Date 16/9/2020

Expt. No. 3 Adm No : U19CS048 Page Nos: 35 - 48

Experiment No : 03
AMPLITUDE MODULATION

Objective: To study amplitude modulated (AM) technique, modulation-index (m), draw wave forms, spectra and trapezoidal display. Illustrate the observed AM signals for double sideband with an without carrier by changing m as : $m>1$, $m<1$ and $m=1$ and draw it. Use virtual mode with appropriate software.

Software: Labalive

Theory: Amplitude modulation (AM) is a modulation technique used in electronic communication, most commonly for transmitting messages with a radio carrier wave. In this, the amplitude of the carrier wave is varied in proportion to that of a message signal, such as the audio signal.

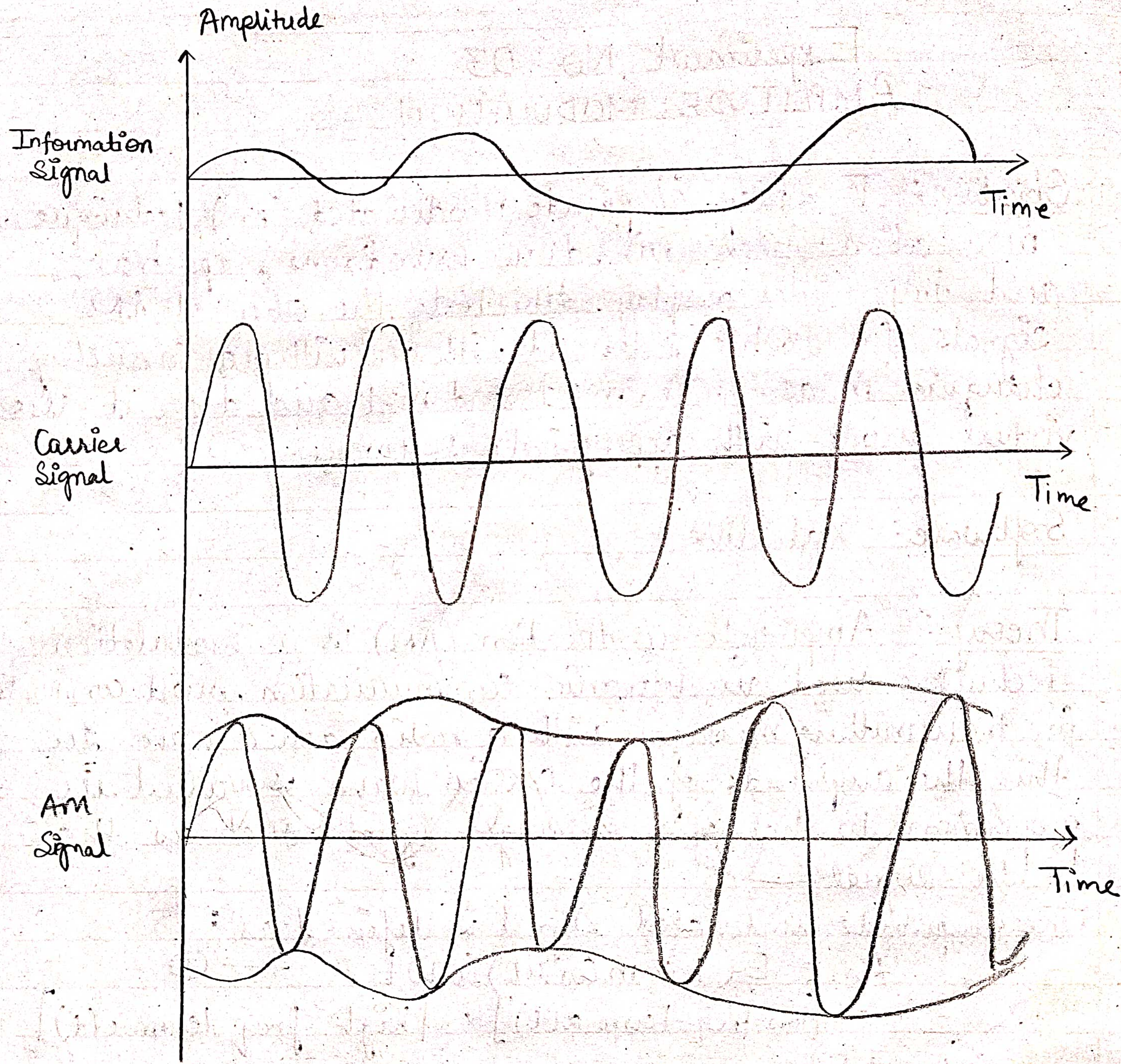
The amplitude modulated signal is defined as :

$$A_m = E(1 + m\cos\mu t)\cos\omega t \quad \text{— (1)}$$

$$= [\text{low freq term } a(t)] \times [\text{high freq. term } c(t)]$$

$(A \cdot B = E)$

→ E is the AM signal amplitude from equation (1), m is the constant and defines 'depth of modulation'. Typically $m<1$ though there is no restriction upon the size of 'm' in eq^n. 'μ' and 'ω' are angular freq in rad/s. $\mu/2\pi$ is low message frequency say in the range of 300 Hz to 3000 Hz and $\omega/2\pi$ is


Amplitude
Information Signal
Time
Carrier Signal
Time
AM Signal
Time

radio, or relatively high 'carrier' frequency. The term a(t) contains for DC and AC components. The AC term 'm Cos Mt' is generally thought of as the message, and is sometimes written as m(t)

$$a(t) = DC + m(t)$$

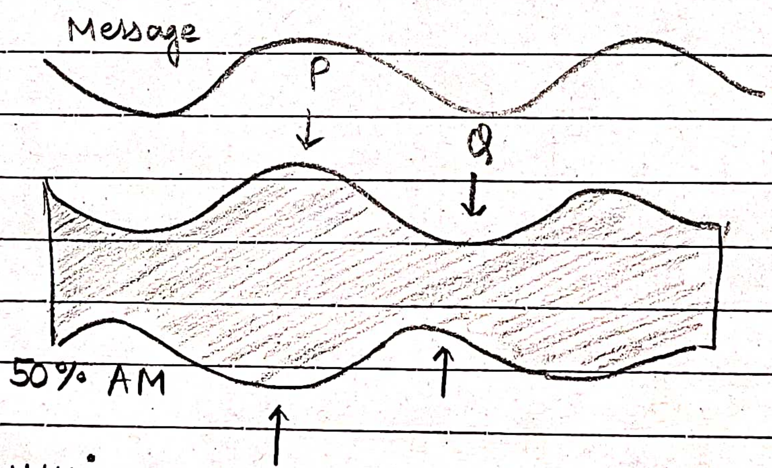
Depth of modulation:

100% modulation is defined when m=1. It requires the amplitude of the DC (A) part of a(t) is equal to the amplitude of the AC part (Am).

