Software Design Objectives

Part I
- Understand Software design process

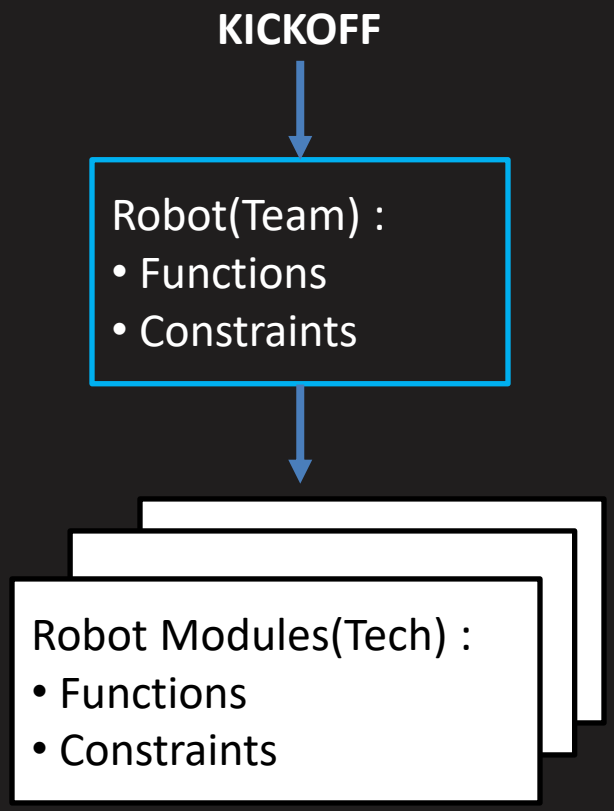
Part II
- Understand FIRST Code Development Environment
- Understand FIRST program structure
- Understand FIRST I/O class library

Part III
- Program Documentation / Best Practices / Safety

Part I – Software Design Objectives

- Understand the program design development process

Robot Program Development Process



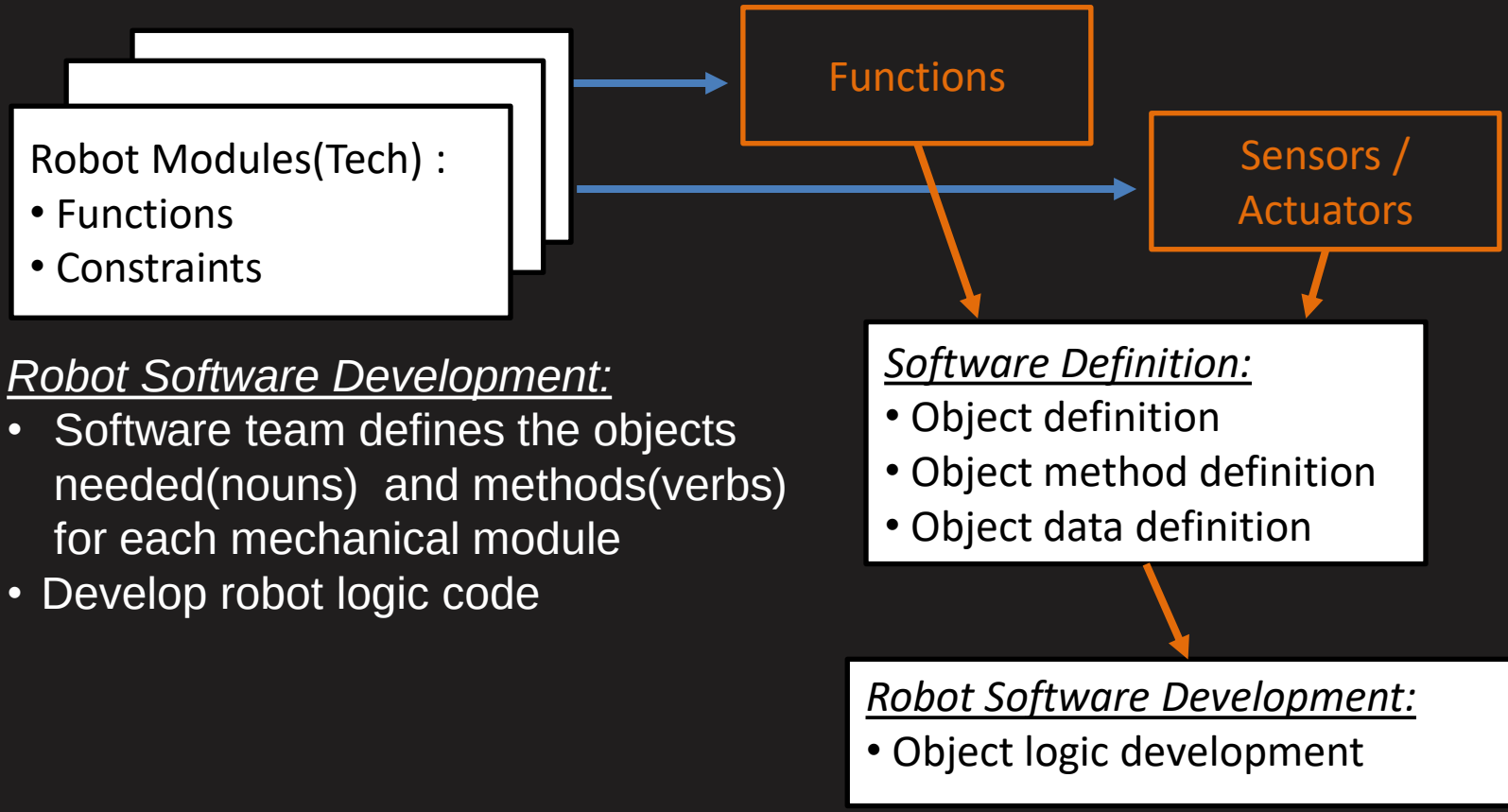
From the kickoff video / game manuals:

- The team develops a game strategy
- The strategy defines the functions the robot has to do and the constraints on the robot

The Technical team (Mechanical/Electrical/Software):

- Groups the functions to the major robot modules per the robot model
- For each robot module a concept and a definition of controlling devices is developed

Robot Program Development Process



Robot Software Development:

- Software team defines the objects needed(nouns) and methods(verbs) for each mechanical module
- Develop robot logic code

Software Design Process Steps

1 Determine and organize functions robot has to perform from robot functional requirements or mechanical module description.

