



**FIRST® Robotics Competition**

## Power Distribution Board Data Sheet 2012 *FIRST* Robotics Competition

---



## Power Distribution Board

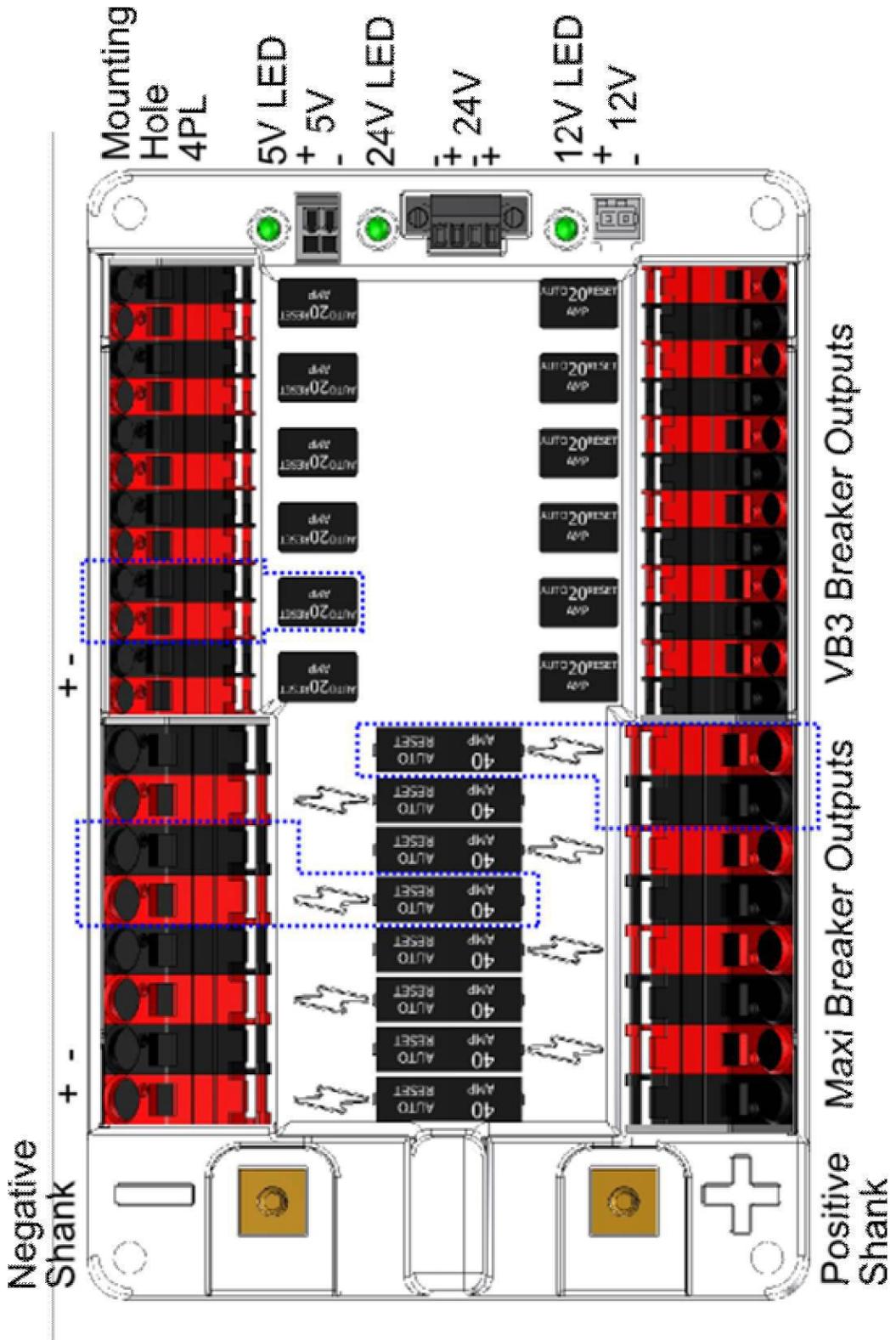


### Functional Description

The PD Module is used to safely distribute battery power via thermal breakers and WAGO connectors. The PD also includes a set of power supplies for various devices.

