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MODEM Process of QPSK signal using DS-SS – CDMA Communication system.

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ABSTRACT

The DSSS is the backbone of the emerging communication system known as CDMA. QPSK MODEM process has to be perform via DSSS technique and compare its BER with SNR. DSSS have some advantages like highly resistant to jamming, reduced signal interception. Formerly BPSK modulation techniques were used. BPSK modulation has some drawbacks. It is unsuitable for high data rate applications. Here QPSK modulation is used which is highly effective than BPSK. It is suitable for high data rate applications. DSSS is used to transmit all types of signals like data, audio and video signals at high data rate. Whereas the former technology was able to transmit only audio signals and not suitable for transmitting video signals. The noise signals have been introduced to detect the interference level. The spread and unspread signals are being modulate and demodulate and finally compare together with the data signal. The sample rate can be limited to 80,000 smaples per second when data is split into Q and I channels. The PRN sequence rate will be set to 20, 000 bps or less. The data rate has been originally desgned to run at 2000 bps. The Theoratical BER for AWGN Rayleigh fading and simulate BER for users will also be compare.

Keywords: QPSK, BER, SNR, DSSS, CDMA

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INTRODUCTION

The direct sequence spread spectrum (DSSS) systems and corresponding code division multiple access (CDMA) systems have been widely utilized for few decades in radar, communication, remote control and telemetry. Generally, the spread-spectrum receiver must be synchronizing before the operation of dispreading. Timing and Pseudo-noise (PN) sequence knowledge is required for DSSS. Thus, synchronization can perform in two methods. First, PN acquisition known as coarse synchronization stage and PN tracking refers the fine synchronization stage. Among these two, PN acquisition is a more challenging to many authors [1,2]. To generate synchronization, internal algebraic structure of PN spreading sequence knowledge can be gathered from the conventional acquisition methods. While demonstrating the good performance with low-noise environments, interference and high levels of noise must be eliminate because of high rate of false alarms. Moreover, significant algebraic methods for synchronization have been developed for chip constellations, nonlinear codes, unknown code structure, frequency offsets, residual delays and narrow-band interferences [1,2]. Cyclic autocorrelation or autocorrelation methods can be facilitate to despread the DSSS signals even without knowing the code [3].

Spread spectrum signals have been utilized for secure communications for two decades. At present, these signals are also favour for military domain, especially in CDMA systems. Spread spectrum signal can transmit at very low power without any interference as jamming to multi-path propagation. This method is more precise for transmitting, since the receiver must know the sequence which is used by the transmitter and recover the transmitted data with the help of correlator. DSSS transmitters facilitate a periodic pseudorandom sequence for modulate the baseband signal before the data transmission. The pseudorandom sequence utilized by the transmitter is unknown in the context of spectrum surveillance. Hence, it is very difficult to demodulate and detect the DSSS transmission data owing to the low noise level [4]. In multi-user CDMA system, one can automatically detect the spreading sequence without the knowledge of the transmitters pseudo-noise (PN) code.

DSSS communication signals power spectrum density is relatively low and buried in ambient noise. Besides these signals has been used for low probability of interception, anti-jamming and secure communication in military for two decades [5]. Nowadays, DSSS are also utilized in civil communications, particularly in CDMA systems.

Owing to their low possibility of interference, these types of signals increase the difficulty of spectrum reconnaissance and surveillance. DSSS transmitters utilize high speed periodical pseudo-noise sequence for modulate the base-band signal before it is proceed for transmission. In spectrum reconnaissance and surveillance, the sequence of pseudo-noise used by the transmitter is unpredictable. Hence, identification, blind detection, demodulation and estimation of a DSSS transmission are really challenge one. But using progress of technology and times, the methods for blind estimation and detection of DSSS signals continuously appear. According to the type of the estimated parameters, the blind estimation and detection of DSSS signals can be classified as signature waveforms estimation of DSSS signals [6-15]. Parameters estimation of DSSS signals and simultaneous estimation of signature waveforms and parameters for DSSS signals [16-18]. Based on the type of estimated signals, the estimated and blind detection of DSSS signals can be classified as long-code modulated DSSS signals [19], base-band DSSS signals [20-22], DSSS signals under narrow band interference, DSSS signals with residual carrier and phase-shift-keying modulated DSSS signals. The inspiration behind the present work is to simulate generation and transmission of a direct sequence spread spectrum modulation of a QPSK signal, injects random and jamming noise into the transmission path and demodulates the received signal. The BER rate has to be comparing with SNR and enhance the MODEM of QPSK signal in DSSS technique. The schematic diagram for QPSK MODEM architecture are shown in Figure 1 and 2.

