KEYSIGHT
TECHNOLOGIES

2018 Global Radio Frequency Test & Measurement Market Leadership Award

FROST & SULLIVAN

2018 BEST PRACTICES AWARD

GLOBAL RADIO FREQUENCY TEST &
MEASUREMENT MARKET LEADERSHIP AWARD

2018
BEST PRACTICES
AWARDS

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With connectivity becoming ubiquitous among most modern devices and machines, radio frequency (RF) technology has proliferated over the years, expanding beyond the communications as well as aerospace and defense (A&D) industries. Today, Frost & Sullivan observes how the technology is experiencing significant uptake in the automotive industry for connected car and autonomous driving applications. In addition, the cellular industry is evolving towards 5G, which represents an exponential increase in capabilities and performance compared to previous generations. These factors, along with new Wi-Fi standard 802.11ax, continuous demand from the A&D industry, emerging need from the medical devices industry, and new Internet of Things (IoT) standards, are all driving the demand for RF test equipment.

Frost & Sullivan notes that the new technologies being developed represent a step-function increase in complexity, challenging both customers and vendors. On one hand, customers need more powerful RF solutions with greater frequency coverage and modulation bandwidth, as well as vendor support to accelerate both their development time and time-to-market (TTM). On the other hand, providing such capable solutions is clearly challenging vendors, requiring deep RF expertise and innovation capabilities.

Market Leadership

Market Share Leadership Position

With 27.8% of global market revenues in 2017, Frost & Sullivan independent analysis confirms that Keysight Technologies (Keysight) is the market share leader in the RF testing and measurement (T&M) industry. This stellar performance is the result of strong market share in the traditional segment (34.5%), combined with growing share in the modular instrumentation segment (24.7%). Keysight's RF product portfolio is broad, encompassing all types of instruments including core RF tools such as signal generators, spectrum and signal analyzers, network analyzers, network emulation, and context instruments (power meters and electronic counters).

In the last three years, Keysight's heightened focus on research and development (R&D) applications has boosted its market share in traditional instrumentation. The company's modular instrumentation business has also grown tremendously, fueled by customers' transition from traditional test equipment to modular instrumentation for automated applications in manufacturing and design validation. Essentially, Keysight has brought to market innovative RF products in the modular form factor, which have helped it to capitalize on this market trend. The company has also come up with a number of solutions that it leverages to pursue opportunities it could not easily address prior to building a strong portfolio of modular RF products.

Keysight boasts a superior level of technical expertise in RF testing - accumulated over the past 80 years in this field. Frost & Sullivan monitors how the company's solutions address the full product lifecycle from R&D to field applications, a key contributing factor that has led to its ability to maintain a leadership position in the RF T&M market.

Growth Strategy

With close to eight decades of operation in the RF T&M market, Keysight benefits from a significant installed base that continuously generates demand for newer and updated products in line with the evolution of communication technologies. In 2010, the company began transforming its value proposition to encompass not only traditional instrumentation, but also modular instrumentation based on the PCI extensions for instrumentation (PXI) and AdvancedTCA extensions for instrumentation and test (AXIe) open standards, thereby addressing its customers' evolving and diverse needs. As it also provides portable instruments, Frost & Sullivan recognizes that Keysight is the only company in the RF T&M market offering all form factors to customers covering every stage of the product lifecycle - including simulation, research, development, design validation, manufacturing, and installation and maintenance.

More recently, Keysight has taken major steps to advance from a hardware-centric company into a software-driven company. It has made significant investments to develop its software capabilities, including the launch of a software design center in Atlanta, GA, and in a bold move even allows third parties to use its software in their offerings. Keysight has recently introduced Pathwave, a design and test software platform that integrates the customer workflow, from design and simulation, to prototype and test, to manufacturing. This growth strategy is aligned with the industry's increasing focus on software - although hardware remains critical in the RF T&M space, especially at the high end to perform the challenging measurements required by complex technologies entering the market (such as 5G).

