Citrus Circuits
Fall Workshop Series

RoboRIO and Sensors

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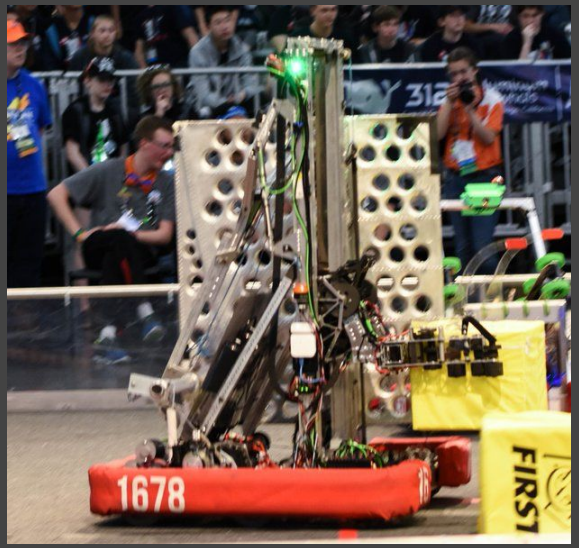
and Rachel Solomon

Introduction to Sensors

Sensor: “a device that detects or measures a physical property and records, indicates, or otherwise responds to it”

Why Use Sensors?

- Feedback for positioning robot parts
  - Potentiometer
  - Encoders
  - Limit switches
- Motion control
  - Drive chain encoders
  - Gyroscope
  - Accelerometer
- Detecting field elements in/out of robot
  - Mechanical limit switch
  - Proximity sensor
  - Vision



Choosing a Sensor

- Sensor output
  - Boolean
  - Analog and Digital
  - Serial
- Application
  - Distance of detection
  - Optical conditions
  - Maximum speed (encoders)
  - Accuracy / precision
- Electrical requirements:
  - Voltage
  - Current
- Price Range

Examples of Sensors

- Limit switch
  - Boolean
  - Potential for mechanical failure
  - Can detect field elements

- Hall effect
  - Boolean or analog
  - Detects magnetic fields
  - replaces limit switch for many applications

Examples of Sensors cont.

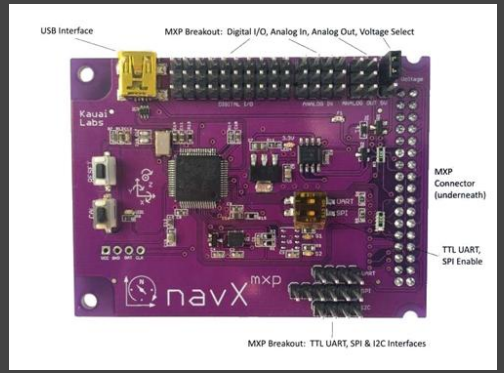
- Encoder
  - Boolean outputs, but more complex information
  - Rotational position / rate

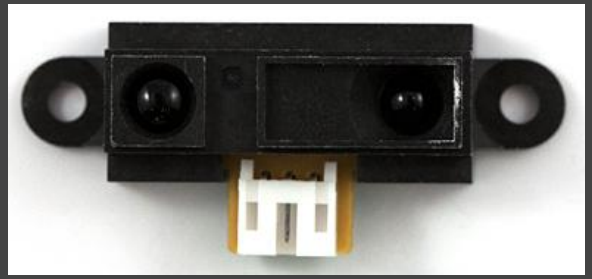
- Potentiometer
  - Analog
  - Rotational position

Examples of Sensors cont.

- Gyroscope
  - Serial
  - Angular motion control

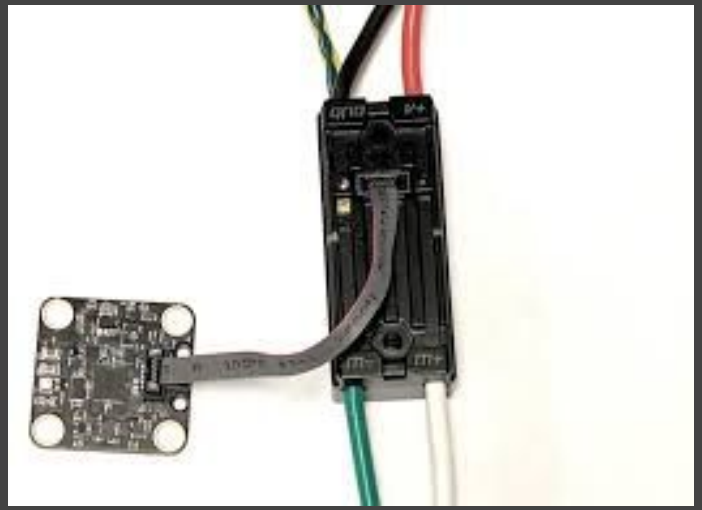
- Accelerometer
  - Serial
  - Translational motion control
  - Included in RoboRIO
    - Not accurate, don't use
- Proximity & beam break
  - boolean / analog / serial
  - detects distance to object
  - optical, use with field elements



