Valve Control System Manual

VCS Computer Controlled Valve Control System

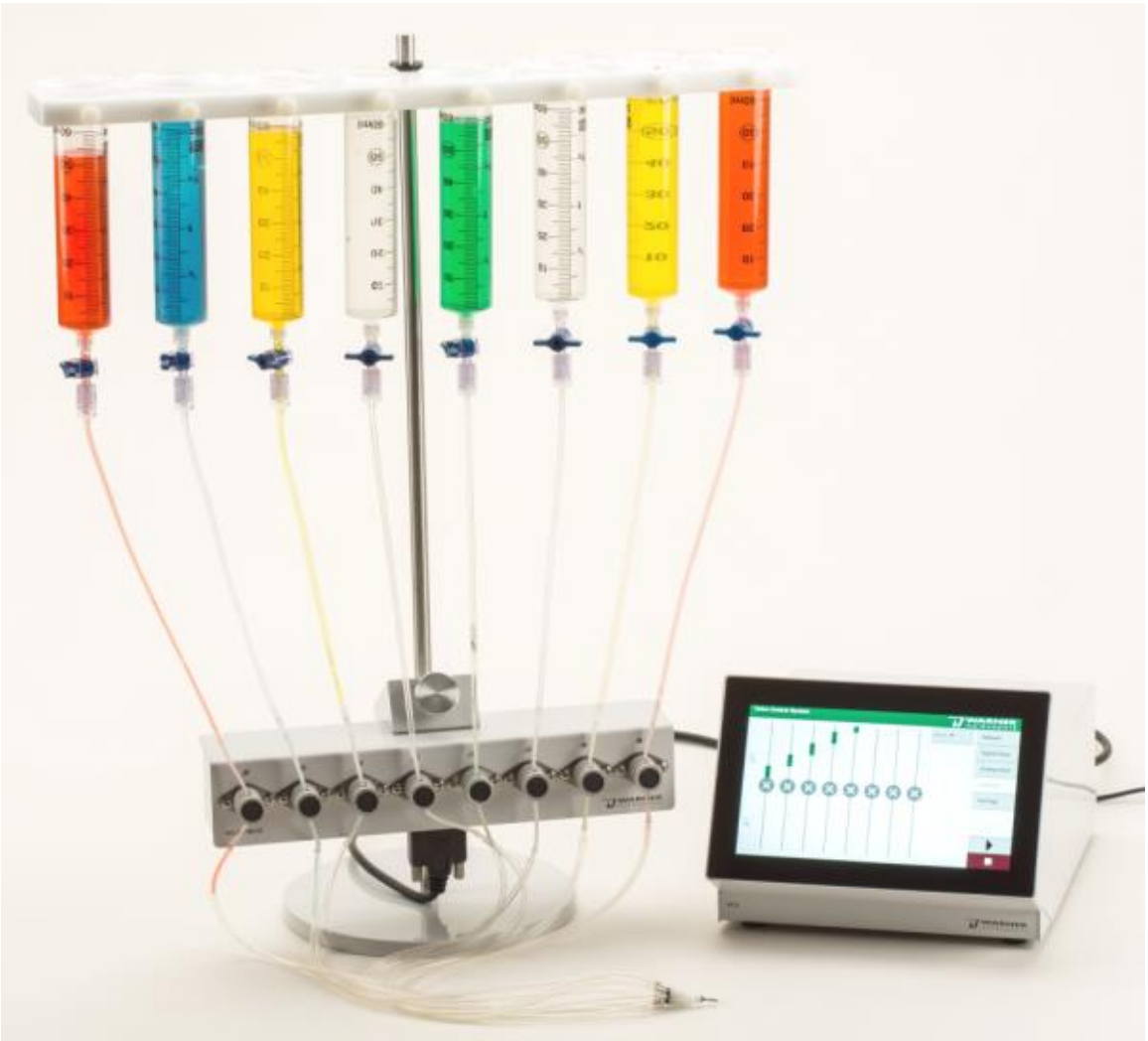


Table of Contents

Compliance Statement

WEEE/RoHS Compliance Statement EU Directives WEEE and RoHS

To Our Valued Customers:

We are committed to being a good corporate citizen. As part of that commitment, we strive to maintain an environmentally conscious manufacturing operation. The European Union (EU) has enacted two Directives, the first on product recycling (Waste Electrical and Electronic Equipment, WEEE) and the second limiting the use of certain substances (Restriction on the use of Hazardous Substances, RoHS).

Over time, these Directives will be implemented in the national laws of each EU Member State.

Once the final national regulations have been put into place, recycling will be offered for our products which are within the scope of the WEEE Directive. Products falling under the scope of the WEEE Directive available for sale after August 13, 2005 will be identified with a “wheelie bin” symbol.

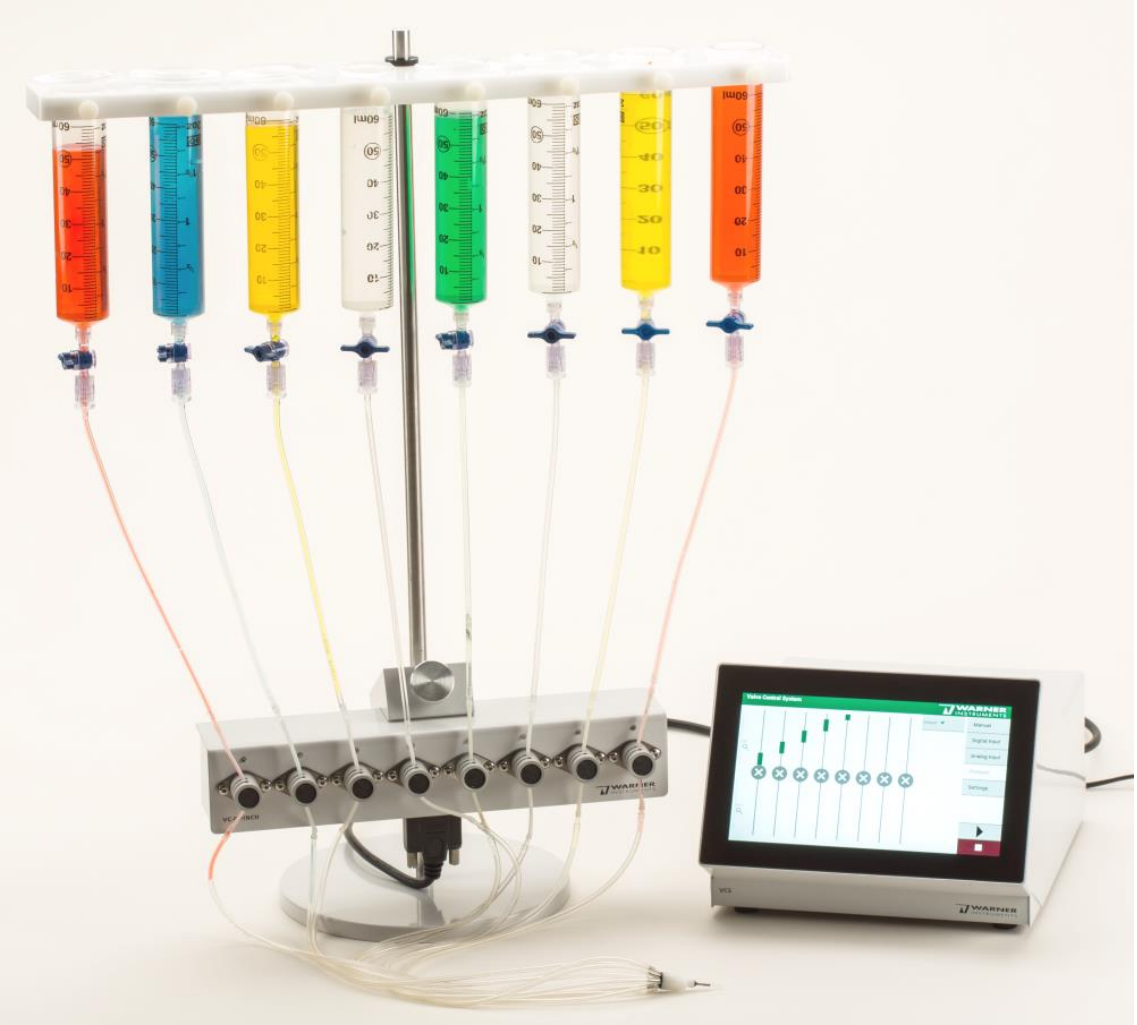
Two Categories of products covered by the WEEE Directive are currently exempt from the RoHS Directive – Category 8, medical devices (with the exception of implanted or infected products) and Category 9, monitoring and control instruments.

Most of our products fall into either Category 8 or 9 and are currently from the RoHS Directive. We will continue to monitor the application of the RoHS Directive to its products and will comply with any changes as they apply.

- Do Not Dispose Product with Municipal Waste
- Special Collection/Disposal Required

1 Introduction

Welcome to the Valve Control System



The Valve Control System (VCS) is a multivalve perfusion system designed to automate and control the delivery of solutions to imaging and recording chambers. Its flexible design also allows the VCS to be used in many diverse applications. Warner Valve Control Systems are configured to control six or eight Pinch or PTFE valves.

The system is straightforward to use and easy to operate. Each valve is individually accessed by either a manual touch display, the included PC software, or an external analog signal or digital (TTL) signal. An event marker pulse, generated each time a valve is switched on, provides for entry into a data acquisition system. A synchronization pulse is generated by use of the trigger or sync connector (Digital I/O, TTL) to align valve triggering with the associated recordings for optimized data analysis.

2 Important Safety Advices

2.1 Important Safety Advice

Warning: Read the following instructions prior to installation or use of the apparatus and software. Failure to satisfy the requirements stated herein may lead to hardware malfunction, breakage, or serious injury.

Warning: Always conform to local regulations and laws. Only qualified personnel should perform laboratory work. Work according to good laboratory practice (GLP) to obtain optimum results and to minimize risks.

The product has been built to the state of the art and in accordance with recognized safety engineering rules.

The device may only

- be used for its intended purpose
- be used when in good operation condition

Improper use could lead to serious, even fatal injuries to the user or third parties or damage to the apparatus or other material elements.

Warning: The device and software are not intended for medical uses and is not to be used on humans. Warner Instruments assumes no responsibility in case of contravention.

Requirements for the Installation and Operation

- Do not use the valve control system for perfusion with flammable or aggressive solutions, for example corrosive liquids.
- Do not store flammable materials near the apparatus, especially during operation.
- Regularly check that the valve control apparatus does not overheat.

2.2 Operator's Obligations

The operator is obliged to allow only persons to work with the apparatus, who

- are familiar with the safety-at-work and accident prevention regulations and have been instructed how to use the VCS;
- are professionally qualified or have specialist knowledge and training and have received instruction in the use of the VCS;
- have read and understood the chapter on safety, the warning instructions in this manual, and have confirmed this with their signature.

It must be monitored at regular intervals that the operating personnel are working safely. Personnel still undergoing training may only work with the VCS under the supervision of an experienced person.

2.3 Guarantee and Liability

The general conditions of sale and delivery apply. The operator will receive these no later than on conclusion of the contract. Guarantee and liability claims in the event of injury or material damage are excluded when they are the result of one of the following.

