2016 Controls Introduction

Mike Anderson
(robot_maker12@verizon.net)

Herndon High School
FRC Team #116

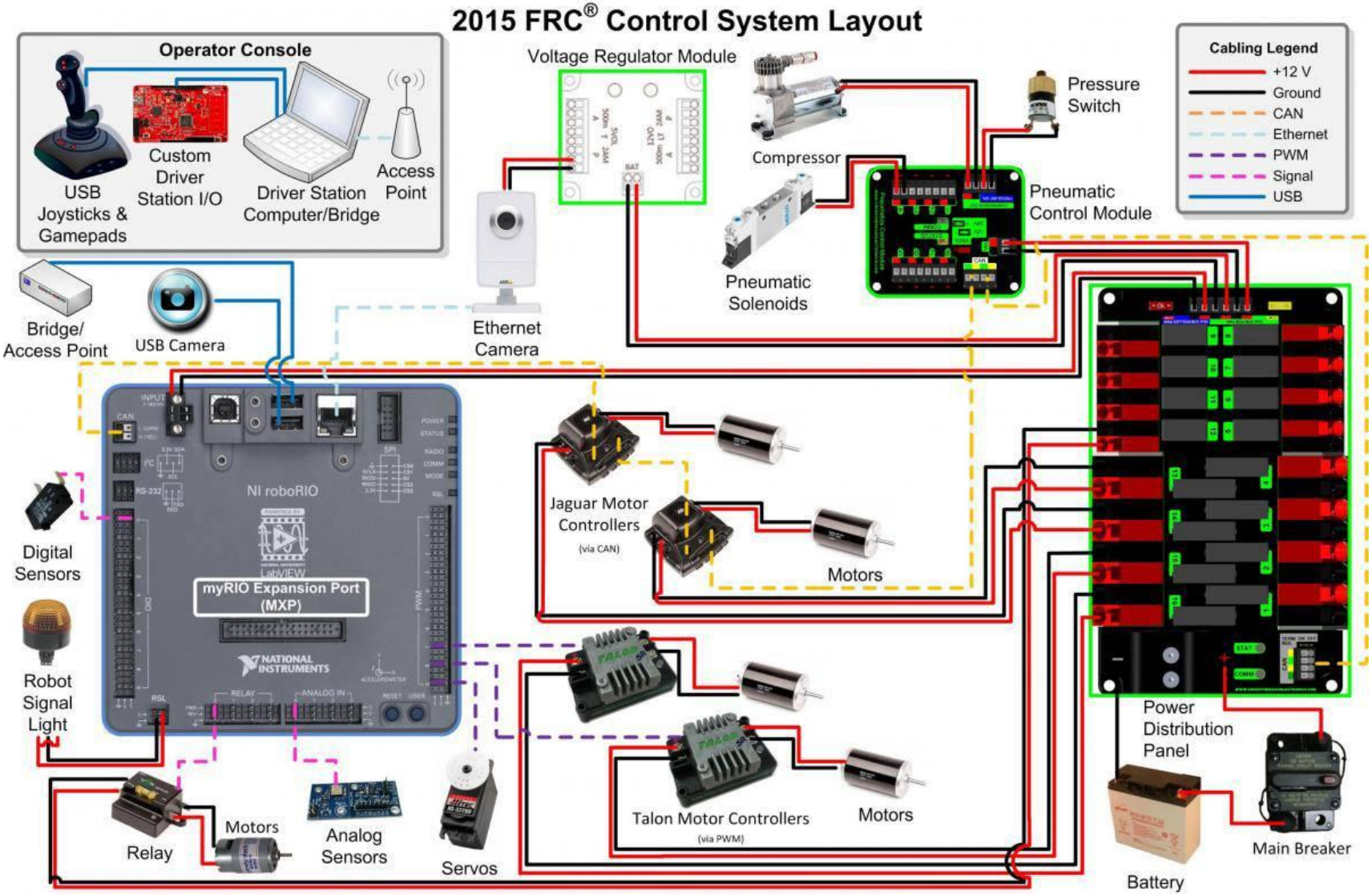
What We'll Talk About

- Goals
- Why switch controls?
- The RoboRIO Controller
- Peripherals
- CAN bus
- Resources
- Summary

