

City University of Hong Kong

Course Code & Title: EE4036 Wireless Communications

Session: Semester A, 2002-2003

Time Allowed: Two Hours

This paper has **SIX** pages (Including this page)

Instruction to candidates:

1. This paper consists of **TWO** sections.
2. Attempt **ALL** the questions in Section A.
3. Attempt **THREE** questions in Section B.
4. Start each section on a **NEW** answer book.
5. Start each question on a **NEW** page.

Boltzmann's constant = 1.38×10^{-23} J/K

Materials, aids permitted to be used during examination:

Approved Calculator

Section A

Answer **ALL** the questions in this section.

Question A1 (11 marks)

- (a) A rectangular shaped microstrip patch antenna is excited in the TM_{10} mode at 5.3GHz. What is the dimensions of the antenna. Take the width to length ratio be 1.5. A substrate thickness of 1mm and dielectric constant 2.32 are used.
(Ignore the fringe field effects) [3 marks]
- (b) Hence, describe a microstrip antenna measurement setup for measuring the radiation pattern inside a compact range chamber using a transmitting horn,
(i) E-plane co-polarization pattern,
(ii) E-plane cross-polarization pattern,
(iii) H-plane co-polarization pattern, and
(iv) H-plane cross-polarization pattern [4 marks]
- (c) Suggest a method to measure the radiation efficiency of a microstrip patch antenna designed in (a). Hence, describe the measurement procedures. [4 marks]

Question A2 (7 marks)

- (a) Compare the strengths and the weaknesses of the following methods for analyzing a microstrip antenna:
(i) transmission line model,
(ii) cavity model,
(iii) full wave analysis. [3 marks]

- (b) Given that the pattern condition of a 4-element linear array is

$$k_0 d \cos \phi + \alpha = 0 ;$$

what are the conditions of ϕ and α for

- (i) broadside array, and
(ii) end-fire array [4 marks]

Question A3 (7 marks)

- (a) The fields radiated by from a current element are given by :

$$E_r = -\frac{Idl}{4\pi}\eta_0 k_0^2 2 \cos\theta \left[\frac{1}{(jk_0 r)^2} + \frac{1}{(jk_0 r)^3} \right] e^{-jk_0 r}$$

$$E_\theta = -\frac{Idl}{4\pi}\eta_0 k_0^2 \sin\theta \left[\frac{1}{(jk_0 r)} + \frac{1}{(jk_0 r)^2} + \frac{1}{(jk_0 r)^3} \right] e^{-jk_0 r}$$

$$H_\phi = -\frac{Idl}{4\pi}k_0^2 \sin\theta \left[\frac{1}{(jk_0 r)} + \frac{1}{(jk_0 r)^2} + \frac{1}{(jk_0 r)^3} \right] e^{-jk_0 r}$$

What is the far field condition? Hence, derive a far field expression for both E and H components. [3 marks]

- (b) The E-plane pattern function of a linear dipole antenna is

$$F(\theta) = \frac{\cos(\beta h \cos\theta) - \cos\beta h}{\sin\theta}$$

Sketch the E-plane radiation pattern for the following center-fed dipole antennas,

- (i) $\frac{2h}{\lambda} = \frac{1}{2}$
- (ii) $\frac{2h}{\lambda} = 1$
- (iii) $\frac{2h}{\lambda} = \frac{3}{2}$
- (iv) $\frac{2h}{\lambda} = 2$

[4 marks]

Section B

This section contains **FOUR** questions. Answer any **THREE** questions.

Question B1 (25 marks)

- (a) Some wireless communication system manufacturers suggest to use ~60GHz for indoor short distance applications. Comment on it.

[6 marks]

- (b) It is well known that the free space path loss is inversely proportional to frequency. Comment on the suitability of using 10-30MHz instead of over gigahertz for terrestrial line-of-sight space wave communications. Assume that the required frequency band is available.

[4 marks]

- (c) Briefly compare and contrast the following wireless communication techniques:

(i) ground wave; (ii) ionospheric propagation; (iii) satellite, and (iv) mobile (terrestrial).

You need to address any five of the following issues: (i) operating frequency, (ii) bandwidth, (iii) data rate, (iv) reliability, (v) communication distance, and (vi) operating cost.

[10 marks]

- (d) How many network operators are using (i) GSM900 and (ii) GSM1800 in Hong Kong? What are the major difference between GSM900 and GSM1800? How many subscribers (including pre-paid SIM cards and both GSM900/GSM1800) are now in Hong Kong?

