ASEN 5067: Lab 4

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1. "DB" is used to initialize storage as bytes in the program memory. The label preceding "DB" is used in the mainline code to point to the constant. The argument after "DB" is a comma-separated list of expressions that are compiled into one byte each and stored in consecutive program memory locations.
2. LCDstr stores 0x33, 0x32, 0x28, 0x01, 0x0C, 0x06, & 0x00 in program memory.
3. For "LCDstr," the instruction listed is RRCF 0x33, F, ACCESS. In binary this is: 0011 0010 0011 0011B, or in hex, 0x3233. This corresponds to the first two bytes defined by the "LCDstr" label. This does make sense as an interpretation of the hex that is placed at 0x9A2, but it is interesting that the remaining four bytes of "LCDstr" do not have a similar disassembly listing but do show up in the program memory view window.
4. I use three timers to meet the main loop timing requirements: Timer0, which runs for 250 ms; Timer 1 which runs for 20 ms, and Timer 3 which runs from 1 ms to 2 ms in 0.2 ms steps. Each was a 16-bit timer. To find the

proper configuration, I divided the delay desired by the time it takes for 1 instruction cycle to find the total number of events required. I divided the total number of events by 2^{16} events to find the appropriate prescaler. Then, I divided total number of events required by the prescaler to determine the number of events to subtract from 2^{16} events. Then, I configured the timer control registers, loaded the appropriate numbers into the timer registers, and started each one. The main loop continuously checks the Timer overflow bits to trigger events properly.
Math reproduced below:

250 ms - Timer 0

$\frac{250\,ms}{250\,ns} = 1M$ resolution = 250 ns · 16 = 4 µs

$\frac{1M}{2^{16}} = 15.2 \rightarrow 16$ prescale

$\frac{1M}{16} = 62{,}500$ events

T0CON = 0x8083

TMR0 = 65536 - 62500

20 ms - Timer 1 resolution = 250 ns · 2 = 0.5 µs

$\frac{20\,ms}{250\,ns} = 80K \rightarrow \frac{80K}{2^{16}} = 1.2207 \rightarrow$ prescale = 2 $\rightarrow \frac{80K}{2} = 40{,}000$

T1CON = 0x8030 T1CON<0> = 1 to start

TMR1 = 65,536 - 40,000

1 ms - Timer 5 (through 2ms) resolution = 256 ns

$\frac{1\,ms}{256\,ns} = 4{,}000$ → prescale = 1 ; $\frac{1.2\,ms}{256\,ns} = 4{,}800$; $\frac{1.4\,ms}{256\,ns} = 5{,}600$; $\frac{1.6\,ms}{256\,ns} = 6{,}400$

$\frac{1.8\,ms}{256\,ns} = 7{,}200$; $\frac{2.4\,ms}{256\,ns} = 8000$

T5CON = 0x8010

1 ms: TMR5 = $2^{16} - 4{,}000$ 1.2 ms: TMR5 = $2^{16} - 4{,}800$

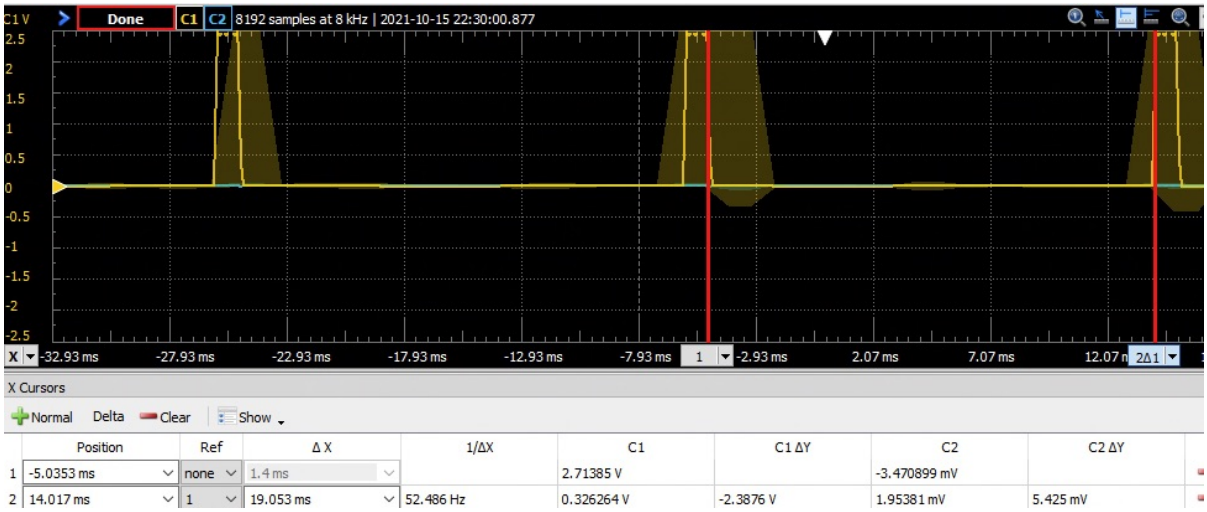
1.4 ms: TMR5 = $2^{16} - 5{,}600$ 1.6 ms: TMR5 = $2^{16} - 6{,}400$

