Success Story

University of L'Aquila Researcher Develops an Active Filter Design Methodology Using NI AWR Software

"The optimization algorithms in NI AWR software provided a unique methodology for my active filter designs. I found it to be the only available software that was able to quickly converge on the correct solution and solve the design problem."

Dr. Eng. Leonardo Pantoli, Researcher, University of L'Aquila

Company

Established in 1952 and located in L'Aquila, administrative center of the Abruzzo Region of Italy, administrative center of the Abruzzo Region, the University is a public teaching and research institution offering a full range of academic programs, including biotechnologies, sciences, economics, engineering, education, humanities, medicine, psychology, and sport sciences. With seven departments, the University of L'Aquila offers its over 18,000 enrolled students 66 degree courses (divided between first and second level degrees), eight research doctorate programs, and specialization schools for master and vocational courses. Many members of its distinguished faculty of about 600 professors and researchers have received international recognition and are considered leaders in their fields of research.

Challenge

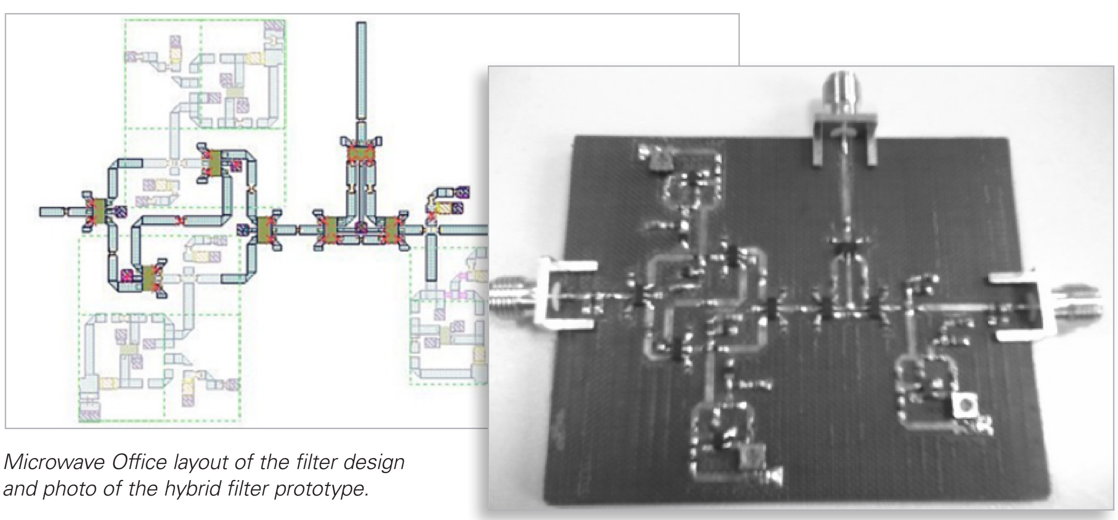
The goal of Dr. Leonardo Pantoli, researcher at the University of L'Aquila, was to develop a methodology for designing high-quality active filters with tunable center frequency, low loss, high-dynamic range, and low-power consumption, all within a small footprint. His design approach for the realization of the active filters included an innovative configuration of the active section based on the use of an active inductor (AI) conceived with a single transistor that could be optimized for the target application taking into account the particular specs.

At-A-Glance

Application
- Filter

Software
- NI AWR Design Environment
- Microwave Office
- AXIEM

Benefits
- Productivity
- Ease of use
- Simulation speed
- Technical support



Microwave Office layout of the filter design and photo of the hybrid filter prototype.

Solution

As an example, a high-order tunable filter was chosen to provide a feasibility demonstration of the proposed approach, which was realized with the structure shown in Figure 1.

Each cell was composed of a shunt L-C cell and two series capacitances. The shunt capacitance was a varactor in series with a fixed capacitance, while the shunt inductance was the AI, with controlled inductance and resistance value (Figure 2). Low-loss switches were added between the cells. Suitable combinations of the switch states enabled the individual tuning and characterization of each cell, as well as the cascading of the three cells for full filter action.

The filter was centered at 1.95 GHz in agreement with the functional bandwidth of the chosen transistor. The -3-dB bandpass was 10 MHz, for a Q of approximately 200, with good input and output matching (Figure 3). The filter required less than 4 mA total bias current, for a power consumption of approximately 4 mW. A prototype board was fabricated and tested.

The tunability characteristics of the proposed design is shown in Figure 3. The varactors allowed the tuning of the center of approximately 250 MHz, showing a relative tuning bandwidth of about 13 percent, with a quite uniform shape factor. The shape factor (30-3 dB) was 2.5 and the attenuation was 6 dB with a limited variation within the tuning range.

In Figure 4 measured S-parameters are reported. The measured P1dB compression point is around -5 dBm, providing a dynamic range of about 75 dB, sufficient for a wide range of applications.

Conclusion

Dr. Pantoli chose Microwave Office circuit design software and the AXIEM planar electromagnetic (EM) simulator because of their ease of use and simulation speed, which enhanced his productivity, and the ready availability of technical support. The AXIEM simulator provided up to 50 percent reduction in EM simulation time without compromising the accuracy. Most importantly, NI AWR software converged on a good solution and was the only design solution able to solve the problem.

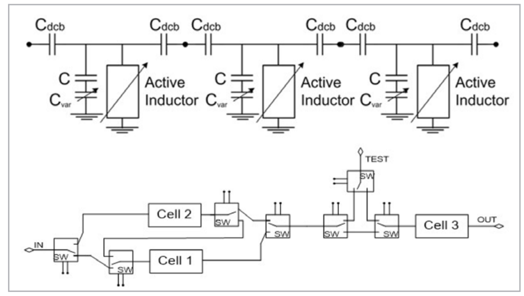


Figure 1: Three-cell filter (above) and detailed structure with low-loss switches (below).

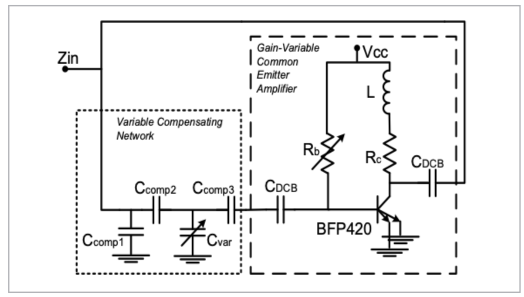


Figure: 2 Simplified schematic of the AI.

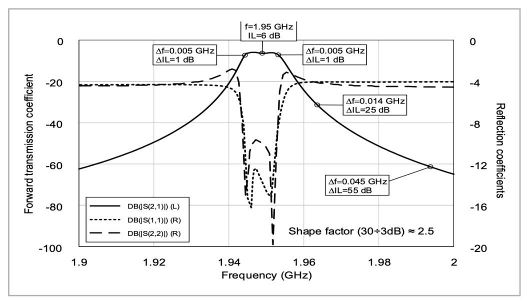


Figure 3: The simulated s-parameters of the filter

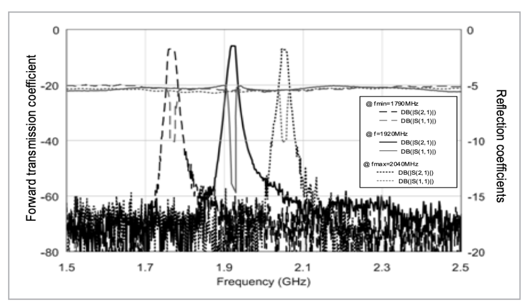


Figure: 4: Measurement results in the overall filter tuning range.

Special thanks to Dr. Leonardo Pantoli for his contributions to this success story.