Measurement of M:-

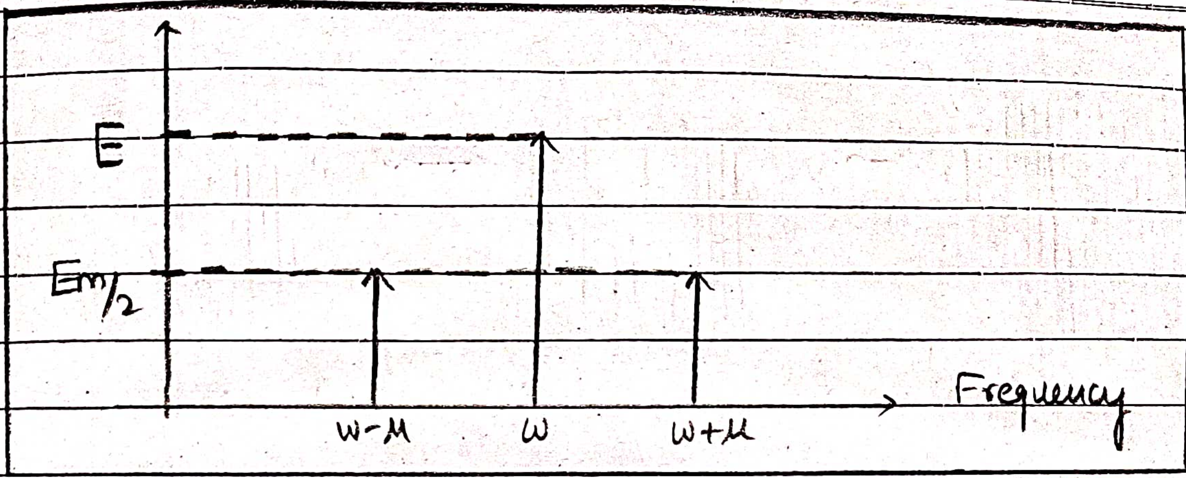
The magnitude of 'm' can be measured directly from the AM display itself.

$$m = \frac{P-Q}{P+Q}$$



Spectrum:

Analysis shows that the sidebands of the AM, when derived from a message of frequency M rad/s, are located either side of the carrier frequency, spaced from it by M rad/s.



In the case of a periodic modulating signal, such it is easy to identify the maximum and minimum voltages of the modulated wave. With a non-periodic signal, Such as speech waveform these quantities will vary, & hence the modulation index will also vary. The modulation index must not exceed unity, if it exceeds unity the negative peak of the modulating waveform is clipped. This is bad enough in itself, but, in addition, such addition is a potential source of interference.

Significance of 'm':
The shape of the outline of envelope of the AM waveform (lower trace) is exactly that of the message of the waveform (upper trace). Examining the varying magnitude of parameter 'm',

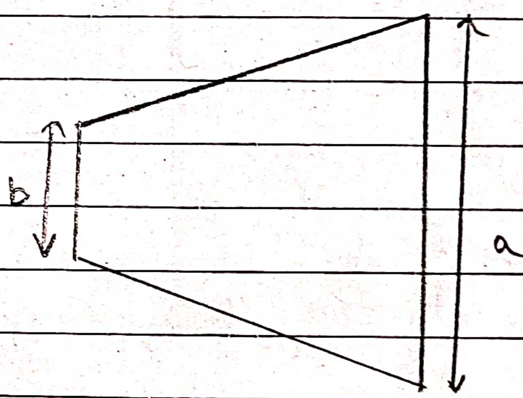
→ For all values of 'm' less than 1, the envelope of the AM is the same shape as that of the message.
→ For all values m>1, the envelope is not copy of the message shape.

It is important to note that for condition $m>1$, it should not be considered that there is envelop distortion, since the resulting shape, whilst not that of the message, is the shape that theory predicts.

The Modulation Trapezoid:

For sinusoidal message, it is easy to set the depth of modulation to any value of 'm'. But it is not convenient for other messages like speech. The trapezoidal display is useful alternative for more complex messages.

- We can calculate m in the time domain using an oscilloscope and the trapezoid methode.
- The scope is placed in the XY mode

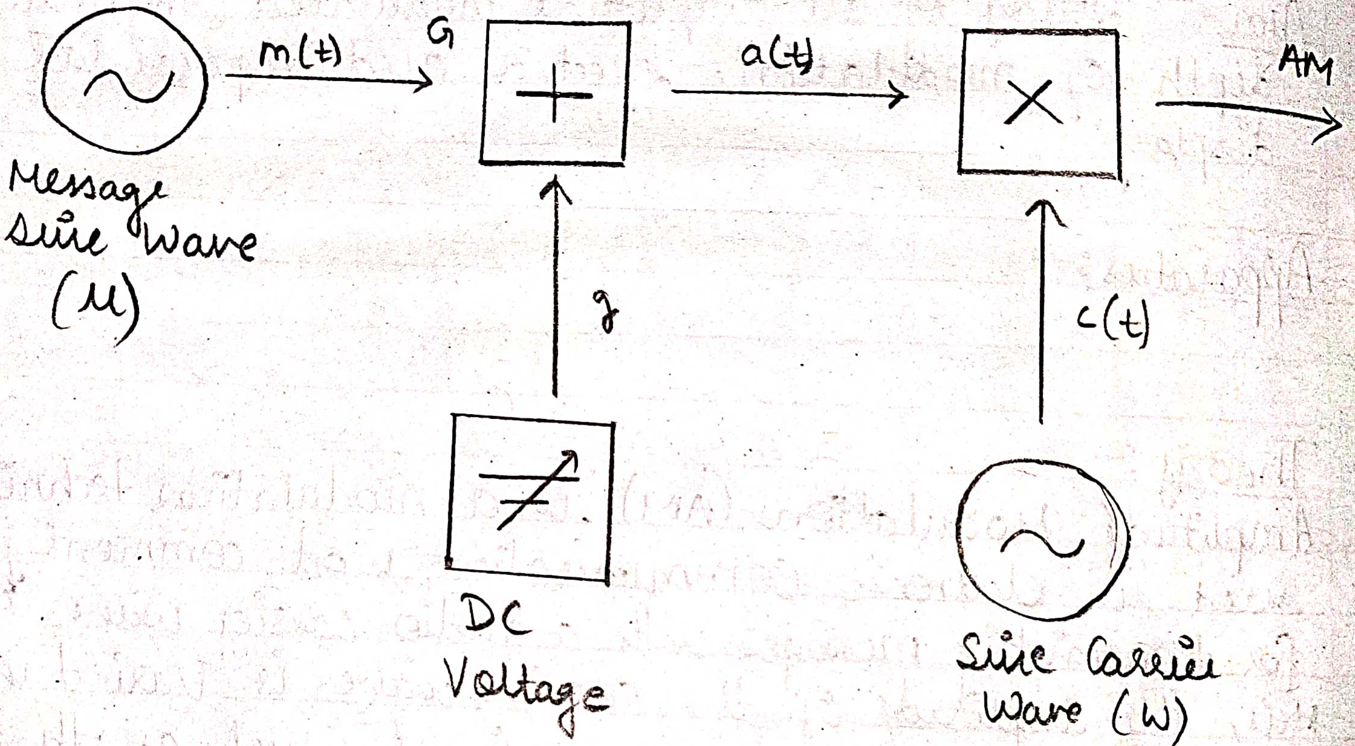


X: modulating signal
Y: modulated signal
Modulation index is then calculated from the vertical edge lengths using:

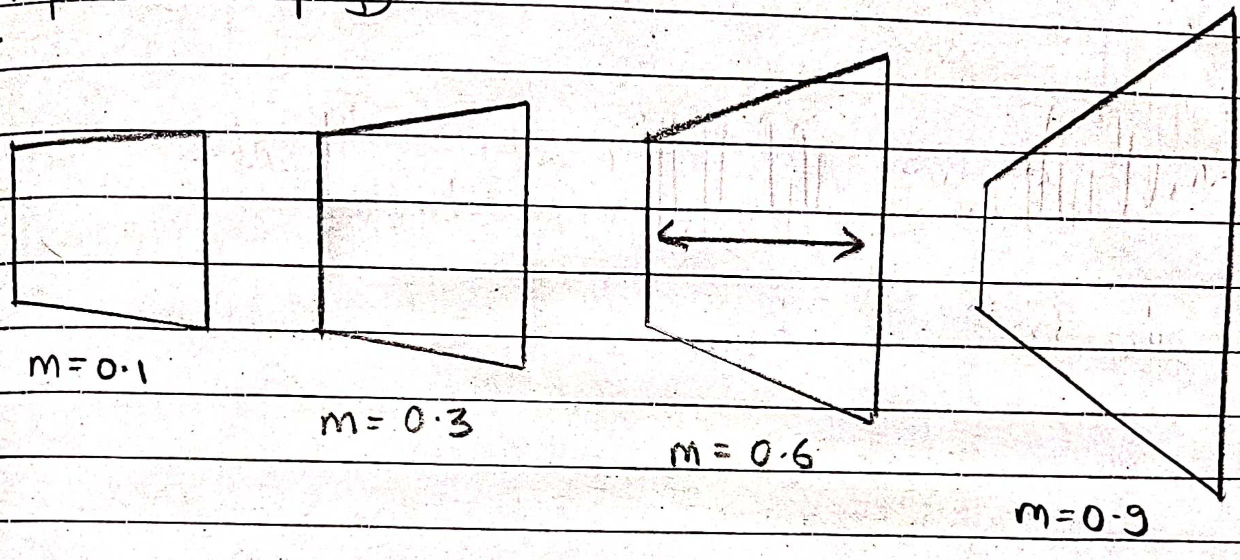
$$m = \frac{a-b}{a+b}$$

- As the modulation index (m) increases, the ratio between the vertical trapezoid edges increases. The ~~modulation~~ trapezoid width is unaffected by the modulation depth.

BLOCK DIAGRAM:-



(Trapezoidal Display)



Observation:

1) Double Side Band with Carrier (DC offset = ON)

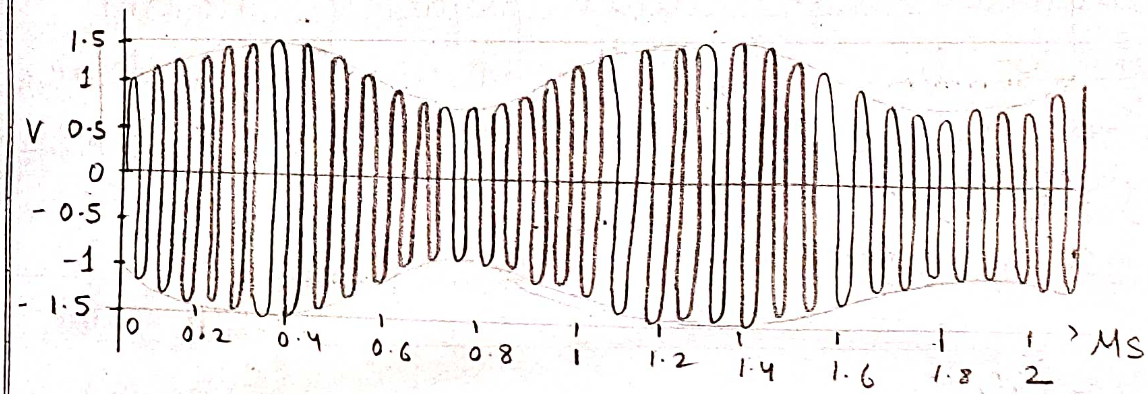
	m (Modulation Index)
m < 1	0.5
	0.8
m = 1	1
m > 1	1.2
	1.5

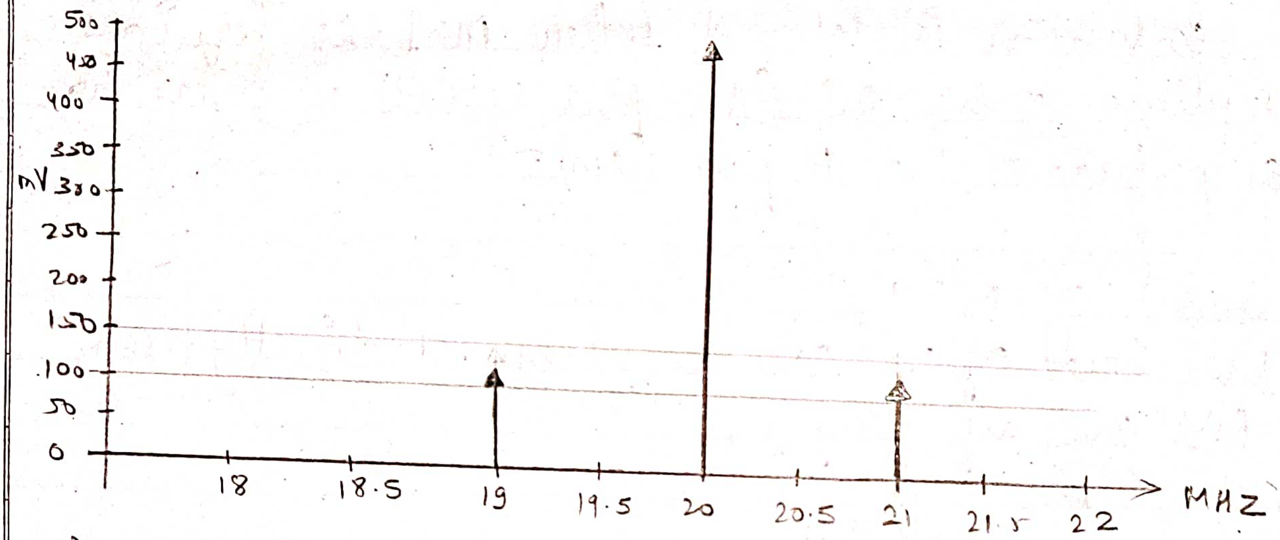
2) Double Side Band Suppressed Carrier (DC offset = OFF)

	m (Modulation Index)
m < 1	0.5
	0.8
m = 1	1
m > 1	1.2
	1.5

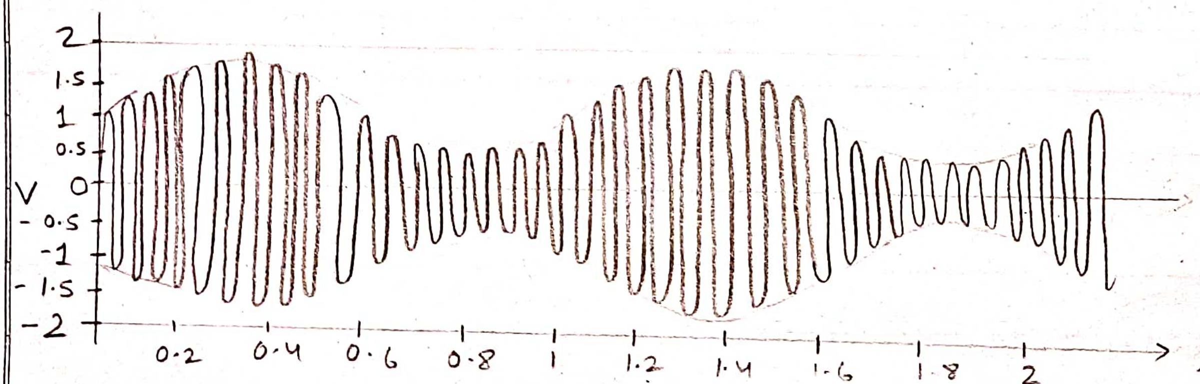
DOUBLE SIDEBAND WITH CARRIER:

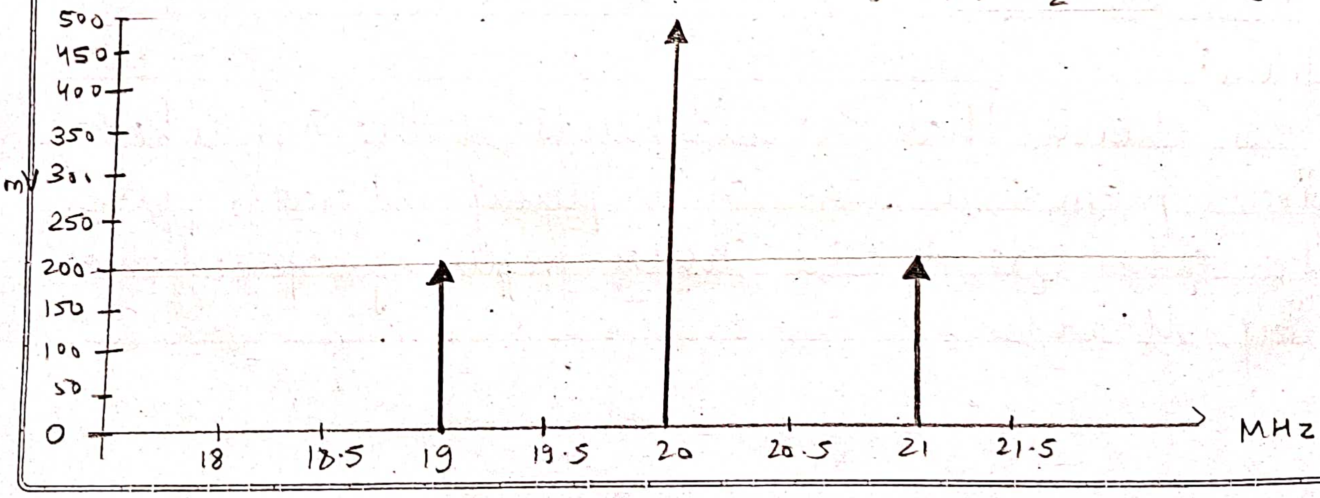
1) **m = 0.5**



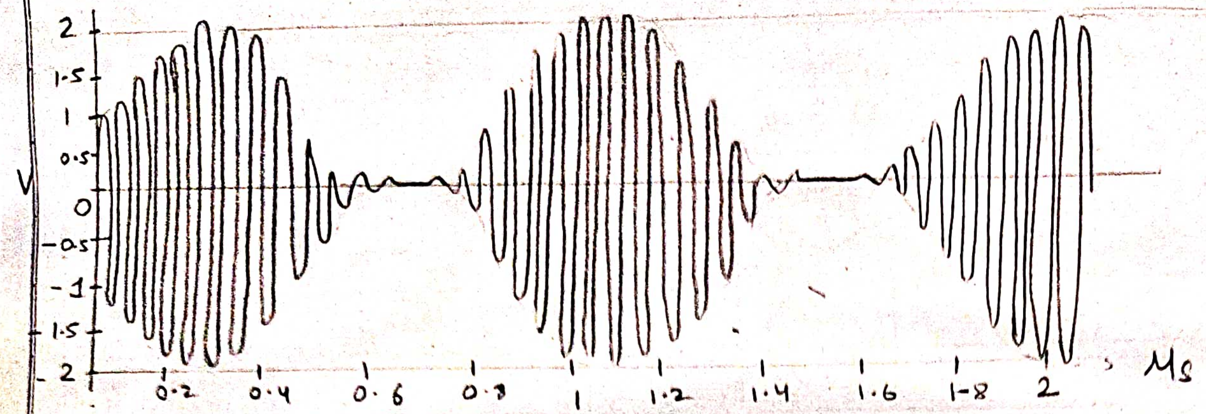


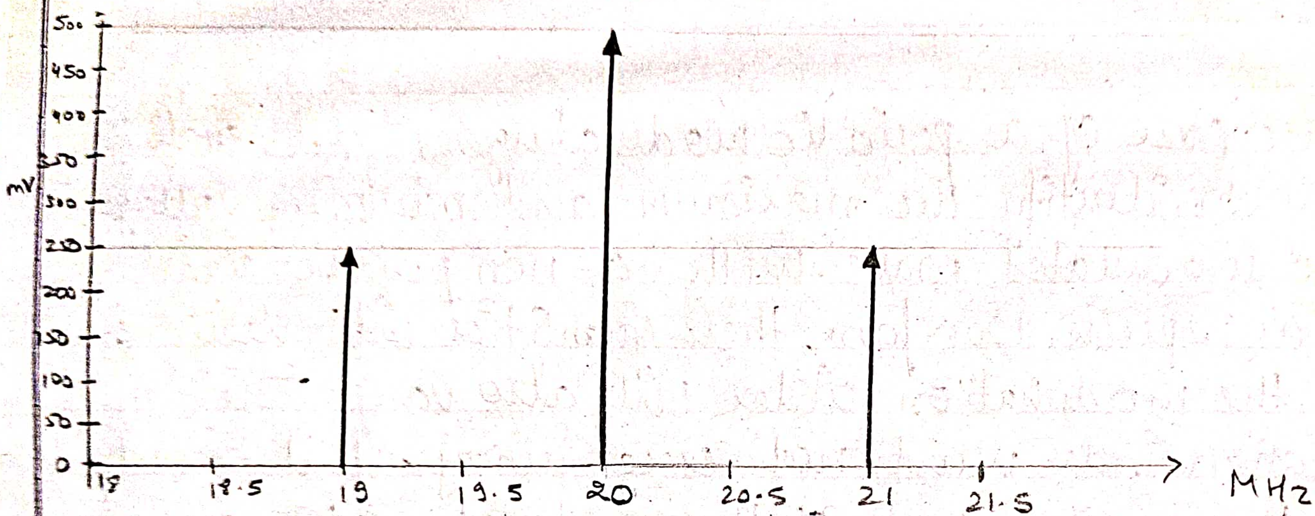
2) **m = 0.8**



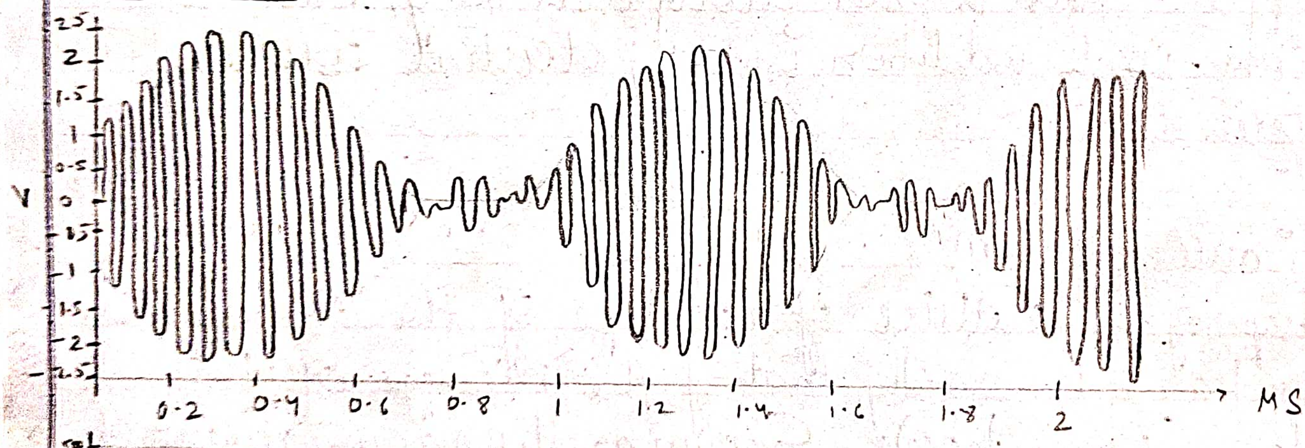


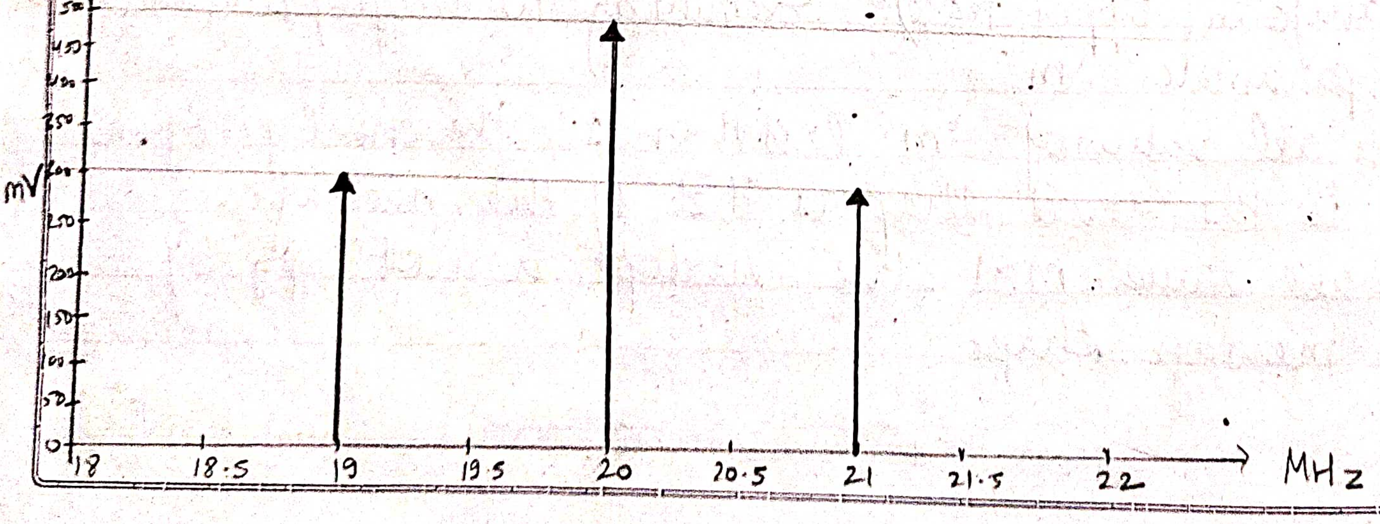
3) m = 1


V
2
1.5
1
0.5
0
-0.5
-1
1.5
-2
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Ms

