pump delivery)
- [164] Exercise: Bending machine (directly-controlled pressure relief valve)
- [165] Exercise: Roller conveyor (flow resistance)
- [166] Exercise: Embossing press (activation of a single acting cylinder)
- [167] Exercise: Ladle (activation of a double acting cylinder)
- [168] Exercise: Paint drying oven (4/3-way valve)
- [169] Exercise: Clamping device (closing speed)
- [170] Exercise: Hydraulic crane (speed reduction)
- [171] Exercise: Feed control for a lathe (speed control)
- [172] Exercise: Planing machine (by-pass circuit)
- [173] Exercise: Drilling machine (pressure regulator)







Educational Films

Educational Films

No.	Title	Length
1	Introduction	3:20
2	Fundamentals: Pressure fluids	2:02
3	Fundamentals: Pressure and Flow Rate	2:41
4	Fundamentals: Transmission of Force and Displacement	1:35
5	Fundamentals: Pressure Transmission	0:53
6	Fundamentals: Types of Flow	2:10
7	Basic Design of Hydraulic Systems	1:13
8	The Hydraulic Power Unit	3:26
9	Hydraulic Drives	6:58
10	Valves	3:12
11	Valves: Directional Control Valves	10.39

12	Valves: Non-Return Valves	1:59
13	Valves: Pressure Control Valves	4:24
14	Valves: Flow Control Valves	4:23
15	Representation of Hydraulic Systems in Circuit Diagrams	2:58





Standard Presentations

For several topics useful presentations have been provided within FluidSIM. The following table lists the titles of the predefined presentations.

Presentations

Presentation Title All topics sorted by number Applications Components of a hydraulic system Graphic and circuit symbols Fundamental physical principles Components of the power supply section Valves in general Pressure valves Directional control valves Non-return valves Flow control valves

Hydraulic cylinders and motors

Measuring devices

Exercises







Messages

This section contains information about the messages that may appear from FluidSIM while working in the Edit Mode, the Simulation Mode, or while saving circuit diagrams.

Electrical Errors

Drawing Errors

Operating Errors

Opening and Saving Files

System Errors





Electrical Errors

Simulation aborted. A short-circuit was detected in an electrical circuit.

The positive and negative poles of a voltage source are directly connected without a load (indicator light, buzzer, relay, or control solenoid). The short circuit must be eliminated before simulation can take place.



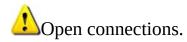


Drawing Errors



Objects are placed outside the drawing area.

At least one object has been placed outside the drawing area. After acknowledging the dialog box the respective objects are shown selected. Either change the papersize or place the selected objects inside the marked drawing area.



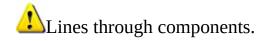
At least one component has an open hydraulic connection. After acknowledging the dialog box, all components with an open hydraulic connection are selected. If the simulation should be started, FluidSIM automatically fits blind plugs to open connections.



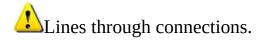
When two connections are superimposed, FluidSIM automatically connects them. When these two connections do not go together, a warning message is given.



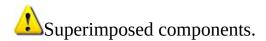
At least two lines are superimposed. After acknowledging the dialog box, these line segments are selected.



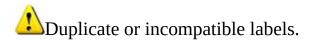
At least one line is passing through a component. After acknowledging the dialog box, the appropriate components are selected.



At least one line is crossing through a connection to which the line is not connected. After acknowledging the dialog box, these lines are selected.



At least two components are superimposed. After acknowledging the dialog box, these components are selected.



A label has been used incorrectly. After acknowledging the dialog box, the appropriate components are selected. To set the circuit diagram into simulation, other labels will have to be chosen.

There are components with the same description.

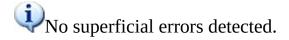
The same description has been assigned to more than one component. After acknowledging the dialog box the respective components appear selected. Modify the component description(s), or, as the case may be, rearrange them such that their assignment becomes definite.

There have been warnings. Start simulation anyway?

This prompt appears when any of the above drawing errors can be found in the circuit diagram. If the simulation is started while connections are open, FluidSIM will supply these open connections with blind plugs.

There is no cylinder close to the distance rule.

A distance rule can only be given a label when it is assigned to a cylinder. Move the distance rule near a cylinder, so that it snaps into place. Now a label can be entered by double clicking the measuring scale.



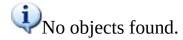
The circuit diagram does not contain any of the following drawing errors:

- objects that are placed outside the drawing area
- hydraulic connections that are open
- connection that are superimposed and do not go together
- lines that are superimposed
- lines that pass through components
- lines that cross through connections to which they are not connected
- components that are superimposed
- labels that do not go together
- components that have the same description





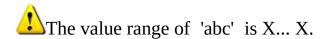
Operating Errors



You tried to check a circuit diagram for drawing errors or to start the simulation; but there are no components located in the current window.

Objects cannot be deleted from the FluidSIM standard libraries. Create a new library if you want to set up a custom library.

Objects can neither be added nor deleted from the FluidSIM *standard libraries*. However, new custom libraries can be created instead, which contain merely your preferred selection of components (see Section <u>Using and Organizing Component Libraries</u>).



The value range for the field has been exceeded. Make sure to observe the indicated limits.





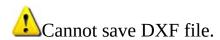
Opening and Saving Files

The circuit diagram has been changed. Save current changes?

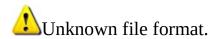
You want to close a circuit diagram window or quit FluidSIM. Since the last save, changes have been made to the current circuit diagram.

The file 'abc' already exists. Replace?

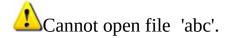
A circuit diagram with the name **name.ct** already exists on the hard disk. To save the current circuit diagram, you must either change the file name, or the already existing file will be replaced with the new circuit diagram.



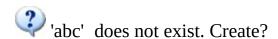
The file (either the current circuit diagram or the component library) cannot be saved due to insufficient disk space or a write-protected disk.



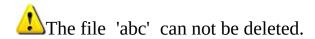
The file cannot be opened since its format is not supported by FluidSIM.



FluidSIM cannot open the file because Microsoft Windows © refuses access to the file. Either the file does not exist or is locked by another application.



You have tried to open a file that does not exist. However, the file can be opened as a new file.



You have tried to delete a file that does not exist or is write-protected.

Circuit 'abc' is already opened. Close this window before?

You want to save a circuit diagram under another name. There is, however, already another open window with this name. If you close this window, the file will be replaced.





System Errors



Simulation aborted. The circuit is too large.

The size of circuit diagrams that can be simulated is bound. You must reduce the number of components.



Internal capacity of FluidSIM exceeded.

The previous action exceeded the capacity of the internal memory. The action cannot be completed.



No more windows available.

Microsoft Windows © cannot provide any more windows most likely because the system resources have been exhausted.



Memory capacity exceeded. Quit other running applications.

There is not enough memory readily available to complete the parameter calculations. To make more memory available, other circuit diagrams should be closed, along with any other Microsoft Windows © programs that are running.

Then attempt to run the simulation again. When there is no other possibility to free up memory, the virtual memory can be increased. Microsoft Windows © then utilizes a section of the hard drive to increase the memory. However, as a result the execution speed of the program decreases greatly. It would be wiser to extend the main memory by increasing the computer's RAM.

This version is not registered. Please repeat the installation procedure.

You have tried to start an unlicensed version of FluidSIM. Most likely you have changed your system configuration, or important system files have become corrupt. Attempt to reinstall FluidSIM into the same directory. If there is a problem with the re-installation, you will receive a message on the screen pertaining to the problem. Notify **Festo Didactic GmbH & Co. KG** of the error or the problem.

Out of memory. Please save changed circuits and quit FluidSIM.

While completing an operation (for example loading a circuit diagram, displaying a component photo, rebuilding the desktop) an error in the memory occurred. FluidSIM could not cancel the operation in a proper manner. You are recommended to quit FluidSIM because the program's stability cannot be assured. However, it is still possible to save changes to circuit diagrams before quitting FluidSIM.

Fatal error. Please save changed circuits and quit FluidSIM.

A program error has occurred. Please save changes to any open circuit diagrams, quit FluidSIM and Microsoft Windows ©, and restart.

The circuit filename.ct has not been saved when the last FluidSIM session was terminated improperly. Shall this file be recovered?

FluidSIM has been terminated in an unexpected manner. However, a backup file was written from which an actual version of the unsaved circuit can be constructed. If the question is answered with "Yes" a window with the recovered circuit is opened; however, the original circuit remains unchanged. You then can decide if to whether the recovered circuit shall be saved under the original name.





Connection (hydraulic)



A hydraulic connection is a place where a hydraulic line can be attached to. To simplify the line drawing process, a connection appears as a small circle in Edit Mode.

Hydraulic connections can be shut by means of a blind plug. An open hydraulic connection may result in leaking oil; FluidSIM-H thus pops up a warning message, if some hydraulic connection was left open.

Note that at each hydraulic connection values for the flow and pressure can be displayed.

Related Topics

Line (hydraulic)

T-junction (hydraulic)

Creating new Circuit Diagrams

<u>Insertion of T-connections</u>

Setting Blind Plugs

Drawing Errors

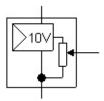
Displaying Quantity Values







Displacement encoder



The displacement encoder is a slide potentiometer with longitudinal contact and no connecting-rods. It delivers a voltage signal that is proportional to the pick up position. The pick up position is determined by the piston stroke. The voltage range, which will depict the minimal and maximal piston position, can be defined within the range -10 V to +10 V by the user. The displacement encoder requires a power supply of at least 13 V.

Related Topics

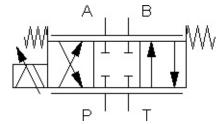
Configurable cylinder

Open-loop and Closed-loop Control by using Continuous Valves





4/3-way regulating valve



The regulating valve transforms an analog electrical input signal into corresponding opening cross-sections at the outputs. The setpoint signal must be within the range -10 V to +10 V. At 0 V the hydraulic mid-position is adopted and the valve stops the flow (in relation to the null overlap).

The cross section area of the flow opening widens with increasing slide distance. How far the area, and with it the flow at the valve, changes depends on the shape and form of the control notches. A triangular shaped notch results in a progressive flow behavior, a rectangular shaped notch in a linear flow behavior.

The hydraulic resistance relates to a completely opened leading edge and the internal leakage relates to one leading edge as appropriate. The overlap of the leading edges can be specified relative to the maximal slide distance.

By the use of an integrated electronic position controller for the slide distance, beneficial static and dynamic characteristics are achieved that are manifested in a minimal hysteresis (less than 0,2 %) and a response time of less than 12 ms at a signal change of 0 - 100 %.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.14)

Internal leakage: 0 ... 100 l/(min*MPa) (0.0026)

Related Topics

Proportional valve solenoid, position controlled

Open-loop and Closed-loop Control by using Continuous Valves





Line (hydraulic)

.....

A hydraulic line links two hydraulic connections. Note that a hydraulic connection may be a simple <u>hydraulic connection</u> or a <u>T-junction</u>. A hydraulic line causes no pressure drop, i. e., it has no fluidic resistance.

From a drawing point of view, FluidSIM distinguishes between control lines and main lines. The former is represented by a dashed line, the latter is represented by a solid line and establishes the default case.

Adjustable parameters

Line Type: Main Line or Control Line (Main Line)

Related Topics

<u>Creating new Circuit Diagrams</u>
Setting Line Type





Terminal assignment diagram

Klemmenbelegungsliste						
X1						
32	+24∨	9	1	X1	5	
		•	2	K1		
	0∨	Q	3	K1	A2	
		9	4	X1	8	
		0	5	X1	1	
S1		0	6	K1	A1	
1Y		0	7	K1		
1Y		0	8	X1	4	

The terminal assignment diagram list automatically creates terminals in the electrical circuit and displays the allocation in a table.

Related Topic

Terminal Assignment Diagrams





Make switch (switch-on delayed)



Switch with delayed closing after pickup. Switch-on delayed make switches are created by using a general make switch and setting a label.

Related Topics

Relay with switch-on delay

Make switch (switch-off delayed)

Coupling Hydraulics, Electrics and Mechanics





Make switch (switch-off delayed)



Switch with delayed opening after dropout. Switch-off delayed make switches are created by using a general make switch and setting a label.

Related Topics

Relay with switch-off delay

Make switch (switch-on delayed)

Coupling Hydraulics, Electrics and Mechanics





Limit switch (make)



Switch that is closed by a cam attached to the cylinder rod. The switch opens immediately when the cam has passed the switch. Limit switches are created by using a general make switch and setting a label.

Related Topics

Switches at Cylinders

Distance rule





Pressure switch (make)



The switch closes when the preset switching pressure of the <u>hydraulic pressure</u> <u>switch</u> is exceeded. Pressure switches are created by using a <u>general make</u> <u>switch</u> and setting a label.

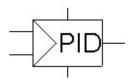
Related Topic

Coupling Hydraulics, Electrics and Mechanics





PID controller



The PID-Controller is a continuous controller consisting of three control elements: Proportional, Integral and Derivative. The adjustable parameters refer to the PID-Controller in the Technology Package TP511 hydraulic control from Festo Didactic.

The output voltage restriction can be set within the range (i) -10 V to + 10 V or (ii) 0 V to +10 V. In the range (i), a manipulated variable offset from -7 V to + 7 V can be specified, and in the range (ii) a manipulated variable offset from 1.5 V to 8.5 V can be specified. The PID-controller requires a power supply of 24 V.

Adjustable parameters

Proportional gain: $0 \dots 1000$ (1)

Integral gain: 0 ... 1000 1/s (0)

Derivation gain: $0 \dots 1000 \text{ ms}$ (0)

Related Topics

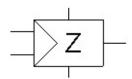
Status controller

Open-loop and Closed-loop Control by using Continuous Valves





Status controller



The status controller is especially suitable for controlling pneumatic positioning circuits. A pneumatic positioning circuit counts to the controlled systems that can only be unsatisfactorily controlled with a standard controller. Three parameters can be attributed to the present status controller: position, speed and acceleration of the piston. The controller is therefore referred to as a "triple loop" controller. Speed and acceleration are not measured with sensors out of cost reasons. They are calculated by the controller from the differences in position. The adjustable parameters refer to the status controller in the Technology Package TP511 Closed-loop hydraulics from Festo Didactic.

The output voltage restriction can be set within the range (i) -10 V to + 10 V or (ii) 0 V to +10 V. In the range (i), a manipulated variable offset from -7 V to + 7 V can be specified, and in the range (ii) a manipulated variable offset from 1.5 V to 8.5 V can be specified. The status controller requires a power supply of 24 V.

Adjustable parameters

Deviation gain: 0 ... 10 (1)

Velocity damping: $0 \dots 100 \text{ ms}$ (0)

Acceleration damping: $0 \dots 10 \text{ ms2}$ (0)

Total gain: 0 ... 1000 (1)

Related Topics

PID controller

Open-loop and Closed-loop Control by using Continuous Valves





Graphic Primitives

Rectangles

Ellipses





Using and Organizing Component Libraries

Displaying the Component Library

Rearranging a Component Library

Building New Component Libraries

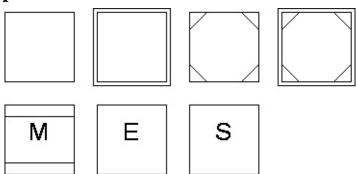
Inserting Components Via Menu







Step



The name of a step may contain the following characters: "0-9", "a-z", "A-Z" and the underscore "_".

You can select from the following seven different step types: simple step, initial step, macro-step, macro input, macro output, enclosing step and initial enclosing step.

Furthermore, you can give the step an activation link.

Related Topics

Admissible characters for steps and variables

Transition

Action

Synchronization

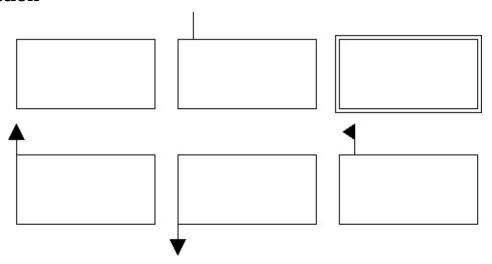
Partial GRAFCET







Action



There are three types of action: assignations, allocations and compulsory commands.

For assignations and allocations, you can enter a variable or an output, whose value is changed by the action. The name of a variable may contain the following characters: "0-9", "a-z", "A-Z" and the underscore "_".

For a "conditional action" or an "action on event", you can enter a condition that has to be fulfilled before the action is executed. Entering a condition is supported by buttons for special symbols (AND, OR, NOT, falling edge, rising edge, delay). Via Variable… you can select an existing GRAFCET variable from a list. Alternatively to the formula, you can show a descriptive text. To do this, you have to select the option "Display description instead of formula".

For an allocation ("action on activation", "action on deactivation" and "action on event"), you can enter any term whose value is to be allocated to the action variable. Entering a term is supported by buttons for special symbols (AND, OR, NOT, falling edge, rising edge). Via Variable... you can select an existing GRAFCET variable from a list. Alternatively to the formula, you can show a descriptive text. To do this, you have to select the option "Display description instead of formula".

For a "compulsory command", you can enter the name of the partial GRAFCET directly or select an existing partial GRAFCET from a list. You can also enter the relevant steps directly or select them from a list of existing steps. You have to

separate the step names with commas. You can select the special commands "*" and "INIT" using the relevant buttons.

Related Topics

Variable names

Functions and formula entry

Compulsory commands

Step

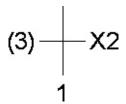
Transition

GRAFCET-I/O





Transition



You can give a transition a name, which is shown to the left of the transition in brackets.

Entering a transition condition is supported by buttons for special symbols (AND, OR, NOT, falling edge, rising edge, delay). Via Variable... you can select an existing GRAFCET variable from a list. Alternatively to the formula, you can show a descriptive text. To do this, you have to select the option "Display description instead of formula".

In the "Connection ID/target information" field, you can enter a step that links to the transition's output without having to draw a connecting line. You can select an existing step from a list.

Related Topics

Variable names

Functions and formula entry

Target information

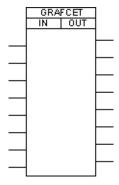
Step

Synchronization





GRAFCET-I/O



The GRAFCET I/O component is used to link the GRAFCET variables with the electrical part of a circuit. You can enter eight GRAFCET input variables and eight GRAFCET output variables into the GRAFCET I/O component. The actions' variables serve as outputs. The inputs can be the allocations and conditions of actions and transitions.

If a potential is created as the input of the GRAFCET I/O component, the corresponding variable is set to "1". If an output variable has a value other than "0", a potential of 24V is created at the corresponding output of the GRAFCET I/O component.

Related Topics

Access to labels of fluidic and electrical components

Linking GRAFCET variables with the electrical part of FluidSIM

Transition

Action



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- 5		

You can connect synchronizations like other FluidSIM components. However, they do not initially have any connections. You always have to draw connecting lines to a synchronization. The corresponding connections are then generated automatically.

Related Topics

Synchronization

Step

Transition

Partial GRAFCET







Partial GRAFCET



If you want to allocate GRAFCET elements to a specific partial GRAFCET, place the partial GRAFCET frame over the relevant GRAFCET part and give it a name. The preceding "G" is not part of the name that you have to enter; it is added automatically by FluidSIM and shown at the bottom left of the partial GRAFCET frame. You can alter the size of the partial GRAFCET frame by dragging its edges with the mouse. For the partial GRAFCET to function correctly, it is important that all its elements are completely within the frame and that the frame does not overlap with any foreign elements or other frames.

Related Topics

Partial GRAFCETs

Enclosing step

Compulsory commands

Step

Transition

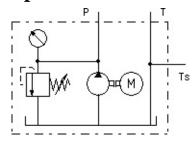
Action

Synchronization





Pump unit



The pump unit supplies a constant volumetric flow. The operating pressure is limited by the internal pressure relief valve. The pump unit has two tank connections.

Adjustable parameters

Max. pressure: 0.01 ... 40 MPa (6)

Flow: 0 ... 500 l/min (2.4)

Internal leakage: 0 ... 100 l/(min*MPa) (0.04)

Related Topics

Pump unit (simplified)

[38] Hydraulic power unit

[40] Externally toothed gear pump





Pump unit (simplified)



Simplified representation of the detailed pump unit. The component does not have tank connections in the circuit diagram.

Adjustable parameters

Max. pressure: 0.01 ... 40 MPa (6)

> Flow: 0 ... 500 l/min **(2)**

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Related Topics

Pump unit

[38] Hydraulic power unit

[40] Externally toothed gear pump







Fixed displacement pump



The fixed displacement pump delivers a constant volumetric flow rate dependent upon the revolutions and the displacement volume.

Adjustable parameters

Revolution: 0 ... 3000 1/min (1320)

Displacement: 0.001 ... 1 Liter (0.0016)

Max. pressure: (6)0.1 ... 40 MPa

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Related Topics

Variable displacement pump

[40] Externally toothed gear pump







Variable displacement pump



The revolutions of the variable displacement pump can be changed under operating conditions. The pump delivers a variable volumetric flow rate dependent upon the variable revolutions and the displacement volume.

