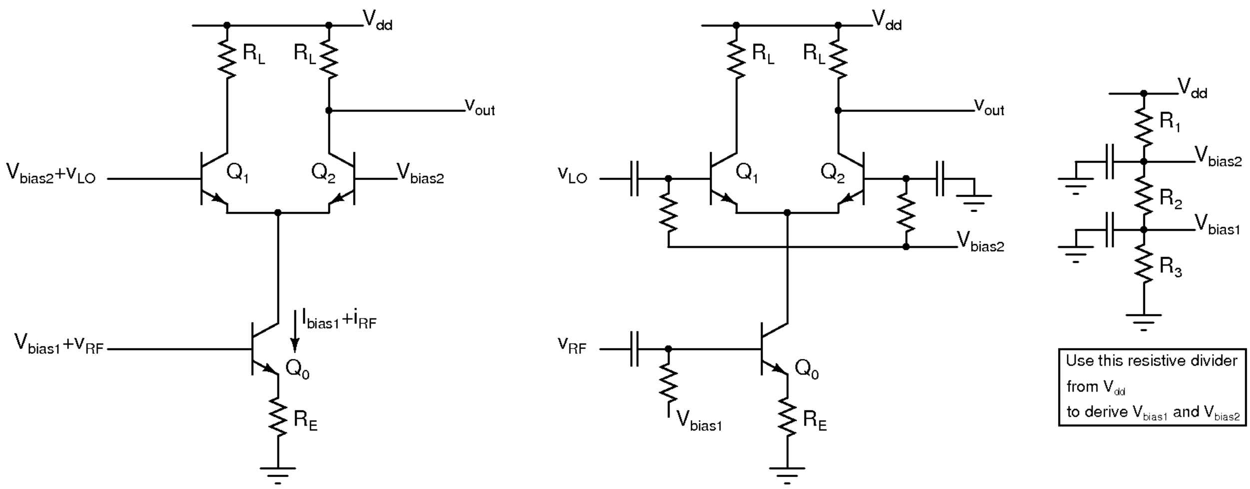
VLSI group, IIT Madras

Search

Double balanced mixer

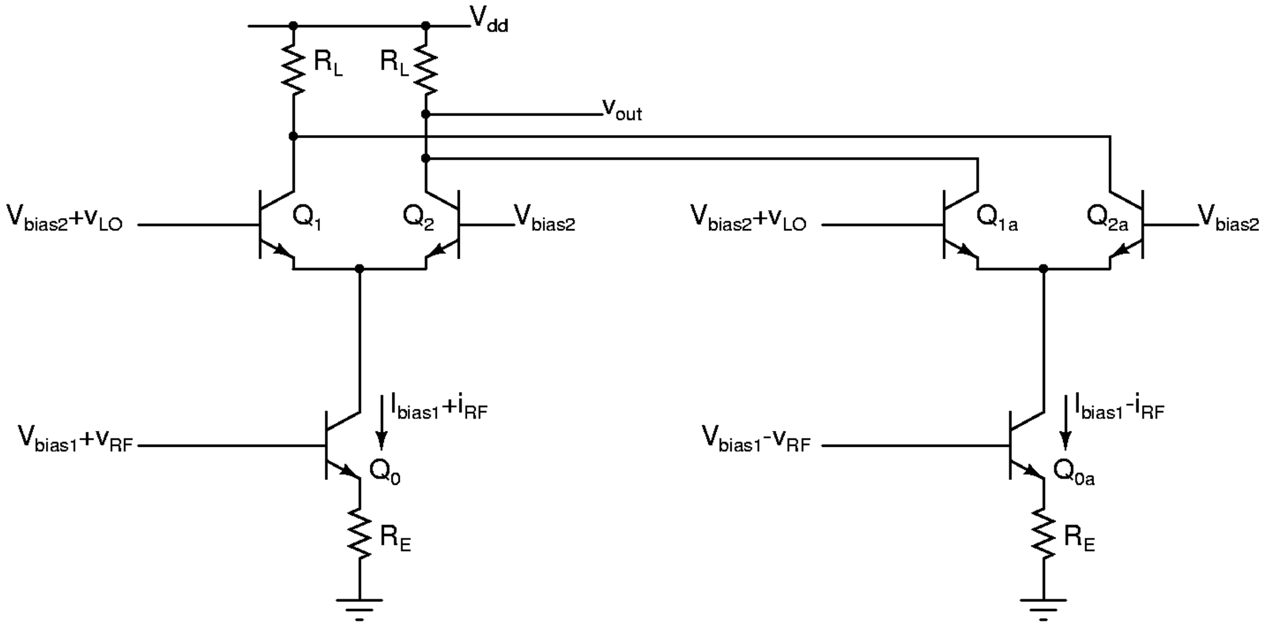
Goals

- Understand the operation of a double balanced mixer

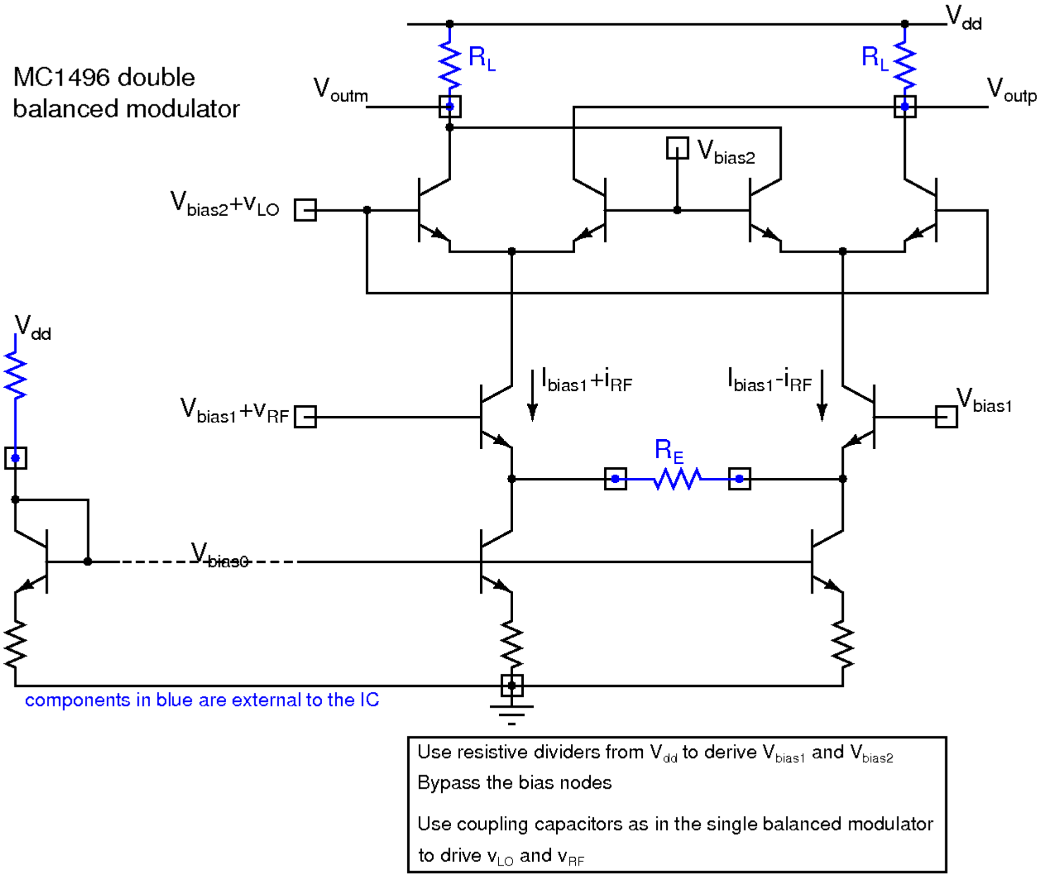


- The above figure shows the mixer designed in the previous experiment. Ideally a mixer fed with V_{RF} and V_{LO} should have only product of these two components at the output. i.e the output should be zero if either of V_{RF} or V_{LO} is zero. But, as seen earlier, with V_{RF}=0, the above mixer still generates an output proportional to V_{LO}(LO feedthrough). Such a mixer is known as a single balanced mixer.

