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Project 2 Embedded Systems

1: If you output an inverted signal for the pulse version of note A4, what sound is output and why? Inverted here means that instead of output being low most of the time with high pulses occurring 440

times per second you instead keep the output pin high most of the time but drop it low at a rate of 440 times per second.

Answer:

The reason we heard the note A4 was because every 440 times we counted to 1000 in TACCR0, we would create a pulse (setting the buffer to a value > 0). If instead we invert that, we now make a pulse every time we count to 1000 except for when the sampling number modulo 440 = 0. The sound will be very similar to hearing a noise with frequency 16MHz/1000 = 16KHz. To the human ear this will sound like a high pitch whine. The only caveat between a 16KHz frequency output and ours is that every 440 times we count to 1000 in TACCR0, we have 1000 samples of no pulse.

2. The rate of the main system clock limits the quality of output signals from the MSP430. If the MSP430's main system clock were running at 16MHz, what is the maximum sample rate that could be supported with a bit depth (the number of bits used to determine discrete values for pulses) of 12 bits? How fast would the MSP430's main clock need to be to support a bit depth of 16 bits and a sample rate of 44100 Hz (cd quality) using pulse width modulation?

Answer:

Bit Depth = 12 bits, so we will be counting up to $2^{12} = 4096$ for a single sample in TACCR0. 16MHz / 4096 = 3906.25Hz. Therefore, the maximum sampling rate the MSP430 could be supported with a 12-bit bit depth assuming a 16MHz clock is 3.9KHz.

To support a CD quality sampling rate of 44.1KHz with a 16-bit bit depth, the MSP430's main clock would have to run at $44100 * 2^{16} = 44100 * 65536 = 2890137600$Hz = 2.89GHz

3. If we were properly designing our reconstruction filter, we would calculate values for the resistor and capacitor such that high frequency noises would be much weaker than our intended, lower frequency signal. The cutoff frequency of a low pass filter is the frequency at which the output signal drops by -3dB. The equation to calculate the cutoff frequency is $f_c = 1/2\pi RC$. Find values for a resistor and capacitor that provide a cutoff frequency of 4KHz.

Answer:

4kHz=1/(2*pi*R*C). If we choose C=1nF, than R=1/(2*pi*4000*1nF)=39.8 kohms. We could have chosen a different value of C as long as R*C=1/(2*pi*4000Hz).