Adjustable parameters

Revolution: 0 ... 3000 1/min (1320)

Displacement: 0.001 ... 1 Liter (0.0016)

Max. pressure: 0.1 ... 40 MPa (6)

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Related Topics

Fixed displacement pump

Proportional pump

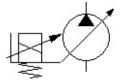
[40] Externally toothed gear pump







Proportional pump



The revolutions of the variable displacement pump can be changed proportionally from zero to maximum through a voltage signal between 0 V and 10 V and the assistance of a proportional-amplifier. The pump delivers a variable volumetric flow rate dependent upon the variable revolutions and the displacement volume.

Adjustable parameters

Max. Revolution: 0 ... 3000 1/min (1320)

Displacement: 0.001 ... 1 Liter (0.0016)

Max. pressure: 0.1 ... 40 MPa (6)

Internal leakage: $0 \dots 100 \text{ l/(min*MPa)}$ (0)

Related Topics

Proportional amplifier, 1-channel

Variable displacement pump

[40] Externally toothed gear pump





Tank



The tank is integrated into the pump unit and has a pressure of 0 MPa. It can be inserted into the circuit diagram as an independent component.

Related Topics

Pump unit

[39] Hydraulic power unit: Reservoir





Hose with quick-action coupling



The hose is available in 3 lengths: 600 mm, 1500 mm, and 3000 mm. The pressure loss in a hose is taken into account by specifying a hydraulic resistance. In FluidSIM no pressure loss is simulated with simple connections between two components.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.012)





Hydraulic reservoir



The reservoir enables the performance of a hydraulic system to be optimized. For example, it can be utilized as an energy reservoir and for the absorbance of pressure surges or flow fluctuations. Reservoirs are capable of absorbing a defined volume of fluid under pressure and releasing it again with minimal losses. The construction consists essentially of a pressure resistant container, generally a gas charge of nitrogen and a separator e.g. a piston, a membrane or a bubble elastomer.

Hydraulic fluid only starts to flow into the reservoir when the fluid pressure is greater than the gas-preload pressure.

Adjustable parameters

Volume: 0.01 ... 100 Liter (0.32)

Gas pre-charge pressure: $0 \dots 40 \text{ MPa}$ (1)

Related Topics

Hydraulic reservoir

Diaphragm accumulator with shutoff block







Hydraulic reservoir



The reservoir enables the performance of a hydraulic system to be optimized. For example, it can be utilized as an energy reservoir and for the absorbance of pressure surges or flow fluctuations. Reservoirs are capable of absorbing a defined volume of fluid under pressure and releasing it again with minimal losses. The construction consists essentially of a pressure resistant container, generally a gas charge of nitrogen and a separator e.g. a piston, a membrane or a bubble elastomer.

Hydraulic fluid only starts to flow into the reservoir when the fluid pressure is greater than the gas-preload pressure.

Adjustable parameters

Volume: 0.01 ... 100 Liter (0.32)

Gas pre-charge pressure: $0 \dots 40 \text{ MPa}$ (1)

Related Topics

Hydraulic reservoir

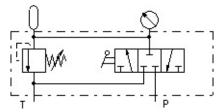
Diaphragm accumulator with shutoff block







Diaphragm accumulator with shutoff block



Stores the pressure and is equipped with a pressure relief valve to prevent overpressure.

Adjustable parameters

Nominal pressure: 0 ... 35 MPa (6)

Gas pre-charge pressure: $0.1 \dots 35 \text{ MPa}$ (1)

Related Topics

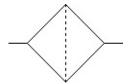
<u>Hydraulic reservoir</u>

Hydraulic reservoir





Filter



The filter limits the contamination of the fluid respecting a certain tolerance value in order to reduce the risk of damage at the components.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.0001)

Related Topics

Pump unit

[38] Hydraulic power unit

[42] Circuit diagram: Return flow filter

[43] Circuit diagram: Pump inlet filter

[44] Circuit diagram: Pressure line filter

[45] Circuit diagram: Contamination indicator







Cooler



An unacceptable fall in the hydraulic fluid's viscosity can be avoided through the use of a cooler.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.0001)

Related Topics

Heater

[46] Water cooler

[47] Air cooler





Heater



The hydraulic fluid's optimal viscosity can be reached quickly through the use of a heater.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.0001)

Related Topics

Cooler

[48] Heating element





T-junction (hydraulic)



A T-junction joins up to four <u>hydraulic lines</u>, thus having a single pressure potential. Note that T-junctions are introduced automatically by FluidSIM when dropping the line drawing cursor onto another line in Edit Mode.

Related Topics

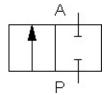
Connection (hydraulic)

Creating new Circuit Diagrams





Configurable 2/n way valve



The configurable 2/n way valve is a way valve with two connections, where both its <u>body elements</u> and its <u>operation modes</u> are user-definable.

Additionally, the hydraulic connections can be closed with <u>blind plugs</u>.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

[17] Circuit symbols for directional control valves (1)

[20] Circuit symbols for manual operation

[21] Circuit symbols for mechanical actuation

[88] 2/2-way valve (1)

[90] 2/2-way valve as by-pass valve

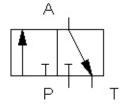
[92] Circuit diagram: 2/2-way valve as final control element







Configurable 3/n way valve



The configurable 3/n way valve is a way valve with three connections, where both its <u>body elements</u> and its <u>operation modes</u> are user-definable.

Additionally, the hydraulic connections can be closed with <u>blind plugs</u>.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

[17] Circuit symbols for directional control valves (1)

[20] Circuit symbols for manual operation

[21] Circuit symbols for mechanical actuation

[55] Negative switching overlap

[96] 3/2-way valve (poppet principle) (1)

[99] Circuit diagram: 3/2-way valve as final control element

[101] 3/2-way valve (slide principle) (1)

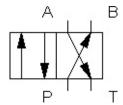
[103] 3/2-way valves as diverter







Configurable 4/n way valve



The configurable 4/n way valve is a way valve with four connections, where both its <u>body elements</u> and its <u>operation modes</u> are user-definable.

Additionally, the hydraulic connections can be closed with <u>blind plugs</u>.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

[18] Circuit symbols for directional control valves (2)

[19] Circuit symbols for directional control valves (3)

[20] Circuit symbols for manual operation

[21] Circuit symbols for mechanical actuation

[104] 4/2-way valve, two pistons (1)

[106] 4/2-way valve, three pistons (1)

[110] 4/3-way valve with pump bypass (1)

[116] 4/3-way valve with closed mid-position (1)

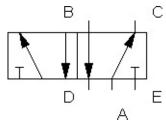
[121] 4/3-way valve: overlap positions (1)







Configurable 5/n way valve



The configurable 5/n way valve is a way valve with five connections, where both its <u>body elements</u> and its <u>operation modes</u> are user-definable.

Additionally, the hydraulic connections can be closed with <u>blind plugs</u>.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

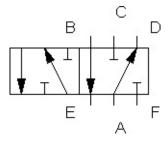
[20] Circuit symbols for manual operation

[21] Circuit symbols for mechanical actuation





Configurable 6/n way valve



The configurable 6/n way valve is a way valve with six connections, where both its <u>body elements</u> and its <u>operation modes</u> are user-definable.

Additionally, the hydraulic connections can be closed with <u>blind plugs</u>.

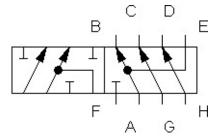
Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)





Configurable 8/n way valve



The configurable 8/n way valve is a way valve with eight connections, where both its <u>body elements</u> and its <u>operation modes</u> are user-definable.

Additionally, the hydraulic connections can be closed with <u>blind plugs</u>.

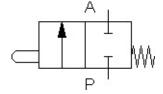
Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)





2/2-way stem-Actuated valve (i)



If the cylinder piston actuates the stem, flow is enabled from P to A.

This valve is derived from a configurable <u>2/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 2/n way valve

2/2-way stem-Actuated valve (ii)

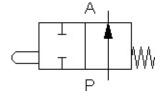
[21] Circuit symbols for mechanical actuation

[88] 2/2-way valve (1)





2/2-way stem-Actuated valve (ii)



If the cylinder piston actuate the stem, the flow from P to A is shut off.

This valve is derived from a configurable <u>2/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 2/n way valve

2/2-way stem-Actuated valve (i)

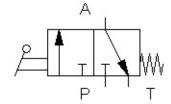
[21] Circuit symbols for mechanical actuation

[88] 2/2-way valve (1)





3/2-way hand-lever valve



In normal position the connection P is closed and A to T opened. When manually actuated T is shut off and P to A opened.

This valve is derived from a configurable <u>3/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

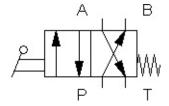
Configurable 3/n way valve

[96] 3/2-way valve (poppet principle) (1)





4/2-way hand-lever valve (i)



In normal position the connection P is open to B and A to T. When manually actuated the valve is set to parallel position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

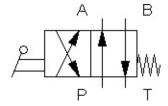
4/2-way hand-lever valve (ii)

[104] 4/2-way valve, two pistons (1)





4/2-way hand-lever valve (ii)



In normal position the connection P is open to A and B to T. When manually actuated the valve is set to crossover position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

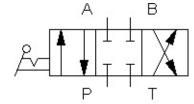
4/2-way hand-lever valve (i)

[104] 4/2-way valve, two pistons (1)





4/3-way hand-lever valve with shutoff position (i)



In normal position all connections are closed. When manually actuated the valve is set to parallel or crossover position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

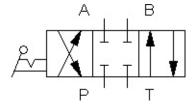
4/3-way hand-lever valve with shutoff position (ii)

[116] 4/3-way valve with closed mid-position (1)





4/3-way hand-lever valve with shutoff position (ii)



In normal position all connections are closed. When manually actuated the valve is set to crossover or parallel position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

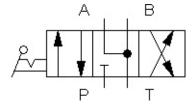
4/3-way hand-lever valve with shutoff position (i)

[116] 4/3-way valve with closed mid-position (1)





4/3-way hand-lever valve with floating position (i)



In normal position the connections A and B are open to T. When manually actuated the valve is set to parallel or crossover position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

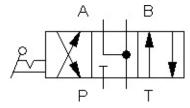
Configurable 4/n way valve

4/3-way hand-lever valve with floating position (ii)





4/3-way hand-lever valve with floating position (ii)



In normal position the connections A and B are open to T. When manually actuated the valve is set to crossover or parallel position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

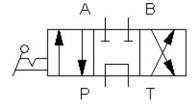
Configurable 4/n way valve

4/3-way hand-lever valve with floating position (i)





4/3-way hand-lever valve with bypass position (i)



In normal position the connections A and B are closed and P to T opened. When manually actuated the valve is set to parallel or crossover position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

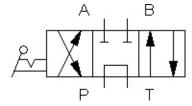
4/3-way hand-lever valve with bypass position (ii)

[110] 4/3-way valve with pump bypass (1)





4/3-way hand-lever valve with bypass position (ii)



In normal position the connections A and B are closed and P to T opened. When manually actuated the valve is set to crossover or parallel position.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

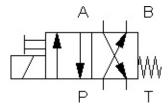
4/3-way hand-lever valve with bypass position (i)

[110] 4/3-way valve with pump bypass (1)





4/2-way solenoid valve (i)



In normal position the connection P is open to B and A to T. When actuated by the control solenoid, the valve is set to parallel position. If no current is flowing through the control solenoid, the valve can be manually actuated.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

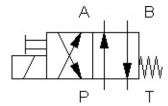
4/2-way solenoid valve (ii)

[104] 4/2-way valve, two pistons (1)





4/2-way solenoid valve (ii)



In normal position the connection P is open to A and B to T. When actuated by the control solenoid, the valve is set to crossover position. If no current is flowing through the control solenoid, the valve can be manually actuated.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

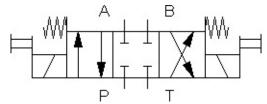
4/2-way solenoid valve (i)

[104] 4/2-way valve, two pistons (1)





4/3-way solenoid valve with shutoff position (i)



In normal position all connections are closed. When actuated by the control solenoids, the valve is set to parallel or crossover position. If no current is flowing through the control solenoids, the valve can be manually actuated.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

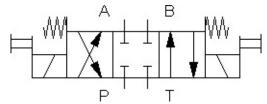
4/3-way solenoid valve with shutoff position (ii)

[116] 4/3-way valve with closed mid-position (1)





4/3-way solenoid valve with shutoff position (ii)



In normal position all connections are closed. When actuated by the control solenoids, the valve is set to crossover or parallel position. If no current is flowing through the control solenoids, the valve can be manually actuated.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

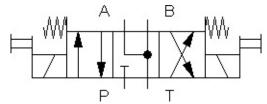
4/3-way solenoid valve with shutoff position (i)

[116] 4/3-way valve with closed mid-position (1)





4/3-way solenoid valve with floating position (i)



In normal position the connections A and B are open to T. When actuated by the control solenoids, the valve is set to parallel or crossover position. If no current is flowing through the control solenoids, the valve can be manually actuated.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

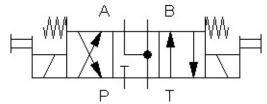
Configurable 4/n way valve

4/3-way solenoid valve with floating position (ii)





4/3-way solenoid valve with floating position (ii)



In normal position the connections A and B are open to T. When actuated by the control solenoids, the valve is set to crossover or parallel position. If no current is flowing through the control solenoids, the valve can be manually actuated.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

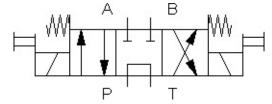
Configurable 4/n way valve

4/3-way solenoid valve with floating position (i)





4/3-way solenoid valve with bypass position (i)



In normal position the connections A and B are closed and P to T opened. When actuated by the control solenoids, the valve is set to parallel or crossover position. If no current is flowing through the control solenoids, the valve can be manually actuated.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

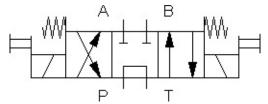
4/3-way solenoid valve with bypass position (ii)

[110] 4/3-way valve with pump bypass (1)





4/3-way solenoid valve with bypass position (ii)



In normal position the connections A and B are closed and P to T opened. When actuated by the control solenoids, the valve is set to crossover or parallel position. If no current is flowing through the control solenoids, the valve can be manually actuated.

This valve is derived from a configurable <u>4/n way valve</u>. You find this valve in the component library "Frequently used Way Valves", under the Library menu.

Related Topics

Configurable 4/n way valve

4/3-way solenoid valve with bypass position (i)

[110] 4/3-way valve with pump bypass (1)





Shutoff valve



The shutoff valve can be manually opened or closed. The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Opening level: 0 ... 100 % (100)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.0625)





Check valve



If the inlet pressure at A is higher than the outlet pressure at B, then the check valve allows the flow to pass, otherwise it blocks the flow.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Check valve, spring loaded

Check valve with pilot control

Pilot to close check valve

[125] Non-return valve (1)

[130] Graetz block







Check valve, spring loaded



If the inlet pressure at A is higher than the outlet pressure at B and the nominal pressure, then the check valve allows the flow to pass, otherwise it blocks the flow.

Adjustable parameters

Nominal pressure: 0.001 ... 40 MPa (0.1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Check valve

Check valve with pilot control, spring loaded

Pilot to close check valve, spring loaded

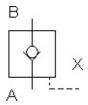
[125] Non-return valve (1)

[130] Graetz block





Check valve with pilot control



If the input pressure is higher than the output pressure, the check valve opens. Otherwise it is shut. In addition, the check valve can be opened via a control line, allowing flow in both directions.

Adjustable parameters

Area ratio: 1 ... 10 (5)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Check valve

Pilot to close check valve

[131] Delockable non-return valve (1)

[134] Circuit diagram: Delockable non-return valve

[135] Delockable non-return valve





Check valve with pilot control, spring loaded



If the input pressure is higher than the output and nominal pressure, the check valve opens. Otherwise it is shut. In addition, the check valve can be opened via a control line, allowing flow in both directions.

Adjustable parameters

Nominal pressure: 0.001 ... 40 MPa (0.1)

Area ratio: 1 ... 10 (5)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Check valve with pilot control

Check valve, spring loaded

Pilot to close check valve, spring loaded

[131] Delockable non-return valve (1)

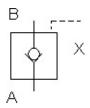
[134] Circuit diagram: Delockable non-return valve

[135] Delockable non-return valve





Pilot to close check valve



If the inlet pressure at A is higher than the outlet pressure at B, then the check valve allows the flow to pass, otherwise it blocks the flow. Additionally, the check valve can be closed using the pilot line X.

Adjustable parameters

Area ratio: 1 ... 10 (5)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Pilot to close check valve, spring loaded

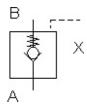
Check valve

Check valve with pilot control





Pilot to close check valve, spring loaded



If the inlet pressure at A is higher than the outlet pressure at B and the nominal pressure, then the check valve allows the flow to pass, otherwise it blocks the flow. Additionally, the check valve can be closed using the pilot line X.

Adjustable parameters

Nominal pressure: 0.001 ... 40 MPa (0.1)

Area ratio: 1 ... 10 (5)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Pilot to close check valve

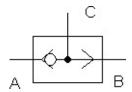
Check valve, spring loaded

Check valve with pilot control, spring loaded





Shuttle valve



If one of the two input pressures is larger than zero, the shuttle valve opens (OR function) and the higher input pressure becomes the output pressure.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

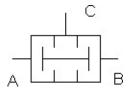
Related Topic

Two-pressure valve





Two-pressure valve



If both input pressures are larger than zero, the two-pressure valve opens (AND function) and the higher input pressure becomes the output pressure.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

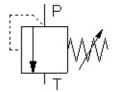
Related Topic

Shuttle valve





Pressure relief valve



In normal position the valve is closed. If the opening pressure is reached at P, T opens. When the pressure drops below the preset level, the valve closes again. The flow direction is indicated by the arrow.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: $0 \dots 40 \text{ MPa}$ (5)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Pressure relief valve with pilot control

Shutoff/counteracting valve

Opening pressure compensator, adjustable

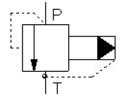
[59] Pressure relief valve (1)







Pressure relief valve with pilot control



In normal position the valve is closed. If the opening pressure is reached at P, T opens. When the pressure drops below the preset level, the valve closes again. In simple terms, the pilot pressure is generated by the input pressure. The flow direction is indicated by the arrow.

The pilot operated pressure relief valve consists of a pilot stage and a main stage. When open, there is less volumetric flow at the pilot stage that leads internally to connection T.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: $0 \dots 40 \text{ MPa}$ (5)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

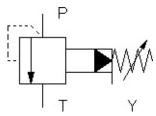
Pressure relief valve

Pressure relief valve with pilot control





Pressure relief valve with pilot control



The valve is closed in the idle position. The hydraulic fluid drains off at T, when the pressure difference at the connections P and T exceeds the nominal pressure. If the pressure falls below the preset value, the valve closes again. The flow direction is marked with an arrow.

The pilot operated pressure relief valve consists of a pilot stage and a main stage. When open, there is less volumetric flow at the pilot stage that leads to connection Y.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: $0 \dots 40 \text{ MPa}$ (5)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Pressure relief valve

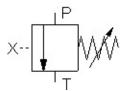
Pressure relief valve with pilot control

Proportional pressure relief valve, piloted





Shutoff/counteracting valve



If the opening pressure is reached at the control line connection, the valve opens from P to T.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: 0 ... 40 MPa (5)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Pressure relief valve

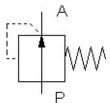
Opening pressure compensator, adjustable

[68] PRV, externally controlled (1)





2-way pressure reducing valve



The pressure regulator valve regulates the pressure at connection A to the preset operating pressure and equalizes the pressure fluctuations. The valve closes when the pressure at connection A exceeds the operating pressure. The setting of the real components is component dependent and cannot be changed.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: 0.01 ... 40 MPa (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

2-way pressure reducing valve, adjustable

3-way pressure reducing valve

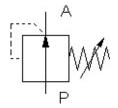
Closing pressure compensator

[73] 2-way pressure regulator (1)





2-way pressure reducing valve, adjustable



The pressure regulator valve regulates the pressure at connection A to the preset operating pressure and equalizes the pressure fluctuations. The valve closes when the pressure at connection A exceeds the operating pressure.

Adjustable parameters

Nominal pressure: 0.01 ... 40 MPa (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

2-way pressure reducing valve

3-way pressure reducing valve

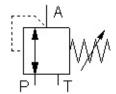
Closing pressure compensator, adjustable

[73] 2-way pressure regulator (1)





3-way pressure reducing valve



The pressure reducing valve maintains a constant output pressure despite fluctuating input pressure. The hydraulic fluid is drained off at T when the pressure at connection A exceeds the operating pressure.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: $0 \dots 40 \text{ MPa}$ (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Pressure relief valve

2-way pressure reducing valve, adjustable

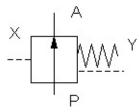
[80] 3-way pressure regulator (1)

[84] 3-way pressure regulator





Closing pressure compensator



The pressure compensator represents a pressure dependent hydraulic resistance. The pressure compensator closes when the pressure difference X-Y exceeds the nominal pressure. A pressure regulating valve is implemented by the combination of connections A and X. The pressure balance is also a component of 2-way flow control valves.

