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**UNIVERSITY OF SWAZILAND**
**FACULTY OF SCIENCE**
**DEPARTMENT OF ELECTRONIC ENGINEERING**
**MAIN EXAMINATION 2005**

TITLE OF PAPER : ANTENNAS AND WAVE PROPAGATION

COURSE NUMBER : ECO510

TIME ALLOWED : THREE HOURS

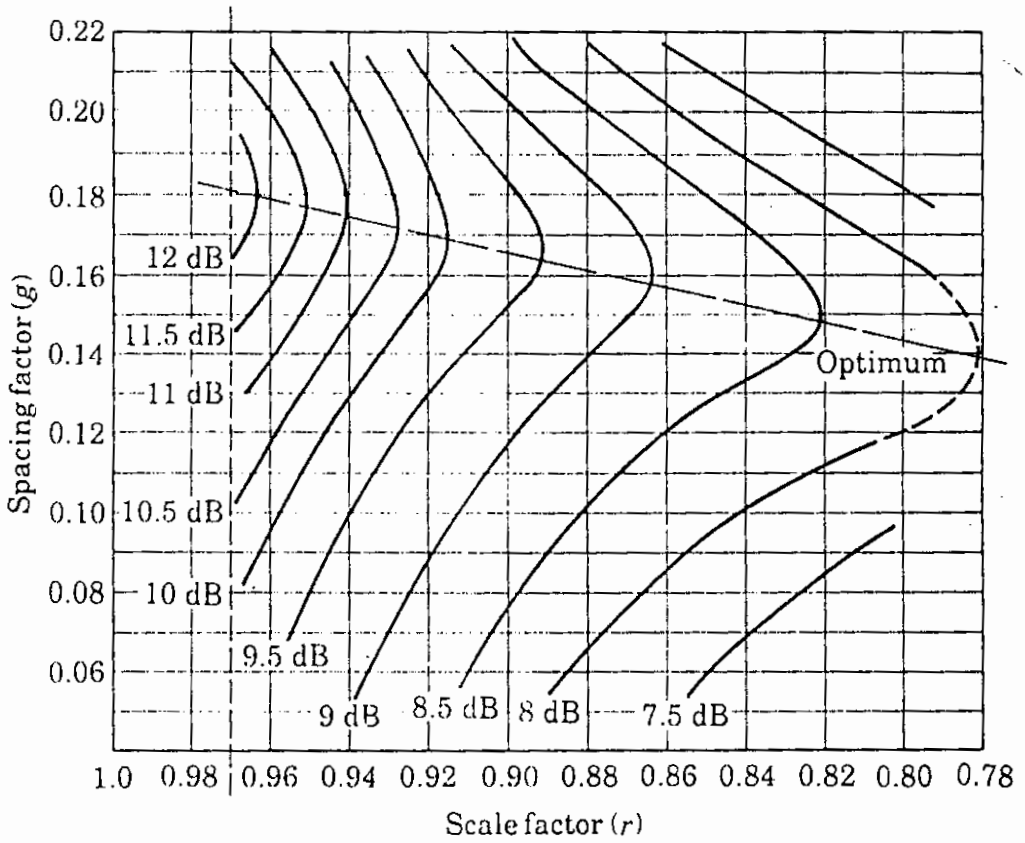
INSTRUCTIONS : READ EACH QUESTION CAREFULLY
ANSWER ANY **FOUR** QUESTIONS.
EACH QUESTION CARRIES **25 MARKS**.
MARKS FOR EACH SECTION ARE SHOWN
ON THE RIGHT-HAND MARGIN.

**THIS PAPER HAS 5 PAGES INCLUDING THIS PAGE.**

**THIS PAPER IS NOT TO BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.**

**USEFUL INFORMATION**

| | |
|---|---|
| Antenna efficiency factor | $k = 0.55$ |
| General expression for gain | $(4\pi k)$ (effective area) / $\lambda^2$ |
| speed of light | $C = 3 \times 10^8$ m/s |
| Boltzman constant | $k = 1.38 \times 10^{-23}$ J/K |
| Power at receiving antenna, | $P_r = (P_t G_t G_r \lambda^2) / (16 \pi^2 r^2)$ |
| Spread angle | $\tan(\alpha/2) = (1 - \tau) / (4\sigma)$ |



## QUESTION 1

(a) It is desired to have an antenna that operates over the FM broadcast band (88 – 108) MHz with a design gain of 10 dB. Present an optimum design of such an antenna.

