qorvo

Next-Gen Wi-Fi Applications and Solutions | Design Guide

MOUSER ELECTRONICS

A Successful Journey Begins with Vision

Solving problems, simplifying and improving lives. At Qorvo, we envision this and so much more.

We are helping customers at the center of communication, building solutions that meet the growing demands of a connected world. Our radio-frequency (RF) expertise and core technologies are critical and life-changing, and our values and commitment to a better world are serving on the ground, at sea and in the air.

Qorvo is ready today with next-generation RF smarts and solutions that Connect, Protect and Power™ people, places and things—faster and further with more reliability. We power more efficient networks and devices, mission-critical defense systems, and emerging commercial and consumer applications.

Qorvo's products have been used in radar, tactical radio, and electronic warfare systems for years. Now our products using GaN, GaAs, silicon, BAW and SAW technologies are being used in wireless infrastructure for emerging 5G networks.

Now, as we are in the midst of The Internet of Things, Qorvo leverages its RF expertise to provide unique and future-proof solutions like our multi-protocol communication controller chips. These ultra-low power, wireless data communication controller chips enable IoT and smart home applications today that will be compatible tomorrow.

Cees Links, who leads Qorvo's Wireless Connectivity business, was the founder and CEO of GreenPeak Technologies. Cees is a Wi-Fi industry visionary who led the development of the world's first wireless LANs and pioneered the development of access points, home networking routers and hotspot base stations. He was involved in the establishment of the IEEE 802.11 standardization committee and the Wi-Fi Alliance and was also instrumental in establishing the IEEE 802.15 standardization committee to become the basis for the Zigbee® sense and control networking.

At Qorvo, what we do matters. We see a future where you remotely control all aspects of connected living, where medical conditions are proactively managed, where your car is self-driving, your reality can be virtual, and new possibilities emerge. A future where our core technologies bring people closer to new frontiers.

Qorvo is all around you—making a better, more connected world possible.

Rodney Hsing
Qorvo Sr. Director of Global Distribution

Wi-Fi 6
What's It All About?

Cees Links GM of Qorvo Wireless Connectivity Business Unit, Formerly Founder & CEO of GreenPeak Technologies

Is Wi-Fi Running Out of Steam?

Despite that nobody could keep track of the array of acronyms underlying Wi-Fi (IEEE 802.11b, .11a/g, .11n, .11ac), the good news was that each new version was a clear step forward in raw data rate. In four generations, that rate went from 11Mb/s to 6.9Gb/s—an increase of more than 650 times.

After all, raw data rate is the "name of the game." This comes as no surprise because Wi-Fi is about pure high-speed data communication.

Now there is the imminent arrival of the new standard, IEEE 802.11ax, with a maximum raw data rate of 9.6Gb/s. This standard has been given a "jazzier" name: Wi-Fi 6. But given its slow appearance and marginal raw data rate improvement, one might wonder if this is an indication that Wi-Fi is running out of steam.

Don't be fooled! Underneath the acronym, there is a real shift going on from raw data rate toward multichannel capacity and improved spectral reuse. This means that the real-life throughput experience of Wi-Fi 6 might be an increase of as much as four times compared to its predecessor Wi-Fi 5 (.11ac). On top of this, Wi-Fi 6 does away with the different network IDs for 2.4GHz, 5GHz and additionally installed extenders, a real improvement in usability.

For the consumer, there are always two important points with Wi-Fi. The first is performance. The second is range.

Let's explore because this all has significant consequences for consumers, as well as for product builders.

Interference

For the consumer, there are always two important points with Wi-Fi. The first is performance (data rate). The second is range (e.g., "how can I get the highest speed in every corner in my house, backyard, basement, etc.?").

In urban areas these days, consumers have grown accustomed to what is now a common scenario–turning on a laptop, for example, and having to weed through the many routers or access points that are visible when trying to find a Wi-Fi network. Many of the routers use the limited number of overlapping channels, which means users are sharing those channels. Or to put it another way, there is interference on those channels.

When two devices are talking through each other over the same channel simultaneously, it means that the messages are getting garbled and both need to be sent again. It's no surprise, then, that the throughput in dense environments can collapse in continuous retransmissions. Again, this is a form of interference.

This interference is made worse by the fact that routers and access points have attempted to improve range via the highest output power possible. Anyone who has ever been to a crowded party can understand this scenario. The more everyone speaks louder to be heard, the more the overall noise goes up and any real opportunity to communicate goes down. More output power just causes more interference. Even worse, higher output power in some channels of the band causes the signal to "bleed" into the neighboring channels—another form of interference—causing the capacity of the band and the total Wi-Fi system to degrade. So, what to do?

Distributed Wi-Fi

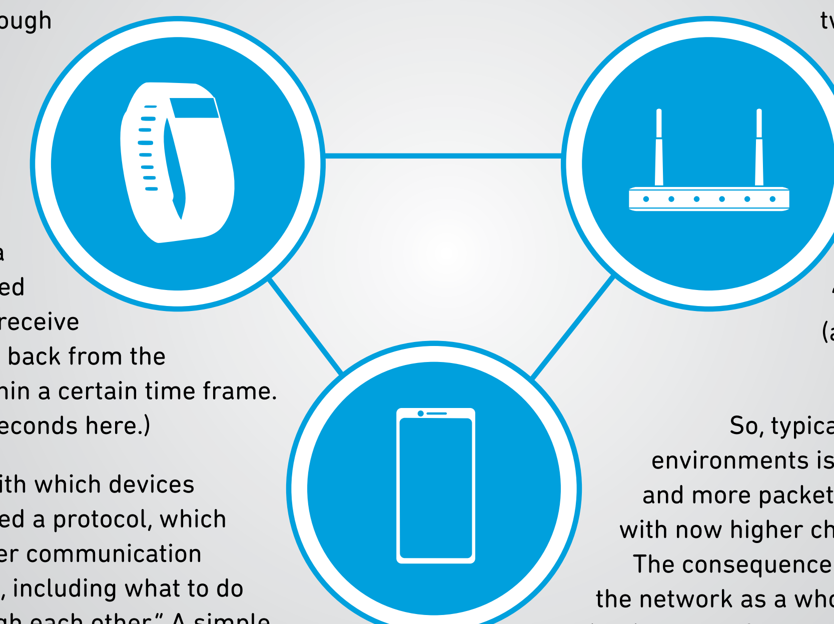
This is where Wi-Fi 6 (.11ax) comes into play. The goal of this new standard is less about higher data rates, and more about the use of as many channels in the 2.4GHz band or the 5GHz band as possible—at the same moment in the same space (for instance, in the same house).

Let's look at an example of why this is needed. Imagine a family living in a house with multiple rooms, running different applications at the same time. In the past, this meant that everyone was using the same channel to communicate with the central router in the closet, but with all the interference limitations discussed above.

The scenario that Wi-Fi 6 enables is that every room in the house has a small access point (the size of a deck of cards) running on a different Wi-Fi channel, and those access points are wirelessly connected over Wi-Fi to the central router in the closet. Now the applications are on different channels and not interfering with each other. This is a true Wi-Fi "system," and the name of the game now is total capacity—using multiple channels at the same time without interfering with each other, thereby optimizing total indoor throughput.

So, the goal of Wi-Fi 6 is full coverage of a home (or a building), and maximum performance in every room, which results in maximum overall capacity for everyone (at the system level).

What happens if two devices are "talking through each other"?

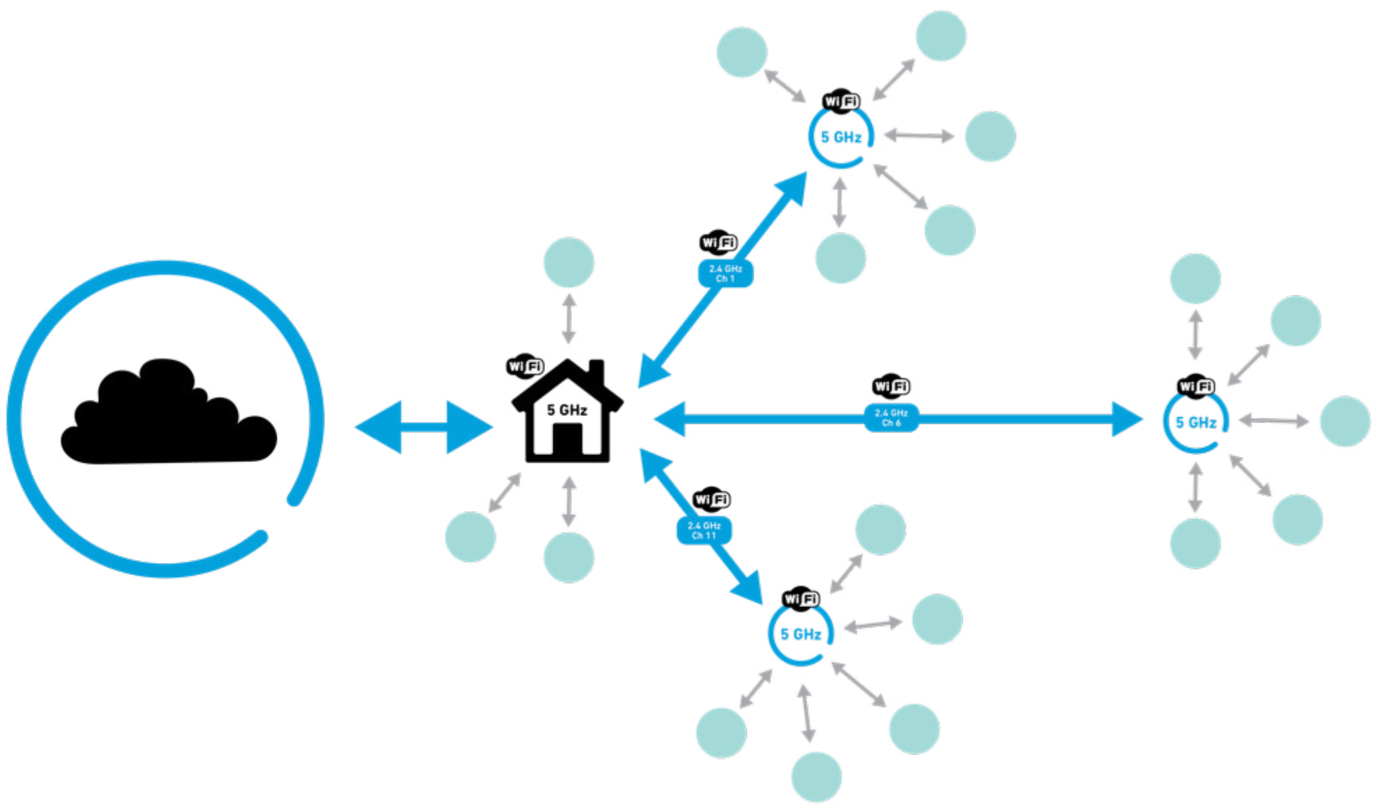


Smartphones, computers, tablets, and routers communicating with each other on the same channel sometimes "talk through each other." Not surprisingly, this jumbles the communication.