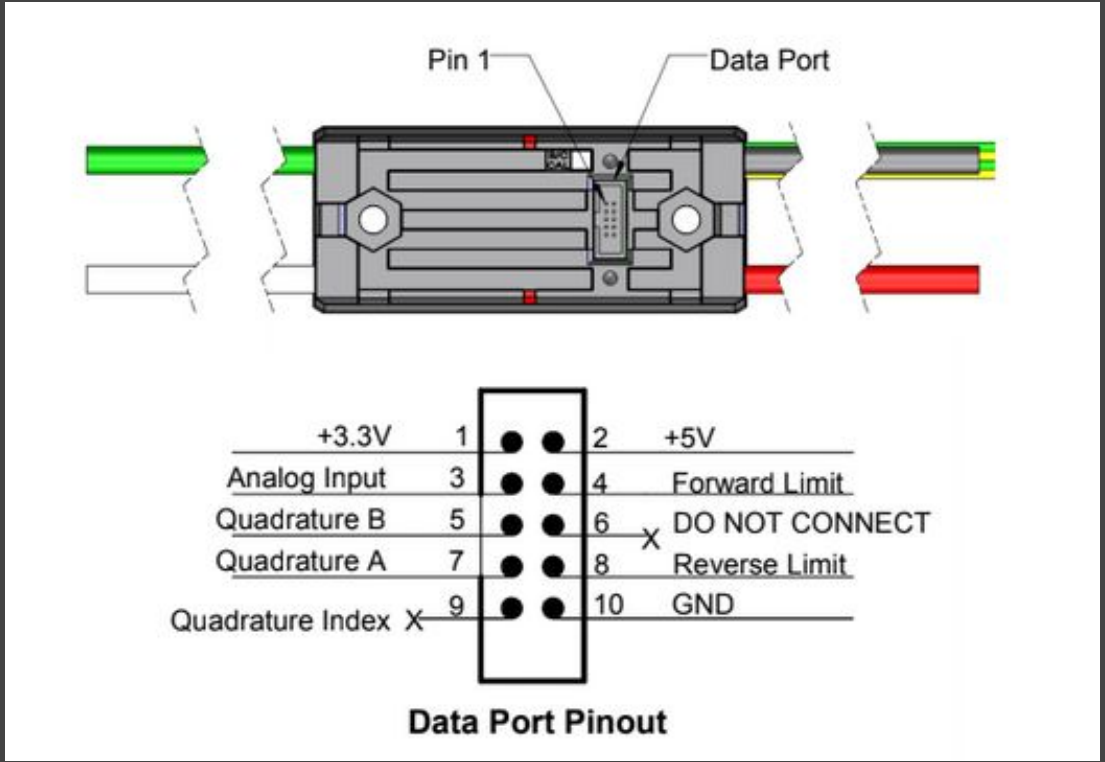


Sensor Boards

- Sensor boards can be such as the Gadgeteer Pigeon IMU, and FRC Gyro board and can be used
- The use of sensor boards can expand your robot's capabilities and improve performance in a competition



