16

SULIT

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN ELEKTRIK

PEPERIKSAAN AKHIR

SESI DISEMBER 2016

DEP5303: MICROWAVE DEVICES

TARIKH : 10 APRIL 2017
MASA : 2.30 PM – 4.30 PM (2 JAM)

Kertas ini mengandungi **SEMBILAN (9)** halaman bercetak.
Bahagian A: Struktur (4 soalan)
Bahagian B: Esei (2 soalan)
Dokumen sokongan yang disertakan : Smith Chart dan Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

16

SECTION A: 60 MARKS

BAHAGIAN A: 60 MARKAH

INSTRUCTION:

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

ARAHAN:

Bahagian ini mengandungi ***EMPAT (4)*** *soalan berstruktur. Jawab semua soalan.*

QUESTION 1

SOALAN 1

CLO1 C1 (a) Describe Transverse Electromagnetic (TEM), then draw a suitable diagram.

Terangkan elektromagnetik melintang (TEM), kemudian lukis gambarajah yang bersesuaian.

[3 marks]
[*3 markah*]

CLO1 C2 (b) Discuss **THREE (3)** types of electromagnetic radiation hazard.

Bincangkan ***TIGA (3)*** *jenis bahaya radiasi gelombang elektromagnetik.*

[6 marks]
[*6 markah*]

CLO1 C2 (c) Explain **THREE (3)** reasons why a microwave is very important in communication technology.

Terangkan ***TIGA (3)*** *sebab mengapa gelombang mikro sangat penting dalam teknologi komunikasi.*

[6 marks]
[*6 markah*]

QUESTION 2

SOALAN 2

CLO1 C2

(a) Differentiate the shape of a rectangular waveguide from a circular waveguide.

Berikan perbezaan bentuk di antara pandu gelombang segiempat tepat dan pandu gelombang bulat.

[3 marks]
[*3 markah*]

CLO1 C3

(b) A rectangular waveguide of cross section 5 cm x 2 cm is used to propagate TM_{11} mode at 10 GHz. Calculate the cut-off wavelength and the characteristic impedance.

Sebuah pandu gelombang segi empat dengan dimensi 5 cm x 2 cm digunakan untuk merambat gelombang TM_{11} pada frekuensi 10 GHz. Kirakan panjang gelombang potong, λc dan Galangan ciri, Zo.

[6 marks]
[*6 markah*]

CLO1 C3

(c) A rectangular waveguide has the cut-off wavelength of 10 cm for the TE_{10} mode and cut-off wavelength of 4 cm for the TE_{21} mode. Calculate the dimension of the guide.

Sebuah pandu gelombang segiempat mempunyai panjang gelombang potong 10 cm bagi mode TE_{10} dan panjamg gelombang potong 4 cm bagi mode TE_{21}. Kirakan dimensi pandu gelombang tersebut.

[6 marks]
[*6 markah*]

QUESTION 3

SOALAN 3

CLO1
C2

(a) Determine the characteristic impedance, Z_0 for a coaxial cable with the following specifications:

d= 0.25 cm, D=0.15 cm, and ϵ_r=2.23.

Tentukan galangan keluaran, Z_0 bagi kabel sepaksi berdasarkan spesifikasi berikut:

d=0.25 cm, D=0.15 cm, and ϵ_r=2.23.

[3 marks]
[3markah]

CLO1
C3

(b) A transmission line is connected to a mismatched load. Calculate both the VSWR and VSWR decibel equivalent if the reflection coefficient, Γ is 0.25.

Suatu kabel penghantaran bersambung dengan beban tidak seimbang. Kirakan bagi kedua-dua VSWR dan $VSWR_{dB}$ jika pekali pantulan, Γ ialah 0.25.

[6 marks]
[6 markah]

CLO1
C3

(c) A coaxial transmission line with a characteristic impedance of 50 Ω is connected to the 50 Ω output (Z_0) of a signal generator, and also to a 20 W load impedance Z_L. Calculate the mismatch loss.

Satu kabel sepaksi yang mempunyai galangan dalaman 50 Ω, disambungkan dengan satu galangan keluaran, Z_0=50 Ω dari penjana isyarat dan satu galangan beban, Z_L=20 W. Kirakan "mismatch loss".

[6 marks]
[6 markah]

QUESTION 4

SOALAN 4

CLO1
C1

(a) Draw a diagram for each of the following waveguide components:

i. Shunt –T

ii. H–bend

iii. Coupler

Lukiskan bentuk bagi komponen-komponen pandu gelombang berikut:

i. T-Selari

ii. Selekoh –H

iii. Pengganding V

[3 marks]
[*3 markah*]

CLO1
C2

(b) Microwave device such as a microwave oven and radar will produce microwave radiation called magnetron. Describe the operation principle of magnetron.

Peralatan gelombang mikro seperti ketuhar gelombang mikro dan radar akan menghasilkan radiasi gelombang mikro yg dikenali sebagai magnetron. Terangkan prinsip kendalian magnetron.

