Department of Electrical Engineering
Final-Assignment
Date: 22/06/2020

Course Details

Course Title: Advance Computer Networks **Module:** 3rd
Instructor: Sir Naeem Ahmad Jan **Total Marks:** 50

Student Details

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Q1.	(a)	The Advanced Mobile Phone System (AMPS) uses two bands. The first band, 800 to 850 MHz, is used for sending; and 860 to 910 MHz is used for receiving. Each user has a bandwidth of 60 KHz in each direction. The 3-KHz voice is modulated using FM, creating 60 KHz of modulated signal. How many people can use their cellular phones simultaneously?	Marks 6
	(b)	Express a period of 1 ms in microseconds, and express the corresponding frequency in kilohertz and A sine wave is offset one-fourth of a cycle with respect to time zero. What is its phase in degrees and radians?	Marks 4
Q2.	(a)	Explain wave division multiplexing and it's applications?	Marks 5
	(b)	Nine channels, each with a 99-KHz bandwidth, are to be multiplexed together. What is the minimum bandwidth of the link if there is a need for a guard band of 13 KHz between the channels to prevent interference?	Marks 5
Q3.	(a)	A constellation diagram consists of sixteen equally spaced points on a circle. If the bit rate is 4800 bps, what is the baud rate?	Marks 5
	(b)	Given a bandwidth of 7000 Hz for a 128-PSK signal, what are the baud rate and bit rate?	Marks 5
Q4.		Explain wireless propagation methods & wireless transmission waves? We need to send 265kbps over a noiseless channel with a bandwidth of 20KHz. How many signal levels do we need?	Marks 10
Q5.		What is the difference between Shannon & Nyquist Capacity? Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with 4 signal levels, the maximum bit rate can be ?	Marks 10

Q1 :(a) The Advanced Mobile Phone System (AMPS) uses two bands. The first band, 800 to 850 MHz, is used for sending; and 860 to 910 MHz is used for receiving. Each user has a bandwidth of 60 KHz in each direction. The 3-KHz voice is modulated using FM, creating 60 KHz of modulated signal. How many people can use their cellular phones simultaneously?

Ans.1 :(a)

Each band is 50 MHz   I.e 850 – 800 = 50

If we divide 50 MHz with 60 KHz,

= 50*10^6 / 60*10^3

We get 833.33, but the band is divided in 832 Channels in real.

42 of these channels are used for control channel while 790 channels are available for cellular mobile phone users.

(b) Express a period of 1 ms in microseconds, and express the corresponding frequency in kilohertz and a sine wave is offset one-fourth of a cycle with respect to time zero. What is its phase in degrees and radians?

Ans#1 : (b)

1 ms = 1 *10^{-3} s   *1 milli Second = 10^{-3} s*

We can also write   *1 second = 10^{6} µs*

= 1 * 10^{-3} * 10^{6}

= 10^{3} µs

- 1ms = 10^{3} µs

As, 1 ms = 10^{-3} s

And f =1 / t

f = 1 / 10^{-3} Hz

f = 10^{3}Hz

f= 1000 Hz

or, **f=1 KHz**

As Complete cycle is 360°

Therefore ¼ cycles is

¼ * 360° = 90°

a sin wave is offset one fourth of a cycle with respect to time zero its phase in radian is :

$90° * \frac{2\pi}{360} = \frac{\pi}{2} ==$ **1.5708 radian**

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Q2 :(a). Explain wave division multiplexing and it's applications?

Ans#2: (a)

