A DIFFERENT APPROACH:

Designing with Modular Filters

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Filter selection and integration is often the most difficult risk to manage when realizing a new RF design. Some of the risks include:

> Over specifying
> Underspecifying
> Late system specification changes
> Long lead times
> Layout is specific to filter part number
> Must commit to layout and assembly to validate filter selection
> Unintended consequences of filter technology choice
> May have to start over if the design doesn't meet performance goals

Modular filters afford a different approach to RF design that addresses these issues. This paper discusses what modular filters are, why their time has come, and how to design with them.

Modular Filters

Modular filters are designed with compatible RF launch geometries on a common mechanical grid and enjoy the ease of "bolt-in" assembly (Figure 1). Standardization is further extended to the extraction of simulation models by moving the reference planes to the RF launches (Figure 2). This lays the foundation for a better way to use filters.

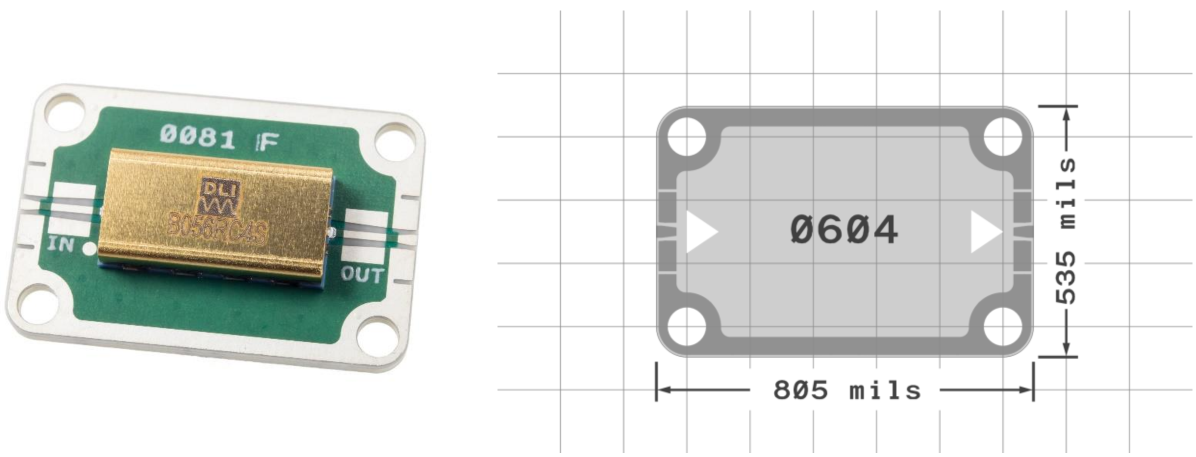


Figure 1. A DLI 6 GHz planar bandpass filter is transformed into a modular Drop-In filter by mounting it on a size 0604 X-MWblock. Note that the gridlines are spaced 135 mils apart. The 0604 size designation comes from the fact that the filter covers 6 horizontal and 4 vertical grid points.

