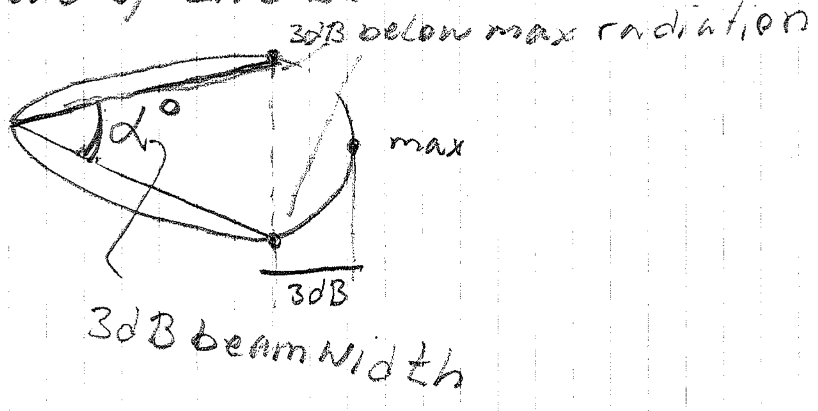
1.

A. An isotropic antenna is a theoretical reference antenna. The antenna is an point in space radiating equal power in all directions, i.e., the radiation pattern is a perfect sphere

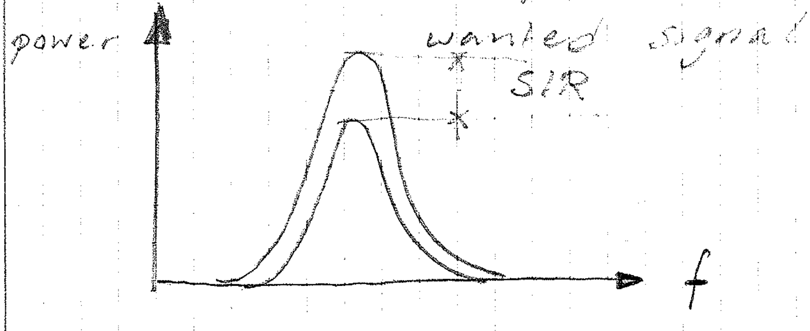
B. Antenna gain is a measure of the directionality of an antenna. Defined as the radiation power in a particular direction, compared to that produced in any direction by an reference antenna, e.g. an isotropic antenna.

C. The 3dB beamwidth is defined as:
In a plane containing the direction of the maximum of a beam, the angle between ~~two~~ the two directions in which the radiation intensity is 3dB below the maximum value of the beam.

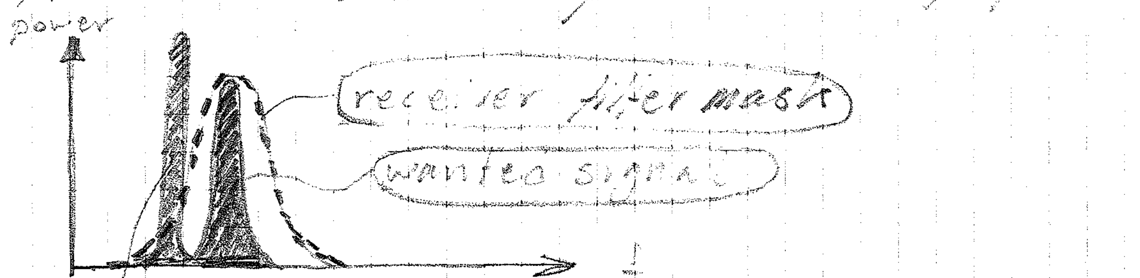


D. The antenna is a circuit having distributed constants of inductance, capacitance, and resistance, which form an resonant circuit. The half-wave antenna is the shortest resonant length of antenna. However, antennas which are two or more wavelengths can also be resonant. Such an antennas are said to operate on harmonics. For a dipole antenna the fundamental resonance frequency is when the frequency of operation equals a physical length of half a wavelength of the antenna. An important thing to keep in mind is that the physical length of the dipole antenna, and the theoretical electrical length are different by about 5 percent, caused by the lower electromagnetic propagation speed in the antenna elements.

