The Emerging Millimeterwave Measurement Frontier

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Millimeterwave (mmW) technology has been identified as one of the key technologies for 5G and many other exciting markets in the commercial space. Because of the large amount of available bandwidth at the mmW frequencies, the number of components and sub-assemblies required will increase rapidly along with the growing number of applications and technologies currently being developed.

Rapid progress in emerging markets like the Internet of Things (IoT), 5G mobile networks, autonomous vehicles, and small satellite communication systems has already created more opportunities for the microwave and mmW industries. For the first time, companies working in mmW are starting to address the possibility of volume production as the estimated number of connected devices reaches an astounding 50 to 100 billion in five years. Understanding how to produce for volume will require semiconductor, component, and subassembly manufacturers to work with system integrators to push the manufacturing processes forward so that the technology can become affordable.

One of the most pressing challenges in the development of manufacturing processes is mmW testing. Traditionally, RF performance testing for microwave and mmW is divided into two main categories: 1) hard connection testing (i.e., connector-to-connector) and 2) radiation testing (i.e., electromagnetic measurement in -- or through -- the air). An example of hard connection testing is the use of a network analyzer to perform gain measurement testing of connectorized mmW amplifiers. And an example of radiation testing is the testing of antenna radiation patterns and gain measurements. However, due to the advancement of the technology and higher levels of integration, today's testing requirements are shifting from fundamental [S] parameter measurement for simple two port networks, to RF front-end effective isotropic sensitivity (EIS), total isotropic sensitivity (TIS), total radiated power (TRP), and system testing for MIMO systems.

All of these methods can become extremely costly because of equipment requirements as well as human capital. Workplaces that are looking to equip their labs for mmW often have to make the difficult decision to invest in brand new vector network analyzers, signal generators, and power sources. These upgrades may also need to be accompanied by new calibration kits and test accessories. Even leasing can be expensive if multiple test stations need to be upgraded to mmW.

In addition, enormous time needs to be dedicated to planning for the expansion. Limited facility or lab space could delay the move to higher frequencies, and some companies may need to grapple with whether there is a real business case in mmW despite what the market suggests. All of this does not consider the engineering time that is required to research, procure, and configure these new testing stations. Often, experienced engineers and technicians find that there is a learning curve despite their extensive experience at lower frequencies.

Fortunately, the industry is starting to see more affordable ways to reach mmW frequencies. Historically, mmW test equipment has been costly because of the expensive nature of high-performance mmW semiconductor devices, components, and modules. While a few big names have always dominated the test equipment market, increased activity in the mmW space has created opportunities for newer companies to approach test challenges in innovative and more cost-effective ways. Often, these newcomers find ways to collaborate with test equipment leaders to push the technology forward. Some examples of such companies are Copper Mountain Technologies, SAGE Millimeter, and General Test:

1. Copper Mountain's Cobalt VNAs offers an alternative and low-cost solution for [S] parameter measurement up to W band.
2. SAGE Millimeter has defined and developed many frequency extenders to be added onto existing microwave frequency synthesizers, VNAs, and noise figure test sets to extend the frequency up to 170 GHz. In addition, it has defined and developed

thousands of mmW COTS and cost-effective products for equipment integrators for their system considerations.

3. General Test Systems (GTS), Inc. has developed accurate, fast and affordable over-the-air (OTA) test solutions for TIS, TRP measurement. GTS has developed radiated two-stage MIMO OTA throughput measurement methods that can provide fast and accurate test solutions for advanced millimeter wave MIMO systems.

The list of teams helping to address mmW testing through innovative technology continues to grow. The enthusiasm from the industry and the ever-increasing creativity of end-user applications fuels these types of developments. Continued progress at all levels of the supply chain through better manufacturing processes and better technology in the design, semiconductor, and machining spaces will also help to make reaching mmW more feasible.

It is truly a collaborative effort, and the benefits of finally taming mmW technology for society's use are absolutely worth the investment.