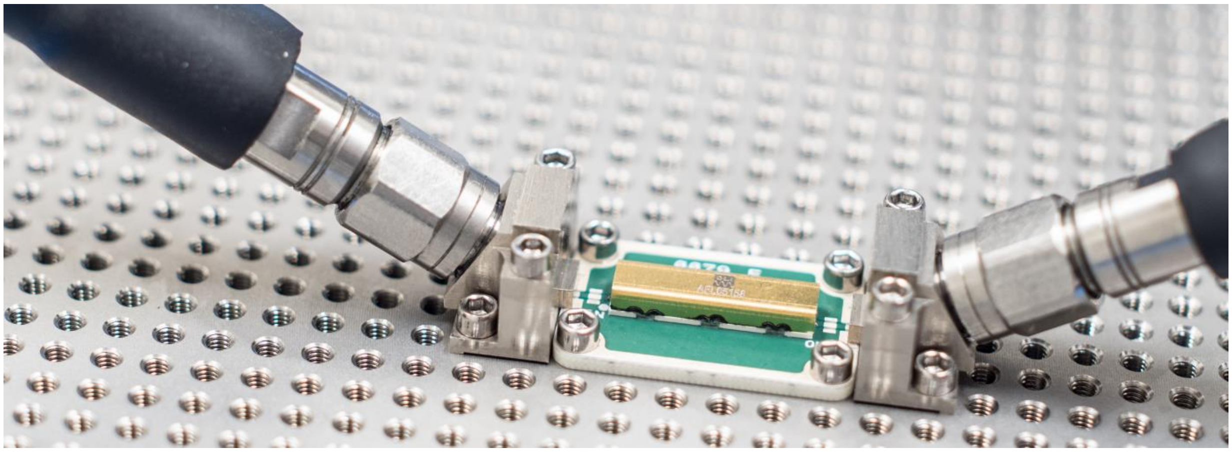


Figure 2. A modular filter is being characterized at its standardized RF launches. Compatible solderless RF contact probes enable repeatable S-parameter extraction to 50GHz.

Different, but the Same

Clearly, it’s not possible for all filters to efficiently share a single form-factor, but the common grid keeps the number of form-factor permutations to a minimum. All of the filter types in Figure 3 are interchangeable. In some cases a transmission line spacer is required to bridge any gap left when changing to a shorter-length modular filter.

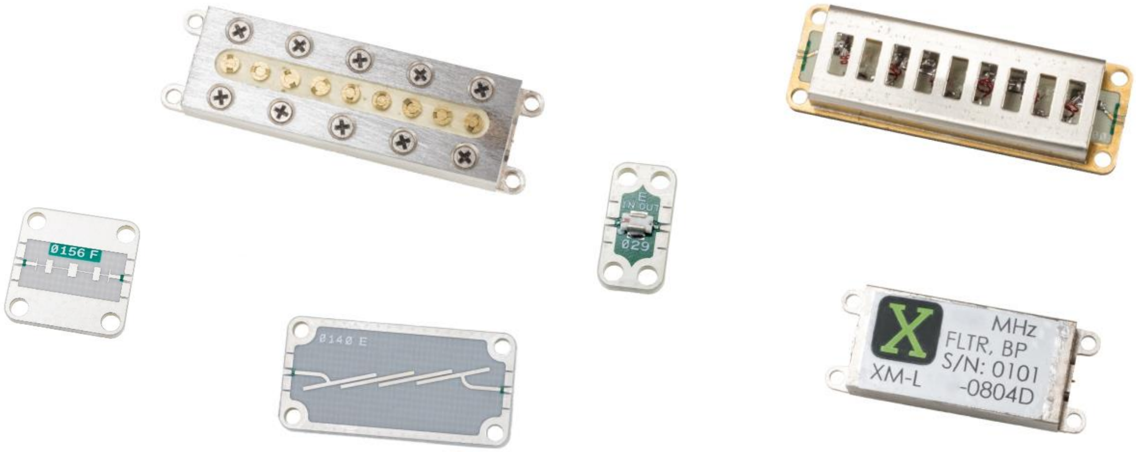


Figure 3. Clockwise from far left: (0404) 15 GHz low-pass planar, (1204) 9 GHz band-pass cavity, (1204) 320 MHz band-pass lumped, (0804) 3 GHz hermetic planar, (0804) 9.8 GHz planar, and in the center an (0204) 12 GHz Mini-Circuits LTCC low-pass.

Drop-In or Drop-On

Drop-In filters refer to modular filters that are fabricated on a printed circuit substrate with coplanar RF launches. Filters that use a machined housing (like hermetic and cavity filters) incorporate a compatible ground-signal-ground RF launch (Figure 4). They are referred to as “Drop-On” filters since their RF launches rest on top of the coplanar launches of adjacent circuitry. Soldering of the RF launches is optional for both Drop-In and Drop-On filters.

