Menoufia University
Faculty of Electronic Engineering
Electronics and Electrical Communications Eng. Dept.
Third Year – Spring 2018

ECE 323 - Microwave Engineering
Problem Set #5

Rectangular Waveguides

[P1] A rectangular waveguide filled with a dielectric material with $\mu = \mu_o$, $\varepsilon = 4\varepsilon_o$ and with inner dimensions a=5 cm and b=3 cm.

(a) Find the lowest 5 modes which can propagate in this waveguide and obtain the cutoff frequencies for each mode. Plot the mode chart.

(b) Find the frequency range of single-mode operation in this waveguide.

[P2] **3.4 (modified) -** Consider a section of air-filled K-band waveguide WR42 with outside dimensions ($0.5'' \times 0.25''$) and thickness $0.04''$. Determine the cutoff frequencies of the first two propagating modes. If it is recommended to operate with the operating frequency at least 25% above the cut-off frequency of the TE_{10} mode but not higher than 95% of the next higher cutoff frequency, determine the percentage reduction in bandwidth that this operating range represents, relative to the theoretical bandwidth for a single propagating mode.

[P3] A metallic rectangular waveguide with a = 5 cm and b = 2 cm operating at 20 GHz in TE mode is filled with a dielectric material with $\mu = \mu_o$, $\varepsilon = 4\varepsilon_o$ has the following electric field component:

$$E_x = jE_o \sin\left(\frac{2\pi y}{b}\right) e^{-j\beta z}$$

(a) operation mode

(b) Cutoff frequency

(c) Propagation constant β

[P4] **3.6-** An attenuator can be made using a section of waveguide operating below cutoff, as shown in **Fig. P4**. If $a = 2.286$ cm and the operating frequency is 12 GHz, determine the required length of the below-cutoff section of

waveguide to achieve an attenuation of 100 dB between the input and output guides. Ignore the effect of reflections at the step discontinuities.

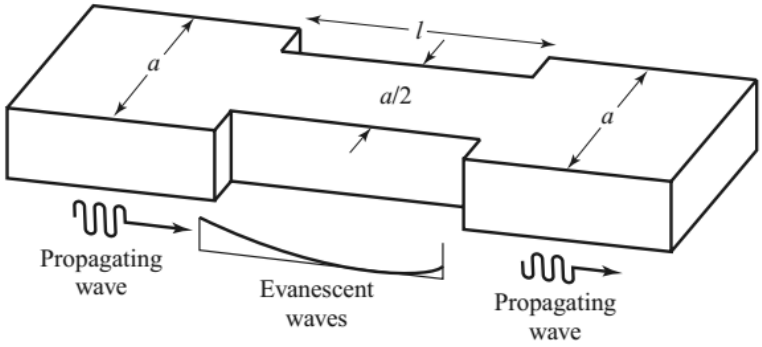

Fig. P4: Circuit for Problem P4.

[P5] A rectangular waveguide filled with air has dimensions $a = 8.636$ cm and $b = 4.318$ cm, and operates at 4 GHz.

(a) Find if the TE_{10} mode can propagate and, if so, calculate the phase and group velocities.

(b) Repeat for the TM11 mode.