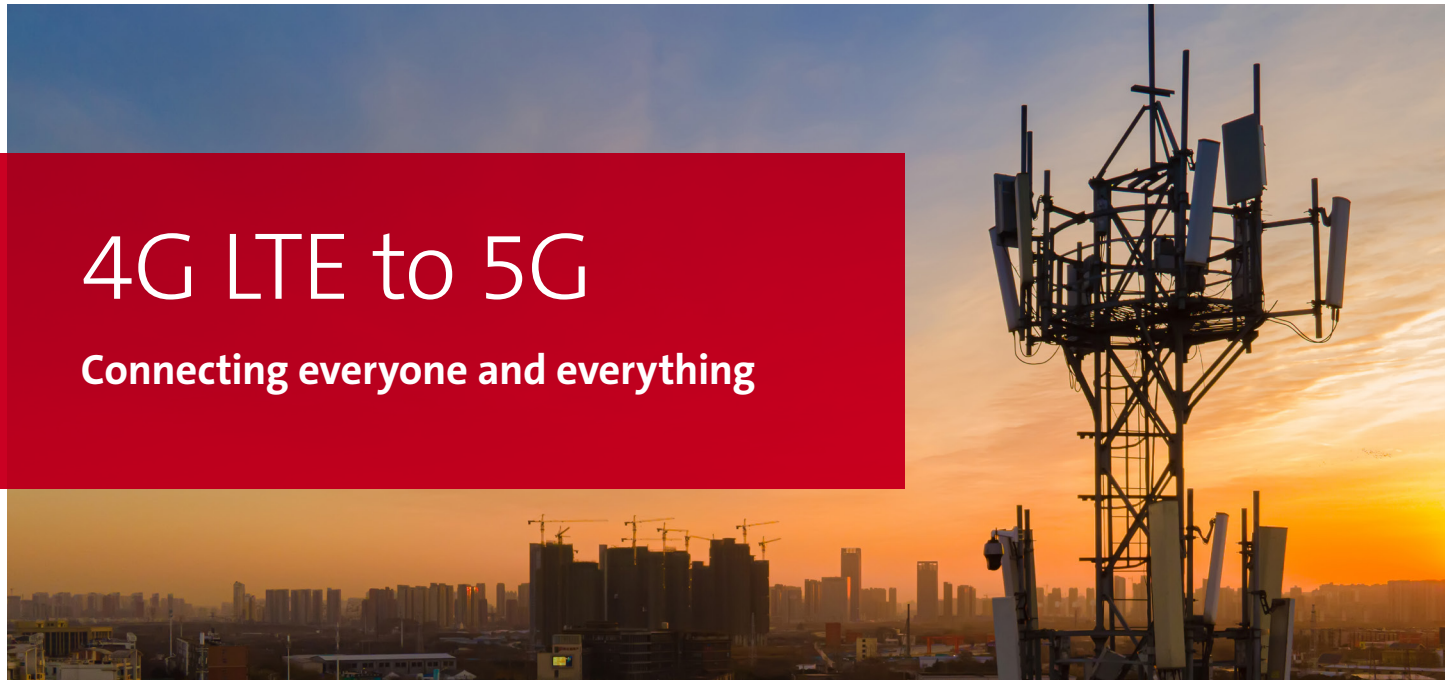

4G LTE to 5G

Connecting everyone and everything

About a decade ago, 4G LTE became the upgrade path for wireless carriers moving on from 3G networking technology. 4G's time may be fading with the spread of the next generation of networking technology — 5G. Introduced in 2019, 5G technology represents a dramatic transformation in mobile technology, and more than 1 billion connected devices already use it. But how big of an upgrade is 5G over 4G? Think exponential rather than linear progression. Let's take a look.

5G has higher speeds, lower latency response time, and zero-failure reliability compared to 4G. But how much faster? 5G has peak download speeds of 10 gigabits per second, which is not a gradual increase over 4G. It is 100 times faster than most 4G speeds. And what is the reduction in latency (the time it takes for a data packet to travel from one point to another)? For 4G, latency is about 200 milliseconds. Divide that number by 200 to get the peak 5G latency rate of 1 millisecond, which is as close as you can get to instantaneous. And zero-failure reliability—is that really possible? It can be: 5G technology and its cloud-based and virtual infrastructure are based on software, rather than hardware, which reduces or eliminates many failure scenarios.

With the virtually limitless potential to connect everyone and everything, 5G is a significant upgrade over 4G LTE. But 5G also presents technical challenges — particularly its reliance on the 5G millimeter wave spectrum (mmWave), which supports up to 1 million devices per square kilometer. (4G supports around 4,000 devices per km^2.) Such performance capability puts a lot of stress on printed circuit boards (PCBs), which are the heart of electronic components. PCBs can be susceptible to failures related to soldering, chemical leakage, barrier breakage and other issues. PCBs for 5G-capable devices must be specially designed and constructed to maximize performance while reducing or eliminating the chance of failure.

Manufacturers of PCBs designed for use in 5G network technologies must produce devices that safely and reliably manage both high-speed digital and high-frequency radio frequency (RF) signals, while also conforming to strict weight, size and space constraints. At UL Solutions, we've been working with 5G since its inception, and we have developed PCB reliability testing for both 5G frequency categories: Frequency Range 1 (410 MHz to 7.125 GHz) and Frequency Range 2 (24.25 GHz to 52.6 GHz). Reliability testing is part of UL Solutions' comprehensive package of PCB compliance and regulatory safety testing services.

UL Solutions

New high-speed printed circuit (PC) materials supporting highly complex integrated designs enable 5G viability — but not without significant changes to PC design and manufacturing. To sustain 5G performance, PC specifications include primary variables of substrate type, copper weight and roughness, trace width and spacing, layer numbers, trace geometry after etch (or additive process), antenna integration and conductive/dielectric lamination processing techniques and quality control.

The significant PC design and electronic performance demands supporting the transition from 4G LTE to 5G include:

- New PC laminate and copper materials for high speed/high frequency.
- Upgraded construction and performance in communication base stations for Multiple-Input Multiple-Output (MIMO) data streams.
- Flatness and zero distortion or delamination of hybrid PC laminates for signal integrity.
- Thermal management of high-speed PC stack-ups and assemblies (overheating is a leading cause of PC failure).
- Low and stable Dk (dielectric constant) and Df (dielectric loss) for ultra-fast signal transmission rates, including ultra-low latency under variable long-term environmental stress.
- Challenging evaluation testing and performance prediction for mixed-signal designs.
- Zero-fail reliability demands in mobile devices, transmission networks and Internet of Things (IoT) devices.
- New high-density multilayer PCs incorporating multiple antennae in package (AIP) technologies.

UL Standards & Engagement developed the current globally adopted PCB safety standards. Learn more about our PCB compliance and regulatory safety testing or contact us for more information.

Related resources:

- PCB testing, certification and validation.
- Comprehensive compliance and performance solutions for printed circuit boards.
- Consumer technology services.

UL Solutions

Safety. Science. Transformation.™

CMIT22CS609505