The nominal pressure setting of the real components is component dependent and cannot be changed.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: 0.01 ... 40 MPa (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Closing pressure compensator, adjustable

2-way pressure reducing valve

2-way flow control valve

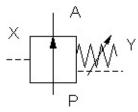
Opening pressure compensator

[146] 2-way flow control valve (1)





Closing pressure compensator, adjustable



The pressure compensator represents a pressure dependent hydraulic resistance. The pressure compensator closes when the pressure difference X-Y exceeds the nominal pressure. A pressure regulating valve is implemented by the combination of the connections A and X.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: 0.01 ... 40 MPa (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

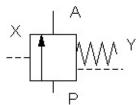
Closing pressure compensator

2-way pressure reducing valve, adjustable





Opening pressure compensator



The pressure compensator represents a pressure dependent hydraulic resistance. The pressure compensator opens when the pressure difference X-Y exceeds the nominal pressure. A pressure relief valve is implemented by the combination of connections P and X. The pressure balance is also a component of 3-way flow control valves.

The nominal pressure setting of the real components is component dependent and cannot be changed.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: 0.01 ... 40 MPa (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Opening pressure compensator, adjustable

Closing pressure compensator

Pressure relief valve

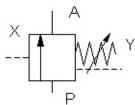
3-way flow control valve







Opening pressure compensator, adjustable



The pressure compensator represents a pressure dependent hydraulic resistance. The pressure compensator opens when the pressure difference X-Y exceeds the nominal pressure. A pressure relief valve is implemented by the combination of connections P and X.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal pressure: 0.01 ... 40 MPa (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Opening pressure compensator

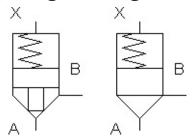
Closing pressure compensator, adjustable

Pressure relief valve





Opening cartridge valve



The 2/2-way cartridge valve is a 2/2-way valve. It is fitted with two working ports and the two switch positions "closed" and "open". Whether or not the cartridge valve is open or closed depends on the effective areas A, B and X, the adjacent pressures pA, pB and pX, as well as the spring force. A+B=X is valid.

If pA*A + pB*B > pX*X + F, then the valve opens, otherwise it is closed.

The valve therefore operates purely pressure dependent and can, with the appropriate control, assume directional-, flow- and pressure functions. The spring force is specified by means of the nominal pressure. This is the minimum pressure, with pressureless connections at B and X, necessary at connection A to open the valve.

Whether the valve has one (A=B) or two (A <> B) effective areas can be specified in the properties window. The relevant symbol is automatically depicted.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Area: 0 ... 100 qcm (6)

Nominal pressure: $0 \dots 1 \text{ MPa}$ (0.1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.001)

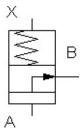
Related Topic

Closing cartridge valve





Closing cartridge valve



The 2/2-way cartridge valve is a 2/2-way valve. It is fitted with two working ports and the two switch positions "closed" and "open". Whether or not the cartridge valve is open or closed depends on the effective areas A and X, the adjacent pressures pA, and pX, as well as the spring force. A=X is valid.

If pA*A > pX*X + F, then the valve closes, otherwise it is open.

The valve therefore operates purely pressure dependent and can, with the appropriate control, assume directional-, flow- and pressure functions. The spring force is specified by means of the nominal pressure. This is the minimum pressure, with pressureless connections at B and X, necessary at connection A to open the valve.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Area: 0 ... 100 qcm (6)

Nominal pressure: $0 \dots 1 \text{ MPa}$ (0.1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.001)

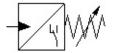
Related Topic

Opening cartridge valve





Analog pressure sensor



The pressure switch takes the pressure and actuates the associated electrical pressure switch if the preset switching pressure is exceeded.

Adjustable parameters

Switching pressure: 0.0001 ... 35 MPa (3)

Related Topics

Coupling Hydraulics, Electrics and Mechanics

Pressure switch (break)





Nozzle



The nozzle represents a hydraulic resistance.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Throttle valve

Orifice

[140] Needle restrictor







Throttle valve



The setting of the throttle valve is set by means of a rotary knob. Please note that by the rotary knob no *absolute* resistance value can be set. This means that, in reality, different throttle valves can generate different resistance values despite identical settings.

Adjustable parameters

Opening level: 0 ... 100 % (100)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.045)

Related Topics

Nozzle

Orifice

One-way flow control valve

[140] Needle restrictor





Orifice



The orifice represents a hydraulic resistance.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Orifice, adjustable

Nozzle

[140] Needle restrictor







Orifice, adjustable



The orifice represents a variable hydraulic resistance.

Adjustable parameters

Opening level: 0 ... 100 % (100)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Orifice

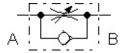
Throttle valve

[140] Needle restrictor





One-way flow control valve



The setting of the One-way flow control valve is set by means of a rotary knob. A check valve (see check valve) is located parallel to the throttle valve. Please note that by the rotary knob no *absolute* resistance value can be set. This means that, in reality, different throttle valves can generate different resistance values despite identical settings.

Adjustable parameters

Opening level: 0 ... 100 % (100)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Throttle valve

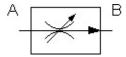
Check valve

[144] One-way flow control valve (1)





2-way flow control valve



If the pressure is sufficient, the preset flow is maintained to a constant level in the direction of the arrow.

The hydraulic resistance relates to the completely opened valve.

Adjustable parameters

Nominal flow: 0.01 ... 500 l/min (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.019)

Related Topics

3-way flow control valve

Flow divider valve

Throttle valve

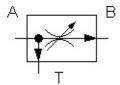
Closing pressure compensator

[146] 2-way flow control valve (1)





3-way flow control valve



With sufficient pressure, the preset flow rate is kept constant in the direction of the arrow. The surplus hydraulic fluid is drained at connection T using a pressure compensator. The inlet pressure pA is load dependent, i.e it changes with the outlet pressure pB. Therefore a parallel circuit of several 3-way flow control valves is not possible. In this case, the inlet pressures would be defined by the valve with the lowest inlet pressure. Compared to the 2-way flow control valve, the 3-way flow control valve is admittedly more efficient in its energy consumption.

The hydraulic resistance relates to the completely closed pressure compensator.

Adjustable parameters

Nominal flow: 0.01 ... 500 l/min (1)

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

2-way flow control valve

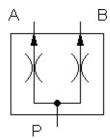
Throttle valve

Opening pressure compensator





Flow divider valve



The flow divider valve divides the flow from P into two equal flows at A and B. This is achieved using two measuring orifices and two variable control resistors. The control resistors are unified in a pressure compensator.

The hydraulic resistance relates to the resistance of the individual measuring orifices and control resistors.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

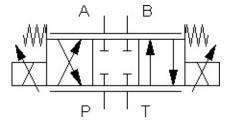
2-way flow control valve

3-way flow control valve





4/3-way proportional valve



By use of a twin-channel proportional amplifier, the proportional valve transforms an analog electrical input signal into corresponding opening cross-sections at the outputs. The setpoint signal must be within the range -10 V to +10 V. At 0 V the hydraulic mid-position is adopted and the valve stops the flow (in relation to the null overlap).

The cross section area of the flow opening widens by increasing slide distance. How far the area, and with it the flow at the valve, changes depends on the shape and form of the control notches. A triangular shaped notch results in a progressive flow behavior, a rectangular shaped notch in a linear flow behavior.

The hydraulic resistance relates to a completely opened leading edge and the internal leakage relates to one leading edge as appropriate. The overlap of the leading edges can be specified relative to the maximal slide distance.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.32)

Internal leakage: 0 ... 100 l/(min*MPa) (0.01)

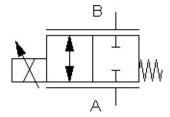
Related Topics

Proportional amplifier, 2-channel





Proportional throttle valve



In order to alter the flow rate through the valve, the cross section of the throttle valve is electrically manipulated with the assistance of a proportional amplifier. The control voltage must be between 0 V and 10 V. The deflection of the slide is proportional to the applied voltage. At 0 V the valve is completely closed (in relation to the null overlap).

The hydraulic resistance relates to the completely opened valve. The overlap of the leading edges can be specified relative to the maximal slide distance.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Related Topics

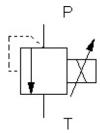
Throttle valve

Proportional amplifier, 1-channel





Proportional pressure relief valve



The proportional pressure relief valve, with the assistance of a proportional amplifier, is a continuous, electrically adjustable pressure relief valve. The control piston has two adjacent areas exposed to pressure. The first area is exposed to the pressure at connection P, the other to connection T. If the magnet is not supplied with electricity, then the piston is fully retracted and the complete passage from connection P to connection T is free. The proportional magnet creates a force proportional to its magnetic current, which moves the control piston according to the balance of the adjacent forces (magnetic force, spring force and pressures).

The control voltage must be in the range 0 V to 10 V. The minimum nominal pressure defines the opening pressure through the spring force at 0 V. The maximum nominal pressure defines the opening pressure at 10 V. The hydraulic resistance relates to the completely opened main stage leading edge.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

Pressure relief valve

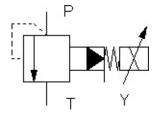
Proportional pressure relief valve, piloted

Proportional amplifier, 1-channel





Proportional pressure relief valve, piloted



The pilot operated pressure relief valve consists of a pilot stage with poppet valve and a main stage with control slide valve. The pressure at connection P acts upon the pilot poppet via a drilling in the control slide valve.

If the force of the proportional magnet is greater than the pressure exercised at connection P, then the pilot stage remains closed. A spring keeps the main stage poppet valve closed and the flow rate is null.

If the force, that the pressure exercises, exceeds the closing force of the pilot poppet, then this opens. A lower flow rate develops from connection P to connection Y. The flow of fluid causes a pressure loss at the throttle valve inside the control slide valve. Thus the pressure at the spring side is lower than the pressure at connection P. Due to the pressure difference, the control slide valve opens so far until the spring force re-establishes an equilibrium of forces and the valve is perfused from P to T.

The control voltage must be between 0 V and 10 V. The minimum nominal pressure defines the opening pressure at the pilot stage via the spring force at 0 V. The maximum nominal pressure defines the opening pressure at 10 V. The hydraulic resistance relates to the completely opened main stage leading edge.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

Related Topics

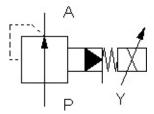
Pressure relief valve with pilot control

Proportional amplifier, 1-channel





Proportional pressure reducing valve, piloted



The pilot operated proportional pressure regulator valve consists of a pilot stage with poppet valve and a main stage with control slide valve. The pressure at connection A acts upon the pilot poppet via a drilling in the control slide valve. The proportional magnet exercises the electrically adjustable counter force with the assistance of a proportional amplifier.

If the pressure at connection A is below the preset value, then the pilot control remains closed. The pressure on both sides of the control slide valve is equal. A spring holds the main stage control slide valve open and the hydraulic fluid flow freely from connection P to connection A.

If the pressure at connection A exceeds the preset value, then the pilot stage opens causing less volumetric flow to flow to connection A. The pressure falls at the throttle valve inside the control slide valve. Thus the pressure at the spring side is lower than the pressure at connection A. Due to the pressure difference, the control slide valve closes so far until the spring force re-establishes an equilibrium of forces. As a result, the flow resistance at the control edge between connections P and A increases and the pressure at connection A sinks.

The control voltage must be between 0 V and 10 V. The minimum nominal pressure defines the opening pressure at the pre stage via the spring force at 0 V. The maximum nominal pressure defines the opening pressure at 10 V. The hydraulic resistance relates to the completely opened main stage leading edge.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.01)

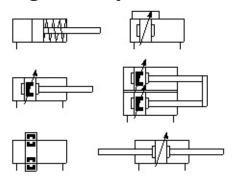
Related Topics

Proportional amplifier, 1-channel





Configurable cylinder



The configurable cylinder can be customized via its <u>properties dialog</u>. Almost any combination of piston type (single-acting, double-acting), the specification of the piston rods (double ended, with magnetic coupling or slide) and the number (none, one, two) is possible. An end position cushioning (without, with, adjustable) can also be defined. FluidSIM automatically adjusts the symbol according to the preset configuration. In addition, a load to be moved (including possible static and sliding friction) and a variable force profile can be defined in the <u>properties dialog</u>.

In the component library from FluidSIM there are several pre-configured cylinders that can be inserted in your circuit and directly used. Should no suitable symbol be available, then simply choose the component with the most similarity to the required component, open the <u>properties dialog</u> and adjust the configuration accordingly.

Adjustable parameters

Max. stroke: 1 ... 5000 mm (200)

Piston position: $0 \dots Max. stroke mm$ (0)

Piston diameter: 1 ... 1000 mm (16)

Piston rod diameter: 0 ... 1000 mm (10)

Mounting angle: 0 ... 360 Deg (0)

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Moving mass: $0 \dots 10000 \text{ kg}$ (0)

Static friction coefficient: $0 \dots 2$ (0)

Sliding friction coefficient: $0 \dots 2$ (0)

Force: -1000000 ... 1000000 N (0)

Related Topics

Double acting cylinder

Double acting cylinder with shock adsorber at stroke end

Double acting cylinder with in and out piston rod and shock adsorber at stroke end

Single acting cylinder

Displacement encoder

[151] Single acting cylinder

[152] Plunger cylinder

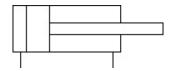
[153] Double acting cylinder

[154] Double acting cylinder with end position cushioning





Double acting cylinder



Double acting cylinder with piston rod on one side. The piston of the cylinder contains a permanent solenoid which can be used to operate a proximity switch.

Adjustable parameters

Max. stroke: 1 ... 5000 mm (200)

Piston position: $0 \dots Max. stroke mm$ (0)

Piston diameter: 1 ... 1000 mm (16)

Piston rod diameter: 0 ... 1000 mm (10)

Mounting angle: 0 ... 360 Deg (0)

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Moving mass: $0 \dots 10000 \text{ kg}$ (0)

Static friction coefficient: $0 \dots 2$ (0)

Sliding friction coefficient: $0 \dots 2$ (0)

Force: -1000000 ... 1000000 N (0)

Related Topics

Double acting cylinder with shock adsorber at stroke end

Double acting cylinder with in and out piston rod and shock adsorber at stroke end

Single acting cylinder

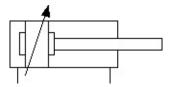
Distance rule

[153] Double acting cylinder





Double acting cylinder with shock adsorber at stroke end



The piston of the cylinder is controlled by the connected pressure loads. The shock adsorber can be adjusted by means of two adjustment screws. The piston contains a permanent solenoid which can be used to operate a proximity switch.

Adjustable parameters

Max. stroke: 1 ... 5000 mm (200)

Piston position: $0 \dots Max. stroke mm$ (0)

Piston diameter: 1 ... 1000 mm (16)

Piston rod diameter: 0 ... 1000 mm (10)

Mounting angle: 0 ... 360 Deg (0)

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Moving mass: $0 \dots 10000 \text{ kg}$ (0)

Static friction coefficient: 0 ... 2 (0)

Sliding friction coefficient: $0 \dots 2$ (0)

Force: -1000000 ... 1000000 N (0)

Related Topics

Double acting cylinder

Double acting cylinder with in and out piston rod and shock adsorber at stroke end

Single acting cylinder

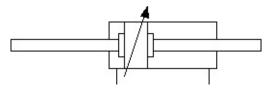
Distance rule

[154] Double acting cylinder with end position cushioning





Double acting cylinder with in and out piston rod and shock adsorber at stroke end



The piston of the cylinder is controlled by the connected pressure loads. The shock adsorber can be adjusted by means of two adjustment screws. The piston of the cylinder contains a permanent solenoid which can be used to operate a proximity switch.

Adjustable parameters

Max. stroke: 1 ... 5000 mm (200)

Piston position: $0 \dots Max. stroke mm$ (0)

Piston diameter: 1 ... 1000 mm (16)

Piston rod diameter: 0 ... 1000 mm (10)

Mounting angle: 0 ... 360 Deg (0)

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Moving mass: $0 \dots 10000 \text{ kg}$ (0)

Static friction coefficient: $0 \dots 2$ (0)

Sliding friction coefficient: $0 \dots 2$ (0)

Force: -1000000 ... 1000000 N (0)

Related Topics

Double acting cylinder

Double acting cylinder with shock adsorber at stroke end

Single acting cylinder

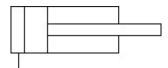
Distance rule

[154] Double acting cylinder with end position cushioning





Single acting cylinder



By connecting a sufficiently high pressure load, the piston of the cylinder is extended to its stop. To move the piston back, an external force must be applied.

Adjustable parameters

Max. stroke: 1 ... 5000 mm (200)

Piston position: $0 \dots Max. stroke mm$ (0)

Piston diameter: 1 ... 1000 mm (16)

Piston rod diameter: 0 ... 1000 mm (10)

Mounting angle: 0 ... 360 Deg (0)

Internal leakage: 0 ... 100 l/(min*MPa) (0)

Moving mass: $0 \dots 10000 \text{ kg}$ (0)

Static friction coefficient: $0 \dots 2$ (0)

Sliding friction coefficient: $0 \dots 2$ (0)

Force: -1000000 ... 1000000 N (0)

Related Topics

Double acting cylinder

Double acting cylinder with shock adsorber at stroke end

Double acting cylinder with in and out piston rod and shock adsorber at stroke end

Distance rule

[151] Single acting cylinder





Hydraulic motor



The hydraulic motor transforms hydraulic energy into mechanical energy.

Adjustable parameters

Displacement: 0.001 ... 5 Liter (0.0082)

Friction: 0.01 ... 100 N*m*s/rad (0.0128)

Moment of inertia: 0.0001 ... 1 kg*m2 (0.0001)

External torque: -1000 ... 1000 Nm (0)

Related Topic

Semi-rotary actuator





Semi-rotary actuator



The semi-rotary actuator is controlled by alternately switching the pressure. In the end positions the swivel cylinder can activate switches or valves via labels.

Adjustable parameters

Rotation angle: 1 ... 360 Deg (180)

Displacement: 0.001 ... 5 Liter (0.1)

Friction: 0.01 ... 100 N*m*s/rad (0.1)

Moment of inertia: 0.0001 ... 1 kg*m2 (0.001)

External torque: -1000 ... 1000 Nm (0)

Initial position: Left, Right (Left)

Related Topic

Hydraulic motor





Manometer



The manometer measures the pressure at its connection.

Related Topics

Differential pressure gauge

Pressure indicator

Pressure sensor, analog

[160] Piston pressure gauge

[161] Bourdon-tube pressure gauge







Differential pressure gauge



The differential pressure gauge displays the pressure difference between the adjacent pressures at the left and the right connection.

Related Topic

Manometer





Pressure indicator



An optical signal is activated when the pressure at the connection to the pressure display exceeds the preset switching pressure.

Adjustable parameters

Switching pressure: 0.0001 ... 40 MPa (3)

Color: 16 standard colors (Dark red)

Related Topic

Manometer





Pressure sensor, analog



This symbol represents the hydraulic part of the analog pressure sensor. The analog pressure sensor measures the adjacent pressure and transforms it into a proportional electrical voltage signal. In the process, only pressures in the specified pressure ranges are considered. Within this range, the pressure in the voltage range from $0\ V$ to $10\ V$ is represented, i.e. the minimum pressure delivers $0\ V$ and the maximum pressure $10\ V$.

Related Topics

Manometer

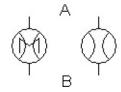
Coupling Hydraulics, Electrics and Mechanics

Open-loop and Closed-loop Control by using Continuous Valves





Flow meter



The flow meter measures the flow rate. Either the current flow or the total quantity flowed can be displayed. The component image is automatically adjusted accordingly.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.0001)

Related Topics

Flow meter

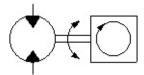
Flow meter, analog

[162] Flow meter





Flow meter



The flow meter consists of a hydraulic motor connected to an RPM gauge.

Adjustable parameters

Displacement: 0.001 ... 5 Liter (0.0082)

Friction: 0.01 ... 100 N*m*s/rad (0.1)

Moment of inertia: 0.0001 ... 1 kg*m2 (0.0001)

External torque: -1000 ... 1000 Nm (0)

Related Topics

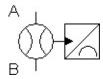
Hydraulic motor

Flow meter





Flow meter, analog



This symbol represents the hydraulic part of the analog flow meter. The analog flow meter measures the volumetric flow and transforms it into a proportional electrical voltage signal. In the process, only flow rates in the specified pressure ranges are considered. Within this range, the flow rate in the voltage range from 0 V to 10 V is represented, i.e. the minimum volumetric flow delivers 0 V and the maximum volumetric flow 10 V.

Adjustable parameters

Hydraulic resistance: 1e-7 ... 100 MPa*min2/l2 (0.0001)

Related Topics

Flow meter

Flow meter, analog





Electrical connection 0V

0V

 \circ

0V connection of the power supply.

Related Topic

Electrical connection 24V







Electrical connection 24V

+24V ○—

24V connection of the power supply.

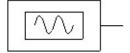
Related Topic

Electrical connection 0V





Function generator



The function generator is a voltage source that can create constant, rectangle, sine and triangle signals. The voltage range is restricted to -10 V to +10 V. The frequency, the amplitude and the Y-offset of the signal can be set within this range.

A voltage profile can be additionally specified. Data points can be set interactively with a mouse-click in the relevant graphic field. These can then be combined to a closed polygon. Alternatively, existing data points can be marked and both numeric values for the time and the corresponding voltage can be entered in the input fields. If the option "loop" is selected, then the voltage profile is started again.