2 Determine electrical hardware interface to computer I/O – electrical CID document

3 Develop SOFTWARE PLAN: description of logic flow

4 Develop program code per team style guide

5 Software team review of code

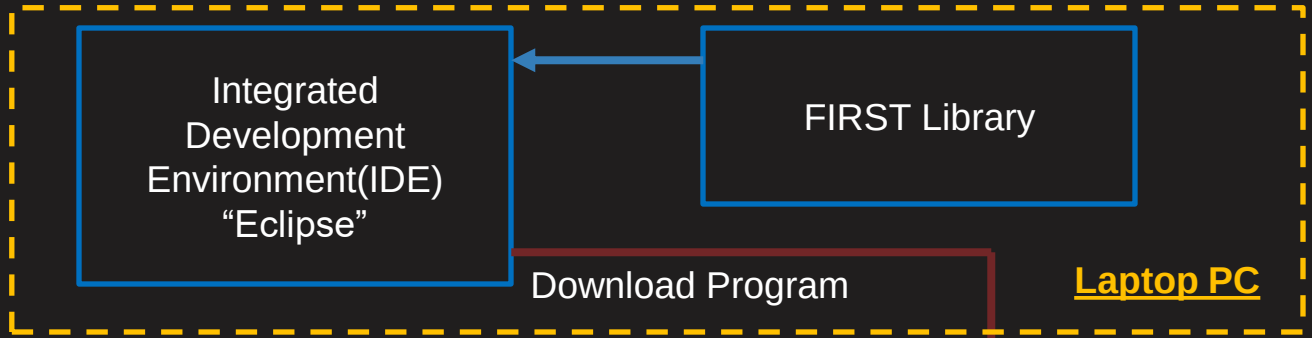
6 Test code: I/O functionality and then module logic

Part II FIRST JAVA Program Stucture Objectives

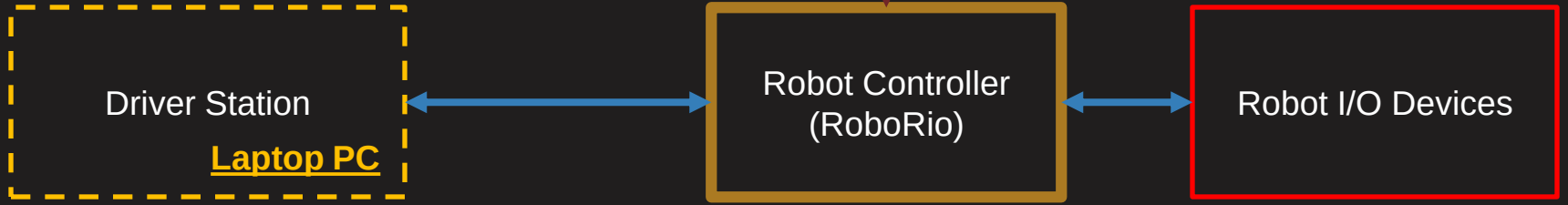
- Understand FIRST Code Development Environment
- Understand the JAVA program structure of FIRST
- Understand the FIRST Classes covered in the “WPILib” library

FIRST Software Development Environment

Software Development:



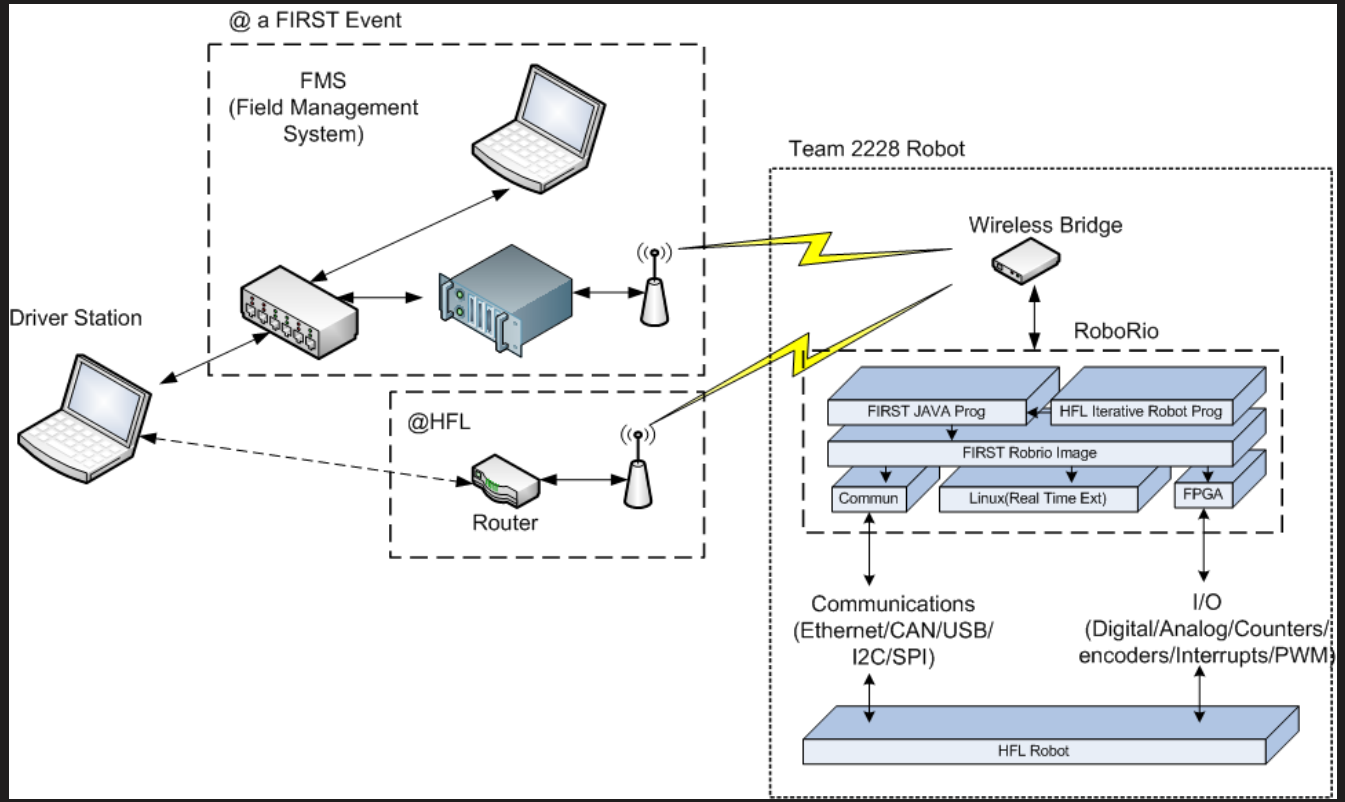
Software Execution:



- Robot monitor
- Human input(Joy Stick / Switches)

