MISR UNIVERSITY FOR SCIENCE AND TECHNOLOGY
COLLEGE OF ENGINEERING
MECHATRONICS DEPARTMENT

MTE 405 SENSORS AND MEASUREMENTS

LAB 4 – SPRING 2020

Lab 4

Goals Of The Lab

Introduction to Sensors and Signal Conditioning with Virtual Prototyping

Working with encoders

Lab 4

Encoders

Mechatronics Usage

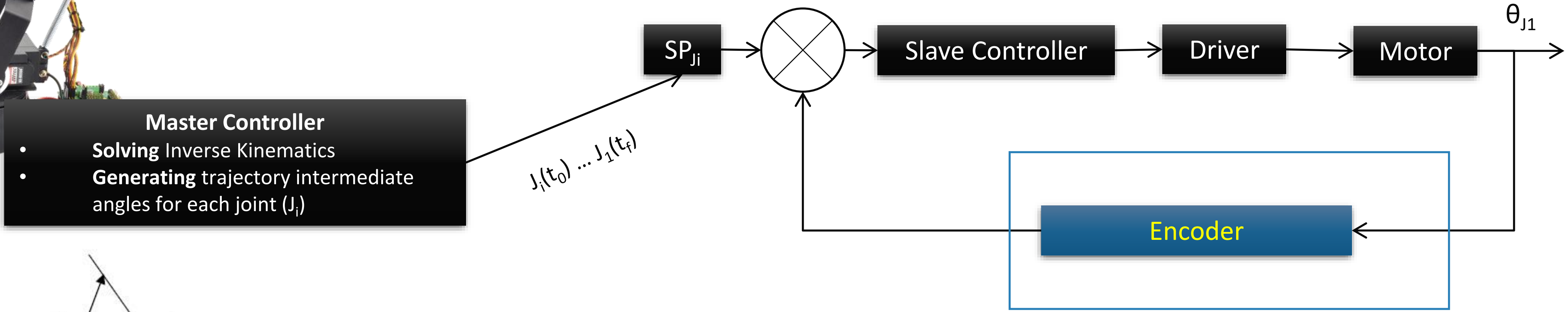
Learning outcome

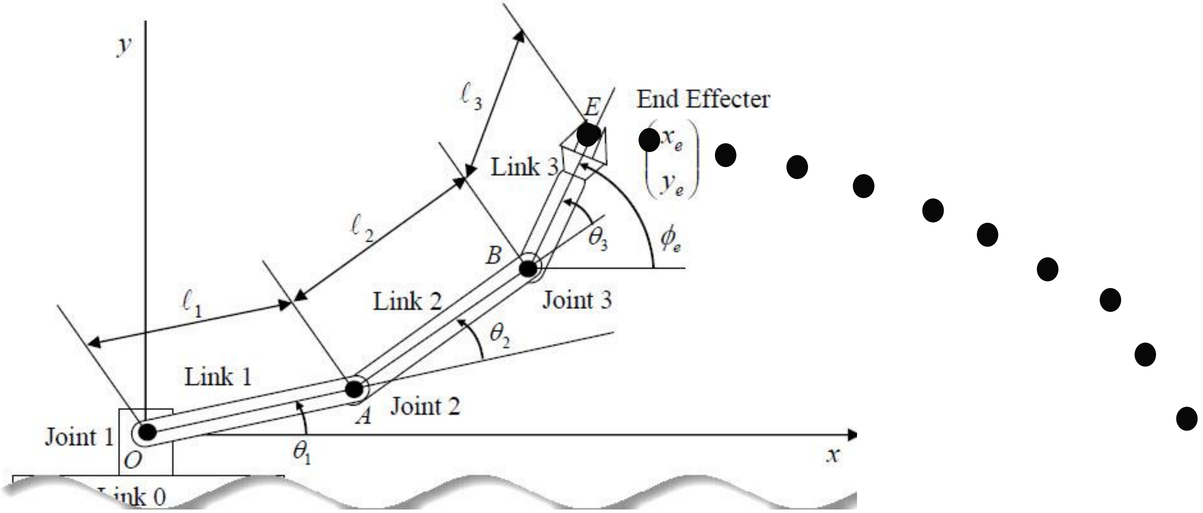
- Implementation of lecture notes
- Building speed monitoring application

