SKYWORKS®

The Future of IoT
Will Require LTE Connectivity

The wide range of wireless connectivity technologies available today have enabled consumers and enterprises the ability to acquire data that can provide a host of marketing, operational, and design insights. Research firm IDC estimates global commerce for the Internet of Things (IoT) will surpass $1 trillion by 2022, spread across consumer, enterprise, healthcare, and industrial applications. As the promise of a wirelessly connected world becomes a reality, there is a growing need for LTE technologies that address low cost, long battery life, security, and reduced complexity—all critical components for IoT.

Figure 1. Common IoT Wireless Connectivity Protocols

Connectivity Options for IoT Devices

With its massive growth, IoT has become a fragmented market with a diverse set of applications and use cases. Whether indoor or outdoor, fixed or mobile, low or high data rate, there are wide ranging and often differing requirements. To address this fragmentation, a broad spectrum of networking protocols in both licensed and unlicensed bands are being utilized by IoT device manufacturers. Wi-Fi® and Bluetooth® have been the most popular standards for Personal and Local Area networks, with newcomers such as LoRaWAN® and WiSUN gaining traction for Field and Wide Area networks (Figure 1). While each of these protocols offers various features and benefits, there are tradeoffs in power consumption, coverage, and cost with each. In this article, we are focusing on the licensed bands for Low Power Wide Area Networks (LPWAN) networks, and in particular, LTE connections for IoT.

Benefits of LTE for IoT

Since many IoT devices are sold and used globally, a key requirement is having a secure connection to the internet — anytime, anywhere. To ensure this safe, ubiquitous connectivity, devices may require a cellular connection
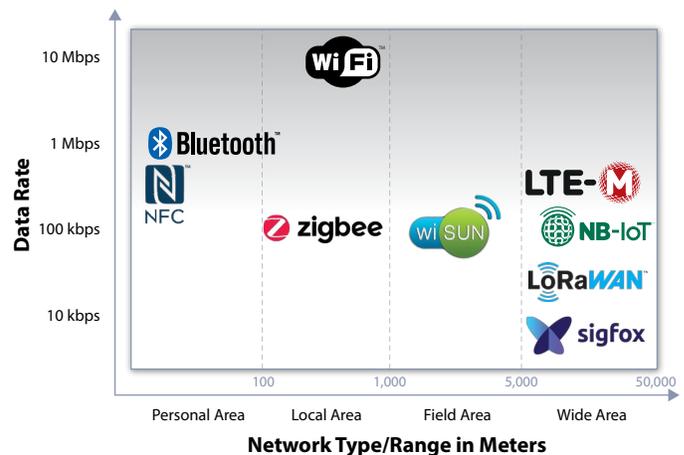
— whether via 4G LTE, or even legacy 2G or 3G standards. A cellular connection guarantees a level of quality and reliability that cannot be achieved with other technologies.

Developed by 3GPP and built on GSM and UMTS technologies, LTE has become the de facto cellular communication standard. LTE network deployments are extensive, and the technology offers multiple user equipment categories with varying data rates, performance, and cost. This flexibility enables LTE to address the full spectrum of IoT applications, from high bandwidth, high data rate applications such as gaming and mobile computing to low power, low data rate applications such as smart metering and asset tracking. With the onset of 5G, IoT devices utilizing LTE technology today will need to be forward compatible with the next generation standard.

The majority of IoT devices are expected to be used in low data rate applications, which is where the value of LTE starts to emerge. Frequently referred to as Mobile IoT, this includes LTE for machines (LTE-M), and narrowband IoT (NB-IoT) (Figure 2). These technologies are being deployed on existing LTE networks, with NB-IoT deployments occurring in-band or within the guard-bands between higher category LTE carriers.

