Final 2018

Q.1

A)

- `Spectrum` of a signal is the range of frequencies that it contains.
- `Channel capacity` is the maximum rate at which the data can be transmitted over a given communication path.
- `propagation delay` is the time it takes for a bit to travel from sender to receiver
- `Piggybacking` is a feature used in sliding-window flow control to enable exchanging the data in two directions. In which each data frame includes a field for the sequence number plus the field for the sequence number for acknowledgment.
- `Statistical TDM` a multiplexing technique that provides more efficient service than synchronous TDM for the support of terminals, time slots are not preassigned to particular data sources, instead, user data are buffered and transmitted as rapidly as possible using available time slots.

B)

- **Digital technology:** The advent of large-scale integration (LSI) and very-large-scale integration (VLSI) technology has caused a continuing drop in the cost and size of digital circuitry. Analog equipment has not shown a similar drop.
- **Data integrity:** With the use of repeaters rather than amplifiers, the effects of noise and other signal impairments are not cumulative. Thus it is possible to transmit data longer distances and over lower quality lines by digital means while maintaining the integrity of the data.
- **Capacity utilization:** It has become economical to build transmission links of very high bandwidth, including satellite channels and optical fiber. A high degree of multiplexing is needed to utilize such capacity effectively, and this is more easily and cheaply achieved with digital (time division) rather than analog (frequency division) techniques. This is explored in Chapter 8.
- **Security and privacy:** Encryption techniques can be readily applied to digital data and to analog data that have been digitized.
- **Integration:** By treating both analog and digital data digitally, all signals have the same form and can be treated similarly. Thus economies of scale and convenience can be achieved by integrating voice, video, and digital data.

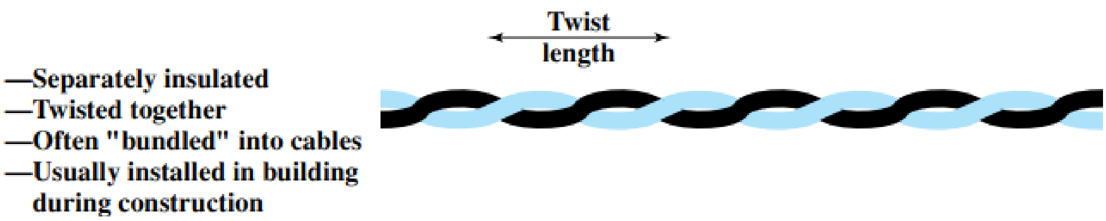
C)

$$60 * 10 - 20 = 10\log(\frac{p_{out}}{0.5})$$
$$40 = 10\log(p_o) - 10\log(0.5)$$
$$p_o = 40 + 10\log(0.5) \simeq 40dB$$

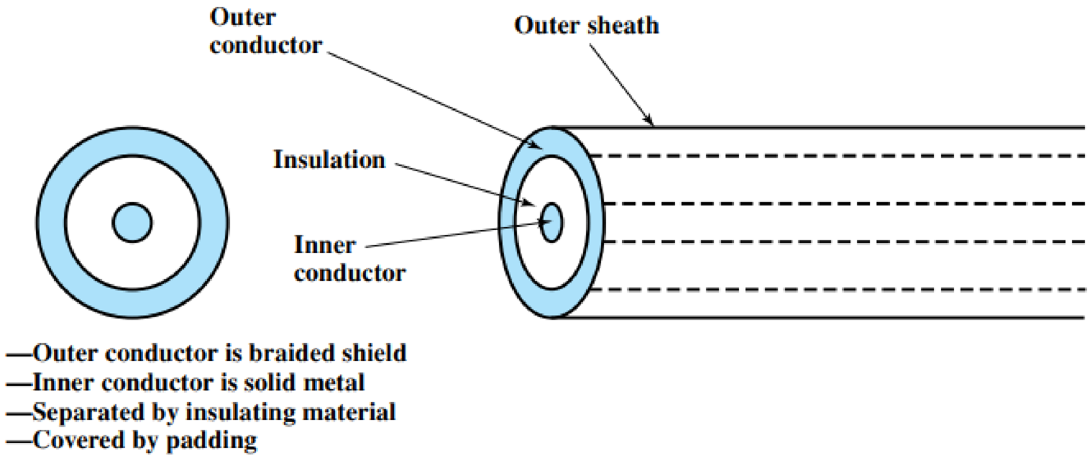
Q.2

A)

