Vol. 52 • No. 9

September 2009

# Microwave Journal

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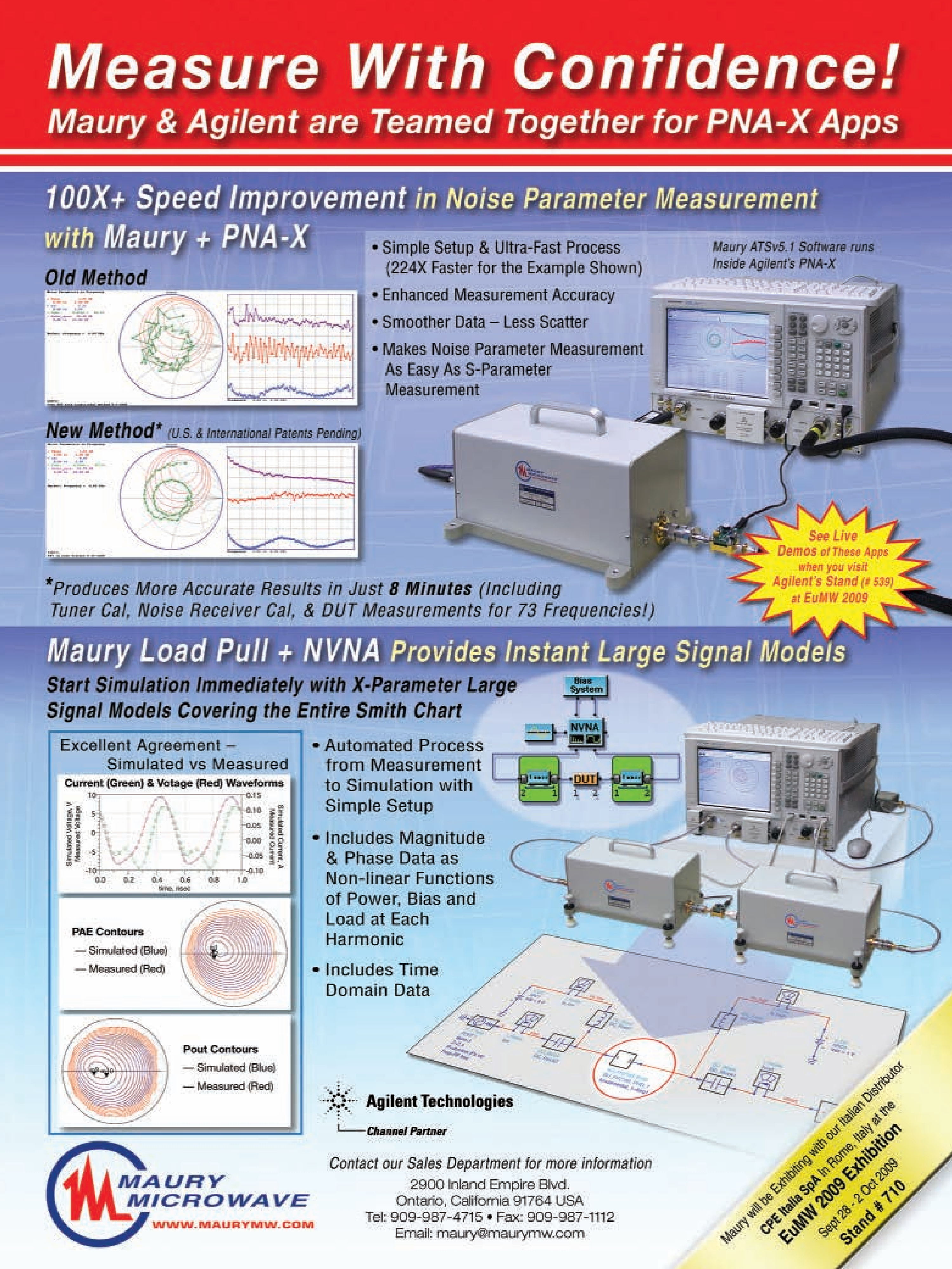
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# Microwave Journal

**SEPTEMBER 2009 VOL. 52 • NO. 9**


## EUROPEAN MICROWAVE WEEK 2009



## SPECIAL REPORT



## APPLICATION NOTE




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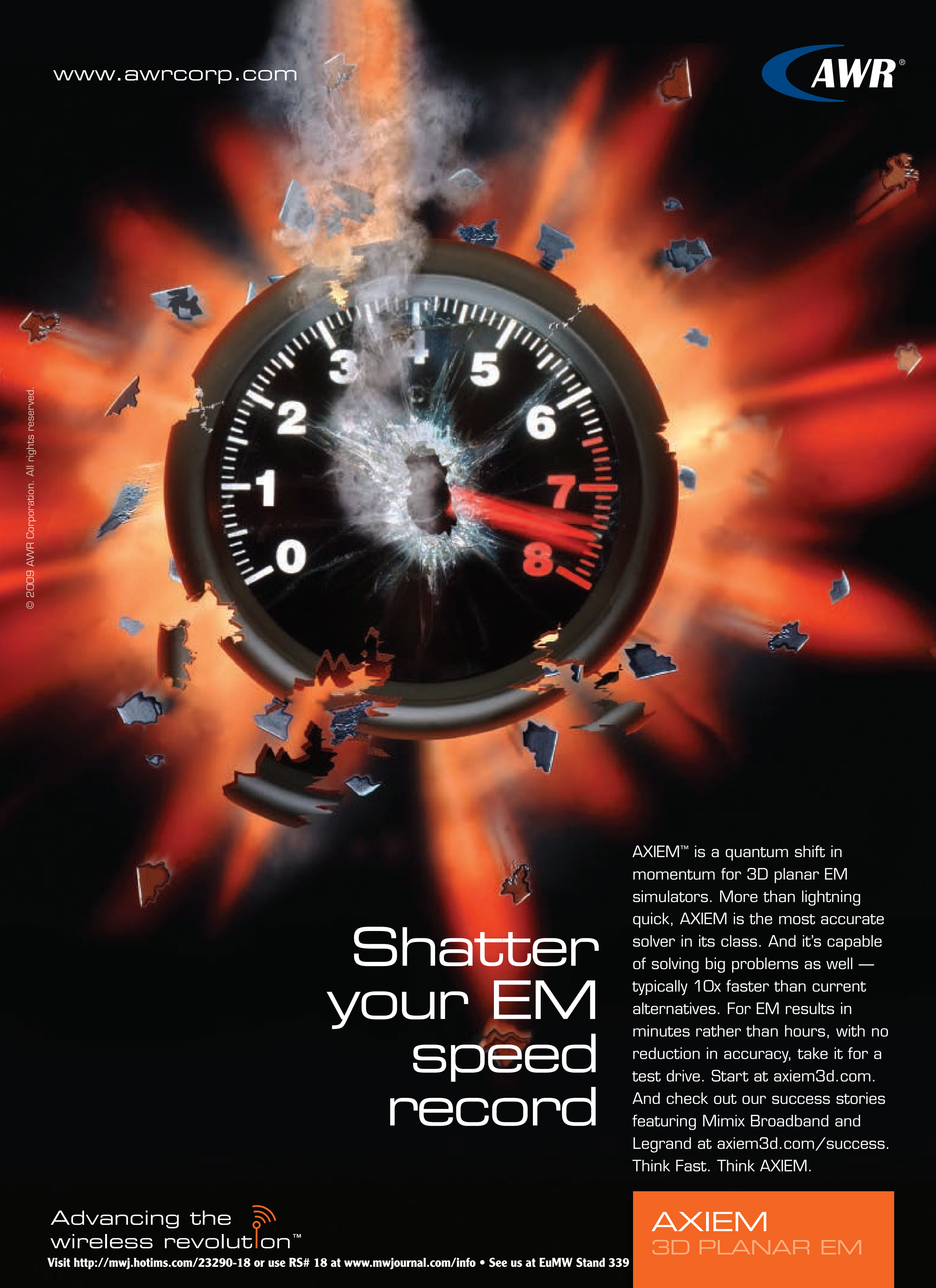
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## Online Technical Papers

**Solutions for Generating X-parameters from Circuit-level Designs**
*White Paper, Agilent Technologies*

**Advances in S-band Radar Technology**
*Brian Battaglia, Jeff Burger and John Titizian, Integra Technologies Inc.*

**Understanding Long Term Evolution Fundamentals and Measurement Challenges**
*White Paper, Rohde & Schwarz*

**Solutions for PCB Electromagnetic Interference**
*Dr. Steven G. Pytel Jr., Ansoft LLC*

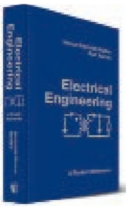
**A Comparison Between Thin Film and Thick Film Capacitors**
*Ron Demcko, AVX*

## Executive Interview

*Microwave Journal* talks with **Mini-Circuits** Founder and President, **Harvey Kaylie**, about the company's history, its formula for success and his take on where the microwave industry is headed in the near-future.

## Expert Advice

X-parameters are poised to re-define how the industry characterizes nonlinear RF/microwave devices and shares design IP. One of the thought-leaders behind this new technology, **Dr. David Root** of **Agilent Technologies**, explains how X-parameters will change the way you work.

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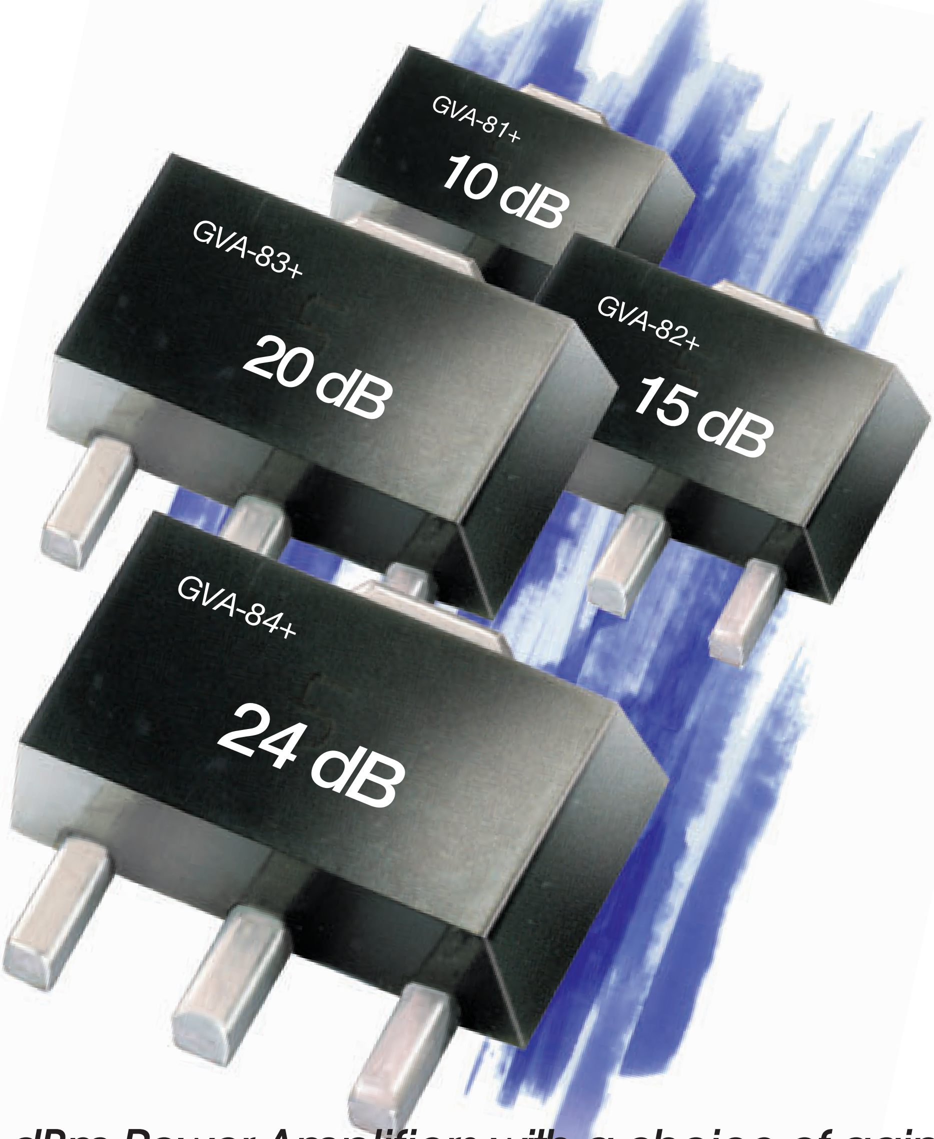
## EuMW Coverage

MWJ Online Show Daily reports directly from the **EuMW 2009 Exhibition**. Keep up to date on the latest product announcements and industry news items along with conference exclusives, editor blogs and more. Visit www.mwjournal.com/eumw2009 from **21 September** through **9 October**.

