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Q.1. Suppose a signal travels through a transmission medium and its power is reduced to one forth. This means, $P_2 = (\frac{1}{4}) P_1$. Then, what is its attenuation?

Solution: Attenuation $= 10 \log_{10} \frac{P_2}{P_1} = 10 \log \frac{\frac{1}{4} P_1}{P_1} = 10 \log_{10}(0.25) = -6\,dB$

Therefore, loss of one-fourth power equivalents $-6\,dB$

Q.2. Suppose an amplifier is utilised to increase the power of a signal 5 times. This means that $P_2 = 5P_1$. Then calculate the amplification.

Solution: Amplification $= 10 \log_{10} \frac{P_2}{P_1} = 10 \log_{10} \frac{5P_1}{P_1} = 10 \log_{10}(5) = 6.98\,dB$

Therefore, gain of five times power equivalents around $+7\,dB$

Q.3. Suppose, a signal travels from point 1 to point 4. The signal is attenuated ($-4\,dB$) by the time it reaches point 2. Between points 2 and 3, the signal is amplified ($8\,dB$). Again, between points 3 and 4, the signal is attenuated ($-3\,dB$). What is the resultant decibal value for the signal?

Solution: Resultant $dB = dB_{12} + dB_{23} + dB_{34}$

$= -4 + 8 + (-3)$

$\therefore dB_{R(14)} = +1\,dB$

Therefore, the resultand decibal value for signal is $+1\,dB$

Q.4. Calculate the power of a signal if its dBm = -30

Solution:

$$1\ dBm = 10 \log_{10} P_m$$

$$1\ P_m = 10^{-3}\ mW$$

$$\therefore 1 dBm = -30\ mW$$

Therefore, $-30 dBm = -30 \times -30 = 900\ mW$

Q.5. If the signal at the beginning of a cable with -0.3dB/km has a power of 2mW, what is the power of the signal at 5km?

Solution:

Attenuation per Km = -0.3dB

So, at 5 km, Attenuation = $-0.3 \times 5 = -1.5$ dB.

$$\text{Or, } 10 \log_{10} \frac{P_2}{P_1} = -1.5\ dB$$

$$\text{Or, } 10 \log_{10} \frac{P_2}{2} = -1.5$$

$$\text{Or, } \log_{10} \frac{P_2}{2} = \log_{10} (10^{-\frac{1.5}{10}})$$

$$\text{Or, } P_2 = 2 \times 10^{-0.15}$$

$$\therefore P_2 = 1.41\ mW$$

$\therefore$ The power of the signal at 5km is 1.41 mW

Q.6. The power of a signal is 10mW and the power of the noise is 1μW, what are the values of SNR and SNRdB?

Solution:

$$SNR = \frac{\text{Avg. Signal Power}}{\text{Avg. Noise Power}} = \frac{10mW}{1\mu W} = \frac{10000\ \mu W}{1\ \mu W} = 10000$$

$$SNR_{dB} = 10 \log_{10} SNR = 10 \log_{10} 10^4 = 4 \times 10 = 40$$

$\therefore$ SNR = 10000 and $SNR_{dB} = 40$

Q.7. What are the values of SNR and SNR_{dB} for a noiseless channel?

Solution: for noiseless channel,

$$SNR = \frac{P}{0} = \infty$$

And, $$SNR_{dB} = 10 \log_{10} \infty = \infty$$

$\therefore$ for noiseless channel, the values of both SNR and SNR_{dB} are undefined or limitless.

Q.8. Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with two signal levels. What is the maximum bit rate?

Solution:

$$\text{Bit Rate} = 2 \times \text{Bandwidth} \times \log_2(L)$$
$$= 2 \times 3000 \times \log_2(2)$$
$$\therefore \text{Bit Rate} = 6000 \text{ bps}$$

Q.9. Consider the same noiseless channel transmitting a signal with four signal levels (for each level, we send 2 bits). What is the maximum bit rate?

