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Modelithics® World's Best RF & Microwave Simulation Models

Using High Frequency Component Models to Reduce Design Costs in RF Filters and Power Amplifiers

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Designing high-frequency systems is difficult and expensive. Although RF/microwave electronic-design-automation (EDA) tools have existed for many years, the accuracy of simulated results is only as good as the models employed. Many circuit designers use either ideal component models or measured S-parameter files to model the performance of RF/microwave components. However, the component and package parasitics, substrate dielectric effects, and electromagnetic (EM) effects of nearby structures significantly impact the actual circuit performance. Also, for active components, the performance of the device over varying bias and power levels is highly dependent on the nonlinear effects of the device (i.e., process material, geometry, package parasitcs, etc.). These factors need to be accurately modeled to simulate the performance.

If the component characteristics are not accurately modeled in the simulation, extensive board-level bench tuning and rework are typically required to achieve the desired results. Oftentimes, a second or third printed-circuit-board (PCB) iteration is needed to achieve acceptable performance. This scenario is costly not only in terms of board fabrication expenses but also engineering time and design productivity. In addition, the missed windows of opportunity for new products can significantly impede the success of companies in the marketplace.

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Teddy is currently in business development at Modelithics. He has worked in the semiconductor and wireless industries in a variety of roles for over 30 years. During this time, he has combined hands-on technical engineering with real-world business and marketing. He has worked for various companies, including Nokia Mobile Phones, MACOM, and IBM Microelectronics. Teddy has a B.E., M.Eng., and Ph. D in electrical engineering from University College Cork, Ireland. He also holds a certificate in executive business management from MIT Sloan Business School.

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The Solution from Modelithics

Modelithics provides top-quality simulation models for many types of RF/microwave components. These models are available for today's most popular EDA tools. The Modelithics COMPLETE Library is an indispensable collection of simulation models for an extensive range of passive and active devices. To date, the company offers models that represent over 25,000 components from more than 70 vendors. These models are compatible with industry-leading high-frequency EDA tools, including Keysight PathWave Advanced Design System (ADS), Keysight PathWave RF Synthesis (Genesys), Cadence AWR Design Environment, and Ansys HFSS.

All Modelithics models are based on consistent measurement and modeling techniques honed over decades of experience. In addition, models typically remain valid beyond the frequency range of the measurements. The models also include complete documentation and professional support.

	Ideal Component Models	Typical S-Parameter Files	Modelithics Microwave Global Models™
Measurement Based		✓	✓
Broadband Validation		✓	✓
Substrate Scalable			✓
Avoid Extrapolation Errors	✓		✓
Consistent Development, Even Across Different Manufacturers			✓
Extensive Documentation			✓
Part Value Scaling	✓		✓
Part Value Selectable			✓
Orientation Selectable (Capacitors)			* ✓
Part Value Optimization	✓		✓
Discrete Optimization			* ✓
Pad Size Scaling			* ✓
Include Pad Layouts			✓
Accurate ESR			✓
Statistical Analysis			✓
Non-Linear Active Device Models			✓
Temperature Dependence			* ✓
Bias Dependence			* ✓
Noise Analysis			✓
Load Pull Validation			✓
X-Parameters**			✓
Professional Support & Updates			✓
Accurate Parasitic Handling		✓	✓
Multi-simulator Compatibility	✓	✓	* ✓
High Order Resonance Treatment		✓	✓
Fixture/Reference Plane Details			✓
Model Customization Services			✓

Figure 1: Comparison between Modelithics Microwave Global Models, ideal component models, and typical S-parameter files.

To illustrate the benefits of using high-quality models in a real-world environment, Modelithics customer Quasonix conducted a performance comparison of a 2.4-GHz harmonic filter.[1] To perform this analysis, the filter was first designed using ideal lumped-element component models. Using Cadence AWR software, the filter was simulated with these ideal models from DC to 20 GHz.

The simulated response shows passband insertion loss below 0.05 dB, 2nd-harmonic rejection of 49 dB, and a minimum of 47 dB of stopband rejection all the way to 20 GHz (Fig. 2). However, this idealized response is obviously not a true indicator of the real performance.

