LAB MANUAL

Communication Systems Lab
(EE-226-F)

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EXPERIMENT NO. – 1

AIM: To study and Perform Amplitude Modulation & Demodulation.

APPARATUS: A.M. Kit, CRO, Connecting Probes.

CIRCUIT DIAGRAM:

![Fig.1: AM Modulator](image1)

![Fig.2: AM De-Modulator](image2)
WAVE FORMS:

![Image of wave forms](image_url)

**THEORY:** Modulation is the process in which some property of the high frequency wave, also called as carrier wave $\omega_c$, is altered in such way by low frequency information signal, called as modulating wave $\omega_m$, to transmit form one place to other place through air. The AM wave is represented as shown in fig. An its side bands as shown in fig. The top envelope is represented as

$$V_c + V_m \sin \omega_mt,$$

Where the bottom envelope is represented as

$$- (V_c + V_m \sin \omega_mt)$$

where $V_c$ is the carrier voltage, $V_m$ is the modulating voltage. The ratio between envelope amplitudes is called as modulation index or factor $m_f$, which is represented as

$$m_f = \frac{V_{\text{max}} - V_{\text{min}}}{V_{\text{max}} + V_{\text{min}}}$$

The value of $m_f$ lies between 0 to 1.

The total power in the modulated wave may be expressed as:

$$P_t = P_c + P_{\text{LBS}} + P_{\text{USB}}$$

$$P_t = P_c (1+m_f^2)/2$$

**PROCEDURE:**

**Modulation:**
1. Connect the circuit as shown on the kit.
2. Connect the CRO probe to the input of modulating signal and see waveform of input signal on CRO and major its frequency and amplitude.
3. Connect the CRO probe to the output of modulation KIT and see the wave forms for the modulated signal.
Demodulation:

1. Connect the output received above to the input of demodulating circuit of the kit.
2. Connect the required terminals internally on the kit marked with dotted lines.
3. See the wave for demodulated signal on CRO by connecting the CRO probes on output of demodulated circuit.

Result: Amplitude Modulation & Demodulation is studied.

Precautions:
1. Switch off the experimental kit during making connections.
2. Set the proper amplitude and frequency of the modulating signal to get a reasonable AM waveform.
3. Use the CRO carefully.
EXPERIMENT NO. - 2

AIM: To study Frequency Modulation and Demodulation.

APPARATUS: F.M. Kit, CRO, Connecting Probes.

THEORY:

In frequency modulation, the amplitude of the carrier wave is kept constant but its frequency is varied in accordance with the amplitude of the audio frequency signal. The phase of the carrier wave is also kept constant. The instantaneous frequency of the resulting frequency modulated signal equals,

\[ \omega_i = \omega_c + K_f f(t) \]

The term \( K_f \) represents the frequency sensitivity of the modulator.

The instantaneous frequency of FM signal varies with time. The maximum change in instantaneous frequency from the average, i.e., \( \omega_c \), is known as frequency deviation \( \Delta \omega \).

\[ \Delta \omega = K_f E_m \]

CIRCUIT DIAGRAM:

![Fig.: FM Modulator](image-url)

Fig.: FM Modulator
PROCEDURE:

1. Keep amplitude control to maximum. Connect frequency counter at the AC marked socket of inbuilt 1 KC oscillator and ground socket of Vco circuit to measure its frequency. Connect CRO in place of counter and observe the AF waveform. Adjust amplitude control to obtain 1 V_{p-p} o/p signal.

2. Connect frequency counter across the FM out sockets and measure free run span by rotating V_R control to both extremes.

3. Connect DC o/p of peak rectifier (given in AF oscillator block) with the DC marked socket. Adjust free run control to 90 KHz and bring AF amplitude control to minimum. Note the new frequency. Find out the frequency division on one side of carrier. The total frequency deviation is 2 times of the found frequency since AC signals has two peaks.