- Robot Program

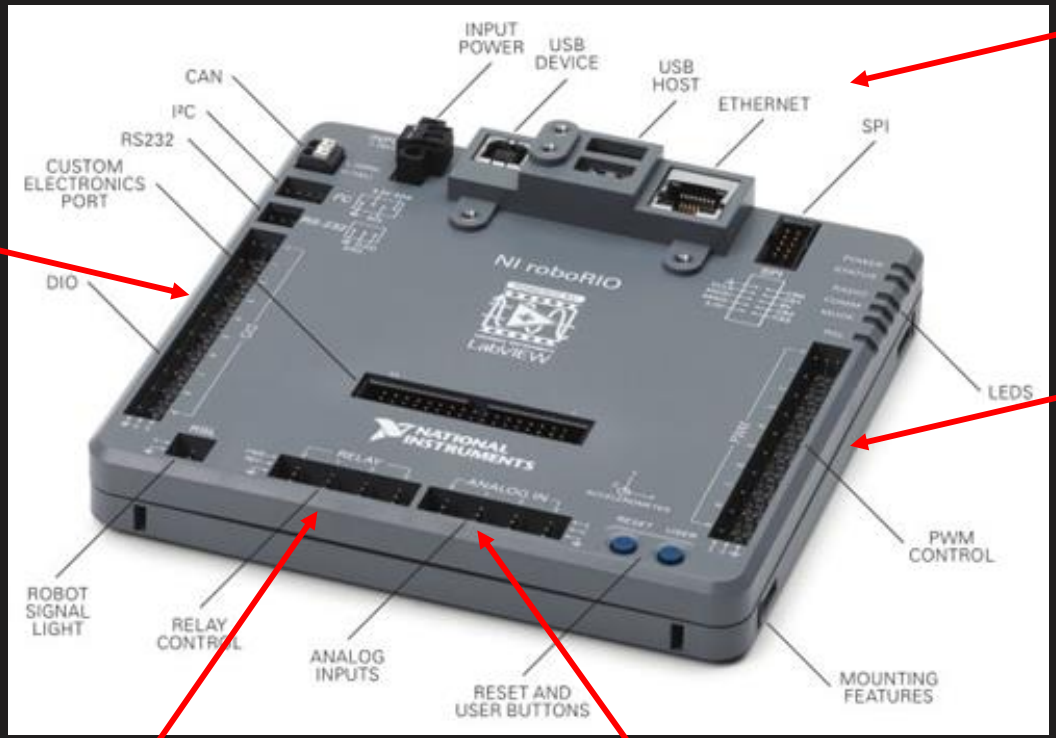
Block Dia: FIRST Hardware Structure for Software



RoboRio Robot Controller

Communication (Ethernet/CAN/Serial/USB/SPI/I2C)

Digital input/output(IO) (10)

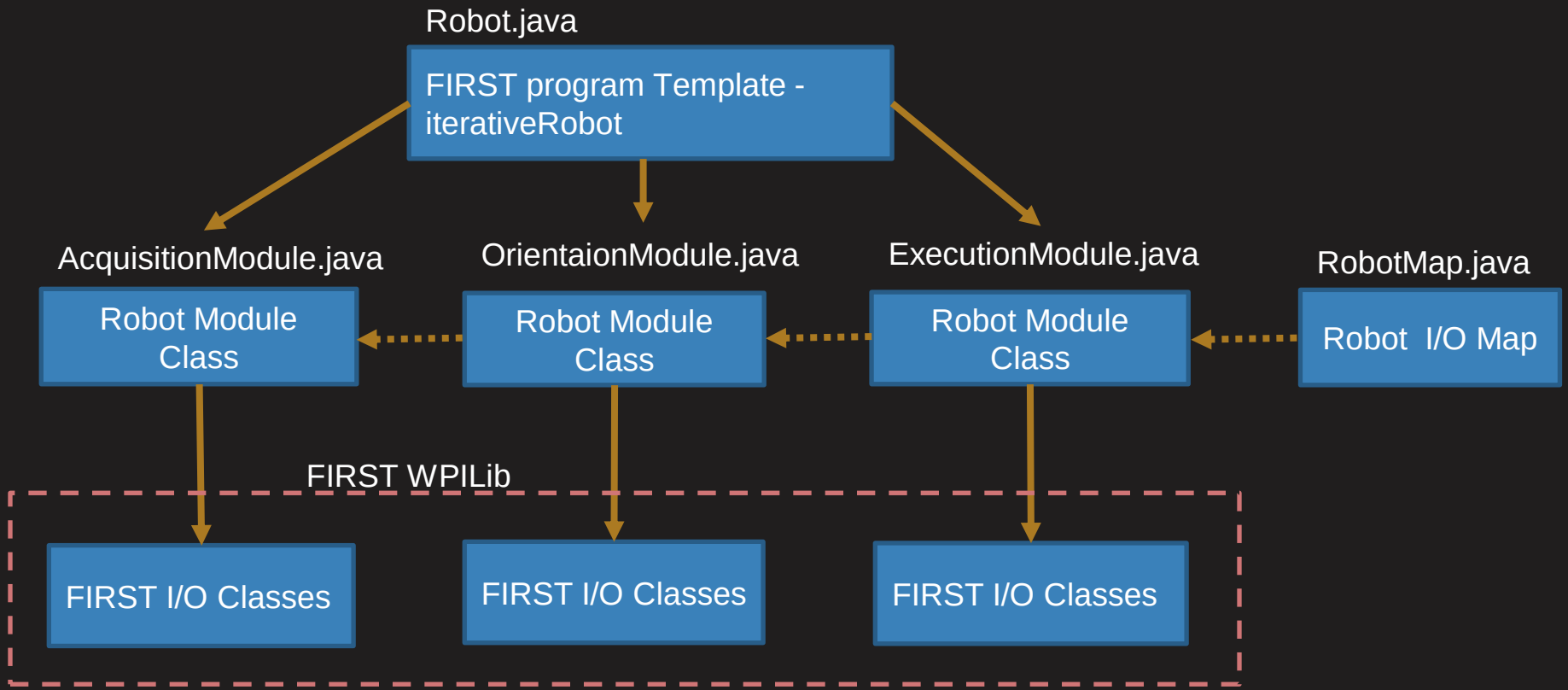


PWM connections (10)

