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Smaller Filters Screen Shrinking RF Circuits

Microwaves and RF
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The relentless trend for miniaturization in high-frequency electronics has RF/microwave filter designers looking for new ways to create high-performance filters in a fraction of the size.

Squeezing high-frequency components into increasingly smaller systems has become the norm. Filters are no exception, with the latest design and fabrication techniques aimed at fitting them into minuscule, high-power-level packages. A growing number of filters of every type now come in surface-mount-technology (SMT) packages for ease of mounting on printed circuit boards (PCBs), while miniature filters in pin packages simplify the integration of filters into multilayer PCBs.

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Needless to say, more services are being packed into available wireless bandwidths. And with the coming deluge of Internet of Things (IoT) devices, which will automate homes and automobiles, and link people to things as well as machines to machines (M2M), filters become more important than ever at doing what they do quite well: Keep RF and microwave signals free of interference from the many signals surrounding them.

Filters achieve this goal by means of numerous spectral responses: bandpass, high-pass, low-pass, and band-reject (or notch). Specifying a filter starts with deciding which response is best for a particular requirement, such as a bandpass filter for minimizing the noise and loss of a signal at a particular center frequency and eliminating surrounding signal interference in the frequency bands above and below the center frequency.

Quite simply, a filter should pass desired signals with as little distortion or change in amplitude, phase, and delay characteristics as possible, and provide as much attenuation of unwanted signals as possible. These functions can be described in various ways, by means of a series of specifications that include definitions (such as 3 dB) for bandwidth and parameters for maximum power-handling capability, operating temperature range, and package style.

Facilitating Finding Filters

One long-time supplier of RF/microwave filters, K & L Microwave, developed an online tool to simplify the task of finding the right filter for a job. The firm's Filter Wizard software allows specifiers to "fill in the blanks" when it comes to the requirements for a particular filter application. This includes whether the filter is defined according to its 0.5-, 1.0-, or 3.0-dB bandwidth, its required maximum power level, filter response type (with graphical depictions of bandpass, band-reject, low-pass, and high-pass shapes), spurious levels, connector types, and operating temperature for performance specifications (–40 to +85°C, 0 to 50°C, or room temperature of +25°C).

Once a set of specifications are entered into the software program, it searches through all of the firm's filter products for the best match, saving the tedious task of downloading and comparing datasheets. The firm offers fixed-frequency as well as tunable-frequency filters with a wide range of package and connector options.

Space-Saving Examples

RF/microwave filters continue to shrink in size for a given frequency and power rating, leveraging advances in the quality of substrate materials such as ceramic and polytetrafluroethylene (PTFE) PCB material reinforced with glass and/or ceramic fillers. Filter designers are also experiencing increased demand for smaller, low-loss ers in portable communications devices, especially as communications-signal density increases within each nmunications protocol, e.g., Bluetooth, Wi-Fi, and LTE wireless standards.

As an example of a more traditional filter design, Anatech Electronics recently introduced a bandpass filter for Wi-Fi applications, with a 22-MHz passband from 2426 to 2448 MHz. Available in versions for indoor or outdoor use, the model WIFI2437-6 *(Fig. 1)* is a cavity filter built to handle as much as 20-g shock and vibration and up to 50-W CW power. The filter exhibits insertion loss of 3 dB or less across the passband, with more than 60-dB rejection of out-of-band signals and more than 90-dB high-side signal rejection. The filter is robust, measuring 4.25 × 2.20 ×1.00 in. with Type N coaxial connectors and operating at temperatures from –40 to +85°C.

Bandstop or band-reject filters can also provide effective separation of closely spaced wireless signals, such as the model 18704 bandstop filter from Microwave Filter Company. Designed to isolate the 700- and 800-MHz frequency bands, the filter passes 800-MHz mobile-radio signals with minimal loss while rejecting public-safety radio signals in the 700-MHz range.

The 18704's passband loss is typically only 1 dB while the out-of-band rejection increases close to 800 MHz, with 45-dB rejection from 763 to 777 MHz, 60-dB rejection from 77 to 787 MHz, and 70-dB rejection from 787 to 794 MHz. The filter, which can handle power levels to 40 W CW, comes with BNC female coaxial connectors. It measures 10.43 × 5.18 × 2.39 in. (26.5 × 13.2 × 6.10 mm).

