# Communications Electronics Laboratory

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# Practical Session 1: BALANCED MODULATOR

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## List of Devices

| | | |
|---|---|---|
| 1 | x | MC1496 (modulator-demodulator chip, **good idea to bring two** in case one burns out) |
| 2 | x | 3.9 kΩ (resistor) |
| 3 | x | 51 Ω (resistor) |
| 2 | x | 750 Ω (resistor) |
| 3 | x | 1 kΩ (resistor) |
| 1 | x | 6.8 kΩ (resistor) |
| 2 | x | 10 kΩ (resistor) |
| 1 | x | 50 kΩ (**potentiometer**) |
| 2 | x | 0.1µF (capacitor) |

## 1.1 Description of the Circuit

The circuit to be built corresponds to the one shown in Figure 27 of the MC1496 manual (reproduced below). The core of the integrated circuit is a differential amplifier that is able to work in the four quadrants and is called a *Gilbert cell* (shown in figure 23). The chip can work either in the linear or saturation (as a switch) mode.

**Figure 27. Balanced Modulator–Demodulator**

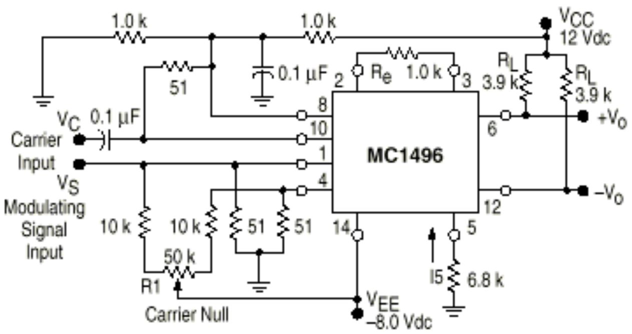
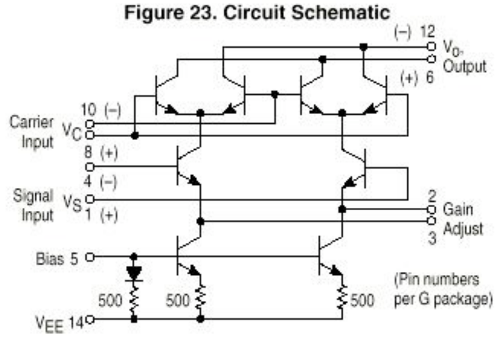


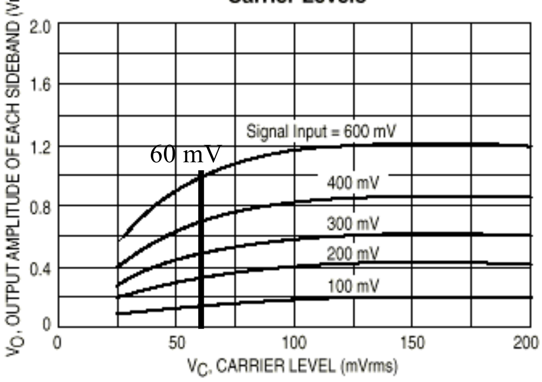
**Figure 23. Circuit Schematic**




## *1.2 Description of the Practical Work*

1. The circuit will be analyzed as a Double Sideband Modulator (DSB).
   a) First, inject a $f_c$ = 500 KHz, 60 $mV_{rms}$ signal into the carrier input (for sinusoids: $V_{rms} = V_p/\sqrt{2}$ ). The, inject a $f_s$ = 30 KHz sinusoid into the modulator signal input using the function generator. Vary the amplitude of the modulator signal between $100mV_{rms}$ and 600 $mV_{rms}$ (taking into account at least 20 values).

**Figure 11. Sideband Output versus Carrier Levels**




For each one of the amplitudes of the modulator signal, observe the oscilloscope output in FFT mode and:

a.1) Suppress the carrier as much as possible by varying the 50 kΩ potentiometer.

a.2) Record both carrier and sideband levels.