( 20 marks )

(b) A Hertzian dipole when energized by a high - frequency current, can be associated with different types of fields. The magnetic field at a distance **r** from the dipole is given by

$$H_{\varphi} = \frac{I_o.dl}{4\pi}.Sin\theta\left[\frac{j\exp^{jw(t-r/c)}.\omega}{cr} + \frac{e^{jw(t-r/c)}}{r^2}\right]$$

Derive an expression for the r.m.s. value of the electric field intensity $\boldsymbol{E}$ ( in terms of $\lambda$ and the peak amplitude in the direction of maximum $\boldsymbol{E}$ ), **r** away from the dipole.

( 5 marks )

## QUESTION 2

(a) Which practical factors affect the actual construction length of antennas? Give a good first estimate to compensate for them.

( 4 marks )

(b) Your manager has asked you to calculate the height of a transmitting Yagi-Uda antenna for a new TV station. The only data obtainable from the marketing department is that the broadcast must reach customers up to 30 km away. As you make a preliminary study of the area, you notice that the highest tower possible on the site is 340 m. Roof height for the buildings is 4 m. Explain how you can provide solutions that will let the original viewing area be maintained .
Include all calculations and recommendations you will make to your manager.

( 16 marks )

(c) A receiving antenna of impedance $Z_{in}$ is connected to a receiver with the input terminated in a resistor $R_g$. The induced voltage in the antenna is $V_{rms}$. Derive an expression of the maximum power transferred from the antenna to its receiver in terms of $V_{rms}$.

( 5 marks )

## QUESTION 3

(a) A 5 - GHz microwave downlink communication is established between a satellite and an earth station.
If the minimum detectable receiver power, $P_r$ = - 70.0 dBm, the transmitter power $P_t$ = 50 dBm and the antenna diameter d = 2.0 m, compute

(i) the maximum possible spacing between the two repeater towers ( 10 marks )

(ii) If the receiver noise temperature is 200 °K, compute the signal - to - noise ratio at the receiver output assuming a bandwidth of 10 MHz, and maximum spacing between the transmitter and receiver. ( 12 marks )

(b) Define radiation resistance and explain its practical significance as a property of antennae. ( 3 marks )

## QUESTION 4

(a) The midband of TV channel 15 is 479 MHz. Design a narrowband 5 element Yagi antenna for reception of the station broadcast.
( 18 marks )

(b) In long distance communication, the signal strength is subject to fading. A well-designed receiver automatic volume control circuit will have very good effects on a severely fading signal but may not completely eliminate the problem.
Discuss a reception method which may have a remarkable effect towards the problem of fading. ( 4 marks )

(c) Can the two terms: optical horizon and radio horizon be used interchangeably? Explain. ( 3 marks )

## QUESTION 5

(a) You are required to design a parabolic reflector which will give a good reception to a live TV broadcast of the national football match. The specifications are :

| | |
|---|---|
| antenna gain | 32 dB |
| $^{F}/_{D}$ ratio | 0.8 |
| operating frequency | 3 GHz |

Compute:

(i) the diameter, ( 5 marks )

(ii) the required depth of the dish and ( 3 marks )

(iii) the 3-dB beam width angle. ( 3 marks )

(b) A research Satellite operating at a frequency of 136 MHz, is at a range of 500 km from a receiving earth station. The satellite transmitter supplies 0.75 W into a 3 dB aerial with reference to an isotrope. For free space propagation with an impedance of 120 $\pi$, compute

(i) the field strength at the earth station ( 4 marks )

(ii) If the receiving antenna has an effective length of 1.5 m and a radiation resistance of 50 $\Omega$, determine the voltage induced in the antenna. ( 3 marks )

(c) Consider a 10 GHz - target- tracking radar which uses a common 2.0 m diameter dish antenna, 100 km from the target. The efficiency of the antenna is 0.7 for both transmission and reception. The average power re-radiated by the target is 1 W. Determine the power received in dBm.

( 7 marks )