2. **A.** co channel interference is interference that is present on the same channel of operation. The ratio between the signal and the interfering signals are often defined as the signal to interference ratio (SIR)



B. Adjacent channel interference, is interference from signals which are adjacent in frequency to the desired signal. Adjacent channel interference results from imperfect receiver filters which allow nearby frequencies to leak into the pass band of operation.



Some of the energy from the adjacent signal will slip through the receiver filter mask and become an interfering signal.

C. All electronic systems have inherent thermal noise. The thermal noise is produced by the random motion of electrons inside a resistor. At all temperatures above absolute zero ($-273.16°$ K) the electrons inside a material are in random motion, i.e. random current is generated. As long as there is any resistance present, the random current will generate a random voltage, $U=RI$, and hence a noise power, $P=U^2/R$. The reason why there is no discernible current flow in one direction is that the random motion cancel out each other even over a very short time period. Thermal noise is uniformly distributed across the frequency spectrum. The power density of thermal noise, N_0, is expressed as W/Hz. $N_0 = kT$ where k is Boltzmann's constant and T is the temperature in Kelvin.

(2.) [redacted]

D. The term fading refers to the time variation of received signal power caused by changes in the transmission medium or paths. In a mobile environment, where one of the two antennas is moving relative to the other, the relative location of various obstacle changes over time, creating complex transmission effects.
The propagated signal can suffer from three major propagation effect that give rise to fading: Reflection, Diffraction and scattering. All these effect creates multiple propagation paths that have different propagation delay i.e, diffrent propagation path distance. This means that the transmitted signal interfere with it self, the propagation paths are additative at the receiver.

Fading effects in a mobile environment can be classified as either fast or Slow.
The fast fading is a consequence of phase shift (delay) between different propagation paths, which change rapidly in space.
Slow fading is a consequence of changing shadowing objects i.e. buildings, trees, hill etc.

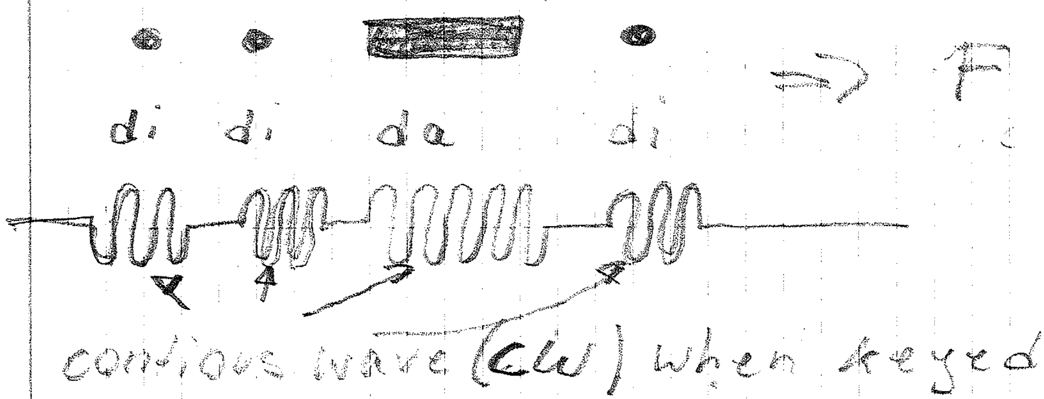
2. D. cont'

[redacted] Fading effects can also be classified as flat or selective. Flat fading or non-selective fading is that type of fading in which all frequency components of the received signal fluctuate in the same proportions simultaneously. Selective fading affects unequally the different spectral components of the received signal, ie, if attenuation occurs over a portion of the bandwidth of the signal, the fading is considered to be selective.

B. and C. Diversity is based on the fact that individual channels experience independent fading events. We can therefore compensate for error effects by providing multiple logical channels between transmitter and receiver and sending part of the signal over each channel. This technique does not eliminate errors but it does reduce the error rate, since we have spread the transmission out to avoid being subject to the highest error rate that might occur.

