**Department of Electronics Engineering,**
***Communication Systems Laboratory***

# Laboratory Manual

**for**

**B. Tech. (Electronics), III Year (V – Semester)**
**Session 2008 - 2009**

## Lab Course EL 392 ( Communication Lab. – I)

**LIST OF EXPERIMENTS FOR THE SESSION 2008 - 2009**

1. Harmonic Analysis using Sigma Harmonic Analyzer Trainer Kit Model COM-118
2. Amplitude Modulation & Demodulation using AM Demonstrator Model AET – 14
3. Frequency Modulation & Demodulation using Trinity kit CS-1204
4. Transmission Lines using TecQuipment Kit model E15i
5. Envelop Detector
6. PWM
7. Sampling & Re-construction using Scientech kit model ST-2101
8. Sensitivity of SHRR using Scientech kit Model ST2202
9. Distortion Measurement using Scientific Distortion Meter model HM-5027

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Note:- This laboratory manual can be downloaded from the following website :-

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# Experiment # 01 (WF Analysis)

**Object:-** (a) Generate a symmetrical Square wave of around 100 Hz using wave-form generator section of the kit supplied. Measure its Amplitude & Frequency.
(b) Determine the amplitudes & frequencies of the first eight harmonics of the wave-form generated in part (a) above, using the same kit.

**Apparatus used:-** **1. Sigma Harmonic Analyzer Trainer Kit Model COM-118**
**2. Dual Trace CRO**

**Brief Theory and Description of the Kit:-**

By making use of Fourier's Theorem, it can be shown that a symmetrical square wave is comprised of a sum of large number of sinusoidal signals bearing a definite relationship between their amplitudes and frequencies with the amplitude and frequency of the square-wave, known as harmonic components of square-wave. The sinusoidal component having the same frequency as that of square-wave is called the first harmonic, or the fundamental component of the square-wave while the other components having 3-times, 5-times, …n-times the frequency of square-wave, are called the 3rd, 4th, …….,nth harmonic component of square-wave respectively; It can also be shown by Fourier's analysis that 2nd , 4th, 6th , that is, even harmonics, are not present in the symmetrical square wave. The purpose of this experiment is to verify these theoretical results obtained from Fourier's Theorem by using the present kit of harmonic analyzer.

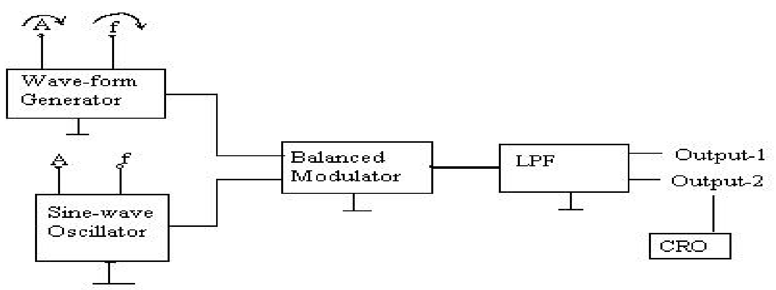
The given kit basically contains the following sections:-

1. **The wave-form generation section**, containing sliders, which can be moved up and down to generate any type of periodic wave-form. The symmetrical square-wave can be generated by setting the first eight sliders in the upper most position, and the last eight sliders in the lower most position in the panel.
2. **The sine-wave generator Section**, providing sine-wave of variable frequency by a potentiometric control.
3. **The Balanced A. M. Modulator Section**, which multiplies the symmetrical square-wave with the sine-wave of variable frequency. Its output is fed to the LPF.
4. **The Low-pass filter section** for removing the RF signals, and its second output is fed to CRO for viewing and measuring harmonic contents.

**Experimental setup:-**

The various sections and signals are connected as shown in the following Figure 1.1:-

**Figure 1.1**




## <u>Procedure</u> :-

1. Generate a symmetrical square wave using wave-form generation section of the kit as explained above. Adjust its amplitude and frequency to 4 Volts p-p and 150 Hz respectively. Connect it to one input of the Balanced Modulator.
2. Display the Sine-wave generator's output on the CRO and adjust its frequency around 100 Hz and Connect it to the other input of the Balanced Modulator.
3. Connect the output of the Balanced Modulator to the input of LPF and connect its second output, $V_{02}$ to the Y-channel of the CRO. Adjust the Vertical and Horizontal controls and the triggering controls of the CRO properly to get the stable display of a thick horizontal line on the CRO screen.
4. Now gradually increase the frequency of the sine-wave above 100 Hz until the horizontal line on the CRO screen starts moving up and down. In this situation, adjust sine-wave frequency more carefully and gradually until you get the largest span of the movement of the horizontal line on the CRO screen. At this situation measure the vertical length of the largest span of the movement of the horizontal line in volts, which is nothing but the relative amplitude of the harmonic content; and measure the frequency of sine-wave, which gives the order of that harmonic, in the present case is the same as the frequency of the square wave, that is, it is the first harmonic or the fundamental component of the square-wave.
5. Following this procedure measure the relative amplitudes of the $2^{nd}$ , $3^{rd}$ , $4^{th}$, …., harmonics, by setting the frequency of the sine-wave to 2-, 3-, 4- times the square-wave frequency and adjusting it in the above manner, to get the vertical movement of the

horizontal line on the CRO screen; and if you get no vertical movement, this implies that the harmonic at this frequency is not present.

