DIGITAL ASSIGNMENT - II

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PROGRAMME : B. TECH ECE SEMESTER : WS 2023-24

COURSE NAME & CODE : BECE307L - WIRELESS & MOBILE COMM.

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① For the power delay profiles shown in Figure 1, estimate the mean delay, rms delay spread, 90% correlation and 50% correlation coherence bandwidth.

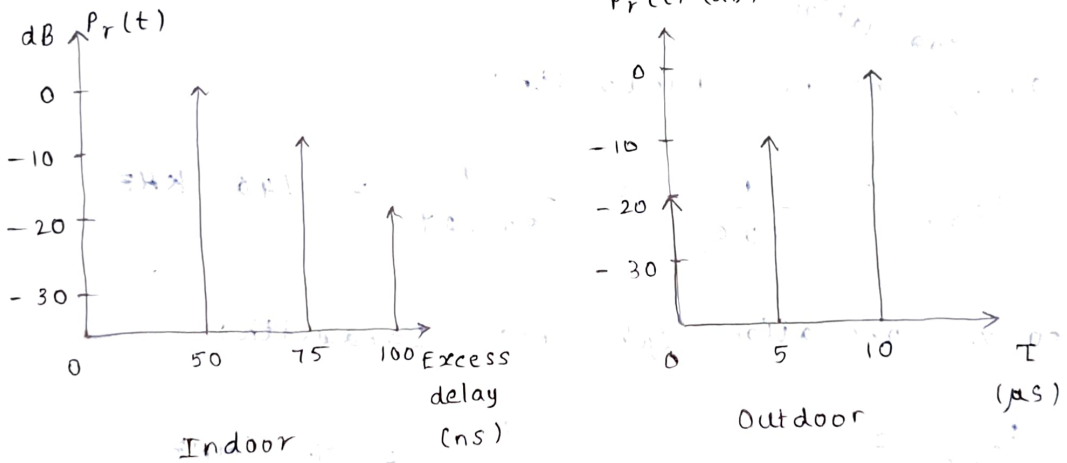


Figure 1

Solution,

$$\bar{\tau} = \frac{\sum_k P(\tau_k)\tau_k}{\sum_k P(\tau_k)} \qquad \sigma_\tau = \sqrt{\bar{\tau}^2 - (\bar{\tau})^2}$$

$0\ dB = 10^{-10\,0/10} = 1\ W$ $\quad -20\ dB = 10^{-20/10} = 0.01$ W

$-10\ dB = 10^{-10/10} = 0.1\ W$

Indoor:

$$\bar{\tau} = \frac{1 \times 50 + 0.1 \times 75 + 0.01 \times 100}{1 + 0.1 + 0.01}$$

$$\bar{\tau} = 27.725 \text{ ns}$$

$$\bar{\tau^2} = \frac{1 \times 50^2 + 0.1 \times 75^2 + 0.01 \times 100^2}{1 + 0.1 + 0.01}$$

$$\bar{\tau^2} = 1498.8 \text{ ns}^2$$

RMS Delay Spread $\sigma_T = \sqrt{1498.8 - (27.725)^2}$

$$\sigma_T = 27 \text{ ns}$$

90% correlation Coherence Bandwidth:

$$B_{c_{0.9}} = \frac{1}{50\sigma_T} = \frac{1}{50 \times 27} = 740 \text{ KHz}$$

50% correlation Coherence Bandwidth:

$$B_{c_{0.5}} = \frac{1}{5\sigma_T} = \frac{1}{5 \times 27} = 7.4 \text{ MHz}$$

Outdoor:

$$\bar{\tau} = \frac{0.01 \times 0 + 0.1 \times 5 + 1 \times 10}{0.01 + 0.1 + 1}$$

$$\bar{\tau} = 9.46 \ \mu s$$

$$\overline{\tau^2} = \frac{0.01 \times 0^2 + 0.1 \times 5^2 + 1 \times 10^2}{0.01 + 0.1 + 1}$$

$$\overline{\tau^2} = 92.34 \ \mu s^2$$

$$\sigma_T = \sqrt{92.34 - (9.46)^2}$$

$$\sigma_T = 1.688 \ \mu s$$

90% Correlation Coherence Bandwidth:

$$B_{c_{0.9}} = \frac{1}{50\,\sigma_T} = \frac{1}{50 \times 1.688} \doteq 11.85 \text{ kHz}$$

50% correlation Coherence Bandwidth:

$$B_{c_{0.5}} = \frac{1}{5\,\sigma_T} = \frac{1}{5 \times 1.688} = 118.5 \text{ kHz}$$

② If a particular modulation provides suitable BER performance whenever $\sigma / T_s \leq 0.1$, determine the smallest period T_s that may be sent through the RF channels shown in Figure 1.

