PreLab 4: AC Total Harmonic Distortion Test

In this lab, we will design a test plan for the total harmonic distortion. This lab is intended to teach you how to set-up the arbitrary waveform generators (AWGs), digitizers, and clock scheme to perform an AC test.

(a) In this lab, we will be testing a general purpose op-amp, the LF741. We will use the Analog Circuit DIB for this chip. To perform the total-harmonic distortion test, the op-amp will be placed in the non-inverting op-amp configuration. Trace the pathway on the DIB that will place the op-amp in this configuration. What is R_F and R_1? Given these values, what input is necessary to push the output to approximately plus/minus 12V?

(b) To perform this test, the pins in your code will need to be modified for the new device pinout. Which resources should be grouped? Vout will be digitized using a new high-precision voltage measurement unit called a QMS.

(c) In this lab, you will generate a sampling rate by dividing down a 50MHz master clock. The maximum sampling rate for the APU that you will use for the input is 100kHz. What integer, m, should be used to divide the master clock down to this frequency?

(d) If you are going to use 512 samples to generate 4 cycles of a sine wave and drive this waveform at the 100kHz sampling rate, what is your signal frequency? (note: $f_{sig} = f_{samp}/N$, where f_{sig} is the signal frequency, f_{samp} is the sampling rate, and N is the number of samples. But, N does not equal 512 in this case!!)

Lab 4 - AC THD Test

In this lab, you will add the AC THD test.

A. QMS Unit

In this lab, we will be using the QMS unit. Note that the QMS is ONLY a high precision voltmeter. It does not measure current and it does not source voltage or current. However, it does have an on-board DSP that allows you to FFT your results.

B. UserInit

In this lab, we will use the AWG on an APU board as the input and digitize the output using a QMS. In UserInit, we must set up the clocking scheme and load the input waveform into the AWG. This “one-time set-up” should only be done once per lot, so it should be placed in UserInit.

Clocking Scheme

The ETS system allows for multiple clocks to be set-up at different clock-frequencies to handle mixed-signal test applications. In order to setup the clocks for the AWG and the digitizer, we must determine the master clock frequency and the divide-down ratio to drive the AWG and the digitizer. They do not have to be the same frequency; however for simplicity, we will make them the same.

(a) Set the master clock to 50MHz.
(b) Divide the clock down to the prelab value.
(c) Connect the clock to the AWG
(d) Set up the pattern being driving by the AWG
(e) Set up the number of clock cycles being used by the pattern
(f) Load the pattern into the AWG
(g) Remove the clock from the AWG so that it doesn't interfere with other DC measurements

C. Create the Test Function

Create the AC function as you have in the past. Since the THD parameter is not given in this datasheet, leave the hi limit / lo limit fields blank.

Close the relays and set up the rails. Next, the APU and QMS must be set-up.

1. Set the APU into AWG mode. Set the voltage to the initial value in your pattern to minimize settling time.
2. Select which AWG pattern to use. You may want to repeat the pattern about 4 times to make sure all of the transients have been settled.
3. Set up the QMS in digitize mode. You may want to set the filter frequency higher depending on what frequencies you are trying to measure.
4. Reconnect the clocks to the resources.
5. Run the clocks.
7. Take the FFT.
8. Before taking the total harmonic distortion, you must also take the power spectral density.
9. Get the data from the transformed array. Calculate the total harmonic distortion.
10. After the dspthd function, store the result into a results structure.
12. Log the result.
13. Turn off all equipment and open the relays.

D. Test the code

First, verify that the code is working as expected ON YOUR LAPTOP!

1. Compile and build the program. Fix any errors.
2. Place a break point right before you datalog your results for the THD specification.
3. Look at the input and output waveforms as a function of time. The output should look similar to the input with a small phase shift.
1. Look at the FFT. The FFT should show you the harmonics used in the calculation. Validate that they are providing the expected information. Save both the time-domain and FFT plots for your report!
2. Modify the input waveform (recall, this is in UserInit). Change the amplitude up and down. Look at the results. A larger amplitude should cause more distortion increasing the THD measurement and causing more harmonic spectral bins to have a larger amplitude in the FFT. Save both the time-domain and FFT plot of one additional input for your report!
3. THD measurement and causing more harmonic spectral bins to have a larger amplitude in the FFT. Save both the time-domain and FFT plot of one addtional input for your report!
4. Record your test time.

E. Write up Your Results

Turn in your final code, test results, and a discussion of the results.