Breadth and Depth of Product Portfolio

In addition to offering solutions in all form factors (traditional, modular, and handheld), the depth of each product line is far-reaching with various models featuring different specifications to match all possible customer needs:

- Spectrum/signal analyzers: Keysight offers more than 50 instruments varying in frequency range from 3 Hz to 110 GHz and in modulation bandwidth from 1 MHz to 1 GHz. While it provides full-featured high-end signal analyzers (X-Series Signal Analyzers), it also offers more affordable instruments, such as Basic Spectrum Analyzers (BSA) at a starting price of only $9,123.

- Signal generators: Keysight's signal generators portfolio, which includes 19 products, consists of several product lines, one with high and mid performance instruments (UXG, PSG, MXG and EXG X-Series Signal Generators) and another for

budget-constrained customers or those with basic requirements (N9310A RF Signal Generator). The UXG offers fast frequency and amplitude switching while PSG brings highest performance in signal fidelity and output power. The MXG Signal Generator line includes 3 models, 2 of which are analog signal generators, one model with a frequency range of 9 kHz to 6 GHz for a starting price of $16,528, and the other with a wider frequency range of 9 kHz to 40 GHz for a starting price of $26,008. The third model is a vector signal generator for 9 kHz to 6 GHz frequencies starting at $28,080. Similarly, the EXG consists of 2 analog models and one vector model with the same frequencies as the MXG models. However, starting prices are about 40% below that of the MXG models.

- Network analyzers: Keysight offers more than 70 products in this category, with different price-performance points ranging from portable (FieldFox) to very high-performance (PNA-X) instruments. Within its range of bench-top network analyzers, Keysight offers 3 different product lines - including the economical ENA, the more capable PNA-L, the high-performance PNA, and finally the very high-end PNA-X. These products cover frequencies from 5 Hz to 130 GHz that can be further extended to 1.1 THz and offer different performance in terms of dynamic range and analysis capabilities.

- Network Emulation: Keysight's wireless test sets portfolio consists of two key product lines: EXM for manufacturing applications and UXM for design validation. Able to handle up to 32 devices, EXM is optimized for testing multiple devices simultaneously with up to 4 TRX channels and 6 GHz frequency range for each channel, as well as 2 full duplex and 2 half duplex or 4 full duplex ports for each channel. Targeted at R&D use, UXM covers 3G and 4G cellular technologies. Keysight recently upgraded the instrument to cover 5G with the addition of new radio (NR) specifications.

- Power meters and sensors: Keysight offers 36 products in this category that range in price from about $2,300 to $33,300 and include average and peak power meters. Various price points are provided based on type and specifications including frequency coverage, power range, and other instrument capabilities.

- Electronic counters: The company offers 13 different frequency counters ranging in price from about $2,250 to $25,000 and from direct current (DC) to 46 GHz in frequency. Keeping customers' diverse needs in mind, each model offers different performance in terms of speed, accuracy, and resolution to best align with specific requirements.

With RF technology transcending industries and being applied in both critical and non-critical applications, the needs for RF test equipment are not only significant, but also quite diverse. The wider breadth and greater depth of Keysight's RF test equipment product portfolio compared to that of other competitors' thus enables the company to meet many more customer needs. Moreover, test systems typically consist of multiple

instruments, and software integration is critical. The wider offering Keysight provides from a solution, software, and instrument type standpoint helps customers save time and effort by acting as a one-stop shop, while making the most business sense, as Keysight ranks first in each discrete product category.

Tradition of Innovation in RF and Microwave Testing

Although the name Keysight Technologies emerged in 2014, the company is no stranger to the RF T&M industry. It benefits from a long history in RF testing dating back to the late 1930s when Hewlett-Packard (HP) was founded. In 2000, HP spun off its original T&M business, which became Agilent Technologies. After expansion into analytical instrumentation in the early 2010s with several large acquisitions, Agilent Technologies then split into two separate companies in 2014, giving rise to Keysight Technologies, which is the former Agilent Electronic Measurement Group.