Goals

- The goal of this presentation is to acquaint you with the 2016-season control hardware
- We clearly can't explain all of the aspects due to time constraints
- But, you should leave here with a better understanding of the current control system
- This information is accurate as of the 2016 beta release
  - The software will likely change a bit prior to kickoff

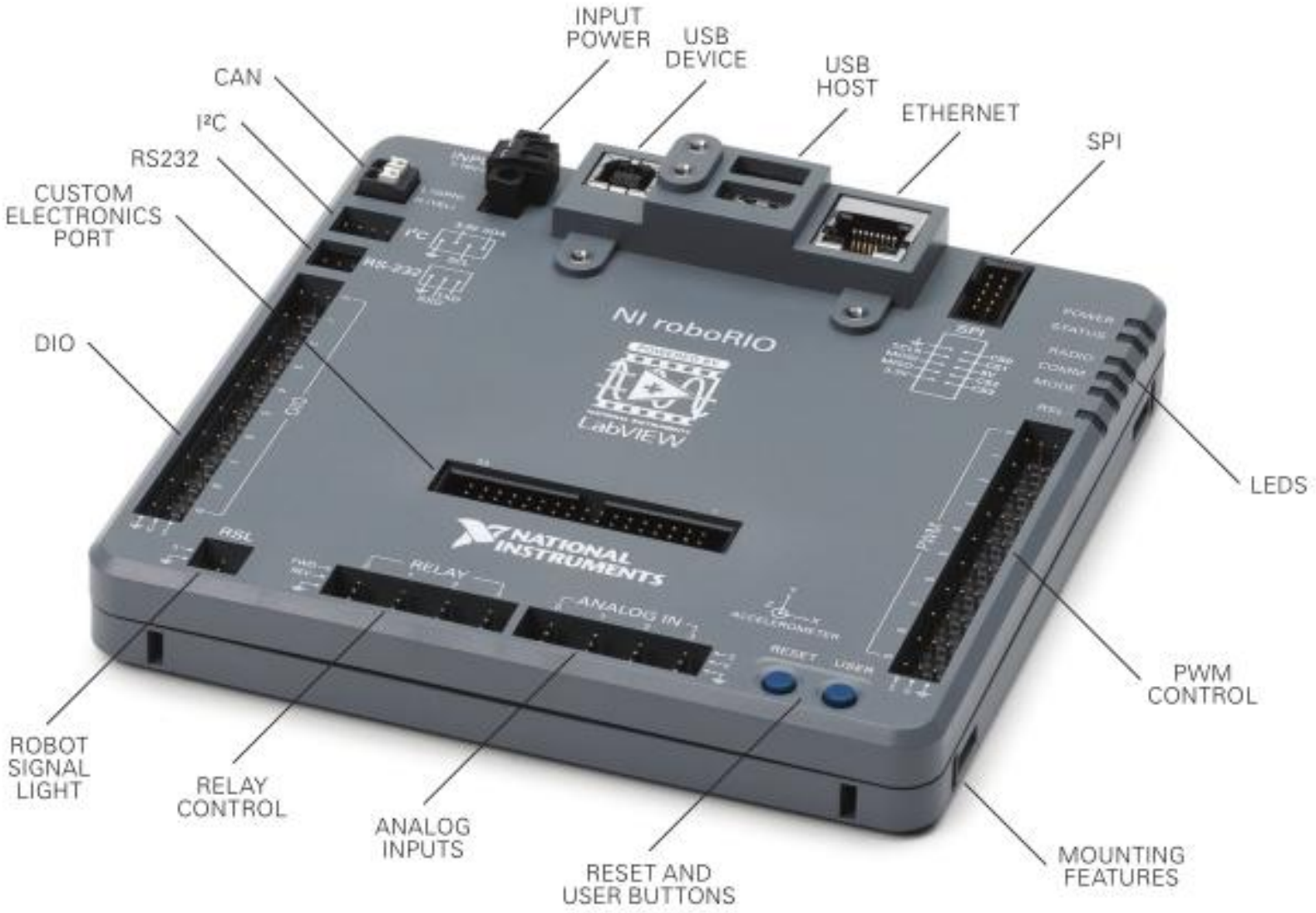
The 2016 Control System



The RoboRIO

- An ARM-based single board computer that increases performance and combines the digital side car into a smaller and lighter platform
  - Dual-core, 667 MHz ARM Cortex A9 with:
    - 256 MBs RAM (232 MBs usable)
    - 512 MBs flash (386 MBs usable)
    - Xilinx Zync-7020 FPGA
- Running NI RT-Linux
  - 3.14.40-rt37 Linux kernel
- File system is derived from Yocto project
  - Uses the same files as the ARM Angstrom/Poky distribution
  - Special .ipk format packages that use “opkg” package manager

