

EE4036 - Tutorial 3

1. If 0 dBm is equal to 1 mW (10^{-3} W) over a 50Ω load; express 10 W in units of dBm.

Ans:

$$1W = 1000mW$$

$$10W = 10 \times 1000mW$$

$$10W = 10,000mW$$

$$10W = 40dBm$$

2. Describe the Timing Diagram of:
A) A call to a mobile user initiated by a landline subscriber;
B) A call initiated by a mobile to a landline user.

Refer to Textbook

3. If 20 MHz of total spectrum is allocated for a duplex wireless cellular system and each simplex channel has 25 kHz RF bandwidth, find:
(a) the number of duplex channels.
(b) the total number of channels per cell site, if $N = 4$ cell reuse is used.

Ans:

a) The number of simplex channels = $20\text{MHz}/25\text{kHz} = 800$

The number of duplex channels = $800/2 = 400$

b) The number of channel per cell site = $400/4 = 100$

4. Assume that we wanted to deploy an analog FM AMPS system with half band of 15kHz rather than the existing 30kHz. Also assume that in analog FM, the signal-to-interference ratio (SIR) requirement is inversely proportional to the square of the bandwidth (4 times increase in SIR requirement for dividing the band into two).
 - a. What is the required SIR in dB for the 15 kHz channel if the required SIR for the 30kHz systems is 18dB?
 - b. Determine the frequency reuse factor N needed for the implementation of this kHz per user analog cellular system.

Ans:

a)

$$SIR(dB) = \frac{K}{B^2}$$

If B is 30 kHz, SIR is 18 dB. By now B is 15 kHz, the SIR is 4 times increased.

$$SIR(dB) = 10 \log \left(4 \times 10^{\frac{18}{10}} \right)$$

$$SIR = 10 \log(4 \times 63.09573445)$$

$$SIR = 10 \times 2.402059991$$

$$SIR = 24.0205991$$

$$SIR \approx 24$$

The required SIR is 24 dB for the 15 kHz channel.

b)

Let N be the cluster size

$$SIR(dB) = 1.76 + 20 \log N$$

$$24.02059991 = 1.76 + 20 \log N$$

$$\log N = 1.113029996$$

$$N = 12.97268867$$

$$N \approx 13$$

5. The one-way bandwidth available to a single operator in the AMPS system is 12.5 MHz with a channel bandwidth of 30 kHz and 21 control channels. We would like to calculate the efficiency with which this system utilizes bandwidth for a particular installation. Use the following parameters:

Cell area = 8 km²

Total Coverage area = 4000 km²

Frequency Reuse Factor = 7

Average number of calls per user during the busy hour = 1.2

Average holding time of a call = 100 s

Target call blocking probability = 2%

- How many voice channels are there per cell?
- Determine the total traffic carried per cell, in Erlangs/cell. Then convert that to Erlangs/ km².
- Calculate the number of calls/hour/cell and the number of calls/hour/ km².
- Calculate the number of users/cell and the number of users/channel.

Ans:

Bandwidth B = 12.5MHz

No. of control Channel = 21

Total Coverage area = 4000 km²

Bandwidth per Channel = 30KHz

Cell area = 8 km²

Frequency Reuse Factor = 7

Average number of calls per user during the busy hour = 1.2 Average holding time of a call = 100 s

Target call blocking probability = 1 %

a)

$$\text{Number of channel} = \frac{\text{Bandwidth}}{\text{Bandwidth per channel}} - \text{Control channel}$$

$$\text{Number of channel} = \frac{12.5\text{MHz}}{30\text{KHz}} - 21$$

$$\text{Number of channel} = 395.6667$$

$$\text{Number of channel} \approx 395 \text{ channels}$$

$$\text{Number of channel per cell} = \frac{395}{7} = 56.4286 \approx 56 \text{ channels per cell}$$

b)

According to the Erlang Loss Equation, Blocking Probabiltiy $E_n(A) = \frac{A^n / n!}{\sum_{j=0}^n A^j / j!}$

By now, the target call blocking probability = 1 % when no. of channels = 56, i.e.

$$E_{56}(A) = 0.01 = \frac{A^{56} / 56!}{\sum_{j=0}^{56} A^j / j!}$$

$$A = 43.3 \text{ Erl}$$

$$\text{Total traffic carrier per km}^2 = \frac{43.3}{8} = 5.4125 \text{ Erl/km}^2$$

c)

$$A = \frac{\lambda}{\mu}$$

$$\therefore \lambda = \mu \times A$$

$$\lambda = 43.3 \times \frac{60 \times 60}{100}$$

$$\lambda = 1558.8 \text{ call/hour/cell}$$

d)

$$\text{Number of users per cell} = \frac{\lambda}{\text{Average number of calls per user}}$$

$$\text{Number of users per cell} = \frac{1558.8}{1.2} = 1299 \text{ user/cell}$$