[5 marks]
[*5 markah*]

CLO1 C3

(c) For a transmit antenna with radiation resistance R_r=*72* Ω, and effective antenna resistance, R_e=*8* Ω, a directive gain, *D*=20 and the input power P_{in}=*100 W.* Calculate:

i. Antenna efficiency
ii. Antenna gain in dB
iii. Radiated power in watt, dBm and dBW
iv. EIRP in watts, dBm, and dBW.

Satu antenna dengan galangan sinaran R_r=72 Ω, kerintangan berkesan bagi antenna R_e=8 Ω, gandaan D=20 dan kuasa masukan Pin=100 W. Kirakan:

i. Kecekapan antenna
ii. Gandaan bagi antenna dalam dB
iii. Pancaran kuasa dalam watt, dBm dan dBW
iv. EIRP dalam watts, dBm, and dBW.

[7 marks]
[*7 markah*]

SECTION B: 40 MARKS
BAHAGIAN B: 40 MARKAH

INSTRUCTION:

This section consists of **TWO (2)** essay questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **DUA (2)** soalan esei. Jawab **SEMUA** soalan.*

CLO1
C3

QUESTION 1

(a) A rectangular air-filled copper waveguide with a dimension (3.1 x 2.0) cm is operated at 9.5 GHz with a dominant mode. Calculate:

i. Cut-off frequency, fc
ii. Guide wavelength, λg
iii. Phase velocity, Vp
iv. Characteristic impedance, Zo (TE)
v. Velocity inside waveguide, Vg

Sebuah pandu gelombang segiempat berisi udara dengan dimensi (3.1 x 0.4) cm berkendali pada frekuensi 9.5 GHz di dalam mod dominan. Kirakan:

i. Frekuensi potong, fc
ii. Panjang gelombang pandu, λg
iii. Halaju fasa, Vp
iv. Galangan ciri, Zo (TE)
v. Halaju dalam pandu gelombang, Vg

[10 marks]
[*10 markah*]

CLO1
C3

(b) TE_{11} mode is propagated through a circular waveguide. The radius of the guide is 5 cm and the guide contains air. Calculate:

i. Cut-off frequency

ii. Wavelength in the guide for operating frequency 3 GHz

iii. Wave impedance Z_o in the waveguide

Mode TE_{11} merambat melalui pandu gelombang bulat. Jejari bagi pandu gelombang adalah 5 cm dan ia berisi udara. Kirakan:

i. Frekuensi potong

ii. Panjang gelombang di dalam pandu gelombang ketika frekuensi

iii. Operasi adalah 3 GHz

iv. Gelombang ciri Z_o di dalam pandu gelombang

[10 marks]
[10 markah]

QUESTION 2

SOALAN 2

CLO2
C4

A 50 Ω transmission line of 6 m length is terminated by a load Z_L of 100 + j100 Ω. The line will be matched by adding a short-circuited single stub as shown in Figure B2. Assume that the stub line has the same characteristic impedance as the main line. With the aid of a Smith chart, determine the actual length of d and l if the operating frequency of the line is 2 GHz.

Satu talian penghantaran 50 Ω yang mempunyai panjang 6 m ditamatkan pada beban Z_L = 100 + j100 Ω. Talian tersebut akan disepadankan dengan menambah satu puntung litar pintas seperti ditunjukkan dalam Rajah B2. Dengan bantuan carta Smith, tentukan panjang sebenar d dan l jika talian tersebut beroperasi pada frekuensi 2 GHz.

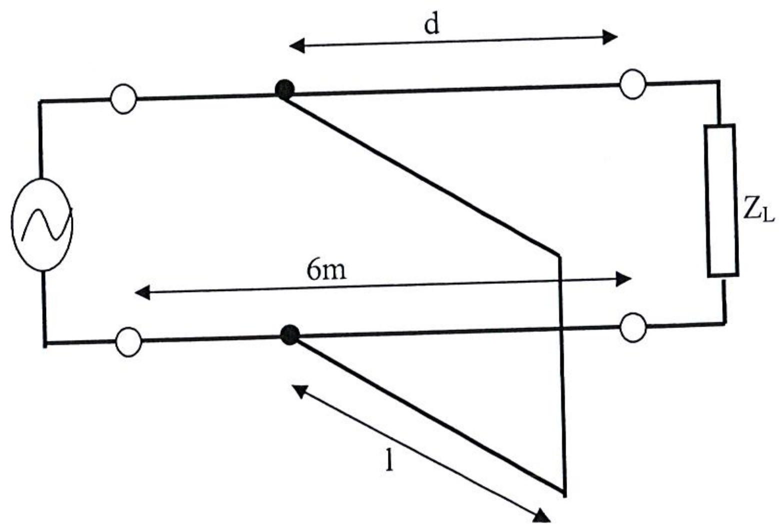

Figure B2 / *Rajah B2*

[20 marks]
[*20 markah*]