Solution:

$$\text{Bit Rate} = 2 \times \text{Bandwidth} \times \log_2(L)$$
$$= 2 \times \text{Bandwidth} \times \log_2(4)$$
$$= 2 \times 3000 \times \log_2(2^2)$$
$$= 6000 \times 2$$
$$\therefore \text{Bit Rate} = 12000 \text{ bps}$$

Q.10. We need to send 265 Kbps over a noiseless channel with a bandwidth of 20 kHz. How many signal levels do we need?

Solution:

$$L = 2^{\frac{\text{Bit Rate}}{2 \times \text{Bandwidth}}} = 2^{\frac{256}{2 \times 10}} = 2^{\frac{256}{20}} = 2^{6.625} = 98.7$$

$\therefore$ We need 98.7 levels for 265 kbps over 20KHz

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So,

However, 98.7 levels is not a power of 2. The immediate powers of 2 closest to 98.7 are 64 and 128.

If we have 64 levels, Bit rate is $(2 \times 20000 \times \log_2(64))$

$= 240\,000$ bps

$= 240$ kbps

This does not suffice the need to send 265 kbps.

So, if we have 128 levels, Bit Rate is $(2 \times 20000 \times \log_2(128))$

$= 280\,000$ bps

$= 280$ kbps

Therefore, we need 128 levels to send 256 kbps over a noiseless channel with a bandwidth of 20 kHz.

Qn 11. Consider an extremely noisy channel in which the value of the signal-to-noise ratio is almost zero. In other words, the noise is so strong that the signal is faint. What is the capacity C for this channel?

Solution:

$$C = \text{Bandwidth} \times \log_2(\text{SNR} + 1)$$
$$= \text{Bandwidth} \times \log_2(0 + 1)$$
$$= \text{Bandwidth} \times \log_2 1$$
$$= \text{Bandwidth} \times \log_2 2^0$$
$$= \text{Bandwidth} \times 0$$
$$\therefore C = 0$$

Therefore, the capacity of an extremely noisy channel is zero, i.e, no data can be received through this channel.

Q.12. A telephone line normally has a bandwidth of 3000 Hz (300 to 3300 Hz) assigned for data communications. The signal-to-noise ratio is usually 3162. for this channel, the capacity is calculated as ?

Solution:

$$C = \text{Bandwidth} \times \log_2(\text{SNR} + 1)$$
$$= 3000 \times \log_2(3162 + 1)$$
$$\therefore C = 34881.23 \text{ bps}$$

Therefore, for this channel, the capacity is 34881 bps.

Q.13. Assume that $SN_{dB} = 36$ and the channel bandwidth is 2 MHz. The theoritical channel capacity can be calculated as?

Solution:

$$SNR_{dB} = 10 \log_{10} SNR$$
$$\therefore SNR = 10^{(SNR_{dB})/10} = 10^{\frac{36}{10}} = 10^{3.6} = 3981.07$$

So,

$$C = \text{Bandwidth} \times \log_2(\text{SNR} + 1)$$
$$= 2 \times 10^6 \times \log_2(3981 + 1)$$
$$= 23918555 \text{ bps}$$
$$\therefore C = 23.91 \text{ Mbps}$$

Therefore, the the theoritical channel capacity is 24 Mbps

Q.14. We have a channel with a 1 MHz bandwidth. The SNR for this channel is 63. What are the appropriate bit rate and signal level?

Solution:

$$C = \text{Bandwidth} \times \log_2(\text{SNR}+1)$$
$$= 10^6 \times \log_2(63+1)$$
$$\therefore \text{Bit Rate} = 6 \times 10^6 \text{ bps} = 6 \text{ Mbps}$$

And,

$$L = 2^{\frac{\text{Bit Rate}}{2 \times \text{Bandwidth}}} = 2^{\frac{6\times10^6}{2\times10^6}} = 2^3 = 8$$

Therefore, Appropriate bit rate is 6 Mbps and signal level is 8.