uOttawa

Master of Engineering

Electrical and Computer Engineering

Assignment 4

ELG7132D

Topics in Electronics I: Simulation of Radio Frequency Circuits

Submitted by

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a) The below table includes the comparison of the results obtained from my program and Hspice for the input amplitude of 1mV and 10 V respectively. A column showing the Percentage difference has also been added to evaluate that these two set of values are almost similar. It shows that the developed code is accurate. This table shows that the amplitudes of even numbered harmonics when compared to odd numbered harmonics are significantly low and also the percentage difference of the even numbered harmonics is a very small value when compared to the odd numbered harmonics.

Frequency	Matlab Results	Hspice Results	Percentage Difference
0	1.48414011	0	-1.48414011
5000000	1.123248043	1.680851436	0.557603393
10000000	0.636153029	1.360189822	0.724036793
15000000	0.154316214	0.997174082	0.842857868
20000000	0.20366189	0.793036759	0.589374869
25000000	0.368532648	0.211688308	-0.156844372
30000000	0.338210735	0.344381498	0.0006170763
35000000	0.171463513	0.288161944	0.116698431
40000000	0.039031663	0.119869312	0.080837649
45000000	0.203353816	0.800328032	0.596974216
50000000	0.266667859	0.810966821	0.544298962
55000000	0.225377158	0.81029542	0.584918262
60000000	0.121907817	0.792439459	0.670531642
65000000	0.021388615	0.01265688	-0.0008731735

Table 1: Comparison of the output amplitudes obtained from the program and Hspice for input amplitude of 10V.

It has been observed that, for the high value of input voltage, more number of time points were required to get a converge result. Any input voltage less than 1V, to converge with the output of Hspice simulated values, it would take more time points. The following table shows that observation.

Time Points	Input 1mV	Input 15V
6	0.0127	1.1518
8	0.0127	1.2808
10	0.0127	1.3318
H-spice simulated result	0.012736	1.3395

b) The table below compares is shown for the behavior of voltage gain (at 5MHz) versus the amplitude of the input voltage $\mathbf{V_{in}}$ as computed through my program and the HSPICE commercial simulator. The following table shows the gain from the simulation of the Harmonic-Balance and HSPICE programs using different values for A, given by 1µV, 10µV, 100µV, 1mV, 10mV, 100mV, 1V, 10V, 15V.

Amplitude A	Result from my program $\frac{\sqrt{X_1^{c^2}+X_1^{s^2}}}{A}$	Results from HSPICE $\frac{\sqrt{X_1^{c^2}+X_1^{s^2}}}{A}$	Percentage of Difference
1µV	12.74001369	12.7474	-0.738630525
10µV	12.74001369	12.74137	-0.135630525
100µV	13.00001342	12.741	25.90134209
1mV	12.70001374	12.7363	-3.628626212
10mV	12.72001372	12.72047	-0.045628372
100mV	10.99200892	10.992	0.000891557
1V	1.649900118	1.657	-0.709988174
10V	0.14796	0.14791	0.005000018
15V	0.088786667	0.0893	-0.051333316

Table 2: Voltage Gains Comparision

It has been observed that, for the high value of input voltage, more number of time points were required to get converged result. Any input voltage less than 1V, to converge with the output of HSPICE simulated values, it would take more time points. The following table shows that observation

c) The Total Harmonic Distortion(THD) for input voltages from 1µV to 10V is tabulated and compared between the values obtained from MATLAB computation and the results from the HSpice simulation. From the above table we can observe that the gain decreases when a signal with a large amplitude is given as an input. This happens because the amplifier reaches saturation and thus no more output can be observed except a straight flat line at saturation. Total Harmonic distortion is the ratio of the summation of powers of all harmonic components to the power of its fundamental frequency. On the other note the THD here is given as

