Modeling Microwave Waveguide Components: The Tuned Stub

Roger W Pryor, Ph.D.[1]

[1]Pryor Knowledge Systems, Bloomfield Hills, MI, USA

Abstract

Microwave signals need to be clear and undistorted to ensure accurate information transfer. The primary function of many waveguides is to convey a complex, high-power, wave-based, electromagnetic signal from the generating source to the consuming load with a minimum of signal dissipation and/or distortion. Because of their great technological importance and application diversity, waveguides are created in a large range of wavelength-specific, application-dictated, shapes, sizes, and configurations. The active waveguide device modeled in this paper specifically demonstrates the exploration of a small, but very important, subset of components of the family of microwave hardware devices designed to facilitate the optimized transfer of power from the generating source to the consuming load. Each of those components is called, in electronics terminology, a Tuned Stub[1]. A Stub is a length of transmission line or waveguide that is connected to the active circuit at one end only. Figure 1 shows a diagram of a section of rectangular waveguide with three adjustable stubs distributed along the upper surface of the waveguide. A waveguide stub is hollow, the same as the waveguide, and is electromagnetically connected to the inner cavity, at right angles to the central axis of the waveguide via an aperture in the wall of the waveguide. In this case, three (3) stubs have been added to the length of the waveguide to achieve performance optimization, as will be discussed in the modeling paper. Use of COMSOL Multiphysics: In this paper, the RF Module of the COMSOL Multiphysics software (version 4.3) is employed to perform a two-port S-parameter[2] analysis of a Three Stub Tuner in the range of 2.2 to 3.3 GHz, the electromagnetic field results of which are shown in Figure 2. The Model Builder set-up of the COMSOL Multiphysics model is shown in Figure 3. One of the primary advantages of COMSOL Multiphysics software is the ability to modify or create suitable equations, as needed. In the case of this model, it was necessary to add the equation for the calculation of the Voltage Standing Wave Ratio (VSWR). The VSWR is a measure of the power transfer match and indirectly of the potential signal dispersion and/or distortion. Results: In this case, the S-parameter analysis is used to calculate the VSWR, as shown in Figure 4. The optimum value for the VSWR would be 1.0 for a perfectly tuned waveguide fabricated using no-loss materials in the walls and that would indicate that there was no (zero) reflected power. This model, however, uses a real value for the conductivity of the wall. In this model, the calculated VSWR for the single position of the three stubs is less than 1.25, throughout the range from 2.4 to 3.3 GHz. Conclusion: Microwave components can be modeled easily and accurately using the techniques readily available in COMSOL Multiphysics software. Any modeler desiring to expand upon the techniques utilized to develop this model could explore such parameters as stub height and/or stub location through the use of the parametric facilities currently available in this software.

Reference

1. Stub(electronics), http://en.wikipedia.org/wiki/Stub_(electronics)
2. Scattering Parameters, http://en.wikipedia.org/wiki/Scattering_parameters

Figures used in the abstract

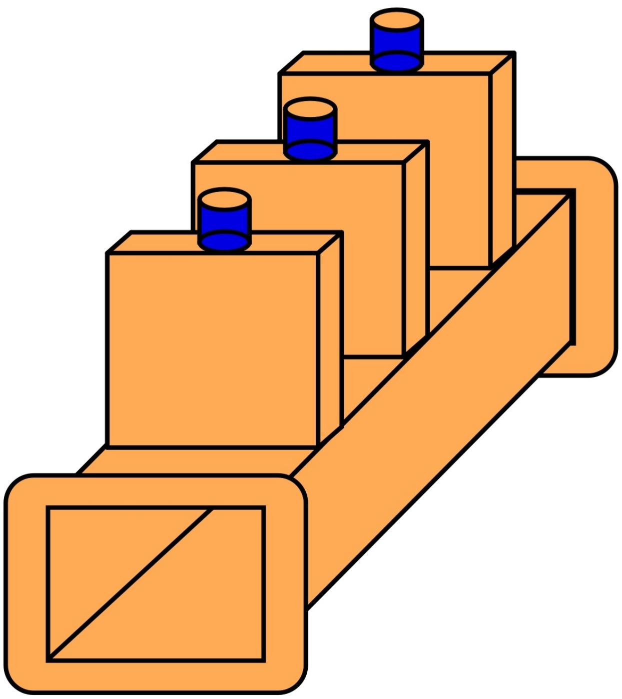

Figure 1: Rectangular Waveguide Three Stub Tuner.

