

# PS48402 User manual

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## Preface

This document is intended to aid in the use and understanding of the Applicos PS48402 Programmable Power Supply.

For support please contact:

### Applicos

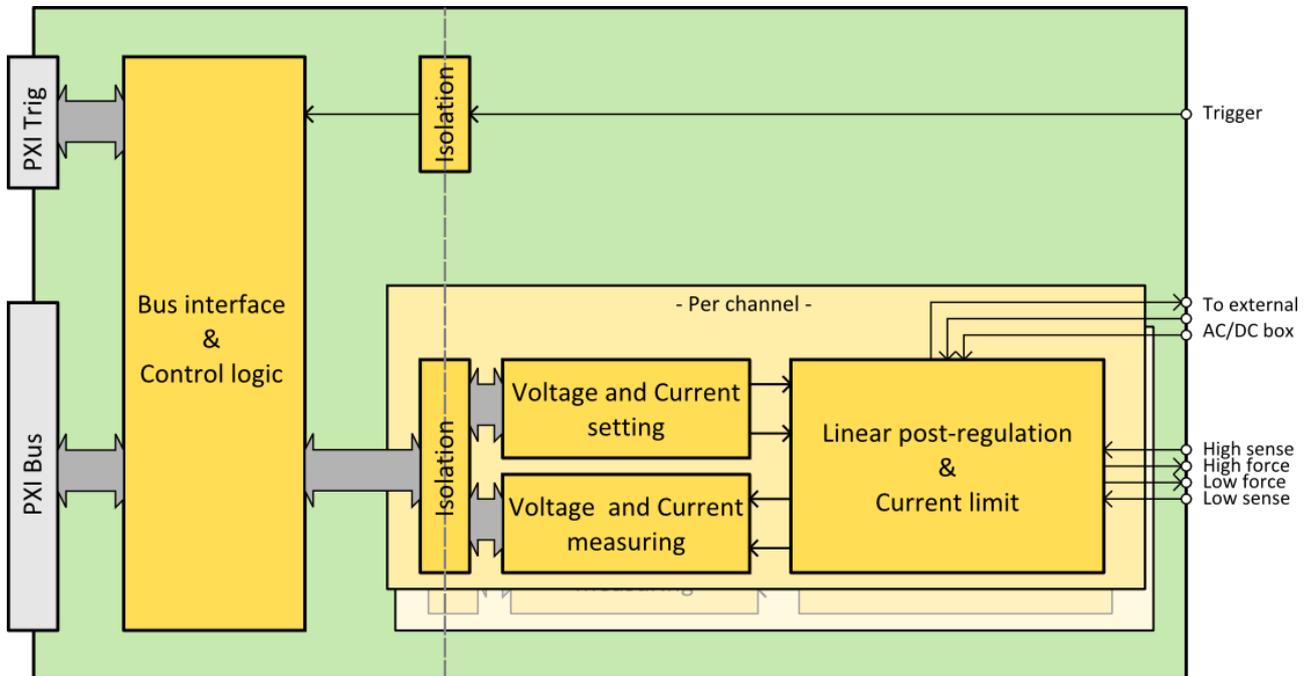
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## Table of Contents

1	Hardware description .....	4
1.1	Block diagram .....	4
1.2	Description.....	4
1.3	Output power .....	5
1.4	Front panel description .....	5
2	Software description .....	6
2.1	Installed components .....	6
2.2	Soft Front Panel .....	6
2.2.1	Getting started.....	7
2.2.2	Channel settings .....	7
2.2.3	Trigger-based actions .....	7
2.2.4	Analyzing captured current/voltage.....	8
2.2.5	Options menu .....	9
2.2.6	Tools menu .....	9
2.3	Sources and binaries.....	10
2.4	Driver documentation .....	10
3	Measurement concepts.....	11
3.1	Two-wire vs. four-wire connection .....	11
3.2	Hot switching (and why this should be prevented!) .....	12
3.3	Increasing current by putting multiple Power Supplies in parallel .....	12
3.4	Increasing output voltage or creating a bipolar supply by putting Power Supplies in series .....	13
4	Calibration .....	14
5	Technical Specifications.....	16
6	Document history .....	17

## 1 Hardware description

### 1.1 Block diagram



### 1.2 Description

The PS48402 is a dual output programmable power supply in a single PXI slot, which draws its power from an external AC/DC power supply box. Each channel is fully isolated, allowing to power two completely independent applications without creating undesired connections between your sites.

The external AC/DC box converts the 100-240V AC, 50/60Hz mains voltage down to a level just a few volts above the programmed output value, to power the output stage. This way, the losses in the output stage can be reduced, optimizing both energy efficiency and heat generation.

An integrated transient recorder allows for capturing up to 8192 samples per channel of measured output voltage or current, initiated on a trigger, at speeds up to 10kS/s. The same trigger signal can also cause the card to update the output voltage and current. The front trigger connector can also be used as a sample clock, giving full control on the measurement timing.

Other key features are:

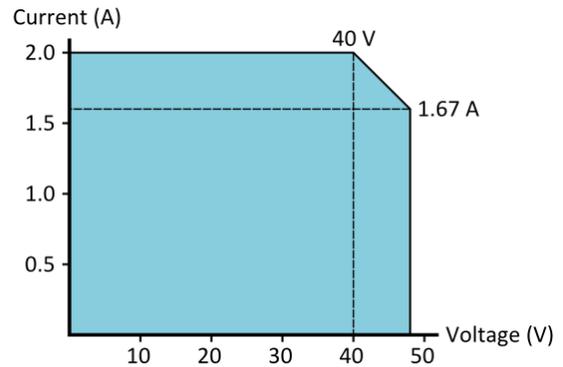
- High resolution voltage/current setting
- High resolution voltage/current read back
- High accuracy
- High output power

The PXI bus interface allows for fast access to the instrument, including a quick transfer of the captured data to the system controller. The PXI triggers (0..7 + Star) are also available as trigger sources.

