MISR UNIVERSITY FOR SCIENCE AND TECHNOLOGY
COLLEGE OF ENGINEERING
MECHATRONICS DEPARTMENT

MTE 405 SENSORS AND MEASUREMENTS

LAB 4 – SPRING 2019

Goals Of The Lab

Introduction to Sensors and Signal Conditioning with Virtual Prototyping

Working with encoders

Lab 4

Encoders

Mechatronics Usage

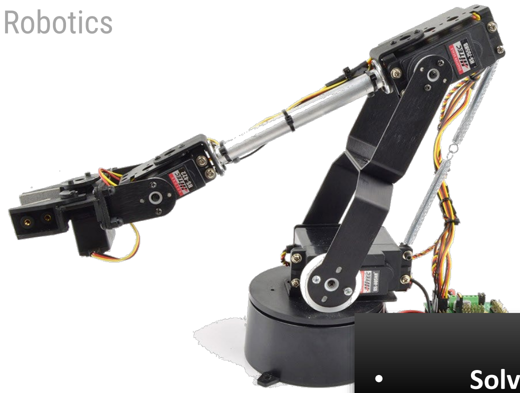
Learning outcome

- Implementation of lecture notes
- Building speed monitoring application

Lab 4

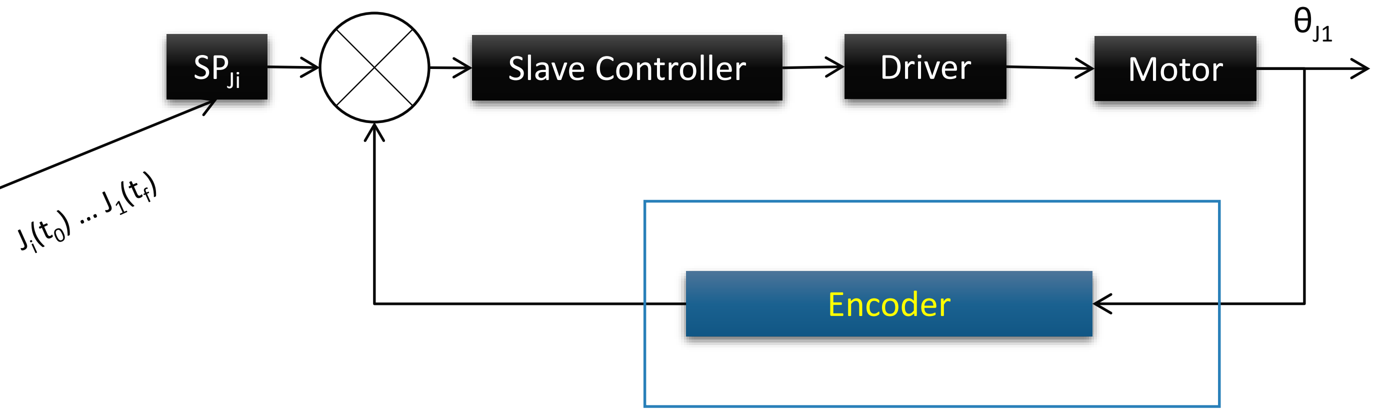
Importance of Encoders

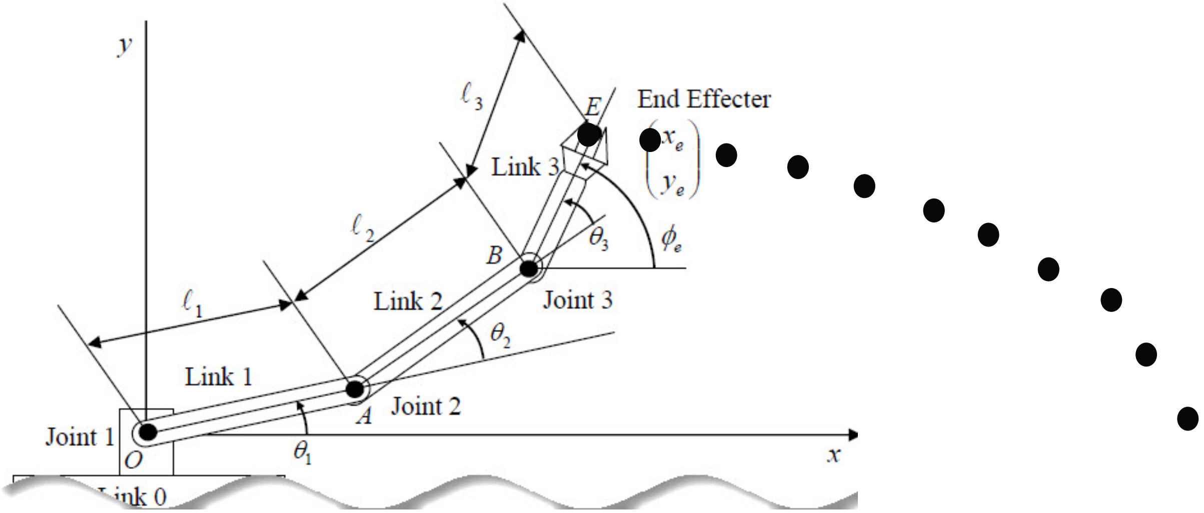
Robotics



Master Controller

- **Solving** Inverse Kinematics
- **Generating** trajectory intermediate angles for each joint (J_i)



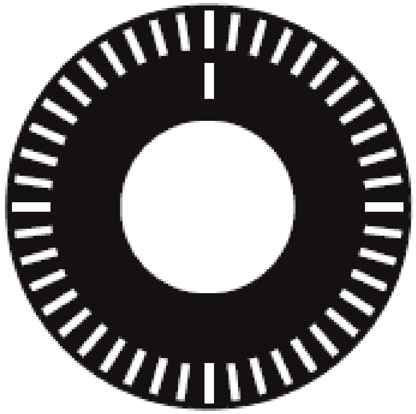


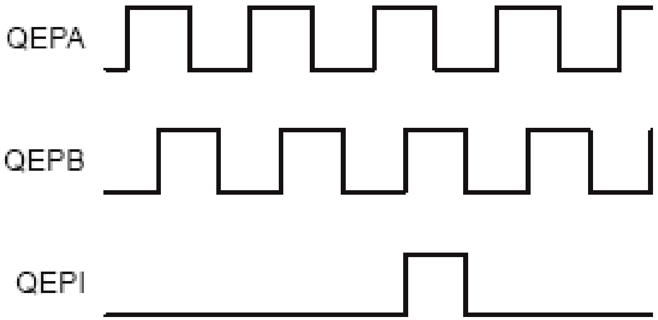
*Each **joint (J)** has its own **closed loop system***

