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Qorvo Special Edition

RF Filter Applications

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Learn:

- About Qorvo's LowDrift™ and NoDrift™ filter technologies
- Applications for duplexers, triplexers, and quadplexers
- How Qorvo addresses special filtering applications



Larry Miller

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by Larry Miller

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Introduction



The ever-increasing demand for limited space in the crowded global frequency spectrum is creating new opportunities for filtering applications. Traditional approaches to challenges such as temperature drift, for example, are no longer sufficient as frequency bands become more crowded and service providers attempt to fully utilize every bit of available bandwidth in the spectrum. Special applications for next-generation technologies, such as V2X (vehicle-to-infrastructure) communication standards and carrier aggregation, require innovative new filtering applications.

This book explores some of the innovative filtering applications that are being used to address unique challenges in the modern LTE environment.

Foolish Assumptions

It's been said that most assumptions have outlived their usefulness, but I assume a few things nonetheless.

First, I assume you have an interest in the wireless industry and filter technologies. If so, this is the book for you! If not, keep reading anyway — I'll change your mind!

Next, I assume you're a design engineer, manager, salesperson, customer, supplier, investor, or just someone who needs to know more about filter technologies. As such, this book is written for both technical and nontechnical readers.

Icons Used in This Book

Throughout this book, I occasionally use special icons to call attention to important information. Here's what to expect:



This icon points out information that may well be worth committing to your nonvolatile memory, your gray matter, or your noggin — along with anniversaries and birthdays!



You won't find a map of the human genome here (or maybe you will, hmm), but this icon explains the jargon beneath the jargon and is the stuff legends — well, nerds — are made of.



Thank you for reading, hope you enjoy the book, please take care of your writers! Seriously, this icon points out helpful suggestions and useful nuggets of information.

Beyond the Book

Although this book is chock-full of information, I can only cover so much in 24 short pages. So, if you find yourself thinking, “Gosh, this is an amazing book — where can I learn more?,” just go to www.qorvo.com and www.triquint.com. There, you can read more about Qorvo's filter solutions, download technical papers and datasheets, watch helpful videos, and much more!

Where to Go from Here

If you don't know where you're going, any chapter will get you there — but Chapter 1 may be a good place to start. However, if you see a particular topic that piques your interest, feel free to jump ahead to that chapter. Each chapter is written to stand on its own, so feel free to start reading anywhere. Read this book in any order that suits you (though I don't recommend upside down or backward).

Chapter 1

Understanding Qorvo's LowDrift and NoDrift Filters

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In This Chapter

- ▶ Understanding temperature drift
 - ▶ Addressing Band 13 challenges with NoDrift SAW
 - ▶ Handling Band 30 challenges with NoDrift BAW
 - ▶ Selecting filters for regional and worldwide applications
-

In this chapter, you learn how temperature impacts filter performance, and how Qorvo addresses temperature variation and regional challenges with its innovative LowDrift and NoDrift filter technology.

How Temperature Drift Can Consume the Entire Guard Band

The rapid growth in mobile wireless data has led to an ongoing need for new spectrum bands to accommodate traffic. Many of these new cellular bands are very close to other wireless applications, and filtering is required to manage interference between the systems. As more new bands are assigned closer to existing bands, the variation of the filters with temperature has become a much more significant design factor. Previous approaches that accepted processes with higher parts per million (ppm) drift are no longer able to meet the needs, and newer filter processes — such as Qorvo's LowDrift and NoDrift filter technology — are required.

The temperature drift of a filter is determined by the ppm/°C characteristic of the process and the temperature excursion the filter experiences in the end application. As an example, let's consider a filter with a -45 ppm/°C characteristic, a center frequency of 1,000 MHz, and an operating temperature range of -20°C to 85°C from a 25°C nominal. You can see that the temperature excursion is -20°C and 85°C. The drift is then:

Temperature drift = Temperature excursion × center frequency × temperature characteristic

Cold drift = -45°C × 1,000 MHz × -45 ppm/°C = 2.025 MHz

Hot drift = 60°C × 1,000 MHz × -45 ppm/°C = -2.70 MHz

The frequency of the filter and the environmental operating condition of the end product are usually fixed, so the only way to minimize the drift is to use a process with a lower inherent temperature characteristic, such as Qorvo's LowDrift and NoDrift filter technology.

