Department of Electrical Engineering

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EE-351 Communication Systems

Lab 05: AM Reception and RF Stage

		PLO4-CLO4		PLO5-CLO5	PLO8-CLO6	PLO9-CLO7
Name	Reg. No	Viva / Quiz / Lab Performance 5 Marks	Analysis of data in Lab Report 5 Marks	Modern Tool Usage 5 Marks	Ethics and Safety 5 Marks	Individual and Team Work 5 Marks
1. Amina Bashir	343489					
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4. Hassan Rizwan	335753					

Lab 5: AM Reception and RF Stage

Objectives:

When you have completed this exercise, you will be able to calculate the AM signal power at an RF filter input, describe how an RF filter is tuned to filter an AM signal, and calculate the power gain of an RF amplifier. You will use an oscilloscope to make AM signal measurements.

Introduction:

AM reception involves the reception and demodulation of amplitude-modulated (AM) radio signals. The RF stage, or radio frequency stage, is an important component of an AM receiver that is responsible for amplifying the radio signal received by the antenna.

The RF stage is typically composed of one or more amplifiers that increase the strength of the incoming radio signal. This is necessary because the signal received by the antenna is often very weak, and needs to be amplified before it can be further processed and demodulated.

After passing through the RF stage, the signal is typically processed by a mixer, which mixes the incoming signal with a local oscillator signal to produce an intermediate frequency (IF) signal. The IF signal is then amplified and processed further by intermediate frequency (IF) stages before being demodulated to recover the original audio signal.

Overall, the RF stage is a critical component of an AM receiver that helps to ensure that weak radio signals can be successfully received and demodulated.

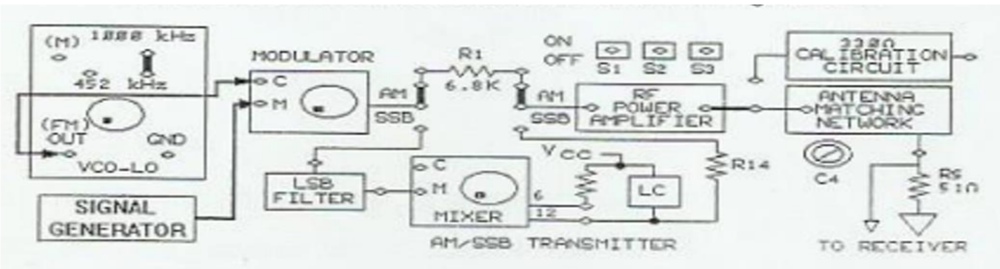
PROCEDURE A:

Connect AM Transmitter Circuit

In this PROCEDURE section, you will connect and adjust the AM transmitter and use the transmitter's output signal as the receiver's input signal.

If you must restart this section at a later time, setup the circuit by completing the steps in the Adjust the AM Transmitter to Output a 100% AM Signal section in the Resources of this manual. Circuit setup guides and the switch function guide are also located in the Resources.

