

8.56 A hollow rectangular waveguide with dimensions $a = 2$ cm and $b = 1$ cm is used to propagate signals at 20 GHz. Use Module 8.5 to determine:

- (a) The cutoff frequency of TE_{10} mode.
- (b) All possible transmission modes.

Solution: (a) According to Module 8.5,

$$f_c = 7.5 \text{ GHz for } TE_{10} \text{ mode.}$$

Module 8.5 Rectangular Waveguide

$|k| = 418.879 \text{ [m}^{-1}\text{]}$ $f = 20.0 \text{ GHz}$
 $\lambda_0 = 0.015 \text{ [m]}$
 $\epsilon_r = 1.0$
 $\mu_r = 1.0$

$a = 0.02 \text{ [m]}$
 $b = 0.01 \text{ [m]}$

Mode Properties

The fundamental mode is the TE_{10}

cutoff frequency $f_c = 7.5 \text{ [GHz]}$
cutoff wavelength $\lambda_c = 0.04 \text{ [m]}$

At the frequency of operation :

phase velocity $u_{pz} = 3.23616 \text{ [10}^8 \text{ m/s]}$
group velocity $u_{gz} = 2.78107 \text{ [10}^8 \text{ m/s]}$
guide wavelength $\lambda_g = 0.016181 \text{ [m]}$
guide impedance $\eta_{TE} = 406.6678 \text{ [}\Omega\text{]}$

Wave vector components :

$k_z = 388.31124 \text{ [m}^{-1}\text{]}$
 $k_x = 157.07963 \text{ [m}^{-1}\text{]}$
 $k_y = 0.0 \text{ [m}^{-1}\text{]}$

Total number of propagating modes = 5

Instructions

This module provides information about TE and TM modes in a metal rectangular waveguide.

Input

- Waveguide dimensions a and b
- TE or TM mode
- frequency f
- ϵ_r of dielectric material

Displayed Information

- Cutoff frequencies of TE and TM modes
- Spatial distribution of **E** for TE modes and **H** for TM modes
- Phase and group velocities

The Mode Spectrum panel only displays cutoff frequencies of lower order modes. Use Mode Selector to scan higher order modes in the Mode Properties panel.

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Input

Width a = 0.02 m

Ratio a / b = 2

Frequency = 2.0E10 Hz

$\epsilon_r = 1.0$ Update $\mu_r = 1.0$

Plot

☐ S_z ☒ $E(x,y)$
☐ mode 1 ☐ mode 2 ☐ mode 3

Mode Selector

☒ TE ☐ TM

<< < > >> 1
<< < > >> 0

Mode Spectrum

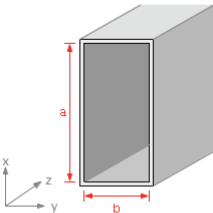
- (b) Possible transmission modes include:

$$TE_{10}, TE_{01}, TE_{20}, TE_{11}, \text{ and } TM_{11}.$$

Module 8.5 Rectangular Waveguide

$|k| = 418.879 \text{ [m}^{-1}\text{]}$ $f = 20.0 \text{ GHz}$
 $\lambda_0 = 0.015 \text{ [m]}$
 $\epsilon_r = 1.0$
 $\mu_r = 1.0$

$a = 0.02 \text{ [m]}$
 $b = 0.01 \text{ [m]}$



Mode Properties

TE_{1,1} **TM_{1,1}**
cutoff frequency $f_c = 16.77051 \text{ [GHz]}$
cutoff wavelength $\lambda_c = 0.0178885 \text{ [m]}$

At the frequency of operation :

phase velocity $v_{pz} = 5.50598 \text{ [10}^8 \text{ m/s]}$
group velocity $v_{gz} = 1.63459 \text{ [10}^8 \text{ m/s]}$
guide wavelength $\lambda_g = 0.02753 \text{ [m]}$
guide impedance $\eta_{TE} = 691.9016 \text{ [}\Omega\text{]}$
guide impedance $\eta_{TM} = 205.4083 \text{ [}\Omega\text{]}$

Wave vector components :

$k_z = 228.23142 \text{ [m}^{-1}\text{]}$
 $k_x = 157.07963 \text{ [m}^{-1}\text{]}$
 $k_y = 314.15927 \text{ [m}^{-1}\text{]}$

Total number of propagating modes = 5

Instructions

This module provides information about TE and TM modes in a metal rectangular waveguide.

Input

- Waveguide dimensions a and b
- TE or TM mode
- frequency f
- ϵ_r of dielectric material

Displayed Information

- Cutoff frequencies of TE and TM modes
- Spatial distribution of **E** for TE modes and **H** for TM modes
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Input

Width a = m

Range

Ratio a / b =

Range

Frequency = Hz

Range

$\epsilon_r = 1.0$ Update $\mu_r = 1.0$

Plot

☐ S_z ☒ $H(x,y)$

☐ mode 1 ☒ mode 2 ☐ mode 3

Mode Selector

☐ TE ☒ TM

< > >>

< > >>

Mode Spectrum

