Department of Electrical and Electronic Engineering (EEE)
Bangladesh University of Engineering and Technology (BUET)

EEE 310: Communication Laboratory

EXPERIMENT NO: 1
DOUBLE SIDEBAND AM AND SINGLE SIDEBAND AM GENERATION AND DETECTION

Exercise 1 (a):

DOUBLE SIDEBAND AM GENERATION AND DETECTION

Part A: Double Sideband AM Generation

***Objectives*:**
1. To investigate the generation of double sideband amplitude modulated (AM) waveforms.
2. To examine the effects of changing audio frequency and amplitude on carrier suppuration.

***Equipment*:**
1) ANACOM 1/1 module
2) Power sources +12Vdc,-12Vdc.
3) Connecting wires.
4) Oscilloscope.

***Procedure*:**
1) Connect the ANACOM 1/1 module to the power supply as shown below:

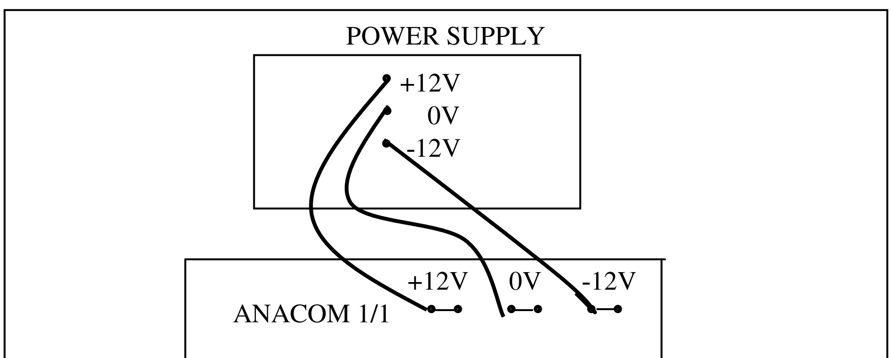


Figure 3

2) Ensure that the following initial conditions exist on the board:
   a) AUDIO INPUT SELECT switch in INT position;
   b) MODE switch in DSB position;
   c) OUTPUT AMPLIFIERE's GAIN preset in fully **clockwise** position;
   d) SPEAKER switch in OFF position.
3) Turn on power to the ANACOM 1/1 board.
4) Turn the AUDIO OSSCILATOR block's AMPLITUDE preset to its fully clockwise (MAX) position, and examine the block's output (t.p.14) on oscilloscope. The audio frequency is a sine wave, which will be used as a modulating signal. The modulating frequency can be varied from 300 Hz to 3.4 kHz by adjusting the AUDIO OSCILLATOR's FREQUENCY preset.
5) Turn the BALANCE preset, in the BALANCE MODULATOR & BANDPASS FILTER CIRCUIT 1 block, to its fully clockwise position.
6) Monitor, in turn, in the BALANCE MODULATOR & BANDPASS FILTER CIRCUIT 1 block, at t.p. 1 and t.p. 9.

7) Next, examine the output in the BALANCE MODULATOR & BANDPASS FILTER CIRCUIT 1 block (at t.p. 3), and check that the wave forms are as shown below:

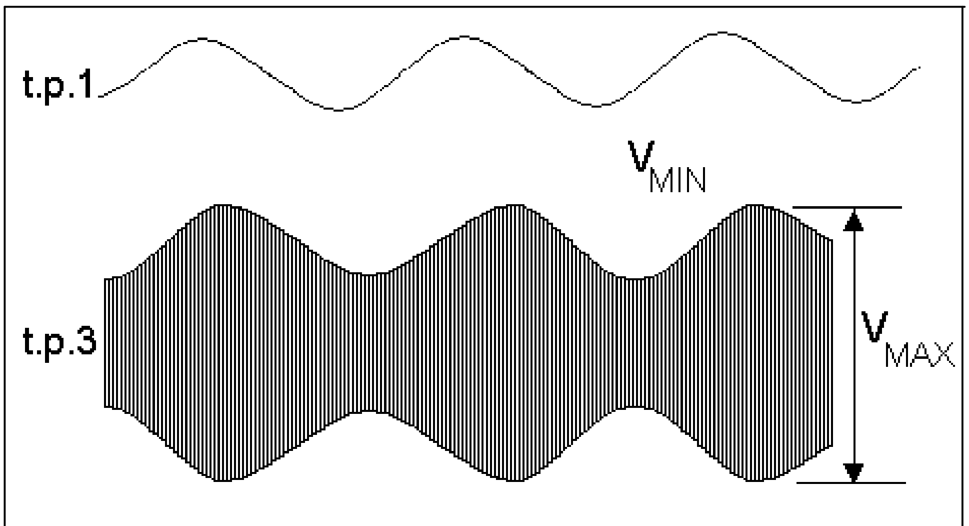
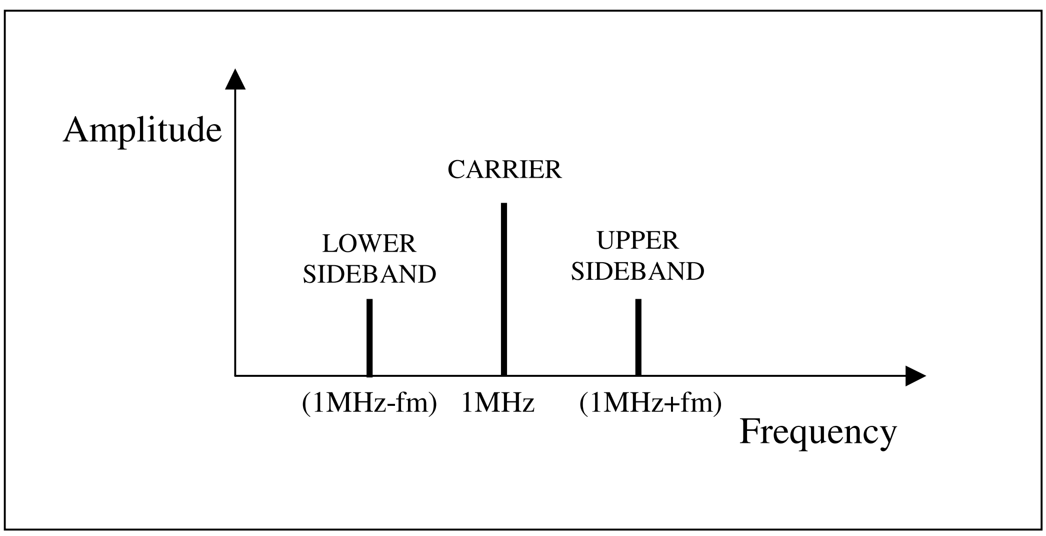


Figure-2

The output from the BALANCED MODULATOR & BANDPASS FILTER CIRCUIT1 block (at t.p. 3) is a double-sideband AM waveform, which has been formed by amplitude-modulating the 1 MHz carrier sinewave with the audio-frequency sinewave from the audio oscillator.

The frequency spectrum of this AM waveform is as shown below:



8) To determine the depth of modulation, measure the maximum amplitude (V_{max}) and the minimum amplitude (V_{min}) of the AM waveform at t.p. 3, and use the following formula:

$$\text{Percentage Modulation} = \frac{Vmax-Vmin}{Vmax+Vmin} \times 100\%$$

9) Now vary the amplitude and frequency of the audio-frequency sinewave, by adjusting the AMPLITUDE and FREQUENCY preset in the AUDIO OSCILLATOR block.

The amplitude of the two sidebands can be reduced to zero by reducing the amplitude of the modulating audio signal to zero. Do this by turning the AMPLITUDE preset to its MIN position.

Return the AMPLITUDE preset to its maximum position before continuing.

10) Now turn the BALANCE preset in the BALANCED MODULATOR & BANDPASS FILTER CIRCUIT 1block, until the signal at t.p. 3 is as shown below:

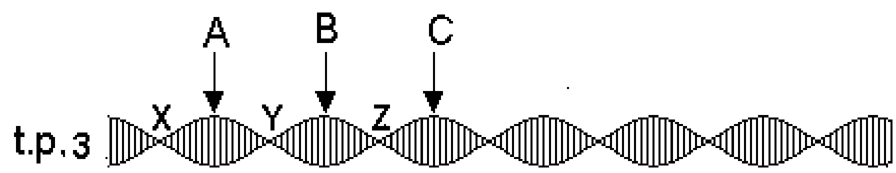
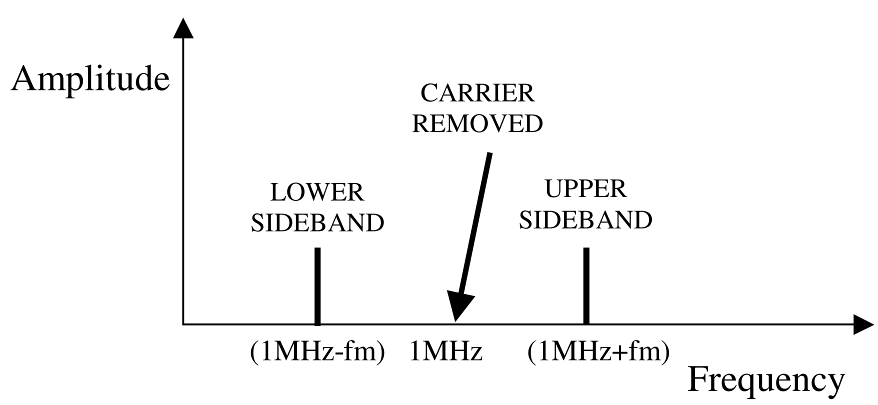


