Mobile and Panvasive Computing

High freq → 3–30 MHz (Short Radio Wave)
HF
→ Reflected by the ionosphere and bounce back and forth between ionosphere and earth surface.

HF → 1) used to convey info. to thousands of km.
2) can penetrate obstructions.

* Range of transmission depends on:
  1. characteristics of a signal.
  2. power of the transmitter.
  3. sensitivity of receiver.
  4. Antenna height.
  5. Quality of transmission medium.
  6. Method to send info.

* Greater the bandwidth, higher the info carrying capacity.

* **Channel** : Individual communication path that carries signals at a specific freq.

  e.g. GSM uses 2 bands (890 – 915 MHz) and (935 – 960 MHz)
  ↳ bandwidth 25 MHz each.
  ↳ there are 125 channels of 200 KHz wide.
  → hence GSM uses 250 channels.

* **Noice** : Unwanted signal that combines to a desired signal and distorts it during transmission as well as reception.
  ↳ Limits the data rate in transmission.

* **Channel Capacity** : The max. rate at which the data can be transmitted over a channel, under a given condition.
  ↳ Upper bound on the amount of info. that can be reliably transmitted over a communication channel.

Signal Strength : Magnitude of electric field at a reference location around the transmitting antenna.

* Greater Sig. strength → improves ability to receive data correctly in the presence of noice.

* $\boxed{\text{SNR}}$: Signal to noise ratio.

$$= \left[\frac{P_{power}}{P_{noise}}\right]^2 = \left[\frac{A_{power}}{A_{noise}}\right]^2$$

$P_{power} \rightarrow$ power in a signal.

$A_{power} \rightarrow$ amp.

$P_{noise} \rightarrow$ noise power.

$P \rightarrow$ avg. power

$A \rightarrow$ rms. amp.

SNR $\rightarrow$ expressed in a log. scale.

$$SNR_{dB} = 10 \cdot \log_{10}\left(\frac{\text{Signal power}}{\text{Noise power}}\right)$$

dB $\rightarrow$ decibel.

e.g. in a cellular system, if. $\frac{\text{signal power}}{\text{noise power}} = 96.2$,

$$SNR \approx 10 \cdot \log_{10}(96.2) \approx \boxed{20\ dB}$$

* High value of SNR $\rightarrow$ Signal received is of high quality.
* SNR = Signal to interference ratio (S/I).

Based on direction of comm.
- $\rightarrow$ simplex ($\rightarrow$)
- $\rightarrow$ half duplex ($\rightarrow$ or $\leftarrow$)
- $\rightarrow$ duplex full ($\rightleftarrows$)

a) Simplex : pager $\rightarrow$ Can receive but can't reply.

b) Half Duplex : Walkie-talkie.

c) full Duplex : Telephone.

In wireless systems, full duplexing is implemented by $\rightarrow$

a) either providing two separate channels (transmission/receiver).

b) providing two adjacent time slots on a single radio channel.

$\rightarrow$ frequency division ~~multiplexing~~ duplexing $\boxed{\text{(FDD)}}$

$\rightarrow$ Time division duplexing. $\boxed{\text{(TDD)}}$

FDD.

1) signals are differentiated based on freq.
2) Two distinct set of freq. are assigned.
3) Each such freq. ~~are~~ corresponds to a simplex.
4) Here one duplex channel → consisting of 2 simplex chnls.
5) In cellular network, duplexer is used in mobile station as well in the B.S. ; allowing simultenous radio transmission and reception, on the duplex channel pair.
6) The freq. split between the forward and reverse channels is constant.
7) FDD is suitable for → Wireless WAN (cellular net.)
   → Wireless M.A.N. (Wireless local loop).

TDD :

1) Signals in forward and reverse directions are assigned separate time slots.
2) A time slot is for a single block of frequency.
   → kept small so that both the transmission and reception appear to be simultenous to user.
3) Suitable for : Short dist. and low power comm.
   → e.g. cordless telecom. system.
4) cost is less + simplified receivers.

Multiple Access Techniques

↳ many users can share the freq. spectrum allocated for an application.

The systems specify

3 types → FDMA, TDMA, CDMA

DMA → Division Multiple Access

F → freq.