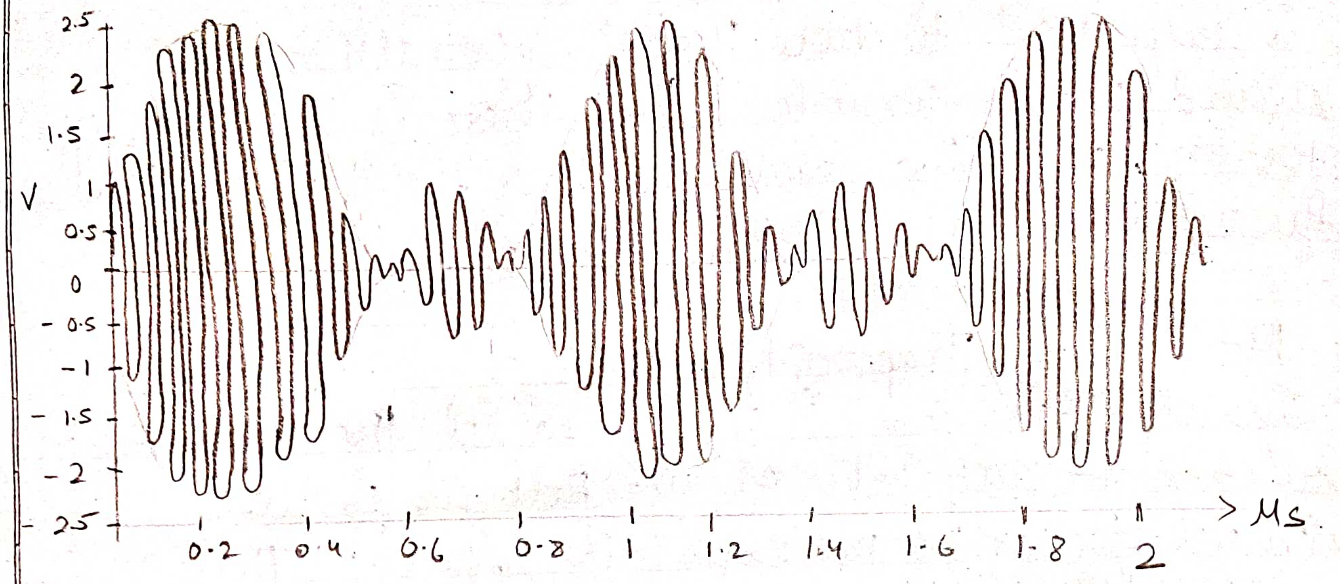

mV
500
450
400
350
300
250
200
150
100
50
0
18
18.5
19
19.5
20
20.5
21
21.5
MHz

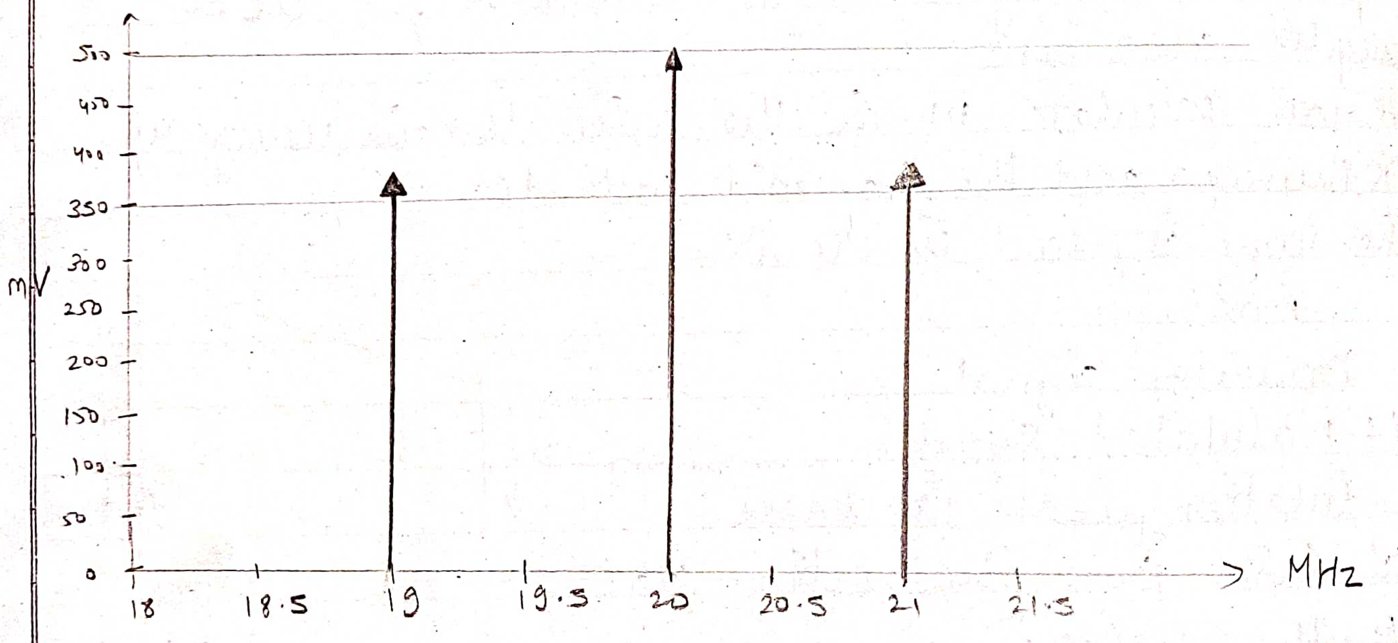
4) m = 1.2


V
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
MS


mV
500
450
400
350
300
250
200
150
100
50
0
18
18.5
19
19.5
20
20.5
21
21.5
22
MHz