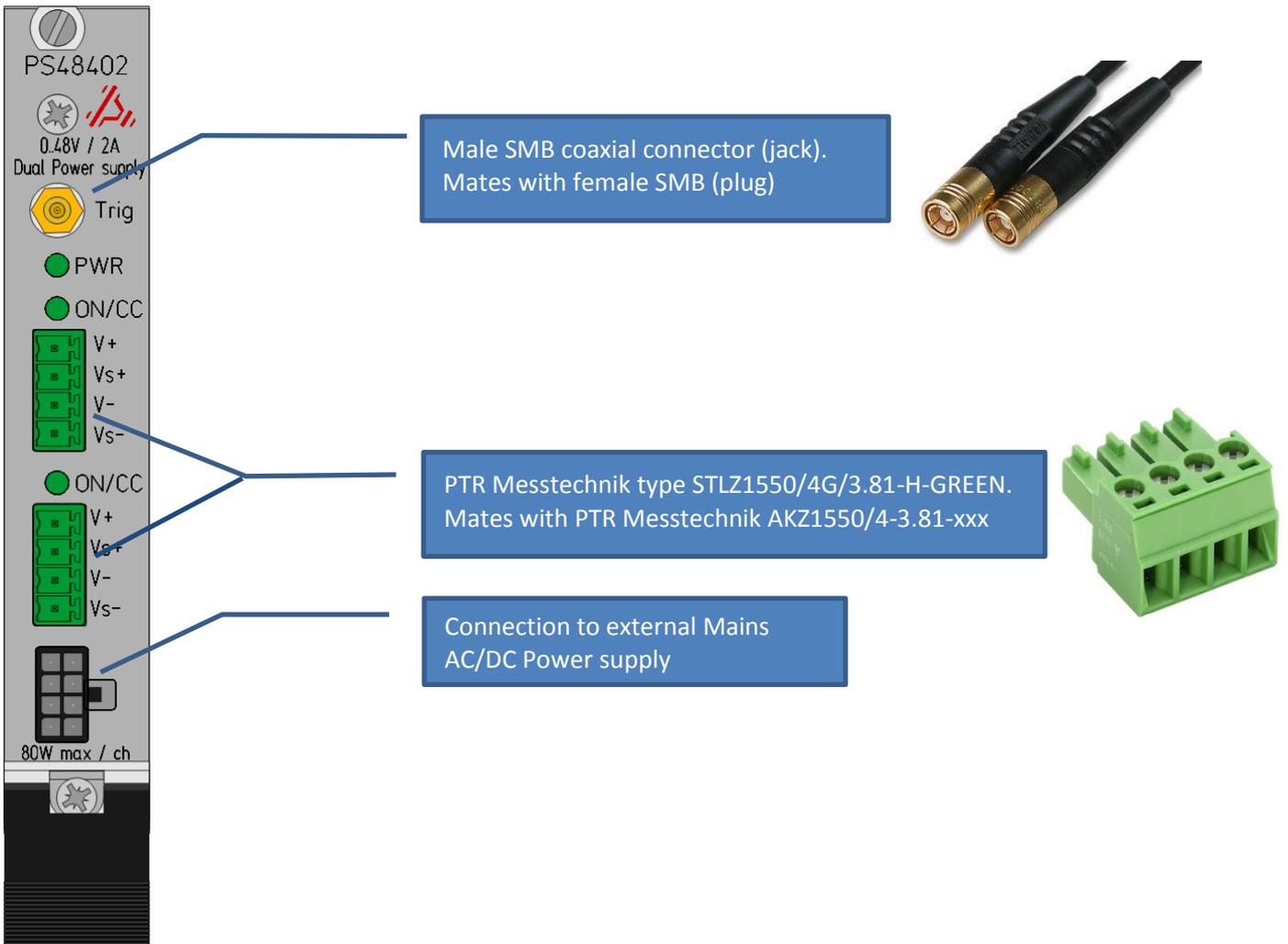
### 1.3 Output power

The maximum total output power is limited to 80 Watt per channel. This means that for output voltages above 40V, the maximum output current is linearly reduced to 1.667A at 48V.

The maximum output current for any output voltage is  $\frac{P_{max}}{V}$  (where  $P_{max}$  is the maximum output power and  $V$  is the output voltage) or 2.0 A, whichever is smaller. The instrument driver functions automatically adjust the programmed output current to meet the 80 Watt limit.



### 1.4 Front panel description



**PWR LED:**

- Off – No external power detected
- Green – External AC/DC box power is OK.
- Red – External AC/DC box power is not OK.

**ON/CC LEDs:**

- Off – Output disconnected
- Green – Output connected
- Green+RED – Connected, Current clamp active

## 2 Software description

### 2.1 Installed components

The PS4840x software package is a combined installer for both the PS48401 and PS48402. It includes the following components:

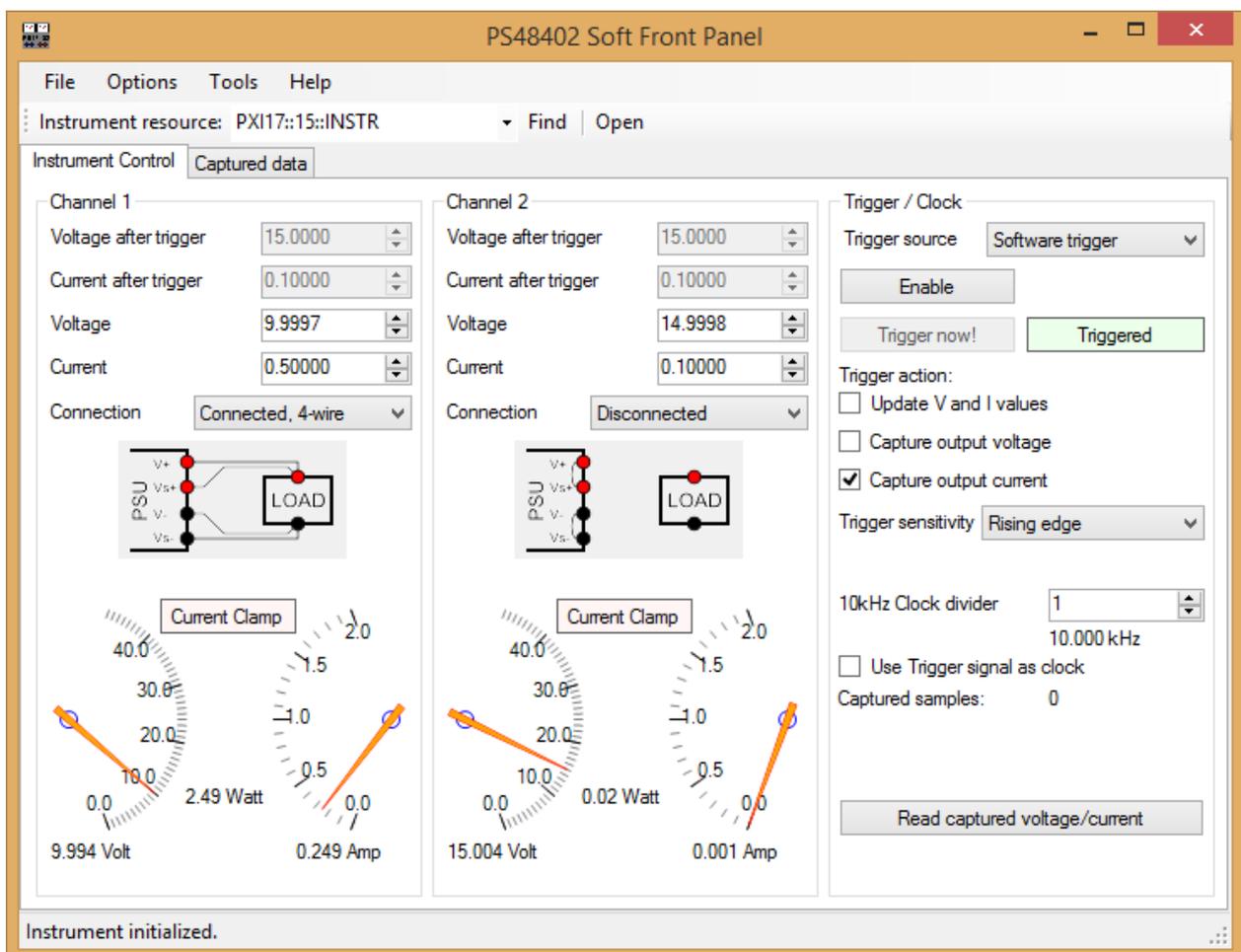
- LabVIEW drivers including an application example
- LabWindows/CVI drivers (compiled binary + source code)
- .NET driver wrapper (compiled binary + C# source code)
- Soft Front panel
- Driver documentation
- User manual

This supports a wide range of development environments.

For both the LabVIEW and the native Windows driver, VISA driver V4.1 or higher should be installed.

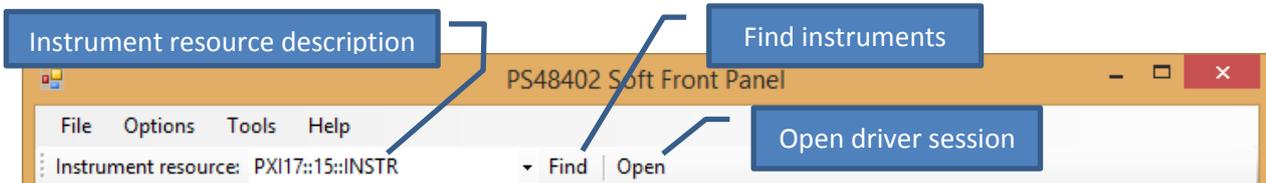
### 2.2 Soft Front Panel

The Soft Front Panel application shown below provides basic functionality for operating the PS48402 module.



### 2.2.1 Getting started

To initialize communication with the PS48402 hardware, the instrument must be opened. Make sure the instrument resource field is set to the PS48402 unit you want to use.



You can also let the software search for available PS48402 units in your system, by clicking the “Find” button.

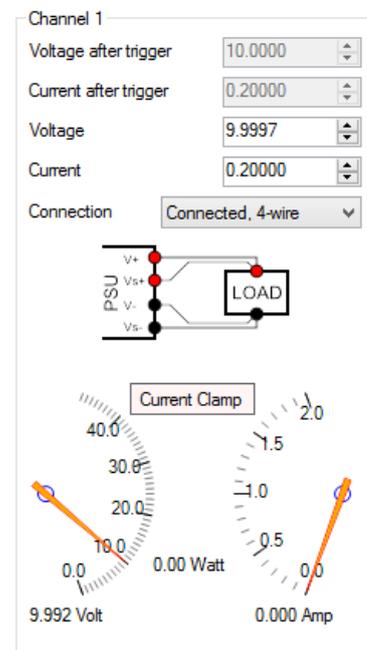
When the correct instrument resource is set, you initialize the driver session by clicking the “Open” button.

### 2.2.2 Channel settings

The Soft Front Panel has a section for each channel.

For each channel you can set the following settings:

- Voltage – The currently programmed output voltage.
- Current – The currently programmed output current.
- Connection – The currently programmed output connection mode. (Disconnect, 2-wire connection, 4-wire connection)
- Voltage after trigger – The voltage that will be the output voltage after a trigger event. (Only available when “Update V and I values” is enabled, see section 2.2.3)
- Current after trigger – The current that will be the output current after a trigger event. (Only available when “Update V and I values” is enabled, see section 2.2.3)
- Additionally, there are two indicators that show the readback value of the output current and the output voltage. Further, the calculated output power is shown and the current clamp status is displayed (red when active).



