EE 391 (All Sections)

Midterm Examination

Friday, October 24, 2008

Time Allowed: 1.5 Hours

Materials allowed: Laboratory Notebooks, Design Reports, Calculators

Instructions:

- **Answer all questions in the space provided (use page backs for rough work if necessary)**
- **State your assumptions; show all relevant work. Box, circle or otherwise highlight your answers where appropriate. For multiple choice, circle the correct answer.**
- ***Put your <u>name</u> and <u>student number</u> on each page; (we may separate them for marking purposes)***
- **Refer to the last page for relevant product data when required**
- **Weighting for each question is indicated in the left margin (Total marks: 120)**

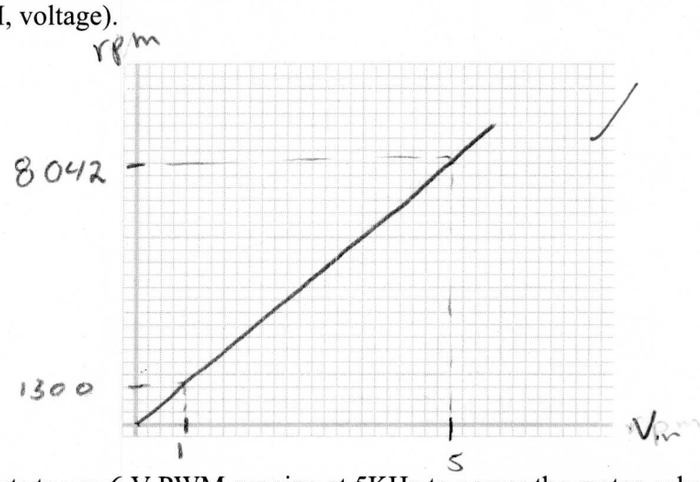
(Marker's use only.)

Governor	SPMS	Total
35 /40	25 /40	60 /80

Design Lab II – Electronic Governor

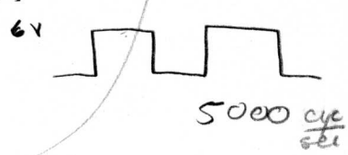
Q1.1) Draw the speed vs. voltage curve for the DC motor you used in the electronic governor design. Label two points in the graph with your actually measurements, indicating their values (velocity/RPM, voltage).

[3]



Q1.2) If a person wants to use 6 V PWM running at 5KHz to power the motor, what duty cycle (%) should be used to give an average DC voltage of 4 V?

[5]



$6V \times = 4V$

$\times = \frac{4V}{6V} = 0.667 = 66.7\%$

What duty cycle (%) would be required for the same *power* (i.e. Effective or RMS value) as 4VDC?

$P =$ 

$P_{out} = \frac{(1-\gamma) V_{out} I_{op}}{2}$

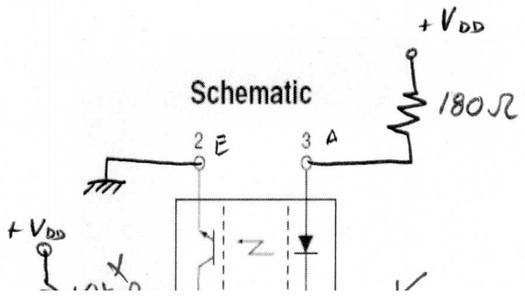
$P = \frac{(1-0.667)\,6V}{2} = 1W$

$P = 1W = \frac{(1-\gamma)(4V)}{2}$

$\frac{2}{4} = 1-\gamma \Rightarrow \gamma = 1-0.5 = 0.5$ **50%**

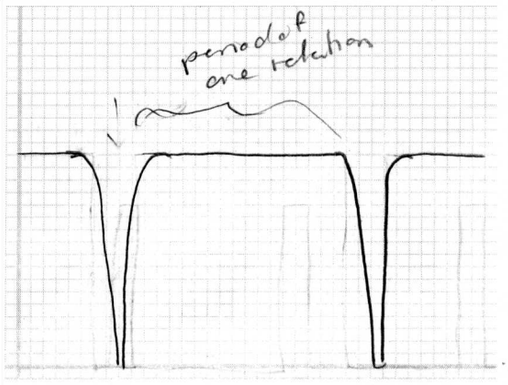
Q1.3) The QRD1113 Reflective Object Sensor was used to measure the speed of the motor. QRD1113 consists of an infra red LED and a photo transistor, which are optically coupled. The sensor characteristics are described by a line of specifications, that is, sensor current Ic(ON) is min. 0.3mA when the forward LED current is 20mA and the reflector is placed at 0.05".

[4] Complete the schematic diagram (below) for using the sensor by showing all the connections you made to get a sensor output for input to Comparator 1 of the PIC16F668.



Sketch a graph of the output signal showing the change when the reflector passes in front of the sensor. Be sure to label all relevant points.

[4] 4



Vc goes to ground when reflective tape passes in front of sensor b/c the transistor has been turned on.

