

TDM, FDM & PLESIOCHRONOUS DIGITAL HIERARCHY

ECE 426 – DIGITAL COMMUNICATION

Monday, 13 April 2026

COURSE OUTLINE

Course Purpose:

To enable students understand the fundamental principles of digital transmission systems as used in fixed and mobile telephony, wired and wireless computer networks, data storage and digital broadcasting.

Expected Learning Outcomes:

At the end of the course, students will be able to:

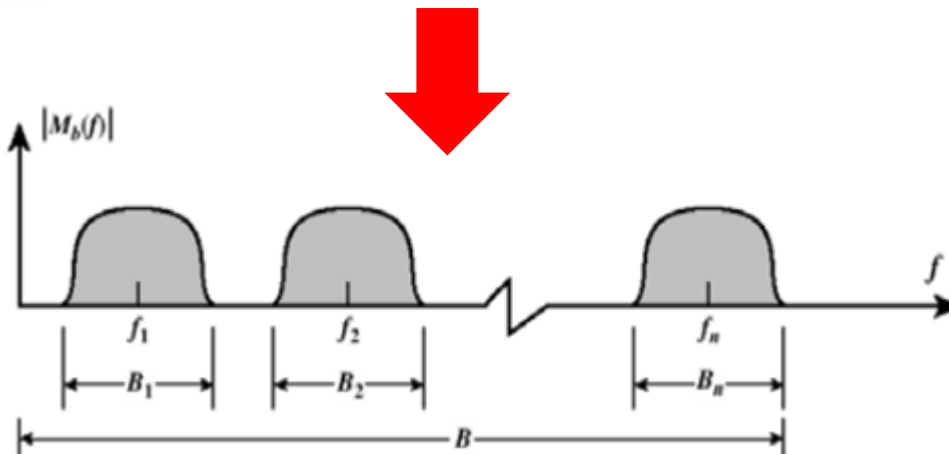
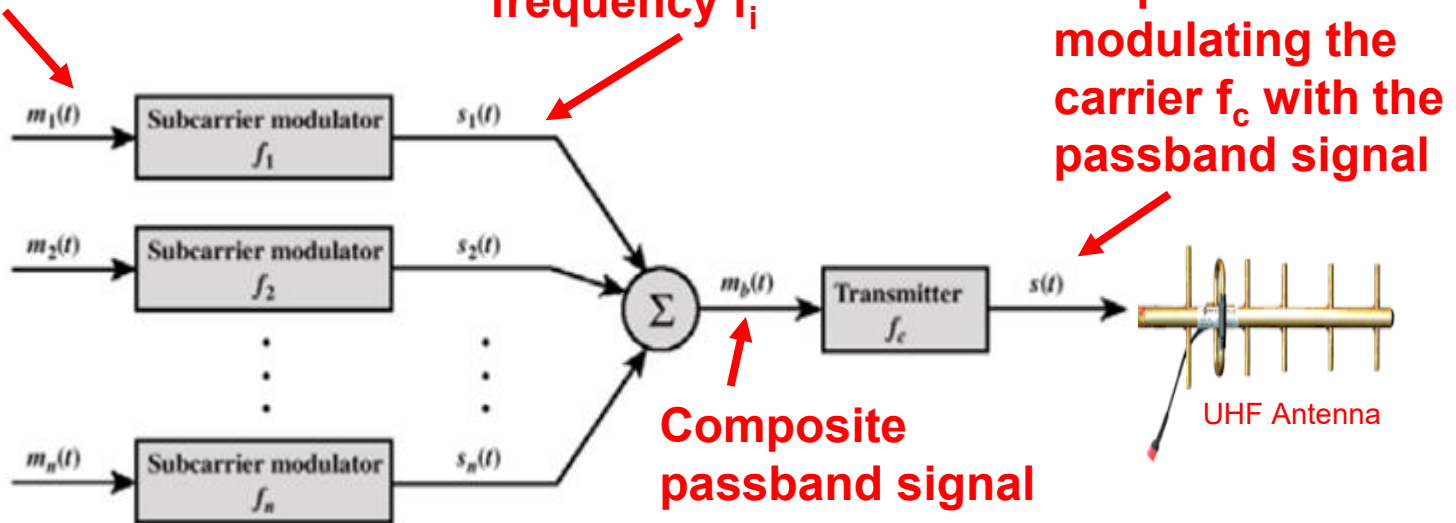
- (i) describe binary and duo binary pulse Amplitude Modulation (PAM);
- (ii) design digital coding schemes;
- (iii) derive error performance equations for digital modulation schemes(ASK,FSK,PSK,DPSK);
- (iv) state strengths and weaknesses of M-ary PSK with QAM signaling schemes;
- (v) design a basic digital communication systems.

Course Content:

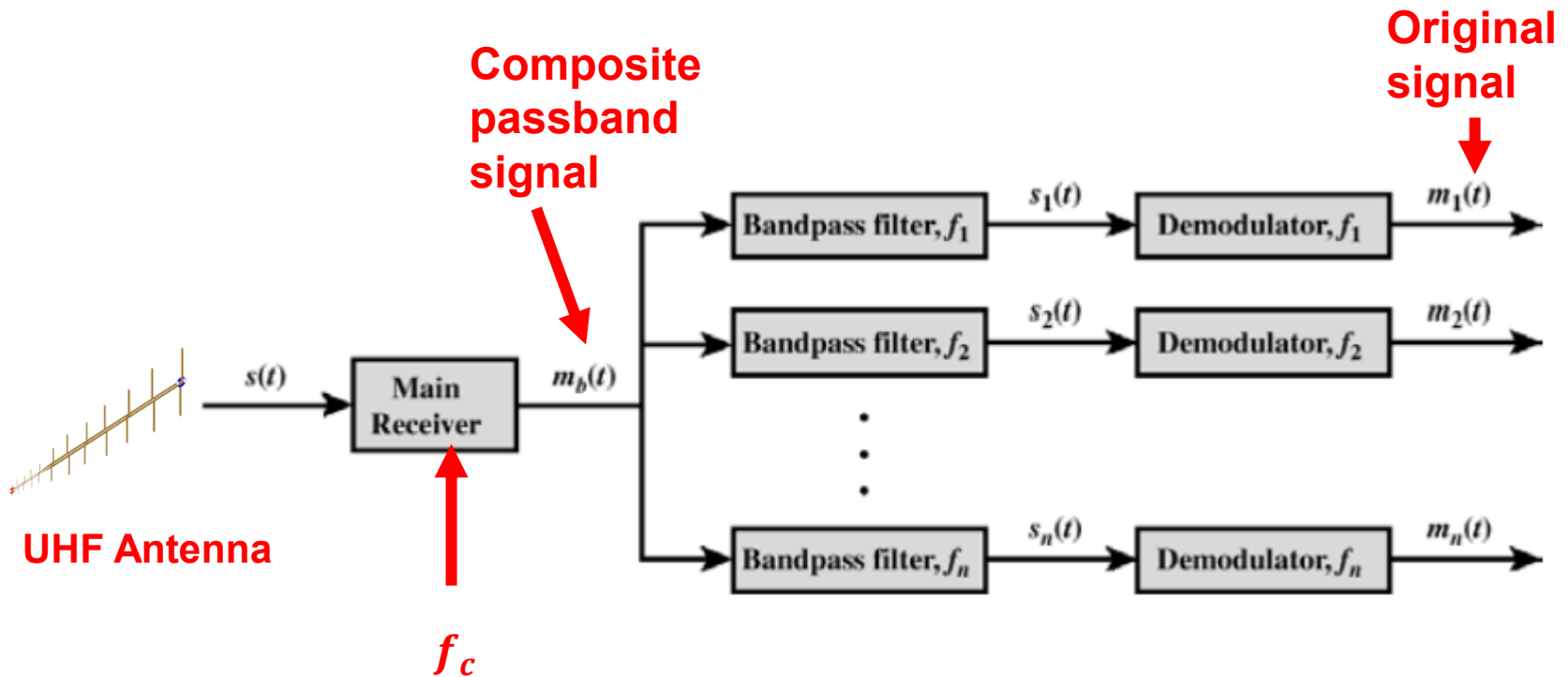
Signal digitization: Pulse Amplitude Modulation (PAM), sampling theorems and sampling circuits, Pulse code modulation (PCM). Quantization and signal conditioning: Uniform and non-uniform quantization; companding methods; vocoders; signal-to- quantization noise ratio. Waveform coding: Pulse transmission, PCM, Pulse-shaping; Delta modulation; adaptive delta modulation; Differential Pulse Code Modulation (DPCM), M-ary encoding. Digital Modulation: Amplitude shift keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Quadrature Amplitude Modulation (QAM) and Differential Phase Shift Keying (DPSK). Signal recovery in ASK, FSK and PSK; Gaussian Minimum Shift Keying (GMSK); Performance comparison. Information theory: information sources, entropy, channel capacity; Source Coding; entropy coding. Error control: Error control coding techniques; Transmission errors; Error detection methods; intersymbol interference and the eye pattern; Linear block codes; Cyclic codes; convolution codes. Multiplexing: Frequency division multiplex (FDM), Time Division Multiplexing (TDM), plesiochronous digital hierarchy (PDH). Spread spectrum communication: Direct sequence and frequency hopping methods; synchronization, spreading codes and their generation. Data transmission: Local data transmission protocols (Ethernet, token ring); Modems; high Asymmetric Digital subscriber line (ADSL); Very-high Speed Digital subscriber line (VDSL), integrated services digital network (ISDN).