The software updates the output state immediately after setting a new value.

### 2.2.3 Trigger-based actions

The PS48402 can perform actions on a triggered basis. Available actions are:

- Update output voltage **and** current
- Capture output voltage **or** output current, using the build-in transient recorder.

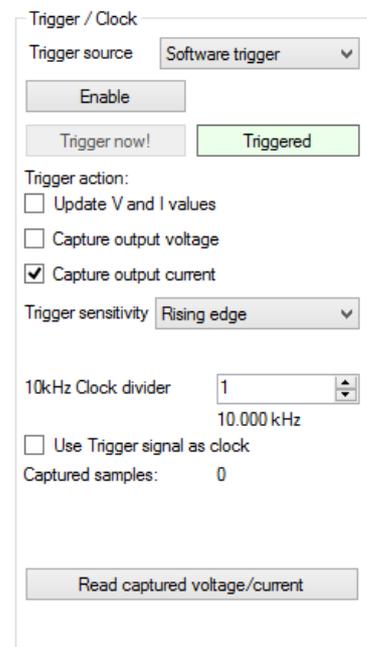
These two actions can be set independently from each other.

As trigger source, there are a number of available options:

- Front
- Software
- PXI trigger 0..7
- PXI Star trigger

The triggering circuit can be configured to respond on a rising edge or on a falling edge.

To perform a triggered action, the software must be set in a mode that makes the instrument sensitive for triggering. This is done by clicking the



“Enable” button. This disables the controls and the readback for the channels, and the instrument now waits for a trigger event.

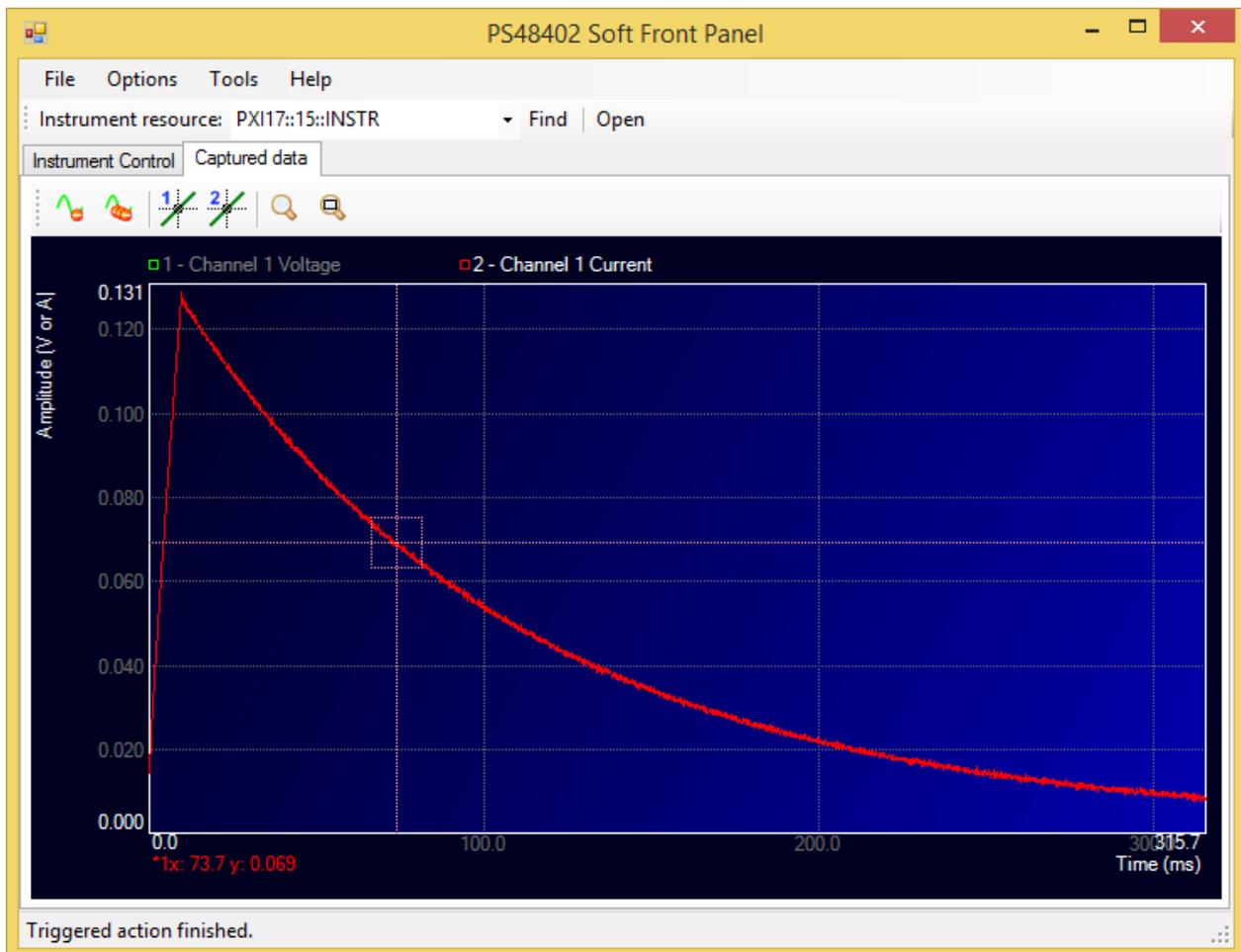
If the trigger source is set to “Software trigger”, the “Trigger” button becomes active. A click on this button will cause the instrument to trigger.

