Experiment #4

I. To study pulse width modulation (PWM) and demodulation and pulse position modulation (PPM) and demodulation.

II. Study of transmission and reception of band limited pulse train in base band transmission system and measurement of bit error rate (BER) using digital data.

EXPERIMENT NO. 4(I)

NAME

To study the Pulse Width Modulation

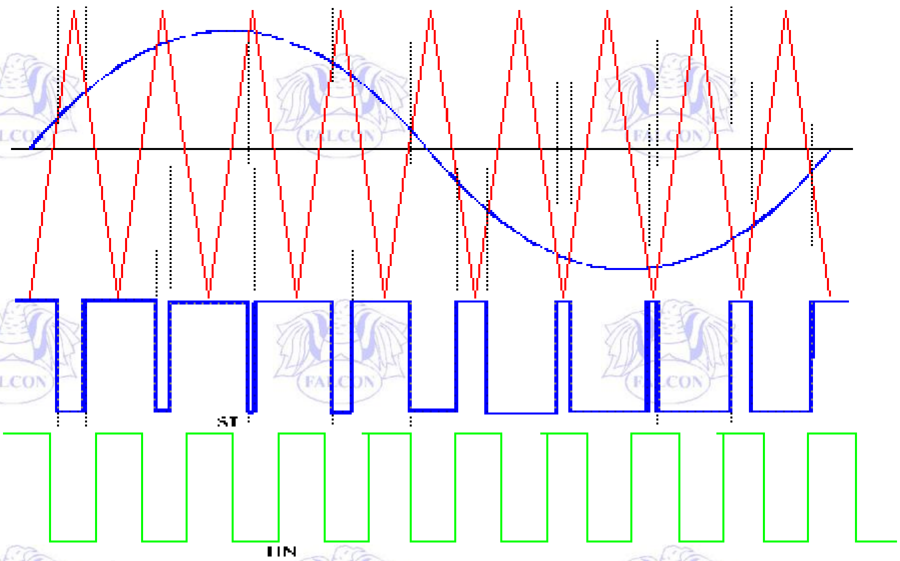
OBJECTIVES

A. To study the Pulse Width Modulation
B. To study the Pulse position Modulation

THEORY

Pulse Width Modulation (PWM) Basics

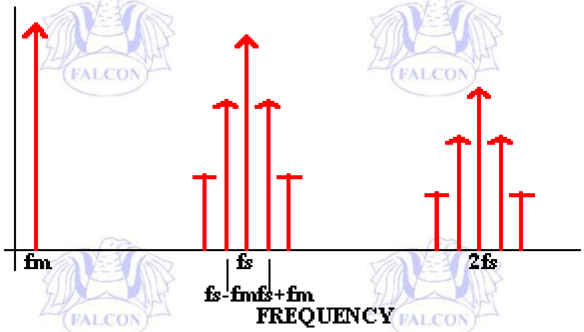
There are many forms of modulation used for communicating information. When a high frequency signal has amplitude varied in response to a lower frequency signal we have AM (amplitude modulation). When the signal frequency is varied in response to the modulating signal, we have FM (frequency modulation. These signals are used for radio modulation because the high frequency carrier signal is needed for efficient radiation of the signal. When communication by pulses was introduced, the amplitude, frequency and pulse width became possible modulation options. In many power electronic converters where the output voltage can be one of the two values, the only option is modulation of average conduction time.



Unmodulated, sine modulated pulses

1. Linear Modulation:

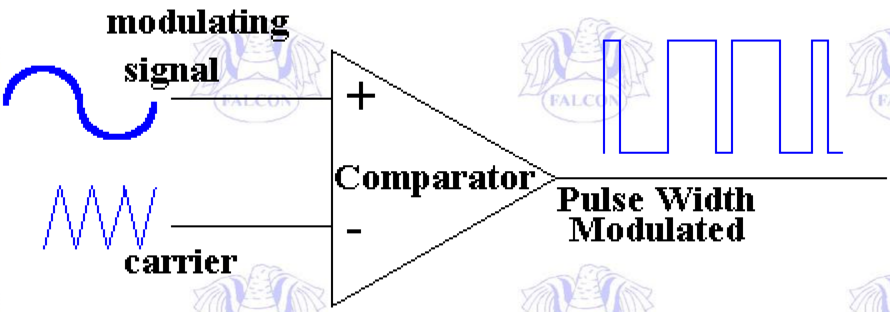
The simplest modulation to interpret is where the average ON time of the pulses varies proportionally with the modulating signal. The advantage of linear processing for this application lies in the ease of de-modulation. The modulating signal can be recovered from the PWM by low pass filtering. For a single low frequency sine wave as modulating signal, modulating the width of a fixed frequency (fs) pulse train, the spectra is as shown in Fig 2. Clearly, a low pass filter can extract the modulating component fm.



Spectra of PWM

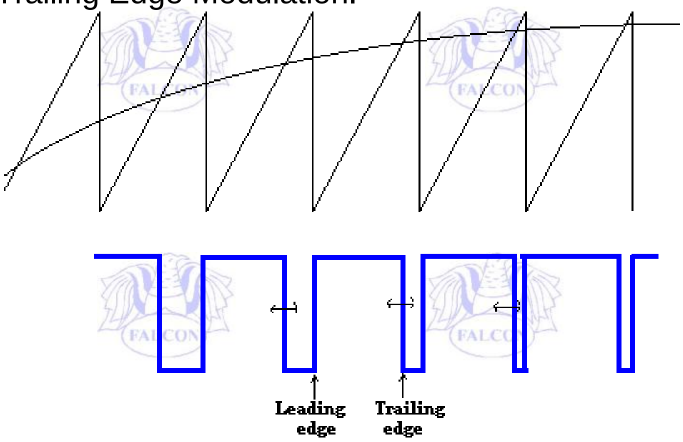
2.Sawtooth PWM:

The simplest analog form of generating fixed frequency PWM is by comparison with a linear slope waveform such as a saw tooth. As seen in Fig 2 the output signal goes high when the sine wave is higher than the saw tooth. This is implemented using a comparator whose output voltage goes to logic HIGH when the input is greater than the other.



Sine Saw tooth PWM

Other signals with straight edges can be used for modulation. A rising ramp carrier will generate PWM with Trailing Edge Modulation.

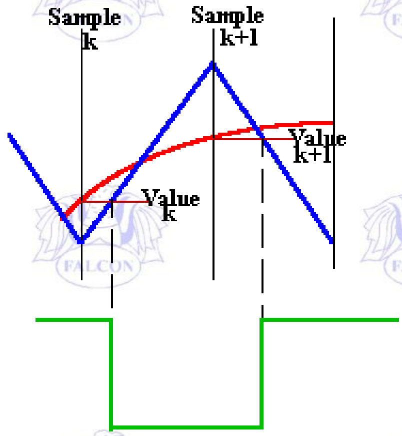


Trailing Edge Modulation

It is easier to have an integrator with a reset to generate the ramp as seen in Fig 4 but the modulation is inferior to double edge modulation.