Talon SRX Data Port

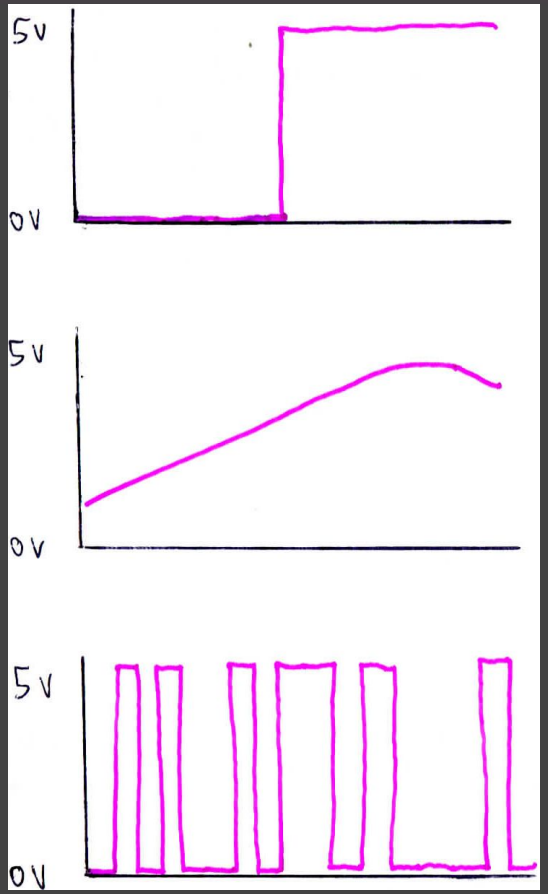


Implementation

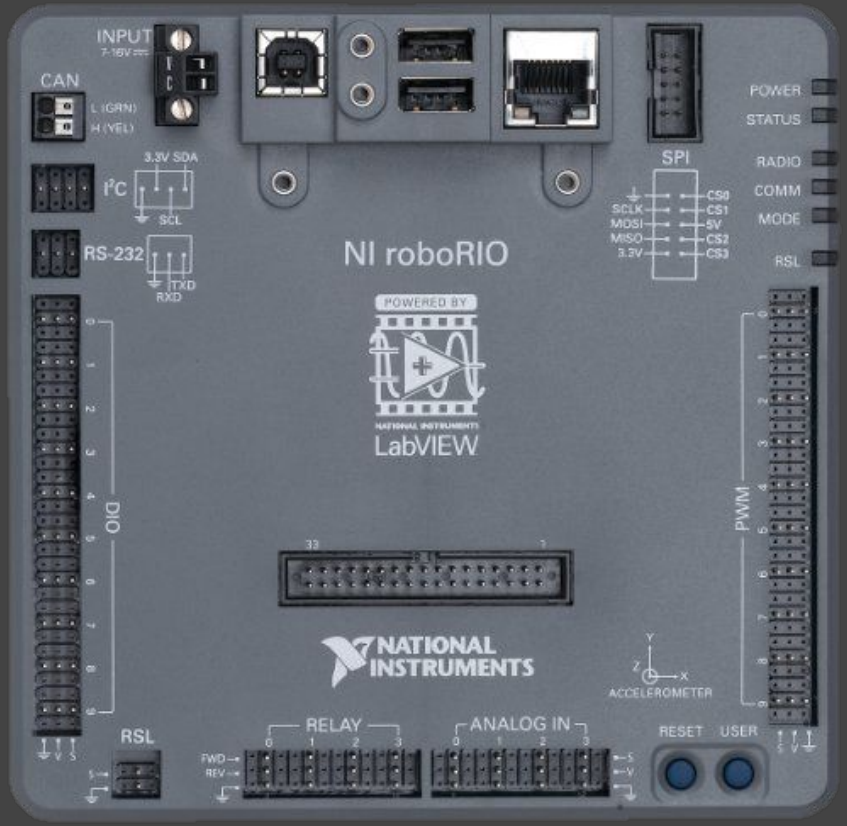
- Mounting
  - Protected
  - Sensor must “see” target
  - Must be secure - not move with respect to what it is mounted to
  - Must be able to easily remove / replace sensor
  - Wires to sensor should be a connector, not soldered
- Noise
  - Motors’ magnetic field can interfere with delicate sensors
  - High current wires can interfere with sensors, or signal from sensor to roboRIO.
  - If a sensor seems inconsistent, try moving it.
  - Faraday cages help with electric field noise, but not with magnetic field noise

Implementation

- Interface types
  - DIO
    - easy to interpret / use
  - Analog
    - more information
    - possible noise, not precise
  - Digital serial
    - Precise
    - high resolution
    - more complex to utilize



The RoboRIO



Pin spacing: .1”

User manual:
http://www.ni.com/pdf/manuals/374474a.pdf

Table 2. NI roboRIO Input Voltage Brownout Behavior

Stage	Input Voltage Range	Behavior
1	6.3 V to 6.8 V	The +6 V voltage rail starts to drop.
2	4.5 V to 6.3 V	The NI roboRIO enters a brownout fault condition and the following precautions are taken: • User voltage rails become disabled. • All PWM generation stops at the conclusion of the current cycle. • GPIOs configured as outputs go to High-Z. • Relay control outputs are driven low. • CAN-based motor controllers become disabled. The following systems continue to function normally with valid data and communication: • FPGA, processor, RAM, disk, and user code • USB power and communication • Radio, if powered by USB • Ethernet • CAN • AI and AO • I^2C • SPI • RS-232 serial • LED and RSL status lights Stage 2 continues until the input voltage rises to greater than 7.5 V or drops to less than 4.5 V.
3	Less than 4.5 V	All controller functions cease and the controller state is lost. This condition continues until the input voltage rises to greater than 4.65 V, at which point the controller starts the normal booting sequence. At startup, the controller remains in Stage 2 until the input voltage rises to greater than 7.5 V.

