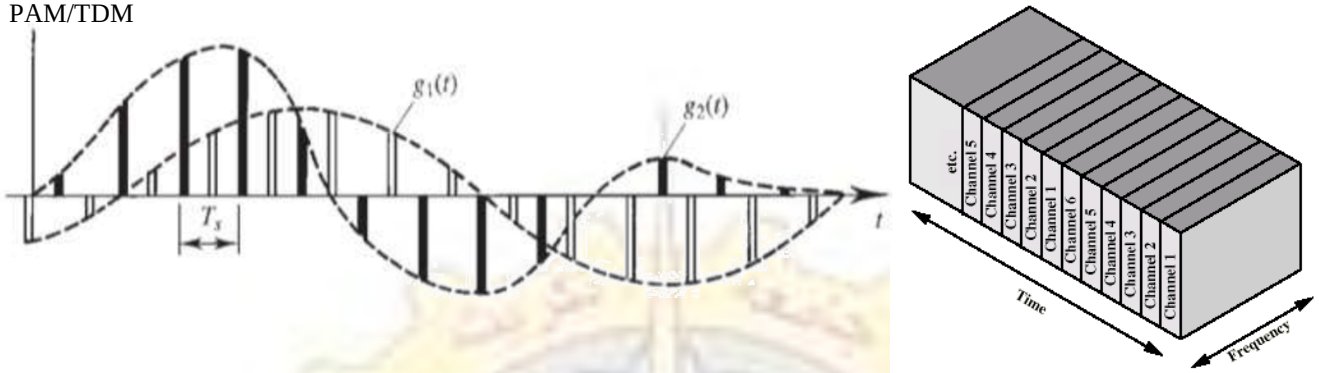
Time Division Multiplexing

Time-division multiplexing (TDM) is a digital process that allows several connections to share the high bandwidth of a line. Instead of sharing a portion of the bandwidth as in FDM, time is shared.

Time Division Multiplexing is the process of dividing up one communication time slot into smaller time slots.

PAM/TDM



The clock periode of PAM/TDM (Tx) is equal to sampling time for each signal (T) over the number of signals (n).

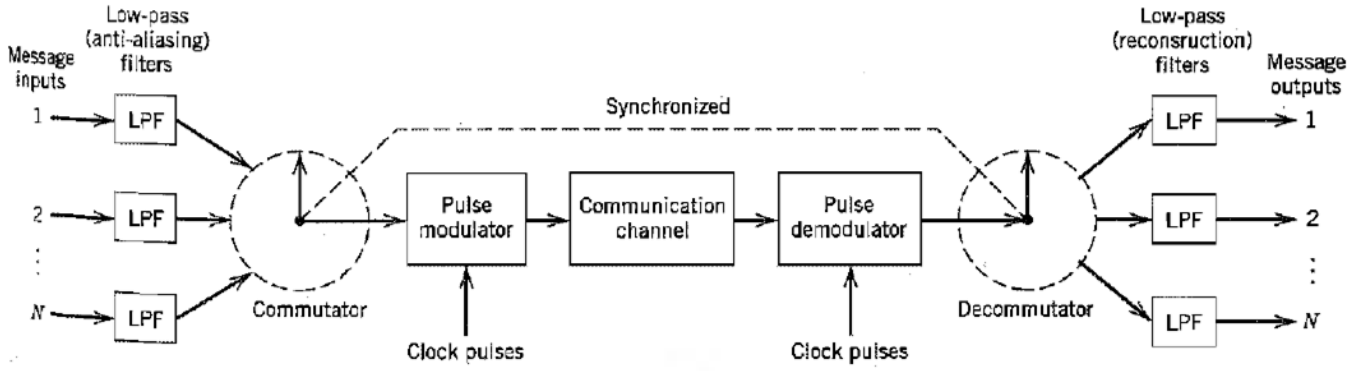
$$T_x = \frac{T}{n}$$

The bandwidth required for LPF (Bx) in inversilly proportional to the doubble Tx

$$B_x = \frac{1}{2T_x}$$

Example 1:

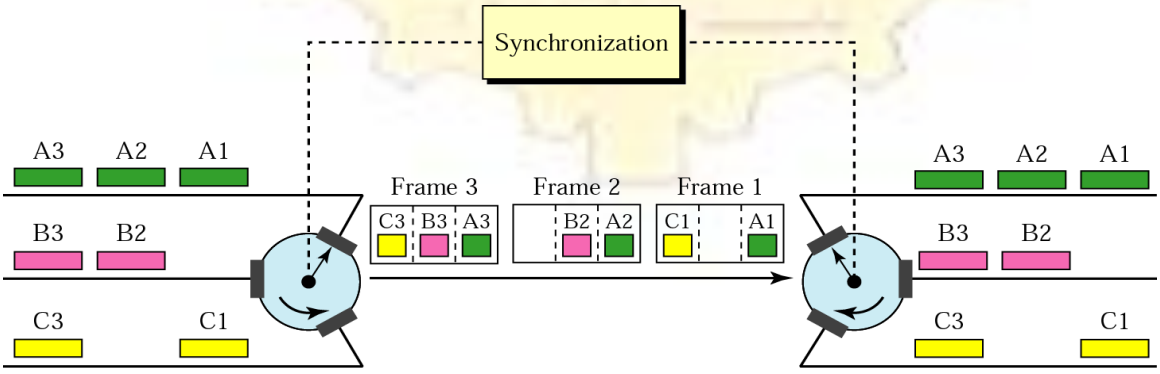
Determine the minimum transmission BW in a TDM system transmitting 20 different messages, each message signal have BW of 5 kHz; compare the result if FDM is used with AM & SSB techniques.