PROPOSED QPSK MODEM ARCHITECTURE

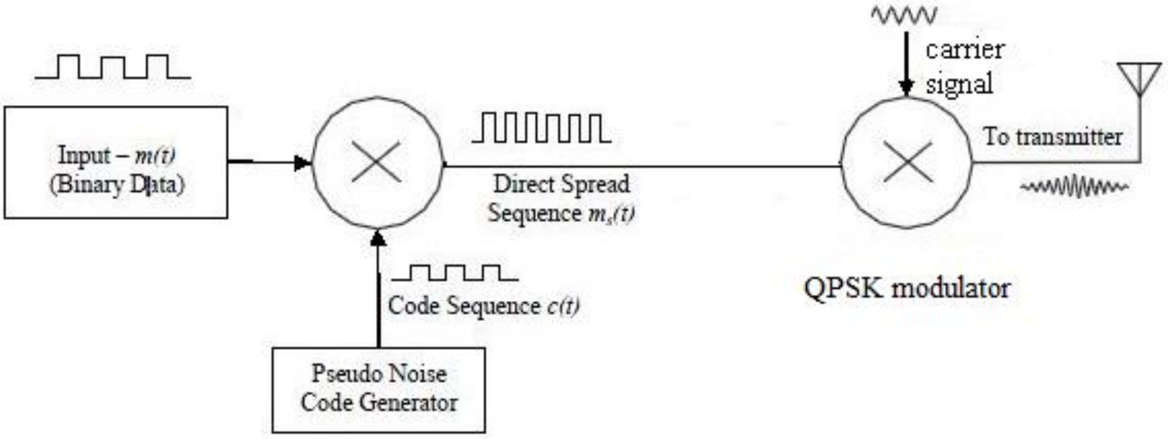


Fig 1. Transmitter Module with QPSK Modulation

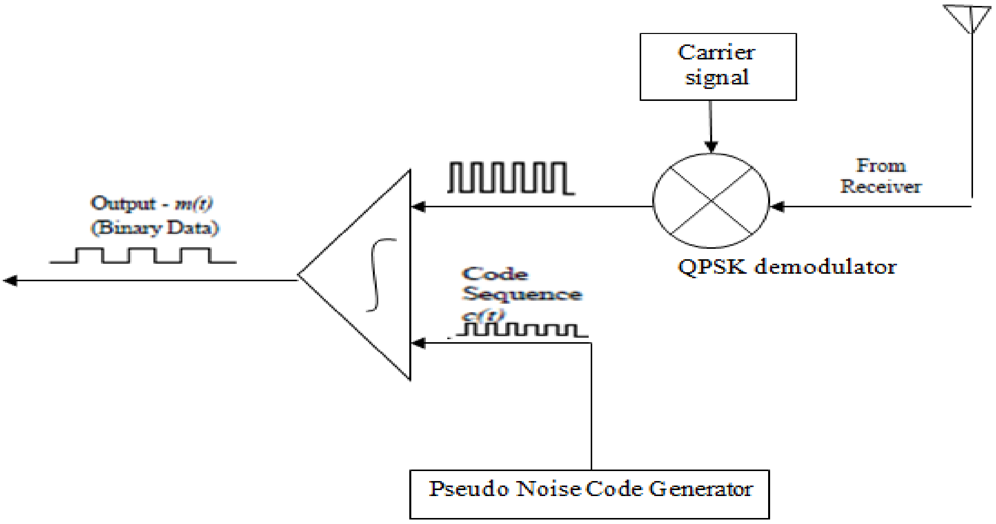


Fig 2. Receiver Module with QPSK Demodulation

QPSK MODEM DESCRIPTION

QPSK MODULATION

QPSK is the digital modulation technique. It is in the form of PSK which two bits are modulated at once, selecting one of four possible carrier phase shifts.(0,π/2,π and 3π/2)

QPSK perform changing the phase of the In-phase(I) carrier from 0 to 180 and the quadrature phase(Q) carrier between 90 and 270.this is use to indicate the four states of a 2-binary code. Each state of these carriers referred to as a symbol.

QPSK is a widely used method of transferring digital data by changing or modulating the phase of a carrier signal. In the digital data is represented by 4 points around a circle which considered to 4 phases of the carrier signal. These points are called symbols. Figure 3 shows the constellation diagram of QPSM.

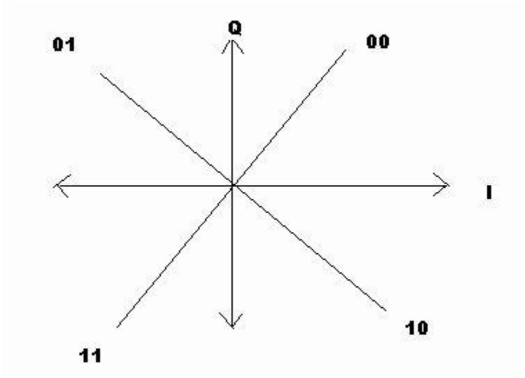


Fig 3. Constellation Diagram of QPSK

IMPLEMENTATION

The implementation of QPSK is more general than that of BPSK and also indicates the implementation of higher-order PSK. Writing the symbols in the constellation diagram in terms of the sine and cosine waves used to transmit them:

$$s_n(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(2\pi f_c t + (2n-1)\frac{\pi}{4}\right), \quad n = 1,2,3,4.$$

This yields the four phases π/4, 3π/4, 5π/4 and 7π/4 as needed.
This results in a two-dimensional signal space with unit basis functions

$$\phi_1(t) = \sqrt{\frac{2}{T_s}} \cos(2\pi f_c t)$$
$$\phi_2(t) = \sqrt{\frac{2}{T_s}} \sin(2\pi f_c t)$$

The first basis function is used as the in-phase component of the signal and the second as the quadrature component of the signal.

Hence, the signal constellation consists of the signal-space 4 points

$$\left(\pm\sqrt{E_s/2}, \pm\sqrt{E_s/2}\right).$$

The factors of 1/2 indicate that the total power is split equally between the two carriers.

Comparing these basis functions with that for BPSK shows clearly how QPSK can be viewed as two independent BPSK signals. Note that the signal-space points for BPSK do not need to split the symbol (bit) energy over the two carriers in the scheme shown in the BPSK constellation diagram.

QPSK systems can be implemented in a number of ways. An illustration of the major components of the transmitter and receiver structure is shown Figure 4 and 5 respectively.

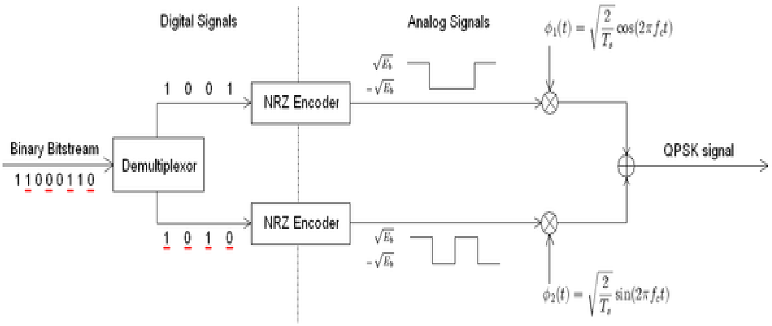


Fig 4. Conceptual Transmitter Structure for QPSk

The binary data stream is split into the in-phase and quadrature-phase components. These are then separately modulated onto two orthogonal basis functions. In this implementation, two sinusoids are used. Afterwards, the two signals are superimposed, and the resulting signal is the QPSK signal. Note the use of polar non-return-to-zero encoding. These encoders can be placed before for binary data source, but have been placed after to illustrate the conceptual difference between digital and analog signals involved with digital modulation.

