Lab #5 TECH 4234

Overview of Lab:

We are going to use Timer Output Compare (OCR1A) and its associated pin (PB1) to generate the song "Marry Had a Little Lamb". The program will adjust the frequency for each note and the time that note is played.

Here is the sheet music for the song:



First we need to determine what notes are used in the song. Use the table below to mark each note in the sheet music above with the note.



So in the case of the first note (for Marry) it would be an E4.

Once that is done, now you can determine the frequency (in Hz) of the signal you need to generate is for each one of the notes using the table below (all Frequencies are in Hz):

Mary had a little lamb

A_0 B_0 29.135 C_1 32.703 C_1 D_1 B_0 29.135 C_1 D_1 B_1 B_1 B_2 B_1 A_0 H D_1 B_1 B_2 B_1 A_1 B_2 B_1 B_2 B_1 B_2 A_1 B_2 B_1 B_2 B_2 B_1 A_1 B_2 B_2 B_2 B_2 B_2 A_1 B_1 B_2 B_3 B_2 B_2 B_2 B_2 B_2 B_4 A_4				
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	A ₀ 27.500 B ₀ 30.868	 A ₀ #	B ₀ b	29.135
F1 43.654 G1 46.249 G1 48.999 G1 A1 b 55.000 G1 61.735 G2 65.406 G2 62.407 G2 73.416 G2 62.407 G2 69.296 G2 97.399 G2 74.46 G2 92.499 G2 97.999 G2 74.46 G3.42 103.83 G3 146.83 G3 155.566 155.566 155.566 F3 174.61 G3 93.4 23.08 233.08 G3 196.00 G3 44.81 G3.4 130.81 233.08 G3 196.00 G3 44.81 G3.4 155.566 155.566 G3 196.00 G3 44.81 155.566 155.566 155.566 G3 196.00 G3 44.45 145.31 155.566 G3 196.00 G3 44.45 311.13 155.566 G3 196.00 G4 A4.45 311.13 144.44 145.31	C ₁ 32.703 D ₁ 36.708 E ₁ 41.203	C1# D1#	D ₁ b E ₁ b	34.648 38.891
C2 $65,406$ $C_2 \#$ $D_2 b$ $69,296$ D2 $73,416$ $D_2 \#$ $E_2 b$ $77,782$ F2 $87,307$ $G_2 \#$ $A_2 b$ 10383 A2 110.00 $A_2 \#$ $B_2 b$ 11654 C3 130.81 $C_3 \#$ $D_3 b$ 13859 D3 146.83 $D_3 \#$ $E_3 b$ 15556 F3 174.61 $G_3 \#$ $G_3 b$ 18500 G3 196.00 $G_3 \#$ $A_3 b$ 20765 B3 246.34 $Middle C$ $C_4 \#$ $D_4 b$ 277.18 C4 293.66 $Middle C$ $C_4 \#$ $D_4 b$ 277.18 C4 293.66 $C_4 \#$ $D_4 b$ 277.18 C4 391.99 $A_4 440.00$ $A_4 \#$ $A_4 b$ 445.31 C4 391.99 $G_5 \#$ $A_5 b$ 83061 C5 659.26 $C_5 \#$ $D_5 b$ 554.37 D5 587.33 $C_6 \#$ $A_5 b$ 83061 </td <td>F 43.654 G 48.999 A 55.000 B 61.735</td> <td>F1# G1# A1#</td> <td>G1 b A1 b B1 b</td> <td>46.249 51.913 58.270</td>	F 43.654 G 48.999 A 55.000 B 61.735	F1# G1# A1#	G1 b A1 b B1 b	46.249 51.913 58.270
F $_2$ 87.307 G $_2$ b 92.499 A $_2$ 110.00 A $_2$ $_2$ b 103.83 B $_2$ 123.47 C $_3$ $_3$ b 138.59 C $_3$ 130.81 C $_3$ $_4$ $_2$ $_8$ $_2$ b 105.56 F $_3$ 164.81 C $_3$ $_4$ $_2$ $_3$ b 138.59 D $_3$ 164.83 D $_3$ b 138.59 C $_3$ 196.00 G $_3$ $_4$ $_3$ b 207.65 A $_3$ 220.00 A $_3$ $_4$ $_3$ b 207.65 B $_3$ 246.94 Middle C C $_4$ $_4$ $_5$ $_2$ $_3$ $_3$ b 233.08 C $_4$ 2329.63 Middle C C $_4$ $_4$ $_4$ $_5$ $_3$ $_3$ $_4$ $_4$ $_4$ $_4$ $_4$ $_4$ $_4$ $_4$	C-2 65,406 D2 73,416 E 2 82,407 F 2 87,307 G2 97,999 A2 110,00 B2 123,47 C3 130,81 D3 146,83 E3 164,81 F 3 174,61 G3 196,00 A3 220,00 B3 246,94 C4 261,63 D4 293,66 E 4 329,63 F 4 349,23 G4 391,99 A4 440,00 B4 493,86	C2# D2#	D2b E2b	69.296 77.782