3. Regular Sampled PWM:

The scheme illustrated above generates a switching edge at the instant of crossing of the sine wave and the triangle. These is an easy scheme to implement using analog electronics, but suffers the imprecision and drift of all analog computation as well as has difficulties in generating multiple edges when the signal has even a small-added noise. Many modulators are now implemented digitally but there is difficulty in computing the precise intercept of the modulating wave and the carrier. Regular sampled PWM makes the width of the pulse proportional to the value of the modulating signal, at the beginning of the carrier period. In Fig 5 the intercept of the sample values with the triangle determine the edges of the Pulses. For a saw tooth wave of frequency fs the samples are at 2fs.

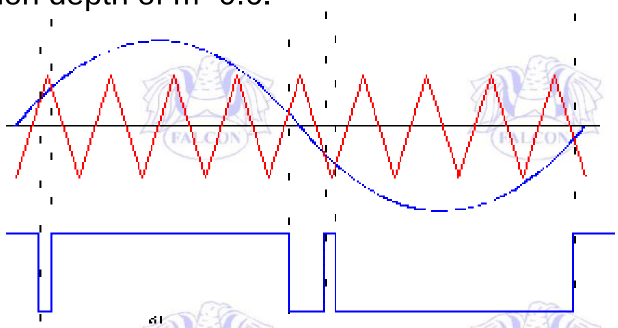


Regular Sampled PWM

There are many ways to generate a Pulse Width Modulated signal other than fixed frequency sine saw tooth. For three phase systems, the modulation of a Voltage Source Inverter can generate a PWM signal for each phase lag by comparison of the desired output voltage waveform for each phase, with the same saw tooth. One alternative, which is easier to implement in any computer and which gives a larger MODULATION DEPTH is using SPACE VECTOR MODULATION.

4. Modulation Depth:

For a single phase inverter, modulated by a sine-saw tooth comparison, if we compare a sine wave of magnitude from -2 to +2 with a triangle from -1 to +1 the linear relation between the input signal and the average output signal will be lost. Once the sine wave reaches the peak of the triangle the pulses will be of maximum width and the modulation will then saturate. The Modulation depth is the ratio of the current signal to the case when saturation is just starting. Thus, sine wave of peak 1.2 compared with a triangle with peak 2.0 will have a modulation depth of m=0.6.



Saturated Pulse Width Modulation:

Pulse Width Modulation

Pulse Width Modulation refers to a method of carrying information on a train of pulses, the information being encoded in the width of the pulses.
In applications to motion control, it is not exactly information we are encoding, but a method of controlling power in motors without (significant) loss.
There are several schemes to accomplish this technique. One is to switch voltage on and off, and let the current recirculation through diodes when the transistors have switched off. Another technique is to switch voltage polarity back and forth with a full-bridge switch arrangement, with 4 transistors. This technique may have better linearity, since it can go right down to an effective 0% duty cycle by having the positive and negative voltage periods precisely equal. On/Off techniques may have trouble going down extremely close to 0% duty cycles and may jitter between minimum duty cycles of positive and negative polarity. In battery systems, PWM is the most effective way to achieve a constant voltage for battery charging by switching the system controller's power devices on and off. The generation of exact working PWM circuitry is complicated, but it is extremely conceptually important since there is good reason to believe that neurons transmit information using PWM spike trains.

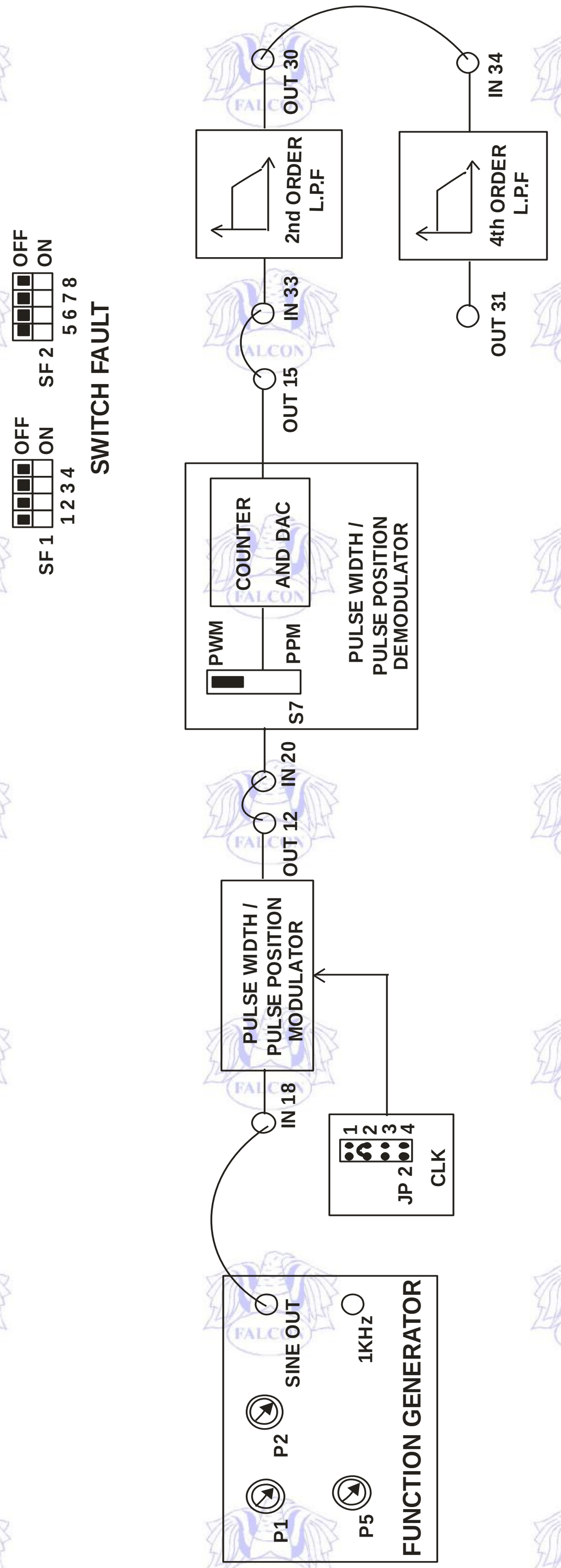


FIG 12A.BLOCK DIAGRAM FOR PULSE WIDTH MODULATION AND DEMODULATION

EQUIPMENTS

DCS-B kit
Connecting Chords
Power supply
20 MHz Dual Trace Oscilloscope
Power connection cables

NOTE: Due to high frequency we cannot observe the variation in the PWM signal. The following experiment is conducted to observe the pulse width variation.

