Experiment No.: 5

Title: Experimental study of QPSK and OQPSK modulation and demodulation.

Roll No.: _________ Batch: __________

Date of Performance: _________________

Date of Assessment: ___________________

Particulars	Marks
Attendance (05)	
Journal (05)	
Performance (05)	
Understanding (05)	
Total (20)	
Signature of Staff Member	

Experiment No: 5

Title: Experimental study of QPSK and OQPSK modulation and demodulation.

Aim: To study and observe the working of a QPSK (Quadrature Phase Shift Keying) transmitter and receiver using a suitable hardware setup or trainer kit.

Prerequisites:

- Basic concepts of digital modulation.
- Binary data representation.
- Phase Shift Keying (especially BPSK).
- Working knowledge of signal generators, oscilloscopes, and spectrum analyzers.

Objectives:

- To understand the principle of QPSK modulation and demodulation.
- To observe the QPSK modulated signal waveform on a CRO/DSO.
- To study the constellation diagram.
- To verify the transmission and reception of QPSK modulated signals.

Apparatus:

QPSK transmitter & receiver trainer kit, function generator, digital storage oscilloscope, connecting wires and probes, DC power supply.

Theory:

To transmit digital data on analog lines (Viz. telephone) or even into space, modulation of analog signal is required. Simplest way is BPSK Where one phase of carrier is transmitted for '1' and inverted carrier is transmitted for digital '0'. Here if bit rate is "Tb' then bandwidth required Is '2Tb'. To reduce this bandwidth requirement QPSK can be used. For QPSK bandwidth required is 'Tb' i. e. half that of BPSK.

'QPSK' technique comes under 'carrier modulation' type. Here I/P to the transmitter is digital data, in between processing is in analog form & finally O/P of receiver is again digital data same as fed to transmitter.

'Q' in 'QPSK' means quadrature i. e. 4, four phases of carrier are transmitted depending upon bit pattern. e.g. we know that incoming bit pattern is divided into 'odd' & 'even' bit patterns. Odd pattern is multiplied by sine wave, & even pattern is multiplied by cos wave. Sine & cos waves are 90 degree phase shifted. Now resulting two PSK's are added & we get vector addition O/P i. e. if both odd & even pattern bits are '1' we get 45degree phase shifted carrier. If odd bit is 1 & even bit is 0 we get 135 degree phase carrier. If odd bit is 0 & even also 0 we get 225 degree. If odd bit is 0 & even bit is 1 we get 315 degree.

In QPSK, two consecutive bits are stored & for resulting four combinations (4) different phases of carrier are transmitted. By using 'D' flip- flop type arrangement incoming bit pattern is divided into two bit patterns Viz. odd pattern & even pattern, for obtaining this, basic clock whose frequency is 'fb' is divided by two, resulting odd & even clock frequencies are 'fb/2 '& they are complementary. Each bit is stored for 2Tb**.** time period.

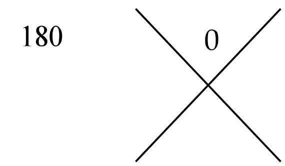
Odd pattern will have bit no. 1,3,5,7, etc. each stored for '2Tb' & even bit pattern will have bit no.2,4,6, etc. stored for '2 Tb'.

Here active edges of, odd & even clocks are separated by time 'Tb'. So out of two bits only one bit is changing (either odd or even) after each 'Tb' period but every bit is there for 2 Tb time ; so in this offset QPSK system every time phase changes by 90 degree only.

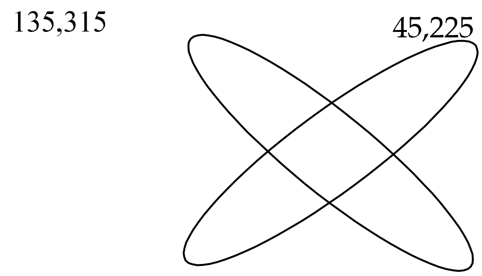
At receiver carrier is recovered from QPSK Signal itself. This is Synchronous reception. To recover carrier QPSK signal is raised to power Four by using analog multiplier. Then resulting signal is passed through Bandpass filter whose center frequency is adjusted to 4 times carrier Frequency. Then O/p of bandpass filter is divided by 4 to get carrier Frequency. In this kit IC 1496 is used as analog multiplier. Then QPSK signal is multiplied by 'SINE & COS' carrier waves. As A result, we get odd & even patterns after filtering & integrating multiplier Outputs. Now by combining these two patterns we can get original bit Patterns. This is done by using switch (analog switch).