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*US patent 6,943,629 *Low frequency determined by coupling cap.*

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# OCTOBER 2009

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|---|---|---|---|---|---|
| 27 MICROWAVE JOURNAL OSD ONLINE SHOW DAILY | 28 *For complete coverage of EuMW 2009, visit www.mwjournal.com/eumw2009 from 21 September–9 October.* | 29 | 30 | 1 | 2 | 3 |
| 4 | 5 | 6 **RF & Hyper 2009** Paris, France (6–9)<br>**Worldwide EW Infrastructure Conference** Atlanta, GA (6–9) | 7 CST **CST Asian User Group Meeting Series** Visit www.cst.com | 8 **COMSOL Conference 2009** Boston, MA (8–10)<br>WAMICON **WAMICON 2010 Call for Papers** Deadline: October 8, 2009 | 9 | 10 |
| 11 **CSICS 2009 IEEE Compound Semiconductor Integrated Circuit Symposium** Greensboro, NC (11–14) | 12 **International Radar Conference** Bordeaux, France (12–16) | 13 Agilent Technologies **Agilent Custom Webinar**<br>ANSOFT **Ansoft Product Training HFSS for SI** Irvine, CA (13–14) | 14 | 15 | 16 | 17 |
| 18 **MILCOM** Boston, MA (18–21) | 19 **EPEPS 2009 18th Conference on Electrical Performance of Electronic Packaging and Systems** Portland, OR (19–21) | 20 Besser Associates The Worldwide Leader in RF & Wireless Training **MWJ/Besser Webinar: RF System Design** | 21 | 22 CST **CST Custom Webinar** | 23 | 24 |
| 25 | 26 | 27 | 28 | 29 | 30 | 31 |

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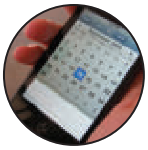

# Coming Events

**CALL FOR PAPERS**

**ISSCC 2010**
IEEE International Solid-state Circuits Conference
Deadline: September 14, 2009

**WAMICON 2010**
IEEE Wireless and Microwave Technology Conference
Deadline: October 8, 2009

**ONLINE**

For complete coverage of the EuMW 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/eumw2009 starting September 21st.

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## SEPTEMBER

**4G World 2009**
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http://4gworld.com

**Antenna Applications Symposium**
*September 22–24, 2009 • Monticello, IL*
www.ecs.umass.edu/ece/allerton

**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

**MILCOM 2009 Military Communications**
*October 18–21, 2009 • Boston, MA*
www.milcom.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

**RFIT 2009**
**IEEE Radio Frequency Integration Technology Symposium**
*December 9–11, 2009 • Singapore*
www.ieee-rfit.org

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

## JANUARY

**IEEE Radio Wireless Week 2010**
*January 10–14, 2010 • New Orleans, LA*
www.radiowirelessweek.org

**MEMS 2010**
**IEEE International Conference on Micro Electromechanical Systems**
*January 24–28, 2010 • Hong Kong, China*
www.ieeemems.org

## FEBRUARY

**ISSCC 2010**
**IEEE International Solid-state Circuits Conference**
*February 7–11, 2010 • San Francisco, CA*
www.isscc.org

**NATE 2010**
**National Association of Tower Erectors**
*February 15–18, 2010 • Orlando, FL*
www.natehome.com

## MARCH

**SATELLITE 2010**
*March 15–18, 2010 • Washington, DC*
www.satellite2010.com

**CTIA with RF/Microwave and M2M Zones**
*March 23–25, 2010 • Las Vegas, NV*
www.ctiawireless.com

## APRIL

**WAMICON 2010**
**IEEE Wireless and Microwave Technology Conference**
*April 12–13, 2010 • Melbourne, FL*
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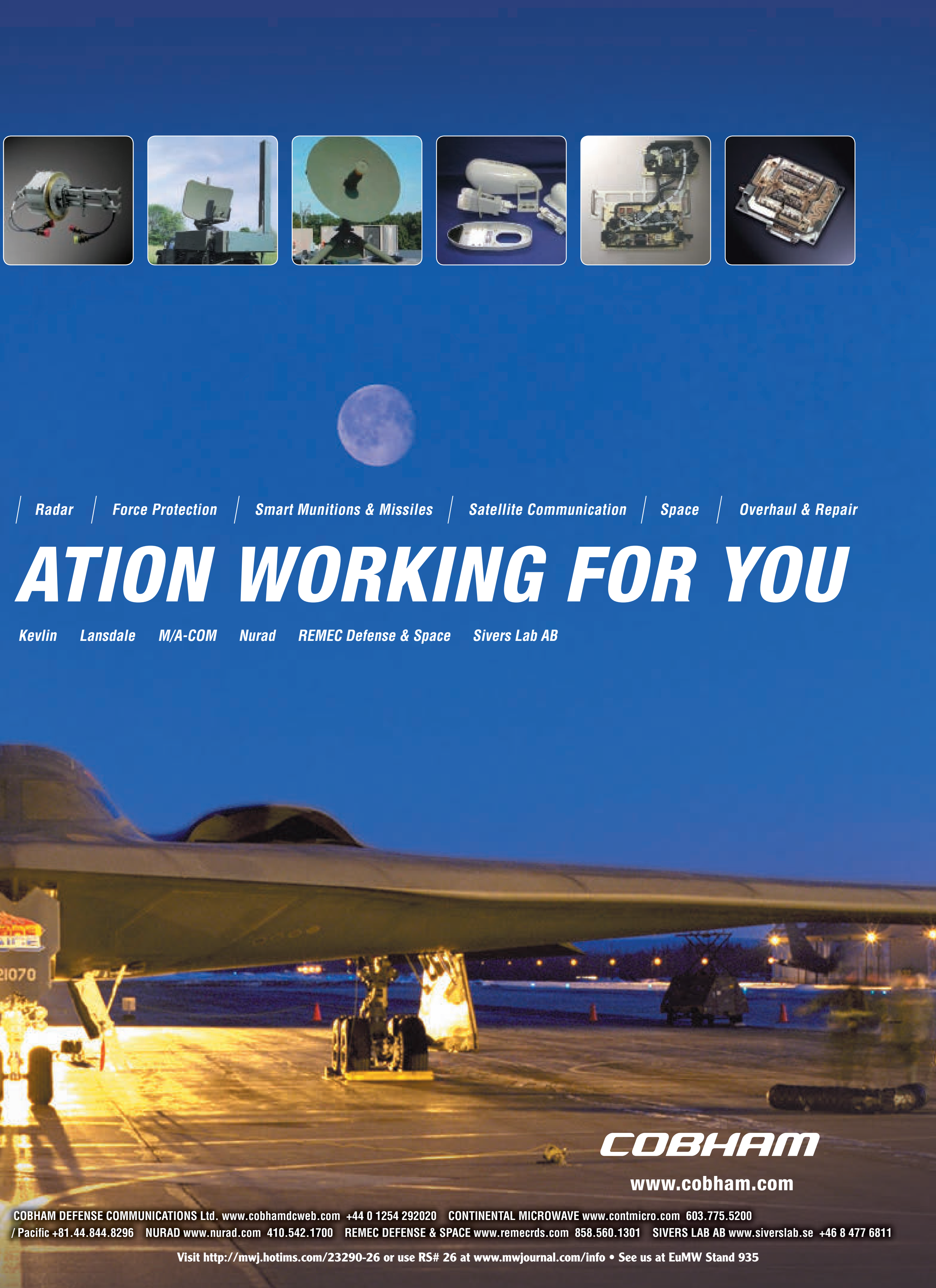

# Welcome to European Microwave Week 2009

**For complete coverage of the EuMW conference, event news, exhibitor product information and special reports from the editors of *Microwave Journal*, visit our online show daily at www.mwjournal.com/eumw2009 starting September 21st.**

For the RF and microwave community, all roads (air lines and train tracks) lead to Rome as the city's Nuova Fiera di Roma plays host to the *12th European Microwave Week*. All modes of transport will bring delegates, exhibitors and visitors from across the globe to Europe's leading event, which runs from 28 September to 2 October. Just as the Eternal City has the lure of ancient history, architecture, art and high fashion, European Microwave Week offers the draw of the latest research and development, innovative products and the opportunity for discussion and networking.

EuMW 2009 intends to build on the *Bridging Gaps* theme that epitomised last year's event in Amsterdam, taking it a stage further and 'extending bridges' by strengthening intellectual, technological and geographical links. The Week is seen as a meeting point and catalyst for unification and growth, not just for those with established RF and microwave industries, but also for emerging regions.

The four conferences—the 39th European Microwave Conference (EuMC), the 4th European Microwave Integrated Circuits Conference (EuMIC), the 2nd European Wireless Technology Conference (EuWiT) and the 6th European Radar Conference (EuRAD)—specifically target ground breaking innovation in microwave research through a call for papers that explicitly invite the submission of presentations on the latest trends in the field, driven by industry roadmaps. The result was an exceptional number of papers (over 1,250) from all over the world, particularly from Eastern Europe, the Middle East and the Far East.

There are also Focused Sessions on cutting-edge technologies, workshops and short courses given by leading experts in a variety of areas from microwave circuits and technologies to wireless and radar applications, together with addresses by invited speakers aimed at stimulating interest and debate.

Rome was not built in a day and neither was the now sold out *European Microwave Week Exhibition*, which has developed gradually over recent years to become the premier RF and mi-

Paolo Lampariello
*General Chairman, EuMW 2009*
Ivar Bazzy
*President, Horizon House Publications*

crowave exhibition in Europe. With a wide and focussed audience it attracts international players, not just from Europe but from across the globe, particularly the US and Asia. This year the choice of Rome as the venue has added a new dimension with all of the leading Italian players in the defence sector taking part, alongside a variety of other local companies.

The exhibition acts as an interactive forum for microwave companies to showcase and discuss the latest technical developments and has established itself as the stage that manufacturers target for launching new products and making major announcements. For those wanting to get hands-on experience and guidance direct from the experts there are also exhibitor workshops and short courses on various subjects. The next generation is also catered for with *Tutorial Seminars for Young Engineers* aimed at encouraging young engineers along their chosen career paths.

Young engineers and researchers are also being challenged to test their technical and application-oriented innovation skills through the *EuMW 2009 Student Challenge*. It continues this year following its successful introduction in 2008, as does the *Women in Engineering* event, which will focus on the contribution and role of women in our industry.

The historical city of Rome warrants that EuMW 2009 recognises the microwave industry's own history. There will be a celebration of the Nobel Prize for Physics that was awarded 100 years ago to Guglielmo Marconi and Karl Ferdinand Braun in 'recognition of their contributions to the development of wireless telegraphy' and a celebration of the 40th anniversary of the European Microwave Conference.

The *EuMW Welcome Reception* is another established element of EuMW, which gathers academia and industry together to interact, network and socialise. Other social highlights include the EuMW Gala Dinner in the Complesso Monumentale Santo Spirito in Saxia, which was a refuge for pilgrims arriving in Rome to visit the Apostle Peter's tomb. The Partner Programme also provides the opportunity to visit historical and cultural sites both in Rome and the surrounding area, including the area of Fori Romani, the Vatican City and the Catacombs.

EuMW 2009 could not be realised without the valuable contribution of many enthusiastic colleagues in universities, industry and research centres all over the world that have helped to organise this year's event. On behalf of the Local Organising Committee, we would like to express our gratitude to the four international Technical Programme Committees and the hundreds of reviewers who worked hard to shape the final conference programme.

Thanks goes to those who organised the special sessions, the focused sessions, the workshops and short courses, and the special events. We also acknowledge the EuMA Board for its continued support and the Horizon House personnel assigned to this event for their experience and guidance that has again proved invaluable in leading the chair and his team through all the steps of organising a challenging, world-class exhibition. Finally, we wish to acknowledge the financial and in-kind sponsorship of many industrial enterprises and other organizations.