FREQUENCY DIVISION MULTIPLEXING (FDM) TRANSMITTER

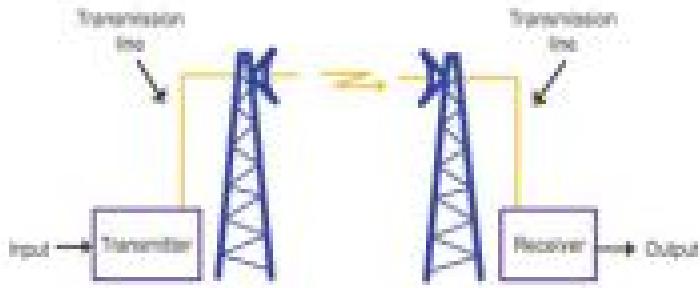
Analogue
channel
Signal



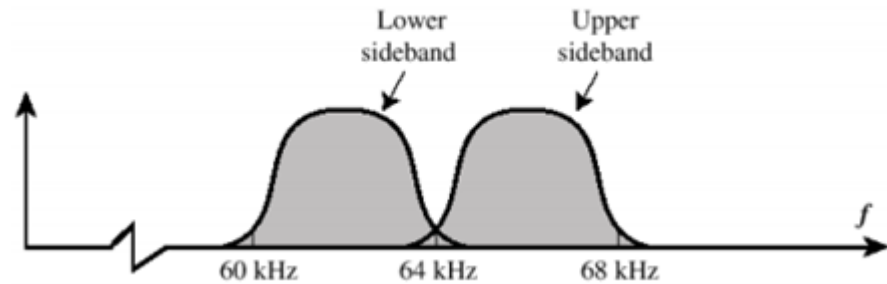
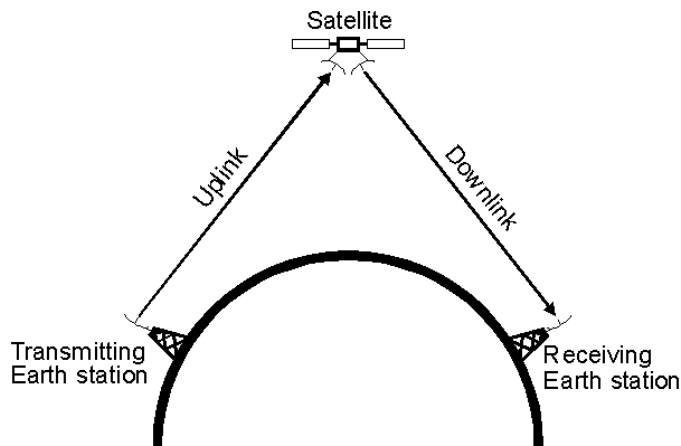
FREQUENCY DIVISION MULTIPLEXING (FDM) RECEIVER



FDM IN ANALOG TELEPHONE MULTIPLEX SYSTEMS (1)

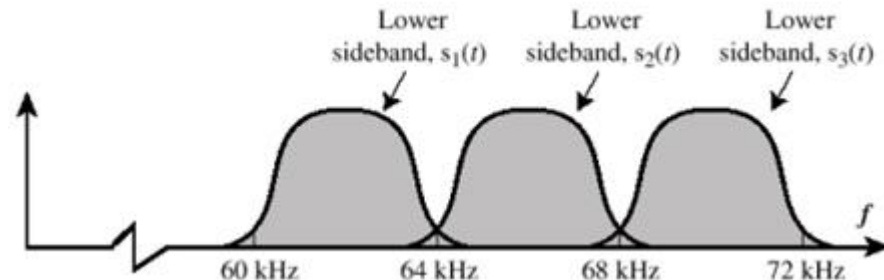


(a) Each voice channel is bandlimited between 0.3 – 3.4 KHz



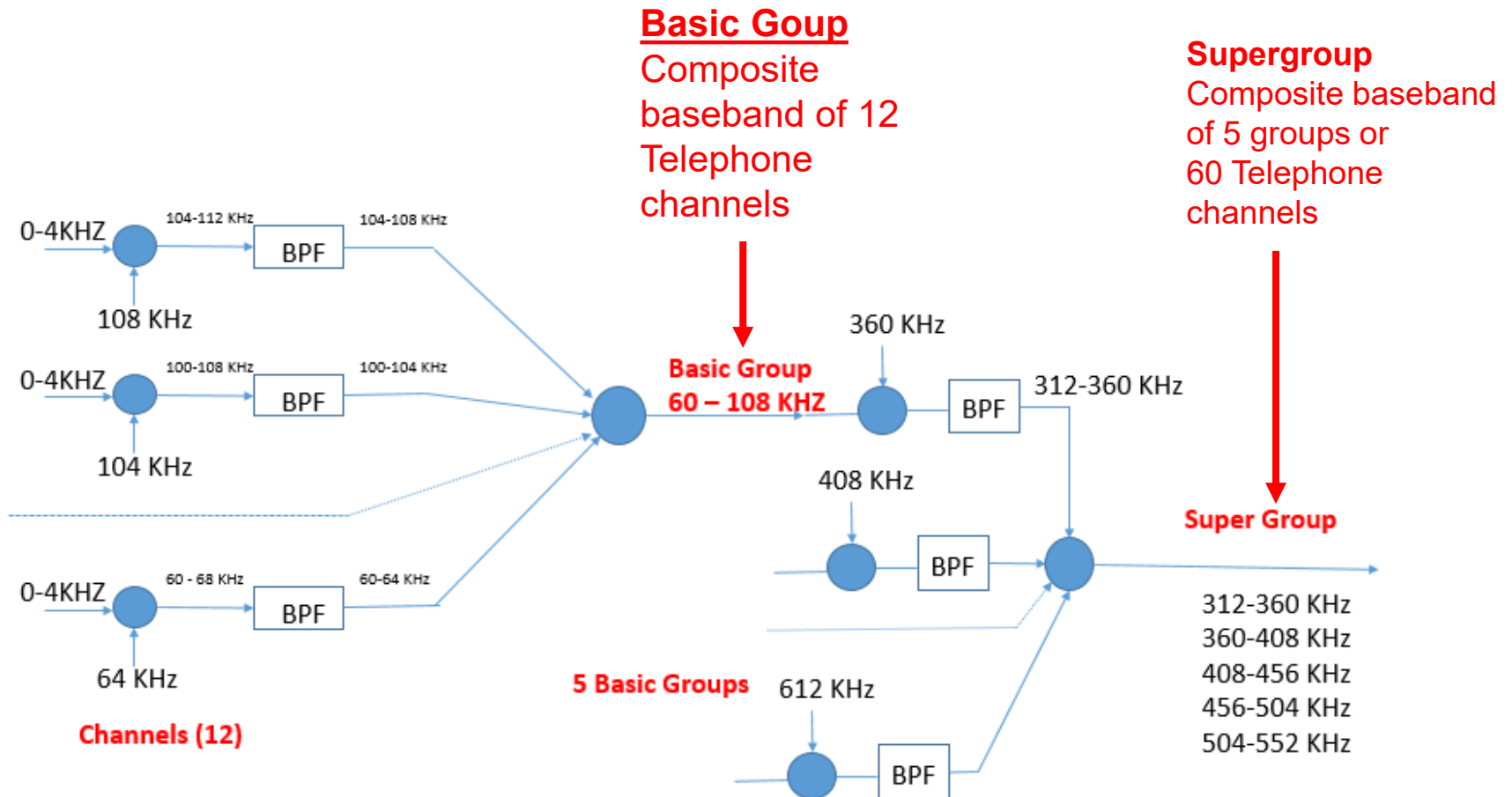
(b) A voice channel is used to amplitude modulate a carrier at 64 KHz