Figure 6

The BALANCE preset varies the amount of the 1 MHz carrier component, which is passed through to the modulator's output. By adjusting the preset, until the peaks of the waveform (A, B, C and so on) have the same amplitude, we are removing the carrier component altogether. Thus the carrier has been 'balanced out' (or suppressed) to leave only the two sidebands. The waveform at t.p. 3 is known as the Double-SideBand Suppressed Carrier (DSBSC) waveform, and its frequency spectrum is as shown below:



Figure

11) Change the amplitude and frequency of the modulating audio signal (by adjusting the AUDIO OSCILLATOR block's AMLITUDE and FREQUENCY presets), and note effect that these changes have on the DSBSC waveform. The amplitude of the two sidebands can be reduced to zero by reducing the amplitude of the modulating audio signal to zero. Do this by turning the AMPLITUDE preset to its MIN position, and note that the monitored signal becomes a D.C. level, including that there are now no frequency components preset.
12) Examine the output from the OUTPUT AMPLIFIER block (t.p. 13), together with the audio modulating signal (at t.p. 1), triggering the scope with the latter. Note that the DSBSC waveform appears, amplified slightly, at t.p. 13. As we will see latter, it is the OUTPUT AMPLIFIER's output signal, which will be transmitted to the receiver.
13) By using the optional AUDIO INPUT MODULE (L.J. Order Code CT7), the human voice can be used as the modulating signal, instead of using ANACOM 1/1's AUDIO OSCILLATOR block.

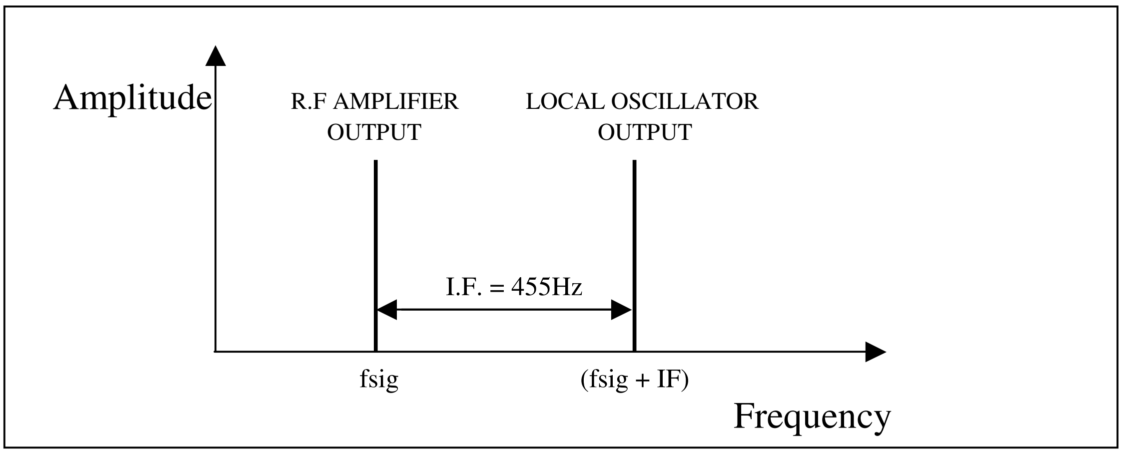
Part B: Double Sideband AM Detection

***Objectives*:**
1. To investigate the detection of double sideband amplitude modulated (AM) waveforms.
2. To examine the effects of changing audio frequency and amplitude on carrier suppuration.

