Department of Electronics Engineering,
Communication Systems Laboratory

Laboratory Manual for EL-492

B. Tech. (Electronics), Final Year (VIII – Semester)
Lab Course EL 492 (Communication Lab. – III)

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APPENDIX
Design and Testing of a 7-bit PRBS Generator

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IV Year B. Tech (Electronics)
Lab. Course EL 492 (Communication Lab - III)
Experiment No. 1 (DSSS using LFSR)

OBJECT: - (a) With suitable shift register's length and feedback tapings, generate m-sequence of 7, 15 and 31 bits. Write the sequence in each case.
(b) Taking 15-bit m-sequence, study DSSS for spreading and de-spreading of the given binary signal.

Apparatus Used:-

1. Pacific Function Generator Model FG-18 (for TTL Clock for message PRBS)
2. PRBS and Noise Generator, SIGMA Model PRBS-100 (for generating m-sequence)
3. 20 MHz Dual Trace Oscilloscope
4. 5 Volts DC Power Supply

OBSERVATIONS:- Clock frequency of the m-sequence generator = ----- KHz

(a) Generation of m-sequence:- Ground the third input of the Ex-OR gate and connect the required feedback tapings to its other two inputs & observe the corresponding m-sequence at its output.

Sequence length	Feedback tapings	Sequence
7-bit m-sequence	(1 & 3)	
15-bit m-sequence	(1 & 4)	
31-bit m-sequence	(5 & 2) or (5 & 3)	

(b) Study of DSSS:- Verify experimentally that recovered binary signal is nothing but the transmitted signal.

Logic Diagram of 7 - bit PRBS Generator
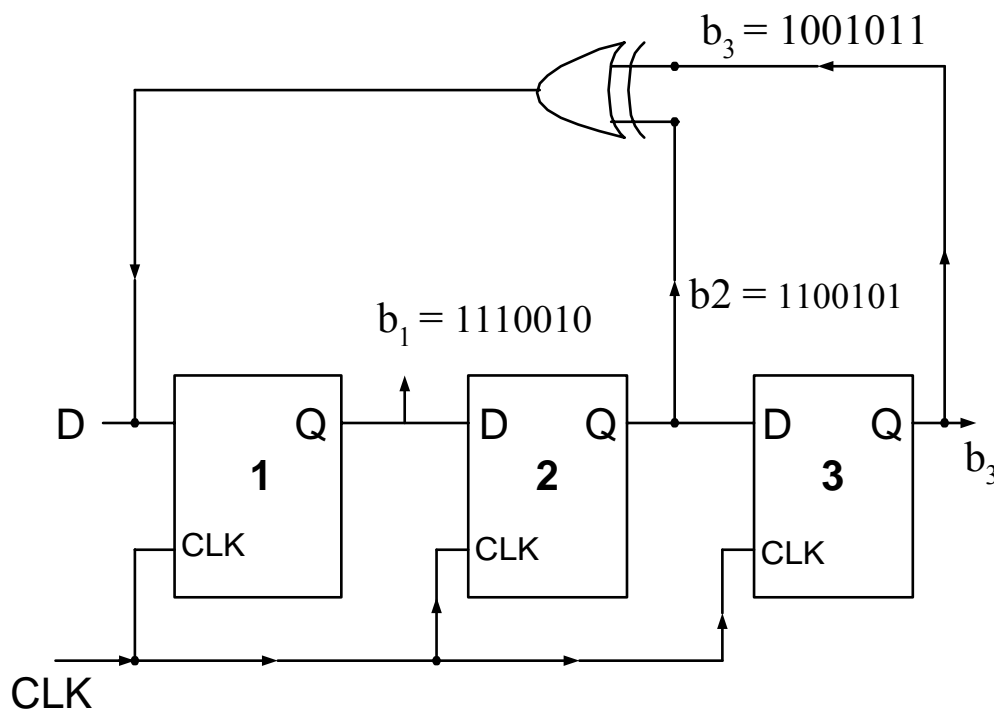
m-sequence code

