PRACTICAL WORK BOOK

For Academic Session 2009

COMMUNICATION ELECTRONICS

(TC-334)

For

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Name: ______________________________

Roll Number: ______________________________

Batch: ______________________________

Department: ______________________________

Year: ______________________________

Department of Electronic Engineering
NED University of Engineering & Technology, Karachi

LABORATORY WORK BOOK

For The Course

TC-334 COMMUNICATION ELECTRONICS

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INTRODUCTION

Communication Electronics Practical Workbook covers a variety of experiments that are designed to aid students in their profession and theory. The practicals are very beneficial to students and will help them in having a core knowledge and understanding of the subject.

The practical covered in this manual give more than a basic introduction to students. They cover a variety of topics which include Amplitude modulation and demodulation, Frequency modulation, Phase locked loops, Radio transmitters and Receivers. A practical exposure to such equipment is necessary as it builds on the theory taught to students.

The practicals are based on modern trainers that incorporate a variety of functions to demonstrate to students the principles of Electronic Communication. The students will develop a profound interest in this course which will facilitate them whether it is in future professional work or higher studies.

Telecommunications Laboratory

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Telecommunications Laboratory

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LAB SESSION 01

OBJECT:-

(a)- Examine the main parameters of an amplitude modulated signal.
(b)- Check the operation of an amplitude modulator.
(c)- carry out characteristic measurement on an amplitude modulator.

EQUIPMENT:-

Modules T10A-T10B. +/- 12Vdc Supply
Oscilloscope.
Frequency counter. Multimeter.

THEORY:-

Modulation:
The modulation is simply a method of combining two different signals and is used in the transmitter section of a communication system. The two signals that are used are the information signal and the carrier signal. The information signal is the signal that is to be transmitted and received and is sometimes referred to as the intelligence .The carrier signal allows the information signal to be transmitted efficiently through the transmission media.
The carrier signal is normally generated by an oscillator and has a constant frequency and amplitude. The information signals that is fed into the transmitter modifies the carrier signal.
Amplitude Modulation:
It is the simplest form of signal processing in which the carrier amplitude is simply changed according to the amplitude of the information signal hence the name amplitude modulation. When the information signals amplitude is increased the carrier signals amplitude is increased and when the information signals amplitude is decreased the carrier signals amplitude is decreased .In other words the ENVELOPE of the carrier signals amplitude contains the informationsignal.

PROCEDURE & OBSERVATIONS:-

1- Carryout the connections between modules T10A and T10B as shown in fig 1.4.
2- Power the modules with the supply and carryout the following presetting:
Function generator sine wave (J1) Freq. about 1KHz amplitude about 0.5Vp-p VCO2 level about 1Vp-p Freq. 450 KHz.
Balanced modulator carrier nulls completely clock wise Outlevel in intermediate position.
3- Connect the oscilloscope to the inputs of the modulator (points 2 and 1) and detect the modulating signal and carrier signal (fig 5a/b)

4- Move the probe from point 1 to point 3 (output of the modulator) where a signal modulated in amplitude is detected (fig1.5c). Note that the modulated signal envelope corresponds to the waveform of the modulating signal.

5- Vary the amplitude of the modulating signal and check the 3 following conditions:
Modulation percentage lower than the 100% (fig1.5c)
Equal to the 100% (fig 1.5d)
Superior to 100% overmodulation fig 1.5e).

Vary the frequency and waveform of the modulating signal and check the corresponding variations of the modulated signal.

6- Vary the amplitude of the modulating signal and note that the modulated signal can result saturated or overmodulated.

LAB SESSION 02

OBJECT:-

To Investigate the Demodulation of an AM signal with an envelope detector.

EQUIPMENT:-

Amplitude Modulation Work board 53-130 which comprises the following blocks:

- Signal Generation
- Modulation
- Filters
- Demodulation

THEORY:-

In this practical you will investigate the demodulation of an AM signal with an **envelope detector.**

The purpose of any detector or demodulator is to recover the original modulating signal with the minimum of distortion and interference. The simplest way of dealing with an AM signal is to use a simple half- wave rectifier circuit. If the signal were simply passed through a diode to a resistive load, the output would be a series of half-cycle pulses at carrier frequency. So the diode is followed by a filter, typically a capacitor and resistor in parallel.

The capacitor is charged by the diode almost to the peak value of the carrier cycles and the output therefore follows the envelope of the amplitude modulation. Hence the term **envelope detector.**

The time constant of the RC network is very important because if it is too short the output will contain a large component at carrier frequency. However, if it is too long it will filter out a significant amount of the required demodulated output.

In this practical the output of the AM generator that you used in the Simple Amplitude Modulator practical is fed to an envelope detector.

You can monitor the output and compare it with the original modulation source. The time constant of the filter following the detector can be adjusted. This filter is often called a post-detection filter. It also introduces a phase shift between the original signal and the output.

