FTC Control System & Programming

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What's New for 2017!

- Rev Robotics Expansion Hub

- OnBot Java Programming option

FTC Hardware System Modern Robotics

- System provided by FIRST in the ResQ and Velocity Vortex Seasons
- No longer in FTC storefront
- Useable and supported by MR
- If purchased for ResQ (2015/16) and not sent in for Firmware update Please see me.

FTC Hardware Systems Modern Robotics

- 5 Core Modules
- Core Power Distribution Module
  - Basically a 7-Port Powered USB Hub and Fused Power Distribution Block
- Core Motor Controller Module
  - Drives 2 DC Motors with or without encoders – **5 Amps per motor Max**
  - 3 operating modes
    - Run at Constant Power (no encoder required)
    - Run at Constant Speed (requires encoder)
      - Warning to Holonomic Drive users – clocks are not consistent from module to module requiring compensation in software (it does work but "how to deal with it?" is left as an exercise for the student!)
    - Run to Position (requires encoder)

FTC Hardware Systems
Modern Robotics

- Core Servo Controller Module
  - Runs six standard 6 Volt servos - **5 Amps maximum total current**
  - Runs 180 Degree or Continuous Rotation Servos
- Core Device Interface Module
  - PWM, Digital I/O, Analog I/O, I^2C ports
- Core Device Legacy Module
    - Provides an Interface to allow use of older legacy FTC hardware
      - Lego NXT Sensors – **But NOT Lego EV3 Sensors!**
      - Hi Technic Sensors
      - Matrix Controllers
      - Hi Technic Tetrix Motor & Servo Controllers

FTC Hardware Systems
Rev Robotics

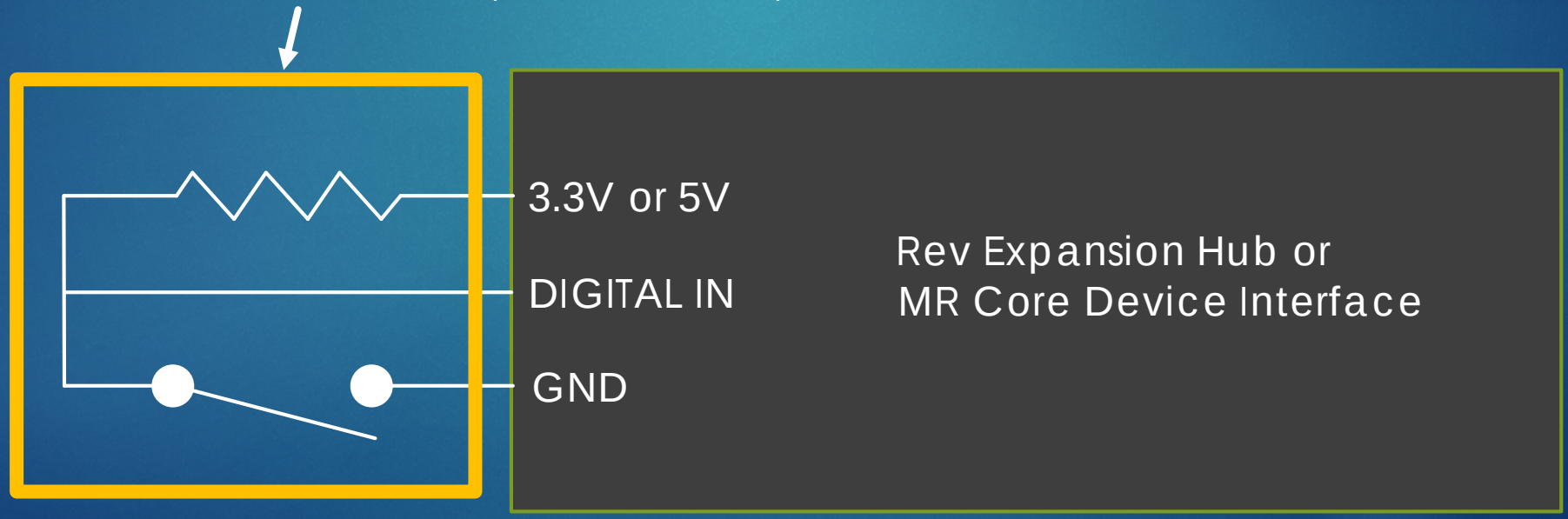
- NEW – Provided in FTC storefront this season
  - Rookie teams will probably have these
- Much cheaper and more highly integrated
- Discount code in FIRST storefront to order an extra module
  - Buy the first one thru FIRST – comes w/ more stuff!
- Requires 3.3V to 5V converters to use with 5V I^2C sensors
  - MR, Lego, Hi-technic, AdaFruit, etc….
  - FIRST Storefront kit has 3 converters
- Includes powerful Bosch BNO055 9-axis IMU