Q1.4) You can use Comparator 1 of the PIC to "shape up" the sensor signal to be a rectangular pulse with sharp rising and falling edges. The threshold voltage (reference voltage) can be internally set with the register called VRCON. (The PIC reference manual describes VRCON – see extract in Appendix.)
Assume the sensor signal swings between 1.5 V to V_{DD} which is 5V, and a reference voltage of 3.5 V is desired. Determine the last four bits of VRCON (VR3,VR2,VR1,VR0) which will give a comparator reference voltage closest to 3.5V. Assume the rest of the bits are set as 1100, or VRCON= 0b1100nnnn (i.e. you must determine 'nnnn' to get a reference closest to 3.5V).

5

[3] 5

when VRR = 1
$CV_{ref} = (VR<3:0>/24) * V_{DD}$
* when VRR = 0
$CV_{ref} = V_{DD}/4 + (VR<3:0>/32) * V_{DD}$

VRCON= 1110 ✓

$\frac{VR<3:0>}{32} = 0.45 \Rightarrow VR<3:0> = 14.4 \simeq 14 = 1110$

Q1.6) The following C-program shows the skeleton of the program (1) to perform measurement of motor speed by means of Comparator 1 interrupts and (2) to regulate the motor speed by varying the duty cycle of PWM. Only those statements related to the Comparator 1 interrupt are shown:

[7]

```
interrupt void isr(void)
{     C1IF = 0;                  // turn comparator1 interrupt flag OFF
- Interrupt Service Routine -
}                                //end of interrupt service routine

void main()
{     //Set up comparators
      CM1CON0 = 0b10100100;
      //Comparator 1 on (bit7=1), C1 output present on C1OUT pin 6
(bit5=1)
      //C1 Reference C1Vin connected to C1Vref (bit2=1)
      //C1 Voltage Reference enabled (bit7=1), CVref voltage output
on C2IN+ (pin4)
      VRCON = 0b11001111;
      //Set up VREF For comparator at about 1.25 volt + 2.5 volts =
3.25 V
      C1RSEL = 1;                //this is bit 5 in CM2CON1
      // route C1REF to C1VREF input of Comparator 1
      TRISA &= 0b11101111;
      //C1OUT should be output pin 6, RA4/T0CKI/C1OUT
```

List the *functionalities* to be included in the Interrupt Service Routine to accomplish this, and any related function in the Main Program. Describe the functions required concisely in plain language. Do not write C-code.

[5]

Do you do all these in ISR? Nothing in MAIN?

In each ISR we need to read the value of timer1 to know the period of one rotation of the motor, we store this value in a count integer to find the rpm of the motor. To regulate the motor we compare count to a preset value of mycount in the main function & depending on whether count < mycount or count > mycount we can decrement or increment CCPR1L (duty cycle) accordingly.

must stop TMR1 at beginning of ISR & reset to 0 before restarting TMR1 at the end of ISR

No statement about MAIN

Q1.7) Which pin of PIC16F866:

do you feed the input signal to Comparator 1? pin 2, RA0 X

can you observe the reference signal for Comparator 1? pin 4, C2INT

can you observe the Comparator 1 output? pin 6, RA4

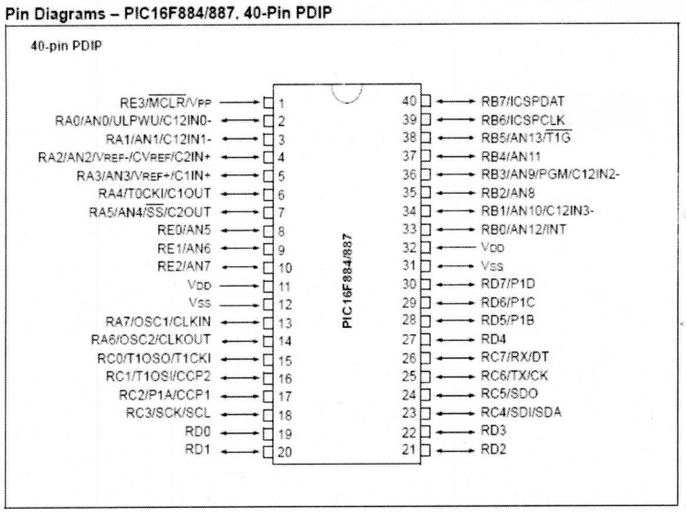
do you feed analog input, if analog channel 4 is selected? pin 7, AN4, RA5

do you get PWM output from Capture/Compare/PWM 1 (CCP1)? pin 13, RC2, CCP1

4/5

[5]

Pin Diagrams – PIC16F884/887, 40-Pin PDIP



[1]

Q1.8) Timer 1 is a 16 bit counter incremented every instruction cycle (8 µs). The upper 8 bits (High byte) is stored in TMR1H, and the lower 8 bits (Low byte) is stored in TMR1L.
Write code in C-language to combine those two bytes to make a 16 bit integer number of the total count. Including define statements for all variables used.

5 [4]

```
volatile unsigned int cantL, cantH;
volatile unsigned int cant;
```