- Improper use.
- Improper installation, commissioning, operation or maintenance.
- Operating the device when the safety and protective devices are defective and / or inoperable.
- Non-observance of the instructions in the manual with regard to transport, storage, installation, commissioning, operation or maintenance of the device. Unauthorized structural alterations to the device.
- Unauthorized modifications to the system settings.
- Inadequate monitoring of device components subject to wear.
- Improperly executed and unauthorized repairs.
- Unauthorized opening of the device or its components.
- Catastrophic events due to the effect of foreign bodies or Acts of God.

The Valve Control System (VCS) is warranted to be free from defects in materials and workmanship for a period of two years from the date of shipment. If a failure occurs within this period, we will repair or replace the faulty component(s) at our discretion. This warranty does not cover failure or damage caused by physical abuse or electrical stress, for example, exceeding specified input limits.

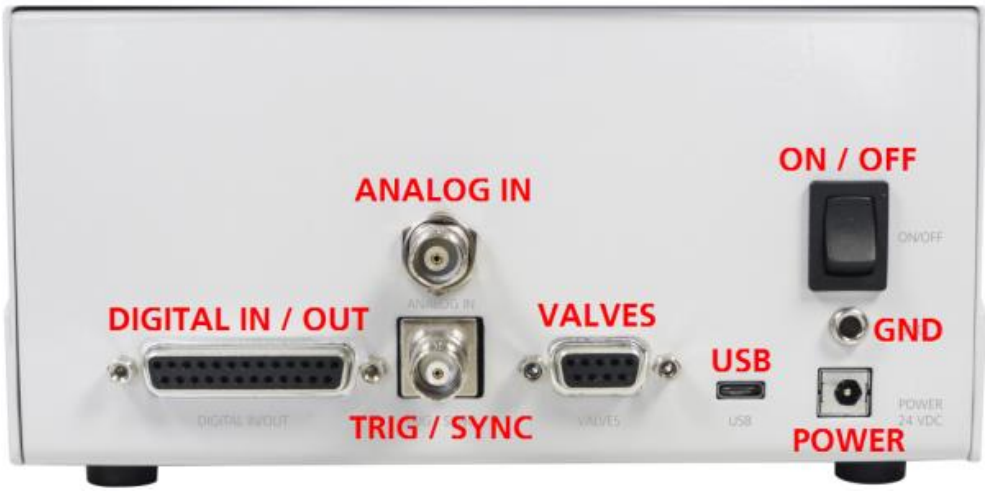
3 Setting up and Connecting the Valve Control System

Setting Up and Connecting the Valve Control System

Warning: Do not start the perfusion until you have verified that all flow lines are properly assembled, and that all perfusion lines are properly assembled and connected, and that the inflow and outflow rates are matched. Spilled liquid may irreversibly damage electronic instruments.

Please visit the Warner web site for information on recommended accessories and spare parts, for example, flow regulators, syringes, fittings, or tubing.

3.1 Cable Connection



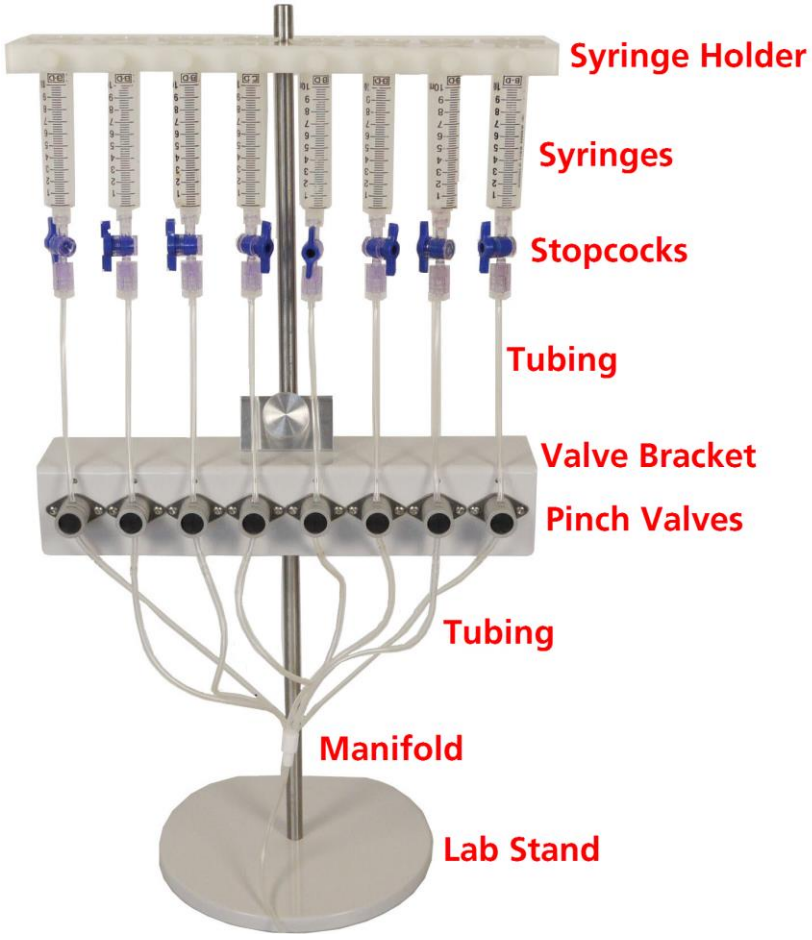
Rear Panel of the Control Unit

1. Begin by connecting the D-Sub9 connector (VALVES) to the valve bracket connecting cable. Next, connect the power connector input (POWER) to the included power supply. Connect a ground cable to the ground connector (GND) if needed.
2. If you will be using the control software, then make a connection between the computer and control unit via the USB-C connector.
3. If you will be using the VCS' digital mode capability, then also connect the "Digital IN / OUT" connector (D-Sub25) to an external digital device. You will define the digital ports in the Settings menu.
4. For "Analog" mode, connect the "Analog IN" connector (BNC).
5. To trigger an external device or to trigger the VCS from an external source, connect the "TRIG / SYNC" (BNC) connector.
6. Switch the device on (ON / OFF).

3.2 Pinch Valve Systems

Pinch valves are the simplest to maintain since the solution never comes into contact with the valve, and the tubing is easily exchanged. Valves are dual acting (3-way) with both normally open and normally closed sides. Placing a Y connector at the valve input permits solution to flow to waste when the valve is in the off position.

Components of a Pinch Valve Control System



The complete VCS Pinch Valve System includes a control unit, a lab stand, a valve bracket with valves and connecting cable, C-Flex®, Tygon, and PE tubing, an MP Series manifold, six or eight 60 cc syringes, a syringe holder, and an assortment of tubing connectors.

Before beginning assembly, take inventory of the plastic fittings supplied with the system. These include eight each of 1/16” ID tube to-tube connectors, 1/16” ID tube-to-tube Y connectors, 1/16” ID Luer-to female barb connectors, and stopcock-with-Luer connectors.

Connectors are shown below. Plastic tubing can be attached to these connectors with minimal effort.

Manifold

MP-8 Manifold (64-0211)

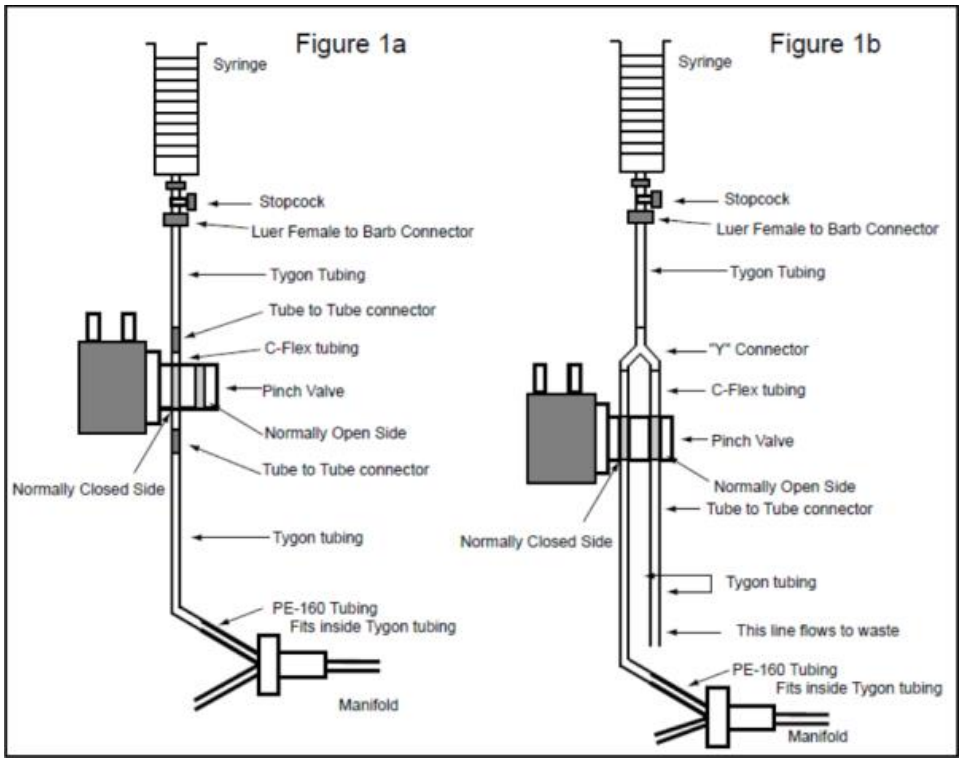
Valve Bracket

The valve bracket is mounted to the supports using the provided screw.

Valve System Setup

Figures 1a and 1b below illustrate two configurations where the perfusion system operates in either a stopped flow or continuous flow-to-waste mode. In general, the shortest response time of the system to the selection of a solution will be achieved by keeping the tube length between the manifold and sample as short as possible.

1. Begin by mounting the valve bracket to the lab stand as described above.
2. Position the valve bracket approximately mid-height on the lab stand rod.
   This is followed by mounting the syringe manifold to the top of the lab stand rod.
3. Next, insert a short length (approximately 2" or 5 cm) of C-Flex® tubing into the pinch valves. Irrespective of the flow arrangement you'll be using, cut enough pieces (12 or 16) of this tubing so you can insert tubes into BOTH sides of the pinch valve. Doing so will allow the valve to properly switch between positions A and B during use.
4. Attach a tube-to-tube connector to each end of the C-flex tubing if using the scheme shown in Figure 1a.
5. Attach a tube-to-tube connector to just the lower end of the C-flex tubing if using the scheme shown in Figure 1b.
6. Once connectors are attached, mount the tubings into the valves by slightly stretching them when slotting in. As discussed above, be sure to place tubing into the unused side if not flowing to waste (Figure 1a).



Note: Minimizing the length of C-Flex® or silicone tubing used will reduce the gas permeability of the system.

Connecting the Syringes and the Tube Sets

The solution reservoir syringes are connected to the tubing via stopcocks. Affix a stopcock-with-Luer connector to each syringe before mounting the syringe into the syringe holder.

Next, cut some Tygon® tubing so it is just long enough to run from the stopcock to the C-Flex® tubing in the pinch valve. Attach a Luer-to-female barb connector to the syringe end of the Tygon tubing, and make attachments to the syringe and C-Flex tubing for each channel.

