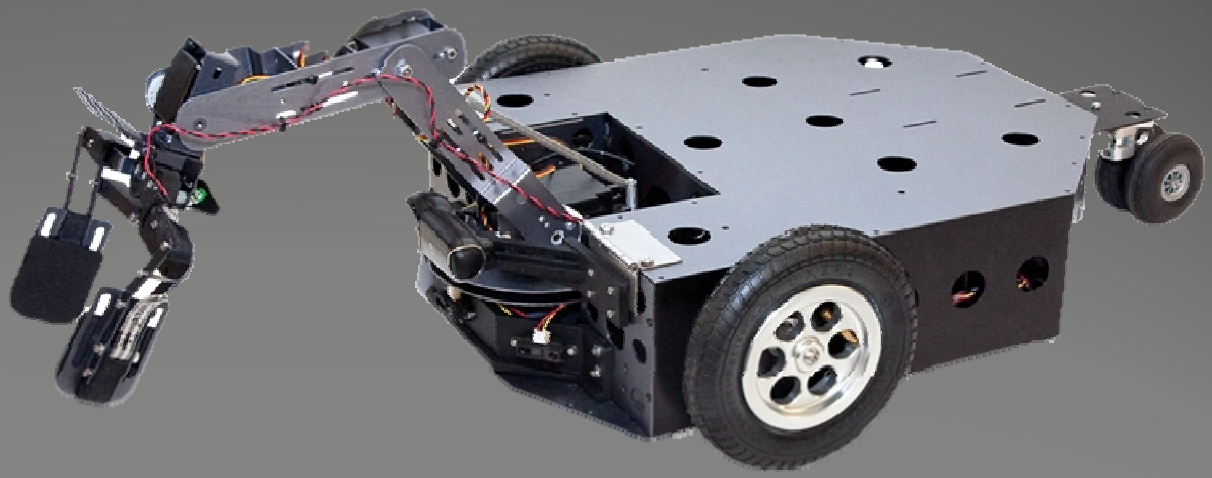
Concordia

Controller Design for a QGV using dsPIC MCU

Course:
MECH 6621
Instructor:
Professor Zhang



Students:
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Pooya Merat
Mohammad Mohajerani

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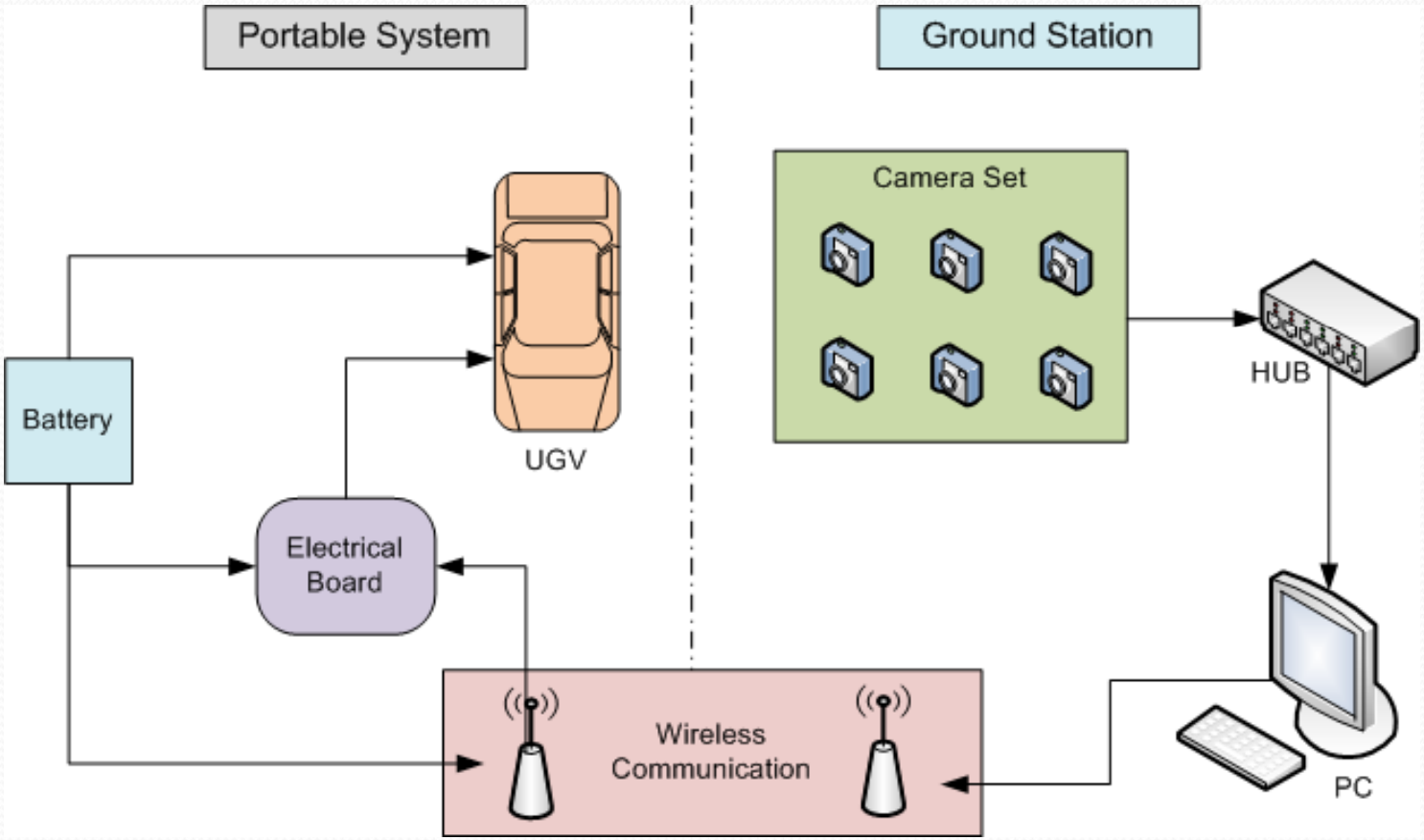
Outline

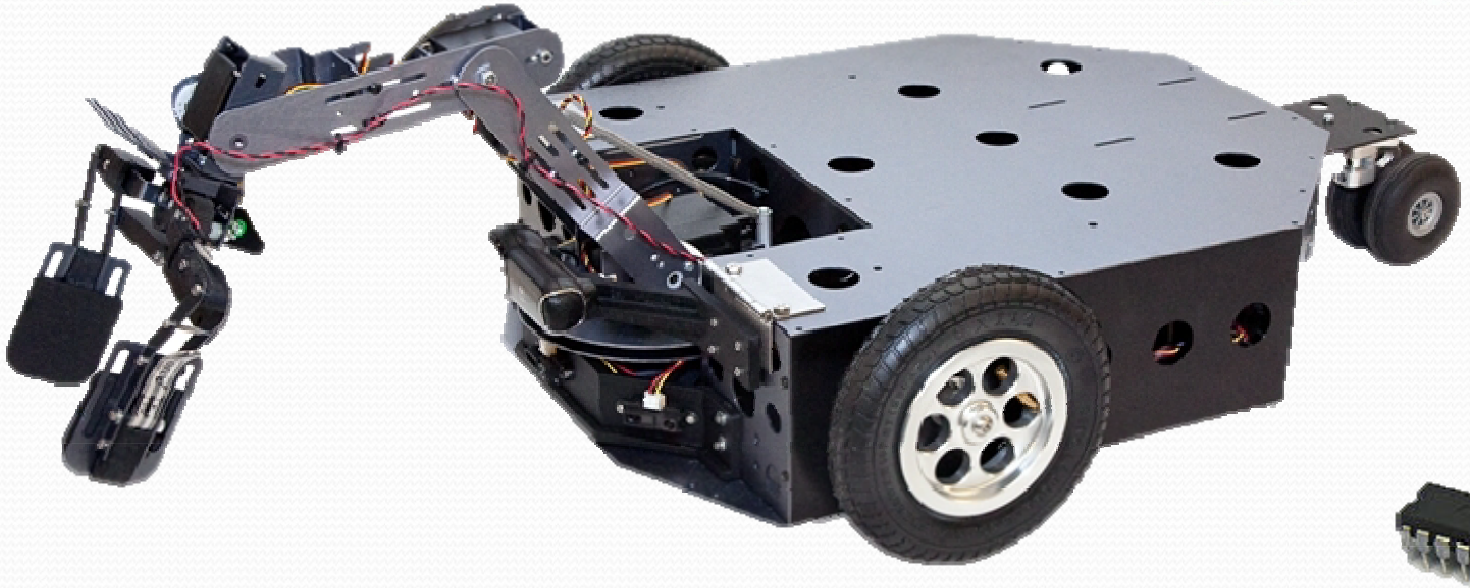
- Problem Definition
- Microcontroller
- Communication
- System Functional Modes
  - Primary Mode: QGV Motion Control
    - UART, MCPWM, Path Tracking, Object Tracking, Feedback Controller
  - Secondary Mode: Gripper Control
    - UART, OCPWM, A/D Convertor
- User Interface
- Results

Problem Definition



Problem Definition

QUANSER
INNOVATE. EDUCATE.



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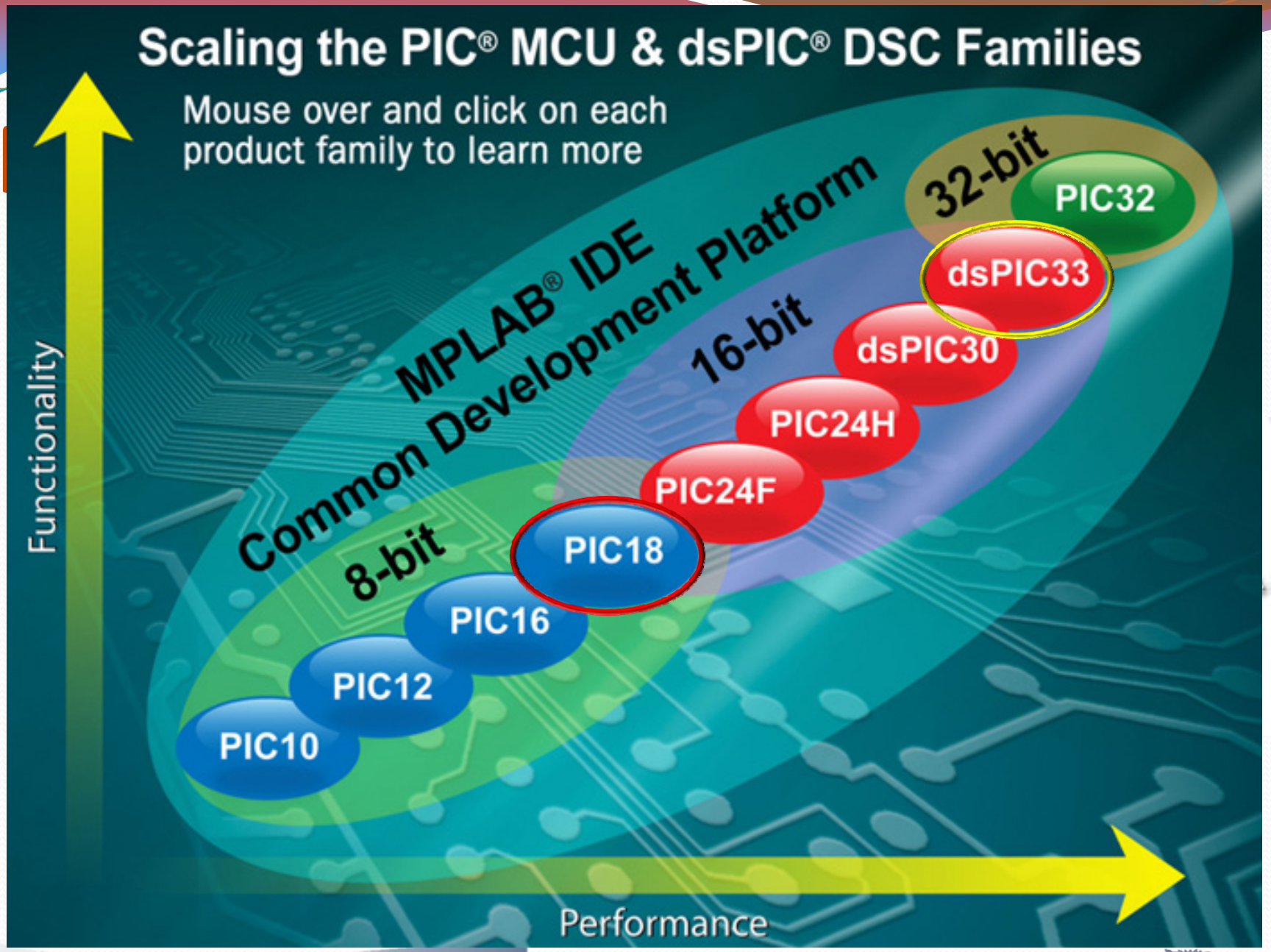
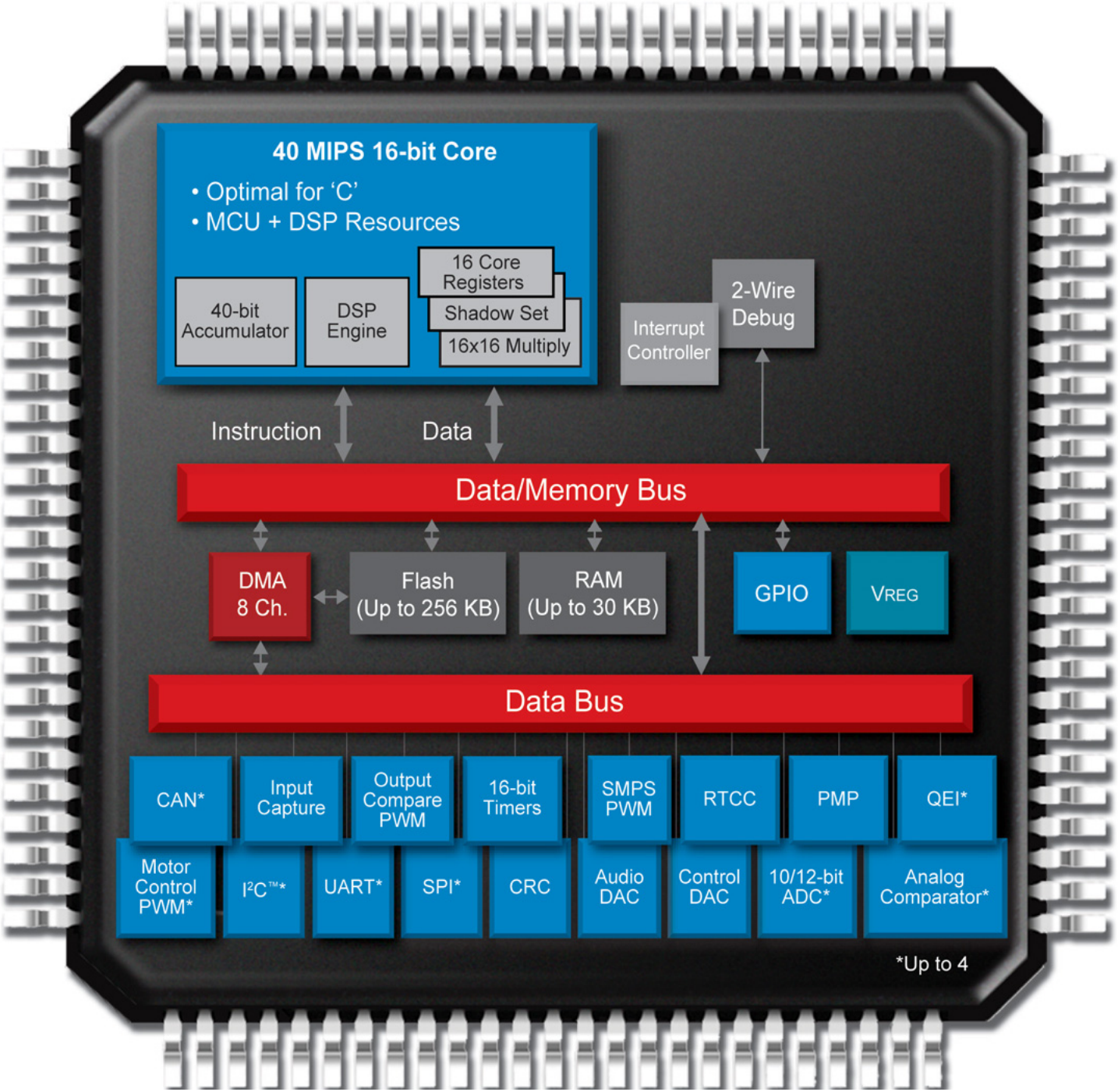

