UNIVERSITÀ DEGLI STUDI DI BRESCIA

Microwave Engineering Midterm Test
April 24, 2019

Student ID:
First Name:
Last Name:

Instructions: You have 2 hours to complete the test. If you need extra blank sheets to complete the test please ask. Please write everything with blue or black ink pen. You can use your calculator or Matlab. Use of cell phone, course notes or personal computer will invalidate the results of the test.

Questions:

1. A plane wave traveling along the x-axis in a polystyrene-filled region with $\varepsilon_r = 4$ has an electric field $E_y = E_0 \cos(\omega t - kx)$. The frequency is f = 3 GHz, and $E_0 = 10.0$ V/m. Find the following:
   (a) the amplitude and direction of the magnetic field;
   (b) the phase velocity;
   (c) the wavelength in the medium;
   (d) the phase shift between the positions $x_1 = 0.1$ m and $x_2 = 0.15$ m.

2. The critical angle for total internal reflection of a certain interface between two materials is exactly 45°. What is the Brewster angle for the same interface and same materials?

3. A 100 Ω coaxial transmission line has a length of 2.0 cm and is terminated with a load impedance of 50 + j100 Ω. If the relative permittivity of the line is $\varepsilon_r = 4$ and the frequency is f = 3.0 GHz, find:
   (a) the input impedance to the line;
   (b) the reflection coefficient at the load;
   (c) the reflection coefficient at the input;
   (d) the SWR on the line.
   NOTE: You can solve this problem with formulas or using the Smith's chart. Both solutions will give you the same score.

4. Consider a section of air-filled K-band rectangular waveguide. From the dimensions given in the table below, determine the cutoff frequencies of the first two propagating modes.

5. A load impedance $Z_l = 150 + j50$ Ω is to be matched to a 100 Ω line using a single series-stub tuner. Using the provided Smith's chart, find two designs using open-circuited stubs.

APPENDIX I STANDARD RECTANGULAR WAVEGUIDE DATA

Band*	Recommended Frequency Range (GHz)	TE_{10} Cutoff Frequency (GHz)	EIA Designation WR-XX	Inside Dimensions [Inches (cm)]	Outside Dimensions [Inches (cm)]
L	1.12–1.70	0.908	WR-650	6.500 × 3.250 (16.51 × 8.255)	6.660 × 3.410 (16.916 × 8.661)
R	1.70–2.60	1.372	WR-430	4.300 × 2.150 (10.922 × 5.461)	4.460 × 2.310 (11.328 × 5.867)
S	2.60–3.95	2.078	WR-284	2.840 × 1.340 (7.214 × 3.404)	3.000 × 1.500 (7.620 × 3.810)
H (G)	3.95–5.85	3.152	WR-187	1.872 × 0.872 (4.755 × 2.215)	2.000 × 1.000 (5.080 × 2.540)
C (J)	5.85–8.20	4.301	WR-137	1.372 × 0.622 (3.485 × 1.580)	1.500 × 0.750 (3.810 × 1.905)
W (H)	7.05–10.0	5.259	WR-112	1.122 × 0.497 (2.850 × 1.262)	1.250 × 0.625 (3.175 × 1.587)
X	8.20–12.4	6.557	WR-90	0.900 × 0.400 (2.286 × 1.016)	1.000 × 0.500 (2.540 × 1.270)
Ku (P)	12.4–18.0	9.486	WR-62	0.622 × 0.311 (1.580 × 0.790)	0.702 × 0.391 (1.783 × 0.993)
K	18.0–26.5	14.047	WR-42	0.420 × 0.170 (1.07 × 0.43)	0.500 × 0.250 (1.27 × 0.635)
Ka (R)	26.5–40.0	21.081	WR-28	0.280 × 0.140 (0.711 × 0.356)	0.360 × 0.220 (0.914 × 0.559)
Q	33.0–50.5	26.342	WR-22	0.224 × 0.112 (0.57 × 0.28)	0.304 × 0.192 (0.772 × 0.488)
U	40.0–60.0	31.357	WR-19	0.188 × 0.094 (0.48 × 0.24)	0.268 × 0.174 (0.681 × 0.442)
V	50.0–75.0	39.863	WR-15	0.148 × 0.074 (0.38 × 0.19)	0.228 × 0.154 (0.579 × 0.391)
E	60.0–90.0	48.350	WR-12	0.122 × 0.061 (0.31 × 0.015)	0.202 × 0.141 (0.513 × 0.356)
W	75.0–110.0	59.010	WR-10	0.100 × 0.050 (0.254 × 0.127)	0.180 × 0.130 (0.458 × 0.330)
F	90.0–140.0	73.840	WR-8	0.080 × 0.040 (0.203 × 0.102)	0.160 × 0.120 (0.406 × 0.305)
D	110.0–170.0	90.854	WR-6	0.065 × 0.0325 (0.170 × 0.083)	0.145 × 0.1125 (0.368 × 0.2858)
G	140.0–220.0	115.750	WR-5	0.051 × 0.0255 (0.130 × 0.0648)	0.131 × 0.1055 (0.333 × .2680)