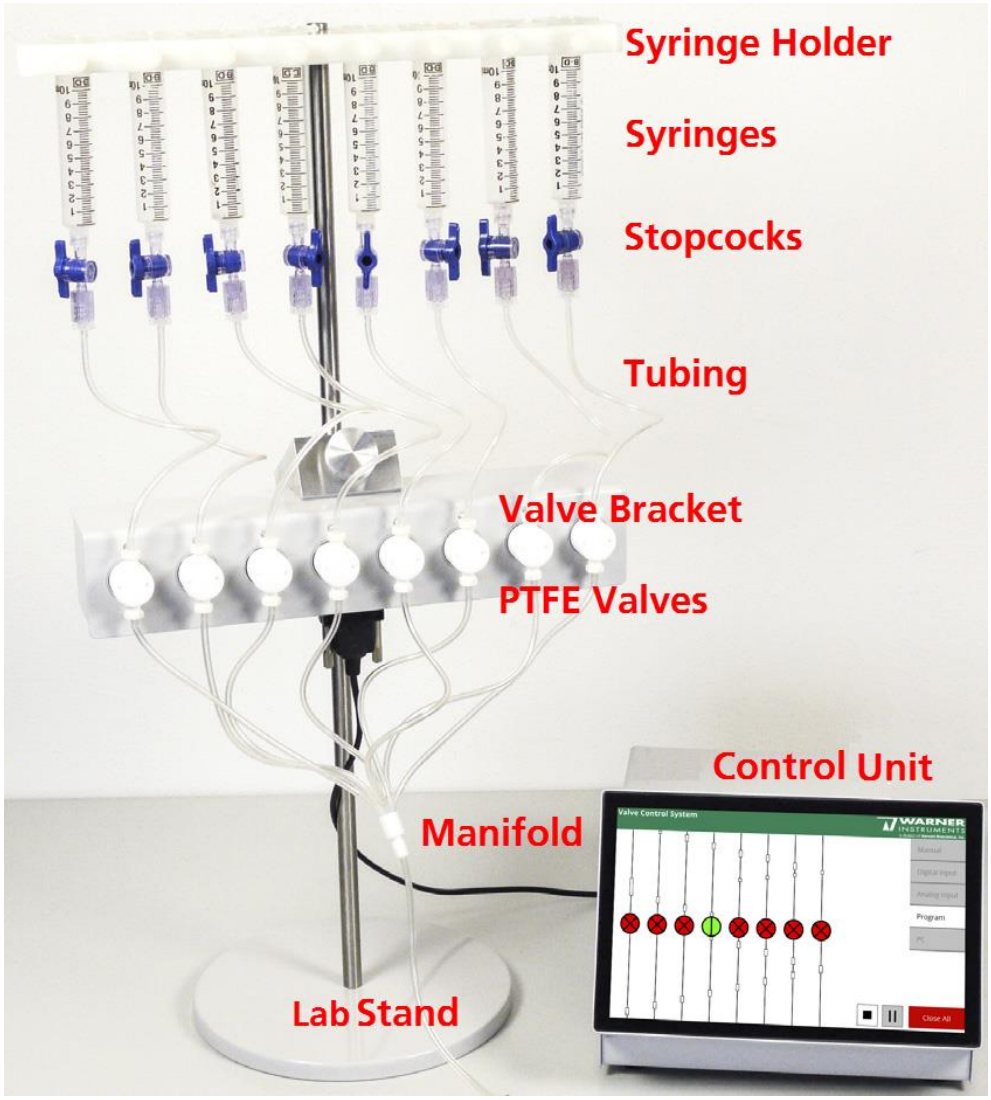
Finally, at the **outboard** end of each valve, attach a tube-to tube connector to the C-Flex® tubing and then attach a short (2" or 5 cm) length of Tygon® tubing onto the connector. The Tygon tubing will act as a coupling element for the PE tubing.

Cut some PE-160 tubing to run from the valve to the MP manifold and insert one end into the Tygon® tubing and the other into the MP manifold.

3.3 PTFE Valve Systems

PTFE valves are available for applications where resistance to chemicals is a concern. Perfusing solutions run through the body of the PTFE valves so proper maintenance is a priority. The PTFE valves are 2-way, either on or off.

Setting up a PTFE Valve Control System



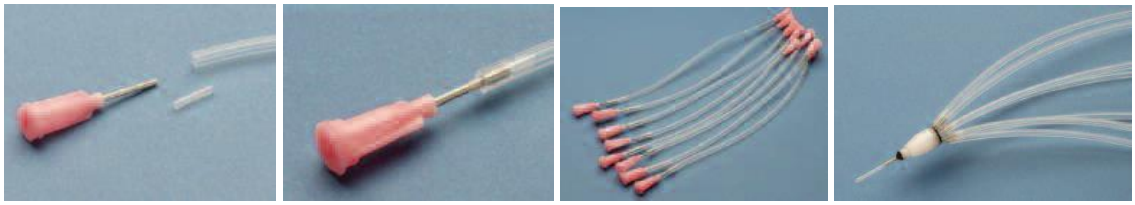
The complete system includes a control unit, a valve bracket with PTFE valves and connecting cable, an MPP-8 manifold, a lab stand, a syringe holder, eight 60 cc syringes, Teflon® and PE tubing, blunt-ended 18-gauge syringe needles, and stopcocks. Before beginning setup, take inventory of the supplied components.

The Valve Control System with PTFE valves is designed to operate as a stopped-flow device wherein the valve for each channel is either open (allowing solution to flow) or is closed.

In general, the shortest response time for delivery of the selected solution will be achieved by keeping the tubing length between the manifold and sample as short as possible.

Assembly

1. Begin assembly by first attaching the valve bracket to the lab stand. Place the valve bracket near the base of the lab stand as shown on previous page.
2. This is followed by attaching the syringe holder to the top of the lab stand.
3. Remove the plungers from the supplied 60 cc syringes and attach stopcocks and Luer fittings to each syringe before placing them into the syringe holder.
4. Cut the Teflon® tubing long enough to run from the syringe Luer fittings to the input ports on the PTFE valves.
5. Attach a blunt-ended, 18-gauge syringe needle to each end of the cut Teflon® tubes to provide a Luer connection point. As described in the pinch valve section, insert a short section of PE-160 onto the needle tip to facilitate a tight seal between the Teflon® tubing and the syringe needle.
6. Using the Luer-ended Teflon® tubes formed in steps 5 and 6, make a connection between the stopcocks on each syringe to the associated input port on each Teflon® valve.
7. Proper tubing lengths, Luer connector attachments, and tubing placements are shown in the montage below.
8. Cut eight pieces of Teflon® tubing to run from the output ports of the Teflon® valve to the supplied MPP manifold. The tubing length needed is left to the discretion of the user but should be sufficient to allow for a short connection between the manifold and the sample chamber.
9. Attach the remaining blunt-end syringe needles to one end of each Teflon® tubing section. Prepare the MPP manifold to accept the Teflon® tubing by first sliding a short length of PE-160 tubing over the manifold input ports. Now route the Teflon® tubing between the output port on each PTFE valve and one input port on the MPP manifold.



10. Finally, make a connection between the output port on the MPP manifold and your sample chamber using a short length of PE-160.

Note: If desired, you can also run Teflon® tubing between the manifold and your chamber. Prepare the manifold to accept the Teflon® tubing by first sliding a short length of PE-160 tubing over the output port on the MPP manifold.

3.4 Cleaning and Maintenance

Do not use alcohol, aromatic hydrocarbons, or chlorinated solvents for cleaning as they may adversely react with the plastic materials used to manufacture the system. If salt solution spills on the valve assembly, it should be cleaned as soon as possible with a soft cloth dampened with water or a mild solution of detergent and water.

Warning: PTFE valves must be completely flushed with distilled water after each use. Permanent damage can result if saline solution is allowed to crystallize inside the valve.

The touch screen of the VCS Controller may be cleaned periodically to remove dust, grease, or other contamination. Use a soft cloth dampened with water or a mild solution of detergent and water. Avoid abrasive cleaners.

Warning: Make sure no liquid is sucked into the touch screen display! This can lead to irreversible damage.

Warning: Empty the syringes and rinse the valves after each experiment. Avoid leaving any solution in the syringe or tubing as this can result in damage or contamination.

4 Operating the Valve Control System

The system can be operated directly via touch screen (on the control unit) or via the provided Valve Control software. An SDK (.net DLL) is available for programming functionality into your own software.

Control modes of the Valve Control System (VCS), available on touch screen and computer, are:

- Manual Mode: Valves can be opened or closed manually.
- Digital Mode: Valves are controlled via digital input.
- Analog Mode: Valves are controlled via analog input.
- Protocol Mode: Protocols are sequences of time steps that are executed in order. In each time step, each valve has a fixed state.

For all modes described above, each valve has a fixed open or closed state within each time step.

Control modes are synchronized between the software and the touch screen. Switching the control mode in one venue will switch it on the other as well. All functionality can be accessed via software or the touch screen with the exception of execution protocols, which can only be created or edited via the software.

Changing the control mode is only possible if the current control mode has been stopped and all valves are closed. This can be easily achieved by pressing the Stop button. When selecting a new control mode, it will be activated by pressing the Play button. The exception to this rule is the Manual Mode where the mode only becomes active when valves are open.

Within the software or on the touch screen interface valves are represented by circles: Green circles with a vertical line indicate an open valve, gray circles with an "X" indicate a closed valve.

Important: If you are using the perfusion system (Pinch valves) in a continuous flow-to-waste mode, the gray circle with an “X” indicates that the flow to waste pathway is open.

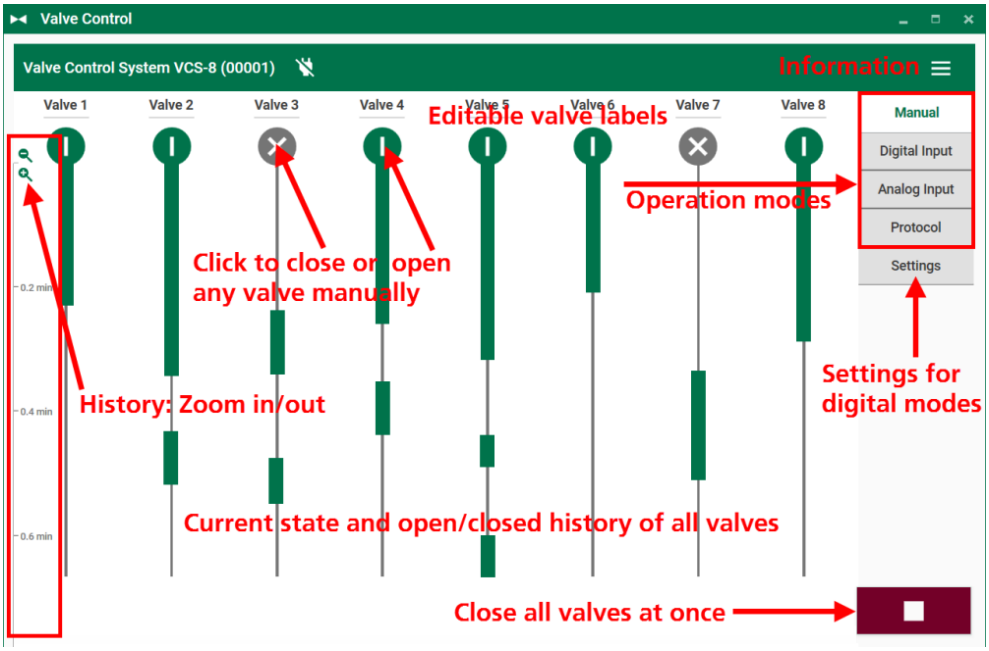
The history of the valve states is displayed below the circles. As long as a valve is open, this state is represented by a thick green line extending further down as time progresses. A closed valve state is indicated by a thinner, gray line. You may change the time scale in this "Waterfall" view in order to see a longer historical display of valve state changes.