recovered message
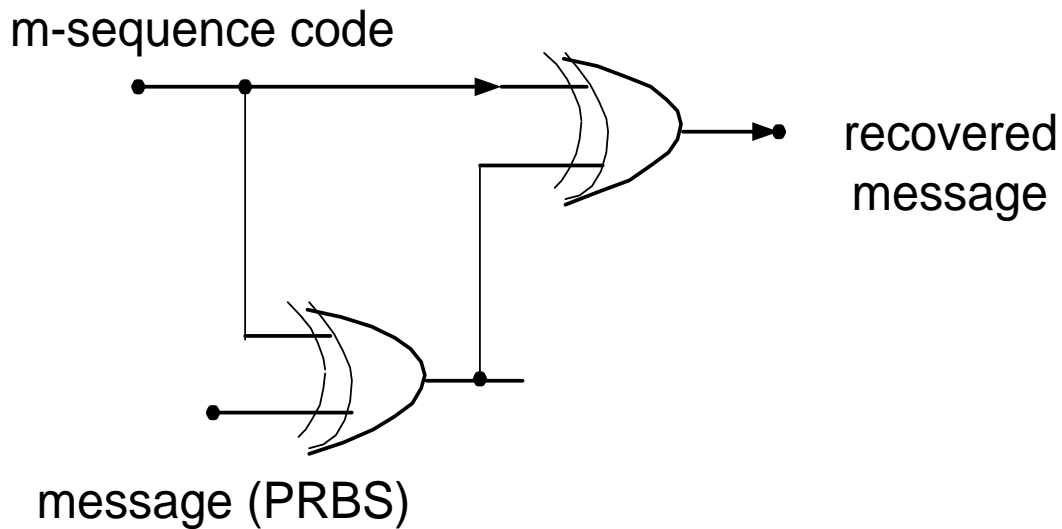
message (PRBS)

Note:-

To recover the message by de-spreading, the clock period of the message PRBS generator should be adjusted to **n- times of the clock period of the m-sequence generator**, where n is the sequence-length. In case, no message PRBS is generated, connect momentarily V_{cc} (+5 V) to D-input of the PRBS generator.

REPORT:-

(1) Discuss the characteristics of m-sequences.

(2) Take m-sequence with feedbacks (5, 2) and (5, 3) and generate at least 10 Gold codes corresponding to these sequences.

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EL-492 (Communication Lab – III)

Experiment No. 2 (Characteristics of Optical Transmitter and Receiver)

<u>Object</u>:-   a) Determination of the output characteristics of the Optical Transmitter ($\mathbf{I_{LED}}$ **vs** **P**)

        b) Determination of the Responsivity ($\mathbf{R_\lambda}$) and Quantum efficiency ($\mathbf{\eta}$) of PIN photo-detector.

Equipments Required:-

1. Fiber-Optic Power Meter FOLK-01
2. FOLK Optical Power Source ($\lambda = 820$ nm),
3. PIN Photo detector (BPX-65),
4. Plastic Fiber (1 mm diameter),
5. Variable DC Power Supply (1 V to 10 V),
6. Milli-ammeter (100 mA range),
7. Carbon-film Potentiometers : 100KΩ,
8. Fixed-resistors : 100KΩ, 47KΩ & 10KΩ

<u>Procedure for (a) :-</u> Output characteristics of the Optical Transmitter (I_{LED} vs P)
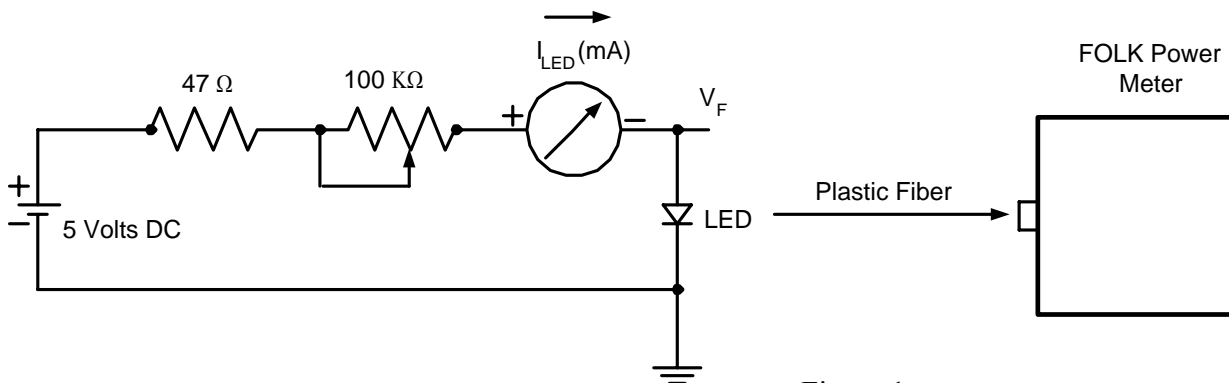
1. Make the connections as shown in Figure 1 below:-

Figure 1

2. Couple one end of the plastic fiber to the optical transmitter (LED) and the other end to the Power Meter.

3. Vary the 100KΩ potentiometer to adjust the current through LED, read by milli-ammater and measure the corresponding Power (P_s) by the Optical Power Meter (FOLK-01).

4. Tabulate your observations as per following table:-

S. No.	I_{LED} (mA)	Output Power, P_s (W)
1.		
2.		
3.		
4.		
5.		
6.		

Plot the curve I_{LED} **versus** P_s , and from the curve check:-

(i.)   Whether the curve is linear,
(ii.)   Find the value of R when I_{LED} is 2 mA.