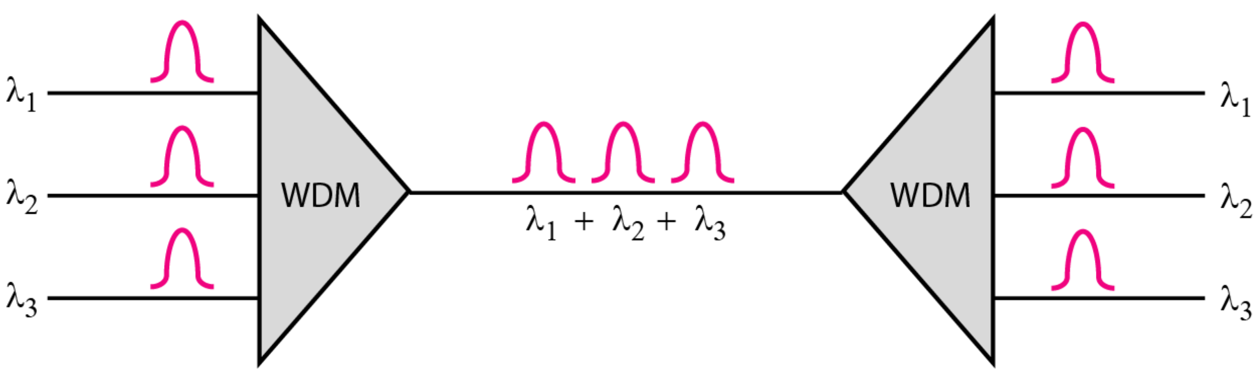
Wavelength division multiplexing (WDM) is a technology or technique modulating numerous data streams, i.e. optical carrier signals of varying wavelengths (colors) of laser light, onto a single optical fiber. It is a technique in which signals of different wavelength are multiplexed together in order to get transmitted over an optical link. WDM enables bi-directional communication as well as multiplication of signal capacity. Two or more colors of light can travel on one fiber and several signals can be transmitted in an optical waveguide at differing wavelengths. It is an analog multiplexing technique used in fiber optic communication. Here, optical signals of multiple wavelengths are transmitted using a fiber link.

In WDM, the optical signals from different sources or (transponders) are combined by a multiplexer, which is essentially an optical combiner. They are combined so that their wavelengths are different. The combined signal is transmitted via a single optical fiber strand. At the receiving end, a de-multiplexer splits the incoming beam into its components and each of the beams is send to the corresponding receivers.

WDM is similar to frequency-division multiplexing (FDM). But instead of taking place at radio frequencies (RF), WDM is done in the IR portion of the electromagnetic spectrum. Each IR channel carries several RF signals combined by means of FDM or time-division multiplexing (TDM). Each multiplexed IR channel is separated, or de-multiplexed, into the original signals at the destination. Using FDM or TDM in each IR channel in combination with WDM or several IR channels, data in different formats and at different speeds can be transmitted simultaneously on a single fiber.

Application of WDM

The technique of wavelength division multiplexing is used in SONET network (Synchronous Optical Network) that includes multiplexing and de-multiplexing of various optical fiber cables.



(b). Nine channels, each with a 99-KHz bandwidth, are to be multiplexed together. What is the minimum bandwidth of the link if there is a need for a guard band of 13 KHz between the channels to prevent interference?

Ans#2: (b)

As we have

9 number of Channels

Each Channel have 99 KHz Bandwidth

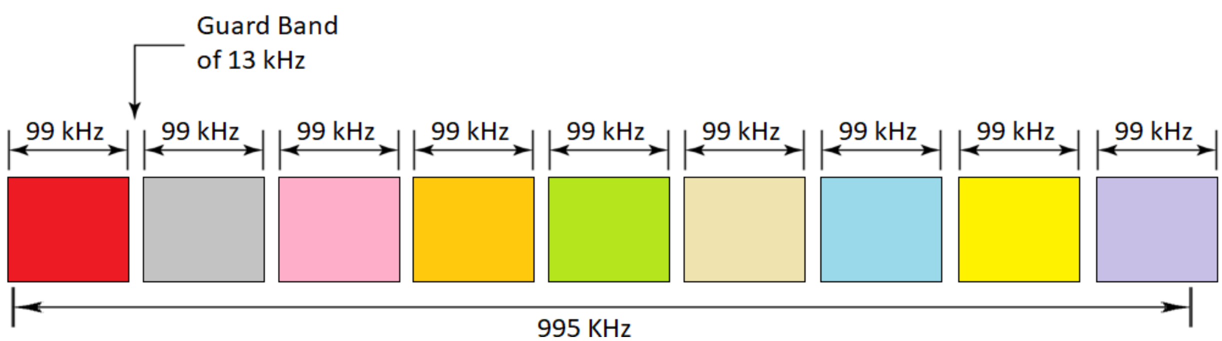
For 9 Number of Channels we need 8 Guard Bands

Guard band =13 KHz

So,

This means that the required bandwidth is at least

B.W= $(9 \times 99) + (8 \times 13) = 995$kHz



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Q3 :(a). A constellation diagram consists of sixteen equally spaced points on a circle. If the bit rate is 4800 bps, what is the baud rate?