A sending device usually knows that a packet has not arrived because it does not receive an acknowledgment back from the receiving device within a certain time frame. (We're talking milliseconds here.)

The "mechanism" with which devices communicate is called a protocol, which describes how proper communication needs to be handled, including what to do when "talking through each other." A simple part of a protocol is "listen before talking," which means that before a device starts to send a data packet, it listens to ensure that nobody else is "on the air." But, if two devices both listen, and both conclude that the "air is clear" and start communicating at the same time, it creates a "collision." Some devices can "hear" the interference and will "back off," or stop and wait (again, milliseconds) before sending again.

So, typically what happens in dense environments is that more packets collide, and more packets need to be retransmitted with now higher chances of another collision. The consequence is that the performance of the network as a whole can break down. This is what happens, for example, with too many people on a single hotspot.



What Are the Consequences for Product Suppliers?

Interestingly, output power to achieve range is no longer the most important criteria. Other things are becoming more important. In the first place, there is "flat power." This means output power is uniform across the band, ensuring that all the channels in the band are at maximum strength. In many products, the channels in the middle of the bands are strong, but channels at the side of the band have to use lower power, essentially creating capacity limitations.

To maximize the overall system capacity, the goals are to achieve maximum output power over all the channels in the 2.4GHz and 5GHz bands, including the channels at the edges of the bands otherwise called "band edge performance." But what is more typical is that the channels at the edges of the band have lower output power to meet radio emission requirements (i.e., to make no noise outside of the band). Many product suppliers squeeze the output power of the channels on the edge of the band to meet the emission requirements, and therefore severely limit the overall system capacity. Qorvo's edgeBoost™ filter is designed to maximize output power at the channels close to the band edge so that the system can support more users without crowding the middle bands.

And Additional Consequence for Consumers

Consumers do not like big boxes with large antennas. And especially with a distributed Wi-Fi router in every room, consumers want small boxes, preferably with no antennas sticking out at all.

Unfortunately, there is a reason that routers today are so big. It's the only way the box can dissipate and get rid of the heat from all the components inside.

All the radio communication components inside the box generate heat. Ever watched a movie on your cell phone and felt how hot it gets?

The component makers for these boxes are working hard to make their components more efficient, which means they can radiate a lot of Wi-Fi with as little heat as possible. Again, remember that the old idea was maximum raw data rate and the highest (allowed) output power. But the new goal is using all the available channels with the highest efficiency. This is what makes Wi-Fi 6 a new standard and a big step forward.

2.4GHz or 5GHz?

There is one final question of note in this scenario. Assuming an access point in every room, and all the access points talking with the router in the closet over Wi-Fi, what frequency bands are preferred?

The reason to ask this question is because 2.4GHz gives better range than 5GHz. So, a logical choice would be to use 2.4GHz as the "backbone" and 5GHz as the connection between the access point and the end device. There is a little issue, though. The backbone is supposed to aggregate the traffic, which means that it is supposed to have the higher data rate (performance). In reality, the data rate at 5GHz is higher than at 2.4GHz, in particular because more channels can be "bundled together" in the 5GHz band. However, the range at 5GHz is less, and therefore it is less suitable for a backbone function.

So, not surprisingly, you can find products today that have different Wi-Fi system design philosophies. Some have 2.4GHz as a backbone, while others are using 5GHz for that. The industry clearly is not unanimous about this yet. And because indoor radio behavior can be fickle, there might not be an ultimate final solution—other than these distributed Wi-Fi systems configuring themselves based on optimizing the indoor environment, if the systems get smart enough. This configuration can even be made dynamic based on the data consumption requirements in various parts of the distributed Wi-Fi system. This means it would reconfigure itself automatically as it "understands" the complete environment, including negotiating with the neighbors so everyone gets a fair share of the spectrum!

For the Wi-Fi 6 user, management of the different channels or signing up to 2.4GHz or 5GHz networks all disappears. Wi-Fi 6 will show itself to the user as one network, with one password. Extended networks or different passwords will be a thing of the past, which makes getting or staying connected becomes very easy.

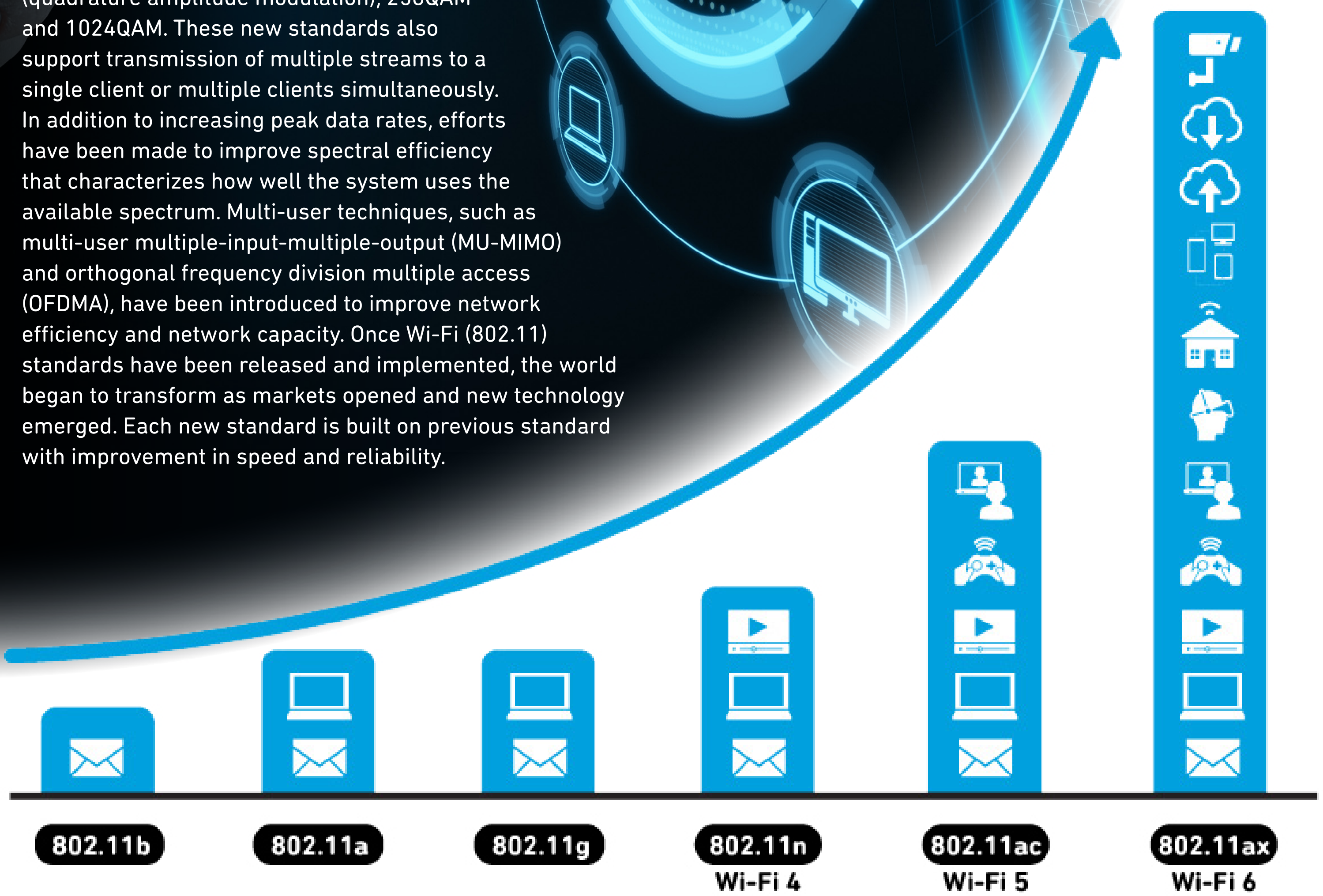
The conclusion is clear—Wi-Fi 6 is not the end of Wi-Fi. It is the start of building even higher-performance systems supporting more users simultaneously and without interference.

The Wi-Fi Evolution

Jaidev Sharma Director, Applications Engineering Wireless Communication Business Unit

Introduction

Over the past 20 years, IEEE 802.11—commonly referred to as Wi-Fi—has evolved from 2Mbps to over gigabit speeds, a 1,000-fold increase in throughput. The standard has continuously advanced itself by introducing new protocols such as 802.11n, 802.11ac and 802.11ax (Wi-Fi 6). The new standards support higher order of modulation schemes such as 64QAM (quadrature amplitude modulation), 256QAM and 1024QAM. These new standards also support transmission of multiple streams to a single client or multiple clients simultaneously. In addition to increasing peak data rates, efforts have been made to improve spectral efficiency that characterizes how well the system uses the available spectrum. Multi-user techniques, such as multi-user multiple-input-multiple-output (MU-MIMO) and orthogonal frequency division multiple access (OFDMA), have been introduced to improve network efficiency and network capacity. Once Wi-Fi (802.11) standards have been released and implemented, the world began to transform as markets opened and new technology emerged. Each new standard is built on previous standard with improvement in speed and reliability.