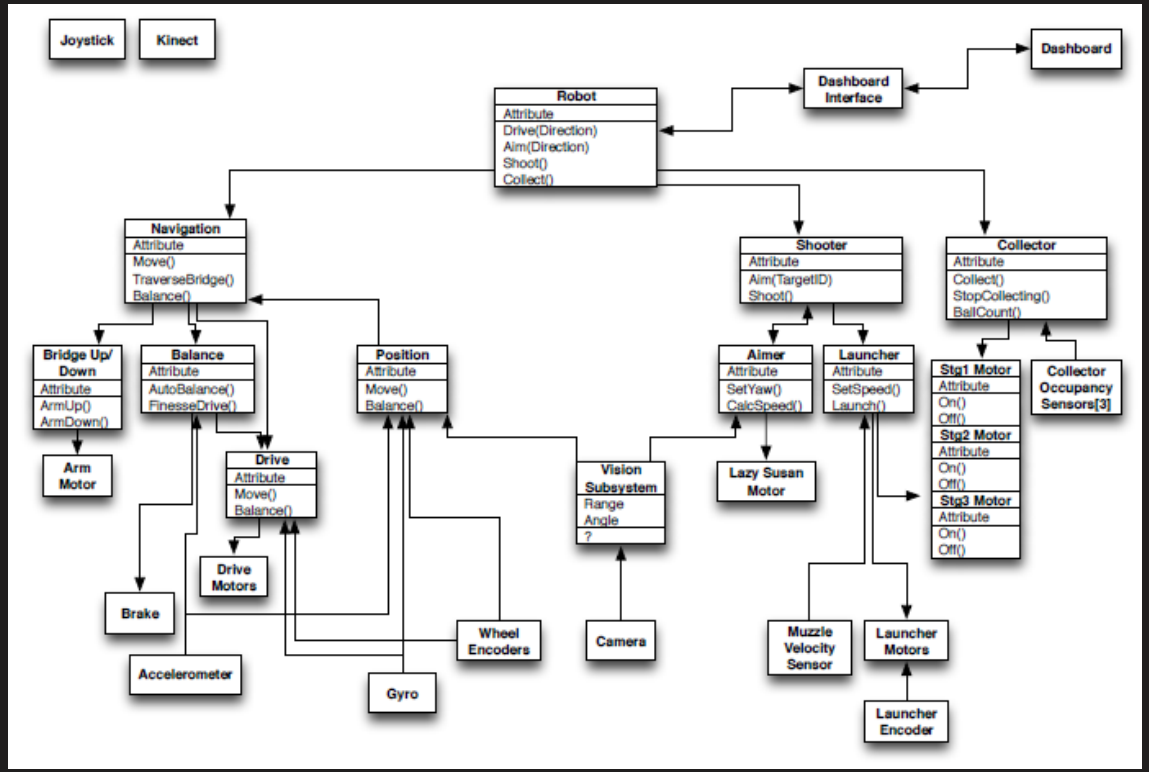
Relay outputs (4-FWD/REV)

Analog inputs(4)

General Program Class Structure



Robot Class Diagram Example



Robot.java Organization

FIRST “IterativeRobot” Main

FIRST “IterativeRobot” Extension Method Template

Class Declarations

- Declare and construct robot module objects
- Construct Object linkages if needed

Methods

robotinit()
  Team code to invoke robot modules

autonomousInit()
  Team code to invoke robot modules

autonomousPeriodic()
  Team code to invoke robot modules

teleoperatedInit()
  Team code to invoke robot modules

teleoperationPeriodic()
  Team code to invoke robot modules

TestPeriodic()
  Team code to invoke robot modules

Robot.java creates module objects and invokes module objects during competition phases

Robot.java also provides linkages between objects

Module.java Organization

Module ClassTemplate
Class Declarations
  declare and construct module component I/O objects

Methods
robotInit()
  Team code for module components
autoInit()
  Team code for module autonomous initialization
autoUpdate()
  Team code for module autonomous logic
teleopnit()
  Team code for module teleoperation initialization
teleopUpdate()
  Team code for module teleoperation logic
testUpdate()
  Team code for module test logic

Module programs contain all sequence logic for each competition phase and test code to verifiy it's I/O functionality

“IterativeRobot” Extension Template

Robot.java

```
package org.usfirst.Rush.team2228.Robot;
import edu.wpi.first.wpilibj.IterativeRobot;
public class MyRobot extends IterativeRobot {
    Public void robotInit(){
    }
    public void autonomousInit() {
    }
    public void autonomousPeriodic() {
    }
    public void teleoperatedInit() {
    }
    public void teleoperatedPeriodic() {
    }
    Public void testPeriodic(){
    }
}
```

Robot.java Declarations Example

```
package org.usfirst.Rush.team2228.Robot;

//Import the other files needed by the Robot Class program
import edu.wpi.first.wpilibj.IterativeRobot;
Import org.usfirst.frc.team2228.modules.Aquisition;
Import org.usfirst.frc.team2228.modules.Orientation;
Import org.usfirst.frc.team2228.modules.Execution;

public class MyRobot extends IterativeRobot{

     //Define Constants just used by IterativeRobot
     final int CONSTANT1 = 0.5; //constant comment

     //Define the variables as members of our Robot class
     int variable1; //variable comment - UNITS!

     //Define robot module object variables as members of our Robot Class
     AcquisitionModule gather;
     OrientationModule elevator;
     ExecutionModule   shooter;
}
```

Robot.java Initialization Program Example

```
//Imports the other files needed by the program
…
public class MyRobot extends IterativeRobot{

    //Define Constants
    …
    //Define the variables as members of our MyRobot class
    …
    //Define object variables as members of our MyRobot Class

    //Initializes the variables in the robotInit method,
    //this method is called when the robot is initializing
    public void robotInit() {
        _gather = new AcquisitionModule();
        _elevator = new OrientationModule();
        _shooter = new ExecutionModule();


        // create module component objects
        _gather.robotInit();
        _elevator.robotInit();
        _shooter.robotInit();
    }
}
```

Create module objects

Have robot modules create I/O objects

Robot.java Autonomous Program Example

```
// This method is called once each time the robot enters autonomous mode
public void autonomousInit() {

   // Each robot module will initialize for autonomous mode
    _gather.autoInit();
    _elevator.autoInit();
    _shooter.autoInit();

}

// This method is called each time the robot receives a packet(approx. 20ms) instructing
// the robot to be in autonomous enabled mode
public void autonomousPeriodic() {

      // Each robot module will update its logic for autonomous operation
      _gather.autoUpdate();
      _elevator.autoUpdate();
      _shooter.autoUpdate();


}
```

Robot.javaTeleoperation (teleop) Program Example

```
// This method is called once each time the robot enters teleoperation mode
public void teleoperatedInit() {

   // Each robot module will initialize for teleoperation mode
    _gather.teleopInit();
    _elevator.teleopInit();
    _shooter.teleInit();

}

// This method is called each time the robot receives a packet(approx. 20ms) instructing
// the robot to be in teleoperation enabled mode
public void teleoperatedPeriodic() {

      // Each robot module will update its logic for teleoperation
      _gather.teleopUpdate();
      _elevator.teleopUpdate();
      _shooter.teleopUpdate();
}
```

