National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

Department of Electrical Engineering

Faculty Member: Dr. Huma Ghafoor **Dated: 15/03/2023**

Course/Section: BEE 12 **Semester: Spring 2023**

EE-351 Communication Systems

Lab7: SSB Transmission

Name	Reg. No	Viva / Quiz / Lab Performance 5 Marks	Teamwork 5 Marks	Ethics 5 Marks	Software tool Usage 5 Marks	Analysis of data in Lab Report 5 Marks
Hassan Rizwan	335753					
M. Ahmed Mohsin	333060					
Syeda Fatima Zahra	334379					
Amina Bashir	343489					

Lab 7: SSB Transmission

Introduction

The goal is to understand how a balanced modulator is used to generate DSB signal. Also, how the SSB is output from LSB filter. And, how an SSB have low power consumption and narrow bandwidth.

1. Objectives:

- Use a balanced modulator to create DSB signal
- Take SSB output from LSB filter
- Calculate power consumption and bandwidth of SSB

2. Lab 7: Lab Tasks

EXERCISE 1: (Balanced Modulator and LSB Filter)

The first section of an SSB transmitter includes a balanced modulator and an LSB filter. The balanced modulator converts the message and carrier signals to a DSB signal. The LSB filter then removes one of the sidebands from the DSB to produce an SSB (Figure 4-3).

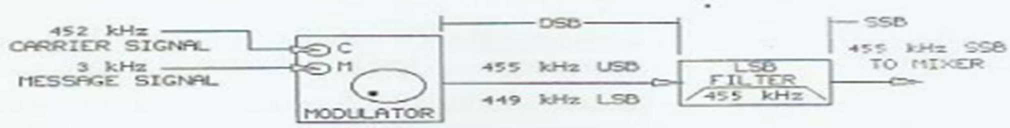
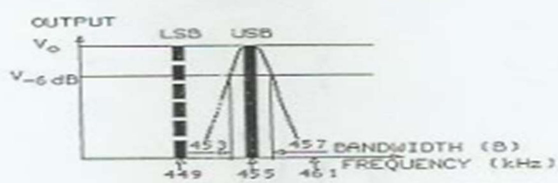


Figure 4-3.

The balanced modulator frequency translates a message signal to two sidebands and suppresses the carrier signal frequency to produce a DSB signal. To make filtering of a sideband easier, the carrier frequency (f_c) is relatively low (452 kHz). A low f_c provides a higher percentage of difference between upper and lower sideband frequencies than a high f_c would provide.

To produce an SSB signal from the DSB signal, a ceramic band pass filter with a narrow 4 kHz bandwidth removes the 449 kHz LSB signal. The 455 kHz USB signal is output from the filter and contains all of the 3 kHz message signal intelligence (Figure 4-4).



LSB FILTER ATTENUATION CHARACTERISTICS

Figure 4-4.

4-5

A filter with a narrow bandwidth is necessary because the USB and the LSB are only 6 kHz apart; the SSB signal is the 455 kHz USB. Because of the narrow bandwidth of the filter, the carrier signal has to be exactly 452 kHz so that a 455 kHz USB frequency is present.

The advantages of SSB transmission are that:

1. Only 16.5% of the total 100% modulated AM signal power is required, because the carrier and one of the sidebands are not present.
2. The SSB bandwidth is less than half of the AM bandwidth.

These advantages are offset, however, because more components are required for an SSB transmitter than for an AM transmitter.

1. Procedure A: Balanced Modulator

1. Locate the AM/SSB TRANSMITTER and VCO-LO circuit blocks on the ANALOG COMMUNICATIONS circuit board, and connect the circuit shown (Figure 4-6). Be sure to place a two-post connector in the 452 kHz position on the VCO-LO circuit block. VCO-LO connects to the MODULATOR'S carrier signal input (C), and the SIGNAL GENERATOR connects to the MODULATOR'S message signal input (M).

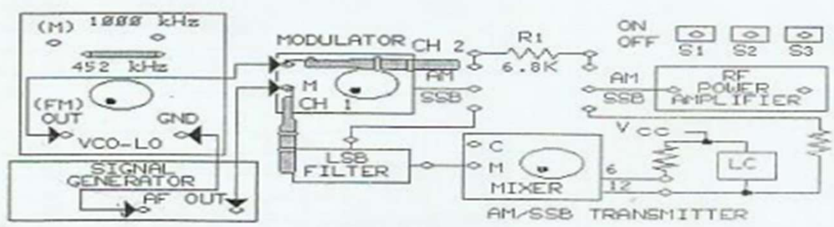


Figure 4-6.

2. Connect the oscilloscope channel 1 probe to the message signal input (M). While observing the signal on channel 1, adjust the signal generator for a 300 mV_{pk-pk}, 3 kHz sine wave (message signal) at M.
3. Connect the oscilloscope channel 2 probe to the carrier signal input (C). While observing the signal on channel 2, adjust the amplitude knob on VCO-LO for a 100 mV_{pk-pk} carrier signal at C.
4. Turn the NEGATIVE SUPPLY knob on the left side of the base unit completely Counterclockwise (CCW) to adjust the VCO-LO frequency to less than 452 kHz.
5. Set switches S1, S2, and S3 to OFF. Adjust the MODULATOR'S potentiometer knob fully CCW.
6. Connect the oscilloscope channel 2 probe to the MODULATOR'S output. Set the oscilloscope vertical mode to channel 2, and trigger on channel 1 (the message signal). Set the channel 2 attenuation to 0.5 V/DIV, and set the oscilloscope sweep to 0.1 ms/DIV.
7. Slowly turn the MODULATOR'S potentiometer knob clockwise (CW) until the AM signal (channel 2) is less than (<) 100% modulated. Continue to turn the knob slowly CW until the AM signal is greater than (>) 100% modulated.
8. Continue to turn the knob slowly CW until the amplitude modulated signal appears, as shown in Figure 4-7. What type of amplitude modulated signal appears on channel 2?