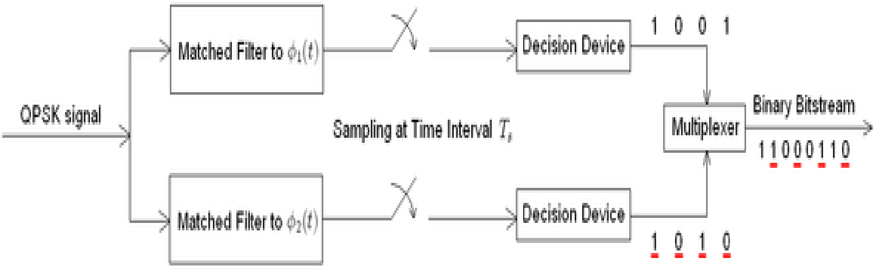


Fig 5. Receiver structure of QPSK

The matched filters can be replaced with correlators. Each detection device uses a reference threshold value to determine whether a 1 or 0 is detected.

Bit error rate

Although QPSK can be viewed as a quaternary modulation, it is easier to see it as two independently modulated quadrature carriers. With this interpretation, the even (or odd) bits are used to modulate the in-phase component of the carrier, while the odd (or even) bits are used to modulate the quadrature-phase component of the carrier. BPSK is used on both carriers and they can be independently demodulated.

As a result, the probability of bit-error for QPSK is the same as for BPSK:

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right).$$

However, in order to achieve the same bit-error probability as BPSK, QPSK uses twice the power (since two bits are transmitted simultaneously).

The symbol error rate is given by:

$$P_s = 1 - (1 - P_b)^2$$

$$= 2Q\left(\sqrt{\frac{E_s}{N_0}}\right) - Q^2\left(\sqrt{\frac{E_s}{N_0}}\right)^2.$$

If the signal-to-noise ratio is high (as is necessary for practical QPSK systems) the probability of symbol error may be approximated:

$$P_s \approx 2Q\left(\sqrt{\frac{E_s}{N_0}}\right)$$

QPSK signal in the time domain

The modulated signal is shown below for a short segment of a random binary data-stream. The two carrier waves are a cosine wave and a sine wave, as indicated by the signal-space analysis above. Here, the odd-numbered bits have been assigned to the in-phase component and the even-numbered bits to the quadrature component (taking the first bit as number 1). The total signal — the sum of the two components — is shown at the bottom. Jumps in phase can be seen as the PSK changes the phase on each component at the start of each bit-period. The topmost waveform alone matches the description given for QPSK as shown in Figure 6.

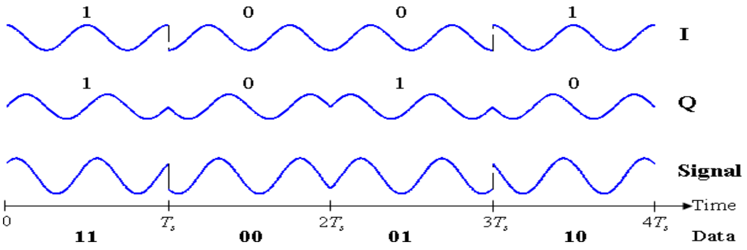


Fig 6. Timing diagram for QPSK.

The binary data stream is shown beneath the time axis. The two signal components with their bit assignments are shown the top and the total, combined signal at the bottom. Note the abrupt changes in phase at some of the bit-period boundaries.

The binary data that is conveyed by this waveform is: 1 1 0 0 0 1 1 0.

- The odd bits, highlighted here, contribute to the in-phase component: 1 1 0 0 0 1 1 0
- The even bits, highlighted here, contribute to the quadrature-phase component: 1 1 0 0 0 1 1 0

Offset QPSK (OQPSK)

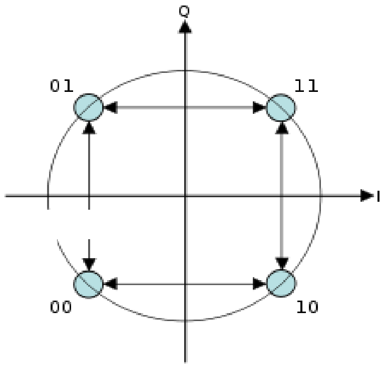


Fig 7. OQPSK

Signal doesn't cross zero, because only one bit of the symbol is changed at a time Offset quadrature phase-shift keying (OQPSK) is a variant of phase-shift keying modulation using 4 different values of the phase to transmit. It is sometimes called Staggered quadrature phase-shift keying (SQPSK) as referred in Figure 8.

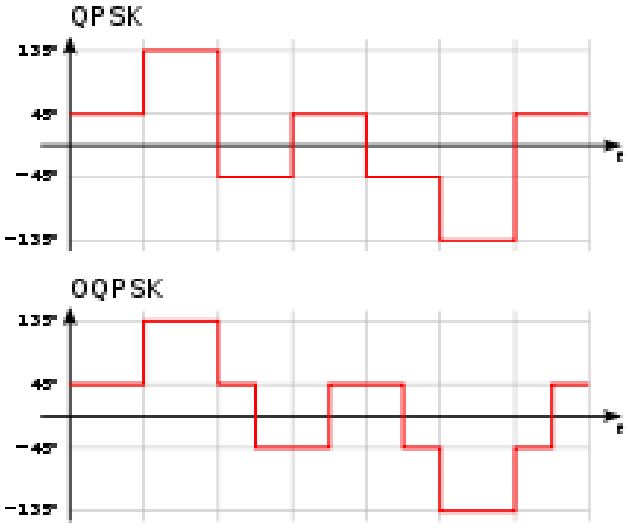


Fig 8. Difference of the phase between QPSK and OQPSK

Taking four values of the phase (two bits) at a time to construct a QPSK symbol can allow the phase of the signal to jump by as much as 180° at a time. When the signal is low-pass filtered (as is typical in a transmitter), these phase-shifts result in large amplitude fluctuations, an undesirable quality in communication systems. By offsetting the timing of the odd and even bits by one bit-period, or half a symbol-period, the in-phase and quadrature components will never change at the same time. In the constellation diagram shown on the right, it can be seen that this will limit the phase-shift to no more than 90° at a time. This yields much lower amplitude fluctuations than non-offset QPSK and is sometimes preferred in practice.