“RobotMap” Class Example

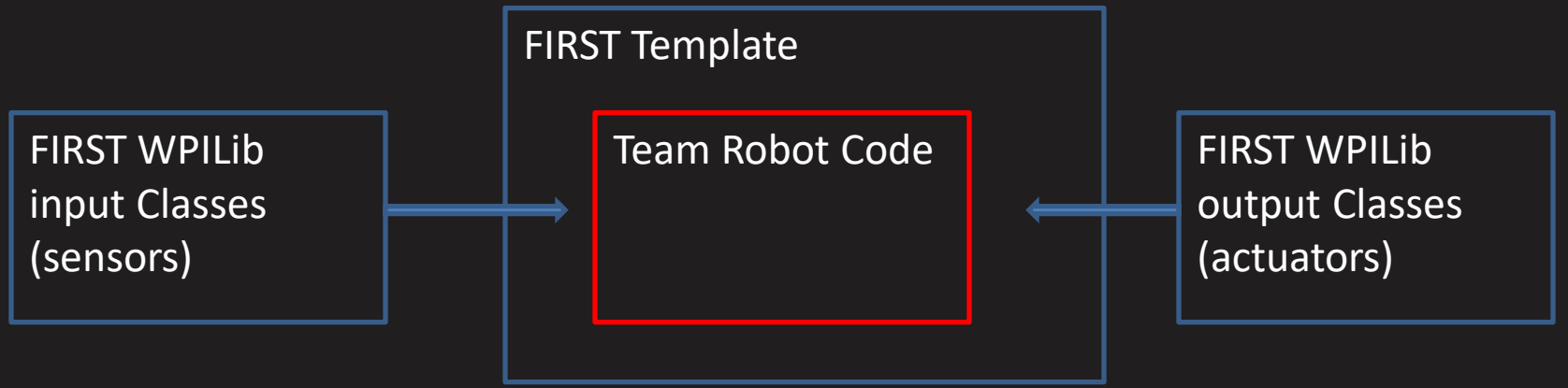
The RobotMap class defines the addressing of all I/O on the RoboRio

```
package org.usfirst.frc.team2228.robot;
/**
 * The RobotMap is a mapping from the ports sensors and actuators
 * are wired into to a variable name. This provides flexibility changing
 * wiring, makes checking the wiring easier
 */
public class RobotMap {
    //---Make RobotMap a singleton object - see software handbook

    // ---DIGITAL I/O---
    final int DIGITAL_IO_CHANNEL0 = 0;

    // For example
    final int ELEVATOR_AT_BOTTOM_SWITCH_PORT = 1;

    final int DIGITAL_IO_CHANNEL2 = 2;
    final int DIGITAL_IO_CHANNEL3 = 3;
    final int DIGITAL_IO_CHANNEL4 = 4;
    final int DIGITAL_IO_CHANNEL5 = 5;
    final int DIGITAL_IO_CHANNEL6 = 6;
}
```

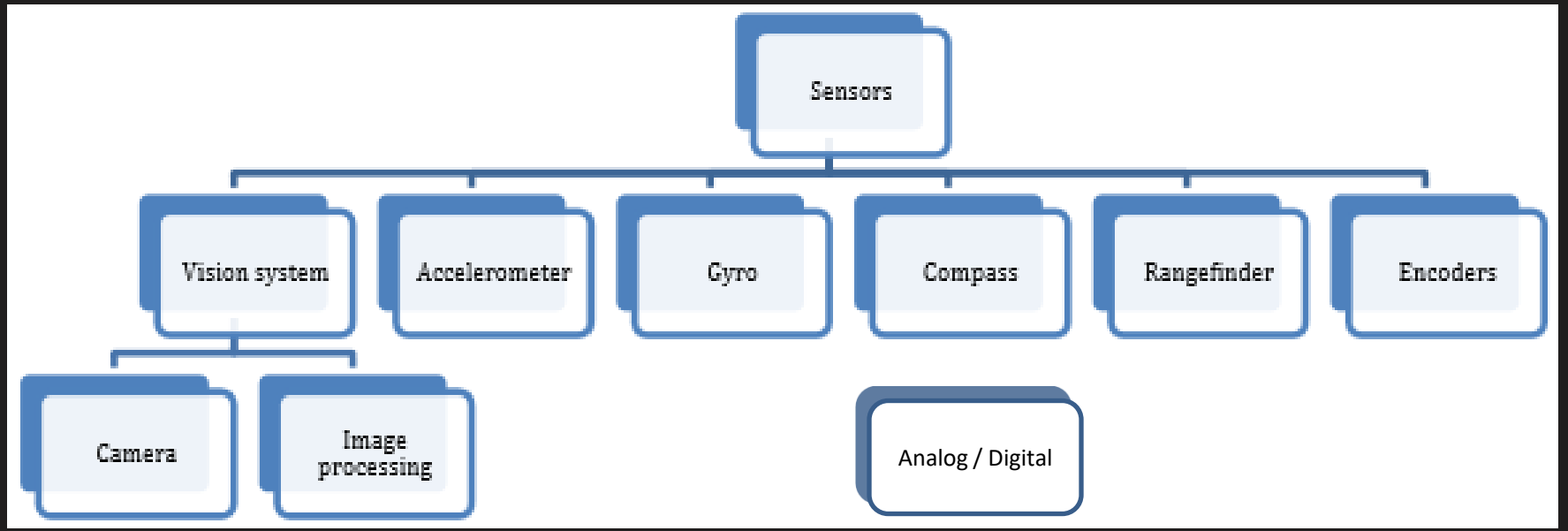
Format in Directory style:
(Constants -> in capital letters)
MODULE_DEVICE_LOCATION
and/or ACTION

FIRST JAVA Class Library

- FIRST has also done most of the “Class” work for us in a library of Classes called “WPILib”
- Team Rule: You must use FIRST Classes for I/O functions. New I/O class should be reviewed by Team leader and Mentor before developing