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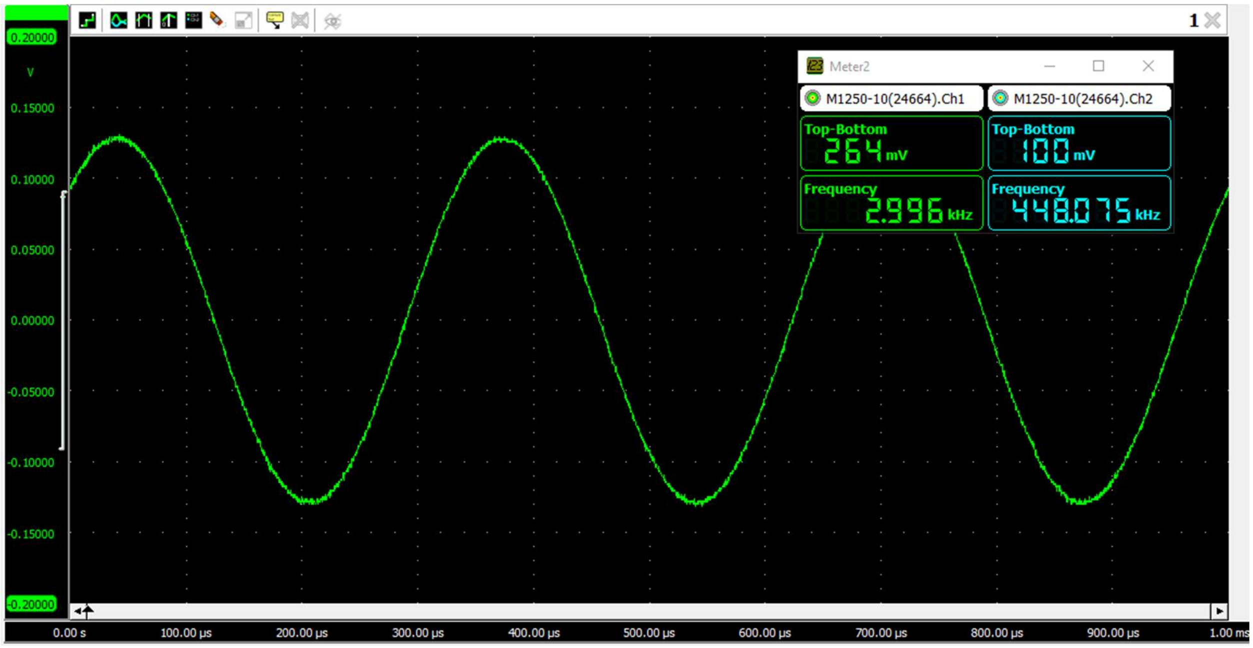
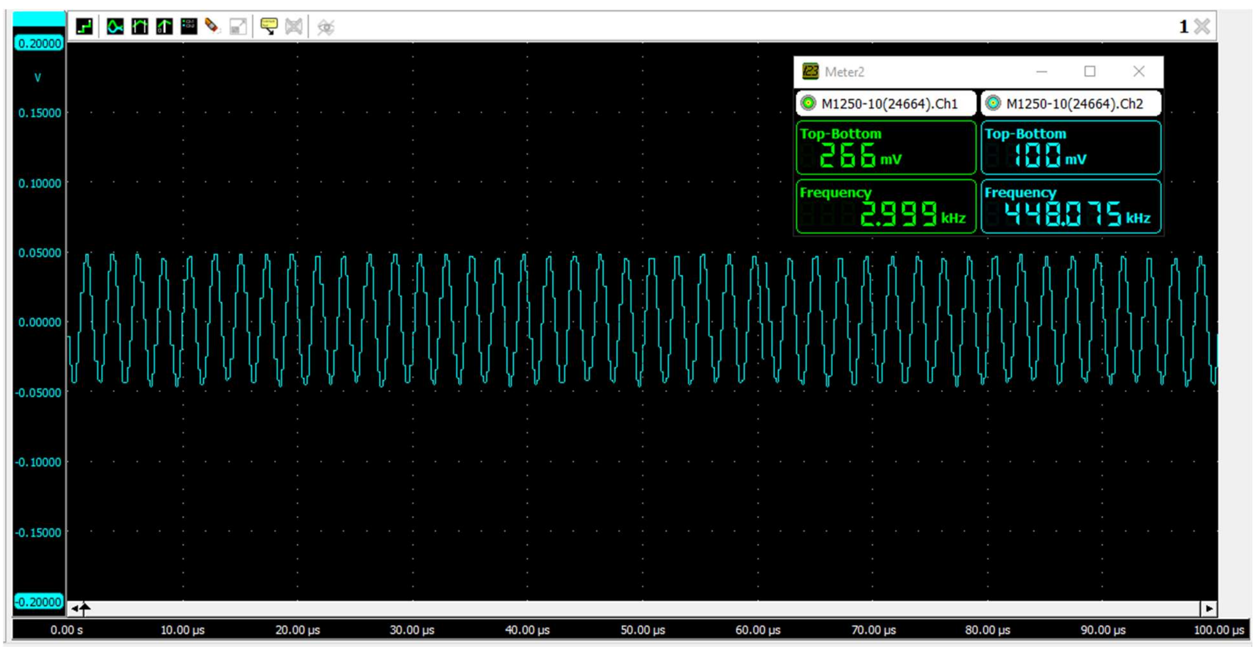
1. TASK 2


Meter2
M1250-10(24664).Ch1
M1250-10(24664).Ch2
Top-Bottom 264 mV
Top-Bottom 100 mV
Frequency 2.996 kHz
Frequency 448.075 kHz
0.20000
V
0.15000
0.10000
0.05000
0.00000
-0.05000
-0.10000
-0.15000
-0.20000
0.00 s
100.00 µs
200.00 µs
300.00 µs
400.00 µs
500.00 µs
600.00 µs
700.00 µs
800.00 µs
900.00 µs
1.00 ms

2. TASK 3


Meter2
M1250-10(24664).Ch1
M1250-10(24664).Ch2
Top-Bottom 266 mV
Top-Bottom 100 mV
Frequency 2.999 kHz
Frequency 448.075 kHz
0.20000
V
0.15000
0.10000
0.05000
0.00000
-0.05000
-0.10000
-0.15000
-0.20000
0.00 s
10.00 µs
20.00 µs
30.00 µs
40.00 µs
50.00 µs
60.00 µs
70.00 µs
80.00 µs
90.00 µs
100.00 µs

4-1

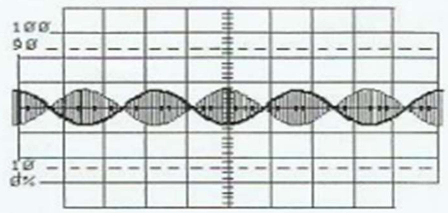
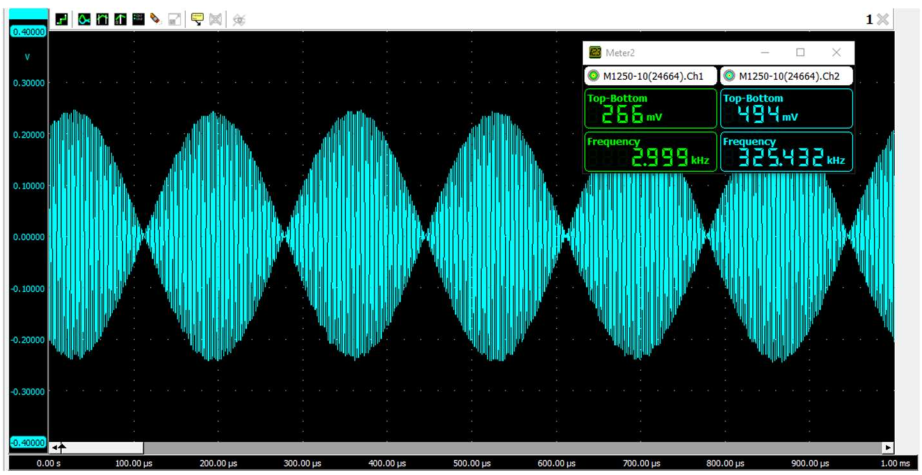