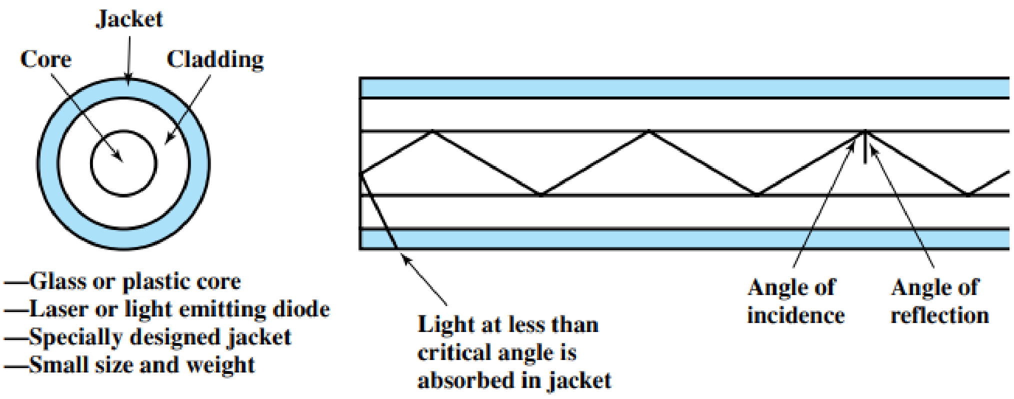
- Twisted pair copper wire
  - consists of two insulated copper wires arranged in regular spiral pattern.
  - Separately insulated
  - often bundled into cables
  - Most common and least expensive
  - limited in distance
  - Used for subscribers loops, and intrabuilding connections



- Coaxial cable
  - consists of two conductors, one is hallow cylinder and the other is wire, the wire is held in place by either insulating rings or by solid dielectric material.
  - Used to be the workhorse of the long distance communication
  - used by television distrbution, long distance telephone transmission, short run computer system links, and local area networks



- Optical Fiber cables
  - consists of
    - `core` is the innermost section: one or more thin strands of fibers made out of glass or plastic
    - `cladding` a glass or plastic coating that has different optical properties that are different from those of the core
    - `Jakect` the outermost layer provides protection against environmental dangers
  - has superior characteristics
    - greater capacity
    - smaller size and lighter weight
    - lower attenuation
    - electromagnetic isolation
    - greater repeater spacing
  - Used in long-haul trunks, subscriber loops, and LANs



(c) Optical fiber

B)

1. Bipolar-AMI
2.
    - advantages
        - less bandwidth than NZR
        - no dc component
        - supports synchronization
        - provides simple means of error detection
    - disadvantages
        - Can detect clock drift for long sequence of zeros
3. The bit at the 7th position is violating the encoding scheme, there's two neighboring negative voltage. The original bit can be recovered by looking at the full history of the signal, the previous non-zero signal was negative and the following non-zero is negative, so this one should be positive
4. 0100101011

Q.3

A)