A.To Study The Pulse Width Modulation

PROCEDURE

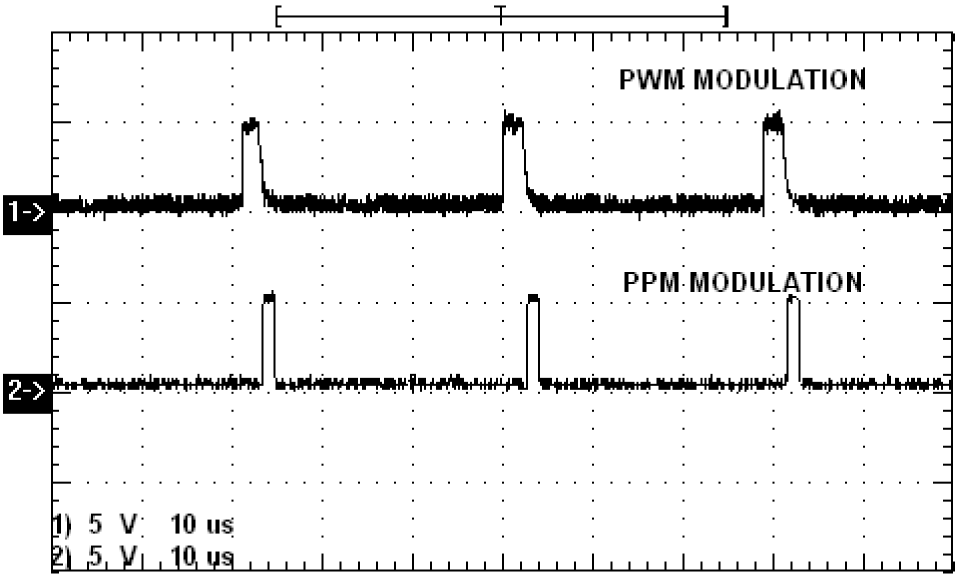
- Connect a low frequency sine wave from **SINE OUT** post having amplitude of 1Vpp using pot **P2** from the Function generator section to the **IN18** post of the PWM/PPM section.
- Keep jumper **JP2** on 2nd position.
- Observe the variation in the width of the carrier at the **OUT12** post of the PWM/PPM section, vary the frequency of input sine wave from 1 to 30 Hz using pot **P1** and observe the variation.
- Now connect **1 KHz** sine wave having amplitude of 1Vpp using pot **P5** from the Function generator section to the **IN18** post of the PWM/PPM section. Also, observe the counter outputs at their corresponding test points (**TP9** to **TP16**).
- Observe the pulse width modulated output at **OUT12** post of the PWM/PPM section.
- Connect **OUT12** post of the PWM/PPM to the **IN20** post of the PWM/PPM Demodulator section.
- Keep switch **S7** to PWM position.
- Observe the pulse width demodulated output at **OUT15** post of the PWM/PPM demodulator section.
- Connect **OUT15** post of the PWM/PPM demodulator section to the **IN33** post of the 2nd order LPF.
- Connect **OUT30** post of 2nd order LPF to **IN 34** of4th order LPF
- Observe the recovered signal at the **OUT31** post of the 4th order LPF.
- Repeat the experiment for different input signals and sampling clocks by changing the position of the jumper **JP2**.

OBSERVATION

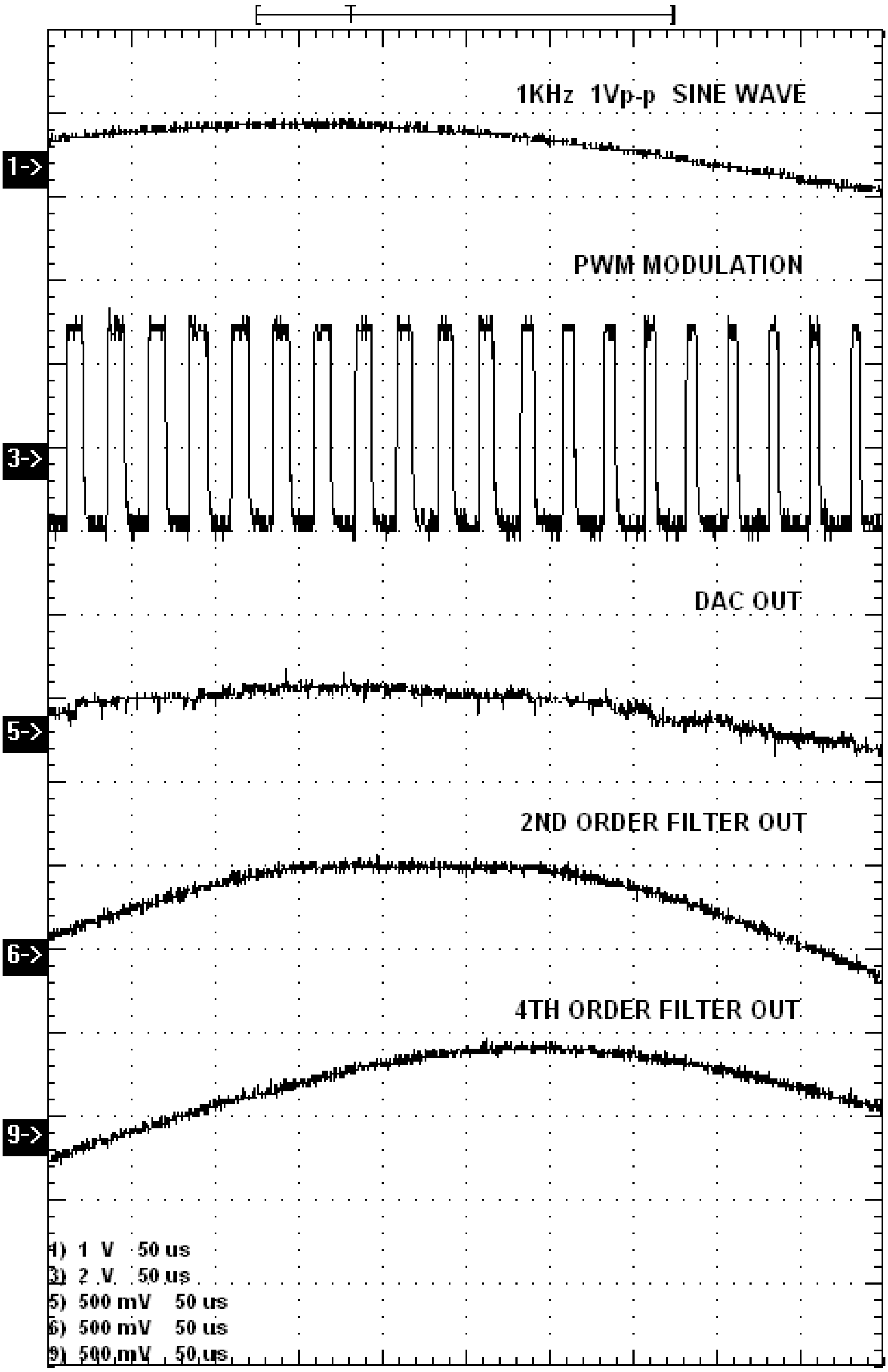
- Input Signal
- PWM Modulated Signal **Out 12**
- DAC Output **Out 15**
- Filter Output **Out 31**