6. Tabulate your observations in the table shown below under Observations.

## Observations:-

Wave-form generated:- Symmetrical Square wave

Amplitude of the symmetrical Square wave = ….. Volts $_{p-p}$ (adjusted)

Frequency of the symmetrical Square wave = 150 Hz (adjusted)

(Relative amplitude of any harmonic = length of the maximum vertical excursion obtained)

(Frequency of any harmonic = the sine-wave frequency at which the vertical excursion is found to be maximum.)

| S.No. | frequency of Sine-wave (Hz) | Relative Amplitude of the Harmonic (mV) | Remarks |
|---|---|---|---|
| 1. | 150 | | |
| 2. | 300 | | |
| 3. | 450 | | |
| 4. | 600 | | |
| 5. | 750 | | |
| 6. | 900 | | |
| 7. | 1050 | | |
| 8. | 1200 | | |

Plot the Spectrum of the above signal.

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# Experiment # 02 (AM & Demodulation)

Object:- (a) Draw the modulation characteristics **(m vs A)** of the AM section of the kit supplied (AQUILA AM Demonstrator Model AET – 14)
(b) Use demodulator section of the kit to recover the message signal.

**Observations:-**

Carrier Signal (RF signal): $A_c$ = …….. $mV_{p\text{-}p}$ (adjusted)
$f_c$ = …….. MHz (fixed)
Modulating Signal (AF signal): $f_m$ = 800 Hz

| S. No. | Am ($volts_{p\text{-}p}$) | Modulation Index (m) | | Modulation Index, m (%) |
|---|---|---|---|---|
| | | A | B | |
| 1. | 0.1 | | | |
| 2. | 0.5 | | | |
| 3. | 1.0 | | | |
| 4. | 1.5 | | | |
| 5. | 2.0 | | | |
| 6. | 2.5 | | | |
| 7. | 3.0 | | | |
| 8. | 3.5 | | | |
| 9. | 4.0 | | | |
| 10. | 4.5 | | | |
| 11. | 5.0 | | | |

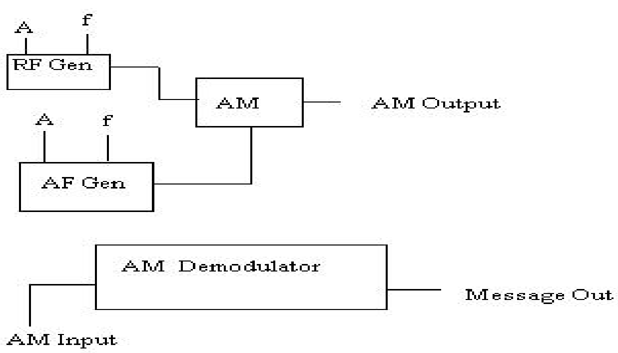
## Sample Calculation:-

The modulation index, m = [ (**A - B**) / (**A + B**) ] **x 100 %**

A curve between **m** versus $\mathbf{A_m}$ gives the modulation characteristics of the AM.

For Recovered Message Signal (at demodulator's o/p), Amplitude = volts p-p
Frequency = Hz

**Experimental Setup:-**

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**Experiment No. 03 (Frequency Modulation and Demodulation)**

**OBJECT**

(a) Generate a frequency-modulated signal using the Trinity Frequency Modulation Trainer kit model CS-1204 and determine its modulation index.
(b) Demodulate the FM wave generated above and determine the amplitude and frequency of the recovered message signal using the same kit.

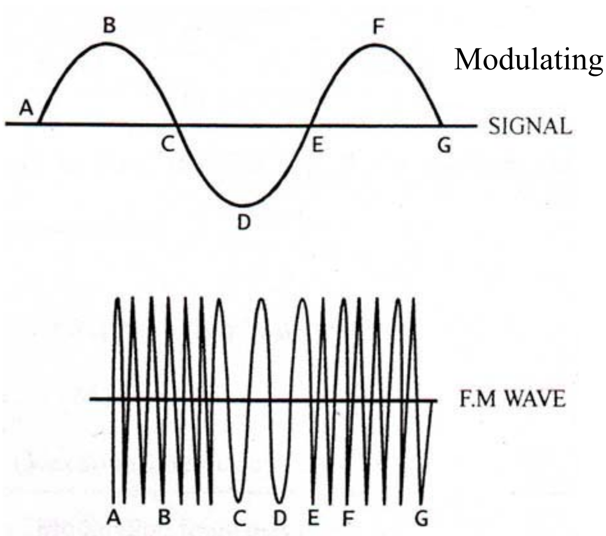
**Apparatus Used:-**

1. Trinity Frequency Modulation and Demodulation Trainer kit model CS-1202
2. A Dual Trace Oscilloscope

**Brief Theory and Description of the Kit:-**

In frequency modulation, the frequency of the high frequency sinusoidal signal, called "Carrier", is made to vary in accordance with the instantaneous value of the amplitude of the low frequency sinusoidal signal, called "message or modulating signal". The Frequency Modulation may be represented in the following diagram:-

**Frequency Modulation**




$$\text{The modulation index of a FM wave is defined as } m_f = \frac{(\text{maximum frequency deviation})}{(\text{modulation frequency})}$$

or, $m_f = (\delta f) / f_m$

The Lay out diagram of the Trinity Frequency Modulation and Demodulation Trainer kit model CS-1202 is shown on the next page in Figure 3.1 :_

