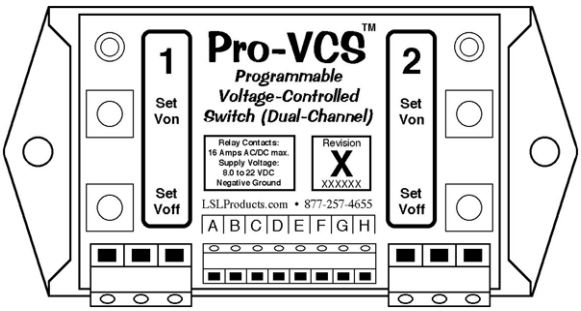
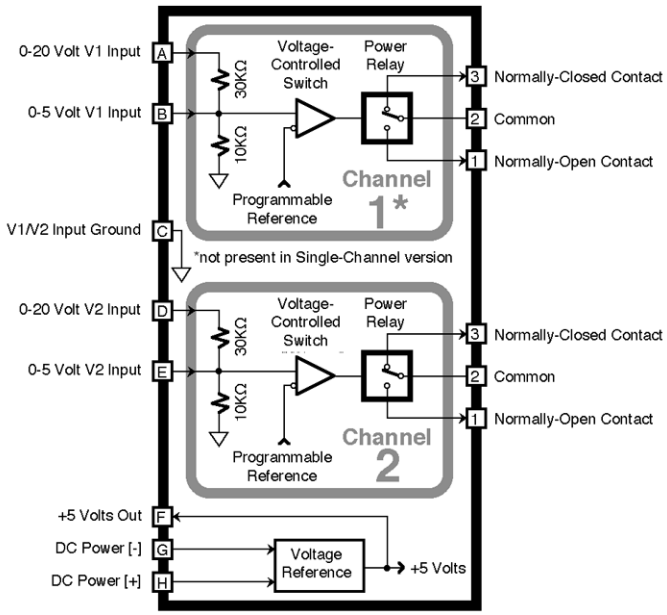
Pro-VCS™
Programmable Voltage-Controlled Switch

Owner's Manual – Applications & Operating Instructions, Trouble-shooting, Specifications & Warranty

GENERAL INFORMATION - The **Pro-VCS™** ("Programmable Voltage-Controlled Switch") consists of either 1 or 2 voltage-controlled switches and power relays, packaged inside a small, epoxy-encapsulated enclosure. Each switch and relay combination (or "Channel") can be independently programmed for turn-on and turn-off input voltages over a range of either 0-5 or 0-20 volts DC. Programming either channel is quick and easy - simply press the **SET Von** or **SET Voff** buttons whenever the desired input turn-on or turn-off voltages are present. The unit "memorizes" these settings, retaining them even after the DC supply is removed.





Equivalent Circuit.

While both **Pro-VCS™** versions are electrically identical, the Single-Channel version is only equipped with relay contacts, connectors and pushbutton switches for one channel ("Channel 2"). The relay contacts for both versions are single-pole double-throw, capable of handling resistive loads of up to 10 amps at 120/240VAC or 12VDC. A user-configurable option on the Dual-Channel version allows both relays to be "strapped" to Channel 1, providing a second set of relay contacts for controlling a second circuit.

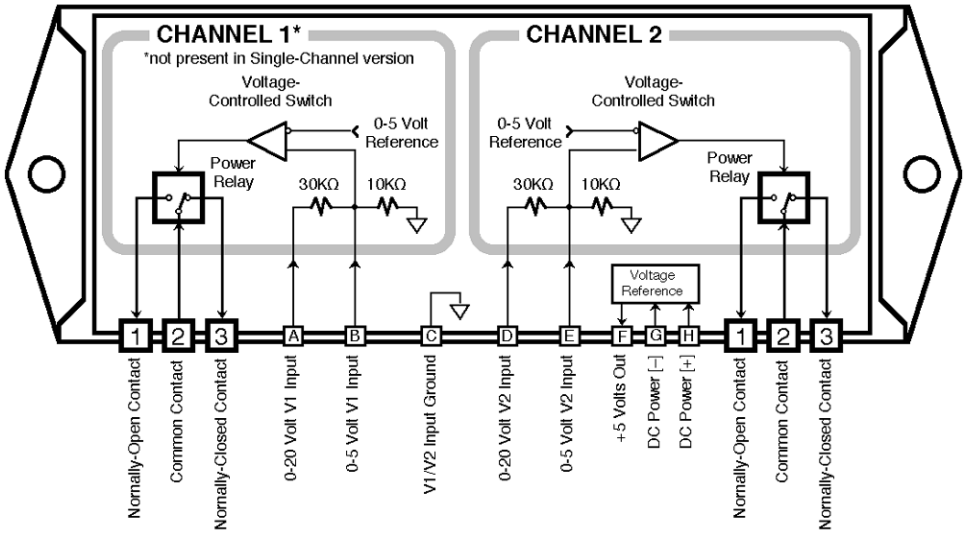
The relay(s) use latching contacts, only consuming DC power for approx. 0.05 seconds when they are actually changing states – The rest of the time, they draw no power whatsoever. The entire unit draws approx. 5 mA of supply current (including the LED indicator lights) at 12.8 VDC, making it ideal for battery-powered applications.

