Communication System Using BPSK Modulation

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Abstract:- **We are living in an era where each of the things is directly related to technology. In past decades methods of transfer of message used to take a lot of time as the technological advancement took place new methods evolved for communication. The methods used were analog and digital methods. Although a significant portion of communication today is analog form, it is being replaced rapidly by digital communication with the next decade most of the communication will become digital, with analog communication playing a minor role. A tremendous technological transformation during the last two decades has provided a potential growth in the area of digital communication and lot of newer applications and technologies are coming up every day due to these reasons. In the present work digital communication system is being used as it provides the capability of information transmission that is both efficient and reliable. Restricting ourselves to the domain of modulation techniques in this article through extensive literature survey in a specific manner enabling to analyze BPSK modulation technique for a particular application. The parameters like symbol error rate , bit error rate are used for analysis. We analyzed the techniques by using modeling and simulating various models by using MATLAB software.**

Keywords- **communication, modulation, BPSK, transmission**

1. INTRODUCTION:-

Today communication enters our daily lives in so many ways that, it is very easy to overlook the multitude of its facets. The purpose of a communication system is to convey any message from an information source in an understandable form to a source destination, with the information source and the destination source be a distant apart from each other physically. To achieve this transmitter at the information source amplifies the message signal into a suitable form for transmission over the channel. The modification is achieved by a process known as modulation, which involves some variation in the some parameter of the carrier wave in and according to the message signal. The receiver receives the degraded version of the transmitted signal after propagation through the channel and recreates it. This recreation is done by a process known as demodulation, which is the reverse of the modulation process used in the transmitter. Modulation is the process of varying some parameter of a periodic waveform in order to use that signal to convey a message. Normally a high-frequency sinusoidal waveform is used as carrier signal. For this purpose ,if the variation in the parameter of the carrier is continuous in accordance to the input analog signal the modulation technique is termed as analog modulation scheme if the variation is discrete then it is termed as Digital Modulation Technique. BPSK is a digital modulation technique which has its basic concept on PSK (phase shift keying). In phase shift keying, the carrier is changed is changed according to the modulating waveform which is usually a digital signal. In binary phase shit keying (BPSK) the transmitted signal is a sinusoid of fixed amplitude. It has one fixed phase when the data is at one level and when the data is at the other level the phase is different by 180^0. If the sinusoid is of amplitude A it has a power $P_s= (1/2) A^2$ so that $A=\sqrt{2P_s}$. BPSK is a form of square-wave modulation of a continuous wave (CW) signal.

2. BINARY PHASE SHIFT KEYING (BPSK):-

In a binary phase shift keying (BPSK),binary symbol '1' and '0' modulation the phase of the carrier. Let us assume that the carrier is given as,

$$S(t)=A\cos(2\pi f_c t)$$

Here 'A' represents peak value of sinusoidal carrier in the standard 1Ω load resistor, the power dissipated would be,

$$P=(1/2)A^2$$

Or,

$$A=\sqrt{2P}$$

Now, when the symbol is changed, then the phse of the carrier is also changed by 180^0.

2.1)BPSK GENERATION:-

The BPSK signal may be generated by applying carrier signal to a balanced modulator. Here the baseband signal b(t) is applied as a modulating signal to the balanced modulator. A NRZ level encoder converts the binary dta sequence into bipolar NRZ.

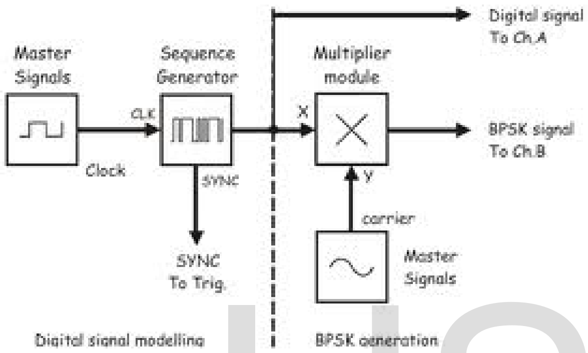


Fig 1:Block diagram of BPSK generator

2.2) BPSK TRANSMITTER:-

In this, a balanced midulator acts as a phase reversing switch. Depending on the condition of the digital input, the carrier is transferred to the output either in phase or 180 degree out of phase with the reference carrier oscillator.