1.8 ms: TMR5 = $2^{16} - 7{,}200$ 2.0 ms: TMR5 = $2^{16} - 8{,}000$

5. The photos show the PWM timing! The "Δx" near the bottom of each photo clearly shows the PWM signal is accurate to 100 µs.

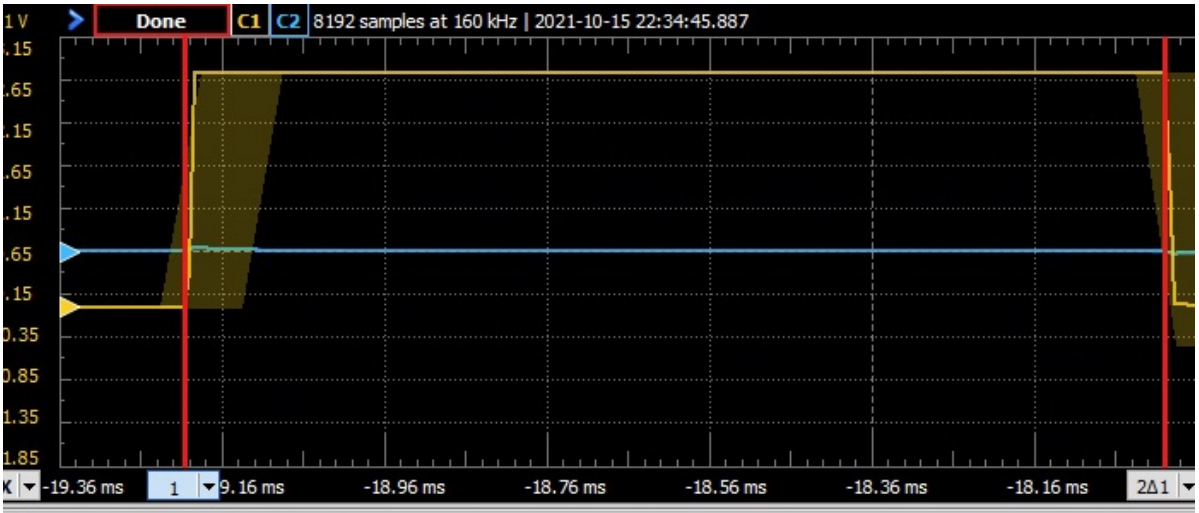
5% Duty cycle (on):

5% Duty cycle (off):