Ans#3: (a)

4 bits are transmitted with each signal i-e 16 = 2^4 and bit rate is 4800 bps given in question

As Baud rate = bit rate/bits per signal

Therefore,

Baud rate = 4800/4 = 1200 Baud

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(b) Given a bandwidth of 7000 Hz for a 128-PSK signal, what are the baud rate and bit rate?

Ans#3: (b)

For PSK the baud rate is the same as the bandwidth, which means the baud rate is 7000, but in 128 – PSK the bit rate is 7 times the baud rate

Bit rate = 7 x 7000

=49000 bps

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Q4. Explain wireless propagation methods & wireless transmission waves?

Ans#4:

Methods of propagation of EM waves: Mesosphere, Troposphere, Ionosphere are the different layers.

These layers are used for propagation of EM waves and that EM waves travel basically in any 1 of the three methods. The mode of propagation of electromagnetic waves in the atmosphere and in free space may be divided into the following three categories:

1. Sky wave propagation
2. Ground wave propagation
3. The line of sight (LOS) propagation

1. **Ground Wave**
   Used for a low-frequency range transmission, mostly less than 1 MHz. This type of propagation employs the use of large antennas order of which is equivalent to the wavelength of the waves and uses the ground or Troposphere for its propagation. Signals over large distances are not sent using this method. It causes severe attenuation which increases with increased frequency of the waves.

2. **Sky Wave**
   Used for the propagation of EM waves with a frequency range of 3 – 30 MHz. Make use of the ionosphere so called due to the presence of charged ions in the region of about 60 to 300 km from the earth surface. These ions provide a reflecting medium to the radio or communication waves within a particular frequency range. We use this property of the ionosphere for long-distance transmission of the waves without much attenuation and loss of signal strength.

   Another important point to note is the consideration of the angle of the emission of these waves from the ground. The transmitter emits the EM Waves at a critical angle to ensure total reflection to the ground just like the total internal reflection of optic waves otherwise the waves may escape into space. Skip Distance is the distance between the 2 points between which the wave transmission happens.

3. **Space Wave**
Used for a line of Sight communication also known as LoS. Space satellite communication and very high-frequency waves use this propagation method. It basically involves sending a signal in a straight line from the transmitter to the receiver. We must ensure that for very large distances, the height of the tower used for transmission is high enough to prevent waves from touching the earth curvature thus preventing attenuation and loss of signal strength.

There is a very important relationship for determining the height of the antennas and their corresponding distance of transmission given by:

$Dm=(2RHt)-1/2 +(2RHr)-1/2$

where Dm=distance between 2 antennas; R=Radius of earth=6400 km Ht=Height of transmission antenna; Hr=Height of receiver antenna. Also, very important to note is another important relation to determining the range of transmission (Dt) for a given antenna of height Ht is:

$Dt=(2RHt)-1/2$

Thus we have reached the end of this discussion. Wherein we have seen and studied about electromagnetic waves, understood the concept of their production and studied their properties. We also looked at various types of EM waves available, their utilization and studied the method of their propagation.

Wireless Transmission Waves
Different types of signals are used in communication between the devices for wireless transmission of data. The following are the different electromagnetic signals are used depending on their wavelength and frequency.

- Radio Frequency Transmission
- Infrared Transmission
- Microwave Transmission
- Light wave Transmission

Radio Frequency Transmission
Radio frequency is a form of electromagnetic transmission used in wireless communication. RF signals are easily generated, ranging 3 kHz to 300GHz. These are used in wireless communication because of their property to penetrate through objects and travel long distances.

Radio communication depends on the wavelength, transmitter power, receiver quality, type, size and height of the antenna.

Drawbacks

- These are frequency dependent
- These have the relatively low bandwidth for data transmission.

Infrared Transmission

Infrared radiations are electromagnetic radiations with longer wavelengths than visible light. These are usually used for short-range communications. These signals do not pass through solid objects.

Examples like Television remote control, mobile data sharing.

Microwave Transmission

Microwaves are the form of electromagnetic transmission used in wireless communication systems. The wavelength of microwave ranges from one meter to one millimeter. The frequency varies from 300MHz to 300GHz. These are widely used for long distance communications and are relatively less expensive.