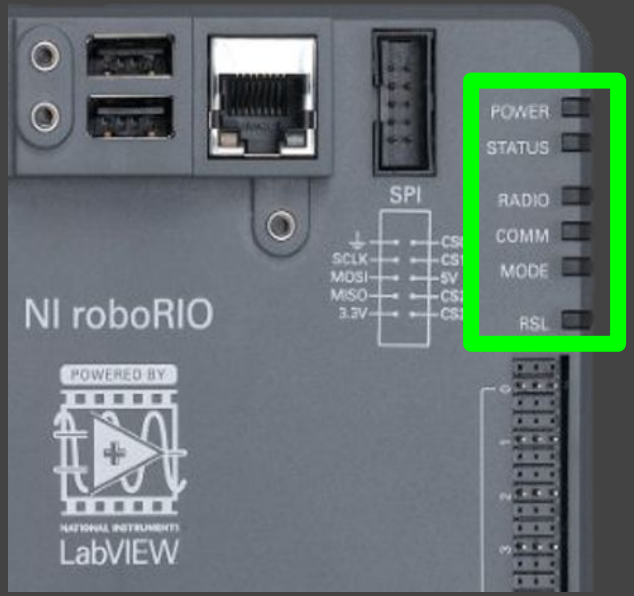
RoboRIO Power

- Input 7V-16V
- When the voltage drops to 4.5V - 6.8V RoboRIO enters brownout mode

RoboRIO Status LEDs

Table 13. Power LED Indications

Color	State	Indication
Off	Off	Power is outside valid input range.
Green	Solid	Power is valid with no fault condition.
Red	Solid	Fault condition detected. One or more user voltage rails are in short-circuit or overcurrent condition.
Red	Flashing	The input voltage is too high (greater than 16 V) and all outputs, including the RSL output, are disabled.
Yellow	Solid	Brownout condition detected. The 6 V user rail and outputs are disabled.



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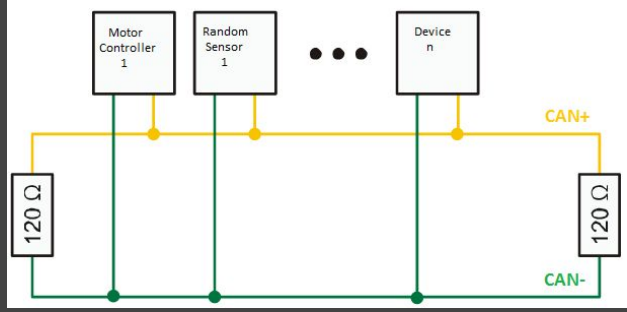
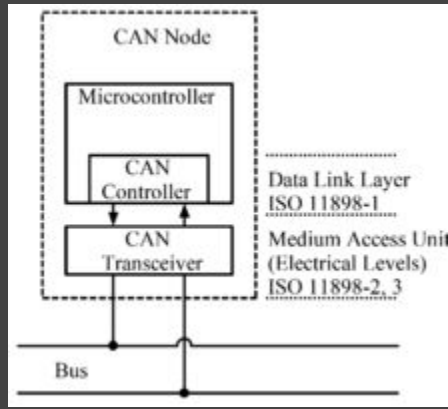
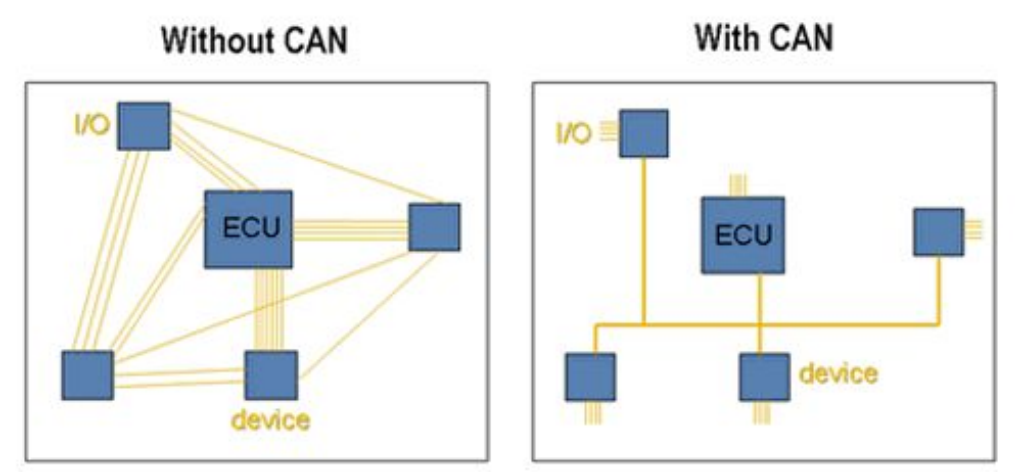
CAN