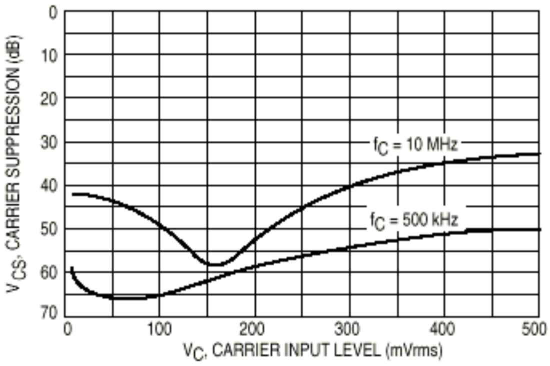
a.3) Measure the carrier suppression level, given by the difference between the carrier level and the sideband levels.

a.4) Compare the obtained carrier suppression level with the curve provided by the manufacturer.

   b) Keeping the modulator signal level at 300 $mV_{rms}$, vary the carrier signal level between 10 and 300 $mV_{rms}$ (taking into account at least 20 different values). Record the carrier suppression level for each carrier. Repeat the same procedure for $f_c$ = 10 MHz instead of 500

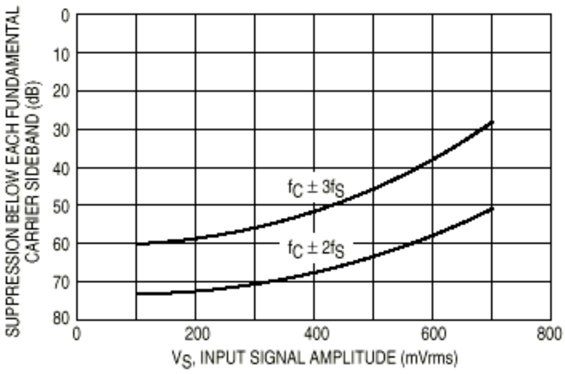
KHz. It will be necessary to increase $f_s$ up to 300 KHz so that the waveforms can be properly analyzed in the oscilloscope. Explain the differences between both cases, and compare them with the results shown in figure 22[1].

Figure 22. Carrier Suppression versus Carrier Input Level




c) In the previous measurements, you should have observed intermodulation products components at the output, especially when modulator and carrier signal levels were high enough. For a carrier signal with frequency $f_c$ =10 MHz and a modulator signal with frequency $f_s$ = 300 KHz (the amplitudes should be properly chosen and justified), measure the absolute (in $mV_{rms}$) and relative (en dB) values of the $f_c \pm f_s$ sidebands with respect to the ($f_c \pm 2f_s$), ($f_c \pm 3f_s$), $2f_c$ and $3f_c$ components. Compare your results with those shown in Figure 20.

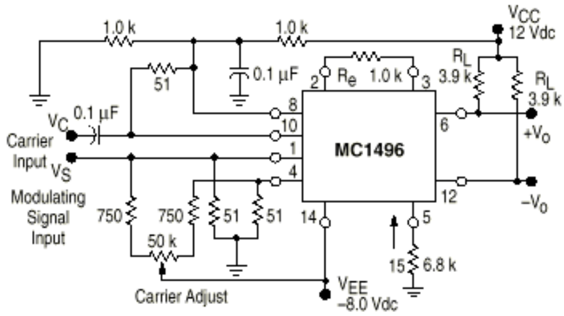
Figure 20. Sideband Harmonic Suppression versus Input Signal Level




2. The scheme shown in Figure 27 is designed to suppress as much as possible the carrier. Hence, if we use it as an AM modulator, the level of carrier injection would not be high enough. This issue can be solved by changing the 10 kΩ resistors, connected to pins 1 and 4, for 750 Ω resistors. The resulting AM modulator can be seen in the Figure below. Generate a 955 KHz, 100 $mV_{rms}$ signal modulated with a 20 KHz tone (m = 50 %). Observe in the oscilloscope the resulting waveform and record its shape. Using the oscilloscope in FFT mode, obtain the frequency

[1] Due to limitations in the resolution of the oscilloscope, it becomes difficult to measure carrier suppression levels larger than 40 dB.

representation of the output. Determine the amplitude range of both modulator and carrier in which the circuit operates linearly.




3. In this section, the circuit shown in Figure 27 will be used as demodulator. Generate a 955 KHz, 300 $mV_{rms}$ signal modulated (AM) with a 20 KHz tone (m = 50 %) and inject it into the modulating signal input. Generate a 500 KHz, 60 $mV_{rms}$ carrier using another function generator and inject it into the carrier input. Observe the resulting signal in the oscilloscope. With the oscilloscope in FFT mode, obtain the spurious components and identify each one with the frequency products that generated them. Show in a table the different frequencies and their power level.