4.1 Valve Control Software

The **Valve Control** software is developed to meet all requirements of the user.

Please see the following overview of important software features:

- Create or edit protocols in the "Protocol Editor" via software.
- Load and save protocols to the computer or to the control unit.
- If no control unit is connected, the "Protocol Editor" can still be used.
- Valves can be given names for easier recognition.
- **Stop** button stops the current mode and closes all valves.
- For internet connected computers, access to online help and tool tips are available.
- Free software and firmware updates.
- Messages will be displayed in the main window to indicate available software or firmware updates.
- Errors are shown on screen and their details can be saved to a file.



Show Information

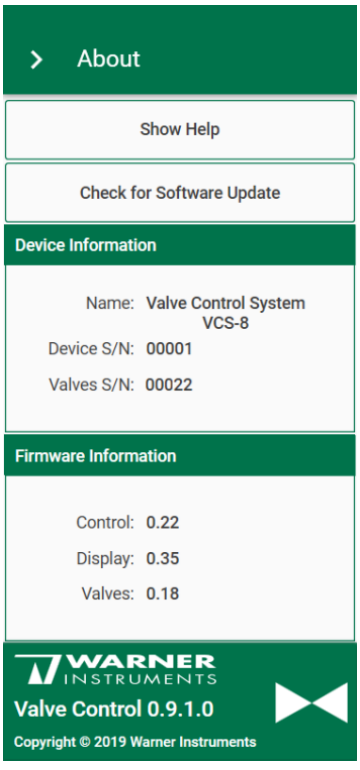
Click the "Show Information" button. Enter the online help with the "Show Help" command and "Check for Software Updates".

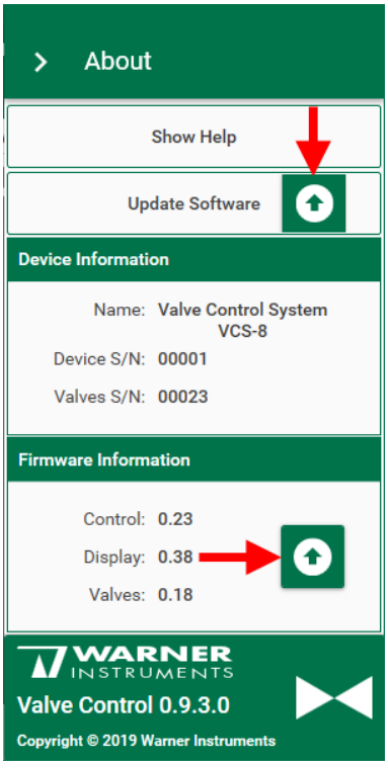
The "Show Information" button is labeled with an arrow on the right side, if a software update is available.

Open the “About” dialog to check for software updates in the upper part and firmware updates in the lower part.

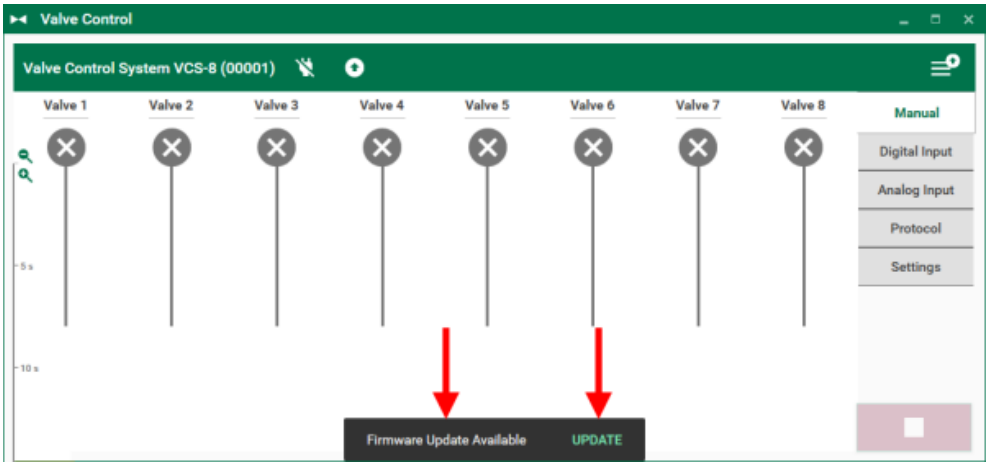
If updates are available, please click the "Update Software" or the “Update Firmware” button or access the product web site. An additional "Arrow" icon will appear next to the "Connect the Device" button if a firmware update is available.

If the software is connected to a control unit, this will also display "Device Information" such as serial numbers and "Firmware Information".



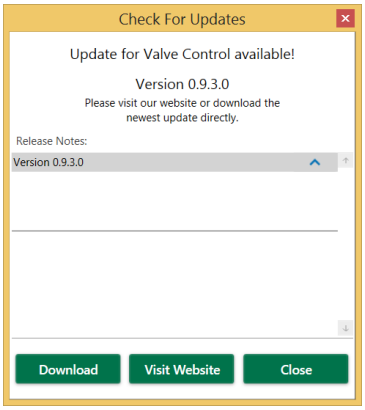


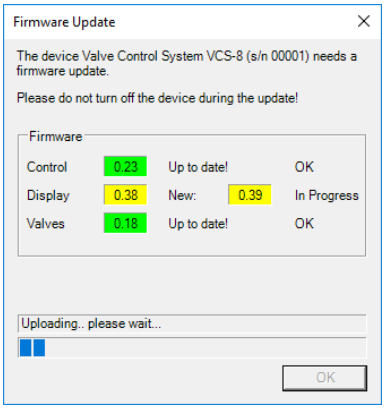
Additionally, there is a hint in the main menu, if updates are available. Click the “UPDATE” button to connect to the web site and to start an update.



Connect or disconnect the Valve Control System via software control from the current device  .

Click "Check for Software Updates" to open the following dialog.





The option "Check for Updates" provides fast access to the Warner website.

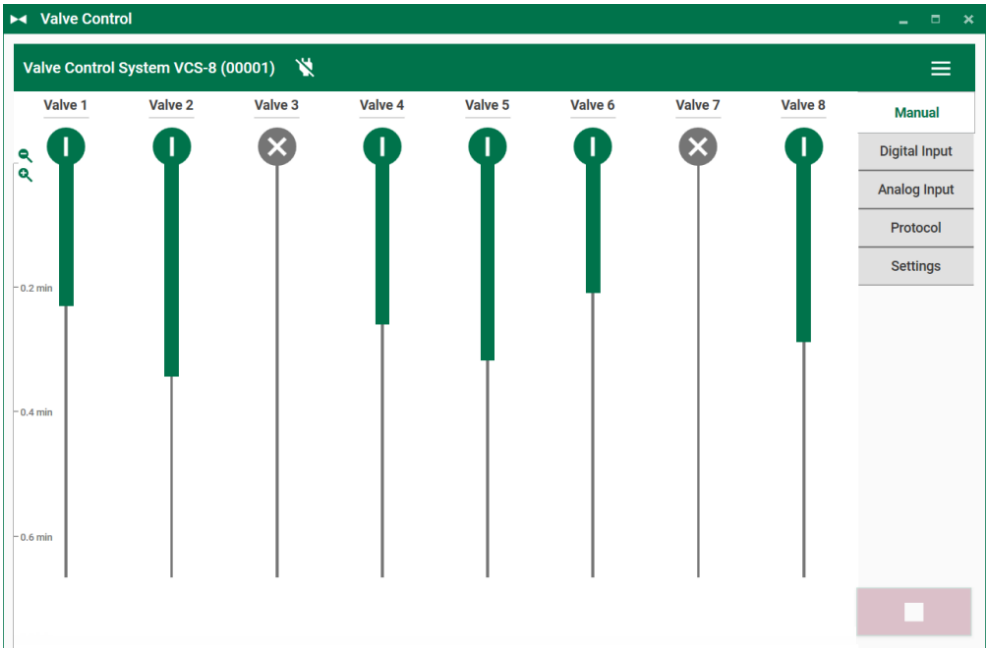
If a software update is available, review the changes in the changelog and click the download button to download the update. If the software is not currently running a protocol, you may directly close the software and install the update. If a software update is available, the "Show Information" button will indicate this with a vertical up arrow. If a firmware update is available, an update button is shown in the "Firmware Information" window and pressing it will start the update.

After the update, the device will be disconnected for a short time and needs to be reconnected manually.

If no device is connected to the software, but one or more control unit are available, then select the correct one from the drop down menu.

4.1.1 Manual Mode

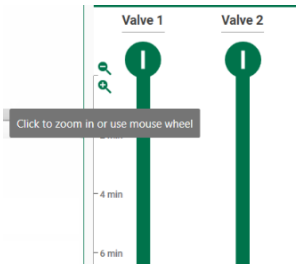
Use **Manual** mode to start and stop valves individually and by hand.



Valve states can be toggled between open and closed by either clicking the valve symbol or with the keyboard shortcut "Ctrl + the valve index". For example, pressing **Ctrl + 3** will toggle the state of valve 3. Open valves are indicated in green, closed valves are gray.

The valve names at the top are editable, so valves can be easily renamed.

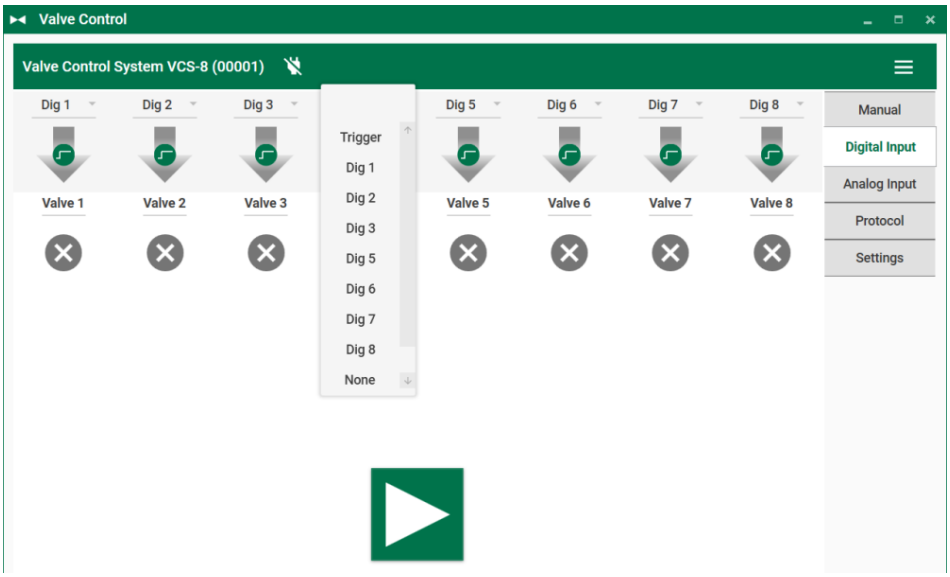
See the history of operation on the screen: Zoom in or zoom out with the buttons on the left side of the screen or with the mouse wheel.



To change the operational mode it is necessary to close all valves before selecting the new mode.