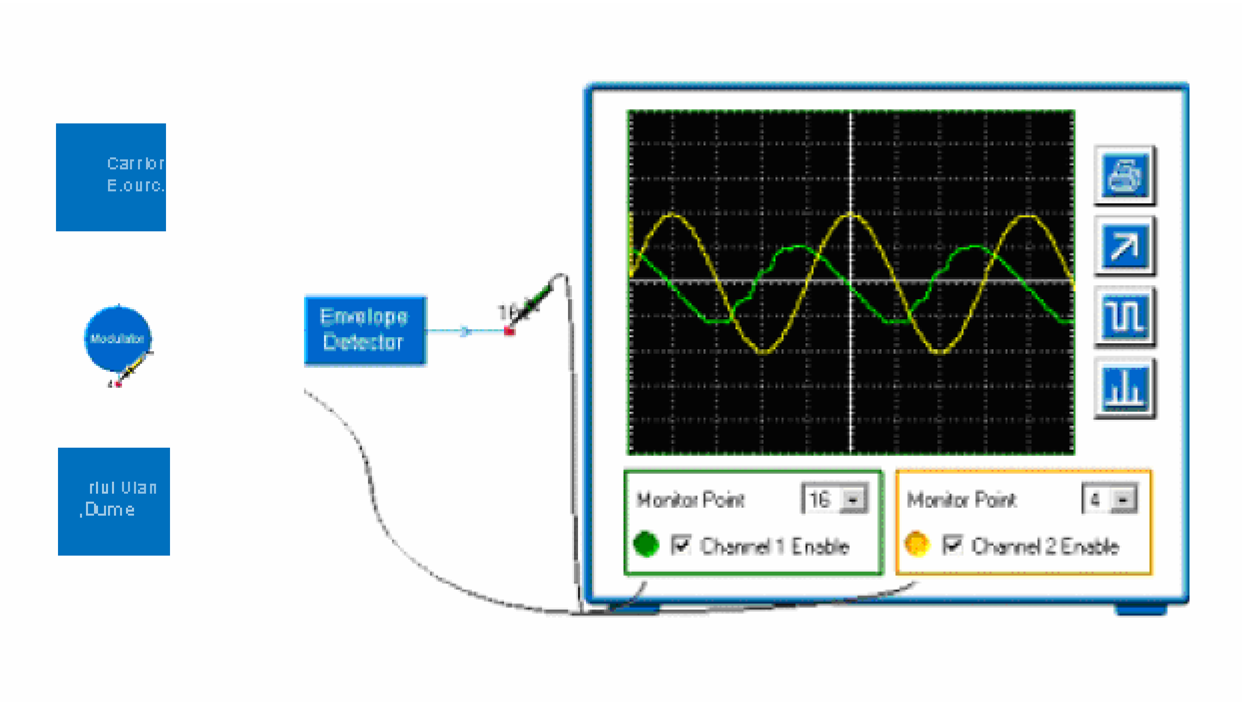
PROCEDURE:-

Here the signal from the amplitude modulator from the previous practical is demodulated using an envelope detector. Confirm that the modulated signal is the same.

Use the oscilloscope to monitor the detector output 16 and adjust the ***time constant.*** Note that a large carrier component is present if the time constant is too short.

Increase the time constant and note that the amplitude of the detected output decreases and becomes distorted as the filter cannot discharge in time to follow the required output. Use the spectrum analyzer to observe the carrier component amplitude

Compare the original modulating signal with the detector output in both shape and phase at various time constants using the oscilloscope


Envelope Detector
Monitor Point
16
Channel 1 Enable
Monitor Point
4
Channel 2 Enable

RESULT:-

LAB SESSION 03

OBJECT:-

To Observe the operation of Product detector.

EQUIPMENT:-

Amplitude Modulation Work board 53-130 which comprises the following blocks:

- Signal Generation
- Modulation
- Filters
- Demodulation

THEORY:-

In this practical you will investigate an alternative demodulator called a product detector. It has certain advantages over the simple envelope detector but at the expense of some complexity. It is not often used for AM but is the only type of detector that will demodulate the suppressed carrier amplitude modulations that are investigated in the next assignment.

It is important to appreciate that a product detector will demodulate all forms of AM.

What is a Product Detector?

If the AM signal is mixed with (i.e., modulated by) a frequency equal to that of its carrier, the two sidebands are mixed down to the original modulating frequency and the carrier appears as a dc level.

The mathematics of the process shows that this will only happen if the mixing frequency is equal not only in frequency to that of the carrier, but also in phase; ie, the two signals are synchronous. This is why a product detector when used for AM is sometimes called a synchronous detector. For AM the effect is very similar to a full-wave rectifier rather than the half-wave of the envelope detector.

The output still needs a post-detection filter to remove the residual ripple, but this time the ripple is at twice the carrier frequency and is therefore further away from the modulation and hence easier to remove. In general terms the product detector gives less distortion, partly because it uses both positive and negative peaks of the carrier.

Generating the Mixing Frequency:

This is produced by an oscillator which is usually referred to as a Beat Frequency Oscillator or BFO. This is because if it is not at the same frequency as the carrier the output of the product detector is a frequency equal to the difference between the two which is called a beat frequency. (You will be able to see this when you adjust the BFO for synchronism).

As previously described, it is vital that the BFO be synchronized to the carrier. In practice this is achieved with a special recovery circuit but here for simplicity a sample of the carrier is fed directly to the BFO and when the free running frequency of the BFO is near to that of the carrier it locks into synchronism.

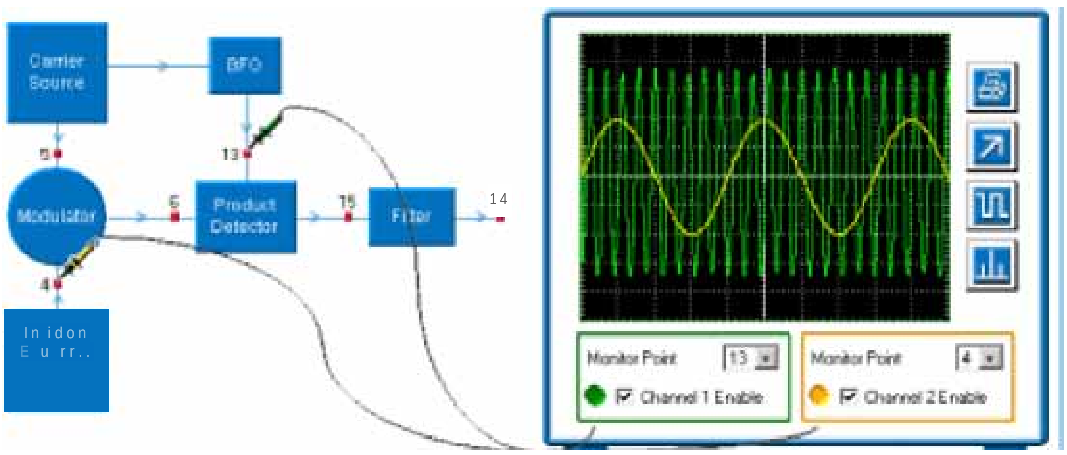
PROCEDURE:-

Here is a product detector demodulating AM. The oscilloscope shows its input at monitor point 6, which is the output of the same modulator as before.

Now monitor the BFO output with the oscilloscope and use the ***BFO frequency*** control to lock it to the carrier. This will be indicated by a stationary TRACE

Use the oscilloscope to look at the output of the detector before the filter and note the frequency of the ripple compared with the carrier. Use the spectrum analyzer to confirm this. Examine the output of the filter and compare it with the modulation source.

Monitor the detector output before the filter with the oscilloscope, then unlock the BFO with the ***BFO frequency*** control and observe the result. Repeat whilst observing the filtered output.



RESULT:-

LAB SESSION 04

OBJECT:-

Measure the frequency response of a ceramic filter.

EQUIPMENT:-

Modules T10A-T10B. +/- 12Vdc Supply
Oscilloscope.
Frequency counter. Multimeter.