Procedure for (b) :- Responsivity (R_λ) and Quantum efficiency (η) of PIN photo-detector,

1. Make the connections as shown in Figure 2 below:-
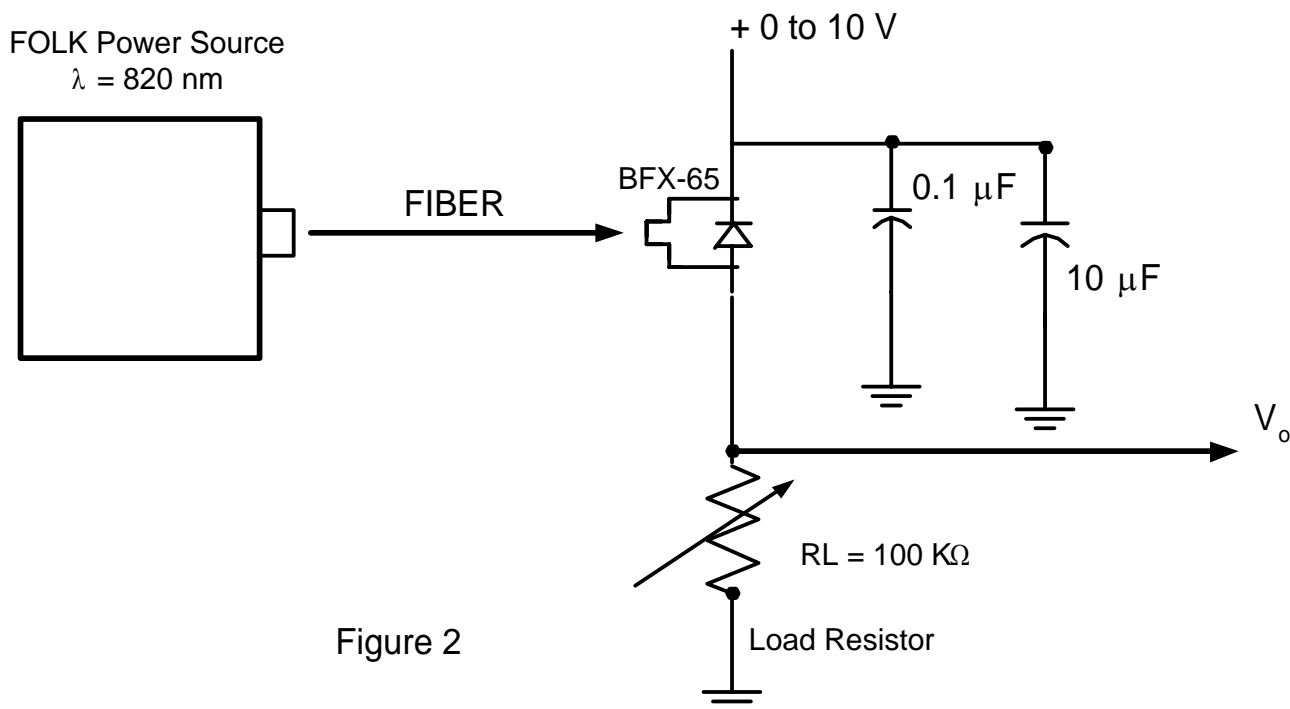

Figure 2

2. Couple one end of the plastic fiber to the optical transmitter (LED) and the other end to the Power Meter.

3. Set the power source so that the power meter indicates a definite amount of power, say 10μW.

4. Now, take out the other end of the fiber from the power meter and connect it to a photo detector.

5. Measure Vo (volts) for various values of PIN diode bias (0 to 10 volts in steps of 1 V or so).

6. Repeat the above step for various values of R_L (e.g., 10K, 47K, 100K etc.).

7. Tabulate the observations as shown below:-

S. No.	PIN Reverse Bias (Volts)	Load Resistor R_L	V_o (Volts)
1.	0 V	100 KΩ	
		47KΩ	
		10KΩ	
2.	1 V	100 KΩ	
		47KΩ	
		10KΩ	
3.	10 V	100 KΩ	
		47KΩ	
		10KΩ	

Results:-

1. Plot the effect of PIN reverse-bias on R_λ and η.
2. Check from your observations that the R_λ and η are independent of load resistance R_L and Optical power P_s.

Theory:-

The *equivalent circuit* of Photo Detector connected to the load resistor is given in the following diagram:-
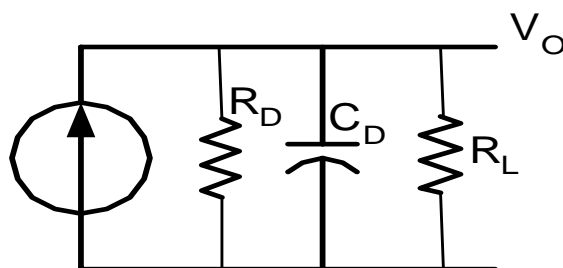
Equivaleant Ckt of Photo Detector

For doing measurement at DC, the effect of C_D is neglected.