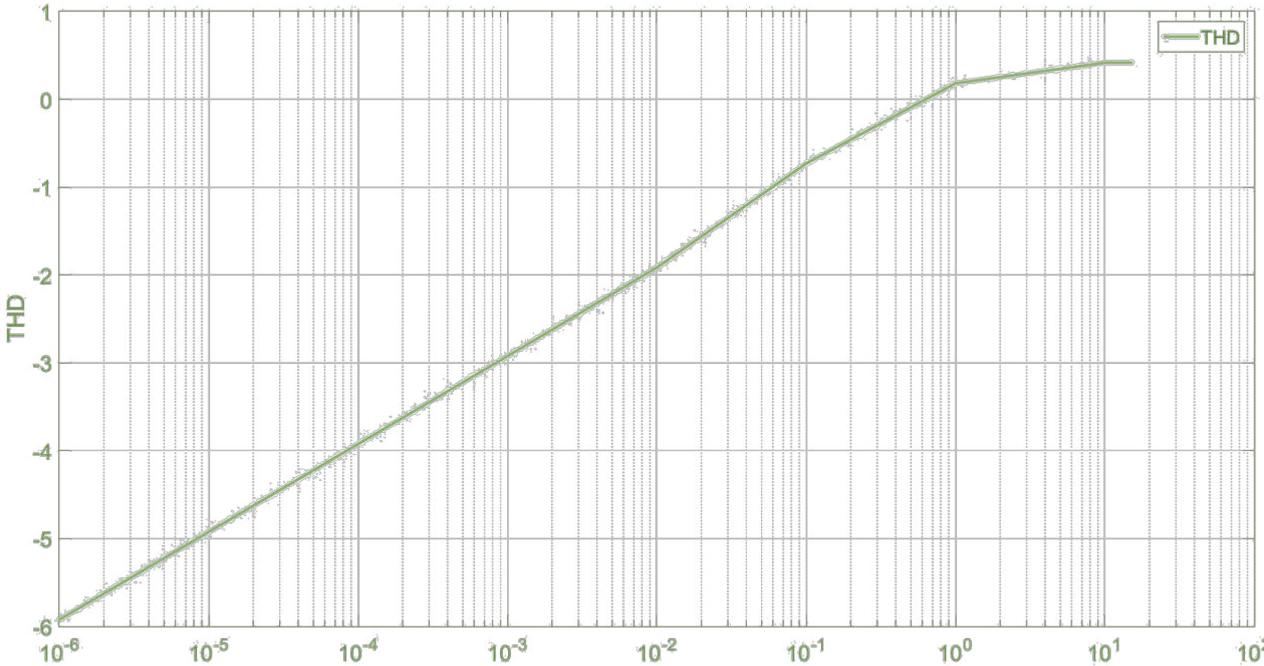
$$THD = \log_{10} \frac{\sum_{i=2}^{M} \sqrt{X_i^{C2} + X_i^{C2}}}{\sqrt{X_1^{C2} + X_1^{C2}}}$$

By observing the graphs, we can conclude that the total harmonic distortion increases with the increase in the amplitude of the input signal which also increases distortions.

Harmonic distortion goes high with the increase of amplitude in the input voltage. It is because for single tone small signal analysis, the input voltage can produce smoother output voltage with less distortion. For small signal, the output is close to sinusoidal but for higher input voltage, the output signal doesn't behave in pure sinusoidal way, as a result, more number of harmonics will be required to get the accurate values. Therefore, HB suffers with large number of Harmonic distortion for high input voltage and Harmonic distortion increase with the increase in the amplitude of the input voltage A.

Input Voltage	Hspice Result	MATLAB Result
1u	-5.965334663	-5.924631387
10u	-4.968439591	-4.924603031
100u	-3.96843392	-3.924602677
1m	-2.943035524	-2.924582699
10m	-1.940822111	-1.922585466
100m	-0.805061647	-0.760598929
1V	-0.06519968	-0.488909976
10V	-0.053031996	-0.564446527

MATLAB Computation Results



Input signal Amplitude in volts