Design of an UWB power splitter of arbitrary split ratio using asymmetrical double ridge waveguide

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Abstract

An asymmetrical double ridge waveguide is used to develop power splitter/combiner with arbitrary power division ratio. The power splitter is inherently wide band covering the whole band of the waveguides. The splitter can have a very short length and needs the same width as the input waveguide. It has a highly constant coupling value with return loss better than 25 dB. Results of a 10-dB power splitter are presented as an example.

1. Introduction

Ridge waveguide technology has great importance in different microwave and antenna system since its invention in 1944 [1]. Its bandwidth is wider than conventional rectangular waveguides and it has a higher power handling capability, compared to planar and coaxial transmission lines. In addition, its ability to work at high frequencies makes it vital for many applications like radio astronomy and satellite communications. Lots of studies are performed to get the cutoff space and the field distribution inside the double and single ridge waveguides. A summary of these studies is available in [2]. Most of the studies on double ridge waveguides concentrate on the symmetric double ridge waveguides. To the best of our knowledge, the analysis of the asymmetric double ridge waveguide can be found only in [3], which presents its design curves.

Here, the asymmetric double ridge waveguide is used to develop an arbitrary-ratio power splitter/combiner that achieves wideband operation. Such splitter may be used either to divide the power equally between two ports or to sample the power propagating in the guide for measurement purposes. The paper is organized as follows: Section 2 introduces the geometry and design concept of power splitter that uses asymmetric double ridge waveguide. Section 3 shows the results of a 10-dB power splitter. Section 4 concludes the paper and states future work.

2. Design Concept and Geometry

Figure 1 shows an asymmetric double ridge waveguide with unequal ridge heights. The inner overall dimensions of the guide are \(a\) and \(b\). \(s\) is the lower and upper ridge widths. Lower and upper ridge heights are denoted by \(h_1\) and \(h_2\), respectively, with an air gap between ridges \(d\) where \(d = b - h_1 - h_2\). If \(h_1 = h_3\), then the double ridge waveguide is said to be symmetric. In this case, the double ridge waveguide cutoff space is determined by the transverse resonance method where the jump in the ridge waveguide on both sides of the ridge is represented by a capacitive susceptance calculated as in [2]. To calculate the cutoff space of the single ridge waveguide, same formulas are used such that the cutoff space of the single ridge waveguide formed by halving a symmetric double ridge waveguide is the same as the double ridge cutoff space. The reason behind this can be understood from the field distribution inside a symmetric double ridge waveguide. At the horizontal plane passing through the half of the structure, the electric field lines are found to be all perpendicular to the plane. It means that dividing the double ridge waveguide into two equal single ridge waveguide using a Perfect Electric Conductor (PEC) sheet at the position of the horizontal plane shall change nothing of the double ridge characteristics. This consequently means that the generated single ridge waveguides have the same cutoff space of double ridge waveguides and same field distribution found in a half of the double ridge waveguide.

In case of asymmetrical double ridge waveguide, the horizontal sheet of zero tangential electric field still exists; however, it is not in the middle of the guide anymore. Since the only asymmetric part of the guide now is the ridge heights then we can consider that height of new symmetry plane \(b_1\) is determined by the ratio of ridge heights such that:

\[
\frac{h_2}{b - b_1} = \frac{h_1}{b_1}. \tag{1}
\]

This means the appropriate position in symmetry plane is:

\[
b_1 = \frac{b h_3}{h_2 + h_1} \tag{2}
\]
The proposed ridge waveguide power splitter/combiner is designed to measure the power ratio of a power splitter designed to work in a very wideband with arbitrary power division ratio. The input port of the splitter is a double ridge waveguide whose symmetry depends on the desired power split ratio while output ports are single ridge waveguides. A design procedure has been outlined for such splitter to have different splitting ratios beyond 10 dB. The results of a 10-dB splitter have shown that the splitter has a very low return loss. Such power divider may be used as a coupler for measurement purposes.

5. References
4- ANSYS® Electronics Desktop 2016, ANSYS Inc., Canonsburg,, Pennsylvania, USA, release 17.0.0.