CHRIS DEMARTINO | Technology Editor

Direct-Synthesis Software Approach Facilitates Filter Design

Design software that incorporates the direct-synthesis technique can be highly beneficial to those involved with designing customized filters.

RF/microwave simulation software has become an increasingly important aspect of today's design process. Anyone tasked with designing RF/microwave filters knows how critical software is in meeting design goals, especially in terms of customization. Today, a variety of software tools is available to help achieve those filter-design objectives.

One effective approach is the direct-synthesis technique, which enables a designer to manage the location of transmission zeros. As a result, filters are able to be designed with customized rejection responses.

This article discusses how Genesys software from Keysight Technologies (www.keysight.com) can be used to design filters with the direct-synthesis technique. A lowpass filter example is also presented to illustrate the software's capabilities.

TRANSMISSION ZEROS

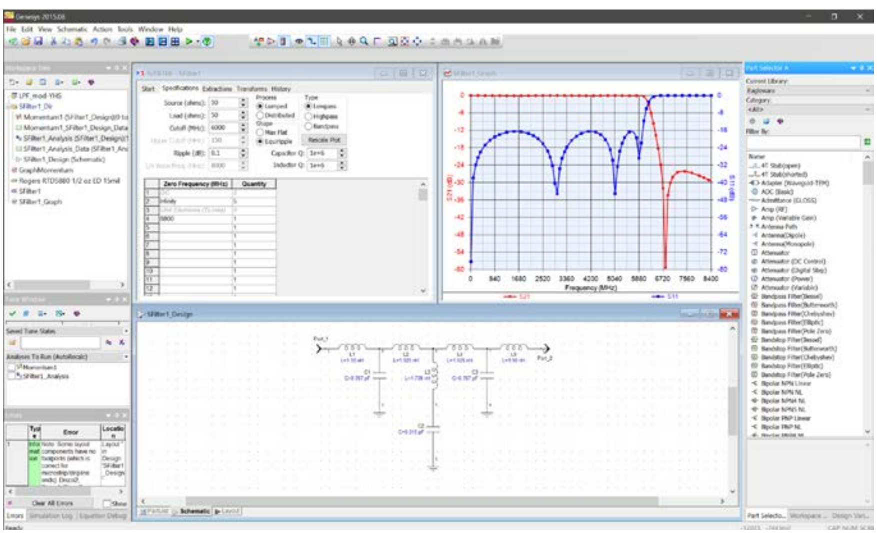
Transmission zeros are frequencies in which there is no signal transmission. A lowpass filter has transmission zeros at infinite frequency, while a highpass filter has transmission zeros at dc. A bandpass filter contains transmission zeros at both dc and infinite frequency.

Finite-frequency transmission zeros (FTZs) are transmission zeroes at frequencies aside from dc and infinite frequency. They can be incorporated into a filter to reject signals at specific frequencies. In other words, FTZs allow unwanted frequencies to be "notched out." FTZs essentially shape a filter's stopband response.

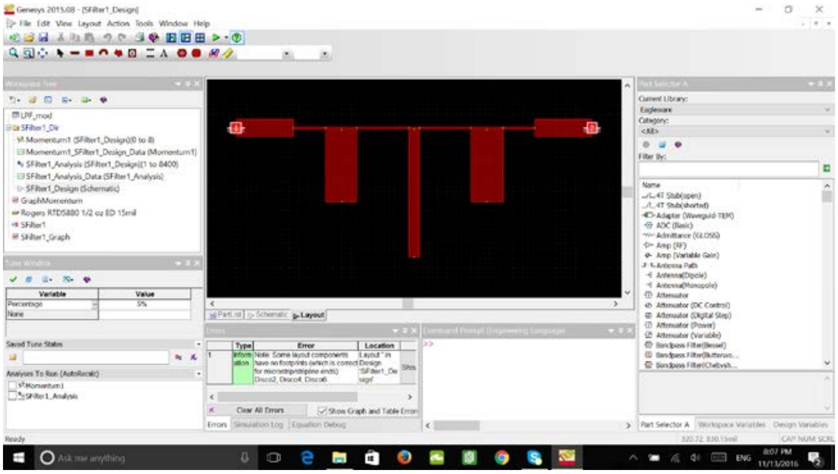
S/FILTER SYNTHESIS PROGRAM

Genesys software can be applied to create both lumped-element and distributed filters. Users can design classic filter types, such as Butterworth, Chebyshev, etc., as well as filters beyond those traditional methods.

