SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN ELEKTRIK

PEPERIKSAAN AKHIR

SESI I : 2024 / 2025

DEP50043 : MICROWAVE DEVICES

TARIKH : 07 DISEMBER 2024
MASA : 8.30 PAGI - 10.30 PAGI (2 JAM)

Kertas ini mengandungi **TUJUH (7)** halaman bercetak.

Bahagian A : Subjektif (3 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)

SECTION A : 60 MARKS

BAHAGIAN A : 60 MARKAH

INSTRUCTION:

This section consists of **THREE (3)** subjective questions.

ARAHAN :

*Bahagian ini mengandungi **TIGA (3)** soalan subjektif. Jawab semua soalan.*

QUESTION 1

SOALAN 1

CLO1 (a) In Radio Frequency and microwave circuits, electromagnetic waves propagate in different modes, namely transverse electromagnetic (TEM) mode, transverse electric (TE) mode, and transverse magnetic (TM) mode. By using the vector diagram, explain transverse electric (TE) mode in the signal propagation.

Dalam litar frekuensi radio dan gelombang mikro, gelombang elektromagnetik merambat dalam mod yang berbeza, iaitu mod Gelombang Elektromagnet Melintang (TEM), mod Elektrik Melintang (TE) dan mod Magnetik Melintang (TM). Dengan menggunakan gambarajah vektor, terangkan mod Elektrik Melintang (TE) dalam perambatan isyarat.

[6 marks]

[*6 markah*]

CLO1 (b) A typical military radar consists of microwave components that are connected by special connectors. A very high-power signal is produced by Magnetron oscillator and is transmitted by a horizontal polarized antenna. Based on Figure A1, explain the function of directional coupler, E-plane corner, rotary joint and twist in this radar system.

Radar tentera terdiri daripada komponen-komponen gelombang mikro yang disambungkan oleh penyambung khas. Isyarat berkuasa tinggi dihasilkan oleh pengayun Magnetron dan dipancarkan keluar oleh antena berpengutupan mendatar. Berpandukan Rajah A1, tuliskan fungsi penjodoh berarah, Selekoh satah-E, penyambung berputar dan pemulas dalam sistem radar ini.

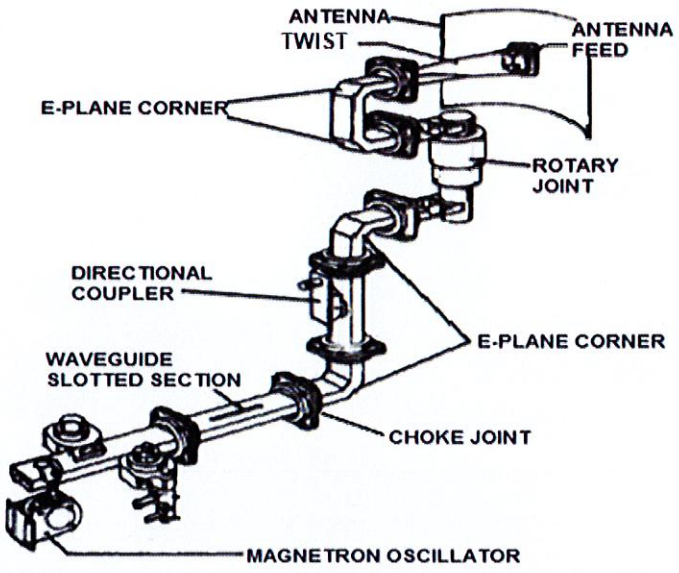


Figure A1/Rajah A1

[7 marks]

[7 *markah*]

CLO1 (c) In line with fast-growing technologies, vacuum tubes used in the microwave sources have been replaced with semiconductor devices. Compare the differences between Magnetron and Gunn diode in terms of features, power and efficiency.

Seiring dengan perkembangan teknologi yang pesat, tiub vakum yang digunakan dalam sumber gelombang mikro telah digantikan dengan peranti semikonduktor. Bandingkan perbezaan di antara Magnetron dan Gunn diod dari segi keistimewaan, kuasa dan kecekapan.