- Battery input voltage range of 6-15V
- M6 shanks for battery connection
- Sufficient copper mass and low-resistance distribution for use with a 120A main breaker supplying the module
- 8 outputs that support up to 40A breakers
- 12 outputs that support up to 30A breakers
- 24V/1.5A boost supply with on-board 1.1A PTC for over-current protection (typically for powering a cRIO from National Instruments)
- 5V/3A buck supply with integral over-current protection (typically for powering an Ethernet camera)
- 12V/2A boost supply with on-board 2A PTC for over-current protection (typically for powering a WiFi adapter, the boost supply tracks battery voltage when the battery is fully charged and greater than 12V)
- Reverse battery protection for the cRIO, WiFi, and Camera power supplies
- LEDs for each power supply They light red if and only if there is a load present and either breaker is absent or the breaker is blown

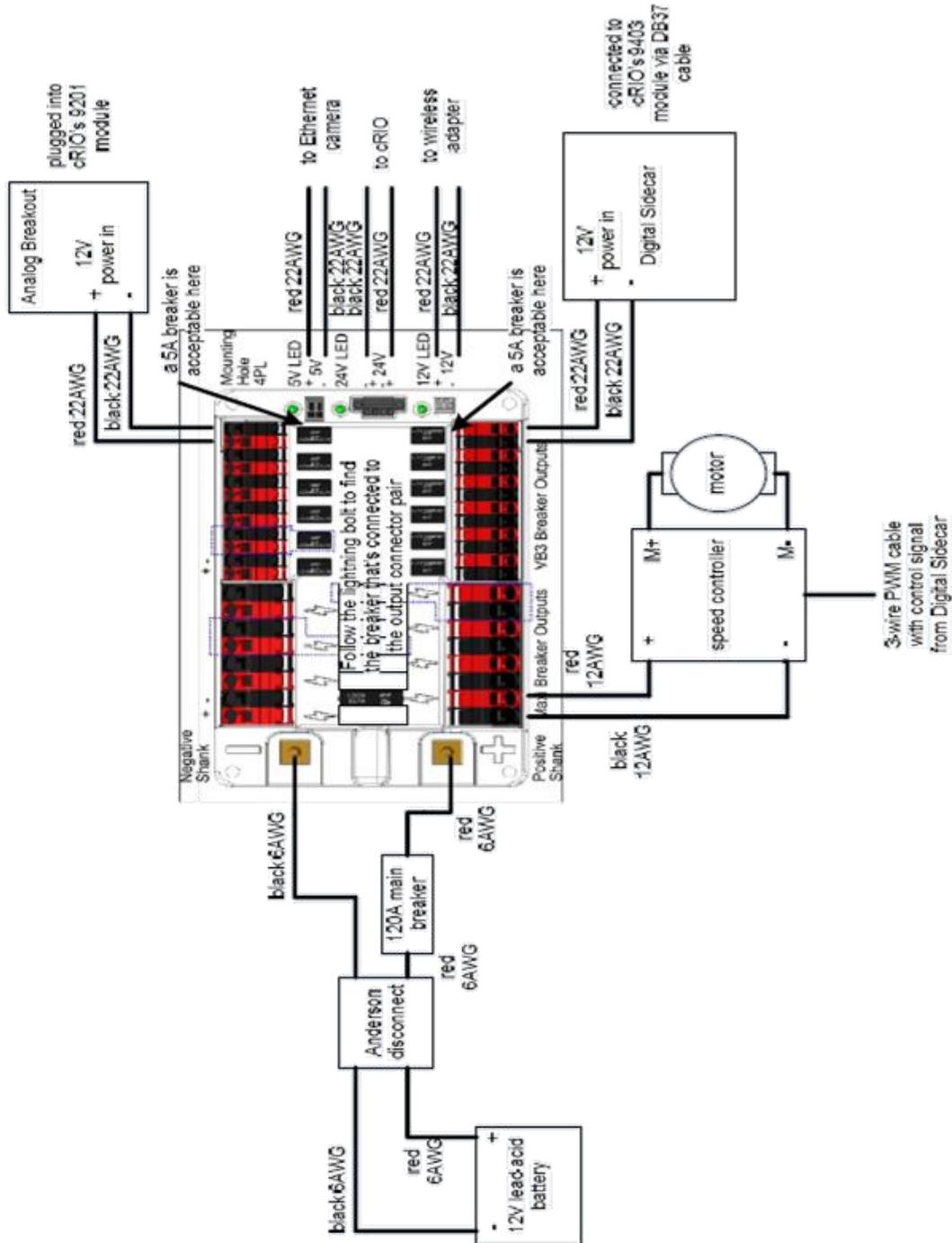
# Pinout



PCB Reference Designator	Name	Description
J27	Negative Shank	M6 post for connecting the negative terminal of a battery
J23	Positive Shank	M6 post for connecting the positive terminal of a battery (typically a 12V sealed lead acid battery through a 120A breaker)
J1/J3, J4/J5, J6,J7, J8/J9, J29/J28, J31/J30, J33/J32, J35/J34	Maxi Breaker Outputs	WAGO 745-85X connector pairs that provide battery positive (red terminals, protected via thermal breaker) and battery negative/return (black terminals) Accepts stranded wire 6-12 AWG stripped 12-13mm
J11-J22, J37-J48	VB3 Breaker Outputs	WAGO 745-83X connector pairs that provide battery positive (red terminals, protected via thermal breaker) and battery negative/return (black terminals) Accepts stranded wire 10-24AWG stripped 11-12mm
CB7-CB14	Maxi Breaker Terminals	Press-in terminals that accept Snap Action Maxi-Style breakers with capacity up to 40A
CB1-CB6, CB19-CB24	VB3 Breaker Terminals	Press-in terminals that accept Snap Action VB3-Style breakers with capacity up to 30A
J26	5V Output	FRC control system usage: Axis camera. Output from a 5V/3A buck supply via WAGO 739-302 terminal strip. Accepts stranded wire 14-22 AWG stripped 7mm
J24	12V Output	FRC control system usage: Linksys WiFi adapter Output from a 12V/2A boost supply via WAGO 734-132 header. WAGO 734-102 is the typical mating connector with wire size between 14 and 22 AWG.
