Amplitude Modulation and Demodulation

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OBJECTIVE

To design, construct and test Amplitude Modulator and Demodulator using multiplier chip MC1496 and to test the output making use of Agilent's 54621A DSO.

EQUIPMENT

- Agilent DSO 54621A Oscillocope
- Agilent E3631A Power Supply
- Agilent 33120A Function Generator
- Transistor Radio Receiver
- Indoor Antenna
- Microphone

Measurements to be made:

a) Depth of modulation for three different amplitude levels of the modulating signal with f_m=1kHz and f_c=600kHz and making a printout of the measured waveforms.

b) Spectra of AM wave to be measured using FFT feature of the DSO and taking a printout of the same.

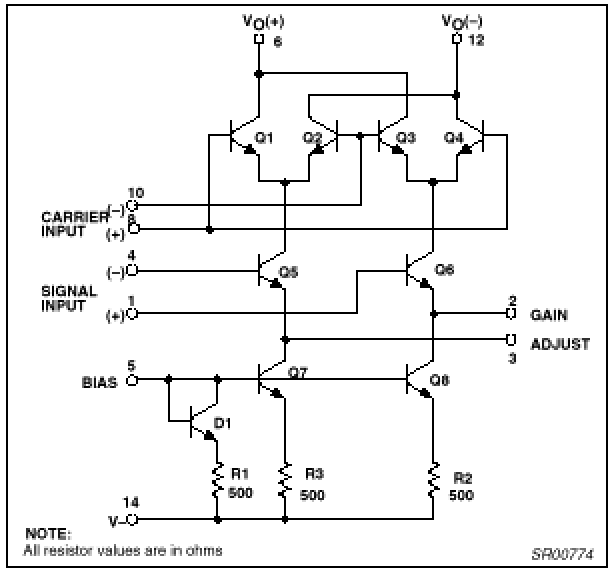
c) Make use of a transistor radio, receive your AM wave at 600kHz, hear the modulating signal at 1kHz (change frequency of modulating signal, change amplitude of modulating signal and see what happens).

d) Construct a OPAMP based microphone amplifier and give your voice signal to the AM circuit as the modulating signal, hear your transmitted voice in the radio receiver.

e) Give this AM wave from the buffer output of the AM modulator to the AM synchronous demodulator and monitor the demodulated output using the DSO and take a printout of the demodulated signal.

DESIGN AND THEORY:

Balanced Modulator (or) Gilbert Cell Schematic of MC1496

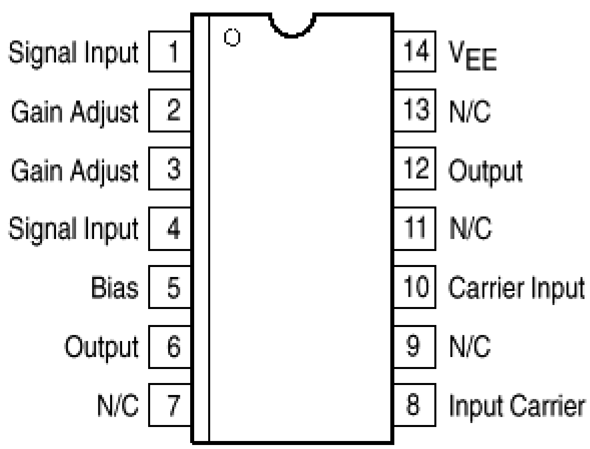


MC1496 is a monolithic transistor array arranged as a balanced modulator.