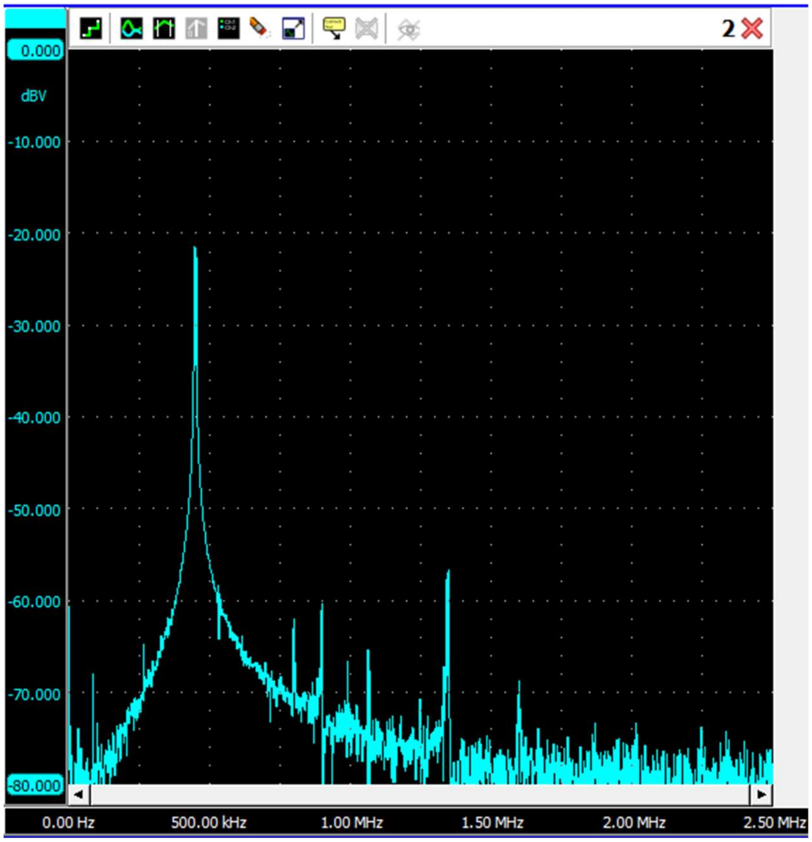
Figure 4-7.

9. The carrier signal frequency (f_C) is 452 kHz, and the message signal frequency (f_m) is 3 kHz. What frequencies are present in the frequency spectrum of the DSB signal?

3. TASK 9



The frequencies in the spectrum can be viewed from the below snippet.



4. PROCEDURE B: LSB Filter (Produce an SSB signal by filtering LSB signal)

10. Connect the LSB FILTER to the MODULATOR with a two-post connector, as shown. Set setup switch S1 to ON. Set setup switches S2 and S3 to OFF. In the previous PROCEDURE section, you connected and adjusted the VCO-LO signal for 100 mV_{pk-pk}; you connected and adjusted the SIGNAL GENERATOR for a 300 mV_{pk-pk}, 3 kHz signal.

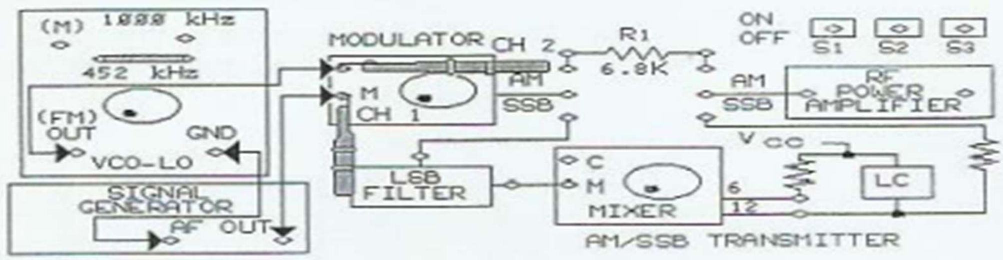


Figure 4-11.

11. Connect the oscilloscope channel 2 probe to the output of the LSB FILTER. Set the channel 2 attenuation to 50 mV/DIV. Connect the channel 1 probe to input M of the MODULATOR. Set the oscilloscope vertical mode to channel 2, trigger on channel 1, and set the sweep to 0.1 ms/DIV. The NEGATIVE SUPPLY knob on the base unit should be fully CCW.

12. A trace like the one in Figure 4-12 (a) appears at the USB FILTER output on channel 2. Increase the VCO-LO's frequency to the MODULATOR by slowly turning the NEGATIVE SUPPLY knob CW until the LSB FILTER'S output appears, as illustrated in Figure 4-12 (b).

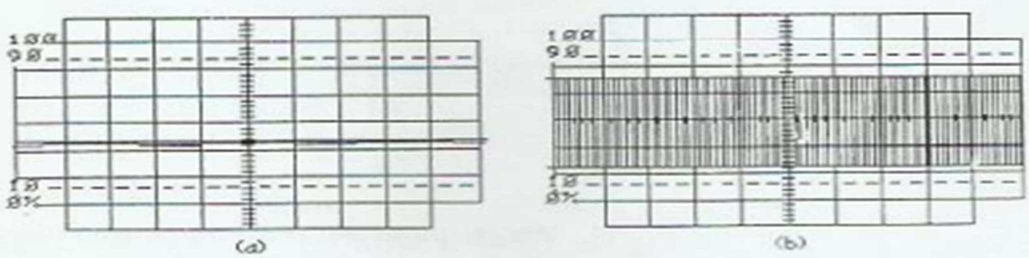
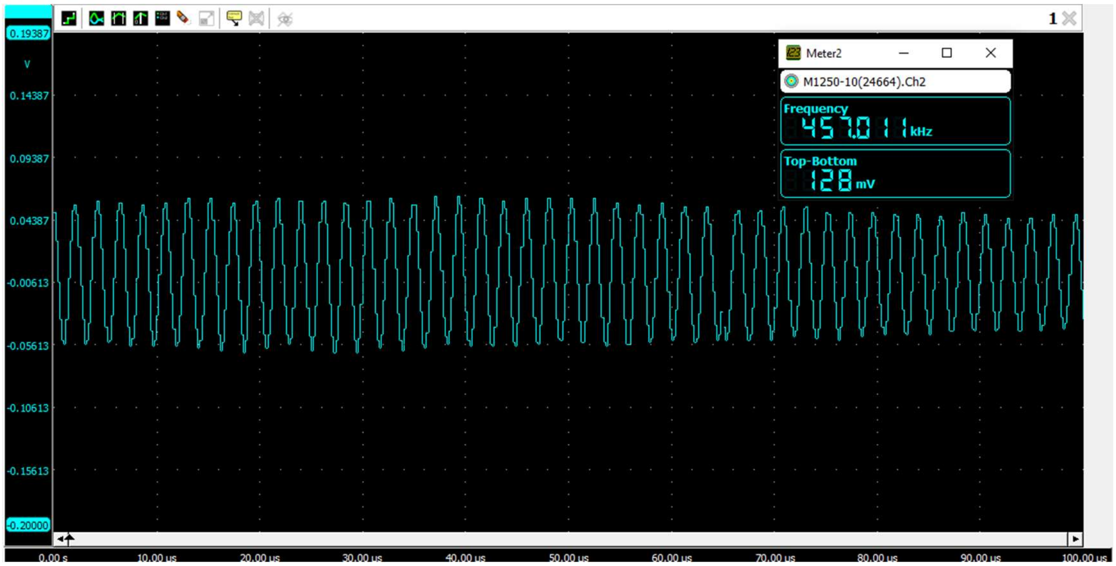


Figure 4-12 (a) and (b).

5. TASK 12:


Meter2
M1250-10(24664).Ch2
Frequency
457.011 kHz
Top-Bottom
128 mV
0.19387
V
0.14387
0.09387
0.04387
-0.00613
-0.05613
-0.10613
-0.15613
-0.20000
0.00 s
10.00 us
20.00 us
30.00 us
40.00 us
50.00 us
60.00 us
70.00 us
80.00 us
90.00 us
100.00 us

13. What is the LSB FILTER'S output signal that is shown on channel 2?

14. Trigger the oscilloscope on channel 2, and set the oscilloscope sweep to 1 μs/DIV so that the channel 2 signal appears, as shown in Figure 4-13.