Importance of Encoders

Anatomy of encoders

Rotating Shaft → Rotary Encoder → Position / Velocity / Acceleration feedback

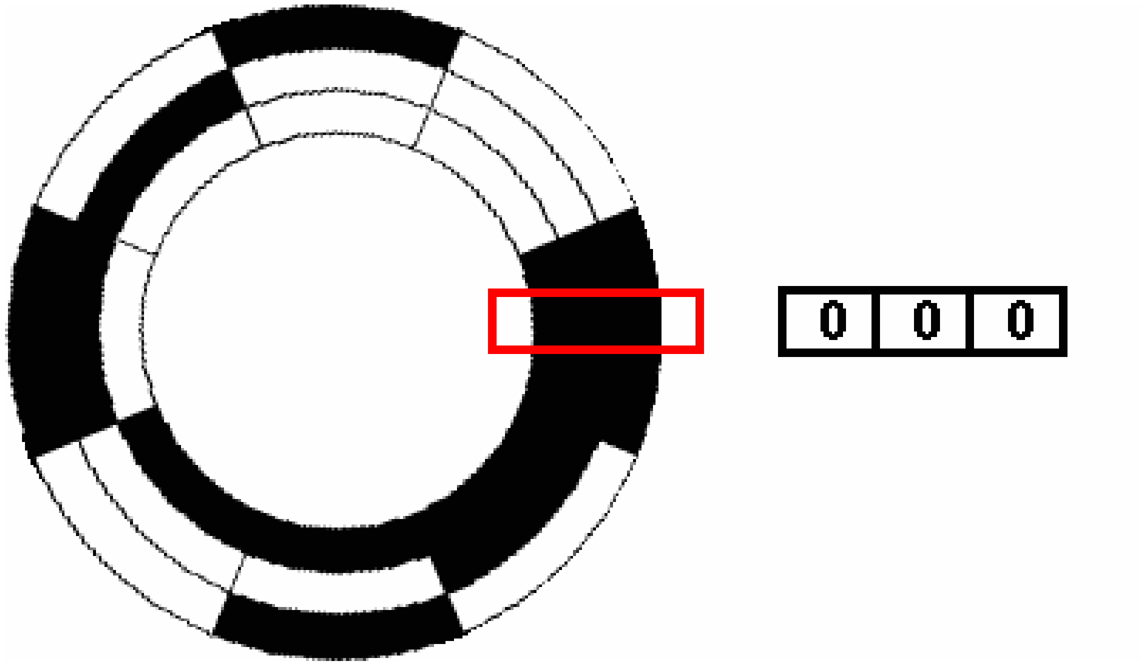


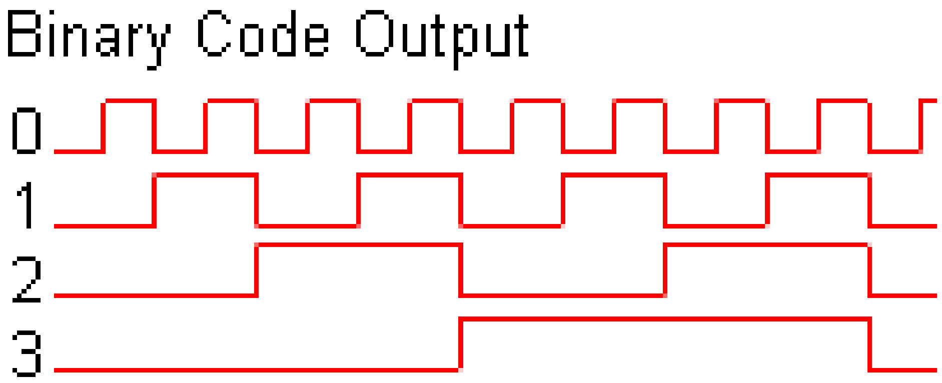


Lab 4

Types of encoders

How it works

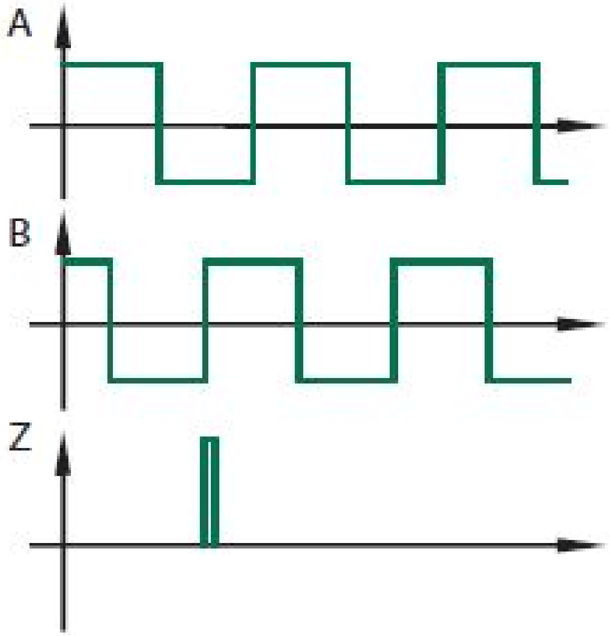


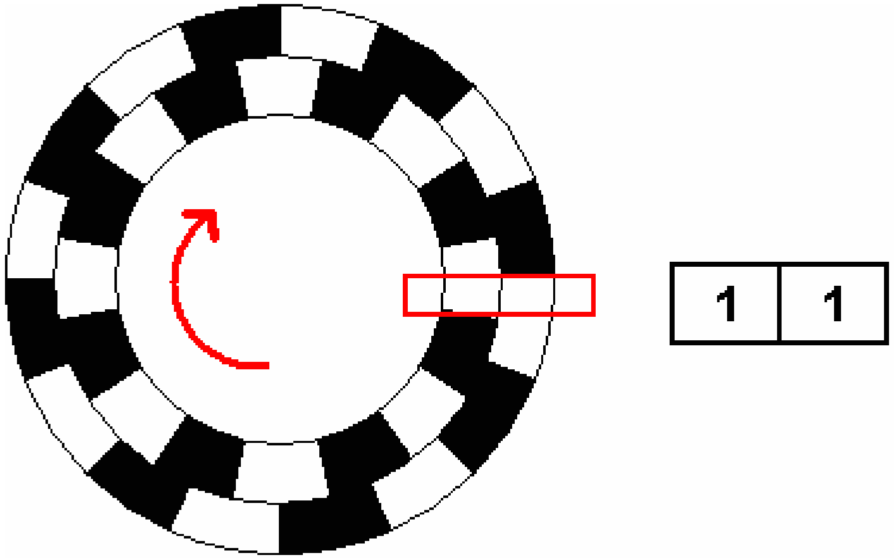


ABSOLUTE ENCODER

Types of encoders

How it works



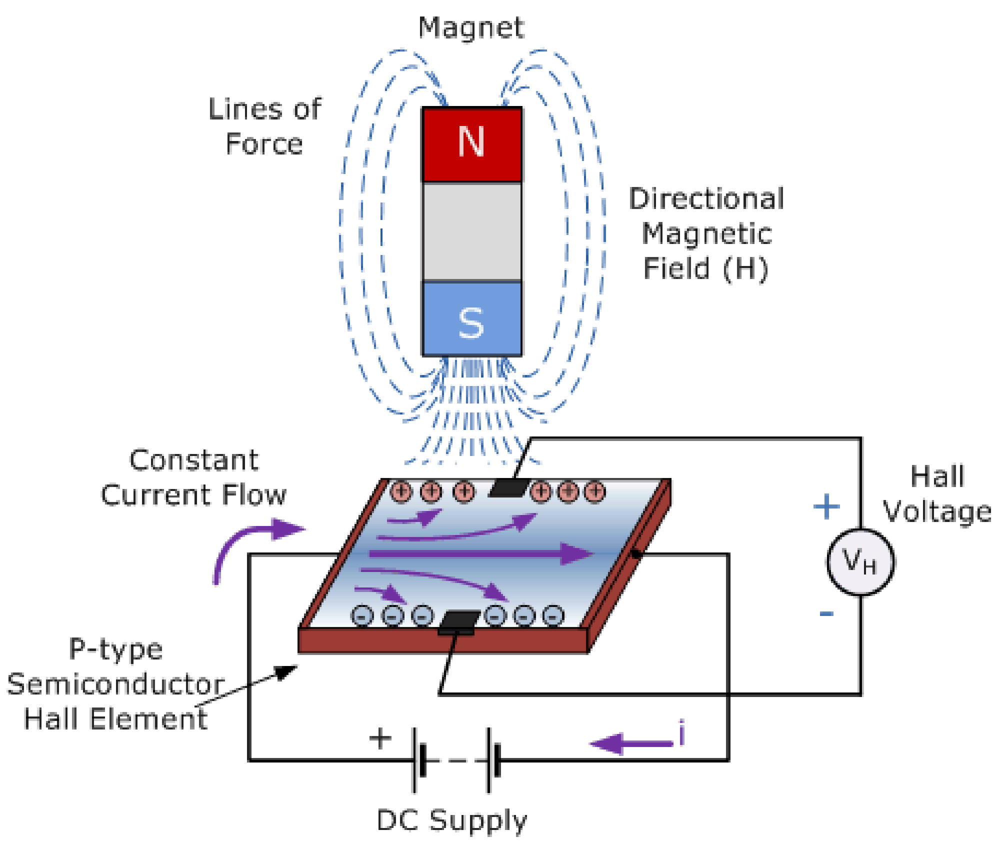