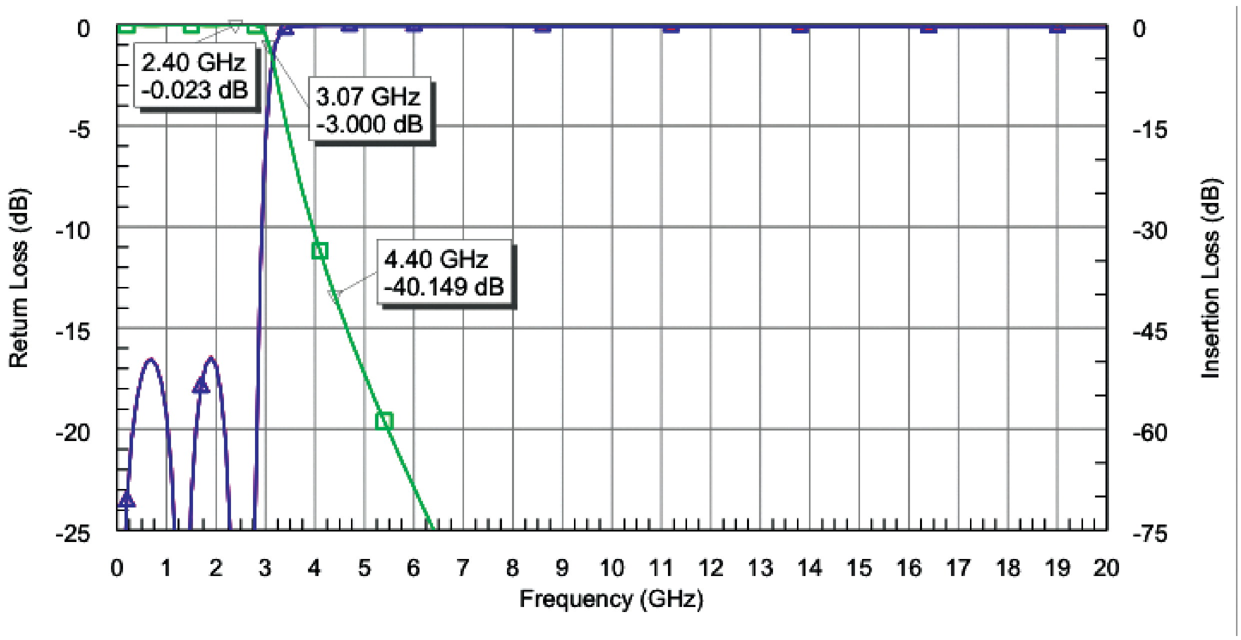

Figure 2: Simulation results of a 2.4-GHz harmonic filter with ideal component models. Transmission line interconnects are included in the design.

The filter was then designed using Modelithics models that account for component parasitics. These models allow for an accurate prediction of the filter's true performance. To demonstrate this, the filter was fabricated using lumped-element components along with the needed PCB elements. The measured performance of the filter was then compared with the simulated performance when using Modelithics models. Figure 3 shows the results.

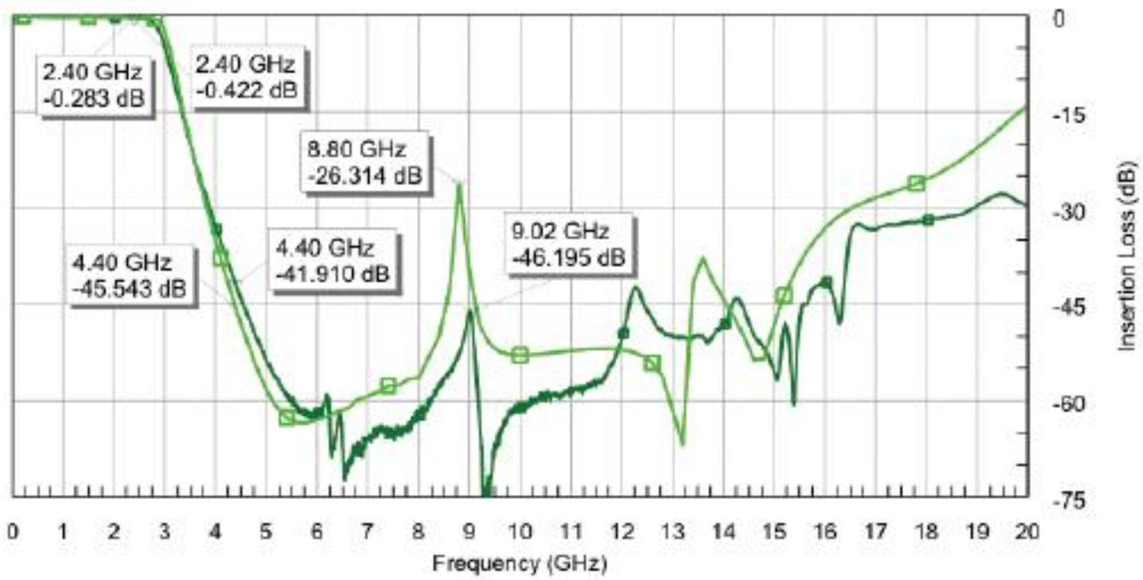

Figure 3: Comparison of simulated performance with Modelithics models with the measured results.

