Performance and Thermal analysis of an RF Band-Stop Filter

Band-Stop Filters

Band-stop filters (BSFs) play a vital role in RF and microwave circuits, effectively suppressing unwanted signals and noise while allowing desired signals to pass through in wireless communication systems. This analysis explores a microstrip line (MSL) BSF design utilizing a quarter-wavelength open-circuited stub, shown in Figure 1. Using HFWorks, an S-parameters study with thermal coupling was conducted to predict its maximum temperature under specific environmental conditions for a given input power.

Figure 1 *- A working prototype of the proposed BSF [1].*

CAD Model

The prototype was crafted using conventional printed board techniques. It features a uniform width strip-line with a 50-? impedance and a quarter-wave open-circuit stub on a Megtron 6 substrate by Panasonic. The Aluminum open metal housing, showcased in Figure 2, is outlined in detail in Table 1 for reference.

Figure 2 *- a)-3D design and b)-Geometrical dimensions of the BSF*

Table 1 *- Geometrical properties*

Geometrical parameter	Dimension (mm)
	30
	25
	20
	0.93

	2
	4.3
	0.15
	5.93

Simulation Setup

The S-parameters solver in HFWorks, integrated with thermal analysis, operates effectively across the frequency range of 4GHz to 16GHz. Essential material properties utilized in the simulation are summarized in Table 2.

Table 2 *- Material properties*

Material	**Relative permittivity**	**Dielectric loss tangent**	**Electrical conductivity (S/m)**	**Thermal conductivity (W/m.K)**
Megatron 6	3.6	0.006	0	0.4
Aluminum	1	0	3.5 E+7	237
Copper	1	0	5.96E+7	401

Electromagnetic boundary conditions

Wave port: Ports are defined on the lateral surfaces of both the substrate and the surrounding air box.
PEC (Perfect Electric Conductor): The bottom face of the substrate, representing the ground metal, is modeled as a perfect electric conductor.
IEC (Imperfect Electric Conductor): The microstrip lines, representing the copper conductors, are modeled as imperfect electric conductors.

Thermal boundary conditions

For an excitation power of applied to the input port, a thermal boundary convection is applied to the outer air box at an ambient temperature of 22°C and a convection coefficient set to 9 .

Mesh

To ensure precision in the results, we applied a fine mesh control to both the ports and the open-circuit stub. This optimized meshing strategy enhances the accuracy of our simulations.