Lab 4

Importance of Encoders

Robotics





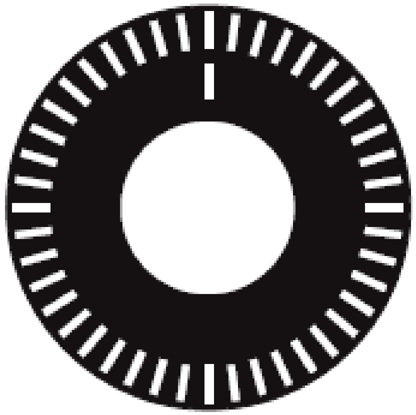
*Each **joint (J)** has its own **closed loop system***

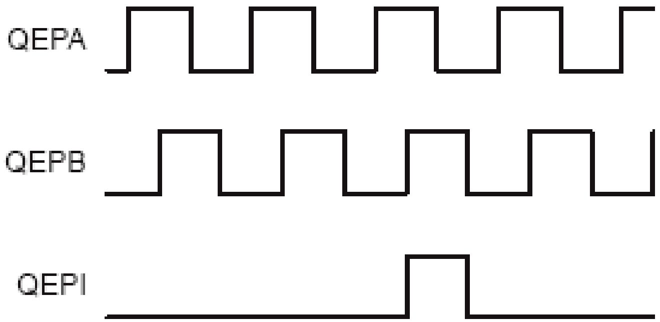
Lab 4

Importance of Encoders

Anatomy of encoders

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

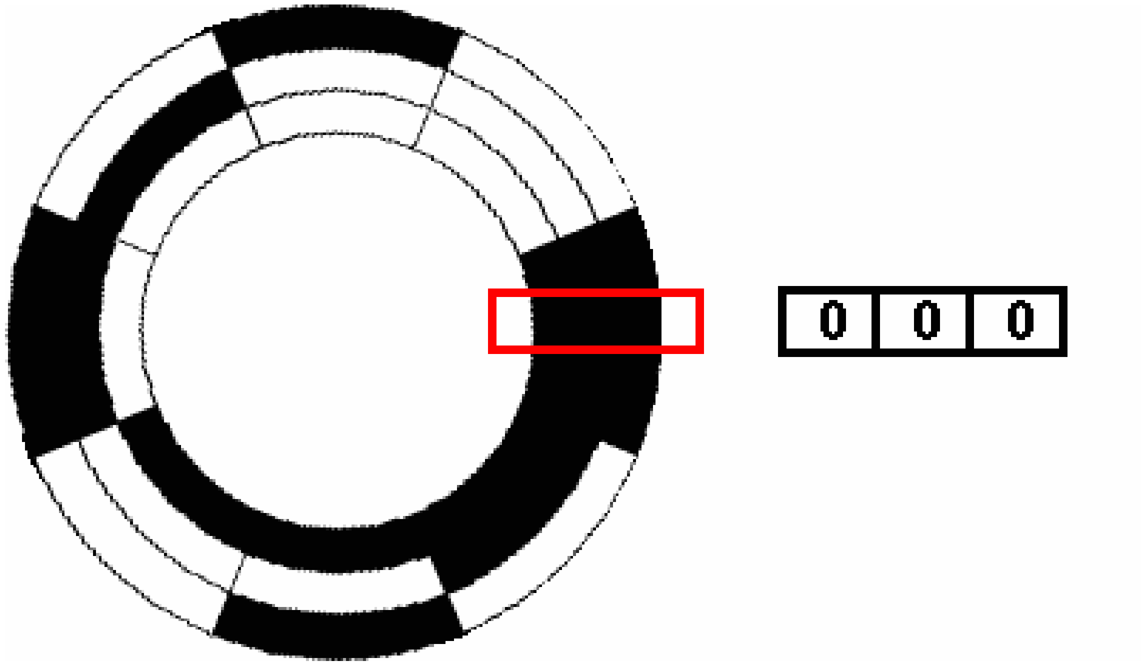


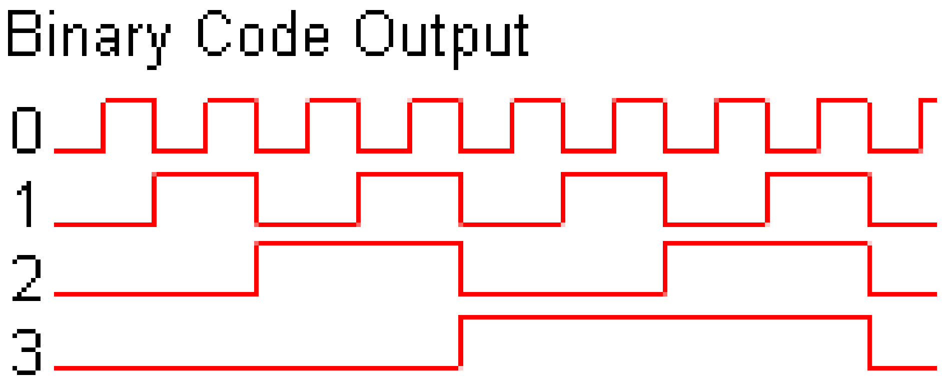


Lab 4

Types of encoders

How it works



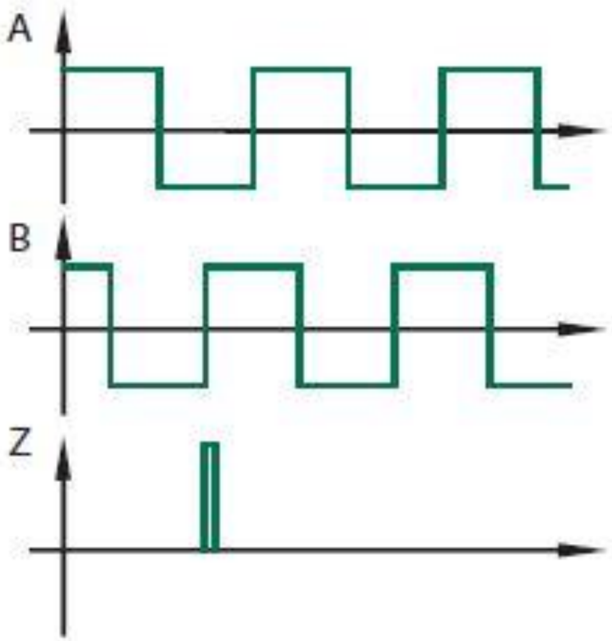


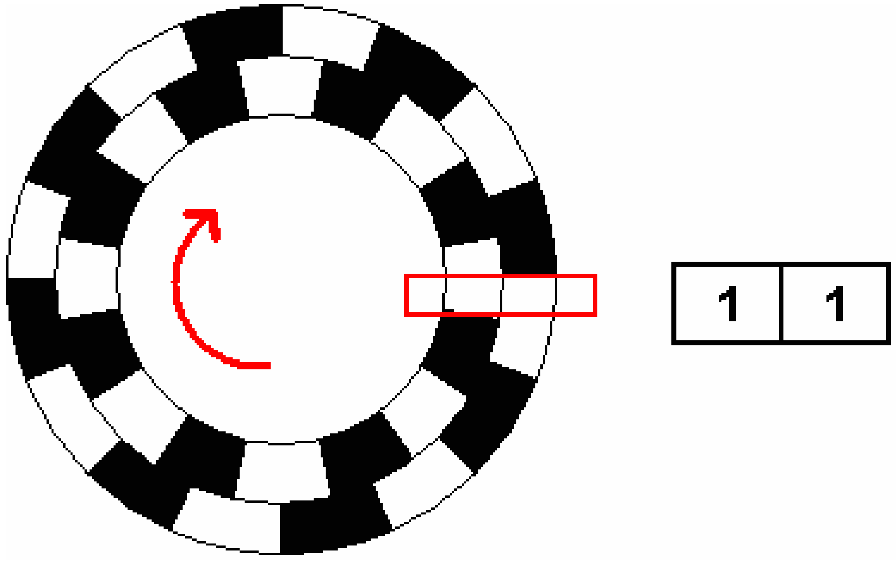
ABSOLUTE ENCODER

Lab 4

Types of encoders

How it works

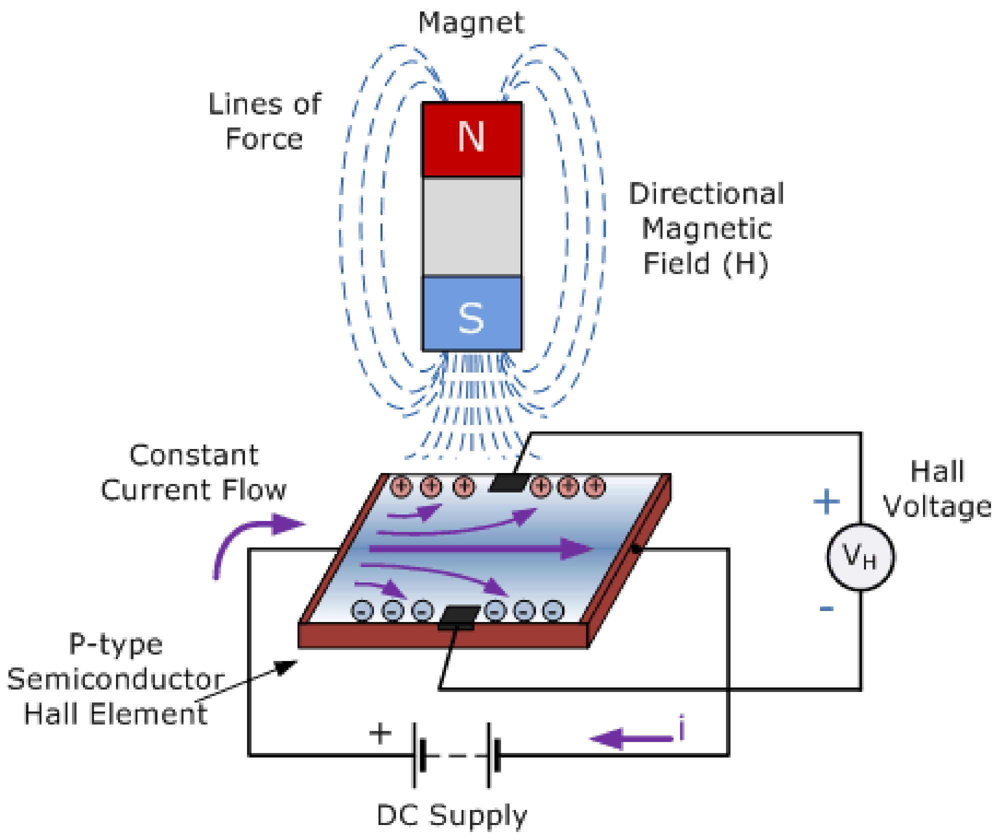


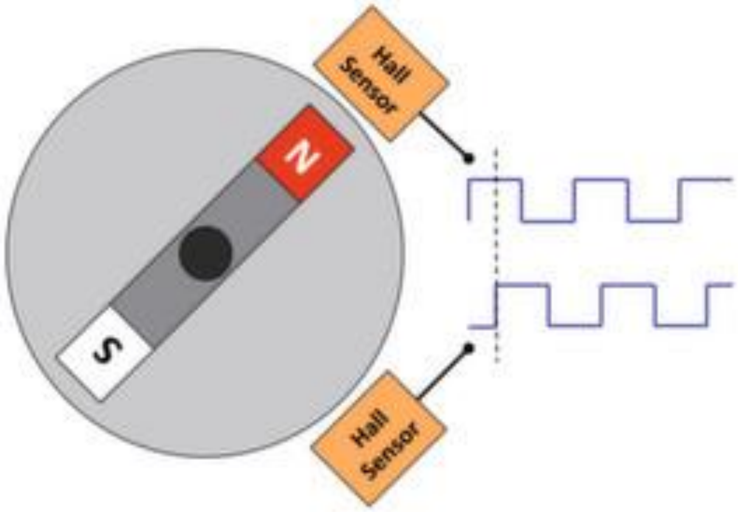


