

Visualization of Electric and Magnetic Fields Inside Circular and Baffle Waveguides and Cavities

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Abstract—This research presents an interactive software to visualize the electric and magnetic field distribution inside circular and baffle waveguides and cavities. This software features a user-friendly interface through which user can specify the design parameters such as dimensions, propagation mode (TE or TM), mode number, operating frequency, and visualization plane. Both transverse and longitudinal field components can be visualized in vector, color contour or both. Field distributions can be displayed as static images or video animations using appropriate sequencing of computed field values. Moreover, this software can give all necessary warnings for invalid user input parameters. Mathematical expressions of the field components used in this software were derived from the classical solution of the wave equations using the separation of variables technique in cylindrical coordinates.

Keywords— *EM Fields, TE Mode, TM Mode, Software, Waveguides, Cavities*

I. INTRODUCTION

The waveguide is a basic transmission line which was first discovered by Southworth for radar systems. Waveguides are commonly used in low-loss filters, hybrid couplers, power dividers, and antennas [1]. Cavity resonators are the most used component in passive wireless sensors. Evanescent-mode cavity resonators inherently fulfil the need for high frequency passive wireless sensor applications because the size can be greatly reduced. Understanding the EM wave distribution inside waveguides and cavities helps microwave engineers in the design manufacturing, testing and installation of electronic components in systems used to transmit and receive microwave signals.

In 1994, Elsherbeni and Taylor, Jr. developed a software (WGC, version 2.1) to compute and visualize EM field distribution inside waveguides and cavity resonators using an interactive BASIC language for a personal computer running DOS operating system [2]. The executable code of the software was available for the IBM-PC computer family, but it is no longer useable due to recent changes and advancements in computing technology and operating systems. Currently, some commercially available software packages such as Ansys HFSS, ADS, CST are used to design and simulate microwave devices [3-4]. But these software packages need substantial memory and

computational resources to compute and visualize field components. Besides, a recent web application has been introduced to visualize EM field pattern inside rectangular and circular waveguides [5]. The software package WGC (version 3) which is introduced in this paper allows users to visualize EM field distribution inside circular and baffle waveguides and cavities. This software offers less memory requirements and computation time to visualize field components in both static images and video animations as the viewing angle and position changes. Besides, users have a lot of flexibility in choosing among shapes, dimensions, mode numbers, plane views (x-y, x-z and y-z). The code is executable on all modern computer families for MATLAB version 2021a and later versions. No internet connectivity is needed to run this software.

II. SOFTWARE DESIGN

In this paper, two different cross-sectional configurations (circular and baffle) are considered for waveguides and cavities. These configurations are shown in Fig. 1.

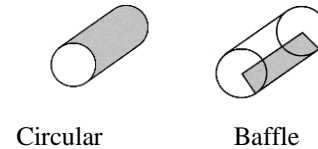


Fig. 1. Different cross-sections of waveguides and cavities.

This software package is designed in the MATLAB App designer platform. First, field equations in this document have been verified with existing figures documented in [6, 7]. Then in MATLAB App designer, GUI has been designed. The window that will appear when a user runs the software is called main window (see Fig. 2). The parameters screen window has a common mode choice option, input for waveguide or cavity dimensions, operation frequency, and plane cut option. Also, there are cut-off frequency calculator option which depends on the dimensions of the cross-sections of waveguides. In the waveguide dimension box, three different units (cm, mm, and inch) are added in the drop-down menu. There is also an input for the number of points along the x, y, and z-axis. It will give the users the flexibility to see the propagation of EM waves as to how they want to see them. In the bottom of the left corner, there are two options for figure creation and video creation. Users can save their works as a picture as well as a video. In the figure creation and video creation buttons, there are 5 different

options in the drop-down menu. At the end of the right corner of the window there are three buttons called “Check”, “Run”, and “Return” buttons. The “Check” button checks all the input parameters. If there is an error in the input parameters, this “Check” button will show users warning messages. If there is no error, the “Run” button will be activated and the user will be able to see the picture or the video. The “Return” button will get the user back to the geometry selection window to work further with the app. The parameters screen for circular cross-section is shown in Fig. 3.

