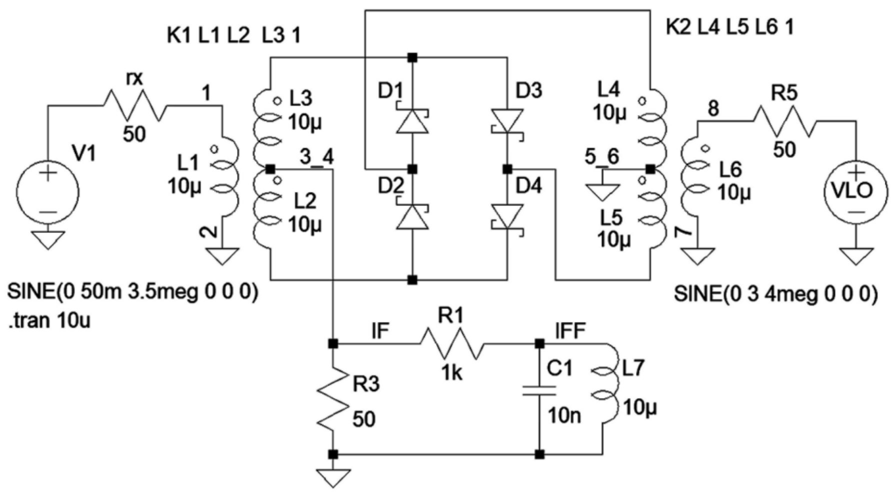
LTspice Simulation: Double Balanced Mixer

This simulation is of a transformer coupled diode ring double balanced mixer such as the Mini-Circuits SBL-1. The transformers are made using inductors, LTspice part 'ind2'. The values of the inductors are not critical, but depend on the frequency range of the mixer. Two ideal transformers are connected as shown in the diagram below.



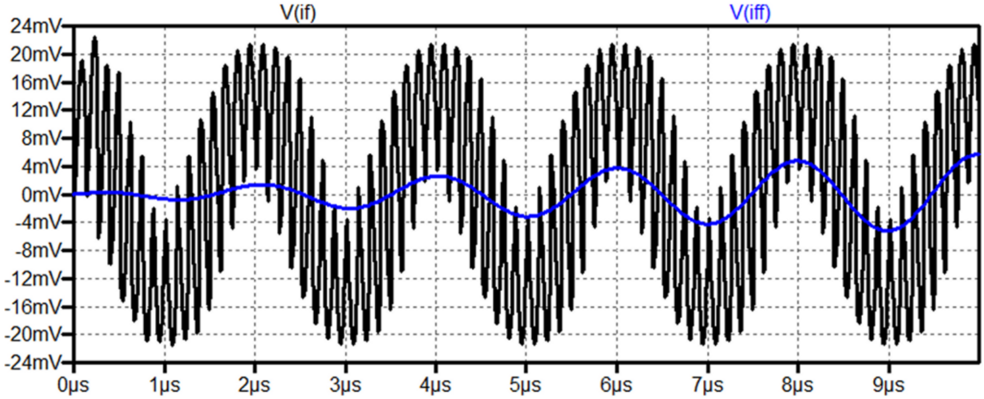
Inductors L1, L2, and L3 are set to 10µH each with a coupling coefficient of unity. They are configured as a transformer with a center-tapped secondary. Observe the phasing markers (small circles). Similarly, inductors L4, L5, and L6 are set to 10µH each with a coupling coefficient of unity.

The coupling coefficients are specified using a 'SPICE Directive'. Select 'SPICE Directive' in the 'Edit' menu. Enter 'K1 L1 L2 L3'. This is the shorthand specifying that the mutual coupling between all 3 inductors is unity. Similarly create a 'SPICE Directive' for L4, L5, and L6. . Enter 'K2 L4 L5 L6'.

Obtain the Schottky diodes by selecting the part 'Schottky'. Right click on the part's symbol to specify a particular part number, such as the 1N5818 used in this example.

Voltage source V1 is the RF input. It is set to 3.5MHz and 50mV. VLO is the local oscillator. It is set to 4.0Mhz and 3V. The IF output frequency is developed across R3. Four frequencies are possible: the RF frequency, the local oscillator frequency, the sum frequency, and the difference frequency. The RF and LO frequencies are highly attenuated as they are balanced out by this mixer. Only the sum (7.5MHz) and difference (0.5Mhz) frequencies will have a significant amplitude.

L7 and C1 are resonant at 500Khz. A transient simulation is performed for 10µS. The graph shows the output across R3 (IF) and across the resonant circuit. You can see the 500Khz beat component in the black trace. The 500Khz filtered waveform is seen increasing in amplitude (blue trace).



Exercises

1. Change the simulation time to 100µS to show that the filtered waveform reaches a steady state amplitude of about 14mV in about 60µS.
2. Measure the RF amplitude at the primary of the transformer and calculate the signal loss to the filtered output (pin 1 to IFF ≈6dB).
3. Change the filter's resonant frequency to 7.5Mhz (L = 1µ, C = 450pF). Measure the RF amplitude at transformer pin 1 and the filtered at IFF.
4. Calculate the signal loss between pin 1 and IFF.
5. Change the resonant frequency of the filter to 4Mhz (C = 1.06nF, L = 1.5µH). Measure the attenuation of the LO signal between pin 8 and IFF.
6. Set resonant frequency of the filter to 3.5 Mhz (C = 1.03nF, L = 2µH) Measure the attenuation of the RF signal between pin 1 and IFF.

ZAP Studio's free "RLC Selector" program was used to select filter components.