CONCLUSION

PWM modulation is technique in which width of the carrier is modulated in accordance with the amplitude of the modulating signal



PWM/PPM using low frequency



PWM Modulation And Demodulation

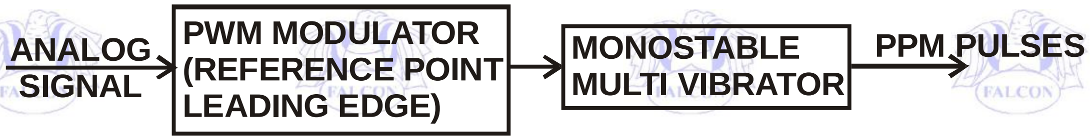
B. Study of Pulse Position Modulation And Demodulation

THEORY

Pulse Position Modulation (PPM)

In this technique of modulation, the position of TTL pulse is changed on time scale, according to the variation of input, modulating signal amplitude. The pulse positions are directly proportional to the instantaneous values of the modulating signal.
The amplitude and width of the pulse is kept constant in the system. The position of each pulse, in relation to the position of a recurrent reference pulse, is varied by each instantaneous sampled value of the modulating wave. PPM has the advantage of requiring constant transmitter power since the pulses are of constant amplitude and duration. It is widely used but has a big disadvantage that it needs synchronization between the transmitter and the receiver.

PPM Modulator
For generating a PPM pulse, a PWM pulse modulator can be made to trigger a monostable multivibrator from the negative going edge of the PWM pulses. Thereby, producing a pulse of fixed height and width, at the negative going edge of the PWM pulse.



GENERATION OF PPM PULSES

EQUIPMENTS

DCS-B kit
Connecting Chords
Power supply
20 MHz Dual Trace Oscilloscope
Power connection cables
NOTE: Due to high frequency, we cannot observe the variation in the PPM signal. The following experiment is conducted to observe the pulse POSITION variation

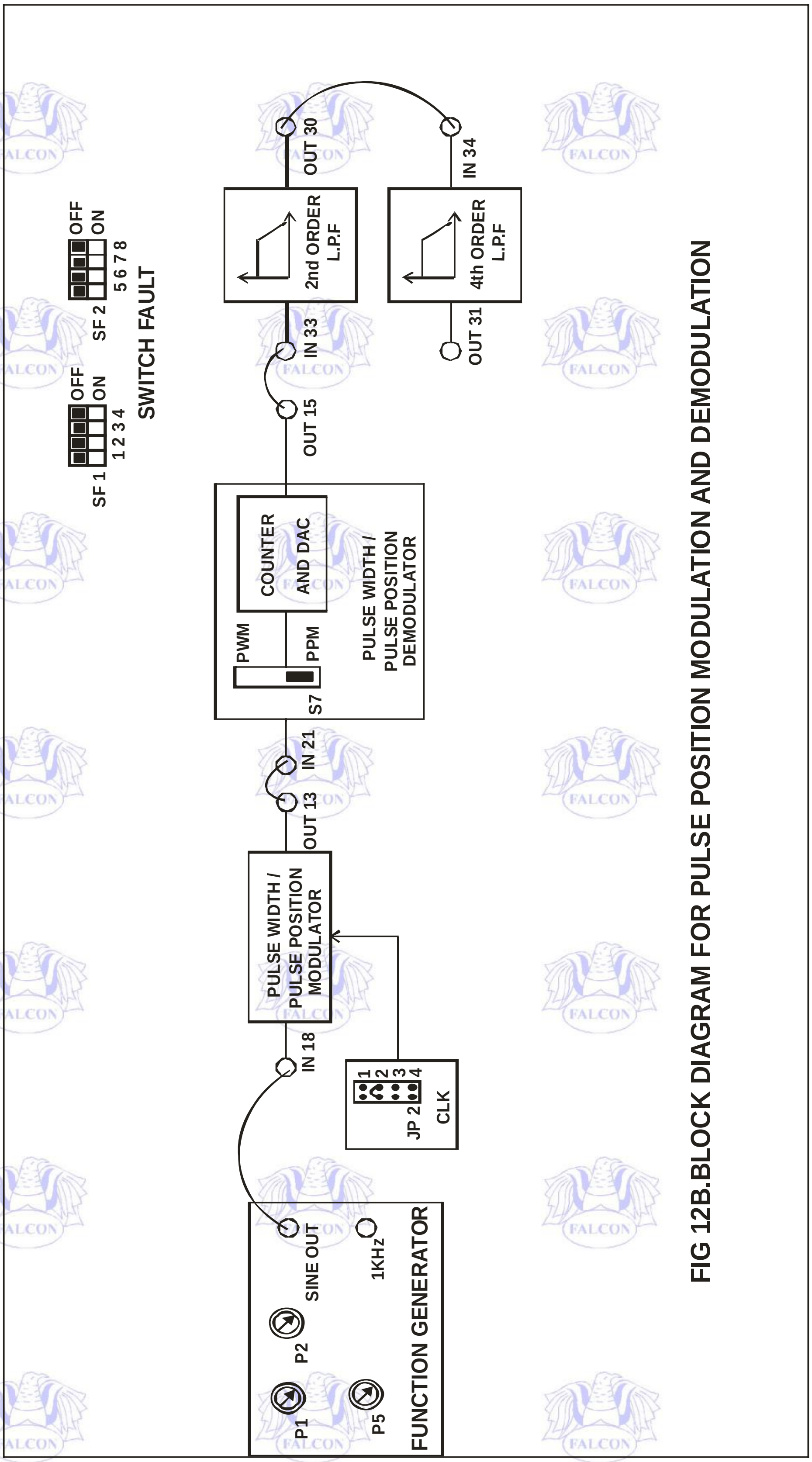
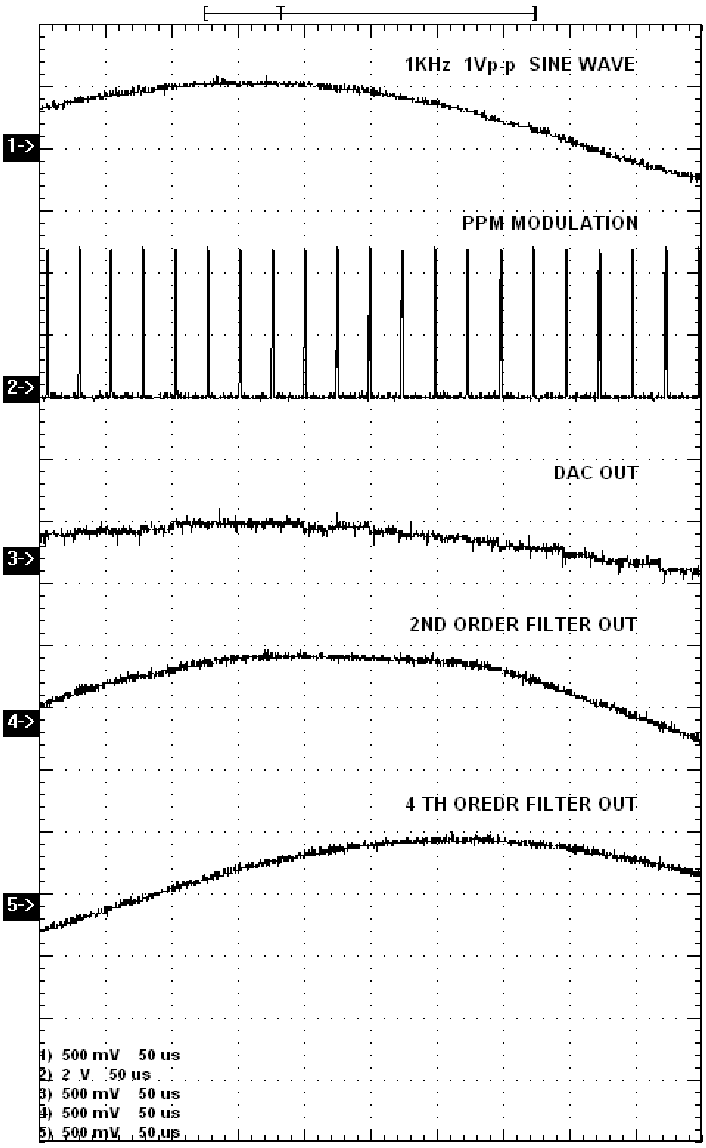