THEORY:-

Ceramic Filter is A ceramic filter is a bandpass filter using a piezoelectric ceramic material. Important parameters of ceramic filter are input & output impedance. The central freq of ceramic is 455KHz. The response curve can be obtained by applying a variable freq across i/p & detecting amplitude at o/p. the attenuation measured at different freq is given by:

$$A = (Vo/ Vi)^{-1}$$

$$A\ dB = -20 \log(Vo/ Vi)$$

Ceramic Filter is comprised of several coupled resonators.
Their general theoretical background is therefore related:

1. Via the piezo-electric effect to that of the crystal filter covered in the **RF Selectivity** Assignment.
2. As a system of coupled resonators, to the simpler case of two coupled L-C circuits Capacitive coupled L/C circuits and Coupled L/C circuits with swept frequency as a system of reactors requiring a resistive termination for correct performance, to the treatment of the passive low-pass filter covered in the **Audio Low-Pass Filters** Assignment.

PROCEDURE:

1. Supply the modules with dc supply.

Carryout the following presetting:
VCO1: switch on 500 kHz level about 2Vp-p Freq. 450 KHz.

2. Apply the signal of 455 kHz corresponding to the central frequency of the ceramic filter.
3. If Vo and Vi are the peak-to-peak voltages measured across the output and the input of the filter. The attenuation A of the filter at 455kHz is given by A=Vo/Vi and in db= 20log (Vo/Vi). .

Frequency (kHz)	Output voltage (Vo)	Input voltage (Vi)	AdB = 20log(Vo/Vi)
445			
446			
447			
448			
449			
450			
451			
452			
453			
454			
455			
456			
457			
458			
459			
460			
461			
462			
463			
464			
465			

4. Start from 445 to 465 kHz at Repeat the measurement carried out in the last step varying the frequency from steps of 1 kHz.
5. Calculate AdB in correspondence to each frequency and report all in the above table
6. With the data in the table plot a graph setting AdB on the Y axis and frequency on the x-axis, you obtain the frequency response curve of the filter

LAB SESSION 05

OBJECT:-

Check the operation of the balanced amplitude modulator with suppressed carrier and observe DSB signal (Double side band signal).

EQUIPMENT:-

Modules T10A-T10B. +/- 12Vdc Supply
Oscilloscope.
Frequency counter. Multimeter.

THEORY:-

Double sideband suppressed carrier modulation: -
In AM modulation two-thirds of the transmitted power appears in the carrier which itself conveys no information. The real information is contained within the sidebands. One way to overcome this problem is simply to suppress the carrier since the carrier does not provide any useful information there is no reason why it has to be transmitted. By suppressing the carrier the resulting signal is simply the upper and lower sidebands. Such a signal is referred to as a double-sideband suppressed carrier (DSSC or DSB) signal. Double sideband suppressed carrier modulation is simply a special case of AM with no carrier.
A circuit called a balanced modulator generates double sideband suppressed carrier signals.

PROCEDURE:-

1. Carryout the connection between T10A and T10B as shown in fig 3.15. Power the modules and carryout the following presetting:
2. Function generator sine wave (J1) Freq. about 1KHz amplitude about 1Vp-p VCO1 switch on 500 kHz level about 2Vp-p Freq. 450 KHz.
Balanced modulator carrier null in central position Outlevel in clockwise position.
3. Connect the oscilloscope to the inputs of the modulator (points 2 and 1)and detect the modulating signal and the carrier signal.
4. Move the probe from point 1 to point 3 (modulator output) where the modulated signal is detected (fig3.1 6c). --
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5. Reset the level of the modulating signal and adjust the carrier null to obtain the min of the output carrier of the modulator. Take to about 0.5Vp-p the amplitude of the modulating signal. Note that the waveform of the modulating signal doesn't correspond to the envelope of the modulated signal as it occurs instead in case of signal AM.

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6. Vary the amplitude of the modulating signal and check the corresponding variation of the modulated signal amplitude. Note that differently from the AM modulation where the modulated signal annuls when the modulating signal is null. --
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7. Vary frequency and waveform of the modulating signal and check the corresponding variations of the modulated signal.

LAB SESSION 06

OBJECT:-

Examine the main parameters of the Single Sideband modulation.

EQUIPMENT:-

Modules T10A-T10B. +/- 12Vdc Supply
Oscilloscope.
Frequency counter. Multimeter.

THEORY:-

Single sideband modulation: -
A modulation technique in which only one sideband out of the two is transmitted is known as single sideband transmission.
In double sideband transmission the basic information is transmitted twice once in each sideband. Therefore transmitting both signals is redundant. The information can be transmitted through one sideband by further suppressing the one sideband. The generated signal is termed as single sideband suppressed carrier.

PROCEDURE & OBSERVATIONS:-

SSB generation:
1- Carryout the connection between T10A and T10B as shown in fig 3.15. Power the modules and carryout the following presetting:
Function generator sine wave (J1) Freq. about 3KHz amplitude about 1Vp-p VCO1 switch on 500 kHz level about 2Vp-p Freq. 452 KHz.
Balanced modulator carrier null in central position Outlevel in clockwise position.
1- Connect the output of the balanced modulator (test point 3) to the input of the 455 kHz ceramic filter (test point 10).

2- With the oscilloscope examine the output signal of the filter (point 11) and check that it is a sine wave.

3- Measure the frequency fc of the carrier (point 1) fm of the modulating signal (point 2) and fssb of the SSB signal across the output of the filter (point 11).

Fssb = fc + fm
This means that the band extracted by the filter corresponds to the upper sideband.

4- Repeat the last measurements setting the frequency of the carrier to 458kHz
You obtain
Fssb = fc – fm
This means that the band extracted by the filter corresponds to the lower sideband.

5- Increase the frequency of the modulating signal and check that the SSB signal attenuates and tends to annul. Explain the reason.

LAB SESSION 07

OBJECT:-

To investigate the Demodulation of SSB signal

EQUIPMENT:-

Modules T10A-T10B.
+/- 12Vdc Supply
Oscilloscope.
Frequency counter. Multimeter.

THEORY:-

SSB demodulation requires the presence of carrier which must be locally generated in the receiver. To obtain modulating signal from modulated signal, multiply modulating signal with locally generated synchronized carrier in phase and frequency with that used at the transmitter end & filter extracts the modulating signal. The circuit carrying out multiplication of two signals can be same used to generate the modulation with suppressed carrier in transmission. When used as demodulator the circuit commonly called *Product detector/ Synchronous detector. I*f the carrier inserted in reception doesn't have same freq of carrier suppressed in transmission the freq of demodulated signal is translated by the difference b/w two carriers altering this way the reception.