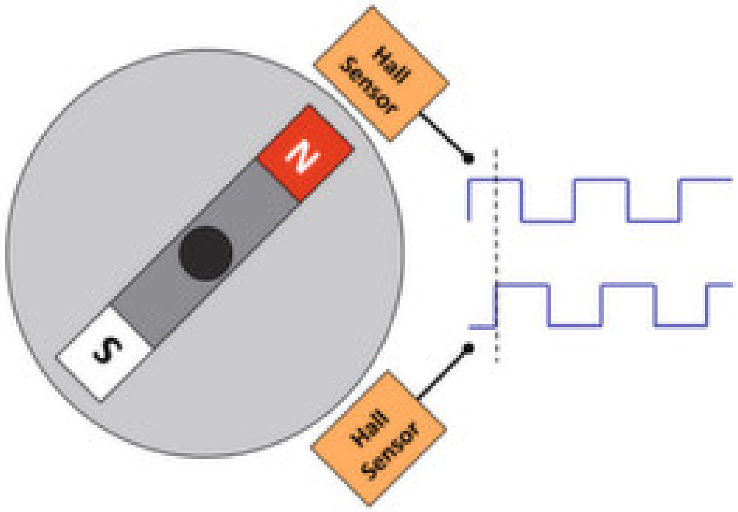
INCREMENTAL ENCODER

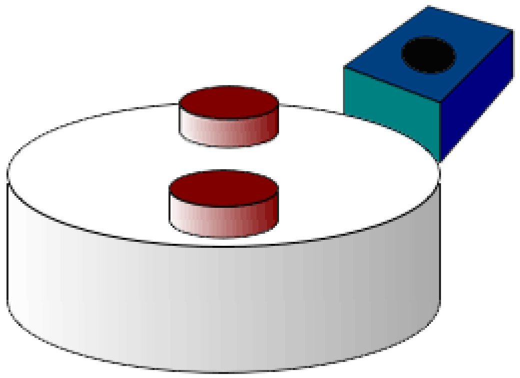
Lab 4

Types of encoders

How it works



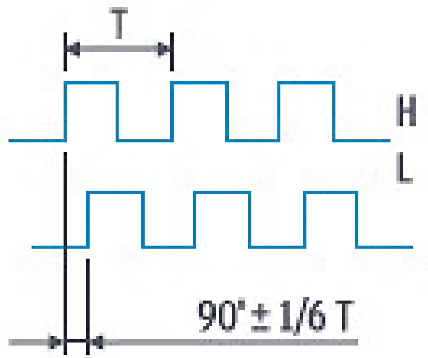




HALL/MAGNETIC

Types of encoders

How it works



Magnetic Encoder

- 3.3 V – 20 V
- 2-Channels
- 6 poles

Two Channel Encoder Connections	
1. Black	: - Motor
2. Red	: + Motor
3. Brown	: Hall Sensor Vcc
4. Green	: Hall Sensor GND
5. Blue	: Hall Sensor A Vout
6. Purple	: Hall Sensor B Vout

