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University of the Witwatersrand, Johannesburg

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| Course or topic No(s) | ELEN4001 |
| Course or topic name(s)<br>Paper Number & title | High Frequency Techniques |
| Examination/Test* to be held during month(s) of<br>(*delete as applicable) | June 2013 |
| Year of Study<br>(Art & Sciences leave blank) | Fourth |
| Degrees/Diplomas for which this course is prescribed<br>(BSc (Eng) should indicate which branch) | BSc (Eng) Elec |
| Faculty/ies presenting candidates | Engineering |
| Internal examiners and telephone number(s) | Professor A.R Clark x77223 |
| External examiner(s) | Mr. T. Reuss |
| Special materials required<br>(graph/music/drawing paper)<br>maps, diagrams, tables,<br>computer cards, etc) | None |

Time allowance

| Course Nos | ELEN4001 | Hours | Two |
|---|---|---|---|

Instructions to candidates
(Examiners may wish to use this space to indicate, inter alia, the contribution made by this examination or test towards the year mark, if appropriate)

Answer all Questions
60 marks available
50 marks = 100%

Dictionary and Textbook permitted. ONE A4 folder of information permitted.

Internal Examiners or Heads of Department are requested to sign the declaration overleaf

1. As the Internal Examiner/Head of Department, I certify that this question paper is in final form, as approved by the External Examiner, and is ready for reproduction.

2. As the Internal Examiner/Head of Department, I certify that this question paper is in final form and is ready for reproduction.

(1. is applicable to formal examinations as approved by an external examiner, while 2. is applicable to formal tests not requiring approval by an external examiner—Delete whichever is not applicable)

Name:_____ Signature:_____

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Note: Show $ALL$ workings, complete with the necessary comments!!—regardless of how fast your calculator can print the results in one step. I am not interested in how well you can read your formulæ from your A4 folder. I am marking your reasoning, not only the answer!! Marks are awarded for the reasoning as well as the "answer". A correct numerical answer will not necessarily attract any marks!

## Question 1

(a) Why does a monopole not achieve 5 dBi at grazing angles, as predicted? (3 marks)

(b) Explain HOW a $\lambda/2$ balun works. (3 marks)

(c) A track on a Printed Circuit Board (PCB) is 150 mm long, and operates at 2.5 GHz, and is correctly terminated in its characteristic impedance ($Z_0$). The PCB is 2 mm thick, and the track is above a ground plane layer. Comment on its Electromagnetic Compatibility properties, and possible solutions. (3 marks)

(d) Your spacecraft employs an Axial-mode Helical antenna, producing Right-Hand Circular Polarization at a Gain of 20 dBi. Your link-budget calculations, however, show that you need 23 dBi. What are your options? (3 marks)

(e) You are given an antenna operating at 3 GHz. It is a flat rectangular aperture of 1m high and 0.5 m wide. The antenna aperture consists of numerous vertical slot antennas in a grid array. You are told that the antennas are fed in-phase, with uniform intensity. Estimate the antenna beam widths in elevation and azimuth. Estimate the antenna directivity using two different methods. (6 marks)

(f) A 2 m monopole is resonated at its base using a 10 turn inductor. The frequency of operation is 2 MHz, and at this frequency, the monopole without the inductor has a capacitive reactance of $-j3000\,\Omega$. Calculate the efficiency and bandwidth of the antenna if the coil quality factor is 30 and 300 respectively. (6 marks)

(g) An isotropic source is located at height $h$ above a perfect ground plane. Derive an expression for the take-off angle $\theta$ (angle between the horizon and the first pattern peak) as a function of $h$ and wavelength, $\lambda$. (6 marks)

[Total Marks 30]

## Question 2

A mobile communication system operates at 400 MHz, and the digital modulation scheme employed requires an antenna bandwidth of 10 MHz. Assuming that a 20 dBm transmit power is used, the base station antenna has a gain of 10 dBi, and the mobiles have a 3 dBi gain. Receivers with a noise temperature of 300 Kelvin are used which require a 10 dB Signal to Noise Ratio. Estimate the maximum free-space range of the system.

(10 marks)

## Question 3

A C-band geostationary satellite operating at 6 GHz, transmits a television signal to earth, requiring 5 MHz bandwidth for a channel, and uses a 100 W transmitter feeding a 2 m diameter parabolic dish antenna.

The geostationary orbit (Clarke orbit) is at 36 000 km.

An earth-based receiver, operating at a system temperature of 580 K, requires a 40 dB signal-to-noise ratio for high quality reception.

What diameter parabolic dish is required? State all assumptions. (10 marks)

## Question 4

A 12 GHz parabolic dish with a diameter of 1 m is used with a horn antenna at a distance of 1 m away from the rim of the dish. Estimate the gain of the horn antenna itself and the gain of the dish with the horn. State all assumptions, and possible causes of error in your estimates. (10 marks)

(Exam Total 60 marks)

(Full Marks 50 marks)