Eastern Mediterranean University
Electrical and Electronic / Information Systems Engineering Programs
Wireless Communications (EENG464)
Mid Term Exam (Date: 13th Apr. 2017, 08.30, Duration: 90 min)
Instructor: Prof. Dr. Hasan AMCA

Question	**Mark**
Q1 (50 pts)	
Q2 (50 pts)	
Total points	

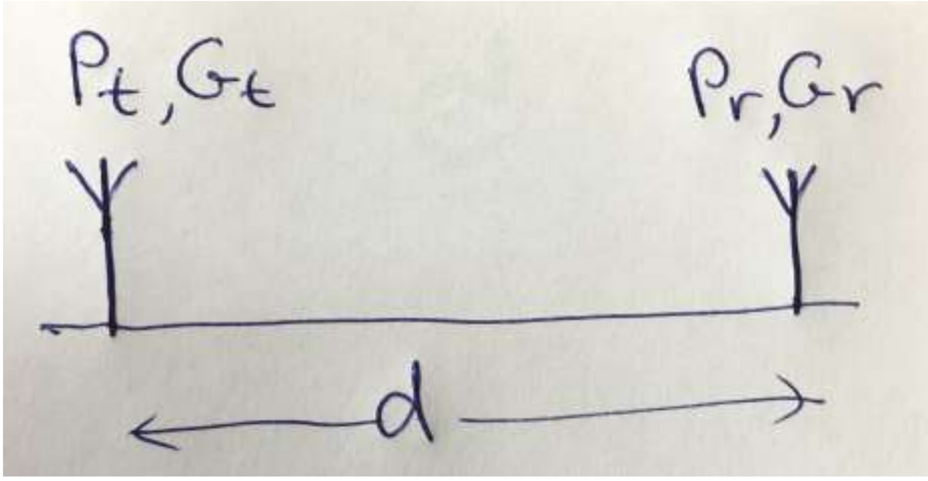
Student Name: ______________________________________ **Student Number:** _______________

IMPORTANT NOTES

1. Please Answer **All** Questions.
2. You may **use only the main course textbook** (Wireless Communications by T.S. Rappaport) in the exam. No other materials are allowed.
3. Make sure that there is **no undesirable writing or note in the textbook**. If anything is written in the book, the books will be taken away and disciplinary action may follow.
4. Having a solution manual in the exam room is strictly forbidden and disciplinary actions will be taken if anyone does so.
5. **No mobile telephones or computers** are allowed in the exam room. Hence, strictly no soft copies of books or other materials.
6. Students are not allowed to leave the exam room within the first **30 minutes**. Late comers are welcome in the first 30 minutes.

Q1) A transmitter provides 10 W to an antenna having 10 dB gain. The receiver antenna has a gain of 3 dB and the receiver bandwidth is 25 kHz. If the receiver system Noise Figure is 10 dB and the carrier frequency is 1500 MHz, find the maximum distance between the transmitter and the receiver that will ensure that a SNR of 20 dB is provided. Draw a clear picture and label all parameters used on the figure. Note that the path loss exponent of the mobile communications channel of interest is $n = 4$. (You may need these, $\sigma = 10\ dB$ and $d_0 = 1$ km. Noise Figure $F = SNRi / SNR_0$).

Soln.



8

The Noise Figure is given as $F = 10$ dB = 10 times. With the Rx $B_w = 25$ kHz, then the Noise Floor will be

$\lambda = \frac{C}{f} = 3 \times \frac{10^8}{1500} \times 10^6 = \frac{3}{15} = 0.2$m

7

$Noise\ Floor = k \times B_w \times F \times T_0 = 1.38 \times 10^{-23} \times 25 \times 10^3 \times 10 \times 290 = 1.0005 \times 10^{-15}$ W or -120 dBm.

$$\text{Noise Floor(dBm)} + \text{SNR(dB)} = -120 + 20 = -100 \text{ dBm}$$

7

No need to these Since $P_\gamma[\Pr(d_{max} > \gamma)] = \mathrm{Q}\left(\frac{\gamma - \overline{\Pr(d_{max})}}{\sigma}\right) = \mathrm{Q}\left(\frac{-100 - \overline{\Pr(d_{max})}}{\sigma}\right) = 100\%$

Since $SNR_0 = 20$ dB, and Noise Figure $F = SNR_i / SNR_0$, then $SNR_i = F * SNR_0 = 10 * 100 = 1000$ or 30 dB

7

$SNR_i = Pr$ / Noise Floor (N_i) => $Pr = SNR_i * N_i = 1000 * 1*10^{-15} = 10^{-12}$

7

Since $P_r = \frac{P_t \times G_t \times G_r \times \lambda^2}{(4\times\pi)^2 d^n} = \frac{10\times10\times2\times0.2^2}{(4\times\pi)^2 d^4} = 10^{-12}$ W. Hence from here d can be found as

7

$d^4 = 0.05071 \times 10^{12}$ => $d = 474$ km

7

Q2) For a frequency division duplex cellular telephone system 24 MHz of bandwidth is allocated. The cellular uses two 30 kHz simplex channels to provide full duplex voice and control channels. Assume each cell phone user generates 0.1 Erlangs of traffic. Assume Erlang B is used.

a) Find the number of channels in each cell for a four-cell reuse system.
b) If each cell is to offer capacity that is 90% of perfect scheduling, find the maximum number of users that can be supported per cell where omnidirectional antennas are used at each base station.
c) What is the blocking probability of the system in (b) when the maximum number of users are available in the user pool?
d) If each new cell now uses 120° sectoring instead of omnidirectional for each base station, what is the new total number of users that can be supported per cell for the same blocking probability as in c)?
e) If each cell covers five square kilometers, then how many subscribers could be supported in an urban market that is 50 km × 50 km for the case of omnidirectional base station antennas?
f) If each cell covers five square kilometers, then how many subscribers could be supported in an urban market that is 50 km × 50 km for the case of 120° sectored antennas?

(a) $\frac{24 \text{ MHz}}{2 \cdot 30 \text{ kHz}} = 400$ channels 5

$\frac{400 \text{ channels}}{4 \text{ cells}} = 100$ channels/cell 5

(b) 90% of 100 Erlangs = 90 Erlangs 5

$90 = U A_u = U(0.1) \Rightarrow U = 900$ users 5

(c) offered: 90E ; C = 100 ⇒ 0.03 from graph (Fig. 3-6) 5

3% GOS

(d) Each sector has 33.3 channels ; GOS = 3%

from graph (Fig. 3-6) ⇒ ≈ 25 Erlangs/sector 5

$25 = U A_u$ (per sector)

⇒ $U = 250 \times 3$ sectors 5

$U = 750$ users

(e) $\frac{2500 \text{ km}^2}{5 \text{ km}^2} = 500$ cells ⇒ 500 × 900 users/cell = 450,000 users 7.5

(f) 500 cells ⇒ 500 × 750 user/cell = 375,000 users 7.5