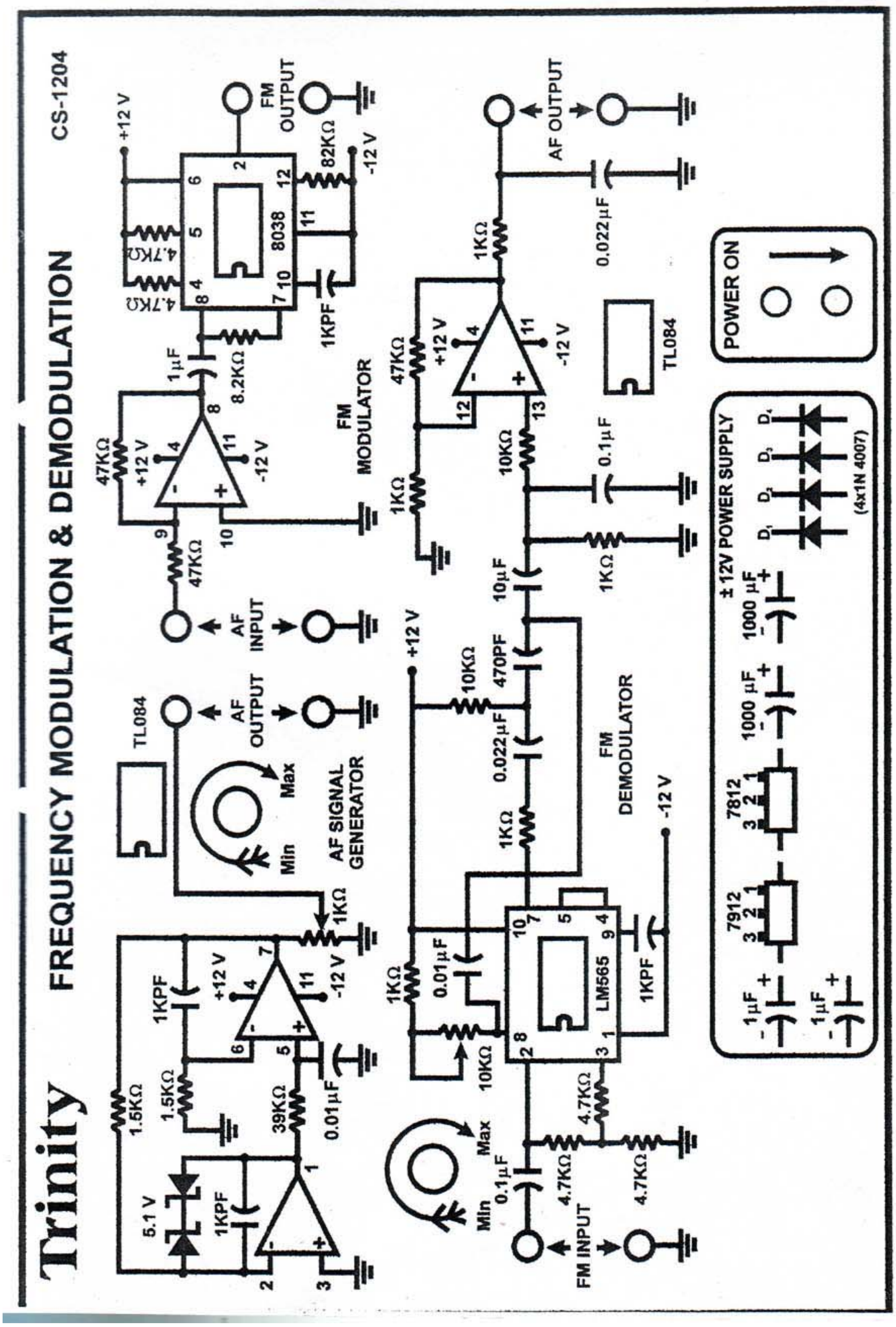



**Figure 3.1** **Trinity Frequency Modulation and Demodulation Trainer kit model CS-1202**

## EXPERIMENTAL PROCEDURE:

1. Switch ON the experimental kit.
2. Observe carrier signal at the FM modulator output, without connecting any signal to it, and measure its amplitude and frequency.
3. Observe modulating signal at the AF signal output; its frequency is fixed but its amplitude is variable from 0 to +12 Volts p-p.
4. Connect AF signal to the modulator input, and observe the modulating signal on one channel and FM signal (at FM output) on other channel of the CRO. Trigger the CRO with ch-1 and adjust amplitude of the AF signal to get undistorted FM output. The maximum frequency deviation in the FM output is directly proportional to the modulating signal amplitude.
5. Calculate the maximum frequency and the minimum frequency from the FM output and calculate the modulation index of the FM wave.
6. Change the amplitude of the modulating signal and calculate the modulation index of the FM wave for new value of the modulating signal amplitude.
7. Now connect the FM wave output to the input of the FM Demodulator and observe the recovered message signal at the demodulator's output.
8. Reduce the modulating signal amplitude to get undistorted output signal at the demodulator's output.
9. Report the maximum amplitude of the modulating signal, that can be recovered after demodulation without any distortion and verify that it around 1.0 Vp-p for the given kit.