Adjustable parameters

Frequency: 0 ... 100 Hz (1)

Amplitude: 0 ... 10 V (5)

y offset: -10 ... 10 V (5)

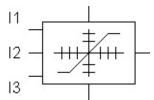
Related Topic

Setpoint value card





Setpoint value card



Voltage profiles in the range -10 V to +10 V can be created using the setpoint value card. Up to 8 setpoints W1 to W8 can be specified in the voltage range -10 V to +10 V. The setpoint card requires a power supply of 24 V.

The increase from the current setpoint to the next setpoint is defined using 4 ramps R1 to R4 with values between 0 s/V and 10 s/V, i.e. a low ramp value signifies a large increase, whereas a high ramp value results in a small increase. The active ramp is defined as follows: R1 by a positive increase of 0 V, R2 by a negative increase up to 0 V, R3 by a negative increase of 0 V and R4 by a positive increase up to 0 V.

Three operating modes can be selected: "Wait for switching time", "Advance setpoints" and "External control".

In operating mode "Wait for switching time" the setpoints are sequentially advanced when the preset change over time has expired.

If "Advance setpoints" is selected then, upon attaining the active setpoint, the next setpoint is started without delay.

In operating mode "External control" the selection of the active setpoint is effected by gating the inputs I1, I2 and I3 with at least 15 V. The corresponding setpoint is selected by means of the specified bit table. During the process, the internal switching time is inactive.

Related Topic

<u>Function generator</u>





Connection (electrical)



An electric connection is a place where an electric line can be attached to. To simplify the line drawing process, a connection appears as a small circle in Edit Mode.

Note that at each electric connection values for the voltage and current can be displayed.

Related Topics

Line (electrical)

T-junction (electrical)

Creating new Circuit Diagrams

Insertion of T-connections

Drawing Errors

Displaying Quantity Values





Line (electrical)

A electrical line links two electrical connections. Note that a electrical connection may be a simple <u>electrical connection</u> or a <u>T-junction</u>. A electrical line causes no voltage drop, i. e., it has no electrical resistance.

Related Topic

Creating new Circuit Diagrams





T-junction (electrical)



A T-junction joins up to four <u>electrical lines</u>, thus having a single voltage potential. Note that T-junctions are introduced automatically by FluidSIM when dropping the line drawing cursor onto another line in Edit Mode.

Related Topics

Connection (electrical)

Creating new Circuit Diagrams





DC motor



The DC motor transforms electrical energy into mechanical energy. DC motors produce the continual rotation through repeated changes in the direction of current. The characteristics of the 24 V Dc motor relate to the motor used by the Festo Didactic conveyor belts.

Adjustable parameters

No load speed: 10 ... 20000 1/min (75)

Torque: 0 ... 20 Nm (0)

Related Topics

Electrical connection 24V

Starting current limiter





Indicator light



If current flows, the indicator light is displayed in the user-defined color.

Adjustable parameters

Color: 16 standard colors (Yellow)

Related Topic

Buzzer





Buzzer



If current flows, a flashing ring around the buzzer is shown. Moreover, if "buzzer" is activated in the menu under Options- Sound..., the buzzer is activated if a sound hardware is installed.

Related Topics

Indicator light

Sound Parameters

Technical Requirements





Voltmeter



With a voltmeter, the voltage between two positions in a circuit can be measured.





Ammeter

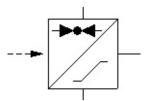


With an ammeter, the amperage (current strength) of the current between two positions in a circuit can be measured.





Pressure sensor, analog



This symbol represents the electrical part of the Analog-pressure sensor

Related Topics

Pressure sensor, analog

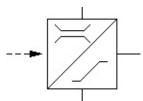
Coupling Hydraulics, Electrics and Mechanics

Open-loop and Closed-loop Control by using Continuous Valves





Flow meter, analog



This symbol represents the electrical part of the **Analog-flow meter**

Related Topics

Pressure sensor, analog

Coupling Hydraulics, Electrics and Mechanics

Open-loop and Closed-loop Control by using Continuous Valves





Break switch



General break switch that is tailored depending on the type of component that actuates it. For example, if the break switch is linked via a label to a switch-off delay relay, the break switch changes to a switch-off delay break switch in the circuit diagram.

Related Topics

Relay

Break switch (switch-on delayed)

Break switch (switch-off delayed)

Limit switch (break)

Switch with roll (break)

Reed contact (break)

Pressure switch (break)

Coupling Hydraulics, Electrics and Mechanics

Automatic Switch Altering





Make switch



General make switch that is tailored according to the component that actuates it. For example, if the make switch is linked via a label to a switch-on delayed relay, the make switch changes to a switch-on delayed make switch in the circuit diagram.

Related Topics

Relay

Make switch (switch-on delayed)

Make switch (switch-off delayed)

Limit switch (make)

Switch with roll (make)

Reed contact (make)

Pressure switch (make)

Coupling Hydraulics, Electrics and Mechanics

Automatic Switch Altering





Changeover switch



General changeover switch that is tailored according to the component that actuates it. For example, if the changeover switch is linked via a label to a switch-on delayed relay, the changeover switch changes to a switch-on delayed changeover switch in the circuit diagram.

Related Topics

Relay

Changeover switch (switch-on delayed)

Changeover switch (switch-off delayed)

Limit switch (changeover)

Switch with roll (changeover)

Reed contact (changeover)

Pressure switch (changeover)

Coupling Hydraulics, Electrics and Mechanics

Automatic Switch Altering





Break switch (switch-on delayed)



Switch with delayed opening after pickup. Switch-on delayed break switches are created by using a general break switch and setting a label.

Related Topics

Relay with switch-on delay

Break switch (switch-off delayed)

Coupling Hydraulics, Electrics and Mechanics





Changeover switch (switch-on delayed)



Changeover switch with delayed changeover after pickup. Switch-on delayed changeover switches are created by using a <u>general changeover switch</u> and setting a label.

Related Topics

Relay with switch-on delay

Changeover switch (switch-off delayed)

Coupling Hydraulics, Electrics and Mechanics





Break switch (switch-off delayed)



Switch with delayed closing after dropout. Switch-off delayed break switches are created by using a general break switch and setting a label.

Related Topics

Relay with switch-off delay

Break switch (switch-on delayed)

Coupling Hydraulics, Electrics and Mechanics





Changeover switch (switch-off delayed)



Changeover switch with delayed changeover after dropout. Switch-off delayed changeover switches are created by using a <u>general changeover switch</u> and setting a label.

Related Topics

Relay with switch-off delay

Changeover switch (switch-on delayed)





Limit switch (break)



Switch that is opened by a cam attached to the cylinder rod. The switch closes immediately when the cam has passed the switch. Limit switches are created by using a general break switch and setting a label.

Related Topics

Switches at Cylinders





Switch with roll (break)



Switch that is opened by a cam attached to the cylinder rod. The switch closes immediately when the cam has passed the switch. Switches with roll are created by using a general break switch, setting a label and selecting the switch type in the component's properties dialog.

Related Topics

Switches at Cylinders

Automatic Switch Altering





Reed contact (break)



Switch that is opened by a cam attached to the cylinder rod. The switch closes immediately when the cam has passed the switch. Reed contacts are created by using a general break switch, setting a label and selecting the switch type in the component's properties dialog.

Related Topics

Switches at Cylinders

Automatic Switch Altering





Switch with roll (make)



Switch that is closed by a cam attached to the cylinder rod. The switch opens immediately when the cam has passed the switch. Switches with roll are created by using a general make switch, setting a label and selecting the switch type in the component's properties dialog.

Related Topics

Switches at Cylinders

Automatic Switch Altering





Reed contact (make)



Switch that is closed by a cam attached to the cylinder rod. The switch opens immediately when the cam has passed the switch. Reed contacts are created by using a <u>general make switch</u>, setting a label and selecting the switch type in the component's properties dialog.

Related Topics

Switches at Cylinders

Automatic Switch Altering





Limit switch (changeover)



Switch that is changed over by a cam attached to the cylinder rod. The switch changes back immediately when the cam has passed the switch. Limit switches are created by using a general changeover switch and setting a label.

Related Topics

Switches at Cylinders





Switch with roll (changeover)



Switch that is changed over by a cam attached to the cylinder rod. The switch changes back immediately when the cam has passed the switch. Switches with roll are created by using a <u>general changeover switch</u>, setting a label and selecting the switch type in the component's properties dialog.

Related Topics

Switches at Cylinders

Automatic Switch Altering





Reed contact (changeover)



Switch that is changed over by a cam attached to the cylinder rod. The switch changes back immediately when the cam has passed the switch. Reed contacts are created by using a general changeover switch, setting a label and selecting the switch type in the component's properties dialog.

Related Topics

Switches at Cylinders

Automatic Switch Altering







Pushbutton (break)



Switch that opens when actuated and closes immediately when released.

In FluidSIM switches can be actuated permanently (locked) when continuing to hold down the mouse button and pushing the **Shift** key. This permanent actuation is released by a simple click on the component.

Related Topics

Detent switch (break)





Pushbutton (make)



Switch that closes when actuated and opens immediately when released.

In FluidSIM switches can be actuated permanently (locked) when continuing to hold down the mouse button and pushing the **Shift** key. This permanent actuation is released by a simple click on the component.

Related Topics

Detent switch (make)





Pushbutton (changeover)



Switch that changes over when actuated and changes back immediately when released.

In FluidSIM switches can be actuated permanently (locked) when continuing to hold down the mouse button and pushing the **Shift** key. This permanent actuation is released by a simple click on the component.

Related Topics

Detent switch (changeover)





Detent switch (break)



Switch that opens and locks when actuated.

Related Topics

Pushbutton (break)





Detent switch (make)



Switch that closes and locks when actuated.

Related Topics

Pushbutton (make)





Detent switch (changeover)



Switch that changes over and locks when actuated.

Related Topics

Pushbutton (changeover)





Pressure switch (break)



Switch that opens when the preset switching pressure of the <u>hydraulic pressure</u> <u>switch</u> is exceeded. Pressure switches are created by using a <u>general break</u> <u>switch</u> and setting a label.

Related Topic





Pressure switch (changeover)



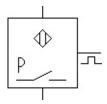
The switch changes over when the preset switching pressure of the <u>hydraulic</u> <u>pressure switch</u> is exceeded. Pressure switches are created by using a <u>general</u> <u>changeover switch</u> and setting a label.

Related Topic





Pressure switch



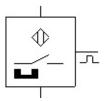
The switch relays an electrical signal when the preset switching pressure at the hydraulic pressure switch is exceeded.

Related Topic





Magnetic proximity switch



Switch that closes when a solenoid is brought near by.

In the Simulation Mode the proximity switch can also be actuated by <u>clicking</u> on it.

Related Topics

Inductive proximity switch

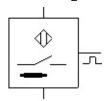
Capacitive proximity switch

Optical proximity switch





Inductive proximity switch



Switch that closes when the induced electro-magnetic field is changed.

In the Simulation Mode the proximity switch can also be actuated by <u>clicking</u> on it.

Related Topics

Magnetic proximity switch

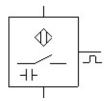
Capacitive proximity switch

Optical proximity switch





Capacitive proximity switch



Switch that closes when its electrostatic field is changed.

In the Simulation Mode the proximity switch can also be actuated by <u>clicking</u> on it.

Related Topics

Magnetic proximity switch

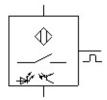
Inductive proximity switch

Optical proximity switch





Optical proximity switch



Switch that closes when the light barrier is interrupted.

In the Simulation Mode the proximity switch can also be actuated by <u>clicking</u> on it.

Related Topics

Magnetic proximity switch

Inductive proximity switch

Capacitive proximity switch





Relay



The relay picks up immediately when current is supplied and drops out immediately when current is removed.

Related Topics

Break switch

Make switch

Changeover switch





Relay with switch-on delay



The relay picks up after a preset time when current is supplied and drops out immediately when current is removed.

Adjustable parameters

Delay time: 0 ... 100 s (5)

Related Topics

Break switch (switch-on delayed)

Make switch (switch-on delayed)

Changeover switch (switch-on delayed)





Relay with switch-off delay



The relay picks up immediately when current is supplied and drops out after a preset time when current is removed.

Adjustable parameters

Delay time: 0 ... 100 s (5)

Related Topics

Break switch (switch-off delayed)

Make switch (switch-off delayed)

Changeover switch (switch-off delayed)





Relay counter

The relay picks up after a predefined number of current pulses has/have been counted between the connections A1 and A2. If a potential is supplied between the connections R1 and R2, the counter is reset to its predefined value.

In the Simulation Mode the relay counter can also be reset by clicking on it.

Adjustable parameters

Counter: 0 ... 9999 pulses (5)

Related Topics

Break switch

Make switch

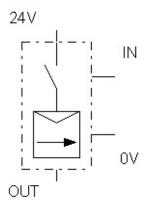
Changeover switch







Starting current limiter



The starting current limiter consists essentially of a relay, whose coil is situated between the connections IN and 0V, and whose switch contact is situated between the connections 24V and OUT. An electronic longitudinal controller restricts, with a switched relay contact, the current flow to the preset value for the specified duration.

The starting current limiter is usually deployed in combination with the <u>electric</u> motor.

Adjustable parameters

Duration: 1 ... 10000 ms (50)

Max. current: 0.1 ... 100 A (2)

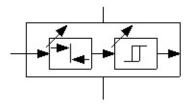
Related Topic

DC motor





Comparator



The comparator is a discontinuous (switching) two-step action controller with differential gap (hysteresis). When activated, it delivers a predefined voltage signal. The switch-on value for the activation is defined by nominal value $\pm 1/2$ hysteresis and the switch-off value by nominal value $\pm 1/2$ hysteresis. The comparator requires a power supply of 24 V.

Adjustable parameters

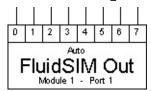
Set value voltage: -10 ... 10 V (5)

Hysteresis: $0 \dots 5 \text{ V}$ (1)





FluidSIM Output Port



Communication with the EasyPort-Hardware and other applications is implemented with the FluidSIM-Output.

Related Topics

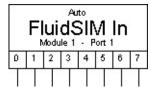
FluidSIM Input Port

OPC and DDE communication with Other Applications





FluidSIM Input Port



The FluidSIM input realizes the communication with other applications. Communication with the EasyPort-Hardware and other applications is implemented with the FluidSIM-Output.

Related Topics

FluidSIM Output Port

OPC and DDE communication with Other Applications





Electrical connection 0V (ladder)



0V connection of the power supply.

Related Topic

Electrical connection 24V (ladder)





Electrical connection 24V (ladder)



24V connection of the power supply.

Related Topic

Electrical connection OV (ladder)





Break switch (ladder)



General break switch that is tailored depending on the type of component that actuates it. For example, if the break switch is linked via a label to a switch-off delay relay, the break switch changes to a switch-off delay break switch in the circuit diagram.

Related Topics

Relay (ladder)

Break switch (switch-on delayed, ladder)

Break switch (switch-off delayed, ladder)

Limit switch (break, ladder)

Pressure switch (break, ladder)





Make switch (ladder)



General make switch that is tailored according to the component that actuates it. For example, if the make switch is linked via a label to a switch-on delayed relay, the make switch changes to a switch-on delayed make switch in the circuit diagram.

Related Topics

Relay (ladder)

Make switch (switch-on delayed, ladder)

Make switch (switch-off delayed, ladder)

Limit switch (make, ladder)

Pressure switch (make, ladder)





Break switch (switch-on delayed, ladder)



Switch with delayed opening after pickup. Switch-on delayed break switches are created by using a general break switch and setting a label.

Related Topics

Relay with switch-on delay (ladder)

Break switch (switch-off delayed, ladder)





Make switch (switch-on delayed, ladder)



Switch with delayed closing after pickup. Switch-on delayed make switches are created by using a general make switch and setting a label.

Related Topics

Relay with switch-on delay (ladder)

Make switch (switch-off delayed, ladder)





Break switch (switch-off delayed, ladder)

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Switch with delayed closing after dropout. Switch-off delayed break switches are created by using a general break switch and setting a label.

Related Topics

Relay with switch-off delay (ladder)

Break switch (switch-on delayed, ladder)





Make switch (switch-off delayed, ladder)



Switch with delayed opening after dropout. Switch-off delayed make switches are created by using a general make switch and setting a label.

Related Topics

Relay with switch-off delay (ladder)

Make switch (switch-on delayed, ladder)





Limit switch (break, ladder)

Switch that is opened by a cam attached to the cylinder rod. The switch closes immediately when the cam has passed the switch. Limit switches are created by using a general break switch and setting a label.

Related Topics

Switches at Cylinders

Distance rule





Limit switch (make, ladder)



Switch that is closed by a cam attached to the cylinder rod. The switch opens immediately when the cam has passed the switch. Limit switches are created by using a general make switch and setting a label.

Related Topics

Switches at Cylinders

Distance rule





Pushbutton (break, ladder)

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Switch that opens when actuated and closes immediately when released.

In FluidSIM switches can be actuated permanently (locked) when continuing to hold down the mouse button and pushing the **Shift** key. This permanent actuation is released by a simple click on the component.

Related Topic

Simultaneous Actuation of Several Components





Pushbutton (make, ladder)



Switch that closes when actuated and opens immediately when released.

In FluidSIM switches can be actuated permanently (locked) when continuing to hold down the mouse button and pushing the **Shift** key. This permanent actuation is released by a simple click on the component.

Related Topic

Simultaneous Actuation of Several Components





Pushbutton (changeover, ladder)

Switch that changes over when actuated and changes back immediately when released.

In FluidSIM switches can be actuated permanently (locked) when continuing to hold down the mouse button and pushing the **Shift** key. This permanent actuation is released by a simple click on the component.

Related Topic

Simultaneous Actuation of Several Components





Pressure switch (break, ladder)

Switch that opens when the preset switching pressure of the <u>hydraulic pressure</u> <u>switch</u> is exceeded. Pressure switches are created by using a <u>general break</u> <u>switch</u> and setting a label.

Related Topic





Pressure switch (make, ladder)



The switch closes when the preset switching pressure of the <u>hydraulic pressure</u> <u>switch</u> is exceeded. Pressure switches are created by using a <u>general make</u> <u>switch</u> and setting a label.

Related Topic





Relay (ladder)



The relay picks up immediately when current is supplied and drops out immediately when current is removed.

Related Topics

Break switch (ladder)





Relay with switch-on delay (ladder)



The relay picks up after a preset time when current is supplied and drops out immediately when current is removed.

Adjustable parameters

Delay time: 0 ... 100 s (5)

Related Topics

Break switch (switch-on delayed, ladder)

Make switch (switch-on delayed, ladder)





Relay with switch-off delay (ladder)



The relay picks up immediately when current is supplied and drops out after a preset time when current is removed.

Adjustable parameters

Delay time: 0 ... 100 s (5)

Related Topics

Break switch (switch-off delayed, ladder)

Make switch (switch-off delayed, ladder)





Digital input



Digital inputs are designated with an "I". In FluidSIM digital components can be used inside and outside a digital module.

If a digital input is used inside a digital module, you can determine the input connector of the digital module in question with which the digital input shall be linked by allocating a number "I1" to "I16". If there is an analog signal of more than 10V at the chosen input of the digital module, the digital input is set to "Hi".

If a digital input is used outside a digital module, there is an additional analog electrical connection at the digital input. If there is an analog signal of more than 10V at this connection, the digital input is set to "Hi".

As an alternative you can click on the digital input with the left mouse button in order to set it to "Hi". Another click resets the value to "Lo".

Related Topics

Digital module

Digital output





Digital output



Digital outputs are designated with an "Q". The output connects a digital signal through from its input to its output. In FluidSIM digital components can be used inside and outside a digital module.

If a digital output is used inside a digital module, you can determine the output connector of the digital module in question with which the digital output shall be linked by allocating a number "Q1" to "Q16". If the status of the digital output is "Hi", a potential of 24V is set at the corresponding output connector of the digital module.

If a digital output is used outside a digital module, there is an additional analog electrical connection at the digital output. If the status of the digital output is "Hi", a potential of 24 V is set a this connection.

Related Topics

Digital module

Digital input

Memory bits





Memory bits



Memory bits are designated with a "M". Memory bits are virtual outputs, with a value at their output analog to that at their input.

When the simulation start is activated, you can define by using the property dialog box if the output Q shall be set to "Lo" or to "Hi", independent on the input value. After the simulation start the value at the output is set to the value of the input.

Related Topic

Digital output





Logic level HI



At the output Q you have the logic level "Hi".

Related Topic

<u>Logic level LO</u>





Logic level LO



At the output Q you have the logic level "Lo".

Related Topic

<u>Logic level HI</u>





Connection (digital)



An digital connection is a place where a digital line can be attached to. To simplify the line drawing process, a connection appears as a small circle in Edit Mode.

Note that at each digital connection its level "Lo" / "Hi" can be displayed.

Related Topics

Line (digital)

T-junction (digital)

Creating new Circuit Diagrams

<u>Insertion of T-connections</u>

Drawing Errors

Displaying Quantity Values







Line (digital)

A digital line links two digital connections. Note that a digital connection may be a simple <u>digital connection</u> or a <u>T-junction</u>.

Related Topic

Creating new Circuit Diagrams





T-junction (digital)



A T-junction joins up to four <u>digital lines</u>, thus having a single digital level. Note that T-junctions are introduced automatically by FluidSIM when dropping the line drawing cursor onto another line in Edit Mode.