4.1.2 Digital Input Mode

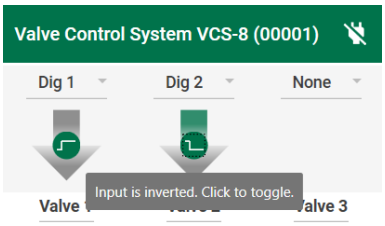
In **Digital Input Mode**, valves are controlled by TTL inputs delivered to the "Trigger/Sync" and "Digital In/Out" ports at the back of the control unit.



Connect the digital input ports on the back side of the device.

TTL stands for Transistor-Transistor Logic. A TTL pulse is defined as a digital signal for communication between two devices. A voltage between 0 V and 0.8 V is considered to be a logical state of 0 (LOW), and a voltage between 2 V and 5 V means 1 (HIGH).

The **Digital In/Out** connector (D-Sub25 connector) has 16 digital input- and output bits for communication with other devices. You can use the digital TTL inputs, for example, to synchronize the Valve Control System with other hardware. The digital TTL outputs can be used for triggering other devices, such as Patch Master or an EPC10 device. The "Digital Out" delivers TTL pulses of 3.3 V amplitude.



Assign valves to digital input ports via the drop down menus. Each valve can be assigned to any of the 16 Digital In bits (D-Sub25) or the Trig/Sync input (BNC). Digital inputs can be used "as is" or "inverted". If a digital input has been assigned to a valve, the valve will directly reflect the logical states on the digital port:

Digital Input	Valve State "as is"	Valve State "inverted"
HIGH	open	closed
LOW	closed	open

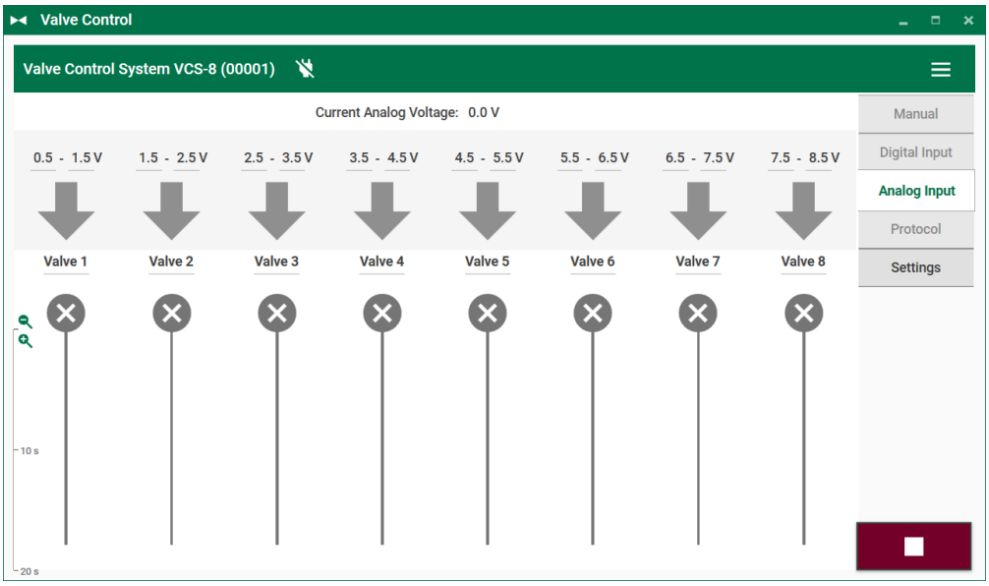
The coloring of the arrows between the digital input drop down menus and the valves indicates both the logical state of the digital input as well as the state of the valve: If the logical state of the digital port is "HIGH", the upper part of the arrow is green, otherwise it is gray. If the valve is open due to the digital input, the lower part of the arrow is green, otherwise it is gray. This is visible even if the "Digital Input Mode" has not been started, yet.

When opening the "Digital Input Mode" page in the software, the mode is not yet active. In order to start the digital input control of the valves, press the "Play" button. To stop it, press the "Stop" button.

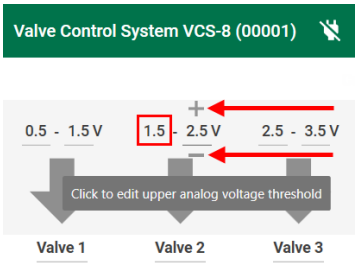
Additionally, it is easy to convert the digital in mode to digital out for triggering third party devices or for synchronization with other devices. Please use in the "Settings" window and see the description in chapter 4.1.5 below.

4.1.3 Analog Input Mode

In "Analog Input Mode", the valves are controlled by an analog signal applied to the "Analog In" input port on the control unit.



Connect the analog input port on the back side of the device. Define the voltage range in which the respective valve should be open. Change the default voltage threshold ranges of the valves by using the "Plus" or "Minus" icon or by overwriting the numbers.



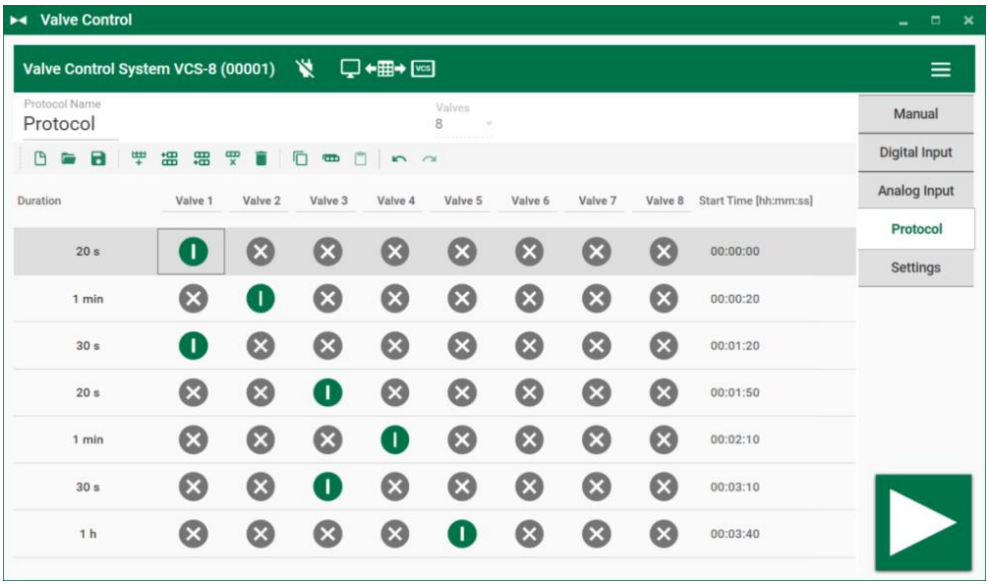
In order to open a valve continuously, set the lower analog input threshold to a value higher than the upper analog input threshold.

The coloring of the arrows between the analog input range and the valves indicates the valve state. If the valve is open due to the analog input, the arrow is green, otherwise it is gray. This is visible even if the "Analog Input Mode" has not been started, yet.

When opening the "Analog Input Mode" page in the software, the mode is not yet active. In order to start the analog input control of the valves, press the "Play" button. To stop it, press the "Stop" button.

4.1.4 Protocol Mode

The "Protocol Mode" of the device makes it possible to execute a sequence of state changes for all valves with predefined durations.



For example, a simple protocol might consist of first opening both valves 1 and 3 for 10 seconds, then closing valves 1 and 3 and opening valves 2 and 4 for an additional 30 seconds.

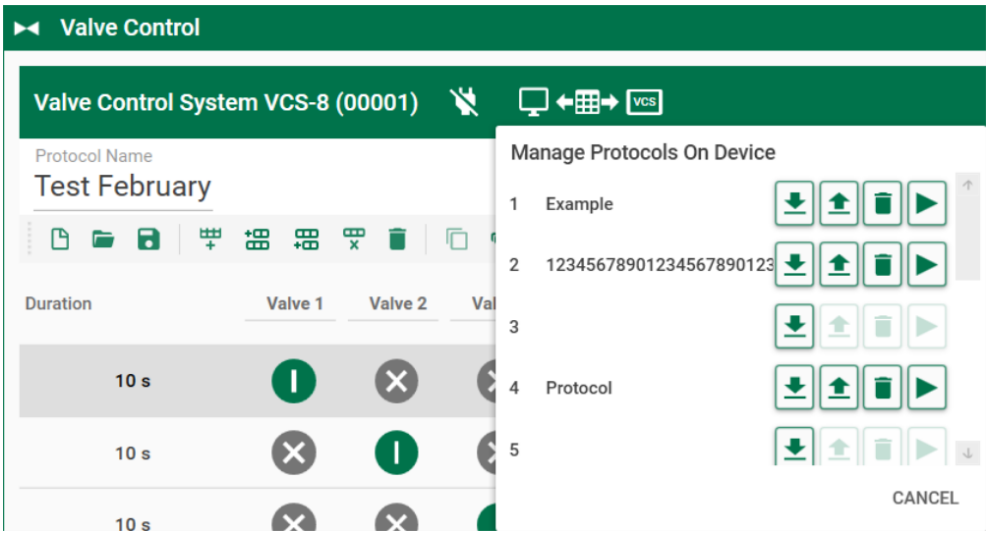
These protocols can be executed from the software or downloaded to the control unit and executed on the apparatus.

The visual display changes depending on whether a protocol is being executed, or not:

- If no protocol is executed or if the software is not connected to a control unit, the "Protocol Editor" is shown. See the next chapter 4.1.4.1.
- If a protocol is being executed by the software, the protocol is shown in a table at the top of the display, with the current protocol step highlighted. The valve states and the state history is shown at the bottom. See chapter 4.1.4.2.
- If a protocol is being executed by the control unit, the valve states and the state history is shown. See chapter 4.1.4.3.

4.1.5 Protocol Editor

Managing Protocols on the Control Unit



Connect or disconnect the Valve Control System via software control from the current device  .

Click one of the buttons to manage the protocols on the device.

Press the "Manage Protocols on Device" button to access the stored protocols on the control unit. In total, there are 14 memory slots for protocols available on the device. If there is a protocol stored in a slot, its name is shown and four buttons are available: "Store", "Load", "Delete" and "Execute". If a memory slot is empty, only the "Store" button is available.

Store: Downloads the current protocol in the "Protocol Editor" to this memory slot. If another protocol is already stored in this slot, it will be overwritten.

Load: Loads a protocol from a memory slot and displays it in the "Protocol Editor". The current protocol in the "Protocol Editor" will be discarded.

Delete: Deletes a protocol from a memory slot.

Execute: Executes the protocol in this memory slot on the device.

Protocol

A protocol is a sequence of time spans, one with a defined configuration of open and closed valves. Protocols are typically displayed as tables with one row per time span. The maximum number of rows in a protocol is 256. Protocols can be created and modified in the "Protocol Editor". It is also possible to create protocols as a "*.csv" file, to be loaded into the editor. If a control unit is connected to the software, then the number of valves in the "Protocol Editor" is fixed to the number of valves on the device.

In order to create or edit protocols for a different number of valves. Disconnect the control unit with the "Disconnect" button. This feature can be useful when editing protocols for devices having different number of valves.