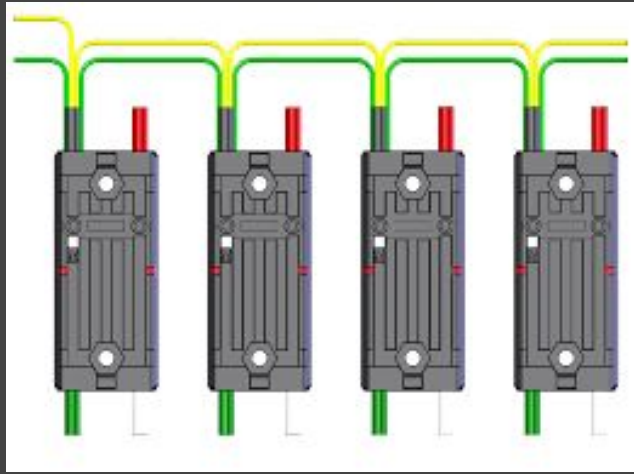


- Controller Area Network
  - Electronic Control Units (nodes), connected by a bus (network)
- Each node requires a:
  - CPU (central processing unit)/microprocessor
    - Decides what the received messages mean and what messages it wants to transmit.
- CAN controller - part of the microcontroller
  - Will wait and store a message until it is fully delivered
  - Will wait until the bus is free before sending a message
- Transceiver
  - Receiving: Converts data from CANbus level (voltage) to levels that the CAN controller uses.
  - Transmitting: Converts data from the CAN controller to (higher) CANbus levels.

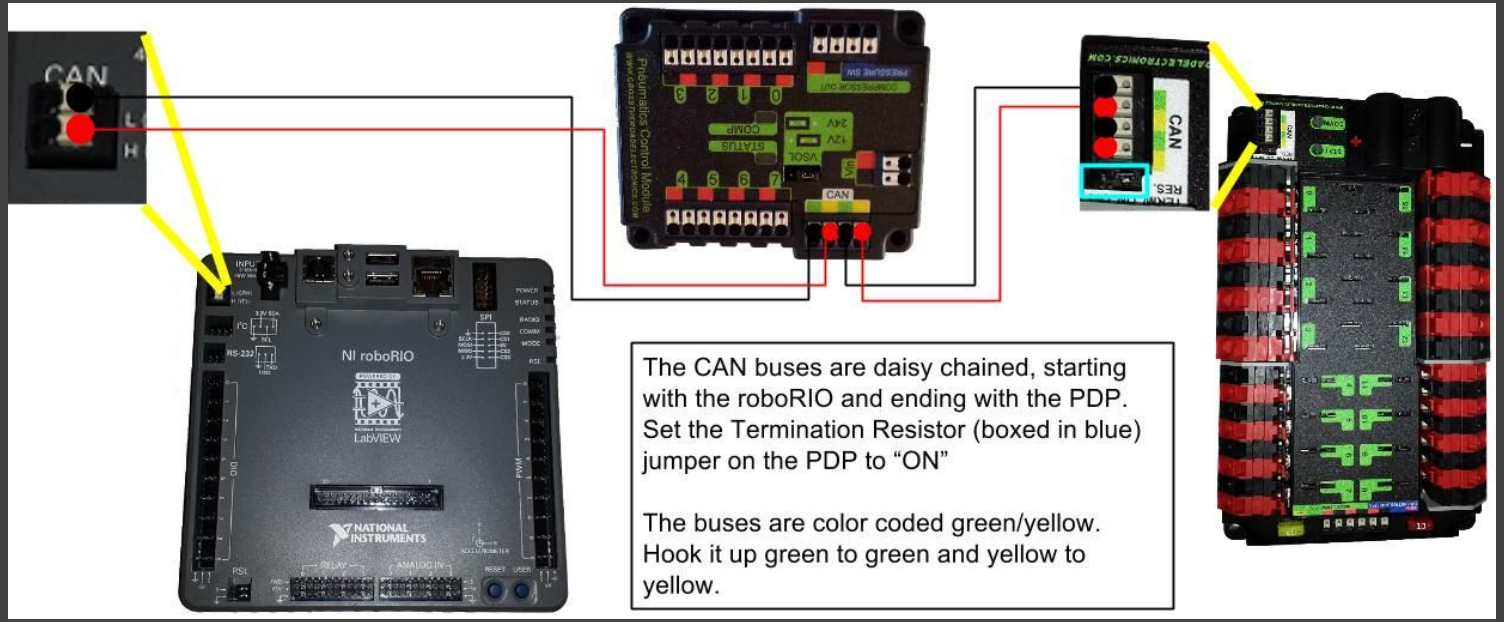


CAN



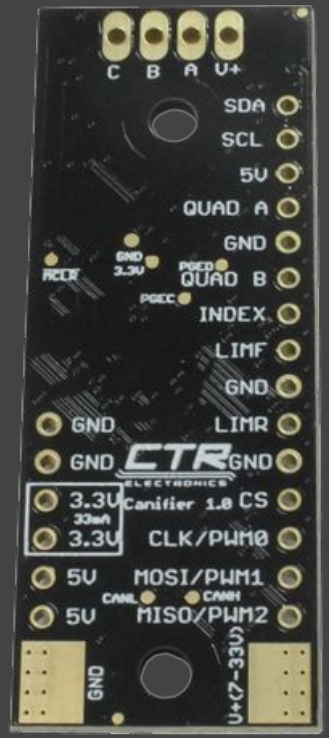


CAN


CAN
NI roboRIO
LabVIEW
NATIONAL INSTRUMENTS
Pneumatics Control Module
CAN
RES.
The CAN buses are daisy chained, starting with the roboRIO and ending with the PDP. Set the Termination Resistor (boxed in blue) jumper on the PDP to “ON”
The buses are color coded green/yellow. Hook it up green to green and yellow to yellow.