Wi-Fi Standards

If you are looking to buy a new wireless networking gear or a mobile device, you are overwhelmed by choices and abbreviations. Since Wi-Fi was first released to consumers in 1997, its standards have been continually evolving—typically resulting in faster speeds and network/spectrum efficiency. As capabilities are added to the original 802.11 standard, they become known by their amendment (802.11b, 802.11g, etc.). **Table 1** lists different standards and max theoretical data rates achieved with those standards. Typical rates are lower than theoretical based on several factors, including the signal degradation with distance, modulation rate and forward error correction coding, bandwidth, MIMO multiplier, guard interval and typical error rates. The 802.11 family consists of a series of half-duplex over-the-air modulation techniques that use the same basic protocol. Here, we will discuss the basics of each Wi-Fi standard.

802.11-1997 Standard

802.11-1997 was the first wireless standard in the family, which was released in 1997, but is now obsolete. This standard defines the protocol and compatible interconnection of data communication equipment via the air in a local area network (LAN) using carrier sense multiple access protocol with collision avoidance (CSMA/CA). This protocol supported three physical layer technologies, including infrared operating at 1Mbps, a frequency hopping spread spectrum (FHSS) supporting 1Mbps and an optional 2Mbps data rate or a direct sequence spread spectrum (DSSS) supporting both 1Mbps and 2Mbps data rates. This protocol was not widely accepted because of interoperability issues, cost and lack of sufficient throughput.

802.11b Standard

802.11b products appeared on the market in mid-1999. It has a maximum theoretical data rate of 11Mbps and uses the same CSMA/CA medium access method defined in the original standard. The dramatic increase in throughput of 802.11b, along with substantial price reduction, led to wide acceptance of 802.11b as a wireless technology. 802.11b uses the ISM unlicensed frequency band from 2400MHz to 2500MHz. 802.11b is a direct extension of DSSS and uses complementary code keying (CCK) as its modulation technique. 802.11b is used in point-to-multipoint configuration where an access point communicates with mobile clients within the range of the access point.

This range depends on radio frequency environment, output power and sensitivity of the receiver. 802.11b has a channel bandwidth of 22MHz, can operate at 11Mbps but scale back to 5.5Mbps, then to 2Mbps, then to 1Mbps

Table 1

IEEE 802.11 Protocol	Release Date	Frequency Band(s)	Bandwidth	Max Throughput
802.11-1997	1997	2.4	22	2Mbps
11b	1999	2.4	22	11Mbps
11a	1999	5	20	54Mbps
11g	2003	2.4	20	54Mbps
11n (Wi-Fi 4)	2009	2.4/5	20/40	600Mbps
11ac (Wi-Fi 5)	2013	2.4/5	20/40/80/160	6.8Gbps
11ax (Wi-Fi 6)	2019	2.5/5	20/40/80/160	10Gbps

(adaptive rate selection), in order to decrease the rate of re-broadcasts that results from errors. The 802.11b standard shares the same frequency bandwidth of other wireless standards. Thus, within the home, wireless devices such as microwave ovens, ***Bluetooth***® devices, and cordless phones can cause interference with Wi-Fi.

802.11a Standard

The 802.11a uses the same core protocol as the original standard. It operates at 5GHz and uses a 52-subcarrier orthogonal frequency division multiplexing (OFDM) with a maximum theoretical data rate of 54Mbps. This achieves a practical throughput of mid-20Mbps. Other data rates it supports includes 6Mbps, 9Mbps, 12Mbps, 18Mbps, 24Mbps, 36Mbps, and 48Mbps. 802.11a is not interoperable with 802.11b as they operate in different unlicensed ISM frequency bands. The 5GHz band gives 802.11a significant advantage because the 2.4GHz is getting crowded, but because of high carrier frequency, the effective overall range is less than 802.11b/g.

Chalk Talk: Qorvo's Wi-Fi Front End Solutions - a video interview with EE Journal

Table 2 802.11a modulation rates and data rates for 20 MHz channel spacing

Modulation Type (802.11a)	Coding Rate	Data Rate (Mbps)
BPSK	1/2	6
BPSK	3/4	9
QPSK	1/2	12
QPSK	3/4	18
16 QAM	1/2	24
16 QAM	3/4	36
64 QAM	2/3	48
64 QAM	3/4	54

802.11a products were not widely accepted initially because of cost, low range, and incompatibility with 802.11b. Of the 52 OFDM subcarriers, 48 are for data and 4 are pilot subcarriers with a carrier separation of 312.5kHz. Each of these subcarriers can be BPSK, QPSK, 16QAM or 64QAM. The bandwidth of channel is 20MHz with occupied bandwidth of 16.6MHz. Symbol duration is 4µsec that includes a guard interval of 0.8µsec. OFDM advantages include reduced multipath effects in reception and increased spectral efficiency. **Table 2** lists the different modulations supported by 11a and their respective theoretical data rate.

802.11g Standard

802.11g became available in the summer of 2003. It uses the same OFDM technology introduced with 802.11a. Like 802.11a, it supports a maximum theoretical rate of 54 Mbps. But like 802.11b, it operates in the crowded 2.4GHz and hence is susceptible to interference issues. 802.11g is backward compatible with 802.11b (i.e., 802.11b devices can connect to an 802.11g access point). 802.11g was able to handle dual-band or dual-mode access points using 802.11a and 802.11b/g.

802.11n Standard

With 802.11n, Wi-Fi became even faster and more reliable. This is achieved by adding multiple-input and multiple-output (MIMO) and 40MHz channels to the physical layer (PHY) and frame aggregation to the media access control (MAC) layer. MIMO is a method for multiplying the capacity of a radio link using multiple transmit and receive antennas to exploit multipath propagation. These antennas need to be spatially separated so that the signal from each transmit antenna to each receive antenna has a different spatial signature, so that on the receiver, it can separate these streams into parallel independent channels. Channels operating with a width of 40MHz, doubles the channel width and provides twice the PHY data rate over a single 20MHz channel. 802.11n draft allows up to 4 spatial streams with a maximum theoretical throughput of 600Mbps.

20MHz channels have 56 OFDM subcarriers, 52 are data and 4 are pilot tones with a carrier separation of 312.5kHz. Each of these subcarriers can be a BPSK, QPSK, 16QAM or 64QAM. Total symbol duration is 3.6µSec or 4µSec, which includes a guard interval of 0.4µSec or 0.8µSec, respectively. **Table 3** lists different modulation and coding schemes for a single stream (for multiple streams, the data rate is multiple of number of streams). 802.11n supports frame aggregation where multiple MAC service data units (MSDUs) or MAC protocol data units (MPDUs) are packed together to reduce the overheads and average them over multiple frames, thereby increasing the user level data rate. Also, 802.11n is backward compatible with 802.11g, 11b and 11a.[3] Qorvo has been a leading provider of 802.11n components, including power amplifiers, low noise amplifiers, switches, and integrated front-end modules (FEMs).

802.11ac Standard

802.11ac revved-up Wi-Fi by providing gigabit speeds per second and this is achieved by extending the 802.11n concepts,which include wider bandwidth (up to 160MHz), more MIMO spatial streams (up to 8), downlink multi-user MIMO (up to four clients) and high-density modulation (up to 256QAM). 802.11ac supports 256QAM at 3/4, 5/6 coding rate (MCS8/9) that required 6dB tougher system level EVM (-34dB) requirements. Qorvo 11ac components were able to easily satisfy those EVM requirements. 802.11ac works exclusively in the 5GHz band, so dual-band access points and clients will continue to use 802.11n at 2.4GHz. The first wave of 802.11ac released in 2013 supported only 80MHz channels and up to three spatial streams delivering up to 1300Mbps at physical layer. Second wave products, or 802.11ac wave 2 products, were released in 2015, support more channel bonding, more spatial streams and MU-MIMO. MU-MIMO is a significant advancement of 802.11ac. While MIMO directs multiple streams to a single user, MU-MIMO can direct spatial streams to multiple clients simultaneously, thus improving network efficiency. Also, 802.11ac uses a technology called beamforming. With beamforming, the antenna basically transmits the radio signals so they are directed at a specific device. 802.11ac routers are backwards compatible with 802.11b, 11g, 11a and 11n, which means all the legacy clients work fine with 802.11ac router.