Drawbacks

- The microwave does not pass through buildings.
- Bad weather affects the signal transmission.
- These are frequency dependent.

Light wave Transmission

Light is an electromagnetic radiation with a wavelength ranging between infrared radiations and ultraviolet radiations the wavelength ranges from 430 to 750THz. These are unguided optical signals such as laser and are unidirectional

Drawbacks

These signals cannot penetrate through rain and fog.

The laser beam gets easily diverted by air.

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(b). We need to send 265kbps over a noiseless channel with a bandwidth of 20 KHz. How many signal levels do we need?

Solution

We can use the Nyquist formula as shown

Formula

$$C = 2 B \log_2 L$$

So,

$$265{,}000 = 2 \times 20{,}000 \times \log_2(L)$$

$$\text{Log}_2 L = 6.625$$

$$L = 2^{6.625} = 98.7 \text{ levels}$$

Since this result is not a power of 2, we need to either increase the number of levels or reduce the bit rate. If we have 128 levels, the bit rate is 280 kbps. If we have 64 levels, the bit rate is 240 kbps.

Q5. What is the difference between Shannon & Nyquist Capacity?

Ans#5:

Nyquist's theorem deals with the maximum signaling rate over a channel of given bandwidth. Shannon's theorem deals with the reconstruction of a signal from a finite number of samples. Since the results are similar, people often associate Nyquist's name with the sampling theorem. But this is not correct.

Two different concepts. Even though Shannon capacity needs Nyquist rate to complete the calculation of capacity with a given bandwidth.

Nyquist rate tells you in order to reconstruct a baseband signal with bandwidth W from sampling, you need to sample the signal at 2W rate. A good intuition is to think about a sine wave. This theory is applying to a signal without noise.

On the contrary, Shannon's Capacity theorem needs to specify noise distribution, Under Gaussian noise,

C=1/2log2 (1+P/N) bits per sample,
where P and N are power of signal and noise respectively.
Combine with Nyquist rate and calculate the noise power properly, you get channel capacity of bandwidth WW to be,
C=W log2(1+P/N_0W) bits per second,
where N0 is 2 times of Gaussian noise spectral density.

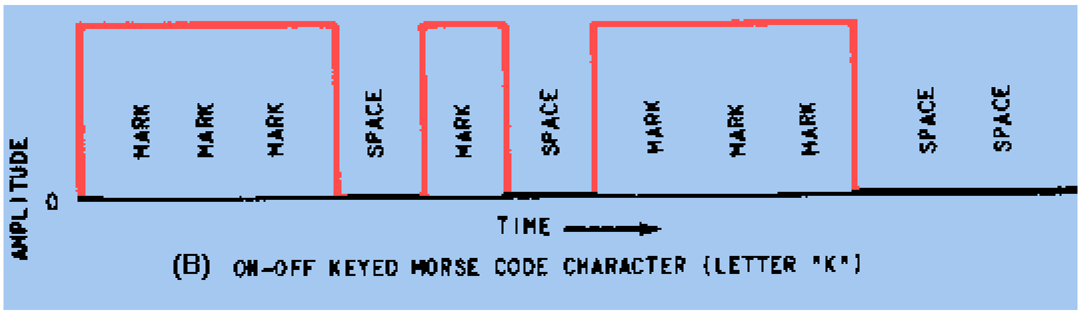
Two theoretical formulas were developed to calculate the data rate- one by Nyquist for a no1seless channel, another by Shannon for a noisy channel.

Noiseless Channel: Nyquist Bit Rate –
For a noiseless channel, the Nyquist bit rate formula defines the theoretical maximum bit rate r = 2 X B X log2 L In this formula, B is the bandwidth of the channel, L is the number of signal levels used to represent data, and r is the bit rate in bits per second. According to the formula, we might think that, given a specific bandwidth, we can have any bit rate we want by increasing the number of signal levels. Although the idea is theoretically correct, practically there is a limit. When we increase the number of signal levels, we impose a burden on the receiver. If the number of levels in a signal is just 2, the receiver can easily distinguish between a 0 and a 1. If the level of a signal is 64, the receiver must be very sophisticated to distinguish between 64 different levels. In other words, increasing the levels of a signal reduces the reliability of the system.