HOW IT WORKS – The **Pro-VCS™** uses an 8-bit microcontroller with a built-in analog-to-digital converter (or "ADC") that continuously measures the input voltage(s). Whenever the voltage(s) precisely match the turn-on or turn-off voltage(s) programmed into the microcontroller, it turns the corresponding relay on or off. The ADC has a resolution of 10 bits, which means that the **Pro-VCS™** is capable of discerning voltage differences as small as approximately 0.02 volts at the 0-20 volt input(s), or approx. 0.005 volts at the 0-5 volt input(s). The 0-5 volt input(s) is fed directly to the ADC; the 0-20 volt input(s) is first scaled to 0-5 volts with a built-in resistive voltage divider. On the Dual-Channel version, both ADC inputs share a common Analog Ground connection - The input voltage to either Channel must be positive with respect to this ground.

The programmed turn-on and turn-off voltage settings are stored in EEPROM memory, and are retained regardless of whether or not DC power is present.

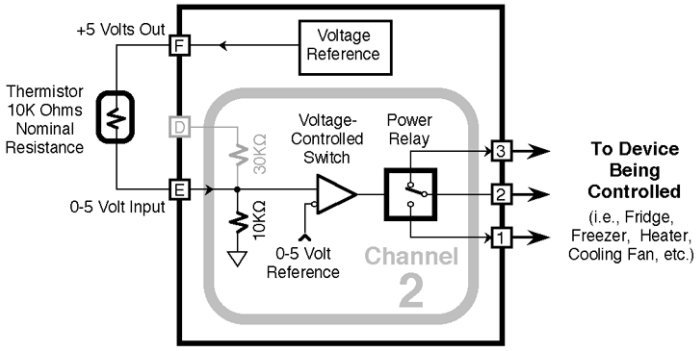
Pro-VCS™ can be operated from just about any +7.5 to +20.0 VDC power source. A regulated 5 volt reference voltage output (terminal **F**) is provided, allowing the unit to be easily connected to potentiometers, thermistors, photoresistors, phototransistors, pressure transducers, humidity sensors or other input devices – Typically, no components other than the sensor itself are required to complete the circuit.

Package Pin-Out



TYPICAL APPLICATIONS - The **Pro-VCS™** is an extremely versatile building block that can be used for a wide variety of applications, including:

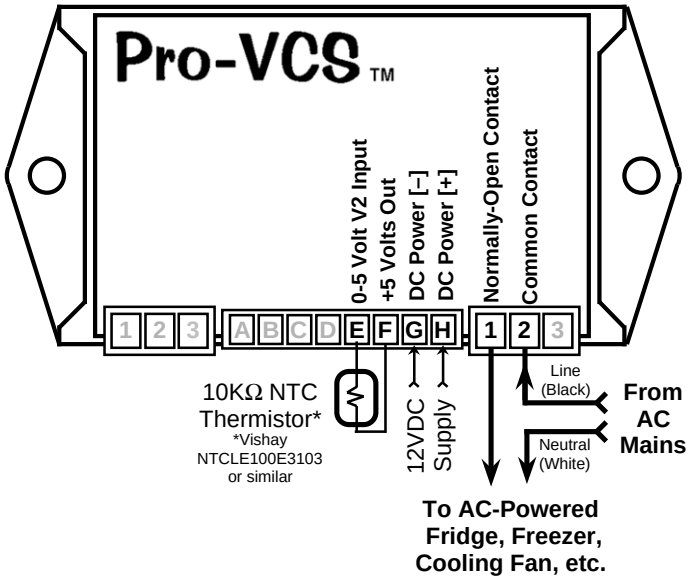
THERMOSTATS – Since the **Pro-VCS™** responds to changes in voltage, the addition of a single temperature-sensitive resistor (or "thermistor") in a voltage-divider circuit allows the **Pro-VCS™** to also respond to changes in temperature:



Basic Thermostat Circuit

Essentially, the Thermistor forms the upper part of the divider circuit, and the 10K Ohm resistor inside the **Pro-VCS™** unit forms the lower part. As the Thermistor is exposed to different temperatures, its resistance will change, causing the voltage at the center of the divider to also change. We can program the **Pro-VCS™** to turn on or off at these different voltages, thereby allowing the unit to function as a thermostat. Here's a practical example:

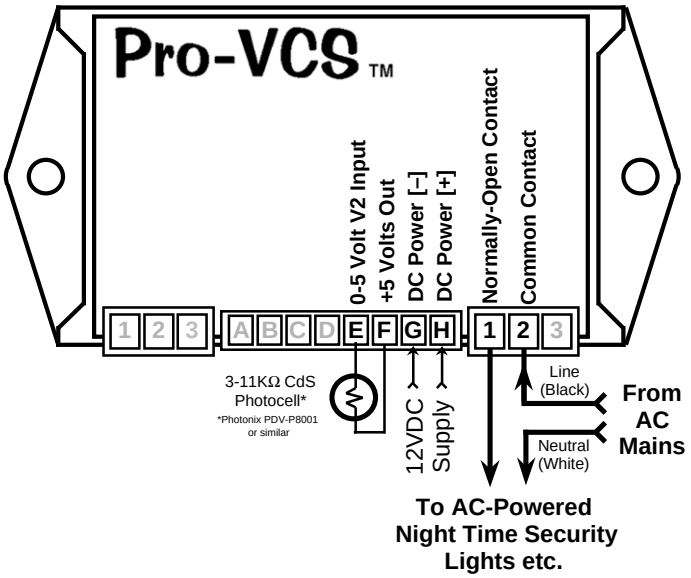
Thermostat (Cooling):



This particular Thermistor has a negative temperature coefficient (as denoted by the "NTC" designation) - which means that its resistance decreases as it gets warmer. Thus, when connected as shown, it will produce a higher voltage in warmer temperatures (closing the **NO** relay contacts), or a lower voltage in cooler temperatures (closing the **NC** relay contacts instead).

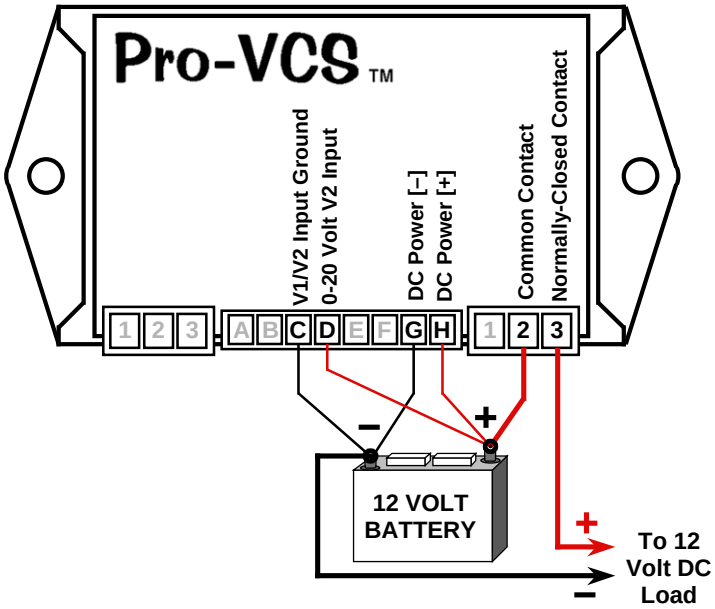
Note that the same configuration which might control a cooling device like a refrigerator could instead be used to control a heating device like a hot water heater, simply by moving the device connection point over from the **NO** to the **NC** relay contact.

Night Time Lamp Control:



LIGHT-ACTUATED SWITCHES – By simply substituting a light-sensitive resistor (i.e., a Cadmium Sulfide Photocell) for the temperature-sensitive Thermistor used in the previous example, we have a configuration that can be programmed to turn a device on or off when a specific amount of light shines on the photocell - Very handy for turning outdoor lights on at dusk, or for automatically keeping solar panels aimed directly at the sun.

