EE345M Final Exam B Fall 2004 Solution

Jonathan W. Valvano December 12, 2004, 7-10pm

(10) Question 1. The first solution technique involves a bridge and instrumentation amplifier.

Part a) Ohm's Law $R=1000\Omega$, $V_{in} = 2.5V(1000/2000)-1.25V = 0V$.
$R=2000\Omega$, $V_{in} = 2.5V(2000/3000)-1.25V = 0.4167V$.

Part b) Gain is 5V/0.4167V = 12.

Part c) Resolution=Range/Precision, which is about (2000Ω-1000Ω)/1024 = 1Ω.

(10) Question 2. The second solution technique involves a current source and linear amplifier.

Part a) The plus terminal is 0V, and because of the negative feedback, the – terminal will also be 0V. Therefore, the current through the 1kΩ resistor is 2.5V/1kΩ = 2.5mA. Since no current goes in the op amp, this 2.5mA flows across the transducer R.

Part b) Using Ohms Law, the voltage range is $-2.5V < V_{in} < -5V$. There are two valid solutions. If you map –2.5V to 5V and –5V to 0V, then the equation is

$$V_{out} = 2V_{in} + 10$$

If you map –2.5V to 0V and –5V to 5V, then the equation is

$$V_{out} = -2V_{in} - 5$$

Part c) Resolution=Range/Precision, which is about (2000Ω-1000Ω)/1024 = 1Ω.

(10) Question 3. The third solution technique involves an astable and period measurement.

Part a) Using input capture, the period resolution is 250ns. The precision is 16 bits, so the maximum period that can be measured is 65536*0.25µs = 16384 µs.

Part b) $P(\mu s) = 0.693 \cdot C \cdot (R+2000)$. At maximum, $16384\ \mu s = 0.693 \cdot C \cdot (4000)$, so $C = 5.9\ \mu F$.

Part c) Using the above equation, the range of periods will be 12266 to 16354 µs, with a resolution of 0.25µs. So, the precision is 16352 alternatives. The resistance resolution=Range/Precision, which is about (2000Ω-1000Ω)/16352 = 0.06Ω. Another way to get the resolution is to pick two periods that the system can resolve. E.g., it can distinguish P=15000µs from 15000.25µs. The two resistances for these two periods are 1668.65Ω and 1668.71Ω, so the resolution is 0.06Ω.

(5) Question 4. First, you write $35678 in binary.

$35678 = 0011 0101 0110 0111 1000

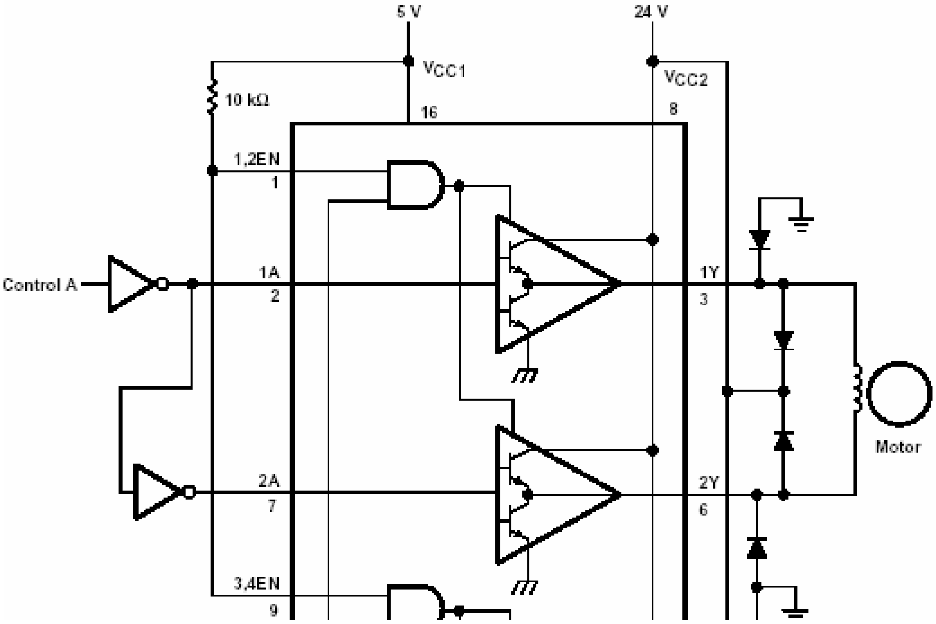
Since PPAGE is 16K, you take the bottom 14 bits for the offset and the rest for the page number

Offset = 01 0110 0111 1000
Page = 0011 01

The Page number is used directly, and $8000 is added to the offset to get the address to access

```
PPAGE = | 0x0D |;
data = *((char *)(| 0x9678 |));
```

(10) Question 5. The L293 is a good solution, from the data sheet change Vcc2 to +12V, connect 1,2EN to PT0 and ControlA to PT1



(10) Question 6. The worst case data available is the shortest interval, which will be the maximum of [80,100] and the minimum of [200,220].