Related Topics

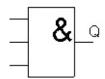
Connection (digital)

Creating new Circuit Diagrams





AND



The output Q of the AND is only "Hi" when all inputs are "Hi", that is, if they are closed. If an input pin of this module is not connected, its status is automatically "Hi".

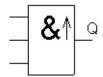
Related Topic

Edge-triggered AND





Edge-triggered AND



The output Q of the edge-triggered AND is only "Hi" when all inputs are "Hi" and if at least one input was "Lo" in the previous cycle. If an input pin of this block is not connected, its status is automatically "Hi".

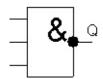
Related Topic

AND





NAND (AND not)



The output Q of the NAND is only "Lo", when all inputs are "Hi", that is, if they are closed. If an input pin of this block is not connected, its status is automatically "Hi".

Related Topic

NAND With Edge Evaluation





NAND With Edge Evaluation



The output Q of the NAND with edge evaluation is only "Hi", if at least one input is "Lo" and if all inputs were "Hi" in the previous cycle. If an input pin of this block is not connected, its status is automatically "Hi".

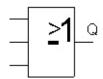
Related Topic

NAND (AND not)





OR



The output Q of the OR is only "Hi", if at least one input is "Hi", that is, if it is closed. If an input pin of this block is not connected, its status is automatically "Lo".

Related Topics

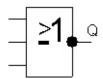
NOR (OR not)

XOR (exclusive OR)





NOR (OR not)



The output Q of the NOR is only "Hi" when all inputs are "Lo", that is, if they are switched off. As soon as any input is switched on (status "Hi"), the output of the NOR is set to "Lo". If an input pin of this block is not connected, its status is automatically "Lo".

Related Topics

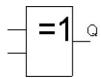
<u>OR</u>

XOR (exclusive OR)





XOR (exclusive OR)



The output Q of the XOR is "Hi", if the inputs are nonequivalent. If an input pin of this block is not connected, its status is automatically "Lo".

Related Topics

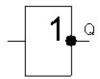
<u>OR</u>

NOR (OR not)





NOT (Negation, Inverter)

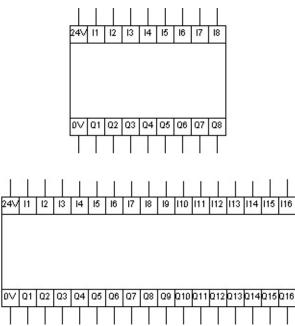


The output Q is "Hi" if the input is "Lo". The NOT block is an input status inverter.





Digital module



The digital module is used for a compact embedding of a digital switching circuit into a electrohydraulic circuit. The digital module offers 8 (16) electrical inputs and outputs, which transfer their states to its digital switching circuit in the inner part. Therefore the digital switching circuit does not need much space in the electrohydraulic circuit for the display of the digital module as a rectangle with a total number of 18 (34) connections. By making a double-click with the left mouse button on the digital module you come to the digital circuit in the inner part of the module. A new window opens. It shows the digital circuit and can be handled in the usual way. The standard configuration in the inner part of a new inserted digital module is a row with 8 (16) inputs and 8 (16) outputs each. They correspond to the inputs and outputs of the module in the electrohydraulic circuit. In order to be able to test the digital circuit during the set-up, it can be simulated separated from the electrohydraulic circuit. As soon as the processing window of the digital module is closed or the original circuit window is put into the foreground, the previously effected changes in the digital circuit are automatically adopted into the digital module of the electrohydraulic circuit. Inside the digital module only digital components can be inserted. Furthermore, an encapsulating of additional digital modules inside a module is not possible. However, you can use several digital modules in one electrohydraulic circuit.

Please note that the digital circuit inside a digital module only works correctly if corresponding potentials are set at the electrical power supply units of the module $(+24\ V)$ and $(0\ V)$.

Related Topics

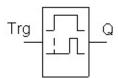
Digital input

Digital output





On delay



An output with on delay is not switched on until a specified time has expired. When the status of input Trg changes from "Lo" to "Hi", the on delay time starts.

If the status of input Trg is "Hi" at least for the duration of the configured time, the output Q is set to "Hi" on expiration of this time. The output follows the input with on delay. The time is reset, when the status of the input changes again to "Lo" before the time has expired. The output is reset to "Lo", when the status at the input is "Lo".

Adjustable parameters

On delay time: 0 ... 100 s (3)

Related Topics

Off delay

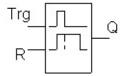
On/Off delay

Retentive On delay





Off delay



The output is not reset until a configured time has expired.

When the input status turns to "Hi", the output Q is switched instantaneously to "Hi". If the status at input Trg changes from "Hi" to "Lo", the off delay starts. After expiration of the configured time, the output is reset to "Lo" (off delay). When the input Trg is switched on and off again, the off delay restarts. The input R (Reset) is used to reset the delay time and the output before the configured time has expired.

Adjustable parameters

Off delay time: 0 ... 100 s (3)

Related Topics

On delay

On/Off delay

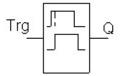
Retentive On delay







On/Off delay



An output with on/off delay is switched on after a specified time and is reset on expiration of a second specified time.

As soon as the status at input Trg changes from "Lo" to "Hi", the configured on delay time starts. If the status at input Trg remains "Hi" at least for the duration of the configured time, the output Q is set to "Hi" on expiration of the on delay time (the output follows the input on delayed). If the status at input Trg changes again to "Lo", before the configured on delay time has expired, the time is reset. When the status at input returns to "Lo", the configured off delay time starts.

If the status at the input remains "Lo" at least for the duration of the configured off delay time, the output is set to "Lo" on expiration of that time (the output follows the input off delayed). If the status at the input returns to "Hi" before this time has expired, the time is reset.

Adjustable parameters

On delay time: 0 ... 100 s (3) **Off delay time:** 0 ... 100 s (3)

Related Topics

On delay

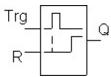
Off delay

Retentive On delay





Retentive On delay



A specified time starts after an input pulse. The output is set on expiration of this time.

As soon as the status at the input Trg changes from "Lo" to "Hi", the specified time starts. After expiration on the configured time, the output Q is set to "Hi". Further switching actions at input Trg have no influence on the running time. The output and the time are only reset to "Lo" when the status at input R is "Hi".

Adjustable parameters

On delay time: 0 ... 100 s (3)

Related Topics

On delay

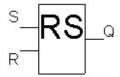
Off delay

On/Off delay





Latching Relay



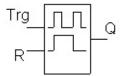
Input S sets output Q. Another input R resets the output Q.

A latching relay is a simple logic memory. The output value depends on the input states and on the previous output status.





Pulse Relay



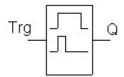
A short one-shot at the input is used to set and reset the output.

Output Q status is toggled at every "Lo" to "Hi" transition of the status at input Trg, that is, the output is switched on or off. Use input R to reset the pulse relay to initial state, that is, the output is set to "Lo".





Wiping Relay - Pulse Output



An input signal generates a signal of specified length at the output.

The output status is switched to "Hi" after the input Trg is set to "Hi". The configured time is started at the same time and the output remains set. After expiration of the configured time, the output is reset to the status "Lo" (pulse output). If the input status changes from "Hi" to "Lo" before the specified time has expired, also the output follows immediately with a with a "Hi" to "Lo" transition.

Adjustable parameters

Delay time: 0 ... 100 s (3)

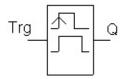
Related Topic

Edge-triggered Wiping Relay





Edge-triggered Wiping Relay



An input signal generates a signal of specified length at the output (retriggering). The output status is switched to "Hi" after the input Trg is set to "Hi". The configured time is started at the same time. After expiration of the configured time, the output Q status is reset to "Lo" (pulse output). If the input status changes again from "Lo" to "Hi" (retriggering), before the specified time has

Adjustable parameters

Delay time: 0 ... 100 s (3)

expired, the time is reset and the output remains switched on.

Related Topic

Wiping Relay - Pulse Output





Timer Switch



With the timer switch you can create timer switches referring to days, weeks and years. Upon reach of the specified on-transition time, the output Q of the timer switch is set to "Hi" and upon reach of the specified off-transition time to "Lo". If you have chosen the option "repeat all", the on and off transition is repeated each time according to the specified repetition time.

Adjustable parameters

0 ... 1000 s On time: (10)

(30)0,1 ... 1000 s Off time:

0,1 ... 1000 s (60)**Repeat every:**

Related Topics

On delay

Off delay

On/Off delay

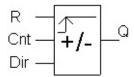
Retentive On delay







Up/Down Counter



Depending on the configuration of the input Dir, an internal value is counted up or down through an input pulse. The output is set when the configured count value is reached.

With every status change at the input Cnt from "Lo" to "Hi", the internal counter is increased (Dir = "Lo") or decreased (Dir = "Hi") by one unit. If the internal counter is equal or larger compared to the specified value, the output Q is set to "Hi".

You can use the reset input R to reset the internal count value and the output to "Lo". As long as R="Hi", also the output is "Lo" and the pulses at input Cnt are not counted.

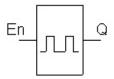
Adjustable parameters

Counter: 0 ... 9999 pulses (5)





Symmetric Clock Generator



A timing signal with a configurable period is given at the output. Via the duration of the pulses you can determine the length of the on and off times. Via the input En (for Enable) you can switch on the clock generator, that is, the clock generator sets the output to "Hi" for the duration of the pulse, subsequent the output to "Lo" for the duration of the pulse and so on, until the input status is "Lo" again.

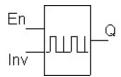
Adjustable parameters

Impulse time: 0,1 ... 100 s (0,5)





Asynchronous Pulse Generator



The pulse profile of the output can be changed via the configurable pulse duration and pulse pause duration.

It is possible to invert the output with input INV. The input INV only negates the output, if the block is enabled via EN.

Adjustable parameters

Impulse time: 0,1 ... 100 s (3)

Impulse pause time: 0,1 ... 100 s (1)

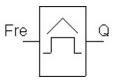
Related Topic

Symmetric Clock Generator





Frequency Threshold Trigger



The output is switched on and off depending on two frequencies which can be specified.

The threshold trigger measures the signals at input Fre. The pulses are captured across a measuring interval which can be specified. If the frequency measured within the measuring interval higher than the input frequency, the output Q is switched to "Hi". Q is switched again to "Lo" when the measured frequency has reached the value of the output frequency or if it is lower.

Adjustable parameters

On frequency: 0,1 ... 10 pulses/sec (6)

Off frequency: 0,1 ... 10 pulses/sec (2)

Time interval: 0,1 ... 100 s (5)





Connection (mechanical)



A mechanical connection constitutes a place holder for the label of a valve solenoid. To simplify clicking, a mechanical connection appears as a small circle in Edit Mode.

Related Topic

Coupling Hydraulics, Electrics and Mechanics





Valve solenoid



The valve solenoid switches the valve.

By means of a label the valve solenoid can be linked to a valve that is solenoid operated.

Related Topics

4/2-way solenoid valve (i)

4/2-way solenoid valve (ii)

4/3-way solenoid valve with shutoff position (i)

4/3-way solenoid valve with shutoff position (ii)

4/3-way solenoid valve with floating position (i)

4/3-way solenoid valve with floating position (ii)

4/3-way solenoid valve with bypass position (i)

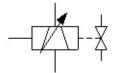
4/3-way solenoid valve with bypass position (ii)

Coupling Hydraulics, Electrics and Mechanics





Proportional valve solenoid, position controlled



In FluidSIM the proportional valve solenoid is coupled to the respective continuous directional valve with the help of a label. The required slide position is predetermined via a voltage signal. The valve slide distance is position controlled. The control and amplifier component is integrated in the valve.

Related Topics

4/3-way regulating valve

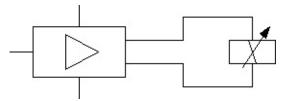
Coupling Hydraulics, Electrics and Mechanics

Open-loop and Closed-loop Control by using Continuous Valves





Proportional amplifier, 1-channel



The amplifier is used to control proportional valves. For this purpose, nominal values (voltage signals) from 0 V to +10 V are transformed into the necessary magnetic current for the proportional valves. In FluidSIM the amplifier is coupled to the respective valve with the help of a label. The maximum current at the amplifier output is hereby automatically adjusted in relation to the coupled valve. A step current relative to the maximum current can be specified, in order to compensate the positive overlap of proportional valves. The amplifier requires a power supply of 24 V.

Related Topics

Proportional pump

Proportional throttle valve

Proportional pressure relief valve

Proportional pressure relief valve, piloted

Proportional pressure reducing valve, piloted

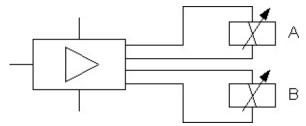
Coupling Hydraulics, Electrics and Mechanics

Open-loop and Closed-loop Control by using Continuous Valves





Proportional amplifier, 2-channel



The amplifier is used to control proportional valves with two magnets. For this purpose, nominal values (voltage signals) from -10 V to +10 V are transformed into the necessary magnetic current for the proportional valves. Output A is gated at a nominal value between 0 V and -10 V, output B between 0 V and -10 V. In FluidSIM the amplifier is coupled to the respective valve with the help of two labels. The maximum currents at the amplifier outputs are hereby automatically adjusted in relation to the coupled valves. A step current relative to the maximum current can be specified, in order to compensate the positive overlap of proportional valves. The amplifier requires a power supply of 24 V.

Related Topics

4/3-way proportional valve

Coupling Hydraulics, Electrics and Mechanics

Open-loop and Closed-loop Control by using Continuous Valves





Valve solenoid (ladder)



The valve solenoid switches the valve.

By means of a label the valve solenoid can be linked to a valve that is solenoid operated.

Related Topics

4/2-way solenoid valve (i)

4/2-way solenoid valve (ii)

4/3-way solenoid valve with shutoff position (i)

4/3-way solenoid valve with shutoff position (ii)

4/3-way solenoid valve with floating position (i)

4/3-way solenoid valve with floating position (ii)

4/3-way solenoid valve with bypass position (i)

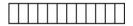
4/3-way solenoid valve with bypass position (ii)

Coupling Hydraulics, Electrics and Mechanics





Distance rule



The distance rule is a device for attaching switches at the cylinder. The labels at the distance rule define links to the actual proximity switches or limit switches in the electrical circuit.

Related Topics

Switches at Cylinders

Double acting cylinder





Status indicator



In Edit Mode, the status indicator is automatically displayed at those components that are actuated in the circuit's initial position.

Related Topics

Break switch

Magnetic proximity switch





Cam switch



In Edit Mode, the cam switch is automatically displayed at those mechanically operated way valves that are actuated in the circuit's initial position.

Related Topics

2/2-way stem-Actuated valve (i)

2/2-way stem-Actuated valve (ii)





Text

Text

The concept of text components in FluidSIM gives the user a way in which to describe components in diagrams, assign identification texts, or to provide commentary on the diagram. The text and the appearance of text components can be customized to the user's liking.

Related Topics

Text Components and Identifications

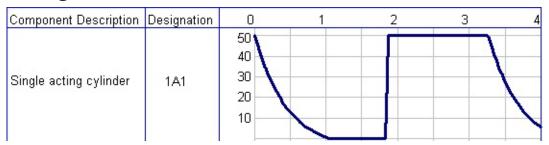
Displaying State Diagrams

Parts Lists





State diagram



The state diagram records the state quantities of important components and depicts them graphically.

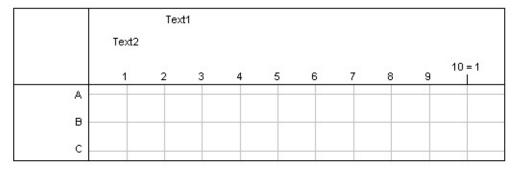
Related Topic

Displaying State Diagrams





Functional diagram editor



With the functional diagram editor, functional diagrams e.g. displacement-step diagrams can be created.

Related Topic

Functional diagram editor





Parts list

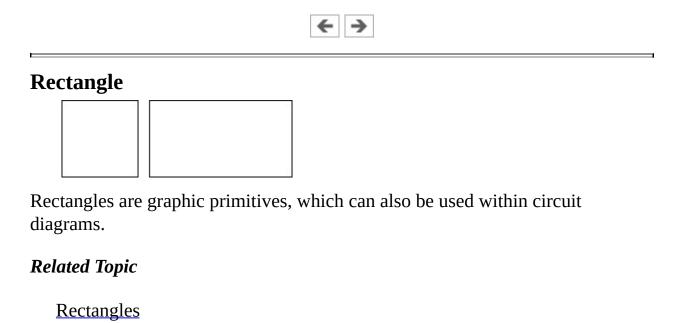
Designation	Component Description
1A	Single acting cylinder
1∨	Throttle check valve
1S	3/n Way Valve

The parts list component creates from the components of a circuit diagram a table, which contains for each component its designation and its description.

Related Topic

Parts Lists

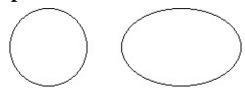








Ellipse



Ellipses are graphic primitives, which can also be used within circuit diagrams.

Related Topic

Ellipses





Bitmap



In FluidSIM images, as with all other components and objects, can be inserted, positioned, moved, rotated and mirrored. In addition, images such as <u>rectangles</u> and <u>ellipses</u> are freely scalable.

Related Topic

Embedding Pictures





[1] Lathe

Machine-tool construction is a typical area of application of hydraulics. With modern CNC machine tools, the tools and workpieces are clamped by hydraulic means. Feed motions and the spindle drive can also be hydraulically powered.

This can also serve as an example of hydraulic circuit with two pressure ranges, for example, 3 MPa (30 bar) for machining and 9 MPa (90 bar) for clamping.





[2] Press with elevated reservoir

This is an application in which extremely high forces are required. Due to the suspended cylinder and the tractive load, special measures are required for the activation of the advance stroke. This in turn requires specially-designed press drives.

A special feature is the elevated reservoir, which utilizes the static pressure in the pressure medium.





[3] Mobile hydraulics: Excavator

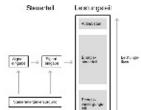
On this hydraulic excavator, not only all working movements (linear drives) but also the propulsion of the vehicle (rotary drive) are hydraulically powered. The primary drive of the excavator is an internal-combustion engine.

A model calculation can be used here to demonstrate an advantage of hydraulics - large forces with relatively small components.





[4] Structure of a hydraulic system



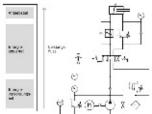
This simplified block diagram shows the division of hydraulic systems into a signal control section and a hydraulic power section. This signal control section is used to activate the valves in the power control section.

The material depicted in these electronic slides is concerned in the main with the hydraulic power section and the three "levels" of this which are shown.





[5] Hydraulic power section

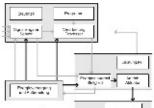


The diagram of the hydraulic power section is complemented in this case by a circuit diagram to allow correlation of the various function groups; the power supply section contains the hydraulic pump and drive motor and the components for the preparation of the hydraulic fluid. The energy control section consists of the various valves used to provide control and regulate the flow rate, pressure and direction of the hydraulic fluid. This drive section consists of cylinders or hydraulic motors, depending on the application in question.





[6] Block diagram of a control system



In analyzing and planning an actual control task, it can be helpful to use a differentiated block diagram showing the actual levels to be found on the machine.

The light arrows show the signal flow, while the solid dark arrows show the energy flow.





[7] Interaction of components



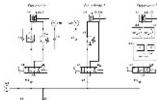
The animations show the sequences in a basic hydraulic circuit in simplified form - the actuation and spring return of the final control element (4/2-way valve), the advance and return of the drive component (double acting cylinder) and the opening and closing of the pressure relief valve.

The representations of the actuator and final control element are based on the relevant circuit symbols. This can be used as a preparation for the introduction of circuit symbols.





[8] Action related numbering



First of all the control chain is numbered sequentially according to the principle. The first actuator is given the supplementary number .0 and the associated final control element the supplementary number .1. The remaining elements get even numbers if they influence the advance stroke and uneven numbers if they influence the return stroke.

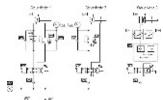
The numbering should always be entered in the circuit diagram and also on the machine to enable systematic fault-finding.







[9] Numbering in accordance with DIN ISO 1219-2

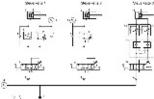


The DIN ISO Standard 1219-2 defines the code structure of the components as a string consisting of the following four parts: number of the plant, number of the circuit, component designation, and component number. If the entire system consists of a single plant only, the plant number may be dropped.





[10] Numbering in accordance with parts list



Another method used in practice is to number all the components in a hydraulic system consecutively. The numbers then correspond to the numbers in the parts list.

This method is used particularly with complex controls systems, for which a control-chain-related numbering system can not be used due the overlaps involved.





[11] Circuit symbols for energy transfer (1)



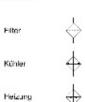
+ + The symbols shown are used in circuit diagrams for energy transfer and hydraulic-fluid preparation.

In the interests of clarity, the lines in the circuit diagram should be drawn without cross-overs as far as possible.





[12] Circuit symbols for energy transfer (2)



The direction of the arrows in the circuit symbols for the heater and cooler correspond to the direction of heat flow.





[13] Circuit symbols for energy conversion



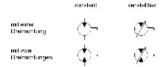
Wartestration of a drive shaft. Triangles in the circles show the direction of flow. The triangles are shown solid, since pressure fluid is used in hydraulics.