Some diversity techniques involve the physical transmission path and are refered to as space diversity.

3. A. On-off keying (telegraphy), using for example Morse code, is refered to as continous wave (CW).

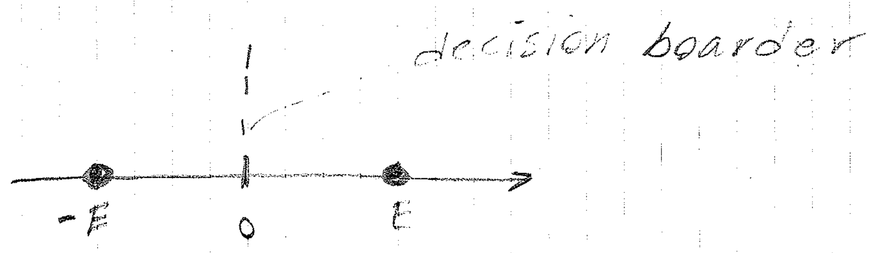


B. Antipodal ⇒ Binary Phase Shift keying

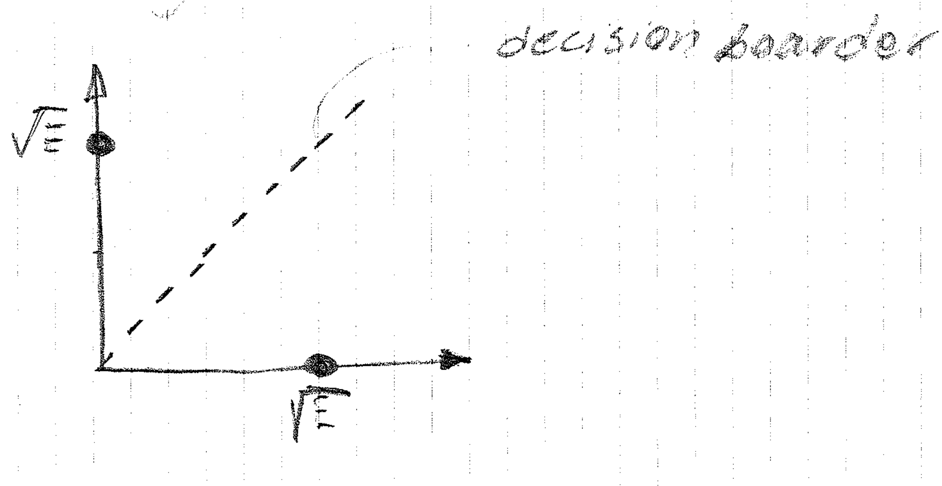
Orthogonal ⇒ Binary Frequency Shift keying

C.

Antipodal

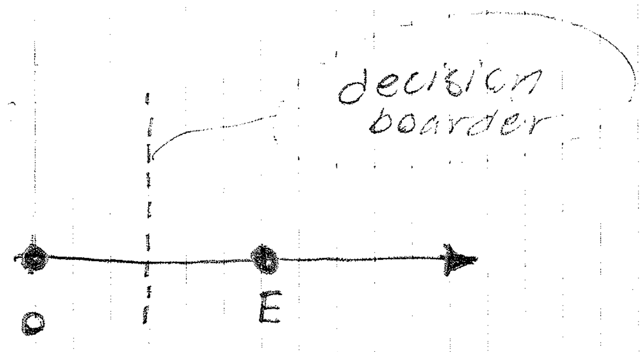


Orthogonal



C. cont'd

On - off keying



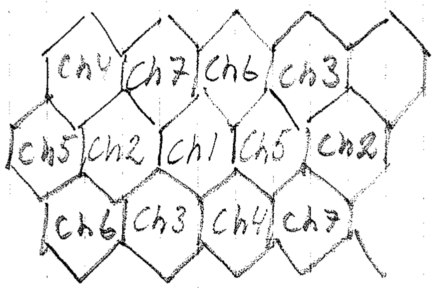
4. A. It is almost always the case that the capacity of the transmission medium exceeds the capacity required for the transmission of a single signal. To make efficient use of the transmission system, it is desirable to carry multiple signals on a single medium, e.g., imagine the telephone network without multiplexing. Each ongoing call would require it's own pair of cables.