To observe QPSK, we have given two bit patterns (i. e. repeated after 5 bits.) so that on analog CRO we can observe the wave forms. Here carrier phase changes every after time 'tb' (bit period) depending upon odd & even bit combination. It is difficult to observe this on analog CRO. Details of these phase changes are shown in diagram attached. To observe QPSK we can use Lissajous patterns. i.e. If we connect 'SINE' wave to one channel & 'COS' wave to the other channel & press 'XY' button of CRO we get circle on screen. (this is Lissajous pattern for 90-degree phase shifted waves)

Now if we connect 'SINE' & its associated PSK signal to two channels & press 'XY' mode button we get two crossed lines. (One of 0 degree & the other for 180-degree phase).



If ‘SINE’ & ‘QPSK’ signals are connected to two channels, on ‘XY’ mode we get two crossed ellipses. This is because for 45 ,135 ,225 & 315 degree we get ellipse as Lissajous fig.



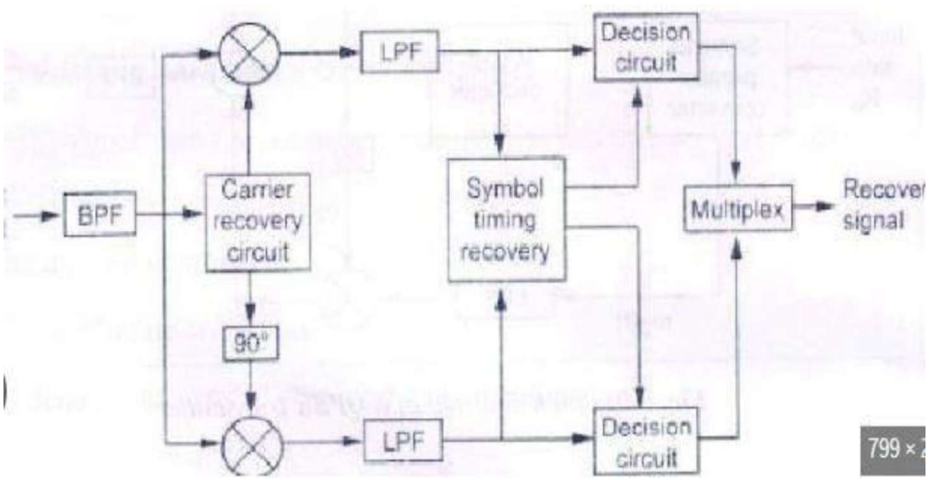
Also, at transmitter observe that ‘SINE’, ‘COS’ wave amplitudes are lesser than resulting ‘QPSK’ wave because of vector addition.