1. Connect the AM transmitter circuit as shown. The highlights show the connections.



2. On the VCO-LO circuit block, insert the two-post connector in the 1000 kHz position.

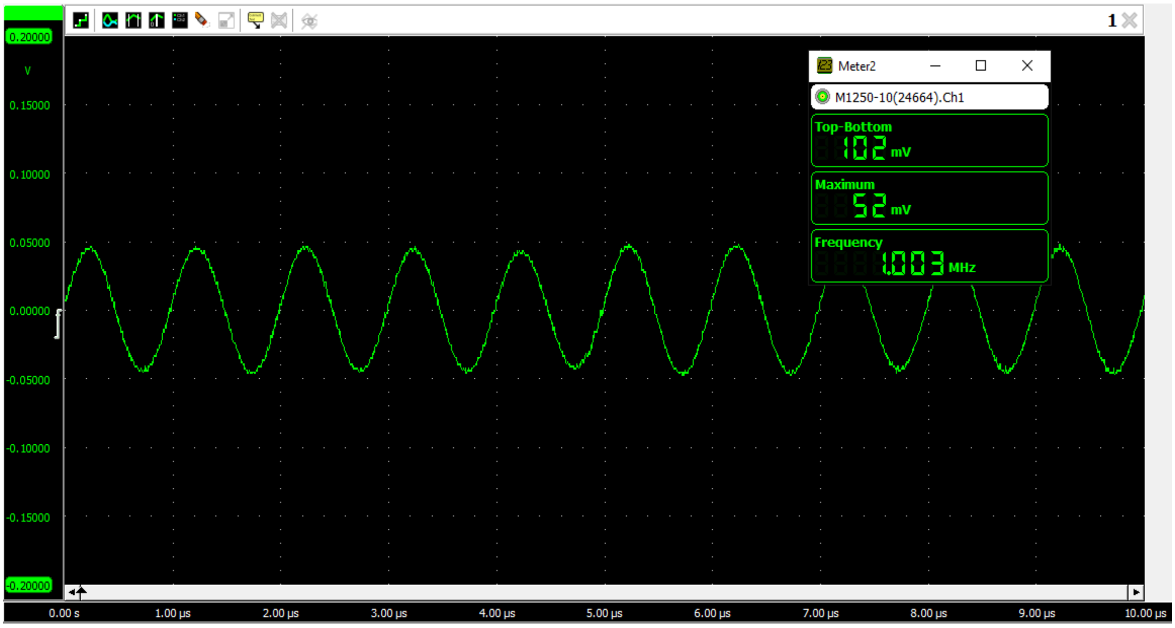
3. Set switches S1 and S2 to OFF.

4. Set S3 to ON. When S3 is on, the ANTENNA MATCHING IMPEDANCE is automatically set to 330.

5. Connect the oscilloscope channel 1 probe to the MODULATOR's carrier signal input (C).

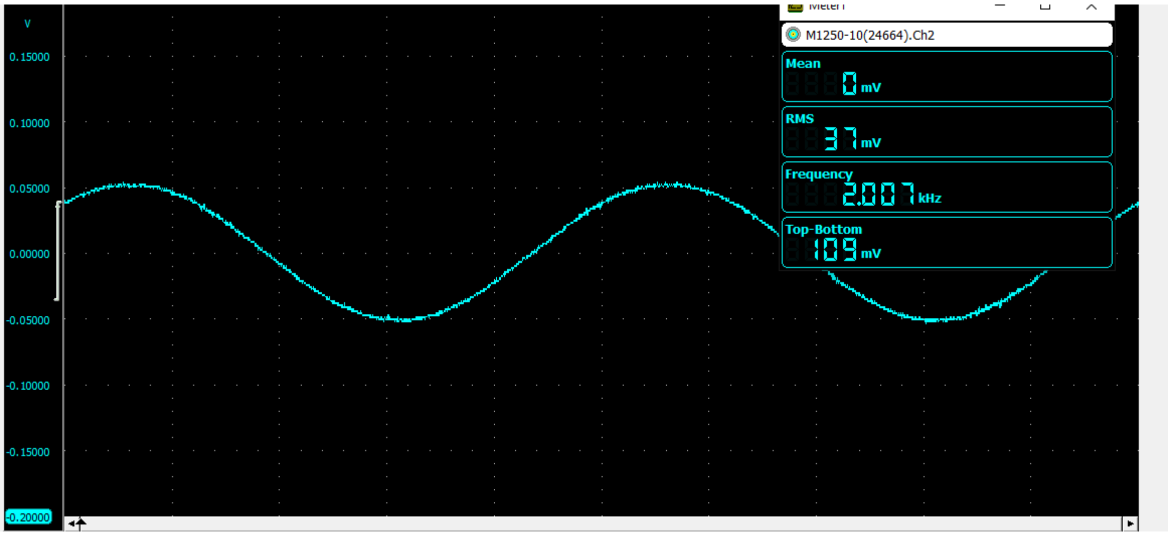
6. While observing the signal on channel 1, set the carrier signal amplitude to 0.1 $V_{pk\text{-}pk}$ by adjusting the knob on the VCO-LO circuit block.