4. Bring free run frequency to lower side e.g. 50 KC. Connect AC o/p socket with AC i/p socket at Vco. Connect CRO across FM o/p sockets and increase the modulating voltage.

5. Observe the effect upon the carrier signal. Connect CRO second channel with modulating signal and adjust time base for single steady waveforms (100\mu s/div). Expand the trace with X-magnifier and observe the deviation in signal following the modulating signal polarities.

6. From the observation made, calculation of the modulation index as $\Delta f/ f_m$ is done. The FM spectrum is similar to amplitude modulation where the carrier component depends upon the FM. Calculate the bandwidth, which is equal to $(2\Delta f + f_m)$.

WAVE FORMS:
Result: Frequency Modulation & Demodulation is studied.

Precautions:
4. Switch off the experimental kit during making connections.
5. Set the proper amplitude and frequency of the modulating signal to get a reasonable FM waveform.
6. Use the CRO carefully.
AIM: - To study Pulse Amplitude Modulation and Demodulation.

APPARATUS: - Dual trace CRO, PAM kit, Connecting leads.

THEORY: - In PAM, amplitude of pulses of carrier pulse train is varied in accordance with the modulating signal. Fig. explains the principle of PAM. A signal i.e. baseband is shown in fig. and carrier pulse train $f_c(t)$ is also shown. The frequency of carrier train is decided by sampling theorem. A pulse amplitude modulated signal $f_m(t)$ is shown. It can be seen that the amplitude of pulse depends upon the value of $f(t)$ during the time of pulse.

CIRCUIT DIAGRAM:

![Fig.1: PAM Modulator](image)

![Fig.1: PAM De-Modulator](image)
WAVE FORMS:

![Waveform Diagram](image)

PROCEDURE: -
1. Using connecting leads connect the output of sampling pulse generator to input-1 of PAM modulator and output of modulating signal generator to input-2 of the PAM modulator.
2. Now after switching on the mains power supply adjust the frequency of the sampling pulse generator and level of modulating signal to obtain the PAM waveform on CRO.
3. Trace these waveforms on tracing paper.

RESULT: Pulse Amplitude Modulation & Demodulation is studied.

PRECAUTIONS:
1. Switch off the experimental kit during making connections.
2. Adjust the frequency of pulse trains carefully to get reasonable PAM waveforms.
3. Use the CRO carefully.
EXPERIMENT NO. - 4

AIM: - To study Pulse Width Modulation and Demodulation.

APPARATUS: - Dual trace CRO, PWM kit, Connecting leads.

THEORY:
The PWM is also known as pulse duration modulation. It modulates the time parameter of the pulses. The width of PWM pulses varies. The amplitude is constant; width of the pulse is proportional to the amplitude of the modulating signal. Bandwidth on transmission channel depends on rise time of the pulse. The demodulation circuit used is a simple filter circuit that demodulator the PWM signal and gives the original message input.

CIRCUIT DIAGRAM:

![PWM Modulator Diagram]

Fig.1: PWM Modulator
WAVE FORMS:

![Waveform Diagram](image)

PROCEDURE:

1. Using connecting leads connect the output of sampling pulse generator to input-1 of PWM modulator and output of modulating signal generator to input-2 of the PWM modulator.
2. Now after switching on the mains power supply adjust the frequency of the sampling pulse generator and level of modulating signal to obtain the PWM waveform on CRO.
3. Trace these waveforms on tracing paper.

RESULT: Pulse Width Modulation and Demodulation is studied.

PRECAUTIONS:

1. Switch off the experimental kit during making connections.
2. Adjust the frequency of pulse trains carefully to get reasonable PWM waveforms.
3. Use the CRO carefully.
EXPERIMENT NO. - 5

AIM: - To study Pulse Position Modulation and Demodulation.

APPARATUS: - Dual trace CRO, PPM kit, Connecting leads.