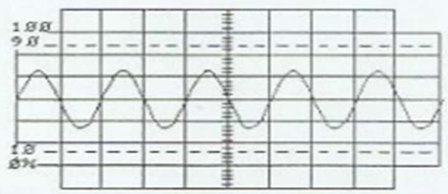


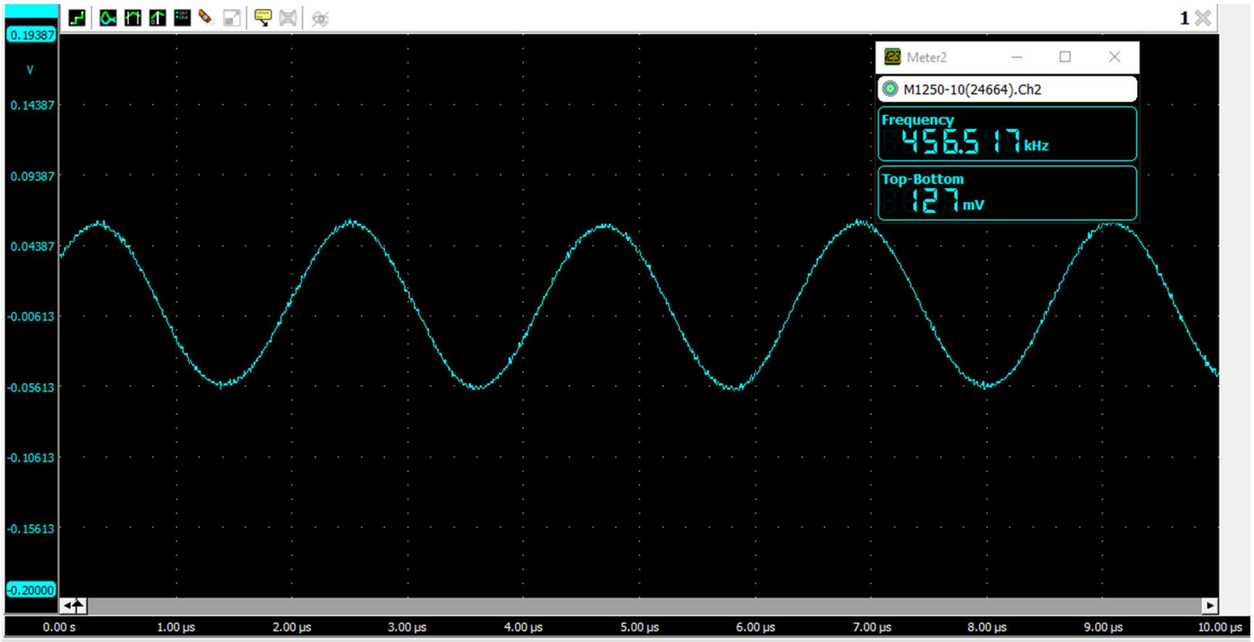
Figure 4-13.

15. While observing the 455 kHz signal at the LSB FILTER's output on channel 2, vary the amplitude of the 3 kHz message signal to the MODULATOR by varying the AF LEVEL knob on the SIGNAL GENERATOR. Does the amplitude of the 455 kHz signal vary with the amplitude of the 3 kHz message signal?

16. How much of the message signal does the SSB signal contain?

17. Which graph (Figure 4-14 (a) and (b)) shows the relationship of the filter's attenuation characteristic curve to the present LSB and USB frequencies being input to the USB FILTER?

6. TASK 14



7. TASK 15

Yes, it varies. It doubles with change in amplitude of message.

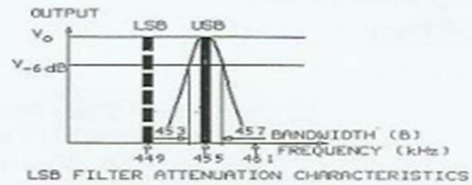


Figure 4-14 (a).

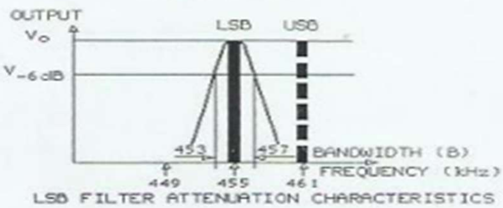


Figure 4-14 (b).

18. Trigger the oscilloscope on channel 1, and set the oscilloscope sweep to 0.1 ms/DIV. Continue to increase the oscillator's frequency by slowly turning the NEGATIVE SUPPLY knob CW until the channel 2 signal appears, as shown in Figure 4-15. What type of signal is the LSB FILTER'S output?

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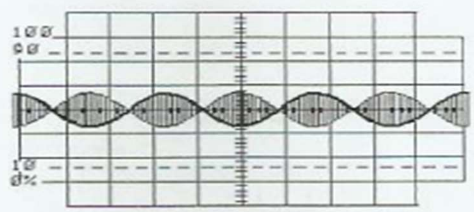

Figure 4-15.

19. What frequencies are in the LSB filter output?

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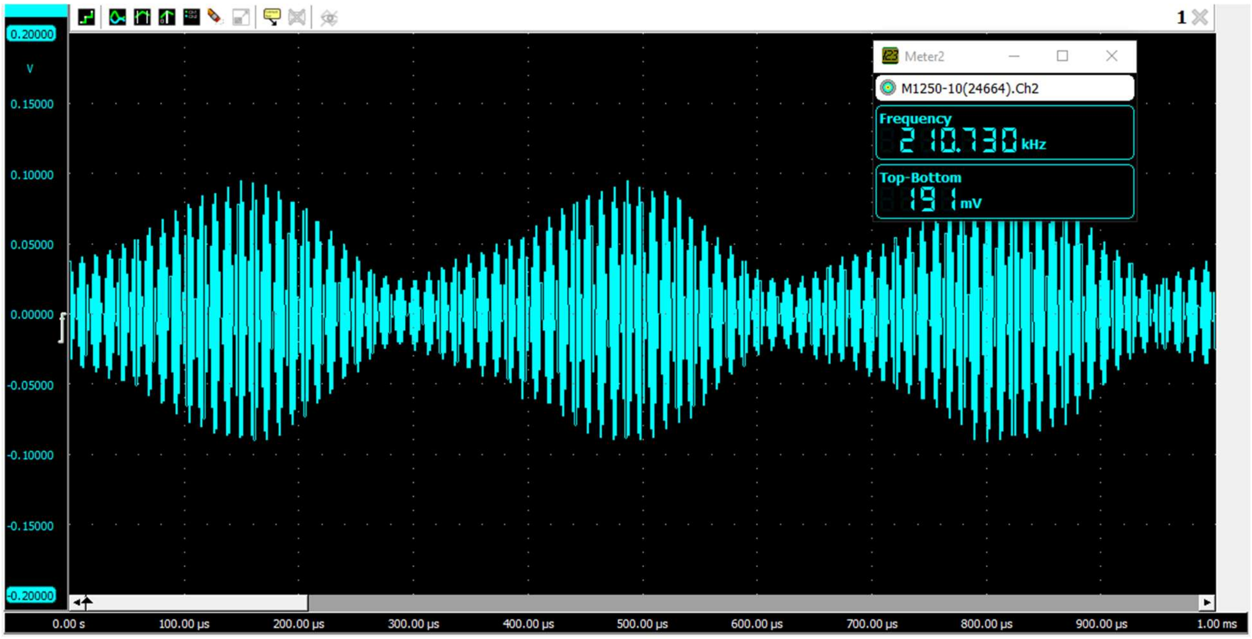
8. TASK 18


0.20000
V
0.15000
0.10000
0.05000
0.00000
-0.05000
-0.10000
-0.15000
-0.20000
Meter2
M1250-10(24664).Ch2
Frequency
210.730 kHz
Top-Bottom
191 mV
0.00 s
100.00 µs
200.00 µs
300.00 µs
400.00 µs
500.00 µs
600.00 µs
700.00 µs
800.00 µs
900.00 µs
1.00 ms

20. Continue to slowly increase the oscillator's frequency by turning the NEGATIVE SUPPLY knob CW until channel 2 appears, as shown in Figure 4-16. What type of signal is the LSB FILTER'S output?