7. While observing the signal on channel 1, set the carrier signal frequency to 1000 kHz by adjusting the NEGATIVE SUPPLY knob on the base unit.



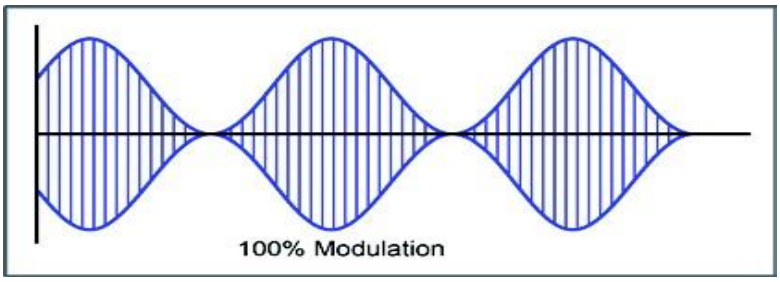
8. Connect the signal generator and the oscilloscope channel 2 probe to the MODULATOR message signal input (M).

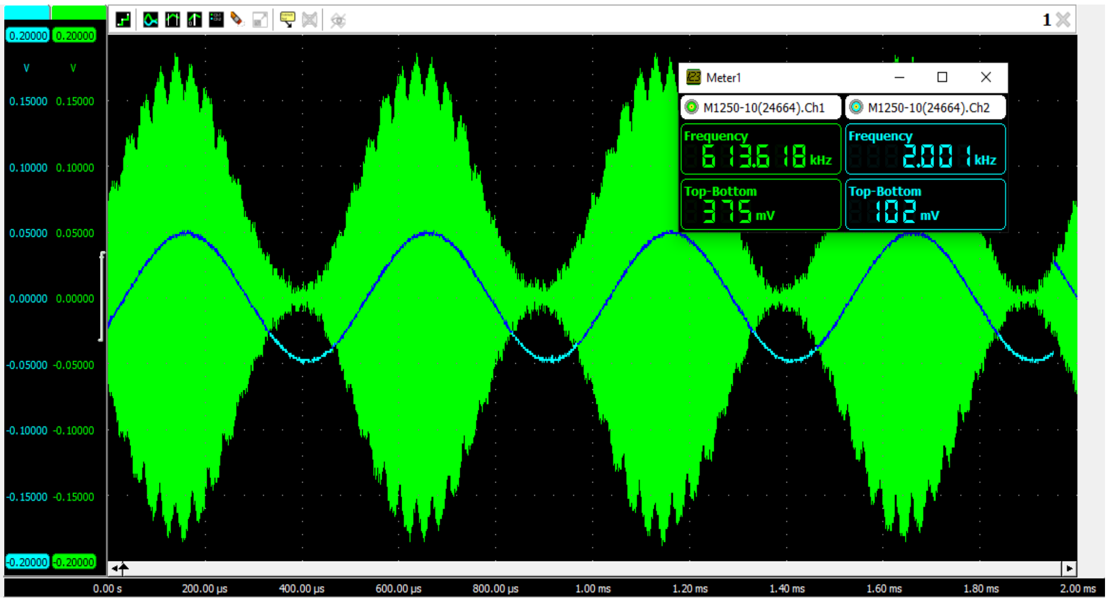
9. While observing the signal on oscilloscope channel 2, adjust the signal generator for a 0.1 $V_{pk\text{-}pk}$, 2 kHz sine wave signal at the message input of the MODULATOR.



10. Connect the channel 1 oscilloscope probe to the output of the antenna (R5). Set the sweep to 0.1ms/div and trigger on channel 2.

Adjust the MODULATOR potentiometer knob so that the AM waveform is 100% modulated, as shown in the image below.





