EE 435

Spectral Characterization of Nonlinear Systems

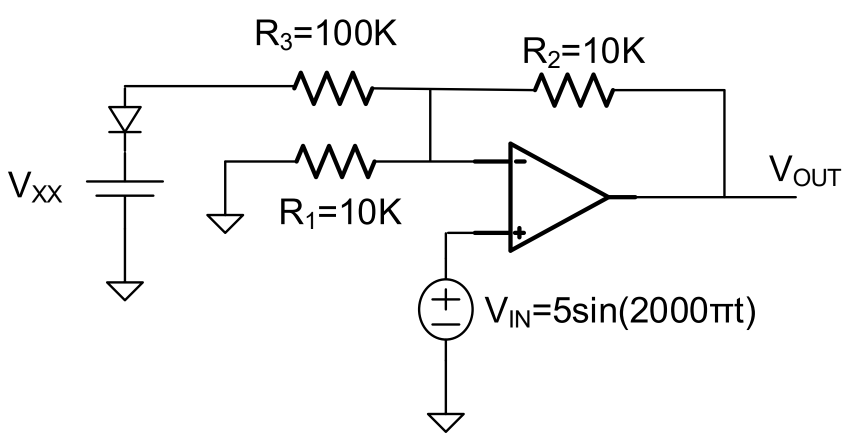
Lab 6 Spring 2022

The spectral characteristics of an analog circuit or system is a widely used and useful metric for characterizing the linearity of the system. Parameters such as the THD, SFDR, SNR, SNDR as well as some of the individual spectral components (such as the dc component, the fundamental, as well as a number of harmonic components) are often of interest. On occasion non-spectral components in the DFT of a signal as well as intermodulation components are of interest as well.

This experiment that will focus on spectral characterization. Though the emphasis at this point in the course is on characterizing the spectral performance of data converters, it is easier to make measurements on a continuous circuit and most of the same issues are relevant. Thus consider the nonlinear amplifier circuit shown below. The amount of nonlinearity can be controlled by adjusting the voltage V_{XX}. For this experiment, assume V_{XX}=0V.

Build this circuit in the laboratory and take a large number of samples of the output with the oscilloscope.

a) From these samples, obtain the DFT of the sample sequence and plot showing, at a minimum, the first 5 harmonics of the fundaments..
b) From the DFT, obtain several of the key spectral performance parameters
c) Using the Math function embedded in the oscilloscope, obtain the DFT and compare with that obtained in Part a)
d) From the DFT, estimate the number of bits of resolution of the ADC internal to the Oscilloscope
e) From the time-domain signals at the op amp output, determine the number of bits of resolution of the ADC that is internal to the oscilloscope.
f) Compare the results obtained using the Math function in the oscilloscope with the results using the sampled sequence and the Matlab program.



In your laboratory report, describe clearly which spectral parameters you have been able to determine for this circuit, clearly describe how you determined these parameters, and compare the results obtained with Matlab with those obtained directly with the oscilloscope.

Notes on Matlab:

```
data = table2array(readtable("filename.csv","NumHeaderLines",21));
```

This command will help import the data into Matlab from the oscilloscope. The CSV file is organized into columns of data, where the first column will be time, and then the subsequent columns will be your channels. There is a heading on the CSV file as shown below, therefor it is important to add the “NumHeaderLines” option and specify the number of lines to skip. This should be 21 for the DPO3034 that is in the lab.

Since Matlab has the lovely ability to plot traces well, please do not upload any pictures taken with your phone. All uploads should be either plotted in Matlab, or an export of the screen image.

Model	DPO3034				
Firmware Version	2.38				
Waveform Type	ANALOG			Waveform Type	ANALOG
Point Format	Y			Point Format	Y
Horizontal Units	s			Horizontal Units	Hz
Horizontal Scale	0.002			Horizontal Scale	25000
Horizontal Delay	0			Horizontal Delay	125000
Sample Interval	2.00E-06			Sample Interval	25
Record Length	10000			Record Length	10000
Gating	0.0% to 100.0%			Gating	0.0% to 100.0%
Probe Attenuation	10			Probe Attenuation	1
Vertical Units	V			Vertical Units	dB
Vertical Offset	0			Vertical Offset	0
Vertical Scale	2			Vertical Scale	20
Vertical Position	0			Vertical Position	3
Label	A			Label	
TIME	CH1	CH2		FREQUENCY	MATH<FFT(CH2, RECTANGULAR, LOGRMS)>
-1.00E-02	0	-0.32		0.00E+00	-26.5656
-1.00E-02	-0.08	-0.32		2.50E+01	-40.9094
-1.00E-02	0	-0.08		5.00E+01	-55.2531
-9.99E-03	0	-0.16		7.50E+01	-56.9719
-9.99E-03	0.08	0		1.00E+02	-58.6906
-9.99E-03	0	-0.08		1.25E+02	-60.3781
-9.99E-03	0.16	0		1.50E+02	-62.0656
-9.99E-03	0.08	0.08		1.75E+02	-64.4781
-9.98E-03	0.08	0.16		2.00E+02	-66.8906
-9.98E-03	0.16	0.32		2.25E+02	-64.2
-9.98E-03	0.16	0.4		2.50E+02	-61.5063
-9.98E-03	0.24	0.32		2.75E+02	-62.025