HW7, Due time: Wednesday 3/27 in class.

1. Consider the circuit shown below. In EE201, we learned how to obtain the Thervelin's equivalent circuit. Now replace the equivalent resistor with a noise free resistor in series with a noise voltage source. Alternatively, each of the original resistors can be replaced with either a noise free resistor in series with a noise voltage source or a noise free resistor in parallel with a noise current source. There are a total of 8 ways to do this. Pick two different ways, compute the total open circuit noise voltage at Vo, and compare with the results obtained in the first step.



- 2. In class, we described some sample Matlab lines of code for evaluating linearity performance of a circuit. Now suppose a pure sine wave is applied to a circuit input and the circuit output is captured with coherent sampling. The captured data is stored as a column vector of length M that is given to you. (I will provide a text file containing the data.) Write a Matlab file (either a function or a script) to perform the spectral analysis. Here are the steps that must be included:
 - a. Compute the complex DFT coefficients, amplitude, power, and phase in each frequency bin.
 - b. Find the fundamental signal's frequency, amplitude, and phase. To accommodate a small amount of frequency leakage, collect the total power in the fundamental bin plus powers in 5 adjacent bins on each side, and use this as the signal power. Then set the power in these bins all to be zero.
 - c. Find the DC power by collecting the total powers in the first bin (frequency =0) plus the next three bins (2,3,4) and the last three bins (M, M-1, M-2). Then set these bins to zero.
 - d. Find the largest remaining frequency bin power, regardless harmonic or non-harmonic. Use this bin power plus powers in two adjacent bins on each side. Use this power to compute the SFDR. (don't set these bins to zero.)
 - e. Locate the 2nd to K-th harmonic frequency bins. Make sure you use mod-M to take care of aliasing. For each harmonic, use the total power in that bin plus powers in 2 adjacent bins on each side as the harmonic power. After collecting the powers, set those bins to zero. Compute the total harmonic power and the THD.
 - f. Compute the total power in the remaining non zero bins. Divide the total power by the number of remaining bins. Then multiply the average noise power per bin by the total number of bins (M) to get the total noise power. Use this to compute the SNR.
 - g. Compute the SNDR (also called SINAD). Use this to compute the ENOB.

- 3. An LNA model is given. Write a Matlab file to perform spectral linearity test for this LNA.
 - a. Choose the number of samples M to be a power of 2. (2^12 to 2^18) Choose the quantization resolution N.
 - b. Suppose the total acquisition time is normalized to be one unit. Therefore the sampling frequency is M and each frequency bin has bandwidth of 1. Select an input sine wave frequency to be around 5% of Nyquist frequency. Make sure the number signal periods in the M points is an odd integer. Choose the amplitude to be 1.2V and initial phase of the sine wave to be 0.
 - c. Generate a vector of M input voltage samples, add an randomly generated noise with Gaussian distribution with zero mean and standard deviation of ¼ of the quantization unit step, pass this noise corrupted input through the LNA, and quantize the LNA output into a vector M output digital codes.
 - d. Use your file from problem 2 to analyze the linearity performance of the LNA.
- 4. 9.4
- 5. 9.10 (Hint: the noise can be thought of as the sum of three noise sources: an 1/f noise with psd of 10/f, a thermal noise filtered by LPF with -3dB frequency of 100Hz, and another thermal noise filtered by LPF with -3dB frequency of 10kHz.)
- 6. 9.24
- 7. 9.28
- 8. 9.17
- 9. 9.20 (bonus)
- 10.9.13 (bonus)