The picture on the right shows the difference in the behavior of the phase between ordinary QPSK and OQPSK. It can be seen that in the first plot the phase can change by 180° at once, while in OQPSK the changes are never greater than 90°.

The modulated signal is shown below for a short segment of a random binary data-stream. Note the half symbol-period offset between the two component waves. The sudden phase-shifts occur about twice as often as for QPSK (since the signals no longer change together), but they are less severe. In other words, the magnitude of jumps is smaller in OQPSK when compared to QPSK.

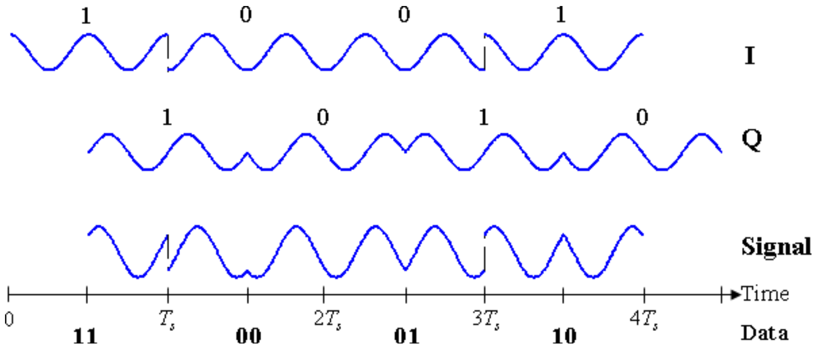


Fig 9. Timing diagram for offset-QPSK.

The binary data stream is shown beneath the time axis. The two signal components with their bit assignments are shown the top and the total, combined signal at the bottom. Note the half-period offset between the two signal components.

π /4–QPSK

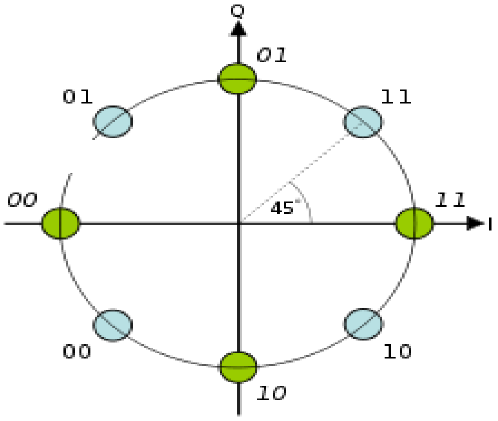


Fig 10. Dual constellation diagram for π/4-QPSK.

This shows the two separate constellations with identical Gray coding but rotated by 45° with respect to each other.

This variant of QPSK uses two identical constellations which are rotated by 45° ($\pi/4$ radians, hence the name) with respect to one another. Usually, either the even or odd symbols are used to select points from one of the constellations and the other symbols select points from the other constellation. This also reduces the phase-shifts from a maximum of 180°, but only to a maximum of 135° and so the amplitude fluctuations of $\pi/4$–QPSK are between OQPSK and non-offset QPSK.

One property this modulation scheme possesses is that if the modulated signal is represented in the complex domain, it does not have any paths through the origin. In other words, the signal does not pass through the origin. This lowers the dynamical range of fluctuations in the signal which is desirable when engineering communications signals.

On the other hand, $\pi/4$–QPSK lends itself to easy demodulation and has been adopted for use in, for example, TDMA cellular telephone systems.

The modulated signal is shown below for a short segment of a random binary data-stream. The construction is the same as above for ordinary QPSK. Successive symbols are taken from the two constellations shown in the diagram. Thus, the first symbol (1 1) is taken from the 'blue' constellation and the second symbol (0 0) is taken from the 'green' constellation. Note that magnitudes of the two component waves change as they switch between constellations, but the total signal's magnitude remains constant (constant envelope). The phase-shifts are between those of the two previous timing-diagrams as shown in Figure 11.

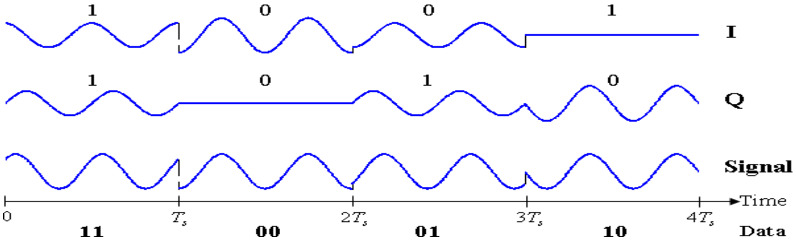


Fig 11. Timing diagram for π/4-QPSK.

The binary data stream is shown beneath the time axis. The two signal components with their bit assignments are shown the top and the total, combined signal at the bottom. Note that successive symbols are taken alternately from the two constellations, starting with the 'blue' one.

SOQPSK

The license-free shaped-offset QPSK (SOQPSK) is interoperable with Feher-patented QPSK (FQPSK), in the sense that an integrate-and-dump offset QPSK detector produces the same output no matter which kind of transmitter is used.

These modulations carefully shape the I and Q waveforms such that they change very smoothly, and the signal stays constant-amplitude even during signal transitions. (Rather than traveling instantly from one symbol to another, or even linearly, it travels smoothly around the constant-amplitude circle from one symbol to the next.)

The standard description of SOQPSK-TG involves ternary symbols.

DPQPSK

Dual-polarization quadrature phase shift keying (DPQPSK) or dual-polarization QPSK - involves the polarization multiplexing of two different QPSK signals, thus improving the spectral efficiency by a factor of 2. This is a cost-effective alternative, to utilizing 16-PSK instead of QPSK to double the spectral efficiency.