Table 3 802.11n modulation and data rates for single stream

MCS Index	Spatial Streams	Modulation Type	Coding Rate	Data Rate (Mbps)	
				20 MHz Channel	
				800nSGI	400nSGI
0	1	BPSK	1/2	6.5	7.2
1	1	QPSK	1/2	13	14.4
2	1	QPSK	3/4	19.5	21.7
3	1	16 QAM	1/2	26	28.9
4	1	16 QAM	3/4	39	43.3
5	1	64 QAM	2/3	52	57.8
6	1	64 QAM	3/4	58.5	65
7	1	64 QAM	5/6	65	72.2
MCS Index	Spatial Streams	Modulation Type	Coding Rate	Data Rate (Mbps)	
				40 MHz Channel	
				800nSGI	400nSGI
0	1	BPSK	1/2	13.5	15
1	1	QPSK	1/2	27	30
2	1	QPSK	3/4	40.5	45
3	1	16 QAM	1/2	54	60
4	1	16 QAM	3/4	81	90
5	1	64 QAM	2/3	108	120
6	1	64 QAM	3/4	121.5	135
7	1	64 QAM	5/6	135	150

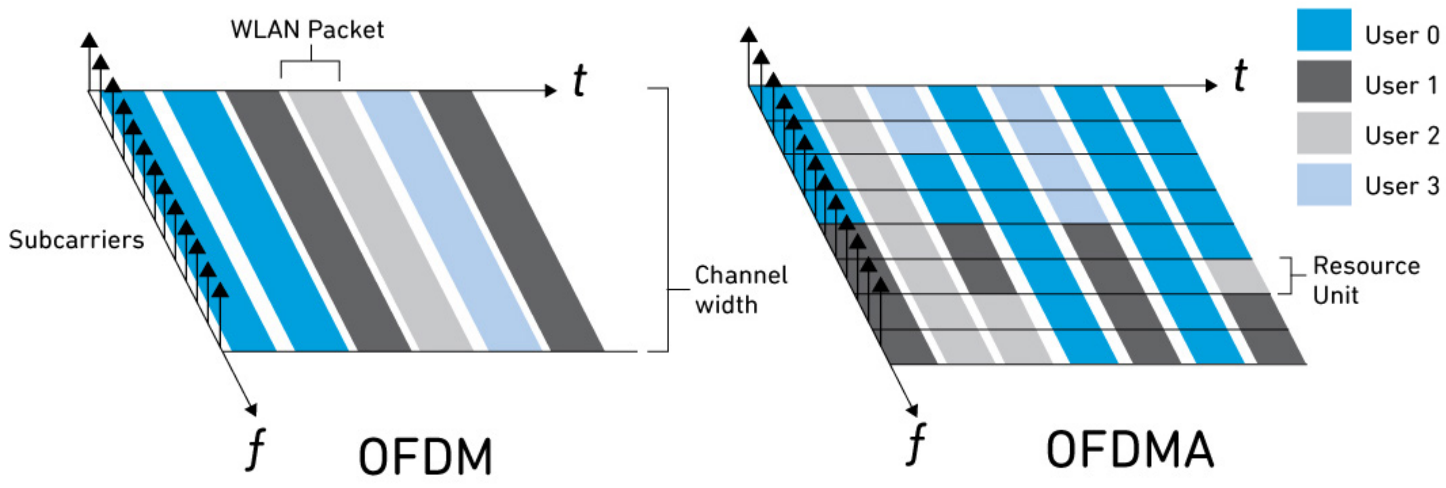


Figure 1 OFDM vs OFDMA resource allocation

Wi-Fi 6 or 802.11ax Standard

802.11ax is the sixth generation of Wi-Fi, built on the strengths of 802.11ac, which provides more wireless capacity and reliability. 802.11ax achieves these benefits by using denser modulation (1024QAM), (OFDMA), reduced subcarrier spacing (78.125kHz) and using scheduled-based resource allocation.

Unlike 802.11ac, 802.11ax is a dual-band 2.4GHz and 5GHz technology. 802.11ax was designed for maximum compatibility, coexisting efficiently with 802.11a/g/n/ac clients. 802.11ax uses OFDMA, which allows resource units (RUs) that divide the bandwidth according to the needs of the clients and provides multiple individuals with the same user experience at faster speeds. With 802.11ac, the Wi-Fi channel was broken down into a collection of smaller OFDM sub-channels. For OFDM, at any given point, the individual subcarriers are all part of one protocol data unit (PPDU). However, with OFDMA (802.11ax), individual groups of subcarriers are individually allocated to clients as resource units on a per-PPDU basis (**Figure 1**). However, with OFDMA (802.11ax), individual groups of subcarriers are individually allocated to clients as resource units on a per-PPDU basis (**Figure 1**).

This method allowed the wireless clients to first sense the channel to avoid collisions, thereby only transmitting when the channel is idle.

Earlier 802.11 standards used CSMA/CA method. This method allowed the wireless clients to first sense the channel to avoid collisions, thereby only transmitting when the channel is idle. Although this clear assessment and collision avoidance serves well, its efficiency decreases when the number of clients grows very large.

802.11ax protocol solves this problem through OFDMA and schedule-based resource allocation. 802.11ax access points dictate when the device will operate, thus handling clients more efficiently. Resource scheduling also significantly reduces the power consumption during sleep time, which improves battery life of clients. **Table 4** lists the differences between 802.11ac and 802.11ax protocols. Qorvo's broad 802.11ax portfolio includes 2.4GHz and 5GHz front-end modules (FEMs) and bulk acoustic wave (BAW) filters. The portfolio's high energy-efficient FEMs reduce thermal issues associated with supporting MIMO in Wi-Fi equipment, allowing manufacturers to reduce product size and cost. Qorvo's edgeBoost™ (bandedge) and coexBoost™ (coexistence) BAW filters improve Wi-Fi quality of service and prevent interference with adjacent LTE frequencies.

Summary

Qorvo is a leading provider of Wi-Fi connectivity solutions with a significant market share. Qorvo's portfolio of radio-frequency (RF) components provide efficient solutions with reliable coverage in smallest form factor that help improve the overall range, capacity, and throughput.

Table 4 802.11ac vs 802.11ax

	802.11ac (Wi-Fi 5)	802.11ax (Wi-Fi 6)
Bands	5GHz	2.4, 5GHz
Channel Bandwidth	20, 40, 80, 160MHz	20, 40, 80, 160MHz
FFT Sizes	64, 128, 256, 512	256, 512, 1024, 2048
Subcarrier Spacing	312.5kHz	78.125kHz
Symbol Duration	3.2μs + 0.8/0.4μs	12.8μs + 0.8/1.6/3.2μs
Highest Modulation	256QAM	1024QAM
Max Data Rate	6933Mbps (160MHz, 8SS)	9607.8Mbps (160MHz, 8SS)

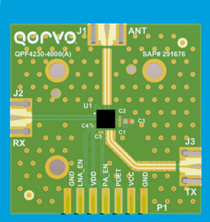
QPF4230 Wi-Fi Front End Modules (FEMs)

- 2412MHz to 2484MHz operating frequency range
- Optimized for 3.3V operation
- 15dB Rx gain and 6dB bypass loss

LEARN MORE https://bit.ly/2Df0bVT

QPF4230EVB-01 Evaluation Board

- Designed to evaluate the QPF4230 Wi-Fi FEM
- 2412MHz to 2484MHz operating frequency range
- For use in wireless routers, access points and IoT applications



LEARN MORE https://bit.ly/33iLgoh

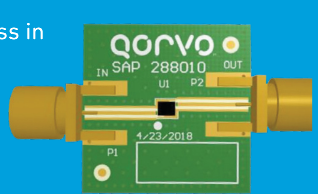
QPQ1906 Wi-Fi/IoT bandBoost™ Filter

- Low loss in the Wi-Fi band
- High near-in rejection in the 2.4GHz freqency
- High power handling to +28dBm averaged input power

LEARN MORE https://bit.ly/2XoYXyb

QPQ1906EVB-01 Evaluation Board

- Evaluate the QPQ1906 Wi-Fi®/IoT bandBoost filter
- This filter features low insertion loss in the Wi-Fi channels 10-11
- Can be used in access points, wireless routers and residential gateways.



LEARN MORE https://bit.ly/3gsMgd2

Wi-Fi 6 Questions Answered

1

Q: What are the main customer pain points regarding interference?

A: In the area of 2.4GHz Wi-Fi, both interference and coexistence are prominent. This is mostly because of the many surrounding signals from our cellular products, Bluetooth®, wireless speakers, microwaves, etc. Qorvo addresses this interference by using RF filter technologies.

2

Q: How do you maximize the potential of the new Wi-Fi 6 standard and meet certification requirements?

A: The Wi-Fi 6 standard improves data capacity, the number of connected user devices per node and throughput. To achieve these capabilities, there is a need for devices with higher levels of linearity, interference mitigation, and lower power consumption—all in smaller devices form factor. Wi-Fi 6 manufacturers will require the RF front-end devices to meet these perameters if they are going to be able to meet certification program requirements.

3

Q: What specific products does Qorvo suggest in Wi-Fi 6 applications?

A: First, select integration level for front-end modules that cover 2.4 and 5GHz with filters that address bandedge and coexistence, and potention tri-band architectures. Second, is to evaluate a component's product data sheet, with key focus upon Dynamic EVM levels. It accurately reflects hoe a PA in a Wi-Fi system preforms.

4

Q: With the buzz in the industry about Wi-Fi 6 moving up into the 6GHz range, what impact it will have on devices?

A: The solution is to increase the bandwidth of Wi-Fi into the 6GHz range, as this will improve cellular range, as this will improve cellular handoff and user handoff and user quality-of-service. 6GHz is well suited to facilitate Wi-Fi's growth and provides greater availability of wider channel sizes—enough to accommodate 14 additional 80MHz channels and seven additional 160MHz channels. Moreover, this provides forward-looking capabilities for Wi-Fi 7 and beyond, where bandwidths of 320MHz are being discussed.

5

Q: What is a mesh Wi-Fi system and how does it help provide better whole-home coverage?