The balanced modulator has two inputs: a carrier that is in phase with the reference oscillator and the binary digital data. For the balanced modulator to bse operate properly, the digital input voltage must be much greater than the peak carrier voltage. This ensures that the digital input controls the on/off stage of diodes. If the binary input is logic 1 diodes A to C. If the binary input is is logic 1, diodes A and D are forward biased and on, while diodes B and C are reverse biased and off. The carrier voltage is developed across transformer T2 in phase with the carrier voltage across T1. Consequently, the output signal is in phase with the reference oscillor.

If the binary input is at logic 0, diode A and D are reverse biased, while B and C forward biased and on. As a result the carrier voltage is developed across transformer T2 180^0 out of phase with the carrier voltage across T1. Consequently the output is 180^0 out of phase with the oscillator.

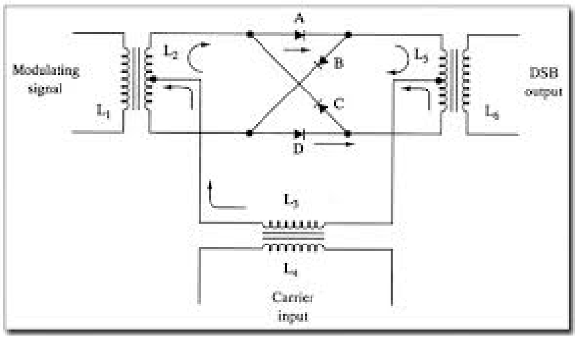


Fig2: block diagram of balanced ring modulator

2.3) BPSK RECEPTION:-

The received signal has the form

$$S(t)=b(t)\sqrt{2P}\cos(2\pi f_c t+\theta)=b(t)\sqrt{2P}\cos 2\pi f_c(t+\theta/2\pi f_c)$$

Here, θ is nominally fixed phase shift corresponding to the time delay $\theta/2\pi f_c t$ which depends on the length of path from transmitter to receiver and a phase shift produced by amplifiers in the "front end" of the receiver preceding the demodulator. The original b(t) is recovered in the demodulator. The demodulation technique usually employed is called synchronous demodulation and requires that there be available at the demodulator the waveform $\cos(2\pi f_c t+\theta)$. The received signal is squared to generate the signal

$$\mathrm{Cos}^2(0.5+0.5\cos 2(2\pi f_c t+\theta)t+\theta)=0.5+0.5\cos 2(2\pi f_c t+\theta)$$

The DC component is removed by the bypass filter whose pass band is centered around $2f_0$ and we then have the signal whose waveform is that of $\cos 2(2\pi f_c t+\theta)$. A frequency divider is used to generate the waveform $\cos 2(2\pi f_c t+\theta)$. In any case, the carrier having been recovered, is multiplied with the received signal to generate

$$b(t)\sqrt{2P}\,\mathrm{Cos}^2(2\pi f_c t+\theta)= b(t)\sqrt{2P}[0.5+0.5\cos 2(2\pi f_c t+\theta)]$$

Which is then applied to integrator. We have included in the system a synchronizer, this device is able to recognize precisely the moment which corresponds to the end of the time interval allocated to one bit and the beginning of the next. Let us assume for simplicity that the bit interval Tb is equal to the duration of an integral number of cycles of the carrier of frequency f_0, that is $n.2\pi=2\pi f_c Tb$. In this case the o/p voltage at the end of a bit interval extending from time (k-1)Tb to kTb.

$$=b(kTb)\sqrt{2P}\int_{(k-1)Tb}^{kTb} 0.5\,dt + b(kTb)\sqrt{2P}\int_{(k-1)Tb}^{kTb} 0.5\cos 2(2\pi f_c t+\theta)dt$$

$$=\mathbf{b(kTb)(\sqrt{P/2})Tb}$$

Since the integral of a sinusoid over a whole number of cycles has the value zero. Thus we see that our systems reproduces at the demodulator output the transmitted bit stream b(t). the operation of the bit synchronizer allows us to sense each bit independently of every other bit. Fig 3 shows a block diagram of a BPSK receiver.

