ECE323 Nick Porter

Lab 1

Approximating the transformer and stray inductance of the ADE-1

The purpose of this lab is to find an approximate model of the inductance behavior of the ADE-1 frequency mixer and simulate it to find the k_ϕ feedback coefficient. The data on the ADE-1's conversion losses can be used to estimate the inductance of its transformer as well as the stray inductance that arises from high frequency signals in its wiring.

The datasheet for this device includes a plot of the conversion losses over a frequency range from 0 to 500 MHz. These values were used to simulate similar effects due to the inductance in the circuit. The coupled inductance of the trifilar windings causes high-pass filtering while the uncoupled stray inductance in the wires causes low-pass filtering.

The effect on bandwidth of the circuit can be modeled separately as a combination of a low pass filter (LPF) and high pass filter (HPF). In an RL model, an inductor in parallel causes a HPF and an inductor in series causes a LPF.

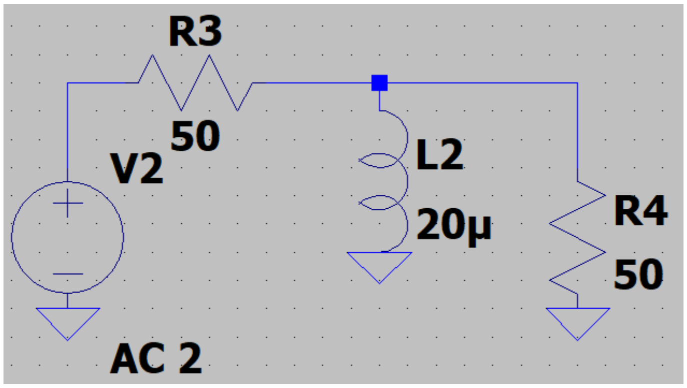

Figure 1: Circuit 1: Model of transformer winding inductance effect on frequency filtering.

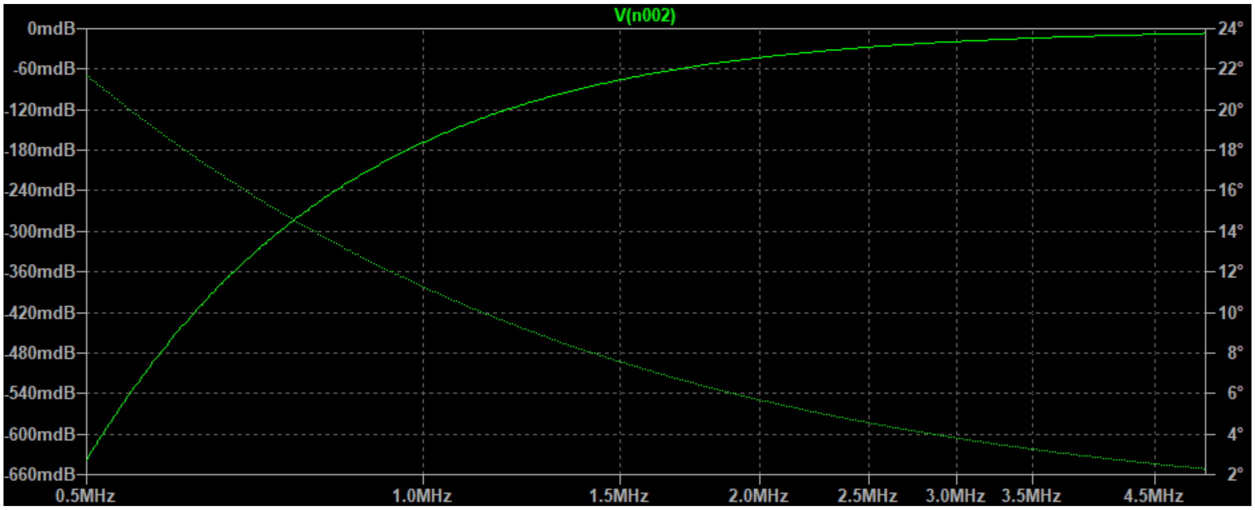

Figure 2: Frequency response of Circuit 1.