THEORY: -
In Pulse Position Modulation, both the pulse amplitude and pulse duration are held constant but the position of the pulse is varied in proportional to the sampled values of the message signal. Pulse time modulation is a class of signaling techniques that encodes the sample values of an analog signal on to the time axis of a digital signal and it is analogous to angle modulation techniques. The two main types of PTM are PWM and PPM. In PPM the analog sample value determines the position of a narrow pulse relative to the clocking time. In PPM rise time of pulse decides the channel bandwidth. It has low noise interference.

CIRCUIT DIAGRAM:
PROCEDURE: -

1. First observe the waveform of modulating signal (TP2) and carrier signal (TP1) on CRO.

2. Now connect the output of carrier section and modulating signal section to the PPM modulator section.

3. Switch on Experimental kit.

4. Observe the PPM signal at the output of modulator section (TP3). Adjust the level of the modulating signal with the pot marked LEVEL in order to obtain a proper PPM signal.

RESULT:- Pulse Amplitude Modulation & Demodulation is studied.

PRECAUTIONS:-

1. Switch off the experimental kit during making connections.

2. Adjust the frequency of pulse trains carefully to get reasonable PPM waveforms.

3. Use the CRO carefully.
EXPERIMENT NO. – 6

AIM: - To study Pulse Code Modulation and Demodulation.

APPARATUS: - PCM kit, Dual trace CRO, Connecting leads.

CIRCUIT DIAGRAM:

Fig. : PCM Modulator

Fig. : PCM De-Modulator

THEORY:
Pulse code modulation pulse code modulation system comprises the following steps:
1. Sampling
2. Quantization
3. Encoding
4. Formatting
Let these four steps should be detailed before circuit description.
1. **Sampling:**
The input is first sampled according to Nyquist criteria. The Nyquist criteria state that a signal must be sampled at a rate of \( >2f_m \), means the sampling frequency must become than the twice of input information highest frequency. For a voice signal it must be \( 2 \times 3.4 \text{ KHz} = 6.8 \text{ KHz} \) or say 8 KHz. The sampled signal is now in the form of pulse amplitude modulated signal. Thus in a pulse code modulation first step is to obtain a PAM signal at Nequist rate.

2. **Quantization:**
The quantization means to compare the stepped PAM signal height with a known reference value.

3. **Encoding:**
The sampled input is compared and encoded into equivalent binary word. Here is to note that a binary ‘0’ represent absence of pulse and ‘1’ presence of the pulse.

4. **Formatting:**
The ready data is now transmitted through cables or being modulated by carrier component. Let take the cable system. To send this data four lines of data stream and one common line is required. If the encoded data eight word length than there must be nine and lines and it is not economical same case it is not possible to modulate this data lines (4 & 8) with a carrier component. Thus prior to send the parallel data is converted into serial form with governing bits. The process is called data formatting. In the block diagram it is drawn as shown below.

**WAVE FORMS:**

![Waveforms Diagram](image)

**PROCEDURE:**

1. Keep DC ADJ control to minimum (fully controlled – clock wise). Switch on the power.
2. Connect the CRO ground with the ground point provided between Tx CK and TX DO sockets.

3. Connect CRO live lead with the TP1, adjust CRO for 2V/div and 1 microsecond/div. Observe the clock signal there. It is the clock signal which is used in conversion of analog to digital function.

4. Connect the CRO at TP2; adjusting time 50 microsecond/div. It is the main clock signal which is used performs all functions. Remain CRO one channel connected here.

5. Connect other channel of CRO with the TP3. Observe the signal there. Adjust CRO time base to appear one complete frame upon the signal there. Adjust CRO time base to appear one complete frame upon the screen. Trace the clock signal with the TP3 signal.

6. Disconnected TP2, probe and connect it with the TP4, TP5, and TP6 signals. Trace these all signals as shown in the figure.

7. Connect the CRO with the TP7, while other input connected with TP3. Observe and trace this signal.

8. Connect CRO with the TxDO output socket and observe the signal there.

9. Trigger CRO with this signal and measure the time T between two successive leading signals. It is the transmission frame time measure the start bit time.