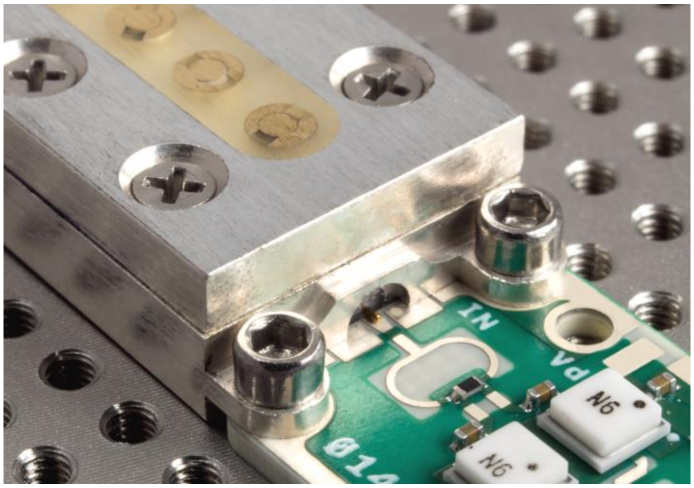


Figure 4. Close-up of the RF launch of a Drop-On cavity filter. Soldering the center pin is optional when prototyping.

Performance Isn’t Compromised

Far from being compromised, modular filter performance is optimal and consistent since no significant electro-mechanical differences exist between the measurement, prototyping, and production manifestations of the filter. Figure 5 shows the performance of a (1204) 9 GHz cavity filter that measures only 1.61 x .53 x .24 inches.

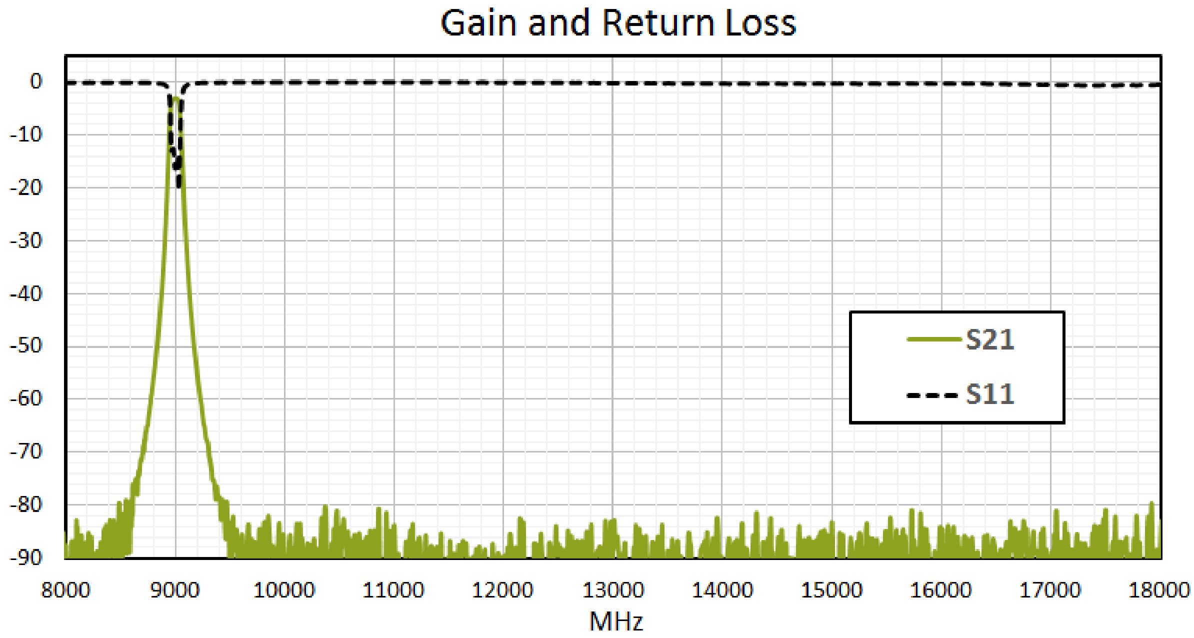
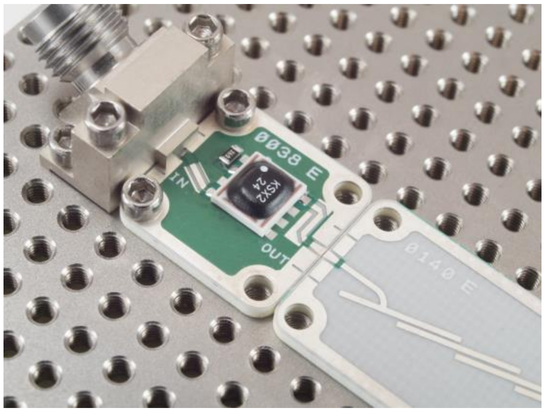