PROCEDURE:-

1- Carryout the following presetting;
Function generator sine wave (J1) Freq. about 3KHz amplitude about 1Vp-p VCO1 switch on 500 kHz level about 2Vp-p Freq. 452 KHz.

2- Connect the output of the SSB modulator (point 11 output of the ceramic filter) to the input signal (point 16) of the balanced modulator 2. In this case the balanced modulator is used as product detector.
3- Across the input carrier of the balanced modulator 2 apply the same carrier supplies to the modulator (VCO1).

4- Connect the output of the balanced modulator 2 to the low pass filter at 3400Hz (point 18).
5- Examine the signals across the following points:
Point 11 (output of the SSB modulator) it is a sine wave which corresponds to the upper sideband at the base of the frequency set for the carrier.

Point 17 (output of the product detector) there is a sine wave with frequency equal to the one of the modulating signal (point 2) to which a component with much higher frequency is laid over.

Point 19 (output of the low pass filter) the high frequency component has been removed and the demodulated signal remains equal to the transmission modulating one.

6- Increase the frequency of the modulating signal and check that the detected signal attenuates and tends to annul. Explain the reason.

7- Disconnect VCO1 from the balanced modulator 2 (point 15) and connect VCO2. In this way you supply the product detector with a different carrier from the one used in the modulator.

8- Vary the frequency of VCO2 to find out a frequency, which is the more equal possible to the one used by the modulator (generated by VCO1). Check that it is really difficult to obtain the starting modulating signal across the output of the filter. This is due to the fact that it is very difficult to set the two VCOs to the same frequency.

LAB SESSION 08

OBJECT:-

Carry out an AM superhetrodyne receiver with Automatic Gain Control.

EQUIPMENT:-

Modules T10A-T10B-T 1 0C-T10G. +/- 1 2Vdc Supply
Oscilloscope.
Frequency counter.
Multimeter.

THEORY:-

The RF signal modulated in AM enters from the antenna and is applied to a mixer stage which is reached also by the oscillation generated by the local oscillator. The signal is converted to a lower frequency (intermediate frequency) and amplified by a 2 stage selective amplifier. The next detector demodulates the AM signal supplying the audio information associated to it. The detected signal results as composed by the low frequency modulating signal and by a continuous component proportional to the amplitude of the IF signal. Only the low frequency component is sent to the next audio amplifier. The only continuous component obtained by filtering the detected signal constitutes the CAG voltage (Automatic gain control) and is used to vary the amplification of the first IF stage. If the IF signal has a high amplitude the amplification is reduced if the IF signal is low the amplification is increased.

PROCEDURE AND OBSERVATIONS:-

1- Carry out the connections between modules t10A and T10C as shown in fig 9.2 (the frequency convector the 2 stage IF amplifier and the envelope detector are contained in T10C the local oscillator is contained in T10A the AM signal is supplied by T10B).
2- Connect the jumpers J4, j9, J10, J12 to T10C (you obtain the IF amplifier/detector circuit of fig 9.3). The connection between points 16 and 9 of T10C carries out the automatic gain control.
3- Power the modules and carry out the following presetting:
Function generator sine wave (J1) Freq. about 1KHz amplitude about 0.5Vp-p VCO2 level about 200mVp-p Freq. 900 KHz.
Balanced modulator carrier null completely clock wise Outlevel 10mVp-p VCO1 level 0.5Vp-p Freq. 1355 KHz.
4- Set the amplitude of the modulating signal to zero. Connect the oscilloscope to the output of the mixer (point 3 of T10C). Eventually adjust the variable capacity of the IF filter to obtain the max amplitude (about 100mVp-p) of the detected sine wave form.

5- Connect the oscilloscope to the output of the TE amplifier (point 15 of T10C). Adjust the variable capacity C5 of the second IF stage and eventually the IF transformers to obtain the max amplitude of the detected sinewave form (about 2Vp-p).

6- Connect the oscilloscope to points 1 and 15 of T10C.

7- Vary the amplitude of the RF input signal to the receiver (point 1 of T10C) from 10 to about 100mVp-p and check that the amplitude of the IF signal (point 15) keeps almost content.

8- Note that when the RF signal increases the CAG voltage across point 8 diminishes. Consequently there is the amplification of the first IF stage and the output amplitude of the same IF signal are in this way kept almost constant.

9- Disconnect the CAG (jumper 16-9) and connect point 9 ground. Check that now the amplitude of the IF signals follows the variations of the RF input signal.

10- Introduce a modulation in the RF carrier (increase the level of the function generator of T10A).

11- Examine the AM signal before and after the mixer (points 1 and 3 of T10C). Check that the carrier frequencies are different. --
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12- Connect the oscilloscope before and after the detector diode (points 15 and 17 of T10C) and measure the AM signal and the detected signal.

AM communication system (with module T10G)

13- Use the microphone signal as modulating signal (connect the microphone between point 13 of T10A and ground connect the function generator and connect point 14 of T10A to point 2 of T10B.

14- Connect the audio amplifier of T10G to the loudspeaker (jumper J1 inserted). Connect the output of the detector (point 17 of T10C) to the input of the audio amplifier (point 3 of T10G).

15- It is possible to introduce the noise in the communication by inserting the noise generator between the AM modulator and the receiver (fig 9.5)

LAB SESSION 09

OBJECT:-

To examine the principle diagram of the operation of a AM Radio Transmitter

EQUIPMENT:-

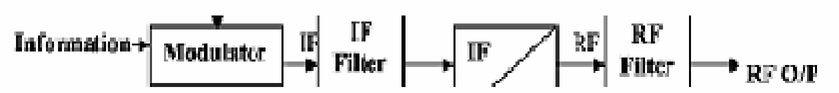
Power supply mod.PSI-PSU/ Ev Support for modules Mod. Mu/EV Experiment Mod MCM25/EV, Dual-trace Oscilloscope,
Function generator,
Frequency meter.

THEORY:-

The purpose of the transmitter is to convert the information that is to be transmitted into modulated radio frequency signal . Through a transmission line, this signal is applied to the antenna that radiates the information is space as electromagnetic waves.
In the past direct modulation was used which guarantee a circuit simplicity to the detriment of the quality in the communication. Today modulation is achieved on a fixed and well stabilized frequency intermediate frequency signal. That makes circuit complex but easily controlled.