Sensors

- Wide variety available – as allowed by <RE11>
- Be careful to use voltage converters where needed w/ Rev Exp. Hub
- 4 Common Interfaces – Digital, Analog, I^2C, Quadrature Encoder
- Legacy Sensors (NXT & HiTechnic) can be used w/ Core Legacy Module
  - Not clear if they can connect to I^2C port of Rev Expansion Hub

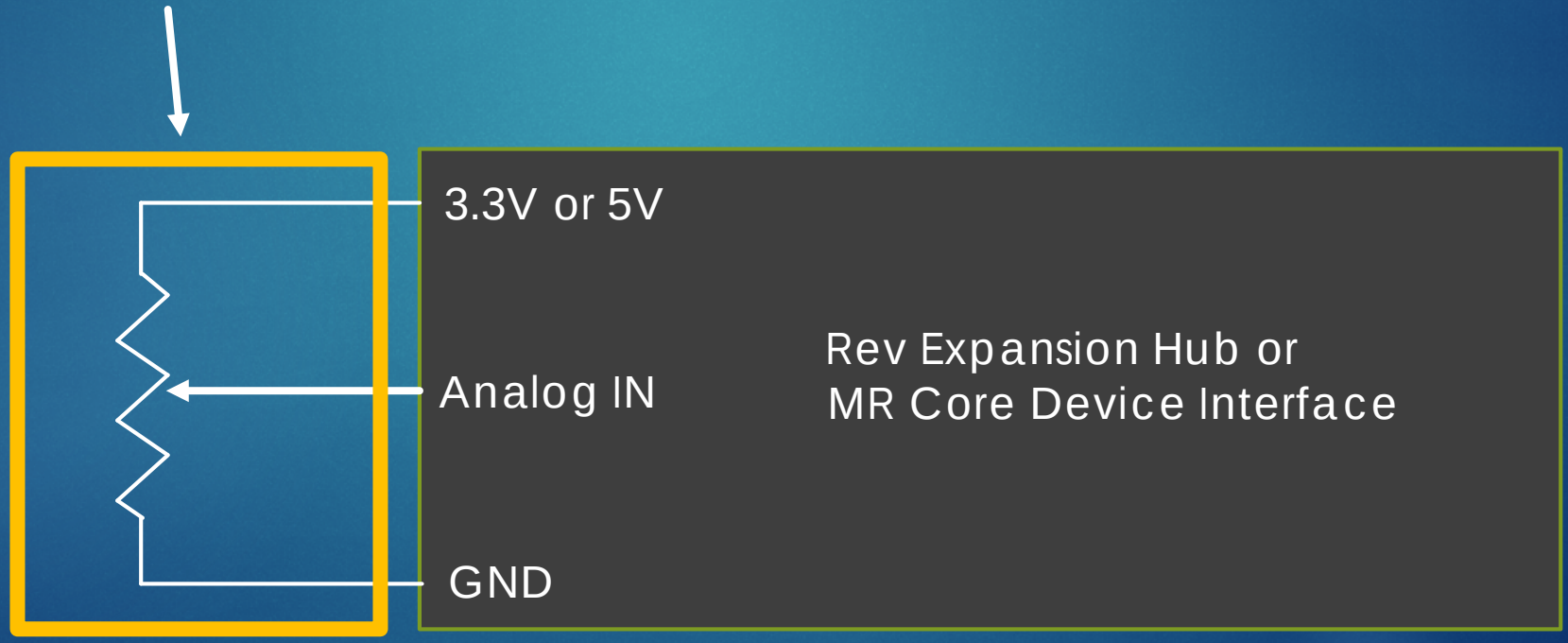
Sensor Interface - Digital

- Simple Digital Input
  - 0 Volts = Logic “0” = False
  - 5 Volts (MR) or 3.3V (REV) = Logic 1 = TRUE
- Used for Touch Sensor, Limit Switch, etc….