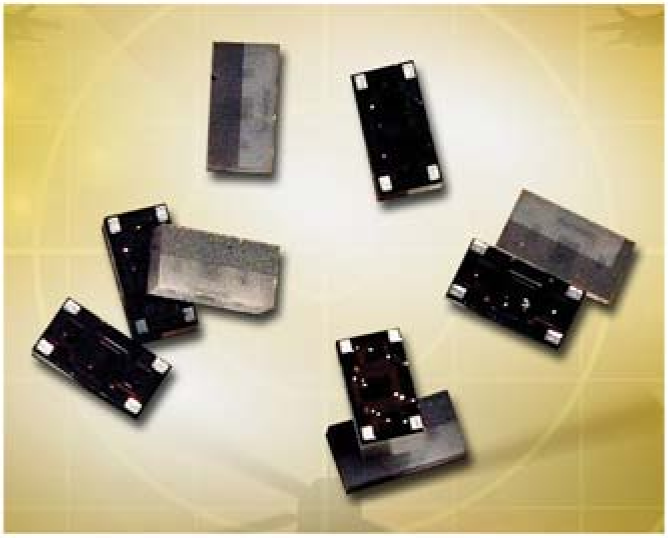
Some designers save space by integrating filters with other components required in a system, such as the 803437 series of switched filter/amplifier units from Bree Engineering. These modules, measuring 3.0 × 6.0 × 1.2 in. (excluding SMA or TNC connectors), integrate filters, amplifiers, and switches to cover multiple passbands within the 20-MHz to 6-GHz frequency range. With switching speed of 5 µs or better, these modules are suitable for saving space in demanding communications, electronic countermeasures (ECM), and radar systems. They can handle temperatures from –40 to +85°C and even include a dc-dc power supply to enable the use of a wide range of voltage supplies.

As filters shrink, the power ratings shrink with them, although board-level connectors generally are not required to pass more than about one watt (+30 dBm) of signal power. Impressive for its size and power, model SXBP-1940+ is one of a line of SMT bandpass filters from Mini-Circuits for applications from 2 to 8750 MHz. This particular bandpass filter measures just 0.44 × 0.74 × 0.27 in. (11.18 × 18.80 × 6.86 mm) but handles power levels to 6 W. The filter features a passband from 1710 to 2170 MHz with 1-dB typical passband insertion loss and more than 20-dB out-of-band rejection. It has an operating temperature range of –40 to +85°C.

Smaller is Better for Miltary Apps, Too

Small filter size should not be totally synonymous with commercial wireless applications, since military and aerospace customers can also benefit from more compact, lighter-weight components, whether on the ground or in space. As an example, Instec LLC, a supplier of filters for screening electromagnetic interference (EMI), recently achieved certification to the U.S. Department of Defense (DoD) specification MIL-PRF-28861 for a ıiature EMI feedthough filter *(Fig. 2)*. The filter will be used to suppress EMI in a U.S. government space gram.

The bolt-style, resin-sealed EMI filter is rated for 5 A and 100 V dc. It features an operating temperature range of –55 to +125°C, and provides 25-dB EMI suppression at 100 MHz and 40-dB suppression at both 1 and 10 GHz. The device consists of a silver-plated brass case and silver-plated copper nail-head lead.



A pair of integrated-thin-film (ITF) 512- and 700-MHz low-pass filters from AVX Corp. rate among the smallest RF/microwave filters of recent vintage, measuring just 3.10 × 1.60 × 0.60 mm in 1206 packages for PCB mounting *(Fig. 3)*. The land-grid-array (LGA) filters are suitable for commercial and military communications.

In spite of the small size, they handle as much as 3-W power over operating temperatures from –40 to +85°C. According to Larry Eisenberger, Senior Marketing Application Engineer at AVX Corp., “Our new high-performance, low-pass ITF filters provide wireless systems engineers with peak performance and quality in an ultra-miniature 1206 chip size that’s compatible with the smaller and more crowded PCBs that next-generation wireless electronics frequently feature.”

The trend for smaller electronic products with more densely packed PCBs should only increase the demand for miniature filters. So far, RF/microwave product designers have been able to meet that demand, learning to combine advanced materials and packaging with innovative designs that defy the seemingly conflicting tradeoffs between small size and power-handling capabilities.

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