We desire to have send a composite signal consisting of N simultaneous telephone conversations between two locations

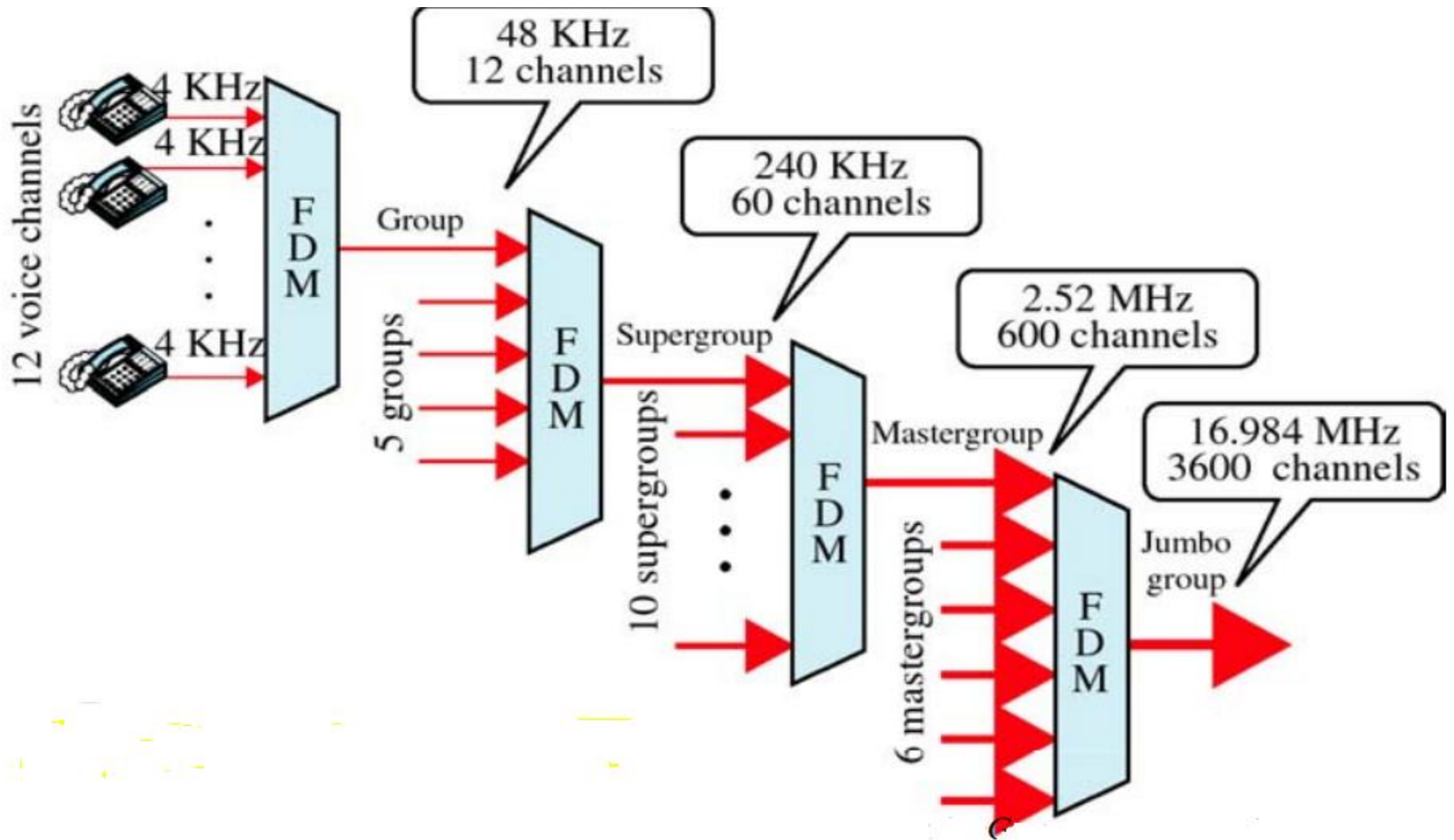


(c) Lower sidebands of 12 channels are created by modulating carriers at 64, 68, --- 108 KHz.

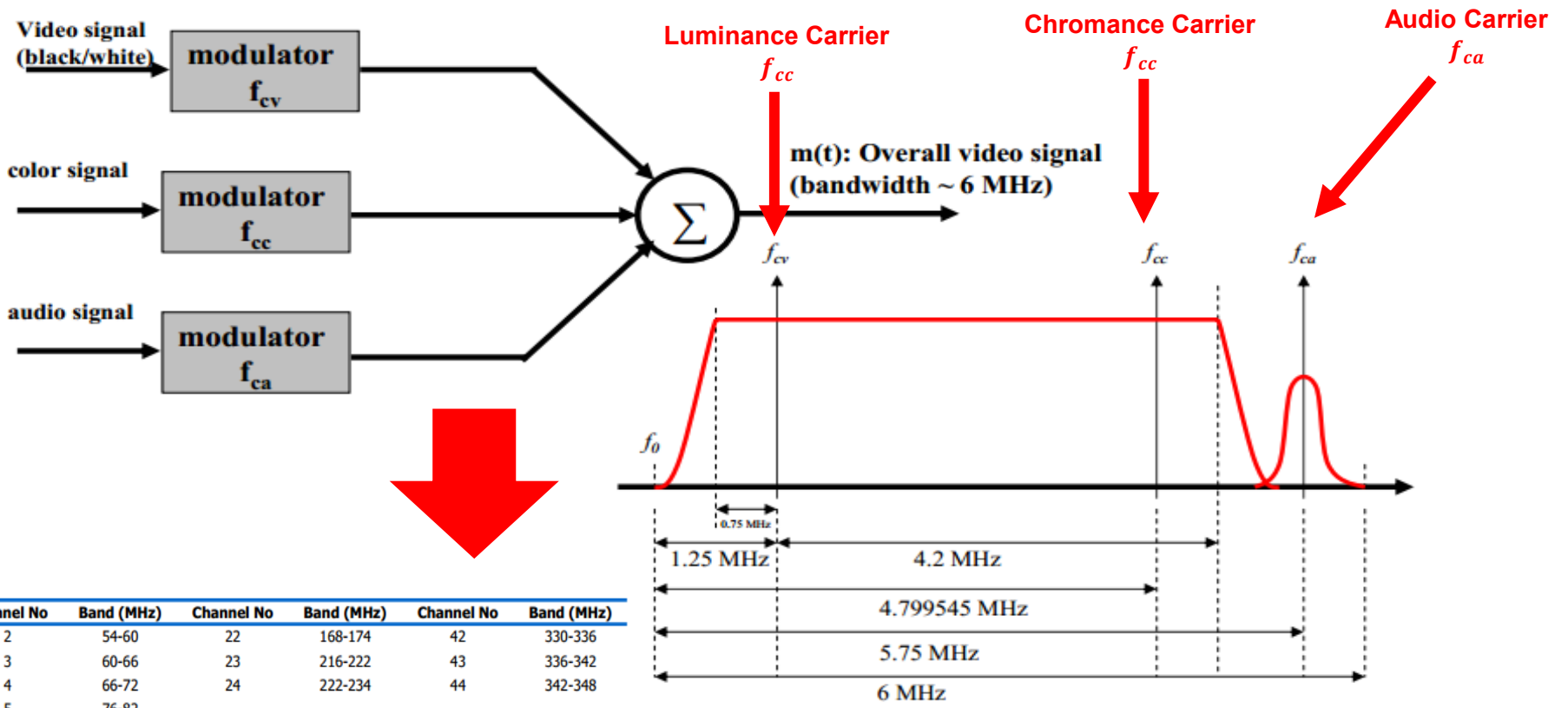
FDM IN ANALOG TELEPHONE MULTIPLEX SYSTEMS (2)