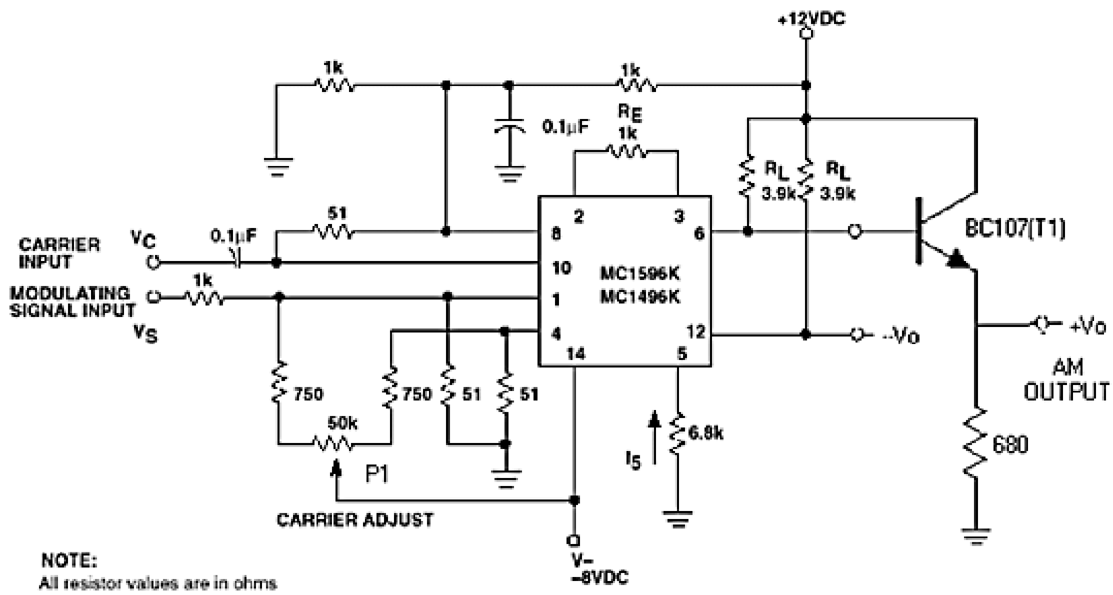
The topography includes three differential amplifiers. Internal connections are made such that the output becomes a product of the two signals V_C and V_S. Thus for sine wave signals V_{OUT} becomes

$$V_{OUT}=E_x E_y [\cos(w_x+w_y) t + \cos(w_x-w_y)t]$$

Pin diagram:



AM Modulator:

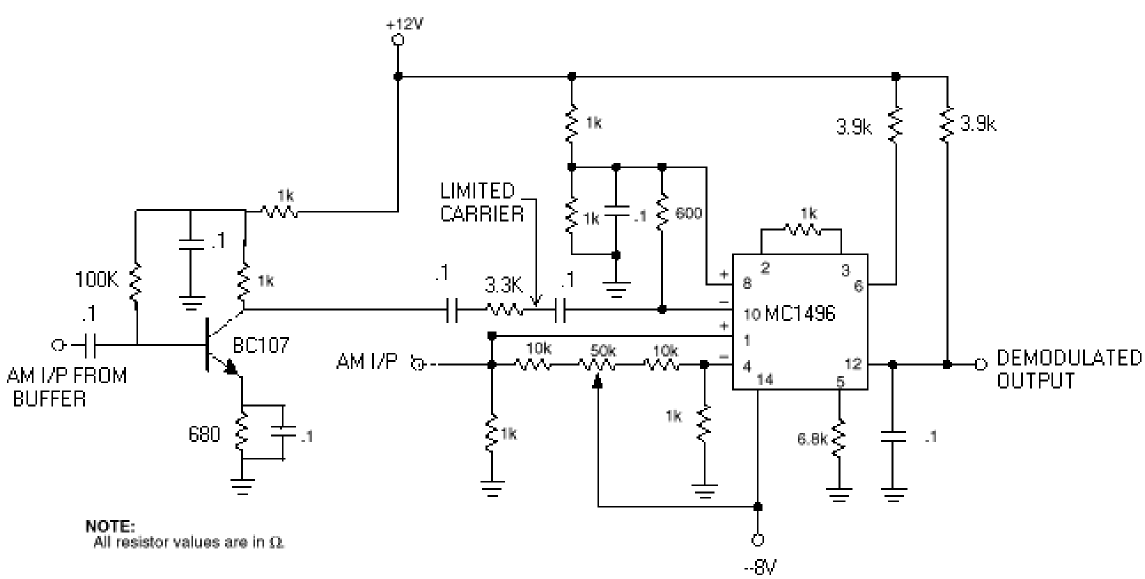


V_C= Carrier input

V_S= Modulating signal input

Due to the balance of both modulating and carrier inputs, the output will contain the sum and difference frequencies suppressing the carrier differential inputs. With the help of a potentiometer (P1), controlled amounts of carrier appears at the output whose amplitude becomes a function of the modulating signal. So this circuit is used as AM modulator. To make use of the output, an emitter follower-using transistor T1 is used as a buffer.

AM Demodulator:



The AM Modulated signal from the buffer output is given to pin number 1 of the AM Demodulator. It is also given to a high frequency amplifier and limiter circuit. The high frequency amplifier and limiter circuit consists of a transistor operated under saturation condition. The Limited carrier output from the high frequency amplifier and limiter circuit is given to pin number 10 of the synchronous AM Demodulator (MC1496) through a capacitor of .1µF. The signal is then demodulated by the synchronous AM demodulator (MC1496) where the carrier frequency is attenuated due to the balanced nature of the device. Output filtering will also be necessary to remove high frequency sum components of the carrier from the audio signal.