T → Time

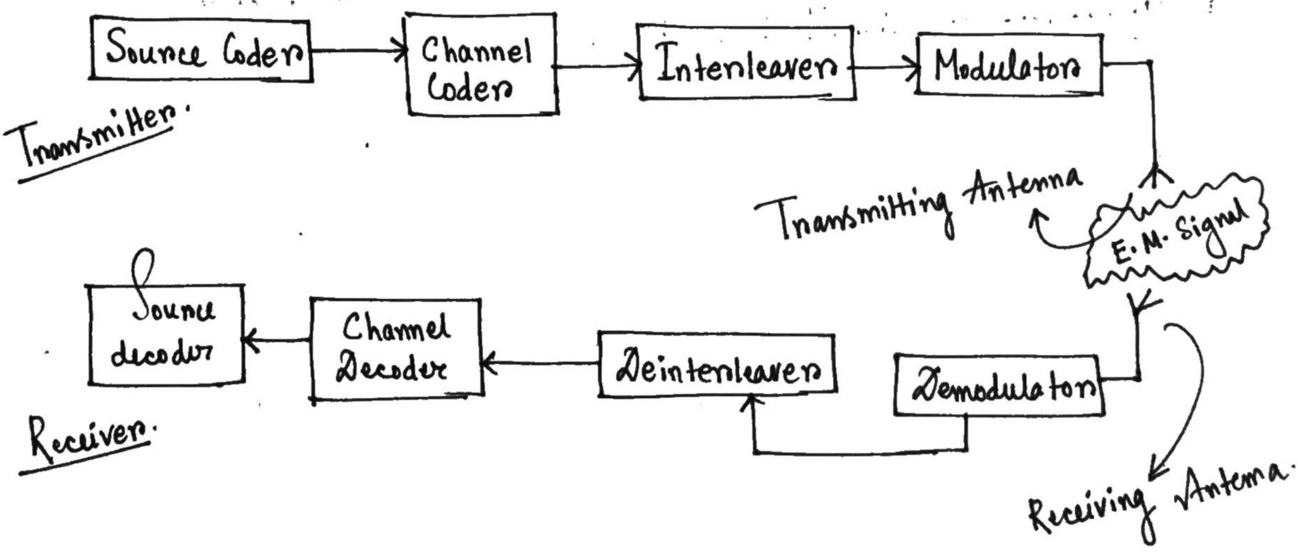
C → Code.

A) $\boxed{\text{FDMA}}$: separates the total available bandwidth into several non-overlapping smaller bands/ channels.
Each channel has the ability to support a user.

B) $\boxed{\text{TDMA}}$: splits users into available time-slot within the channel. In each slot, only one user is allowed to transmit/receive.

C) $\boxed{\text{CDMA}}$: Unique Digital Codes are used to differentiate users. A specific code to each user, and only that code can demodulate the transmitted signal.

Operational Modules for Radio Comm.



$\boxed{\text{Source Coding}}$ ① Input signal ~~is to be t~~ is transformed from Analog → Digital.

② Then encoded data bits (source bits) carry the info.

③ To save bandwidth, removal of redundant info. is also done.

④ Some source bits have more impact than others, hence requires more protection from errors.

[challanges: Scarcity of bandwidth, ensuring high quality for voice comm.

$\boxed{\text{Channel Coding.}}$: ① Improves quality of transmission by protecting source data from errors caused by → Multipath fading, Doppler Shift.

② The data is protected from errors through introduction of redundancies, but in a controlled manner.

③ However, block error caused by fading can't be efficiently corrected by channel coding schemes. → It requires Interleaving.

④ Some channel coding techniques used in mobile comm. are ⇒

a) convolution coding

b) parity check coding.

c) block coding.

[$\boxed{\text{block error}}$ results in alteration of a sequence of bits (block of bits) from transmitted bits.

$\boxed{\text{Interleaving.}}$: ① Main task : Protection against block errors.

② Incase of fading, errors tend to occur in blocks.

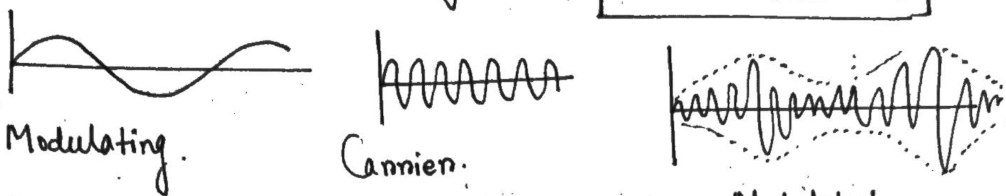
③ length of a block of errors depends on the depth of encountered fading.