Block diagram of TDM

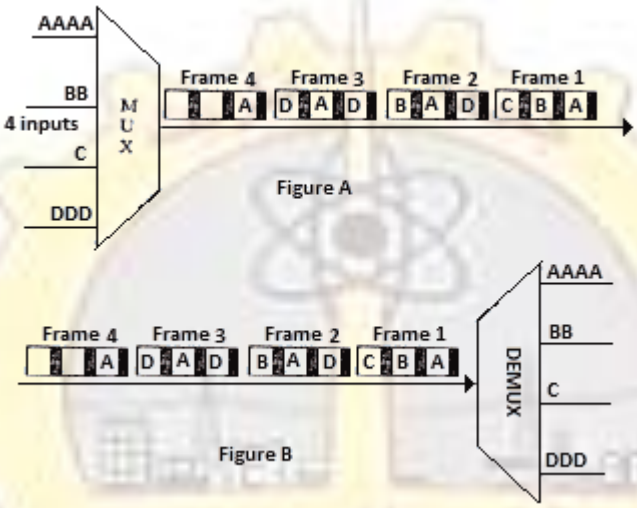
synchronous TDM

- In synchronous TDM, the data flow of each input connection is divided into *units*, and the link combines one unit of each connection to make a *frame*. The size of the unit can be 1 bit or several bits.
- For *n* input connections, a frame is organized into a minimum of *n time slots*, each slot carrying one unit from each connection.
- The data rate of the link that carries data from *n* connections must be *n* times the data rate of a connection to guarantee the flow of data.
- The duration of a unit on a connection is 3 times that of the time slot in the frame (duration of a unit on the link).
- Time slots are grouped into frames. A frame consists of one complete cycle of time slots, with one slot dedicated to each sending device.
- In a system with *n* input lines, each frame has *n* slots, with each slot allocated to carrying data from a specific input line.

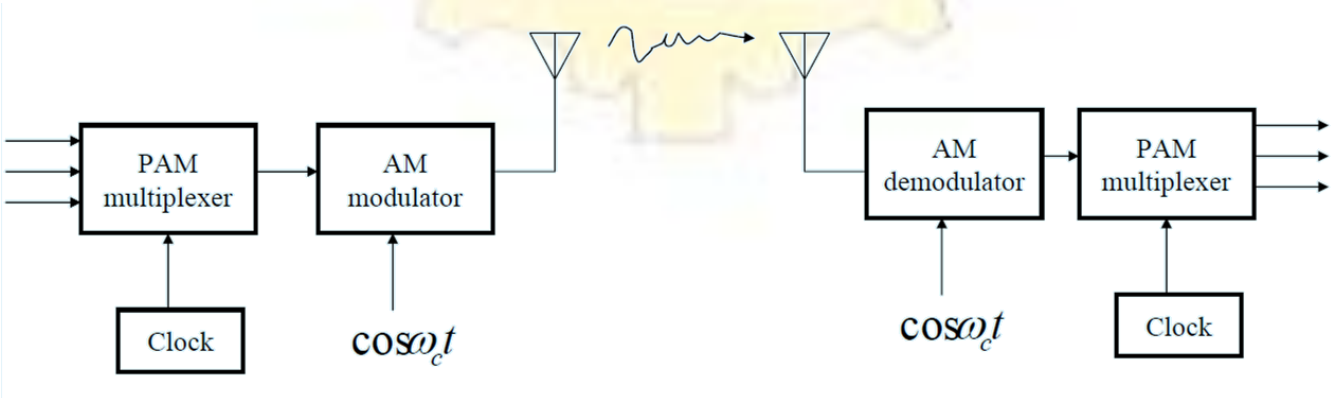


Asynchronous TDM (Statistical TDM)

- In synchronous TDM, each input has a reserved slot in the output frame. This can be inefficient if some input lines have no data to send.
- In statistical time-division multiplexing, slots are dynamically allocated to improve bandwidth efficiency. Only when an input line has data to send is given a slot in the output frame.
- In statistical multiplexing, the number of slots in each frame is less than the number of input lines. The multiplexer checks each input line in roundrobin fashion; it allocates a slot for an input line if the line has data to send; otherwise, it skips the line and checks the next line.



For long distance transmission, the multiplexed signal is used as the modulating signal to modulate a carrier. For example, PAM/AM



Advantages of TDM

– high reliability and efficient operation as the circuitry required is digital.

– Relatively small interchannel cross-talk arising from nonlinearities in the amplifiers that handle the signals in the transmitter and receiver.

Disadvantages of TDM

– timing jitter

Example 2:

Twelve speech signals are TDM-PAM transmitted, find minimum sample rate at the channel and minimum required BW.

Example 3:

Two thousand signal (each one has 5KHz banswidth) are sampled at Nyquist rate. Find the sampling time and the maximum duration of each signal.

Example 4:

Find the output waveform of TDM when the input signals are $m_1(t)=5\cos(4\pi t-30^o)$, $m_2(t)=4\cos(5\pi t)$, with 20Hz sampling frequency.

Example 5:

Find the output waveform of time divisiom multiplexing when the input signals are $m_1(t)=10\sin(10\pi t-45^o)$, $m_2(t)=4\cos(8\pi t)$, with 25Hz sampling frequency. Sketch the PAM output signal.

Example 6:

Find the output waveform of time divisiom multiplexing when the input signals are $m_1(t)=5\sin(400\pi t-72^o)$, $m_2(t)=4\cos(500\pi t)$, with 1KHz sampling frequency. Sketch the PAM output signal and draw the circuit diagram.