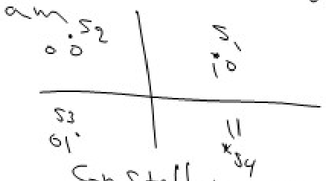
Quadrature phase Shift keying QPSK

* In QPSK the phase of the Carrier is varied into 4 discrete levels
* each level Carries two bit of informations
* The equation which describes the QPSK System is given by

$$S_i(t) = \sqrt{\frac{2E}{T}} \cos\left[2\pi f_c t + (2i-1)\pi/4\right] \quad i=1,2,3,4$$

E is the symbol energy
T is the symbol duration
$f_c = \frac{n}{T}$, where n is an integer

* If we plot the constellation diagram for QPSK Signal, we may got the following diagram



Constellation diagram

* The constallation diagram can be used to derive an expression for the average probability of error, which is given by

$$P_e = \frac{1}{2} \operatorname{erfc} \sqrt{\frac{E_b}{N_o}}$$

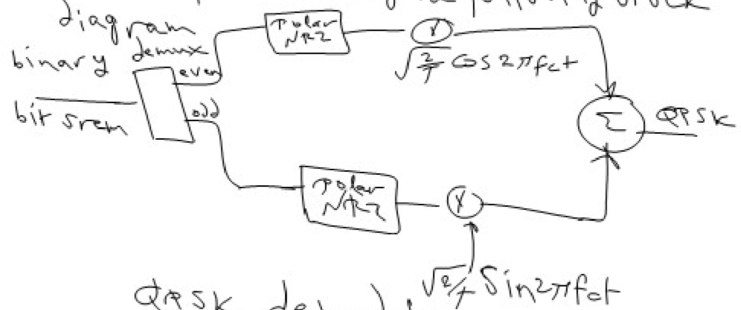
Why we call QPSK quadrature modulation??

* The answer to this question came from $S_i(t)$ equation

$$S_i(t) = \sqrt{\frac{2E}{T}} \cos\left(2\pi f_c t + (2i-1)\frac{\pi}{4}\right)$$

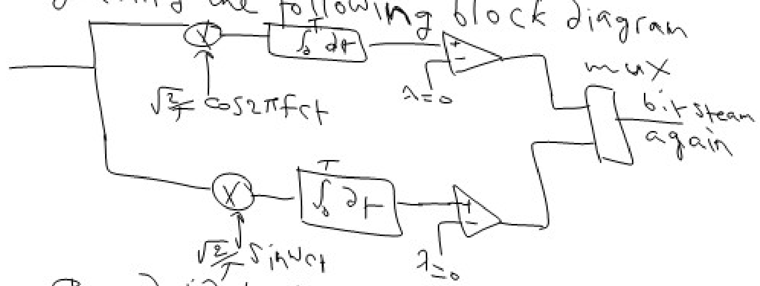
$$= \sqrt{\frac{2E}{T}} \cos\left((2i-1)\pi/4\right) \cos 2\pi f_c t - \sqrt{\frac{2E}{T}} \sin\left((2i-1)\pi/4\right) \sin 2\pi f_c t$$

* from the above equation we can see that the QPSK modulation is indeed a two BPSK systems
* This means that the QPSK modulator can be presented by the following block diagram



QPSK demodulator

* The QPSK demodulator can be implemented by using the following block diagram



Bandwidth of QPSK Signaling

* The bandwidth for QPSK system is given by

$$B.W = \frac{1}{2} B.W_{BPSK} = \frac{1}{2}(2) R_b = R_b$$

Ex A given communication system transmit informations at a bit rate of 1.75 mbps. If the modulation scheme used is QPSK and the power spectral density for the noise is $N_o = 1.26 \times 10^{-20}$ W/Hz. Determine the system transmission power if the average probability of error is not to exceed 1×10^{-7} and the path loss of the system is 144 dB including antenna gains

Solution

$$P_e = \frac{1}{2} \operatorname{erfc} \sqrt{\frac{E_b}{N_o}}$$

$$1 \times 10^{-7} = \frac{1}{2} \operatorname{erfc} \sqrt{\frac{P_r T_b}{1.26 \times 10^{-20}}}$$

from the erfc table, we have

$$\sqrt{\frac{P_r T_b}{1.26 \times 10^{-20}}} = 3.67$$

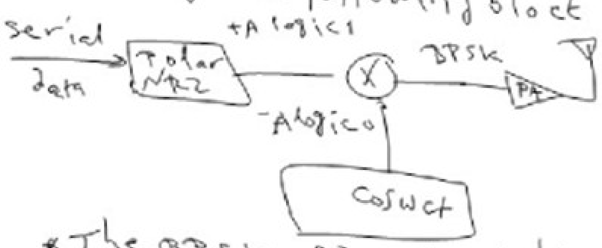
$$T_b = \frac{1}{R_b} = \frac{1}{1.75 \times 10^{6}}$$

by solving the above square root, we have the received power

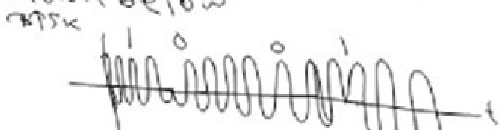
$P_r =$

Binary phase shift keying BPSK

* BPSK signaling is used in some wireless communication sysytems such as blue tooth and Zig-bee technonlogy
* BPSK signals can be generated by using the following block diagram



* The BPSK signal might appear as shown below



* Note that the bit duration T_b is related to the carrier frequency by

$$f_c = \frac{n}{T_b}$$

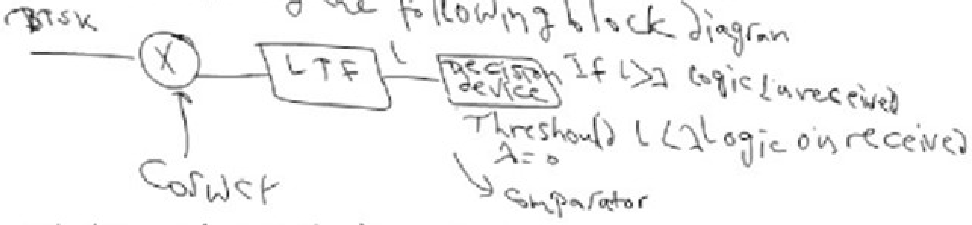
Where is an integer number

Note also logic 1 is represented by $s_1(t) = A\cos\omega_c t$ logic 1

while logic zero is denoted by

$s_2(t) = -A\cos\omega_c t = A\cos(\omega_c t + \pi)$ logic 0

* The demodulator of BPSK signal is illustrated by the following block diagram



Note the BPSK demodulator is in fact is a synchronuous (coherent) detector, therefore it requires a synchronization circuit between the transmitter and the receiver.

Bandwidth of BPSK Signal

* The B.W of BPSK signal is given by

$$\boxed{BW = 2R_b}$$

where R_b is the bit rate

Average probability of error of BPSK Signals

* The average probability of error is used to indicate how many bits are received correctly when we have a noisy communication channel
* The average probability of error for BPSK system is given mathematically by

$$P_e = \frac{1}{2}\,\mathrm{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$$

where E_b is the energy per bit which is defined by $E_b = \frac{A^2}{2} T_b$

T_b: is the bit duration

A : is the amplitude of the carrier

N_0: is the power spectral density for the noise watt/Hz

erfc is the complementrary error function which is given in tables

x	erfc(x)
0	1
0.1	0.99