Basic block diagram for transmitter **Functions of the blocks of transmitter:**

Local Oscillator Freq. Converter



Above diagram shows a typical modern transmitter.
The local oscillator provides the modulator with a signal which frequency is stabilized through a PLL circuit, the modulator changes the frequency spectrum of the signal provided by the local oscillator, according to the kind of modulation used and the provided information and generates the IF signal . The IF frequency is always equal and dose not depend on the frequency of the RF channel that is to be used . This enables the optimization of the modulation and filtering circuits.The IF filter cleans the useful signal from any intermodulation products or noise. As the IF is always the same the filter doesnot need any regulation or calibration, The frequency converter has the purpose to translate the frequency from IF to RF and so to the frequency of the channel that is to be used .The RF filter or output filter, cleans the useful signal from the intermodulation products that was added during frequency conversion . As the RF can be changed the filter must be calibrated again.

PROCEDURE:-

1) Set the sw1 on the modulation selectors Section to AM/DSB/FM.
2) Turn the trimmer Level completely Clockwise to obtain the maximum amplitude on the signal VCO1 out provided by the local Oscillator VCO1.
3) Set switch SW6 to DC to obtain the manual control of the local Oscillator frequency.
4) Adjust VCO1 out obtain a frequency of about 10750 kHz.
5) Connect the input AM/DSB/MOD in to a sign signal with amplitude of 1Vpp and frequency of 50 kHz using an external generator.
6) Set switch SW4 to Mix out so that the signal of the local oscillator reaches the input CARRIER in of the mixer.
7) Set switch SW3 to DSB: in this condition the mixer is perfectly balanced and does not show the signal with higher frequency (carrier) across the output.
8) Connect and set the oscilloscope as follows:
Channel 1 to the input AM/DSB/MOD in
Channel 2 to the output of the mixer (TP2)
Trigger source to channel 1
9) Check that the signal across TP2 which is the product of the carrier and modulating signal. Is of the following shape:
10) With the current setting of SW4, the signal produced by the mixer reaches the section IF filter.
11) Set switch SW5 to **QUARTZ** so that the signal crosses the quartz band filter which characteristic is to have a pass band of few kHz.
12) Turn the trimmer LEVEL completely clockwise to obtain the maximum amplitude of the signal across TP3 at the output of the section IF FILTER.
13) Connect the frequency meter to TP3 and measure the frequency of the present signal. (frequency=)
14) Set switch SW5 to **ceramic** so that the signal crosses the ceramic band pass filter which characteristic is to have a pass band of about 130 kHz.
15) Connect One probe of the Oscilloscope to TP3 IF filter. We have the following output:
16) Set switch SW10 to LPF that corresponds to the low pass filter with cut-off frequency of 1.5MHz.
17) Connect one probe of the oscilloscope to the out put **cable out** and check there is the sine signal, besides use the frequency meter to check that the frequency is equal to ……….kHz.
18) Adjust the LEVEL of the section RF FILTER for the best display.

LAB SESSION 10

OBJECT:-

To examine the principle diagram of the operation of An AM Radio Receiver

EQUIPMENT:-

Base unit.
Power supply mod PSI-PSU/EV. Experiment module MCM 25 Dual trace Oscilloscope .
Function generator.
Frequency meter.

THEORY:-

The purpose of receiver is to convert the modulated radio frequency signal is picked up by the space in which it traveled electromagnetic wave and sent through a transmit ion line to the electronic circuit of the receiver in order to be de-modulated .

Operation of block of receiver:

The filter and RF amplifier remove the channel we do, not want to receive from the useful signal and increases its amplitude level as the RF signal can be different , the input filter must change its characteristics . Typically this occurs automatically without the user intervention by means of D.C control circuits.
The frequency converter translates the frequency from RF channel frequency that is to be received to IF . it employs a frequency stabilized oscillator with a PLL circuit The filter and IF amplifier cleans the useful signal from any inter-modulation products or noise and increases its amplitude level. As the IF is always the same the filter does not need regulation calibration and can be a commercial component optimized for this purpose.
The demodulator must receive or extract the information contained into the IF signal. The frequency spectrum of the IF signal depends on the kind of used modulation and on
the same information the IF frequency is always equal and dose not depend on the frequency of the RF channel that is to be used. This optimizes the modulation and filtering circuits.

PROCEDURE:-

1. Set the switch SW1 of the antenna / Cable section to cable.
2. Set switch SW2 of the RF filter section to by pass in the AGC / Level meter section .
3. In the AGC/LEVEL METER section :Turn switch SW6 off. Turn the D.C source trimmer completely clockwise to obtain the maximum gain of the voltage controlled amplifier .
4. In the LOCAL Oscillator ½ section (Local Oscillator 1)
5. Set switch SW8 to FM
6. Set switch SW10 to PLL to obtain the automatic control of the frequency of the local oscillator (in these condition the frequency is fixed)
7. Set switch SW4 of the 10.7MHz if filter section of CERAMIC .
8. Set switch SW7 of the IF amplifier / FM demodulator section to FM/SSB(to enable the operation of the local oscillator 1)
9. Insert a sine signal to the input CABLE in with amplitude of 1 Vpp and frequency of 1 MHz using an external generator .

10. Connect the Oscilloscope and check the presence and amplitude of the signal in the following test point.

TP2 input signal it about half the value set on the generator as the input has an impedance of 50 ohm equal to the one of the generator so the voltage reduce to half ,

11. TP3 signal after the RF switch : equal to the one in TP2,
12. TP4 signal after the RF filter :it is about one across its input using or not (by pass setting) the same filter .
13. TP5 out put signal across the variable attenuator: changing the DC source control, the signal amplitude change from some tens of mV (in maximum position) up to negligible values .
14. TP6 out put signal of the amplifier : changing the DC source control the signal amplitude increases until saturation with evident signal distortion .
15. Adjust the DC source command of AGC /Level Meter section to obtain about 1Vpp in TP6 .
16. With the frequency meter check that the signals in the last test points are all at the same frequency.
17. Use the frequency meter to check that the frequency of the local oscillator 1 (test point local oscillator 1 of VCO out) is equal to 11.7MHz .
18. Remove the frequency meter and measure the amplitude of the same signal

LAB SESSION 11

OBJECT:-

(a) Carryout a FM superhetrodyne receiver with automatic frequency control.
(b) Carryout an FM communication system.
(c) Examine the noise influence on the FM connection.

EQUIPMENT:-

Modules T10A-T10C-T10D-T10G. +/- 12Vdc Supply
Oscilloscope.
Frequency counter.
Multimeter.