④ It scrambles and/or spreads source data bits, essentially randomizing the block errors. → However it introduces delay

⑤ System designer has to trade off between → Removal of errors / → ~~Errors~~. Delay.

Modulation :

1. Wireless medium allows only analog transmission.
2. Hence to transmit digital data, modulation is required.
3. Source / Baseband Msg. Signal $\xrightarrow[\text{signal}]{\text{carrier}}$ Bandpass Signal i.e. Modulated → freq. content is concentrated in a narrow band.



Modulating.   Carrier.   Modulated.

4. Reason why baseband signal can't be directly transmitted in a wrless mdm.
   ↳ Imp one: Antenna height. ($H \propto |\lambda|$).
   ↳ wavelength of signal.
5. Modulation phase basically perform two tasks :
   A) Digital Modulation : Translation of source encoded and channel encoded digital data into square wave binary pulses. This is the baseband signal if presented in frequency domain.
   B) Frequency Shifting : It is necessary to shift the baseband signal spectrum to reside at a much higher centre frequency of the baseband signal. Reason for shifting : 1) Signal attenuation 2) Impractical Antenna height
6. 3 basic methods for Digital modulation are →
   a) ASK → Amplitude Shift keying.
   b) FSK → Frequency " "
   c) PSK → Phase " "

There are 3 basic method for Analog modulation → AM, FM, PM.
ASK, FSK and PSK → digital versions of AM, FM and PM.

Amplitude Modulation

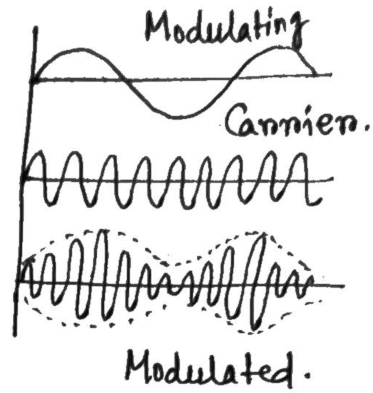
: ① Carrier signal amplitude is altered to match with base band modulating signal.

② The freq. and phase of the carrier signal remain unaltered.

③ It also must be ensured that the carrier signal frequency must be higher than the highest baseband frequency.

④ Demodulation Process filters out the carrier signal.

⑤ Bandwidth req. in modulated signal
= 2 × [bandwidth of modulating signal].



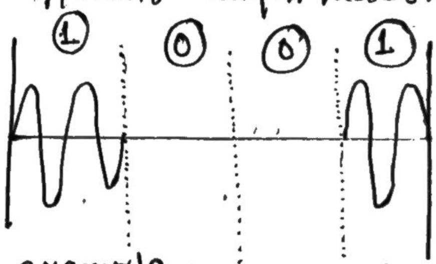
Amplitude Shift Keying

: ① Inputs are binary bits 0 and 1.

② Two binary values represents two different amplitudes.

③ Here, carrier signal strength is varied in modulating signal.

④ Freq. and phase of carrier signal is constant, amplitude is changed to match with the input binary signal (repeatation)



example : 1001 input bit stream.

⑤ ASK generally not preferred in wireless Radio Transmission.

Frequency Modulation

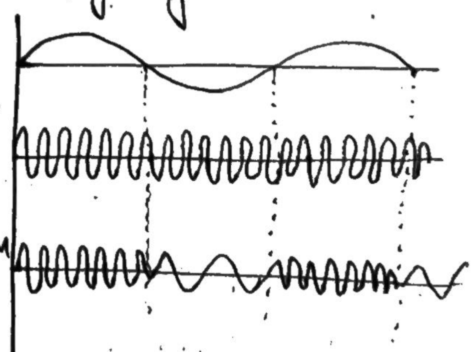
① Freq. of the carrier signal altered to carry the content of modulating signal.

② Amplitude and Phase of carrier → const.

③ FM → more immune to noise than AM (because Amp. → const)

④ FM → improves overall SNR of system.

⑤ Here, power output is constant unlike AM



⑥ Bandwidth for FM (B_{FM}) → 10 × (bandwidth of modulating signal (B)). Actually, $B_{F.M.} = 2(1+\beta) \cdot B$, β has a common val = 4.
β → depends on modulation technique.