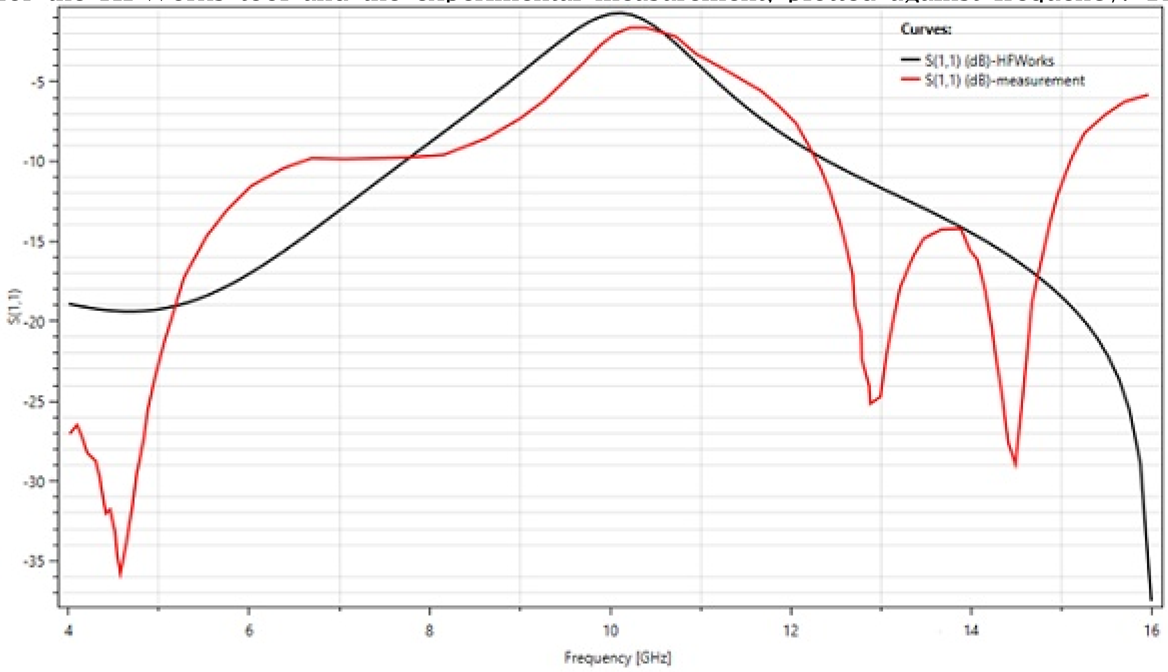
Figure 3 *- the meshed model.*

Results

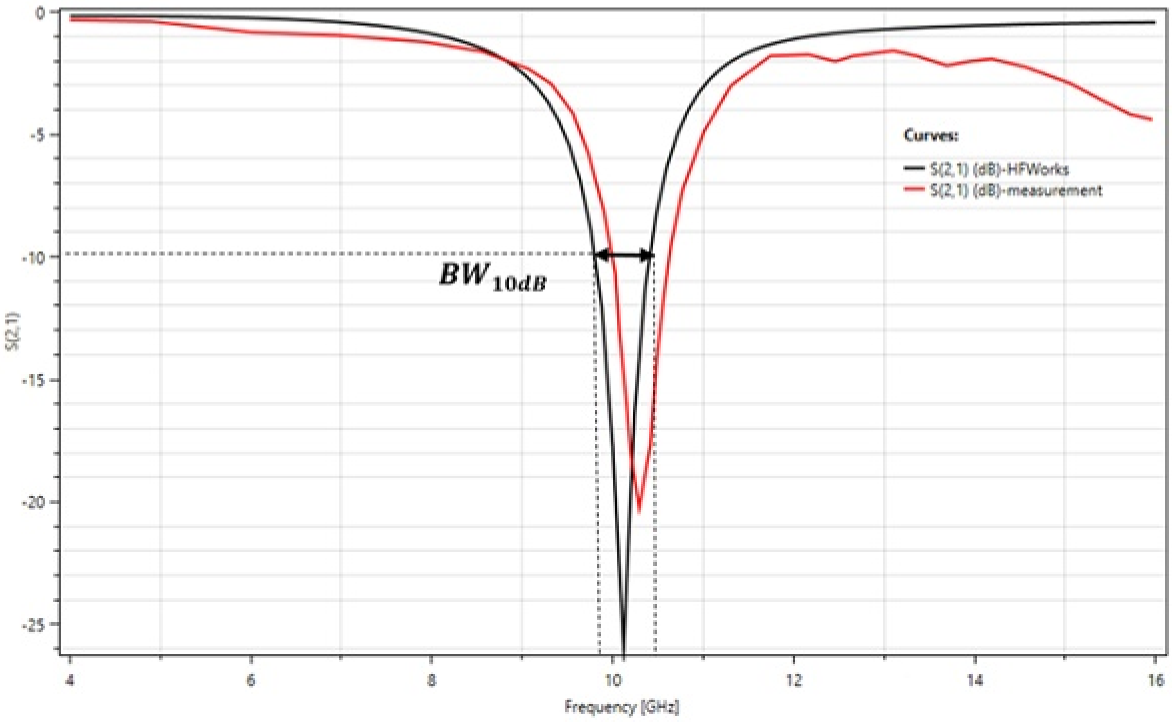
A fast sweep S-parameters study conducted over the frequency range of 4 GHz to 16 GHz yielded the following results for a resonant frequency of 10 GHz:

Figure 4 *- Electric field distribution at 10GHz*

The following figures depict the 2D plot of the S-parameters results: S11 and S21 (Return and insertion losses) for the HFWorks tool and the experimental measurement, plotted against frequency. The deepest rejectio topband bandwi



(a) Return loss results



(b) Insertion loss results

Figure 5 *- 2D plot of Return and insertion losses versus frequency.*

Following the completion of the primary electromagnetic analysis, HFWorks transfers the thermal loads (conductor and dielectric losses) to the thermal solver. With a power excitation of 2W applied to the input port, the simulation yields temperature distribution results across the BSF, considering the applied thermal boundary conditions. The maximum temperature reaches 47°C, aligning well with experimental measurements as documented in Reference [1].

Figure 6 *- Temperature distribution for a frequency of 10 GHz*

Conclusion

This application note delves into the design and analysis of a band-stop filter (BSF) using a microstrip line with a quarter-wavelength open-circuited stub for RF and microwave circuits. Utilizing HFWorks for an S-parameters study coupled with thermal analysis, the study assesses the filter's performance and thermal behavior under specific input power and environmental conditions. The BSF prototype, constructed on a Megtron 6 substrate with an aluminum housing, aims to suppress unwanted signals within a defined stopband while maintaining low insertion loss outside this range.

The electromagnetic simulation conducted over the frequency range of 4 GHz to 16 GHz identified a resonant frequency at 10 GHz, demonstrating significant signal attenuation of approximately 25 dB within the stopband. Thermal analysis, prompted by a 2W power excitation, revealed a maximum temperature of 47°C across the filter, validating the simulation's accuracy against experimental data.

References

[1]. Sánchez-Soriano, Miguel Á., et al. "Average power handling capability of microstrip passive circuits considering metal housing and environment conditions." IEEE Transactions on Components, Packaging and Manufacturing Technology 4.10 (2014): 1624-1633.