***Equipment*:**
5) ANACOM 1/1 module, 1/2 module
6) Power sources +12Vdc,-12 Vdc.
7) Connecting wires.
8) Oscilloscope.

***Procedure*:**
1) Position the ANACOM 1/1 and 1/2 modules, with the ANACOM 1/1 board on the left, and a gap of about three inches between them. Then connect them to the power supply as shown below:
2) Ensure that the following initial conditions exist on the ANACOM 1/1 board:
   a) AUDIO OSCILLATOR's AMPLITUDE preset in fully clockwise position;
   b) AUDIO INPUT SELECT switch in INT position;
   c) BALANCE preset in BALANCED MODULATOR & BANDPASS FILTER CIRCUIT 1 block, in fully **clockwise** position;
   d) MODE switch in DSB position;
   e) OUTPUT AMPLIFIERE's GAIN preset in fully **counter-clockwise** position;
   f) TX OUTPUT SELECT switch in ANT. Position;
   g) AUDIO AMPLIFIERE's VOLUME preset in fully **counter-clockwise** position;
   h) SPEAKER switch in ON position.
   i) On-board antenna in vertical position, and fully extended.
3) Ensure that the following initial conditions exist on the ANACOM 1/1 board:
   a) RX INPUTSELECT switch in ANT. position;
   b) R.F. AMPLIFIERE's TUNED CIRCUIT SELECT switch in INT position;
   c) R.F. AMPLIFIERE's GAIN preset in fully **clockwise** position;
   d) AGC switch IN position;
   e) DETECTOR switch in DIODE position;
   f) AUDIO AMPLIFIER's VOLUME preset in fully **counter-clockwise** position;
   g) SPEAKER switch in ON position;
   h) BEAT FREQUENCY OSCILLATOR switch in OFF position
   i) On-board antenna in vertical position, and fully extended.
4) Turn on power to the modules.
5) On the ANACOM 1/2 module, slowly Turn the AUDIO AMPLIFIERE's VOLUME preset clockwise, until sounds can be heard from the on-board loudspeaker. Next, turn the vernier TUNING dial until a broadcast station can be heard clearly, and adjust the VOLUME control to a comfortable level.
6) The first stage, or 'front end', of the ANACOM 1/2 AM Receiver is the R.F AMPLIFIER stage. This is a wide-bandwidth tuned amplifier stage, which is tuned into the wanted station by means of the TUNING dial. Once it has been tuned into the wanted station, the R.F. AMPLIFIER, having little selectivity, will not only amplify the wanted frequency, but also those frequencies which are close to the wanted frequency. As we will see later, these nearby frequencies will be removed by subsequent stages of the receiver, to leave only the wanted signal.
7) The next stage of the receiver is the MIXER stage, which mixes the R.F. AMPLIFIER's output with the output of a LOCAL OSCILLATOR. The frequency of the LOCAL OSCILLATOR is also tuned

by means of the TUNING dial, and is arranged so that its frequency is always 455Hz above the signal frequency that the R.F. AMPLIFIER is tuned to. This fixed frequency difference is always present frequency.

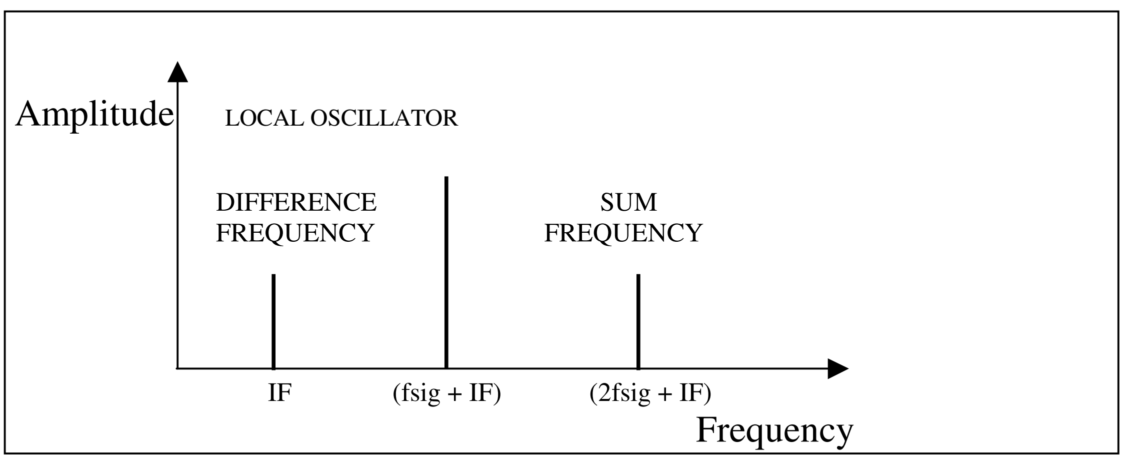


Re-tuned the receiver to a radio station before continuing.

8) The operation of the MIXER stage is basically to shift the wanted signal down to the I.F. frequency, irrespective of the position of the TUNING dial. This is achieved in two stages :
   (a) by mixing the LOCAL OSCILLATOR's output sinewave with the output from the R.F. AMPLIFIER block. This produces three frequency components :

The local oscillator frequency =(fsig +IF)
The sum of the original two frequencies, fsum =(2fsig + IF)
The difference between the original two frequencies fdiff = (fsig + IF – fsig) = IF

These three frequency components are shown below :



9) Note that, since the mixer's bandpass filter is not highly selective, it will not completely remove the LOCAL OSCILLATOR and SUM frequency components from the mixer's output. This is the case particularly with the LOCAL OSCILLATOR component, which is much larger in amplitude than the SUM and DIFFERENCE components.