Great efforts have been made to ensure that European Microwave Week's first visit to Rome is productive and memorable. It gives the RF and microwave industry the perfect arena to showcase its undoubtable skills and provide impetus for moving forward. See you there.

*Paolo Lampariello*

*Ivar Bazzy*

Welcome from Paolo Lamariello, General Chairman of EuMW 2009, and Ivar Bazzy, President, Horizon House Publications. ■

EuMW 2009 — EUROPEAN MICROWAVE WEEK Rome
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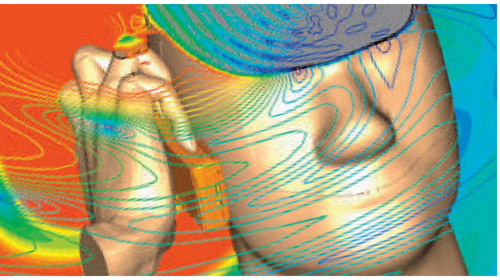


# Attending European Microwave Week 2009

The city of Rome is steeped in history and from 28 September to 2 October history is again being made as the Eternal City plays host to European Microwave Week for the very first time. And, when in Rome there will be plenty to do as EuMW 2009 offers four focused conferences and associated workshops and short courses, along with the premier RF and Microwave Exhibition in Europe that attracts international players, complemented by a vibrant social agenda.

The Week intends to build on the Bridging Gaps theme that epitomised last year's event in Amsterdam, taking it a stage further and 'extending bridges' by strengthening intellectual, technological and geographical links. EuMW 2009 is envisaged as a meeting point and catalyst for unification and growth, not just for those with established RF and microwave industries, but also for emerging regions.

Successful initiatives have been carried forward from EuMW 2008. These include the Women in Engineering event, which takes place on Tuesday evening after the conference sessions. Titled, "Woman in Engineering, Experience Teaches… What?," the debate will centre on the way women perform within the engineering profession. For the second time PhD and Master students are invited to take up the Thales Nederland sponsored EuMW 2009 Student Challenge, where participating students aim to achieve a novel application-oriented concept from oral presentations and posters. The Challenge complements the Agilent Technologies sponsored Tutorial Seminars for Young Engineers, aimed at encouraging young engineers along their chosen career paths.

Additionally, the historical city of Rome warrants that EuMW 2009 recognises the microwave industry's own history. There will be a celebration of the Nobel Prize for Physics that was awarded 100 years ago to Guglielmo Marconi and Karl Ferdinand Braun in 'recognition of their contributions to the development of wireless telegraphy' and a celebration of the 40th anniversary of the European Microwave Conference.

During the Week over 5,000 attendees—comprising delegates, exhibitors and visitors—are expected to descend on the Nuova Fiera di Roma, where they will discover four focused conferences that reflect the groundbreaking and innovative work currently being undertaken in the RF, microwave, integrated circuit, wireless and radar sectors. There were 1,250 paper submissions, enabling the Technical Programme

Richard Mumford
Microwave Journal *International Editor*


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Committee to fashion a high-level programme, complemented by a wide range of workshops and short courses.

The actual products borne out of research and development can be found at the European Microwave Week Exhibition in Hall 9, which for three days will be home to more than 250 exhibitors spread over more than 7,500 m$^2$ (gross). Visitors will be able to see first hand the latest innovations and new product introductions, discuss specific areas of interest with development engineers and find the right products for their specific applications.

The official European Microwave Week opening ceremony at 11.00 on Tuesday morning is open to delegates from all conferences, while later that evening academia and industry come together at the EuMW Welcome Reception (see Social Events), which has become a highlight of the week. On Wednesday the Finmeccanica sponsored EuMW Gala Dinner will be held in the historical hall of the Vatican Museums.

This and other important events, both business related and social, should not be missed. To help you plan your visit, the following quick reference guide is designed to complement the Conference Programme and Exhibition Show Guide, where you will find more detailed information.



## THE CONFERENCES

There are four separate conferences that are scheduled throughout the Week as follows:

- The 4$^{th}$ European Microwave Integrated Circuits Conference (EuMIC) takes place on Monday 28 and Tuesday 29 September
- The 2$^{nd}$ European Wireless Technology Conference (EuWiT) runs on Monday 28 and Tuesday 29 September
- The 39$^{th}$ European Microwave Conference (EuMC) extends from Tuesday 29 September to Thursday 1 October
- The 6$^{th}$ European Radar Conference (EuRAD) ends the Week and runs from Wednesday 30 September to Friday 2 October.

The registration area is located in Conference Hall 10 (Centro Convegni), where delegate bag collection will also be available. On-site registration begins on Sunday 27 September (16:00 to 19:00) and commences at 07:30 each morning from Monday 28 September to Friday 2 October. Delegates can register for one, two, three or all four of the conferences. Registration at one conference does not allow access to other conference sessions, but those who register for two or more conferences will receive a discount.

## THE EUROPEAN MICROWAVE INTEGRATED CIRCUITS CONFERENCE

The EuMIC is the successor of the GAAS application symposium, which was first held in Rome in 1990. Since 2007 the conference has been organised under the umbrella of both the European Microwave Association and GAAS® Association. This year the conference programme offers more than 100 technical papers. A significant number of sessions and workshops are joint sessions with EuMC and EuWiT,


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emphasising the strong interaction between these conferences.

In line with conference tradition, the programme is aimed at both industry and academia, with a large number of sessions ranging from basic process and device physics to integrated circuit theory based on different compounds in a number of different applications.

The opening and closing sessions feature renowned speakers. Dr. Saggese, Commissaire of the Italian Space Agency, and Admiral Flagiello will open the conference with a discussion on how microwave technologies are crucial for today's space systems and dual use applications. Prof. Mishra from UCSB will conclude the opening session with an overview of the recent progress in AlGaN/GaN HEMTs as well as the potential in alternate planes of GaN over the conventional Ga-plane.

The closing session will feature speeches on the GaN HEMT reliability physics-based approach from Prof. Zanoni and Prof. Meneghesso from the University of Padova and from Dr. Barnes of ESA-ESTEC, concerning current reliability and the path ahead for space applications.

The traditional Foundry Round Table Discussions, organised by the GAAS Association, will enable selected European and non-European foundries to address the new trends in microwave and mm-wave integrated circuits from their individual perspectives.

### Prizes and Awards

To acknowledge the high quality of papers presented, the Best Paper Prize of €3,000 and a Young Engineer Prize of €2,000 will be awarded. The winners receive a plaque commemorating their achievements. In addition, the GAAS Association will provide three Student Fellowships of €2,000 each, to recognise the valuable work of students and to support them in the early stages of their technical and scientific career.

## EUROPEAN WIRELESS TECHNOLOGY CONFERENCE

The EuWiT conference (formerly known as the European Conference on Wireless Technology (ECWT)) is a forum for the presentation and discussion of new developments in the field of wireless communication technologies. The focus is on the interdisciplinary competence that is needed to meet the challenges of the emerging generation of wireless communications. This conference brings together researchers and product developers from all over the world to update and share their knowledge.

The session will open with a presentation on: "Convergence: A Step towards an Unpredictable Future," which will discuss the convergence of networks and access technology, followed by "SDR Technology for High Capacity and Interoperable BMS Systems." There are various podium sessions, including one addressing the creation of 'Information Cities'. EuWiT will close with two invited speeches: "Satellite's Role in Emergency Services" and "Spectrum Management for Future Generation Wireless Based Technology."

### Prizes and Awards

To acknowledge the high quality

of papers presented, the Best Paper Prize of €3,000 and a Young Engineer Prize of €2,000 will be awarded.

## THE EUROPEAN MICROWAVE CONFERENCE

Forty years ago, in September 1969, the opening ceremony of the 1st European Microwave Conference (EuMC) took place in London. Following the third conference in Bruxelles in 1973, the EuMC became an annual event and will celebrate its 39th edition in Rome in 2009. The most important and authoritative RF and microwave conference in Europe became part of European Microwave Week in 1998. A special historical session devoted to the 40th anniversary of the EuMC will take place on Wednesday.

This year a record 843 papers from 56 different countries were received. There are also 73 technical sessions (13 of which are common to other EuMW conferences) and 14 workshops, covering the entire range of topics related to microwave technology, including antennas.

During the opening session on Tuesday the two major European Microwave Association awards—the Eu*MA* Distinguished Service Award and the Eu*MA* Outstanding Career Award—will be presented.

To reflect the fact that the Asia Pacific region now contributes almost 15 per cent of the paper submissions to the EuMC, a special session devoted to the region has been organised for Wednesday. Three distinguished invited speakers from Korea, Japan and Singapore will elaborate on the most advanced achievements in their respective fields of activity.

Closer to home the European Radio and Microwave Interest Group (EuRaMIG) Workshop entitled "Microwave for European Growth," aimed at providing an overview of the European microwave technology roadmap, its application scenario and its relevance to European society will run on Monday.

### Prizes and Awards

The EuMC Microwave Prize, valued at €5,000, will be awarded to the best paper contributed to the European Microwave Conference. In addition, two EuMC Young Engineer Prizes of €2,000 each, sponsored by EADS, will be awarded to young engineers or researchers who present the most outstanding papers at the conference.

## THE EUROPEAN RADAR CONFERENCE

Over the six years that the European Radar Conference has been in existence it has grown into one of the largest European and worldwide recognised radar events, both in terms of quality and quantity. In fact, this year there were 189 submissions to the conference, which is an 18 percent increase on 2008. EuRAD paper submissions now make up about 15 percent of the whole of EuMW. This makes the conference the second largest and has led to its duration being extended to more than two full days.

The papers are organised into 12 oral sessions plus four focused sessions and one common EuMC/EuRAD session, adding up to 83 podium pre-

sentations, complemented by a poster session. The programme covers a wide range of radar topics including Radar Subsystems and Technology, Signal Processing, Design and Evaluation, Systems and Applications. Two focused sessions are dedicated to Space Radars and their Environmental Remote Sensing Applications, one to Space-Time Adaptive Processing and another to Passive Radar. The common session with EuMC is dedicated to through-the-wall radar imaging.

The programme also includes ‘hot’ topics such as ultra-wideband (UWB) radar, multi-lateration, interception/analysis of radar signals, new radar waveforms and OFDM radar, sea and OTH radar, phased arrays and more, with a wide and updated overview of the most recent advances in radar technology and applications.

In the opening session there will be a discussion on the Compatibility of Frequencies in the Italian Defence and Civilian Environments, complemented by a presentation on the Advances in Radar Systems by SELEX Sistemi Integrati and the analysis of recent advances in radar waveforms, including those with communication capability.

At the closing session the presentations will focus on future radar procurement for the Italian Ministry of Defence, and on the status, results and perspectives of the Italian Earth Observation SAR COSMO-SkyMed.

The conference programme is completed with four workshops: Advances in UWB Localisation and Sensing (joint EuMC/EuRAD); Understanding High Resolution SAR Images; Imaging Radars in Earth Observation: Techniques and Applications; and Advanced Radar Techniques (joint EuRAD/EuMC).

### Prizes and Awards

The Eu*M*A EuRaD Radar Prize and Young Engineer Prize, which are both sponsored by Raytheon, will be presented. The Radar Prize of €3,000 is awarded to the paper that best advances the state-of-the-art in radar. The Young Engineer Prize of €2,000 is awarded to a young engineer or researcher who has presented an outstanding paper at the conference.

## THE EXHIBITION

The European Microwave Week Exhibition has become the focus of leading companies from around the globe that want to reach the international audience that EuMW attracts. Of course, western European companies are to the fore, but the US and Asia are well represented, with eastern Europe also making its presence felt at this sold out exhibition.