What's the number of pulses per revolution / channel?

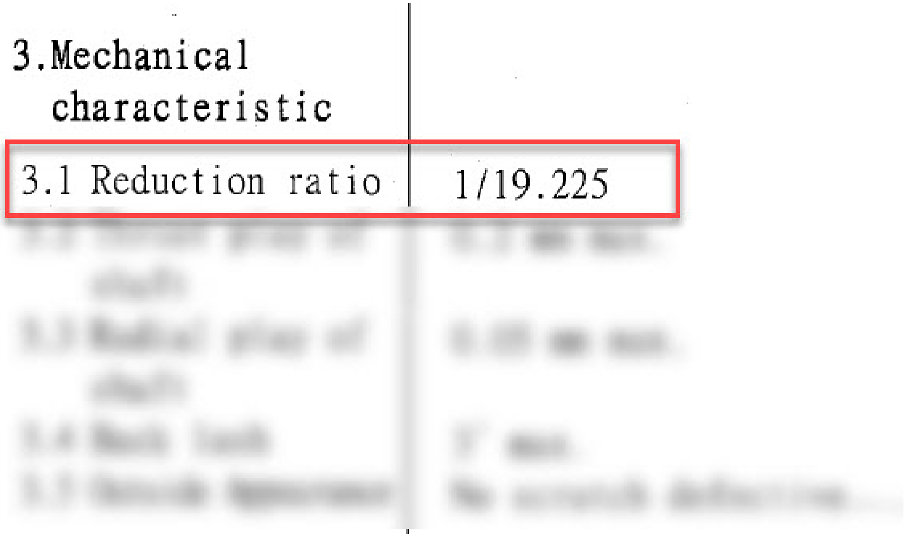
Can we increase the encoder resolution? XOR?

HALL/MAGNETIC

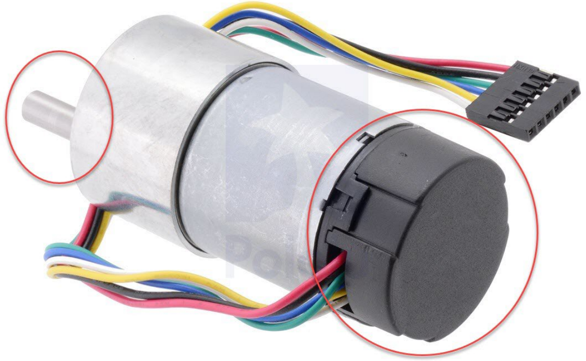
Lab 4

Types of encoders

Geared DC Motor



3.Mechanical characteristic	
3.1 Reduction ratio	1/19.225



Advantages of Gear Reduction

- Boosting torque.
- Enhancing encoder resolution

$$\text{Encoder (PPR)} = 6\,(\text{poles}) X\ 2(\text{channels}) X\ 19\text{Reduction Ratio}$$

$$\text{Encoder (PPR)} \cong 231$$

GEARED DC MOTOR

Lab 4

Encoders

Calculations

MATHEMATICAL FORMULAE

Basic calculations for incremental encoders

Formulations

Given

$Number\ of\ slots\ per\ channel: \boldsymbol{N_s\ (slots)}$

$Number\ of\ channels: \boldsymbol{N_c}$

Computed

$Encoder\ resolution\ per\ channel: R_c\ (\frac{degrees}{step})$ $\quad$ $R_c = \frac{360^o}{N_s}\ (\frac{degrees}{step})$

