EE361 Microcomputer-Based Digital Design

Quiz 2 Solution

Open book, open notes.

Name: _____
Section: _____
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There is another problem on the back of this sheet.

1. Consider the schematic drawing in Figure 1. If the LED drops 1.4 V when it is conducting and if the supply voltage is $V_{\text{DD}} = 3.5$ V, what value of 5%-accurate resistor R should you choose in order to limit the current to not more than 10 mA? The values of 5%-accurate resistors are multiples of 1, 11, 12, 13, 15, 16, 18, 2, 22, 24, 27, 3, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, and 91.

   Solution

   By Kirchoff's voltage law and Ohm's law,

$$\begin{aligned} V_{\text{DD}} &= V_R + V_D \\ &= I_R R(1 \pm 0.05) + V_D. \end{aligned}$$

   Solving for R yields

$$\begin{aligned} R &= \frac{V_{\text{DD}} - V_D}{I_R(1 \pm 0.05)} \\ &= \frac{3.5\text{ V} - 1.4\text{ V}}{(10\text{ mA})(1 \pm 0.05)} \\ &\in [200\ \Omega, 221.1\ \Omega]. \end{aligned}$$

   If the current is to be kept lower than the specified value, then we should round this up to the next standard size, $\boxed{240\ \Omega.}$

   We should check that this choice prevents the current from being too high:

$$\begin{aligned} I_R &= \frac{V_{\text{DD}} - V_D}{R(1 \pm 0.05)} \\ &= \frac{3.5\text{ V} - 1.4\text{ V}}{(1 \pm 0.05)(240\ \Omega)} \\ &\leq 9.2\text{ mA} \\ &< 10\text{ mA}. \end{aligned}$$

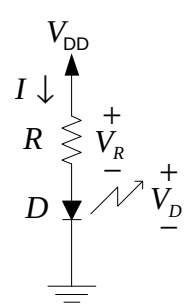

Figure 1: Problem 1

2. This table shows the contents of three registers in the PIC16F884:

Address	**Contents**
0x0E	135_{10}
0x0F	254_{10}
0x10	165_{10}

How long will it be before Timer 1 is cleared (becomes zero again) if the PIC is being driven by an oscillator with frequency $f_{\text{OSC}} = 15\,\text{MHz}$?

Solution

Address 0x0E is the TMR1L register; address 0x0F is the TMR1H register. TMR1L holds the value $135_{10} = 87_{16}$ and TMR1H holds the value $254_{10} = \text{FE}_{16}$. Taken as a 16-bit pair, TMR1H:TMR1L contains the 16-bit number $\text{FE87} = -0179_{16} = -377_{10}$. So Timer 1 will take 377 increment cycles before it is cleared.

Address 0x10 is the T1CON register and it contains the bit pattern $165_{10} = \text{A5} = 1010\,0101_2$.

Bit 0 is 1, so TMR1ON is asserted: Timer 1 is on.

Bit 1 is 0, so TMR1CS specifies that the internal clock drives Timer 1, that is, the basic period is $T_{\text{INST}} = 4/f_{\text{OSC}} = 267\,\text{ns}$.

Bit 2 is 1, so $\overline{\text{T1SYNC}}$ is true, but this is immaterial because TMR1CS is 0.

Bit 3 is 0, so T1OSCEN is true and the LP oscillator is off. This doesn't matter anyway because the instruction clock, not the external input, is driving Timer 1.

Bits 5–4 are 10, so T1CKPS specifies a 1:4 prescale value.

Bit 6 is 0, so TMR1GE is 0. This means that Timer 1 is always counting, since TMR1ON is true.

Bit 7 is 1, so T1GINV is true, but with TMR1GE false, the value of T1GINV is immaterial.

So Timer 1 will count $(377)(4)(267\,\text{ns}) = 402.1\,\mu\text{s}$.