Low Battery Voltage Cut-Off:



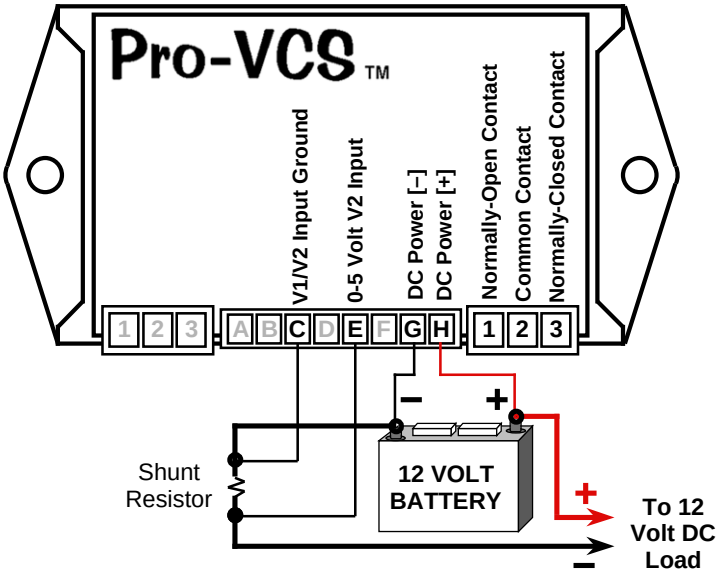
UNDERVOLTAGE (OR OVERVOLTAGE) PROTECTION – One of the most common applications, this configuration simply disconnects a load from its battery whenever the battery voltage drops below (or exceeds) a safe value.

Low/High Battery Voltage Cut-Offs are widely used to protect the battery from damage due to excessive discharge, and to keep the powered device from "crashing" or operating in an unpredictable manner due to excessively low (or high) supply voltage.

DC CURRENT-OPERATED SWITCH – This configuration measures the voltage developed across a "Shunt" resistor. Since this voltage is proportional to the amount of current being drawn by the connected load, it can be used to operate one of the **Pro-VCS™** relays whenever it exceeds (or falls below) some pre-set value. Some typical applications include automatically turning on one device whenever another device is turned on, or disconnecting a device that is drawing too much (or not enough) current.

Note that the Shunt must be located on the load's NEGATIVE connection. Typically, the resistance of the Shunt is chosen to produce no more than 50 - 100 mV of voltage drop when the load is drawing maximum current.

DC Current-Operated Switch:

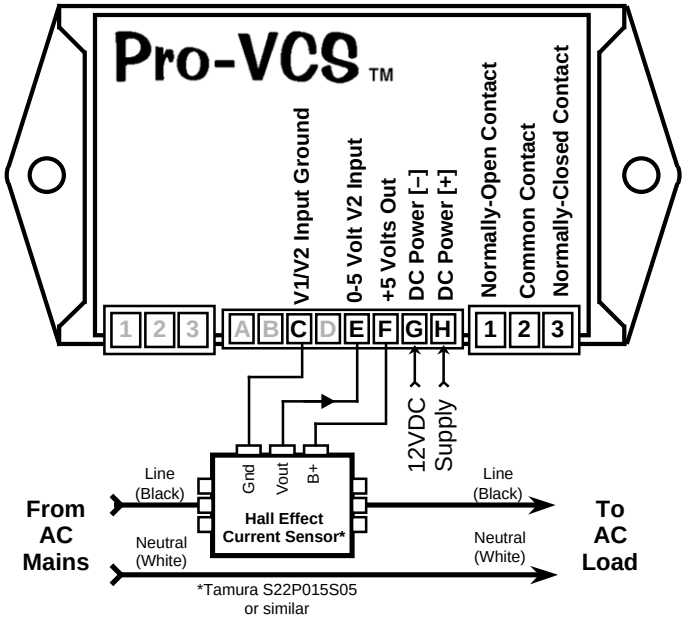


AC CURRENT-OPERATED SWITCH – This configuration measures the DC voltage developed by a Hall Effect Current Sensor, which is proportional to the amount of current being drawn by the connected AC load. Unlike a Shunt resistor, this sensor electrically isolates the **Pro-VCS™** from the AC mains - which is absolutely essential for safety.