[7 marks]

[7 *markah*]

QUESTION 2

SOALAN 2

CLO1 (a) Explain phase velocity and group velocity of electromagnetic wave that propagates inside the waveguide.

Terangkan halaju fasa dan halaju kumpulan bagi gelombang electromagnetik yang merambat dalam pandu gelombang.

[4 marks]

[4 *markah*]

CLO1 (b) A rectangular waveguide with a dimension of 4 cm × 2 cm has $\mu_r = 1$ and $\varepsilon_r = 9$ is used to propagate a 9 GHz signal in TM_{11} mode. Calculate cutoff frequency and cutoff wavelength of the signal. Show whether the signal can propagate inside the waveguide based on the rule of propagation.

Satu pandu gelombang yang berisi udara dengan dimensi 4cm × 2cm mempunyai $\mu_r = 1$ dan $\varepsilon_r = 9$ digunakan untuk merambat isyarat pada 9 GHz dalam mod TM_{11}. Kirakan frekuensi potongan dan panjang gelombang potong bagi isyarat tersebut. Tunjukkan sama ada isyarat tersebut dapat merambat dalam pandu gelombang berpandukan peraturan perambatan.

[8 marks]

[8 *markah*]

CLO1 (c) A lossless transmission line of 75 Ω has $V_{max} = 7.5$ V and $V_{min} = 2.5$ V when terminated by an unknown pure resistive load. Calculate the voltage standing wave ratio (VSWR), reflection coefficient (Γ) and load impedance (Z_L).

Talian penghantaran tanpa kehilangan 75 Ω mempunyai $V_{maks} = 7.5$ V and $V_{min} = 2.5$ V, apabila ditamatkan oleh beban rintangan tulen yang tidak diketahui nilainya. Kirakan nisbah voltan gelombang pegun (VSWR), pekali pantulan (Γ) dan galangan beban (Z_L).

[8 marks]

[8 *markah*]

QUESTION 3

SOALAN 3

CLO1 (a) By using a suitable diagram, explain the construction structure of a microstrip antenna used in microwave communication system.

Dengan menggunakan gambarajah yang sesuai, terangkan struktur binaan bagi antena mikrostrip yang digunakan dalam sistem gelombang mikro.

[4 marks]

[4 *markah*]

CLO1 (b) A parabolic antenna with a gain of 40 dB and diameter of 4.5 m is used to transmit 4 GHz microwave signal. Calculate the wavelength of the signal, beamwidth and antenna efficiency for the system.

Antena parabolik dengan nilai gandaan 40 dB dan diameter 4.5 m digunakan untuk menghantar isyarat gelombang mikro berfrekuensi 4 GHz. Kirakan panjang gelombang isyarat, sudut lebaralur dan kecekapan antena bagi sistem tersebut.

[8 marks]

[8 *markah*]

CLO1 (c) A horn antenna with the dimension of w = 35 cm and h = 20 cm operates at 8 GHz. If the aperture efficiency is 0.648, calculate beamwidth angle, antenna gain and antenna gain in decibel.

Sebuah antena penerima horn di penerima mempunyai dimensi, w = 35 cm dan h = 20 cm beroperasi pada 8 GHz. Jika kecekapan apetur ialah 0.648, kirakan sudut lebaralur, gandaan antena dan gandaan antena dalam desibel.

[8 marks]

[8 *markah*]

SECTION B : 40 MARKS

BAHAGIAN B : 40 MARKAH

INSTRUCTION:

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

ARAHAN:

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

QUESTION 1

CLO1

SOALAN 1

A 6 GHz signal propagates inside a rectangular waveguide with internal dimensions of 5.2 cm × 2.8 cm. The waveguide is filled with dielectric material with relative permeability 1.0 and the cutoff frequency for the guide is 1.9 GHz. Calculate the relative permittivity of the dielectric material, phase velocity, group velocity, guide wavelength and characteristic impedance in dominant transverse electric mode.