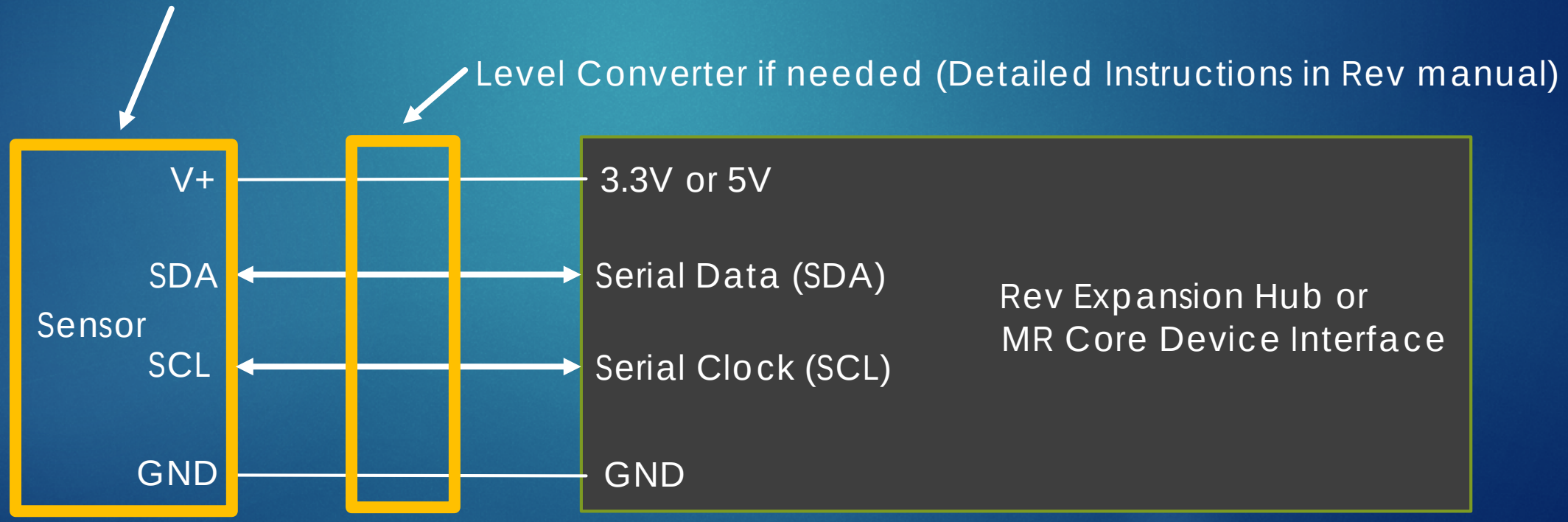
Sensor Interface - Analog

- Simple Analog Input
  - 0 Volts to 3.3 or 5 Volts, 12 Bits of resolution (0 to 4095)
- Used for Potentiometer Position Sensor, Voltage Sensor....



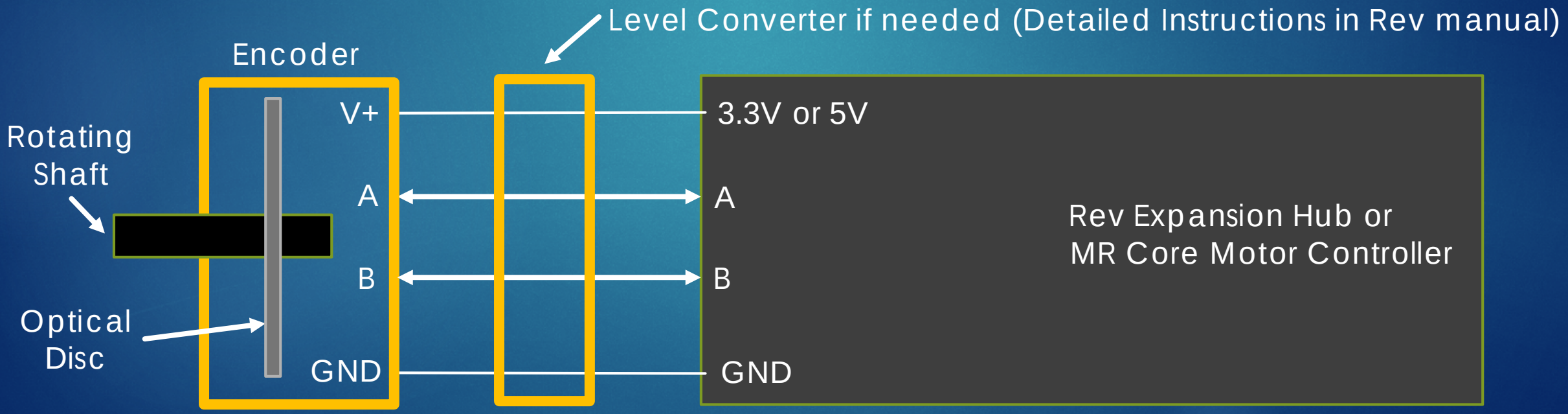
Sensor Interface – I²C

- Inter-Integrated Circuit (I²C) Serial Interface
  - Industry standard 2-wire serial interface developed in the 1970's
  - Used by many advanced sensors & IC's
- Used for Advanced Sensors w/ I2C Communication