A: Distributed or mesh W-Fi systems include a router that connects you to your main modem and multiple satellite router-like devices, or nodes, placed around the home to provide full Wi-Fi coverage. The distributed Wi-Fi systems protect high capacity connectivity (backhaul) to the cloud connection while protecting dedicated streams of communication to the multiple client devices (phone, laptop, game systems, etc.) connected to the Wi-Fi system.

mouser.com/Qorvo

MOUSER ELECTRONICS

qorvo

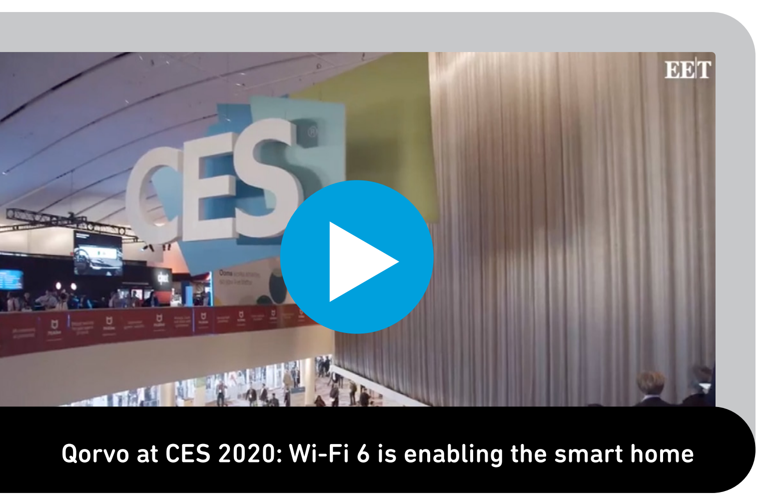
5G or .11ax?

Cees Links GM of Qorvo Wireless Connectivity Business Unit,
Formerly Founder & CEO of GreenPeak Technologies

Have you ever wondered why your phone has three radios (LTE, Wi-Fi and Bluetooth®), while your tablet and computer typically have two (Wi-Fi and Bluetooth®)? For that matter, why do you know names like Wi-Fi, Bluetooth® and LTE? What about 5G or **Zigbee**?

At the same time that wireless data-communication technology and standards are still in development, new standards and proprietary technologies (like Zigbee) are clamoring for attention. How do we separate the noise from what is real and important? Should consumers care about any of this? **Figure 1** offers an impression of the variety of wireless technologies that play a role in our daily lives.

Despite all the marketing chatter, it is relatively easy to look at the bigger picture and understand where things are going. And as it is often the case, it can be helpful to remind ourselves how we got to where we are today.



Qorvo at CES 2020: Wi-Fi 6 is enabling the smart home

Maybe a Little Bit of Technology First

There are only three things of overriding importance in radio technology, and we experience them all in our daily lives. These three things are range, data rate, and power.

We experience **range** as our phone is connected to a base station (or not), or when our laptop is connected to the router at home, or when our headset is connected to our phone. And we all know from experience what happens if a device gets "out of range."

We are also quite familiar with **data rate**, particularly when we watch videos or listen to music. Wi-Fi has been the king of data rate until now, but we have been able to receive similar data rates with LTE and 5G—though perhaps at a higher price.

Finally, while we have grown accustomed to regularly recharging our phones and laptops, we are reminded of the importance of **power** consumption in those annoying moments when we discover that our smaller devices, like headsets or Fitbits, are not charged when we are ready to use them.

These three items fit together in an interesting way, a sort of basic law of physics. Try to improve one, and the two others must give way. Of course, general overall improvements have been made over time on all three, but the relationship between them is the same.

For instance, if you want increased data rate, then you must either lose range or increase the output power. Wi-Fi today, with its higher speeds (data rate), has less range than in the past and more often needs repeaters–this is one of the motivators for distributed Wi-Fi, or mesh Wi-Fi. This same relationship holds true for Zigbee ("low power Wi-Fi"). It essentially gets the same range as Wi-Fi, at a low data rate, but with significantly lower power, thereby achieving a very long battery life.

There is a fourth element in this equation, also based on physics, that we might be less aware of in our daily lives. That element is frequency. Higher frequencies reduce range or require higher power to achieve the same range. But higher frequencies have the advantages of more bandwidth and, thus, higher data rates. This explains the tendency for higher data rates to "look for" higher frequencies. The newest versions of Wi-Fi are in the 60GHz frequency band, with targets up to 100Gb/s (.11ay).

Back to the Radios Present in Phones and Laptops

Clearly a lot more can be said about this, but to a large extent, these parameters are the reasons you have three radios in your phone. One radio (LTE) to get the range to connect to the closest base station in your neighborhood; one radio (Wi-Fi) to get performance when you are at home or in the office; and one radio (Bluetooth®) to enable short-range connectivity to the small devices that you carry with you, like your phone headset or your Fitbit.

Why, then, do laptops and tablets usually only have two radios? There is a logical answer, but we must also understand a bit of history.

A Brief History: the Technology Players

In a relatively short period of time, we have seen three new technologies develop and converge:

1. The phone, to remotely connect us via low-speed data communications.
2. Radio/TV, to broadcast audio/video, via cable or satellite, with one-way high-speed data communications.
3. The computer, including two-way high-speed networking that pulls everything together. All the communication was initially over a wired cable (copper or fiber), but when the convenience of wireless came along, it became ubiquitous.

As technology progresses, the differences between phones, TVs, laptops, and tablets are slowly disappearing. In a way, they are all becoming "networked computers," but each still has its own history of wireless communication standards as each experienced its own transition from wired to wireless technology. Phones and computers had a more dynamic path, but because TVs are largely static (non-mobile) devices, the cable/satellite industry mostly stayed in its own wired world.

As phones became more computer-like (i.e., smart phones), and computers began supporting all kind of video- and phone-like communication capabilities, it should come as no surprise that the variety of networking technologies that have developed, past and present, are sometimes at odds.

	Wearables	Home	Phone
Range (typical)	<10m/30ft	<100m/300ft	Outdoor (Km/miles)
Content	Bluetooth®	Wi-Fi®	lte, 5G
Sense & control	Bluetooth®	zigbee	NB-IoT
Typical applications	Personal appliances (wristband, smart watch, step counter, keyboard, mouse, pointer, etc.)	Indoor networks (Internet, email, phone, security, energy management, home monitoring, etc.)	Outdoor networks (phone, chat, Internet, smart city, industry 4.0, agriculture, smart logistics, etc.)

Figure 1 Wireless data communications technologies

Different Networking Technologies Standards—Developing Very Differently

The standardization body for wireless phone communication today is 3GPP; for wireless computer data communication, it is IEEE 802.11. The roots of 3GPP are with the telephone operators and their governmental sponsors, because operators were originally governmental bodies. (In some countries, they still are.) The IEEE 802.11 is rooted in the computer industry. In addition to academics and regulators, IEEE 802.11 has a large engineer membership, most of whom are sponsored by their employer companies.

The IEEE 802.11 and the 3GPP had another complete and fundamental difference. The government-sponsored 3GPP worked to license spectrum–spectrum that could be acquired for a certain amount of time to provide communication services. The government, as licensor of the spectrum, is responsible for making sure that the spectrum can only be used by the licensee. Not so with the IEEE 802.11. This standardization body has developed standards in the "unlicensed" bands–bands that have been set aside by the government for "free usage," based on a set of rules with limited power, so that the interference range for realistic applications stays local. These bands are called ISM (Industrial, Scientific and Medical) bands and can be found in the 2GHz, 5GHz, and 60GHz bands.

The companies that sponsored their engineers to develop IEEE 802.11 then needed to enforce compliance to the IEEE 802.11 standard definitions. (The IEEE 802.11 itself does not regulate compliance.) So, the Wi-Fi Alliance was founded by these interested companies for enforcing and promoting the IEEE 802.11 standard under the Wi-Fi brand—without exaggeration one of the most valuable brands today. 3GPP, on the other hand, never really focused on a cohesive brand strategy aimed at consumers. This makes sense because 3GPP was the interest group of operators, who always had a certain control of the market. They never had to win the hearts and minds of the consumers, like Wi-Fi and Bluetooth® did. So instead of bothering with brand consistency issues, whole sets of ever-improving standards migrated from GSM/GPRS to 3G, Edge, 4G, LTE, and now 5G, which will likely involve a new set of implementations.

The Battles and Successes of Wi-Fi–and the Answer to Why Computers Have Two Radios

When Wi-Fi was emerging in the late 1990s, the general tendency in "3GPP-land" was to ask: Why do you need Wi-Fi? At that time, the standardization of 3G was progressing well and promising high data rates, and 3G modems connected to or integrated in laptops would provide ubiquitous connectivity. So, why bother with Wi-Fi? The general opinion was that this "unlicensed technology" would disappear, probably sooner than later, because in the unlicensed bands the lack of oversight would bring the performance spiraling down quickly.

Of course, we know today that things turned out rather differently. Wi-Fi has found a way to properly operate in the unlicensed ISM-bands and satisfy the needs for wireless connectivity indoor, in-home or in-building, where 3G was not able to penetrate well. Also, Wi-Fi rapidly increased its data rate and expanded its capabilities by moving from the 2.4GHz band into the 5GHz band, and it is expected to further extend these by going into the 6GHz band. Range extender technologies and, more recently, the concept of distributed Wi-Fi ("Wi-Fi Mesh"), have also supported Wi-Fi's success to date.

A significant part of the reason that Wi-Fi was successful was the fact that data communications via 3G required a paid subscription from telephone operators and a data plan that initially led to quite hefty bills, not to mention roaming charges. By comparison, Wi-Fi was free—or at least, the incremental cost for Wi-Fi via a fixed telephone, ISDN and later with ADSL, was limited.

So now we had wired operators directly competing with the wireless operators, which ultimately stimulated worldwide acceptance of Wi-Fi. The wireless operators helped this along by initially discouraging the use of 3G for data (and therefore encouraging the use of Wi-Fi) due to concern for a voice service collapse if 3G was "overused" for data. By marketing 3G as having a data element, even though it really was designed for voice, the 3G folks didn't help themselves in this regard.

By the way, this answers the question of why most computers and tablets have only two radios. 3G-licensed radios (and their successors) were rarely integrated in computers or tablets because Wi-Fi offered a cost-effective and versatile internet connection. An integrated 3G radio was just too expensive by comparison. When a mobile solution is needed, users have turned to devices like 3G dongles or, more commonly today, using their mobile phone as a hotspot.

