Say What? My Cross-talk Problem is at the Component Level? A Filter, You Say?

The oft-neglected filter takes on renewed significance for system engineers designing RF and microwave products. An industry expert offers tips to avoid interference.

The devil is in the details. For system engineers who work for U.S.-based manufacturers of RF and microwave products, that seems to be the message they are painfully discovering. As their products get rushed into the marketplace and put to the test by wireless service providers and consumers, shortcomings in frequency management come home to roost in the form of noise, cross-talk, signal dropouts and even complete transmission interruption. While the product design holds up under scrutiny on paper, test engineers are increasingly rooting out the source of the problem, and oftentimes the solution turns out to be one single component: the filter.

Air combat

Of course, the difficulty in transmitting and receiving a clear signal stems, in large part, from competition for band space. Just as surely as nature abhors a vacuum, wireless service providers are quickly filling every available frequency gap from UHF frequencies of 300 MHz, all the way up to super high frequencies of 30 GHz and beyond. Even the FCC can't bend the laws of physics, as useful bands quickly fill to capacity, forcing manufacturers to develop devices that operate within tighter and tighter bandwidths.

Take the case of cellular phone service providers, who, despite utilizing competing multiplexing protocols, still run into conflict when signal frequencies are adjacent to each other. For instance, the CDMA passband ends at 888.9 MHz, quickly followed by the GSM 900 passband, which begins at 890.1 MHz. With only 1.2 MHz of space between the two, there is little room for error. Harmonics and other spurious signals add to the challenge of maintaining distinct borders between the two.

The only sentinels in guarding against interference across such relatively narrow gaps are filters. Using the above example: without sufficient filtering of GSM signals below 890 MHz, blocking and intermodulation can occur at the high end of the CDMA passband.

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In general, the consequences of inadequate filtering translate into cross-talk and dropped calls for the cellular phone consumer; and loss of data and interrupted network connections for wireless LAN and WAN users. For the service provider, loss of customers and market share represent the ultimate price to pay for failing to focus on filtering.

Too big a picture?

So how is it that some U.S.-based manufacturers of wireless products have lost touch with the fundamentals, such as proper filtering? Consider that much of the design process of subassemblies has now been farmed out to offshore manufacturers. Few, if any, local manufacturers can afford to compete on a mass scale when it comes to cranking out circuit card assemblies that perform simple functions such as frequency generation.

Rather, many on-shore designers spend their time at the line replaceable unit (or "box") and system level, combining the various subassemblies to ultimately create the finished goods. The result is a product that oftentimes looks good in theory, but fails to deliver when put in the field. Oftentimes, the problem often arises at the component level, and in cases of interference, the filter usually lies at the root of problem.

Back to the component level - an expert offers solutions

Sam Benzacar is Founder of Anatech Electronics, a Garfield, New Jersey-based manufacturer that specializes in filters. With three decades of experience in the RF and microwave filter industry, Benzacar provides the following tips on improving the performance of wireless products.

1) Don't make the filter an afterthought.

"Imagine getting your design out in the field only to discover bad reception," says Benzacar. "This happens only too often, especially in active metropolitan areas, and it usually occurs because little forethought was given to filter performance."

Benzacar points out that once a defective product is deployed into the field, the cost to remedy the problem—by sending out field technicians to swap out the parts at base stations, for example - almost always exceeds any up-front expense to upgrade filter performance in the first place.

"Instead, at the start of design, look at the frequencies around the target band and ask what conflicting signals could appear in your specified time frame," advises Benzacar. "Preparing for interference at the start of design will more than pay for itself."

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2) Insist on a filter with sharp cut-off and isolation.

"A filter screening out a signal just 3 MHz away must be able to reject over 40 dB of signal strength outside its passband," explains Benzacar. "Filters today must exhibit sharp cut-off characteristics, and this requirement becomes all the more important as various frequency bands close in on each other."

On duplexers, for example - which are necessary for any simultaneous send-receive communication and are essentially two bandpass filters hooked together - the filters must be especially sharp with good isolation and as little insertion or return loss as possible so that neither the send or receive frequencies will interfere with each other.

3) Don't test the product in too "friendly" an environment.

In an eagerness to rush a product to market, environmental testing can take place under artificially ideal conditions. Just because a filter may breeze through EMF testing within a lab in rural Arizona, doesn't mean that it won't cause interference, or fail to preclude spurious signals, on a corner in midtown Manhattan.

"Avoid making a product 'environmentally dependent,' forcing the customer to roll the dice when taking the product into new fields," cautions Benzacar. "Plan on incorporating filters that ensure proper performance everywhere, under various conditions."

4) Retain a filter manufacturer able to change component characteristics on short notice.

Even the best of designs are occasionally comprised by a frequency conflict that could not have been foreseen. In such instances, it pays to work with a local component manufacturer who can readily modify its filters.

"A manufacturer may have to change the center frequency of a filter to improve the performance of its device within a particular band," says Benzacar. "A cost effective way to do this without scrapping the design is to initially work with a filter manufacturer who can quickly adapt a standard offering."

For example, a design might have called out a standard filter at 915 MHz. But once tested in field, it might be determined that what is actually needed is a center frequency of 920 MHz. Filter manufacturers like Anatech can quickly and cost-effectively shift the frequency because they have full, in-house design and manufacturing capability. It's difficult to obtain that kind of response from a distributor who might be getting parts from offshore sources.

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For the same reasons, working directly with a local filter manufacturer can enable last-minute mechanical design changes when needed. Anatech, for instance, can quickly shift an input/output connector from one side of the filter to another. Such flexibility can simplify cabling and lower manufacturing costs.

5) Consider filter size with the future in mind.

"As circuit card 'real estate' gets smaller and performance demands increase, old algorithms aren't enough anymore," notes Benzacar. "So it's also important to rely on a manufacturing partner committed to developing and using the latest mathematical algorithms and techniques to optimize filter size and performance. To accommodate the need for smaller component footprints, I would say the bulk of the work we do is in custom designs. Short production runs are also common."

6) Pick a filter supplier that keeps you in the worldwide market.

To tap into the burgeoning overseas demand for wireless communication products, manufacturers must incorporate filters produced by vendors that take a proactive stance in meeting global environmental certifications such as ISO-9001-2000 and RoHS compliance.

Since 1990, Anatech Electronics has responded to the changing RF and microwave marketplace with a product line that includes: bandpass, lowpass, highpass, and bandstop filters; crystal filters; diplexers and duplexers, ceramic, cavity and monoblock filters for WIMAX applications; as well as filters for WIFI applications. All components are ruggedly built to meet stringent military and commercial specifications.

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