Scaling the PIC® MCU & dsPIC® DSC Families
Mouse over and click on each product family to learn more
Functionality
Performance
Common Development Platform
MPLAB® IDE
8-bit
16-bit
32-bit
PIC10
PIC12
PIC16
PIC18
PIC24F
PIC24H
dsPIC30
dsPIC33
PIC32


40 MIPS 16-bit Core
• Optimal for 'C'
• MCU + DSP Resources
40-bit Accumulator
DSP Engine
16 Core Registers
Shadow Set
16x16 Multiply
Interrupt Controller
2-Wire Debug
Instruction
Data
Data/Memory Bus
DMA 8 Ch.
Flash (Up to 256 KB)
RAM (Up to 30 KB)
GPIO
VREG
Data Bus
CAN*
Input Capture
Output Compare PWM
16-bit Timers
SMPS PWM
RTCC
PMP
QEI*
Motor Control PWM*
I²C™*
UART*
SPI*
CRC
Audio DAC
Control DAC
10/12-bit ADC*
Analog Comparator*
*Up to 4

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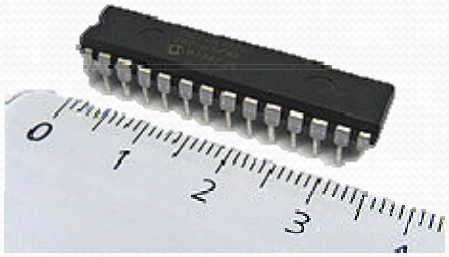
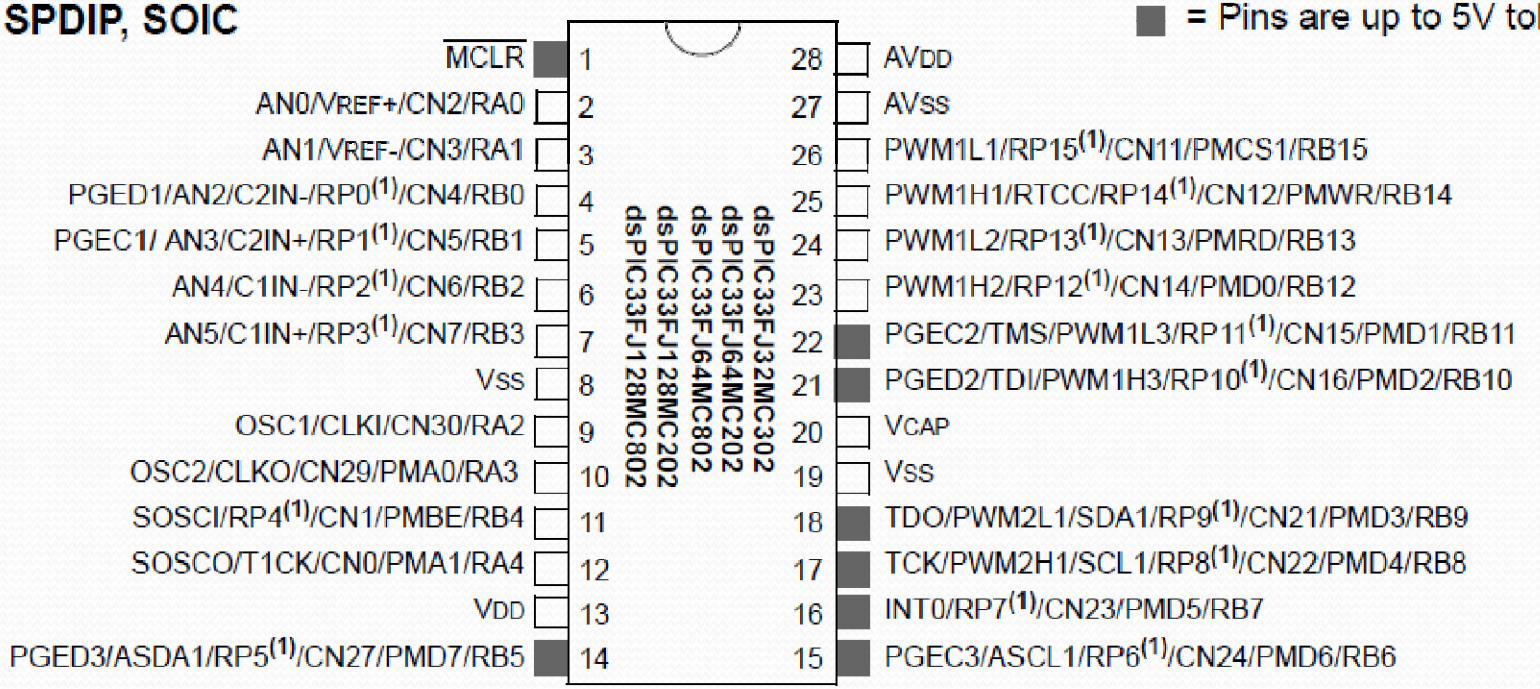
dsPIC33FJ128MC802



28-Pin SPDIP, SOIC

■ = Pins are up to 5V tolerant



dsPIC Oscillator

- Internal Oscillator
  - Pulse Freq. ≈ 8 MHz
- External Source
  - External Pulse
  - Crystal (20 MHz)

    + PLL → 80 MHz Pulse Freq. → 40 MHz Instruction Freq.

- **PLL** is MCU option to obtain higher operating speeds.

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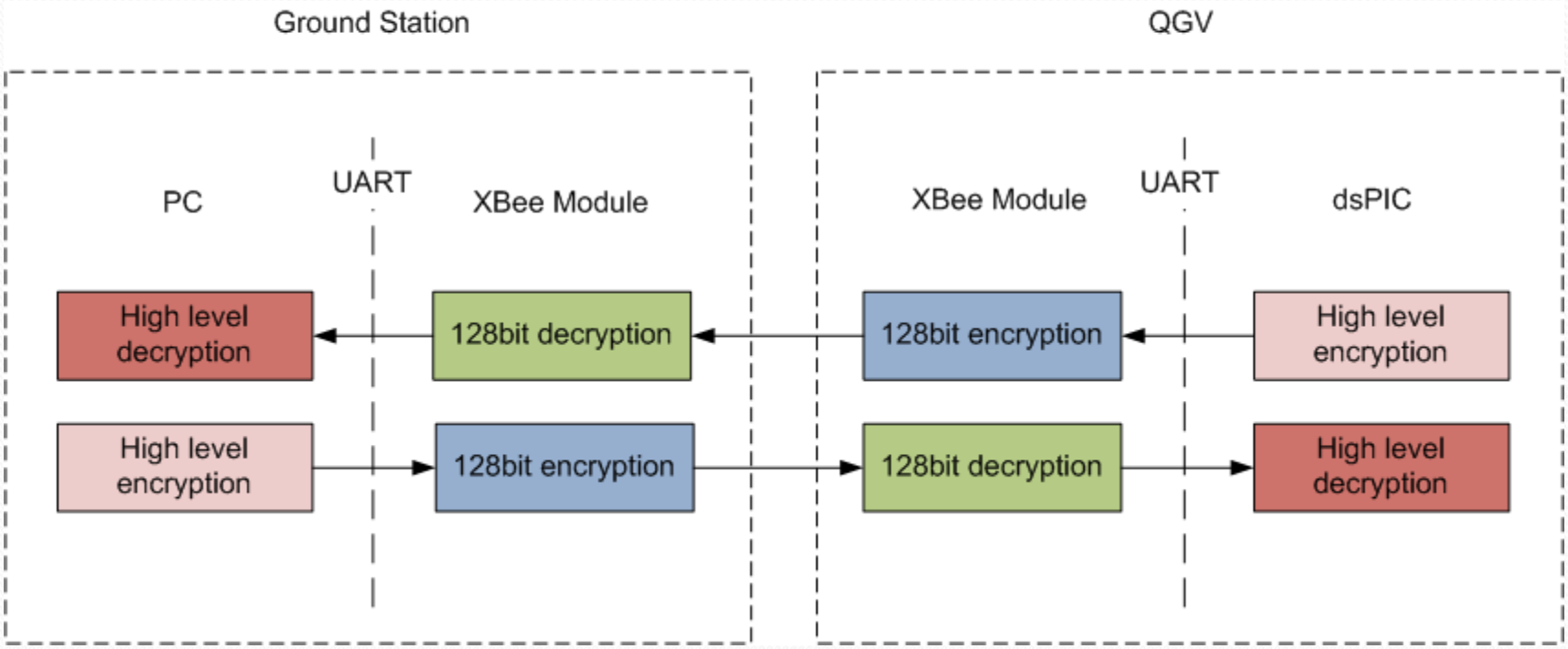
System Initialization

- **No internal EEPROM**
- After system power-on all initial data which is stored in a file in computer is transferred to dsPIC via XBee.

- Whenever the dsPIC is powered it sends a message to the PC indicating that it should be initialized.
- Trimming information (motor calibration values) are sent to dsPIC.
- The user defined desired points are also sent.

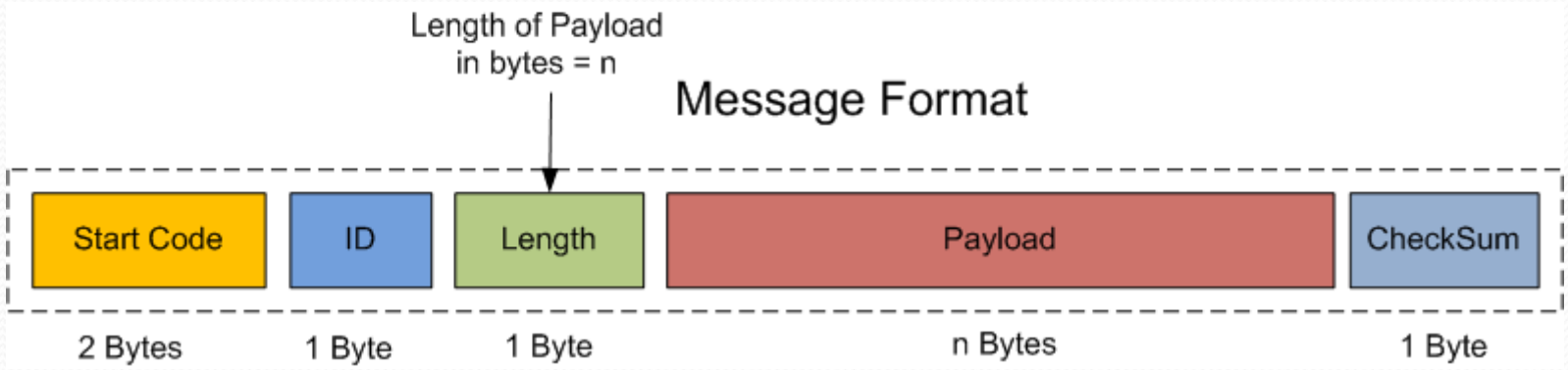
Serial Communication

- Baud Rates ranging from 10 Mbps to 38 bps at 40 MIPS
- Universal Asynchronous Receiver/Transmitter



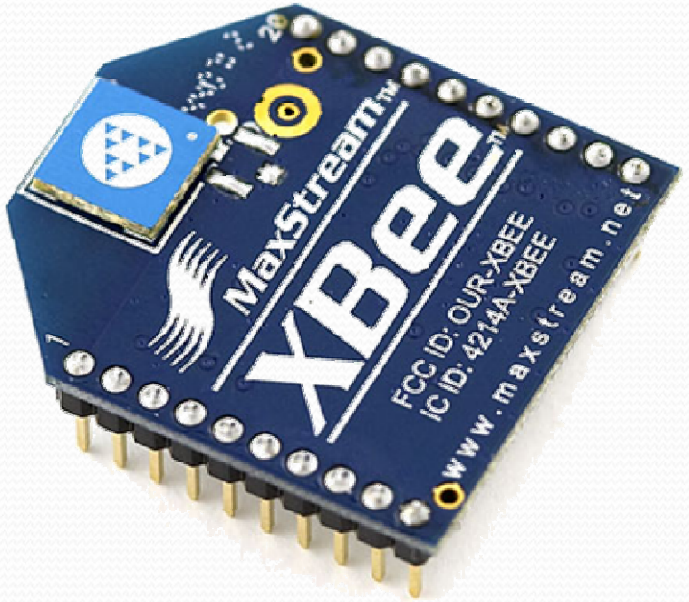
High Level Encryption

- Implemented in MATLAB (PC) and dsPIC



XBee Communication Module

- 50mA @ 3.3V
- 250kbps max data rate (UART)
- 300ft (100m) range
- 128-bit encryption
- Built-in antenna