## OBSERVATIONS:-

Modulating signal : Amplitude ($A_m$) = ………Vp-p , frequency ($f_m$) = ………. KHz
Carrier signal : Amplitude ($A_c$) = ………Vp-p , frequency ($f_c$) = ………. KHz
FM Signal : maximum frequency, $f_{max}$ = …….., KHZ. minimum frequency, $f_{min}$ = …….. , KHz

## CALCULATION:-

Maximum frequency deviation = $\delta f = (f_{max} - f_{min})$ ; and modulation index, $\mathbf{m_f = (\delta f) / f_m}$

**Result:-**

**Reference:-**

1. Carlson : Communication Systems
2. Manual of the Trinity Frequency Modulation and Demodulation Trainer kit model CS-1202

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# Experiment # 04 (Transmission Lines)

**Object:-** (a) Determine the velocity of propagation of HF pulses through the given Transmission line. Calculate the inductance per meter (L) and the capacitance per meter length (C) of the given line.

(b) Trace the reflections observed at the other end of the given line terminated into different loads.

**Observations:-**

**Part (a) :- Propagation Characteristics of the " open-circuited " transmission line:-**

Specifications of the HF pulses transmitted:- PRR = 160 KHz; Amplitude = volts, Pulse-duration = 0.2 μs

Specifications of the transmission line used:- Length ( $l$ ) = 30 meters; $Z_o$ = 50 Ω

Time-delay between the transmitted & reflected pulses, $t_d$ = (1.6/5)μs = 0.32 μs $V_p = (2l)/t_d$ = 1.8 x $10^8$ m/s

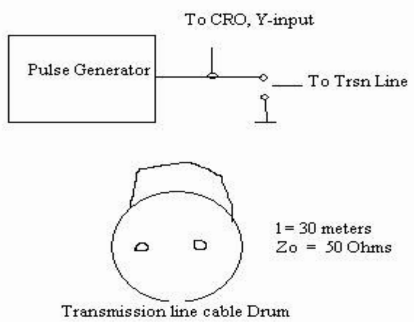
$L = Z_o / V_p$ = ………… micro-Henry/meter;

$C = 1 / Z_o V_p$ = ………… μF/meter

**Part (b) :- Reflections due to different load terminations (a load connected to the line)**

Use three tracing papers only to trace the reflections in the following way:-

Use single tracing paper to trace the Reflections corresponding to "Resistive load terminations" of **0 Ω, 50 Ω** and **100 Ω ;** ( show the reflected pulses by the dotted lines) ;
Use one tracing paper to trace the Reflections corresponding to any one "capacitive load termination" and use one tracing paper to trace the Reflections corresponding to "Inductive load termination"



# Experiment # 05 (Envelop Detector)

**Object:-** (a) Determine the typical values of the parameters of the AM signal properly detected by the given Envelop Detector Circuit.
(b) Determine its Detection Characteristics (max. m at a constant $f_m$ & max. $f_m$ at constant m).

## Observations:-

Part (a): Specifications of the AM signal for its proper detection (without distortion) :-

AM Level, $A_{max}$ = ………. Vp-p
Modulation frequency, $f_m$ = ………. Hz
Modulation Index, m = ………. %
Carrier frequency, $f_c$ = ………. KHz

Part (b): Detection Characteristics:-

(a) Max. m (at $f_m$ = 500 Hz) = ………. %
(b) Max $f_m$ (at m = 30 %) = ………. KHz

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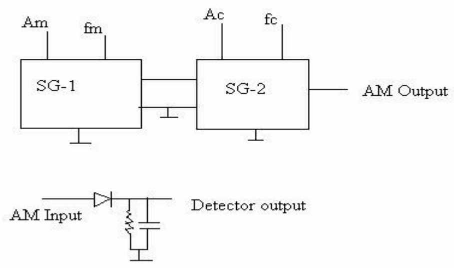
**Experimental Setup :-**




(1) Maximum permissible value of the modulation frequency of the AM signal detected by the given Envelop Detector without any distortion is governed by the expression:-

max $f_m$ =

For m = 30 %, R = 2.7 K and C = 0.01 μF; max $f_m$ = $5.8(m^{-2} - 1)^{1/2}$ = 18.44 KHz;

(2) Maximum permissible value of the modulation index of the AM signal detected by the given Envelop Detector without any distortion is governed by the expression:-

$m_{max}$ =

For $f_m$ = 1 KHz; $m_{max}$ = 92 %
% error =

| m | $f_m$ | m | $f_m$ | m | $f_m$ |
|---|---|---|---|---|---|
| 20 % | 28 KHz | 40 % | 13.5 KHz | 80 % | 4 KHz |
| 30 % | 18.7 KHz | 50 % | 10 KHz | 90 % | 1.5 KHz |

# Experiment # 06 (PWM)

**Object:-** Generate a PWM signal using the given kit of PWM and plot its modulation characteristics ( $\tau$ vs $V_D$).