B. Time, frequency and space.

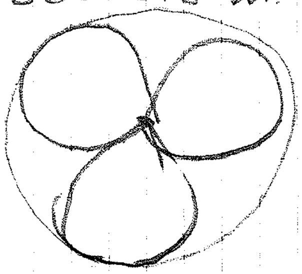
Frequency: A number of signals can be carried simultanously over a single medium if each signal is modulated onto a different carrier frequency. And the carrier frequncies are sufficciently separated so that the bandwidth of the signals overlap i.e. to prevent interference, the channels are separated by guard bands, which are unused portions of the available spectrum.

Time: takes advantage of the fact that the achivable bitrate of the medium exceeds the required data rate of a single signal. Multiple signals can be carried on a single medium by interleaving portions of each signal in time.

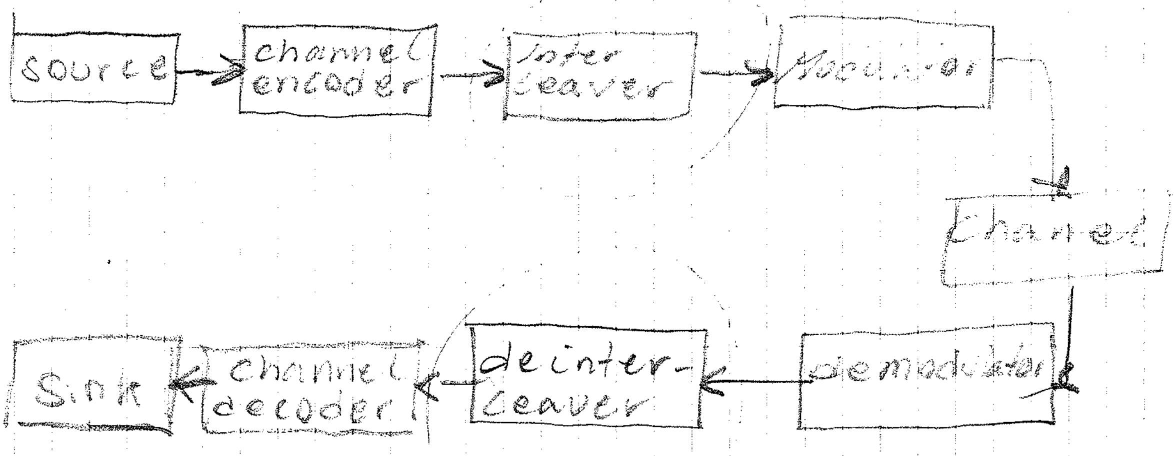
B. cont' **Space:** since electromagnetic waves are attenuated proportional to distance there are a possibility for spatial reuse of channels in space. For example in cellular system