Annotated RoboRIO

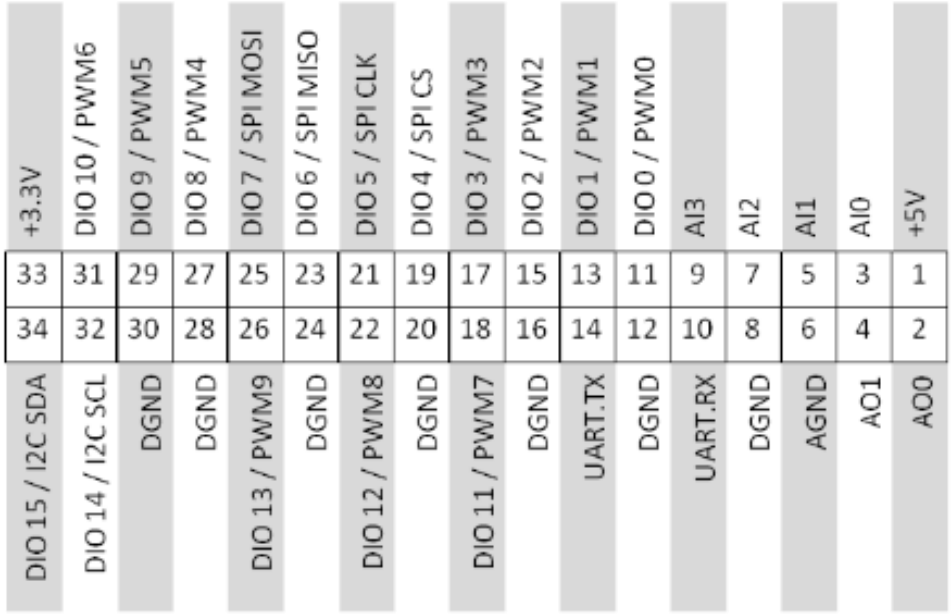


Power-Related Info

- The RoboRIO requires 7-16VDC
  - Max current 45W
  - Idle current 5W
- Most of the signals are 5V tolerant
- Voltages are:
  - 3.3V (max 1.225A)
  - 5V (max 1A)
  - 6V (max 2.2A)
  - 7-16V (120mA)
- Beware! The UART is 5V EIA RS232
  - Ready to plug into a PC
  - Do not use level shifters on the UART or the magic blue smoke will escape!
  - Do not plug directly into BBB, Rpi or Arduinos either

RoboRIO MXP Pin-out

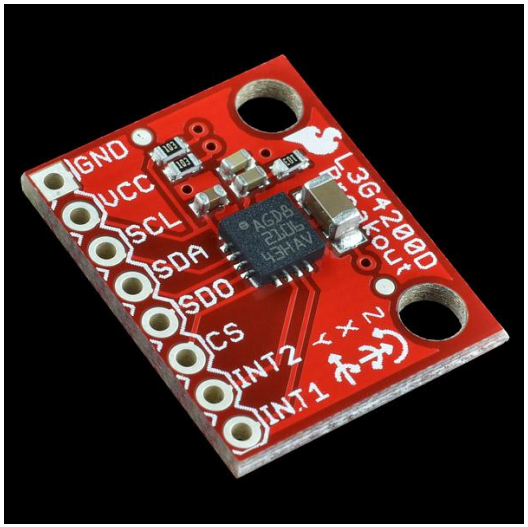
- The *M*yRIO E*x*pansion *P*ort allows for additional I/O opportunities
  - Gives expansion beyond what we saw with digital side car



