Pneumatic Control Module User’s Guide

Rev 1.2

Cross The Road Electronics

www.crosstheroadelectronics.com

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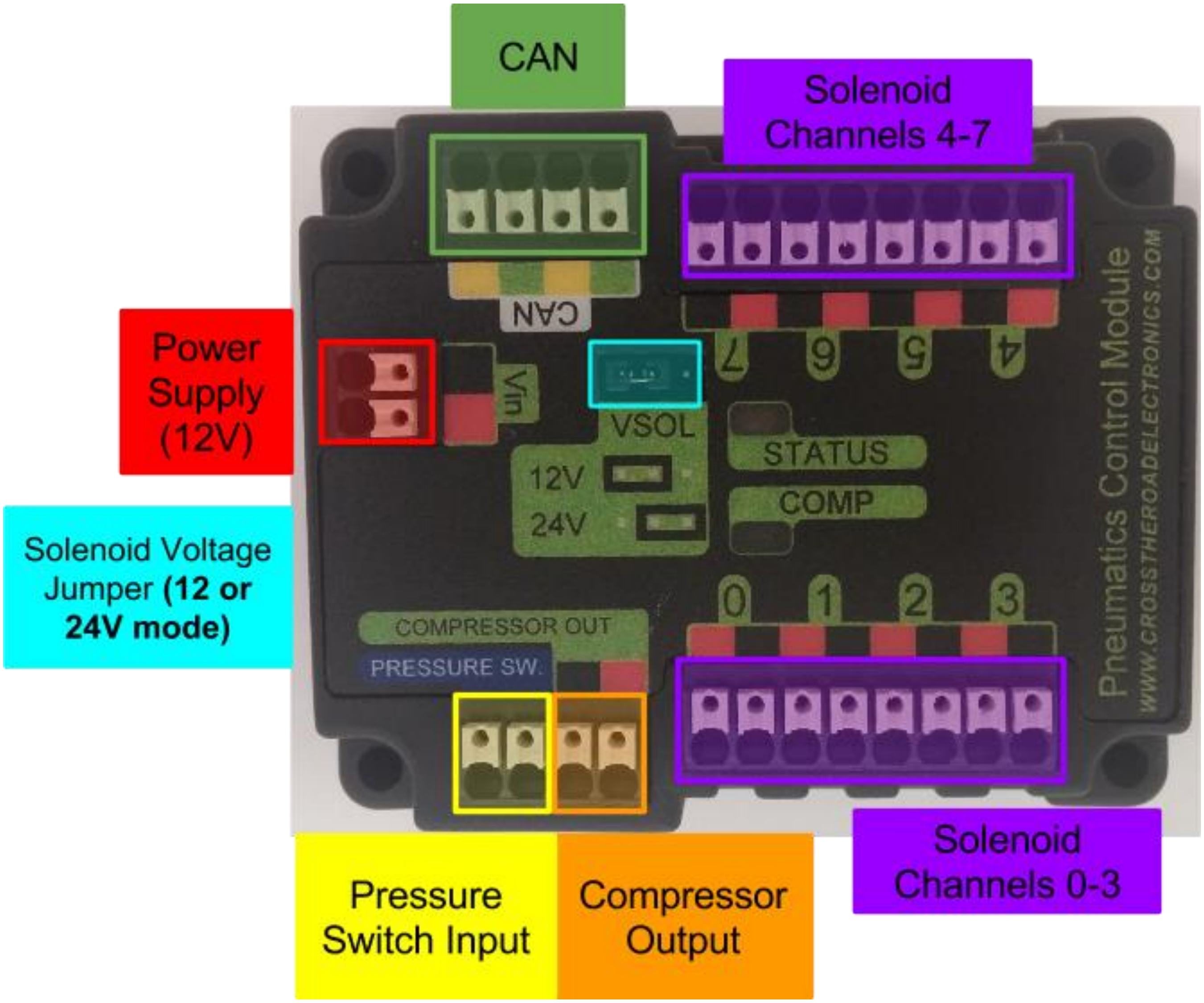
1. Pneumatics Control Module at a Glance



1.1. Connection Specifications

- **Power / Pressure Switch / Compressor / Solenoid Channels / CAN**
  - All connections are Weidmuller Connectors
    - **Max Size:** 16 AWG
    - **Min Size:** 24 AWG

See Section 2.1. Weidmuller Connectors for wire insert instructions.