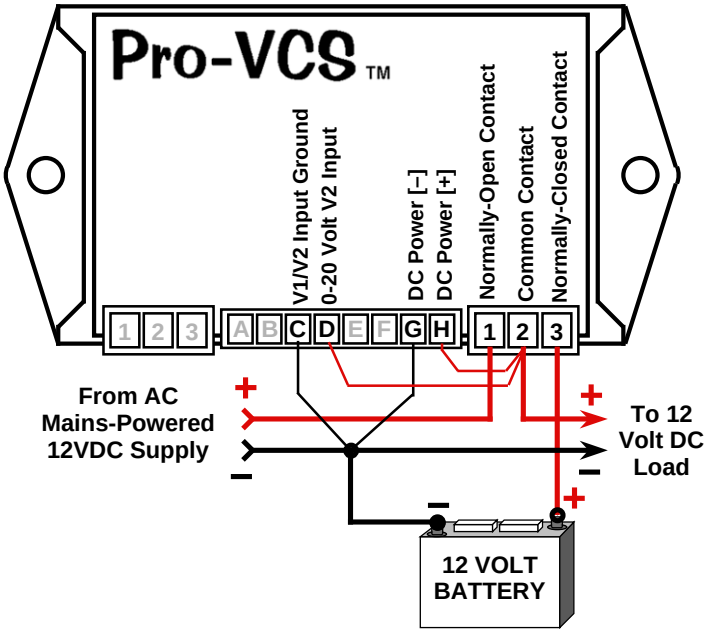
Most Hall Effect sensors will accurately measure AC current over a wide range of line frequencies, even down to pure DC.

This particular Tamura current sensor only requires a +5 VDC power source (which can be supplied by Terminal F on the **Pro-VCS™** unit). The AC side of the sensor has several different connection options, allowing it to be configured to measure several different ranges of AC current. This sensor also produces different DC output voltages for the same AC current flowing in opposite directions, allowing the **Pro-VCS™** to trigger on either forward or reverse current flow.

AC Current-Operated Switch:



Uninterruptable DC Power Supply:



AUTOMATIC BATTERY CHANGEOVER – This configuration constantly monitors the voltage being supplied to a DC load, automatically switching the load to a backup battery whenever the primary power supply fails.

Note that the DC load must have enough "hold up" time to continue operating during the short period of time when the relay contacts are in the process of switching. In some cases, adding a large-value electrolytic capacitor across the load helps in this regard.

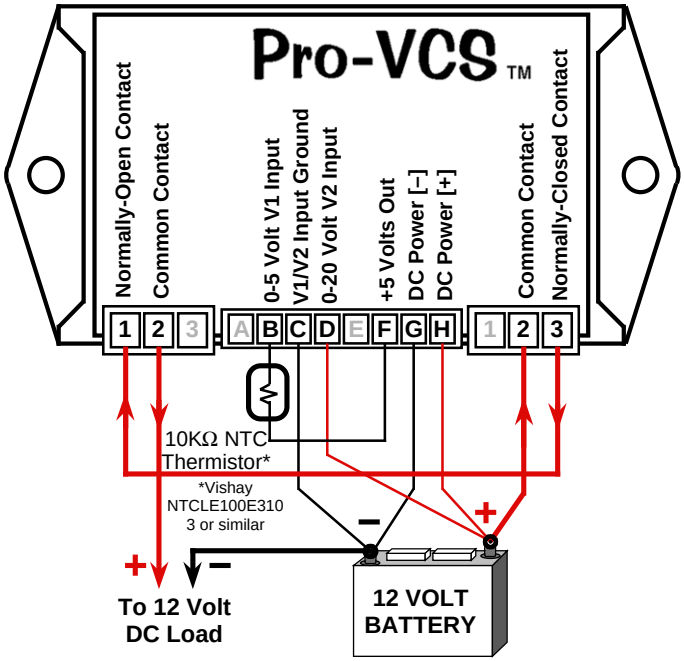
Although not shown in this diagram, some means of recharging and maintaining the battery is also usually present - and the **Pro-VCS™** Dual-Channel version has a second channel which might be configured to serve this purpose.

COMBINING SEVERAL FUNCTIONS – Having two separate channels in a single package greatly increases the versatility of the Dual-Channel version - For example, if one channel is configured as a thermostat, the other channel can be used to modify the operation of the thermostat - i.e., add a humidistat, low battery voltage shutdown, overvoltage protection, photoelectric switch, low pressure alarm, mechanical limit switch, airflow sensor, etc.

In this particular example, Channel 1 is configured as a thermostat, and Channel 2 is configured as a low battery voltage disconnect.

For more applications and circuit examples, please visit the **LSLProducts.com** website. New examples are being added periodically.

Thermostat (Cooling) with Low Battery Voltage Cut-Off:



INSTALLATION CONSIDERATIONS

WIRING TIPS: The 0-5 volt input of each switch is internally connected to its associated 0-20 volt input through a pair of voltage divider resistors. Thus, only one these two inputs should be used at any given time - e.g., if the 0-5 volt input is being used, the 0-20 volt input should be left unconnected.