FDM IN ANALOG TELEPHONE MULTIPLEX SYSTEMS

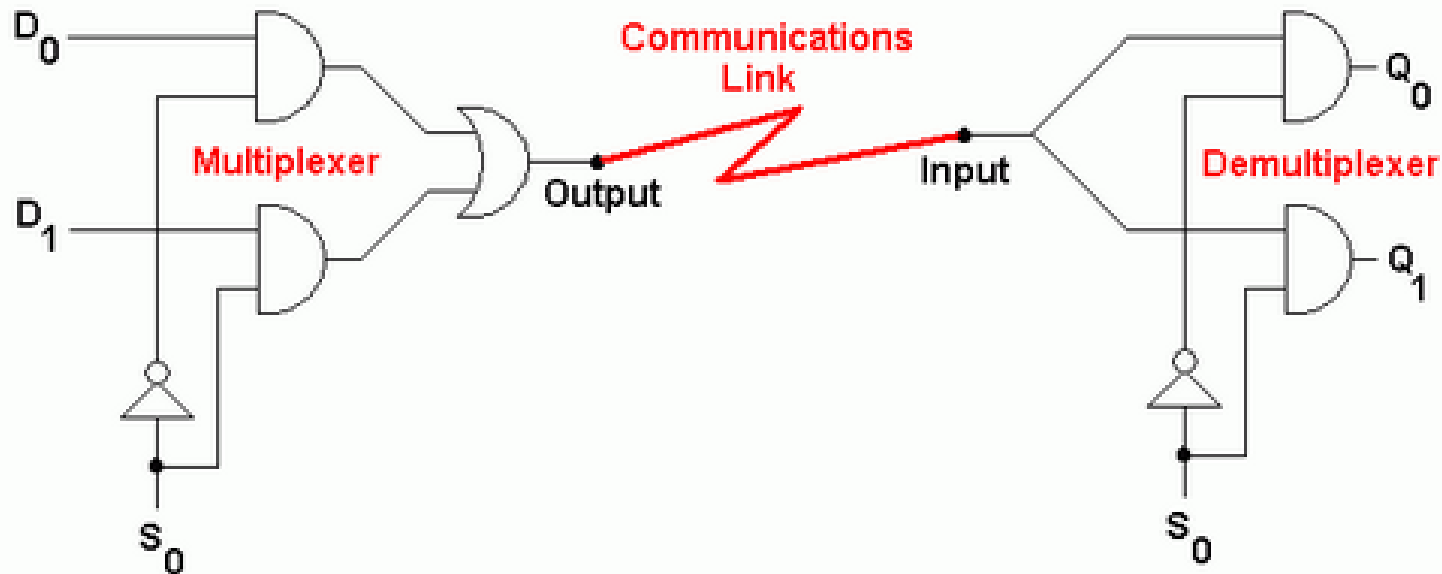


FDM OF CABLE TV SIGNAL

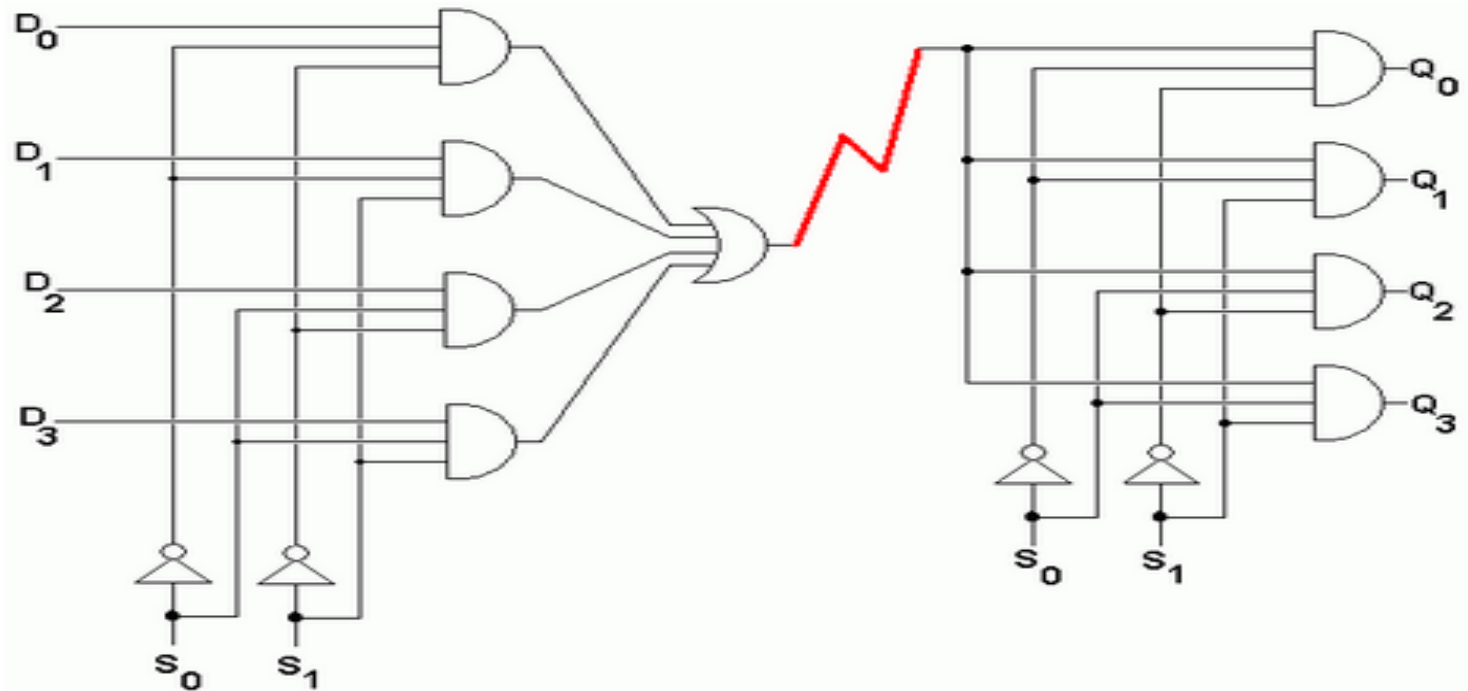
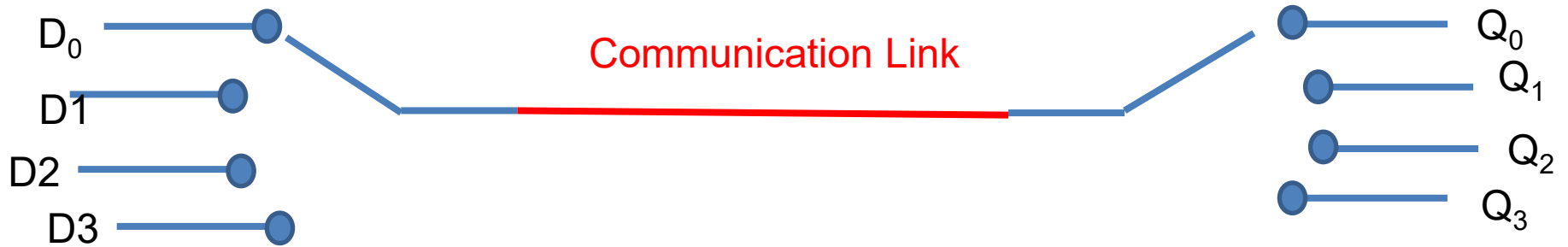


Channel No	Band (MHz)	Channel No	Band (MHz)	Channel No	Band (MHz)
2	54-60	22	168-174	42	330-336
3	60-66	23	216-222	43	336-342
4	66-72	24	222-234	44	342-348
5	76-82
6	82-88				
7	174-180				
8	180-186				
9	186-192				
10	192-198				
11	198-204				
12	204-210				
13	210-216				
FM	88-108				
14	120-126				
15	126-132				
16	...				
...	...				