PROCEDURE B:

RF Filter: Input Power

In this PROCEDURE section, you will calculate the AM receiver antenna signal's rms voltage and power at the RF FILTER input. Your results will be used to calculate the RF stage power gain.

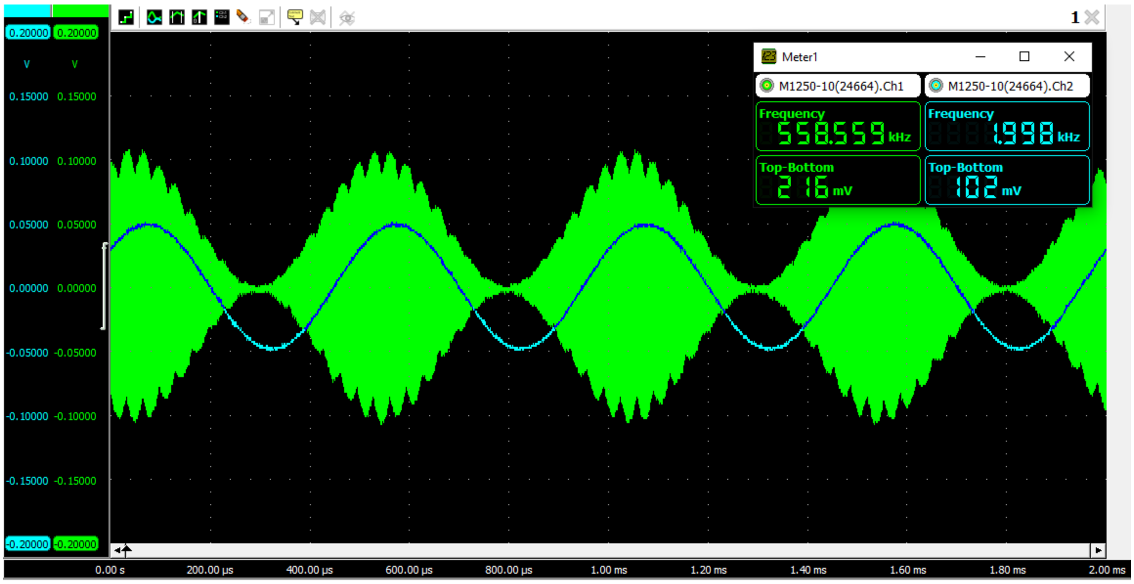
If you are not proceeding directly from the Connect AM Transmitter Circuit portion of this procedure or if you must restart this section at a later time, setup the circuit by completing the steps in the Adjust the AM Transmitter to Output a 100% AM Signal section in the Resources of this manual. Circuit setup guides and the switch function guide are also located in the Resources.

The AM signal from the AM transmitter antenna connects to the 1 M ohm resistor (R8) that reduces the power of the transmitted AM signal at the receiver.

11. With a two-post connector, connect the TRANSMITTER to the 1 M ohm resistor (R8). Connect the channel 1 oscilloscope probe to the R8 input. Is the transmitted AM signal at the R8 input?