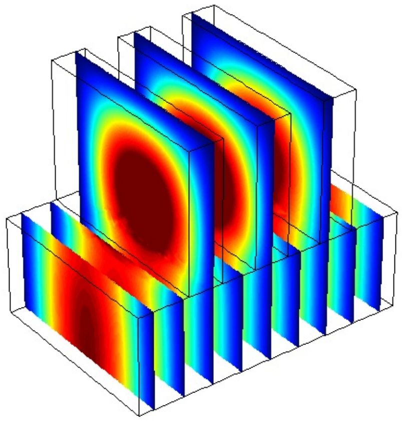

Figure 2: Three Stub Tuner Electromagnetic Field Distribution.

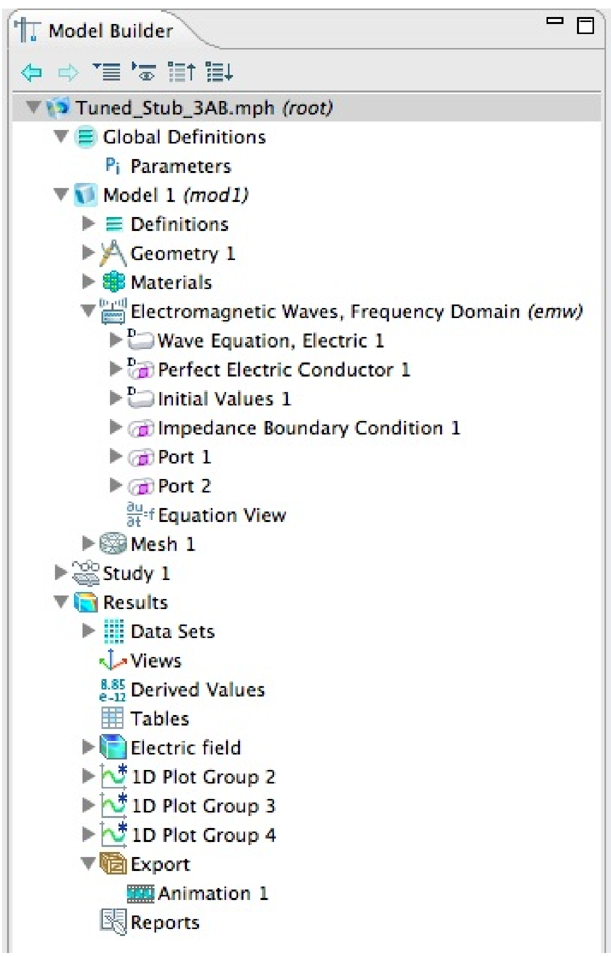

Figure 3: Model Builder Tree for a Two-Port, Three Stub Tuner Model.

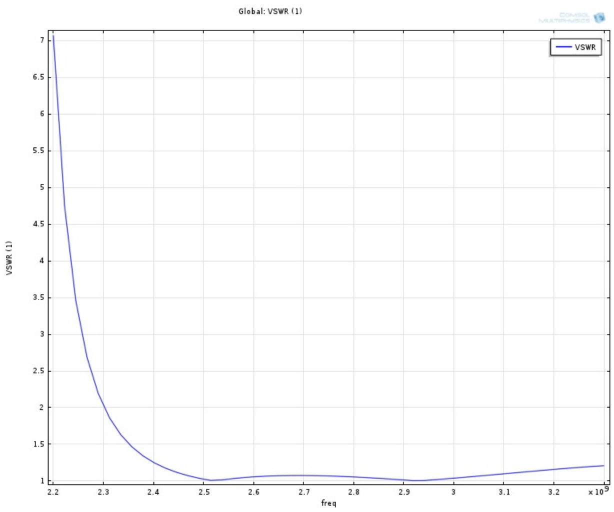

Figure 4: Calculated VSWR for a Two-Port, Three Stub Tuner Model.