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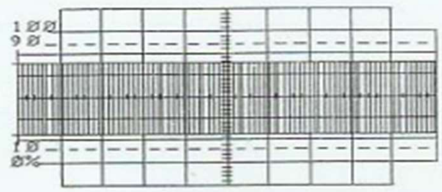

Figure 4-16.

21. Continue to increase the oscillator's frequency by slowly turning the NEGATIVE SUPPLY knob CW until the channel 2 signal is a thick line.

22. Which graph (Figure 4-17 (a) or (b)) represents the sideband frequencies in relationship to the filter's attenuation characteristic curve?

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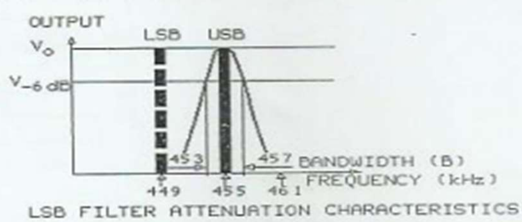
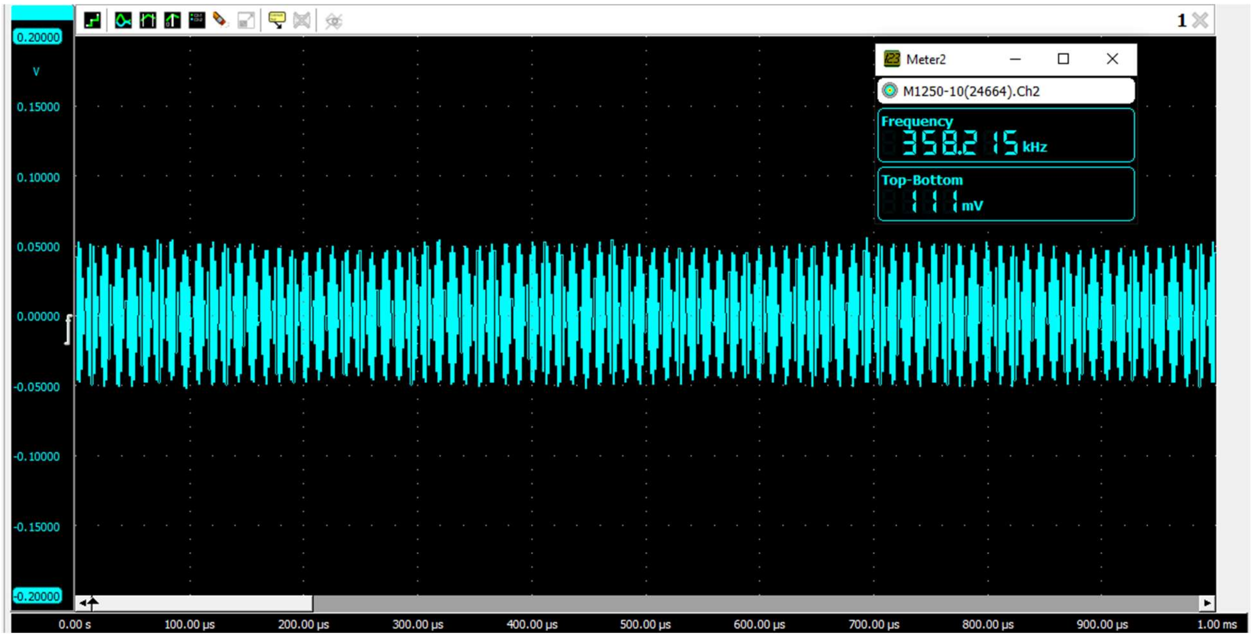


Figure 4-17 (a).

9. TASK 21



10. TASK 22

Spectrum has type B attenuation characteristics.

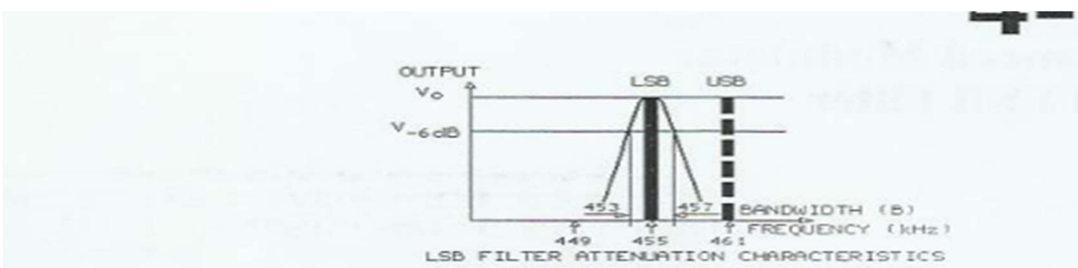


Figure 4-17 (b).

11. Exercise (2): Mixer and RF Amplifier

Procedure A: Adjust the Circuit for a 455kHz to the MIXER

1. To connect and adjust the SSB TRANSMITTER circuit for an SSB signal to the MIXER, first connect the circuit shown. Be sure to place a two-post connector in the 452 kHz position on the VCO-LO circuit block. The LSB FILTER connects to the MODULATOR with another two-post connector (Figure 4-22).

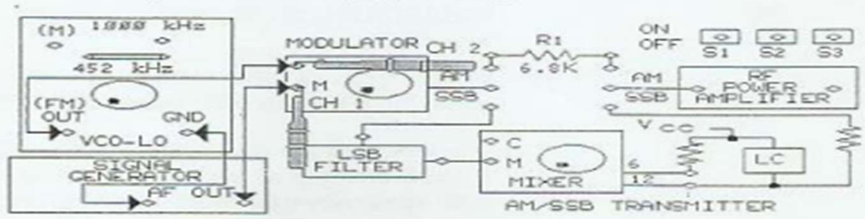
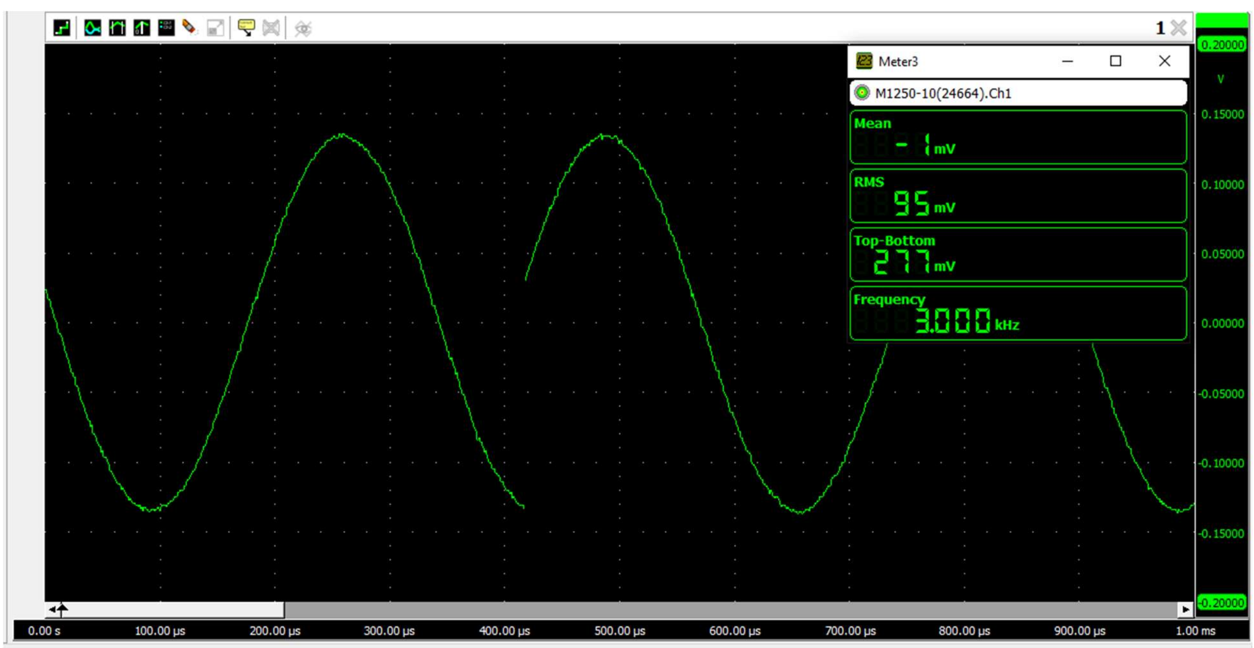