The Dual-Channel **Pro-VCS™** uses the same "analog ground" connection (Terminal **C**) for both switch inputs. Inside the unit, this ground is also loosely tied to the **POWER [–]** terminal (Terminal **G**). For best performance, the negative connections of any devices being monitored should be connected to Terminal **C** instead of the **POWER [–]** terminal. Similarly, in applications where the **Pro-VCS™** is monitoring the same voltage source that is supplying DC power to the unit, best performance is obtained by connecting a separate, dedicated wire between one of the **Vin** terminals and the positive side of the voltage source.

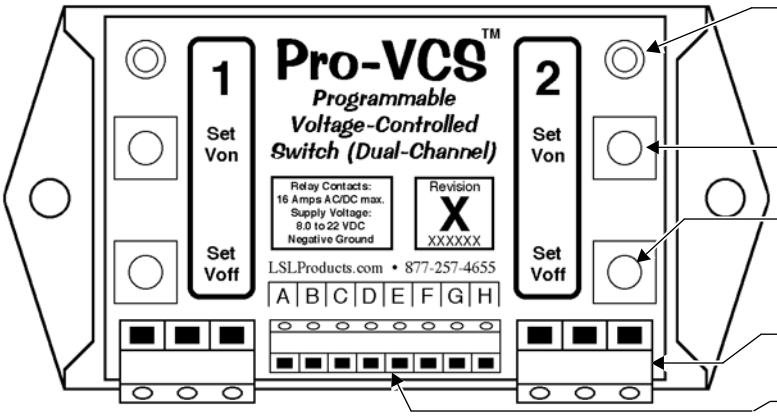
There are several "tricks" for obtaining the most consistent performance:

1. Apply DC power to the unit for at least a few minutes before programming in your desired settings. This allows the unit's internal voltage reference to "warm up" to operating temperature, increasing its voltage stability (and thus increasing the consistency of the turn-on and turn-off voltage settings).

2. Program the unit in the same environment (i.e., same temperature range) where it will be installed. This helps ensure that the unit's voltage reference produces exactly the same voltage after installation as during programming, thus ensuring consistent turn-on and turn-off voltage settings.

3. When using **Pro-VCS™** as a thermostat, be sure to completely seal the temperature-sensing thermistor - This will prevent moisture from changing the measured resistance of the thermistor.

OPERATING INSTRUCTIONS



Status Indicator LED

- Steady Glow: Relay for that channel is engaged.
- 3 Flashes: New setting has been successfully programmed.
- 9 Flashes: Setting has been restored to its default value.
- LEDs flicker rapidly: New setting is invalid, has been rejected.
- Not Illuminated: Relay is disengaged.

Turn-On Voltage Programming Button

Push and hold this button* **for 2 seconds** to program in a new relay turn-on voltage ("Von").

Turn-Off Voltage Programming Button

Push and hold this button* **for 2 seconds** to program in a new relay turn-off voltage ("Voff").

*NOTE: Press and hold either button for 5 seconds to revert to the original factory-programmed turn-on or turn-off voltage.

Relay Contacts Output Terminal

N.O., Common & N.C. output contacts for this channel

Input Voltage & DC Power Terminal

Inputs for both channels, and for DC Power Supply

When DC power is first applied, the indicator LED(s) will flash once to confirm that the unit is operating normally. At the same time, the contacts for the relay(s) are initially set in the "normal" (unactuated) position (i.e., the NC contact is closed).

The channel(s) in the **Pro-VCS™** are factory-programmed with the turn-on setting(s) at 20* volts, and the turn-off setting(s) at 0 volts. Consequently, new turn-on and turn-off voltages must be programmed into a channel before it can be used for the first time. (If only one channel in the Dual-Channel version will be used, the other channel can be left with its factory-programmed default settings unchanged).

To program in a new turn-on voltage for a channel, press and hold its **SET Von** button **FOR 2 SECONDS** as soon as the desired turn-on voltage is present. Upon release of the button, that indicator LED will flash 3 times to confirm acceptance of the new voltage setpoint. The relay for that switch will also immediately turn on, as evidenced by a steady glow from the indicator LED. Similarly, press and hold the **SET Voff** button **FOR 2 SECONDS** as soon as the desired turn-off voltage is present. (Requiring the buttons to be held down for 2 seconds helps prevent inadvertent changes to the settings, caused by accidentally bumping the buttons.) Each time a button is used to program in a new setting, the new setting permanently replaces the old one.