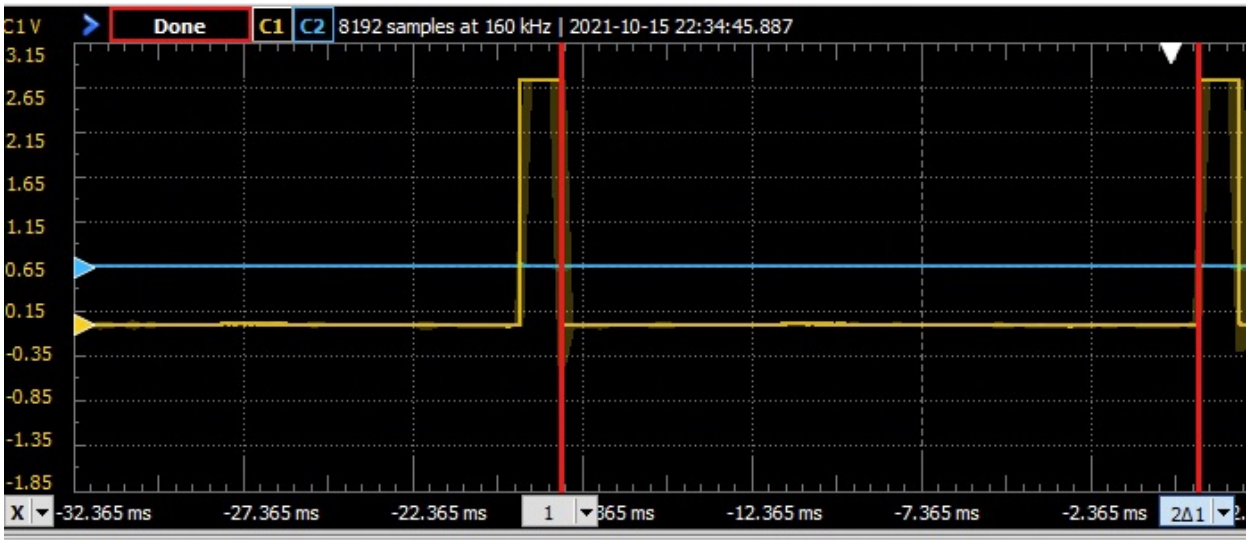
	Position	Ref	Δ X	1/ΔX	C1	C1 ΔY	C2	C2 ΔY
1	-5.0353 ms	none	1.4 ms		2.71385 V		-3.470899 mV	
2	14.017 ms	1	19.053 ms	52.486 Hz	0.326264 V	-2.3876 V	1.95381 mV	5.425 mV

6 % Duty cycle (on):



	Position	Ref	Δ X	1/ΔX	C1	C1 ΔY
1	-19.207 ms	none	1.4 ms		-0.013453 V	
2	-18 ms	1	1.2063 ms	828.97 Hz	2.71385 V	2.727 V

6% Duty cycle (off):

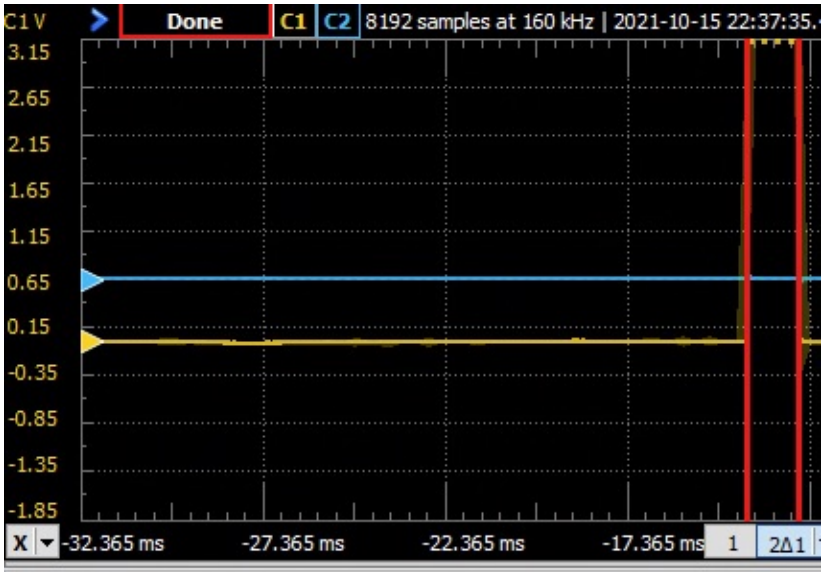


X Cursors

Normal Delta Clear Show

	Position	Ref	Δ X	1/ΔX	C1	C1 ΔY
1	-18.049 ms	none	1.4 ms		2.71385 V	
2	740.26 us	1	18.789 ms	53.221 Hz	-8.496301 mV	-2.7223 V

7% Duty cycle (on):