DEMODULATION

A QPSK demodulator is depicted in block diagram as shown in Figure 12

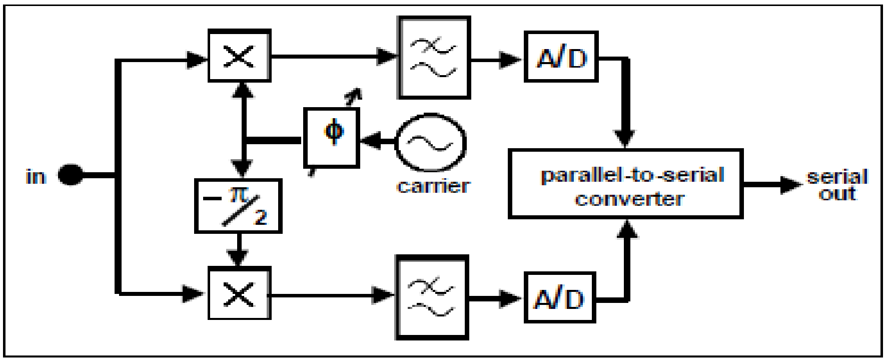


Fig 12. QPSK Demodulator

This demodulator assumes the original message data stream was split into two streams, A and B, at the transmitter, with each converted to a PSK signal. The two PSK signals were then added, their carriers being in phase quadrature. The demodulator consists of two PSK demodulators, whose outputs, after analog-to-digital (A/D) conversion, are combined in a parallel-to-serial converter. This converter performs the recombination of the two channels to the original single serial stream. It can only do this if the carriers at the demodulator are synchronous, and correctly phased, with respect to those at the transmitter.

For QPSK demodulator , a coherent demodulator is taken as an example. In coherent detection technique the knowledge of the carrier frequency and phase must be known to the receiver. This can be achieved by using a PLL (phase lock loop) at the receiver. A PLL essentially locks to the incoming carrier frequency and tracks the variations in frequency and phase. For the following simulation , a PLL is not used but instead we simple use the output of the PLL. For demonstration purposes we simply assume that the carrier phase recovery is done and simply use the generated reference frequencies at the receiver (cos(ωt)) and (sin(ωt)).

In the demodulator the received signal is multiplied by a reference frequency generators (cos(ωt)) and (sin(ωt)) on separate arms (in-phase and quadrature arms). The multiplied output on each arm is integrated over one bit period using an integrator. A threshold detector makes a decision on each integrated bit based on a threshold. Finally the bits on the in-phase arm (even bits) and on the quadrature arm (odd bits) are remapped to form detected information stream as inferred in Figure 13. Detector for in-phase arm is shown below. For quadrature arm the below architecture remains same but sin(ωt) basis function must be used instead.

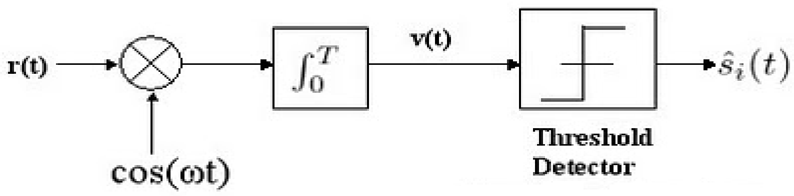


Fig 13. QPSK Demodulator with Threshold Detector

9. DESPREADING

De-spreading is the reverse of spreading.
This implies that from de-spreading sequence, the original message bits are to be extracted.
The dispreading is done by using PN codes.
The PN codes are generated by PN Sequence generator
The main parameters are chosen as follows: clk and period.rst is set to 0. The output is the original message data recovered
Thus the input data given in the transmitter side and the output now got are compared for verification of similar results.
Now TXb is received signal then
Recovered data=dr=TXb.PNr
When PNr=PNt

dr=(dt.PNt).PNt=dt

- The effect of multiplication of the spread spectrum signal rxb with the PN sequence pnt used in the transmitter is to despread the bandwidth of rxb to Rs
- If pnr ≠ pnt, than there is no despreading action. The signal dr has a spread spectrum. A receiver not knowing the PN sequence of the transmitter cannot reproduce the transmitted data (it will basically produce yet another version of the spectrum spread of the original signal - with a different code).

The multiplier output becomes dr = rxb · pnr = (dt · pnt) · pnr

RESULTS AND DISCUSSION

The input data waveform and the data spread into I channel and Q channel in one bit/symbol waveform is given in Figure 14.

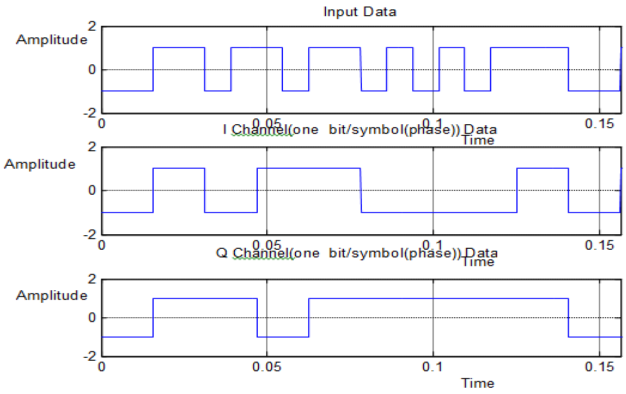


Fig 14. The input data waveform and data spread in I and Q channel

Figure 15 represents the I channel and Q channel data waveform

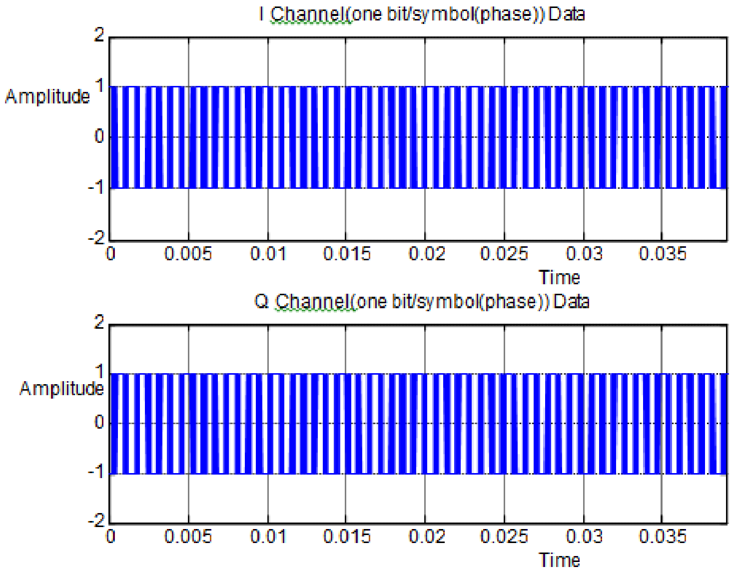


Fig 15. Q and I channel data waveform

The I channel output data form ,Q channel output data waveform and QPSK output data waveform as shown in Figure 16.