Solution,

0 dB = 1 W, −10 dB = 0.1 W, −20 dB = 0.01 W

$$\bar{\tau} = \frac{\sum_k P(\tau) \cdot \tau}{\sum_k P(\tau)} \qquad \sigma_T = \sqrt{\overline{\tau}^2 - (\bar{\tau})^2}$$

$$\bar{\tau} = \frac{1 \times 50 + 0.1 \times 75 + 0.01 \times 100}{1 + 0.1 + 0.01}$$

$$\bar{\tau} = 27.725 \text{ ns}$$

$$\overline{\tau^2} = \frac{1 \times 50^2 + 0.1 \times 75^2 + 0.01 \times 100^2}{1 + 0.1 + 0.01}$$

$$\overline{\tau^2} = 1498.8 \text{ ns}^2$$

RMS Delay Spread $\sigma_T = \sqrt{\overline{\tau^2} - (\bar{\tau})^2}$

$$\sigma_T = \sqrt{1498.8 - (27.725)^2}$$

$$\sigma_T = 27 \text{ ns}$$

Smallest Symbol Period T_s

$$T_s \gg \frac{\sigma_T}{0.1} \quad \text{---- (} \sigma_T \ (T_s \ll 0.1) \text{ Given)}$$

$$= \frac{27}{0.1}$$

$$T_s \gg 270 \text{ ns}$$

$$R_s = 1/T_s = 1/270 = 3.7 \times 10^{-3} \text{ bps}$$

$$\boxed{R_s = 3.7 \text{ mbps}}$$

③ For a mobile receiver operating at 860 MHz and moving at 100 kmph.

ⓐ Sketch the Doppler Spectrum if the CW signal is transmitted and indicate the max and min frequencies.

ⓑ Calculate the level crossing rate and average fade duration if $\rho = -20$ dB.

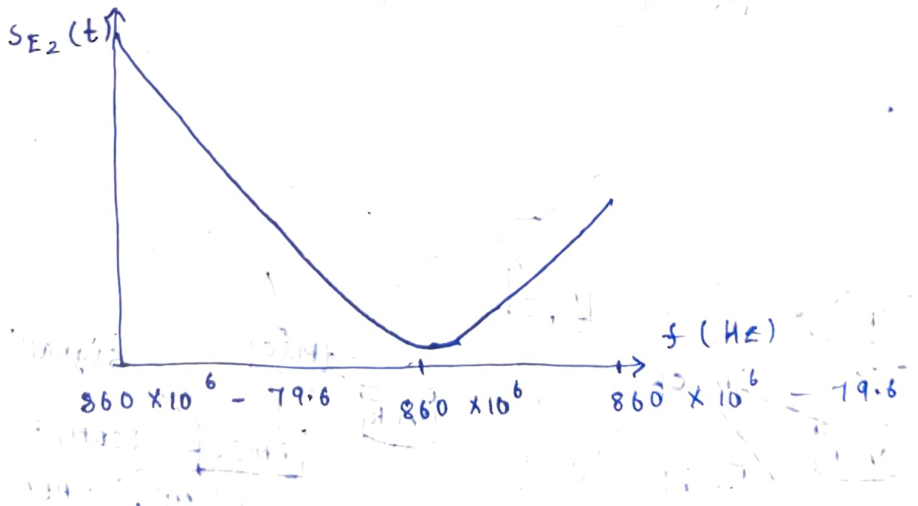
Solution,

ⓐ $$\lambda = \frac{c}{f_c} = \frac{3 \times 10^8}{860 \times 10^6} = 0.349 \text{ m}$$

$$v = 100 \text{ km/hr} = \frac{100 \times 10^3}{3600 \text{ s}} = 27.78 \text{ m/s}$$

$$f_m = \frac{v}{\lambda} = \frac{27.78}{0.349} = 79.6 \text{ Hz}$$

The doppler spectrum is shown as :



(b)

