ECE323
HW#3
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Diode Ring Mixer

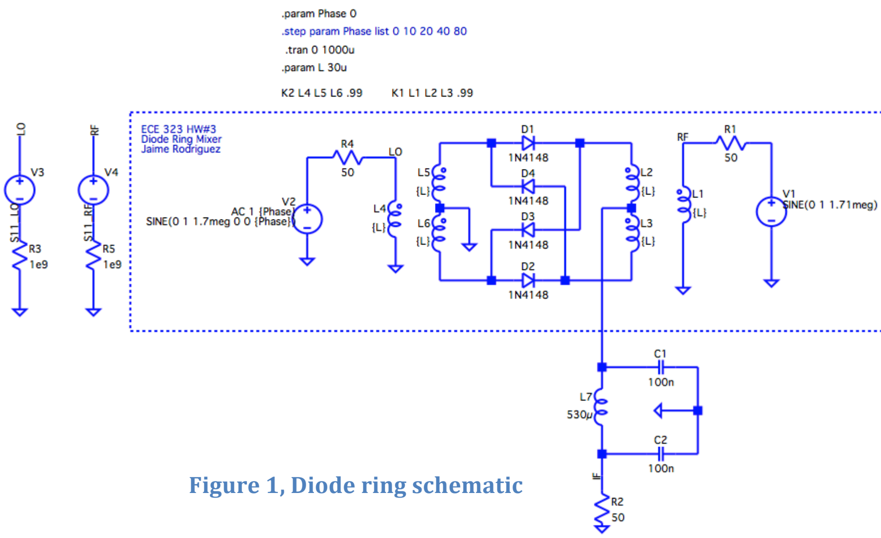


Figure 1, Diode ring schematic

Introduction:

In this homework we are exploring the use of a diode ring mixer as a Phase detector, but first we see how the diode ring mixer is used to mix two different frequencies, when applying two different frequencies one at 1.7Mhz and the other at 1.71Mhz

The product is

$$cos(wt_1)\cos(wt_2) = \frac{1}{2}\cos(wt_1 + wt_2) + \frac{1}{2}\cos(wt_1 - wt_2),$$

Using a low pass filter we are able to filter out the higher frequency product and we are left the difference of the two input signals.

To demonstrate this in Ltspice I setup two input signals one at 1.7Mhz and the other at 1.71Mhz input into the diode ring mixer, the output shown below is a 10Khz sine wave.

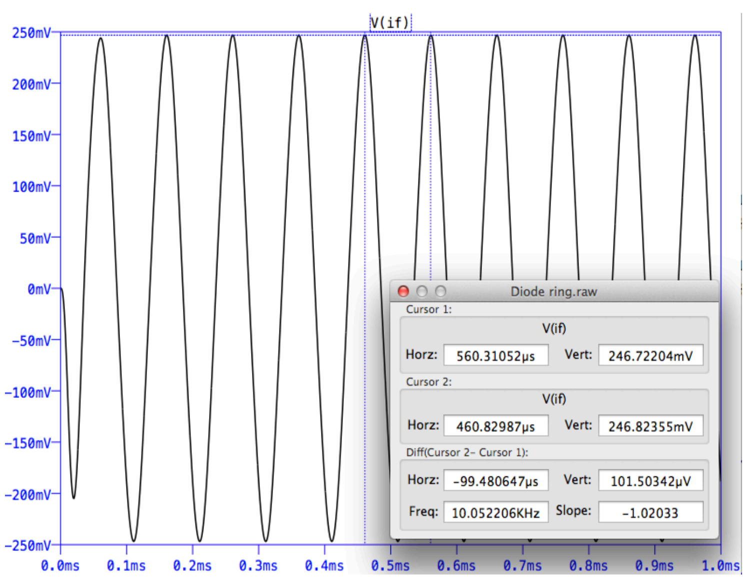


Figure 2, IF output (LO-RF)

Next I calculated the $k\phi$, which was found by looking at the slope of the output at the zero crossing, but first I needed to find out how many seconds per radian to move along the slope

$$\omega = 2\pi f\left(\frac{Rad}{\mathrm{Sec}}\right)$$

$$\omega = 2\pi(10K) = 62.8K\left(\frac{Rad}{\mathrm{Sec}}\right)$$

$$\frac{1}{\omega} = \left(\frac{sec}{\mathrm{Rad}}\right) = 15.9\mu\ seconds\ per\ Radian$$

Starting at the zero crossing and moving forward 15.9 $\mu seconds$, we find that $k\phi \approx 200mV\ per\ radian$, next I set both signals to equal each other (LO=RF=1.7MHZ), this produces no sine wave as the difference of both inputs cancel each other out.