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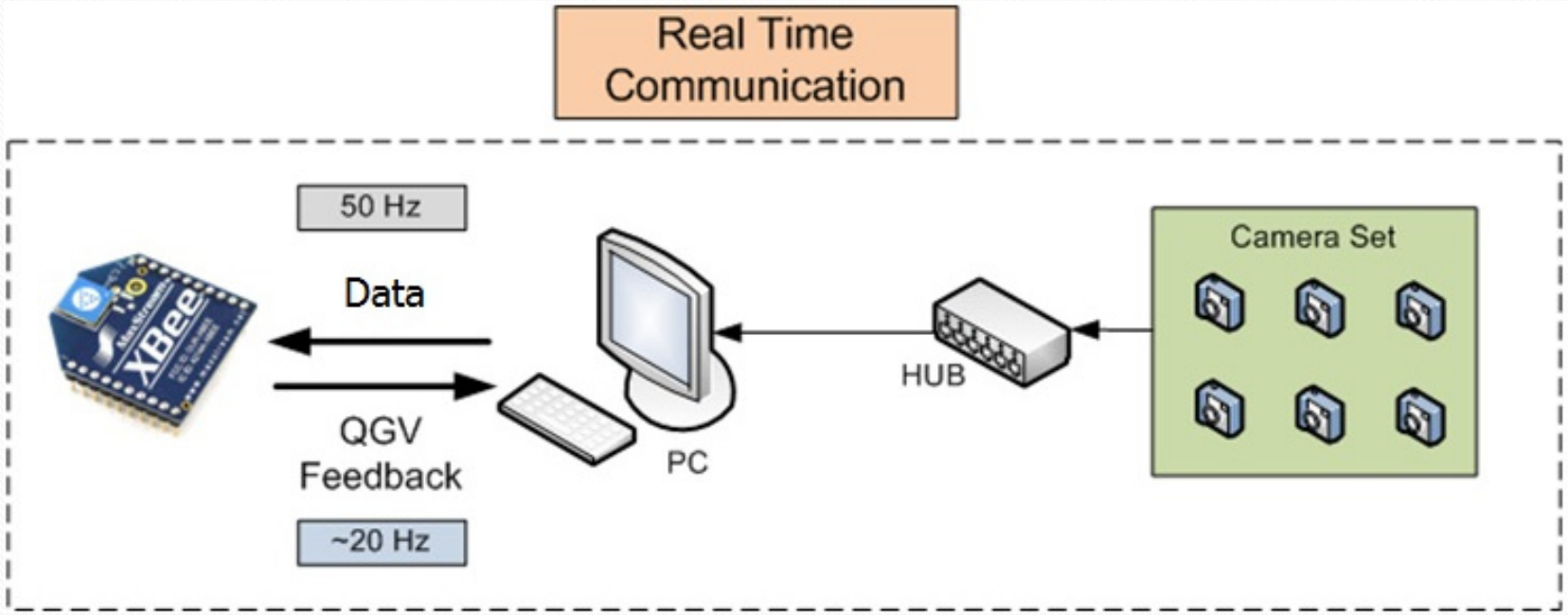
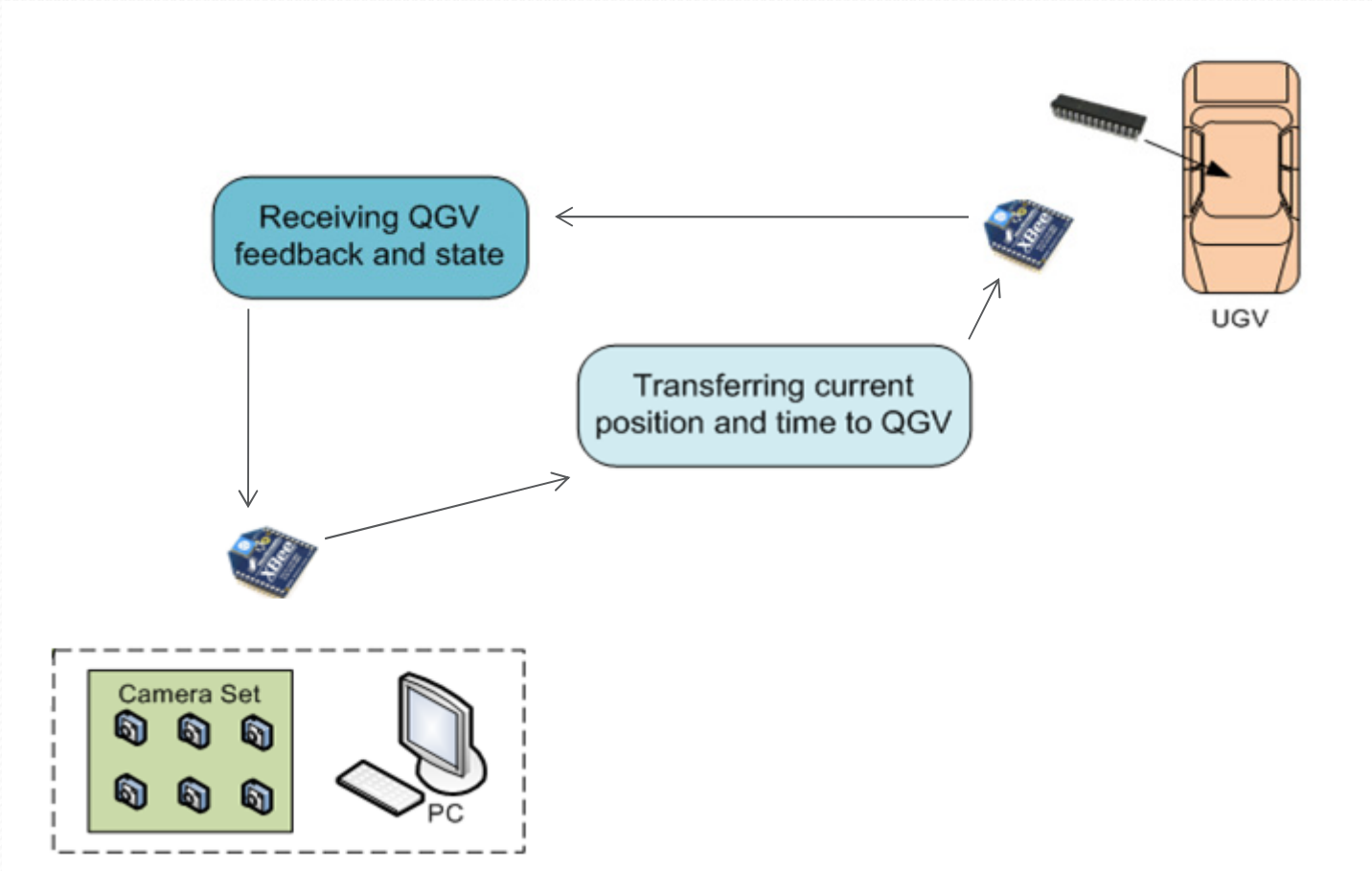
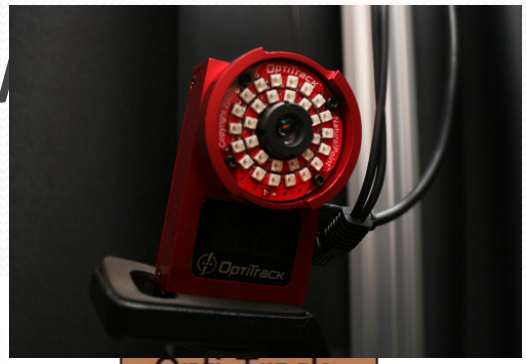
Real Time Communication