For $\rho = -20\ dB = 0.1$

$$N_R = \sqrt{2\pi} \cdot f_m \cdot \rho \cdot \rho^{-\rho^2}$$

$$= \sqrt{2\pi} \times 19.6 \times 0.1 \times \rho^{-0.01}$$

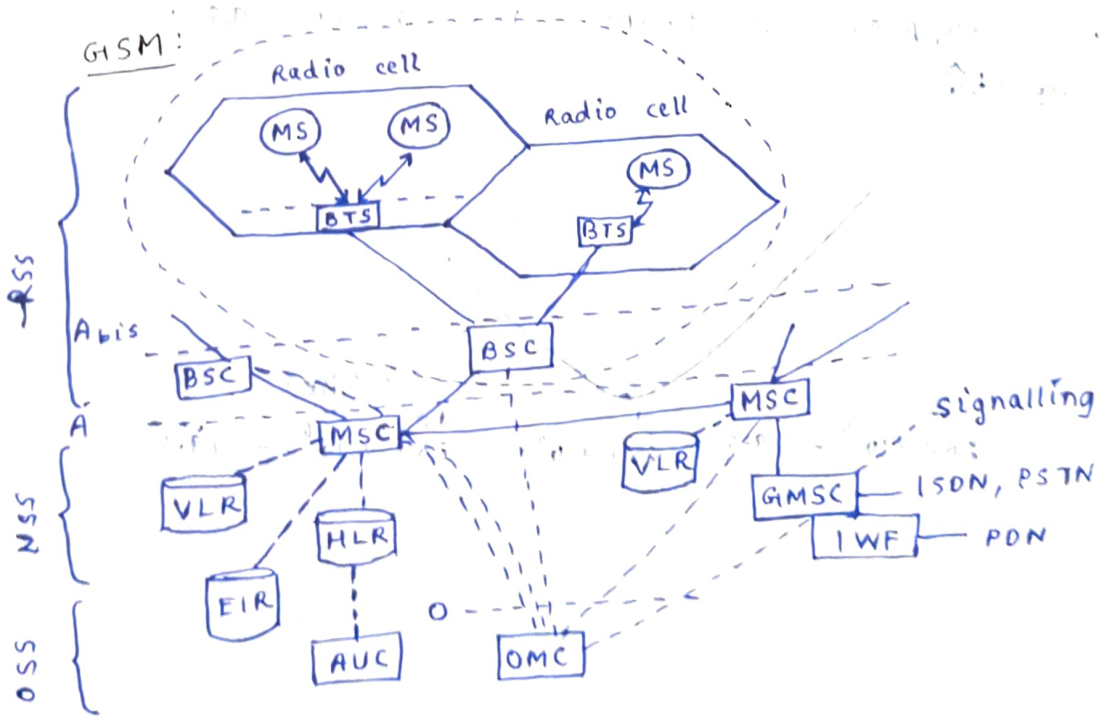
$$= 19.7 \text{ (crossing rate s/s)}$$

$$\bar{\tau} = \frac{e^{\rho^2} - 1}{\rho f_m \sqrt{2\pi}} = \frac{\rho^{0.01} - 1}{0.1 \times 19.6 \times \sqrt{2\pi}} = 0.5 \text{ ms}$$

(4) Study and understand the architecture of GSM, GPRS and LTE. Compare and contrast the typical entities, architecture and operation of GSM, GPRS and LTE systems

Answer,

GSM:



Entities :

* Mobile Station (MS) : The device used by end user.
* Base station Subsystem : It consists of Base Station Controller (BSC) and Base Tranceiver Station (BTS).
* Network Subsystem (NSS) : Consists of Mobile switching Center (MSC), Home Location Register (HLR), Visitor Location (VLR), Authentication center (AuC)
* Operation and Maintenance center (OMC)

