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May 2009

# Microwave Journal

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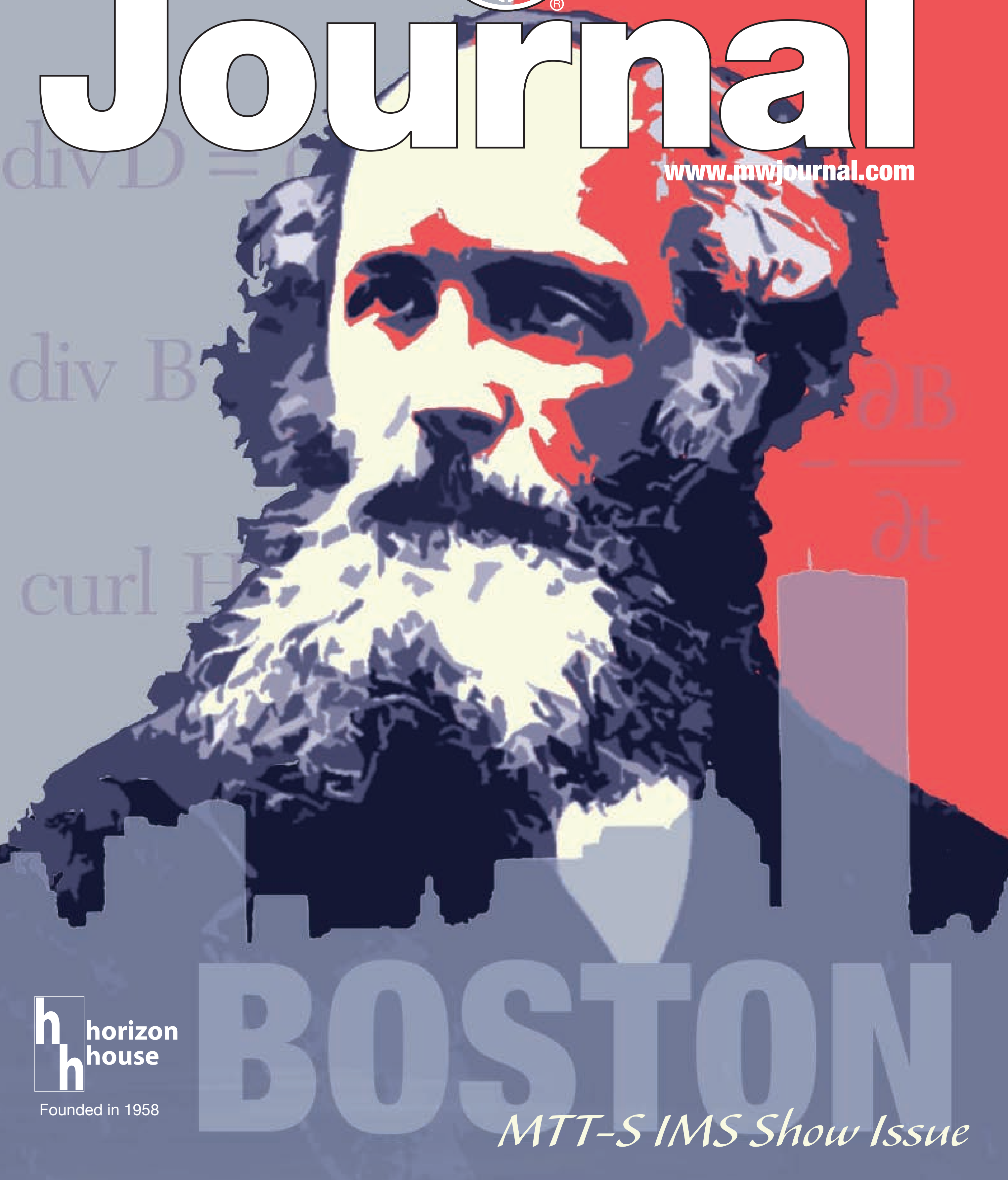


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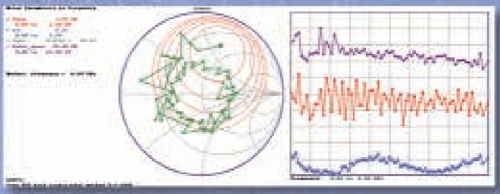

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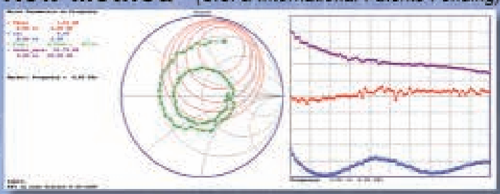

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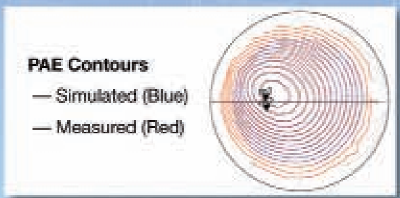


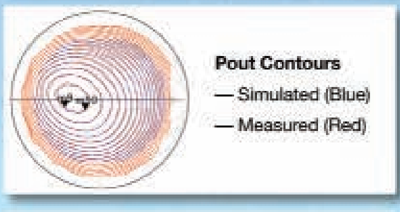


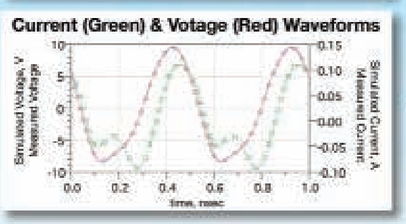


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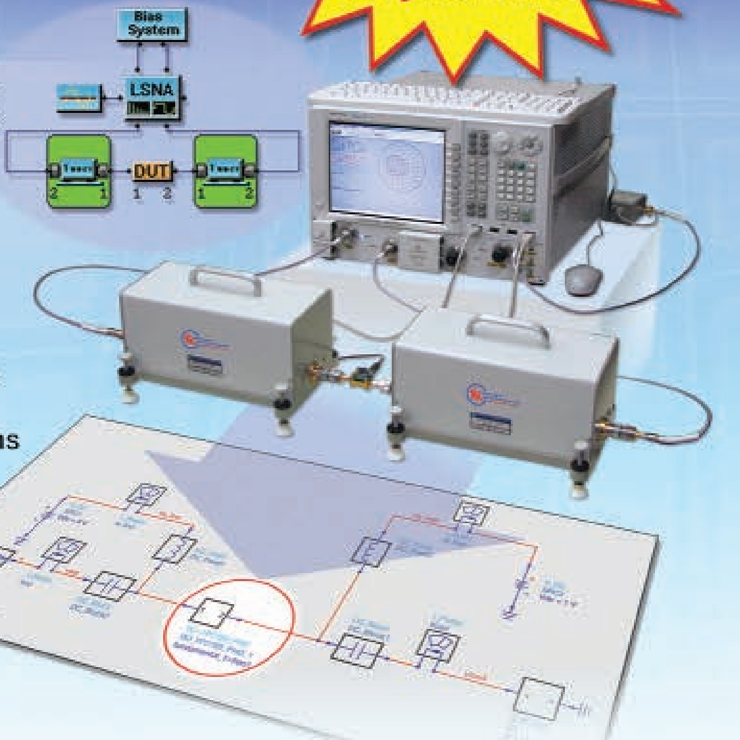


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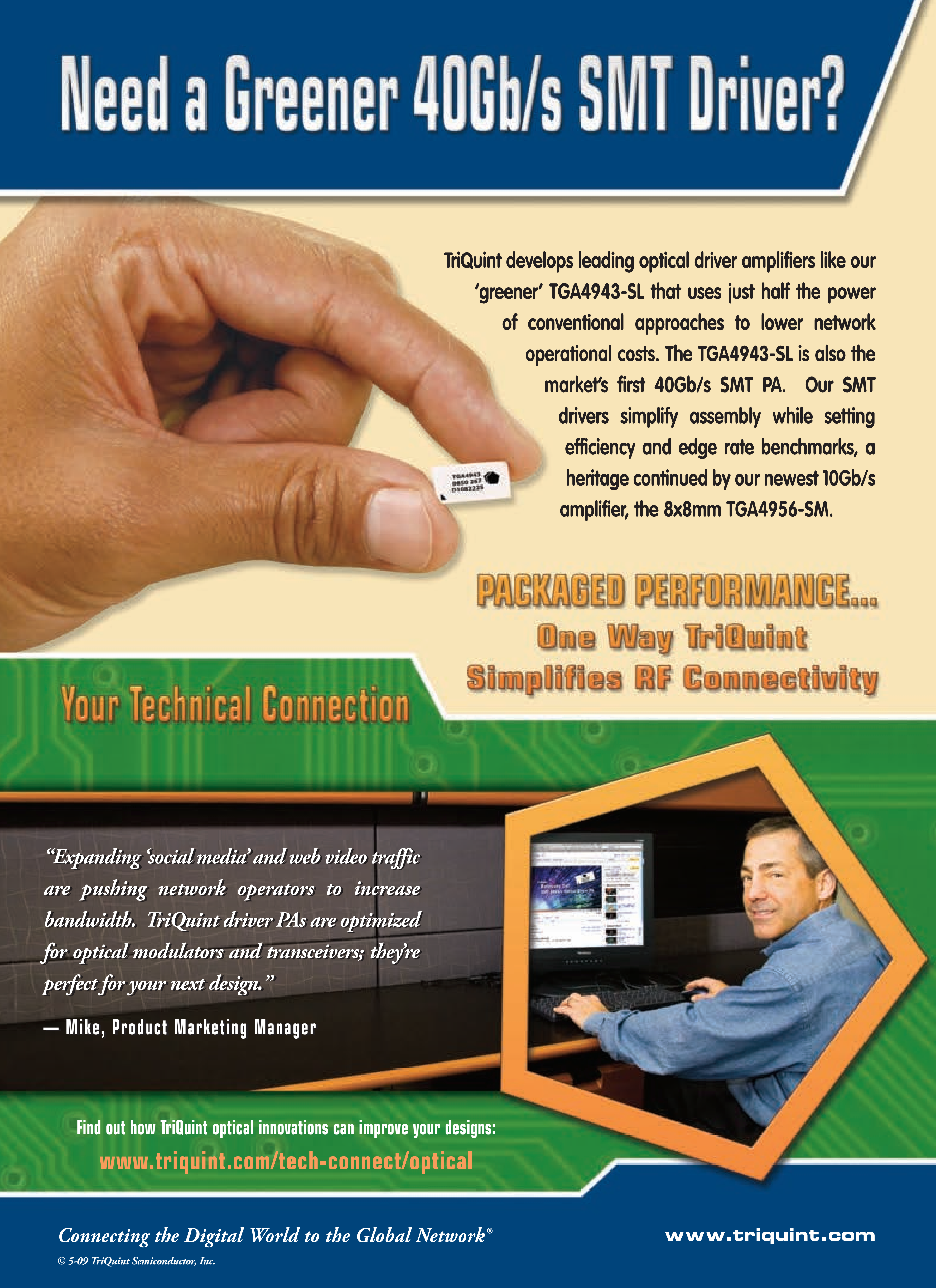

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# 2009 IEEE MTT-S International Microwave Symposium & Exhibition



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Microwave Journal

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## SPECIAL REPORTS



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This webinar presents two new driver amplifiers for the 10 and 40 Gb/s market. Both offer assembly convenience and high performance while also being nearly 50% more efficient than other solutions, significantly reducing power consumption for network operators while reducing waste heat and the need for cooling in the overall system.

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## Executive Interview

MWJ asks **Petteri Alinikula**, Laboratory Director Nokia Research Center Helsinki, about his plenary speech at the 2009 IMS, the global reach of the NRC and the role of research in the current economic climate.

## Expert Advice

**Gayle Collins** of **Freescale Semiconductor** will be at IMS in June. This month she writes, "IMS provides a wealth of topics for the interested high power amplifier engineer. This column will provide a perspective of what to look for from a high power PA engineer's point of view." Read her commentary on the potential impact of different papers on the field.


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

## Online Show Daily

MWJ reports directly from the 2009 MTT-S IMS exhibition. Keep up to date on the latest product announcements and industry news items along with conference exclusives, editor blogs and video. Visit www.mwjournal.com/IMS2009.

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## Featured White Papers

**IP2 and IP3 Nonlinearity Specifications for 3G/WCDMA Receivers**

*Chris (Wei) Liu, Broadcom*

**New Analog & Digital Variable Gain Amplifiers Span DC - 6 GHz**

*Application Note, Hittite*

**Utilizing Time Domain (TDR) Test Methods**

*Bill Rosas, Southwest Microwave*

**Phase Coherent Multi-channel RF Synthesis**

*Jason Breitbarth and Joe Koebel, Holzworth Instrumentation*

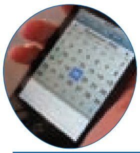


# JUNE 2009

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|---|---|---|---|---|---|
| 31 | 1<br>**IEEE International Symposium on Antennas and Propagation** North Charleston, SC | 2<br>**Webinar: Advantages of MIMO in Wireless and Radar Applications**<br>**GSA and IET International Semiconductor Forum** Munich, Germany | 3<br>**Wireless Personal Communications** Blacksburg, VA | 4 | 5 | 6 |
| 7<br>**IEEE MTT-S International Microwave Symposium** Boston, MA | 8<br>**RFIC 2009 IEEE Radio Frequency Integrated Circuits Symposium** Boston, MA | 9 | 10 | 11 | 12<br>**73rd ARFTG Microwave Measurement Conference** Boston, MA | 13 |
| 14 | 15<br>**Georgia Tech: Near-field Antenna Measurement Techniques** Boulder, CO | 16<br>**EMC 2009/China International Exhibition on Electromagnetic Compatibility** Beijing, China<br>**China MW 2009 China Microwave 2009 Exhibition** Beijing, China<br>**CEM-TD 2009 Workshop on Computational Electromagnetics in Time Domain** Victoria, BC, Canada | 17 | 18 | 19 | 20 |
| 21 | 22<br>**CST 2009 Innovations Workshop Microwaves and Antennas** Madrid, Spain | 23<br>**MWJ/Besser Webinar: High Speed Board Design**<br>**Ansoft Product Training HFSS for SI** San Jose, CA | 24<br>**Military Testing and Evaluation Summit** Washington, DC | 25 | 26 | 27 |
| 28 | 29 | 30 | 1 | 2 | 3 | 4 |

*For complete coverage of IMS 2009, visit www.mwjournal.com/IMS2009 from 5/26–6/19.*

**Go to: www.mwjournal.com/events**



# Coming Events

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APMC 2009
Deadline: June 19, 2009

**ONLINE**

For complete coverage of the IMS 2009 conference, event news, exhibitor product information and special reports from the editors of *Microwave Journal*, visit our online show daily at www.mwjournal.com/ims2009 starting May 26th.

**www.mwjournal.com/events**

## MAY

**16TH RF and Microwave Measurement Training Course**
*May 18–22, 2009 • Middlesex, UK*
www.theiet.org/microwave-course

**MIE 2009**
**Microwave Industry Exhibition in China**
**NCMMW 2009**
**National Conference on Microwave and Millimeter Wave in China**
*May 23–26, 2009 • Xi'an, China*
www.cnmw.org

## JUNE

**IEEE International Symposium on Antennas and Propagation**
*June 1–5, 2009 • Charleston, SC*
www.apsursi2009.org

**RFIC 2009**
**IEEE Radio Frequency Integrated Circuits Symposium**
*June 7–9, 2009 • Boston, MA*
www.rfic2009.org

**IMS 2009**
**IEEE MTT-S International Microwave Symposium**
*June 7–12, 2009 • Boston, MA*
www.ims2009.org

**73RD ARFTG Microwave Measurement Conference**
*June 12, 2009 • Boston, MA*
www.arftg.org

**EMC 2009/China**
**International Exhibition on Electromagnetic Compatibility**
*June 16–18, 2009 • Beijing, China*
http://expo.ces.org.cn

**China MW 2009**
**China Microwave 2009 Exhibition**
*June 16–18, 2009 • Beijing, China*
http://chinamw2009.ces.org.cn

## JULY

**ASQED 2009**
**The 1ST Asia Symposium on Quality Electronic Design**
*July 15–16, 2009 • Kuala Lumpur, Malaysia*
www.isqed-asia.org

## AUGUST

**EMC 2009**
**IEEE International Symposium on Electromagnetic Compatibility**
*August 17–21, 2009 • Austin, TX*
www.emc2009.org

## SEPTEMBER

**4G World 2009**
*September 15–18, 2009 • Chicago, IL*
www.4gworld.com

**EuMW 2009**
**European Microwave Week**
*September 28–October 2, 2009*
*Rome, Italy*
www.eumweek.com

## OCTOBER

**RF & Hyper 2009**
*October 6–8, 2009 • Paris, France*
www.rfhyper.com

**International Radar Conference**
*October 12–16, 2009 • Bordeaux, France*
www.radar09.org

**AOC 2009**
**46TH Annual AOC International Symposium and Convention**
*October 18–22, 2009 • Washington, DC*
www.crows.org

**ISAP 2009**
**International Symposium on Antennas and Propagation**
*October 20–23, 2009 • Bangkok, Thailand*
www.isap09.org

## NOVEMBER

**AMTA 2009**
**Antenna Measurement Techniques Association**
*November 1–6, 2009 • Salt Lake City, UT*
www.amta.org

**COMCAS 2009**
**The International IEEE Conference on Microwaves, Communications, Antennas and Electronic Systems**
*November 9–11, 2009 • Tel Aviv, Israel*
www.comcas.org

## DECEMBER

**APMC 2009**
**Asia-Pacific Microwave Conference**
*December 7–10, 2009 • Singapore*
www.apmc2009.org

**IEEE Applied Electromagnetics Conference**
*December 14–16, 2009 • Kolkata, India*
www.ieee-aemc.org


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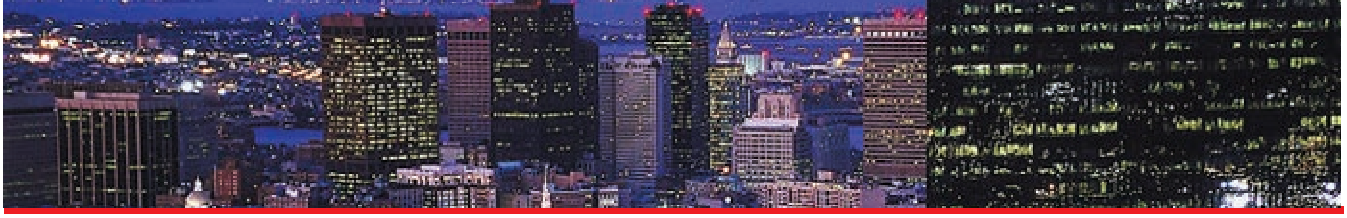
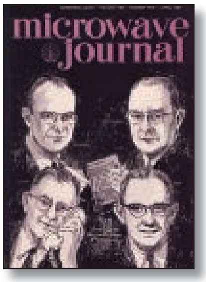


# IMS in Boston: Reflections from the Past

For the sixth time since its conception, the MTT-S International Microwave Symposium (IMS) will be held in Boston, historically one of the most popular venues for the event based on attendance numbers. This year, *Microwave Journal* has invited the past steering committee chairpersons to reflect on their experiences with organizing these colossal events. Ted Saad (1967), Harlan Howe (1983), Peter Staecker (1991), Glenn Thoren (2000) and Fred Schindler (2009) graciously accepted our invitation to share their stories with our readers. The following are their impressions of shows past and present.

## A Conversation with Ted Saad

**Ted Saad, Chairman, 1967 MTT-S Boston Symposium**




For many IEEE members, the name Ted Saad is synonymous with the Microwave Theory and Techniques Society (MTT-S) and the IMS. Saad's early and invaluable involvement with the society helped make it the strong and vibrant organization that it is today. The MTT-S started off as a Professional Group within the Institute of Radio Engineers (IRE) back in March, 1952, and held its first symposium in New York City in November of that year. Saad became a member of the group's Administration Committee (AdCom) in its second year of existence and by 1958 he was the chairman. Saad also served as the symposium chair when the G-MTT was held in Boston in 1967 for the second time (the first time was in 1959).

In a recent conversation with Saad regarding his chairing the 1967 Boston symposium, he fondly reminisced about his days as an active member of the society and his participation in MIT's Rad Lab during World War II. He proudly referred us to his 1983 *IEEE Transactions* article, "MTT the Early Days," remarking that upon rereading it, he felt many warm memories. Saad's article is full of references to the people who formed the society, worked


**Ted Saad, Harlan Howe, Jr., Peter Staecker and Glen Thoren**
*Former IMS Chairmen*
**Fred Schindler**
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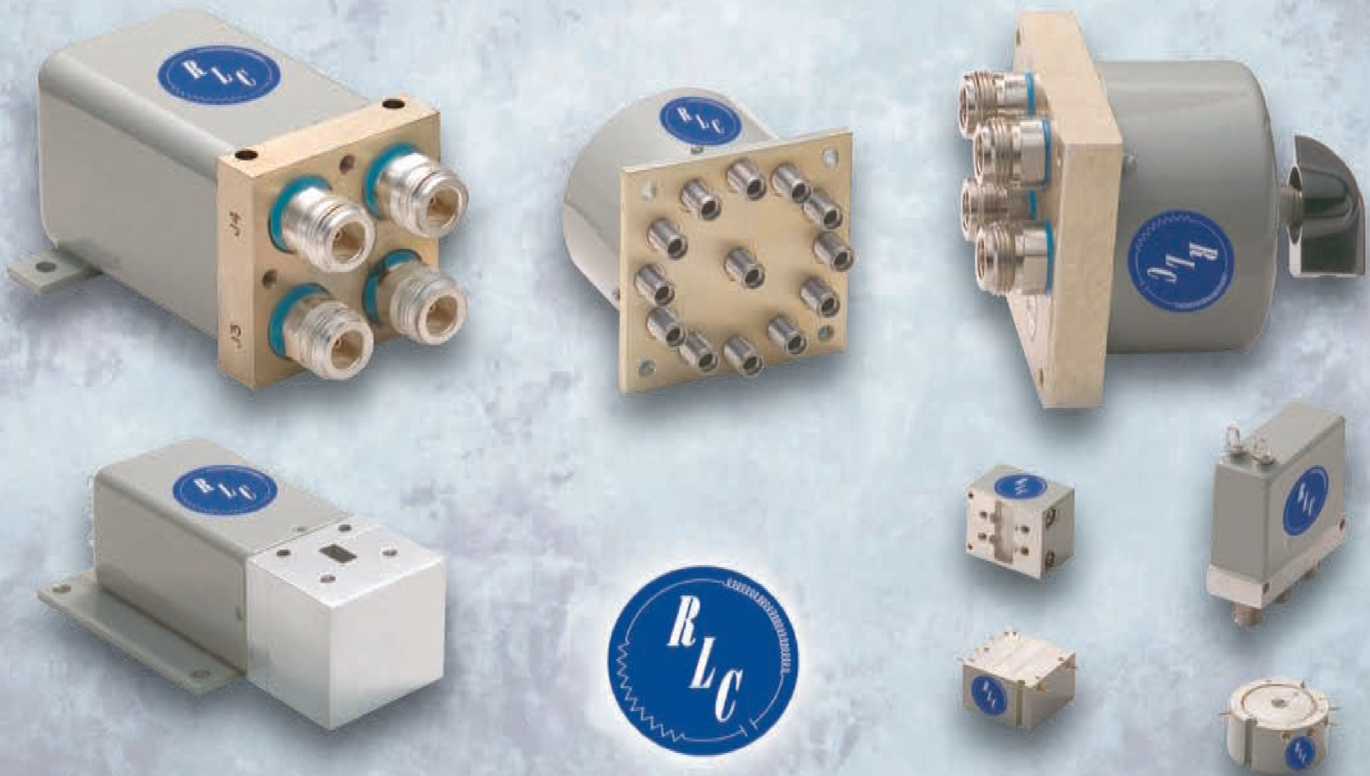

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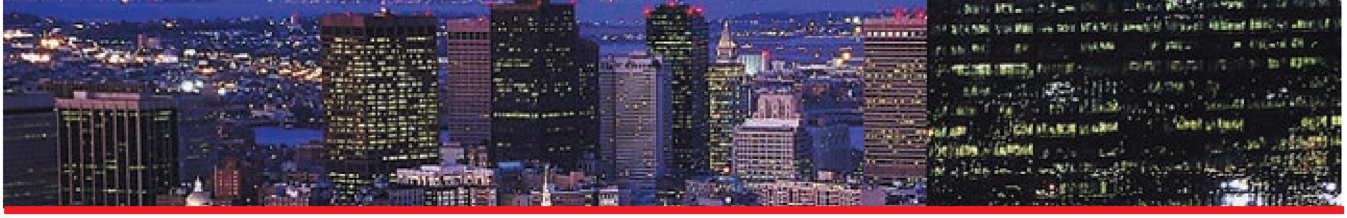
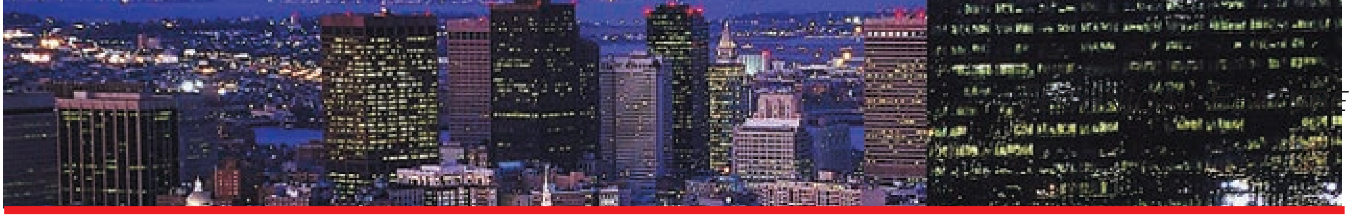


on publishing and editing the *Transactions* periodical and organized the symposia. It was clear in our conversation that the "warm memories" stem from his connection to these people, a reminder that the society is about more than just technology. Talking with Saad reminds us that the IMS is that time of year when the community comes together, personal bonds are made or re-established and one finds that they are surrounded by like-minded people who know what VSWR means.

In 1967, the symposium was strictly a technical gathering, held without an industry-based exhibition. This presented certain challenges for the organizers. In his 1983 *IEEE Transactions* article on the MTT Symposia, Saad wrote, "Again, following along in the Palo Alto example, an attempt was made to solicit funds from various government agencies to defray the cost of the visiting foreign attendees. Unfortunately, the agencies refused to provide funding and at the last minute, some local area microwave companies helped finance expenses for visitors coming from Japan and Western Europe."

In a companion article that same year on the early days of the MTT, Saad wrote, "The MTT had always been unique with regard to (not) having exhibits at their annual Symposia. But back in the mid-1960s, when finances were getting tight, there was some discussion as to the possibility of having paid exhibits at the Symposia to help defray expenses. The discussion was carried on at many AdCom meetings, and initially there was great opposition. I was one of those who initially opposed the idea, concerned that the Symposia would lose some of their flavor and become industry/sales oriented. Finally, however, the vote was taken to have the exhibits, which started modestly in 1972 in Arlington Heights, outside Chicago. As it turned out, they have proven to be very profitable for the Society, but there is no question that it has altered the tone of the Symposia. The fact remains, however, that the Symposium is the highlight of the Society year and perhaps, with exhibits, the industry year."

Noted highlights from the 1967 Boston symposium included the banquet, which featured Professor John C. Slater, who, at the time, was with the University of Florida, speaking of his days at MIT and at the MIT Radiation Laboratory and the early days of microwaves. Also of note during the banquet was the presentation of the Morris E. Leeds Award to Bill Mumford, the AdCom's third Chairman (1954-1955). That year Boston set a record for attendance at 794, which



held until 1977 in San Diego, CA. Saad wrote the following preview of the 1967 symposium in an editorial for *Microwave Journal* in May 1967.

"This year the G-MTT Symposium is being held in Boston. Since I was involved in the preparation of the technical program I had a close view of the technical activity in the industry.

Because of the many fine papers that had to be evaluated, the symposium will once again last four full days. 109 papers were submitted for consideration, 9 more were invited. This compares with 93 papers submitted for consideration and 16 invited last year.

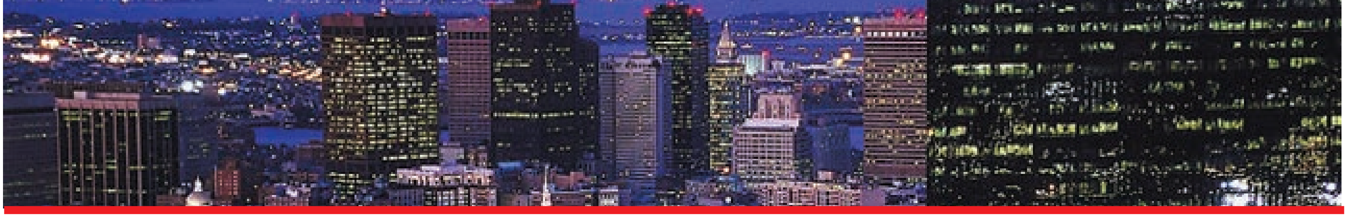
Judging from the program that has resulted, the industry is active in a number of interesting areas. The list of papers provides a good measure of the technical trends taking place. For example, in addition to the session on waveguides, the session on filters and couplers and two sessions on ferrites, there are sessions on microwave integrated circuits, solid-state sources, microwave control devices and microwave delay lines. One mild surprise was the large number of ferrite papers. The activity in ferrites seems greater than ever. Recently it has even begun to invade the field of integrated circuits.

The two areas that seem to be of greatest interest and importance to the industry are still solid-state sources and microwave integrated circuits. To satisfy that interest, the first evening of the symposium will be devoted to a rump session on microwave sources in parallel with a tutorial session on microwave integrated circuits. Audience participation at both sessions will be a feature. It is hoped that attendees with late information will take the opportunity to present their material at that time.

It is difficult to measure the changes in the technology by comparing this year's program with last year's. The changes are too gradual. For a better gauge of the changes I went back to the 1959 symposium which was also held in Boston (Editor's note: A three-day event held at Harvard University). Then as now, one of the most important topics of discussion was ferrites. In addition there was great interest in masers and variable reactance devices. At the time, I'm sure we thought the direction of the technology was obvious.

One thing that seems apparent today is that in 1959 the technology was narrower. Many of the problems that faced us then have been solved. The results have been applied to give us new tools and capabilities which have in effect broadened today's technological base.

The 1959 program seems somewhat un-inspirational in retrospect. But while we beat our



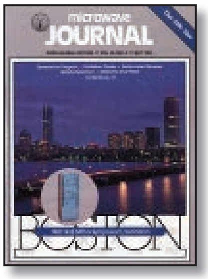
chests with pride for many of our achievements we must remember that the 1975 symposium attendees in Boston (Editor's note: The 1975 symposium venue was re-located to Palo Alto, CA, and did not return to Boston until 1983) will probably look back at the 1967 program and think it even dull.

One of the special bonuses the attendees will receive this year will be the invigorating walk between the Statler Hilton Hotel, the official hotel of the symposium and the New England Mutual Hall, where the papers will be presented. If nothing else is achieved, this may be the healthiest symposium in our history."



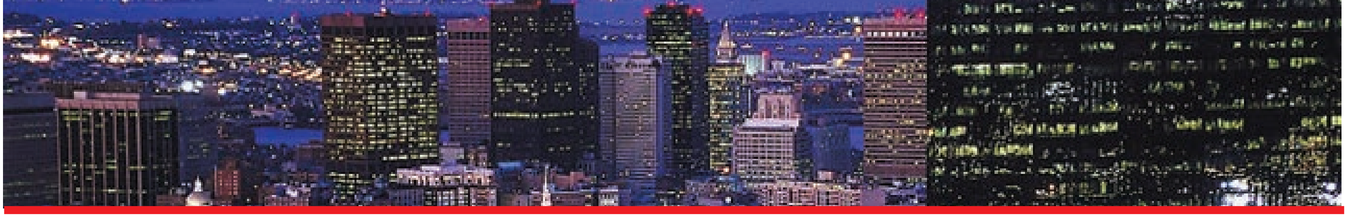
## THE 1983 MTT-S SYMPOSIUM: SOME PERSONAL MEMORIES

**Harlan Howe, Jr., Chairman, 1983 MTT-S Boston Symposium**




The 1983 MTT-S International Microwave Symposium, held in Boston, broke all existing records and generated a number of "firsts". Total attendance was 5168 with 1523 people registered for the main symposium and additional registrants for the Microwave and Millimeter-wave Monolithic Circuit Symposium, the workshops and the ARFTG meeting for a total technical attendance of 2306. There were a total of 126 technical papers presented in three parallel sessions, which was a reduction from four sessions in order the let the attendees hear more of the papers. Two Open Forum sessions with 20 papers each were introduced for the first time. Those sessions were the responsibility of Peter Staecker. Staecker and the Technical Program Chairman, Ralph Levy, were determined that the quality of those papers be up to the standards of the other papers and that they be chosen to be appropriate for the format. Staecker and Levy vetoed the plan to have wine and cheese because they thought it would detract from the professionalism of the sessions. The introduction was a success and has been repeated ever since with significant expansion including industry-sponsored refreshments.

Another "first" was a full sized program instead of the previous pocket size. At that time, the employers of the committee members were much more supportive of the event than they are today. The program was created at no cost by the M/A-COM Publications Department, although MTT-S paid for printing and mailing. We also introduced the first hard cover digest instead of the paperback version. Unfortunately,



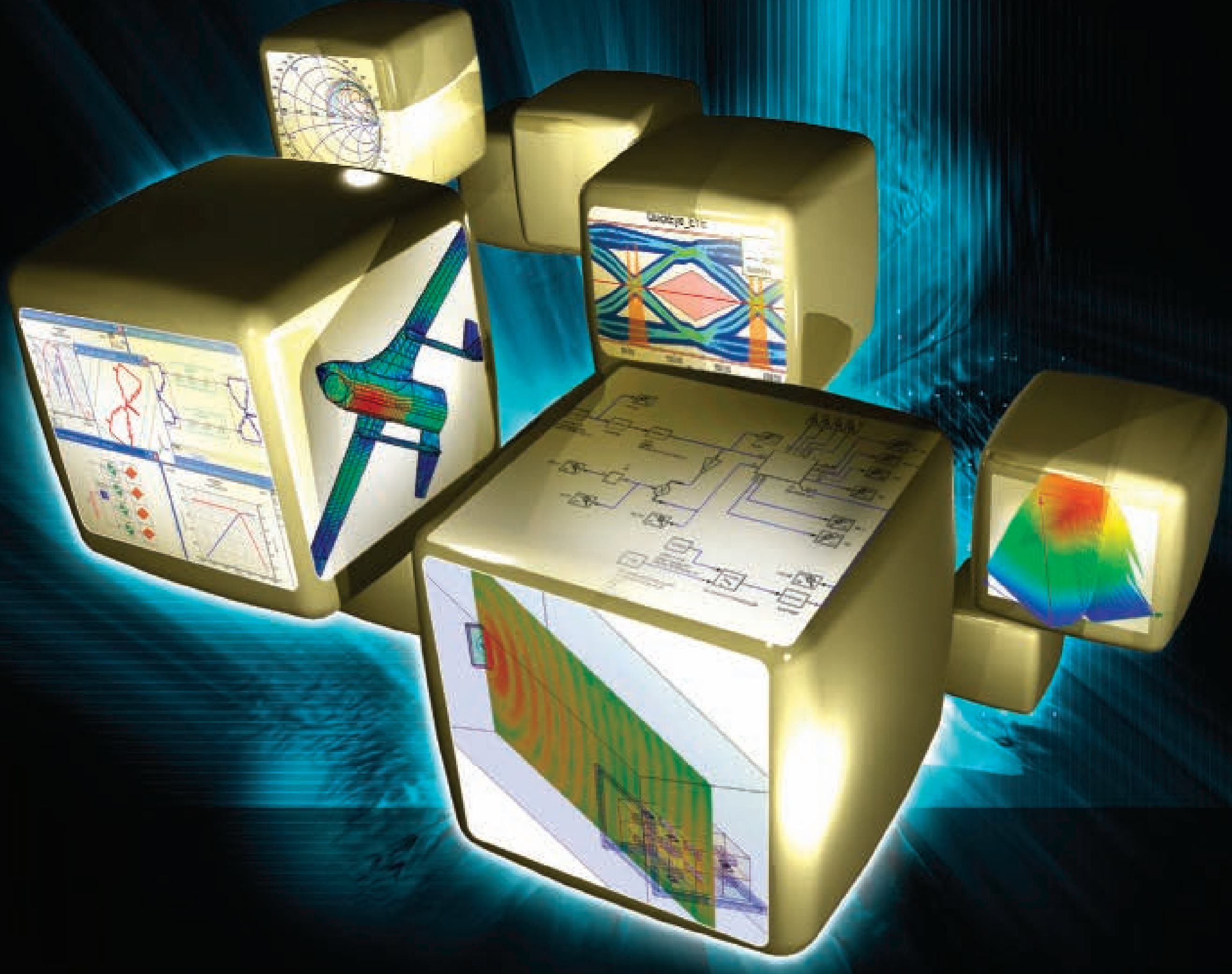
there was also an unpleasant "first" to the digest. At the last minute, after it was printed, someone in the Navy decided that one of the papers contained classified information. A crew of volunteers (with security clearances) spent the weekend slicing pages out of the digest. Despite the strict requirement for written releases, several companies have reneged on their releases, claiming security issues, and this problem has been repeated two more times, most recently at the Phoenix meeting in 2000 where they also had to destroy and remake all the CD-ROMs.

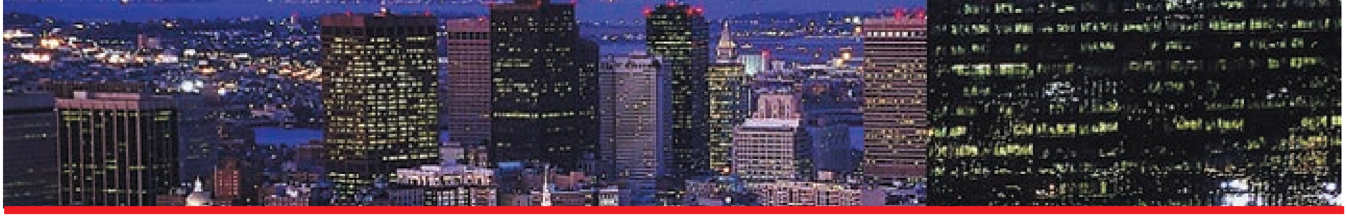
In addition to the digest problem we had several other surprises. When we arrived on-site, we discovered that we were backed up to a Mary Kay Cosmetics show. They were occupying the area scheduled for our registration and refused to move. The Sheraton Hotel allowed us to set up registration in the lobby bar near the entrance to the exhibition hall. LRW Associates was responsible for registration at that time and they coped nicely with the change; however, it was crowded and we received a number of complaints. It turned out that Mary Kay wasn't through with us. At midnight before the opening day, we discovered that there was a pink Cadillac hanging from the ceiling of the ballroom scheduled for our opening session the next morning. During a worrisome night, the car was removed and we opened without incident and without the pink decoration.

The *Microwave Journal* Reception, which had previously been a relatively small reception for exhibitors only, was opened to all attendees for the first time. Over 800 people attended an elegant event held at the Boston Museum of Fine Arts, complete with live chamber music and lavish refreshments in honor of the *Microwave Journal*'s 25th anniversary.

The exhibition was very successful and broke records again. There were 243 exhibiting companies in 264 booths. It fit nicely on the first floor of the Hynes Convention Center, which was very convenient to the technical meetings. It was decided to keep the exhibition open until 9:00 p.m. one night to allow people who were too busy during the day or who couldn't get away from work to attend. The experiment was a failure. At 7:00 p.m. the hall was empty except for unhappy exhibitors and we closed down. An evening extension has not been repeated.

For me, the highlight of the week was the Awards Banquet. Special Events Chairman, Joe White and I decided that we wanted a well-known speaker who could attract a large audience including families. Our prime candidate was Dr. Carl Sagan of

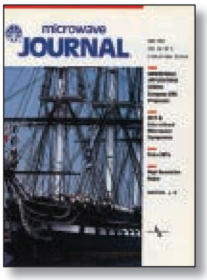




Cornell University and television fame. However, his agent wouldn't book him since he was returning from an overseas trip on that day. White went around the agent, contacted Dr. Sagan directly and convinced him that he should speak to us, since we were the people who developed the hardware that made radio astronomy possible. He agreed, changed his travel plans and returned through Boston instead of New York. All the credit for arranging his talk belongs to Joe White. I just paid the bill, which was more than we had ever spent for a speaker before and raised a few eyebrows at the MTT-S AdCom. However, he was worth every penny. His presentation was spectacular and afterward he stayed on stage to answer questions from the audience. The one that I shall never forget came from a young boy (Tatsuo Itoh's son) who asked, "All the moons on the other planets have names. Why doesn't our moon have a name?" Sagan replied that the other planets have multiple moons, so we give them names to distinguish them from one another. We only have one moon, so we simply call it "The Moon". It was a memorable ending to a memorable evening and a memorable symposium.

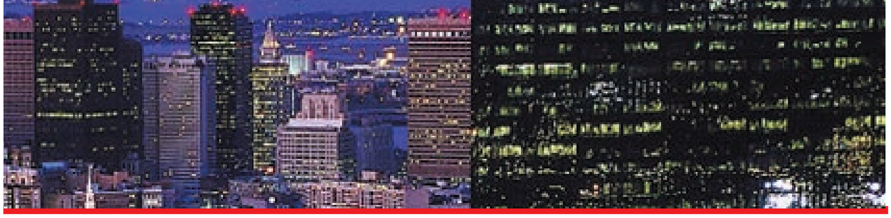
## ECHOES OF THE 1991 IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM

**Peter Staecker, Chairman, 1991 MTT-S Boston Symposium**



Having done our site due diligence in hard hats in 1985, when the present Marriott, Westin and Hines Convention Center in Copley Place were still holes in the ground, we approached MTT's AdCom meeting in St. Louis with the proposal for Boston 1991. Chuck Buntschuh had just given an updated forecast of the 1988 NYC Symposium in which room rates were projected to be $150, a figure that was met by groans from the audience. So the first question after our proposal was, "What are the hotel rates in Boston, Peter?" The answer, still a guess, was in excess of $160. The immediate response from Fred Rosenbaum: "Well, Chuck, you're off the hook!"

And so it was an auspicious occasion in late 1990, when Don Lawrence, the legendary Sales Director at the Sheraton Boston, offered to reduce room rates. In the end, 1991 Boston again defined itself as the venue to beat as it topped all previous IMS performance statistics… with one exception: Attempting to surpass the attendance of the 1983 blow-out awards banquet featuring Carl Sagan, the

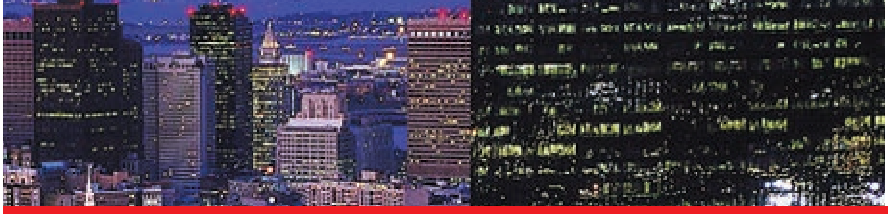


Committee again engaged impresario Joe White, responsible for Sagan's memorable appearance in Boston 1983, to repeat his magic. His target: Tom Clancy. The connection failed, and Sagan's 1983 record still stands.

The major theme of IMS 1991, of course, was the celebration of the 50th anniversary of the MIT Radiation Laboratory. As early as 1987 a small local RadLab Celebration Committee led by Ted Saad (who was in RadLab Group 71: Racons as a young engineer) started to identify and engage the RadLab alumni, and their response was exuberant. As plans developed, historical events took center stage:

*Fig. 1 584 Radar set up at Lincoln Labs for 1991 MTT-S.*

- Our small Committee had decided to make a home video of RadLab, and after a very slow and painful beginning, eagerly pursued and validated a rumor that WGBH TV in Boston, which produces the NOVA Series, was interested in making a documentary on radar. The MTT-Society, through Roger Sudbury and Saad, played a major role in supplying equipment. In preparation for a part of that movie, a 584 Radar set was refurbished by a group of retired Westinghouse engineers in Baltimore, MD, and brought to Lincoln Laboratory in Massachusetts for filming by the WGBH crew (see ***Figure 1***). Dr. Ivan Getting, who headed the group at RadLab that designed the 584 was there, along with his deputy Lee Davenport and Leo Sullivan, who operated the 584 at the Anzio beachhead, and Hank Abajian, who trained operators of the 584 in the South Pacific. The final act of filming was having a WWII P51 fly overhead while the 584 tracked its flight.[1] The NOVA documentary, "Echoes of War," was first shown on October 25, 1989.
- With the passing of time, certain anecdotes dealing with the preparation of the 584 have come forward, this one from Roger (keep him out of the lab) Sudbury relating some of the more obscure events of the flyover day: In activating the SCR 584 the transmitter was double-pulsing, which was sometimes caused by the tube. As a number of tubes had been assembled I decided to replace the magnetron. In taking it out I turned the knurled collar and suddenly cracked the glass envelope. Of course, the instruction manuals clearly stated: Do not turn the knurled collar. To compound the problem all of our spare tubes were gassy. With time running short a Raytheon employee drove to Radio Research in Waterbury, CT, who stocked magnetrons. He returned just in time to bring the radar up for the filming of the flyover.[2]
- Also when we first brought the radar to operational status, the rotating feed was not rotating and a veteran SCR 584 technician indicated this happened at times as he took a 2 by 4 piece of lumber and gave it a good

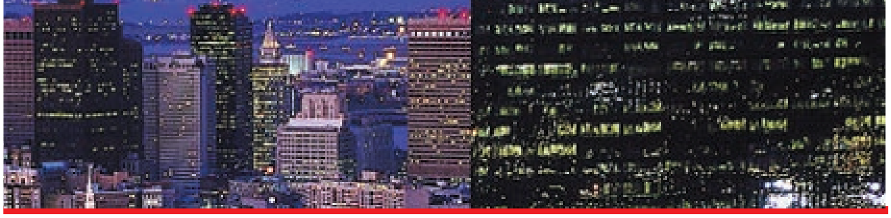



whack. Suitably prompted, the feed began to turn properly.

- MIT Radiation Lab was designated an IEEE Milestone on October 9, 1990. The nomination had been initiated by Harlan Howe and the IEEE Boston Section, and the designation ceremony was chaired by Dick Sparks, then Boston Section Chair.
- Harlan Howe, with the help of Warren Seamans of the MIT Museum and the M/A-COM Publications Department, assembled a pictorial event calendar that was distributed to attendees and members of the MTT-Society in October 1990.
- Roger Sudbury took on the project of re-issuing the *5 Years at the MIT Radiation Laboratory* history/picture book to all Symposium attendees. This 1991 edition included previously deleted photos, a section from E.G. "Taffy" Bowen's discussion of the Tizard mission that brought the first magnetrons from England to the United States, and a complete list of all RadLab technical staff members.[3]

At the Symposium, the cost of hotel rooms ranged from $95 to $140 (not so bad after all). On Tuesday, June 11, 1991, radar, the technical roots of the IEEE Microwave Theory and Techniques Society, and the people of the MIT Radiation Laboratory were the main event:

- When Roger Sudbury arrived to open the special registration booth for RadLab attendees at 7:00 Tuesday morning a Chinese man was sitting near by. A younger Chinese man quickly appeared, and asked if he could register his father as he had been up since four o'clock to be sure he did not miss anything. He said his father was trapped in this country in WWII and had gone to work at the RadLab and he considered this the most important event in his life. He had gone back to China to establish microwave technology there and coming back for this reunion was most important to him. The older gentleman's name was Chia Shan Pao (RadLab Group 43); the story of him and his son, Dr. Hsueh-Yuan Pao, is captured in this reference.[4]
- At the Plenary Session, following the reading of opening remarks and greetings from former Laboratory Director Lee DuBridge, Norman F. Ramsey, first leader of Group 41, Fundamental Development, and one of nine RadLab alumni who later became Nobel Laureates, delivered the keynote speech.
- Immediately following, a Special Session (Al Hill [leader, Group 53: RF] and Ted Saad, co-chairs) featured talks by Nathan Marcuvitz (Group 41) on microwave theory, Bob Pound (Group 53) on components and Ivan Getting (Division 8: Fire Control and Army Ground Forces) on systems. As the session started, the air conditioning system failed on the 4th floor, transforming the session room into a 500 person standing-room-only sauna. Very few exited the room.
- Over 200 RadLab alumni visited old friends in a special room that housed the historical exhibit, had comfortable chairs, 1940's music, copies of *Life Magazine*, and plenty of ash trays.
- A second special session on microwave radiometers was closed by Bob Dicke (also Group 41). During his Brief Remarks (the title of his talk), Bob recalled the visit to his lab by the Associate Laboratory Director, I.I. Rabi, who during some skeptical comments on the utility of microwave sensors waved his lit cigar too close to the sensing element, thus "pegging" the detector meter. The following evening at the Awards Banquet, Dicke received the MTT-S Pioneer Award for his invention of the microwave radiometer. Rabi was doubtless smiling from above.
- In another closely held anec-



dote, it has been rumored that after the banquet, a band of merry pranksters allegedly led by the intrepid John Putnam relocated a three times life-size ice sculpture of a swan from the Banquet into the bathtub of the Chairman's bathroom. Professors Rabi and Rosenbaum would probably have approved.

## REMEMBERING IMS 2000

**Glen Thoren, Chairman, 2000 MTT-S Boston Symposium**

Do you remember the year 2000? The Internet bubble was still expanding and no one had yet seen the "wall" we were about to run into at full throttle. The NASDAQ was over 5000 in March and the Dow Jones was over 11,700 in January. It seems like yesterday. And so does MTT-S IMS 2000.

IMS 2000 really started seven years earlier, shortly after IMS 1991 in Boston. Boston won the bid to carry on the tradition of the IMS as it did in 1991 and in 1983 before that. As the Chairman in 2000, I previously served as a digest editor in 1983 and co-chairman of the technical program for the 1991 Boston symposia. But in 2000 it was the whole ball of wax. Our technology had changed remarkably over the years. That's why we hold these events. We must stay up to date, get ahead of the curve and push out the edge of the state-of-the-art. A cliché, perhaps, and undeniably true. The Internet bubble was still expanding and the enthusiasm for RF and microwave technology was exceeded only by the photonic industries and the "dot com" world. It was a "heady" time.

Three things were remarkable about IMS 2000. It was the end of a century of technology and the beginning of a new one. Many of the early pioneers of our industry were still with us, attended the meeting, accepted our appreciation, allowed us to honor them, and let us know that now we had the responsibility to "carry on". The attendance set a new record, as did the number of exhibitor booths (803), all the result of the Boston IMS Steering Committee's unbelievable, and I think heroic, dedication and work. The team at Horizon House and *Microwave Journal* put in long hours organizing the exhibitors and exhibit floor so that all companies could showcase their new achievements. There were booths in the halls of the Hynes Convention Center because we had simply run out of exhibit space. The IMS was too large to fit in the largest conference center in Boston and it was getting larger.

I even had to lead a large delegation of workshop attendees on a last minute hike from the Hynes Convention Center to the Sheraton Hotel because of the huge interest in one workshop. It was a long walk and I felt like the Pied Piper apologizing for the inconvenience all the way. The workshop turned out very well so I was forgiven.

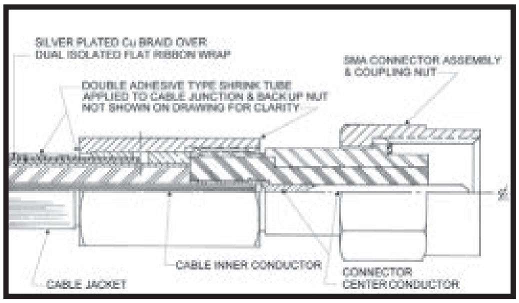
One of the most amazing operations that continued throughout the event was the "sign shop" manned by volunteers and under the control of Bob Alongi, the head of the IEEE Boston Section Office. So many events were being revised on the fly and the need for instructive "direction signs" to guide everyone to the appropriate location was unending. We had a large format HP color printer set on "turbo" to make the signs that Bob would mount on posters and deploy throughout the convention center and adjoining hotels. This and dozens of other "behind the scenes" heroics that are almost invisible to the attendees are what makes the IMS, certainly in Boston, successful.

There were many tours and events for the families of the attendees that wanted to combine the trip to Boston with a family vacation. New England is rich with heritage: Concord and Lexington tours, the Newport, RI mansions,

UNITED MICROWAVE PRODUCTS INC.

# MICROFLEX 170

MICROFLEX 170 is designed for stability & durability under test conditions. A silver plated copper braid is applied over a mylar ribbon which is over a silver plated copper ribbon. The construction of the outerconductor offers outstanding RF shielding characterisitics along wiht stability & isolation. the SMA & Type N connectors are fabricated from statnless steel & the SMA's feature a thick wall design for durability & continued mating cycles.



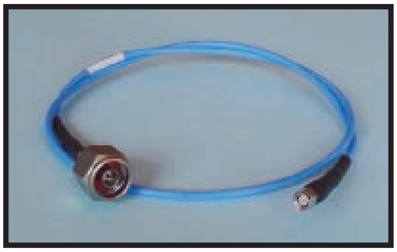

## AFFORDABLE TEST CABLES

## DC-26GHz Performance

THICKWALLED CONSTRUCTION OF SMA BODY FOR DURABILTY

CAPTIVE CONTACT & NO RETAINING RING FOR RUGGEDNESS

ISOLATED SHIELDS FOR STABILITY OVER TIME & RF SHIELDING



### ELECTRICAL PROPERTIES

| | |
|---|---|
| **Impedance** 50 ± 2 OHMs | |
| **Cut off Frequency** 33.0 GHz | |
| **Nominal Capacitance** 29.4 pf/f | |
| **Velocity of propagation** 69.5% | |
| **Max Operating Voltage** 1200 Volts RMS | |
| **RF Shielding** Greater than 90db | |

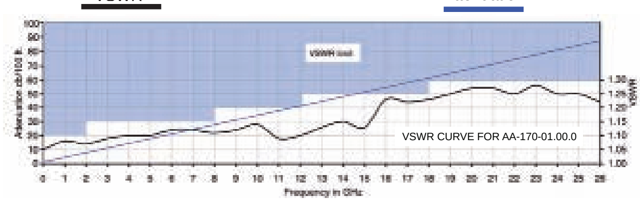
### MATERIALS

| |
|---|
| **Inner Conductor** Ag Over Cu Clad Steel .036 Dia. |
| **Outer Conductor** SIL PL Cu Round Wire Braid Over A Mylar Ribbon Over A Flat SIL PL Cu Ribbon .145 DIA |
| **Dielectric** Solid PTFE .116 Dia. |
| **Jacket** FEP Teflon .170 Dia. |

### MECHANICAL PROPERTIES

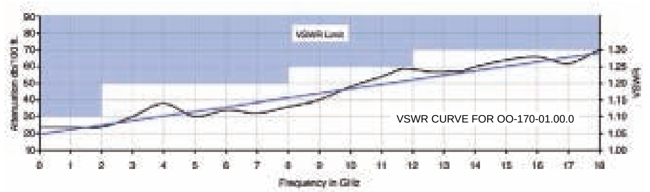
| |
|---|
| **Bend Radius** Minimum 1.0 Inch |
| **Temp Range** -55ºF/+400ºF |
| **Weight** .47 oz/ft |

VSWR Attenuation




Operating Frequency DC-26.0 GHz

VSWR Attenuation




Operating Frequency DC-18.0 GHz

**SMA MALE TO SMA MALE**

| PART NO. | LENGTH | 1-9 | 10-24 | 25-49 |
|---|---|---|---|---|
| AA-170-01.00.0 | 1.0 Ft. | $63.50 | $62.25 | $61.00 |
| AA-170-01.06.0 | 1.5 Ft. | $65.00 | $63.75 | $62.50 |
| AA-170-02.00.0 | 2.0 Ft. | $66.50 | $65.25 | $64.15 |
| AA-170-02.06.0 | 2.5 Ft. | $68.00 | $66.75 | $65.50 |
| AA-170-03.00.0 | 3.0 Ft. | $69.25 | $68.75 | $67.25 |
| AA-170-04.00.0 | 4.0 Ft. | $72.50 | $71.25 | $70.50 |
| AA-170-05.00.0 | 5.0 Ft. | $75.75 | $74.75 | $73.75 |
| AA-170-06.00.0 | 6.0 Ft. | $78.50 | $77.25 | $76.25 |
| AA-170-10.00.0 | 10.0 Ft. | $89.50 | $88.25 | $87.50 |

**SMA MALE TO SMA MALE RIGHT ANGLE**

| PART NO. | LENGTH | 1-9 | 10-24 | 25-49 |
|---|---|---|---|---|
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| AB-170-01.06.0 | 1.5 Ft. | $90.00 | $89.00 | $88.00 |
| AB-170-02.00.0 | 2.0 Ft. | $91.50 | $90.50 | $89.50 |
| AB-170-02.06.0 | 2.5 Ft. | $93.00 | $92.00 | $91.00 |
| AB-170-03.00.0 | 3.0 Ft. | $94.50 | $93.50 | $92.50 |
| AB-170-04.00.0 | 4.0 Ft. | $97.50 | $96.50 | $95.50 |
| AB-170-05.00.0 | 5.0 Ft. | $100.50 | $99.50 | $98.50 |
| AB-170-06.00.0 | 6.0 Ft. | $103.50 | $102.50 | $101.50 |
| AB-170-10.00.0 | 10.0 Ft. | $115.50 | $114.50 | $113.50 |

**SMA MALE TO TYPE N MALE**

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| AO-170-01.00.0 | 1.0 Ft. | $79.50 | $78.50 | $77.50 |
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| AO-170-02.00.0 | 2.0 Ft. | $82.50 | $81.50 | $80.50 |
| AO-170-02.06.0 | 2.5 Ft. | $84.00 | $83.00 | $82.00 |
| AO-170-03.00.0 | 3.0 Ft. | $85.50 | $84.50 | $83.50 |
| AO-170-04.00.0 | 4.0 Ft. | $88.50 | $87.50 | $86.50 |
| AO-170-05.00.0 | 5.0 Ft. | $91.50 | $90.50 | $89.50 |
| AO-170-06.00.0 | 6.0 Ft. | $94.50 | $93.50 | $92.50 |
| AO-170-10.00.0 | 10.0 Ft. | $106.50 | $105.50 | $104.50 |

**TYPE N MALE TO TYPE N MALE**

| PART NO. | LENGTH | 1-9 | 10-24 | 25-49 |
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| OO-170-01.06.0 | 1.5 Ft. | $92.00 | $91.00 | $90.00 |
| OO-170-02.00.0 | 2.0 Ft. | $93.50 | $92.50 | $91.50 |
| OO-170-02.06.0 | 2.5 Ft. | $95.00 | $94.00 | $93.00 |
| OO-170-03.00.0 | 3.0 Ft. | $96.50 | $95.50 | $94.50 |
| OO-170-04.00.0 | 4.0 Ft. | $99.50 | $98.50 | $97.50 |
| OO-170-05.00.0 | 5.0 Ft. | $102.50 | $101.50 | $100.50 |
| OO-170-06.00.0 | 6.0 Ft. | $105.50 | $104.50 | $103.50 |
| OO-170-10.00.0 | 10.0 Ft. | $117.50 | $116.50 | $115.50 |

**SMA MALE TO SMA BULKHEAD FEMALE**

| PART NO. | LENGTH | 1-9 | 10-24 | 25-49 |
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| AC-170-01.00.0 | 1.0 Ft | $73.50 | $72.25 | $71.00 |
| AC-170-01.06.0 | 1.5 Ft | $75.00 | $73.75 | $72.50 |
| AC-170-02.00.0 | 2.0 Ft | $76.50 | $75.25 | $74.15 |
| AC-170-02.06.0 | 2.5 Ft | $78.00 | $76.75 | $75.50 |
| AC-170-03.00.0 | 3.0 Ft | $79.25 | $78.75 | $77.25 |
| AC-170-04.00.0 | 4.0 Ft | $82.50 | $81.25 | $80.50 |
| AC-170-05.00.0 | 5.0 Ft | $85.75 | $84.75 | $83.75 |
| AC-170-06.00.0 | 6.0. Ft | $88.50 | $87.25 | $86.25 |
| AC-170-06.00.0 | 10.0. Ft | $99.50 | $98.25 | $97.50 |

**SMA MALE RIGHT ANGLE TO SMA MALE RIGHT ANGLE**

| PART NO. | LENGTH | 1-9 | 10-24 | 25-49 |
|---|---|---|---|---|
| BB-170-01.00.0 | 1.0 Ft. | $108.50 | $107.50 | $106.50 |
| BB-170-01.06.0 | 1.5 Ft. | $110.00 | $109.00 | $108.00 |
| BB-170-02.00.0 | 2.0 Ft. | $111.50 | $110.50 | $109.50 |
| BB-170-02.06.0 | 2.5 Ft. | $113.00 | $112.00 | $111.00 |
| BB-170-03.00.0 | 3.0 Ft. | $114.25 | $113.25 | $112.25 |
| BB-170-04.00.0 | 4.0 Ft. | $117.50 | $116.50 | $115.50 |
| BB-170-05.00.0 | 5.0 Ft. | $120.75 | $119.50 | $118.50 |
| BB-170-06.00.0 | 6.0 Ft. | $123.50 | $122.50 | $121.50 |
| BB-170-10.00.0 | 10.0 Ft. | $134.00 | $133.00 | $132.00 |

**TYPE N MALE TO TYPE N MALE RIGHT ANGLE**

| PART NO. | LENGTH | 1-9 | 10-24 | 25-49 |
|---|---|---|---|---|
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| OP-170-01.06.0 | 1.5 Ft. | $113.00 | $112.00 | $111.00 |
| OP-170-02.00.0 | 2.0 Ft. | $114.50 | $113.50 | $112.50 |
| OP-170-02.06.0 | 2.5 Ft. | $116.00 | $115.00 | $114.00 |
| OP-170-03.00.0 | 3.0 Ft. | $117.50 | $116.50 | $115.50 |
| OP-170-04.00.0 | 4.0 Ft. | $120.50 | $119.50 | $118.50 |
| OP-170-05.00.0 | 5.0 Ft. | $123.50 | $122.50 | $121.50 |
| OP-170-06.00.0 | 6.0 Ft. | $126.50 | $125.50 | $124.50 |
| OP-170-10.00.0 | 10.0 Ft. | $138.50 | $137.50 | $136.50 |

**TYPE N MALE TO TYPE N BULKHEAD FEMALE**

| PART NO. | LENGTH | 1-9 | 10-24 | 25-49 |
|---|---|---|---|---|
| OS-170-01.00.0 | 1.0 Ft. | $100.50 | $99.50 | $98.50 |
| OS-170-01.06.0 | 1.5 Ft. | $102.00 | $101.00 | $100.00 |
| OS-170-02.00.0 | 2.0 Ft. | $103.50 | $102.50 | $101.50 |
| OS-170-02.06.0 | 2.5 Ft. | $105.00 | $104.00 | $103.00 |
| OS-170-03.00.0 | 3.0 Ft. | $106.50 | $105.50 | $104.50 |
| OS-170-04.00.0 | 4.0 Ft. | $109.50 | $108.50 | $107.50 |
| OS-170-05.00.0 | 5.0 Ft. | $112.50 | $111.50 | $110.50 |
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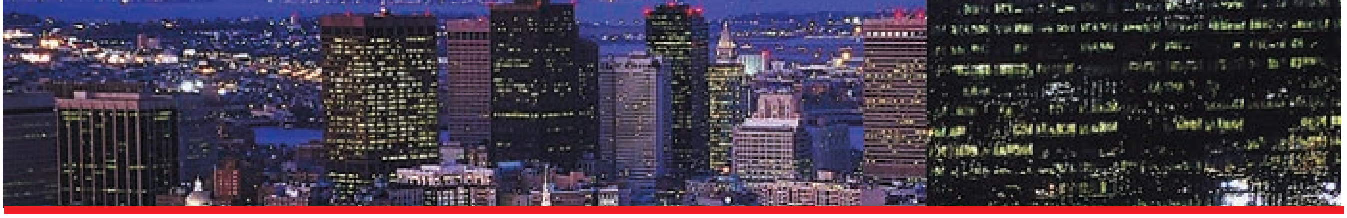

Faneuil Hall marketplace and stores, walking around beautiful Boston and much more. This added dimension to the symposium experience that was spoken of for years.

Our banquet speaker was noted presidential historian, Doris Kearns Goodwin. She astounded some with her anecdotes about the Kennedy's and Roosevelt's. Others would have preferred a more technical presentation and speaker, but I loved it. Earlier we recognized one of the beloved pioneers of the industry and of the Boston microwave traditions, Ted Saad. For those of you that know Ted, you know the honor it was for me to be able to honor him. Saad was and still is a cornerstone of the foundation of the microwave industry. There are few pioneers like him that measure their entire lives with the dimensions being an entire industry, our industry of microwaves and RF. More importantly, he has successfully passed on many torches to the next generation of leadership so that they can do the same. What more can we say. Thanks, Ted.

Then if you were one of the hardworking volunteers on the Steering Committee or the Administrative Committee of the society there were the mysterious "white buses". As a "thank you" for the sweat, dedication, long hours of planning and commitment, these tireless workers were treated to a bus ride unlike any other they had ever taken to dinner through the streets of Boston with a full police escort and sirens blaring. Four unmarked white buses left the Marriot Hotel with eight police motorcycle escorts traveling unimpeded through the streets of Boston as hundreds of people on the sidewalk looked in amazement at the smoked glass bus windows wondering what dignitaries deserved this treatment. We looked out at the crowds on the sidewalk that stopped, like statues, to look at our busses and we looked out at them in amazement. Everyone on those busses earned that ride through many years of work. No one remembers what they had at that dinner or my congratulatory presentation; they remember the bus ride that even took them the "wrong way" up one way streets in downtown Boston. For 15 minutes during this brief trip spirits soared, adrenaline rushed, people were staring at the unseen occupants and the white busses as a once in a lifetime police escort guided the way.

We made many mistakes at IMS 2000 and more were queued up each hour during the event. The real skill is to make the problems invisible to the attendees. Rooms were overbooked, too few meals were ordered at some meetings, attendees were constantly looking for rooms or their colleagues,

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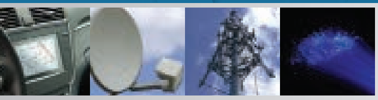

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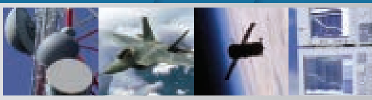

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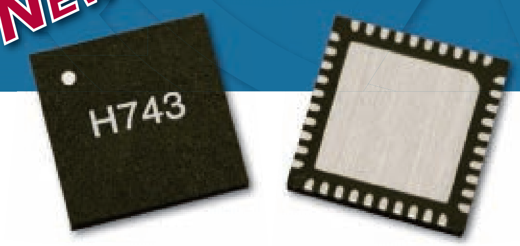


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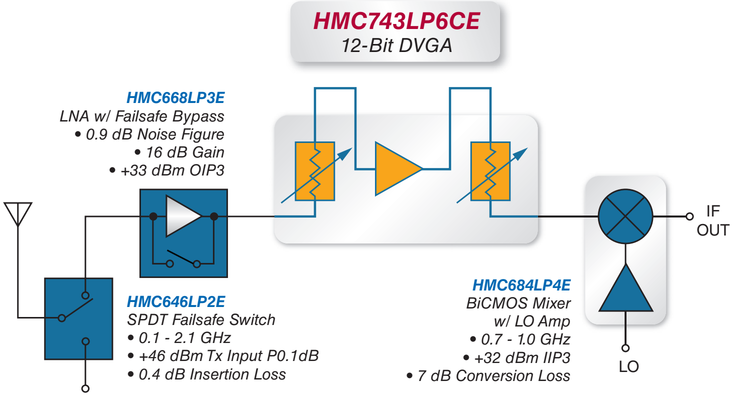


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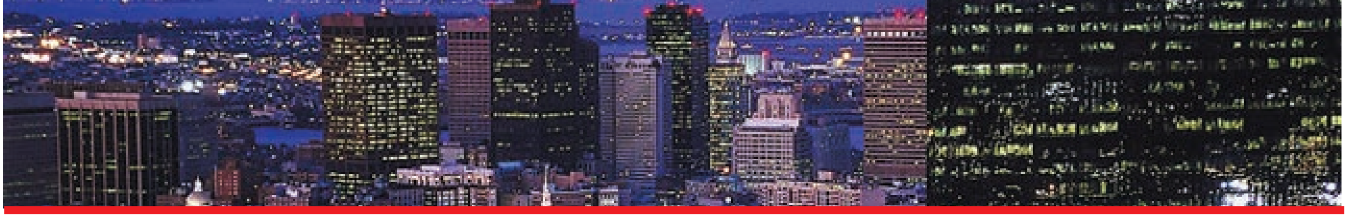


and some companies and their exhibits were placed in meeting rooms or halls. I mentioned the sign operation that was constantly making new signs to direct the attended to the right location as we shifted meeting rooms to accommodate larger the than expected audiences.

Every square inch was booked. We had to fix each challenge on the spot as quickly as possible. The space challenge will not happen in 2009 because the new Boston Convention and Exhibition Center is HUGE and state-of-the-art. But we do occupy most of it in 2009 with room to spare. LCD displays will replace many of the paper signs, but not all.

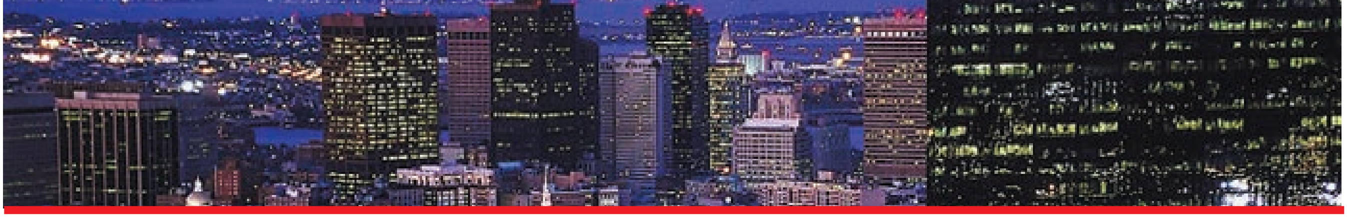
There are simply too many Steering Committee members to thank personally in these "rememberings". They were and are a unique (and heroic) group of dedicated individuals that made up the winning Boston team. I was "blessed" to have them at my side because, as you should already know, they "made it happen" and truly did all the work.

I held the meetings, made a few decisions, and watched. The good news is that you will see them and may meet them at IMS 2009. Yes, they are still at it. Some are retired, some busier than ever at their jobs, some passing on valuable information to new members of the IMS Boston team as they resume their roles as volunteers and as members of the team. I especially remember the tireless dedication of co-chairmen of the Technical Program Committee, Peter Staecker, who was the Chairman of IMS 1991 when I was Co-chairman of the 1991 Technical Program Committee (we switched roles for IMS 2000), and his fellow co-chairman of the TPC, Fred Schindler. Fred is now Chairman of IMS 2009. You see how that goes in Boston. Both Peter and Fred were real leaders in getting the most comprehensive and educational microwave technology program together. And as you can see they are both involved today. That is what makes it all work; year to year, decade to decade.

## LOOKING TOWARD IMS 2009

**Fred Schindler, Chairman, 2009 MTT-S Boston Symposium**

The IMS has a storied history in Boston. As you've read in the articles from past Boston IMS chairs, strong Boston teams work hard to create very successful symposia. So it was a real honor when I was asked to organize a proposal for the 2009 symposium. That was in 2000, just as IMS 2000 was getting underway. After wrapping up IMS 2000 we prepared a proposal, and in June 2001 made a presentation to the MTT AdCom. AdCom, the governing body of the MTT Society, selects IMS sites, usually eight years in advance. It was an un-



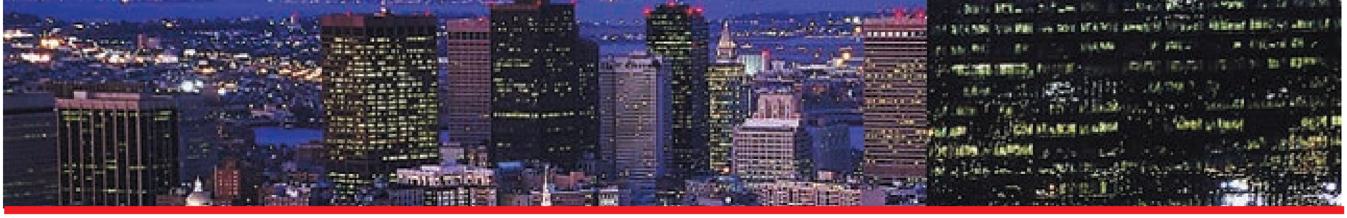
usual selection process that year, including the first AdCom site selection vote to result in a tie. After much discussion Boston prevailed in a second ballot. We were on our way. The challenges we faced in the selection process may have been a foreshadowing of the challenges to come.

This year the IMS returns to Boston for the sixth time, 50 years after the first Boston area IMS. If you look at the IMS 2009 Program Book, you'll see excerpts from the 1959 program. In 1959 the National Microwave Symposium was held on the campus of Harvard University in Cambridge, MA, across the river from Boston. The symposium has grown with each return to Boston. Boston symposia have a tradition of being innovative and a history of breaking records. We plan to continue the tradition, but history is not something we can control.

The IMS has grown into a large, complex event. This year over 80 people have been involved organizing the symposium and will be on site helping to run things smoothly. You can see a full list of them and what they've done on our website, www.ims2009.org. The IMS is a remarkable volunteer endeavor, where people give their time to serve the community and the MTT Society. When you come to the symposium, you'll see steering committee members bustling about. Look for them wearing shirts with the IMS 2009 logo, or with white IMS 2009 ribbons on their badges. Thank them!

We have quite a few innovations for 2009. Hopefully they'll work well. Regardless, I'm confident that we'll learn from all of them and future symposiums will be better and richer as a result. Here's a list of some of them:

- Monday Night Plenary Session. The session will run 5:30-6:45 p.m., and the reception will follow immediately in the adjoining room. This frees Tuesday morning for more technical sessions.
- Focus Tracks. The technical program is organized into four focus tracks to help you better find what interests you.
- Interactive Forum during breaks. To enhance the Interactive Forum, they will be held during the breaks between podium sessions of related topics.
- Virtual Participation. Certain sessions, workshops and short courses will be recorded and made available for delayed viewing on www.IEEE.tv. Some items will be free, including the Plenary Session and MicroApps. Others will be available for a fee.
- Registration. We've made a number of changes to the registration system and offerings.



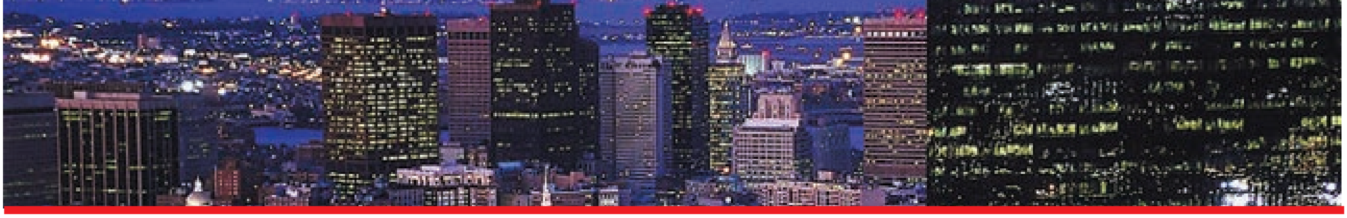
Chief among them is that registration remains open until the day before the Symposium opens. We've also introduced a third tier of pricing. Early Bird registration opened in February and runs until May 15. Advance registration pricing is then available until the day before the symposium opens, when on site pricing takes over. We've also introduced a SuperPass—a single registration item that gives you virtually everything and a discount too.

- Special Offers. Wednesday afternoon Exhibit Only passes are free. Thursday Single Day IMS registration is free for retirees. If you are between jobs, you can apply for discounted registration.



- Print-on-demand. Kiosks will be available throughout the convention center and will allow you to print any IMS paper for free.
- Short Courses. Five professionally presented Short Courses for enhanced learning.
- Wednesday Workshops. In addition to the traditional Sunday, Monday and Friday workshops.
- Industry Hosted Reception. The usual reception will be in the Exhibit Hall for the first time, 5-6:30 p.m. Wednesday evening. You can even attend with your free Exhibit Only pass.
- Upgraded MicroApps. An open, inviting and comfortable theater located in the exhibit hall just inside the registration area. All presentations will be recorded and available via IEEE.tv for free.
- Feedback Surveys. Each talk in every session will be scored. There will be accolades for the best papers and a drawing for prizes for attendees that submit scoring sheets.
- Thursday Evening Social. To help you stay a little longer, a Boston Harbor cruise with food and drink and very economically priced—only $10 during the Early Bird registration period.
- Student Job Fair. Open only to students, Thursday afternoon 1-4 p.m.
- Local Historical Displays. The usual historical exhibit will be enhanced with local historical artifacts and information.

Boston has always broken IMS records. It's not difficult to understand why. With a heavy concentration on RF and microwave industry and research facilities in the area, there is always a strong local attendance. Boston is also an attractive destination, which encourages attendance from afar. The Boston history of always breaking records may seem in jeopardy, given economic conditions. Our Steering Committee is



also working hard to overcome that obstacle.

Certainly IMS 2009 will break some records. There are already some strong signs. Paper submissions, while not at the all time record level, were still 14 percent above last year and higher than for the last Boston symposium, IMS 2000. Booth sales for the exhibition are another important indicator. I'm writing this in late March, and at this point more booths have been sold for IMS 2009 than for any previous IMS in the same timeframe. Perhaps booths are selling so well because of the troubled economy. The premier RF/microwave trade show in the world is the best opportunity to connect with customers, an opportunity not to be missed in a difficult economy.

For the trade show to be successful, IMS attendance must be high. And strong attendance is also key for the technical sessions and informal networking opportunities to serve their purpose—a meaningful exchange of ideas. The good news is that early technical attendee registrations are also usually high. This may well be because registration is opening two weeks earlier than it has in the past. Hotel bookings are also a promising indicator. Two hotels in the block are essentially sold out already.

One key to the success of any Boston IMS is local attendance. The large local population of RF and microwave researchers, engineers and technicians always flock to the IMS. This is the primary factor that makes me confident IMS 2009 will be a success. I am sure we will have the unusual problems to address; every IMS seems to have something unexpected pop up. We already have an unplanned economic obstacle to overcome, and it may throw us an additional curve or two. But I remain confident. We have a large, committed and experienced Steering Committee, and we are all focused on making sure IMS 2009 is the best event possible. See you there!



## References


1. T.S. Saad, "The Story of the MIT Radiation Laboratory," *IEEE AESS Magazine*, October 1990, pp. 46-55.
2. Author's note: Roger did insert a three-stage solid-state amplifier in the receive chain to make up for loss of gain in the tube circuits.
3. E.G. Bowen, *Radar Days*, IOP Publishing Ltd., 1987.
4. Washington University Department of Physics Newsletter, Winter 2007-2008 (Alumni News), p. 12 (www.physics.wustl.edu/News/NewsLetters/PhysicsNewsW08.pdf).

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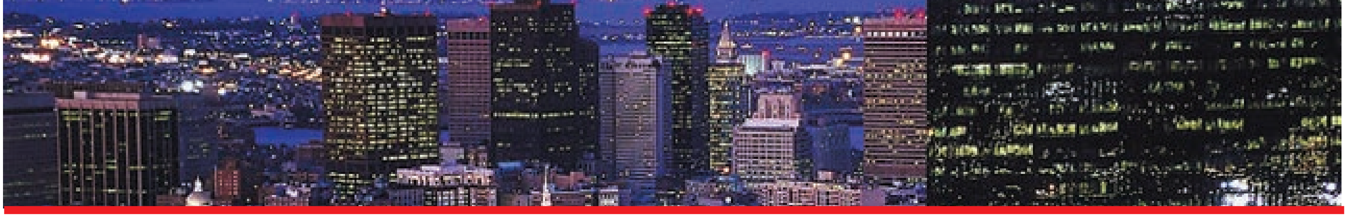


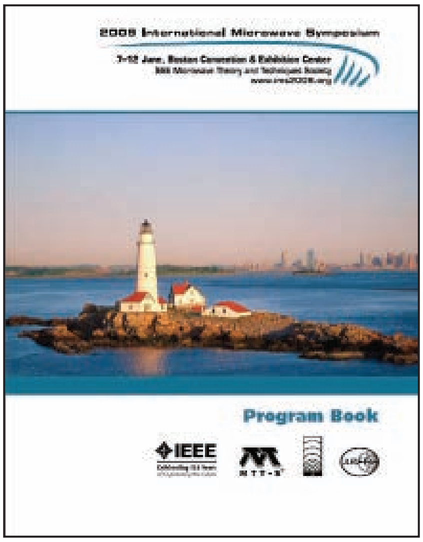
# Tracking the 2009 Technical Program

If you are planning to attend the technical conference at this year's IMS and just received your technical program book, you may be overwhelmed by the volume of content presented. There were, after all, 430 papers accepted (294 oral presentations and 136 interactive forums). In addition, there are 30 workshops, five short courses and one rump session. Whew!

Recognizing that one can't be in two places at the same time, the technical committee spent considerable time and effort trying to minimize scheduling conflicts. Still, with this much content stuffed into six days, one might have to resort to a coin toss. The committee also worked to spread out the conference so that attendance did not fall off toward the end of the week. In other words, good stuff right through the end.

IMS or Microwave Week is made up of three conferences: RFIC, which provides a focus on wireless and wireline communication ICs; ARFTG, dedicated to RF and microwave test and measurement techniques; and, of course IMS, which has a focus on almost any technology happening at RF, microwave and millimeter-wave frequencies.

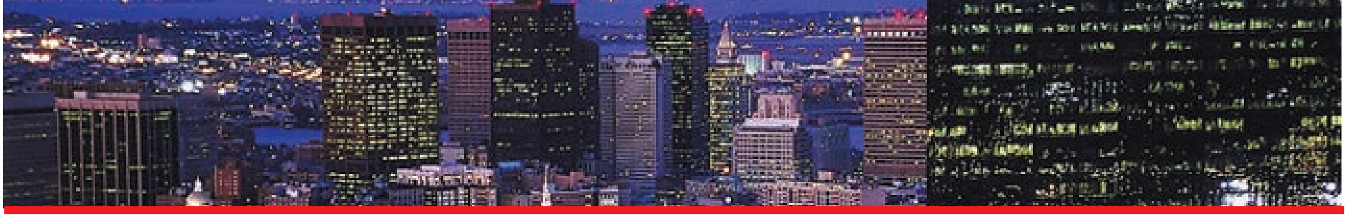
The week starts with workshops and short courses on Sunday and Monday. Monday also features the start of the RFIC technical sessions, which spill over into Tuesday along with the RFIC interactive forum. Tuesday through Thursday belongs largely to IMS (along with some joint sessions with the RFIC and ARFTG conferences). With such a broad range of materials, the IMS technical program organizers created the following four tracks to manage the content and allow attendees to easily pick out their area of interest from a sea of sessions and forums.




The **microwave modeling** track (color coded green in the program) includes talks on nonlinear circuit and system analysis, CAD algorithms, field analysis and EM simulation, time/frequency domain, nonlinear modeling, optimization and modeling novel devices such as metamaterials. The **active components** track (red) includes CMOS, millimeter-wave (including Terahertz) devices, power amplifiers, switching architectures, LNAs, signal control and sources, semiconductor devices, ICs and GaN. The **passive components** track (yellow) includes transmission lines, ferrites, combiners, hybrids, multiplexers, passive structures, MEMS, acoustic wave devices and, of course, filters. The **microwave system** track (blue) includes front-ends, communication systems, smart antennas, phased arrays and radar, bio and medical systems, test and measurement, photonics and various system-level packaging sessions and forums. This is but a high level view of the hundreds of talks being presented.

The technical sessions take place in the morning and afternoon, panel sessions are held during the lunch hour and each day has an overlapping series of interactive forums that run from 9:20 in the morning to 3:40 in the afternoon. Friday concludes with the ARFTG conference and additional workshops. There is also considerable student participation (competition), focus and special sessions, and a plenary session. Choose your sessions wisely and make sure you save some time to get down to the exhibition floor. See you there.


**David Vye**
*Editor,* Microwave Journal



# 73RD ARFTG CONFERENCE

Automatic Radio Frequency Techniques Group (ARFTG) is a technical organization interested in all aspects of RF and microwave test and measurement.

ARFTG was originally set up in 1972 to help the end user get the most from the latest generation test and measurement equipment. This was exemplified by the introduction and eventual widespread use of instruments such as vector network analyzers (VNA) with internal computing power to handle functions such as calibrations. ARFTG has continued to evolve and now has more than 600 members worldwide. ARFTG's core mission is one of education. It achieves this by hosting conferences, workshops and training courses.

ARFTG's close association with the top vendors of measurement instrumentation ensures excellent equipment exhibits at ARFTG events. Vendors often choose to launch their new product ranges during our exhibits. The extended breakouts from conference technical sessions enable excellent interactions to take place among colleagues, experts and vendors. Oral technical sessions at ARFTG conferences are conducted in a single-track workshop style, with papers on topical subjects both theoretical and practical, user and manufacturer, modeling and measurement.

More details on all of this can be found at www.arftg.org.

## ARFTG AT MICROWAVE WEEK 2009

ARFTG will be well represented at this year's MTT-S Microwave Week in Boston, MA. In fact, the ARFTG conference forms an integral part of Microwave Week and will take place on the last day of that week (Friday, 12 June).

The venue will be the Boston Convention and Exhibition Center. If you are at all interested in measurements, particularly high-frequency measurements (measurements in the range 1 kHz to 1 THz, or thereabouts), why not come along and join us? You'll find the atmosphere informal and friendly. The chances are you will take away much more that you came with—perhaps some fresh ideas to help with your current projects; certainly some new technical contacts; and perhaps even some opportunities to take your own career to that next level.

The theme of this year's conference is "Practical Applications of Nonlinear Measurements." In setting up the technical program for the conference, papers were solicited from areas including:

- Nonlinear vector analysis
- Nonlinear time domain techniques
- On-wafer nonlinear microwave measurement
- Nondestructive in-circuit testing
- Complex waveform analysis.

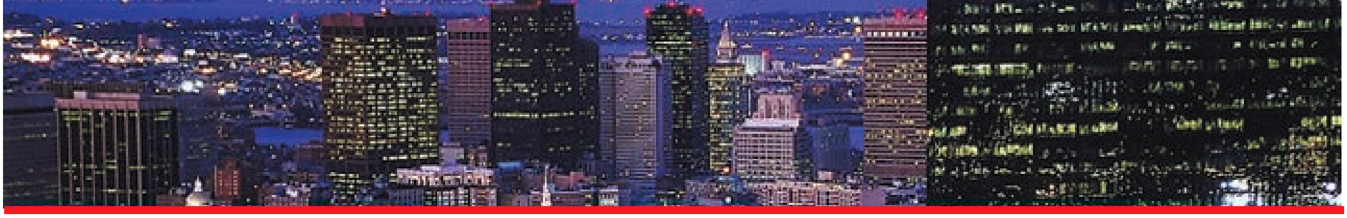
The most stimulating part of the ARFTG experience is the opportunity to interact one-on-one with colleagues, experts and vendors in the RF and microwave test and measurement community.

## NEED TO KNOW MORE?

ARFTG's website (www.arftg.org) usually has all you need to know about up-and-coming events. This includes our conference during Microwave Week 2009. Alternatively, there are some key contacts within the ARFTG organizing group:

- For exhibits information, contact exhibits@arftg.org
- For sponsorship information, contact Leonard Hayden at leonard.hayden@ieee.org
- For conference technical program information, contact Dave Blackham at dave_blackham@agilent.com
- For all other conference matters, contact Charles Wilker at wilker@ieee.org.

**CHARLES WILKER**
*73rd ARFTG Conference Chair*
*Wilmington, DE*



# 2009 RFIC SYMPOSIUM

Welcome to the IEEE Radio Frequency Integrated Circuits (RFIC) Symposium (www.RFIC2009.org), which will be held in Boston, MA from June 7-9, 2009. Held in conjunction with the IEEE MTT-S International Microwave Symposium, it opens Microwave Week 2009, the largest world-wide RF/microwave meeting of the year.

The RFIC Symposium continues to build upon its heritage as one of the foremost IEEE technical conferences by bringing focus to the technical accomplishments in RF circuits, systems and devices. This year's exciting technical program will showcase the latest innovations in RF integrated circuit design, cellular and wireless connectivity system ICs, broadband wireless communications, silicon millimeter-wave ICs, and RF device technology, modeling and characterization.

The RFIC Symposium will start on Sunday with a full day line up of half-day and full-day workshops covering a large breadth of topics. The Plenary Session will take place on Sunday evening. Keynote addresses will be given by two renowned industry leaders who will share their views and insights on the direction and challenges that the RF IC industry is facing. The first speaker, Christopher Snowden, PhD, Vice-Chancellor and Chief Executive of the University of Surrey, Guildford, UK, will discuss "Cost-effective Semiconductor Technologies for RF and Microwave Applications." The second speaker, George W. Everhart, CEO of Alien Technology Corp., will discuss "Real-world RFID Deployments: What Makes Them Work?" The highly anticipated RFIC Reception will follow immediately after the Plenary Session, providing a relaxing time for all to mingle with old friends and catch up on the latest news.

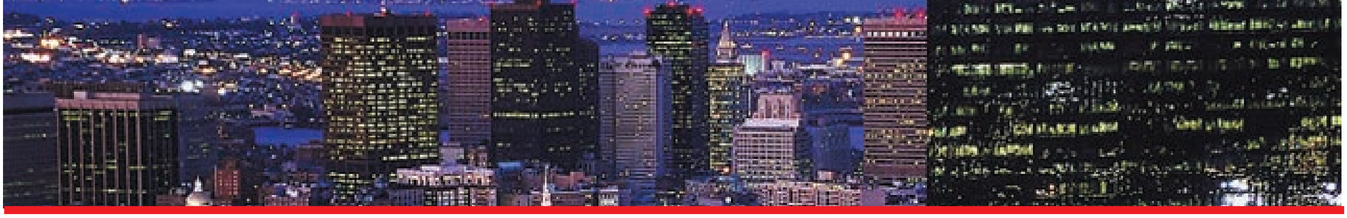
On Monday and Tuesday, the conference will feature lunch time panel sessions. The Monday panel session is entitled "Who Will Win the Battle for the Gigabit Wireless in Your Home: Wireless HD, 802.11n, Wireless USB, or UWB?;" the Tuesday panel session is entitled "60 GHz CMOS Radio: Reality or Fiction?" Be sure to attend these lively and entertaining forums. Technical papers will be presented during oral sessions throughout Monday and Tuesday. The technical program will conclude with an Interactive Forum session on Tuesday afternoon.

This year's location also highlights one of the cultural centers of America. Famous for everything from the Red Sox and Paul Revere to Cheers and seafood, Boston is a popular destination. Between landmarks, you can shop stores on Newbury Street, have an authentic Italian meal or browse the antique shops.

On behalf of the RFIC Steering Committee, we look forward to seeing you at the 2009 RFIC Symposium in Boston.

*Tina Quach received her BSEE degree from the University of California at San Diego and her MSEE from Arizona State University. She joined Motorola in 1989 as a Monolithic Microwave Integrated Circuits designer. In April 2004, Freescale was spun off from Motorola, and she has worked at Freescale as a Power Amplifier Designer ever since. Over the years, Quach has served on the RFIC Steering Committee in many different capacities.*

**TINA QUACH**
*General Chair*



# 2009 MicroApps: Learning from the Experts

The Microwave Applications Seminars (MicroApps) is a mini-event within the exhibition that serves as a forum for participating exhibitors to present the technology behind their commercial products and special capabilities. This year's MicroApps is hosted by Agilent Technologies and will take place in the Exhibition Hall between the main entrance escalators. Featuring a variety of technology, products, design and measurement specific presentations, the sessions will be held throughout the exhibition (Tuesday, Wednesday and Thursday).

Each MicroApps session is a 20-minute long tutorial or application presentation that provides IMS attendees with useful and contemporary information on a broad variety of subjects. The flexible and informal format of MicroApps and the commercial nature of the presentations augment the product displays of the exhibitor space and the more formal Technical Program talks of the IMS conference itself. These seminars are where research and real-world applications meet. With the help of hardware and software demonstrations, the MicroApps sessions are expected to be highly interactive with audience participation.

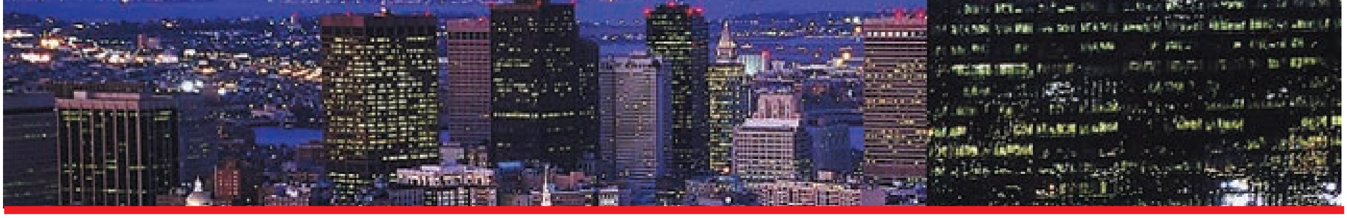
One example of the content being presented is the session on Nonlinear Vector Network Analysis and Applications of X-parameters. This workshop will discuss the Agilent Nonlinear Vector Network Analyzer (NVNA) as well as the application of X-parameters for the design and analysis of active components. Applications of measured X-parameters in design and validation of active components including the simulation/optimization of complex stimulus/response behavior in ADS will be presented. New load dependent measurement-based X-parameters will be introduced and used in the simulator providing an efficient and correct method for the designer to maximize linearity with a nonlinear model that is valid over a wide range of impedances.


Other session topics include:

- Fast, Flexible Automated Pulsed IV/RF Measurements for Accurate Nonlinear Model Development
- Ultra-fast Noise Parameter Measurements with Improved Accuracy are Described Resulting in a 200x Speed-up Over Traditional Methods
- High-speed Testing of Multi-state RF/Microwave Devices and Sub-systems
- Load Pull with X-parameters Produces Instant Large Signal Model with High Accuracy
- Test Solutions for LTE/MIMO Base Station Antennas

Presentations are scheduled from exhibitors such as TriQuint, Maury Microwave, Auriga, Custom Microwave, OEWaves, Cap Wireless, IMST GmbH, Micronetics, Mician GmbH, M2 Global Technology, Jazz Semiconductor and Holzworth Instrumentation, as well as measurement experts from the MicroApps sponsor, Agilent. Attendees will receive a free CD-ROM that includes informative details from every presentation.

**Barry Alcorn**
*Agilent Technologies Inc.*



# Please Come to Boston in the Springtime

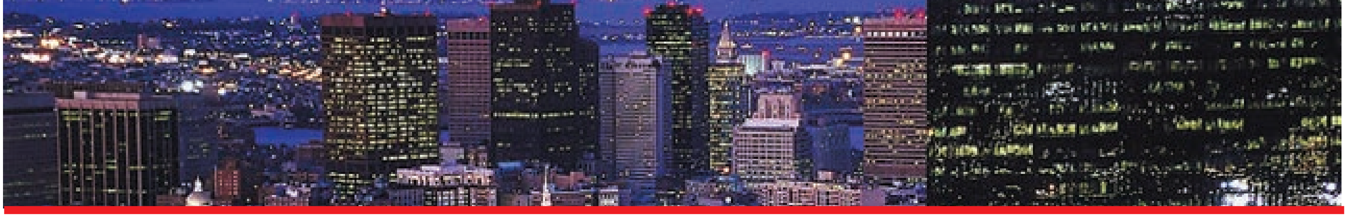
"Please Come to Boston in the Springtime. I'm stayin' here with some friends and they've got lots of room." Anyone remember that 1974 song, which made Dave Loggins a one-hit wonder? Can't say that I was a big fan, but the lyrics seem eerily appropriate for this year's IMS. The show is just a few weeks away and one can't help wondering if the economy will be the elephant in the room. Will it weigh heavily on everyone's minds or will Boston magic once again inspire us all and result in a rewarding show?

Microwave conferences in this city have a history of surpassing attendance and revenue records. Hopefully, that will be the case this year in spite of industry-wide budget cutting. Now is the time to apply the "power of positive thinking" and come to Boston ready to make a big splash with new products to exhibit and compelling technologies to present at the workshops and sessions. Think opportunity! In return, we need Microwave Week to give the industry a boost. The kind we would expect from a show in this location. History would seem to be on our side.

To understand the draw of a Boston-based IMS, this month's lead story comes by way of the four, former planning committee Chairmen. Our guest authors—Ted Saad, Harlan Howe, Jr., Peter Staecker and Glenn Thoren—re-visit their experiences organizing the Boston conferences in 1967, 1983, 1991 and 2000, respectively. Our article concludes with a look toward this year's show from current General Chair, Fred Schindler. This is a great read for those who were present at the time and fondly remember those past events and are curious about 2009. Each contribution provides a behind-the-scenes look at what it takes to organize Microwave Week and the special bond that is passed from conference to conference even when separated by a decade or so.

What makes Boston so special? As they say in real estate—location, location, location. New England is home to many microwave folks and the companies for which they work. The long history of microwaves in Boston goes back all the way to Marconi's wireless transatlantic transmissions from Cape Cod in 1903. The work carried out at the MIT Radiation Lab during World War II and the invaluable contributions of local powerhouse companies such as Raytheon, Microwave Associates and others have all contributed to the region's microwave leg-

**David Vye**
*Editor*, Microwave Journal



acy. No doubt the abundance of local engineering talent has been a leading factor in high attendance numbers in the past and this year's conference organizers are actively pursuing local engineers and their companies to encourage their participation in 2009.

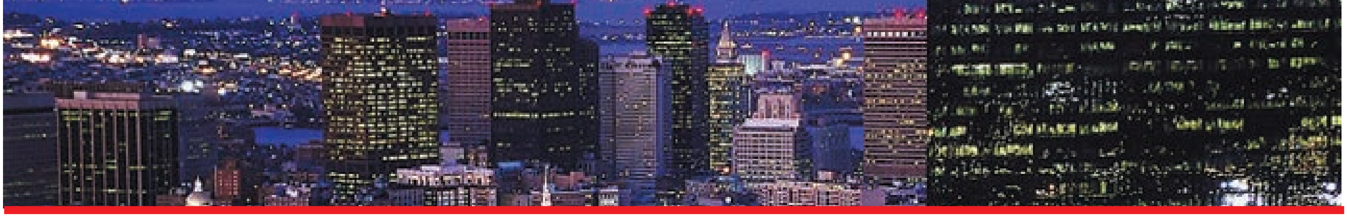
A number of Boston-area microwave companies can also point to their 50+ year history of military/aerospace activity. Defense-related work may have been out of vogue at the 1991 or 2000 conferences when the commercial markets were riding high; however, that won't be the case this year as many exhibitors look to offset declines in financially turbulent commercial markets in favor of any well-funded military and government opportunities. I have heard from multiple exhibitors planning to target mil/aero applications at this show. We may witness a fair amount of marketing in that direction in 2009. We may also see a few vendors (especially within the semiconductor sector) leveraging recent advances in device efficiency to address the "green" economy, as is the case with two webinars (sponsored by TriQuint and Tektronix) being hosted by the *Journal* this month.

Other notable items in this month's show issue include messages from the 2009 RFIC Symposium General Chair, Tina Quach; the Chair of the 73rd ARFTG Microwave Measurement Conference, Charles Wilker, and MicroApps organizer Barry Alcorn of Agilent Technologies. Our International Editor, Richard Mumford, conducts our online Executive Interview with this year's IMS Plenary Speaker, Petteri Alinikula, Laboratory Director Nokia Reserch Center Helsinki. Richard also pens a profile on the Research Center itself. Closer to Boston, our Norwood staff has taken advantage of its home-court status to compile a true insider's guide to the city and its surroundings.

Our online Expert Advice this month comes from Gayle Collins, a power amplifier (PA) designer from Freescale Semiconductor writing about what to look for in the PA papers being presented at IMS and their potential impact on the field. I first met Gayle at IMS 2007 in Hawaii, where she had just presented a paper and her enthusiasm was infectious. In Atlanta last year, Gayle and I bumped into each other between technical sessions; once again she impressed me with her analysis and rating of the many sessions she had attended. This year I invited her to write about the upcoming conference for our readers.

Our exhibition coverage for this show issue includes our "New Waves" MTT-S Product Showcase as well as a new exhibitor profile section. We believe both the product showcase and exhibitor profiles will provide the extra information attendees need to help decide who to fit into their schedules while at the show. This guide will also be part of our Online Show Daily, along with special editorial, conference and daily news updates from the show. This is the time of year when companies let loose with a flood of product releases and news items, so check in often for the latest information.

MTT-S IMS is an important networking event. Attendees get the chance to tap into what is going on in the industry, display their products, meet customers face-to-face and check out the competition. The entire *Microwave Journal* staff is excited to have the industry back in the 'hood. We take great pride in this city by the sea with its rich colonial history, home to many of the world's leading colleges and universities, outstanding sports teams, restaurants, neighborhoods, clubs, bars and more. So, please come to Boston in the springtime. The Red Sox and Yankees will be in town. We hope you are too.



# THE IMSIDER'S GUIDE TO BOSTON

There are few better places to be than Boston in June. The weather is normally very comfortable, the city is alive with students and tourists, the Red Sox are in full stride and the Harbor is bustling with activity.

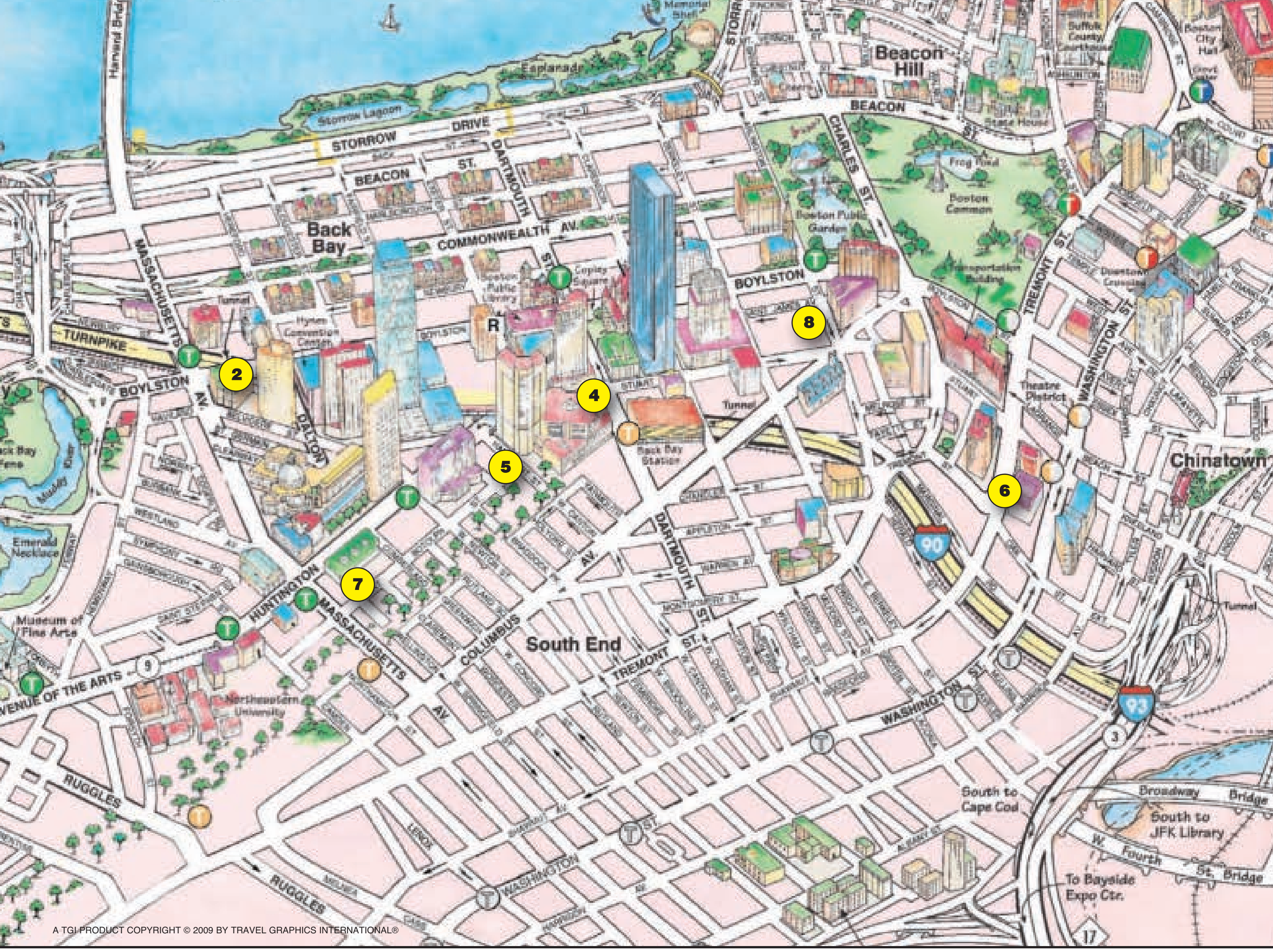
As you'll see in the information that follows, there is no shortage of great restaurants, museums, activities and events in Boston. Your biggest problem may be in deciding where and how to spend the limited time that you have in town.

If you're staying in the Back Bay/Copley area of the city, you will enjoy the benefit of having a plethora of shops and restaurants at your disposal. Newbury and Boylston Streets boast an assortment of high-end retail shops and restaurants with patio seating, allowing you to watch the bustling activity of tourist season. It's also a short walk to both the Boston Common/Public Gardens and the Esplanade, which provides a park-like environment along the Charles River.

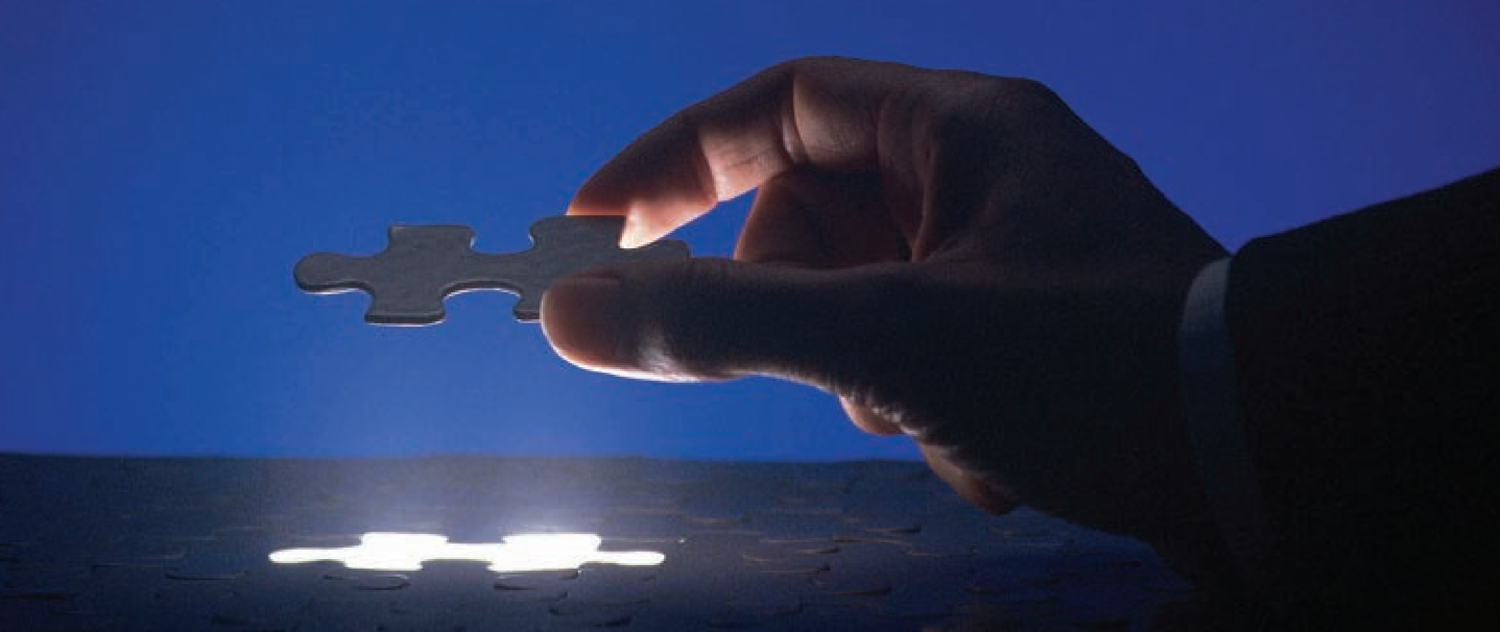
If you have opted to stay near the Convention Center (BCEC), you have easy access to Faneuil Hall, the Seaport District and the North End. The North End is our "Little Italy", where the streets are narrow and compact, and there is plenty of history—Old North Church, Paul Revere's house, burial grounds—seemingly around every corner. The neighborhood is packed with restaurants, virtually all of them Italian, and the locals carefully maintain their deeply-rooted ties to Italian culture. It's difficult to recommend any one particular restaurant, as all are good. Just walk the streets until you find one that strikes your fancy. After dinner, stroll over to Mike's Pastry or one of the other local establishments, for coffee and the best cannoli you may ever experience.

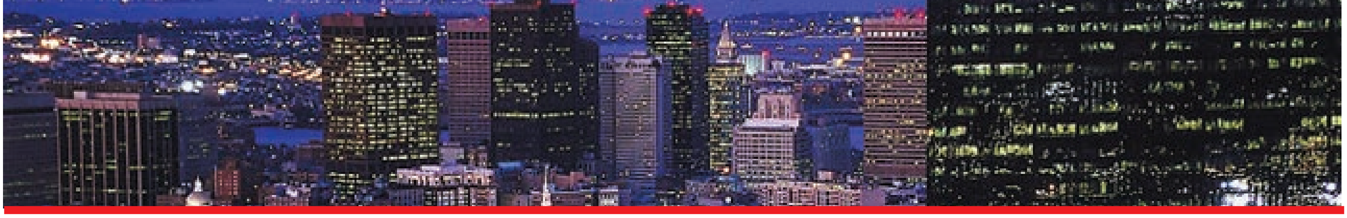
If you can extend your stay post-IMS, there are a variety of destination options. Cape Cod and the islands of Nantucket and Martha's Vineyard are some of the finest vacation spots in the world, as several past Presidents and our current one will attest. The mansions of Newport, RI and surrounding beaches are worth the trip. The northern New England states of Maine, New Hampshire and Vermont provide incredible scenery, lakes, mountains and ocean beaches. If you're looking for a casino resort, you'll find the best of them down in our neighbors in Connecticut.

**MICROWAVE JOURNAL STAFF**




# Infusing new technology into legacy systems.





We have compiled a brief guide to help you navigate your stay in town. Hopefully, this will give you some ideas on where to go, what to do and where to dine. It is by no means a definitive guide, so feel free to ask the locals for their recommendations. We think that you'll find us to be friendly hosts.

## HISTORY

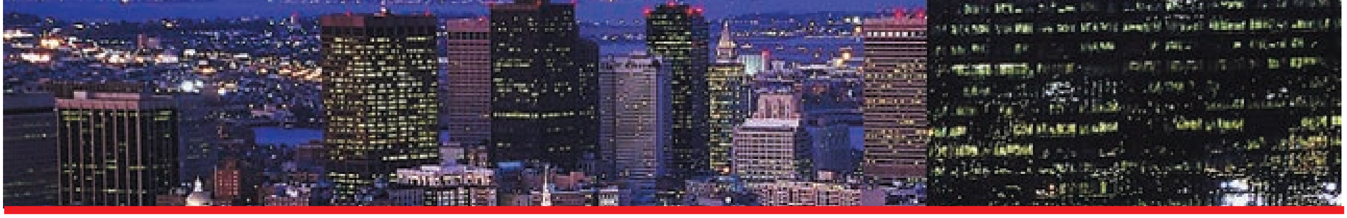
The Freedom Trail is a 2.5 mile red-brick walking trail that leads you to 16 nationally significant historic sites, every one an authentic American treasure. Preserved and dedicated by the citizens of Boston in 1958, the Freedom Trail today is a unique collection of museums, churches, meeting houses, burying grounds, parks, a ship, and historic markers that tell the story of the American Revolution and beyond. Visit http://www.freedomtrail.org for more information.

Another great way to see the city is aboard a "DUCK", a W.W.II style amphibious landing vehicle run by Boston Duck Tours. Guests will cruise by all the places that make Boston the birthplace of freedom and a city of firsts, from the golden-domed State House to Bunker Hill and the TD Banknorth Garden, Boston Common and Copley Square to the Big Dig, Government Center to fashionable Newbury Street, Quincy Market to the Prudential Tower, and more. The trip also includes a dip into the Charles River for a breathtaking view of the Boston and Cambridge skylines. Cost: Adults $29.95; children $20. Visit www.bostonducktours.com for more information.

## ART AND PERFORMANCE

The new Institute of Contemporary Art (ICA) building was designed by award-winning architects and weaves together the interior space and the surrounding waterfront to produce shifting perspectives throughout the museum's galleries and public spaces. The museum is a key component in Boston's plan to revitalize the neighborhood surrounding the convention center. Based on its proximity to the symposium, visitors who appreciate contemporary art and intend to visit some museum during their stay in Boston but may have limited free time should consider putting the ICA at the top of their list.

For a more traditional art museum experience, visitors may want to venture over to the Museum of Fine Arts (MFA), where they can enjoy works from the permanent collection including art from Europe, Asia, America and the ancient world as well as contemporary art. The museum's collection



includes many famous works from artists such as Titian, Dürer, Rembrandt, van Gogh, Gauguin and Renoir. Although there is no blockbuster show scheduled during the IMS, the museum has several upcoming exhibitions that may interest visitors. Visit their website at www.mfa.org for more details.

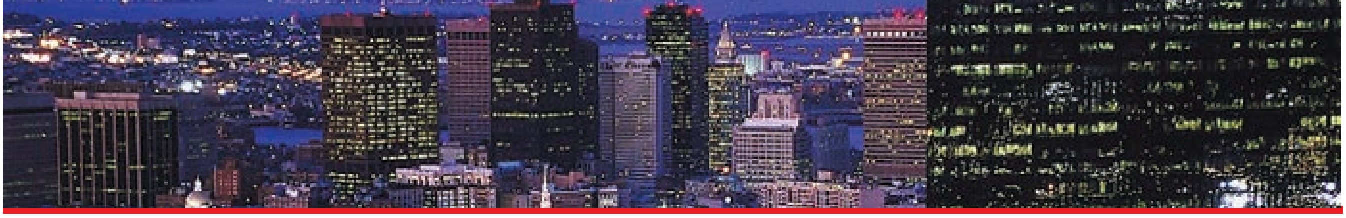
It's June when the summer concert season kicks off in the Boston area, and there is no better venue to catch a show than at the Bank of America Pavillion. You could do worse than to wrap up a busy week with a Diana Krall concert, which takes place on Friday, June 13th. For those looking to get away from the city for a while, the Cape Cod Melody Tent in Hyannis offers an intimate concert setting in the round. The Indigo Girls, in support of a brand new CD, play there on the same day. Boston certainly isn't a hotbed for country music, but Grammy Award winning artist Vince Gill takes his traveling road show to the Lowell Memorial Auditorium on Wednesday, June 10th. Those looking to take a trip back in time can see Linda Eder sing the songs of Judy Garland at Symphony Hall on both Tuesday, June 9th and Wednesday, June 10th. In addition, funny lady and Emmy award winner Kathy Griffin takes the stage at the Wang Theater on Thursday, June 12th.

## SPORTS

Experiencing Fenway Park, home of the Boston Red Sox, should be on the top of your "Things to do in Boston" list during MTT-S. One of the few remaining "old time" ballparks, Fenway is a great place to watch any game. This year, the baseball gods have blessed us with a Red Sox/Yankees matchup, smack in the middle of Microwave Week. If you have never witnessed this ancient rivalry in person, it's well worth it, whether you're a fan of the Sox, Yankees or any other team. If you're a baseball fan, or even just a fan of having fun, try to get tickets. Since basically all Sox games are sold out, you'll need to check www.stubhub.com or one of the other online broker sites, or make your way down to Yawkey Way and haggle with the scalpers. Be prepared to drop some serious cash. For a chance at free tickets, stop by the Reactel booth and enter their raffle for two tickets to each game.

## BOSTON: A RUNNER'S TOWN

Despite the spotty weather and long hard winter, Boston is a great town for a run. If you like to lace up the Reeboks, New Balance or Saucony (all three of these running shoe companies are based in and around Boston), this city has many routes that will get the blood pumping and provides inspiring views.



Every spring, the city is host to the granddaddy of road races—the Boston Marathon. This daunting 26.2 miles of hilly terrain stretches from the town of Hopkinton in the west to the Prudential Center in downtown bean-town. Apart from the Olympics, Boston is the only marathon that requires runners to qualify. The course has an uninterrupted six-mile downhill stretch to wear down runners before their attack of the Newton hills at the 16-mile mark. The third and final hill at the 20-mile point (known as "the wall") has earned the legendary name of "Heartbreak Hill". On the other side of Heartbreak Hill is yet another punishing downhill and six more miles to the finish. In the distance, the famous CITGO sign looms over Kenmore Square and Fenway Park, encouraging runners to dig deep and finish the race despite their pain.

For a less epic run, the Westin Hotel next to the BCEC provides its guests with a runner's map designed by *Runner's World* magazine. Of the two routes (three and five mile), the longer path will take runners around the Boston Common and down majestic Commonwealth Avenue. Alternatively, a runner can follow part of this route around the Common and then cross Storrow Drive over the Arthur Fiedler pedestrian bridge to run through the park adjacent to the Charles River. Wherever you may go, have fun but be

**From Reactel Inc.**

**The Barking Crab**

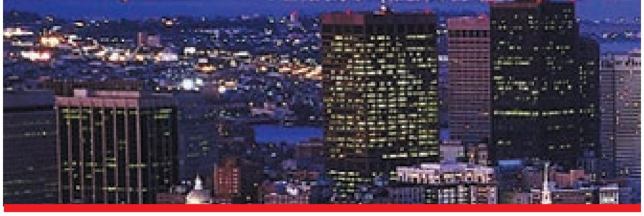
It wouldn't be a stop in Boston without the seafood, and Adam knows The Barking Crab has some of the best—and biggest—seafood dishes Boston has to offer.
88 Sleeper Street
www.barkingcrab.com

**East Coast Grill**

Three nights a year, East Coast Grill is home to Hell Night, featuring some of the spiciest dishes on the planet. Adam couldn't miss out on that!
1271 Cambridge Street
www.eastcoastgrill.net

**Eagle's Deli**

Adam Richman takes on a challenger in an epic battle of New York versus Boston. Adam attempts to finish the 12-pound Eagle Burger, complete with five pounds of burger, two pounds of bacon and cheese, and five pounds of fries.
1918 Beacon Street
www.eaglesdeli.com



cautious of the traffic. Boston drivers have a reputation for being very aggressive. Apparently, some get cranky from the long winter.

## ENTERTAINMENT

### Bowling and Billiards

If you have plans to go to a Red Sox game, make sure to stop in at Jillian's, which is located just minutes from Fenway Park. Jillian's offers non-stop entertainment including bowling, a restaurant and bar, and is a great option for parties of all sizes. Kings is also a premier spot for bowling, billiards and dining. Located in the Back Bay, Kings offers flat-screen televisions making this an ideal spot for those baseball and basketball games, good music, and a menu of pizzas, sandwiches and appetizers.

### Comedy

The Comedy Connection, which has been around for more than a quarter century, has featured big names such as Chris Rock, Dane Cook, Rosie O'Donnell, Dennis Miller and Robin Williams. Check out its new location at 246 Tremont Street. The Improv Asylum is a comedy theater that features improvisation and sketch comedy. Locals often describe the act as *Whose Line is it Anyway?* meets *Saturday Night Live!* (www.improvasylum.com/). Also, check out Dick's Beantown Comedy Vault, which is located in a remodeled bank with a 12-foot vault door and cartoon wall murals.

## RESTAURANTS, BARS AND PUBS

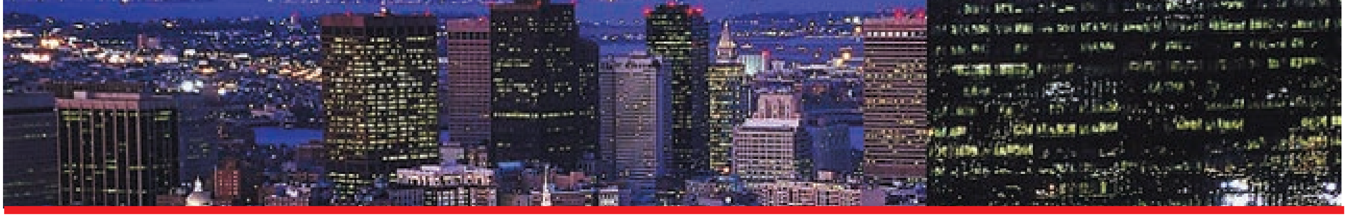
Eat, drink and be merry is something we hope

**From Response Microwave**

**The Greatest Bar**
Close to the BankNorth Gahhden this combination restaurant/bar rocks on three floors. Unlike your typical nightspot, three diverse floors of entertainment allow you the opportunity to camp out or roam around. Food is good, drinks are better and the mingling is great.
www.thegreatestbar.com

**Modern Pastry**
Not the best known, but certainly the best pasticheria in Boston's traditionally rich North End. Atmosphere is not as quaint and serviceable as other locations, but the pastries are worth it. The cannoli's and/or a slice of ricotta pie are a must!
www.modernpastry.com

**Trattoria Il Panino**
Fabulous Italian central coast food with a relaxing and authentic atmosphere located in the heart of Boston's North End (Little Italy) district. From antipasto to main course, menu selection accommodates all tastes and prices are very reasonable. A taste of Italy in Boston. Mangia bene!
www.trattoriailpanino.com



you find time to do in your travels to Boston. With so much to do and see, our hope is that we offer a good sampling of places to visit and restaurants/pubs that will be sure to whet your appetite.

Across the street from the Boston Public Garden, the Bull and Finch Pub inspired the famous '80s sitcom *Cheers*. Then, after reaching some degree of fame, *Cheers* inspired some major changes to the Bull and Finch Pub in order to accommodate the increasing number of tourists attracted to it. There are two Cheers in Boston, the original and a new one in Quincy Market, which is set up to resemble the tv show's bar.

Faneuil Hall presents 17 restaurants and pubs, including Sam's Café at Cheers, McCormick & Schmick's, Plaza III and Rustic Kitchen. Dine beneath beautiful glass canopies and outdoor cafes. Plus, find over 40 eateries and an infinite combination of choices in the Quincy Market Colonade, one of the most visited food halls in the world. Faneuil Hall also has many street performers including world-class jugglers, clowns, magicians, mimes and musicians. Be sure to check www.faneuilhall-marketplace.com as it gets closer for specific events. Voted one of America's top ten Irish establishments: The Black Rose, established in 1976, is located in the historic Faneuil Hall-Quincy market area of Boston. It's known far and wide for its convivial atmosphere, good food and live Irish entertainment.

The Purple Shamrock is a great place to stop by and have a bite to eat. The fare is composed of Irish and New England specialties with burgers, sandwiches, hearty pastas, fresh seafood, tender steaks and other great favorites. After dark, The Purple Shamrock has nightly entertainment.

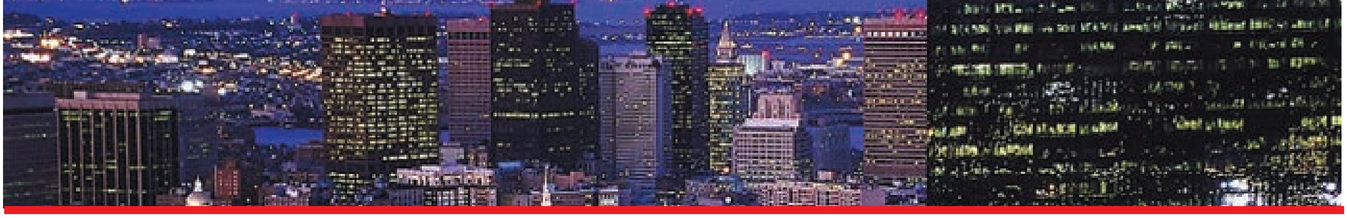
Located in the heart of Boston, on the Freedom Trail, a stone's throw between the Garden and Faneuil Hall Marketplace, the Bell-in-Hand Tavern is a lively place to be. During the early part of the week, folks stop in for a bite to eat, drinks and to listen to local bands play a variety of live music. On Thursday, Friday and Saturday night the crowd picks up as does the music scene including two floors, five bars and live music.

The Harp provides a mecca of sports and entertainment and is one of Boston's best singles and meeting spots. It provides two floors with three bars for after work drinks, pre and post Garden events, the latest in sports and live entertainment, DJs and dancing.

### BCEC/Seaport Area

**Salvatore's**

This upscale Italian restaurant, located in the heart of the Seaport district, delivers excellent food and ambiance at affordable pric-



es. Entrees like Veal Parmesan top out at $23, with most pasta dishes priced under $20.

225 Northern Avenue
(617) 737-7676
www.salvatoresboston.com

**No-Name Restaurant**

Don't go here for the décor or ambiance, because you won't find any. What you will find is fish fresh off the docks, at incredibly low prices. If you must have lobster while in town (and you must), this is the place to have it. A boiled lobster is the same anywhere, so you might as well get an inexpensive one. The wait staff is competent but indifferent, so don't expect service with a smile.

15 Fish Pier Street W
(617) 338-7539



## Back Bay/Copley Area

**Abe & Louie's**

There is no better steakhouse in Boston, and their many "Best of Boston" awards support this claim. It's expensive, but the atmosphere and décor are fantastic, the service is tremendous, and the food is consistently superb. It also boasts a lively and comfortable bar area for drinks and appetizers.

793 Boylston Street
(617) 536-6300
www.abeandlouies.com

**Brown Sugar Café**

This cozy neighborhood place offers what many locals consider to be the best Thai food in town. The menu is huge and the service is friendly. The Fisherman Madness dish, a spicy combo of crustaceans and filets, is worth the trip. Beer and wine is available.

1033 Commonwealth Avenue
www.brownsugarcafe.com

**Stella**

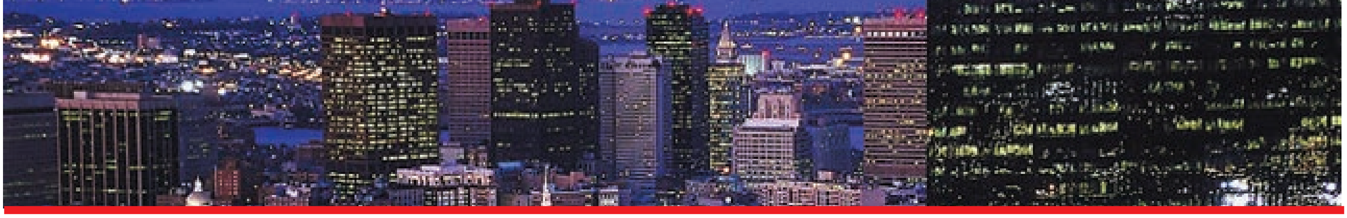
Located in Boston's South End neighborhood, Stella offers affordable and innovative Italian cuisine in a chic environment like no other in the city. *MWJ* dined here recently during "Restaurant Week" and the food and service were fabulous. Try the outdoor patio if the weather permits.

1525 Washington Street
(617) 247-7747
www.bostonstella.com

**Newbridge Café**

If you're looking for a real Boston neighborhood bar/restaurant experience, take the short drive/cab ride to the Newbridge. While it's no longer the "hidden gem" that it was, having won several "Best of Boston" awards, this place is an all-time favorite. The absolute best plate of steak tips and huge fries anywhere, at great prices. Tucked away in a classic Boston neighborhood right off the Expressway.

650 Washington Avenue
(617) 884-0134
www.newbridgecafe.com



# 2009 IMS Exhibitors

*The following list is complete as of April 15, 2009. Exhibitors in bold have an ad in this issue.*

2COMU 1644
3G Metalworx Inc. 1244
A-Alpha Waveguide Co. 2526
**A.J. Tuck Co. 533**
Acceleware Corp. 2709
Actipass R&M Co. Ltd. 225
**AdTech Ceramics 1738**
Advance Reproductions Corp. 1848
**Advanced Control Components Inc. 1726**
Advanced Microwave Components 2024
Advantage Business Media 2320
**Aeroflex Inc. 1428**
**Aethercomm Inc. 725**
**Agilent Technologies 1407**
**AKON Inc. 1628**
Aldetec Inc. 1839
Allrizon-TG Communications Equipment 836
AMCAD Engineering 635
American Beryllia Inc. 2809
**American Microwave Corp. 1646**
American Standard Circuits Inc. 444
American Technical Ceramics 1324
Ametek HCC Industries 1840
**AML Communications Inc. 2430**
**AmpliTech Inc. 607**
Analog Devices Inc. 2030
**AnaPico AG 2542**
Anaren Inc. 2037
**Anatech Electronics Inc. 2242**
Anoison Electronics Ltd. 209
**Anritsu Co. 2718**
**Ansoft LLC 2207**
Antcom Corp. 1304
Antenna Magus 204
Antenna Research Associates-ARA Inc. 315
*Antenna Systems & Technology Magazine* 2738
APA Wireless Technologies 126
Apollo Microwaves Ltd. 1635
Applied Radar Inc. 1536
Applied Thin-Film Products 1841
**AR RF/Microwave Instrumentation 1912**
**ARC Technologies Inc. 837**
Arlon Tech. Enabling Innovation 1745
**Artech House 2613**
Artek Ink. 109
**ASB Inc. 629**
Assemblies Inc. 2424
**Astrolab Inc. 1633**
AT Wall 604
ATTEN Microwave Components Co. Ltd. 835
Auriga Measurement Systems LLC. 1811
Aurora Software & Testing SL 2741
Avago Technologies 1215
Averna 1813
Avnet Electronics Marketing 2227
**AWR Corp. 1418**
AWT Co. Ltd. 2734
**B&Z Technologies 530**
Barry Industries Inc. 2831
Besser Associates Inc. 1113
Bliley Technologies Inc. 2921
**Bonding Source 536**
Bowei Integrated Circuits Co. Ltd. 2639
Brush Ceramic Products 1942
C W Swift & Associates Inc. 2524
C-Tech Co. Ltd. 2323
CAD Design Software 2934
Cadence Design Systems Inc. 2815
Cambridge University Press 307
CAP Wireless Inc. 930
CapeSym Inc. 133
**Carlisle Interconnect Technologies 1910**
Cascade Microtech Inc. 1307
**Centellax Inc. 2123**
Centerline Technologies LLC 1945
Century Seals Inc. 1045
**Cernex Inc. 2348**
**Channel Microwave Corp. 1739**
**Charter Engineering Inc. 1348**
Chengdu AINFO Inc. 211
**Ciao Wireless Inc. 1414**
Cirexx International Inc. 2246
**Cobham DES 1218**
**Coilcraft Inc. 2433**
Coining Inc. 2240
Coleman Microwave Co. 131
Colorado Microcircuits 2812
COM DEV Ltd. 1310
**Communications & Power Industries 1226**
**Compex Corp. 833**
Component Distributors Inc. 818
Connectronics Inc. 2042
Constant Wave Inc. 105
Corning Gilbert Inc. 2607
Corry Micronics 2324
CORWIL Technology Corp. 2247
**Crane Aerospace & Electronics 1141**
Crane Polyflon 1140
Cree Inc. 2418
Cristek Interconnects Inc. 1838
**Crystek Corp. 313**
**CST of America Inc. 2013**
**CTT Inc. 2627**
Cuming Microwave Corp. 2349
Custom Cable Assemblies Inc. 737
Custom Interconnects 1829
Custom Microwave Components Inc. 534
Daa-Sheen Technology Co. Ltd. 2628
**dBm 1440**
**Delta Electronics Mfg. Corp. 1433**
Delta Microwave 2344
Design Workshop Technologies Inc. 212
DeWeyl Tool Co. 1024
Diablo Industries Thin Film 1735
Diamond Antenna & Microwave Corp. 627
Dielectric Laboratories Inc. 810
Diemat Inc. 1144
DiTom Microwave Inc. 2107
Dorado International Corp. 2111
DowKey Microwave Corp. 712
**Ducommun Technologies Inc. 2711**
DuPont Electronic Technologies 2428
Dyconex AG 208
**Dynawave Inc. 1728**
e2v 411
**EADS North America 2638**
Eagle Comtronics Inc. 634
Eclipse Microwave Inc. 2108
**Elcom Technologies Inc. 1540**
Electro Rent Corp. 1515
ElectroMagneticWorks Inc. 2604
**EM Research Inc. 2633**
EM Software & Systems-SA (PTY) Ltd. 108
EMAG Technologies Inc. 2233
Emerson & Cuming Microwave Products 2336
Emerson Connectivity Solutions 2203
**Empower RF Systems 1037**
Endicott Interconnect Technologies Inc. 2044
Endwave Corp. 909
Epoch Microelectronics Inc. 2537
Equipment Management Technology 2425
**ET Industries 1730**
ETL Systems 2047
ETS-Lindgren 1312
Eudyna Devices Inc. 826
**EuMW2009 2612**
Excelics Semiconductor Inc. 1021
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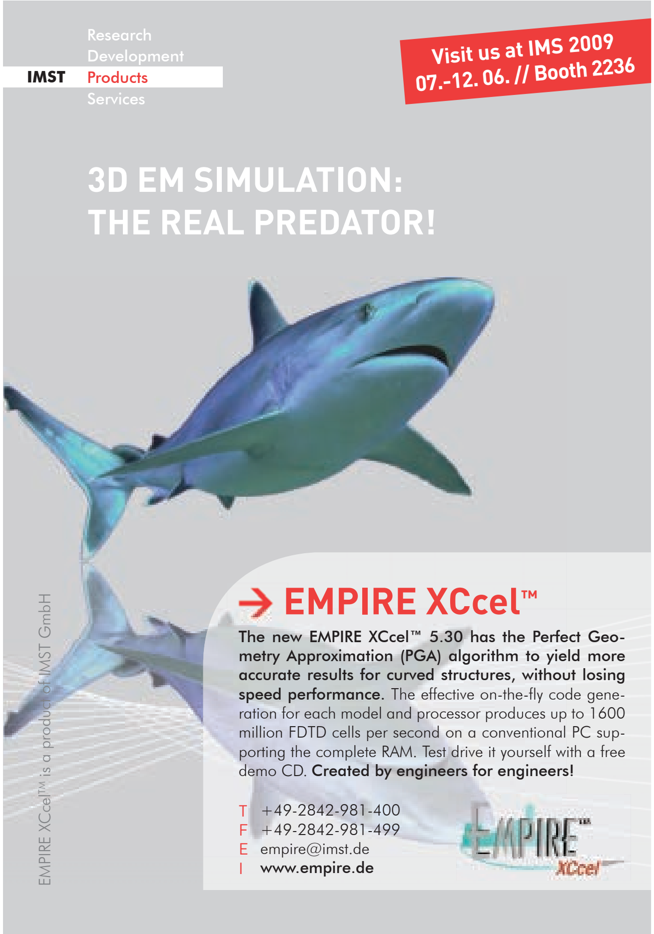




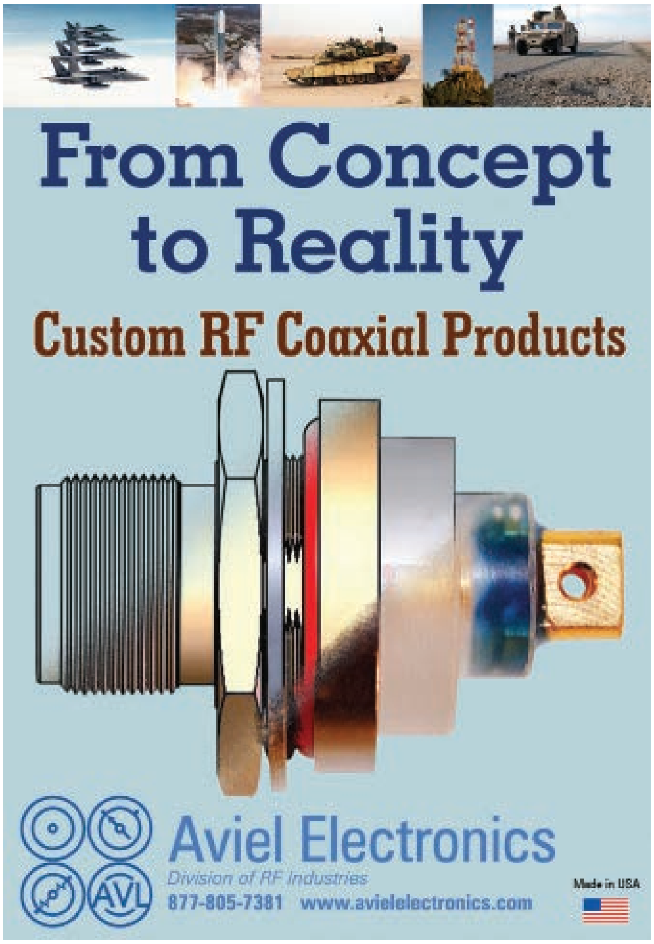


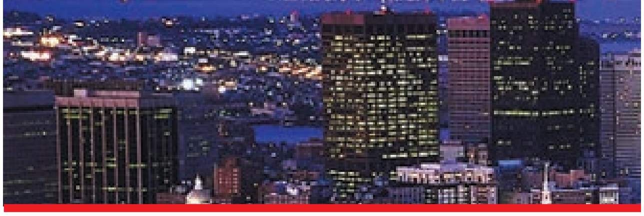

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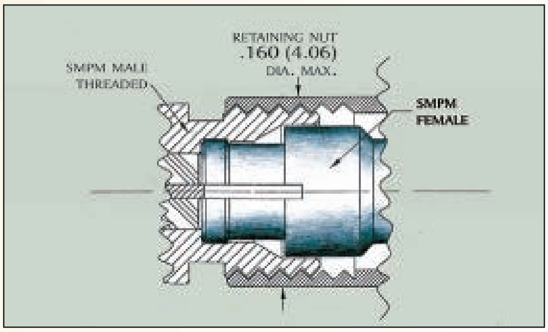


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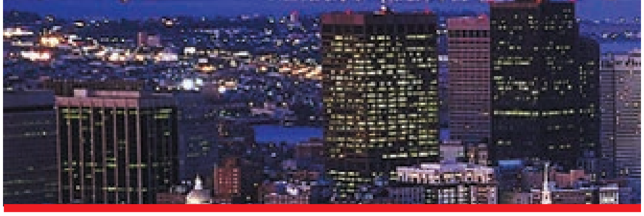

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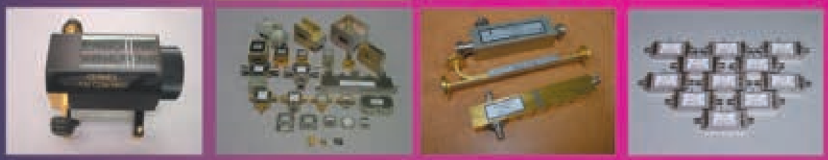

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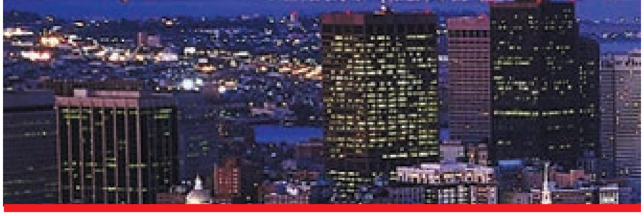

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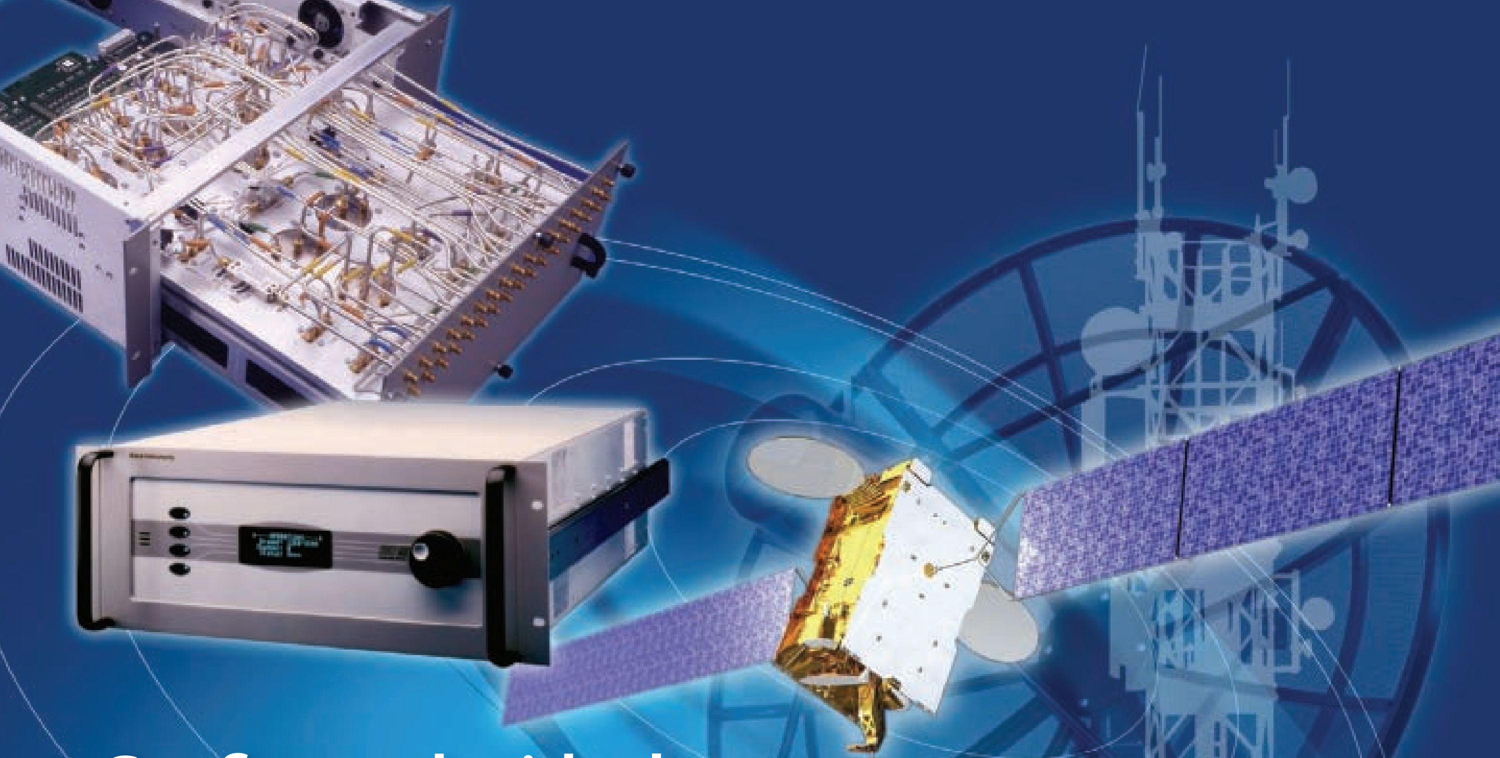



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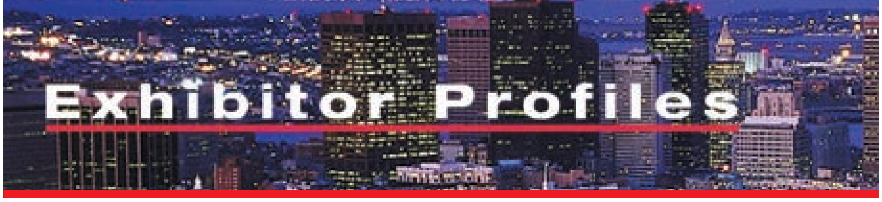


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B&Z Technologies, located in Stony Brook, NY, is a leader in the design and manufacture of state of the art medium power and low noise amplifier and related components. B&Z's competitive advantage lies in our unique ability to turn around our regular catalog items into products with customer specific performance, within a very short time frame.

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# Exhibitor Profiles

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www.bondingsource.com

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Carlisle Interconnect Technologies is one of the world's leading designers and manufacturers of high performance wire and cable, RF/microwave connectors and cable assemblies. Our products are targeted at applications in the aerospace, defense electronics, wireless infrastructure, optical telecommunications, and test and measurement industries.

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**cernex@cernex.com**
www.cernex.com

Cernex is a manufacturer of Microwave and Millimeter-wave components and subsystems up to 325 GHz. Cernex has been supplying amplifiers, multipliers, switches, sources, sub-systems, antennas, ferrite products, waveguide products, attenuators, couplers, terminations/loads, transitions/adapters, mixers, phase shifters, limiters, detectors, converters, combiners, etc. to the commercial and military markets since 1988. Our goal is always to provide good quality products with on time delivery and exceed our customers' expectations.

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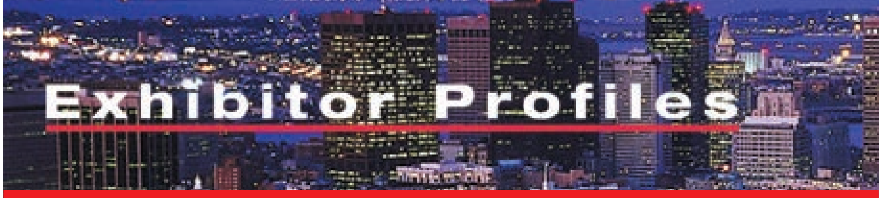


**Ciao Wireless**
**4000 Via Pescador**
**Camarillo, CA 93012**
**(805) 389-3224 (ph)**
**glen@ciaowireless.com**
www.ciaowireless.com

Ciao Wireless designs and manufactures Microwave Amplifiers for Low Noise, Medium Power, Narrow and Ultra-Wide Band Applications. Custom designs are offered at the catalog pricing and delivery of 1-2 weeks ARO. Ciao features Octave Band and Specialty Radar & Communications Band Amplifiers. Ciao manufactures Low Phase Noise Amplifiers with internal phase noise testing capability. Ciao Wireless manufactures Limiting Amplifiers with high dynamic ranges. Ciao's noise figures offered are as low as 0.28 dB TYP.

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CPI BMD designs and manufactures a broad range of microwave products for radar, communications and industrial heating applications. CPI BMD is the world's largest manufacturer of receiver protectors and related products. Other product lines include Integrated Microwave Assemblies, Control Components, Magnetrons, TWTs, CFAs, transmitter assemblies, industrial heating systems, high-power solid-state switches and switch assemblies, pressure windows and a wide variety of multifunction super components and subassemblies.

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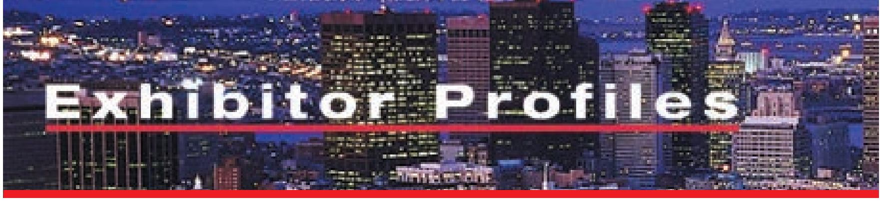

# Exhibitor Profiles

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**(508) 665-4400 (ph)**
**info@cst.com**
www.cst.com

CST develops and markets high performance EM field simulation software. Its products allow you to characterize, design and optimize electromagnetic devices before going into the lab or measurement chamber. This can help save substantial costs especially for new or cutting edge products, reduces design risk, and improves overall performance and profitability. CST's flagship product, CST MICROWAVE STUDIO®, enables the fast and accurate 3D electromagnetic simulation of high frequency devices such as antennas, filters and multi-layer structures.

**Booth No. 2013**

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**CTT Inc.**
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www.cttinc.com

CTT Inc. designs and manufactures GaAs- and GaN-based solid-state, low-noise and high power microwave amplifiers and subassemblies, and offers build-to-print contract manufacturing for the domestic and international defense electronics and commercial communications markets. Our goal is to be the number one supplier of amplifiers and subassemblies in the marketplace. In fact, we are currently supplying replacements for many hard-to-find assemblies. CTT products are designed and built in the US.

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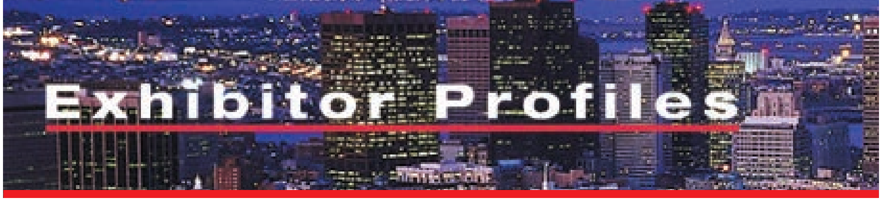


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**23301 Wilmington Avenue**
**Carson, CA 90745**
**(310) 513-7200 (ph)**
www.ducommun.com

Ducommun Technologies serves the aerospace, defense, industrial, and telecommunications markets. Our heritage includes industry stalwarts as Jay-El, Dynatech, DB Products, AEI, and Wise Wave Technologies. We design and build RF, microwave and millimeter-wave components, sub-systems and systems including passive and active switches; video switches; couplers; amplifiers; antennas; control devices; frequency converters; oscillators; ferrite devices; filters; diplexers; Doppler sensors heads; ranging sensor heads and a variety of test lab equipment. We hold ISO-9100 and AS9100 certifications.

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**P.O. Box 8224**
**Haverhill, MA 01835**
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www.dynawave.com

Dynawave is the leader in the design and manufacture of high quality, standard and special, RF and microwave DC-60 GHz connectors, adapters, blindmate interconnecting components and cable assemblies. Today we continue to bring new ideas to the defense industry as well as the commercial microwave, RF and wireless industries. We have built respect through dynamic engineering capabilities and the follow through from design to manufacture.

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**fran.bennett@eads-nadefense.com**
www.eads-nadefense.com

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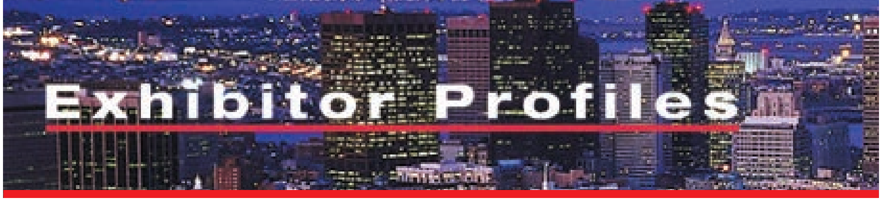


**Empower RF Systems**
**316 W. Florence Avenue**
**Inglewood, CA 90301**
**(310) 412-8100 (ph)**
www.empowerrf.com

Empower RF Systems, headquartered in Los Angeles, CA, designs and builds solid-state high power amplifiers and amplifier-based, multi-function assemblies. Products are offered as building block modules, rack mount amplifiers, or multifunction assemblies up to 6 GHz. The company is featuring an array of amplifiers that span the globe in terms of frequencies and modulation requirements. These products utilize the latest device technologies, including high efficiency Gallium Nitride (GaN). Visit us at Booth 1037.

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**Electromagnetic Technologies Industries Inc.**
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**sales@etiworld.com**
www.etiworld.com

Electromagnetic Technologies Industries Inc. (ET Industries) is a leading manufacturer of directional couplers, power dividers, 90° and 180° hybrid couplers, QPSK modulators, demodulators, active/ passive antenna beamforming networks, and T/R modules. In addition to components manufacturing, ET Industries also provides systems solutions to WiMAX Point to Point & Point to Multipoint systems requirements.

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**European Microwave Week**
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European Microwave Week is the largest event dedicated to RF, Microwave, Radar and Wireless Technologies in Europe. Capitalising on the success of the previous shows, the event promises growth in the number of visitors and delegates. EuMW 2009 will provide: 7,000 sqm of gross exhibition space; 5,000 key visitors from around the globe; 1,700 - 2,000 conference delegates; In excess of 250 exhibitors. Running alongside the exhibition are 4 separate, but complementary conferences: EuMIC; EuMC; EuWiT; EuRAD Plus Workshops and Short Courses. Interested in exhibiting? Book online NOW!

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EZ Form Cable Corp. is a leading designer and manufacturer of RF and microwave products for a variety of applications including low-noise amplifiers, microwave components, military, space, wireless communications and high-performance instrumentation. The company's products include miniature semi-rigid coaxial cable, semi-rigid and flexible cable assemblies, coaxial delay lines and RF connectors. In 2009, EZ Form Cable is proudly marking its 25th anniversary in business.

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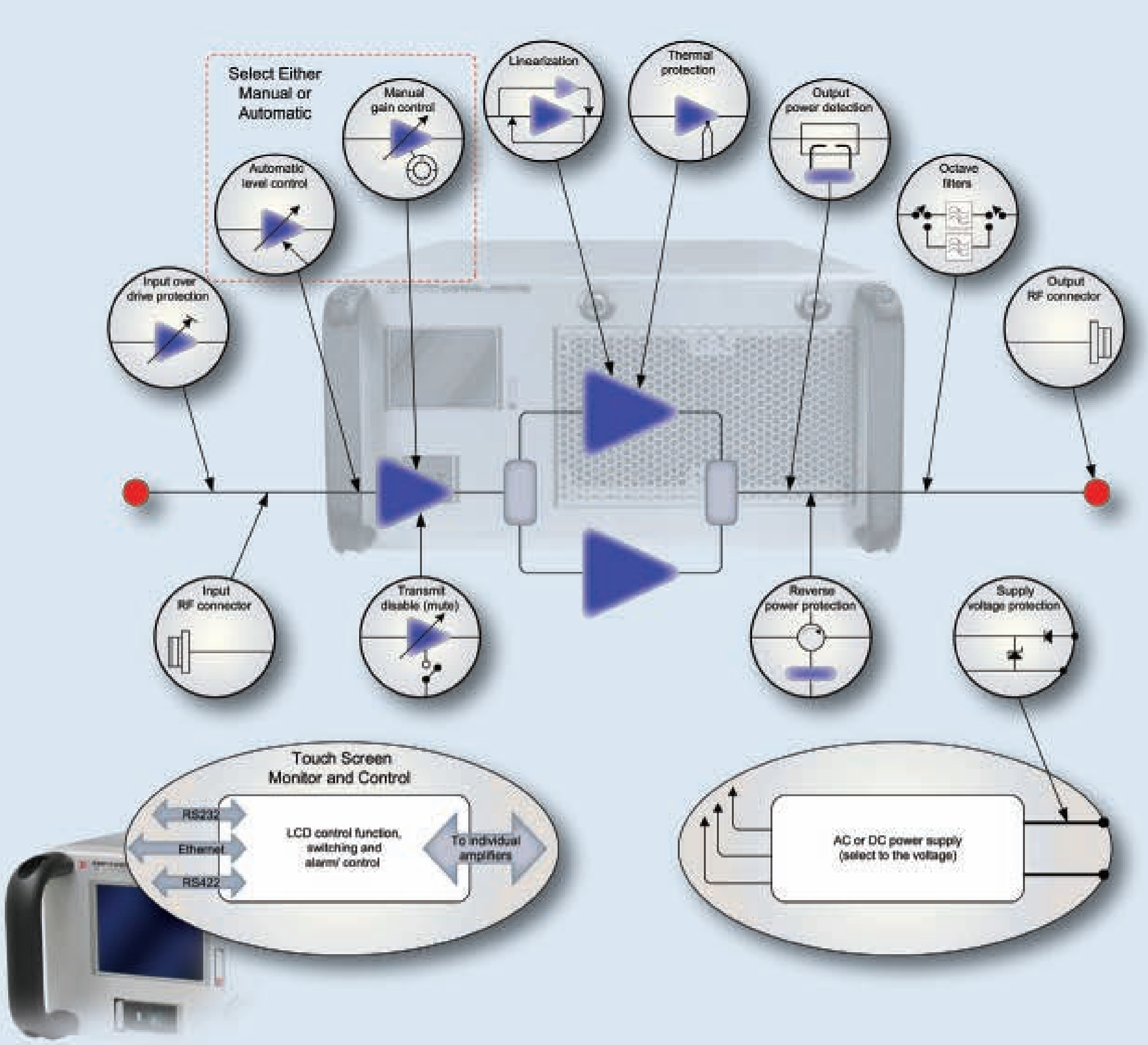


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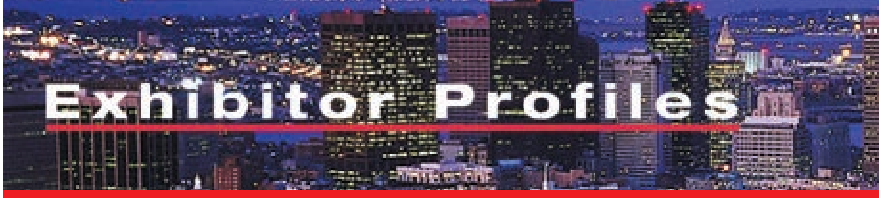


**Filtel Microwave Inc.**
**424 Aime Vincent**
**VAUDREUIL-DORION**
**Quebec, Canada J7V 5V5**
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**filtel@filtel.com**
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Filtel Microwave Inc. specializes in the custom design and manufacture of high-performance cavity filters and diplexers. Our main focus is point-to-point radio, military and satellite communications up to 50 GHz. Between the Montreal, Canada Head Office and Suzhou, China's manufacturing facilities, Filtel is well-positioned to supply small and large volume requirements. Filtel has developed Hot Standby Couplers for various OEMs and their ODU RADIO applications. Filtel also offers delay filters, couplers, high power terminations, waveguide assemblies, splitters, isolators and circulators.

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Hittite is an innovative designer and manufacturer of analog and mixed-signal ICs, modules, subsystems and instrumentation for RF, microwave and millimeter-wave applications covering DC to 110 GHz. Our RFIC/MMIC products are developed using state-of-the-art GaAs, GaN, InGaP/GaAs, InP, SOI, SiGe, CMOS and BiCMOS semiconductor processes utilizing MESFET, HEMT, pHEMT, mHEMT, HBT and PIN devices supporting a wide range of wireless/wired communications and radar applications for Automotive, Broadband, Cellular/3G, Fiber Optics, Microwave & Millimeter-wave Communications, Military, Test & Measurement and Space markets.

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The HUBER+SUHNER Group, based in Switzerland, is a leading international manufacturer of components and systems for electrical and optical connectivity for communication, transportation and industry. The company can draw on core competencies in the areas of high-frequency, fiber optics and low frequency.
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IKE Micro is a build to print manufacturer serving the RF/microwave industry since 1981. We target both the commercial and defense markets with turnkey and consignment solutions. IKE uses a combination of automatic and manual assembly processes to build an array of complex high frequency modules, to basic subassemblies for our international customer base. IKE is ISO certified and ITAR Compliant.

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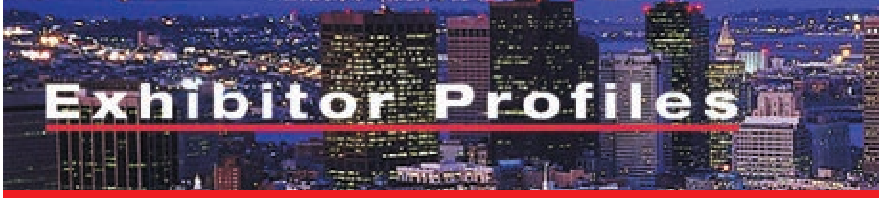

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www.ionbeammilling.com

Founded in 1982, Ion Beam Milling Inc., a ISO 9001:2000 certified company, serves the microelectronic, microwave and photonics communities in creating ultra high density micro-machined and thin film devices. The company utilizes photolithography and ion beam milling to fabricate electronic and mechanical elements for an array of commercial (automotive), industrial, military, satellite, biomedical, optical and magnetic applications. Custom thin film circuits, laser diode submounts and heat spreaders are our specialty as well as our complete line of standard products. See our website: www.ionbeammilling.com.

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**Booth No. 1326**

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**sales@klmicrowave.com**
www.klmicrowave.com

K&L Microwave offers a full line of RF and microwave filters, duplexers, and subassemblies for military and commercial applications, including ceramic, lumped element, cavity, waveguide and tunable filters, as well as switch filter banks, high-performance receive and transmit filters, delay line filters, combiners, receive multi-couplers and base station wireless system assemblies.

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**Cleveland, OH 44139**
**(440) 248-0400, (800) 552-1115 (ph)**
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With more than 60 years of measurement expertise, Keithley Instruments has become a world leader in advanced electrical test instruments and systems from DC to RF (radio frequency). Our customers are scientists and engineers in the worldwide electronics industry involved with advanced materials research, semiconductor device development and fabrication, and the production of end products such as portable wireless devices.

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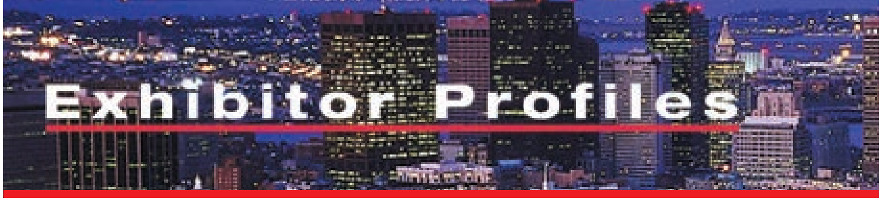




**M/A-COM Technology Solutions Inc.**
**100 Chelmsford Street**
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www.macom.com

M/A-COM Technology Solutions is a leading supplier of semiconductors, active and passive components and subassemblies for radio frequency, microwave and millimeter wave applications. M/A-COM Tech has expertise in solving complex circuit design, packaging and manufacturing challenges. The company has earned its stellar reputation by providing unparalleled expertise in a broad range of complex technical challenges faced by top OEMs and systems integrators.

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**Maury Microwave Corp.**
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**Ontario, CA 91764**
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**(909) 987-1112 (fax)**
www.maurymw.com

This year Maury will showcase new ATSv5.2 device characterization software for complete on wafer/module/fixture load pull & noise solutions; new PNA-X applications (100x faster noise parameters & instant large-signal models for PA design); broadband harmonic measurements with cascaded tuning and high-gamma tuning. Coaxial & waveguide cal standards for all VNAs; precision adapters, test bench accessories, measurement services, system integration, calibration & repair services.

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**Micro Lambda Wireless Inc.**
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www.microlambdawireless.com

We offer superior performance and competitive pricing on YIG-based products such as Extreme Low Noise Oscillators, Frequency Synthesizers, Wide Band Tunable Filters and Millimeter-Wave Components for Commercial & Military Applications. Come visit our booth to discuss your needs.

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**Micronetics Inc.**
**Hudson, NH**
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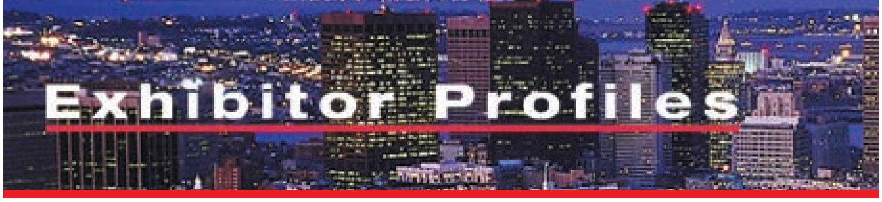
**(603) 882-8987 (fax)**
**marketing@micronetics.com**
www.micronetics.com

Micronetics manufactures RF/microwave components, integrated subassemblies and RFID solutions that are the enabling technology used in a variety of wireless, aerospace and defense applications (satellite communications, electronic warfare and countermeasures). We also design and manufacture test equipment and components that test the strength, durability and integrity of signals in communications and Internet infrastructure equipment. Micronetics will be joined by three of its divisions, Stealth Microwave, Microwave Concepts and Mica Microwave.

**Booth No. 2341 & 2441**




**Microsemi Corp.**
**2381 Morse Avenue**
**Irvine, CA 92614**
**(949) 221-7100 (ph)**
www.microsemi.com

Whether the application is in radar, avionics, communications or defense systems, Microsemi delivers superior RF/microwave components for the most challenging designs. From breakthrough Silicon Carbide RF power transistors cramming the highest peak power into the smallest packages, to high performance, high reliability Silicon and GaAs PIN diodes, varactors, oscillators and modules, Microsemi's breadth of materials and component design technology supports the most demanding RF/microwave systems. All backed by more than three decades of manufacturing expertise.

**Booth No. 1925**

**Microtech Inc.**
**1425 Highland Avenue**
**Cheshire, CT 06410**
**(203) 272-3234 (ph)**
**jim@microtech-inc.com**
**bill@microtech-inc.com**
www.microtech-inc.com

Micro-tech Inc. is a designer and full-capability manufacturer of flexible and rigid waveguide assemblies as well as passive microwave components. Microtech produces a product to the quality expectations of our customers, on time and at a competitive price. We do this by providing the incentive and the means for continuous improvement in our processes, technology, products and services.

**Products:** Passive microwave components, waveguides, antennas, filters, couplers, attenuators, diplexers, flexible waveguide and double-ridged waveguide.

**Booth No. 2827**

**MIcable Inc.**
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**Gulou Dist., Fuzhou**
**Fujian, 35003 P.R. China**
**86 591 87382856 (ph)**
**86 591 87382857 (fax)**
**sales@micable.cn**
www.micable.cn

MIcable has a diverse product list, such as DC to 40 GHz test cable assemblies, flexible MIL-C-17 RG series cable assemblies, conformable cable assemblies, and semi-rigid cable assemblies. All assemblies are made to customer specifications. We also design and produce various precise coaxial cable connectors.

**Booth No. 1834**

**Microwave Development Labs Inc.**
**135 Crescent Road**
**Needham Heights, MA 02494**
www.mdllab.com

MDL offers a complete line of passive waveguide components from 1 to 50 GHz. We specialize in low cost components, custom waveguide assemblies, monopulse components and rotary joints. We have HFSS and Solidworks software to model, simulate and manufacture to your requirements.

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# Exhibitor Profiles

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**Houston, TX 77099**
**(281) 988-4600 (ph)**
www.mimixbroadband.com

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**Products**: Power Amplifiers, Receivers, Transmitters, Gain Blocks.

**Booth No. 1114**

**Mini-Circuits**
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**Brooklyn, NY 11235**
**(718) 269-5288 (ph)**
www.minicircuits.com

A global leader in the design, manufacturing, and distribution of RF, IF, and microwave components covering the DC to 20 GHz band, for commercial, industrial, space, and military, including: WiMAX, CATV, Cellular Wireless, RFID, Medical Equipment, Test Equipment, Receivers, Transmitters and Satellite applications. Rapid response, innovative design, demanding quality standards, fast turnaround, value pricing, on-time delivery, and top-notch customer service have helped make Mini-Circuits an industry leader. With 22 different product lines representing thousands of off-the-shelf and custom models, Mini-Circuits offers the world's largest variety of over 4000 signal processing components.

**Booth No. 618**

**MITEQ Inc.**
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**Hauppauge, NY 11788**
**(631) 436-7400 (ph), (631) 436-7430 (fax)**
**component@miteq.com**
www.miteq.com

MITEQ is a leading designer and manufacturer of microwave components and subsystems. MITEQ's components include Low Noise Amplifiers, Power Amplifiers, Mixer Products, Frequency Generation Products, IF Products, Passive Components (couplers, splitters, etc.), Fiber Optic Transmitters and Receivers, and Integrated Assemblies. MITEQ's subsystems include Upconverters, Downconverters, Translators, Redundant Switchover Units, Redundant Amplifier Systems, RF Fiber Optic Links, INMARSAT equipment, Traveling Wave Tube Amplifiers, and High Power Broadband TWT Amplifiers.

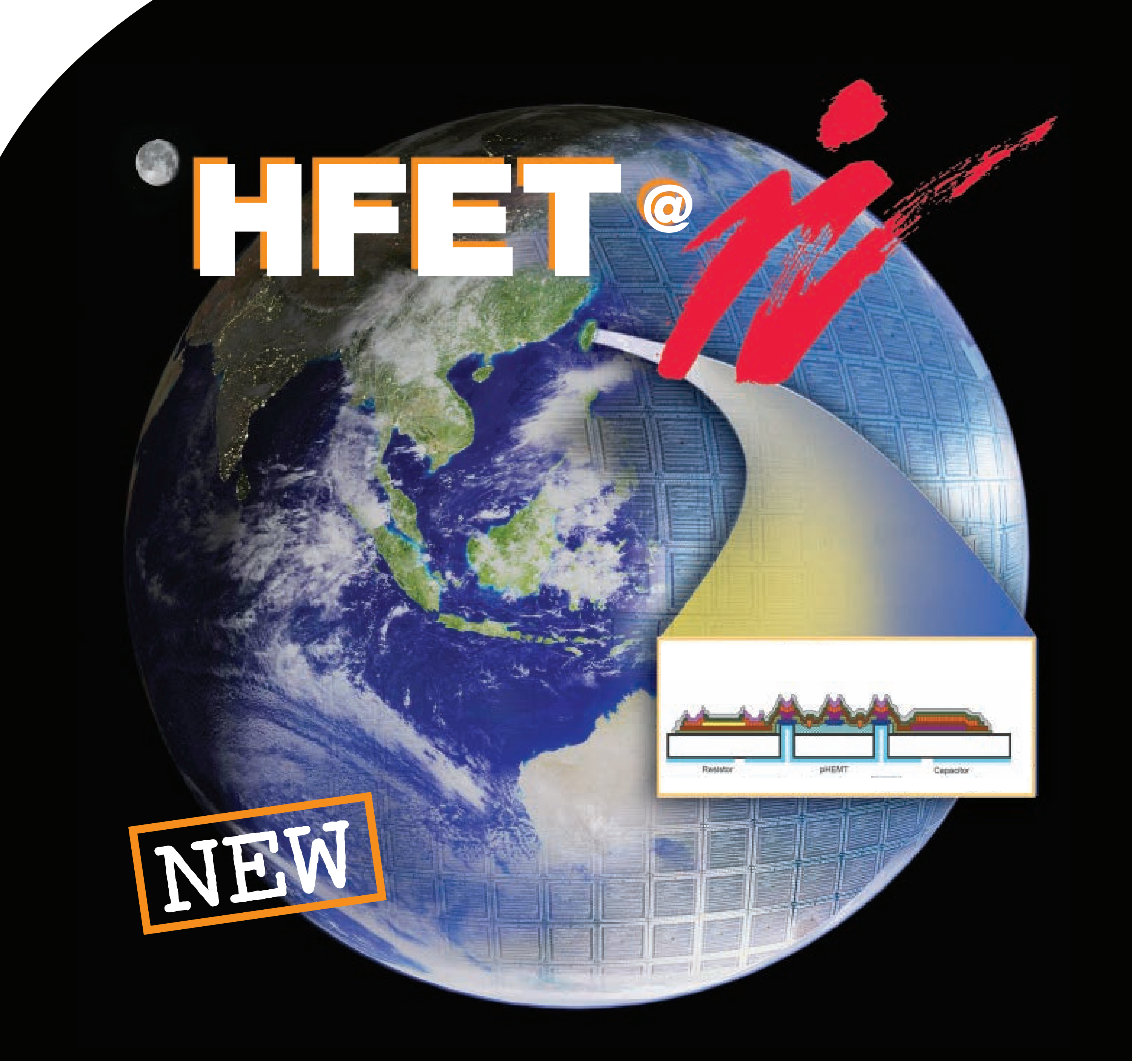
**Booth No. 2121, 2221**

Modular Components National, Inc.

**Modular Components National**
**105 E. Jarrettsville Road**
**PO Box 453**
**Forest Hill, MD 21050**
**(410) 879-6553 (ph)**
**sales@modularcomp.com**
www.modularcomp.com

Manufacture of high frequency PCBs and assemblies. Expertise includes: mixed dielectric multilayers, PTFE multilayers, aluminum, copper or brass backed PTFE with PTH, blind and buried vias, and screened resistors. Highlighted products will include thermal management techniques with conductive and non-conductive adhesives and via fill combinations.

**Booth No. 1122**




## High linearity high voltage technology

## High Voltage HFET @ WIN

| Parameter | Value |
|---|---|
| Ft @VDS=4 V | 12.5 GHz |
| BVDGO @ VGS=-3.0 V | 33 V |
| IDSS @VDS=4V | 175 mA/mm |
| Idmax @VDS=4V, VGS=+0.5V | 250 mA/mm |
| VPO @VDS=4 V | -1.1 V |
| MIM Capacitance | 500 pF/mm$^2$ |
| CGS | 1900 pF/mm$^2$ |
| EPI Sheet Resistance | 250 Ohm/sq |
| TFR Sheet Resistance | 50 Ohm/sq |

High linearity, high breakdown power process is ready for your most demanding applications.

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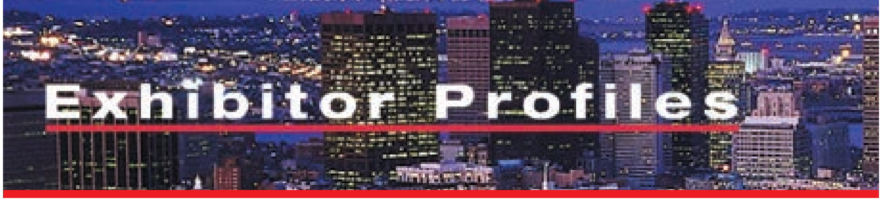


# Exhibitor Profiles

narda microwave-east
an L3 communications company

**Narda Microwave-East**
www.nardamicrowave.com/east

Narda Microwave - East has been serving the microwave/RF components and subsystems markets for over 50 years. Under the world-renowned Narda brand name, our employees and field sales representatives take great pride in bringing the highest quality catalog and custom components to our valued military and commercial end users. We specialize in the manufacture of: passive components, mechanical and PIN diode-based switching products, data drivers, oscillators and integrated assemblies for fiber optic communications systems and state-of-the art MIC multi-function assemblies.

**Booth No. 1637**

NIC

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**15237 Broadmoor**
**Overland Park, KS 66223**
**(913) 685-3400 (ph)**
**sales@nickc.com**
www.nickc.com

Networks International Corp. (NIC) is a leading manufacturer of custom RF & Microwave Filters and Assemblies. For over 20 years, we have been a trusted partner for military, commercial & space solutions specializing in Filters: Cavity, Ceramic and Crystal and Lumped Component; Mutliplexers & Diplexers; Oscillators; Integrated Assemblies: Switched Filter Banks, Phase Shifters, Filter/Amplifiers.

**Booth No. 2631**

Noisecom

**Noise Com (Wireless Telecom Group)**
**25 Eastmans Road**
**Parsippany, NJ 07054**
**(973) 386-9696 (ph)**
**(973) 386-9191 (fax)**
**info@noisecom.com**
www.noisecom.com

At Noisecom, our mission is simple -- To create innovation in noise test solutions and provide service beyond customer expectations. How we go about fulfilling this mission is what makes us a unique and fast growing company. Noisecom's technical team is a community of dedicated, knowledgeable, and creative people from a wide range of backgrounds in test and measurement. We have a unique mix of talent in RF, microwave, and software development, which delivers powerful solutions to customer's problems backed by outstanding service.

**Booth No. 1615**

PMI

**Planar Monolithics**
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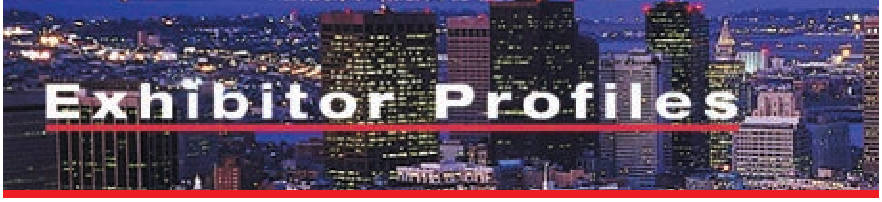
**Frederick, MD 21704**
**(301) 631-1579 (ph), (301) 662-2029 (fax)**
**kmason@planarelec.com**
www.planarmonolithics.com

PMI's staff of experienced project engineers and program managers are integrating the latest DC to 40 GHz Hybrid Microwave Monolithic Integrated Circuits (HMMIC) into receiver front-end components such as Successive Detection Logarithmic Amplifiers (SDLVA), Log RF/IF Log Amplifiers, Threshold Detectors, Phase Shifters, Limiters, Diode Detectors/Limiter Detectors, Directional Detectors, Bi-Phase Modulators, I&Q Vector Modulators/Detectors, Directional Detectors, Power Dividers (Inphase & Quadrature), Linear Amplifier Detectors and High Speed Video Buffer Amplifiers, to produce units with higher reliability, more uniform performance and lower cost.

**Booth No. 1646**






**Pole/Zero Corp.**
**5530 Union Centre Drive**
**West Chester, OH 45069**
**(513) 870-9060 (ph), (513) 870-9064 (fax)**
**support@polezero.com**
www.polezero.com

Pole/Zero Corp. designs and manufactures products to expand the linear dynamic range of communications systems operating from 1.5 MHz to 3 GHz. With its full line of digitally tunable RF devices including bandpass and notch filters as well as Integrated Cosite Equipment (ICE), Pole/Zero effectively solves most interference issues. Through constant product, technology, and process development, Pole/Zero continues to expand its role as the leading supplier of unique, cost-effective solutions to solve difficult RF problems.

**Booth No. 711**

**Quinstar Technology Inc.**
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**Torrance, CA 90505**
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**(310) 320-9968 (fax)**
www.quinstar.com

QuinStar Technology Inc. is the leader in providing a broad range of millimeter-wave technology and product solutions. Our standard products include antennas, amplifiers, oscillators, control devices and passive components covering the 18 to 220 GHz frequency range. We also provide subsystems, integrated modules and engineering services. Our product applications are radar and communication systems, test and instrumentation sets, plasma diagnostic tools, antennas, transceivers, remote sensing instrument, surveillance & EW systems, space flight and ground system hardware. We are ISO 9001:2008 certified.

**Booth No. 441**

**Reactel Inc.**
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**reactel@reactel.com**
www.reactel.com

Reactel Inc. is expanding on its robust Notch Filter product line. Reactel offers a full line of Notch Filters including dual notch filters, and notched diplexers. Low loss, and extremely high selectivity are hallmarks of these unit and power levels of up to 1 kW are available. Please visit us in booth 1504 to speak with one of our engineers about your requirements.

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1. The demand for more power and higher frequencies will continue.
2. AR will always be several steps ahead, with the amplifiers and accessories that meet all your testing needs, even as those needs keep changing.

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And all "S" Series amps generate 100% of rated power and make it available to the load – even when mismatch is severe. They reproduce signals with exceptional linearity. Spurious signals, noise figures and distortion are extremely low.

AR's expansive in-house capabilities – which include a state-of-the-art Microelectronics lab – make it possible to offer these new solid-state amplifiers along with a level of performance and dependability that is unmatched in the industry. No one beats AR's quality. Period.

And of course all AR products are backed by the strongest, most comprehensive warranty in the industry, and a global support network that's second to none.

To learn more, visit www.ar-worldwide.com or call us at 215-723-8181

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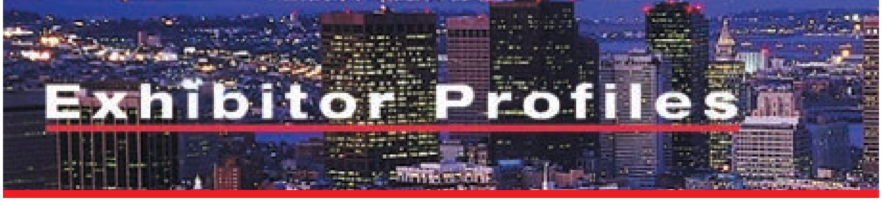


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www.rfhic.com

RFHIC provides comprehensive product portfolios of active RF components for the infrastructure and broadcasting industry on DC to 6 GHz, with extensive experience on GaN Technology. Major area of business include Base Station, Repeaters, Cable-Networks, LTE, WiMAX, UMTS, DTV, Radar, Medical, Military and Test Equipments for infrastructure markets. RFHIC is serving over 1000 customers in over 45 international countries. **Products:** GaN/GaAs amplifiers, MMIC, CATV hybrids, Wideband Amplifiers, LNA, PLL synthesizers & Pallet/hybrid amplifiers.

**Booth No. 738**

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RFMD® is a global leader in the design and manufacture of high-performance RF systems and solutions. At IMS 2009, RFMD will showcase its innovative RF product portfolio for broadband transmission, aerospace and defense, WiFi and WiMAX, wireless infrastructure and general purpose RF markets. A live demo of a GaN high-power amplifier providing >300 W at 48 V covering 500 MHz bandwidth and targeting pulsed applications such as L-band and S-band radar will be featured.

**Booth No. 2412**

RLC

**RLC Electronics Inc.**
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**Mount Kisco, NY 10549**
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**sales@rlcelectronics.com**
www.rlcelectronics.com

RLC Electronics has for almost 50 years provided innovative RF and microwave products to this industry. Currently offering switches up to 65 GHz, programmable attenuators, connectorized and surface-mount filters, power dividers, couplers and detectors. Waveguide switches, filters, couplers and adapters have recently been added to the product range.

**Booth No. 2610**

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Advanced Circuit Materials Division

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Rogers is a global technology leader providing high performance laminates & components for use in high frequency and/or high reliability applications. Rogers will be showcasing their wide range of products including RO4000® with LoPro™, RO3000® and RT/duroid® 5880LZ high frequency laminate materials.

**Booth No. 1018**

# Exhibitor Profiles

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**Tru Corp.**
**Ed Kersten (978) 836-1031 (ph)**

Sage designs and manufactures RF/Microwave components and integrated subsystems for ECM/ESM, Radar, Test & Measurement, and anti-IED. Product expertise includes: filters, converters, multi-function assemblies, DFDs, mixers and more. TRU provides unique, creative RF/Microwave interconnect solutions in a fast turnaround, flexible manufacturing environment, and is known for its expertise in cable assemblies, high power and quick-disconnect connectors with unique attachment/assembly methods.

**Booth No. 937**

**San-tron Inc.**
**4 Turnpike Road**
**Ipswich, MA 01938**
**(978) 356-1585 (ph), (978) 356-1573 (fax)**
**sales@santron.com**
www.santron.com

Engage with Santron and experience our superior customer service. We take pride in being one of the world's most trusted suppliers of standard and custom engineered coaxial connectors and cable assemblies for over 50 years. And today, we're building on that legacy by empowering our sales and engineering departments, broadening our product offerings, and improving lead times and pricing across the board. When you engage with San-tron you get more than just a solid interconnection, you get a whole team of pros ready to make sure you're 100% satisfied.

**Booth No. 733**

**Skyworks Solutions Inc.**
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**(781) 376-5112 (fax)**
**sales@skyworksinc.com**
www.skyworksinc.com

Skyworks Solutions Inc. is an innovator of high reliability analog and mixed signal semiconductors. Leveraging core technologies, Skyworks offers diverse standard and custom linear products supporting automotive, broadband, cellular infrastructure, energy management, industrial, medical, military and mobile handset applications.
**Products:** Diodes, Switches, Power Amplifiers, Low Noise Amplifiers, Filters, Mixers, Synthesizers, Attenuators, Front-End Modules, RF Subsystems and Technical Ceramics.

**Booth No. 1818**

**Sonnet Software Inc.**
**100 Elwood Davis Road**
**North Syracuse, NY 13212**
**(315) 453-3096, (877) 7Sonnet (ph)**
**(315) 451-1694 (fax)**
**info@sonnetsoftware.com**
www.sonnetsoftware.com

Sonnet Software is dedicated to the development of high-frequency electromagnetic analysis software. Sonnet's software is aimed at today's demanding design challenges involving predominantly 3D planar circuits and antennas (including microstrip, stripline, coplanar waveguide, PCB (single and multiple layers) and RF packages incorporating any number of layers of metal traces embedded in stratified dielectric material. Sonnet introduces the Sonnet Suites Release 12, with up to 30x or faster analysis over the previous release.

**Booth No. 1002**

# Exhibitor Profiles

**Spectrum Elektrotechnik GmbH**
**P.O. Box 450533**
**80905 Munich, Germany**
**+49-89-3548-040 (ph)**
**+49-89-3548-0490 (fax)**
**sales@spectrum-et.com**
www.spectrum-et.com

Spectrum Elektrotechnik GmbH was founded in 1981 and has become a leading supplier of state-of-the-art components used in RF and microwave technology, such as Coax Connectors, Multi-Pin-Connectors, Push-On Connectors, Adapters, Cable Assemblies, Phase Shifters, Couplers, Gain Amplitude Equalizers, Terminations, Duplexers, Calibration Kits, etc. Throughout the world, Spectrum Elektrotechnik GmbH has established a reputation as a design, development and manufacturing center.

**Booth No. 2218**

**SV Microwave**
**2400 CentrePark West Drive**
**West Palm Beach, FL 33409**
**(561) 840-1800 (ph)**
**sales@svmicrowave.com**
www.svmicrowave.com

SV Microwave continues to expand our line of Multiport High Frequency Contacts. Beginning with the size 8 BMZ operating to 18 GHz and fitting into M38999 cavities, it now includes size 8 to 40 GHz, size 12 to 60 GHz and size 16 to 65 GHz. Other industry standard designs SV has applied high frequency contacts into include ARINC 404 and 600, MIL-DTL-83527 and VITA connectors. Whatever your multiport need or speed, SV has it covered.

**Booth No. 2707**

**Synergy Microwave Corp.**
**201 McLean Blvd.**
**Paterson, NJ 07504**
www.synergymwave.com

Synergy Microwave Corp. is a leading provider of RF/Microwave sources and signal processing components for the commercial and defense markets. Our latest products include high performance tiny VCOs (0.3" sq. package) and synthesizers (0.6" sq. package). Other products include high resolution frequency synthesizers with step size as small as 1 Hz, mixers, power dividers, directional couplers, filters, transformers, modulators and demodulators, switches and oven controlled crystal oscillators.

**Booth No. 1111, 1211**

**TECDIA**
**(408) 748-0100 (ph)**
**(408) 748-0111 (fax)**
**chung@tecdia.com**
**kmccaughan@tecdia.com**
www.tecdia.com

For over 30 years, Tecdia Inc. has been a key supplier of passive components to both the Microwave and Lightwave industries. Products include Single Layer Chip Capacitors, Chip Resistors, Bias-T's and DC power boards. For our thin film products, we are capable of providing Class H and Class K screening for space level applications.

**Booth No. 912**

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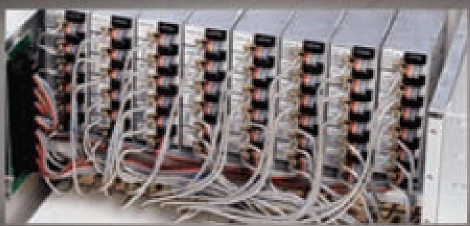

Trilithic provides test system solutions that are designed to specific requirements. With as little as a block diagram or a detailed description of your application Trilithic can deliver a custom solution to meet your expectations.

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www.teledynerelays.com

Teledyne Relays & Teledyne Coax Switches introduces two new innovative products. The GRF312 relays are designed to provide a practical surface-mount solution with improved RF signal repeatability from DC-8 GHz as well as signal integrity measured to 12 Gbps. The 3-State Attenuated Coaxial Switch CAS-37 is designed for frequencies from DC to 25 GHz to allow users to switch between three different states: Through Path (low loss), Attenuated Path (known high loss), and Open State (with path for user to ground). These products are in production and can be delivered in 4 weeks.

**Booth No. 1028**

**Teledyne Cougar**
**927 Thompson Place**
**Sunnyvale, CA 94085**
**(408) 522-3838 (ph)**
**(408) 522-3839 (fax)**
**cougar@teledyne.com**
www.teledyne-cougar.com

Teledyne Cougar provides leading-edge RF and microwave components, integrated assemblies, and custom integrated assemblies to the aerospace, defense, and industrial markets. Designed and manufactured to meet the highest performance and reliability requirements, Teledyne Cougar's catalog and custom lines cover frequencies from 100 kHz to 20 GHz. We also offer a full line of value added services, including die testing and up-screening, full element evaluation, quality conformance and qualification testing and more.

**Products:** Amplifiers, Attenuators, Hybrids, Mixers/Modulators/Detectors, Oscillators, Power Dividers, Systems/Subsystems, Switches.

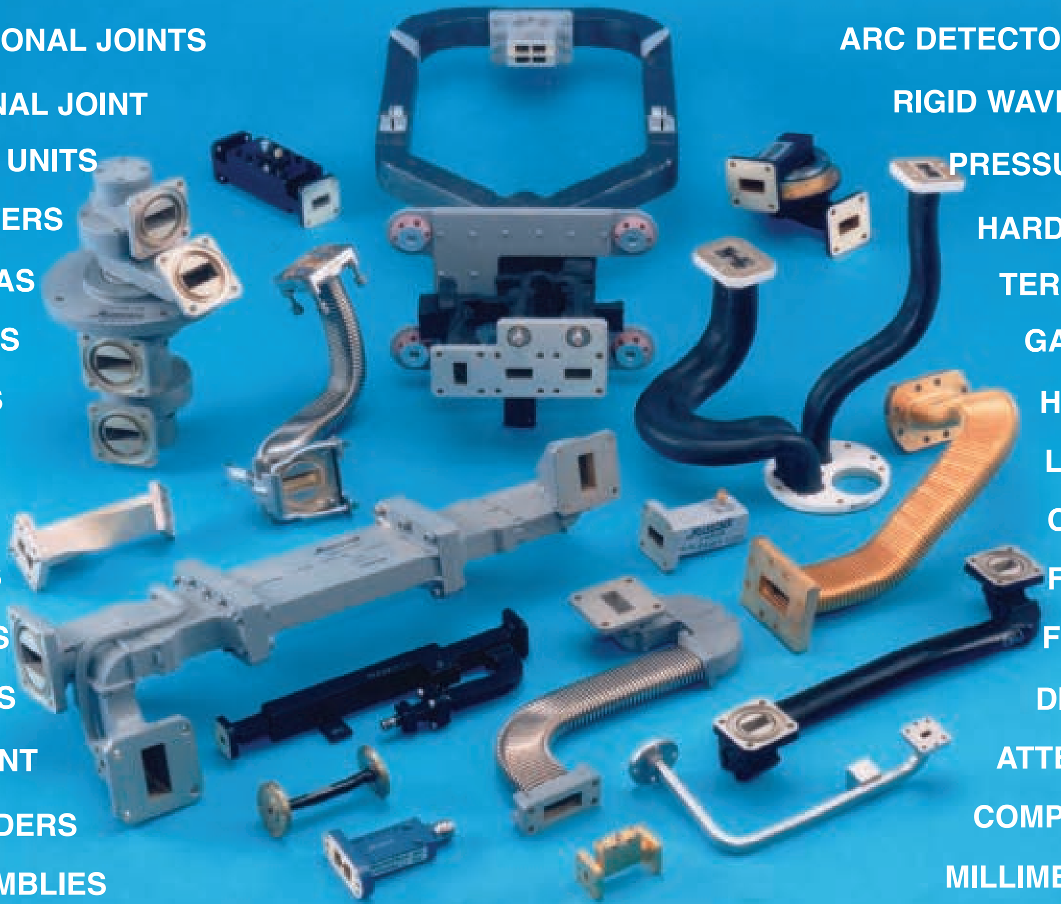
**Booth No. 1028**

**Teledyne Storm Products**
**Woodridge, IL 60517**
**(630) 754-3300 (ph)**
www.teledynestorm.com

Over 30 years providing customized and catalog microwave interconnect solutions for demanding applications through 50 GHz. Flexible and semi-rigid cable assemblies utilized in the Defense/Aerospace and Telecommunications industries and a wide variety of Test & Measurement applications spanning the full range of instrumentation market needs.

**Products:** True Blue®, Phase Master®, Storm Flex®, and Accu-Test® flexible assemblies addressing Low Loss, Phase Stability, Miniaturization, and Test requirements. High performance, low loss Maximizer™ semi rigid products for Build-to-Print applications.

**Booth No. 614**



# Exhibitor Profiles

THUNDERLINE-Z®

**Thunderline-Z Inc.**
**11 Hazel Drive**
**Hampstead, NH 03841**
**(603) 329-4050 x14 (ph)**
**(603) 329-4474 (fax)**
**len.stpierre@emerson.com**
www.thunderlinez.com

Thunderline-Z, a designer and manufacturer of RF, DC, Capacitive Feedthrus and soldered and direct sealed hermetic packages, is pleased to announce an exciting new product release, a mini surface-mount 50 ohm feedthru. Based on Thunderline's very successful initial SMT Bell Pin offering, this new product emulates the existing design but will be one third less in size and will be built with a smaller pin. This will enable Thunderline customers to use this part in both J band and K band frequency ranges. Volume quantities are available now. Thunderline will offer the part in both discrete form and installed in packages. Thunderline-Z is owned by Emerson Electric, a Fortune 500 company.

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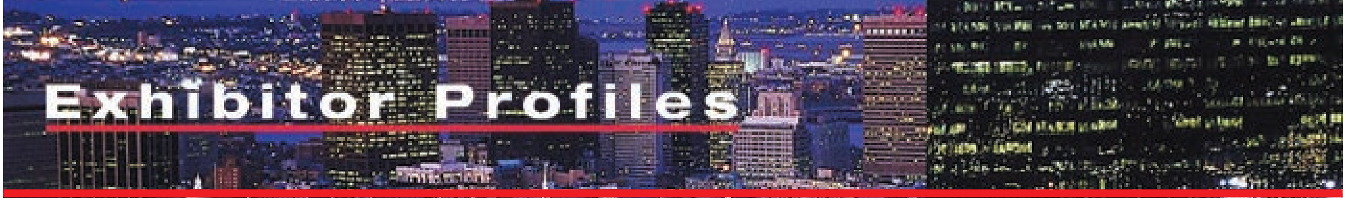


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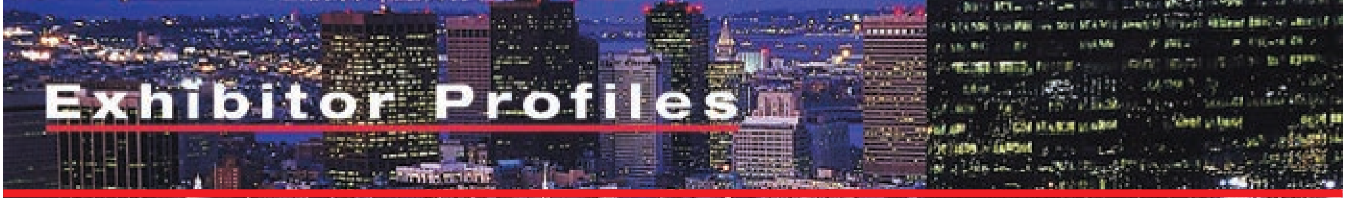


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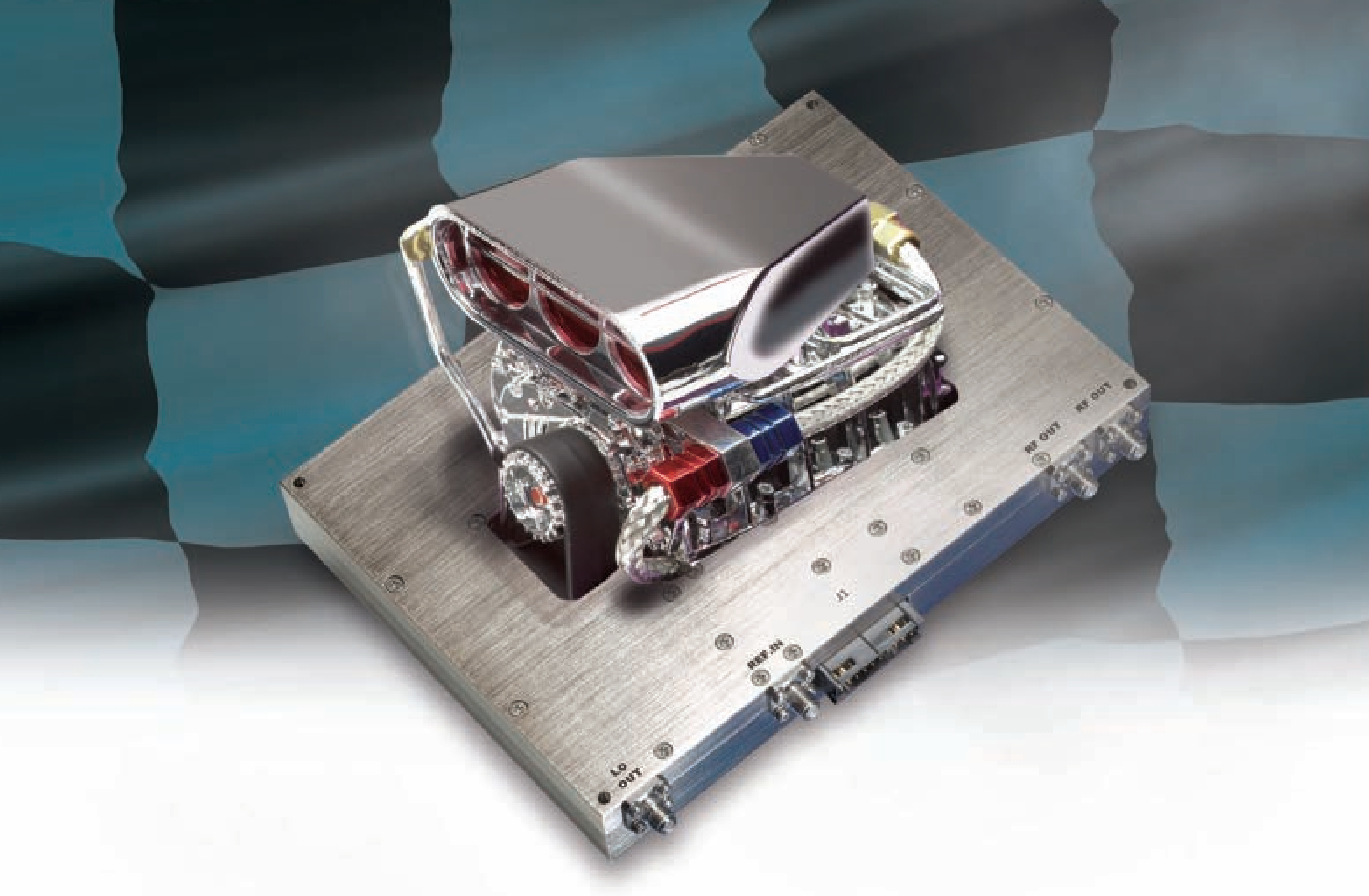
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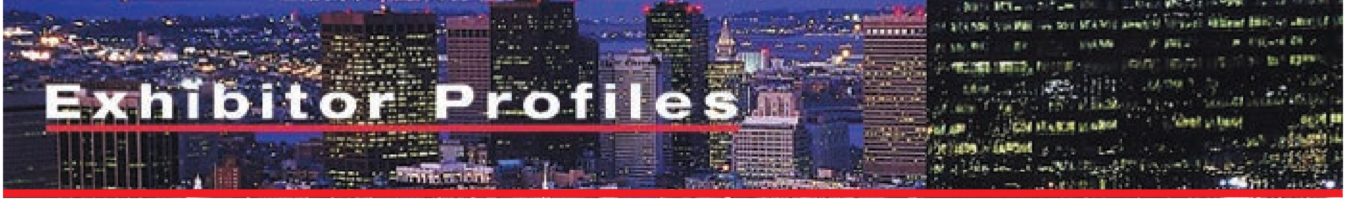


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Headquartered in Taiwan, the company was established in 1992. It uses state-of-the-art technology to manufacture RF/microwave coaxial connectors, cables, cable assemblies and adaptors, such as the SEMI-RIGID series, REVERSE POLARITY series, as well as MMCX, MCX, MA, SMB, 1.6/5.6, 1.0/2.3 products. To provide higher frequency RF/microwave coaxial connectors, the company launched the K (40 GHz) and SMP (40 GHz) series in 2008. Having originally concentrated on domestic sales, Zifor now operates an international marketing oriented strategy focused on setting up distribution networks in Europe, America and Asia, including mainland China.

**Booth No. 1937**

**For complete coverage of the IMS 2009 conference, event news, exhibitor product information and special reports from the editors of *Microwave Journal*, visit our online show daily at www.mwjournal.com/IMS2009 starting May 26th.**

## Defense Dept. Selects Northrop Grumman for RFID III Contract

Northrop Grumman Corp. was one of four companies selected to receive a contract to provide radio frequency identification (RFID) hardware, software and engineering services to the US Department of Defense under the RFID III contract, providing increased network functionality, visibility and security control. RFID III is a multiple award, indefinite delivery/indefinite quantity contract with a $429 M ceiling available for task order awards. Work on the contract will be conducted over a three-year base period with up to seven, one-year option years.

Under the terms of the contract, Northrop Grumman's Information Systems sector will supply active RFID tags, readers, mobile kits, software and the technical engineering services to implement this technology. The terms also include providing the hardware, maintenance, design, development, integration, deployment, training and data management of the tags.

"Northrop Grumman has more than ten years of experience providing RFID solutions to government customers," said Tom Shelman, vice president and general manager of Northrop Grumman Information Systems' Civil Systems division. "This win is a tribute to our excellent record of integrating legacy systems with new RFID technologies."

Work on the contract will take place primarily in Williamsburg, VA, with additional services conducted at government facilities worldwide. Northrop Grumman's teammates include Evigia Systems Inc., Ann Arbor, MI; Onyx Government Services Inc., Manassas, VA; CYTEC Software Systems Inc.; and XIO Strategies Inc., Vienna, VA.

## Lockheed Martin Achieves Key Milestones in Design Review Phase

The Lockheed Martin team developing the US Air Force's next-generation Global Positioning System (GPS) spacecraft, known as GPS III, continues to meet or exceed key milestones on schedule in the Preliminary Design Review (PDR) phase of the program.

Lockheed Martin, along with teammates ITT, Clifton, NJ, and General Dynamics of Gilbert, AZ, have successfully completed 61 of 71 subsystem and assembly PDRs, with the Global Positioning Systems Wing of the US Air Force Space and Missile Systems Center, Los Angeles, CA. The GPS III PDRs successfully completed within the last month include a spacecraft bus PDR, consisting of 31 individual bus assemblies and seven bus subsystem PDRs. General Dynamics completed a series of 12 network communication PDRs in late March. The team is now gearing up for a navigation payload PDR at ITT. This process will culminate with a comprehensive spacecraft Segment PDR in late May that will validate that the design meets warfighter and civil requirements prior to entering the Critical Design Review phase.

"The entire team is executing according to plan, achieving important design milestones and retiring risk for this critical program," said Col. Dave Madden the US Air Force GPS Wing Commander. "Our steady progress is the result of a joint government-industry team focused on mission success and delivering the much-needed capabilities that GPS III will provide to users around the globe." GPS III will improve position, navigation and timing services and provide advanced anti-jam capabilities yielding superior system security, accuracy and reliability. The team is working under a $3 B Development and Production contract awarded in May 2008 to produce up to 12 GPS IIIA satellites, with first launch projected for 2014. The new generation GPS IIIA satellites will deliver significant improvements over current GPS space vehicles, including a new international civil signal (L1C), and increased M-Code anti-jam power with full earth coverage for military users.

"Our proven heritage design of the various elements and strong partnership with the Air Force has been critical to the success of the PDRs and meeting the planned schedule," said Dave Podlesney, Lockheed Martin's GPS III program director. "We are on track to deliver a successful Segment PDR for our customer and move quickly and efficiently into the next phase of this essential program." The GPS constellation provides critical situational awareness and precision weapon guidance for the military and supports a wide range of civil, scientific and commercial functions—from air traffic control to the Internet—with precision location and timing information. Air Force Space Command's 2nd Space Operations Squadron (2SOPS), based at Schriever Air Force Base, CO, manages and operates the GPS constellation for both civil and military users.

## Raytheon Achieves Critical Dual Band Radar Testing Milestone

Raytheon Co. and the US Navy successfully completed initial "lightoff" testing of the Dual Band Radar. The Dual Band Radar is an integrated active phased-array radar suite composed of the X-band AN/SPY-3 Multi-function Radar and the S-band Volume Search Radar, both of which radiated at high power during lightoff at the Navy's Engineering Test Center, Wallops Island, VA.

"This is an enormous milestone for Raytheon and the Navy—demonstrating the reliability and effectiveness of the most advanced naval surface radar in the world," said Raytheon Integrated Defense System's Bob Martin, Vice President and Deputy of Seapower Capability Systems. "The Dual Band Radar provides unmatched mission capabilities and functionality, while delivering commonality and affordability for the fleet."

The system will be installed on the Zumwalt-class destroyer (DDG 1000), Ford-class aircraft carrier (CVN 78), and other future surface combatants to provide superior surveillance capabilities and support ship self-defense across a broad range of missions. The Dual Band Radar leverages proven technologies to meet mission requirements in deep water and littoral, or near shore, environments. The radar supports a wide variety of mission requirements, including ship self-defense and anti-air warfare; anti-submarine warfare; anti-surface ship warfare; situational awareness; land attack; naval gunfire support; surface search; navigation; and air traffic control. The radar's capabilities include horizon search; volume surveillance; fire control tracking; missile guidance; and illumination functionality for the Evolved SeaSparrow missile and Standard missile family. Following this successful lightoff testing, the radar suite will begin an extended period of operational performance testing.

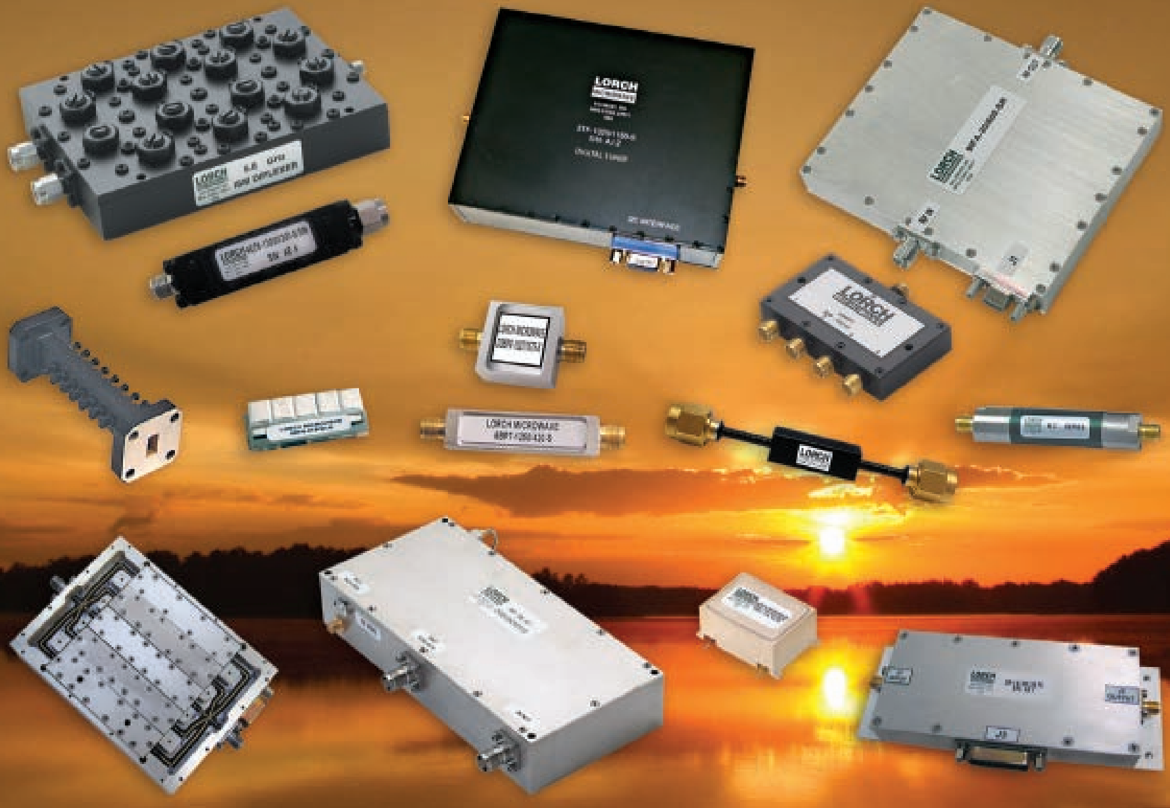
## Harris Corp. Awarded Contract to Develop Interoperable Radio Architecture

Harris Corp. and the National Aeronautics and Space Administration (NASA) have embarked on a cooperative effort to advance a common, software-defined, radio architecture for future space missions. NASA has awarded Harris a 14-month, multimillion-dollar contract to develop Ka-band capable radios as part of the Communication Navigation and Networking reConfigurable Testbed (CoNNeCT), which will be installed onboard the International Space Station (ISS). CoNNeCT is currently scheduled to be launched to the Space Station via a Japanese H-II launch vehicle in 2011. The announcement was made during the 25th National Space Symposium being held March 30 through April 2 at the Broadmoor in Colorado Springs, CO.

The overall goal of the CoNNeCT program is to demonstrate Space Telecommunications Radio System-compliant software-defined radios (SDR) that will provide an on-orbit, adaptable radio facility to conduct a suite of experiments. The experiments will advance communications technologies, reduce risk, and demonstrate future mission capabilities such as those planned for NASA's Constellation Program.

"We are excited to participate in this initiative, which will define the next generation of space radios for use on a variety of launch and exploration vehicles, as well as in the astronauts' space suits," said Frank Van Rensselaer, vice president NASA Programs at Harris Government Communications Systems. "Harris has a rich history of SDR development dating back to 1988, and we have supported major NASA programs since the 1960s. We are committed to helping NASA realize its vision for the next generation of space exploration." Harris also produced the Internal Audio System and the Internal Video Distribution Subsystem that help make up the fiber-optic communications network onboard the Space Station.

# Smart Solutions for Challenging Applications



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## EADS DS Wins NATO DCIS Contract

NATO has awarded EADS Defence & Security (DS) the contract for the supply of the new NATO Deployable Communication and Information System (DCIS) in accordance with the operational requirements of the NATO Response Force (NRF). The contract is worth around £40 M with an optional Customer Logistic Support contract valued at around £14 M. Under the terms of the contract DS will deliver to NRF Commanders the communications facilities to support their headquarters in the field anywhere that the NRF is required to operate.

The project represents a major upgrade in the capability of NATO forces. It will become the standard for NATO deployable communications and will be the cornerstone for the NATO Signals Battalion capability to support deployment in operational theatres. The system will allow NATO forces to deploy small (up to 20 users) or large (up to 150 users) communications headquarters on the field with both voice and data connections to other NATO forces.

Voice interoperability will be provided by the DS developed Tactical Voice Gateway (TVG), a product based on commercial off the shelf products that has been made bespoke for military purposes. All features of the solution have been designed with future proofing in mind to align with NATO's short and long term requirements and objectives. The common components used will facilitate a seamless transition between existing services.

The project is managed and delivered from Newport, South Wales, UK, by the DS integrated team which is a joint group of French, German and British employees. Other members of the team include US-based partners such as Booz Allen Hamilton, HP, Cisco, OSPL and SELEX SI.

## BAE Systems Partners with Greek Armed Forces Duo

BAE Systems Integrated System Technologies Ltd. has entered into a definitive Memorandum of Understanding with SSMART S.A. and SIGNAAL HELLAS S.A., to establish a long term strategic partnership in support of the Hellenic defence forces acquisition and integration programmes. SSMART specialises in hardware production and services primarily for sensors and naval applications and SIGNAAL HELLAS in software production for real time environments for the defence and civilian markets. Both companies are based in Mandra Attikis, Greece.

The strategic partnership supports BAE Systems' significant installed base with the Hellenic defence forces and long term commitment to providing the forces with advanced operational equipment and systems. To underpin the delivery of this strategy, BAE Systems, SSMART and SIGNAAL HELLAS will bring together proven capabilities from across their home markets and thereby strengthen local and in-country support to the armed forces.

SSMART S.A. and SIGNAAL HELLAS S.A., with over eight years experience, are an independent, flexible and dynamic team, capable of offering products and services of the high standards and specifications demanded by the Armed Forces and Defence Industries. Each company is uniquely structured and focused in its area of expertise and fully ISO 9001:2000 and AQAP 2110 certified by Lloyds and compliant with national and NATO security requirements for defence industries.

## Six European Countries Collaborate on SDR

The industry and departments of defence in six European countries have joined together to develop the next generation of standardised software defined radio (SDR). The organisation behind the order is Organisation Conjointe de Coopération en matière d'Armement (OCCAR) on behalf of the armed forces of Finland, Spain, Poland, Sweden, Italy and France, via the European Defence Agency (EDA).

The contract for European Secure Software defined Radio (ESSOR), which is worth more than SEK1.1 B in total, was signed by a joint venture created by six international companies—EB, INDRA, Radmor, Saab, Selex Communication and Thales Communication. The standardisation being developed will facilitate a secure and robust collaboration between different nations.

The standardised SDR software will enable the functionality of several different radio equipment on the same SDR radio platform. This means that the users will be free from the constraints of a specific radio platform, will gain access to new and more advanced functionality, and at the same time will be able to interact with existing radio systems, whether they are military or civil and commercial.

## UK KTPS Get Financial Boost

The Technology Strategy Board, the organisation that has been established to drive the development and exploitation of technology and innovation in the UK, has made a commitment to reduce the cost of its Knowledge Transfer Partnerships (KTP) programme to Small and Medium sized companies (SME).

The move has the full support of all the other UK government organisations that are funding KTPs and will mean that organisations will receive a cash payment that reduces their contribution from 33 percent to 25 percent for one year. The aim of this incentive is to encourage SMEs and third sector organisations to take part in the KTP programme despite the uncertain financial climate.

The KTP programme helps to ensure that specialist knowledge is transferred between the research and business worlds and supports business by giving organisations access to the knowledge and skills base in the UK's universities, colleges and research bodies. Recent graduates undertake a strategic project working in the organisation with staff whilst developing themselves for a career in the commercial world as managers and potential leaders of the future.

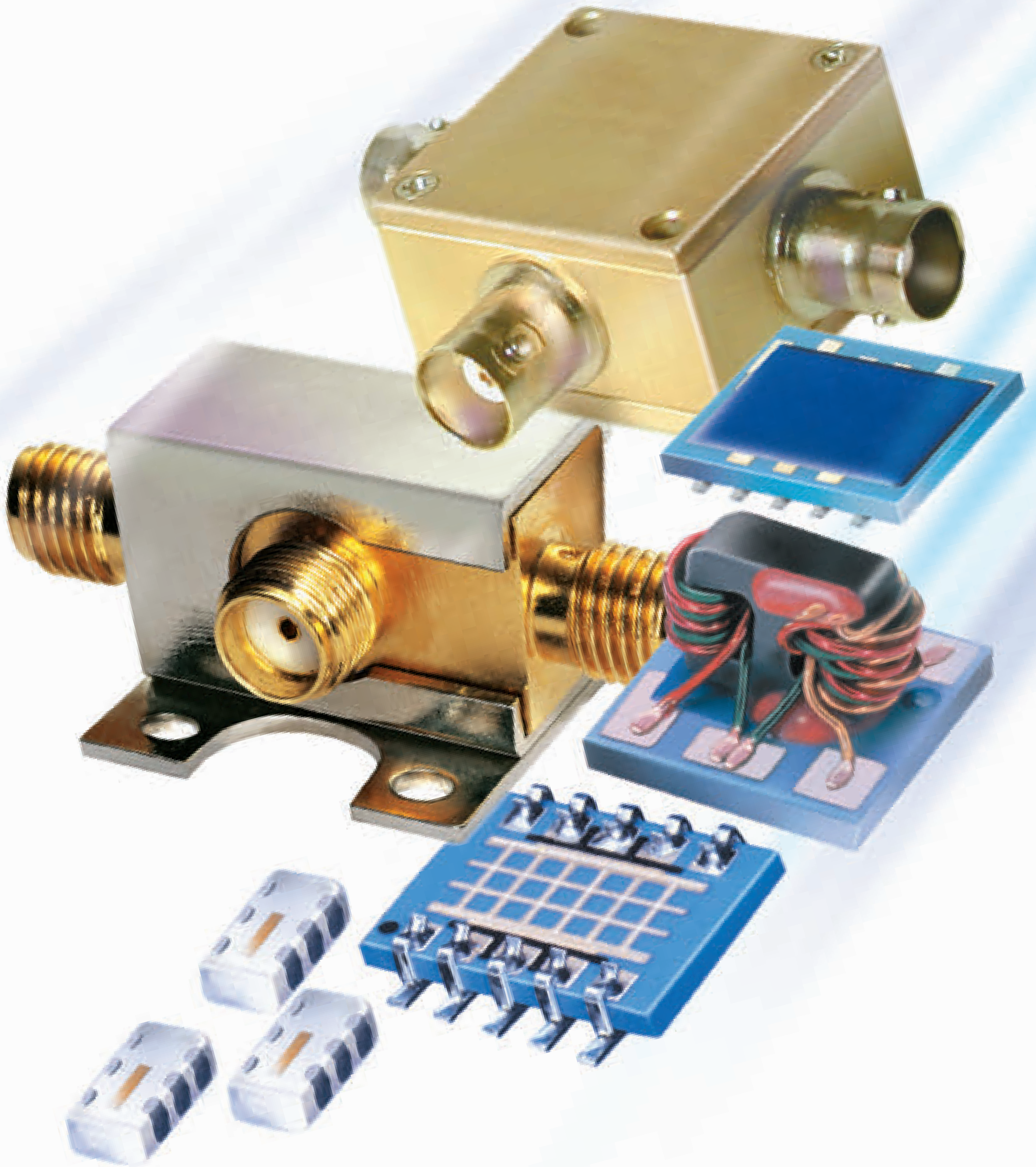
Pete Munday, the national programme manager for KTPs at the Technology Strategy Board, said, "Organisations that participate in Knowledge Transfer Partnerships have been shown to derive great benefit from their participation. The current economic conditions are making participation in KTPs more difficult for SMEs. Government and the Technology Strategy Board are therefore prepared to cover a bit more of the risk so that these companies or organisations are better placed to exploit the upturn when it arrives."

## GTEL-Mobile Selects NEC Microwave System for Vietnam

Vietnam's GTEL-Mobile has contracted NEC Corp. to deploy a mobile backhaul solution based on NEC's ultra compact PASOLINK microwave communications system. GTEL is the latest mobile operator to enter the Vietnamese market and its mobile services are expected to begin later this year.

PASOLINK will be introduced in Ho Chi Minh and the surrounding area in support of the operator's network. Its flexibility enables the system to process a wide variety of transmission speeds and interfaces within the same platform, which facilitates mobile traffic growth and expansion of mobile network coverage in Vietnam. The system is capable of expanding transmission capacity in reaction to increases in communications traffic, as well as flexibly responding to various interfaces via identical platforms through software upgrades, rather than the addition of new hardware.

NEC has supplied PASOLINK to nearly all of the mobile operators in Vietnam, and views its selection to provide this latest microwave system as recognition of GTEL's high regard for the company's services and systems.



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## Wireless Infrastructure Vendors Hunkering Down for a Tough 2009

Radio Access Network equipment expenditure is expected to contract by 6 percent as wireless infrastructure vendors brace for a stormy year. The latest market data from ABI Research pegs infrastructure spending at about $49 B in 2009. "2009 will be a tough year for wireless infrastructure vendors," says Vice President of Forecasting Jake Saunders. He identifies two underlying trends determining the course of this market.

First, deployment cycles for 2G and 3G coverage are rapidly approaching maturity in the industrialized world. There is the lure of 3.5G and 4G infrastructure spending, but 3.5G infrastructure upgrades (HSUPA, HSPA+) are more incremental in value. 4G deployments such as LTE and WiMAX 802.16m represent more than just software upgrades to the network, but will only contribute meaningfully to equipment spending in the 2011-2015 timeframe.

Second, there is intense rivalry between the incumbents (Nokia-Siemens Networks, Ericsson, Alcatel-Lucent and Motorola) and the price-competitive and increasingly innovative Chinese vendors Huawei and ZTE. "Huawei in particular has been moving up the ranks," notes Senior Analyst Nadine Manjaro. "In 2005, Huawei held just 5 percent of the market. In 2008, it chalked up nearly $18 B in telecom sales. As a result, the firm moved into third place with 12.5 percent of the wireless infrastructure market."

While the market will contract in 2009, there are hotspots to brighten up the infrastructure vendors' day. In China, 3G licenses have been handed down. So far the Chinese vendors have been majority winners. Indian operators have provided veteran infrastructure vendors with substantial contracts. Ericsson assisted BSNL to roll out 3G infrastructure in 400 towns and cities in India. Not only is 3G penetration comparatively low in Asia, but there are still opportunities in South America, the Middle East and Africa. In these regions carriers are still very much expanding their footprints and improving in-fill and in-building coverage. Voice and messaging traffic are the main drivers.

ABI Research's "Wireless Infrastructure Forecasts" database includes a range of wireless base station data: vendor market share, infrastructure revenue broken down by region and technology, and new base station deployments. It is part of the firm's Mobile Networks Research Service.

## Femtocells to Dominate Market for Indoor Cell Coverage

While femtocells were virtually non-existent in 2006, and deployed by one operator in 2007, they will make up 61 percent of small cellular base station revenue by 2013, reports In-Stat. Microcells, picocells and femtocells provide indoor cell phone coverage in a cost-effective manner.

"As mobile operators migrate from larger base stations to smaller access points, the number of units deployed will explode dramatically," says Allen Nogee, In-Stat analyst. "In-Stat expects the smaller and cheaper cells to be more immune to the recession, compared with more expensive macro and micro base station shipments."

Recent research by In-Stat found the following:

- Femtocells, picocells and microcells are expected to surpass 15 million units by 2013.
- Worldwide annual femtocell semiconductor revenue will approach $400 M by 2013.
- Sprint was the first to market with a femtocell-based service in 2007, while others entered the market in 2008.
- In mid-2009, Airwalk introduced a new enterprise femtocell. These products have the capacity of a traditional picocell and the ease-of-use of a femtocell.

The research, "A Cell of Your Own: Worldwide Micro, Pico, and Femtocell Market Analysis," covers the worldwide market for small cellular base stations. It includes:

- Forecasts of femtocell, picocell and microcell equipment unit sales and revenue through 2013.
- Forecasts of femtocell, picocell and microcell semiconductor revenue through 2013.
- Regional five year unit forecasts for each segment.
- WiMAX micro, pico- and femtocells and semiconductor revenue forecasts.
- Market and technology overviews.
- Vendor profiles.

## Handset Manufacturers Aiming to Design Their Way Out of Recession

The global recession may have drastically slowed many forms of economic activity, but not the efforts of mobile device manufacturers to drive growth by design innovation. "It is quite remarkable to see mobile handset trends in play," says ABI Research Vice President Jake Saunders. "Despite the recession, there are some really exciting developments taking place right now. Mobile handset innovation is not going to wait for the recession to abate."

In the last quarter, 35 percent of new handsets registered with ABI Research's Global Mobile Device Tracking Database (OD-DBHA) were smartphones, up from 6 percent just a year ago. While clamshell device form factors are still popular with the manufacturers (25 percent of new devices released), slider-type handsets (where a larger, hidden, keyboard is revealed) are seen as an exciting design opportunity within the manufacturers' design labs (35 percent).

Although GSM-based handsets still rule the roost in terms of shipment volumes (713 million in 2008), handset manufacturers are substantially boosting the number of W-CDMA-capable handset models in their portfolios (85 percent versus 35 percent year-over-year). Manufacturers are doing their best to give end-users as much memory flexibility as possible. External memory ports have evolved from Mini to the Micro format and SD is a clear favorite (55 percent). GPS is increasingly becoming a 'must have' feature, not just for smartphones but also for other phone categories (35 percent versus 15 percent YoY). While users still have to watch their GPS usage, GPS no longer eats batteries.

Research practice director Kevin Burden adds, "While mobile operators are still struggling to find viable revenue models from mobile music downloads, handset manufacturers clearly see music playback as de rigueur. Eighty-five percent of handsets logged into our database had mp3 capabilities." They are also determined to undermine the standalone digital camera market. Fifty percent of mobile handset models released in the current quarter include a 4 Megapixel (or higher) camera. The Sony-Ericsson Idou will even support a whopping 12 MP.

New handsets offering a wide variety of new capabilities are appearing all the time. ABI Research's "Mobile Devices Tracking Database" provides up-to-the-minute information about new handsets, according to vendor, part number, air-interface(s) and features. It is a component of the firm's Mobile Devices Research Service.

## Tight Capital Complicates Digital Terrestrial TV Set Top Market

The global credit crunch could endanger many large digital terrestrial TV deployment projects, which require large amounts of financed capital, reports In-Stat. This could cause delays in DTT conversion programs worldwide, with consumers purchasing fewer set top boxes (STB) as a result.

"Another scenario, however, is more upbeat for the STB market," says Gerry Kaufhold, In-Stat analyst. "The economic slowdown could spur governments to fund the DTT transition at an accelerated rate to stimulate the economy. By auctioning off the analog spectrum, governments would receive income. Converting analog spectrum for other uses will spur new innovation."

Recent research by In-Stat found the following:

- Total DTT STB unit shipments will peak at 44 million in 2009.
- Standard Definition DTT Set Top Box unit shipments will peak in 2011.
- The Component Value of Standard Definition DTT Set Top Boxes will reach nearly $500 M in 2011.
- The European DTT STB Market Value will peak in 2011 at $1.6 B.



## INDUSTRY NEWS

■ **Cobham** announced that it has sold **M/A-COM Technology Solutions** (MTS) to **John Ocampo** for $30 M in cash, $30 M in senior loan notes secured on the MTS assets and $30 M dependent on future revenue in the period 2010 to 2012. The loan notes carry a rate of interest of 7.5 percent, which increases over time, and they are repayable in two equal tranches in December 2011 and 2012. There are no conditions to closing and the transaction has been completed, the company said. At the time of the acquisition of M/A-COM on May 13, 2008, Cobham said it planned to divest the commercial business segment MTS, as it was not core to the group's strategy. Excluded from the sale are cash and the freehold of the Walker Building in Lowell, MA, valued at $10 M.

■ **Micronetics Inc.** announced it has acquired the pedestal and forklift mounted radio frequency identification (RFID) product line of **M/A-COM RFID Inc.**, an indirect, wholly owned subsidiary of Cobham plc. RFID is a wireless identification technology that is being adopted by certain leading commercial retailers and the Department of Defense (DoD) to track inventory.

■ **Aeroflex** has announced it is expanding its communications test capabilities with the strategic acquisition of **VI Technology Inc.**, a provider of integrated baseband test solutions, specializing in audio, video and multimedia test.

■ **Paratek** announced that the company has completed a transaction involving the purchase by Paratek of **Gennum**'s barium strontium titanate (BST) technology group and its associated assets. Paratek has developed a proprietary form of BST, ParaScan™, as a leading RF tuning component technology for mobile handsets. The transaction augments an agreement with STMicroelectronics announced in January 2009. That relationship advances the next generation of Paratek's ParaScan materials technology for high volume manufacturing and establishes a program to jointly develop tunable products that improve Total Radiated Power (TRP) for mobile phones, leading to longer battery life and fewer dropped calls for mobile handsets. Initial production of the RF tuning components will take place at STMicroelectronics' fabrication facility in Tours, France by the end of 2009.

■ **Analytical Graphics Inc.** (AGI), a producer of commercial off-the-shelf software for integrated analysis of space, defense and intelligence assets, announced its new partnership with **Remcom**, a provider of electromagnetic simulation software products. AGI is extending its STK/Communications software with Remcom's rapid urban propagation models. The combination will model how mobile ad-hoc network performance influences net-centric intelligence, surveillance and reconnaissance (ISR) operations in urban terrain. Release is scheduled for fall 2009.

■ **Aeroflex** has announced an agreement with **Icom Inc.** to provide automated test and alignment capabilities for Icom radios on the Aeroflex 3920 Digital Radio Test Set. Initial test capabilities will be focused on the IC-F9010/F9510 APCO Project 25 Conventional and Trunked Radios and the IC-F4029SDR Series dPMR Portable Digital Radios. The test programs will be expanded to include Icom's IDAS™ Series NXDN™ compatible radios and D-STAR digital amateur radios.

■ **Harris Stratex Networks Inc.**, a specialist in backhaul solutions for mobility and broadband networks, announced that the Harris Board of Directors has approved the spin-off to Harris shareholders of its majority position in the company. Harris Corp. announced December 8, 2008, that it was evaluating strategic alternatives related to Harris Stratex Networks, which was formed January 26, 2007, through the combination of Harris Corp.'s Microwave Communications Division and Stratex Networks Inc.

■ **European Antennas** is now trading as **Cobham Antenna Systems, Microwave Antennas**. The change follows the announcement by Cobham that all their companies will adopt the refreshed Cobham image and trade under the Cobham brand. The new name is a brand only and operations are still carried out under the company name of European Antennas Ltd. so existing approvals and export documentation are valid. Orders and accounting details should be addressed Cobham Antenna Systems, Microwave Antennas; however, any paperwork addressed to European Antennas will still be valid. Specific agreements that need to be updated will be addressed on a case by case basis, where appropriate.

■ **Auriga Measurement Systems LLC** and **WIN Semiconductors** announced their modeling collaboration for the release of WIN's new Ku- and Ka-band GaAs PHEMT process. Auriga's nonlinear Large Signal Model (LS6) will be offered and distributed by WIN to its PP-25 customers. The models were validated against load-pull measurements and accurately represent small and large signal transistor performance. In related news, WIN Semiconductors announced that is has opened FAB B in Taiwan. Co-located in the Hwaya Technology Park with FAB A will offer cost-effective synergy in operations. FAB B capacity of 5K Wafer Per Month (WPM) in addition to the existing FAB A operating capacity of 7K WPM will offer WIN customers surety of supply.

■ Three prominent technology design, development and testing businesses, **ERA Technology**, **Culham Lightning** and **Vector Fields** have been brought together under the new name of **Cobham Technical Services** as part of a group wide rebranding programme by FTSE 100 parent company Cobham plc. Cobham plc has revenue of £1.5 B and employs more than 12,500 people worldwide on five continents, with customers in over 100 countries. In the past, individually branded business units have provided products and services to primarily aerospace and defence customers, many of whom have been unaware of the breadth of capabilities available to them from across Cobham. The unification of all businesses under a single

unified brand is designed to make it easier for customers to understand the group and highlight the career opportunities available to current and future employees.

■ Privately-held **Innovative Micro Technology** (IMT) of Santa Barbara, CA, announced that it has formed a life sciences division focused on developing miniaturized products for the medical, diagnostics and research markets that employ micro-electromechanical systems (MEMS). In conjunction with formation of the new division, the company also announced the appointment of James P. Linton, a 20-year veteran of the life sciences industry, as the division President.

■ ***AWR***, a leader in high frequency electronic design automation (EDA), and the James Cook University (JCU) School of Engineering & Physical Sciences, announced that a comprehensive RF and microwave electronic engineering course developed by Associate Professor Keith Kikkert is now available free of charge to other universities worldwide. The course, which is based on AWR's Microwave Office and Visual System Simulator™ (VSS) design software, can be downloaded by qualified universities at the AWR website (www.awrcorp.com). Under terms of the agreement, AWR will distribute Associate Professor Kikkert's Microwave Office-based course materials to electrical engineering programs worldwide, and Associate Professor Kikkert will keep the course material current as new versions of Microwave Office and VSS software are released.

■ A microcosm of the recently ISO 9001:2008 certified **Litron**, the Hermetic Laboratory has been making some strides of its own. In sync with the company goal of continuous improvement and living out the mission to serve as a true partner, the Hermetic Lab team has aimed to meet certain high standards. After thorough auditing from Uni-Clean, the clean room has been formally ranked as a Class 10,000. In addition, BSI Management has again recognized the Lab as complying with ANSI/ESD S20.20-2007 Standard for the laser welding of static sensitive devices.

■ **International Manufacturing Services Inc.** (IMS) announced the company's Therma-Bridge™ has won EN-Genius Network's product of the year for the category of "Most Cost-Effective Cooling Technology". The Therma-Bridge is a simple and cost-effective thermal management device that uses thermally-conductive Aluminum Nitride with metalized terminals to transport heat from one location to another, thus enhancing overall board performance.

## CONTRACTS

■ **Communications & Power Industries Inc.** (CPI) has received an approximately $13 M follow-on award from **General Dynamics SATCOM Technologies** to support Increment One of the US Army's Warfighter Information Network Tactical (WIN-T) program. With this latest contract, CPI has received more than $26 M in total awards from General Dynamics to support the WIN-T program. CPI, a subsidiary of CPI International Inc., is a provider of microwave, radio frequency, power and control solutions for critical defense, communications, medical, scientific and other applications.


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■ **Micronetics Inc.** announced that its New Jersey-based subsidiary, **Microwave Concepts** (Micro-Con), has received advanced funding of approximately $5 M from a major defense OEM for highly integrated microwave subassemblies. These subassemblies are used as part of a complex jamming system. In addition to this advanced funding, full funding of production quantities is expected within 90 days. The anticipated period of performance on this program is approximately 24 months.

■ **TRAK Microwave**, a Smiths Interconnect business, announced the award of several contracts from multiple customers for integrated microwave assemblies (IMA) and high performance RF mixers in support of ongoing production of the Eurofighter (EFA) aircraft. The contracts in total are valued in excess of $2.1 M USD. These contracts support the EFA Tranche 2 and SALAAM programs.

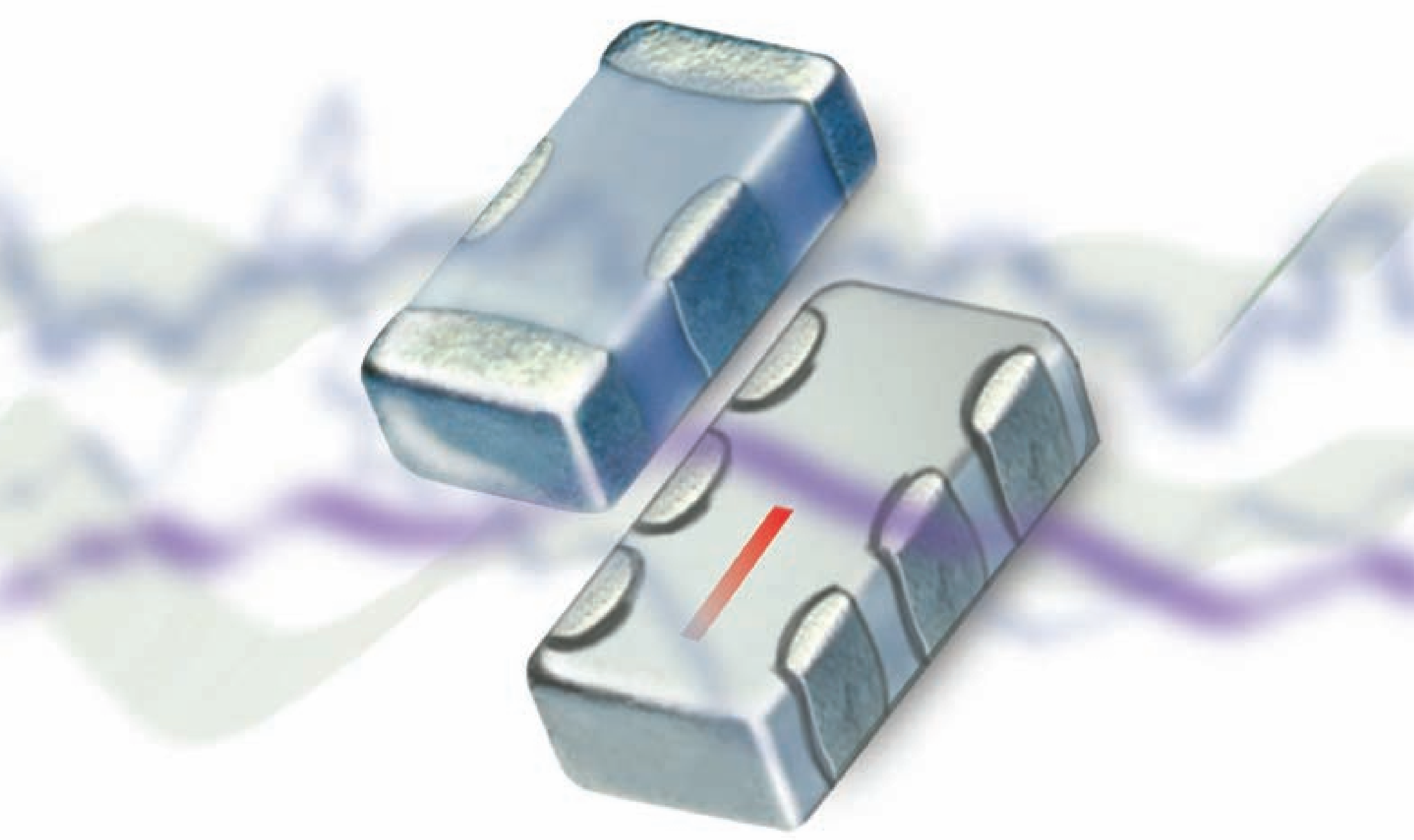
■ **Vida Products**, a four-person Santa Rosa, CA company, has won a Small Business Innovation Research grant to develop a key component of a satellite constellation NASA will use to assess global warming. The small business grants are phased, with an initial $100,000 going toward a proposal for Phase II, which brings an additional $690,000 or more for the development and testing of hardware. Phase III, for an unspecified amount, takes the hardware to production.

■ **RF Micro Devices Inc.** (RFMD®), a leader in the design and manufacture of high performance semiconductor components, announced that the company has been selected by a leading manufacturer of smartphones to supply its high performance RF1450 single-pole four-throw (SP4T) switch into an upcoming multi-featured CDMA smartphone device. RFMD's RF1450 will operate as the antenna switch in the CDMA smartphone and was selected over a competing part due to its robust performance and superior linearity. The dual-band CDMA smartphone is expected to launch in the second half of calendar 2009 and target the consumer smartphone market.

## PERSONNEL

■ American Microwave Corp. (AMC), a supplier of active microwave products since 1978, announced the appointment of **John Guenard** as Director of Sales and Marketing. Guenard will focus his nearly 25 years of experience in the microwave industry on expanding the market awareness of AMC's standard and custom switch, attenuator, DLVA and subsystem capability.

■ Valpey Fisher Corp. announced that **John Fortune** has joined the company as North America Director of Sales and Marketing. Fortune is a veteran in the frequency control industry having held sales, strategic account and product manager positions at Vectron International and Zarlink Semiconductor. Prior to that, Fortune held



marketing and engineering positions at Toshiba and Digital Equipment Corp.

## REP APPOINTMENTS

■ **Technical Communities** announced a new exclusive government services partnership agreement with **Centellax Inc.**, a manufacturer of low cost, high performance components and test solutions. The agreement authorizes Technical Communities to distribute Centellax products, including PRBS pattern generators, bit error rate testers (BERT), clock recovery modules and units, clock synthesizers, system power amplifiers, modulator driver modules, band multipliers, amplifier modules, frequent dividers and prescalers. More product information is available at centellax.gsamart.com.

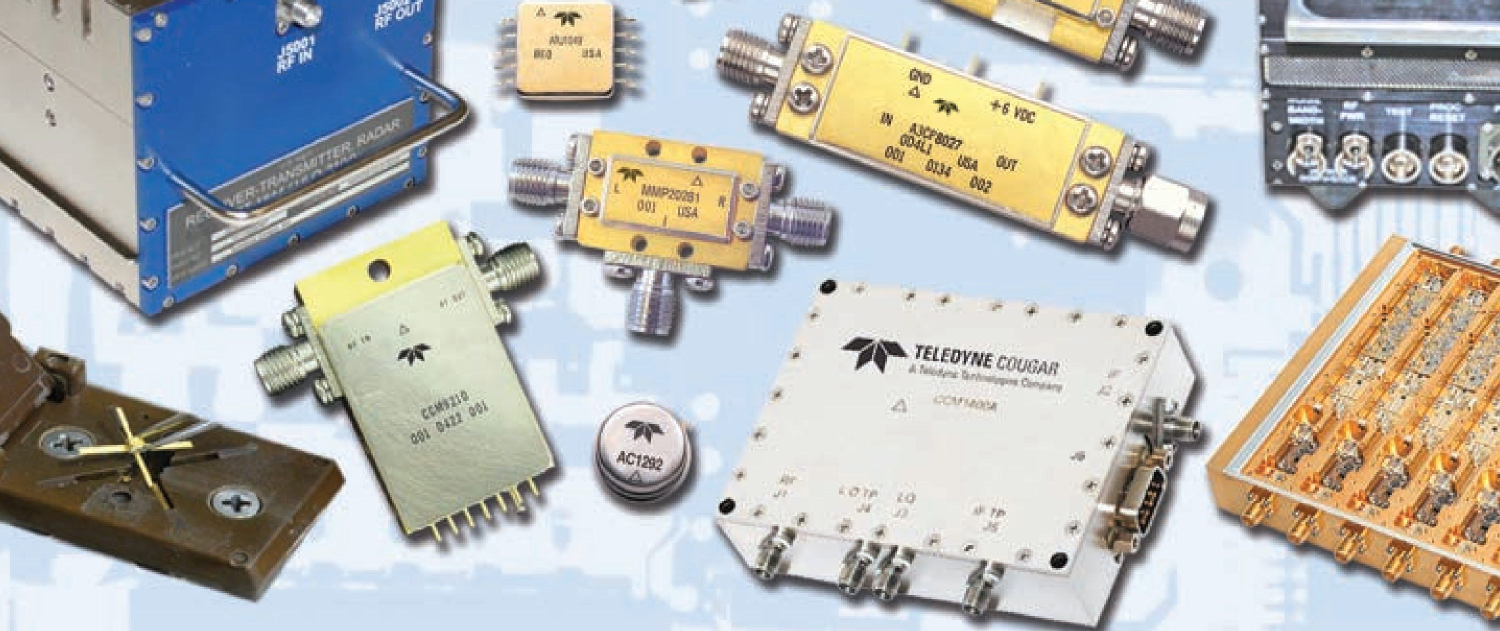
■ **Mouser Electronics Inc.** announced it is stocking the MC13224V advanced ZigBee™ compliant Platform-in-Package and development tools from **Freescale Semiconductor**, an industry leader in the design and manufacture of embedded semiconductors for the wireless, networking, automotive, consumer and industrial markets.

■ **AtlanTecRF**, the UK-based manufacturer of microwave and RF components and equipment, has appointed its first distributor in North America. **Amawave** of Ocean-side, CA will stock the company's range of coaxial passives including attenuators, terminations, power dividers and directional couplers for distribution to customers throughout the United States and Canada. The company's range of passives are form-fit-function compatible to many of the industry's most popular and widely used products and delivery from stock within the US is seen as a distinct advantage for customers who are already using and designing in the AtlanTecRF brand.

## WEB UPDATES

■ **Response Microwave Inc.**, a global specialist in providing RF/microwave customer solutions, announced the launch of its new website selection guide. The new site has migrated to a products focus and provides an overview of corporate capabilities and selection tables of the company's passive component and connectivity product offering that covers DC to 60 GHz. The site also offers application notes on the company's HYBRIDLINE series of drop-in quad hybrids and couplers. For more information, visit www.responsemicrowave.com.

■ **Lark Engineering** now offers an easy to use Online Filter Design tool that enables system engineers to quickly and accurately determine the correct filter for their application. For more information, visit www.larkengineering.com/lark/IFD/idfmenu.htm.


TELEDYNE COUGAR
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# FREQUENCY GENERATION AND SYNTHESIS: COST-EFFECTIVE & POWER-EFFICIENT SOLUTIONS

*This article presents the theoretical analysis and experimental verification of a frequency generation voltage-controlled oscillator (VCO) circuit that overcomes past attempts to combine a miniaturized (0.3" × 0.3") wideband VCO and a phase-locked loop (PLL) in a compact package (0.6" × 0.6") for configurable frequency synthesizer operations.*

Compact frequency synthesizers fill many needs in modern communications systems. To achieve full-sized performance in miniature packages, this research work describes a line of extremely compact frequency synthesizers that leverage a novel, patented voltage-controlled oscillator technology for the stability and low noise needed for emerging wideband, high-data-rate wireless communications systems.[1-8]

There are two cost-effective synthesized source generation techniques: (1) the integrated IC, which consists of a PLL and an onboard VCO and (2) the VCO module with PLL circuitry added internally. While the first approach offers integrated solutions with a compromise in performance, a discrete planar VCO's solution requires a large real estate PCB area. In addition, integrated chip solutions require an additional resonator tank or loop filter with dedicated control software.

RF system designers stress the need for higher levels of integration in RF function blocks. Such a modular approach provides amenable RF and digital interfaces, therefore speeding the time to market and simplifying system-level integration. Unfortunately, commercially available VCOs do not provide a low-cost and power-efficient solution in a compact size that addresses these needs. This article addresses the above limitations and offers a line of plug-n-play tiny VCOs with PLL, providing a high performance synthesized source that features cost-effectiveness and quick development.

VCOs provide the frequency generation in a wide range of frequency synthesizers for communications. Ideally, they deliver wide tuning ranges with low phase noise. Resonators for these oscillators can be formed in many ways, including ceramic and surface-acoustic-wave (SAW) structures. But such three-dimensional (3D) resonators do not lend themselves to integrated circuit (IC) realizations and tend to be sensitive to vibration, microphonics and phase

ULRICH L. ROHDE
AND AJAY K. PODDAR
*Synergy Microwave Corp., Paterson, NJ*

hits. To overcome the limitations of VCOs based on 3D resonators, the planar resonators were shrunk, while also applying a unique evanescent-mode electromagnetic (EM) coupling mechanism to improve the loaded quality factor (Q) of the coupled planar resonators and thus reduce the phase noise. The result is a line of patent-pending, compact, coupled-planar-resonator VCOs that fit in packages measuring just 0.3" × 0.3", but can match the phase noise performance of much larger, high-Q resonator-based oscillators. Because of their (low mass) printed coupled resonators, they are immune to high levels of shock and vibration, a major advantage over oscillators using crystal, ceramic, SAW and YIG resonators. The tiny VCOs are RoHS compliant and can be supplied in tape-and-reel format for automated assembly. They have been tested through 12 GHz and are in production. The innovative, low-power, low-phase noise oscillator technology is currently available in discrete-component form, but is ready to make a transition to integrated circuits. In addition, the planar resonator approach readily lends itself to semiconductor processing methods for fabrication of integrated-circuit reference oscillators using CMOS/BiCMOS/SiGe/GaAs technologies.

## THEORY AND REQUIREMENTS

Frequency synthesizers come in many shapes and sizes, from tiny system-on-a-chip (SoC) devices and compact modules to rugged military-grade rack-mount systems and bench-top instruments. Available technologies are almost as diverse as the number of package options, using analog methods, digital techniques and often a combination of the two. Frequency synthesizers have traditionally relied on a phase-locked loop architecture in which the phase of a tunable oscillator, such as a VCO or YIG-tuned oscillator, is locked to the phase of a reference source with higher stability, such as an oven-controlled crystal oscillator (OCXO).

## BASIC REQUIREMENTS

### Bandwidth and Frequency Coverage

Bandwidth is vital to the spread of wireless multimedia, instant data, high voice quality and other key services.[26-28] However, it is also a limited resource, requiring the use of advanced amplitude- and phase-based modulation formats to squeeze the maximum amount of information into a given portion of bandwidth. One of the most critical components in enabling maximum bandwidth efficiency is the microwave frequency synthesizer. Modern synthesizers leverage available digital techniques to reach the level of noise, stability and resolution needed for most modern communication systems. Therefore, it may be advantageous to develop a broadband "generic" but low cost and power-efficient solution that can cover a number of applications.[26]

### Spurs and RF Output Power

Spurs are undesired artifact products generated by synthesizers at discrete frequencies and their location and level are determined by synthesizer architecture and frequency plan. Care must be taken to minimize the spurs' levels down to -80 dBc and below. The RF output power level is another key factor that drives the frequency conversion (up- and down-conversion) mechanism in mixer circuits and can range over wide limits, typically -10 to +18 dBm, although some applications may need even more power.[26]

### Phase Noise and Switching Speed

Phase noise is the prime parameter that limits the sensitivity of receivers. Synthesizer close-in phase noise and stability depend on the reference frequency standard and synthesizer topology, which derives its output from the reference. Switching speed (tuning speed) is a demanding parameter for data processing, which determines how fast the synthesizer response jumps from one desired frequency to another. The major challenge a designer faces is increasing the switching speed (<< milliseconds) of the synthesizer without sacrificing the performance (phase noise and spurious) as dictated by ongoing increasing data rates of current and later generation communication systems.

### Size and Power Consumption

Compact size and low power consumption are key criteria for modern synthesizer technology. Therefore, they are a true motivation towards integrated circuits, avoiding costly, bulky and power hungry YIG-tuned synthesizers. System designers feel persistent pressure to deliver high performance synthesizers in compact size with low power-consumption, including inexpensive solutions. The above limitations (tuning speeds, power consumptions, phase noise, spurious, stability and size) present design challenges and tradeoffs and are likely to be the key driving factors towards overcoming these as well as reducing complexity and cost.[26-29]

## SYNTHESIZER ARCHITECTURES

Frequency synthesizers provide the fixed and tunable signals for local oscillators in a wide range of commercial and military communications systems, including wireless base stations. Technologies for creating frequency synthesizers are diverse, from traditional analog methods using PLLs to direct digital synthesizers (DDS) that rely on high-speed digital-to-analog converters (DAC) to transform digital input words into analog output signals.[27] While reviewing classical synthesizer architecture, the current technology trend toward increasing the flexibility and functional integration is specifically addressed as well as reducing its complexity and cost without compromising the phase noise performance and switching speed. Various synthesizer architectures along with their main characteristics are described below.[26]

### Direct Analog Synthesizers (DAS)

The function of a synthesizer is translating one or more reference signals to a number of output frequencies with a desired step size. Direct analog synthesizers are conceptualized by mixing base frequencies, followed by switched filters, as shown in ***Figure 1***. The base frequencies can be obtained from a low frequency high performance signal source (crystal and SAW resonator-based oscillators) or high frequency spectral pure signal source (Dielectric Resonator, Bulk Acoustic Wave Resonator, Sapphire Resonator, Metal Cavity Resonator and Coaxial Resonator-based oscillators) by frequency multiplication, division, phase locking or injection-mode locking. The advantage of DAS is low phase noise (due to high performance base


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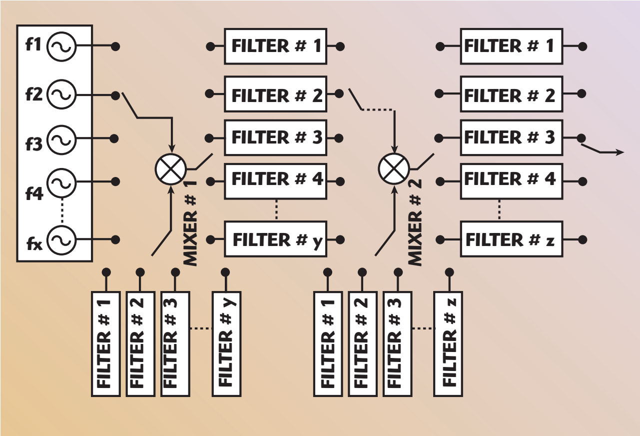



Fig. 1 *Typical block diagram of a DAS.*

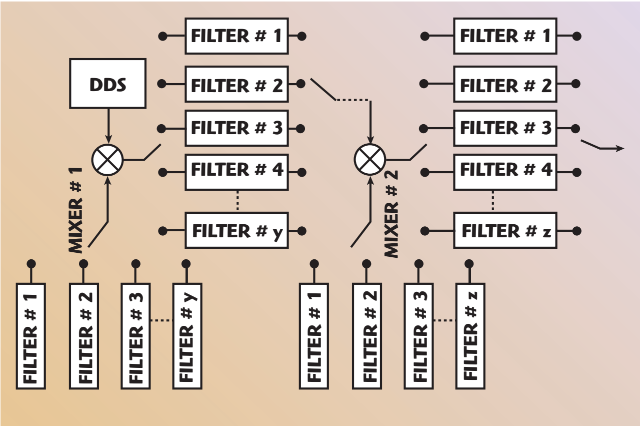



Fig. 2 *Typical block diagram of a DAS using DDS at the input.*

frequency sources extracted from high Q-factor resonator-based oscillators: (crystal/SAW/SRO/CRO) and fast switching speed, but at the cost of step size, design complexity and overall component counts (base frequency source, mixer and filter circuits).

The alternative solution is to incorporate a DDS module at the input of the DAS to increase the minimum step size required from the direct analog approach, as shown in ***Figure 2***. Again the drawback of this approach is a large amount of undesired mixing products, which can be filtered out with expensive filtering hardware structures if small frequency step size and wide coverage are needed.

Although DAS techniques are a promising solution for reasonably good switching speed and phase noise performance, their applications are limited due to high cost factor.

## Direct Digital Synthesizers (DDS)

In contrast to traditional concepts, DDS offers exceptionally fine resolution sub-hertz level, but at the cost of limited usable bandwidth and spurious performances. Therefore, due to bandwidth and spurs limitations DDS techniques are not attractive for microwave applications and are generally used as a fine frequency resolution module in direct analog or indirect architecture. The above limitations can be overcome by incorporating software and hardware techniques similar to the DAS approach (large

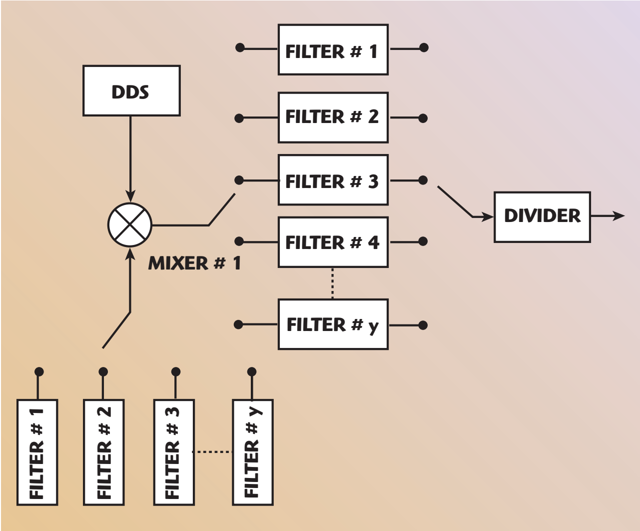



Fig. 3 *Typical block diagram of a DDS using a divider at the output.*

number of component counts), followed by a frequency divider, as shown in ***Figure 3***.

## Indirect Frequency Synthesizers (IFS)

***Figure 4*** shows a typical single-loop IFS, which utilizes frequency conversion (mixing) in the feedback path to improve the switching speed, phase noise and spurious performances. The drawback of a conventional IFS is degradation in the phase noise performance, due to the large division ration N, which is required to provide a high frequency output with a fine resolution. In addition, IFS is sensitive to false lock due to undesired mixing products. Using a fractional divider, the overall loop division ratio can be reduced for improved phase noise and tuning speed characteristics.

The problem of false locking can be overcome by incorporating a digital to analog converter (DAC) to provide a sufficiently accurate coarse tune of the VCO to a reason-

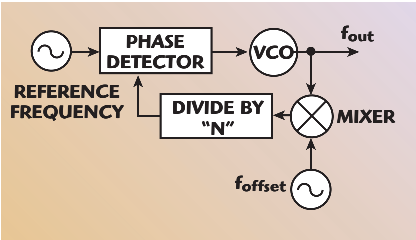



Fig. 4 *Typical block diagram of an IFS.*

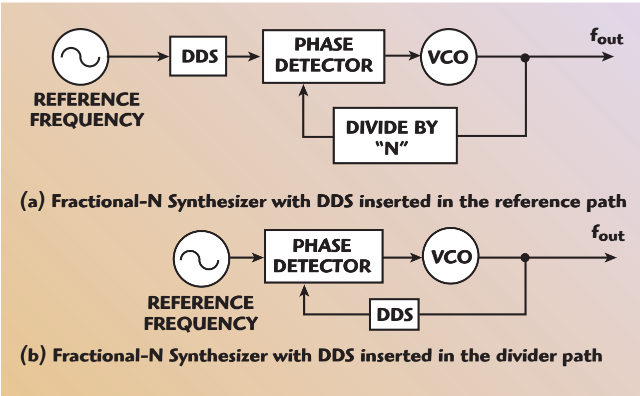
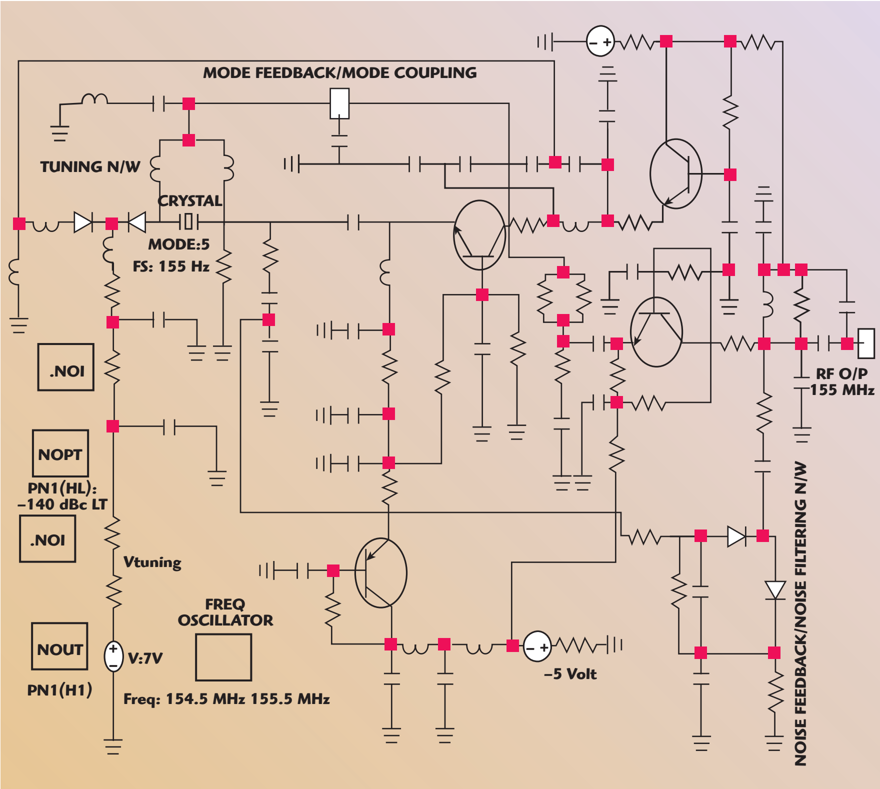



Fig. 5 *Typical block diagrams of fractional-N synthesizer with DDS inserted.*

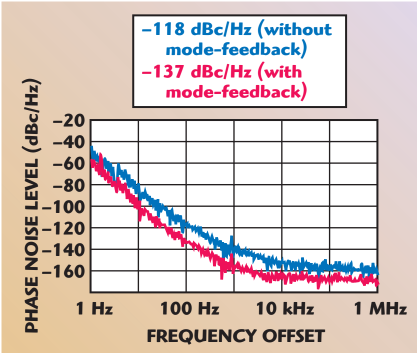



▲ *Fig. 6 155.6 MHz active-mode coupled VCXO (0.5" × 0.5").*

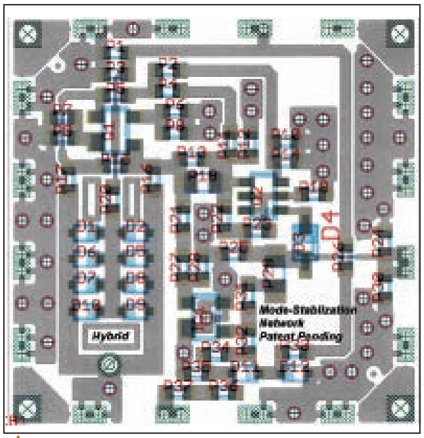
ably correct frequency. This acquisition aid needs linear and repeatable tuning characteristics over the operating frequency band and temperature range. But DACs are noisy and adversely affect the synthesizer phase noise performance if they are not properly removed after the initial frequency acquisition.[29]

For a given step size, fractional-N schemes enable a higher phase detector (PD) comparison frequency, resulting in improved phase noise and tuning speed characteristics. However, the main drawback of the fractional-N topology is high spurious levels due to phase errors inherent to the fractional division mechanism.

IFS architecture strongly depends on the VCO characteristics; therefore, a promising solution is to use a low phase noise and fast switching compatible VCO, including a DDS module as a fractional divider, inserted into the reference or divider path (see ***Figure 5***). This approach leads to a complex hardware architecture, but offers a cost-effective high performance solution. Although

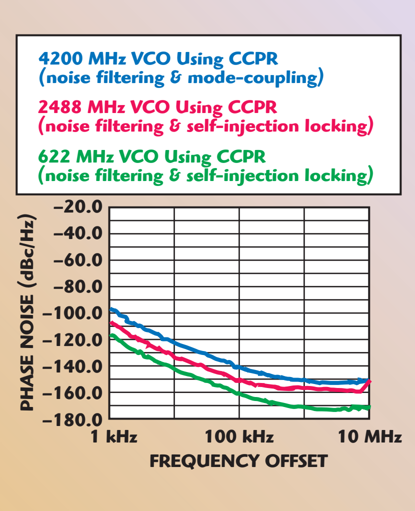



▲ *Fig. 7 Measured phase noise for a 155.6 MHz VCXO.*




▲ *Fig. 8 Typical layout of a 1000 MHz low noise oscillator (0.5" × 0.5").*

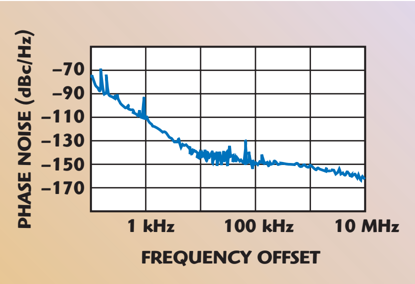
high performance synthesizer compatible VCO solutions complicate the overall design philosophy, the complexity can be effectively spread and optimized, which leads to a high performance and reasonably priced frequency generation and synthesis solutions for current and later generation communication systems.




▲ *Fig. 9 Measured phase noise for a CCPR VCO.*

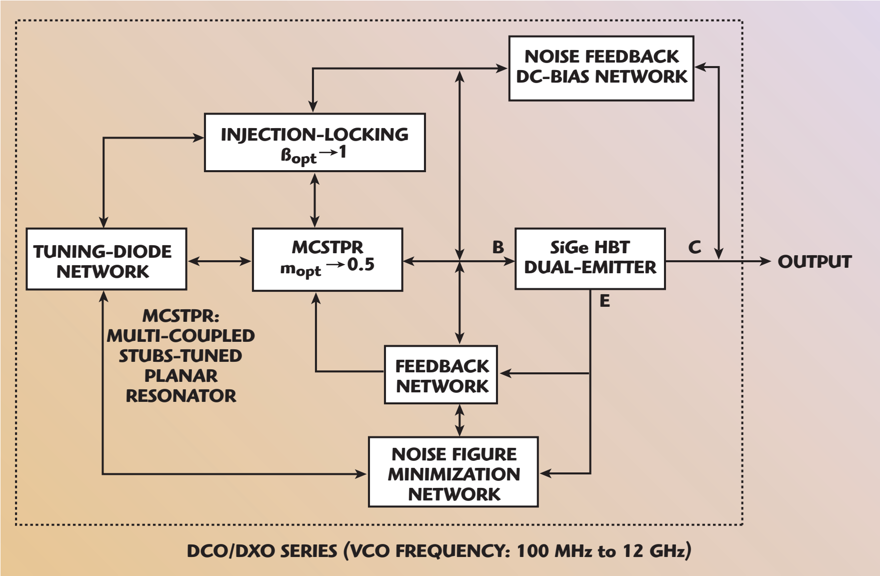
## SYNTHESIZER COMPATIBLE VCOS

Historically, synthesizer designers have relied on YIG oscillators, characterizing broadband operation with excellent phase noise performance. The YIG oscillator offers linear tuning characteristics that simplify the synthesizer coarse-tuning algorithm in multi-loop schemes. These unique features allowed the YIG-based synthesizers to dominate over the last decades. But YIG oscillators are power hungry and require larger real estate area, which recently contributed to a transition to printed coupled resonator-based solid-state VCO architectures. Since the printed resonator-based VCO noise performance is inferior to its YIG counterpart, care must be taken in choosing spectral pure reference frequency sources (crystal oscillators). The typical phase noise performance of commercially available 100 MHz crystal oscillators is -168 dBc/Hz at 10 kHz offset from the carrier.[25] The phase noise at 10 kHz offset for a 100 MHz crystal oscillator can be translated to -128 dBc/Hz for a 10 GHz output, which even supersedes the performance of commercially available low cost YIG oscillators (assuming the translation is not affected by the synthesizer system noise floor). As shown in ***Figure 6***, this work addresses the noise minimization mechanism for a 155 MHz reference frequency standard, using a patented active-mode-feedback and noise filtering techniques.[1-8] ***Figure 7*** shows the typical measured phase noise plot at 10 kHz offset, which is better than the commercially available low cost frequency standard. At a lower offset (1 Hz), the improvement in phase noise performance is limited due to the influence of the 1/f noise, which can be optimized by selecting a transistor that has low value of 1/f noise.




▲ *Fig. 10 Measured phase noise for a 1000 MHz oscillator.*

Tunable oscillators are instrumental in the operation of many systems, from commercial communications to military radars. Many characteristics define the performance of a tunable RF/microwave oscillator, but one of the more difficult parameters to optimize is phase noise. Because of the importance of bandwidth and phase noise in modern systems, this research work is focused on those two parameters in their innovative line of compact coupled planar resonator (CCPR) oscillators. ***Figure 8*** shows the typical layout of a reference frequency standard using evanescent node and extended resonance techniques in CCPR configuration. ***Figure 9*** shows the measured phase noise plots for different carrier frequency. At 10 kHz offset from the carrier, the typical values are: -138 dBc/Hz (carrier frequency: 622 MHz), -128 dBc/Hz (carrier frequency: 2488 MHz) and -118 dBc/Hz (carrier frequency: 4200 MHz). The circuit operates at 5 V, 30 mA and its typical output power is 5 dBm. The second harmonic rejection is better than -20 dBc. ***Figure 10***

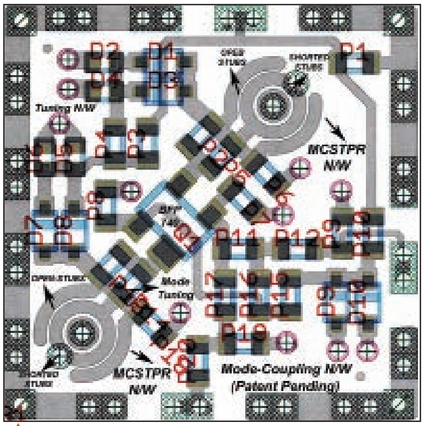



▲ *Fig. 11 Block diagram of a miniaturized VCO.*

shows the measured phase noise plot for a 999.96 MHz spectral pure VCO using hybrid techniques (combination of planar resonator and inexpensive low Q SAW resonator). The typical measured phase noise at 10 kHz offset is -142 dBc/Hz, which is state-of-the-art technology in low-cost series of reference frequency standards in planar technology.

The above discussions on reference frequency standards call for wideband VCO solutions; the results are evident. The printed resonator VCO described in this article potentially achieves faster tuning speed with






▲ *Fig. 12 Layout of the miniaturized VCO (0.3" × 0.3" × 0.1").*

comparable phase noise and spurious performance without the use of expensive, bulky and power hungry YIG oscillators. Recent progress is in the direction of minimizing the system residual noise floor and extending the loop bandwidth to a few megahertz, where printed coupled resonator-based solid-state VCO noise becomes competitive with the YIG oscillators. Incorporating a high performance planar resonator-based VCO with a crystal oscillator as a reference results in a cost-effective synthesizer with faster tuning speed. Besides choosing the right VCO, the PLL bandwidth is one of the most important design parameters. If the noise in the input or feedback path is dominant, the bandwidth should be small to filter it out by the PLL loop. If the VCO noise is dominant, the bandwidth should be large, since this noise is high-pass filtered to the PLL output.

These characteristics, accompanied with the low cost inherent to printed coupled resonator-based VCO designs, are likely to secure their domination in the foreseeable future. VCOs based on IC technology can be made small, but at the cost of power consumption and limited tuning range. This work describes the power-efficient fundamental frequency VCO solution that supports as much as 2:1 bandwidths from 1 to 12 GHz, with fast tuning and low phase noise performance that challenge the best performance of commercially available integrated circuit or discrete SMD packaged VCOs (for given constraints of power consumption, tuning, performance and cost factor).

***Figures 11*** and ***12*** show the block diagram and layout for the DCO/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| MADP-042405 | 80 | 25 | 0.58 | 0.62 |
| MADP-042505 | 80 | 20 | 0.27 | 0.83 |
| MADP-042905 | 80 | 3.2 | 0.06 | 3.14 |
| MADP-017015-1314 | 115 | 100 | 0.31 | 0.6 |
| MADP-030015-1314 | 115 | 100 | 0.78 | 0.43 |
| MADP-017025-1314 | 135 | 25 | 0.23 | 0.85 |
| MADP-030025-1314 | 135 | 50 | 0.5 | 0.56 |
| MA4SPS502 | 200 | 10 | 0.09 | 2.8 |
| MA4SPS552 | 200 | 5 | 0.06 | 2.65 |
| MA4SPS421 | 200 | 10 | 0.07 | 5 |
| MA4SPS422 | 200 | 10 | 0.13 | 2.4 |

Measurements made at 1 GHz CW
Cj measured at 40V

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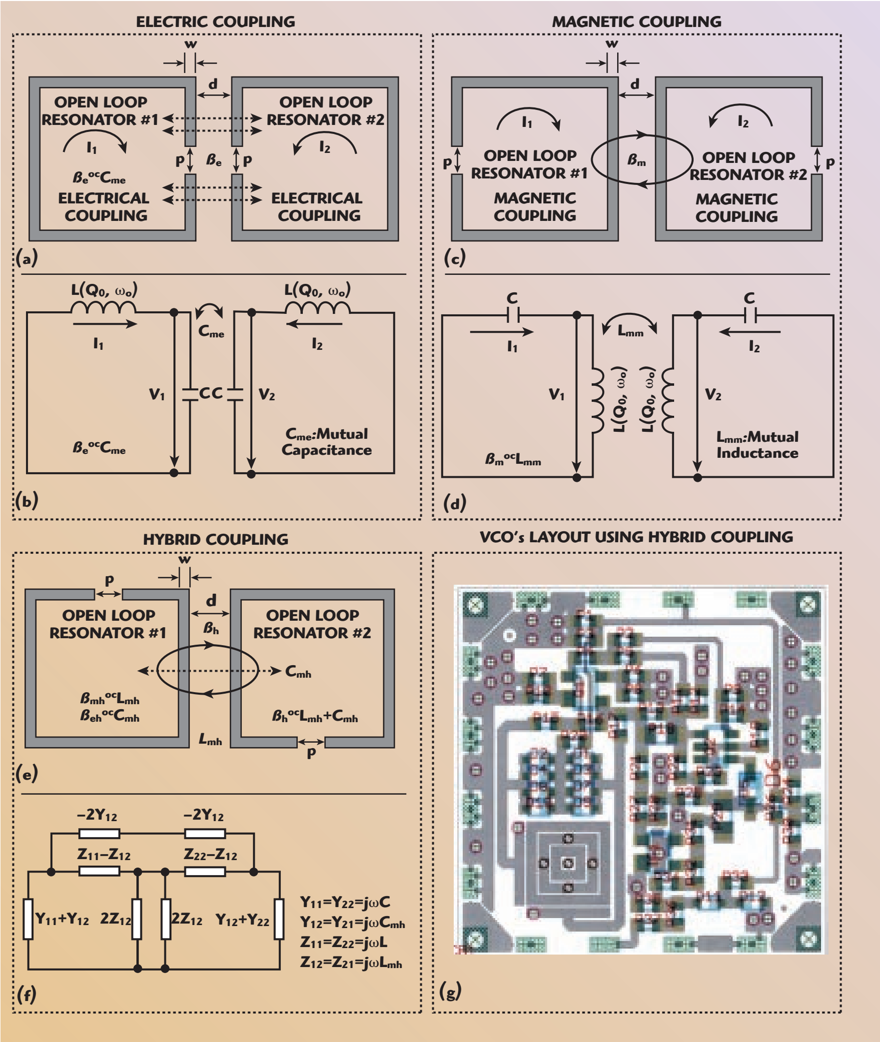
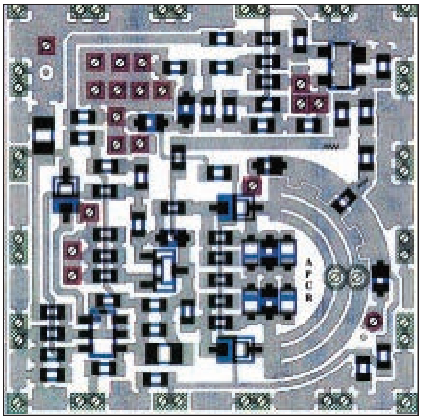
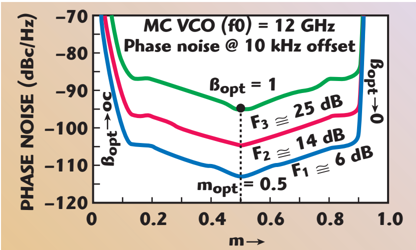


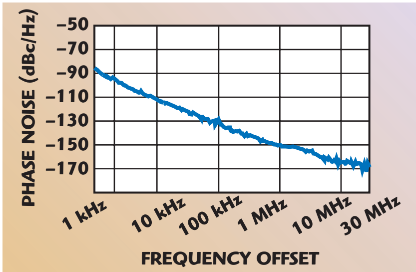

▲ *Fig. 13 Typical simplified structure of open loop microstrip coupled resonator networks.*



▲ *Fig. 14 Typical layout of a 12 GHz MC VCO active planar coupled resonator (APCR).*




▲ *Fig. 15 Simulated phase noise of an MC VCO with respect to $M_{opt}$.*




▲ *Fig. 16 Measured phase noise of an MC VCO.*

DXO VCOs. It is the miniature size of the discrete-device DCO and DXO series VCOs that make the surface-mount MFSH series synthesizers possible. They can be used with supply voltages of 2.1, 3.0, 3.2, 3.5, 4.0, 4.5, 5.0, 8.0 and 12 V, with supply current as low as 10 mA, without much degradation in phase noise performance and characteristics. VCO models are available for narrowband tuning (approximately 10 percent of center frequency), moderate bandwidth (approximately 50 percent of center frequency) and wideband tuning (greater than 100 percent of center frequency). The tiny VCOs are suitable for use as free-running sources as well as for space-saving synthesizer designs. They are designed for reliable performance over temperatures from -40° to +85°C and are well suited for applications in industrial, military and commercial systems. They employ a miniaturized, multi-coupled, stubs-tuned-planar-resonator (MCSTPR) approach, fabricated on low-loss 30 mil-thick dielectric material with a dielectric constant of 3.38. The VCO's active device is a discrete low-noise silicon-germanium (SiGe) hetero-junction bipolar-transistor (HBT) device.

The MCSTPR structure is modeled using a 2.5D or 3D EM simulator and incorporated into an optimized nonlinear oscillator circuit to achieve configurability and low-phase noise operation over the desired frequency band. The nonlinear circuit model contains the oscillator's active device, represented by its S-parameters. This partitioning of the oscillator into its modeled component parts works quite well, and the combination of the S-parameters and the nonlinear circuit model agrees closely with measured data from circuits already constructed. The active device SiGe HBT is represented by large-signal S-parameters in order to better understand the behavior of the device under quasi-linear (low-signal drive level) and nonlinear (large-signal drive level) conditions. This approach improves the optimization cycles using harmonic-balance simulators such as Advanced Design System (ADS 2008) from Agilent Technologies and Ansoft/Nexxim/Ansys from Ansoft Corp. to limits allowed by physics.

## PRINTED COUPLED RESONATORS

The Q (quality) factor of the coupled planar resonator network can be enhanced by introducing an optimum coupling mechanism (electric/magnetic/hybrid). ***Figure 13*** illustrates the layout of the typical electric, magnetic, hybrid-coupling planar resonator networks, and oscillator circuits for comparative analysis.[24] As described, the coupling dynamics can be characterized by proximity effect through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| Frequency (MHz) | IL (dB) | Isol (dB) | IMD (dBc) | Application |
|---|---|---|---|---|
| 869-894 | 0.15 | 23 | -80 | GSM |
| 925-960 | 0.15 | 23 | -80 | GSM |
| 1850-1910 | 0.2 | 25 | -80 | GSM |
| 1805-1880 | 0.2 | 25 | -80 | GSM |
| 728-768 | 0.3 | 23 | -70 | LTE |
| 1475.9-1500.9 | 0.2 | 23 | -80 | LTE |
| 2605-2705 | 0.15 | 25 | -75 | LTE |
| 2010-2025 | 0.15 | 25 | -75 | TD-SCDMA |
| 2110-2170 | 0.15 | 25 | -75 | WCDMA |
| 2500-2700 | 0.15 | 25 | -75 | WiMAX |
| 3400-3600 | 0.15 | 25 | -75 | WiMAX |

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the fringing fields, which exponentially decay outside the region; the electric and magnetic field intensities tend to concentrate near the side having maximum field distribution. The coupling factor $\beta$ ($\beta_e$: electric, $\beta_m$: magnetic and $\beta_h$: hybrid) can be described as

$$\beta_e \cong \frac{\text{coupled-electrical energy}}{\text{stored-energy of uncoupled-resonator}} \cong \frac{f_{me}^2 - f_{ee}^2}{f_{me}^2 + f_{ee}^2} \cong \frac{C_{me}}{C} \tag{1}$$

The loaded quality factor $Q_L$ of the coupled resonator network is given in terms of unloaded quality factor $Q_o$ as[24]

$$\beta_m \cong \frac{\text{coupled-magnetic energy}}{\text{stored-energy of uncoupled-resonator}} \cong \frac{f_{em}^2 - f_{mm}^2}{f_{em}^2 + f_{mm}^2} \cong \frac{L_{mm}}{L} \tag{2}$$

$$\beta_h \cong \frac{\text{coupled-electromagnetic energy}}{\text{stored-energy of uncoupled-resonator}} \cong \frac{f_{eh}^2 - f_{mh}^2}{f_{eh}^2 + f_{mh}^2} \cong \frac{CL_{mh} + LC_{mh}}{LC + L_{mh}C_{mh}} \tag{3}$$

where

$$f_{ee} = \frac{1}{2\pi\sqrt{L(C + C_{me})}}, f_{me} = \frac{1}{2\pi\sqrt{L(C - C_{me})}},$$

$C_{me}$: Mutual Capacitance

$$f_{em} = \frac{1}{2\pi\sqrt{C(L - L_m)}}, f_{mm} = \frac{1}{2\pi\sqrt{C(L + L_m)}},$$

$L_{mm}$: Mutual Inductance

$$f_{eh} = \frac{1}{2\pi\sqrt{(L - L_{mh})(C - C_{mh})}}, f_{mh} = \frac{1}{2\pi\sqrt{(L + L_{mh})(C + C_{mh})}},$$

$L_{mh}$: Hybrid Inductance

$$f_0 = \frac{1}{2\pi\sqrt{LC}},$$ $f_0$: Fundamental resonance frequency of uncoupled resonator. (4)

The loaded quality factor $Q_L$ of the coupled resonator network is given in terms of unloaded quality factor $Q_o$ as[24]

$$Q_L(\omega_0) = \frac{\omega_0}{2}\left[\frac{\partial\phi}{\partial\omega}\right] \tag{5}$$

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$$\left[Q_L(\omega_0)\right]_{\text{electrical-coupling}} \cong 2\left[\frac{Q_0}{(1+\beta_e)}\right]_{\beta_e \ll 1} \cong 2Q_0 \qquad (6)$$

$$\left[Q_L(\omega_0)\right]_{\text{magnetic-coupling}} \cong 2\left[Q_0(1+\beta_m)\right]_{\beta \to 1} \cong 2Q_0 \qquad (7)$$

$$\left[Q_L(\omega_0)\right]_{\text{hybrid-coupling}} \cong 2\left[Q_0\frac{(1+\beta_{mh})}{(1+\beta_{eh})}\right]_{\beta_e \ll 1, \beta_m \to 1} \cong 2Q_0 \qquad (8)$$

where $\frac{\partial\phi}{\partial\omega}$ is the rate of change of the phase, and $Q_0$ is the unloaded Q-factor of the uncoupled single open loop microstrip line resonator.

From Equations 6, 7 and 8, there is trade-off between improving the Q factor and the permissible attenuation required (which is compensated by active device for oscillation build up). The coupling mechanism described shows improvement in quality factor in comparison to a single uncoupled planar resonator, but the drawback is a limited tuning range (less than 1 percent).

From Equations 6, 7 and 8, the loaded quality factor ($Q_L$) can be maximized by either lowering the value of mutual capacitance ($C_m$) and inductance ($L_m$) or maximizing the self-capacitance (C) and inductance (L). Therefore, the upper limit of the loaded Q-factor is dependent on the coupling β that can be optimized by controlling the width of the transmission line (w), the gap of the open line resonator (p) and the spacing between the two open line resonators (d). However, dynamically controlling and tuning the parameters w, p, and d at high frequency in IC technology is a challenging task. For wideband tunability, the coupling factor $\beta_j$ has to be dynamically tuned for low phase noise performances over the operating frequency band. The simplified approach for the realization of a dynamically controlled coupling factor $\beta_j$ can be achieved by incorporating a tuning diode as a coupling capacitor across the coupled resonator networks.

## VCOS PHASE NOISE ANALYSIS

The expression for the phase noise can be given by[11]

$$\pounds(f_m) = 10\log\left\{\left[1+\frac{f_0^2}{(2f_mQ_L)^2}\right]\left(1+\frac{f_c}{f_m}\right)\frac{FkT}{2P_0}+\frac{2kTRK_0^2}{f_m^2}\right\} \qquad (9)$$

$$\pounds(f_m) = 10\log\bullet \left\{\left[1+\frac{f_0^2}{(2f_mQ_0)^2 m^2(1-m)^2}\right]\left(1+\frac{f_c}{f_m}\right)\frac{FkT}{2P_0}+\frac{2kTRK_0^2}{f_m^2}\right\} \qquad (10)$$

where $\pounds(f_m)$, $f_m$, $f_0$, $f_c$, $Q_L$, $Q_0$, F, k, T, $P_o$, R, m and $K_0$ are the ratio of the sideband power in a 1 Hz bandwidth


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at $f_m$ to total power in dB, the offset frequency, the flicker corner frequency, the loaded Q, the unloaded Q, the noise factor, the Boltzman's constant, the temperature in °K, the average output power, the equivalent noise resistance of the tuning diode, the ratio of the loaded and unloaded quality factors and the voltage gain. From Equations 6, 7 and 8, m is given in terms of coupling coefficient as

$$m=\frac{Q_L}{Q_0}\cong\left[\frac{2}{(1+\beta_e)}\right]_{electrical}\cong\left[2(1+\beta_m)\right]_{magnetic}$$
$$\cong\left[\frac{2(1+\beta_{mh})}{(1+\beta_{eh})}\right]_{hybrid} \qquad (11)$$

By differentiating Equation 10 with respect to m and equating to zero, the local minimum value of the phase noise for a given resonator and oscillator topology can be given by

$$\frac{\partial^2}{\partial m^2}\left[\pounds(f_m)\right]_{m=m_{opt}}=0\Rightarrow\frac{d^2}{dm^2}\bullet$$
$$\left[10\log\left\{\left[1+\frac{f_0^{\,2}}{(2f_mQ_0)^2m^2(1-m)^2}\right]\left(1+\frac{f_c}{f_m}\right)\frac{FkT}{2P_0}+\frac{2kTRK_0^2}{f_m^2}\right\}\right]$$
$$=0\Rightarrow m_{opt}=0.5 \qquad (12)$$

$$m_{opt}\to 0.5\Rightarrow\left[\beta_e\right]_{opt}\ll 1,\left[\beta_m\right]_{opt}\to 1,0<\left[\beta h\right]_{opt}<1 \qquad (13)$$

From Equation 13, for low phase noise applications, $m_{opt}$ and $\beta_{opt}$ should be dynamically tuned and must converge in the vicinity of $m_{opt}\cong 0.5$ and $0<\beta_{opt}<1$ respectively for best phase noise performances. As an example for validation, ***Figure 14*** shows the typical layout of a fixed frequency 12 GHz mode-coupled (MC) VCO, using a SiGe heterojunction bipolar transistor (HBT), fabricated on a Rogers substrate material with a dielectric constant of 3.38 and a thickness of 30 mils (microstripline/stripline) for the validation of the new approach (dynamically controlling $m_{opt}$ and $\beta_{opt}$ for minimum noise figure). ***Figure 15*** shows the CAD simulated phase noise plot for a 12 GHz MC VCO at a 10 kHz offset from the carrier with respect to $m_{opt}$ and $\beta_{opt}$. ***Figure 16*** shows the measured phase noise plot of the discrete version of the MC VCO (which is planar and amenable to a MMIC manufacturing process), typically –110 dBc/Hz at 10 kHz from the carrier that agrees with the simulated results within 3 to 4 dB.

## APPLICATIONS: TINY VCOS ARM FREQUENCY CONFIGURABLE SYNTHESIZERS

Technologies for creating frequency synthesizers are diverse, from traditional analog methods using PLLs to direct digital synthesizers (DDS) that rely on high-speed digital-to-analog converters (DAC) to transform digital input words

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**MWJ:** **I guess the first obvious question is, why the outfit?**

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**MWJ:** **How does IKE Micro produce at such a high level?**

**SM:** We have a veteran, low-turnover workforce, and a good balance of automated and manual assembly capability. Because of our 100% focus on build-to-print manufacturing, design and market issues don't get in the way of the delivery schedule.

**MWJ:** **Are your company's assembly capabilities comprehensive?**

**SM:** Yes, from DC to 100GHz. Our capabilities include surface mount, epoxy and solder board mount, feedthru installation, die attach, wire/ribbon bond, coil and beam lead bonding, and all the crazy RF soldering and bonding needed so our units make it through test with minimal tuning.

**MWJ:** **What types of customers take advantage of IKE's experience and capabilities?**

**SM:** It's a good mix. It includes the big systems companies and many of the small to mid-sized module suppliers. Many of these companies advertise with you. We do complex modules and pretty basic subassemblies. Our domestic and international customer mix is 65% defense and 35% commercial.

**MWJ:** **What are your goals for 2009?**

**SM:** I want to continue to produce at high levels and exceed customer expectations. More importantly, I plan to steer clear of the EE design guys, some of those guys freak me out, especially when I'm wearing this dress.

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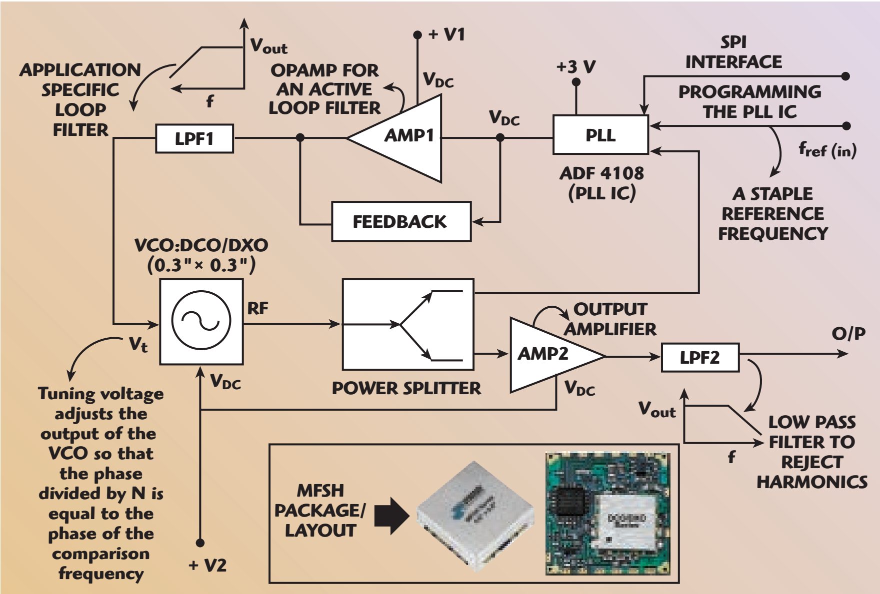


▲ *Fig. 17 Block diagram of a configurable synthesizer (MFSH series).*

into analog output signals. Frequency synthesizers can be categorized into mainly three groups: analogue, digital or mixed signal (hybrid). The frequency synthesizer described in this article falls into the hybrid category. The block diagram for a typical MFSH frequency synthesizer (see ***Figure 17***) includes a VCO, PLL, IC, charge pump, loop filter, amplifier and voltage regulator.

## CONCLUSION

System designers stress the need for higher levels of integration in RF function blocks. Such modules provide simple digital and RF interfaces and, thus, speed the time to market and simplify system-level integration and production. Unfortunately, the RF/microwave signal sources currently available do not provide a satisfactory solution that addresses these needs. Fortunately, a line of pick-n-place tiny power-efficient VCOs offer a practical solution, providing a high performance frequency synthesized source that features quick development. ■

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# Synthesizers


## 56 MHz - 6010 MHz

Mini-Circuits®
ISO 9001 ISO 14001 AS 9100 CERTIFIED

# DIFFERENT TYPES OF SYNTHESIZERS

*Let the Mini-Circuits design team create a custom frequency synthesizer tailored to your requirements. We will review your requirements and, following technical discussions between your engineers and Mini-Circuits designers, we will work closely with you to create final specifications that meet or exceed your requirements. To ensure high yields, we will factor in component tolerances and even variations in manufacturing processes. You will have full access to performance data from sample units, and can even evaluate sample units in your system to ensure that final production units fulfill your performance requirements.*

**To meet the needs of a wide range of systems and applications, Mini-Circuits offers seven different types of custom frequency synthesizers:**

## 1 Fixed Frequency

For applications requiring a highly stable single frequency, Mini-Circuits engineering team can customize a low-noise synthesized source for any frequency from 56 MHz to 6010 MHz. Fixed-frequency synthesizers feature low phase noise with spurious performance of -90 dBc or better. They operate with low power consumption and are supplied in compact surface-mount or connectorized packages.

- *Settling times of typically 100 ms or better*
- *Harmonics of -20 dBc or better*

## 2 Tunable Narrow Bandwidth

For applications requiring tunable bandwidths of center frequency ± 10% (or less), Mini-Circuits custom narrowband frequency synthesizers can be specified to 6010 MHz with low phase noise, low harmonics, and spurious levels of -85 dBc or better. Available with customer-specified step sizes, these high-performance synthesizers are housed in compact surface-mount or connectorized packages.

- *Typical settling times of 30 ms or less*
- *Harmonics of -20 dBc or better*

## 3 Tunable Medium Bandwidth

Mini-Circuits medium-bandwidth frequency synthesizers can be specified for center frequency ±10% to ±30% over a frequency range of 56 MHz to 6010 MHz. They offer spurious performance of -90 dBc typical or better, with customer specified step sizes, low power consumption, and packaged in compact surface-mount or connectorized housings.

- *Typical settling times of 25 ms or less*
- *Harmonics of -20 dBc or better*

## 4 Tunable Wide Bandwidth

For tuning bandwidths of center frequency ±30% to ±50% Mini-Circuits wide-bandwidth frequency synthesizers can be specified from 56 MHz to 6010 MHz with custom step sizes.They feature outstanding spurious performance of -80 dBc or better with output levels to +9 dBm or more. Mini-Circuits wide-bandwidth frequency synthesizers are supplied in surface-mount or connectorized packages.

- *Bandwidths greater than 500 MHz*
- *Typical settling times of 25 ms or less*
- *Harmonics of -20 dBc or better*

## 5 Tunable Very Wide Bandwidth

For extremely wide tuning bandwidths up to 6 octave ex; 700 MHz to 4000 MHz, achieved in one model, Mini-Circuits very-wide-bandwidth frequency synthesizers can be specified with customer-specified step sizes. These broadband synthesizers boast output levels of +8 dBm typical spurious performance of -80 dBc or better, and low phase noise. Very-wide-bandwidth frequency synthesizers can be supplied in surface-mount or connectorized packages.

- *Typical settling times of 15µs or less*
- *Harmonics of -20 dBc or better*
- *Frequency 700 to 4000 MHz*

## 6 Tunable Fast Settling Time

Fast switching speed alone is not enough. Mini-Circuits custom fast-settling-time frequency synthesizers provide fast switching speed while also settling to a stable, new frequency quickly. Fast-settling-time frequency synthesizers settle within ±5.4 deg. of a new tuned frequency in microseconds even for large frequency steps.

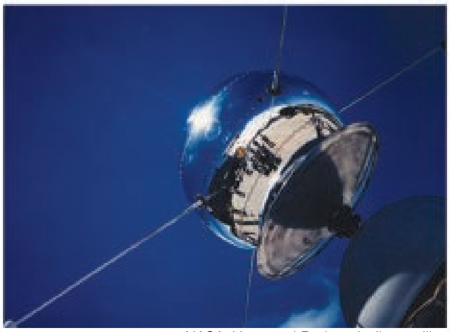
- *Settling time of 25 µs or less*
- *Typical spurious of -65 dBc or better*
- *Frequency 714 to 1618 MHz*

## 7 Dual Frequency

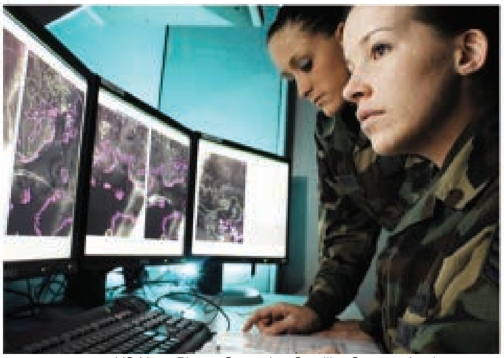
For savings in cost and system real estate, Mini-Circuits can customize a single package containing two discrete, single frequency synthesizers, with any two frequencies. Both synthesizers are characterized by low phase noise and spurious levels of -90 dBc or less. These dual-frequency synthesizers can be supplied in compact surface-mount or connectorized packages.

- *Harmonics of -20 dBc or better*
- *Typical phase noise of -92 dBc/Hz or better at 1 kHz offset*
- *Programmable*

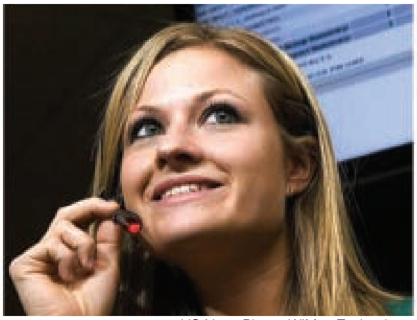
# FOR DIFFERENT APPLICATIONS



NASA: Vanguard Radar missile satellite



US Navy Photo: Ground to Satellite Communication center



US Navy Photo: WiMax Technology

US Navy Photo: X-45A / Unmanned combat aerial vehicle

NASA: Discovery Launch

*Mini-Circuits is an industry leader in synthesizer designs, with models designed into major programs world wide. Mini-Circuits has designed over 250 synthesizer models, most of which were developed from face-to-face discussions with customers.*

*In addition to which, Mini-Circuits has designed these synthesizers in both SMT and connectorized packages for applications including:*

- *TDSCDMA*
- *CDMA Repeaters*
- *WCDMA*
- *EDGE*
- *GSM*
- *TDMA*
- *PCS*
- *UMTS*
- *L-Band Satellite*
- *Wireless LAN*
- *Point-to Point Radio*
- *Test Equipment*
- *Microwave Radio High Data Transfer Rate Applications, up to 600 Mbytes/Sec*
- *CATV*
- *WiMAX*
- *Military Programs*
- *LTE*
- *Mobile TV*

## LET MINI-CIRCUITS DESIGN YOUR NEXT SYNTHESIZER USING OUR TIME-PROVEN PROCESS:

**1 *Customer consultation***

Every new frequency synthesizer starts with a set of requirements; Mini-Circuits experienced and knowledgeable staff will review your performance requirements and reliability concerns, and develop a draft specification that precisely documents your needs and clearly details project milestones and final delivery dates.

**2 *Synthesizer simulation***

Once we've documented your synthesizer specifications, Mini-Circuits engineering staff will use the latest computer-aided-engineering (CAE) tools to create a computer model for your design along with simulations of expected performance. These simulations will help fine-tune your design to meet or exceed its target performance specifications.

**3 *Customer approval of specs and simulation***

After your design has been computer simulated, Mini-Circuits synthesizer design team will share the simulation results with you. At that time, we will also offer any comments or recommendations, such as tradeoffs that could result in lower power consumption or lower phase noise. Your approval of the preliminary specification will be based on simulation and expected performance levels.

**4 *Prototyping your synthesizer***

Armed with your approval of the specifications and the simulation, Mini-Circuits synthesizer design team will create a hardware prototype of your design, using the highest performance components available and the latest RoHS-compliant assembly practices. Assembled prototypes are 100% tested for electrical performance, over the full operating temperature range to evaluate key parameters such as frequency margin stability, output power, phase noise, harmonics, spurious, power consumption, etc.

**5 *Customer approval of prototype performance***

After your prototype synthesizer has been 100% tested, over the full operating temperature range, Mini-Circuits staff shares the results of those tests with you, providing clear descriptions of each performance parameter, such as frequency, output power, and phase noise, and thorough details on how each test was performed, right down to the type of test equipment used in the measurements. Only when you are fully satisfied with the results will we proceed to the next step in our synthesizer design process.

**6 *Engineering run***

Following your approval, Mini-Circuits will transfer your prototype frequency synthesizer design to engineering production, with the same component bill of materials (BOM) and RoHS-compliant assembly procedures used to produce the prototype. In addition, the same rigorous 100% testing over the full operating temperature range procedures will be applied to each production synthesizer, to ensure that each unit in your production run is of the highest quality and highest reliability.

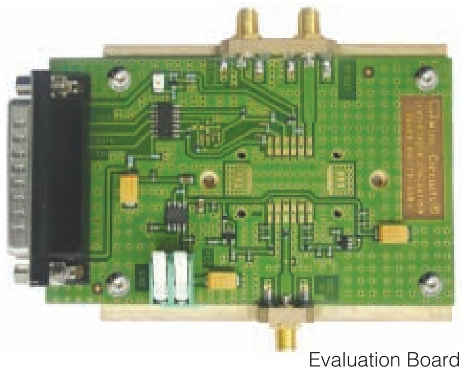
**7 *Customer acceptance and sign off***

After engineering run has been completed, units will be sent to you for qualification in your system. In parallel, a final specification will be created and sent for your approval. The final specification will be created based on the engineering run data that was taken over the full operating temperature range and reflects the specification we can guarantee for mass production.

**8 *Model finalized***

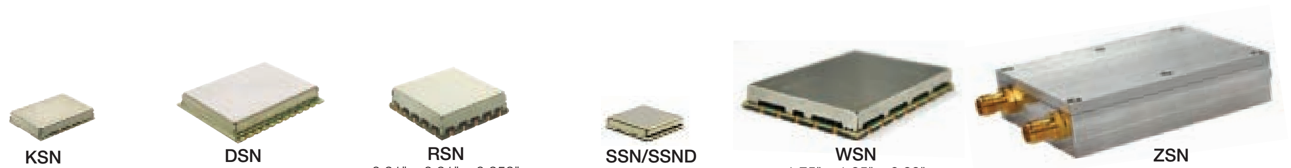
Every Mini-Circuits synthesizer is 100% tested during production, where we perform over 44 electrical tests (see page 7) in automated setups to ensure and guarantee quality and performance repeatability.


Working "Face-to-Face" with customers in a close cooperative relationship, ensures that Mini-Circuits provides optimal State-of-the-Art solutions to our customers needs.



Evaluation Board

# Some Examples Of Custom Synthesizers Provided To Customers



**KSN** 0.800" x 0.584"x 0.154 (20.32 x 14.83 x 3.91mm)

**DSN** 1.25" x 1.00" x 0.20" (31.75 x 25.40 x 5.08 mm)

**RSN** 0.91" x 0.91" x 0.252" (23.11 x 23.11 x 6.40 mm)

**SSN/SSND** 0.60" x 0.60" x 0.138" (15.24 x 15.24 x 3.50 mm)

**WSN** 1.75" x 1.25" x 0.22" (44.45 x 31.75 x 5.99 mm)

**ZSN** 2.75" x 1.96" x 0.62" (69.85 x 49.78 x 15.75 mm)

| Model Package Style | Freq. Min. (MHz) | Freq. Max (MHz) | Ref. Freq. (MHz) | Step Size (kHz) | VCC PLL (V) | VCC VCO (V) | Output Power (dBm) Typ. | Harmonics (-dBc) Typ. | Reference Spurious (-dBc) Typ. | Comparison Spurious (-dBc) Typ. | Phase Noise 100 Hz (-dBc/Hz) Typ. | Phase Noise 1 K (-dBc/Hz) Typ. | Phase Noise 10 K (-dBc/Hz) Typ. | Phase Noise 100 K (-dBc/Hz) Typ. | Settling Time (mSec) Typ. | Case Style | Application |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fixed Frequency Synthesizers (with internal microcontroller)** | | | | | | | | | | | | | | | | | |
| KSN | 144 | 144 | 52 | N/A | 3 | 5 | 3 | 25 | 95 | 90 | 95 | 105 | 106 | 134 | 100 | 99-01-1251 | WIMAX 2.5 GHz |
| KSN | 675 | 675 | 27 | N/A | 3 | 5 | 3 | 20 | 85 | 85 | 97 | 92 | 110 | 134 | 30 | DK1042 | BROADBAND ACCESS |
| KSN | 768 | 768 | 52 | N/A | 3 | 5 | 6 | 25 | 85 | 90 | 75 | 96 | 103 | 129 | 35 | 99-01-1251 | WIMAX 3.5 GHz |
| KSN | 1024 | 1024 | 10.24 | N/A | 5 | 5 | 0 | 27 | 95 | 78.5 | 74 | 78 | 104 | 131 | 10 | DK1042 | CATV |
| ZSN * | 4950 | 4950 | 26 | N/A | 15 | 15 | -3 | 35 | 102 | 86 | 60 | 80 | 84 | 112 | 27 | 99-01-1336 | MILITARY |
| **Tunable Narrow Band Synthesizers (center frequency ±10% or less)** | | | | | | | | | | | | | | | | | |
| KSN | 620 | 660 | 30 | 20 | 3.3 | 5 | -0.5 | 40 | 90 | 75 | 70 | 74 | 106 | 129 | 15 | DK801 | CDMA |
| KSN | 900 | 960 | 8 | 100 | 5 | 5 | 3 | 20 | 85 | 85 | 82 | 75 | 100 | 125 | 5 | DK1042 | RFID READER |
| KSN | 1150 | 1160 | 20 | 250 | 5 | 5 | 2 | 30 | 100 | 80 | 86 | 81 | 104 | 130 | 5 | DK801 | CATV |
| KSN | 1850 | 1970 | 76.8 | 1280 | 5 | 5 | 5 | 50 | 95 | 95 | 88 | 86 | 95 | 125 | 10 | DK1042 | TD-SCDMA |
| KSN | 2110 | 2170 | 10 | 200 | 5 | 5 | 2 | 35 | 100 | 90 | 67 | 81 | 108 | 129 | 10 | DK801 | W-CDMA |
| KSN | 2110 | 2170 | 4.8 | 200 | 5 | 5 | 5 | 45 | 100 | 90 | 62 | 75 | 106 | 126 | 30 | DK801 | UMTS 2.5 |
| KSN | 2090 | 2190 | 12.8 | 100 | 5 | 5 | 1 | 40 | 105 | 95 | 68 | 73 | 104 | 124 | 5 | DK801 | UMTS |
| KSN | 2027 | 2222 | 52 | 125 | 3 | 5 | 4 | 25 | 90 | 95 | 77 | 87 | 104 | 129 | 20 | 99-01-1251 | WIMAX 2.5 GHz |
| KSN | 2045 | 2310 | 14.4 | 50 | 5 | 5 | 6 | 25 | 100 | 80 | 50 | 69 | 94 | 115 | 15 | DK801 | REPEATER |
| SSN | 2495 | 2690 | 52 | 250 | 3 | 5 | 3 | 30 | 80 | 95 | 77 | 88 | 95 | 123 | 25 | 99-01-1367 | WIMAX 2.5 GHz |
| DSN | 2300 | 2700 | 10 | 250 | 12.5 | 5 | 5 | 25 | 95 | 90 | 56 | 67 | 97 | 119 | 25 | 99-01-942 | POINT TO MULTIPOINT |
| ZSN * | 2536 | 2736 | 26 | 200 | 12 | 12 | 9.5 | 27 | 87 | 80 | 70 | 89 | 94 | 123 | 27 | 99-01-1336 | MILITARY |
| SSN | 2932 | 3132 | 52 | 250 | 3 | 5 | 3 | 20 | 80 | 80 | 82 | 88 | 95 | 118 | 10 | 99-01-1367 | WIMAX 3.5 GHz |
| **Tunable Medium Band Synthesizers (center frequency ±10% to ±30%)** | | | | | | | | | | | | | | | | | |
| DSN | 1100 | 1500 | 10 | 500 | 12 | 5 | 5 | 20 | 115 | 100 | 61 | 72 | 98 | 122 | 5 | 99-01-942 | POINT TO MULTIPOINT |
| DSN | 1200 | 2200 | 20 | 10000 | 22 | 10 | 9 | 20 | 75 | 75 | 84 | 97 | 99 | 106 | 0.5 | 99-01-1294 | CABLE TV |
| DSN | 1690 | 2310 | 10 | 250 | 12 | 5 | 5 | 25 | 100 | 95 | 58 | 68 | 97 | 121 | 10 | 99-01-942 | POINT TO MULTIPOINT |
| DSN | 1788 | 3019 | 10 | 100 | 15 | 5 | 2 | 11 | 85 | 75 | 51 | 60 | 81 | 106 | 20 | 99-01-942 | RECEIVER |
| DSN | 2700 | 3500 | 10 | 1000 | 16 | 5 | 3.5 | 25 | 92 | 85 | 83 | 84 | 85 | 105 | 0.22 | 99-01-1294 | VSAT |
| **Tunable Wide Band Synthesizers (center frequency ±30% to ±50%)** | | | | | | | | | | | | | | | | | |
| DSN | 900 | 2000 | 10 | 250 | 19 | 10 | -2 | 20 | 100 | 80 | 80 | 84 | 80 | 107 | 3 | 99-01-1294 | SATELLITE |
| **Tunable Very Wide Band Synthesizers (up to 6 octave)** | | | | | | | | | | | | | | | | | |
| WSN | 700<br>1110<br>2220 | 1110<br>2220<br>4000 | 20<br>20<br>20 | 10000<br>10000<br>10000 | 22<br>22<br>22 | 10<br>10<br>10 | 8<br>8<br>8 | 30<br>30<br>30 | 98<br>98<br>94 | 80<br>75<br>91 | 93<br>89<br>84 | 105<br>101<br>96 | 107<br>102<br>97 | 105<br>100<br>94 | 0.015<br>0.015<br>0.015 | 99-01-1368 | MILITARY |
| **Tunable Fast Settling Time Synthesizers (less than 30 micro Sec)** | | | | | | | | | | | | | | | | | |
| RSN | 714 | 749 | 52 | 200 | 3.3 | 5.5 | 4 | 25 | 100 | 90 | 95 | 100 | 104 | 106 | 0.025 | 99-01-1228 | GSM 850 |
| RSN | 760.6 | 795.4 | 52 | 200 | 3.3 | 5.5 | 5 | 25 | 90 | 65 | 92 | 102 | 104 | 105 | 0.025 | 99-01-1228 | GSM 900 |
| RSN | 1543 | 1618 | 52 | 200 | 3.3 | 5.5 | 4.5 | 25 | 85 | 61 | 88 | 94 | 98 | 106 | 0.025 | 99-01-1228 | GSM 1800 |
| **Dual Band Frequency Synthesizers** | | | | | | | | | | | | | | | | | |
| SSND | 600<br>1390 | 600<br>1390 | 10<br>10 | 2000<br>2000 | 2.5<br>2.5 | 3<br>3 | -10<br>3 | 24<br>29 | 85<br>76 | 91<br>91 | 89<br>84 | 96<br>91 | 95<br>90 | 122<br>122 | -<br>- | 99-01-1373 | GPS |
| SSND | 1000<br>1440 | 1000<br>1440 | 10<br>10 | 2000<br>2000 | 2.5<br>2.5 | 3<br>3 | -9.7<br>3 | 31<br>31 | 77<br>102 | 96<br>97 | 85<br>82 | 92<br>89 | 90<br>89 | 119<br>119 | -<br>- | 99-01-1373 | GPS |

* Available with & without external reference.

See our web site for RoHS Compliance methodologies and qualifications.

*RoHS compliant in accordance with EU Directive (2002/95/EC)*

# ACHIEVING THE HIGHEST SYNTHESIZER QUALITY

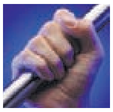
***Frequency Synthesizers from Mini-Circuits*** *are manufactured to the industry's most demanding quality standards, with a relentless commitment to providing our customers with the highest-quality products in the industry. Achieving quality for any electronic product requires adhering to proven standards, and Mini-Circuits has qualified its manufacturing practices to three of the most recognized quality standards in the industry: ISO 9001:2000, ISO 14001:2004, and aerospace standard AS 9100B.*

*But at Mini-Circuits, quality manufacturing practices alone are not enough-quality must start at the design stage. To create your custom frequency synthesizer, Mini-Circuits synthesizer design team draws upon years of engineering experience, reinforced by skillful use of the latest computer-aided-engineering ( CAE ) software design tools, such as the Advanced Design System (ADS) suite of simulation and analysis software from Agilent Technologies. Such software tools allow Mini-Circuits engineering team to evaluate different design approaches to find the right strategy for your requirements.*

*To maintain tight quality control in manufacturing, process controls meet the requirements of the above-mentioned quality standards. Components are purchased from a short list of suppliers with parts known for proven, long-term reliability and lot-to-lot performance repeatability. Once a model design is fixed, components from the specified manufacturer cannot be substituted with a different vendor. In addition, semiconductor devices must be supplied from the same wafer foundry. The goal of such attention to detail is to ensure that the performance and quality of the first synthesizer delivered to you precisely matches that of the last synthesizer you receive, with every synthesizer in your order meeting or exceeding your expectations.*

*Mini-Circuits takes exceptional measures to ensure the highest quality and performance levels in its frequency synthesizers. For example, components are epoxied in place on each circuit board to restrict movement during vibration, virtually eliminating microphonics and phase hits during synthesizer operation. Components are assembled to circuit boards by means of computer-controlled automated assembly systems, in order to ensure minimal manufacturing variations and consequently high unit-to-unit repeatability.*

*To verify quality, each production unit must pass 100% visual inspection, including x-ray analysis of solder joints of leadless chips. Electrically, each unit must also pass a rigorous series of RF tests, with 44 performance parameters typically evaluated during production testing. Mechanically, frequency synthesizers in surface-mount packages are checked for coplanarity within 4 mils (0.1 mm) to ensure our customers will have trouble-free mounting and soldering of these synthesizers in their applications. In addition, they must pass mechanical solder joint testing, shear testing, and visual inspection per IPC-A-610 criteria. Finally, they are subjected to electrostatic-discharge (ESD) sensitivity testing according to the ANSI ESD S5.1 and ANSI ESD S5.2 standards.*



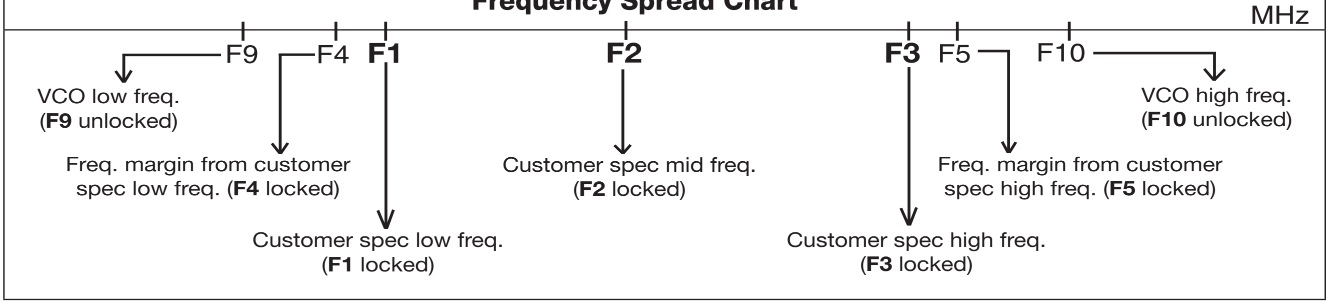
*Mini-Circuits...*
*the industry's trusted name*
*for quality and reliability.*

## 44 Synthesizer Parameters Tested In Production

### Test Descriptions

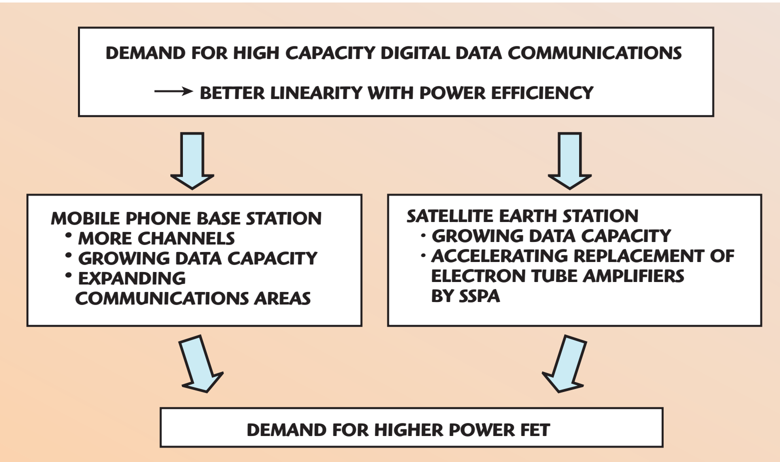
| | |
|---|---|
| 1 | Power Out (locked at Freq F4) |
| 2 | Power Out (locked at Freq F1) |
| 3 | VCO Current (at Freq F1) |
| 4 | PLL Current (at Freq F1) |
| 5 | Phase Noise (at Freq F1, @ 1 kHz offset) |
| 6 | Phase Noise (at Freq F1, @ 10 kHz offset) |
| 7 | Phase Noise (at Freq F1, @ 100 kHz offset) |
| 8 | F2 Harmonic Suppression (at Freq F1) |
| 9 | Comparison Spurious (at Freq F1 ± Comp Freq) |
| 10 | Comparison Spurious (at Freq F1 ± 2Comp Freq) |
| 11 | Comparison Spurious (at Freq F1 ± 5Comp Freq) |
| 12 | Reference Spurious (at Freq F1 ± Ref Freq) |
| 13 | Power Out (locked at Freq F2) |
| 14 | Comparison Spurious (at Freq F2 ± Comp Freq) |
| 15 | Comparison Spurious (at Freq F2 ± 2Comp Freq) |
| 16 | Comparison Spurious (at Freq F2 ± 5Comp Freq) |
| 17 | Reference Spurious (at Freq F2 ± Ref Freq) |
| 18 | Power Out (locked at Freq F3) |
| 19 | VCO Current (locked at Freq F3) |
| 20 | PLL Current (at Freq F3) |
| 21 | Phase Noise (at Freq F3, @ 1 kHz offset) |
| 22 | Phase Noise (at Freq F3, @ 10 kHz offset) |
| 23 | Phase Noise (at Freq F3, @ 100 kHz offset) |
| 24 | F2 Harmonic Suppression (at Freq F3) |
| 25 | Comparison Spurious (at Freq F3 ± Comp Freq) |
| 26 | Comparison Spurious (at Freq F3 ± 2Comp Freq) |
| 27 | Comparison Spurious (at Freq F3 ± 5Comp Freq) |
| 28 | Reference Spurious (at Freq F3 ± Ref Freq) |
| 29 | Power Out (locked at Freq F5) |
| 30 | LOCK Detect (PLL Lock at Freq F4) |
| 31 | LOCK Detect (PLL Lock at Freq F1) |
| 32 | LOCK Detect (PLL Lock at Freq F2) |
| 33 | LOCK Detect (PLL Lock at Freq F3) |
| 34 | LOCK Detect (PLL Lock at Freq F5) |
| 35 | LOCK Detect (PLL Unlock at Freq F9) |
| 36 | PLL Current (PLL Unlock at Freq F9) |
| 37 | LOCK Detect (PLL Unlock at Freq F10) |
| 38 | PLL Current (PLL Unlock at Freq F10) |
| 39 | Frequency Margin Minimum (PLL Lock relative to Freq F1) |
| 40 | Frequency Margin Maximum (PLL Lock relative to Freq F3) |
| 41 | Power at Minimum Frequency (Unlock at Freq F9) |
| 42 | Power at Maximum Frequency (Unlock at Freq F10) |
| 43 | Minimum Frequency (Unlock at Freq F9) |
| 44 | Maximum Frequency (Unlock at Freq F10) |

### Frequency Spread Chart



# DEVELOPMENT REPORT OF POWER FETS FOR SOLID-STATE POWER AMPLIFIERS FROM GAAS TO GAN

Major advances in microwave device development in recent years have enabled a transition to solid-state power amplifiers (SSPA) for wireless communications and radar systems in microwave to millimeter-wave bands. In particular, SSPAs are rapidly replacing electronic tube amplifiers, such as magnetron and traveling-wave tube-based amplifiers (TWTA), for base stations of mobile phones using L- and S-band, and for satellite communications and base stations for terrestrial communications at C- to Ku-band frequencies.



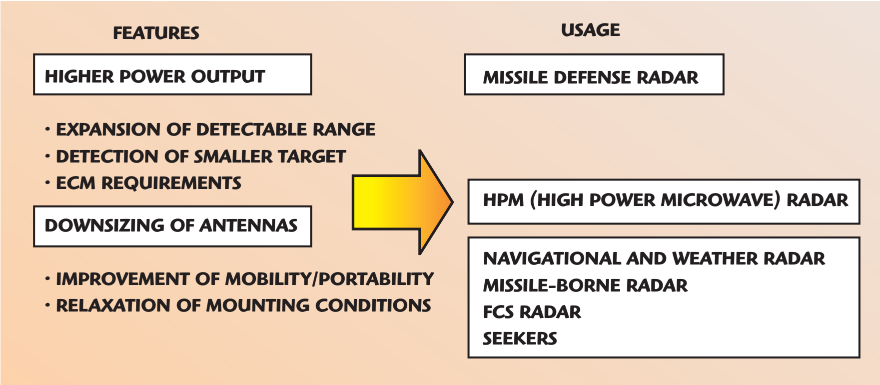

▲ *Fig. 1 Demand for higher power FETs for communication equipment.*

The advantages of SSPA include: 1) the ability to reduce size and weight of devices including the power supply; 2) the ability to reduce spurious signals; and 3) longer-life than electronic tubes (even though technology advances have recently extended the life of tube-based amplifiers). With the spread of multi-carrier modulation and growing requirements for high capacity digital data communications, there has been strong demand for higher power amplifiers, as well as lower distortion for communications applications (see ***Figure 1***).

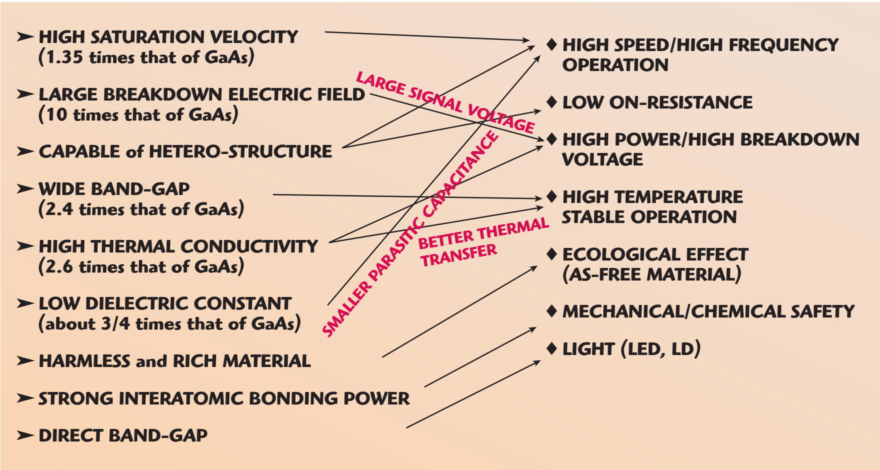
Higher power amplifiers are in demand for radar systems as well, to expand the detectable range, improve detection of smaller targets and meet electronic countermeasure (ECM) requirements. Moreover, downsizing of power amplifiers has been expected yearly for both communications and radar systems applications to improve mobility and portability, and to relax installation and mounting conditions (see ***Figure 2***).

To address these trends and continue to expand communications applications for SSPAs, further advances are needed to take advantage

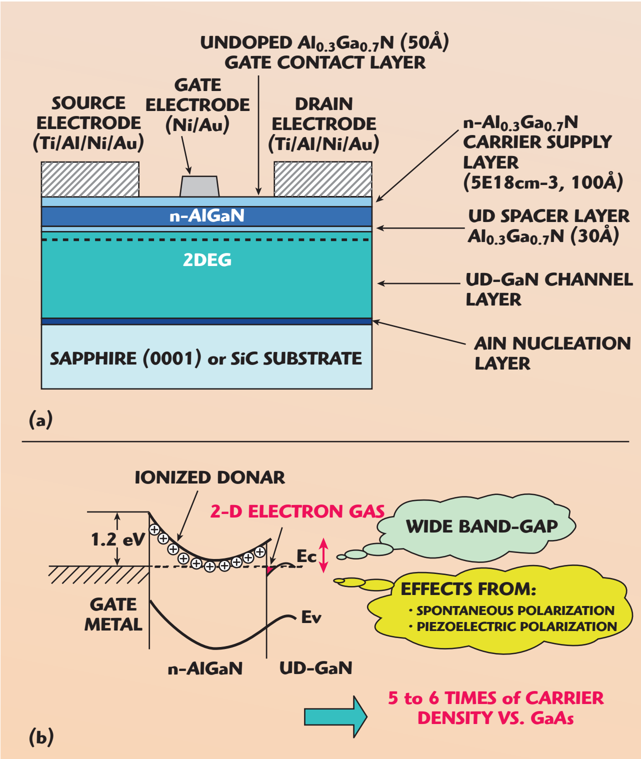
HOMAYOUN GHANI
*Toshiba America Electronic Components Inc.*
*Irvine, CA*




▲ *Fig. 2 Demand for higher power in radar applications.*




▲ *Fig. 3 Features of GaN material.*




▲ *Fig. 4 Example of a GaN HEMT structure (a) and a band structure model (b).*

of GaN's merits to downsize the equipment and obtain higher output power. This article summarizes the development status of GaN devices, which are expected to further expand SSPA applications in microwave and millimeter-wave bands, due to the outstanding GaN material characteristics.

## WHY GaN?

Until now, GaAs FETs have typically been used for microwave high power amplifiers. As an example, Toshiba Corp. has commercialized C-band 90 W GaAs FET and X-/Ku-band 30 W GaAs FET technology. However, after 30 years of development, the output power of GaAs FET technology is now reaching its physical limits. Practical manufacturing of much higher power FETs than those currently available is facing significant technical difficulties.

Wide Band Gap (WBG) semiconductors have recently been noted as potential alternatives to GaAs devices. Making use of a large band-gap material enables high power operation with high breakdown voltage. As one WBG solution, GaN has those characteristics and features several other benefits: 1) creation of a HEMT (high electron mobility transistor) structure is relatively easy; 2) its electron saturation velocity is high and capable of high frequency operation; 3) among the WBG alternatives, GaN is easier to work with; and 4) it can share production processes with GaAs. As a result of these characteristics, GaN is a prime candidate for the next-generation of higher power devices. ***Table 1*** and ***Figure 3*** show the GaN material constants and features, and compare them to other major semiconductor materials.

Due to a process similar to the GaAs devices shown in items 1) and 3) above, the realization of the HEMT structure shown in ***Figure 4*** is a big advantage for GaN, compared to other potential WBG alternate materials from a practical application standpoint. Compared to GaAs HEMT, GaN has a wider bandgap, and also has a higher 2D electron density that is capable of larger current output as a result of spontaneous polarization/piezoelectric polarization effects.

The features of GaN in an electronic device include:

- Wide bandgap = High breakdown voltage
- Piezoelectric effect = High electron density → capable of higher power output
- High saturation velocity = Faster and higher-frequency operation
- High thermal conductivity (2.6 times of GaAs) = Capable of higher power output
- Strong inter-atomic bonding power = Stable mechanically and chemically
- High frequency, high power amplifier from L-band to millimeter-waves
- Withstands high temperature, high radiation = Environmentally-resistant devices

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
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| AM-1431 | 0.001-1000 | 38 | 42 | 1.00 | 1.2 | 1.4 | 1.7 | 10 | 10 | 9 | 2.0:1 | 75 |
| AM-1309 | 0.001-1000 | 50 | 54 | 1.00 | 1.2 | 1.4 | 1.7 | 10 | 10 | 9 | 2.0:1 | 90 |
| AM-1616-3000 | 0.01-3000 | 20 | 21 | 2.00 | 3.2 | 3.5 | 4.3 | 14 | 11 | 7 | 2.0:1 | 60 |
| AM-1607-3000 | 0.01-3000 | 40 | 42 | 2.00 | 3.0 | 3.5 | 4.6 | 13 | 12 | 7 | 2.0:1 | 100 |

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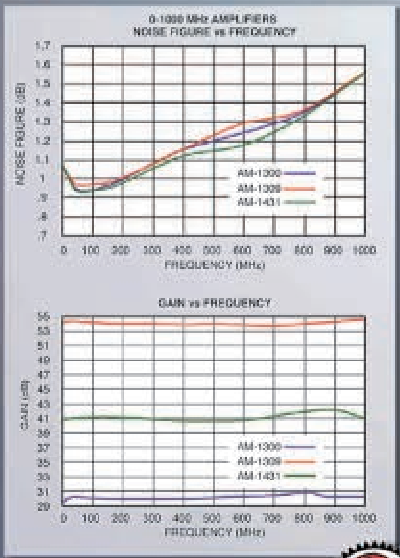
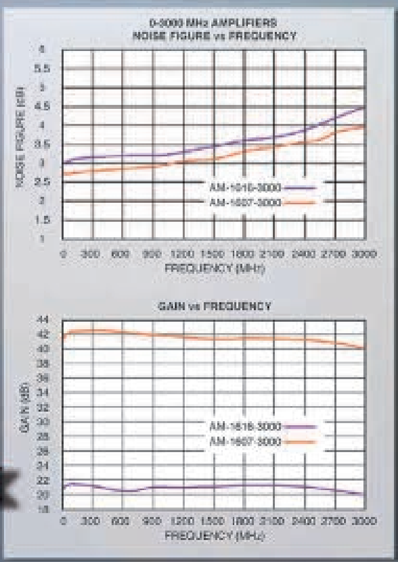



Most low frequency amplifiers are internally regulated to +12V and require a minimum +15V. All are reverse voltage protected and may be used up to +30V. Some models can be modified to operate off a +12V supply with some reduced low frequency performance. Please contact MITEQ with your specific requirements.

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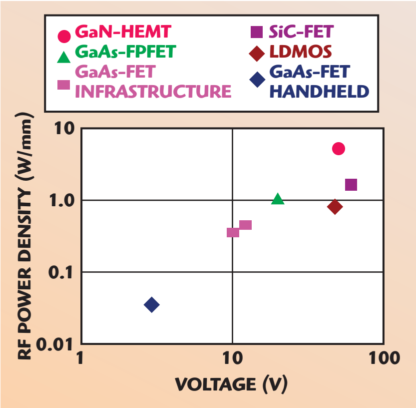



Fig. 5 RF power density for high frequency semiconductors.

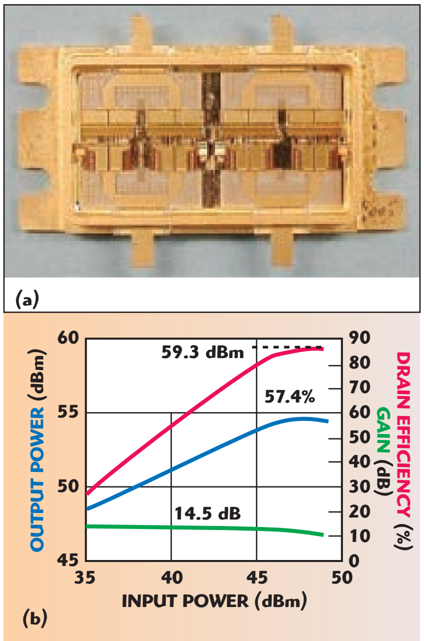



Fig. 6 800 W S-band GaN HEMT from Eudyna.[1]

- Low-loss power devices

Comparison data of the output power per gate width in transistor units between existing Si-/GaAs- and GaN HEMT can be seen in ***Figure 5***, which indicates GaN's capability for high power output.

## PROGRESS IN GaN DEVICE DEVELOPMENT

Research and development on GaN devices began in the mid-1990s. In 2006, 200 W-class devices in the L-/S-band for mobile phone base stations were produced; in 2009, 50 W-class devices in X-band for satellite communications base station and radar use were commercially available. The released research and development reports are summarized here.

**TABLE I**

**SEMICONDUCTORS' SOLID-STATE PROPERTIES AND PERFORMANCE MATRIX**

| Material | GaN | 4H-SiC | 6H-SiC | GaAs | Si |
|---|---|---|---|---|---|
| Lattice constant (Å) | a 3.189<br>c 5.185 | a 3.073<br>c 10.053 | a 3.08<br>c 15.12 | 5.6533 | 5.4301 |
| Forbidden band (eV) | 3.39 | 3.26 | 3 | 1.43 | 1.12 |
| Electron mobility (μ) | 900<br>2DEG 2000 | ⊥ 850<br>// 1020 | ⊥ 400<br>// 80 | 8500 | 1400 |
| Hole mobility | 150 | 115 | 90 | 400 | 600 |
| Breakdown electrical field Ec | 3.3 E+06 | 2.2E+06 | 2.5E+06 | 4.0E+05 | 3.0E+05 |
| Thermal conductivity (λ) (W/cmK) | 1.3~2 | 4.9 | 4.9 | 0.5 | 1.5 |
| Saturation velocity $v_{sat}$ | 2~2.7E+07 | 2.2E+07 | 1.9E+07 | 1.3E+07 | 1.0E+07 |
| Dielectric constant | 9 | 9.7 | 10 | 12.8 | 11.8 |
| Bulk growth | ×→△ | △→○ | △→○ | ◎ | ◎ |
| Epitaxial growth | △→○<br>SAP, SiC, Si | △→○ | △→○ | ◎ | ◎ |
| BM (vs. Si) | 653 | 340 | 191 | 16 | 1 |
| BHFM (vs. Si) | 78 | 50 | 25 | 11 | 1 |
| Device target | Blue photonic device/High-frequency device/Power device | Power device | Power device | High-frequency device | Main material semi-conductor industry |

BM: Baliga's figure of merit for low-frequency= $\varepsilon\mu Ec^3$
BMFM: Baliga's figure of merit for high-frequency=$\mu Ec^2$
⊥: Perpendicular to crystal plane, //: Parallel to crystal plane

×=poor △=acceptable ○=good ◎=excellent

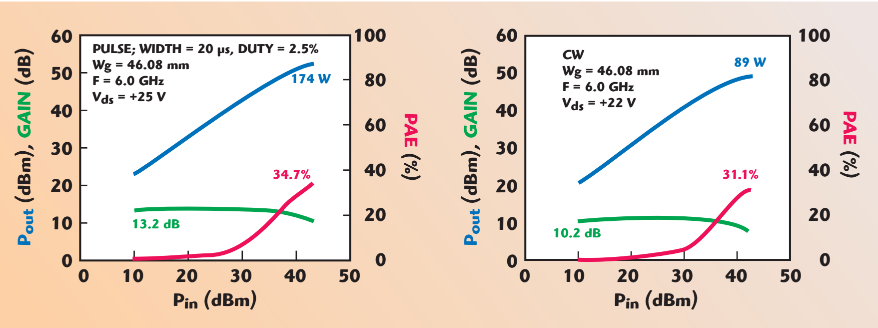


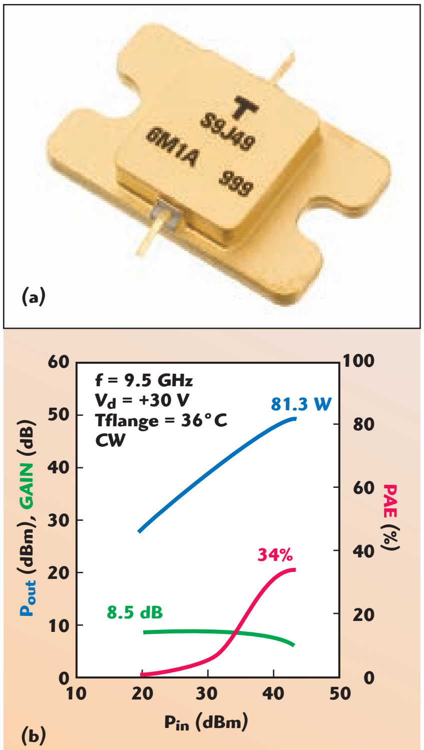

Fig. 7 C-band GaN HEMT from Toshiba.

### L-/S-band (0.5 to 4 GHz)

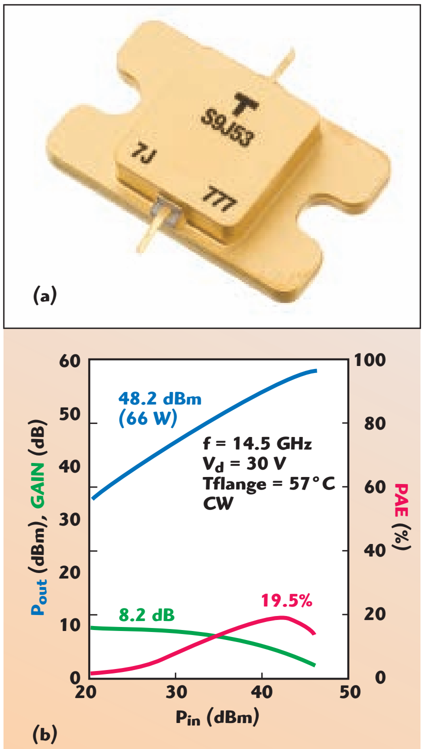
This frequency band is used primarily for mobile phones, WiMAX or airport surveillance radar. The gain achieved to date with GaN devices is suitable in this band, and some manufacturers have reported output power of over 200 W in pulse-mode operation. ***Figure 6*** shows the photograph and $P_{in}/P_{out}$ characteristics[1] of an S-band, 800 W-class GaN HEMT released from Eudyna Device Co. Ltd. An output power of 851 W and a drain efficiency of 57.4 percent were reported at 2.9 GHz, with a 200 μs pulse width, a 10 percent duty cycle and 65 V drain-source voltage (Vds) supply.

### C-band (4 to 8 GHz)

Satellite communications, FWA, Wireless LAN, weather radar, etc.,




▲ *Fig. 8 50 W X-band GaN HEMT: (a) photograph and (b) RF performance.*




▲ *Fig. 9 Ku-band 50 W AlGaN/GaN HEMT: (a) photograph and (b) RF performance.*

are widely used in this frequency band. There has been great interest in replacing electron tube amplifiers with SSPA in these applications. Recently, over 200 W devices in pulse-mode operation have been reported as the result of process and quality improvement of GaN crystals. ***Figure 7*** shows an example of characteristics released in 2005 by Toshiba Corp.: 174 W output power and PAE of 34.7 percent (approximately 43 percent of drain efficiency) were obtained at 6 GHz, with a 20 µs pulse width, 2.5 percent duty cycle, and a Vds = 25 V supply.[2] At present, Toshiba has successfully obtained 200 W at 6 GHz by improving the crystal material and process. In addition, a 220 W device, with approximately a 38 percent PAE at C-band with a 20 µs pulse width, a 10 percent duty cycle and a 60 V Vds supply, was also reported by Mitsubishi Electric Co. Ltd. in 2006.[3]

### X-band (8 to 12 GHz)

This frequency band is used for satellite communications, earth observation satellites and various radar systems. As the frequency increases, it becomes more difficult to obtain higher gain. To solve this challenge requires refinement of the device structure. Although GaN has a higher breakdown electric field as a material, refinement of the device itself, such as the electrodes, increases the electrical field of its components. As a result, it is more difficult to obtain high power output with more than 50 V of operating voltage than has been possible with devices at C- and lower bands. That is one of the reasons that practical devices operating above 10 GHz have been rarely reported so far.

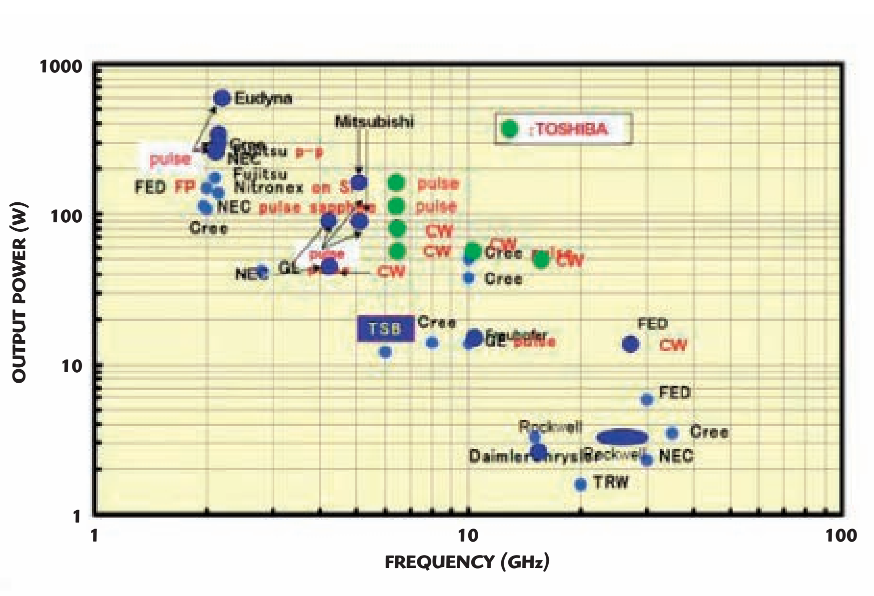
***Figure 8*** shows a photograph and the characteristics of an X-band GaN HEMT that Toshiba developed in 2006.[4,5] Toshiba achieved 81.3 W output power in continuous wave (CW) operation and a PAE of 34 percent at 9.5 GHz, with a Vds = 30 V supply. X-band power GaN HEMTs in the 50 W-class have also been produced and shipped in the market for over a year.

### Ku-band (12 to 18 GHz)

This frequency band is used for satellite communications, satellite television and related applications. However, continued growth of data capacity in recent years is expected

to shift additional communications to Ku-band. C-band had also been used for satellite communications with the benefit of lower rain-fading factor in many tropical countries. However, the use of Ku-band satellite communications in those countries has been increasing, despite the drawback of rain-fading. The availability of portable VSAT terminals at Ku-band with small antennas drives this trend.

Refining device structures at Ku-band is harder than it is for the lower X-band frequency. Additionally, some problems have been encountered with heat radiation and in maintaining the breakdown voltage and high-frequency characteristics. Moreover, depending on the device package size, the wavelength becomes nearly equal to the cavity resonance, or the wavelength passing through the package. The cavity resonance frequency must be maintained at a higher level than the operating frequency of the device. Therefore, the size of the package, especially its width, is severely restricted and the technical requirements to obtain higher power become more challenging. Due to such restrictions, GaAs devices are thought to have an output power limit of approximately 30 W. In contrast, GaN has the capability to achieve power output three to five times that of GaAs devices, even under various restrictions, as a result of its material characteristics. ***Figure 9*** shows a photograph of a Ku-band GaN HEMT and its characteristics.[6,7] It employs the same package as the X-band GaN HEMT (21.0 x 12.9 mm) and has two GaN HEMT chips mounted inside. The device obtained 65 W output power in CW operation and a PAE of 19.5 percent at 14.5 GHz, with a Vds = 30 V supply.




▲ *Fig. 10 Development status of GaN HEMTs.*



### Above K-band (18 to 26 GHz)

This frequency band is for the next-generation satellite communications, to deal with larger data capacity. As mentioned previously, the technical challenge is much higher at high frequencies than at lower bands and no practical devices have yet appeared. Ongoing R&D to address these challenges is centered at various research institutions throughout the world. A report that an output power of 20 W was achieved at 26 GHz was issued from the Research & Development Association for Future Electron Devices.[8] This has raised the industry's expectations for practical devices in the near future.

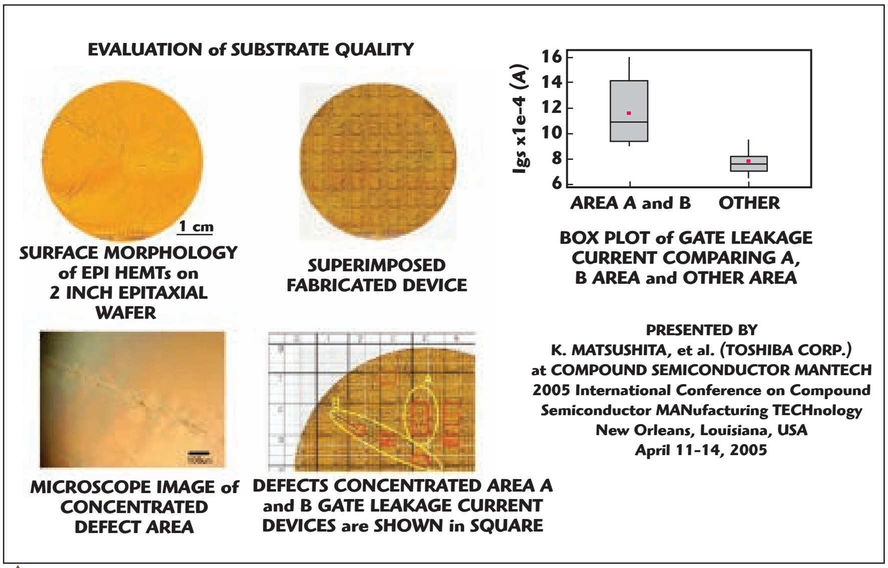
### Benchmark

***Figure 10*** indicates the development status of cutting-edge GaN HEMT high power devices, based on the released data found. From this summary, it is known that 100 W-class devices up to Ku-band are already commercially available.

## RELIABILITY AND FUTURE ISSUES

### Current Reliability

Improvements in crystal substrate quality and progress in developing process techniques have made GaN devices more reliable in recent years. As a result, practical devices have now been brought to market. Recently a device that can operate for 100 years or more at 200°C channel temperature has been reported[9] and ongoing testing is confirming the reliability of GaN devices. Research into factors concerning device lifetime is ongoing on material and device structures, and correlation between manufacturing process and long life is also being confirmed.[10] GaN has not yet been widely employed in many practical uses as a semiconductor device, and some unexpected failure modes may occur that have not yet been anticipated. However, the lifetimes estimated by accelerated testing during manufacturing have now reached an acceptable level.




▲ *Fig. 11 Surface defects on GaN HEMT wafer and their effects on device characteristics.*



## FUTURE ISSUES

### Quality and Price of Crystal Substrate

As mentioned earlier, the crystal substrate for GaN devices has been improved significantly over the past several years. However, it still requires further refinement, and there is much room to improve the substrate to levels comparable to that of Si and GaAs. The characteristics of GaN/SiC HEMT structures fabricated by an epitaxial growing method can be easily influenced by the crystal quality of GaN or AlGaN layers growing on SiC. Surface defects, which can be observed with a microscope, have been shown to influence device characteristics and reliability,[11] but have not been completely eliminated so far. Established techniques to grow defect-free crystals will be required as soon as possible to achieve improvements of GaN device characteristics and a corresponding reduction in price.

***Figure 11*** shows the relationship between surface defects on the wafer and their influence on the device characteristics.[11] As shown in the photograph at the left lower part of the figure, some defects were observed by microscope on the surface of the wafer, and the devices composed on them apparently show differences in electrical characteristics from those on a defect-free part, referring to the graph in the right upper portion of the figure.

### Current Collapse

Current collapse is a unique phenomenon of GaN-based devices, in which the drain current starts to decrease beyond a certain relatively higher drain voltage with a certain fixed gate voltage. This effect has also been seen on GaN HEMTs fabricated on defect-free parts of the wafer (see

***Figure 12***). Although the mechanism of the current collapse has not been thoroughly clarified, researchers have determined that current collapse is related to defect levels at the boundary between the GaN and SiC in a GaN/SiC structure, on the surface of the GaN crystal near the gate electrode, or on the boundary between GaN and the topcoat. For the products now on the market, current collapse has been suppressed to a level suitable for practical use. If it can be suppressed completely, the characteristics and reliability of the device will be improved even more. Research is ongoing at many companies and universities, in an effort to solve this problem associated with GaN devices.

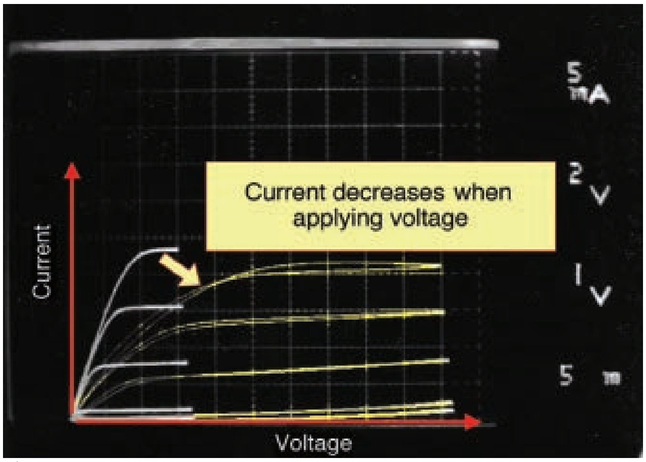



*Fig. 12 Example of current collapse.*

### Measures for Heat Radiation

Development of high power GaN HEMTs has progressed rapidly, taking advantage of GaN's material characteristics. The power added efficiency (PAE) levels of GaN HEMTs are estimated as approximately the same as GaAs devices. As a result, the power density and output power are higher than GaAs devices, which make the heat density higher as well. Consequently, increasing the PAE of the chip itself and developing techniques to effectively cool the device will be needed to achieve the full power of GaN HEMTs.

***Figure 13*** compares the heat density of the existing commercial devices and equipment. If the potential of the GaN devices is increased to the highest level possible with current techniques, the heat density may exceed that of a Pentium4® processor. To maximize the GaN's potential, every measure to effectively cool the device should be considered.

## FORECAST AND EXAMPLES OF SSPA APPLICATIONS

### Forecast

As mentioned throughout the preceding descriptions, the market seems to be cautious to employ GaN HEMT, due to its unknown technical aspects, in spite of high expectations for the eventual development of higher power devices. More specifically, the high potential of GaN to achieve 10 times the power output of GaAs devices will also cause 10 times the heat. This will require special techniques to deal with the thermal issues. However, the degree to which this is a problem depends on the application. For example, the issue of heat dissipation is not as important in radar use because of its pulse operation.

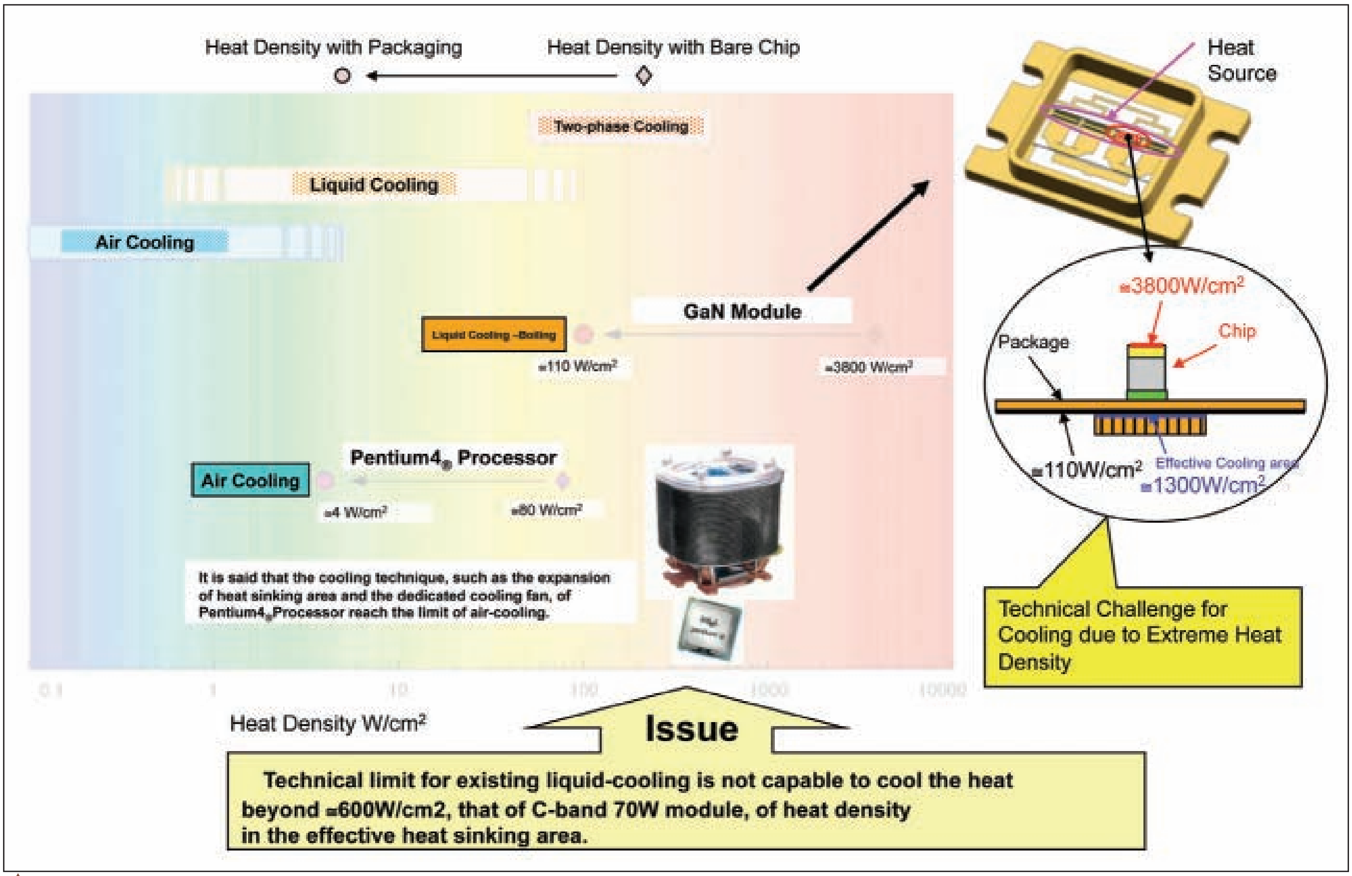



*Fig. 13 Heat density of the devices and equipment.*

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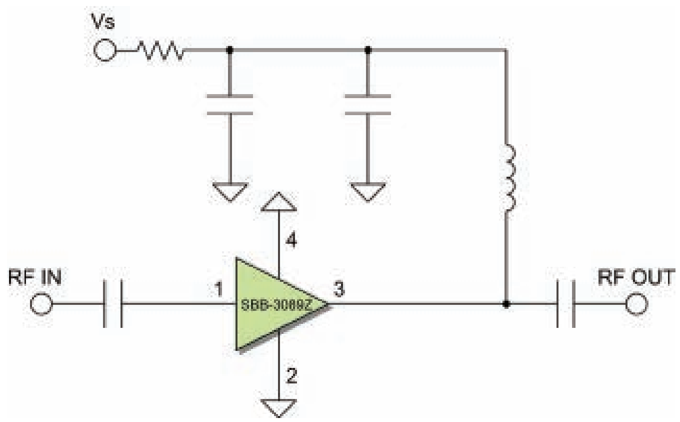
|---|---|---|---|---|---|---|---|
| SBB-1089Z | 50-850 MHz | 15 dB [1] | 90 mA | 3.1 dB | 43 dBm [2] | 19 dBm | 5 |
| SBB-2089Z | 50-850 MHz | 20 dB [1] | 90 mA | 2.6 dB | 42 dBm [2] | 20 dBm | 5 |
| SBB-3089Z | 50-6000 MHz | 16.5 dB | 40 mA | 3.8 dB [3] | 28 dBm | 15 dBm | 5 |
| SBB-4089Z | 50-6000 MHz | 15 dB [1] | 80 mA | 4.6 dB | 35 dBm | 19 dBm | 5 |
| SBB-5089Z | 50-6000 MHz | 20.5 dB [1] | 75 mA | 4.2 dB | 35 dBm | 20.5 dBm | 5 |

1 - at 850 MHz; 2 - at 240 MHz; 3 - at 2200 MHz

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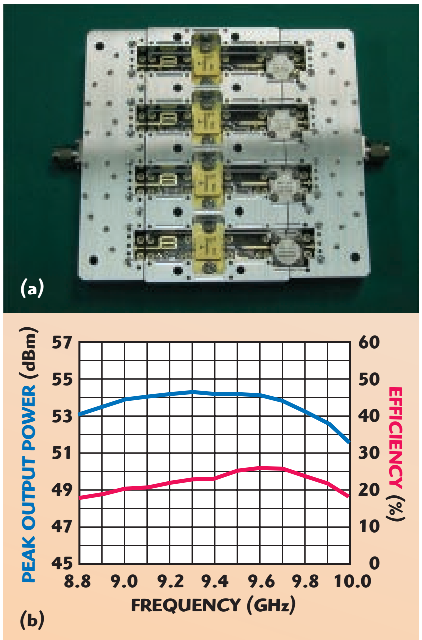


▲ *Fig. 14 X-band 250 W GaN high power amplifier: (a) photograph and (b) RF performance.*


SPECIFICATIONS of GaN TRANSMITTER

| | |
|---|---|
| FREQUENCY | X-BAND (500 MHz BW) |
| OUTPUT POWER | ≥166 W |
| NF | ≤5 dB |
| SUPPLY VOLTAGE | DC 48 V |
| SIZE | 214 × 450 × 153 mm |

▲ *Fig. 15 Weather radar with GaN SSPA transmitter.*

Eudyna Devices Inc. released the kW-class palette amplifier at S-band last year.[12] It outputs 1000 W at 3.2 GHz with an 80 Vds supply, 200 μs pulse width and 10 percent duty cycle, with a drain efficiency of 49.5 percent. This indicates that the heat challenges of GaN can be worked through at a high level in pulse operation.

As mentioned in the Ku-band section, the package size has restriction in applications above X-band because of cavity resonance. This is also the reason why the technical limit of GaAs devices on Ku-band is currently said to be 30 W. Yet, this package seems to have capability for up to twice the heat density of GaAs, even with ordinary cooling methods. Therefore, it can be said that a 60 W GaN device in CW operation at X-/Ku-band is realizable, by designing it to achieve twice the power density of GaAs. At this level of power output, the heat problem is manageable.

## Radar Applications

SSPA have gathered high expectations as potential replacements for radar transmitters using magnetron and klystron tubes because of their increased reliability. This has become even more important because of limited availability of the electronic tubes. Using GaAs, replacement of electronic tubes by SSPA has been ongoing for transmitters at microwave frequencies (up to C-band), but it has not been practical with GaAs to achieve high power SSPA above C-band. However, GaN devices are now becoming available for pulse-operated applications that take advantage of the new material's potential. ***Figure 14*** shows a photograph and an example of the characteristics[13] of the high power amplifier developed for a X-band weather radar, using a X-band GaN HEMT shown in

Figure 8. It delivers over 250 W of output power in the range of 9.1 to 9.6 GHz with at least 38 dB gain and a PAE of 21 percent. ***Figure 15*** shows a photograph of a GaN SSPA transmitter for radar that uses GaN HEMT amplifiers and a photo of the weather radar using that amplifier.[14] SSPAs, with semiconductor devices mounted in the transmitting section, have successfully reduced the equipment size to one sixth of that of the existing equipment, using electronic tubes. The equipment has been in operation since the end of 2007 and is the first practical weather radar using SSPA. Recently developed GaN SSPAs that process signals by a pulse compression method have increased peak capacity, strike a balance between reduction in size and weight, and achieve high output powers equivalent to existing products. At the same time, the product has contributed to effective utilization of radio waves by suppressing spurious signals with a full-digital process and narrowing the guard band to one quarter, to prevent radio interference.

## CONCLUSION

GaN HEMTs are the front-runners for the next-generation of high power devices, and developers foresee applications for these devices expanding from their initial use with pulse-mode operation for radar. Toshiba estimates that GaN devices with power output two to three times that of GaAs devices, above C-band, can be achieved by developing GaN technology to its full potential. The realization of such devices will accelerate the trend of replacing electronic tubes with SSPA in the amplifier market for terrestrial communications base stations, satellite communications earth station and radar use at C- to K-band (4 to 26 GHz) frequencies. ■

NOTE: Pentium is the registered trademark and the brand name of Intel Corp. and its subsidiaries in the US and other countries.

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# A Reconfigurable Microstrip Antenna with Frequency and Polarization Diversities

*In this article, a novel microstrip patch antenna is presented, with both frequency and polarization reconfigurabilities. By controlling the states of the switches loading on the patch, the antenna can operate in two distinct frequency bands (the frequency ratio is 1.16) and, at the upper band, it can provide two reversed circular polarizations (CP). Simulation and measured results validate the design. The frequency and polarization diversities of this design could potentially improve the functionality and reliability of wireless communication systems.*

The ever increasing development of wireless communication systems has led to a great demand for mobile devices that can operate using different standards such as GSM, GPS, DCS, UMTS and wireless local-area network (WLAN). Moreover, for the standards working under a complicated environment such as WLAN, the polarization diversity is also required to reduce multi-path fading and co-channel interference. These two requirements demand the design of antennas with both frequency and polarization diversities. The design of the antennas with single diversity has been widely developed,[1-5] but designs with both frequency and polarization diversities are seldom addressed in the current literature.

A reconfigurable antenna is a good solution to meet the challenge described above. Nanbo Jin, et al.[6] have presented a novel reconfigurable antenna structure, with only one switch that can provide both frequency and polarization diversities. However, its axial ratio (AR) bandwidth is too narrow and the relevant return loss performance is not very good (80 MHz at 4.55 GHz for $S_{11}$=–6.8 dB and 60 MHz at 4.2 GHz for $S_{11}$=–10.5 dB).

To solve the problem mentioned above and obtain a good AR bandwidth performance, a novel reconfigurable antenna structure is described in this article. By loading four PIN-diode switches on the surface of the microstrip patch, the antenna can operate in two different bands; at the upper band, it can provide two reversed circular polarization diversities. Meanwhile, by etching a capacitive gap on the patch, good impedance and AR bandwidths are achieved. Antenna prototypes with ideal switch models were fabricated and measured. Simulation and measured results show that the design is a good candidate for future frequency and polarization diversity applications in wireless communication systems.

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## ANTENNA STRUCTURE AND WORKING MECHANISM

The geometry of the proposed antenna is shown in ***Figure 1***. The antenna consists of a square patch with a capacitive gap, four slots at each corner and four PIN-diode switches, which are used to connect the corners with the main patch. A 50 Ω SMA coaxial probe is used as the feeding structure. The antenna is fabricated on an FR-4 substrate 0.5 mm thick with a relative permittivity of 2.65. The substrate of the radiating patch and the ground plane are separated by an air layer 3 mm thick (the supporting posts are not shown in the figure). The antenna dimensions are: $L_p$=17.8 mm, $l_s$= 6 mm, $w_s$=1 mm, $l_f$=4 mm, $w_1$=2.5 mm and $w_2$=2 mm.

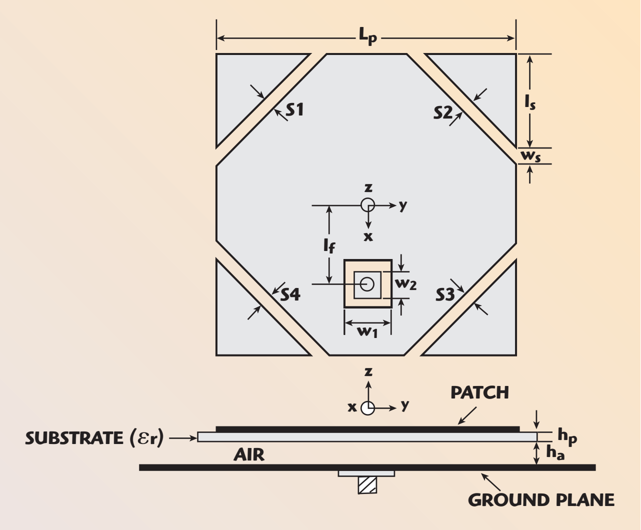



Fig. 1 Geometry of the proposed antenna.

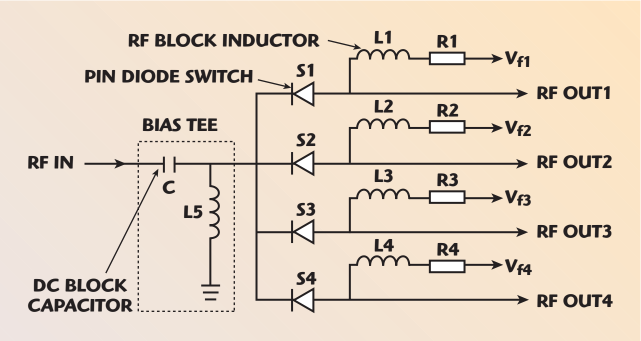



Fig. 2 Bias network for the PIN diode switches.

The proposed antenna can operate at a lower frequency band with a linear polarization (LP) and two reversed circular polarization (CP) at the upper frequency band by switching the four PIN-diode switches loaded on the patch. The different switch configurations of the proposed antenna and the associated operation status are shown in ***Table 1***.

When all the four switches are turned on, the antenna is approximately a square patch. By feeding it along the x axis at an appropriate position, a $TM_{10}$ mode is fully exited. Hence, the antenna operates in the LP state at the corresponding frequency called $f_{LP}$.

When S1 and S3 are switched on and S2 and S4 are switched off, the antenna becomes a patch with a pair of truncated corners along the diagonal line. Because of the perturbation at the corners, both $TM_{10}$ and $TM_{01}$ modes are excited. The $TM_{10}$ mode resonates at approximately $f_{10}$ and the $TM_{01}$ mode resonates at a higher frequency $f_{01}$. The CP conditions can be achieved at a frequency between $f_{10}$ and $f_{01}$. This frequency is called $f_{CP}$, which is higher than $f_{LP}$, so that frequency diversity is obtained. Because the geometry of the proposed antenna is symmetrical, when S2 and S4 are switched on and S1 and S3 are switched off, the antenna operates in the LHCP state, so that polarization diversity is obtained at $f_{CP}$.

**TABLE I**

**SWITCH CONFIGURATIONS AND ASSOCIATED OPERATION**

| Switch Status | Polarization | Frequency (GHz) |
|---|---|---|
| S1, S2, S3, S4 on | LP | 5.19 to 5.54 |
| S1, S3 on; S2, S4 off | RHCP | 6.08 to 6.35 |
| S2, S4 on; S1, S3 off | LHCP | |

In order to enhance the operating bandwidth, a capacitive gap technique is adopted.[7] This capacitive component can compensate the inductive impedance produced by a feeding probe, so that a wider impedance bandwidth is obtained at both lower and upper bands.

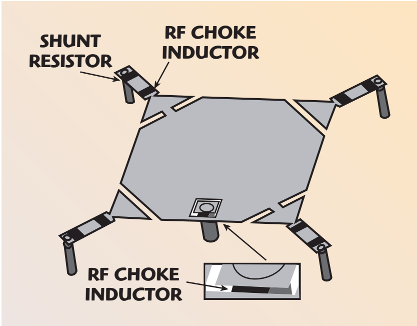



Fig. 3 Antenna model used in the HFSS simulation including bias components.

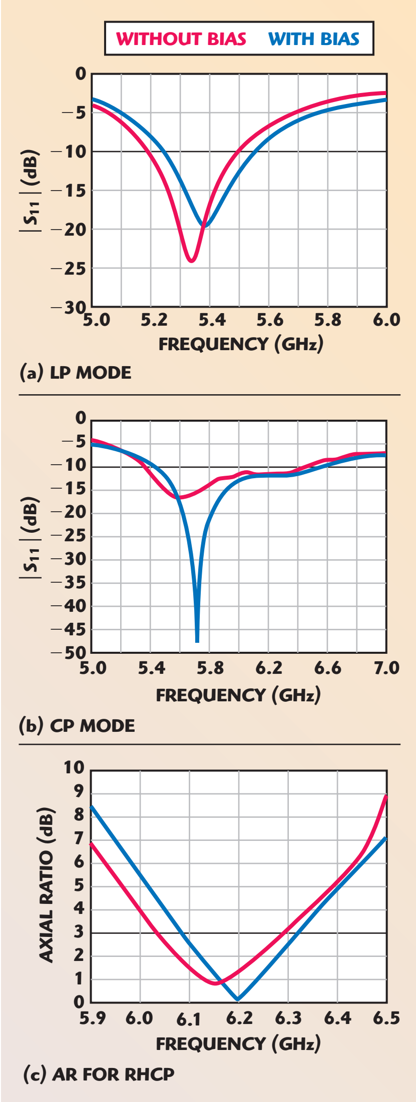
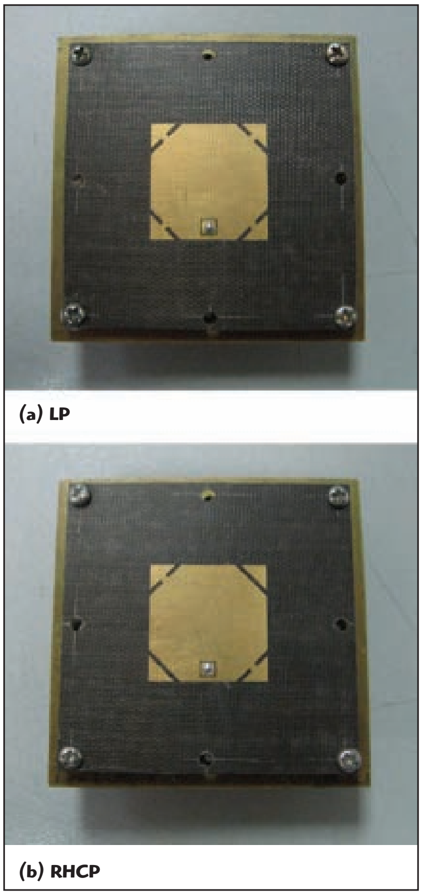



Fig. 4 Simulated results for the antenna model with and without bias network.

## SIMULATION AND MEASUREMENT RESULTS

The simulation has been performed with Ansoft HFSS software. The bias network of the switches is shown in ***Figure 2***. The main patch of the square antenna is chosen as the DC ground, which is shared by the four PIN-diode switches. Each corner of the antenna is connected to a DC bias circuit, which consists of a RF choke inductor in series with a shunt resistor connected to the DC source. This circuit appears as an open circuit (very high impedance) at the antenna terminal, so that the antenna return loss is not appreciably affected by the bias circuit. The design is verified through simulation by adding the bias network to the ideal antenna structure. The antenna model with bias network, used in the simulation, is shown in ***Figure 3***. The ground plane and substrate are not shown for clarity. It should be noted that a RF choke inductor is placed between the capacitive gap to maintain the DC ground connection. ***Figure 4*** shows the simulation results for the antenna structure with and without bias circuit. From the figure, it can be seen that the effect of the bias circuit on the radiation properties is slight. This indicates that the bias network can be ignored in the antenna prototype, for simplicity.



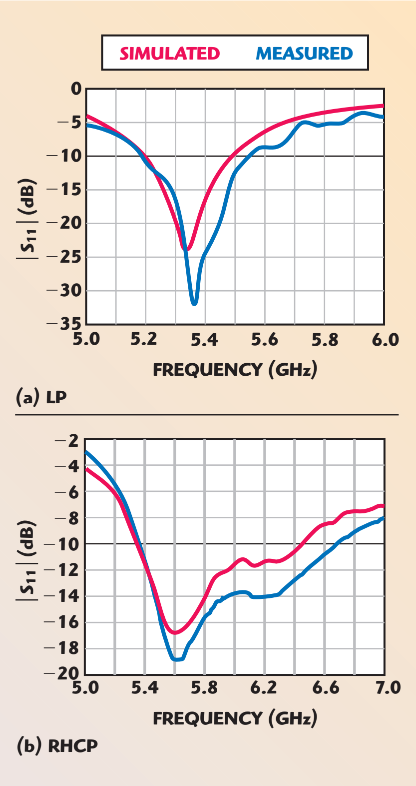
(a) LP

(b) RHCP

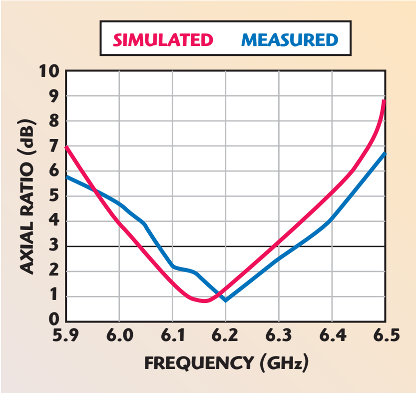
▲ *Fig. 5 Photographs of the fabricated antenna prototypes.*

The fabricated prototypes are shown in ***Figure 5***. Following F. Yang and Y. Rahmat-Samii,[8] the PIN-diode switch is treated as an ideal model in the prototypes. That is, when the switch is in the off-state, it is removed from the patch, and when the switch is in the on-state, it is modeled as a metal pad. Return losses of the antenna prototypes are measured with an Agilent 8722ES network analyzer. The far-field radiation patterns are measured in an anechoic chamber. Because the structure is symmetrical for the CP states, RHCP results are sufficient to show the CP radiation properties.

Simulated and measured return losses are shown in ***Figure 6***. The measured 10 dB impedance bandwidth for the LP state is 350 MHz, ranging from 5.19 to 5.54 GHz. The measured 10 dB impedance bandwidth for the CP

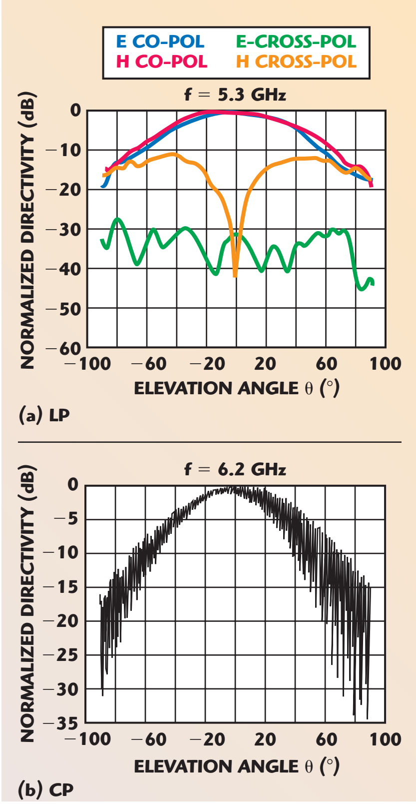



▲ *Fig. 6 Simulated and measured return losses.*




▲ *Fig. 7 Simulated and measured AR vs. frequency.*

state is 1380 MHz, ranging from 5.36 to 6.74 GHz. ***Figure 7*** shows the simulated and measured results of the AR of the proposed antenna in the CP state. The best broadside AR of 0.824 dB is observed at 6.20 GHz. The associated AR bandwidth for less than 3 dB is 250 MHz, ranging from 6.08 to 6.33 GHz. ***Figure 8*** shows the measured radiation patterns of the co-polarization and cross-polarization of the E-plane and H-plane for the LP state at 5.3 GHz. The




▲ *Fig. 8 Measured radiation patterns of the proposed antenna.*

measured linear spinning pattern of the CP state at 6.2 GHz in the yz-plane is also shown. Similar radiation patterns are observed in the xz-plane. An AR of less than 3 dB is achieved within a 60° beam width.

## CONCLUSION

A novel reconfigurable antenna with both frequency and polarization diversities is proposed. Using four PIN-diode switches on a square patch, the antenna can be operated either in an LP state or in a pair of orthogonal CP states at two distinct frequency bands. The frequency bandwidths are improved by using a capacitive gap. Experimental results show that good performance is achieved. This novel antenna can be a good candidate for future frequency and polarization diversity applications in wireless communication systems. ■

## ACKNOWLEDGMENTS

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# FOCUS ON RESEARCH

**EXECUTIVE INTERVIEW SERIES**

**THIS MONTH ONLINE, PETTERI ALINIKULA, LABORATORY DIRECTOR NOKIA RESEARCH CENTER HELSINKI, DISCUSSES THE GLOBAL REACH OF THE NRC, THE ROLE OF RESEARCH IN THE CURRENT ECONOMIC CLIMATE AND HIS PLENARY SPEECH AT IMS 2009.**

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Nokia is one of the most familiar names worldwide, but not everyone is conversant with the fact that the company started out in 1865 with a mill producing paper—the original communications technology—and that it took a merger with a cable company and a rubber firm to set the new Nokia Corp. on the path to electronics in the 1960s. This article offers a brief history going back to the 19th century, explains key developments of the 20th century before focusing on how the Nokia Research Center is taking technology forward in the 21st century.

## PULP FACT

Having built a wood pulp mill on the banks of the Tammerkoski rapids, in southern Finland in 1865, Fredrik Idestam built a second mill by the Nokianvirta River—the place that gave the company its name when it became Nokia Ab in 1871. Electricity generation was added to its business activities in 1902.

Nokia Ab, Finnish Cable Works and Finnish Rubber Works, which had been jointly owned since 1922, officially merged in 1967 to form the Nokia Corp. Finnish Cable Works originally branched out into electronics in the 1960s, making its first electronic device in-house in 1962: a pulse analyzer designed for use in nuclear power plants. The company's involvement with telecommunications systems also began in the '60s, and in 1963 it started to develop radio telephones for the army and emergency services.

Nokia would later make: TVs (by 1987 the company was the third largest TV manufacturer in Europe), computers (the MikroMikko became the best known computer brand in Finland), radio telephones, data transfer equipment, radio links and analyzers, and digital telephone exchanges.

Nokia ceased consumer electronics manufacture in the 1990s, with the telecommunications expertise that it had developed from the 1960s onwards becoming its core activity.

## NOKIA RESEARCH CENTER

The corporation views R&D as a key tool to keeping the company at the forefront of technology. To facilitate vital innovation, the company founded the Nokia Research Center (NRC) in 1986 from the Nokia Electronics R&D unit.

NRC is chartered with exploring new frontiers for mobility, solving scientific challenges to transform the converging Internet and communications industries. Teams are strategically located worldwide to collaborate with leading universities and research institutes in the mode of Open Innovation—deep research collaborations with world-leading academia, industry collaborators and independent developers—sharing resources, leveraging ideas and tapping into the prevalent expertise. Some of the largest collaboration projects take place with the Massachusetts Institute of Technology in Cambridge, MA, USA, Stanford University in Palo Alto, CA, USA, the University of Cambridge in the United Kingdom, and Tsinghua University in Beijing, China. Current research is focused on the areas of high performance mobile plat-

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forms, cognitive radio, rich context modeling and new user interface.

## HIGH PERFORMANCE MOBILE PLATFORMS

The focus is on crafting a comprehensive superior mobile platform to radically improve the performance to power ratio, empower new sensing capabilities and extend the platform and architecture beyond a single device. Research is centered in Finland, complemented by teams in the US and UK, and is focused on: ubiquitous architectures (extending the single device), energy efficient computing architectures, computational structures, nano-based enablers for sensing and computing, platform security and holistic system-level power management.

## COGNITIVE RADIO

In connectivity, the world is moving towards a fundamentally disruptive new era where intelligent devices leverage awareness of environmental circumstances and user needs to determine how to communicate on the fly via dynamic spectrum use for improved capacity. Research is centered in Helsinki, Finland, including at the Lablet at Otaniemi and is focused on: methods for flexible spectrum use, novel ways of sensing the radio environment and location using radio waves, distributed networks and low power flexible implementation of radio front-ends and protocols.

## RICH CONTEXT MODELING

Rich context is characterized by the use of a wide range of sensor information to aggregate data into a coherent model of a user's surroundings, including things like their location, motion, weather, connectivity options and proximity to others. This data and its analysis form the backbone for a new class of services in areas like weather, traffic, wellness, or entertainment. Research, spread evenly in the United States, Europe and China, is focused on: service architectures and enabling technologies such as data management and mining, pervasive sensing and context data economics.

## NEW USER INTERFACE

Future user interfaces will need to integrate the personalization and adaptive aspects of the device with data-sharing enabled by the Internet and back-end infrastructure. In addition, they will incorporate a user's physical attributes (movements, activities and environment) and personal needs (unique input methodologies) to seamlessly blend with their lives. Research, located in Europe and in the United States, with teams in China, India and Africa providing regional and cultural variation, is focused on: user experience that meets cultural preferences, mixed reality technologies in conjunction with multi-modal interaction and immersive communications and media representation.

## NRC GLOBAL LOCATIONS

Ten locations worldwide enable NRC to engage with the foremost minds and partners in the mobile field to conduct leading-edge research. By bridging this wide variety of cultures, environments and skill-sets across these diverse geographies, NRC empowers Nokia to develop products and services that meet the needs of its customers.

Collaborating with the Tampere University of Technology (TUT), Finland, NRC Tampere is chartered with exploring the areas of sensing and context, media representation, social media, user experience, mixed reality solutions and 3D platforms.

NRC Helsinki is just a few minutes from Nokia worldwide headquarters in Espoo, Finland. Working in conjunction with the Helsinki University of Technology (TKK), which is also the location of the Nokia Research Lablet at Otaniemi, NRC Helsinki projects are pushing forward the fields of user experience, mobile security, power management and computing architectures, as well as cognitive radio. The Otaniemi Lablet works in an open mode with various laboratories of TKK. This means establishing joint research programs and daily interaction between Nokia and university researchers who share the same facilities.

NRC Cambridge USA is a cross-disciplinary research organization working closely with the Massachusetts Institute of Technology (MIT). The laboratory consists of approximately 20 Nokia researchers, investigating all aspects of mobile phones, from computer and network architecture to user interfaces and its charter is to bring new ideas into Nokia products ranging from rich content-based services to user interfaces.

NRC Palo Alto, CA, USA, is located in the heart of Silicon Valley. Collaborating with both Stanford University and the University of California at Berkeley, the NRC's work consists of mobile Internet services systems, mobile business solutions, context-specific content, visual computing and ubiquitous imaging and other user experience enhancing technologies.

NRC Hollywood in Los Angeles, CA, USA, is positioned centrally in the media industry. It works with members of the media and entertainment industry, including new technology companies and creative talent, together with leading universities in the region, including the University of California at Los Angeles and the University of Southern California.

The NRC Cambridge UK laboratory is located on the campus of the University of Cambridge. Collaborating extensively with the university, the laboratory develops nanotechnologies for mobile communication and ambient intelligence.

NRC Lausanne, Switzerland, is one of Nokia's newest research facilities and is chartered with collaborating with the Ecole Polytechnique Fédérale de Lausanne (EPFL) and ETH Zürich to explore the field of pervasive sensing and computing.

NRC India team focuses on emerging market services for both urban and rural India. Collaborating with the Srishti School of Art, Design and Technology in Bangalore and the MIT Media Lab in Cambridge USA, its aim is to explore user-centric technologies to generate new business opportunities for Nokia in India and other emerging markets.

Beijing is seen as an ideal location for NRC to take advantage of China's fast growing economy and the world's largest mobile market. NRC Beijing works with Tsinghua University to explore the key research topics of context computing architectures, context data modeling and management, and mobile social networks.

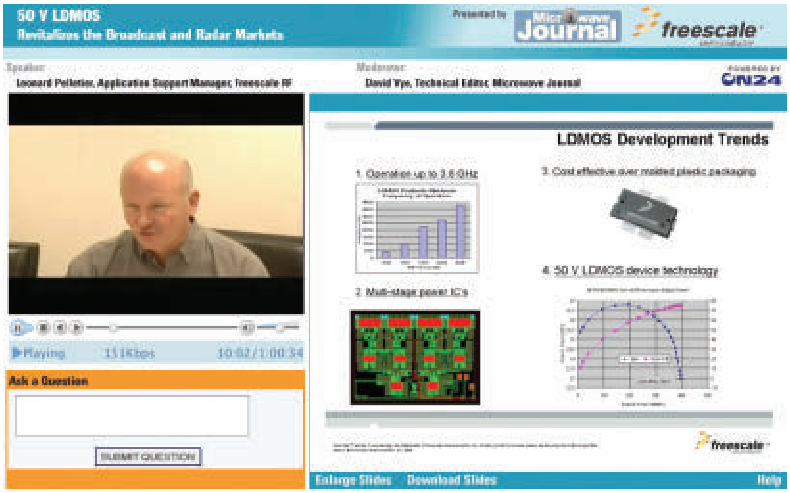
NRC Africa works with various groups to solve the unique African language, cultural, educational and infrastructure challenges that can all be improved through mobile technologies.

Those are the facts. For the inside story, read Petteri Alinikula's Executive Interview online at www.mwjournal.com.

# THE NEW MWJOURNAL.COM RESOURCES SECTION

## *Effective Communications through Multiple Mediums*

Microwave engineers appreciate the need for different communication schemes to serve diverse channels and receivers. How information is transmitted directly impacts successful reception. In publishing today, print and the Internet are used to communicate to an intended audience. Where print is tried and true, the *Journal*'s website is constantly evolving to help our audience connect to content from editors, contributing authors and advertisers. To do so, we have introduced more articles online for reading, webinars and video for viewing, and blogs (expert and editors) for dialog. With this increase in content and different formats, it is important for our site visitors to have all this information well organized and accessible. It is with this goal in mind that we are pleased to unveil the new *MWJ* Resources section.




Most of our magazine readers, newsletter recipients and website visitors are familiar with our efforts to deliver more meaningful content through electronic means. Our Executive Interview series provides the industry with insight into how company decision makers view their respective technology, business climate and market opportunities. The Expert Advice column offers practical information and thought-provoking opinions from an invited industry guru. The Expert Advice column begins the technical discussion. Readers consume the information and can further the discussion if they so choose. Webinars, in these days of restricted travel, are definitely growing in popularity and the Q&A sessions that follow the presentation represent lively, real-time feedback. Finally, the *Journal* strives to be the source for technical articles and reference materials. This material is now assembled in our new Technical Library. These four elements—Webinars,

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## ExecutiveInterviews

The Executive Interview Series began in September 2007 with dual interviews between *Microwave Journal* and Agilent EEsof's Todd Cutler and AWR's Sherry Hess. Both EDA companies had new Product Feature stories in that month's magazine and we took the opportunity to ask each executive what the new product features meant for their customers and how their business was shaping up. Since then we have had one (and sometimes two) interview(s) per month with executives from leading microwave companies in the US and Europe. We have heard from semiconductor and integrated device manufacturers such as TriQuint's Brian Balut, Chuck Fox of Jazz Semiconductor, RFMD's Bob Van Buskirk, Rick Montgomery of Mimix Broadband, Rodd Novak of Peregrine Semiconductor and Bryan Ingram of Avago Technologies. In August and September of this past year we had back to back interviews from RF module developers, Endwave and Narda. We have presented viewpoints from the test and measurement world (Michael Vohrer of Rohde & Schwarz, Bryan Sayler of ETS-Lindgren and Greg Maury of Maury Microwave Corp.) as well as the simulation world (Bernhard Wagner of CST and Peter Krauss of Mician GmbH).

The Executive Interview Series is among our most widely read online articles each month and we continue to get lots of positive feedback from our readers. Archiving these interviews in the new Resources section should inspire readers to go back and take another look at what was presented, consider how well the responses stood up to the test of time and compare the view of the industry from different sectors.

## ExpertAdvice

The Expert Advice column was started after the retirement of *MWJ* editor Harlan Howe and his popular online feature "Ask Harlan". Test and measurement is a big topic of discussion among our experts. We have heard from test gurus such as Joel Dunsmore of Agilent Technologies on the expansion of network analyzers beyond S-parameters, Vince Rodriguez of ETS-Lindgren on antenna measurements, Darren McCarthy of Tektronix on measuring noise, Mark Elo from Keithley Instruments on the challenges of MIMO characterization and Larry Dunleavy on device modeling (one of the end products of microwave measurements). Design software has been the subject of discussion with input from Rob Lefebvre from Agilent and Joel Kirschman of AWR. Both Rob and Joel discussed design flows and the user-software interface; both considered what new features in EDA would address engineering productivity. Meanwhile, Jeremy Raines, an independent consultant, proposed an alternative to sophisticated EM simulation when it comes to antenna design.

Several of our experts, including Dan Nehring of Valpey Fisher, Ray Crampton of Nitronex, Rafi Hershtig of K&L Microwave and Robert Aigner of Tektonix explained the technical nuances of various microwave devices including oscillator phase noise, working with GaN, bandpass/band-stop diplexers and BAW filters, respectively. Two of our experts, Pierre Piel of Freescale and Moray Rumney of Agilent, looked at the system requirements for the medical microwave industry and emerging cellular wireless industry (such as LTE), respectively, in back to back columns last year. We present these past columns chronologically in our new Expert Advice archive for your review. The "comment" capability of the latest Expert blog has also been enhanced for more of your feedback.

### WEBINARS

Webinars are the future and the future is now. The new Resources section let's visitors preview what is coming up and what has already been presented, "on demand" and from the comfort of your home or office. Since 2007, the *Journal* has teamed up with Besser Associates to present free monthly webinars on topics ranging from basic microwave principles such as impedance matching and using the Smith Chart to more advanced topics such as MIMO and LTE. We have also moderated webinars from leading companies such as Freescale, TriQuint and M/A-COM. This month *MWJ* will host custom webinars from TriQuint and Tektronix and in the near future look for webinars from additional software vendors, test equipment manufacturers, RFIC/MMIC providers and more.

## Technical Library

Nothing may be more important for working professionals than access to technical information. In addition to our regular monthly content, the *Microwave Journal* website has been featuring "web exclusives" consisting of technical articles, tutorials, application notes and the so-called white paper. The term "white paper" arose over the past few decades in England to distinguish short government reports from longer, more detailed ones that were bound in blue covers and referred to as "blue books". Today, many engineering organizations provide detailed technical information in the form of a white paper. In information technology, a white paper is often a paper written by a lead product designer to explain the philosophy and operation of a product in a marketplace or technology context. Our new Technical Library houses all the web exclusives including white papers that have appeared on our site over the past several years. Papers are organized by topic (i.e., amplifiers, antennas, filters, packaging, etc.) for easy access and can be downloaded in PDF format for your own use, free of charge.

The Resources section also hosts design tools from various vendors and will eventually be home to more multi-media and interactive web capabilities as we add future functionality. You are busy working on the next generation of communication and so are we. We hope you enjoy it.

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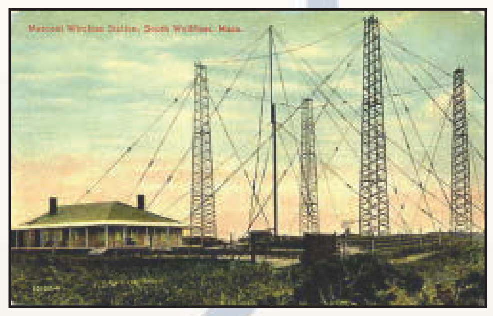

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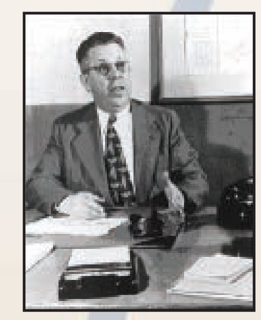
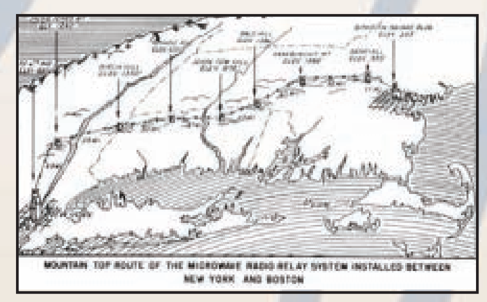
1900

**1922**
Two Harvard University engineers perform analysis indicating that typical RF transformers of the day were too tightly coupled. They convince National Radio to manufacture components to their specifications resulting in the Browning-Drake Receiver



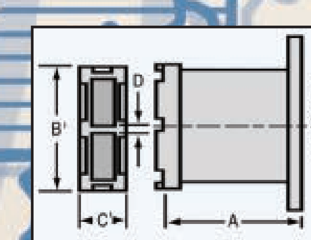
**1946**
Dr. Percy Spencer (Raytheon) discovers the microwave oven when the candy bar in his pocket melts

1920

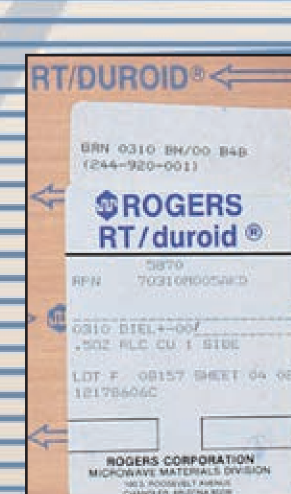


**1947**
AT&T sets up first microwave link between Boston and New York

**1940**
MIT Radiation Lab goes into operation (Cambridge, MA)



**1950**
The waveguide sidewall invented by Henry Ribl




**1949**
Rogers introduces the first Duroid product line (Rogers, CT)

1940

**1948**
Microwave Development Laboratories (MDL) is established (Needham, MA)

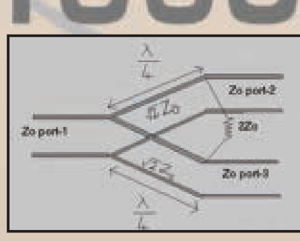
**1941**
U.S. Navy contracts with Raytheon on the delivery of 100 ship radar systems

**1958**
Gerald Adams founded Adar Russell Inc. in Waltham

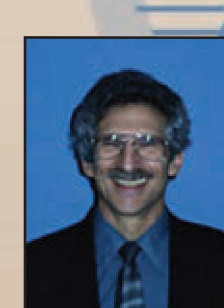
**1957**
MIT Lincoln Lab's Millstor radar is completed, the f utilize all-solid-state, pro mable digital computer f real-time tracking of obj space

1960

**1955**
Ted Saad starts Sage Laboratories



**1960**
Ernest Wilkinson of Sylvania's Missile Systems Laboratory in Waltham, MA publishes "An N-way Power Divider" in IRE Trans. on Microwave Theory and Techniques



**1960**
Allen Podell co-founds Anzac electronics

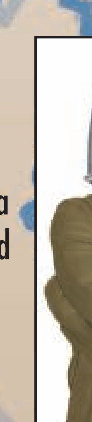
1980

**1962**
George and Andrew Kariotis form Alpha Microwave (later to be renamed Alpha Industries, now part of Skyworks)

**1965**
Analog Devices founded by Ray Stata and Matthew Lorber in 1965. An initial public offering was held, on March 11, 1969

**1967**
IMS held in Boston at New England Mutual Hall

**1971**
A Mass. General Hospital attendant discovers electronics engineer Leonard Kille holding a metal wastebasket over his head to "stop the microwaves". (Kille was co-inventor of the Polaroid Land camera and had involuntary brain surgery to correct his violent outbursts)

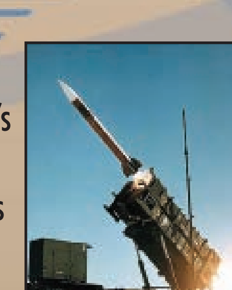


2000

**2000**
IMS held at Hynes Convention Center, Boston

**1995**
M/A-COM launched a proprietary voice and data network that was first adopted by Federal Express

**1991**
George H W Bush travels to Raytheon's Andover plant in MA to thank his 'friend', retiring chairman Tom Phillips for building what he called the 'scud busters'

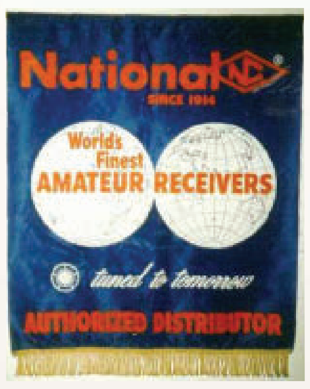


IMS 2

BOSTO

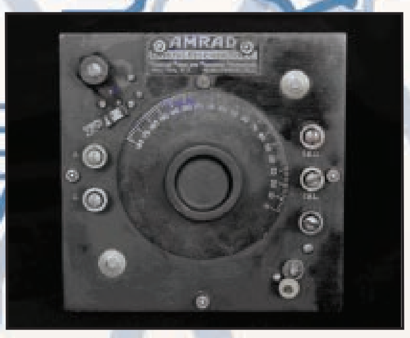
IEEE

# Milestones




**1914**
The National Radio Company, one of the "big three" manufacturers of shortwave receivers and communications equipment began as the National Toy Company, in Cambridge. In the early 1920s, National agreed to supply a Boston representative of Cardwell Capacitors with capacitors and thus entered the radio business

1910




**1915**
AMRAD (The American Radio and Research Corporation) opens for business from Medford Hillside, about four miles from Boston. Founder procures company funding from JP Morgan after a chance meeting

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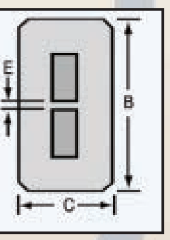
**1932**
National Radio Company introduced the first of a long line of classic receivers. This was the model AGS, for Aircraft Ground Station use, probably the most advanced communications receiver available at that time

**1932**
Draper Labs was founded in Cambridge by MIT professor Charles Stark Draper

1930

MICROWAVE ASSOCIATES

**1950**
Chiga, Roberts, Wainwright and Walker start Microwave Associates in a loft in Boston. The company eventually changes its name to M/A-COM and is later acquired by AMP, then Tyco Electronics and then partially sold to Cobham Defense



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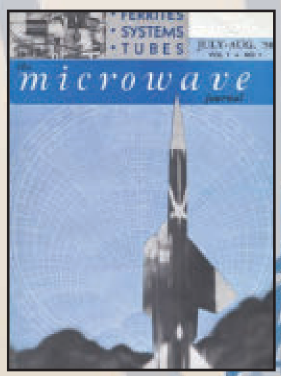


**1958**
Microwave Journal founded in Boston

**1951**
Lincoln Labs founded. In 1950, MIT undertook a summer study to explore the establishment of a laboratory to be operated by MIT for the Army, Navy and Air Force. The name "Project Lincoln" was chosen because of location near the towns of Bedford, Lexington, and Lincoln and the names "Project Lexington" and "Project Bedford" were already taken

1950

Russell

ms-

SA SANDERS ASSOCIATES, INC.

**1951**
Sanders, founded in Waltham, Massachusetts by eleven engineers and scientists from Raytheon was named for Royden C. Sanders, Jr. one of original founders. The company moved to Nahua NH the following year where there have remained despite acquisition by Lockheed and then BAE Systems


**1959**
PGMTT first ever Boston symposium held at Harvard University (Cambridge)

1970

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MITRE

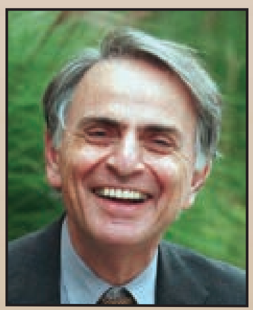
**1959**
April 1959, a site was purchased in Bedford, Massachusetts near Hanscom Air Force Base (AFB), to develop a new Mitre laboratory, which Mitre occupied in September 1959

Hittite MICROWAVE CORPORATION

**1985** Hittite Microwave Corp. founded in Chelmsford, MA

millitech

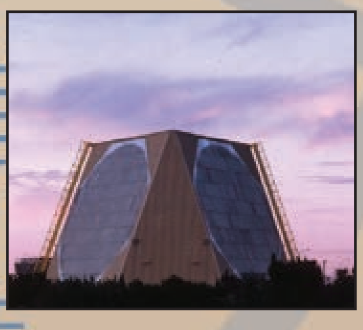
**1982**
Millitech, Inc. is founded by five UMass professors



**1983**
IMS held in Boston for the first time since 1967, Carl Sagan is the Banquet speaker

1990

**1984** atnmicrowave
ATN Microwave Inc. specializes in microwave measurements for wireless and high-speed data communications is founded



**1978**
Construction of the PAVE PAWS radar system, located on upper Cape Cod is completed.

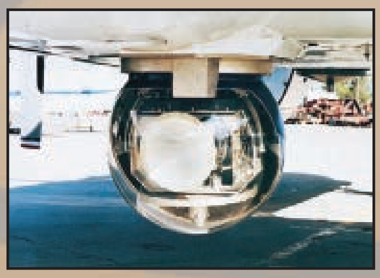
SANDERS ASSOCIATES INC.

**1986**
Sanders Associates was bought out by Lockheed Corporation to become Sanders, a Lockheed Company

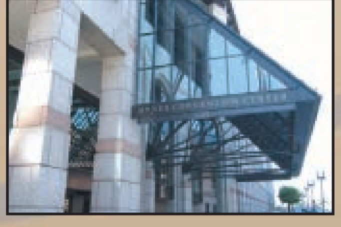
2010

2009

ON MA



**1987**
a high-resolution, multiple-polarization, Ka-band synthetic-aperture radar (SAR), called the Advanced Detection Technology Sensor (ADTS), was developed by Lincoln Labs under DARPA sponsorship



**1991**
IMS held at Hynes Convention Center in Boston

AURIGA MEASUREMENT SYSTEMS, LLC

**2004**
Auriga Measurement Systems founded in Lowell

MTT-S®


# A NEW 13 GBPS, +3.3 V HIGH SPEED LOGIC FAMILY

Over the last few years, the transition from analog to digital RF technology has signaled the need for high performance digital logic at higher data rates. The evolution of high speed digital communication demands more emphasis on S-parameter measurements, the ability to measure lower jitter, and more widespread use of differential circuits to provide noise immunity. These new requirements necessitate high speed logic and control circuits with lower random and deterministic jitter specifications, lower propagation delay, reduced data skew values and lower power consumption.

High speed logic is a key requirement in many wideband data acquisition and test systems, high capacity microwave or optical communications, and real time digital imaging. In these systems, the common design trend is to simplify the complexity of all of the stages from signal acquisition (the antenna) to analog-to-digital conversion (ADC), resulting in digitization of RF signals at higher sample rates. These higher data rates have caused more stringent specifications to be placed on the high speed interface and control logic devices.

To meet all of these requirements, Hittite Microwave began introducing a new line of 13 Gbps digital building blocks in early 2008. Most of these early products operated from -3.3 V supplies, provided adjustable output voltage swing capability, but with unique pinouts. Over time Hittite has significantly expanded the line, introducing a total of 23 SMT 13 Gbps logic devices in all. The product line features many -3.3 V devices with faster rise times, fixed or programmable output voltages, as well as versions with very competitive industry-compatible pinouts. Hittite's strong commitment to the high speed logic product line continues, and now high performance versions operating from a single +3.3 V supply are available.

This new family of +3.3 V devices includes the HMC706LC3C NRZ-to-RZ Converter, the HMC744LC3C 1:2 Fanout Buffer, the HMC745LC3C XOR/XNOR gate, the HMC746LC3C AND/NAND/OR/NOR gate, the HMC747LC3 D-Type Flip Flop, the HMC748LC3C 2:1 Selector and the HMC749LC3C T-Flip Flop with reset capability (see ***Table 1***). These logic devices may be used individually, or in combination to implement many critical digital subsystems spanning a myriad of applications, including broadband test equipment, ATE, military communications, radar, frequency synthesis, 10/100G Ethernet and SONET/SDH optical systems.

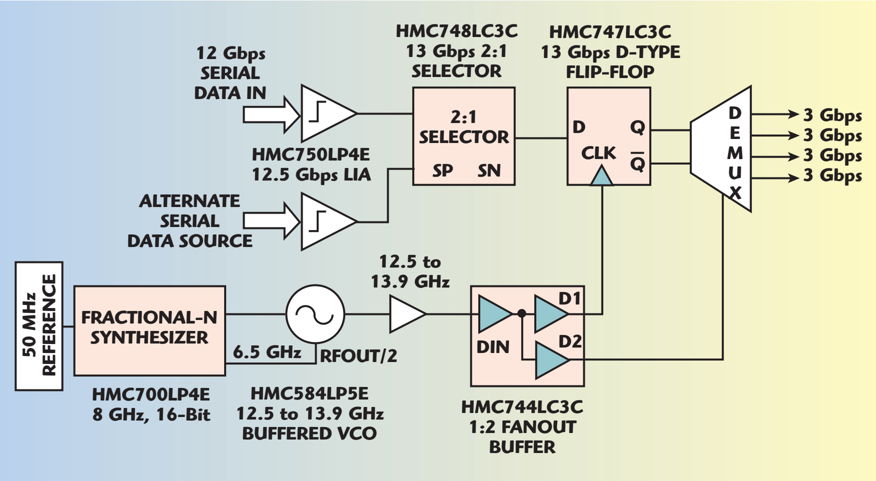
HITTITE MICROWAVE CORP.
*Chelmsford, MA*

The HMC706LC3C is a NRZ-to-RZ Converter designed to support data transmission rates up to 13 Gbps and clock rates up to 13 GHz. During normal operation RZ data is transferred to the outputs on the positive edge of the clock, while negative edge-triggered applications are supported by reversing the clock inputs. Ideal for use in SONET OC-192 equipment, Mach-Zehnder optical modulators, 10 Gbps Ethernet applications and broadband test equipment, the HMC706LC3C provides typical rise and fall times of 15 and 13 ps, respectively. The device also exhibits 275 ps propagation delay and 2 ps of deterministic jitter while dissipating only 594 mW.

The HMC744LC3C 1:2 Fanout Buffer distributes precise clock or data signals in high performance applications. The device provides buffering capability for clock frequencies up to 13 GHz and serial data transmission rates up to 13 Gbps. The HMC744LC3C Fanout Buffer also provides very low data skew (< 2 ps) between data ports, which is ideal for critical time domain measurements since any skew between data ports may create race conditions. The HMC744LC3C is also ideal for bit-error-rate testing (BERT) applications since it helps designers to reduce the complexity of the clock distribution chain. The HMC744LC3C also exhibits fast rise and fall times of 22/20 ps and a propagation delay of 120 ps. The device exhibits less than 2 ps of deterministic jitter, less than 200 fs of random jitter and typically dissipates 287 mW.

The HMC745LC3C provides either an XOR or XNOR logic function. When configured as a XOR gate, the HMC745LC3C may be used to generate inverted data streams or may be used to implement a phase detector or a bit-error rate detector. The HMC745LC3C provides a typical propagation delay of 95 ps and typical rise and fall times of 21/19 ps while dissipating only 240 mW.

The HMC746LC3C may be configured to provide either AND, NAND, OR or NOR logic functions, providing system designers with maximum utility from a single device part number. When this device is configured as an AND gate, it may be used to gate high speed clock or data signals. The HMC746LC3C is ideal for this application since it provides high isolation of 50 dB in the off mode. The device also exhibits typical rise and fall times



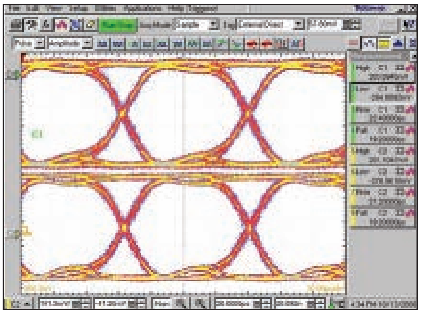

▲ *Fig. 1 Typical example where 12 Gbps serial data stream is retimed and demultiplexed.*

## TABLE I

**+3.3 V HIGH SPEED DIGITAL LOGIC ICs**

| Data/Clock Rate (Gbps/GHz) | Function | Rise/Fall Time (ps) | Deterministic Jitter (ps) | Differential Output Voltage Swing (Vpp) | DC Power (mW) | DC Power Supply (Vdc) | Package | Part Number |
|---|---|---|---|---|---|---|---|---|
| 13/13 | Fast Rise Time 1:2 Fanout Buffer* | 22/20 | 2 | 0.6-1.2 | 290 | +3.3 | LC3C | HMC744LC3C |
| 13/13 | 2:1 Selector* | 22/22 | 2 | 0.6-1.2 | 250 | +3.3 | LC3C | HMC748LC3C |
| 13/13 | Fast Rise Time AND/NAND/OR/NOR* | 22/21 | 2 | 0.6-1.2 | 230 | +3.3 | LC3C | HMC746LC3C |
| 13/13 | Fast Rise Time D Flip Flop* | 22/20 | 2 | 0.6-1.2 | 264 | +3.3 | LC3C | HMC747LC3C |
| 13/13 | NRZ-to-RZ Converter* | 15/13 | 2 | 0.3-1.2 | 594 | +3.3 | LC3C | HMC706LC3C |
| 26/26 | T Flip Flop w/Reset* | 18/17 | 2 | 0.6-1.2 | 270 | +3.3 | LC3C | HMC749LC3C |
| 13/13 | Fast Rise Time XOR/XNOR* | 21/19 | 2 | 0.6-1.2 | 240 | +3.3 | LC3C | HMC745LC3C |

* These products feature programmable output voltage swing.



▲ *Fig. 2 HMC747LC3C output eye diagram using Agilent N4901B serial BERT with 12 Gbps $2^{15-1}$ PRBS data pattern.*

of 22/21 ps, and less than 2 ps of deterministic jitter while dissipating only 230 mW.

The HMC747LC3C D-Type Flip Flop is also designed to support data transmission rates up to 13 Gbps and clock rates up to 13 GHz. During normal operation, the data is transferred to the outputs on the positive edge of the clock, but for application flexibility, the clock inputs may be reversed to support negative edge-triggered applications. This device also exhibits a very low set up-and-hold time of less than 6 ps. The HMC747LC3C also provides excellent clock phase margin of 320 degrees at 13 GHz. This specification permits very robust system timing, and allows for a large range of clock data drift. Since the HMC747LC3C exhibits less than 2 ps of deterministic jitter and provides a propagation delay of 105 ps, this device may also be used in a wide range of applications where data bit streams need to be retimed as they travel across high speed system backplanes (see ***Figure 1***). The rise and fall times are typically 22/20 ps and the device typically dissipates 264 mW.

The HMC748LC3C is a 2:1 Selector designed to support data transmission rates of up to 13 Gbps and selector port operation of up to 13 GHz. The selector routes one of the two single-ended inputs to the differential output upon assertion of the appropriate select port. The HMC748LC3C is ideal for redundant path switching or built-in test applications, since propagation delay is only 125 ps while rise and fall times are both 22 ps. The device exhibits only 2 ps of deterministic jitter while dissipating 250 mW.

The HMC749LC3C is a T Flip Flop with reset capability supporting clock frequencies as high as 26 GHz. During normal operation, with the reset pin not asserted, the output toggles from its prior state on the positive edge of the clock. This results in a divide-by-two function of the clock input. Asserting the reset pin forces the Q output low regardless of the clock edge state (asynchronous reset assertion). Reversing the clock inputs allows for negative edge-triggered applications. Propagation delay is typically 95 ps while rise and fall times are 18 and 17 ps, respectively. Ideal as a high speed frequency divider, the HMC749LC3C exhibits only 2 ps of deterministic jitter while dissipating 270 mW. See ***Figure 2*** for output eye diagram.

Each of these high performance logic devices feature an output level control pin, VR, that permits signal loss compensation that can occur when very high speed signals travel over transmission lines. This feature is also ideal for signal level optimization. In this way, the signal output level could be reduced to generate lower output voltage swings, permitting faster rise time and lower propagation delay. The output signal level can be adjusted by either applying a voltage directly to VR, or by connecting the pin to ground with a suitable resistor value. In some applications this voltage may be accurately set with a low-cost DAC. The programmable differential output voltage swing may be set anywhere in the range from 0.6 to 1.2 V.

The current mode logic (CML) inputs and outputs of this family of logic devices provide a wide common mode operating range. These devices can accommodate input signals in the range of +2.1 to +3.8 V, and can operate with a DC supply in the range of +3.0 to +3.6 V. These devices also feature over-voltage protection on the power supply and ground pins, and all of the inputs and outputs are ESD protected.

As shown in ***Figure 3***, these 13 Gbps logic devices may be used to support a wide range of termination schemes accommodating both AC and DC coupling requirements. These devices feature differential inputs and outputs, which are DC coupled and terminated on chip

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|---|---|---|---|---|---|---|---|
| Low Loss Flexible cable assembly with good Phase Stability vs. Flexure | C02-01-01-1M | 18 | 2.09 | 22 | 42 | ± 0.05 | |
| Ultra Low Loss Flexible cable assembly with Excellent Phase Stability vs. Flexure & Temperature | A02-01-01-1M | 18 | 1.35 | 21 | 50 | ± 0.20 | 220 |
| | A03-01-01-1M | 18 | 1.28 | 21 | 64 | ± 0.20 | 220 |
| | A04-01-01-1M | 18 | 0.95 | 18 | 89 | ± 0.30 | 220 |
| Millimeter Wave Ultra Low Loss Flexible cable assembly with Excellent Phase Stability vs. Flexure & Temperature | A05-47-47-1M | 32 | 2.20 | 18.5 | 50 | ± 0.20 | 220 |
| | B01-40-40-1M | 40 | 3.01 | 19.0 | 51 | ± 0.20 | 400 |

**Remarks:**
1. "01"means SMAMALE straight connectors, "40"means 2.92mm MALE straight connectors,"47"means 3.5mm MALE straight connectors.
2. Custom designed assemblies are available
3. The insertion loss and VSWR are given at working frequency.

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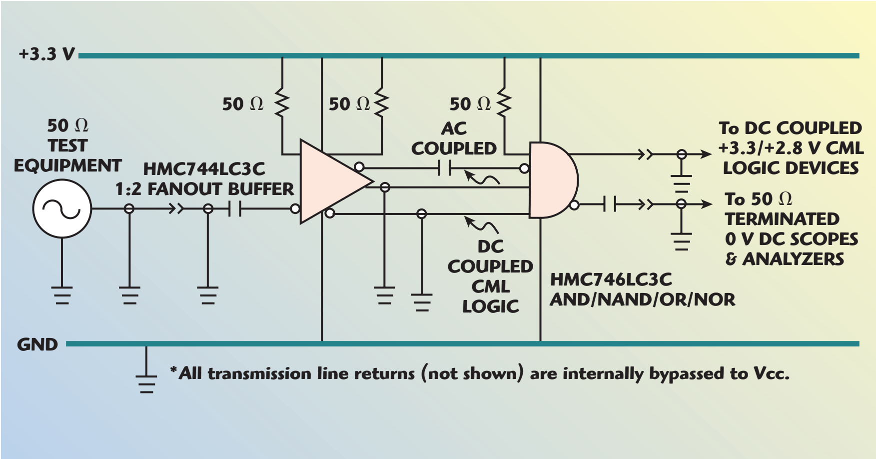


▲ *Fig. 3 High speed logic showing various interfacing and termination schemes.*

with 50 Ohm resistors to ground. With the exception of the HMC748LC3C 2:1 Selector, the inputs or outputs of this family of devices may be used in either single-ended or differential modes. Unfortunately, many high speed logic devices available on the market today suffer severe degradation when used in single-ended modes. One of the key features of these Hittite logic devices is that excellent jitter performance is maintained even when they are operated with single-ended inputs and outputs.

It should also be noted that while inputs and outputs are terminated to the positive supply, all transmission line returns are at ground and are internally bypassed on-chip to support high speed operation. This allows the CML inputs and outputs to be connected to RF test equipment referenced to ground.

The HMC706LC3C, HMC744LC3C, HMC745LC3C, HMC746LC3C, HMC747LC3C, and the HMC749LC3C logic devices represent the first products in this new +3.3 V logic family; additional products with complementary functions will be released in the coming months. These devices are specified for operation from -40° to +85°C, and are housed in ceramic RoHS compliant 3 x 3 mm SMT packages.

In addition to the seven +3.3 V logic devices discussed here, Hittite offers a wide range of -3.3 V, 13 Gbps/13 GHz logic products to cover a variety of design specifications. The HMC670LC3C through HMC673LC3C series were the first generation of 13 Gbps devices operating from -3.3 V supply, but with proprietary pinouts, adjustable voltage outputs and rise/fall times in the 24/22 ps range. The HMC678LC3C and HMC679LC3C also provide proprietary pinouts, adjustable voltage outputs but with faster rise/fall times in the 17/15 ps range. The HMC720LC3C through HMC723LC3C series also feature proprietary pinouts, and adjustable voltage outputs, but with faster rise times than the original HMC670LC3C through HMC673LC3C series. The HMC724LC3C through HMC729LC3C are pin-compatible industry replacements with rise/fall times as fast as 17/15 ps. To cover OC-768 market requirements, Hittite recently released four 43/50 Gbps connectorized logic devices that are housed in miniature hermetically sealed modules and operate from -3.3 V, while consuming less than 690 mW.

Designers looking for versions of these products with alternate pinouts, alternate DC power supply voltages or higher operating speeds should contact Hittite Microwave directly. Multiple logic functions may also be combined to provide products with higher levels of integration, and these may be made available in SMT packages or module format to meet the needs of custom applications.

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

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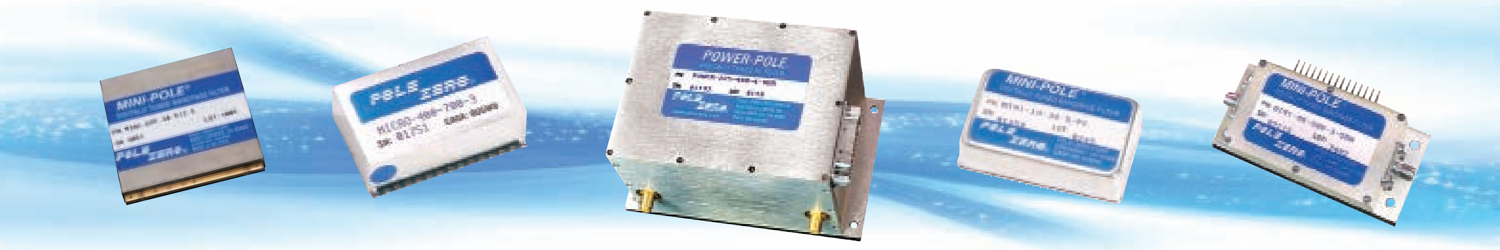


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# PORTABLE 6.4 GHZ RF SIGNAL GENERATOR

In order to provide customers with a light weight, compact, low cost alternative to high-end laboratory-grade instruments, AnaPico has developed the APSIN range of RF signal generators. First came the APSIN3000 that covers the 9 kHz to 3.3 GHz frequency range, which has now been joined by the newly introduced APSIN6000, which, like its sister version, is a truly portable RF signal generator. The new model completes the company's product family with an instrument extending the frequency coverage up to 6.4 GHz, especially covering all frequency bands of interest between 5 and 6 GHz. The APSIN6000 is available with an optional internal rechargeable battery that makes it ideally suited for applications outside of the lab, without any compromise in RF performance.

Both the APSIN3000 and the APSIN6000 have a 0.001 Hz fine resolution, and the wide frequency coverage makes them suitable for EMC and R&D labs. The key performance characteristics of both signal generators are summarized in ***Table 1***. Also, users benefit from very low phase noise, fast switching speeds, high reliability, and ease of operation in a variety of applications, especially mobile or airborne applications, automated testing and manufacturing, military communications and radar, or wireless systems research and field testing.

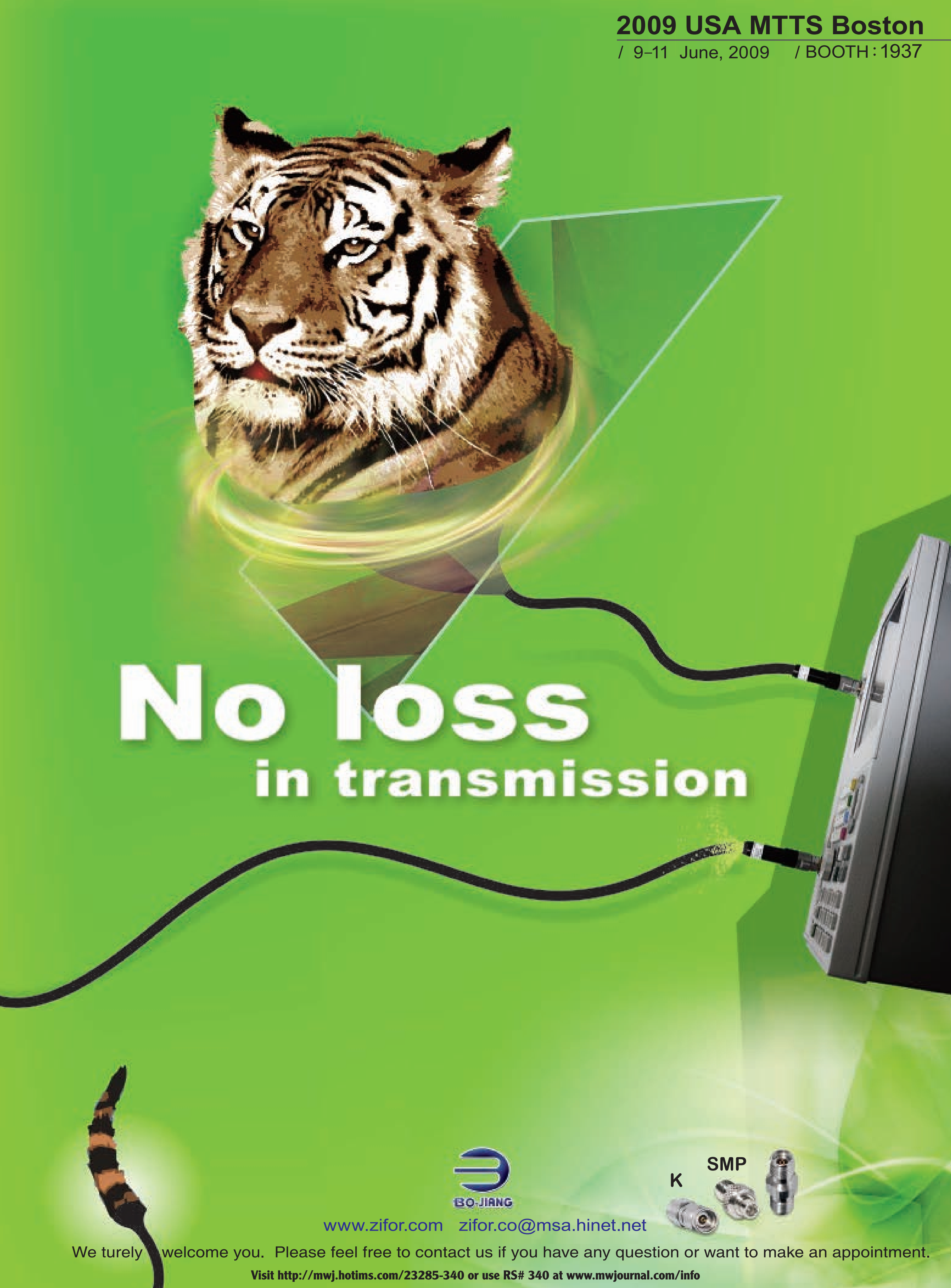
The APSIN6000 emulates the APSIN3000 in providing all required functions in one small box and is fully equipped in its standard configuration, supporting analog AM, FM, φM and pulse modulation. Moreover, an internal low frequency generator provides modulation and pulse signals, which are directly accessible at the rear panel. That multi-function output can also be configured to provide the pulse video or trigger signal.

The internal rechargeable battery makes it a truly portable instrument, which is particularly attractive for service installation and maintenance applications. Importantly too, a powerful PC user interface (Ethernet-based) allows very efficient remote access from a PC or laptop.

## SYSTEM ARCHITECTURE

***Figure 1*** shows a block diagram of the signal source core. The RF signal generator uses advanced phase-locked loop and direct digital synthesis concepts in combination with intelligent frequency planning, thus avoiding bulky microwave components like YIGs or mechanical filters, to deliver key performance without compromising a compact and power-saving design.

ANAPICO AG
*Zurich, Switzerland*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The signal generator uses an ultra-stable 100 MHz oven-controlled crystal oscillator (OCXO) as an internal reference. The OCXO has a temperature stability of 100 ppm over a range of 0° to 85°C. If required, the OCXO can be phase locked to an external reference between 1 and 100 MHz using the reference phase-locked loop. Both the reference input and output are at the rear panel.

The 100 MHz OCXO signal is multiplied and divided down (FRAC N1) to derive a variable reference frequency with micro-hertz resolution to the main phase-locked loop. The PLL along with a second divider (FRAC N2) phase locks the voltage-controlled oscillator (VCO) to the variable reference frequency. The VCO output, or the respective multiplied (N3) or divided (N2) versions thereof, are then filtered by programmable bandpass filters and fed into an amplifier chain. Several RF switches (SPxT) combine the multiple signal paths into a common output.

The internal power sensor of the automatic level control (ALC) circuit detects the power level and provides error voltages that are fed back to the variable gain amplifiers to adjust the output power to the desired level. The internal power detector is calibrated individually for each device and has a low temperature drift, guaranteeing a very accurate and temperature-stable output power level. An output circuit provides more attenuation and protects against overvoltage and reversed power.

**TABLE I**

**PERFORMANCE SUMMARY OF THE APSIN RF SIGNAL GENERATORS**

| | APSIN3000 | ASPIN6000 |
|---|---|---|
| Frequency resolution | 9 kHz to 3400 MHz 0.001 Hz | 9 kHz to 6400 MHz 0.001 Hz |
| Level uncertainty | –100 to +13 dBm<br>< 1 dB | –100 to +13 dBm<br>< 1 dB |
| Spectral purity | –130 dBc/Hz<br>(1 GHz; 20 kHz off) | –115 dBc/Hz<br>(5 GHz; 20 kHz off) |
| Harmonics | < –35 dBc | < –35 dBc |
| Switching time | 1 ms | 1 ms |
| Modulation | AM, FM; PM, pulse modulation | |
| Remote control | Ethernet (TCP/IP); SCPI 1999 | |
| Connectors | RF, pulse, FM/PM in, Trigger in, Func out (Pulse video out, LF generator out, Trigger out), REF in, REF out | |

## SIGNAL PURITY

A signal with excellent phase noise, low spurious and harmonic content is derived. The measured phase noise is shown in ***Figure 2***. A single-sideband phase noise of less than –130 dBc/Hz at 1 GHz carrier and 20 kHz offset is achieved, making the signal generator attractive for all applications that require spectrally pure signals.

## A FAST SWITCHING SYNTHESIZER

Today, most ATE applications require fast switching of power and frequency to maximize throughput in manufacturing and testing, and special care has be taken to minimize transients during switching from one frequency to another. As a result, both the APSIN6000 and APSIN3000 offer frequency and power sweeps with very short settling times, typically below 50 µs for a 1 GHz step.

This inherent fast-switching yields fast sweeps with very precise timing. List sweeps can be run with individual dwell time, off time and power level for each frequency. Even long lists can be loaded and executed with high timing accuracy because transients are taken into account. Short dwell times as low as 200 µs are supported and external triggering (via rear panel input or SCPI) allows full synchronization to the test environment.

## HIGH OUTPUT POWER

In many applications (such as mixers with high LO drive level), a high RF power is desirable to avoid complicated and costly setups with external power amplifiers. As standard, the new RF signal generator provides high output power with low harmonic content. The level setting range is –100 to +13 dBm over the entire frequency range, with typical over-range greater than 18 dBm (see ***Figure 3***).

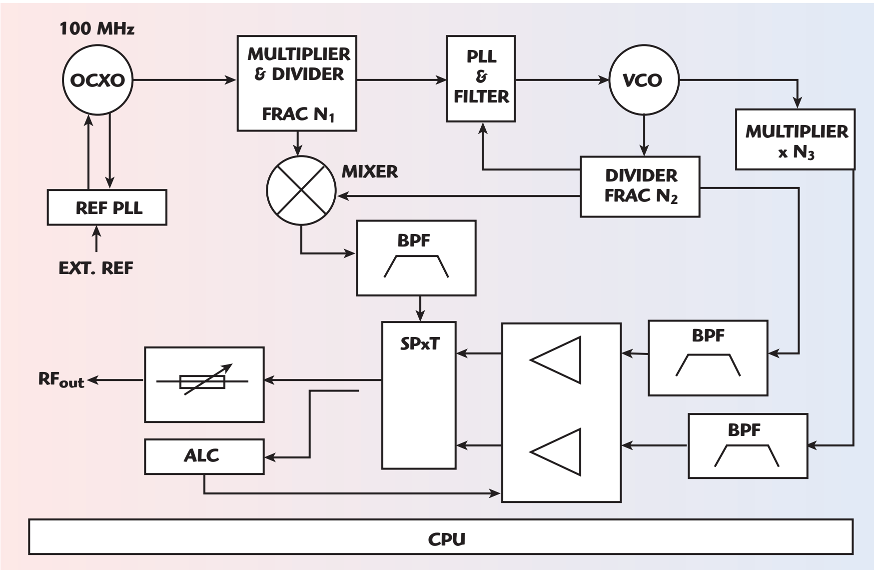



*Fig. 1 Block diagram of APSIN RF signal generators.*

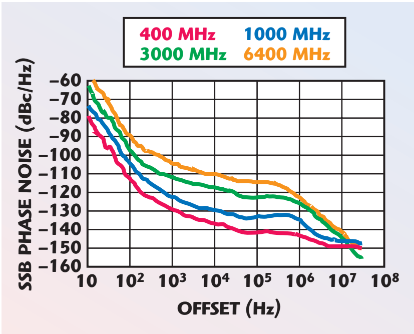
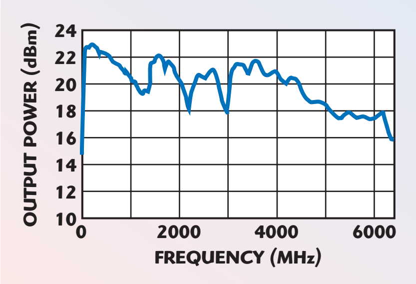
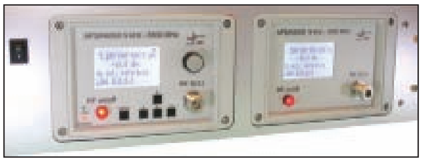



*Fig. 2 Measured SSB phase noise.*




▲ *Fig. 3 Maximum output power of the APSIN6000.*

▲ *Fig. 4 The mains-free operation provides advantages in field testing.*



▲ *Fig. 5 Nineteen-inch rack mount holding two APSIN signal generators at 3U height and 30 cm depth.*

For applications requiring a level setting range not exceeding 45 dB, a cheaper solution is available without the output attenuator. The good level accuracy and repeatability of the instrument (level uncertainty typically < 0.5 dB with ALC on) provides users with reliable measurement results.

## FAST PULSE MODULATION

Besides supporting basic AM, FM and PM modulation, both the APSIN6000 and APSIN3000 support fast pulse modulation with on/off dynamics of 80 dB. The internal pulse modulator produces pulses as short as 100 ns with programmable duty cycle and rise and fall times of only 5 ns. Bit streams can be loaded into the signal generator to generate arbitrary pulse patterns.

## VERSATILE REMOTE CONTROL

Another key feature of the new instrument is that its ease of use helps to ensure that lab staff and manufacturers can use it very efficiently. User-friendly features, such as an intuitive front panel with an LCD display, a Windows™-based graphical user interface, Ethernet LAN connectivity for effortless automated tests and remote control, and web-browser access allow efficient handling and control of the instrument. Supporting the standard SCPI interface language, the signal generator is more than just a replacement for older bulky GPIB-controlled equipment.

When test systems include legacy signal generators that are no longer manufactured or can no longer be repaired, switching to other types of generators is usually a costly exercise. It often results in the time consuming task of modifying the remote control software, provided that the source code is still available. On request, the APSIN models can be supplied with control emulation modes for a wide variety of signal generators, which allows cost-efficient substitution of legacy signal generators.

## HANDHELD APPLICATIONS

A major feature is a battery-operated (good for three hours of operation), field-proven design so powerful, yet so small that it can fit into a backpack. Its excellent performance combined with ease-of-use and broad functionality makes it an ideal solution for field environments and applications that require mobility such as site surveys (as illustrated in ***Figure 4***), on-site system test or base station receive level calibration.

Both CW and modulated test signals can be generated over a wide range of frequencies and levels. This provides the user with test signals required to carry out measurements such as intermodulation, gain or sensitivity. The instrument's flash memory holds several setups and preloaded list sweeps that can be executed on-site, while the rugged but light weight (2.5 kg) design makes the instrument truly portable.

## AUTOMATED TESTS AND PRODUCTION

The low-power and fan-less design is ideal for applications in space-limited and thermal-constraint ATE systems. The variety of connectivity options and the signal generator's low profile of 10 cm high by 17 cm wide, which are dimensions shared by the APSIN3000, further enhance the APSIN6000's ATE advantages.

The increased throughput and lower cost of test created by the fast switching speed also make it suitable for high volume component manufacturing such as RFIC and MMIC testing. The 19-inch rack-mount kit holds two units side-by-side in a 3 HE format (as shown in ***Figure 5***), allowing dense installations in space critical environments.

A front panel with only the status display and the RF on/off button is available for applications that exclusively use computer remote control and, on request, the RF output can be configured to the front or rear panel.

## CONCLUSION

With the new APSIN6000 signal generator, AnaPico has completed its product offerings with a highly flexible, truly portable RF signal generator that does not make performance compromises. Alongside the APSIN3000, it provides all functionality and performance that is expected from today's RF signal generators. Its small form factor, light weight, optional internal batteries, low cost and high reliability make it the right RF signal source for a wide range of applications.

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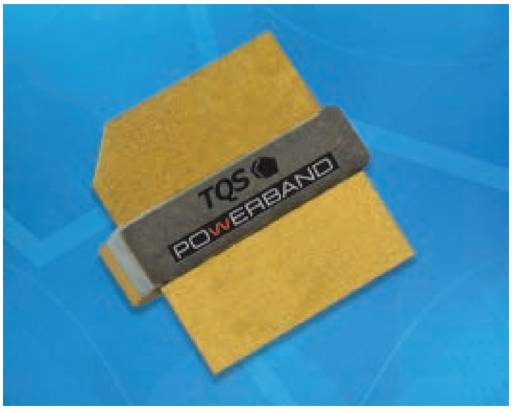


# REDEFINING EFFICIENCY FOR HIGH POWER WIDEBAND RF DESIGN

Engineers who have only witnessed the challenges of wideband design from a distance may wonder why their peers take on such projects. After all, narrowband is more 'comfortable', with ample choices of low cost, high performance RF transistors. But for broadband applications such as two-way radios for first-responders, RF jammers and select radar or repeater applications, designing lightweight, highly portable end-user products is hampered by the necessity of large amplifier systems that trade efficiency performance for frequency bandwidth coverage.

In the narrowband universe, relatively high efficiency performance is possible when devices are placed in ideal impedance environments; delivering a cost-effective design approach is fairly straightforward. The broadband landscape is altogether different. Amplifiers are more difficult to design and the performance trade-offs can discourage even the most die-hard engineering intellect. Broadband high power amplifiers are typically inefficient comparatively speaking, resulting in larger, heavier systems. A wideband application by necessity often requires more elaborate cooling mechanisms and despite the best engineering efforts, exhibits inferior performance in key categories compared to narrowband counterparts.

For the design engineer who has fought the wideband battle and persevered, for those still struggling and for those who seek a better way, TriQuint has developed a solution. There's a new discrete RF transistor that changes the equation dramatically and is already being designed into wideband systems around the globe. This new solution is called PowerBand™ (see ***Figure 1***).

## COMMON GROUND

There are several elements common to both narrowband and broadband high power amplifier designs with semiconductors, including operating voltage, class of operation and matching network considerations. Operating voltage is a key design element in high power applications. RF amplifier design becomes more difficult as the requirement for RF output power increases. This is due to several factors, but it is dominated by the inverse relationship between device size and device impedance. Later in the design process, the engineer will have to transform low impedances to higher levels via matching networks. Device impedance is primarily a factor of operating voltage, semiconductor technology and device size. As a result, designers naturally want to start with RF tran-

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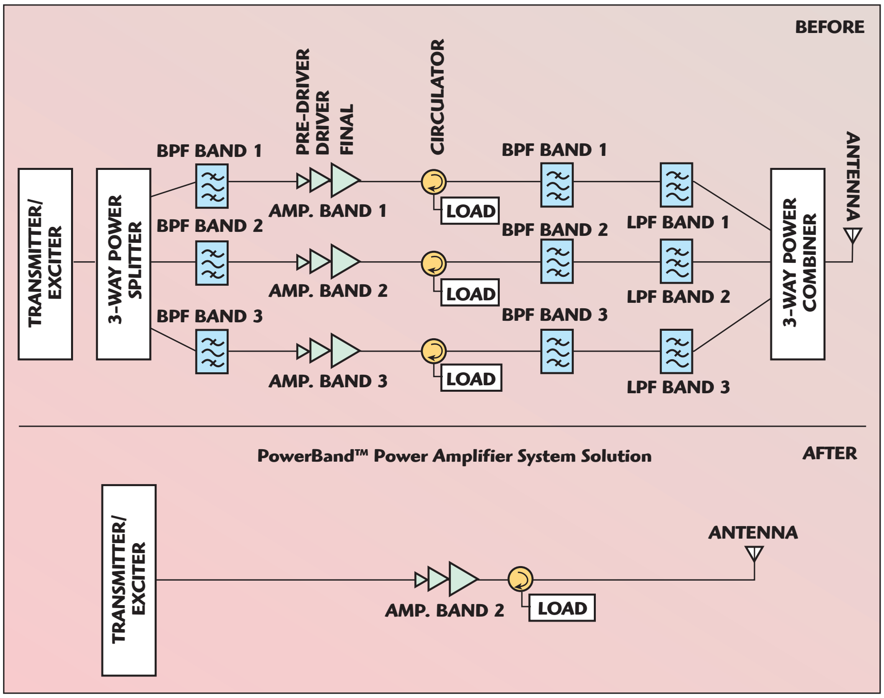



▲ *Fig. 1 Block diagram illustrating how PowerBand can streamline system architecture.*

sistors that can function at the highest possible operating voltage since impedance matching is much easier with transistors that operate at higher voltages, such as 28 V compared to 12 V.

Class of operation is often dictated by system linearity design goals at the expense of efficiency. The RF amplifier designer therefore strives to fine tune the point in a given class of operation that maximizes efficiency while meeting linearity goals. Communications systems tend to be very focused on linearity for digital modulation schemes whereas applications such as RF jammers focus on power and efficiency.

The challenge for matching networks is to create the impedance for both the input and output of the transistor so that optimal performance can be obtained from the device. The input matching network must also allow the incoming RF signal from the stage feeding the PA to transition fully into the power amplifier stage without excessive reflection, which is also known as input return loss. Similarly, the output must provide the impedance the device requires for strong performance while also producing acceptable impedance for the circuit it feeds, such as another amplification stage, filters, switches, the antenna, etc.

In creating matching networks, designers rely on impedance and associated device performance data in the form of load-pull and source-pull tables and graphical contours provided by manufacturers. As engineers tackling these designs discover, various performance characteristics, such as gain, efficiency and output power actually require different impedances for peak performance. The designer is challenged with selecting an impedance point that provides the best overall trade-off in performance for meeting system design goals. Generally speaking, gain is sensitive to obtaining a good input match while efficiency and RF output power tend to be more sensitive to the output match.

## THE CHALLENGE OF GOING WIDE

Wideband high power RF amplifier designers must deal with all the challenges of narrowband designs while simultaneously coping with the added complexity of creating matching networks that continue to provide the RF power transistor with an acceptable impedance as the frequency changes by two octaves or more. If this wasn't already difficult enough, many manufacturers of RF power transistors do not provide load and source-pull data across the entire useful frequency band of a given device. If the designer

is fortunate enough to have an automated source and load-pull tuner system, which most do not, and is able to obtain the device impedances across the entire band of interest, they often find that the impedances required for stable, high performance operation are beyond the abilities of traditional matching networks. The problem is proportional to device capacitance, which is proportional to device size. This often leads engineers down a path of designing smaller (in terms of RF output power) amplifiers and then combining these smaller stages to achieve the desired system RF output power. This comes at a huge expense in terms of development cost, size and weight, as well as overall system costs. If the bandwidth is too great, designers resort to "channelizing" or breaking the frequency band into sections, creating amplifier stages that only target frequencies in a given range. Again, this comes with a significant financial, size and weight burden.

## ADVANCED SEMICONDUCTORS & BROADBAND DESIGN

In general, high voltage compound semiconductors such as Gallium Nitride (GaN) technology have much lower capacitance per Watt of RF output power than those of other process technologies. In other words, they have higher impedances. For this reason, narrowband systems that require very high output power from a single-ended amplifier tend to turn to high voltage GaN-based power transistors. Similarly, broadband designers also take advantage of the impedance benefits of GaN because it allows them to build matching networks that operate over a greater bandwidth for a given output power level. Although more expensive than traditional technologies such as LDMOS on a per device basis, the system level cost savings of GaN are undeniable. Often, use of an advanced technology like GaN is the only reasonable solution for systems with aggressive design goals.

While advanced semiconductors like GaN have made wideband designs easier and in many cases possible, the performance is still quite low relative to what can be achieved in narrowband designs, especially in terms of efficiency. Even employing the GaN technologies now available, most current wideband designs are only able to achieve 25 to 35 percent efficiency in the final power amplifier stage.

## DATA THAT DOESN'T FIT A WIDEBAND WORLD

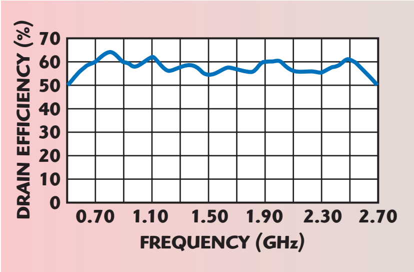
Some manufacturers market traditional RF transistors without internal matching as wideband devices. But they do not adequately characterize the transistors for use in wideband circuits. In many cases, narrowband data is published on a given device at only the high and low ends of the intended frequency range. It is much more useful to publish the "instantaneous bandwidth" RF performance, to include, at minimum, gain, efficiency and output power. Instantaneous bandwidth is commonly defined as performance for a given device in an RF fixture with bias circuitry and matching network in place so the device can be tested from one end of the frequency band to the other, with no changes being made to the circuit or device. This is different than testing a device at various frequencies in different test fixtures, each tuned to work well at a single frequency.

## POWERBAND BRIDGES THE DATA DIVIDE

In contrast to traditional RF transistors, PowerBand device data sheets contain instantaneous bandwidth as well as narrowband RF performance. A table of source and load impedances is also provided along with the RF gain, efficiency and P1dB output power performance levels. In addition, a Smith chart graphic shows the optimal input and output impedance of the matching network from the low end to the high end of the band. This data is derived from placing a given device in the stated impedance environment across the entire band of operation in 100 MHz increments.

TriQuint offers narrowband data on PowerBand devices since it is useful, providing designers a sense for the degree of trade-off between wideband and narrowband performance. In addition, wideband devices are very versatile and engineers are designing them into narrowband applications for several reasons. First, wideband devices offer greater flexibility than internally matched devices, in that a




▲ *Fig. 2 Measured efficiency data of a PowerBand device in a test fixture.*


▲ *Fig. 3 PowerBand 100 W GaN device under development.*

single device can be used on multiple product platforms. For example, communication radio manufacturers often have several versions of a given radio that operate at different frequencies. In this case, a single PowerBand device can be used for all three radios, whereas a design employing traditional, internally matched RF transistors would require different devices for each frequency variation. In addition, designers of non-telecom systems often find it difficult to locate internally matched RF power transistors that are designed to operate in their band of interest.

## A NEW WIDEBAND DESIGN PERSPECTIVE

TriQuint Semiconductor approached the challenges of wideband design from an entirely new perspective that included studying the various approaches to broadband matching and impedances across a given frequency band. The goal was to create an RF power transistor that would perform well in such an impedance environment, with an emphasis on output power and efficiency. The results were dramatic: efficiency across the band (500 MHz to 3 GHz) was increased from an average of 25 to 35 percent to between 45 and 55 percent, as shown in ***Figure 2***. This was accomplished while being able to simultaneously utilize more than 75 percent of the devices' rated narrowband P1dB output power capability compared to a more typical usage of approximately 25 percent with traditional approaches.

## THE POWERBAND PORTFOLIO

The TriQuint PowerBand portfolio currently consists of five products. The T1P2701012-SP is a 12 V (operating voltage) pHEMT device, operating from 500 MHz to 3 GHz; it produces 10 W P1dB (instantaneous bandwidth). The T1L2003028-SP is a 28 V (operating voltage) LDMOS-based device, operating from 500 MHz to 2 GHz and producing 30 W P1dB (instantaneous bandwidth). The T1P3002028-SP, T1P3003028-SP and T1P3005028-SP are 28 V (operating voltage), pHEMT-based products operating from 500 MHz to 2 GHz. They are designed specifically for pulsed applications and produce 20, 30 and 50 W P1dB output power (instantaneous bandwidth), respectively.

## CONCLUSION

High power amplifier design is difficult; high power, broadband design pushes the envelope farther. Until now, performance-reducing compromises were inevitable as part of the balancing act every broadband designer was forced to perform to achieve system operating goals. While offering significantly greater bandwidth coverage and breakthrough levels of efficiency, the current PowerBand device portfolio achieves output power levels from 10 W (P1dB CW) through 50 W (P1dB pulsed). Many applications require even higher output power. The PowerBand design team recognizes this need and is at work to introduce a GaN-based portfolio in 2009 that will include a 100 W P1dB CW device (see ***Figure 3***).

**TriQuint Semiconductor Design Center, Boulder, CO (720) 834-0017, info-powerband@tqs.com, www.triquint.com/powerband.**

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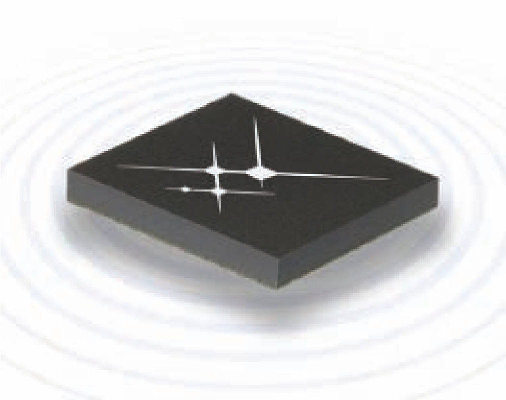
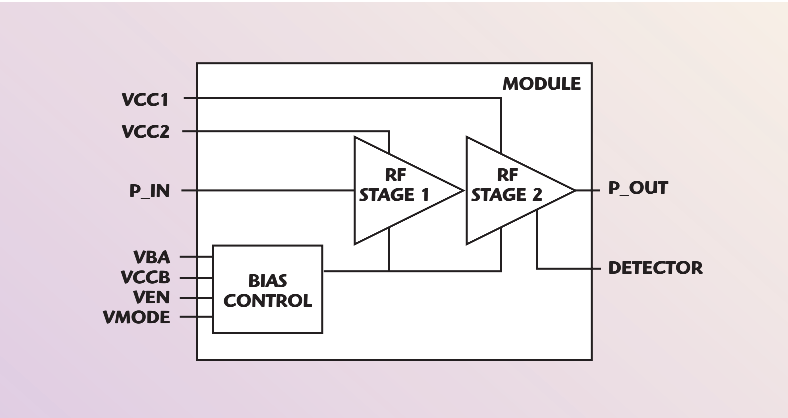


# MULTI-MODE, MULTI-BAND PA MODULE FOR LTE

The SKY77441 Power Amplifier Module (PAM) is one of the first products available specifically targeting Long Term Evolution frequency division duplex (TDD) bands 38 and 40. LTE TDD is expected to become a widely used 4G standard that mobile operators utilize in China and other parts of the world. According to Strategy Analytics, the global LTE handset market is expected to reach 150 million units by 2013.

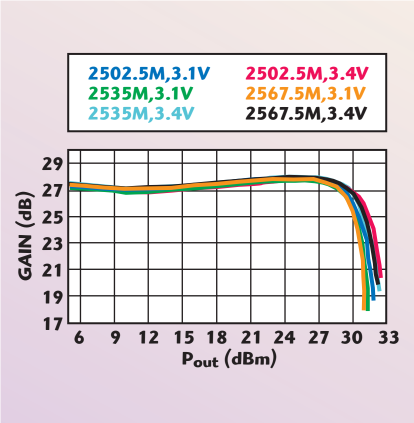
The SKY77441 is a fully matched, surface-mount module developed for Long Term Evolution (LTE) and Evolved Universal Terrestrial Radio Access Network (EUTRAN) frequency division duplex (FDD) and TDD applications. Its compact size makes it ideal for mobile applications such as data cards and handsets. This small and efficient module packs full coverage of LTE FDD Band VII and LTE FDD Bands 38 and 40 into a single compact package, and is capable of delivering the linear wideband code division multiple access (W-CDMA) power up to 28.5 dBm from 2.3 to 2.7 GHz. The SKY77441 meets the stringent spectral linearity requirements of LTE modulation with quadrature phase-shift keying (QPSK) and 16 quadrature amplitude modulation (16QAM) from 1.4 to 20 MHz bandwidth and up to 100 full or partial resource block allocations with high power-added efficiency.

Integration of the PAM simplifies the design of the 4G-compatible handset radios and data cards as all the active RF circuitry, including the PA, input, interstage and output matching circuits and power detector are optimized within the single module component. See ***Figure 1*** for a block diagram of the module. Output match is realized off-chip within the module package to optimize efficiency and power performance into a 50 Ω load. The device is manufactured with Skyworks' InGaP BiFET process that provides for all positive voltage DC supply operation while maintaining high efficiency and good linearity. Primary

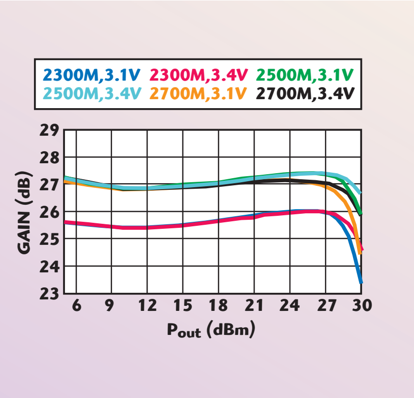



▲ *Fig. 1 Block diagram of SKY77441.*

SKYWORKS SOLUTIONS INC.
*Woburn, MA*



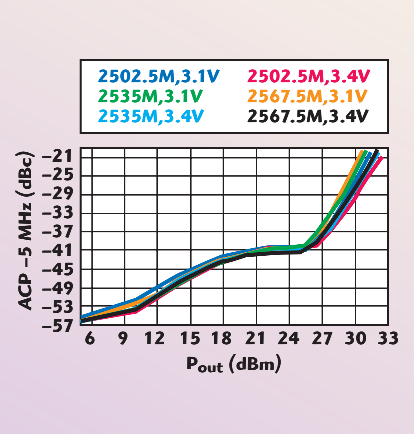

▲ *Fig. 2a SKY77441 gain for LTE QPSK–5 MHz –8RB left/right modulation at 3.1 and 3.4 V across Band VII frequencies (2.5 to 2.57 GHz).*



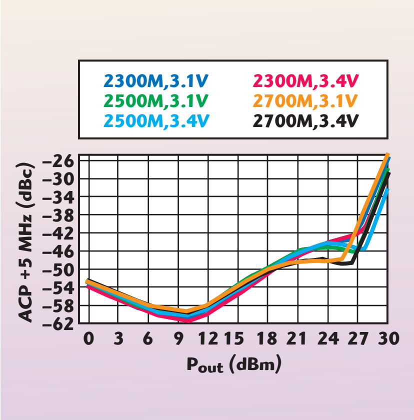

▲ *Fig. 2b SKY77441 gain W-CDMA GTC1 modulation at 3.1 and 3.4 V across Band VII, 38 and 40 frequencies (2.3 to 2.7 GHz).*

bias to the SKY77441 is supplied via the VCC1 and VCC2 pads directly from a three-cell Ni-Cad, a single-cell Li-Ion, or other suitable batteries with outputs in the 3.0 to 4.6 V range, while the bias network is powered up with the VCCB pad. DC-DC converter operation can be supported with lower power operation down to 1.5 V. Power down is accomplished by setting a logic low level on the VEN pad. No external supply side switch is needed as typical "off" leakage is 100 microamperes with full primary voltage supplied from the battery. The VMODE pad is used to switch between high and low power modes to reduce current consumption and gain in the back-off conditions. VBA is used to further control the current consumption in the low power mode.

The SKY77441 delivers over 26 dBm of linear power output with full LTE resource block allocation under either QPSK, or 16QAM, and 28.5



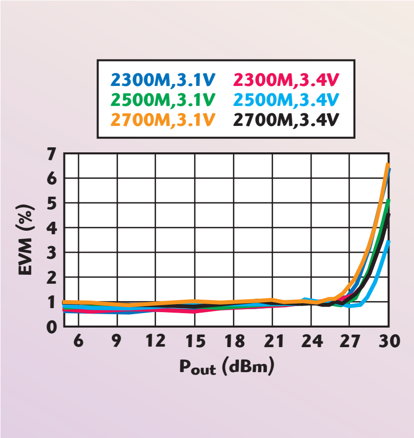

▲ *Fig. 3a SKY77441 ACPR1 for LTE QPSK –5 MHz –8RB left/right modulation at 3.1 and 3.4 V across Band VII frequencies (2.5 to 2.57 GHz).*



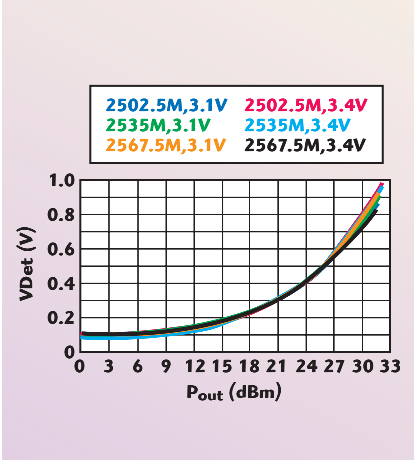

▲ *Fig. 3b SKY77441 ACPR1 for W-CDMA GTC1 modulation at 3.1 and 3.4 V across Band VII, 38 and 40 frequencies (2.3 to 2.7 GHz).*

dBm of linear output power under W-CDMA modulation. See ***Figure 2a*** and ***2b*** for plots of gain versus $P_{out}$ at 25°C at various frequencies and voltages for LTE QPSK and W-CDMA, respectively. ***Figures 3a*** and ***3b*** show ACPR1 for LTE QPSK and W-CDMA modulations versus $P_{out}$ at various frequencies and voltages. ***Figure 4*** shows EVM versus $P_{out}$ at various frequencies and voltages for W-CMDA. EVM is less than 2 percent up to 27 dBm at 3.1 V and up to 28 dBm at 3.4 V. ***Figure 5*** shows a plot of the detector response for LTE QPSK at various frequencies and voltages. The module supports low-operating voltage down to 3 V with high power added efficiency and high reliability.

The SKY77441 is packaged in a low profile 16 lead, 4 × 4 × 0.85 mm surface-mount leadless package. The part uses Skyworks' Green Packag-




▲ *Fig. 4 SKY77441 EVM for W-CDMA GTC1 modulation at 3.1 and 3.4 V across Bands VII, 38 and 40 frequencies (2.3 to 2.7 GHz).*




▲ *Fig. 5 SKY77441 detector response for LTE QPSK –5 MHz –8RB left/right modulation at 3.1 and 3.4 V across Band VII frequencies (2.5 to 2.57 GHz).*

ing Technology so it is lead (Pb) free, Restriction of Hazardous Substances (RoHS) compliant, conforms to the EIA/EICTA/JEITA Joint Industry Guide (JIG) Level A guidelines, and is free from antimony trioxide and brominated flame retardants.

The SKY77441 is a multi-mode, multi-band LTE PAM that enables enhanced talk, viewing and broadcast times while complying with the stringent linearity requirements across wide frequency ranges for use in data cards, handsets and other applications where compact size and high performance are needed.

**Skyworks Solutions Inc.**
**Woburn, MA**
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**www.skyworksinc.com.**

***RS No. 301***

# IEEE Radio & Wireless Symposium

10 - 14 January, 2010, New Orleans, LA, USA

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**Electronic Submission Deadline: 2 August 2009 www.radiowireless.org**

# First Call For Papers

The 2010 IEEE Radio and Wireless Symposium (RWS2010) will be held the week of January 10, 2010 in New Orleans, LA. This year, RWS10 and SiRF10 will hold more joint sessions to highlight the indispensable use of silicon in modern wireless systems. In addition, RWS10 will include a ***Two Day Track of Sessions*** on:

- **RF Power Amplifiers**
- **Biomedical Applications of Microwave Systems**
- **Sensors and Sensor Networks**

Each of these highlighted topics will be organized separately, with their own call for papers found at http://www.radiowireless.org/. In addition to these topics, RWS invites papers on all areas of radio and wireless systems, including but not limited to:

- 3G/4G Wireless Communication Services
- Satellite Network Systems
- Wireless LAN Systems
- Software Defined/Cognitive Radio and other Emerging Technologies
- 802.16/LMDS Broadband Fixed Wireless Techniques and Last-Mile Access Techniques
- Wireless Mesh and Broadband Local/Personal Area Networks
- Wireless Sensor Technologies
- RFID Systems and Applications
- Spectrum Sensing Technologies
- Powerline Communication Technologies
- RF Tracking and Positioning Devices
- Ad Hoc Network Techniques for Anytime, Anywhere Internetworking
- Ultra-Wideband (UWB) Systems
- Microwave Energy Transmission
- Propagation and Channel Characterization and Modeling for RF and THz Systems
- Heterogeneous Mobile Networks and Mobile Network Convergence
- Multicasting and Broadcasting
- High Data Rate THz Communication Links, and THz Imaging Radar



Papers describing technologies that enable Radio and Wireless Systems are welcome including:

- Transmitter Components
- Receiver Components
- Highly Integrated Packaging
- Multilayer integration of RF, energy and sensing components
- Electrically Small, MIMO, and Smart Antennas
- Signal Generation and Modulation Circuits
- Methods of Maintaining Signal Integrity
- RF/Optical, Optical, and Fiber Techniques

Paper submission instructions will be found at http://www.radiowireless.org/. Submissions should be properly formatted with all figures included within a maximum of four pages. Only electronic submissions in pdf format will be accepted for review. Authors should indicate their preference for oral or poster presentation. All submissions must be received by **August 2, 2009**. All accepted papers will be published in a digest and be included in IEEE Xplore.

Submissions will be evaluated based on novelty, significance of the work, technical content, interest to the audience, and presentation.

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Allen Katz, *Linearizer Technology Inc./ TCNJ*

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Victor Lubecke, *Univ. of Hawaii*
Arye Rosen, *Drexel Univ.*

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# NEW WAVES: MTT-S PRODUCT SHOWCASE

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FEATURING VENDORVIEW STOREFRONTS

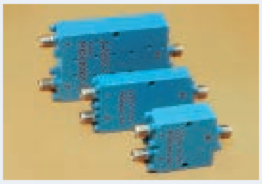
*The following booth numbers are complete as of April 15, 2009.*

## Aluminum Flange Stock

A-Alpha stocks aluminum waveguide flange stock in sizes from WR22 to WR137 and double-ridged sizes WRD180, 475, 580, 650 and 750. This 6063 extruded aluminum material precludes the need to broche corners in the windows of aluminum bar stock to manufacture flanges. The waveguide window is centered within 0.002 of the outside dimensions, and is within 0.002 of the selected waveguide opening. Aluminum flange stock compliments other waveguide products in stock at A-Alpha, including aluminum, copper, bronze, invar, stainless steel and coin silver waveguide tube, and aluminum and bronze cast bends. A-Alpha offers "same day" shipping for all items in stock.

***A-Alpha Waveguide Co.,***
***El Segundo, CA (310) 322-3487,***
***www.a-alphawaveguide.com.***
**Booth 2526** **RS 216**

## Power Dividers



Aeroflex/Inmet introduces a new family of Wilkinson Power Dividers to complement its current offering of resistive divider models. The new units are two-way SMA models and are of octave and multi-octave designs covering the popular bands of 0.5 to 1, 0.8 to 2.5, 1 to 2 and 2 to 4 GHz. All models are currently available from stock.

***Aeroflex/Inmet,***
***Ann Arbor, MI (734) 426-5553,***
***www.aeroflex-inmet.com.***
**Booth 1428** **RS 217**

## SPST Series Switch Elements

These new PIN diode series switch elements are designed for WiMAX, WiBro, TD-SCDMA, radios and other wireless telecommunication applications. They offer excellent thermal dissipation with the innovative thermal path to circuit board thermal ground. These products can support 10 W, DC to 10 GHz; 20 W, DC to 6 GHz; 50 W, DC to 3 GHz; and 100 W, DC to 2 GHz.

***Aeroflex Metelics West,***
***Sunnyvale, CA (408) 737-8181,***
***www.aeroflex.com/metelics.***
**Booth 1428** **RS 218**

## PIN Diode Attenuator

These state-of-the-art, digitally-controlled, voltage-variable PIN diode attenuators feature industry-leading temperature stability and are available in three bands from 0.5 to 18 GHz. Designs offer unsurpassed attenuation linearity and flatness over frequency address challenging requirements for ESM, ECM, EW and communication applications.

***Aeroflex/KDI – Integrated Products,***
***Whippany, NJ (973) 887-5700,***
***www.aeroflex.com/kdi-integrated.***
**Booth 1428** **RS 219**

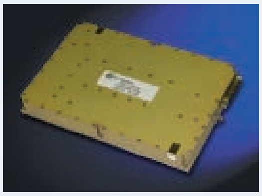
## Programmable Attenuators

VENDORVIEW

Models 3406 and 3408 are a series of 6 GHz relay switched programmable attenuators that are specifically designed for wireless/cellular, RF simulation/emulation and communication test applications. This series is available in many standard attenuation ranges and cell configurations (0 to 55/1 dB, 0 to 103/1 dB and 0 to 55.75/0.25 dB). Other features include SmartStep® (Models 3406T and 3408T) and optional TTL control circuitry; low SWR 1.45; maximum insertion loss is less than 5.0 dB at 6 GHz (for eight cell units); rugged construction and SMA connectors. These units are also available in the Aeroflex/Weinschel's SmartStep single or multi-channel attenuator units (8310 and 8311 Series). Custom designs and configurations are available.

***Aeroflex/Weinschel,***
***Frederick, MD (301) 846-9222,***
***www.aeroflex.com/weinschel.***
**Booth 1428** **RS 220**

## High Power Linear Amplifier

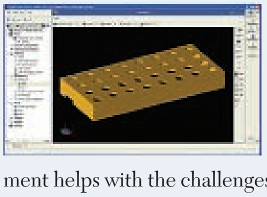


Model number SSPA 0.4-0.6-100 is a high power, high efficiency, RF amplifier that operates from 400 to 600 MHz. This PA is ideal for military platforms as well as commercial applications because it is robust and offers high power over a 200 MHz bandwidth with excellent power added efficiency. This amplifier was designed for high efficiency applications. It is packaged in a modular housing that is approximately 6" (width) by 9" (long) by 1.5" (height). This amplifier has a minimum P1dB of 100 W at room temperature. Noise figure at room temperature is 15 dB maximum. This amplifier offers a typical gain of 28 dB with a typical gain flatness of ±1.0 dB.

***Aethercomm Inc.,***
***San Marcos, CA (760) 598-4340,***
***www.aethercomm.com.***
**Booth 725** **RS 221**

## 3D EM Integration Streamlines Design Flows

VENDORVIEW

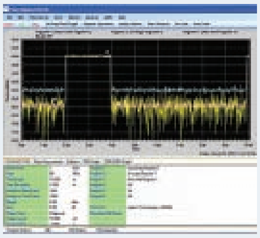


The integrated EM (Electromagnetic) portfolio inside Agilent's Advanced Design System (ADS) environment helps with the challenges of high frequency and highly integrated design work. EMPro, EMDS G2 and Momentum G2, assure the success of RF designs from circuit level up to the highest level of integration by eliminating errors and delays from re-entering designs into a separate EM tool. Agilent has just released EMPro 2009, which combines FDTD and FEM simulation technology to cover the broadest range of applications and cross-validation between frequency- and time-domain solvers to ensure the highest confidence in 3D EM simulation.

***Agilent Technologies Inc., EEsof Division,***
***Santa Clara, CA (800) 829-4444,***
***www.agilent.com.***
**Booth 1407** **RS 222**

## Pulse Measurement Software

VENDORVIEW



Automate pulse measurements and extend the value of a spectrum analyzer by combining signal analysis and time domain measurements. Electronic warfare and radar design and maintenance engineers can now quickly identify desired pulse parameters with the new Agilent N9051A pulse measurement software. The combination of the N9051A and an Agilent signal analyzer or oscilloscope performs calibrated pulse analysis for signals up to 50 GHz in carrier frequency and analysis bandwidths up to 13 GHz. Quickly characterize pulse performance using a wide range of parameters, including pulse width, rise/fall time, PRI, PRF, duty cycle, peak to average ratio, and much more in accordance IEEE 181 standards. Use the pulse analyzer software to gain statistical information such as PDF, CDF and CCDF.

***Agilent Technologies Inc.,***
***Signal Analyzer Division,***
***Santa Clara, CA (800) 829-4444,***
***www.agilent.com.***
**Booth 1407** **RS 223**

## Signal Generator

VENDORVIEW

This microwave signal generator with ultra-high output power capability simplifies high power test configurations and lowers costs by removing the extra hardware. The E8257D option 521 delivers from +24 to +28 dBm specified output power over a frequency range of 10 MHz to 20 GHz. Typical maximum unleveled output power exceeds +30 dBm over a large portion of the frequency range. To help protect users and UUTs (units under test) from high power accidents, a user adjustable RF output hardware power clamp (settable from +15 to +33 dBm at the output of the PSG) that works with both internal and external leveling configurations will be provided. For higher power, narrow frequency range applications,

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Now, Mini-Circuits offers a USB Power Sensor and software together with your laptop that will ***reduce your equipment costs*** and provide new application features that will simplify your power measurements. Having a measurement range of -30 to +20 dBm at frequencies from 1 to 6000 MHz. The PWR-6G+ is supplied with easy-to-use, Windows-compatible measurement software to speed and simplify your power measurements, allowing you to set as many as 999 averages and to record results for further analysis. The PWR-6G+ USB Power Sensor provides 0.01-dB measurement resolution and impressive accuracy over temperature.
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457 rev D

# NEW WAVES

the maximum RF output clamp setting of +33 dBm provides access to the PSG's maximum available unleveled power.

***Agilent Technologies Inc.,***
***Signal Sources Division, Santa Clara, CA***
***(800) 829-4444,***
***www.agilent.com.***
***Booth 1407*** ***RS 224***

## High Power Pulsed IV/RF System

This new generation high power pulsed IV/RF measurement system is designed for GaN or LDMOS high power devices. The PIV-240-10 high power pulse pattern generator (240 V, 10A) can be used as a standalone application for semiconductor pulsed IV characterization (or integrated in a load-pull environment), combining input/output pulse power heads and voltage/current acquisition units. Synchronized with Agilent PNA-X with a flexible application, it offers the most versatile, robust and accurate pulsed IV/RF measurement system on the market.

***AMCAD Engineering,***
***Limoges, France +33 555 040 531,***
***www.amcad-engineering.com.***
***Booth 635*** ***RS 225***

## Digital Programmable Attenuator

VENDORVIEW

AMC Model PI-DVAN-8012 OPTION JC is an 8 to 12 GHz phase invariant digital programmable attenuator. A double-balanced arrangement of quadrature couplers and PIN diodes gives phase invariant attenuation. It offers an attenuation range of 40 dB, insertion loss of < 6.5 dB and VSWR of 1.8. This model offers attenuation accuracy of ±0.5 dB, flatness of ±0.8 dB from 0 to 20 dB and ±1.0 dB from 20 to 40 dB. Phase shift of ±7° from 0 to 20 dB and ±20° maximum from 20 to 40 dB. Switching speed is < 200 nSec. It has a 9 bit TTL control. Power supply is +7 to +12 V DC at 300 mA maximum. Size is 2.5" × 3.5" × 0.4".

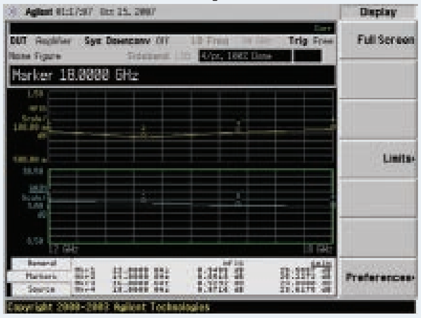
***American Microwave Corp.,***
***Frederick, MD (301) 662-4702,***
***www.americanmicrowavecorp.com.***
***Booth 1646*** ***RS 314***

## Ultra-broadband Capacitor

ATC's new 550L ultra-broadband capacitor is manufactured with high quality materials to provide reliable and repeatable ultra-broadband performance from 16 kHz through 40+ GHz. It exhibits ultra-low insertion loss, flat frequency response and excellent return loss. The 550L is a one-piece orientation-insensitive 0402 SMT package, fully compatible with high speed automated pick-and-place manufacturing. It is designed to meet the most stringent requirements of optical high speed data networks, broadband wireless communications, broadband test equipment, high speed Internet routers and many other applications.

***American Technical Ceramics,***
***Huntington Station, NY (631) 622-4700,***
***www.atceramics.com.***
***Booth 1324*** ***RS 226***

## 12 to 18 GHz Amplifier




This amplifier operates in a frequency range from 12 to 18 GHz. The amplifier is a breakthrough in amplifier technology because the noise figure is 0.9 dB over the entire band. Not only is the noise figure consistent across the band, but so is the gain and output power. The APT2-12001800-1105-D2 is available in the company's smallest housing (D2).

***AmpliTech Inc.,***
***Holbrook, NY (631) 521-7831,***
***www.amplitechinc.com.***
***Booth 607*** ***RS 227***

## RF Mixers


ADL5801 single-channel active mixer complements the ADL5802 dual-channel active mixer. ADL-5355/57 high performance, single-channel passive mixers, specified for operation across the cellular frequency ranges, complement the ADL5356, ADL5358 and ADL5360 dual-channel passive mixers.

***Analog Devices Inc.,***
***Norwood, MA (781) 329-4700,***
***www.analog.com.***
***Booth 2030*** ***RS 228***

## Portable RF Signal Generator

AnaPico AG presents the APSIN6000 portable RF signal generator ranging from 9 kHz to 6500 MHz with a 0.001 Hz frequency resolution. Key performance figures (e.g. phase noise, long-term frequency stability, maximum power level) of the APSIN6000 compare well with today's high-end equipment while coming in a very small form factor. The low DC power consumption makes the generator an ideal solution for automated test systems (VXI-11/SCPI 1999 is supported), laboratory use, and outdoor and mobile environments (available with internal rechargeable battery).

***AnaPico AG, Zürich, Switzerland***
***+41-44-440 00 51, www.anapico.com.***
***Booth 2542*** ***RS 229***

## WiFi Cavity Bandpass Filter

VENDORVIEW

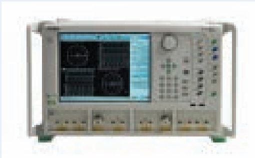
The model AB2436B479 is a cavity bandpass filter designed for suppressing interference to improve the performance of IEEE 802.1a/b/n

access points located in outdoor environments. The eight-cavity model AB24-36B479 has a center frequency of 2436.5 MHz, -3 dB bandwidth of 70 MHz, typical insertion loss of 0.9 dB at center frequency, typical return loss of 18 dB, and typical harmonic rejection of 90 dB. Selectivity at center frequency ranges from less than 91 MHz at a 20 dB bandwidth to less than 150 MHz at a 60 dB bandwidth. The filter will handle an RF input power of 50 W, has an operating temperature of -40° to +85°C and measures 4.84" × 2.8" × 1.22".

***Anatech Electronics Inc.,***
***Garfield, NJ (201) 772-4242,***
***www.anatechmicrowave.com.***
***Booth 2242*** ***RS 230***

## Microwave Vector Network Analyzer

VENDORVIEW



Anritsu Co. introduces the VectorStar® premium series of microwave vector network analyzers (VNA). VectorStar delivers best-in-class frequency coverage of 70 kHz to 70 GHz, dynamic range of 103 dB at 67 GHz, and measurement speed of 20 µs/point to establish a new performance benchmark for S-parameter measurements on RF, microwave and millimeter-wave devices. It brings unprecedented performance to traditional VNA markets, including aerospace/defense, satellite, commercial microwave communications, materials measurement and advanced research.

***Anritsu Co.,***
***Richardson, TX***
***(800) 267-4878***
***www.anritsu.com.***
***Booth 2718*** ***RS 231***

## RF Amplifiers

VENDORVIEW

AR RF/Microwave Instrumentation has unveiled the first model in its new "A" Series RF amplifier line. Model 500A250A covers 10 kHz to 250 MHz, and provides a minimum of 500 W of swept power when used with an RF sweep generator. The new design packs more power into a smaller size and boasts roughly a

# NEW WAVES

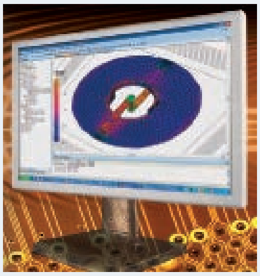
35 percent reduction in size and weight compared to existing products. Model 500A250A replaces the following models: 250A250A, 500A100A and 500A250. The new model also has an improved noise figure for increased dynamic range.
***AR RF/Microwave Instrumentation,***
***Souderton, PA (215) 723-8181,***
***www.ar-worldwide.com.***
**Booth 1912** **RS 232**

## RF Design Book

Be among the first to see and save on the just-released second edition of *Design of RF and Microwave Amplifiers and Oscillators* by Pieter L.D. Abrie at the Artech House booth (#2613). Featuring new material on class A, B, AB, F, E and Doherty amplifiers, this expanded edition covers amplifier stability, the influence of harmonic terminations, models for MIM capacitors and more. The included CD-ROM provides a Visual C++ 2008 menu-driven executable for LSM, with updated Fortran source code. Exclusive 20 percent IMS show discount.
***Artech House,***
***Norwood, MA (781) 769-9750,***
***www.artechhouse.com.***
**Booth 2613** **RS 233**

## High Frequency EDA

VENDORVIEW



AWR®, the innovation leader in high frequency EDA, is showcasing the next releases of its microwave and RF products including Microwave Office®, Visual System Simulator™ and AXIEM™ design software at IEEE MTT-S. Stop by booth #1418 for the latest information on all products as well as demonstrations of AWR's innovative technologies such as AXIEM, ACE™, APLAC® and shortly Analyst®. Learn more today at www.awrcorp.com and www.awr.tv.
***AWR®,***
***El Segundo, CA (310) 726-3000,***
***www.awrcorp.com.***
**Booth 1418** **RS 234**

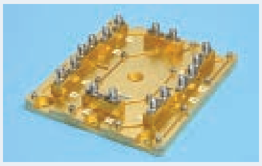
## Customizable Crystal Oscillators

Bliley's satellite and space qualified crystal oscillators incorporate Z-swept technology meeting the requirements of MIL-PRF-3098. With frequency ranges from 10 to 130 MHz and based on proven designs supplied to military and space customers, Bliley is now manufacturing these devices for multiple customer programs. Key product features include optimized phase noise performance and excellent frequency versus temperature stability. Bliley is equipped to meet increasing demand for customizable space and satellite oscillators. The company has in-house processes in place to facilitate ease of product and program adaptation.
***Bliley Technologies Inc.,***
***Erie, PA (814) 838-3571,***
***www.bliley.com.***
**Booth 2921** **RS 235**

## Broadband Horn Antenna

Cobham Sensor Systems announces a compact broadband horn antenna for electronic countermeasures (ECM) application. Model 122HC7 operates over the 6.5 to 18 GHz frequency range with VSWR of 2.4 at 6.5 to 7 GHz and 2.0 at 7 to 18 GHz. The antenna employs Cobham's unique quad-ridged output using a single dual ridged WRD-650 waveguide input to generate circular polarization. This antenna provides gain of 8 dBiC at 7 GHz and 14.5 dBiC at 18 GHz, and it handles RF power of 350 W CW and 1700 W peak. A variant of this antenna is also available with bifurcating lenses to broaden the field of view coverage. The antenna is designed for the extreme environment of military aircraft.
***Cobham Sensor Systems,***
***Baltimore, MD (410) 542-1700,***
***www.cobhamdes.com.***
**Booth 1218** **RS 236**

## 8 × 8 Butler Matrix



COM DEV introduces the versatile 8 × 8 Butler matrix INET/ONET-S/L-200 family in compact PCB form covering the S- and L-band frequency ranges. Amplitude and phase balance is better than 1 dB and 5 degrees respectively, with insertion loss of 1 dB, and measures 137 × 117 × 28 mm. Also available in high power 360 W versions, with amplitude and phase balance of 0.4 dB and 5 degrees respectively and 0.3 dB insertion loss.
***COM DEV International Products,***
***Cambridge, Ontario, Canada***
***(519) 622-2300,***
***www.comdevinternational.com.***
**Booth 1310** **RS 237**

## GaN HEMT Microwave Transistor

Cree will demonstrate its latest high power GaN HEMT microwave transistor, the CGH-21240F. Providing 240 W of peak power, this highly-efficient transistor is ideal for telecommunication applications such as W-CDMA and LTE. Under W-CDMA stimulus, the transistor provides 50 W average power with 40 percent efficiency in Class A/B operation.
***Cree,***
***Durham, NC (919) 313-5300,***
***www.cree.com.***
**Booth 2418** **RS 238**

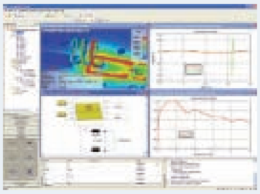
## 2400 to 2569 MHz VCO

Crystek's CVCO55CC-2400-2569 voltage-controlled oscillator (VCO) operates


from 2400 to 2569 MHz with a control voltage range of 0.5 to 4.5 V. This VCO features a typical phase noise of -102 dBc/Hz at 10 kHz offset and has excellent linearity. Output power is typically +4 dBm. Engineered and manufactured in the USA, the model CVCO55CC-2400-2569 is packaged in the industry-standard 0.5" × 0.5" SMD package. Input voltage is 5 V, with a maximum current consumption of 35 mA. Pulling and pushing are minimized to 2.5 MHz and 1.5 MHz/V, respectively. Second harmonic suppression is -15 dBc typical.
***Crystek Corp.,***
***Fort Myers, FL (239) 561-3311,***
***www.crystek.com.***
**Booth 313** **RS 239**

## 3D Electromagnetic Simulation

VENDORVIEW



CST develops and markets software for the simulation of electromagnetic fields. CST will be previewing new features in its flagship product, CST MICROWAVE STUDIO®, due for release Q4 2009. CST MWS enables the fast and accurate 3D electromagnetic simulation of high frequency devices such as antennas, filters, couplers, planar and multi-layer structures. Benefits include shorter development cycles through virtual prototyping before physical trials and optimization instead of experimentation.
***CST of America® Inc.,***
***Framingham, MA***
***(508) 665-4400 www.cst.com.***
**Booth 2013** **RS 240**

## SPDT Coaxial Switch

The D1 Series SPDT coaxial switch is a terminated switch with SMA connectors and operates in a frequency range from DC to 22 GHz. Actuator options come in latching and in failsafe modes. Also available are units with TTL circuitry with integrated indicator circuits. These switches offer an RF impedance of 50 ohms nominal, operating temperature of -35° to +85°C ambient, operating life of 1,000,000+ cycles and switching time of 15 mS maximum.
***Ducommun Technologies Inc.,***
***Carson, CA (310) 513-7214,***
***www.ducommun.com.***
**Booth 2711** **RS 315**

## Attenuator Design Kit

VENDORVIEW

EMC Technology introduces a new wideband temperature variable attenuator design kit (WTVA-DKIT) optimized for performance

SEE US AT MTT-S BOOTH 614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### Highly shielded, phase stable assemblies

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- Reduced insertion loss & increased amplitude stability

▶ **Download the data sheet:** www.teledynestorm.com/PM190E

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Microwave Business Unit
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Woodridge, Illinois 60517

Tel 630.754.3300
Fax 630.754.3500
storm_microwave@teledyne.com

# NEW WAVES

from DC to 20 GHz. Using EMC's Thermopad technology, the WTVA-DKIT offers a solution for design engineers with broadband and thermal challenges including optimal temperature coefficients of attenuation (TCA) at frequencies from 12.4 up to 20 GHz. The WTVA has been noted for its excellent performance and small size, measuring only 0.075" × 0.060". These devices have wire bondable gold terminals.

***EMC Technology,***
***Stuart, FL (772) 286-9300,***
***www.emct.com.***
**Booth 1933** **RS 241**

## Dielectric Constant

Eccostock® FFP is a free flowing syntactic foam powder, low loss, low dielectric constant. Designed to infiltrate densely populated electronic packages, and readily filling available volumes around components. This lightweight foam provides physical support and thermal insulation to delicate components without increasing the weight or dielectric constant. This new and improved product offers lower shrinkage and improved thermal stability.

***Emerson & Cuming Microwave Products Inc.,***
***Randolph, MA***
***(800) 650-5740, www.eccostock.com.***
**Booth 2336** **RS 242**

## X-band Frequency Synthesizer


The HLX-10000 is a small integrated X-band fixed-frequency synthesizer that operates at 10 GHz with a 50 MHz reference. The unit features good phase noise (<-80 dBc/Hz at 10 kHz), with high vibration tolerance, (0 dB degradation at a min of 6 G's RMS). The unit also features low spurs (<-60 dBc), low sub-harmonics (<-60 dBc) and low power consumption. The HLX-10000 is housed in a hermetically-sealed, surface-mount package (0.81" × 0.81"× 0.15") and is manufactured to MIL-STD-883 and IPC-A-610 Class III. Standard operating temperature for all HLX units is -40° to +85°C. Custom units can be designed from 200 MHz to over 13 GHz. The HLX series frequency synthesizers are ideal for military and avionics applications requiring a robust surface-mount design with exceptional performance.

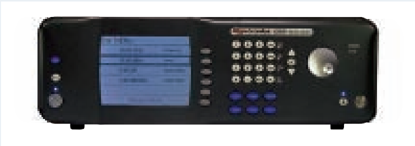
***EM Research Inc.,***
***Reno, NV (775) 345-2411,***
***www.emresearch.com.***
**Booth 2633** **RS 243**

## Mini POL Converters


FDK introduces five new products to its DK Series of non-isolated point of load (POL) DC-DC converters. These very small, low profile converters deliver up to 6 Amperes (A) of output current at power densities up to 860 W/cubic inch in an SMD package and up to 4A of output current at power densities up to 760 W/cubic inch in a SIP package. They have efficiencies up to 93 percent and provide a complete power conversion solution, without the need for external input and output capacitors. Under natural convection, these new DK Series converters deliver the full rated output current with no derating in ambient temperatures up to 85°C in the SMD package, and up to 70°C in the SIP package.

***FDK America Inc.,***
***San Jose, CA (408) 922-1163,***
***www.fdkamerica.com.***
**Booth 1011** **RS 244**

## 50 GHz Microwave Signal Generator



The 2550B 50 GHz microwave signal generator features fast switching speed, ultra-low close-in phase noise and a full suite of analog modulation is well suited to today's R&D and manufacturing. Featuring 50 GHz frequency range with high output power, fast switching speed and high signal purity including ultra-low close-in phase noise, low harmonics and low spurious, the 2550B represents the best in high performance microwave signal generators.

***Giga-tronics Inc.,***
***San Ramon, CA (925) 328-4650,***
***www.gigatronics.com.***
**Booth 1121** **RS 245**

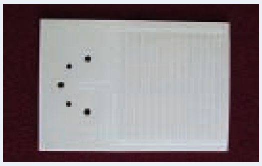
## Zero Bias Schottky Detectors

The DHM265AA is a high sensitivity zero bias Schottky detector that operates in a frequency range from 10 MHz to 26.5 GHz. The DHM265AA -3 dB (1.0 mV/μW) more sensitive regular than traditional matched Zero Bias Schottky Detectors for use in lab testing, power monitoring or leveling circuit with maximum power input of 200 mw. It has matched input for excellent VSWR, wide dynamic range, 10 μV to 5 V (for input power -50 to +20 dBm), and extremely flat frequency response. SMA(M) input connector and SMA(F) output connector.

***Herotek Inc.,***
***San Jose, CA (408) 941-8399,***
***www.herotek.com.***
**Booth 1237** **RS 246**

## LTCC Foundry Service

HIRAI LTCC foundry service provides its featured 2D/3D hybrid fabrication technology for high Q multi-layered substrates of micro- and millimeter-wave applications. Exhibited are the millimeter-wave module that integrates a slot array antenna, a hollow layer underneath, a post-wall waveguide and an aperture coupled waveguide-to-microstrip line transition, presently under development with Tokyo Institute of Technology, Japan, and a novel BPF as well. The design kit CD will be available and Marubeni T/S is present at the booth, too.



***HIRAI SK CORP.,***
***Shibuya-ku, Tokyo, Japan +81-334991351,***
***www.hirai.co.jp/index_e.html.***
**Booth 2436** **RS 247**

## Synthesized Signal Generator

VENDORVIEW

The HMC-T2100 is a compact synthesized signal generator that operates from 10 MHz to 20 GHz with 10 kHz frequency resolution and a switching speed of 300 μs. It can deliver up to +27 dBm output power in 0.1 dB steps over a 40 dB dynamic range. Spurious rejection exceeds -60 dBc at 1 GHz, while phase noise is -113 dBc/Hz at 100 kHz offset at 1 GHz. The HMC-T2100 is affordably priced at $7,998.00 and features USB, GPIB or Ethernet control.

***Hittite Microwave Corp.,***
***Chelmsford, MA (978) 250-3343,***
***www.hittite.com.***
**Booth 1007** **RS 248**

## High Performance RF Synthesizers

This multi-channel RF synthesizer product line is unique due to the complete elimination of phased-locked loops. Proprietary architectures have been developed to achieve broadband frequency generation with ultra low phase noise performance and unsurpassed settling times. Phase coherency for multi-channel synthesis benefits greatly by eliminating PPLs. The phase relationship amongst channels is absolutely coherent in properly architected non-PLL systems.

***Holzworth Instrumentation,***
***Boulder, CO (303) 325-3473,***
***www.holzworth.com.***
**Booth 504** **RS 249**

## MMPX Connector Solution

With very small outside dimensions, a tried and tested snap mechanism, and unique electrical performance that guarantees fast and reliable connections, the HUBER+SUHNER MMPX offers superb electrical performance from DC to 65 GHz and optimal connections to printed circuit boards. Featuring linear VSWR from DC to 65 GHz, excellent shielding, and HUBER+SUHNER MMCX compatibility, the MMPX family is an ideal solution for high speed test, defence and mobile radio applications.

# NEW WAVES

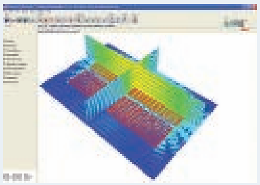
***HUBER+SUHNER,***
***Herisau, Switzerland (802) 878-0555 (USA),***
***www.hubersuhner.com.***
**Booth 2833** **RS 250**

## RF Power Transistors

HVVi Semiconductor introduces the HVV1011-500, the latest in its family of extremely rugged L-band (1030 to 1090 MHz) RF power transistors aimed at IFF, TCAS and transponder/interrogator markets. This robust 50 V device achieves output power over 500 W P1dB providing 19 dB gain and 50 percent drain efficiency under the following pulse condition (50 µs P.W., 5 percent D.C.), while withstanding industry leading output load mismatch tolerance of 20:1 VSWR. The HVV1011-500 is a single-ended pulsed power transistor assembled in an HV800, two-lead, bolt-down, metal flanged package with LCP lid.

***HVVi Semiconductors Inc.,***
***Phoenix, AZ (480) 776-3800,***
***www.hvvi.com.***
**Booth 435** **RS 251**

## EMPIRE XCel™ 5.3



The new 3D EM solver EMPIRE XCcel 5.3 will be presented at IMS booth 2236. EMPIRE XCcel covers nearly all today's design challenges for RF designers, like antennas, passive circuits, packages, waveguides or EMC/EMI problems. Due to the unique structure and processor adapted code generation a simulation performance up to 1600 million FDTD cells per second can be achieved on a conventional PC with full access to the built-in memory. Thus very complex structures can be modeled very fast and highly accurate (e.g. 23 lambda × 16 lambda × 4.5 lambda array antenna simulation at 24 GHz needs only 12 GB memory).

***IMST GmbH, Kamp-Lintfort, Germany***
***+49 2842 981 0, www.empire.de.***
**Booth 2236** **RS 317**

## RF Power Amplifiers

These ruggedized militarized amplifiers are designed for mobile and fixed applications. These models operate over the required frequency bands of 1.5 to 30 MHz, 20 to 100 MHz, 100 to 500 MHz, 500 to 1000 MHz and 1000 to 3000 MHz. IFI offers various power levels of these amplifier systems from low power levels to killowatt power levels. These systems can also incorporate high speed T/R switching. The models feature outstanding RF performance in a compact lightweight design for all possible applications. IFI also offers other frequency ranges to meet virtually any customer's requirement.

***Instruments for Industry Inc. (IFI),***
***Ronkonkoma, NY (631) 467-8400,***
***www.ifi.com.***
**Booth 1209** **RS 252**

## Pulsed Power Transistor

The ILD3135-M130 is an S-band LDMOS pulsed high power transistor. This all gold metal LDMOS device sets a new standard for performance in the 3.1 to 3.5 GHz radar band by offering 130 W peak pulsed power under a 300 µs, 10 percent pulse format. The device has typical P1dB greater than 150 W, gain of 10.5 dB and efficiency of 40 percent. Devices are available for sampling now.

***Integra Technologies,***
***El Segundo, CA (310) 606-0855,***
***www.integratech.com.***
**Booth 2737** **RS 253**

## Three-way Resistive Power Splitter

The models IPS2480 and IPS2481 are 3 W three-way resistive power splitters. Both models are of planar architecture and are suitable for RF and microwave applications. These devices are designed for microstrip or wirebond implementation in continuous 50 ohm impedance environments. The IMS three-way resistive splitters have 9.5 dB evenly split attenuation and operate from DC to 7 GHz ±0.7 dB amplitude flatness and maximum VSWR of 1.3. Samples of the IPS2480 and IPS2481 resistive power splitters can be obtained through the web site.

***International Manufacturing Services Inc.,***
***Portsmouth, RI (401) 683-9700,***
***www.ims-resistors.com.***
**Booth 913** **RS 254**

## Probe Stations

Lake Shore Cryotronics Inc. has redesigned its line of cryogenic micro-manipulated probe stations. The streamlined product portfolio includes tabletop, field upgradeable, superconducting and electromagnet-based, full four-inch wafer, and closed cycle refrigerator based probe stations. These new designs provide greater flexibility and expandability by providing in-field upgrade paths, ensuring the probe stations keep up with demanding, ever changing research requirements. Lake Shore probe stations provide a platform for measurement of electrical, electro-optical, parametric, high Z, DC, RF, and microwave (to 67 GHz) properties of materials and test devices.

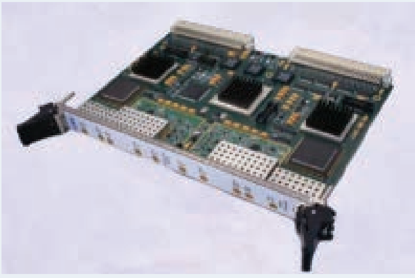
***Lake Shore Cryotronics Inc.,***
***Westerville, OH (614) 891-2244,***
***www.lakeshore.com/crps.html.***
**Booth 512** **RS 255**

## SiGe Capabilities

Jazz Semiconductor offers a wide range of SiGe capabilities, along with advanced CMOS, complimentary-CMOS and bipolar processes for wireless and high performance applications. Jazz's SiGe process platform provides an ideal launch pad for analog integration and board space savings along with high performance. With the emergence of new applications such as WLAN for the home, embedding Jazz's cost-effective 0.18 µm SiGe or 0.13 µm SiGe with Ft's ranging from 30 to 300 GHz presents a clear advantage over other solutions in the market.

***Jazz Semiconductor,***
***Newport Beach, CA (949) 435-8181,***
***www.jazzsemi.com.***
**Booth 2642** **RS 256**

## Dual Channel Digital RF Memory



The LNX SP030302-001 is a dual-channel digital RF memory (DRFM) module based on LNX's DRFM ASIC technology. Each channel has 600 MHz of instantaneous bandwidth and uses four-bit phase sampling. It can handle pulse widths from 20 nsecs to CW and has over 1 millisecond of memory storage per channel, configurable as multiple files. The center (IF) frequency can be independently set providing 1.2 GHz of instantaneous bandwidth using both channels. The module is a single-slot VME card and is rated from -40° to +85°C.

***LNX Corp.,***
***Salem, NH (603) 898-6800,***
***www.lnxcorp.com.***
**Booth 2339** **RS 257**

## 7-section Cavity Bandpass Filter

Model 7IZ7-7000/4600-S is a 7-section cavity bandpass filter. Center frequency is 7000 MHz with a 3 dB bandwidth of 4700 to 9300 MHz. Insertion loss is 0.5 dB at center frequency with a stopband rejection of 25 dB at 3000 MHz and 11,000 MHz. Operating temperature is -55° to +85°C with a VSWR of 2.0 typical.

***Lorch Microwave,***
***Salisbury, MD (410) 860-5100,***
***www.lorch.com.***
**Booth 1233** **RS 258**

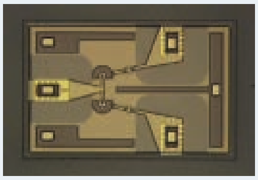
## HMIC Broadband Surmount Switches

VENDORVIEW

M/A-COM Technology Solutions has developed a unique approach to the packaging and integration

# New Waves

of ultra-wideband switches, such as the MASW-002103 (SPDT), MASW-003103 (SP3T) and MASW-004103 (SP4T) that deliver both superior RF and thermal performance. Switches packaged using standard plastic packaging techniques continue to have upper frequency range limitations, as well as repeatability issues caused by die attach, and chip and wire assembly techniques. M/A-COM Technology Solution's HMIC technology utilizes semiconductor wafer-scale processes to realize repeatable broadband monolithic surface-mount devices.



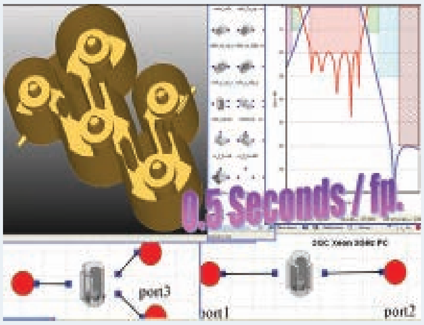
***M/A-COM Technology Solutions,***
***(800) 366-2266,***
***www.macom.com.***
**Booth 2214** **RS 259**

## V-Line Power Divider/Combiners

These V-Line power divider/combiners offer increased power rating and extended frequency range. Two-way thru 16-way 40 W, power divider/combiners are optimized for excellent performance across all wireless bands from 0.7 to 2.7 GHz and their rugged construction makes them ideal for both base station and in-building wireless systems. These products are always available from stock to two weeks ARO in N, SMA, BNC or TNC connector configurations for your next generation equipment deployments. Made in the USA – 36 month warranty.

***MECA Electronics Inc.,***
***Denville, NJ (973) 625-0661,***
***www.e-meca.com.***
**Booth 1204** **RS 260**

## EM CAD and Optimization Tool




WASP-NET® is a unique hybrid MM/FE/MoM/FD CAD tool that features EM CAD precision in seconds, provides further speed enhancement, a modern user-friendly graphical user interface, and convenient waveguide filter, combline filter and slot-array synthesis wizards for highly efficient design solutions. WASP-NET proves preferential EM CAD choice of leading space, defense and microwave industry, when efficiency and costs count. Typical design examples: All kinds of waveguide and coaxial components, combline/interdigital and dielectric resonator filters, feed systems, corrugated horn antennas, shaped reflector antennas, large slot arrays, dielectric loaded antennas, lenses and radomes.

***Microwave Innovation Group (MiG) GmbH & Co. KG, Bremen, Germany***
***+49 421 223 7966 0,***
***www.mig-germany.com.***
**Booth 1207** **RS 261**

## MMIC Power Amplifier


This GaAs MMIC high power amplifier (HPA) offers +41 dBm pulsed saturated output power and 17 dB small-signal gain. This HPA, identified as XP1057-BD, uses a dual-sided bias architecture, covers 13.5 to 16 GHz and achieves +48 dBm OIP3. The device is well suited for millimeter-wave military, radar, satellite and weather applications.

***Mimix Broadband Inc.,***
***Houston, TX (281) 988-4600,***
***www.mimixbroadband.com.***
**Booth 1114** **RS 262**

## Fixed Frequency Synthesizers


For applications requiring a highly stable single frequency, Mini-Circuits' engineering team can customize a low noise synthesized source for any frequency from 56 to 6010 MHz. Fixed-frequency synthesizers feature low phase noise with spurious performance of -90 dBc or better. They operate with low power consumption and are supplied in compact surface-mount or connectorized packages. These synthesizers offer settling times of typically 100 ms or better and harmonics of -20 dBc or better.

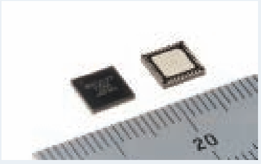
***Mini-Circuits,***
***Brooklyn, NY (718) 934-4500,***
***www.minicircuits.com.***
**Booth 618** **RS 263**

## Power Amplifier and Transmitter

MITEQ introduces a new medium power X-band antenna-mount solid-state power amplifier (SSPA) and transmitter product line. The PA-H model series was designed for outdoor SSPA applications required for satellite uplink applications. These ruggedized antenna-mount SSPA systems were built and tested to meet the rigorous requirements of extreme outdoor environmental conditions. The systems incorporate amplifier modules engineered using state-of-the-art GaAs FET technology, a high efficiency power supply and a microprocessor-based monitor and control system. MITEQ offers solid-state power amplifiers in C- and Ku-bands, as well as rack mounted configurations.

***MITEQ Inc.,***
***Hauppauge, NY (631) 436-7400,***
***www.miteq.com.***
**Booths 2121, 2221** **RS 264**

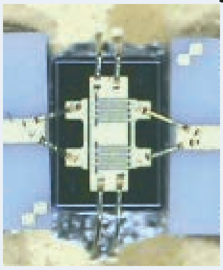
## WiMAX Power Amplifiers



These two power amplifier monolithic microwave integrated circuits (MMIC) are designed for WiMAX CPE applications. The MGFS39E2527A is designed to provide +30 dBm of linear output power in the 2.5 to 2.7 GHz frequency band, while the MGFS39E3336 does so in the 3.3 to 3.6 GHz band. These MMIC amplifiers are based on an InGaP HBT process; operating at +6 V, the amplifiers feature 40 dB linear gain, a 1 bit 20 dB step attenuator, and an output power detector. Operation at +5 V is also possible with approximately a 1 dB power penalty. The amplifiers are matched to 50 Ω at the input while the outputs are partially matched.

***Mitsubishi Electric Corp.,***
***Cypress, CA (408) 987-5480,***
***www.mitsubishichips.com.***
**Booth 1423** **RS 265**

## Modelithics Library Complete



The Modelithics Library Complete is a comprehensive collection of accurate models for active and passive devices, inclusive of the CLR Library™ for passives the NLT Library™ for transistors, the NLD Library™ for diodes, and the SLC Library™ for system level components, such as amplifiers, attenuators and filters. Modelithics continues to release upgraded versions of these libraries for popular microwave circuit simulators. Modelithics® also supports custom modeling services to meet just about any RF/microwave modeling need.

***Modelithics Inc.,***
***Tampa, FL (813) 866-6335,***
***www.modelithics.com.***
**Booth 1309** **RS 266**

## GPS Disciplined Oscillators

The M9100 Series of Global Positioning System Disciplined Oscillators (GPSDO) is an extremely small device that has been designed to meet military environmental requirements, timing system demands including holdover, and is ideal for man-pack, vehicle mount and airborne applications. The M9100 product is the first device with such a small form factor that can work in systems that not only require extremely precise timing accuracy, but exact geo-location needs as well. The ultra-small device is 1.5" × 1" × 0.5" in size and weighs approximately one ounce.

***MtronPTI,***
***Orlando, FL (800) 762-8800,***
***www.mtronpti.com.***
**Booth 407** **RS 267**

# NEW WAVES

## Ultra-small Switch Connector

The SWG Series is the latest in Murata's line of ultra-miniature microwave switch connectors. This miniaturized switch connector measures only 2.0 × 2.0 × 0.9 mm and is designed to reliably test frequencies from DC to 11 GHz. The small footprint is ideal for cell phones, smart phones, GPS units and high frequency measurement equipment. The SWG series is also an excellent fit for advanced applications such as Wireless Local Area Networks (WLAN), WiMAX, ultra-wideband (UWB), Bluetooth and Zigbee technologies.

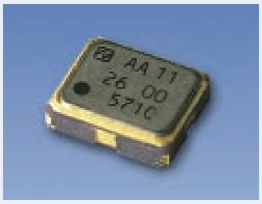
***Murata,***
***Smyrna, GA (770) 436-1300,***
***www.murata.com.***
**Booth 2223** **RS 268**

## RF VSA and VSG

This RF vector signal analyzer, RF vector signal generator and PXI Express 18-slot chassis offer flexible RF measurements up to 10 times faster than traditional RF instrumentation. The new software-defined modular instruments – the NI PXIe-5663 6.6 GHz RF vector signal analyzer and the NI PXIe-5673 6.6 GHz RF vector signal generator – are complemented by the NI PXIe-1075 18-slot high-bandwidth chassis. The NI PXIe-5663 can perform signal analysis from 10 MHz to 6.6 GHz with up to 50 MHz of instantaneous bandwidth. The NI PXIe-5673 delivers signal generation from 85 MHz to 6.6 GHz and up to 100 MHz of instantaneous bandwidth.

***National Instruments Corp.,***
***Austin, TX (800) 531-5066,***
***www.ni.com.***
**Booth 1845** **RS 269**

## Temperature-compensated Crystal Oscillator



NDK has developed the NT2016SB series temperature-compensated crystal oscillator (TCXO) measuring 2.0 × 1.6 mm with a height of 0.8 mm maximum, making it one of the smallest GPS grade TCXOs in the world. The standard frequency range is from 16.367667 to 38.4 MHz. The device features an enable/disable function that deactivates the oscillation circuit to reduce power consumption when operation is unnecessary.

***NDK,***
***Belvidere, IL (815) 544-7900,***
***www.ndk.com.***
**Booth 2721** **RS 270**

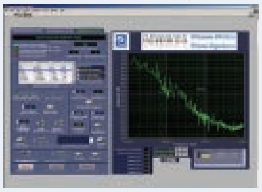
## GaN HEMT Power Transistor

The NPT1007 is designed for applications up to 1.2 GHz. The NPT1007 comprises two power transistors, 100 W each, in an industry standard four lead Gemini package. This small footprint

allows easy combining of both transistors into a compact high power amplifier solution. After combining losses, the device achieves 200 W at 63 percent efficiency with 18.3 dB gain at 900 MHz. The NPT1007 is robust to an output mismatch of 10:1 while in saturation.

***Nitronex Corp.,***
***Durham, NC (919) 807-9100,***
***www.nitronex.com.***
**Booth 1736** **RS 271**

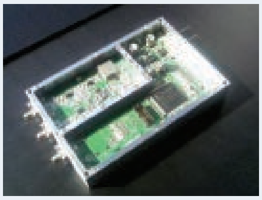
## Ultra-low Phase Noise Measurement System



OEwaves introduces the OE8000 family of fully-automated ultra-low phase noise measurement system products. OE8000 is capable of measuring absolute phase noise of -75 dBc/Hz at 10 Hz offset and down to -174 dBc/Hz at 10 MHz offset for any frequency between 6 to 12 GHz without requiring a separate low phase noise reference source or down-converter. Simple setup and user friendly graphic interface allows quick high performance absolute phase noise measurement with a click of the mouse, and in one to three minutes.

***OEwaves Inc.,***
***Pasadena, CA (626) 449-5000,***
***www.oewaves.com.***
**Booth 2439** **RS 272**

## PLL Frequency Synthesizers



Orient Microwave Corp. provides frequency synthesizers based on the phase lock loop system. The product series is available for a frequency range of 50 MHz to 3.6 GHz, and any frequency of maximum 2048 ways can be selected by input of 11 bit parallel signals. Features include: 118.4 × 78.6 × 20.5 mm; local output level of +10 dBm minimum; PLL lock alarm; 10 MHz REF input level of +4 dBm ±6 dB; El consumption of 600 mA maximum and RoHS compliant.

***Orient Microwave Corp.,***
***Higashiomi, Shiga, Japan***
***+81-749-45-8121,***
***www.orient-microwave.com.***
**Booth 1435** **RS 273**

## Custom Microwave Sub-assemblies

Phase Matrix designs and manufactures custom RF and microwave sub-assemblies up to 50 GHz with built-in control, monitoring and test functions. The company uses soft-board, thin-film chip and wire as well as surface-mount assembly techniques as required for specific applications. Microwave functions include amplifiers, oscillators, up- and down-converters, frequency multipliers and dividers, SPMT switches, filters, variable attenuators and phase-locked loops (PLL). Subassemblies are available for commercial, avionics and military applications.

***Phase Matrix Inc.,***
***San Jose, CA (408) 428-1000,***
***www.phasematrix.com.***
**Booth 523** **RS 274**

## Amplified and Filter Switch

PMI has developed model number PEC-1D575G-1AFS-SFF. This multi-function, integrated module provides amplification and filtering within the GPS L1 frequency band of 1575.42 MHz. Two input channels are switchable to a common output. This product is designed to handle exposure to extreme environmental conditions including airborne and launch rocket environments.

***Planar Monolithics Industries Inc.,***
***Frederick, MD (301) 662-5019,***
***www.planarmonolithics.com.***
**Booth 1646** **RS 275**

## Extended Range Filter

Pole/Zero announces the availability of its new extended range filter. This digitally tunable, two-pole bandpass filter delivers continuous coverage from 30 to 512 MHz and has been designed for integration in radio transceivers where small size and low power consumption are paramount. The filter has a 3 dB bandwidth of 5 percent, typical insertion loss of 4 dB, provides linear performance with RF input levels up to +24 dBm, and is powered by a single +5 V DC supply.

***Pole/Zero Corp.,***
***West Chester, OH (513) 870-9060,***
***www.polezero.com.***
**Booth 711** **RS 276**

## Precision Connectors

This new line of precision connectors is designed exclusively for Harbour Industries LL142 cable. Both Male and Female connectors are offered for 2.92 mm (32 GHz), SMA (24/26 GHz), TNCA (18 GHz) and Type N (18 GHz) series. The connectors feature Solder/Clamp terminations and fully captive soldered center contacts. Straight, right angle and bulkhead configurations are available and have been designed for minimum VSWR and insertion loss. In addition, the connectors employ both front and rear environmental seals for superior moisture resistance.

***Precision Connector Inc.,***
***Franklin, IN (317) 346-0029,***
***www.precisionconnector.com.***
**Booth 842** **RS 277**

# NEW WAVES

## GPS Notch Filter

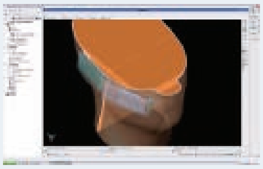
VENDORVIEW

Reactel part number 6R7-1575.42-X15N11 is a highly selective GPS cavity notch filter. Centered at 1575.42 MHz, this 15 MHz wide unit exhibits loss of less than 1.25 dB at DC to 1560 and 1591 to 4000 MHz while rejecting CF ±1 MHz by a minimum of 70 dB. Power levels of up to 1 kW are available, and this unit can be fitted with any type of RF connector you may need.

***Reactel Inc.,***
***Gaithersburg, MD (301) 519-3660,***
***www.reactel.com.***
**Booth 1504** **RS 278**

## EM Simulation Software

VENDORVIEW



Remcom announces the release of XFdtd® 7.0 (XF7), a new electromagnetic simulation tool for antenna design and analysis, biological EM analysis, microwave circuit design and other EM simulation applications. XF7 marks a departure from other standard 3D EM solvers with a simplified and streamlined user interface, cross-platform functionality, and several time-saving features that are unique to the market. XF7's most important benefit is improved efficiency due to faster, easier simulation workflow.

***Remcom Inc.,***
***State College, PA (814) 861-1299,***
***www.remcom.com.***
**Booth 2622** **RS 279**

## Hermetic Leadless SMT Packages

Remtec has developed cost-effective, hermetic (to $10^{-8}$) ceramic leadless SMT substrates and packages with PCTF® Technology for RF components and modules from DC to 40 GHz with enhanced thermal management. Solid thermal vias (K > 200 W/M°K) and wraparounds provide low-inductance. Printed resistors and transmission lines, excellent solderability, capability to withstand multiple soldering and RoHS compliance, combined with low upfront tooling and high reliability are additional benefits. Remtec also offers microwave modeling, circuit design, and test and assembly.

***Remtec Inc.,***
***Norwood, MA (781) 762-9191,***
***www.remtec.com.***
**Booth 611** **RS 280**

## Coupler-cabler

VENDORVIEW

These drop-in or connectorized hybrid couplers are suitable for use as a directional coupler or 90° quadrature hybrid. The new RMCL series offers average power handling options between 60 and 1400 W average and nominal coupling options from 3 through 52 dB. Typical electrical performance includes insertion loss of 0.3 dB, VSWR of 1.20 and isolation of 20 dB. Units can be cascaded to obtain broadband widths and is ideal for use in military power amplifier combine/divide stages. Part of the HYBRIDLINE family of board mount couplers, the new devices are available in bulk 1 meter lengths, pre-cut to your frequency or with N or SMA female connectors.

***Response Microwave Inc.,***
***Devens, MA (978) 772-3767,***
***www.responsemicrowave.com.***
**Booth 2125** **RS 281**

## Jumper Cables

Many wireless PC board RF modules use Hirose U.FL or I-PEX MHF miniature connectors. RF Connectors, a division of RF Industries, offers jumper cables to connect the PC board to devices housing or case. They use the I-PEX brand MHF connector and 1.13 mm coax cable, compatible with Hirose U.F.L. Assemblies are available with a variety of connector terminations. Most assemblies are manufactured in standard lengths. Electrical performance is good up to 6 GHz with a VSWR rating of 1.3.

***RF Connectors,***
***a Division of RF Industries,***
***San Diego, CA (858) 549-6340,***
***www.rfindustries.com.***
**Booth 633** **RS 282**

## High Isolation Switches

VENDORVIEW

RFMD® introduces its new line of single-pole double-throw (SPDT) low loss, high isolation switches. Designed for general purpose switching applications requiring low insertion loss and high power handling capability, the RF3021, RF3023, RF3024 and RF3025 are also ideally suited for battery operated applications. The RF3021 and RF3025 are packaged in a compact, 3×3, 6-pin leadless QFN package, while the RF3023 and RF3024 are contained in a small, 6-pin, SC-70 package.

***RFMD,***
***Greensboro, NC (336) 664-1233,***
***www.rfmd.com.***
**Booth 2412** **RS 283**

## 12-Throw Coaxial Switch

RLC Electronics' terminated single-pole, 12-throw coaxial switch combines reliability, long life and outstanding electrical performance in a compact package. Available options include a choice of coil voltages, indicators and TTL drivers or arc suppression diodes.

***RLC Electronics Inc.,***
***Mount Kisco, NY (914) 241-1334,***
***www.rlcelectronics.com.***
**Booth 2610** **RS 284**

## RT/duroid® 5880LZ Laminates

VENDORVIEW

RT/duroid 5880LZ material is a PTFE composite designed for exacting stripline and microstrip circuit applications. Rogers' ground-breaking filler system results in a low density (1.37 gm/$cm^3$), lightweight material making it an ideal choice for high performance, weight sensitive applications such as airborne antennas. RT/duroid 5880LZ laminate has a dielectric constant (Dk) of 1.96 at 10 GHz, providing the lowest Dk of a copper clad microwave material available today. In addition, the dielectric constant is uniform from panel-to-panel and constant over a wide frequency range. Its low dissipation factor extends the usefulness of RT/duroid 5880LZ to Ku-band and above.

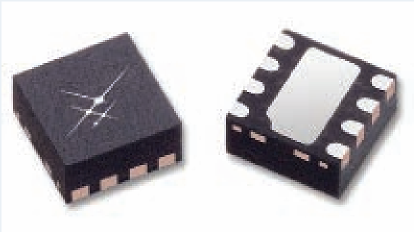
***Rogers Corp. Advanced Circuit***
***Materials Division,***
***Chandler, AZ (480) 917-5223,***
***www.rogerscorp.com.***
**Booth 1018** **RS 285**

## Broadband and WiMAX Filters

SANGSHIN ELECOM offers fully customizable broadband and WiMAX filters. A leading supplier of ceramic filters, Sangshin offers over 700 designs in these areas with frequency coverage from < 2 to > 6 GHz in both narrow and ultra wide bandwidths. Configurations range from 2.5 mm through 6 mm heights and from 2 to 6 poles. With the ability to match a custom footprint already in use, Sangshin provides a competitive option to other suppliers. Sample lead times are two to three weeks with full production in four to six weeks. For more information contact SANGSHIN's exclusive technical distributor, RFMW.

***RFMW Ltd.,***
***San Jose, CA (877) 367-7369,***
***www.rfmw.com/sangshin.***
**Booth 418** **RS 286**

## Ultra Low Noise Amplifiers



Skyworks' new ultra low noise amplifiers offer performance under 0.7 dB while providing high linearity amplification with OIP3 up to 35 dBm. The SKY65037-360LF, operating from 0.7 to 1.2 GHz, and SKY65040-360LF, operating from 1.5 to 2.4 GHz, have the flexibility of external tuning to set gain up to 25 dB and sup-

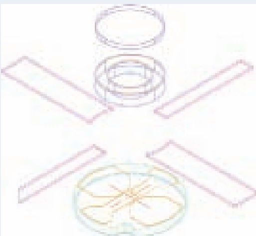
# NEW WAVES

ply current adjustment of 30 to 100 mA. The devices serve high performance receiver applications for wireless infrastructure base stations, repeaters or access points.

***Skyworks Solutions Inc.,***
***Woburn, MA (781) 376-3000,***
***www.skyworksinc.com.***
**Booth 1818** **RS 287**

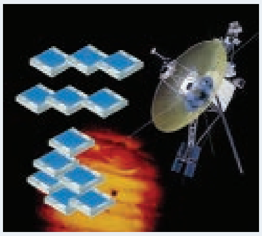
## High Power Switch Package

This Beryllium Oxide (BeO) package and full assembly and testing services are designed for high power semiconductor switches and small Gallium Nitride (GaN), Silicon Carbide (SiC) and Gallium Arsenide (GaAs) devices. Applications for these packages include test and measurement, military radios and radar. The StratEdge BeO package has a thermal conductivity of 270 W/meter Kelvin (w/mK). The 0.205 inch diameter circular package has a BeO disk base to accommodate devices of up to 0.030 by 0.040 inches. This standard hermetic package comes with a circular metal lid with gold tin preform. The package is designed with four leads to accommodate single-pole, three-throw switch (SP3T) devices. The maximum assembled package height, including the lid, is 0.056 inches.



***StratEdge,***
***San Diego, CA (866) 424-4962,***
***www.stratedge.com.***
**Booth 1011** **RS 288**

## High Frequency Products



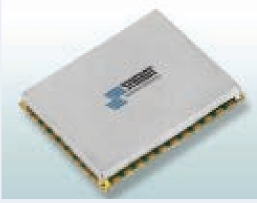
SOTA announces the addition of the FiltenatorR to its high frequency product line. The FiltenatorR is a clean attenuator that uses an integrated filter to eliminate high frequency signals. The cut-off frequency can be varied between 5.5 and 8.5 GHz. Standard attenuation values are 1, 3, 6 and 10 dB. VSWR for all four values is less than 1.5, with attenuation tolerance less than ±1 dB. Measuring 0.150" × 0.120" × 0.015" these devices are available with wire bondable or solderable terminations.

***State of the Art Inc.,***
***State College, PA (800) 458-3401,***
***www.resistor.com.***
**Booth 2129** **RS 289**

## Fast Settling Synthesizers

VENDORVIEW

The FSFS series of surface-mount fast settling synthesizers is ideal for frequency hopping and jamming applications. The FSFS315555-500 is the first model released in the series providing under 50 uSec of settling time when



commanded for start/stop and stop/start frequency jumps. The synthesizer tunes in 5 MHz steps within the tuning band of 3150 to 5550 MHz, having spurious rejection of 75 dBc typical. The phase noise is -80 dBc/Hz up to 100 kHz and -100 dBc/Hz at 1 MHz offset from the carrier. This synthesizer requires +5 and +15 V DC for operation and is packaged in a small surface-mount RoHS compliant package, measuring 1.25" × 1" × 0.3".

***Synergy Microwave Corp.,***
***Paterson, NJ (973) 881-8800,***
***www.synergymwave.com.***
**Booths 1111, 1211** **RS 316**

## PCB Prototyping System

T-Tech Inc. introduces the Quick Circuit J5 – an advanced state-of-the-art in-house circuit board prototyping system series. The J5 features full z-axis motion control; 32-position automatic tool change; automatic tool-depth control; vacuum table; 0.00025" resolution; integrated front-panel control; and a 60,000/100,000 rpm variable speed spindle. With customers in over 46 countries, T-Tech is a leading manufacturer of in-house circuit board prototyping systems and equipment for microwave and RF applications.

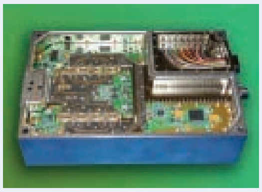
***T-Tech Inc.,***
***Norcross, GA (770) 455-0676,***
***www.t-tech.com.***
**Booth 1313** **RS 290**

## Three-state Attenuated Switch

This three-state attenuated switch is designed for frequencies from DC to 25 GHz. The three-state attenuated switch was designed to allow users to switch between three different states: through path (low loss), attenuated path (known high loss) and open state (with path for user to ground). The 3-State attenuated switch eliminates the use of external cables or attenuators maximizing RF characteristics and minimizing space and weight.

***Teledyne Coax Switches,***
***Hawthorne, CA (800) 351-7368,***
***www.teledynecoax.com.***
**Booth 1028** **RS 291**

## High Performance Power Amplifier



This 25 W linear Ku-band SSPA that is based on wideband driver modules and a balanced Ku-band MMIC output stage. The 14.40-15.4 GHz amplifier includes a TTL enable/disable function, a temperature compensation circuit, low drop-out (LDO) regulators, a negative voltage generator and a sequencer circuit to guarantee that the negative voltage is presented to the power MMICs before the positive voltage is applied. The unit is nominally designed to operate from -40° to

+65°C with a supply voltage of +20 V DC and 33 V DC. Power consumption is 250 W maximum when running at 1 dB compression.

***Teledyne Microwave,***
***Mountain View, CA (650) 962-6944,***
***www.teledynemicrowave.com.***
***Booth 1028*** ***RS 292***

## Ultra-miniature Relays


This series of DPDT surface-mount ultra-miniature relays delivers RF performance over a bandwidth from DC to 8 GHz. Signal integrity of the new GRF312 performs up to 12 Gbps. The relays are designed to provide a practical surface-mount solution with improved RF signal repeatability over the frequency range. The GRF312 utilizes unique construction features including all resistive welding techniques and specific manufacturing techniques that provide excellent resistance to environmental extremes that contribute to its overall reliability.

***Teledyne Relays,***
***Hawthorne, CA (800) 284-7007,***
***www.teledynerelays.com.***
***Booth 1028*** ***RS 293***

## Cables

Phase Master® 190E Series cables are designed with an enhanced, multilayer shielding that increases shielding effectiveness to levels suitable for the most demanding applications (120 dB at 1 GHz, minimum) and significantly reduces shielding degradation after use. In addition, the construction increases product durability, especially with regard to torsion and connector retention (> 40 lbs straight pull with SMA connectors), while offering a high level of phase stability vs. temperature and flexure, reduced insertion loss and increased amplitude stability.

***Teledyne Storm Products,***
***Woodridge, IL (630) 754-3300,***
***www.teledynestorm.com.***
***Booth 614*** ***RS 294***

## RF Attenuators

This new line of RF attenuators is for use in reducing RF signal levels. Designed for use at frequencies up to 10 GHz, these devices guarantee a precise signal attenuation of 3, 6, 10 or 20 dB depending on the type used. These attenuators are available in SMA, BNC, TNC and 7/16 DIN series. Typical applications include testing and measurement as well as antenna lines where emissions must be set at precise levels.

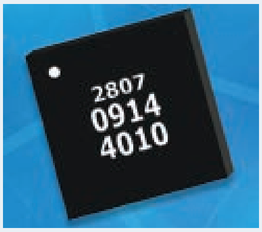
***Telegärtner Inc.,***
***Franklin Park, IL (630) 616-7600,***
***www.telegartner.com.***
***Booth 610*** ***RS 295***

## Broadband Power Dividers

This series of broadband power dividers operates in a frequency range from 2 to 18 GHz. These compact Wilkinson designs use single or multistage designs that include two-, four- and eight-way configurations. The octave band models feature low insertion loss and high port-port isolation typically > 20 dB. Wilkinson power dividers are used in applications that require distribution of the RF signal such as antenna sharing and lab environ-

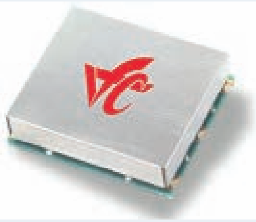
ments. All units are RoHs compliant and most models ship from stock.
***Trilithic Inc.,***
***Indianapolis, IN (317) 895-3600,***
***www.trilithic.com.***
***Booth 1833*** ***RS 296***

### High Efficiency Cable TV Amplifier




TriQuint Semiconductor introduces the high output, ultra-linear TGA2807-SM gain block for cable TV headend applications. It is tailored for the performance requirements of DOCSIS® 3.0 systems and builds on the successful heritage of TriQuint's TGA2806-SM and TGA2803-SM. The new TGA2807-SM offers ACPR ~2 dB better than previous generations for given bias and power levels. It can also be operated with significantly reduced power consumption while still meeting DOCSIS 3.0 specifications. It comes in a standard 5 × 5 mm QFN package for highly-efficient thermal operation. The device can replace two similar amplifiers in conventional designs, thus reducing overall system costs and eliminating the need for the extra matching circuitry while freeing PC board space.
***TriQuint Semiconductor,***
***Hillsboro, OR (503) 615-9000,***
***www.triquint.com.***
***Booth 1618*** ***RS 297***

### Ultra Low Noise and Low Jitter TCXO



The VFTX210 is a TCXO providing low jitter and phase noise, timing solutions for applications such as wideband ADC and DDS architectures, radar systems, point-to-point radios and wireless communication systems. The VFTX210 is a low noise TCXO capable of providing a sine wave output frequency up to 1 GHz with jitter less than 0.3 ps. The temperature stability is less than 1.0 ppm over a temperature range of -40° to +85°C. Operating with a +3.3 V power supply, the device typically consumes 0.24 W. The device contains an internal voltage regulator for improved stability and noise performance. The VFTX210 is available in a 20.0 × 20.0 mm surface-mount package and is RoHS 6/6 compliant.
***Valpey Fisher Corp.,***
***Hopkinton, MA (508) 435-6831,***
***www.valpeyfisher.com.***
***Booth 2104*** ***RS 298***

### Microwave Measurement System

The SWAP-X402 is an innovative yet affordable tool for characterizing microwave power transistors. SWAP-X402 can be used as an add-on to any tuner system. Next to providing loadpull information like power and gain, SWAP-X402 measures the time domain waveforms of voltages and currents at the transistor terminals under realistic operating conditions. The additional time domain data result in an unprecedented insight in transistor behavior and are needed for validating large signal models, designing amplifiers and studying reliability.
***Verspecht-Teyssier-DeGroote SAS***
***Brive-la-Gaillarde, France***
***+33 5 55 86 73 01, www.vtd-rf.com.***
***Booth 2245*** ***RS 299***

### Magnetically-tuned Synthesizers

These new synthesizers (the "V-USB-S") utilize VIDA's patented technology to achieve octave tuning with excellent phase noise performance where operating power and control is by a single PC USB port. The synthe-

# NEW WAVES

sizers performance makes this the choice for portable testing applications: control software included; phase noise of -103 at 20 kHz; -120 at 100 kHz and -150 at 1 MHz; output power is 15 dBm ±1 dB; minimum frequency step of 1 kHz; low spurious; and only 1" × 1" × 3" and weighs less than nine ounces. The synthesizers are available in four octave bands from 6 to 18 GHz. These synthesizers will be available at IMS 2009 for $3500 each.

***VIDA Products Inc.,***
***Santa Rosa, CA (707) 541-7000,***
***www.vidaproducts.com.***
**Booth 2525** **RS 310**

## 40 dB Dual Directional Coupler

The model C8155-102 is only the first in a new family of patented, broadband dual directional couplers. This coupler provides continuous 10 to 500 MHz bandwidth and 100 W CW power, at 40 dB coupling. Available with all SMA connectors, this low loss design provides insertion loss of 0.35 dB, VSWR (ML): 1.20, coupling flatness of 40 dB ±0.5 dB and directivity of 20 dB in a small 1.5" × 0.95" × 0.52" package. Non-connectorized version, model C8189, is also available. RoHS version available.

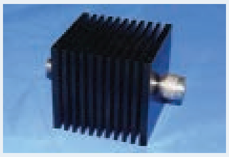
***Werlatone Inc.,***
***Brewster, NY (845) 279-6187,***
***www.werlatone.com.***
**Booth 729** **RS 311**

## Ka Band Optical Gate Technology

WIN Semiconductors PP25-1x family of optical gate GaAs PHEMT processes provide Ft of 70 GHz, 14 V breakdown voltage and P1dB of 600 mW/mm at 29 GHz with 6 V operation. These technologies are intended for low cost high volume millimeter-wave applications such as point to point radio and broadband amplification. All versions have airbridge crossovers (with or without BCB protection) and are available in 50 µm and 100 µm thicknesses. All technologies in the family are fabricated at WIN's 6" GaAs fabrication facility in Tao Yuan Shien, Taiwan.

***WIN Semiconductors Corp.***
***Tao Yuan Shien, Taiwan +886-3-397-5999,***
***www.winfoundry.com.***
**Booth 921** **RS 318**

## 50 W Coaxial Attenuators



The superior performing 50 W coaxial attenuator family significantly broadens the XMA/Omni Spectra® power products offering. Available in SMA, Type N, TNC and 7-16 connector configurations in both in-series and between series variations. This product offers the trusted reliability and quality of XMA/Omni Spectra products, featuring MIL compliant stainless steel connectors and black anodized heatsink. This durable construction coupled with solid electrical performance and attractive prices, make this an outstanding value. This product is ideal for test and measurement applications as well as both military and telecommunications production applications.

***XMA Corp.,***
***Manchester, NH (603) 222-2256,***
***www.xmacorp.com.***
**Booth 144** **RS 312**

## Fixed Frequency Synthesizer


The model SFS10000Z-LF in X-band is an RoHS compliant fixed frequency synthesizer. This single frequency signal source is preprogrammed to operate at 10000 MHz and features a self-locking mechanism with lock detect. This synthesizer has a typical phase noise of -85 dBc/Hz at 10 kHz offset with a typical reference spur suppression of -70 dBc. The SFS10000Z-LF is designed to deliver a typical output power of 0 dBm with a VCO voltage supply of 5 V DC while drawing 90 mA (typical) and a PLL voltage of 3 V DC while drawing 11 mA (typical) over the temperature range of -40° to 85°C. This fixed frequency synthesizer features typical second harmonic suppression of -30 dBc and comes in Z-Comm's SFS-L1 package measuring 1" × 1" × 0.22".

***Z-Communications Inc.,***
***San Diego, CA (858) 621-2700,***
***www.zcomm.com.***
**Booth 609** **RS 313**

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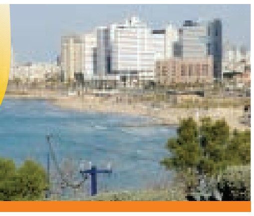
# IEEE COMCAS 2009

**The International IEEE Conference on Microwaves, Communications, Antennas and Electronic Systems**

**David Intercontinental Hotel, Tel Aviv, Israel, November 9-11, 2009**



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# Call for Papers

**COMCAS 2009** continues the tradition of providing a multidisciplinary forum for the exchange of ideas in the areas of microwaves, antennas, communications, solid state integrated circuits, sensing and electronic systems engineering. The venue will be exciting and enjoyable with many opportunities for networking, candid exchange of ideas and a strong sense of community. This year we will expand the program to include RF and microwave photonics, biomedical technologies, cognitive radios and networks, radar, radio frequency identification, electron devices and photonic means for IC inspection among other topics. A diverse assembly of researchers, engineers and scientists will be invited to present their ideas and discuss new results, providing a unique opportunity for attendees to view a variety of interesting and innovative technologies in one location. Invited papers and tutorial talks from international experts will be presented in key topical areas. So please join us for the 2nd Annual IEEE COMCAS meeting in the exciting and vibrant city of Tel Aviv, Israel from 9-11 November 2009.

**Technical Topics:**

- Ad Hoc, Sensor and Mesh Networking
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- RF/Microwave Photonics
- Power Amplifiers and Electron Devices
- Radar and Electronic Systems
- RFID Devices, Technologies and Systems
- Solid State Devices, RFICs, Circuits and Modeling
- Terahertz Technology & Applications

**Regular oral presentations will be 20 min. in length; there will also be Poster sessions.** All submitted papers will be peer reviewed and assessed on key accomplishments, contribution to technology, advancement of the state-of-the-art, originality and interest to the attendees. Accepted papers will be published in the COMCAS 2009 Proceedings which will be available through IEEE Xplore after the conference.

**Papers should first be submitted as a 1 to 2 page summary. Please refer to the detailed author instructions provided on the conference web site www.comcas.org.**

**The official language of the Conference is English.**

**Deadline for Summary Submission: 15 June 2009. Final manuscripts due 15 Sept. 2009**

The technical program will be complemented with a **Technical Exhibition**, which will be held on November 9-10, offering companies and agencies a unique opportunity to visit Israel and present related products and services in display and printed advertisement. **For further details please contact the Conference Secretariat.**


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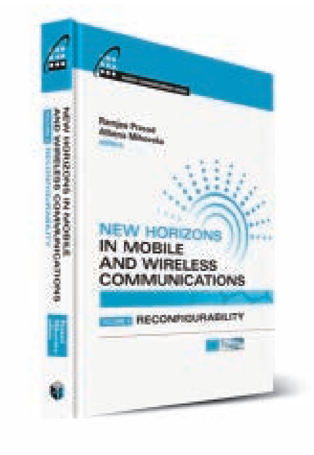
## *New Horizons in Mobile and Wireless Communications, Vol. 3: Reconfigurability*




### Ramjee Prasad and Albena Mihovska, Eds.

Based on cutting-edge research projects in the field, this book (part of a comprehensive four-volume series) provides the latest details and covers the most impactful aspects of mobile, wireless and broadband communications development. These books present key systems and enabling technologies in a clear and accessible manner, offering a detailed roadmap of the future evolution of next generation communications. Other volumes cover Radio Interfaces; Networks, Services and Applications; and Ad Hoc Networks.

*To order this book, contact:*

Artech House · 685 Canton St. · Norwood, MA 02062 · (781) 769-9750 ext. 4030; or
16 Sussex St. · London SW1V 4RW, UK · +44 (0) 207-8750
350 pages; $169, £91 · ISBN: 978-1-60783-971-2

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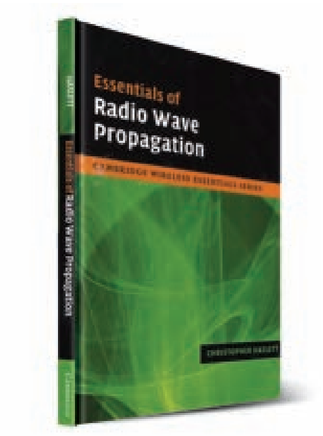
## *Essentials of Radio Wave Propagation*




### Christopher Haslett

This is a quick reference guide for understanding radio propagation issues in order to maximize efficiency in wireless networks. Using real-world case studies, practical problems and minimum mathematics, it explains how to predict signal strengths in a variety of situations. Fundamentals are explained in the context of their practical significance. Applications, including point-to-point radio links, broadcasting and earth-space communications, are thoroughly treated, and more sophisticated methods, which form the basis of software tools for both network planning and spectrum management, are also described. For a rapid understanding and insight into radio propagation, sufficient to enable one to undertake real-world engineering tasks, this concise book is useful for network planners, hardware designers, spectrum managers, senior technical managers and policy makers who are either new to radio propagation or who need a quick reference guide.

*To order this book, contact:*

Cambridge University Press · 100 Brook Hill Drive · West Nyack, NY 10994-2133 · (845) 353-7500
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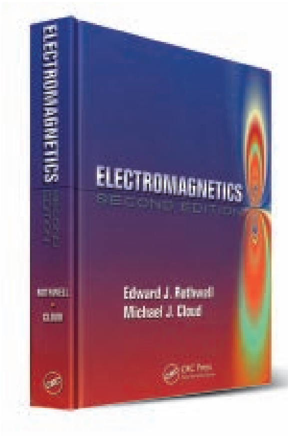
## *Electromagnetics, Second Edition*




### Edward J. Rothwell and Michael J. Cloud

This second edition of a popular text continues to offer coverage that spans the entire field, from electrostatics to the integral solutions of Maxwell's equations. The book provides a firm grounding in the fundamental concepts of electromagnetics and bolsters understanding through the use of classic examples in shielding, transmission lines, waveguides, propagation through various media, radiation, antennas and scattering. Mathematical appendices present helpful background information in the areas of Fourier transforms, dyadics and boundary value problems. The second edition adds a new and extensive chapter on integral equation methods with applications to guided waves, antennas and scattering.

*To order this book, contact:*

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markm@actintl.com.hk


## ACROSS

**3** Popularized S-parameters with paper in 1965

**4** Proved the existence of electromagnetic waves with spark gap

**6** Discovered electromagnetic induction

**7** Founded Sage Labs, Chair of 1967 Boston IMS, Distingished IEEE member

**11** Developed noise figure theory

**13** Invented CW voice transmitter

**17** Missile system called the Scud Buster

**18** First company to start commercial broadcasts

**19** Simplified Maxwell's equations, developed transmission line theory

**21** Proposed waveguide in 1983

**22** First to describe metal semiconductor junction behavior

**23** Organization that developed the first RADAR system that helped the Allied Forces win WWII (3 words)

**25** Developed FM radio, superheterodyne and regenerative circuits

## DOWN

**1** Company that made the first cell phone in 1983

**2** Predicted electromagnetic waves by developing equations to unify electricity and magnetism (and graces our cover this month)

**5** Coined the term RADAR in 1935 (hyphenated name)

**8** First casino to use RFID chips

**9** TI employee co-credited with developing the first integrated circuit

**10** Proposed patch antenna in 1953

**12** Developed the microwave oven after melting a candy bar in his pocket

**14** Credited with inventing the first radio

**15** Developed single crystal grow method that is widely used to make semiconductor wafers

**16** First to bounce radio waves off of moon as part of a Fort Monmouth project in 1946

**20** Fairchild employee co-credited with developing the first integrated circuit

**24** Company that developed CMOS in 1968

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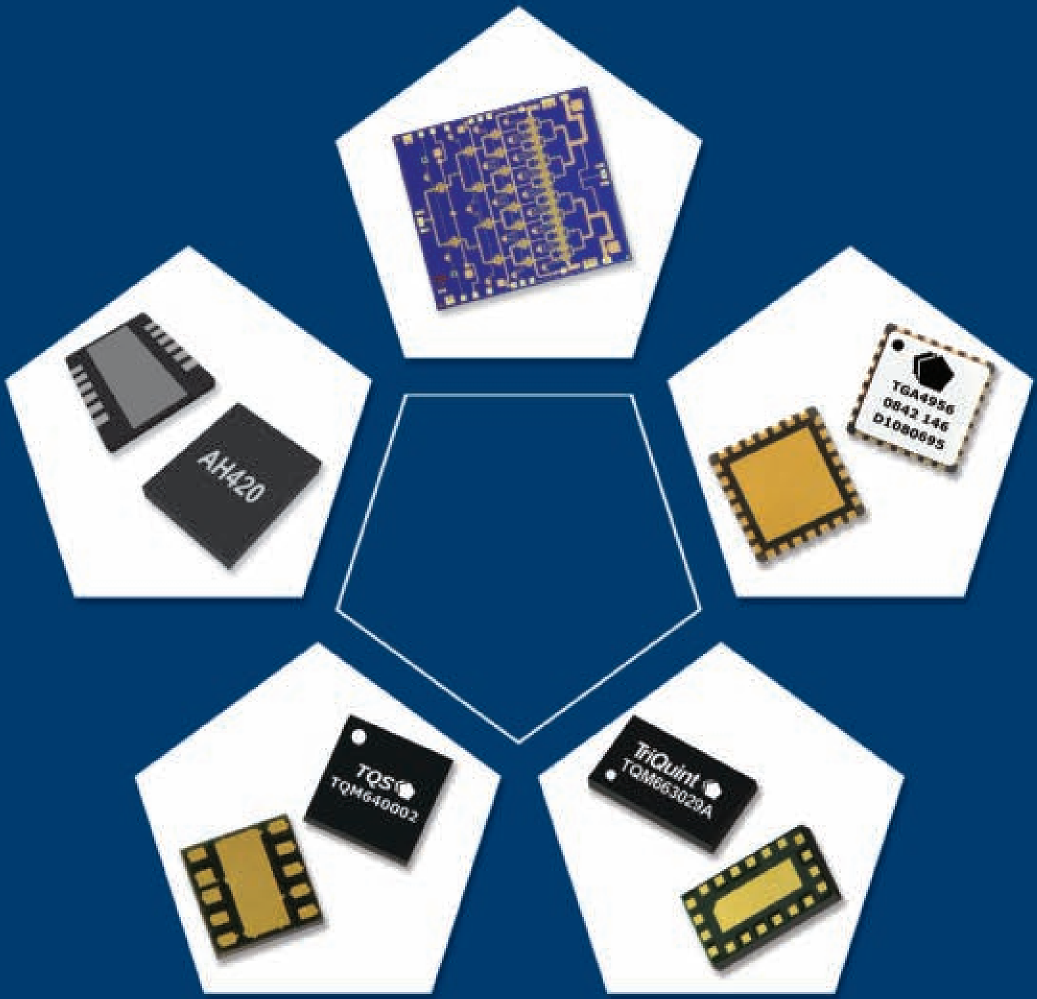
# PRODUCT SELECTION GUIDE

**MAY 2009**




***AMPLIFIERS • GAIN BLOCKS • LOW NOISE AMPLIFIERS • DISCRETE TRANSISTORS***
***SWITCHES • FREQUENCY CONVERTERS & MIXERS • OPTICAL COMPONENTS***
***CONTROL PRODUCTS • INTEGRATED PRODUCTS • FILTERS***

TriQuint® SEMICONDUCTOR

***Connecting the Digital World to the Global Network®***

# TABLE OF CONTENTS



*This guide contains a subset of the total selection of products available from TriQuint. If you are unable to locate the product you need, please contact your local sales representative or the factory for more information.*

# ABOUT TRIQUINT SEMICONDUCTOR

Corporate Headquarters – Hillsboro, OR

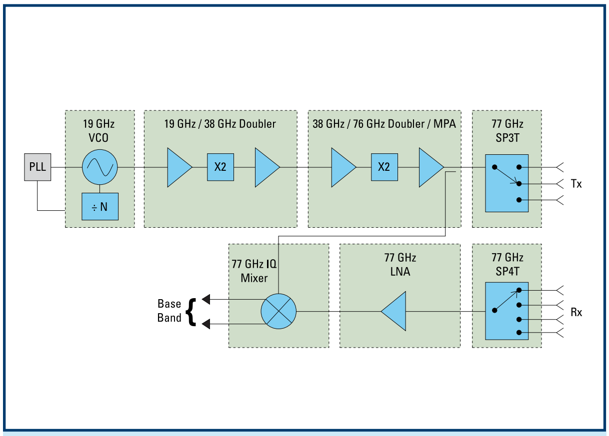
TriQuint Semiconductor is a leading supplier of high-performance RF components for wireless communications infrastructure and mobile devices. Our advanced technology and uncompromising quality have also enabled us to become a leading supplier for the high-reliability, high-frequency needs of defense, space and aerospace markets. Our customers span a wide range, from start-ups working in their first offices to major global corporations. All our customers share a common desire for cost-conscious, high-performance solutions tailored to the rigorous requirements of present and next-generation design applications.

At TriQuint, we 'Connect the Digital World to the Global Network®' with products based on key process technologies including Gallium Arsenide (GaAs), Surface Acoustic Wave (SAW), Bulk Acoustic Wave (BAW) and LDMOS (Laterally Diffused Metal Oxide Semiconductor). TriQuint is headquartered in Hillsboro, Oregon (USA) and has additional design and manufacturing centers in North America, plus design centers in Boulder, Colorado; Boston, Massachusetts; Greensboro, North Carolina; San Jose, California and Munich, Germany. Additional field application support and sales offices are located across the globe. Our customers are also served by a world-wide network of sales representatives and distributors.

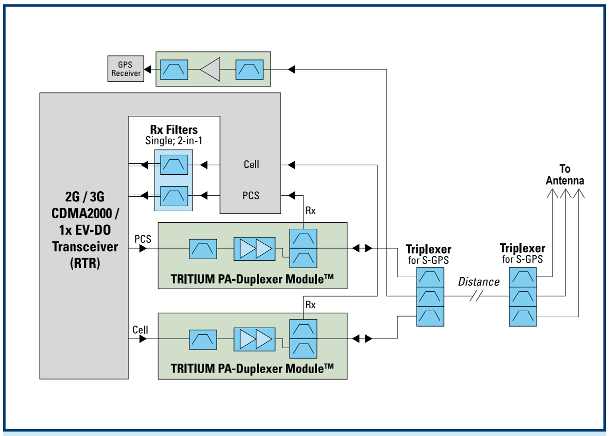
In 2008 and 2009 TriQuint released new devices based on continuing high-frequency gallium nitride (GaN) advancements. In 2008 we also added a wide selection of high quality devices from WJ Communications, including those for base station and RFID, that joined the TriQuint portfolio through acquisition. TriQuint's heritage in custom design applications and uncompromising standards led Strategy Analytics in 2008 to name TriQuint the number-one commercial GaAs foundry, followed in 2009 with naming TriQuint the third-largest overall producer of GaAs devices. In 2008, TriQuint became a Department of Defense (DoD) accredited 'Trusted Foundry' for circuit fabrication requiring the highest security. We continue pursuing the quality and reliability that led to these distinctions, offering more GaAs and GaN fabrication process than any other company in addition to our extensive standard and application-specific product portfolios.

TriQuint has brought all of its standard products together into one easy-to-use Product Selection Guide. Here you will find a wide variety of components and modules to suit your needs, from DC to 100 GHz. When creating new products or looking to add efficiency and cost-effectiveness to an existing design; you can depend on TriQuint's uncompromising quality and superior service. Take a look through our new Product Selection Guide and discover just how easy it is to include high-performance, high-quality products from TriQuint in your next design.


Image Courtesy of U.S. Navy




*Example for a 77 GHz Radar Front-End*




*Cellular & GPS Transceiver for Auto Telematics*

## AUTOMOTIVE AMPLIFIERS & LOW NOISE AMPLIFIERS

| Description | Frequency Range (GHz) | (Psat) / IIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 77 GHz LNA | 72 - 80 | 5 / – | 20 | 5 | 3.5 / 54 | Die | TGA4705-FC |
| 77 GHz MPA | 76 - 80 | (14) / – | 12 | – | 3.5 / 75 | Die | TGA4706-FC |

## AUTOMOTIVE SWITCHES

| Description | Frequency (GHz) | Insertion Loss (dB) | Isolation (dB) | P1dB (dBm) | Control Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| SP3T | 60 - 90 | 2.3 | 20 | >-13 | -5 / 1.35 | Die | TGS4305-FC |
| SP4T | 70 - 90 | 3.0 | 20 | >-8 | -5 / 1.35 | Die | TGS4306-FC |
| SP5T VPIN 77 GHz | 71 - 90 | 2.5 | 25 / 40 | >-8 | -5 / 1.35 | Die | TGS4307 |

## AUTOMOTIVE FREQUENCY CONVERTERS & MIXERS

| Description | RF Frequency Range (GHz) | Conversion Gain (dB) | LO / RF Isolation (dB) | IIP3 / Psat (dBm) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 38 / 77 GHz Converter / MPA | 76 - 78 | 6.0 | – | – / 15.0 | 4 / 230 | Die | TGC4704-FC |
| 19 / 38 GHz Converter / MPA | 36 - 40 | 9.0 | – | – / 14.5 | 3.5 / 65 | Die | TGC4703-FC |
| Down Converting I/Q Mixer | 75 - 80 | -13.5 | 22 | – | 1.1 / 7 | Die | TGC4702-FC |
| 19 GHz VCO with 8:1 Prescaler | 18.5 - 19.5 | – | -105** | – / 7.0 | 5 / 158 | Die | TGV2204-FC |

*NOTES: ** = Phase Noise (dBc / Hz @ 1 MHz Offset)*

## AUTOMOTIVE INTEGRATED PRODUCTS

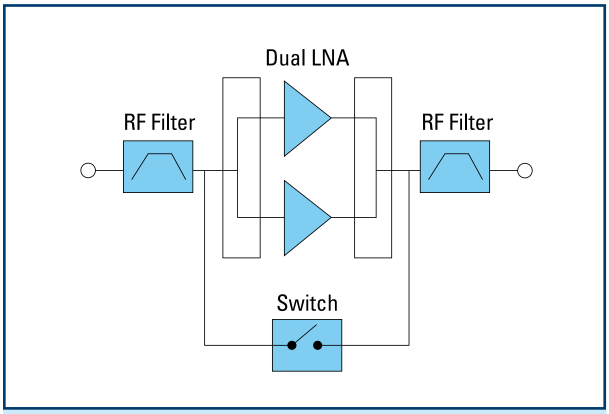
| Description | Frequency Bands | Package Size (mm) | Part Number |
|---|---|---|---|
| QB GSM / GPRS Tx Module; PA / LPF / SP6T Switch | GSM850 / 900, DCS / PCS | 6.0 x 6.0 x 1.1 | ***TQM6M4003**** |
| QB GSM / GPRS / EDGE-Polar PA Module | GSM850 / 900, DCS / PCS | 5.0 x 5.0 x 1.0 | ***TQM7M5012**** |

*NOTES:* **** = New***

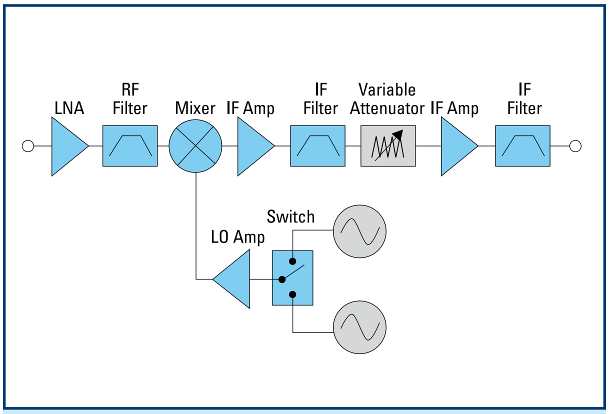
## AUTOMOTIVE FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| Duplexer, Cell Band | 836.5 / 881.5 | 25 / 25 | 1.9 / 1.9 | SE / SE | – | 3.8 x 3.8 | 856356 |
| CDMA 2-in-1 Rx Filter | 881.5 / 1960 | 25 / 60 | 1.6 / 2.2 | SE / BAL | – | 2.0 x 1.5 | 856565 |
| GPS RF Filter | 1575.42 | 2 | 1.25 | SE / SE | 30 @ 1624.00 | 2.0 x 1.5 | 856584 |
| GPS RF Filter | 1575.42 | 2 | 0.75 | SE / SE | 35 @ 1635.00 | 1.4 x 1.2 | 856561 |
| GPS RF Filter | 1575.42 | 2 | 1.1 | SE / BAL | 20 @ 1635.00 | 1.4 x 1.2 | 856576 |
| GPS RF Filter, Auto | 1575.42 | 2 | 1.8 | SE / SE | 45 @ 1637.00 | 3.0 x 3.0 | 856039 |
| GPS RF Filter, Auto | 1575.42 | 2 | 1.3 | SE / SE | 45 @ 1640.00 | 3.0 x 3.0 | 856139 |
| SDARS Filter | 2332.5 | 45 | 1.7 | SE / BAL | 35 @ 2100.00 | 1.4 x 1.2 | 856604 |
| GSM850 Rx Filter | 881.5 | 25 | 1.6 | SE / BAL | 40 @ 836.5 | 1.4 x 1.2 | ***856522**** |
| GSM1900 Rx Filter | 1960 | 60 | 1.5 | SE / BAL | 17 @ 1880.00 | 1.4 x 1.2 | ***856577**** |

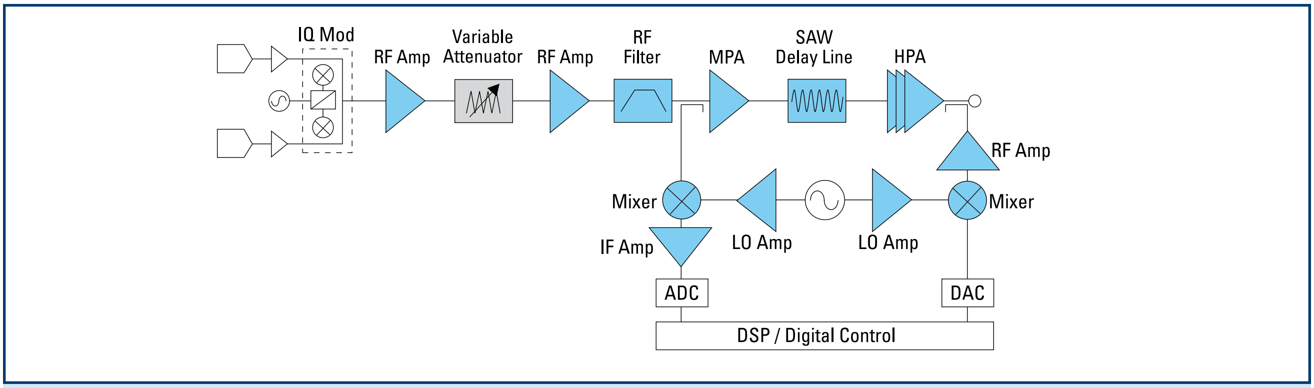
*NOTES:* **** = New***




*Tower Mounted LNA*




*Base Station Receiver (Single Branch Shown)*




*Base Station Transmitter and PA*

## BASE STATION GENERAL PURPOSE AMPLIFIERS

| Description | Frequency Range (MHz) | P1dB / OIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| General Purpose Gain Block | DC - 3000 | 18.5 / 33 | 16.5 | 3.8 | 6 / 75 | SOT89 | AG603 |
| General Purpose Gain Block | DC - 3500 | 18.5 / 33 | 13.6 | 4.4 | 6 / 75 | SOT89 | AG602 |
| General Purpose Gain Block | DC - 3500 | 20.5 / 33.5 | 17.2 | 3.5 | 7 / 96 | SOT89 | EC1078 |
| General Purpose Gain Block | DC - 4000 | 19.5 / 31 | 18.5 | 2.9 | 6 / 70 | SOT86 / SOT89 | EC1019 |
| General Purpose Gain Block | DC - 4000 | 17.5 / 32 | 21.5 | 3.4 | 6 / 65 | SOT89 | ECG005 |
| General Purpose Gain Block | DC - 4000 | 23.5 / 37 | 14.3 | 4.6 | 9 / 120 | SOT89 | ECG008 |
| General Purpose Gain Block | DC - 4000 | 18 / 34.5 | 15.3 | 5.5 | 6 / 70 | SOT89 | ECG040 |
| General Purpose Gain Block | DC - 5500 | 15 / 30 | 14.2 | 3.7 | 5 / 45 | SOT86 / SOT363 / SOT89 | ECG006 |
| General Purpose Gain Block | DC - 6000 | 5.8 / 18.5 | 11 | 4.4 | 5 / 20 | SOT86 / SOT363 | AG201 |
| General Purpose Gain Block | DC - 6000 | 7.5 / 19.5 | 17.7 | 3.1 | 5 / 20 | SOT86 / SOT363 | AG203 |
| General Purpose Gain Block | DC - 6000 | 12 / 25 | 14.3 | 3.2 | 5 / 35 | SOT86 / SOT363 | AG302 |
| General Purpose Gain Block | DC - 6000 | 12.5 / 25 | 18.4 | 3 | 5 / 35 | SOT86 / SOT363 | AG303 |
| General Purpose Gain Block | DC - 6000 | 16 / 28.5 | 14.5 | 3.7 | 6 / 60 | SOT86 / SOT89 | AG402 |
| General Purpose Gain Block | DC - 6000 | 16 / 28 | 18.9 | 3 | 6 / 60 | SOT86 / SOT89 | AG403 |
| General Purpose Gain Block | DC - 6000 | 14.5 / 27.5 | 19.1 | 2.9 | 6 / 45 | SOT86 / SOT89 | AG503 |
| General Purpose Gain Block | DC - 6000 | 19 / 33 | 18.2 | 3.5 | 6 / 75 | SOT86 / SOT89 | AG604 |
| General Purpose Gain Block | DC - 6000 | 12.5 / 26 | 21.4 | 3.4 | 5 / 30 | SOT363 / SOT89 | ECG001 |
| General Purpose Gain Block | DC - 6000 | 15 / 29 | 19.5 | 3.7 | 5 / 45 | SOT86 / SOT363 / SOT89 | ECG002 |
| General Purpose Gain Block | DC - 6000 | 23 / 36 | 19 | 3.5 | 9 / 110 | SOT89 | ECG003 |
| General Purpose Gain Block | DC - 6000 | 13 / 27 | 15.5 | 3.2 | 5 / 35 | SOT89 | ECG004 |
| General Purpose Gain Block | DC - 6000 | 18 / 32 | 20.1 | 3.4 | 6 / 65 | SOT86 / SOT89 | ECG055 |
| MESFET IF Gain Block | 50 - 870 | 20 / 36 | 13 | 3 | 5 / 150 | SOT89 | AG103 |
| MESFET IF Gain Block | 50 - 870 | 20 / 41 | 13 | 3 | 5 / 150 | SOT89 | AH3 |

## BASE STATION GENERAL PURPOSE AMPLIFIERS (cont.)

| Description | Frequency Range (MHz) | P1dB / OIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| MESFET IF Amplifier | 50 - 1000 | 22 / 42 | 19 | 2.2 | 5 / 150 | SOT89 | AH31 |
| +5V Active Bias IF Gain Block | 50 - 1000 | 20.5 / 44 | 19.5 | 5 | 5 / 95 | SOT89 | WJA1500 |
| +5V Active Bias IF Gain Block | 50 - 1000 | 19.5 / 36.5 | 19.3 | 4.7 | 5 / 65 | SOT89 | WJA1505 |
| +5V Active Bias IF Gain Block | 50 - 1000 | 20 / 47 | 14.4 | 5.4 | 5 / 95 | SOT89 | WJA1510 |
| +5V Active Bias IF Gain Block | 50 - 1000 | 19 / 38 | 14.4 | 5 | 5 / 70 | SOT89 | WJA1515 |
| +5V Active Bias Gain Block | 50 - 1200 | 18.5 / 34.5 | 18.3 | 5.3 | 5 / 85 | SOT89 | WJA1000 |
| +5V Active Bias Gain Block | 50 - 1200 | 17 / 35 | 18.2 | 5.1 | 5 / 65 | SOT89 | WJA1005 |
| MESFET Amplifier | 50 - 1500 | 26.5 / 47 | 13.5 | 3.5 | 9 / 200 | SOT89 | AH101 |
| MESFET Amplifier | 50 - 2200 | 30 / 47 | 17 | 2.5 | 11 / 330 | 6 x 6 QFN28 | AH202 |
| VGA, 20 dB Range, 5V Control | 50 - 2200 | 22 / 42 | 15.5 | 4.5 | 5 / 150 | 4 x 4 QFN16 | VG025 |
| +5V Active Bias Gain Block | 50 - 2300 | 19 / 36.5 | 15 | 5.2 | 5 / 85 | SOT89 | WJA1010 |
| +5V Active Bias Gain Block | 50 - 2300 | 17 / 37 | 15 | 5 | 5 / 65 | SOT89 | WJA1015 |
| +5V Active Bias Gain Block | 50 - 3000 | 20 / 44 | 19 | 5.4 | 5 / 100 | SOT89 | WJA1001 |
| +5V Active Bias Gain Block | 50 - 4000 | 18.5 / 33.5 | 18.5 | 5.1 | 5 / 70 | SOT89 | WJA1020 |
| +5V Active Bias Gain Block | 50 - 4000 | 20 / 40 | 18.5 | 5.6 | 5 / 90 | SOT89 | WJA1021 |
| +5V Active Bias Gain Block | 50 - 4000 | 17.5 / 33 | 18.5 | 5 | 5 / 60 | SOT89 | WJA1025 |
| +5V Active Bias Gain Block | 50 - 4000 | 19.5 / 37 | 14.5 | 5.5 | 5 / 80 | SOT89 | WJA1030 |
| +5V Active Bias Gain Block | 50 - 4000 | 18 / 35 | 14.5 | 5.4 | 5 / 65 | SOT89 | WJA1035 |
| MESFET Amplifier, 2-Stage | 60 - 2700 | 27 / 46 | 29 | 2.5 | 4.5; 9 / 275 | SOIC-8 | AH103A |
| MESFET Gain Block | 60 - 3000 | 15 / 32 | 14 | 2.4 | 4.5 / 50 | SOT89 | AG101 |
| MESFET Gain Block | 60 - 3000 | 18 / 36 | 14 | 2.4 | 4.5 / 70 | SOT89 | AG102 |
| MESFET Gain Block | 60 - 3000 | 18 / 39 | 14 | 2.4 | 4.5 / 78 | SOT89 | AM1 |
| MESFET Dual Amplifier | 150 - 3000 | 24 / 46 | 12 | 4.1 | 5 / 300 | SOIC-8 | AH11 |
| MESFET Amplifier | 250 - 4000 | 21.5 / 42 | 14 | 3.2 | 5 / 150 | SOT89 | AH1 |
| MESFET Amplifier | 250 - 4000 | 21.5 / 42 | 14 | 3.2 | 5 / 150 | SOT89 | AH1-1 |
| MESFET Amplifier | 350 - 3000 | 27 / 46 | 14.5 | 3.1 | 9 / 200 | SOT89 | AH102A |
| VGA, 29 dB Range, 5V Control | 700 - 1000 | 22 / 40 | 16 | 3.5 | 5 / 150 | 6 x 6 QFN28 | VG101 |
| Gain Block | 800 - 2500 | 17 / 27 | 16 | 4.1 | 5 / 85 | SOIC-8 | TQ9132 |
| VGA, 28 dB Range, 5V Control | 1800 - 2200 | 30 / 46 | 23 | 8 | 5 / 415 | 6 x 6 QFN28 | VG112 |
| VGA, 27 dB Range, 5V Control | 1800 - 2700 | 22 / 39.5 | 13.5 | 4.5 | 5 / 150 | 6 x 6 QFN28 | VG111 |

## BASE STATION HBT HIGH LINEARITY DRIVER AMPLIFIERS

| Description | Frequency Range (MHz) | P1dB / OIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 24 dBm HBT Amplifier | 10 - 2500 | 24 / 40 | 15.5 | 5.1 | 5 / 160 | SOT89 | EC1089 |
| 23 dBm HBT Amplifier | 50 - 2000 | 23 / 39 | 20.5 | 5 | 8 / 100 | SOT89 | AH110 |
| 28.5 dBm HBT Amplifier | 50 - 2700 | 28.5 / 45 | 20 | 4.5 | 5 / 150 | SOT89 | ***AH125**** |
| 24 dBm HBT Amplifier | 60 - 2500 | 24 / 40 | 19 | 5 | 5 / 150 | SOT89 | AH114 |
| 24 dBm HBT Amplifier | 60 - 3500 | 24 / 40 | 19.5 | 4 | 5 / 160 | SOT89 | AH118 |
| 24.5 dBm HBT Amplifier | 60 - 3500 | 24.5 / 41.5 | 19.5 | 4.5 | 5 / 115 | SOT89 | ***AH128**** |
| 31 dBm HBT Amplifier | 400 - 2300 | 31 / 46 | 18 | 7 | 5 / 450 | 4 x 4 QFN16 | ECP100 |
| 33 dBm HBT Amplifier | 400 - 2300 | 33 / 49 | 18 | 8 | 5 / 800 | 4 x 4 QFN16 | ECP200 |
| 31 dBm HBT Amplifier | 400 - 2300 | 31 / 46 | 18 | 7 | 5 / 450 | SOIC-8 | AH215 |
| 33 dBm HBT Amplifier | 400 - 2300 | 33 / 49 | 18 | 8 | 5 / 800 | SOIC-8 | AH312 |
| 31.5 dBm HBT Amplifier | 400 - 2700 | 31.5 / 46 | 20 | 7 | 5 / 300 | SOIC-8 | ***AH225**** |
| 33.5 dBm HBT Amplifier | 400 - 2700 | 33.5 / 50 | 19 | 8 | 5 / 500 | SOIC-8 | ***AH322**** |
| 35.5 dBm HBT Amplifier | 400 - 2700 | 35.5 / 50 | 16 | 7 | 5 / 800 | 4 x 5 DFN12 | ***AH420**** |
| 39 dBm HBT Amplifier | 700 - 2900 | 39 / – | 16.5 | 8 | 12 / 300 | 5 x 5 QFN20 | AP561 |
| 28.7 dBm HBT Amplifier | 800 - 1000 | 28.7 / 43 | 17.5 | 7 | 5 / 250 | SOIC-8 | AH116 |
| 28.7 dBm HBT Amplifier | 800 - 1000 | 28.7 / 43 | 17.5 | 7 | 5 / 250 | 4 x 4 QFN16 | ECP052 |
| 28.5 dBm HBT Amplifier | 1800 - 2300 | 28.5 / 44 | 14.5 | 6 | 5 / 250 | SOIC-8 | AH115 |
| 28.5 dBm HBT Amplifier | 1800 - 2300 | 28.5 / 44 | 14.5 | 6 | 5 / 250 | 4 x 4 QFN16 | ECP050 |
| 30 dBm HBT Amplifier | 1800 - 2700 | 30 / 46 | 24.6 | 5.5 | 5 / 400 | SOIC-8 / 4 x 5 DFN12 | AH212 |
| 33 dBm HBT Amplifier | 2300 - 2900 | 33 / – | 23 | 6.4 | 5 / 600 | 5 x 5 QFN20 | AH314 |
| 33 dBm HBT Amplifier | 3300 - 3800 | 33 / – | 25 | – | 5 / 600 | 5 x 5 QFN20 | AH315 |

*NOTES:* **** = New***

## BASE STATION LOW NOISE AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB / IIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| LNA, Discrete | DC - 4000 | – / 13 | 17 | 0.5 | 3 / 30 | SOT343 | CFH800 |
| LNA, Balanced FET Low Band | 700 - 915 | – / 13.5 | 17 | 0.7 | 2.5 / 100 | 4 x 4 QFN16 | *TQP3M6004** |
| LNA, Discrete Low Band High Linearity | 700 - 915 | 26 / 23.5 | 16 | 0.8 | 5 / 150 | SOT89 | *TGF2021-04-SD** |
| LNA, Balanced FET | 800 - 3000 | 21 / 11 | 22 | 0.7 | 4 / 100 | SM-02-6 | TGA2602-SM |

NOTES: * = New

## BASE STATION DISCRETE TRANSISTORS

| Description | Frequency Range (MHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| MESFET | DC - 2500 | 26.5 / – | 11 | 1.72 / 55 | 2 - 6 / 350 | SOT223 | CLY5 |
| MESFET | DC - 3000 | 23.5 / – | 15.5 | 1.48 / 55 | 2 - 6 / 180 | MW6 | CLY2 |
| 0.5W HFET | DC - 6000 | 28 / 40 | 18 | 3.2 / – | 8 / 100 | SOT89 | TGF2960-SD |
| 1W HFET | DC - 6000 | 31 / 43 | 16 | 4 / – | 8 / 200 | SOT89 | TGF2961-SD |
| MESFET | 50 - 4000 | 21 / 42 | 19 | 2 / – | 5 / 140 | SOT89 | FH1 |
| MESFET | 50 - 4000 | 18 / 36 | 19 | 2 / – | 5 / 140 | SOT89 | FH101 |
| 0.5W HFET | 50 - 4000 | 27 / 40 | 19 | 2.7 / – | 8 / 125 | SOT89 | FP1189 |
| 1W HFET | 50 - 4000 | 30 / 44 | 18 | 4.5 / – | 8 / 250 | SOT89 | FP2189 |
| 2.5W HFET | 50 - 4000 | 34 / 46 | 18 | 3.5 / – | 9 / 450 | 6 x 6 QFN28 | FP31QF |

## BASE STATION 28V TRANSISTORS

| Description | Frequency Range (MHz) | P1dB / IMD3 (dBm) / (dBc) | Gain (dB) | Efficiency (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| InGaP HBT PA, 1.8W, Ultra High Linearity | 800 - 2350 | 32.5 / -60 | 15.8 | 55 | 28 / 40 | 5 x 6 DFN14 | AP601 |
| InGaP HBT PA, 3.7W, Ultra High Linearity | 800 - 2350 | 35.7 / -62 | 15.5 | 55 | 28 / 80 | 5 x 6 DFN14 | AP602 |
| InGaP HBT PA, 7W Ultra High Linearity | 800 - 2350 | 38.5 / -51 | 17 | 53 | 28 / 160 | 5 x 6 DFN14 | AP603 |
| LDMOS PA, 30W IS95 | 865 - 895 | 44.8 / -31 | 21 | 57 | 28 / 330 | EU, EF | AGR09030E |
| LDMOS PA, 45W IS95 | 865 - 895 | 46.5 / -31 | 20.5 | 59 | 28 / 450 | EU, EF | AGR09045E |
| LDMOS PA, 85W IS95 | 865 - 895 | 49.3 / -30 | 18 | 55 | 28 / 800 | EU, EF | AGR09085E |
| LDMOS PA, 180W IS95 Push Pull | 865 - 895 | 52.6 / -30 | 15.5 | 58 | 28 / 2x850 | EF | AGR09180E |
| LDMOS PA, 70W GSM / EDGE | 921 - 960 | 48.5 / -60 | 18 | 56 | 26 / 800 | EF | AGR09070E |
| LDMOS PA, 90W GSM / EDGE | 921 - 960 | 49.5 / -60 | 18 | 60 | 26 / 700 | EF | AGR09090E |
| LDMOS PA, 130W GSM / EDGE | 921 - 960 | 51.1 / -60 | 18 | 55 | 26 / 1000 | EU, EF | AGR09130E |
| LDMOS PA, 30W GSM / EDGE | 1805 - 1880 | 44.8 / -64 | 15 | 51 | 26 / 300 | EF | AGR18030E |
| LDMOS PA, 45W GSM / EDGE | 1805 - 1880 | 46.5 / -63 | 15 | 53 | 26 / 400 | EF | AGR18045E |
| LDMOS PA, 60W GSM / EDGE | 1805 - 1880 | 47.8 / -62 | 15 | 52 | 26 / 500 | EU, EF | AGR18060E |
| LDMOS PA, 90W GSM / EDGE | 1805 - 1880 | 49.5 / -63 | 15 | 50 | 26 / 800 | EU, EF | AGR18090E |
| LDMOS PA, 125W GSM / EDGE | 1805 - 1880 | 51 / -60 | 13.5 | 50 | 26 / 1200 | EU, EF | AGR18125E |
| LDMOS PA, 30W CDMA / GSM / EDGE | 1930 - 1990 | 44.8 / – | 16 | 55 | 28 / 300 | EF | AGR19030E |
| LDMOS PA, 45W CDMA / GSM / EDGE | 1930 - 1990 | 46.5 / – | 16 | 54 | 28 / 400 | EF | AGR19045E |
| LDMOS PA, 60W CDMA / GSM / EDGE | 1930 - 1990 | 47.8 / – | 15.5 | 53 | 28 / 500 | EU, EF | AGR19060E |
| LDMOS PA, 90W CDMA / GSM / EDGE | 1930 - 1990 | 49.5 / – | 15.5 | 50 | 28 / 800 | EU, EF | AGR19090E |
| LDMOS PA, 125W CDMA / GSM / EDGE | 1930 - 1990 | 51 / – | 15 | – | 28 / 1250 | EU, EF | AGR19125E |
| LDMOS PA, 180W CDMA / GSM / EDGE Push Pull | 1930 - 1990 | 52.6 / – | 14.5 | – | 28 / 2x800 | EF | AGR19180E |
| LDMOS PA, 30W WCDMA | 2110 - 2170 | 44.8 / -34 | 14.5 | 26 | 28 / 300 | EF | AGR21030E |
| LDMOS PA, 45W WCDMA | 2110 - 2170 | 46.5 / -33 | 14.5 | 26 | 28 / 400 | EF | AGR21045E |
| LDMOS PA, 60W WCDMA | 2110 - 2170 | 47.8 / -34 | 14.5 | 26 | 28 / 500 | EU, EF | AGR21060E |
| LDMOS PA, 90W WCDMA | 2110 - 2170 | 49.5 / -33 | 14.5 | 26 | 28 / 800 | EU, EF | AGR21090E |
| LDMOS PA, 120W WCDMA Push Pull | 2110 - 2170 | 50.8 / – | 14 | 22 | 28 / 2x700 | EF | PTF102003 |
| LDMOS PA, 125W WCDMA | 2110 - 2170 | 51 / -34.5 | 14 | 27 | 28 / 1200 | EU, EF | AGR21125E |
| LDMOS PA, 180W WCDMA Push Pull | 2110 - 2170 | 52.6 / -36 | 14 | 26 | 28 / 2x800 | EF | AGR21180E |
| LDMOS PA, 25W MMDS WCDMA | 2300 - 2500 | 44 / -30 | 12 | – | 28 / 330 | EF | PD25025F |
| LDMOS PA, 45W MMDS WCDMA | 2535 - 2655 | 46.5 / -38 | 13 | 21 | 28 / 430 | EF | AGR26045E |
| LDMOS PA, 125W MMDS WCDMA | 2535 - 2655 | 51 / -38 | 12 | 20 | 28 / 1300 | EU, EF | AGR26125E |
| LDMOS PA, 180W MMDS WCDMA Push Pull | 2535 - 2655 | 52.6 / -36 | 12 | 20 | 28 / 2x850 | EF | AGR26180E |
| LDMOS PA, 25W MMDS WCDMA | 2500 - 2700 | 44 / -30 | 11 | – | 28 / 330 | EF | PD27025F |

## BASE STATION SWITCHES

| Description | Frequency (MHz) | Insertion Loss (dB) | Isolation (dB) | P1dB (dBm) | Control Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| SP3T High Power CDMA | DC - 2000 | 0.45 | 28 | >36.5 | 2.6 / 0 | MLP12 | TQP4M3018 |
| SP3T High Power CDMA | DC - 2000 | 0.6 | 22 | >34.5 | 2.6 / 0 | STSLP12 | TQP4M3019 |
| SP2T General Purpose | DC - 2500 | 0.3 | 24 | 30 | 3 / 0 | SOT363 | CSH210R |
| SP2T 802.11a/b/g | DC - 6000 | 0.6 | 28 | 31.5 | 3 / 0 | SLIM7 | TQS5200 |
| Diversity Switch 802.11a/b/g | DC - 6000 | 0.8 | 33 | 33 | 3 / 0 | MLP12 | TQS5202 |

## BASE STATION FREQUENCY CONVERTERS & MIXERS

| Description | RF Frequency Range (MHz) | Conversion Gain (dB) | LO / RF Isolation (dB) | IIP3 (dBm) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| WB Mixer, LO | 500 - 2500 | -5.7 | 8 | 24 | 3 - 6 / 6 | MW6 | CMY210 |
| WB Mixer, LO, IF | 500 - 2500 | 10 | 8 | 9 | 3 - 6 / 12 | SCT598 | CMY212 |
| WB Mixer, LO, IF, Low Current | 500 - 2500 | 9.5 | 10 | 10 | 3 - 6 / 8 | SCT598 | CMY213 |
| WB Mixer, LO | 500 - 2500 | 4 | – | 9 | 3 - 6 / 6.2 | SOT23-6 | TQ5M31 |
| Single Branch Converter, RF, LO, IF | 800 - 915 | 22 | 60 | 15 | 5 / 360 | 6 x 6 QFN28 | CV110-1A |
| Dual Branch Converter, LO, IF | 800 - 915 | 10 | 20 | 20 | 5 / 385 | 6 x 6 QFN28 | CV210-1A |
| Mixer | 800 - 960 | -7.3 | 30 | 34 | N/A | SOIC-8 | MH203A |
| Mixer | 800 - 960 | -7 | 37 | 35 | N/A | SOIC-8 | MH205A |
| Single Branch Converter, RF, LO, IF | 800 - 960 | 22 | 60 | 15 | 5 / 360 | 6 x 6 QFN28 | CV110-2A |
| Single Branch Converter, RF, LO, IF | 800 - 960 | 22 | 60 | 15 | 5 / 360 | 6 x 6 QFN28 | CV110-3A |
| Dual Branch Converter, LO, IF | 800 - 960 | 10 | 18 | 19.5 | 5 / 360 | 6 x 6 QFN28 | CV210-2A |
| Dual Branch Converter, LO, IF | 800 - 960 | 10.5 | 14 | 18.5 | 5 / 390 | 6 x 6 QFN28 | CV210-3A |
| Mixer, LO | 1600 - 3200 | -8.5 | 2 | 35 | 5 / 40 | MSOP-8 | ML485 |
| Mixer | 1700 - 2000 | -8.3 | 30 | 35 | N/A | SOIC-8 | MH1A |
| Single Branch Converter, RF, LO, IF | 1700 - 2000 | 21 | 45 | 17 | 5 / 360 | 6 x 6 QFN28 | CV111-1A |
| Dual Branch Converter, LO, IF | 1700 - 2000 | 10 | 8 | 19.5 | 5 / 380 | 6 x 6 QFN28 | CV211-1A |
| Mixer, LO | 1700 - 2200 | -8.2 | 9 | 30 | 5 / 105 | SOIC-8 | ML401 |
| Single Branch Converter, RF, LO, IF | 1900 - 2200 | 21 | 40 | 17 | 5 / 360 | 6 x 6 QFN28 | CV111-3A |
| Dual Branch Converter, LO, IF | 1900 - 2700 | 10 | 12 | 20 | 5 / 380 | 6 x 6 QFN28 | CV211-2A |
| Dual Branch Converter, LO, IF | 1900 - 2700 | 9 | 12 | 19 | 5 / 315 | 6 x 6 QFN28 | CV221-2A |
| Mixer, LO | 1900 - 2700 | -8.1 | 9 | 30 | 5 / 110 | SOIC-8 | ML501 |
| Mixer | 1900 - 2700 | -8.2 | 28 | 34 | N/A | SOIC-8 | MH103A |

*NOTES: RF = RF Amplifier, LO = LO Amplifier, IF = IF Amplifier*

## BASE STATION RF FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| FRS RF or GPS IF Filter | 465 | 6 | 1.4 | SE / SE | 40 @ 445.00 | 3.0 x 3.0 | 856288 |
| RF Filter, 700 MHz Band | 751.5 | 11 | 1.5 | SE / SE | 40 @ 776.00 | 3.0 x 3.0 | ***856794**** |
| RF Filter, 700 MHz Band | 781.5 | 11 | 1.5 | SE / SE | 38 @ 757.00 | 3.0 x 3.0 | ***856764**** |
| RF Filter, Cell Band | 836.5 | 25 | 2.7 | SE / SE | 28 @ 869.00 | 3.0 x 3.0 | 855729 |
| RF Filter, Cell Band | 836.5 | 25 | 1.8 | SE / SE | 30 @ 869.00 | 3.0 x 3.0 | 855779 |
| RF Filter, Cell Band | 836.5 | 25 | 1.9 | SE / SE | 35 @ 869.00 | 3.0 x 3.0 | 855821 |
| RF Filter, Cell Band | 836.5 | 25 | 2.0 | SE / SE | 10 @ 869.00 | 3.0 x 3.0 | ***856704**** |
| RF Filter, Cell Band | 881.5 | 25 | 2.7 | SE / SE | 40 @ 849.00 | 3.0 x 3.0 | 855728 |
| RF Filter, Cell Band | 881.5 | 25 | 1.8 | SE / SE | 35 @ 849.00 | 3.0 x 3.0 | 855782 |
| Cell Band Delay Filter, 450 ns | 881.5 | 25 | 25 | SE / BAL | N/A | 7.0 x 5.5 | 856716 |
| RF Filter, EGSM | 897.5 | 35 | 1.9 | SE / SE | 14 @ 930.00 | 3.0 x 3.0 | 856671 |
| RF Filter, EGSM | 897.5 | 35 | 1.5 | SE / SE | 15 @ 930.00 | 3.0 x 3.0 | 856657 |
| RF Filter, EGSM | 942.5 | 35 | 2 | SE / SE | 5 @ 915.00 | 3.0 x 3.0 | 855820 |
| RF Filter, EGSM | 942.5 | 35 | 3.2 | SE / SE | 12 @ 915.00 | 3.0 x 3.0 | 855810 |
| RF Filter, EGSM | 942.5 | 35 | 2.5 | SE / SE | 25 @ 915.00 | 3.0 x 3.0 | 856528 |
| GSM Band Delay Filter, 450 ns | 942.5 | 35 | 25.5 | SE / SE | N/A | 7.0 x 5.5 | ***856766**** |
| RF Filter, DCS | 1747.5 | 75 | 2 | SE / SE | 22 @ 1676.00 | 3.0 x 3.0 | 856654 |
| RF Filter, DCS | 1842.5 | 75 | 1.9 | SE / SE | 10 @ 1785.00 | 3.0 x 3.0 | 855860 |
| RF Filter, PCS (Split Band) | 1880 | 30 | 2.0 | SE / SE | 35 @ 1930.00 | 3.0 x 3.0 | 855833 |
| RF Filter, PCS | 1880 | 60 | 2.4 | SE / SE | 7 @ 1930.00 | 3.0 x 3.0 | 855849 |
| RF Filter, PCS | 1880 | 60 | 2.8 | SE / SE | 30 @ 1930.00 | 3.0 x 3.0 | 856530 |

## BASE STATION RF FILTERS (cont.)

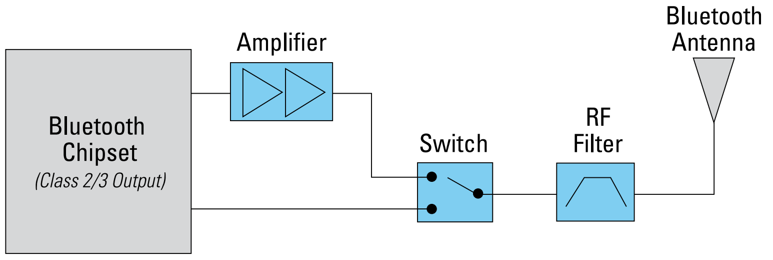
| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| RF Filter, PCS | 1880 | 60 | 2.2 | SE / SE | 15 @ 1806.00 | 3.0 x 3.0 | *856705** |
| RF Filter, UMTS | 1950 | 60 | 2.2 | SE / SE | 40 @ 2110.00 | 3.0 x 3.0 | 856532 |
| RF Filter, UMTS | 1950 | 60 | 1.8 | SE / SE | 20 @ 2100.00 | 3.0 x 3.0 | *856678** |
| RF Filter, PCS | 1960 | 60 | 2.1 | SE / SE | 10.3 @ 1910.00 | 3.0 x 3.0 | 855817 |
| RF Filter, PCS | 1960 | 60 | 2.3 | SE / SE | 8 @ 1910.00 | 3.0 x 3.0 | 855850 |
| RF Filter, PCS | 1960 | 60 | 2.9 | SE / SE | 15 @ 1910.00 | 3.0 x 3.0 | 855859 |
| RF Filter, PCS | 1960 | 60 | 2.25 | SE / SE | 14 @ 1910.00 | 3.0 x 3.0 | 856531 |
| Delay Filter, PCS 450 ns | 1960 | 60 | 25 | SE / BAL | N/A | 7.0 x 5.5 | 856717 |
| Delay Filter, UMTS 450 ns | 2140 | 60 | 25 | SE / BAL | N/A | 7.0 x 5.5 | 856649 |
| RF Filter, UMTS | 2140 | 60 | 2.3 | SE / SE | 25 @ 1980.00 | 3.0 x 3.0 | *856738** |

*NOTES:* ***** = New**

## BASE STATION IF FILTERS

TriQuint Semiconductor offers a wide variety of base station IF filters. To view a selection of the most common filters, please go to the SAW filter section on pages 31-35.

# GUIDE BY MARKET – BLUETOOTH




*Bluetooth Application*

## BLUETOOTH AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB (dBm) | Gain (dB) | PAE (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Bluetooth PA | DC - 2.5 | 22.5 | 26 | 50 | 0 - 5.5 / 200 | SLIM-7 | CGB241 |
| Bluetooth PA | DC - 2.5 | 22.5 | 26 | 50 | 0 - 5.5 / 200 | MSOP-10 | CGB240 |
| Bluetooth Class 1 PA | 2.4 - 2.5 | 21.5 | 27 | 50 | 0 - 3.3 / 160 | STSLP-12 | TQP770001 |
| ISM Band Matched PA, PD | 2.4 - 2.5 | 25 | 30 | – | 3.3 / 200 | VQFN-16 | TQP777002 |

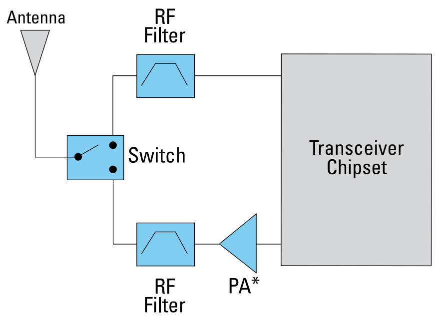
*NOTES: PD = Power Detector*

## BLUETOOTH SWITCHES

| Description | Frequency (GHz) | Insertion Loss (dB) | Isolation (dB) | P1dB (dBm) | Control Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| SP2T General Purpose | DC - 2.5 | 0.3 | 24 | 30 | 3 / 0 | SOT363 | CSH210R |
| SP2T 802.11a/b/g | DC - 6 | 0.6 | 28 | 31.5 | 3 / 0 | SLIM7 | TQS5200 |

## BLUETOOTH RF FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| Bluetooth RF Filter | 2441 | 83.5 | 2.8 | SE / SE | 26 @ 2200.00 | 3.0 x 3.0 | 855916 |
| Bluetooth RF Filter | 2441 | 83.5 | 2 | SE / SE | 20 @ 2300.00 | 1.4 x 1.2 | 856539 |
| Bluetooth RF Filter | 2441 | 83.5 | 2.7 | SE / BAL | 40 @ 2170.00 | 1.4 x 1.2 | 856548 |
| Bluetooth & GPS Filter | 2441 / 1575.42 | 83.5 / 2 | 2 / 1.2 | SE / SE | – | 2.0 x 1.5 | 856646 |




** Note: For MIMO implementations, multiple PAs may be required*

*Broadband Transceiver*

## BWA / WiMAX AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB / OIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 39 dBm HBT Amplifier | 0.7 - 2.9 | 39 / – | 16.5 | 8 | 12 / 300 | 5 x 5 QFN20 | AP561 |
| WiMAX Driver Amp / PA, SB | 2.3 - 2.8 | 29 / 40 | 28 | – | 6 / 710 | SM-05-28 | TGA2702-SM |
| 33 dBm HBT Amplifier | 2.3 - 2.9 | 33 / – | 23 | 6.4 | 5 / 600 | 5 x 5 QFN20 | AH314 |
| 10W HPA, HFET | 2.6 | 40 / 51 | 12 | – | 8 / 1200 | SG-A4-2 | TGA2924-SG |
| 33 dBm HBT Amplifier | 3.3 - 3.8 | 33 / – | 25 | – | 5 / 600 | 5 x 5 QFN20 | AH315 |
| 39 dBm HBT Amplifier | 3.3 - 3.8 | 39 / – | 11.5 | – | 12 / 400 | 5 x 6 DFN14 | AP562 |
| 10W HPA, HFET | 3.3 - 3.8 | 40 / 51 | 9 | – | 7 - 9 / 1200 | SG-A3-2 | TGA2923-SG |
| WiMAX Driver Amp / PA, SB | 3.4 - 3.8 | 30 / 42 | 24 | – | 6 / 770 | SM-05-28 | TGA2703-SM |
| 5W HPA, HFET | 3.5 | 37.5 / 49 | 11 | – | 8 / 750 | SG-A4-2 | TGA2925-SG |

*NOTES: SB = Self Biased*

## BWA / WiMAX DISCRETE TRANSISTORS

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| MESFET | DC - 3000 | 23.5 / – | 15.5 | 1.48 / 55 | 2 - 6 / 180 | MW6 | CLY2 |
| 0.5W HFET | DC - 6000 | 28 / 40 | 18 | 3.2 / – | 8 / 100 | SOT89 | TGF2960-SD |
| 1W HFET | DC - 6000 | 31 / 43 | 16 | 4 / – | 8 / 200 | SOT89 | TGF2961-SD |
| MESFET | 50 - 4000 | 21 / 42 | 19 | 2 / – | 5 / 140 | SOT89 | FH1 |
| MESFET | 50 - 4000 | 18 / 36 | 19 | 2 / – | 5 / 140 | SOT89 | FH101 |
| 0.5W HFET | 50 - 4000 | 27 / 40 | 19 | 2.7 / – | 8 / 125 | SOT89 | FP1189 |
| 1W HFET | 50 - 4000 | 30 / 44 | 18 | 4.5 / – | 8 / 250 | SOT89 | FP2189 |
| 2.5W HFET | 50 - 4000 | 34 / 46 | 18 | 3.5 / – | 9 / 450 | 6 x 6 QFN28 | FP31QF |

## BWA / WiMAX SWITCHES

| Description | Frequency (GHz) | Insertion Loss (dB) | Isolation (dB) | P1dB (dBm) | Control Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| SP2T General Purpose | DC - 2.5 | 0.3 | 24 | 30 | 3 / 0 | SOT363 | CSH210R |
| SP2T 802.11a/b/g | DC - 6 | 0.6 | 28 | 31.5 | 3 / 0 | SLIM7 | TQS5200 |

## BWA / WiMAX BAW FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| WCS Passband RF Filter | 2332.5 | 55 | 3 | SE / SE | 10 @ 2300.00 & 2370.00 | 1.70 x 1.30 | 885002 |
| SDARS Notch RF Filter | 2332.5 | 55 | 1.5 (Out of Band IL) | SE / SE | 17 @ 2332.50 (Notch Rej) | 1.70 x 1.30 | 885003 |
| ISM Passband Filter | 2436 | 72 | 2 | SE / SE | 20 @ 2495.00 | 1.70 x 1.30 | ***885007**** |
| ISM Notch RF Filter | 2440 | 72 | 1.5 (Out of Band IL) | SE / SE | 25 @ 2440.00 | 1.70 x 1.30 | ***885008**** |
| ISM Notch RF Filter | 2440 | 85 | 2 (Out of Band IL) | SE / SE | 18 @ 2440 (Notch Rej) | 1.70 x 1.30 | ***885010**** |

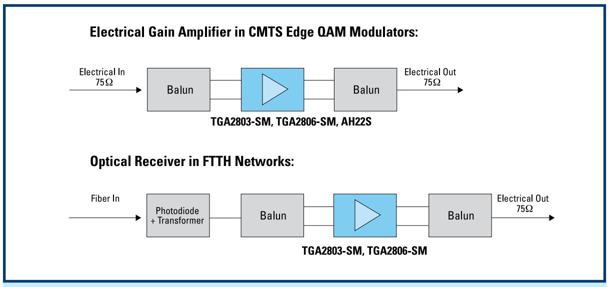
*NOTES:* **** = New***

## BWA / WiMAX IF FILTERS

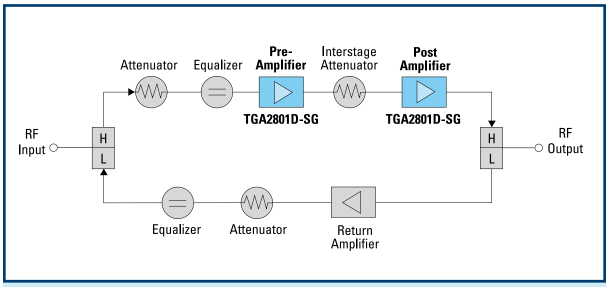
TriQuint Semiconductor offers a wide variety of BWA / WiMAX filters. To view a selection of the most common filters, please go to the SAW filter section on pages 31-35.

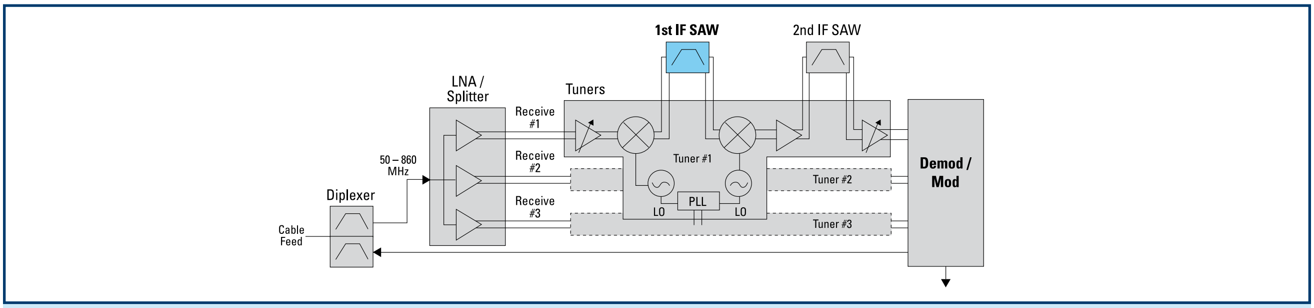
TriQuint SEMICONDUCTOR




*Amplifiers for QAM Modulators*




*CATV Line Extender*




*Typical STB Architecture*

## CABLE AMPLIFIERS

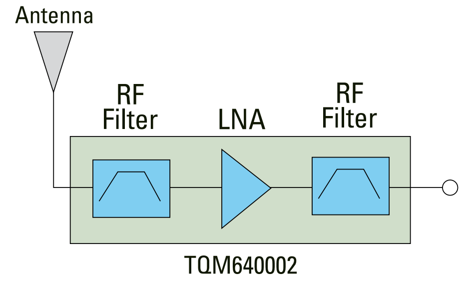
| Description | Frequency Range (MHz) | P1dB / OIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| CATV TIA / Gain Block, SB | 40 - 1000 | 27 / 46 | 20 | 1.5 | 8 / 350 | SM-08-20 | TGA2803-SM |
| CATV TIA / Gain Block, SB | 40 - 1000 | 27 / 46 | 20 | 1.5 | 8 / 350 | SM-08-02 | ***TGA2806-SM**** |
| CATV Ultra Linear HPA | 40 - 1000 | 31.5 / 55 | 12 | 2.75 | 12 / 510 | SG-01-16 | TGA2801D-SG |
| MMIC Gain Block | 60 - 3000 | 15 / 32 | 14 | 2.4 | 4, 5 / 50 | SOT89 | AG101 |
| Dual HBT Amplifier | DC - 2700 | 19 / 33 | 18 | 3.5 | >6 / 75 | SOT86 / SOT89 | AG604 |
| Dual HBT Amplifier | 50 - 1000 | 20 / 37 | 13.5 | 4.5 | >7 / 165 | SOIC-8 | AG606 |
| MESFET Amplifier | 50 - 1500 | 30 / 50 | 10.4 | 5.3 | 9 / 400 | SOT89 | AH101 |
| MESFET Amplifier | 50 - 1000 | 20 / 40 | 14.8 | 3.5 | 5 / 150 | SOT89 | AH2 |
| Dual MESFET Amplifier | 50 - 1000 | 25.5 / 43 | 11.1 | 4.5 | 5 / 320 | SOIC-8 | AH22S |
| MESFET Gain Block | 60 - 3000 | 21 / 39 | 10 | 2.4 | 4.5 / 150 | SOT89 | AM1 |
| HFET | 50 - 4000 | 27 / 39 | 12.4 | 2.7 | 8 / 200 | SOT89 | FP1189 |

*NOTES: *** = New**, SB = Self Biased*

## CABLE FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| Cable IF Filter | 36.15 | 8 | 19.7 | SE / SE | 38 @ 10.23 | DIP | 855748 |
| Cable IF Filter | 44 | 6 | 20.4 | SE / SE | 38 @ 7.60 | DIP | 855079 |
| Cable IF Filter | 44 | 6 | 20.8 | SE / SE | 38 @ 7.40 | 24.6 x 9.0 | 856129 |
| Cable IF Filter | 202.75 | 1.2 | 6.6 | SE / SE | 40 @ 10.00 | 13.3 x 6.5 | 855068 |
| Cable IF Filter | 499.25 | 1 | 7 | SE / SE | 35 @ 6.00 | 9.0 x 7.0 | 855104 |
| Tuner IF Filter | 1086 | 10 | 4 | BAL / BAL | 40 @ 1046.00 | 3.0 x 3.0 | 855964 |
| Tuner IF Filter | 1086 | 10 | 4 | BAL / BAL | 40 @ 1046.00 | 3.0 x 3.0 | 856330 |
| Tuner IF Filter | 1090 | 10 | 5 | BAL / BAL | 50 @ 1050.00 | 3.8 x 3.8 | 856096 |
| Tuner IF Filter | 1216 | 8 | 3.75 | BAL / BAL | 12 @ 24.00 | 3.0 x 3.0 | 856365 |
| Tuner IF Filter | 1220 | 10 | 4.5 | BAL / BAL | 30 @ 60.00 | 3.0 x 3.0 | 856298 |
| Tuner IF Filter | 1220 | 50 | 3.9 | BAL / BAL | 33 @ 96.00 | 3.8 x 3.8 | 856598 |
| Tuner IF Filter | 1250 | 96 | 6 | BAL / BAL | 44 @ 1152.00 | 3.0 x 3.0 | 856653 |
| Tuner IF Filter | 1892 | 8 | 4.2 | BAL / BAL | 23 @ 1932.00 | 2.5 x 2.0 | 856236 |

# GUIDE BY MARKET – GPS




*GPS Intgrated Module*

## GPS INTEGRATED PRODUCTS

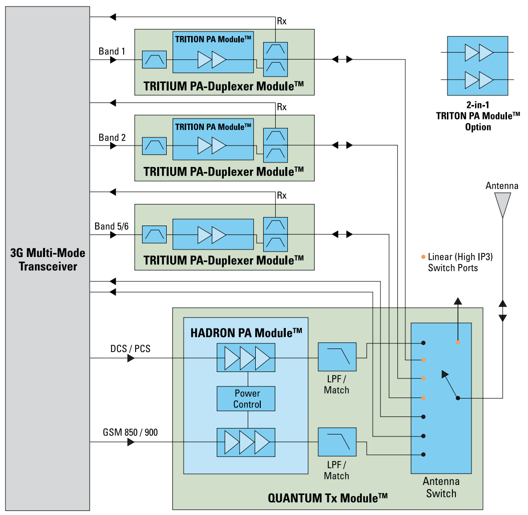
| Description | Frequency Bands | Package Size (mm) | Part Number |
|---|---|---|---|
| GPS LNA Filter Module | GPS L1 Band | 3.0 x 3.0 x 1.1 | TQM640002 |

## GPS FILTERS

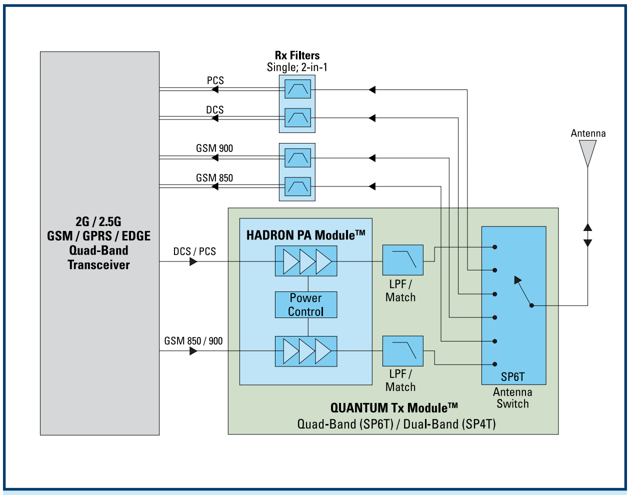
| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| GPS IF Filter | 298.75 | 2.4 | 8.35 | BAL / BAL | 50 @ 20.00 | 7.0 x 5.5 | 856305 |
| FRS RF or GPS IF Filter | 465 | 6 | 1.43 | SE / SE | 40 @ 445.00 | 3.0 x 3.0 | 856288 |
| GPS L5 RF Filter | 1176 | 20 | 2.4 | SE / SE | 20 @ 1226.00 | 2.0 x 1.5 | 856440 |
| GPS L2 RF Filter | 1227.6 | 20 | 1.1 | SE / SE | 27 @ 1152.00 | 2.0 x 1.5 | 856700 |
| GPS RF Filter | 1575.42 | 2 | 1.3 | SE / SE | 30 @ 1625.00 | 3.0 x 3.0 | 855969 |
| GPS RF Filter | 1575.42 | 2 | 1.25 | SE / SE | 30 @ 1624.00 | 2.0 x 1.5 | 856584 |
| GPS RF Filter | 1575.42 | 2 | 1.1 | SE / SE | 20 @ 1628.00 | 2.5 x 2.0 | 856042 |
| GPS RF Filter | 1575.42 | 2 | 2.5 | SE / SE | 30 @ 1625.00 | 2.5 x 2.0 | 856049 |
| GPS RF Filter | 1575.42 | 2 | 0.53 | SE / SE | 16.5 @ 1700.00 | 2.0 x 1.5 | 856326 |
| GPS RF Filter | 1575.42 | 2 | 1 | SE / SE | 27 @ 800.00 | 1.5 x 1.5 | 856463 |
| GPS RF Filter | 1575.42 | 2 | 0.5 | SE / SE | 20 @ Cell Bands | 1.4 x 1.2 | ***856756**** |
| GPS RF Filter | 1575.42 | 2 | 0.7 | SE / SE | 27 @ 1700.00 | 1.5 x 1.5 | 856398 |
| GPS RF Filter | 1575.42 | 2 | 0.75 | SE / SE | 35 @ 1635.00 | 1.4 x 1.2 | 856561 |
| GPS RF Filter | 1575.42 | 2 | 0.6 | SE / SE | 21 @ Cell Bands | 1.4 x 1.2 | ***856793**** |
| GPS RF Filter | 1575.42 | 2 | 1.1 | SE / BAL | 20 @ 1635.00 | 1.4 x 1.2 | 856576 |
| Bluetooth & GPS Filter | 2441 / 1575.42 | 83.5 / 2 | 2 / 1.2 | SE / SE | – | 2.0 x 1.5 | 856646 |

*NOTES:* **** = New***

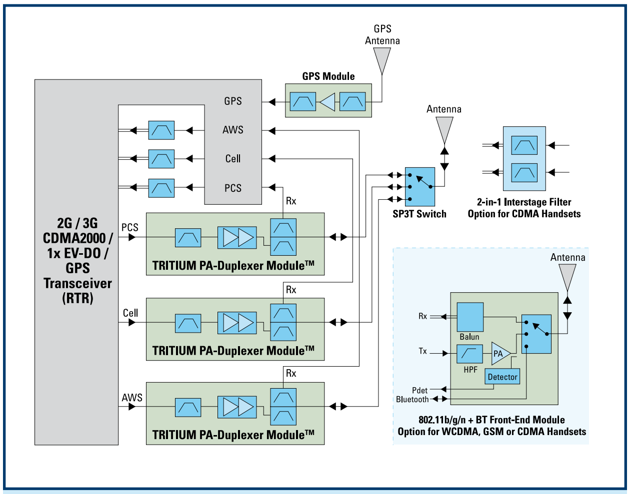
# GUIDE BY MARKET – HANDSET




*3G - WCDMA / EDGE*




*GSM / GPRS / EDGE*




*CDMA*

## HADRON PA MODULE™ FAMILY (EDGE, 7x7mm FOOTPRINT)

| *Description* | *Frequency Bands* | *Features* | *Package Size (mm)* | *Part Number* |
|---|---|---|---|---|
| QB GSM / GPRS / EDGE-Polar | GSM850 / 900, DCS / PCS | Excellent AM to PM Performance | 7.0 x 7.0 x 1.1 | TQM7M5002 |
| QB GSM / GPRS / EDGE-Polar | GSM850 / 900, DCS / PCS | 0 to +6 dBm Pin Nom | 7.0 x 7.0 x 1.1 | TQM7M5003 |
| QB GSM / GPRS / EDGE-Polar | GSM850 / 900, DCS / PCS | -87 dBm Typ Rx Noise, +3 to +8 dBm Pin Nom | 7.0 x 7.0 x 1.1 | TQM7M5008 |

## HADRON II PA MODULE™ FAMILY (EDGE, 5x5mm FOOTPRINT)

| *Description* | *Frequency Bands* | *Features* | *Package Size (mm)* | *Part Number* |
|---|---|---|---|---|
| QB GSM / GPRS / EDGE-Linear | GSM850 / 900, DCS / PCS | Low Band Ibatt < 1.5A @ Pcal with PAE 55% | 5.0 x 5.0 x 1.0 | TQM7M5005+ |
| QB GSM / GPRS / EDGE-Polar | GSM850 / 900, DCS / PCS | -90 dBm Typ Rx Noise, +3 to +8 dBm Pin Nom | 5.0 x 5.0 x 1.0 | TQM7M5012 |
| QB GSM / GPRS / EDGE-Next Gen | GSM850 / 900, DCS / PCS | Reduced Current Consumption; 1mm Max Height | 5.0 x 5.0 x 0.9 | ***TQM7M5013**** |
| QB GSM / GPRS / EDGE-Polar | GSM850 / 900, DCS / PCS | DC / DC Converter Compatible, Current Limiter | 5.0 x 5.0 x 1.0 | ***TQM7M5015**** |

*NOTES:* **** = New*** + For 2.5G EDGE phones and 3G WEDGE phones.

## TRITON PA MODULE™ FAMILY

| *Description* | *Frequency Bands* | *Features* | *Package Size (mm)* | *Part Number* |
|---|---|---|---|---|
| WCDMA / HSUPA, w/Coupler | Band 1 | 2-Bit (Hi / Med / Lo Power Modes) | 4.0 x 4.0 x 0.9 | ***TQM776003**** |
| WCDMA / HSUPA, w/Coupler | Band 1 | 2-Bit (Hi / Med / Lo Power Modes) | 3.0 x 3.0 x 0.9 | ***TQM776011**** |
| WCDMA / HSUPA, w/Coupler | Band 2 | 2-Bit (Hi / Med / Lo Power Modes) | 3.0 x 3.0 x 0.9 | ***TQM766012**** |
| 2-in-1 WCDMA / HSUPA, w/Coupler | Bands 1 & 8 | 2-Bit (Hi / Med / Lo Power Modes) | 5.0 x 3.0 x 0.9 | ***TQM7M6018**** |
| 2-in-1 WCDMA / HSUPA, w/Coupler | Bands 2 & 5 | 2-Bit (Hi / Med / Lo Power Modes) | 5.0 x 3.0 x 0.9 | ***TQM7M6025**** |

*NOTES:* **** = New***

## TRITIUM II PA-DUPLEXER MODULE™ FAMILY (CDMA, 7x4mm FOOTPRINT)

| *Description* | *Frequency Bands* | *Features* | *Package Size (mm)* | *Part Number* |
|---|---|---|---|---|
| CDMA PA-Duplexer Module; BAL Input w/Coupler | Cellular | 1-Bit (Hi / Lo Power Modes) | 7.0 x 4.0 x 1.1 | TQM613027 |
| CDMA PA-Duplexer Module; SE Input w/Coupler | Cellular | 2-Bit (Hi / Med / Lo Power Modes) | 7.0 x 4.0 x 1.1 | ***TQM613029**** |
| CDMA PA-Duplexer Module; SE Input w/Coupler | PCS | 2-Bit (Hi / Med / Lo Power Modes) | 7.0 x 4.0 x 1.1 | ***TQM663029A**** |
| CDMA PA-Duplexer Module; SE Input w/Coupler | AWS | 2-Bit (Hi / Med / Lo Power Modes) | 7.0 x 4.0 x 1.1 | ***TQM653029**** |

*NOTES:* **** = New***

## TRITIUM III PA-DUPLEXER MODULE™ FAMILY (HSUPA, 7x4mm FOOTPRINT)

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| WCDMA / HSUPA; SE Input w/Coupler, Detector | Band 1 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | TQM676021 |
| WCDMA / HSUPA; SE Input w/Coupler, Detector | Band 2 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | TQM666022 |
| WCDMA / HSDPA; SE Input w/Coupler, Detector | Bands 5 & 6 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | *TQM616020*+* |
| WCDMA / HSUPA; SE Input w/Coupler, Detector | Bands 5 & 6 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | TQM616025 |
| WCDMA / HSUPA; SE Input w/Coupler, Detector | Band 8 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | *TQM626028** |

NOTES: * = New + For a specific HSDPA transceiver variant. Contact Customer Service.

## QUANTUM Tx MODULE™ FAMILY (GSM / GPRS / EDGE)

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| QB GSM / GPRS; PA / LPF / SP6T | GSM850 / 900, DCS / PCS | Ultra Compact Size | 6.0 x 6.0 x 1.1 | TQM6M4003 |
| DB GSM / GPRS; PA / LPF / SP4T | GSM900, DCS | Ultra Compact Size | 6.0 x 6.0 x 1.1 | TQM6M4028E |
| DB GSM / GPRS; PA / LPF / SP4T | GSM850, PCS | Ultra Compact Size | 6.0 x 6.0 x 1.1 | TQM6M4028U |
| DB GSM / GPRS; PA / LPF / SP4T | GSM900, DCS | ULC with Limited Antenna Port ESD | 6.0 x 6.0 x 1.1 | *TQM6M4038E** |
| DB GSM / GPRS; PA / LPF / SP4T | GSM850 / 900, DCS / PCS | High Eff & Smaller Application Size | 6.0 x 6.0 x 1.1 | *TQM6M4048** |
| QB GSM / GPRS; PA / LPF / SP6T | GSM850 / 900, DCS / PCS | High Eff & Smaller Application Size | 6.0 x 6.0 x 1.1 | *TQM6M4049** |
| QB GSM / GPRS / EDGE-Linear; PA / LPF / SP6T | GSM850 / 900, DCS / PCS | World's Smallest EDGE Tx Module | 6.0 x 6.0 x 1.1 | TQM6M5001 |
| QB GSM / GPRS / EDGE-Linear TRP; PA / LPF / SP6T | GSM850 / 900, DCS / PCS | High GMSK Efficiency and Best TRP | 6.0 x 8.0 x 1.0 | *TQM6M5014** |

NOTES: * = New

## QUANTUM II Tx MODULE™ FAMILY (WEDGE)

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| QB GSM / GPRS / EDGE-Linear TRP with Tri-Band WCDMA Antenna Pass-Through | GSM850 / 900, DCS / PCS WCDMA B1, B2, B5/6 | QB EDGE PA & UMTS Antenna Switch, TRP Compliant at 4:1 | 7.0 x 7.5 x 1.1 | TQM6M9008 |
| QB GSM / GPRS / EDGE-Linear TRP with Quad-Band WCDMA Antenna Pass-Through | GSM850 / 900, DCS / PCS WCDMA B1, B2, B5/6, B8 | QB EDGE PA & UMTS Antenna Switch, TRP Compliant at 4:1 | 7.0 x 7.5 x 1.1 | *TQM6M9014** |

NOTES: * = New

## CDMA PA MODULES

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| CDMA PA Module | Cellular | 1-Bit (Hi / Lo Power Modes) | 4.0 x 4.0 x 1.5 | TQM713019 |
| CDMA PA Module | Cellular | 1-Bit (Hi / Lo Power Modes) | 3.0 x 3.0 x 1.1 | TQM713024 |

## CDMA SWITCHS

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| CDMA SP3T Switch | Cellular / PCS / AWS | Antenna Routing | 3.0 x 3.0 x 0.9 | TQP4M3018 |
| CDMA SP3T Switch | Cellular / PCS / AWS | Antenna Routing | 2.0 x 2.0 x 0.57 | TQP4M3019 |
| SPDT Switch | 0.1 to 2.5 GHz | General Purpose, Medium Power | 2.0 x 2.1 x 0.9 | CSH210R |

## GSM / GPRS PA MODULE

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| QB GSM / GPRS | GSM850 / 900, DCS / PCS | Low Band Ibatt < 1.5A @ Pcal with PAE 55% | 5.0 x 5.0 x 1.1 | *TQM7M4007** |

NOTES: * = New

# GUIDE BY MARKET – MILITARY

## MILITARY LEVEL & OTHER HIGH-RELIABILITY DEVICES & ASSEMBLIES

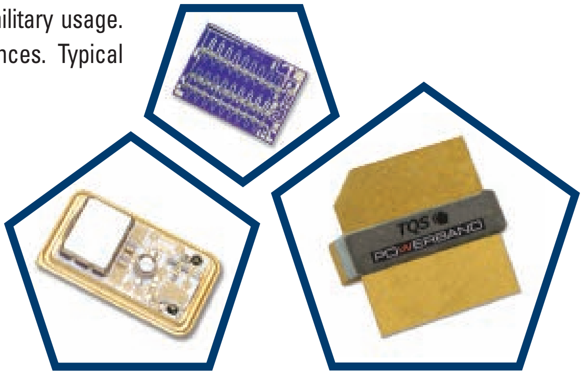
TriQuint Semiconductor is a major supplier of high-reliability, high-performance devices for military and other demanding applications. TriQuint has gained substantial expertise in packaging die-level devices for commercial markets and has demonstrated how similar processes can benefit military customers. We are a technology and customer service leader in these applications:

- Phased Array Radar
- Communications
- GPS Navigation Systems
- Missile Systems
- EW, ECM, ECCM

Many TriQuint products listed elsewhere in this brochure see widespread military usage. Class B screening provides an extra level of quality assurance for these instances. Typical MMIC products in GaAs HFET, pHEMT, mHEMT or VPIN include:

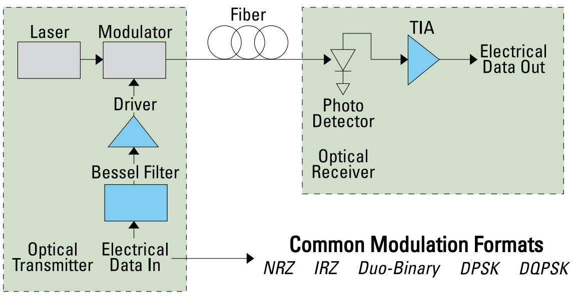
- Amplifiers
- Phase Shifters
- Switches
- Couplers

SAW and BAW technology products for military applications include filters and oscillators. Filter solutions (center frequencies: 30 MHz to 20 GHz) are available in package sizes potentially as small as 1.5 x 0.8 mm. TriQuint oscillators, with superior phase noise (as low as -180 dBc / Hz; with exceptional g-sensitivity), can provide best-in-class performance.




*PowerBand™ is a discrete transistor that supports a wide range of defense, aerospace, wireless communications and other applications.*

# GUIDE BY MARKET – OPTICAL




*Optical Systems (10 & 40 Gb/s)*

## OPTICAL DRIVERS

| Description | Frequency (GHz) | Power (Vpp or dBm) | Gain (dB) | Noise Figure (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 10.7 Gb/s Diff. TIA | DC - 10 | – | 8K dB Ω SE | 6pA √Hz | 3.3 / 80 | Die | TGA4815 |
| 10.7 Gb/s Diff. TIA | DC - 10 | – | 1.6K dB Ω SE | 6pA √Hz | 3.3 / 60 | Die | TGA4816 |
| 10.7 Gb/s Diff. TIA | DC - 10 | – | 3.2K dB Ω SE | 11pA √Hz | 3.3 / 70 | Die | TGA4817 |
| 9.9 - 12.5 Gb/s 3V-7V Driver | DC - 13 | 3 - 7 Vpp | 20 | – | 3.3 - 5 / 100 | SM-A5-28 | ***TGA4955-SM**** |
| 9.9 - 12.5 Gb/s 3V-7V Driver | DC - 13 | 3 - 7 Vpp | 32 | – | 3.3 - 5 / 115 | SM-A8-28 | ***TGA4956-SM**** |
| 40 Gb/s 8Vpp SE Driver | DC - 35 | 5 - 8 Vpp | 30 | – | 8 / 300 | SL-A7-21 | ***TGA4942-SL**** |
| 28 Gb/s 8Vpp SE Driver | DC - 30 | 3 - 9Vpp | 32 | – | 6 -7 / 270 | SL-A7-21 | ***TGA4943-SL**** |
| 9.9 - 12.5 Gb/s Mod. Driver | DC - 16 | 3V - 10V | 35 | 2.5 | 5.5 - 8 / 210 | SL-A2-18 | TGA4953-SL |
| 9.9 - 12.5 Gb/s Mod. Driver | DC - 16 | 3V - 10V | 35 | 2.5 | 5.5 - 8 / 210 | SL-A4-18 | TGA4954-SL |
| 12.5 Gb/s NRZ Driver | DC - 18 | 11V | 16 | – | 8 / 285 | Die | TGA4807 |
| 12.5 Gb/s NRZ Driver | DC - 18 | 24 dBm | 16 | 3.5 | 5 - 8 / 70 - 175 | Die | TGA1328-SCC |
| 12.5 Gb/s NRZ Driver | DC - 18 | 8V | 16 | 3.5 | 8 / 175 | SL-A1-12 | TGA8652-SL |
| 12.5 Gb/s RZ Driver | DC - 25 | 7V | 15 | – | 9 / 100 | Die | TGA4802 |
| 43 Gb/s NRZ Driver | DC - 35 | 7V | 15 | – | 6.5 / 170 | Die | TGA4801 |
| Wideband Driver (40 Gb/s) | DC - 35 | 4V | 12 | – | 5 / 135 | Die | TGA4832 |
| 40 Gb/s TIA, SE | DC - 40 | – | 250 dB Ω | 15pA √Hz | 5 / 30 | Die | TGA4812 |

### OPTICAL DRIVERS (cont.)

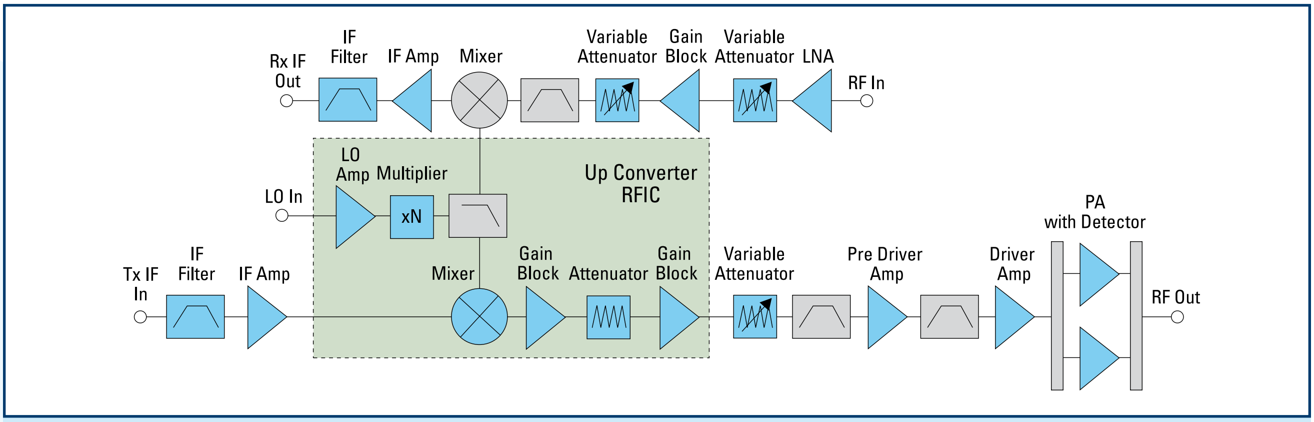
| Description | Frequency (GHz) | Power (Vpp or dBm) | Gain (dB) | Noise Figure (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| LNA / Gain Block | DC - 40 | 11.5 dBm | 13 | 3.2 | 5 / 50 | Die | TGA4830 |
| LNA / Gain Block | DC - 60 | 13 dBm | 15 | 3 | 6 / 50 | Die | TGA4811 |
| 43 Gb/s Driver | DC - 78 | 3V | 8 | 5 | 6 / 82 | Die | TGA4803 |
| 10.7 - 12.5 Gb/s Linear Mod. Driver | 0.03 - 8 | 25 dBm | 20 | – | 8 / 310 | SM-A8-28 | TGA4823-2-SM |
| CATV TIA / Gain Block, SB | 0.04 - 1 | 27 dBm | 20 | 1.5 | 8 / 350 | SM-08-20 | TGA2803-SM |

NOTES: *** = New, ** = Coming Soon**, SB = Self Biased, SE = Single-Ended

### OPTICAL CONTROL PRODUCTS

| Description | Frequency (GHz) | Insertion Loss (dB) | Control Range (dB) | P1dB (dBm) | Supply Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Discrete Thru (0 dB Attenuator) | DC - 65 | 0 | 0 | – | N/A | Die | TGL4201-00 |
| Analog Attenuator | DC - >50 | 2 | 17 | – | 0 to -2 | Die | TGL4203 |
| Analog Attenuator | DC - 30 | 2 | 17 | – | 0 to -2 | SM-012-16 | TGL4203-SM |
| Discrete Attenuators | DC - 65 | – | 2,3,6,10 | – | N/A | SM-012-16 | TGL4201-02, 03, 06, 10 |
| Bessel Filter | – | 6,7,8,9,10&11 Cut-Off Freq | – | – | N/A | Die | TGB2010-00,-09 etc. |
| Bessel Filter | – | 5,6,6.5,7.5,8&9 Cut-Off Freq | – | – | N/A | SM-02-6 | TGB2010-00,-09-SM etc. |

# GUIDE BY MARKET – PTP RADIO




*Point-to-Point Radio*

### PTP RADIO AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| HPA | 6 - 18 | (34.5) / – | 24 | – / 20 | 8 / 1200 | Die | TGA9092-SCC |
| Gain Block | 6 - 18 | 12.5 / – | 13 | 5 / – | 5 / 80 | Die | TGA8035-SCC |
| 2.8W HPA | 6 - 18 | (34.5) / – | 24 | – / 20 | 7 - 9 / 800-1200 | Die | TGA2501 |
| HPA | 7 - 8.5 | (38) / – | 21 | – / 42 | 7 / 2000 | Die | TGA2701 |
| 2W HPA | 5.5 - 8.5 | 32 (34) / 41 | 30 | 7 / – | 6 / 1260 | SM-013-24 | ***TGA2706-SM**** |
| Driver Amp | 7 - 13 | (30) / 37 | 25 | – / 30 | 9 / 450 | Die | TGA2700 |
| Wideband Driver Amp | 8 - 18 | 13 / – | 17 | 5 / – | 4.5 / 50 | Die | TGA8399C |
| HPA | 9 - 10.5 | (38) / – | 20 | – / >38 | 4 - 9 / 2000 | Die | TGA2704 |
| HPA | 10.5 - 12 | (38) / – | 19 | – / >39 | 4 - 9 / 2000 | Die | TGA2710 |
| Driver Amp, SB | 11 - 17 | 17 / – | 23 | 6 / – | 6 / 75 | SM-06-12 | TGA2507-SM |
| Driver Amp, SB | 12 - 18 | 14 / – | 17 | – | 6 / 40 | Die | TGA2506 |
| Driver Amp, SB | 12 - 18 | 20 / – | 28 | 6 / – | 6 / 80 | Die | TGA2507 |
| 1W HPA | 12 - 19 | 30 / – | 30 | – | 5 - 7 / 435 | Die | TGA2508 |
| HPA | 12 - 19 | 29 / – | 25 | – | 5 - 7 / 435 | SM-06-12 | TGA2508-SM |

## PTP RADIO AMPLIFIERS (cont.)

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 2W HPA | 12.3 - 15.7 | (31) / – | 33 | 7.0 / – | 6 / 850 | Die | TGA2520 |
| 2W HPA | 12.5 - 16 | (32) / 37 | 32 | – | 6 - 7 / 680 | SM-01-24 | TGA2503-SM |
| 2W HPA | 12.5 - 17 | (34) / – | 26 | – / 25 | 7.5 / 650 | Die | TGA2510 |
| 2W HPA | 12.5 - 17 | (33.5) / – | 25 | – / 25 | 7.5 / 650 | SG-A1-6 | TGA2510-SG |
| 2W HPA | 13 - 17 | (34) / 40 | 32 | – | 6 - 7 / 680 | Die | TGA2503 |
| 2W HPA | 13 - 17 | (34) / – | 25 | – | 6 - 7 / 640 | Die | TGA2505 |
| 2W HPA | 13 - 17 | (34) / – | 33 | – | 5 - 8 / 680 | FL-A1-10 | TGA2904-FL |
| 2W HPA, PD | 13 - 17 | (34) / 38.5 | 26 | – / 30 | 7.5 / 650 | SG-A1-6 | TGA2902-1-SCC-SG |
| 2W HPA | 13 - 17 | (34) / 40 | 33 | – | 5 - 8 / 680 | SG-A1-6 | TGA8658-SG |
| 4W HPA, Balanced | 13 - 17 | (36) / 44 | 25 | – / 30 | 6 - 7 / 1300 | Die | TGA2502 |
| HPA | 13.5 - 15 | 33 / 39 | 34 | – | 7 / 680 | Die | TGA1152-SCC |
| 2W HPA, PD | 13.75 - 14.5 | (34) / 38.5 | 26 | – / 30 | 7.5 / 650 | SG-A1-6 | TGA2902-2-SCC-SG |
| 1W HPA, PD | 17 - 20 | 30 (32) / 42 | 20 | – | 5 - 7 / 825 | Die | TGA4530 |
| 1W HPA, PD | 17 - 21 | 29 (31) / 41 | 21 | – | 6 / 825 | SM-A4-20 | TGA4530-SM |
| Driver Amp | 17 - 24 | 22 / – | 19 | 4 / – | 5 / 270 | SM-09-16 | TGA2521-SM |
| HPA | 17 - 24 | 31 (32) / 40 | 23 | 6 / – | 7 / 720 | Die | ***TGA4531**** |
| HPA, AGC, PD | 17 - 24 | (29) / 38 | 22 | – | 5 / 712 | SM-010-20 | TGA2522-SM |
| HPA | 17 - 27 | 29 (31) / 37 | 22 | – | 7 / 760 | Die | TGA4502-SCC |
| Gain Block & 2x / 3x Multiplier | 17 - 37 | 18 (22) / 26 | 20 | 7 / – | 5 / 140 | SM-03-16 | TGA4030-SM |
| Gain Block & 2x / 3x Multiplier | 17 - 40 | 18 (22) / 24 | 22 | 7 / – | 5 / 140 | SM-A3-16 | TGA4031-SM |
| Gain Block, Multiplier | 17 - 43 | 22 / – | 25 | – | 5 / 225 | Die | TGA4040 |
| 2W HPA | 18 - 23 | 32 (33) / 39 | 26 | – | 7 / 840 | Die | TGA4022 |
| HPA | 18 - 27 | 29 / 37 | 14 | – | 6 / 480 | Die | TGA1135-SCC |
| MPA | 19 - 27 | 25 / 32 | 22 | – | 5 - 7 / 220 | Die | TGA1073G-SCC |
| Gain Block | 19 - 38 | (22) / 30 | 20 | – | 5 / 160 | Die | TGA4036 |
| MPA | 25 - 35 | 25 / – | 18 | – | 6 / 220 | SM-A4-20 | TGA4902-SM |
| MPA | 26 - 35 | 25 (32) / – | 19 | – | 5 - 7 / 220 | Die | TGA1073A-SCC |
| 1W HPA | 27 - 31 | 30 / – | 22 | – / 25 | 4 - 6 / 420 | Die | TGA4509 |
| 2W HPA | 27 - 31 | 32.5 (33) / 36.5 | 20 | 25 / – | 6 / 840 | Die | TGA4513 |
| 2W HPA | 27 - 31 | 32.5 (33) / – | 22 | – | 6 / 840 | CP-A2-8 | TGA4513-CP |
| HPA | 27 - 32 | 28.5 / – | 25 | – | 6 - 8 / 420 | Die | TGA1073B-SCC |
| HPA | 27 - 32 | 29 / – | 16 | – | 6 - 7 / 630 | Die | TGA1172 |
| 1W HPA | 28 - 31 | 30 / – | 19 | – / 25 | 6 / 420 | SM-A4-20 | TGA4509-SM |
| Driver Amp | 29 - 31 | 16 (17) / 22 | 15 | – | 6 / 60 | SM-A4-20 | TGA4510-SM |
| Driver Amp | 29 - 37 | 16 / – | 16 | – | 6 / 60 | Die | TGA4510 |
| 2W HPA | 30 - 40 | 31.5 (33) / – | 20 | – | 6 / 1050 | Die | TGA4516 |
| MPA | 32 - 45 | 24 (25) / 33 | 16 | – | 6 / 175 | Die | TGA4521 |
| MPA | 33 - 47 | 27 (27.5) / 36 | 18 | – | 6 / 400 | Die | TGA4522 |
| HPA | 36 - 40 | 26 / – | 15 | – | 5 - 7 / 240 | Die | TGA1073C-SCC |
| HPA | 36 - 40 | 30 / – | 14 | – | 6 - 7 / 500 | Die | TGA1171-SCC |

*NOTES: *** = New**, SB = Self Biased, AGC = Automatic Gain Control, PD = Power Detector*

## PTP RADIO LOW NOISE AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB / IIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| LNA, AGC | 2 - 18 | 18 / 29 | 17 | 2.0 | 5 / 75 | Die | TGA2525 |
| LNA, AGC | 2 - 20 | 19 / – | 17.5 | 2.5 | 5 / 100 | Die | ***TGA2526**** |
| LNA, AGC | 2 - 20 | 17.5 / – | 9 | 3.5 | 5 - 8 / 60 | Die | TGA1342-SCC |
| LNA, AGC | 2 - 20 | 16 / – | 17 | 2.5 | 5 / 75 | SM-07-12 | TGA2513-SM |
| LNA, AGC | 2 - 23 | 17 / 26 | 17 | 2 | 5 / 75 | Die | TGA2513 |
| LNA, SB, AGC | 4 - 14 | 6 / 16 | 22 | 2.3 | 5 / 90 | SM-04-12 | TGA2512-1-SM |
| LNA, AGC, GB | 4 - 14 | 13 / 24 | 25 | 2.3 | 5 / 160 | SM-04-12 | TGA2512-2-SM |
| LNA, SB, AGC | 5 - 15 | 6 / 13 | 27 | 1.4 | 5 / 90 | Die | TGA2512 |
| LNA | 6 - 12 | 2 / – | 31 | 0.7 | 2.5 / 17 | Die | TGA2600 |
| LNA, SB | 6 - 13 | 11 / – | 26 | 1.5 | 5 / 65 | Die | TGA8399B-SCC |
| LNA, SB, AGC | 6 - 14 | 6 / 12 | 20 | 1.3 | 5 / 90 | Die | TGA2511 |
| LNA | 20 - 27 | 12 / – | 21 | 2.2 | 3.5 / 60 | Die | TGA4506 |

## PTP RADIO LOW NOISE AMPLIFIERS (cont.)

| Description | Frequency Range (GHz) | P1dB / IIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| LNA | 21 - 27 | 10 / – | 21 | 2.5 | 3.5 / 60 | SM-A4-20 | TGA4506-SM |
| LNA | 28 - 36 | 12 / 21 | 22 | 2.3 | 3 / 60 | Die | TGA4507 |
| LNA | 30 - 42 | 14 / – | 21 | 2.8 | 3 / 40 | Die | TGA4508 |
| LNA | 57 - 69 | – | 13 | 4 | 3 / 41 | Die | TGA4600 |

*NOTES: *** = New**, SB = Self Biased, AGC = Automatic Gain Control, GB = Gate Bias*

## PTP RADIO DISCRETE TRANSISTORS

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 24mm HFET | DC - 4 | 40 / – | 13 | – / 51 | 8 / 2170 | Die | TGF4124 |
| 18mm HFET | DC - 6 | 38.5 / – | 13.5 | – / 53 | 8 / 1690 | Die | TGF4118 |
| 12mm HFET | DC - 8 | 37 / – | 14 | – / 55 | 8 / 750 | Die | TGF4112 |
| 4.8mm HFET | DC - 10.5 | 34 / – | 8.5 | – / 53 | 8 / 200 | Die | TGF4250-SCC |
| 9.6mm HFET | DC - 10.5 | 37 / – | 9.5 | – / 52 | 8.5 / 520 | Die | TGF4260-SCC |
| 1.2mm HFET | DC - 12 | 28.5 / – | 10 | – / 55 | 8 / 50 | Die | TGF4230-SCC |
| 2.4mm HFET | DC - 12 | 31.5 / – | 10 | – / 56 | 8 / 100 | Die | TGF4240-SCC |
| 1mm Pwr pHEMT | DC - 12 | (31.5) / – | 11 | – / 55 | 12 / 900 | Die | TGF2021-01 |
| 2mm Pwr pHEMT | DC - 12 | (34.5) / – | 11 | – / 55 | 12 / 150 | Die | TGF2021-02 |
| 4mm Pwr pHEMT | DC - 12 | (37.5) / – | 11 | – / 55 | 12 / 300 | Die | TGF2021-04 |
| 8mm Pwr pHEMT | DC - 12 | (40.2) / – | 11 | – / 55 | 12 / 600 | Die | TGF2021-08 |
| 12mm Pwr pHEMT | DC - 12 | (42) / – | 11 | – / 52 | 12 / 900 | Die | TGF2021-12 |
| 0.3mm MESFET | DC - 18 | 13 / – | 11 | 1.5 / – | 3 / 15 | Die | TGF1350-SCC |
| 0.6mm Pwr pHEMT | DC - 20 | (29) / – | 13 | – / 56 | 12 / 45 | Die | TGF2022-06 |
| 1.2mm Pwr pHEMT | DC - 20 | (32) / – | 13 | – / 56 | 12 / 90 | Die | TGF2022-12 |
| 2.4mm Pwr pHEMT | DC - 20 | (35) / – | 13 | – / 58 | 12 / 180 | Die | TGF2022-24 |
| 4.8mm Pwr pHEMT | DC - 20 | (38) / – | 13 | – / 58 | 12 / 360 | Die | TGF2022-48 |
| 6.0mm Pwr pHEMT | DC - 20 | (39) / – | 12.5 | – / 53 | 12 / 448 | Die | TGF2022-60 |
| 0.3mm pHEMT | DC - 22 | 16 / – | 13 | 0.8 / – | 3 / 15 | Die | TGF4350 |

## PTP RADIO SWITCHES

| Description | Frequency (GHz) | Insertion Loss (dB) | Isolation (dB) | P1dB (dBm) | Control Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| SP2T 802.11a/b/g | DC - 6 | 0.6 | 28 | 31.5 | 3 / 0 | SLIM7 | TQS5200 |
| SPDT FET | DC - 18 | 1.5 | 36 | 27 | -5 | Die | TGS2306 |
| SPDT FET | DC - 18 | 2 | 39 | 21 | -7 / 0 | Die | TGS8250-SCC |
| SP4T FET | DC - 18 | 2.5 | 37 | 19 | 0 / -5 | Die | TGS8422-SCC |
| SP3T VPIN | 1 - 20 | 0.5 | 35 | 23 | 10 mA | Die | TGS2303-EEU |
| SP4T VPIN | 1 - 20 | 0.6 | 38 | 23 | 10 mA | Die | TGS2304-SCC |
| SP3T VPIN | 4 - 18 | 1 | 35 | 20 | +/- 2.7 | Die | TGS2313 |
| SPDT VPIN | 4 - 20 | 0.9 | 35 | >20 | +/- 2.7 | Die | TGS2302 |
| SPDT VPIN | 24 - 43 | <2 | 36 | 27 | +/- 5 | Die | TGS4301 |
| SPDT VPIN | 27 - 46 | 0.9 | 30 | >34 | +/ -5 / 15 | Die | TGS4302 |
| SPDT VPIN Absorptive | 32 - 40 | 1 | 36 | >33 | +/- 5 / 18 | Die | TGS4304 |

## PTP RADIO FREQUENCY CONVERTERS & MIXERS

| Description | RF Frequency Range (GHz) | Conversion Gain (dB) | LO / RF Isolation (dB) | IIP3 (dBm) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Doubler with Amplifier | 16 - 30 | 18 | 30 | 22 | 5 / 150 | Die | TGC4403 |
| Doubler with Amplifier | 16 - 30 | 18 | 30 | 19 | 5 / 150 | SM-011-16 | TGC4403-SM |
| Upconverting Mixer | 17 - 26 | -9 | 40 | – | -0.9 / 0 | SM-011-16 | TGC4402-SM |
| Upconverting Mixer | 17 - 27 | -9 | 35 | 18 | -0.9 / 0 | Die | TGC4402 |
| Upconverter | 17 - 27 | 13 | 30 | – | 5 / 425 | Die | TGC4405 |
| Upconverter | 17 - 27 | 13 | 30 | – | 5 / 425 | SM-011-16 | TGC4405-SM |
| Gain Block & 2x / 3x Multiplier | 17 - 37 | 9 | N/A | 6 | 5 / 140 | SM-03-16 | TGA4030-SM |
| Gain Block & 2x / 3x Multiplier | 17 - 40 | 9 | N/A | 2 | 5 / 140 | SM-A3-16 | TGA4031-SM |
| Doubler (Input 10 - 20 GHz) | 20 - 40 | -12 | 25 | 18 | – | Die | TGC1430F |
| Tripler (Input 8.5 - 13.5 GHz) | 20 - 40 | -15 | 15 | 18 | – | Die | TGC1430G |

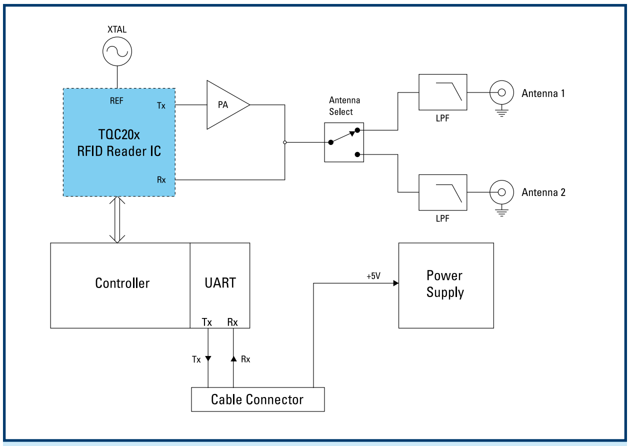
## PTP RADIO CONTROL PRODUCTS

| Description | Frequency (GHz) | Insertion Loss (dB) | Control Range (dB) | P1dB (dBm) | Supply Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Discrete Thru (0 dB Attenuator) | DC - 65 | 0 | 0 | – | N/A | Die | TGL4201-00 |
| Analog Attenuator | DC - >50 | 2 | 17 | – | 0 to -2 | Die | TGL4203 |
| Analog Attenuator | DC - 30 | 2 | 17 | – | 0 to -2 | SM-012-16 | TGL4203-SM |
| Discrete Attenuators | DC - 65 | – | 2,3,6,10 | – | N/A | SM-012-16 | TGL4201-02, 03, 06, 10 |
| Digital Attenuator | 0.5 - 18 | 4 | 15.5 | 20 | 0 / -5 | Die | TGL6425-SCC |
| Analog Attenuator | 2 - 20 | 2 | 15 | 23 | 2.5 | Die | TGL8784-SCC |
| Passive Wideband Limiter | 3 - 25 | <0.5 | N/A | 18 | N/A | Die | TGL2201 |
| Lange Coupler | 12 - 21 | <0.25 | – | – | N/A | Die | TGB2001 |
| Lange Coupler | 18 - 32 | <0.25 | – | – | N/A | Die | TGB4001 |
| Lange Coupler | 27 - 45 | <0.25 | – | – | N/A | Die | TGB4002 |

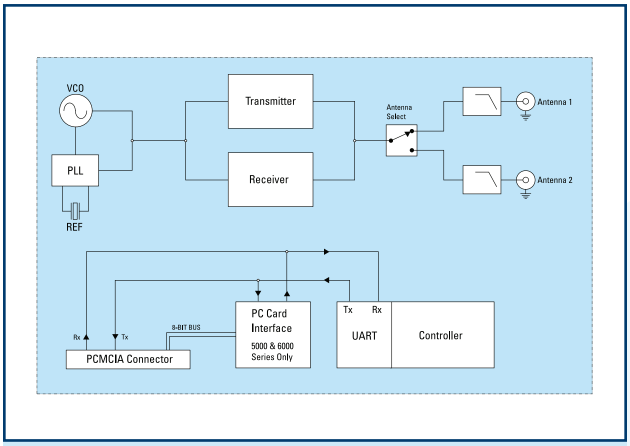
## PTP RADIO FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| High Selectivity IF Filter | 140 | 1.5 | 12.1 | SE and BAL | 48 @ 143.00 | 9.1 x 4.8 | 856691 |
| High Selectivity IF Filter | 140 | 3 | 13.6 | SE and BAL | 46 @ 144.00 | 9.1 x 4.8 | 856692 |
| High Selectivity IF Filter | 140 | 6 | 11 | BAL / BAL | 39 @ 147.00 | 9.1 x 4.8 | 856693 |
| High Selectivity IF Filter | 140 | 7 | 13.6 | SE and BAL | 43 @ 147.00 | 9.1 x 4.8 | 856694 |
| High Selectivity IF Filter | 140 | 10 | 10 | BAL / BAL | 41 @ 152.50 | 9.1 x 4.8 | 856695 |
| High Selectivity IF Filter | 140 | 14 | 8.5 | SE and BAL | 43 @ 155.00 | 9.1 x 4.8 | 856696 |
| High Selectivity IF Filter | 140 | 20 | 9.8 | BAL / BAL | 40 @ 158.50 | 9.1 x 4.8 | 856697 |
| High Selectivity IF Filter | 140 | 28 | 18 | SE and BAL | 42 @ 168.00 | 9.1 x 4.8 | 856698 |

# GUIDE BY MARKET – RFID




*WJM Series Application Block Diagram*




*WJR Series Functional Block Diagram*

## UHF RFID MODULES

| Description | Frequency (MHz) | Channels / Spacing (kHz) | Max Output Power (W) | Protocol Support | Region of Operation | Interface | Part Number |
|---|---|---|---|---|---|---|---|
| Reader PCMCIA Form Factor Module (FCC Pt 15) | 902.75 - 927.25 | 50 / 500 | 1W | ISO18000-6C | N. America | Serial TTL | WJR7000 |
| Reader PCMCIA Form Factor Module (ETSI 302.208) | 865.7 - 867.5 | 4 / 600 | 1W | ISO18000-6B & -6C | Europe | Serial TTL | ***WJR7081**** |
| PCMCIA Form Factor Module | 910.6 - 913.4 | 15 / 200 | 1W | ISO18000-6B & -6C | Korea | Serial TTL | WJR7090 |
| PCMCIA Reader Module (FCC Pt 15) | 902.75 - 927.25 | 50 / 500 | 0.5W | ISO18000-6B & -6C | N. America | PCMCIA | MPR6000 |
| PCMICA Reader Module (FCC Pt 15) w/ Int. Antenna | 902.75 - 927.25 | 50 / 500 | 0.5W | ISO18000-6B & -6C | N. America | PCMCIA | MPR5000 |
| Embedded Reader Module (FCC Pt 15) | 902.75 - 927.25 | 50 / 500 | 1W | ISO18000-6B & -6C | N. America | Serial TTL | WJM3000 |
| Embedded Reader Module (FCC Pt 15) | 902.75 - 927.25 | 50 / 500 | 0.25W | ISO18000-6B & -6C | N. America | Serial TTL | WJM1000 |

*NOTES:* **** = New***

## SPACE LEVEL DEVICES AND ASSEMBLIES

TriQuint has a proud aerospace history, supplying highly-reliable active / passive devices for satellite and planetary missions. Space-level qualification includes high-level visual inspection, 100% element electrical results and wafer lot qualification testing. See tables for standard products already space qualified; most Foundry and standard products throughout this brochure may be space qualified.

## SPACE QUALIFIED AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 12.5 Gb/s NRZ Driver | DC - 18 | 24 / – | 16 | 3.5 / – | 5 - 8 / 70 - 175 | Die | TGA1328-SCC |
| Wideband Driver (40 Gb/s) | DC - 35 | 18 / – | 12 | – | 5 / 135 | Die | TGA4832 |
| Gain Block, SB | 2 - 10 | 17 / – | 17 | 6 | 5 / 90 | Die | TGA8810-SCC |
| Gain Block, AGC | 2 - 18 | 22 / – | 23 | 6 | 7 / 340 | Die | TGA6345-EEU |
| Gain Block | 2 - 18 | 20 / – | 7.5 | 5.5 | 6 / 100 | Die | TGA8300-SCC |
| Wideband Gain Block, AGC | 2 - 20 | 20 / – | 7.5 | 7 | 6 / 150 | Die | TGA8622-SCC |
| Wideband PA, AGC | 2 - 20 | 26 / – | 8 | – | 8 / 440 | Die | TGA8334-SCC |
| 0.5W PA | 6 - 18 | 27 / – | 11 | 8 / – | 8 / 400 | Die | TGA8014-SCC |
| HPA | 6.5 - 11.5 | 37 (39) / – | 19 | 35 | 7 - 9 / 1200 | Die | TGA9083-SCC |
| Wideband Driver Amp | 8 - 18 | 13 / – | 17 | 5 / – | 4.5 / 50 | Die | TGA8399C |
| HPA | 9 - 10.5 | (38) / – | 20 | >38 | 4 - 9 / 2000 | Die | TGA2704 |
| Driver Amp, SB | 11 - 17 | 17 / – | 23 | 6 | 6 / 75 | SM-06-12 | TGA2507-SM |
| Driver Amp, SB | 12 - 18 | 20 / – | 28 | 6 | 6 / 80 | Die | TGA2507 |
| 4W HPA, Balanced | 13 - 17 | (36) / 44 | 25 | 30 | 6 - 7 / 1300 | Die | TGA2502 |
| Gain Block | 19 - 38 | (22) / 30 | 20 | – | 5 / 160 | Die | TGA4036 |
| HPA | 24 - 31 | 35.5 (36) / – | 23 | – | 6 / 2100 | Die | TGA4505 |
| 3.5W HPA | 31 - 37 | (35.5) / – | 20 | – | 6 / 2000 | Die | TGA4517 |
| MPA | 32 - 45 | 24 (25) / 33 | 16 | – | 6 / 175 | Die | TGA4521 |

*NOTES: SB = Self Biased, AGC = Automatic Gain Control*

## SPACE QUALIFIED LOW NOISE AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB / IIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| LNA, AGC | DC - 14 | 16 / – | 11 | 3.1 | 8 / 80 | Die | TGA8349-SCC |
| LNA, AGC | 2 - 18 | 16 / – | 19 | 4 | 5 / 120 | Die | TGA8344-SCC |
| LNA, AGC | 2 - 20 | 17.5 / – | 9 | 3.5 | 5 - 8 / 60 | Die | TGA1342-SCC |
| LNA, AGC | 2 - 20 | 17.5 / – | 9 | 3.5 | 5 - 8 / 60 | Die | TGA8310-SCC |
| LNA, SB | 6 - 13 | 11 / – | 26 | 1.5 | 5 / 65 | Die | TGA8399B-SCC |
| LNA | 20 - 27 | 12 / – | 21 | 2.2 | 3.5 / 60 | Die | TGA4506 |
| LNA | 21 - 27 | 10 / – | 21 | 2.5 | 3.5 / 60 | SM-A4-20 | TGA4506-SM |
| LNA | 30 - 42 | 14 / – | 21 | 2.8 | 3 / 40 | Die | TGA4508 |

*NOTES: SB = Self Biased, AGC = Automatic Gain Control*

## SPACE QUALIFIED FREQUENCY CONVERTERS & MIXERS

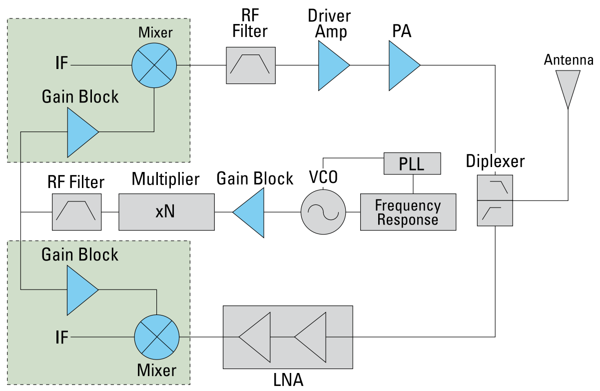
| Description | RF Frequency Range (GHz) | Conversion Gain (dB) | LO / RF Isolation (dB) | IIP3 (dBm) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Tripler (Input 8.5 - 13.5 GHz) | 20 - 40 | -15 | 15 | 18 | – | Die | TGC1430G |

## SPACE QUALIFIED OPTICAL DRIVERS

| Description | Frequency (GHz) | Power (Vpp or dBm) | Gain (dB) | Noise Figure (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 12.5 Gb/s NRZ Driver | DC - 18 | 24 dBm | 16 | 3.5 | 5 - 8 / 70 - 175 | Die | TGA1328-SCC |
| Wideband Driver (40 Gb/s) | DC - 35 | 4V | 12 | – | 5 / 135 | Die | TGA4832 |

## SPACE QUALIFIED CONTROL PRODUCTS

| Description | Frequency (GHz) | Insertion Loss (dB) | Control Range (dB) | P1dB (dBm) | Supply Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Analog Attenuator | DC - >50 | 2 | 17 | – | 0 to -2 | Die | TGL4203 |
| Digital Attenuator | 0.5 - 18 | 4 | 15.5 | 20 | 0 / -5 | Die | TGL6425-SCC |
| Analog Attenuator | 2 / 20 | 2 | 15 | 23 | 2.5 | Die | TGL8784-SCC |




*VSAT RF Subsystem*

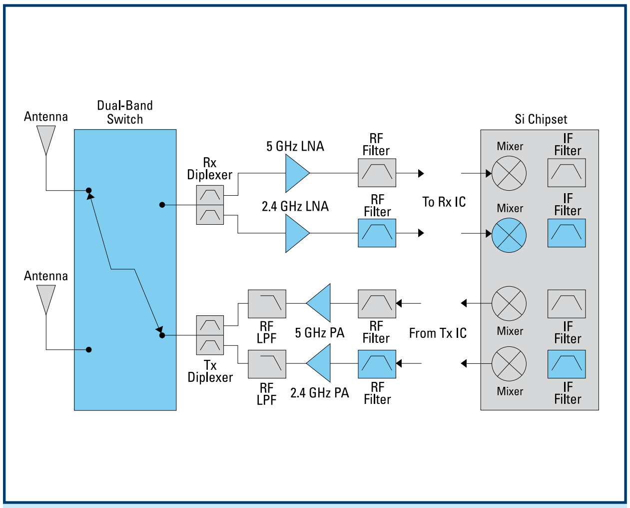
## VSAT AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Driver Amp, SB | 11 - 17 | 17 / – | 23 | 6 / – | 6 / 75 | SM-06-12 | TGA2507-SM |
| Driver Amp, SB | 12 - 18 | 14 / – | 17 | – | 6 / 40 | Die | TGA2506 |
| Driver Amp, SB | 12 - 18 | 20 / – | 28 | 6 / – | 6 / 80 | Die | TGA2507 |
| 1W HPA | 12 - 19 | 30 / – | 30 | – | 5 - 7 / 435 | Die | TGA2508 |
| HPA | 12 - 19 | 29 / – | 25 | – | 5 - 7 / 435 | SM-06-12 | TGA2508-SM |
| 2W HPA | 12.3 - 15.7 | (31) / – | 33 | 7 / – | 6 / 850 | Die | TGA2520 |
| 2W HPA | 12.5 - 16 | (32) / 37 | 32 | – | 6 - 7 / 680 | SM-01-24 | TGA2503-SM |
| 2W HPA | 12.5 - 17 | (34) / – | 26 | – / 25 | 7.5 / 650 | Die | TGA2510 |
| 2W HPA | 12.5 - 17 | (33.5) / – | 25 | – / 25 | 7.5 / 650 | SG-A1-6 | TGA2510-SG |
| 4W HPA | 13 - 15 | (36) / 41 | 25 | – | 7 / 1300 | FL-A1-10 | TGA8659-FL |
| 6.5W HPA | 13 - 16 | (38) / – | 24 | – | 8 / 2600 | FL-A2-10 | TGA2514-FL |
| 2W HPA | 13 - 17 | (34) / 40 | 32 | – | 6 - 7 / 680 | Die | TGA2503 |
| 2W HPA | 13 - 17 | (34) / – | 25 | – | 6 - 7 / 640 | Die | TGA2505 |
| 2W HPA | 13 - 17 | (34) / – | 33 | – | 5 - 8 / 680 | FL-A1-10 | TGA2904-FL |
| 2W HPA | 13 - 17 | (34) / 40 | 33 | – | 5 - 8 / 680 | SG-A1-6 | TGA8658-SG |
| 2W HPA, PD | 13 - 17 | (34) / 38.5 | 26 | – / 30 | 7.5 / 650 | SG-A1-6 | TGA2902-1-SCC-SG |
| 4W HPA, Balanced | 13 - 17 | (36) / 44 | 25 | – / 30 | 6 - 7 / 1300 | Die | TGA2502 |
| 6.5W HPA | 13 - 18 | (38) / 44 | 24 | – | 8 / 3600 | Die | TGA2514 |
| 2W HPA, PD | 13.75 - 14.5 | (34) / 38.5 | 26 | – / 30 | 7.5 / 650 | SG-A1-6 | TGA2902-2-SCC-SG |
| 4W HPA | 24 - 31 | 35.5 (36) / – | 23 | – | 6 / 2100 | Die | TGA4505 |
| 4W HPA | 25 - 31 | 35.5 (36) / – | 22 | – | 6 / 2100 | CP-A1-8 | TGA4905-CP |
| MPA | 25 - 35 | 25 / – | 18 | – | 6 / 220 | SM-A4-20 | TGA4902-SM |
| 7W HPA | 26 - 31 | (38.5) / – | 22 | – | 6 / 4200 | CP-A3-8 | TGA4915-CP |
| 1W HPA | 27 - 31 | 30 / – | 22 | – / 25 | 4 - 6 / 420 | Die | TGA4509 |
| 2W HPA | 27 - 31 | 32.5 (33) / 36.5 | 20 | – / 25 | 6 / 840 | Die | TGA4513 |
| 2W HPA | 27 - 31 | 32.5 (33) / – | 22 | – | 6 / 840 | CP-A2-8 | TGA4513-CP |
| 1W HPA | 28 - 31 | 30 / – | 19 | – / 25 | 6 / 420 | SM-A4-20 | TGA4509-SM |
| 4W HPA | 28 - 31 | 36 (36.5) / – | 22 | – / 22 | 6 / 1600 | Die | TGA4906 |
| 4W HPA | 28 - 31 | 36 (36.5) / – | 22 | – / 22 | 6 / 1600 | SM-A5-24 | TGA4906-SM |
| 7W HPA | 28 - 31 | (38.5) / – | 22 | – / 20 | 6 / 3200 | Die | TGA4916 |
| Driver Amp | 29 - 31 | 16 (17) / 22 | 15 | – | 6 / 60 | SM-A4-20 | TGA4510-SM |
| Driver Amp | 29 - 37 | 16 / – | 16 | – | 6 / 60 | Die | TGA4510 |

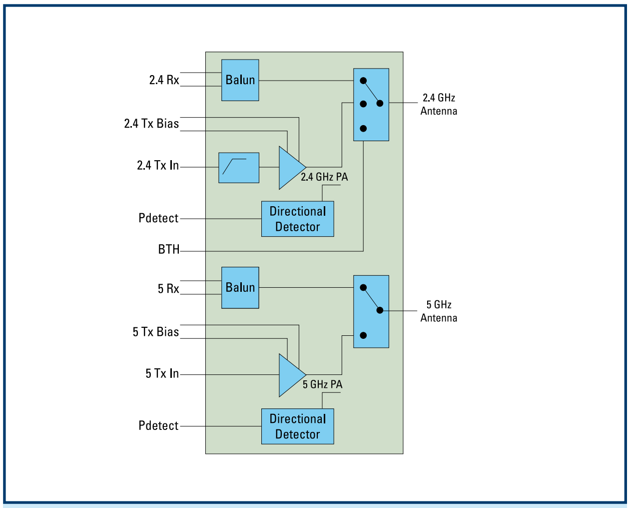
*NOTES: SB = Self Biased, PD = Power Detector*

## VSAT FREQUENCY CONVERTERS & MIXERS

| Description | RF Frequency Range (GHz) | Conversion Gain (dB) | LO / RF Isolation (dB) | IIP3 (dBm) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Doubler with Amplifier | 16 - 30 | 18 | 30 | 22 | 5 / 150 | Die | TGC4403 |
| Doubler with Amplifier | 16 - 30 | 18 | 30 | 19 | 5 / 150 | SM-011-16 | TGC4403-SM |




WLAN Transceiver




WLAN Dual-Band Handset

## WLAN AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB / OIP3 (dBm) | Gain (dB) | PAE (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Bluetooth PA | DC - 2.5 | 22.5 / – | 26 | 50 | 0 - 5.5 / 200 | SLIM-7 | CGB241 |
| Bluetooth PA | DC - 2.5 | 22.5 / – | 26 | 50 | 0 - 5.5 / 200 | MSOP-10 | CGB240 |
| Bluetooth Class 1 PA | 2.4 - 2.5 | 21.5 / – | 27 | 50 | 0 - 3.3 / 160 | STSLP-12 | TQP770001 |
| ISM Band Matched PA, PD | 2.4 - 2.5 | 25 / – | 30 | – | 3.3 / 200 | VQFN-16 | TQP777002 |
| Dual-Band Matched PA | 2.4 / 4.9 - 6.0 | 25 / 25 | 30 | – | 3.3 / 180: 3.3 / 200 | 4.0 x 4.0 | ***TQM7M7012**** |

*NOTES: * = **New**, PD = Power Detector*

## WLAN INTEGRATED PRODUCTS

| Description | Frequency Range (GHz) | Pout / EVM (dBm) | Gain (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|
| 802.11b/g/n PA, SP3T, Balun, PD, WLAN + BT | 2.4 - 2.5 | 17 / 2.2% | 33 | 3.3 / 115 | ETSLP-16 | ***TQM679002**** |
| 802.11a/b/g/n PA, SP3T, SP2T, Balun, PD, WLAN + BT | 2.4 - 2.5: 4.9 - 5.9 | 17 / 2.2%: 15 / 2.6% | 33 / 32 | 3.3 / 115: 3.3 / 150 | ETSLP-24 | ***TQP6M9002**** |

*NOTES: * = **New**, PD = Power Detector*

## WLAN LOW NOISE AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB / IIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| LNA, Dual-Band | 2.4 / 4.9 - 6 | 8 / 6, 12.5 / 1 | 16.5, 22.5 | 1.2, 1.5 | 3.3 / 11.5, 3.3 / 18.5 | VQFN12 | TQM3M7001 |
| LNA | 4.9 - 6 | 5 / -3 | 18 | 1.3 | 3 / 8 | SLIM-7 | TQL5000 |

## WLAN SWITCHES

| Description | Frequency (GHz) | Insertion Loss (dB) | Isolation (dB) | P1dB (dBm) | Control Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| SP2T General Purpose | DC - 2.5 | 0.3 | 24 | 30 | 3 / 0 | SOT363 | CSH210R |
| SP2T 802.11a/b/g | DC - 6 | 0.6 | 28 | 31.5 | 3 / 0 | SLIM7 | TQS5200 |
| Diversity Switch 802.11a/b/g | DC - 6 | 0.8 | 33 | 33 | 3 / 0 | MLP12 | TQS5202 |

## WLAN FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| WLAN IF Filter | 374 | 17 | 9 | SE / BAL | 30 @ 33.00 | 3.8 x 3.8 | 856278 |
| WLAN IF Filter | 770 | 17 | 3 | BAL / BAL | 32.5 @ 750.00 | 5.0 x 5.0 | 855942 |
| WLAN IF Filter | 1150 | 16 | 4.4 | BAL / BAL | 20 @ 1170.00 | 3.0 x 3.0 | 856256 |
| ISM Passband Filter | 2436 | 72 | 2 | SE / SE | 20 @ 2495.00 | 1.70 x 1.30 | ***885007**** |
| ISM Notch RF Filter | 2440 | 72 | 1.5 (Out of Band IL) | SE / SE | 25 @ 2440.00 | 1.70 x 1.30 | ***885008**** |
| ISM Notch RF Filter | 2440 | 85 | 2 (Out of Band IL) | SE / SE | 18 @ 2440 (Notch Rej) | 1.70 x 1.30 | ***885010**** |

*NOTES: * = **New***

## AMPLIFIERS – UP TO 1W

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Bluetooth PA | DC - 2.5 | 22.5 / – | 26 | – / 50 | 0 - 5.5 / 200 | SLIM-7 | CGB241 |
| Bluetooth PA | DC - 2.5 | 22.5 / – | 26 | – / 50 | 0 - 5.5 / 200 | MSOP-10 | CGB240 |
| 12.5 Gb/s NRZ Driver | DC - 18 | 24 / – | 16 | 3.5 / – | 5 - 8 / 70 - 175 | Die | TGA1328-SCC |
| 12.5 Gb/s NRZ Driver | DC - 18 | 8 Vpp | 16 | 3.5 / – | 8 / 175 | SL-A1-12 | TGA8652-SL |
| Wideband Driver (40 Gb/s) | DC - 35 | 18 / – | 12 | – | 5 / 135 | Die | TGA4832 |
| 24dBm HBT Amplifier | 0.01 - 2.5 | 24 / 40 | 15.5 | 5.1 / – | 5 / 160 | SOT89 | EC1089 |
| CATV TIA / Gain Block, SB | 0.04 - 1 | 27 / 46 | 20 | 1.5 | 8 / 350 | SM-08-02 | TGA2806-SM |
| MESFET IF Gain Block | 0.05 - .87 | 20 / 36 | 13 | 3 / – | 5 / 150 | SOT89 | AG103 |
| MESFET IF Gain Block | 0.05 - .87 | 20 / 41 | 13 | 3 / – | 5 / 150 | SOT89 | AH3 |
| MESFET Amplifier | 0.05 - 1 | 20 / 40 | 14.8 | 3.5 / – | 5 / 150 | SOT89 | AH2 |
| Dual HBT Amplifier | 0.05 - 1 | 20 / 37 | 13.5 | 4.5 / – | >7 / 165 | SOIC-8 | AG606 |
| Dual MESFET Amplifier | 0.05 - 1 | 25.5 / 43 | 11.1 | 4.5 / – | 5 / 320 | SOIC-8 | AH22S |
| MESFET IF Amplifier | 0.05 - 1 | 22 / 42 | 19 | 2.2 / – | 5 / 150 | SOT89 | AH31 |
| MESFET Amplifier | 0.05 - 1.5 | 26.5 / 47 | 13.5 | 3.5 / – | 9 / 200 | SOT89 | AH101 |
| 23 dBm HBT Amplifier | 0.05 - 2 | 23 / 39 | 20.5 | 5 / – | 8 / 100 | SOT89 | AH110 |
| MESFET Amplifier | 0.05 - 2.2 | 30 / 47 | 17 | 2.5 / – | 11 / 330 | 6 x 6 QFN28 | AH202 |
| VGA, 20 dB Range, 5V Control | 0.05 - 2.2 | 22 / 42 | 15.5 | 4.5 / – | 5 / 150 | 4 x 4 QFN16 | VG025 |
| 28.5 dBm HBT Amplifier | 0.05 - 2.7 | 28.5 / 45 | 20 | 4.5 / – | 5 / 150 | SOT89 | ***AH125**** |
| 24 dBm HBT Amplifier | 0.06 - 2.5 | 24 / 40 | 19 | 5 / – | 5 / 150 | SOT89 | AH114 |
| MESFET Amplifier, 2-Stage | 0.06 - 2.7 | 27 / 46 | 29 | 2.5 / – | 4.5; 9 / 275 | SOIC-8 | AH103A |
| 24 dBm HBT Amplifier | 0.06 - 3.5 | 24 / 40 | 19.5 | 4 / – | 5 / 160 | SOT89 | AH118 |
| 24.6 dBm HBT Amplifier | 0.06 - 3.5 | 24.5 / 41.5 | 19.5 | 4.5 / – | 5 / 115 | SOT89 | ***AH128**** |
| MESFET Gain Block | 0.06 - 3 | 15 / 32 | 14 | 2.4 / – | 4.5 / 50 | SOT89 | AG101 |
| MESFET Gain Block | 0.06 - 3 | 18 / 36 | 14 | 2.4 / – | 4.5 / 70 | SOT89 | AG102 |
| MESFET Gain Block | 0.06 - 3 | 18 / 39 | 14 | 2.4 / – | 4.5 / 78 | SOT89 | AM1 |
| MESFET Dual Amplifier | 0.15 - 3 | 24 / 46 | 12 | 4.1 / – | 5 / 300 | SOIC-8 | AH11 |
| MESFET Amplifier | 0.25 - 4 | 21.5 / 42 | 14 | 3.2 / – | 5 / 150 | SOT89 | AH1 |
| MESFET Amplifier | 0.25 - 4 | 21.5 / 42 | 14 | 3.2 / – | 5 / 150 | SOT89 | AH1-1 |
| MESFET Amplifier | 0.35 - 3 | 27 / 46 | 14.5 | 3.1 / – | 9 / 200 | SOT89 | AH102A |
| VGA, 29 dB Range, 5V Control | 0.70 - 1 | 22 / 40 | 16 | 3.5 / – | 5 / 150 | 6 x 6 QFN28 | VG101 |
| 28.7 dBm HBT Amplifier | 0.8 - 1 | 28.7 / 43 | 17.5 | 7 / – | 5 / 250 | SOIC-8 | AH116 |
| 28.7 dBm HBT Amplifier | 0.8 - 1 | 28.7 / 43 | 17.5 | 7 / – | 5 / 250 | 4 x 4 QFN16 | ECP052 |
| Gain Block | 0.8 - 2.5 | 17 / 27 | 16 | 4.1 / – | 5 / 85 | SOIC-8 | TQ9132 |
| VGA, 28 dB range, 5V Control | 1.8 - 2.2 | 30 / 46 | 23 | 8 / – | 5 / 415 | 6 x 6 QFN28 | VG112 |
| 28.5 dBm HBT Amplifier | 1.8 - 2.3 | 28.5 / 44 | 14.5 | 6 / – | 5 / 250 | SOIC-8 | AH115 |
| 28.5 dBm HBT Amplifier | 1.8 - 2.3 | 28.5 / 44 | 14.5 | 6 / – | 5 / 250 | 4 x 4 QFN16 | ECP050 |
| VGA, 27 dB Range, 5V Control | 1.8 - 2.7 | 22 / 39.5 | 13.5 | 4.5 / – | 5 / 150 | 6 x 6 QFN28 | VG111 |
| Wideband PA, AGC | 2 - 20 | 26 / – | 8 | – | 8 / 440 | Die | TGA8334-SCC |
| Wideband PA, AGC | 2 - 22 | 28.5 (30) / 36 | 17 | – | 12 / 1100 | Die | TGA2509 |
| WiMAX Driver Amp / PA, SB | 2.3 - 2.8 | 29 / 40 | 28 | – | 6 / 710 | SM-05-28 | TGA2702-SM |
| Bluetooth Class 1 PA | 2.4 - 2.5 | 21.5 / – | 27 | – / 50 | 0 - 3.3 / 160 | STSLP-12 | TQP770001 |
| ISM Band Matched PA, PD | 2.4 - 2.5 | 25 / – | 30 | – | 3.3 / 200 | VQFN-16 | TQP777002 |
| Dual-Band Matched PA | 2.4 / 4.9 - 6.0 | 25 / 25 | 30 | – | 3.3 / 180: 3.3 / 200 | 4 x 4 LAM16 | ***TQM7M7012**** |
| WiMAX Driver Amp / PA, SB | 3.4 - 3.8 | 30 / 42 | 24 | – | 6 / 770 | SM-05-28 | TGA2703-SM |
| 0.5W PA | 6 - 18 | 27 / – | 11 | 8 / – | 8 / 400 | Die | TGA8014-SCC |
| Driver Amp | 7 - 13 | (30) / 37 | 25 | – / 30 | 9 / 450 | Die | TGA2700 |
| Wideband Driver Amp | 8 - 18 | 13 / – | 17 | 5 / – | 4.5 / 50 | Die | TGA8399C |
| 1W HPA | 12 - 19 | 30 / – | 30 | – | 5 - 7 / 435 | Die | TGA2508 |
| HPA | 12 - 19 | 29 / – | 25 | – | 5 - 7 / 435 | SM-06-12 | TGA2508-SM |
| 1W HPA, PD | 17 - 20 | 30 (32) / 42 | 20 | – | 5 - 7 / 825 | Die | TGA4530 |
| 1W HPA, PD | 17 - 21 | 29 (31) / 41 | 21 | – | 6 / 825 | SM-A4-20 | TGA4530-SM |
| Driver Amp | 17 - 24 | 22 / – | 19 | 4 / – | 5 / 270 | SM-09-16 | TGA2521-SM |
| HPA, AGC, PD | 17 - 24 | (29) / 38 | 22 | – | 5 / 712 | SM-010-20 | TGA2522-SM |
| HPA | 17 - 27 | 29 (31) / 37 | 22 | – | 7 / 760 | Die | TGA4502-SCC |
| HPA | 18 - 27 | 29 / 37 | 14 | – | 6 / 480 | Die | TGA1135-SCC |
| MPA | 19 - 27 | 25 / 32 | 22 | – | 5 - 7 / 220 | Die | TGA1073G-SCC |
| MPA | 25 - 35 | 25 / – | 18 | – | 6 / 220 | SM-A4-20 | TGA4902-SM |

## AMPLIFIERS – UP TO 1W (cont.)

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| MPA | 26 - 35 | 25 (32) / – | 19 | – | 5 - 7 / 220 | Die | TGA1073A-SCC |
| 1W HPA | 27 - 31 | 30 / – | 22 | – / 25 | 4 - 6 / 420 | Die | TGA4509 |
| HPA | 27 - 32 | 28.5 / – | 25 | – | 6 - 8 / 420 | Die | TGA1073B-SCC |
| HPA | 27 - 32 | 29 / – | 16 | – | 6 - 7 / 630 | Die | TGA1172 |
| 1W HPA | 28 - 31 | 30 / – | 19 | – / 25 | 6 / 420 | SM-A4-20 | TGA4509-SM |
| Driver Amp | 29 - 31 | 16 (17) / 22 | 15 | – | 6 / 60 | SM-A4-20 | TGA4510-SM |
| Driver Amp | 29 - 37 | 16 / – | 16 | – | 6 / 60 | Die | TGA4510 |
| MPA | 32 - 45 | 24 (25) / 33 | 16 | – | 6 / 175 | Die | TGA4521 |
| HPA | 36 - 40 | 26 / – | 15 | – | 5 - 7 / 240 | Die | TGA1073C-SCC |
| HPA | 36 - 40 | 30 / – | 14 | – | 6 - 7 / 500 | Die | TGA1171-SCC |
| MPA | 33 - 47 | 27 (27.5) / 36 | 18 | – | 6 / 400 | Die | TGA4522 |
| 0.5W HPA | 40 - 45 | 28 / – | 9 | – | 7 / 500 | Die | TGA4043 |
| Driver Amp | 41 - 45 | 18 / – | 14 | – | 6 / 168 | Die | TGA4042 |

*NOTES: *** = New**, SB = Self Biased, AGC = Automatic Gain Control, PD = Power Detector*

## AMPLIFIERS – 1W TO 4W

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| CATV Ultra Linear HPA | 0.04 - 1 | 31.5 / 55 | 12 | 2.75 / – | 12 / 510 | SG-01-16 | TGA2801D-SG |
| 31 dBm HBT Amplifier | 0.4 - 2.3 | 31 / 46 | 18 | 7 / – | 5 / 450 | 4 x 4 QFN16 | ECP100 |
| 33 dBm HBT Amplifier | 0.4 - 2.3 | 33 / 49 | 18 | 8 / – | 5 / 800 | 4 x 4 QFN16 | ECP200 |
| 31 dBm HBT Amplifier | 0.4 - 2.3 | 31 / 46 | 18 | 7 / – | 5 / 450 | SOIC-8 | AH215 |
| 33 dBm HBT Amplifier | 0.4 - 2.3 | 33 / 49 | 18 | 8 / – | 5 / 800 | SOIC-8 | AH312 |
| 31.5 dBm HBT Amplifier | 0.4 - 2.7 | 31.5 / 46 | 20 | 7 / – | 5 / 300 | SOIC-8 | ***AH225**** |
| 33.5 dBm HBT Amplifier | 0.4 - 2.7 | 33.5 / 50 | 19 | 8 / – | 5 / 500 | SOIC-8 | ***AH322**** |
| 35.5 dBm HBT Amplifier | 0.4 - 2.7 | 35.5 / 50 | 16 | 7 / – | 5 / 800 | 4 x 5 DFN12 | ***AH420**** |
| InGaP HBT PA, 1.8W, Ultra High Linearity | 0.8 - 2.35 | 32.5 / 49 | 15.8 | – / 55 | 28 / 40 | 5 x 6 DFN14 | AP601 |
| InGaP HBT PA, 3.7W, Ultra High Linearity | 0.8 - 2.35 | 35.7 / 52 | 15.5 | – / 55 | 28 / 80 | 5 x 6 DFN14 | AP602 |
| 30 dBm HBT Amplifier | 1.8 - 2.7 | 30.5 / 46.5 | 27 | 5.5 / – | 5 / 400 | SOIC-8 / 4 x 5 DFN12 | AH212 |
| 33 dBm HBT Amplifier | 3.3 - 3.8 | 33 / – | 25 | – | 5 / 600 | 5 x 5 QFN20 | AH315 |
| 2W HPA | 5.5 - 8.5 | 32 (34) / 41 | 30 | 7 / – | 6 / 1260 | SM-013-24 | ***TGA2706-SM**** |
| 2.8W HPA | 6 - 18 | (34.5) / – | 24 | – / 20 | 7 - 9 / 800 - 1200 | Die | TGA2501 |
| HPA | 6 - 18 | (34.5) / – | 24 | – / 20 | 8 / 1200 | Die | TGA9092-SCC |
| 2W HPA | 12.3 - 15.7 | (31) / – | 33 | 7 / – | 6 / 850 | Die | TGA2520 |
| 2W HPA | 12.5 - 16 | (32) / 37 | 32 | – | 6 - 7 / 680 | SM-01-24 | TGA2503-SM |
| 2W HPA | 12.5 - 17 | (34) / – | 26 | – / 25 | 7.5 / 650 | Die | TGA2510 |
| 2W HPA | 12.5 - 17 | (33.5) / – | 25 | – / 25 | 7.5 / 650 | SG-A1-6 | TGA2510-SG |
| 4W HPA | 13 - 15 | (36) / 41 | 25 | – | 7 / 1300 | FL-A1-10 | TGA8659-FL |
| 2W HPA | 13 - 17 | (34) / 40 | 32 | – | 6 - 7 / 680 | Die | TGA2503 |
| 2W HPA | 13 - 17 | (34) / – | 25 | – | 6 - 7 / 640 | Die | TGA2505 |
| 2W HPA, PD | 13 - 17 | (34) / 38.5 | 26 | – / 30 | 7.5 / 650 | SG-A1-6 | TGA2902-1-SCC-SG |
| 2W HPA | 13 - 17 | (34) / – | 33 | – | 5 - 8 / 680 | FL-A1-10 | TGA2904-FL |
| 2W HPA | 13 - 17 | (34) / 40 | 33 | – | 5 - 8 / 680 | SG-A1-6 | TGA8658-SG |
| 2W HPA, PD | 13.75 - 14.5 | (34) / 38.5 | 26 | – / 30 | 7.5 / 650 | SG-A1-6 | TGA2902-2-SCC-SG |
| HPA | 13.5 - 15 | 33 / 39 | 34 | – | 7 / 680 | Die | TGA1152-SCC |
| HPA | 17 - 24 | 31 (32) / 40 | 23 | 6 / – | 7 / 720 | Die | ***TGA4531**** |
| 2W HPA | 18 - 23 | 32 (33) / 39 | 26 | – | 7 / 840 | Die | TGA4022 |
| 4W HPA | 24 - 31 | 35.5 (36) / – | 23 | – | 6 / 2100 | Die | TGA4505 |
| 4W HPA | 25 - 31 | 35.5 (36) / – | 22 | – | 6 / 2100 | CP-A1-8 | TGA4905-CP |
| 2W HPA | 27 - 31 | 32.5 (33) / 36.5 | 20 | – / 25 | 6 / 840 | Die | TGA4513 |
| 2W HPA | 27 - 31 | 32.5 (33) / – | 22 | – | 6 / 840 | CP-A2-8 | TGA4513-CP |
| 2W HPA | 30 - 40 | 31.5 (33) / – | 20 | – | 6 / 1050 | Die | TGA4516 |
| 2W HPA | 31 - 35 | 31.5 (33.5) / – | 19 | – | 6 - 7 / 1150 | Die | TGA4514 |
| 3.5W HPA | 31 - 37 | (35.5) / – | 20 | – | 6 / 2000 | Die | TGA4517 |
| 2W HPA | 41 - 47 | (33) / – | 16 | – | 6 / 2000 | Die | TGA4046 |
| 77 GHz MPA | 76 - 80 | 14 / – | 12 | – | 3.5 / 75 | Die | TGA4706-FC |

*NOTES: *** = New**, PD = Power Detector*

## AMPLIFIERS – MORE THAN 4W

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | PAE (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| InGaP HBT PA, 7W Ultra High Linearity | 0.8 - 2.35 | 38.5 / 55.5 | 17 | 53 | 28 / 160 | 5 x 6 DFN14 | AP603 |
| 10W HPA, HFET | 2.6 | 40 / 51 | 12 | – | 8 / 1200 | SG-A4-2 | TGA2924-SG |
| 39 dBm HBT Amplifier | 3.3 - 3.8 | 39 / – | 11.5 | – | 12 / 400 | 5 x 6 DFN14 | AP562 |
| 10W HPA, HFET | 3.3 - 3.8 | 40 / 51 | 9 | – | 7 - 9 / 1200 | SG-A3-2 | TGA2923-SG |
| 5W HPA, HFET | 3.5 | 37.5 / 49 | 11 | – | 8 / 750 | SG-A4-2 | TGA2925-SG |
| HPA | 6.5 - 11.5 | 37 (39) / – | 19 | 35 | 7 - 9 / 1200 | Die | TGA9083-SCC |
| 16W HPA | 6.5 - 12.5 | 42 / – | 27 | 35 | 12 / 3000 | Die | TGA2517 |
| HPA | 7 - 8.5 | (38) / – | 21 | 42 | 7 / 2000 | Die | TGA2701 |
| HPA | 9 - 10.5 | (38) / – | 20 | >38 | 4 - 9 / 2000 | Die | TGA2704 |
| HPA | 10.5 - 12 | (38) / – | 19 | >39 | 4 - 9 / 2000 | Die | TGA2710 |
| 6.5W HPA | 13 - 16 | (38) / – | 24 | – | 8 / 2600 | FL-A2-10 | TGA2514-FL |
| 4W HPA, Balanced | 13 - 17 | (36) / 44 | 25 | 30 | 6 - 7 / 1300 | Die | TGA2502 |
| 6.5W HPA | 13 - 18 | (38) / 44 | 24 | – | 8 / 3600 | Die | TGA2514 |
| 7W HPA | 26 - 31 | (38.5) / – | 22 | – | 6 / 4200 | CP-A3-8 | TGA4915-CP |
| 4W HPA | 28 - 31 | 36 (36.5) / – | 22 | 22 | 6 / 1600 | Die | TGA4906 |
| 4W HPA | 28 - 31 | 36 (36.5) / – | 22 | – / 22 | 6 / 1600 | SM-A5-24 | TGA4906-SM |
| 7W HPA | 28 - 31 | (38.5) / – | 22 | 20 | 6 / 3200 | Die | TGA4916 |

## AMPLIFIERS – GAIN BLOCK

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| General Purpose Gain Block | DC - 3 | 18.5 / 33 | 16.5 | 3.8 | 6 / 75 | SOT89 | AG603 |
| General Purpose Gain Block | DC - 3.5 | 18.5 / 33 | 13.6 | 4.4 | 6 / 75 | SOT89 | AG602 |
| General Purpose Gain Block | DC - 3.5 | 20.5 / 33.5 | 17.2 | 3.5 | 7 / 96 | SOT89 | EC1078 |
| General Purpose Gain Block | DC - 4 | 19.5 / 31 | 18.5 | 2.9 | 6 / 70 | SOT86 / SOT89 | EC1019 |
| General Purpose Gain Block | DC - 4 | 17.5 / 32 | 21.5 | 3.4 | 6 / 65 | SOT89 | ECG005 |
| General Purpose Gain Block | DC - 4 | 23.5 / 37 | 14.3 | 4.6 | 9 / 120 | SOT89 | ECG008 |
| General Purpose Gain Block | DC - 4 | 18 / 34.5 | 15.3 | 5.5 | 6 / 70 | SOT89 | ECG040 |
| General Purpose Gain Block | DC - 5.5 | 15 / 30 | 14.2 | 3.7 | 5 / 45 | SOT86 / SOT363 / SOT89 | ECG006 |
| General Purpose Gain Block | DC - 6 | 5.8 / 18.5 | 11 | 4.4 | 5 / 20 | SOT86 / SOT363 | AG201 |
| General Purpose Gain Block | DC - 6 | 7.5 / 19.5 | 17.7 | 3.1 | 5 / 20 | SOT86 / SOT363 | AG203 |
| General Purpose Gain Block | DC - 6 | 12 / 25 | 14.3 | 3.2 | 5 / 35 | SOT86 / SOT363 | AG302 |
| General Purpose Gain Block | DC - 6 | 12.5 / 25 | 18.4 | 3 | 5 / 35 | SOT86 / SOT363 | AG303 |
| General Purpose Gain Block | DC - 6 | 16 / 28.5 | 14.5 | 3.7 | 6 / 60 | SOT86 / SOT89 | AG402 |
| General Purpose Gain Block | DC - 6 | 16 / 28 | 18.9 | 3 | 6 / 60 | SOT86 / SOT89 | AG403 |
| General Purpose Gain Block | DC - 6 | 14.5 / 27.5 | 19.1 | 2.9 | 6 / 45 | SOT86 / SOT89 | AG503 |
| General Purpose Gain Block | DC - 6 | 19 / 33 | 18.2 | 3.5 | 6 / 75 | SOT86 / SOT89 | AG604 |
| General Purpose Gain Block | DC - 6 | 12.5 / 26 | 21.4 | 3.4 | 5 / 30 | SOT363 / SOT89 | ECG001 |
| General Purpose Gain Block | DC - 6 | 15 / 29 | 19.5 | 3.7 | 5 / 45 | SOT86 / SOT363 / SOT89 | ECG002 |
| General Purpose Gain Block | DC - 6 | 23 / 36 | 19 | 3.5 | 9 / 110 | SOT89 | ECG003 |
| General Purpose Gain Block | DC - 6 | 13 / 27 | 15.5 | 3.2 | 5 / 35 | SOT89 | ECG004 |
| General Purpose Gain Block | DC - 6 | 18.2 / 32 | 20.1 | 3.4 | 6 / 65 | SOT86 / SOT89 | ECG055 |
| LNA / Gain Block | DC - 40 | 11.5 / 20 | 13 | 3.2 | 5 / 50 | Die | TGA4830 |
| LNA / Gain Block | DC - 60 | 13 / 21 | 15 | 3 | 6 / 50 | Die | TGA4811 |
| CATV TIA / Gain Block, SB | 0.04 - 1 | 27 / 46 | 20 | 1.5 | 8 / 350 | SM-08-20 | TGA2803-SM |
| +5V Active Bias IF Gain Block | 0.05 - 1 | 20.5 / 33 | 17.5 | 5 | 5 / 95 | SOT89 | WJA1500 |
| +5V Active Bias IF Gain Block | 0.05 - 1 | 19 / 33.5 | 17.5 | 4.7 | 5 / 65 | SOT89 | WJA1505 |
| +5V Active Bias IF Gain Block | 0.05 - 1 | 20 / 36 | 14 | 5.4 | 5 / 95 | SOT89 | WJA1510 |
| +5V Active Bias IF Gain Block | 0.05 - 1 | 19 / 35.5 | 14 | 5 | 5 / 70 | SOT89 | WJA1515 |
| +5V Active Bias Gain Block | 0.05 - 1.2 | 19 / 29 | 15.3 | 5.3 | 5 / 85 | SOT89 | WJA1000 |
| +5V Active Bias Gain Block | 0.05 - 1.2 | 17 / 27 | 14.9 | 5.1 | 5 / 65 | SOT89 | WJA1005 |
| +5V Active Bias Gain Block | 0.05 - 2.3 | 19 / 28.5 | 14 | 5.2 | 5 / 85 | SOT89 | WJA1010 |
| +5V Active Bias Gain Block | 0.05 - 2.3 | 17 / 28 | 14 | 5 | 5 / 65 | SOT89 | WJA1015 |
| +5V Active Bias Gain Block | 0.05 - 3 | 20 / 34 | 16.7 | 5.4 | 5 / 100 | SOT89 | WJA1001 |
| +5V Active Bias Gain Block | 0.05 - 4 | 17 / 33 | 16.7 | 5.1 | 5 / 70 | SOT89 | WJA1020 |
| +5V Active Bias Gain Block | 0.05 - 4 | 20 / 37.5 | 16.7 | 5.6 | 5 / 90 | SOT89 | WJA1021 |
| +5V Active Bias Gain Block | 0.05 - 4 | 15.5 / 32 | 16.7 | 5 | 5 / 60 | SOT89 | WJA1025 |
| +5V Active Bias Gain Block | 0.05 - 4 | 19.3 / 36.5 | 14.5 | 5.5 | 5 / 80 | SOT89 | WJA1030 |