+3.3V	DIO 10 / PWM6	DIO 9 / PWM5	DIO 8 / PWM4	DIO 7 / SPI MOSI	DIO 6 / SPI MISO	DIO 5 / SPI CLK	DIO 4 / SPI CS	DIO 3 / PWM3	DIO 2 / PWM2	DIO 1 / PWM1	DIO 0 / PWM0	AI3	AI2	AI1	AI0	+5V
33	31	29	27	25	23	21	19	17	15	13	11	9	7	5	3	1
34	32	30	28	26	24	22	20	18	16	14	12	10	8	6	4	2
DIO 15 / I2C SDA	DIO 14 / I2C SCL	DGND	DGND	DIO 13 / PWM9	DGND	DIO 12 / PWM8	DGND	DIO 11 / PWM7	DGND	UART.TX	DGND	UART.RX	DGND	AGND	AO1	AO0

Digital I/O

- The main RoboRIO has:
  - 10 DIO lines (each can be programed as input or output)
    - 20ns minimum pulse width
  - 1 I2C (1 SDA and 1 CLK)
    - 3.3V
    - 400KHz max frequency
  - 1 SPI bus (up to 4 devices)
    - 4 MHz max frequency
- Logic level:
  - 5V-compatible LVTTL input
  - 3.3V LVTTL output
- MXC has
  - 16 additional DIOs
    - Some pins can be used as aux I2C and SPI
  - 4 analog inputs
  - 2 analog outputs
  - 1 UART



PWM and Relay Lines

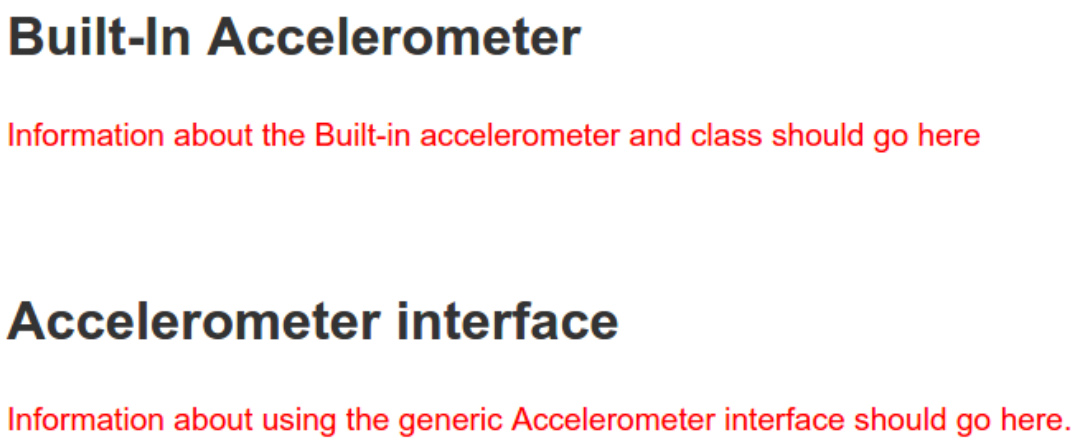
- 10 PWM channels
  - Output only
  - 15mA max output current
  - 330 ohm resistor in series
- 4 relay channels
  - 4 forward, 4 reverse
  - 5V output
  - 7.5mA max current
  - 680 ohm resistor in series
- Max frequency 150 KHz
- Output High Voltage: 4.75V-5.25V max
- Output Low Voltage: 0.0V-0.25V max

Analog I/O

- Analog input:
  - 500 kS/s @ 12-bit resolution
  - +/- 16V overvoltage protection
  - 500k ohm input impedance @ 500 kS/s
- Analog output:
  - 345 kS/s @ 12-bit resolution
  - +/- 16V overvoltage protection
  - 0-5V output range
  - 50 mV accuracy
  - 3mA current drive