Millimeter-wave frequencies are currently garnering significant attention with 5G and other new technologies. Keysight is especially well-positioned to support customers in testing at such high frequencies by benefiting from significant field experience dating back to the 1940s. The company first started operating in the microwave field with the Model A Signal Generator in 1943 and subsequently developed a full product line of microwave test equipment that was enhanced in the 1950s. It introduced the 8551 spectrum analyzer, the 8551A/851A microwave spectrum analyzer, and the 8420 network analyzer in the 1960s, sustaining its product innovation efforts in RF and microwave T&M from then on.

In the past 3 years, Keysight has been working quite closely with industry leaders to advance 5G. For instance, it hosted 200 thought leaders at a company event called 5G Tech Connect in December 2017, during which it announced the availability of its 5G NR network emulation solutions. Similarly, Keysight is collaborating with automotive original equipment manufacturers (OEM) and their suppliers for the development of next-generation automotive technologies, especially those related to the connected car and autonomous driving concepts. In fact, the company opened its Automotive Solution Center in Detroit, MI in November 2017.

Conclusion

Holding close to 30% of total market revenues, Keysight leads the global RF T&M market by a significant margin, the result of a broad and deep product portfolio developed over 8 decades. Keysight uses the experience gained from innovating in this field to help customers across industries (wireless communications, A&D, automotive) tackle the challenges brought by new, increasingly complex technologies. For instance, powerful solutions are required to address 5G connectivity, and the proliferation of RF technology in industries like automotive and medical devices calls for strong vendor support to accelerate development time and TTM in what are uncharted waters for customers. Keysight delivers on these needs.

Offering the most diversified portfolio of RF test equipment and software integrated solutions that address the breadth of customer workflow from design to manufacturing, Keysight's products span all categories (signal generators, signal analyzers, network emulation, network analyzers, power meters, frequency counters) with various models within each category featuring different specifications (frequency range, modulation bandwidth, accuracy, measurement capabilities) to best align with customer requirements. Committed to its objective of providing the most choices possible to customers, Keysight products are also available in different form factors (traditional, modular, portable) in line with today's requirements for each phase of the product lifecycle.

With its strong overall performance, Keysight Technologies has achieved and maintained an unmatched, trailblazing position in the RF T&M market. Frost & Sullivan is proud to bestow Keysight with the 2018 Global Market Leadership Award.

Significance of Market Leadership

Ultimately, growth in any organization depends upon customers purchasing from a company, and then making the decision to return time and again. Loyal customers become brand advocates; brand advocates recruit new customers; the company grows; and then it attains market leadership. To achieve and maintain market leadership, an organization must strive to be best-in-class in three key areas: understanding demand, nurturing the brand, and differentiating from the competition.

Understanding Market Leadership

Driving demand, strengthening the brand, and differentiating from the competition all play a critical role in a company's path to market leadership. This three-fold focus, however, is only the beginning of the journey and must be complemented by an equally rigorous focus on the customer experience. Best-practice organizations, therefore, commit to the customer at each stage of the buying cycle and continue to nurture the relationship once the customer has made a purchase. In this way, they build a loyal, ever-growing customer base and methodically add to their market share over time.

Key Performance Criteria

For the Global Market Leadership Award, Frost & Sullivan Analysts focused on specific criteria to determine the areas of performance excellence.