This year the choice of Rome as the host city has added a new dimension with all of the leading Italian players in the defence sector signing up to take part, alongside a variety of other local companies. The presence of these key defence leaders and associated companies strengthens EuMW’s commitment to comprehensively cover all major sectors of the RF and microwave industry. Italian industry is well represented and its close neighbour is too, by way of the French Pavilion, which has maintained its presence

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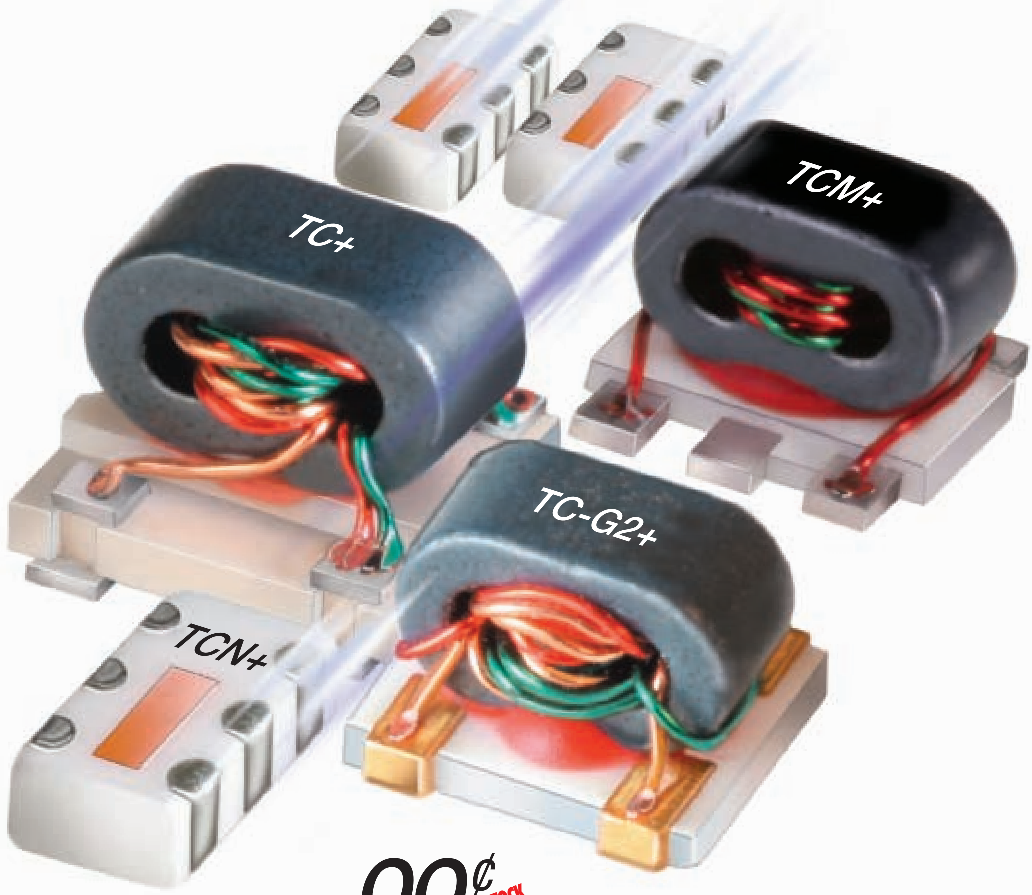


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since EuMW last visited Paris in 2005. It brings together the country's large and small companies and distributors, all under one defined roof.

Irrespective of origin, numerous companies have come to recognise the exhibition as an essential platform for them to launch new products. This year is no exception as leading manufacturers are specifically targeting the show to make important product announcements. For many it is also important to get hands-on experience and guidance direct from the experts, which the exhibitor workshops and short courses on various subjects provide.

For the three days, Hall 9 will also be where academia and industry come together, interact and do business. As well as being a showcase for the latest products, it will also be the home of the coffee breaks and the conference Poster Sessions, feature a Publisher's Corner and provide that all important Internet access via the popular CST sponsored Cyber Cafés.

### Exhibition Hours

Tuesday 28 October: 09:30 – 17:30
(followed by the Welcome Reception)
Wednesday 29 October: 09:30 – 17:30
Thursday 30 October: 09:30 – 16:30

## GETTING TO THE NUOVA FIERA DI ROMA

The site of European Microwave Week is less than five kilometres from the Leonardo da Vinci (Fiumicino) Airport with rail connections by Trenitalia from the Rome Tiburtina, Tuscolana, Ostiense and Trastevere Stations.

### By Shuttle Bus

D.G.M.P. Travel is the Officially Appointed Travel Agency for EuMW 2009. As part of its service they have organised shuttle buses from a selection of hotels to the venue each day; this service is sponsored by Finmeccanica. Please see their website at www.dgmp.eu/eumw2009 to book accommodation and for information on which hotels include free courtesy transfers.

### By Bus

Atac is the Rome bus company—take line 808 to Fiera Roma or from Fiumicino airport take Cotral Line W0001.

### By Car

From the Grande Raccordo Anulare (GRA)—the Rome ring road—take exit 30 to Fiumicino and then follow directions for Fiera Roma.

### By Train

From the Tuscolana, Tiburtina and Ostiense Stations that are connected to the A and B lines, take the Metro train FR1, in the direction of Fiumicino Airport and get off at the Fiera di Roma stop. The cost is €1.

### By Air

From Fiumicino Airport, connections to Fiera Roma are by the FR1 train, getting off at the Fiera di Roma stop, taxi and Cotral bus.

## HOTEL RESERVATIONS

D.G.M.P. Travel has carefully selected hotels near the Nuova Fiera di Roma and in the city centre at the 'Best

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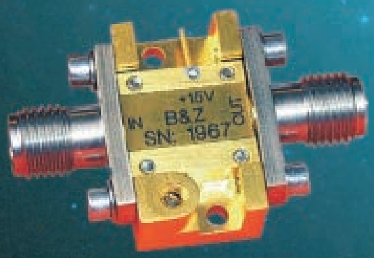


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Available Rate' during EuMW. Demand for hotel rooms in Rome will be high during the Week, so booking well in advance is advisable. Visit www.dgmp.eu/eumw2009 for more information on hotels and accommodation, air fares, car rental, excursions and airport transfers.

## SIGHTSEEING & SHOPPING

Rome is a beautiful and exciting city, known for its history, cuisine and fashion, and whether you are looking to relax or sightsee, it has so much to offer. Popular sites include The Vatican, the Trevi Fountain, St Peter's Square, Spanish Steps and the Colosseum as well as many museums and galleries.

Rome is also a great place for shopping, with designer outlets and department stores all over the city. The most popular shopping areas include:

- Piazza di Spagna (Spanish Steps, Via dei Condotti)
- Via del Corso
- Trastevere (located just over the River Tiber)
- Viale Marconi and Porta Portese
- Piazza Navona (Via del Governo Vecchio)

For even more sightseeing ideas, including what to do and where to eat, see "When in Rome..." on page 40.

## SOCIAL EVENTS

Established as one of the social highlights of the Week, the EuMW 2009 Welcome Reception will take centre stage in Exhibition Hall 7 of the Nuova Fiera di Roma on Tuesday evening. All registered conference delegates from all four EuMW conferences, as well as representatives from the companies participating in the exhibition are invited, making it a forum where academia and industry can meet, interact and network, while enjoying good food and drink. The reception will feature a brief address by Platinum Co-Sponsor Elettronica S.p.A, while Platinum Co-Sponsor, Agilent Technologies will host the Delegate Prize Award Ceremony.

The following evening (Wednesday) the highlight is the EuMW Gala Dinner sponsored by Finmeccanica/Selex in the Complesso Monumentale Santo Spirito in Saxia, which was a refuge for pilgrims arriving in Rome to visit the Apostle Peter's tomb.

The EuRAD 2009 Chamber Music Concert in the Sacrestia del Borromini takes the spotlight on Thursday evening. Jointly sponsored by Rheinmetall-Italy, the Associazione Vito Volterra and Centro Vito Volterra of the University of Rome, the concert will feature Alessandro Carbonare Gabriele Geminiani and Linda di Carlo playing music by Beethoven and Brahms.

Also, an extensive Partner Programme has been organised throughout the Week, offering the opportunity to visit historical and cultural sites both in Rome and the surrounding area, including the area of Fori Romani, the Vatican City and the Catacombs.

## GENERAL INFORMATION

In advance, take time to familiarise yourself with the event and plan your visit by logging onto the show website: www.eumweek.com and visit www.mwjournal.com/eumw2009 for exclusive show coverage by *Microwave Journal*.


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# When in Rome...

Even those who have not visited Italy's capital before will be aware of much of Rome's history, its famous sites and breathtaking landmarks. The Eternal City has a colourful and varied past. It is the seat of the world's greatest Empire, has witnessed turbulence and upheaval as rivals have fought over its riches, and been at the forefront of religious and cultural development.

However, Rome is more than an open air museum of ruins and statues. Its modern culture makes it a vibrant 21st century European capital of fashion, style and sophistication that epitomises the Italian way of life. It is a cosmopolitan city with a wide variety of places to eat, from traditional to international, together with a vibrant nightlife.

Rome was not built in a day and it will take a fair amount of time to explore all of its riches. Of course, any guide to the city has to include the world famous Colosseum, Pantheon, Roman Forum, Spanish Steps, Trevi Fountain and the Vatican City, but this guide also aims to offer of flavour of the everyday ambience that is enjoyed by Rome's three million inhabitants.

## GETTING AROUND ROME

Of course, the easiest and cheapest way to see the city is on foot. For those seeking ancient Rome, the historic centre with its monuments and ruins is quite compact, with the journey from the Colosseum to the Piazza di Spagna being only 2.5 km.

If you want to go further afield, Rome has an extensive bus and tram network and efficient metro system. Please note, however, that it does not serve the historic heart of the city. Public transportation tickets must be purchased in advance of the journey from tabacchis, news stands, bars, or vending machines (exact change only) at major bus stops and metro stations.

### Buses and Trams

Buses run from 05:30 until midnight and there are also over 20 night bus lines that operate from 00:30 to 05:30. The main terminal stations are Termini (Piazza dei Cinquecento) and Piazza Venezia. Night bus stops are marked with an owl and tickets can be purchased on board.

### Metro

The 'Metropolitana' consists of two lines, Linea A (red) and Linea B (blue), which intersect at the Termini Central Station. Trains run approximately every seven to 10 minutes and

Lucia David
*Selex Sistemi Integrati, Rome, Italy*

run from 05:30 until 23.30 every day and until 00:30 on Saturdays.

Atac is the company that runs Rome's public transport services and within the city Metrebus combined tickets are valid across the full range of services. A single ticket, called a BIT, can be used on any form of transport, but only includes a single metro journey. There are various one-day, three-day and seven-day options and the all-inclusive Roma Pass, which lasts three days and includes public transport, a map and a couple of museum admission tickets.

### Taxis

It is nearly impossible to hail a taxi driving down the streets, particularly at night, so aim for one of the taxi ranks that are situated in various locations throughout the city centre. Also, be sure to use the official metered white or yellow taxis.

## WHAT TO DO AND SEE

The visitor is spoilt for choice. Rome has over 400 churches and four major basilicas—St Peter's, St John Lateran, St Mary Major and St Paul's—and there are numerous museums and art galleries catering from the ancient to the modern, famous fountains and inviting Piazzas. This guide is not comprehensive, but hopefully will highlight some well known attractions and a few less well known ones, and give you a flavour of the city.

The Colosseum, Roman Forum and Palatine Hill are close neighbours. The Circus Maximus is a short walk away and the Baths of Caracalla are a little further.

### The Colosseum

This has to be Rome's most famous landmark (see ***Figure 1***). The elliptical-shaped building, also known as the Flavian Amphitheatre, took about ten years to build and is situated at the foot of the Via dei Fori Imperiali. It gets its popular name from the giant statue, or colossus, of Nero, which stood close to the spot. For 450 years this great amphitheatre hosted the 'games' when up to 50,000 spectators gathered for violent and bloody gladiatorial contests and wild beast hunts.

*▲ Fig. 1 The Colosseum (photo courtesy of www.galttech.com).*

### The Roman Forum

A symbol of the power of the city in its Golden Age, it is the central area around which ancient Rome developed (see ***Figure 2***). It was the administrative and corporate heart of the city. A little imagination is required to envisage that the remaining ruins once housed a market place that was the political, commercial and social hub of ancient Rome and the symbolic centre of its Empire.

### Palantine Hill

The Palatine is where Rome began, back in 753 BC when Romulus killed Remus. Due to its magnificent views over the city Palatine Hill, it is where the emperors of Rome chose to live and is still one of the best locations. It presents one of the most serene and splendid views over Rome.

