UNIVERSITY OF CALIFORNIA, RIVERSIDE

Department of Computer Science and Engineering

CS/EE120B – Introduction to Embedded Systems

Final

Summer 2 August 30, 2002

20

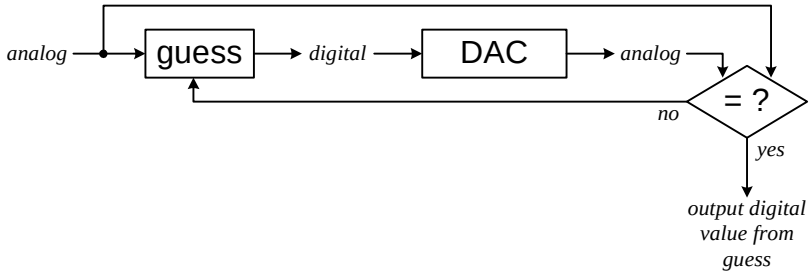
Name: Solution Key **Student ID#:**

Please print legibly

(Numbers in parenthesis denote total possible points for question.)

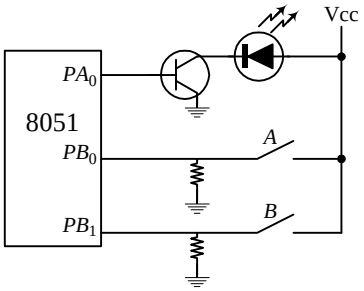
1. Explain how an ADC works. (4)

Answer



Given an analog input signal, a guess circuit guesses what the digital value should be. This digital value is inputted into a DAC. The resulting analog signal is compared with the original analog signal. If they are equal, then the guess digital signal is outputted. Otherwise the guessing continues. The guessing can be similar to a binary search algorithm.

2. Given the circuit shown on the right, write a segment of code that will turn on the LED at 75% brightness when button *A* is pressed and at 50% brightness when button *B* is pressed. The code has to continuously sense when button *A* or *B* is pressed. The LED stays on at the current brightness when no key is pressed.



(4)

Answer

```
while(1){
     if(PB0 == 1){ // button A pressed
          // delay for the on and off must be 75% duty cycle
          ontime = 75;
          offtime = 25;
     }else if(PB1 == 1) {               // button B pressed
          // delay for the on and off must be 50% duty cycle
          ontime = 50;
          offtime = 50;
     }
     // the following on/off must be outside of the above IF, otherwise
     // the LED is off when no key is pressed
     PA0 = 1;      // turn on LED
     for(I=0;I<ontime;I++) ;         // delay
     PA0 = 0;      // turn off LED
     for(I=0;I<offtime;I++) ;        // delay
}
```

3. Instead of the circuit from question 2, a special IC can also be used to control the brightness of the LED. What is the functional name for this IC? (2)

Answer

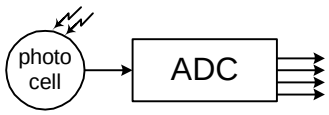
A *pulse width modulator*.

4. Describe the signaling on the USB D+ and D- lines that represents a logic 0 and logic 1. (2)

Answer

A logic 0 is when the voltage of D- is higher than the voltage of D+. A logic 1 is just the reverse.

5. A photocell that converts light to electricity is connected to the analog input of a 4-bit ADC as shown in the figure on the right. This photocell is capable of outputting 10v maximum, but on this particular day, this photocell is only outputting $3\frac{1}{3}$ v. What is the value of the digital signal that the ADC outputs? (4)



Answer

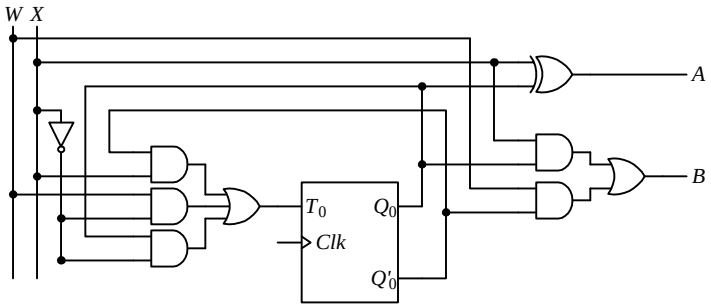
The equation to use is

$$\frac{\text{analog V}}{V_{max}} = \frac{\text{digital value}}{2^n - 1}$$

$$\frac{3\frac{1}{3}\text{v}}{10\text{v}} = \frac{\text{digital value}}{2^4 - 1}$$

digital_value = $5_{10} = 00101_2$

6. Derive the state diagram for the following sequential circuit. (4)



Answer

Excitation equation:

$T = Q'X + WX' + QX'$

Characteristic equation for the T flip-flop:

$Q_{next} = TQ' + T'Q = T \oplus Q$

Next-state equation:

$Q_{next} = TQ' + T'Q$
$= (XQ' + WX' + X'Q)Q' + (XQ' + WX' + X'Q)'Q$
$= XQ' + WX'Q' + \cancel{X'QQ'} + (XQ')'(WX')'(X'Q)'Q$
$= XQ' + WX'Q' + (X'+Q)(W'+X)(X+Q')Q$
$= XQ' + WX'Q' + \cancel{X'W'XQ} + \cancel{X'W'Q'Q} + \cancel{X'XXQ} + \cancel{X'XQ'Q} + QW'XQ + \cancel{QW'Q'Q} + QXXQ + \cancel{QXQ'Q}$
$= XQ' + WX'Q' + W'XQ + XQ$
$= X + WX'Q' + W'XQ$

Output equations:

$A = Q \oplus X$ $B = QX + Q'W$

Next-state / output table:

Current	Next State Q_{next} / Output A,B			
State	WX			
Q	00	01	11	10
0	0/A=B=0	1/A=1,B=0	1/A=0,B=1	1/A=B=1
1	0/A=1,B=0	1/A=0,B=1	1/A=1,B=0	0/A=0,B=1

State diagram: