LECTURE # 11 – TOPIC 3 (PART 1).

3.2.4.4 Vestigial Sideband Modulation (VSB).

(Reference: Taub & Schilling; Kennedy)

Principal Application of VSB modulation Method:

The principal application of VSB modulation Method is the Commercial Television Broadcasting. It is used where the Bandwidth (BW) of the baseband message information signal (m(t)) to be transmitted is very large. e.g when BW is as large as 4.5 MHz as in case of video signal in US.. It is also used where the baseband signal has a significant low frequency or dc component or when the lowest frequency component is very near the dc position (ω=0) on the spectrum

Example: Lowest Component of Video Signal ≅ 0 HZ
Maximum Component of Video Signal ≅ 4.5 MHZ

If DSB - Full-carrier is employed for the transmission of the video signal then we require BW of fmin to fmax around a carrier. This implies that by DSB-Full Carrier the frequency spectrum will be as below:

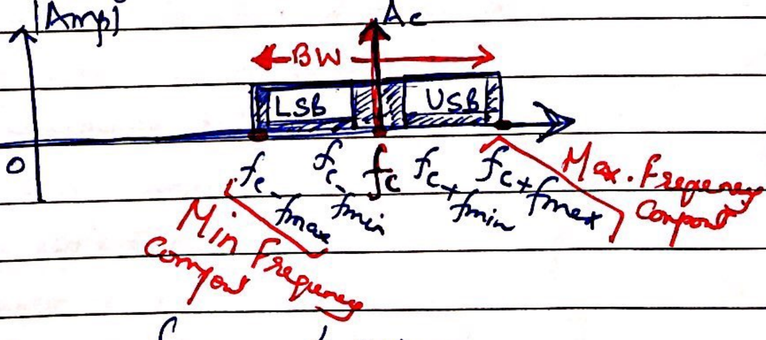


Fig: 1
If video signal is transmitted by DSB - Full carrier

Here $f_{min} = 0\,HZ$; $f_{max} = 4.5\,MHZ$

$$B.W = (f_c + f_{max}) - (f_c - f_{max})$$

$$\boxed{B.W = 2[f_{max}] = 9\,MHZ}$$

In this example it shows that the video transmission requires a Bandwidth of 9MHZ. This is too large and requires such a transmission BW to carry 9MHZ. Such other information signals that require large BW handling by transmission media are TV Telecast, facsimile and high speed data. These examples suggest that we should use such modulation techniques which smaller transmission BW.

Q. Could DSB-SC, or SSB-SC used for B.W reduction for efficient trasmission of such message information signal that have large BW spread?

If if consider DSB-SC, here also BW covered by a signal after modulation is same as DSB-Fullcarrier because $(B.W)_{DSB\text{-}Fullcarrier} = (B.W)_{DSB\text{-}SC} = 2f_{max}$

If SSB-SC is used then B.W is $= (f_c + f_{mx}) - (f_c) = f_{mx}$ SSB-SC could be a preferred alternative modulation technique because it occupies half of B.W as compared to DSB-Full carrier & DSB-SC Carrier B.W. But a serious issue with SSB-SC modulation is that it exhibits a poor low frequency response and on the other hand DSB-SC or DSB-Fullcarrier exhibits a good low frequency response but occupies very large BW.

For this reason we use a suitable modulation technique which has both good low frequency response and yet occupies smaller bandwidth. Such a modulation scheme is VSB techniques.

Q. What is VSB modulation technique?

VSB is a compromise modulation scheme between DSB-SC and SSB-SC which combines the advantages of DSB-SC and SSB-SC with none of its disadvantages in terms of Generation, BW and Detection. Vestige means a trace or portion. Here in VSB technique there is present in the spectrum trace or Portion of one of sideband. as shown in Fig below (Fig (2))

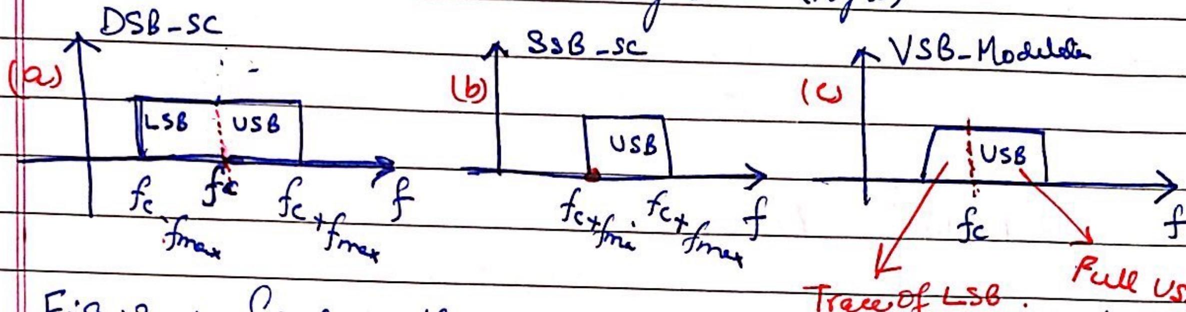


Fig:2 :- Compares the Spectrum of VSB-Modulation (Fig (2.c)) with that of DSB-SC (Fig. 2.a) and SSB-SC (Fig 2.b).

B.W Ease

Above Spectrum of VSB-Modulation shows that the Spectrum is made up of full USB where as it covers only a trace or portion of the LSB. In this way the BW of VSB is less than DSB-SC and only slightly greater than SSB-SC spectrum.
In VSB, instead of rejecting one sideband Completely as in SSB-SC but a gradual cutoff of one sideband is accepted. A trace or Vestige of unwanted sideband is passed along with the wanted sideband. In VSB the LSB is attenuated partially. It offers BW practically same, however slightly more as that of SSB.
Generation of VSB from DSB-SC signal is simple as compared to the generation of SSB-SC and DSB-SC generation In case of VSB we can use relatively simpler filters with gradual cut off characteristics. On the contrary SSB-SC requires filter with Sharp cutoff characteristics at fc.
As studied & discussed in Previous lecture it is obtained

from DSB- Full carrier by filtering a standard AM in such a fashion such that one sideband is passed completely while passing just a trace of other sideband.

Detection Ease

VSB is a promising technique even where Detection at Rx is concerned. SSB-SC and DSB-SC requires coherent detection where the information of carrier frequency as well its phase at the Receiver should be known. The carrier at Rx must be coherent and synchronized in frequency as well as phase with the carrier at Tx. To overcome this problem we can have VSB+ Carrier modulation. This type of modulation is used for Television, Video transmission. The unsuppressed carrier allows the use of envelope detector as in DSB- Fullcarrier while retaining the BW conservation of suppressed sideband. VSB-SC is also used and in that case a synchronous detection is employed. VSB + Carrier could be employed for TV Rxs. VSB+Carrier will ensure simpler envelope detection circuits in the innumerable number of TV Rxs rather than using more complicated product detector. The VSB+Carrier is a compromise scheme which is a compromise between the spectrum conserving characteristics of SSB modulation and the demodulation of simplicity of DSB- Full carrier.

Generation Ease

VSB- Modulation scheme generation requires Filters which are much easier to design than the Filters required for SSB-SC Generation from DSB- Full carrier signal. A fact about filters is that with attenuation not only is the signal attenuated but a phase is also introduced resulting in distortion of those frequencies in this figure as a function of ...

frequency from the carrier frequency (fc). Therefore components just in the vicinity of the cut off frequency. It is found generally in real filters that low frequency spectral components which lie within passband but close to cut off suffer distortion, producing phase shifts. The nature of the picture signal is such that its waveform suffers from substantial distortion from even from relatively small phase shifts at its low frequency. In VSB as seen from spectrum of Fig. 2(c), VSB can keep the distortion within tolerable limits. In VSB we are not keeping cut off frequency of filter at the carrier but the cut off of filter is adjusted a little away from carrier.

Q. Describe the Transmitter filter response in case of VSB-Modulation technique.

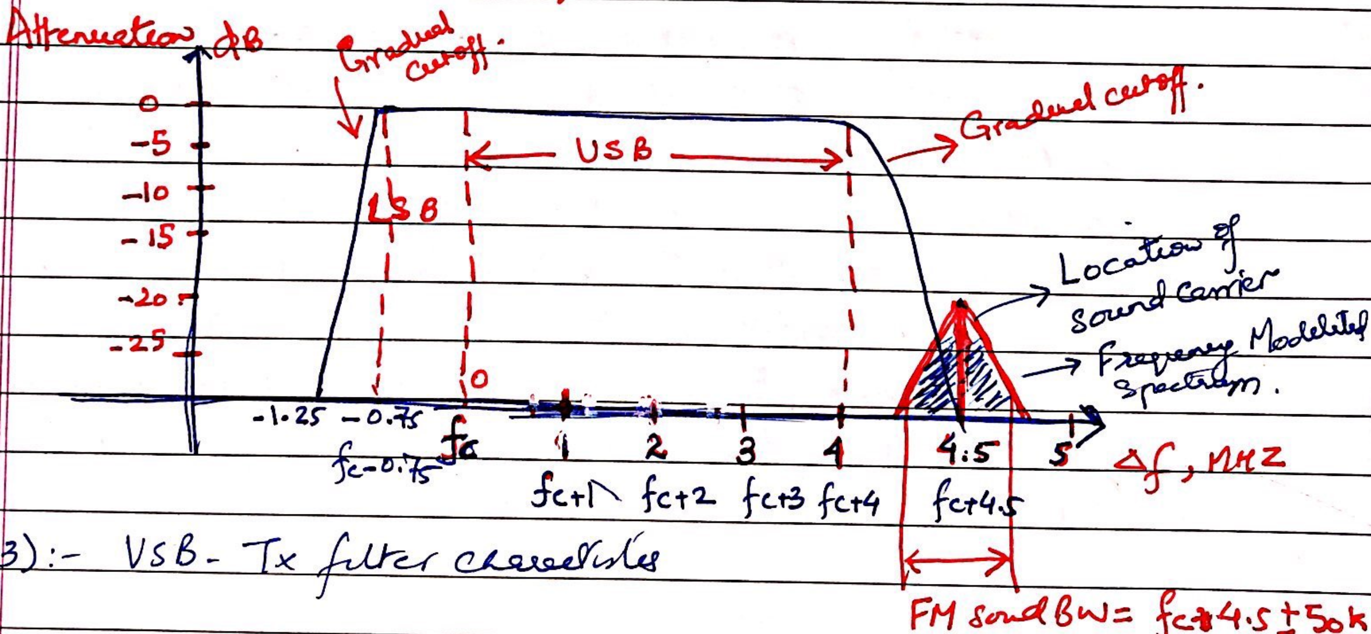


Fig (3):- VSB-Tx filter characteristics

In VSB system, the amplitude modulated signal (DSB-Full carrier) is passed through a filter with characteristics as shown in fig (3). The response is drawn in this figure as a function of deviation (Δf) of frequency from the carrier frequency (fc). Therefore position fc corresponds to a deviation of 0; fc+1 corresponds to deviation of 1MHz so on. Thus position 4.5 MHz would mean a deviation of 4.5MHz above fc whereas the least frequency position of -1.25 MHz would mean that this is -1.25MHz below the carrier. The sound which accompanies the video signal is transmitted by frequency modulation on a carrier located at 4.5 MHz above the picture carrier. A frequency range of 100kHz is allowed on each side of the sound carrier for the sidebands. The upper sideband of the picture carrier is transmitted without attenuation upto 4MHz. There after the sideband is attenuated so that it does not interfere with the lower sideband of sound carrier. The lower sideband of picture carrier is transmitted without attenuation over the range 0.75 MHz and is entirely attenuated at 1.25 MHz. Thus the picture signal transmitted double sideband over the range 0 to 0.75 MHz and single sideband over range 1.25 MHz and above while in the intermediate range from 0.75 to 1.25MHz, the transition is made from one to another. Altogether however the entire transmission is confined to a range about 6MHz; This is 1/3 of the BW that would be required for the full DSB transmission.

TSheet # 03

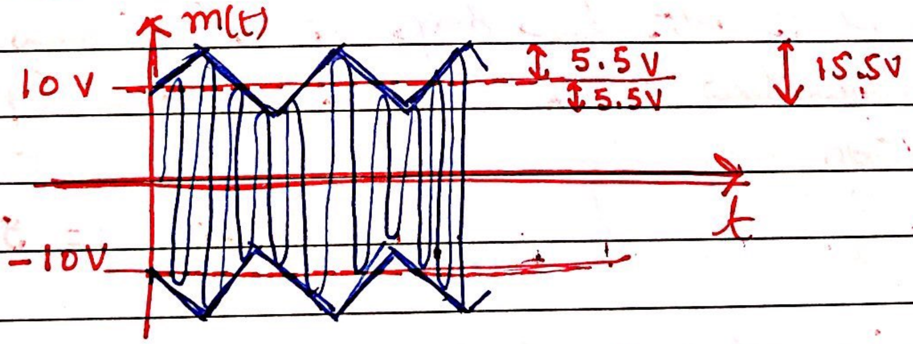
Q.1 The tuned circuit in an oscillator is a simple AM transmitter that employs a 50μH coil and 1μF capacitor. If the oscillator output is modulated by audio frequency upto 10KHz, what is the frequency range occupied by the sidebands?

Ans:- Lo freq. = 712 KHz;
Frequency range = 702 KHz to 722 KHz

Q.2 A 1000 KHz carrier is simultaneously modulated with 300 Hz, 800 Hz and 2 KHz audio sine waves. What will be the frequencies present in the output?

Ans: 1000.3 KHz, 999.7 KHz, 1000.8 KHz, 999.2 KHz, 1002 KHz, 998 KHz.

Q.3 A modulating signal consists of a symmetrical triangular wave having a zero dc component and peak-to-peak voltage of 11V. It is used to amplitude modulate a carrier of peak voltage 10V. Calculate the modulation index.



Ans: $m_a = 0.55$

A 400 watt carrier is modulated to a depth of 75%. Calculate the total power in the modulated wave.

Ans:- $P_T = 512.5$ watt.

Q.5 A broadcast radio transmitter radiates 10 KW when the modulation percentage is 60. How much of this carrier's power? How much of this is carrier power?

Ans:- $P_c = 8.47$ kW

$P_{LSB} = P_{USB} = 0.765$ kW.

Q.6 The antenna current of an AM transmitter is 8 ampere (when only the carrier sent). But it increases to 8.93A when the carrier is modulated by a single sine wave. Find the percentage modulation. Determine the antenna current when depth of modulation changes to 0.8.

Ans:- $m = 70\%$.

$I_C = 8$ amps; $I_T = 8.93$ Ans.

In continuation with above Q.6 find the following:-

Q.7 Determine the antenna current when the depth of modulation changes to 0.8.

Ans:- $I_T = 9.19$ Amps

Q.8 The positive RF peak of an AM waves is a max value of 15 volts and drops to a minimum of 5V. Determine the modulation Index and the unmodulated carrier amplitude assuming sinusoidal modulation. Also determine Ac.

Ans: $m = 5\%$, $A_c = 10V$ Ans

Q.9 A carrier of 10V peak and frequency 100 KHZ is amplitude modulated by a sine wave of 4V peak and frequency of 1000 HZ. Determine the modulation index for the waves and sketch the spectrum.

Ans:- $m = 0.4$,

99 KHZ; 100 KHZ; 101 KHZ

Q.10 The rms antena current of a radio transmitter is a 10A when unmodulated rising to 12A. When the carrier is sinusoidally modulated. Calculate modulation Index.

Ans :- m = 0.93
= 93%.

Q.11 The rms antena current from an AM transmitter increases by 15% over the unmodulated value when the sinusoidal modulation is applied. Determine the modulation Index.

Ans :- m = 0.8 Ans.

Quiz # 02

(i) Lecture # 07 - Topic 03 (Part - I) - pg 70

(ii) Lecture # 08 - Topic 03 (Part - I) - pg 81

(iii) Lecture # 09 - Topic 03 (Part - I) - pg 93

(iv) Lecture # 10 - Topic 03 (Part - I) - pg 106

(v) Lecture # 11 - Topic 03 (Part - I) - pg 120

(vi) Submission of Tutorial - Sheet # 03 - pg 126

NOTE :- OPEN BOOK TEST