**Apparatus Used** :-
1. A PWM unit,
2. A pulse generator,
3. A Dual Trace CRO
4. A 5-volts DC supply and a variable DC supply (Aplab model 7711)

**Observations:-**
1. Specifications of the pulses used:- Amplitude = ……… Vp-p
   PRR = ……… KHz, Duty Cycle = … %
   ( T = 500 µs, & $\tau$ = 100 µs)
2. Magnitude of the built-in DC voltage at modulating-signal input = …. V DC
3. Corresponding pulse-width at PWM output = …. µs
4. Measurements for modulation characteristics:-

| S. No. | DC Volts at modulation Input (volts) | Pulse-duration at PWM output (µs) |
|---|---|---|
| 1. | 0.5 | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | 3.5 | |

**Experimental Setup for PWM :-**

1. Obtain a train of pulses from external pulse generator having A = 4.5 V, f = 2 KHz and $\tau$ = 100µs and apply it at the Carrier input of the PWM unit.
2. Observe the PWM output on the CRO screen. Measure the duration of the pulses appearing on the CRO.
3. Connect a variable dc voltage (0.2 volt to 3.4 volts) obtained from an external variable dc supply at the modulating signal input of the PWM unit.
4. Note the effect of variable dc voltage on the pulse-width at the PWM output.

The modulation Characteristics of the PWM is the curve plotted between the Pulse-duration versus DC voltage.

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# Experiment No. 07 (Sampling and Re-construction of Signals )

**Object:-**

(a) Experimentally verify the Sampling Theorem and observe the Aliasing effect, using the Scientech **Sampling Trainer Kit model ST-2101**. Trace the "Sampled signal" at any three different sampling frequencies.
(b) Observe the effect of the variation of duty cycle of the sampling pulses and the order of the low-pass filter on the re-construction of the sampled signal. Trace the wave-shapes of the re-constructed signal using $2^{nd}$ order and $4^{th}$ order LPF.

**Apparatus Used:-**

1. Sampling and Reconstruction Trainer kit, model ST-2101 (Scientech Technologies)
2. A 20 MHz, dual channel Oscilloscope.

## Brief Theory

**NYQUIST CRITERION (Sampling Theorem):-**

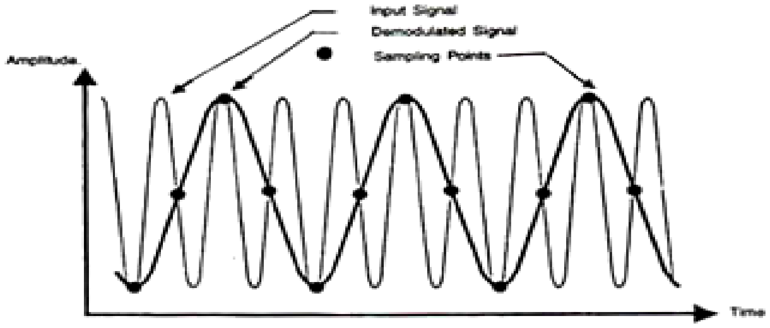
The Nyquist criterion states that a continuous signal band limited to $f_m$ Hz, can be completely represented by and reconstructed from, the samples taken at a rate greater than or equal to $2f_m$ samples per second. This minimum frequency is called as "**Nyquist Rate**". Thus, for the faithful reconstruction of the information signal from its samples, it is necessary that the sampling rate, $f_s$ must be greater than $2f_m$.

## Aliasing;-

If the information signal is sampled at a rate lower than that stated by Nyquist criterion, than there is an overlap between the information signal and the side bands of the harmonics. Thus the lower and the higher frequency components get mixed and cause unwanted signals to appear at the demodulator output. This phenomenon is termed as **Aliasing** or Fold-over Distortion. The various reasons for aliasing and the ways for its prevention may be summarized as under:-

**A) Aliasing due to under-Sampling:-**

If the signal is sampled at a rate lower than $2f_m$, then it causes aliasing, as illustrated in the following figure, where a sinusoidal signal of frequency $f_m$ is being sampled at a rate $f_s<2f_m$, and the dots represent the sample points.




ALIASING DUE TO UNDER - SAMPLING

The LPF at demodulator effectively joins the sample causing an unwanted frequency component to appear at the output. This unwanted component has a frequency $= (f_s – f_m)$

**B) <u>Aliasing due to wide band signal</u>**:-

The system is designed to take samples at a frequency slightly greater than that stated ny Nyquist rate. If higher frequencies are ever present in the information signal, or it is affected by H. F. noise, then the aliasing will occur. To prevent the aliasing, Anti-aliasing filters are usually installed prior to sampling. In telephone networks, the speech signals are band-limited by filters before sampling to avoid the effect of aliasing.

**C) <u>Aliasing due to noise</u>**:-

If very small duty cycle is used in sample-and-hold circuit, aliasing may occur if the signal has been affected by the noise. High frequency noise generally mix with the High frequency component of the signal. and hence causes undesirable frequency components to appear at the output. This type of aliasing may, therefore, be prevented by slightly increasing the duty cycle of the sampling pulses.

**D) <u>Aliasing due to Filter Roll-off</u> :-**

Aliasing may also occur, if appropriate filter response is not chosen and the frequencies above the nominal cut-off frequency of the filter, have significant amplitudes at the filter's output. This is called Aliasing due to Filter Roll-off.

## <u>Brief Description of the Kit</u>

The lay-out diagram of the experimental kit is shown on the next page:-

The kit contains the circuits for the following five sections: -

**1. <u>Sampling Frequency Selector Section</u>**:-

By default, the sampling frequency is set to 32 KHz. But pushing successively the sampling frequency selector switch can change it and the value of the selected frequency is one-tenth of the frequency indicated by the corresponding glowing LED. For example, if the LED corresponding to 20 KHz is glowing, then the selected value of the sampling frequency is 2 KHz.