Satu isyarat 6 GHz merambat dalam satu pandu gelombang yang mempunyai ukuran dalaman 5.2 cm × 2.8 cm. Pandu gelombang tersebut diisi dengan bahan dielektrik yang mempunyai ketelapan relatif 1.0 dan frekuensi potong ialah 1.9 GHz. Kirakan kebolehterapan relatif bahan dielektrik, halaju fasa, halaju kumpulan, panjang gelombang pandu dan galangan ciri dalam mod elektrik melintang dominan.

[20 marks]

[*20 markah*]

CLO1

QUESTION 2

SOALAN 2

An engineer is assigned by the company to setup a microwave transmission line. The input impedance of the transmission line is (120 – j60) Ω and the length of the transmission line is 0.2λ with characteristic impedance of 50 Ω. By using the Smith Chart, determine the load impedance, voltage standing wave ratio, reflection coefficient with angle and the distance from the load to the first maximum voltage for the transmission line.

Seorang jurutera dilantik oleh syarikat untuk membina satu talian penghantaran gelombang mikro. Galangan masukan talian penghantaran tersebut ialah (120 – j60) Ω dan panjang talian penghantaran tersebut ialah 0.2λ dengan galangan ciri 50 Ω. Dengan menggunakan Carta Smith, tentukan galangan beban, nisbah voltan gelombang pegun, pekali pantulan dengan sudut dan jarak dari beban ke voltan maksimum pertama bagi talian penghantaran tersebut.

[20 marks]

[*20 markah*]

SOALAN TAMAT

APPENDIX: FORMULA TABLE

$c = f\lambda = 3 \times 10^8$ m/s or $c = \frac{1}{\sqrt{\mu_o \varepsilon_o}}$ m/s

$\varepsilon_o = 8.85 \times 10^{-12}$ F/m

$\mu_o = 4\pi \times 10^{-7}$ H/m

$\mu = \mu_o \mu_r$

$\varepsilon = \varepsilon_o \varepsilon_r$

$v_c = \frac{c}{\sqrt{\varepsilon_r \mu_r}}$

$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$ or

$f_{c\,mn} = \frac{1}{2\sqrt{\mu\,\varepsilon}}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$

$\lambda_{c\,mn} = \frac{2}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$ or $\lambda_{c\,mn} = \frac{2\sqrt{\varepsilon_r \mu_r}}{\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}}$

$\lambda_g = \frac{\lambda_o}{\sqrt{1-\left(\frac{f_c}{f_0}\right)^2}}$ or $\lambda_g = \frac{\lambda_o}{\sqrt{1-\left(\frac{\lambda_0}{\lambda_c}\right)^2}}$

$v_g = c\sqrt{1-\left(\frac{f_c}{f_0}\right)^2}$ or $v_g = c\sqrt{1-\left(\frac{\lambda_0}{\lambda_c}\right)^2}$

$v_p = \frac{c}{\sqrt{1-\left(\frac{f_c}{f_0}\right)^2}}$ or $v_p = \frac{c}{\sqrt{1-\left(\frac{\lambda_0}{\lambda_c}\right)^2}}$

$\eta = \sqrt{\frac{\mu}{\epsilon}}$ or $\eta = 377\sqrt{\frac{\mu_r}{\varepsilon_r}}$

$Z_{O(TE)} = \frac{\eta}{\sqrt{1-\left(\frac{f_c}{f_0}\right)^2}}$ or $Z_{O(TE)} = \frac{\eta}{\sqrt{1-\left(\frac{\lambda_0}{\lambda_C}\right)^2}}$

$Z_{O(TM)} = \eta\sqrt{1-\left(\frac{f_c}{f_0}\right)^2}$ or $Z_{O(TM)} = \eta\sqrt{1-\left(\frac{\lambda_o}{\lambda_C}\right)^2}$

