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 II : 2023/2024

DEP50043: MICROWAVE DEVICES

TARIKH : 12 JUN 2024
MASA : 8.30 PAGI - 10.30 PAGI (2 JAM)

Kertas ini mengandungi **LAPAN (8)** halaman bercetak.
Bahagian A: Subjektif (3 soalan)
Bahagian B: Esei (2 soalan)

Dokumen sokongan yang disertakan : Smith Chart

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)** structured questions. Answer **ALL** questions.
ARAHAN :
*Bahagian ini mengandungi **TIGA (3)** soalan berstruktur. Jawab semua soalan*

QUESTION 1
CLO1 ***SOALAN 1***

Microwaves are a type of electromagnetic waves that have a frequency higher than that of television signals. Unlike television signals, microwaves have a very short wavelength, measuring only a few millimeters.
Gelombang mikro ialah sejenis gelombang elektromagnet yang mempunyai frekuensi lebih tinggi daripada isyarat televisyen. Melainkan seperti isyarat televisyen, gelombang mikro mempunyai panjang gelombang yang sangat pendek, ukurannya hanya beberapa milimeter.

(a) Explain the **THREE (3)** types of electromagnetic wave propagation in microwave applications.
*Terangkan **TIGA (3)** jenis perambatan gelombang elektromagnet dalam aplikasi gelombang mikro.*

[6 marks]
[6 *markah*]

(b) Explain the function of circulator, band pass filter, amplitude limiter, power amplifier and antenna in microwave propagation system.
Terangkan fungsi pengedar, penapis jalur perantaran, penghad amplitud, penguat kuasa dan antena dalam sistem perambatan gelombang mikro.

[7 marks]
[7 *markah*]

(c) Compare the differences between Reflex Klystron, TWT, and Magnetron vacuum tube sources in the context of microwave propagation.
Bandingkan perbezaan antara sumber tiub vakum Reflex Klystron, TWT dan Magnetron dalam konteks perambatan gelombang mikro.

[7 marks]
[7 *markah*]

QUESTION 2

CLO1 ***SOALAN 2***

Waveguides are utilized in satellite systems, high precision test applications, and high-power microwave and radio frequency systems to transmit electromagnetic signals. Different types of waveguiding structures, such as metallic waveguides, dielectric waveguides, parallel-plate waveguides, and rectangular waveguides, are available for signal transmissions.

Pandu gelombang digunakan dalam sistem satelit, aplikasi ujian ketepatan tinggi, dan sistem gelombang mikro berkuasa tinggi dan frekuensi radio untuk menghantar isyarat elektromagnet. Pelbagai jenis struktur pandu gelombang, seperti pandu gelombang logam, pandu gelombang dielektrik, pandu gelombang plat selari, dan pandu gelombang segi empat tepat, digunakan untuk penghantaran isyarat.

(a) Explain with diagram, the boundary condition for the rectangular waveguide propagation.

Terangkan bersama gambarajah, syarat sempadan bagi perambatan pandu gelombang segi empat tepat.

[4 marks]

[4 *markah*]

(b) The rectangular waveguide, with dimensions of 3 cm × 1.5 cm, is employed for the propagation of a 7 GHz frequency within the waveguide. The waveguide possesses a permeability of 2.2 and a permittivity of 1.8. Calculate the cutoff frequency, cutoff wavelength, and guide wavelength for TE_{11} mode.

Pandu gelombang segi empat tepat, dengan dimensi 3 cm × 1.5 cm, digunakan untuk perambatan frekuensi 7 GHz dalam pandu gelombang. Pandu gelombang mempunyai kebolehtelapan 2.2 dan kebolehpercayaan 1.8. Kirakan potongan frekuensi, potongan panjang-gelombang, dan pandu panjang-gelombang untuk mod TE_{11}.

[8 marks]

[8 *markah*]

(c) Calculate the reflection coefficient and voltage standing wave ratio for each load when testing them individually using a transmission line with a characteristic impedance of 50 ohms. The loads to be tested are (100 + j50) ohms and (50 + j100) ohms.
Kirakan pekali pantulan dan nisbah gelombang berdiri voltan untuk setiap beban apabila diuji secara individu menggunakan talian penghantaran dengan impedans cirinya 50 ohm. Beban yang diuji ialah (100 + j50) ohm dan (50 + j100) ohm.