### Circus Maximus

Modern-day Romans go for walks, cycle and play games in this large oblong field in a valley where ancient Romans sat on the slopes to watch sporting events. The shape and structure of the Circus Maximus changed to be the venue of one of the great

*▲ Fig. 2 The Roman Forum (photo courtesy of www.freefoto.com).*

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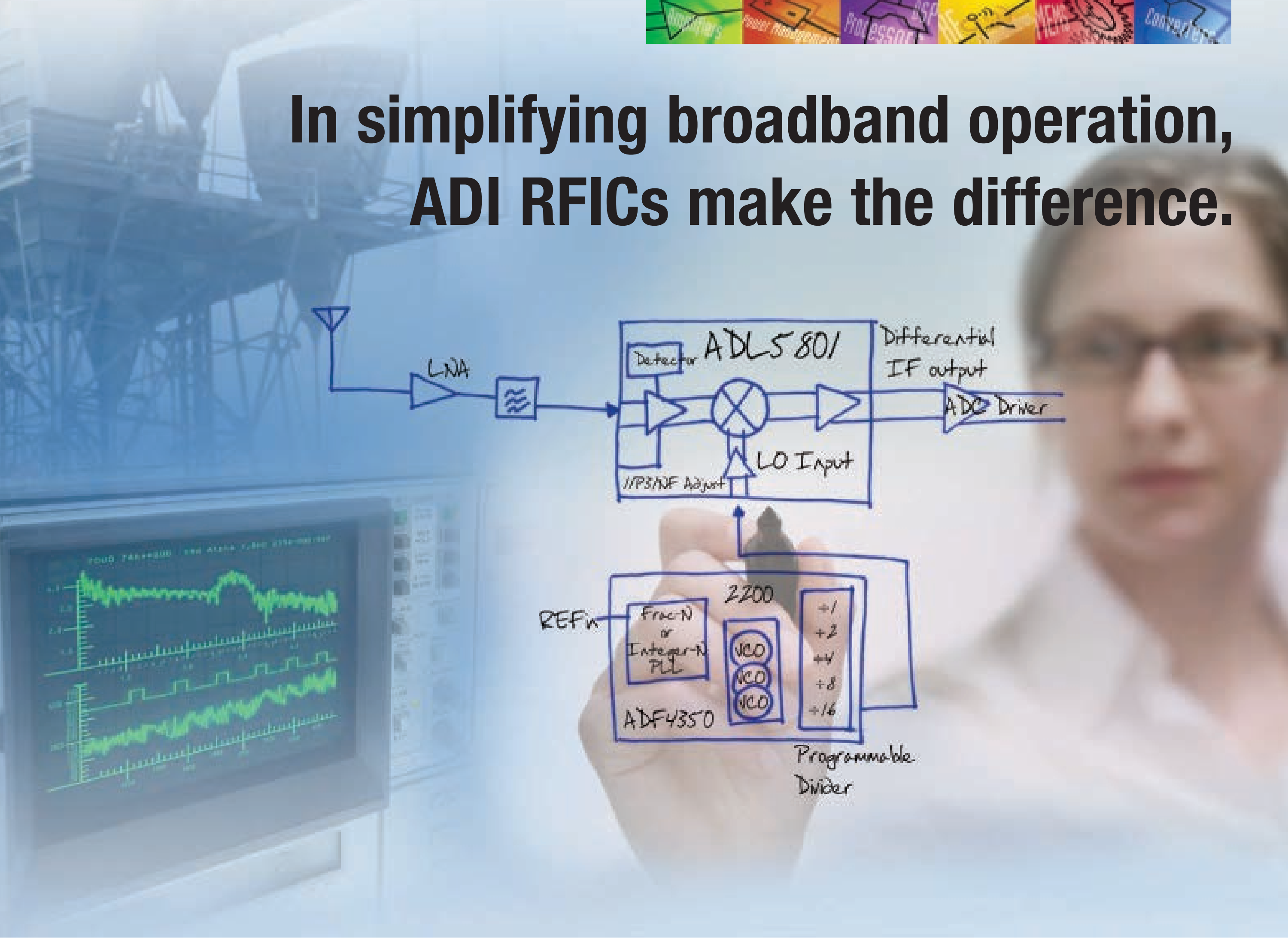


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Roman passions, chariot racing. The first building that was built in the seventh century was made of wood, but in its heyday it was completely covered in marble and travertine stone.

Fig. 3 *The Pantheon (photo courtesy of www.galttech.com).*

### Baths of Caracalla

This is the best preserved of the imperial bath complexes. The brick structures and mosaics illustrate the grandness and luxury of bathing in Roman times. Visitors can still see the changing rooms, the caldarium, tepidarium and frigidarium. There are also libraries and the outside exercise areas.

### The Pantheon

Situated in the Piazza della Rotonda, this pristine, preserved building is one of Rome's jewels (see ***Figure 3***). The word 'Pantheon' signifies all the deities, and the building was originally dedicated as a temple to 12 of the most important Roman gods. It was built in the reign of the Emperor Hadrian (around 125 AD) and replaced an earlier building constructed by Agrippa, which is commemorated in the inscription on the portico.

### The Vatican City

The Citta del Vaticano is the smallest state in the world. Inside the City there are 11 Vatican Museums. In the Vatican Palace, the Sistine Chapel, which was built as a private chapel of the popes between 1475 and 1480, displays one of the world's most famous artworks—Michelangelo's depiction of The Creation. The artist began in May 1508; the frescoes were unveiled in August 1511, and completed in October 1512. Twenty-one years later Michelangelo created the Last Judgment, depicting souls of the dead rising to meet God.

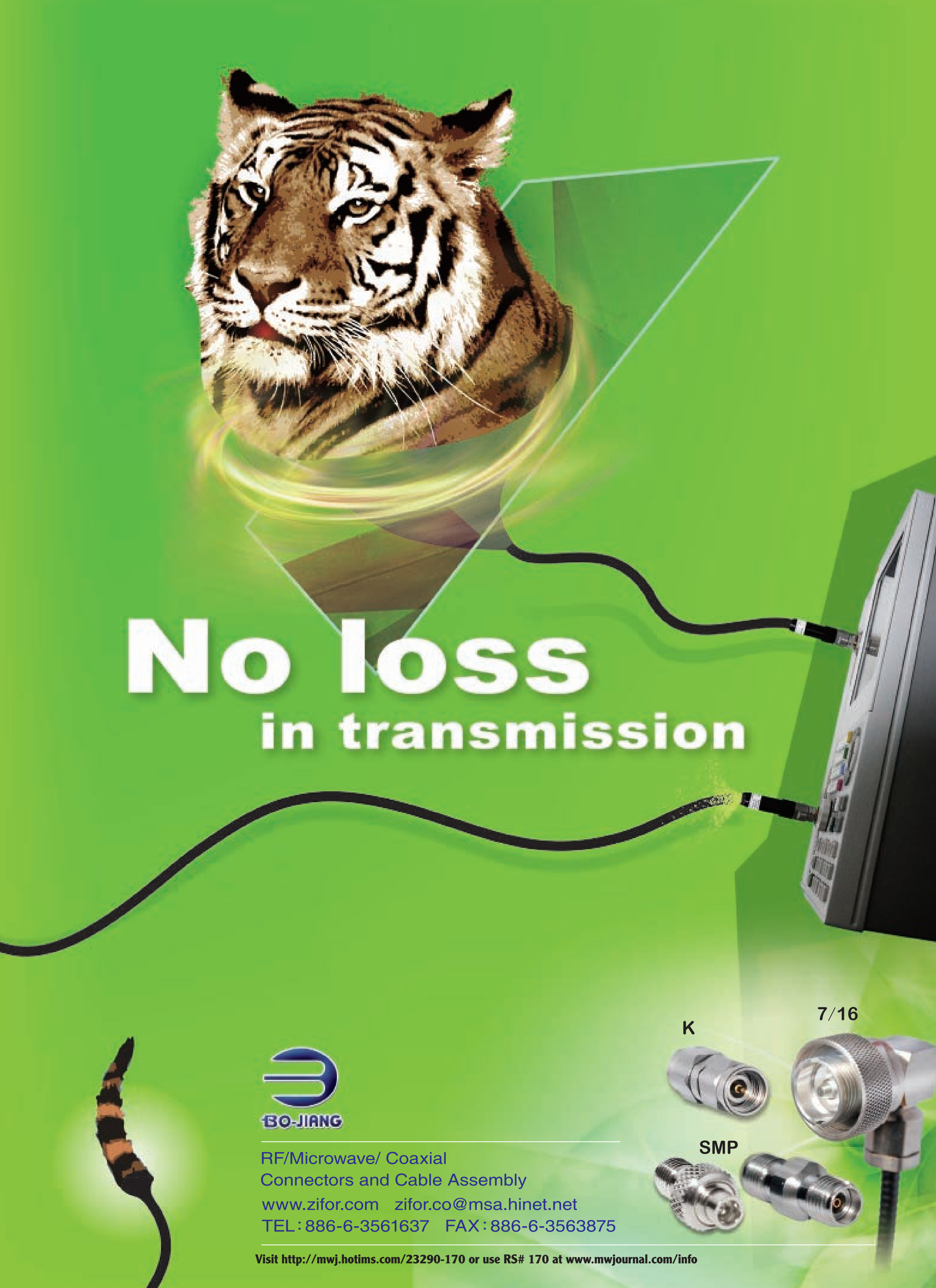
Fig. 4 *St. Peter's Basilica (photo courtesy of www.galttech.com).*

### St Peter's Basilica

Basilica di San Pietro lies above a former shrine, which is said to mark the burial ground of the saint (see ***Figure 4***). Pope Julius II pulled down the original structure in 1506. Construction lasted 120 years, during which time a team of architects and artists including Alberti, Bramante, Raphael, Peruzzi, Sangallo the Younger and Michelangelo were employed.

## FOUNTAINS

There are numerous fountains scattered throughout the city. The Fontana di Trevi (Trevi Fountain) has been made famous on film (see ***Figure 5***). The site originally marked the terminal of the Aqua Virgo aqueduct built in 19 BC. The extravagant baroque creation, featuring travertine palm trees, tritons, seahorses and Neptune that greets visitors today was designed by Nicolò Salvi for Pope Clement XII and completed in 1762.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### Fountain of Four Rivers

Designed by Gian Lorenzo Bernini, this fountain is located in the Piazza Navona, the ancient stadium of the Emperor Domitian and the site of the Pamphilj family palace. The fountain depicts Gods of the four great rivers in the four continents, which were recognized by the Renaissance geographers: The Nile in Africa, the Ganges in Asia, the Danube in Europe and the Río de la Plata in America.

### Spanish Steps

The Piazza di Spagna is dominated by the elegant double steps known as the Spanish Steps, which were designed by Francesco de Sanctis to link Via del Babuino with Via Felice, in the style of the grand ascent to the Sacré Coeur in Paris (see ***Figure 6***). At the foot of the steps lies the Bernini designed boat-shaped Barcaccia fountain, while they lead up to the 16th century Trinità dei Monti, from where there are spectacular views over the city.

## MUSEUMS AND ART GALLERIES

There is a wealth of museums and art galleries in Rome filled with paintings and sculptures of the Renaissance and the Baroque. Here is a brief selection:

### Museums

The Vatican Museums house masterpieces in palaces originally built for Renaissance popes such as Julius II, Innocent VIII and Sixtus IV. Look for the Sistine Chapel, Raphael Rooms and the Etruscan Museum.

### Capitoline Museum

Situated on the Capitoline Hill, in Piazza del Campidoglio, the Capitoline Museums are home to some of the most renowned and beautiful statues in the world. They include the Capitoline She-Wolf, an Etruscan bronze suckling Romulus and Remus, the Capitoline Venus, the original bronze equestrian statue of Marcus Aurelius, not to mention a room full of Caesars!

### Museum of Rome

The Museo di Roma is housed in Palazzo Braschi on Via San Pantaleo, where you will find a vast collection dedicated to the history of the city from the Middle Ages to the early 20th century. Exhibits include busts of popes to paintings of peasants and large scenic paintings of Rome, showing grand events.