$A_{dB} = 20 \log_{10} e^{-\alpha z}$ or $A_{dB} = \frac{54.5z}{\lambda_c}$

$\alpha_{d\,mn} = \frac{\alpha_d \eta}{2\sqrt{\left[1-\left(\frac{f_{c\,mn}}{f_o}\right)^2\right]}}$

$\alpha_{c\,TM\,mn} = \frac{2R_S}{b\eta\sqrt{\left[1-\left(\frac{f_{c\,mn}}{f_o}\right)^2\right]}}\left[\frac{b^3m^2+a^3n^2}{ab^2m^2+a^3n^2}\right]$

$R_S = \sqrt{\frac{\pi f_o \mu_r}{\sigma_c}}$ and $\delta = \frac{1}{\sqrt{\pi f_o u_r \sigma_c}}$

$\alpha_{c\,TE\,mn} = \frac{2R_S}{b\eta\sqrt{\left[1-\left(\frac{f_{c\,mn}}{f_o}\right)^2\right]}}\left[\frac{1}{2} + \frac{b}{a}\left(\frac{f_{c\,mn}}{f_o}\right)^2\right]$

$\alpha_{c\,TE\,mn} = \frac{2R_S}{b\eta\sqrt{\left[1-\left(\frac{f_{c\,mn}}{f_o}\right)^2\right]}}\left\{\left[1+\frac{b}{a}\right]\left(\frac{f_{c\,mn}}{f_o}\right)^2 + \frac{b^2m^2+abn^2}{b^2m^2+a^2n^2}\left[1-\left(\frac{f_{c\,mn}}{f_o}\right)^2\right]\right\}$

$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$ and $|\Gamma| = \frac{VSWR-1}{VSWR+1}$

$VSWR = \frac{V_{max}}{V_{min}}$ or $VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$

$Z_L{}' = \frac{Z_L}{Z_0}$

$\theta = \frac{80\lambda}{W}$ or $\theta = \frac{70\lambda}{d}$

$A_e = kA$

$A = \frac{\pi d^2}{4}$ or $A = \pi r^2$ or $A = W \times H$

$G = \frac{4\pi kA}{\lambda^2}$ or $G = \frac{4\pi A_e}{\lambda^2}$

$G(dB) = 10\log\frac{4\pi kA}{\lambda^2}$ or $G(dB) = 10\log\frac{4\pi A_e}{\lambda^2}$