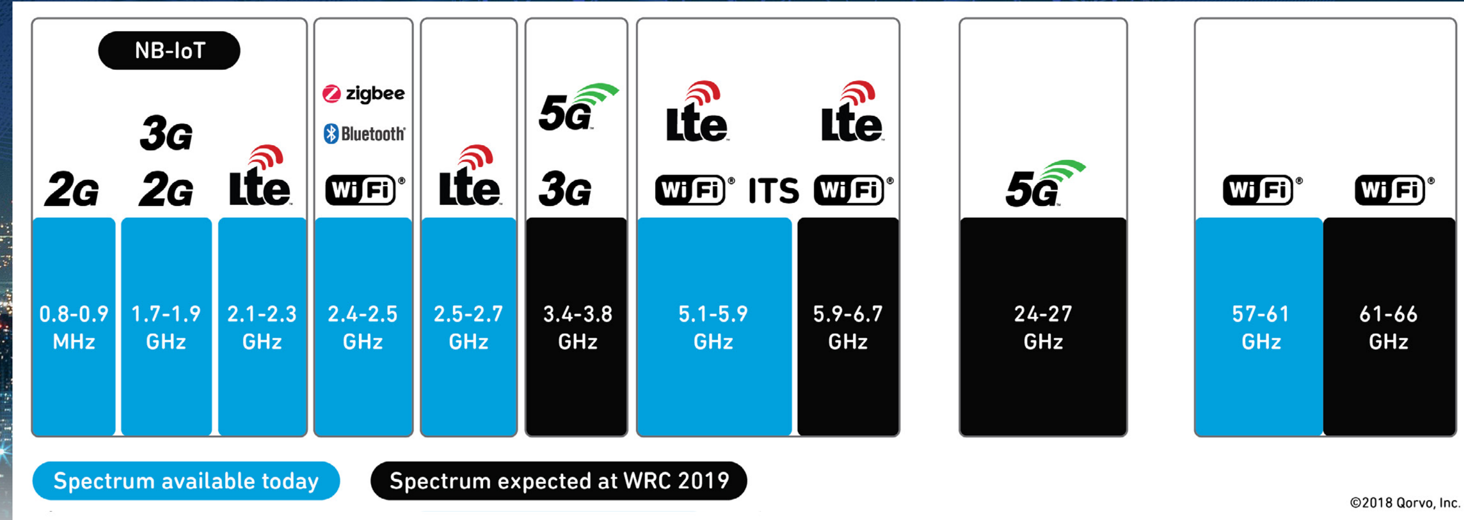


Figure 2 Current and expected frequency bands for major wireless technologies

Wi-Fi Versus Bluetooth® (and Now Zigbee)

At the same time, the battle between Wi-Fi and 3G unfolded, another battle emerged. Several companies that were suppliers to the telephone industry (notably Ericsson and Nokia) saw another usage for ISM bands—to improve phone connectivity when connecting to a hotspot for information downloads and when connecting wireless headsets and other devices to the phone. To create a standard for type of phone connectivity, the Bluetooth® SIG (Special Interest Group) was formed, with companies as members (as opposed to the engineer members of IEEE 802.11). Fairly soon, the Bluetooth® SIG echoed 3GPP in declaring Wi-Fi redundant and telling the market Wi-Fi would soon disappear.

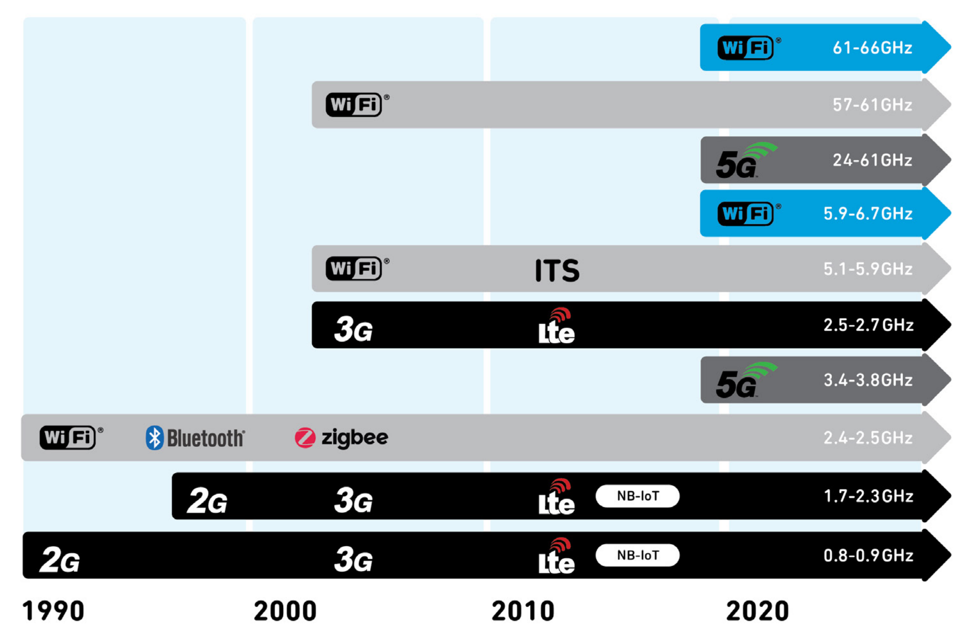


Figure 3 Evolution of spectrum availability for major wireless technologies (approximate frequency bands and dates)

Again, not so much. After a few years, it became clear that Wi-Fi and Bluetooth® had separate, defined application domains—Wi-Fi for "networking" and Bluetooth® for "peripheral connectivity." Since then, many devices have emerged with both Wi-Fi and Bluetooth®–Wi-Fi for high-speed networking and Bluetooth® for connecting devices. For a while, there was an effort to make Bluetooth® part of IEEE, but their organizational and membership differences drove them apart.

Interestingly, there is a sequel of this battle in the works today. Zigbee, the low-power variant of Wi-Fi (based on IEEE 802.15.4) is under threat from Bluetooth® Low Energy, the low-power variant of Bluetooth®. The Bluetooth® SIG is developing a networking variant (Bluetooth® Mesh) that is supposed to compete with Zigbee. Looking at the early proposals, however, it seems that considerable complexity would need to be added to Bluetooth® Low Energy to achieve what is already available with Zigbee. We will have to wait and see how this plays out.

Spectrum Availability

The evolution of these wireless technologies was made possible by growing amounts of radio spectrum made available by the worlds' regulatory authorities. **Figures 2** and **3** give rough indications of the major technologies and frequency bands involved. At the 2019 World Radio Conference, significant new allocations are expected for Wi-Fi and 5G to support the increasing demands for wireless data communications. The exact details of spectrum availability and usage conditions is beyond the scope of this document.

Consumers and companies are learning that running Wi-Fi networks is becoming more complex...

Telephone Operators and Wi-Fi...Working Together?

One would think that after 3G and Wi-Fi fought their battles, the demarcations between the two technologies would be clear—Wi-Fi for private areas (home, office) and 3G everywhere else.

But, no. Initially the telephone operators in 3GPP were naturally quite suspicious about the development of so-called "hotspots," public places where people could get access to high-speed internet without the need for a subscription. Fortunately for the telephone operators, it turned out that running a large number of hotspots was not a trivial effort, in particular for large retail and hotel chains, cities, trains, etc. Public hotspot companies have been slowly absorbed by the telephone operators, who started to further embrace Wi-Fi and learned that "unlicensed" was not as bad as it sounded. Operators even developed strategies to use public hotspots along with private routers to "off-load." In other words, use Wi-Fi connected hotspots for traditional phone services.

At the same time, consumers and companies are learning that running Wi-Fi networks is becoming more complex, and telephone operators (and more recently, also cable operators) are finding out that private Wi-Fi networks are business opportunities—helping consumers and smaller companies run their Wi-Fi networks.

And finally, with the further rapid growth of data traffic, especially via video applications like YouTube, the operators need increased capacity. But getting more frequency bands is not easy. A faster way of getting this capacity, next to leveraging Wi-Fi, was realizing that the successor of 3G, 4G or LTE technology can also run in the ISM band. This realization gave rise to the concept of LTE-LAA–LTE with Licensed Assisted Access.

The 3GPP specifications allow both Wi-Fi and LTE-LAA to be used in the same 5GHz spectrum. The first installations of LTE-LAA are being planned now, but we will have to wait and see if LTE-LAA is a hit.

So, What's Happening Now, and What Happens Next?

Armed with this understanding of history, we can see a new battle is looming. The IEEE 802.11 has been working diligently on higher-speed versions—.11n and .11ac, and it is in the process of completing .11ax. At the same time, the 3GPP is moving on from 4G/LTE and is investing heavily in 5G. (As an aside, the Wi-Fi Alliance is doing a great marketing job by calling everything higher-speed Wi-Fi, while 3GPP continues to be technology-driven, making the different generations explicit and creating disruptions that are detrimental for a smooth migration.)

In any case, it should now not come as a surprise that the talk is (again) about which technology is going to win: 5G or IEEE 802.11ax? Both will be in the high data rates (Gb/s), and both will be quite power intensive to get good range, and both are trying to infringe on each other's territory. 5G is claiming that it will have "way better indoor penetration", and .11ax is throwing out the slogan, "5G has arrived and it is called .11ax."

IEEE 802.11ax has a clear path worked out, although with the increased data rate, the range is definitely reducing. Interestingly, Wi-Fi has turned this disadvantage into an advantage by focusing this new IEEE 802.11ax standard on distributed Wi-Fi (Wi-Fi Mesh) and enabling the usage of multiple channels at the same time to connect multiple access points in different rooms to the main router. The focus of IEEE 802.11ax is on full indoor coverage—every nook and cranny in your house or office building covered with the same high data rate, creating an experience that will not be easily replaceable with 5G. (Lest this sounds too good to be true, IEEE 802.11ax turns out to be a very difficult standard, and its completion has just been delayed by another six months, with ratification now expected in early 2019.)