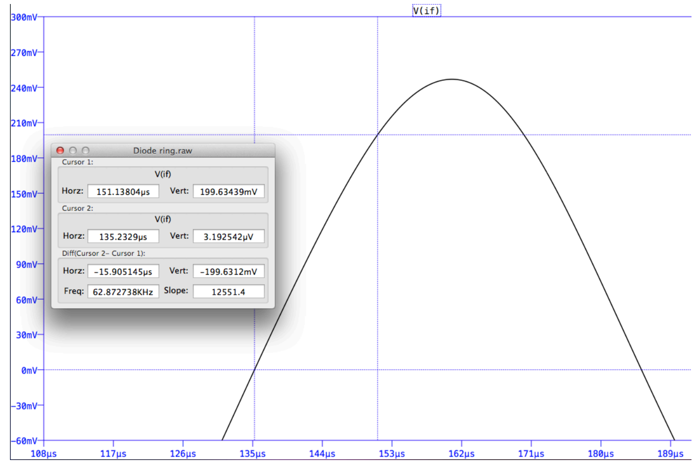


Figure 3, $k\phi \approx 200mV$ crossing

But what is seen is a dc term that is left over from the phase, as the phase is stepped through various values the dc term also changes values from a range that is dependent on the max and min of the 10KHz sine wave seen earlier, which was $\pm\ 240mV$. This range also reaches its max point when the phase is equal to π and odd multiples of π, and its min value for even multiples of π; this can be seen on the left.

The outputs on the left have a 240mV offset to raise the dc term to 0mv for a phase of 0 degrees, we can see as the phase goes up to 180 degrees the dc offset reaches its max and then begins to come back down, this property of controlling the dc term with the phase makes this circuit very useful in many application and the core element in the phase lock loop.

