Experiment 1

Objective:

1. Double Sideband AM Generation
2. To calculate modulation index of DSB wave by trapezoidal pattern.
3. Double Sideband AM Reception

Equipment Required:

1. ST2201 and ST2202 with power supply cord
2. CRO with connecting probe
3. Connecting cords

Theory:

Amplitude Modulation (AM)

The method that we are going to use is called amplitude modulation. As the name suggest, we are going to use the information signal to control the amplitude of the carrier wave. As the information signal increases in amplitude, the carrier wave, is also made to increase in amplitude. Likewise, as the information signal decreases, then the carrier amplitude decreases.

By looking at Figure 5 below, we can see that the modulated carrier wave does appear to 'contain' in some way the information as well as the carrier.

We will see later how the receiver is able to extract the information from the amplitude modulated carrier wave.

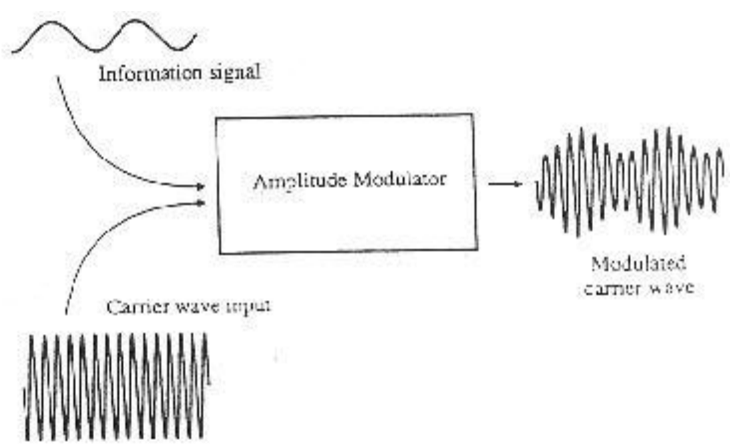

Figure 1

Block Diagram of Amplitude Modulation

Depth of Modulation :

The amount by which the amplitude of the carrier wave increases and decreases depends on the amplitude of the information signal and is called the 'depth of modulation'.

The depth of modulation can be quoted as a fraction or as a percentage.

$$\text{Percentage modulation} = \frac{V\max - V\min}{V\max + V\min} \times 100\%$$

Here is an example,

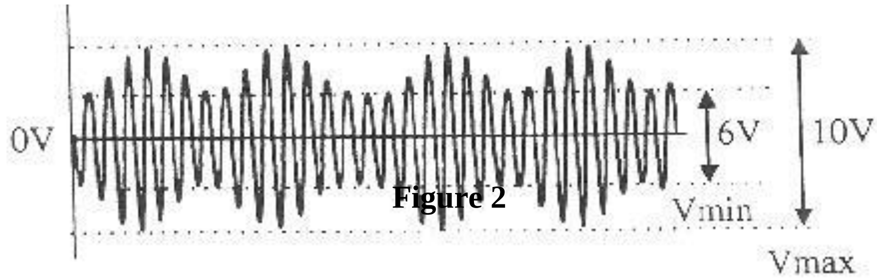

Figure 2

Figure 2

Calculation of Modulation Index

In above Figure 2 we can see that the modulated carrier wave varies from a maximum peak-to-peak value of 10 volts, down to a minimum value of 6 volts. Inserting these figure in the above formula, we get:

$$\text{Percentage modulation} = \frac{10 - 6}{10 + 6} \times 100\%$$

$$= \frac{4}{16} \times 100\ \%$$

$$= 25\% \text{ or } 0.25$$

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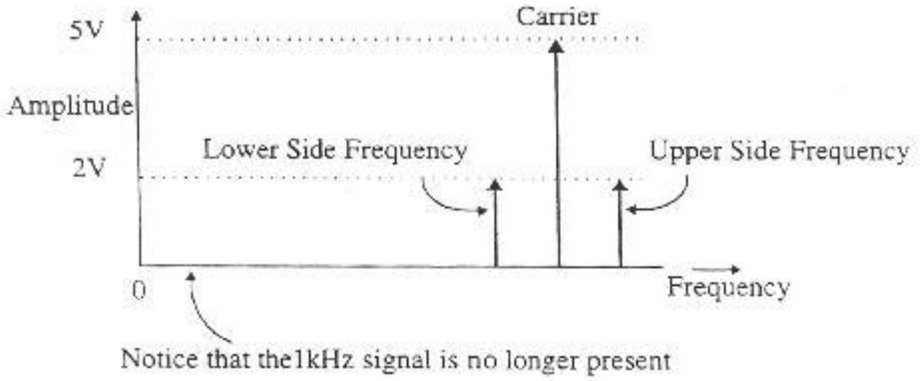

Figure 3

Frequency Spectrum of AM Signal

There are two components :

1. Carrier frequency (fc) plus the information frequency, called the *upper side frequency* (fc + fm).
2. Carrier frequency (fc) minus the information frequency, called the *lower side frequency* (fc - fm).

Procedure :

A. Setup for Double Sideband AM Generation.

1. Ensure that the following initial conditions exist on the board.
   - **a.** Audio input select switch should be in INT position:
   - **b.** Mode switch in DSB position.
   - **c.** Output amplifier's gain potentiometer in full clockwise position.
   - **d.** Speakers switch in OFF position.
2. Turn on power to the **ST2201** board.
3. Turn the audio oscillator block's amplitude pot to its full clockwise (MAX) position, and examine the block's output (TP14) on an oscilloscope.

   This is the audio frequency sine wave which will be as our modulating signal. Note that the sine wave's frequency can be adjusted from about 300 Hz to approximately 3.4 KHz, by adjusting the audio oscillator's frequency potentimeter.

Note also that the amplitude of this audio modulating signal can be reduced to zero, by turning the Audio oscillator's amplitude present to its fully counter-clockwise (MIN) position.

Return the amplitude present to its max position.

4. Turn the balance pot, in the balanced modulator & band pass filter circuit 1 block, to its fully clockwise position. It is this block that we will use to perform *double-side band amplitude modulation.*

5. Monitor, in turn, the two inputs to the balanced modulator & band pass filter circuits 1 block, at TP1 and TP9. Note that:

a. The signal at TP1 is the audio-frequency sinewave from the audio oscillator block. This is the modulating input to our double-sideband modulator.

b. Test Point 9 carries a sine wave of 1MHz frequency and amplitude 120mVpp approx. This is the carrier input to our double-sideband modulator.

6. Next, examine the output of the balanced modulator & band pass filter circuit 1 block (at tp3), together with the modulating signal at TP1 Trigger the oscilloscope on the TP1 signal. The output from the balanced modulator & band pass filter circuit 1 block (at TP3) is a double-sideband. AM waveform, which has been formed by amplitude-modulating the 1MHz carrier sinewave with the audio-frequency sinewave from the audio oscillator.

Related O/P waveforms:

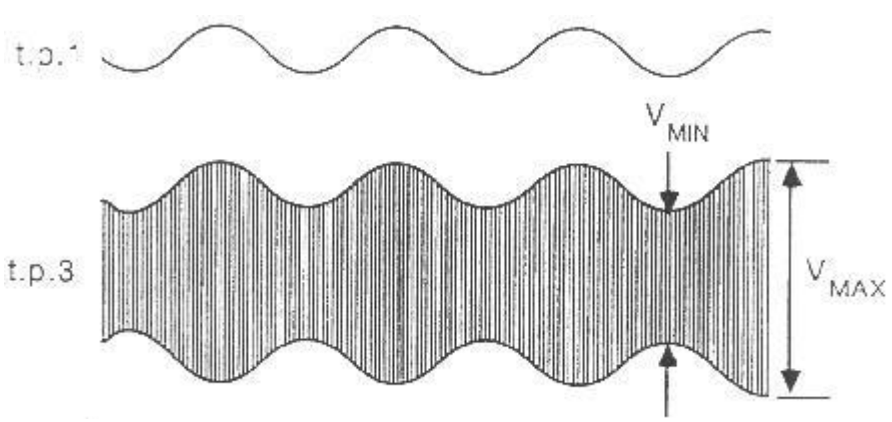

Figure 4

DSB-FC Waveform

B. Setup for calculation of modulation index by Trapezoidal pattern.

Procedure :