Qorvo's LowDrift and NoDrift Filter Technology

One way that Qorvo is solving the problems of temperature drift is through its LowDrift and NoDrift filter technology, which greatly improves temperature performance. LowDrift surface acoustic wave (SAW) achieves a value of -15 ppm/°C to -25 ppm/°C, while NoDrift SAW reduces this even further to essentially 0 ppm/°C. NoDrift bulk acoustic wave (BAW) achieves similar temperature performance to NoDrift SAW. These technologies enable Qorvo to offer highly temperature-stable solutions across the entire range of mobile filters.



Learn about the basics of LowDrift and NoDrift filter technology in Chapter 2 of *RF Filter Technologies For Dummies*.

Qorvo's advances in temperature-compensated LowDrift and NoDrift technology enable its BAW and SAW products to meet more demanding performance requirements for new and emerging applications. NoDrift and LowDrift technology brings the following benefits:

- ✓ Lower insertion loss, steeper filtering skirts, and more stable filtering performance than non-temperature-compensated SAW and BAW filters
- ✓ Better receive sensitivity, isolation, and rejection

For mobile device users, these technical advantages mean higher data rates, fewer dropped calls, longer battery life, and simultaneous data and voice capabilities. For device designers, Qorvo's premium filters help simplify radio frequency (RF) design and enable LTE advances.

Looking at an Example in SAW Technology

One example of a SAW filter that takes advantage of this temperature stability to meet challenging specifications is Qorvo's TQQ1013. It uses NoDrift SAW technology to support Band 13 uplink (777 to 787 MHz), which is close to the U.S. public safety band (769 to 775 MHz), as shown in Figure 1-1. A network signaling case (NS_07) is defined in which the network signals mobile devices when there is a narrowband public safety system in the area. In response to this signaling, mobile devices need to improve their emissions in the 769 to 775 MHz range by 22 dB.



Figure 1-1: Band 13 spectrum.

In the initial development of Band 13, the only feasible way to get this emissions improvement was to reduce the output power of the mobile device. The required reductions were a function of the number and location of the reference blocks in the uplink transmission. The worst-case values of these reductions are significant, ranging as high as 12 dB.

Reductions this high have a significant impact on system performance, and the operators using Band 13 have long wanted a solution that would address the interference issue without requiring large reductions in output power. Filtering solutions must provide 22 dB of attenuation (the emissions specification improvement) at 775 MHz, while still passing 777 MHz (the lower edge of Band 13).

Complicating this problem is the need to meet this attenuation over temperature. Figure 1-2 shows the drift of industry-standard SAW filters and Qorvo's LowDrift and NoDrift SAW. Given that the space between the passband and stopband is 2 MHz, it's clear that only the most temperature stable of filter processes — Qorvo's NoDrift SAW — can be used for this requirement.

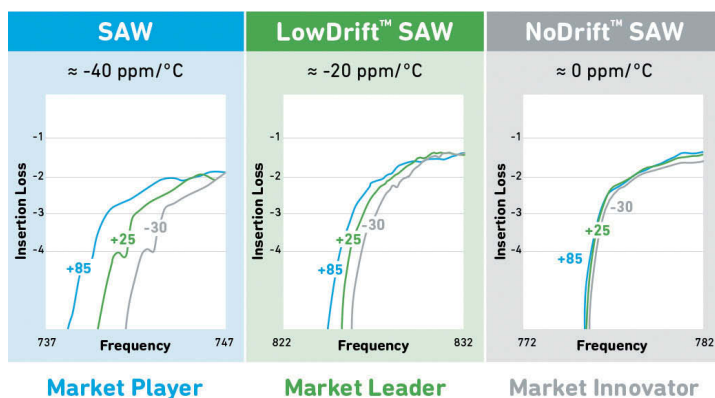


Figure 1-2: Temperature drift of Qorvo's LowDrift and NoDrift SAW filters.

Looking at an Example in BAW Technology

LowDrift and NoDrift BAW filters are effective in the same frequency range as BAW and are also equally well suited to 3G and 4G filters and duplexers. One example using this technology is Qorvo's TQQ1030 Band 30 duplexer, which uses NoDrift BAW.

This Band 30 transmit (Tx) filter must help support a stringent spectrum mask (see Figure 1-3). This band is located below a satellite radio service, and emissions into the satellite service must be minimized. The mask is also constrained to minimize emissions below Band 30 government usage bands.