Let i_s = photo current due to P_s = $R_\lambda P_s$,

where $\mathbf{R_\lambda}$ is the **Responsivity** of the photo detector.

Now, $\mathbf{V_o = i_s R_L}$,

But $\mathbf{i_s = (\eta e / h\nu) \, P_s = R_\lambda \, P_s = V_o / R_L}$,

where η = efficiency of the photo detector,

h = Plank's constant = 6.64×10^{-34} JS,

e = electric charge = 1.6×10^{-19} Coulombs,

v = frequency of light = $(3 \times 10^8) / (820 \times 10^{-9})$ Hz,

Responsivity = $R_\lambda = (V_o / R_L) P_s$ = Ampere / Watt

Quantum Efficiency = $\eta = \mathbf{Q.E = R_\lambda \, (h\nu / e) \, ;}$

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Lab. Course EL 492 (Communication Lab – III)

Experiment No. 3 (Pulse Radar)

Object:-   **To measure the distance of an object (target) using :-**
(a) the Pulsed Radar System in Time-domain
**(b) the Pulsed Radar System using Polar Plot**

Equipments Used:-

1. Simulated Pulsed Radar System, TeQuipment (UK) Model E15s
2. A Dual-Trace Oscilloscope having Z-modulation facility, 20 MHz CRO (Kenwood, Japan)
3. A Target (non-metallic)
4. Tape or Scale for measurement of actual distance,

Introduction:-

The word **'RADAR,** is an abbreviation of "**Ra**dio **D**etection **A**nd **R**anging". The Radar is basically a means of gathering information about the distant objects or targets, by sending electromagnetic waves to them and receiving back the same waves reflected by the object / target, in the form of echoes. On analyzing the echoes thus received, the distance, position and the speed of that target can be determined.

In fact, a Radar System consists of a transmitter and a receiver, each connected to a directional antenna. The transmitter is capable of sending out a large amount of power using microwaves through an antenna. The receiver collects as much amount of energy from the echoes received after reflection from the target, as possible, and then process these reflected echoes and displays the information about the distance, direction etc. of target, contained in these echoes, in a suitable way on a display screen. The receiving antenna is very often the same as the transmitting antenna. This is accomplished through a kind of time division multiplexing arrangement.

Experimental Setup
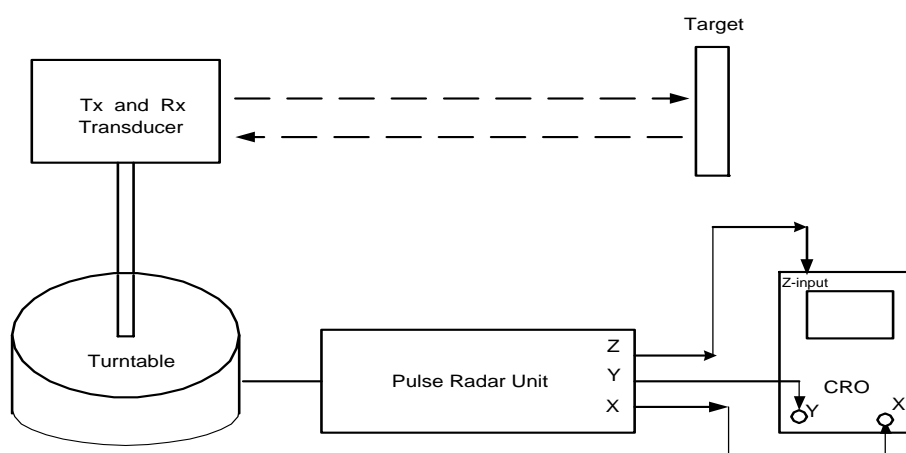
Experimental Setup for Pulse Radar System

The equipment consists of an electronic unit containing transmit-receive circuitry and a circuitry for the measurement of angular position & connection for oscilloscope and antenna.

In this Radar system, an **ultrasonic wave (40 KHz)** is used, so the transmitter consists of a 40 KHz carrier oscillator feeding a power output stage to derive an ultra-sonic transducer. The output stage is gated by a low frequency pulse source in order to produce a burst of **800 μsec** duration and repetition rate varying from 22 ms to 34 ms and a 40 KHz carrier frequency. The repetition rate can be adjusted by a potentiometer called **"Pulse rate".** The output of this goes to the ultra-sonic transducer.

The receiver consists of an ultrasonic detector mounted adjacent to the transmitter. The received signal is fed to the tuned amplifier followed by a variable gain control. The amplified received signal is then detected and is fed to a variable threshold comparator, the output of which is used to modulate the brightness of an oscilloscope (Z-modulation input).