As can be seen, there's good agreement between the simulated and measured S_{21} (insertion loss) both in-band and at the higher out-of-band frequencies. Therefore, this design example demonstrates that using Modelithics models can eliminate one or two PCB spins and shorten the development cycle by one to two months.

It's also interesting to explore the savings in project cost and development time that occur thanks to a successful first-pass design. The Modelithics website includes an ROI calculator that lets users input their own project details. The calculator determines the ROI associated with first-pass design success due to using high-quality models. (The ROI calculator is available for free on the Modelithics website).

For this project, employing inaccurate models would likely result in a second design iteration. For that scenario, the ROI calculator was used to estimate how both cost and scheduling is impacted versus using Modelithics models. The following highlights the total savings:

- **% Cost Savings = 54%**
- **Total savings in schedule = 5 weeks**

When looking at the cost of the required models, it's clear that the ROI is justified for this design alone. On top of that, the models can also be useful for future designs. Another way of looking at this ROI is that investing in models that enable first-pass success resulted in a 90% productivity improvement. Therefore, the same engineer could complete nearly twice as many similar designs in a single year.

A related project was completed to highlight the benefits of using accurate models to design a power amplifier (PA). A paper in High Frequency Electronics magazine provides further details.[2] Figure 4 shows the measured versus simulated output power, efficiency, and current consumption. Modelithics models were used for the power transistor and passive components. Again, there's very good correlation between the simulated results and measured data.

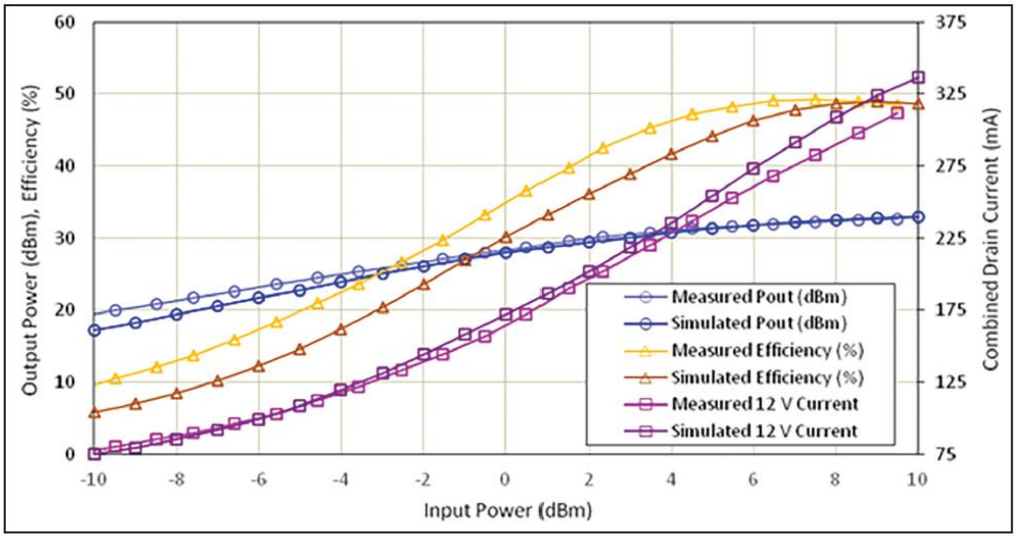

Figure 4: Measured and simulated output power, current, and efficiency.

Again, the ROI calculator highlights the following results in terms of total savings:

- **% Cost Savings = 63%**
- **Total savings in schedule = 17 weeks**

This PA example illustrates the importance of using high-quality models for circuit designs that operate at high frequencies. A relatively minor additional investment in device models results in reduced costs and quicker time to market for new products.

Finally, if you have not already done so, please check out our libraries of models on the Modelithics website. Modelithics offers multiple options to suit your budget and technical requirements. In addition to a variety pricing options, potential users can avail of a free trial of a subset of the COMPLETE library, as well as vendor sponsored libraries (upon approval). Modelithics also provides custom and special order modeling for devices not yet in our libraries.

References

1. T. Longshore, L. Dunleavy, “Using Component Models to Achieve First Pass Success – A Transmitter Case Study: Part 1, Harmonic Filter Design,” High Frequency Electronics, August 2017

2. T. Longshore, L. Dunleavy, “Using High Accuracy Models to Achieve First Pass Design Success - A Transmitter Case Study: Part 2, Power Amplifier Design,” High Frequency Electronics, September 2017