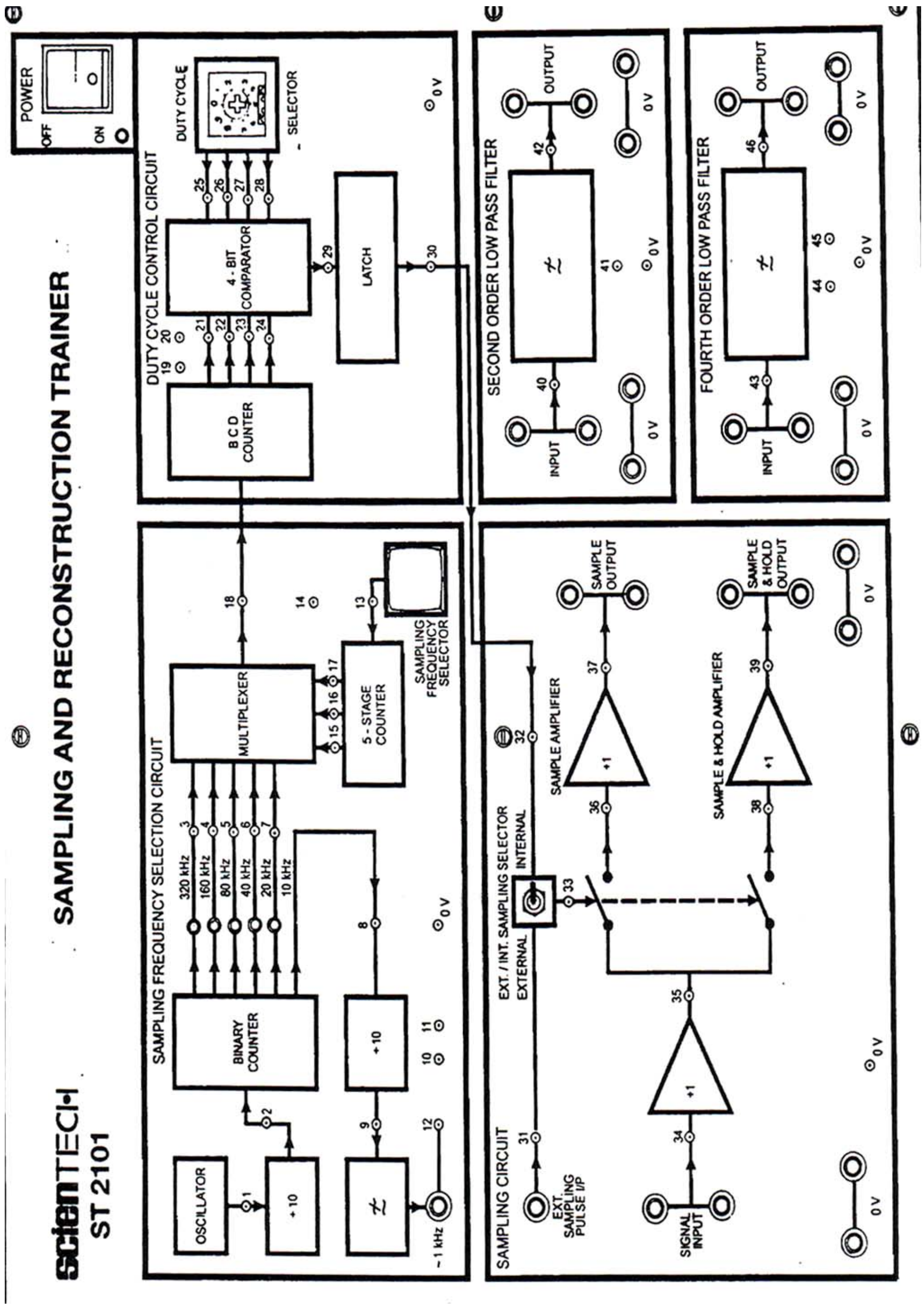
**2. <u>Duty cycle control section</u>**:-

Here the duty cycle of the sampling pulses can be varied from **10% to 90%**.

**3. <u>Sampling Section</u>:-**

It provides: Sampled “ output at **TP-37** and the “sample and hold” output at **TP-39**. The input sampling pulses are also selected in this section by the **INTERNAL / EXTERNAL** sampling selector switch.

**The lay-out diagram of the experimental kit , model ST-2101**




**NB:-**

The internal pulses are usually selected; because the external pulses need to be synchronized with the information signal (1 KHz internally generated sinusoidal signal available at **TP-12** on the sampling frequency selection circuit board) to get the stable trace on the CRO screen.

**4. <u>Two Low-pass Filter sections</u>:-** $2^{nd}$ order and $4^{th}$ order, which provide the reconstructed signal at their outputs, **TP-**42 and **TP-**46 respectively.