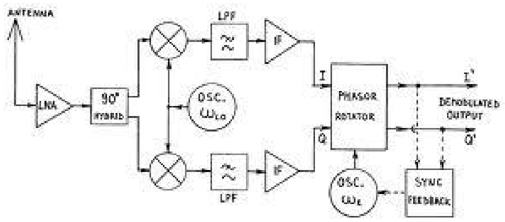


Fig3: Block diagram of BPSK receiver

2.4) BANDWIDTH CONSIDERATIONS OF BPSK:-

In a BPSK modulator, the carrier input signal is multiplied by the binary data. If +1V is assigned to a logic 1 and -1V is assigned to a logic 0, the input carrier ($\sin\omega_c t$) is multiplied by either a + or -1. Consequently, the output signal is either +1 $\sin\omega_c t$ or -1 $\sin\omega_c t$; thhe first represents a signal that is in phase with the reference oscillator, the latter a signal that is 180^0 out of phase with the reference oscillator. Each time the input logic condition changes, the output phase changes. Consequently, for BPSK, the output rate of change is equal to the input rate of change, and the widest output bandwidth occurs when the input binary data are an alternating 1/0 sequence. Mathematically, the output of a BPSK modulator is proportional to

$$=[\sin 2\pi f_a t]*[\sin 2\pi f_c t]$$

Where f_a= max.fundamental frequency of binary input

$f_{c=}$ reference carrier frequency

solving for the trig. Identity for the product of two sine functions

$$0.5\cos[2\pi(f_c-f_a)t]-0.5\cos[2\pi(f_c+f_a)t]$$

Thus, the minimum double-sided nyquist bandwidth (B) is

$$=2f_a$$

And because $f_a=f_b/2$, where f_b=input bit rate,

$$B=f_b$$

Where B is the minimum double-sided Nyquist bandwidth.

2.5) SPECTRUM AND INERT SYMBOL INTERFERENCE, INTER CHANNEL INTERFERENCE:-

The waveform b(t) is a NRZ binary waveform whose power spectral density is given below for a waveform which makes excursion between $+\sqrt{P}$ and $-\sqrt{P}$.

$$G_b(f)=PTb(\sin\pi fTb/\pi fTb)$$

The BPSK waveform is the NRZ waveform multiplied by $\sqrt{2}\cos\omega_0 t$. we found the power spectral density of the BPSK signal as

$$\mathbf{G_{BPSK}(f)=PTb\{[\sin\pi(f-f_o)Tb/\pi(f-f_o)Tb]^2 =[\sin\pi(f+f_o)Tb/\pi(f+f_o)Tb]^2\}}$$

Suppose then that we tried to multiplex signals using BPSK, using different carrier frequencies for different baseband signals. There would inevitably be overlap in the spectra of the various signals and correspondingly a receiver tuned to one carrier would also receive, albeit at a lower level, a signal in different channel. This overlapping of spectra causes inter channel interference.

Since efficient spectrum utilization is extremely important in order to maximize the number of simultaneous users in a multi user communication system, the FCC and CCITT require that the side-lobes produced in BPSK be reduced below certain specific levels. To accomplish this we employ a filter to restrict the bandwidth allowed to the NRZ baseband signal. For ex-before modulation we might pass the bit stream b(t) through a low pass filter which suppresses all the spectrum except the principal lobe. However, the difficulty that such spectrum suppression distorts the signal and as a result, there is a partial overlap of a bit and its adjacent bits in a single channel. This overlap is inter symbol interference (ISI).