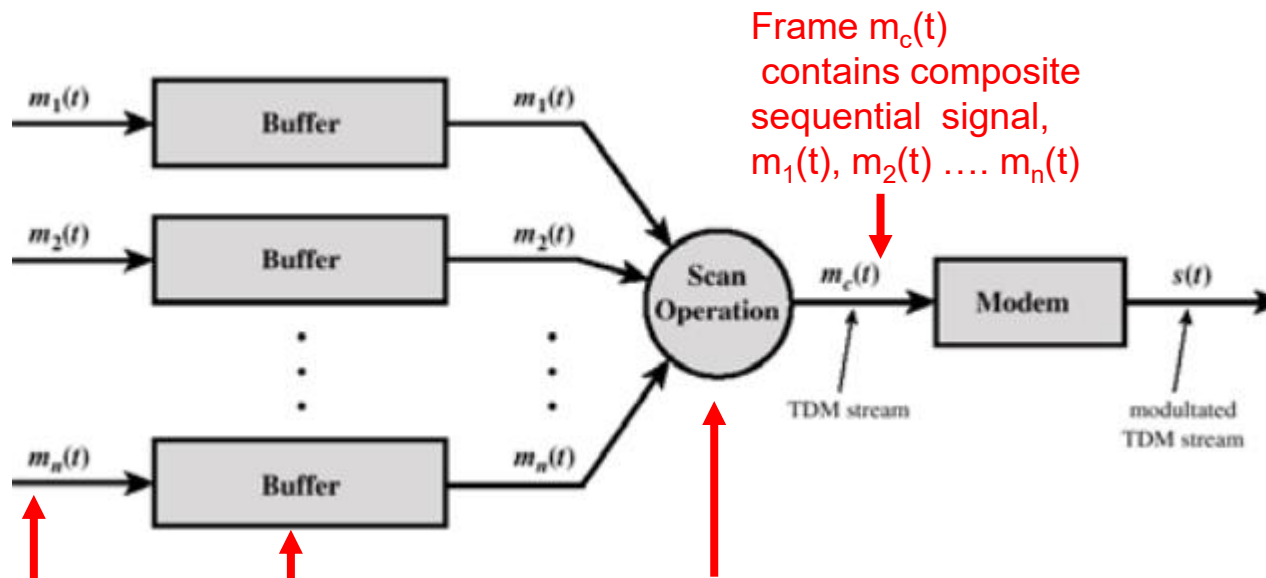
TIME DIVISION MULTIPLEX (TDM) OF TWO DIGITAL CHANNELS



TDM OF FOUR DIGITAL CHANNELS



SYNCHRONOUS TDM TRANSMITTER

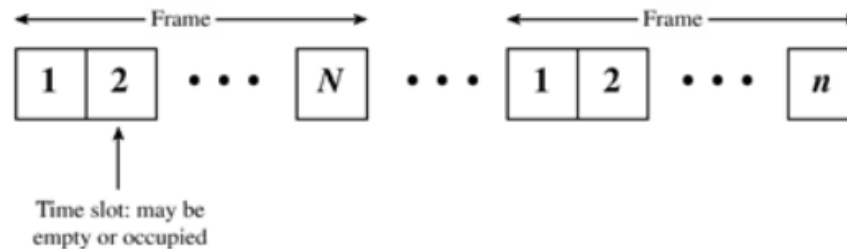


Frame $m_c(t)$
contains composite
sequential signal,
 $m_1(t), m_2(t) \dots m_n(t)$

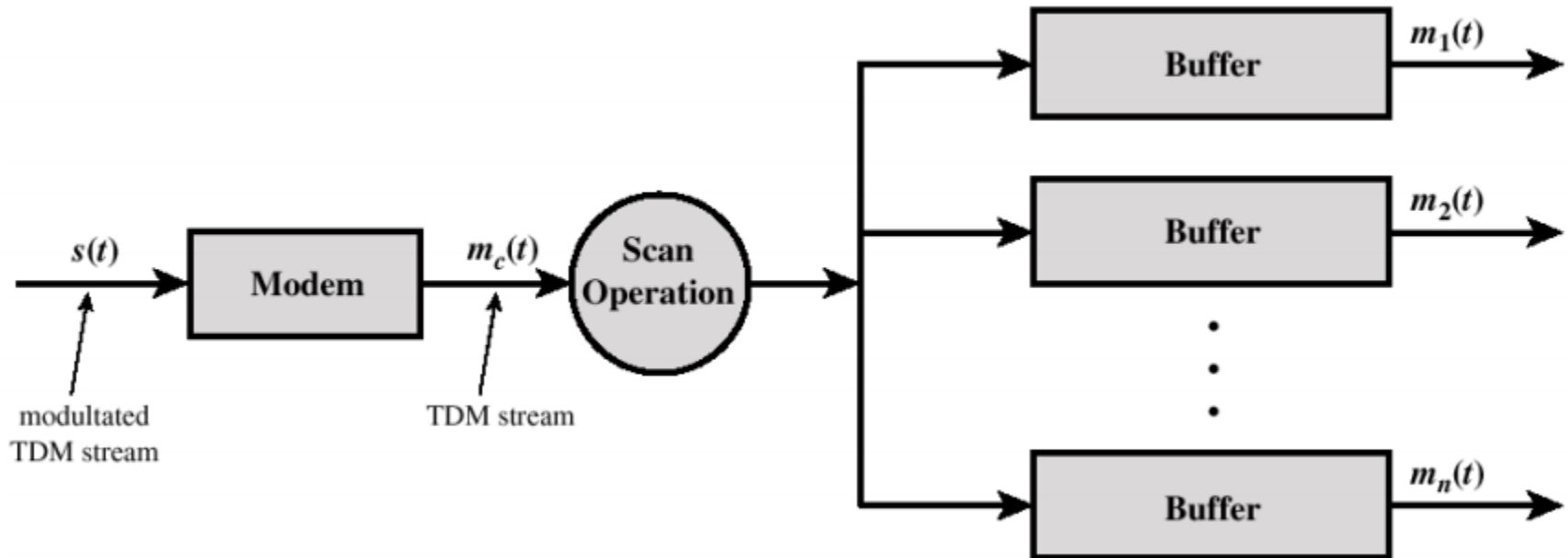
$m_i(t)$
Digital signals
coming from n
sources