1.2. Electrical Specifications

Input Voltage (Vbat)	
● **Solenoids 12V Mode(1)**	11V - 16V
● **Solenoids 24V Mode(2)**	5.5V - 16V
Absolute Max Input Voltage(3)	18V
Output Voltage	
● **Solenoids**	12V or 24V
● **Max Continuous Compressor Out**	12V / 17A
Solenoid Current (Sum of all channels)	500 mA

Note 1: PCM functions below 11V, however 12V solenoids may not engage. This depends on the 12V solenoid, see solenoid datasheet for its capabilities.

Note 2: PCM boosts solenoid voltage in 24V mode, allowing solenoids to be fired in low voltage conditions.

Note 3: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

1.3. Mechanical Specifications

Length	2.720 in.
Width	2.240 in.
Height	0.774 in.
Weight	2.2 oz.

1.4. Communication Specifications

CAN bus	DW-CAN (ISO 11898)
Baud Rate	1 MB/s
CAN Termination	None
CAN High / Low	2 Ports each.
Pressure Sw.	1 Port

2. Installing a PCM

2.1. Weidmuller Connectors

Wire Insertion

- Disconnect PDP from Battery before adding or modifying connections
- Strip wire back **~0.375" (3/8")**
- Press and hold down connector button. Though this isn't necessary, it ensures the stripped wire does not deform and split into "whiskers" after excessive use. A small screwdriver can be used to easily hold down the connector button.
- Insert wire into connector opening
- Release connector button
- Pull wire to ensure wire is locked in connector
- Confirm wire strands are not extruded

Wire Inspection

- Verify that there are no "whiskers" outside of the connector that may cause a short.
- Verify that the stripped portion of the wire is not excessive enough to cause a short.
- Tug on the wire and verify wire does not pull out. If it does then recheck gauge and/or strip the wire back further.

Wire Removal

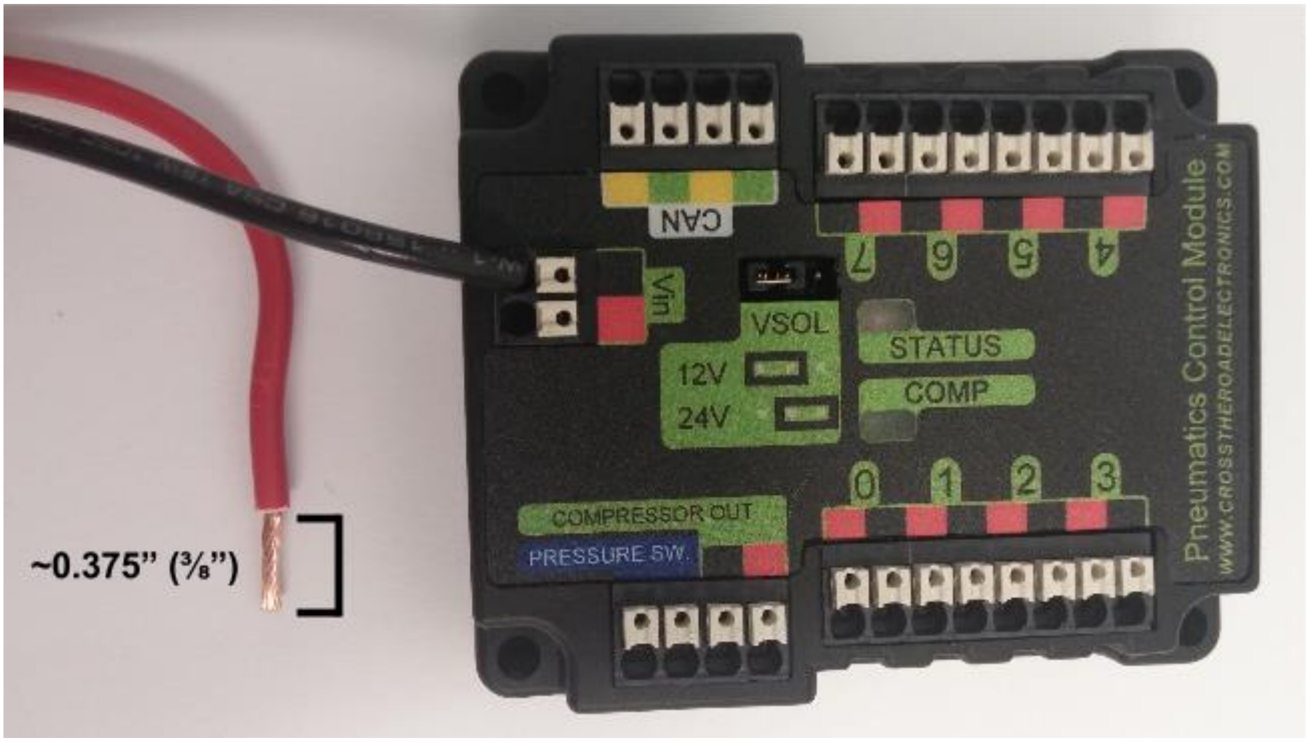
- Press and hold down connector button immediately above connector opening
- Pull wire to remove from connector