System Primary Functional Mode



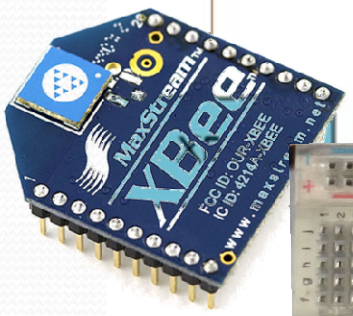
Hardv

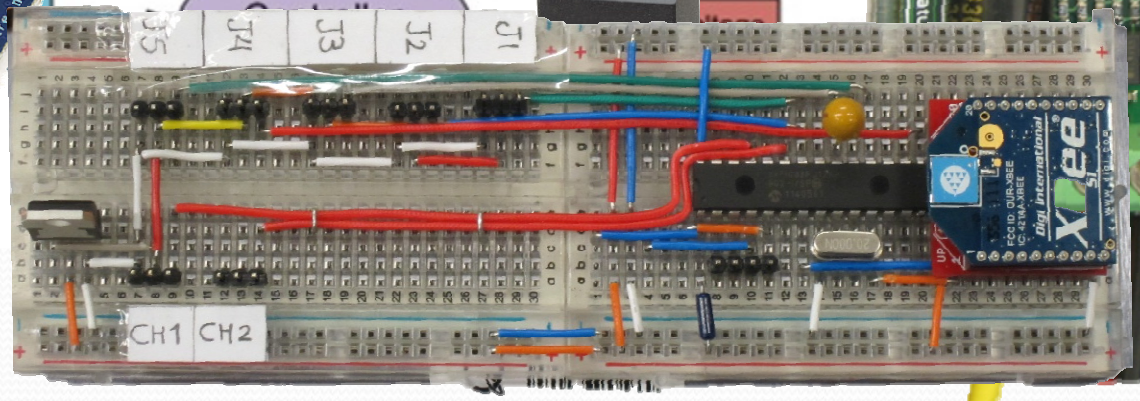


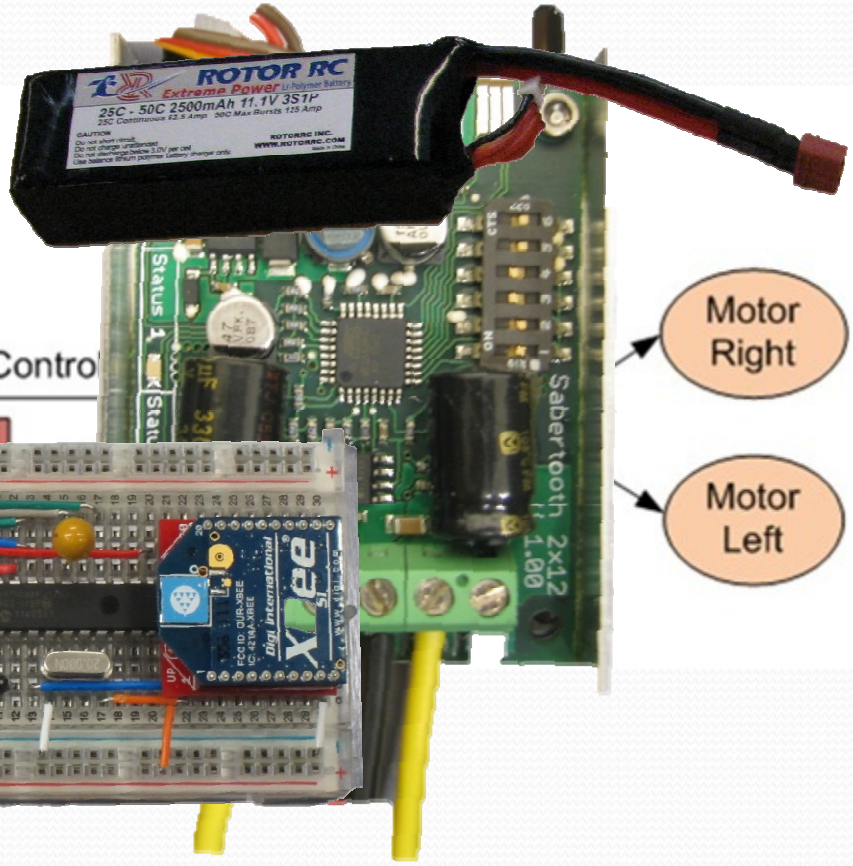
XBee

Opti-Track Cameras

Contro







Motor Right

Motor Left

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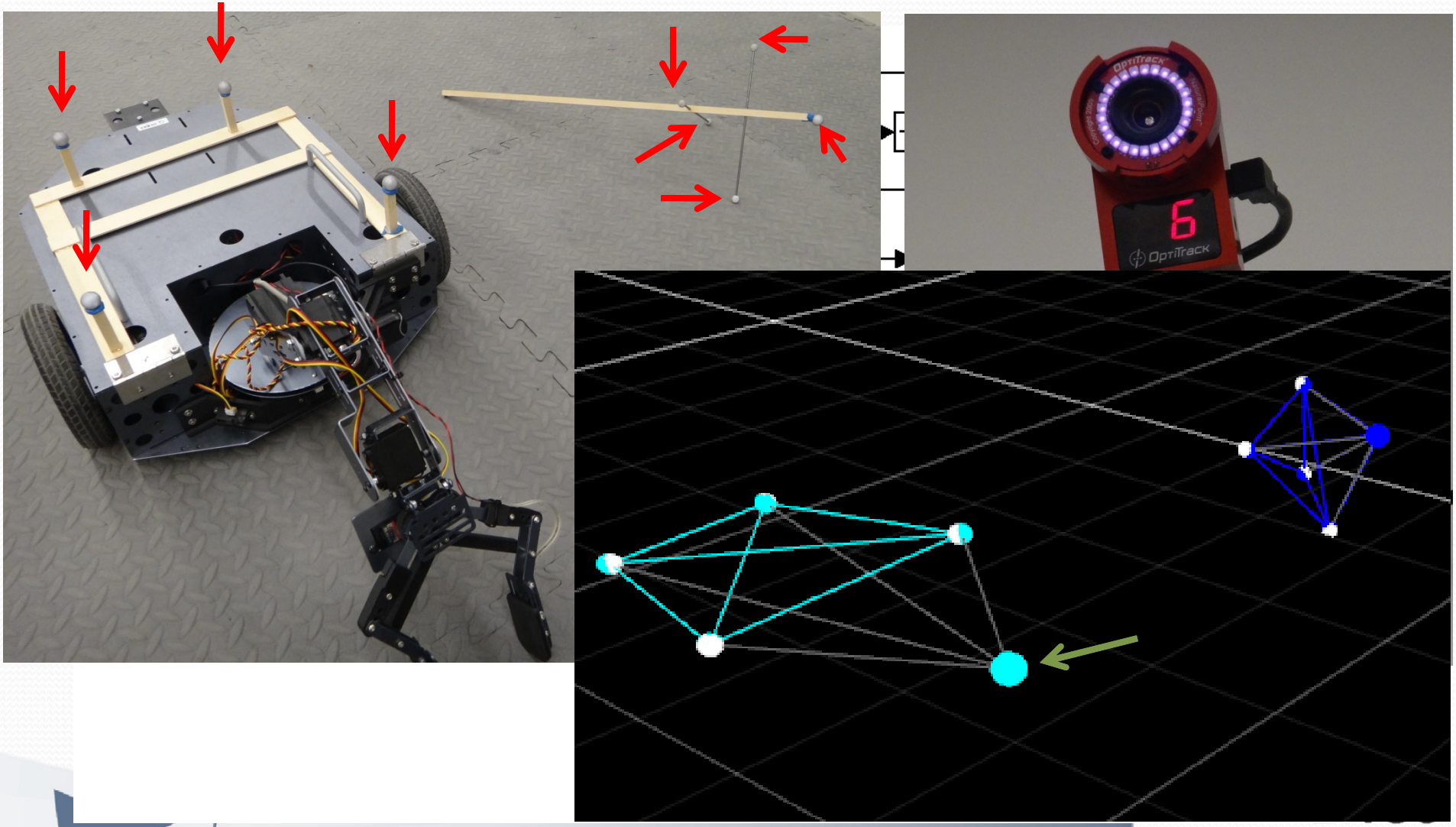
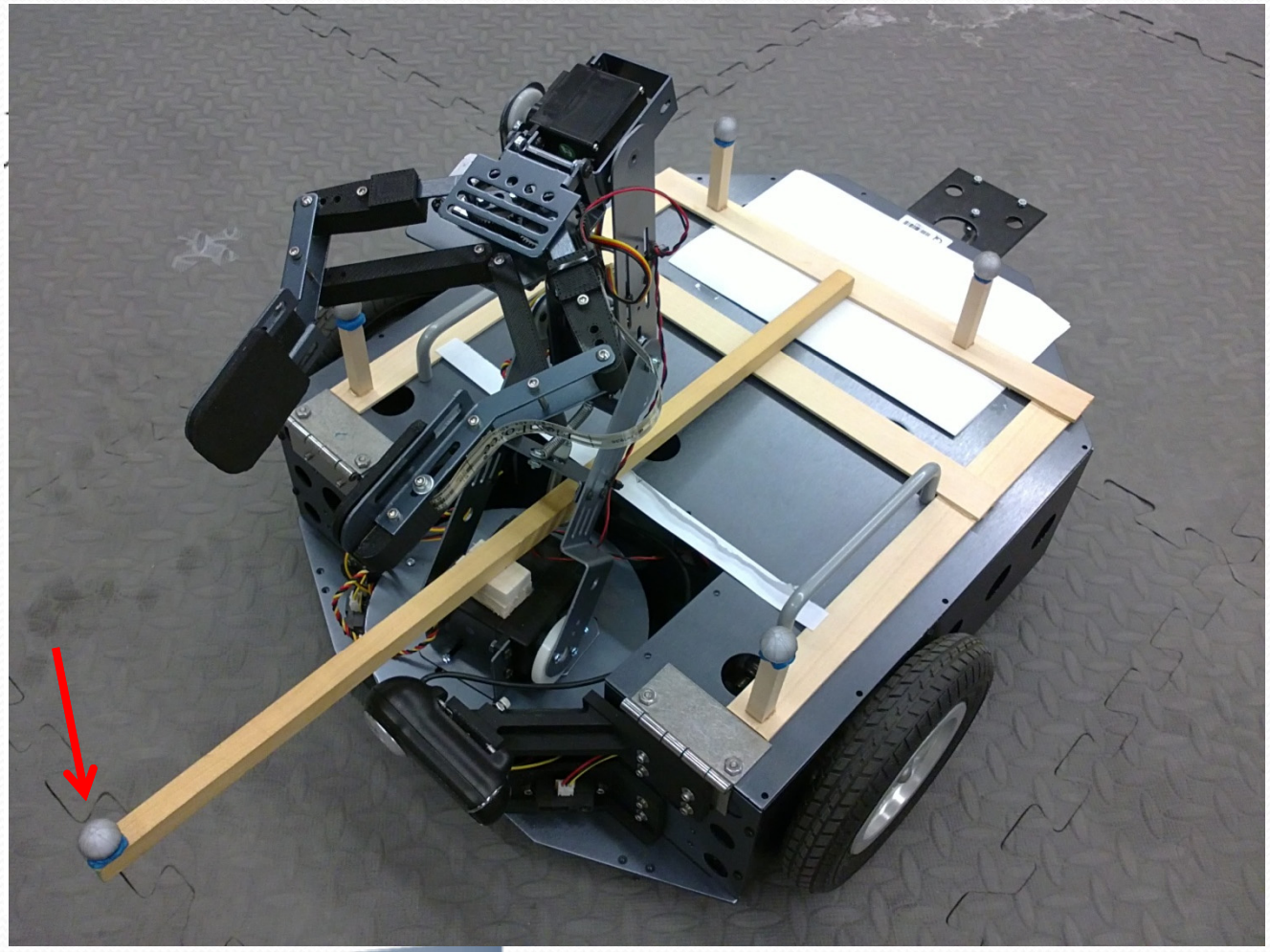
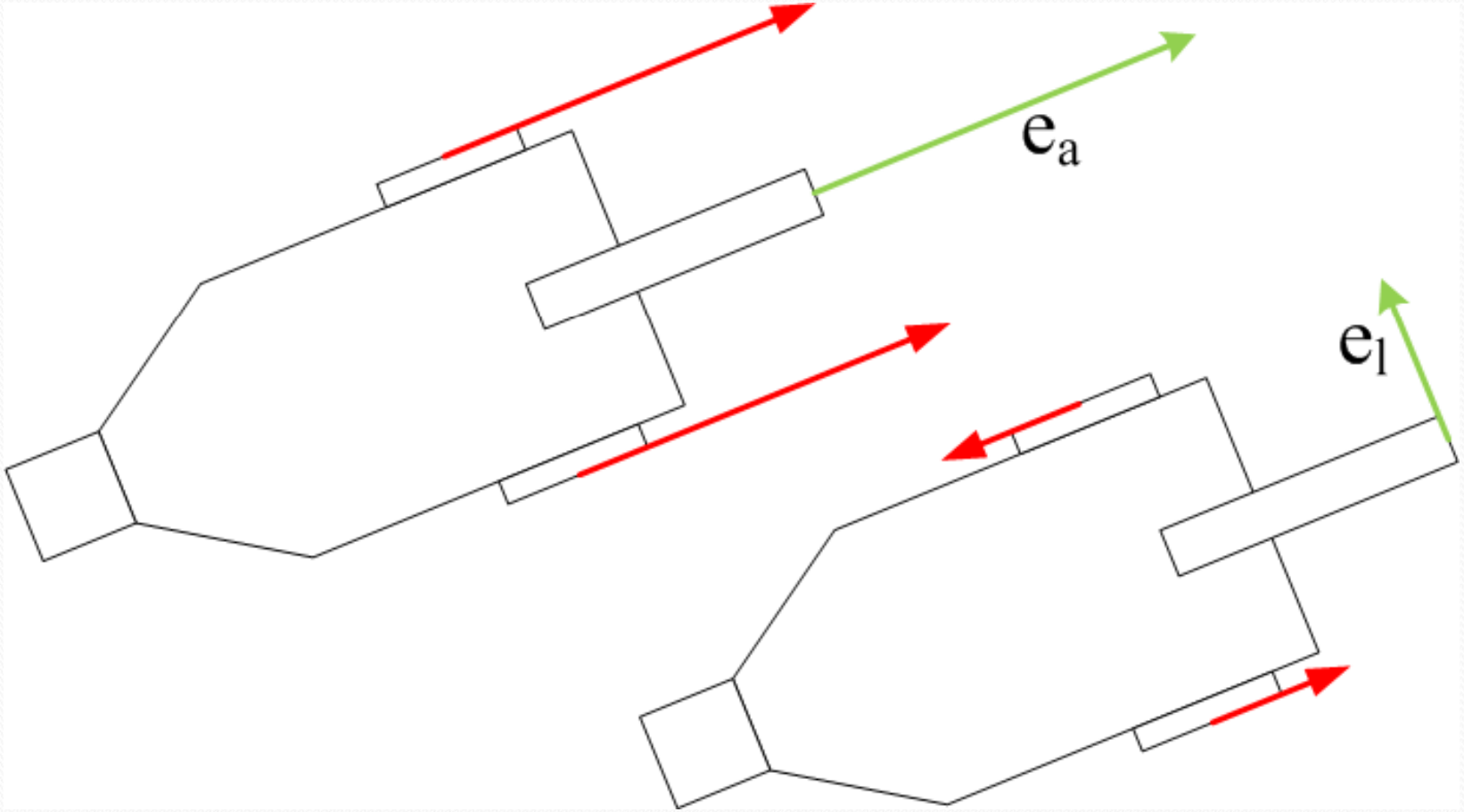
OptiTrack



Kinematic Model: Coordinates



Kinematic Model: Error Conversion



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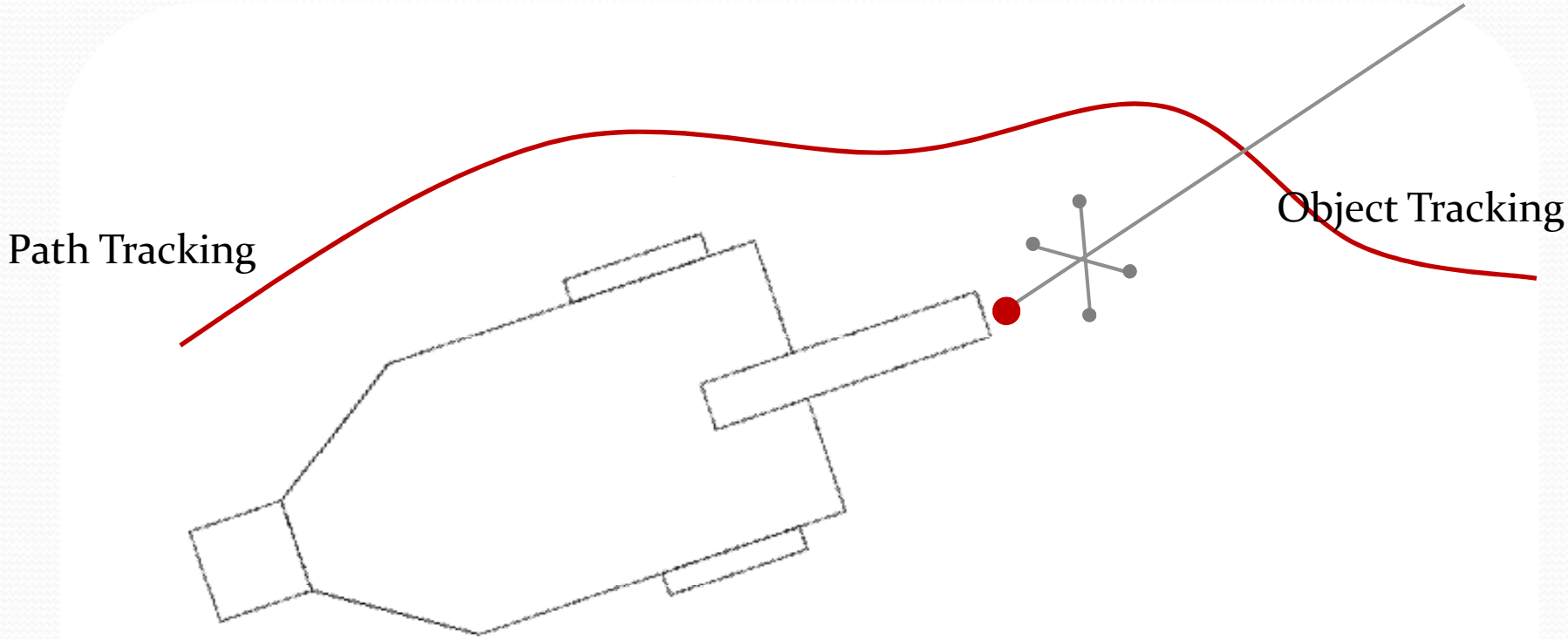
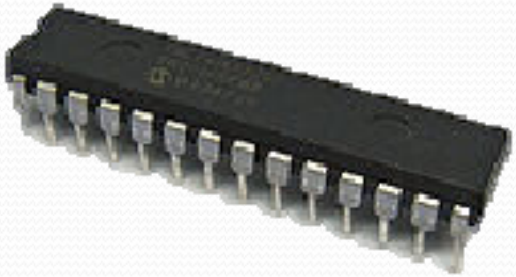
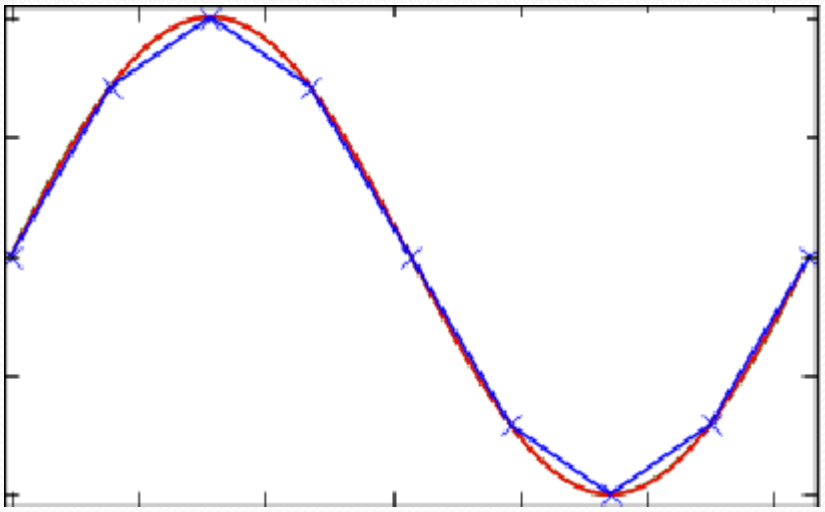
Target Definition