If the instrument is set up to capture the output voltage or current on a trigger, the transient recorder stores up to 8192 samples per channel in its internal memory. If “Use Trigger signal as clock” is checked, every sample is taken when a trigger is detected. Otherwise, the internal sample clock is used to time the storage of the samples. The internal sample clock source has a base frequency of 10kHz, but can be divided down to 5kHz, 3.3kHz, 2.5kHz, etc. by setting the clock divider to 2, 3, 4, etc.. Maximum value is 16384.

The “Captured samples:” field shows how many samples are stored. When the counter is at its maximum, the software automatically returns to its normal state (re-enabling the channel controls and the readback loop). The normal state can also be forced earlier by clicking the “Disable” button.

### 2.2.4 Analyzing captured current/voltage

When the built-in transient recorder has been used to record voltage or current measurements, the results can be read by clicking the “Read I/V” button at the bottom of the “Trigger/Clock” section. This reads all captured samples of both channels. The focus is switched to the “Captured Data” tab page (shown below), and for each channel a trace is added to the graph.



You can select a trace by clicking on the corresponding label in the graph’s legend (above the graph).

Above the graph a toolbar is visible, allowing performing some actions on the graph:

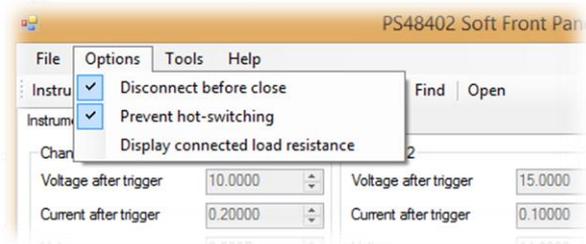
	Remove the currently selected trace from the graph.
	Remove all traces from the graph.
	Enable/disable cursor 1 or 2 on the selected trace.
	Toggle zoom mode.
	Reset zoom to fit all traces on the graph.

The graph’s cursors can be moved with the keyboard arrow keys, or by dragging them with the mouse. When a cursor is enabled, the exact cursor position is shown below the graph.

### 2.2.5 Options menu

In the “Options” menu, some application options are available:

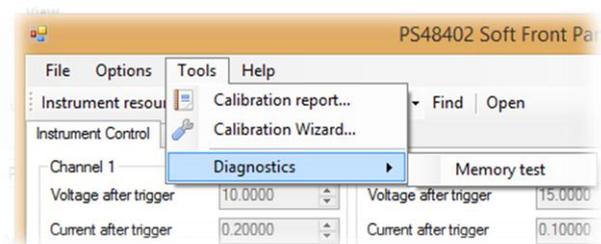
- Disconnect before close – When checked, the instrument’s outputs are disconnected when the software is closed.
- Prevent hot-switching – When checked, the software prevents the occurrence of hot-switching by bringing the output voltage to zero before switching the output connection. See section 3.2 to find out what hot-switching is, and why this should be prevented.
- Display connected load resistance – Show the calculated load resistance on the front panel.



### 2.2.6 Tools menu

The “Tools” menu contains some useful software-tools:

- Calibration report – Show a calibration report (see section 4 for more information)
- Calibration wizard – Start the calibration wizard (see section 4 for more information)
- Diagnostics, Memory Test – Perform a memory read/write test on the capture memory.



## 2.3 Sources and binaries

At installation, the driver binaries, sources, documentation, etc. are copied to the installation location.

The default installation location is:

[VPNPPATH]\WinNT\ps4840x

Where [VPNPPATH] is the *VXIplug&play* default installation path, read from the registry key:

HKLM\SOFTWARE\VXIPNP\_Alliance\VXIPNP\CurrentVersion\VXIPNPPATH

If this key is not available the directory is:

Program Files\Appligos\ps4840x

The user can change the installation directory during the installation process.

## 2.4 Driver documentation

The driver functions documentation files are accessible from the start menu.

### **Native driver functions:**

ps48402.chm (compiled HTML Help) and ps48402.txt (plain text file)

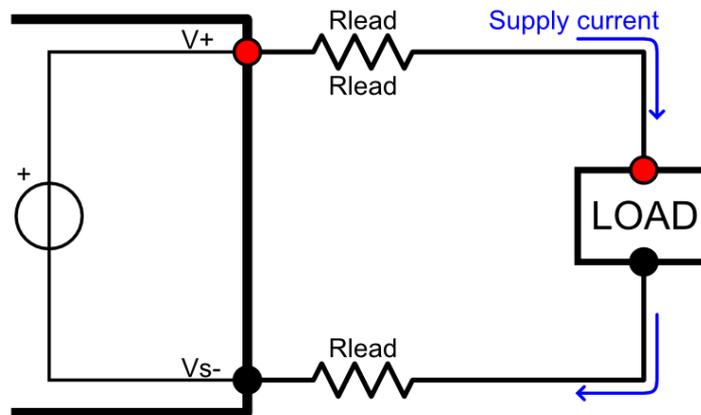
### **C#/.NET driver wrapper functions:**

PS4840x\_Driver\_Documentation.chm

### 3 Measurement concepts

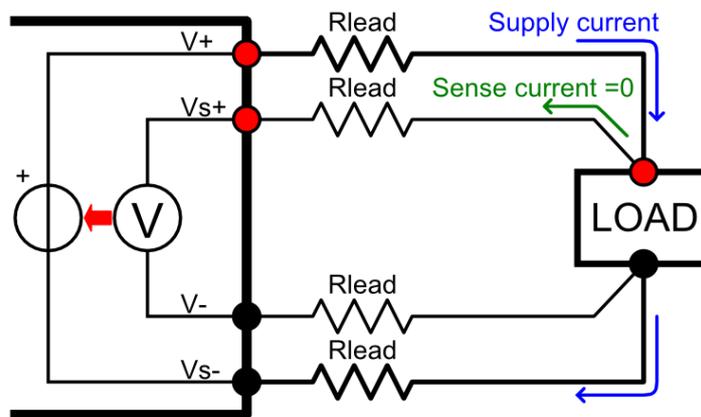
#### 3.1 Two-wire vs. four-wire connection

The diagram below shows a Power Supply unit with a typical 2-wire connection to the load.