CAN

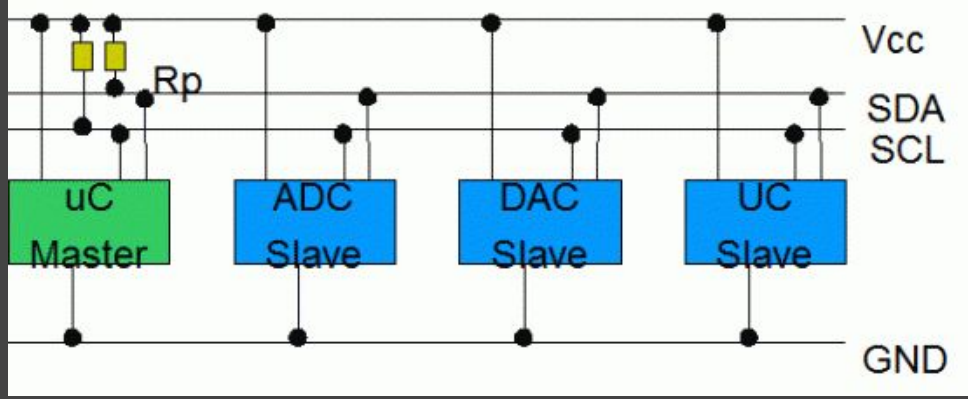
A useful component that can be used in a CAN wiring setup is the CANifier. The CANifier is a CAN controlled device that can be used to control LEDs and interface sensors into the bus. The use of a CANifier eliminates the need for sensors to be directly wired to the roboRIO's DIO ports.



I2C

I2C is a simple protocol to talk to sensors

That said, using I2C with sensors may require some tricky programming



One master, three slaves (3.3Vcc)
Device addresses to communicate, 7 bits for an address and the 8th for r/w.
Serial Clock Line (labeled SCL on the RoboRIO), Serial Data Line (labeled SDA)

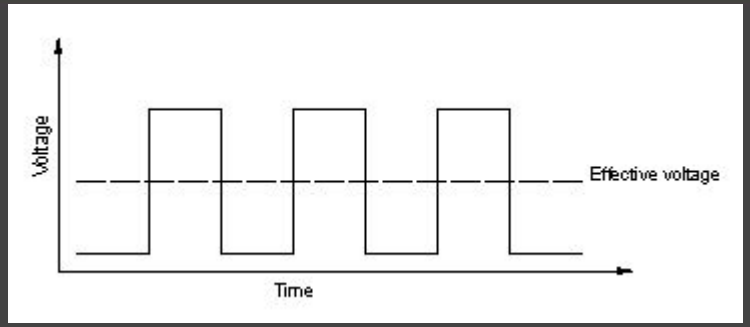
- LCD/LED drivers
- EEPROMs (*nonvolatile* electrically erasable programmable read-only memory)
- capacitive sensors (can measure non-air conductivity)
- real-time clocks
- digital temperature ICs
- IR Range Finders
- Arduino

DIO

Three Pins

- Ground
- Voltage (5V)
  - This gives the sensor power
- Signal (boolean)
  - The sensor outputs a 1 (3.3V/5V) or a 0 (0V) for the RoboRIO to detect

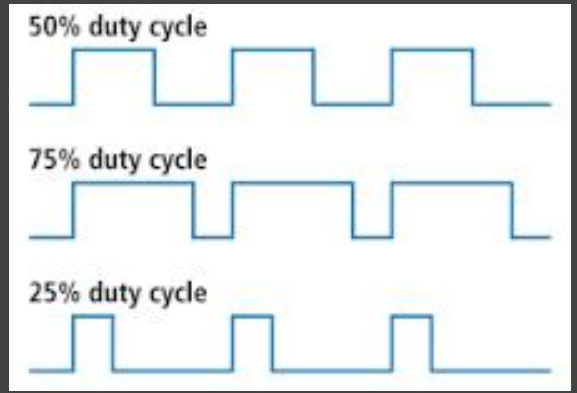
PWM



Pulse Width Modulation

- Cycles of full and ground voltage; the programmers can control the width of the pulse (high time)
- Usually mirrors a percentage in actuators (motor voltage%, servo motor degrees out of 360)
- Three pins
  - Voltage (6V) - will work with many ‘5V’ devices
  - Ground
  - Signal (boolean) - 5V/0V

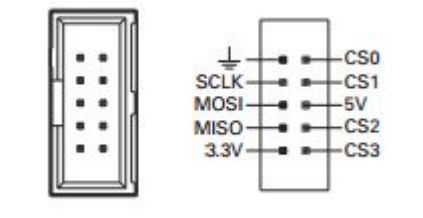
The RoboRIO (and most computers) use PWM to approximate an analog signal.