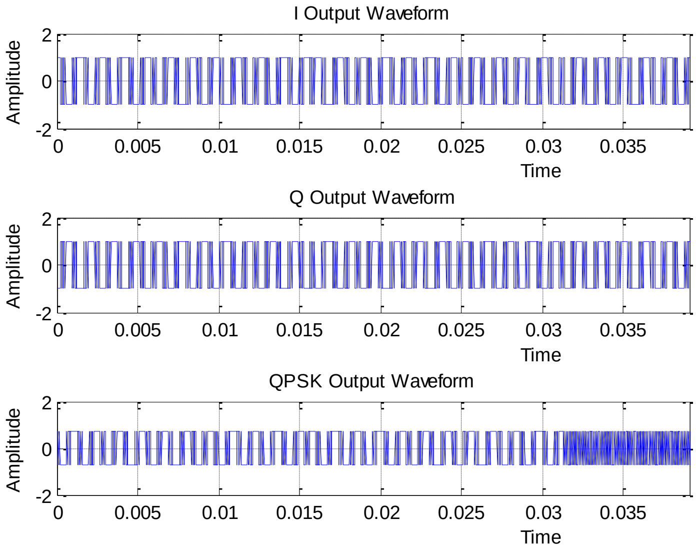


Fig 16. QPSK output data waveform

The signal has to multiplied by a carrier signal for modulation. Here the comparison is done by modulating both spread and unspread signal. The unspread data occupies a single position in the band and the spread data occupies the whole band. The representation of spread and unspread signal is illustrated in Figure 17.

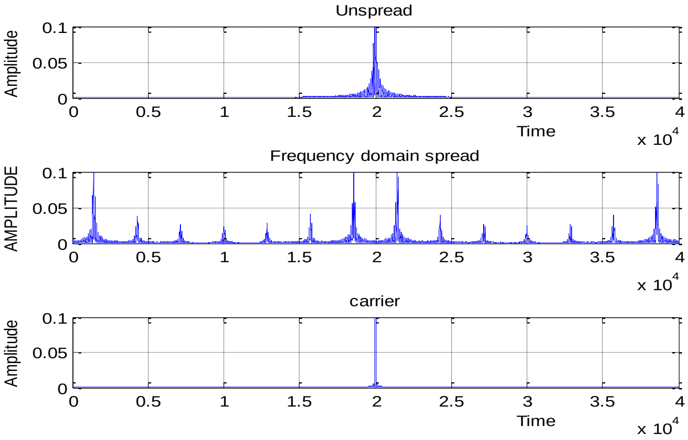


Fig 17. Spread and unspread signal

Since we already told, both the spread and unspread signals are modulated. The modulated graph of unspread signal,spread signal and the carrier signal used in the modulation are all given in the Figure 18.

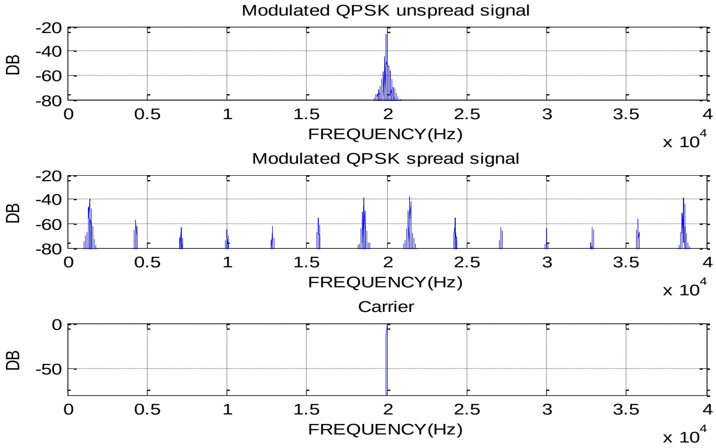


Fig 18. Modulated spread and unspread signal

The final ouput waveform is of two types. One waveform for spread signal and another waveform for unspread signal. Since two channels (I,Q) are used, there exists two waveform per channel. One is spread output waveform and another is unspread output waveform. So the spread and unspread waveform for both I and Q channel data is given in the Figure 19

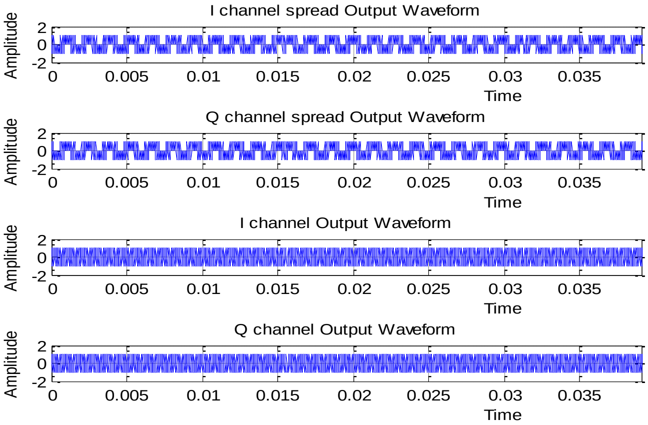


Fig 19. spread and unspread waveform for both I and Q channel data

The modulated signal has to be demodulated to get the original data. So both the I channel and Q channel signals are demodulated and the demodulated I channel waveform and demodulated Q channel waveform as shown in Figure 20.