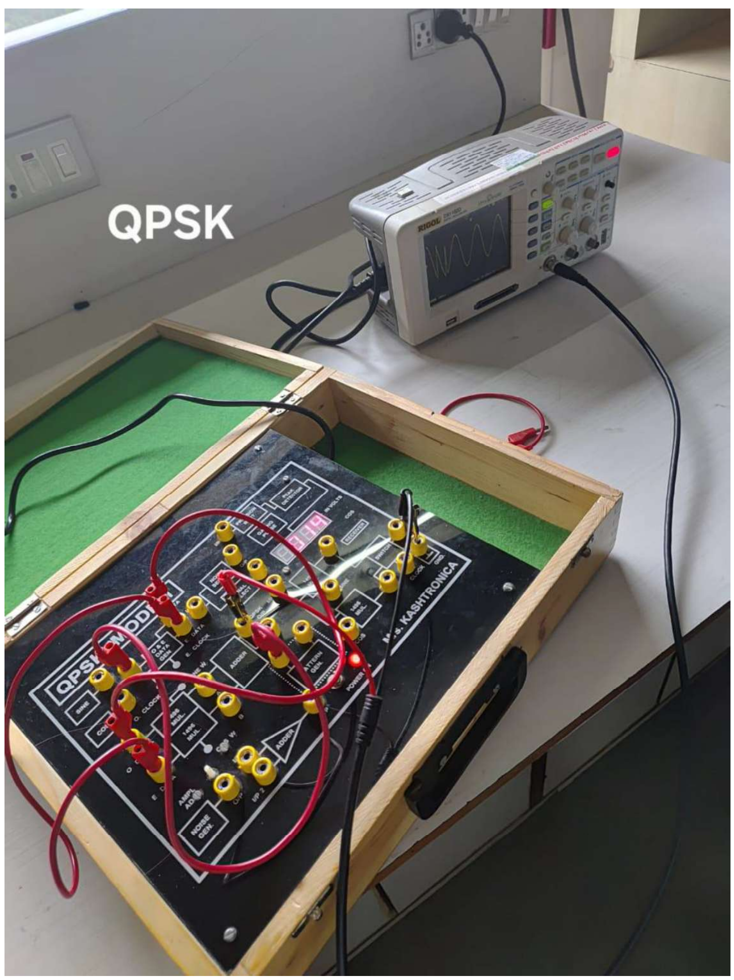
We are doing this complex processing to save on bandwidth requirement of the system. This can be observed on CRO also. Observe bit pattern on CRO along with odd or even bit pattern, you will come to know that odd or even bit pattern frequency is lesser than original bit pattern frequency.

Comments on carrier recovery section:-

Here we extract original carrier from transmitted QPSK signal itself. To raise QPSK signal to power 4 first we use squaring cct. & then again one more is squaring cct. to raise QPSK to power 4, if we observe O/P of 1^{st} SQ. cct. its frequency is double that of original ‘SINE’ wave at transmitter (observe these two signals simultaneously on dual trace CRO) also O/Ps of both SQ. ccts. are not exact SINE wave shape, since it contains other harmonics also. O/P of 2^{nd} SQ. cct. is having 4 times freq. that of ‘SINE’ to suppress other harmonics we use band pass filter whose center freq. is 4 times original ‘SINE’ wave freq. Then we divide this freq. by four. Since 4 possible phases are transmitted, finally we get exact ‘SINE’ wave but it will have 4 diff. possible phase shifts. So we cannot use same carrier directly at receiver. This recovered carrier has to be passed through all pass N/W to match phase shift. This is not included in this kit to avoid complexity.

CONNECTION DIAGRAM:



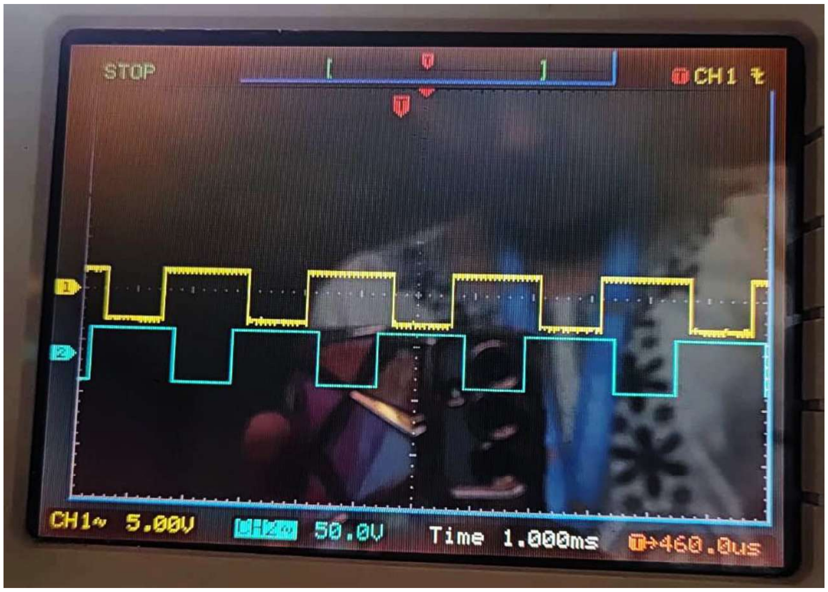


Procedure: -

1] Observe 'CLK'O/p, measure its frequency. This is nothing but 'Fb'.

2] Connect 'CLK'O/p to I/p of 'Odd & Even CLK Gen' observe 'O' CLK (i. e. odd CLK) & 'E CLK' Frequency is 'fb/2'.