The turntable consists of a rotating platform onto which the Tx and Rx transducers are mounted. The angular position of the turntable is detected by means of a sine-cosine potentiometer. The voltages produced by the potentiometer are fed into the integrator stages which charges during the receive phase and discharges during the transmit phase. The resulting ramp waveforms are used to control X – Y inputs of an oscilloscope together with Z-modulation input.

An auxiliary output is provided which gives access to the X- Y- & Z- signals and provides the facility for gain and offset adjustment of the X and Y signals. The range of the signal offset is +/- 4 V and the gain range is from 2 V to 5 V p-p.

(a) Procedure for operating Pulsed Radar System in time domain:-

1. Use a working surface away (upto 3 meters radius) from major obstructions.
2. Connect the electronic control unit to appropriate electrical main supply using the integral mains lead. Check for the required voltage.
3. Connect the 5-pins DIN leads from the Tx and Rx on the turntable to the 'transmit' and 'receive' sockets on the panel of the control unit.
4. Connect the 7-pins DIN lead from the turntable to the control unit.
5. Connect channel 1 (or A) of an oscilloscope to the transmit output socket and channel 2 (or B) to the receive output.
6. Select internal trigger on the oscilloscope and trigger from channel 1.
7. Set both oscilloscope channels to 5V/cm sensitivity and 5-ms/cm time base.
   ♦ Channel 1 will display 800 μs 'bursts' of 40 KHz carrier followed by a receive period which is variable by the 'pulse rate' potentiometer.
   ♦ Channel 2 displays the received echoes from target objects after amplification and detection.

♦ By relating the time taken to receive echo and the propagation speed, the target distance can be calculated and the Radar system can also be caliberated.

♦ Vary the PRR and see the effect.

(b) Procedure for Polar Plot :-

1. Connect channel 1 (Y-input) of the oscilloscope to "Scope Y" socket on the panel.
2. Connect channel 2 (X-input) of the oscilloscope to "Scope X" socket on the panel.
3. Connect the Z-modulation input of the oscilloscope to "Scope Z" socket on the panel.
4. Switch the oscilloscope sensitivity controls to 2 V/cm.
5. Ground both the coupling inputs of the scope and adjust the resulting dot to the center of the screen using the Y- and X-shift controls. Switch both inputs to DC.
6. Set the threshold control to approximately mid position and direct the Tx / Rx assembly towards a defined target placed within 3 meters operating radius.
7. Adjust oscilloscope INTENSITY control to optimize the trace.
8. When the turntable is rotated, the position, both angle and distance, will be indicated by the Radar plot. In fact the angular position of the target is nothing but the angular location of the antenna.

Observations:-

(a) For measurement of distance of the target in Time-domain:-

Duration between two consecutive pulses of the transmitter = ------ ms

So, range of the Pulse Radar = {(duration)x(velocity of sound)}/2

= --------------- meters

S. No.	Actual Distance of the Target (m)	Duration between Transmitted & Received pulses = Δt (ms)	Experimental distance (m)	% error
1.				
2.				
3.				
4.				
5.				

(b) For measurement of distance of the target using Polar Plot:-
For maximum range : X-Co-ordinate = ---------- cms
                    Y-Co-ordinate = ---------- cms
K = Calibration constant = -----------

S. No.	Actual Distance (m)	Experimental Distance				% error
		x-direction (x)	y-direction (y)	Angle	Calibrated distance $D = (x^2 + y^2)^{1/2}$ (m)	
1.						
2.						
3.						
4.						
5.						
6.						
7.						

Sample Calculations :-

(a) For measuring distance in Time-domain:-

$$D \;=\; (V_s . \, \Delta t\,)\,/\,2$$

Where, D = distance of the object from radar, (meters)

V_s = velocity of sound = 330 meters/sec

Δt = duration between the transmitted and the delayed received pulse, (secs)

(b) For measurement of distance using Polar Graph :

The length of the line in polar graph corresponds to the duration between consecutive transmitted pulses.

Length of the line in polar graph = $[(x)^2 + (y)^2]^{1/2}$

$$= \text{---------} = l$$

So, in terms of distance, l corresponds to (duration between two consecutive pulses) x 330m/s