10) Tune in to a strong broadcast station again, and note that the monitored signal shows little, if any, sign of modulation. This is because the wanted component, which is now at the I. F. frequency of 455kHz, is still very small in comparison to the LOCAL OSCILLATOR component.

11) Examine the output of I. F. AMPLIFIER 2 (t.p.28) with an a.c.-coupled oscilloscope channel, noting that the amplitude of the signal has been further amplified by this second I.F. amplifier stage.

12) The next step is tc extract this audio information from the amplitude variations of the signal at the output of I.F. AMPLIFIER 2 (at t.p.28).

13) The final stage of the receiver is the AUDIO AMPLIFIER block. The block contains a simple low-pass filter which passes only audio frequencies., and remove the high frequency ripple from the DIODE DETECTOR's output signal. This filtered audio signal is applied to the input of an audio power amplifier, which drives the onboard loudspeaker. The final result is the sound you are listening to!

14) Now that we have examined the basic principles of operation of the ANACOM ½ receiver for the reception and demodulation of AM broadcast signals, we will try receiving the A.M. signal from the ANACOM 1/1 Transmitter.

15) On the ANACOM 1/1 module, turn the VOLUME preset clockwise, until you can hear the tone of the AUDIO OSCILLATOR's output signal, from the on-board loudspeaker.

16) On the ANACOM ½ Receiver, adjust the VOLUME preset so that the receiver's output can be clearly heard. Then adjust the receiver's TUNING dial until the tone generated at the Transmitter is also clearly audible at the Receiver and adjust the Receiver's VOLUME preset until the tone is at a comfortable level.

17) We will now investigate the operation of the Receiver's AGC CIRCUIT. The AGC CIRCUIT prevents the receiver from overloading when it is tuned into a strong A.M. broadcast signal, by monitoring the d.c. bias voltage at the output of the DIODE DETECTOR.

18) The receiver's AGC CIRCUIT is currently in operation. To examine its behavior, monitor the output of I.F. AMPLIFIER 2, together with the output of the DIODE DETECTOR.

19) We will prevent the AGC CIRCUIT from controlling the gain of the receiver, by disconnecting it from the R.F. AMPLIFIER and I.F. AMPLIFIER 1 blocks. Do this by putting the receiver's AGC switch in the OUT position, and note the effect on the two monitored wavefroms.

20) By using the optional AUDIO INPUT MODULE, the human voice can be used as the transmitter's audio modulating signal, instead of using ANACOM 1/1's AUDIO OSCILLATOR block.

Exercise 1 (b):

SINGLE SIDEBAND AM GENERATION AND DETECTION

Part A: Single Sideband AM Generation

Objective:

1) To investigate the generation of single sideband amplitude modulated (AM) waveforms.
2) To examine the effects of changing audio frequency and amplitude on carrier suppuration.

Equipment:

9) ANACOM 1/1 module
10) Power sources +12Vdc,-12Vdc.
11) Connecting wires.
12) Oscilloscope.

Procedure:

14) Connect the ANACOM 1/1 module to the power supply as shown below:

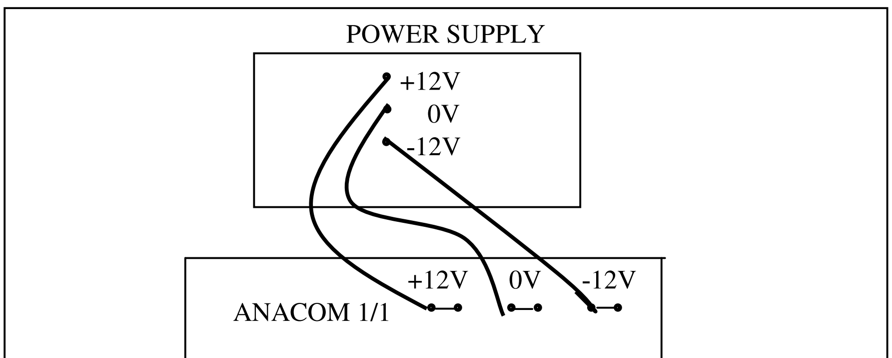


Figure 1

15) Ensure that the following initial conditions exist on the board:
    e) AUDIO INPUT SELECT switch in INT position;
    f) MODE switch in SSB position;
    g) OUTPUT AMPLIFIER's GAIN preset in fully **clockwise** position;
    h) SPEAKER switch in OFF position.