### The National Museum of Castel Sant'Angelo

This Castel Sant'Angelo Fortress was built as a mausoleum for the Emperor Hadrian, but it has also been a prison and a papal residence and a covered passageway still connects Castel Sant'Angelo to the Vatican. The National Museum of Castel Sant'Angelo inside retraces its history and has various exhibits ranging from

▲ *Fig. 5 Fontana di Trevi (photo courtesy of www.galltech.com).*

▲ *Fig. 6 Spanish steps (photo courtesy of www.freefoto.com).*

Renaissance paintings and pottery to antique military weapons.

Other museums include the more unusual:

- National Museum of Pasta
- Numismatic Museum of the Italian Mint
- The Rome Jewish Community Museum

## ART GALLERIES

### Galleria Borghese

Along with the Borghese Museum, the Borghese Gallery is housed in the Villa Borghese. Cardinal Scipione Borghese commissioned the young Bernini for several sculptures, which are considered some of the most important of their kind. The Museum is on the ground floor and displays sculptures, while on the upper floor the Gallery offers displays of paintings, including significant works by Titian and Raphael, along with what is considered to be some of Caravaggio's best work.



### National Gallery of Ancient Art

Located in the Palazzo Barberini, the Galleria Nazionale d'Arte Antica contains treasures by artists including Raphael and Holbein. The collection has been amassed from the galleries of Rome's great families and includes works dating from the 12th to the 18th century.

### Galleria Spada

This small art gallery is crowded into a few rooms in the decorative Palazzo Spada. The artworks come from the Cardinal's art collection and include many sixteenth and seventeenth-century paintings as well as some fine Roman sculptures. Artists include Guido Reni, Titian, Jan Breughel the Elder, Guercino and Artemisia Gentileschi.

## EATING AND DRINKING

As a cosmopolitan capital city Rome has a wealth of good food, from good quality pizzerias and trattorias, to traditional dishes from the different regions of Italy and exotic menus from all around the globe. There are restaurants bars and cafés to suit all pockets and tastes. Addresses and phone numbers are given, but if calling from outside Italy use the International Dialling Code: +39 and include the zero. Even when in Rome the 06 code is required.

## ROMAN CUISINE

### Agata e Romeo

Elegance and cutting-edge creativity takes Roman cuisine to the next level in this popular restaurant. The menu offers Roman dishes with a modern twist, but does not come cheap.

Via c. Alberto 45, Esquilino
Tel: 06 4466115

### Alfredo ed Ada

For over 60 years this quaint, cosy restaurant has been characterised with paper table cloths and a Roman menu that has changed very little over time.

Via dei Banchi nuovi 14
Tel: 06 6878842

### Checco er Carettiere

Located in the heart of the typically Roman Trastevere district, this restaurant sums up the roman gastronomic culture and traditional dishes.

Via Benedetta 10
Tel: 06 5817018

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**Da Lucia**

This rustic, family run trattoria serves generous servings of traditional homemade cuisine such as Roman style gnocchi.

Via del Mattonato 2B, Trastevere
Tel: 06 5803601

**Sora Margherita**

In the heart of the (Jewish) Ghetto, this is the place for those looking for authentic atmosphere and good food and where the Roman-Jewish traditions are to the fore.

Piazza delle Cinque Scole 30
Tel: 06 6874216

## TRADITIONAL ITALIAN CUISINE

**Alfredo alla Scrofa**

This is where the famous Fettuccine Alfredo was invented in 1907. As well as this signature dish there are also traditional fish and meat and tiramisu.

Via della Scrofa 104/a, San Eustachio
Tel: 06 68806163



**Capricci Siciliani**

As its name suggests this eatery offers the tastes and flavour of the beautiful island of Sicily right in the heart of Rome.

Via di Panico 83, Castel San Angelo
Tel: 06 45433823

**La Pentolaccia**

This restaurant is elegant without being expensive and offers traditional Italian cuisine, alongside a good selection of Italian wines.

Via Flavia 38, Via Veneto
Tel: 06 483477

**Santa Lucia**

The food is inspired by the Naples and Campania region, served in a relaxing setting that often attracts local celebrities.

Largo Febo 12, Piazza Navona
Tel: 06 68802427

## PIZZERIAS

**Birra & Fud**

As well as good quality pizzas, this restaurant serves tasty roman style appetizers.

Via Benedetta 23, Trastevere
Tel: 06 5894016

**Brasia**

The crisp Roman pizzas are cooked in a traditional wood oven, but there are also alternatives on the menu such as appetizers, pasta and grilled meat.

Vicolo delle Grotte 17
Tel: 06 97277119

**Gusto**

This is not just a very good pizzeria, but also a restaurant and a wine bar rolled into one.

Piazza Augusto Imperatore 9
Tel: 06/3226273

**Panattoni**

An institution in Rome, this informal restaurant is renowned for its authentic thin and crispy pizzas, but due to its popularity you may have to wait for a table.

Viale Trastevere 53/57
Tel: 06 5800919

## INTERNATIONAL CUISINE

**Akropolis**

Enjoy authentic Greek recipes in an informal and casual atmosphere.

Via San Francesco a Ripa 103, Trastevere
Tel: 06 5833260


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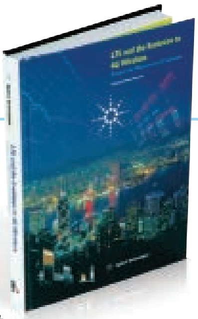

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### Franz

Situated in the Vatican area this restaurant offers Bavarian and Austrian dishes such as goulash, knodel and desserts like sacher torte.

Via di Porta Castello 23/24
Tel: 06 6873921

### Ketumbar

The Mediterranean menu, together with fusion dishes and sushi, attracts local celebrities to this sophisticated, minimalist restaurant.

Via Glavani 24, Testaccio
Tel: 06 57305338

### Mahrajah

Cosy and quiet even when crowded, this eatery offers a very rich menu that includes many northern Indian specials.

Via dei Serpenti 124, Monti
Tel: 06 4747144

### Sciam

Discover Arabian Nights in a candlelit setting and enjoy the diversity and delights of Middle Eastern cuisine.

Via del Pellegrino 55, Campo De' Fiori
Tel: 06 68308957

## SEAFOOD

### Alberto Ciarla

High quality ingredients and attention to detail make this one of Rome's celebrated restaurants, but you might have to pay a bit more.

Piazza San Cosimato 40, Trastevere
Tel: 06 5818668

### La Gensola

In this traditional Roman fish restaurant, located in a 15th century palazzo, you can savour dishes such as pasta with sea-urchin, grilled cod with tomato sauce and tuna fish.

Piazza Gensola 5, Trastevere
Tel: 06 58332758

### Riccioli Café

This is seafood for the modern day, served in a high tech setting. There is also sushi and an oyster bar with an international wine list.

Piazza delle Coppelle 10/a, Pantheon
Tel: 06 68210313

## VEGETARIAN CUISINE

### Arancia Blu

Located away from the centre of the city in San Lorenzo, which is the university district, this restaurant offers a wide variety of vegetarian dishes.

Via dei Latini 55/65
Tel: 06 4454105

### Jaya Sai Ma

This no frills vegetarian restaurant is situated near the Porta Portese market. Not only does it offer organic food, but also serves vegan specials.

Via Bargoni 10, Trastevere
Tel: 06/5812840

### Margutta Ristorante

This refined restaurant is famed for its inventive and varied vegetarian dishes.

Via Margutta 18, Piazza Del Popolo
Tel: 06 32650577

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www.rome.info
www.enjoyrome.com
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# TriQuint PtP Radio Drivers

## PtP Radio Amplifiers

| Description | Frequency Range (GHz) | P1dB (Psat) / OIP3 (dBm) | Gain (dB) | Voltage / Current (V / mA) | Part Number |
|---|---|---|---|---|---|
| 2W HPA | 5.5 - 8.5 | 32 (34) / 41 | 30 | 6 / 1260 | TGA2706-SM |
| Driver Amp, SB | 11 - 17 | 17 / – | 23 | 6 / 75 | TGA2507-SM |
| 2W HPA | 12.5 - 16 | (32) / 37 | 32 | 6 - 7 / 680 | TGA2503-SM |
| 1W HPA, PD | 17 - 21 | 29 (31) / 41 | 21 | 6 / 825 | TGA4530-SM |
| HPA, AGC, PD | 17 - 24 | (29) / 38 | 22 | 5 / 712 | TGA2522-SM |
| HPA | 17 - 24 | 31 (32) / 40 | 23 | 7 / 720 | TGA4531 |
| 1W HPA | 28 - 31 | 30 / – | 19 | 6 / 420 | TGA4509-SM |
| Driver Amp | 29 - 31 | 16 (17) / 22 | 15 | 6 / 60 | TGA4510-SM |
| 2W HPA | 30 - 40 | 31.5 (33) / – | 20 | 6 / 1050 | TGA4516 |
| MPA | 32 - 45 | 24 (25) / 33 | 16 | 6 / 175 | TGA4521 |
| MPA | 33 - 47 | 27 (27.5) / 36 | 18 | 6 / 400 | TGA4522 |

NOTES: 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) | Part Number |
|---|---|---|---|---|---|---|
| LNA, AGC | 2 - 20 | 19 / – | 17.5 | 2.5 | 5 / 100 | TGA2526 |
| LNA, AGC | 2 - 20 | 16 / – | 17 | 2.5 | 5 / 75 | TGA2513-SM |
| LNA, SB, AGC | 4 - 14 | 6 / 16 | 22 | 2.3 | 5 / 90 | TGA2512-1-SM |
| LNA | 21 - 27 | 10 / – | 21 | 2.5 | 3.5 / 60 | TGA4506-SM |
| LNA | 28 - 36 | 12 / 21 | 22 | 2.3 | 3 / 60 | TGA4507 |
| LNA | 30 - 42 | 14 / – | 21 | 2.8 | 3 / 40 | TGA4508 |

NOTES: SB = Self Biased, AGC = Automatic Gain Control, GB = Gate Bias

## PtP Radio Frequency Converters & Control Products

| Description | RF Frequency Range (GHz) | Conversion Gain (dB) | LO / RF Isolation (dB) | IIP3 (dBm) | Voltage / Current (V / mA) | Part Number |
|---|---|---|---|---|---|---|
| Doubler with Amplifier | 16 - 30 | 18 | 30 | 19 | 5 / 150 | TGC4403-SM |
| Upconverting Mixer | 17 - 26 | -9 | 40 | – | -0.9 / 0 | TGC4402-SM |
| Gain Block & 2x / 3x Multiplier | 17 - 40 | 9 | N/A | 2 | 5 / 140 | TGA4031-SM |

*This table 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.*

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*Exhibitors in bold have an ad in this issue.*