The load draws a certain amount of current from the source. Resistance in the connection wires ( $R_{Lead}$ ) cause a voltage drop when current flows through it. Depending on the magnitude of the resistance and the current, this may lead to significant errors. If, for instance, the resistance of a single lead is 10 milliOhm, the total lead resistance in the V+ and the V- wire is 20mOhm. According to Ohm's law  $U = I * R$ , when drawing 2 Amp from the power supply unit, this will lead cause a voltage drop of  $(2 * 0.010) \Omega * 2.000 A = 0.040 V$ . Depending on your application this might be a problem.

The solution is to connect remote sensing wires, as shown below:



The sense lines are connected to as close to the load as possible. The sensing lines will also have a certain amount of resistance, but since the voltage measurement is high impedance, hardly any current will flow through the sense lines. Therefore the lead resistance will cause nearly no voltage drop, allowing for an accurate measuring of the voltage on the point of load. Using a closed loop voltage regulation, the output voltage is automatically increased until the sensed voltage matches the programmed voltage.

The PS48402 PXI Programmable Power Supply is equipped with sense line connections. **Please note that in 4-wire mode, sense lines should never be left floating**, because that would greatly influence the output voltage. When the test setup does not accommodate remote sense lines, choose the 2-wire connection mode. This will connect the sense lines to the force lines internally.

### 3.2 Hot switching (and why this should be prevented!)

Hot Switching is a term used to describe when a relay changes state while carrying a signal.

When a relay is connected or disconnected with a voltage across the contacts, arcs may arise. This greatly reduces the contact's life, as it heats and erodes the contacts.

The PS48402 uses relays to connect/disconnect the output lines from the card. Therefore it is sensitive for hot-switching.

To prevent hot-switching, make sure the voltage on both sides of the relay will be equal when the relay is in the open-state. Usually it is easiest to set this to 0 Volt.

Example sequence to connect the PS48402:

1. Program the output voltage to 0 Volt (assuming the load is un-powered, and at 0 Volt).
2. Wait for the output voltage to be settled.
3. Connect the output.
4. Wait for the relays to be settled.
5. Program the output voltage and current to the desired values.

Example sequence to disconnect the PS48402:

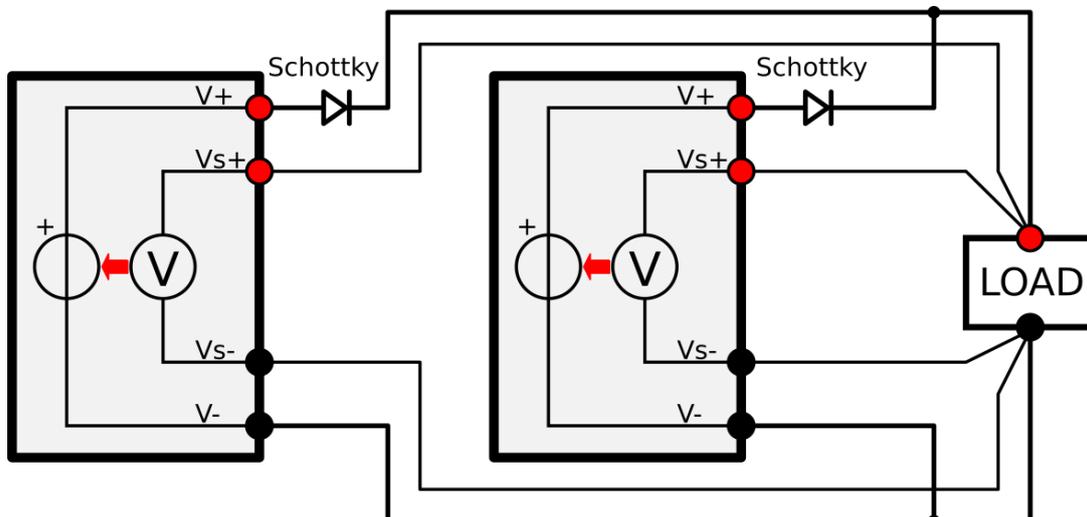
1. Program the output voltage to 0 Volt (assuming the load will be at 0 Volt when un-powered).
2. Wait for the output voltage to be settled.
3. Disconnect the output.

### 3.3 Increasing current by putting multiple Power Supplies in parallel

When the required output current is higher than what the power source can supply, multiple power supply channels can be put in parallel to share the requested output current sourcing. However, care must be taken not to damage the power supply in the process.

When both outputs are not sourcing exactly the same voltage, the channel with the lowest output voltage will start sinking current from the channel with the higher output voltage. The PS48402 is intended for 1-quadrant operation (positive voltages, sourcing current only), but there is a small current sink that helps discharging the output capacitors when the output voltage is changed down. This circuit however does not make it a real 2-quadrant power supply, as it cannot handle a continuous current.