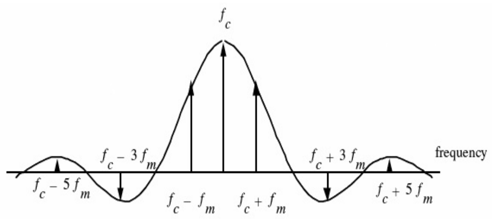


Fig 4: Spectra of BPSK Signal

2.6) GEOMETRICAL REPRESENTATION OF BPSK:-

We know that BPSK signal carries the information about two symbols. These symbols are symbol '1' and symbol '0'. We can represent BPSK signal geometrically to show these two symbols. We know that BPSK signal is expressed as,

$$s(t)=b(t)\sqrt{2P}\cos(2\pi f_c t)$$

on rearranging the equation,

$$s(t)=b(t)\sqrt{PTb}.(\sqrt{2/Tb})\cos(2\pi f_c t)$$

now, let $\theta_1(t) = (\sqrt{2/Tb})\cos(2\pi f_c t)$ represents an orthonormal carrier signal.
And,

$$s(t) = b(t)\sqrt{PTb}\,\theta_1(t)$$

the bit energy Eb is defined in terms of power 'P' and bit bit duration Tb as,

$$Eb = PTb$$

Therefore,

$$s(t) = \pm\sqrt{Eb}\,\theta_1(t)$$

b(t) is simply ± 1.
Thus, on the single axis of $\theta_1(t)$, there will be two points. One point will be located at $+\sqrt{Eb}$ and the other point will be located at $-\sqrt{Eb}$.

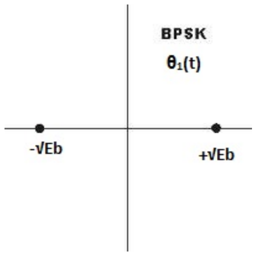


Fig 5: Geometrical representation of BPSK.

The separation between these two points represents the isolation in symbols. The separation is called distance 'd'.

$$d = 2\sqrt{Eb}$$

as this distance increases the isolation is more. Thus, probability of error reduces.

3. PARAMETERS USED FOR COMPARISON:-

The certain parameters used for comparison are discussed below

3.1) BIT ERROR RATE:-

In digital transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that have been altered due to noise, interference, distortion, or bit synchronization errors. The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as percentage.
Mathematical formula for the calculation of bit error rate (BER) is:

$$Pb = 0.5\,\mathrm{erfc}(\sqrt{Eb/No})$$

3.2) SYMBOL ERROR RATE:-

In digital communications, symbol rate (also known as modulation rate) is the number of symbol changes (waveform changes or signaling events) made to the transmission medium per second using a digitally modulated signal or line code. The symbol rate is measured in baud(Bd). In the case of a line code, the symbol rate is the pulse rate in pulses/second. Each symbol can represent or convey one or several bits of data. The symbol rate is related to, but should not be confused with, the gross bitrate expressed in bit/second. The symbol duration time, also known as unit interval, can be directly measured as the time between transitions by looking into an eye diagram of an oscilloscope. The symbol duration time Ts can be calculated s:

$$Ts = 1/Fs$$

If N bits are conveyed per symbol, and the gross bit rate is R, inclusive of channel coding overhead, the symbol rate can be calculated s:

$$Fs = R/N$$

Mathematical formula for symbol error rate

$$Pb = 0.5\,\mathrm{erfc}(\sqrt{Eb/No})$$

3.3) SCATTER PLOT:-

A scatter plot or scatter graph is a type of mathematical diagram using Cartesian coordinates to display values for two variables for set of data. The data is displayed as a collection of points, each having the value of one variable determining the position on the horizontal axis an the value of the other variable determining the position on the vertical axis. This kind of plot is called scatter plot. A scatter plot is used when a variable exists that is below the control of the experimenter. A scatter plot can suggest various kinds of correlations between variables with a certain confidence interval.

3.4) EYE DIAGRAM:-

In telecommunication, an eye pattern, also known as an eye diagram, is an oscilloscope display in which a digital data signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep. It is also called because, for several types of coding, the pattern looks like a series of eyes between a pair of rails. It is an experimental tool for the evaluation of the combined effects of channel noise and inter symbol interference on the performance of baseband pulse-transmission system. It is synchronized superposition of all possible realizations of the signal of interest viewed within a particular signaling interval. Several systems performance measures can be derived by analyzing the display. If the signals are too long, too short, poorly synchronized with the system clock, too high, too low, too noisy, or too slow to change, or have too much undershoot or overshoot, this can be observed from the eye diagram. An open eye pattern corresponds to minimal signal distortion. Distortion of the signal waveform due to ISI and noise appears as closure of the eye pattern.

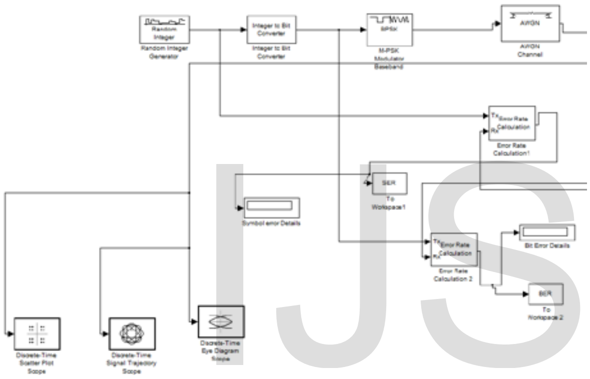
3.5) DISCRETE TIME SIGNAL TRAJECTORY SCOPE:-

The discrete time signal trajectory scope displays the trajectory of a modulated signal in its signal space by plotting its-in phase component versus its quadrature component.

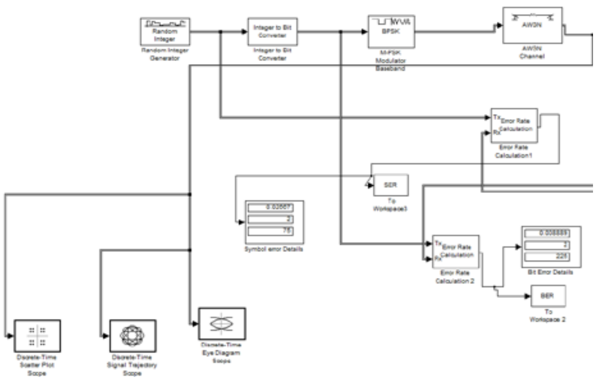
4.) MODELING OF BPSK SYSTEM USING MATLAB:-

The modeling is done on Simulink of MATLAB.

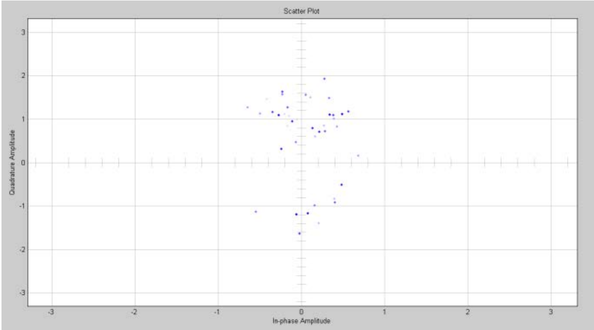
4.1) INPUT MODEL OF BPSK:-



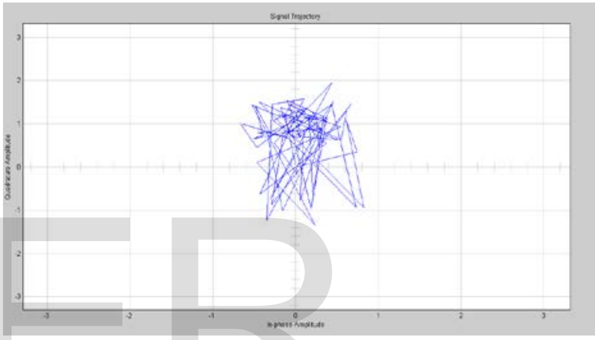
4.2) OUTPUT MODEL OF BPSK:-



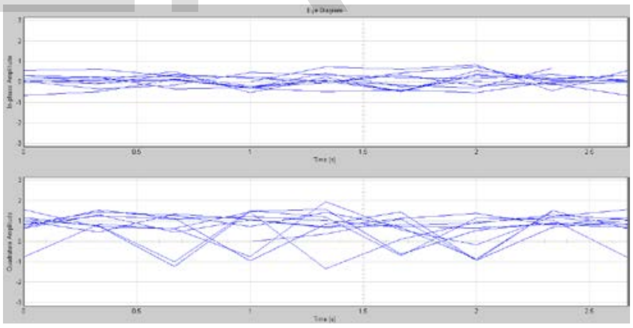
4.3) SCATTER PLOT OF BPSK:-



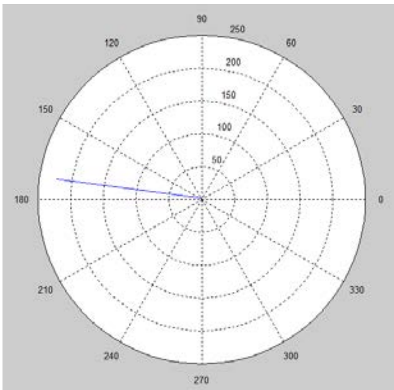
4.4) SIGNAL TRAJECTORY SCOPE OF BPSK:-



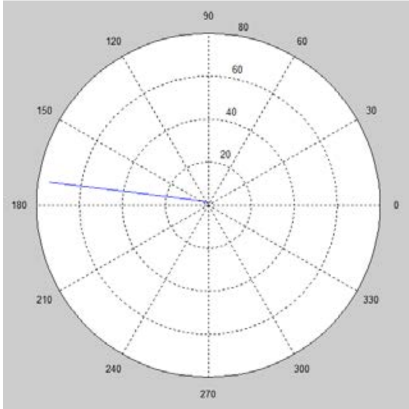
4.5) EYE PATTERN OF BPSK:-



4.6) POLAR PLOT OF BER OF BPSK:-



4.7) POLAR PLOT OF SER OF BPSK:-



5.) ADVANTAGES OF BPSK:-

BPSK modulation technique is a technique that offers several advantages over other modulation techniques that is it has the simplest of the system design, and it has power efficiency to be optimum.

6.) DRAWBACKS OF BPSK:-

To regenerate the carrier in the receiver, we start by squaring $b(t)\sqrt{2P}\cos(2\pi f_c t+\theta)$. If the received signal is $-b(t)\sqrt{2P}\cos(2\pi f_c t+\theta)$ then the squared signal remains same. Hence, the recovered carrier is unchanged even if the input signal as changed its sign. Therefore, it is not possible to determine whether the received signal is equal to b(t) or –b(t). In fact, this results in ambiguity in the output signal.

7.) APPLICATIONS OF BPSK:-

BPSK offer several distinct properties different from other modulation techniques due to which it can be used in data transmission with lower data rates that is BPSK found its most implies applications in low speed communication systems.

8.) CONCLUSIONS:-

Every modulation techniques has some pros and cons, BPSK modulation has also some pros and cons. Although this modulation technique is not possible to determine whether the received signal is equal to b(t) or –b(t) but it has a good power efficiency and has a simple system. It can also be used in low speed communication. On over all basis it can be said that BPSK modulation technique that can be used efficiently with lower data rate system.

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- TECHNIA International Journal of Computing Science and Communication Technologies, VOL. 3, NO. 1, July 2010. (ISSN 0974-3375) "**ANALOG & DIGITAL MODULATION TECHNIQUES: AN OVERVIEW"**