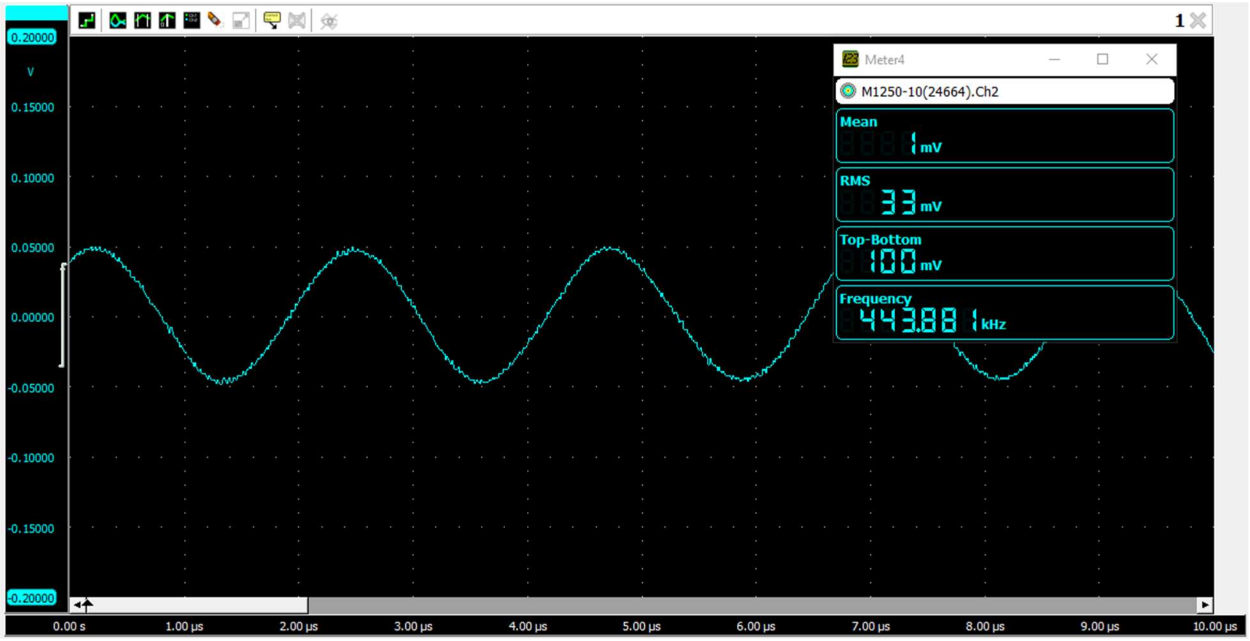
Figure 4-22.

2. Connect the oscilloscope channel 1 probe to the MODULATOR'S M input. While observing the signal on channel 1, adjust the signal generator for a 300 mV_{pk-pk}, 3 kHz sine wave (message signal) at M.
3. Turn the NEGATIVE SUPPLY knob on the left side of the base unit fully CCW to set the VCO-LO frequency less than 452 kHz.
4. Connect the channel 2 probe to the MODULATOR'S C input. While observing the signal on channel 2, adjust the amplitude knob on VCO-LO for a 100 mV_{pk-pk} carrier signal at C.
5. Set switch S1 to ON to automatically output a DSB from the MODULATOR. Set S2 and S3 to OFF.
6. Connect the channel 2 probe to the M input of the MIXER. Set the oscilloscope channel 2 attenuation to 50 mV/DiV, set the vertical mode to channel 2, trigger on channel 1, and set the sweep to 0.1 ms/DIV.

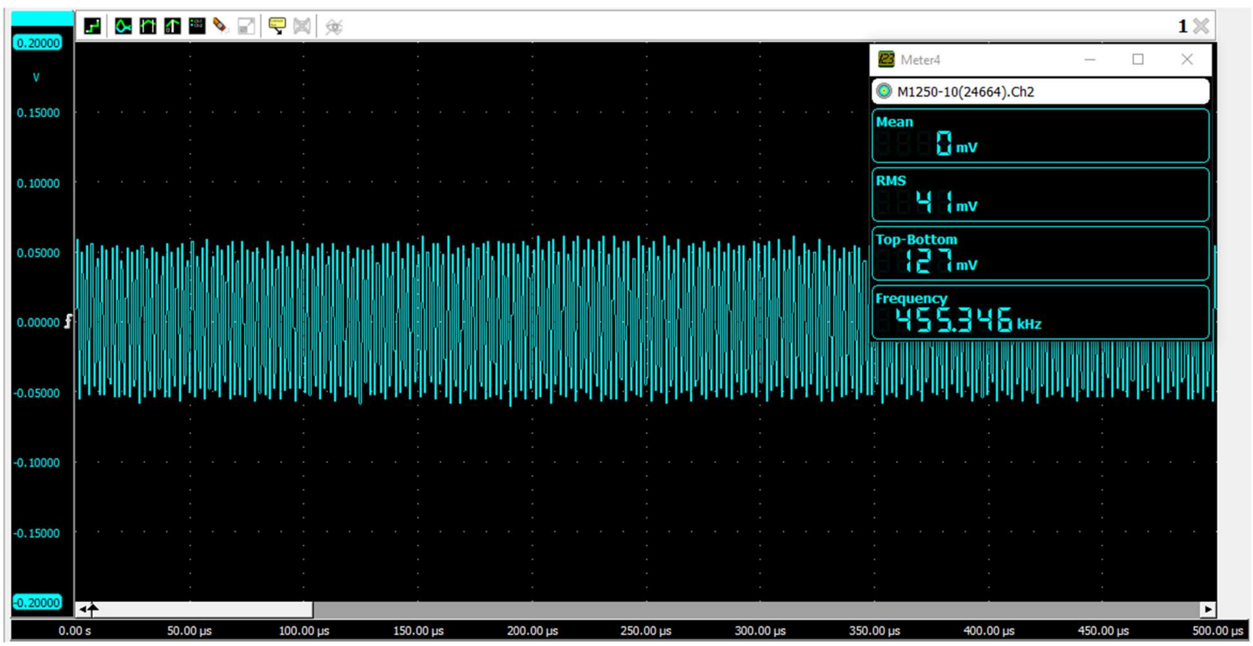
12. TASK 2



13. TASK 4



14. TASK 7



7. A trace appears at the LSB FILTER output on channel 2 (Figure 4-23 (a)). Slowly increase the VCO-LO's frequency to the MODULATOR by turning the NEGATIVE SUPPLY knob CW until the LSB FILTER'S output amplitude is maximum (Figure 4-23 (b)). This output is an SSB signal.