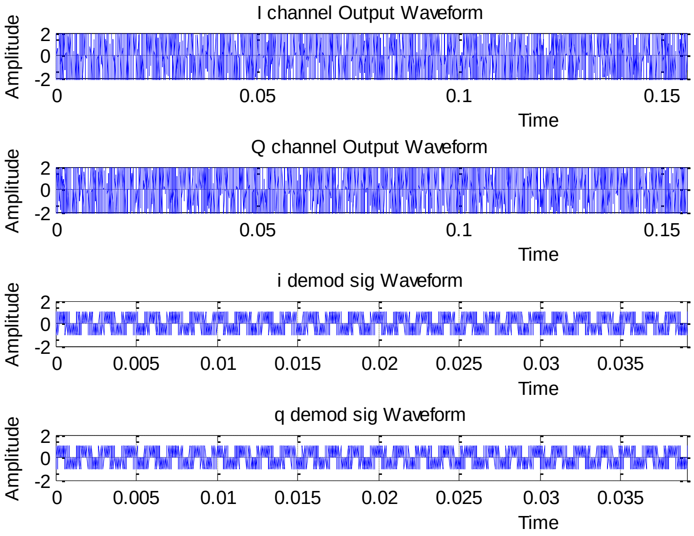


Fig 20. Demodulated I and Q channel signal

The spreading is done having the basics of Spread Spectrum. The spread spectrum (SS) output waveform of I and Q channel data are given in the Figure 21

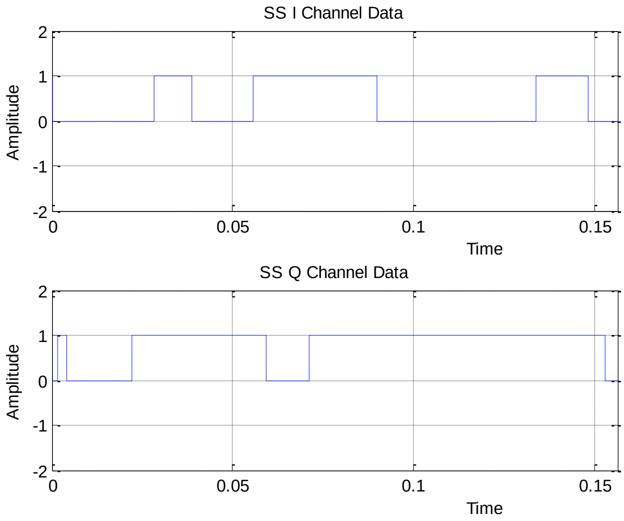


Fig 21. Spread spectrum waveform of I and Q channel data

The received signal is also in the form of spreade I and Q channel. So there exists graph for both I and Q channel. The I and Q channel's spread and unspread output waveform as referred in Figure 22.

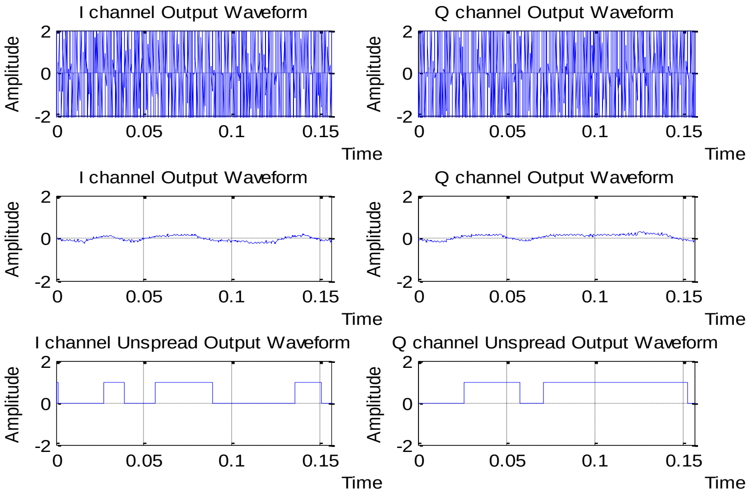
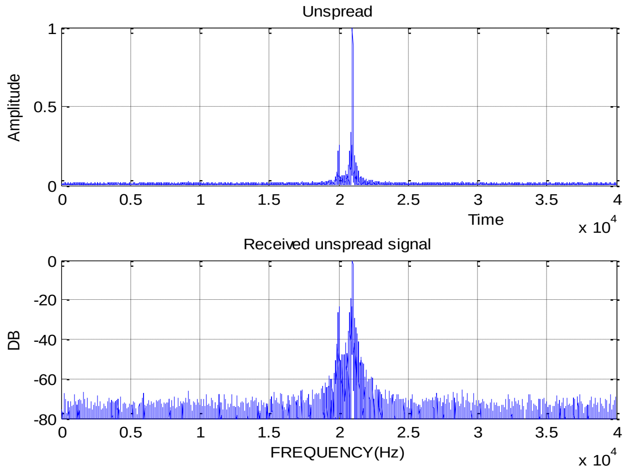


Fig 22. I and Q channel spread and unspread output waveform

Since unspread signal is also modulated, it is transmitted and received. The received unspread signal is given in the Figure 23



Fig

23. Received unspread signal

The modulated QPSK spread signal is demodulated and the received QPSK spread signal is given in Ffigure 24

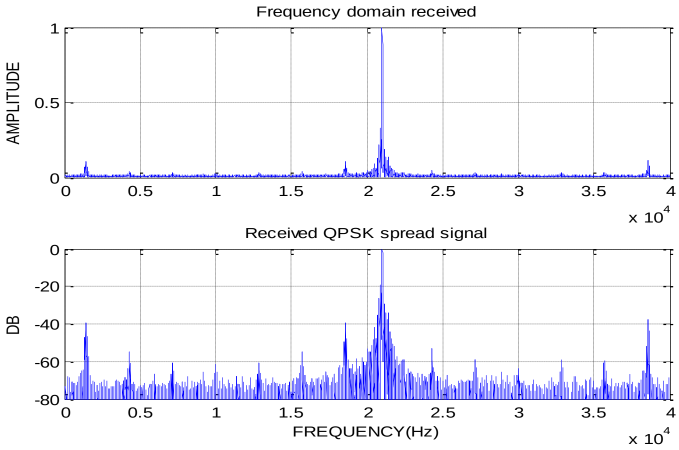


Fig 24. Received QPSK spread signal

The noise signal is introduced to check the BER and performance of the signal. The noise level is introduced and suppressed to get the error free output signal. The noise signal representation as shown in Figure 25.