Feedback Control



- Onboard Controller
- PID Controller
- Noise Filtering
- Desired Point Interpolation



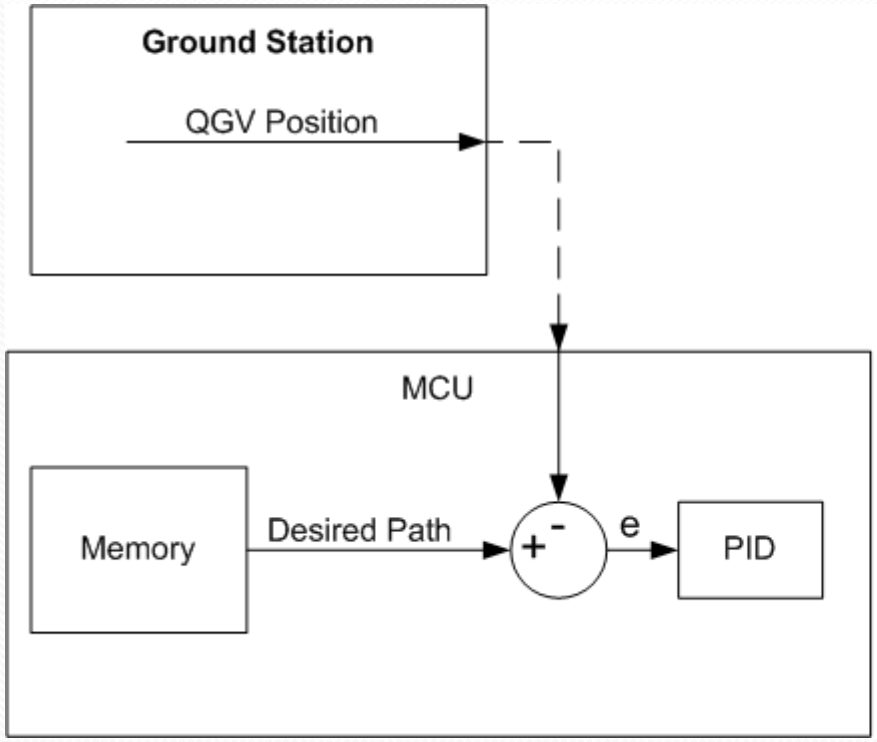
PID Controller

$$u = P.e + I.\int e.dt + D.\dot{e}_f$$

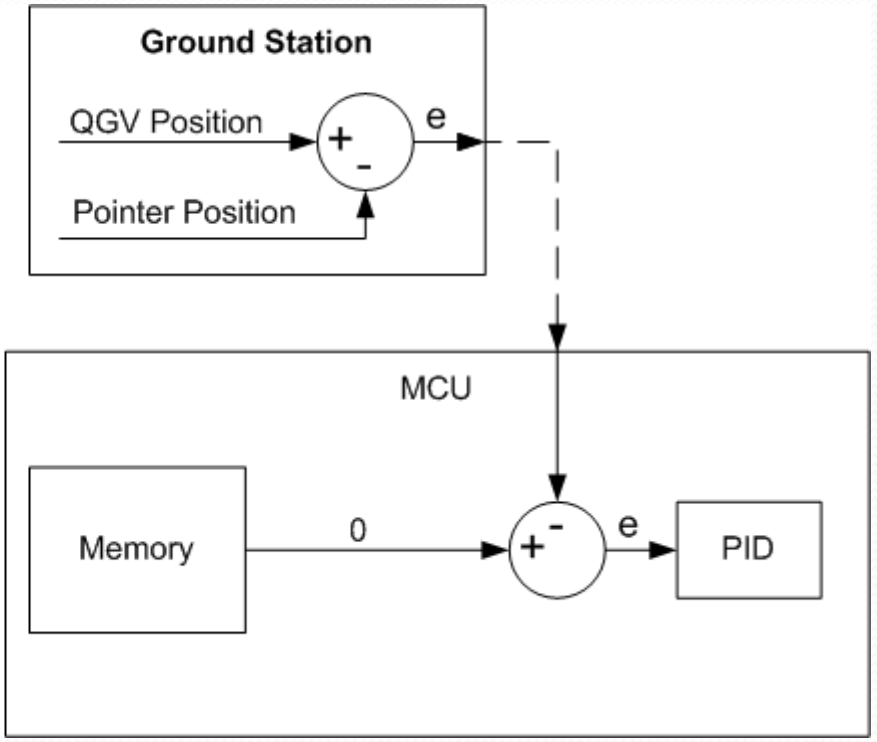
$$\dot{e}_f = -k.\int e_f.dt + e$$

$$\mathcal{L}\{\dot{e}_f\} = \frac{ks}{s+k}\mathcal{L}\{e\}$$

PID Controller



Path Tracking



Object Tracking

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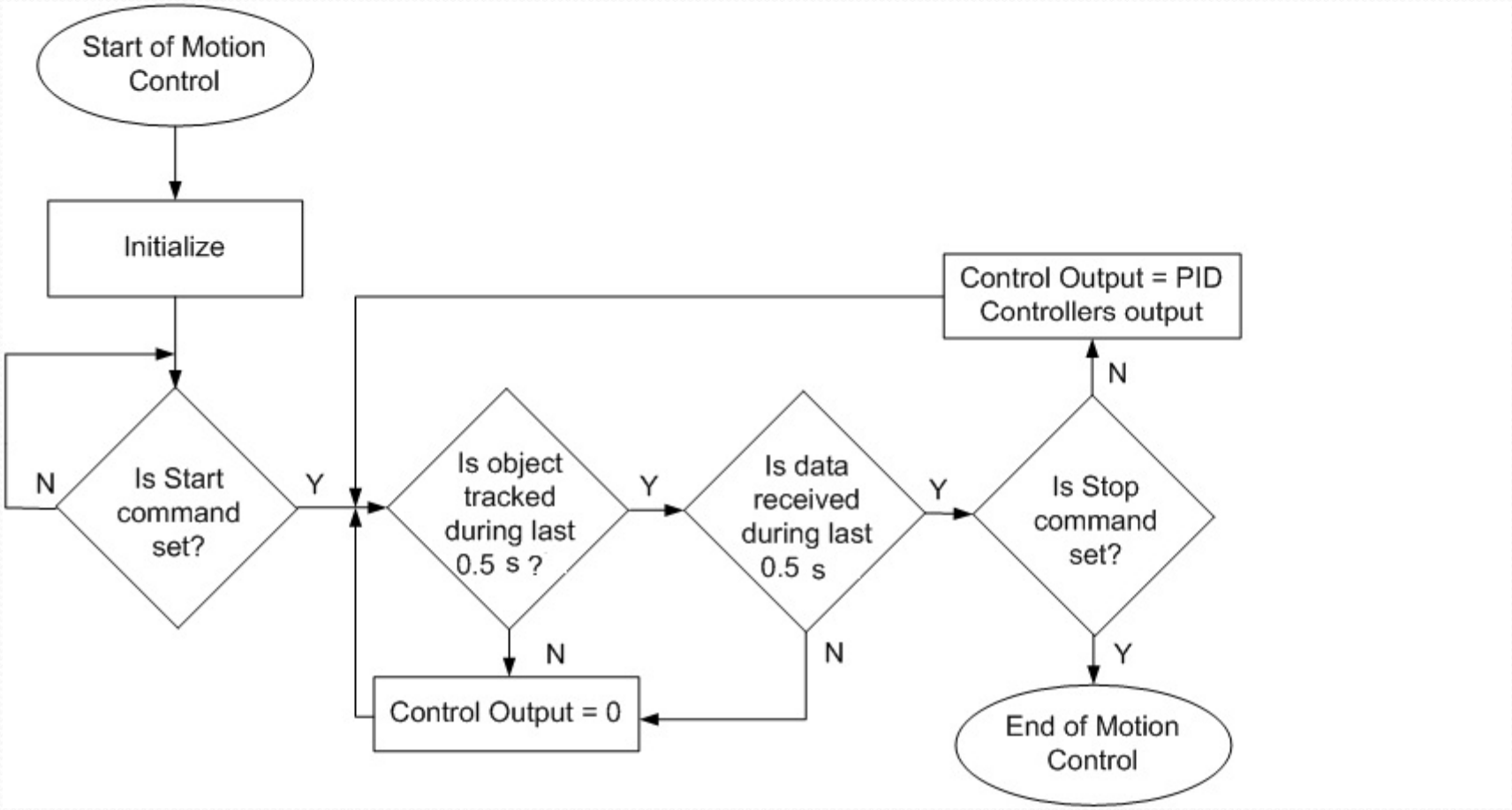
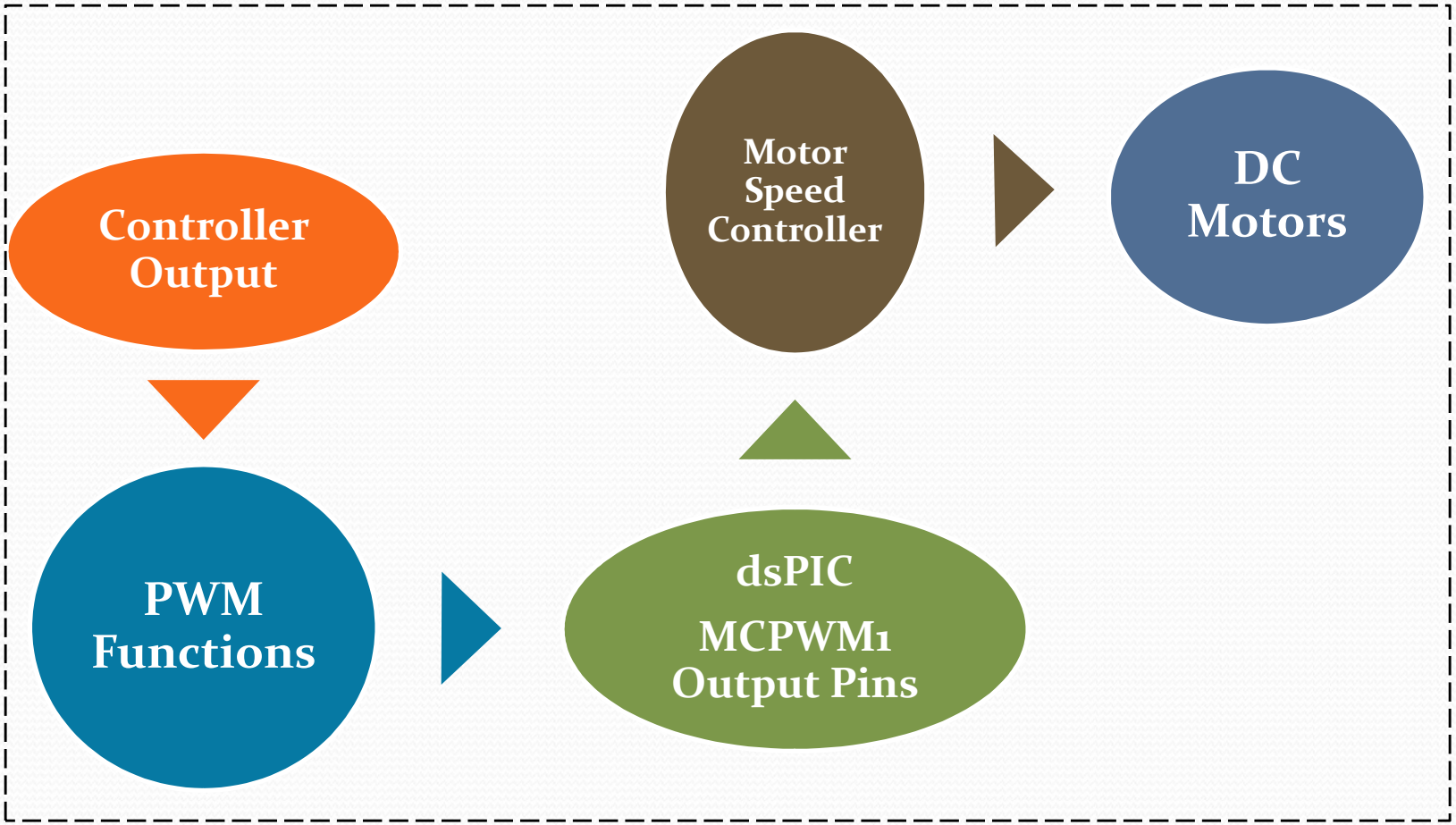
Control Philosophy