J25	24V Output	FRC control system usage: National Instruments cRIO Output from a 24V/1.5A boost supply via Sauro CTM040V8 connector. The mating connector is Sauro CTF04BV8-CN. The positive and negative terminals are duplicated on the 4-position header to mimic the input structure on the National Instruments cRIO power entry connector. Use wire size between 14 and 22 AWG.

## Typical Application

\*\*Always refer to FIRST rules for using this module in competition robots. The following diagram shown an example application that may not fully comply with FIRST rules.



## Specifications

### 24V Supply

Parameter	Min	Nom	Max	Units	Description
Input Voltage, Operational	4.5	12	15	V	
Input Voltage, Survive	-20		20	V	Limited by TVS and reverse battery protection FET
Output Voltage, Unloaded	23	24	25	V	
Output Voltage Ripple (pk-pk), Unloaded			1	V	
Output Current Limit, PTC		1.1	2.2	A	Hold characteristic, this PTC is in the ground return path to the power supply
Output Power Limit			20	W	Boost channel protection
Input Current Limit		15		A	Input fuse (at the input to the power supply from battery input terminal, the primary purpose of this fuse is to protect from shorts on the PD)

### 12V Supply

Parameter	Min	Nom	Max	Units	Description
Input Voltage, Operational	4.5	12	15	V	
Input Voltage, Survive	-20		20	V	Limited by TVS and reverse battery protection FET
Output Voltage, Unloaded	11	12	13	V	For Vbattery < 11 V, for Vin > 11V the power supply output tracks Vbattery
Output Voltage Ripple (pk-pk), Unloaded			1	V	
Output Current Limit, PTC		2	4	A	Hold characteristic, this PTC is in the ground return path to the power supply
Output Power Limit			20	W	Boost channel protection
Input Current Limit		15		A	Input fuse (at the input to the power supply from battery input terminal, the primary purpose of this fuse is to protect from shorts on the PD)

## 5V Supply

Parameter	Min	Nom	Max	Units	Description
Input Voltage, Operational	5.5	12	15	V	
Input Voltage, Survive	-20		20	V	Limited by TVS and reverse battery protection FET
Under-Voltage Lockout	5.3		5.5	V	
Output Voltage, Unloaded	4.8	5	5.2	V	
Ripple (pk-pk), Unloaded			1	V	
Continuous Current Limit		3	4	A	

