Microwave Journal

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Microwave Journal

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FEATURES

NOTE FROM THE PUBLISHER: THEN AND NOW

NOTE FROM THE EDITOR: THEN AND NOW

COMMEMORATIVE FEATURES

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Microwave Journal

FEATURES

COMMEMORATIVE FEATURES

COMMEMORATIVE FEATURE

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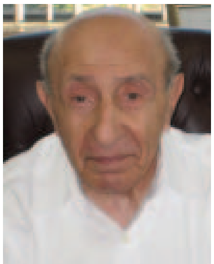
Read advice from a noted industry expert, respond with comments and win a complimentary copy of *Electrical Engineering: A Pocket Reference* from Artech House (see www.mwjournal.com for details).

July: Darren McCarthy, Technical Marketing Manager at Tektronix, talks about modern analyzers and the display technologies that allow engineers to better detect and represent the types of noise that can impact EMI design and compliance, wireless communication systems, or in some cases, show the mere existence of wireless devices.

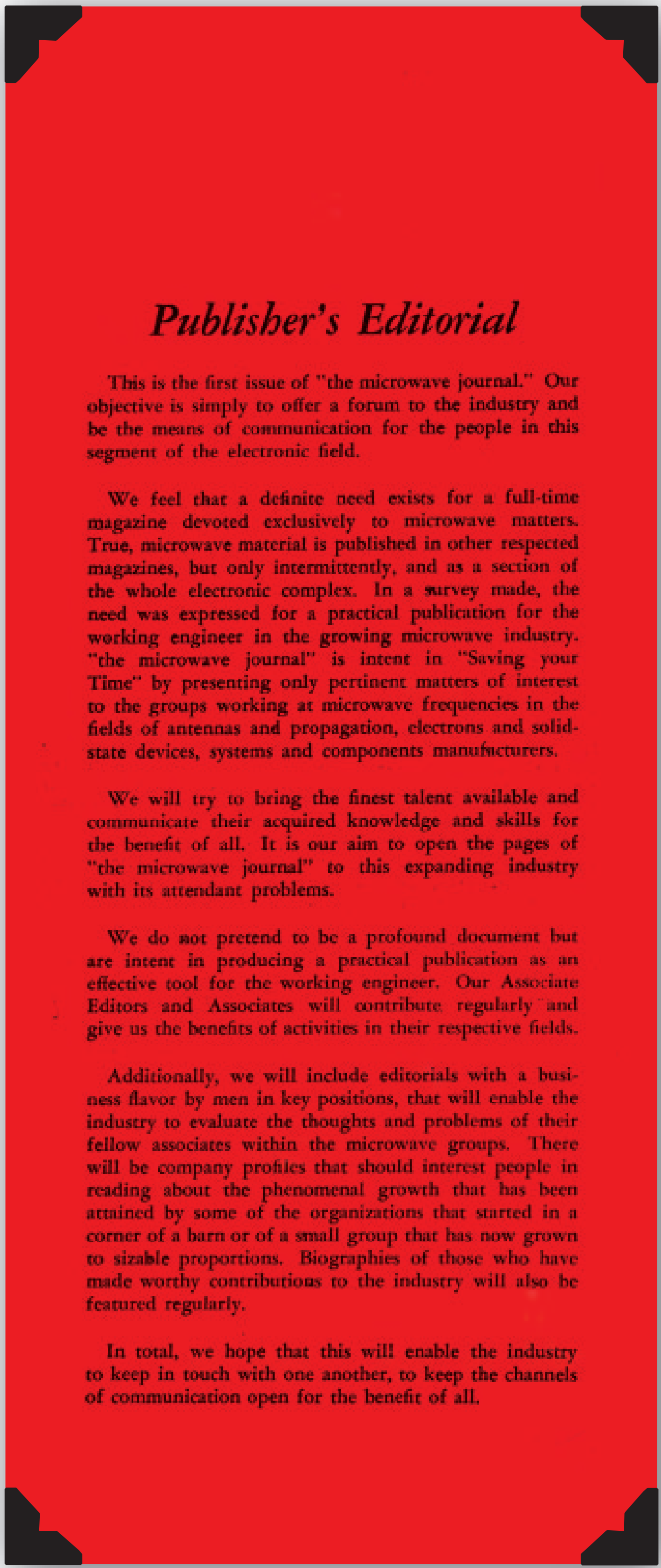
Retrospective

Rohde & Schwarz celebrates its 75th Anniversary with an in-depth online exclusive charting the company's development from a two-man lab into the global organization it is today. This article looks at R&S's introduction of large-scale production, its fresh start following the end of the Second World War and how it dealt with the ban on producing equipment with frequencies above 300 MHz.

Executive Interviews



William and Ivar Bazzy, Horizon House CEO/Chairman and President, respectively, talk with *Microwave Journal* about the early days of the magazine and the publishing business, the company's special relationship to the industry it serves and what lies ahead in the future.



Publisher's Editorial

This is the first issue of "the microwave journal." Our objective is simply to offer a forum to the industry and be the means of communication for the people in this segment of the electronic field.

We feel that a definite need exists for a full-time magazine devoted exclusively to microwave matters. True, microwave material is published in other respected magazines, but only intermittently, and as a section of the whole electronic complex. In a survey made, the need was expressed for a practical publication for the working engineer in the growing microwave industry. "the microwave journal" is intent in "Saving your Time" by presenting only pertinent matters of interest to the groups working at microwave frequencies in the fields of antennas and propagation, electrons and solid-state devices, systems and components manufacturers.

We will try to bring the finest talent available and communicate their acquired knowledge and skills for the benefit of all. It is our aim to open the pages of "the microwave journal" to this expanding industry with its attendant problems.

We do not pretend to be a profound document but are intent in producing a practical publication as an effective tool for the working engineer. Our Associate Editors and Associates will contribute regularly and give us the benefits of activities in their respective fields.

Additionally, we will include editorials with a business flavor by men in key positions, that will enable the industry to evaluate the thoughts and problems of their fellow associates within the microwave groups. There will be company profiles that should interest people in reading about the phenomenal growth that has been attained by some of the organizations that started in a corner of a barn or of a small group that has now grown to sizable proportions. Biographies of those who have made worthy contributions to the industry will also be featured regularly.

In total, we hope that this will enable the industry to keep in touch with one another, to keep the channels of communication open for the benefit of all.

William Bazzy's introductory message from the publisher, first published in the July/August 1958 issue of *Microwave Journal*.

William Bazzy *learned communications and electronics engineering while serving in the military in the 1940s. As a young radio and television broadcast engineer in Boston, he participated in the explosive growth of national broadcast networks, including intensive working sessions at RCA technologies, where new standards were being developed. In 1958, he brought together a team of engineering colleagues to address a need for technology information to serve professionals in the broadcasting and communications industries and* Microwave Journal *was born. As publisher, Bazzy led the magazine through tremendous growth as RF and microwave technology markets grew across the United States and around the world. In 1968, Mr. Bazzy's company, Horizon House, launched* Telecommunications *magazine to serve technical and management professionals in the fast rising voice and data communications industry. The company evolved to include industry exhibitions and conferences for the microwave and telecom industries, organized and produced from offices in the US and in London. Mr. Bazzy continues to serve as Chairman of Horizon House.*

CELEBRATING THE MICROWAVE INDUSTRY

CARL SHEFFRES, *Publisher*

2008 marks the 50th year of *Microwave Journal* (MWJ) in print. To celebrate the occasion, we have been running a monthly "Then and Now" feature, reprinting a classic article from the early years and inviting industry experts to write about the current state and future projections of each technology or product area. I hope that you've enjoyed this feature to date and will continue to enjoy them through the remainder of the year.

This issue is a very special one, as we commemorate the debut of *Microwave Journal* 50 years ago this month. In July of 1958, a group of entrepreneurs launched MWJ with the basic mission to "… offer a forum to the industry and be the means of communication for the people in this segment of the electronic field." That simple mission has proven successful for half a century and counting.

But this issue is more than a celebration of *Microwave Journal*. It's a celebration of the industry as a whole; an industry with countless pioneers, innovators and entrepreneurs. Randy Rhea touches on many of the visionaries and events that helped to create and shape our industry in his article titled "Historical Highlights of Microwaves." Representatives from SiGe Semiconductor and Raytheon share their views on "Future Projections for RF/Microwave Technologies" and James Rautio provides an interesting angle on the history of James Clerk Maxwell in his article titled "Twenty Three Years: The Acceptance of Maxwell's Theory." Editor David Vye expands on the past 50 years of RF/microwave events through the pages of MWJ with his first installment of a monthly series to run through the remainder of the year. We have also included some "Company Profiles" from the early years, which I think you'll find interesting.

Many companies in our community have recently, currently are, or shortly will be, celebrating their own major milestones. In speaking with companies during the year, it became readily apparent that we could not adequately cover every such company, without invariably and inadvertently leaving some out. With that in mind, we decided to offer a special "Company Profile" feature in this issue, allowing companies to tell their own story in an advertorial format. These profiles will give you a peek at the histories, milestones and successes of some of the companies that make our industry so unique.

From meeting with companies throughout the year and doing some quick research, I was amazed at the longevity of so many RF/microwave companies. Of particular note are Rogers Corp., who celebrated their 175th last year, Anritsu with a history of over 110 years, Valpey Fisher at 77, Rohde & Schwarz are celebrating their 75th, Aeroflex at 71, and HP/Agilent Technologies and Molex, now in their 70th year. Companies with histories longer than 50 years include Tektronix, Keithley, Maury Microwave, M/A-COM (Microwave Associates), Boonton (WTG), Microphase, Microwave Development Labs (MDL), Microtech, TRU Corp./ Sage Labs, Times Microwave Systems (Smiths), Coilcraft, San-tron, Spinner, Daico, Narda Microwave and Carlisle Interconnect Technologies. Rosenberger is celebrating their 50th anniversary this year. Companies with more than 40 years include RLC (49), TRAK, Greenray, Herley, Delta Electronics, Voltronics, SV Microwave, Werlatone, MECA, Astrolab, EMC Technologies (Smiths) and Microwave Filter Co. Companies celebrating their 40th anniversaries next year include MITEQ, Mini-Circuits, AR Worldwide and Huber & Suhner. Those celebrating anniversaries this year not previously mentioned include Sonnet Software (25), Teledyne Storm (30), American Microwave (30) and Delta Microwave (35).

I'm certain to have omitted many deserving companies, and I apologize in advance. But that only serves to support my assertion that we work in a very unique industry, where companies continue to innovate and grow over many years and its people tend to stick around for the long haul. It's unique in a very good way. If I have not mentioned your company, please visit http://microwavejournal.blogspot.com and add your comments. Randy Rhea has invited our readers to add their comments to his historical piece as well.

We're proud to be celebrating our 50th anniversary and equally proud of the industry we serve. We're also thankful to our loyal readers and advertisers, without whom we would not have reached this milestone.

EDITORIAL

One of the most important policies of "the microwave journal" is to strive for balance of content without diluting the quality of the magazine. In each issue an effort will be made to include a variety of articles rather than articles similar in type or content.

A quick study of the results of our first reader response confirms the original beliefs of the editorial board regarding the need for variety in the magazine. The greatest response indicated a desire for tutorial or survey type papers. In the field of specialization, most of the reader response indicated a desire for papers on antennas. Following these two major groupings, the reader response was greatest in the fields of Ferrites, Solid State (especially parametric amplifiers) and microwave tubes (especially traveling wave types). There were a number of requests for papers on Measurements, Systems, Components, and news items. A happy note was that many readers wanted issues similar to Vol. I, No. 1.

In future issues there will be the usual engineering papers which will try to feature the three "D's" — designs, dimensions, and data. In addition, there will also be tutorial papers, survey papers, and summary papers.

The regular departments, including the biography, company profile, and business editorial, will also strive for balance between systems people and component people, between the East and the West, and between the large and the small.

In keeping with policy, the next issue will include the second part of Dr. Ginzton's article on "Microwaves," a guest editorial on antennas by Carl Sletten of AFCRC, a paper on masers by William From of Ewen Knight Corporation, and a paper on Ferrite Circulators by Dr. Peter Rizzi of Raytheon.

It may be well to stress here that the papers by From and Rizzi are excellent examples of the type of technical paper that we want to encourage for publication in our journal. They present to the engineer clear descriptions of the working of masers and ferrites, with a minimum of mathematics, and offer him facts and information that he can readily use. It is this type of paper that we expect to feature in each issue of "the microwave journal."

The biography will feature Royden Sanders, President of Sanders Associates, the company profile will describe Litton Industries, and the business editorial will be authored by Dave Ingalls, President of Airtron, Inc., a division of Litton Industries.

Your continued response, of course, is essential in keeping us aware as to the needs of the industry. It is our intention to present a balanced program of information to the engineer and his associates. We will include articles with a business flavor as well as information about people and companies.

An early editorial column from Ted Saad, *Microwave Journal*'s first editor, originally published in September/October of 1958.

Ted Saad *worked at RadLab from August 1942 to December 1945. His first assignment was under Norman Ramsey and later Ed Purcell, in Group 42 studying the low pressure, high power breakdown of waveguide components. From there he moved to Group 53 to work under Jerrold Zacharias devising microwave components that would withstand high altitudes. This project included creating the layout design for radio frequencies used in airborne search and bombing radar heads. Finally, he transferred to the beacon group, number 71, where, under Dr. Riekel, he helped develop X-band beacon waveguide components.*

After RadLab he continued work as a radar engineer with the Submarine Signal Company. From there he and a few others, including Dr. Henry Riblet, formed a new company (Microwave Development Labs or MDL) specializing in microwave waveguide technology. Waveguide plumbing would represent a large segment of the microwave activity at this time. Later, he worked at Sylvania Electric Products alongside future Microwave Journal *associate editors – Dr. Benjamin Lax and Marshall Pease. Eventually, he started a company of his own, called Sage Laboratories in 1955. In 1958, he joined William Bazzy to launch* Microwave Journal, *serving as the magazine's first technical editor. He held positions as editor-in-chief, vice-president and consulting editor up to his retirement in the mid-1990s.*

Saad was one of the organizers and first chairman of the Boston chapter of the PGMTT. He was also editor of the society's The Transactions *publication for two and a half years.*

IN SEARCH OF THE NEXT MICROWAVE HORIZON

DAVID VYE, *Microwave Journal* Editor

In 1958, a microwave engineer might earn $11,500 a year, might have one or two customers (the government or sub-contractor), might have worked in ferrites, solid-state, travelling wave tubes, or microwave plumping and, in July, might have been among the 12,000 subscribers to receive the first issue of a new trade magazine written specifically for them and their colleagues.

Sensing the need for a full-time periodical devoted exclusively to microwaves, several entrepreneurs began publishing *Microwave Journal*. This month, we celebrate that moment and the 50 years of industry achievement that have occurred since. Following tradition, we have asked two leading members of our community to share their insights about the history of microwaves. We also begin a six-part series on our reporting of the past five decades.

Perhaps it is unavoidable to celebrate a milestone such as turning 50 with a reflection on the past and a desire to forecast the future. Beyond nostalgia, the past helps us to recognize trends, providing some glimpse of what's to come. From the start, the *Journal* was intended to provide such insight by tapping into the finest talent available and communicating their acquired knowledge. It is not surprising that the first editors looked to the industry's short past to "see over the horizon," an appropriate metaphor for an industry born from radar.

Early articles helped define our industry's identity—the nature of its existence, the scope of its technology and applications, and the prospects for its growth. In 1958, contributors were opining without the benefit of hindsight. They did have a solid understanding of microwave theory and an entrepreneurial "can-do" spirit common to many high-tech start-ups. Their excitement fueled much of our industry's early success. The knowledge and vision of guest authors such as Dana Atchley, president of Microwave Associates (Vol. 1, No. 1), would give readers a front row seat on important industry happenings.

So what did the early editors see for the microwave industry? Seymour Cohn very wisely commented that "technological growth is never steady, but comes as a random series of inventive explosions." Of course, Cohn knew the dangers of making predictions. While asking "the inevitable question of what are the major advancements to come," he remarked that no one could predict "the time or the exact nature of discoveries." Yet from past trends, Cohn was confident that future inventions would be based on earlier ideas and technologies such as "ferrites, parametric amplifiers and solid-state theory hold great promise."

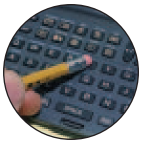
Articles in this first issue acknowledged our reliance on military spending but tried (somewhat in vain) to envision commercial opportunities. Prevailing capabilities and needs clouded their predictions. Consider the following from this 1958 article with respect to new microwave applications: "On the horizon we see large-scale use of low-loss millimeter-wave transmission in circular waveguides that will carry thousands of messages simultaneously." Change circular waveguide to fiber optics and thousands to millions and the prediction is right on the mark.

As engineers, we solve problems. During World War II, engineers and scientists would evolve microwave theory and techniques for radar. After the war, our industry would make constant improvements to the components in these systems. Many past articles reveal an ongoing battle between competing technologies: TWTs versus solid-state; MESFETs versus PHEMT and HBT; microwave radio links versus fiber optics; GaAs versus Silicon; and WiMAX versus LTE. While the market will ultimately decide the winner, the engineer prepares these competing technologies for battle and the *Journal* is there to report the score.

With regard to predicting the future, some things are inevitable. We will be asked to make components that are faster, smaller, weigh less, consume less power, cost less and do more. We will play a critical role in defense and communication systems. But just as it was challenging for the first editor's to conceive of commercial opportunities that were on par with the military microwave spending at the time, it is hard for us to know what sizable opportunities lie in wait for us.

Our industry's good health is due in part to our adept ability to apply microwaves in creative ways to address the needs of mankind. By recent research and development efforts the industry is poised to play a greater role in medical systems, automobile safety and traffic management.

In 1958, movie producer Frank Capra predicted global warming in a documentary called *The Unchained Goddess*. That year, a gallon of gas cost $0.24. Given the ongoing concern over global climate change and the soaring cost of gas, communication systems that reduce the need for travel and smart traffic that leads to less fuel-wasting congestion are two items "on the horizon." Beyond that, we shall wait and see. ■



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HISTORICAL HIGHLIGHTS OF MICROWAVES

The history of our industry is a productive mix of theory and pragmatism. James Clerk Maxwell, a brilliant theoretician, predicted the existence of electromagnetic (EM) waves in a paper presented in 1864, although their form was not the four-equation set used today. James Rautio has penned a more complete history of James Clerk Maxwell[1] in this issue of *Microwave Journal*. While Maxwell's work predicted EM waves, credit to proving their existence fell to Heinrich Hertz, a student of Kirchhoff and Helmholtz. In 1886, 22 years after Maxwell's paper, Hertz used an induction coil and spark gap to produce a spark in a gapped receiving loop resonant at about 450 MHz. Hertz, asked what his discovery was useful for, replied, "Nothing, I guess."[2] Hertz also discovered the photoelectric effect, later described by Einstein. The IEEE Heinrich Hertz Medal was established in 1987 "for outstanding achievements in Hertzian waves…" It is presented annually for theoretical or experimental achievements. In the summer of 1894, Oliver Lodge demonstrated Hertzian waves before the Royal Society in London. Like Hertz, Lodge did not view EM waves as useful, declaring a half-mile as the maximum range, and certainly not beyond line of sight.[3] Lodge used a coherer for detection rather than a ring with a gap. The coherer is a simple device that I constructed as a boy. Two wire terminals embedded in a small tube filled with metal fillings has a relatively high resistance until cohered by a nearby spark. Tapping the tube returns the resistance to its original state. In 1896, Bose of India gave a lecture at the Royal Society describing his experiments with special spark gaps to produce frequencies as high as 60 GHz.[4] He also carefully investigated the coherer. Reference 4 is an interesting technical book on the history of wireless.

These researchers, however, did not capture the world's imagination. Rather, it was a young Italian by the name of Guglielmo Marconi, born in 1874. He was not a theoretician, certainly not of Maxwell's caliber. In fact, his education was rather haphazard, consisting

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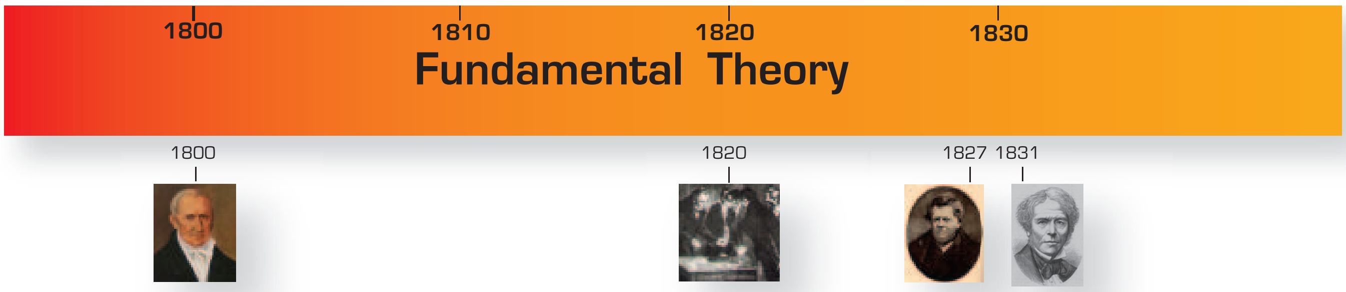


largely of miscellaneous tutors. But of the men of his time, he was the first with the vision and determination to use Hertzian waves for the purpose of long-distance communication. By shear trial and error, constantly seeking greater range, he improved the coherer, discovered the effectiveness of taller antennas and ground systems, and developed antenna loading. By 1895, he triggered a coherer at 1500 yards. He traveled to England and garnered the support of William Preece, the Chief Electrical Engineer of the British Post Office. In 1897, with the financial aid of a cousin, Marconi formed what was later named Marconi's Wireless Telegraph Company Limited. By the spring of 1899 he spanned the English Channel from Wimereux, France to South Foreland Lighthouse, England. He claimed to span the Atlantic on December 12, 1901, from Poldhu, Cornwall to St. John's Newfoundland (see ***Figure 1***). Because of a lack of independent confirmation and the weakness and brevity of the signal, this claim was met with skepticism. Nevertheless, by 1902, repeated successes silenced his critics. Due to conflicting records, the wideband frequency is not certain but was probably near 500 kHz. Marconi did not develop new technologies. He was a pragmatist and secretive about his equipment. Above all, he was a promoter. The aid brought to the Titanic by wireless SOS and the apprehension of London's infamous Hawley Crippen escaping to the United States by ship were just a few of the events that brought Marconi wireless to the attention of the world. *Thunderstruck*[3] is a fascinating, non-technical read about the development of wireless. Once Marconi demonstrated the importance of wireless, Lodge and others developed renewed interest, and numerous tiffs over patents and credit erupted. Marconi was awarded the Nobel Prize along with Braun in 1909. Marconi tarnished his reputation by embracing Fascism between the World Wars.

In the timeline that accompanies this article, I categorized five periods in the history of our industry. These periods are oversimplified, but they illustrate trends. The first period is the Fundamental period. Of course, fundamental discoveries continue to be made, but the Fundamental period was dominated by discovery as the scientific method dawned. Wired communication existed, but wireless and microwave applications were non-existent during this period.

The advent of wireless telegraphy began the Communication and Broadcast period, a period whose heyday reigned until the 1930s. While world navies quickly embraced wireless telegraphy, this is a period of primarily commercial activity, and technological developments paving the way for the electronic explosion that soon occurred. During this period the term radio supplanted the term wireless. Like the previous period, Communication and Broadcast is dominated by individual effort, inventive minds working alone, often driven by the thirst for profit bearing and sellable patents. Large companies grew by acquiring patents.

Fessendon was one of the first to transmit voice rather than Morse code. He also used alternators to produce low-frequency radio waves and wireless transatlantic communication became routine. Working with GE, they built alternators generating coherent signals as high as 100 kHz, an improvement over the tuned broadband spark, but it was brute force and the upper frequency was limited. The electronic era began with the development of the vacuum tube diode by Fleming in 1904 and the triode by De Forest in 1906. Thereafter progress was rapid. Broadcast joined the Communication period in 1920 when 8MK, later WWJ, began regular broadcasting from Detroit. In 1920, in one of the first broadcasted sports events, Jack Dempsey knocked out Billy Miske. By 1925, radio broadcasts included music, news, sports, educational programs, commercials and President Coolidge's inaugural address on 25 stations.

Important technological developments during the Communication

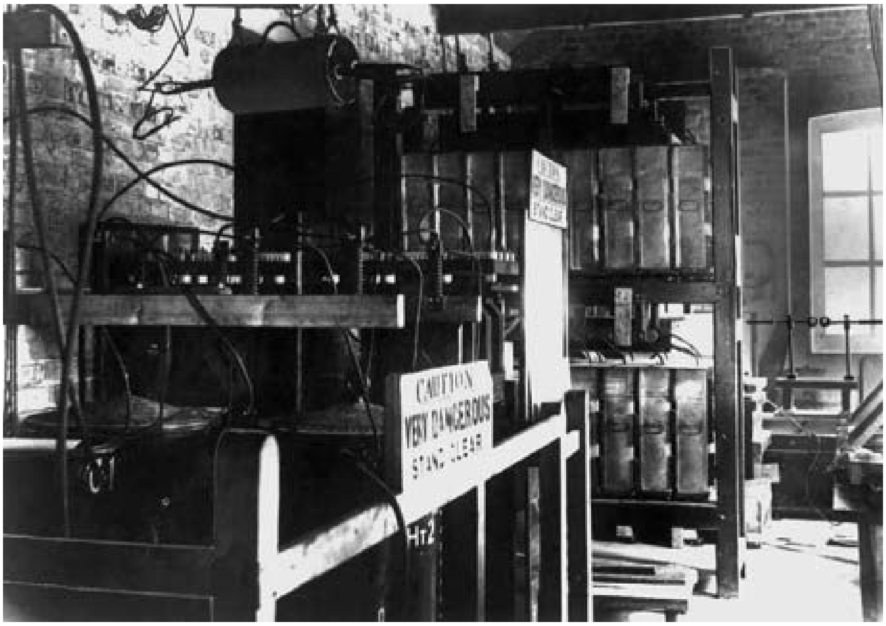
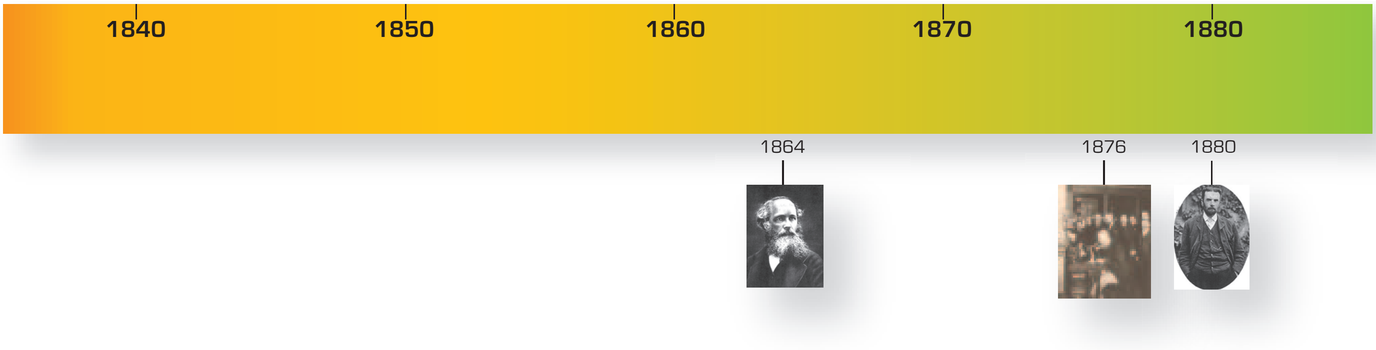


Fig. 1 Transmitting equipment at Marconi's Poldhu station (courtesy of ARRL.org).

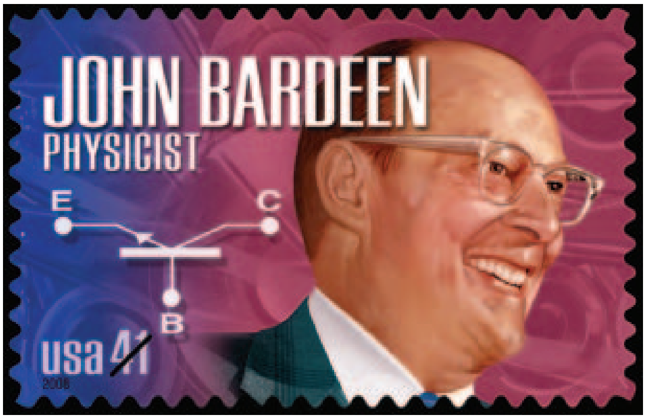


and Broadcast period included the CRT by Braun in 1897, the discovery of superconductivity in 1911 by Onnes, the growth of single crystals by Czochralski in 1916, the flip-flop in 1919, the magnetron by Hull in 1920, the quartz crystal oscillator by Cady in 1922 and the Yagi-Uda antenna in 1926. These examples illustrate the latency involved in many technological advancements. It was 75 years from the discovery of superconductivity until its widespread use in microwave systems. It was 27 years from the development of the flip-flop to the ENIAC computer and 62 years to the personal computer. The application of the flip-flop and superconductivity required the additional technical developments of the integrated circuit and higher temperature superconductors. Potocnik[5] suggested geo-synchronous orbital positions in 1928, but neither electronics nor booster rockets were ready. Other technologies were unencumbered by latency, such as the Yagi-Uda parasitic array and the magnetron, as it and waveguide ushered in the Military period.

While commercial electronic applications continued to advance, in the 1930s, tensions in Europe and movement by Japan onto the Asian continent gave impetuous to radar development. Enabled by the magnetron and waveguide, radar development became rampant. Page tested a monopulse radar in 1934, Watson-Watt coined the term radar in 1935, Russell and Sigurd Varian developed the klystron in 1937, and by 1940 the MIT Radiation Laboratory began and England was protected by the Chain Home radar. The Military period had clearly begun. World War II was also the driving force of the quartz piezoelectric industry. Huge quantities of bulk-quartz resonators employing pressure-plate electrodes stabilized communication radios. World War II and the Cold War dominated our industry for 50 years. Governments worldwide pumped vast sums of money into the industry. The original issue of *Microwave Journal* was published in July/August 1958 with a Bomarc missile on the cover and with Phillip Smith's 1939 chart in the background. A biography of Smith was included in that original *Microwave Journal*. Military dominance of the industry was evidenced in the original issue by all three technical features concerning radar components. Also, 13 of 21 ads included images or material for waveguide. Semiconductors were featured in only one ad!

While microwave applications were driven by the military, technology that sprang from the spending was the foundation for the periods that followed. Certainly not all developments of the period were military driven, but many were. The most important development of the period was at Bell Labs: the point-contact transistor in 1947 by Bardeen and Brattain. Shockley followed soon thereafter with the planar transistor. All three were awarded the Nobel Prize in 1956. Bardeen was a formidible engineer. He shared a second Nobel Prize in 1972 for the Bardeen, Cooper and Schrieffer (BCS) theory of superconductivity and his first PhD student, Holonyak, invented the light emitting diode (LED). A postage stamp was released in Bardeen's honor in March 2008 (see ***Figure 2***). In 1958, Kilby at TI and Noyce at Fairchild invented the integrated circuit (IC), and the rest is history. Other important, non-military events of the period were the approval of the National Television System Committee standard in 1941, a description of an Instrument Landing System by Pickles in 1946, experiments with NMR by Bloch and Purcell in 1946, the AT&T C-band long haul network beginning in 1950, Deschamps proposal of the patch antenna in 1953, and the first meeting in New York in 1952 of the PGMTT, now the MTT-S.[6]

On October 4, 1957, the Soviet Union launched Sputnik I. As a boy of 10, I kept a scrapbook with news clips about Sputnik and the failed December 1957 Vangard launch and I listened to the periodic and persistent beep from Sputnik on a shortwave radio. On January 1, 1958, the United States launched Explorer I. These events precipitated my interest in astronomy, radio and rocketry, and I later chose radio engineering as a career. I was not alone. The Soviet Union launched not only an 84 kg, 58 cm sphere, but also the careers of many engineers. It also launched the United States government into funding of local secondary schools for science, the establishment of NASA in 1958, and the Space Exploration period depicted in the timeline. Luna 1 flew by the moon in 1959 and a number of space probes followed. Yuri Gagarin, the first human to orbit Earth in 1961, died at age 34 during a routine MIG 15 flight. The first geo-synchronous satellite was Syncom 2 in 1963. After successful Mercury, Gemini and Apollo test flights by



▲ *Fig. 2 Postage stamp released March 2008 commemorating John Bardeen.*

NASA, on July 20, 1969, Neil Armstrong and Buzz Aldrin set foot on the moon. As a testament to the pace of technology, my grandfather never believed man set foot on the moon. I knew they at least orbited the moon. My thesis at Arizona State University was the construction of an earth station which received Unified S-band voice communications from Apollo 16 and 17. Each night I watched the moon move 13° further East, approaching the point in the sky where my antenna was pointed and Apollo was headed.

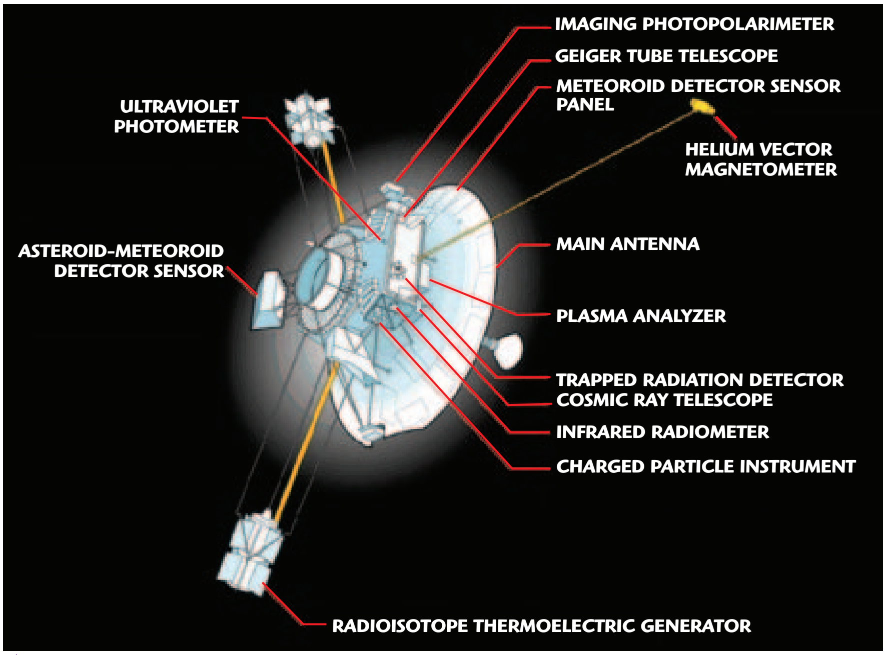
Pioneer 10 (see ***Figure 3***), powered by a radioisotope thermoelectric 154 W generator, and built by TRW, was launched in 1972. It used a 2.74 m dish for the high-gain antenna. The downlink was an 8 W TWT at 2292 MHz. In 1973 it passed by Jupiter, and in 2003 NASA communicated with Pioneer 10 for the last time at a range of 7.5 billion miles[7] on its way toward Aldebaran. What would Marconi think of that distance record? It was 172 years from Volta's battery to the launch of Pioneer 10. For the manned near-Earth exploration that followed Apollo, NASA augmented the S-band systems with the Ku-band Tracking and Data Relay Satellite Communication Systems (TDRSS). In roughly two million years, as Pioneer 10 approaches the area of Aldebaran, what might the Aldebarians think of the parabolic dish, the transistors, the TWT and the nearly dead radioactive battery? What will be the story of mankind?

Other important events of the Space Exploration and Military periods were numerous, including the first laser by Maiman in 1960, Kurokawa's paper popularizing S-parameters in 1965, RCA developing CMOS in 1968, AT&T proposing AMPS cellular in 1971, the first commercial microwave software in 1973, and GPS approval and RFID patents in 1973. Just as one of the first radio broadcasts was a boxing match, ironically, one of the first satellite delivered events from HBO to a cable TV operator was the 1975 "Thriller in Manila" between Muhammad Ali and Joe Frazier. GTE deployed a fiber optic link in 1977, GaAs FETs reached 10 W at 10 GHz in 1980 and AT&T divestiture occurred in 1982. In 1983 Motorola released a cell phone and by 1987 the operating temperature of superconductor materials abruptly rose.

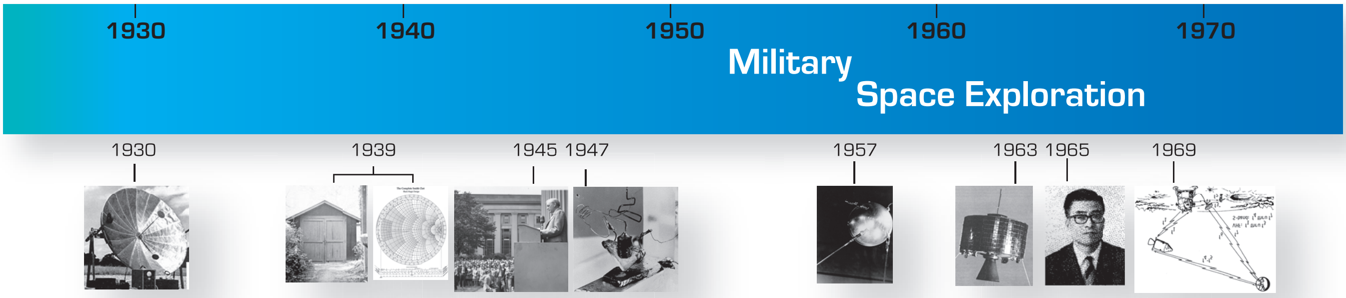
During Ronald Regan's eight-year tenure as President, the United States spent $2.2 trillion for the military. In December 1989, George W. Bush and Gorbachev, meeting in Malta, declared and end to the Cold War.[8] The dissolution of the Soviet Union in 1991 left little doubt and the Commercial and Data period was born. Not that military spending would decrease, but more of the budget would go to operations. Many engineers of my era transitioned from defense related work. For me, it was somewhat earlier, from radar to cable television and earth station work. The term wireless became fashionable again.

The metonym Silicon Valley was coined by Ralph Vaerst and published by a friend in 1971, but Stanford University and the earlier founding of Hewlett-Packard in 1939 were the seeds. Many companies in Silicon Valley had either been commercially driven or made the transition from military to commercial. If his employer didn't make the transition, an engineer often did. The Commercial and Data period made heavy use of technologies developed, or at least conceived earlier. New semiconductor processes were released, MEMS devices matured from pressure sensors to RF applications, LTCC work began in earnest and FBAR devices were used as RF filters.

On Thanksgiving Day in 1966, Howard Hughes moved into the top two floors of the Desert Inn in Las Vegas with a ten-day reservation.[9] After an extended stay, the Desert Inn requested that he vacate to accommodate high-rollers. Instead, he purchased the Inn, and later several other properties on the Strip. Aside from the role Hughes and his companies played



▲ *Fig. 3 Design of Pioneer 10 space probe (courtesy of NASA).*



in our industry, and his Spruce Goose being the centerpiece of an MTT-S reception in Long Beach, CA, in 1989, what does the Desert Inn have to do with our industry? The beautiful and classy Desert Inn was razed in 2001 to make way for the modern Wynn Las Vegas. The Wynn opened in 2005 with its casino poker chips among the first to use RFID tags.

My last entry on the timeline is the termination of NTSC television broadcasts in the United States in 2009. In the United States, television broadcast is going digital ATSC (Advanced Television Systems Committee). An obvious trend in the timeline is a bubble of increased events in the period from 1930 through the 1970s. Were there actually more watershed events during this period than later? Have important developments slowed? Or is the bubble an artifact of my selection process? It could very well be the latter. For example, few would have foreseen the significance of the printed wiring board when it was patented in 1936. It was some 30 years later before the PWB dominated electronics. From 1980 and on, I have probably missed many truly important events that are buried in the myriad of reported technologies and technical papers of our time. Certainly nanotechnology, MEMS and new material technologies are truly watershed. But what have I missed?

I intentionally avoided the association of names with important developments after 1965. The passage of time disengages us from the moment and often clears our vision. Even so, the assignment of credit can be difficult, as evidenced by the debate over whether Hertz, Marconi, Tesla or others are due the credit for wireless. The number of contributors in our industry has exploded, as evidenced by 12 papers presented to 210 attendees at the first PGMTT meeting in 1952. Compare that with MTT meetings of today. More importantly, the assignment of credit is particularly difficult for one individual specialized in a narrow field of our industry. Therefore, I put the question to you. Visit www.microwavejournal.blogspot.com and nominate your candidates for important developments and contributors, from the past to the present. ■

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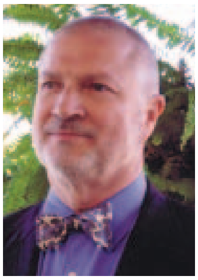
6. T. Saad, "The MTT Symposia," *IEEE MTT Trans.*, September 1983.
7. www.wikipedia.com: Pioneer 10.
8. www.wikipedia.com: Cold War.
9. www.wikipedia.com: Desert Inn.



Randall Rhea *graduated from the University of Illinois in 1969 and Arizona State University in 1973 and worked at the Boeing Co., Goodyear Aerospace and Scientific-Atlanta. He founded Eagleware Corp., which was acquired by Agilent Technologies in 2005, and Noble Publishing, which was acquired by SciTech Publishing in 2006. He has authored numerous papers, the books* Oscillator Design and Computer Simulation *and* HF Filter Design and Computer Simulation *and has taught seminars on oscillator and filter design to over 1000 engineers. His hobbies include antiques, astronomy and amateur radio (N4HI). In 2004 he toured 48 states by motorcycle. He and his wife Marilynn have two adult children and reside near Thomasville, GA.*

WEB RESOURCES

www.nobelprize.org
www.wirelesshistory.org
www.wikipedia.org: history of radio
www.microwaves101.com: history of microwaves
www.ideafinder.com
www.ieee-virtual-museum.org

What Happened in 1958?

- NASA North American Space Agency is formed
- 14 year old Bobby Fischer wins the United States Chess Championship
- Munich air disaster—21 dead, including seven Manchester United players
- Toyota and Datsun cars go on sale in the US
- Nikita Khrushchev becomes Premier of the Soviet Union
- Nelson Rockefeller elected Governor of New York
- US unemployment reaches 5.2 million
- US passenger jet flights start with a National Airlines Boeing 707
- The first Trans Atlantic passenger jetliner service begins with flights between London and New York on the new Comet Jet
- The Great Chinese Famine begins in 1958 and ending in 1961 causing the death of nearly 30 million through a combination of natural disasters and poor planning
- Elvis Presley is inducted into the Army
- General Charles de Gaulle becomes Prime Minister of France
- Brazil wins the 1958 World Cup in Sweden

Technology

- The Microchip first developed in US by Intel
- London Gatwick Airport opens after two years of extensive reconstruction
- US nuclear submarine "Nautilus" passes under Ice Cap at North Pole
- The US Military says it will be possible with satellites orbiting the earth to make detailed maps from space

Inventions Invented by Inventors and Country

- Microchip USA by Jack Kilby
- Computer Modem USA
- Remote Control USA Zenith Corp.

Popular Culture

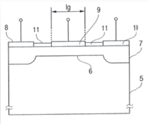
- The Wham-O company introduces the Hula Hoop; over 100 million are sold
- The Broadway musical "My Fair Lady" opens in London, with Rex Harrison as Professor Higgins and Julie Andrews playing Eliza Doolittle

1970 1980 1990 2000 2010

Commercial & Data

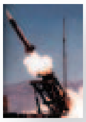
1971

1980

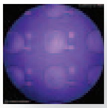


1982

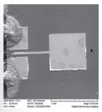
1991



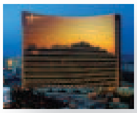
1997



2002



2005



1800:
Volta develops battery
1820:
Oersted discovers current deflects a compass
1827:
Ohms Law is published
1831:
Faraday discovers moving wire in magnetic field produces current
1864:
Maxwell presents key paper on electromagnetics
1876:
Bell utters "Watson, I want to see you"
1880:
Heaviside develops transmission line theory; rewrites Maxwell's equations
1886:
Hertz confirms EM propagation using spark
1893:
J.J. Thompson proposes waveguide
1896:
Bose generates sparks as high as 60 GHz
1897:
Braun constructs CRT; also invents Galena detector (first semiconductor)
1897:
Lord Rayleigh describes waveguide mathematically
1900:
Fessenden demonstrates voice by wireless; constructs alternators for wireless
1901:
Marconi spans Atlantic using spark
1906:
De Forest invents triode vacuum tube
1911:
Onnes discovers superconductivity
1912:
Armstrong improves tube amplifier, later FM and the superheterodyne
First electronic oscillators by De Forest and others
1916:
Czochralski grows single crystals
1917:
Wagner and Campbell refine electric filters
1919:
Eccles and Jordan invent flip-flop
1920:
Hull develops magnetron
8MK, later WWJ, in Detroit begins regular broadcasting
1922:
Cady produces quartz crystal oscillator
Taylor and Young detect wooden ships with CW radar
1926:
Trains between Berlin and Hamburg have radio telephones
Yagi-Uda antenna developed
1928:
Nyquist publishes his sampling theory
Potocnik suggests geosynchronous belt

1930:
Clavier uses parabolic dish for experimental microwave phone link
1932:
Jansky discovers noise from Sagittarius
1935:
Watson-Watt coins term radar and later the term ionosphere; patents radar in UK
1936:
Eisler devises printed circuit
1937:
Varian brothers develop klystron
Stibitz develops digital computer with relays
1938:
Schottky describes metal-semiconductor junctions
1939:
Hewlett and Packard launch a garage shop
Phillip Smith publishes his chart
1940:
MIT Radiation Laboratory opens
Chain Home radar in service in UK
1941:
B&W TV NTSC standard adopted
1942:
Friis develops noise figure theory
1944:
Rabi suggests using magnetic resonance for clocks
1946:
Signal bounced off moon
Pickles describes Instrument Landing System
Bloch and Purcell experiment with NMR
1947:
Bardeen and Brattain develop transistor
1948:
Watson builds first CATV system; also first to use microwaves to import TV
1950:
AT&T 3.7–4.2 GHz long haul network begins operation
1952:
First MTT meeting then the PGMTT
1953:
Deschamps proposes patch antenna
NTSC color TV introduced
MTT Transactions first published
1956:
First commercial atomic clock
1957:
Sputnik launched
1958:
Kilby at TI and Noyce at Fairchild develop the IC
Microwave Journal first published
DARPA established
1959:
Feynman foresees nanotechnology
1960:
Maiman constructs first laser (ruby)
1963:
Syncom 2 is first geosynchronous satellite
1964:
Matthaei, Young and Jones publish "The Book"
Penzias and Wilson discover cosmic background radiation

1965:
Kurokawa's paper popularizes S-parameters
1968:
RCA develops CMOS
1969:
Unified S-band system links LEM and Earth
Internet began as Arpanet
1971:
AT&T proposes AMPS to FCC
Alohanet packet radio data network launched
1972:
Pioneer 10 launched
First MTT-S with exhibition
1973:
First commercial microwave software
GPS development approved
Patents for RFID issued
1974:
Volume production of MEMS pressure sensor by National
1977:
GTE deploys 6 Mbps fiber-optic link in Long Beach
1978:
AT&T begins testing of cellular phone system
1980:
GaAs FETs reach 10 W at 10 GHz
1981:
IBM PC released
1982:
AT&T divestiture
1983:
Motorola releases cell phone
1985:
FCC approves data in ISM bands
1987:
Temperature of practical superconductor materials abruptly rise as do applications
1990:
LTCC work begins in earnest
1991:
Radar guided Patriot makes nightly news
1993:
GPS with Block II operational
1996:
FCC adopts ATSC for digital TV broadcast
1997:
Work on HF MEMS begins in earnest
2002:
Agilent releases MEM FBAR filter for PCS transmitters
2003:
NASA's last contact with Pioneer 10 at 7.5 billion miles
2004:
Microwave cancer treatment trials begin
2005:
Wynn Casino opens with RFID tags in poker chips
2009:
NTSC TV broadcast ceases

LOOKING AHEAD: THE FUTURE OF COMMERCIAL WIRELESS— RF PLUG AND PLAY

The future of wireless communications is about its evolution from a technology to a resource—as common to our experience as water and electricity. In order to get there, though, the industry has to overcome some significant design challenges in mobile devices, many of which will be helped by advancements in semiconductor technology. Today's consumer mobile devices can include as many as nine RF chains, and engineers are taxed to meet the size, power and coexistence requirements of next-generation form factors.

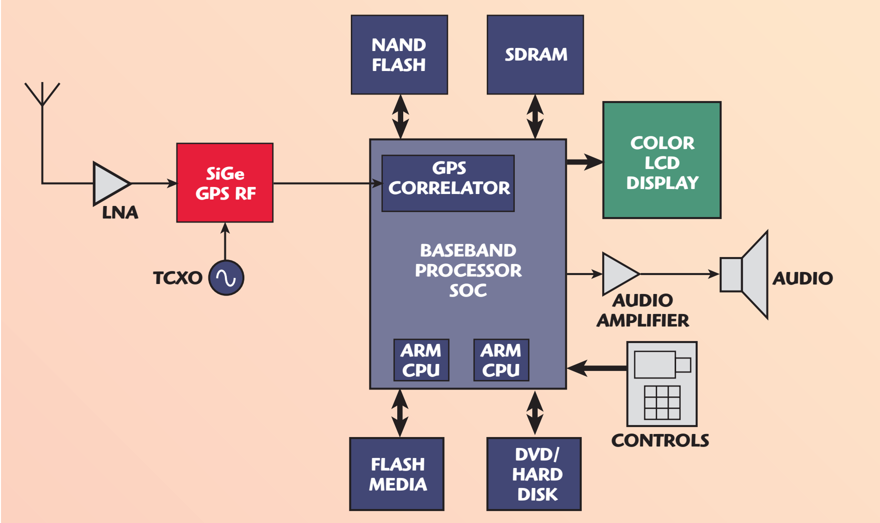
While many of us tend to focus on the evolution of networking technology standards and technologies as the driver of ubiquitous wireless (EDGE or 1xRTT? LTE or WiMAX? Satellite-based or terrestrial-based? Single-carrier or multi-carrier?), the reality is that the future of wireless communications is as much about the consumer device as it is about the network on which the device operates. The future of wireless communications is about how seamlessly wireless capability—and, most critically, RF technology—integrates into the various devices, vehicles, tools and spaces defining our daily lives. In addition, next-generation designs must be able to keep up with changing usage models. For instance, few predicted the explosive growth of text messaging, and dramatic improvements in RF and SoC capability and power consumption have enabled a richer mobile Internet browsing experience. Many are now focused on adding location-based services to mobile handsets, and the mobile device needs to have the required RF circuitry to handle all of these diverse signal chains.

INNOVATION REQUIRED

Seamless inclusion of wireless communications into our day-to-day existence has, until recently, often frustrated the best efforts of the wider electronics industry. Often referred to as "the black art of electronics," RF signal processing has long resisted the transition from circuit board-based discrete components to IC subsystems. Discussions of "the future of wireless communications" over the last decade have often referenced relatively exotic RF physical layer architectural innovations such as "software-defined radio" and "polar modulation," implying that fundamental rethinking of the approach to RF signal processing represented the best path to wireless pervasiveness.

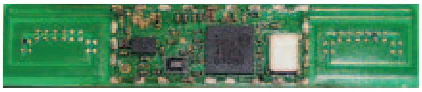
JOHN BREWER AND PETER GAMMEL
SiGe Semiconductor Inc.

▲ *Fig. 1 Google maps on a mobile device.*

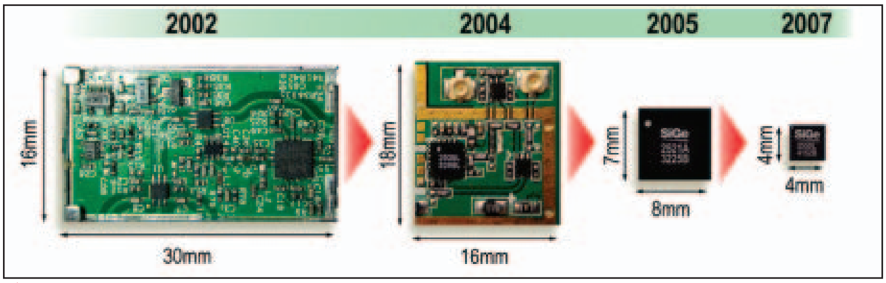


▲ *Fig. 2 Block diagram for an integrated RF physical layer GPS receiver.*

Instead, the future of commercial wireless communications lies not with exotic architectures, but with fundamental advances in how we use existing semiconductor manufacturing technologies. If the microprocessor industry has taught the RF industry anything, it is that, when done well, system-level functional integration enables lower power consumption, increased performance and smaller component footprints. As the user's experience of a wireless service is defined by the performance of the device, so the performance of the device is defined by the quality of the RF physical layer. The future of wireless communications lies with innovations in RF physical layer integration on the scale achieved for the operational amplifier in the 1970s: reliable, repeatable performance; standardized interfaces; user-programmable functionality; and ease of manufacture. Borrowing from the software industry, the promise of truly ubiquitous wireless requires a "plug-and-play" RF physical layer.



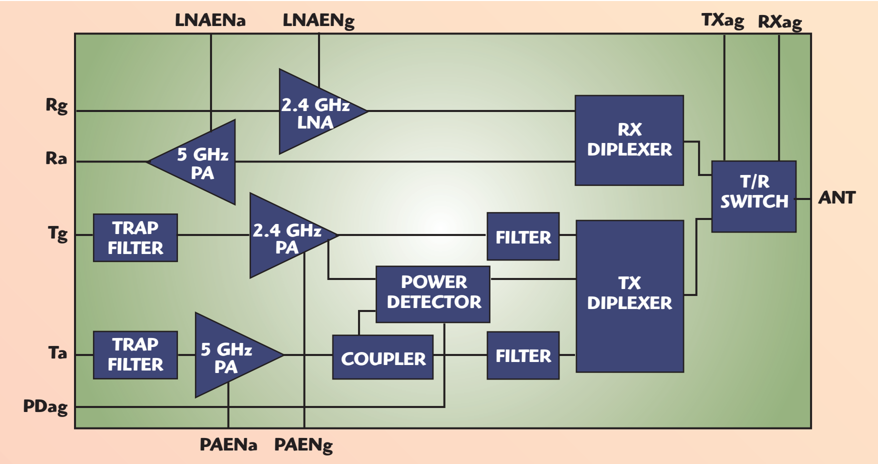
▲ *Fig. 3 Integrated antenna-RF front-end for GPS (courtesy of Antenova).*



▲ *Fig. 4 The shrinking of the RF PA form factor over the past few years.*

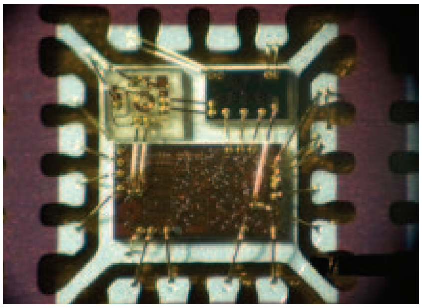
INTEGRATION OPPORTUNITIES

A crucial impact on the future of wireless communications comes from the transition to multi-carrier orthogonal frequency division multiplexing (OFDM) modulation as a means for gaining increased bandwidth from a scarce worldwide spectrum resource. All next generation radios will be based on OFDM, including those used in Long Term Evolution (LTE) mobile handsets, WiMAX and WLAN systems. OFDM most notably results in high peak to average power ratios, which drives a need for higher efficiency RF power amplifiers.



FUNCTION	TECHNOLOGY	DRIVER
5 GHz PA	GaAs HBT	PERFORMANCE
DUAL LNA	E/D PHEMT	NOISE
SWITCH	D-PHEMT	IL, COST
FILTER, DIPLEXER	IPD	COST
2.4 GHz PA	SiGe BiCMOS	COST, LOGIC

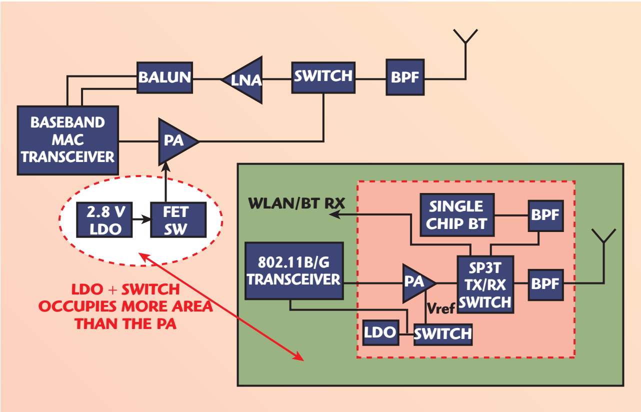
▲ *Fig. 5 802.11a/b/g/n system in package.*



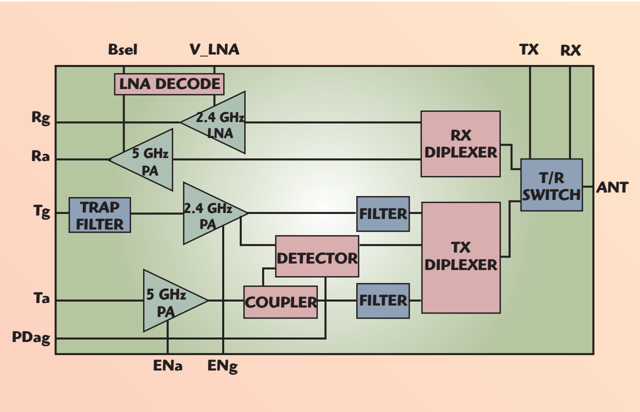
▲ *Fig. 6 Multi-die 3 × 3 QFN package.*

The interrelationships between signal processing quality, power consumption and transmit power/receiver sensitivity are complicated by the requirements of OFDM signal processing for the RF physical layer.[1] Yet, along with these inherent challenges, the transition to OFDM provides the opportunity to develop converged multi-mode RF physical layer functionality. As high-bandwidth wireless content is delivered to a wide variety of consumer platforms, system designers will need the RF physical layer to have "operational amplifier-like" qualities, meaning it will need the ability to be optimized for specific requirements and self-compensate performance for wide variations in operating conditions.

An op amp integration model for RF would also invite collaboration between numerous product and technology partners, such as what has occurred at the content processing level. This will surely stimulate innovations that will improve the wireless experience. The rapid introduction of navigation as a mobile phone application was made possible by the relative ease of introduction of the GPS hardware solution onto the mobile phone platform. As GPS becomes integral to the mobile phone, applications and operating systems will better integrate navigation and other location-based services into the mobile phone experience.



▲ *Fig. 7 RF signal chain that requires 18 mm² of board space.*



▲ *Fig. 8 Highly integrated SiGe front-end module.*

For instance, if mobile handsets could support more bandwidth, Google maps could download fast enough to provide real-time information while driving, and still leave enough power to make a phone call (see ***Figure 1***). RF physical layer integration on par with that of the op amp will enable the types of collaboration necessary to continue integrating wireless services into the full range of daily activities. But how do we get there?

RF PLUG AND PLAY

As a matter of fact, this concept of RF "plug-and-play" is already becoming a reality. For instance, location-based services in mobile phones have been eagerly anticipated for almost a decade. Although CDMA phones have incorporated GPS-based baseband signal processing since their inception, the need for high receiver sensitivity (roughly –160 dBm) and near-frequency high-power interference from cellular signals created a natural impediment to small footprint, low-power GPS solutions for full-featured, location-based consumer services. However, this all changed with the introduction of high performance, low power consumption, integrated RF physical layer GPS receivers that are capable of coexistence with cellular networks (see ***Figure 2***). Their release has been the catalyst for rapid integration of GPS-based navigation services in mobile phone platforms.

The need for WLAN functionality in handheld devices led to the convergence of WLAN, FM radio, GPS and Bluetooth technologies onto single digital signal processing platforms. We are now seeing multi-function RF front-ends—combining the power amplifier, low noise amplifier, RF switch and filtering in a single package, creating multi-mode RF signal processing solutions. These higher levels of integration and modularization are made possible by semiconductor technologies such as silicon germanium (SiGe), which enables single-chip mode-programmable RF front-ends with the RF performance, low power consumption and small form factors required for thin, display-centric devices similar to Apple's iPhone.® The end result of RF plug-and-play integration will be a rich suite of wireless connectivity-based applications—in-car navigation systems with roadmaps showing location through GPS, local traffic using FM radio data system (RDS), which is linked to the car's audio system via Bluetooth, and the ability to upload audio and video entertainment via WLAN.

The migration of RF signal processing design from "device-centric" to "function-centric" lies at the core of the evolution of the RF physical layer from "black art" to functional block. Today's technologies are driving the trend for multiple radios in a system, supporting multiple transmit/receive chains and frequency bands. The net result is, without continuing innovation in functional integration of the RF physical layer, wireless connectivity solutions will simply be too big and consume too much power. As wireless connectivity is incorporated into mobile handsets, the major push for change is coming from this powerful market, with more than 1.2 billion units sold per year. In the end, whatever drives the mobile device handset market drives the wireless connectivity industry. Right now it is battery life, power control and thinner, smaller packages. The antenna-RF front-end interface is often a source of performance limitations in the RF physical layer. System solutions integrating the antenna and the RF front-end such as this solution for GPS in ***Figure 3*** will certainly drive the incorporation of wireless connectivity into the devices we use each day.

RF CHALLENGES

The RF front-end tends to have a high number of surface-mount components. Currently, this has been reduced to only a few components, down from more than 100 only a few years ago. For instance, note that the form factor of the RF PA has shrunk considerably over the past few years (see ***Figure 4***). Area has tended to shrink by a factor of 2 or more each year, with the latest PAs measuring at about 4 mm^2. Increased integration has allowed wireless RF to proliferate in consumer electronics, including printers, cameras and mobile phones. But this level of integration is simply not enough. What the industry really needs is a complete, pretested, plug-and-play RF functional block that can be effectively dropped onto a motherboard.

However, in RF designs, monolithic integration needs to be carefully considered in terms of trade-offs to performance and power consumption. To balance these concerns, many of the latest wireless designs are incorporating RF system in package (SIP) technology, which brings together the best processes for different RF front-end functionalities, optimizes system performance and houses it all in a single package. SIP designs tend to have the best balance of low cost, high performance and power consumption. In addition, RF front-ends in a SIP configuration are simple 50 ohm in/out, allowing ease of system integration.

OPTIMIZED BUILDING BLOCKS

In a SIP design, each block is optimized for cost versus performance (see ***Figure 5***). By creating standard building blocks, SIP designers can quickly customize a design for a particular application or customer. SIPs also offer the advantage of a laminate substrate, which can be used for routing and the inclusion of surface-mount components within the package. The substrate also allows designers to make small changes/adjustments to optimize performance for each customer, a type of mass customization. By developing pre-validated RF building blocks, SIP designers can include them in different modules, providing a validated design in one third to one quarter the time it takes to spin an IC.

For example, Figure 5 shows a dual-chain RF front-end module (FEM) for 802.11 a/b/g/n designs where designers were able to choose a specific technology for each block in order to optimize performance. For instance, the 5 GHz PA is GaAs HBT, the dual-band LNA and switch are GaAS HEMT, the filters are implemented in a passive component only process, and the 2.4 GHz PA and logic are integrated in BiCMOS. In this type of application, the SIP approach allows a mix of technologies in a single package, allowing system designers to choose the best technologies and then do a module integration to deliver all of the functions that a customer wants in a short time. The advantage here is a single package with the RF front-end functionality that can be dropped into a design to add wireless capability.

AVAILABLE TECHNOLOGIES

Despite its many advantages, the use of a laminate substrate in SIP designs affects package height, assembly complexity and cost, so package and assembly are becoming important areas of research. One recent trend is toward the use of multi-die QFN. ***Figure 6*** shows a multi-die 3×3 mm QFN that achieves the < 0.5 mm height required for mobile phones. The innovative package shown here also includes a number of thru-die vias, which are critical to reducing size and the number of required wire bonds.

In the latest state-of-the-art smartphones, the RF signal chain requires a surprising 18 mm^2 of board space. In ***Figure 7***, the RF chain is the area surrounded by the dotted line. Note the large footprint also required for voltage regulators and enable functions. The addition of WLAN in mobile handsets is driving a need to integrate all of these components into a 3×3 mm package.

To address this need, some designers using GaAs for power amplification are achieving good integration of the PA with low-noise amplifiers (LNA) and switches. These multifunction RFICs have only become available recently, and foundry support for fabless RF design companies planning to use these technologies is still not mature. TriQuint Semiconductor recently announced GaAs RFICs for the front-end with this level of integration. However, because it is implemented in GaAs, the device still requires external filtering and control circuitry that needs to be implemented in silicon. In addition, since the designs are transistor-based, they cannot integrate CMOS-based control logic.

Taking the RF functionality to the next level of integration requires the use of BiCMOS to address the addition of control logic. As a result, the integration of SiGe bipolar RF performance with SiGe CMOS bias-and-control functionality onto a single, small-footprint integrated circuit is a key enabler for the rapid growth of wireless connectivity for multimedia services in mobile consumer electronics devices. The next generation front-end modules (FEM) under development integrate multiple power amplifiers, LNAs, power detectors, a T/R switch, filters, diplexers and associated matching circuitry (see ***Figure 8***). This type of module can operate directly off of the battery, which removes the need for external regulators, as required in GaAs RFICs.

During all of this advanced integration, coexistence filtering will also be of paramount importance. To be successful, the RF signal chains required for Bluetooth, WiMAX, FM radio, Wi-Fi, NFC and GPS services cannot interfere with each other. Of great concern will be Wi-Fi and CDMA because of their close proximity to each other, so module and RFIC designers will need to be especially careful with filtering. When logic can be implemented in the module/chip, programmable filters can be used to alleviate coexistence issues, and each function can be fully optimized. This programmability will allow tighter production controls as well, giving OEMs a more uniform product.

Some SiGe BiCMOS products are already available in flip-chip chip scale packaging (CSP). Most wireless connectivity modules, including the transceiver and RF front-end, are all trending toward flip-chip architectures because of the low cost of assembly. In addition, flip-chip CSP offers the smallest footprint, lowest height solution, making it very desirable for portable wireless applications. Another advantage of BiCMOS is that there are mature foundry services available for manufacturing in high-volume, low-cost production quantities, and the world's big foundries all have well-established roadmaps that are based on BiCMOS.

FUTURE DEVELOPMENTS

With the drive toward BiCMOS integration, the future of the RF signal chain will likely see a serial interface, which will also allow designers to reconfigure PAs on the fly as part of the power control loop to address the needs of emerging multi-band, multi-standard wireless designs. For example, if you want to have Wi-Fi operate at a low power level, with a serial interface you can reconfigure the PA depending on the local power level required. Currently, this is done by simply backing off power, which negatively impacts efficiency. You will be able to optimize efficiency, which is particularly important for next-generation OFDM designs.

For designers, there is also a well-established roadmap for involving BiCMOS technology nodes and integrating pre-validated standard blocks. So, with BiCMOS, instead of designing transistors for customized functionality, engineers can pull and license intellectual property (IP) blocks for standard functions or trade them between development groups within a company. This allows companies to focus their limited design resources on supporting customers and speeding time to market.

Most designers recognize the advantages of silicon CMOS, and many see SiGe as the natural bridge technology to silicon. In the end, BiCMOS technology uniquely combines the strengths of HBTs (PA, LNA, RF switch) and CMOS (bias and control) in a single manufacturing process.

As a result of a transition to BiCMOS technology and plug and play RF functionality, we can expect RF to be the third wave of the fabless design revolution, following in the successful tradition of digital CMOS and high-speed analog design. At the highest level, the future of wireless is simple: making the world a smaller place. In 2007, social networking became the largest contributor to Internet traffic,[2] and we can expect this trend to migrate to mobile devices. Wireless provides human beings with personal interaction and access to information and entertainment in ways no other technology can provide—on-demand, anytime, anywhere, in any format. And people who interact with each other, who share access to information and entertainment with each other, tend to be people who enjoy each other. This is indeed a great model for the future of wireless. ■

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John Brewer, Jr.*'s 25 years in the wireless semiconductor industry extend across the disciplines of engineering, marketing and management at the senior executive level. Prior to joining SiGe Semiconductor, he was CEO and president of Xindium, a company providing RF power amplifiers for next-generation mobile handsets and terminals. Previously, he founded Vincio, a marketing consultancy. Brewer was also a founder and vice president, marketing of Tropian, a company that developed a revolutionary approach to cell phone front-ends. Over the years he has successfully grown wireless transceiver product lines in management positions at SEIKO Communications, Analog Devices and Tektronix. He holds a BS degree in electrical engineering from Santa Clara University.*

Peter L. Gammel *has worked with single-electron devices, superconducting devices, and MEMS and RF acoustic wave devices for more than 20 years. He is well acquainted with the processes of intellectual property investment, new product and funding development. Gammel previously served as VP engineering at a venture-backed startup. He was chief technology officer at both Advance Nanotech Inc. and Agere Systems, and was a research director at Bell Laboratories. He has more than 200 referred technical publications and more than 25 patents issued and in process. He holds a PhD degree in physics from Cornell University and BS degrees in physics and mathematics from the Massachusetts Institute of Technology (MIT).*

T&M Milestones

Rohde & Schwarz: 75 Years of Driving Innovation

Higher, faster, more precise – the T&M industry is almost Olympic in nature, and not only since yesterday. Numerous new technologies and increasingly higher frequencies are challenging T&M. For 75 years now, Rohde & Schwarz has been in business and successfully combining seasoned know-how with strong innovation. And the company's T&M solutions for wireless communications, general electronics and microwave are often ahead of their time. A historical snapshot.

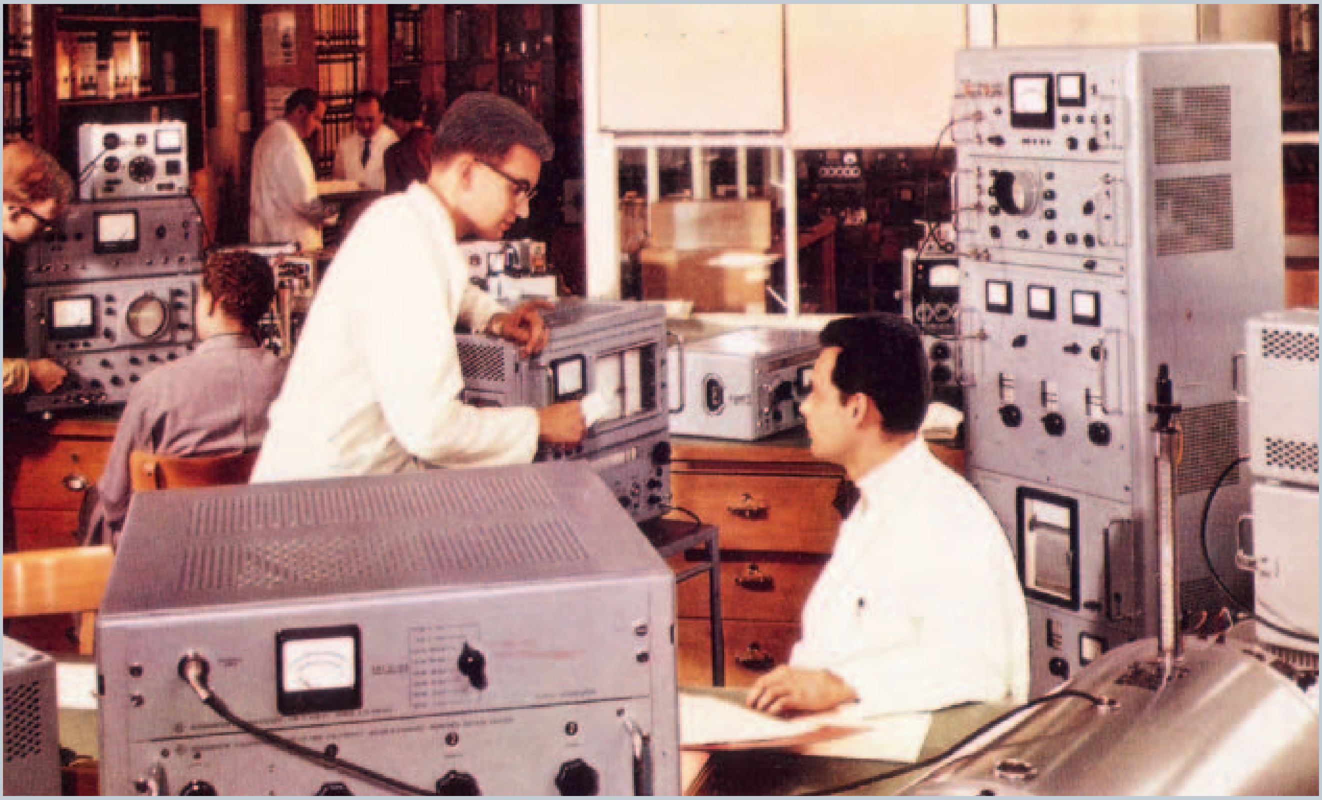
The present – 2008: Rohde & Schwarz is a leading global supplier of T&M equipment for wireless communications and electromagnetic compatibility (EMC). Every second mobile phone is produced or developed using T&M equipment from the Munich-based electronics group. Manufacturers of electronics around the world rely on high-quality products from the T&M expert – regardless whether in spectrum and network analysis, signal generation or power measurement. More than 70 subsidiaries and offices stand ready with direct customer care, and the company's great manufacturing depth translates into maximum quality and precision. But how did all of this start?

We glance back to the year 1932. Even before founding the company, Dr. Lothar Rohde and Dr. Hermann Schwarz developed their first T&M solution: a dissipation factor meter. Starting in autumn 1933, the company launched operations under the name „Physikalisch-Technisches Entwicklungslabor Dr. L. Rohde und Dr. H. Schwarz" – now known as Rohde & Schwarz since the 1940s. The company's first bestseller was the WIP interference wavemeter from 1933, sold throughout the world for more than 20 years.

Since its early days, the company's objective has been to provide customers with cost-efficient solutions and to achieve high integration. To avoid the use of numerous separate test instruments, the company in 1952 developed the URI electronic multimeter – a small, ten kilogram tester. Likewise in the 1950s, the T&M expert became a pioneer in network analysis: The first vector network analyzer worldwide finally made it possible to measure the magnitude and phase of S-parameters and to display them in a Smith chart. A further highlight from this era was the compact SWOB wideband sweep generator, whose successors were considered a standard in TV set alignment for years to come.

Germany's Wirtschaftswunder (economic miracle) and the continued general evolution of technology led to a strong increase in the number of electronic components and instruments over the following decades. EMC measurements gained in significance. Rohde & Schwarz responded logically by using its expertise in receiver development as a springboard to the field of EMC T&M. In 1987/88, for example, the company equipped Europe's most advanced and largest EMC anechoic chamber in Greding, Germany.

During this phase, Rohde & Schwarz step-by-step gained a solid foothold in further T&M fields. In 1985, the UPA audio



Rohde & Schwarz not only develops and sells T&M instruments– it also uses them in its own labs (picture from 1963).

analyzer rapidly became a standard in audio engineering. In 1982, the SWP became the first synthesized sweeper on the market. And the high-quality SMPC frequency synthesizer also won over customers worldwide with its low single sideband phase noise and high spurious suppression. The company's entry into spectrum analysis followed in 1986 – and, to the surprise of the competition, Rohde & Schwarz bounded into the major leagues in one leap with its FSA. Plus, the story of power and voltage measurement – one of the company's business fields since its founding – stands out owing to numerous innovations. In the mid-1980s, for example, a data memory for calibration data was directly integrated into a power sensor for the first time. In 2002, the world's first USB power sensors were brought to market.

Finally, Rohde & Schwarz has for decades been playing a major role in T&M equipment for the wireless market. By introducing the first GSM system simulator in 1991, the company helped GSM conquer the world. The system helped determine whether mobile phones performed to standard. Since then, test systems and testers from Munich have accompanied all major developments in the wireless industry.

This brief journey through seven and a half decades is now nearing an end. Manufacturers of electronics and wireless companies know Rohde & Schwarz as a supplier of customized solutions. The company's signal generators offer dual-path capability and generate spectrally ultra-pure signals. In network analysis, the product portfolio offers the economy-priced R&S ZVL vector network analyzer as well as the high-end model up to 50 GHz with four-port architecture. The R&S ESIB and R&S ESU have become fixtures in EMC labs as reference standards for compliance measurements. Users can also find everything they need in spectrum analysis – from a handheld instrument for mobile use all the way up to a 67 GHz analyzer. And in the field of T&M equipment for the wireless sector, Rohde & Schwarz stands shoulder-to-shoulder with other pioneers in next-generation wireless, which is already taking shape with WiMAX and 3GPP LTE. In 2008, the company's sixth-generation wireless testers appeared on the market: The R&S CMW500 embodies decades of combined know-how.

A success story that is far from over.

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LOOKING AHEAD: THE FUTURE OF RF TECHNOLOGY, MILITARY AND HOMELAND PERSPECTIVES

Persistent surveillance, assuring identification and affecting the threat all sound like military terms in the protection of the free world. They are, of course, but they equally apply to other phenomena that affect the quality of life. The future pull and push of RF technology will continue to provide our military with unprecedented capabilities as well as provide opportunities for new commerce. The government pull comes from the DOD, DHS, DOC (NOAA & FAA) and DOT. What are some of the pulls? We need systems that can observe the world around us, look closer and farther away, find smaller and hidden objects, some that move fast, and others that move slow. Persistent surveillance, assuring identification and affecting the threat are applicable in military operations and homeland security and for terrorists and severe weather. What are some of the RF technology pushes that are applicable to these pulls? We're seeing unprecedented high power RF devices, more affordable, faster and highly integrated RF electronics, components that support higher frequencies and wider frequency bandwidths, and man-made materials with RF properties not realized previously, just to name a few. We've come a long way from the first transistor radio.

Today's research and development at Raytheon is focused on RF technologies and subsystems that improve the performance and capability of current and future systems and include:

- Solid-state Active Electronically Scanned Arrays (AESA)
- High-efficiency power amplifiers
- Directed energy technologies
- Semiconductors, including CMOS, SiGe, InP, GaAs and GaN for higher levels of integration, higher power and higher speed
- High Density MMICs and TR Modules
- Frequency Agile sources
- Digital receivers and transmitters
- Software Defined Radios
- Higher bandwidth and higher sensitivity RF components

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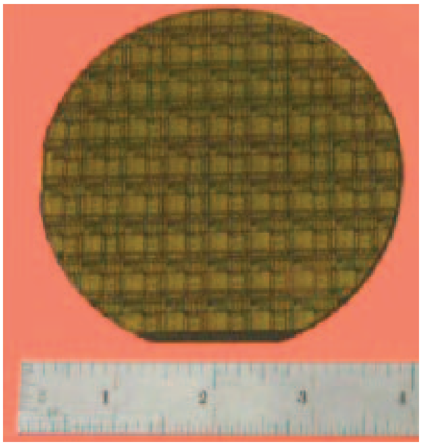
TABLE I

GaN vs. GaAs COMPARISON

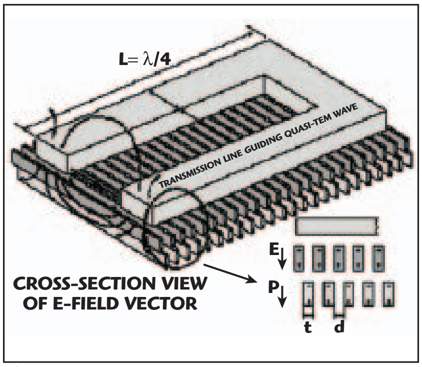
Parameter	GaAs	GaN
Output power density (W/mm)	0.5 to 1.5	3 to 6
Operating (V)	5 to 20	28 to 48
Breakdown voltage (V)	20 to 40	> 100
Maximum current (A/mm)	~ 0.5	~ 1
Thermal conductivity (W/m-K)	47	390(z)/490 (SiC)

- Radar stealth coatings and materials
- Micro Electro Mechanical Structures (MEMS) RF Switches
- Ka-band frequencies for higher resolution and pointing accuracy
- Integrating multiple beams and simultaneous modes into multi-function systems
- Space-time, adaptive processing (STAP) and jammer-nulling techniques
- Netted Communications across platforms

The following sections first discuss some of the key RF technology pushes and finish with some of the novel pulls that solve critical needs for our nation. It is clear that RF technology will continue to play a critical role in providing our military and homeland the best, most affordable and reliable capabilities for the next 50 years and beyond.



▲ *Fig. 1 100 mm GaN wafer.*



▲ *Fig. 2 Artificial dielectric and on-chip λ/4 resonator.*

THE NEXT GENERATION OF ACTIVE ELECTRONICALLY SCANNED ARRAYS (AESA): WIDEBAND, MULTI-FUNCTION AND DIGITAL RF

How can a platform obtain more functionality given the limitations in size, weight and cost? The military began investing in architectures and technologies several years ago to improve and streamline the proliferation of aperture systems on airplanes and ships. Many platforms need to support radar, communications and electronic warfare functions. Platforms regularly have to trade off capabilities and cost because there isn't room for everything that's desired. The challenge is to develop architectures and technologies that may one day realize a concept whereby each platform would possess a minimal set of apertures that can be dynamically reconfigurable—in real time—to perform radar, communications and electronic warfare tasks independently and simultaneously, using only software. There are several key technologies that need to be invented and developed before wideband multi-function systems can be realized. Highly linear amplifiers, tunable channelizers, wideband apertures, high speed analog and digital converters, digital beamforming, and efficient dense packaging are just some of the challenges going forward.

THE NEXT GENERATION OF MICROWAVE SOLID-STATE RF DEVICE AND MMIC TECHNOLOGY

New advanced-device technologies will also play role in future AESAs. Maturation of gallium nitride (GaN) and silicon germanium (SiGe) semiconductor technologies show excellent promise. GaN is focused on achieving an order of magnitude increase in amplifier power density for the same MMIC area. SiGe is a predominant commercial semiconductor for the telecom industry.

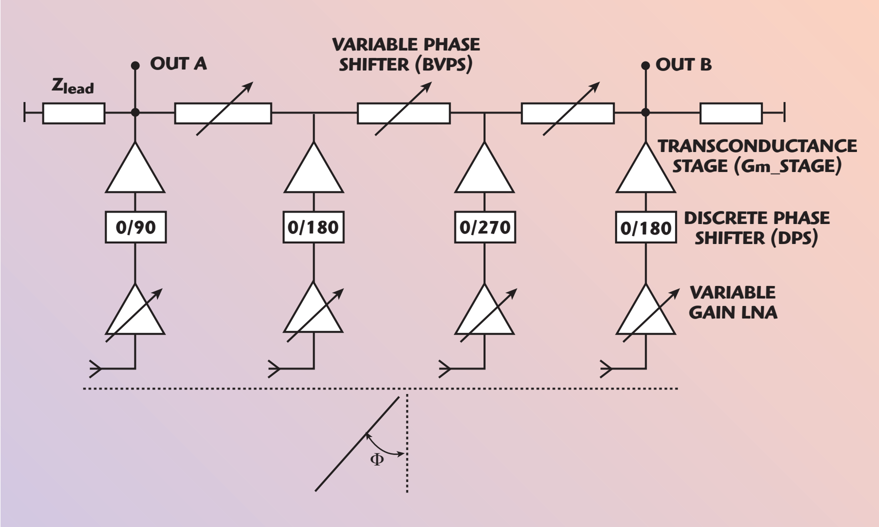
GaN transistors have a high frequency power handling capability well beyond silicon, GaAs or any other semiconductor yet fabricated. This capability makes it the technology of choice for the monolithic MMIC power amplifiers that are the building blocks of the RF portions of next-generation defense systems. Use of GaN MMICs leads to weight, range, sensitivity, prime power, cooling and cost advantages at the system level. GaN's material properties allow it to support device operation at much higher voltages than the GaAs that dominates today's defense systems. GaN MMICs easily operate at 28 V,

TABLE II

VCO PERFORMANCE COMPARISON

Reference	Process	f_0 (GHz)	V_{DD} (V)	P_{DC} (mW)	PN@1MHz (dBc/Hz)	FOM	Die Area (mm²)
This work	90 nm CMOS	60	1	1.9	–107	–200	0.015
J. Kim[1] MTT-S 2003	InGaP/GaAs HBT	60	3.5	158	–93	–167	0.78
B.A. Floyd[2] RFIC 2004	SiGe HBT	67	3	25	–98	–181	—
Y. Cho[3] RFIC 2005	0.18 μm CMOS	53	2.1	27	–97	–177	0.20
R. Liu[4] ISSCC 2004	0.25 μm CMOS	63	1.8	119	–85	–160	0.32
P. Huang[5] ISSCC 2005	0.13 μm CMOS	57	1.2	8.4	–70	–136	0.20

have ~2 times the maximum channel current and can produce five to 10 times the power (with comparable gain and efficiency) of an equivalently sized GaAs MMIC typically operating at less than 10 V. So-called high voltage GaAs PHEMT MMICs can be engineered to operate at higher voltage (10 to 20 V) but at the expense of operating current, limiting power density to 1.5 to 2 times that of a typical GaAs PHEMT. Amplifiers of equivalent total power can be made more compactly using GaN because of the higher GaN power density. In addition, the higher voltage of GaN results in higher matching impedance, which enables broader bandwidth design than GaAs. ***Table 1*** compares GaAs and GaN device properties. In terms of reliability, tests predict a mean time to failure (MTTF) of greater than one million hours at a standard transistor channel temperature of 150 degrees Celsius.

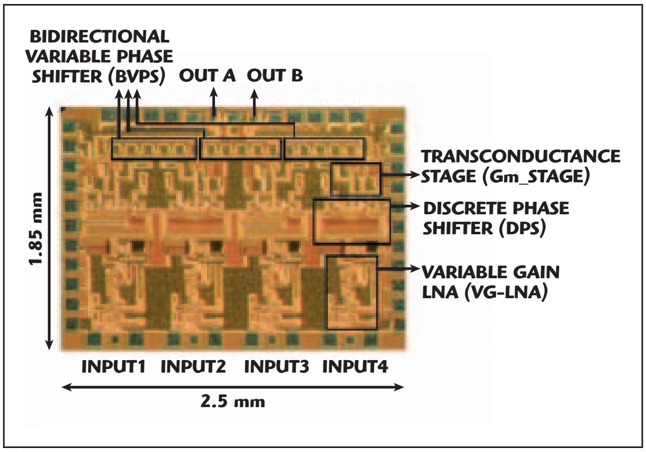


▲ *Fig. 3a Block diagram of a 60 GHz phased-array front-end.*

Raytheon is presently transitioning the fabrication of GaN MMICs into its high-volume 100 mm diameter wafer production fabrication (see ***Figure 1***). GaN is a disruptive high-power semiconductor technology that will enable a new class of microwave and millimeter-wave RF systems envisioned for the near future and beyond.

UCLA, working on a Raytheon university grant, has developed an artificial dielectric structure for use in SiGe BiCMOS integrated circuits at military frequencies. Two major challenges in CMOS millimeter-wave IC designs include: (1) device noise, which is typically one or two orders higher than that of compound or SiGe HBTs; and (2) signal attenuation due to the skin effect and substrate losses, which inevitably result in low performance on-chip lumped passive components. An artificial dielectric is formed by embedding metal obstacles in a periodic pattern, as shown in the upper part of ***Figure 2***. A 60 GHz VCO was designed and implemented in a 90 nm CMOS to verify the effects of the embedded artificial dielectric on resonator size, loss and noise reduction. Compared to resonators without artificial dielectrics or those using conventional spiral inductors at this frequency, a much lower loss resonator can be accomplished. A 60 GHz CMOS VCO with a measured phase noise of –107 dBc/Hz and a record low F.O.M. of –200 dBc/Hz at 1 MHz frequency offset has been realized. This VCO dissipates only 1.9 mW from a 1 V power supply and occupies a chip area of 0.015 mm^2, which is less than 10 percent of the prior arts (see ***Table 2***).

Raytheon supports the Caltech Microelectronics Center in the research of silicon circuits for microwave and millimeter-wave applications. Professor Ali Hajimiri and his staff are developing novel approaches that leverage the strengths of silicon while supporting mixed signals to provide more affordable solutions for sensor applications.



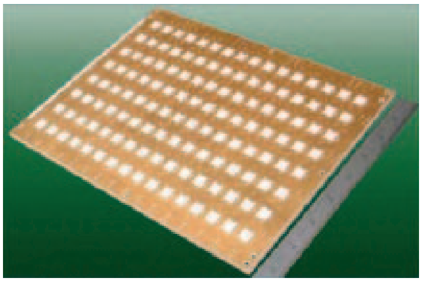
▲ *Fig. 3b Die photograph of 60 GHz phased-array receiver front-end.*

A 60 GHz RF-combined 4-element phased array front-end is implemented in silicon using a novel hybrid parallel/series-fed approach that reduces on-chip phase shifter requirements. The array, which includes amplitude control as well as continuous phase adjustment, provides for simultaneous illumination of two angles of incidence. We combine the series-fed and parallel-fed array architectures to further relax the RF phase-shifter requirements to enable RF signal-combining. As shown in the simplified block-diagram of ***Figure 3a***, discrete phase shifters (DP) in every element choose one of two phase-shift settings (e.g., 0° or 180° in Element 2). The signals are then fed into bidirectional series phase shifters, each of which provides a certain amount of phase shift. The important point is that the signals on the series phase shifters travel in both directions, yielding the following signal summations at the two outputs providing for two concurrent receive beams. The input to each element is first amplified by a four-stage 60 GHz LNA that has variable gain to compensate for downstream gain variation. The fourth stage of each LNA provides variable gain by current steering. The output of the LNA is provided to a DP that can choose between two phase-shift settings. The front-end has a noise figure lower than 6.9 dB at 60 GHz and the array achieves full spatial coverage with better than 20 dB peak-to-null ratio. The four-element 60 GHz front-end consumes 270 mW and occupies 4.6 mm^2 of die area. ***Figure 3b*** shows a die photo of the array, which was implemented in a SiGe process with a BJT cut-off frequency of 200 GHz.

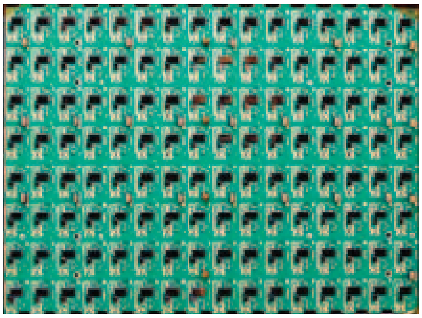
DENSE LOW POWER RADAR NETWORKS

Today's weather forecasting and warning infrastructure uses data from high-power radars that have helped meteorologists improve forecasts significantly in the past 20-plus years.

Despite having substantial capability to measure wind and rainfall and to diagnose storms, these long-range radars have limited ability to observe the lowest and most critical part of the atmosphere owing to the Earth's curvature. This prevents the radars from observing the behavior of tornadoes and other hazards at or near ground level. As a result, one in five tornadoes goes undetected by current technology, and 80 percent of all tornado warnings turn out to be false alarms. Raytheon, in partnership with a team of academic, government and industrial collaborators, has formed a National Science Foundation Engi-



▲ *Fig. 4a 128 T/R channel panel arrays, radiator side.*



▲ *Fig. 4b 128 T/R channel panel arrays, active components side.*

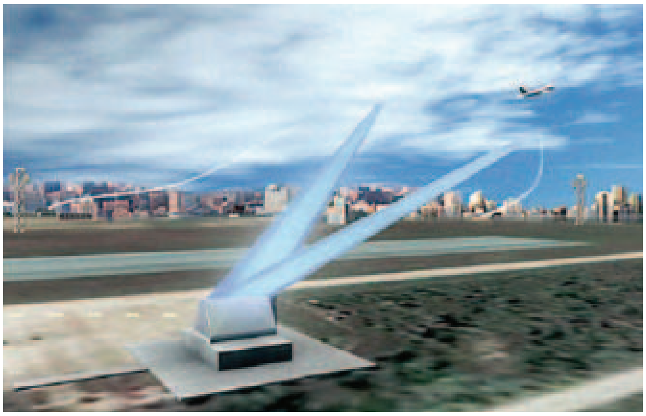


Fig. 5 Vigilant Eagle system.

neering Research Center (ERC) called the Center for Collaborative Adaptive Sensing of the Atmosphere (CASA) to address this problem. CASA is researching a new weather hazard forecasting and warning technology based on a low-cost, dense networks of radars that operate at short range, communicate with one another, and adjust their sensing strategies in direct response to the evolving weather and to changing end-user needs. In contrast to today's large weather radars with 10-meter-diameter antennas, the antennas in CASA networks are expected to be one meter in diameter with electronics that are about the size of a personal computer. This small size allows these radars to be placed on existing cellular towers and rooftops, enabling them to comprehensively map damaging winds and heavy rainfall from the top of storms down to the critical boundary layer region beneath the view of current technology. This approach can achieve breakthrough improvements in resolution and update times, leading to significant reductions in tornado false alarms; quantitative precipitation estimation for more accurate flood prediction; fine-scale wind field imaging; and the estimation of thermodynamic state variables for use in short-term numerical forecasting and other applications such as airborne hazard dispersion forecasting. Cost, maintenance and reliability issues, as well as aesthetics, motivate the use of small (approximately one-meter diameter, two-degree beamwidth) antennas that could be installed on either low-cost towers or existing infrastructure elements (such as rooftops or cellular communication towers).

AESA arrays are a key enabling technology in many production radars today and a desirable technology for use in dense networks since they do not require maintenance of moving parts and they permit flexibility in beam steering. A particular challenge in realizing cost-effective dense networks composed of thousands of radars will be to achieve a design that can be volume-manufactured for approximately $10,000 per array (current dollars). Several thousand transmit/receive (T/R) channels are needed to realize a phased array capable of electronically steering a two-degree beam in two dimensions over the desired scan range of these radars. The realization of such an antenna will benefit from leveraging commodity silicon RF semiconductors to achieve T/R functions, in combination with very low-cost packaging, fabrication and assembly techniques. Prototypes of the sub-panels are shown in ***Figure 4a*** (front view) and ***Figure 4b*** (rear view).

BEYOND THE MICROWAVE OVEN

As the pioneer and inventor of the microwave oven, Raytheon has leveraged high power RF confined in metallic boxes (or resonant cavities) to defrost, cook, cure adhesives, etc. Now and in the future, high power RF energy may be harnessed to protect airports and stop intruders in their tracks without killing them. Two particular systems being examined are called Vigilant Eagle and Silent Guardian.

VIGILANT EAGLE

Vigilant Eagle provides an invisible dome of protection around airports or airfields, offering all aircraft—international and domestic commercial flights, as well as military and private planes—protection from terrorist surface-to-air missiles including the Man-Portable Air Defense System (MANPADS). Vigilant Eagle had already been proven

▲ *Fig. 6 Silent Guardian emits a focused beam that heats the water molecules around the skin's pain and heat receptors, creating a burning sensation intended to get the aggressor's attention and repel them.*

against real missiles in field tests. In 2006, Raytheon was awarded a $4.1 M DHS contract to demonstrate the suitability of the Vigilant Eagle airport protection system to function in a civilian environment and its ability to protect aircraft from the threat of shoulder-fired missiles. Vigilant Eagle uses a simple technique of illuminating the missile body with electromagnetic energy tailored to divert the missile (see ***Figure 5***). It aims a focused, precisely steered beam of electromagnetic energy at a terrorist's missile, diverting the threat away from the targeted aircraft. Vigilant Eagle would be installed at airports, rather than on individual aircraft. The system includes a distributed missile detect and track subsystem (MDT), a command and control (C2) system and the Active Electronically Scanned Array (AESA), which consists of a billboard-size array of highly efficient antennae linked to solid-state RF amplifiers. The electromagnetic waveforms disrupt the missile and deflect it away from the aircraft. Created electromagnetic fields are well within the Occupational Safety and Health Administration (OSHA) standards for personnel exposure limits.

SILENT GUARDIAN

Another new application of military-proven technology is Raytheon's directed-energy protection system called Silent Guardian that employs millimeter-wave energy to stop, delay, deter and turn back violent aggressors. Silent Guardian can be utilized from up to 250 meters away against would-be attackers, while enabling the operator to distinguish friend from foe in real-time without having to use lethal force. Potential applications include facility and critical asset protection, riot control, home and perimeter security, and counter-terrorism. The system emits a focused beam of millimeter-wave energy to repel individuals without causing any physical damage. The beam heats the water molecules around the skin's pain and heat receptors (located 1/64 of an inch under the skin), creating a burning sensation intended to get the aggressors' attention and repel them (see ***Figure 6***). There are legislative and policy questions that must be answered before DHS is able to implement this technology.

CONCLUSION

The passions of invention and pushing performance, plus the capability and affordability needs of the government agencies will mold the next 50 years of RF technology. We can expect to see the maturation of emerging RF technologies paired with our digital, mixed signal and systems cousins that will continue to provide an exciting portfolio of diverse products and capabilities for our government customers. ■

ACKNOWLEDGMENT

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US Air Force Awards Lockheed Martin Contract to Build GPS III

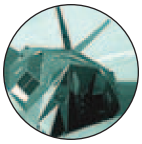
The US Air Force announced that a team led by Lockheed Martin has won the competition to build the next generation Global Positioning System (GPS) Space System Program, known as GPS III. This program will improve position, navigation and timing services for the warfighter and civilian users worldwide, and provide advanced anti-jam capabilities yielding superior system security, accuracy and reliability. "Lockheed is proud to serve as the Air Force's partner on this critical national program," said Joanne Maguire, executive vice president of Lockheed Martin Space Systems Co. "Our low-risk, back-to-basic solution is based on the team's outstanding record of success in developing and evolving navigation satellites and we look forward to building a next-generation system that will deliver enhanced performance for military and civilian users around the globe." Under the $1.4 B development and production contract awarded by the secretary of the Air Force, Michael Wynne, and the Global Positioning System Wing, Space and Missile System Center, Los Angeles Air Force Base, CA, the team of Lockheed Martin Space Systems Co., ITT Corp. and General Dynamics will produce eight GPS IIIA satellites, with first launch projected for 2014. The development contract will result in approximately 500 new jobs for Lockheed Martin. Eight GPS IIIB and 16 GPS IIIC satellites are planned for later increments, including additional capabilities based on technical maturity. When fully deployed, the GPS III constellation will feature a cross-linked command and control architecture, allowing the entire GPS constellation to be updated simultaneously from a single ground station. Additionally, a new spot beam capability for enhanced military (M-Code) coverage and increased resistance to hostile jamming will be incorporated. These enhancements will contribute to improve accuracy and assured availability for military and civilian users worldwide. As the program's Space System prime contractor, Lockheed Martin is leveraging its proven record of providing progressively advanced spacecraft for the current GPS constellation. The team designed and built 21 GPS IIR satellites for the Air Force and subsequently modernized eight of those spacecraft, designated GPS IIR-M, to enhance operations and navigation signal performance. For GPS III, Lockheed Martin's program management and spacecraft development effort will occur at its facility in Newtown, PA, with final assembly, integration and tests located in Denver, CO. The company's Sunnyvale, CA, operations will provide various spacecraft components and a launch support team will be based at Cape Canaveral, FL. Lockheed Martin's flight-proven A2100 bus will serve as the GPS III spacecraft platform. ITT, Clifton, NJ, will provide the navigation payload, and General Dynamics Advanced Information Systems, Gilbert, AZ, will provide the Network Communication Element (NCE), which includes the UHF Crosslink and Tracking Telemetry and Command (TT&C) subsystems.

Harris Corp. Awarded Contract for US Navy Commercial Broadband Satellite

Harris Corp., an international communications and information technology company, has been awarded a potential five-year, $85 M indefinite delivery/indefinite quantity (IDIQ) contract from the US Navy for multiband satellite communications terminals that will provide advanced communications for aircraft carriers and other large deck ships. Under the IDIQ contract, the company received an initial award valued at $15 M. Harris will supply 2.7-meter satellite communications terminals with C- and Ku-band capabilities for the Navy's Commercial Broadband Satellite Program (CBSP) Force Level Variant. The higher bandwidth capacity of these terminals will enable the Navy to augment military satellite communications by supporting essential mission requirements and by providing high-speed Internet access for as many as 5000 military personnel onboard each aircraft carrier. The new terminals will replace existing Harris AN/WSC-8 terminals that have provided shipboard C-band communications for the Navy for more than 10 years. "This contract reflects Harris Corp.'s ongoing commitment to providing the US military with the most advanced communications technology available, and puts us at the forefront of providing cutting-edge, multiband SATCOM terminal solutions for the US Navy," said Wes Cowell, president of Harris Defense Programs. "As the leading wideband communications provider to the Navy, Harris is proud to have been selected to provide this new generation of shipboard communications capability."

Raytheon Awarded US Air Force Contract for DCGS Architecture

Raytheon Co. has been awarded a US Air Force contract to continue evolving a system for sharing of near real-time, actionable intelligence information among warfighters. Known as the Distributed Common Ground System (DCGS) Integration Backbone (DIB), the next generation DIB—DIB1.3—will address standard compliance, baseline convergence, enterprise interoperability and unique US Air Force, Army and Navy requirements. The Web-based DIB is an open service-oriented architecture through which military analysts and the intelligence communities can collaborate globally, regardless of their military service affiliation, thereby enabling joint interoperability. Raytheon first developed the DIB under the



DCGS 10.2 contract for the Air Force and has supported the integration of the software into existing and emerging systems for the Army and Navy. Raytheon developed the DIB roadmap process to logically add enhancements to the DIB product. The roadmap provides a plan for regular enhancement cycles of commercial technologies and standards to enable new features and services in the user community in a rapid and cost-effective approach. Raytheon will work closely with the government's DIB Management Office to incorporate the latest inputs from the user community to make it easier and faster to join the enterprise and share information.

Lockheed Martin-built Phoenix Successfully Lands on Mars

NASA has a new spacecraft operating on the surface of Mars. The Phoenix Mars Lander, built by Lockheed Martin, navigated a dramatic descent through the planet's atmosphere, positioning Phoenix to dig down and touch the planet's subsurface ice. Onboard commands fired six separation nuts and jettisoned the cruise stage of the spacecraft while it was 635 miles away from the surface. That started a series of events that took the spacecraft through six different configurations and from a speed of 12500 mph to a gentle touchdown on the surface. The data signal confirming the spacecraft had successfully landed was received on Earth. Flight operations since launch and through landing were performed by a tight-knit team in Pasadena, CA and Denver, CO. Mission management and navigation were handled by JPL and spacecraft operations were performed by Lockheed Martin. The joint team stayed in daily contact with the spacecraft through the Deep Space Network since launch on August 4, 2007. After landing, the spacecraft waited 20 minutes for dust to settle before it deployed its stereo camera, meteorology mast, robotic arm bio-barrier bag and, most importantly, its twin solar arrays. The camera took images of each 6' 10" solar array, which confirmed both were fully deployed, allowing the spacecraft to generate its own power. It also took other pictures of a lander's foot pad and instruments on the lander's deck. Those images were returned to Earth via the Mars Odyssey orbiter. The University of Arizona leads this first Mars Scout mission from its Lunar and Planetary Laboratory in Tucson. Most of the scientific study for the mission will be performed out of the university's Science Operations Center. The NASA mission, valued at $420 M, includes the spacecraft development, science instruments, the Delta II launch vehicle, mission operations and science operations. ■

e2v Wins ESA Satellite Communications Contract

e2v has been awarded a major contract by the European Space Agency (ESA) for the development of an analogue to digital converter for next-generation broadband satellite payloads. The contract covers the development of a high performance, low power, 10-bits 1.5 Gsps ADC that will meet the future needs of aerospace industries. It will be designed to offer superior linearity, flat spectral response, wide analogue input bandwidth and a demultiplexed output, all within a total power budget of around 1 W.

Digital processing in satellite payloads optimises the use of expensive and scarce frequency spectrum. This maximises operational flexibility and provides the opportunity to broaden satellite system functionality to include, for example, high-speed multimedia Internet, cellular telephone and HDTV services. Satellite manufacturers need to secure state-of-the-art electronic component technologies to make this possible and e2v's new ADC will be a key enabling component in this regard.

The ADC to be designed under this contract will benefit from e2v's design expertise and the European high speed bipolar SiGe technology used to deliver key advantages to the aerospace market including high performance and low power consumption. The ADC will achieve a high, spurious free, dynamic range and a technology leading gain flatness over the useful bandwidth, combined with a power consumption that is claimed to offer a factor of three saving when compared to existing devices. The device will also be radiation hardened to ensure operation under extreme conditions.

Commenting on the contract win, Thierry Gouvernel, e2v's business unit general manager, said, "ESA's award of this strategic development contract is a great recognition of our successful track record in complex and leading edge projects." He added, "This win underscores 15 years of work supporting the aerospace marketplace, and other demanding industries, with state-of-the-art data converters."

WiMAX Trial for Alcatel-Lucent in Thailand

Alcatel-Lucent has announced plans to conduct a trial of wireless broadband services using WiMAX Rev-e technology with True Corp., Thailand's only fully integrated telecommunications provider and leader in convergence lifestyle. For the trial Alcatel-Lucent will provide True Corp. with a comprehensive WiMAX solution that operates on the 2.5 GHz frequency band, including base stations, wireless access controller, operation and maintenance centre and customer premises equipment to deliver Internet broadband access when on the move.

The company will also provide its WiMAX engineering expertise and integration services for the trial, which will take place in the Phatumthanee province on the outskirts of Bangkok. This trial has also been designed to test several applications that improve the overall welfare of the community by leveraging advances in telecommunications technology.

Thiti Nantapatsiri, managing director home/consumer solution and high speed access, True Corp. PCL., said, "True's initiative reflects our position as Thailand's convergence solutions leader. We plan to offer our customers the advantages of WiMAX-based technologies that allow for seamless and uninterrupted nomadic connection to advanced services for customers in the remote areas of Thailand while on-the-go using WiMAX-enabled devices. With more than 12.5 million mobile subscribers and 570,000 wireline broadband customers under the True Group, we hope to further propel the concept of today's convergence lifestyle with the addition of WiMAX broadband services."

Ciba and VTT Agree to Intelligent Collaboration

VTT Technical Research Centre of Finland and Ciba have signed a medium to long-term cooperation agreement in the field of printed intelligence. The agreement accelerates both companies' current research collaboration in printed organic electronics, established in early 2007, and expands it to new printable functionalities in high-volume packaging and diagnostics applications.

The aim of the partnership is to develop new commercial products and solutions based on emerging printing technologies. The cooperation involves product development, mutual IPR licensing and other joint technology commercialization efforts. The first jointly developed products and solutions are to be launched in the next few years.

Ciba Inc.'s interest is to combine its expertise in materials design and manufacturing with VTT's expertise in advanced printing techniques. One of the techniques is roll-to-roll printing that accesses the mass-produced functional devices, including solar cells, holograms, organic light emitting devices for signage, sensors and photo diodes. VTT will carry out its work on behalf of the collaboration at its Centre for Printed Intelligence.

The Ciba-VTT research cooperation benefits from the multidisciplinary technology know-how of VTT in printing/converting, chemistry, biochemistry, nanotechnology, electronics and diagnostics, and from Ciba's experience and know-how in specialty chemicals. The collaboration has been built through a series of successful Tekes (the Finnish Funding Agency for Technology and Innovation) and EU FP6 projects.

Vincotech: A New Name with Established Credentials

Vincotech has been announced as a new name in the world of power and navigation electronics, but it holds a long and successful tradition. Originating from the former Electronic Modules division of Tyco Electronics, Vincotech is now a stand-alone company focussing on telematics applications, industrial drives and solar power generation.

In 2007, when Tyco International split into three separate legal entities, one of them being Tyco Electronics, the decision was taken to divest the Power Systems business unit to the Gores Group. This business unit included the Electronic Modules division that has now become Vincotech and which can boast more than 10 years of successful operation.

This internationally expanding company is headquartered in Munich, Germany, and has production sites in Bicske, Hungary as well as in Shenzhen, China, with sales offices worldwide. With a current turnover of about $100 M the company employs approximately 600 people globally.

Thales Alenia Space Wins Egyptian Satellite Contract

Thales Alenia Space has signed a contract with Nilesat, the Egyptian satellite company, to provide the Nilesat-201 broadcasting communication satellite and associated services and ground stations. As prime contractor, the company will be in charge of the design, manufacturing, test and in-orbit acceptance of the satellite. In addition, Thales Alenia Space will provide a satellite and mission control system for the Nilesat stations in both Cairo and Alexandria.

Based on a Spacebus 4000B2 platform, Nilesat-201 will carry Ku- and Ka-band transponders—24 BSS Ku-band transponders over North Africa and the Middle East, plus 4 Ka-band channels over North Africa and the Gulf region. With a lifetime of more than 15 years, the satellite will have a launch mass of 3.2 tons and will deliver 5.7 kW of payload power end of life.

Reynald Seznec, president and CEO of Thales Alenia Space, commented, "As provider of Nilesat's first two satellite payloads, we are delighted that Nilesat reiterates its confidence in our company with this satellite contract. This order highlights the dynamic demand for 3-ton class satellites." ■

UWB Questions Loom as Bluetooth Announces Use of 802.11

Members of the Bluetooth Special Interest Group (SIG) announced the development of Bluetooth over 802.11, giving Bluetooth a boost in data rate transfer and helping to quench consumer demand for added speed. Consequently, the Ultra-wideband (UWB) market worries that this announcement may slow down or even suspend its relationship with Bluetooth; however, ABI Research does not believe this will be the case. Mike Foley, executive director of the Bluetooth SIG, stated, "We are taking classic Bluetooth connections—using Bluetooth protocols, profiles, security and other architectural elements—and allowing it to jump on top of the already present 802.11 radio, when necessary, to send bulky entertainment data faster. When the speed of 802.11 is overkill, the connection returns to normal operation on a Bluetooth radio for optimal power management and performance."

So where does this leave UWB?

"The Bluetooth SIG announcement will not have an impact on the timing of the UWB market," says ABI Research senior analyst Douglas McEuen. "UWB remains set to be delivered as a viable radio to wireless handsets during the 2009/2010 time frame." Moreover, the utilization of 802.11 is meant to fill a short-term role to the extent that UWB is being developed further, with UWB expected to be quite common in the future. Additionally, a combined Bluetooth/UWB WiMedia radio effectively opens the door to companies like Alereon, Wisair and WiQuest for entry into the Bluetooth market. The inclusion of 802.11 inside the realm of Bluetooth can only attract more customers, thereby setting the stage for UWB's implementation to attain its full potential in the coming years.

"Ultra-wideband Connectivity" analyzes critical UWB market conditions—from drivers and obstacles, to global regulations and standards. Key market semiconductor vendors are profiled, and the study concludes with an in-depth market forecast that traces both positive and negative market forces numerically.

Certification Arrives for Mobile WiMAX

After many months of delay, there are now eight officially certified 802.16e, or WiMAX products. The WiMAX Forum made this announcement at its WiMAX Forum Congress in Singapore. Samsung, Sequans Communications, POSTDATA and Runcom Technologies all gained certification for a subscriber device and a base station. All four certified subscriber devices are basic data devices for connecting a desk or laptop computer to a network. All certified products, while mobile, are only for Wave 1. Wave 1 802.16e mainly addresses the South Korean market. It does not support MIMO or other features to be found in Wave 2 certification. Most mobile WiMAX networks, such as Sprint's, will deploy Wave 2 equipment. The overall market for Wave 1 certified equipment will be limited. However, that does not diminish the significance of finally reaching this certification. "As many equipment vendors have explained to me over the last year," said Daryl Schoolar, senior analyst at In-Stat, "while they have no interest in attaining Wave 1 certification, it was important to them as Wave 1 was a stepping stone to Wave 2." Lessons learned with Wave 1 can be applied to Wave 2. It also has significance as it shows progress on the part of the WiMAX Forum in sheparding the technology. Sheparding the market to Wave 2 will be especially important as a high-profile deployment by Sprint comes on line. The Forum has publicly stated expectations to certify over 100 802.16e devices by end of the year.

Honeywell Introduces In-flight E-mail Wi-Fi Enabled BlackBerry Smartphones

Honeywell announced the availability of its Honeywell In-flight Messaging Service accessible via Wi-Fi® enabled BlackBerry® smartphones from Research in Motion through Honeywell's OneLink™ satellite communications services.

The Honeywell In-flight Messaging Service can configure Swift64 or SwiftBroadband SATCOM and router equipment to enable customers with Wi-Fi enabled BlackBerry smartphones to send and receive e-mail while onboard business jet aircraft. This service provides the most efficient use of existing Inmarsat satellite capabilities to enable BlackBerry e-mail and PC-based Internet applications while in-flight. The Honeywell In-flight Messaging Service provides continuous, uninterrupted always-on access to e-mail while on the ground and from take-off to landing for Wi-Fi enabled BlackBerry smartphones. Honeywell can configure systems for general access to all passengers or for secure access by designated passengers.

"This new Honeywell In-flight Messaging Service capability, coupled with satellite technology, is a tremendous advancement in improving cabin communications utilization and efficiency in all phases of aircraft operation," said Rob Wilson, president, Honeywell Business and General Aviation. "This is the number one communication service that Honeywell customers have asked for, and we are able to deliver this enhanced capability that supports BlackBerry smartphones, plus regular PC Internet traffic in a very efficient and cost-effective manner."

New G.hn Home Networking Standard Has Significant Potential

There is a new home networking industry alliance on the block. The HomeGrid Forum aims to promote the work of the International Telecommunication Union's G.hn working group in developing a new triple-wire standard for home networking. But many in the industry have been wondering where a new standard would fit in an already crowded market. The success of Wi-Fi for consumer-installable networks and the recent momentum for HomePlug and MoCA in service provider networks raise the question: why add another specification—as well as an industry alliance such as HomeGrid—to the mix? According to ABI Research director Michel Wolf, "G.hn—which has been under development for nearly two years—is intended to create a unifying standard for the different home network technologies, aimed at distributing next-generation service-provider offering in the home. We at ABI Research see several applications, such as multi-room high-definition video, that would ultimately benefit from the move towards a single MAC/PHY for multiple media in the home."

Where would G.hn fit in the home network? ABI Research sees the infrastructure and technology requirements for service provider, whole-home media as unique. Successful service provider deployments of MoCA and HomePNA 3.1 in North America and HomePlug and UPA worldwide, suggest that carrier-oriented media networking technologies can assist in rolling out new services. The effort to build a higher-speed single specification for the three primary in-home wiring types (power line, coax and phone line) will provide a roadmap for next generation service provider deployment. "While it is still early, ABI Research sees promise in the efforts by ITU G.hn," says Wolf. "Ultimately, if G.hn sees integration into carrier devices by 2010, we expect that in 2013 some 42 million G.hn-compliant nodes will ship into the market, in devices such as set-top boxes, residential gateways and other service provider CPE hardware."

A new research brief from ABI Research, "G.hn: Will Next-generation Triple-wire Networking Standard Hit the Digital Home Trifecta?," supplies an update of the various no-new-wires standards such as HomePlug AV, UPA MoCA and HomePNA 3.1, and considers how G.hn might fare as the evolution toward next-generation service provider entertainment networks gathers speed. It also examines the HomeGrid Forum and whether it will be a Wi-Fi alliance-like body that will propel the new standard in the market place.

ABI Research is a market research firm focused on the impact of emerging technologies on global consumer and business markets. Utilizing a blend of market intelligence, primary research and expert assessment, ABI Research assists many with its strategic growth initiatives. ■

INDUSTRY NEWS

■ **Cobham plc** announced that it has reached an agreement to purchase **M/A-COM** from **Tyco Electronics** for a cash consideration of US$425 M on a debt and cash free basis payable on completion, which will be satisfied from Cobham's existing cash and debt facilities. The goodwill arising on completion is an allowable tax expense with an estimated net present value of US$45 M, resulting in an effective price of US$380 M. It is anticipated that in 2008 the aerospace and defense (A&D) business of M/A-COM will be just under 40 percent of its total revenue. Cobham intends to hold for resale the commercial business, which represents the balance, as it is non-core. Based on the encouraging level of interest believed to have been expressed during Tyco Electronics' auction, Cobham anticipates this can be divested expeditiously. The acquisition of M/A-COM is expected to complete in the second half of 2008 and is subject only to customary regulatory approval.

■ **Tower Semiconductor Ltd.**, an independent specialty wafer foundry, and **Jazz Technologies Inc.**, a leader in analog-intensive mixed signal (AIMS) foundry solutions, announced the signing of a definitive agreement by which Tower will acquire all of the outstanding shares of Jazz in a stock-for-stock transaction valuing Jazz at a fully diluted equity value of approximately $40 M, based on Tower's closing price on NASDAQ on May 19, 2008. Under the terms of the agreement, each outstanding share of Jazz common stock will be converted into the right to receive 1.8 Tower ordinary shares. The total value of the transaction, including net debt, is approximately $169 M.

■ **Comtech Telecommunications Corp.** and **Radyne Corp.** jointly announced the signing of a definitive merger agreement pursuant to which Comtech has agreed to acquire Radyne in an all-cash transaction. Aggregate sales of the two companies would have been $651.5 M based on Comtech's sales of $504.3 M for its four fiscal quarters ended January 31, 2008, and Radyne's sales of $147.2 M for its four fiscal quarters ended March 31, 2008.

■ **TriQuint Semiconductor**®, a leading RF semiconductor manufacturer and foundry services provider, announced the completion of its acquisition of **WJ Communications Inc.** WJ is a leading supplier of RF solutions for wireless infrastructure. Its devices complement TriQuint's existing portfolio, broadening the networks market product line while adding RF design expertise to TriQuint's global facilities through a Silicon Valley (US) site.

■ **Carlson Wireless** announced that it recently acquired the SafeTLink™ point-to-point T1 digital microwave 4.9 GHz radio. The radio operates in the 4.9 GHz public safety frequency band and transmits a full or fractional T1 signal along with an independent IP data stream. The SafeTLink will compliment Carlson Wireless's existing Trailblazer™ and EB-4.9™ public safety band products.

■ **Orbit**, a leader in the development of advanced solutions for mobile SATCOM, tracking antennas and audio management for commercial and government applications, announced the delivery of six Marine Stabilized Satellite systems—the OrSat—to **AITelecom**. AITelecom, a Mexican company operating in the field of satellite communications and ground installations, will provide Orbit's OrSat systems to one of the most recognized suppliers of PEMEX, the Mexican government's gas and oil company.

■ **XMA Corp.** announced its acquisition of the esteemed Omni Spectra™ brand of microwave components. Since purchasing the CAT line from M/A-COM in 2003, XMA has carried on the Omni Spectra tradition by not only producing many of its original designs, but also drafting customized solutions for use in some of the most advanced communications, aerospace and military applications today. Now, after years of developing high-performance Omni Spectra products, XMA has officially trademarked the brand as part of its strategy to become an industry leader in passive microwave and RF components.

■ **Z-Communications Inc.** announced a new division named **Z-Comm Microwave** based in San Jose, CA. The division is chartered with the development and manufacture of integrated microwave, millimeter-wave assemblies and highly linear power amplifiers for the RF/microwave industry. These products are designed to be used in wireless transmission systems, WiMAX base stations, licensed point-to-point and other microwave radio applications.

■ **RF Micro Devices** (RFMD®) and **SELEX GALILEO**, one of Europe's leading defense electronics suppliers, announced the two companies have signed a strategic supply agreement. The strategic supply agreement expands upon a former agreement signed in 2001 between SELEX GALILEO and a division of the former Filtronic Compound Semiconductor Ltd., which was acquired by RFMD earlier this year. The strategic supply agreement is expected to encompass multiple high performance semiconductor components. As a result of the supply agreement, the two companies expect RFMD will increasingly support SELEX GALILEO's delivery of a range of current and future state-of-the-art defense electronics programs. Accordingly, both companies anticipate the strategic supply agreement to be valued at approximately $20 M through 2013.

■ **Acceleware Corp.**, a developer of acceleration solutions for high-performance computing applications, in conjunction with **Schmid & Partner Engineering AG** (SPEAG), announced that Korea's Radio Research Laboratory (RRL) is adopting their combined simulation solution to conduct the testing and certification of all cellular handsets in Korea. RRL is mandated to certify all cellular handsets for the Korean market as well as perform compliance testing and simulations to create national standards. The Acceleware and SPEAG accelerated simulation solution is currently used by RRL to solve advanced

Electromagnetic Compliance (EMC), Electromagnetic Interference (EMI) and Signal Integrity problems to determine the electromagnetic safety of mobile devices for human exposure.

■ **Tektronix Inc.**, a worldwide provider of test, measurement and monitoring instrumentation, and **LitePoint Corp.**, a provider of wireless test system solutions, announced their collaborative solution to LTE product development. LitePoint's RSALTE software is designed to run on Tektronix RSA3000A/B and RSA6100A real-time spectrum analyzers, and offers 3.9G compliance support for designers of UMTS-Long-Term Evolution (LTE) systems.

■ **Finisar Corp.**, a global technology leader in fiber optic solutions for high-speed networks, and **Technical Communities Inc.**, a service provider for technical organizations that sell to US government agencies, military and prime federal contractors, announced a government services partnership agreement. The agreement authorizes Technical Communities to market Finisar's Network Tools products including high-speed serial design and test equipment, protocol training and testing services to the government community.

■ **Northrop Grumman Corp.** recently presented Gold Supplier awards to 49 companies that routinely demonstrated excellence in product quality, on-time delivery, competitive pricing and other value-added services in 2007. ***SV Microwave*** is proud to be one of the companies that received Northrop Grumman Space Technology's rigorous Supplier Rating Program, which requires suppliers and subcontractors to participate in an ongoing performance assessment. Gold suppliers are selected on the basis of a scorecard that rates each supplier's management, quality, technical, schedule and financial performance.

CONTRACTS

■ **Anaren Inc.** announced that it has received two contracts totaling $13.7 M in follow-on orders for jamming and passive ranging subsystems to be deployed in airborne applications.

■ ***Jersey Microwave*** has been awarded a multi-year $1.6 M dollar contract to supply high performance block converters into a major SATCOM program. The award is only an initial release that is estimated to have a total potential of over $4 M.

FINANCIAL NEWS

■ ***Ansoft Corp.*** reports sales of $33.9 M for the fourth quarter of fiscal 2008 ended April 30, 2008, compared to $28.6 M for the same period in 2007. On a GAAP basis, net income was $8.5 M ($0.34/per diluted share), compared to a net income of $7.9 M ($0.30/per diluted share) for the fourth quarter of last year.

■ ***Alerion Capital Group***, a technology focused private equity group, and **Merit Capital**, a mezzanine and equity provider, have partnered with management to invest in **VXI Technology Inc.** (VTI). Irvine, California-based VTI provides test instruments for a wide variety of industrial, military and commercial applications. With customer applications ranging from testing electronic devices to super-structures to launch vehicles, the company has established a worldwide reputation for providing high-density, modular products for functional test and data acquisition.

PERSONNEL

▲ *Danny Cheadle, Jr.*

■ **Danny Cheadle, Jr.**, vice president and general manager of Teledyne Cougar, passed away on May 15, 2008, at home in San Jose, CA after a year and a half struggle with cancer. He is survived by his wife and three daughters. Cheadle joined Teledyne through the acquisition of Cougar Components in 2005. He started at Cougar Components in 1994 and was instrumental in the successful transition to Teledyne. Teledyne Cougar will always remember Cheadle for his respect for fellow employees, technical knowledge and warm heart.

■ Auriga Measurement Systems LLC announced it has appointed **Yusuke Tajima** as CTO. Tajima will steer Auriga's technical direction as it focuses on enhancing its position as an international leader in modeling and measurement of RF, microwave and millimeter-wave technologies, and the design of sophisticated amplifier-based solutions requiring high power, high efficiency, high frequency and high linearization. Tajima, a founder of the company, spent the past four years as director of modeling and design. He began his career at Toshiba Central Lab in Japan then joined Raytheon Research in Massachusetts.

▲ *Scott Conrad*

■ LadyBug Technologies LLC recently announced the appointment of **Scott Conrad** as the company's vice president of sales and marketing. In his new position, Conrad will hold responsibility for LadyBug's overall sales and marketing strategies worldwide, and will oversee the company's direct sales force, field representatives and distribution network. Conrad brings over two decades of high-technology sales, engineering, sales-management and channel-management experience to his new position. Prior to joining LadyBug, he served as senior vice president of sales for wireless-test-solution provider LitePoint Corp., Sunnyvale, CA.

■ M2M provider RF Monolithics Inc. (RFM) announced the election of **Farlin A. Halsey** to the position of vice president of product marketing. In this position, Halsey will direct and expand RFM's product marketing and its focus on customer requirements and market trends to improve customer satisfaction, return on investment and overall brand awareness. Prior to joining RFM, Halsey was vice president of marketing and most recently vice president of strategy and alliances for NovAtel Inc., a leading OEM of precision global navigation satellite system (GNSS) components and subsystems.


▲ *Jeff Baker*

■ **Jeff Baker** has joined the Nurad division of Cobham DES as director of advanced technology. Baker has over 23 years of experience in the aerospace and defense industry. He brings a strong systems engineering and business development background, in addition to being a recognized expert in aerospace composite structures development. Prior to joining Nurad, Baker worked on various NASA & National Security applications and programs with Swales Aerospace & TRW Spacecraft Division.


▲ *Rich Crabtree*

■ Ducommun Technologies, a manufacturer of RF and microwave products, announced that **Rich Crabtree** has joined Ducommun Technologies as director, business development microwave products. Crabtree will be responsible for the sale of Ducommun's microwave products. With over 20 year's industry experience, he brings a successful background of sales and sales management in the avionics, defense and commercial markets with RF and microwave components and subsystems. Prior to joining Ducommun Technologies, Crabtree was with Renaissance Electronics Corp.

■ Endwave Corp. announced that **Chuck Piercy** was named site manager for the company's El Dorado Hills, CA facility. Piercy joined Endwave in April of 2007 with the company's acquisition of ALC Microwave Inc., a leading provider of logarithmic amplifiers and other integrated subsystems to many US and international defense prime contractors. He also currently serves as a strategic business manager for Endwave's Defense and Security business unit. As a key member of ALC Microwave since 2004, Piercy contributed as senior design engineer on many of the integrated subsystems used in early warning radars, threat detection equipment, electronic countermeasures and missile guidance systems. Prior to that, Piercy worked for over a decade at DBS Microwave (which was later acquired by L-3 Communications), where he served as the product line manufacturing manager.


▲ *Peter Hoctor*

■ AMETEK Specialty Metal Products (SMP) has named **Peter Hoctor** as regional sales manager for Europe. Hoctor will be responsible for sales and marketing of AMETEK's full line of specialty metal products. He brings extensive metals industry experience and a strong background in international marketing to his new position. Hoctor has more than 15 years of experience in the sales and marketing of specialty metals. He is currently sales manager, Europe, for Reading Alloys, a global leader in specialty titanium alloys and highly engineered metal powders acquired by AMETEK in April 2008. Hoctor will retain his position with Reading Alloys as he assumes additional responsibilities for AMETEK Specialty Metal Products.

▲ *Wally Strader*

■ Communication Infrastructure Corp.® announced that **Wally Strader** has joined the company as account executive for microwave sales. Based in Addison, TX, Strader will lead the microwave sales team in expanding CIC's engineering services while overseeing existing accounts and growing other aspects of the business. For nearly 25 years, Strader held various positions at NEC Corp., most recently as western region sales manager responsible for microwave radio sales and account management, where he helped NEC substantially increase its presence in the western US, Canada and the Pacific.

REP APPOINTMENTS

■ **ClearComm Technologies LLC** announced the appointment of the **Cain-Forlaw Co.** headquartered in Palatine, IL. Cain-Forlaw will cover the central portion of the US from Illinois to Texas. This group brings a broad experience and complimentary products to ClearComm. ClearComm is a leading manufacturer of filters, duplexers, diplexers and RF assemblies covering the frequency range of 10 MHz to 18 GHz. Contact Cain-Forlaw's main office at (847) 202-9898 or on the web at www.cain-forlaw.com or ClearComm Technologies at (410) 860-0500, sales@clearcommtech.com.

■ **Modelithics Inc.** announced the appointment of international distributors, **Ultram Technologies Ltd.**, as the corporation's exclusive representative covering Israel. Larry Dunleavy, Modelithics' CEO, and director of Ultram, Yossi Yuran, have signed a comprehensive agreement designed to fully support the Israeli market for RF and microwave simulation models and characterization services.

■ **CAP Wireless Inc.**, a supplier of high performance microwave and RF amplifiers and amplifier-based subsystems, announced that in order to provide localized service and support to customers in the northern California and northern Nevada regions, the company has signed **Component Solutions** of San Jose, CA, as a manufacturers' representative. Component Solutions specializes in providing technical services and support to microwave/RF and fiber optic customers in the military, communications, test and measurement, and medical markets.

WEB SITE

■ **Hittite Microwave Corp.** announced the launch of its redesigned web site at www.hittite.com. Many exciting features have been added including crisp new webpage designs and a dynamic homepage featuring Hittite's new products, markets, press releases and featured articles.

A MICROWAVE JOURNEY: 1958–2008, PART I

This history of Microwave Journal *as told through the articles that appeared in the magazine over the past 50 years is also the history of the microwave industry as told by those in the business. This series will journey through the evolution of our technology over the past five decades as described in the nearly 600 issues of* Microwave Journal*. This first part in our series presents the background of the individuals behind the magazine, the state of the industry in the 1950s and a glimpse at the content appearing in our earliest editions. Throughout the rest of this year, this series will take a decade by decade look at our journey and the challenges the microwave business faced over time as documented on the pages of* Microwave Journal*.*

EXECUTIVE INTERVIEW SERIES

MWJ SPEAKS WITH WILLIAM AND IVAR BAZZY, HORIZON HOUSE PUBLICATIONS.

VISIT WWW.MWJOURNAL.COM TO READ THIS IN-DEPTH INTERVIEW.

We start this story of the microwave industry with the invention of the cavity magnetron in England under wartime pressures. By 1939, English scientists had already installed a coastal radar system. Based on the early success of radar, the British military now desired radar sets small enough to fit on ships, airplanes and munitions. To do so, engineers needed to use much shorter wavelengths, like those in the microwave region. And so, English researchers—Boot and Randall—developed a working cavity magnetron, which was able to produce over 400 watts of power at the extremely short wavelength of 9.8 cm (about four inches). In September of 1940, a British delegation under Sir Henry Tizard carried a cavity magnetron secretly across the Atlantic and persuaded the US government to begin large-scale development and manufacturing of the device.

The Tizard mission convinced the US government that radar was becoming an important weapon in the war, which consequently led to the establishment of the MIT Radiation Lab (RadLab) to pursue this technology. The work at the RadLab opened up an extensive new realm known as microwave engineering. After the war, the RadLab work would be shared with the world in a monumental publishing effort known as the MIT Radiation Laboratory Series of books. The 28 volumes of this series encapsulated a huge amount of knowledge generated during the war and strongly influenced many areas of postwar engineering.

RadLab also established a strong institutional link between government, industry and academia. With the US government as the sole customer for radar systems, companies such as GE, Westinghouse, Sylvania, Sperry Gyroscope, Motorola, Bell Labs, Hughes Aircraft and Raytheon would each get into the microwave component development and manufacturing business.

After the war, defense spending dropped dramatically and with little or no civilian use of radar at the time, the industry all but disappeared. Some looked for jobs outside of microwaves while others pursued niche commercial applications and the few defense contracts available. Then the Korean War began and the defense department began substantial funding of R&D again.

DAVID VYE
Microwave Journal *Editor*

The RadLab experience and ensuing post-war lean times may have been responsible for producing individuals who knew microwave technology, were connected to each other and had learned the hard rules of business when the industry went into its post-war slow down. As government money returned, a number of these people became entrepreneurs, leaving larger organizations or returning from outside the industry to launch small start-up companies specializing in microwave components for the defense department and its contractors. Among this new wave of start-ups between 1948 and the early 1950s were companies such as MDL, Microwave Associates, Varian Associates, Narda Microwave, Microlab and Polarad.

A PUSH TO PUBLISH

The microwave community was growing. Eventually, certain companies and individual entrepreneurs would look for new customers by expanding the technology into different commercial applications. Given the success of the RadLab series to help with the rapid advance of the post-war state-of-the-art, several forward-looking people came to believe that a new publication was needed to share information about the technology and the issues faced by young businesses. They felt dialogue within the community would open up new markets for microwave devices.

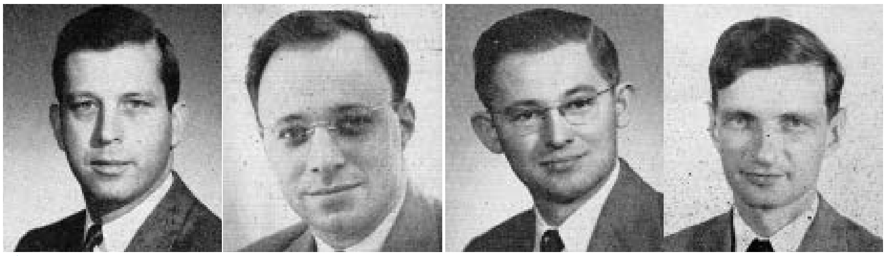
From the ranks of RadLab engineers turned entrepreneur, Theodore "Ted" Saad would become a leading advocate for publishing technical information. Saad witnessed how the RadLab series had become the foundation of microwave engineering at the time. By 1958, Ted had gained some editorial experience with the *IEEE Transactions* and was about to enter into a collaboration that would lead to *Microwave Journal*.

William "Bill" Bazzy learned communications and electronics engineering while serving in the military in the 1940s. As a young radio and television broadcast engineer in Boston, he participated in the explosive growth of national broadcast networks, including intensive working sessions at RCA Technologies, where new standards were being developed. The communications field would represent the first, big non-defense market for the microwave industry. Seeing a need for technology information to serve professionals in the broadcasting and communications industries, Bill and his brother Emil organized a corporation named Horizon House Inc. to pursue a publishing venture.

Through Bill's relationship with Ted Saad, the decision was made to publish a trade magazine about microwave technology. The Bazzy brothers would handle the production of the magazine and the business of selling advertising. Bill would be the publisher and Ted would serve as the magazine's first technical editor (see ***Figure 1***). Together they brought together a team of engineering colleagues that would solicit and review articles from the community at large.

▲ *Fig. 1 Bill Bazzy and Ted Saad.*

The early writers for *Microwave Journal* would follow in the footsteps of well-known Americans who published papers to unite their countrymen against a foreign monarchy. Benjamin Franklin, John Adams, Thomas Payne and Thomas Jefferson had successfully used the power of the press to spread the concepts of freedom and self-governance. Similarly, many of the *Journal*'s first contributors had been brought together by World War II to fight a foreign threat using science and engineering. They would now create a forum dedicated to the free exchange of ideas pertaining to microwave technology and business. From their passion for this field of science and perhaps driven by post-war optimism and Cold War patriotism, these men conceived a trade journal and recruited its staff and early contributors.



▲ *Fig. 2 The early* Microwave Journal *editors mentioned above.*

These notable contributors included industry pioneers such as Seymour Cohn, Henry Jasik, Ben Lax, Marshall Pease, Tore Anderson and Gershon Wheeler (see ***Figure 2***). Personal connections defined the early days of the microwave industry and the new publication that would serve it. Microwave social networks had been formed at universities such as Harvard, Stanford and Princeton. Each of these institutions had been busy developing the fundamental microwave theories needed to support the American government's radar research, but it was RadLab (see ***Figure 3***) that had brought most of them together.

THE MIT RADLAB NETWORK

Saad had worked at RadLab from August 1942 to December 1945. His first assignment was under Norman Ramsey and later Ed Purcell, in Group 42 studying the low pressure, high power breakdown of waveguide components. From there he moved to Group 53 to work under Jerrold Zacharias devising microwave components that would withstand high altitudes. This project included designing the layout for components operating at radio frequencies used in airborne search and bombing radar heads (i.e., the magnetron, mixer and signal processing devices). Finally, he transferred to the beacon group, number 71, where, under Dr. Riekel he helped develop the wave guide components for an X-band beacon. This work involved measuring and modifying antenna, designing directional couplers, inventing an appropriate power meter, as well as the tests to gauge the effectiveness of radar systems operating at high altitudes.

In an interview years after the RadLab effort (with A. Goldstein – IEEE History Center, May 1991), Saad said that "the scientists at RadLab felt at liberty to apply what they had learned to industry. They took basic designs that were not patentable, created new technology, and expanded on some of the ideas they had developed at RadLab. This provided the basis for the new microwave industry after World War II." Notable companies included RCA, Westinghouse, Raytheon, Sperry Gyroscope, Western Electric, Microwave Associates, Airtron, Weinschel and Bell Laboratories.

"CENTERS OF ACTIVITY"

Over the years immediately following the war, Saad would be among many RadLab employees spreading their microwave knowledge. These ex-RadLab people were drawn to the few companies sprouting up around the country, often near the universities that conducted research during the war. In turn "centers of activity" came into existence, whereby emerging microwave companies would be located in close proximity to each other.

These pockets of microwave companies in California, Massachusetts, New York, Greater Washington and other hotbeds would lead to the formation of regional chapters of the IEEE Microwave Theory and Techniques Society (MTT-S) and an annual symposium that would be held (at least initially) in host cities nearby a center of microwave activity. The Professional Group on Microwave Theory and Technique (PGMTT) held its first symposium in New York City in 1952. Saad was one of the organizers and first chairman of the Boston chapter. He was also editor of the society's *Transactions* publication for two and a half years. This group would play an important role in supporting the industry. Regionalization would yield a widely dispersed, yet tightly knit collection of engineering communities that would also be *Microwave Journal*'s audience, advertisers and source of contributors.

BOSTON

While various components were designed by the people at RadLab, much of the actual machining, soldering and fabrication of hardware was done on the outside. A number of companies such as Raytheon (see ***Figure 4***) and Sylvania were located nearby in the Boston area, but companies from all over the country were

▲ *Fig. 3 Transporting a microwave dish through Building 20 corridors at the MIT Radiation Lab.*

also winning bids and began manufacturing products. These companies would send people to RadLab to learn and as a result microwave knowledge would spread among the contractors. For instance, working closely with RadLab, Sylvania would acquire information on microwave point-contact diodes and Raytheon would learn about microwave tubes, klystrons and magnetrons, which they would in turn commercialize and offer to others working on radar systems.

Saad held a number of positions that provided him with important connections to the industry. In 1945, he was in California, still employed by RadLab, but working with a company called Gilfillan. After RadLab he continued work as a radar engineer with the Submarine Signal Co., which merged with Raytheon in 1946. From there he and a few others including Dr. Henry Riblet formed a new company (Microwave Development Labs or MDL) specializing in microwave waveguide technology. Waveguide plumbing would represent a large segment of the microwave activity at this time. Later, he worked at Sylvania Electric Products alongside future Associate Editors—Dr. Benjamin Lax and Marshall Pease. In 1955, he started a company of his own, called Sage Laboratories.

NEW YORK

Spreading microwave theory from RadLab out to prominent New York companies would come notably by way of the Varian brothers (Russell and Sigurd) (see ***Figure 5***) and MIT Professor W.L. Barrow among others. The brothers, along with Stanford Professor W.W. Hansen, had invented the klystron and worked together at RadLab during the war. Later, the Varians would go to Sperry Gyroscope in Great Neck, NY and essentially help them build klystrons. Hansen worked and lectured at MIT during the war years and returned to Stanford afterwards, but beforehand he would travel weekly from MIT to Sperry on Long Island with lecture notes from Julian Schwinger on microwave theory, measurement techniques and applications to pulsed and Doppler radar. Meanwhile, Barrow who had published work in 1936 (the first paper on microwave technology presented to the IEEE) on propagating radio waves in "hollow pipes" would become a chief scientist and vice president at Sperry.

Saad had worked for Professor Barrow while writing his thesis on mi-

▲ *Fig. 4 The Raytheon Spencer Laboratory Equipment Division in Burlington, MA, ca. 1959.*

▲ *Fig. 5 Russel Varian, left, and Sigurd Varian appear in this 1951 photograph with a high-powered klystron.*

crowaves at MIT. The experience of working with an innovator in the field of waveguide would serve Saad and the other co-founders of MDL well, just as it would serve Sperry and a variety of other Long Island microwave companies jumping into the microwave plumbing business. As this segment would grow, *Microwave Journal* would enjoy a strong connection to those developing similar components in this and other parts of the country.

CALIFORNIA

Also working at Sperry Gyroscope was future *Microwave Journal* Associate Editor—Dr. Seymour B. Cohn. Dr. Cohn received a BE degree from Yale University and then joined Harvard University's Radio Research Laboratory, eventually receiving his PhD in Engineering Science and Applied Physics. After Harvard, Dr. Cohn worked at Sperry alongside the Varian brothers and W.L Barrow. In 1953, Dr. Cohn joined the Stanford Research Institute in Menlo Park, CA, heading the Microwave Group of the Electromagnetics Laboratory (later to be named after W.W. Hansen). This group was engaged in R&D of microwave antennas, waveguide, strip-line circuits, microwave solid-state devices and microwave systems. As one of the associate editors in the first issue, Dr. Cohn would provide *Microwave Journal* with his expertise in all these areas and provide an important link to the west coast technical community. Additionally, fellow Stanford colleagues and famed authors on filter theory—Leo Young and George Matthaei—would both be regular early contributors. Young first appeared in December 1962 and Matthaei first appeared in January 1959 and went on to author multiple editorials and even book reviews for the magazine. Special reporting on west coast microwave news would be picked up by Editorial Specialist Gershon Wheeler, in his column "On the Peninsula" starting in the mid-60s.

THE EARLY ISSUES

The history of the microwave industry post-1958 is now told through the following defining issues in the *Microwave Journal*'s 50 years of technical articles, business perspectives and editorial content. This material, written by the thought leaders of the industry is particularly insightful when viewed through the lens of time.

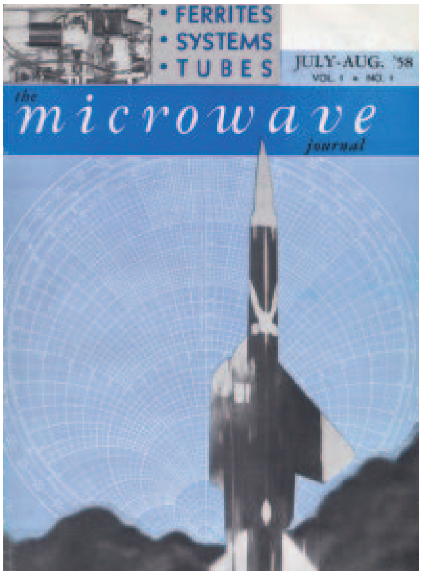
July/August 1958

The Bomarc Missile appears on the first issue of *Microwave Journal* Vol. 1, No. 1 (see ***Figure 6***). W.B. Bazzy is the first publisher along with Ted Saad as the first Technical Editor. The associate editors include: Seymour Cohn, Henry Jasik, Benjamin Lax, Marshall Pease with guest editorial from Colin Bowness, Tore Anderson and Dana Atchley. At 48 pages in length, this first issue looks at microwave components—ferrites, plumbing and tubes. Seymour Cohn wrote about "Microwave Horizons," an editorial piece on what the future of microwave technology might bring. Cohn discussed how knowledge from one field benefits another (citing advances in magnetic materials advancing the state of ferrites, and solid-state theory advancing parametric amplifiers).

The first issue contains the regular departments that will be a part of the *Journal* throughout its history including biographies, company profiles, and business editorials among the technical features and new product information. A *Microwave Journal* tradition of event coverage also begins in the very first issue with a report on a microwave conference in Boulder, CO, that included the dedication of a new Electronic Calibration Center of the National Bureau of Standards, which would eventually become today's NIST. The industry news includes a pending merger between Airtron and Litton. Congratulatory letters to the editor by Henry Magnuski (Motorola), George Southworth, William Bourke (Narda) and Marvin Ingalsbe (Lockheed Aircraft) in anticipation of this new venture appear in this first issue. Also, Dr. Henry Riblet (member of Radlab, inventor of the Riblet coupler and co-founder of MDL along with T. Saad) is quoted describing the state of microwave component tuning at the time: "The two most important tools for a microwave engineer are the straight and the curved file." Dana Atchley, then president of Microwave Associates, writes the first business editorial (Notes of the Industry).

September/October 1958

With a nod toward Professor W.W. Hansen, a high power Stanford klystron, one of 22 used to power the Stanford linear accelerator, capable of generating 30 million watts at a wavelength of 10 cm graces the cover of the second issue (see ***Figure 7***). It is likely that Editor Seymour Cohn via his affiliation with Stanford Research Institute is responsible for this selection. In this issue, Editor Ted Saad discusses the new magazine's goal of striving "for balance of content without diluting the quality of the magazine. In each issue an effort will be made to include a variety of articles



▲ *Fig. 6* Microwave Journal *cover, July–August 1958.*

rather than articles similar in type or content." Ted goes on to note that the results of an early reader survey indicate a desire for tutorial or survey type papers. Readers also wanted papers on antennas, ferrites, solid state, measurements, systems, components and news items. Future issues would focus on the three "Ds"—designs, dimensions and data. (This tradition continues as a principle consideration for paper acceptance by the *Microwave Journal* editorial review board.) To address the readers' desire for practical information, editors invite leading innovators from the industry along with a general call for technical papers that "present to the engineer clear description of the working of microwave components, with a minimum of mathematics, and offer him the facts and information that he can readily use." The result is a plethora of tutorials and technical papers from many of the leading authorities at the time. Tutorials such as "A Novel Aid to Slotted Line Measurements" by Bernard Lamberty, "VSWR Nomograph" by Gershon Wheeler, "Materials for Microwaves" by Dr. Benjamin Lax and a multi-part series on "Using the Smith Diagram" by George C. Southworth appear regularly. Business editorial for the second issue comes from William Burke, Executive VP of Narda Microwave.

January 1959

The first monthly issue features a picture of a parametric amplifier developed by Raytheon Manufacturing Co.

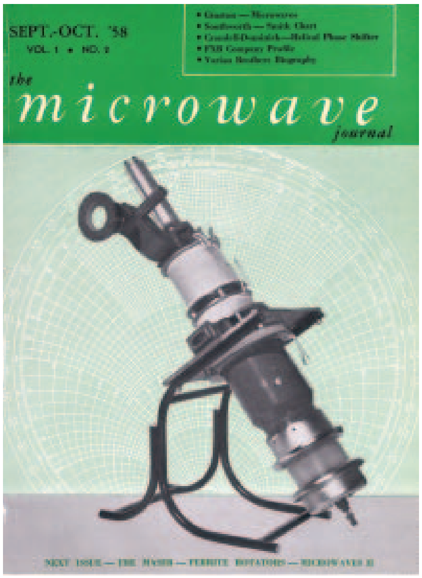


Fig. 7 Microwave Journal *cover, September–October 1958.*

Fig. 8 Microwave Journal *cover, January 1959.*

(see **Figure 8**). Wesley Matthaei writes the lead technical feature on the "Recent Advances in Solid State Receivers." Coming events include an upcoming three day meeting for the National Symposium of the IRE Professional Group on Microwave Theory and Techniques (PGMTT) in June, to be held at Harvard University in Cambridge, MA. Due to strong subscriber response, the editorial scope is expanded to include microwaves in systems; e.g., electronic packages, communications, etc. The editors also acknowledge a small but growing use of microwaves outside of the military and put out a call for more submitted material including more graphs, nomographs and tables. The editors also note that interest in the magazine is extending beyond the US with requests for subscriptions coming from Canada, Scotland, England, France, Sweden, Italy, Jordan, Japan and Brazil.

May 1959

Color photography makes it first appearance on a *Microwave Journal* cover in **Figure 9**, which featured a picture of a complete 400 mc (mega cycle) low-noise receiving system using a reactance (parametric) amplifier as the input stage. The letter from the editor that month focused on the PGMTT National Symposium, wherein Saad gave a brief summary of the organization's previous seven meetings and declared even back in 1959 that, "this is without question the high point of the Microwave year." The PGMTT National Symposium advance program is printed in the *Microwave Journal* for

▲ *Fig. 9* Microwave Journal *cover, May 1959.*

▲ *Fig. 10* Microwave Journal *cover, December 1959.*

the first time. A listing of the presented papers for all seven session takes up two full pages of the magazine.

August & September 1959

The magazine looks toward the international market with an August guest editorial called, "A Look at the Export Market" by William Hewlett, co-founder of Hewlett-Packard Co. and "A View of the Electronics Industry in Scotland" by A.L. Whitwell of James Scott Ltd. By pure coincidence, this early attention to the microwave industry outside the US and specifically in Europe would be a precursor to *Microwave Journal*'s annual European Microwave week show issue published in September. By this time, the *Journal* was being mailed to over 10,000 people in 43 countries. At the time, the editors credit an ever-shrinking world due to advances in communications, the emergence of international technical societies and increased global competition. Sound familiar? Content also seems to be driving reader interest at home and abroad. The guest editorial by William Hewlett reflects the willingness of leading company executives to talk directly to the industry through this magazine, a tradition that carries on to this day.

December 1959

The last issue of the decade features a symbolic depiction of the Bogart Antenna Coupler being used to Flight-line test an aircraft antenna. At the end of its first full year as a monthly publication, *Microwave Journal* (see ***Figure 10***) saw its circulation nearly double from an initial 12,000 subscribers to 23,000. The number of companies on the *Journal*'s mailing list had grown from 300 to 800. Reporting on the microwave business at the dawn of a new decade, publisher William Bazzy summed up the state of the industry in that month's business editorial: "Fabulous Sixties! Or Decade of Problems?" Bazzy notes "the major concentrations of microwave activities are in the mid-Atlantic area, with both the northeast and west coast areas about evenly divided in concentration of talents and companies." Putting the microwave industry of 1959 in terms of dollars, ferrite sales ran approximately $15 M, the large antenna market was at roughly $25 M, both the small antenna and microwave tube markets were at $250 M each, test instrumentation was about $40 M, $15 M for waveguides and coaxial products, and sub-systems were near $200 M. All in all, total component sales (including systems and antennas) in 1959 were believed to add up to $1 B. Bazzy's final thoughts concern the growing global interest in microwaves and the likelihood of further expansion of the *Microwave Journal*'s editorial coverage. Interestingly enough, Red China was the noted exception to the global interest in microwave activity of 1959.

With the December issue, the 1950s come to an end with a new industry strong and growing, an industry trade journal with clear editorial focus established and, thanks to the insight of many knowledgeable contributors, a sizable number of readers in place. Next month, this series looks at the 1960s. ■

TWENTY THREE YEARS: THE ACCEPTANCE OF MAXWELL'S THEORY

On October 21, 1805, flying splinters of wood wreck carnage in the battle of Trafalgar as the final and perhaps greatest sailing ship battle of all time is fought to its gory end. Twenty-seven of Lord Nelson's British battle ships with 2150 cannon face Napoleon's fleet of 33 French and Spanish ships carrying 2640 cannon. At the height of battle, Lord Nelson's flag ship, the HMS Victory, becomes locked, side-by-side with the French ship Redoubtable, their rigging entangled. The British crew gains the upper hand by reducing the gun powder in each charge, allowing the cannon balls to bounce around inside, which wrecks even more carnage against the French ship (see ***Figure 1***).

Fig. 1 Lord Nelson's flag ship, HMS Victory, and Lord Nelson's final moments.

While Lord Nelson himself does not survive the battle, the British navy is victorious due to the extensive damage inflicted by its radical gun powder tactic and a major storm which soon scatters the remaining survivors. Today you can view a statue of Nelson on a hundred foot column in the exact center of London's Trafalgar Square, signifying the importance of this battle to Britain's history. Little known is the fact that the radical battle-winning strategy Nelson used was first suggested by John Clerk of Eldin, great-great uncle of James Clerk Maxwell.[1]

Britain's victory assures British dominance of the oceans for the remainder of the 19th century. As part of this dominance, Britain will discover and secure a monopoly on the production of "gutta percha," a natural plastic made from the sap of a tropical tree. Gutta percha will become the perfect, and for many years, the only practical insulator for the undersea cables used by the early communication networks, which will link the far-flung dominions of the Empire.

JAMES C. RAUTIO
Sonnet Software
Syracuse, NY

Flash forward 60 years to 1865. The American Civil War is ending. Maxwell publishes "A Dynamical Theory of the Electromagnetic Field" in the *Royal Society Transactions*, Vol. CLV (he actually presented the paper orally in December 1864). Comparing several measurements of the speed of light to that calculated by his new electromagnetic theory, he notes, "The agreement of the results seems to show that light and magnetism are affections of the same substance, and that light is an electromagnetic disturbance propagated through the field according to electromagnetic laws."

The directly measured values for the speed of light that Maxwell quotes are 314,858,000 m/s (M. Fizeau), 298,000,000 m/s (M. Foucault) and 308,000,000 m/s (by stellar aberration). Measurements of a capacitor discharge applied to Maxwell's theory yields 310,740,000 m/s (M.M. Weber and Kohlrausch). Given our modern knowledge of the speed of light, we know which results are presented to appropriate precision and with minimum error, and even with that knowledge, Maxwell's conclusion is strong.

Thus, one of the greatest problems of physics is now solved. Or is it? It is actually too early to break out the champagne, for we must patiently wait 23 years. One problem is that Maxwell offers no mechanical model for the "luminiferous ether," the medium in which this supposed wave travels. Maxwell and friends all know that light is a transverse wave (assuming that it is actually a wave, not a particle as Newton had insisted). So whatever medium you propose, it must not allow a longitudinal wave. The medium cannot have translational stiffness. The earth plows through this medium without spiraling into the sun, so either it has no mechanical effect on matter or it has no shear strength. But without shear strength, it can not support a transverse wave. And if there is no interaction with matter, how can any wave get started? And so, Maxwell's theory is just a bunch of equations with no model whatsoever.

And what a bunch of equations—there are 20 of them, simultaneous differential equations, rather than the four equations we know today. Maxwell has the concepts of divergence (he uses the opposite sign and calls it convergence) and curl. But vector calculus is not yet formalized, so he must write out all 20 equations. To do so, he sometimes relies on the use of "quaternions." Quaternions are a combination of a scalar and a vector, which require the use of a squared magnitude of –1, further complicating the equations.

Wait, there's more. Those 20 equations are not easily recognized today. Maxwell places as primary something he calls "electromagnetic momentum" (because its time derivative is force). Electric and magnetic fields are secondary. His friend, Michael Faraday, who originated the field concept as an alternative to the then popular "action at a distance," called it the "electrotonic state." It is, Faraday said, changes in the electrotonic state surrounding magnets that cause magnetic induction. Maxwell formalized Faraday's field concept. The electrotonic state is today called the magnetic vector potential, usually introduced only in graduate level EM courses as a side-effect of a cute little vector identity (primacy of the vector potential is returning to popularity in physics).

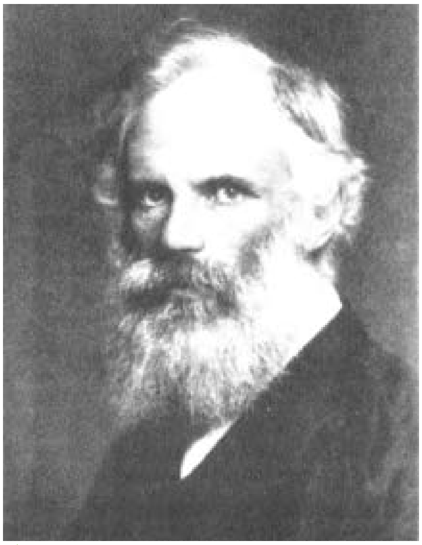
Maxwell viewed magnetic vector potential as primary (presumably why he gave it the symbol A) and magnetic field as secondary (presumably why he gave it the symbol B). However, by making the vector (and scalar) potentials primary, Maxwell's equations became complicated. And so, very few took the time to learn them.

Finally, recognition of his work would take longer because of Maxwell himself. Unlike Newton, Maxwell was not an aggressive self-promoter. For example, while president of Section A of the British Association, he gave a presidential address (published in Vol. 2 of the new British journal *Nature*) at the 1870 annual meeting with high praise for a vortex theory of molecules due to his good friend William Thomson (later Lord Kelvin). Rather than wave the flag to the scientific world about his electromagnetic theory, he only mentioned briefly at the end, "Another theory of electricity which I prefer…," not even taking credit for his own work.[2]

MAXWELLIAN: FITZGERALD

Maxwell died in 1879. There was no one, no students or colleagues, to carry on his work in electromagnetics. Well, almost no one. Two days after Maxwell's death, the Royal Society mailed a paper review that had been written months earlier by Maxwell back to George Francis FitzGerald (see ***Figure 2***). FitzGerald was a fellow and soon to be professor of Trinity College Dublin.[3] The future of electromagnetics would now lie in the hands of FitzGerald.

FitzGerald was a brilliant idea man, although self-described as "lazy" when it came to follow up experimental work. Typically, he would do the initial work and then rely on others (usually friends or students) to continue the effort. In the paper that Maxwell reviewed, FitzGerald had linked Maxwell's electrodynamic theory to an earlier theory of Prof. James MacCullagh also of Trinity College. This theory modeled the luminiferous ether required by Fresnel's wave theory of light and required a purely rotational elasticity, i.e., no translational stress was allowed to form. MacCullagh had shown that given this form for the ether, one could model refraction, reflection and polarization perfectly. Quite the coincidence. However, there were a couple of problems. First, MacCullagh did not suggest a physical form for this mysterious ether (it is certainly unknown in normal matter). Second, in 1862, G.G. Stokes, in reviewing a number of proposed ethereal models, pointed out that MacCullagh's ether violates conservation of angular momentum. A nice idea while it lasted.



▲ *Fig. 2 George Francis FitzGerald, one of the few scientists to pursue Maxwell's theory.*

Maxwell published his treatise on electromagnetics (the founding document of our field) in 1873. However, in this, and in all of Maxwell's EM theory publications, there is no electromagnetic treatment of reflection or refraction. FitzGerald is one of the very few people who read and learned the treatise in detail. FitzGerald also extensively studied MacCullagh's ether model while preparing for his fellowship exam. His well annotated copy of Maxwell's treatise includes a long note dated 7 September 1878 where he first mentions that it might be possible to connect Maxwell's theory to MacCullagh's. Over-simplifying just a bit, FitzGerald found a mapping of variables from Maxwell's theory to MacCullagh's. In his paper he describes the mapping and points out that MacCullagh's work now brings reflection and refraction to Maxwell's theory.

However, Stokes's objections still hold; MacCullagh's ether does not conserve angular momentum. If MacCullagh's ether is the same as Maxwell's, then Maxwell cannot be correct either. FitzGerald, a life long believer in some kind of ether, optimistically announces that perhaps we should "emancipate our minds from the thralldom of a material ether."

MAXWELLIAN: LODGE

Oliver Lodge (see ***Figure 3***) was the son of a pottery clay merchant. His path takes a higher road when he wins a scholarship and completes a University of London external de-

▲ *Fig. 3 Oliver Lodge worked with FitzGerald in puzzling out Maxwell's theory.*

gree. He completes a doctorate at University College in London and later becomes the first professor of physics at the new University College in Liverpool in 1881. Lodge had acquired a copy of Maxwell's treatise in 1873, right after it was published. He started studying it in 1876. He first met FitzGerald at the August 1878 Dublin meeting of the British Association. Sharing a strong interest in Maxwell's treatise, they quickly became fast friends.

A great unsolved mystery is why Maxwell never tried to produce electromagnetic waves. Historians suggest that Maxwell himself simply missed the implication of his theory. The possibility that changing currents could make light and that radiation could happen is not obvious from Maxwell's equations, especially in the form Maxwell used. Maxwell appears to have believed that light was made by mechanically vibrating molecules somehow coupling to and vibrating the ether. And EM waves of long wavelength? At that time, such "dark light" was outside human experience.

Lodge was more comfortable working with mechanical models, rather than directly with equations. In 1879, one of his models suggested that it might be possible to create light electromagnetically. But how? Lodge proposed applying a voltage source through a switch that switches ("breaks") 400 times a second. The square wave is applied to a coil that somehow doubles the frequency. A cascade of 40 such coils should yield light. FitzGerald gently points out that the square wave would be smoothed into a sine wave after only several coils and thus would not work.

Lodge, not one to give up easily, suggests that a discharging condenser (i.e., capacitor, in the form of a Leyden jar) is oscillatory. FitzGerald's response was not preserved, but he likely told Lodge that the frequency would be too low for light. So close, yet they missed the idea that the experiment would generate long wavelengths. If only they could find a way to "see" such wavelengths.

FitzGerald then pursued the problem mathematically, using Maxwell's treatise and making several errors along the way. First he reads Maxwell too literally, as though the treatise is an electromagnetic bible. For example, Maxwell states repeatedly that his theory gives results equivalent to the old "action at a distance" concept. In this case, there can be no radiation. However, it appears that Maxwell's comment was limited to the non-time varying situation, something FitzGerald did not realize. A second very serious error concerns what is now called the gauge condition. Maxwell selected what we call the Colomb gauge (divergence of A is zero) and then incorrectly specified the scalar potential to be independent of time, yielding a static solution. Eventually FitzGerald realizes the problem, in part by toying with mechanical models of the ether that he had built. Then likely inspired by Lord Rayleigh's Theory of Sound, and by electromagnetic research published by Lorenz, he introduces retarded potentials to Maxwell's theory.

FitzGerald, with considerable effort, does find a solution to Maxwell's equations for a time varying current, but it is a non-radiating solution, "like the nodes and loops in an organ pipe." He thus concludes that generating EM waves electrically is impossible. What FitzGerald did not realize at the time, is that he had unwittingly found the solution assuming a conducting wall boundary condition. This illustrates a problem of the vector potential; boundary conditions are difficult to see. Years later FitzGerald realizes that an alternative solution (assuming a different boundary condition) takes the form of traveling waves. Regardless, the damage is done. FitzGerald and Lodge continue enthusiastically working with Maxwell's theory, but the search for EM wave generation is terminated... until 1888.

MAXWELLIAN: HEAVISIDE

Described by a friend[4] as a "first rate oddity," Oliver Heaviside (see ***Figure 4***) was also an exceptionally prolific writer, albeit difficult to read, and an absolute mathematical genius. He was raised in poverty in Camden Town, London around the corner from where Dickens himself had lived. In addition to the harsh treatment, he was often ill and never attended a university. Beyond a reasonable early education (partially provided by his mother), he was self-taught in science and mathematics. He learned by reading books from the library. It appears he passionately avoided books on theology and metaphysics (unlike Maxwell), but he adored books dealing with Newton and Laplace, to name a few.

His started his first and only job in 1867 as a telegraph clerk. His uncle by marriage, Charles Whetstone (of bridge fame), helped him obtain the position. Because of its importance to the Empire, much of British science was focused on problems relating to undersea telegraph cables. The first undersea cable (Dover to Calais) was laid in 1851. By 1885, there are nearly 100,000 miles of cable under the ocean, mostly laid by Britain due to their dominance on the ocean and monopoly in the only viable undersea cable insulator, gutta percha.

Heaviside obtained a copy of Maxwell's treatise in 1873. "I browsed through it and I was astonished! I read the preface and the last chapter, and several bits here and there; I saw that it was great, greater and greatest… I was determined to master the book and set to work." Heaviside left his job the next year and moved in with his parents to pursue the mathematics of Maxwell, especially with regard to telegraphic (and soon, telephonic) cable problems.

Heaviside had no patience with perceived stupidity and one person in particular, William Henry Preece, the Engineer-in-Chief of the British General Post Office (which controlled all British telegraph and telephone lines). In turn, Preece, who considered himself to be an especially intelligent, "practical man," had no need for theoretical mathematicians.

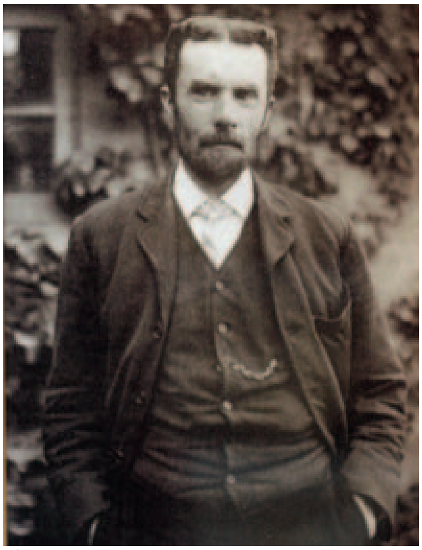


Fig. 4 Oliver Heaviside, a reclusive mathematical genius, cast Maxwell's equations into their modern form.

In one case, Heaviside derived the transmission line "telegraphers" equation directly from Maxwell's theory. William Thomson (Lord Kelvin) had successfully analyzed undersea cables based on the diffusion equation, i.e., just resistance and capacitance, but no inductance. In this case, a pulse effectively diffuses into the cable and Thomson's model provided reasonable results for most undersea cables but failed miserably for overhead lines. When Heaviside derived the full telegrapher's equation, he determined that if the ratio of L/R is equal to C/G, distortion (i.e., pulse spreading) could be eliminated. Since G is very small, thanks to gutta percha, decreasing R to the required value would be prohibitively expensive. So, the solution to addressing distortion was simply increase L. However, his work is effectively suppressed over a long period by Preece, who was vehement that the inductance of a transmission line is zero and increasing it would only lead to disaster. As a "practical man," he could not be convinced otherwise by these silly mathematicians. Later engineers in the United States successfully make, apply and patent the same discovery, to which Heaviside received no credit.

In the summer of 1884, Heaviside starts working on energy flow in the electromagnetic field. The derivation is complicated, but the result is simple: S=E×H. Heaviside, being reclusive and not well connected with the rest of the scientific community, is later only a little disappointed to find that Prof. Poynting of the new Mason College of Science in Birmingham had published the same result a few months earlier.

As an example of energy flow, take the field around a straight copper wire at DC. E×H points radially into the wire. Energy does not flow along the wire as had been thought. It flows from the field surrounding the wire and dissipates as heat as it enters the wire. This is the big clue. In sharp contrast to action at a distance, where energy is viewed as flowing along the wire with the current like water in a pipe, Maxwell's equations suggest that energy is in the field and flows from the field into the resistance of the conductor.

In fact, the Maxwellian view at this time is that charge and current are not physical. Rather they are changes in the stresses and strains of the ether. The conductor of the wire relieves the stress of the field and dissipates the energy as heat. This view fades with the advent of a new concept a few years later, the electron. As for the modern view, electromagnetic energy is calculated in terms of either the field or the current. It's hard to say precisely "where" it is.

Heaviside went further than Poynting. As Heaviside was working with his energy concept, he came upon a new form for Maxwell's equations, the "duplex" form, the four equations with which we are familiar today. These differential curl equations involve E, H, D and B. The potentials are gleefully "murdered" according to Heaviside. "I never made any progress until I threw all the potentials overboard," he later wrote to FitzGerald. With the duplex form, the symmetries in Maxwell's equations are beautifully seen, but something was missing. Heaviside adds the fictitious magnetic current to complete the symmetry.

If Heaviside modified Maxwell's equations to this degree, why don't we call them Heaviside's equations? Heaviside answered this question in the preface to Vol. 1 of his three-volume, lifetime culminating work, *Electromagnetic Theory*, stating that if we have good reason, "to believe that he [Maxwell] would have admitted the necessity of change when pointed out to him, then I think the resulting modified theory may well be called Maxwell's."

▲ *Fig. 5 Heinrich Hertz experimentally validated Maxwell's equations 23 years after Maxwell first published them.*

In 1888, Lodge is requested to give two lectures on lightning protection and he conducts experiments by discharging condensers in the vicinity of models of various structures. The lectures stimulate major controversy with Preece as Lodge's results contradict standard practice. But all that is minor. In the course of his experiments, Lodge notices arcs being induced in nearby circuits. In one experiment, he sees an arc at the end of two parallel wires. In the dark, he can even see a distinct standing wave glowing in the air around the wires. Lodge has generated and detected electromagnetic waves. The British Association is meeting in Bath in September. In July, Lodge plans to report his astounding results at that meeting, right after he returns from vacation in the Alps. On the train out of Liverpool, he picks up the July issue of *Annalen der Physik*. He immediately notices an article, "Ueber elektrodynamische Wellen in Luftraume und deren Reflexion" ("On Electromagnetic Waves in Air and Their Reflection").

MAXWELLIAN: HERTZ

Heinrich Hertz (see ***Figure 5***) studied in Berlin under Hermann von Helmholtz. Helmholtz had incorporated the electromagnetic theories of Maxwell, Weber and Neumann into a single theory with a parameter (k), whose value selected the theory to be used (later it would be realized that Maxwell's theories were not correctly incorporated fully). Helmholtz had encouraged Hertz to perform experiments to test and differentiate the theories. Hertz at first declined, having determined that the experiments would be difficult to perform. However, a few years later, while teaching at Technische Hochschule in Karlsruhe, he noticed while discharging a condenser through a loop, that an identical loop some distance away developed arcs. He instantly recognized a resonance condition and suspected electromagnetic waves. The experiments he subsequently conducted would verify reflection, refraction, diffraction and polarization for both free space waves and wire guided waves. It is Hertz's experimental results that Lodge is reading in *Annalen der Physik* as he leaves for vacation.

As Lodge read the paper, he realized that his own results were now superfluous. However, his disappointment is more than compensated by the beauty and completeness of Hertz's work. Hertz presents at the September 1888 British Association meeting in Bath and is hailed a hero. His results provide full confirmation of Maxwell's electromagnetic theory. The British Maxwellians, after 15 years of careful theoretical preparation of Maxwell's theory, are catapulted to the top of British science thanks to Hertz's timely experimental validation. Hertz is warmly welcomed into the small Maxwellian group and takes an active role, but, unfortunately, for far to short a period of time. In Germany, the importance of Hertz's results is not at first fully recognized. Some will say (only partly in jest), that word of Hertz's experiments reached Germany by way of England. However, once recognized, German researchers likewise embrace Maxwell's theory as well.

Hertz had, independently of Heaviside, discarded Maxwell's potentials and developed the modern duplex form of Maxwell's equations. When Hertz becomes aware of Heaviside's work, he graciously yields priority to Heaviside and likewise chooses to call them Maxwell's equations. As a tribute to Hertz, they are for a few years also sometimes called the Hertz-Maxwell equations.

EPILOG

Hertz returned to England for one final visit to receive the prestigious Rumford Medal from the Royal Society in 1890. The year before, Hertz had received a major promotion and moved to the chair of physics at the University of Bonn. Unfortunately, the move also deprived him of experimental facilities. In close collaboration with the British Maxwellians, Hertz continued to make significant theoretical contributions, although work becomes difficult as he starts suffering from an infection that spreads to his jaw and sinuses. He writes to his parents in August 1892, "At present my nose is my universe." He dies tragically and painfully at the age of 36 from blood poisoning after an operation.

Michelson and Morley performed their interferometer experiment in 1887, which casts doubt on the existence of an ether. British researchers continue searching for mechanical models of the ether well into the 20th century before the effort is gradually dropped as pointless.

FitzGerald passes away after a particularly difficult bout of indigestion at the age of 49. To Heaviside and Lodge his death is a great shock. Lodge does not contribute any further work to Maxwell's theory after 1900, shifting his efforts toward researching communication with the dead. He died on August 22, 1940, promising to make public appearances after his death. No such appearances have been recorded.

In 1896, Heaviside's father dies, leaving him on his own for the first time in his life. FitzGerald and John Perry arrange a Civil List pension for him. In a more difficult task, they convince him to accept it, offering it as recognition of service to his country. Heaviside became senile in his old age ("I am as stupid as an owl"). He dies on February 3, 1925 after falling off a ladder and landing on his back. He is 74. His ride to the hospital is his first and final ride in an automobile.

I close with a paragraph written January 30, 1891 in Heaviside's *Electromagnetic Theory*: "Lastly, from millions of vibrations per second, proceed to billions, and we come to light (and heat) radiation, which are, in Maxwell's theory, identified with electromagnetic disturbances. The great gap between Hertzian waves and waves of light has not yet been bridged, but I do not doubt that it will be done by the discovery of improved methods of generating and observing very short waves."

We truly do stand on the shoulders of giants. ■

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Company Profiles

In the early years of *Microwave Journal*, the editors ran a monthly series focused on the pioneering companies of the industry, highlighting their technical achievements and formulas for growth. We have featured several of them in the following pages, with the full "profiles" available online at mwjournal.com

COMPANY PROFILE

HEWLETT-PACKARD COMPANY
Palo Alto, California

William R. Hewlett and David Packard.

In describing the rapid growth of electronics firms, probably no other adjective is as overworked as "spectacular." One can hardly review the development of the Hewlett-Packard Company, however, without observing that the company's growth *is* spectacular — in every sense of the word.

Founded in a garage workshop in 1939, Hewlett-Packard today is the world's largest manufacturer of electronic measuring equipment. Its precision instruments are known, used and respected not only throughout the U.S., but in over 30 countries in the Free World.

As the company pauses to observe its 20th anniversary, it can point with justifiable pride to an impressive array of statistics. Sales volume, for example, is running at a $40-million a year clip. Employment is over 2,000 and the company's annual payroll is approaching $13 million. Production facilities are being rapidly expanded; in 1960 the firm's two plants in Palo Alto, Calif., will encompass 570,000 square feet of factory space.

Most impressive, perhaps, is the breadth of the Hewlett-Packard product line. The company now manufactures and sells approximately 400 precision instruments and accessory devices, ranging from simple bolometer mounts selling for less than $100 to sophisticated electronic counters and signal generators costing several thousand dollars. These instruments have a variety of applications, not only as important research tools but as practical design, manufacturing, quality control and maintenance devices for industry.

To indicate the magnitude of the Hewlett-Packard line, the company's latest product catalog is a weighty volume comprising 166 pages. It is one of the largest publications of its kind in the electronic industry.

It is difficult, of course, to describe the scope of *-hp-* equipment in a few short paragraphs. Generally speaking, however, the company's products can be broken down into four broad categories:

Microwave equipment — This equipment, consisting of signal generators, power meters and devices for use in waveguide and coaxial systems, is employed in microwave communications, military and commercial radar, air navigation and guided missile control.

Frequency and time measurement equipment — The principal instruments in this classification are frequency and time standards, digital frequency counters, digital recorders, digital delay generators and tachometers.

Oscillators and vacuum tube voltmeters — This class of equipment is basic for both laboratory and production use. Its applications range from maintenance of telephone systems to development of control systems for industrial and defense needs.

Oscilloscopes — These instruments are also basic measuring tools in various segments of industry. They comprise the field of instrumentation most recently entered by Hewlett-Packard.

There are, of course, several other instruments of a miscellaneous nature which are sold both in the U.S. and abroad.

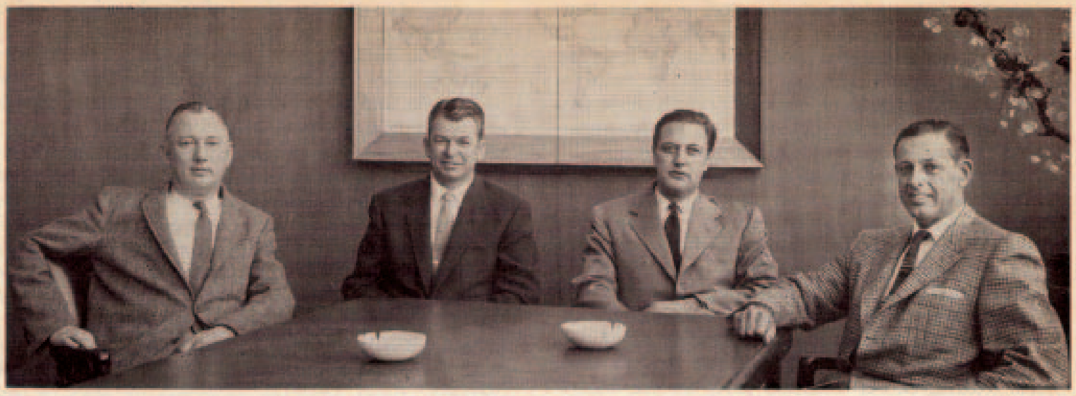
The history of Hewlett-Packard is a story of hard work and determined purpose. It actually started a few years prior to 1939 when two young electrical engineers, David Packard and William R. Hewlett, were about to graduate from Stanford University. Although they had given considerable thought to going into business for themselves, they were advised by Frederick E. Terman, Stanford's world-famous Dean of Electrical Engineering and now Provost, to gain additional experience and knowledge before launching their own enterprise.

This they did. Packard went to work for General Electric at Schenectady. Hewlett pursued graduate work at Stanford, went to Massachusetts Institute of Technology and then returned to Stanford to do some practical research. By now, Packard had also returned to the Palo Alto campus on a research fellowship.

On a part-time basis the two informal partners began building various devices in their first "plant," a small garage in a quiet residential district of Palo Alto. One of these devices, an audio oscillator, was presented by Hewlett at the 1938 I.R.E. meeting in Portland, Ore. An engineer for Walt Disney Studios was impressed with the instrument and bought nine oscillators for the sound presentation of "Fantasia."

This "big" order did it. In January, 1939, the company came formally into existence as a partnership. The new oscillator, dubbed Model 200A "because the number sounded impressive," began to pay off immediately. It was followed by a harmonic wave analyzer, then a square wave generator. By 1940 the partners had rented part of a small building on Page Mill Road in Palo Alto. At year's end, several instruments had been added to the line, a small production team had been hired and Hewlett-Packard was on its way.

By 1943, the company was deep into war production



Company Vice-Presidents Porter, Cavier, Oliver and Eldred.

and its 100 employees were turning out $1 million worth of instruments annually. The firm had also built the first of its own buildings, a 10,000 square-foot office, laboratory and factory. During the war years Hewlett-Packard was awarded the Army-Navy "E" for Efficiency honors on four different occasions, a distinguished production record.

In 1947 the firm was incorporated and still other products were being developed to meet the needs of an expanding post-war economy. By 1953 sales volume had reached $1 million per month, and *-hp-* had assumed a position of leadership in the field of electronic measuring instruments. Since then the company has continued to grow — not only in measurable yardsticks such as product line and total sales, but in stature and reputation among its thousands of world-wide customers.

Dave Packard and Bill Hewlett continue to chart the course of their 20-year-old company — Packard as president and Hewlett as executive vice-president. Both are well-known throughout the electronics industry, not only for their remarkable achievements in building the Hewlett-Packard Company but for their active interest and participation in industry affairs. Their reputation as "doers" extends into fields outside electronics, as well. Packard, for example, is chairman of Stanford's Board of Trustees and a director of several major corporations. Hewlett also holds several directorships and is a trustee of Mills College.

Despite their busy schedules and heavy participation in industry and community projects, Packard and Hewlett keep a firm hand on the tiller. Both are "shirtsleeve" executives; they spend many hours each week in the company's laboratories and plants. The doors of their offices are seldom closed — an indication of their easy accessibility to employees. As a result, there is a freedom of communication at Hewlett-Packard which is unique in a company its size and which is a cornerstone of its success.

Another management skill which has contributed greatly to the firm's progress is delegation of authority. Packard believes that it is one thing to give a man the ball and another thing to let him carry it.

"Here we try to do both," he says. "Generally speaking, we've found this policy results in very few fumbles and a great many touchdowns."

Hewlett-Packard's top management team includes four vice-presidents, each responsible for a major function of the company's operation. The V.P.'s are Bernard M. Oliver, research and development; Noel E. Porter, manufacturing; W. Noel Eldred, marketing and W. F. Cavier, finance.

Oliver's research and development group, considered one of the finest in the industry, includes over 150 graduate engineers and scientists who are engaged in the development of new and improved instruments and occasionally in government research projects. The R & D staff includes four principal groups, each concentrating on a given field of instrumentation. One group, under Alan Bagley, is responsible for frequency counters and related instruments. Heading the second division is Norman Schrock, in charge of the oscilloscopes and oscilloscope accessory program. The third division, supervised by Bruce Wholey, is devoted to microwave signal generators, noise meters and noise sources, and waveguide components. John Cage heads the fourth division, which is responsible for audio and video voltmeter projects.

The company has always placed great emphasis on research and development, as evidenced by the heavy and increasing investment in R & D. In 1950, *-hp-* spent $207,000 in development engineering. By 1955 this had increased to $862,000 and in 1960 the company estimates its expenditure will be a whopping $2.6 million.

The effectiveness of this aggressive R & D program is indicated by the productivity of the engineering group. While many instrument manufacturers have only 10 to 15 products in their entire line, it frequently develops this many new instruments in just one year. In 1958, for example, the company introduced to the market 20 new instruments plus related equipment and accessories.

To match the company's growing R & D activity, Hewlett-Packard has been expanding its production facilities. Noel Porter's manufacturing department now operates two Palo Alto plants, one on Page Mill Road and the other on a 40-acre hilltop site adjoining the Stanford University campus. The Stanford plant, as the company calls it, is an ultra-modern facility commanding a magnificent view of the Coast Range mountains and lower San Francisco Bay. It provides the ultimate in working conditions for employees and is designed for maximum production efficiency.

Since quality is such a vital ingredient in its precision instruments, the company maintains extensive facilities for making many of its own parts. Some of the "extra" manufacturing steps it performs to insure top quality products

the microwave journal for October, 1959

Please visit www.mwjournal.com to read this article in its entirety.

WE WHO ARE preoccupied with the microwave industry are surrounded by evidence of its flourishing condition. As we relax over the Sunday papers, we cannot fail to be struck by the increasing numbers of pages of employment ads for microwave engineers. As we take the family out for a Sunday drive along most any highway, if we dare take our eyes off the car ahead, we must note the clusters of buildings comprising so-called "industrial parks," and observe that microwave firms form a relatively large percentage of these groups. We must conclude that since emergence from the laboratory such a short time ago, microwaves has rapidly become a big business, and in common with all business, competition has become a force that each firm must reckon with in its own way. Signs of the times have been amply available — mergers, stock issues, expansion by borrowing, in order to prevent watering down of equity. We present these company profiles to indicate how representative companies in the microwave industry meet problems that the realities of modern business deal out to them. We hope that each will prove of interest and value to our readers; and we welcome comment and suggestions.

COMPANY PROFILE

MICROWAVE ASSOCIATES, Inc.

BOX SCORE

NAME: Microwave Associates, Inc.
LOCATION: Middlesex Turnpike, Burlington, Mass.
PRODUCTS: Magnetrons, silicon diodes, duplexer tubes, varactors, waveguide components, etc.
HIGHLIGHTS: Strongly R & D oriented, this firm is prepared to meet ever increasing demands for new, improved microwave products.

Left to Right: Richard Walker, Vice-President Engineering; George Karlotis, Vice-President Sales; Vess Chigas, Executive Vice-President, and Dana Atchley, President.

Microwave Associates, Inc., of Burlington, Mass., is a company whose directors say that "in this competitive electronics industry, a growth company must offer specific capabilities to succeed." These capabilities must include, not only engineering skills, but also aggressive management and sound business judgment.

The firm was started in 1950 by three engineers, two of whom, Vess Chigas and Richard Walker are today Executive Vice-President and Engineering Vice-President, respectively. They rented 2800 square feet of floor space on Columbus Avenue in Boston, Mass., and their plan was to do microwave consulting, research and development work, and to establish a line of millimeter wave components for the swelling microwave industry.

In the first year the company did R&D work for the Signal Corps, including some pioneering in circular waveguide elements, as well as design and development of special items for industry. Encouraged by these early operations, the young company decided to enter the electron tube field, and was successful in receiving the award of an Industrial Preparedness Study contract from the Signal Corps for two magnetron types.

Meeting this contract required additional capital which was supplied out of the pockets of the founders, and from a few key personnel who joined the firm and were given an opportunity to invest in the company.

42 the microwave journal for January, 1959

Soft soldering cooling tubes on an S-Band isolator

Having entered the magnetron field, the company decided also to produce duplexer tubes, and expanded to new quarters of about 6000 sq. ft. in 1951. As the young company worked on establishing their electron tube producing facilities and on the Signal Corps contract, they successfully bid on additional R&D work and received contracts for waveguide components, magnetrons, duplexer tubes and semiconductors. Here, then, was a turning point to be faced by the management; which way to go to obtain the additional facilities and people to meet these new contract requirements? Vess Chigas arranged for a $100,000 loan from a Boston Bank; but about this time Chigas and Walker met with Dana Atchley, then Technical Co-ordinator for ABC-Paramount Theatres, Inc. They had known each other professionally earlier; and Atchley became convinced of the potential of the young company. He interested ABC-Paramount in Microwave Associates, and in 1952, ABC-Paramount invested in the firm, buying up 50% of newly-issued shares, and Atchley joined Microwave Associates, Inc., as President of the Corporation.

The company was now located on Cummington St. in Boston, and with the growing demands for space kept adding square feet in this plant; 6000 ft. in 1952 for R&D functions, then again late in 1952, more space to accommodate the demand resulting from their decision to enter the microwave diode line. By 1955 Microwave Associates had expanded along Cummington Street in five buildings occupying about 20,000 square feet.

At about this time, the Western Union Telegraph Company became interested in the firm and in the significance of its products and potential contribution to future communications techniques. They entered the Microwave Associates picture with strong financial backing, purchasing shares such that ownership now rested on an equal basis between ABC-Paramount, Western Union, and management.

A new building, located along route 128, known sometimes as "Electronics Highway" was next in the expansion program, and in 1957 the company moved to this new location. This plant provides Microwave Associates with 50,000 sq. ft. of operating space; and as this is being written, a new wing is being constructed, which will add another 18,000 sq. ft., and which will house completely the enlarged semiconductor operations, including both R&D and production functions. With an eye to the future, there is ample land for further growth.

The rate of growth, at a glance, amounts to this: between 1951 and the present, the number of employees rose from 13 to 360. In its first full year of operation, Microwave Associates did $80,000 worth of business. At present, it is passing the rate of $5 million per year.

Organization

Reasons that the company advances for its success are not primarily modern technical facilities or strong financial backing. Both are, obviously, important; but also important are the presence of authority where it is required and the ability to move and execute its programs rapidly.

President Dana Atchley does not allow himself to be tied to day to day operations, but remains free to plan and develop future areas of endeavor.

Chief executive officer, Vess Chigas, as Executive Vice President, does not like to "dilute expert talents" and believes in delegating authority as liberally as possible. This, he says, gives better incentive at all levels, and equally important, translates into efficiency.

Heading the sales force is Vice-President George Kariotis, who operates at a busy pace from both the home office and on the road to co-ordinate the company's efforts with those of seventeen sales representatives throughout the U.S. Having no company field salesmen, he and his sales engineer often service key accounts on a personal basis in order to effect the closest liaison between customer, problem, and home office engineering.

Joseph Bothwell, Vice-President for Finance has helped to maintain a firm financial position with the fluidity necessary to allow the firm to operate with competitive freedom. The proper investment of funds in proper areas at the right time has been a key factor in the company's development.

General assembly and inspection area.

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Please visit www.mwjournal.com to read this article in its entirety.

COMPANY PROFILE

NARDA MICROWAVE CORPORATION

Mineola, New York

THE IMAGE OF A COMPANY IS very often the reflection of one man.

That of The Narda Microwave Corporation, however, is the reflection of four men: the four founders — Dr. John McGregor, Bill Bourke, Stu Casper and Jim McFarland.

From the beginning the four have worked as a team — a nicely-balanced team, too, with each man contributing certain unique talents and experience which have served to supplement those of the other three.

All four are still active in the firm and provide its top management (see page 63).

Each of the four was an experienced microwave engineer in his own right when they decided to join forces (in February, 1953), and launch their own venture.

The happy blending of these four personalities in large part accounts for the company's steady growth. The combination of skills has provided a solid foundation on which to build a smoothly-functioning, continuously expanding organization.

The company's first products were several X-band instruments, a wide-range frequency meter, and several kinds of attenuators and terminations. The four founders divided up among themselves the burden of design, testing, selling, and sweeping out the plant. Manufacturing was initially sub-contracted to the machine shop on Herricks Road in Mineola from whom the four associates rented a small back room.

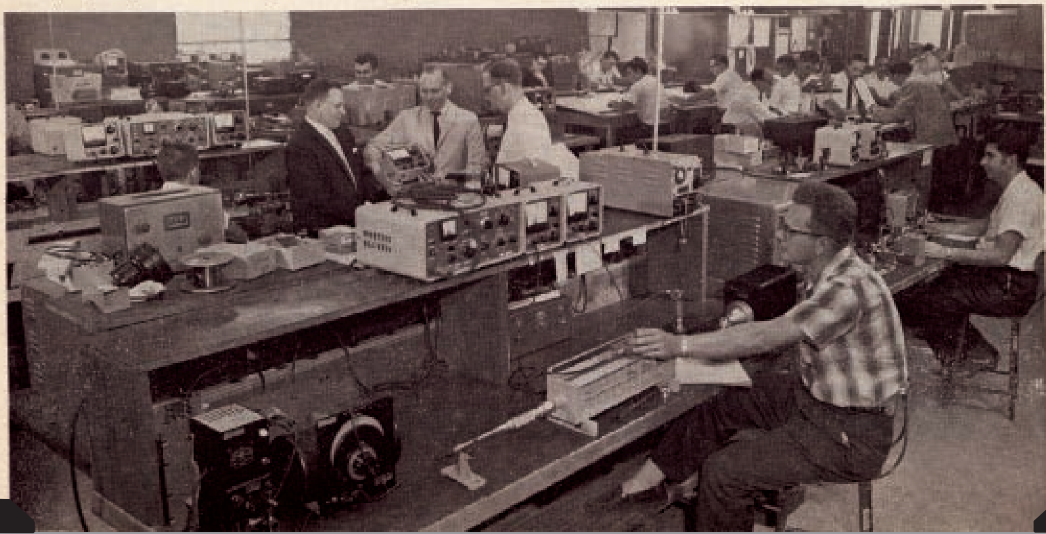
Initial sales to Kollsman Instrument Company, the Signal Corps, the Bureau of Standards, and Maxson Corporation sustained the infant company during its first few months, and by the end of the summer of 1953 the group had perfected its first "sophisticated" product, the Model 802 Frequency Meter which covered S to X bands — a design which, in greatly improved form, is still a popular catalog item. That fall also saw the design of a High Power Impedance Meter, a fairly expensive item, and the sale of one of these meters, in October, set a new all-time record sales figure. Bell Laboratories then came through with an order for five of these, all of which were delivered in November.

A development contract from the Navy's Bureau of Ships covering the investigation of the degree of protection offered by various finishes to waveguides exposed to salt spray, marked a new direction for the group.

By this time, also, the little company had relocated in its own plant at 66 Main Street, Mineola, and was quite proud of its 1600 sq. ft. In December, 1953, its first frequency meters started coming off the production line, destined for such customers as Wheeler Laboratories, Trans-American Precision Gear, Aircraft Armaments, Gabriel Laboratories, Bell Labs, and the University of California.

Just about every dollar of revenue was plowed back into the company by its four executives — none of whom drew any salary from August to the beginning of De-

In this spacious engineering lab, Narda's further contributions to microwave engineering are now being worked on. Group standing in center guide the company's product-development program. Left to right: Leonard I. Kent, chief microwave engineer; Stuart D. Casper, vice-president in charge of engineering; and James E. McFarland, vice-president in charge of manufacturing.



Box Score

NAME: The Narda Microwave Corporation.

LOCATION: 118-160 Herricks Road, Mineola, L.I., New York.

PRODUCTS: Microwave and UHF test equipment and components covering the frequency range from 20 to 90,000 mc, including: Waveguide and coaxial attenuators; Bolometers and thermistors; Waveguide and coaxial detector mounts, crystal mixers and harmonic mixers; High directivity directional couplers; Coaxial hybrid junctions and couplers; Frequency meters; Low pass filters; Harmonic generators; Impedance meters (waveguide and coaxial), r-f probes, standard reflections; VSWR amplifiers and microwave power meters; Klystron power supplies; Radar performance checkers, echo boxes, tuned pre-amplifiers; Precision fixed and sliding coaxial and waveguide terminations and high power loads; Tuneable waveguide shorts, double stub and E-H tuners; Tube mounts, waveguide-to-coaxial adapters, straight waveguide sections, flange adapters, stands and clamps, tees, twists, bends.

High Power Electronics Division: Microwave modulators.

HIGHLIGHTS: Only six-and-a-half years old, Narda Microwave has grown to a position as one of the leaders in this highly-specialized field by developing a very complete range of both waveguide and coaxial equipment, in which a high degree of creative engineering has been applied, strongly oriented toward fulfilling the needs of the systems-builders who will put the equipment to use.

STATISTICS: Narda's main plant and laboratory occupy four buildings strung out along one block of Herricks Road in Mineola with a total floor space of about 20,000 sq. ft. In the latest fiscal year, ended June 30, 1959, microwave sales exceeded the $1.5 million mark, a 50% increase over the previous year. In the first quarter of the current fiscal year orders have been received at a rate that indicates a $2.5 million total for the year. This does not include estimated sales for the newly-established High Power Electronics Division.

Operations have resulted in a net profit in each of the past four years. Five cash dividends have been paid, plus six pro-rata distributions of the stock of Narda Ultrasonics Corporation, a subsidiary now 38% owned.

The company is publicly-owned with about 1500 shareholders residing in more than 30 states and several foreign countries. As of June 30, 1959, there were 600,000 shares outstanding. The company at this writing employs about 200 people, more than half of whom are also stockholders.

cember in that first year. Much of the money went for additional test equipment — so that every product shipped could be certified as having completely met its performance claims.

At the same time, the group worked hard on the development of bolometers, which were announced to the world in January, 1954.

This was Narda's first bold bid for recognition as a company that was not only willing but able to contribute to the advancement of the art.

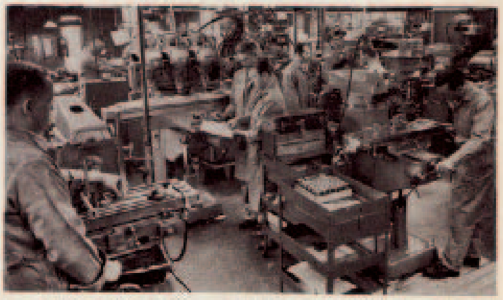
Conditions like these separate "the men from the boys." And, under conditions like these, Narda now stands out.

By the late spring of 1955, the company's range of products had grown to such an extent that the 1600 square feet on Main Street was completely inadequate. So, in July, Narda moved to 160 Herricks Road in Mineola. And, in the months since then it has added one building after another in the same block until it now occupies four, strung out like beads on a chain.

(*Story continued on page 64*)

Coaxial couplers are carefully calibrated after production, and the calibrations are stamped individually and directly on the scale attached to each coupler. Les Lipset, Chief Test Engineer of Narda's production test department, spot-checks the work of James Lautermilch.

Well-filled milling machine department (only partly shown in this photograph) turns out components in quantity for Narda's products. Center foreground: Thomas Duff, milling machine leadman, reviews the many close tolerances of parts to be made on a new three-spindle tracer-controlled milling machine with Wallace Hassenfratz. Other operators in foreground are, left to right, Don Wilson and Thomas Ford.



Raytheon top management guides company activities throughout the world. Shown are Percy L. Spencer, senior vice president; Charles F. Adams, president; Harold S. Geneen, executive vice president; Allen E. Reed, vice president and treasurer; and E. Douglas Graham, vice president, manufacturing services.

Company Profile—Raytheon Mfg. Co., Inc.

Raytheon—Pioneer in Microwaves

BOX SCORE

NAME: Raytheon Manufacturing Co.

LOCATION: Headquarters, Waltham, Mass. Plants in Massachusetts, Connecticut, Tennessee, California, New Hampshire, New Mexico, and Ontario.

PRODUCTS: Missiles, Radar, Countermeasures, Sonar, Magnetrons, Marine Equipment, Microwave Communications Relays, Industrial Equipment, Electronic Ovens, Transformers, Magnetic Components, Tubes, Transistors, Diodes, Rectifiers.

HIGHLIGHTS: One of world's largest electronic companies.
Largest industrial employer in Mass.
Only electronics company with prime contracts for two missiles.
World's largest producers of magnetrons and klystrons.
Ranks among top 1% of all U.S. industrial employers.

"Ray of the Gods"

On a memorable day in 1925, Laurence K. Marshall and Charles G. Smith, co-founders of the American Appliance Company, sat down to a "brainstorming" session to devise a distinctive trade-name for their first product: a helium rectifier tube invented by Smith. In that session the name "Raytheon" was born.

According to Marshall, "Raytheon" didn't come out of any one brain; it simply evolved. All agreed that it had exactly the right sound; and either by accident or by subconscious design, it turned out to mean "ray of the gods." This meaning, reasonably appropriate at the time, was strikingly prophetic of a company destined to become a leading pioneer in microwaves.

First Success

The Raytheon type BH rectifier tube was the sensation of the industry because it was the first to free the home radio from batteries and make it a practical plug-in household appliance. In 1926, the firm, now called Raytheon Manufacturing Company, made a profit of over $300,000 on sales of $1 million.

This success did not remain uncontested. Profits dwindled, for competition forced down the early price of $5 or $6 per tube to a figure barely above cost.

In 1929 the company moved from the original location in Cambridge, Mass. to a plant in Newton, where it weathered the depression decade by gaining and holding ten percent of the receiving tube market in the face of intense competition.

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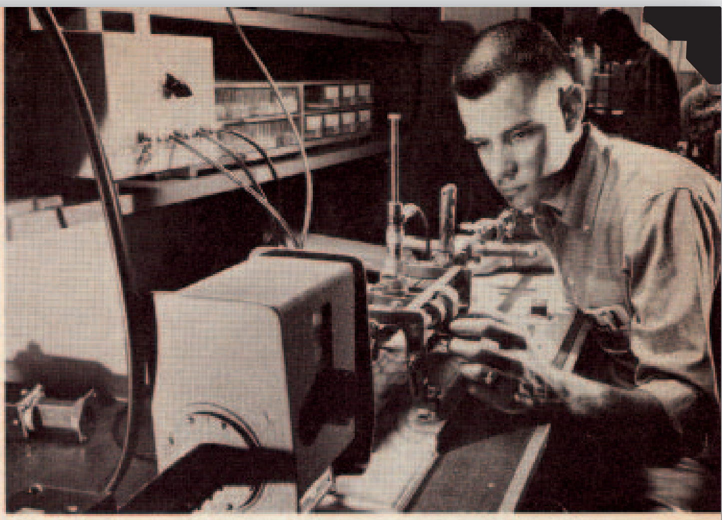
X-band and other ferrite components are electrically tested before shipment.



In 1933, Raytheon expanded its interests by acquiring Delta Manufacturing Company of Cambridge.

Enter Microwaves

As early as the Battle of Britain (1940-1941), a primitive long-wave radar installation on the cliffs of Dover was playing a vital role in the defense of the British Isles. British and American scientists proceeded to pool their resources to develop improved radar sets for air, sea, and land and to produce them in quantity. The British version of the magnetron power tube had emerged as the most promising means of generating the microwave energy needed for sharp radar pictures. The early magnetron, however, was a precision assembly of metal and glass which required hundreds of hours of machine work and highly skilled labor to produce.

Late in 1940, Raytheon was awarded one of the first magnetron development contracts and thus found itself in the microwave field. The tricky job was entrusted to Percy L. Spencer, then head of high-frequency tube development, who had joined Marshall and Smith in 1925.

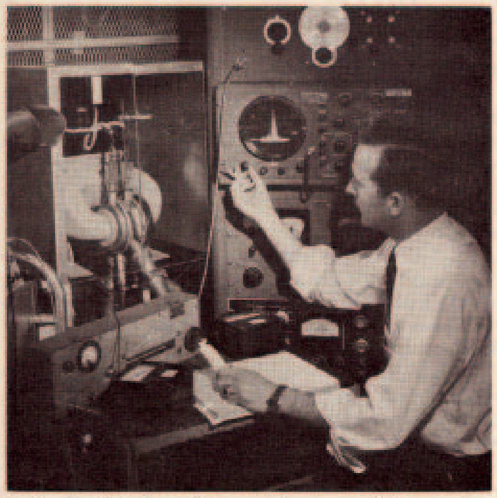
Spencer quickly converted the British prototype into a production item and commenced production, but with skilled machinists practically unobtainable, the yield was a pitiful 17 tubes a day. However, the Navy was sufficiently encouraged to build a new plant in Waltham for magnetron production. The company's executive offices were moved to this plant, thus establishing Raytheon as a Waltham institution. With improvements in design and manufacture, magnetron output reached one hundred per day by 1942.

Magnetrons by the Thousand

Meanwhile, Spencer devised a way to put the magnetron into full mass production. Instead of machining the intricate shapes from solid copper, he proposed to stamp laminations out of thin sheet stock which could be stacked and brazed to make up the required thickness. Conversion to the new process required a large outlay for dies, tools, and machines; Mr. Marshall persuaded the company to "put up $75,000 that it didn't have" for the purpose. Tube production rose to 1000 per day and eventually to 2600. Some fifty types were made. Although the lamination process was made available to other companies, 80 percent of the magnetrons received by the Navy during World War II were made by Raytheon. In the same period, reflex klystrons were produced in quantity for use as radar local oscillators.

"Eyes of the Fleet"

As early as 1941, Raytheon was awarded a contract to produce a microwave surface-search radar set for the Navy. With a design group headed by Fritz Gross (now director of engineering for Raytheon's Government Equipment Division) and including Dr. William M. Hall from the MIT faculty (who is now staff assistant to Mr. Gross), the first production equipment was completed in less than a year, and by Easter 1942 was installed on the *U.S.S. Augusta*, ready for sea-trials. This was the Model SG, the first microwave surface-search radar installed by the U.S. Navy. These sets won a reputation for ruggedness and dependability, and their material aid in the Battle of the



Raytheon's "Amplitron," shown under test at left center, is a new microwave power tube that increases energy output of radars. Added to the CAA air traffic control radars, for example, this tube increases the operational range by better than 50 percent.

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Please visit www.mwjournal.com to read this article in its entirety.

COMPANY PROFILE

SPERRY MICROWAVE ELECTRONICS COMPANY

Clearwater, Florida

(Top photo) — engineering management. (Left to right) R. E. Lazarchik, antennas and radiometers; L. Rehberg, microwave products; G. R. Barton, system performance monitors; J. O. Lalli, engineering planning; P. C. Ely, Microline engineering; F. D. Mirabella, test instrumentation; P. Henry, automatic checkout equipment; J. E. Pippin, research; Dr. R. E. Henning, chief engineer; R. Aucremann, automatic checkout equipment; B. J. Duncan and G. J. Neumann, microwave and solid state devices. (Lower left) — company management. (Left to right) G. W. Jaynes, Controller; Dr. R. E. Henning, chief engineer; P. J. Andresakis, industrial relations manager; John H. Leutwiler, division manager; G. M. Scheblein, quality control manager; John G. Sager, special projects manager; Frank J. Lavelle, marketing manager; E. J. Friebele, manufacturing manager.

Sperry Microwave Electronics Company is an autonomous operating Division of the Sperry Rand Corporation. Within the framework of its Charter, its activities are completely independent of those of other Corporate Divisions. However, as a member of the vast Sperry Rand family, Sperry Microwave can take advantage of the capabilities and specialized facilities of other divisions. This arrangement offers technical and management personnel wide latitude in the selection, performance, and management of all programs.

Sperry Microwave occupies a modern two-story building on 80 acres of tropical greenery just outside Tampa, Florida. Apparently, locating the plant in a so-called 'tourist paradise' was a good idea. Since its inception in 1957, Sperry Microwave has been able to attract and retain high calibre technical personnel; this can't all be attributed to the location. Interesting, varied, and stimulating work along with liberal employee benefit plans play a big part in making Sperry a 'good place to work'. Employing about 1000 people, Sperry's programs range from basic and applied research through large scale production for industry and the Armed Forces. Current products include: microwave solid state devices and materials, microwave components, microwave radiometric systems, ground spectral measurement equipment, manual and automatic checkout equipment, custom built support equipment and modules, antennas, and Microline* test and measuring equipment for laboratory and production line use.

Management of Sperry Microwave is in the hands of a Division Manager and his Staff. The lion's share of the credit for organizing and getting Sperry Microwave under way must go to E. J. Venaglia, Division Manager until May 1961. At that time, Mr. Venaglia was selected by the Sperry Rand Corporation to transfer his skill to the management of its multi-million dollar MARS (Mobile Atlantic Range Stations) program, and division management was turned over to the Company's Marketing Manager, J. H. Leutwiler. With Sperry since 1960, Mr. Leutwiler spent 12 years as Vice President of the Missouri Research Laboratories, responsible for its sales and operations, and was Director of Market Research for the E & A

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Division of Emerson Electric Company. He received his BS degree in Engineering from Washington University, St. Louis, in 1941.

Products for Industry and the Armed Forces

Product lines at Sperry Microwave fall into two broad categories. The first includes special-purpose custom-tailored items that are strictly military in application (i.e., ground spectral measurement equipment for the Military Collection Plan for Equipment Spectrum Signatures, part of the Department of Defense's Electromagnetic Compatibility Program; automatic checkout equipment for the B-58 Hustler aircraft, parametric amplifiers for the Navy's Talos Radar, etc.). In the second class are components and equipments with a far broader application which Sperry sells both to commercial and military customers. Test sets, microwave components, solid state devices and materials, radiation monitors, and the Microline product line are just a few of the items being manufactured by Sperry Microwave for the dual market. Many of these products are developed at Sperry's expense and manufactured in relatively large quantities. Competition — both technically and economically — is keen . . . and engineering, production, and marketing departments work closely together to produce and distribute the best product at the lowest price. One example of a successful team effort is the entire Microline operation, with its line of almost 200 items.

Advances in microwave technology during and shortly after World War II created the need both for advanced measurement techniques and for new equipments which could be used to make the required measurements rapidly and easily. During this early period, Sperry was responsible for numerous state of the art advances in measurement techniques and instrumentation (for example, the development of a practical barretter, self-balancing wattmeter bridge concepts, crossguide couplers, resonant waveguide cavities). All of these techniques are still in widespread use by the industry as a whole.

During the Korean War (despite the fact that Sperry's pioneering efforts had put Microline on top), emphasis was transferred to projects for the Military. The skilled Microline engineers and manufacturing personnel were needed to develop and produce test equipment for the Armed Forces.

With the formation of the Sperry Microwave Electronics Company in Florida, Microline was given a planned and deliberate 'shot in the arm'. A separate, integrated organization was set up within the company to handle every aspect of the Microline operation . . . to develop new items at competitive prices and build up and market a well-rounded line of off-the-shelf units. Ed Friebele, Manufacturing Manager at Sperry Microwave, put the entire program into action. Paul C. Ely, Jr. heads an enthusiastic team of engineers who are responsible for all engineering phases of Microline . . . from initial concept through set up and tooling for manufacture. (Many Sperry-ites wonder whether Microline laboratory and engineering personnel ever go home!) On the production line, careful monitoring combined with many highly ingenius assembly techniques assure that high quality low cost units are turned out on schedule. To complete the integrated Microline operation, the Marketing section has energetic Charles Brown in the driver's seat.

Under the new set up, the entire line of almost 200 instruments — which range from waveguide components through rf power meters and klystron power supplies to microwave receivers — has been redesigned, restyled, and made available as off-the-shelf items. In fact, at the 1961 IRE Show, more than 70 new instruments were introduced. Another innovation has been the quarterly Microline Monitor which provides technical information on new or improved measurement techniques and new product applications.

Plans have been set up to accelerate Microline activities even further in the coming year and additional instruments with new specifications, improved performance, and competitive prices will be made available as stock items.

Solid State Materials and Devices . . . Some of Sperry Microwave's most challenging and rewarding programs are being carried out in its Solid State Materials Laboratory, a combined research lab and materials production facility. Lab scientists work very closely with members of the Solid State Devices Department. Frequently, materials research and studies are directed specifically toward development of a solid state material whose properties will satisfy a new component or system requirement. And, conversely, new component development is often initiated because a new material makes them possible and practical.

Dr. John Pippin, who directs the basic and applied research in materials and microwave circuitry, came to Sperry in 1958 from Harvard University. Robert Duncan, who is responsible for new component development, production, and application, has been with Sperry since 1952.

Creative studies and painstaking experiments are part of the continuous search for advanced materials, superior compositions, and new applications. Company Management budgets a substantial amount of money yearly to support new solid state materials research and component development. Both Mr. Leutwiler and Mr. G. Jaynes, Sperry's Controller, recognize that ample funds are necessary and, based on past experience, that the money will be used to maximum advantage by technically competent, imaginative, and practical leaders and their high level technical staffs . . . and that an alert Marketing Department knows what to do with the finished product.

When Sperry Microwave was established, the men heading each Department were given complete freedom in seeking out and hiring those scientists who, in their opinion, were best qualified in every possible respect for the contemplated work. Each man was literally hand picked.

Having set up such a working environment, Sperry Microwave's management expected to see significant results . . . ranging from major technological breakthroughs through real sales volume.

In the Solid State Materials Laboratory, four types of projects are underway at all times: long range studies, programs in which the feasibility of new compositions is being demonstrated, manufacture of solid state materials for use in components and systems, and manufacture of materials for sale on the open market.

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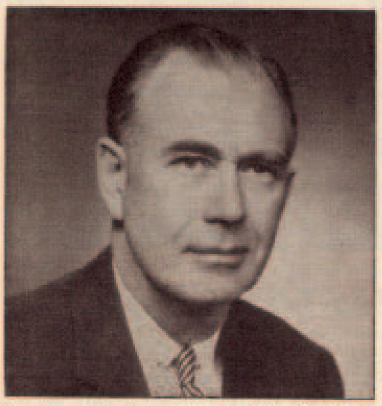
COMPANY PROFILE

SYLVANIA ELECTRIC PRODUCTS Inc.

A SUBSIDIARY OF
GENERAL TELEPHONE AND ELECTRONICS CORPORATION



Robert E. Lewis, President, Sylvania Electric Products, Inc., a subsidiary of General Telephone & Electronics Corporation.

BOX SCORE

NAME: Sylvania Electric Products Inc. a subsidiary of General Telephone & Electronics Corporation

LOCATION: Executive offices, 730 Third Avenue, New York 17, N.Y.
Plants, laboratories, sales offices and distribution centers throughout the United States.

PRODUCTS: See Sylvania Statistics Table.

HIGHLIGHTS: Sylvania, which was founded in 1901, is a highly diversified company. It is a leader in the fields of electronics, television-radio, lighting, photography, chemistry and metallurgy.
Microwave work includes all phases, from pure research through full production, both of components and systems.
In March 1959, Sylvania merged with General Telephone, largest independent (non-Bell) phone company, to form General Telephone and Electronics Corp. Although a wholly-owned subsidiary, Sylvania will retain its identity.

STATISTICS: 45 plants, with 2 under construction.
22 laboratories, with 1 under construction.
32 sales offices; 29 distribution centers.
5 wholly-owned subsidiaries.
1959 sales: approaching $400 millions.
27,000 employees.

DIVISIONS AND TYPICAL PRODUCTS

Sylvania Electronic Systems Military electronic systems and equipment, including electronic countermeasures and counter-counter measures; weapons systems, including missile and anti-missile systems; data processing systems; computer components, radar and navigational equipment; reconnaissance support systems; commercial and industrial electronic equipment.

Special Tube Operations Magnetrons, TWT's, BWO's, BWM's, (Carcinotrons), klystrons, ferrite devices, TR/-ATR's, "Rocket" planar triodes, decade counter tubes, trigger tubes, Pirani gauges; extensive microwave R & D.

Semiconductor Division Crystal diodes including microwave diodes, transistors.

Sylvania Lighting Products Incandescent, fluorescent and mercury vapor lamps: Panelescent (electro-luminescent) lamps; photoflash bulbs, fixtures, accessories, etc.

Receiving Tube Operation Receiving tubes; subminiature tubes; special tubes for computers, military and industrial applications; ceramic stacked tubes.

Picture Tube Operation TV picture tubes; oscilloscope tubes; industrial cathode ray tubes; military and radar cathode ray tubes.

Sylvania Home Electronics TV and radio receivers, high-fidelity phonographs, tape recorders.

Argus Cameras Cameras; motion picture and slide projectors; photographic accessories.

Parts Division Tube sockets and bases; lamp holders and bases; custom molded plastics; metal stampings and deep-drawn parts; wire and ribbon; tools and dies.

Chemical and Metallurgical Division Tungsten and molybdenum powder, wire and parts; germanium and silicon; television phosphors.

Sylvania Research Laboratories Basic research in fields of electronics, physics, chemistry and metallurgy.

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Introduction

Previous articles in this series have largely focused on relatively young companies devoted primarily or entirely to some aspect of the microwave business. This month we turn to a company which is 58 years old and which is involved in not one but several phases of microwave — and a vast complex of other industries, as well.

History

The two predecessor companies of Sylvania — one founded in Massachusetts in 1901 and the other in Pennsylvania in 1906 — merged in 1931 to form the nucleus of Sylvania as it is today. At the time of this merger, both companies primarily were producers of incandescent lamps and radio receiving tubes. On March 5, 1959, Sylvania was merged into General Telephone Corporation, the country's second largest telephone system which provides telephone service in parts of 30 states and manufactures a wide range of telephone equipment and devices. The name of the company at the time of the merger was changed to General Telephone & Electronics Corporation.

Keeping in Touch

With plants spread literally from coast to coast, communication and coordination might seem to pose a problem. It is the very electronics industry of which Sylvania is so much a part that has made possible the solution: virtually every plant, laboratory, office and warehouse is linked together by a unique 21,000 mile private communications and data processing network, in addition to direct phone lines between many of the plants. Focal point of communications is the Data Processing Center at Camillus, New York, which houses a giant electronic computer. Among the functions handled by the system are the preparation and distribution of payrolls, including the high speed printing of checks; customer invoicing and record keeping; and preparation of statistical operational reports. The system supplies the entire company organization with a wide variety of vital information in more detail, more accurately, and more quickly than would be otherwise possible.

Tube Maker Par Excellence

One of the firm's major fields of endeavor is tube-making, in which it has over a quarter-century of experience. Sylvania is one of the two largest manufacturers of receiving tubes in the U.S. (having made over 1½ billion!), and one of the two largest manufacturers of television picture tubes. Over the years of fighting its way up to this enviable position in the industry, Sylvania has made numerous significant technical contributions including ceramic stacked receiving tubes, the 110° picture tube and, most recently, the "Framelok" grid, a revolutionary method of mounting grid wires which prevents sagging.

Putting Know-How to Use

What does all this have to do with microwave? Plenty! From the time they started to produce "Rocket" planar triodes for UHF applications at the end of World War II, they began to draw on the pool of talent accumulated through years in the tube business. As the field of microwave began to grow and take on new significance, Sylvania gathered a nucleus of experts in research, in product development, in production, and in quality control. Many came from other divisions of the company; others came from leading colleges and universities, from MIT Radiation Lab and elsewhere. Though small in number at first, all brought a wealth of knowledge and experience. This group formed the basis of what has since grown into the company's Special Tube Operations.

STO — Microwave's Specialists

Special Tube Operations now utilizes the skills of almost 1,000 people, about half of whom are scientists, engineers and technicians whose efforts are devoted primarily to development and production of microwave devices, or pure microwave research. The Operation occupies over 100,000 square feet of space in two plants in Mountain View and Palo Alto, California, and one at Williamsport, Pennsylvania. Plans are underway to add another 30,000 square feet during 1959 to accommodate STO's expanding production requirements.

A perusal of the list of STO's employees reveals many familiar names in the microwave field who have made numerous contributions. Only a few can be mentioned here.

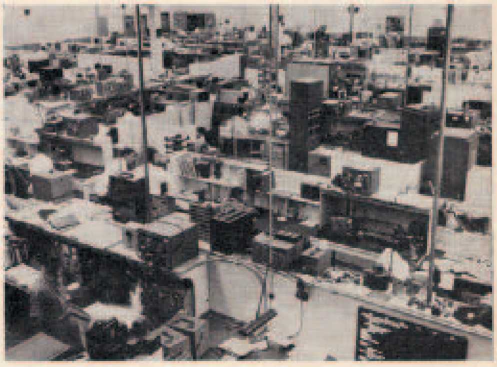
Meyer Leifer, Manager of STO, who has about twelve years experience in microwaves, is a Fellow of the IRE and a graduate of MIT's special training program for senior executives.

Dr. Rudolf Hutter, STO's Chief Engineer, a leading Sylvania engineer for close to two decades and the author of numerous patents and technical articles in the fields of microwave electronics and electron optics.

Dr. Daniel Goodman, Manager of STO's Research and Advanced Development, who has been responsible for traveling wave tube development since 1953.

Marshall Pease, known to microwave researchers primarily for his contributions in the area of crossed-field theories and as an Associate Editor of this journal.

Dr. Walter Kohl, holder of seven U.S. patents in the electronics field, who initiated work which led to the development of the electron microscope on this continent.



Traveling wave tube engineering area, Mountain View.

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COMPANY PROFILE

VARIAN ASSOCIATES

STANFORD INDUSTRIAL PARK — PALO ALTO, CALIFORNIA

BOX SCORE

NAME: Varian Associates.

LOCATION: Stanford Industrial Park, Palo Alto, California.

PRODUCTS: Klystrons, traveling-wave tubes, backward wave oscillators, linear accelerators, microwave system components, NMR and EPR spectrometers, laboratory magnets, magnetometers, stalos, power amplifiers, graphic recorders, vacuum products, research and development services.

HIGHLIGHTS: World's largest dollar-volume producer of klystron tubes, continuing injection of new products, with heavy emphasis on research.

Anniversary Times Two

On November 2, 1958, two significant anniversaries were noted at Stanford Industrial Park, Palo Alto, when Varian Associates held an Open House. Ten thousand visitors helped the firm celebrate (1) Russell and Sigurd Varian's invention and development of the klystron tube in 1938, and (2) the founding of the Company in 1948.

Twenty years before, working in a basement laboratory at Stanford University, the Varian brothers succeeded with their experiments when a klystron tube oscillated for the first time. This feat was a giant step forward in the microwave art, and inspired the founding of the Company ten years later.

The activities of the Varian brothers during the war years have been described in these pages.* After the war, the Varian brothers and four associates pooled assets of $22,000, and returned to California from their Eastern wartime jobs to organize Varian Associates as a custom research organization. The new company's management, trained in high level R & D, also had to learn about business administration, finance and manufacturing, and then combine these elements into an efficiently operating business.

A 1200 square-foot building was rented in San Carlos, Calif. and Varian Associates was in business.

Growth

In 1949, H. Myrl Stearns, at that time the company's executive vice president and general manager, and now president, landed a government contract and Varian Associates was in the business of manufacturing tubes. (Today, the company is the world's largest manufacturer, in dollar

* Russell H. and Sigurd F. Varian, Inventors of the Klystron, *the microwave journal*, Sept./Oct. 1958.

Varian's top management conference in President Myrl Stearns' office. Around the table, left to right: Sigurd Varian, vice chairman of the board; Ralph Kane, vice president, Instrument Division; Merle Zinser, vice president, Finance; Myrl Stearns; Emmet Cameron, vice president and general manager; Howard Patterson, vice president, Tube Division and Russell Varian, board chairman.

56 — the microwave journal for September, 1959

Artist's conception of Varian Associates' Palo Alto, California facilities, present and future. Existing buildings are shown left of the track which cuts through the 65 acre leasehold in Stanford Industrial Park. Work has begun on expansion "across the tracks" to the right, another step toward the ultimate one million square feet planned for Varian's Palo Alto plant.

volume, of klystron tubes.) Soon the San Carlos plant proved inadequate as new product lines were developed and a healthy backlog of orders built up. Varian was the first lessee of Stanford Industrial Park in Palo Alto, California. There Varian started with a 6-acre leasehold, later increased to 33-acres, on which facilities provide 300,000 square feet of space for research, development and manufacturing. This is still not enough, and building is almost continuously underway at Varian, under the direction of Emmet Cameron, Executive Vice President and General Manager. Acreage has now been increased to 65, and the "master plan" calls for a million square feet for the Palo Alto plant.

Products

Although founded as a research company, Varian Associates has succeeded both as a research and production firm. Dominant developers and manufacturers in the major areas of their operation — klystrons, spectrometers and electromagnets — Varian is also becoming a strong factor in other areas. These include traveling wave tubes, magnetometers, electron linear accelerators, backward wave oscillators, vacuum products, graphic recorders, components and accessories and electronic systems.

Tubes

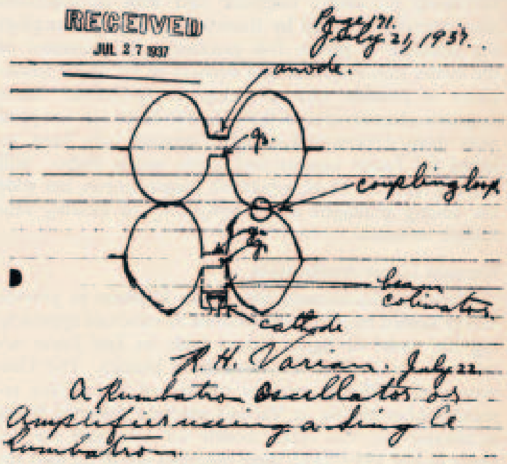
In a modern and efficient tube manufacturing building, Varian produces, under Howard Patterson, Vice President for Tubes, more than 100 different kinds of klystrons. Dr. Theodore Moreno, manager of Tube Research and Development, has in his department 35 additional klystron types in development. Varian also manufactures klystron parts, such as grids and flanges; accessories, such as power supplies and power meters; sub-systems incorporating klystrons such as pulsers and radar transmitters; and traveling wave tubes and backward wave oscillators. Their VA-125 is the largest sealed-off travelling wave tube ever built.

In addition to furnishing small tubes for military communications applications, Varian also produces large power tubes such as the VA-800C used in the NATO system. The firm has also manufactured complete systems, such as the high power transmitter designed and built for MIT's Lincoln Laboratories which is being used for investigation of long distance microwave communications using tropospheric scatter technique.

NMR - EPR

"Nuclear Magnetic Resonance," a new text by John D. Roberts, professor of organic chemistry at California Institute of Technology, calls NMR's discovery "one of the most important events in the past 50 years in the advancement of organic chemistry."

Intensive development of high resolution NMR equipment at Varian has resulted in the commercial reality of completely new techniques of NMR and EPR (electron paramagnetic resonance) spectroscopy. This accomplishment of Varian's Instrument Division under the direction of Vice President Ralph Kane, provides researchers two new tools for the physical and chemical analysis of materials.



A page from Russell Varian's notebook showing the diagram of the first Klystron Tube.

the microwave journal for September, 1959 57

Please visit www.mwjournal.com to read this article in its entirety.

INDUSTRY *Leaders* NOW

Company Profiles – In the following advertorial section, *Microwave Journal* presents the milestones and technical achievements of companies that have made and continue to make significant contributions to the microwave industry

INDEX OF COMPANY PROFILES: NOW

Advertiser — *Page No.*

Aethercomm®

Company History: Aethercomm was founded in June 1999 by Todd Thornton, Terri Thornton, Jim Daube, Ed Takacs, Dr. Larry Larson and Dr. Peter Asbeck in the Thorntons' living room. We moved to our current facilities in January 2000.

Aethercomm designs and manufactures RF and microwave systems and subsystems for radar, electronic warfare and other communication systems. Our company's first products were RF amplifier modules. We have added multiple product lines since our inception. Our products are predominantly found in military systems on the ground, in the air and at sea. While the majority of Aethercomm products are defense-related, we maintain a strong presence in the commercial arena.


This artist's rendition depicts Aethercomm's new facilities.

From humble beginnings, we have grown significantly over the past nine years. Aethercomm now employs 90 people and has outgrown our current facilities. We will relocate to our new, state-of-the-art, 47,000 square-foot building in Carlsbad, California, in the first quarter of 2009. Aethercomm maintains a deep appreciation for our customers and our ultimate end-user, the United States Military Warfighter.

Company Today:

Aethercomm has transitioned from a small-to-medium production facility to a very large production facility. In the past 2 years, we shipped more than 30,000 RF amplifiers in support of the Global War on Terror.

Our ability to manufacture thousands of high quality, complicated RF amplifier assemblies per week has enabled Aethercomm to enjoy exponential growth in both personnel and revenue over the past 4 years. Our new, high volume research and development and production facilities will allow us to meet current demand and expand to accommodate ever growing production programs.

Aethercomm RF amplifiers are combat-proven and built to operate in the harshest environments. Our company transitioned from providing RF modules to designing and manufacturing complex RF and microwave systems that incorporate receivers and transmitters, power conversion circuitry, microprocessor control and complex thermal management systems. These systems are used in fighter and attack aircraft, ground vehicular environments and on shipboard systems. Aethercomm products are also found on sounding rockets that travel 50 to 1500 kilometers above the surface of the Earth.

Company Product Lines:

Aethercomm specializes in manufacturing custom products in the categories below. We also offer an extensive line of commercial-off-the-shelf products. Our product lines include:

- *High Power Microwave System Design:* Radar transceivers, electronic warfare systems, communication systems, transmitter sections, airborne and ground data links, high power amplifier systems and modules.
- *Linear High Power Amplifier Modules:* RF amplifier modules from DC to 40 GHz. Power levels up to several thousand watts with high linearity and medium levels of efficiency.
- *Broadband High Power Amplifier Modules:* RF amplifier modules from DC to 40 GHz with frequency ranges from octave to multi-octave bandwidths. Additional bandwidths include decade level to multi-decade level. The broadest band currently covered is 20 MHz to 6000 MHz in a single module with 10+ watts of output power. The typical power level for these modules is several watts to several hundred watts.
- *High Power Pulsed Amplifier Modules:* RF amplifier modules for pulsed applications such as TACAN, IFF, Radar, LINK16 and other pulsed applications. Frequencies range from DC to 40 GHz with power levels up to 5000 watts.
- *Low Noise and Medium Power Amplifiers:* Low noise figure and power levels up to several watts. Typical frequencies are DC to 40 GHz.
- *Transmitters and Receivers:* High power transmitters and low noise amplification in a single low profile RF module with filtering, power conversion and microprocessor control for airborne and ground data links and communications systems. Frequencies from DC to 40 GHz with power levels up to 1000 watts.
- *High Power Amplifier Assemblies:* Multiple RF modules combined to achieve a much higher power level across broad and narrow bands. These assemblies have custom packaging and heat sinking with power levels up to several thousand watts. Typical frequency ranges are DC to 18 GHz. Higher frequencies are available.
- *Rack Mounted Amplifiers and Assemblies:* Amplifiers and complete systems and subsystems are available packaged in a standard, 19-inch rack or custom rack as required. Standard features include high power over a broad or narrow band with internal power conversion, thermal management, digital control and numerous self-protect features. Power levels of several thousand watts are easily achievable with typical operating frequencies from DC to 18 GHz and higher frequency operation available.
- *High Efficiency Amplifiers:* We manufacture extremely high efficiency amplifiers employing Class AB, Class B, Class C, Class D, Class E, Class F, Class J and Class S amplifiers. These amplifiers are employed in constant envelope modulation schemes powered by battery or solar cells. Typical frequencies are up to 4 GHz with power levels of 20 to 100 watts. Narrowband power-added efficiencies range from 50 to 70 percent depending on frequency and power.
- *Build-to-Print, High Volume Manufacturing Services:* Aethercomm offers quick, reliable build-to-print and manufacturing services for low, medium and high volumes. We have proven capabilities in engineering and program management, and use automated assembly and test for excellent repeatability. Aethercomm is a small company with low overhead and is an attractive alternative for large prime contractors to utilize us for this service.

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Agilent Technologies

Company History: Agilent Technologies, a spin-off of Hewlett-Packard Co., broke records on Nov. 18, 1999 as the largest initial public offering (IPO) in Silicon Valley history. The US $2.1 billion raised from that IPO was a sharp contrast to the $538 in working capital that founders Bill Hewlett and Dave Packard began with in 1938. From a small garage in Palo Alto, CA, to employees around the world serving customers in 110 countries, Agilent has a long history of innovation and leadership in the communications, electronics, semiconductor, test and measurement, life sciences and chemical analysis industries. Following its successful IPO in 1999, Agilent is now a fully independent company focusing on high-growth markets in communications, electronics and life sciences. Agilent is recognized as an industry and global leader.


Our start, the HP garage, Palo Alto, CA.

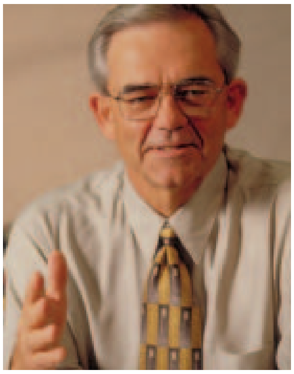
Company Today:

As the world's premier measurement company, Agilent works in close collaboration with engineers, scientists and researchers around the globe to meet the communications, electronics, life sciences and chemical analysis challenges of today and tomorrow. The company operates two primary businesses—electronic and bio-analytical measurement—supported by Agilent Laboratories, its central research group. Agilent is committed to providing innovative measurement solutions that enable our customers and partners—the leaders in their fields—to deliver the products and services that make a measurable difference in the lives of people everywhere. With a singular focus on measurement, Agilent helps:

- Test more than half of the world's 1.13 billion cell phones
- Equip more than 200 communications service providers
- Advance next-generation integrated voice, video and data
- Enable the military to be more flexible, mobile and reliable

Agilent's electronic measurement business provides standard and customized electronic measurement instruments and systems, monitoring, management and optimization tools for communications networks and services, software design tools and related services that are used in the design, development, manufacture, installation, deployment and operation of electronics equipment and communications networks and services.

In 2006 Agilent introduced the E4898A Bit Error Ratio Tester (BERT) that is the industry's first to operate at speeds of up to 100 Gb/s. That same year Agilent introduced the MXA signal analysis platform which is the industry's fastest signal analyzer with the highest accuracy of any midrange analyzer. In 2007 the Agilent E6651A was introduced and became the worlds first integrated Mobile WiMAX™ test set enabling designers and manufacturers of Mobile WiMAX™ subscriber products to rapidly move from development to volume production—improving the integrity and quality of WiMAX devices while reducing cost. Recently Agilent introduced the Industry-First HSPA+ test solution for 3GPP-compliant components making it the only commercially available HSPA+ signal analysis test solution in the industry. Agilent also released its newest LTE test products, including the first-to-market LTE UE development test platform, the Agilent E6620A with real-time protocol development tools created in partnership with Anite plc. This LTE UE platform will help R&D engineers speed development of LTE UE design for next-generation mobile communications products.


Bill Sullivan, President and Chief Executive Officer.

Company Product Categories:

Agilent's markets for our electronic measurement business include communications test and general purpose test. In communications test, Agilent sells products and services for the following types of networks and systems:

- Fiber Optics Networks
- Transport Networks
- Broadband and Data Networks
- Wireless Communications
- Microwave Networks

We also provide solutions to enable network, service and customer assurance for network operators.

Additional test products include:

- General Purpose Instruments
- Modular Instruments and Test Software
- Digital Design Products
- Parametric Test Products
- High Frequency Electronic Design Tools
- Electronics Manufacturing Test Equipment
- Thin-film Transistor Array Test Equipment

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AMERICAN MICROWAVE CORPORATION

30 Years

1978–2008

"In Pursuit of Excellence through Engineering"

Company History: In 1978, Mr. Raymond L. Sicotte founded American Microwave Corporation (AMC). Originally AMC manufactured ferrite products and eventually expanded and developed complete product lines of solid state microwave switches, voltage variable attenuators operating up to 18 GHz. AMC has been dedicated to providing state of the art technology in high quality microwave components that meet or exceed the customer's specifications.

In 1990, Dr. Ashok K. Gorwara joined AMC as President & CEO bringing many new developments including Detector Logarithmic Video Amplifiers (DLVAs) and sophisticated Integrated Assemblies.

Company Today:

Today, the President & CEO, Dr. Ashok K. Gorwara and Chairman & CFO, Mr. Raymond L. Sicotte along with the staff of American Microwave Corporation (AMC) celebrate their 30th Anniversary. American Microwave Corporation (AMC) is currently ISO 9001:2000 certified within the areas of Research, Development, Design and Manufacture of RF & Microwave Components and Integrated Assemblies from DC to 40 GHz. American Microwave Corporation (AMC) has a sister company, Planar Monolithics Industries, Inc. (PMI), www.planarmonolithics.com/pmi.

Products:

Switches:

- DC to 40 GHz in Sub-Octave, Octave and Broadband Models
- SPST thru SP64T Solid State Switches
- TTL, ECL, CMOS & RS422 Controls
- High Speed, High Isolation and Low Loss Models
- Variable Rise Time and other specialties available

Attenuators:

- 10 MHz to 18 GHz in Sub-Octave, Octave and Broadband Models
- 15 dB to 120dB Dynamic Ranges available
- Linearized Analog and Digitally Variable Models available
- Non-Linearized Current Controlled models also

Detector Log Video Amplifiers:

- 10 MHz to 40 GHz in Narrowband and Broadband Models
- 45 dB and 70 dB Dynamic Ranges available
- CW & Noise Immune Models
- Linear Detector Models
- Very High Sensitivity Models

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Anritsu

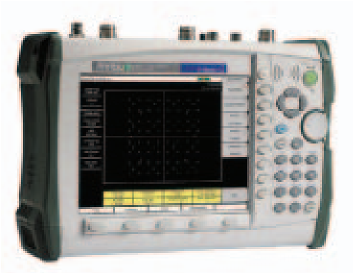
Company History: Anritsu Company is the American subsidiary of Anritsu Corporation, a global provider of innovative communications solutions for more than 110 years. Anritsu is a global leader in the telecommunications, optical and wireless industries through its diverse product offerings ranging from test and measurement solutions to high-speed devices and components for use in R&D, production and maintenance.

Since incorporating in 1895, Anritsu has been leading the way in innovation. Among the company's advances are the world's first 43.5 GHz 4-channel ultra high-speed error detector, and the V and K connectors. Innovation has stretched into the field, as Anritsu introduced the Site Master™ handheld cable and antenna analyzer nearly a decade ago, which redefined the field measurement market.

Those market innovations have helped Anritsu grow through the years and the company now has more than 3,900 employees and is represented in 90 countries for a global presence. Manufacturing is done in Morgan Hill, CA; Atsugi, Japan; and Stevenage, England. US sales headquarters are in Richardson, TX. Additional sales and service offices are within the US, as well as in Canada, Latin America, Europe, Asia and Japan.

Company Today:

A commitment to developing test and measurement solutions for Next Generation Networks (NGNs) is evident in Anritsu's present product offering. Anritsu unveiled the first operational LTE signaling analyzer earlier this year when its MD8430A conducted 100 Mbps downlink demonstrations at CTIA. Anritsu was also the first company to release field test solutions for Fixed and Mobile WiMAX, and is working with partners to develop other instruments used in the development, manufacturing, deployment and maintenance of NGNs.



Holding a market leadership position is nothing new for Anritsu. Its handheld cable and antenna analyzers are now the de facto industry standard for base station deployment, installation and maintenance. Anritsu has also been the market leader in Bluetooth test for years.

Anritsu continues to be one of the leading test and measurement suppliers to the Department of Defense (DoD) and other branches of the US government, and to the contractors supporting them. As commercial wired and wireless technologies migrate into government applications, Anritsu is leveraging its worldwide industry leadership to provide a full complement of solutions supporting core programs in the Global Information Grid, including MUOS, FCS, and JTRS, and the Department of Homeland Security.

Company Product Categories:

- BER Testers
- Optical Test Instruments
- Bluetooth Testers
- Power Meters
- Conformance Test Systems
- Scalar Network Analyzers
- Handheld Base Station Analyzers
- Signal Generators
- Handheld Cable and Antenna Analyzers
- Signaling Analyzers
- Handheld Vector Network Analyzer
- Spectrum Analyzers
- Jitter Test Solutions
- Vector Network Analyzers

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ANSOFT

Company History: Ansoft was founded in 1984 and grew out of research conducted at Carnegie Mellon University by Ansoft's chairman and chief technology officer, Zoltan J. Cendes, and his colleagues. In 1990, Ansoft shipped the first version of HFSS™ which has become the industry-standard software for S-parameter, Full-Wave SPICE™ extraction, and 3D electromagnetic field simulation of high-frequency and high-speed components. Propelled by the strength of HFSS, Ansoft grew to become a leading developer of high-performance Electronic Design Automation (EDA) software. The software's unique ability to leverage electromagnetics across component, circuit and system design has allowed companies worldwide to design mobile communication, internet-access, broadband networking components and systems, integrated circuits (ICs) and printed circuit boards (PCBs) as well as electromechanical systems such as automotive components and power electronics systems. In April 1996, Ansoft completed its initial public offering and began trading on the NASDAQ stock exchange under the symbol "ANST."


Zoltan J. Cendes

Company Today:

On March 31, 2008 Ansoft Corporation and ANSYS, Inc. announced the signing of a definitive agreement to combine the two companies to create the leading provider of "best-in-class" simulation capabilities. ANSYS is a leading developer of engineering simulation software and technologies widely used by engineers and designers across a broad spectrum of industries. The combined company will have combined trailing 12-month revenues of $485 million, over 40 direct sales offices and 21 development centers on three continents and approximately 1700 employees worldwide. The combined global operations of Ansoft and ANSYS will enhance the breadth, functionality, usability and interoperability of the combined portfolio of engineering simulation solutions. The combination is expected to increase operational efficiency and lower design and engineering costs for our customers, and accelerate development and delivery of new and innovative products to the marketplace. The complementary combination of Ansoft's and ANSYS' software products and services will give the combined company one of the most complete, independent engineering simulation software offerings in the industry.

Company Product Categories:

- Electronic Design Automation software
- RF & microwave design
- Signal- & Power-integrity analysis
- EMI/EMC

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rf/microwave instrumentation • modular rf • receiver systems • ar europe

Company History: Amplifier Research began in 1969 with just two men in a cellar, moonlighting from their regular jobs. Don ("Shep") Shepherd and his late partner, Dan Roth, worked for AEL (American Electronics Laboratories), producing radio frequency designs for military applications. They saw a market for their skills in designing amplifiers for test applications, but AEL was not set up for such jobs. So they decided to try and make it on their own, working out of a makeshift laboratory in Shep's cellar. The first sale was a 2 watt, 250 MHz amplifier that sold for $600 including $60 for special connectors.

In 1973, AR moved its headquarters to Souderton, PA and 3 years later introduced a 10,000 watt, 10 kHz–100 MHz tube amplifier that's still available today. AR expanded its capabilities in 2001 with the acquisition of Kalmus in Bothell, WA to include amplifier modules and amplifier systems. A year later, Carnel Labs in Canoga Park CA joined the AR family.

Company Today:

Today, AR, celebrating 40 years in business in 2009, has grown dramatically from the 2-person company that started in Shep's cellar to a corporation that employs over 200 people and continues to lead the industry with innovative, superior quality, technologically-advanced products and a global support system that's second to none.

AR, comprised of 3 divisions, provides products and solutions for RF and EMC testing, Wireless & Military communications and beyond. AR RF/Microwave Instrumentation is the world-class source for broadband high power, solid state RF and microwave amplifiers, TWT amplifiers, transient generators, log periodic and high-gain horn antennas, EMC test software, field probes and much more. AR Modular RF provides RF amplifier systems, RF modules and booster amplifiers for a wireless and military communication, electronic warfare and a variety of industrial/scientific/medical applications. AR Modular RF also helps customers find the best solutions to their most demanding requirements by offering customer-specific designs and semi-custom modifications to our existing product line. AR Receiver Systems manufactures a quality line of products for EMC testing including EMI receivers, impulse generators and measurement systems and leak detectors.

At AR, there's no substitute for quality. It's the foundation of our business and the AR value that's recognized around the globe. With the combined resources of all the AR companies, we simply have more of the best people making the best products to overcome your toughest challenges.

Company Product Categories:

- RF Amplifiers and Antennas, 1 to 50,000 watts, dc to 1 GHz
- Microwave Amplifiers, 1 to 16,000 watts, 0.8 to 45 GHz
- Transient Generators
- Precompliance EMC Test Systems
- Radiated Immunity Test System
- EMC Accessories and Software
- Broadband Solid-State RF amplifier Systems, 5–5000 watts, 0.1–6000 MHz
- RF Modules - broadband, narrowband and custom designs, 5–500 watts, 0.1–6000 MHz
- Military Amplifier Systems and Accessories
- EMI Receivers
- Leak Detectors

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ARC TECHNOLOGIES, INC.

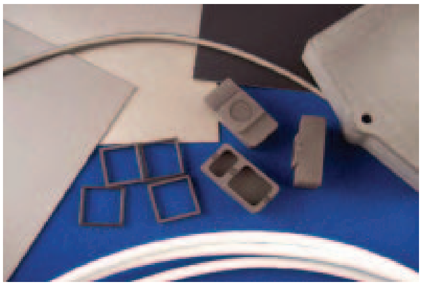
20 Years' Experience in Absorber Technology

Now in its 20th year, ARC Technologies continues to serve the commercial and military electronics industries with a complete line of absorber products and electrically tuned composite materials of the highest quality, manufactured in ARC's 100,000 sq. ft. facility in Amesbury, MA. ARC offers a complete range of absorbers, providing innovative solutions to interference problems faced by military, aerospace and commercial electronics design engineers.

ARC concentrates on four major product lines

- MAGRAM
- Dielectric materials
- Composites
- Advanced Materials

These product lines are produced by dedicated internal "focus factories"—interdisciplinary teams of ARC scientists and engineers well versed in the disciplines of microwave, radar, EMI/EMC, polymer science as well as advanced production processes such as polymer processing, composites fabrication, laminated materials and secondary processing.



In response to unique customer challenges, whether at 50 MHz or 100 GHz, near-field, narrowband or broadband, ARC brings in-depth expertise to each situation. Over the years we have invested heavily in materials expertise, process knowledge and capital equipment to meet evolving customer needs.

Capabilities and Expertise in Advanced Materials and Processes

ARC process capabilities include extruded profiles, sandwiched composites with embedded electronics, precision painted coatings and fluorinated polymer composites fabrication.

Expertise in advanced materials is also one of ARC's critical strengths. Each application has inherent functional and material property requirements to consider. Multifunctional materials, for example, exhibit gradients in some properties as a function of location in the part. ARC's Radar Camouflage Units (RCU) are such a material. These units must survive severe environmental exposure while maintaining unique structural properties dictated by the functional requirements of the part. And they must still perform an important electrical task.

ARC's experience and capabilities in compression molded elastomer, combined with their in-house rubber milling operation, make them the only fully integrated MAGRAM manufacturer in the nation. The Syntactic Foam product line, consisting of both tailored dielectic and controlled loss versions, have gained widespread acceptance in a range of applications.

An ISO 9001 company, ARC works continuously to improve its test and inspection capabilities. They maintain a state-of-the-art, environmentally controlled Quality Lab utilizing the most advanced and accurate measuring equipment.

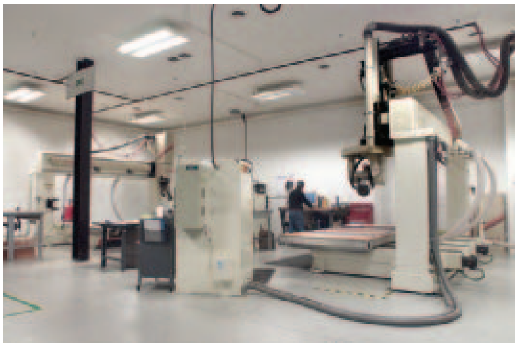
When it comes to solving microwave interference problems in even the most advanced electronic enclosures, ARC Technologies has a product in hand or will develop an application-specific solution to meet the most demanding customer specifications.

Radar Absorbing Materials

Dielectric Foam, Gumstock, MAGRAM Sheets, Coated Honeycomb, Wave-X

Radar Absorbing Solutions:

Composite structures, embedded antenna structures, radar camouflage units, resin injection molded boots, thermoplastic extruded profiles and boots, and decoy subassemblies



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AWR

In the beginning....

In 1994, while designing chipsets for radar systems using current high-frequency EDA tools, Dr. Joe Pekarek realized there had to be a better way. He believed the Windows operating system offered unique opportunities that could let RF and microwave designers do their work faster, with greater accuracy – and a lot easier. He felt new tools should address design from the device level through component and system levels seamlessly, from within a single environment. Armed with a vision, a little cash, and the commitment of two like-minded associates, Joe Pekarek founded Applied Wave Research (AWR).

Four years later, the company introduced its first major product, Microwave Office® design environment, which gave high-frequency design the "look and feel" of office productivity tools, and the AWR Design Environment™ was born.

The response was overwhelmingly positive, verifying their belief that immense productivity gains could be achieved by building on a unified data model. In one platform, designers could now take an idea from concept through simulation to physical implementation, whether driving the design from the schematic, simulation, or layout. And unlike "closed" high-frequency software solutions that restricted access to third-party tools, the "open" AWR Design Environment embraced them by design. That commitment is stronger today than ever.

AWR Today

Thousands of users at hundreds of companies around the world rely on AWR's high-frequency design solutions. Along the way, AWR scored impressive industry "firsts," such as real-time tuning of component parameters, EM based models, "project tree" view of design, measurement-driven simulation, real-time layout viewing in 3D, and many more. The Microwave Office design environment has advanced by leaps and bounds in terms of accuracy, speed, and capabilities while remaining true to its creators' vision of openness and ease of use. It is complemented by the Analog Office® suite for RFIC design, Visual System Simulator™ for system-level analysis and optimization, as well as ACE™ circuit extraction technology, APLAC® harmonic balance and time-domain transient analysis software, and AXIEM™ for 3D planar EM analysis.

With the recent release of the 2008 AWR Design Environment, AWR further increases the power of the platform with more than 100 enhancements encompassing every solution, tool, and technology. Equally impressive, the user interface, already more intuitive than any alternative product, now allows users far greater customization to satisfy personal preferences and improves productivity even further. Joe Pekarek knew there had to be a better way, and 14 years later, legions of customers would agree that he found it.

Major Products

- Microwave Office
- Analog Office
- Visual System Simulator
- APLAC
- AXIEM

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info@awrcorp.com

DAICO Industries

Original location in Dominguez, California

Modern 41,000-sq. ft. facility in Carson, California

Last year Daico Industries marked its 40th year serving the dynamic microwave industry. Just nine years after *Microwave Journal* began publishing, Daico began filling a critical need for high-precision, super-reliable IF/RF and microwave products and solutions. Early products included switches, phase shifters and other control products operating in the DC to 18 GHz range.

Customer-driven Growth:

Over the years, Daico has added to and expanded its large families of products to provide advanced IF/RF and Microwave Control products and Amplifiers for the ever-demanding Defense Electronics, Aerospace, Commercial Space and other high-end industries. These custom high-reliability products are integral to the complex operations of major radar, navigation, communications, fire control, EW and satellite systems.

Today, Daico offers a broad range of microwave products for custom solutions in IF/RF and microwave frequencies through its large and ready families of control products, amplifiers and multi-function assemblies.

More Than Design and Manufacturing:

We design, build, test and screen products specifically to meet customers' rigorous requirements. Additionally, we offer build-to-print (contract manufacturing) services. With its stable and repeatable processes, along with skilled manufacturing and test personnel, Daico builds legacy products to the same exacting standards of performance and reliability to which you build them. In the process, Daico also redesigns and updates them to extend the service while reducing manufacturing costs and improving overall performance.

Major Products:

Custom Products in RF/IF and Microwave Frequencies, DC to 18 GHz:

- *Control Products:* Switches, Attenuators, Phase Shifters, Antenna Selectors
- *Amplifiers:* High-Power, Low Noise, Broadband
- *Multifunction Assemblies:* Adaptive Gain Modules, 4-channel Up-converters, Switchable Filters
- *Build-to-Print:* Contract Manufacturing

Markets Served:

- *Defense:* Surveillance, Training, Fire Control
- *Aerospace:* Radar, Communications, ECM
- *Commercial Space:* Communications, Payloads
- *Industrial:* Controls

Contact Information

1070 East 233rd Street
Carson, CA 90745
Phone: 310 507 3242
Fax: 310 507 5701
www.daico.com

EADS NORTH AMERICA

Company History: EADS North America Test and Services was originally founded in 1959 and became one of the 13 original Racal Group companies. Originally it was named Racal-Dana, but ultimately became known as Racal Instruments. A brief synopsis of our history follows:

1960s: Introduced the industry's first Auto-Ranging RF Counter. With over 35,000 instrumentation units deployed to-date, this established the Company as the de facto choice for time and frequency measurement instrumentation worldwide.

1970s: Developed the industry's first modular instrument chassis and plug-in switching cards and patents a novel technique for phase-locked RF signal synthesis—a method that is still the basis for all products of this kind today.

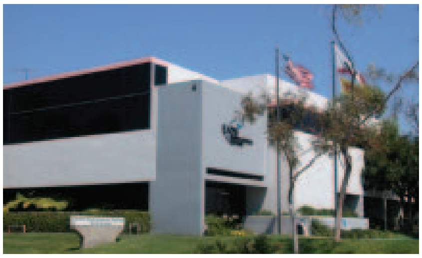
1980s: Delivered the first DIANA battlefield-deployable, integrated test and repair mobile platform to the MOD, establishing a new level of integration and Test Program Software (TPS) performance for the military and commercial markets.

1990s: Commanded a market leadership position within the Wireless and Broadband/Photonics markets, through an unprecedented level of innovation in product design in our GSM base station testers, Air Interface Protocol test systems, laser diode burn-in stations, and LIV characterization systems. We also launched our turnkey test system business with the establishment of a Test Program Set (TPS) group.

Early 2000s: Became a major player in the semiconductor production market through the development of our semiconductor burn-in test system. We were purchased by EADS North America and folded into EADS North America Test and Services with the former ARC, a leader in legacy software migration and the former Talon Instruments, a leader in digital instrumentation.

Company Today:

We are true to our roots and continue to develop state-of-the-art instruments adapted for the ever demanding and developing technology market. We continue to upgrade and modify our existing product lines in a variety of test platforms: VXI, PXI, GPIB, Ethernet-controlled, and more. Our company continues to expand our wide range of switch cards for RF/Microwave, digital power, and optical signals.

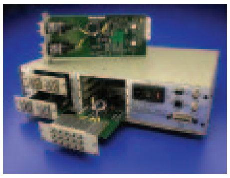


We have furthered our presence in the semiconductor market through the development of our hybrid and burn-in testers and have developed the turnkey standard for the US Navy jet and shaft engine test. EADS North America Test and Services has gone one step further and introduced a new N-GEN™ tester that can be used in both military and commercial engine test applications.

Our company's mission statement is to enable our customers to deliver reliable and technologically advanced products by providing creative solutions that exceed expectations with consistent results. With our engineering and business development talent located throughout the world, we are able to anticipate the challenges our customers will experience and design, develop, and produce the test products and systems required for the future.

Company Product Categories:

We design, manufacture, and service modular, test instruments, chassis and switching systems. We provide turnkey test systems that take advantage of today's most advanced hardware and software. These systems are versatile, scalable, multivendor solutions that are easily upgraded by incorporating modular COTS equipment. We can even develop resource performance verification, calibration, programs, and system self-tests. Because our customers have invested great resources in test programs and fixtures, we continue to service legacy systems through an eclectic mix of cutting-edge solutions, including Total System Life Management.



From modular instruments to turnkey automatic test systems and legacy systems support, we are experts in an ever-widening spectrum of testing applications. This includes commercial functional test and measurement, laser diode burn-in and production, microprocessor production, jet engine and shaft engine test, and communications test. We are able to address all markets - military, aerospace, telecommunications, semiconductor, and commercial manufacturing and services. Testing is our business. Excellence is what we know.

Contact Information:

EADS North America Test and Services
4 Goodyear
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(800) 722-2528
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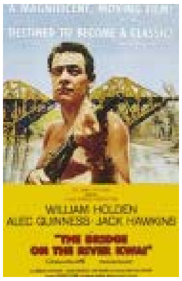
info@eads-nadefense.com
http://www.ts.eads-na.com

A LOOK BACK: 1958

Cost of Living

- Yearly inflation rate US 2.73%
- Yearly inflation rate UK 2.7%
- Average cost of new house $12,750.00
- Average monthly rent $92.00
- Average yearly wages $4600.00
- Cost of a gallon of gas is 25 cents

Popular Films



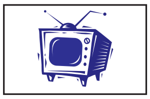
- The Bridge on the River Kwai
- South Pacific
- Gigi
- King Creole
- Vertigo

Popular Singers

- Elvis Presley
- Billie Holiday
- Ricky Nelson
- Frank Sinatra
- The Everly Brothers
- Ella Fitzgerald
- Jerry Lee Lewis

Popular TV Programs

- Candid Camera
- The Ed Sullivan Show
- Come Dancing
- The Jack Benny Show
- Panorama
- Alfred Hitchcock Presents



- By now, more than 45 million American households have television sets.

Miscellaneous

- The John Birch Society, a radical anti-Communist organization, is created in the US.

- Dr. Zhivago is published in the US. Banned in the USSR, Zhivago won author Boris Pasternak the Nobel Prize which he was forced to decline due to political forces at home.

- The price of 1st class US postage is raised to 4¢ from 3¢ where it had been for 26 years. Hard to believe—only a penny in 26 years.

- Charles de Gaulle becomes premier of France, a position he will hold until 1969.

(Continued on page 174)

HUBER+SUHNER

Company History: HUBER+SUHNER's roots lie with two family-owned companies that were founded in the 19th century and evolved independently along similar lines. The Aktiengesellschaft R+E. HUBER, established in Pfäffikon, Switzerland, in 1882 was a telegraph wire and cable factory with the additional designation of 'Rubber and Gutta-percha Goods Factory.' The SUHNER & Co. AG was established in Herisau, Switzerland in 1864 and was well-known for its cables and cable insulation, plastics compression factory and injection moulding. The two companies merged in 1969 into HUBER+SUHNER AG, with the corporate philosophy of 'Excellence in Connectivity Solutions.' The company focuses on the core competencies of radio frequency, fiber optics and low frequency technologies.

Company Today:

Today, HUBER+SUHNER is a leading global supplier of components and systems for electrical and optical connectivity. The industrial group with its headquarters in Switzerland was established in 1969. Currently, it operates 17 subsidiaries and employs 3500 people. It is also represented by 100 distributors in additional countries. The shares of HUBER+SUHNER are listed on the Swiss stock exchange (SWX Swiss Exchange) in Zurich.

The company offers technical expertise in radio frequency, fiber optics and low frequency engineering under a single roof, providing a broad range of products that can be relied on in the company's target markets of communication, transportation and industrial applications.

Company Product Categories:

HUBER+SUHNER serves the communication, industrial and transportation markets with cables, connectors, assemblies, cable systems, antennas and accessories that are developed and produced utilising fiber optics and high and low frequency technologies.

Contact Information:

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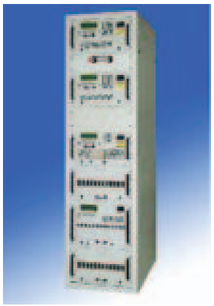
Instruments For Industry

The Power Of Choice

Company History: IFI is a leader in amplifier technology, originally founded in 1953, and now the only manufacturer building product in-house from DC–45 GHz. The staff of IFI has several decades of individual experience in amplifier configurations beginning with devices such as Solid State transistors of all types, Tetrode Tubes and Traveling Wave Tubes. Our staff has been involved with the design, development and manufacturing of everything from the most basic test equipment to the most sophisticated military systems. This abundance of education and experience is what we put to work for our customers, working in concert to find cost effective solutions for their requirements.

Company Today:

IFI is located in Ronkonkoma, New York on Long Island and just minutes from Islip MacArthur airport, and 40 miles from JFK and LaGuardia airports. IFI is an ISO9001-2000 registered company and our 14,000 square foot facility is where we design and manufacture the best amplifier products available today. We build in accordance to MIL-I-45208A and can implement special quality control procedures as required by the end user. IFI is actively involved in the design & manufacture of Solid State, Traveling Wave Tube (TWT) and Tetrode tube amplifiers (Pulsed & CW) and continues with development of low, medium & high power state-of-the-art products enhancing our product lines. Our designs are the simplest for customers to use, while providing the maximum amount of user information for the test application. The equipment is designed for any remote control a customer could require, which is why IFI equipment is used successfully in applications all around the world.



RS1802-1KW-500.

IFI offers customers the ability of tailoring our products for the required application. We can add, delete or configure our amplifier products to best fit any customer's need. See our Amplifier option list @ http://www.ifi.com/web/html/amplifiers/ampmain.html. Although most amplifiers come fully loaded, we continue our tradition of customizing our equipment for a customer's specific application. IFI's experience extends to ruggedized environmentally protected equipment for Military applications which include outdoor applications for EW/ECM applications as well as communications.

Company Product Categories:

IFI manufactures low, medium and high power amplifiers; CW amplifiers with power levels to 5000 watts and Pulse amplifiers to 50,000 watts.

IFI manufactures a full range of TWT, Solid State and Tetrode Tube Amplifiers, as well as Antennas, E-Field Sensors, TEM Cells and RF & Microwave accessories. These products are used for EMC/RF testing applications for commercial and military programs as well as Military EW/ECM applications and are utilized by the automotive, aircraft, military, medical, electronics, wireless, communications and educational markets. Customers can purchase a complete solution for all their testing requirements from a single source. IFI is offering "Single Amplifier Solutions" from 10 KHz to 3 GHz, 0.8 GHz to 18 GHz and 18 GHz to 40 GHz. These single amplifier solutions are ideal for all types of testing, simplifying the customers' test setups by providing time savings for other necessary lab tasks.

T251-1500

Contact Information:

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Website: www.ifi.com

• Dodger catcher Roy Campanella is paralyzed when the car he was driving skidded into a telephone pole. Campanella was the NL's MVP in '51, '53 and '55.

• The Jolly Green Giant appears on TV with less than stellar results. In his first incarnation he looks like a monster that scares kids. So they lightened him up and added "Ho, ho, ho" and the lilting "Good things from the garden" song.

• Modern consumer credit is born. The American Express Company introduces a charge card meant to compete with the successful Diners Club card. The Bank of American introduces the BankAmericard, which will become the Visa card.

• Crest toothpaste inaugurates the "Look, Ma! No cavities!" ad campaign.

• Eighteen-year-old Frank Carney sees a story in the Saturday Evening Post about the "pizza fad" among teenagers and college students. With $600 borrowed from his mother, he opens the first Pizza Hut in Wichita, KS.

• On the Air! You'd find 3156 AM radio, 537 FM radio and 492 TV Stations.

• 31.3% of all domestic passenger travel was by railroad; 27.7% by bus; and 38% by air.

• 30.6% of all advertising dollars are spent on newspapers—13.3% on TV. Complete allocation of ad dollars.

• It's Here! The Hula Hoop.

• Sweet 'n Low is introduced as an artificial sweetener, using saccharin instead of sugar. Sweet 'n Low received US trademark patent no. 1,000,000.

• Nelson Mandela weds Winnie Madikizela.

• UP & International News Service merge into United Press International.

• Vice President Richard Nixon is shoved, stoned, booed and spat upon by protesters in Peru as he makes a goodwill tour of South and Latin America.

• NASA is created and Explorer is launched. A big year for the US in the Space Race.

• RIAA awards the very first Gold record to Perry Como.

• The first ever Grammy Awards!

• Stereophonic recordings, which use two separately recorded channels of sound to recreate a sense of space, come into commercial use.

• Friskees introduces the first dry cat food.

• Japan's new Datsun (Model 211) cars begin shipping to the US but only 52 will sell. An especially meager number since in 1958 America will import 430,808 passenger cars.

• Pope Pius XII declares Saint Clare of Assisi patron saint of television. Her placement on the television set is said to guarantee good reception.

• Right after that, Pope Pius XII died. Angelo G Roncalli crowned Pope John XXIII.

• Harry Winston Inc. donates the 45.52 carat Hope Diamond to the Smithsonian Institution.

• This is the peak year for drive-in movies with 4063 outdoor screens nationwide.

• In the worst recession since World War II, nearly 5.5 million people are out of work.

• The first women are admitted to the British House of Lords.

• Bill and Mark Richards of Dana Point, CA, invented the first skateboard. They attached roller skate wheels to a square board and sold them at their Val Surf Shop for $8 each.

• The first domestic jet-airline passenger service is begun by National Airlines between New York City and Miami.

• Rice-a-Roni, The San Francisco Treat, is introduced.

• 9000 scientists of 43 nations petition UN for nuclear test ban.

• Prime commercial paper (4 to 6 mos) was at 2.46%. In New York City a commercial loan ran 4.12%

• Air Force Academy opens in Colorado Springs, CO. The all male facility won't go co-ed unto 1976.

• Mao Tse Tung starts "Great Leap Forward" movement in China

• Charles Starkweather and Caril Fugate go on their killing spree.

• The National Association of Broadcasters bans subliminal ads.

• There is a 55.9% business failure rate.

• The Chevrolet Impala is introduced.

• Cocoa Krispies breakfast food is introduced by the Kellogg Company; it's 45.9% sugar.

• Cocoa Puffs is introduced by General Mills; it contains 43% sugar.

• Dr. Ake Senning installs the first pacemaker.

• American will import 430,808 passenger cars.

• There are 36,981 motor vehicle related deaths. While in the air, there were 8 accidents resulting in 125 fatalities.

• Unemployment is 6.8%.

• US GNP (Gross National Product) is $468.3 billion.

1958–2008

Other organizations celebrating 50th anniversaries this year

• Defense Advanced Research Projects Agency (DARPA)

• National Aeronautics and Space Administration (NASA)

• Small Business Administration (SBA)

Tyco Electronics

Our commitment. Your advantage.

M/A-COM

Company History: Founded in 1950 by three engineers, M/A-COM began as Microwave Associates in a small rented office on Columbus Avenue in Boston, Massachusetts. Launched with just $10,000 in capital, its first customer was the US Army Signal Corps, which funded R&D for cutting-edge radar systems. In the years to follow, the company firmly established itself as a technological powerhouse through continued devotion to investment in research and development (R&D).

Focused on the rapidly emerging semiconductor business, M/A-COM expanded its horizons in the 1960s and 1970s through strategic acquisitions and the company's faithful commitment to R&D. To reflect the evolving nature of the industry and the company's involvement in the growing communications market, Microwave Associates legally changed its name to M/A-COM, Inc. in 1978. During the 1980s and 1990s, M/A-COM reinvented itself again, shifting its major business focus from the aerospace and defense sector to the commercial market. In 1998 M/A-COM changed its name to Tyco Electronics M/A-COM. Still a major player in aerospace and defense, the company brought its expertise to the wireless telecommunications and automotive markets over the past decade.

Company Today:

Tyco Electronics M/A-COM: The First Name in Radio Frequency: As a leader in wireless RF and microwave components and subsystems, Tyco Electronics M/A-COM's products are vital to many of the world's largest wireless telecom, aerospace and defense, and automotive companies.

Tyco Electronics M/A-COM has a long history of realizing synergies between commercial and defense applications, i.e., developing technologies and products for one market and then applying them to the other. This "dual use" approach allows the company to successfully serve both commercial and defense markets. To ensure responsive customer service, the company's products are marketed by a global sales team, including direct sales engineers, sales representatives, and distributors.

On May 13, 2008, Tyco Electronics Ltd. announced the company has entered into a definitive agreement to sell its Radio Frequency Components and Subsystem business to Cobham Defense Electronic Systems, a subsidiary of Cobham plc.

Company Product Categories:

Tyco Electronics M/A-COM's technology and expertise extend across a broad range of solutions for the aerospace and defense, commercial wireless telecommunications, broadband, automotive, and RFID markets. Tyco Electronics M/A-COM products are utilized around the globe in cellular infrastructure, handsets, WLAN, WiMAX, CATV, VSAT, RFID, automotive, test and measurement, radar, electronic warfare, missile guidance, and space applications.

Tyco Electronics M/A-COM offers one of the broadest selections of standard and custom products in the industry, including:

Commercial
- RF/microwave diodes, power transistors and RFIC/MMICs
- Ferrite isolators and circulators
- Synthesizers
- Short-range sensors and antenna modules for automotive applications
- RFID subsystems and active tags

Defense
- High-performance subsystems for missile, electronic warfare, and radar systems
- Signal intelligence receivers
- Antennas
- Cable assemblies
- Active components

Tyco Electronics M/A-COM enjoys a reputation for strengths in manufacturing, reliability, and quality. M/A-COM's operations are certified to ISO 9001, ISO 14001, AS 9100, and QS-9000.

Contact Information:

Tyco Electronics M/A-COM
1011 Pawtucket Blvd.
Lowell, MA 01853
Americas – Phone: 1-800-366-2266
Europe/Middle East/Africa –
Phone: 44 (1908) 574200
Asia/Pacific – Phone: 81.44.844.8296

Company History: After many years as a Senior Projects Engineer at ITT Federal Laboratories in Nutley, NJ; Ronald R. Davo founded Microwave Electronic Components of America in July of 1961. MECA's main business focus through the 1960s and early 1970s was primarily components used in radar systems for the United States Government. During the mid-1970s, MECA began designing and producing customized products for Bell Laboratories (Murray Hill, NJ). These components were utilized in the Series I AUTOPLEX Cell Sites nationally deployed in the late-1980s/early-1990s. Since Ron's passing in 1992, MECA has remained a privately-owned, family business, and his son William (Chuck) Davo is now owner and President of the company.


Founder, Ronald R. Davo.

Company Today:

MECA is recognized worldwide as a primary source of supply for rugged and reliable components to commercial OEM's, Service Providers and Installers but has also kept true to the original business focus of supporting Military OEMs with American-made products for L, S, C, X and Ku bands applications. Extensive distribution channels internationally have increased MECA's global presence to a large extent; however, the key to successfully delivering products to the field on time, every time continues to be MECA's unique ability to manufacture cost-effective products without reliance on foreign materials and labor. The quality and consistency of our products differentiates us from the countless start-ups & brokers who buy/resell off-shore materials and is the reason why we proudly offer a 36 month warranty on ALL of our components.


MECA shop—1965.

Company Product Categories:

MECA designs and manufactures an extensive line of RF/Microwave components with industry leading performance including:

- Adapters
- Bias Tees
- Cable Assemblies
- DC Blocks
- Directional & Hybrid Couplers
- Fixed Attenuators
- Isolators/Circulators
- Power Divider/Combiners
- RF Loads

MECA serves all areas of the RF and Microwave industries including world class network providers and supporting supply chain infrastructure, and has long been the "backbone" of high performance wired and air-interfaced networks such as base station, in-building applications, satellite communications, radar, radio communications, telemetry applications, mobile radio, aviation & air traffic communications.

Catalogs, Then and Now.

Contact Information:

MECA Electronics, Inc.
459 East Main Street
Denville, NJ 07834
sales@e-MECA.com
www.e-MECA.com

MICRO LAMBDA WIRELESS, INC.

Company Description

Micro Lambda Wireless, Inc. was founded in June 1990 with the purpose of supplying the microwave community with YIG-Based products that provide technically superior performance at competitive prices with the highest regard to customer service and quality.

A privately held corporation, Micro Lambda Wireless, Inc. has been formed from a core of individuals with specialized YIG-based component experience combined with analog, digital and PLL specialists to yield a strong dynamic technical staff. High volume manufacturing techniques have been implemented across all product lines along with standardized mechanical and electrical designs, which lend themselves to low cost and high volume applications.

Micro Lambda Wireless, Inc. maintains a commitment to Total Quality Management and Just-In-Time concepts throughout the organization. Our integrated manufacturing system combines sales orders, work orders, accounting, inventory and scheduling. Material planning is supported by an MRP module, which coordinates subcontractor material requirements. Product standardization focusing on a repeatable manufacturing process enables Micro Lambda Wireless, Inc. to stock material, allowing for very short build cycles.

Our quality program is based on MIL-I-45208A with internal procedures written to the intent of ISO-9000 and MIL-Q-9858. Emphasis is placed on training and each individuals responsibility to quality from customer service to shipping.

Micro Lambda Wireless, Inc. is a market driven company, which has been pushing YIG-Technology on a consistent basis into new and foreign markets and applications. Consistent product development based on "Standard Module Concepts" has yielded many "State-of-the-Art" designs and products currently being deployed in the latest Instrumentation, Wireless and Military applications around the world. This has lead Micro Lambda Wireless, Inc. to become the largest independent YIG-Based component supplier in the market today.

Markets Served

- Test and Measurement Instrumentation
- VXI, PXI and VME Miniaturized Instrumentation
- ELINT and SIGINT Receivers
- SATCOM and TELECOM Applications
- LMDS/MVDS Wireless Data & Voice
- Digital Radio
  - Point-to-Point
  - Point-to-Multi Point
- Radar
- ESM
- ECM & EW

Major Products

- YIG Oscillators 500 MHz to 40 GHz
  - Electro-Magnetic
- YIG Oscillators 2 GHz to 20 GHz
  - Permanent Magnet
- YIG Filters 500 MHz to 46 GHz
  - Bandpass
  - Band Reject (Notch)
  - Dual Channel
  - Permanent Magnet
- YIG Harmonic Generators (Multipliers) 1 GHz to 20 GHz
- Analog and Digital Interfaces
  - TTL Binary
  - 3 Wire Serial
- Phase Locked Sources 2 GHz to 20 GHz (40 GHz with doublers)
  - Fixed Frequency
  - Internal Reference
  - Tunable
- Frequency Synthesizers 500 MHz–16 GHz
  - Wideband Low Noise
  - Narrowband Low Noise
  - Digital Radio
  - Integrated Frequency Doublers
- YIG-Based Sub-Assemblies

Contact Information:

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Fremont, CA 94538
P: (510) 770-9221 • F: (510) 770-9213
www.microlambdawireless.com
sales@microlambdawireless.com

Present at the Dawn of the Microwave Age

Microwave Development Laboratories has been at the forefront of the microwave industry for sixty years, ever since its inception in the years immediately following World War II. The company, started in 1948 by Dr. Henry Riblet, a former mathematics professor and MIT Radiation Lab veteran, quickly became the largest independent producer of waveguide and subassemblies in the industry.

Dr. Riblet's life work with MDL resulted in many patents on mechanical and electrical devices and many contributions to the theory and application of microwave circuitry. None of his contributions proved more enduring than the short-slot coupler, known throughout the industry as the Riblet Coupler. The Riblet Coupler proved to be a foundational component for the microwave industry and is still found in microwave systems today.

Throughout its history MDL has led the industry with imaginative and innovative microwave solutions. In the 1950s MDL was among one of the first companies to design rotary joints. For NASA's Apollo moon program in the 1960s MDL designed a thin wall monopulse comparator for the Lunar Excursion Module, the lander portion of the Apollo spacecraft. In the 1970s MDL developed waveguide feed and monopulse networks for the F-14 and F-15 fighter aircraft. In the 1980s the company introduced internally milled technology to reduce the size and weight and improve the performance of MDL components used in the radar systems on the F-18 and B-2 aircraft.

Quality from CAD to Crate

Today MDL's product lines include waveguide assemblies used on unmanned vehicles such as the Predator and Global Hawk, the Patriot system and Phalanx close-in weapon systems. All are engineered and manufactured at MDL's state-of-the-art manufacturing and testing facility, which includes in-house NC machining, Dip Brazing and Finishing, and where all products undergo 100% functional performance verification and R.F. testing using the latest network analyzers.

Custom work is MDL's stock in trade. MDL engineers, highly experienced in the very latest SolidWorks, Ansoft HFSS, and proprietary software, quickly turn customer design challenges into real solutions. Using Ansoft HFSS, MDL engineers compute s-parameters and full wave fields. Designs are modeled mechanically on SolidWorks and then exported directly to the NC machine.

As the microwave industry continues to grow and the demand for higher frequencies and smaller, more precise waveguide products accelerates, MDL will remain a trusted supplier known for its exceptional service, high reliability and leading edge solutions.

Major Products

Custom waveguide assemblies, monopulse comparators, rotary joints, microwave filters, rotary switches, waveguide to coax adapters, waveguide pressure windows, cast bends and twists, waveguide and flanges.

Contact Information:

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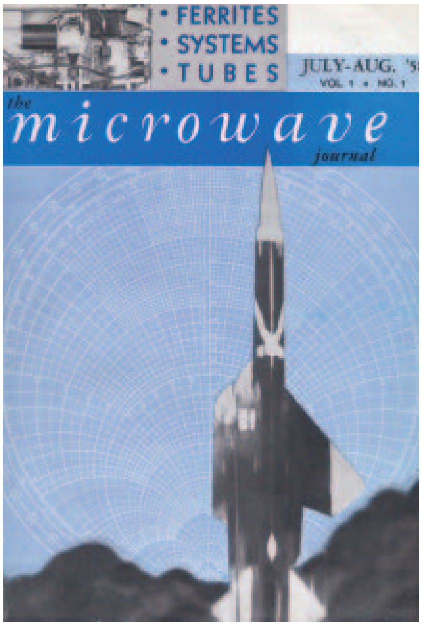
www.mdllab.com
mdlsales@mdllab.com

Microwave Journal

Company History: *Microwave Journal* published its first issue in July of 1958. Founder and Publisher William Bazzy declared that "Our objective is simply to offer a forum to the industry and be the means of communication for the people in this segment of the electronic field." Led by Editor Ted Saad, a distinguished group of associates contributed their knowledge and talent to the pages of *MWJ*, sharing their expertise on the cutting edge products and technologies of the time. The first issue carried several now "classic" articles, including "The Forward Look in Microwave Plumbing" by Tore Anderson, reprinted earlier this year as part of our retrospective series. It carried twenty three ads in its fifty pages and was distributed to 12,000 microwave engineers.



Company Today:

Microwave Journal celebrates its 50th year in print this month, and has established itself as the leading news and information resource for RF/microwave engineers worldwide. Today, the magazine reaches 50,000 readers in more than sixty countries, and carries more than two hundred pages of content each month. The publishing industry has certainly changed over the past fifty years, with the most dramatic change coming in recent years. The emergence of electronic media has brought dynamic new platforms for the delivery of information. *Microwave Journal* led the market with the first website to serve the industry and the first digital edition in the industry. The website now serves more than 50,000 registered users and the digital edition is becoming ever more popular. Several eNewsletters provide subscribers with current news and product information. Webinars, including the popular *MWJ*/Besser series present tutorials by distinguished speakers at no cost. Industry events are covered with Online Show Dailies and event "wrap-ups" for those unable to attend. It's been an exciting fifty years, and the next half century looks to be just as exciting.

Company Product Categories:

Microwave Journal serves the RF and microwave design engineering community with a portfolio of print and electronic products that deliver news, technical information and resources in daily, weekly and monthly formats.

Contact Information:

Microwave Journal
685 Canton Street
Norwood, MA 02062
781-769-9750
mwj@mwjournal.com
www.mwjournal.com

Microwave Solutions, Inc.

Company History: The name was chosen because we wanted to show we recognized that our real mission wasn't just providing hardware, but rather that we were solving a customer's technical problems.

The year 1984 was a good year to start a new microwave amplifier company! We knew this because right away we noticed we had a lot of competitors who were also recent start-ups. Our first order was from a major aero-space company for a dozen each of a thin-film amplifier operating at a classified Ku-band frequency. At that point we were basically just a three person company, the founder, one assembler and one technician, so for us, this was quite a technical, engineering, manufacturing and administrative challenge! We had to really work to get our Q/A and manufacturing capabilities qualified by our customer while at the same time doing the engineering designs and getting all the paperwork completed for our security clearance and all the other government regulations. Not only did we successfully complete that order but we were subsequently awarded additional contracts for hundreds of more units from that same customer sometimes competing, successfully, for the business against companies that had thousands of employees.

1st order: with Motorola, November 1985

MSI early years, May 1988


Founder and President: Edward M. Teyssier

Company Today:

Now in our twenty-fourth year, Microwave Solutions, Inc.® continues to have the reputation for demanding the highest standards for our products. Microwave Solutions, Inc.® upholds this reputation by maintaining strong relationships with our suppliers and a strong engineering base, state-of-the-art manufacturing facility, and a professional staff dedicated to the principle that the key to satisfied customers is product quality, competitive prices and on-time delivery. Our continued success, both in terms of growing sales and number of satisfied customers, stands as validity of our approach to excellent customers' service.

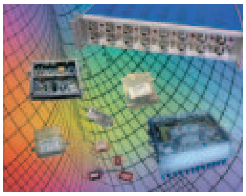

MSI 20 years

• *Today, our mission remains the same:* To supply the highest quality microwave components at the lowest possible prices.

Company Product Categories:

Our core products are still primarily custom microwave amplifiers. But we've also leveraged that capability into building a large variety of related products, such as modules that have phase shifters, couplers, filters, gain control, limiting and other microwave circuit functions in addition to amplification.


Early products, still available today


Some of todays products

Contact Information:

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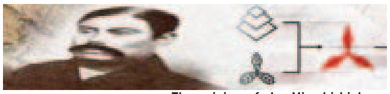
www.microwavesolutions.com

MITSUBISHI ELECTRIC

Changes for the Better

Company History: Mitsubishi was founded by Yataro Iwasaki in 1870. He began by leasing three steamships, thus founding a transport company and establishing Mitsubishi with a firm base in the shipping industry. Iwasaki chose the three diamond-mark as the emblem for his company.



The origins of the Mitsubishi logo.

In 1921, when Mitsubishi Shipbuilding Co. began making electric motors for ocean-going vessels the Mitsubishi Electric Corporation was formed. In the 1930s Mitsubishi Electric started manufacturing and installing elevators and escalators and continued to grow. By 1960 the company had emerged as one of the most innovative electrical equipment manufacturers in Japan. Subsequently Mitsubishi Electric became a world leader in developing, manufacturing and marketing electronic and electrical equipment.

In 1978 Mitsubishi Electric Europe GmbH was established as a wholly owned subsidiary of Mitsubishi Electric Corporation in Ratingen, Germany to take over all the European sales and marketing business. In 1996 Mitsubishi Electric Europe B.V. was founded. It has nine divisions in the fields of Air Conditioning, Automotive, Electronic Visual Systems, Industrial Automation, Semiconductors and others.

Kita-Itami Works, Japan.

Company Today:

Today Mitsubishi Electric has bases for production, sales and other operations in over 110 locations worldwide. It is a global giant with operations in 35 countries with more than 100,000 employees. The Mitsubishi Electric Semiconductor European Business Group operates all sales and export activities for Western and Eastern Europe, Russia and South Africa. The company's success is a result of expertise in the High Frequency, Opto and Power Semiconductors product areas. Quality and reliability are core values and we have achieved ISO 9001 certification continuously since 1995. In the field of High Frequency semiconductors we have more than 25 years of experience in GaAs technology. High power GaAs FETs are typically used as power amplifiers in radio links and satellite communication systems, while integrated GaAs circuits (GaAs HBT MMICs) are used in large volumes as amplifiers for UMTS mobile phones or WiMAX terminals. Our low noise GaAs HEMTs are used as amplifiers for satellite receivers (DBS) and automotive radar. The key applications for MOSFET modules and transistors are analogue and digital communication systems like TETRA.

Company Product Categories:

- High Frequency Semiconductors
- Low Noise HEMTs
- High Power GaAs FETs
- GaAs HBT MMICs
- MOSFET Modules and Transistors

Contact Information:

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Germany
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Semis.info@meg.mee.com
www.mitsubishichips.com

Company History: Founded in 2001, Modelithics has provided products/services to over 180 corporations, including repeat business with Fortune 500 companies like: Boeing, Northrop Grumman, Du Pont, Motorola, Honeywell, Raytheon, and EMC Corporation, as well as several other industry leaders such as Tyco Electronics, Harris, Cree, Vishay, American Technical Ceramics, RFMD, Sennheiser, Triquint, NXP, Mitre and Draper Laboratories among many others. Modelithics also has alliances with several leaders in RF/MW instrumentation and software, including: Anritsu, Accent, Agilent Technologies, Ansoft, AWR, Cadence, J-Micro Technologies, GGB Industries, Keithley, and Maury Microwave. The company supplements its in-house modeling capabilities with its strong network of highly-experienced external consultants and partners.

Company Today:

Modeling Expertise

- Experience in all common device formats: wafer-level, die & package
- Linear, non-linear & noise model development
- Silicon & III-V FET characterization model extractions: LDMOS, VDMOS, CMOS, GaAs, GaN, InP HEMTs pHEMTs, etc.
- Silicon and III-V, BJT/HBT Characterizations/Extractions Silicon, SiGe, GaAs, InGaP, etc.
- Extensive background in packaged & surface mount component modeling
- Complete coverage of passive modeling (surface mount, discrete and IC)
- Behavioral modeling for sub-system blocks (e.g. IC amplifiers, switches, mixers)
- Broad expertise for model library implementation in RF/Microwave EDA tools

Instrumentation & Characterization Capabilities

- S-parameter measurements for 30 kHz–110 GHz, –50C to 200C; 4-port capability to 26 GHz
- Load- and source-pull in multiple bands from 200 MHz–110 GHz (power, TOI, efficiency, etc.)
- Noise parameter measurements through 26 GHz; noise figure measurement 10 MHz–40 GHz (higher frequency as custom); 1/f through 1 MHz
- Manual & semi-automatic on-wafer RF probing systems
- DC-IV, CV and pulsed IV
- IC-CAP, and all major microwave EDA tools
- Spectrum analysis through 110 GHz
- Impedance measurements from 1–3000 MHz
- High-power testing capability (up to 300 W in some bands)
- Hybrid assembly (solder re-flow, wire-bonding, epoxy match)
- On-wafer, chip and packaged devices
- Custom fixture and calibration standards design

Company Product Categories:

CLR LIBRARY™
Models for Surface Mount RLC

NLD LIBRARY™
Non-linear Models for: Varactor Schottky, PIN Diodes

NLT LIBRARY™
Nonlinear Transistor Models for: FET, BJT, HBT

SLC LIBRARY™
Linear and Non-linear System Component Models for: Filters, Switches, Amplifiers, Mixers

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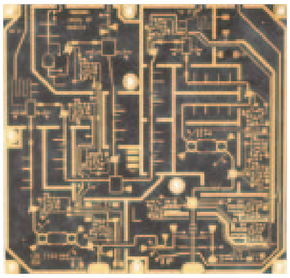
Fax: 813-558-1102
www.modelithics.com
info@modelithics.com

Irka Zazulak

MCN

Modular Components National, Inc.



Company History: Modular Components National (MCN) was founded in 1981 in Massachusetts by Irka Zazulak and her husband Peter, with a focus on the future of microwave technology, providing quality products and engineering expertise for both the commercial and military markets. Peter who was then an engineer at Raytheon realized the needs in product and technology facing a fledgling microwave industry. His knowledge and experience in microwave technology enabled him to design and develop microwave circuit boards, matching materials and processes, to accommodate critical performance in any application. In 1985, as the company continued to grow, MCN relocated to a larger facility in Forest Hill, Maryland where it is still headquartered.

After Peter's death, Irka maintained ownership fostering MCN's dedication to the microwave industry through the development of cutting-edge products and technologies. MCN purchased Microwave Printed Circuit Company in Lowell, Massachusetts in 1997. The two companies grew together to become the industry's leading microwave circuit board fabricators. This merger of skills and expertise enabled the new entity to analyze, master and enhance any technological challenge to the science of PTFE circuit fabrication. As part of a corporate growth strategy to encourage lean manufacturing and shorter lead times, in 2005 the Lowell facility consolidated with the headquarters in Forest Hill to expand capacity, and streamline operations for efficiency and cost-effectiveness.

MCN's value-added assembly and test operation was developed to accommodate prototype and short production runs, and eliminate costly, time consuming full line assembly when applicable. By specializing in the assembly of microwave and RF components, the skilled technicians at MCN have the experience and training required to complete build to sketch, or build to print designs. The engineering staff can also assist with product design or provide a turnkey design through assembly option. MCN is an ISO9001:2000 certified facility with AS9100 certification pending.

A six acre tract of land has been purchased in Forest Hill for the construction of a new manufacturing facility to accommodate the increase in volume that MCN continues to experience each year.

Company Today:

With well over 25 years of service to the microwave industry, Modular Components National remains dedicated to providing quality products and cutting-edge processes for microwave applications. MCN's ability to anticipate and fulfill the changing needs in microwave technology has earned the company an established place as a worldwide leader in the manufacture of microwave circuit boards for the defense and commercial telecommunications markets. MCN's recent increase in capacity will foster growth in the automotive, aerospace, and medical markets. MCN offers rapid prototyping and fast delivery of production runs with rapid response to requests for pricing, engineering assistance and prototypes, concentrating on customer satisfaction. MCN guarantees a rapid response to requests for pricing, engineering assistance and prototypes concentrating on customer satisfaction.

Investing in a highly skilled staff of engineers and support personnel, over $2,000,000 in capital equipment, and a state-of-the-art clean room for pristine assembly, MCN combines manufacturing expertise with a range of advanced and innovative production systems. The company offers a unique in-house machine shop for the milling and drilling of thick metal back and metal core multilayer designs.

Two custom designed CO2 lasers, developed internally using MCN's proprietary technology, incorporate a high-tech vision system for precise, smaller radii cuts on Teflon materials. MCN recently acquired an MKII Plasma Etch System to accommodate high-speed through hole preparation, contributing to overall process consistency. The MKII will be used in processing a variety of boards including mixed dielectrics, multilayers, PTFE and PTFE multilayers of any size and configuration for both the commercial and military markets. The high-speed MKII etching process ensures critical uniformity in board production.

With a broad range of product offerings, expanded capabilities and capacity in assembly and test, plating, precision etching, and internal laser cutting, MCN is now the preferred soft substrate supplier to leading OEMs worldwide.

The future of microwave technology starts at MCN. From concept through production, standard to complex, MCN's investment in cutting-edge equipment, highly-skilled engineering personnel and a customer friendly support team, guarantees complete satisfaction for each customer's unique requirements. The needs of the microwave industry are constantly changing. Modular Components National continues to meet those needs. But the dedication to microwave technology will never change. MCN's commitment to the future will always remain the same.

Products

- Fine Line Etching
- Laser Routing and Drilling
- PTFE and Hybrid Multilayer Construction
- Microstrip and Housing Assembly
- Pre and Post Bonded Circuits with Aluminum Backing
- Screened Resistors, Blind and Buried Vias

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www.modularcomp.com
sales@modularcomp.com
A Woman-Owned Business

Molex Incorporated

Company History: The late Frederick A. Krehbiel founded the Molex Products Company in Brookfield, Illinois, in 1938. He named the company after Molex, a plastic material he developed, and soon was manufacturing a variety of products from this material, including clock cases, flowerpots, valve wheels and salt tablet dispensers.

In 1940, one of Frederick's sons, John H. Krehbiel, Jr., joined Molex and soon recognized the importance of this material's excellent electrical insulating properties. Later in the decade, Molex added metal stamping to its molding processes, resulting in its first connector assembly for Hotpoint/GE home appliances.

In the 1950s, Molex rapidly penetrated the appliance market with its low-cost connector terminal blocks. The company launched its first plug-and-receptacle connector line in 1953. Through the rest of the decade, Molex continued to expand its product offerings in the commercial and consumer goods markets.

In 1960, the company introduced its first nylon plug-and-receptacle line, marking its evolution from a manufacturer of material called Molex to an electronics corporation named Molex.

By 1967, Molex had established an international division, opening its first plant in Japan in 1970 and its second in Ireland in 1971. Today, more than two-thirds of annual Molex revenues are derived from products manufactured and sold outside the United States.

Molex kept pace with the growth of the electronics industry in the 1980s by expanding its product lines to better serve the computer and business equipment markets. The company also established itself as a preferred supplier to the automotive industry.

In the early 1990s, Molex again proved its versatility by entering global growth industries such as telecommunications, industrial automation and premise networking.

More recently, Molex has expanded and strengthened its position in key markets through a variety of strategic acquisitions, as well as organic growth. In 2006, Molex made its largest acquisition to date by acquiring Woodhead Industries, increasing its presence in factory automation and other industrial, harsh-environment applications.

Company Today:

Molex is a leading one-source supplier of interconnect products. Our team of more than 33,000 highly skilled individuals is focused on the design, development and distribution of innovative solutions critical to products that touch virtually every walk of life. Our portfolio is among the world's largest with over 100,000 reliable products, including everything from electronic, electrical and fiber optic interconnect solutions to switches and application tooling.

We leverage extensive worldwide resources to meet customer needs on a local, regional and global level. We have strong, well-established sales, product development and manufacturing resources in Asia, Europe and the Americas. Our engineering, development and manufacturing capabilities are organized into product divisions.

- *Transportation Products Division:* Focuses on interconnection for advanced engine, cockpit and infotainment functions in automobiles and other transportation equipment.
- *Commercial Products Division:* Handles multi-market products for a diverse range of applications. Today, the division focuses its new product development on high-speed, high-density, high-signal-integrity interconnect applications.
- *Micro Products Division:* Known for developing the smallest connectors in the world, focused on the portable digital product applications. The division is headquartered in Japan.
- *Automation and Electrical Products Division:* Specializes in harsh-environment technology for factory automation, power, temporary lighting and ergonomic products in industrial, construction and other applications.
- *Integrated Products Division:* Produces higher-level assemblies utilizing Molex interconnect technologies, typically in printed circuit board, fiber optic, flex circuit, RF and other applications.

Within the Global Integrated Products Division is our RF Products Business Unit. This rapidly growing entity provides RF and Microwave Connectors and Cable Assemblies to a wide range of markets and geographies. In addition to standard coaxial connectors, Molex has developed an impressive offering of multi-port coax and custom solutions.

This business unit is headquartered in Indianapolis, Indiana and also manufactures products in Asia. Our customers and markets are global and cover many applications including wireless infrastructure, telecommunications, computer, automotive, HDTV/video, test and measurement, medical, military and more.

Company Product Categories:

Molex RF Products include a wide range of styles and sizes, from our very small Microcoaxial RF, SSMCX, MMCX and MCX; up to DIN 7/16. Coaxial cable assemblies are available in 50 and 75 Ohm with flexible and semi-rigid cable options.

Contact Information:

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RF Products
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www.molex.com/product/rf.html

narda
microwave-east
an L3 communications company

Narda Microwave: 55 years strong

In February 1953, just a few months after The Saddlemen became Bill Haley and His Comets, four design engineers armed with a $20,000 engineering services contract formed Nassau Research & Development Associates. From these inauspicious beginnings in the back of a machine shop in Mineola, NY, the company steadily broadened its product line from instruments to passive components to multifunction subsystems. It was one of the first microwave manufacturers to exploit the benefits of GaAs-based devices, introducing the world's first 6-to-18 GHz low-noise GaAs FET amplifier. Narda also created the world's first solid-state sweep frequency generator, as well as dozens of other innovations that would propel Narda's sales and influence both in the US and throughout the world. In 1967, Narda became a publicly-traded company on the American Stock Exchange, which further spurred its growth both organically and through acquisition. Narda itself was later acquired by Loral Corp., which later was integrated into Lockheed Martin. When L-3 Communications was formed in 1997 Narda was one of its 10 original business units. L-3 Communications today is the sixth largest defense contractor in the US, with an extremely diversified product and services portfolio and 2007 sales of $14 billion.

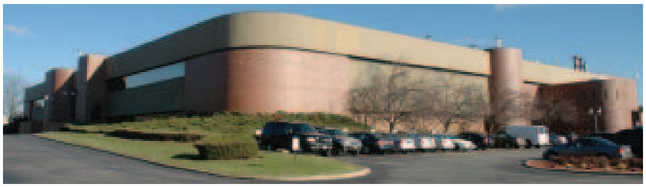
Narda's first facility, in Mineola, NY

Narda Microwave Today

Narda Microwave has a more diversified product portfolio than at any time in its history, and maintains the world's largest inventory of RF and microwave components, many of which are available from stock. Narda designs and manufactures state-of-the-art RF and microwave passive components, microwave integrated circuits (MICs), highly-integrated multi-function assemblies, and complete subsystems over a frequency range of DC to 60 GHz. The company's products are employed in commercial and military applications on land, at sea, in the air, and in space. Narda is also a leading manufacturer of fiber optic modulator drivers and oscillators for OC-768 applications and other products for lightwave applications at up to 100 Gb/s. The company has for decades been the leader in RF safety products for monitoring the compliance of RF and microwave emitters with recognized international standards and guidances. Narda's presence in this area was further strengthened in 2000 with the acquisition of the safety test solutions product group of Wandel & Goltermann. Narda Safety Test Solutions holds 95% of all patents for EMF measurement, and its instruments are considered the standard of reference by industry as well as government agencies worldwide.

Major Products

- Microwave components
- Microwave integrated circuits
- RF safety products
- Satellite communications products



Narda's 150,000 square foot facility in Hauppauge, NY

Contact Information:

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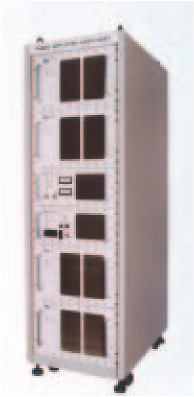
www.nardwamicrowave.com
E-mail: nardaeast@L-3com.com/east

Company History: R&K Laboratory was founded by Reichiro Kobana in August 1977 and began shipping RF double balanced mixers in late 1978. His mission was to develop unique RF and microwave products for academic and commercial applications in Japan.

R&K Laboratory became R&K Company Limited in February 1980, when it began manufacturing custom products for nuclear fusion PLASMA, Very Long Baseline Interferometry, Magnetic Resonance Imaging systems and Electron Spin Resonance. In 1996 R&K started to ship power amplifiers for PHS base stations in response to the fast-growing wireless communications market in Asia. To date the company has shipped more than 2,110,000 power amplifiers for PHS base stations.

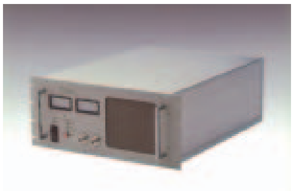
The 8-story main factory was completed in January 2002, with an additional 10-story second factory constructed alongside in August 2004. R&K has a quality management system that operates in accordance with ISO 9001:2000, which was certified by RCJ-QA in February 2007.



Company Today:

R&K currently manufactures small RF components as 8-pin packaged and surface-mountable products, connectorized components, broadband power amplifier products and analog phase shifters. It also manufactures a variety of custom products for frequencies ranging from 10 kHz to 15 GHz at power levels from 1 mW to 10 kW.

The company was also one of the first to release GaN power amplifiers for communication and EMC applications and now proudly supplies state of the art GaN power amplifiers to the worldwide market. The contribution of this technology is to reduce power consumption and manufacturing cost, especially for broadband high power amplifiers.

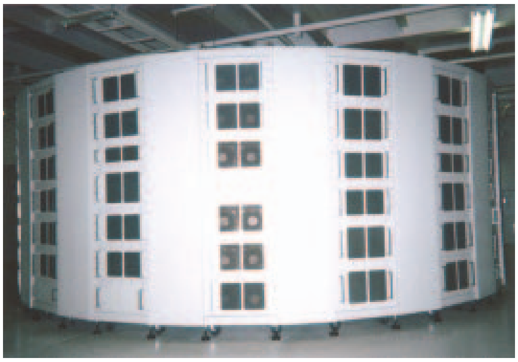


R&K continues to develop new products using the latest technology with the aim of shaping the future development of wireless communication and the RF and microwaves industries.

Company Product Categories:

R&K's main product categories are:

- High Power Test Systems
- Broadband High Power Amplifiers
- Surface Mount Components
- Small Signal Amplifiers
- GaAs FET/GaN Amplifiers



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Reactel, Incorporated

RF & Microwave Filters, Multiplexers, Switched Filter Banks and Sub-Assemblies – DC to 50 GHz

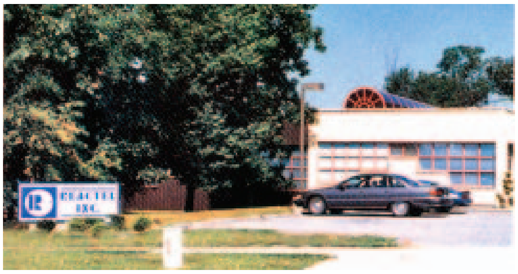
ISO-9001 CERTIFIED

Company History: The roots of Reactel, Incorporated began when founder Emanuel (Manny) Assurian was employed as an Engineer by suburban Washington, DC filter manufacturer I-tel in the mid 1960's. Eventually, Manny was named President of CIR-Q-TEL (I-tel's new name) and remained there for several years. In 1979, Manny decided to go out on his own and formed Reactel, Incorporated. A former colleague, Don Claycomb, joined him in this new venture.
Founded in 1979, Reactel, Incorporated grew from a two man operation located in less than 1000 square feet of manufacturing space into one of the industry leaders in the design and manufacture of RF and Microwave filters, diplexers, switched filter banks and sub-assemblies. Reactel's goal has always been to provide high performance units that are reliable and cost effective. Individual engineering attention and support has been a staple of the company from the beginning. Reactel takes great pride in their thousands of satisfied end-users, which range from other small businesses to large multi-national corporations to prime defense contractors. Reactel has separated itself from other manufacturers by offering hard-to-do, custom, application specific units in a timely fashion. Reactel has the ability to tailor their filters to meet your system's unique requirements.

Manny Assurian.

Company Today:

Building on their first 9 unit order for COMSAT totaling $1086.00, Reactel continues to broaden its customer base and has expanded their list of products offered. Recent additions include "flat pack" combline filters, monoblock ceramic filters and ceramic diplexers. These new products enhance their full line of tubular, LC, cavity, combline, waveguide, and suspended substrate units as well as switched filter banks and integrated sub-assemblies. While the geographic location has hardly changed, the manufacturing space certainly has. Reactel is currently housed in a 15,000 square foot state-of-the-art facility which contains all facets of its operation. As a testament to their focus on quality, Reactel was one of the first filter manufacturers to receive ISO-9001 Certification, having done so in 1996, and maintains that certification to this day.



Company Product Categories:

Reactel manufactures RF and Microwave filters, multiplexers, switched filter banks and sub-assemblies for military, commercial and industrial markets.

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reactel@reactel.com
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Reactel, Incorporated

Then & Now

Since it was established in 1979, Reactel, Incorporated has become one of the industry leaders in the design and manufacture of RF and Microwave filters, diplexers, switched filter banks, and sub-assemblies. During our nearly 30 years of business, we have come to value the leadership that the Microwave Journal has given to our industry, and we congratulate them on their golden anniversary.

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Phone: (301) 519-3660 • Fax: (301) 519-2447
E-mail catalog@reactel.com to receive your Reactel Product Catalog or go online to www.reactel.com to download your copy today.

FM Approvals
ISO 9001-2000 Registered

Visit http://mwj.hotims.com/16343-114 or use RS# 114 at www.mwjournal.com/info

Remcom

Company History: Remcom has been a pioneer in the field of electromagnetic simulation since it was founded in 1994, introducing the first commercial FDTD solution. Raymond Luebbers and his graduate students H. Scott Langdon and Christopher Penney formed Remcom as an extension to the research that they were conducting at the Pennsylvania State University. They discovered that a need existed for a product that combined a user-friendly graphical user interface (GUI) with the power of the Finite Difference Time Domain (FDTD) method. The result is XFdtd®, a full wave 3D electromagnetic solver with unique, true MPI capability.
Using the experience gained in bringing XFdtd to market, Remcom continued to develop additional methods for solving difficult electromagnetic problems and began to offer an even wider array of electromagnetic analysis tools. A continual investment in product development guided by strong customer relationships has enabled Remcom to grow into a market leader in both innovation and providing exceptional service.

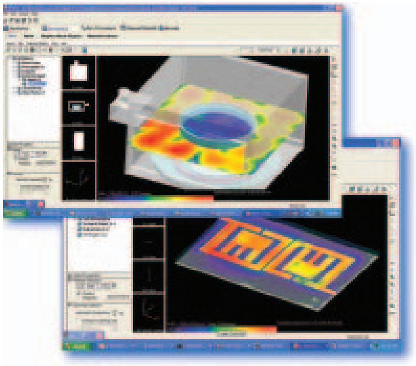
Company Today:

Today, Remcom's products are used by organizations of all sizes, from multi-national corporations to small consulting firms. Our software licensing is flexible enough to accommodate any team structure, from single-office installations to globally accessible license servers. We are proud of our evolution to a full service partner, providing a suite of innovative software and services, accessible and responsive support provided by a staff of experts, and comprehensive training.

Our family of products includes:

- XFdtd®: Allows larger and faster computations than any other solver via the capability of computer clusters.
- XStream®: Acceleration hardware that dramatically shortens the calculation times for many projects, including non-trivial geometries.
- XGtd®: A high frequency GTD/UTD based package for the design and analysis of antenna systems.
- Wireless InSite®: A radio propagation analysis package for analyzing the impact of the physical environment on the performance of wireless communication systems.
- VariPose®: A geometric modeling package for the manipulation and refining of high-resolution human mesh models for the medical and biomedical markets.
- Rotman Lens Designer®: A tool for the design, synthesis, and analysis of Rotman Lenses and their variants based on Geometrical Optics combined with the classical Rotman Lens design equations.

While maintaining focus on our software products, Remcom is also active in consulting and contract efforts. Our Government Services Division develops and maintains government-owned software with applications in radio propagation prediction and general electromagnetic analysis. In addition, Remcom has emphasized a strong focus on providing custom engineered solutions for customers that need specific functionality.



Company Product Categories:

Remcom's technical core competencies are our electromagnetics knowledge base and software development expertise. Our products are used in a wide variety of markets and applications, including:

- Antenna Analysis/Design
- Bio-Medical/EM Effects
- EMC/EMI
- Guided Wave Devices
- Implantable Devices
- Lens Design
- Microwave Circuits
- Photonics
- Ray Tracing
- Scattering
- Specialized Materials and Components
- Ultra Wideband Devices
- Wireless and Radiowave Propagation
- Wireless Communication

As a result of diversified expansion in research and commercial development of our products and services, Remcom has become an established center for innovation. Our business philosophy is to satisfy our customers by delivering exceptional quality, unmatched reliability and state-of-the-art software and services, all backed by our comprehensive customer support.

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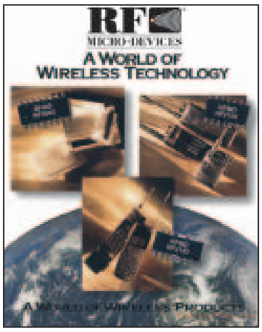
Tel: 814-861-1299
Email: sales@remcom.com
Web: www.remcom.com

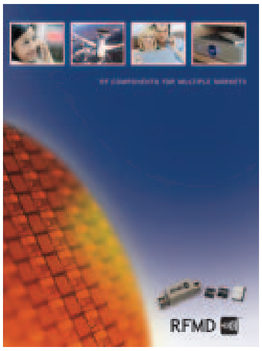
Company History: In 1991, William (Bill) J. Pratt, Powell T. Seymour and Jerry D. Neal founded RF Micro Devices® in Greensboro, North Carolina. Their mission was to bring gallium arsenide (GaAs) heterojunction bipolar transistor (HBT) technology to the burgeoning wireless communications semiconductor marketplace, also in its early stages of growth. By 1995, RFMD® had become a recognized leader in the development of advanced communications technology for cellular handsets, and, by 1996, the Company's GaAs HBT power amplifiers—pioneered by Bill Pratt—had become the gold standard for amplification in digital cellular handsets. RFMD grew rapidly and, in September 2000, *Fortune* magazine recognized RFMD as the second fastest-growing company in America, with revenue of approximately $325 million. In April 2007, RFMD reported revenue of approximately $1 billion.



Soon thereafter, RFMD formed the Multi-Market Products Group (MPG), with the aim of leveraging into multiple industries their leadership in the design and manufacture of RF components and compound semiconductor technologies. In November 2007, RFMD completed the acquisition of Sirenza Microdevices, significantly bolstering its diversification efforts and creating the world's largest, most diversified and best-positioned RF company.

Company Today:

In 2008, RFMD will proudly celebrate its 17th year as a provider of high-performance semiconductor components. In the cellular handset marketplace, RFMD delivers its industry-leading cellular front ends to all of the top-five mobile device manufacturers, with an estimated 45 percent of the world's handsets containing an RFMD power amplifier. RFMD's Cellular Products Group (CPG) remains focused on its core, high-volume cellular front end business while pursuing other opportunities to diversify its cellular components portfolio. CPG's business provides the Multi-Market Products Group (MPG) significant competitive advantages by enabling large scale manufacturing, rich technology innovation and a deep knowledge of system architectures. MPG leverages these strengths to focus on a diverse set of RF, microwave and millimeter wave component opportunities across a broad range of markets, including wireless infrastructure, broadband, Wi-Fi and WiMAX, consumer, and aerospace & defense.



RFMD is a recognized leader in high-performance semiconductor components, supporting multiple industry segments with a total addressable market (TAM) exceeding $20 billion and growing. RFMD continues to expand its product offerings and addressable markets, which leverage its unique core competencies. Its core markets are fast-growing and lucrative, providing the opportunity to increase the value of RFMD for its customers and stakeholders.

Company Product Categories:

- Cellular Front End Components
- Wireless Infrastructure Components
- Broadband/CATV Transmission Products
- Broadband/CATV CPE Products
- Wi-Fi and WiMAX Components
- Aerospace and Defense Components
- Switches/Switch Filter Modules
- PLLs and VCOs
- Microwave Amplifiers
- Low Noise Amplifiers
- High Power Amplifiers
- Passive RF Devices

Contact Information:

7628 Thorndike Road
Greensboro, NC 27409
336-664-1233
www.rfmd.com

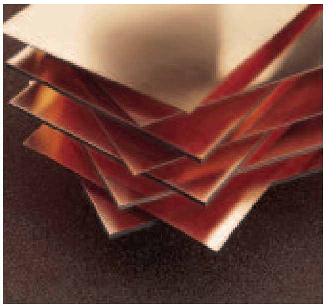
ROGERS CORPORATION

Advanced Circuit Materials

The world runs better with Rogers®.

50 Years of History:

In 1958, when the first issue of *Microwave Journal* came out, Rogers Corporation was already producing products for the nascent electronics market. At the time Rogers' DUROID™ line of fiber-reinforced polymer materials were being used in gaskets and electrical insulation. DUROID brand products like RT/duroid® 5870/5880 and DUROID 5600 went on to find wide usage in military, industrial, computer and electronics applications, making DUROID materials one of Rogers most successful products ever.



The business unit that has come to be known as the Advanced Circuit Materials Division (ACMD) was established in 1966 in Chandler, Arizona, to focus on meeting the growing demand for circuits and materials with excellent electrical, thermal and mechanical properties used in high performance applications. In the 1990s the RO3000® and RO4000® commercial lines of materials were launched to provide designers with a laminate material with strong properties priced to support high volume applications. These product platforms not only extended Rogers' reach in the industry, but enabled application designers to create high functionality consumer products never previously imagined possible.

ACMD Today:

Today, Rogers offers over 50 PCB material types developed to fit thousands of high performance design configurations making Rogers the leading high performance circuit laminate manufacturer in the world. ACMD supports its robust product line with world class design and fabrication support and ISO-9002 registered manufacturing facilities in Arizona and Belgium with a new plant in China under construction.

Rogers takes pride in innovating new materials that meet the evolving expectations of the electronics industry. Rogers Corporation understands the intense competition its customers face and offers unique laminate system solutions to exceed their price-for-performance expectations. ACMD customers include printed circuit board fabricators (from quick-turn prototype shops to high volume corporations) and Original Equipment Manufacturers (OEM) for specialty electronic applications worldwide.

Company Product Categories:

High Frequency/High Performance Laminates

Applications for Rogers' High Frequency Circuit Laminates include linear power amplifiers and antennas for cellular and PCS base stations, low noise block down-converters for direct broadcast satellite television receivers, phased array antennas, radar systems and high performance wireless components. Rogers' high frequency laminates are also used in high-speed digital applications where signal integrity is critical.

Product Brands:

RO4000®, RO3000®, RT/duroid®, ULTRALAM® High Frequency Circuit Materials

Thin Dielectric/Flexible Materials

Rogers' Thin Dielectric/Flexible Materials are used in high layer count printed circuit boards for high speed digital and semi-conductor packaging applications. In addition, they are used in a variety of consumer applications including hard disk drives, cellular phones, laptop computers and PDAs.

Product Brands:

R/flex JADE®, R/flex®, R/flex CRYSTAL® Flexible Circuit Materials, R/flex® 8080 Photoimageable Covercoats

(All Rogers ACMD products are consistent with ROHS directives and China's Electronic Information Products Standard.)

Contact information

Advanced Circuit Materials Division
100 S. Roosevelt Ave.
Chandler, AZ 85226
Phone: 480-961-1382 • Fax: 480-961-4533
e-mail: litacm@rogerscorporation.com
www.rogerscorporation.com/acm

ROHDE & SCHWARZ

Company History: As early as 1932, Dr. Lothar Rohde and Dr. Hermann Schwarz, the company's founders, developed their first measuring instrument, an interference wavemeter. In 1933, they set up shop under the name 'Physikalisch-Technisches Entwicklungslabor Dr. L. Rohde und Dr. H. Schwarz' in Munich (renamed Rohde & Schwarz in 1945). Demand increased continuously, and the step from low-volume to high-volume industrial production was taken. In the 1950s, Rohde & Schwarz soon realized the need to go international as more and more inquiries for its products came from abroad. To expand export business, a global network of independent representatives gradually emerged. This was the basis for steady growth in orders in the 1960s and 1970s, resulting in the need for a second production plant in Teisnach (Germany). 1980 saw another strategic decision in terms of worldwide presence. The company realized that it was better to operate through its own network of subsidiaries. The first phase focused on Europe and continued with the creation and expansion of a worldwide service network, including subsidiaries in the Asia/Pacific, Middle East/Africa, South and North America. Today, the company operates in over 70 countries


The first laboratory in Munich (Germany).

Company Today:

Rohde & Schwarz has stood for quality and precision in test & measurement, broadcasting, secure communications, and radiomonitoring and radiolocation for 75 years. The company is a world market leader in mobile radio and EMC test and measurement equipment as well as terrestrial TV transmitters. The electronics group with headquarters in Munich is also among the leading providers worldwide in all its other business fields. Rohde & Schwarz supplies mobile phone manufacturers and network operators, manufacturers of electronic equipment, TV networks, etc., with innovative solutions and products. The Executive Board is made up of Michael Vohrer (Chairman), Manfred Fleischmann, and Christian Leicher.Approximately 7200 employees currently generate a turnover of 1.4 billion Euros (fiscal year from July 2006 to June 2007). In recent years, the company's main focus has been on expanding its international presence. It operates in over 70 countries and serves more than 90 percent of its market directly. The share of its exports is around 80 percent. The high-tech company thrives on innovation with a good 14 percent of the annual turnover going into research & development.

Company Product Categories:

- Wireless Communications Testers & Systems
- Spectrum & Signal Analyzers
- Signal Generators
- Network Analyzers
- EMC & Field Strength Test Solutions
- Power & Voltmeters
- Audio Analyzers
- RF & Microwave Accessories

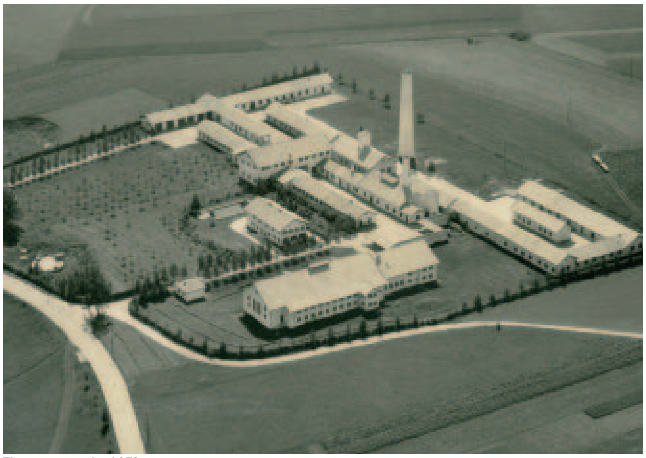
Company headquarters in Munich.

Contact Information:

Customer Support Europe, Africa, Middle East
Tel. +49 1805 12 42 42 or +49 89 4129 137 74
customersupport@rohde-schwarz.com
Customer Support North America
Tel. 1-888-TEST-RSA (1-888-837-8772)
customer.support@rsa.rohde-schwarz.com
Customer Support South America
Tel. +1-410-910-7988
customersupport.la@rohde-schwarz.com
Customer Support Asia/Pacific
Tel. +65 65 13 04 88
customersupport.asia@rohde-schwarz.com
www.rohde-schwarz.com

Rosenberger

Company History: *1958:* The company was initially founded by Hans Rosenberger Senior in a locksmith shop that today forms the custom machining center.
1967: When Mr. Rosenberger bought some turning machines from a bankrupt company he was asked to handle an outstanding order for this company, giving Rosenberger access to high-frequency technology. His three sons; Hans Jr., Bernhard and Peter joined the company in the early 1980s and broadened the company's focus from a German based supplier to the wider European market. In the 1990s, due to the foundation of Rosenberger of North America, Lancaster (Pennsylvania), USA, and the opening of Rosenberger Beijing, China, the company evolved to become one of the world's leading manufacturers of RF coaxial-connectors. Business volumes in the Americas and Asia increased considerably.
2005: Rosenberger is the world leading coaxial connector manufacturer (source: Connector Supplier).
2008: Rosenberger turns 50.


The company in 1973.

Company Today:

Today the company employs more than 2600 people in its 13 strategically located facilities around the world, including The United States, Hungary, Brazil, China and India. Adding to its broad line of coaxial connectors, cable assemblies and related microwave products, the company is a major supplier of FAKRA-RF connectors, the coaxial products standardized by the global automotive industry. Rosenberger OSI Fiber Optic Company further enhances the company's diverse technological base. Today, Rosenberger is a global supplier—with renowned customers all over the world.

Company Product Categories:

- RF coaxial products
- RF test & measurement products
- RF automotive products
- RosenbergerHSD® connectors and cable assemblies (High Speed Data Systems)
- MobilCom infrastructure site solutions
- Cables and cable assemblies
- Fiber optic products


The company in 2007.

Contact Information:

Rosenberger Hochfrequenztechnik
GmbH & Co. KG
Hauptstr. 1
D-83413 Fridolfing
Phone: +49 8684 180
info@rosenberger.de
www.rosenberger.de

Company History: For more than 30 years, the heritage companies which comprise Spectrum Microwave have supplied its defense and commercial customers with innovative and sophisticated RF & Microwave components and assemblies for demanding applications.

Spectrum Microwave originally evolved under the direction of Spectrum Control's CEO Richard Southworth out of their expertise in RF & Microwave ceramic filter and antenna technologies. Spectrum's initial strategic acquisitions in 2002 were FSY Microwave and Salisbury Engineering, both companies were leaders in there own right.

Since then, Spectrum Microwave has grown into a Multi-Million dollar corporation, made up of eight synergistic microwave companies whose mission is to deliver a quality product with exceptional performance. The growth of Spectrum can be attributed to those heritage companies that make up the core of our organization, including Amplifonix, Qbit, Magnum Microwave, Radian Technologies, EMF Systems, FSY Microwave and Salisbury Engineering.

Walt Gordon
(head of Spectrum Microwave).

Company Today:

Spectrum Microwave, a wholly owned subsidiary of Spectrum Control, is now a leader in RF Component & System designs. Spectrum Microwave combined the rich history and talented staff of eight RF & Microwave corporations, into one world class organization.

With 5 East Coast Design/Manufacturing facilities and 2 International Commercial Manufacturing Centers abroad, Spectrum, last year in keeping with industry demands, opened a 250,000 sq. foot facility in State College, Pa. Now, with over 325 employees and 37 engineers, Spectrum Microwave is ideally suited for both specialty prototype designs as well as large multi-thousand piece requirements.

Spectrum is also an innovator in pushing technology even further with new designs everyday, including recent additions of a line of small 4 watt Broadband 2–6 GHz Surface Mount Power Amplifiers, a series of Broadband 0.1 to 22 GHz high +95 dB Isolation Switches, and a brand new small surface mount GPS Filtered Low Noise Amplifier.

Other innovations include a new line of Low Profile, Phase-Matched Multi-octave High Directivity Couplers, a new Series of Low Cost, Low Phase Noise Ku-band DROs, and our popular High Linearity Low Cost Amplifiers.

Company Product Categories:

- Low Phase Noise, Low Noise & Broadband Power Amplifiers
- Cavity, Lumped Element, Ceramic, Coaxial and Waveguide Filters
- Low Loss Mixers, High Isolation Broadband Switches
- Low Phase Noise Broadband VCOs
- DTOs, CROs, PLOs, Synthesizers, Comb Generators, Switch Filter Banks, GPS LNAs, Frequency Sources and Integrated RF & Microwave Assemblies.

Spectrum Microwave's facilities.

Contact Information:

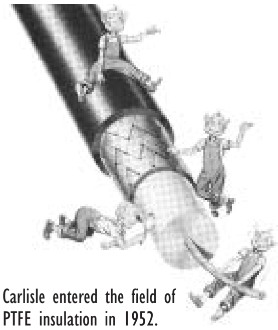
Philadelphia Operations
2707 Black Lake Place
Philadelphia, PA 19154
PH: (888) 553-7531
FAX: (888) 553-7532
info@SpectrumMicrowave.com
www.SpectrumMicrowave.com

INTERCONNECT TECHNOLOGIES

The combination of Tensolite and CARLYLE INC.

Company History:

1940: Tensolite Corporation was founded.
1950: Tensolite Insulated Wire Co., Inc. was founded.
1952: Tensolite entered the field of PTFE insulation.
1960: Tensolite became part of Carlisle Companies, Inc.
1962: Tensolite developed a process to wrap polyimide tapes on wire to produce a tougher, lighter airframe wire.
1985: Tensolite developed a process to extrude and expand PTFE in a continuous process which led to a patented high-speed wire and cable insulation system that is the foundation of our RF/Microwave cable technology.



Carlisle entered the field of PTFE insulation in 1952.

1998: Tensolite acquired VEMCO. High Speed and High Density Cable assemblies such as HDSI® were added to the Product line.
1998: Tensolite acquired QMI. RF/Microwave Cable assemblies and connectors such as Semi-Flex,® Q-Flex,® and Work Horse® test cables were added to the product line.
2000: Tensolite acquired UniTrek. Complex harness assembly capabilities such as Combo D-Sub assemblies and overmolding were added to the product line.
2001: Tensolite acquired Connecting Devices Inc (CDI). RF/Microwave connector manufacturing including the SMP and SSMP® were added to the product line.
2007: Tensolite acquired Dongguan Qiaotou Yichang Wire and Cable Assembly Factory in China. Low cost manufacturing capabilities and Medical cable assembly capabilities were added to the product line.

Company Today:

2008: Tensolite acquired Carlyle Inc. (not to be confused with Tensolite's parent company, Carlisle Companies Incorporated)—a move that will better position our organization to provide our customers with a vertically integrated supplier of complete interconnect solutions.

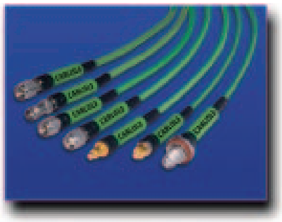
By combining our talented staffs, cutting-edge technologies and state-of-the-art products, we have created Carlisle Interconnect Technologies. While we have changed our name, we are not changing our unwavering commitment to our customers. Carlisle Interconnect Technologies' value proposition to its customers is founded on the proven principles of both Tensolite and Carlyle, Inc. By doing business with Carlisle Interconnect Technologies, you will realize:

- Interconnect solutions encompassing every facet of design and production.
- Advanced engineering services, design prototyping and state-of-the-art testing.
- Industry leading lead-times and superior cost efficiency through lean manufacturing techniques, just in time scheduling, and dock-to-stock systems.
- Global Manufacturing Capabilities including Low Cost Manufacturing through our world-class facility in China.
- Long term focus on emerging technologies and new opportunities as they come to light.

This strategic combination has only strengthened our commitment to customer service and delivering leading edge interconnect solutions to you our valued customer. We thank you for your support.

Company Product Categories:

RF/Microwave Connectors, RF/Microwave Coax Cable, RF/Microwave Cable Assemblies for Military Electronics, Aerospace Wire & Cable, Aerospace Assemblies, Electronic Manufacturing Services, Test & Measurement, Defense Electronics, Aerospace, Medical and other Specialty Applications.



Carlisle specializes in phase stable high frequency interconnect solutions.

Contact Information:

2400 Grand Ave.
Long Beach, CA 90815
(866)282-4708 Toll Free • (562)494- 0955 Fax
Email: rfassembly@tensolite.com
www.carlisleit.com

Company History: TNO Defence, Security and Safety provides innovative contributions towards the advance of comprehensive security and is a strategic partner of the Dutch Ministry of Defence, with the objective of expanding the defence knowledge-base. We employ this acquired knowledge for and together with contractors. The company focuses on defence in the broadest sense of the word and our involvement covers a range of activities: military operations, military equipment, command & control and operational decision making, threat and protection, and instruction and training. In the area of Security and Safety, the emphasis is on combating crime, catastrophe and terrorism.

TNO Defence, Security and Safety also works for the aviation and maritime sectors, which are markets where our knowledge can be put to good use. In terms of aviation, we concentrate largely on improving safety while for the maritime sector the focus is on naval architecture. We collaborate with the defence industry and with small and medium-sized enterprises to develop innovative solutions.

F. (Frank) L.M. van den Bogaart, MSc
Manager Research, Business Unit Observation Systems.

Company Today:

The know how base Front-Ends (F/E) concentrates on the design and development for firstly the Ministry of Defence and the Armed Forces and secondly for OEMs and ODMs in the field of Electronic systems. The company focuses on integrated key front-end technologies (i.e., radome, FSS, antenna and microwave electronics) for current and future radar and other electronic systems. We specifically focus on array systems that operate at RF frequencies. The combination of the 'arrayed' property with the 'RF' property means that solutions need to be realised within a limited volume. The main challenges associated to the front-end of these systems are hence integration, electromagnetic coupling and thermal design.

The KHB Front-Ends knows how to combine and design in different technologies and material systems to realise optimal electromagnetic sensor systems by correctly choosing Front-End technology and shows leadership in this field.

Company Product Categories:

Our activities include RF miniaturisation, MMIC design and test, semiconductor characterisation, antenna element design, array system design, digital beamforming, microwave photonics, IED protection and sub-system specification.

Contact Information:

TNO Defence, Security and Safety
PO.Box 96864, 2509 JG Den Haag
The Netherlands
Tel: +31 70 374 00 00
www.tno.nl, info-denv@tno.nl

DARMSTADT UNIVERSITY: CELEBRATING 125 YEARS OF ELECTRICAL ENGINEERING

History is often shaped by seemingly unlikely and largely unheralded sources and that is certainly the case for Darmstadt University. From the early 1880s this university, in the relatively poor state of the Grand Duchy of Hesse, Germany, played a significant role in the development of electrification, invented the 'Electrical Engineer', shaped relationships between academic research and industry, and forged institutional links that have impacted on both sides of the Atlantic.

The university's origins begin with the Höhere Gewerbschule (Higher Trade School), which was founded in 1836, followed by the Technische Schule (Technical School) in 1864 and the Großherzoglich Hessische Polytechnische Schule (Grand Ducal Hessian Polytechnic) in 1868. In 1877 Ludwig IV, Großherzog von Hessen und bei Rhein (Grand Duke of Hesse), named the Polytechnic School, Technische Hochschule zu Darmstadt, raising the status of the educational institution to that of a university. By 1882, however, in the wake of recession, student numbers had declined by 60 percent and TH Darmstadt was threatened with closure.

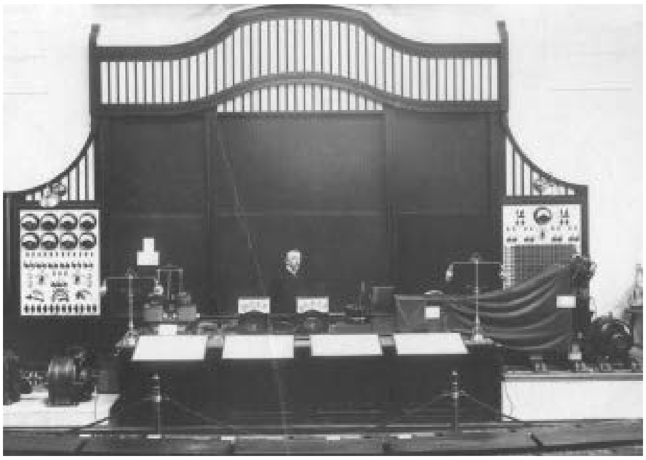
However, recognising the growth of industrial and technological development at the time in Europe in general and Germany in particular, the university took a leap of faith to appoint physicist Erasmus Kittler as Professor of Electrical Engineering in 1882. Consequently, in 1883, the very first School of Electrical Engineering was established and the 'electrical engineer' was 'invented'. This initiative contributed to a rapid rise in overall student numbers and to the growing international reputation of TH Darmstadt as a first class institution for the training of engineers.

The establishment of the School of Electrical Engineering separated the subject from the traditional disciplines of physics and mechanical engineering and brought it within the range of academic disciplines at the still young technical universities in the German Empire. The course extended over four years of study that included a final examination, but what was innovative was the emphasis on practical work. In addition to laboratory courses, Kittler took his students on field trips to study power stations, transmission networks and even the newly established Sachsenhausen electrical railway.

Kittler was not only the academic chair but also, through his expertise, played a role in the electrification of Darmstadt. Electricity was the 'high technology' of the 1880s and 1890s. Kittler was instrumental in the development of a public power station, which was constructed by Siemens as a DC network and began operation in 1888. Through such activity Kittler developed the 'Darmstadt Model'—a close cooperation between teaching and research and he consulted on planning public as well as private networks all over Germany and in many parts of Europe.

The School of Electrical Engineering attracted engineering students and associates that

RICHARD MUMFORD
Microwave Journal *European Editor*



▲ *Fig. 1 Erasmus Kittler in a lecture theatre with his equipment.*

would make and shape the industrial world. In 1884 Carl Hering, a mechanical engineer from the US, commenced his studies in electrical engineering as Kittler's first research associate. In 1902 he was co-founder of the American Electrochemical Society and in 1908 he developed the Heringscher Versuch (Hering's Experiment).

His successor as a research associate between 1885 and 1887 was Michael von Dolivo-Dobrowolsky who was born in St. Petersburg, but moved to Germany to escape the Russian revolution. In 1888 he invented the first practical three-phase motor with AEG and is famous for establishing the notion of three-phase current. Also, in 1891 he constructed the world's first long distance transmission of electrical energy, delivering 15,000 V over 175 km.

Kittler's successor was Waldemar Petersen, who is said to have paved the way for high-voltage engineering and invented, among other things, the Petersen Coil. Karl Wirtz was appointed as the first Chair for Communications Engineering in Germany in 1894. His successor, Hans Busch, established the Institute of Telecommunications and his discovery of the electronic lens in 1926 laid the foundation for the invention of the electron microscope.

Such achievements and notoriety attracted an extraordinarily large number of foreign students to TH Darmstadt. In 1906, for instance, as many as 75 percent of the electrical engineering students were from abroad, mainly from eastern Europe states.

Educational reform after World War I impacted on the university, extending the curriculum beyond purely technical education in order to prepare the engineer for his leading role in society. However, in 1933 the university was brought in line with Germany's national policy during the Nationalsozialistische Diktatur (National Socialist Dictatorship). As early as October 1933 the new constitution according to the 'Führerprinzip' (Leadership Principle) came into force; the Dean became the Führer of the university, appointed by the Führer of the state.

After World War II the university endeavoured to maintain its position at the forefront of development and embrace evolving technologies. Karl Küpfmüller, who developed the theory of Signals and Systems for Communications Engineering, was appointed in 1952. The university took the lead in Federal Republic of Germany establishing the first Chairs in the country in Control Engineering (1957), Electromechanical Design (1963), Power Electronics (1963) and Computer Science (1964).

The post-war period of reconstruction in Germany was largely based on

▲ *Fig. 2 TU Darmstadt today.*

a major development programme in the 1960s, through which universities and the state reacted to the continuously rising numbers of students. TH Darmstadt was affected by university reform in 1968, and in 1970 the 'Hessisches Hochschulgesetz' (Higher Education Laws of the Federal State of Hesse) came into force.

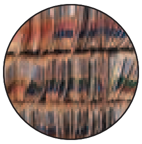
From then until the end of the century the university continued to see significant initiatives. In 1977 Thomas Weiland developed the Finite Integration Technique, which amongst other things allows the computation of electromagnetic fields in the human body. In 1988 Ottmar Kindl and Werner Langheinrich developed Cryogenic temperature CMOS Technology for cameras in the European Space Agency (ESA) Infrared Space Observatory (ISO). In 1996 the first Chair for Renewable Energy in Germany was established, and in 1999 Markus Anders, Egon Christian Andresen and Andreas Binder developed the Linear Power Train of the NASA Stratospheric Observatory for Infrared Astronomy (SOFIA).

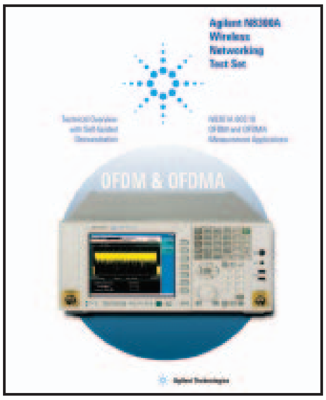
With the objective of sharpening public awareness of the university's status at home and abroad, TH Darmstadt was renamed Technische Universität Darmstadt (Darmstadt University of Technology or TU Darmstadt) on October 1, 1997, and on January 1, 2005, it became the first public German university to be given administrative autonomy. New administrative structures were put into place, which means the university can autonomously administer its budget and buildings. It can also hire professors and negotiate their salaries (formerly this was done by the State of Hesse).

2008 sees TU Darmstadt celebrate 125 years since the world's first School of Electrical Engineering was established and the world at large should celebrate the university's contribution to academic and technological advancement. ■

ACKNOWLEDGMENTS

The author would like to acknowledge Dr. Martin Timm, Marketing Director of CST, for instigating this article and for his help with research and translation, and also Darmstadt University for its support.





Demonstration Guide

A new technical overview with a self-guided demonstration is now available for WiMAX test developers and application engineers. The guide shows how the Agilent N8300A wireless networking test set can be used with the Agilent N6301A 802.16 OFDM and OFDMA measurement applications and the Agilent N7615B Signal Studio software to expedite transmitter and receiver test development, lower costs and shorten time to market. "Agilent N8300A Wireless Networking Test Set" can be viewed and downloaded at http://cp.literature.agilent.com/litweb/pdf/5989-7609EN.pdf.

Agilent Technologies Inc.,
Santa Clara, CA (800) 829-4444, www.agilent.com.

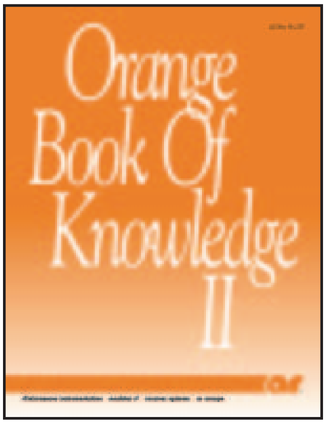
RS No. 310

Product Guide

This new software product guide and application literature on CD presents the features and capabilities of the company's LINC2 RF software suite. Included is a menu of topics on RF and microwave circuit design and analysis spanning a wide area of interest. Interactive presentation software guides the viewer through LINC2's circuit design, synthesis, simulation and verification solutions.

Applied Computational Sciences LLC (ACS),
Escondido, CA (760) 612-6988, www.appliedmicrowave.com.

RS No. 311

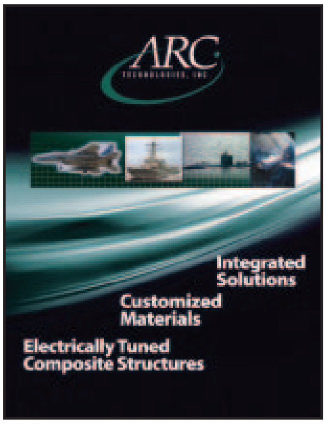


AR's Orange Book of Knowledge: 2nd Edition

The second edition of AR's "Orange Book of Knowledge" is now available. The book contains articles and application notes on a wide range of topics and applications – from the importance of mismatch capability to testing beyond specs and everything in between. The second edition includes a DVD of web demo videos as well as many new application notes and reference materials.

AR RF/Microwave Instrumentation,
Souderton, PA (215) 723-8181, www.ar-worldwide.com.

RS No. 312



Capabilities Brochure

This brochure outlines the company's capabilities as a leading developer of microwave-absorbing materials and electrically tuned composite structures for use in commercial and defense applications. The six-page brochure showcases ARC Technologies' extensive capabilities and processes; expertise in advanced materials for both functional and material property requirements; in-house testing and analytical methodologies; and advanced equipment.

ARC Technologies,
Amesbury, MA (978) 388-2993, www.arc-tech.com.

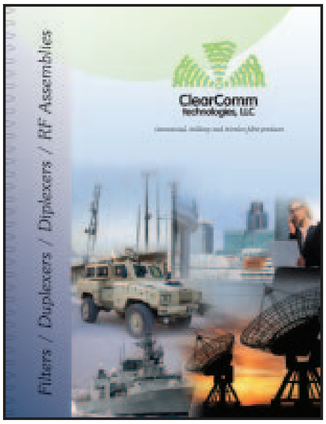
RS No. 313

Fast Pulse Test Solutions

This four-page web guide and short form catalog 17S outlines the company's large family of high speed (40 ps to 100 ns rise time), high current (0.1 to 500 Amp) and high voltage (2 to 3000 V) pulse generators, drivers and amplifiers for research lab and production testing applications. Pulsed laser diode and discrete semiconductor device switching time applications are extensively highlighted along with ten other application areas.

Avtech Electrosystems Ltd.,
Ottawa, Ontario, Canada (613) 226-5772, www.avtechpulse.com.

RS No. 314



Product Catalog

ClearComm Technologies LLC, a designer and manufacturer of RF and microwave filter products for the military, commercial and wireless markets, has released a new product catalog featuring a complete line of cavity and discrete element filters covering the frequency range of 1 MHz to 20 GHz. The catalog features information about ClearComm including contact information and customer service. To download the catalog, visit www.clearcommtech.com.

ClearComm Technologies LLC,
Fruitland, MD (410) 860-0500, www.clearcommtech.com.

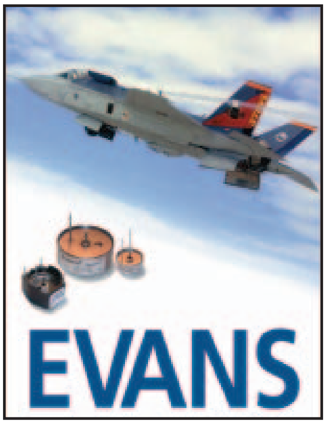
RS No. 315

Technical Computing

COMSOL News 2008, the newest edition of COMSOL's technical magazine, is available as a PDF download from the company's web site. A printed copy of the annual magazine is also available upon request. Both versions are free of charge. The 36-page *COMSOL News 2008* covers a broad range of user-focused articles demonstrating how scientists, engineers and researchers worldwide use the COMSOL Multiphysics® scientific software environment.

COMSOL Inc.,
Burlington, MA (781) 273-3322, www.comsol.com.

RS No. 316



Hybrid Capacitors Catalog

This catalog features the company's Hybrid® Capacitors that have been specified in numerous systems throughout the F-35 Joint Strike Fighter. Hermetically sealed, tantalum Hybrid Capacitors have more than 4× the energy density of other military-style capacitors. These capacitors are found in laser targeting, communications modules, controls, cockpit displays, phased-array radars, fire control systems and elsewhere on many advanced commercial and military aircraft.

Evans Capacitor Co.,
East Providence, RI (401) 435-3555, www.evanscap.com.

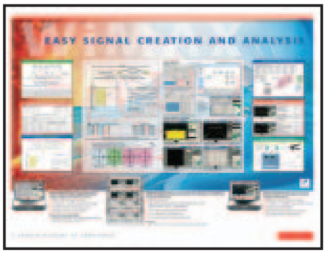
RS No. 317

Product Selection Guide

Hittite Microwave's Product Selection Guide summarizes over 625 products, including 63 new products not included in Hittite's 2008 Designer's Guide Catalog. The selection guide organizes the company's portfolio by product line as well as by market applications including: broadband, cellular, microwave and mmWave, fiber optic, military and space. Full specifications for each product are available at www.hittite.com or a CD-ROM may be ordered.

Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343, www.hittite.com.

RS No. 318

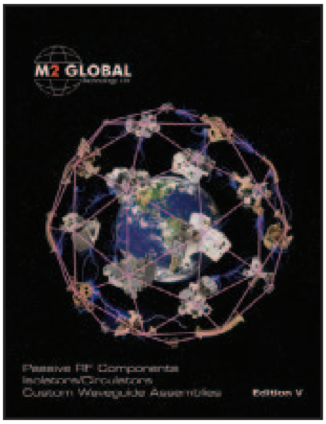


WiMAX Technology Poster

A free WiMAX technology poster is available upon request from Keithley Instruments Inc., providing an overview of the company's RF testing solutions, including the Series 2800 Vector Signal Analyzers and Series 2900 Vector Signal Generators. To request a free copy, visit www.keithley.com/at/554.

Keithley Instruments Inc.,
Cleveland, OH (800) 588-9238, www.keithley.com/at/554.

RS No. 319



RF Products Catalog

The Edition V of the RF Components catalog features a full line of isolators, circulators, power dividers and combiners. In addition, M2 Global offers a complete line of RF waveguide assemblies and products including custom waveguide sections, E and H waveguide bends, terminations, directional couplers, mitered bends, adapters, filters, diplexers and custom field installation kits. M2 Global's products cover frequency ranges from 1.7 GHz (WR430) to 60 GHz (WR19).

M2 Global Technology Ltd.,
San Antonio, TX (210) 561-4800, www.m2global.com.

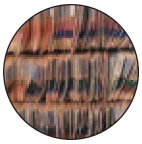
RS No. 320

Precision Frequency Sources

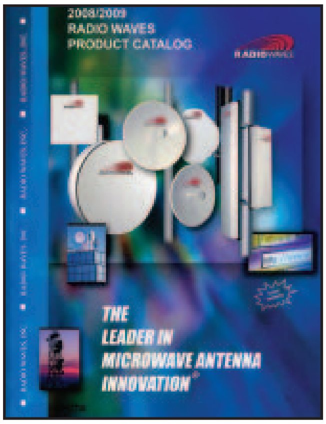
This catalog describes the company's complete line of PTS frequency synthesizers. These synthesizers produce fast-switching, low phase-noise precision frequencies. With easy remote programming they are vital in advanced measurement or production systems and also serve as stand-alone test equipment. Numerous options and accessories that can be combined to provide a product that will closely match custom specifications are included.

Programmed Test Sources Inc.,
Littleton, MA (978) 486-3400, www.programmedtest.com.

RS No. 321



Catalog Update



Product Catalog

This new catalog includes new products such as Radio Waves' complete family of WiMAX antennas, new sector, Xcelarator™ panel and omni antennas for 4.9 GHz public safety networks, new high performance parabolic antennas for the 4.9 and 5 GHz bands, and new high frequency licensed band antennas. For a free copy, e-mail sales@radiowavesinc.com.

Radio Waves Inc.,
N. Billerica, MA (978) 459-8800, www.radiowavesinc.com.

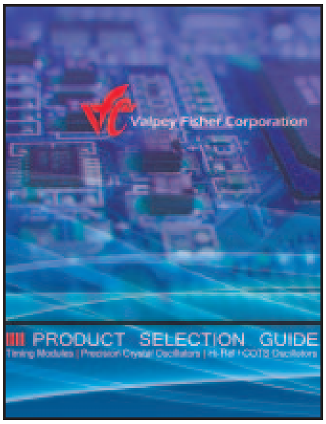
RS No. 322

Short Form Power Divider Catalog

This catalog provides a comprehensive listing of DC to 40 GHz standard designs as well as the company's capabilities to customize in accordance with your specifications. RLC has designed and manufactured a wide variety of power dividers for both commercial and military applications.

RLC Electronics Inc.,
Mount Kisco, NY (914) 241-1334, www.rlcelectronics.com.

RS No. 323



Timing Modules and Oscillators

From discrete high precision crystal oscillators to highly integrated low noise timing modules, Valpey Fisher offers a broad array of frequency control products needed in advanced timing applications including wireless and wireline infrastructure, avionics, test and measurement, and military communications. This product catalog is filled with the latest innovative timing and frequency control products, including timing modules–jitter attenuators, frequency translators and clock generators.

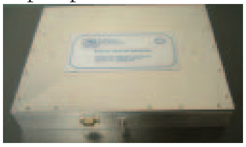
Valpey Fisher Corp.,
Hopkinton, MA (800) 982-5737, www.valpeyfisher.com.

RS No. 324

COMPONENTS

SP32T Switch with Decoder

The model MSN-32DT-05-DEC-MP is a port-to-port phase matched, SP32T switch, with options 100M20, PM10 that operates within a frequency range from 100 MHz to 20 GHz. The switch offers an amplitude balance of ±1.2 dB maximum and is phase matched to ±10° maximum. The switch has a five-bit binary TTL compatible decoder. Insertion loss is 3 dB typical (14 dB maximum), isolation is 80 dB typical (70 dB minimum) and VSWR is 2.0. Size: 13" × 10" × 2".

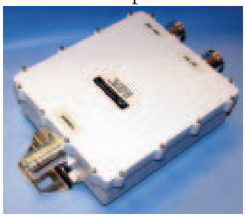


American Microwave Corp., Frederick, MD (301) 662-4700, www.americanmicrowavecorp.com.

RS No. 216

AWS Band Duplexer

The model CCDP-620-1 is a highly selective, AWS band duplexer that offers low insertion loss combined with specific, out of band rejection. The unit has been specifically designed for high rejection of channels in the 850 (AMPS) and 1900 (PCS) bands. Power handling is 500 W average or CW and 12.5 kW peak. The approximate size of the unit is 4.5" × 5" × 2". 7/16 DIN female connectors are provided on the unit. Mounting options include rack mountable, ladder suspension as well as customized mechanical configurations. An outdoor, weather-sealed option is also available.



ClearComm Technologies LLC, Fruitland, MD (410) 860-0500, www.clearcommtech.com.

RS No. 218

Ka-band Up/Down Converter Assembly

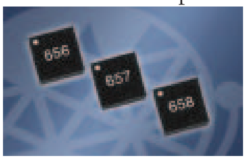
The model SSS-35251105-R1 Ka-band up/down converter assembly is a custom designed system. It operates in an anechoic chamber in order to simulate a radar receiver with realistic target echoes. The system includes four transmitter channels (up converter), one receiver channel (down converter), detectors, control circuitry and DC power supplies. The system operates in a frequency range from 33.3 to 36.3 GHz RF and 4.3 to 5.3 GHz IF. The receiver channel has gain of greater than 40 dB and noise figure of 5 dB, while the transmitter P1dB varies from +20 to +32 dBm with different channels according to requirements. The assembly is in the standard rack mountable box with dimensions of 19" × 7" × 19".

Ducommun Technologies Inc., Carson, CA (310) 847-2859, www.dt-usa.com.

RS No. 219

Wideband Passive Attenuators

The HMC656LP2E, HMC657LP2E and HMC658LP2E are passive wideband fixed value SMT 50 ohm matched attenuators that offer relative attenuation levels of 10, 15 and 20 dB, respectively. Housed in compact 2 × 2 mm plastic SMT packages, these wideband fixed attenuators can handle up to +25 dBm of RF input power, while maintaining excellent attenuation accuracy and VSWR performance versus frequency over the DC to 25 GHz frequency range. These fixed attenuator devices are an ideal choice for use in a wide range of applications including microwave radio, military, fiber optics, scientific instruments and general engineering prototypes.



Hittite Microwave Corp., Chelmsford, MA (978) 250-3343, www.hittite.com.

RS No. 220

Wireless Duplexer Assemblies

These antenna duplexer assemblies utilize K&L's state-of-the-art filter design expertise. The duplexers are combined in a single assembly providing high power transmit filtering, extended stop band to 12.5 GHz and high accuracy power monitoring. The receive side filtering includes a dual gain LNA. The filter and LNA have total noise figure as low as 2 dB, while maintaining an output intercept point over 40 dBm.

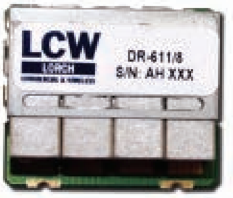
K&L Microwave, Salisbury, MD (410) 749-2424, www.klmicrowave.com.

RS No. 221

NEW WAVES

600 MHz WMTS Filter

Lorch Commercial and Wireless offers model DR-611/8, a ceramic filter that covers the wireless medical telemetry service (WMTS) frequencies from 608 to 614 MHz.



The filter exhibits less than 3.5 dB of insertion loss across the passband while providing greater than 50 dB of rejection at 551 and 671 MHz. The unit measures approximately 1.10" × 0.87" × 0.30" and is available from stock.

Lorch Microwave,
Salisbury, MD (410) 860-5100,
www.lorch.com.

RS No. 222

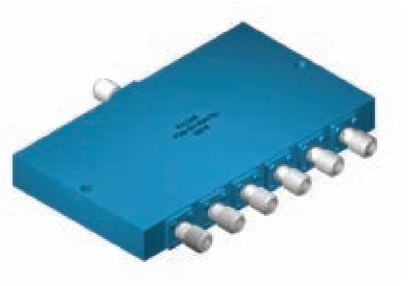
2.4 to 5.8 GHz Frequency Transverter

The RFMD ML5825 frequency transverter is designed to upconvert transmitted 2.4 GHz signals to 5.8 GHz and downconvert received 5.8 GHz signals to 2.4 GHz and is specifically optimized for streaming video applications. The addition of this frequency translation functionality to a pre-existing 2.4 GHz ISM band radio allows original equipment manufacturers (OEM) to quickly bring to market products for operation in the 5.8 GHz ISM band, including digital cordless phones and custom wireless data systems such as streaming audio and video appliances. The ML5825 is packaged in a 4 × 5 × 0.9 mm, 28-pin QFN package and is priced at $1.46 each, in quantities of 10,000 units with samples available immediately.

RF Micro Devices,
Greensboro, NC (336) 664-1233,
www.rfmd.com.

RS No. 225

Six-way Power Divider



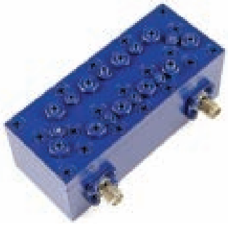
Pulsar P/N PS6-51-434/3S is a new six-way power divider that operates in the frequency range from 12 to 22 GHz with 2 dB insertion loss, 15 dB isolation and input/output VSWR of 1.8 maximum. Amplitude and phase balance are 0.8 dB and 10 degrees, respectively. Outline dimensions are 2" × 3.5" × 0.4" and SMA female connectors are utilized.

Pulsar Microwave Corp.,
Clifton, NJ (973) 779-6262,
www.pulsarmicrowave.com.

RS No. 223

L1 and L2 Dual GPS Cavity Filter

Reactel part number DF-1227/1575-S11 is a narrowband dual filter that passes both the L1 and L2 GPS frequencies.



It is the perfect unit for applications that are utilizing both of these GPS bands simultaneously, yet can only tolerate a two-port device. This small unit features loss of less than 1 dB and isolation in excess of 40 dB. The company manufactures many different varieties of GPS filters; contact Reactel for your specific needs.

Reactel Inc.,
Gaithersburg, MD (301) 519-3660,
www.reactel.com.

RS No. 224

Air Dielectric Directional Couplers

These miniature air dielectric directional couplers are rugged lightweight devices that offer lower insertion loss than comparable stripline units.

The simplified construction allows for greater flexibility in creating customized configurations. Any port can be used as the input with these symmetrical devices. The standard units are available with a choice of coupling values and frequency ranges and an optional termination.

RLC Electronics Inc.,
Mount Kisco, NY
(914) 241-1334,
www.rlcelectronics.com.

RS No. 226

High Frequency Contacts

To meet the requirements of customers looking to simplify system level interconnect, SV Microwave introduces a new family of high frequency contacts for Series 1 and 3 MIL-DTL-38999 connectors.

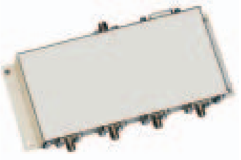
Based on SV's proven blind mate technology to accommodate misalignment during mating, the product line consists of size 8 contacts with the option of 18 or 40 GHz performance and size 12 contacts operating to 65 GHz, all of which fit into standard cavities and are fully removable using standard extraction tools. Designs are available for common cable sizes; custom versions can be produced for special cables and PCB mount applications.

SV Microwave Inc.,
West Palm Beach, FL
(561) 840-1800,
www.svmicrowave.com.

RS No. 227

Broadband Solid-state Switch

The model PS-4.2/2S-5V-TTL-R is a solid-state non-reflective RF switch that features a frequency range of 1 MHz to 4.2 GHz.



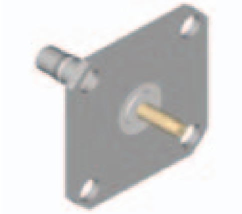
This model has a switching speed of < 100 ns and the isolation is > 50 dB at 4.2 GHz. Insertion loss is 4 dB maximum and the operating temperature range is 0° to +70°C. The 1P2T configuration features SMA female connectors on all ports and a DB-9 for the TTL control interface. Applications include: automated switching systems, switch matrices and manufacturing test systems. Standard delivery is five to six weeks.

Trilithic Inc., Indianapolis, IN (317) 895-3600, www.trilithic.com.

RS No. 229

QMA Adaptor

This QMA adaptor is designed for use with the Bird Electronics Watt Meter. The four-hole



flange-mount QMA jack is designed to Bird Electronics specifications for connectors that mate to its bench top Watt Meter. The new adaptor designated 3191-202EA complements the SilverLine-QMA, quick mating test leads and adaptors that replace aging BNCs in two-way radio test applications. Features include: push on, pull off fast mating interface; rugged, stainless steel construction; 5000 mate life cycle; 360° rotation of DUT with little or no RF performance change; extremely accurate, consistent insertion loss and low VSWR.

Times Microwave Systems, Wallingford, CT (203) 949-8400, www.timesmicrowave.com.

RS No. 228

WiMAX Dual SPDT Switch

This low-cost, RoHS compliant, SPDT switch is for applications requiring fast settling time,

low insertion loss and high isolation. The M/A-COM MASW-008899 is designed for use in 802.11 and 802.16 WLAN and WiMAX applications with a bias voltage as low as 3 V. The MASW-008899, with its low leakage current and low gate lag, offers excellent switch settling where multiple switches and high data rates are critical for optimal system performance. The MASW-008899 features a typical insertion loss of 0.4 dB at 2.4 GHz while achieving an isolation of 27 dB and P1dB of 28 dBm. The M/A-COM MASW-008899 is available from stock and is priced at $0.34 for quantities of 100,000.

Tyco Electronics, Lowell, MA (800) 368-3277, www.tycoelectronics.com.

RS No. 230

AMPLIFIERS

4 W Amplifier

The model SM1025-36MQ2 is a GaAs FET amplifier designed for various applications.

The unit operates in a frequency range from 1 to 2.5 GHz with a P1dB of +36 dBm. Small-signal gain is 10 dB with a flatness of ±0.5 dB across the band. Standard features include a single +12 VDC supply and over/reverse voltage protection. Optional features include TTL on/off and RF bypass mode. The unit measures 4" × 2" × 0.54".

Stealth Microwave Inc., Trenton, NJ (609) 538-8586, www.stealthmicrowave.com.

RS No. 234

Power Amplifier

The AWT6309 is a linear power amplifier (PA) designed specifically for use in CDMA wireless handsets and data devices that operate in 1.7 GHz bands.

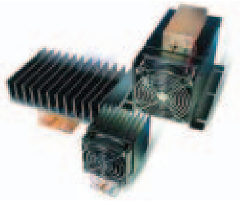
The new PA is designed to be compatible with Qualcomm CDMA2000™ and EVDO™ chipsets. The newest member of the ANADIGICS family of HELP2™ CDMA power amplifiers, the AWT6309 reduces average current consumption as much as 50 percent, compared to conventional two-stage amplifiers. The new amplifier's power saving feature is the result of ANADIGICS' proprietary designs and unique InGaP-*Plus*™ technology. This semiconductor process integrates switches and amplifier components onto the same die thus enabling creative new architectures and solutions for product designers and engineers. Measuring 3.0 × 3.0 mm with a height of 1.0 mm, the AWT6309 enables designers to create ultra slim and compact products.

ANADIGICS Inc.,
Warren, NJ (908) 668-5000,
www.anadigics.com.

RS No. 231

High Power Amplifiers

Heavy duty, ruggedness and reliable operation to meet demanding communication applications describe Mini-Circuits' collection of 5, 10, 20, 50 and 100 W ZHL high power amplifiers.



Covering 20 MHz up to 2 GHz, these broadband solutions are available with or without integrated heat sink/fan to fit custom system requirements. Each amplifier operates with low current consumption and is designed to work off a single +24 V DC supply, including the fan. Price: from $945.00 each (Qty. 1–9).

Mini-Circuits,
Brooklyn, NY (718) 934-4500,
www.minicircuits.com.

RS No. 232

Broadband High Power Amplifier

The model AMF-6B-06001800-70-40P-PS is a self-cooled 3RU rack-mount high power amplifier (PA) that operates in a frequency range from 6 to 18 GHz and delivers approximately 10 W of power. The SMA connectorized box is 3.47" high, 16.99" wide excluding brackets and 12.12" deep including fans. This model can be horizontally or vertically mounted. Housing is EMI shielded, CE certified and can operate in ambient temperature up to 50°C. The PA includes over temperature protection in addition to full internal regulation. DC on/off switch is optional as is input connector through the front panel.

MITEQ Inc.,
Hauppauge, NY (631) 436-7400,
www.miteq.com.

RS No. 233

ANTENNA

Blade Antenna

The model 11C23300 is a high performance, robust blade antenna qualified for supersonic flight.

This L-band (960 to 1220 MHz) antenna features omni-directional azimuth coverage, gain of a quarter wave monopole (3 dB peak), vertical polarization and low VSWR. It has been designed and qualified for use aboard new aircraft with signature control requirements. This antenna includes a single coaxial connector, a flat conductive base plate for easy installation and an all metallic antenna design. The antenna is designed to withstand high aerodynamic loads. The antenna employs sealed construction and rain erosion antistatic coating.

Cobham Defense Electronic Systems – Nurad Division,
Baltimore, MD (410) 542-1700,
www.cobhamdes.com.

RS No. 235

NEW WAVES

DEVICE

Schottky Detectors 0.5 to 40 GHz

The CSM, CST and CSP Series Schottky Detectors provide a comprehensive line of detectors covering most applications. These three AC coupled biased Schottky detector designs may be optimized for frequency range, voltage sensitivity, flatness or VSWR parameters. The CSM series provides a broadband, high voltage sensitivity and good flatness response, with a low video impedance of 350 Ω at 150 microamps of bias. The CST series provides high voltage sensitivity, good VSWR at both low and high input power levels, and excellent flatness response. The CSP series offers low VSWR response at both low and high input power levels over broadbands, exceptional flatness response, but with the performance trade off of lower voltage sensitivities when compared to the CSM and CST.

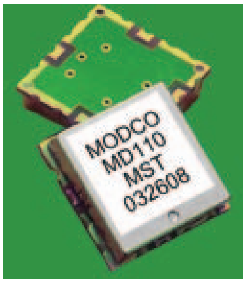
Microphase Corp.,
Norwalk, CT (203) 866-8000,
www.microphase.com.

RS No. 236

SOURCES

Voltage-controlled Oscillators

The MD series of economical voltage-controlled oscillators (VCO) offer low phase noise in the industry standard one half inch square package. Model MD110MST operates in a frequency range of 1175 to 1275 MHz and is rated –118 dBc at 10 kHz offset. Many other catalog models are available and custom designs can be supplied with no NRE.

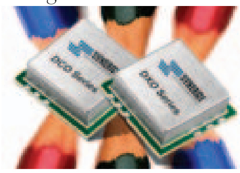


Modco Inc.,
Sparks, NV (775) 331-2442,
www.modcoinc.com.

RS No. 237

Mini Voltage-controlled Oscillators

The DCO and DXO micro series of miniature voltage-controlled oscillators (VCO) are designed for C-band and X-band applications. These VCOs are based on Synergy's proprietary patented technology and



patents pending, which enhances bandwidth, reduces phase noise and improves immunity to phase hits. Several models are available with starting frequency at approximately 4 to 10 GHz, in tuning bandwidths of approximately 1000 MHz, and tuning voltages ranging from 0 to 24 V DC. Phase noise for 8 to 9 GHz is typically better than 85 dBm at 10 kHz. These new series of VCOs are packaged in a tiny surface-mount package measuring 0.3" × 0.3" × 0.1", RoHs compliant, and can be delivered in tape and reel for automatic assembly processes.

Synergy Microwave Corp.,
Paterson, NJ
(973) 881-8800,
www.synergymwave.com.

RS No. 238

Coaxial Resonator Oscillator

The model CRO5700Z is a coaxial resonator oscillator in C-band (5690 to 5719 MHz) using

a doubler inside and featuring ultra low phase noise performance of –106 dBc/Hz at 10 kHz offset. This unique design offers a typical tuning sensitivity of 30 MHz/V and covers the band between 0.5 to 4.5 V at 5 VDC supply while drawing 140 mA (typical, due to the doubler) over the extended operating temperature range of –40° to 85°C. CRO5700Z is ideally suited for digital radios applications that require ultra low phase noise performance. CRO5700Z comes in Z-COMM's VCO-24H package measuring 0.6" × 0.8" × 0.22". This VCO is ideal for automated surface-mount assembly and reflow.

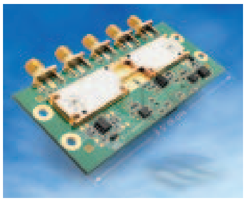
Z-Communications Inc.,
San Diego, CA
(858) 621-2700,
www.zcomm.com.

RS No. 239

SUBSYSTEMS

60 GHz T/R Module

This 60 GHz T/R module targets short-range indoor communications that must transport



data traffic at multi-gigabit speeds. The design allows full-duplex operation with flexible modulation and can also be operated in various radar modes, if desired. Typical specifications at 60 GHz are a receiver noise figure of 5 dB and a transmitter output power (at P1dB) of over +5 dBm with ±1 dB flatness over a 2 GHz operating bandwidth. Balance between I and Q ports measures better than 1.5 dB in amplitude and 10 degrees in phase over a 10 MHz (DC) to 1 GHz baseband frequency range. Measuring only 9 cm (3½ in) in length, the transceiver includes independent Tx and Rx local oscillators and versatile programmable phase lock loops.

Endwave Corp.,
San Jose, CA
(408) 522-3100,
www.endwave.com.

RS No. 246

8×8 Switch Matrix

The model 112 is an 8×8 switch matrix that is housed in a 19 inch 4U rack mounted chassis for ease of installation in new or existing ATE systems. The 50 ohm, 18 GHz switch matrix offers low insertion loss and excellent isolation over its entire operating frequency band. The standard unit utilizes a LAN interface. However, units requiring either an RS-232 or LXI interface can also be provided. Indicator telemetry and operation manuals are provided with each switch.

In-Phase Technologies Inc., Clarksburg, NJ (609) 259-8555, www.in-phasetech.com.

RS No. 240

Direction Finding Receiver Front-end

The model RFE-218-70-BB is a 2 to 18 GHz direction finding receiver front-end. The minimum dynamic range of the subsystem is –60 to +5 dBm; while the input VSWR in frequency range is 3.0 and the frequency flatness at the outputs is ±3 dB maximum. The Log slope is 50 mV/dB (±10 percent), the Log linearity is ±2.25 dB maximum and the TSS is –63 minimum. The rise time is 30 ns maximum and the recovery time is 350 ns maximum. The typical gain is +3 dB and the isolation between the outputs is 24 dB minimum.

Planar Monolithics Industries Inc., Frederick, MD (301) 631-1579, www.planarmonolithics.com.

RS No. 241

RF Peak Power Analyzer

The model 4500B is the instrument of choice for capturing, displaying, analyzing and characterizing RF power in both the time and statistical domains. Applications include: pulsed RF such as RADAR, TDMA and GSM, pseudo-random or noise-like signals such as CDMA and WLAN, and modulated time slotted signals such as GSM-EDGE and TD-SCDMA. The 4500B features 100 psec timebase resolution, video bandwidth greater than 50 MHz (sensor dependent), flexible triggering and greater than 80 dB dynamic range (sensor dependent) without any range switching to cover the most demanding peak power measurement applications.

Boonton Electronics, Parsippany, NJ (973) 386-9696, www.boonton.com.

RS No. 244

Suite of Antennas for HIRF Testing

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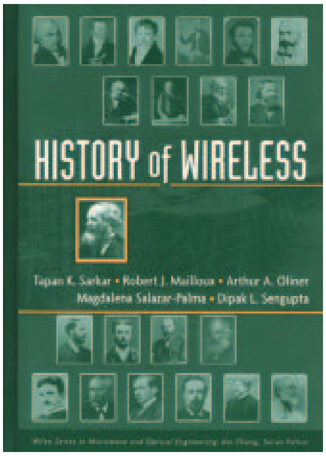

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Traditionally used to transmit radio signals, wireless technology has experienced explosive growth in recent years and now comprises a large share of the telecommunications industry. Challenging traditional assumptions about the origins and growth of wireless, *History of Wireless* is a comprehensive treatment of the history and evolution of this vital technology.

Introducing previously unacknowledged pioneers and developments, this book offers new insights into the initial theory and experimental exploration of wireless. It explores the development of magnetism, electricity and light, covering the widely recognized contributions of James Clerk Maxwell; Heinrich Hertz, who discovered electromagnetic waves in the late 19th century; and Guglielmo Marconi, who introduced the first wireless telegraph. The book also examines the work of Oliver Heaviside and Nikola Tesla, who both contributed significantly to the development of radio. Incorporating the approach that one cannot understand the science of wireless without knowing how various components and systems evolved, this book supplements conventionally accepted stories with more specific, less known discoveries and individuals. The history of wireless also covers German, Japanese and Soviet contributions to the physics and applications of electromagnetic oscillations and waves, wireless telegraphic and telephonic developments, and attempts to achieve transatlantic wireless communications, wireless telegraphy in South Africa in the early 20th century, antenna development in Japan, Soviet quasi-optics at near-mm and sub-mm wavelengths, the evolution of electromagnetic waveguides, and the development of phased-array antennas.

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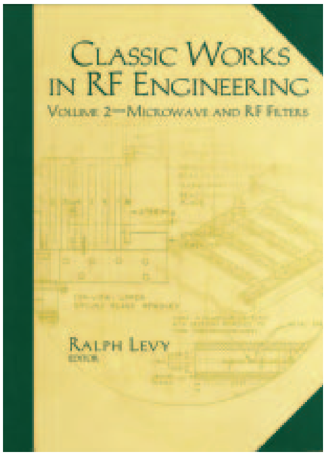

Ralph Levy, Editor
418 pages; $129, £61 • Artech House
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This book does a beautiful job of presenting the reader with a selection of 51 papers on RF and microwave filters that are most relevant to the requirements that exist today. Some early papers that were considered to be breakthroughs at the time they were published are not included if they have become superseded by later work. The reprints are grouped in ten categories, each one preceded by an introduction giving an overview of the particular class of filters in a given category. Chapter 1 is concerned with basic bandpass filters of the simple Chebyshev or Butterworth type, that is without finite frequency loss poles or transmission zeros. Modern filter design relies to a considerable extent on so-called transformed-variable synthesis, which is the subject of Chapter 2. This is similar to synthesis using the standard complex frequency variable, but with the addition of a frequency transformation. Chapter 3 is devoted to cross-coupled and pseudo-elliptic filters. Chapter 4 describes parallel-coupled line, hairpin-line and microstrip bandpass filters. Chapter 5 is concerned with dielectric-resonator filters, which are used for two purposes: to reduce the size of filter cavities and to increase the unloaded Q, resulting in much lower loss. Bandstop filters are the subject of Chapter 6, while Chapter 7 is consecrated to low pass filters. Suspended substrate stripline filters are described in Chapter 8. It is not always realized that lumped element filters may be built to operate at frequencies up to perhaps 18 GHz. Chapter 9 offers examples of this kind of filter. Chapter 10 comprises papers on power-handling, insertion loss, group delay and tuning. It is very interesting to read these classic works and learn from the best selection of papers in this field.

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Career Corner

About Job Market and Marketing RF/Microwave Engineering Part II

The June Career Column discussed the job market as a resource for companies' marketing. This month we will demonstrate how to increase the return on job postings by handling them as act of sales and employing marketing communication disciplines.

The idea that attracting talent is "selling" the position is commonly accepted. But are you really handling your job postings the same as the marketers next door would handle their campaigns? If posting a job is like advertising a product, then let's see what they would have done…

A job posting on a job site is similar in many ways to a banner ad. They both have a goal to create leads (applications). They are designed to initiate direct communication with target prospects and they both "work" in a very narrow time frame of exposure.

Like other types of online advertisements, the job posting aims to invoke the visitor's immediate reaction first by clicking the title to the posting page and through to making the contact. This is to be achieved in a very short window of attention (opportunity) as the candidate scrolls down the search results page.

Use of Keywords: Unlike a banner ad, which relies on the traffic on a host web site for exposure, a job posting affects its own exposure by inclusion of keywords corresponding to relevant job searches.

Our first goal is then to come up high on the searches under the keywords that we assume "perfect-fit" candidates would be looking for. Making up the list of keywords is not enough. Many of the job search functions default to sort the search results by relevance in a descending order. The relevance grade is based on the number of appearances of keywords in the job title and text. It is therefore good practice to repeat each keyword in the job description more than once.

The Role of the Title: Banner ads use graphics to create a subliminal association, so that just by glancing the visitor can make the "click" decision. Job postings, however, typically show in a list of titles. The title is therefore the first line of attraction. A well thought-out title can capture more attention as well as filter out/discourage unqualified candidates.

Job Posting Content: Now that we have succeeded to pull those "perfect fits" into our job posting, how can we motivate them to apply? The content of this page has an impact on whether the candidate will 1) move to the next ad, 2) bookmark the ad for later or 3) read it thoroughly and follow through with the online application.

Working with "basic" job postings using the template furnished by the job site, you don't have much graphical means to support this "sale." You can only rely on your well thought-out verbiage to attract candidates.

Without getting into what makes a job appealing, the posting works better if it mentions or implies the reasons that our best-fit candidate would want to come to work for the company. This is where we make our sales pitch, only that we are not there to complete or clarify. In addition to being informative, the job posting verbiage should highlight the points that would appeal to the candidate profile for which we are searching. Putting aside benefits and compensation, you may find the appealing factors to be professional challenge, opportunity for rapid career path, organizational environment and so on. The key is in understanding the possible expectations of the desired candidate profile. Including your logo distinguishes your posting and associates it with your company's reputation.

Hands-On the Response: Response to online job postings has a weekly cycle, as candidates tend to spend more time searching jobs on weekends. After the first week or two you should have a pretty good idea for the level of response to the posting. If the host job site provides an exposure report (the number of times your posting page was viewed), you can figure out the rate of applications to the exposures the ad gained. This rate can be used to evaluate the appeal of the job posting content. If supported by the host job site, you can tweak the posting to improve the response.

Conclusions: Job posting includes these three elements affecting the quantity and quality of returning applications: Keywords, Title and posting verbiage. Smart selection of keywords results in a higher position on the search results, a deliberate title is an invitation to click and the posting verbiage is the marketing document influencing the visitor's final decision to apply. Monitoring the response rate can provide real-time feedback and an opportunity to fine-tune online.

Isaac Mendelson
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