Channel Bandwidth –

The range of frequencies that contain the information is called as Bandwidth.

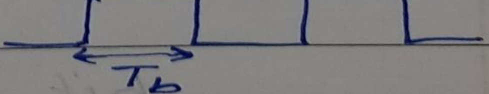
Channel Bandwidth is used to describe the range of frequencies required to transmit the desired information.

Example

1 → CHANNEL BANDWIDTH = 10 KHZ
for signal B.W. = 5 KHZ
FOR DSB-AM

2 – CHANNEL B.W. = 5 KHZ
for signal B.W. = 5 KHZ in SSB

BIT INTERVAL – Time required to send one bit



BIT RATE (Data rate) – The number of bits transmitted in one second.

$$\text{Bit rate} = \frac{1}{\text{Bit Interval}}$$

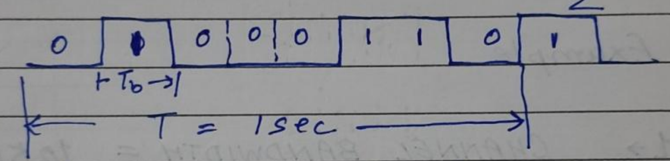
Baud rate –

It indicates the rate at which a signal level changes over a given period of time.

for BPSK – bit rate = baud rate

for QPSK → $\text{baud rate} = \frac{\text{bit rate}}{2}$

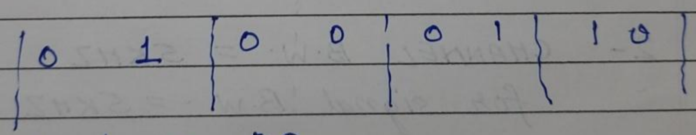
BPSK



$0 \rightarrow A\cos\omega_0 t$ | bit rate = 8 bits/sec.

$1 \rightarrow -A\cos\omega_0 t$ | Baud rate = 8 bauds

QPSK –



4 levels = 00, 01, 10, 10 — two level signal

bit rate = 8 bits/sec

baud rate = 4 bauds

$00 - A\cos\omega_0 t$ $\quad$ $10 \rightarrow -A\sin\omega_0 t$

$01 \rightarrow A\sin\omega_0 t$ $\quad$ $11 \rightarrow -A\cos\omega_0 t$

Ex-1 – For a binary system PCM, the number of bits per transmitted word is 8 and the sampling freq. $f_s = 8\,KHZ$. Calculate bit rate and baud rate.

Given, $N = 8$, $f_s = 8\,KHZ$

$N \times f_s$

bit rate $= 8 \times f_s = 8 \times 8\,KHZ$

$= 64\,Kbps$

baud rate $= 64\,KHZ$

(Since transmission is binary)

Ex. 2 – Find baud rate if QPSK system is used.

In QPSK, two successive bits are clubbed together to form one symbol.

So, baud rate $= \frac{1}{2} \times$ bit rate

$= \frac{1}{2} \times 64\,Kbps$

$= 32\,Kbps.$

Ex-3- A system sends a signal that can assume 8 different voltage levels. It sends 400 of these signals per second. What are baud rates and bit rate.

(i) As signal assume 8 different voltage levels. we required 3 bit digital signal to have 8 different combinations. Hence number of bits per voltage level is 3.
Hence, no. of bits/symbol = 3

(ii) Number of symbols/sec = 400
So, Baud rate = 400

(iii) bit rate = 3 × symbol rate
= 3 × 400
= 1200 bps
= 1.2 Kbps.

Relationship between B.W. & bit rate –

bit rate is proportional to B.W.

$B.W. \geq \frac{n}{2}$ $\quad n \leq 2B.W.$

Nyquist's limit –

max. data rate $R = 2B\log_2 L$

$$\boxed{C = 2B\log_2 L}$$

Shannon's channel capacity –

$$R \leq C$$

for noisy channel –

$$R = B\log_2\left[1 + SNR\right]$$

Ex– 1 – A channel has a B.W. of 5 KHZ and SNR = 63. Evaluate the B.W. required if SNR is reduced to 31. What will be signal power required if the channel B.W. is reduced to 3 KHZ.

Given : B.W. = 5 KHZ

SNR = 63

So, $C = B\log_2(1 + SNR)$

$= 5 \times 10^3 \log_2(1 + 63) = 30$ Kbps new value of SNR = 31

Channel capacity is constant so,

$$30 \times 10^3 = B \log_2 (1 + SNR)$$

$$= B \log_2 (1 + 31)$$

$$B.W. = \frac{30 \times 10^3}{5} = 6 KHZ$$

Now new B.W. is 3 KHZ

Noise power $N = N_0 \times B$

Let the noise power corresponding to B.W. of 6 KHZ be

$$N_1 = 6 N_0$$

and

noise power corresponding to new B.W. of 3 KHZ be

$$N_2 = 3 N_0$$

Old SNR $\frac{S_1}{N_1} = 31 \Rightarrow S_1 = 31 N_1$

new SNR $\frac{S_2}{N_2}$

$$30 \times 10^3 = 3 \times 10^3 \log_2 \left(1 + \frac{S_2}{N_2}\right)$$

$$\frac{S_2}{N_2} = 2^{10} - 1 = 1023$$

$$\frac{S_2}{N_2} = 1023$$

$$S_2 = 1023\ N_2$$

As $\rightarrow$ $N_2 = \frac{N_1}{2}$

So, $S_2 = 1023 \times \frac{N_1}{2}$

So,

$$\frac{S_2}{S_1} = \frac{1023 \times N_1/2}{31\ N_1}$$

$$= 16.5$$

$$\boxed{S_2 = 16.5\ S_1}$$

Therefore, if the B.W. is reduced by 50% then the signal power must be increased by 16.5 times to get the same capacity.

Ex.2 Evaluate the maximum bit rate for a channel having B.W. 3100 HZ and SNR of 20 dB.

Given $B = 3100$ HZ

$SNR = 20dB$

So,

$$20\ dB = 10\log_{10}(SNR)$$

$$SNR = 100$$

max. data rate

$$R_{max} = B\log_2(1+SNR)$$

$$= 3100\log_2(1+100)$$

$$R_{max} = 20{,}640\ bps.$$

Assignment

Q.1. — Find the maximum bit rate for a channel having B.W. 3100 HZ and SNR = 10 dB.

Q.2. Determine the max. bit rate for a channel having B.W. equal to 1600 HZ if (i) SNR = 0 dB
(ii) SNR = 20 dB

Q.3. The B.W. of channel is 2 MHZ and SNR = 63. Determine the appropriate bit rate & signal level.