## Notes and Warnings

- The PD's power input/battery shanks are Metric 6. A ¼" nut WILL strip these nuts. Use M6 nuts for the PD Shanks.
- The PD's power input/battery shanks can shear if torqued more than 3.9 Nm. Do not over-tighten.
- The reverse battery protection only protects the power supplies on the PD (and their attached loads). Applying batteries to the PD with reversed polarity may damage devices attached to the thermal breakers.
- Don't panic if the 12V power supply output is a bit higher than 12V. The supply tracks battery voltage when the battery is fully charged and greater than 12V.
- When under light load, the 24V boost supply will emit an audible whining noise and have a larger voltage ripple. This is an artifact of its power saving mode, and should not cause concern.
- The thermal breaker outputs will read as 12V when the breaker is removed and there is no load.
- There is a weak (100kOhm) connection to power that is an artifact of the blown breaker LED circuit. It is not cause for concern.
- The large 40A-capable Maxi-style breakers are interleaved – follow the lightning bolt to the connector.
- The smaller VB3 breakers must be correctly oriented or they will interfere.
- When designing the layout of the electronic components, leave enough room to access the WAGO connectors with the WAGO tool.

## Troubleshooting and FAQ

### What are the part numbers for the mating connectors?

Connector	Manufacturer and P/N for Mating Connector
24V Power Output	Sauro CTF04BV8-CN
12V Power Output	WAGO 734-102

### How do I build a cable for passing 24V power to the cRIO?

- Take a color coded pair of 22-14AWG wire and cut to length
- Optionally twist the pair now for better cable management.
- Strip 5-6mm off of both ends of both wires.
- Use a small flat head screwdriver to actuate the Sauro CTF04BV8-CN connectors
- Insert the positive wire in the port labeled “V”
- Insert the negative wire into the port labeled “C” next to the “V” port.
- Insert into the Sauro CTM040V8. Tighten screws to  $\sim\frac{1}{4}$ Nm.
- Give a smart tug to verify the connection is secure.