1. Perform the experiment number 1 upto step number 6.
2. Now apply the modulated waveform to the Y input of the Oscilloscope and the modulating signal to the X input.
3. Press the XY switch, you will observe the waveform similar to the one given below:

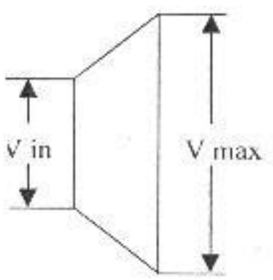

Figure 5

Trapezoidal Pattern

Calculate the modulation index by substituting in the formula

$$\text{Percentage Modulation} = \frac{V\ max - V\ min}{V\ max + V\ min}$$

C. Setup for Double Sideband AM Reception

Procedure :

1. Position the **ST2201** & **ST2202** modules, with the **ST2201** board on the left, and a gap of about three inches between them.

2. Ensure that the following initial conditions exist on the **ST2201** board.

- **a.** Audio oscillator's amplitude pot in fully clockwise position.
- **b.** Audio input select switch in INT position.
- **c.** Balance pot in balanced modulator & band pass filter circuit 1 block, in full clockwise position;
- **d.** Mode switch in DSB position.
- **e.** Output amplifier's gain pot in full counter-clockwise position.
- **f.** TX output select switch in ANT position:
- **g.** Audio amplifier’s volume pot 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 **ST2102** board:

- **a.** RX input select switch in ANT position.
- **b.** R.F. amplifier's tuned circuit select switch in INT position.
- **c.** R.E amplifier's gain pot in fully clock-wise position;
- **d.** AGC switch in INT position.
- **e.** Detector switch in diode position.
- **f.** Audio amplifier's volume pot 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. The first stage or 'front end' of the **ST2202** 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, but also those frequencies that 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. Examine the envelope of the signal at the R.F. amplifier's output (at TP12), with an a.c. - coupled oscilloscope channel. Note that :

a. The amplifier's output signal is very small in amplitude (a few tens of millivolts at the most). This is because one stage of amplification is not sufficient to bring the signal's amplitude up to a reasonable level.

b. Only a very small amount of amplitude modulation can be detected, if any. This is because there are many unwanted frequencies getting through to the amplifier output, which tend to 'drown out' the wanted AM Signal.

You may notice that the waveform itself drifts up and down on the scope display, indicating that the waveform's average level is changing. This is due to the operation of the AGC circuit, which will be explained later.

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 455 KHz above the signal frequency that the R.F. amplifier is tuned to. This fixed frequency difference is always present, irrespective of the position of the tuning dial, and is arranged so that its frequency is always 455 KHz above the signal frequency that the R.F. amplifier is tuned to. This fixed frequency difference is always present, irrespective of the position of the tuning dial, and is known as the intermediate frequency (IF for short). This frequency relationship is shown below, for some arbitrary position of the tuning dial.

Examine the output of the local oscillator block, and check that its frequency varies as the tuning dial is turned. Re-time the receiver to a radio station.

8. The operation of the mixer stage is basically to shift the wanted signal down to the IF 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 = (f sig + IF)

The sum of the original two frequencies, f sum = (2 f sig + IF)

The difference between the original two frequencies,

f diff = (f sig + IF - f sig) = IF

b. By strongly attenuating all components. except the difference frequency, IF this is done by putting a narrow-bandwidth band pass filter on the mixer's output.