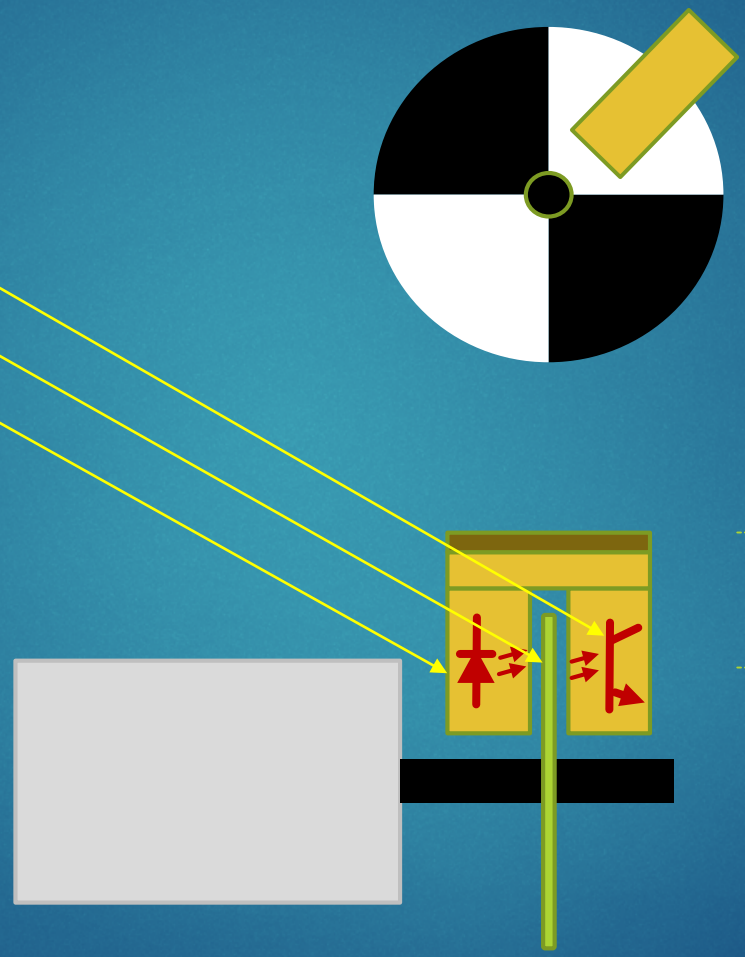
Sensor Interface – Encoders

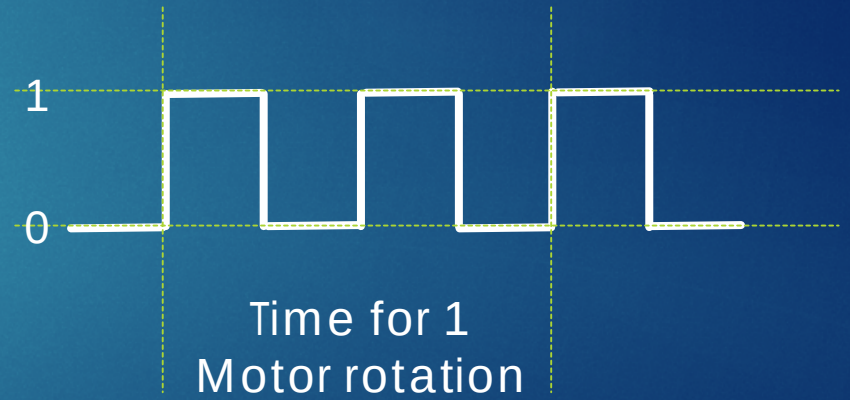
- Specifically for Quadrature Encoders
  - Used on Motors for “Constant Speed” and “Run to Position”
  - Used on Moving Assemblies for precise measurement of motion
- 4 wire interface