16) Turn on power to the ANACOM 1/1 board.

17) Turn the AUDIO OSSCILATOR block's AMPLITUDE preset to its fully clockwise (MAX) position, and examine the block's output (t.p.14) on oscilloscope. The audio frequency is a sinewave, which will be used as a modulating signal. The modulating frequency can be varied from 300Hz to 3.4KHz by adjusting the AUDIO OSCILLATOR's FREQUENCY preset.

18) Turn the BALANCE preset, in the BALANCE MODULATOR & BANDPASS FILTER CIRCUIT 1 block, to its fully clockwise position.

19) Monitor, in turn , in the BALANCE MODULATOR & BANDPASS FILTER CIRCUIT 2 block, at t.p.15 and t.p.6.

20) Next, examine the output of the , in the BALANCE MODULATOR & BANDPASS FILTER CIRCUIT 1 block (at t.p.3), and check that the wave forms are as shown below:

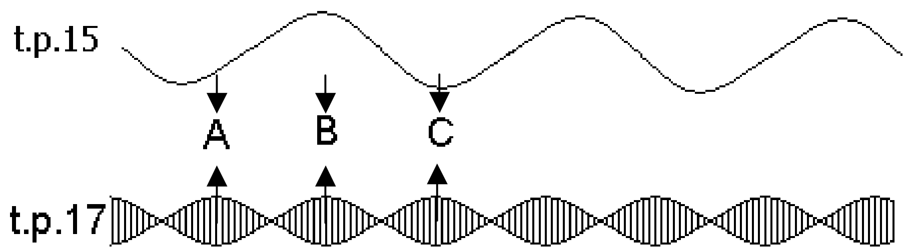
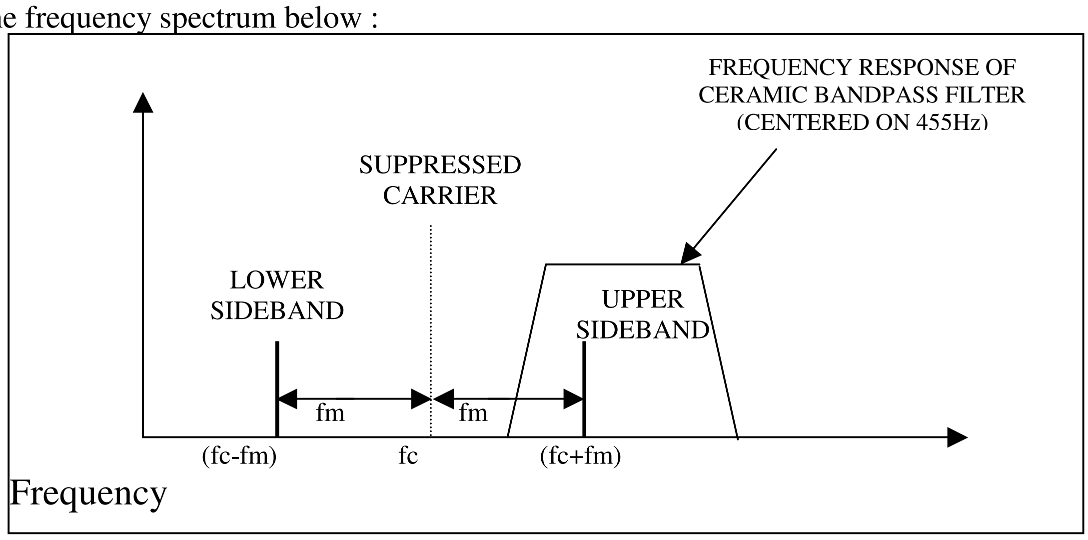
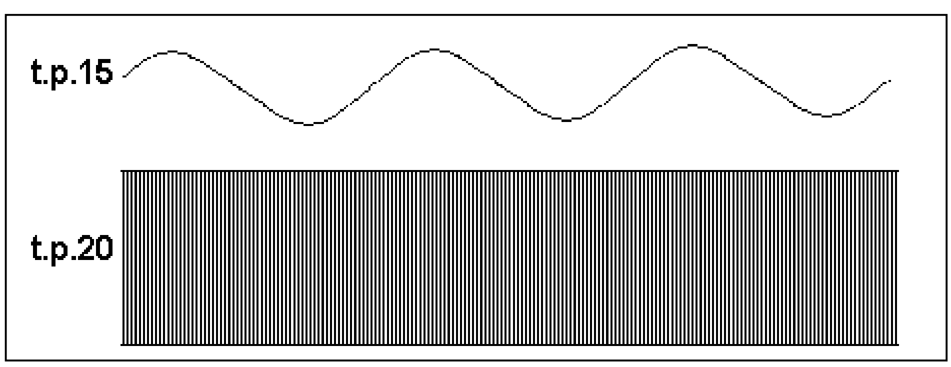


