



# Subject: Digital Communications

Class: 3<sup>rd</sup>

## Lecture One

# "Multiplexing Techniques"

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2021-2022



## Lecture Outlines

- ☒ **Multiplexing Techniques**
  - ❖ **Frequency Division Multiplexer (FDM)**
  - ❖ **Time Division Multiplexing (TDM)**

### **1.Fixed TDM**

### **2.Dynamic TDM**

## Teaching Tools:

- White Board, white board marker and eraser

## Teaching Methods:

1. Method of lecture.
2. Method of discussion and dialogue.
3. Brain storming

## ❖ Multiplexing techniques:

Multiplexing is the transmission of information (either voice or data) from more than one source to more than one destination on the same transmission medium. The most two common methods used are frequency division multiplexing (FDM) and time division multiplexing (TDM).

### A. Frequency Division Multiplexer (FDM)

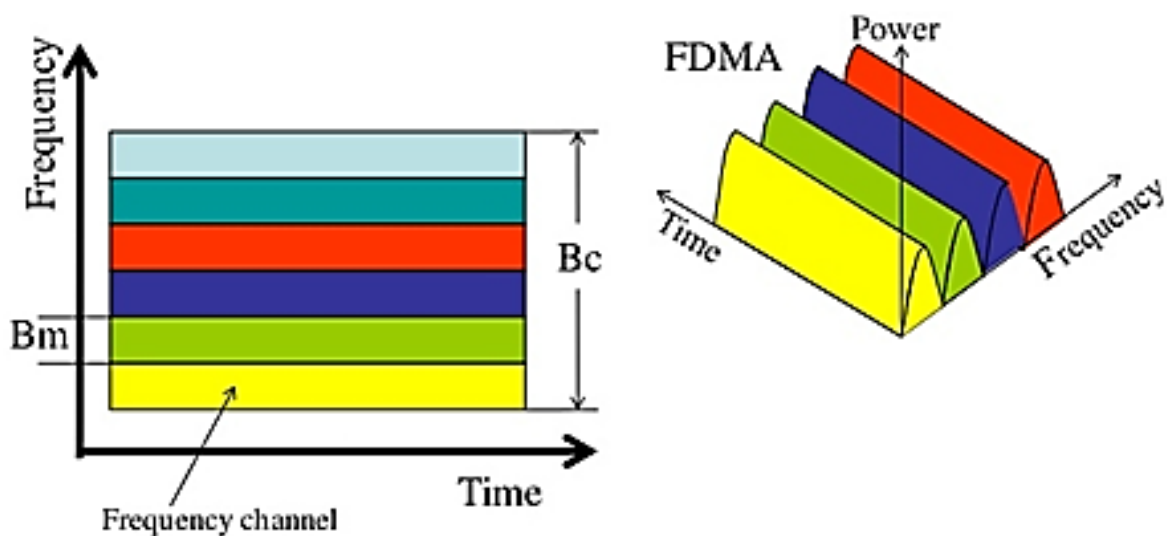


Figure (1): Frequency Division Multiplexing (FDM)

In FDM multiple sources that originally occupied the same frequency spectrum are each converted to a different frequency band and transmitted simultaneously over a single transmission medium. FDM is an analog multiplexing scheme. Figure below shows the frequency-time plane.

If two input signals to a mixer are sinusoids with frequencies  $f_A$  and  $f_B$ , the mixing or multiplication will yield new sum and difference frequencies at  $f_{A+B}$  and  $f_{A-B}$ . Equation below describes the effect of the mixer.

$$\cos A \cos B = \frac{1}{2} [\cos(A + B) + \cos(A - B)]$$

A simple FDM example with three translated voice channels is shown in figure below.

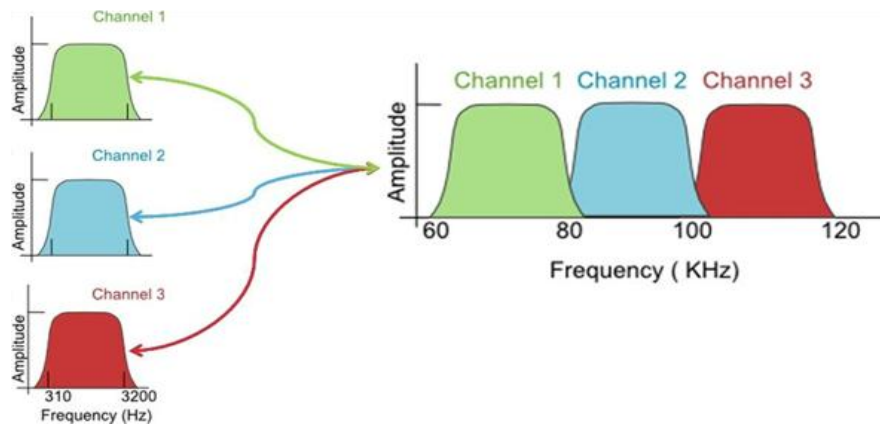


Figure (2): Multiplexing of three channels using (FDM)

