## ME425/625

Time Limit: 90-min

**Final Part 1 (Theory)**

 **Closed-book - worth 50% of Final Exam Grade**

1. Fill in the blanks for the following - some blanks may be multi-worde d ones **(20-points)**
	1. A is an electromechanical switch.
2. Since the PCF8574 can only source about 20 mA, an is needed.
3. The IRF510 is called a MOSFET and allows to flow when its gate pin is above a certain voltage (about 5 Volts) .
4. A 10-bit analog-to-digital converter results in (raw) decimal values ranging from 0 to

E. Shannon's sampling theorem puts a limit on the sampling time

1. Motors, relays and pneumatic valves are examples of
2. I2C is a low-speed, data transfer between integrated circuits
3. I2C has a interface consisting of data and clock lines
4. from the motor could kick-back enough current to damage the digital line.

J. Serial ports are asynchronous ; devices must agree to a rate a priori 2. Numbering systems **(20-points)**

Convert the following numbers. Show relevant calculations

A. 67 (from base 10 to base 2)

1. 608 (from base 10 to base 3)
2. 16 (from base 10 to base 8)
3. FF (from base 16 to base 10)

E. 1101 (from base 2 to base 3)

Given the following eight LED circuit, what decimal number inputs are needed to light the appropriate LEDs?

 

1. LEDs A0, A2 , A4, A6 and A7 on and the rest are off?
2. LEDs A1, A3 , A5, and A7 on and the rest are off?
3. LEDs A5 and A7 on and the rest off?

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* 1. LEDs A0, A1 , A2 , A3, A4, A6 on and the rest off?

J. LEDs A0 and A7 on and the rest off?

1. Motors and first order systems **(20-points)**

Given that the Open Loop Transfer Function for the NXT motor is given by $G\_{OL}=\frac{b}{s+a}=\frac{Ω(s)}{V(s)}$

Where the input is the motor command$ V(s) $and the output is motor velocity Ω(s)

Given a step input *v( t)* = $\left\{\begin{array}{c}0: t \leq 0\\M: t >0\end{array}\right.$

A. Show using ordinary differential equations that $ω(t)=\frac{Mb}{a}(1-e^{-at})$ **(5 points)**

B. Show using Laplace transform (table provided on last page) techniques that $ω(t)=\frac{Mb}{a}(1-e^{-at})$ **(5 points)**



C. What is the steady-state velocity? **(2-points)**

D. What is the rise-time - show relevant calculations? **(3-points)**

E. What is the transfer function relating input (motor command [%]) and output (motor velocity [RPM]) - show relevant calculations? **(5-points)**

4. Operational Amplifiers **(Total 20-points)**

A. What are the 2 rules and 5 properties of an ideal op-amp? **(5-points)**

B. Use the 2 rules to mathematically derive the input-output relationship of the op-amp below. This op-amp circuit converts what to what? **(10-points)**



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C. Sketch a non-inverting op-amp and mathematically derive its input-output relationship

**(10-points)**

5. Digital Systems and H-Bridge **(Total 20-points)**

Consider a 4-bit Digital-to-Analog Converter (DAC) **(2 points each)**

A What is the resolution in volts if the reference voltage is +SV

B. List all the possible analog voltages this DAC can deliver for +SV reference voltage

 C. Suppose you want an analog voltage of precisely 0.625V. What should the decimal number for a reference voltage of +SV?

 D. For the decimal number calculated above, suppose you want an analog voltage of precisely 0.6V. What should reference voltage be?

 E. What is the resolution in volts if one uses an 8-bit DAC and +SV reference voltage?

H-Bridge with 4 SPST switches S1;S2, S3, S4, a supply voltage VCC and GND **(2.5 points each)**

F. Sketch 1: Switch positions so that motor is free to rotate

G. Sketch 2: Switch positions so that motor rotates in one direction

H. Sketch 3: Switch positions so that motor rotates in the opposite direction of B

I. Sketch 4: Switch positions so that the motor is braked

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**Reference if needed:**

**Laplace Transform Table:**