However, 5G is facing its own quite serious challenges, including delays. 5G's higher data rates create a penalty on its range, too, and for cellular base stations, coverage goes "by the square." The expectation is that the range for 5G will probably decrease by less than half, forcing the number of base stations to more than quadruple. In dense urban areas, where finding real estate to place base stations is expensive, this will mean that rolling out 5G infrastructure will be at significant expense, at the same time, that many operators are still recovering from their 4G investments.

3GPP is moving on from 4G/LTE and is investing heavily in 5G.

Although it varies a bit by country and the financial structure of the telephone operators, the belief is that higher data rates will be needed to sustain the consumer and business appetites for higher data rates, particularly in dense population settings, where the usage of licensed spectrum can be better controlled than unlicensed. So the money flowing into further developing and maturing 5G is continuing, and the first trials are planned for early 2018 around the Winter Olympics in Korea.

Conclusion

So, who is going to win the battle? Honestly, there shouldn't even be a battle. Both 5G and Wi-Fi have very particular characteristics that will be beneficial for connecting "computers" (including all the devices that can now be classified under this term) to the internet. So, the operator that best can exploit both technologies to its advantage and can define and execute a strategy that leverages them both, will become the winner. Seen from this perspective, the ultimate winner of these technology battles will be the end-user.

The Next Generation of

Wi-Fi is one of the most used widely used technologies today. The next generation Wi-Fi 6 could make it easier for multiple people in a household to hold higher quality work video calls, or a teacher to better engage with more students through distance learning.

Wi-Fi 6 means faster internet across several devices on one network; making it easier to work and learn at home.

Christina Unarut Mouser Electronics
Cees Links GM of Qorvo Wireless Connectivity Business Unit, Formerly Founder & CEO of GreenPeak Technologies

Linking into Wi-Fi

Wi-Fi is taken for granted in the current generation. We are connected almost all the time. I've grown up always being connected to the internet, first through AOL's dial up, and now always being connected through my home Wi-Fi or my phone's data plan. Unless my phone dies, I'm connected almost wherever I go. CNBC, a recognized leader in business news and real-time financial market coverage, reported that over 70 percent of web surfers will use the internet solely on their phone by 2025.

Wi-Fi is one of the most widely used technologies today. Open Wi-Fis are found in coffee shops, boutiques, sporting events, and even some grocery stores. Most campuses have Wi-Fi available for their students throughout each building and through the dorms with their ID and password. Wi-Fi has become even more used and important now-a-days as people work or learn from home. The next-generation Wi-Fi 6 (802.11ax) will make it easier for multiple people in a household to hold higher quality work video calls, or better engagement with larger class sizes via distance learning.

I've had the pleasure of interviewing Cees Links, General Manager of the Low Power Wireless Business Unit in Qorvo, and one of the leading pioneers of Wi-Fi. He is responsible for the world's first wireless LAN product in 1990 and is still working on the latest Wi-Fi products with Qorvo.

'For the rest, it's Wi-Fi'

Wi-Fi 6 will still do the same thing Wi-Fi has always done: connecting you to your latest cute cat videos, downloading your latest Netflix show, or uploading your TikTok. Technology will be working in the background to make things happen more efficiently, speeding up your connection along the way. These changes won't be noticed immediately; but over time as our devices adapt to the new threshold. Wi-Fi 6 could be as fast as 9.6Gbps, about 3.5Gbps faster than the current generation. Although it's unlikely that you'll reach this maximum speed, this big jump could mean faster internet across several devices.

Cees Links explains this big difference as a matter of convenience. Until recently, Wi-Fi 4 and Wi-Fi 5 routers had separate 2.4GHz and 5GHz networks with their own SSID and network IDs that had to be set up. If the Wi-Fi signal is not strong enough throughout a home, an additional repeater will need to be added to the network. "So your whole home network has become a bit of a mission to set-up," Cees says, "You had to change network ID quite regularly, depending on where you want them to have coverage." Some providers have implemented proprietary fixes for this, so that it would be possible to cover all the different network IDs under one overall network ID, but this was only possible if you buy products from the same supplier. With Wi-Fi 6 technology, this concept has been standardized across vendors and all the different networks can be automatically integrated into one network. If you have more than one repeater, you won't have to know each network ID. Because they'll be part of the same network infrastructure, you'll be able to roam over different frequencies with products from different suppliers on one Wi-Fi network. "Eventually with Wi-Fi 6, besides the increase in data rates, but there's all kinds of engineering and technology prowess at work," Cees says.

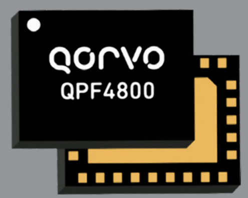
"And if you ask me what the big difference with Wi-Fi 6 is going to be I think its going to be the convenience. With the lowered cost, you can call the repeater, you can call a satellite station, you can call whatever you want but now its just the same network. Once it's installed as part of your network you don't have to add in another network ID or have another password in mind. Convenience will be the major difference with Wi-Fi 6"

'Wi-Fi 6 could become the backbone for all indoor connectivity'

Wi-Fi empowers the smart home, but not all routers and modems are created equal. Without updating the equipment, your home Wi-Fi could struggle to keep up with the data strain. New equipment can handle the bandwidth of connected devices and the increase in internet speed. Another update to keep in mind is that the internet service provider (ISP) needs to be updated with the fastest speed plan available for your home.

A relatively new technology is expanding the reach of Wi-Fi throughout a home. Wi-Fi mesh systems boost the Wi-Fi signal series of satellite modules or nodes placed around the home. The nodes are convenient because they share the same SSID, there is not another network ID that has to be set up. "Let's say one (hot) spot per room for all your large rooms and each spot in every room has a Wi-Fi mesh connection. Maybe we will find out so with the Wi-Fi mesh will become the backbone (of indoor connectivity)," Cees says. With several nodes throughout your home, it would be easy to have a strong consistent speedy Wi-Fi signal, enough for all the smart lights and switches.

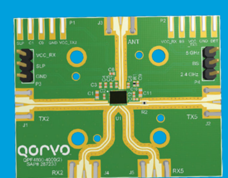
QPF4800 Dual-Band Wi-Fi® 6 Front End Module



- Optimized for +5.0V operation
- Broad range integrated DC power detector
- Package dimensions: 4.0mm x 3.0mm

LEARN MORE ➔ https://bit.ly/2BT63mY

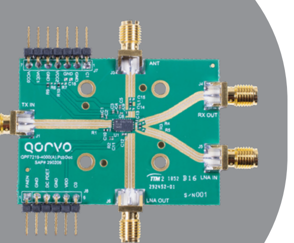
QPF4800EVB-01 Evaluation Board



- Acts as a reference design for the QPF4800
- Performance-focused on optimizing the 2.4GHz and 5.0GHz PAs
- Multiple ways to offer access to the 28-pin signals of the QPF4800

LEARN MORE ➔ https://bit.ly/3k5Ydl3

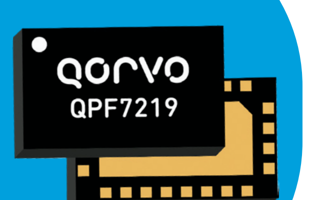
QPF7219 Evaluation Board



- Operates within 2.402GHz to 2.472GHz frequency range
- Supports 802.11ax Wi-Fi 6 standards
- Evaluate the performance of the QPF7219 Wi-Fi integrated Front End Module

LEARN MORE ➔ https://bit.ly/33og0nY

QPF7219 Wi-Fi Integrated Front End Module



- 2402MHz to 2472MHz frequency range
- POUT=25dBm FCC restricted bandedge compliance
- Optimized for 5V operation

LEARN MORE ➔ https://bit.ly/3a3B8kN

Bluetooth Mesh

Another new mesh system is also being used in smart home application. Bluetooth® mesh allows for many-to-many device communications over Bluetooth radio. One advantage is that a Bluetooth mesh system would consumes less energy than Wi-Fi mesh. It passes the signal along through peers that are in range, creating a high tech version of the game telephone. Qorvo is "by the way, developing Bluetooth mesh because some of our customers are asking for it."

"Wi-Fi 6 and 5G will continue to be as nicely complementary"

The next generation of technology standard for cellular networks. "It will really get library networking even more pervasive and comprehensive, it will improve certain features that will improve the data rate and latency somewhat," Cees says. The main advantage is that the new networks will have greater bandwidth, allowing for faster download speeds; up to 10Gbits/s. It is able to provide this wide service by operating on three different frequency bands, each requiring a different antenna. Each antenna will compare download speed vs distance and service area to connect to the highest speed within that area. With these faster speeds, it is expected that this network could be used as general ISPs where cable internet is not available.