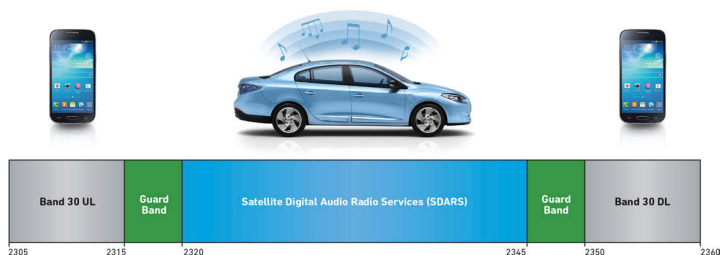


Figure 1-3: Band 30 spectrum.

The required filter response to achieve the spectral emission mask is shown in Figure 1-4. The passband is 2,305 to 2,315 MHz and the most difficult attenuation points are at 2,296 and 2,324 MHz. These are both 9 MHz away from the passband edge and require 11 dB of absolute attenuation.

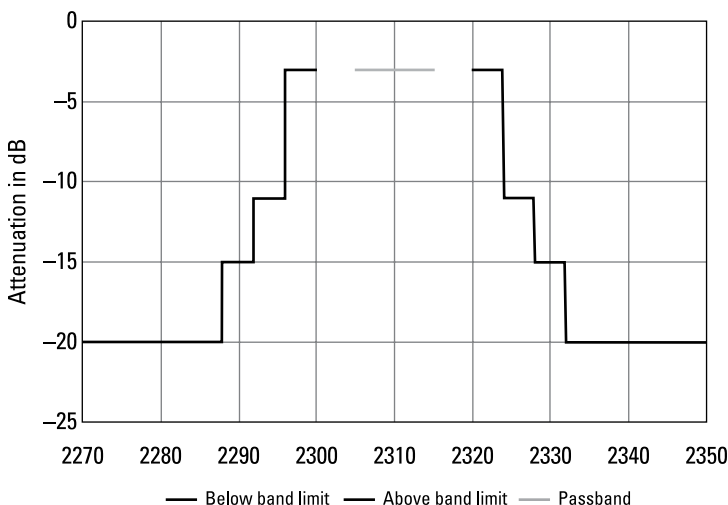


Figure 1-4: Band 30 Tx filtering requirements.

As in the case of Band 13 (discussed earlier in this chapter), there is a need to meet this attenuation requirement over temperature. Figure 1-5 shows the drift of Qorvo's LowDrift and NoDrift BAW filters compared to competing FBAR BAW technology. Although LowDrift BAW is an excellent choice for many applications, the very demanding emissions mask and high frequency in this case require the improved temperature stability of NoDrift BAW.

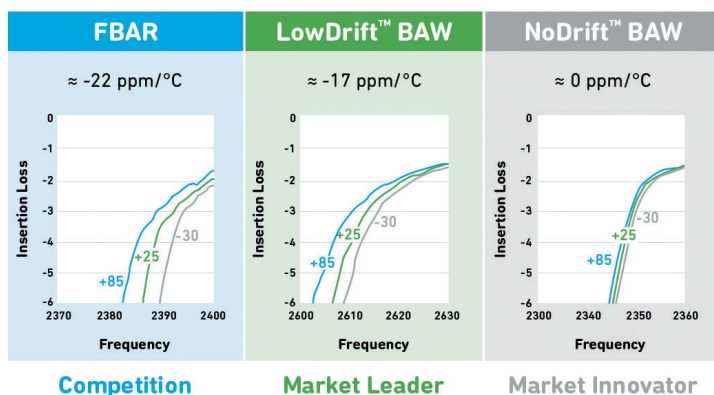


Figure 1-5: Temperature drift of Qorvo's LowDrift and NoDrift BAW filters.



BAW filters are inherently less sensitive to temperature change than standard SAW filters. LowDrift and NoDrift BAW reduce temperature sensitivity even further, making this technology ideal for extremely challenging applications in frequency ranges handled by BAW.

Selecting the Right Filters for Regional Applications

To add to the complexity, smartphone designers must also account for regional and carrier requirements, as well as global roaming for high-end next-generation devices. The filtering requirements vary in each region or country because of local differences in spectrum allocation, and the situation will only become more complicated as more LTE bands are allocated. Some bands are tougher than others, depending on the region where the device will be used.