Or, l corresponds to (--------) meters

Therefore   1 corresponds to = (--------) / l = K meters/div

Hence calibration constant for polar graph, K = ------ meters/div ,

Calibrated distance, d = $K.(x^2 + y^2)^{1/2}$ = meters
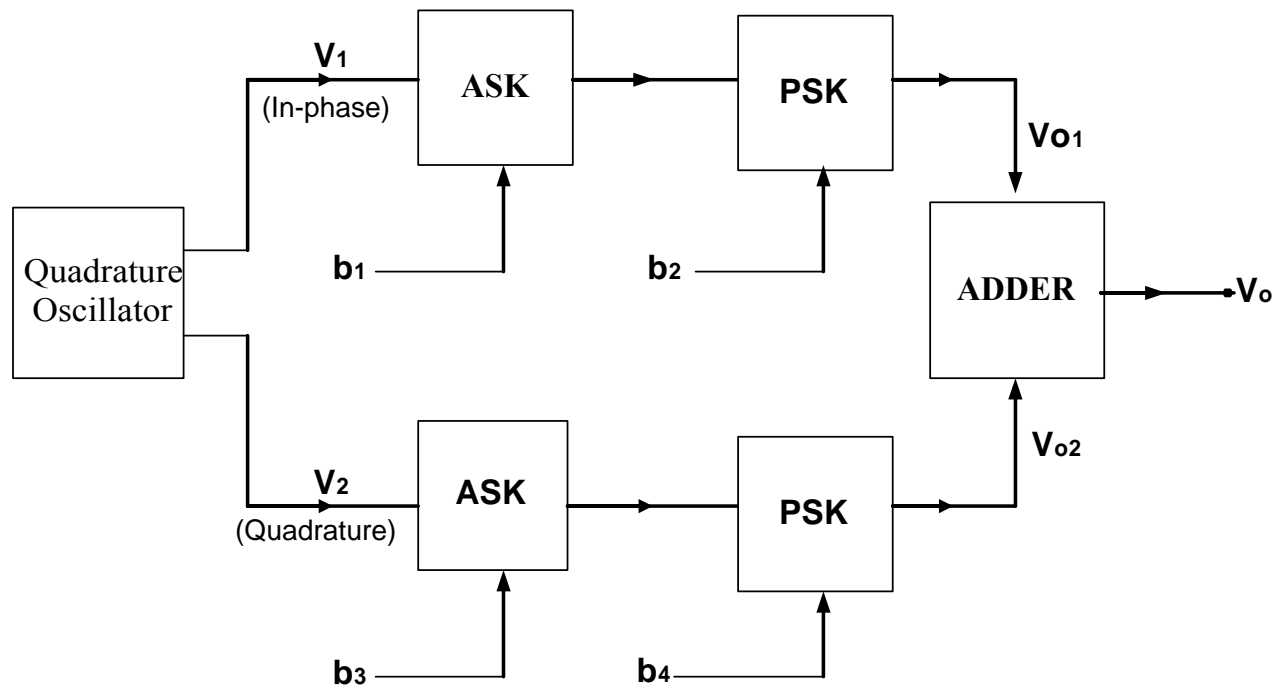
$$= \text{-------} \text{ meters}$$

Results :-

1. The distance of the object is measured by Pulse Radar (using ultrasonic waves) in time-domain and also by using polar plot.
2. The range of the Radar is found to be = ------ meters.

Discussion and Comments :-

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Study of 16-QAM

Block Diagram of 16 - QAM

PROCEDURE:-

1. Trace and identify different wires used in the circuits for inputs & outputs of different circuits. For example:-

    v_1 = In-phase component of the quadrature oscillator => brown wire,

    v_2 = quadrature component of the quadrature oscillator => yellow wire,

    The ASK & PSK circuits to be used for inphase component have one black wire for making connection with inphase component and two red wires for b_1 & b_2 and one red wire for its output v_{01}. Similarly, the ASK & PSK circuits to be used for quadrature component have one red wire for making connection with quadrature component and another red wire for b_3 & one black wire for b_4 and the one violet wire for its output v_{02}. The adder circuit uses two red wires for its two inputs and one black wire for its output.

2. Trace and identify the three wires to be used for connecting the symmetrical dual DC supply for biasing the QAM kit.

3. Now, make connections as shown in the above block diagram and keep the four binary input wires un-connected.

4. Connect the symmetrical dual DC supply for biasing the QAM kit.

5. Now, connect one external red wire to the +15 Volt terminal and another different color wire to the "Ground" terminal of the symmetrical dual DC supply, to be used for connecting '1' and '0' respectively to the four binary inputs wires.

6. Now, firstly, connect all the binary inputs b1, b2, b3 and b4 to '0' and turn ON the power supply, and connect the in-phase output of the quadrature oscillator (v_1) to one channel & the final output of the adder circuit (v_0) to the other channel of the oscilloscope, and view them simultaneously on the same screen after adjusting various controls of the CRO.

7. Now measure the amplitude of the output v_0 and its phase with respect to the in-phase signal v_1.

8. Take observation for all combinations of b_4 b_3 b_2 b_1 and record your readings in a tabular form as shown under observations.

OBSERVATIONS

| S. No.	b_4	b_3	b_2	b_1	Amplitude of v_0 (Volts)	Phase difference of v_0 w.r.t. v_1 (degrees)
1.	0	0	0	0		
2.	0	0	0	1		
3.	0	0	1	0		
4.	0	0	1	1		
15.	1	1	1	0		
16.	1	1	1	1		

Plot the signal constellation identifying the message points.