[8 marks]
[8 *markah*]

CLO1

QUESTION 3
SOALAN 3

Microwave antennas are specifically engineered to either send out or pick up microwave signals. These signals fall within the electromagnetic spectrum, with wavelengths spanning from 1m to 1mm and frequencies ranging between 300 MHz (0.3 GHz) to 300 GHz.
Antena gelombang mikro direka bentuk secara khusus untuk menghantar atau menerima isyarat gelombang mikro. Isyarat ini tergolong dalam spektrum elektromagnet, dengan panjang gelombang menjangkau dari 1m hingga 1mm dan frekuensi antara 300 MHz (0.3 GHz) hingga 300 GHz.

(a) Explain with diagram, the features of horn antenna in microwave transmission.
Terangkan dengan gambarajah, ciri-ciri antena hon dalam penghantaran gelombang mikro.

[4 marks]
[4 *markah*]

(b) Parabolic antenna with a gain of 30dB is employed for microwave signal transmission. The antenna has a diameter of 2 meters, k value of 0.5, and an efficiency of 70%. Calculate the operational frequency, beamwidth, and antenna power gain (Gp).
Antena parabolik dengan nilai gandaan 30dB digunakan untuk penghantaran isyarat gelombang mikro. Antena tersebut mempunyai diameter 2 meter, nilai k bersamaan 0.5, dan kecekapan 70%. Kirakan frekuensi operasi, lebarjalur dan gandaan kuasa antena (Gp).

[8 marks]
[8 *markah*]

(c) A patch antenna with dielectric permittivity of 2.2 and operating frequency 7 GHz is used to set up a directional antenna. Calculate the height, width, and effective dielectric constant of microstrip patch antenna.

Antena patch dengan kebolehpercayaan dielektrik 2.2 dan frekuensi operasi 7 GHz dipasang sebagai antena arah. Kirakan ketinggian, lebar dan pemalar dielektrik berkesan bagi antena patch jalurmikro.

[8 marks]

[8 *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

QUESTION 1
SOALAN 1

The student employed a rectangular waveguide for transmitting a 10 GHz frequency along the transmission line. The waveguide functions on transverse magnetic modes 1,1 with a permittivity of 2.8 and a permeability of 1.4. Upon measurement with a caliper, the inner width of the waveguide was determined to be 40 mm, while the height was half of the waveguide width. Calculate the critical frequency, critical wavelength, phase velocity, group velocity, guide wavelength and characteristic impedance.

Pelajar menggunakan pandu gelombang segi empat tepat untuk menghantar frekuensi 10 GHz di sepanjang talian penghantaran. Pandu gelombang berfungsi pada mod magnet melintang 1,1 dengan kebolehpercayaan 2.8 dan kebolehtelapan 1.4. Selepas pengukuran dengan angkup, lebar dalaman pandu gelombang didapati 40 mm, manakala ketinggian pandu gelombang tersebut adalah separuh daripada lebar pandu gelombang. Kirakan frekuensi kritikal, panjang gelombang kritikal, halaju fasa, halaju kumpulan, panjang gelombang pandu dan galangan ciri.

[20 marks]
[20 *markah*]

CLO1

QUESTION 2

SOALAN 2

The circulator is connected to an antenna which propagates at 6 GHz. The (60 + j105) Ω antenna is not matched with the 75 Ω transmission line, so a short-circuited single stub needs to be added to match the transmission line with the circulator. Determine the standing wave ratio (SWR), load admittance (Y_L), stub distance (*d*) and stub length (*l*) using Smith Chart, and generic layout of the short-circuit stub.

Antena disambung dengan peredar yang merambat pada 6 GHz. Antena (60 + j105) Ω tidak dipadankan dengan talian penghantaran 75 Ω, jadi stub tunggal litar pintas perlu ditambah untuk memadankan talian penghantaran dengan pengedar. Tentukan nisbah gelombang berdiri (SWR), admitan beban (Y_L), jarak stub (d) dan panjang stub (l) menggunakan Carta Smith, dan susun atur generic stub litar pintas.

