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DEPARTMENT OF ELECTRONIC ENGINEERING

Analog and Digital communication (6th Term Third Year) Lab. Experiment # 04

Name: ______________________ **Roll:No:**__________________

Signature of Teacher: _________________ **Date:**_____________________

SINGLE SIDE BAND MODULATION (SSB)

Objectives:

- To examine the single side band modulation parameters
- To check the operation of the DSB suppressed carrier amplitude modulator
- To check the use of filters to generate the single side band

Material:

- Base unit:
  - Power supply mod.PS1-SU/EV
- Experiment module mod.MCM24/EV
- Dual-trace oscilloscope
- Function generator

THEORY:

The theory of AM modulation shows that the modulation process produces a carrier and two side bands as shown in Figure 4.1 below.

It is evident that the carrier does not carry any information, as it keeps constant in amplitude as well as in frequency independently from the modulating signal.
It is evident, too, that the two side bands are exactly the same: the amplitude of both of them change in fact in the same second mode $m.A/2$, and so the frequencies shift of the same quantity f from the carrier frequency.
It follows that all the information can be transmitted using a single side band: the carrier is superfluous and the other side band redundant.

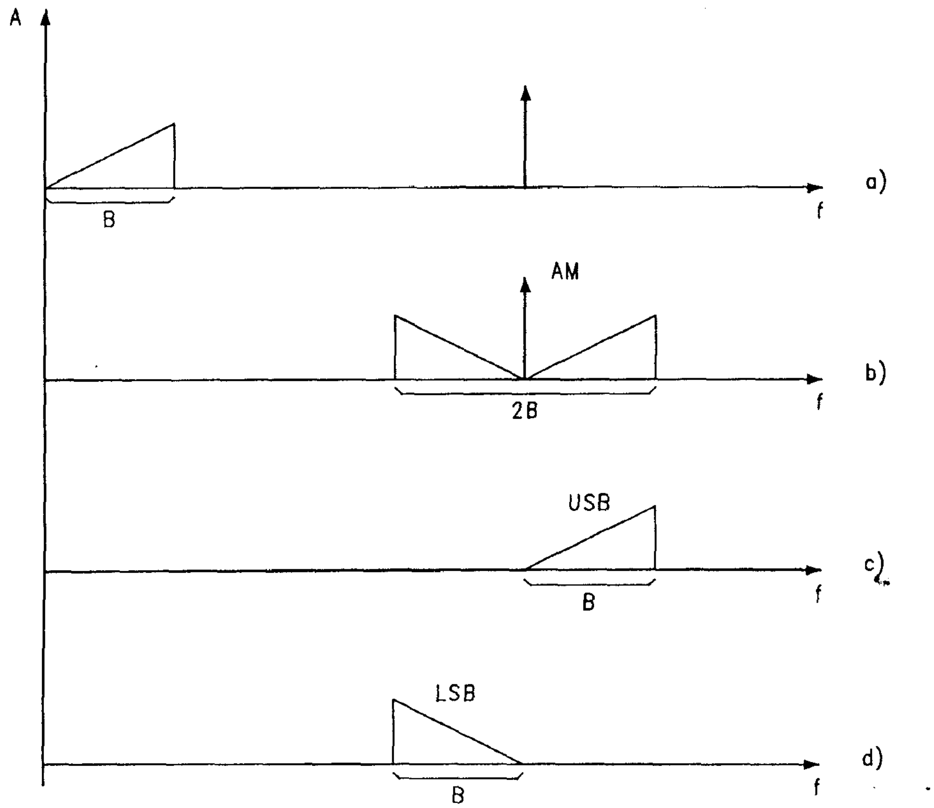

Figure 4.1

DSB: passage modulation toward the SSB

Removing the carrier only the two side bands wc have seen can be transmitted which transport the useful information.
This signal is called suppressed carrier modulation or Double Side Band modulation.
The energy saving that is obtained is at least of the 50% with a modulation index of the 100%.
So, in normal modulation conditions, lower than the theoretical limit the energy saving will be over the 50%. The band is always the same used by the AM.
The DSB is the modulation which is not used in practice because it is clear that there is an advantage when one of the two side bands is removed: half band and doubled energy saving.
It is a "passage" modulation necessary to obtain the SSB.
There are particular circuits, as we have already seen and used in our module, that resets the carrier of the modulated signal and provide
DSB signal in a simple way.

SSB against AM

The Single Side Band has the following advantages in respect to Amplitude Modulation:

- The band occupied by the modulated signal is reduced to half. This means, e.g. that there can be a number in the same frequency range which is double the communication channels
- All power emitted by the transmitter is associated to the information to be transmitted, unlike the AM in which most of the power is associated to the carrier.

Among the most evident disadvantages of the SSB in respect to the AM we can mention:

- More circuit complexity in the modulator as well as in the demodulator
- Need to generate the carrier locally in the receiver to properly detect the modulated signal.