Limitations

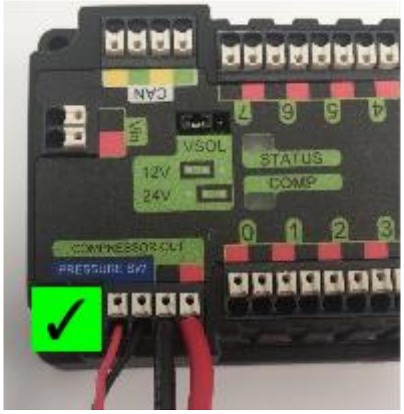
- Wire should **not be frayed** upon insertion. Extruded wire may short to adjacent channels.
- Wire should be **no larger than 16 AWG**, larger gauges will not properly fit in connector
- Wire should be **no smaller than 24 AWG**, smaller gauges will not lock in connector

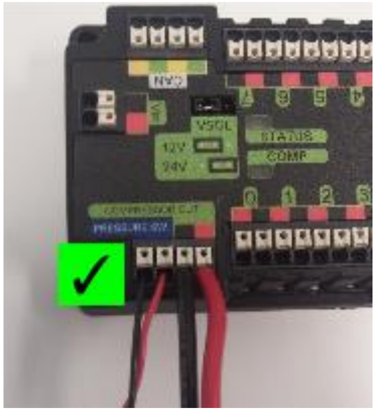
2.2. Wiring the Power Input

- 12 Volt Supply (Battery, Power Supply, etc.)
- 24 to 16 AWG Wire stripped ~0.375" (⅜")



2.3. Wiring the Compressor/Pressure Switch





- Pressure Switch may be attached in either direction, so long as both connections are made
- Compressor must match coloring on PCM

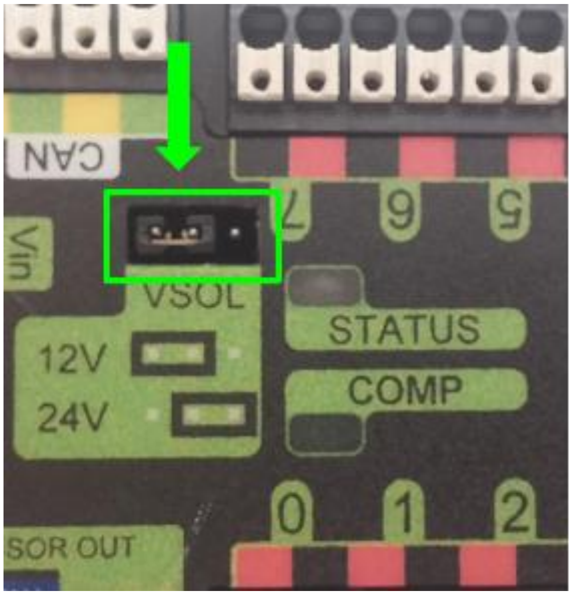
2.4. Wiring the Solenoids

Each solenoid channel has a **red**/**black** pair of Weidmuller connectors. The positive input of the solenoid connects to **red**, the negative input of the solenoid connects to **black**.

2.4.1 Selecting Solenoid Voltage

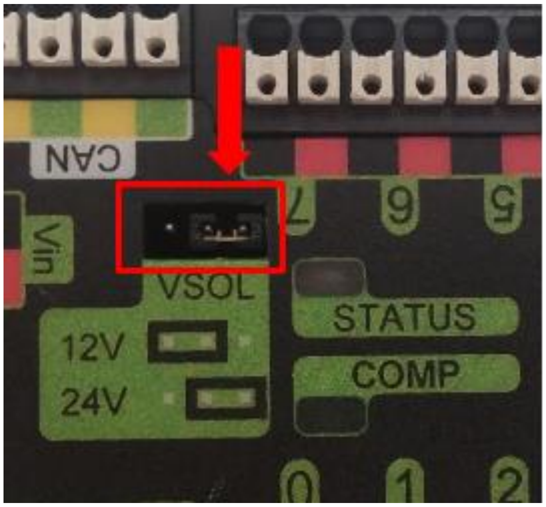
An "out of the box" PCM will default to 12V mode. This is prevents teams from connecting a 24V PCM to 12 V solenoids when initially installing a PCM.