## **B. Time Division Multiplexing (TDM)**

With TDM system, transmission from multiple sources occurs on the same transmission medium but not at the same time. Transmission from various sources is interleaved in time domain.

Figure below shows the time-frequency plan in TDM system, the same communication resources is shared by assigning each of  $N$  symbols or users the full spectral occupancy of the system for a short

duration of time called *time slot*. The unused time regions between slot assignments, called *guard times*, act as buffer zone to reduce interference.

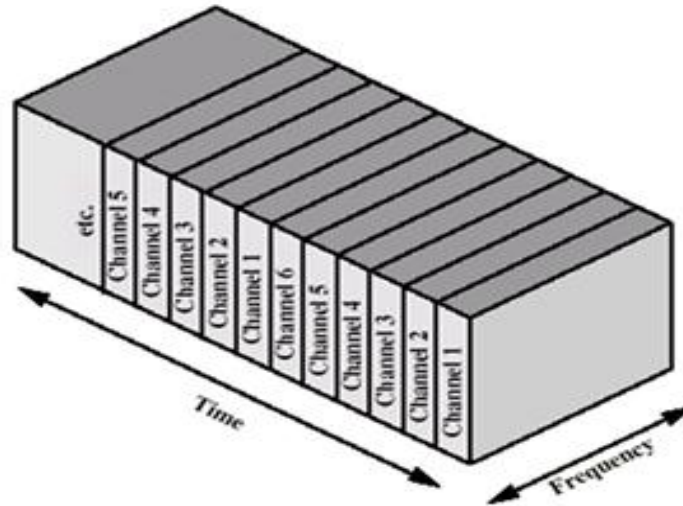


Figure (3): The time-frequency plan in TDM system

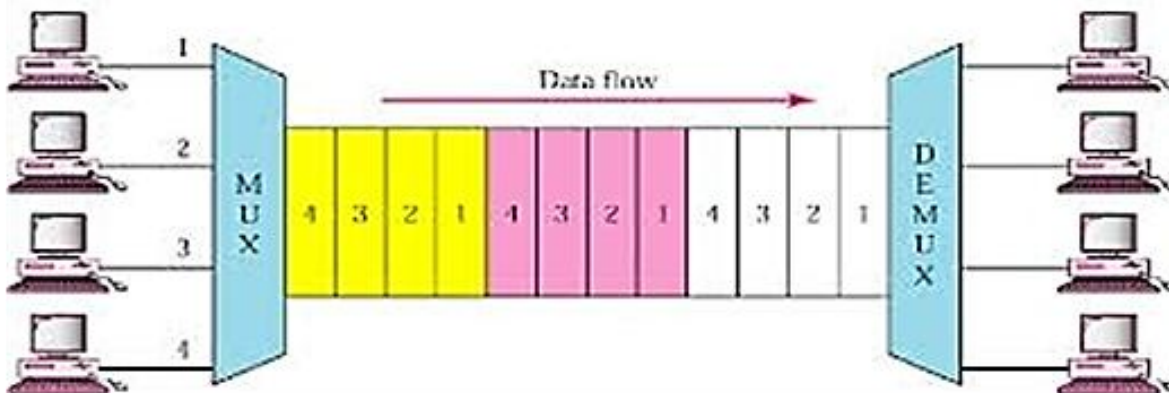


Figure (4): Typical TDM system

The multiplexing operation consists of providing each source with an opportunity to occupy one or more slots.

The demultiplexing operation consists of deslotting the information and delivering the data to the intended sink.

