EE461 Microprocessor-based Digital Design

Asynchronous Serial I/O

1. Suppose you have two quartz crystals available. One is nominally a 6.0 MHz crystal; the other is nominally a 5.0 MHz crystal. Choose the best crystal and find the optimal settings for the Baud rate generator of a PIC16F874 operating in HS oscillator mode which will give the least possible error at 19200 BAUD. Be sure to explain your reasoning fully.

SOLUTION

The formula for computing BAUD rate is given in Table 10-1 of the PIC16F87X data sheet and can be expressed as

$$f_{BAUD} = \frac{f_{OSC}}{16(4 - 3m)(x + 1)}$$

where

$$m = \text{BRGH} \in 0,1 \text{ and}$$
$$x = \text{SPBRG} \in [0,255].$$

Solving for the unknown quantities in the denominator, we have

$$(4-3m)(x+1) = f_{OSC} / 16 f_{BAUD}$$

Considering first the case where f_{OSC} = 6.0 MHz, we want

$$(4 - 3m)(x + 1) = \frac{6.0\text{MHz}}{16(19.200\text{ kBAUD})}$$

$$= 19.531.$$

The two solutions are m = 0, x = 4 and m = 1, x = 19. The first of these yields BAUD rate

Fbaud = 6.0Mhz / 16*4-3(0))(4+1) = 18.750kBaud

The second of these also yields BAUD rate

fBaud = 6.0MHZ / 16(4-3(1))(19+1) = 18.750kBAUD

Considering now the second case where f_{OSC} = 5.0 MHz, we want

$$(4 - 3m)(x + 1) = 16\left(\frac{5.0\text{MHz}}{19.200\text{ kBAUD}}\right)$$

$$= 16.276.$$

The two solutions are $m = 0$, $x = 3$ and $m = 1$, $x = 15$. The first of these yields BAUD rate

fBAUD = 5.0MHZ/ 16(4-3(0))(3+1) = 19.531kBAUD

The second of these also yields BAUD rate

fBAUD = 5.0MHZ/ 16(4-3(1))(15+1) = 19.531kBAUD

The only question left, then, is which crystal to choose, since the two solutions for each crystal are equivalent. The relative error is given by

p = rate achieved - rate desired/ rate desired

$$p = \left(\frac{(18.750\text{kBAUD})-(19.200\text{kBAUD})}{19.200}\right. = -2.34\% \quad \text{if fosc} = 6.0$$

$$p = \left(\frac{(19.531\text{kBAUD})-(19.200\text{kBAUD})}{19.200}\right. = 1.73\% \quad \text{if fosc} = 5.0$$

We can conclude that either of the two solutions with f_{OSC} = 5.0 MHz will do. We can pick either BRGH = 0 with SPBRG = 3 or BRGH = 1 with SPBRG = 15.