Buffers
Used to hold signals
temporarily until they
have stabilized

Scanner
Picks sequentially
stabilized from n
buffers

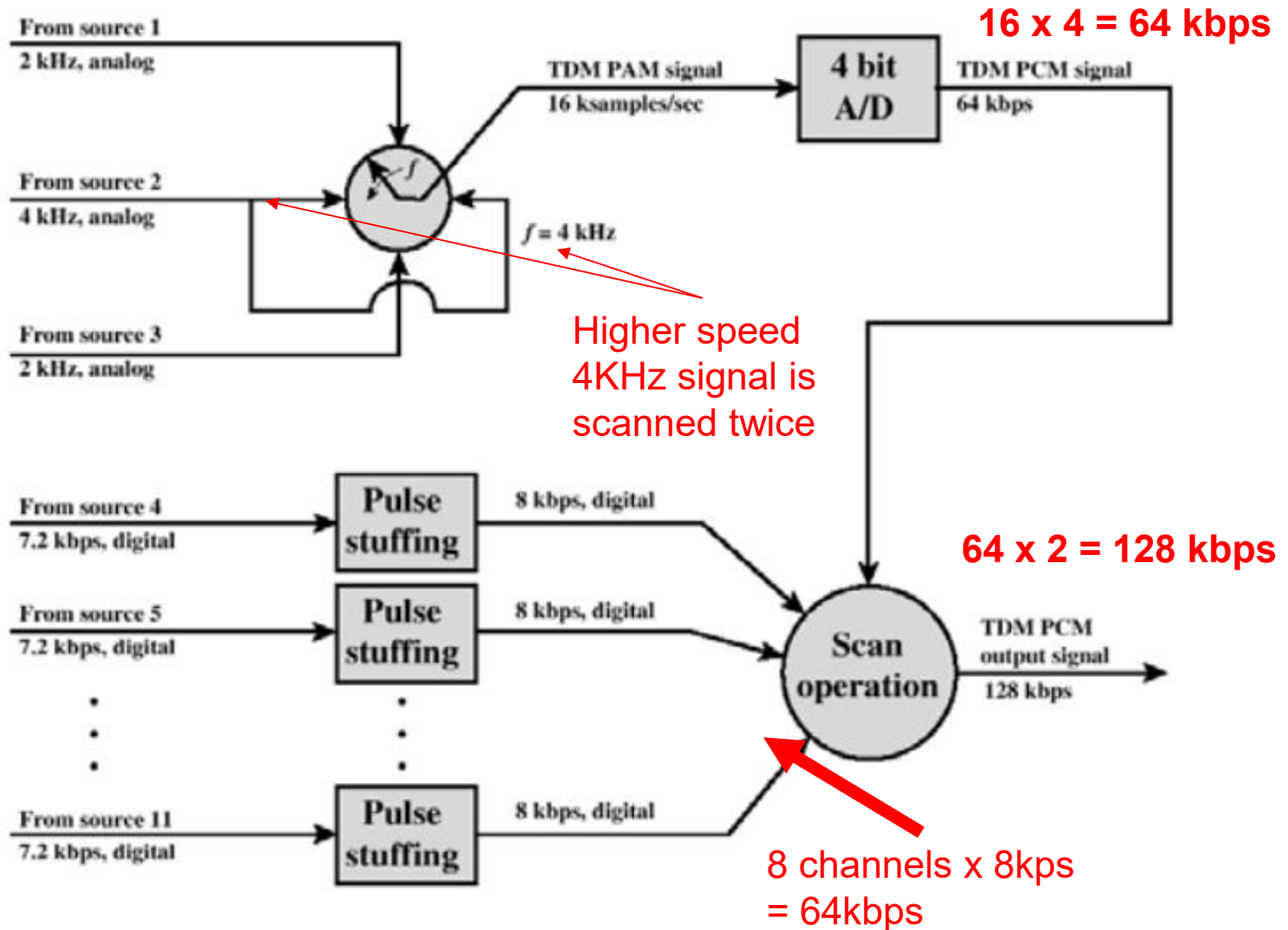


SYNCHRONOUS TDM RECEIVER



1. TDM signal $s(t)$ is demodulated to yield TDM digital frame $m_c(t)$
2. $m_c(t)$ is then scanned into n parallel buffers;
3. The i^{th} buffer correspond to the original $m_i(t)$ digital information

TDM EXAMPLE

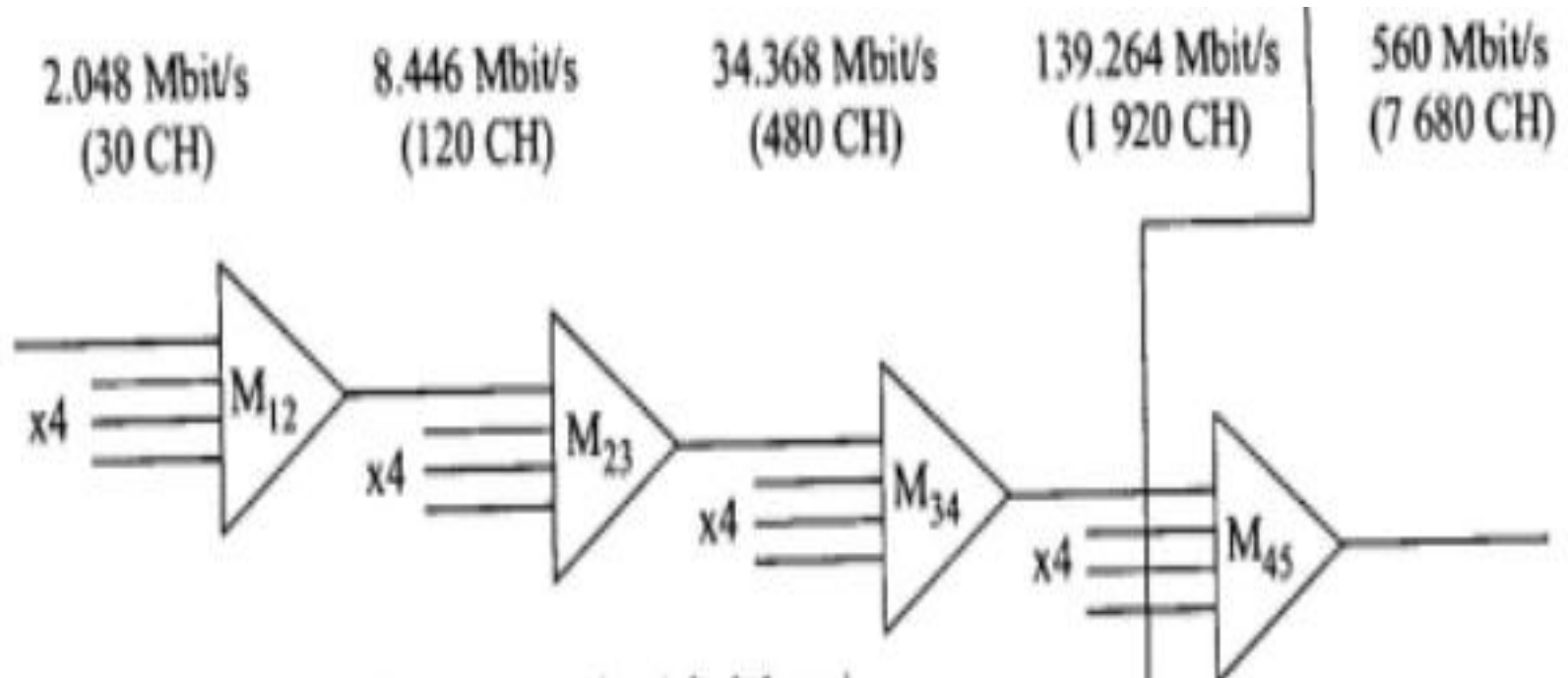


PLESIOCHRONOUS DIGITAL HIERARCHY

- Plesiochronous Digital Hierarchy has for over four decades provided a very **cost effective means of transmission of a large number of telephone voice channels.**
- Its widespread use has been **due to reduced cost of integrated circuits and advances in fibre optic technology.**