If the pressure medium is gaseous, as in the case of pneumatics, the triangles are shown in outline.





[14] Circuit symbols for hydraulic motors



The symbols for hydraulic motors are distinguished from the symbols for hydraulic pumps by the fact that the arrows showing the direction of flow are the other way round.





[15] Circuit symbols for single acting cylinders

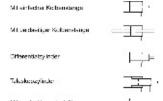
Rückstellung durch bulsere Kraft	
Federrückstellung	4/5
Teleskoozylinder	

Single acting cylinders have one port, i.e. pressure fluid can be applied only to the piston side. With these cylinders, the return stroke is produced either by external force, shown in the symbol by an opening bearing cap, or by a spring is shown within the symbol in this latter case.





[16] Circuit symbols for double acting cylinders



Double acting cylinders have two ports to allow pressure fluid to be applied to both cylinder chambers. The symbol for a differential cylinder is distinguished from the symbol for a double acting cylinder by the two lines added to the end of the piston rod. The area ratio is generally 2:1. In the case of cylinders with double- ended piston rods, the symbol shows that the piston areas are of equal size (synchronous cylinders).





[17] Circuit symbols for directional control valves (1)

Wagazanti	Rubestalung	Symbol
2/2	Gespert (P.A)	1 1
22	Dundriluser (** - A*)	==
3/2	Gespert (P.A-T)	1-1/2
3,5	D.ndrluser(P-A,T)	XI.

Designations for directional control valves always give firstly the number of ports and then the number of switching positions. Directional control valves always have at least two ports and at least two switching positions. The number of squares shows the number of possible switching positions of a valve. Arrows within the squares show the direction of flow. Lines shown how the ports are interconnected in the various switching positions of the valve. The designations always relate to the normal position of the valve.





[18] Circuit symbols for directional control valves (2)

Wegevend	Ruheste lung	Symbol
4-2	Durchfloss (P - B, A - T)	ПĴХÍ
5/2	Durchfluss (A - R, P - B - T)	r#4

This illustration shows the circuit symbols for 4/2- and 5/2- way valves.

There are two general methods for the designation of ports, using either the letters P, T, R, A, B and L or consecutively using A, B, C, D etc.; the first method is the preferred one in the relevant standard.





[19] Circuit symbols for directional control valves (3)

Wegeventil	Miteletellung	Symbol
43	Gespert (P. A. B. T)	MŢ.
40	Pumperumlauf (P - T, A, B)	ПĖĮХ
45	$H\text{-}Mitelstalling \ (P\cdot A\cdot B\cdot T)$	ni-jix
48	Arbeitskelungen enfestet (P.A. B. T)	ni ix
		miller.

The illustration shows the circuit symbols for 4/3-way valves with various mid-positions.





[20] Circuit symbols for manual operation



The switching position of a directional control valve can be changed by various actuation methods. The symbol for the valve is accordingly supplemented by a symbol indicating the actuation methods shown, such as pushbuttons and pedals, a spring is always necessary for resetting. Resetting can, however, also be achieved by actuating the valve a second time, for example in the case of valves with hand levers and detents.

The various actuating methods possible are listed in DIN ISO 1219.





[21] Circuit symbols for mechanical actuation

Stößel oder Taster

Feder

M

Rollenstößel

This illustration shows the symbols for stem or push button, spring and roller stem.





[22] Circuit symbol for pressure valves

Druckbegrenzungsvenit $\begin{bmatrix} \sum_{i=1}^{N} A_i & \sum_{i=1}^{N} A_i \\ \sum_{i=1}^{N} A_i & \sum_{i=1}^{N} A_i \end{bmatrix}$ 2-Wege-Gruckregelvenit $\begin{bmatrix} \sum_{i=1}^{N} A_i & \sum_{i=1}^{N} A_i \\ \sum_{i=1}^{N} A_i & \sum_{i=1}^{N} A_i \end{bmatrix}$

Pressure valves are represented using squares. The flow direction is indicated by an arrow. The valve ports can be designated as P (supply port) and T (tank return port) or as A and B. The position of the arrow within the square indicates whether the valve is normally open or normally closed. Adjustable pressure valves are indicated by a diagonal arrow through the spring. Pressure valves are divided into pressure relief valves and pressure regulators.





[23] Circuit symbols for flow control valves

A distinction is made in flow control valves between types which are affected by viscosity and those which are unaffected. Flow control valves unaffected by viscosity are termed orifices. A 2-way flow control valve consists of restrictors, one adjustable restrictor which is unaffected by viscosity (orifice) and a regulating restrictor (pressure compensator). These valves are represented by a rectangle containing the symbol for the adjustable restrictor and an arrow to represent the pressure compensator. The diagonal arrow through the rectangle indicates that the valve is adjustable.





[24] Circuit symbols for non-return valves

Rückschagventil, federbelastet

designated by the letter X.

Entsperitures

The symbol for non-return valves is a ball which is pressed against a seat. Delockable non-return valves are shown by a square containing the symbol for a non- return valve. The pilot control for unlocking the non-return valve is indicated by a broken line at the pilot port. The pilot port is





[25] Circuit symbols for measuring devices

Druckmessgerät

Thermometer

☐

Durchflussmessgerät

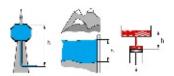
☐

The illustration shows the symbols for measuring devices used in hydraulics.





[26] Hydrostatic pressure



Hydrostatic pressure is the pressure created above a certain level within a liquid as a result of the weight of the liquid mass. Hydrostatic pressure is not dependent on the shape of the vessel concerned but only on the height and density of the column of liquid.

Hydrostatic pressure can generally be ignored for the purpose of studying hydraulics (exception: see <u>topic 2</u>).





[27] Pressure propagation

If a force F acts on an area A of an enclosed liquid, a pressure p is produced which acts throughout the liquid (Pascal's Law).

Hydrostatic pressure has been ignored here. The term pressure propagation is also used to mean the pulse velocity in liquids (approx. 1000 m/s).





[28] Power transmission

If a force F_1 is applied to an area A_1 of a liquid, a pressure p results. If, as in this case, the pressure acts on a larger surface A_2, then a larger counter-force F_2 must be maintained. If A_2 is three times as large as A1, then F_2 will also be three times as large as F_1.

Hydraulic power transmission is comparable to the mechanical law of levers.





[29] Displacement transmission (1)

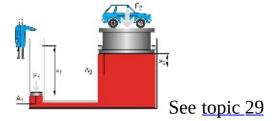
If the input piston of the hydraulic press travels a distance s_1, a volume of fluid will be displaced. This same volume displaces the output piston by the distance s_2. If the area of this piston is larger than that of the input piston, the distance s_2 will be shorter than s_1.

Hydraulic displacement transmission is comparable to the mechanical law of levers.





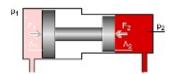
[30] Displacement transmission (2)







[31] Pressure transfer (1)



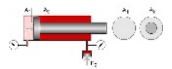
The fluid pressure p_1 exerts a force F_1 on the surface A_1 which is transferred via the piston rod to the small piston. The force F_1 thus acts on the surface A_2 and produces the fluid pressure p_2 . Since the piston area A_1 is smaller than the piston area A_1 , the pressure p_2 must be larger than the pressure p_1 .

The pressure-transfer (pressure-intensification) effect is put to practical use in pneumatic/hydraulic pressure intensifiers and also in purely hydraulic systems when extremely high pressures are required which a pump cannot deliver.





[32] Pressure transfer (2)



A pressure-transfer effect also occurs in conventional double acting cylinders with single piston rod.

This effect also causes problems in hydraulics. If, for example, an exhaust flow control is fitted to a differential cylinder for the advance stroke, a pressure-intensification effect results in the piston-rod chamber.





[33] Types of flow



A distinction is made between laminar flow and turbulent flow. In the case of laminar flow, the hydraulic fluid moves through the pipe in ordered cylindrical layers. If the flow velocity of the hydraulic fluid rises above a critical speed, the fluid particles at the center of the pipe break away to the side, and turbulence results.

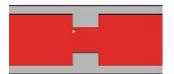
Turbulent flow should be avoided in hydraulic circuits by ensuring they are adequate sized.





[34] Diesel effect



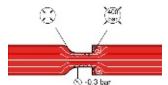


A pressure drop to the level of vacuum may occur at points of restriction, causing precipitation of the air dissolved in the oil. When the pressure rises again, oil bursts into the gas bubbles and spontaneous ignition of the oil/air mixture may occur.





[35] Cavitation



Motion energy is required for an increase in the flow velocity of the oil at a restriction. This motion energy is derived from the pressure energy. If the vacuum which results is smaller than -30 kPa (-0.3 bar), air dissolved in the oil is precipitated out. When the pressure rises again due to a reduction in speed, the oil bursts into the gas bubbles.

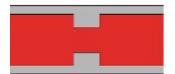
Cavitation is a significant factor in hydraulic systems as a cause of wear in devices and connections.





[36] Cavitation





Local pressure peaks occur during cavitation. This causes the erosion of small particles from the wall of the pipe immediately after the reduced cross-section, leading to material fatigue and often also to fractures. This effect is accompanied by considerable noise.





[37] Input and output power

Various losses occur at the individual devices within a hydraulic control chain. These consist essentially of mechanical, electrical and volumetric losses.

After an installation has been in service for some time, there will be a change in particular in the volumetric efficiency of the pump, as the result, for example, of cavitation (see <u>topic 35</u>).





[38] Hydraulic power unit

The hydraulic power unit (power supply unit) provides the energy required for the hydraulic installation. Its most important components are the reservoir (tank), drive (electric motor), hydraulic pump, pressure relief valve (safety valve), filter and cooler. The hydraulic power unit may also act as a carrier for other devices (gauges, directional control valves).





[39] Hydraulic power unit: Reservoir

The hydraulic reservoir contains the hydraulic fluid required the operate the installation. Within the reservoir, air, water and solid matter are separated out of the hydraulic fluid.

The size of the reservoir will depend on the practical application involved; for stationary systems, the volume of fluid delivered by the pump in 3 to 5 minutes can be taken as a guide. In mobile hydraulic systems, on the other hand, the reservoir contains only the maximum quantity of hydraulic fluid required.





[40] Externally toothed gear pump

The increase in volume which results when a tooth moves out of mesh produces a vacuum in the suction area. The hydraulic fluid is conveyed into the pressure area. The hydraulic fluid is then forced out of the tooth gaps by the meshing of the teeth and displaced into the above supply line.





[41] Internally toothed gear pump



The inner gear is driven by a motor. The teeth of the inner wheel drive the outer gear wheel. The rotary motion creates a vacuum in the gaps between the teeth, causing hydraulic fluid to be sucked in. On the other side, the teeth engage once more and oil is displaced from the tooth chambers.

The design can deliver pressures of up to approx. 17.5 MPa (175 bar). Hydraulic motors represent the reverse of the function principle.





[42] Circuit diagram: Return flow filter

An oil filter situated in the return line to the tank has the advantage that the filter is thus easy to maintain. A disadvantage, however, is that contamination is removed from the hydraulic fluid only after it has passed through the hydraulic components.

This configuration is often used.





[43] Circuit diagram: Pump inlet filter

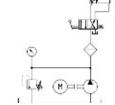
With this configuration, the pump is protected from contamination. The filter is, on the other hand, less easily accessible.

If these filters have a too fine mesh, suction problems and cavitation effects may occur. Additional coarse filters upstream of the pump are recommended.





[44] Circuit diagram: Pressure line filter



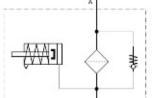
Pressure filters can be installed selectively upstream of valves which are sensitive to contamination; this also enables smaller mesh sizes to be used.

A pressure-resistant housing is required, which makes this configuration more expensive.





[45] Circuit diagram: Contamination indicator



It is important that the effectiveness of a filter can be checked by a contamination indicator. The contamination of a filter is measured by the pressure drop; as the contamination increases, the pressure upstream of the filter increases. The pressure acts on a spring- loaded piston. As the pressure increases, the piston is pushed against a spring.

There are a number of different display methods. Either the piston movement is directly visible or it is converted into an electrical or visual indication by electrical contacts.





[46] Water cooler

With this design of cooler, hydraulic fluid is fed through tubes over which coolant (water) flows. The heat which is discharged can be reused.

The operating temperature in hydraulic installations should not exceed 50 - 60°C, since this would cause an unacceptable reduction in viscosity, leading to premature aging of the fluid. In comparison with air cooling, operating costs a higher due to the required coolant and the susceptibility to corrosion. Temperature difference of up to approx. 35°C can be handled.





[47] Air cooler

Hydraulic fluid from the return line flows through a coiled pipe which is cooled by a fan.

The advantages here are simplicity of installation and low operating costs. The noise of the fan may be a nuisance (see also <u>topic 46</u>).





[48] Heating element



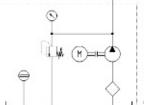
Heaters are often required to ensure that the optimum operating temperature is reached quickly. Heating elements or flow preheaters are used for heating and pre-heating hydraulic fluid.

If the viscosity is to high, the resulting increase in friction and cavitation leads to greater wear.





[49] Circuit diagram: Hydraulic power unit



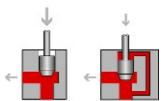
The illustration shows the detailed circuit symbol for a hydraulic power unit.

Since this is an combination unit, a dot/dash line is placed around the symbols representing the individual units.





[50] Actuating force

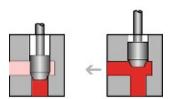


With some types of poppet valves, the actuating force, which is dependent on pressure and area, may be very high. In order to avoid this, pressure compensation may be provided at the valves.





[51] **Poppet principle**

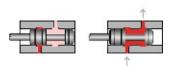


Valves are based either on the poppet principle or slide principle. In poppet valves, a ball, a cone or a disc is pressed by a spring against the seat of a passage. The high pressure per unit area which is created, means that valves of this kind provide a very efficient seal. The illustration shows a cone used as a sealing element.





[52] Slide principle



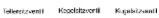
This illustration shows the principle of a longitudinal slide valve. In order to allow the piston to move, it has a certain clearance and floats in hydraulic fluids. Ring grooves ensure an even film of oil and thus pressure equilibrium. The piston can thus be moved with minimal frictional losses.

This type of valve cannot provide a perfect seal, which means that there is always a certain oil leakage.





[53] **Poppet valves**







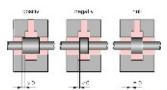


In poppet valves, a ball, cone or occasionally a disk is pressed against a seat area to act as a sealing element. Valves of this type provide a very efficient seal.





[54] Piston overlap



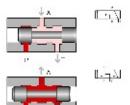
The switching characteristics of a valve are governed by, among other things, its piston overlap. A distinction is made between positive, negative and zero overlap. In the case of positive overlap, the port in question is completely covered by the piston, while with negative overlap it is less than completely covered. In the case of zero overlap, the distances between the control edges of the piston and of the port are exactly the same.

The individual control edges of the pilot piston can have different overlaps.





[55] Negative switching overlap



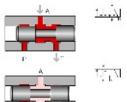
In the case of negative overlap, flow from A to T is not quite closed when the inlet P is opened. This means that the pressure at port A rises slowly and the piston starts gently.

In manufacturers' data sheets, overlap positions are shown within dotted lines between the switching positions, or the overlap positions are shown in color or with a patterned background.





[56] Positive switching overlap



In the case of positive overlap, the left-hand piston does not open the passage from P to A until the tank has been completely isolated by the other piston. Pressure is immediately fed to the load device (cylinder or hydraulic motor) with the result that this starts abruptly.





[57] Control edges



The control edges of the pistons are often either sharp, chamfered or notched. The profiling of the control edges means that the throttling action of the flow when switching is gradual rather than abrupt.

See also the example in topic 144.





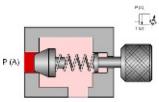
[58] Vertical interconnection system

Vertical interconnection systems ("modular hydraulics") mean that less space is required and that no piping is needed between the components. The circuit symbols directly marked on the components give greater clarity in the installation.





[59] Pressure relief valve (1)



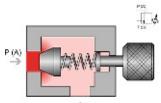
In this design incorporating a poppet valve, a seal is pressed against the inlet port P by a pressure spring when the valve is in its normal position.

In this situation, for example, an unloaded piston rod is executing an advance stroke and the entire pump delivery is flowing to the cylinder.





[60] Pressure relief valve (2)



As soon as the force exerted by the inlet pressure at A exceeds the opposing spring force, the valve begins to open.

In this situation, for example, the piston rod is fully advanced; the entire pump delivery is flowing at the preset system pressure to the tank.





[61] PRV used to limit system pressure

This illustration shows a pressure relief valve within a basic hydraulic circuit (used to control a double acting cylinder).

The resistances at the outlet (tank line, filter) must be added to the force of the spring in the pressure relief valve. See also the animation <u>"Interaction of components"</u> (topic 7).





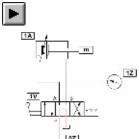
[62] Circuit diagram: PRV used to limit system pressure

This illustration shows the same circuit as the previous illustration, but with the cut-away view of the PRV replaced by the appropriate circuit symbol.





[63] Circuit without brake valve



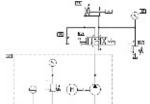
One application of pressure relief valves is as brake valves; these prevent pressure peaks which may otherwise occur as the result of mass moments of inertia when a directional control valve is suddenly closed. The animation shows an (incorrect) circuit in schematic form in which the working line on the exhaust side has fractured due to the absence of a brake valve.

The next animation (topic 64) shows the correct circuit.





[64] Circuit diagram: Brake valve



This illustration shows the correct circuit for the problem in topic 63. This circuit incorporates not only a brake valve on the piston-rod side but also a non-return valve on the inlet side via which oil can be taken in from a reservoir during the vacuum phase following the closure of the directional control valve.

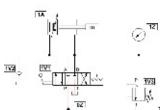
The <u>following animation</u> shows the events which occur in the two working lines.





[65] Circuit with brake valve





First the animation shows in schematic form the behavior of the PRV during the braking phase, then it shows the behavior of the non-return valve (NRV) in the supply line.

The necessity of the brake valve can be demonstrated by topic 63.





[66] Circuit diagram: PRV as back-pressure valve

Back-pressure valves counteract mass moments of inertia with tractive loads. The illustration shows a circuit with a back-pressure valve on the piston-rod side. On the return stroke, the PRV is by-passed by an NRV.

The PRV must be pressure-compensated and the tank port must be capable of carrying a pressure load.





[67] PRV, internally controlled, cushioned

Pressure relief valves often incorporate cushioning pistons or flow control valves. The cushioning device shown provides fast opening and slow closing of the valve. This prevents damage caused by pressure shocks (smooth valve operation).

Pressure shock arise, for example, when the pump delivers oil in an almost unpressurized condition and the supply port of the load device is abruptly closed by a directional control valve.

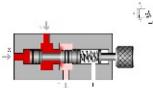


[68] PRV, externally controlled (1)

This pressure relief valve controls the flow in accordance with an external pressure setting. This pressure acts against an adjustable spring force. The passage from the supply port P to the tank port T remains closed as long as no load acts on the pilot piston.



[69] PRV, externally controlled (2)



Pressure can be fed to the pilot piston via the pilot port X. As soon as the pressure force at the pilot piston exceeds the preset spring force, the pilot piston is displaced, allowing free flow.



[70] Sequence valve

The example shows a circuit with a pressure relief valve used as a pressure sequence valve. The pressure at the pilot piston of the PRV rises via the pressure regulator. The PRV opens and the high-pressure pump delivers directly to the tank. As soon as the 2/2-way valve opens, the pressure drops. The pressure relief valve closes and the high pressure pump is connected to the system.





[71] Circuit diagram: Sequence valve

This illustration shows the same circuit as the <u>previous</u> illustration, but with the cut-away view of the sequence valve replaced by the appropriate circuit symbol.





[72] Pressure relief valve

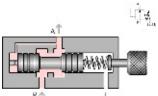


Actual photograph of a pressure relief valve.





[73] 2-way pressure regulator (1)



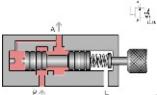
This valve is normally open. The outlet pressure (A) acts via a pilot line on the left-hand surface of the pilot piston against an adjustable spring force.

Pressure regulators reduce the inlet pressure to an adjustable outlet pressure. It is appropriate to use these in hydraulic installations only if different pressures are required.





[74] 2-way pressure regulator (2)



When the pressure rises at outlet A, the force at the left-hand surface of the pilot piston becomes greater, the piston is displaced to the right and the throttle gap becomes narrower. This causes a pressure drop.

In the case of slide valves, it is also possible to design the control edges in such way that the opening gap increases only slowly. This gives greater control precision.



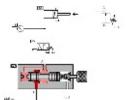
[75] 2-way pressure regulator (3)

When the preset maximum pressure is reached, the throttle point closes completely; the pressure set on the pressure relief valve is produced at the inlet P.





[76] 2-way pressure regulator (4)



In the circuit illustrated, the piston rod of the cylinder is executing an advance stroke. The pressure at the outlet A of the pressure regulator is less than the system pressure at P and constant.





[77] 2-way pressure regulator (5)

The piston rod of the cylinder is now in its forward end position. The pressure at outlet A thus continues to rise and the throttle point closes completely.



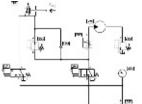


[78] Circuit diagram: 2-way pressure regulator

The illustration shows the same circuit as the previous illustration, but with the 2-way pressure regulator in the form of a circuit symbol.