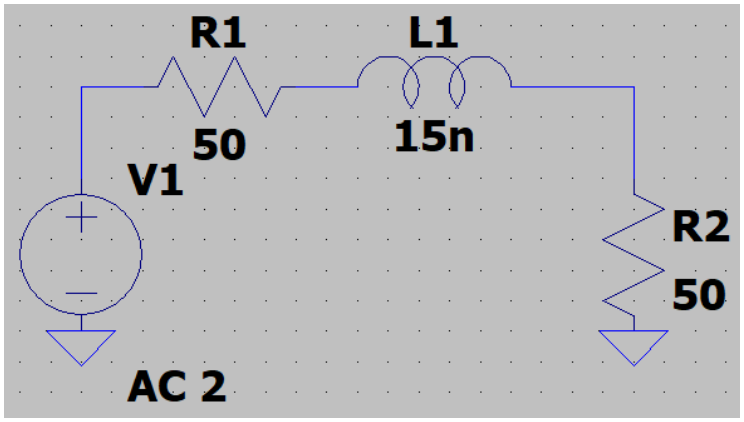

Figure 3: Circuit 2: Model of stray inductance effect on frequency filtering.

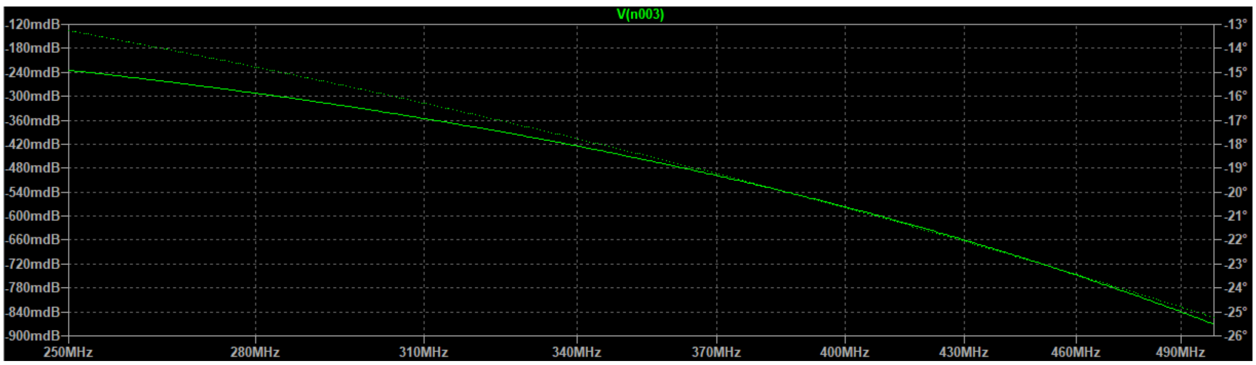

Figure 4: Frequency response of Circuit 2.