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| ACCEL-RF | 917 |
| Acreo AB | 103 |
| Advanced Control Components | 517 |
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| **Agilent Technologies** | **539** |
| Alfa Microonde Srl | 715 |
| Alroy Microwave Ltd. | 903 |
| AMCAD Engineering | 123 |
| American Technical Ceramics | 1010 |
| **AML Microtechnique Lorraine** | **127** |
| **Analog Devices** | **306** |
| **Anritsu EMEA Ltd.** | **335** |
| **Ansoft** | **939** |
| **Antech SpA** | **901** |
| **Antenna Research Associates** | **708** |
| Applied Thin-Film Products | 715 |
| AR Europe | 707 |
| **AR RF/Microwave Instrumentation** | **707** |
| Arkivator AB | 103 |
| Arlon-Materials for Electronics Div. | 315 |
| **Artech House** | **301** |
| ARVA-RF SARL | 903 |
| **ASB Inc.** | **302** |
| AT Wall Co. | 703 |
| Aurora Software & Testing SL | 307 |
| AVX Corp | 915 |
| **AWR Corp** | **339** |
| BAE Systems | 1106 |
| BEA Coax Srl | 503 |
| BL Microwave Ltd. | 214 |
| BSC Filters Ltd. | 810 |
| Cambridge University Press | 614 |
| CapeSym Inc. | 802 |
| Cascade Microtech Inc. | 539 |
| CELTE SRL | 906 |
| Chalmers Microwave Electronics | 103 |
| **Channel Microwave Corp.** | **107** |
| Chengdu AINFO Inc. | 1020 |
| Chengdu BoCen Microwave | 906 |
| CIMULEC | 127 |
| CISTEME | 123 |
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| CPE Italia SpA | 710 |
| Creowave Oy | 902 |
| **CST-Computer Simulation Tech.** | **527** |
| DAA Sheen Technology Co. Ltd. | 1014 |
| Deltron Italia Srl | 503 |
| **Dielectric Labs Inc.** | **218** |
| Dow-Key Microwave Corp. | 218 |
| DSPM Telecomunicazioni Srl | 1102 |
| Efield AB | 103 |
| Elettronica SpA | 139 |
| EM Research Inc. | 814 |
| EM Software & Systems GmbH | 1108 |
| Emerson & Cuming Microwave | 918 |
| Eudyna Devices International | 701 |
| **EuMW 2010** | **141** |
| European Radio & Microwave | 103 |
| Excelics Semiconductor Inc. | 915 |
| Farran Technology Ltd. | 715 |
| FGAN-FHR | 723 |
| FH Aachen | 908 |
| Finmeccanica | 135 |
| Flann Microwave Ltd. | 1102 |
| Focus Microwaves Inc. | 502 |
| Fraunhofer IAF | 723 |
| GigaHertz Center | 103 |
| GNI Microwave Co. Ltd. | 1002 |
| Gruppo Pasquali | 309 |
| GS Instruments Co. Ltd. | 210 |
| Heuermann HF Technik GmbH | 908 |
| Hirai SK Corp. | 200 |
| **Hittite Microwave Corp.** | **1010** |
| **Huber & Suhner AG** | **507** |
| IHP GmbH | 406 |
| IMS 2010 | 300 |
| **IMST GmbH** | **115** |
| Innertron Inc. | 600 |
| Inoveos Sarl | 123 |
| Integra Technologies Inc. | 906 |
| IPHOBAC | 702 |
| Jazz Semiconductor | 1116 |
| **JFW Industries Inc.** | **804** |
| John Wiley & Sons Ltd. | 402 |
| KDWave SRL | 111 |
| Keithley Instruments Srl | 327 |
| KJ Comtech Co. Ltd. | 602 |
| **KR Electronics Inc.** | **915** |
| **Krytar Corp** | **107** |
| Kyocera Fineceramics GmbH | 610 |
| **L-3 Communications - NARDA** | **706** |
| L-3 Electron Devices | 706 |
| Labtech Ltd. | 711 |
| Linkra Srl | 920 |
| Linwave Technology Ltd. | 814 |
| LP Instruments Srl | 518 |
| **LPKF Laser & Electronics AG** | **1114** |
| **M/A-COM Technology Solutions** | **316** |
| Marki Microwave | 107 |
| Marubeni Techno-Systems Corp. | 900 |
| **Maury Microwave Corp.** | **539** |
| MBDA | 937 |
| MEGA Industries LLC | 903 |
| MEUSONIC | 127 |
| MGC Componenti Srl | 1100 |
| **MiCIAN GmbH** | **618** |
| *Microwave Engineering Europe* | 101 |
| ***Microwave Journal*** | **500** |
| Microwave Marketing Ltd. | 814 |
| Microwave Road | 103 |
| Microwave Vision | 539 |
| Microwavefilters Srl | 703 |
| MiG Microwave Innovation Group | 510 |
| **Mimix Broadband Inc.** | **319** |
| Mitsubishi Electric Europe BV | 923 |
| Momentive Performance Materials | 800 |
| Nagase Europa GmbH | 109 |
| National Instruments | 604 |
| **NMDG NV** | **739** |
| **Norden Millimeter Inc.** | **107** |
| NTT Advanced Technology Corp. | 1004 |
| Officine Pasquali Srl | 309 |
| **OMMIC** | **727** |
| Pacific Millimeter Products | 107 |
| **Pascall Electronics Ltd.** | **519** |
| Passive Plus Ltd. | 906 |
| PERITEST | 917 |
| Phase 2 Microwave Ltd. | 903 |
| Pole ELOPSYS | 123 |
| Radar Systems Technology | 107 |
| Reinhardt Microtech AG | 511 |
| **Remcom Inc.** | **303** |
| RF Microtech | 716 |
| **RFHIC Corp** | **910** |
| RFWave srl | 418 |
| RHe Microsystems GmbH | 509 |
| RJR Polymers Inc. | 715 |
| **Rogers BVBA** | **514** |
| **Rohde & Schwarz GmbH & Co. KG** | **739** |
| **Rosenberger Hochfrequenztechnik** | **117** |
| RTW Ride the Wave Srl | 309 |
| Sage Laboratories Inc. | 400 |
| **San-tron Inc.** | **814** |
| Satimo | 539 |
| Schleifring und Apparatebau GmbH | 719 |
| Schmid & Partner Engineering | 516 |
| SELEX Communications SpA | 135 |
| SELEX Galileo | 135 |
| SELEX Sistemi Integrati SpA | 135 |
| SHF Communication Technologies | 1000 |
| SINCRON Srl | 915 |
| Skycon Kft. | 501 |
| **Skyworks Semiconductor** | **410** |
| **Sonnet Software Inc.** | **311** |
| Southwest Microwave Inc. | 515 |
| Space Engineering SpA | 700 |
| Special-Ind SpA | 1010 |
| Spinner GmbH | 719 |
| Sumitomo Electric Europe Ltd. | 701 |
| Sumitomo Electric Industries | 701 |
| SUSS MicroTec Test Systems GmbH | 1118 |
| Taconic Advanced Dielectric Div. | 317 |
| Tektronix | 907 |
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| **Teledyne Reynolds Ltd.** | **506** |
| Teledyne-MEC | 715 |
| Telemobile Electronics | 901 |
| Telmec Broadcasting Srl | 503 |
| Telprom Srl | 810 |
| TeS Teleinformatica e Sistemi | 700 |
| Thales Alenia Space | 135 |
| TNO Defence, Security and Safety | 933 |
| Trans-Tech | 410 |
| **TriQuint Semiconductor** | **323** |
| TRU Corp. | 400 |
| United Monolithic Semiconductors | 927 |
| Universitat Duisburg-Essen | 702 |
| Valvo Bauelemente GmbH | 903 |
| Varioprint AG | 314 |
| **Vectron International** | **218** |
| Verspecht-Teyssier-DeGroote | 123 |
| Voltronics Corp. | 218 |
| VTT Technical Research Centre | 714 |
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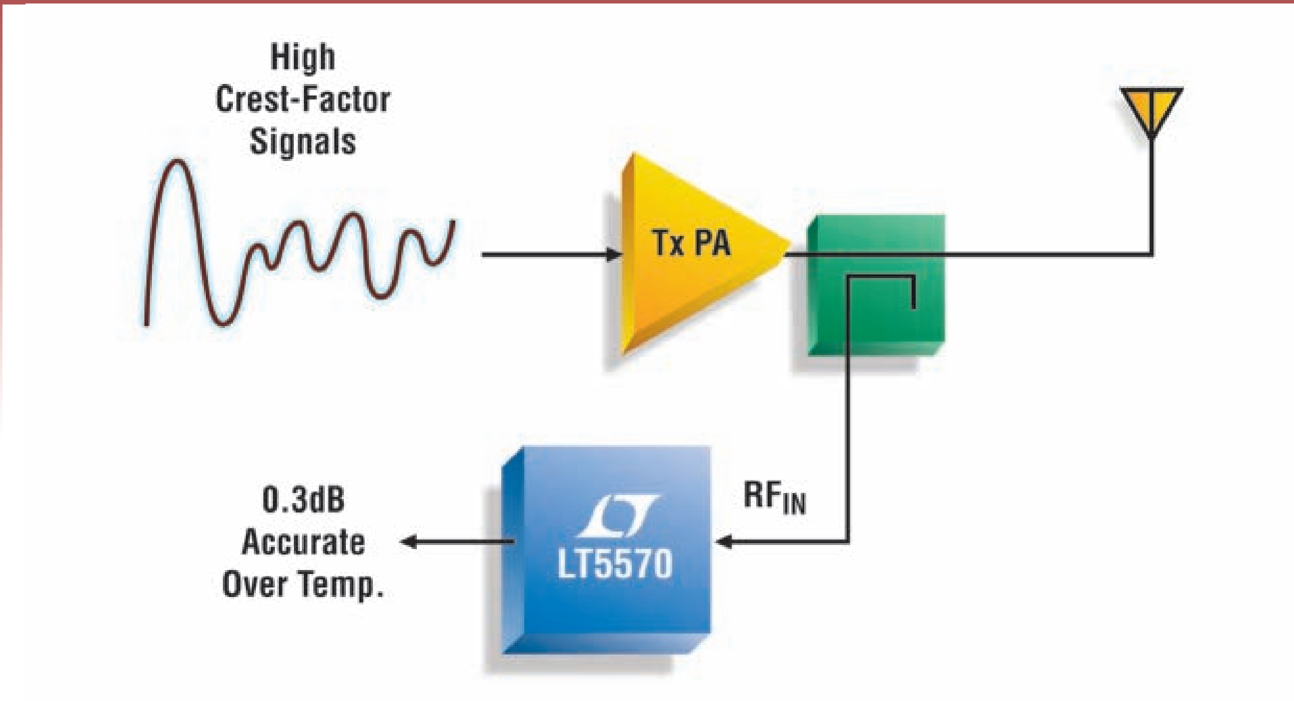


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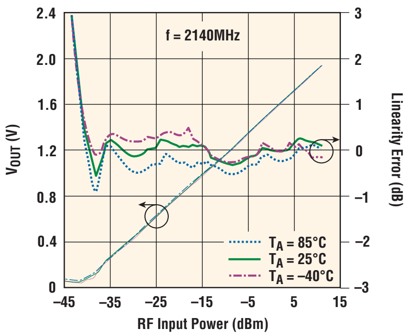


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**Pittsburgh, PA 15219**
**(412) 261-3200 (ph)**

www.ansoft.com

Ansoft, a subsidiary of ANSYS Inc., is the leading provider of electromagnetics and circuit simulation software for RF and microwave design. Ansoft will debut HFSS™ v12 with domain decomposition, a high-performance computing option for the industry standard 3D full wave electromagnetic field simulation software. Ansoft will also demonstrate new integrated multiphysics capability to solve problems such as electromagnetic-induced heating in high-power microwave and RF structures and antenna performance while under mechanical deformation through links with ANSYS® Workbench™.

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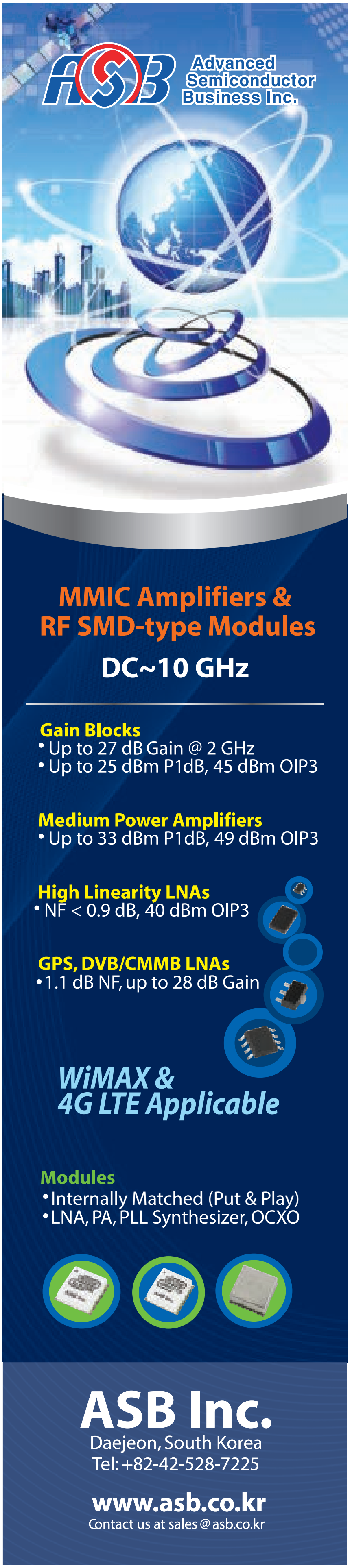




# EXHIBITOR PROFILES

**AR Europe**
**National Technology Park**
**Limerick, Ireland**
**353-61-504300 (ph)**

www.ar-europe.ie

AR Europe distributes broadband, high-power amplifiers from DC to 45 GHz, 1 to 100,000 W; and are primarily used for radiated and conducted susceptibility testing. Available test accessories include antennas, directional couplers, field monitoring equipment, test software and more. We also offer a line of hybrid power modules from DC to 40 GHz, power up to 37 dBm–bring us your system requirements.