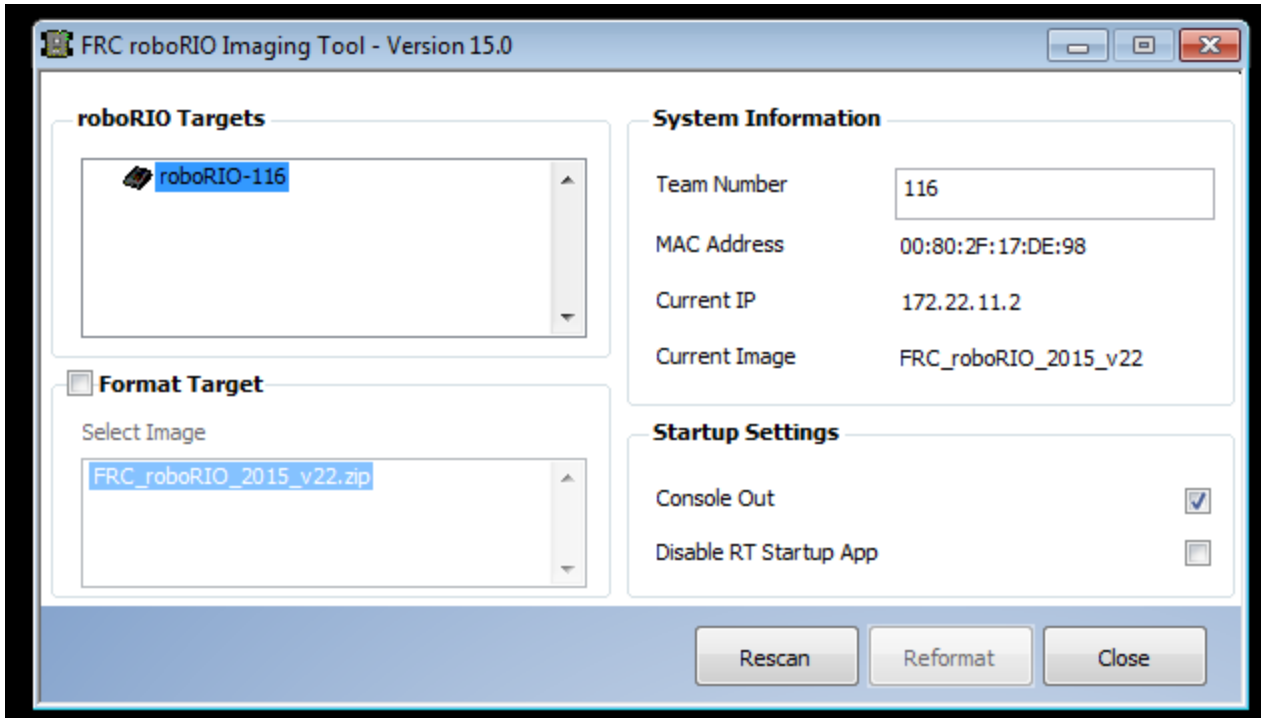
Onboard 3-axis Accelerometer

- +/- 8G range
- 12-bit resolution
- 800 S/s
- Very little information available during the beta cycle about programming



Imaging of RoboRIO

- There is a new imaging tool
- Same image for C/C++, Java and LabVIEW
  - LabVIEW enable option in web interface

