Department of Communications Engineering

Communication Systems

Third Year Class

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Lecture 19

Multiplexing Systems, and Frequency Division Multiplexing (FDM)

Multiplexing Systems

* Enables several users to share a channel resource.
* provides redundancy to improve the reliability of a message reaching its destination.

* Multiplexing can be achieved by either Time, or, frequency, or code, or spatial.

- Time Division Multiplexing (TDM)
- Frequency Division Multiplexing (FDM)
- Code Division Multiplexing (CDM)

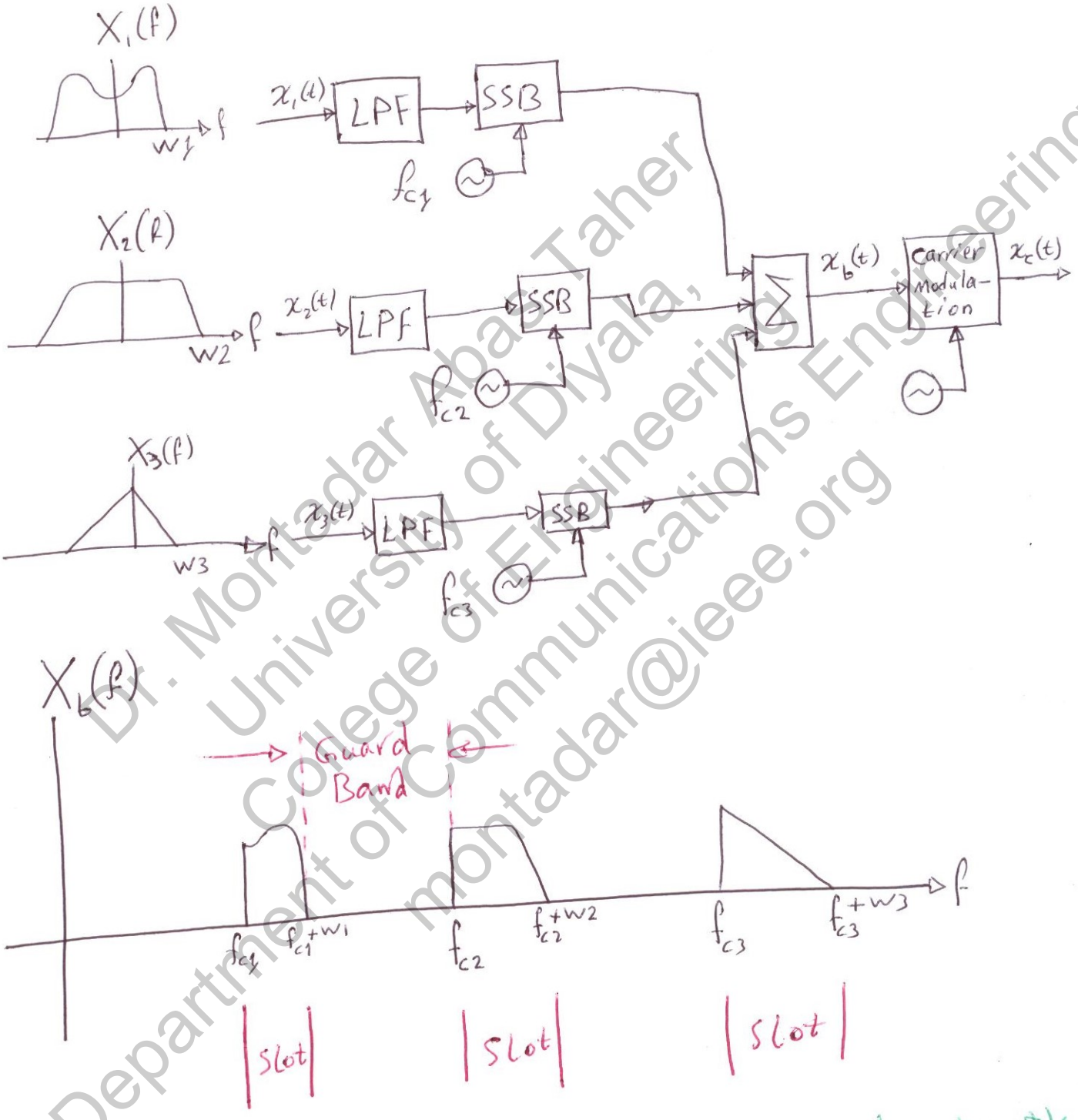
* If these schemes used for sharing a channel by different users, they will be called