For instance, in North America, Bands 13 and 30 (highlighted earlier in this chapter) are particularly challenging due to coexistence issues, while a designer supporting roaming across Europe must pay special attention to Bands 3, 7, 20, and 38. For Asia, the question for manufacturers is whether to build phone designs that can be used throughout the entire region or only for individual Asian countries. China has a huge market potential and its own unique requirements, such as Bands 40 and 41 and the country's predominance of TDD-LTE technology (in contrast to most of North America, which uses FDD-LTE). Along with Japan and the U.S., Korea is one of the top three adopters of LTE and has distinct needs, including Bands 3, 5, 7, and 26. Japan, in contrast, is unusual in its use of Bands 26, 11, and 21, as well as Band 41.

With their low insertion loss and extremely precise selectivity, Qorvo's LowDrift and NoDrift filters can help solve the toughest interference and coexistence challenges worldwide. They enable operators and manufacturers to deliver higher speeds and greater bandwidth by utilizing spectrum that might be lost with older filtering technologies.

But which technology is appropriate for which band or region? Table 1-1 identifies the filter technologies that designers should consider as they seek to build devices to serve each regional market.

Table 1-1 Recommended Filter Technologies by Band and Region

<i>Band</i>	<i>Filter Technology</i>	<i>Region(s) of Usage</i>	<i>Duplexer/ Filter Mode</i>
1	SAW	Asia, EMEA*, Japan	FDD
2	LowDrift BAW	Latin America, North America	FDD
3	LowDrift BAW	Asia, EMEA	FDD
4	SAW	Latin America, North America	FDD
5	SAW	Latin America, North America	FDD

(continued)

Table 1-1 (continued)

<i>Band</i>	<i>Filter Technology</i>	<i>Region(s) of Usage</i>	<i>Duplexer/ Filter Mode</i>
7	LowDrift BAW	Asia, EMEA	FDD
8	SAW/LowDrift SAW	EMEA, Latin America	FDD
12	SAW	North America	FDD
13	NoDrift SAW	North America	FDD
17	SAW	North America	FDD
20	SAW/LowDrift SAW	EMEA	FDD
23	LowDrift BAW	North America	FDD
25	LowDrift BAW	North America	FDD
26	LowDrift SAW	Japan, North America	FDD
27	SAW	Latin America	FDD
28	SAW	Asia, Latin America	FDD
29	SAW	North America	FDD
30	NoDrift BAW	North America	FDD
32	SAW	Japan, EMEA	FDD
34	LowDrift BAW	China	TDD
38	LowDrift BAW	Asia, EMEA	TDD
39	LowDrift BAW	China	TDD
40	LowDrift BAW	China, India	TDD
41	LowDrift BAW	China, North America	TDD
42	LowDrift BAW	Japan, EMEA	TDD
43	LowDrift BAW	EMEA	TDD

* Europe, the Middle East, and Africa



See Qorvo’s Advanced Filtering Solutions Brochure at www.qorvo.com/brochures for additional details on key frequency bands and regional considerations. See Chapter 1 in *RF Filter Technologies For Dummies* for an overview of FDD-LTE and TDD-LTE and the role of duplexing.

Chapter 2

Taking the Complexity Out of Duplexers, Triplexers, and Quadplexers

In This Chapter

- ▶ Discovering duplexers
- ▶ Taking on triplexers
- ▶ Understanding quadplexers

In this chapter, you learn about duplexers, triplexers, and quadplexers, and their filtering applications. Don't get perplexed — it's not as complex as it sounds!

Duplexers, triplexers, and quadplexers are all part of a class of devices called *multiplexers*. Multiplexers have a single input port and multiple output ports. Multiplexers are a set of non-overlapping filters that are combined in such a way that they don't load each other and achieve high levels of isolation between the outputs.

Duplexers

A duplexer combines two filters (transmit and receive) and shares a common node (antenna), allowing a device to transmit (Tx) and receive (Rx) simultaneously (see Figure 2-1).

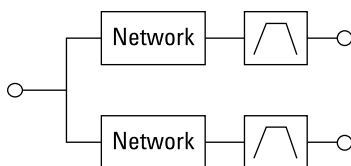


Figure 2-1: A duplexer.