⑦ (The range of freq. deviation in the modulated signal) $\propto$ (Amp. of modulated signal.)

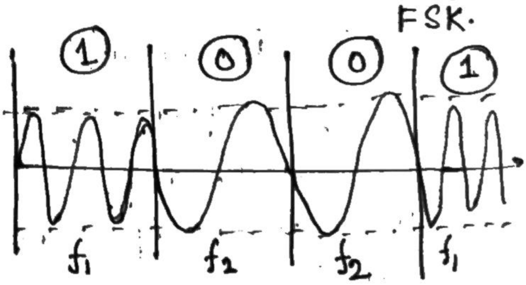
⑧ e.g. if carrier freq = 1000 MHz, modulating signal's amplitude is 20, then for 40 KHz freq. shift / unit amplitude, the modulated signal's freq. ~~is 20~~ variati. (1000 MHz ~~and modulating signal's amplitude~~ − 20 × 40 KHz) and (1000 MHz + 20 × 40 KHz). = (999.2 − 1000.8 MHz)

⑨ ↳ Such variations of frequency within the modulated signals are equal to freq of modulating signals.
i.e. if modulating signal freq. is 2 KHz, then freq. variation of (999.2 → 1000.8 MHz) in modulating signal occur 2000 (2K) times/second. *.

Frequency Shift Keying : ① Binary FSK → simplest form of FSK.

② 1 and 0 in BFSK are depicted by two different freq. (f_1 and f_2 say).

③ Here peak amplitude and phase remain constant.



FSK representation of 1001.

④ FSK → more immune to noise than ASK.

⑤ Since both f_1 and f_2 are carrier freq., they have high values and hence $\Delta f = |f_1 - f_2|$ is small.

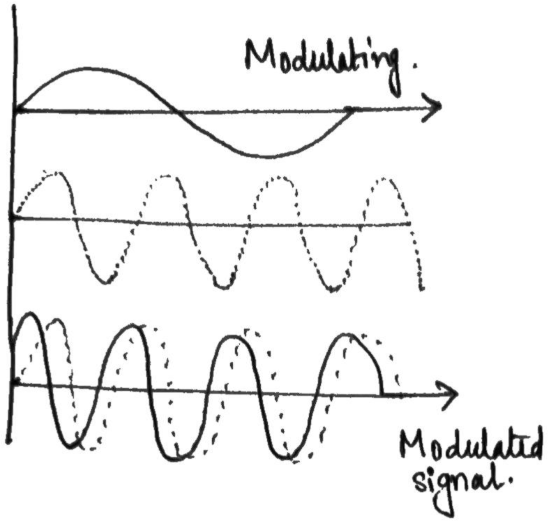
Phase Modulation : ① Carrier Signal's Amp and freq. const. after modulation.

② It is advanced / retarded phase cycle by modulating signal.

③ (Amount of phase shift) $\propto$ (Amp. of modulating signal).

④ Less prone to noise interference.

⑤ Bandwidth $B_{P.M.} = 2(1+\beta) \cdot B$, but $\beta \approx 1$ → narrow band
$\gtrsim 3$ → wide band.

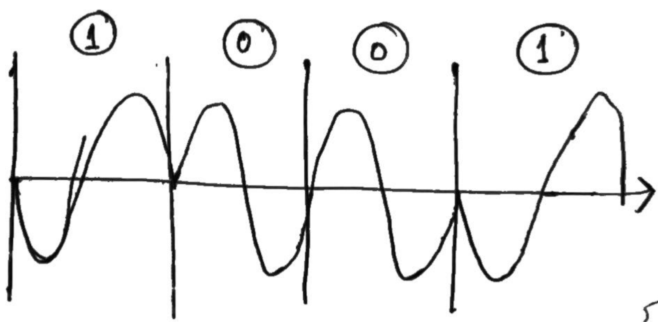


Phase Shift Keying

: (1) Phase is shifted according to the input data.

(2) When binary data is changed, phase shifts by π (180°).

(3) Constant → Amplitude
→ Frequency.



Binary PSK (BPSK) for 1001.

(4) More resistant to interfounce compared to the FSK. Also more used than FSK / ASK.

(5) Noise can change the amplitude easily, but not phase. Hence it's more resistant towards Noice.