Jumper on **12V-side pins** sets **12 Volt Mode** - **12 Volts** will be output on **red** solenoid ports at all times.



12 Volt Mode

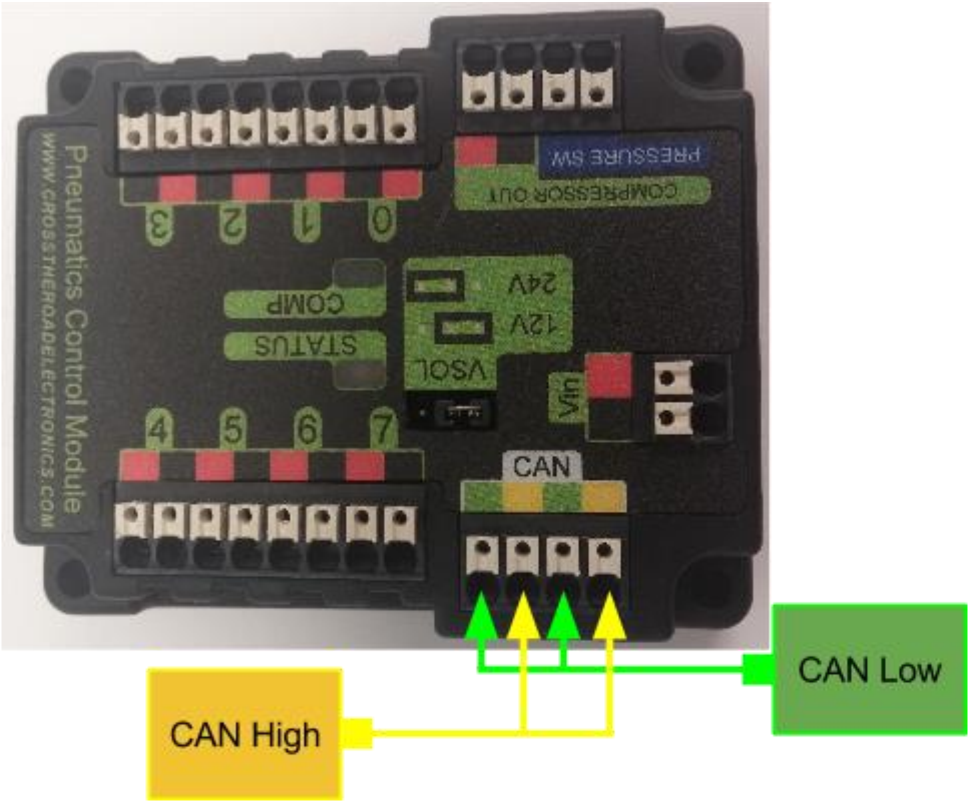
Jumper on **Status-Side pins** sets **24 Volt Mode** - **24 Volts** will be output on **red** solenoid ports at all times.



24 Volt Mode

The absence of a **Solenoid Voltage Jumper** will place the PCM in **24 Volt Mode** by **default.**

2.5. CAN bus



Weidmuller Connectors are also used for CAN Communication. See Section 2.1. Weidmuller Connectors for for wire insertion and removal procedures. PDP provides termination and may be placed at the end of CAN bus chain.

NOTE: There is no Termination Resistor in the PCM. If the PCM is to be placed at the end of a CAN Bus, a termination resistor must be placed on the open PCM CAN port. To avoid this, place the PCM in the middle of the CAN Bus.

3. LED States

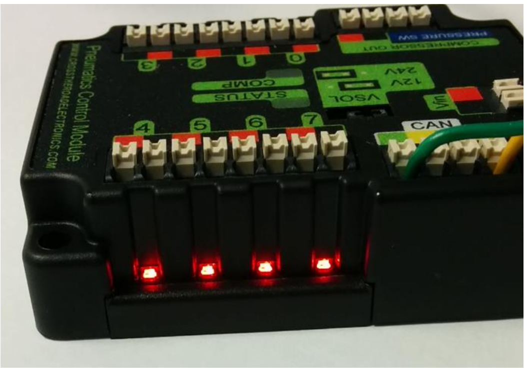
The PCM has two (2) LEDs indicating **Status (STATUS)** and **Compressor State (COMP)**.

