A NOVEL NONCONTACTING WAVEGUIDE BACKSHORT FOR SUBMILLIMETER WAVE FREQUENCIES

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Received November 21, 1994

Abstract

A novel noncontacting waveguide backshort has been developed for millimeter wave and submillimeter wave frequencies. It employs a metallic bar with rectangular or circular holes. The size and spacing of the holes are adjusted to provide a periodic variation of the guide impedance on the correct length scale to give a large reflection of rf power. This design is mechanically rugged and can be readily fabricated for high submillimeter wave frequencies where conventional backshorts are difficult or impossible to fabricate. Model experiments have been performed at 4 GHz - 6 GHz to empirically optimize the design parameters. Values of reflected power greater than 95% over a 30% bandwidth have been achieved. A specific design is presented which has also been successfully scaled to WR-10 band (75 GHz - 110 GHz). A theoretical analysis is compared to the experiments and found to agree well with the measured data.

Key words: submillimeter wave, waveguide, backshort, tuning element

I. Introduction

Rectangular waveguides are used in a wide variety of applications and instruments covering frequencies from low microwave to high submillimeter wave bands. A frequent use of waveguide is as a variable length transmission line. Such a line serves as an adjustable rf tuning element in complex circuits and is formed by placing a movable short-circuit or "backshort" in the waveguide. A common example is a contacting backshort where a springy metal, such as beryllium copper, makes DC contact with the waveguide broadwalls. These backshorts are
generally excellent and essentially frequency independent. However, they are susceptible to wear from sliding friction and are difficult to fabricate for frequencies above a few hundred GHz where waveguide dimensions are small; for WR-3 band (220 GHz - 325 GHz) for example, the dimensions are 0.864 mm x 0.432 mm.

Another approach, commonly used at millimeter wave frequencies, is the noncontacting backshort [1,2,3]; an example is shown in Fig. 1. A thin insulator, such as mylar [4], prevents DC contact. In order to obtain a large reflection of rf power, a noncontacting backshort provides a series of properly phased reflections, which result from cascaded high-impedance and low-impedance transmission line sections. These sections are approximately $\lambda_g/4$ long where $\lambda_g$ is the guide wavelength. The rf impedance at the reference plane at the front of this backshort is given approximately by

$$Z_{rf} = \left( \frac{Z_{low}}{Z_{high}} \right)^n \cdot Z_{low}$$

where $Z_{low}$ is the guide impedance of the thick (low-impedance) section and $Z_{high}$ is the impedance of the thin (high-impedance) section and $n$ is the number of sections. While good performance is possible [1] (i.e., $Z_{rf} << Z_g$, where $Z_g$ is the characteristic waveguide impedance), this design is not readily scalable to submillimeter wave frequencies (above 300 GHz). The high-impedance sections would become too thin and weak to allow the backshort to slide snugly inside the waveguide. In principle, a single thick bar would give a large reflection due to the large impedance.

![Figure 1](image-url)