Applications / Use of the SSB

Typical uses of the SSB are:

- Radio communications
- Multichannel telephone transmission with the technique of *Frequency Division Multiplexing (FDM)*
- High speed data transmission (modem V35/V36/V37).

SSB generation via filtering

The purpose of the methods used for the generation of an SSB signal is to suppress the carrier and a side band.

The most used method is the filtering one, that is obtained in two next phases (fig.4.2):

- An amplitude modulation with suppressed carrier (DSB) is generated
- A next band pass filter extracts one of the two side bands.

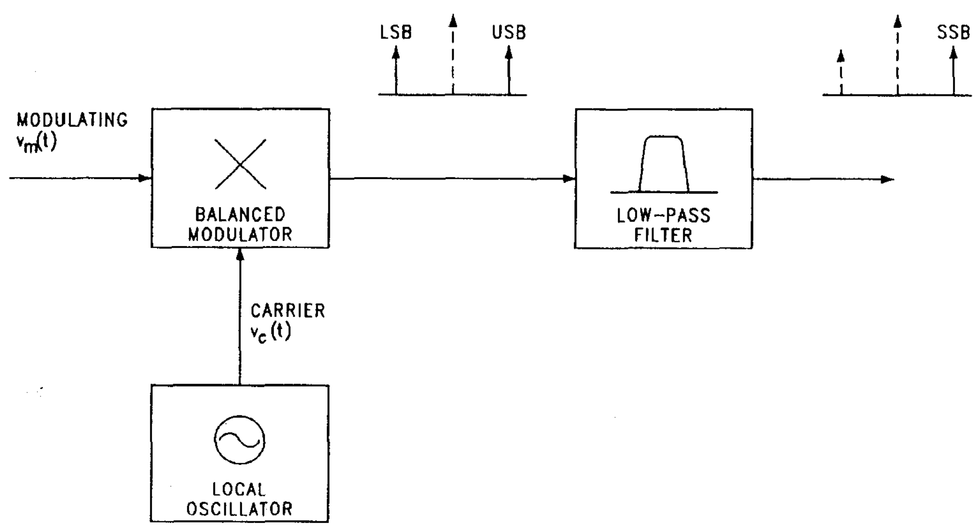

Figure 4.2

The most common suppressed carrier modulators arc the balanced *modulators,* and the *ring modulators* described hereafter.
The filters used for the separation of a side band must show a high steepness of the attenuation curve between the pass band and the attenuated band.
Quartz, ceramic, L-C active or passive filters arc used as functioirof the operating frequencies and the applications.

To obtain the lower side band or the upper side band, change the frequency of the carrier generator, keeping the filter unaltered.

Balanced modulator

The "balanced modulator " is a circuit that can generate a suppressed carrier amplitude modulation, consisting only in the single side bands. To achieve this result, it is sufficient to multiply the carrier signal and the modulating signal between them.

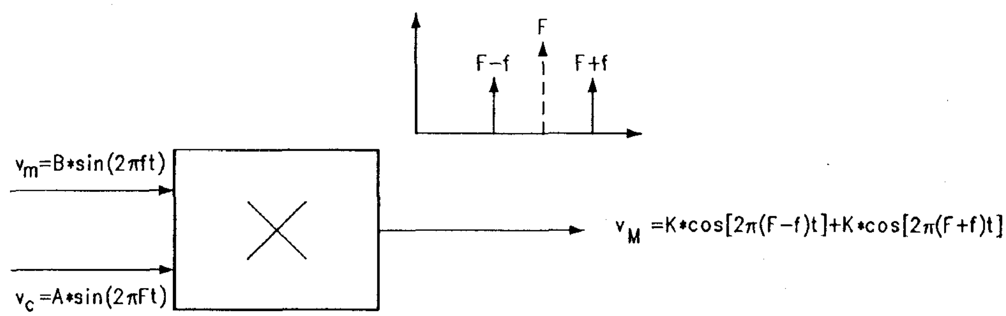

Figure 4.3

Single Side Band Radio transmitter:

We have seen how to obtain the single side band signal.
To transmit this signal, it is necessary to convert the SSB signal, with intermediate frequency, on the RF channel.
For the experiments with this modulation we will use the transmission channel with 3.5-MHz frequency synthesized across the I'LL circuit or with variable tuning in the same frequency range.

The *MODULATION SELECTORS* display the kind of signal with luminous Leds in the frequency domain.

The suppression of the not wished side band will be made through a quartz filter, that has a narrow useful band sufficient only for a voice channel.

According to the selected side band, the frequency of the local oscillator 1 is moved so that the useful side band can cross the pass band of the quartz filter.

This becomes the IF signal that must be converted into the RF channel using a conversion stage.
Let's use the sections *RF MIXER* and *LOCAL OSCILLATOR 2* as already studied in the first chapter.