3.1. Compressor LED

The **Compressor LED** is a green LED that indicates when the Compressor is active by illuminating. When the LED is on, the Compressor output is driving. When the LED is off, the Compressor output is **NOT** driving.

3.2. Solenoid LEDs

When a solenoid channel is activated, a corresponding red LED will illuminate on the outside border. There is one LED per channel. The LED will turn off when the solenoid output is off.



3.3. Status LED

The **Status LED** is a bi-color LED capable of three color states: **Red**, **Green**, and **Orange**. When the **Status LED** is green at any time, the PCM is functioning properly with no faults. Red or Orange indicates the presence of a fault condition. An **orange** **Status LED** indicates a sticky (persistent) fault, meaning a fault has occurred at some point and has not been cleared by the user. Sticky faults are persistent over power cycles. A **red** **Status LED** indicates an active fault. Active faults protect hardware from damage and cannot be cleared by the user. Active faults are reset upon PCM boot.

The **PCM Status LED** should **always** be illuminated (**red**, **green**, or **orange**). If the **Status LED** does not illuminate, check to ensure input power has the correct polarity and that power is supplied to the PCM.

3.3.1. STATUS LED Fault Table

*LED Color	Strobe	Slow	Long
Green	No Fault - Robot Enabled	No Fault - Robot Disabled	NA
Orange	NA	Sticky Fault	NA
Red	NA	No CAN Comm. OR Compressor Fault OR Solenoid Fault (Blinks Solenoid Index)	Compressor Fault

***If STATUS LED contains more than one color, see LED Special States Table**

3.3.2. Fault Resolution Table

Problem	Behavior	Resolution	CAN State	Robot State
Sticky Fault	PCM will slow blink orange. PCM has previously encountered (but is not actively having) a Solenoid Fault or Compressor Fault. Sticky Fault clears via user command over the CAN bus. Sticky Fault does NOT clear on power cycle.	1. Access PDP logger 2. Identify the most recent fault (Solenoid Fault or Compressor Fault) 3. Respond to the fault via the Fault Resolution Table 4. Clear the sticky fault via CAN	Good	Disabled
Solenoid Fault	PCM will blink the number of the faulted solenoid followed by a pause. Fault clears on power cycle.	1. Check faulted solenoid 2. Remove damaged solenoids 3. Remove any metal debris 4. Power cycle 5. Clear sticky fault	Good	NA
Compressor Fault	PCM will blink red in 2 second intervals. Compressor will allow new run attempt every 5 seconds. Fault clears on power cycle OR successful enabling of compressor	1. Check for short across compressor ports 2. Remove any metal debris 3. Clear sticky fault	Good	Enabled
No CAN Comm.	No PCM functionality	1. Connect CAN cable 2. Apply termination resistor 3. Power roboRIO	Bad	NA

3.3.3. Special States Resolution Table

STATUS LED Behavior	Problem	Resolution
STATUS LED alternates red and orange	Damaged Hardware	1. Contact CTRE. Device needs to be serviced 2. PCM is not warranted for use until hardware is repaired 3. DO NOT attempt to use PCM
STATUS LED alternates green and orange	In Boot-loader	1. Download latest FIRST PCM firmware from CTRE 2. Firmware field-upgrade PCM
STATUS LED will not illuminate	No Power / Incorrect Polarity	1. Connect robot battery 2. Connect Vin (PCM) to PDP power 3. Ensure no wires broken 4. Ensure correct polarity 5. Power robot

3.3.4. Complete LED Guide

Live - Solenoids NOT blacklisted are live and controlled by EnableSolX (see functional diagram)
Live - Compressor is live and controlled by CompOutput (see functional diagram)

STATUS LED Color	Blink Type	CAN Comm.	Robot State	Solenoid State	Compressor State	Problem
Green	Strobe	Good	Enabled	Live	Live	None
Green	Slow	Good	Disabled	All Channels OFF	Disabled	None
Orange	Slow	Good	Disabled	All Channels OFF	Disabled	Sticky Fault
Red	*Slow blinks bad solenoid	Good	Enabled	Live	Live	Solenoid Fault
Red	*Slow blinks bad solenoid	Good	Disabled	All Channels OFF	Live	Solenoid Fault
Red	Long Strobe	Good	NA	All Channels OFF	Disabled	Compressor Current Too High
Red	Strobe	Bad	NA	All Channels OFF	Disabled	No CAN Comm.
Red/ Orange	Slow	NA	NA	All Channels OFF	Disabled	Damaged Hardware
Green/ Orange	Slow	NA	NA	All Channels OFF	Disabled	In Boot-loader
No LED	None	NA	NA	NA	NA	No Power / Incorrect Polarity

*The number of **red** blinks correlates to the index of the blacklisted solenoid. One blink corresponds to solenoid ‘0’. Eight blinks corresponds to solenoid ‘7’. If there are multiple blacklisted solenoids, the least-value solenoid index is selected.