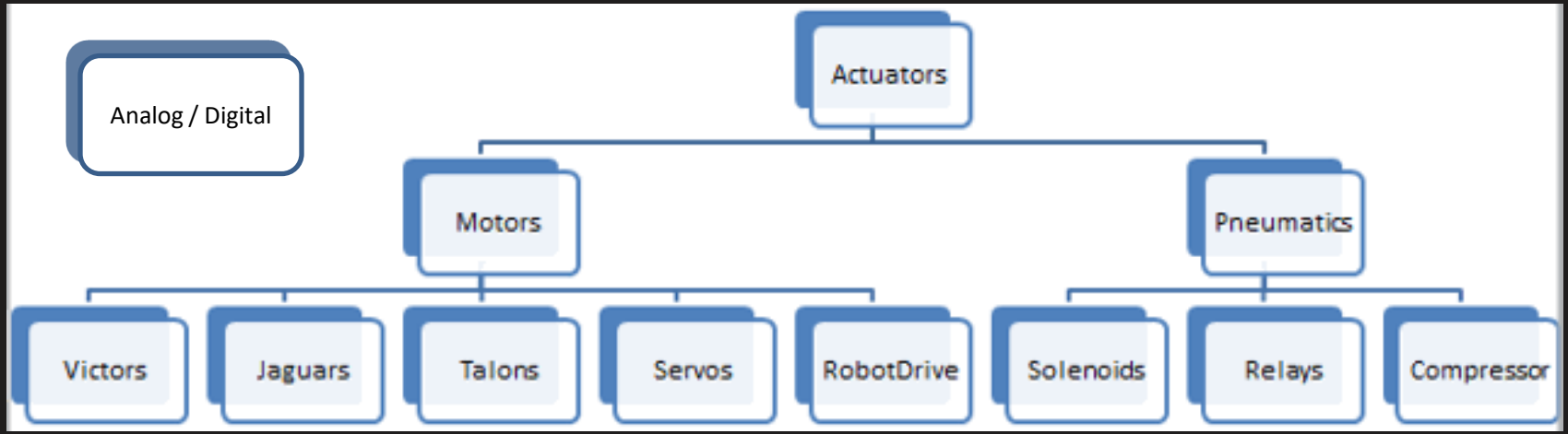


FIRST JAVA Class Library: Sensors



See CTSoft-FIRST_2015_FRC_Java_Programming.pdf

FIRST JAVA Class Library: Actuators



See CTSoft-FIRST_2015_FRC_Java_Programming.pdf

Part III RoboRio IO objects

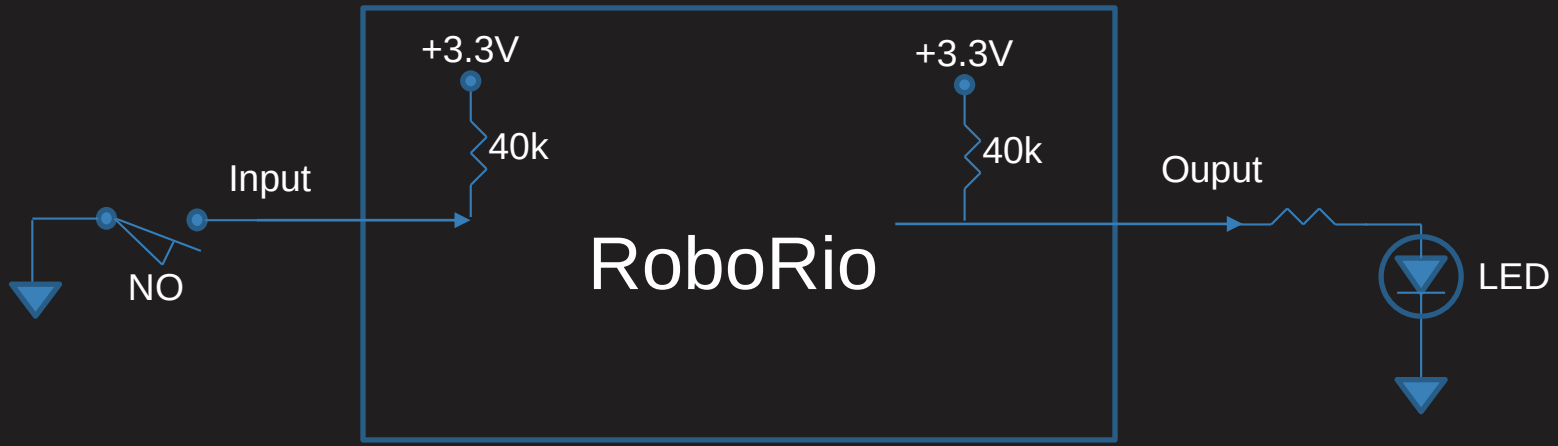
1 Understand the Software Development Environment

2 Understand the “FIRST WPI Library”,
FIRST has the following IO Classes:

- Digital Input /Output
- Relay
- Solenoid
- Double Solenoid
- Analog Input
- Motor control
- CAN

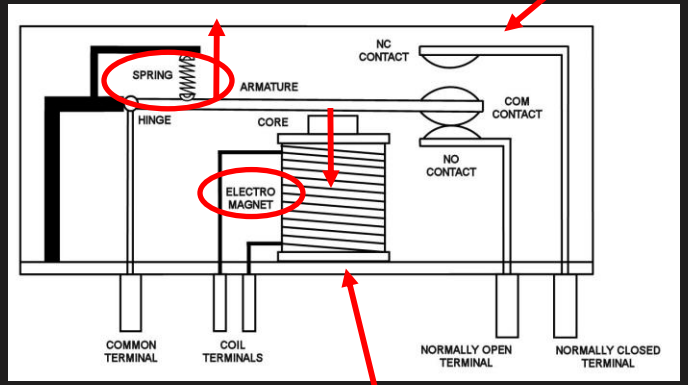
Digital Input / Digital Output

RoboRio input/output example:



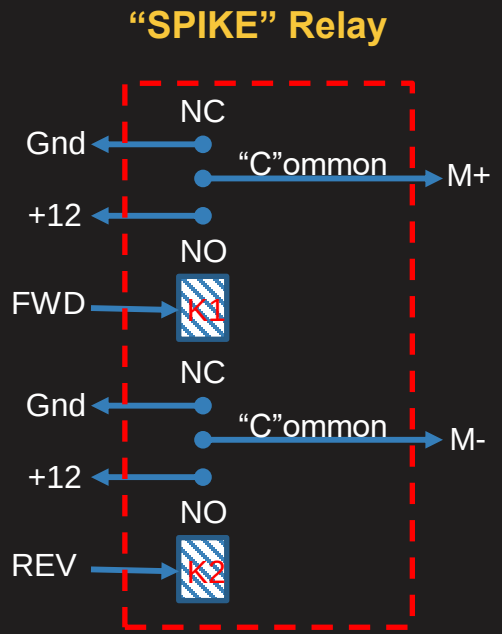
Relay

"NO" / "NC" output contacts

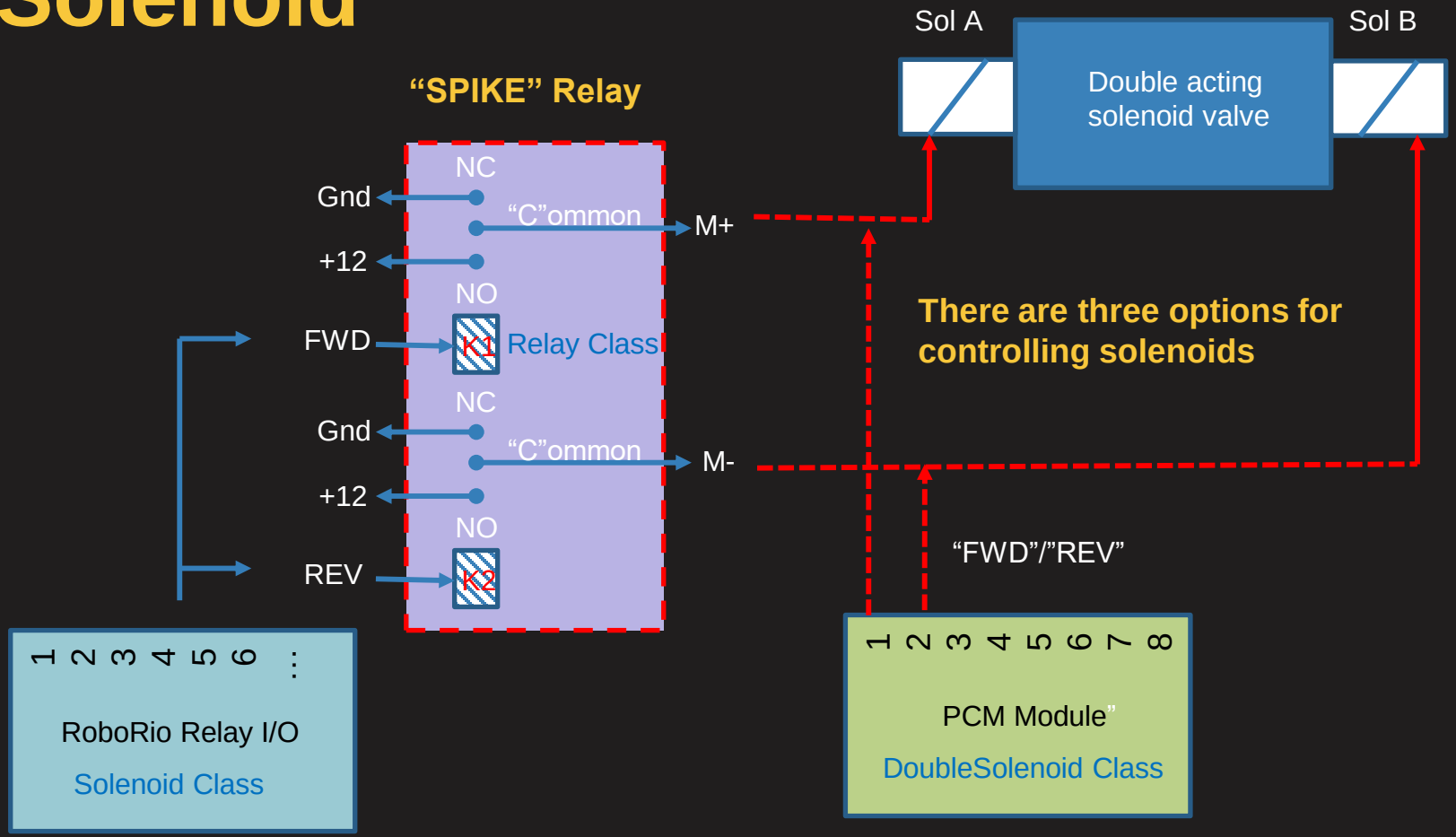


"Common Contact"

Electromagnet shown energized



Solenoid


Sol A
Sol B
Double acting solenoid valve
“SPIKE” Relay
NC
Gnd
“C”ommon
M+
+12
NO
FWD
K1
Relay Class
NC
Gnd
“C”ommon
M-
+12
NO
REV
K2
There are three options for controlling solenoids
“FWD”/”REV”
1 2 3 4 5 6 ⋮
RoboRio Relay I/O
Solenoid Class
1 2 3 4 5 6 7 8
PCM Module”
DoubleSolenoid Class

Solenoid Class / DoubleSolenoid Class

Java

```
Solenoid   _exampleSolenoid;

_exampleSolenoid = new Solenoid(1);

_exampleSolenoid.set(true);
_exampleSolenoid.set(false);
```

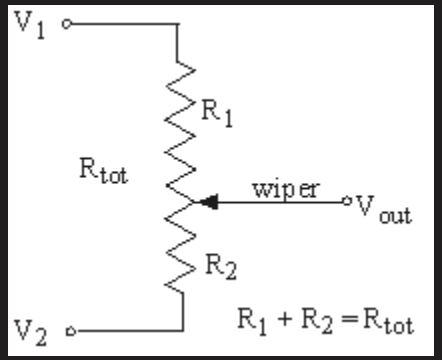
Java

```
DoubleSolenoid  _exampleDouble;
_exampleDouble = new DoubleSolenoid(1, 2);

_exampleDouble.set(DoubleSolenoid.Value.kOff);
_exampleDouble.set(DoubleSolenoid.Value.kForward);
_exampleDouble.set(DoubleSolenoid.Value.kReverse);
```

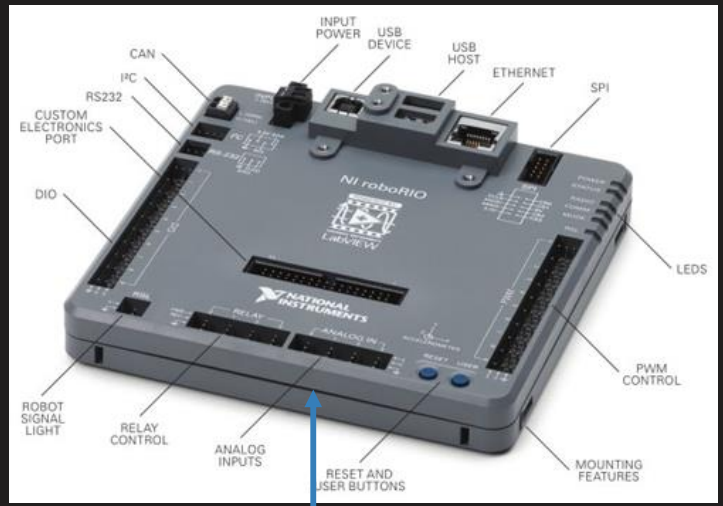
See Software Handbook, section 7 “FRC JAVA and JAVA Library” Links to FIRST documentation