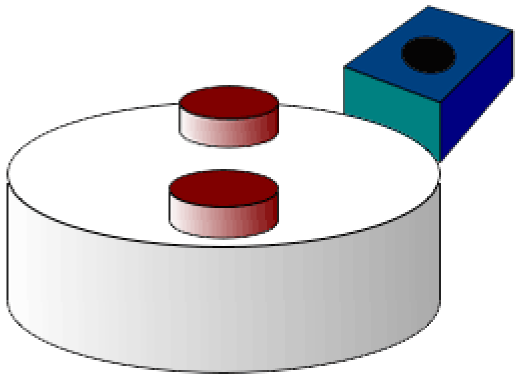
INCREMENTAL ENCODER

Types of encoders

How it works



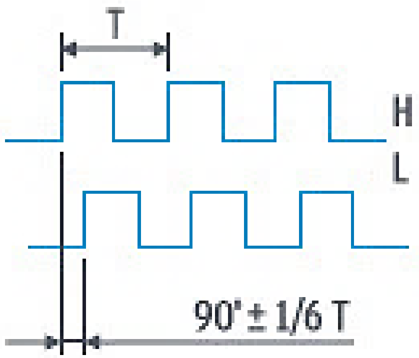




HALL/MAGNETIC

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?

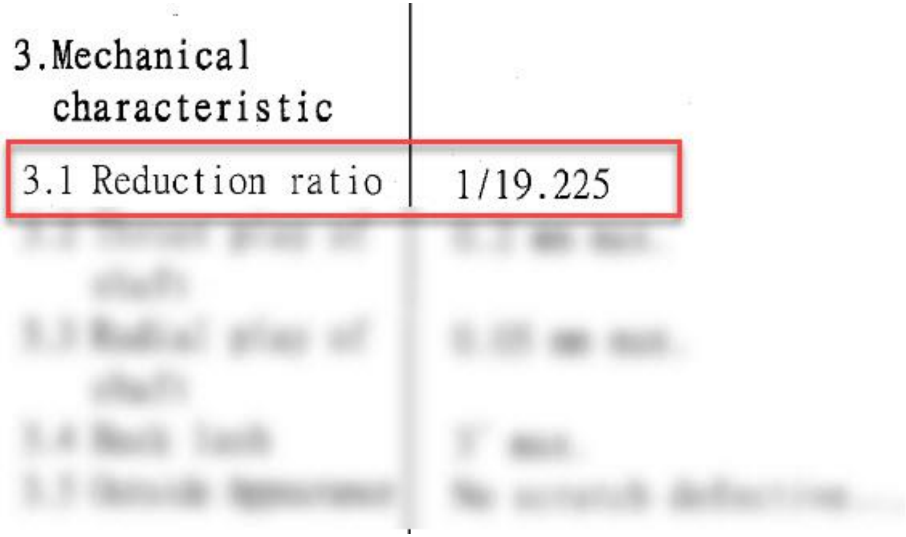
Can we increase the encoder resolution? XOR?

HALL/MAGNETIC

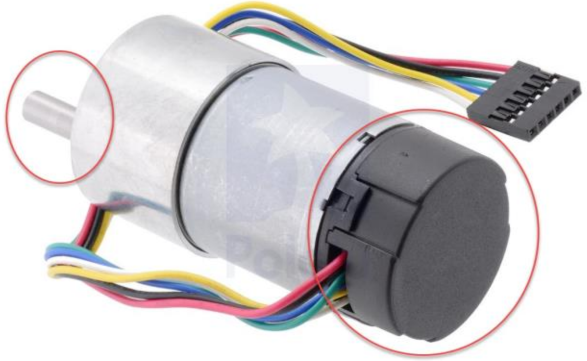
Lab 4

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

$$Encoder\ (PPR) = 6\ (poles) X\ 2 (channels) X\ 19 Reduction\ Ratio$$

$$Encoder\ (PPR) \cong 231$$

GEARED DC MOTOR

Lab 4

Encoders

Calculations

MATHEMATICAL FORMULAE

Basic calculations for incremental encoders

Formulations

Given

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

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

Computed

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

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

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

$$R_c = \frac{360^o}{N_s} = \frac{360}{60} = \frac{6^o}{step}$$

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

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

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

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

$$\because R_t = \frac{3^o}{step} \text{ and } \frac{Distance}{One\ Rotation} = 0.314\ m$$

$$\because C_t = 1240\ count$$

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

Basic calculations for incremental encoders

Formulations

Example

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

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

$\boldsymbol{Notation\ (continued)}$

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

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

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

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

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

Basic calculations for incremental encoders

Formulations

Notation (continued)

