Electromagnetic Waveguides

Turki Zamil Al-Sulaim, Student, 200334610, Dept. of EE, KFUPM, Dhahran 31261, Saudi Arabia

***Abstract*— This paper presents some basic introduction to waveguides, electromagnetic waveguides, their history, their advantages and disadvantages, their analysis and principle of operation. Finally I'll present my conclusion.**

I. Introduction

Waveguides are basically transmission lines made up of metal. They are used to interconnect transmitters and receivers (transceivers) with antennas at microwave frequencies [1]. But some argue that waveguide is not a transmission line as it doesn't have two conductors. There are different types of waveguide depending upon the type of wave to be guided [2]. For example:

- Electromagnetic waveguides,
- Optical waveguides,
- Acoustic waveguides etc.

II. History

In 1893, Sir J. J. Thomson proposed the first waveguide [3]. It was experimentally verified by O. J. Lodge in 1894 [4]. In 1897, Lord Rayleigh performed the mathematical analysis of the propagating modes within a hollow metallic cylinder [5].

III. WHAT ARE ELECTROMAGNETIC WAVEGUIDES?

Waveguides which guide electromagnetic waves are called as electromagnetic waveguides. They are constructed to carry waves over a wide portion of the electromagnetic spectrum. They are employed for transferring power and communication signals over short distances [6].

The different electromagnetic waveguide structures available include rectangular, flexible, circular and double-ridged.

Rectangular and Flexible waveguides are shown in figures 1 and 2 respectively.

IV. PRINCIPLE OF OPERATION

The electromagnetic waves in rectangular waveguide propagate in a zig-zag fashion, but the waves here get repeatedly reflected between opposite walls of the guide. Propagation in dielectric waveguide may be imagined in a similar way, but the waves here are confined to the dielectric by total internal reflection at its surface [6].

Waveguides are constructed using either conductive or dielectric materials depending on the frequency. In General, the lower the frequency to be passed the larger the waveguide is. The width of a Waveguide can also be less than a millimeter. For example waveguides that are used in Extremely High Frequency (EHF) Satellite Communications (SATCOM) [6].

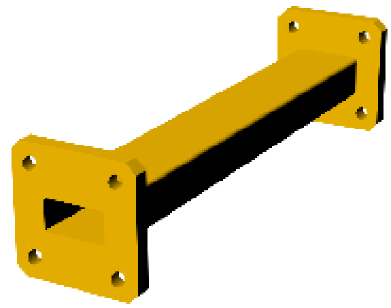

Fig. 1. Rectangular Waveguide.

Fig. 2. Flexible Waveguide.

V. ANALYSIS

The analysis of electromagnetic waveguides is done by solving either Maxwell's equations or the electromagnetic wave equation, which are their reduced form. The properties of the materials and their interfaces determine the boundary conditions. These equations have multiple solutions, or modes, which are eigen functions of the equation system. Therefore each mode is characterized by an eigen value, which corresponds to the axial propagation velocity of the wave in the guide [6].

The propagation mode of the waveguide depends on the operating wavelength, polarization, the shape and size of the guide. The longitudinal mode of a waveguide is a particular standing wave pattern formed by waves confined in the cavity. The transverse modes are classified into different types. For example [6]:

- TE (Transverse Electric) modes have no electric field component in the direction of propagation.
- TM (Transverse Magnetic) modes have no magnetic field component in the direction of propagation.
- TEM (Transverse Electro Magnetic) modes have neither

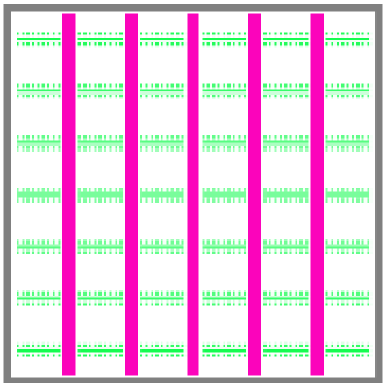

Fig. 3. TE1,0 mode of a Hollow Metallic Rectangular Waveguide.

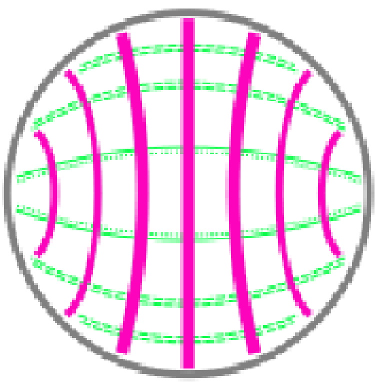

Fig. 4. TE1,1 mode of a Hollow Metallic Circular Waveguide.

electric nor magnetic field component in the direction of propagation.

- Hybrid modes have both electric and magnetic field components in the direction of propagation.
  TE1,0 and TE 1,1 modes of a Hollow Metallic Rectangular and Flexible waveguides are shown in figures 3 and 4 respectively.

VI. ADVANTAGES AND DISADVANTAGES

The advantages of electromagnetic waveguide over coaxial cables, microstrip and stripline include [1]:

- It is completely shielded.
- It can transmit extremely high peak powers.
- It has very low loss, which is negligible at microwave frequencies.

The disadvantages of electromagnetic waveguide over coax, microstrip and stripline include [1]:

- It is expensive as the materials used to construct waveguides are usually copper and silver.
- Its size and mass.
- It is not possible to pass DC currents along with Radio Frequency (RF) signal.

VII. CONCLUSION

In this paper a brief introduction to waveguides and electromagnetic waveguides in particular was presented. The electromagnetic waveguides have both advantages and disadvantages against their counterparts like coaxial cables. Despite their drawbacks waveguides find tremendous applications in the field of communications, medicine etc.

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