Main Menu Toolbar

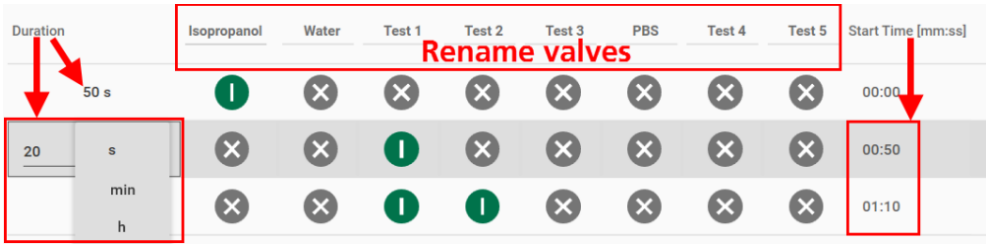
Use hot keys to create protocols, use the numeric keypad for the designated valves.

	Start a new protocol	
	Load a protocol from file	Ctrl + O
	Save to file	Ctrl + S
	Add row	Ctrl + N
	Insert rows above	Ctrl + Shift + I
	Insert rows below	Shift + I
	Remove row	Ctrl + DEL
	Clear protocol	
	Copy cell	Crtl + C
	Copy row	Ctrl + Shift + C
	Paste cell or row content	Ctrl + V
	Undo	Ctrl + Z
	Redo	Ctrl + Y

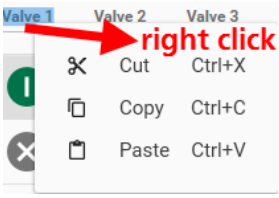
Pasting the contents of the clipboard is only possible if the currently selected cell matches the clipboard contents:

If the content of a duration cell has been copied, it may only be copied to another duration cell. Likewise for valve cells. Copied rows may be pasted anywhere.

Valves names can be edited from the table column headers.



Click the valve header with the right mouse to cut this name of the valve, to copy and to paste it into another column.



Click valves to toggle the valve state, or press the "Control" key together with the valve index to toggle it.

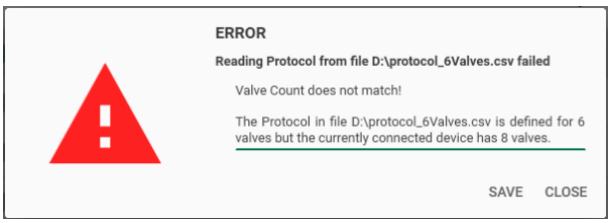
Click “Duration” cells to edit their contents.

Show Protocol in Excel

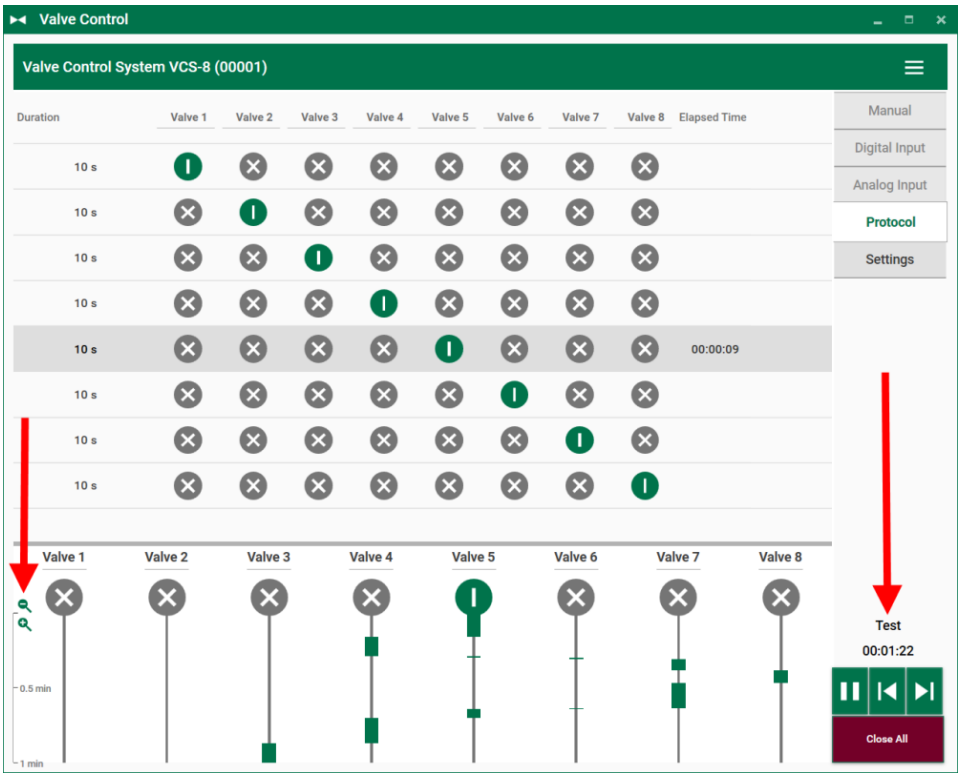
Protocols can be saved as a “*.csv” ASCII file and can be edited in Excel. The “comma separated file” format is as follows:

	A	B	C	D	E	F	G	H	I
1	Valve Control Protocol								
2	Version: 1								
3									
4	Valves: 8								
5									
6	Protocol Name: Test								
7									
8	Duration [ms]	Valve 1	Valve 2	Valve 3	Valve 4	Valve 5	Valve 6	Valve 7	Valve 8
9	10000	1	0	0	0	0	0	0	0
10	10000	0	1	0	0	0	0	0	0
11	10000	0	0	1	0	0	0	0	0
12	10000	0	0	0	1	0	0	0	0
13	10000	0	0	0	0	1	0	0	0
14	10000	0	0	0	0	0	1	0	0
15	10000	0	0	0	0	0	0	1	0
16	10000	0	0	0	0	0	0	0	1
17									

Comma separated files "*.csv" with the same format may also be loaded from file. If a control unit is connected, but the number of valves in the protocol does not match the number of valves of the device, an error is shown.

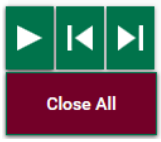


4.1.6 Running a Software controlled Protocol



Select a protocol and start it with the "Start" button. The "Start" button is replaced by the "Stop" button in red.

In order to stop a running protocol and exit "Protocol" mode, first press the "Close All" button. This pauses the protocol, closes all valves and also replaces the "Close All" button with the "Stop" button. Pressing the "Stop" button will then terminate the protocol.



While the protocol is running, the touch screen is set to "PC" mode and is not responsive for user interaction, with the exception of the "Stop" button. The "Stop" button can always be pressed on the touch screen and will terminate the protocol immediately and close all valves.

Pause: Pressing the "Pause" button will pause the protocol and keep the valves in their current states.

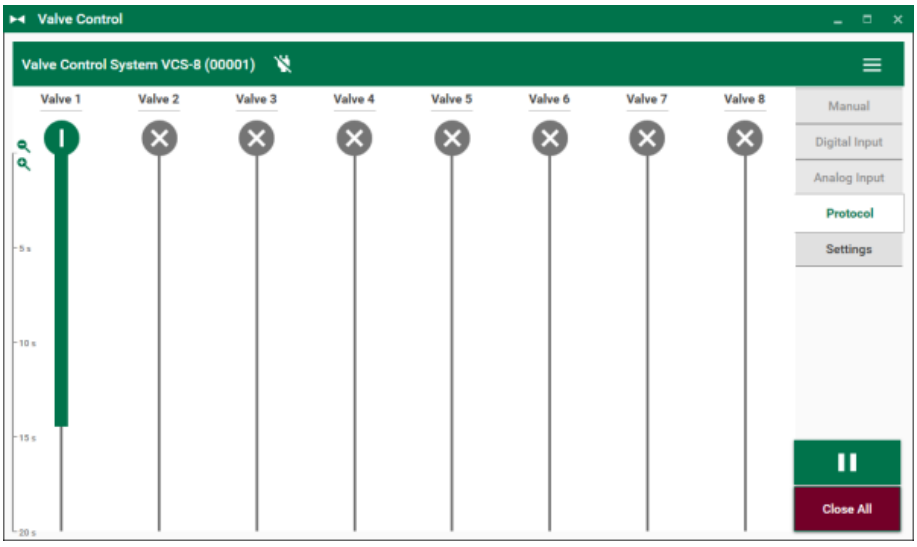
Close All: Pressing the "Close All" button will pause the protocol and in addition close all valves.

Resume: Resumes a paused protocol from the currently selected protocol entry. If you have skipped to a different protocol entry during the pause, the timer for this entry will start at zero, otherwise it will resume from the elapsed time. This button is available only if the protocol has been paused by pressing either the "Pause" or the "Close All" button.

Skip Forward / Backward: Pressing the "Skip Forward"/"Skip Backward" button jumps to the next or to the previous entry in the protocol, respectively. If the protocol is running, this entry is directly executed and its timer started. If the protocol is currently paused without changing the valve states (after pressing the "Pause" button), the valve states of the new entry are activated, but the timer is not started. If the protocol is currently paused with valves always closed (after pressing the "Close All" button), all valves stay closed and the timer is also not started.

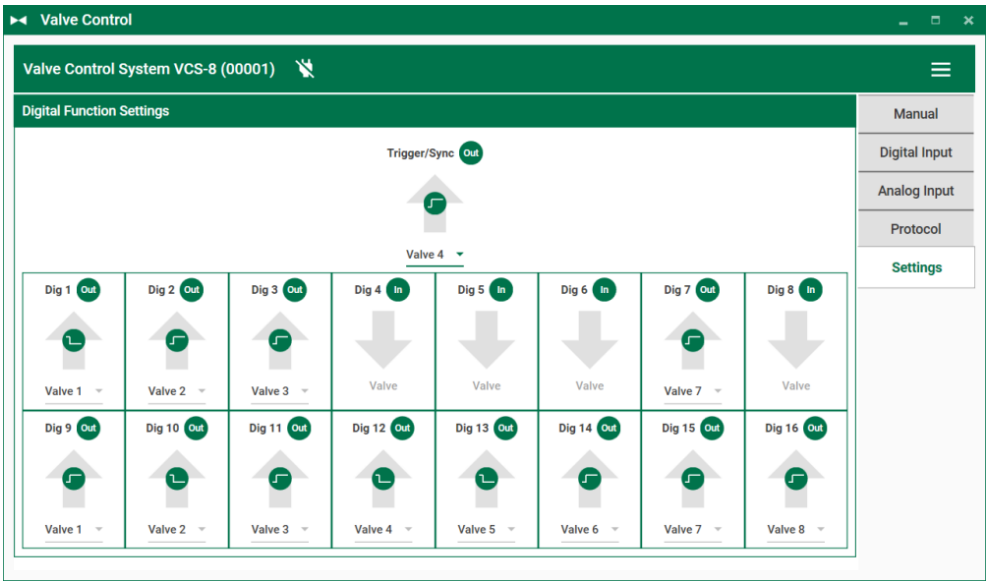
Stop: The "Stop" button is available only after the "Close All" button has been pressed. It terminates the running protocol and returns the display to the Protocol Editor mode.

4.1.7 Running Protocol on the Control Unit



If a protocol is currently being executed on the control unit, the software displays the valves along with the state history. You may use either the "Pause" or the "Close All" button in the software to pause the protocol. The difference between the two buttons being that valves will retain their state if "Pause" is pressed, while all valves are closed if "Close All" is pressed. In order to stop a running protocol and exit the "Protocol Mode", first press the "Close All" button. This pauses the protocol, closes all valves, and replaces the "Close All" button with the "Stop" button. Pressing the "Stop" button then terminates the protocol.