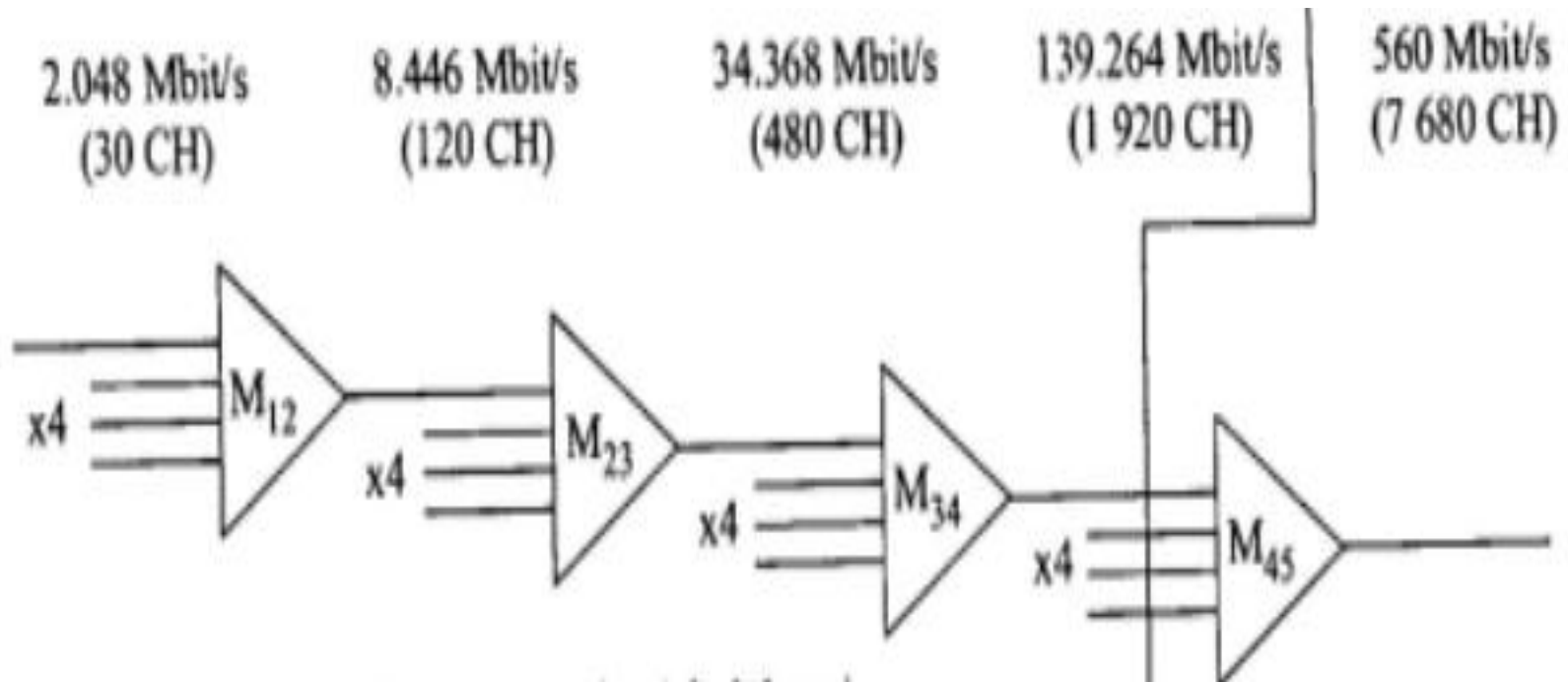
PDH PRINCIPLE/1

1st Level: The first level hierarchy also called the primary group **operates at 2,048 Kbps** in the ITU-T standard. It contains thirty 64Kbps traffic carrying channels and two additional 64 Kbps channels carrying framing and signalling information. It can therefore carry **30 telephone voice channels**.



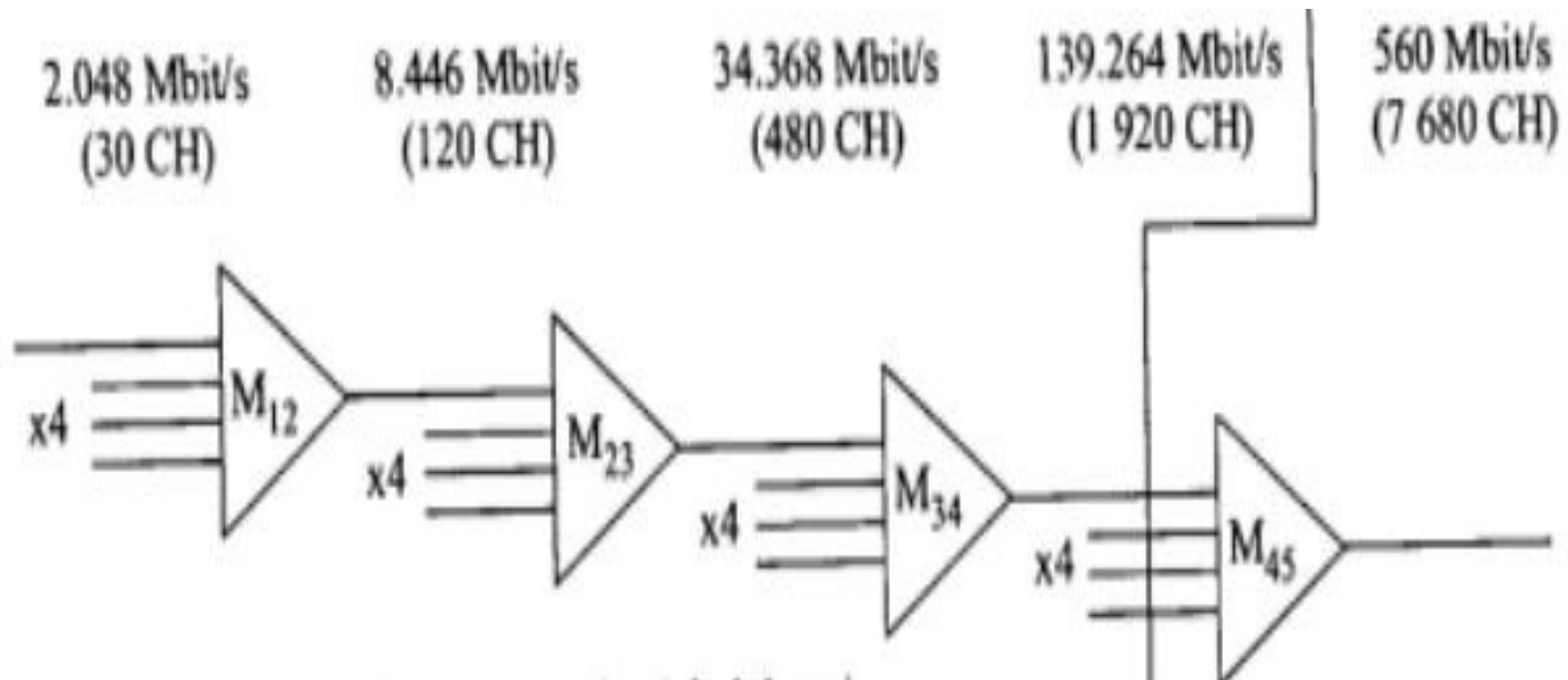
PDH PRINCIPLE/2

2nd Level: Operates at 8.446 Mbps and is formed by combining four basic groups. It can carry 120 telephone voice channels.