Report:-

1 Discuss the demodulation scheme for this system.

2 What are the limitations of the circuit used? How can they be minimized?

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APPENDIX

Design and Testing of a 7-bit PRBS Generator

$b_3 = 1001011$

$b_1 = 1110010$

$b2 = 1100101$
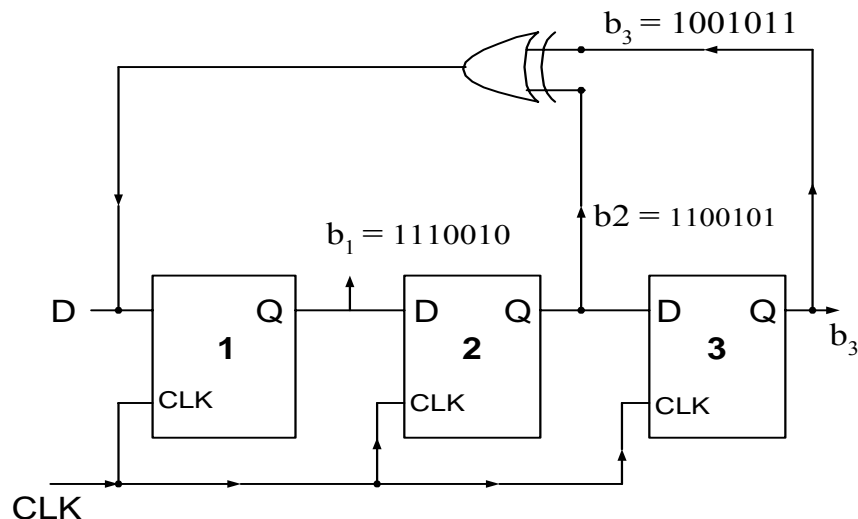
Logic Diagram of 7 - bit PRBS Generator

NB:-Touch Vcc (+5V) momentarily to 'D' (pin 2 of IC-1) to re-circulate the Data (in case no PRBS appears). To check the PCB wiring, take out all Ics, & check continuity of **Vcc**, GND, CLK to their respective pins as shown in the figure 2 below and also the continuity between other pins. (See Fig 2 below).

1. **Connect/check Vcc (+5V)** to pins # 1, 4, 10, 13, 14 of IC-1 (7474) and to pins # 1, 4, 14 of IC-2 (7474) & to pin # 14 of IC-3 (7486).
2. **Connect/check GND (0 V)** to pin # 7 of all ICs
3. **Pins Not connected**: - 6, 8 of IC-1, 6, 8, 9, 10, 11, 12, 13 of IC-2 & 4,5,6,8,9,10,11,12,13 of IC-3
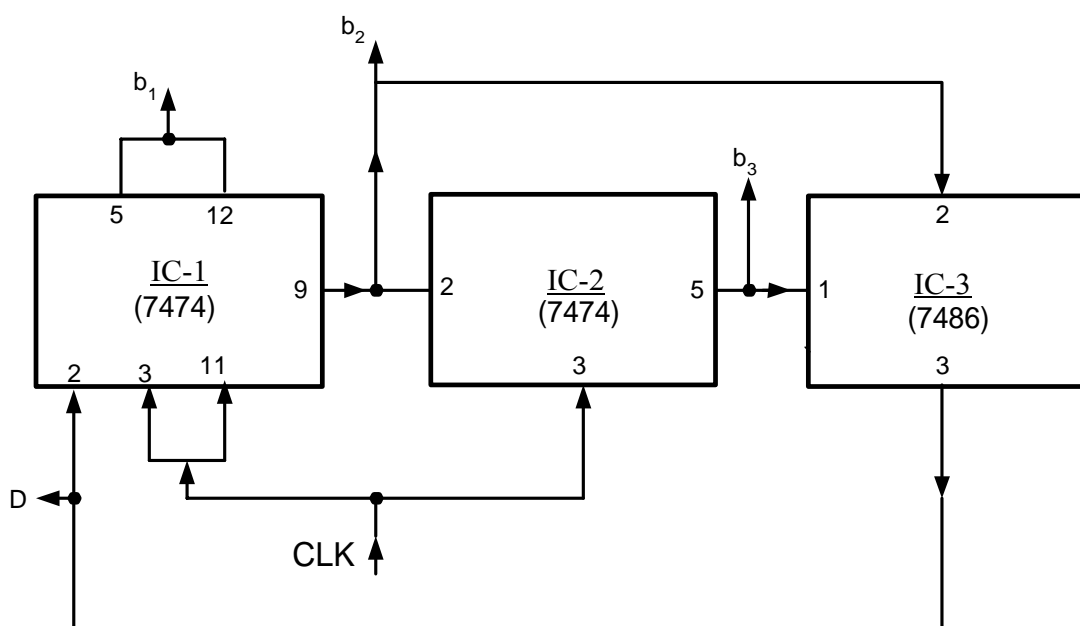4. **Connect/check TTL Clock (6 KHz) to** :- pins # 3 & 11 of IC-1, and 3 of IC-2
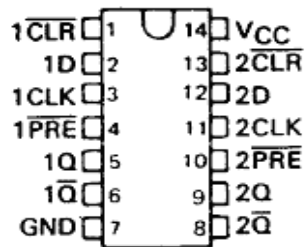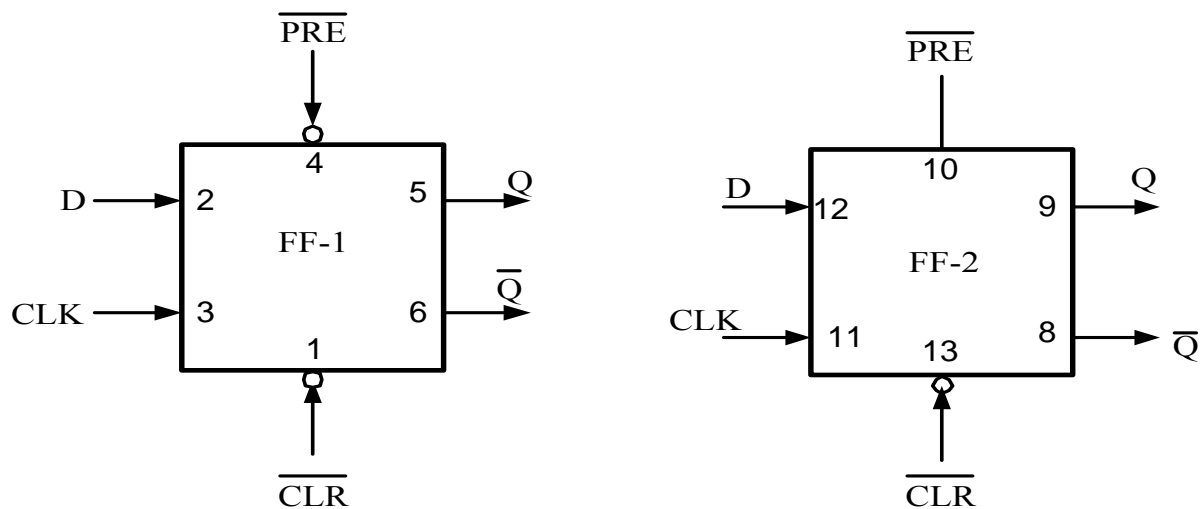