How Encoders Work

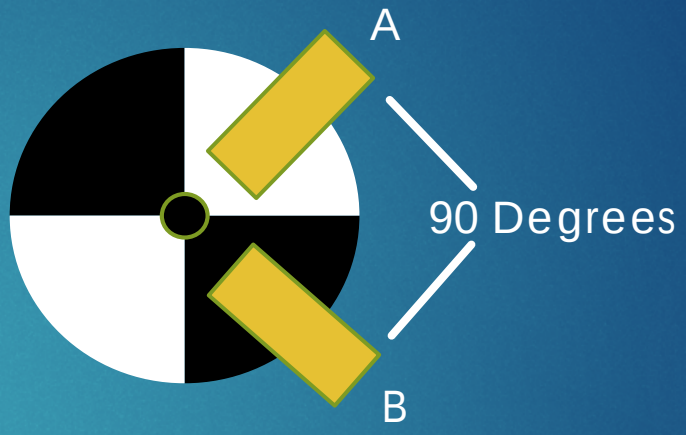
- Layered Optical Sensor
  - Photo-Transistor
  - Glass Disk
  - LED Light Source
- 2 pulses per rotation of the motor
- 4 edges per rotation of the motor

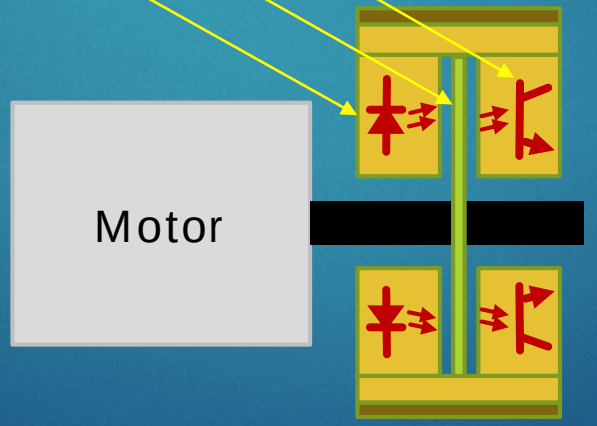


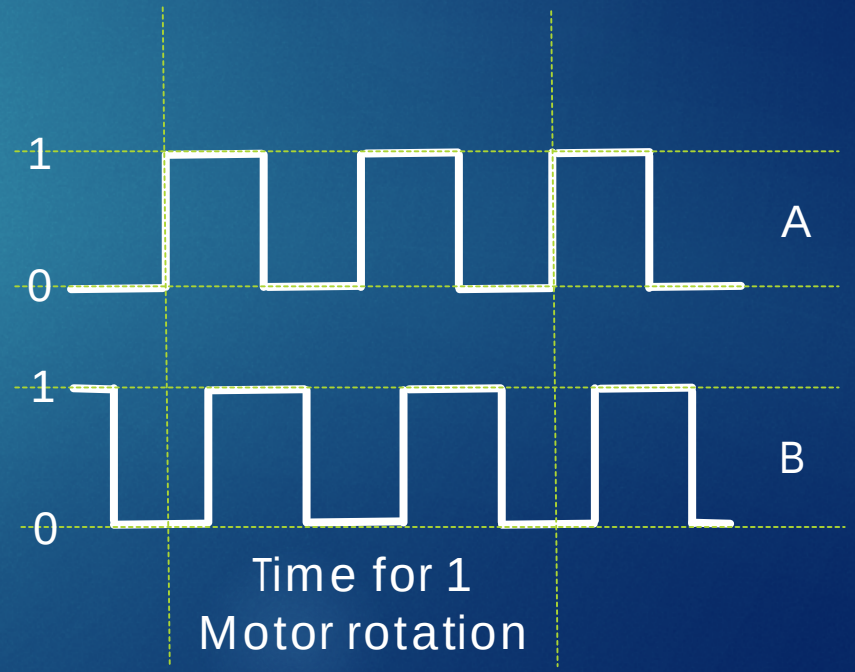


How Encoders Work

- Quadrature Encoders
- 2x Layered Optical Sensors
  - Spaced to create 2 waveforms 90º apart
  - Photo-Transistor
  - Glass Disk
  - LED Light Source
- 2 pulses per rotation of the motor per sensor
- 4 edges per rotation of the motor per sensor (8 total)
- Can now sense direction
  - CW – A leads B
  - CCW – B leads A
- Can be 1 to 10000's lines around the glass disc
  - more lines = more resolution







Vuforia Augmented Reality

- Uses Phone Camera
- Image recognition and alignment
- Software built into FTC SDK
- 4 Images on field – randomly selected
- Tutorials & discussions on line – google FTC Vuforia

Control System Tips

Control System Tips

Electro-Static Discharge

E.S.D.