Specifically, Genesys contains the S/Filter synthesis program, which utilizes the direct-synthesis technique. When using S/Filter, a designer can place FTZs at specific frequencies to obtain the desired filter stopband performance. This capability allows for custom filter design, as frequency responses can be shaped to meet the needs of a specific application. Direct synthesis is particularly effective in practical scenarios, such as when a certain amount of rejection is needed at a given frequency or frequencies.



1. Users can enter FTZ frequency values by clicking on the Specifications tab.



2. This lowpass filter is designed on a 15-mil-thick Rogers RT/duroid 5880 laminate.

S/Filter accommodates design of lowpass, highpass, and bandpass filters. Its operation is simple: Click on the *Specifications* tab in the user interface to enter the desired FTZ values *(Fig. 1)*. Then, once the criteria are entered, the software directly synthesizes custom filter schematic solutions. Users can click on the *Extractions* tab to cycle through all of the schematic extractions that satisfy their criteria.

The white paper, "Genesys S/Filter Software Synthesizes Custom RF, MW and Analog Filters for Realization," discusses S/Filter in greater detail. The paper, written by How-Siang Yap from Keysight Technologies, also includes a bandpass-filter design example. This filter has a passband from 300 to 350 MHz, and is designed with one FTZ initially set to 400 MHz and then varied.

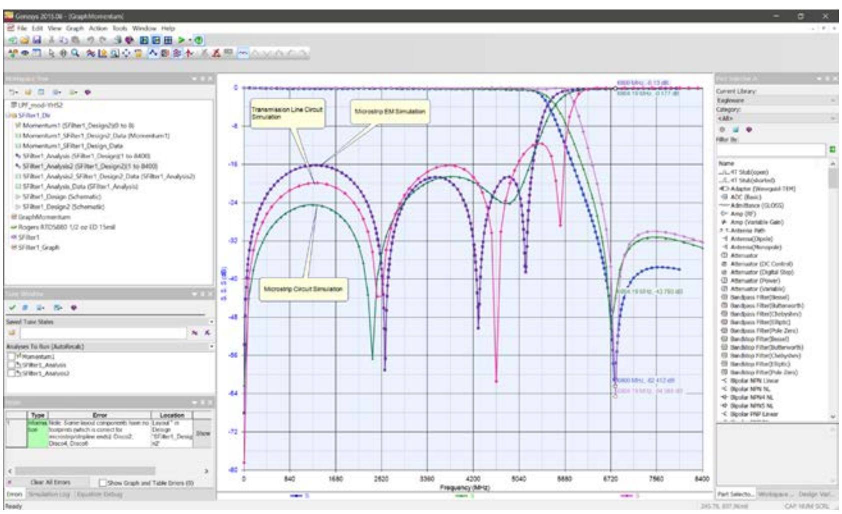
In addition, Keysight has produced a video titled "How To Design Custom RF, Microwave and Analog Filters," which demonstrates the design of a lowpass filter using S/Filter. This particular filter contains an FTZ at 2.4835 GHz to satisfy IEEE 802.11 compliance requirements. The video shows the creation of a lumped-element filter, which is then converted to a distributed filter by means of S/Filter's circuit-transformation capabilities. In fact, a large number of circuit transforms can be performed in S/Filter, including lumped-to-distributed transformations, distributed-to-lumped transformations, Norton transforms, and many others.

DESIGN EXAMPLE

Now let's take a look at the design of a simple lowpass filter using S/Filter. This filter has a passband to 5.2 GHz, and an FTZ at 6.8 GHz.

After the criteria were entered, a lumped-element schematic was chosen from among the several extracted schematics. Subsequently, this lumped-element filter was converted to a distributed filter via lumped-to-distributed transformations. The filter is designed on a 15-mil-thick Rogers RT/duroid 5880 laminate. The layout is presented in *Fig. 2*.

Figure 3 shows the electromagnetic (EM) simulation results. As can be seen, the filter has a passband response to 5.2 GHz, with less than –16-dB return loss across the entire band. It also achieves more than 60 dB of rejection at 6.8 GHz. In comparison, approximately 37 dB of rejection occurs at 7.6 GHz, demonstrating the effect of placing an FTZ at 6.8 GHz. Of course, some optimizations were performed to obtain the desired results. In summary, this lowpass filter—though relatively simple—was modeled in a very short amount of time with S/Filter.



3. These simulation results reveal that the lowpass filter achieves greater than 60 dB of rejection at 6.8 GHz.

Those who wish to further explore the topics discussed in this article should consider obtaining a copy of Randall Rhea's book, *Filter Synthesis Using Genesys S/Filter*. The book serves as a practical guide for RF/microwave filter design, covering the design of lumped-element, distributed, and resonator-based filters using Genesys software.