EECS 142/242M

VCO Lab

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1  Prelab

In this lab you will design and build a voltage-controlled oscillator at 600 MHz using a bipolar transistor active device. Using your background in oscillator design, begin by choosing an appropriate topology. Keep in mind the restrictions of the amplifier board since ultimately you will build the oscillator with the same board. Calculate the component values so that your oscillator meets the following specifications:

- Center frequency of 600 MHz.
- Output swing of 200mV into a 50 ohm load.
- Tuning range of 15%. The tuning range is defined as the maximum range over which you can oscillate (and meet the specifications) compared to the average frequency

\[ TR = 2 \frac{f_{\text{max}} - f_{\text{min}}}{f_{\text{max}} + f_{\text{min}}} \]

- In practice, another important specification would be the phase noise. For this lab we will only measure the resulting phase noise.

Design your VCO based on the components available to you in the lab (values of L and in particular the expected quality factor of components). Simulate your design in SPICE and verify that you meet the specifications. You should also simulate the phase noise of your design. In Spectre, use a pss analysis for an autonomous circuit and plot the phase noise. Report the phase noise at an offset of 1 MHz from the carrier.

2  Experimental Work

Build your VCO using the components available to you. For the first pass you may want to avoid using a varactor and simply build an oscillator at a fixed frequency:

1. Verify that the oscillator DC bias current matches your calculations. Be sure that your oscillator has a DC current limitation scheme in place (resistor degeneration) or otherwise the DC current will not match your expectations.

2. Using an oscilloscope, observe the output waveform. Verify oscillation frequency and amplitude.

3. Observe the oscillator spectrum on a spectrum analyzer. Plot the spectrum with various frequency scales. Zoom in to observe the skirts of the oscillator.

4. How stable is the oscillation frequency? Measure the frequency with maximum accuracy and then wait ten minutes and re-measure the frequency. Has it moved?

5. Plot the phase noise of the oscillator by using a the special phase noise option on the Spectrum Analyzer. This mode eliminates the carrier and allows a very high dynamic range measurement of the skirts of the frequency spectrum.
6. Observe the amplitude stability of your oscillator by introducing a glitch into the circuit (pulse the power supply by 100mV up and then back down to the nominal value). If the glitch is periodic, you should be able to observe it on the oscilloscope. If you are having difficulty getting a clean trace, you can set the trigger point to capture the glitch. Does the amplitude return back to its nominal value?

7. Plot the frequency spectrum with the glitch waveform. Can you explain the observed spectrum?

8. Repeat the above measurements with a varactor. Verify the tuning range.

9. Introduce a modulation waveform (sine wave) on the control port of the varactor. Now observe the spectrum. This is a simple FM transmitter.

10. How much time did you spend on this lab? Any feedback is appreciated.