- LO feedthrough can be eliminated as shown in the circuit below by having two mixers driven by $+v_{RF}$ and -v_{RF} and taking the difference between them. It can be seen by inspection that, when v_{RF}=0, the sum of currents through Q_1 and Q_{2a} is a constant as is the sum of currents through Q_2 and Q_{1a}. This is a double balanced mixer.



- The above circuit is available in the form of an IC-the MC1496 double balanced modulator. Its internal schematic is shown below. Most of the circuitry including the biasing arrangements are inside the IC. Only R_E, the load resistors, and the bias current setting resistor need to be connected externally. Compared to the circuit above, the bottom two transistors and their degenerating resistors are arranged as a differential pair inside the MC1496 integrated circuit.



To be done before the lab session

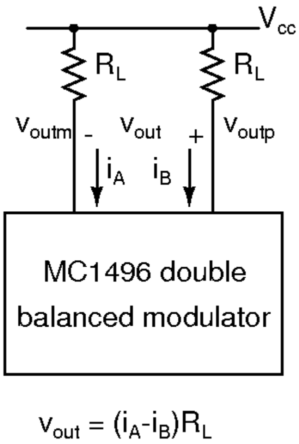
- Go through the lecture on double balanced mixers [http://www.ee.iitm.ac.in/~nagendra/EC330/200901/lectures/ec330-mixer2/ec330-mixer2.swf].

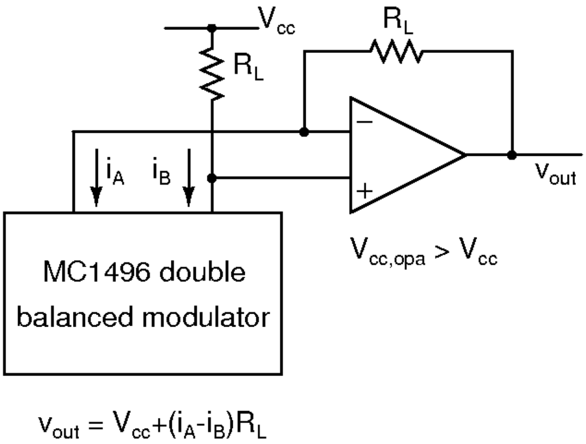
- Design a double balanced mixer around the MC1496 IC. Use a 12V supply and 1mA current through the bias branch. The mixer should be able to take in an RF input peak of 1V and have a conversion gain(ratio of the *sinusoidal component* at $f_{RF}+f_{LO}$ OR $f_{RF}-f_{LO}$ at the differential output to the amplitude of the *input sinusoid*) of 4.

To be done in the lab session

Verify the circuit designed above:

- Take V_{outp} or V_{outm} as the output.
- Drive the input with a low frequency v_{RF}(~ 1kHz) and a high frequency v_{LO}(~10kHz) and observe the output. You can use the oscillator designed in the previous experiment as the 10kHz source.
- Verify that the outputs are as expected.





- Build the differential to single ended converter shown above and drive it from the mixer. Choose appropriate supply voltages for the opamp.
  - Drive the mixer with a low frequency v_{RF} and a high frequency v_{LO} and observe the output.
  - Drive the mixer with a v_{RF} and v_{LO} at close by, but not identical frequencies and observe the low frequency($f_{RF}-f_{LO}$) output. For filtering out the high frequency component, use a capacitor of appropriate value across R_L(both of them) which will short it out at high frequencies. Filtering will be a lot easier if you choose a higher f_{LO}, say 25kHz or 50kHz, and a difference frequency around 1kHz.
  - Remove the RF input and observe the output.
  - Remove the LO input and observe the output.

Applications

- This circuit is very commonly used for frequency translation in radio transmitters and receivers.

Something to try on your own

- Drive the lower input with audio, say from your computer or digital player. Drive the LO input with a sinusoid in the AM band(0.5-1.5MHz). You should be able to use an AM radio placed close by to receive the transmitted audio. You can use a short wire connected to the output node as an antenna.