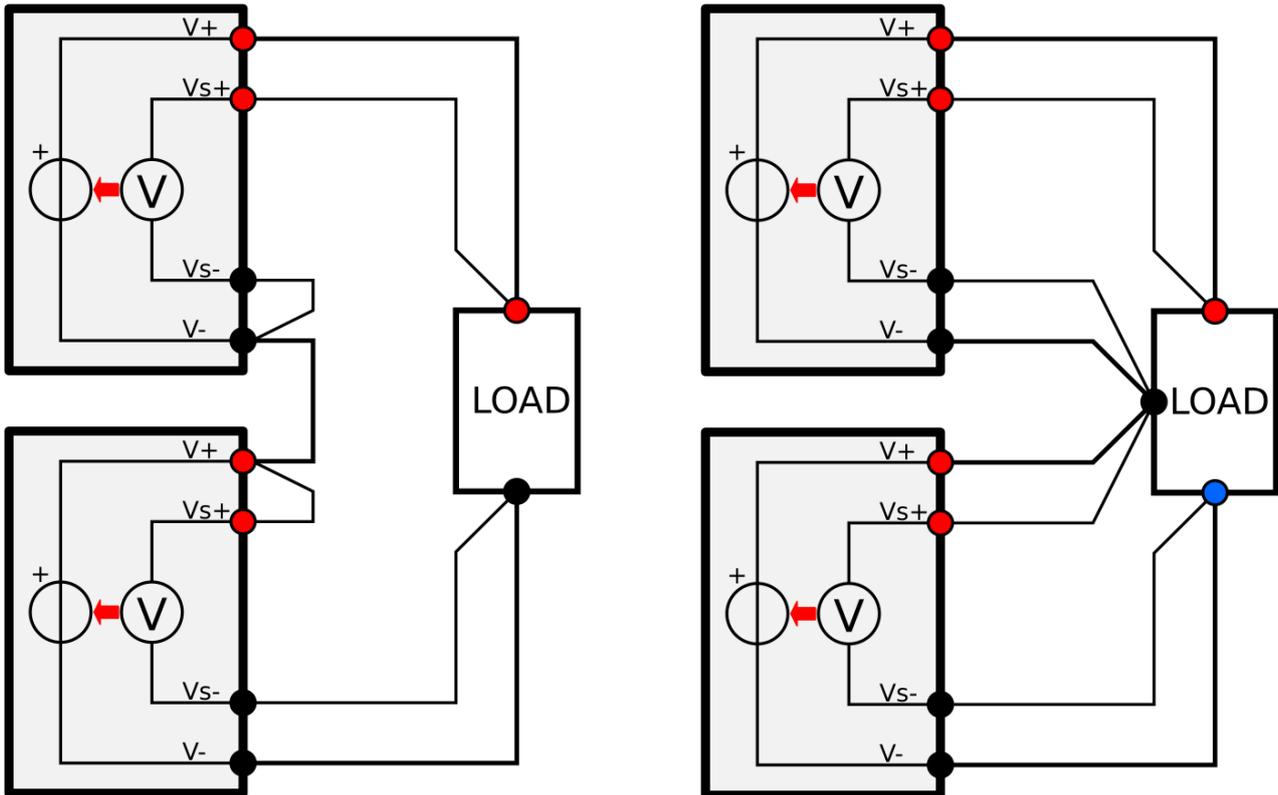
So care must be taken to prevent the lower-output-voltage channel from sinking current. The recommended way is to use a Schottky diode in series with each '+' output. A Schottky diode typically has a low voltage drop, and this drop can be compensated by connecting the sense lines after the diodes. A diode with sufficient current rating should be selected.



### 3.4 Increasing output voltage or creating a bipolar supply by putting Power Supplies in series

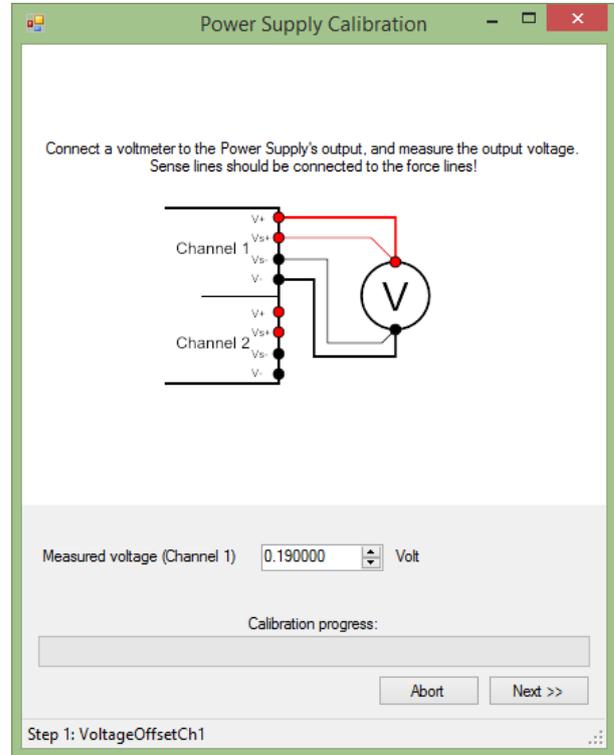
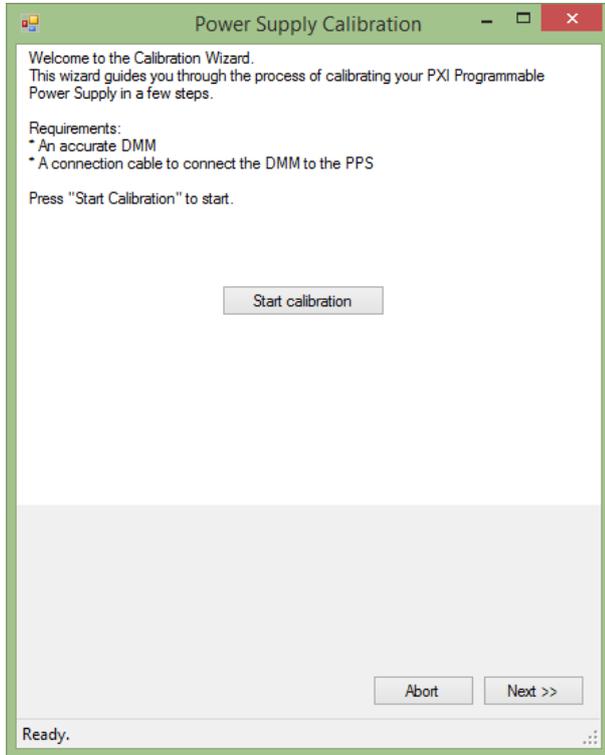
When the required output voltage is higher than what the power source can supply, multiple power supply channels can be put in series to increase the total output voltage. This can be seen in the left diagram below.