[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

$\mu = \mu_o \mu_r$

$\varepsilon = \varepsilon_o \varepsilon_r$

$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$ 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 $\eta = 377\sqrt{\frac{\mu_r}{\varepsilon_r}}$

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

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

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

$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$ 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

$P_T = P_R\, G$

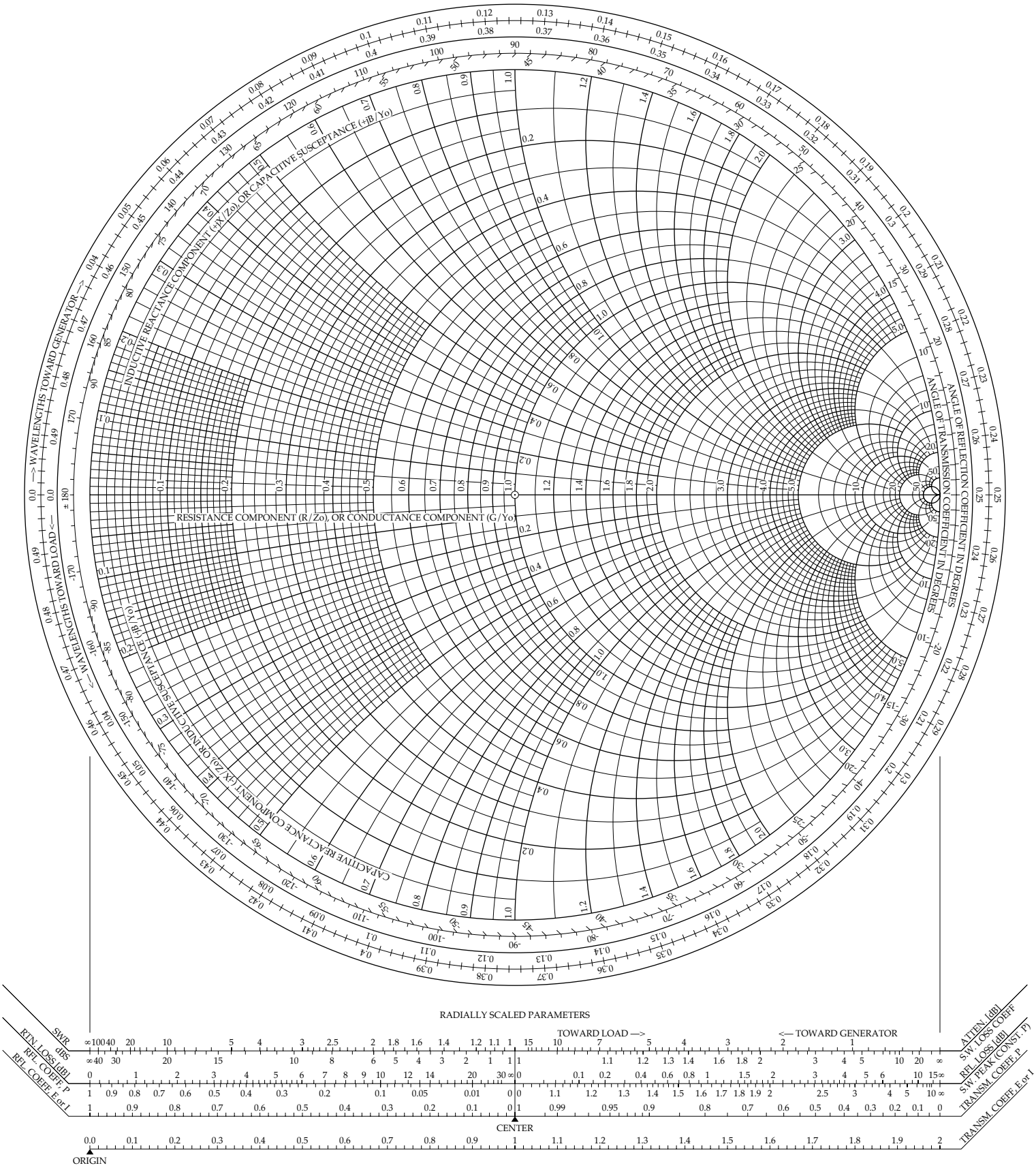
$G_P = \eta G_D$ which $G_D = \left(\frac{\pi d}{\lambda}\right)^2$

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

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

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

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)
REFL. COEFF. P
REFL. COEFF. E or I
ATTEN. (dB)
S.W. LOSS COEFF
REFL. LOSS (dB)
S.W. PEAK (CONST. P)
TRANSM. COEFF. P
TRANSM. COEFF. E or I
CENTER
ORIGIN