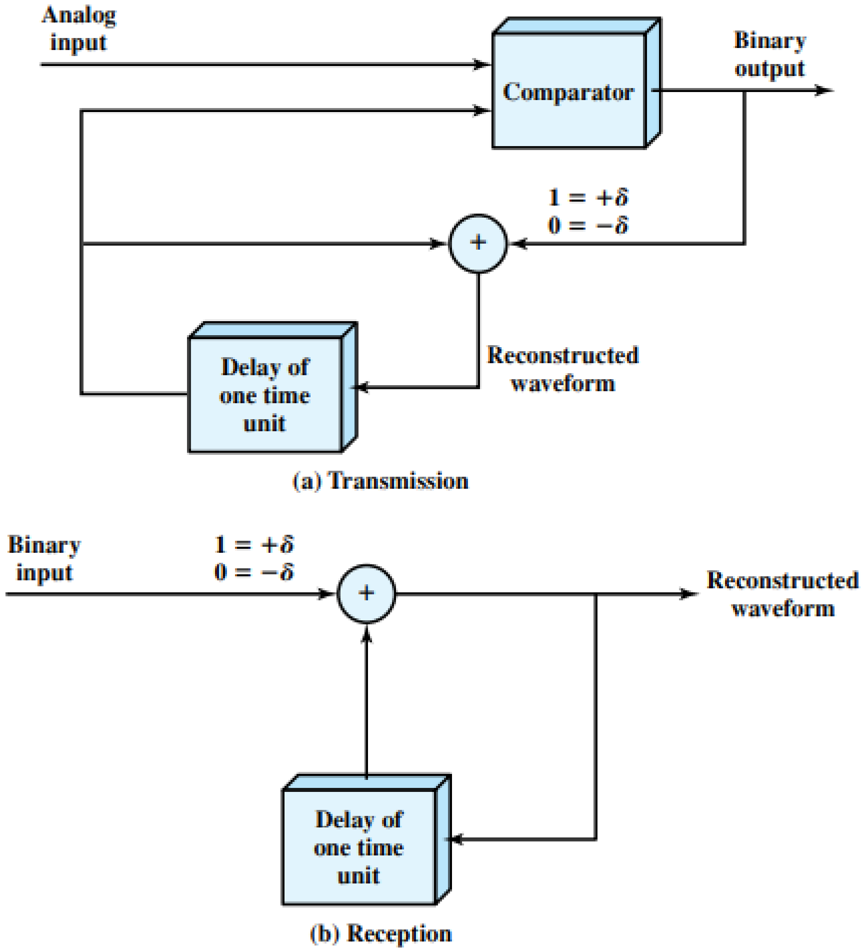


Figure 5.21 Delta Modulation

1. Operation
   - One quatization level at each sampling interval
   - A single binary digit for each sample
   - Approximation of the derivative of analog signal rather than it's amplitude
   - staircase function track the original anlog wave form
2. dis/advatages
   - advantages
     - simplicy of its implementation
     - use digital signal to encode anlog data enable
       - use of repeaters instead of amplifiers, no cumulative noise

        - use of TDM muliplexing, no intermodulation noise
        - more efficient switching techniques
    - disadvantages
        - Worse SNR compared to PCM

B)

1.

Therefore, the overall condition: $0.956 f_{bit} < f_{clock} < 1.045 f_{bit}$

6.6 In worst-case conditions, the two clocks will drift in opposite directions. The resultant accuracy is 2 minutes in 1 year or:
$2/(60 \times 24 \times 365) = 0.0000038$
The allowable error is 0.4
Therefore, number of bits is $0.4/0.0000038 = 105{,}000$ bits

2. won't change

6.6 Suppose that a synchronous serial data transmission is clocked by two clocks (one at the sender and one at the receiver) that each have a drift of 1 minute in one year. How long a sequence of bits can be sent before possible clock drift could cause a problem? Assume that a bit waveform will be good if it is sampled within 40% of its center and that the sender and receiver are resynchronized at the beginning of each frame. Note that the transmission rate is not a factor, as both the bit period and the absolute timing error decrease proportionately at higher transmission rates.

Q.4

A)

- Error detction process

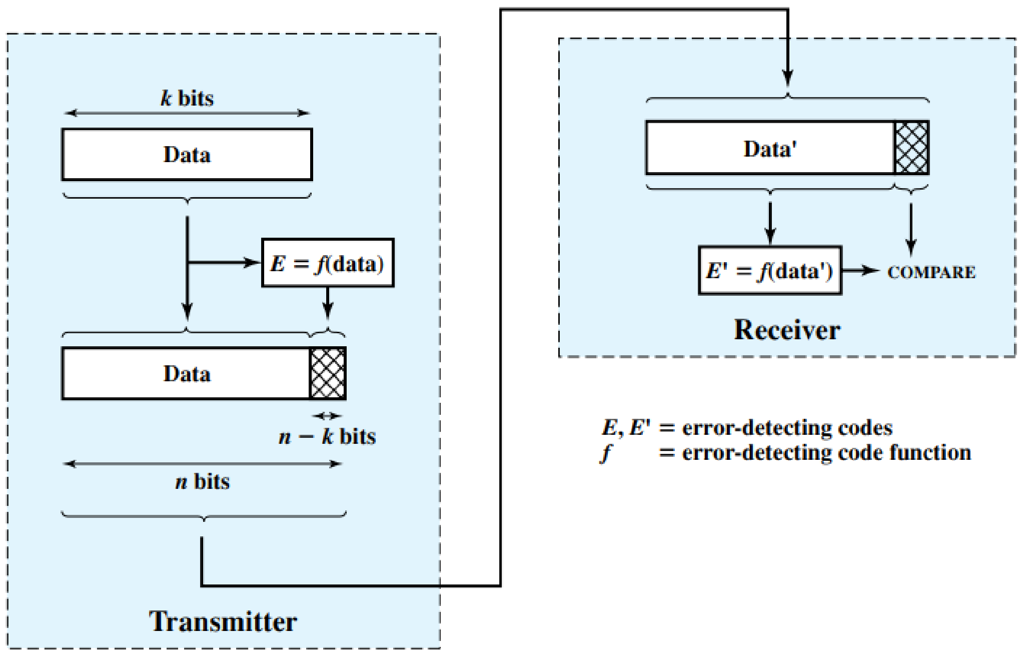


Figure 6.3 Error Detection Process

1. Each k-bit of data is mapped into an n-bit block called codeword using FEC encoder.
2. The codeword is then transmitted
3. At the receiver the incoming signal is then de-modulated
4. The block is passed through an FEC decoder, with one of four possible outcomes:
   1. There's no errrors
   2. It's possible for the decoders to detect and correct those errors. In this case the FEC decoder is able to map this block into the original data block
   3. The decoder can detect but not correct the errors. In this case, the decoder reports an uncorrectable error
   4. Rarely the decoder doesn't detect any error patterns while the errors already exists.