+ Time Division Multiple Access (TDMA)
+ Frequency Division Multiple Access (FDMA)
+ Code Division Multiple Access (CDMA)

* FDM has some other submethods such as:
  + quadrature-carrier multiplexing, and → QAM
  + Orthogonal Frequency Division Multiplexing (OFDM).

* Spatial multiplexing: also a scheme of multiplexing used in wireless systems.
  + Spatial multiplexing can be done using different parameters such as the antenna polarization:-
    - Horizontal
    - Vertical
    - Circular - Right hand
    - Circular - Left hand

FDM



* Major problem in FDM is the crosstalk due to th nonlinearity of the amplifiers, thus, cross-talk (intermodulation) appears.

Hence, there are Intelligible Crosstalk (cross-modulation) and Unintelligible crosstalk.

* Unintelligible crosstalk may come from nonlinear effects or imperfect spectral separation by the filter bank.

* Unintelligible crosstalk can be reduced by using the guard band

* net bandwidth, thus, is the sum of guard bands and the modulated messages.

$$BW = \sum_{i=1}^{N-1} G_i + \sum_{n=1}^{N} m(t)_n$$

* The commercial AM or FM broadcast bands are everyday examples of FDMA

* To increase the reliability of a user's message transmission, frequency diversity can be used.

* Frequency diversity stands for Multicarrier (MC) modulation.

* Multicarrier (MC) modulation is the process where the message of a certain user is parsed, and then the pieces will be sent over different carrier frequencies.

* Frequency diversity used to cope with frequency selective channel fading.

* Examples of frequency diversity are GSM phones, and OFDM.

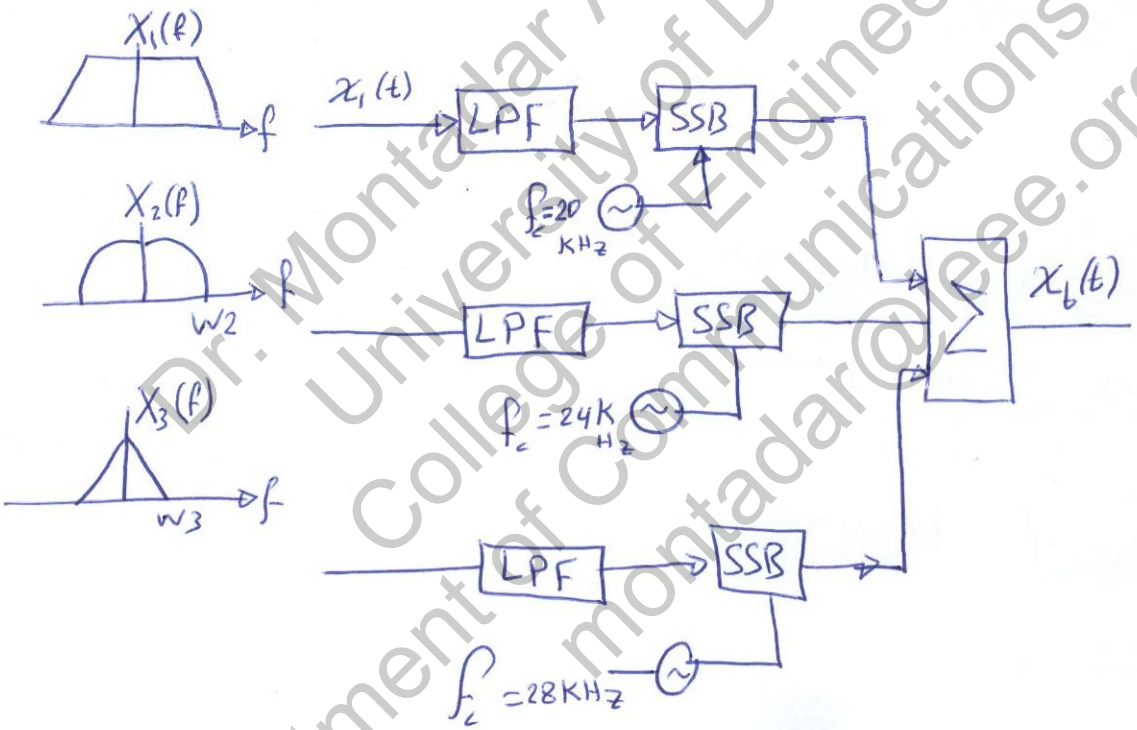
Ex.4 Assume that a voice channel occupies a bandwidth of 4 KHz. We need to combine three voice channels into a link with a bandwidth of 12 KHz, from 20 to 32 KHz. Show the configuration, using frequency domain. Assume there are no guard bands.