Actuator: DC Motor



MCPWM Module

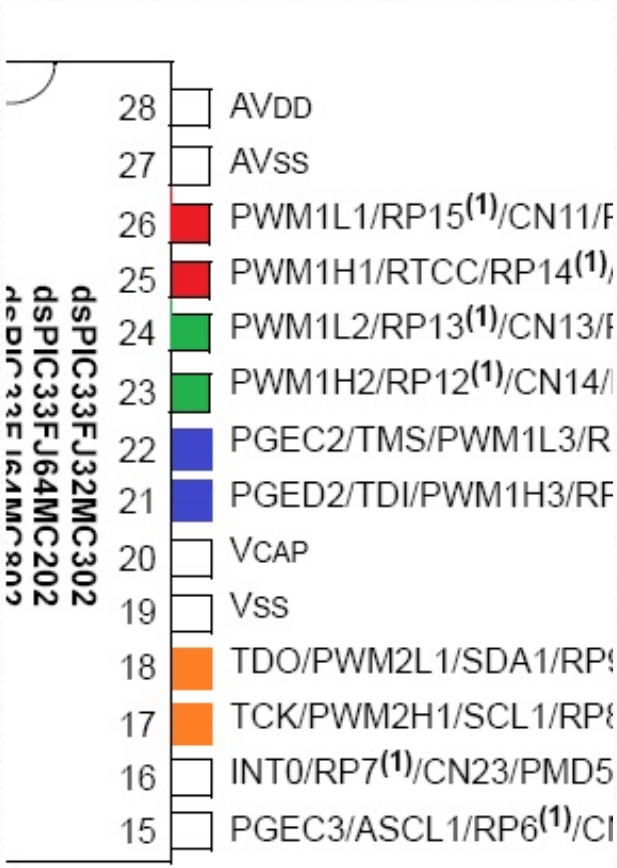
- Motor Control PWM

MCPWM1

- 6 PWM output
- 3 duty cycle register

MCPWM2

- 2 PWM output
- 1 duty cycle register



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MCPWM Spec

Acts as a **Timer** to count up to a period count value

Programmable **Duty Cycle** and **Time Period** Registers

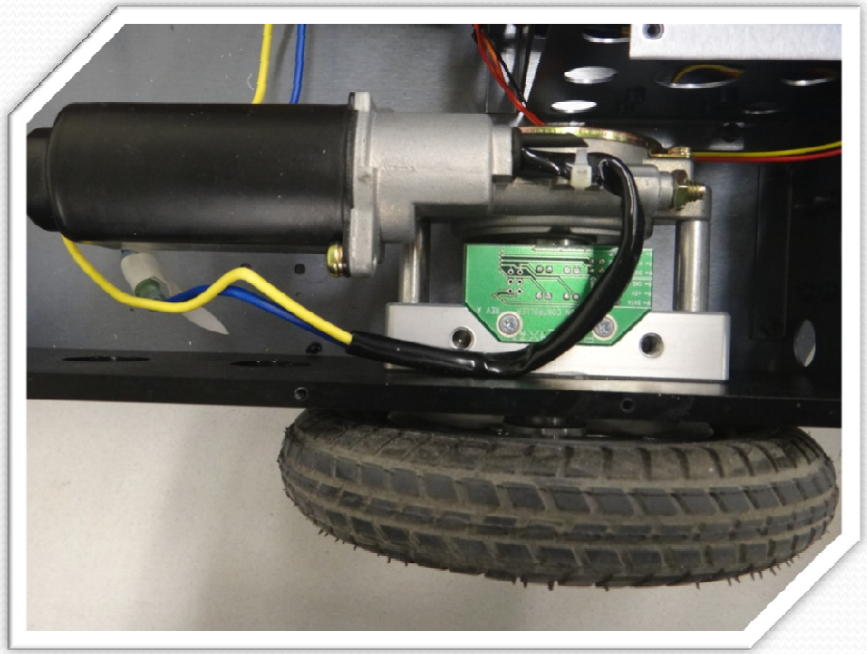
Time Base **Interrupt**

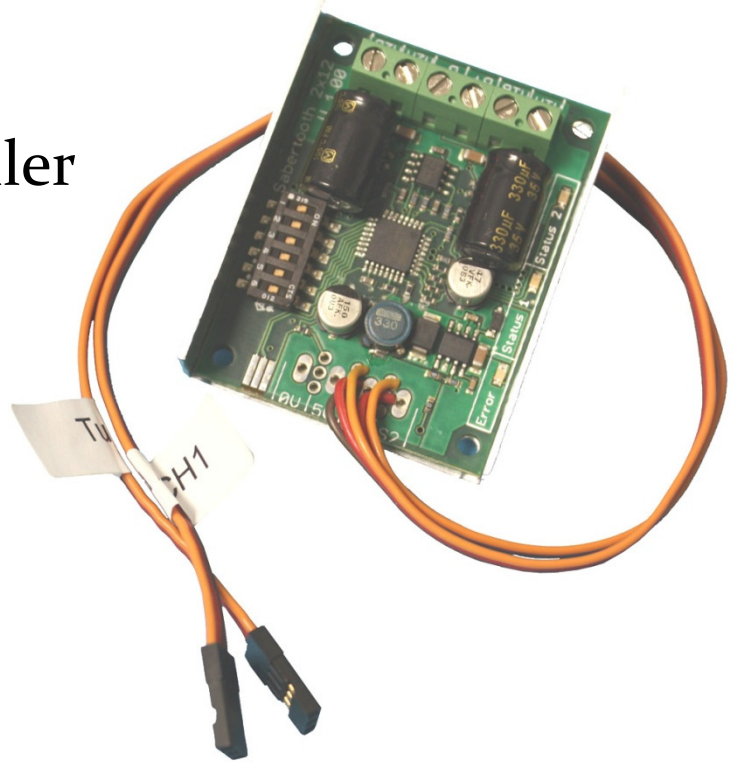
Interrupt occurs on **timer rollover**

Used for updating PWM values **smoothly**

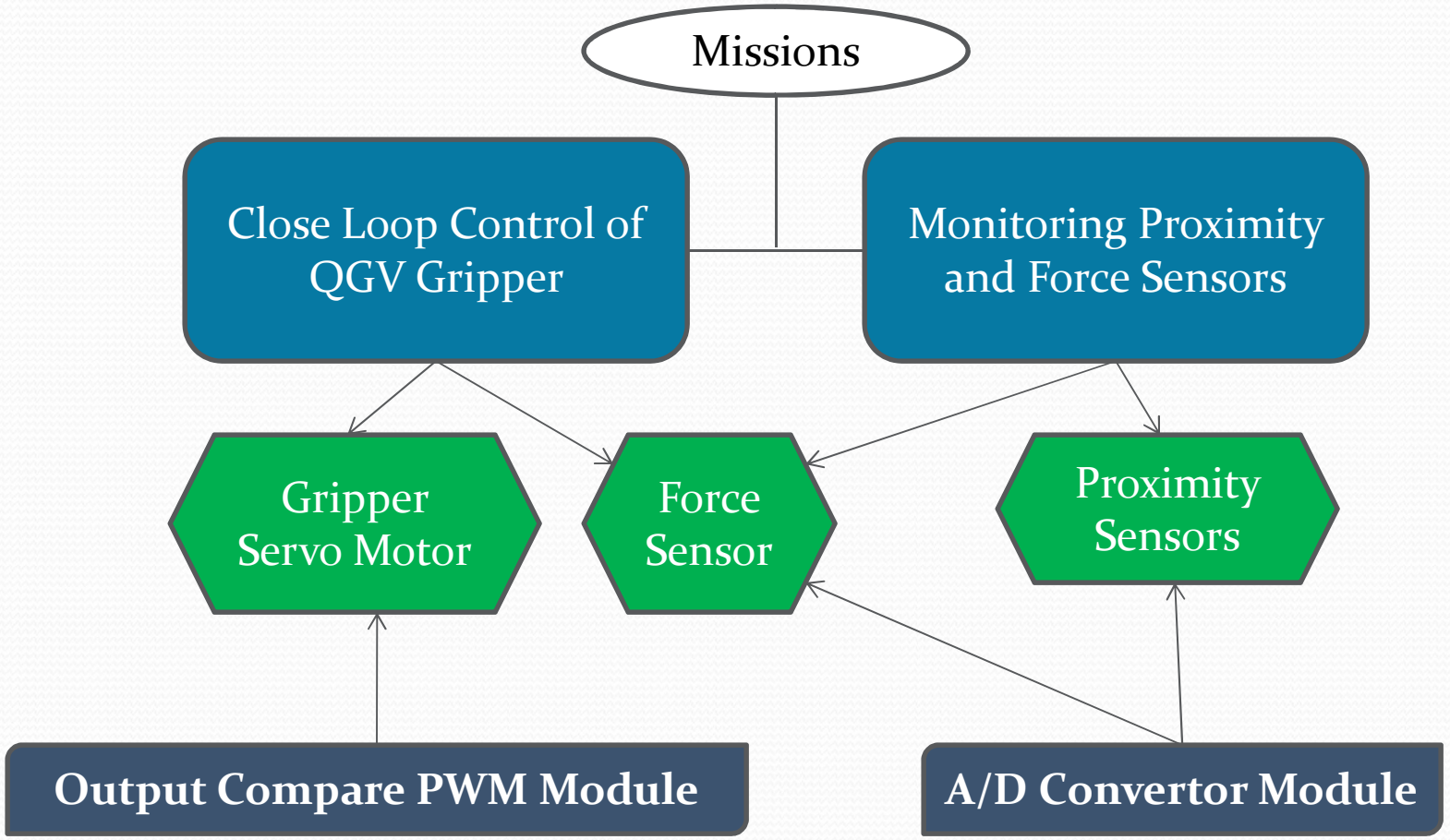
Motors

- Two-channel motor speed controller
- Two DC Motors

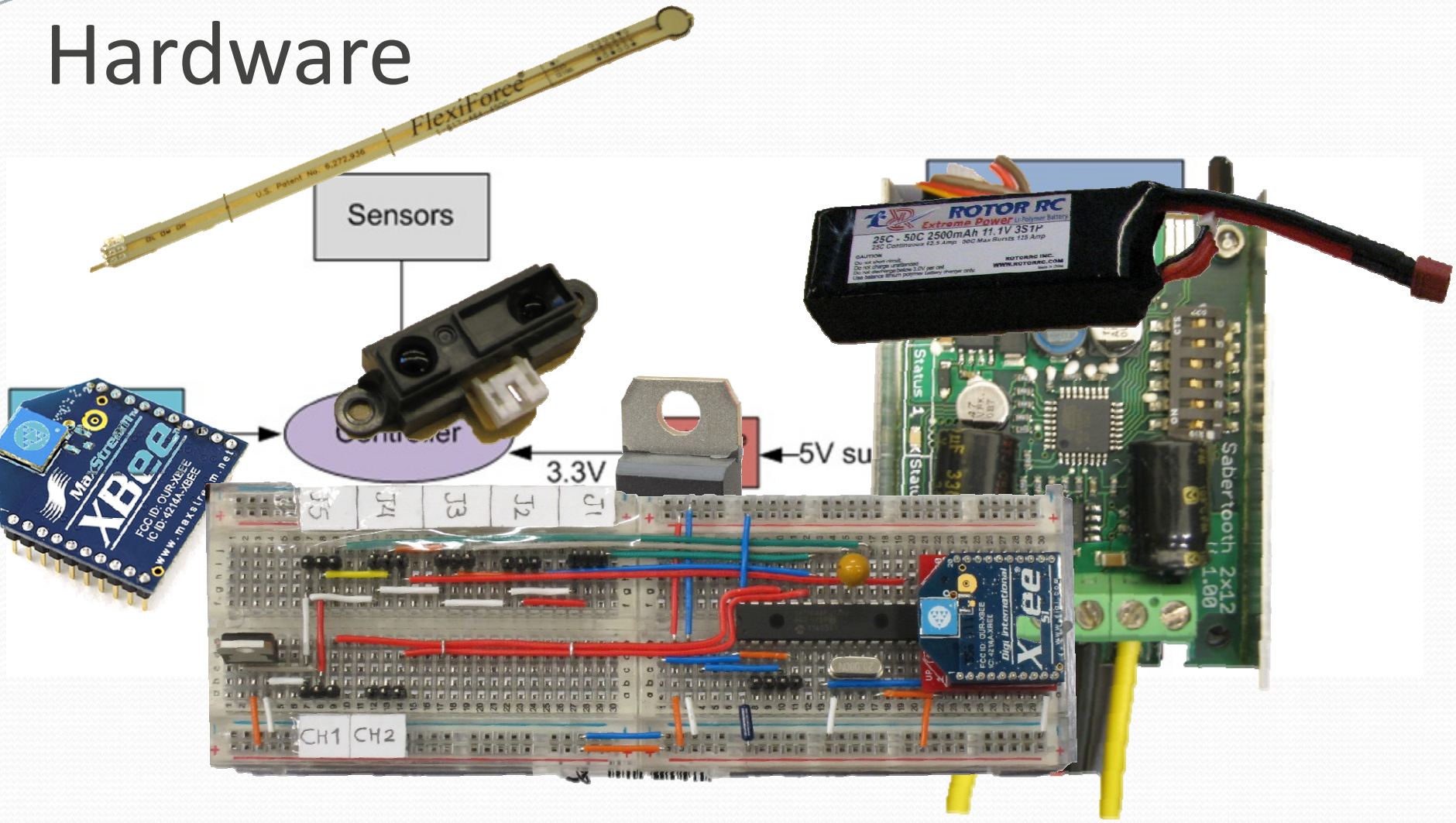




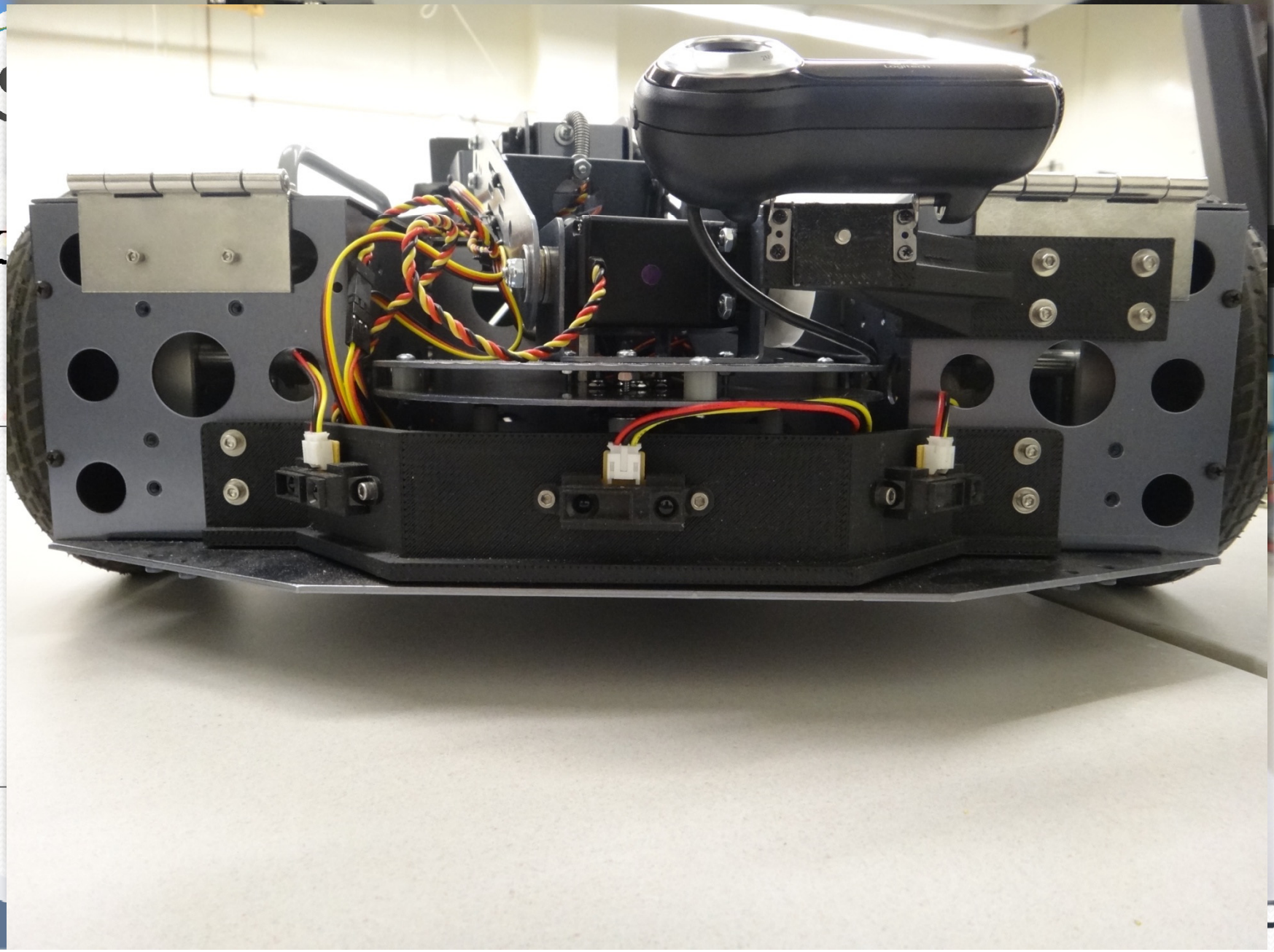
System Secondary Functional Mode



Hardware

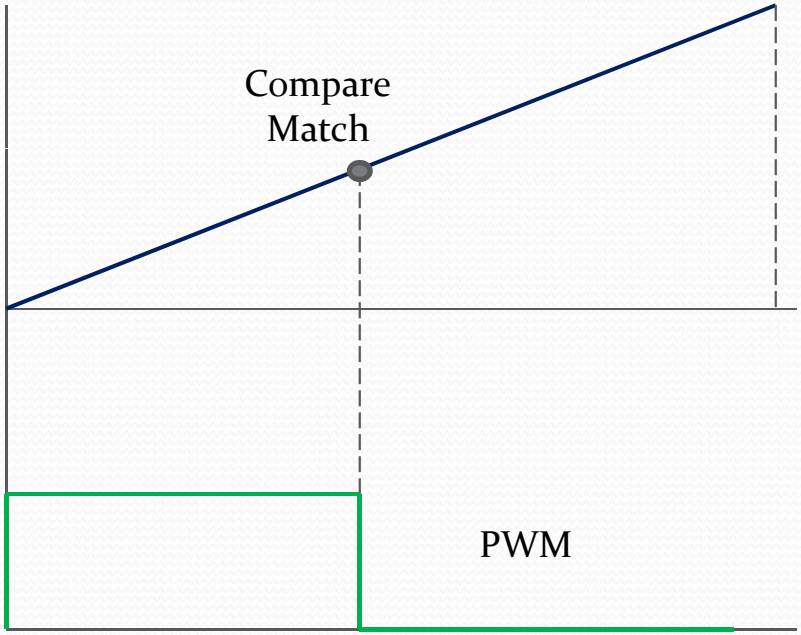

FlexiForce
Sensors
3.3V
5V su
ROTOR RC
Extreme Power
25C - 50C 2500mAh 11.1V 3S1P
Sabertooth 2x12
1.00
J5
J4
J3
J2
J1
CH1
CH2

Monitoring Proximity Sensor Output