## AMPLIFIERS – GAIN BLOCK (cont.)

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| +5V Active Bias Gain Block | 0.05 - 4 | 18 / 34 | 14.5 | 5.4 | 5 / 65 | SOT89 | WJA1035 |
| Gain Block | 2 - 6 | 17 / – | 13.5 | 5.5 | 15 / 68 | Die | TGA8226-SCC |
| Gain Block, SB | 2 - 10 | 17 / – | 17 | 6 | 5 / 90 | Die | TGA8810-SCC |
| Gain Block, AGC | 2 - 18 | 22 / – | 23 | 6 | 7 / 340 | Die | TGA6345 |
| Gain Block | 2 - 18 | 20 / – | 7.5 | 5.5 | 6 / 100 | Die | TGA8300-SCC |
| Wideband Gain Block, AGC | 2 - 20 | 20 / – | 7.5 | 7 | 6 / 150 | Die | TGA8622-SCC |
| Gain Block | 6 - 18 | 12.5 / – | 13 | 5 | 5 / 80 | Die | TGA8035-SCC |
| Driver Amp, SB | 11 - 17 | 17 / – | 23 | 6 | 6 / 75 | SM-06-12 | TGA2507-SM |
| Driver Amp, SB | 12 - 18 | 14 / – | 17 | – | 6 / 40 | Die | TGA2506 |
| Driver Amp, SB | 12 - 18 | 20 / – | 28 | 6 | 6 / 80 | Die | TGA2507 |
| Gain Block & 2x / 3x Multiplier | 17 - 37 | 18 (22) / 26 | 20 | 7 | 5 / 140 | SM-03-16 | TGA4030-SM |
| Gain Block & 2x / 3x Multiplier | 17 - 40 | 18 (22) / 24 | 22 | 7 | 5 / 140 | SM-A3-16 | TGA4031-SM |
| Gain Block, Multiplier | 17 - 43 | 22 / – | 25 | – | 5 / 225 | Die | TGA4040 |
| Gain Block | 19 - 38 | (22) / 30 | 20 | – | 5 / 160 | Die | TGA4036 |

*NOTES: SB = Self Biased, AGC = Automatic Gain Control*

## LOW NOISE AMPLIFIERS

| Description | Frequency Range (GHz) | P1dB / IIP3 (dBm) | Gain (dB) | NF (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| LNA, Discrete | DC - 4 | – / 13 | 17 | 0.5 | 3 / 30 | SOT343 | CFH800 |
| LNA, AGC | DC - 14 | 16 / – | 11 | 3.1 | 8 / 80 | Die | TGA8349-SCC |
| LNA / Gain Block | DC - 40 | 11.5 / 20 | 13 | 3.2 | 5 / 50 | Die | TGA4830 |
| LNA / Gain Block | DC - 60 | 13 / 21 | 15 | 3 | 6 / 50 | Die | TGA4811 |
| LNA, SB | 0.1 - 3.5 | 15 / – | 18 | 2.4 | 12 / 112 | Die | TGA8061-SCC |
| LNA, Balanced FET Low Band | 0.7 - 0.92 | – / 13.5 | 17 | 0.7 | 2.5 / 100 | 4 x 4 QFN16 | ***TQP3M6004**** |
| LNA, Discrete Low Band | 0.7 - 0.92 | 26 / 23.5 | 16 | 0.8 | 5 / 150 | SOT89 | ***TGF2021-04-SD**** |
| LNA, Balanced FET | 0.8 - 3 | 21 / 11 | 22 | 0.7 | 4 / 100 | SM-02-6 | TGA2602-SM |
| LNA, AGC | 2 - 18 | 18 / 29 | 17 | 2.0 | 5 / 75 | Die | TGA2525 |
| LNA, AGC | 2 - 18 | 16 / – | 19 | 4 | 5 / 120 | Die | TGA8344-SCC |
| LNA, AGC | 2 - 20 | 17.5 / – | 9 | 3.5 | 5 - 8 / 60 | Die | TGA1342-SCC |
| LNA, AGC | 2 - 20 | 19 / – | 17.5 | 2.5 | 5 / 100 | Die | ***TGA2526**** |
| LNA, AGC | 2 - 20 | 17.5 / – | 9 | 3.5 | 5 - 8 / 60 | Die | TGA8310-SCC |
| LNA, AGC | 2 - 20 | 16 / – | 17 | 2.5 | 5 / 75 | SM-07-12 | TGA2513-SM |
| LNA, AGC | 2 - 23 | 17 / 26 | 17 | 2 | 5 / 75 | Die | TGA2513 |
| LNA, SB, AGC | 4 - 14 | 6 / 16 | 22 | 2.3 | 5 / 90 | SM-04-12 | TGA2512-1-SM |
| LNA, AGC, GB | 4 - 14 | 13 / 24 | 25 | 2.3 | 5 / 160 | SM-04-12 | TGA2512-2-SM |
| LNA | 4.9 - 6 | 5 / -3 | 18 | 1.3 | 3 / 8 | SLIM-7 | TQL5000 |
| LNA, Dual-Band | 2.4 / 4.9 - 6 | 8 / 6, 12.5 / 1 | 16.5, 22.5 | 1.2, 1.5 | 3.3 / 11.5, 3.3 / 18.5 | VQFN12 | TQM3M7001 |
| LNA, SB, AGC | 5 - 15 | 6 / 13 | 27 | 1.4 | 5 / 90 | Die | TGA2512 |
| LNA | 6 - 12 | 2 / – | 31 | 0.7 | 2.5 / 17 | Die | TGA2600 |
| LNA, SB | 6 - 13 | 11 / – | 26 | 1.5 | 5 / 65 | Die | TGA8399B-SCC |
| LNA, SB, AGC | 6 - 14 | 6 / 12 | 20 | 1.3 | 5 / 90 | Die | TGA2511 |
| LNA | 20 - 27 | 12 / – | 21 | 2.2 | 3.5 / 60 | Die | TGA4506 |
| LNA | 21 - 27 | 10 / – | 21 | 2.5 | 3.5 / 60 | SM-A4-20 | TGA4506-SM |
| LNA | 28 - 36 | 12 / 21 | 22 | 2.3 | 3 / 60 | Die | TGA4507 |
| LNA | 30 - 42 | 14 / – | 21 | 2.8 | 3 / 40 | Die | TGA4508 |
| LNA | 57 - 69 | – | 13 | 4 | 3 / 41 | Die | TGA4600 |
| 77 GHz LNA | 72 - 80 | 5 | 20 | 5 | 3.5 / 54 | Die | TGA4705-FC |

*NOTES:* **** = New****, SB = Self Biased, AGC = Automatic Gain Control, GB = Gate Bias*

## DISCRETE TRANSISTORS

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| MESFET | DC - 2.5 | 26.5 / – | 11 | 1.72 / 55 | 2 - 6 / 350 | SOT223 | CLY5 |
| MESFET | DC - 3 | 23.5 / – | 15.5 | 1.48 / 55 | 2 - 6 / 180 | MW6 | CLY2 |
| 24mm HFET | DC - 4 | 40 / – | 13 | – / 51 | 8 / 2170 | Die | TGF4124 |
| 18mm HFET | DC - 6 | 38.5 / – | 13.5 | – / 53 | 8 / 1690 | Die | TGF4118 |

## DISCRETE TRANSISTORS (cont.)

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | NF / PAE (dB) / (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 12mm HFET | DC - 8 | 37 / – | 14 | – / 55 | 8 / 750 | Die | TGF4112 |
| 0.5W HFET | DC - 6 | 28 / 40 | 18 | 3.2 / – | 8 / 100 | SOT89 | TGF2960-SD |
| 1W HFET | DC - 6 | 31 / 43 | 16 | 4 / – | 8 / 200 | SOT89 | TGF2961-SD |
| 4.8mm HFET | DC - 10.5 | 34 / – | 8.5 | – / 53 | 8 / 200 | Die | TGF4250-SCC |
| 9.6mm HFET | DC - 10.5 | 37 / – | 9.5 | – / 52 | 8.5 / 520 | Die | TGF4260-SCC |
| 1.2mm HFET | DC - 12 | 28.5 / – | 10 | – / 55 | 8 / 50 | Die | TGF4230-SCC |
| 2.4mm HFET | DC - 12 | 31.5 / – | 10 | – / 56 | 8 / 100 | Die | TGF4240-SCC |
| 1mm Pwr pHEMT | DC - 12 | (31.5) / – | 11 | – / 55 | 12 / 900 | Die | TGF2021-01 |
| 2mm Pwr pHEMT | DC - 12 | (34.5) / – | 11 | – / 55 | 12 / 150 | Die | TGF2021-02 |
| 4mm Pwr pHEMT | DC - 12 | (37.5) / – | 11 | – / 55 | 12 / 300 | Die | TGF2021-04 |
| 8mm Pwr pHEMT | DC - 12 | (40.2) / – | 11 | – / 55 | 12 / 600 | Die | TGF2021-08 |
| 12mm Pwr pHEMT | DC - 12 | (42) / – | 11 | – / 52 | 12 / 900 | Die | TGF2021-12 |
| 0.3mm MESFET | DC - 18 | 13 / – | 11 | 1.5 / – | 3 / 15 | Die | TGF1350-SCC |
| 0.6mm Pwr pHEMT | DC - 20 | (29) / – | 13 | – / 56 | 12 / 45 | Die | TGF2022-06 |
| 1.2mm Pwr pHEMT | DC - 20 | (32) / – | 13 | – / 56 | 12 / 90 | Die | TGF2022-12 |
| 2.4mm Pwr pHEMT | DC - 20 | (35) / – | 13 | – / 58 | 12 / 180 | Die | TGF2022-24 |
| 4.8mm Pwr pHEMT | DC - 20 | (38) / – | 13 | – / 58 | 12 / 360 | Die | TGF2022-48 |
| 6.0mm Pwr pHEMT | DC - 20 | (39) / – | 12.5 | – / 53 | 12 / 448 | Die | TGF2022-60 |
| 0.3mm pHEMT | DC - 22 | 16 / – | 13 | 0.8 / – | 3 / 15 | Die | TGF4350 |
| MESFET | 0.05 - 4 | 21 / 42 | 19 | 2 / – | 5 / 140 | SOT89 | FH1 |
| MESFET | 0.05 - 4 | 18 / 36 | 19 | 2 / – | 5 / 140 | SOT89 | FH101 |
| 0.5W HFET | 0.05 - 4 | 27 / 40 | 19 | 2.7 / – | 8 / 125 | SOT89 | FP1189 |
| 1W HFET | 0.05 - 4 | 30 / 44 | 18 | 4.5 / – | 8 / 250 | SOT89 | FP2189 |
| 2.5W HFET | 0.05 - 4 | 34 / 46 | 18 | 3.5 / – | 9 / 450 | 6 x 6 QFN28 | FP31QF |

## 28V LDMOS TRANSISTORS

| Description | Frequency Range (MHz) | P1dB / IMD3 (dBm) / (dBc) | Gain (dB) | Efficiency (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| LDMOS PA, 30W IS95 | 865 - 895 | 44.8 / -31 | 21 | 57 | 28 / 330 | EU, EF | AGR09030E |
| LDMOS PA, 45W IS95 | 865 - 895 | 46.5 / -31 | 20.5 | 59 | 28 / 450 | EU, EF | AGR09045E |
| LDMOS PA, 85W IS95 | 865 - 895 | 49.3 / -30 | 18 | 55 | 28 / 800 | EU, EF | AGR09085E |
| LDMOS PA, 180W IS95 Push Pull | 865 - 895 | 52.6 / -30 | 15.5 | 58 | 28 / 2x850 | EF | AGR09180E |
| LDMOS PA, 70W GSM / EDGE | 921 - 960 | 48.5 / -60 | 18 | 56 | 26 / 800 | EF | AGR09070E |
| LDMOS PA, 90W GSM / EDGE | 921 - 960 | 49.5 / -60 | 18 | 60 | 26 / 700 | EF | AGR09090E |
| LDMOS PA, 130W GSM / EDGE | 921 - 960 | 51.1 / -60 | 18 | 55 | 26 / 1000 | EU, EF | AGR09130E |
| LDMOS PA, 30W GSM / EDGE | 1805 - 1880 | 44.8 / -64 | 15 | 51 | 26 / 300 | EF | AGR18030E |
| LDMOS PA, 45W GSM / EDGE | 1805 - 1880 | 46.5 / -63 | 15 | 53 | 26 / 400 | EF | AGR18045E |
| LDMOS PA, 60W GSM / EDGE | 1805 - 1880 | 47.8 / -62 | 15 | 52 | 26 / 500 | EU, EF | AGR18060E |
| LDMOS PA, 90W GSM / EDGE | 1805 - 1880 | 49.5 / -63 | 15 | 50 | 26 / 800 | EU, EF | AGR18090E |
| LDMOS PA, 125W GSM / EDGE | 1805 - 1880 | 51 / -60 | 13.5 | 50 | 26 / 1200 | EU, EF | AGR18125E |
| LDMOS PA, 30W CDMA / GSM / EDGE | 1930 - 1990 | 44.8 / – | 16 | 55 | 28 / 300 | EF | AGR19030E |
| LDMOS PA, 45W CDMA / GSM / EDGE | 1930 - 1990 | 46.5 / – | 16 | 54 | 28 / 400 | EF | AGR19045E |
| LDMOS PA, 60W CDMA / GSM / EDGE | 1930 - 1990 | 47.8 / – | 15.5 | 53 | 28 / 500 | EU, EF | AGR19060E |
| LDMOS PA, 90W CDMA / GSM / EDGE | 1930 - 1990 | 49.5 / – | 15.5 | 50 | 28 / 800 | EU, EF | AGR19090E |
| LDMOS PA, 125W CDMA / GSM / EDGE | 1930 - 1990 | 51 / – | 15 | – | 28 / 1250 | EU, EF | AGR19125E |
| LDMOS PA, 180W CDMA / GSM / EDGE Push Pull | 1930 - 1990 | 52.6 / – | 14.5 | – | 28 / 2x800 | EF | AGR19180E |
| LDMOS PA, 30W WCDMA | 2110 - 2170 | 44.8 / -34 | 14.5 | 26 | 28 / 300 | EF | AGR21030E |
| LDMOS PA, 45W WCDMA | 2110 - 2170 | 46.5 / -33 | 14.5 | 26 | 28 / 400 | EF | AGR21045E |
| LDMOS PA, 60W WCDMA | 2110 - 2170 | 47.8 / -34 | 14.5 | 26 | 28 / 500 | EU, EF | AGR21060E |
| LDMOS PA, 90W WCDMA | 2110 - 2170 | 49.5 / -33 | 14.5 | 26 | 28 / 800 | EU, EF | AGR21090E |
| LDMOS PA, 120W WCDMA Push Pull | 2110 - 2170 | 50.8 / – | 14 | 22 | 28 / 2x700 | EF | PTF102003 |
| LDMOS PA, 125W WCDMA | 2110 - 2170 | 51 / -34.5 | 14 | 27 | 28 / 1200 | EU, EF | AGR21125E |
| LDMOS PA, 180W WCDMA Push Pull | 2110 - 2170 | 52.6 / -36 | 14 | 26 | 28 / 2x800 | EF | AGR21180E |
| LDMOS PA, 25W MMDS WCDMA | 2300 - 2500 | 44 / -30 | 12 | – | 28 / 330 | EF | PD25025F |
| LDMOS PA, 45W MMDS WCDMA | 2535 - 2655 | 46.5 / -38 | 13 | 21 | 28 / 430 | EF | AGR26045E |
| LDMOS PA, 125W MMDS WCDMA | 2535 - 2655 | 51 / -38 | 12 | 20 | 28 / 1300 | EU, EF | AGR26125E |
| LDMOS PA, 180W MMDS WCDMA Push Pull | 2535 - 2655 | 52.6 / -36 | 12 | 20 | 28 / 2x850 | EF | AGR26180E |
| LDMOS PA, 25W MMDS WCDMA | 2500 - 2700 | 44 / -30 | 11 | – | 28 / 330 | EF | PD27025F |

## SWITCHES

| Description | Frequency (GHz) | Insertion Loss (dB) | Isolation (dB) | P1dB (dBm) | Control Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| SP3T High Power CDMA | DC - 2 | 0.45 | 28 | >36.5 | 2.6 / 0 | MLP12 | TQP4M3018 |
| SP3T High Power CDMA | DC - 2 | 0.6 | 22 | 34.5 | 2.6 / 0 | STSLP12 | TQP4M3019 |
| SP2T General Purpose | DC - 2.5 | 0.3 | 24 | 30 | 3 / 0 | SOT363 | CSH210R |
| SP2T 802.11a/b/g | DC - 6 | 0.6 | 28 | 31.5 | 3 / 0 | SLIM7 | TQS5200 |
| Diversity Switch 802.11a/b/g | DC - 6 | 0.8 | 33 | 33 | 3 / 0 | MLP12 | TQS5202 |
| SPDT FET | DC - 18 | 1.5 | 36 | 27 | -5 | Die | TGS2306 |
| SPDT FET | DC - 18 | 2.0 | 39 | 21 | -7 / 0 | Die | TGS8250-SCC |
| SP4T FET | DC - 18 | 2.5 | 37 | 19 | 0 / -5 | Die | TGS8422-SCC |
| SP3T VPIN | 1 - 20 | 0.5 | 35 | 23 | 10 mA | Die | TGS2303 |
| SP4T VPIN | 1 - 20 | 0.6 | 38 | 23 | 10 mA | Die | TGS2304-SCC |
| SP3T VPIN | 4 - 18 | 1.0 | 35 | 20 | +/- 2.7 | Die | TGS2313 |
| SPDT VPIN | 4 - 20 | 0.9 | 35 | >20 | +/- 2.7 | Die | TGS2302 |
| SPDT VPIN | 24 - 43 | <2 | 36 | 27 | +/- 5 | Die | TGS4301 |
| SPDT VPIN | 27 - 46 | 0.9 | 30 | >34 | +/ -5 / 15 | Die | TGS4302 |
| SPDT VPIN Absorptive | 32 - 40 | 1.0 | 36 | >33 | +/- 5 / 18 | Die | TGS4304 |
| SP3T | 60 - 90 | 2.3 | 20 | >-13 | -5 / 1.35 | Die | TGS4305-FC |
| SP4T | 70 - 90 | 3.0 | 20 | >-8 | -5 / 1.35 | Die | TGS4306-FC |
| SP5T VPIN 77 GHz | 71 - 90 | 2.5 | 25 / 40 | >-8 | -5 / 1.35 | Die | TGS4307 |

## FREQUENCY CONVERTERS & MIXERS

| Description | RF Frequency Range (GHz) | Conversion Gain (dB) | LO / RF Isolation (dB) | IIP3 (dBm) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| WB Mixer, LO | 0.5 - 2.5 | -5.7 | 8 | 24 | 3 - 6 / 6 | MW6 | CMY210 |
| WB Mixer, LO, IF | 0.5 - 2.5 | 10 | 8 | 9 | 3 - 6 / 12 | SCT598 | CMY212 |
| WB Mixer, LO, IF, Low Current | 0.5 - 2.5 | 9.5 | 10 | 10 | 3 - 6 / 8 | SCT598 | CMY213 |
| WB Mixer, LO | 0.5 - 2.5 | 4 | – | 9 | 3 - 6 / 6.2 | SOT23-6 | TQ5M31 |
| Single Branch Bonverter, RF, LO, IF | 0.8 - 0.92 | 22 | 60 | 15 | 5 / 360 | 6 x 6 QFN28 | CV110-1A |
| Dual Branch Converter, LO, IF | 0.8 - 0.92 | 10 | 20 | 20 | 5 / 385 | 6 x 6 QFN28 | CV210-1A |
| Mixer | 0.8 - 0.96 | -7.3 | 30 | 34 | N/A | SOIC-8 | MH203A |
| Mixer | 0.8 - 0.96 | -7 | 37 | 35 | N/A | SOIC-8 | MH205A |
| Single Branch Converter, RF, LO, IF | 0.8 - 0.96 | 22 | 60 | 15 | 5 / 360 | 6 x 6 QFN28 | CV110-2A |
| Single Branch Converter, RF, LO, IF | 0.8 - 0.96 | 22 | 60 | 15 | 5 / 360 | 6 x 6 QFN28 | CV110-3A |
| Dual Branch Converter, LO, IF | 0.8 - 0.96 | 10 | 18 | 19.5 | 5 / 360 | 6 x 6 QFN28 | CV210-2A |
| Dual Branch Converter, LO, IF | 0.8 - 0.96 | 10.5 | 14 | 18.5 | 5 / 390 | 6 x 6 QFN28 | CV210-3A |
| Mixer, LO | 1.6 - 3.2 | -8.5 | 2 | 35 | 5 / 40 | MSOP-8 | ML485 |
| Mixer | 1.7 - 2.0 | -8.3 | 30 | 35 | N/A | SOIC-8 | MH1A |
| Single Branch Converter, RF, LO, IF | 1.7 - 2.0 | 21 | 45 | 17 | 5 / 360 | 6 x 6 QFN28 | CV111-1A |
| Dual Branch Converter, LO, IF | 1.7 - 2.0 | 10 | 8 | 19.5 | 5 / 380 | 6 x 6 QFN28 | CV211-1A |
| Mixer, LO | 1.7 - 2.2 | -8.2 | 9 | 30 | 5 / 105 | SOIC-8 | ML401 |
| Single Branch Converter, RF, LO, IF | 1.9 - 2.2 | 21 | 40 | 17 | 5 / 360 | 6 x 6 QFN28 | CV111-3A |
| Dual Branch Converter, LO, IF | 1.9 - 2.7 | 10 | 12 | 20 | 5 / 380 | 6 x 6 QFN28 | CV211-2A |
| Dual Branch Converter, LO, IF | 1.9 - 2.7 | 9 | 12 | 19 | 5 / 315 | 6 x 6 QFN28 | CV221-2A |
| Mixer, LO | 1.9 - 2.7 | -8.1 | 9 | 30 | 5 / 110 | SOIC-8 | ML501 |
| Mixer | 1.9 - 2.7 | -8.2 | 28 | 34 | N/A | SOIC-8 | MH103A |
| Doubler with Amplifier | 16 - 30 | 18 | 30 | 22 | 5 / 150 | Die | TGC4403 |
| Doubler with Amplifier | 16 - 30 | 18 | 30 | 19 | 5 / 150 | SM-011-16 | TGC4403-SM |
| Upconverting Mixer | 17 - 26 | -9 | 40 | – | -0.9 / 0 | SM-011-16 | TGC4402-SM |
| Upconverting Mixer | 17 - 27 | -9 | 35 | 18 | -0.9 / 0 | Die | TGC4402 |
| Upconverter | 17 - 27 | 13 | 30 | – | 5 / 425 | Die | TGC4405 |
| Upconverter | 17 - 27 | 13 | 30 | – | 5 / 425 | SM-011-16 | TGC4405-SM |
| Gain Block & 2x / 3x Multiplier | 17 - 37 | 9 | N/A | 6 | 5 / 140 | SM-03-16 | TGA4030-SM |
| Gain Block & 2x / 3x Multiplier | 17 - 40 | 9 | N/A | 2 | 5 / 140 | SM-A3-16 | TGA4031-SM |
| Doubler (Input 10 - 20 GHz) | 20 - 40 | -12 | 25 | 18 | – | Die | TGC1430F |
| Tripler (Input 8.5 - 13.5 GHz) | 20 - 40 | -15 | 15 | 18 | – | Die | TGC1430G |
| 38 / 77 GHz Converter / MPA | 76 - 78 | 6.0 | – | – / 15.0 | 4 / 230 | Die | TGC4704-FC |
| 19 / 38 GHz Converter / MPA | 36 - 40 | 9.0 | – | – / 14.5 | 3.5 / 65 | Die | TGC4703-FC |
| Down Converting I/Q Mixer | 75 - 80 | -13.5 | 22 | – | 1.1 / 7 | Die | TGC4702-FC |
| 19 GHz VCO with 8:1 Prescaler | 18.5 - 19.5 | – | -105** | – / 7.0 | 5 / 158 | Die | TGV2204-FC |

*NOTES: ** = Phase Noise (dBc / Hz @ 1 MHz Offset), LO = LO Amplifier, IF = IF Amplifier*

## OPTICAL COMPONENTS

| Description | Frequency (GHz) | Power (Vpp or dBm) | Gain (dB) | Noise Figure (dB) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 12.5 Gb/s NRZ Driver | DC - 18 | 24 dBm | 16 | 3.5 | 5 - 8 / 70 - 175 | Die | TGA1328-SCC |
| 12.5 Gb/s NRZ Driver | DC - 18 | 8V | 16 | 3.5 | 8 / 175 | SL-A1-12 | TGA8652-SL |
| Wideband Driver (40 Gb/s) | DC - 35 | 4V | 12 | – | 5 / 135 | Die | TGA4832 |
| 10.7 Gb/s Diff. TIA | DC - 10 | – | 8K dB Ω SE | 6pA √Hz | 3.3 / 80 | Die | TGA4815 |
| 10.7 Gb/s Diff. TIA | DC - 10 | – | 1.6K dB Ω SE | 6pA √Hz | 3.3 / 60 | Die | TGA4816 |
| 10.7 Gb/s Diff. TIA | DC - 10 | – | 3.2K dB Ω SE | 11pA √Hz | 3.3 / 70 | Die | TGA4817 |
| 9.9 - 12.5 Gb/s Mod. Driver | DC - 16 | 3V - 10V | 35 | 2.5 | 5.5 - 8 / 210 | SL-A2-18 | TGA4953-SL |
| 9.9 - 12.5 Gb/s Mod. Driver | DC - 16 | 3V - 10V | 35 | 2.5 | 5.5 - 8 / 210 | SL-A4-18 | TGA4954-SL |
| 12.5 Gb/s NRZ Driver | DC - 18 | 11V | 16 | – | 8 / 285 | Die | TGA4807 |
| 12.5 Gb/s RZ Driver | DC - 25 | 7V | 15 | – | 9 / 100 | Die | TGA4802 |
| 43 Gb/s NRZ Driver | DC - 35 | 7V | 15 | – | 6.5 / 170 | Die | TGA4801 |
| 40 Gb/s TIA, SE | DC - 40 | – | 250 dB Ω | 15pA √Hz | 5 / 30 | Die | TGA4812 |
| 43 Gb/s Driver | DC - 78 | 3V | 8 | 5 | 6 / 82 | Die | TGA4803 |
| 10.7 - 12.5 Gb/s Linear Mod. Driver | 30 kHz - 8 | 25 dBm | 20 | – | 8 / 310 | SM-A8-28 | TGA4823-2-SM |
| 9.9 - 12.5Gb/s 3V - 7V Driver | DC - 13 | 3 - 7 Vpp | 20 | – | 3.3 - 5 / 100 | SM-A5-28 | TGA4955-SM |
| 9.9 - 12.5Gb/s 3V - 7V Driver | DC - 13 | 3 - 7 Vpp | 32 | – | 3.3 - 5 / 115 | SM-A8-28 | TGA4956-SM |
| 40 Gb/s LN / MZ Mod. Driver | DC - 35 | 5 - 8 Vpp | 30 | – | 8 / 300 | SL-A7-21 | TGA4942-SL |
| 28 Gb/s 8Vpp SE Driver | DC - 30 | 3 - 9 Vpp | 32 | – | 6 -7 / 270 | SL-A7-21 | ***TGA4943-SL**** |

*NOTES:* **** = New**, SE = Single-Ended*

## CONTROL PRODUCTS

| Description | Frequency (GHz) | Insertion Loss (dB) | Control Range dB or (Deg.) | P1dB (dBm) | Supply Voltage (V) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| Discrete Thru (0 dB Attenuator) | DC - 65 | 0 | 0 | – | N/A | Die | TGL4201-00 |
| Analog Attenuator | DC - >50 | 2 | 17 | – | 0 to -2 | Die | TGL4203 |
| Analog Attenuator | DC - 30 | 2 | 17 | – | 0 to -2 | SM-012-16 | TGL4203-SM |
| Discrete Attenuators | DC - 65 | – | 2,3,6,10 | – | N/A | SM-012-16 | TGL4201-02, 03, 06, 10 |
| Digital Attenuator | 0.5 - 18 | 4 | 15.5 | 20 | 0 / -5 | Die | TGL6425-SCC |
| Analog Attenuator | 2 - 20 | 2 | 15 | 23 | 2.5 | Die | TGL8784-SCC |
| Passive Wideband Limiter | 3 - 25 | <0.5 | N/A | 18 | N/A | Die | TGL2201 |
| 5-Bit Phase Shifter | 6 - 18 | 9 | (348) | – | 6 | Die | TGP6336 |
| Bessel Filter | – | 6,7,8,9,10&11 Cut-Off Freq | N/A | – | N/A | Die | TGB2010-00,-09 etc. |
| Bessel Filter | – | 5,6,6.5,7.5,8&9 Cut-Off Freq | N/A | – | N/A | SM-02-6 | TGB2010-00,-09-SM etc. |
| 6-Bit Phase Shifter | 8.5 - 11 | 5 | (354) | – | 0 / -5 | Die | TGP2103 |
| Lange Coupler | 12 - 21 | <0.25 | – | – | N/A | Die | TGB2001 |
| 5-Bit Phase Shifter | 18 - 20 | 5 | (180) | – | -2.5 | Die | TGP1439 |
| Lange Coupler | 18 - 32 | <0.25 | – | – | N/A | Die | TGB4001 |
| Lange Coupler | 27 - 45 | <0.25 | – | – | N/A | Die | TGB4002 |
| 5-Bit Phase Shifter | 28 - 32 | 6 | (348) | – | 5 | Die | TGP2100 |
| 5-Bit Phase Shifter | 33 - 37 | 6 | (348) | – | -5 | Die | TGP2102 |
| 1-Bit Phase Shifter | 34 - 36 | 4 | 180 | – | 0 / 5 | Die | TGP2104 |

## INTEGRATED PRODUCTS – AUTOMOTIVE

| Description | Frequency Bands | Package Size (mm) | Part Number |
|---|---|---|---|
| QB GSM / GPRS Tx Module; PA / LPF / SP6T Switch | GSM850 / 900, DCS / PCS | 6.0 x 6.0 x 1.1 | ***TQM6M4003**** |
| QB GSM / GPRS / EDGE-Polar PA Module | GSM850 / 900, DCS / PCS | 5.0 x 5.0 x 1.0 | ***TQM7M5012**** |

*NOTES:* **** = New***

## INTEGRATED PRODUCTS – GPS

| Description | Frequency Bands | Package Size (mm) | Part Number |
|---|---|---|---|
| GPS LNA Filter Module | GPS L1 Band | 3.0 x 3.0 x 1.1 | TQM640002 |

## INTEGRATED PRODUCTS – 3G - WCDMA / EDGE HANDSET

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| QB GSM / GPRS / EDGE-Polar HADRON PA Module™ | 850 / 900, DCS / PCS | 0 to +6dBm Pin Nom | 7.0 x 7.0 x 1.1 | TQM7M5003 |
| QB GSM / GPRS / EDGE-Polar HADRON PA Module™ | 850 / 900, DCS / PCS | -87 dBm Typ Rx Noise, +3 to +8 dBm Pin Nom | 7.0 x 7.0 x 1.1 | TQM7M5008 |
| QB GSM / GPRS / EDGE-Polar HADRON II PA Module™ | 850 / 900, DCS / PCS | -90 dBm Typ Rx Noise, +3 to +8 dBm Pin Nom | 5.0 x 5.0 x 1.0 | TQM7M5012 |
| QB GSM / GPRS / EDGE-Next Gen HADRON II PA Module™ | 850 / 900, DCS / PCS | Reduced Current Consumption | 5.0 x 5.0 x 0.9 | ***TQM7M5013**** |
| QB GSM / GPRS / EDGE-Polar HADRON II PA Module™ | 850 / 900, DCS / PCS | DC / DC Conv Compatible, Current Limiter | 5.0 x 5.0 x 1.0 | ***TQM7M5015**** |
| WCDMA / HSUPA TRITON PA Module™ w/Coupler | Band 1 | 2-Bit (Hi / Med / Lo Power Modes) | 4.0 x 4.0 x 0.9 | ***TQM776003**** |
| WCDMA / HSUPA TRITON PA Module™ w/Coupler | Band 1 | 2-Bit (Hi / Med / Lo Power Modes) | 3.0 x 3.0 x 0.9 | ***TQM776011**** |
| WCDMA / HSUPA TRITON PA Module™ w/Coupler | Band 2 | 2-Bit (Hi / Med / Lo Power Modes) | 3.0 x 3.0 x 0.9 | ***TQM766012**** |
| 2-in-1 WCDMA / HSUPA TRITON PA Module™ w/Coupler | Bands 1 & 8 | 2-Bit (Hi / Med / Lo Power Modes) | 5.0 x 3.0 x 0.9 | ***TQM7M6018**** |
| 2-in-1 WCDMA / HSUPA TRITON PA Module™ w/Coupler | Bands 2 & 5 | 2-Bit (Hi / Med / Lo Power Modes) | 5.0 x 3.0 x 0.9 | ***TQM7M6025**** |
| WCDMA / HSUPA TRITIUM III PA-Duplexer Module™ | Band 1 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | TQM676021 |
| WCDMA / HSUPA TRITIUM III PA-Duplexer Module™ | Band 2 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | TQM666022 |
| WCDMA / HSDPA TRITIUM III PA-Duplexer Module™ | Bands 5 & 6 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | ***TQM616020*+*** |
| WCDMA / HSUPA TRITIUM III PA-Duplexer Module™ | Bands 5 & 6 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | TQM616025 |
| WCDMA / HSUPA TRITIUM III PA-Duplexer Module™ | Band 8 | 1-Bit (Hi / Lo Power Modes), Internal Vref | 7.0 x 4.0 x 1.1 | ***TQM626028**** |
| QB GSM / GPRS / EDGE-Linear TRP QUANTUM II Tx Module™ w/ Tri-Band WCDMA Antenna Pass-Through | 850 / 900, DCS / PCS B1, B2, B5/6 | QB EDGE PA & UMTS Antenna Switch, TRP Compliant at 4:1 | 7.0 x 7.5 x 1.1 | TQM6M9008 |
| QB GSM / GPRS / EDGE-Linear TRP QUANTUM II Tx Module™ w/Quad-Band WCDMA Antenna Pass-Through | 850 / 900, DCS / PCS B1, B2, B5/6, B8 | QB EDGE PA & UMTS Antenna Switch, TRP Compliant at 4:1 | 7.0 x 7.5 x 1.1 | ***TQM6M9014**** |

*NOTES:* **** = New*** + *For a specific HSDPA transceiver variant. Contact Customer Service.*

## INTEGRATED PRODUCTS – GSM / GPRS / EDGE HANDSET

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| QB GSM / GPRS PA Module | 850 / 900, DCS / PCS | Low Band Ibatt < 1.5A @ Pcal w/ PAE 55% | 5.0 x 5.0 x 1.1 | ***TQM7M4007**** |
| QB GSM / GPRS / EDGE-Polar HADRON PA Module™ | 850 / 900, DCS / PCS | Excellent AM to PM Performance | 7.0 x 7.0 x 1.1 | TQM7M5002 |
| QB GSM / GPRS / EDGE-Linear HADRON II PA Module™ | 850 / 900, DCS / PCS | Low Band Ibatt < 1.5A @ Pcal w/ PAE 55% | 5.0 x 5.0 x 1.0 | TQM7M5005+ |
| QB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP6T | 850 / 900, DCS / PCS | Ultra Compact Size | 6.0 x 6.0 x 1.1 | TQM6M4003 |
| DB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP4T | 900, DCS | Ultra Compact Size | 6.0 x 6.0 x 1.1 | TQM6M4028E |
| DB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP4T | 850, PCS | Ultra Compact Size | 6.0 x 6.0 x 1.1 | TQM6M4028U |
| DB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP4T | 900, DCS | ULC with Limited Antenna Port ESD | 6.0 x 6.0 x 1.1 | ***TQM6M4038E**** |
| DB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP4T | 850 / 900, DCS / PCS | High Eff & Smaller Application Size | 6.0 x 6.0 x 1.1 | ***TQM6M4048**** |
| QB GSM / GPRS QUANTUM Tx Module™; PA / LPF / SP6T | 850 / 900, DCS / PCS | High Eff & Smaller Application Size | 6.0 x 6.0 x 1.1 | ***TQM6M4049**** |
| QB GSM / GPRS / EDGE-Linear QUANTUM Tx Module™; PA / LPF / SP6T | 850 / 900, DCS / PCS | World's Smallest EDGE Tx Module | 6.0 x 6.0 x 1.1 | TQM6M5001 |
| QB GSM / GPRS / EDGE-Linear TRP QUANTUM Tx Module™; PA / LPF / SP6T | 850 / 900, DCS / PCS | High GMSK Efficiency and Best TRP | 6.0 x 8.0 x 1.0 | ***TQM6M5014**** |

*NOTES:* **** = New*** + For 2.5G EDGE phones and 3G WEDGE phones.

## INTEGRATED PRODUCTS – CDMA HANDSET

| Description | Frequency Bands | Features | Package Size (mm) | Part Number |
|---|---|---|---|---|
| CDMA PA Module | Cellular | 1-Bit (Hi / Lo Power Modes) | 4.0 x 4.0 x 1.5 | TQM713019 |
| CDMA PA Module | Cellular | 1-Bit (Hi / Lo Power Modes) | 3.0 x 3.0 x 1.1 | TQM713024 |
| CDMA TRITIUM II PA-Duplexer Module™; BAL Input w/Coupler | Cellular | 1-Bit (Hi / Lo Power Modes) | 7.0 x 4.0 x 1.1 | TQM613027 |
| CDMA TRITIUM II PA-Duplexer Module™; SE Input w/Coupler | Cellular | 2-Bit (Hi / Med / Lo Power Modes) | 7.0 x 4.0 x 1.1 | ***TQM613029**** |
| CDMA TRITIUM II PA-Duplexer Module™; SE Input w/Coupler | PCS | 2-Bit (Hi / Med / Lo Power Modes) | 7.0 x 4.0 x 1.1 | ***TQM663029A**** |
| CDMA TRITIUM II PA-Duplexer Module™; SE Input w/Coupler | AWS | 2-Bit (Hi / Med / Lo Power Modes) | 7.0 x 4.0 x 1.1 | ***TQM653029**** |

*NOTES:* **** = New***

## INTEGRATED PRODUCTS – UHF RFID

| Description | Frequency (MHz) | Channels / Spacing (kHz) | Max Output Power (W) | Protocol Support | Region of Operation | Interface | Part Number |
|---|---|---|---|---|---|---|---|
| Reader PCMCIA Form Factor Module (FCC Pt 15) | 902.75 - 927.25 | 50 / 500 | 1W | ISO18000-6C | N. America | Serial TTL | WJR7000 |
| Reader PCMCIA Form Factor Module (ETSI 302.208) | 865.7 - 867.5 | 4 / 600 | 1W | ISO18000-6B & -6C | Europe | Serial TTL | ***WJR7081**** |
| PCMCIA Form Factor Module | 910.6 - 913.4 | 15 / 200 | 1W | ISO18000-6B & -6C | Korea | Serial TTL | WJR7090 |
| PCMCIA Reader Module (FCC Pt 15) | 902.75 - 927.25 | 50 / 500 | 0.5W | ISO18000-6B & -6C | N. America | PCMCIA | MPR6000 |
| PCMICA Reader Module (FCC Pt 15) w/ Int. Antenna | 902.75 - 927.25 | 50 / 500 | 0.5W | ISO18000-6B & -6C | N. America | PCMCIA | MPR5000 |
| Embedded Reader Module (FCC Pt 15) | 902.75 - 927.25 | 50 / 500 | 1W | ISO18000-6B & -6C | N. America | Serial TTL | WJM3000 |
| Embedded Reader Module (FCC Pt 15) | 902.75 - 927.25 | 50 / 500 | 0.25W | ISO18000-6B & -6C | N. America | Serial TTL | WJM1000 |

*NOTES:* **** = New***

## INTEGRATED PRODUCTS – WLAN

| Description | Frequency Range (GHz) | Pout / EVM (dBm) | Gain (dB) | PAE (%) | Voltage / Current (V / mA) | Package Style | Part Number |
|---|---|---|---|---|---|---|---|
| 802.11b/g/n PA, SP3T, Balun, PD, WLAN + BT | 2.4 - 2.5 | 17 / 2.2% | 33 | – | 3.3 / 115 | ETSLP-16 | ***TQM679002**** |
| 802.11a/b/g/n PA, SP3T, SP2T, Balun, PD, WLAN + BT | 2.4 - 2.5: 4.9 - 5.9 | 17 / 2.2%: 15 / 2.6% | 33 / 32 | – | 3.3 / 115: 3.3 / 150 | ETSLP-24 | ***TQP6M9002**** |

*NOTES:* **** = New****, PD = Power Detector*

## SAW FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| Cable IF Filter | 36.15 | 8 | 19.7 | SE / SE | 38 @ 10.23 | DIP | 855748 |
| Cable IF Filter | 44 | 6 | 20.4 | SE / SE | 38 @ 7.60 | DIP | 855079 |
| Cable IF Filter | 44 | 6 | 20.8 | SE / SE | 38 @ 7.40 | 24.6 x 9.0 | 856129 |
| CDMA IF Filter | 69.99 | 1.26 | 19 | SE / BAL | 35 @ 1.50 | DIP | 854550-1 |
| CDMA IF Filter | 69.99 | 1.26 | 17.1 | SE / SE | 25 @ 1.68 | 24.6 x 9.0 | 856199 |
| CDMA IF Filter | 70 | 1.26 | 19 | SE / BAL | 35 @ 1.50 | DIP | 854747-1 |
| BWA / WiMAX IF Filter | 70 | 8 | 12.95 | SE / SE | 35 @ 3.20 | 13.3 x 6.5 | 855677 |
| Low Loss IF Filter | 70 | 0.5 | 7.6 | SE / SE | 35 @ 1.28 | 19.0 x 6.5 | 854651 |
| Low Loss IF Filter | 70 | 1 | 7.3 | SE / SE | 40 @ 2.80 | 19.0 x 6.5 | 854652 |
| Low Loss IF Filter | 70 | 1.5 | 7.5 | SE / SE | 40 @ 3.20 | 19.0 x 6.5 | 854653 |
| Low Loss IF Filter | 70 | 2 | 7.85 | SE / SE | 40 @ 4.25 | 19.0 x 6.5 | 854654 |
| Low Loss IF Filter | 70 | 2.5 | 8.75 | SE / SE | 40 @ 4.60 | 19.0 x 6.5 | 854655 |
| Low Loss IF Filter | 70 | 3 | 6.95 | SE / SE | 35 @ 6.90 | 13.3 x 6.5 | 854656 |
| Low Loss IF Filter | 70 | 3.5 | 7.25 | SE / SE | 35 @ 7.20 | 13.3 x 6.5 | 854657 |
| Low Loss IF Filter | 70 | 4 | 6.8 | SE / SE | 40 @ 8.25 | 13.3 x 6.5 | 854658 |
| Low Loss IF Filter | 70 | 4.5 | 6.8 | SE / SE | 35 @ 8.50 | 13.3 x 6.5 | 854659 |
| Low Loss IF Filter | 70 | 5 | 7.25 | SE / SE | 40 @ 9.35 | 13.3 x 6.5 | 854660 |
| Low Loss IF Filter | 70 | 6 | 7.5 | SE / SE | 40 @ 10.20 | 13.3 x 6.5 | 854661 |
| Low Loss IF Filter | 70 | 7 | 8.5 | SE / SE | 40 @ 11.55 | 13.3 x 6.5 | 854662 |
| Low Loss IF Filter | 70 | 8 | 9 | SE / SE | 40 @ 13.25 | 13.3 x 6.5 | 854663 |
| Low Loss IF Filter | 70 | 9 | 9.75 | SE / SE | 40 @ 13.90 | 13.3 x 6.5 | 854664 |
| Low Loss IF Filter | 70 | 10 | 10 | SE / SE | 40 @ 15.00 | 13.3 x 6.5 | 854665 |
| Low Loss IF Filter | 70 | 12 | 11.5 | SE / SE | 40 @ 17.35 | 13.3 x 6.5 | 854666 |
| Low Loss IF Filter | 70 | 14 | 12.5 | SE / SE | 40 @ 19.50 | 13.3 x 6.5 | 854667 |
| Low Loss IF Filter | 70 | 16 | 12.5 | SE / SE | 40 @ 21.40 | 13.3 x 6.5 | 854668 |
| Low Loss IF Filter | 70 | 18 | 13.5 | SE / SE | 40 @ 23.40 | 13.3 x 6.5 | 854669 |
| Low Loss IF Filter | 70 | 20 | 14.5 | SE / SE | 40 @ 25.40 | 13.3 x 6.5 | 854670 |
| Low Loss IF Filter | 70 | 22 | 15 | SE / SE | 40 @ 27.25 | 13.3 x 6.5 | 854671 |
| Low Loss IF Filter | 70 | 24 | 16.25 | SE / SE | 40 @ 29.65 | 13.3 x 6.5 | 854672 |
| Low Loss IF Filter | 70 | 26 | 17 | SE / SE | 40 @ 32.00 | 13.3 x 6.5 | 854673 |
| Low Loss IF Filter | 70 | 28 | 17.6 | SE / SE | 40 @ 33.75 | 13.3 x 6.5 | 854674 |
| Low Loss IF Filter | 70 | 30 | 17.5 | SE / SE | 40 @ 37.00 | 13.3 x 6.5 | 854675 |
| Low Loss IF Filter | 70 | 36 | 20.2 | SE / SE | 40 @ 43.30 | 13.3 x 6.5 | 854678 |
| Low Loss IF Filter | 70 | 40 | 21.5 | SE / SE | 40 @ 47.25 | 13.3 x 6.5 | 854680 |
| High Selectivity IF Filter | 70 | 0.3 | 16.36 | SE / SE | 40 @ 0.90 | 24.6 x 9.0 | 855735 |
| High Selectivity IF Filter | 70 | 0.5 | 21.3 | SE / SE | 40 @ 1.63 | 24.6 x 9.0 | 855736 |
| High Selectivity IF Filter | 70 | 1 | 22.2 | SE / SE | 40 @ 2.11 | 24.6 x 9.0 | 855737 |
| High Selectivity IF Filter | 70 | 1.5 | 21.6 | SE / SE | 40 @ 2.52 | 24.6 x 9.0 | 855738 |

## SAW FILTERS (cont.)

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| High Selectivity IF Filter | 70 | 2 | 23 | SE / SE | 40 @ 3.40 | 24.6 x 9.0 | 855739 |
| High Selectivity IF Filter | 70 | 2.5 | 20.25 | SE / SE | 40 @ 4.30 | 24.6 x 9.0 | 855740 |
| High Selectivity IF Filter | 70 | 3 | 23 | SE / SE | 40 @ 4.46 | 24.6 x 9.0 | 855741 |
| High Selectivity IF Filter | 70 | 3.5 | 19 | SE / SE | 40 @ 6.00 | 15.3 x 6.5 | 855742 |
| High Selectivity IF Filter | 70 | 4 | 23 | SE / SE | 40 @ 6.00 | 19.0 x 6.5 | 855743 |
| High Selectivity IF Filter | 70 | 4.5 | 23.7 | SE / SE | 40 @ 6.64 | 19.0 x 6.5 | 855744 |
| High Selectivity IF Filter | 70 | 5.5 | 22.2 | SE / SE | 40 @ 7.84 | 19.0 x 6.5 | 855745 |
| CDMA IF Filter | 73.59 | 1.2 | 11.9 | SE / SE | 45 @ 79.58 | 19.0 x 6.5 | 856111 |
| BWA / WiMAX IF Filter | 80 | 8 | 11.7 | SE / SE | 35 @ 14.25 | 13.3 x 6.5 | 855679 |
| GSM IF Filter | 86.6 | 0.4 | 5.3 | SE / BAL | 28 @ 1.58 | 19.0 x 6.5 | 854823 |
| GSM IF Filter | 87 | 0.4 | 4.4 | BAL / BAL | 28 @ 1.59 | 19.0 x 6.5 | 855500 |
| CDMA IF Filter | 114.99 | 1.4 | 21.5 | SE / SE | 50 @ 6.00 | DIP | 854733-1 |
| CDMA IF Filter | 118.58 | 3.69 | 17.4 | SE / SE | 43 @ 123.48 | 13.3 x 6.5 | 855958 |
| GSM IF Filter | 125 | 0.4 | 5.9 | SE / SE | 20 @ 2.40 | 9.1 x 4.8 | 856444 |
| Low Loss IF Filter | 140 | 4 | 10.85 | SE / SE | 40 @ 9.10 | 13.3 x 6.5 | 854909 |
| Low Loss IF Filter | 140 | 7 | 5.5 | SE / SE | 40 @ 11.10 | 13.3 x 6.5 | 854913 |
| Low Loss IF Filter | 140 | 10 | 8.3 | SE / SE | 35 @ 15.00 | 13.3 x 6.5 | 854916 |
| Low Loss IF Filter | 140 | 10 | 11 | SE / SE | 35 @ 15.00 | 13.3 x 6.5 | 856656 |
| Low Loss IF Filter | 140 | 12 | 8.87 | SE / SE | 35 @ 21.30 | 13.3 x 6.5 | 854917 |
| Low Loss IF Filter | 140 | 15 | 11 | SE / SE | 35 @ 22.00 | 13.3 x 6.5 | 856684 |
| Low Loss IF Filter | 140 | 16 | 8.4 | SE / SE | 35 @ 22.00 | 13.3 x 6.5 | 854919 |
| Low Loss IF Filter | 140 | 18 | 9.1 | SE / SE | 40 @ 48.00 | 13.3 x 6.5 | 854920 |
| Low Loss IF Filter | 140 | 20 | 11 | SE / SE | 35 @ 24.00 | 13.3 x 6.5 | 856592 |
| Low Loss IF Filter | 140 | 24 | 11.3 | SE / SE | 35 @ 33.50 | 13.3 x 6.5 | 854923 |
| Low Loss IF Filter | 140 | 32 | 11.5 | SE / SE | 35 @ 44.00 | 13.3 x 6.5 | 854927 |
| High Selectivity IF Filter | 140 | 0.8 | 20.8 | SE / SE | 40 @ 1.93 | 19.0 x 6.5 | 856062 |
| High Selectivity IF Filter | 140 | 1.5 | 21.9 | SE / SE | 40 @ 2.71 | 19.0 x 6.5 | 856063 |
| High Selectivity IF Filter | 140 | 2 | 21.5 | SE / SE | 40 @ 3.45 | 19.0 x 6.5 | 856064 |
| High Selectivity IF Filter | 140 | 3 | 22.4 | SE / SE | 40 @ 4.86 | 19.0 x 6.5 | 856065 |
| High Selectivity IF Filter | 140 | 6 | 23 | SE / SE | 40 @ 8.34 | 13.3 x 6.5 | 856066 |
| High Selectivity IF Filter | 140 | 7 | 24.5 | SE / SE | 40 @ 9.15 | 13.3 x 6.5 | 856067 |
| High Selectivity IF Filter | 140 | 8 | 23.4 | SE / SE | 40 @ 11.28 | 13.3 x 6.5 | 856068 |
| High Selectivity IF Filter | 140 | 10 | 20.87 | SE / SE | 40 @ 13.17 | 13.3 x 6.5 | 856069 |
| High Selectivity IF Filter | 140 | 14 | 23.3 | SE / SE | 40 @ 18.26 | 13.3 x 6.5 | 856070 |
| High Selectivity IF Filter | 140 | 16 | 21.7 | SE / SE | 40 @ 20.69 | 13.3 x 6.5 | 856071 |
| High Selectivity IF Filter | 140 | 28 | 20 | SE / SE | 40 @ 37.00 | 9.0 x 7.0 | 856019 |
| High Selectivity IF Filter | 140 | 28.56 | 27.7 | SE / SE | 40 @ 44.00 | 13.3 x 6.5 | ***856817**** |
| High Selectivity IF Filter | 140 | 32 | 21.7 | SE / SE | 40 @ 40.70 | 9.0 x 7.0 | 856072 |
| High Selectivity IF Filter | 140 | 44 | 21.75 | SE / SE | 40 @ 54.10 | 9.0 x 7.0 | 856073 |
| High Selectivity IF Filter | 140 | 56 | 18.65 | SE / SE | 40 @ 75.60 | 9.0 x 7.0 | 856074 |
| High Selectivity IF Filter | 140 | 64 | 17.8 | SE / SE | 40 @ 84.00 | 9.0 x 7.0 | 856020 |
| High Selectivity IF Filter | 140 | 72 | 21 | SE / SE | 40 @ 102.00 | 9.0 x 7.0 | 856314 |
| High Selectivity IF Filter | 140 | 1.5 | 12.1 | SE and BAL | 48 @ 143.00 | 9.1 x 4.8 | 856691 |
| High Selectivity IF Filter | 140 | 3 | 13.6 | SE and BAL | 46 @ 144.00 | 9.1 x 4.8 | 856692 |
| High Selectivity IF Filter | 140 | 6 | 11 | BAL / BAL | 39 @ 147.00 | 9.1 x 4.8 | 856693 |
| High Selectivity IF Filter | 140 | 7 | 13.6 | SE and BAL | 43 @ 147.00 | 9.1 x 4.8 | 856694 |
| High Selectivity IF Filter | 140 | 10 | 10 | BAL / BAL | 41 @ 152.50 | 9.1 x 4.8 | 856695 |
| High Selectivity IF Filter | 140 | 14 | 8.5 | SE and BAL | 43 @ 155.00 | 9.1 x 4.8 | 856696 |
| High Selectivity IF Filter | 140 | 20 | 9.8 | BAL / BAL | 40 @ 158.50 | 9.1 x 4.8 | 856697 |
| High Selectivity IF Filter | 140 | 28 | 18 | SE and BAL | 42 @ 168.00 | 9.1 x 4.8 | 856698 |
| CDMA IF Filter | 141 | 1.18 | 11.7 | SE / SE | 42.5 @ 2.50 | 19.0 x 6.5 | 855395 |
| CDMA IF Filter | 150 | 1.18 | 18.6 | SE / BAL | 30 @ 4.50 | 19.0 x 6.5 | 854833-1 |
| CDMA IF Filter | 150 | 8 | 12.1 | SE / SE | 35 @ 14.25 | 13.3 x 6.5 | 855678 |
| CDMA IF Filter | 153.6 | 3.75 | 12.04 | SE / SE | 45 @ 9.80 | 13.3 x 6.5 | 856048 |
| TDSCDMA / WCDMA IF Filter | 153.6 | 15 | 10 | SE/SE | 40 @ 25.00 | 13.3 x 6.5 | ***856748**** |
| CDMA IF Filter | 160 | 1.18 | 19.5 | SE / BAL | 30 @ 4.50 | 19.0 x 6.5 | 855049 |
| GSM IF Filter | 160 | 0.2 | 3.3 | BAL / BAL | 30 @ 12.00 | 7.0 x 5.5 | 855626 |



TriQuint SEMICONDUCTOR

**SAW FILTERS** (cont.)

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| WCDMA IF Filter | 167 | 5 | 8 | SE / SE | 20 @ 11.80 | 9.1 x 4.8 | *856683** |
| CDMA IF Filter | 167.1 | 1.18 | 10.9 | SE / SE | 15 @ 2.00 | 19.0 x 6.5 | 855394 |
| CDMA IF Filter | 167.1 | 11 | 13.1 | SE / SE | 40 @ 16.00 | 13.3 x 6.5 | 855753 |
| WCDMA IF Filter | 168.5 | 20 | 8 | SE / BAL | 33 @ 190.00 | 5.0 x 5.0 | 856512 |
| WCDMA IF Filter | 168.96 | 3.84 | 11.5 | SE / SE | 30 @ 16.00 | 9.1 x 4.8 | 856320 |
| WCDMA IF Filter | 169 | 4 | 10.4 | SE / SE | 40 @ 10.00 | 9.1 x 4.8 | 855927 |
| GSM IF Filter | 170.6 | 0.18 | 5 | BAL / BAL | 40 @ 1.60 | 9.1 x 4.8 | 856706 |
| WCDMA IF Filter | 172.8 | 8.84 | 12.5 | SE / BAL | 32 @ 16.00 | 7.0 x 5.5 | 856620 |
| WCDMA IF Filter | 172.8 | 20 | 8 | SE / BAL | 30 @ 194.30 | 5.0 x 5.0 | *856802** |
| WCDMA IF Filter | 190 | 5.5 | 9.8 | SE / BAL | 30 @ 7.60 | 13.3 x 6.5 | 855529 |
| WCDMA IF Filter | 190 | 5 | 8 | SE / SE | 25 @ 9.00 | 5.0 x 5.0 | 855770 |
| GSM IF Filter | 190 | 0.2 | 4.2 | BAL / BAL | 30 @ 12.00 | 7.0 x 5.5 | 855625 |
| WCDMA IF Filter | 190 | 3.84 | 10 | SE / SE | 30 @ 7.75 | 7.0 x 5.5 | 856386 |
| GSM IF Filter | 199 | 0.2 | 5.4 | SE / SE | 20 @ 1.20 | 9.0 x 7.0 | *856730** |
| GSM IF Filter | 199 | 0.2 | 6 | SE / SE | 45 @ 1.60 | 19.0 x 6.5 | 855131 |
| GSM IF Filter | 199 | 0.5 | 6.8 | SE / SE | 30 @ 47.00 | 13.3 x 6.5 | 855780 |
| GSM IF Filter | 201 | 0.22 | 6.1 | BAL / BAL | 27 @ 0.80 | 13.3 x 6.5 | 856541 |
| Cable IF Filter | 202.75 | 1.2 | 6.6 | SE / SE | 40 @ 10.00 | 13.3 x 6.5 | 855068 |
| GSM IF Filter | 208 | 0.4 | 5.9 | SE / SE | 20 @ 2.40 | 9.1 x 4.8 | 856445 |
| WCDMA IF Filter | 208 | 3.84 | 11.5 | BAL / BAL | 17 @ 5.03 | 9.1 x 4.8 | 856496 |
| GSM IF Filter | 211 | 0.2 | 5.2 | SE / SE | 25 @ 0.80 | 13.3 x 6.5 | 856378 |
| WCDMA IF Filter | 219 | 20 | 9.6 | BAL / BAL | 35 @ 36.00 | 9.0 x 7.0 | *856795** |
| WCDMA IF Filter | 230 | 4 | 16.2 | SE / SE | 40 @ 10.00 | 13.3 x 6.5 | 855832 |
| CDMA IF Filter | 240 | 3.6 | 14.3 | SE / SE | 12 @ 5.00 | 13.3 x 6.5 | 855992 |
| CDMA IF Filter | 240 | 1.1 | 13 | SE / SE | 10 @ 1.80 | 19.0 x 6.5 | 856151 |
| BWA / WiMAX IF Filter | 240 | 2 | 9.8 | SE / BAL | 45 @ 10.50 | 7.0 x 5.5 | 855091 |
| BWA / WiMAX IF Filter | 240 | 10 | 11 | SE / BAL | 40 @ 35.00 | 7.0 x 5.5 | 855092 |
| CDMA IF Filter | 249.6 | 3.84 | 16.11 | SE / SE | 40 @ 11.00 | 7.0 x 5.5 | 855915 |
| BWA / WiMAX IF Filter | 280 | 34 | 8.2 | BAL / BAL | 45 @ 15.00 | 7.0 x 5.5 | 855393 |
| BWA / WiMAX IF Filter | 280 | 17 | 8.95 | SE / BAL | 38 @ 60.00 | 5.0 x 5.0 | 855975 |
| GPS IF Filter | 298.75 | 2.4 | 8.35 | BAL / BAL | 50 @ 20.00 | 7.0 x 5.5 | 856305 |
| BWA / WiMAX IF Filter | 325 | 10 | 9.6 | BAL / BAL | 40 @ 35.00 | 7.0 x 5.5 | 855094 |
| CDMA IF Filter | 326.4 | 15 | 12.61 | SE / SE | 40 @ 25.00 | 7.0 x 5.5 | 855914 |
| BWA / WiMAX IF Filter | 330 | 5.45 | 18.26 | SE / SE | 50 @ 13.60 | 15.3 x 6.5 | 855730 |
| BWA / WiMAX IF Filter | 350 | 2.4 | 13.1 | SE / BAL | 35 @ 12.00 | 7.0 x 5.5 | 855398 |
| BWA / WiMAX IF Filter | 350 | 1.7 | 13.7 | SE / BAL | 45 @ 6.00 | 13.3 x 6.5 | 855399 |
| BWA / WiMAX IF Filter | 350 | 1 | 8.2 | SE / BAL | 45 @ 15.00 | 7.0 x 5.5 | 855377 |
| WCDMA IF Filter | 358.4 | 19.2 | 10.1 | BAL / BAL | 40 @ 61.40 | 7.0 x 5.5 | *856771** |
| WLAN IF Filter | 374 | 17 | 8.5 | SE / BAL | 10 @ 33.00 | 7.0 x 5.5 | 855653 |
| WLAN IF Filter | 374 | 17 | 8.5 | SE / BAL | 35 @ 33.00 | 5.0 x 5.0 | 855898 |
| WLAN IF Filter | 374 | 17 | 9 | SE / BAL | 30 @ 33.00 | 3.8 x 3.8 | 856278 |
| BWA / WiMAX IF Filter | 374 | 10 | 9 | BAL / BAL | 10 @ 25.00 | 3.8 x 3.8 | 856466 |
| Low Loss IF Filter | 374 | 17 | 9 | SE / BAL | 36 @ 357.00 | 3.8 x 3.8 | 856438 |
| WCDMA IF Filter | 380 | 5.4 | 15.4 | SE / BAL | 30 @ 8.30 | 13.3 x 6.5 | 855530 |
| WCDMA IF Filter | 380 | 3.84 | 12 | SE / SE | 30 @ 8.30 | 9.1 x 4.8 | 856392 |
| BWA / WiMAX IF Filter | 380 | 13.75 | 9.4 | SE / SE | 40 @ 367.00 | 7.0 x 5.5 | 856272 |
| General Purpose IF Filter | 380 | 3.75 | 10 | SE / SE | 35 @ 8.00 | 7.0 x 5.5 | 856279 |
| BWA / WiMAX IF Filter | 380 | 3.75 | 11 | BAL / BAL | 30 @ 8.30 | 7.0 x 5.5 | 856464 |
| BWA/WiMAX IF Filter | 380 | 7 | 10 | BAL / BAL | 40 @ 20.00 | 7.0 x 5.5 | 856490 |
| BWA / WiMAX IF Filter | 380 | 10 | 8.7 | BAL / BAL | 40 @ 36.00 | 7.0 x 5.5 | 856631 |
| WCDMA IF Filter | 398 | 4.3 | 9.9 | SE / SE | 50 @ 36.00 | 9.1 x 4.8 | 855561 |
| WCDMA / WiMAX IF Filter | 398 | 15 | 7.5 | SE / SE | 30 @ 60.00 | 9.1 x 4.8 | 855559 |
| WCDMA IF Filter | 398 | 35 | 12 | SE / SE | 50 @ 368.00 | 9.1 x 4.8 | 856097 |
| BWA / WiMAX IF Filter | 398 | 10 | 11.2 | BAL / BAL | 35 @ 388.50 | 5.0 x 5.0 | 856652 |
| BWA / WiMAX IF Filter | 426 | 5.16 | 18.02 | SE / SE | 50 @ 14.00 | 13.3 x 6.5 | 855731 |
| BWA / WiMAX IF Filter | 456 | 3.5 | 9.1 | BAL / BAL | 40 @ 6.70 | 7.0 x 5.5 | 856494 |
| BWA / WiMAX IF Filter | 456 | 7 | 12 | BAL / BAL | 33 @ 449.30 | 7.0 x 5.5 | 856498 |

**SAW FILTERS** (cont.)

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| WiBRO IF Filter | 456 | 8.75 | 7.9 | BAL / BAL | 36 @ 443.25 | 5.0 x 5.0 | 856549 |
| BWA / WiMAX IF Filter | 456 | 10 | 8.3 | BAL / BAL | 37 @ 440.00 | 7.0 x 5.5 | 856672 |
| BWA / WiMAX IF Filter | 456 | 10 | 8.3 | BAL / BAL | 37 @ 440.00 | 5.0 x 5.0 | 856638 |
| WCDMA IF Filter | 456 | 19 | 10 | BAL / BAL | 40 @ 61.40 | 7.0 x 5.5 | *856687** |
| General Purpose IF Filter | 460 | 3.75 | 11.1 | SE / SE | 35 @ 8.00 | 7.0 x 5.5 | 856282 |
| BWA / WiMAX IF Filter | 464 | 3.5 | 10.6 | BAL / BAL | 53 @ 417.00 | 7.0 x 5.5 | 856623 |
| WLAN IF Filter | 465 | 17 | 11.9 | SE / BAL | 40 @ 50.00 | 5.0 x 5.0 | 855991 |
| FRS RF or GPS IF filter | 465 | 6 | 1.43 | SE / SE | 40 @ 445.00 | 3.0 x 3.0 | 856288 |
| BWA / WiMAX IF Filter | 467 | 7 | 3 | SE / SE | 65 @ 438.00 | 3.8 x 3.8 | 856660 |
| BWA / WiMAX IF Filter | 479.75 | 9 | 19.5 | SE / SE | 35 @ 22.00 | 7.0 x 5.5 | 855271 |
| BWA / WiMAX IF Filter | 479.75 | 23 | 9.8 | BAL / BAL | 35 @ 36.00 | 7.0 x 5.5 | 855272 |
| BWA / WiMAX IF Filter | 468 | 7 | 13 | SE / SE | 70 @ 305.00 | 7.0 x 5.5 | 856624 |
| Cable IF Filter | 499.25 | 1 | 7 | SE / SE | 35 @ 6.00 | 9.0 x 7.0 | 855104 |
| BWA / WiMAX IF Filter | 580 | 10 | 10.7 | BAL / BAL | 40 @ 36.00 | 5.0 x 5.0 | 856665 |
| RF Filter, 700 MHz Band | 751.5 | 11 | 1.5 | SE / SE | 40 @ 776.00 | 3.0 x 3.0 | *856794** |
| WLAN IF Filter | 770 | 17 | 3 | BAL / BAL | 32.5 @ 750.00 | 5.0 x 5.0 | 855942 |
| RF Filter, 700 MHz Band | 781.5 | 11 | 1.5 | SE / SE | 38 @ 757.00 | 3.0 x 3.0 | *856764** |
| BWA / WiMAX IF Filter | 810 | 5 | 4.6 | SE / SE | 10 @ 26.00 | 3.0 x 3.0 | 856534 |
| BWA / WiMAX IF Filter | 810 | 10 | 3.5 | SE / SE | 10 @ 31.00 | 3.0 x 3.0 | 856526 |
| RF Filter, Cell Band | 836.5 | 25 | 2.7 | SE / SE | 28 @ 869.00 | 3.0 x 3.0 | 855729 |
| RF Filter, Cell Band | 836.5 | 25 | 2.0 | SE / SE | 10 @ 869.00 | 3.0 x 3.0 | *856704** |
| RF Filter, Cell Band | 836.5 | 25 | 1.8 | SE / SE | 30 @ 869.00 | 3.0 x 3.0 | 855779 |
| RF Filter, Cell Band | 836.5 | 25 | 1.9 | SE / SE | 35 @ 869.00 | 3.0 x 3.0 | 855821 |
| Duplexer, Cell Band | 836.5 / 881.5 | 25 / 25 | 1.9 / 1.9 | SE / SE | – | 3.8 x 3.8 | 856356 |
| GSM850 Rx Filter - Auto Qualified | 881.5 | 25 | 1.6 | SE / BAL | 40 @ 836.5 | 1.4 x 1.2 | *856522** |
| RF Filter, Cell Band | 881.5 | 25 | 2.7 | SE / SE | 40 @ 849.00 | 3.0 x 3.0 | 855728 |
| RF Filter, Cell Band | 881.5 | 25 | 1.8 | SE / SE | 35 @ 849.00 | 3.0 x 3.0 | 855782 |
| Single Rx Filter | 881.5 | 25 | 1.6 | SE / BAL | – | 1.4 x 1.2 | 856522 |
| CDMA 2-in-1 Rx Filter | 881.5 / 1960 | 25 / 60 | 1.6 / 2.2 | SE / BAL | – | 2.0 x 1.5 | 856565 |
| Cell Band Delay Filter, 450 ns | 881.5 | 25 | 25 | SE / BAL | N/A | 7.0 x 5.5 | 856716 |
| RF Filter, EGSM | 897.5 | 35 | 1.5 | SE / SE | 15 @ 930.00 | 3.0 x 3.0 | 856657 |
| RF Filter, EGSM | 897.5 | 35 | 1.9 | SE / SE | 14 @ 930.00 | 3.0 x 3.0 | 856671 |
| ISM 915 Band RF Filter | 915 | 26 | 2.3 | SE / SE | 35 @ 882.50 | 2.0 x 1.5 | 856327 |
| ISM 915 Band RF Filter | 915 | 4.4 | 2.4 | SE / SE | 55 @ 849.00 | 3.0 x 3.0 | 856686 |
| RF Filter, EGSM | 942.5 | 35 | 2 | SE / SE | 5 @ 915.00 | 3.0 x 3.0 | 855820 |
| RF Filter, EGSM | 942.5 | 35 | 3.2 | SE / SE | 12 @ 915.00 | 3.0 x 3.0 | 855810 |
| RF Filter, EGSM | 942.5 | 35 | 2.5 | SE / SE | 25 @ 915.00 | 3.0 x 3.0 | 856528 |
| GSM Band Delay Filter, 450 ns | 942.5 | 35 | 25.5 | SE / SE | N/A | 7.0 x 5.5 | *856766** |
| Tuner IF Filter | 1086 | 10 | 4 | BAL / BAL | 40 @ 1046.00 | 3.0 x 3.0 | 855964 |
| Tuner IF Filter | 1086 | 10 | 4 | BAL / BAL | 40 @ 1046.00 | 3.0 x 3.0 | 856330 |
| Tuner IF Filter | 1090 | 10 | 5 | BAL / BAL | 50 @ 1050.00 | 3.8 x 3.8 | 856096 |
| WLAN IF Filter | 1150 | 16 | 4.4 | BAL / BAL | 20 @ 1170.00 | 3.0 x 3.0 | 856256 |
| GPS L5 RF Filter | 1176 | 20 | 2.4 | SE / SE | 20 @ 1226.00 | 2.0 x 1.5 | 856440 |
| Tuner IF Filter | 1216 | 8 | 3.75 | BAL / BAL | 12 @ 24.00 | 3.0 x 3.0 | 856365 |
| Tuner IF Filter | 1220 | 10 | 4.5 | BAL / BAL | 30 @ 60.00 | 3.0 x 3.0 | 856298 |
| Tuner IF Filter | 1220 | 50 | 3.9 | BAL / BAL | 33 @ 96.00 | 3.8 x 3.8 | 856598 |
| GPS L2 RF Filter | 1227.6 | 20 | 1.1 | SE / SE | 27 @ 1152.00 | 2.0 x 1.5 | 856700 |
| Tuner IF Filter | 1250 | 96 | 6 | BAL / BAL | 44 @ 1152.00 | 3.0 x 3.0 | 856653 |
| GPS RF Filter | 1575.42 | 2 | 1.3 | SE / SE | 30 @ 1625.00 | 3.0 x 3.0 | 855969 |
| GPS RF Filter | 1575.42 | 2 | 1.25 | SE / SE | 30 @ 1624.00 | 2.0 x 1.5 | 856584 |
| GPS RF Filter | 1575.42 | 2 | 1.1 | SE / SE | 20 @ 1628.00 | 2.5 x 2.0 | 856042 |
| GPS RF Filter | 1575.42 | 2 | 2.5 | SE / SE | 30 @ 1625.00 | 2.5 x 2.0 | 856049 |
| GPS RF Filter | 1575.42 | 2 | 0.75 | SE / SE | 35 @ 1635.00 | 1.4 x 1.2 | 856561 |
| GPS RF Filter | 1575.42 | 2 | 1.1 | SE / BAL | 20 @ 1635.00 | 1.4 x 1.2 | 856576 |
| GPS RF Filter | 1575.42 | 2 | 0.53 | SE / SE | 16.5 @ 1700.00 | 2.0 x 1.5 | 856326 |
| GPS RF Filter | 1575.42 | 2 | 1 | SE / SE | 27 @ 800.00 | 1.5 x 1.5 | 856463 |
| GPS RF Filter | 1575.42 | 2 | 0.5 | SE / SE | 20 @ Cell Bands | 1.4 x 1.2 | *856756** |

## SAW FILTERS (cont.)

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| GPS RF Filter | 1575.42 | 2 | 0.7 | SE / SE | 27 @ 1700.00 | 1.5 x 1.5 | 856398 |
| GPS RF Filter | 1575.42 | 2 | 0.6 | SE / SE | 21 @ Cell Bands | 1.4 x 1.2 | *856793** |
| GPS RF Filter, Auto | 1575.42 | 2 | 1.8 | SE / SE | 45 @ 1637.00 | 3.0 x 3.0 | 856039 |
| GPS RF Filter, Auto | 1575.42 | 2 | 1.3 | SE / SE | 45 @ 1640.00 | 3.0 x 3.0 | 856139 |
| RF Filter, DCS | 1747.5 | 75 | 2 | SE / SE | 22 @ 1676.00 | 3.0 x 3.0 | 856654 |
| RF Filter, DCS | 1842.5 | 75 | 1.9 | SE / SE | 10 @ 1785.00 | 3.0 x 3.0 | 855860 |
| RF Filter, PCS (Split Band) | 1880 | 30 | 2.0 | SE / SE | 35 @ 1930.00 | 3.0 x 3.0 | 855833 |
| RF Filter, PCS | 1880 | 60 | 2.2 | SE / SE | 15 @ 1806.00 | 3.0 x 3.0 | *856705** |
| RF Filter, PCS | 1880 | 60 | 2.4 | SE / SE | 7 @ 1930.00 | 3.0 x 3.0 | 855849 |
| RF Filter, PCS | 1880 | 60 | 2.8 | SE / SE | 30 @ 1930.00 | 3.0 x 3.0 | 856530 |
| Tuner IF Filter | 1892 | 8 | 4.2 | BAL / BAL | 23 @ 1932.00 | 2.5 x 2.0 | 856236 |
| RF Filter, UMTS | 1950 | 60 | 1.8 | SE / SE | 20 @ 2100.00 | 3.0 x 3.0 | *856678** |
| RF Filter, UMTS | 1950 | 60 | 2.2 | SE / SE | 40 @ 2110.00 | 3.0 x 3.0 | 856532 |
| GSM1900 Rx Filter - Auto Qualified | 1960 | 60 | 1.5 | SE / BAL | 17 @ 1880.00 | 1.4 x 1.2 | *856577** |
| RF Filter, PCS | 1960 | 60 | 2.1 | SE / SE | 10.3 @ 1910.00 | 3.0 x 3.0 | 855817 |
| RF Filter, PCS | 1960 | 60 | 2.3 | SE / SE | 8 @ 1910.00 | 3.0 x 3.0 | 855850 |
| RF Filter, PCS | 1960 | 60 | 2.9 | SE / SE | 15 @ 1910.00 | 3.0 x 3.0 | 855859 |
| RF Filter, PCS | 1960 | 60 | 2.25 | SE / SE | 14 @ 1910.00 | 3.0 x 3.0 | 856531 |
| Delay Filter, PCS 450 ns | 1960 | 60 | 25 | SE / BAL | N/A | 7.0 x 5.5 | 856717 |
| Delay Filter, UMTS 450 ns | 2140 | 60 | 25 | SE / BAL | N/A | 7.0 x 5.5 | 856649 |
| RF Filter, UMTS | 2140 | 60 | 2.3 | SE / SE | 25 @ 1980.00 | 3.0 x 3.0 | *856738** |
| Bluetooth RF Filter | 2441 | 83.5 | 2.8 | SE / SE | 26 @ 2200.00 | 3.0 x 3.0 | 855916 |
| Bluetooth RF Filter | 2441 | 83.5 | 2.5 | SE / SE | 20 @ 2300.00 | 1.5 x 1.5 | 856486 |
| Bluetooth RF Filter | 2441 | 83.5 | 2.7 | SE / BAL | 35 @ 2250.00 | 1.5 x 1.5 | 856435 |
| Bluetooth RF Filter | 2441 | 83.5 | 2 | SE / SE | 28 @ 2300.00 | 1.4 x 1.2 | 856539 |
| Bluetooth RF Filter | 2441 | 83.5 | 2.7 | SE / BAL | 39 @ 2250.00 | 1.4 x 1.2 | 856548 |
| Bluetooth & GPS Filter | 2441 / 1575.42 | 83.5 / 2 | 2 / 1.2 | SE / SE | – | 2.0 x 1.5 | 856646 |

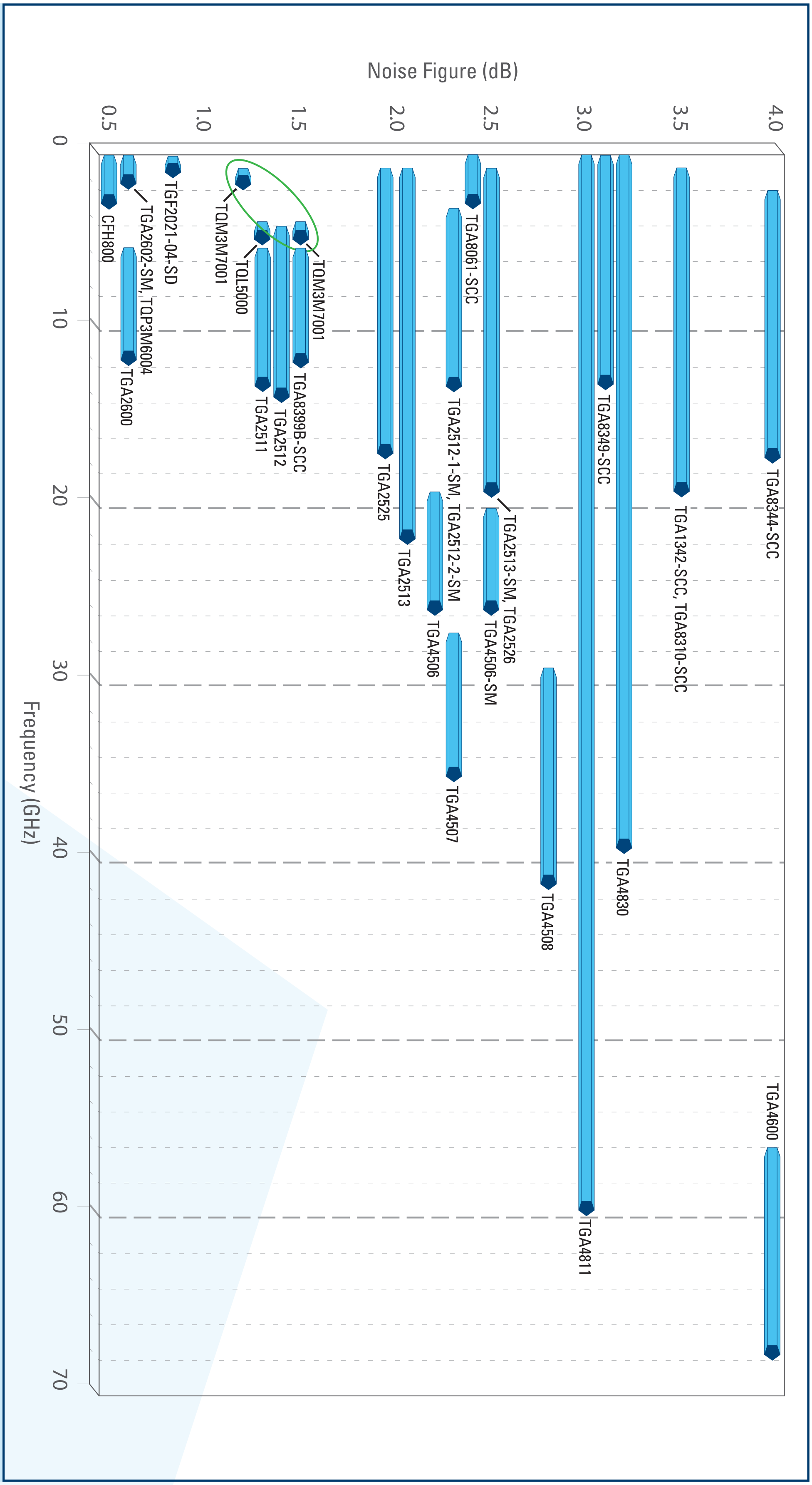
*Notes:* ***** = New**

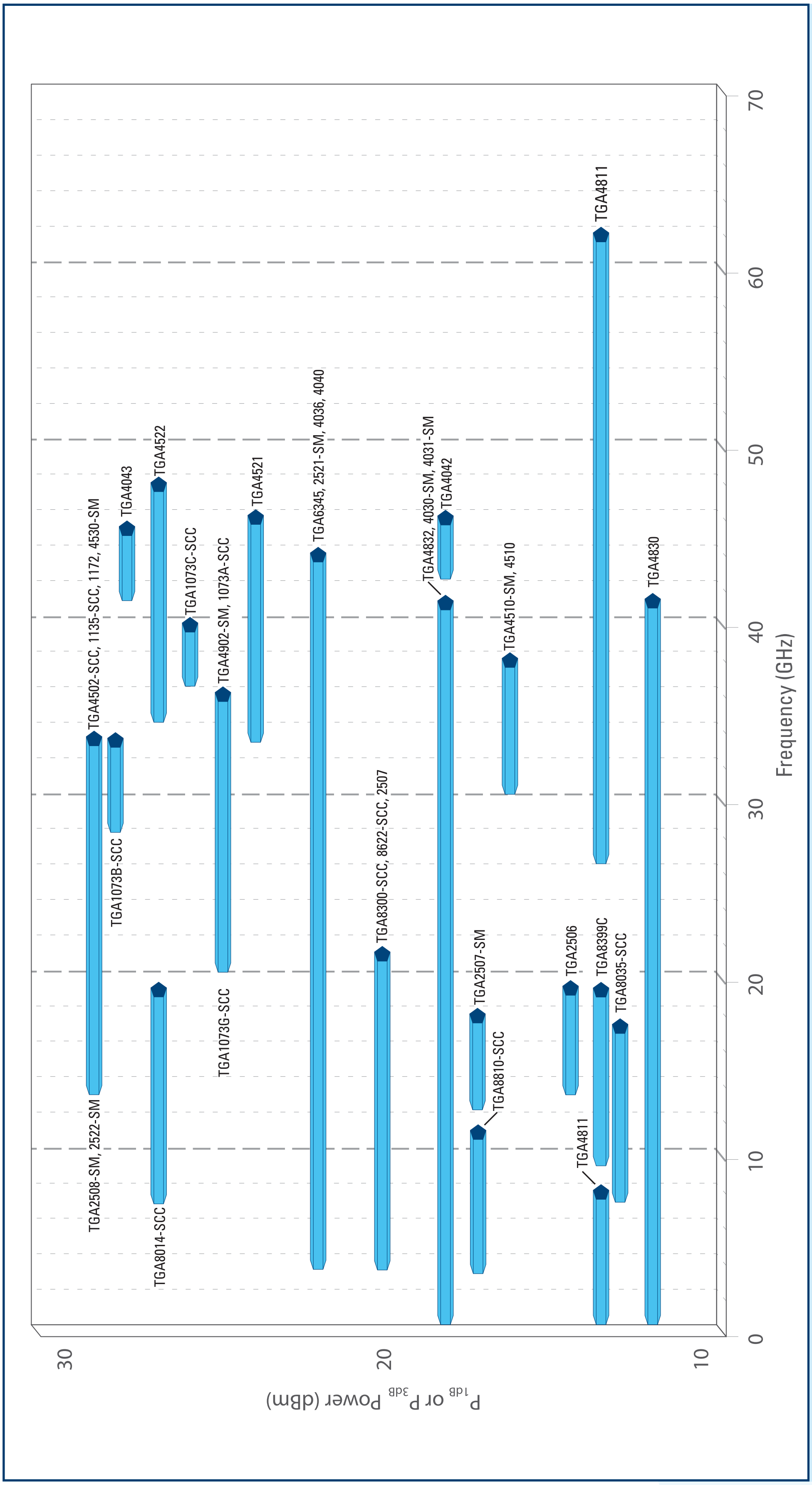
## BAW FILTERS

| Description | Frequency (MHz) | Bandwidth (MHz) | Typical IL (dB) | I / O Configuration | Rejection [dB @ BW or Freq (MHz)] | Package Size (mm) | Part Number |
|---|---|---|---|---|---|---|---|
| RF Filter | 710 | 20 | 2 | SE / SE | 50 @ 140.00 | 3.81 x 2.54 | 880370 |
| RF Filter, ISM | 915 | 15 | 3.5 | SE / SE | 40 @ 35.00 | 6.35 x 4.57 | 880371 |
| RF Filter | 1030 | 15 | 2.5 | SE / SE | 40 @ 45.00 | 3.81 x 2.54 | 880367 |
| RF Filter | 1090 | 15 | 2.5 | SE / SE | 40 @ 45.00 | 3.81 x 2.54 | 880374 |
| GPS RF Filter, L5 | 1176 | 28 | 2.75 | SE / SE | 40 @ 140.00 | 3.26 x 1.60 | 880364 |
| GPS RF Filter, L2 | 1227 | 30 | 2.75 | SE / SE | 40 @ 140.00 | 3.26 x 1.60 | 880272 |
| GPS RF Filter, L2 | 1227 | 15 | 1.5 | SE / SE | 40 @ 250.00 | 3.26 x 1.60 | 880366 |
| GPS RF Filter, L2 | 1227 | 15 | 3 | SE / SE | 40 @ 45.00 | 3.81 x 2.54 | 880372 |
| RF Filter | 1280 | 20 | 3 | SE / SE | 40 @ 105.00 | 3.81 x 2.54 | 880368 |
| GPS RF Filter, L3 / L4 | 1380 | 30 | 3 | SE / SE | 40 @ 160.00 | 3.26 x 1.60 | 880365 |
| GPS RF Filter, L1 | 1575 | 30 | 3 | SE / SE | 40 @ 160.00 | 3.26 x 1.60 | 880273 |
| GPS RF Filter, L1 | 1575 | 18 | 1.5 | SE / SE | 40 @ 350.00 | 3.26 x 1.60 | 880085 |
| GPS RF Filter, L1 | 1575 | 25 | 3 | SE / SE | 40 @ 60.00 | 3.81 x 2.54 | 880373 |
| RF Filter | 2324 | 38 | 3 | SE / SE | 40 @ 150.00 | 3.81 x 2.54 | 880148 |
| WCS Passband RF Filter | 2332.5 | 55 | 3 | SE / SE | 10 @ 2300.00 & 2370.00 | 1.70 x 1.30 | 885002 |
| SDARS Notch RF Filter | 2332.5 | 55 | 1.5 (Out of Band IL) | SE / SE | 17 @ 2332.50 (Notch Rej) | 1.70 x 1.30 | 885003 |
| ISM Passband Filter | 2436 | 72 | 2 | SE / SE | 20 @ 2495 | 1.70 x 1.30 | *885007** |
| ISM Notch RF Filter | 2440 | 72 | 1.5 (Out of Band IL) | SE / SE | 25 @ 2440 | 1.70 x 1.30 | *885008** |
| ISM Notch RF Filter | 2440 | 85 | 2 (Out of Band IL) | SE / SE | 18 @ 2440 (Notch Rej) | 1.70 x 1.30 | *885010** |
| RF Filter, MMDS | 2560 | 30 | 3 | SE / SE | 40 @ 150.00 | 3.81 x 2.54 | 880157 |
| RF Filter, ISM | 5775 | 100 | 4.5 | SE / SE | 20 @ 350.00 | 3.26 x 1.60 | 880369 |

*Notes:* ***** = New**

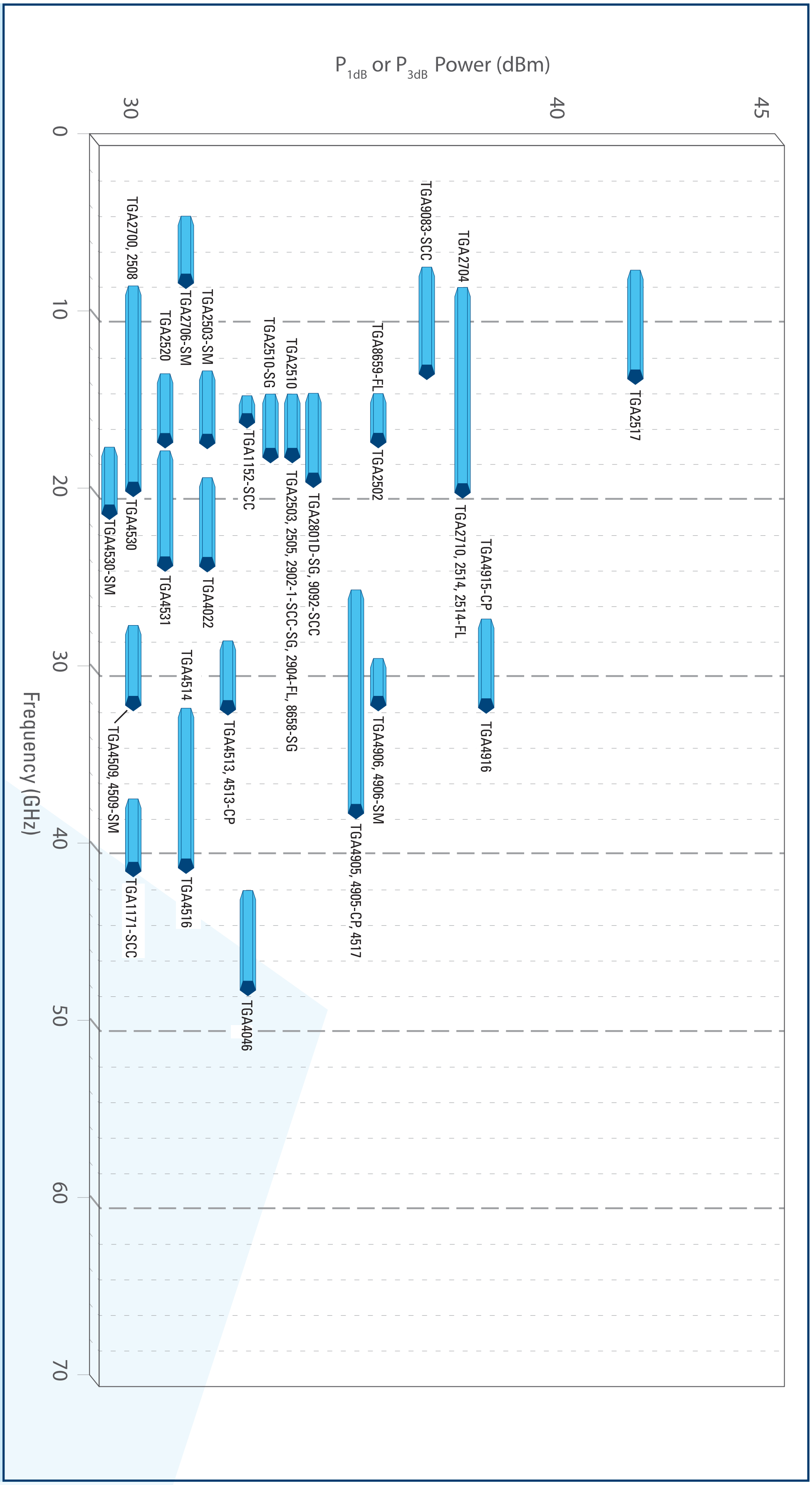
*LNA Noise Figure vs. Frequency*






*Less Than 1W Amplifiers, Power vs. Frequency*

More Than 1W Amplifiers, Power vs. Frequency



## PACKAGING

For detailed information on TriQuint product packaging, please visit our website at **www.triquint.com/prodserv**

## ORDERING

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- ***Distributors / Resellers:***
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- ***Product Data Sheets and Literature:***
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- ***Applications Support:***
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## QUALITY POLICY

The people of TriQuint Semiconductor are committed to continuous improvement, quality, reliability and customer satisfaction in everything we do.

## QUALITY SYSTEMS

- ISO-9001:2000 Certified (Select Sites)
- ISO / TS 16949:2002 Certified (Select Sites)
- ISO / AS9100 Certified (Select Sites)

## QUALITY TOOLS UTILIZED

- Design Failure Mode & Effects Analysis (DFMEA)
- Process Failure Mode & Effects Analysis (PFMEA)
- Process Control Plan (PCP)
- Production Part Approval Process (PPAP)
- Eight Discipline Problem Solving (8-D)
- Real Time Statistical Process Control (SPC)

For further details on TriQuint quality information, please visit our website at **www.triquint.com/company/quality**

## RELIABILITY PROGRAMS

Our programs are in line with JEDEC and other industry standards.

## ENVIRONMENTAL POLICY

TriQuint Semiconductor is committed to managing environmental matters as an integral part of our business, complying with all applicable laws, regulations and other requirements, preventing pollution and continually improving.

## ENVIRONMENTAL SYSTEMS

- ISO-14001:2004 (Select Sites)

## PRODUCT COMPLIANCE POLICIES

TriQuint is committed to meeting all global product environmental regulations that affect its products. These regulations include:

- Directive 2002 / 95 / EC (RoHS Directive)
- Management Methods for Control of Pollution Caused by Electronic Information Products (China RoHS)
- Directive 94 / 62 / EC (Packaging Directive)
- Directive 2006 / 122 / EC (PFOS Directive)
- Regulation (EC) No 1907 / 2006 (REACH Regulation)

All active TriQuint commercial standard products are compliant with these Directives. Contact TriQuint for the RoHS Compliance status of custom products, military products and products manufactured prior to June 2006. All new product designs are halogen-free since late 2008. TriQuint does not use any REACH Substances of Very High Concern (SVHCs) in its products or packaging materials.

Contact TriQuint at **rohs_info@tqs.com** for any product compliance information requests.

In addition to being compliant with RoHS, TriQuint participates in the following customer programs:

- Sony Green Partner
- Samsung Eco-partner

For further details on TriQuint Environmental, Health & Safety information, please visit our website at **www.triquint.com/company/ehs**

## NOTICE

The data provided in this selection guide is subject to change without notice. TriQuint reserves the right to make changes to specifications and other information at any time.

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**Visit www.triquint.com/rf and register for TriQuint product & process updates.**

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