P_T (dB) = 10 log P_T

P_R (dB) = 10 log P_R

$P_T = P_R\,G$

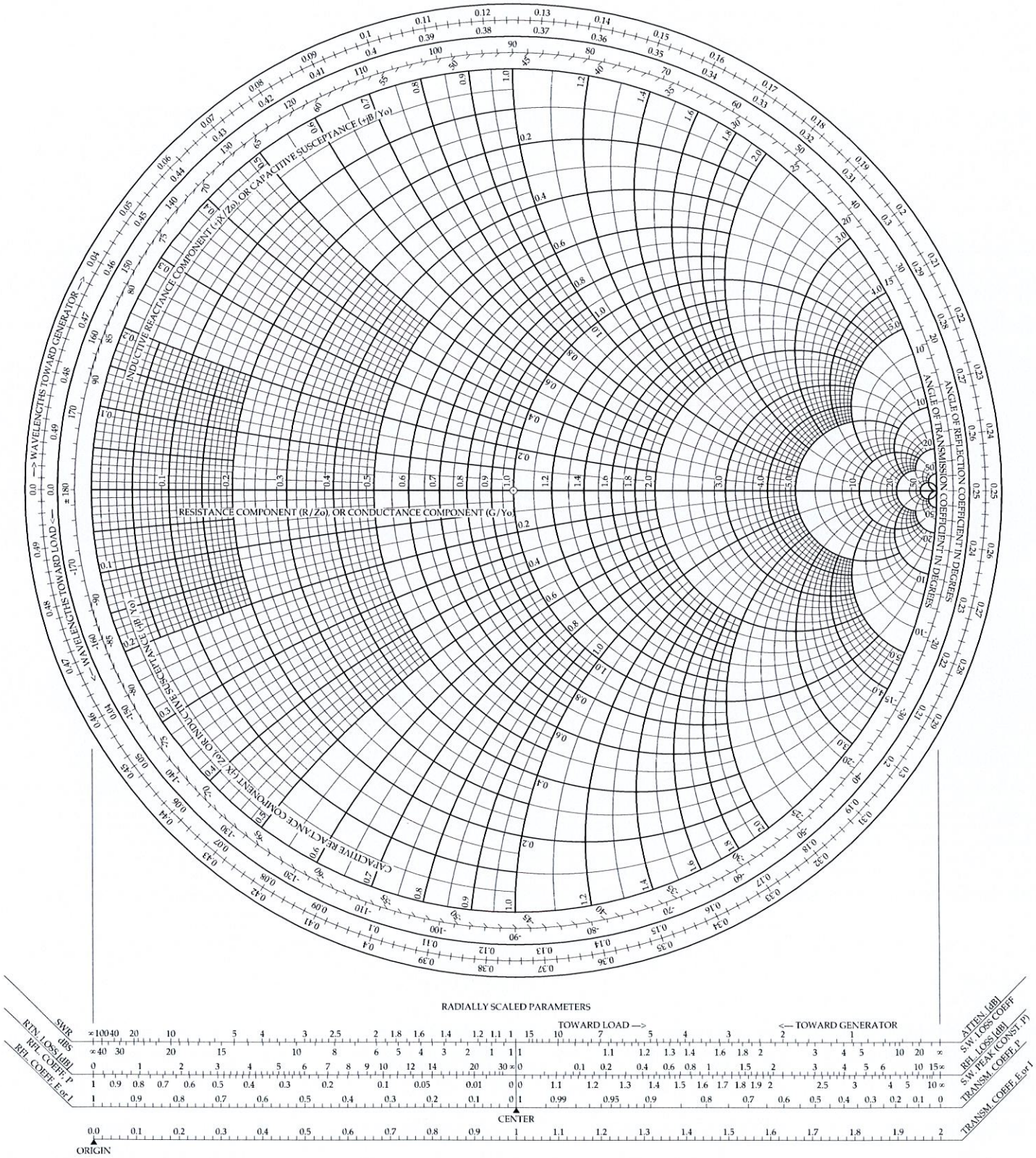
$G_P = \eta G_D$ which $G_D = \left(\frac{\pi d}{\lambda}\right)^2$

$Height, h = \frac{0.3c}{2\pi f_0\sqrt{\varepsilon_r}}$

$Width, W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r+1)}{2}}}$

$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\frac{\varepsilon_r-1}{2}}{\sqrt{1+12\frac{h}{W}}}$

Smith Chart


RESISTANCE COMPONENT (R/Zo), OR CONDUCTANCE COMPONENT (G/Yo)
INDUCTIVE REACTANCE COMPONENT (+jX/Zo), OR CAPACITIVE SUSCEPTANCE (+jB/Yo)
CAPACITIVE REACTANCE COMPONENT (-jX/Zo), OR INDUCTIVE SUSCEPTANCE (-jB/Yo)
ANGLE OF REFLECTION COEFFICIENT IN DEGREES
ANGLE OF TRANSMISSION COEFFICIENT IN DEGREES
WAVELENGTHS TOWARD GENERATOR
WAVELENGTHS TOWARD LOAD
RADIALLY SCALED PARAMETERS
TOWARD LOAD —>
<— TOWARD GENERATOR
SWR
RTN. LOSS [dB]
RFL. COEFF. P
RFL. COEFF. E or I
ATTEN. [dB]
S.W. LOSS [dB]
S.W. LOSS COEFF
S.W. PEAK (CONST. P)
TRANSM. COEFF. P
TRANSM. COEFF. E or I
CENTER
ORIGIN