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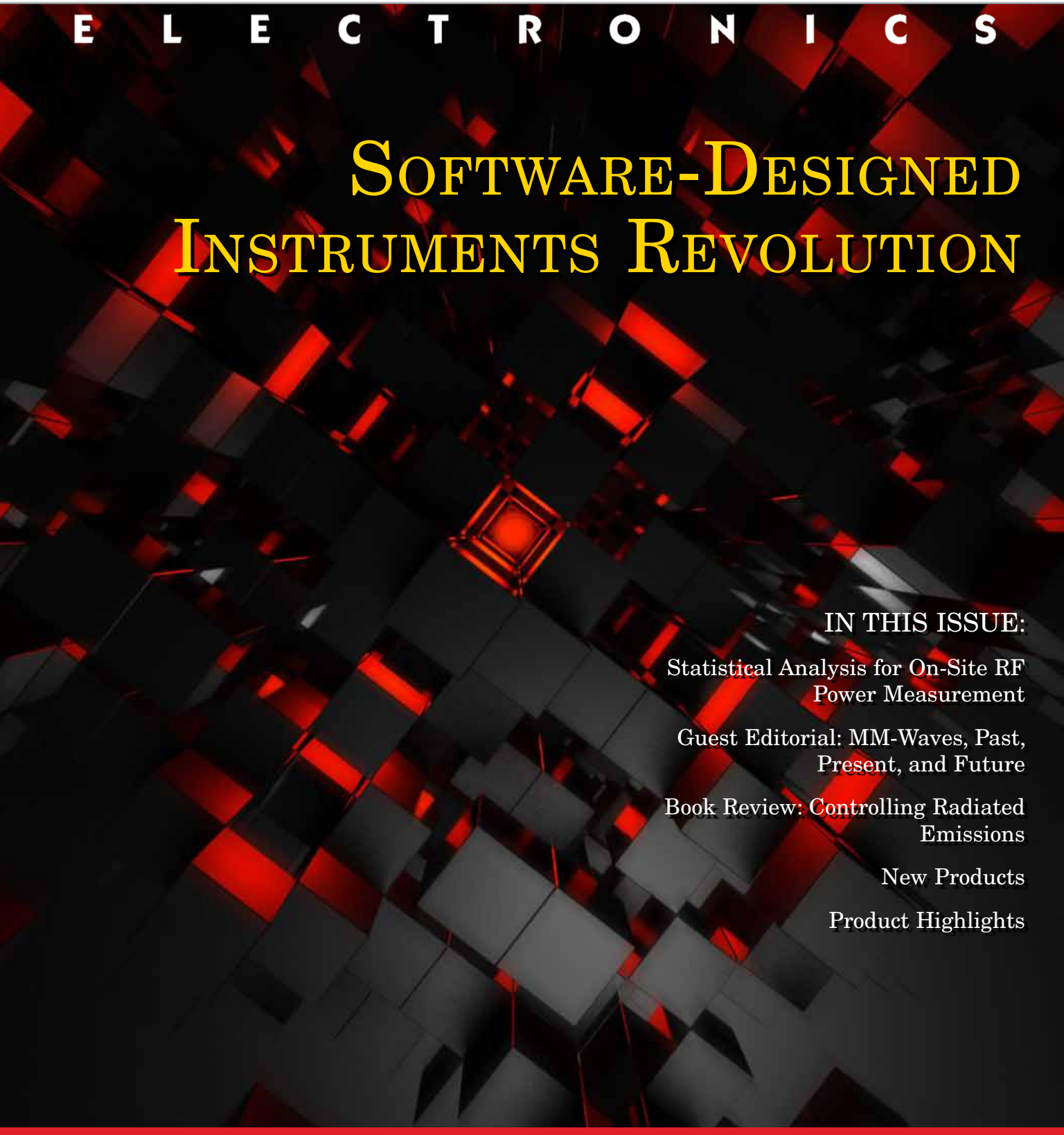

Software-Designed Instruments Revolution

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Millimeter-wave: Its Past, Present and Future

