Stepped Impedance Metal-Mesh Filters for Terahertz Frequencies

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***Abstract*—Square metal grids embedded in low-loss dielectrics have been studied and used extensively as quasi-optical (i.e. multi-mode and coupled to free space) low pass filters in ground and space-based astronomical instrumentation applications. Multilayer designs incorporating grids separated by dielectric spacers have been modeled as capacitive shunts or open circuit resonant stubs separated by ideal transmission lines. Typical low pass filter designs with quarter wavelength transmission line spacing to transform alternating capacitive shunts into inductive shunts at the cutoff frequency have been found to have leaks at approximately twice the stub's resonance frequency. Stepped impedance structures manufactured using multilayer dielectric films are one of the most commonly encountered structures for optical wavelengths [1]-[3] and also for microwave filters. In this poster, we describe the design of stepped impedance metal mesh quasi-optical filters using artificial dielectrics for THz frequencies.**

Keywords—Stepped Impedance filters, Metal-Mesh filters, Terahertz.

I. Introduction

In this poster, we discuss a prototype design for a stepped impedance low-pass filter with a wide passband. Stepped impedance filter designs are the most prevalent designs for filters implemented in microstrip where wideband performance is required. Here we demonstrate the simulated performance a low-pass filter where the stepped impedance sections are designed as artificial dielectric layers using square metal grids embedded in polypropylene that virtually behave like an ideal transmission line section with a specific impedance and phase length. The impedance of an array of square metal grids can be calculated as [4]

$$\frac{X_c}{Z} = \frac{1}{n^2}\left[\frac{4g}{\lambda}\ln\left(cosec\left(\frac{\pi a}{g}\right)\right)\right]^{-1}$$

Where n is the refractive index of the artificial dielectric material, a is the gap between two adjacent metal grids and g is the period of the adjacent metal grids. The impedance of capacitive metal grid is completely described by the refractive index, geometrical ratio (a/g) and the wavelength of interest [4]. The effective impedance of the grid can be calculated as,

$$Z_{eff} = \sqrt{\frac{\mu_0}{\varepsilon_0\varepsilon_r + \left(\frac{C_{grid}}{l}\right)}}$$

Fig.2 shows the simulated performance of the prototype stepped impedance low-pass filter.

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II. Results

The prototype stepped impedance low-pass filter was designed to have a pass-band cutoff at 175 GHz. The stop-band response seen below from the simulated design does not have leakages at twice the desired center frequency.

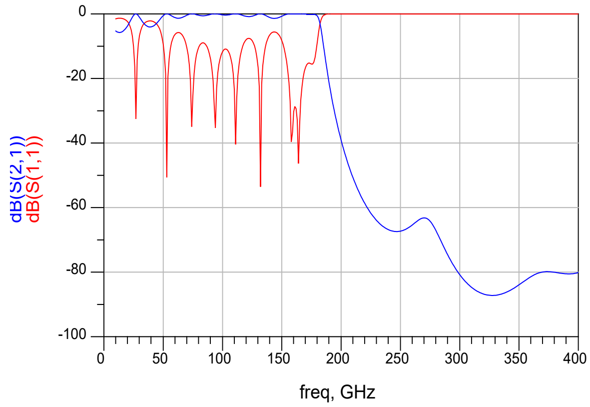

Fig.1 : Simulated Transmission and Reflection Performance of the prototype stepped imedance filter design

The use of a low refractive index anti-reflection coating on the outer sections of the filter is found to further improve the matching and suppress reflections in the passband.

As the next step, this prototype design is planned to be fabricated by spin coating layers of dielectric with embedded square metal grids as opposed to hot-pressing of sections of dielectric. The fabricated filter structure would subsequently be measured to validate the simulated results presented here and would be presented in a future article.

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