- Error detection techniques
  - `Parity check` the simplest error-detecting scheme, in which a `parity bit` is added to the end of the transmitted data, the value of the bit is selected that the character has an even number of 1s(even parity) or odd number of 1s(odd parity)

- `CRC` One of the most common, and one of the most powerful, error-detecting codes is the cyclic redundancy check (CRC), which can be described as follows. Given a k-bit block of bits, or message, the transmitter generates a sequence, known as a frame check sequence (FCS), such that the resulting frame, consisting of n bits, is exactly divisible by some predetermined number. The receiver then divides the incoming frame by that number and, if there is no remainder, assumes there was no error. It's done by one of three procedures
    - modulo 2 arithmetic
    - polynomials
    - digital logic.

B)

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7.18 N(R) = 2. This is the number of the next frame that the secondary station expects to receive.

Q.5

A)

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1. Block diagram & operation

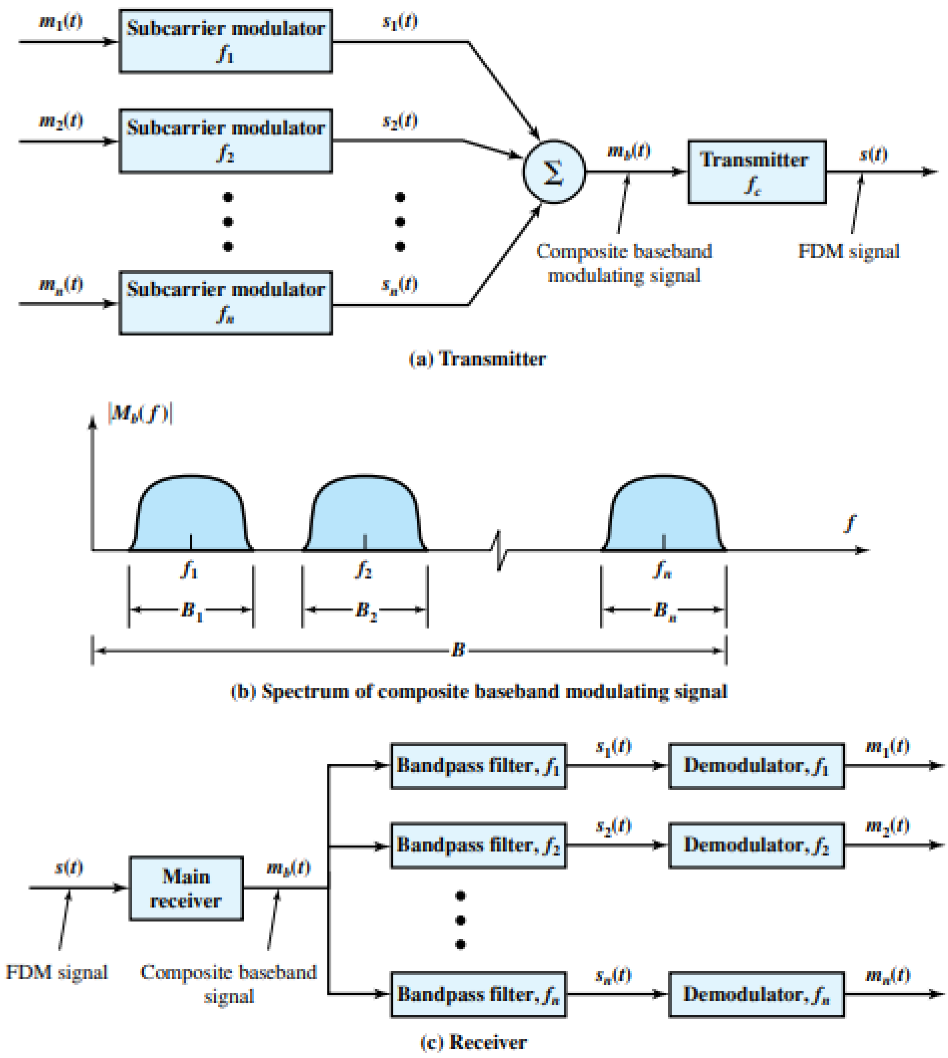

Figure 8.4 FDM System [COUC01]

- A number of signals can be carried simultaneously if each signal is modulated onto a different carrier frequency and the carrier frequencies are sufficiently separated that the bandwidths of the signals do not significantly overlap.
- Each modulated signal requires a certain bandwidth centered on its carrier frequency, referred to as a channel. To prevent interference, the channels are separated by guard bands, which are unused portions of the spectrum
- At the receiving end, the FDM signal is then passed through n bandpass filters, each filter centered on and having a bandwidth B_i, for $1 \le i \le n$. In this way, the signal is again split into its component parts. Each component is then demodulated to recover the original signal.