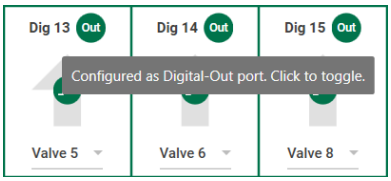
4.1.8 Settings Mode



You configure the digital ports via the "Settings" menu. Two digital connectors are available on the rear panel of the control unit: "Trigger/Sync" and "Digital In".

If only a single digital connection is required, connect via the BNC connector "Trigger/Sync" port.

The D-Sub25 connector at the "Digital In/Out" port at the back of the control unit provides 16 bits which either can be used as digital in or digital out ports. The BNC connector at the "Trigger/Sync" port provides an additional bit which also can be used either as digital in or digital out.



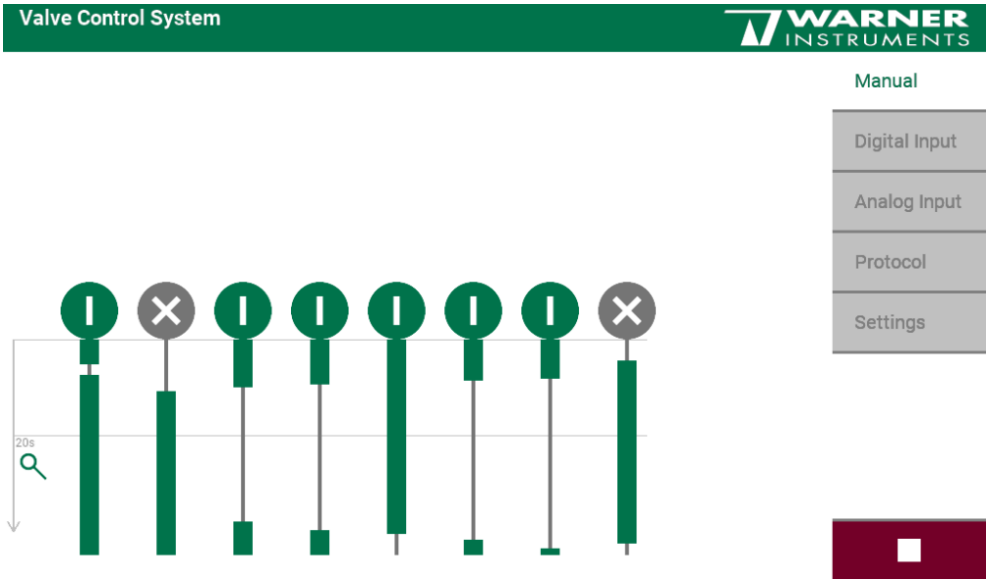
The purpose of a digital in port is to receive a control signal in "Digital Input Mode" and is used to control one or more valves by opening and closing while synchronizing them to state changes in the control signal. See the section "Digital Input Mode" for more details. If a digital out port is assigned to a valve, then the port's state reflects the state of the valve. It is possible to configure if the valve's state should be presented "as is" on the digital out port or as "inverted":

Valve State	Digital Output State "as is"	Digital Output State "inverted"
open	HIGH	LOW
closed	LOW	HIGH

The digital out ports can be used to trigger external devices or to record the valve states into an appropriate data acquisition system.

4.2 Valve Control via Touch Screen on the Control Unit

4.2.1 Manual Mode on the Touch Screen



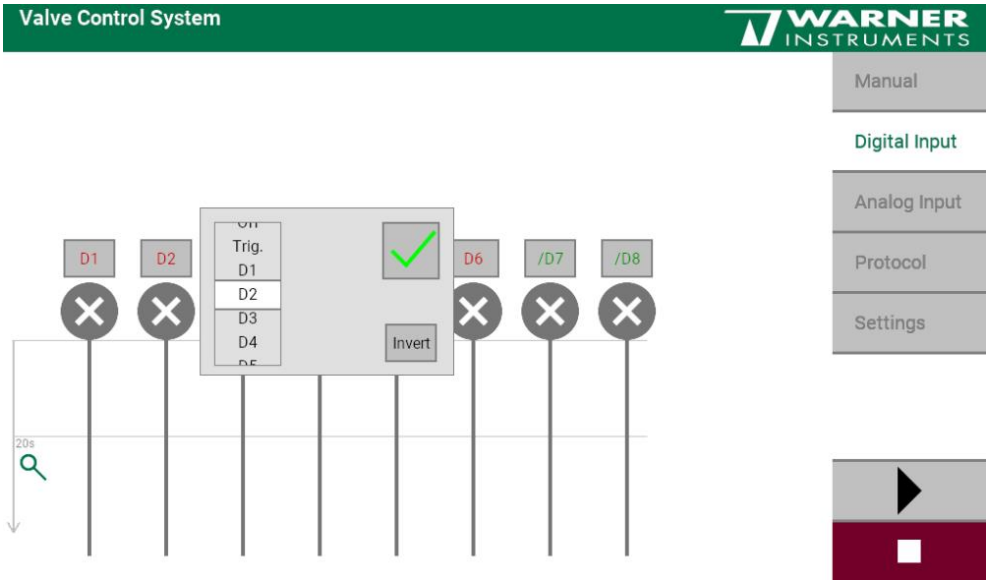
Each valve can be controlled individually by clicking on its circular icon or start and stop or all valves can be started and stopped together via "Start" button. Use the "Stop / Emergency" button to immediately close all valves, if needed. Green circles with a vertical line indicate an open valve, gray circles with an "X" indicate closed valves.

The time span after starting the first valve is recorded in the history part of the screen. Times with open valves are shown with vertical green bars. Times with closed valves, are shown with gray lines.

The history of the valve states is displayed below the circles. As long as a valve is open, this state is represented by a thick green line extending further down as time progresses. The closed valve state is indicated by a thinner, grey line. You may change the time scaling in this "Waterfall" view in order to see different proportions of the history of valve state changes. Zoom in and out by clicking the zoom button or moving the mouse wheel.

Before changing the operation mode it is necessary to close all valves.

4.2.2 Digital Input Mode on the Touch Screen

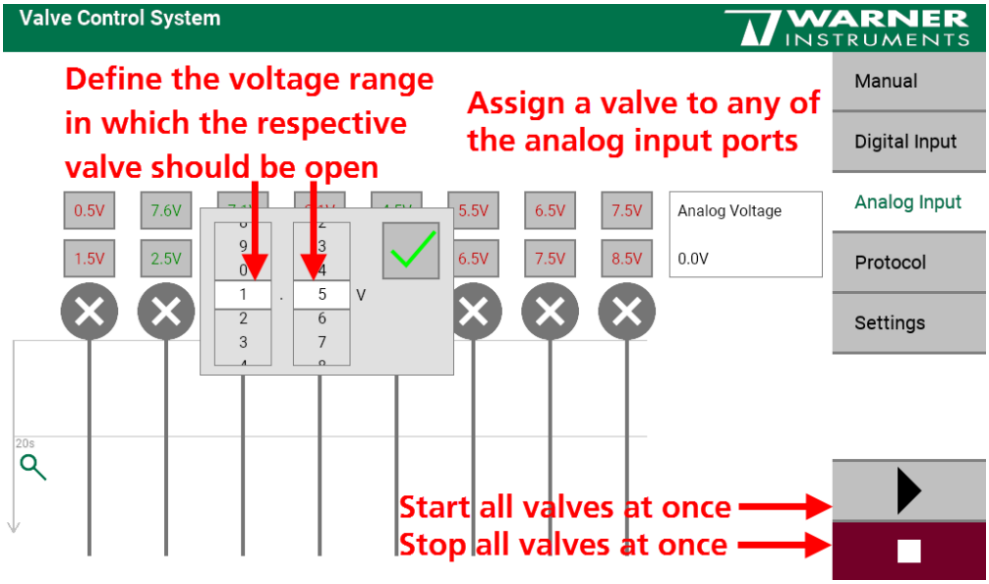


Connect the digital input port on the back side of the device. Assign valves to digital input ports via the drop down menus and determine if the digital input should be used "as is" or "inverted". Inverted valves are indicated in green letters above the valve icon. If a digital input has been assigned to a valve, the valve will directly reflect the logical states on the digital port:

Digital Input	Valve State "as is"	Valve State "inverted"
HIGH	open	closed
LOW	closed	open

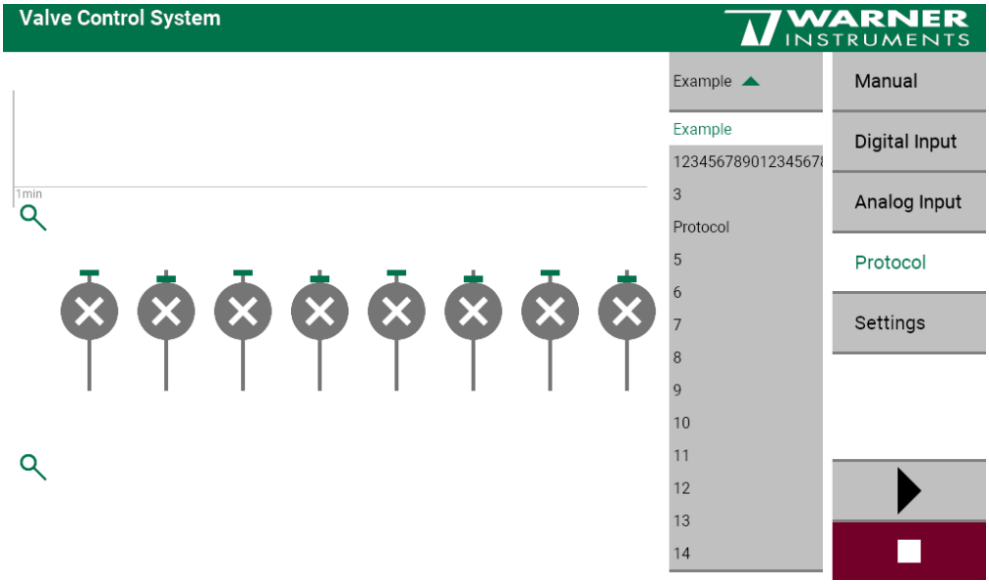
Change digital port orientation during ongoing experiment.

4.2.3 Analog Input Mode on the Touch Screen

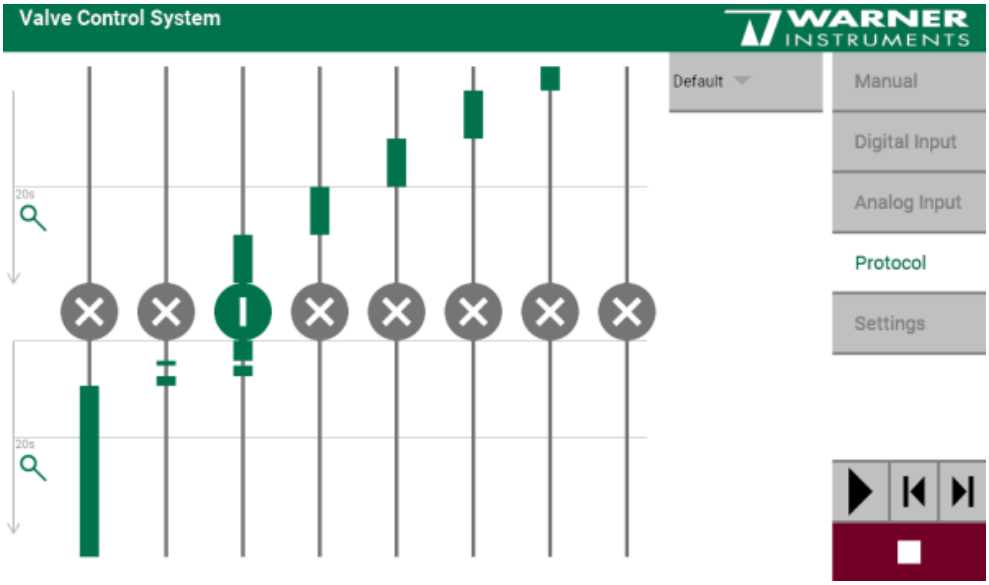


Connect the analog input port on the back side of the control unit. In "Analog Input Mode", valves are controlled by an analog signal applied to the "Analog In" input port. Define the voltage range in which the respective valve should be open. Change the default voltage threshold ranges of the valves by using the drop down menu. Adapted values are indicated in green numbers. Voltage threshold ranges may overlap each other: In order to open a valve continuously, set the lower analog input threshold to a value higher than the upper analog input threshold.