FIG 12B.BLOCK DIAGRAM FOR PULSE POSITION MODULATION AND DEMODULATION

PPM Modulation and Demodulation



To Study Pulse Position Modulation

PROCEDURE

- Connect a low frequency sine wave from **SINE OUT** post having amplitude of 1Vpp, using pot **P2** from the Function generator section to the **IN18** post of the PWM/PPM section.
- Keep jumper **JP2** on the 2nd position.
- Observe the variation in the position of the carrier at the **OUT13** post of the PWM/PPM section. Change the frequency of input sine wave from 1 to 30 Hz using pot **P1** and observe the variation.
- Now connect **1 KHz** sine wave having amplitude of 1Vpp, using pot **P5** to the IN18 post of the PWM/PPM section.

- Observe the pulse position modulated output at **OUT13** post of the PWM/PPM section. Also, observe the counter outputs at their corresponding test points (**TP9** to **TP16**).
- Connect **OUT13** post of the PWM/PPM to the **IN20** post of the PWM/PPM Demodulator section.
- Keep switch **S7** to PPM position.
- Observe the pulse width demodulated output at **OUT15** post of the PWM/PPM Demodulator section.
- Connect **OUT15** post of the PWM/PPM demodulator section to the **IN33** post of the 2nd order LPF.
- Connect **OUT30** post of 2nd order LPF to **IN 34** of4th order LPF
- Observe the recovered signal at the **OUT31** post of the 4th order LPF.
- Repeat the experiment for different input signals and sampling clocks by changing the position of the jumper **JP2**.

OBSERVATIONS

Input Signal
PPM Modulated Signal **Out 13**
DAC Output **Out 15**
Filter Output **Out 31**

CONCLUSION

PPM modulation is technique in which Position of the carrier is modulated in accordance with the amplitude of the modulating signal. In PPM the width of carrier remains same, only position of pulse varies on time scale.

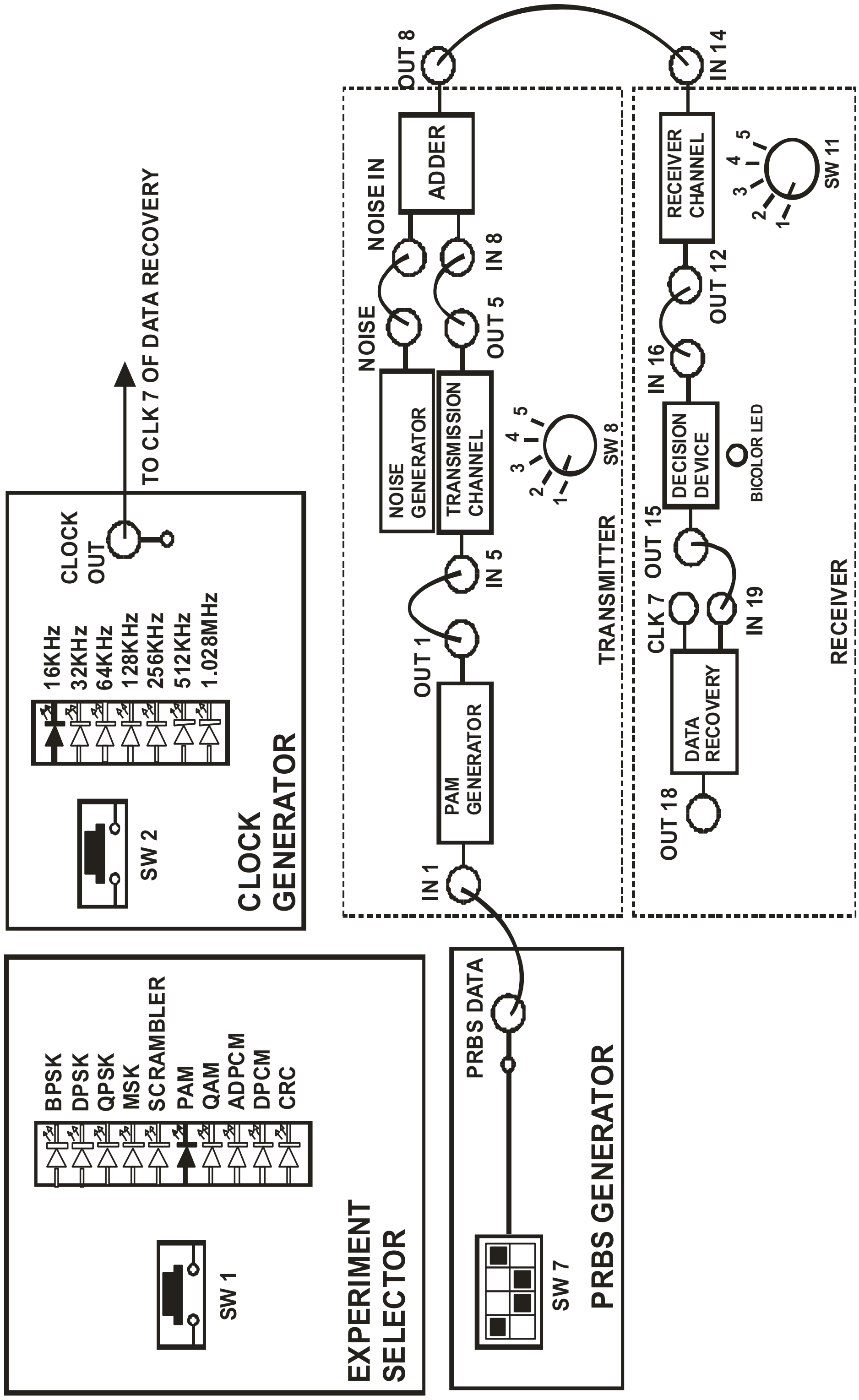


FIG 6A.BLOCK DIAGRAM FOR DIGITAL BASEBAND TRANSMISSION SYSTEM

EXPERIMENT NO-4 (II)