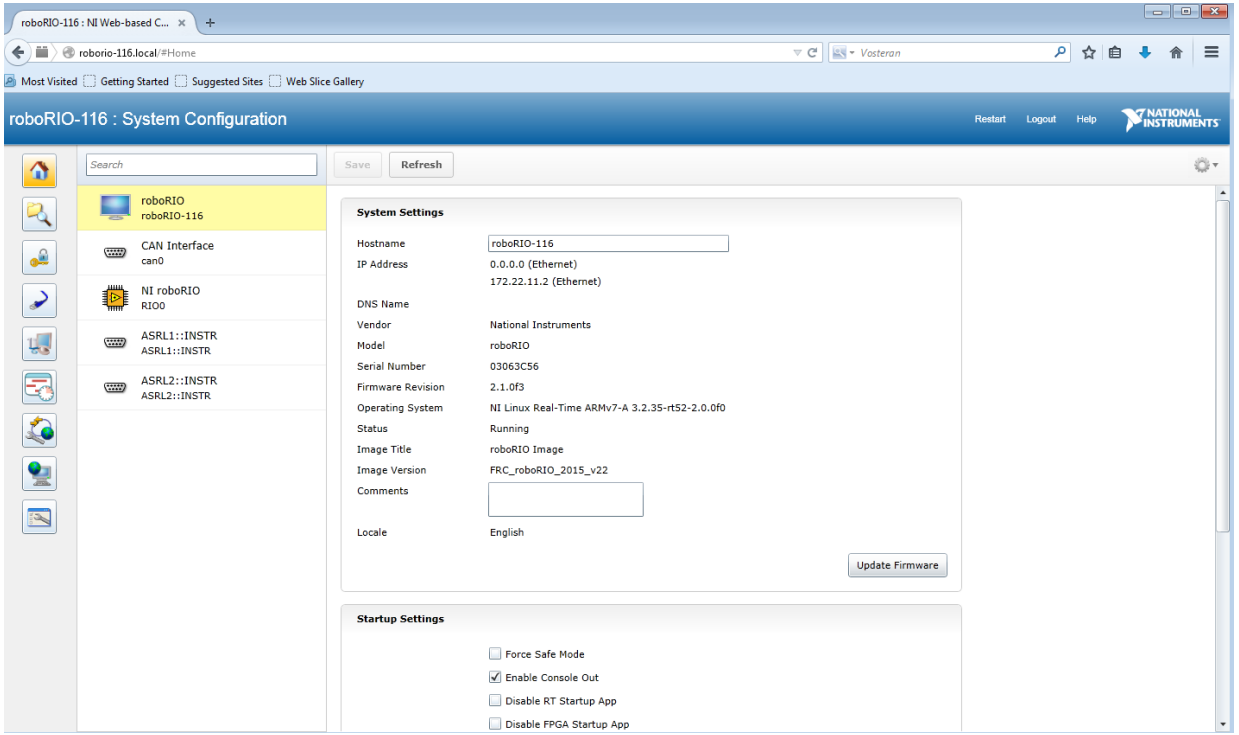


Imaging RoboRIO #2

- Imaging should use the USB device (type B) interface
  - This sets up a USB IP point-to-point network with 172.22.11.x network link
  - Do not use Ethernet to image the RoboRIO
- mDNS addressing will work at this point
- Ethernet interface will DHCP an address from the wireless interface

New RoboRIO Web Server

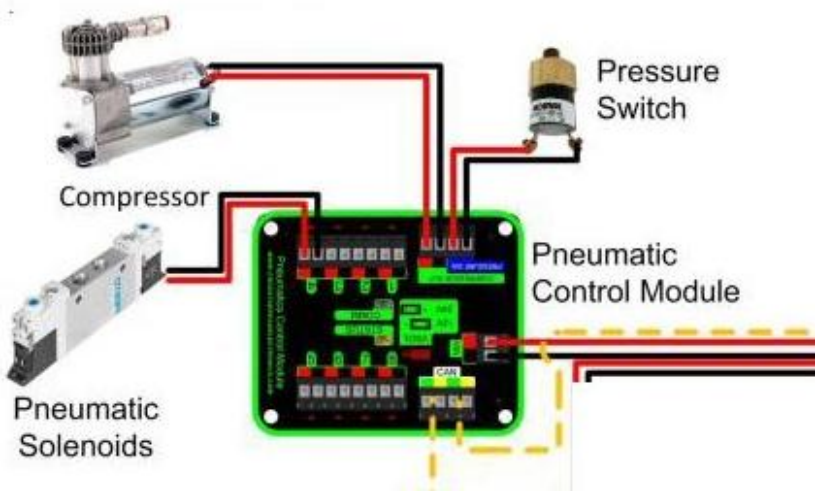
- New interface for RoboRIO
  - Used to load new firmware
- Requires Microsoft Silverlight



- Addressing is now done via mDNS
  - roborio-<team #>-FRC.local
- Option for enabling ssh server

Pneumatics Control Module (PCM)

- CAN-controlled
- Supports more than 1 PCM
- Closed-loop operation
- Jumper selectable 12V or 24V solenoid operation



Voltage Regulator Module

- Regulated 5V and 12V
  - Both 500mA and 2A
- Great for powering Wi-Fi access point
- Good brown-out capability

Power Distribution Panel

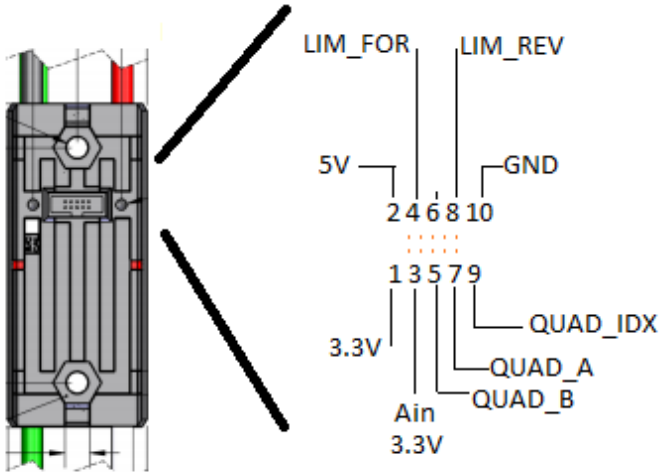
- PDP is smaller than 2014 unit
- Dedicated outputs for PCM and VRM
  - Separate fuses
- Power input is now shielded
  - Requires 2.5mm metric hex drive
- CAN bus interface
  - Allows measurement of current draw from slots
  - Has option for CAN bus termination