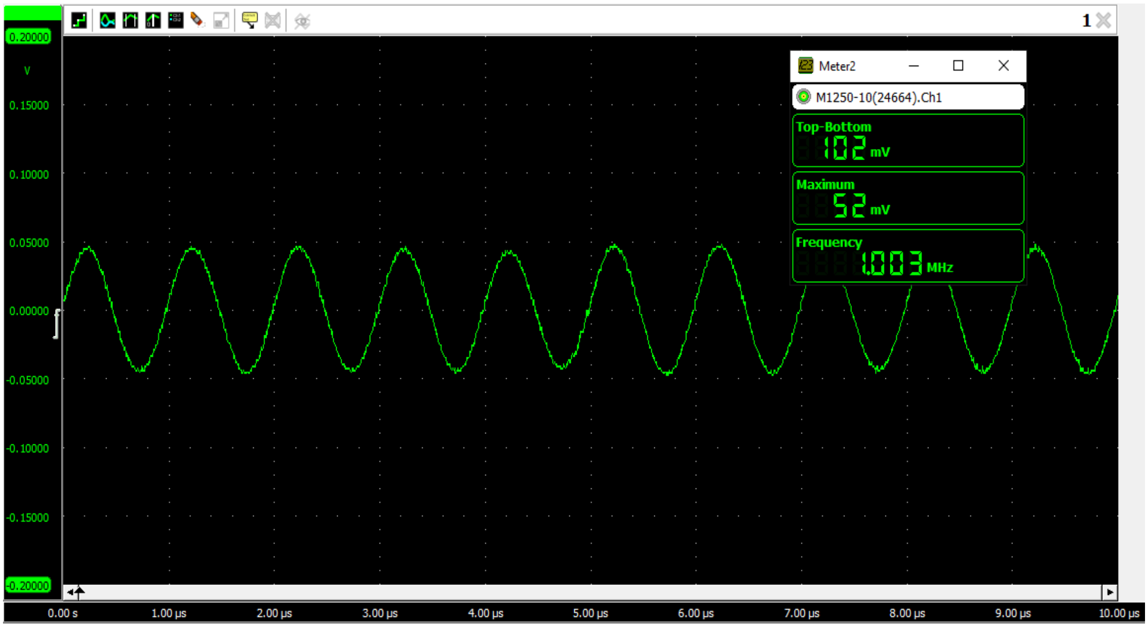
    a. Yes

    b. no



12. To simplify signal observations and adjustments at the RF FILTER and RF AMPLIFIER, use circuit block, disconnect the signal generator from the MODULATOR message signal input (M).

13. On channel 1, measure the peak-to-peak voltage of the carrier signal at the input to R8.



V_{R8} =102 m$V_{pk\text{-}pk}$

14. Calculate the carrier signal's peak-to-peak voltage at the RF FILTER input. Use the voltage divider equation.

$$V_{RF(i)} = (50/1000050)\ V_{R8} = 4.99 \text{ microvolts}$$

15. Calculate the carrier signal's rms power using 50 ohms as the input impedance.

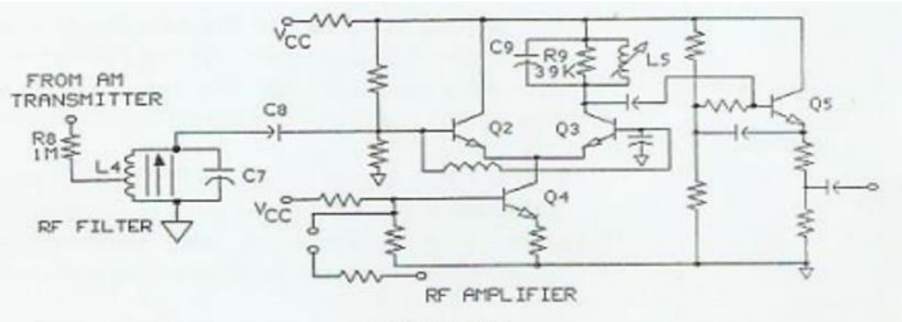
$$P_{RF(i)} = V^2_{RF(i)rms}/50 = 498 \text{ picoWatts}$$

PROCEDURE C:

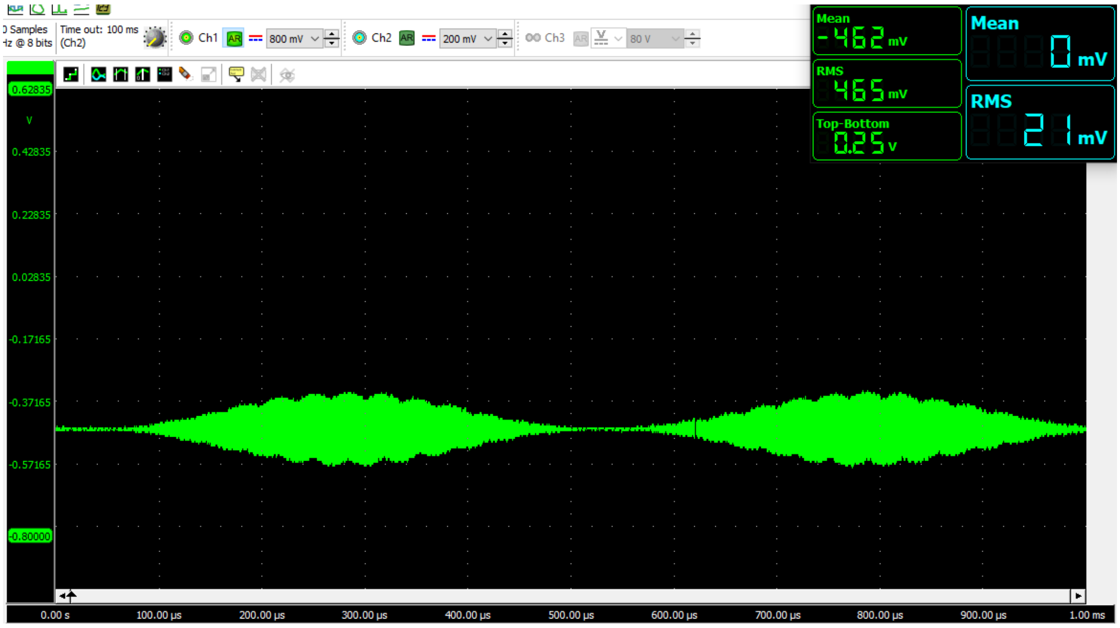
RF Filter: Adjust for the AM Signal

Due to the delicate nature of the variable inductors, it is suggested that once a student makes a proper adjustment not to change this adjustment. Later when the board is reused, the new student need only tweak the variable inductor. This approach will extend the life of the variable components.

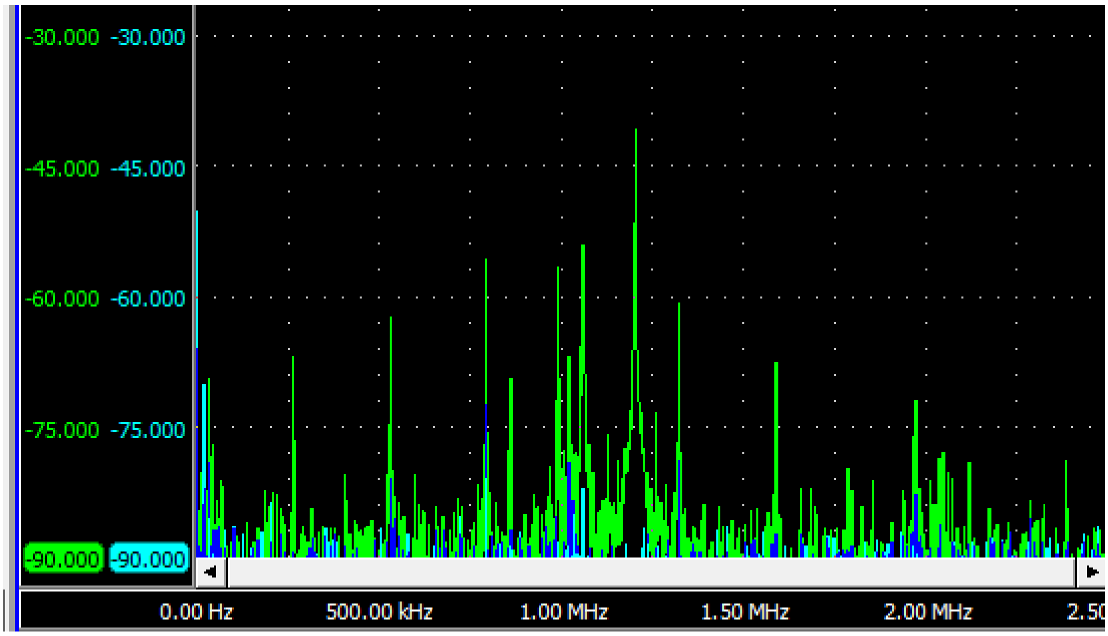
16. No connections are necessary in the RF FILTER and RF AMPLIFIER sections of the receiver circuit except for the two-post connector that connects the TRANSMITTER circuit.