Criterion	Requirement
Growth Strategy Excellence	Demonstrated ability to consistently identify, prioritize, and pursue emerging growth opportunities
Implementation Excellence	Processes support the efficient and consistent implementation of tactics designed to support the strategy
Brand Strength	The possession of a brand that is respected, recognized, and remembered
Product Quality	The product or service receives high marks for performance, functionality, and reliability at every stage of the life cycle
Product Differentiation	The product or service has carved out a market niche, whether based on price, quality, or uniqueness of offering (or some combination of the three) that another company cannot easily duplicate
Technology Leverage	Demonstrated commitment to incorporating leading-edge technologies into product offerings, for greater product performance and value
Price/Performance Value	Products or services offer the best value for the price, compared to similar offerings in the market
Customer Purchase Experience	Customers feel they are buying the most optimal solution that addresses both their unique needs and their unique constraints
Customer Ownership Experience	Customers are proud to own the company's product or service, and have a positive experience throughout the life of the product or service
Customer Service Experience	Customer service is accessible, fast, stress-free, and of high quality

Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices
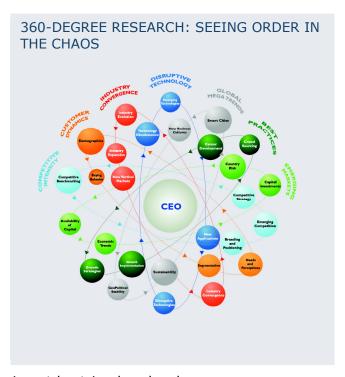
Frost & Sullivan Awards follow a 10-step process to evaluate Award candidates and assess their fit with best practice criteria. The reputation and integrity of the Awards are based on close adherence to this process.

STEP	OBJECTIVE	KEY ACTIVITIES	OUTPUT
1 **Monitor, target, and screen**	Identify Award recipient candidates from around the globe	• Conduct in-depth industry research • Identify emerging sectors • Scan multiple geographies	Pipeline of candidates who potentially meet all best-practice criteria
2 **Perform 360-degree research**	Perform comprehensive, 360-degree research on all candidates in the pipeline	• Interview thought leaders and industry practitioners • Assess candidates' fit with best-practice criteria • Rank all candidates	Matrix positioning of all candidates' performance relative to one another
3 **Invite thought leadership in best practices**	Perform in-depth examination of all candidates	• Confirm best-practice criteria • Examine eligibility of all candidates • Identify any information gaps	Detailed profiles of all ranked candidates
4 **Initiate research director review**	Conduct an unbiased evaluation of all candidate profiles	• Brainstorm ranking options • Invite multiple perspectives on candidates' performance • Update candidate profiles	Final prioritization of all eligible candidates and companion best-practice positioning paper
5 **Assemble panel of industry experts**	Present findings to an expert panel of industry thought leaders	• Share findings • Strengthen cases for candidate eligibility • Prioritize candidates	Refined list of prioritized Award candidates
6 **Conduct global industry review**	Build consensus on Award candidates' eligibility	• Hold global team meeting to review all candidates • Pressure-test fit with criteria • Confirm inclusion of all eligible candidates	Final list of eligible Award candidates, representing success stories worldwide
7 **Perform quality check**	Develop official Award consideration materials	• Perform final performance benchmarking activities • Write nominations • Perform quality review	High-quality, accurate, and creative presentation of nominees' successes
8 **Reconnect with panel of industry experts**	Finalize the selection of the best-practice Award recipient	• Review analysis with panel • Build consensus • Select recipient	Decision on which company performs best against all best-practice criteria
9 **Communicate recognition**	Inform Award recipient of Award recognition	• Present Award to the CEO • Inspire the organization for continued success • Celebrate the recipient's performance	Announcement of Award and plan for how recipient can use the Award to enhance the brand
10 **Take strategic action**	Upon licensing, company is able to share Award news with stakeholders and customers	• Coordinate media outreach • Design a marketing plan • Assess Award's role in future strategic planning	Widespread awareness of recipient's Award status among investors, media personnel, and employees

The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of our research process. It offers a 360-degree-view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often companies make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry participants and for identifying those performing at best-in-class levels.

360-DEGREE RESEARCH: SEEING ORDER IN THE CHAOS

About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best-in-class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages more than 50 years of experience in partnering with Global 1000 companies, emerging businesses, and the investment community from 45 offices on six continents. To join our Growth Partnership, please visit http://www.frost.com.