THEORY:-

The RF signal modulated in frequency enters from the antenna and is applied to a mixer stage where it reaches also the oscillation generated by the local oscillator. The signal is converted to a lower frequency (455 kHz) and amplified. It is then applied to a limiter stage, which removes the amplitude variations contained in the FM signal. The next discriminator demodulates the FM signal supplying the audio information associated to it.
The detected signal results composed by the low frequency modulating signal and by a continuous component proportional to the shift between the carrier frequency of the FM signal (after the IF conversion) and the frequency to which the discriminator is calibrated. Only the low frequency component is sent to the next audio amplifier. The continuous component is integrated and used to control the frequency of the local oscillator so that an intermediate frequency equal to the central frequency of the discriminator is obtained.

PROCEDURE AND OBSERVATIONS:-

1- Carryout the connection between T10A T10C and T10D as in fig10.2.
2- Set the frequency discriminator (module T10D) in R (ratio) mode.
3- Power the modules and carryout the following presetting.
Function generator sine wave (J1) Freq. about 1KHz amplitude about 0.2 Vp-p VCO2 level about 200mVp-p Freq. 455 KHz.

4- Connect the oscilloscope to the output of the mixer (point 3 of T10C). Adjust the variable capacity of the IF filter to obtain the larger response curve (detect an FM signal as in fig 10.3 where the light amplitude peaks are due to the non flat response of the IF filter). Eventually adjust the coils (accessible on the rear side) to center the IF filter to 55 kHz. Examine the waveform across the output of the limiter (point 6 of T10D) and observe that the amplitude of the FM signal now is uniform.

5- Connect the oscilloscope in continuous to the output of the discriminator (between 21 and ground). Reset the modulating signal and eventually adjust the variable capacity of the discriminator to obtain a null voltage.

6- Connect the local oscillator (VCO1 of t10A) to the input LO IN of the frequency converter (point 19 of T10A with point 2 of T10C).
Carryout the following presetting;
VCO2 level about 200mVp-p Freq. 900 KHz.
VCO1 level 200mVp-p Freq. 1355 KHz.
7- Introduce a modulation into the RF signal (increase the level of the function generator of T10A to about 0.2Vp-p).
8- Examine the FM signal before and after the mixer (points 1 and 3 of T10C). Check that the carrier frequencies are different.

9- Examine the FM signal before and after the limiter (points 5 and 6 of t10D). Check that the amplitude of the FM signal is uniform across the output.

10- Connect the oscilloscope to the output of the discriminator (point 21 of T10D) and detect the detected signal.

11- Note that the detected signal is distorted if the frequency of the RF signal is varied of about +/-5 KHz in respect to the nominal value. This distortion is due to the fact that also the IF signal is moved in respect to the central frequency of the discriminator.

<u>FM communication system (with module T10G):</u>

12- Use the microphone as the modulating signal (Connect the microphone between point 13 of t10A and ground, connect the function generator and connect points 14 and 10 of t10A.
Connect the audio amplifier of T10G to the loudspeaker (jumper J1 inserted). Connect the output of the discriminator (point 21 of T10D) to the input of the audio amplifier (point 3 of T10G).

13- Noise can be introduced into the communication by inserting the noise generator between the FM modulator and the receiver (fig10.5).

14- It is interesting to examine even only quantitatively how the effect of is reduced by the limiter stage. Across the input of the receiver and the output of the frequency converter (points 1 and 3 of T10C) the noise is added to the FM signal and varies its amplitude. Across the output of the limited the amplitude variations are removed. Insert the noise and examine the detected signal with and without the presence of the limiter circuit.

LAB SESSION 12

OBJECT:-

To carry out FM demodulation using PLL detector

EQUIPMENT:-

Frequency modulation work board 53-140 which comprises the following blocks

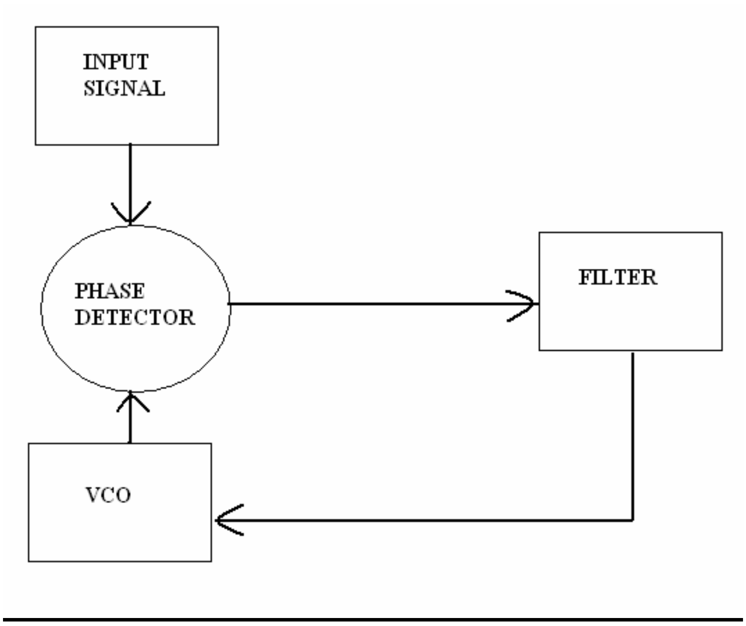
- Signal generation
- Modulator
- Limiter
- Quadrative demodulator
- VCO
- Phase comparator