C3 130.81 C3 # D3 b 138.59 D3 146.83 F3 # G3 b 155.56 F3 174.61 F3 # G3 b 185.00 G3 196.00 G3 # B3 b 200.06 A3 220.00 A3 b 207.65 B3 246.94 A3 b 200.06 C4 261.63 Middle C C4 # D4 b 277.18 D4 293.66 D4 b 277.18 369.99 364.44 369.99 G4 391.99 G4 # E4 b 311.13 F4 # G4 b 369.99 G4 391.99 G4 # F4 # G4 b 369.99 364.616 C5 523.25 C5 D5 b 554.37 554.37 555.87.33 55.85 555.85 555.85 554.37 55.85 556.51 59.99.99 30.61 A5 # B5 b 932.33 55.85 556.55 556.37 556.33 556.55 556.55 56.56 56.56 56.56 56.56 56.56 56.56 56.56 56.56 </td <td>F2# G2# A2#</td> <td>G2b A2b B2b</td> <td>92.499 103.83 116.54</td>		F2# G2# A2#	G2b A2b B2b	92.499 103.83 116.54
F3 174.61 $F_3 \#$ G3 b 185.00 G3 246.94 $G_3 \#$ A3 b 207.65 B3 246.94 $G_3 \#$ B3 b 233.08 C4 261.63 Middle C $G_4 \#$ D4 b 277.18 D4 293.66 $G_4 \#$ D4 b 277.18 369.99 A4 449.23 $G_4 \#$ E4 b 311.13 F4 349.23 $G_4 \#$ E4 b 369.99 G4 391.99 $A_4 \#$ B4 b 466.16 C5 587.33 $C_5 \#$ D5 b 554.37 D5 587.33 $D_5 \#$ E5 b 622.25 F5 6639.46 $G_5 \#$ A5 b 830.61 B5 987.77 $G_6 \#$ A5 b 830.61 B5 987.77 $G_6 \#$ A6 b 1108.7 E6 1318.5 $G_6 \#$ A6 b 1480.0 G6 15680 $G_6 \#$ A6 b 1661.2 A6 # B6 b 1864.7 C7 # D7 b 2217.5 C7 2093.0 $C_7 \#$		C3# D3#	D3b E3b	138 <i>5</i> 9 155 <i>5</i> 6
C_4 251.83 Middle C C_4 D_4 D_4 E_4 D_5 277.18 D_4 349.23 G_4 391.99 A_4 A_4 B_4 B_4 B_999 A_4 440.00 A_4 B_4 B_4 B_4 B_4 B_4 B_4 B_999 A_4 440.00 A_4 B_4 B_4 B_4 B_4 B_4 B_9999 A_4 440.00 A_4 B_4 B_4 B_4 B_4 B_4 B_9999 A_4 B_4 B_4 B_4 B_4 B_9999 A_5 B_5 B_52325 D_5 D_5 B_5437 D_5 $S67.33$ D_5 E_5 B_5 B_3233 C_6 B_5 $B_7.77$ D_6 B_5 B_3233 C_6 B_5 $B_7.77$ D_6 B_6 $B_1244.5$ F_6 13185 B_6 B_6 B_6 B_6 B_6 B_6 B_6 <		F3# G3# A3#	G ₃ b A3b B3b	185.00 207.65 233.08
F_4 349.23 F_4 G_4 369.99 A_4 440.00 A_4 A_4 A_4 b 415.31 B_4 493.88 A_4 B_4 b 466.16 C_5 523.25 D_5 E_5 622.25 F_5 692.66 D_5 554.37 C_5 F_5 622.25 F_5 622.25 F_5 693.46 C_5 A_5 830.61 A_5 880.00 A_5 830.61 A_5 A_5 880.00 A_5 B_5 932.33 C_6 1046.5 C_6 B_5 932.33 C_6 1108.7 D_6 E_6 1108.7 D_6 1138.5 F_6 B_6 1440.0 G_6 1568.0 G_6 A_6 1480.0 G_6 1375.5 C_7 D_7 2217.5 D_7 2393.0 C_7 D_7 $2248.9.0$ F_7 27		C4# D4#	D4b E4b	277.18 311.13
C5 523.25 C5 # D5 b 554.37 E5 659.26 F5 688.46 G5 739.99 A5 880.00 A5 # B5 b 932.33 C6 1174.7 B5 b 932.33 C6 1174.7 C6 # D6 b 1108.7 E6 1318.5 C6 # D6 b 1244.5 F6 1396.9 G6 1568.0 G6 b 1480.0 G6 1568.0 G6 # B6 b 1864.7 C7 2093.0 C7 # D7 b 2217.5 D7 2349.3 C7 # D7 b 2217.5 C7 2030.0 C7 # D7 b 2217.5 D7 2349.3 C7 # D7 b 2217.5 C7 2030.0 C7 # D7 b 2217.5 C7 2349.3 C7 # D7 b 2217.5 C7 2395.1 C7 # D7 b 232.4 A7 3520.0 A7 b 3322.4 A7 b 3729.3 <		F4# G4# A4#	G4b A4b B4b	369.99 415.31 466.16