NAME

Study of Digital Base Band Transmission

OBJECTIVE

A) Study of Transmission and Reception of Band Limited Pulse Train in Base Band Transmission System.
B) Measurement of Bit Error Rate Using Digital Data.

EQUIPMENT

DCS-A Board and Its Power Supply

THEORY

Baseband Requirements

In the case of baseband the data bits are transmitted directly as pulses. These pulses may have to be shaped so as

- To minimize the effect of noise on the received pulses,
- To minimize the distortions introduced by the transmission medium,
- To minimize the bandwidth required for transmission of the signals and hence to maximize the throughput of data across the medium,
- To prevent inter symbol interference (ISI),
- To reduce crosstalk with other channels using the same medium, etc., etc.

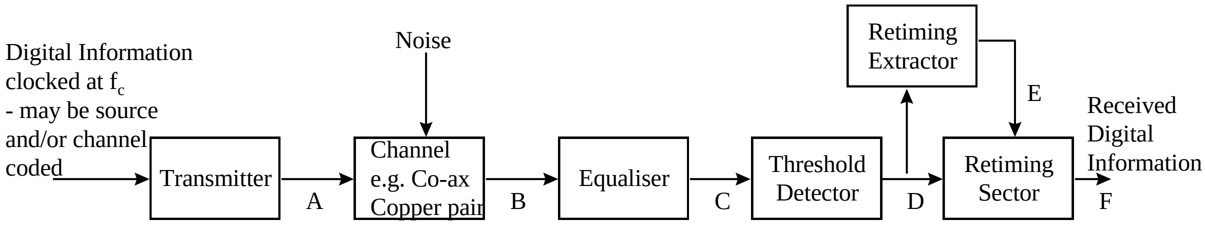
In addition various line coding systems may be used

- To ensure that there is at least one voltage transition per pulse to assist in clock synchronization and data recovery at the receive end
- To eliminate long term dc voltages on the medium
- To minimize the bandwidth requirements, and maximize throughput.

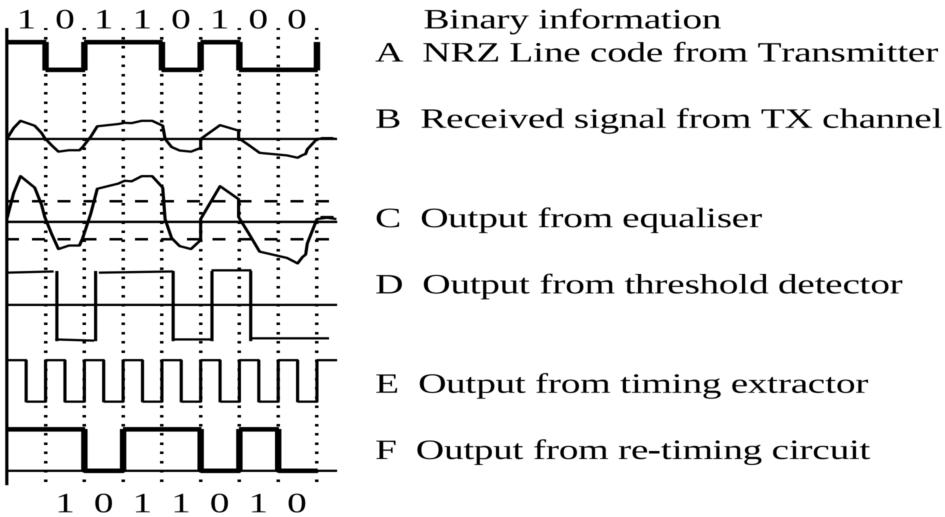
In general the pulse shape, and coding system is optimized for the particular application and medium, but it may not be possible to optimize all requirements simultaneously.
If one bit of data is transmitted per pulse then the pulse is defined as binary (the pulse has only two levels, or only two shapes, corresponding to “1” and “0”). It may be possible to combine a number of data bits into a single multi-level, (or multiple shaped) pulse prior to transmission to give, for example, 3 levels (ternary), 4 levels (quaternary), 5 levels (QUINARY), or in General, M Levels (M-Ary) Coding Prior To Transmission. This Permits More Than 1 Bit Of Data To Be transmitted per pulse, so that a higher bit rate is achieved. However because there are more voltage levels they are inevitably closer together than in the case of binary so that a lower level of noise/distortion picked up on the transmission

medium can cause a level to be mis-identified on reception, leading to errors on the received signal. Therefore, if the transmission medium is sufficiently quiet, m-ary coding can be used to increase throughput, where the value of m depends on the noise on the medium.

Problems are encountered when a digital signal is sent through a channel. This shows the basic stages in a digital signal transmission. Non-return-to-zero (nrz) is assumed. The transmission medium might be a coaxial cable or a copper twisted pair used in local area networks or digital telephone systems. The principles apply to systems using other media and//or codes.



Typical waveforms at the points labeled a to f in the system are shown. The original waveform a is attenuated and a noise component is added. Because of finite system response time and propagation delays, the transition between voltage levels becomes indistinct.



To counteract the distortion the system includes an equalizer. Which reshapes the received waveform, so that the relationship of the equalizer output c to the original binary symbols is much clearer, e.g. If a copper cable to picks up 50 Hz noise from the mains or other electromagnetic interference the equalizer must remove it. Or in the case of pulse spreading leading to ISI, or reflections in the case of radio signals leading to multiple receptions, the equalizer eliminates these also. The input to the equalizer must be protected from over-voltages such as induced lightning and other transients.

Passing the equalized waveform through a threshold detector (e.g. A Schmitt trigger) generates a binary signal very similar to the transmitted one. If the threshold settings are too small then noise will trigger the detector. If the settings are too large then the data may not trigger the detector. It is important that the slew rate of the comparator used in the detector is fast enough for the data rate.