Figure 2:- Connection Diagram

SN74LS74A, SN74S74 . . . D OR N PACKAGE
(TOP VIEW)

```
        ┌──┬─┬──┐
1CLR ─┤1  U  14├─ V_CC
 1D  ─┤2     13├─ 2CLR
1CLK ─┤3     12├─ 2D
1PRE ─┤4     11├─ 2CLK
 1Q  ─┤5     10├─ 2PRE
 1Q̄  ─┤6      9├─ 2Q
GND  ─┤7      8├─ 2Q̄
        └──────┘
```

7474 = Dual D- Flip-flop with Preset (PRE) & Clear (CLR) :-

FUNCTION TABLE

INPUTS				OUTPUTS	
PRE	CLR	CLK	D	Q	Q̄
L	H	X	X	H	L
H	L	X	X	L	H
L	L	X	X	H↑	H↑
H	H	↑	H	H	L
H	H	↑	L	L	H
H	H	L	X	Q_0	$\overline{Q}_0$

Note:-
1. The Preset control (PRE) and the Clear control (CLR) are active at logical '0'.
2. When PRE = 0 (i.e., active), then the FF is 'Set" and Q = 1, irrespective of all other inputs.
3. To reset (i.e., clear) the FF (Q = 0), make the control PRE = 1 & CLR = 0.
4. The FF will transfer the Data from D to Q, only at rising edges of CLK, as long as PRE & CLR are both '1' (high) and the Data will stay on Q, until the next CLK rising edge comes.

Pin-wise Checking of All ICs of PRBS Generator

Pin #	IC-1 (7474)	IC-2 (7474)	IC-3 (7486)
1.	Vcc (+5V)	Vcc (+5V)	b_3
2.	D	b_2	b_2
3.	CLK	CLK	D
4.	Vcc (+5V)	Vcc (+5V)	NC
5.	b_1	b_3	NC
6.	NC	NC	NC
7.	GND (0 V)	GND (0 V)	GND (0 V)
8.	NC	NC	NC
9.	b_2	NC	NC
10.	Vcc (+5V)	NC	NC
11.	CLK	NC	NC
12.	b_1	NC	NC
13.	Vcc (+5V)	NC	NC
14.	Vcc (+5V)	Vcc (+5V)	Vcc (+5V)

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

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