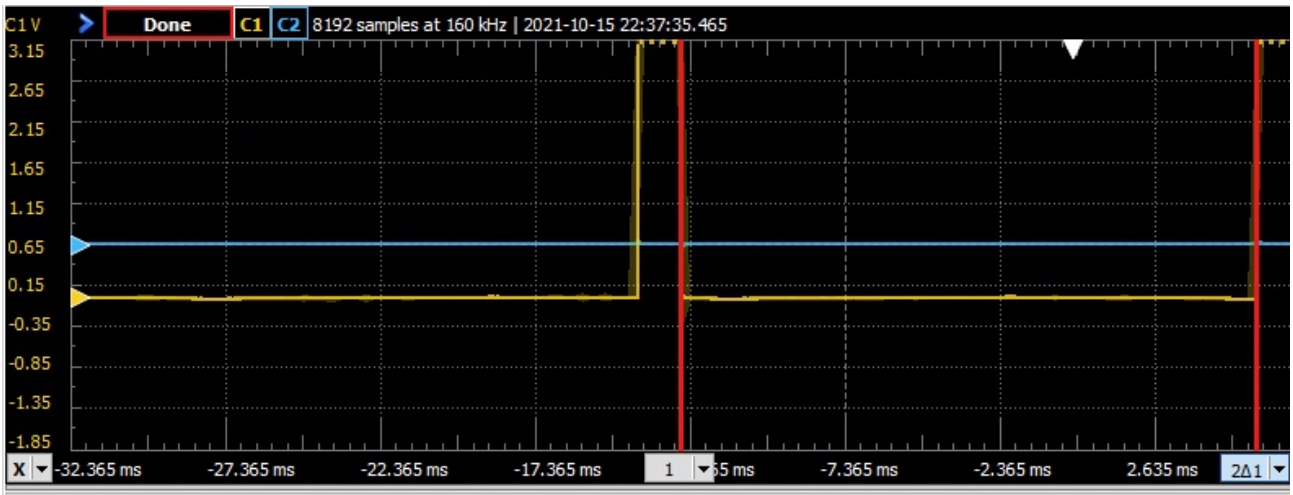


X Cursors

Normal Delta Clear Show

	Position	Ref	Δ X	1/ΔX
1	-14.154 ms	none	1.4 ms	
2	-12.733 ms	1	1.4211 ms	703.7 Hz

7% Duty cycle (off)

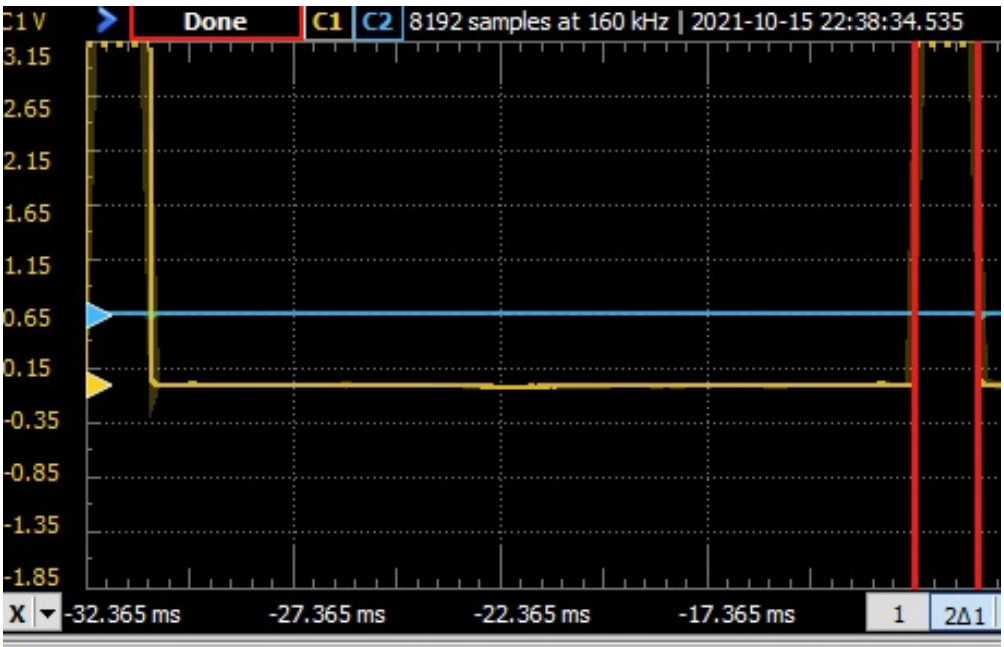


X Cursors

Normal Delta Clear Show

	Position	Ref	Δ X	1/ΔX	C1	C1 ΔY	C2
1	-12.733 ms	none	1.4 ms		3.2752 V		0.620603 mV
2	5.8455 ms	1	18.579 ms	53.824 Hz	-0.01889 V	-3.2941 V	5.95064 mV

8% Duty cycle (on):