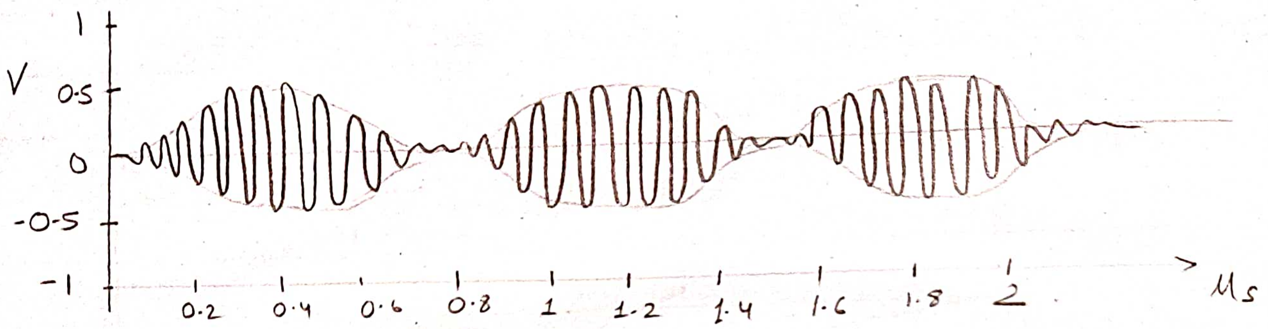
5) m = 1.5

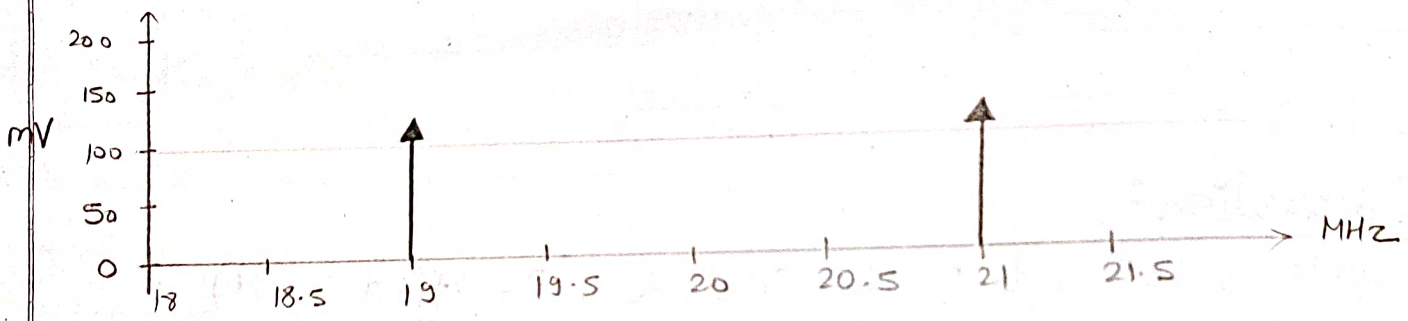

2.5
2
1.5
V
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
μs


500
450
400
350
300
mV
250
200
150
100
50
0
18
18.5
19
19.5
20
20.5
21
21.5
MHz

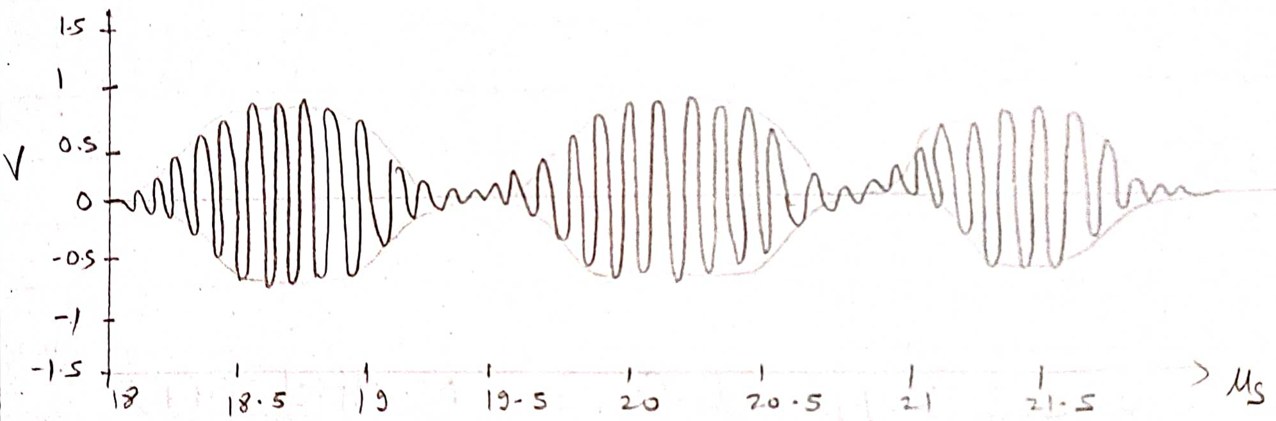
DOUBLE SIDEBAND SUPPRESSED CARRIER :