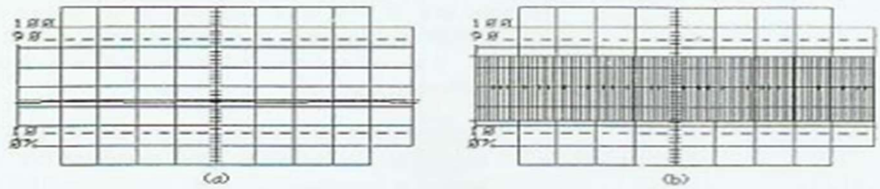


Figure 4-23 (a) and (b).

15. Procedure B:

Mixer: Convert the 455kHz SSB to a 1000kHz SSB

8. Connect the output of the VCO-HI circuit block to input C of the MIXER (Figure 4-25).

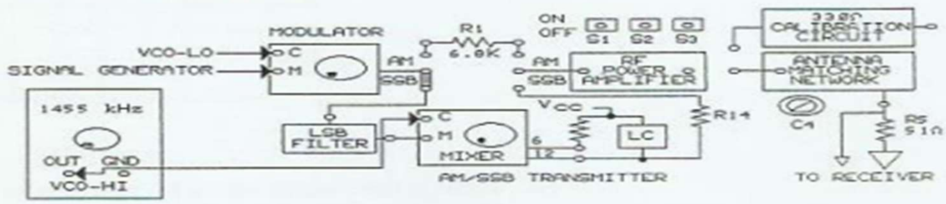


Figure 4-25.

9. Set S1 to ON to automatically output a DSB from the MODULATOR. Set S2 and S3 to OFF.
10. Connect the channel 2 probe to the MIXER'S C input. Adjust the VCO-HI signal to 100 mV_{pk-pk} with the VCO-HI potentiometer knob.
11. Set the VCO-HI frequency to approximately 1455 kHz by adjusting the POSITIVE SUPPLY knob on the base unit.
12. Connect channel 1 to the filter's output, and trigger on channel 1.
13. Connect channel 2 to the MIXER'S pin 6 output. Adjust the MIXER'S potentiometer knob for a DSB signal at pin 6.
14. Connect channel 2 to the MIXER'S pin 12 output. Fine tune the 1455 kHz VCO-HI frequency by adjusting the POSITIVE SUPPLY knob on the base unit for the maximum SSB signal at pin 12.
15. Trigger on channel 2. Set the oscilloscope sweep to 0.5 μs/DIV. The signal at pin 12 should appear as shown. If it does not, slightly adjust the MIXER'S potentiometer knob so that the signal appears .
16. Measure and record the period (T) between peaks of the waveform (Figure 4-23). Each horizontal division is 0.5 μs.

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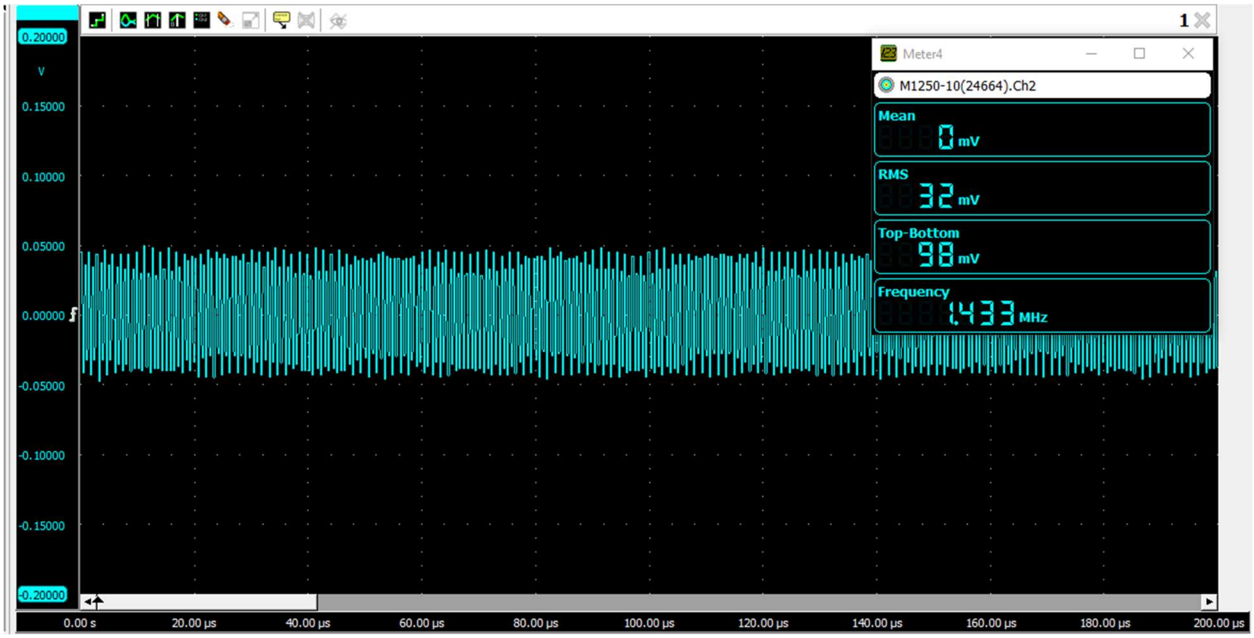
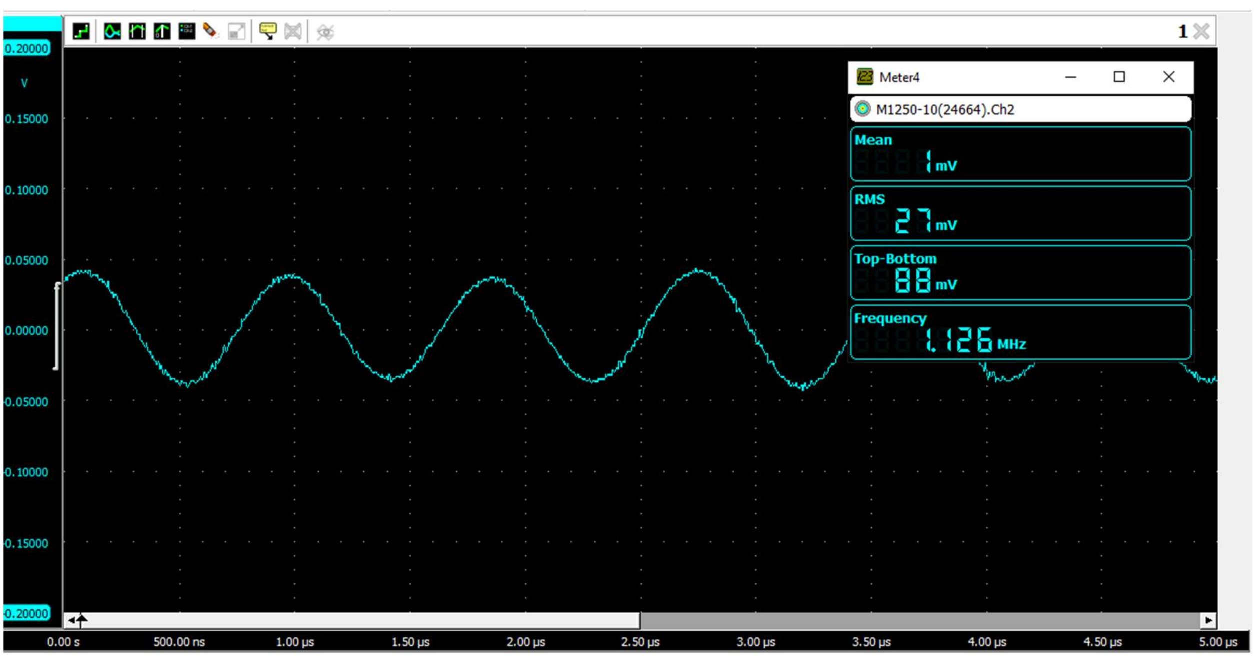
16. TASK 10



17. TASK 16



The time period obtained is 800.8 ns.