THEORY:-

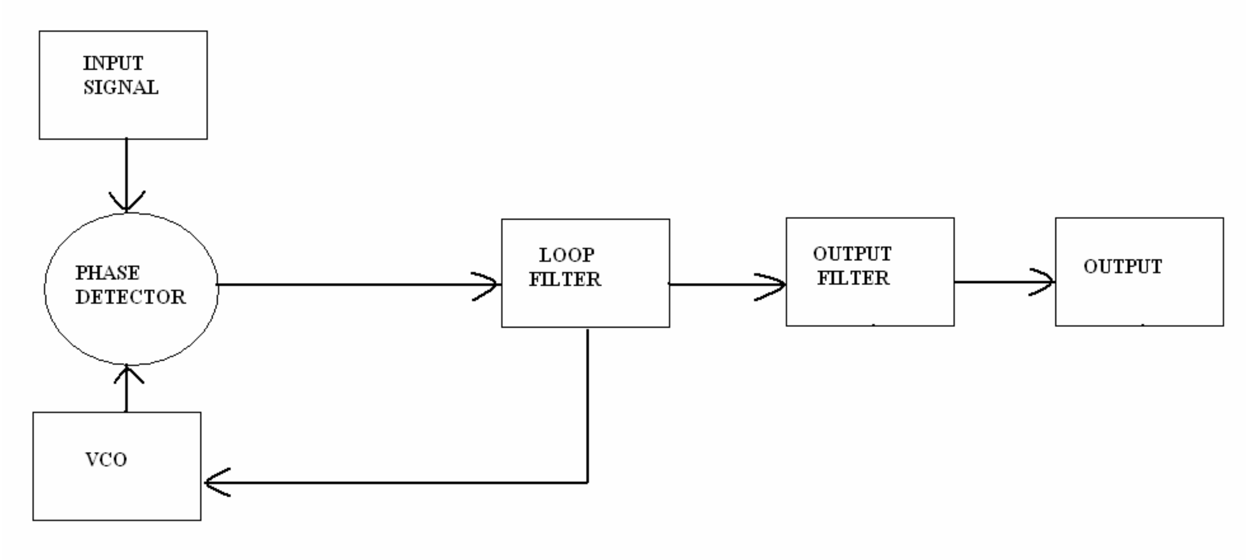
This practical introduces the **phase locked loop (or PLL) demodulator.** This type of detector offers some advantages over the quadrature detector when the signal to noise ratio is poor.
Before trying to understand how a PLL can demodulate an FM signal it is necessary to understand what a PLL is. The concept is of an oscillator synchronized in phase to an external signal source using a feedback loop.
As frequency is the same thing as rate of change of phase, once the phase of the local oscillator is synchronized to the external signal, the frequencies are automatically made identical
A phase locked loop consists of three main blocks:

1. An **oscillator,** the frequency of which is controlled by an external voltage or current source. A voltage controlled oscillator or VCO is used in this assignment.
2. A **phase detector,** which compares the phase of the oscillator with that of the external signal.
3. A **filter,** which smoothes the output from the detector to provide the control signal to the VCO,
4. adjusting its frequency so as to reduce the phase difference.

Operation of a PLL:
Imagine an incoming signal at a constant frequency within the range of the VCO.
Its phase is compared with that of the VCO and a voltage produced that alters the VCO frequency. The phase of the VCO therefore starts changing relative to the incoming signal, until eventually the phases match. Once they are equal, the control signal goes to zero and the system settles into equilibrium. Any drift of the VCO will be corrected by the control voltage which again appears. The two signals are said to be **phase locked.**
A filter is used in the control loop to keep the system stable and limit the maximum rate of change of oscillator frequency.
This whole description is a very simplified view, and the parameters that set the filter characteristics are very complex. An important factor in the design is the time before the two signals become locked.
Phase locked loops are used extensively in communications systems where it is necessary to produce a reference oscillator in phase with an incoming signal, also in special signal sources called frequency synthesizers

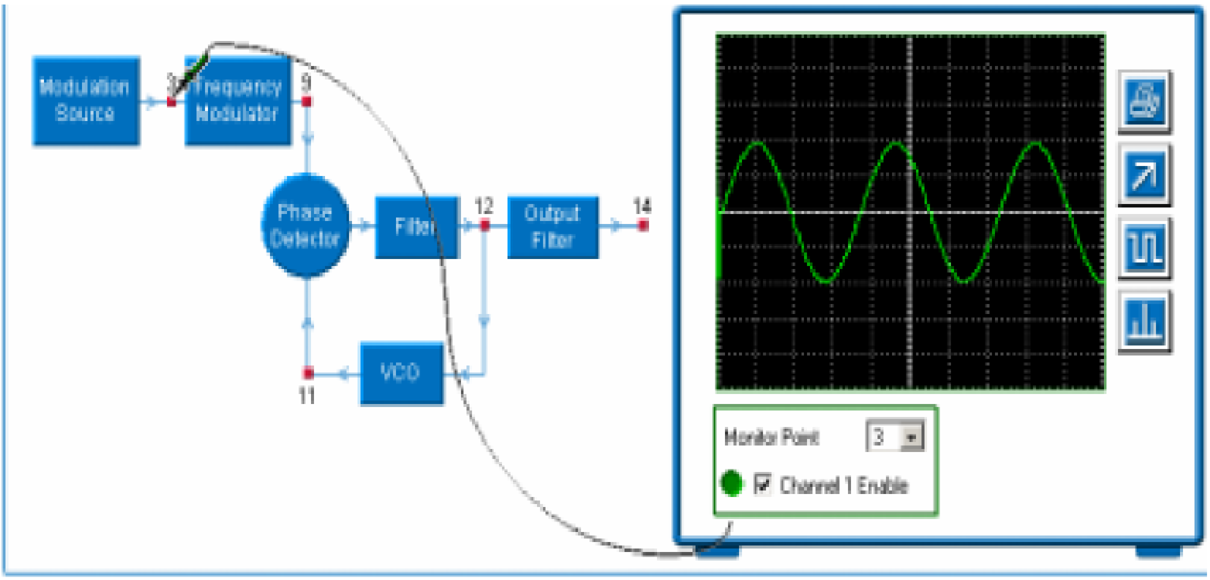


The PLL as an FM Detector:
Suppose that there was a PLL locked onto an incoming carrier which was unmodulated. The VCO would be at the same frequency as the carrier and the VCO control voltage would be constant.
If the carrier were to change in frequency the VCO would follow the change by means of a change in control voltage. So the VCO control voltage varies with the carrier frequency, and if the carrier were frequency modulated the modulation would appear superimposed on the VCO control voltage.
When a post-detection filter is added to the simple PLL to remove all the frequency components above the maximum modulating frequency we now have a PLL FM detector.