Control System Tips

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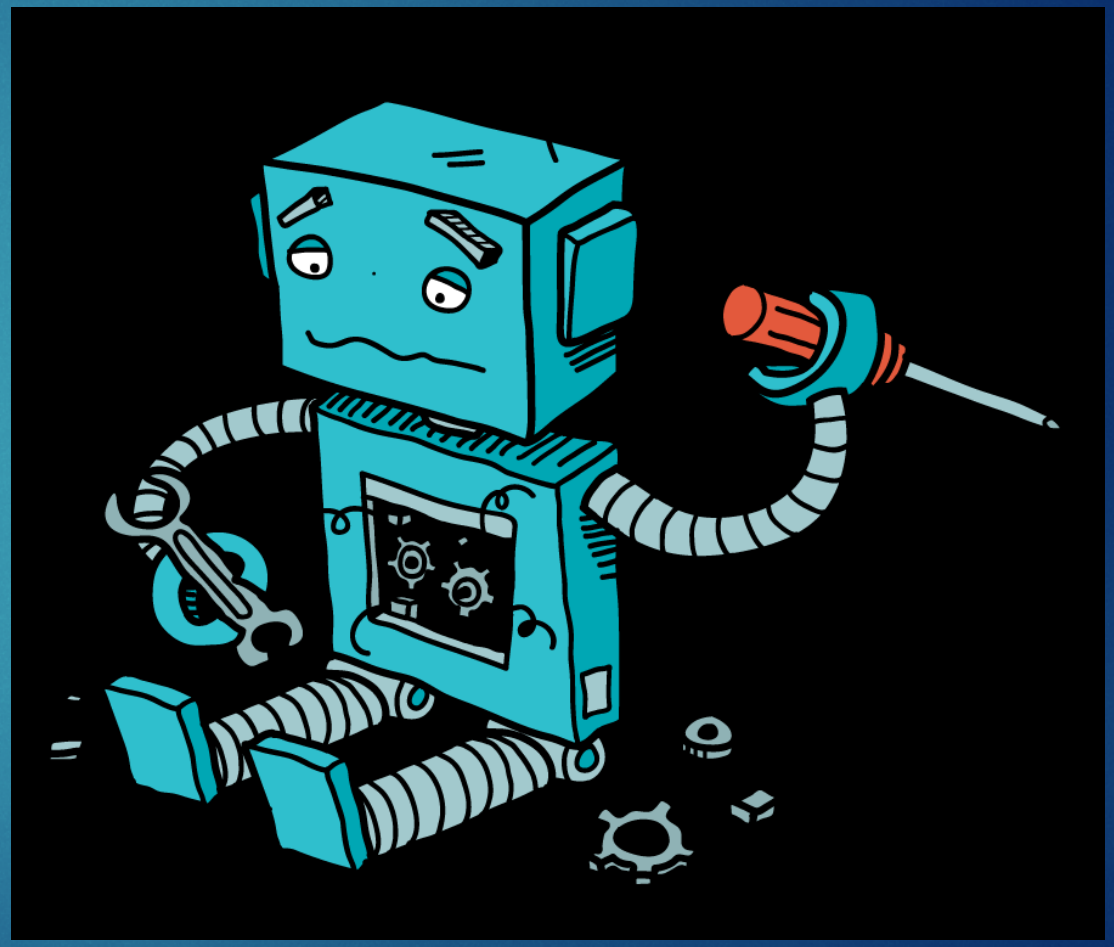


Control System Tips

- Recipe for static electricity build-up:
  - Drive robots with plastic & rubber wheels on foam mats, surrounded by acrylic walls in a low humidity, southwest climate
- Discharge occurs when robots contact walls, field elements, or each other
  - When it gets into the electronics – **BAD THINGS HAPPEN!**
- Keep wiring neat & organized!
- Use ESD plastics to protect parts (particularly sensors)
- Use insulated connectors, splice blocks or electrical tape
- During practice, occasionally spray light mist of water on field tiles

Control System Tips

- Keep Wiring Neat & organized!
  - More Reliable!
  - Won't get tangled in other robots or field elements
  - Messy wiring is common cause of Robot Inspection Failure!
  - Use Anderson Powerpole connectors
  - Make sure to use some kind of retention on motor cables
    - Tape, Ty-wraps, 3D printed retainer
    - Or solder the wires on but be careful and quick, you can damage the motor!
- 3D Printable Components on https://www.thingiverse.com/
  - Cable Strain reliefs
  - Phone / Electronics/ Sensor Mounts
  - Many Mechanical Components
  - If you don't find it – design & build it yourself then share on Thingiverse!
    - Good Core Values!