3] Observe two patterns of pattern gen. & connect first pattern to I/p of O & E Data generator.

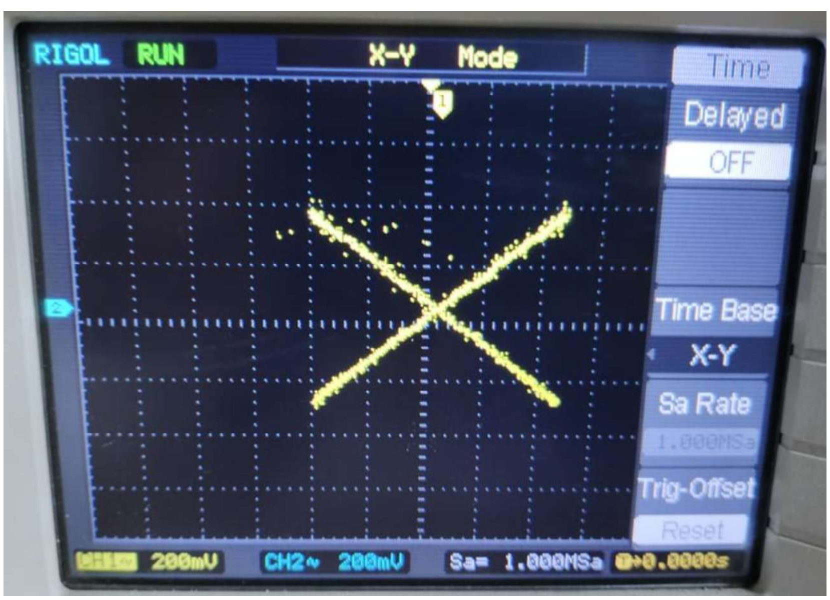


4] Observe 'O Data' (i. e. Odd Data) & 'E' Data along with I/p pattern on dual trace CRO.

5] Connect 'O' Data to 'O' Data pt. Pf 1496 Mul'. [I.e. 1496 Multiplier].

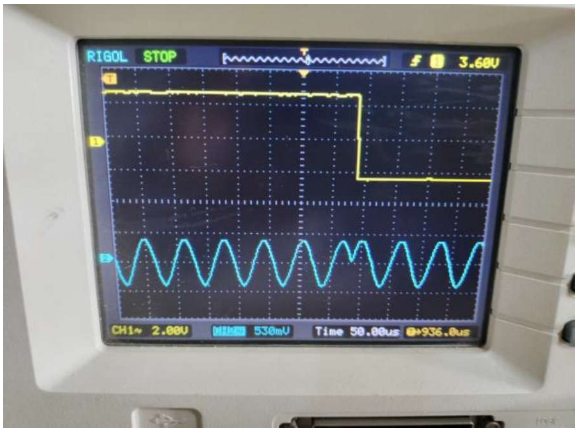
6] Connect 'E. Data' to 'Edata' pt. of 1496 'Mul'.

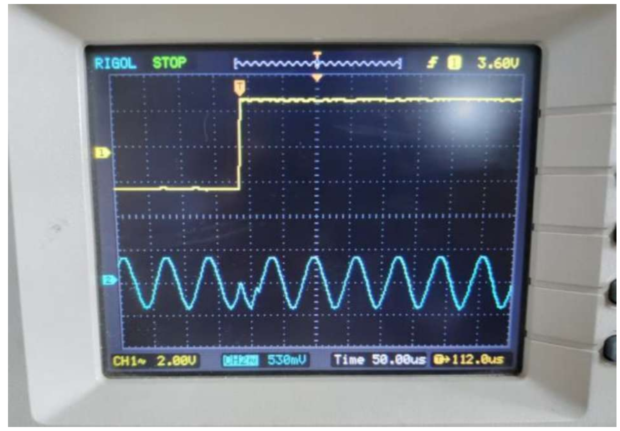
7] Observe 'SINE & COS waves & measure their frequencies. & also observe on 'XY' mode of CRO.



8] Observe pt. A with 'O. Data' on dual trace CRO. This is PSK signal of 'O' Data.