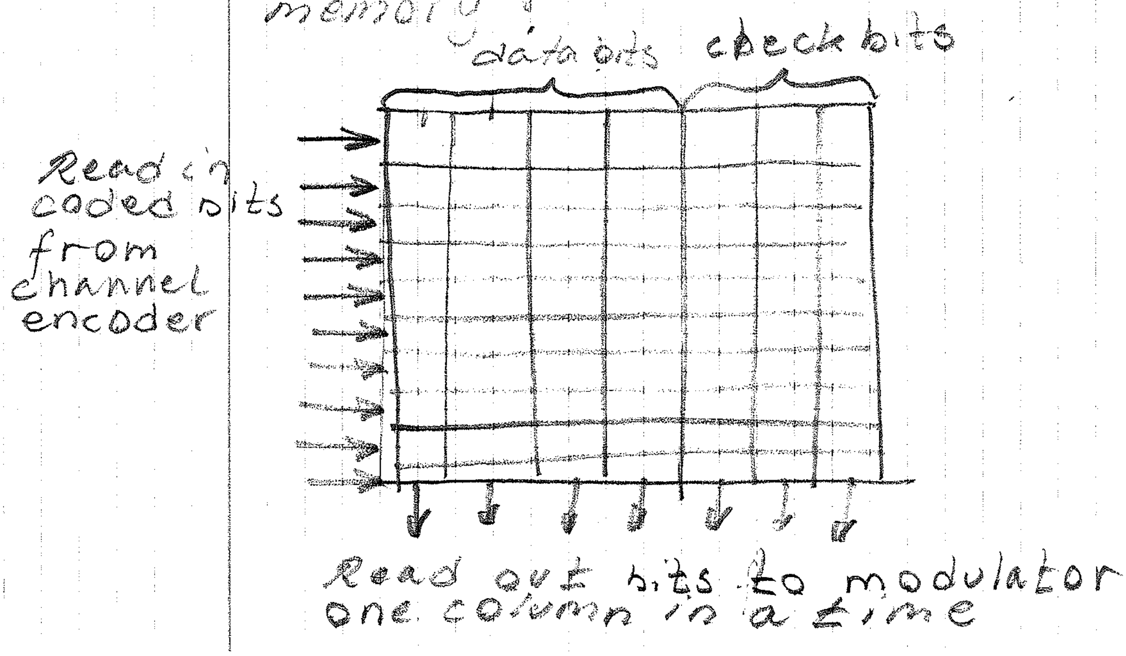
A way to further increase the space division is to divide the cells into sectors with directional antennas



5. A. Interleaving is accomplished by reordering the order of the bit stream of channel encoded bits. Often achived by reading and writing data from a memory in different orders. The advantage of interleaving is that a burst error that affect a sequence of bits is spread out over a number of separate channel code blocks. So that error correction is possible. A burst error is when a number of bits in sequence are erranous, often caused by a deep fading dip.



An interleaver can be implemented as a memory:



(5.)

B. The rate which data can be transmitted over a given communication channel under given conditions, e.g., Bandwidth and SNR at the receiver.

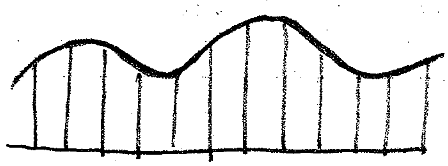
C. The reduction in E_b/N_0 achived by using a channel code at a constant error-rate.

7. [redacted]

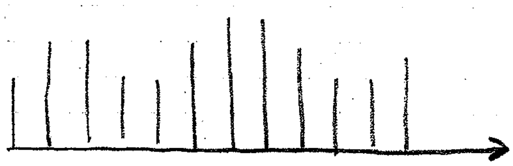
Pulse Code Modulatio (PCM) is used to covert analog signals to digital and the opposit. We can describe the PCM in three steps

- Sampling
- quantizing
- coding

Sampling is done by taking a sample of a continous signal periodically (8000 Hz).

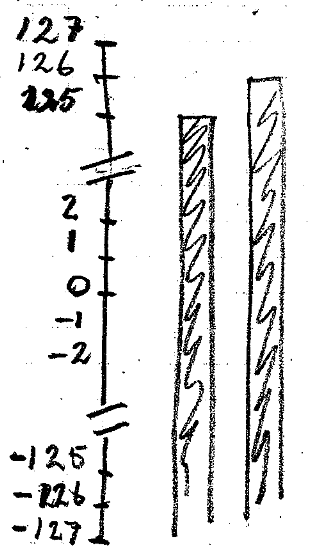


The result is a pulse amplitude modulated (PAM) signal (see figure below)