[79] Circuit diagram: 2-way pressure regulator



It is appropriate to use PRVs only when different pressures are required in an installation. The mod of operation of pressure regulator will thus be explained here by taking an example with two control circuits. The first control circuit acts via a flow control valve on a hydraulic motor which drives a roller. This roller is used to stick together multi-layered printed circuit boards. The second control circuit acts on a hydraulic cylinder which draws the roller towards the boards at an adjustable reduced pressure.

This example can be used as a preliminary stage to the introduction of the 3-way PR. If the 2-way PR is closed due to the fact that the preset maximum pressure has been reached, thickening of the material of the workpieces would cause an increase in the pressure on the outlet side of the PR to a higher value than desired. (See also the animation for topic 84.)





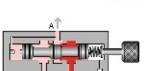
[80] 3-way pressure regulator (1)

The 3-way pressure regulator can be regarded as a combination of a 2-way PR and a pressure relief valve (PRV). The PR is in its normal position here; only a low pressure has built up at the outlet A.





[81] 3-way pressure regulator (2)



When the pressure at A rises the result of external conditions, this pressure acts via a pilot line on the left-hand piston surface of the pilot piston against an adjustable spring force. Every pressure increase causes the throttle gap to become narrower, resulting in a pressure drop.



[82] 3-way pressure regulator (3)

200 IV

When the maximum preset pressure is reached, the throttle point closes completely. The pressure set on the system-pressure limiter is produced at the inlet P.





[83] 3-way pressure regulator (4)

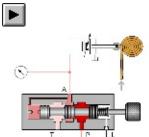
If the pressure rises above the preset value as the result of an external load at outlet A, the valve opens to allow flow from A to the tank port T (pressure-limiter function).

3-way pressure regulators are available with both positive and negative piston overlap. If a 3-way pressure regulator is created by combining a 2-way pressure regulator and a pressure relief valve, the "overlap" is adjustable.





[84] 3-way pressure regulator



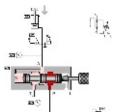
The animation shows both the pressure-regulator and pressure-limiter function of a 3-way pressure regulator through the example of a roller which exerts a constant pressure on moving material of variable thickness.

The final control element which is normally interposed has been omitted here in the interests of clarity.





[85] 3-way pressure regulator (5)



A 3-way PR is shown here in a functional representation, incorporated into a model circuit diagram. The piston rod of the cylinder is subject to external force and the pressure regulator provides a pressure-limiter function.





[86] 3-way pressure regulator (6)



The illustration shows the same circuit as the <u>previous</u> illustration, but with the functional representation of the 3-way pressure regulator replaced by a "detailed" circuit symbol.

3-way pressure regulators are available with both positive and negative piston overlap. If a 3-way pressure regulator is created by combining a 2-way pressure regulator and a pressure relief valve, the "overlap" is adjustable.





[87] Circuit diagram: 3-way pressure regulator

The illustration shows the same circuit as the <u>previous</u> <u>illustration</u>, but with the standard circuit symbol for a 3-way pressure regulator.





[88] **2/2-way valve (1)**



The 2/2-way valve has a working port A, a supply port P and a leakage-oil port L. In the case of the valve shown here, of slide design, flow from P to A is closed in the normal position.

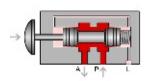
A relief line leading to the leakage-oil port is provided to prevent a build-up of pressure in the spring and piston chambers.





[89] **2/2-way valve (2)**





open.

The 2/2-way valve is actuated and the passage from P to A is

2/2-way valves are also available which are normally open from P to A.



[90] 2/2-way valve as by-pass valve

This example shows a 2/2-way valve used as a by-pass valve; when the 2/2-way valve is actuated, the flow control valve 0V2 is by-passed, causing the piston rod of the cylinder to advance at maximum speed.





[91] Circuit diagram: 2/2-way valve as by-pass valve

The illustration shows the same circuit as the <u>previous</u> <u>illustration</u>, but with the functional representation of the 2/2-way valve replaced by a circuit symbol.





[92] Circuit diagram: 2/2-way valve as final control element

In its initial position, the cylinder is advanced. If the 2/2-way valve 0V1 is actuated, the entire volumetric flow passes to the tank and piston rod of the cylinder is reset by the external load m. If 0V1 is not actuated, the system pressure set on the pressure limiter 0V2 builds up and the piston rod advances.

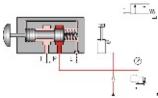
In the initial position, the pump operates against the preset system pressure, which has an unfavorable effect on the power balance of the circuit shown.





[93] **2/2-way valve as final control element**



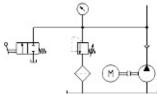


The animations show the actuation and release of the 2/2-way valve, which causes the piston rod of the cylinder to advance and retract.





[94] Circuit diagram for pressure-less pump recirculation



The part circuit diagram shows a 2/2-way valve used as a by-pass valve to achieve pressure-less pump recirculation; if the valve is actuated, the pump no longer needs to operate against the preset system pressure.

One application of this circuit is with 4/3-way valves which are closed in their mid-position in cases where, with the installation operational, it is desired to switch to pump recirculation (see also <u>topic 116</u>).





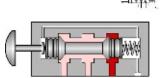
[95] Circuit diagram: Pressure stage circuit

The part circuit diagram shows a 2/2-way valve used as a selector switch for one of two preset system pressures ("pressure levels"); if the 2/2-way valve is actuated, flow is enabled to a second system-pressure limiter.





[96] 3/2-way valve (poppet principle) (1)



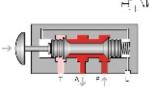
The 3/2-way valve has working port A, a supply port P and a tank port T. Volumetric flow can be routed from the supply port to the working port or from the working port to the tank port. The third port in each case is closed. In the normal position shown, P is closed and flow released from A to T.

See also topic 101 (slide principle).





[97] 3/2-way valve (poppet principle) (2)



The 3/2-way valve is actuated; flow is released from P to A, the outlet T is closed.

3/2-way valves which are normally open from P to A and T closed are also available.





[98] 3/2-way valve as final control element

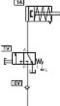
The circuit shows the 3/2-way valve in a functional representation as a final control element of a single acting cylinder.

The non-return valve protects the pump in cases where the 3/2-way valve is actuated and the piston rod is subject to an external load.





[99] Circuit diagram: 3/2-way valve as final control element



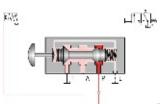
The illustration shows the same circuit as the <u>previous</u> <u>illustration</u>, but with the circuit symbol for the 3/2-way valve.





[100] 3/2-way valve





The animations show the actuation and release of the manual pushbutton for a 3/2-way valve, which causes the piston rod of the cylinder to advance and retract.





[101] 3/2-way valve (slide principle) (1)

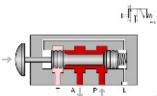
The 3/2-way valve has a working port A, a supply port P and a tank port T. The volumetric flow can be routed from the supply port to the working port, or from the working port to the tank port. The third port in each case is closed. In the normal position shown, P is closed and flow is released from A to T.

See also the 3/2-way valve designed on the poppet principle (Topic 96).





[102] 3/2-way valve (slide principle) (2)



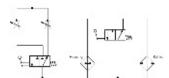
The 3/2-way valve is actuated; flow is released from P to A, and the outlet T is closed.

3/2-way valves which are normally closed from P to A and T are also available.





[103] 3/2-way valves as diverter



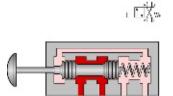
In addition to their application as final control elements, 3/2-way valves can also be used as diverters. In this case, port T is connected to a further device, to which a switch-over can then be made. The part circuit diagrams show the facility to switch between the flow control valves with different settings and between heating and cooling.

The circuit symbol is drawn reversed to simplify the representation of the circuit diagram.





[104] **4/2-way valve, two pistons (1)**



port P and a tank port T. The supply port is always connected to one of the working ports, while the second working port is routed to the tank. In the normal position, there is flow from P to B and from A to T.

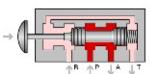
In contrast to valves with three pistons, 4/2-way valves with two pistons do not require a leakage-oil port (see <u>topic 106</u>).





[105] **4/2-way valve, two pistons (2)**





and from B to T.

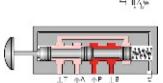
The 4/2-way valve is actuated, and there is flow from P to A

4/2-way valves are also available which are normally open from P to A and from B to T.





[106] **4/2-way valve, three pistons (1)**



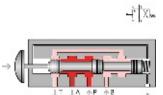
This 4/2-way valve has two working ports A and B, a supply port P and a tank port T. The supply port is always connected to one of the working ports, while the second working port is routed to the tank. In the neutral position, there is flow from P to B and from A to T.

4/2-way valves with three pistons require a leakage-oil port, since hydraulic fluid would otherwise be trapped within the valve.





[107] **4/2-way valve, three pistons (2)**



The 4/2-way valve is actuated, and there is flow from P to A and from B to T.





[108] 4/2-way valve, three pistons (3)

The circuit shows the 4/2-way valve in functional representation as a final control element of a double acting cylinder.

The non-return valve protects the pump in cases where the piston rod of the cylinder is subject to an external load.





[109] Circuit diagram: 4/2-way valve

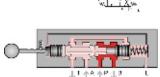


The illustration shows the same circuit as the <u>previous</u> <u>illustration</u>, but with the 4/2-way valve as a circuit symbol.





[110] 4/3-way valve with pump bypass (1)



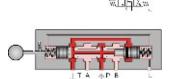
From the logic point of view, 4/3-way valves are 4/2- way valves with an additional mid-position. There are various versions of this mid-position (in the mid-position in the example shown, the supply port P is directly connected to the tank T, see next illustration). In the switching position shown, there is flow from P to B and from A to T.

4/3-way valves are easy to construct as slide valves and of complex design as poppet valves.





[111] 4/3-way valve with pump bypass (2)



The 4/3-way valve is in its mid-position; there is flow from P to T, while A and B are closed. Since the output from the pump flows to the tank, this switching position is called pump bypass or also pump recirculation.

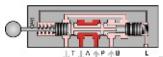
In the case of pump bypass, the pump needs to operate only against the resistance of the valve, which has a favorable effect on the power balance.





[112] 4/3-way valve with pump bypass (3)





The valve is in its left-hand switching position; there is flow from P to A and from B to T.





[113] 4/3-way valve with pump bypass (4)

The circuit shows the 4/3-way valve in functional representation as a final control element of a double acting cylinder. The valve is in its mid-position; the pump delivery flows via the by-pass line within the pilot piston to the tank.

The non-return valve protects the pump in cases where the piston rod of the cylinder is subject to an external load.





[114] Circuit diagram: 4/3-way valve with pump bypass

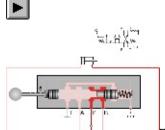


The illustration shows the same circuit as the <u>previous</u> <u>illustration</u>, but with the 4/3-way valve as a circuit symbol.





[115] 4/3-way valve with pump bypass



The animations show the switching of the 4/3-way valve into the three switching positions and the corresponding cylinder movements. During the advance stroke, movement can be halted by switching to the mid- position.

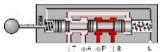
As appropriate to the application in question, a circuit of this kind must be equipped with a brake valve to prevent damage to the installation when the valve is switched to the mid-position (see also <u>topic 64</u>).





[116] 4/3-way valve with closed mid-position (1)





From the logic point of view, 4/3-way valves are 4/2- way valves with an additional mid-position. There are various versions of this mid-position (in the mid-position in the example shown, all ports are closed in the mid-position, see next-illustration). In the switching position shown, there is flow from P to B and from A to T.





[117] 4/3-way valve with closed mid-position (2)





The 4/3-way valve is in its mid-position; all ports apart from the leakage-oil port are closed.

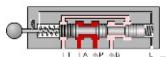
In this mid-position, the pump is operating against the system pressure set on the pressure relief valve.





[118] 4/3-way valve with closed mid-position (3)



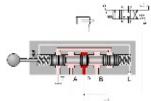


The valve is in its left-hand switching position; there is flow from P to A and from B to T.





[119] 4/3-way valve with closed mid-position (4)



The circuit shows the 4/3-way valve in functional representation as a final control element of a double acting cylinder. The valve is in its mid-position; the pump is operating against the system pressure set on the PRV.

If, with an operational installation, it is desired to switch to pump recirculation, this can be achieved by using an additional 2/2-way valve as a changeover valve (see part circuit-diagram in topic 94).





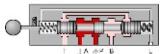
[120] Circuit diagram: 4/3-way valve with closed mid-position

The illustration shows the same circuit as the previous illustration, but with the 4/3-way valve as a circuit symbol.





[121] 4/3-way valve: overlap positions (1)



The illustration shows the left-hand overlap position of a 4/3-way valve with positive overlap in the mid-position (closed mid-position). This overlap position is a mixture of positive and negative overlap; P is connected to A, B and T are closed.

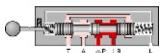
With 4/3-way valves, the types of overlap positions is generally specified in the data sheet.





[122] 4/3-way valve: overlap positions (2)





The illustration shows the "right-hand" overlap position of a 4/3-way valve with positive overlap in the mid-position (closed mid-position). This overlap position, too, is a mixture of positive and negative overlap; P is connected to B, A and T are closed.





[123] Directional control valve



Actual photograph of a directional control valve with lever





[124] **4/3-way module**

This 4/3-way module with hand-lever actuation is used in vertical interconnection systems ("modular hydraulics").

See also the illustration in <u>topic 58</u>.





[125] Non-return valve (1)



Non-return valves block flow in one direction and allow free flow in the other. In the direction of flow shown, the sealing element is pressed against a seat by a spring and the hydraulic fluid.

These valves are also available in designs without springs. Since there must be no leaks in the closed position, these valves are generally of poppet design.





[126] Non-return valve (2)

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In the direction of flow shown, the valve is opened by the hydraulic fluid, which lifts the sealing element from the seat.



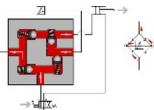
[127] Circuit diagram: Pump protection

In this circuit, the non-return valve is used to protect the pump. This prevents a load pressure from driving the pump in reverse when the electric motor is switched off. Pressure peaks do not affect the pump but are discharged via the pressure relief valve.





[128] **Graetz block (1)**



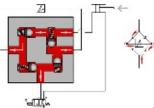
In the Graetz rectifier circuit (Graetz block), four non- return valves are combined to form a function unit. The circuit diagram shows how this operates in conjunction with a flow control valve; flow passes through this valve from left to right during both the advance and return strokes of the cylinder. The situation during the advance stroke is shown.

During the advance stroke shown here, flow control is carried out on the inlet side.





[129] **Graetz block (2)**



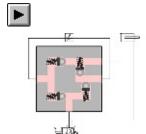
The cylinder is on its return stroke. The rectifier circuit means that flow once again passes through the flow control valve from left to right.

During the return stroke shown here, flow control is carried out on the outlet side.





[130] Graetz block



The animation shows the actuation and spring return of a 4/2-way valve and the flow through the Graetz block during the advance and return strokes.

Similar rectifier circuits are also used in conjunction with line filters or brake valves.





[131] Delockable non-return valve (1)



In the cases of delockable non-return valves, flow in the closed direction can be released by means of an additional pilot port (X). The illustration shows the valve in its normal position; flow from B to A is closed.





[132] Delockable non-return valve (2)



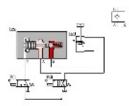
The released piston is pressurized via pilot port X. This lifts the sealing element from its seat and releases flow from B to A.

In order to release the valve reliably, the effective area of the pilot piston must always be greater than the effective area of the sealing element. Piloted non-return valves are also available with lockable non-return function.





[133] Delockable non-return valve (3)



The model circuit diagram shows how a load can be positioned by holding a cylinder using a suitable delockable non-return valve. The valve becomes active in the return stroke whereby the restriction on the piston side is released by actuation of the 3/2-way valve.

See also the <u>animation 135</u> on this topic.





[134] Circuit diagram: Delockable non-return valve

The illustration shows the same circuit as the <u>previous</u> <u>illustration</u>, but with the piloted non-return valve as a circuit symbol.



[135] **Delockable non-return valve**



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The 4/2-way valve is actuated, the hydraulic fluid passes through the non-return valve against the force of the return spring and the piston rod advances. When the 4/2-way valve is reset, the outlet on the piston side is closed by the non-return valve, and the cylinder remains advanced. The 3/2-way valve is now actuated, the pilot piston is reversed and the outlet flow released; the piston rod begins to retract. During the return stroke, the 3/2-way valve is brought temporarily into its normal position. This causes the outlet to be closed again, and the piston rod and load remain in their current position. When the 3/2-way valve is actuated again, the piston rod travels to its retracted end position.





[136] Delockable double non-return valve (1)

Delockable double non-return valves allow a load to be positioned reliably with the cylinder at a standstill, even if eternal leaks exist around the cylinder piston. When, as in the case, neither of the inlets A_1 or A_2 is pressurized, B_1 and B_2 are closed.





[137] Delockable double non-return valve (2)

When A_1 is pressurized, the left-hand sealing element is lifted from its seat, enabling flow to B_1. At the same time, the pilot piston is displaced to the right, releasing flow from B_2 to A_2.

The opposite is true when inlet A_2 is pressurized.





[138] Delockable double non-return valve (3)

The model circuit diagram shows a delockable double non-return valve used in conjunction with a 4/3-way valve to allow the vertical positioning of a load. In the mid-position of the final control element shown, ports A and B are connected to the tank. This means that the inlets A_1 and A_2

of the double non-return valve are pressure-less and both cylinder supply lines are closed.





[139] Circuit diagram: Delockable double non-return valve

The illustration shows the same circuit as the <u>previous</u> <u>illustration</u>, but with the delockable double non-return valve as a circuit symbol.



[140] Needle restrictor

Throttle and orifice valves are used to achieve a certain pressure drop. This is done by creating a specific flow resistance. The needle flow control valve shown generates considerable friction due to its long narrowing. This means that the action of the flow control valve is difficult to adjust due to the fact that a small adjustment produces a large change in cross-section.

One advantage is the simple and inexpensive design. Needle flow control valves can be used if the above- mentioned negative properties can be ignored for the purposes of a given control task.





[141] Gap restrictor with helix

Its short narrowing means that the action of this gap flow control valve is virtually independent of viscosity. The helix provides precise adjustability, since adjustment from fully open to fully closed requires a 360° turn. The helix is, however, very costly to produce.





[142] Circuit diagram: Flow division using restrictor

Throttle and orifice valves control the volumetric flow rate in conjunction with a pressure relief valve. The PRV opens when the resistance of the flow control valve becomes greater than that of the opening pressure set on the PRV. This produces a division of flow.

The volumetric flow to the load device varies, i.e. the action of flow control valves is load-dependent.





[143] Flow control valve



Actual photograph of a flow control valve.





[144] One-way flow control valve (1)

The one-way flow control valve is a combination of an orifice or throttle valve and a non-return valve. In the closed direction shown of the non-return valve, the volumetric flow passes via the variable throttle gap, which creates a considerable resistance.

Speed reduction can be achieved by using a one-way flow control valve in conjunction with a pressure relief valve or a variable-delivery pump. The pressure rises upstream of the flow control valve until the PRV opens and routes part of the flow to the tank.





[145] One-way flow control valve (2)

In the reverse direction, from B to A, flow is unrestricted, since the ball in the one-way flow control valve allows free flow (non-return function).

One-way flow control valves are available with a fixed restrictor and with variable flow control.



[146] 2-way flow control valve (1)

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Flow control valves have the task of providing constant volumetric flow independently of pressure changes at the inlet or outlet of the valve. This is achieved firstly by means of an adjustable restrictor which is set to the desired volumetric flow. In order to keep the pressure drop across the throttle point constant, a second regulating restrictor (pressure compensator) is also required. The illustration shows the valve in its normal position.

2-way flow control valves always operate in conjunction with a pressure relief valve. The part of the flow which is not required is discharged via the PRV.





[147] 2-way flow control valve (2)

When fluid flows through the valve, the pressure drop across the adjustable restrictor is kept constant by the pressure compensator, which varies the resistance at the upper throttle point in accordance with the load at the inlet or outlet.

See also the <u>animation 150</u> for this topic.





[148] 2-way flow control valve (3)

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In the case of this flow control valve, the pressure difference is kept constant by a adjustable restrictor, i.e. between p_1 and p_2. If the pressure p_3 rises as the result of an external load, the overall resistance of the valve is reduced by opening the regulating restrictor.





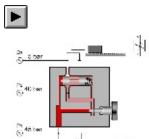
[149] Circuit diagram: 2-way flow control valve

The model circuit diagram shows the arrangement of a 2-way flow control valve in the piston-side supply line in order to achieve a constant feed speed even under varying load. A non-return valve is fitted in the by-pass to allow the flow control valve to be by-passed on the return stroke.





[150] 2-way flow control valve



The advancing piston rod encounters a load half-way through its stroke. The flow control valve nonetheless ensures that the advance speed remains constant. From 0 to 2 seconds (shown at bottom right) the piston rod is unloaded and the pressure conditions remain constant. When the piston rod encounters the load, the pressure p_3 rises at the outlet of the flow control valve. (In order to allow the rapid control operations to be shown more clearly, the time scale now changes to 1/100ths of a second.) The flow control valve briefly raises the pressure p_2 downstream of the adjustable restrictor. Following this, the regulating restrictor moves to the left, and p_2 falls back to its original value, i.e. the pressure difference between p_1 and p_2 remains constant. The regulating operation shown is repeated a number of times, as the result of which p_3 increases to 2.5 MPa (25 bar) in several steps and the regulating restrictor opens more and more. (At the point at which 2.5 MPa (25 bar) is reached, the time scale changes back to 0.1 seconds.) The piston rod now travels under load just as fast as previously without load.





