GX547

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

SPRING EXAMINATIONS, 1999

THIRD YEAR ELECTRONIC ENGINEERING

E.M. THEORY & APPLICATIONS II

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Duration of Examination: *Two* Hours

Instructions: Answer *all* questions in Section A
and *three* questions in Section B

Section A

(Attempt **all questions** in this section - 25 marks)

A1. For a transmission line to be completely loss-free it holds that:

a) R = 0 or L = 0
b) R = 0 and C = 0
c) R = 0 or G = 0
d) R = 0 and G = 0
e) R = 0 and L = 0 and G = 0
f) none of the above

A2. The requirements for a distortion-free line are:

a) LG = CR
b) LC = GR
c) LR = CG
d) RL = GC
e) CL = RG
f) none of the above

A3. Which of the following types of EM wave occur in rectangular waveguides?

a) TM and TE
b) TM only
c) TE only
d) TEM only
e) all of the above
f) none of the above

A4. Which of the following type of EM wave occur in cylindrical waveguides?

a) TM and TE
b) TM only
c) TE only
d) TEM only
e) all of the above
f) none of the above

A5. High quality optic fibres are made from:

a) crystaline quartz
b) galium arsenide
c) diamond microfibres
d) oxides of silicon
e) optically clarified nylon
f) none of the above

A6. Electro-Magnetic Interference can be caused by:

a) relay contacts
b) car engines
c) lightning
d) consumer electronics
e) all of the above
f) none of the above

A7. The group velocity in a waveguide is given as:

a) $\upsilon_g = \lambda_0 c/\lambda_g$
b) $\upsilon_g = \lambda_0/\lambda_g c$
c) $\upsilon_g = \lambda_g c/\lambda_0$
d) $\upsilon_g = \lambda g/\lambda_0 c$
e) $\upsilon_g = \lambda_0\lambda_g/c$
f) none of the above

A8. The velocity of propagation in a transmission line can be written in terms of the phase change coefficient, β, as:

a) $\upsilon_p = \omega/\beta$
b) $\upsilon_p = \omega/2\pi\beta$
c) $\upsilon_p = \beta/\alpha$
d) $\upsilon_p = 2\pi\beta/\alpha$
e) $\upsilon_p = 2\pi\beta\alpha$
f) none of the above

A9. The phase change coefficient for the n,m mode in a rectangular waveguide is given as:

a) $$\beta_{nm} = \left[k_0^2 - \left(\frac{n}{\pi a}\right)^2 - \left(\frac{m}{\pi b}\right)^2 \right]^{\frac{1}{2}}$$

b) $$\beta_{nm} = \left[k_0^2 - \left(\frac{n\pi}{a}\right)^2 - \left(\frac{m\pi}{b}\right)^2 \right]$$

c) $$\beta_{nm} = \left[k_0^2 - \left(\frac{n\pi}{a}\right)^2 - \left(\frac{m\pi}{b}\right)^2 \right]^{2}$$

d) $$\beta_{nm} = \left[k_0^2 - \left(\frac{n\pi}{a}\right)^{1/2} - \left(\frac{m\pi}{b}\right)^{1/2} \right]^{2}$$

e) $$\beta_{nm} = \left[k_0^2 - \left(\frac{n\pi}{a}\right)^2 - \left(\frac{m\pi}{b}\right)^2 \right]^{\frac{1}{2}}$$

f) none of the above

A10. The best waveform to minimize high- order frequency harmonics in an electronic system is:

a) a square wave
b) a triangular wave
c) a pulse train
d) a sine wave
e) a step function
f) none of the above

A11. Printed circuit board (PCB) tracks of > 10cm behave like a:

a) cavity resonator
b) transmission line
c) optic fibre cladding
d) negative impedance convertor
e) analog-to-digital converter
f) none of the above

A12. The equivalent operating frequency of optic fibres is:

a) 10 - 100 GHz
b) 100 - 1000 GHz
c) 1 - 10THz
d) 10 - 100 THz
e) 100 - 1000 THz
f) none of the above

Section B

(Attempt **3 questions**in this section - 75 marks)

1. **(a)** Discuss briefly the circuit theory model of a transmission line and obtain general hyperbolic solutions for the voltage and current along such a line.

[10 marks]

(b) Derive an expression for the sending-end impedance, Z_S, of such a line in terms of the characteristic impedance, Z_O, the receiving-end impedance, Z_R, the propagation constant, γ, and the line length, L..

[8 marks]

(b) Describe how the values of γ and Z_O can be determined if equipment is available to measure the imput impedance of a line.

[6 marks]

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2. **(a)** Explain how a TE wave can propagate in a waveguide. Derive modified forms of Maxwell's equations, in terms of field components parallell and perpendicular to the main axis of the waveguide.

[8 marks]

(b) Outline the main steps in the analysis of the propagation of a TE wave in a guide. In the TE_{10} mode of propagation, given that:

$$H_Z = A_0 Cos\frac{\pi x}{a}$$

then derive expression for the

(i) cut-off wavelength
(ii) phase velocity in the guide
(iii) group velocity

[12 marks]

(c) Sketch diagrams to illustrate the the electric and magnetic field distributions in the guide for this lowest order TE mode. Pay particular attention to the orientation of the fields so that they obey the RH rule and that the direction of the Poynting vector is uniform along the guide.

[4 marks]

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3. **(a)** Sketch the standing wave patterns of RMS voltage and current for both the open and short-circuit cases of a transmission line which is two wavelengths long.

[4 marks]

(b) What is meant by the reflection coefficient and the voltage-standing-wave-ratio (VSWR) of a transmission line? Derive expressions for both of these quantities in terms of the characteristic impedance, Z_O, and the receiving end impedance, Z_R.

[8 marks]

(c) If reflection occurs at both receiving and sending ends of a transmission line, develop an expression for the total voltage at some arbitrary point along the line. Show that this expression is of the form:

$$V(x) = A_0 \exp(-\gamma x) + B_0 \exp(+\gamma x)$$

[12 marks]

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4. **(a)** Describe the principle sources of Electro-Magnetic Interference (EMI) in a large industrial complex.

[8 marks]

(b) What frequency bands does EMI span? Describe their characteristics and give some examples of typical source mechanisms in each frequency band.

[8 marks]

(c) EMI can cause major problems at both the board and systems levels in Electronic Systems. Describe some of the measures which can help avoid problems at the design stage.

[8 marks]

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5. **(a)** What are the basic elements of a fibre optic data transmission system? What is the main limitation on the rate of data transmission in such a system?

[8 marks]

(b) Describe the principle mechanisms of attenuation and distortion in an optic fibre.

[8 marks]

(c) What are the two main light sources used in optic fibre systems? Describe their physical behaviour and characteristics. .

[8 marks]