4. Troubleshooting Tips and Common Questions

4.1. Why isn't the Compressor turning on? Why does the PCM COMP LED not turn on?

In order for the compressor output to activate, certain conditions have to be met.
-The robot must be enabled.
-Robot software must have a pneumatics related object (compressor or solenoid).
-PCM must be powered/wired to CAN bus.
-PCM's device ID must match robot software.
If any of these conditions are not met, the compressor will **not** activate.

The best method for root-causing wiring or software issues is to check the following conditions and symptoms in **sequential order**.

4.1.1. PCM must be powered.

This can be checked by ensuring the STATUS LED is illuminated. If the STATUS LED is off, recheck the power path from the PDP to the PCM. If using the fused output of the PDP, check the fuse. This can be done by removing the fuse and checking its continuity/DC-resistance, or simply by measuring the voltage across the power/ground wires that connect into the PCM's Vin Weidmuller input (should be approximately battery voltage or ~12V).

4.1.2. PCM must be on CAN Bus.

The PCM must be connected to the CAN bus chain. If a PCM does not see a healthy CAN bus it will blink the STATUS LED **red** (See section 3. LED States).

Additionally the PCM will **not** appear in the roboRIO's Web-based configuration page or will report loss of communication. *This is important to check because a* ***red*** *STATUS LED pattern* ***may*** *also reflect a fault condition (if robot is enabled). To distinguish a fault condition, confirm the PCM* ***does*** *appear in the configuration page, and use the Self-Test to identify which fault condition is occurring (see Section 4.1.3).*

If these negative symptoms are noticed, recheck CAN bus harness and termination resistors. If several CAN devices are also blinking red then check the CANH/CANL chain. If it's just the PCM then inspect the Weidmuller CAN contacts on the PCM.

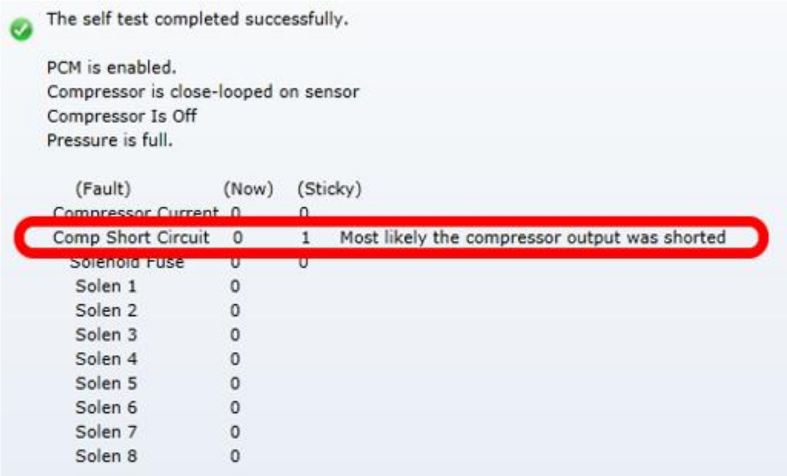
If the PCM CAN connection is healthy, then it should slowly **blink** **green** (when robot is disabled). It may **blink** **orange** instead to signal that a sticky fault has been logged. Use the Self-Test in the roboRIO Web-based configuration to inspect and clear sticky faults.

More information on faults and sticky faults is available under "Updating and Configuring Pneumatics Control Module and Power Distribution Panel" at http://wpilib.screenstepslive.com.

4.1.3. Confirm PCM is not faulting.

At this point the PCM should appear in the roboRIO Web-based configuration page. Using the self-test, determine if any faults are occurring "Now". Checking the sticky faults can also be helpful for identifying recent faults.

More information on faults and sticky faults is available under "Updating and Configuring Pneumatics Control Module and Power Distribution Panel" at http://wpilib.screenstepslive.com.