If the noise levels are sufficiently low, and the equalizer and threshold detector are set correctly, the only difference between waveforms a and d is that the transitions are not perfectly in step. The transitions of d will correspond to the threshold-crossings of waveform c which will not precisely mirror those of the original binary waveform. This

gives timing irregularities (jitter) requiring re-timing of the received waveform, else the jitter build up to cause error over a long link or multiple links.
A regular timing reference signal f - the data clock - is derived from the received waveform itself using a timing extraction circuit (maybe based on a phase locked loop). The clock signal and the output from the threshold detector are processed to give a regenerated digital signal f whose transitions now coincide with the clock transitions.
Waveforms c and f shows that the combined effect of threshold detection and re-timing is equivalent to sampling waveform c near its peaks and troughs to determine the appropriate binary states. So even in the presence of noise, regenerated signal f can be an almost perfect (delayed) replica of the transmitted signal provided only that the noise is not sufficient to cause an incorrect decision to be made at the threshold detector.

PROCEDURE (A)

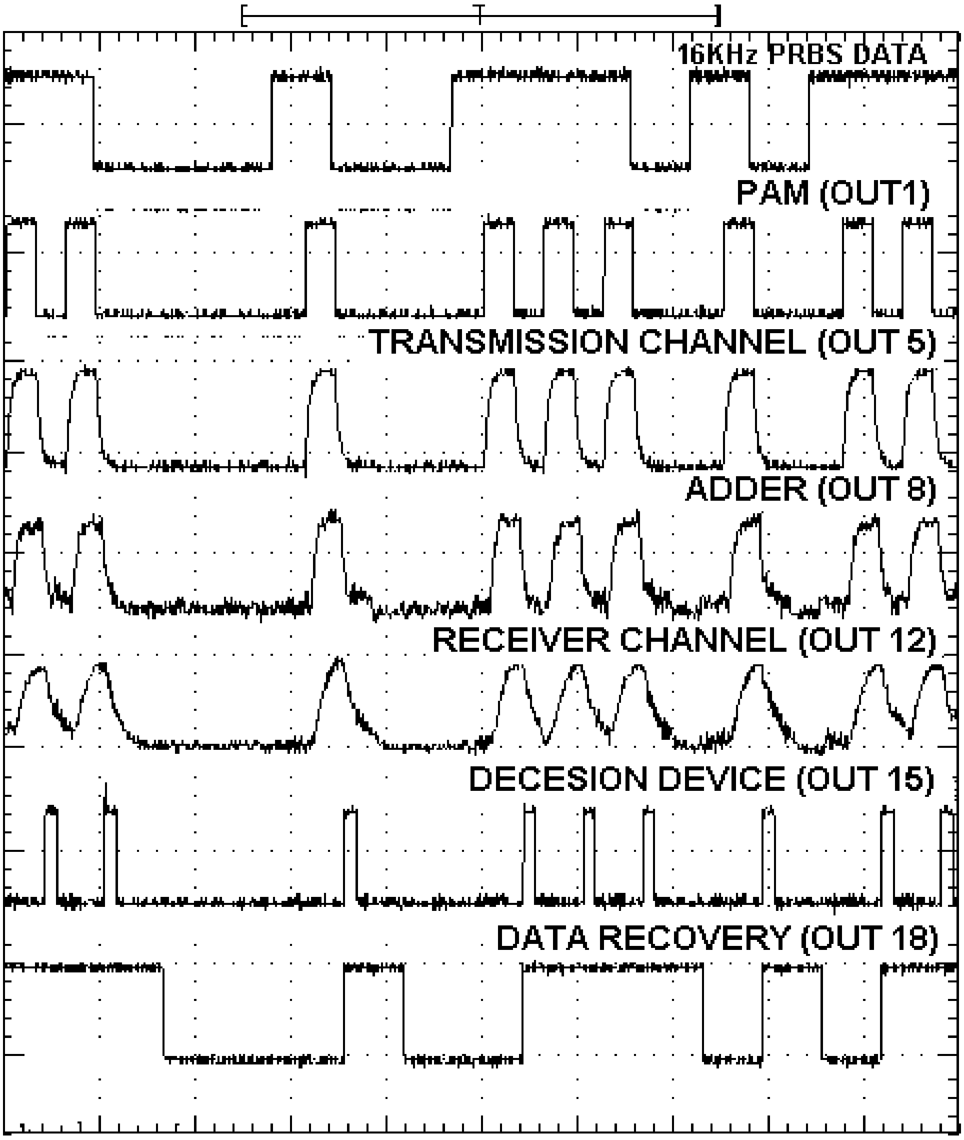
- Do the connections as per block diagram shown.
- Connect the power supply to the kit and switch it on.
- Select the **PAM** Experiment using **SW1**. Observe the Corresponding Led Indication.
- Set the Switch **SW7** in **PRBS Generator** Section as Per Block Diagram To Generate the PRBS. Observe the 16 Bit PRBS Data at **PRBS Data** Post.
- Set the Clock to **16 KHZ** using **SW2** in **Clock Generation** Section. Observe the Clock at **Clock OUT** Post.
- Connect **PRBS Data** to **IN 1** of **PAM GENERATOR.** Observe the PAM Data at **OUT 1** Post Of **PAM GENERATOR.**
- Connect **OUT1** Post to **IN 5** of **Transmission Channel**. Set **SW8** to Position 1
- Observe the Output of Transmission Channel at **OUT 5** Posts.
- Connect **OUT 5** To **In 8** Of **Adder.** Connect **Noise** from **Noise Generator** Section To **Noise In** Post of **Adder**. Initially keep Noise to Minimum Level by Rotating **P3** Fully Anticlockwise Direction.
- Observe the Adder Output at **OUT 9** Posts. Observe the Adder Output by increasing the Noise by Pot P3.
- Connect **OUT 9** Post to **IN 14** Post of **Receiver Channel**. Set **SW11** to Position 1. Observe the Output of Receiver Channel at **OUT 12** Posts.
- Connect **OUT 12** to **IN 16** of **Decision Devise**. Observe the Output of Decision Device at **Out 15** Posts. Observe the Led Indication by Changing the Noise Level.
- Connect **OUT15** to **IN 19** Post of **Data Recovery**. Observe **Clk7** at Test Point, it should be the same Clock which is used to generate PRBS. Observe the received data at **OUT18** post of data recovery. Compare it with PRBS.
- Observe the received data by increasing clock frequency and by increasing noise level. Also observe data by changing transmitter and receiver channel bandwidth.

OBSERVATIONS

- PRBS at **PRBS Data** Post of PRBS Generator**.**
- Pam Data At **OUT 1** Post of PAM GENERATOR.
- **NOISE** at Noise Generator Post.
- Signal Through Transmitter Channel At **OUT 5**
- Adder Output At **OUT 8** Post.
- Signal Through Receiver Channel At **OUT 12**
- Output of Decision Device at **OUT 15** Post.
- Output of Data Recovery at **OUT 18** Post.

CONCLUSION

The Recovered Data has some Delay because of the Transmission and Receiver Filter Response.