LTE-M **NB-IoT**

	LTE-Cat-1	LTE-Cat-M1*	LTE-Cat-NB1	LTE-Cat-NB2
3GPP Release	Rel-9	Rel-13	Rel-13	Rel-14
Peak Date Rate	DL: 10 Mb/s UL: 5 Mb/s	DL: 300 kb/s UL: 375 kb/s	DL: 27 kb/s UL: 63 kb/s	DL: 120 kb/s UL: 170 kb/s
Bandwidth	20 MHz	1.4 MHz	180 kHz	180 kHz
Typical Duplex Mode	Full Duplex FDD	Half-Duplex FDD	Half-Duplex FDD	Half-Duplex FDD
Typical Output Power	23 dBm	23 dBm	20 dBm	20 dBm
Network Deployment	In-band	In-band	In-band Guardband Standalone	In-band Guardband Standalone

3GPP Rel-14 increases peak DL/UL data rates to 600 kbps / 1 Mpbs

Figure 2. Mobile IoT Technology Comparison

Mobile IoT supports data rates below 1 Mbps and as low as 30 Kbps, offering IoT device makers the flexibility to address both voice and data centric applications.

Designers have embraced M-IoT connectivity in their products for a number of reasons. It is ideal for any application requiring secure, real time device-to-cloud connectivity that can be used for remote monitoring, control, and management. M-IoT enables low-power, wide area network connectivity not only for well-known consumer devices such as pet trackers and smartwatches, but also for industrial applications such as oil and gas metering, machine monitoring, and factory warehousing. It is also being widely deployed, with more than 100 LTE-M/NB-IoT networks announced or launched as of May 2019, according to the GSMA*.

LTE-M and NB-IoT feature an improved power consumption profile, partly because they work in half duplex mode, taking turns sending and receiving data instead of simultaneously doing both. These standards also support power savings modes as a core feature of how the network and device communicate. As such, these technologies are extremely attractive for battery powered IoT devices. In addition to the power savings, using half-duplex architecture reduces the complexity and cost of the front-end — which is critical for "billions" of connections. To complement LTE-M and NB-IoT, LTE Cat-1 is beneficial for voice-based IoT applications such as alarm panels and ATM machines, as well as for music streaming through wearable devices, where higher data rates and lower latency are essential.

Another key benefit of LTE for end users is a more seamless connection experience — no need for passwords or pairing.

An LTE-enabled IoT device is always connected to a cellular network and can be remotely provisioned as needed. The security of LTE provides another differentiator. LTE devices utilize an embedded SIM to identify the device on a network, where the network utilizes multiple authentication and encryption schemes. In addition, quality-of-service (QoS) controls provided by the network ensure the best encrypted data handling and lowest traffic latency possible.

Design Considerations for Adding LTE Connectivity

There are some important considerations that product designers should address up front when incorporating LTE. First, it is imperative to know where the device will operate – if it is a global or a regional SKU. The required band coverage will determine the amount of gain and filtering that will be needed, as well as the network operator performance requirements.

Other key considerations include the required data rate for the device, whether it will support voice commands, or if it will need to maintain backward capability with legacy 2G/3G networks. These factors determine which cellular modem platform can be used — LTE Cat-1, LTE-M, NB-IoT, or 2G/3G. The battery choice also has a huge impact on how connectivity is implemented. If a direct battery connection is required without the use of a regulator (either internal to the cellular modem platform or external), the RF front-end needs to operate over a wide supply voltage range. Therefore, voltage range and current consumption become key factors in the power amplifier (PA) selection.

Source GSMA May 2019 - https://www.gsma.com/iot/mobile-iot-commercial-launches/

Further, LTE device certification can be lengthy and time consuming. Devices need to pass network operator certification (Verizon, AT&T, etc.), 3GPP standards (Global Certification Forum - GCF), and industry (Lightweight M2M) and regulatory certification (FCC, CE, etc.). Fortunately for product designers, there are turnkey LTE module manufacturers and modem vendors that address these certifications as part of their product offering.

Finally, since products can incorporate multiple connectivity standards, an LTE-enabled device should not violate coexistence requirements with other radios such as GPS and Wi-Fi. Ensuring coexistence of a mix of RF technologies within the typically confined physical space of an IoT device can be quite challenging.