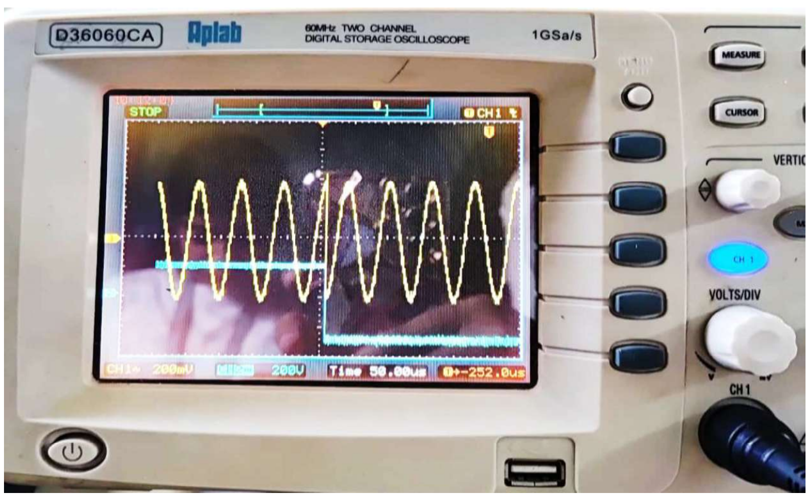
9] Observe pt. A with sine wave on CRO. ('XY' mode)



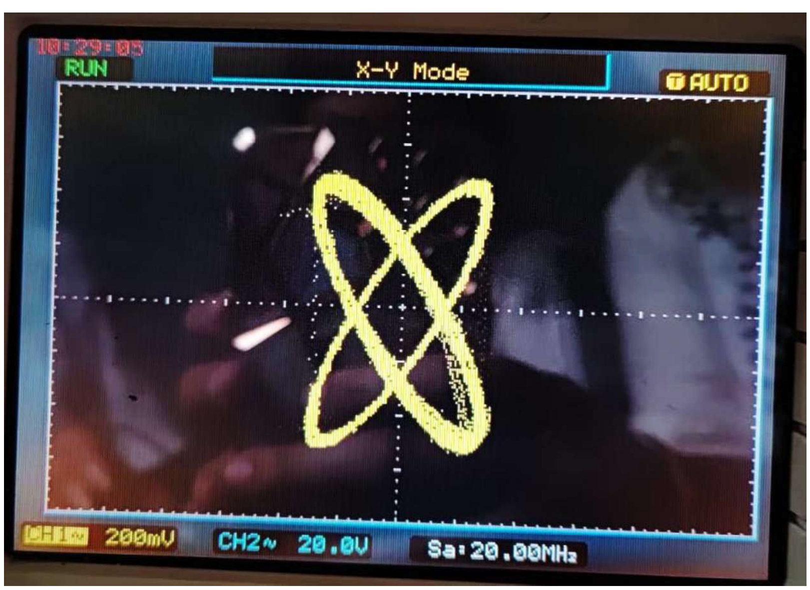


10] Observe pt. 'B' with 'E' Data', this is PSK signal of 'E. Data'.

11] Observe pt. B with cos wave on CRO. ('XY' mode)



12] Observe QPSK O/p with bit pattern. & then with Sine wave. Press 'XY' mode & observe two ellipses.



13] Connect QPSK O/p to I/p of '1496 Sq. 1' block, observe its O/p, this is squared O/p. (frequency doubled).

14] Connect O/p. of above to I/p of '1496 sq. 2' block & observe its O/p, it is powered 4 O/p (its frequency is 4 times carrier Frequency).

15] Connect O/p of 1496 Sq. 2' to I/p of 'BP Filter 4F' adjust pot given above this block to get carrier properly at the O/p of BP Filter.

16] Connect O/p of 'BP Filter' to I/p of -:- 4 N/W' observe SINE & COS O/ps.

17] Connect QPSK O/p to common I/p pt. of 2, 1496 Mul blocks.

18] Connect SINE wave from transmitter section to SINE of 1496 MUL block.

19] Connect COS wave from transmitter section to COS of 1496 MUL block.

20] Observe final O/p with the original I/p bit pattern. There is delay between i/p & o/p.

21] Observe pt. 'C' & 'D'. These are odd & even bit patterns received at receiver.

Conclusion:

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