Control System Tips

- Pay attention to the specs of your components!
  - Exceeding rated power supply & input voltages:
    - Causes unpredictable behavior
    - Damages modules
  - Exceeding maximum currents on modules, wiring, motors & servos:
    - Causes unpredictable behavior
    - Let's out the "Magic Smoke" that makes it work!
    - Damages modules, Weakens or burns out motors & servos.
    - Can cause fires! (NO FLAMING ROBOTS PLEASE!)
  - Exceeding specs of mechanical parts:
    - Causes unpredictable behavior
    - Breaks stuff!
    - CREATES SAFETY HAZARDS!
- If you have unexplainable behavior occurring – THINK ABOUT THIS SLIDE!

Allowed Android Phones <RS03>

- Very specific (and somewhat outdated!) models
  - ZTE Speed
  - Motorola Moto G 2nd Generation
  - Motorola Moto G 3rd Generation
    - If you have these **Please See Me!**
  - Motorola Moto G4 Play
  - Google Nexus 5
  - Samsung Galaxy S5
- Keep an eye on revisions to Game Manual 1 for possible additions
- Android OS as specified in <RS03>
- Other phones / tablets may work but are **not legal for competition**

Driver Station Setup

Mount Phones to something Non-metallic for best WiFi

USB OTG Cable

Optional USB Battery
(required for Moto G 3rd gen phones)

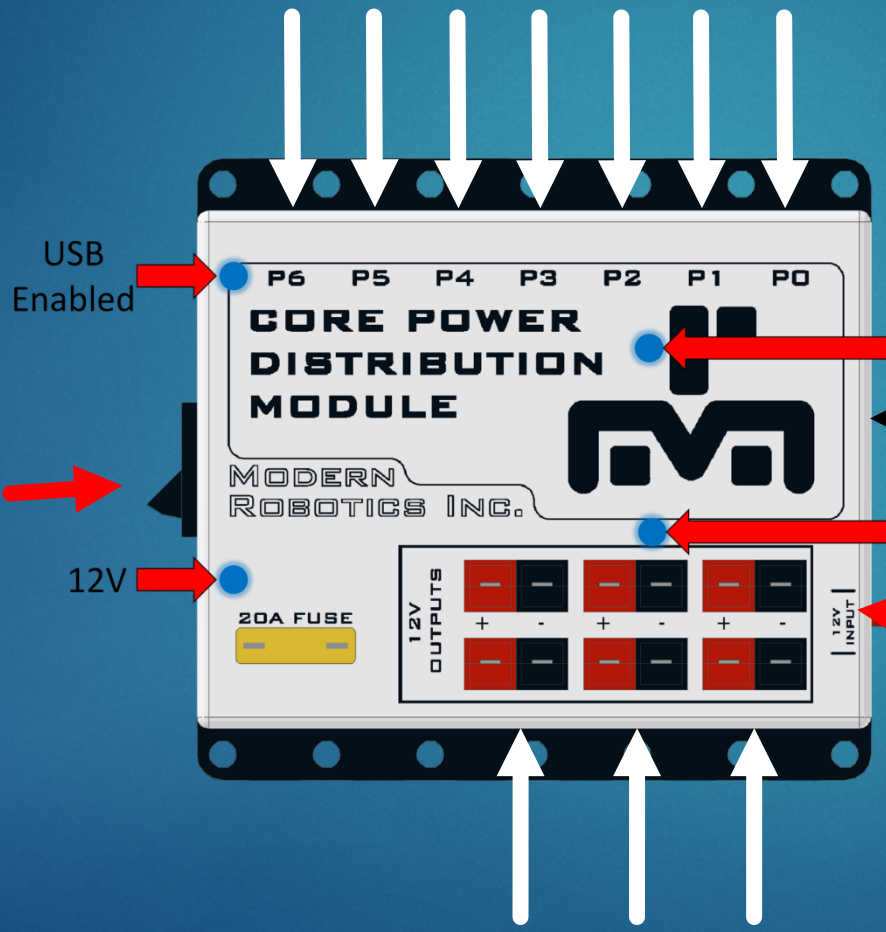
Driver Station App

- Two Install Options:
  - Free download from Google Play Store
    - will be latest official release version
  - Install APK included with FTC SDK
    - Will be the version that goes with that SDK (including beta releases)
- Be certain Installed version is same as the Robot Controller Version
- Make sure no stray Robot Controller App on Driver Station Phone
  - Causes unpredictable results & phone crashes
- Phone WiFi Name should be #####-DS (##### = team number)