SOALAN TAMAT

FORMULA

$$c = \lambda f = \left(3\times10^{8}\right) ms^{-1}$$

Rectangular waveguide	Circular waveguide
Cut-off wavelength $\lambda_c = \dfrac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$	Cut-off wavelength (TE_{mn}) $\lambda_c = \dfrac{2\pi r}{\chi'_{mn}}$ Cut-off wavelength (TM_{mn}) $\lambda_c = \dfrac{2\pi r}{\chi_{mn}}$
Cut-off frequency $f_c = \dfrac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$ $f_c = \dfrac{1}{2\sqrt{\mu\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$ $\mu_0 = 4\pi \times 10^{-7}$ H/m $\varepsilon_0 = 8.854 \times 10^{-12}$ F/m	Cut-off frequency (TE_{mn}) $f_c = \dfrac{c\chi'}{2\pi r}$ Cut-off frequency (TM_{mn}) $f_c = \dfrac{c\chi}{2\pi r}$

Value of X'_{mn}

	$m=0$	$m=1$	$m=2$	$M=3$	$m=4$	$m=5$	$m=6$
$n=1$	3.8318	1.8412	3.0542	4.2012	5.3175	6.4155	7.5013
$n=2$	7.0156	5.3315	6.7062	8.0153	9.2824	10.5199	11.7349
$n=3$	10.1735	8.5363	9.9695	11.3459	12.6819	13.9872	15.2682
$n=4$	13.3237	11.7060	13.1704	14.5859	15.9641	17.3129	18.6375
$n=5$	16.4706	14.8636	16.3475	17.7888	19.1960	20.5755	21.9317

Value of X_{mn}

	$m=0$	$m=1$	$m=2$	$M=3$	$m=4$	$m=5$	$m=6$
$n=1$	2.4049	3.8318	5.1357	6.3802	7.5884	8.7715	9.9361
$n=2$	5.5201	7.1056	8.4173	9.7610	11.0647	12.3386	13.5893
$n=3$	8.6537	10.1735	11.6199	13.0152	14.3726	15.7002	17.0038
$n=4$	11.7915	13.3237	14.7960	16.2235	17.6160	18.9801	20.3208
$n=5$	14.9309	16.4706	17.9598	19.4094	20.8269	22.2178	23.5861

$$\lambda_{guide} = \lambda_{pandu} = \frac{\lambda_o}{\sqrt{\left[1-\left(\frac{\lambda_o}{\lambda_c}\right)^2\right]}} \text{ meter} \quad \text{or} \quad \lambda_{guide} = \lambda_{pandu} = \frac{\lambda_o}{\sqrt{\left[1-\left(\frac{f_c}{f_0}\right)^2\right]}} \text{ meter}$$

$$v_{group} = v_{kumpulan} = c\sqrt{\left[1-\left(\frac{\lambda_o}{\lambda_c}\right)^2\right]}\, ms^{-1} \quad \text{or} \quad v_{group} = v_{kumpulan} = c\sqrt{\left[1-\left(\frac{f_c}{f_o}\right)^2\right]}\, ms^{-1}$$

$Z_{o(TE)} = \frac{377}{\sqrt{\left(1-\left(\frac{\lambda_o}{\lambda_c}\right)^2\right)}}$ or $Z_{o(TE)} = \frac{377}{\sqrt{\left(1-\left(\frac{f_c}{f_o}\right)^2\right)}}$	
$Z_{o(TM)} = 377 \times \sqrt{\left(1-\left(\frac{\lambda_o}{\lambda_c}\right)^2\right)}$ or $Z_{o(TM)} = 377 \times \sqrt{\left(1-\left(\frac{f_c}{f_o}\right)^2\right)}$	
$Z_{IN} = j\, Z_{TEmn} \tan(\beta l)$; $Z_{IN} = j\, Z_{TMmn} \tan(\beta l)$; $\beta = \frac{2\pi f_o}{c}\sqrt{\left(1-\left(\frac{f_c}{f_o}\right)^2\right)}$	
Transmission Lines Equation	
$Reflection\ Coefficient, \Gamma = \left(\frac{Z_O - Z_L}{Z_L + Z_L}\right)$	$VSWR = \left(\frac{1+\lvert\Gamma\rvert}{1-\lvert\Gamma\rvert}\right)$
Antenna	
$front\ to\ back\ ratio = \frac{front\ lobe\ power}{back\ lobe\ power}$	$front\ to\ side\ ratio = \frac{front\ lobe\ power}{side\ lobe\ power}$
(Parabolic Antenna) $Beam\ Width, \alpha = \frac{70\lambda}{D}$	Horn Antenna, $Beam\ Width, \alpha = \frac{80\lambda}{W}$
$P_T = \eta\left(\frac{\pi D}{\lambda}\right)^2$	$P_T = (P_R G)$
$G(dB) = 10\ log\frac{4\pi kA}{\lambda^2}$	$Attenuation\ (dB) = \frac{54z}{\lambda c}$

The Complete Smith Chart

Black Magic Design