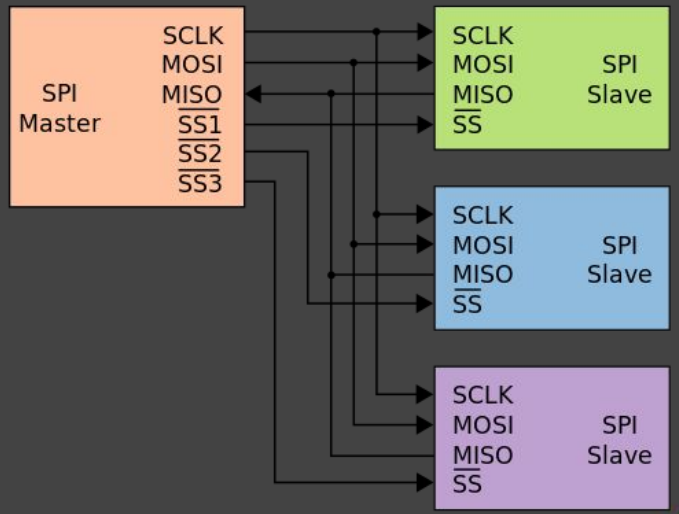


SPI - Serial Peripheral Interface (Bus)

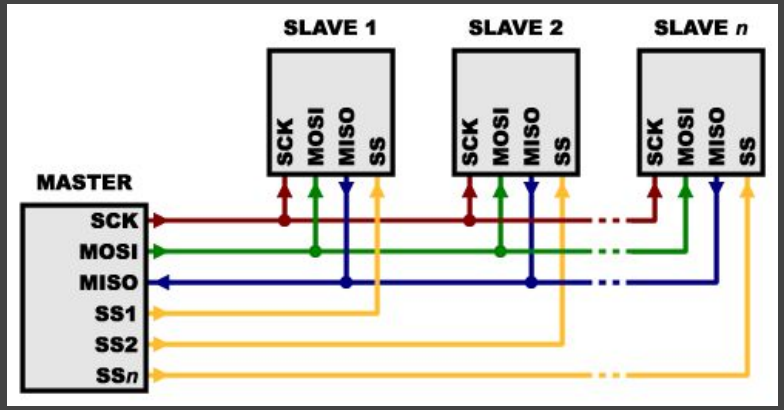
Another master-slave control example; however, in this case, once the master has initiated the selection of the slave (SS or CS-chip select) and the clock, the slave and master output 8 (or 12 or 16) bit ‘words’ to each other in a loop. Only the slave that has been selected with CS(#) will respond with this loop.

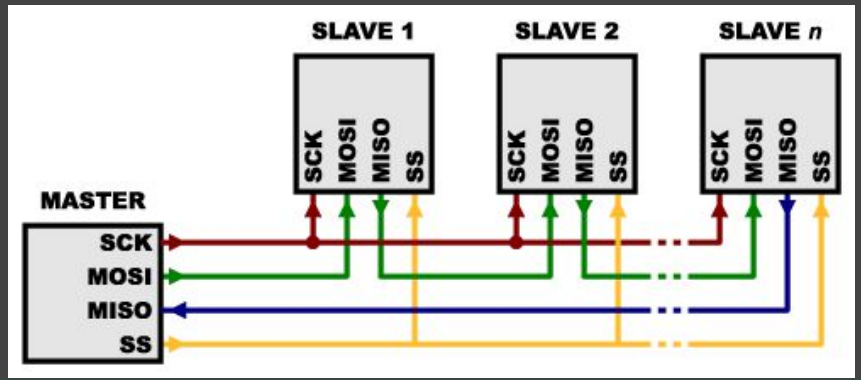
5V and 3.3V sources
SCLK: Set Clock, used for timing signals
MOSI: Master Output, Slave Input
MISO: Master Input Slave Output