IMPORTANT NOTE: Von MUST ALWAYS BE HIGHER THAN Voff. The **Pro-VCS™** will only accept a turn-on voltage that is higher than the already-programmed turn-off voltage - If you attempt to program either a turn-on or turn-off voltage that violates this rule, the indicator LED(s) will flicker rapidly, and the new setting will not be accepted.

To revert back to the factory default value for **Von** or **Voff**, press and hold that **Von** or **Voff** button for at least 5 seconds - The indicator LED next to that button will flash 9 times to confirm that the setting has been changed back to the factory default value (20* volts for **Von**, or 0 volts for **Voff**).

RELAY STRAPPING – On the Dual-Channel version, a "strapping" feature allows both relays to be controlled by Channel 1, thereby allowing two separate relay circuits to be controlled by the same Channel. When relay strapping is enabled, both relays are only controlled by input voltages on Channel 1 - any Channel 2 input voltages are ignored. (**NOTE:** The unit is factory-programmed with the relay strapping function turned **OFF**). To enable relay strapping, press and hold the **SET Von** button for several seconds while initially applying DC power to the unit. Upon release of the button, the LEDs will slowly flash several times in unison to confirm strapping. The unit will remain in this mode indefinitely (even when DC power is not present), or until this same procedure is repeated (at which point the LEDs will alternately flash several times to confirm unstrapping of the relays).

*Measured at the 20 VDC input terminals, or 1/4th of that amount when measured at the 5 VDC input terminals.

IN CASE OF TROUBLE

WHY ISN'T IT DOING ANYTHING? The **Pro-VCS™** unit is shipped without any settings pre-programmed, and won't operate until the user has programmed in his/her own settings for **Von** and **Voff**.

WHY WON'T IT ACCEPT A SETTING THAT I AM ATTEMPTING TO PROGRAM IN? A button must be pressed and held **FOR 2 SECONDS** before anything happens. Also, your new voltage setting for **Von** must be higher than the **Voff** value currently programmed into that channel - otherwise, the **Pro-VCS™** unit will reject your new **Von** value. Similarly, a new **Voff** voltage must be lower than the current **Von** value.

If a new value is rejected, the indicator LED(s) will rapidly flicker. To remedy the problem, reset the value for **Voff** before attempting to program in your new value for **Von**, or vice-versa. (To reset **Von** or **Voff**, press and hold the Von or Voff button for 5 seconds - For **Von**, the new value after reset will be 20.0 volts*; for **Voff**, it will be zero volts.)

WHY IS THE RELAY RANDOMLY TURNING ON AND OFF? If the **Von** setting is very close to the **Voff** setting, small amounts of electrical noise can momentarily increase the input voltage enough to trigger the switch. Similarly, this noise can also momentarily reduce the input voltage enough to turn the switch off. Since many kinds of electrical noise are random in nature, this can result in the relay operating randomly.

Some tips for remedying this problem:

1. Avoid setting **Von** any closer to **Voff** than absolutely necessary.

2. Consider using twisted wire or shielded cable to connect the **Pro-VCS™** unit to the device being monitored, particularly on long wire runs. This helps shield the wires from noise pick-up.

3. Connect the negative side of the device being monitored to the **Vin Input Ground** pin (Terminal **C**), rather than to the **POWER [–]** pin (terminal **G**).

4. Avoid routing the **Vin** wires near any other wiring that might produce noise (i.e., AC power mains, ignition system wiring in vehicles, antenna cables for Ham/CB/MURS/GMRS/Public Service/VHF Marine radios or other communications equipment that transmits a radio signal).

5. In extremely noisy environments, adding some capacitance between the **Vin** and **Input Ground** pins can be helpful. (**NOTE:** Adding too much capacitance may slow down the switch's response time).

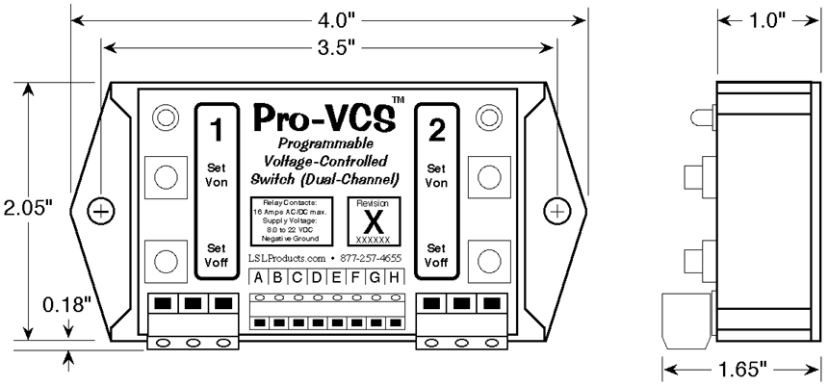
6. If interference from strong radio signals is suspected, consider installing ferrite beads on the Vin wires, immediately before they connect to the **Pro-VCS™** unit.