10. Now increase the analog input (DC ADJ control) signal gradually till LSB, LED(D0) glows. Observe the modulated signal.

RESULT: Pulse Code Modulation & Demodulation is studied.

PRECAUTIONS:

4. Switch off the experimental kit during making connections.

5. Adjust the frequency of pulse trains carefully to get reasonable PCM waveforms.

6. Use the CRO carefully.
AIM: To study Time Division Multiplexing (TDM) system.

APPARATUS: Time Division Multiplexing Kit, CRO, Connecting Wires.

THEORY:
In time division multiplexing, we use the fact that narrow pulses with wide spaces between them are generated in any of the pulse modulation system, so that spaces can be used by the signal from other sources. Moreover although the spaces are relatively fixed in width, pulse may be as narrow as desired, thus permitting the generation of high level hierarchies. There are two types of time division multiplexing. One is slow speed TDM and other is high speed TDM. Slow speed TDM is often used in radio telemetry and is produced simply with rotating mechanical switches. The high speed TDM uses electronic switching and delay lines to accomplish the same result.
PROCEDURE:
1. Set the duty cycle control switch in position 5.
2. Turn the all potentiometers in Function Generator block fully clockwise.
3. Make the following connections with banana to banana connectors:
   - 250 Hz to CH.0 input socket of TX. block.
   - 500 Hz to CH.1 input socket of TX. block.
   - 1 kHz to CH.2 input socket of TX. block.
   - 2 kHz to CH.3 input socket of TX. block.
4. Turn on the power supply of the trainer.
5. Observe the TX. output along with CH.0 input for reference with the aid of oscilloscope. The transmitter circuit samples all channels at different time intervals. The Time Division Multiplexed samples appear at the TX. output. Vary the amplitude of the input sine-waves by varying the potentiometers in the function generator block. This will help identifying which sample belong to which input channel.

RESULT: Time Division Multiplexing and Demultiplexing is studied.

PRECAUTIONS:
1. Switch off the experimental kit during making connections.
2. Use the CRO carefully.
**AIM:** - To study Amplitude Shift Keying (ASK) Modulation and De-Modulation.

**APPARATUS:** -, ASK kit, Dual trace CRO, Connecting leads.

**CIRCUIT DIAGRAM:**

![Block Diagram of ASK Modulator](image)

**THEORY:**
Amplitude shift keying (ASK) is the simplest digital modulation technique. In this modulation method there is only one carrier which is switched ON/OFF depending upon the input binary sequence to transmit symbol 0 and 1. The binary ASK system was one of the earliest form of digital modulation used in wireless telegraphy. In an binary ASK system binary symbol 1 is represented by transmitting a sinusoidal carrier wave of fixed amplitude \( A_c \) and fixed frequency \( f_c \) for the bit duration \( T_b \) where as binary symbol 0 is represented by switching of the carrier for \( T_b \) seconds. This signal can be generated simply by turning the carrier of a sinusoidal oscillator ON and OFF for the prescribed periods indicated by the modulating pulse train. For this reason the scheme is also known as on-off shift testing. The ASK signal can be generated by applying the incoming binary data and the sinusoidal carrier to the two inputs of a product modulator. The resulting output is the ASK wave.
WAVE FORMS:

PROCEDURE: -
1. Make connections as per block diagram.
2. Set the input and carrier signal.
3. Obtain ASK modulated and de-modulated signal on CRO and trace it on trace paper.

RESULT: The Amplitude Shift Keying (ASK) Modulation and De-Modulation is studied.

PRECAUTIONS:
1. Switch off the experimental kit during making connections.
2. Set the value of carrier signal precisely.
3. Use the CRO carefully.
**AIM:** - To study Frequency Shift Keying (FSK) Modulation and De-Modulation.

