UNIVERSITÀ DEGLI STUDI DI BRESCIA

Microwave Engineering Final Test
June 15, 2022

Student ID:
Name:
Instructions: You have 2 hours to complete the test. Please write everything with blue or black ink pen so that all your work can be read easily. You can use your calculator. If you don't have a calculator, you can leave the formulas in expression forms and still get full score for the questions/exercises. Use of course notes or internet resources will invalidate the results of the test.
VERY IMPORTANT: Please WRITE YOUR FULL NAME AND STUDENT ID on this sheet and all your sheets where the problems are solved!

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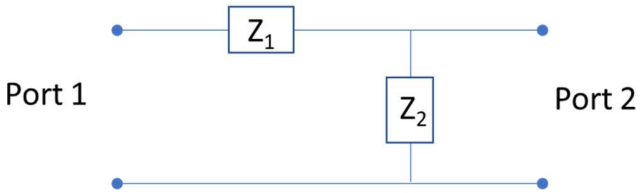
1. A terminated lossless transmission line with Z_0 = 60 Ω has a reflection coefficient at the load of Γ = 0.4. Calculate:

a. The load impedance.
b. The input impedance at a distance 0.3λ from the load.
c. The reflection coefficient at a distance 0.3λ from the load.

2. Find the ABCD matrix for the circuit shown below:



3. A transmission line of length *l* connects a load to a sinusoidal voltage source with an oscillation frequency *f*. Assuming that the velocity of the wave propagation on the line is *c*, for which of the following situations is <u>not reasonable</u> to ignore the presence of the transmission line in the solution of the circuit (motivate your answer):

a. *l* = 30 cm, *f* = 20 KHz
b. *l* = 50 km, *f* = 60 Hz
c. *l* = 30 cm, *f* = 600 MHz

4. Consider a section of a K-band waveguide operating at f=20GHz and filled with a dielectric material with $\epsilon_r = 2.2$ and $tan\delta = 0.002$. Using the data in the table below (Appendix I), calculate:

a. The cut-off frequencies of the first 3 propagating modes.
b. The TE_{10} mode attenuation if the waveguide is made of copper ($\sigma_{copper} = 5.8 \times 10^7 \frac{S}{m}$).

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)

* Letters in parentheses denote alternative designations.

USEFUL FORMULAS:

$$f_{c_{m,n}} = \frac{k_c}{2\pi\sqrt{\mu\epsilon}};$$

$$\alpha_d = \frac{k^2 tan\delta}{2\beta};$$

$$\alpha_c = \frac{R_s}{a^3 b\beta k\eta}(2b\pi^2 + a^3k^2);$$

$$R_s = \sqrt{\frac{\omega\mu}{2\sigma}};$$