DataAvailable = (100], 200)

The data required interval is the rise of the clock minus setup to rise of the clock plus the hold time

DataRequired = (?**Clk**-50,?**Clk**+20)

The worst case data required is the longest interval, which will be the minimum of [170,190] when considering setup and the maximum of [170,190] when considering hold time.

DataRequired = (170-50,190+20) = (120,220)

The data will **NOT** be properly stored, because it violates the hold time if the data available ends early at 200, and the ?**Clk** is late at 190).

(10) Question 7. A fuzzy logic controller

Part a) The first slope is 256/(165-80) = 3.0118, which we will approximate as 3. The second slope is 256/(240-197)= 5.9535, which we will approximate as 6.

```
Tab: dc.b 80,3,240,6
```

or

```
Tab: dc.b $50,$03,$F0,$06
```

Part b) The Fuzzy Logic **OR** is the maximum. The Fuzzy Logic **AND** is the minimum

```
     Healthy+Wise= 200  (maximum of 200,50)
     Happy*200 = 100    (minimum of 200,100)
```

Part c) Show the ROM-based data structure uses the 8-bit index, not 16-bit address

```
Rules: dc.b happy,healthy,$FE,good,$FE ; good=good+happy*healthy
       dc.b happy,wise,$FE,good,$FE    ; good=good+happy*wise
       dc.b $FF
```

(10) Question 8. Design an analog circuit

Step one, rewrite with reference chip voltage (none needed).

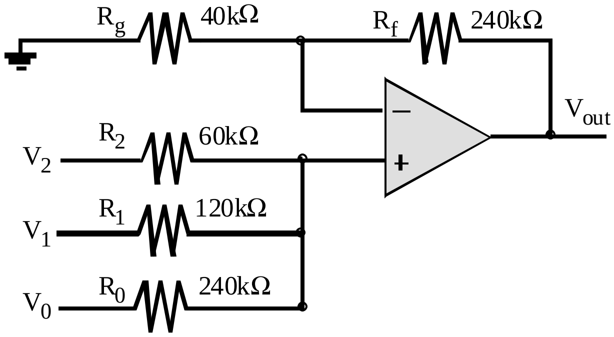
$$V_{out} = 4V_2 + 2V_1 + V_0$$

Step two, add a ground as a extra input, with a gain such that the sum of the gains is 1.

$$V_{out} = 4V_2 + 2V_1 + V_0 - 6\ V_g$$

Step three, choose a feedback resistor which is a common multiple of 1,2,4,6. R_f=240kΩ.

Step four, select four input resistors to get the desired gains.



(25) Question 9.

```
int Path[4][4]={ /*   Init    InChar  OutChar   Close */
/*            column    0        1       2        3    */
/* Init    row 0*/ {  0    ,    1    ,   1    ,   1   },
/* InChar  row 1*/ {  0    ,    1    ,   1    ,   1   },
/* OutChar row 2*/ {  0    ,    1    ,   1    ,   1   },
/* Close   row 3*/ {  1    ,    0    ,   0    ,   0   }};
```

Part b)

```
void SCI_Init(void){
  if(Path[State][0]==0) OS_Kill();  // kill if illegal
  State = 0;                        // perform valid Init
  SCIBD = 13;
  SCICR1 = 0;
  SCICR2 = 0x0C;
}
char SCI_InChar(void){
  if(Path[State][1]==0) OS_Kill();  // kill if illegal
  State = 1;                        // perform valid InChar
  while((SCISR1 & RDRF) == 0){};
  return(SCIDRL);
}
void SCI_OutChar(char data){
  if(Path[State][2]==0) OS_Kill();  // kill if illegal
  State = 2;                        // perform valid OutChar
  while((SCISR1 & TDRE) == 0){};
  SCIDRL = data;
}
void SCI_Close(void){
  if(Path[State][3]==0) OS_Kill();  // kill if illegal
  State = 3;                        // perform valid Close
  SCICR2 = 0x00;
}
```