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

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

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

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

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

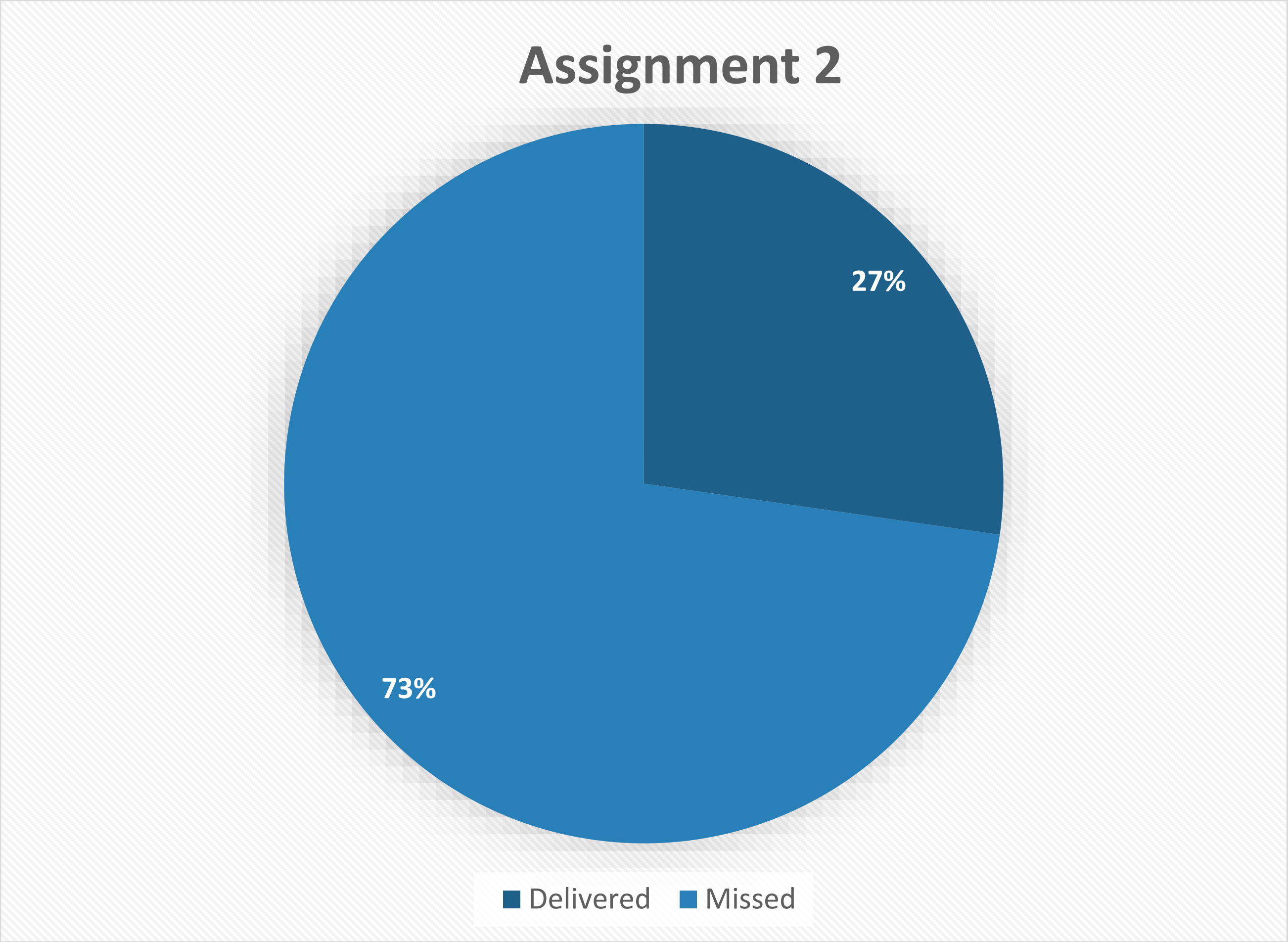
Assignment 3

An encoder fixed on a wheel of 10 cm diameter is rotating at speed of 20 Pulse Per Second. If the encoder has 5 slots around circumference, compute the distance travelled after 3 min.

Due 15-04-2020

PAST ASSIGNMENT

ASSIGNMENT



Waleed El-Badry

Don’t forget to pull the lab update from.

http://github.com/wbadry/mte405

END OF Lab 4