When a bipolar power supply is required, the wiring is very similar, except that the connection putting the two channels in series is becoming the GND net. This can be seen in the right diagram below.



## 4 Calibration

The calibration wizard can be started from the “Tools” menu of the Soft Front Panel application that is included. This wizard guides you through all steps that are required to calibrate the PS48402 voltage and current DAC and the readback ADCs.

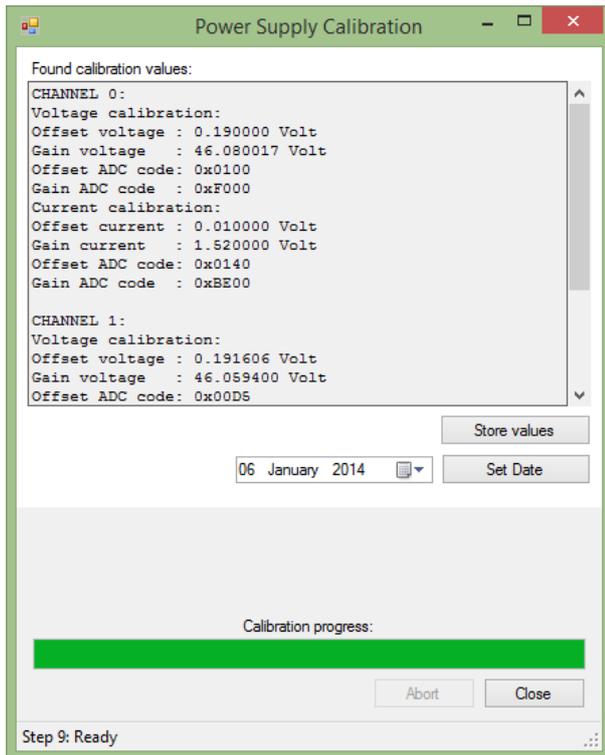


Filling in the DMM readings allows the calibration routine to verify both its programmed value and its readback value.

**Make sure to not mix up currents and voltages, and make sure you measure the proper channel!**

Expected values for the different steps are:

Step	Min.	Max.	Units
Voltage Offset	0.180	0.200	V
Voltage Gain	45.62	45.54	V
Current Offset	0.008	0.012	A
Current Gain	1.49	1.55	A



When all steps are completed for both channels, a calibration report is shown. These values are now used in the current driver session, until the driver session closes (closing the software or opening another instrument).

You now have the options to:

- Store the calibration values to EEPROM. This will make sure these calibration values will be loaded the next time the driver initializes the instrument. To do this, click “Store values”
- Set the calibration date. This is useful to store the date on which the instrument is last calibrated in the instrument’s EEPROM. This date is displayed in the calibration report from the “Tools” menu.

If the calibration wizard is closed without saving the calibration values, a confirmation dialog pops up, offering you to restore the calibration values to what they were before the calibration wizard was started.

## 5 Technical Specifications

### Output

Output Voltage	0 to 48 V per channel
Voltage setting resolution	0.74 mV (16-bits)
Voltage setting accuracy	$\pm 0.2$ % of programmed value $\pm 25$ mV
Load regulation	0.1 % of programmed value + 5 mV (10 to 90 % load change)
Output current	0 to 2 A (Above 40 V: Linearly de-rating to 1.67A (80 W max. total power))
Maximum output power	80 Watt per channel
Current limit resolution	35 $\mu$ A
Current limit accuracy	0.5 % of programmed value $\pm 10$ mA
Sense line regulation area	0.5 V (sum of both sense lines)
Output ripple (typical)	<3 mV RMS under full load (Bandwidth 20Hz - 1MHz)
Rise time:	1 V/ms (typical at full load)

### Readback

Voltage Read back resolution	0.74 mV (16-bit)
Voltage Read back accuracy	$\pm 0.1$ % of reading $\pm 10$ mV
Current read back resolution	35 $\mu$ A (16-bit)
Current read back accuracy	$\pm 0.2$ % of reading $\pm 5$ mA

### Triggering

Trigger sources	Software trigger, Front trigger, PXI0..7, PXI Star
Front trigger input	Floating opto-coupler input (220 $\Omega$ in series with a diode)
Front Trigger level	4.0 V – 12 V (approx. 10 mA – 50 mA)
Minimum trigger pulse low / high time	20 $\mu$ s
Trigger actions	Update output voltage and current, Capture output voltage or current, Update voltage and current + Capture output voltage or current

### Capturing measurements

Capture Memory Depth	8192 samples per channel
Maximum capture clock frequency	10 kHz
Internal capture clock divider	1 .. 16384 (generates 10kHz .. 0.6 Hz capture clock)
Capture clock sources	Internal sample clock, Trigger source

### Operating limits

Voltage to chassis (any pin)	60 VDC (safety limit, design breakdown voltage > 250VDC)
Insulation resistance	> 100 M $\Omega$
Operating temperature	0°C to 50°C
External AC/DC box input range:	100-240V AC, 50/60Hz

## 6 Document history

Version	Date	Editor	Changes
0.1	December 2013	JvdV	Initial draft.
0.2	January 2014	JvdV	Improved Soft Front Panel description. Added calibration procedure.
0.3	January 2014	JvdV	Updated Calibration description text to latest requirements. Updated screenshots as the SW layout has been slightly changed.
1.0	January 2014	JvdV	Added support contact information to "Preface". Finalized specifications.
1.1	February 2015	JvdV	Updated chapter 2.1: "Installed components". Split "Driver documentation" to "2.3 Sources and binaries" and "2.4 Driver documentation".
1.2	September 2015	JvdV	Added chapter 3.3: "Increasing current by putting multiple Power Supplies in parallel".
1.3	October 2015	JvdV	Added chapter 3.4: "Increasing output voltage or creating a bipolar supply by putting Power Supplies in series".