Duplexers are commonly used in frequency division duplexing (FDD) radio applications where one filter is a Tx filter and the other filter is a Rx filter. Duplexers are designed so that the passbands of each filter don't load the other filter. In addition, it's important that the transmit signal appearing at the output of the receive filter be attenuated significantly. This high level of isolation is required so that this signal doesn't overdrive the front end of the receive. This is often referred to as transmit-receive (Tx-Rx) isolation at the Tx frequency, and values of 55 dB or higher are common.

There is also a requirement for high Tx to Rx isolation at the receive frequency. This is to prevent noise at wide offsets from the transmit signal (that is, at the receive frequency) from appearing at the receiver input and degrading sensitivity. These two isolation requirements form the *in-band isolation requirements* — the Tx and Rx filters are for the same band. We will look at cross-band isolation requirements in higher-order multiplexers in the “Quadplexers” section later in this chapter.

Qorvo makes a large variety of duplexers in both SAW and BAW technologies. Some examples are the TQQ1013, the Band 13 NoDrift SAW duplexer (see Chapter 1), and TQQ1007, which is a Band 7 LowDrift BAW duplexer. (Learn more about Qorvo's duplexers at www.qorvo.com and www.triquest.com.)



Don't confuse duplexers and diplexers! A diplexer allows two different *devices* to share a common communications channel. A diplexer may be used as a duplexer, but a duplexer is not a diplexer.

Triplexers

A triplexer combines three filters (or ports) and shares a common node (or port) as shown in Figure 2-2. Triplexers have the same passband loading and isolation goals as duplexers. Examples of triplexers are Band 12/13 and Band 1/4 triplexers.

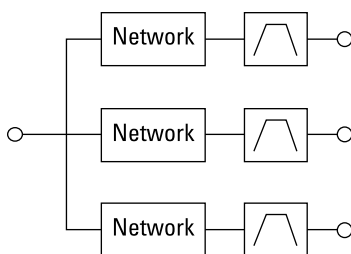


Figure 2-2: A triplexer.

A common application of a triplexer in FDD systems is to save board space by combining what would normally be done with two duplexers into a triplexer. Examples are shown in Figure 2-3. On the top, Bands 12 and 13 are combined into a single triplexer because their receive or downlink (DL) bands are adjacent to each other. A single wider filter to combine both of these is created and the three filter structure results. On the bottom, Bands 1 and 4 are combined into a single triplexer because the DL for Band 4 is a subset of the DL for Band 1.

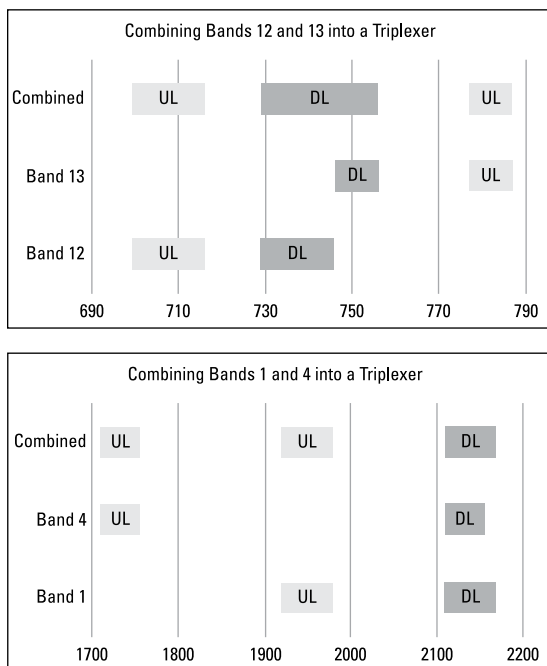


Figure 2-3: Examples of combining two duplexers into a triplexer.

Quadplexers

A quadplexer combines four filters with a common node (see Figure 2-4). Quadplexers have the same passband loading and isolation goals as duplexers. Examples include Band 25/4 and 1/3 quadplexers. Quadplexers allow two bands to be connected to the antenna at the same time, which is very useful for things like carrier aggregation where a handset may want to receive on two bands at the same time. (I discuss carrier aggregation in Chapter 3.) Quadplexers are more complex than duplexers and triplexers because the filters must be designed together to meet stringent cross-isolation specifications.