**The $4^{th}$ order and the $2^{nd}$ order Low Pass Filters**:-

The nth order filter has a rate of fall off of 6n dB/Octave or 20ndB/decade and one capacitor or inductor is required for each pole (order). The following table summarizes the effect of fall-off gradient on a signal such as square wave:-

| Filter Order | Fall-off Octave | Fall-off Decade | Phase at cut-off frequency |
|---|---|---|---|
| First | 6 | 20 | -45 |
| Second | 12 | 40 | - 90 |
| Fourth | 14 | 80 | -180 |

**PROCEDURE:-**

1. Set the INTERNAL / EXTERNAL sampling selector switch in INTERNAL position.
2. Put the DUTY CYCLE SELECTOR switch in position 5 (to set 50 % duty cycle).
3. Connect 1 KHz internally generated sinusoidal signal available at $t_p$12 to SIGNAL INPUT on the Sampling Circuit board.
4. Now, turn the ON/OFF switch of the kit to ON.
5. Observe the information signal (1 KHz at $t_p$12) on one channel and the Sample output (at **TP-37)** on the other channel of the CRO.
6. Connect the Sample Output (**TP-37)** to the input of $4^{th}$ order LPF.
7. Trace the Sampled output at **TP-37.** Note that 32 samples are appearing in one cycle of the information signal, as the default value of the sampling frequency is 32 KHz.
8. Now, keep on reducing the sampling frequency in steps and trace the sampled output at any other two values of the sampling frequencies.
9. Observe the reconstructed signal at the output of the $4^{th}$ order LPF at $t_p$46 on setting the sampling frequency equal to 2 KHz. Note that it is distorted as $f_s = 2\ f_m$ (Ref: Nyquist criteria).
10. Now, Connect the Sample Output (**TP-37)** to the input of $2^{nd}$ order LPF, and observe the reconstructed signal at the output of the $2^{nd}$ order LPF (TP-42) at different values of sampling frequencies. Compare the outputs of both the LPFs for the same value of sampling frequency. Which one is better and why? This completes the first part of the experiment.

11. For the second part, keep the sampling rate constant at some appropriate value (say 8 or 16 KHz), and vary the position of DUTY CYCLE SELECTOR switch, and observe the Sampled signal (TP-37) and the reconstructed signal at the output of the $4^{th}$ order LPF (TP-46) and also at the output of the $2^{nd}$ order LPF (TP-42) at different values of the duty cycle varying from 40 % (position 4) to 90 % (position 9 of duty cycle selector switch). Record your observations. How does the amplitude of the reconstructed signal vary with the variation of the duty cycle?
12. Now, disconnect the sample output (TP-37) from the input of the LPF and connect "Sample and Hold output (TP-39) to the inputs of the LPFs, and observe the reconstructed signals at their outputs one by one.
13. Vary the duty cycle again and observe that the reconstructed signal has now become independent of duty cycle variation. Measure the amplitude of the reconstructed signal at (TP-46) and at (TP-42) one by one.
14. Comment on the results obtained by using the 4th order LPF and the $2^{nd}$ order LPF.

**OBSERVATIONS**:-

For a 1 KHz sine wave (internal information signal at TP-12) and for 50 % duty cycle pulses,

Minimum sampling rate for undistorted reconstructed signal using $4^{th}$ order LPF =

Minimum sampling rate for undistorted reconstructed signal using $2^{nd}$ order LPF =

Tabulate your observations for the second part of the experiment:-

**RESULT**:-

## Comments:-

**References:-**


1) B. P. Lathi : Communication Systems
2) Scientech Technologies Pvt. Ltd. : WORK BOOK of Sampling and Reconstruction Trainer ST-2101 WB
3) Scientech Technologies Pvt.Ltd. : Operating Manual of Sampling and Reconstruction Trainer ST-2101 OM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## Experiment No. 9 : THE CHARACTERISTICS OF AM RADIO RECEIVERS

The important characteristics of AM Radio Receivers are Sensitivity, Selectivity and fidelity described as under:-

**SENSITIVITY**

The sensitivity of Radio receiver is that characteristic which determines the minimum strength of signal input capable of causing a desired value of signal output. Therefore, expressing in terms of voltage or power, the sensitivity can be defined as the minimum voltage or power at the receiver input for causing a standard output.

In case of amplitude-modulation broadcast receivers, the definition of sensitivity has been standardized as “amplitude of carrier voltage modulated 30 % at 400 Hz, which when applied to the receiver input terminals through a standard dummy antenna will develop an output of 0.5 watt in a resistance load of appropriate value substituted for the loud speakers.”

**SELECTIVITY**

The selectivity of a radio receiver is that characteristic which determines the extent to which it is capable of differentiating between the desired signal and signal of other frequencies.

**FIDELITY**

This is defined as the degree with which a system accurately reproduces at its output the essential characteristics of signals which is impressed upon its input.

**NOTE** :-

The experiment on the **Sensitivity characteristics** is described on the following page :-

**<u>Object</u>:- Plot the Sensitivity Characteristics of Superhetrodyne Radio Receiver.**

**<u>Apparatus Used</u>:-**

1. Scientech AM Receiver Trainer Kit Model ST2202
2. Scientech 2 MHz AM/FM/Function Generator Model ST4062
3. Pacific AF Signal Generator Model PG18
4. 20 MHz CRO Model ……………..