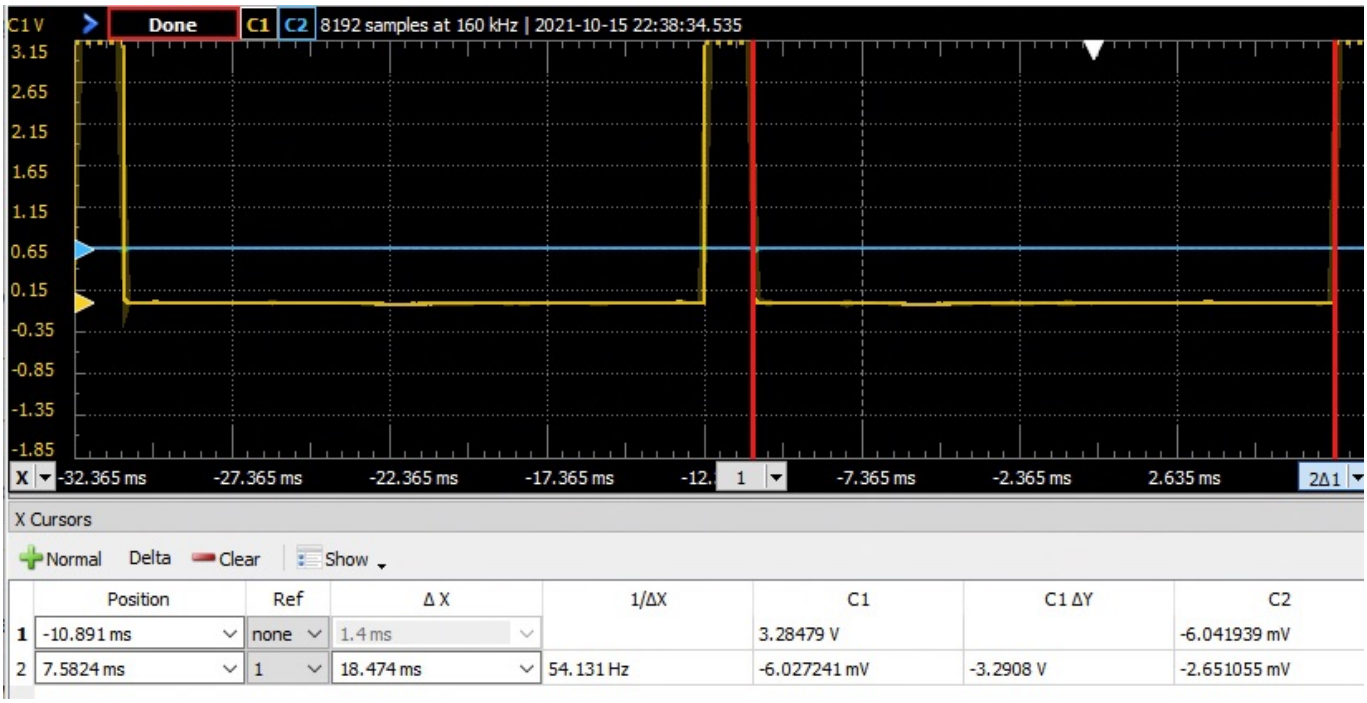


X Cursors

Normal Delta Clear Show

	Position	Ref	Δ X	1/ΔX	
1	-12.418 ms	none	1.4 ms		1
2	-10.891 ms	1	1.5263 ms	655.17 Hz	3

8% Duty cycle (off):