[5 marks]

Question B2 (25 marks)

The following shows the system parameters of an unprotected non-diversity 30km digital microwave link:

<i>RF frequency</i>	<i>4GHz</i>
<i>Bit Rate</i>	<i>135Mb/s</i>
<i>Modulation</i>	<i>256QAM</i>
<i>Transmitter Output Power</i>	<i>38dBm</i>
<i>Transmitter Antenna</i>	<i>37.2dB</i>
<i>Receiver Antenna</i>	<i>37.2dB</i>
<i>Total branching, feeder, and connector losses</i>	<i>8.8dB</i>
<i>Equivalent Noise temperature at the receiver (including antenna) at the receiver input</i>	<i>600K</i>

The practical carrier-to-noise ratio (C/N) at $BER = 10^{-3}$ for various modulation schemes are (includes all imperfect hardware degradations):

	8PSK	64QAM	256QAM
C/N (dB)	19.2	27.2	33.4

Assume that (i) an ideal brick wall filter is used, (ii) the RF bandwidth should be confined within 20MHz, and (iii) the net fade margin equals 0.55 X Flat-fade-margin (dB).

- (a) Choose a suitable modulation scheme from the above table and briefly justify your selection. Estimate the corresponding RF bandwidth and baseband bandwidth of the system; [5 marks]
- (b) Estimate the system gain at $BER=10^{-3}$; [4 marks]
- (c) Estimate the flat fade margin at $BER=10^{-3}$; [4 marks]
- (d) Estimate the outage time (i.e. $BER \geq 10^{-3}$) in seconds of the worst month. [3 marks]
[Note: Fading Probability of the worst month = $(\text{hop length})^{3.2}(\text{RF frequency})^{1.1} \times 9 \times 10^{-7}$]
- (e) State two techniques to reduce the outage time. [2 marks]
- (f) If both transmitting and receiving antennas are at the same height, estimate the suitable mounting height for the antennas above the surface of the earth to maintain the clearance of line-of-sight path. Assume that the earth is a smooth sphere of radius 6400km, and the worst case refractivity of the atmosphere is:

$$N(h) = 300X \exp(0.12h)$$

where h is the height above earth surface in km.

[7 marks]

Question B3 (25 marks)

- (a) In satellite communications, it is well known that inter-modulation distortion (IMD) of a power amplifier is one of the major degradations in FDMA operation.
- (i) Express the transfer function of a power amplifier to model the IMD.
 - (ii) Assume that there are three tones: 3.860GHz, 3.900GHz, and 3.915GHz, for transmission. State any six of the IMD components.
 - (iii) Why the IMD can't be completely eliminated by simple filtering in a practical environment? [7 marks]
- (b) Briefly describe the major features of a VSAT system. The following shows the outroute of a C-band link for a Hub to VSAT network:

Uplink

<i>Frequency</i>	<i>6 GHz</i>
<i>Saturation power flux density at satellite input</i>	<i>-111.8 dBW/m²</i>
<i>Input backoff at satellite input</i>	<i>2.5 dB</i>
<i>Satellite G/T</i>	<i>0.8 dB/K</i>
<i>Equivalent noise bandwidth</i>	<i>500 kHz</i>

Downlink

<i>Frequency</i>	<i>4 GHz</i>
<i>EIRP</i>	<i>18.2 dBW</i>
<i>Path loss + other losses</i>	<i>196.5 dB</i>
<i>VSAT receiver G/T</i>	<i>19.1 dB/K</i>
<i>Equivalent noise bandwidth</i>	<i>500 kHz</i>

- Determine the
- (i) uplink C/N
 - (ii) downlink C/N
 - (iii) overall C/N

[18 marks]

Question B4 (25 marks)

- (a) Briefly describe the authentication process in the GSM, and sketch the flow diagram. [10 marks]
- (b) What are the major advantages of using 3G mobile communication systems? State the name of the system(s) which can be upgraded from the current (i) GSM, and (ii) NADC (i.e. DAMP, IS-54, IS136). [8 marks]
- (c) (i) Briefly describe the battery power saving mechanism for pagers using POSCAG.
(ii) Briefly explain why it is possible to have twenty or more Paging Network Operators in Hong Kong now but not for that of the Cellular Mobile Radio Network Operators. [7 marks]

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