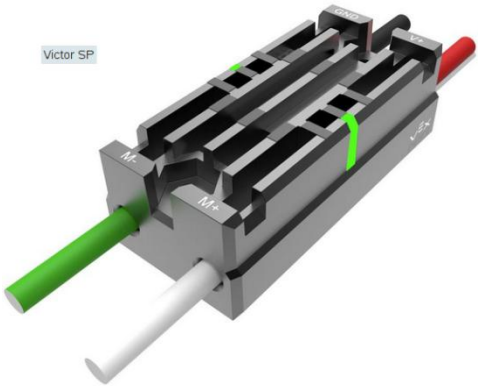
New Wi-Fi Radio

- We will be seeing a new Wi-Fi radio in 2016
  - The OM5P-AN Access Point
    - Dual-band, 450 Mbps access point
    - IEEE 802.11b/g/n (2.4 GHz) and 802.11a/n (5 GHz)
- Based on 520 MHz Atheros AR9344 MIPS 74K CPU
- Does not come with firmware or power supply
  - Power is 12V instead of D-Link's 5V although the connector is the same
- User must flash the unit with new firmware before use
  - Uses OpenWRT Linux distribution
  - Flash update process is a bit clunky in the Beta
- Supports PoE, but it's not clear if PoE will be legal in 2016
  - Otherwise, hook it up to the 12V/2A output of the VRM
- Supports 2 Ethernets and wireless access

New Motor Controllers

- Talon SRX
  - CAN-based equivalent to Jaguar
  - Quadrature encoder input
  - Forward and reverse limit switch inputs
- VexPRO Victor SP
  - Essentially, PWM-based Talon SRX
  - No additional inputs or capability



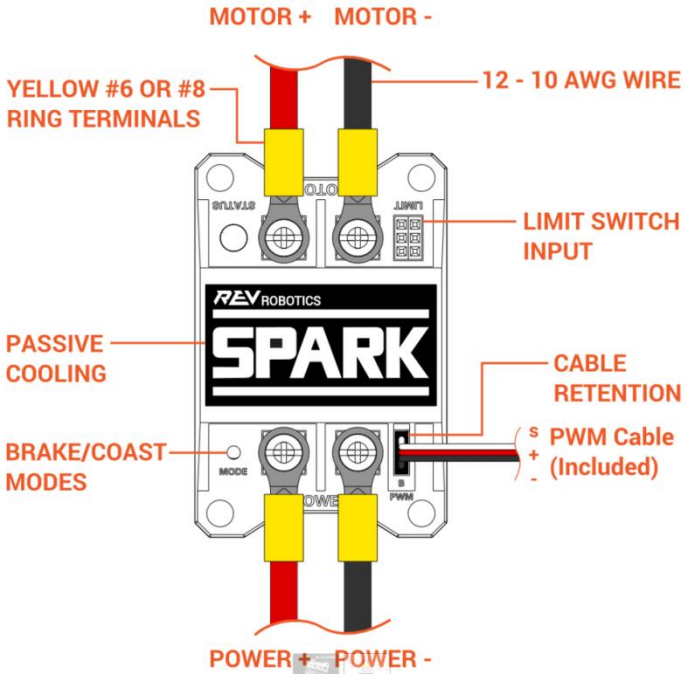


Mind Sensors SD540

- New motor controller for 2016 season
- PWM-based motor controller
- Load capacity: 60 amps continuous, 100 amps peak
- Passive Cooling
- Bidirectional limit switches
- Power, direction and status indicator LEDs
- Brake/coast and direction selection with flip of a switch
- Field upgradable firmware
- Available in 1x, 2x or 4x blocks