Analog

5 volts



0 volts



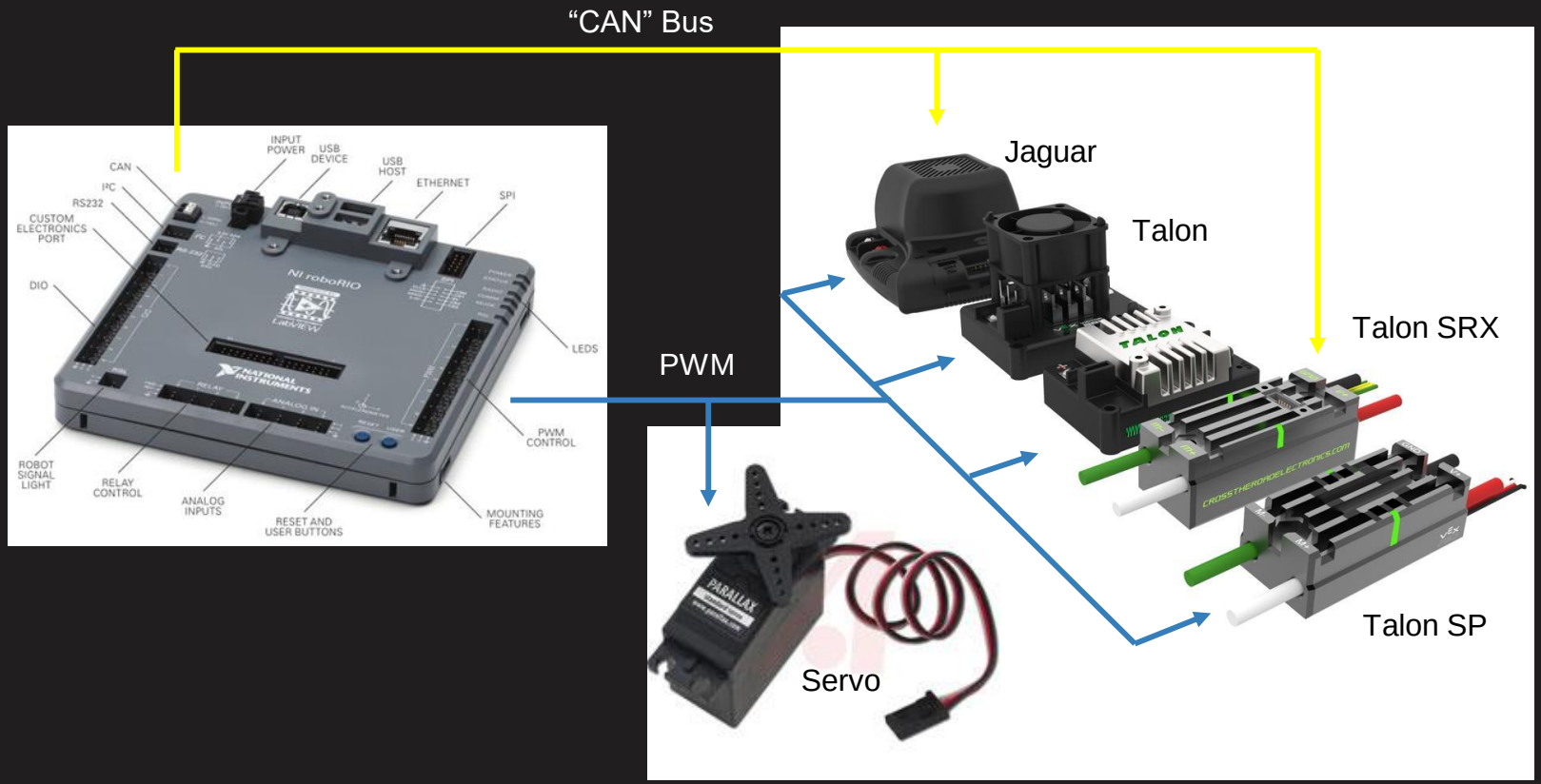
Analog Class

Java

```
AnalogInput   _exampleAnalog; //analog input object

AnalogInput   _exampleAnalog = new AnalogInput(0);

int raw =                    _exampleAnalog.getValue();
double volts =               _exampleAnalog.getVoltage();
int averageRaw =             _exampleAnalog.getAverageValue();
double averageVolts =  _exampleAnalog.getAverageVoltage();
```

See Software Handbook, section 7 “FRC JAVA and JAVA Library” Links to FIRST documentation

Motor Control



Motor Control Classes

Java

```
Jaguar      _exampleJaguar;
Talon       _exampleTalon;
TalonSRX    _exampleTalonSRX;
Victor      _exampleVictor;
VictorSP    _exampleVictorSP;

_exampleJaguar = new Jaguar(0);
_exampleTalon = new Talon(1);
_exampleTalonSRX = new TalonSRX(2);
_exampleVictor = new Victor(11);
_exampleVictorSP = new VictorSP(12);
```

See Software Handbook, section 7 “FRC JAVA and JAVA Library” Links to FIRST documentation

FIRST JAVA Class Library: CAN

CAN(Controller Area Network) is a communications system to pass data between control components

There are a number of CAN devices supported in the FRC control system:

- Jaguar speed controllers
- CAN-Talon speed controllers
- The Power Distribution Panel (PDP)
- The Pneumatics Control Module (PCM)

- Device status is returned every 20ms for each device automatically - the program does not need to request those updates. Whenever the program requests status from a CAN device it will be no sooner than 20ms.

- If no information is received within 50ms, the device creation will fail (either an exception in Java or an error status in C++).

See CTSoft-FIRST_2015_FRC_Java_Programming.pdf

Part III Prog Docs / Best Practice / Safety

This part covers:

1 Program Documentation: What documentation is needed along with the program code

2 Best Practices: List of questions in reviewing your code

3 Safety: Robot software activation protocol

Software Documentation

Software Specification:

- ❑ Definition of I/O and I/O type for each control module
  (RobotMap.java from CIM document)
- ❑ List of functions that need to be done for each control module
  (Class model)

Class header:

- ❑ List of all methods, how a method is called and method description
- ❑ Description of all methods
  (See Software Handbook)

Method Code:

- ❑ COMMENT-COMMENT-COMMENT (Why not How)
- ❑ JAVA Style Guide (syntax and readability guide – see Software Handbook)

Program Development Best Practices

Code Review:

- All code should be reviewed by software sub-team and sub-team mentor. More than the author needs to understand the code.

- Code review consists of checking the following:
  - ✓ Input range check
  - ✓ output range check
  - ✓ Check for magic numbers (Documented? Better: Constant variable?)
  - ✓ Check that any code written is already done in FIRST library
  - ✓ Comments document why the program is written as it is
  - ✓ Is the code backed up
  - ✓ Does the code meet the robot function requirements!!!!!

Remember : There are many ways to solve a problem – The is only one question to ask: Does the code meet the requirements and comply with Team 2228 style guide?!!!

Programming Best Practices

Sensor Inputs: All sensor inputs should be checked for range values.

Actuator outputs: All method outputs should be checked for range as not to exceed the range input to actuators

Comments: There should be enough comments such that if they were grouped together anyone would understand what the program was supposed to do

Failures: All code should consider what to do in a failure condition. For example: variable out of range, stuck in a loop, external processes take too long due to failure, communications errors, etc

NO MAGIC NUMBERS: All constant numbers should be associated with a constant name

Programming Style: Follow the programming style guide in the handbook..

A consistent style is beneficial when other members of our team and other teams read your code

Program Execution Safety

- On powering up the robot check that the robot software mode is **“DISABLED”**
- Check to see that the robot wheels are off the ground
- On enabling the robot software, the person enabling the robot software needs to **HOLLER** – **“ROBOT ENABLING”** and then **WAIT** for a **“CLEAR”** response from the assigned robot safety observer. The person enabling then responds: **“ROBOT ACTIVE”**
- Someone needs to be within reach of the robot **“DISABLE”** button to kill the robot program.
- Safety glasses must be worn whenever the battery is connected to the robot or any electronic devices**.**