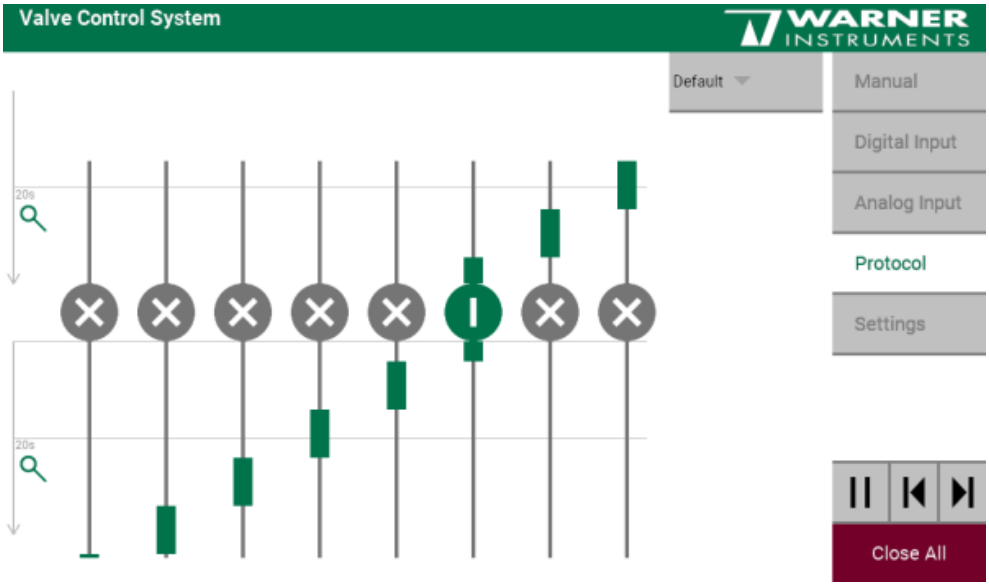
4.2.4 Protocol Mode on the Touch Screen



Select the desired protocol from the drop down menu. The protocol should be downloaded onto the control unit, if it should be processed without computer connection.



Running a Protocol on the Control Unit



Start a protocol with the "Start" button. The "Start" button is replaced by the "Stop / Emergency" button in red and the "Pause" and "Skip to Next Step" and "Skip to Previous Step" buttons in green. So it is possible to jump from one step to the next or back to the step before or to pause the protocol.

Pause: Pressing the "Pause" button will pause the protocol and keep the valves in their current states.

Close All: Pressing the "Close All" button will pause the protocol and in addition close all valves.

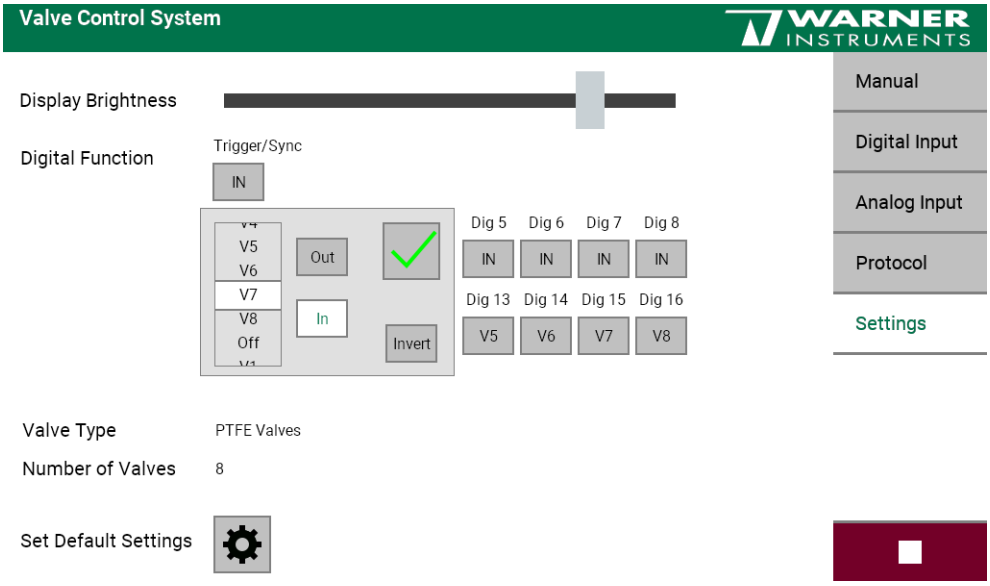
Resume: Resumes a paused protocol from the currently selected protocol entry. If you have skipped to a different protocol entry during the pause, the timer for this entry will start at zero, otherwise it will resume from the elapsed time. This button is available only if the protocol has been paused by pressing either the "Pause" or the "Close All" button.

Skip Forward / Backward: Pressing the "Skip Forward"/"Skip Backward" button jumps to the next or to the previous entry in the protocol, respectively. If the protocol is running, this entry is directly executed and its timer started. If the protocol is currently paused without changing the valve states (after pressing the "Pause" button), the valve states of the new entry are activated, but the timer is not started. If the protocol is currently paused with valves always closed (after pressing the "Close All" button), all valves stay closed and the timer is also not started.

Stop: The "Stop" button is available only after the "Close All" button has been pressed. It terminates the running protocol and returns the display to the Protocol Editor mode.

In the upper half of the screen track the proceedings in the protocol. The actual step is highlighted in gray and the time left for this step is displayed. In the lower half of the screen see the history. Zoom in or zoom out with the "Zoom" buttons or with the mouse wheel. The time for the running protocol is counted up and the name of the protocol is displayed above the buttons.

4.2.5 Settings Mode on the Touch Screen



The "Settings" menu on the touch screen has two additional functions in relation to the software "Settings": Adapt the "Display Brightness" with the ruler above and "Set Default Settings" with the button below. In addition the "Valve Type" and the "Number of Valves" is displayed.

Please configure the digital ports via "Settings" menu. Two digital connectors are available on the rear panel of the control unit: "Trigger/Sync" and "Digital In".

If only one digital connection is necessary, connect a BNC cable to the BNC connector "Trigger/Sync" port.

The D-Sub25 connector at the "Digital In/Out" port at the back of the control unit provides 16 bits which can be used as digital in or digital out ports. The BNC connector at the "Trigger/Sync" port provides 1 bit which can also either be used as digital in or digital out.

The purpose of a digital in port is to receive a control signal in "Digital Input Mode" and use it to control one or more valves by opening and closing them synchronized to state changes in the control signal. See the section "Digital Input Mode" for more details.

If a digital out port is assigned to a valve, then its state reflects the state of the valve. It is possible to decide whether the valve state should be replicated "as is" on the digital out port, or "inverted":

Valve State	Digital Output State "as is"	Digital Output State "inverted"
open	HIGH	LOW
closed	LOW	HIGH

The digital out ports can be used to trigger external devices or to record the valve states as a digital signal with an appropriate data acquisition system.

5 Appendix

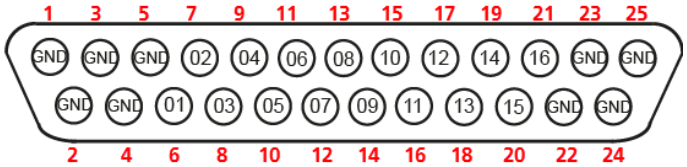
5.1 Technical Specifications

Operating Temperature	10° to 40° C
Altitude	Sea level to 2000 m
Relative Humidity	0 to 95 %
Valve Stand	
Dimensions (H x W x D)	89 mm x 203 mm x 305 mm
Weight	± 4950 g
Valve Bracket	Delrin, mounts on 3/8” or 1/2” lab stand
Syringe Holder	Delrin, holds eight syringes with thumb screws for each reservoir
Reservoirs	60 cc capacity syringes
Control Unit	
Dimensions (H x W x D)	144 mm x 187 mm x 265 mm
Weight	2005 g
Digital In/Out (16 bit)	Dsub25 connector
Analog In	BNC connector
Trig/Sync (1 bit)	BNC connector
Valves	Dsub9 connector
USB port	USB-C connector
Power	24 VDC DC power plug
Ground	Common jack 4 mm, banana plug

Accessories	**Warner Instruments**
Replacement PTFE valve	Warner Instruments: 64-0139 (PV-1)
Replacement pinch valve	Warner Instruments: 64-0140 (TV-2)
MP Mini manifold, 1 to 8 ports	Warner Instruments: 64-0211 (MP-8)
Syringe holder with 8 x 60 cc syringes	Warner Instruments: 64-0385 (SH-8/60)
Syringe holder with 8 x 10 cc syringes	Warner Instruments: 64-0143 (SH-8/10)
Lab (Support) stand	Warner Instruments: 64-0162 (RS-1)
Luer stopcock, 6 pack	Warner Instruments: 64-0165 (SL-6)
Polyethylene tubing	Warner Instruments: 64-0752 (PE-50, 10 ft)
Polyethylene tubing	Warner Instruments: 64-0166 (PE-50, 100 ft)
C-Flex® tubing	Warner Instruments: 64-0166 (CFL-6 1/32" x 6 (ID x ft)) for pinch valves)
Tygon tubing	Warner Instruments: 64-0167 (TY50 1/16" x 50 (ID x ft))
PTFE (Teflon®) tubing	Warner Instruments: 64-0168 (TT-25 1/16" x 25 (ID x ft))
Tubing connectors, 24 pack	Warner Instruments: 64-0164 (TC-3)
Fitting barb, Y style, 25 pack	Warner Instruments: 64-1575 (1/16" to 1/16")

Fitting barb, 25 pack	Warner Instruments: 64-1575 (1/16" in to Luer female)
Fitting barb, 25 pack	Warner Instruments: 64-1567 (1/16" to 1/16")

5.2 Pin Layout Digital IN/OUT Connector



D-Sub25 Connector

Pin 1	GND	Pin 2	GND
Pin 3	GND	Pin 4	GND
Pin 5	GND	Pin 6	Bit 1
Pin 7	Bit 2	Pin 8	Bit 3
Pin 9	Bit 4	Pin 10	Bit 5
Pin 11	Bit 6	Pin 12	Bit 7
Pin 13	Bit 8	Pin 14	Bit 9
Pin 15	Bit 10	Pin 16	Bit 11
Pin 17	Bit 12	Pin 18	Bit 13
Pin 19	Bit 14	Pin 20	Bit 15
Pin 21	Bit 16	Pin 22	GND
Pin 23	GND	Pin 24	GND
Pin 25	GND		