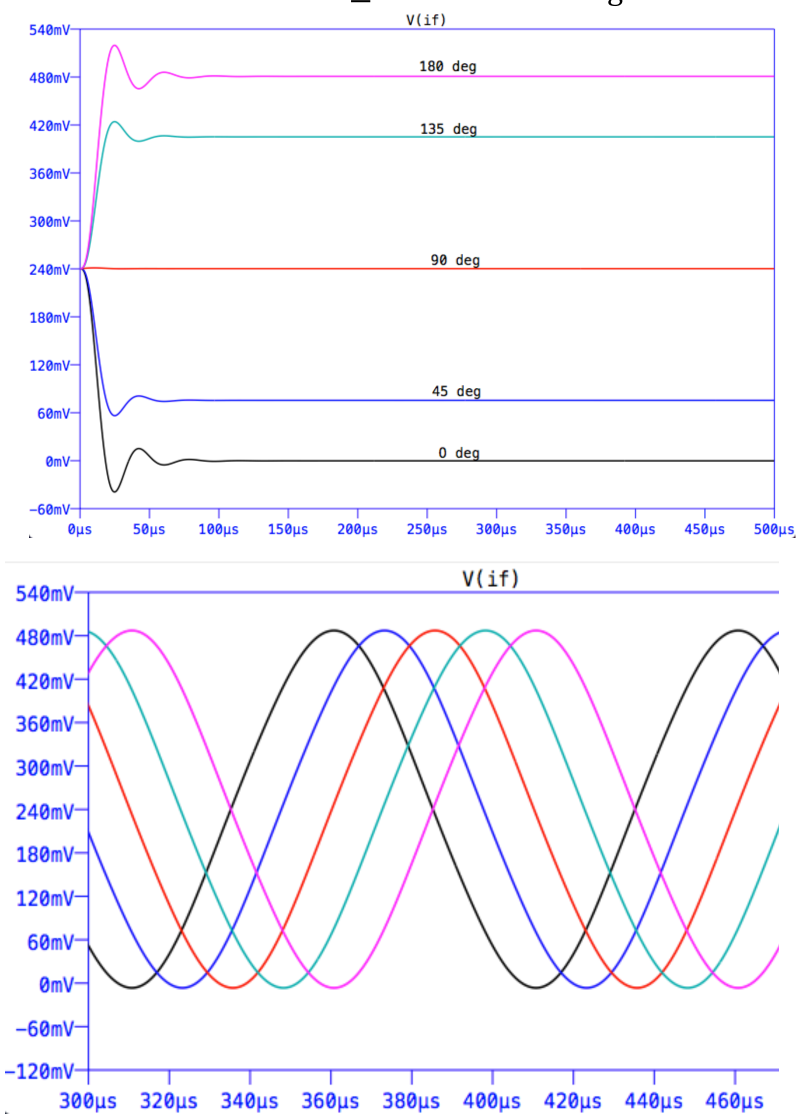
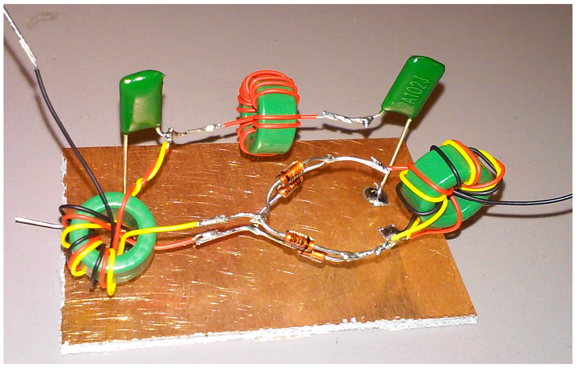


Figure 4, varying phase output

In further study of the diode ring mixer I tried to calculate the dc offset term for a given phase, in reading Stephan R. Kurtz tech note "*Mixers as Phase Detectors*" he states that is the phase detectors output is characterized by

$$V_{IF} = V * \cos\left(\Delta\phi + \pi\right)$$

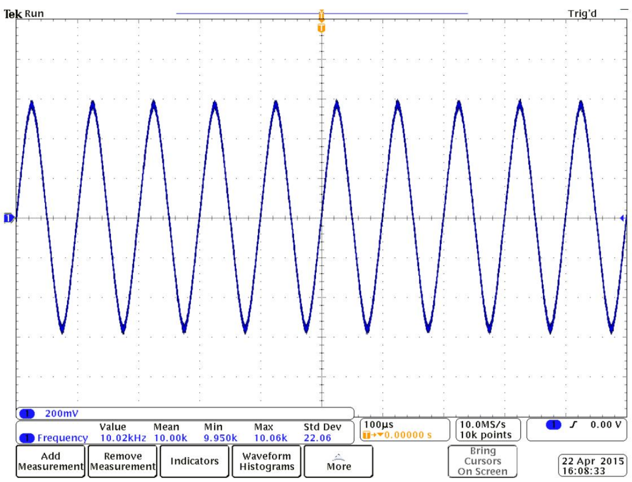
With V being the maximum voltage seen at π, however this equation seemed to give the appropriate response, I tried many ways to calculate this but proved unsuccessful.



In the lab I decided to build the diode ring mixer, and found it relatively easy to make-work, I set up the mixer in the same configuration as in Ltspice and first put in a 1.7Mhz for the LO and a 1.71Mhz signal for the RF, down below is a screen capture of the 10KHz signal that was seen.

Next I set both signals equal to each other and tested the dc offset by varying the phase, I found very similar results as in the simulation as the phase reached π the offset increased and then began falling, this would continue going up and down for even and odd multiples of π, which makes sense for $\cos(\pi) = \cos(3\pi)$ and $\cos(0) = \cos(2\pi)$.

One difference seen that was not in simulation was an additional 90 degrees phase shift that was caused by the trifilars, this was also seen in the previous lab.



J.Rodriguez Diode Ring(1.7*1.71MHZ)