Solutions for Midterm #1 - EECS 145M Spring 2009

1.1 Edge-triggered D-type flip-flop:
one digital data input
one digital clock input
one digital data output
the output is set equal to the input on every rising edge of the clock

1.2 Transparent latch:
one digital data input
one digital gate input
one digital data output
the output is equal to the input when the gate signal is high
the output does not change when the gate signal is low

1.3 Sample and hold amplifier
one analog data input
one digital control input
one analog data output
the output is equal to the input when the control is set to sample mode
the output does not change when the control is set to hold mode

1.4 Tri-state buffer
one digital data input
one digital "output enable" input
one digital data output
the output is equal to the input when the "output enable" signal is low
the output is high impedance when the "output enable" signal is high

1.5 A/D converter (12 bit)
one digital "start conversion" input
one analog input
one digital "data available" output
one 12-bit digital output
Note: V_{ref}^{+} and V_{ref}^{-} are also needed, but no points were deducted if these were omitted

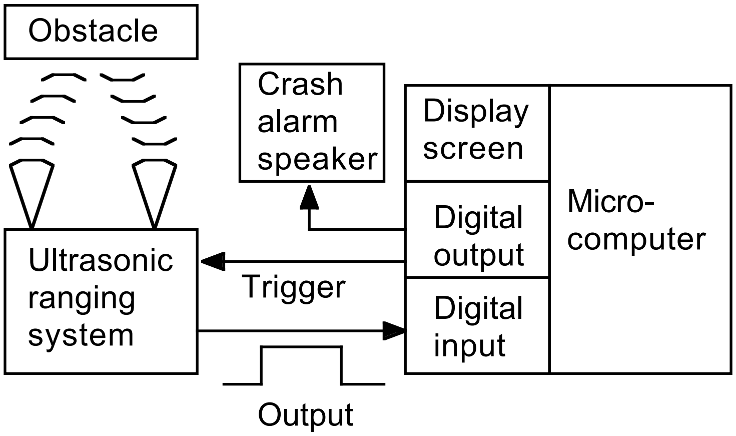
2 Error 1: clock input is pulsed in step 2 before input is asserted. Fix by asserting the input before providing the clock edge (reverse second part of step 2 and first part of step 3)

Error 2: the external circuit never resets "input data available" to FALSE so that step 4 is executed and the program reads the flip-flops over and over again, without regard for when the external circuit asserts and clocks new data. Fix by adding a step 6 so that the external circuit sets "input data available" FALSE when it detects "ready for input data" FALSE

[3 points off for only reversing steps 2 and 3- this sets "input data available" before the flip-flops are clocked and could cause the program to read data too soon]

[10 points off for missing either error]

3.1



- A trigger pulse causes the ultrasonic ranging system to emit an ultrasonic pulse and output a low-to-high edge.
- When the echo is received, the output pulse goes high-to-low

3.2

1) set trigger output low
2) read T1 = microsecond clock value
3) set trigger output high
4) set trigger output low
5) read T2 = microsecond clock value
6) if T2 > T1 + 200,000 go to step 2)
7) read input port
8) if low, go to step 5)
9) if high, compute distance d = (T2-T1) * c/2
10) approach speed = (previous d minus new d)/0.2 sec
    (go to step 13) on first iteration)
11) display distance and approach speed
12) if (distance in ft) < (approach speed in ft/sec), sound the alarm
13) read T3 = microsecond clock value until T3 > T1 + 200,000
14) loop back to step 2)

Note: step 6) handles the case of no echo for 200 ms; it was not required for full credit

[3 points off if an echo return < 200 ms will start another trigger without waiting the remainder of the 200 ms]

[3 points off for not reading the microsecond clock]

[3 points off for velocity = $(d_2 - d_1)/(t_2 - t_1)$]

[5 points off for not pulsing at 5 Hz]

[3 points off for incorrectly calculating alarm condition]

3.3 $\bar{t} = \frac{1}{100}\sum_{i=1}^{100} t_i \qquad \sigma_t^2 = \frac{1}{99}\sum_{i=1}^{100}\left(t_i - \bar{t}\right)$

3.4 (1) $d = (c/2)t \quad \sigma_d = (c/2)\,\sigma_t$

(2) $s_i = (d_i - d_{i-1})/\Delta T = (c/2)\,(t_i - t_{i-1})/(0.2\text{ s})$
Note: d_i and d_{i-1} are two measurements of distance taken $\Delta T = 0.2$ s apart

(3) $\sigma_s^2 = (c/0.4\text{ s})^2\,(\sigma_t^2 + \sigma_t^2) = (c/0.4\text{ s})^2\,(2\sigma_t^2)$

[1 point off for $\sigma_d = c\sigma_t$]
[3 points off for $\sigma_d = \sqrt{c}\sigma_t$]
[3 points off for $\sigma_d = \frac{c}{t^2}\sigma_t$]
[3 points off for $s_i = c/(t_i - t_{i-1})$]
[3 points off for $s_i = (d_i - d_{i-1})/(t_i - t_{i-1})$]
[3 points off for $s_i = (d_i - d_{i-1})/t_i$]
[3 points off for $s_i = d_i/(t_i - t_{i-1})$]
[3 points off for $s_i = t_{i-1}/t_i$]

3.5 $\sigma_{\bar{d}}^2 = \sigma_d^2/5 \qquad \sigma_{\bar{s}}^2 = \sigma_s^2/5$

Averaging five values will decrease the standard deviation of the distance and relative speed by the square root of five. The disadvantage is that it will take one second to fully register an abrupt change in relative speed.
[1 point of for 200 ft]

3.6 The system will not be able to determine the distance to an obstacle if the echo arrives after the next emitted pulse, i.e. after 0.2 s. This distance = (1 ft/ms) (1/2) (0.2 s) = 100 ft.

EECS145M Midterm #1 class statistics:

Problem	max	average	rms
1	30	27.6	2.6
2	20	18.6	2.8
3	50	35.4	8.3
total	100	81.6	10.7

Grade distribution:

Range	number	*approximate* letter grade
40-49	0	F
50-59	0	D
60-69	2	C
70-79	3	B
80-89	7	A–, B+
90-99	3	A
100	0	A+