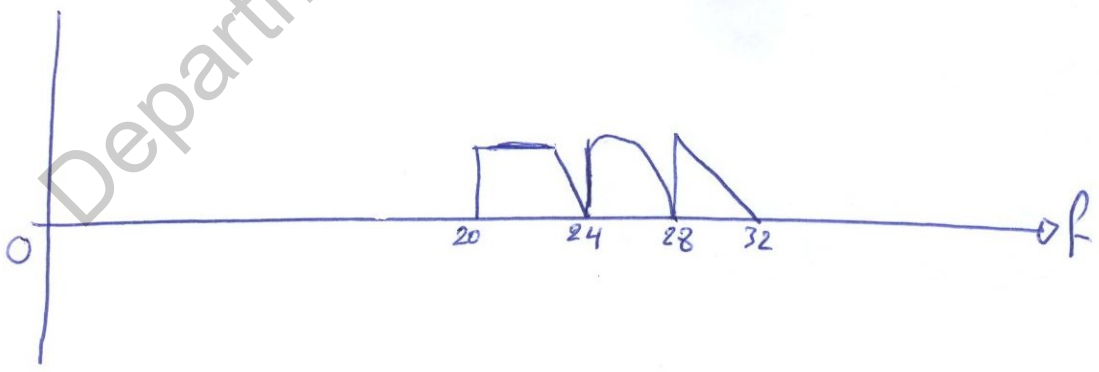
Solution

First channel : 20 – 24 KHz

Second channel : 24 – 28 KHz

Third channel : 28 – 32 KHz





EX. 2 Fifteen channels, each with a 200 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 15 KHz between the channels to prevent interference?

Solution

Number of channels $N = 15$

Bandwidth of each channel $W = 200$ KHz

Number of Guard bands = number of channels $- 1 = 14$

Bandwidth of each Guard band $= 15$ KHz

$\therefore$ Total bandwidth $= 14 \times 15K + 15 \times 200K$

$B_T = 210K + 3000K = 3210$ KHz.

EX.3 A cable TV service uses a single coaxial cable with a bandwidth of 860 MHz to transmit multiple TV signals to subscribers. Each TV signal is 6 MHz wide. How many channels can be carried? Assuming no guard bands.

Solution

Total bandwidth $B_T = 860$ MHz

Channel Bandwidth $= 6$ MHz

$\therefore$ Number of channels $= \frac{860}{6} = 143.3 = 143$ channel.

EX. 3 The advanced mobile phone system (AMPS) uses two bands. The first band of 824 to 849 MHz is used for uplink, and 869 to 894 MHz is used for downlink. Each user has a bandwidth of 30 kHz in each direction. How many people can use their cellular phones simultaneously if you know that there are 42 channels reserved for control and signaling?

Solution

Uplink Band = $849 - 824 = 25$ MHz.

Downlink Band = $894 - 869 = 25$ MHz.

for each direction:

each user band = 30 kHz

∴ total number of channels N

$$N = \frac{25 \times 10^6}{30 \times 10^3} = 833.33 = 833$$

in reality $\boxed{N = 832}$

since 42 channels are for control

∴ the channels for users are $832 - 42 = 790$ users can use their cellphones simultaneously.