PDH PRINCIPLE/3

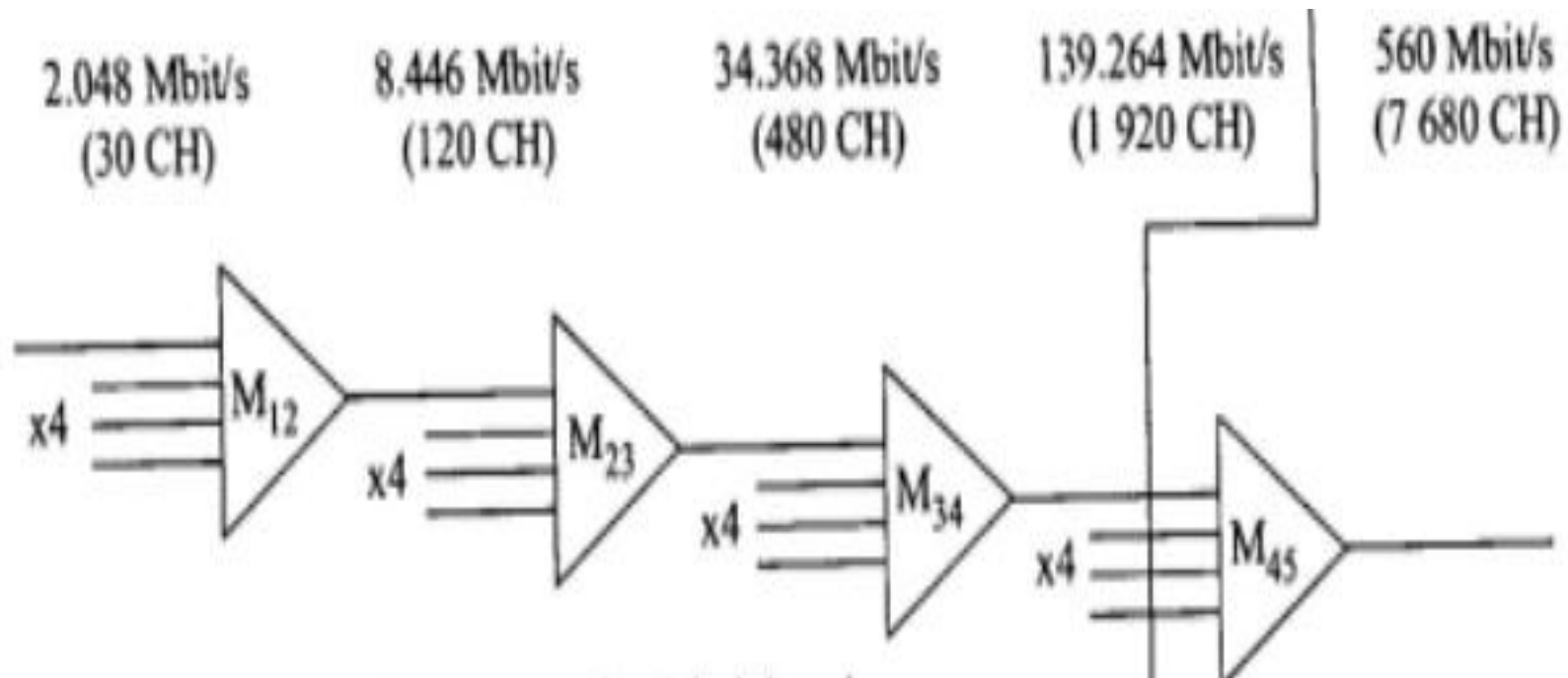
3rd Level: Operates at 34.368 Mbps and is formed by combining four level two bit-streams. It can carry 480 telephone voice channels.



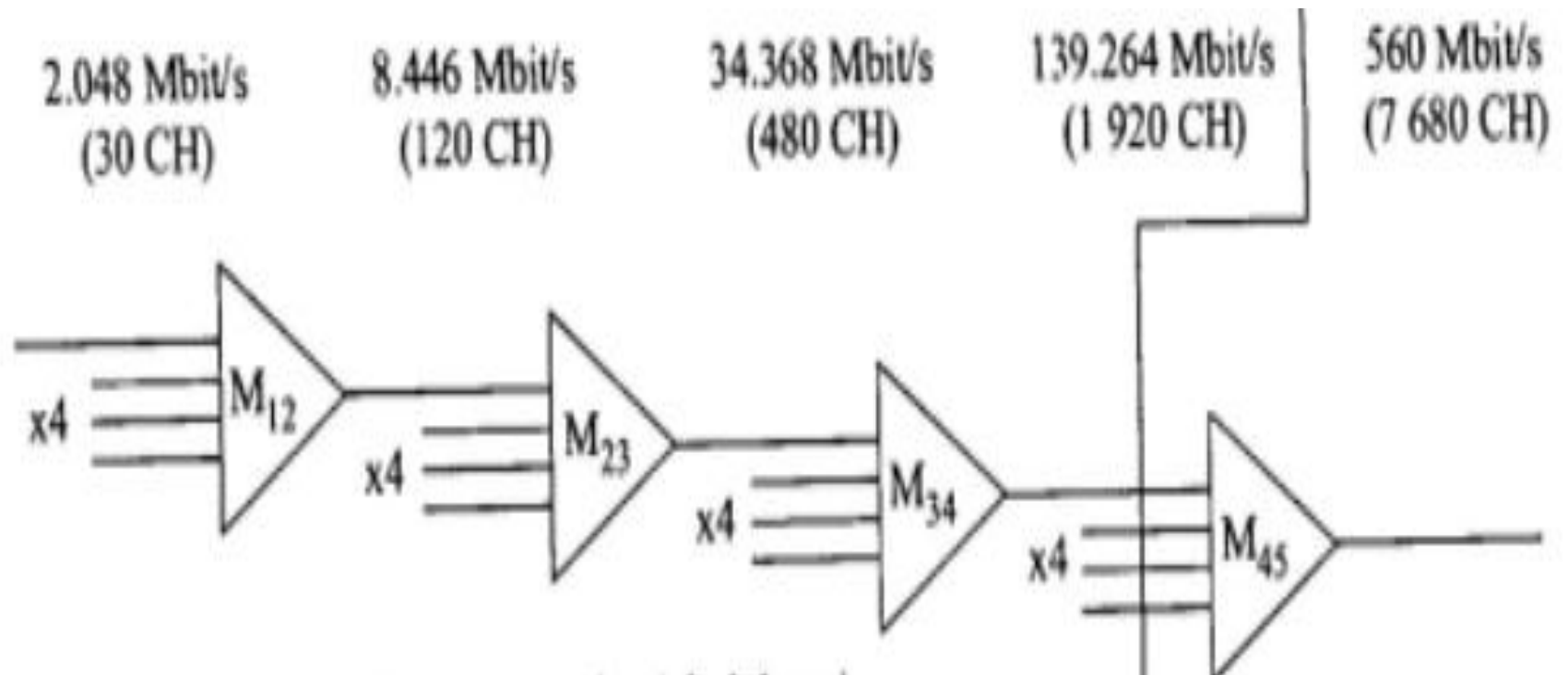
PDH PRINCIPLE/4

4th Level: Operates at **139.264Mbps** and is formed by combing four level three bit-streams. It can carry 1,920 telephone voice channels.

5th Level: Operates at **560 Mbps** and is formed by combing four level four bit-streams. It can carry 7,680 telephone voice channels



PDH ARCHITECTURE (SCHEMATIC)



WHY NEARLY BUT NOT EXACTLY SYNCHRONOUS

Plesiochronous means nearly synchronous. The reasons why PDH is not synchronous are:

- (a) Bit streams to be multiplexed are **generated from different locations** that do not have a common clock system. There are therefore small variations in the bit rates.
- (b) Different **sources will have different clock stabilities** and are therefore not synchronous with one another or the earth terminal clock.
- (c) Bit streams may arrive **with significant delays caused by the length of the transmission path**, e.g. satellite communication resulting in differences in the timing of different bit-streams.

PROBLEMS OF UNSYNCHRONIZED CLOCKS

1. Since these clocks are not synchronised, **large variations can occur in the clock rate** and thus the signal bit rate.
2. For example, an E3 signal specified at **34 Mbit/s ± 20 ppm (parts per million)** can produce a timing difference of up to **1280 bit/s** between one incoming E3 signal and another.

MAIN PROBLEMS WITH PDH

1. Although PDH is capable of transmitting many types of lower speed signals at a higher rate, PDH structure suffers from the following problems:
 - a) It does not provide a means to **access the original tributaries without completely de-multiplexing** the high speed frame.
 - b) It is **not easy to modify the hierarchy to add or drop channels**
 - c) There is **no means to monitor network performance.**
 - d) The frame structure does not have provisions for carrying **equipment and network management functions.**

CORRECTING PDH TIMING IMPERFECTIONS

To correct these variations in timing the following takes place:

- (a) The bit-streams are time-multiplexed after **buffering of one or more bit streams.**
- (b) The bit streams have **'stuff' bits added** to create synchronization.