To filter the output signal from the section *RF MIXER* and take the single components we are interested in, use the section *RF FILTER,* in particular the band pass filter with frequency center equal to 3.5 MHz.

The amplifiers present in the path of the signal *(buffer)* arc used to match the output or input impedance of the filters.

The final power section *RF PWR AMP* consists in two amplifier stages for the antenna and the cable and for the frequency of use - but only the one for the output via cable will be used as it is wide band.

Operation of the suppressed carrier amplitude modulator (DSB)

- The following sections are used:
  -*FREQUENCY MODULATOR / LOCAL OSCILLATOR I* that provide the carrier signal
  -*LOW FREQUENCY* that provides the modulating signal
  -*MODULA TOR /MIXER* to carry out the modulation
- Set switch *SW1* of the section *MODULATION SELECTORS* to AM/DSB/FM
- Turn the trimmer *LEVEL* completely clockwise to obtain the maximum amplitude on the signal *VCO1 OUT* provided by the local oscillator VCOl
- Set switch *SW6* to PLLI to obtain the automatic control of the local oscillator frequency
- Connect the output *OUT2* to the input *AM/DSB MOD IN*
- Set the switch *SW3* to DSB to obtain the DSB modulator with a balanced mixer
- Set switch *SW4* to MIX OUT to take the mixer signal and not the VCO 1 one
- Connect the probes of the oscilloscope as follows:
  -*Probe CHI* to the input of the modulating signal *AM/DSB MOD IN*
  -*Probe CH2* to the output of the mixer where there is the modulated signal and all products of mixing
- Adjust the trimmer *LEVEL* of the modulating signal up to overlay the two waveforms: modulating signal and modulated signal
- See the waveform of the DSB signal (fig.4.4)

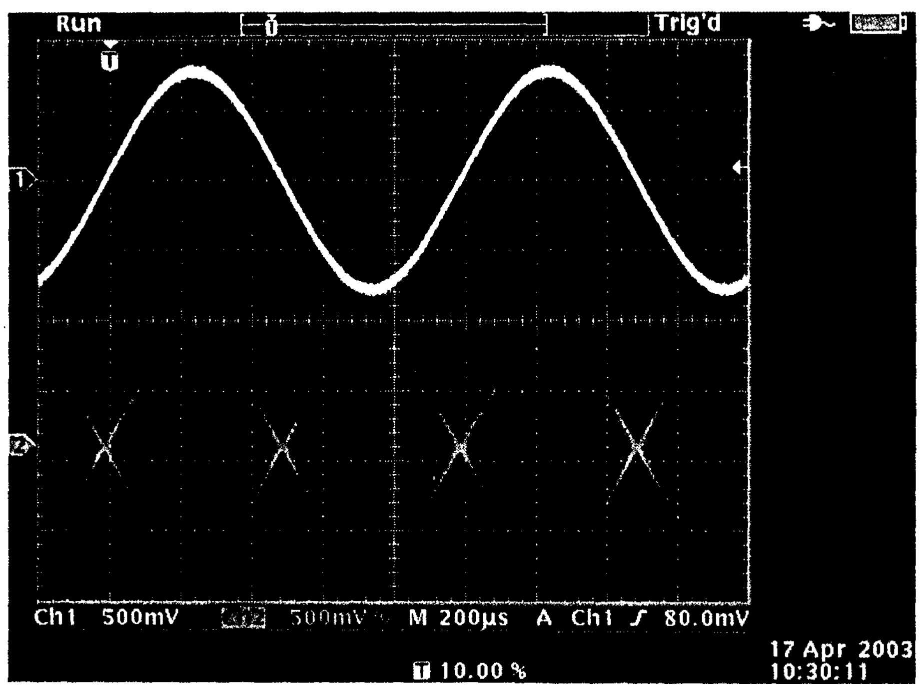

Figure 4.4

Single Side Band generation (SSB)

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- Set switch *SW1* to SSB and *SW2* to LSB
- Set switch *SW5* to QUARTZ to use the quartz band pass filter
- Connect the output *OUT3* to the input *AM/DSB MOD IN*
- Connect the probes of the oscilloscope as follows:
  - *Probe CHI* to the input of the modulating signal *AM/DSB MOD IN*
  -*Probe CH2* to the output of the mixer where there is the modulated signal and all products of mixing.

- Move the probe from TP2 to TP3 and check the presence of a sine signal: we can state that the filter extracts only one of the two components generated by the balanced modulator, so there is the SSB signal across this test point.

- As seen for the AM Radio transmitter, analyze the signal during the path from the IF frequency up to the RF frequency output on *CABLE OUT*.

- Check the signal transmitted via cable.

Review Questions

Q#1 What kind of signal is displayed across Test point 2 (TP2)?

Q #2 How can you recognize the DSB signal?

Q#3 What is transmitted using SSB technique?

Q #4 What are the main advantages of SSB over AM and DSB signals?

Q#5 Write some applications of the SSB.