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President and CEO
SAGE Millimeter

The millimeter-wave spectrum has many advantages over its lower-frequency microwave counterpart. Widely accepted to comprise 30 to 300 GHz, millimeter-wave offers smaller wavelength and wider bandwidth. Each feature has its own advantages. Small wavelength is attractive to users because it allows more available spectrum; is the choice technology for small components used in missiles, satellites, and aircraft; and has narrower beamwidth that allows greater angular resolution and precision in target tracking and discrimination. Wider bandwidth results in higher data rates in communications systems; higher range resolution and target identification in radar systems; greater sensitivity and resolutions in passive image systems; and higher immunity to jamming and interference.

"Niche" Technology?

Despite all of these advantages, millimeter-wave technology has always been seen as expensive and even unapproachable. The newness of the technology led many to consider the marketspace as "niche." Traditionally, this frequency spectrum was mainly used for military, aerospace and scientific research programs and equipment. The applications were generally limited to weapon guidance, seekers, radars, military communication equipment, remote control, remote sensing, radiometry, material science and research and development.

However in recent years, technological advances—especially those improvements related to simulation and design tools, semiconductor device performance and consistency and manufacturing methods—have allowed millimeter-wave technology up to 100 GHz, to reach the final stage of maturity. I believe that millimeter-wave technologies are finding **increasing** opportunities in traditional military and aerospace system applications and **explosive** opportunities in commercial applications. Today, the excitement surrounding "internet connectivity," "safety and security," "smart homes," and "smart clothing" shows that millimeter-wave technologies and products have more commercial and consumer-oriented applications than we have ever experienced. Research and development in the areas of high data rate communications, passive imaging, transportation safety and management systems, automotive ACC radar, security systems, commercial small satellites and test/measurement equipment, etc., confirms that the industry is healthy and growing.

MM-Wave Customer Base Expanding

SAGE Millimeter has empirical data to support these trends. This year, our customer list is not limited to government agencies, defense contractors, large commercial manufacturers, research organizations, and universities; it has also expanded to internet service providers, smart phone and wireless network manufacturers, and semiconductor manufacturers. We know that more development and demand will emerge in the frequency bands of 58 to 64 GHz and 71 to 86 GHz. That's why we feel that 2015 will be an important year for the millimeter-wave industry as our technology matures and applications become more clearly defined.

Perhaps one of the most promising commercial applications in 2015 and beyond is E-band products for "Last Mile" along with V Band "WiGig" because of how they will liberate users. As we become increasingly inseparable from our smartphones, the demand for faster media streaming and delivery will push the industry to provide solutions. With this technology, users who previously had to rely upon wired connections can now experience the same quality of connectivity with much less infrastructure and cost. The technologies in these frequency bands are becoming more mature, and consumers are pushing for both more cost-effectiveness and higher quality. Meantime, I expect that traditional applications in the area of military and aerospace will benefit from commercial development and will become increasingly robust as we continue to understand how this technology becomes more affordable.

Multi-Disciplinary Coordination

In order to complement these trends, industry leaders, government agencies, and legislators are working together to make this transition a reality. Of course, our

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industry's challenges have and always will be continued technological advancement and skilled personnel development. On the technology side, our industry is no different from any other—we need to continue to study, innovate, and improve.

Specific goals include developing higher frequency and higher performance semiconductors, designing and implementing better packaging and manufacturing techniques, and reducing cost. The larger challenge that needs to be addressed is the shortage of experienced and next-generation RF and microwave engineers and technicians who are specially trained to address technology, product development and realization challenges.

It was recently reported that the average RF engineer is 51 years old and has worked in the industry for 25 years. This confirms my opinion, published previously, that educational institutions and career-development centers need to collaborate with industry leaders to design new course works and programs focused on practical skill development. These programs need to mirror those found in other disciplines such as IT, programming, and mechanical engineering. Because our industry is unique and specialized, real attention needs to be given to students so that they can enter the industry with not only a strong foundation in theory, but also the hands-on ability necessary for success.