Robot Controller Setup (MR)

Mount Phones to something Non-metallic for best WiFi

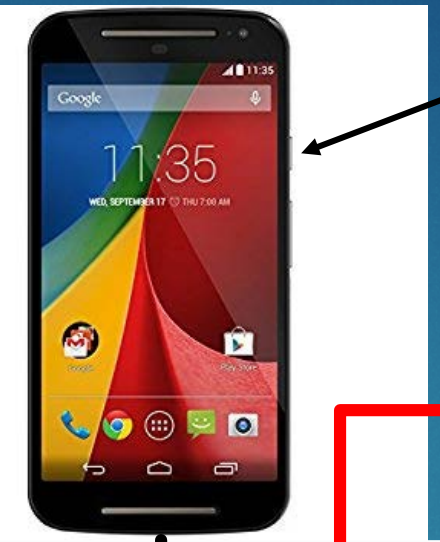
USB Cables to Modules



Robot Power Switch (Must be Accesible)

Power to Modules

Robot Controller Setup (Rev)



Mount Phones to something Non-metallic for best WiFi

Second Hub (if used)

Robot Power Switch (Must be Accessible)

USB Cable

Sensors (w/ Level Shifters as needed)

Motors & Encoders

Servos

Robot ControllerApp

- This is the app you are putting your team's Robot Code in!
- Two initial install options:
  - Free download from Google Play Store
    - Will be latest official release version
  - Build and Install using Android Studio from FTC SDK
    - Will be whatever version you choose (including beta releases)
- Be certain installed version is same as the Driver Station app version
- Make sure no stray Driver Station app is on Robot Controller phone
  - Causes unpredictable results & phone crashes
- Must be only one Robot Controller app on the phone
  - Causes unpredictable results (even if they have different names!)
- Phone WiFi name should be #####-RC (##### = team number)

Programming Environments <RS02>

- Google Android Studio, Oracle Java Development Kit, FTC SDK
  - Text based Java programming environment
  - Most powerful but also the most complicated
- Brand new “OnBot” Java Programming development tool
  - Text based Java Programming built into the Robot Controller app
  - Only exists in FTC SDK 3.4 release
  - Doesn’t currently show in <RS02> but presumably being added
- FTC Blocks Programming development tool
  - Visual Blocks Based Programming built into the Robot Controller app
  - Based on Google’s Blockly language but similar to FTC/MIT App Inventor
- FTC/MIT App Inventor
  - Visual Blocks based Programming Tool using a Virtual Box based server
  - According to Tom Eng at FIRST – going away after this season
  - 2017 legal minimum 3.1 version not released yet – not a good sign for support

Programming Key Web Links

- FTC Control System Wiki
  - https://github.com/ftctechnh/ftc_app/wiki
- FTC Software Development Kit Current Release (now v3.4)
  - Just released Wed, Sept 6
  - https://github.com/ftctechnh/ftc_app
- FTC Software Development Kit Beta Release
  - https://github.com/ftctechnh/ftc_app/tree/beta/doc/apk
  - Not currently a beta version available (3.4 just released Wednesday)
  - Experimental – beta versions allowed for use, but **AT YOUR OWN RISK!**
- FTC App Inventor Current Release (now v2.4 – not legal for use)
  - https://frc-events.firstinspires.org/ftcimages/2017

Blocks and OnBot Quick Demo

- Can be used on the Robot Controller phone screen
  - Small but useable in a pinch
- Typically used in a Java enabled browser on a PC
  - Chrome seems to be the recommended browser
- Steps:
  - Ensure WiFi direct is configured on the phone (named #####-RC)
  - Start Robot Controller App on phone, select “Program & Manage”
  - The phone will display a screen with the WiFi name, password & http address
  - Connect your PC to the phone using the WiFi name & Password
  - Start Chrome and open the displayed http address
  - You will be in the environment for Blocks and OnBot