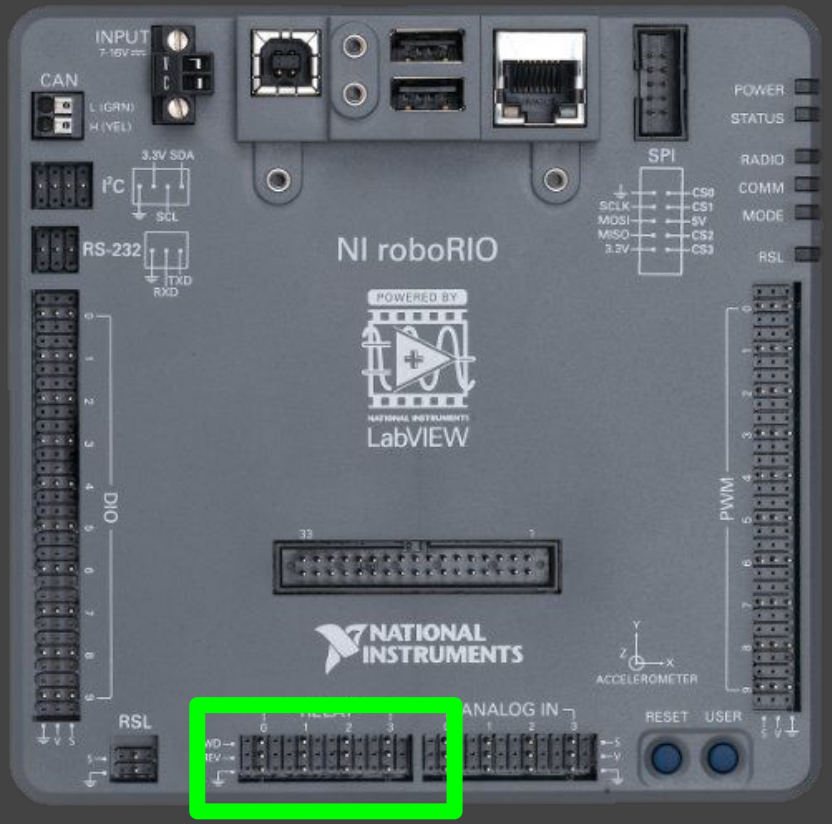
SPI - Serial Peripheral Interface (Bus)





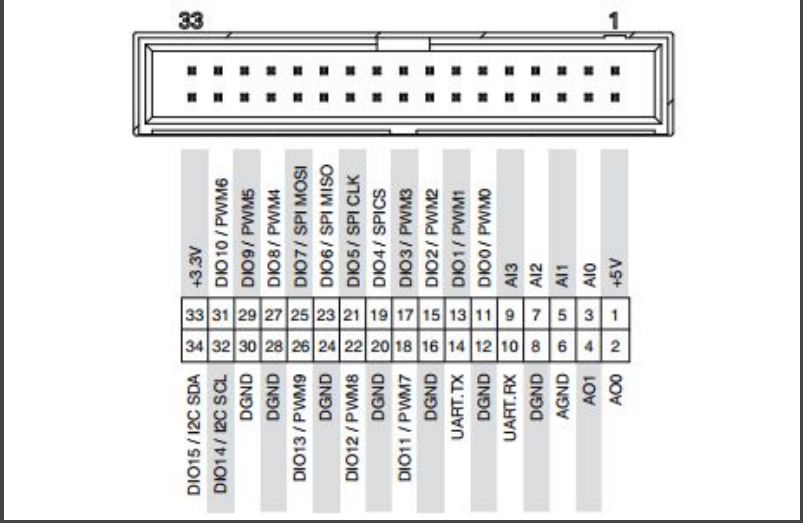
Relay

5V controllable outputs on both FWD and REV pins.
Ground pin on GND.
Useful for certain devices: Spike H-Bridge Relay from VEX Robotics, for motor control (forward and reverse)



MXP (myRIO Expansion Port)

Multi-purpose extension for DIO,I2C, PWM and UART.RX (receiving) and UART.TX (transmitting)
Has an analog input which is multiplexed and interpreted by the RoboRIO.
Also has an analog output which involves a digital to analog converter.

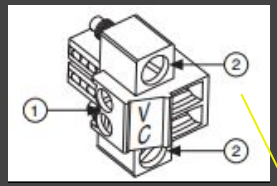


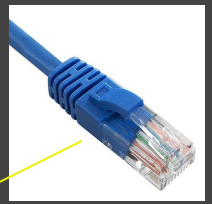
MXP Expansion Boards

- Teams can make circuit boards to extend signal pins.
  - Premade circuits such as the REV Robotics More Board can be used

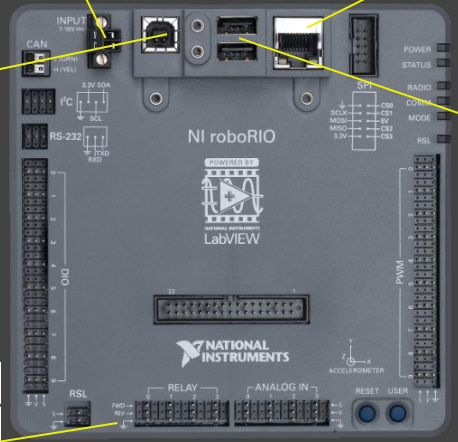
- The active devices that are approved by FIRST for use with the MXP in FRC events are:
  - Kauai Labs navX MXP
  - RCAL Daughter MXP Daughter Board
  - REV Robotics RIOduino
  - Rev Robotics Digit Board
  - West Coast Products Spartan Sensor Board
  - Huskie Robotics HUSKIE 2.0 Board

RSL, Ethernet, USB device and host, and power



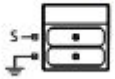


USB device port



USB host ports

Figure 9. RSL Port Pinout



Questions?

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