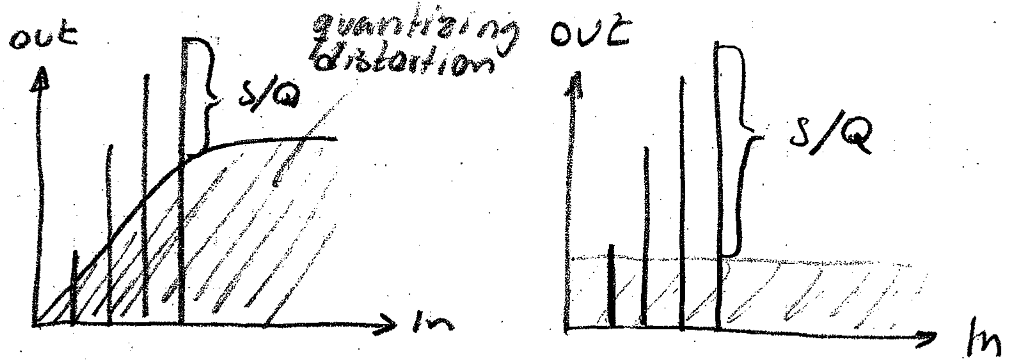


In order to digitize the signal the height of each puls must be quantized.

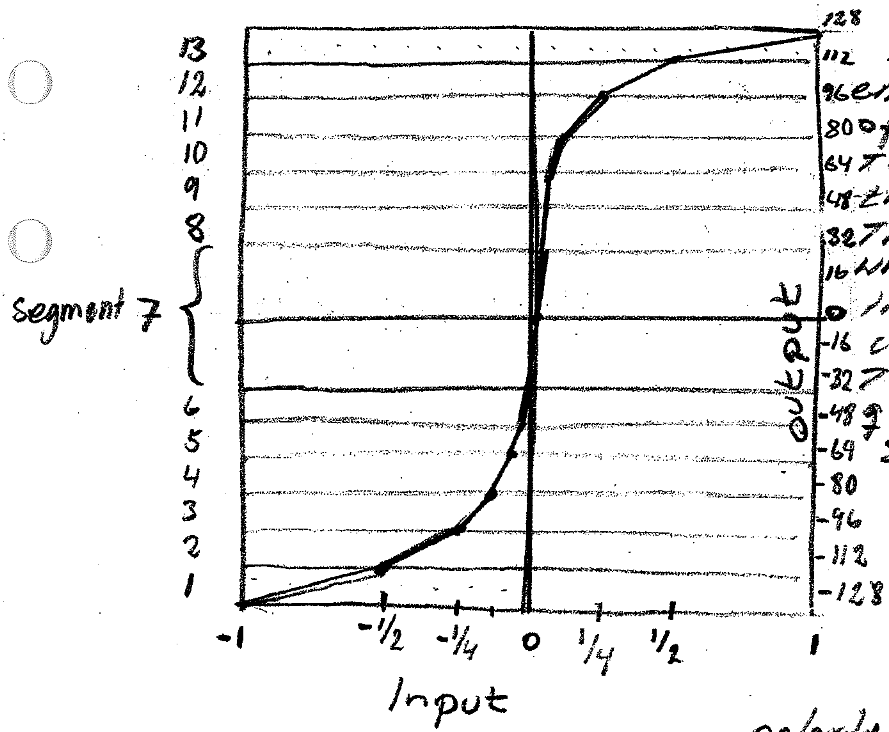
PCM has a word with 8 bits which means that the height can be reprented by 256 different levels (± 128).



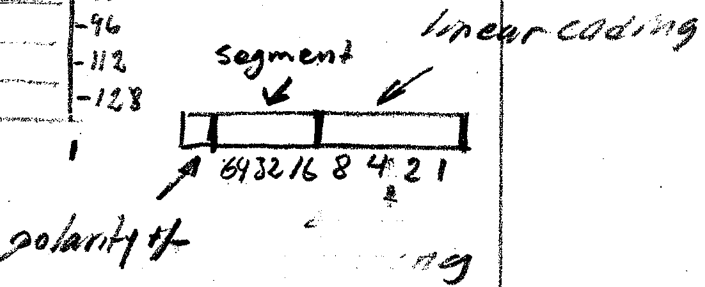
The quantizing steps in PCM are not linear in order to enhance the signal to distortion ratio. By using a greater number of quantizing steps for signals of low amplitude and smaller number of quantizing steps for signals of large amplitude, a reduction in the overall signal distorsion is achived.