Design:

Select

$+V_{DC}=+12V$, $I_c=3mA$,

$R_L= +V_{DC}/I_C =12/(3*10^{-3})=4k\Omega\cong3.9k\Omega$

$V_{BE}=700mV$, $I_5=160mA$

Voltage at pin number 5= 1.7V

$V_{BIAS}= (-8+1.7)= -6.3V$

$R_S=V_{BIAS}/I_5=6.3/160mA=7k\Omega\cong6.8k\Omega$

PROCEDURE AND OBSERVATION:

***AM Modulation*:**

(1) Configure the circuit as shown in the circuit diagram

(2) Give the modulating signal f_m=1kHz and V_m=2V(Vp-p) to pin number 1 through a resistor of 500Ω from the function generator.

(3) Give the carrier signal f_c=600kHz and V_c=1V(Vp-p) to pin number 10 through a capacitor of .1µF from another function generator.

(4) Note down the AM modulated signal at the IC output pin 6 and also at the emitter of the buffer (emitter follower).

(5) Change the amplitude levels of the modulating signal, keeping f_c and f_m as constant and find out the depth of modulation

Depth of Modulation = $(V_{max}-V_{min})/(V_{max}+V_{min})*100\%$

S1.No	V_m (volts)	Depth of Modulation = $(V_{max}-V_{min})/(V_{max}+V_{min})*100\%$
1		
2		
3		

(6) Measure the spectra of AM wave using FFT feature of the DSO by setting Span frequency=200KHz and Center frequency =600KHz

(7) Note down the spectra for 100% modulation. Take a printout of it

(8) Note down the spectra for 150% modulation. Take a printout of it

(9) Note down the spectra for 200% modulation. Take a printout of it

(10) Also note down the spectra keeping the potentiometer in the center position

(11) To see the upper side band and lower side band clearly, increase the frequency of the modulating signal to 10kHz.

(12) Take a printout of the spectra.

***AM Demodulation*:**

(1) Give the Amplitude Modulated signal to pin number 1 of MC1496 in the synchronous demodulator circuit.

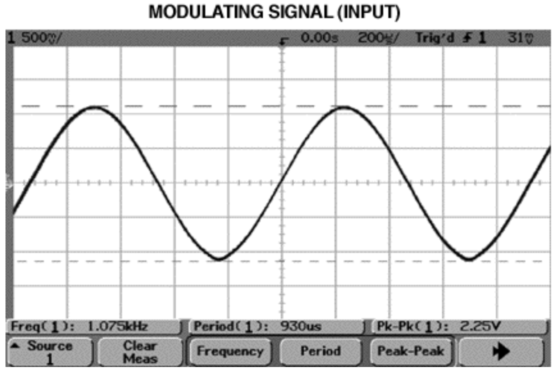
(2) Also give the AM wave from the buffer output of the AM Modulator to the limiter circuit of the synchronous Demodulator. Output of the limiter circuit is given to the pin number 10 of the IC MC1496.

(3) Note the Demodulated signal at pin number 12 of IC MC 1496.

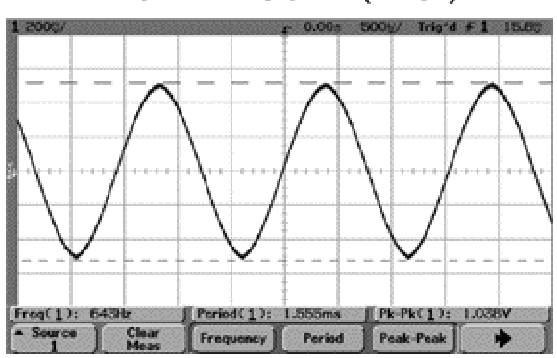
(4) See the demodulated signal in channel 1 and modulating signal in channel 2 simultaneously and make a printout .

Do FFT analysis for the signals at channel 1 and channel 2 . Note down the difference and make a printout.