### How do I build a cable for passing 12V power to the Power Converter then to the radio?

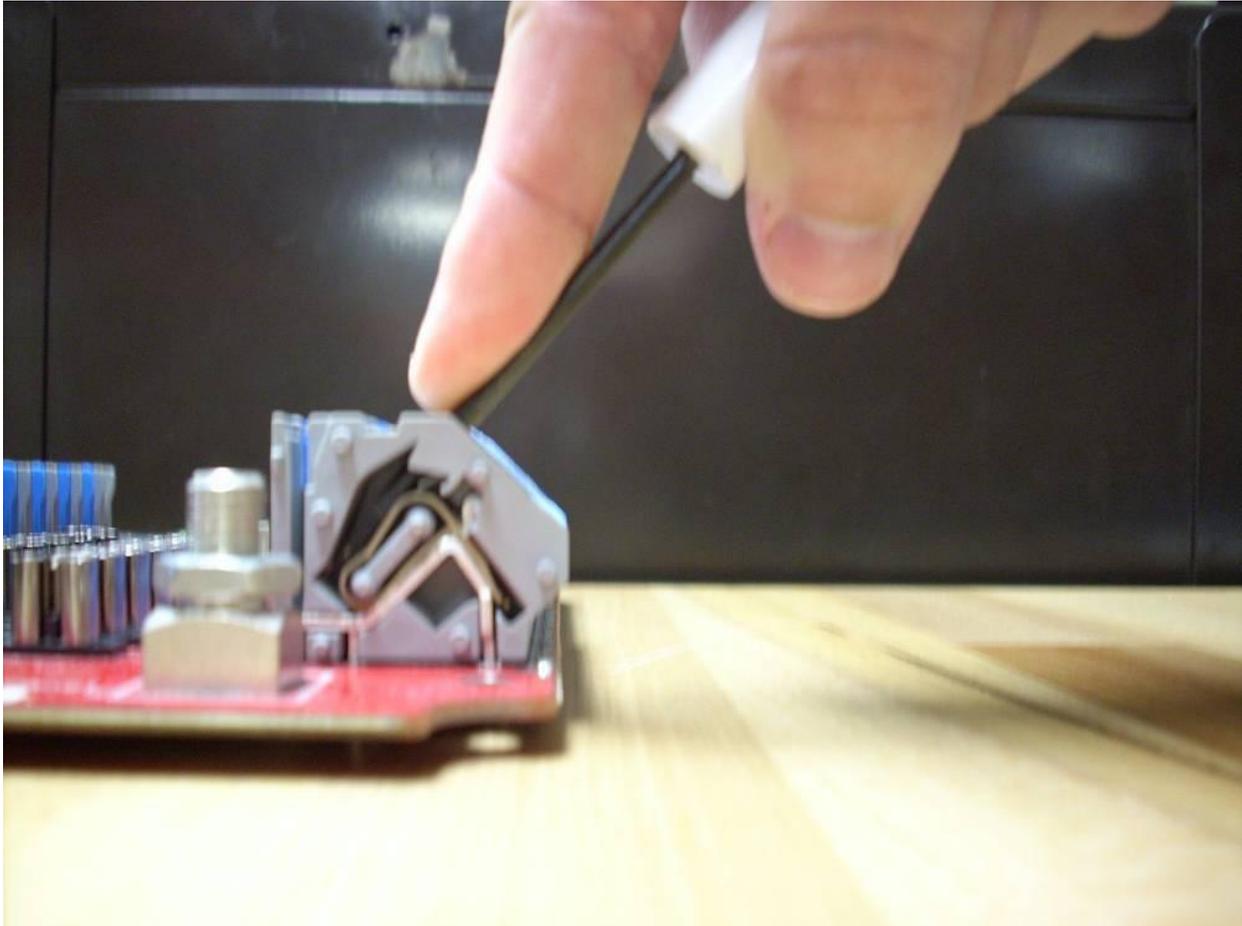
- Take the module’s power adapter and cut the wire off a few inches from the Wall-Wart.
- Separate the wires and strip 7mm off the ends.
- Splice the positive (striped) wire to the yellow 18 AWG wire coming from the power converter and the solid black wire the black wire coming from the power converter.
- To insert wire into a WAGO 734-102 connector, push down on the actuation port in back. Alternatively, use the plastic actuation lever.
- Insert the positive (red) wire from the converter in the right port of the WAGO 734-102 connector. Note: the correct orientation can be verified by looking at the silk screen on the PD Module.
- Insert the negative wire in the left port of the WAGO 734-102 connector.
- Give a smart tug to verify the connection is secure.
- Insert the WAGO 734-102 into the mating connector on the PD.
- Power the PD, and verify that the barrel connector’s center conductor is positive.

### How do I build a cable for passing 5V power to the Ethernet camera?

- Take the camera’s power adapter (PN SA106A-0512-6) and cut the wire off a few inches from the Wall-Wart. Note: There are two power adapters for the camera included in the Kit, one in the camera box and one separate. Use the separate one (PN SA106A-0512-6) to make this adapter.
- Separate the wires and strip 5-6mm off the ends.
- Use a small flat head screwdriver to open the WAGO 739-302.
- Insert the positive (striped) wire in the right port. Note: the correct orientation can be verified by looking at the silk screen on the PD Module.
- Insert the negative wire in the left port.
- Give a smart tug to verify the connection is secure.
- Power the PD, and verify that the barrel connector’s center conductor is positive.

### How do I operate the large WAGO connectors?

To actuate a 745-85X or 745-83X series connector, gently shove your WAGO tool into the actuation port until it hits a hard stop. Beginning with the tool parallel to the circuit board, push inward and up with the palm of your hand, while pushing down with your finger. The tip of the tool will scrape along the back of the connector and hit a hard stop. The tool can now stand on its own, and the connector's clamp is fully open.



**DO NOT** attempt to pry the connector open. This will result in frustration. If you require two hands for this you are probably doing it wrong.

**NOTE:** It is possible to “stab” the 745-8XX connector by inserting the tool at too great an attack angle. This may break the plastic tab. This is only aesthetic. Try again with a flatter angle.

## Mechanicals