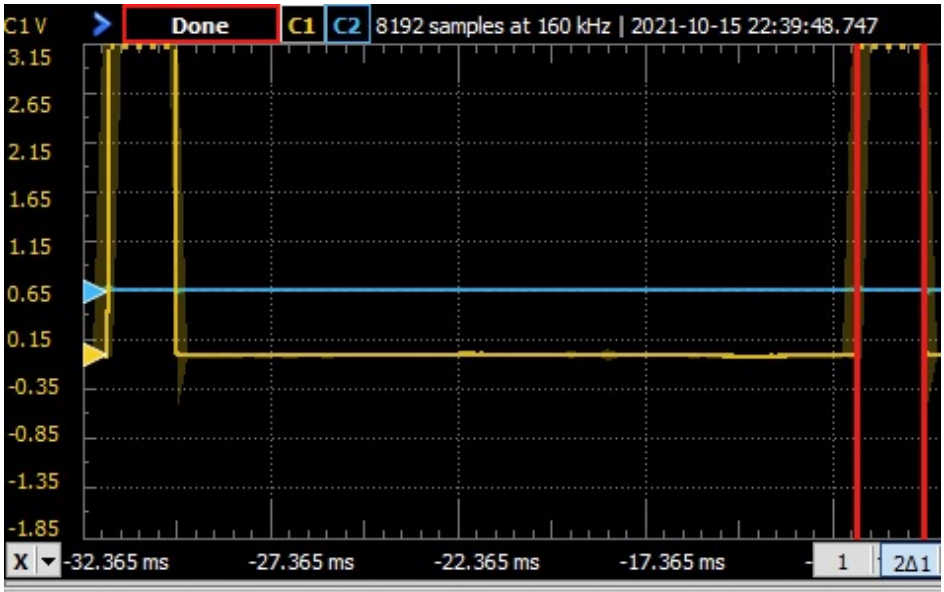


X Cursors

Normal Delta Clear Show

	Position	Ref	Δ X	1/ΔX	C1	C1 ΔY	C2
1	-10.891 ms	none	1.4 ms		3.28479 V		-6.041939 mV
2	7.5824 ms	1	18.474 ms	54.131 Hz	-6.027241 mV	-3.2908 V	-2.651055 mV

9% Duty cycle (on):

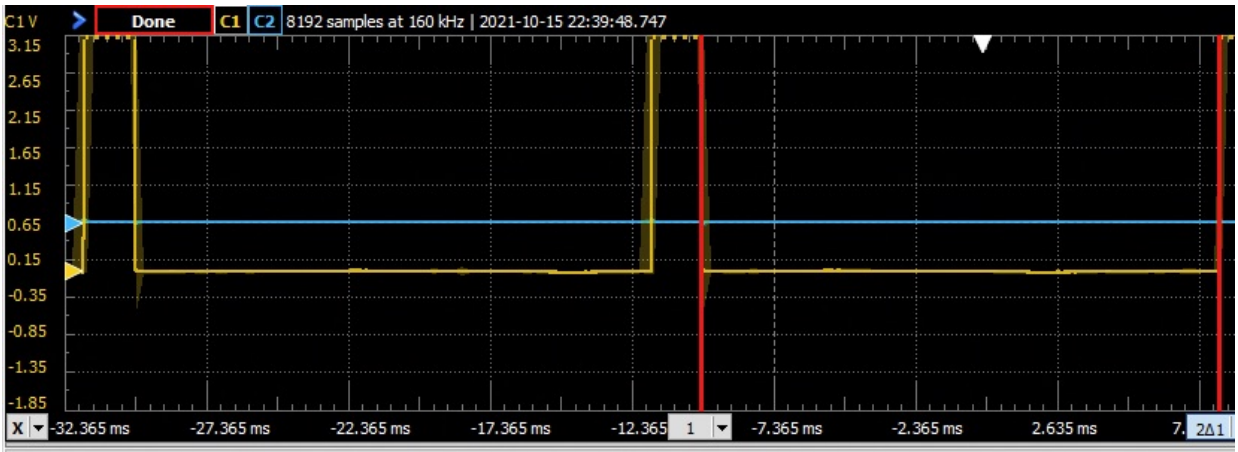


X Cursors

Normal Delta Clear Show

	Position	Ref	Δ X	1/ΔX	
1	-11.786 ms	none	1.4 ms		-0.0
2	-9.9966 ms	1	1.7895 ms	558.82 Hz	3.27

9% Duty cycle (off):



X Cursors

Normal Delta Clear Show

	Position	Ref	Δ X	1/ΔX	C1	C1 ΔY	C2
1	-9.9966 ms	none	1.4 ms		3.27664 V		1.61998 mV
2	8.2666 ms	1	18.263 ms	54.755 Hz	-8.517538 mV	-3.2852 V	0.070067 mV

10% Duty cycle (on):

X Cursors

Normal Delta Clear Show

	Position	Ref	Δ X	1/ΔX	C
1	-10.628 ms	none	1.4 ms		-0.015908 V
2	-8.6282 ms	1	2 ms	500 Hz	3.27249 V

10% Duty cycle of 1ms

6. When the PWM signal is applied, the servo snaps to a position and resists changes to that position. As the pulse width is increased, the servo rotates, and eventually the servo had rotated approximately 90° from its original position. When the pulse width was reset to 1ms, the servo returned to its original position.

7. The servo has power and a signal going to it. The signal commands the position of the servo motor, and logic inside the servo drives the motor to that position.