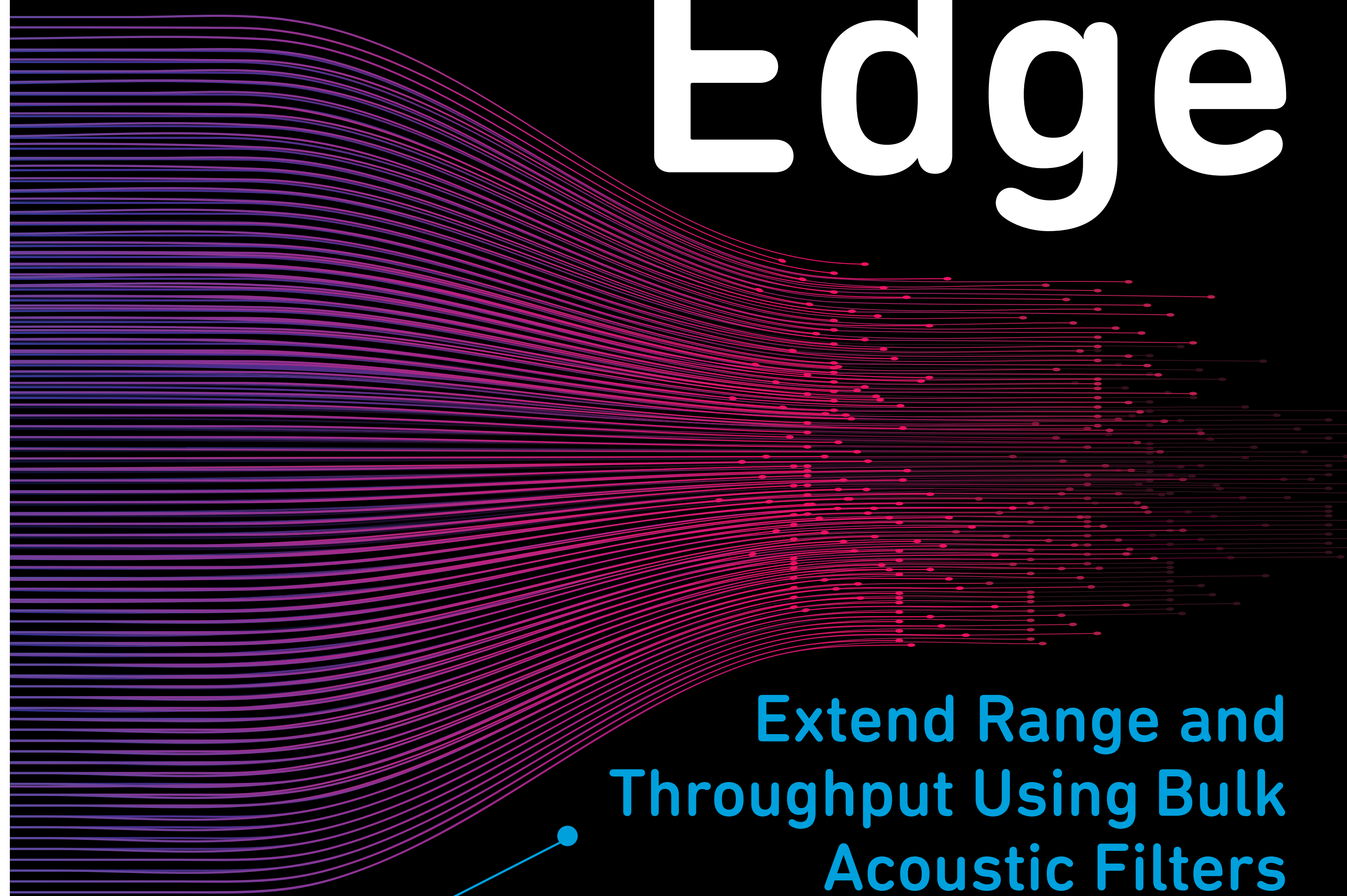
China is leading the way with implementing its 5G infrastructure. "They are really charging ahead on 5G as a sort of protection of their smartphones and I expect that the United States will start catching up very rapidly," Cees says. China sees 5G as vital next step in its wireless technology on the global stage with current testing alone representing the largest 5G network in the world. A new smart city being built south of Beijing will use 5G for smart infrastructure and connected cars.

This big jump in the 5G speed complements the speed that will be provided with Wi-Fi 6 home and office networks. It could be an uninterrupted day of wireless access between Wi-Fi 6 at homes and offices and 5G outside. We would notice big discrepancy if we could not have similar speeds in and out of the home.

Conclusion

Even before Wi-Fi was called Wi-Fi, Cees Links was involved with its creation. As Wi-Fi and cellular network technologies continue to evolve and improve, I hope that I never take being connected for granted. The next few years will be exciting as connectivity increases in availability and speed. Our devices are becoming smarter and more efficient. Think of a fully automated house, a smart city with connected cars, an augmented reality classroom, etc.

Living on the Edge



Extend Range and Throughput Using Bulk Acoustic Filters

Jon Gabay for Mouser Electronics

As more airwaves get filled with data, it becomes critical that the use of the spectrum is maximized. This means noise immunity from other sources, as well as adjacent bands, must assure sharp band slope edges. With 40 bands to filter expected soon, Bulk Acoustic Wave technology is the answer.

Fighting for wireless bandwidth, especially in tightly packed device-filled environments such as stadiums and rallies is sketchy at best. Over-subscribed carriers are part of the problem. They just cannot provide enough raw data to so many people in real time.

But competing in the same space as some cellular bandwiths is Wi-Fi, ZigBee™, Bluetooth®, DECT, HAL, and several other protocols we may be aware of–all sharing RF space, all using different modulation schemes, channel widths, channel spacings, and frequency-hopping algorithms.

As next-generation services and devices emerge, more frequencies, bandwidth, coexistence, and interference immunity are needed. This means claiming more of the spectrum that was lost using older technologies. Read on to learn how Bulk Acoustic Wave (BAW) technology offers a promising solution to maximize spectrum utilization by supporting more precision filtering to recover stronger, more reliable signals with greater noise immunity.

Next-generation wireless: Bulk Acoustic Wave filters are small, handle high power, feature sharp band edges, and low insertion loss.

Maximizing Spectrum Utilization

Spectrum utilization is the key, and while the move from 3G to 4G increased from 5 bands to 20 bands, soon 40 4G bands will be up for grabs, all trying to recover clean signals from a world of muddying interference.

In other words, reaching deep into a turbulent pool of RF, more precision filtering is needed to recover stronger and more reliable signals with improved noise immunity. And with handheld devices that feature multi-protocol transceivers that can operate simultaneously, the need for 40 filters is not uncommon.

Even within home settings, Wi-Fi routers suffer and end-point devices fall victim here as well. We need more reliable data, more throughput, fewer retries, more effective range, more simultaneous channels, and so on.

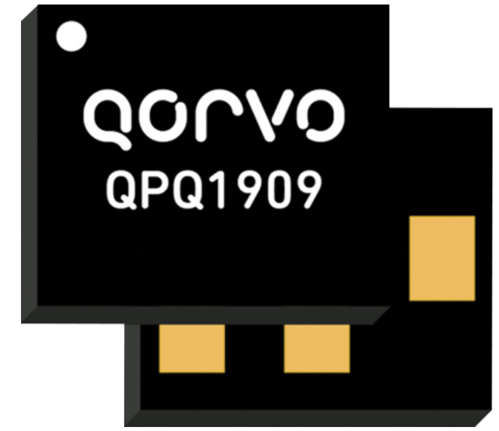


Figure 1 Packing multiple high-performance RF front-end filters in smaller space while improving performance lets hexaplexers such as this multiband filter provide superior performance in smaller designs

Improving Performance Through Precision Filitering

Key to improving performance are filters, but older space-eating Surface Accoustic Wave (SAW) filter technologies are reaching a brick wall as far as being effective solutions to the doubling of RF bands we will see in the near future.

Supplanting SAW filters is BAW technology. This technology can handle higher power levels than surface accoustic wave devices. Electric current distrubutes more freely and there are no narrow channels of fingers prone to electromigration damage as in SAW filters. Bulk filters have been used to partition the bands and are proving a more reliable bandwidth within band. Bulk Accoustic Wave technology extends the edges of the filters while maintaining sharp band edges.

SAW and BAW filters are forms of electromechanical resonators. Bulk Accoustic Wave filters, which can be made using crystal quartz, can be 1,000 times smaller than ceramic technologies while retaining low cost at high-volume manfacturing. As this technology supplants older Surface Accoutstic Wave solutions, the tightly packed bulk filters can allow smaller, more clever use of specific bands and power levels to set up a next-generation band-sharing technique.

New Ways of Partitioning

With more filters exhibiting higher power levels taking up less space, device-specific, and even protocol-specific partitioning of the air waves can take place. Additionally, design engineers can classify power levels of criticality, throughput, or other importance so that channel assignments for noncritical transmissions avoid these channels.

For example, a high-speed streaming multimedia link has higher bandwidth needs than SMS texting services. An interruption in the streaming could be a turnoff if not enough bandwidth or buffering is used. Seconds of delay in SMS services would not even be noticed.

By the same token, newly emerging medical devices connected to the Internet of Things could use specific subsets of the newly evolved bandwidth to assure the most reliability while monitoring a patient, or transferring error-free vitals. Even assigned fallback channels can be used to increase reliability.

Where to Begin

Those pioneering the technology usually have a lot to say. In this case, check out what Qorvo is introducing. Qorvo BAW filters range from 1.5GHz to 9GHz, encompassing the consumer wireless bands as well as carrier services. Parts such as the QPQ1909SR perform signal-conditioning filtration within the 2402MHz to 2494MHz bands for Wi-Fi bandage (**Figure 1**). Terminating into 50Ω, the low 0.8db to 1.2db insertion loss is important for maintaining signal integrity.

But while many are unfamiliar with how to design with BAW, aids are available to guide you through the journey. Take for example the QPQ1909EVB01 Active Filter Development Tools Evaluation Board Kit. This uses the high-performance, high-power edgeBoost™ Wi-Fi technology for channels 1 through 14. This means end users will see a better quality of service as well as higher regulatory power allowances (to +30dBm averaged input power). Note how the higher performance channels in conjunction with a priority scheme can ensure more reliable data communications to more critical applications.

And don't just think of BAW as a better Wi-Fi solution. Other BAW technologies from Qorvo are useful for GPS, diplexers, duplexers, and other assorted protocol-specific access points, routers, gateways, and wearables. If you are going to filter, do it in bulk.

Conclusion

With the introduction of next-generation services and devices, more frequencies, bandwidth, coexistence, and interference immunity are required. As a result, design engineers must maximize spectrum utilization. BAW technology and filters enable the partitioning of frequency bands for more precision filtering to capture stronger and more reliable signals with enhanced noise immunity.

Mouser stocks the widest selection of the newest products

qorvo®

mouser.com/qorvo

Worldwide leading authorized distributor of
semiconductors and electronic components

MOUSER ELECTRONICS