**<u>Procedure</u>:-**

1. Obtain an AM signal from the Function Output socket of Scientech 2 MHz AM/FM/Function Generator Model ST4062 by selecting its function switch to "Sine" & its Modulation switch to "AM Standard" positions and feed an AF Sinusoidal signal from another signal generator to its "Modulation Input" socket.
2. View the AM signal obtained as above, on the CRO screen and adjust the relevant controls to keep the AM Level within 800mV range, audio frequency in 400 Hz to 2 KHz, carrier frequency in the Medium wave broadcast range (700 KHz, 800 KHz, 900 KHz, & so on) and set its modulation index to 30 %.
3. Now turn ON the AM receiver kit ST2202 and make the following setting on it:-
   (a) Set the detector switch in diode mode.
   (b) Set the AGC switch to "out"
   (c) Set the volume control fully clockwise
4. Apply the AM signal as adjusted above in step 2, to the Rx input socket of the AM receiver ST2202.
5. Tune the receiver to the carrier frequency of the input AM signal and adjust "Gain" potentiometer provided in the RF section of **ST2202** so as to get unclipped demodulated signal at detector's output. (The maximum level of the unclipped demodulated signal at detector's output will ensure the correct tuning of the receiver.)
6. Record input carrier frequency, and the voltage level at receiver's final output stage i.e., audio amplifier's output on CRO.
7. Now, keep on changing the input carrier frequency in steps of 100 KHz (in the medium-wave broadcast range) and also tuning the receiver to that frequency and repeating the above step at 6.
8. Tabulate the readings as under:-

| S. No. | Carrier Frequency | Rx Output voltage Level |
|---|---|---|
| 1 | 700 KHz | |
| 2 | 800 KHz | |
| | | |
| 9 | 1500 KHz | |

Plot the graph between carrier frequency and output level, which gives the **Sensitivity characteristics** of SHRR. Also record the settings done for modulation frequency, signal level at the receiver input terminal (in mV) and the modulation index of the input AM signal.

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# Experiment No. 9 Measurement of Distortion

**OBJECT** :- To measure the Distortion content of the signal. Study the variation of distortion content by changing the signal content and the noise contents of the signal using an inverter adder circuit..

**APPARATUS**

1. Two signal generators,
2. An adder circuit
3. Distortion Factor Meter, Scientific Model HM 5027
4. CRO

**PROCEDURE**:-

1. Study the specifications and function of various controls of the Distortion Factor Meter, ( Scientific Model HM 5027).
2. Apply the signal to be investigated to the Input socket (10) of HM 5027.
3. Calibrate HM 5027 by adjusting the attenuator controls (12) and the level control (3), (within the admissible voltage range from 0.3 V to 50 V of the signal to be investigated); the instrument HM 5027 is fully calibrated when it reads 100 %.
4. Next, carry on the frequency alignment of the instrument. During the frequency alignment, the frequency of the integrated filter is tuned to the input signal frequency. First the FREQUENCY RANGE push button (3) are pressed to select the required range of from the following ranges: 20 Hz to 200 Hz, 200 Hz to 2 KHz, 2 KHz to 20 KHz. The continuous adjustment within the selected range is performed by means of knob (6) During the course of alignment. One of the two LEDs indicates the direction of frequency deviation of the integrated filter with respect to the input signal; i.e., when the LED on the right lights up, the adjustment knob must be turned counter- clockwise, until the LED goes off, and vice versa. When both LEDs are off, the alignment procedure is completed.
5. Select the desired range of distortion by pressing the appropriate push-button (7). In case of unknown magnitude of the distortion factor, the 100 % range should be selected first; otherwise the display will start flashing as soon as the full deflection value of the measurement range is exceeded. In case of insufficient resolution of the display, the next smaller range should be selected. The distortion factor is directly read out on the display in percent, requiring no further conversion. The read-out range extends from 99.9 % to 0.1 % or from 9.99 % to 0.01 % respectively.

6. Now, increase the amplitude of the signal under measurement, in equal steps, and keep on measuring the distortion content corresponding to each value of the amplitude, by following the procedure described as in steps 3, 4 & 5 above.
7. Next, design & test an inverting adder circuit as shown in figure 1 below.
8. Connect two Sinusoidal signals: V1 (2.0 V / 1 KHz) and V2 (3V / 1 KHz) at the inputs of the adder; and connect the output of the adder to the Distortion meter for measuring the distortion.
9. Keeping $v_2$ constant, vary the amplitude of $v_1$ from 1.0 V to 5.0 V and measure distortion of the output signal of adder; plot a curve between D versus A.
10. Keeping $v_1$ constant at 3.0 V, vary amplitude of $v_2$ & measure distortion of the output signal of adder; plot a curve between D versus A.

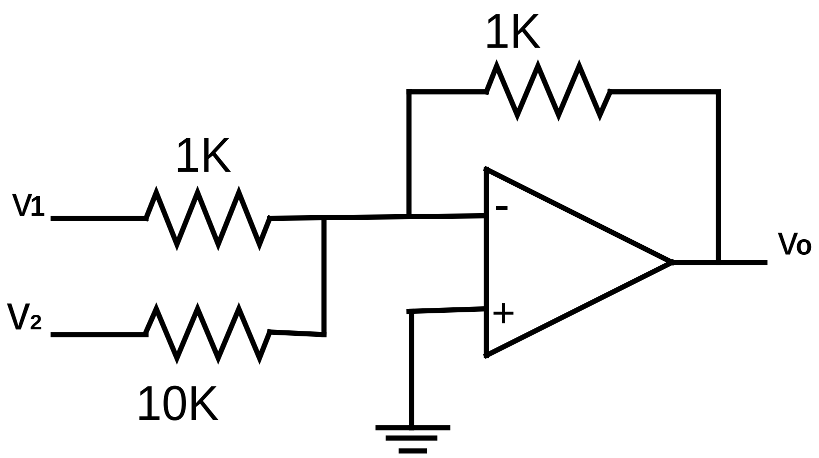


Figure 1: An Inverting Adder

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