RC Servo Motor Drive

- **Output Compare module** in PWM mode



Servo Model	HS-485HB
Working Voltage	3 – 5 V
PWM range	0.9 – 2.1 ms
PWM Frequency	50 Hz

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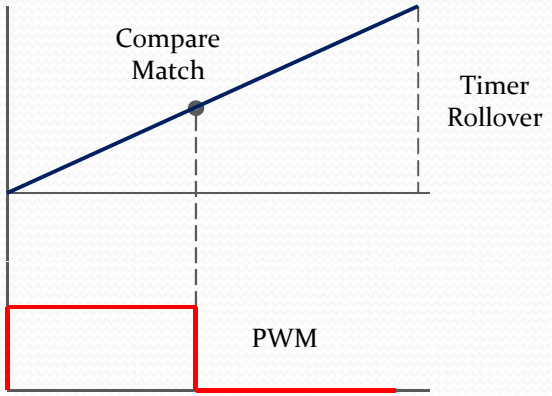
OC Module in PWM mode

- dsPIC has **4** Output Compare Module
- Uses Timer2 or **Timer3** for its time base
- On timer rollover **OC interrupt** flag is set
- **OC Pin** selected by Peripheral Pin Select



- In OC PWM mode:

  Timer 3 Period Register = **PWM Period**

  Output Compare Register = **PWM Duty Cycle**

  Duty Cycle update occurs on timer rollover in ISR

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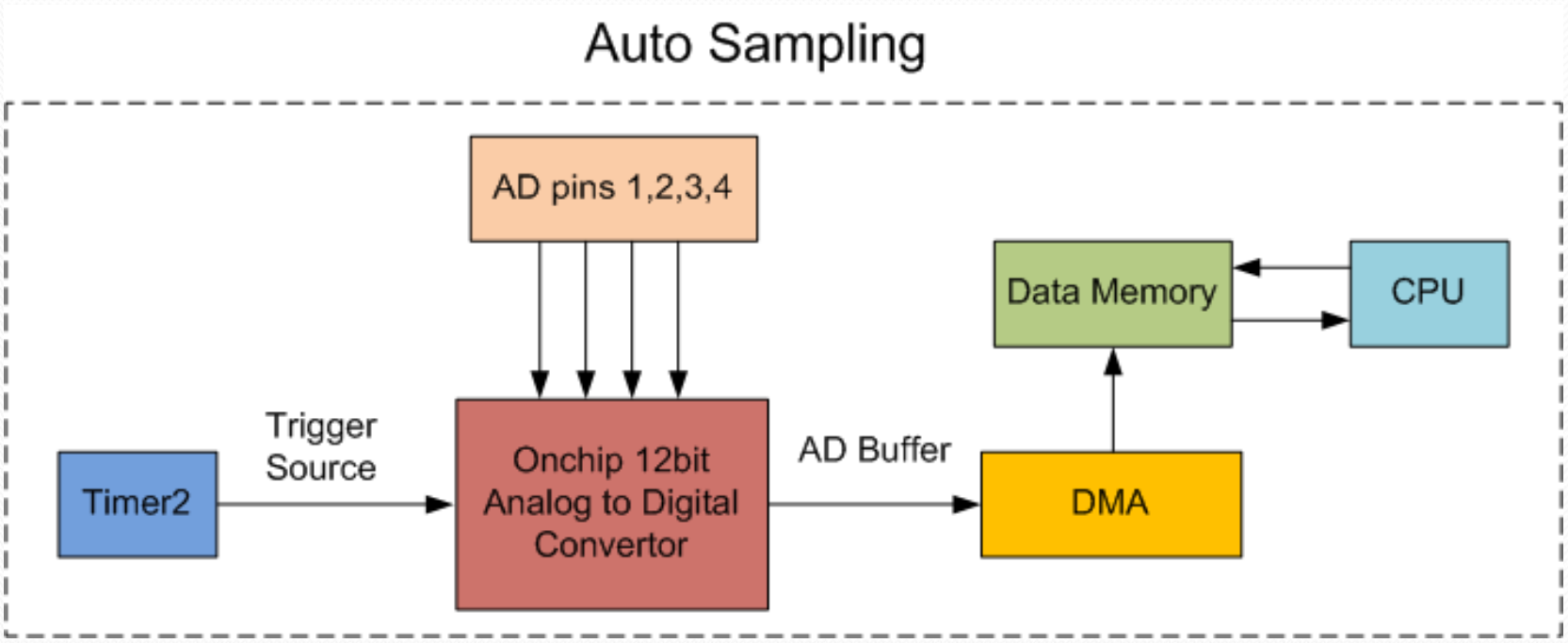
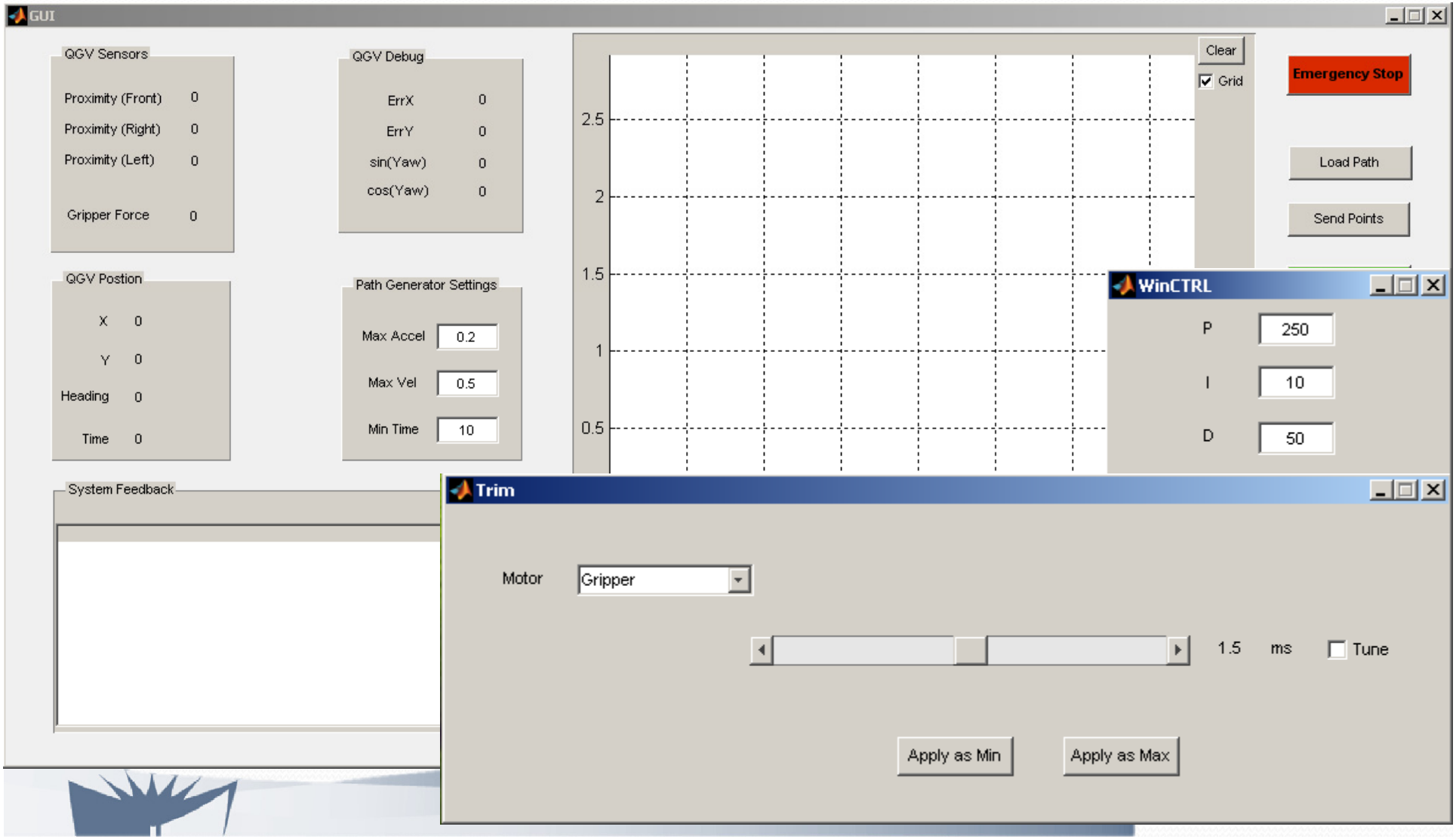
AD Convertor

- Conversion speed up to 1.1 Msps
- Simultaneous sampling of up to four analog input pins
- Automatic Channel Scan mode
- Selectable conversion trigger source
- DMA support, including Peripheral Indirect Addressing
- Operation during CPU Sleep and Idle modes