$Total\ encoder\ resolution: R_t\ (\frac{degrees}{step})$ $\quad$ $R_t = \frac{360^o}{N_s N_c}\ (\frac{degrees}{step})$

Basic calculations for incremental encoders

Formulations

Example

$A\ quadrature\ encoder\ of\ (2-channels)\ holding\ 60\ slots\ per\ channel. Calculate\ the\ resolutoj\ per\ channel\ and\ if\ both\ channels\ are\ XORed.$

Answer

$$R_c = \frac{360^o}{N_s} = \frac{360}{60} = \frac{6^o}{step} \qquad R_t = \frac{360^o}{N_s N_c} = \frac{360}{(60)(2)} = \frac{3^o}{step}$$

Basic calculations for incremental encoders

Formulations

Example

From ***previous calculations****, the same encoder was mounted on a wheel drive. If the wheel diameter is 0.1 m and the received count is 1240. What is the distance travelled? What is the reading error?*

Answer

$$\because R_t = \frac{3^o}{step} \quad and \quad \frac{Distance}{One\ Rotation} = \pi D_{wheel} = (\pi)(0.1) = 0.314\, m$$

Basic calculations for incremental encoders

Formulations

Example

From ***previous calculations****, the same encoder was mounted on a wheel drive. If the wheel diameter is 0.1 m and the received count is 1240. What is the distance travelled? What is the reading error?*

Answer

$$\because R_t = \frac{3^o}{step} \; and$$

$$\frac{Distance}{One\ Rotation} = 0.314\ m$$

$$\because C_t = 1240\ count$$

$$\because \frac{C_t}{One\ Rotation} = 120 \frac{Count}{One\ Rotation}$$

Basic calculations for incremental encoders

Formulations

Example

From ***previous calculations****, the same encoder was mounted on a wheel drive. If the wheel diameter is* $0.1\,m$ *and the received count is* 1240*. What is the distance travelled? What is the reading error?*

Answer

$$Total\ Distance\ (L) = \frac{1240\ (Count)}{120\ \left(\frac{Count}{Rotation}\right)} * \left(0.314 \frac{m}{Rotation}\right) = 3.24\,m$$

Basic calculations for incremental encoders

Formulations

Notation (continued)

$Total\ distance\ travelled : \boldsymbol{L}\ (m)$

$Total\ encoder\ counts : \boldsymbol{C_t}\ (counts)$

$Total\ encoder\ counts\ per\ rotation : C_{t-r}\ (\frac{counts}{rotation})$

$Distance\ travelled\ \ after\ one\ rotation : L_{t-r}\ (\frac{m}{rotation})$

$$\boldsymbol{L(m) = \frac{C_t\ (Count)}{C_{t-r}\ (\frac{Count}{Rotation})} * L_{t-r}(\frac{m}{rotation})}$$

Basic calculations for incremental encoders

Formulations

Notation (continued)

$Motor\ speed : \boldsymbol{S_{motor}}\ (RPM)$

$Total\ encoder\ speed : \boldsymbol{S_{encoder}}\ (Pulse\ Per\ Second\ - PPS)$

$Microcontroller\ sampling\ time : \Delta t\ (Seconds)$

$$\boldsymbol{S_{encoder}}\ (PPS) = \frac{Encoder\ Count\ @(t) - Encoder\ Count\ @(t - \triangle\ t)}{\triangle\ t}$$

$$\boldsymbol{S_{motor}}\ (RPM) = \boldsymbol{S_{encoder}} \left(\frac{\boldsymbol{pulse}}{\boldsymbol{s}}\right) * \frac{\boldsymbol{R_t}\left(\frac{\boldsymbol{degree}}{\boldsymbol{pulse}}\right)}{\boldsymbol{360^o}\left(\frac{\boldsymbol{degree}}{\boldsymbol{revolution}}\right)} * \boldsymbol{60.0}\left(\frac{\boldsymbol{s}}{\boldsymbol{min}}\right)$$

Don’t forget to pull the lab update from.

http://github.com/wbadry/mte405

END OF Lab 4