Figure-2

21) The DSBSC output from the BALANCE MODULATOR block is next passed on to the CERAMIC BANDPASS FILTER block, whose purpose is to pass the upper sideband, but block the lower sideband. This is shown in the frequency spectrum below :



22) Monitor the output of the CERAMIC BANDPASS FILTER block (at t.p.20), together with audio modulating signal (at t.p.15), using the latter signal to trigger the oscilloscope. Note that the envelope of the signal at t.p. 20 now has fairly constant amplitude, as shown below :



10. Now trigger the oscilloscope with the CERAMIC BANDPASS FILTER's output signal (t.p.20) and note that the signal is a good, clean sinewave, indicating that the filter has passed the upper only.

11. Note that there is some variation in the amplitude of the signal at the filter's output (t.p.20) as the modulating frequency is changed. This variation is due to the frequency response of the CERAMIC

BANDPASS FILTER and is best explained by considering the spectrum of the filter's input signal at the MIN and MAX positions of the FREQUENCY preset.

12. Note that , by passing only the upper sideband (of frequency (fc +fm)), all we have actually done is to shift our audio modulating signal (of frequency fm) up in frequency by an amount equal to the carrier frequency fc.

13. With the AUDIO OSCILLOSCOPE block's FREQUENCY preset roughly in this midway position, turn the block's AMPLITUDE preset to its MIN position, and note that the amplitude of the signal at the CERAMIC BANDPASS FILTER's output (t.p.20) drops to zero.

14. You will recall that we have used a CERAMIC BANSPASS FILTER to pass the wanted upper sideband, but reject the unwanted lower sideband which was also produced by the amplitude modulation process. We used this type of filter because it passes the upper sideband, yet has a sufficiently sharp response to strongly attenuate the lower sideband, which is closeby.

15. Now examine the output of the BALANCED MODULATOR & BANDPASS FILTER CIRCUIT 2 block (at t.p. 22) and check that waveform is a good sinewave of frequency approximately 1.455MHz.

16. Monitor the 1.455MHz SSB signal (at t.p.22), together with the audio modulating signal (at t.p.15), triggering the scope with the latter.

17. Examine the final SSB output (at t.p. 22) together with the output from the OUTPUT AMPLIFIER block (t.p.13). As we will see later, it is the OUTPUT AMPLIFIER's output signal which will be transmitted to the receiver.

18. By using the optional AUDIO INPUT MODULE , the human voice can be used as the audio modulating signal, instead of using ANACOM 1/1's AUDIO OSCILLATOR block.

Part B: Single Sideband AM Detection

Objective:
1) To investigate the detection of single sideband amplitude modulated (AM) waveforms.
2) To examine the effects of changing audio frequency and amplitude on carrier suppuration.

Equipment:
1) ANACOM 1/1 module, 1/2 module.
2) Power sources +12Vdc,-12Vdc.
3) Connecting wires.
4) Oscilloscope.

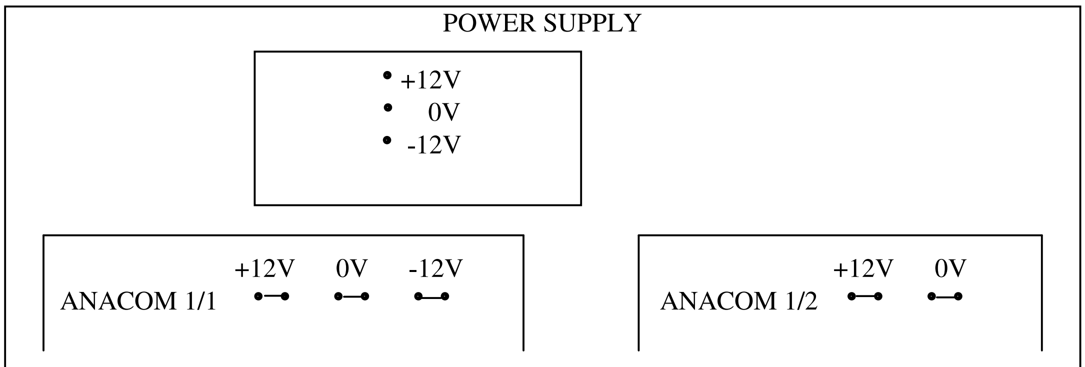
Procedure:

21) Position the ANACOM 1/1 and 1/2 modules, with the ANACOM 1/1 board on the left, and a gap of about three inches between them. Then connect them to the power supply as shown below:

22) Ensure that the following initial conditions exist on the ANACOM 1/1 board:

   a) AUDIO OSCILLATOR's AMPLITUDE preset in fully clockwise position;
   b) AUDIO INPUT SELECT switch in INT position;
   c) MODE switch in DSB position;

d) OUTPUT AMPLIFIERE's GAIN preset in fully **counter-clockwise** position;
e) TX OUTPUT SELECT switch in ANT. Position;
f) AUDIO AMPLIFIERE's VOLUME preset in fully **counter-clockwise** position;
g) SPEAKER switch in ON position.
h) On-board antenna in vertical position, and fully extended.