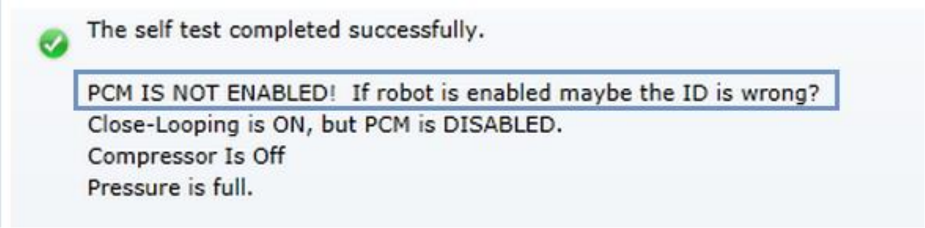
```
The self test completed successfully.

PCM is enabled.
Compressor is close-looped on sensor
Compressor Is Off
Pressure is full.

    (Fault)             (Now)   (Sticky)
  Compressor Current  0       0
  Comp Short Circuit   0       1     Most likely the compressor output was shorted
    Solenoid Fuse       0       0
    Solen 1             0
    Solen 2             0
    Solen 3             0
    Solen 4             0
    Solen 5             0
    Solen 6             0
    Solen 7             0
    Solen 8             0
```

4.1.4. The Robot must be enabled, Robot Software must create a pneumatics-related object.

The PCM should appear in the roboRIO Web-based configuration page, however when enabling the robot, the STATUS LED may **not** transition to **strobe green**. Additionally, when performing the Self-Test, the report may read "PCM IS NOT ENABLED".



```
The self test completed successfully.

PCM IS NOT ENABLED!  If robot is enabled maybe the ID is wrong?
Close-Looping is ON, but PCM is DISABLED.
Compressor Is Off
Pressure is full.
```

This is typical if the robot is not enabled OR if the robot application did not create any Solenoid or Compressor objects. This is how the programming API signals the intent of using pneumatics, and thus enabling the PCM.

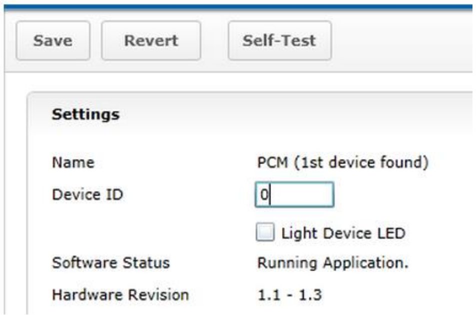
Make sure the robot is truly enabled by looking at the Driver Station.

Instructions for creating a Solenoid, DoubleSolenoid or Compressor object in LabVIEW, C++, and Java can be found at http://wpilib.screenstepslive.com, (search for keyword "PCM"). Creating a single object of any pneumatics related type is sufficient for enabling the PCM (and therefore enabling compressor closed-loop).

Creating an explicit Compressor object is not necessary for closed-loop behavior, but is helpful for teams that are…
-implementing power-management or disabling compressor explicitly.
-want access to the additional status signals the PCM provides.
…otherwise **just** creating Solenoids and DoubleSolenoids is sufficient.

In order to create a software object for Solenoid or Compressor, typically the caller **may specify the CAN Device ID** (not specifying it typically **defaults to selecting Device ID zero**). This value **must match** what is specified in the roboRIO Web-Based configuration. For more information see “Updating and Configuring Pneumatics Control Module and Power Distribution Panel” at http://wpilib.screenstepslive.com.

TIP : Since PCMs default with a device ID of zero, teams only using one PCM may prefer to leave the default device ID. PCM Device ID range is allowed to overlap with the device ID of other non-PCM CAN devices.



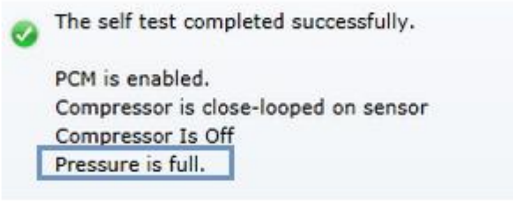
Settings

Name PCM (1st device found)
Device ID 0
□ Light Device LED
Software Status Running Application.
Hardware Revision 1.1 - 1.3

4.1.5. Pressure Switch must be wired and must signal “not full”.

Even though a robot and PCM are enabled, the compressor output will **not** activate if the pressure switch is not connected or is indicating full pressure. The only way to inspect this reliably is to perform the Self-Test in the roboRIO Web-based configuration.

If Self-Test is reading “pressure is full” when the pressure gauge clearly is not full, recheck the wiring on the pressure switch and PCM.



✓ The self test completed successfully.