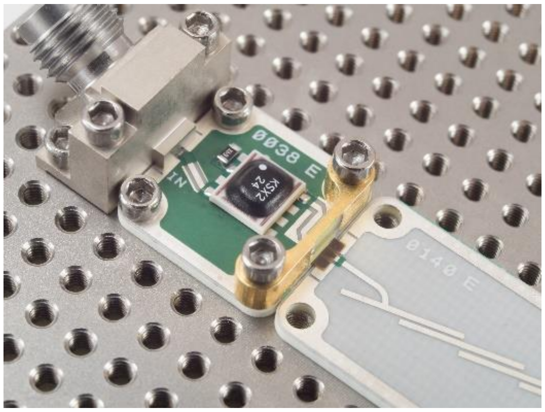
Figure 5. S21 and S11 plots of a Drop-On (1204) 9 GHz cavity filter.

Getting Connected

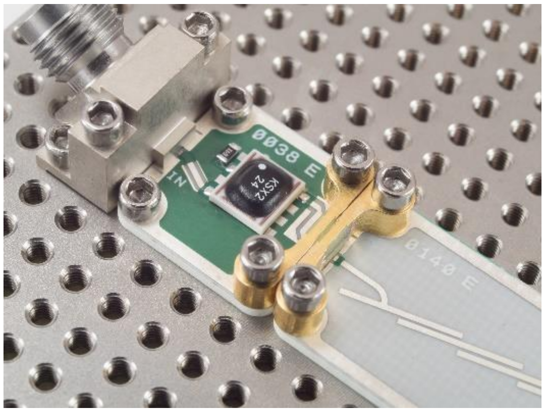
Drop-In filters support a high performance, highly reliable solderless RF interconnect technology. A compliant ground-signal-ground (GSG) polyimide jumper, which is plated with diamonds and gold is held firmly in place with rugged anchors. It takes three steps to complete a connection:



1) **Align the Drop-In filter's RF launch.**



2) **Place the solderless diamond/gold-plated GSG jumper and fix in place with an anchor.**



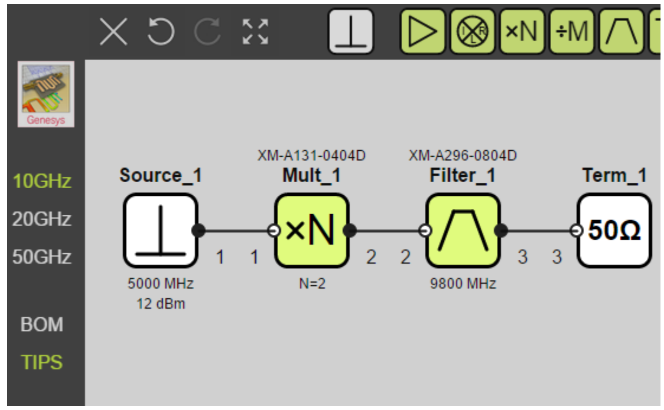
3) **Complete the solderless connection by installing the second anchor.**

Concept to Prototype to Production

Through electro-mechanical standardization, modular filters make it possible to efficiently translate design concepts into shippable product.

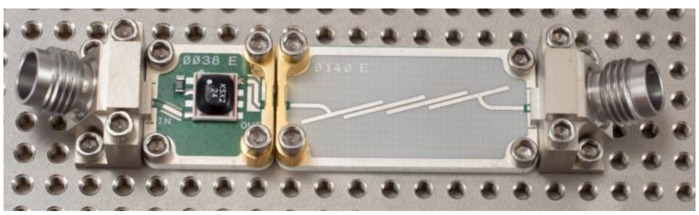
Simulate

Since the simulation models for all of the modular filters have their reference planes coincident with the RF launch one can be confident that the simulation results will be consistent across multiple filter types and technologies. The full power of predicting system performance through simulation is realized when the modular concept is applied to the rest of the system affording accurate characterization at standardized launches.