Figure

23) Ensure that the following initial conditions exist on the ANACOM 1/1 board:

a) RX INPUTSELECT switch in ANT. position;
b) R.F. AMPLIFIERE's TUNED CIRCUIT SELECT switch in INT position;
c) R.F. AMPLIFIERE's GAIN preset in fully **clockwise** position;
d) AGC switch IN position;
e) DETECTOR switch in DIODE position;
f) AUDIO AMPLIFIER's VOLUME preset in fully **counter-clockwise** position;
g) SPEAKER switch in ON position;
h) BEAT FREQUENCY OSCILLATOR switch in OFF position
i) On-board antenna in vertical position, and fully extended.

24) Turn on power to the modules.

25) On the ANACOM 1/1 module, examine the Transmitter's output signal (t.p. 13), and make sure that this is a good SSB waveform, by checking that the signal is a reasonably good sinewave for all positions of the AUDIO OSCILLATOR's FREQUENCY preset.

26) Turn ANACOM 1/1's AMPLITUDE preset to its fully counter-clockwise position and note that the amplitude of the monitored output signal from ANACOM 1/1 (at t.p. 13) drops to zero. This illustrates that the SSB waveform contains no carrier – if the amplitude of the modulating audio signal drops to zero, so does the amplitude of the transmitted SSB signal.

27) We will now transmit the SSB waveform to the ANACOM 1/2 Receiver. Since ANACOM 1/1's TX OUTPUT SELECT switch is in the ANT. Position, the SSB signal at t.p.13 is fed to the transmitter's antenna. Prove this by touching ANACOM 1/1's antenna and noting that the loading caused by your hand reduces the amplitude of the SSB waveform at t.p.13.

28) On the ANACOM 1/2 module, monitor the output of the I.F. AMPLIFIER 2 block (t.p.28) and turn the TUNNING dial until the amplitude of the monitored signal is at its greatest. This should occur at about 85-95 on the TUNNING dial.

29) Since the incoming SSB signal contains no carrier component, the Receiver's AGC CIRCUIT cannot make use of incoming carrier amplitude, in order to control the Receiver's gain.

30) For SSB reception, the following blocks of the Receiver operate in the same way as they did for the reception of Double-sideband AM signals:

R.F AMPLIFIER LOCAL OSCILLATOR MIXEAR
I.F. AMPLIFIER 1 I.F. AMPLIFIER 2

31) The receiver's BEAT FREQUENCY OSCILLATOR (BFO) produces a sinewave at the I.F. frequency of 455kHz. This 455kHz sinewave is input to the Receiver's PRODUCT DETECTOR block, where it is mixed with the SSB signal from I.F. AMPLIFIER 2.

32) Monitor the output of ANACOM ½'s BEAT FREQUENCY OSCILLATOR block (t.p.46) and note that this carries a sinewave of 455kHz. On the ANACOM 1/2 Receiver, adjust the VOLUME preset so that the receiver's output is clearly audible.

33) On the ANACOM 1/1 module, turn the VOLUME preset clockwise, until you can hear the tone of the AUDIO OSCILLATOR's output signal, in addition to the tone from the ANACOM 1/2 board.

34) On the ANACOM 1/2 module, monitor the output of the PRODUCT DETECTOR block (at t.p.37), together with the output of the AUDIO AMPLIFIER block (t.p.39), triggering the 'scope with the latter signal. Vary the frequency of the Transmitter's audio modulating signal by adjusting the AUDIO OSCILLATOR's FREQUENCY preset on the ANACOM 1/1 module.

35) With the Receiver's TUNNING dial adjusted for correct demodulation of the transmitted SSB signal, you may notice that there is a slight drift in the tone generated by the Receiver. This is due to small frequency drifts in the Transmitter and receiver oscillator circuits, leading to changes in the difference frequency produced by the PRODUCT DETECTOR.

36) In practice, it would not be possible to align the Receiver to the Transmitter by comparing tones, since the Receiver's operator would not have access to the original audio modulating signal.

Labsheet revised by:
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