The Design Decision

Product designers face the typical "make-or-buy" decision when looking to add LTE connectivity to any IoT device. Creating a solution in-house offers the most flexibility but also carries significant risk. Without a strong understanding of the standard specifications and extensive experience in RF, design engineers can make critical mistakes, wasting development time and resources.

There are also a number of common issues that often emerge when testing an LTE device: limited range, higher than expected current consumption, insufficient output power, degraded receiver sensitivity, and increased spurious emissions. These challenges can typically be traced back to the RF front-end component selection, PCB layout, antenna design, and PA matching and filtering. Unfortunately, this happens even when the design looks good in simulation, or even as an engineering prototype. For consumer IoT devices with short product lifecycles, time-to-market is a huge competitive advantage. This is one of the reasons why LTE adoption has been limited to date – manufacturing iterations to optimize LTE connectivity is time and cost intensive. To expedite time-to-market, it has become increasingly important for OEMs to have a fully-integrated, certified connectivity solution.

With decades of experience in developing innovative solutions over successive technology generations, Skyworks is a leader in enabling seamless LTE connectivity for IoT devices. Specifically focused on designing products with IoT applications in mind, Skyworks offers cost effective RF wireless engines that address key requirements including global band coverage, integrated functionality, direct battery
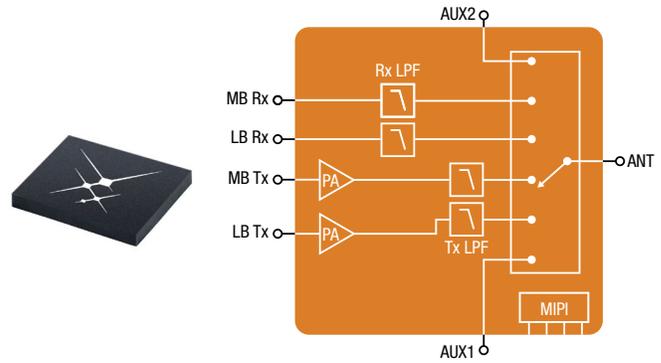

Figure 3. Skyworks' SKY68020-11 LTE Universal Multi-Band Front-end Module
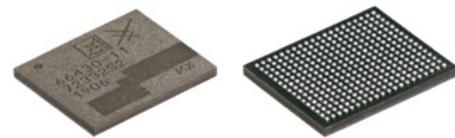

Figure 4. Skyworks' SKY66430-11 Mobile IoT System-in-Package

connectivity, and network and regulatory compliance. Our SKY680xx series of LTE universal multi-band front-end modules (Figure 3) for example, are already powering millions of IoT devices on networks worldwide through collaboration and reference designs with major modem platform vendors.

Skyworks is also pioneering DIE level intelligent integration into Mobile IoT, leveraging years of power amplifier design and system engineering experience with advanced packaging techniques to develop system-in-package (SiP) solutions. The SKY66430-11 (Figure 4) is a unique, fully certified all-in-one Mobile IoT solution that integrates Sequans' Monarch platform with the entire RF front-end within a single 8.8 x 10.8 x 0.95 mm package. This fully shielded device provides a complete solution for OEMs looking to streamline the design process and expedite commercialization.

With consumers expecting always-on connectivity and IoT devices proliferating across the globe, Mobile IoT technology will become more prevalent. Manufacturers must be ready to respond with the most advanced wireless solutions that simplify design and support multiple protocols and standards. Skyworks also offers both discrete and integrated solutions supporting full-duplex cellular/LTE, Wi-Fi®, Bluetooth®, LoRaWAN™, Thread, and Zigbee®. By taking advantage of a full suite of process and packaging technologies, Skyworks is able to offer RF front-end solutions to meet the diverse and fragmented needs of the IoT market, fulfilling its vision of **Connecting Everyone and Everything, All the Time**.

For more information about our solutions, please visit us at www.skyworksinc.com