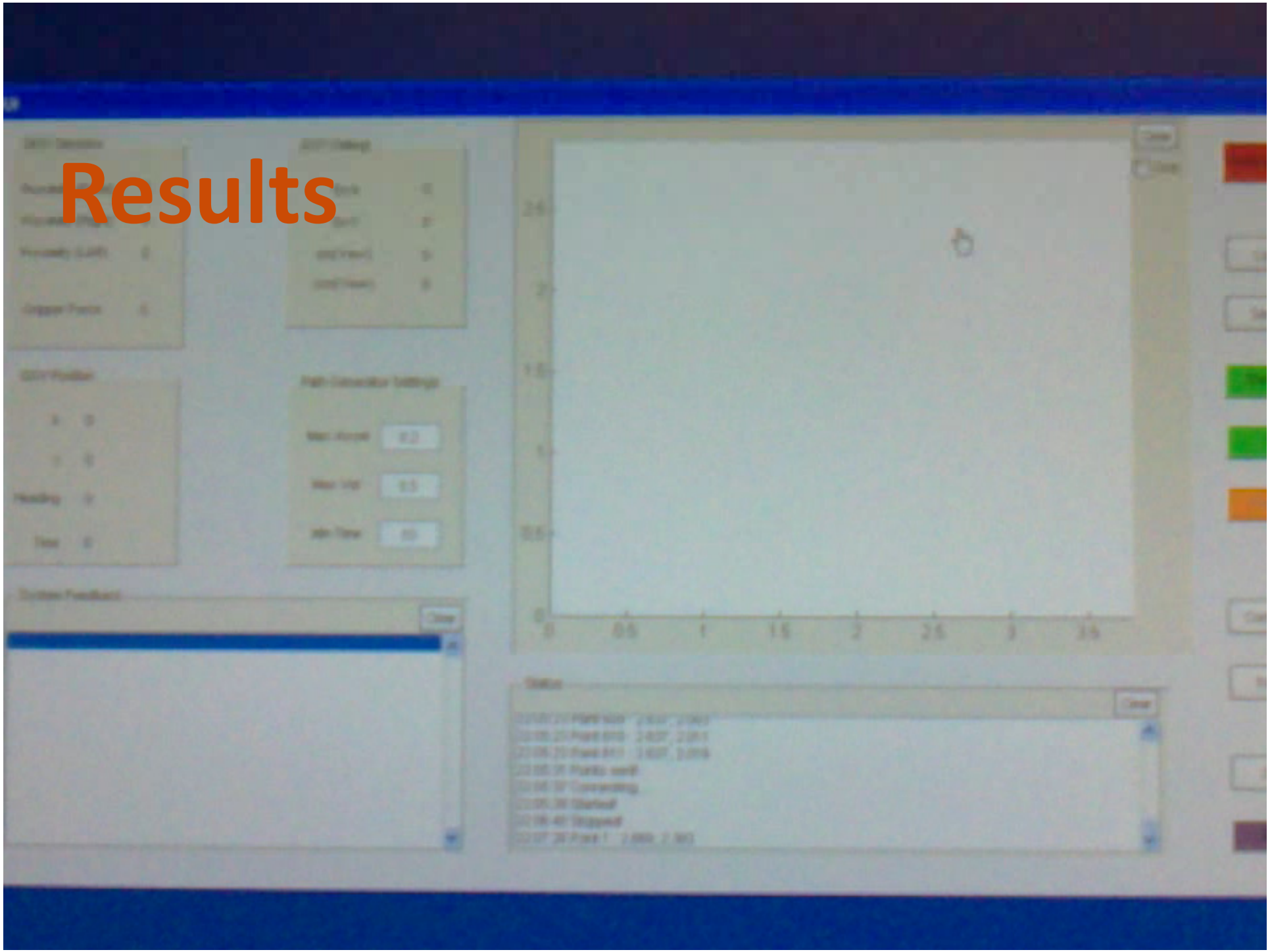
Automatic Sampling

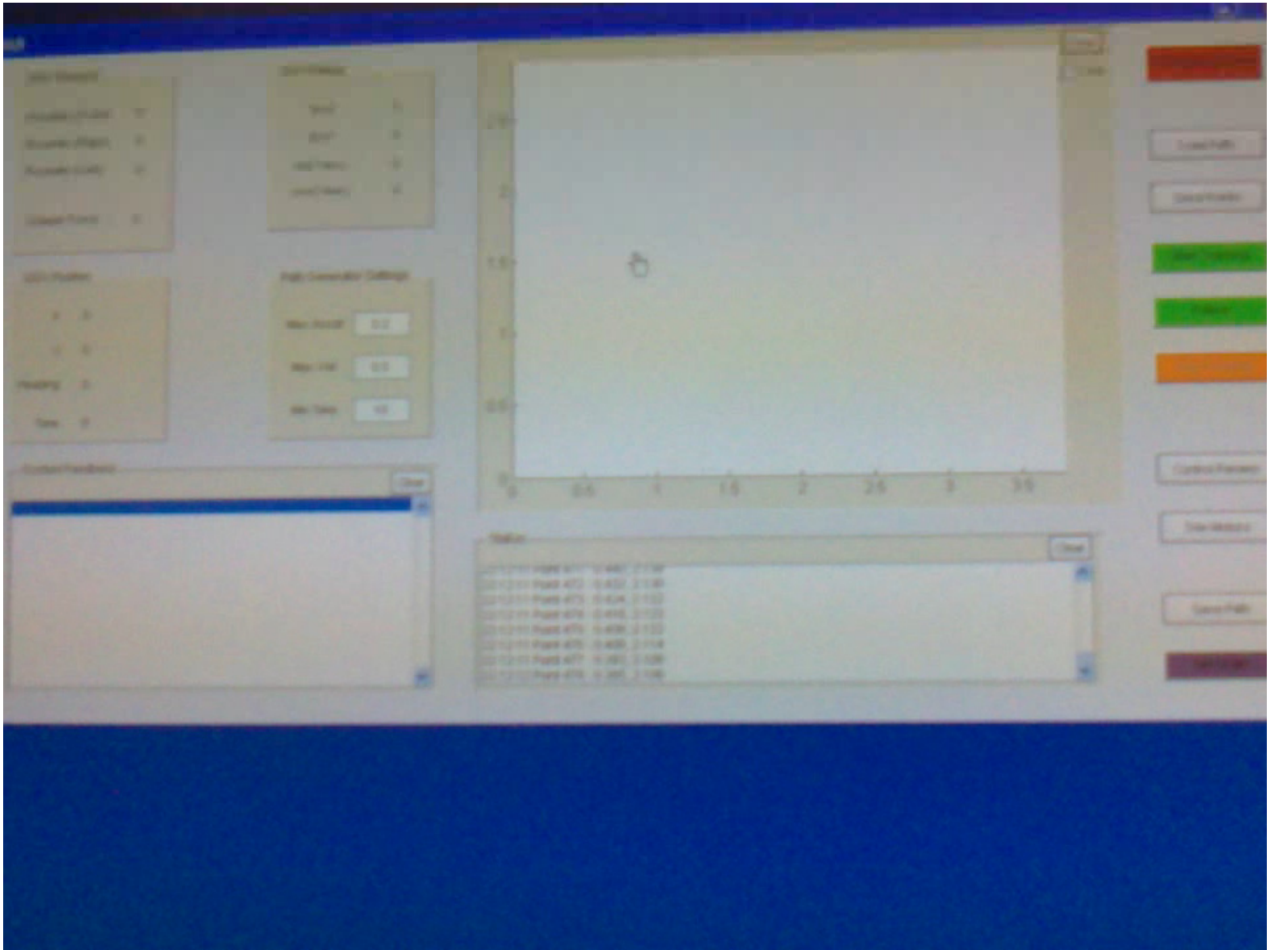


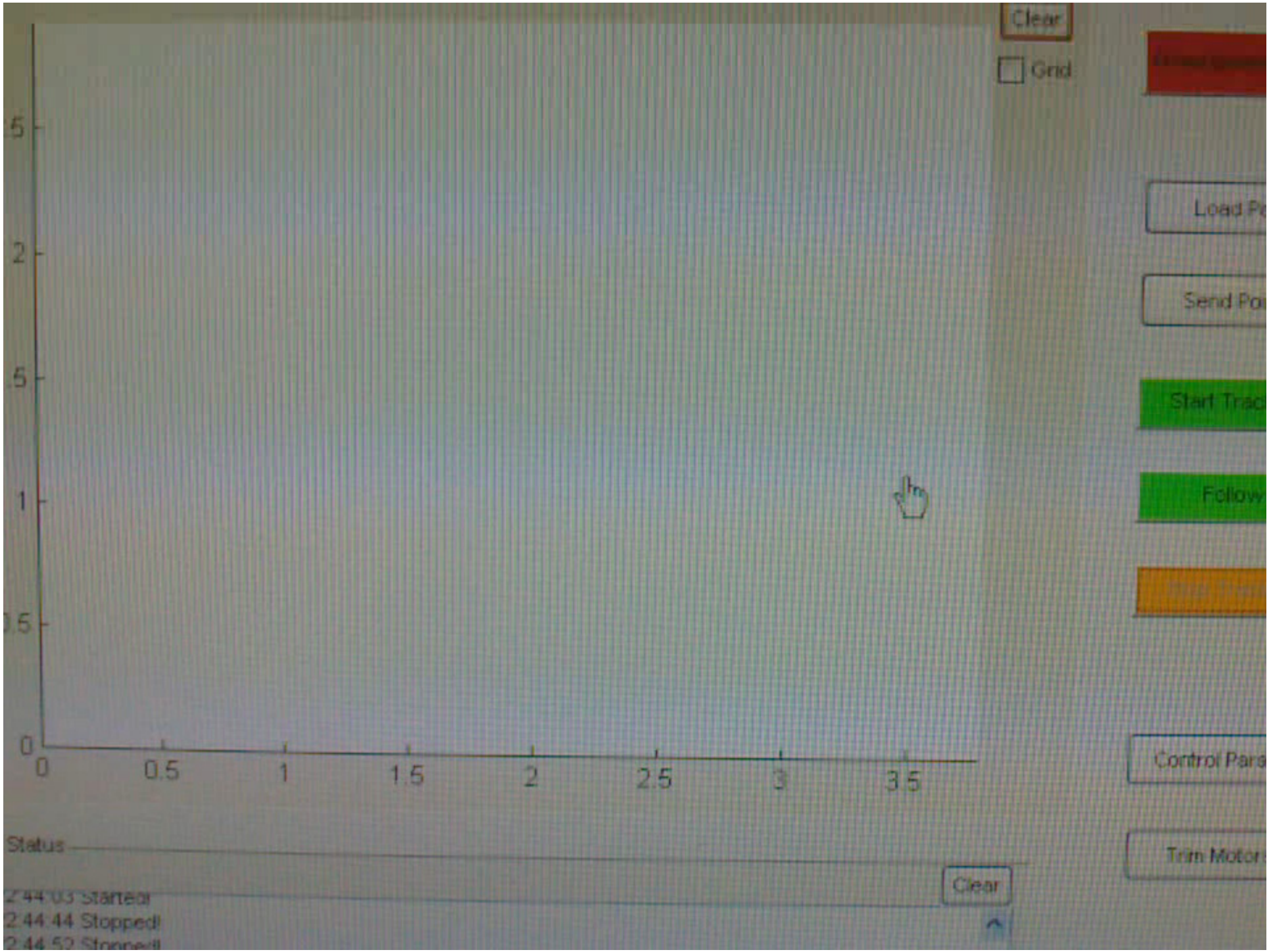
Graphical User Interface (GUI)

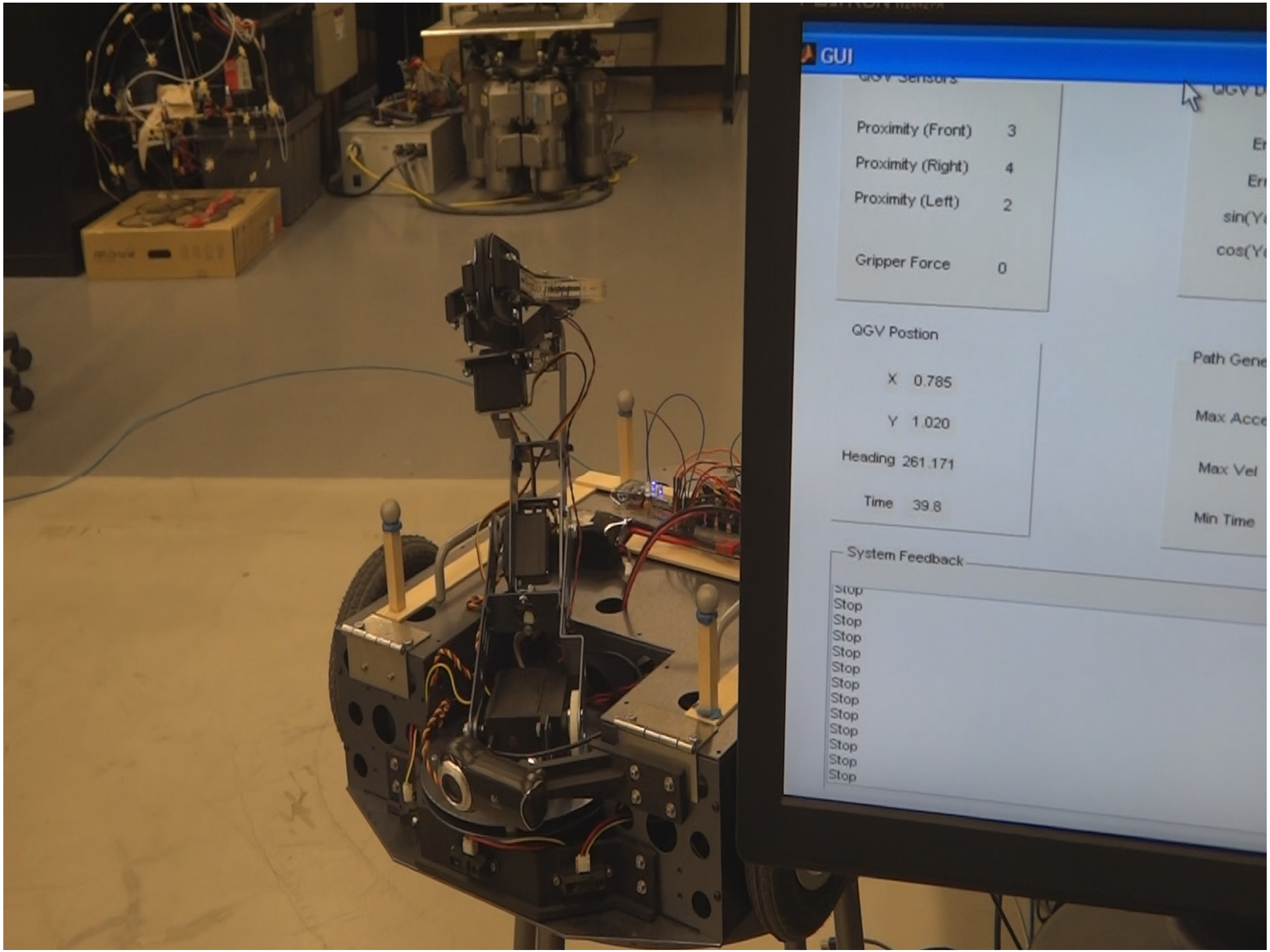


Results






Clear
Grid
Load Pa
Send Pa
Start Trac
Follow
Control Para
Trim Motor
.5
2
.5
1
).5
0
0
0.5
1
1.5
2
2.5
3
3.5
Status
Clear
2:44:03 Started
2:44:44 Stopped!


GUI
Proximity (Front) 3
Proximity (Right) 4
Proximity (Left) 2
Gripper Force 0
QGV Postion
X 0.785
Y 1.020
Heading 261.171
Time 39.8
System Feedback
Stop
Stop
Stop
Stop
Stop
Stop
Stop
Stop
Stop
Stop
Stop
Stop
Stop

Future Works

- Using proximity sensors for obstacle avoidance and path defining
- Application of advanced controller considering the high process speed of dsPIC controller
- Control of arms by controlling all the corresponding motors
- Application of the controller for Formation motion

Acknowledgement

- Special Thanks to **Mr. Mahyar Abdolhosseini.**
- **Thanks for Your Attention!**

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Any Question?