Also, if the supply voltage for the **Pro-VCS™** unit falls below approximately 7.5 volts, the internal reference voltage may drop out of regulation, causing the switches to operate at input voltages which are different from their programmed values.

WHY IS IT NOT RESPONDING TO SMALL CHANGES IN INPUT VOLTAGE? The **Pro-VCS™** has a measurement resolution of 10 bits (1024 voltage increments) - which means that the input voltage must change by at least 20 mV* before the unit will respond. To avoid problems with this limitation, try to configure the unit so that it receives a broad range of input voltages in your intended application - For example, in thermostat applications, select a thermistor that has a wide swing in resistance between the anticipated turn-on and turn-off temperatures.

*Measured at the 20 VDC input terminals, or 1/4th of that amount when measured at the 5 VDC input terminals.

SPECIFICATIONS



Absolute Max. Supply Voltage (at **POWER [+]** Terminal): +22.0 VDC
Absolute Min. Supply Voltage (at **POWER [+]** Terminal): +7.5 VDC
Absolute Max. Input Voltage Range (at Terminals **A** or **D**): -0.6 to +22.0 VDC
Absolute Max. Input Voltage Range (at Terminals **B** or **E**): -0.6 to +6.0 VDC
Nominal DC Power Supply Voltage (at **POWER [+]** terminal): +12.8 VDC
DC Current Consumption: (at **POWER [+]** terminal) :

Both LEDs Off:	**Both LEDs On:**
4.0 mA typ.	4.5 mA typ.

Default Turn-On Voltage (at Terminals **A** or **D**) : 20.0 VDC
Default Turn-On Voltage (at Terminals **B** or **E**) : 5.0 VDC
Default Turn-On Voltage (at Terminals **A,B,D** or **E**) : 0.0 VDC
Von, Voff Input Measurement Range (at Terminals **A** or **D**) : 0 to 20.0 VDC
Von, Voff Input Measurement Range (at Terminals **B** or **E**) : 0 to 5.0 VDC
Input Measurement Resolution: 1024 increments (10 Bits)
Input Resistance: 40 K Ohms typ. (terminals **A** or **D**), 10 K Ohms typ. (terminals **B** or **E**)
Switch Response Time: 50 ms initial typ., 250 ms sequential typ.
(measured between switch input and relay contacts)
Maximum Relay Contact Current: 10 Amps Resistive @ 120/240 VAC or 12.0 VDC
Minimum Relay Contact Current: 0 mA AC or DC
Maximum Contact Bounce Time: 3 ms
Minimum Relay Contact Isolation Voltage:
5 KV RMS (between contacts and low-voltage inputs or ground)
1 KV RMS (between open relay contacts)
Relay Electrical Endurance: 300,000 cycles typ. (240 VAC at 10 amps applied)
Reference Voltage Output (at Terminal **F**): 5.0 volts typ.
Reference Voltage Temperature Coefficient: -0.007% / °F. typ.
Operating Temperature Range: +20 to +130 °F.
Storage Temperature Range: 0 to +140 °F.
Net Weight: 5.6 Ounces typ.

Note - Unless otherwise stated:
1. All voltages are POSITIVE with respect to **POWER [–]** (terminal **G**).
2. Specifications are valid 1 hour after applying DC power, at 72 °F.
3. Electrical and mechanical specifications for the Single- and Dual-Channel versions are identical.
4. All specifications subject to change without notice.

WARRANTY

LSL Products warranties this item against defects in materials and workmanship for a period of **ONE YEAR** from the date of purchase. LSL Products will, at its option, repair or replace any defective components, at no charge to the owner. Please (1.) save your receipt as proof of warranty coverage, and (2.) contact us prior to returning the unit.

This warranty does not cover damage due to improper installation or unreasonable use of the product. In no event shall LSL Products or any of its representatives be responsible for incidental or consequential damages. This warranty gives you specific legal rights, and you may have other rights which vary from state to state.