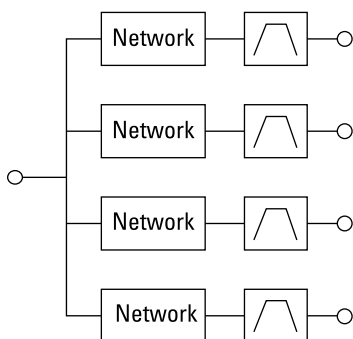


Figure 2-4: Quadplexers.

Cross-isolation refers to isolation across bands. Recall that a duplexer requires the Tx signal to be attenuated significantly at its corresponding Rx frequency output. For a quadplexer, the Tx signal needs to be attenuated significantly at both Rx outputs. Similarly, isolation of the Tx signal at the Rx frequency to control noise in the Rx band now must also apply at both Rx outputs. When you consider all the cases, there are eight isolations in a quadplexer that are important versus two in a duplexer!

Chapter 3

Special Filtering Applications

In This Chapter

- ▶ Addressing coexistence challenges
 - ▶ Exploring diversity filter situations
 - ▶ Understanding carrier aggregation
 - ▶ Looking at network infrastructure applications
-

In this chapter, you learn about some unique challenges that can be addressed with filtering applications.

Coexistence Filters

The demand for faster wireless networks to support bandwidth-intensive applications (such as web browsing and video streaming) is fueling the growth of LTE-enabled smart mobile devices with Wi-Fi capability. Within the 2.4 GHz Wi-Fi band, there is an increased potential for interference with cellular communications — notably LTE networks — that use closely adjacent frequency bands (see Figure 3-1).

Designers therefore must address the potential for transmitted Wi-Fi signals to desensitize LTE reception on the device, and for LTE signals to interfere with Wi-Fi communications. The challenges will increase as the complexity of mobile devices grows; many next-generation smartphones will support significantly more radio frequency (RF) bands than earlier-generation models.

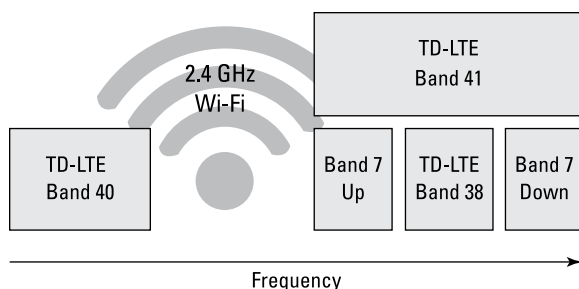


Figure 3-1: The challenge of LTE/Wi-Fi coexistence.

Solving this Wi-Fi coexistence challenge requires RF filters that are capable of rejecting closely adjacent frequencies. At the same time, the filters must minimize insertion loss in the Wi-Fi transmission pathway, to help maintain the high signal-to-noise ratio and correspondingly low error vector magnitude (EVM) required for 802.11n and 802.11ac.

Qorvo's bulk acoustic wave (BAW) filters are particularly effective at meeting these requirements, offering significant advantages over the surface acoustic wave (SAW) and ceramic filters traditionally used for cellular Wi-Fi applications. In the several-gigahertz operating range, Qorvo's BAW filters can achieve quality factors (Q values) that are superior to other traditional acoustic technologies. As a result of the high Q values, the filter skirts will be very steep while insertion losses remain low even at the edges of the passband. Some examples of Qorvo's high-performance BAW coexistence filters are the 885032, 885033, 885070, and 885067. (You can find more information on these filters at www.qorvo.com and www.triquint.com.)

Qorvo's BAW devices also have unmatched temperature stability. Looking ahead to future coexistence applications, BAW filters can address frequencies up to 6 GHz, while the performance of conventional SAW filters degrades at higher frequencies and reaches its practical limits at 2.5 GHz.

Diversity Modules

Modern smartphones typically incorporate multiple wireless technologies covering a broad range of wireless spectrum, from FM radio and Bluetooth to Wi-Fi and LTE. To support all this functionality, smartphones today use multiple antennas.

So, what is antenna diversity and why is it required? In simplistic terms, *antenna diversity* means using multiple antennas to receive the same signal and is required to improve the quality and reliability of a wireless link. Diversity can be implemented using a discrete SPxT switch and external diversity filters, or it can be integrated into one module, as shown in Figure 3-2.