[151] Single acting cylinder





In the case of a single acting cylinder, only the piston side is pressurized with hydraulic fluid. The cylinder can thus carry out work only in one direction. The fluid which flows into the piston chamber causes a pressure to build up the surface of the piston. The piston travels into its forward end position. The return stroke is effected by a spring, the dead weight of the piston rod or an external load.





[152] Plunger cylinder

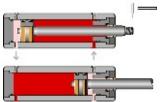


In the case of plunger cylinders, the piston and rod form a single component. Due to the design of the cylinder, the return stroke can only be effected by external forces. The cylinders can therefore generally be installed only vertically.





[153] **Double acting cylinder**



In the case of double acting cylinders, both piston surfaces can be pressurized. A working movement can thus be performed in both directions.

With double acting cylinders with a single-sided piston rod, different forces and speeds are obtained on the advance and return strokes due to the difference in area between the piston surface and annular piston surface.





[154] Double acting cylinder with end position cushioning

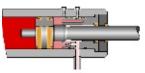
Cylinder with end position cushioning are used to brake high stroke speeds smoothly and prevent hard impacts at the end of the stroke. Shortly before the end position is reached, the cross- section for the outflow of fluid is reduced by the built-in cushioning pistons and then finally closed. The hydraulic fluid is then forced to escape through a flow control valve.





[155] End position cushioning (1)





The piston is a short distance before its end position; the hydraulic fluid on the piston-rod side must escape via the adjustable flow control valve above the piston rod

This type of end position cushioning is used for stroke speed between 6 m/min and 20 m/min. At higher speed, additional cushioning or braking devices must be used.





[156] End position cushioning (2)



The piston rod is on its return stroke; in this flow direction, the non-return valve below the piston rod is opened, thus by-passing the flow control valve. The piston rod retracts at maximum speed.

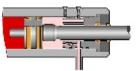




[157] End position cushioning







The illustration shows first the advance of the piston rod from a mid-position to the forward end position, with cushioning at the end of the advance movement. The non-return valve is open during the return stroke.

In addition the animation shows the opening of the pressure limiter after a certain pressure has been built up on the outlet side by the cushioning piston.





[158] **Double acting cylinder**

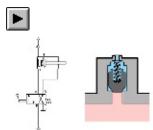


Actual photograph of a double acting cylinder.





[159] Automatic bleed valve



When the cylinder is retracted, the piston of the bleed valve is closed. It is lifted as the piston rod advances. Air can then escape via the bleed hole until the hydraulic fluid reaches the piston and pushes it upwards. In the forward end position, the piston is pushed fully upwards by the hydraulic fluid and thus provides an external seal.

Bleed valves should be fitted at the highest point in a piping system, since this is where any trapped air will collect.





[160] Piston pressure gauge

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Pressure gauges operate on the principle that pressure acting on a given area will produce a given force. In the case of piston pressure gauges, the pressure acts on a piston against the force of a spring. The pressure value is now shown on a scale either by the piston itself or by a pointer driven magnetically by the piston.





[161] Bourdon-tube pressure gauge

Most pressure gauges operate on the principle of a Bourdon tube. When hydraulic fluid flows into the tube, an identical pressure is produced throughout. Due to the difference in area between the outer and inner curved surfaces, the tube is bent. This movement is transferred to a pointer.

This type of gauge is not protected against overload. A cushioning restrictor must be installed in the inlet connection prevent pressure surges from damaging the tube.





[162] Flow meter

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The flow of oil to be measured passes through a movable orifice. The orifice consists of a fixed cone and a hollow piston mounted on a spring. The piston is pressed against the spring in proportion to the flow rate concerned. The measuring error of this type of flow meter is approx. 4%. Measuring turbines, oval disk meters or toothed-wheel gauges are used when higher accuracy is required.





[163] Exercise: Horizontal grinding machine (pump delivery)

The slide on a horizontal grinding machine is hydraulically actuated. A machine operator determines that the reciprocating movement of the machine is no longer reaching the desired speed. A possible cause of this is reduced pump delivery. To investigate this, it is necessary to plot a characteristic curve for the pump and compare this with the values achieved during initial commissioning. As an additional exercise, the circuit diagram and parts list for the necessary test assembly should be prepared.

In order to draw the characteristic curve for the pump, the volumetric flow of hydraulic fluid delivered by the pump (Q) is plotted against the operating pressure achieved (p). The manufacturer's characteristic curve exhibits a slight downward gradient, since the new pump manifests increasing internal leakage losses as necessary to provide internal lubrication. The newly-plotted curve shows a clear deviation; the leakage oil losses have become greater at higher operating pressures, the volumetric efficiency has become worse. The main reason for this is pump wear. Regarding the circuit diagram for the test assembly: The adjustable flow control valve 1V3 is adjusted in such a way that the pressure gauge 1Z1 shows the desired system pressure. The pressure relief valve 1V2 is used to limit the system pressure, while valve 1V1 acts as a safety valve for the pump.

The measured values taken as the basis for this exercise do not allow for the characteristic curve of the electric motor. The motor characteristic thus forms part of the calculated error.





[164] Exercise: Bending machine (directly-controlled pressure relief valve)

A bending machine is used to bend steel plates. The bending tools are driven by hydraulic cylinders. It is now desired to use the bending machine for considerably thicker steel plates than before. This requires a hydraulic system pressure of 45 bar against the previous 30 bar. According to the manufacturer's data, the pump used is suitable for the higher operating pressure. Testing reveals, however, that the bending process is now much too slow. In this case, leakage losses in the piping or directional control valve are ruled out as the cause of the problem. A directly-controlled pressure relief valve (PRV) is installed as a safety valve. Measurements of the volumetric flow (Q) as a function of pressure (p) are available for this valve. A characteristic curve can than be used to determine whether the loss of speed in the bending process is due to the PRV.

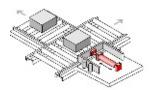
The volumetric flow which is discharged to the tank when the PRV opens is entered on the horizontal axis. The characteristic curve shows that the opening point of the PRV is 44 bar, although it is set to 50 bar. This means that part of the pump delivery is diverted at pressures greater than 44 bar. Pressures of more than 44 bar are achieved during the bending process. Since, however, the flow is divided from 44 bar onwards, the volumetric flow to the cylinder is reduced from this point and the bending process slows down. Measure to be taken: The PRTV can be set to 60 bar if the overall installation has been designed for this higher pressure. Flow diversion will then take place from a pressure of 54 bar onwards.

An alternative solution would be to use a valve with a different response pressure.





[165] Exercise: Roller conveyor (flow resistance)



Steel blocks are transported on a roller conveyor. A hydraulic transfer station makes it possible to transfer blocks from one track to another. A pressure of at least 30 bar is required for the transfer of blocks by means of hydraulic cylinders. Every component through which the hydraulic fluid flows represents a resistance and causes a constant pressure loss. The question is, what pressure is to be set at the pressure relief valve.

The total resistance is the sum of all the individual resistances. The resistance must be determined separately for the advance and return strokes. The overall balances do not include data for the pressure losses at the 4/2-way valve. These can be determined from the flow characteristic for the 4/2-way valve, based on a volumetric flow of 8 l/min. In the calculation, allowance must be made for the resistance of the directional control valve on the inlet and outlet sides respectively. Allowance must also be made for the pressure intensification factor of 2:1 in the case of the differential cylinder. This enables values to be calculated as shown in the solution figure. In the case of the advance stroke, 6 bar hysteresis for the PRV (see exercise 164) must be added to the calculated 42.5 bar in order to ensure that the opening pressure is higher than the required operating pressure. The value finally chosen is 50 bar in order to make allowance for unknown variables such as pipe elbows and the static friction in the cylinder.

In order to keep pressure losses in large installations to a minimum, it is advisable to select valves on the basis of their flow characteristics. It is better to select a valve which is one size too large than to accept large pressure losses. This furthermore reduces wear resulting from cavitation in the valves.





[166] Exercise: Embossing press (activation of a single acting cylinder)

Additional hydraulic components are to be added to an embossing press to eject the finished workpieces. A single acting cylinder (1A) is to be fitted for this purpose. A proposed solution in the form of a circuit diagram with a 2/2-way valve is to be examined to see if it is suitable for this control problem. Following this, a circuit diagram with a 3/2-way valve as final control element is to be developed and a parts list prepared. A comparison is to be made of the behavior of these two circuits during the advance and return strokes.

When a 2/2-way valve is used to activate a single acting cylinder, the final control element must be reversed and the hydraulic power unit switched off in order to retract the piston rod. The load acting on the piston rod must be larger than the resistance of the directional control valve. This solution cannot be used due to the presence of the second control chain (embossing cylinder). If a 3/2-way valve is used, a direct switch-over can be made from the advance stroke to the return stroke without switching off the hydraulic power unit. Halting at overlap positions, on the other hand (which are not required here), would be possible only by switching off the hydraulic power unit.

The non-return valve fitted in each case protects the pump against oil backpressure. This is necessary in case the hydraulic power unit is switched off with the cylinder advanced and under load.





[167] Exercise: Ladle (activation of a double acting cylinder)

Liquid aluminum is transferred from a holding furnace into a channel leading to a die-casting machine. A ladle is required for this. A double acting cylinder is used to enable the ladle to carry out the appropriate movements. A circuit diagram is provided for the activation of the cylinder with a 4/2-way valve as final control element. This must be examined to see if it is suitable for the control task concerned. The ladle must not be allowed to dip into the furnace when the valve is not actuated. A circuit diagram with a back-pressure valve must be developed to cater for the case in which the ladle is very heavy.

The requirements of the exercise are met by the first circuit diagram only if the ladle represents a light load. If the ladle is very heavy, the advance speed could rise to an unacceptably high level during the advance stroke of the piston rod (ladle moving towards furnace), and the ladle could as a result plunge too quickly into the molten metal. This can be prevented by installing a backpressure valve in the B line between the valve and cylinder (tractive load).

If, as is required in this exercise, the power component must positively assume a defined end position when the installation is at rest, valves with spring return must be used, as in this case. Here, a 4/2-way valve with spring return has been used, since this ensures that the cylinder remains in the desired position if the hydraulic power unit is switched on unexpectedly. The required cylinder diameter and the return speed of the piston rod can also be calculated as additional optional tasks in the exercise: see the model calculations in the textbook.





[168] Exercise: Paint drying oven (4/3-way valve)

Workpieces are fed continuously through a paint drying oven on a conveyor belt. In order to minimize the heat loss through the door, this should be opened only as much as required by the height of the workpieces. The hydraulic control system should be designed so that the door can be held reliably in position for a long period of time without slipping down. Firstly, a 4/3-way valve with suitable mid-position functions should be selected as a final control element. Secondly, a delockable non-return valve should be provided in the circuit diagram to act as a hydraulic safety device to prevent slippage of the door under load (i.e. its own weight) over a long period of time as the result of leakage losses in the directional control valve. The question is, which type of 4/3-way valve has a suitable mid-position function?

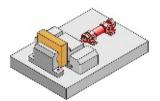
A 4/3-way valve with an "all ports closed" mid-position will solve the problem only if a poppet valve is used. If a slide valve would be used, the oven door would slip down slowly as the result of internal leakage losses.

The second solution would be to fit a delockable non- return valve in the supply line to the piston rod side of the cylinder downstream of the directional control valve. In order to ensure that the non-return valve closes immediately when the door stops, both the outlets A and B of the directional control valve to the tank must be de-pressurized (A, B and T connected, P closed).





[169] Exercise: Clamping device (closing speed)



■Workpieces are clamped by a hydraulic cylinder. The closing speed must be reduced in order to prevent damage to the workpieces. The opening speed must, however, be maintained. The question here is how to incorporate the necessary one-way flow control valve in the circuit. Possible solutions must be examined to see what thermal side- effects occur and to determine the pressure load placed on the components concerned.

The advance stroke can as a general principle be made slower by using either inlet or outlet flow control. Either solution can be used in this control; in comparison with outlet flow control, inlet flow control has the advantage that no pressure intensification will take place. The oil heated at the throttle point will, however, then pass through the power component. The resulting expansion of material is not, however, of significance for this simple vice. If the solution with outlet flow control is selected, it should be borne in mind that pressure intensification will take place in accordance with the area ratio of the differential cylinder of 2:1. The pressure relief valve will respond, i.e. flow division will occur, only when a pressure has built up on the piston-rod side which is approximately twice as high as the system pressure set on the PRV. The cylinder, flow control valve and connectors used must therefore be suitable for this intensified pressure.

Precision drives for machine tools are a good example of cases in which it is essential to make allowance for expansion of the material of power components due to the passage through these of heated oil.





[170] Exercise: Hydraulic crane (speed reduction)



Press tools of varying weights are inserted into a press by means of a hydraulic crane. A double acting cylinder raises and lowers the load. During the commissioning of the hydraulic crane, it has become apparent that the advance speed of the piston rod is too high. The solutions have been proposed to reduce this speed; a circuit with exhaust flow control and a circuit with a back-pressure valve. A suitable solution must be selected and reasons stated for this choice. Since the second solution is not capable of operating in this form, this must be rectified by correcting the circuit diagram.

If the solution with exhaust flow control is selected, it must be borne in mind that the cylinder, flow control valve and connectors must be suitable for this intensified pressure. The solution chosen is the circuit with the back-pressure valve; in this case, the load is clamped hydraulically and a pressure-intensification effect does not occur, since the pressure can be adjustable by means of the pressure relief valve as appropriate to the load. A non-return valve must be installed to provide a by-pass on the return stroke.

Inlet flow control cannot be used to control a tractive load; the load forces oil out of the piston-rod chamber faster than oil can flow into the piston chamber. Vacuum is created and air will escape.





[171] Exercise: Feed control for a lathe (speed control)

The feed movement of a lathe has previously been carried out manually. In future, this is to be performed automatically by a hydraulic control system. The feed movement must be adjustable and remain constant even with changing tool loads. Since a simple throttle valve is not able to provide a constant feed speed under changing load, a 2-way flow control valve must be used. On the basis of a circuit diagram with data for the no- load situation, values for pressures, pressure differences and feed speed under load must be added. The circuit diagram must be modified to ensure that the flow control valve is not operative on the return stroke. Finally, the relationship must be investigated between Q of the PRV and the feed speed and between Δ p_2 and the volumetric flow to the load device.

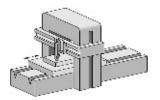
In order to prevent the flow control valve from acting as a resistance on the return stroke, a non-return valve is installed parallel to this as a by-pass. The pressure at the PRV remains constant despite the effect of the load. The outlet flow from this is therefore a constant 7 l/min. A constant volumetric flow Q at the PRV in turn means a constant volumetric flow to the load device and thus constant feed speed. Regarding the last question: No matter whether operation is with or without a load, the pressure drop Δ p_2 at the adjustable throttle remains constant. A constant pressure drop means a constant volumetric flow.

Regarding the necessity for the non-return valve in the by-pass: When flow passes through 2-way flow control valves in the reverse direction, they act either as flow control valves if the regulating restrictor is fully open or non-return valves if the regulating restrictor is closed.





[172] Exercise: Planing machine (by-pass circuit)



with the aid of a hydraulic control system. The power section of this hydraulic control system consists of a double acting differential cylinder. The area ratio of the full piston surface of this cylinder to the annular piston surface is 2:1. Since the piston-rod chamber is only half the volume of the piston chamber, the return stroke is twice as fast as the advance stroke. Machining has previously been carried out only during the advance stroke. In future, working movements are to be carried out in both directions. To make this possible, the hydraulic control system must be modified so that forward and return strokes are at the same speed. The speed should now also be adjustable. The connecting lines should be added to the given circuit diagram. The mode of operation of the circuit in the three switching positions should be described and the various piston speeds and forces compared.

In order to achieve the same speed on the advance and return strokes, a differential circuit (by-pass circuit) can be used with differential cylinders with an area ratio of 2:1. Picture 116.2 The second picture shows the principle of a by-pass circuit with a 3/2-way valve. In the case of the parallel planing machine, the necessary differential circuit can be achieved by using the mid-position of a 4/3-way valve (A, B and P connected, T closed). In this switching position (advance stroke), the piston speed and force are twice as high as in the right-hand switching position (return stroke). In the left-hand switching position, on the other hand, the advance stroke is half as fast and the force twice as great as in the other two switching positions. The speed for the advance and return strokes can be adjusted by means of a flow control valve fitted upstream.

It should also be noted that only half the force is available on the advance stroke at the mid-position. In the case of a tractive load, the by-pass position has the advantage that the piston is hydraulically clamped. Differential circuits are used not only as synchronization circuits but also as rapid-traverse circuits when, for

example, different speeds are required in the same direction with constant pump delivery. If it is desired to calculate forces and piston speeds using concrete values, the model values given in the TP 501 textbook can be used for this purpose.





[173] Exercise: Drilling machine (pressure regulator)

The drill feed and clamping device of a drilling machine are hydraulically actuated. The hydraulic control system contains two cylinders, a clamping cylinder 1A and a feed cylinder 2A. The clamping pressure at cylinder 1A must be adjustable, since different workpiece clamping forces are required. A pressure regulator is used for this. The return stroke of the clamping cylinder must be at maximum speed. The drilling feed must be adjustable for various feed speeds, which must however remain constant under varying load. It should also be noted that the drive spindle fitted to the piston rod of the drilling cylinder acts as a tractive load. The return stroke of the drilling cylinder should also be at maximum speed. A circuit should be drafted with the above-mentioned characteristics.

Pressure regulators can as general principle be used to reduce the general system pressure in a part of a hydraulic installation. If we consider the two control chains for the drilling machine without pressure regulation, we can observe the following undesirable effects: When 1V1 is actuated, the workpiece is first clamped at full system pressure. If 2V1 is now actuated, the system pressure will drop to the operating pressure of the drilling cylinder. The same applies to the pressure at the clamping cylinder. If the circuit is expanded to include the pressure regulator 1V3, this enables the clamping pressure to be adjusted. The system pressure upstream of the PRV will, however, continue to fall during the advance stroke of 2A. In order to maintain the preset clamping pressure at outlet A of the PRV reliably, the pressure at inlet P must be higher than this. This can be achieved by fitting the additional flow control valve 0V2 upstream of the final control element 2V1. Maximum return-stroke speed is achieved for the clamping cylinder by means of 1V2, which is used to by-pass 1V3. The flow control valve 2V3 means that the advance-stroke speed of the drilling cylinder is independent of load and adjustable. Due to the tractive load of the attached spindle, however, an additional PRV must be fitted as a back-pressure valve. The non-return valves 2V2 and 2V5 provide a by-pass during the return stroke and

allow maximum speed to be achieved during this.

A parts list can be specified to help in the drafting of this circuit.





The text that was exported using the DXF filter does not appear as it did in FluidSIM.

The DXF format does not sufficiently support textual objects. I.e., CAD programs may not possess the ability to translate all fonts, font attributes, font colors, and special symbols.





Simultaneous Actuation of Several Components

During the Simulation Mode, it is sometimes necessary to actuate more switches or valves simultaneously. It is possible in FluidSIM to simulate just such an actuation by means of setting a component in a permanently actuated state. A button (or a manually operated valve) will become permanently actuated when clicking on it while holding down the **Shift** key. This permanent actuation will be released by a simple click on the component.

At times it may be necessary to release several actuated objects at once. In this case, while clicking the object, hold the **Ctrl**-key instead of the **Shift**-key. The reversed components will remain actuated until the **Ctrl**-key is released again; this is how all applicable objects will simultaneously switch back to their original position.



Simulation aborted. A short-circuit was detected in an electrical circuit.

The positive and negative poles of a voltage source are directly connected without a load (indicator light, buzzer, relay, or control solenoid). The short circuit must be eliminated before simulation can take place.





②DXF Export... is not available from the menu.

Make sure that you are in the Edit Mode and that the window is not empty.





The circuit filename.ct has not been saved when the last FluidSIM session was terminated improperly. Shall this file be recovered?

FluidSIM has been terminated in an unexpected manner. However, a backup file was written from which an actual version of the unsaved circuit can be constructed. If the question is answered with "Yes" a window with the recovered circuit is opened; however, the original circuit remains unchanged. You then can decide if to whether the recovered circuit shall be saved under the original name.







Simulation aborted. The circuit is too large.

The size of circuit diagrams that can be simulated is bound. You must reduce the number of components.





The mouse cursor is not switching as described, especially on top of connections.

Make sure that the option Large Mouse Cursor has not been activated. The large mouse cursor is designed to be used with a projector; here the switching of the mouse cursor is undesirable.







!Objects are placed outside the drawing area.

At least one object has been placed outside the drawing area. After acknowledging the dialog box the respective objects are shown selected. Either change the papersize or place the selected objects inside the marked drawing area.







Open connections.

At least one component has an open hydraulic connection. After acknowledging the dialog box, all components with an open hydraulic connection are selected. If the simulation should be started, FluidSIM automatically fits blind plugs to open connections.