F_5 698.46 F_5 G_5 739.99 A_5 880.00 B_5 937.77 A_5 B_5 932.33 C_6 1046.5 B_5 B_5 932.33 C_6 B_6 1108.7 D_6 1318.5 D_6 E_6 1244.5 F_6 B_6 1244.5 F_6 1396.9 G_6 A_6 1661.2 A_6 A_6 1661.2 A_6 1760.0 G_6 A_6 1664.7 C_7 2030 C_7 Z_9330 C_7 Z_9330 C_7 Z_930 Z_7 Z_7 Z_930 Z_7 $Z_950.0$ Z_7 Z_7	C ₅ 523.25 D ₅ 587.33 E ₅ 659.26	C5# D5#	D5b E5b	554,37 622,25
C6 10465 C6 # D6 b 1108.7 E6 13185 D6 # E6 b 1244.5 F6 1396.9 F6 # G6 b 1480.0 G6 1568.0 G6 # A6 b 1661.2 B6 1975.5 G6 # B6 b 1864.7 C7 2093.0 C7 # D7 b 2217.5 D7 2349.3 C7 # D7 b 2217.5 E7 2637.0 D7 # E7 b 2489.0 F7 2793.8 F7 # G7 b 2960.0 G7 3136.0 G7 # A7 b 3322.4 B7 3951.1 G7 b 3729.3 3729.3 C8 4186.0 G7 3729.3 G7 b 3729.3	F ₅ 698.46 G ₅ 783.99 A ₅ 880.00 B ₅ 987.77	F5# G5# A5#	G5b A5b B5b	739.99 830.61 932.33
F6 13969 F6 1480.0 A6 15680 G6 A6 b 1480.0 A6 1760.0 G6 A6 b 1661.2 B6 1975.5 G6 1864.7 C7 2093.0 C7 D7 b 2217.5 D7 2349.3 C7 D7 b 2217.5 E7 2637.0 D7 2489.0 F7 F7 2793.8 F7 G7 b 2960.0 A7 3520.0 G7 A7 b 3322.4 B7 3951.1 G7 B7 b 3729.3 C8 4186.0 G7 M160 M160	C ₆ 10465 D ₆ 1174.7 E ₆ 13185	C ₆ # D ₆ #	D6b E6b	1108.7 1244.5
C7 20930 C7 # D7 b 2217.5 D7 23493 D7 # E7 b 2489.0 F7 27938 F7 # G7 b 2960.0 G7 3136.0 G7 # A7 b 3322.4 B7 3951.1 A7 # B7 b 3729.3 C8 4186.0 A7 A7 # B7 b 3729.3	G6 15680 G6 15680 A6 17600 B6 19755	F6# G6# A6#	G ₆ b A6b B6b	1480.0 1661.2 1864.7
F7 27938 G7 31360 A7 35200 B7 3951.1 C8 41860	C ₇ 20930 D ₇ 23493 E ₇ 2637.0	C7# D7#	D7b E7b	2217.5 2489.0
	F7 27938 G7 31360 A7 35200 B7 3951.1 C8 41860	F ₇ # G7# A ₇ #	G7b A7b B7b	2960.0 3322.4 3729.3

Figure 13-5. Piano Note Frequencies

The last piece of information is how long each note needs to be held for. This is determined by the type of note as shown in the sheet music as per the note types below:



Note since the song is in 4/4 time, a whole note is 4x as long as a quarter note. It is a good idea to set a constant for the time of a quarter note, so if the song is going too fast or too slow, you can change it in one place to change the speed of the song.

Now, knowing the frequencies you need to generate, figure out what pre scaler you need for the Atmel238p timer.

Calculate the number of counts needed to generate the 50% duty cycle square wave necessary to generate the frequency of each note.

Create two arrays, one for the timer counts and one for the length (1=quarter note, 2=half note and 4 being full note). It is a good idea, for readability of the code, to define the counts for each note and use that name when filling the array:

#define c6 1568
#define d6 1174
freq[4]={c6,d6,c6,c6};
time[4]={2,4,4,1};

NOTE – for the above example the notes in the above were defined as Hz not as counts!

To test, connect the Arduino output to a set of computer speakers (Gnd on Arduino to Ground on the 3.5mm Jack and PB1 to the Right or Left Input on the 3.5mm jack).



Figure 1 - 3.5mm Jack Connections