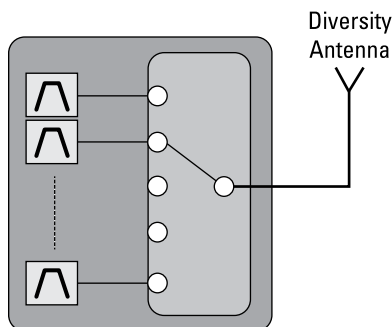


Figure 3-2: An integrated diversity module.

Manufacturers of mass-market smartphones that are not designed for global coverage and are targeted for lower cost may still prefer to use discrete components because they allow design flexibility. However, high-end smartphones with global coverage are faced with compact profiles (hence, the need for diversity modules).

Leveraging Qorvo's world-class filter technologies, diversity modules are another testament to Qorvo's broad portfolio of products for the fast-growing cellular market.

Carrier Aggregation

Network operators are striving to improve network performance in the face of increasing demands for data. Higher data rates are required to maintain the customer experience, and the direct path to achieve this is increased bandwidth. Carrier aggregation (CA) is a feature of 4G LTE-Advanced that allows service providers to offer higher data rates by bonding blocks of spectrum into a wider channel (see Figure 3-3). CA became

a major trend in 2014, and markets leading in LTE deployment will be the first to utilize CA.

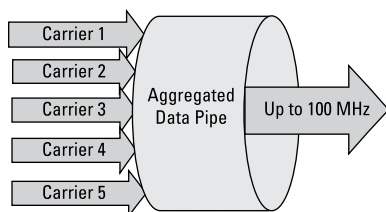


Figure 3-3: Carrier aggregation for faster throughput.

CAs are divided into three types, as shown in Figure 3-4. The first type is *inter-band aggregations* and refers to the aggregation of spectrum in different bands. These bands may be widely separated or close together. Widely separated aggregations are the easiest to implement, requiring only a diplexer. Bands that are closer together may require a quadplexer or multi-antenna solutions to address.

The other two types of aggregations involve bonding of spectrum within the same band. If the spectrum blocks are adjacent, they're called *intra-band contiguous aggregations*. If the blocks are separated, they're called *intra-band non-contiguous aggregations*.

Aggregations pursued by operators vary in response to spectrum holdings, their geographic distribution, and the amount of bandwidth to aggregate. Initial deployments were two-carrier aggregations and used widely separated bands. As the need to aggregate greater bandwidth has emerged, three-carrier aggregations are being proposed. Three-carrier aggregations significantly increase the probability of using close-together bands and will drive the development of quadplexers, which I discuss in Chapter 2.

CA impacts filter designs in several ways. The diplexers that are used to split the signals for widely separated aggregations create extra loss, which low-loss filters must then compensate for. Filter stopband attenuation must also be planned to ensure adequate attenuation in the other band(s) that will be aggregated together. Finally, bands that are close together require more complex multiplexers.

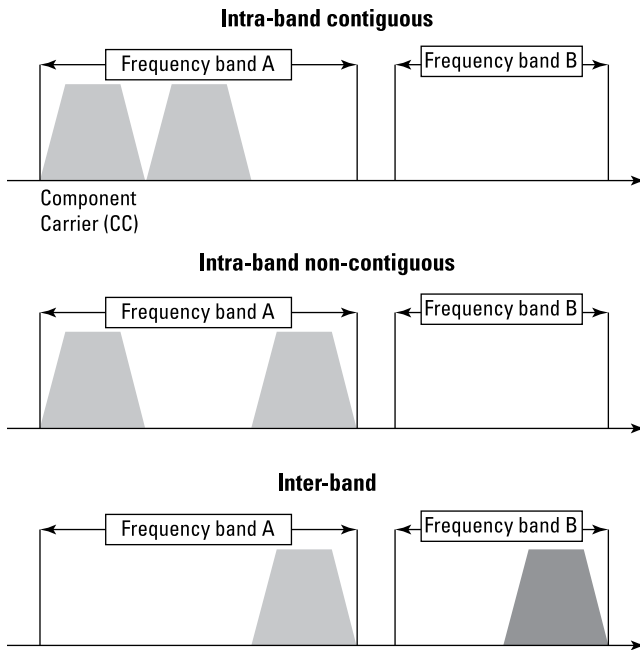


Figure 3-4: Types of carrier aggregation.