PCM is enabled.
Compressor is close-looped on sensor
Compressor Is Off
Pressure is full.

4.1.6. The COMP LED must illuminate green.

If the COMP LED is off then the PCM is not activating the compressor output. The Self-Test is the best method for determining why. If the PCM is **not** present in the roboRIO web-based configuration recheck section 4.1.1 and 4.1.2. If the PCM is present and not enabled, recheck section 4.1.4. If the Compressor is **not** “close-looped on sensor”, then the robot application must be using programming API to disable it. If pressure is erroneously reading “full”, recheck section 4.1.5.

4.1.7. Compressor must be wired and functional.

If the COMP LED is illuminated green but the compressor still is not activating, then there may be a wiring issue between the PCM and the compressor. A voltmeter can be used to confirm that the PCM is applying 12V across the high and low side compressor output, and that 12V is reaching the compressor.

5. Functional Limitations

Functional Limitations describe behavior that deviates from what is documented. Feature additions and improvements are always possible thanks to the field-upgrade features of the PCM.

5.1. roboRIO power up: roboRIO startup software may not be ready for Robot Application. As a result, certain resources (like CAN actuators) may not enable on teleOp-Enabled after a roboRIO power boot.

This is a specific race condition that causes the RIO’s start up processes to boot in a different order then intended. The symptom a team would see is: we power cycled the robot, enabled, and some of our CAN devices (PCM for example) does not enabled (LEDs blink orange). Although the circumstances are intermittent, the workaround to guarantee the Robot Application is robust is simple. In the Disable Loop, “set” one of the following signals periodically to ensure the roboRIO background process is well-aware of what CAN actuators the Robot Application intends to use.

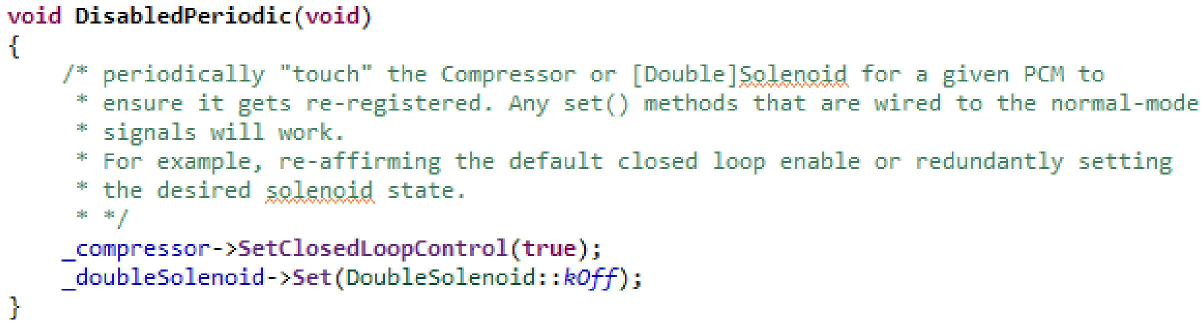
Setting **any** of these signals in the disabled loop will meet the workaround requirements. Also setting these will have no effect on the PCM itself since these signals are not sent over CAN bus until the robot is enabled. The signals that can be used for this workaround are…

```
Solenoid Output (Single or Double),
Closed Loop Control,
```

These signals exist in the periodic control frame. As such, setting them will not block or hold up program execution.

In this C++ workaround example, we redundantly set the closed-loop control mode and a solenoid channel of a PCM, however either one is sufficient. Additionally the signal values selected are the default values, so the actual behavior of the PCM hasn’t changed, and no additional CAN traffic is generated since the control frame is unsolicited and periodic.

In this example any brake mode will work and the new signal value does **not** have to be different than the original signal value.



```
void DisabledPeriodic(void)
{
    /* periodically "touch" the Compressor or [Double]Solenoid for a given PCM to
     * ensure it gets re-registered. Any set() methods that are wired to the normal-mode
     * signals will work.
     * For example, re-affirming the default closed loop enable or redundantly setting
     * the desired solenoid state.
     * */
    _compressor->SetClosedLoopControl(true);
    _doubleSolenoid->Set(DoubleSolenoid::kOff);
}
```

6. Revision History

Rev	Date	Description
1.2	19-Feb-2015	Section 5 Revision History moved to Section 6. Section 5 added for Functional Limitations.
1.1	8-Feb-2015	Section 4 Revision History moved to Section 5. Section 4 added for troubleshooting compressor.
1.0	30-Dec-2014	Initial Creation