The end result of this process is that the carrier frequency of the selected AM station is shifted down to 455 KHz (the IF Frequency), and the sidebands of the AM signal are now either side of 455 KHz.

9. Note that, since the mixer's band pass filter is not highly selective, it will not completely remove the local oscillators 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.

Examine the output of the mixer block (TP20) with an a.c. coupled oscilloscope channel, and note that the main frequency component present changes as the tuning dial is turned. This is the local oscillator component, which still dominates the mixer's output, in spite of being attenuated by the mixer's band pass filter.

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 IF frequency of 455 KHz, is still very small in component, which is now at the IF frequency of 455 KHz, is still very small in comparison to the local oscillator component.

What we need to do now is to preferentially amplify frequencies around 455 KHz, without amplifying the higher-frequency local oscillator and SUM components.

This selective amplification is achieved by using two IF amplifier stages, IF amplifier 1 and IF amplifier 2, which are designed to amplify strongly a narrow band of frequencies around 455 KHz, without amplifying frequencies on either side of this narrow band.

These IF amplifiers are basically tuned amplifiers which have been pre-tuned to the IF frequency-they have a bandwidth just wide enough to amplify the 455 KHz carrier and the AM sidebands either side of it. Any frequencies outside this narrow frequency band will not be amplified.

Examine the output of IF amplifier 1 (at. TP24) with an a.c.-coupled oscilloscope channel, and note that :

a. The overall amplitude of the signal is much larger than the signal amplitude at the mixer's output, indicating that voltage amplification has occurred.

b. The dominant component of the signal is now at 455 KHz, irrespective of any particular station you have tuned into. This implies that the wanted signal, at the IF frequency, has been amplified to a level where it dominates over the unwanted components.

c. The envelope of the signal is modulated in amplitude, according to the sound information being transmitted by the station you have tuned into.

11. Examine the output of IF amplifier 2 (TP28) with an a.c.-coupled oscilloscope channel, noting that the amplitude of the signal has been further amplified by this second IF amplitude of the signal has been further amplified by this second IF amplifier stage.

IF amplifier 2 has once again preferentially amplified signals around the IF frequency (455 KHz), so that:

a. The unwanted local oscillator and sum components from the mixer are now so small in comparison, that they can be ignored totally,

b. Frequencies close to the I F frequency, which are due to stations close to the wanted station, are also strongly attenuated.

The resulting signal at the output of IF amplifier 2 (TP28) is therefore composed almost entirely of a 455 KHz carrier, and the A.M. sidebands either side of it carrying the wanted audio information.

12. The next step is extract this audio information from the amplitude variations of the signal at the output of IF amplifier 2. This operation is performed by the diode detector block, whose output follows the changes in the amplitude of the signal at its input.

To see how this works, examine the output of the diode detector block (TP31), together with the output from. IF amplifier 2 (at tp28). Note that the signal at the diode detector's output:

- Follows the amplitude variations of the incoming signal as required:
- Contains some ripple at the IF frequency of 455 KHz, and
- The signal has a positive DC offset, equal to half the average peak to peak amplitude of the incoming signal. We will see how we make use of this offset later on, when we look at automatic gain control (AGC).

Frequently Asked Questions

Q1: Define Amplitude Modulation.
Ans.: Amplitude Modulation is the type of modulation technique in which the amplitude of high frequency carrier wave is varied in accordance with the instantaneous amplitude of modulating signal.

Q2: What is Modulation Index ?
Ans.: Modulation Index is measure of the depth of modulation. It is a numerical value between 0 & 1. Ideally it should be 1 or close to 1.

Q3: **What is the range of commercial AM broadcast bands?**
Ans.: 535 KHz-1605 KHz (Medium Wave), 1.6-4.5 MHz (Short Wave-I), 4.5-16 MHz (Short Wave-II) and 16-25 MHz (Short Wave-III).

Q4: **Which kind of modulation is used in picture signal in Television broadcast?**
Ans.: VSB (Vestigial Sideband).