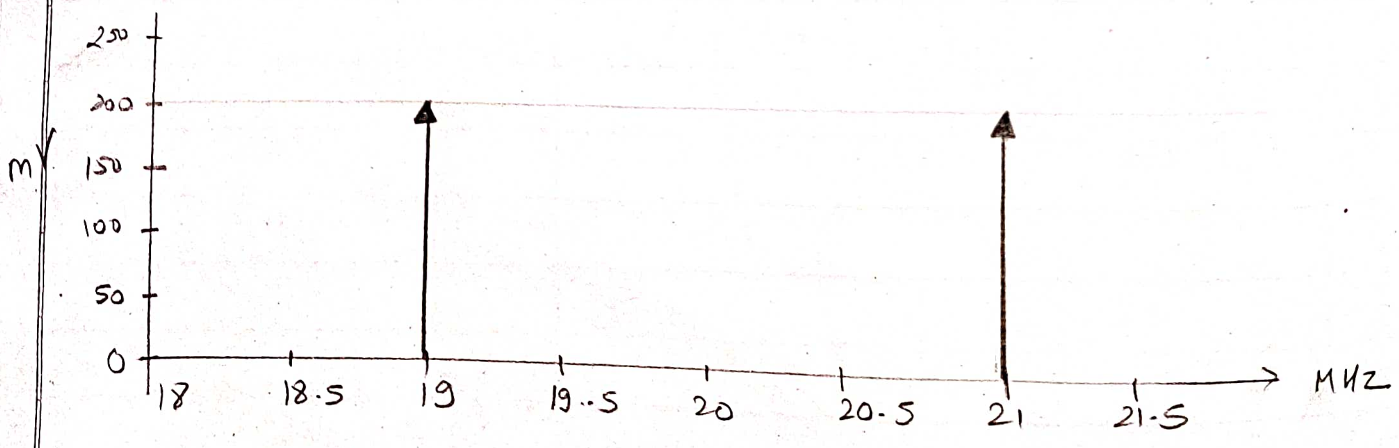
1) m = 0.5



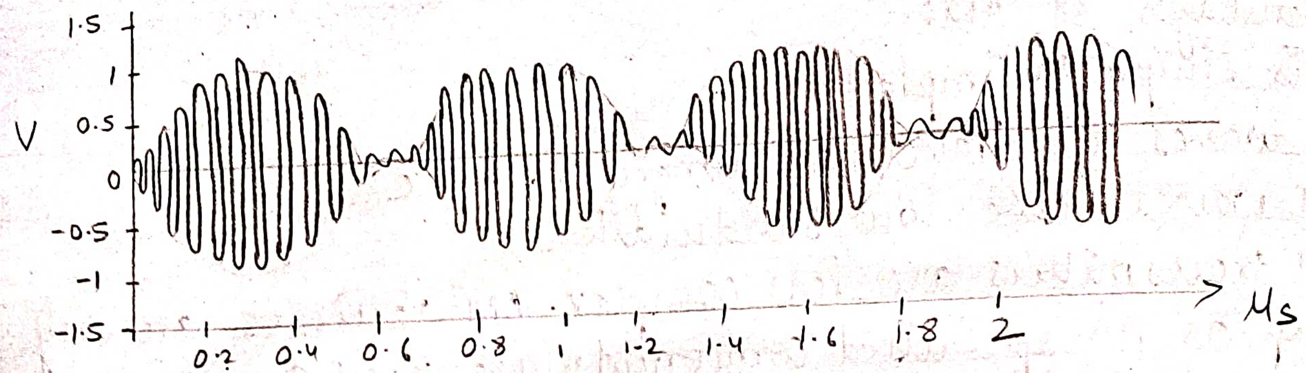


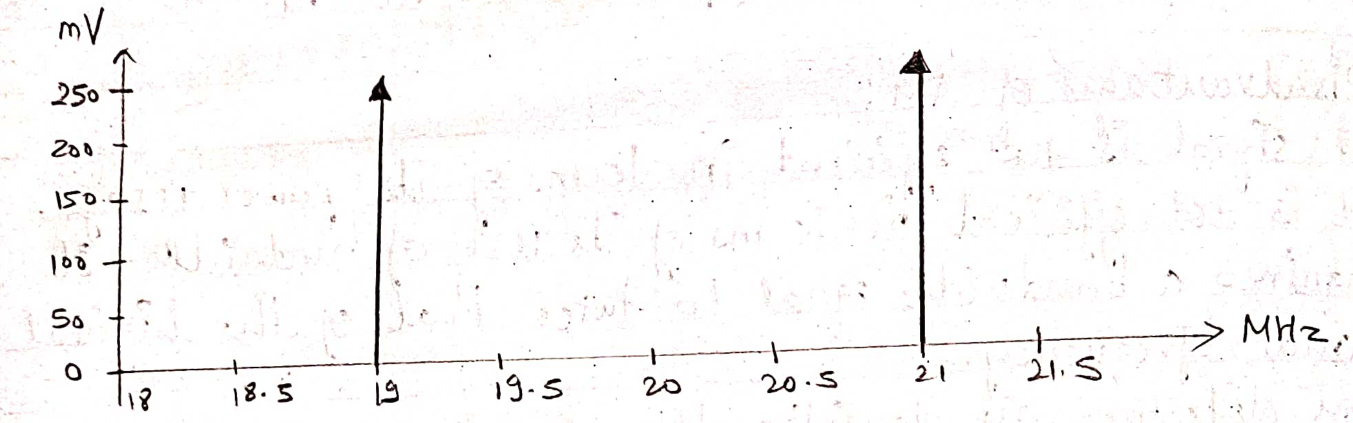
2) m = 0.8



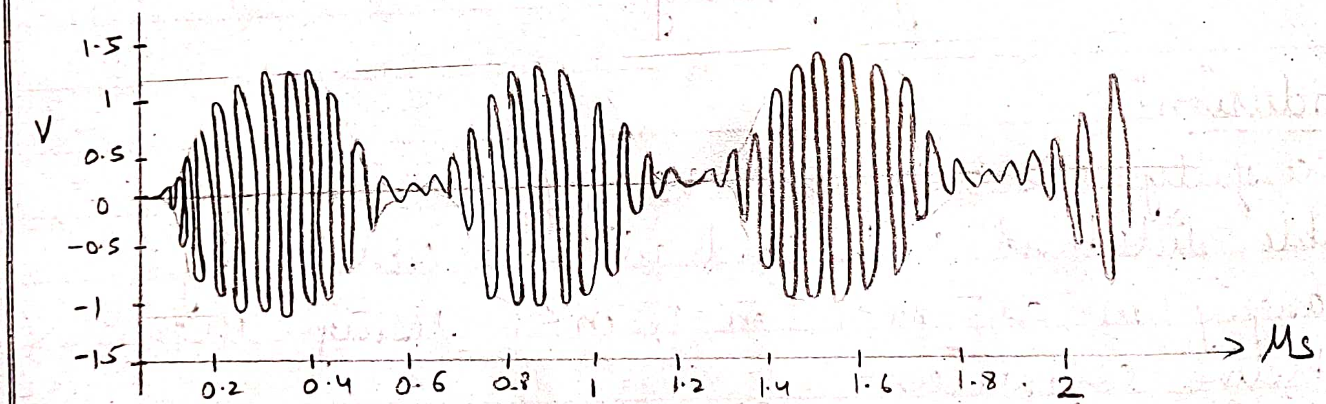


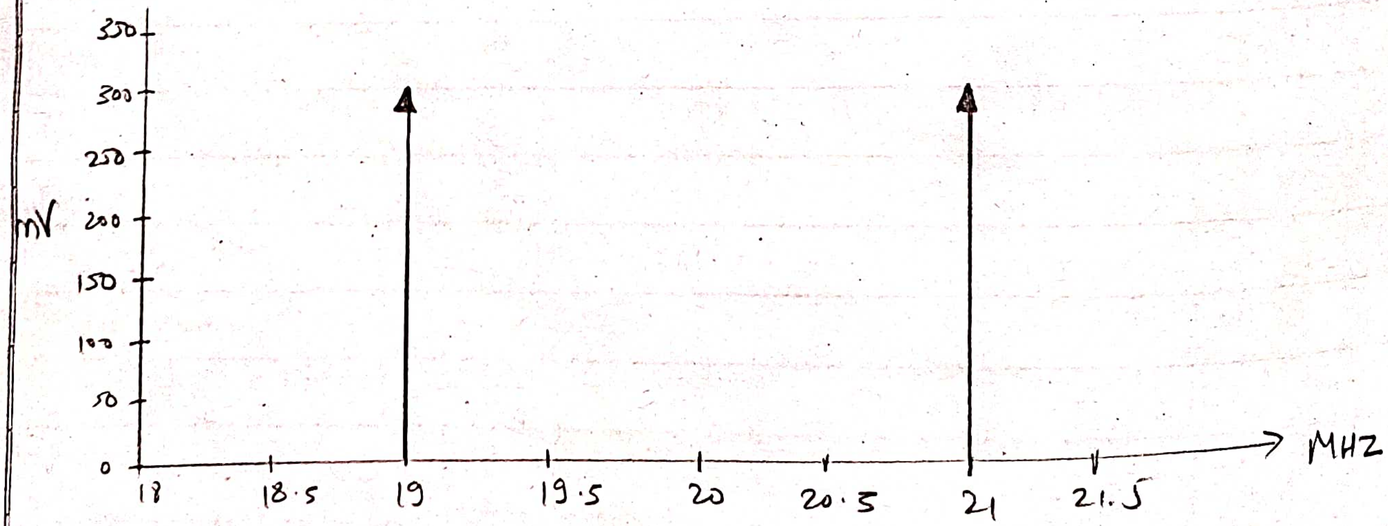
3) m = 1


V
1.5
1
0.5
0
-0.5
-1
-1.5
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
μs

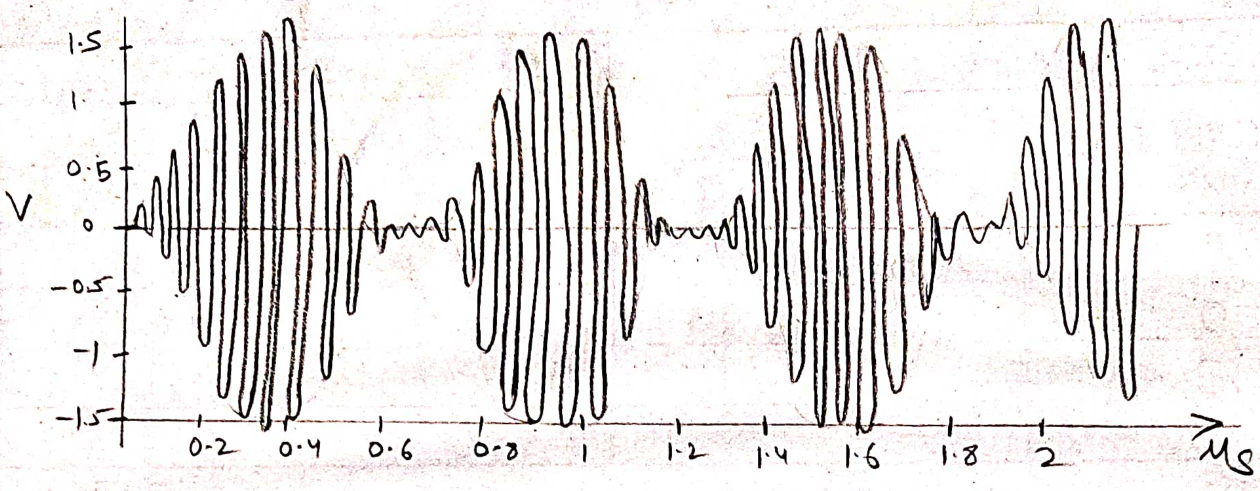

mV
250
200
150
100
50
0
18 18.5 19 19.5 20 20.5 21 21.5
MHz

4) m = 1·2

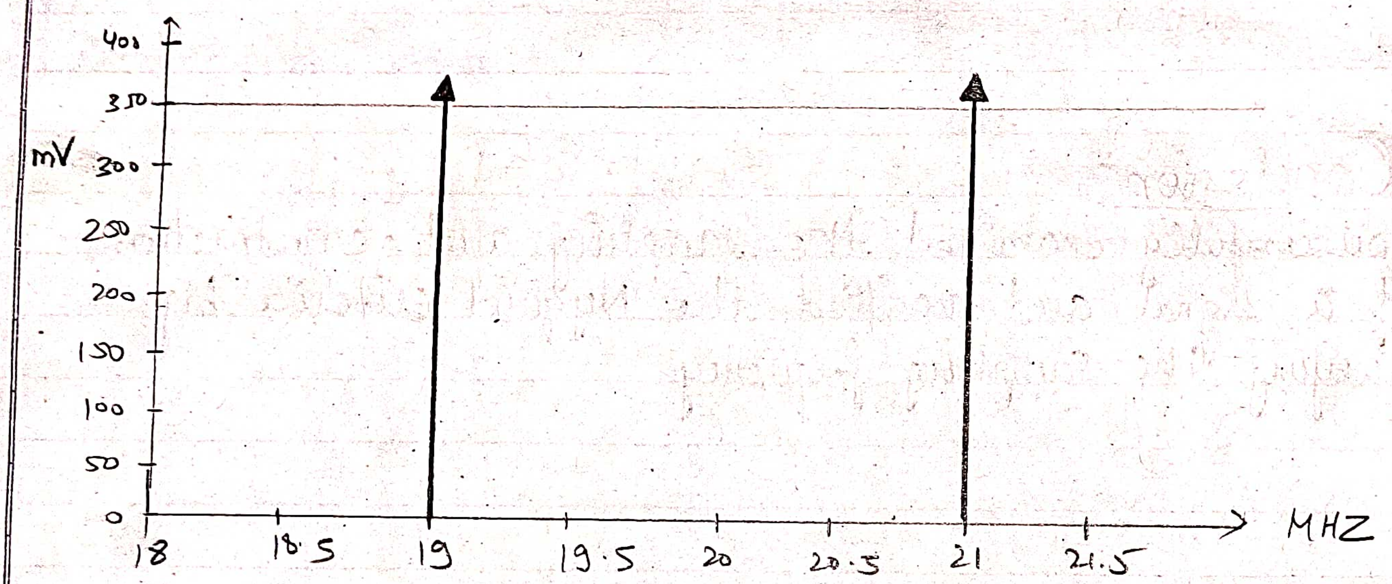

V
1.5
1
0.5
0
-0.5
-1
-1.5
0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
μs


mV
350
300
250
200
150
100
50
0
18 18.5 19 19.5 20 20.5 21 21.5
MHZ

5) m = 1.5



1.5
1
0.5
V
0
-0.5
-1
-1.5
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
μs



400
350
mV
300
250
200
150
100
50
0
18
18.5
19
19.5
20
20.5
21
21.5
MHZ

Advantages of AM:

- It is simple to implement.
- AM waves can travel ~~at~~ longer distance
- AM waves have low bandwidth
- AM transmitters are less complex. AM receivers are very cheap as no specialised components are needed.

Disadvantages of AM:

- AM signal is not efficient in terms of its power usage.
- It is not efficient in terms of its use of bandwidth. It requires a bandwidth equal to twice that of the highest audio frequency.
- AM detectors are sensitive to noise hence an AM signal is prone to high levels of noise
- Reproduction is not high fidelity

Conclusion:

Successfully observed and verified AM signals for double sideband with and without carrier by changing m as:- $m>1$, $m=1$, $m<1$ using the Labalive software.