Validate

Build a prototype to validate the performance predicted by simulation using the same modular filter that will be used in the production version.



Produce

Proceed confidently to production . . .

. . . *knowing* it's not too late or costly to make a significant filter change.

Leveraging Modular Filters

Switched Filter Banks (SFB) can be quickly built, modified, tested, and shipped. Figure 6 shows an SFB using five different filter types. In the bottom channel a low-pass filter follows a planar bandpass filter for extra rejection of the bandpass filter's recurring passbands. One might even try back-to-back low-pass and high-pass filters when very broadband bandpass filtering is required.

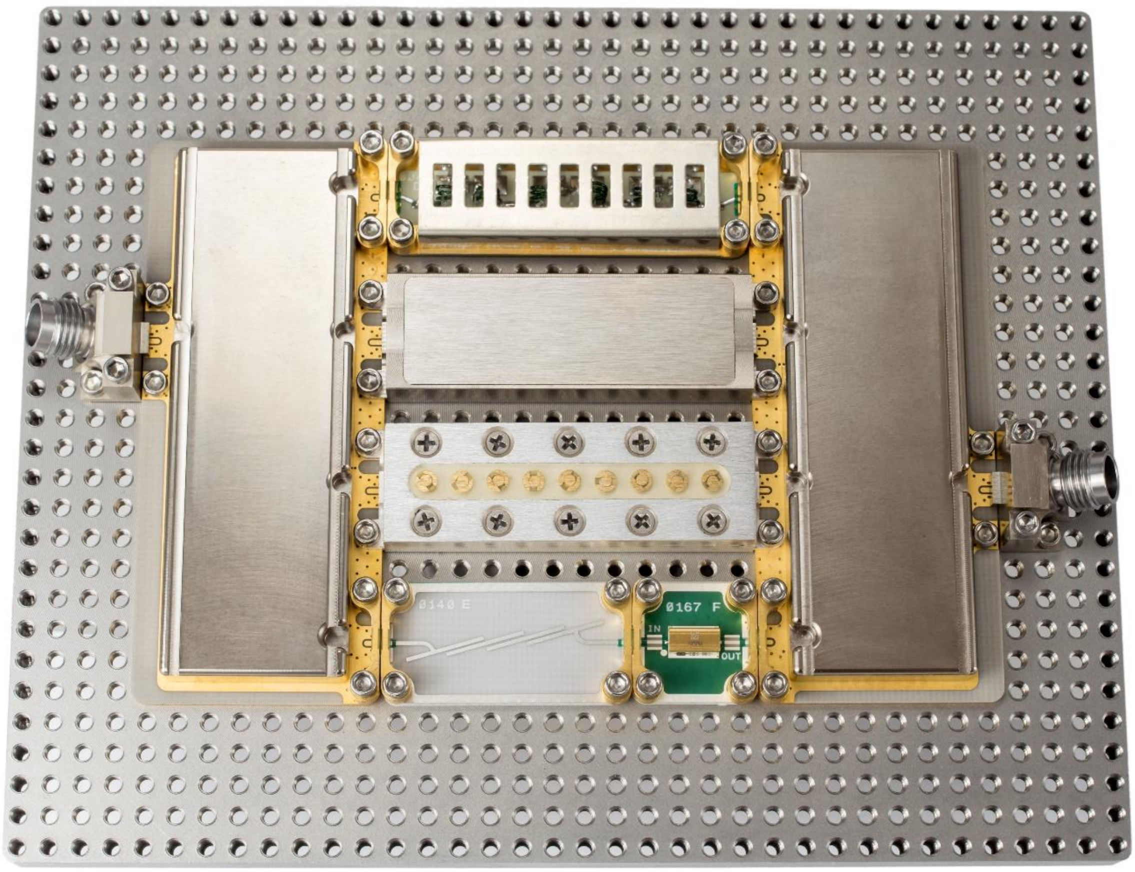


Figure 6. A 12 GHz 4-Way Switched Filter Bank that uses five different filter types.

Get on the Grid

Every now and then it's good to take a step back and consider a different approach. This exciting new physical implementation of established filter technology offers a fresh opportunity to innovate with fast-turn products.