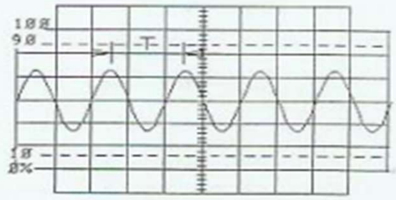


Figure 4-23.

17. What is the output signal's frequency at pin 12 ?(Calculate the answer from the time period.)

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18. While observing the 1000 kHz SSB signal at the MIXER'S pin 12, vary the amplitude of the 3 kHz message signal to the MODULATOR by varying the AF LEVEL knob on the SIGNAL GENERATOR. Does the amplitude of the 1000 kHz signal at pin 12 vary with the changing amplitude of the 3 kHz message signal?

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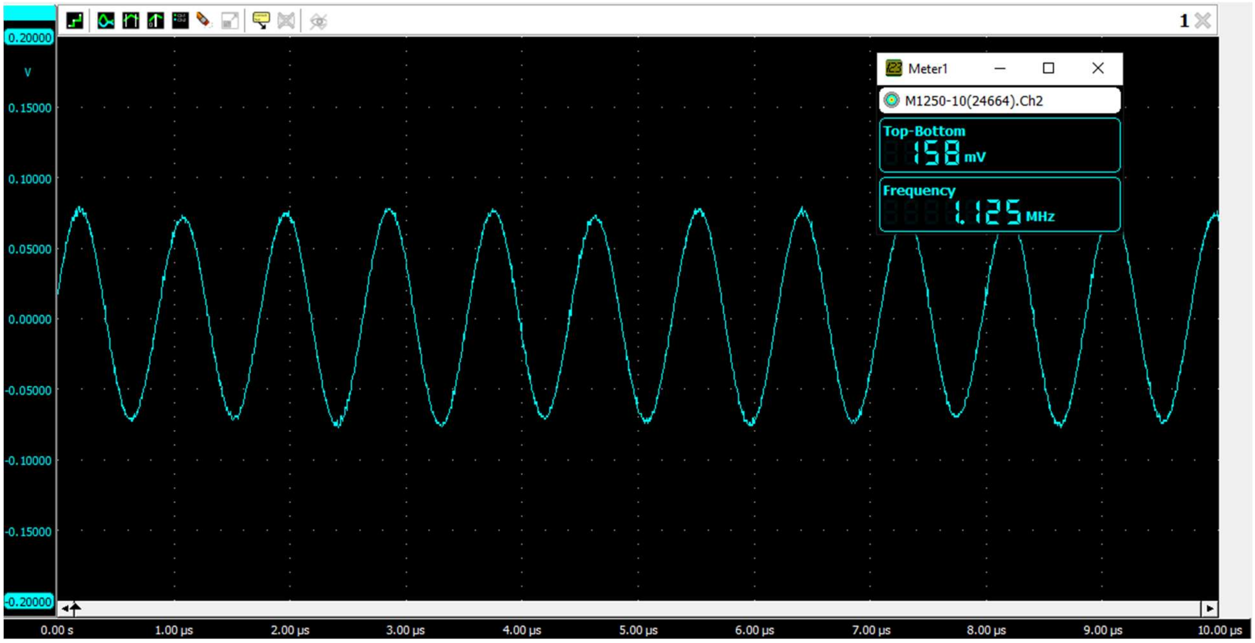
19. Connect the channel 2 probe to M of the MODULATOR, and adjust the SIGNAL GENERATOR for a 300 $mV_{pk\text{-}pk}$, 3 kHz message signal (the original setting).

18. TASK 17

Using the period to calculate frequency as: freq = 1.126 MHz.

19.TASK 18



There is no dependence of 1000 KHz signal on amplitude of message signal.

20. Procedure C:

RF Power Amplifier and Antenna Matching Network

20. With two-post connectors, connect the RF POWER AMPLIFIER to the MIXER and the ANTENNA MATCHING NETWORK (Figure 4-27).

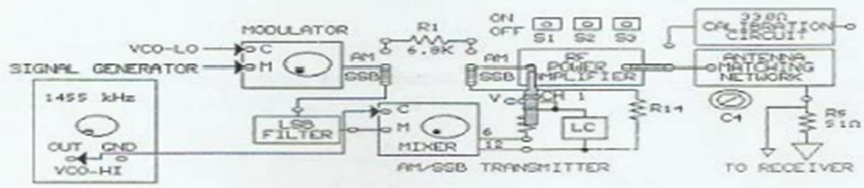


Figure 4-27.

21. Set S1, S2, and S3 to ON. When S1 and S2 are on, they automatically balance the MODULATOR and MIXER, respectively, for DSB signals. When S3 is on, the ANTENNA MATCHING NETWORK impedance is automatically set to 330Ω.

22. Connect the channel 1 probe to the input of the RF POWER AMPLIFIER. Measure and record the peak-to-peak voltage.

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21. TASK 22

Peak-to-peak voltage (measured) = 60mV

23. With the existing circuit conditions, the input current (I_i) to the RF POWER AMPLIFIER is about 26 μArms. Using the V_i value of 23.7 mVrms, calculate the input power ($P_i = V_i \times I_i$).

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24. Connect the channel 2 probe to the output of the ANTENNA MATCHING NETWORK. Measure and record the peak-to-peak output voltage across R5 (Vo). This resistor simulates the impedance of the transmitting antenna.

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25. Calculate the rms power dissipated by R5 (P_o). $((.353\ P_o)^2/51)$

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26. Calculate the power gain (Ap) across the RF POWER AMPLIFIER and the ANTENNA MATCHING NETWORK. ($A_p = P_o/P_i$)

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27. In a 100% modulated AM signal, the USB accounts for 16.65% of the total signal power. If the SSB power that you measured across R5 was part of the 100% modulated AM signal's power, what is the total signal power (P_T) of the 100% modulated AM signal? ($P_T = P_o/0.1665$)

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22. TASK 23

Power input = 0.123 μW

23. TASK 24

Peak-to-peak voltage = 200 mV

28. If you were using a message signal that contained frequencies from 1 kHz to 3 kHz, the SSB signal would have a 2 kHz bandwidth (from 1001 kHz to 1003 kHz). What is the bandwidth (B) of a 100% modulated signal containing a message signal with frequencies between 1 kHz and 3 kHz?

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24. TASK 25

P(out) = 37 μw

25. TASK 26

A = 329

26. TASK 27

P = 660 W

27. TASK 28

B.W = approx.. 4 KHz

28. CONCLUSION:

This report has provided an overview of using a balanced modulator to produce DSB signals and the subsequent retrieval of SSB signals by applying a LSB filter. Compared to DSB signals, SSB signals have various benefits, including low power usage and a narrower bandwidth. These modulation techniques have numerous practical applications, especially in radio communication and signal processing fields.