17. Connect the channel 1 oscilloscope probe to the RF AMPLIFIER output. Adjust L5 at about the midpoint so that a signal appears on channel 1.



18. Adjust inductor L4 for the maximum peak-to-peak signal at the RF AMPLIFIER output. After adjusting L4 for the maximum signal at the RF AMPLIFIER output, what is the resonant frequency (f_r) of the RF FILTER?



19. With the 1000 kHz carrier signal and a 2 kHz message signal, what is the LSB that the RF has to pass?

In DSB-AM, the carrier signal is suppressed, and the modulated signal contains both the upper and lower sidebands, each of which contains a copy of the message signal. The upper sideband is located above the carrier frequency, while the lower sideband is located below the carrier frequency.

To recover the original message signal at the receiver, the carrier frequency and one of the sidebands (usually the lower sideband) must be selected and demodulated. In this case, the RF stage must pass the lower sideband, which has a frequency of 998 kHz.

LSB = 100-2 = 998 kHz

20. With a 1000 kHz carrier signal and a 2 kHz message signal, what is the RF FILTER's minimum bandwidth (B) necessary to pass the received AM signal?

The minimum bandwidth of the RF filter necessary to pass the received AM signal depends on the type of modulation and the amount of bandwidth required to transmit the signal without distortion.
For double-sideband amplitude modulation (DSB-AM), the minimum bandwidth required to pass the signal without distortion is equal to the bandwidth of the modulating signal, which is 2 kHz in this case.

Bandwidth=2 kHz

PROCEDURE D:

RF Power Amplifier (Maximize Power Gain)

21. On channel 1, measure the peak-to-peak voltage of the carrier signal at the RF AMPLIFIER output.

22. Record your result.

$$\mathbf{V_{RF(o)} = 250mV_{pk\text{-}pk}}$$

23. Calculate the carrier signal's rms power at the RF AMPLIFIER output. The RF AMPLIFIER output impedance is 2 kilo ohms.

$$\mathbf{P_{RF(0)} = V^2_{RF(o)} /2k = 31.25 \text{ milli Watts}}$$

24. The carrier signal's input and output power to and from the RF stage (RF FILTER and RF AMPLIFIER) are shown. Calculate the input power in decibels with reference to 1 mW (dBm).

$$\mathbf{dBm_{RF(i)} = 10x\ log_{10}\ (P_{RF(i)}/1mW) = -23.0277dBm}$$

25. Calculate the output power in decibels with reference to 1 mW (dBm).

$$\mathbf{dBm_{RF(o)} = 10x\ log_{10}\ (P_{RF(o)}/1mW) = 44.9485dBm}$$

26. From input and output powers in dBm find power gain.

$$\mathbf{Ap_{RF} = dBm_{RF(o)} - dBm_{RF(i)} = 44.9485-(-23.0277) = 67.9762dBm}$$

Conclusion:

In conclusion, this lab exercise provided an opportunity to develop skills related to the calculation of AM signal power, tuning of an RF filter to filter an AM signal, and calculation of power gain of an RF amplifier. Through the use of an oscilloscope, we were able to make accurate measurements of AM signals and to analyze the effects of various components on the signal.

The objectives of the lab were successfully met as we were able to calculate the AM signal power at an RF filter input, describe the tuning process of an RF filter to filter an AM signal, and calculate the power gain of an RF amplifier.

The lab exercise has been beneficial in reinforcing the concepts of amplitude modulation, RF filtering, and amplification, and their practical applications in modern communication systems. The skills learned in this lab exercise will be valuable in future coursework and research in the field of electrical engineering