PROCEDURE:-

In this practical we will see a PLL detector demodulating the same FM signal.The PLL is used when the ability to demodulate in the presence of noise is important. The distortion produced by this type of detector is determined mainly by the linearity of the VCO but this is often less important in noisy applications.
This practical shows a phase lock loop detector working. Monitor at **9** and observe the FM signal at different settings of ***modulation level.*** Examine the two signals at the input of the phase detector at **9** and the tracking VCO at *11* . Set ***carrier level*** to maximum.Observe the signal at the phase detector output **12** and then after the post detection filter at **14**



LAB SESSION 13

OBJECT:-

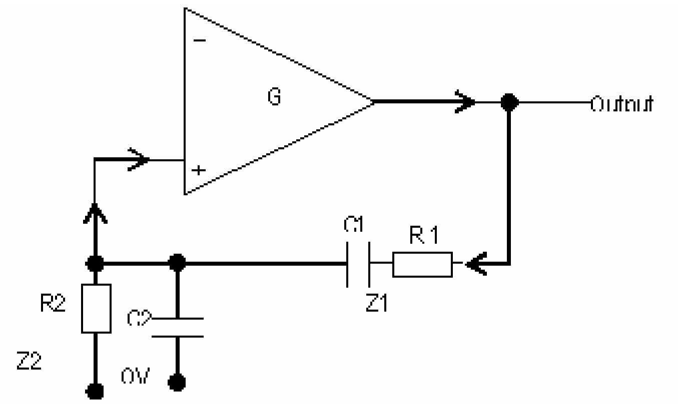
To Examine the conditions for oscillation of a Wien bridge oscillator and observe the Amplitude stabilization.

EQUIPMENT:-

Signal Sources Workboard 53-110 which comprises the following blocks:
- Wien Bridge Oscillator,
- L-C Pass Filter,
- Crystal Oscillator,
- Multivibrator

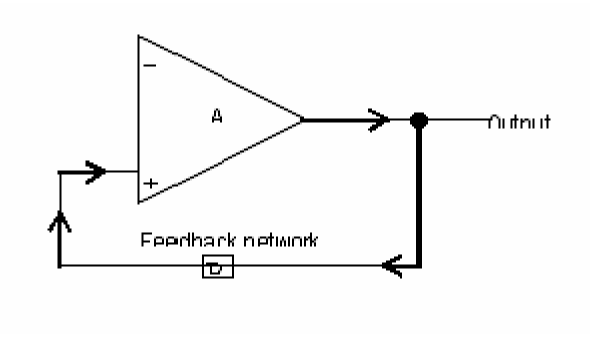
THEORY:

Wien Bridqe Oscillator:
The theory of the **Wien Bridge oscillator** is usually presented for equal values of R and C in the series and parallel arms. Here we look at the more general case of arbitrary R and C values.



Here Z1 is the impedance of the combination of C I and R I and Z2 is the impedance of the combination of C2 and R2.
It is easier to consider the reciprocal 1/B of the feedback fraction, (Z1 + Z_2)/Z_2, which simplifies to:
1/B=1 + Z 1 / Z 2
where Z1 = R1 + 1 /jwC_1 and Z2 = R2 / (1 +jwC_2R_2)
Routine manipulation produces the result:
1/B = [1 - $w^2C_1C_2R_1R_2$ + jw (C1R1 + $^C2^R2$ + $^C1$ $^R2$)] / jwC_1R_2 1/B = [1 - $w^2C_1C_2R_1R_2$ + jw (C1R1 + $^C2^R2$ + $^C1$ $^R2$)] / jwC_1R_2 which has zero phase shift when:
$1 - w^2C_1C_2R_1R_2 = 0$
This enables the frequency to be calculated.
Now,
1/B = jw (C_1R_1 + C_2R_2 + C_1R_2) / jwC_IR_2
1/B = (CA_I} + **C_2R_2 + C_1R_2) / C_1R_2**
which is the required value of gain.
It is not difficult to see that if all the CR terms have equal values, the required gain is 3.
Every oscillator has the requirement that, following some initial disturbance, the behavior is

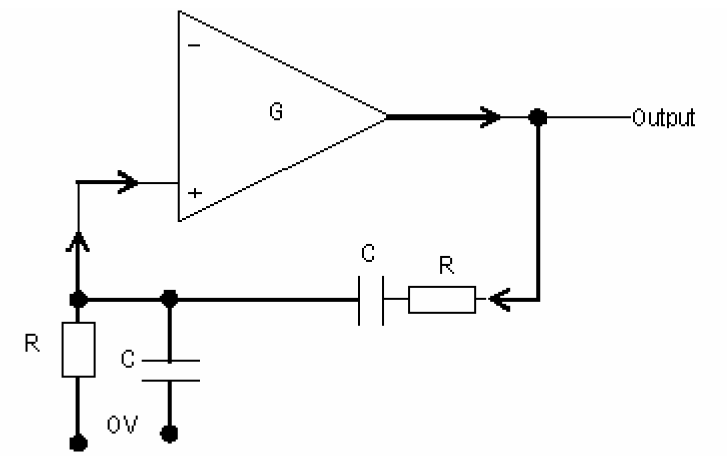
modified so as to increase that disturbance, until a useful level of signal has been built up. This happens at some particular frequency, so that a periodic disturbance is built up.



An oscillator typically comprises an amplifier with feedback around it, as shown. If a steady oscillation is to be maintained, then the input to the amplifier must satisfy two conditions:

- it must have exactly the right amplitude to generate the output
- its phase must be correct to generate the output.

If we suppose that the amplifier has a positive gain A and no phase oscillations will be maintained if AB=1 where B is the gain of the feedback network.
For sinusoidal oscillation, the condition AB=1 should be satisfied at the one required frequency, and at no other. This will then cause only the one, required, frequency to be produced.
The Wien Bridge oscillator is so called because the circuit is based on a frequency-selective form of Wheatstone bridge known as the Wien bridge. The form of oscillator you will use is in fact a high-gain amplifier with a Wien bridge around it, but it is more usual to consider the circuit as being an amplifier of the requisite low value of gain, working with a feedback network equivalent to half of the Wien bridge.



PROECDURE:-

In this practical an operational amplifier is provided with a simple negative feedback network which allows its gain to be adjusted within narrow limits.
A second, positive, feedback network incorporates the Wien half-bridge, comprising series- and parallel-connected R and C
The positive feedback has zero phase shift at just one frequency. It is shown in the

Theory that **both zero phase shift and a particular value of gain are needed to maintain oscillation.**
You will see that excessive gain causes oscillation to build up until limited by the available output swing from the amplifier.
You will need to be careful when adjusting the gain control in order to see oscillations building up and dying down.
Notice that the frequency meter may give high or erratic readings before falling to 0Hz as the amplitude is decreased. This is typical of frequency meter behavior when the signal falls to a level it cannot distinguish from noise.
You have available an oscilloscope and a frequency meter. The frequency meter is always connected to the oscillator output.
R5 is adjustable to control the ***gain*** of the amplifier.
Start with the gain control at maximum. Look at the waveforms at both monitoring points while varying the gain, Observe how a very slight change of gain can stop or start