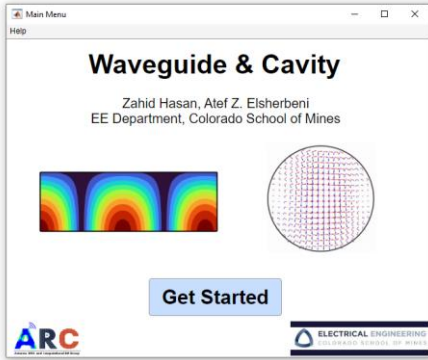


Fig. 2. Main window of the software.

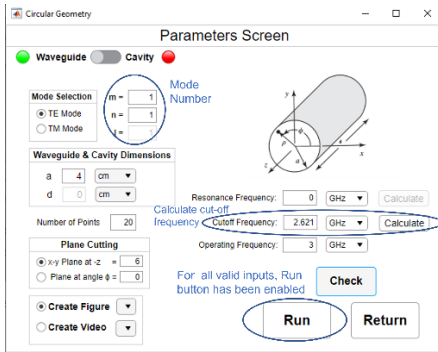


Fig. 3. Parameter screen for circular waveguide.

III. ILLUSTRATIVE EXAMPLE

Some examples of electric and magnetic fields distribution inside circular and baffle waveguides are shown in Figs. 4-5.

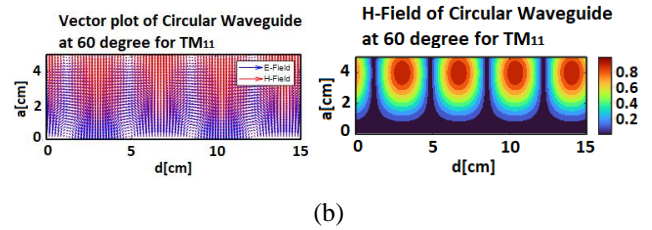
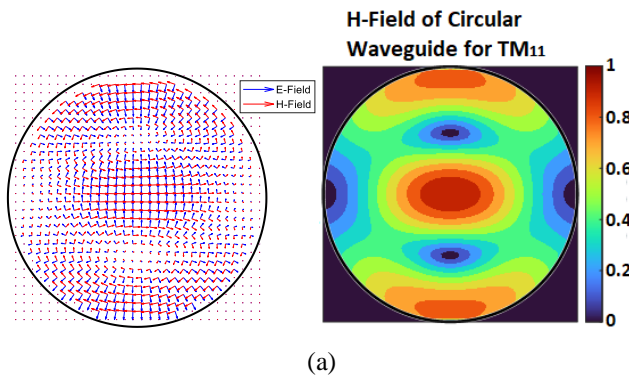


Fig. 4. Vector and field strength of circular waveguide for TM_{11} mode (a) x-y plane, (b) 60-degree plane angle.

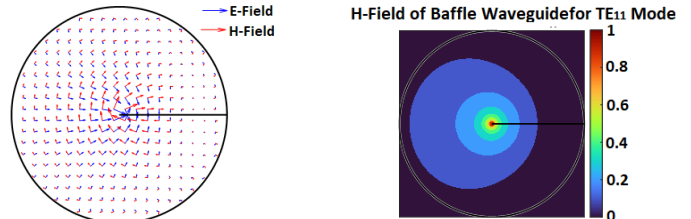


Fig. 5. Vector and field strength of baffle waveguide for TE_{11} mode.

IV. CONCLUSION

The software package presented in this paper WGC (version 3) has been developed in the MATLAB App designer platform. It is easy to use and self-explanatory. Parameters screen allows the user to enter physical dimensions, operating frequency and select how to visualize the results. Users will get warning messages for invalid input parameters. WGC allows users to save the computed field values for comparison and validation against theoretical calculations and measurements.

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