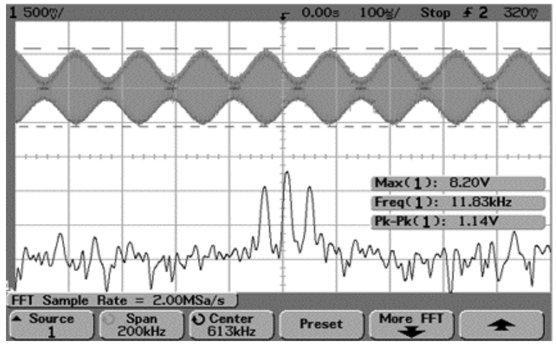
AM MODULATOR
MODULATING SIGNAL (INPUT)



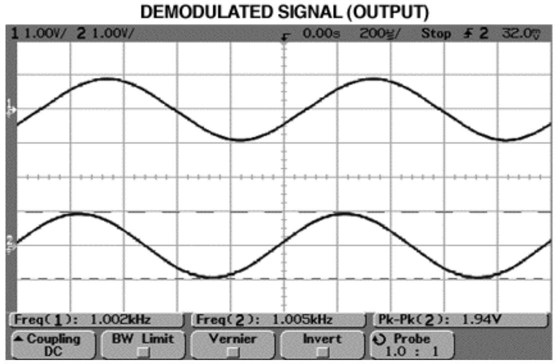
CARRIER SIGNAL (INPUT)



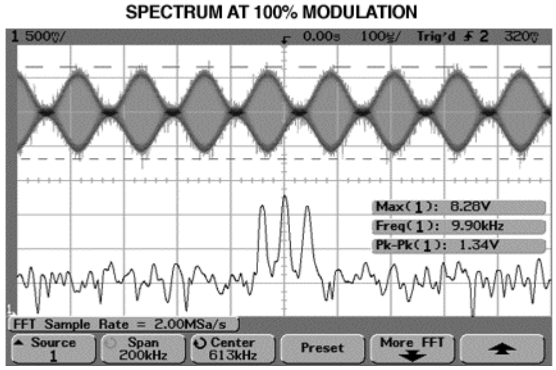
MODULATED SIGNAL (OUTPUT)
AND ITS SPECTRA



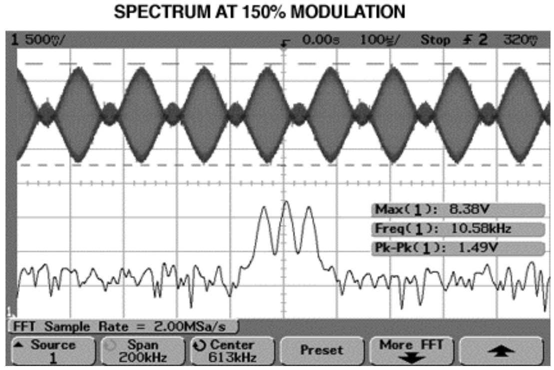
AM DEMODULATOR
DEMODULATED SIGNAL (OUTPUT)



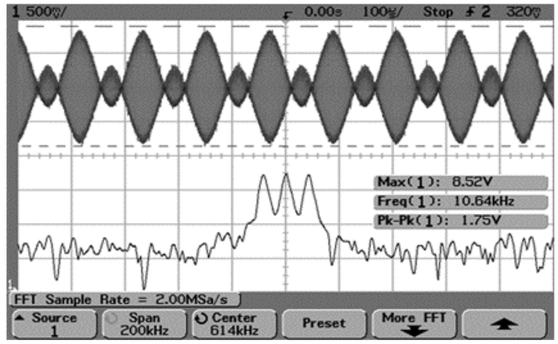
SPECTRUM AT 100% MODULATION



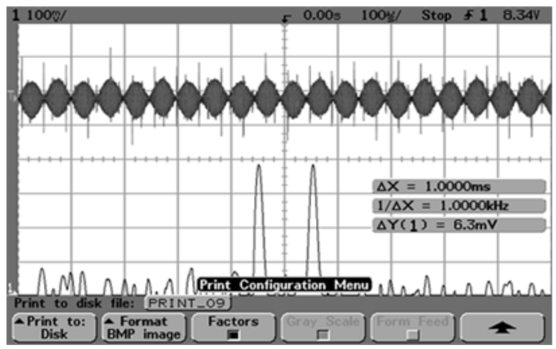
SPECTRUM AT 150% MODULATION



SPECTRUM AT 200% MODULATION



SPECTRUM WITH SUPRESSED CARRIER



QUESTIONS:

(1) Use f_c=600KHz. Modulate it with f_{m1}=300Hz, f_{m2}=700Hz and f_{m3}=2KHz audio sine waves and see the spectra of the AM wave. Take a printout of it.

(2) Connect the AM output to the given antenna and test the range of the signal with a transistor radio receiver?