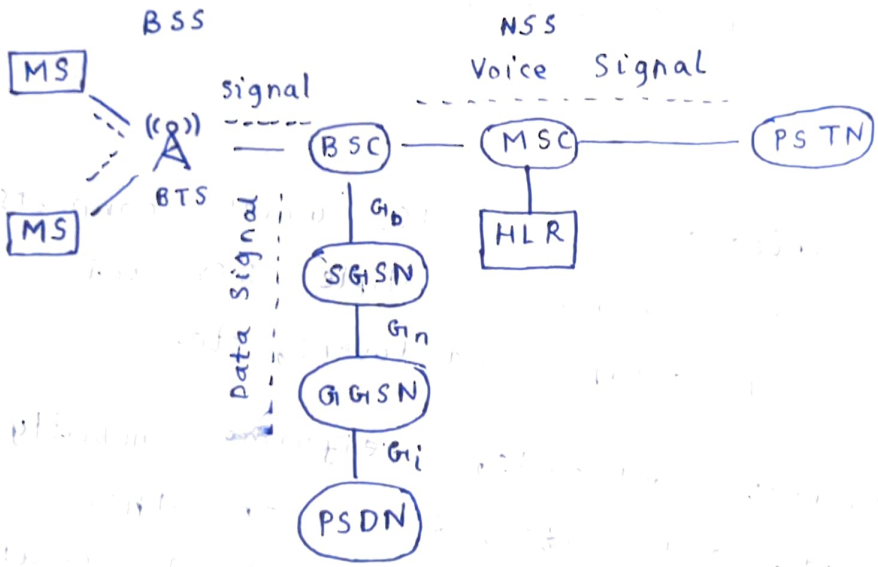
Architecture :

* MS communicates with BTS, which connects to BSC. BSC manages multiple BTS and handles call setup, handovers, etc.
* MSC connects calls, performs mobility management, and interfaces with other networks. HLR stores subscriber information and VLR stores temporary information about subscribers in its area.
* BTS are connected to the MSC through BSC.

Operation:

- MS initiates a call, BTS forwards the request to BSC, which communicates with MSC. MSC connects the call.
- Authentication, encryption and mobility management is essential functions.
- GSM operates in TDMA for multiple users to share the same frequency channel.

GPRS:



Entities:

- Serving GPRS Support Node (SGSN): Manages packet-switching data sessions.
- Gateway GPRS Support Node (GGSN): Interfaces GPRS network with external packet data
- Operations & Maintenance Center (OMC)

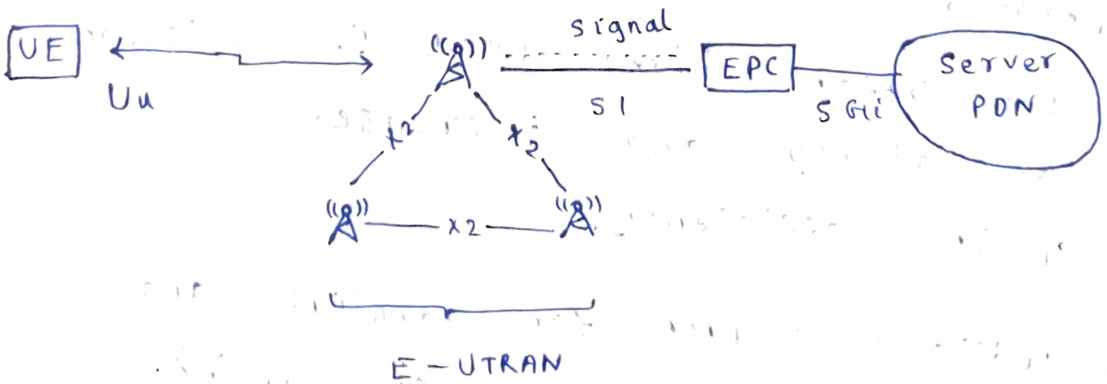
Architecture :

- Addition of SGSN and GGSN to GSM Architecture.
- SGSN handles packet routing and mobility management within the GPRS network.
- GGSN acts a gateway to external packet data networks.

Operation :

- GPRS introduces packet switched data services alongside circuit - switched voice.
- Allows "always-on" connectivity for data, facilitating services like internet browsing, email, etc...
- Packet data transmission is prioritized based on QoS.

LTE :



Entities:

* Evolved Node B (eNodeB): Equivalent to GSM BTS
* Mobility Management Entity (MME): Performs Mobility management and authentication.
* Serving Gateway and Packet Data Network Gateway
* Operations & Maintenance Center

Architecture:

* LTE is based on all IP - Flat Architecture.
* eNodeB communicates directly with Evolved Packet Core which includes MME, SGW, PGW.
* Simplified architecture leads to reduced latency and increased data rates.

Operation:

* LTE offers high-speed transmission low latency and increased spectral efficiency.
* Utilized OFDMA for downlink and Signal Carrier - FDMA for uplink.

* seamless handovers between eNode B enhance mobility support.