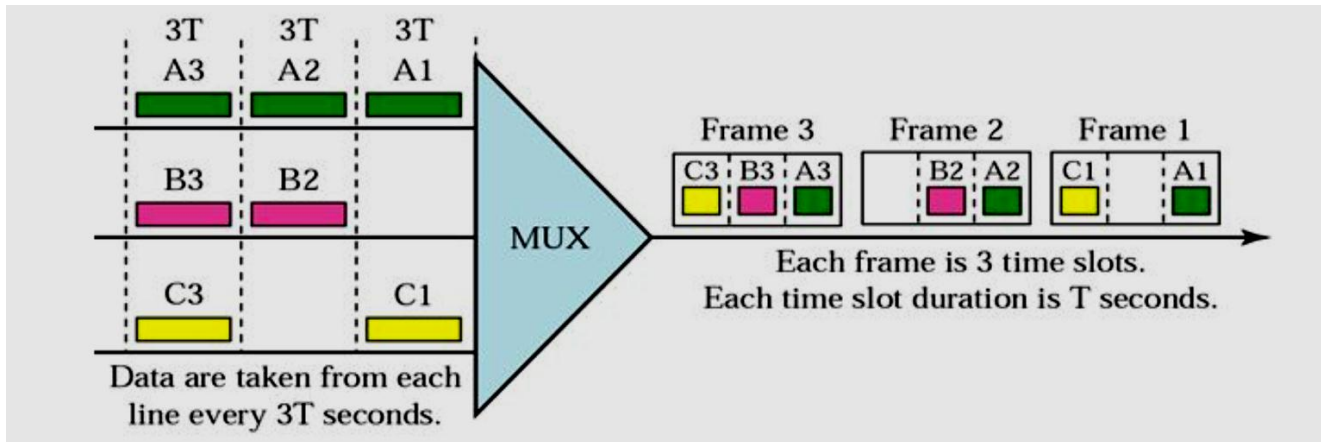


Figure (5): Example of Fixed TDM

The communication switches ( $S_1 \dots S_M$ ) have synchronized so that the message corresponding to signal (1), for example, appears on the channel (1) output, and so on. Time is segmented in to intervals called *frames*. Each frame is further partitioned in to assignable user time slots. The simplest TDM scheme called *fixed-assignment TDM*. In fixed assignment TDM scheme, the entire slot has no data to send during a particular frame, that slot is wasted.

Another more efficient scheme is the *dynamic assignment TDM* of the slots rather than fixed assignment.

Figures below show the fixed and dynamic assignment TDM system.

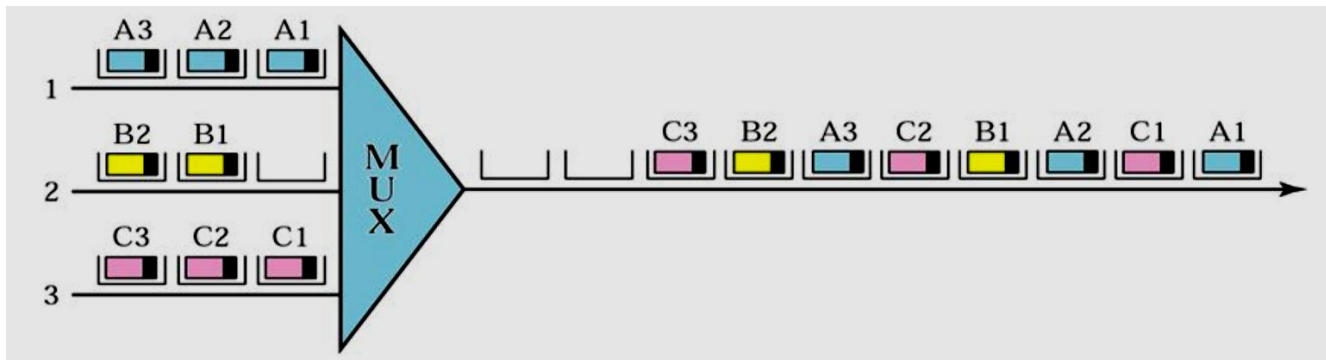


Figure (6): Example of Dynamic TDM

## Summary

1. In this lecture the principle and techniques of digital communications had been introduced.
2. The main types of multiplexers had been presented.
3. The digital communications will be considered as the best transmission technique as compared with analog systems

## Homework

- 1.** Explain the types of multiplexing techniques.
- 2.** Define: FDM and TDM.
- 3.** What are the types of TDM system? Explain them?



## ❖ References:

1. "Digital communications ", J.G .Proakis, 2001.
2. "Digital Communications Fundamentals ", B. Sklar, A. V. Oppenheim, and W. Ronald, 2008.