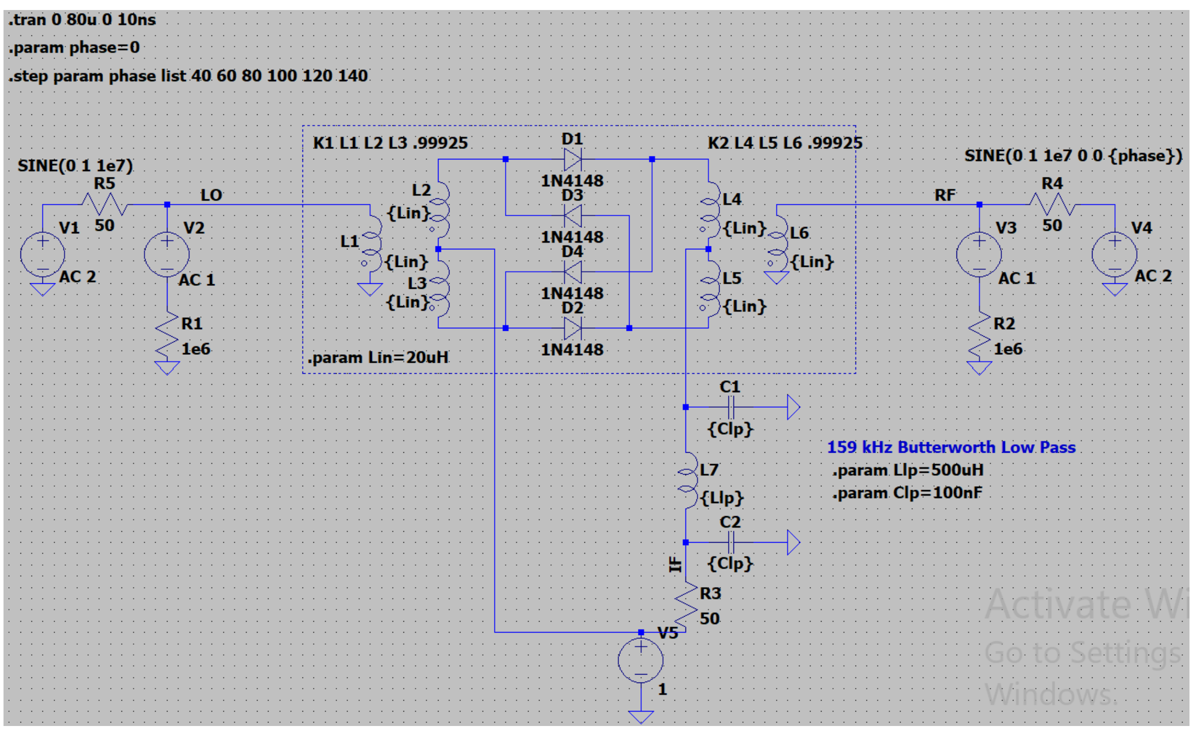

Figure 5: Circuit 3: Model of ADE-1 for determining the transient and steady state response.

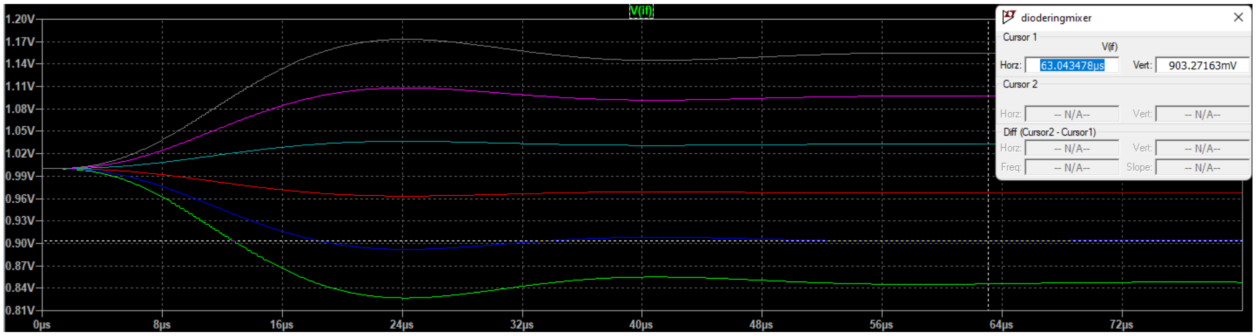

Figure 6: Transient response of Circuit 3.

Through simulations in LTSpice, the bandpass filtering caused by conversion losses seen in the datasheet can be modeled with $L_{transformer} = 20\mu H$ and $L_{stray} = 15nH$. This creates a transformer coupling of $k = 0.99925$.

The purpose of this circuit is to form a method of relating the phase difference between the LO and the input RF signal with a corresponding variable output voltage. That variable output voltage is the k_{ϕ} coefficient which has units [V/rad]. 1 radian = 57.3°. k_{ϕ} is found by the voltage output of IF when the phase difference between the LO and RF is about 60 degrees. Since the circuit is inherently self-correcting by nature, this value does not have to have extreme precision.

From the transient simulation of Circuit 3, when the phase difference between LO and RF is about 60°, the output at IF is about 0.9 V. Therefore, $k_{\phi} = 0.9\ V/rad$.