# Transmission-Line Reflectionless Filters

Spec Sheet

## Introduction

This is a summary of the general performance characteristics for a novel technology called "Transmission-Line Reflectionless Filters." These build upon the lumped-element reflectionless filters already deployed to commercial markets by Mini-Circuits, Inc. *Reflectionless*, in this context, refers to the property that the filter, in principle, has identically zero reflection coefficient at all frequencies and from both ports, given ideal components.

As with the lumped-element versions (or any filter, for that matter) the actual performance will depend on a number of factors including fabrication technology and details of the implementation. The reflectionless transmission-line topologies presented here are intentionally generic, and may be implemented in a wide variety of formats, including, for example, microstrip, stripline, CPW, or micro-coax, and on a variety of substrate/material systems, including ceramic, semiconductor, microwave laminate (softboard), micro-machined, or PolyStrata[1]. Each of these approaches will have its own parasitics and losses which will contribute to both the transmission and reflection performance of the filters. Since the range of implementations is so widespread, the intent here is provide a theoretical projection of performance given broadly-defined (but realistic) loss and impedance characteristics, rather than achieved performance for a specific implementation.

## Generic Topologies

The generic transmission-line topologies are given in Figure 1 for third-order. (They may be extended to higher orders, but in doing so develop high stop-band peaks which would be deemed unacceptable for most applications.) Ideal responses for these topologies are shown in Figure 2 for 3-dB bandwidths ranging from about 30% to 90% — limited by the feasibility of the required transmission-line impedance and coupling factors. Note that the peak stop-band rejection is coupled to the pass-band width. Should more rejection be needed, multiple stages may be cascaded, as is often done with the lumped-element filters (the good impedance match of these filters in their transition- and stop-bands ensures that the cascade response is reliably the sum of its parts).

## Specifications

The key performance parameters of the transmission-line reflectionless filters are summarized by the bullets below:

- Type = Band-pass
- Fractional Bandwidth (3 dB) = approx. 30% to 90% depending on feasible line impedances
- Loss = approx. 1–2 dB per stage for typical microstrip parameters (e.g. gold traces on GaAs)
- Rejection = 17–27 dB per stage, dependent on fractional bandwidth as shown in Figure 2
- Die/substrate size = $\lambda/2$ (e.g. 2 x 2 mm at 30 GHz, 1 x 1 mm at 60 GHz, for $\varepsilon_{eff} \approx 6$)

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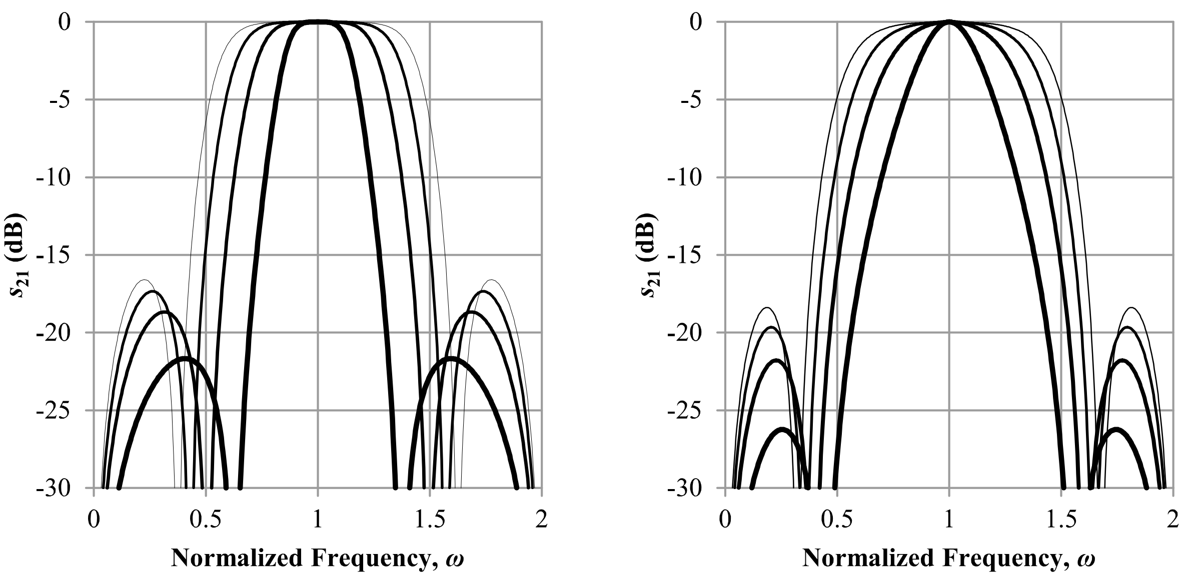
[1] PolyStrata is a patented fabrication technology of Nuvotronics, Inc.


(a) (b)

Figure 1. Generic, third-order, transmission-line reflectionless filter topologies. (a) With stub resonators. (b) With cascade-line resonators. All transmission lines are a quarter-wavelength long at the center of the pass-band.




(a) (b)

Figure 2. Ideal frequency responses for the filters in Figure 1.

## Further Reading

For a much more comprehensive and technical treatment of these filters and the many different forms they can take, the reader is referred to:


**M. Morgan, *Reflectionless Filters*, Norwood, MA: Artech House, January 2017.**

**M. Morgan and T. Boyd, "Reflectionless filter structures," *IEEE Trans. Microw. Theory Techn.*, vol. 62, no. 4, pp. 1263-1271, April 2015.**

**M. Morgan, "Transmission-line Reflectionless Filters," *U.S. Patent Application No. 14/927,881*, October 30, 2015.**