**APPARATUS:** - FSK kit, Dual trace CRO, Connecting leads.

**CIRCUIT DIAGRAM:**

![Block Diagram of FSK Modulator](image)

**THEORY:**

Frequency-shift keying (FSK) is a frequency modulation scheme in which digital information is transmitted through discrete frequency changes of a carrier wave. The simplest FSK is binary FSK (BFSK). BFSK uses a pair of discrete frequencies to transmit binary (0s and 1s) information. With this scheme, the "1" is called the mark frequency and the "0" is called the space frequency. If the incoming bit is 1, a signal with frequency $f_1$ is sent for the duration of the bit. If the bit is 0, a signal with frequency $f_2$ is sent for the duration of this bit. This is the basic principle behind FSK modulation.

In the demodulator circuit, the FSK modulated signal is applied to a high Q tuned filter. This filter is tuned to the frequency of either 0 or 1. This filter passes the selected frequency and rejects the other.
The output is then passed through a FWR (Full Wave Rectifier) circuit and the output is now above zero volts only. It is then passed through a comparator; if the input to the comparator is greater than threshold value, the output is 1, else it is 0. This digital output of the comparator is the demodulated FSK output.

**WAVE FORMS:**

**PROCEDURE:**

(a) **Modulation:**

1. Connect any one data output of the decade counter to the Data Inputs of the FSK Modulator.
2. Also connect the outputs of carrier generator to the input of Modulator.
4. Observe the waveforms at the output of Data Generator and Modulator output using a dual trace CRO.
5. Repeat the above step for remaining Data also.

(b) **Demodulation:**

1. Connect the output of the FSK Modulator to the input of the FSK demodulator.
2. Observe the output of the FSK demodulator on the CRO.
3. Adjust the potentiometers provided in demodulator circuit until we get the demodulator output corresponding to the data input.
RESULT: The Frequency Shift Keying (FSK) Modulation and De-Modulation is studied.

PRECAUTIONS:
1. Switch off the experimental kit during making connections.
2. Use the CRO carefully.
3. Set the values of amplitude and frequencies of oscillators precisely.
EXPERIMENT NO. – 10

AIM: - To study Phase Shift Keying (PSK) Modulation and De-Modulation.

APPARATUS: -, PSK kit, Dual trace CRO, Connecting leads.

CIRCUIT DIAGRAM:-

![Block Diagram of BPSK Modulator](image)

THEORY:-

PSK is a digital modulation scheme which is analogous to phase modulation. Binary Phase Shift Keying (BPSK) is the simplest form of PSK. In binary phase shift keying two output phases are possible for a single carrier frequency one out of phase represents logic 1 and logic 0. As the input digital binary signal change state the phase of output carrier shift two angles that are 180° out of phase. In a PSK modulator the carrier input signal is multiplied by the digital data. Each time a change in input logic condition will change the output phase consequently for PSK the output rate of change equal to the input rate range and widest output bandwidth occurs when the input binary data are alternating 1/0 sequence. The fundamental frequency of an alternate 1/0 bit sequence is equal to one half of the bit rate. For demodulation coherent detector is used. It has 3 parts, a multiplier, and integrator and decision device.
WAVE FORMS:

![Waveforms Diagram]

PROCEDURE:

(A) **Modulation:**
1. Connect the carrier output of the carrier generator to the carrier input of the PSK modulator.
2. Connect any data output from the data outputs of the Data Generator to the Data Inputs of the PSK modulator.
4. Observe the connected Data Input on Channel-1 and PSK output on the Channel-2 of a dual trace CRO.
5. Change the Data Inputs and observe the PSK output changes accordingly.

(B) **Demodulation:**
1. Connect the PSK output to the PSK input of the PSK Demodulator.
2. Connect the carrier to the carrier input of the PSK Demodulator.
3. Observe the demodulated data at the output of demodulator output on the CRO.
RESULT: The Phase Shift Keying (PSK) Modulation and De-Modulation is studied.

PRECAUTIONS:
1. Switch off the experimental kit during making connections.
2. Use the CRO carefully.