2. bandwidth for transmitting 12 voice channels over FDM

$$bandwidth\ for\ single\ voice\ channel = 4kHz$$
$$bandwidth\ for\ 24\ voice\ channels = 4 * 24 = 96kHz$$

3. TDM

$$PCM\ data\ rate\ for\ single\ voice\ channel = 64kbps$$
$$PCM\ data\ rate\ for\ 24\ voice\ channels = 64 * 24 = 1.536Mbps$$
$$bandwidth = \frac{1.536Mbps}{1bps/Hz} = 1.536MHz$$

B)

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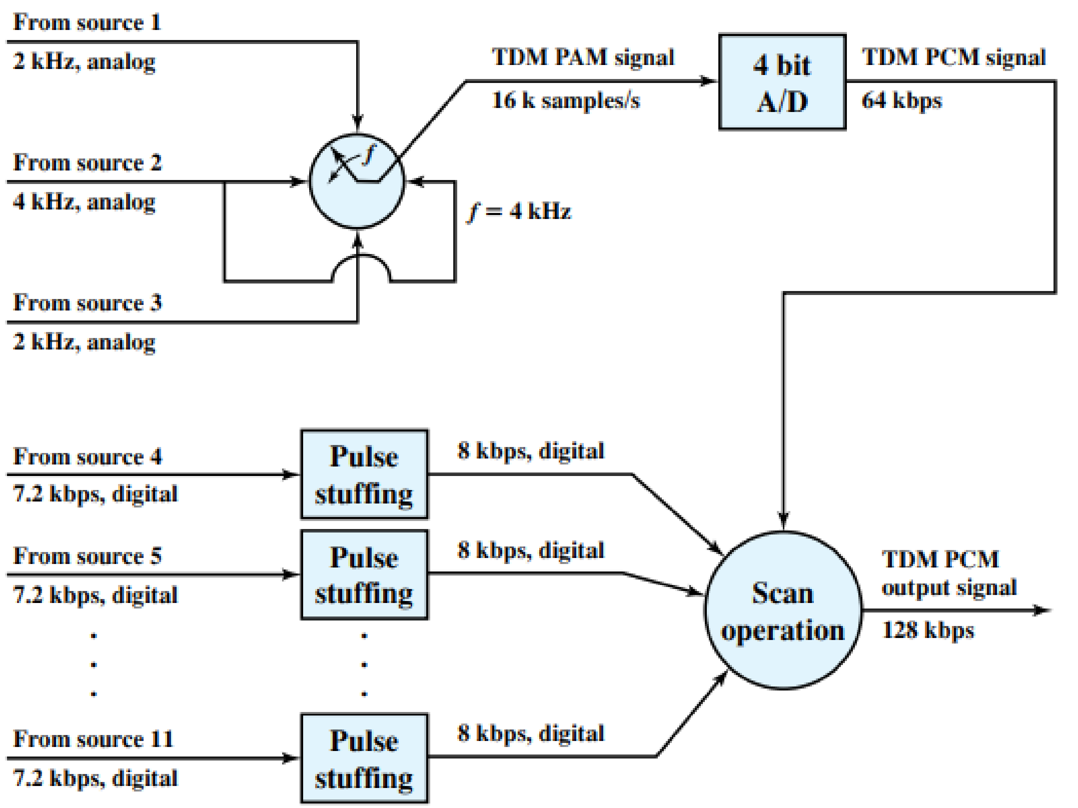

8.10 The structure is that of Figure 8.8, with one analog signal and four digital signals. The 500-Hz analog signal is converted into a PAM signal at 1 kHz; with 4-bit encoding, this becomes a 4-kbps PCM digital bit stream. A simple multiplexing

technique is to use a 260-bit frame, with 200 bits for the analog signal and 15 bits for each digital signal, transmitted at a rate of 5.2 kbps or 20 frames per second. Thus the PCM source transmits at (20 frames/sec) × (200 bits/frame) = 4000 bps. Each digital source transmits at (20 frames/sec) × (15 bits/frame) = 300 bps.