Noisy Channel: Shannon Capacity
In reality, we cannot have a noiseless channel; the channel is always noisy. In 1944, Cloudeshannon introduced a formula called the shannon capacity, to determine the theoretical highest data rate for a

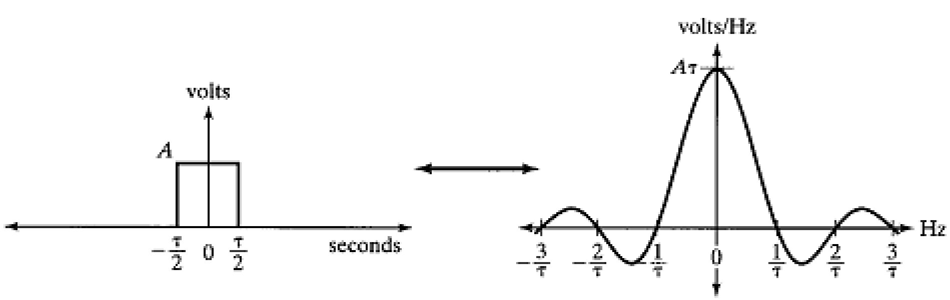
noisy Channel. C = B x log2(1 + SNR) In this formula B is the bandwidth of the channel, SNR is the signal-to noise ratio, and C is the capacity of the channel in bits per second. Note that the Shannon formula there is no indication of the signal level, which means that no matter how many levels we have. We cannot achieve a data rate higher than the capacity of the channel. in other words, the formula defines a characteristic of the channel, not the method of transmission. 10 In conclusion, we can say for channel capacity that the Shannon capacity gives us the' upper limit while the Nyquist formula tells us how many signal levels we need

Consider a rectangular pulse used for On-Off keying (ASK) as for example, in a telegraph:

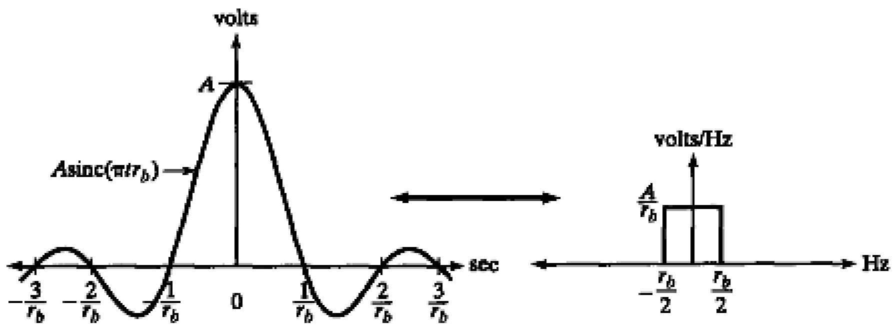


The spectral characteristics of the pulse should match that of the channel. If the pulse spectrum is broader than that of the channel, then it will be attenuated. The inverse relation between the time and frequency domains implies that the pulse would be spread out in the time domain, causing pulses in adjacent symbol periods to overlap - a phenomenon called inter-symbol interference. This makes detection difficult.

Shown below is the ISI arising from using a rectangular pulse to represent the symbols. The frequency spectrum of the rectangular pulse is a sinc whose frequency spectrum extends up to infinity. Any band limited channel will hence attenuate it, causing the signal to spread out in the time domain.



Nyquist proposed using a band limited pulse for transmission, instead of a a time-limited pulse. This would shift the problem of inter-symbol interference to the time domain (thus rendering filter design easy.)



But then, how would you deal with ISI in the time domain?

Nyquist observed that, the zero crossings of the sinc pulse, occur at a spacing of t = 1/2B seconds. So if the sinc pulses are transmitted at a rate of 2B pulses per second, then the peak of each sinc pulse, will occur at the first zero crossing of the preceding sinc pulse, making them easy to detect.

This is the Nyquist theorem, that the maximum number of band limited pulses that can be sent through a channel of bandwidth B, in a second is 2B. This rate is the maximum possible, because we've used a pulse whose bandwidth is exactly equal to the channel bandwidth. If we use a pulse with a smaller bandwidth, then the time domain sinc will get broader, scaling up the location of the zeroes and hence decreasing the signaling rate possible.

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(b). Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with 4 signal levels, the maximum bit rate can be ?

Formula:

BitRate = 2 * Bandwidth * log2 (L)

So,

$$BitRate = 2 * 3000 * \log_2 4$$

BitRate = 12,000 bps