REV Robotics Spark Motor Controller

- New for 2016 season
- Passive cooling
- Synchronous rectification
- Limit switch inputs
- Calibration
- Integrated cable retention for PWM port
- Clamping screw terminals
- RGB status LED
- Input Voltage (nominal): 12V
- Continuous Current: 60A
- Peak Current (2 second surge): 100A
- Input Pulse Width Range (nominal): 1ms – 2ms



Motor Controller Comparison

REV ROBOTICS

SPARK MOTOR CONTROLLER COMPARISON CHART

	REV SPARK	Talon SR	Victor 888	Victor SP	Talon SRX	Jaguar
Current Retail Price (10/29/2015)	$45	$65	$70	$60	$90	$80
Manufacturer	REV Robotics	CTRE	VEX	VEX/CTRE	VEX/CTRE	LMI/TI/VEX
Status	Available November 2015	Discontinued	Discontinued	In Production	In Production	Discontinued
Limit Switch Inputs	Yes	No	No	No	Yes	Yes
Embedded Permanent Wires	No	No	No	Yes	Yes	No
Communication Protocol	PWM	PWM	PWM	PWM	PWM, CAN, SPI, UART	PWM, CAN, UART
Nominal Input Voltage	12V	12V	12V	12V	12V	12V
Operating Voltage Range	5.5V - 30V	6V - 28V	6V – 15V	6V - 16V	6V - 28V	5.5V - 30V
Continuous Current	60A	60A	60A	60A	60A	40A
Peak Current (2 second surge)	100A	100A	150A	100A	100A	60A
Cooling	Passive	Passive	Fan – Always On	Passive	Passive	Fan - Dynamic
Status LED	7 colors	3 colors	3 colors	3 colors	3 colors	3 colors
Input Pulse Width Range (nominal)	1ms - 2ms	1ms - 2ms	1ms – 2ms	1ms - 2ms	1ms - 2ms	1ms - 2ms
Input Deadband	4%	4%	5.4%	4%	4%	5.5%
Output Frequency	15.625 kHz	15 kHz	1 kHz	15 kHz	15 kHz	15.625 kHz
Switching Method	Synchronous Rectification	Synchronous Rectification	Sign Magnitude	Synchronous Rectification	Synchronous Rectification	Synchronous Rectification
Dimensions	2.84" x 1.9" x.875"	2.73" x 1.9" x 1.15"	2.75" x 2.24" x2.1"	2.5" x1.125" x.875"	2.75" x 1.185" x.96"	2.85" x 4.25" x2.0"
Weight	.22 lbs	0.20 lbs	0.22 lbs	0.20 lbs	.21 lbs	0.34 lbs

All Data in this chart taken from product source websites and is accurate as of 10/29/2015. REV Robotics LLC has done its best to provide accurate information, but does not guarantee the accuracy of the information about competitive products, please refer to each product's own documentation to verify the information. All trademarks, service marks, registered trademarks, and registered service marks are the property of their respective owners. This data is provided for comparative reference only and should only be used in such a manor.

CAN Bus

- Controller Area Network
  - If you've got a car made since 1968, you've got CAN bus
  - CAN is very reliable
- CAN bus got a bad rep from the early Jaguar motor controllers
  - Finicky connectors
  - Tricky termination issues
  - Slow update speeds
  - Thin traces would melt if the motor stalled for excessive time
- If you want to use Jaguars, they must be wired separately
  - Their CAN packet format is different than the rest of the CAN control system
  - Suggest using CTRE 2CAN to speed Jaguar CAN updates

CAN Bus #2

- New PCM, PDP, Talon SRX and RoboRIO all have CAN bus support
  - Two-wire daisy chain with fail-through capability
    - Failed component doesn't kill the bus
  - Much faster than serial CAN from earlier seasons
- RoboRIO has CAN termination
  - PDP has a jumper to select termination option
- CAN bus is *required* for PCM and PDP (if you want current-related data)
  - You can have more than one PCM on the robot if you need more solenoids

Summary

- The new control system is working pretty well at this point
  - New software loads are coming every few days up to kick-off
- Requirement for CAN bus if you want pneumatics
  - Closed-loop PCM makes working with pneumatics much easier
- New motor controllers are smaller and easier to work with than previous versions
  - Assuming they get approved by FIRST for competition