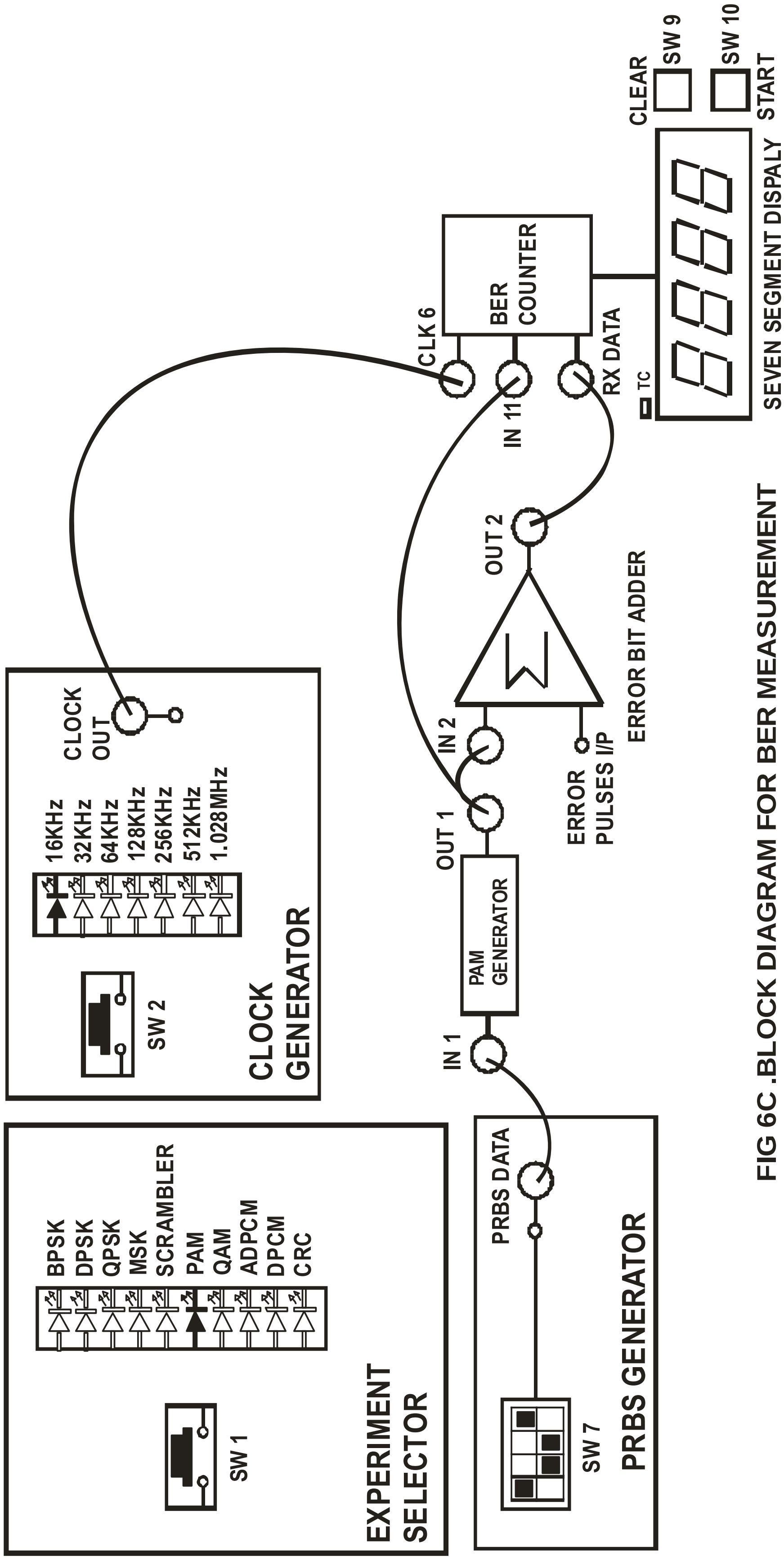


FIG 6C .BLOCK DIAGRAM FOR BER MEASUREMENT

B) Measurement of Bit Error Rate Using Digital Data.

PROCEDURE: (B)

- Do the connections as per block diagram shown.
- Connect the Power Supply to the Kit And Switch It On.
- Select The **PAM** Experiment using **SW1**. Observe the Corresponding Led Indication.
- Set The Switch **SW7** In **PRBS Generator** Section As Per Block Diagram to Generate The PRBS. Observe the 16 Bit PRBS Data at **PRBS Data** Post.
- Set the Clock to **16 KHZ** Using **SW2** In **Clock Generation** Section. Observe the Clock at **Clock OUT** Post.
- Connect **PRBS Data** To **IN 1** of **PAM GENERATOR.** Observe the Pam Data at **OUT 1** Post of **PAM GENERATOR.**
- Connect **OUT1** Post To **IN 2** Of **Error Bit Adder**. Keep **P1** Fully Anticlockwise Position So That No Error Is Added In Data. Observe The Error Pulses At Test Point Provided.
- Connect **OUT 2** Post of Error Bit Adder to **Rx data** Post of **BER Meter**. Also Connect **Clock OUT** Post to **Clk6** Post and **PRBS Data** Post To **In 11** post.
- To Clear the Display to 0 Press **Clear** Switch to start the Counting Press **Start**. The Counting Process will run for Approximately 10 -15 Sec. The Counting Process will indicated By **Tc** Led.
- Now Rotate The P1 To Halfway And Start the Ber Process and Observe the Count.
- Observe the BER Count for Various Positions of Error.

OBSERVATIONS

- PRBS at **PRBS Data** Post of PRBS Generator**.**
- Error Pulses At **Error Pulses I/P** Test Point Of Error Bit Adder.
- Data with Error at **OUT 2** Post of Error Bit Adder.
- BER Clock at **CLK 6** Post of BER Meter.

BER Measurement

The Noisy Data From The OUT Post Of The Error Bit Adder Is Connected To The Rx Data Of The Ber Meter As Ber Is The Ratio Of Error Bits (Eb) To Total Bits Transmitted (Tb) In A Period Time *T* Sec I.E.
Ber = Eb/Tb

E.G. If Prbs Data is transmitted at 32kbits Per Sec for a Period Of 10 Sec.
The Total Bits Transmitted In 10 Seconds. (Tb) = 320 Kbits.
The Ttl Out Data with Noise Is Fed To Ber Counter, which compares the two Data Input at Each Clock Input. The Counter Gives The 10 Bit Binary From Error Count (Eb) Which Is Converted Into Decimal Form And Displayed.
E. G.
(0000001010 = 10 (Decimal Form))

BER Ratio Then Becomes:
Ber = $10/320*10e^{3}$= 0.00003125
i.e. The Channel Bit Error Rate Ratio Is $3.1*10e^{3}$ (3/100000) Or In Other Words We can say that out of 100000 Bits transmitted through the channel, the channel gives 3 bits in error.