Network Infrastructure and Automotive Applications

Qorvo's filters can also have many applications in network infrastructure and the automotive market, including the following:

- ✓ **Intermediate frequency (IF) filters:** IF filters support lower frequencies than RF filters and remain a strong component of base station radio architectures. Qorvo's IF filters enable large bandwidth and excellent passband flatness and ripple over large temperature ranges up to -40°C . An example of an IF filter is Qorvo's 857218, which is a low-loss filter covering more than 44 percent fractional bandwidth.
- ✓ **Small cell base stations, including pico cells:** Pico cells, cellular repeaters, and distributed antenna systems (DAS) are set to grow significantly to augment existing macro cell networks, especially in high population-density or urban

areas. Qorvo has a unique advantage because it provides a full suite of duplexers and RF filters for all LTE frequencies using both SAW and BAW, which very few other companies can. Qorvo's products enable small size and offer high power handling capability (27 to 30 dBm), low insertion loss, and excellent isolation — all of which are a premium for small cell applications.

✓ **Filters in automotive applications:** Similar to the trends in mobile devices, “connected vehicles” are adopting connectivity standards such as LTE, Wi-Fi, Bluetooth, GPS, and satellite digital audio radio service (SDARS), to support a wide variety of services including safety and infotainment. Additionally, filters in automotive applications must comply with the stringent reliability standards defined by the Automotive Electronics Council (AEC). Qorvo's filters — such as the 885062 BAW bandpass filter and 885014 Band 30 NoDrift BAW filter, both of which are AEC-Q200 certified — enable the coexistence of signals in this tightly packed spectrum without interference.

BAW filters will also provide the selectivity necessary for digital short-range communications (DSRC) at 5.9 GHz, which will be used for vehicle-to-vehicle communications. Steep band-edges are needed in this band to allow proximity to Wi-Fi and e-toll systems.

Chapter 4

Ten (Or So) Key Filter Market Trends

In This Chapter

- ▶ Identifying trends you should know about
- ▶ Seeing how these trends will affect you

Here are ten (or so) important trends to remember about filter technologies:

- ✔ New frequency bands are increasingly packed closer and closer together. This can lead to a situation where the temperature drift of the filter response can be greater than the transition region between stopbands. Next-generation smartphones will demand higher performance and new technologies to support these new bands.
- ✔ Qorvo has developed LowDrift and NoDrift filter technologies to address these challenging temperature drift situations. NoDrift surface acoustic wave (SAW) and bulk acoustic wave (BAW) technologies help achieve a near-zero temperature coefficient of frequency (TCF) across -20°C to 85°C .
- ✔ In late 2013, a leading North American carrier required stringent standards for attenuation of the public safety band that is in between Band 13. Qorvo developed its NoDrift SAW technology in response to this new standard.
- ✔ Multiplexers — such as duplexers, triplexers, and quadplexers — combine multiple frequencies into a single device, which saves board space and simplifies

radio frequency (RF) design. Multiplexers have a common input and are designed to achieve low insertion loss along with high isolation between the outputs.

- ✔ Carrier aggregation (CA) will allow carriers to use increased bandwidth to get higher data rates. Quadplexers are one common method to support closely spaced CAs.
- ✔ With more smartphones simultaneously supporting 2.4 GHz Wi-Fi and LTE Band 40, Band 7, Band 38, and Band 41, the need for Wi-Fi coexistence filters has skyrocketed. Qorvo's BAW coexistence filters offer significant advantages over traditional SAW and ceramic filters used for cellular Wi-Fi applications.
- ✔ Today's smartphones employ antenna diversity — using multiple antennas to receive the same signal — to support a broad range of wireless spectrum. Lower-end smartphones may use multiple discrete switches and diversity filters to maximize flexibility, while high-end devices may use integrated diversity modules to save precious board space.
- ✔ Stringent space and size constraints in small cell base stations are making it necessary for systems designers to choose SAW and BAW filters over ceramic or cavity filters. Qorvo is the world leader in offering a broad range of RF filters, duplexers, and multiband filter modules to serve pico cell market requirements.
- ✔ “Connected vehicles” are adopting all interface standards such as LTE, Wi-Fi, Bluetooth, GPS, and vehicle-to-infrastructure (V2X) for a wide range of services such as safety and infotainment. Qorvo filters enable the coexistence of this tightly packed spectrum without interference.

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