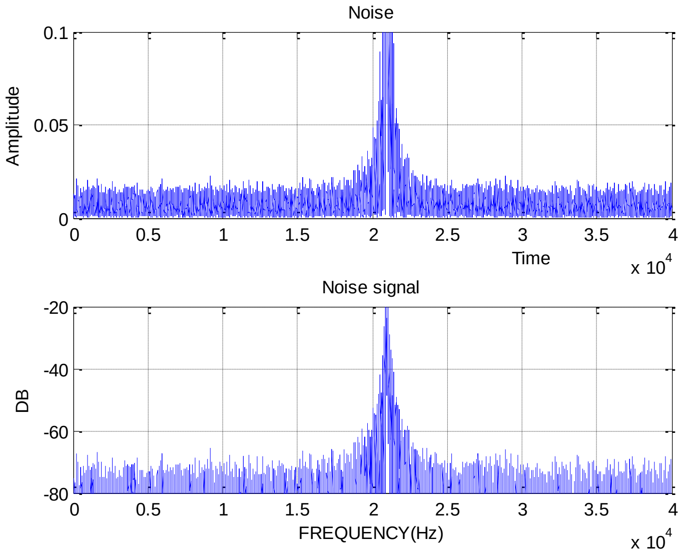


Fig 25. Noise signal

The time domain signals are to be transformed again and have to be shown in frequency domain in its natural form. The output despread waveform represented in frequency domain is given in Figure 26

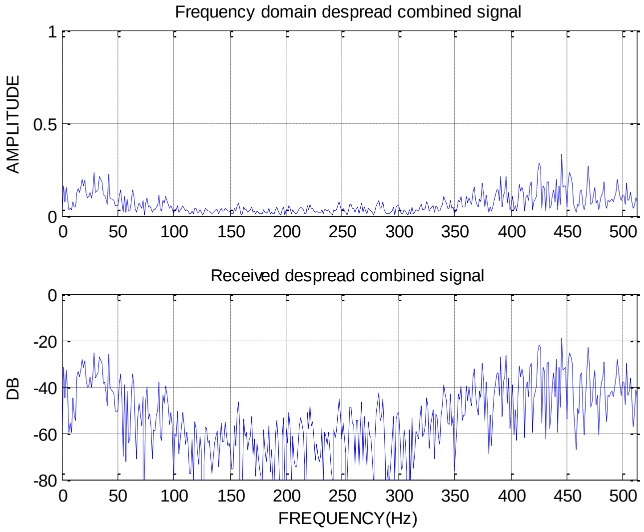


Fig 26. Despread output waveform frequency domain

The comparison between SNR and BER is studied and the graph comparing both are given in the Figure 27.

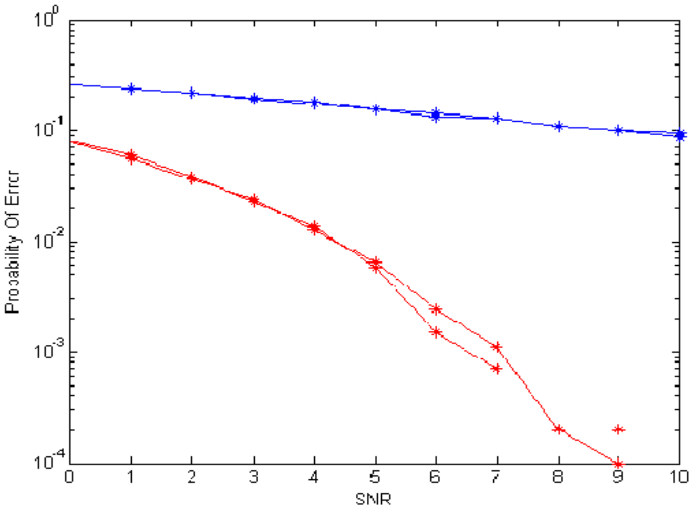


Fig 27. SNR and BER comparison

The BER performance in AWGN and Rayleigh flat fading channels with w-sequences for better orthogonality is also studied and the comparison between simulated BER and theoretical BER is also done. The graph comparing BERs for AWGN Rayleigh and BER for the users simulation as shown in Figure 28.

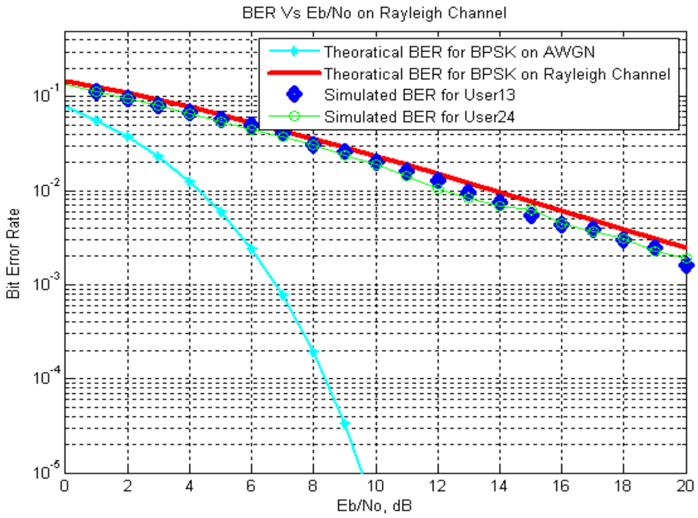


Fig 28. comparison of AWGN Rayleigh BER and simulated BER

CONCLUSION

In conclusion, signal has been modulated and demodulated with the help of QPSK in the DSSS technique. It is the backbone of future communication standard. A noise signal is introduced to detect the interference level. Both the spread and unspread signals are modulated and demodulated and compared. The sample rate was limited to 80,000 samples per second (which winds up at 40,000 samples per second when data is split into I and Q channels. The PRN sequence rate is set to 20,000 bps or less. The data rate was originally designed to run at 2000 bps. The BER and SNR are compared. The Theoretical BER for AWGN , Rayleigh fading and Simulated BER for users are also compared.

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