In Europe a coding schem called A-law is applied in PCM



The output from the encoder is a digital word of 8 bits. The first bit tells the the polarity +/- The next 3 bits tells which segmement that the sample amplitude is in. The last 4 bits a linearly quantized inside each segment



8. ~~LEO~~ GEO, LEO and MEO stands for geostationary earth orbit, low earth orbit and medium earth orbit respectivly. The traditional GEO satellite is in a circular orbit in an equatorial plane such that the satellite rotates about the earth at the same angular velocity that the earth spins of its axis. To accomplish this the satellite must be approximatley 35,838 km above the earth's surface at the equator. LEO satellites are satellites with much lower orbits, on the order of 700 to 1400 km high. Finally, MEO satellites, are on the order of 5000 to 12.000 km high. Because of the high altitude of the GEO satellite the signal strength is relatively weak compared to LEOs. The propagation delay for a GEO satellite is about 1/4th of second; that of a LEO is much less. Because the GEO satellite must be over the equator, the coverage near the north and south pole is inadequate. For these regions better communication can be achived with by LEO and MEO satellites. On the other hand, tracking and handoff is not necessary for GEO satellites because they appear stationary relative to earth.

(10.) A. This database is used for authentication activities of the system for example, it holds the authentication and encryption keys for all the subscribers in both the home and visitor location registers. The center controls access to user data as well as being used for authentication when a subscriber joins a network. GSM transmission is encrypted, so it is private. A stream cipher, A5, is used to encrypt the transmission from subscriber to base transceiver. However, the conversation is in the clear in the land-line network. Another cipher, A3, is used for authentication.

(see page 314)

10. B. One important, temporary piece of information is the location of the subscriber. The location is determined by the VLR into which the subscriber is entered. The visitor location register maintains information about subscribers that are currently physically in the region covered by the switching center. It records weather or not the subscriber is active and other parameters associated with the subscriber. For a call coming to the subscriber, the system uses the telephone number associated with the subscriber to identify the home switching center of the subscriber. This switching center can be find in its HLR the switching center in which the subscriber is currently physically located. For a call coming from the subscriber, the VLR is used to initiate the call Even if the subscriber is in the area covered by its home switching center, it is also represented in the switching centers VLR for consistency.

(11.)

$D = 1101101 \Rightarrow x^6 + x^5 + x^3 + x^2 + 1$

$P = x^3 + x^2 + 1$

$$
\begin{array}{r|l}
 & x^3 \\
\hline
x^3 + x^2 + 1 & x^6 + x^5 \quad x^3 + x^2 \quad 1 \\
 & x^6 + x^5 \quad x^3 \\
\hline
 & x^2 + 1
\end{array}
$$

$S = x^2 + 1 \Rightarrow 101$

Using the syndrom table

$101 \Rightarrow 0001000$

$1101101 \oplus 0001000 = \underline{1100101}$

Thus taking away the three check bits we get $\underline{1100}$

12.

$P_{ERP} = P_L G_L$

$100 = 20\ G_L$

$\frac{100}{20} = 5$ ggr

$10 \log 5 = 6{,}99 \approx 7$ dBi

13.

$$C = B\log_2\left(1+\frac{S}{N}\right) \Rightarrow$$

$$\frac{C}{B} = \log_2\left(1+\frac{S}{N}\right) \Rightarrow$$

$$2^{\frac{C}{B}} = 1+\frac{S}{N} \Rightarrow$$

$$2^{\frac{C}{B}} - 1 = \frac{S}{N} \Rightarrow$$

$$2^{\cancel{\frac{1\cdot 10^6}{1\cdot 10^6}}} - 1 = \frac{S}{N} \Rightarrow$$

$$2^{1} - 1 = 1 \Rightarrow$$

$$\frac{S}{N} = 1 \quad \text{or} \quad \left(\frac{S}{N}\right)_{dB} = 0\,dB$$