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Artech House provides today's professionals and students with books and software from the world's top authorities, from hot areas such as nanotechnology, MEMS, biomedical engineering and GPS/GNSS, to established fields including communications engineering, RF/microwave design and computer security. Artech House publishes the forward-looking titles that engineers need to excel.

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**AWR Corp.**
**1960 E. Grand Avenue, Suite 430**
**El Segundo, CA 90245**
**(310) 726-3000 (ph)**
**info@awrcorp.com**

www.awrcorp.com

AWR®, the innovation leader in high-frequency EDA, improves productivity by dramatically reducing development time and costs for the design of high-tech products employed in wireless, high-speed wired broadband, aerospace and defense, and electro-optical applications. AWR is showcasing a full suite of microwave & RF software products including Microwave Office®, Visual System Simulator™, and Analog Office® design environment as well as AXIEM™ 3D planar EM simulator. Stop by booth #339 for the latest information on all products as well as demonstrations of AWR's innovative technologies such as ACE™, APLAC® and shortly Analyst™. AWR - Advancing the wireless revolution. Learn more today at www.awrcorp.com and www.awr.tv.

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**Brook Road**
**Wimborne, Dorset, BH21 2BJ UK**
**+44 (0) 1202 882020 (ph)**
**Fax: +44 (0) 1202 849401 (fax)**

www.cobham.com

Cobham integrates the experience of some of the most respected leaders in the microwave and communications industry, delivering all classes of high performance RF/microwave and millimeter-wave products, integrated sensor and antenna systems, active and passive components, complex rotating electro-mechanical and microwave components and subsystems, composite products including radomes, microwave and mmWave antennas, RF/EO/IR sensors. Technology from the M/A-COM division includes transmitters, receivers, GaAs, MMICs, cables, and related equipment for signal intelligence.

**Booth No. 935**

# EXHIBITOR PROFILES

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**Bad Nauheimer Strasse 19**
**64289 Darmstadt, Germany**
**+49 6151 7303-0 (ph)**
**info@cst.com**

www.cst.com

CST develops and markets software for the simulation of electromagnetic fields. CST will be previewing CST STUDIO SUITE version 2010, including its flagship product, CST MICROWAVE STUDIO® (CST MWS). 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.

**Booth No. 523–527**

**Dielectric Laboratories Inc.**
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**(315) 655-8710 (ph)**
**(315) 655-0445 (fax)**

www.dilabs.com

DLI has listened to the “Voice of our Customer” for more than 35 years as a preeminent global supplier of Single Layer and Multilayer capacitors, build-to-print thin film circuits and custom thin film applications specific ceramic components such as filters, gain equalizers and resonators. DLI products can be found wherever customization, tight tolerance, unique technologies and exceptional customer service is required. DLI is certified to AS9100 and supplies RF/MW & MMW ceramic components to the Aerospace, Medical, Military, Optical, Semiconductor, Transportation and Wireless Communication markets.

**Booth No. 218**

**Hittite Microwave Corp.**
**20 Alpha Road**
**Chelmsford, MA 01824**
**(978) 250-3343 (ph)**
**(978) 250-3373 (fax)**

www.hittite.com

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/4G, Fiber Optics, Microwave & Millimeter-wave Communications, Military, Test & Measurement and Space markets.

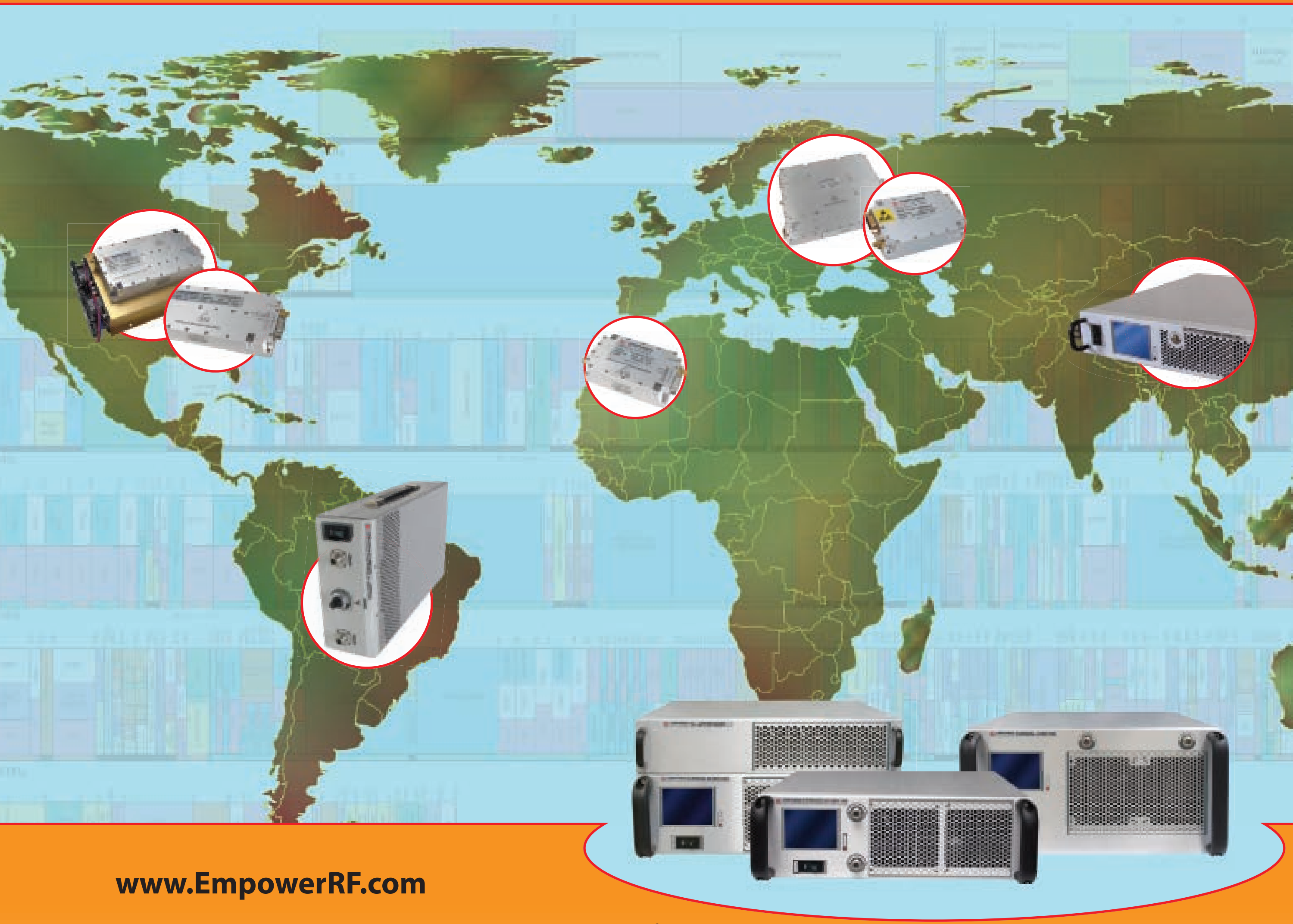
**Booth No. 1010**

**HUBER+SUHNER**
**Degersheimer Str 14**
**Herisau, CH 9100**
**Switzerland**
**othmar.fuchs@hubersuhner.com**

www.hubersuhner.com

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.
**Products:** coaxial, fiber optic and copper cables, cable systems, connectors, wireless ethernet bridges, antennas and lightning protection components.

**Booth No. 507**



# EXHIBITOR PROFILES

**JFW Industries Inc.**
**5134 Commerce Square Drive**
**Indianapolis, IN 46237**
**(317) 887-1340, (877) 887-4539 (ph)**
**(317) 881-6790 (fax)**

www.jfwindustries.com

Introducing the 50S-1820 and 50S-1821 from JFW, our latest innovations in our line of high-power, solid-state RF switches. The 50S-1820 is capable of switching 100 W of RF power from 800 to 2700 MHz (cold switch), while the 50S-1821 will switch 75 W from 800 to 3000 MHz. Both switches boast 10-Microsecond switching speeds and a minimum isolation of 55 dB. Available with SMA, N, BNC, or TNC connectors.

**Booth No. 804**

**M/A-COM Technology Solutions Inc.**
**100 Chelmsford Street**
**Lowell, MA 01851**
**(800) 366-2266 (ph)**
**(978) 656-2804 (fax)**

www.macomtech.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.

**Booth No. 316**

**Maury Microwave Corp.**
**2900 Inland Empire Blvd.**
**Ontario, CA 91764**
**(909) 204-3285 (ph)**
**(909) 987-1112 (fax)**

www.maurymw.com

Maury will conduct demos at Agilent's booth (#539) of two unique breakthrough applications for the NVNA and PNA-X: 1) Maury Load Pull with NVNA X-parameter data extraction providing a simple, effective and instantaneous path from measurement to circuit design, with "drag-and-drop" compatibility to ADS; and 2) PNA-X based noise parameter measurements (patent pending) that yield 100x speed improvement and enhanced accuracy versus the traditional method. These Maury/Agilent applications are perfect examples of Channel Partners working together for your benefit. Maury will also exhibit products with our Italian distributor, CPE Italia SpA (booth #710).

**Booth No. 539**

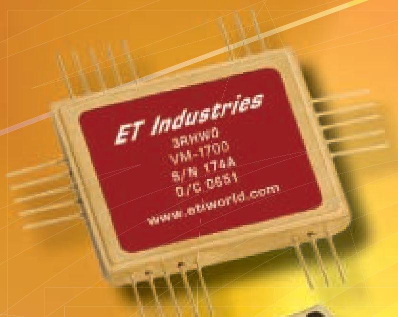
**Mimix Broadband Inc.**
**10795 Rockley Road**
**Houston, TX 77099**
**(281) 988-4600 (ph)**

www.mimixbroadband.com

Mimix Broadband Inc. supplies high performance gallium arsenide (GaAs) semiconductors from DC to 50 GHz for RF, microwave and millimeter-wave applications. We are featuring high power and linear amplifiers covering L-, C-, Ku- and Ka-band with power levels up to 10 W; highly integrated, QFN packaged, Mimix SmartSet chipset solutions; and a new line of linear gain blocks up to 6 GHz. Stop by our booth #319 to celebrate 2009: The Year of MMIX!
**Products**: Power Amplifiers, Receivers, Transmitters, Gain Blocks.

**Booth No. 319**

# Modulators Demodulators




## Vector Modulators

- 360 Degree Phase Shift
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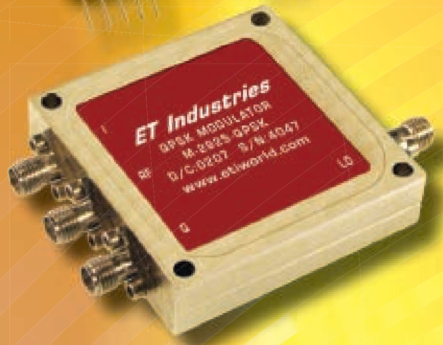


## QPSK Modulators

- 0, 90, 180, 270 Degree Phase Shift
- Built-in Output Amplifier and Low-Pass Filtering


## BPSK Modulators

- 0, 180 Degree Phase States
- Fast Switching Speed


## Demodulators

- I&Q Outputs With Linear Phase

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email: sales@etiworld.com website: www.ETIworld.com


# EXHIBITOR PROFILES

**Narda Microwave - East**
**L-3 Communications Corporation**
**435 Moreland Road**
**Hauppauge, NY 11788**
**(631) 231-1700 (ph)**
**(631) 231-1711 (fax)**
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. 706**

**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. 518**

**REMCOM**
**315 S. Allen Street, Suite 222**
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**(814) 861-1308 (fax)**
**sales@remcom.com**
www.remcom.com

Remcom provides innovative electromagnetic simulation software and wireless propagation tools for antenna design, bio study, MRI, microwave circuits, RFID, military and defense applications, EMC/EMI, and more. Our newly released 3D EM solver, XFdtd 7.0, simplifies the analysis of complex EM problems resulting in faster delivery of your products to the market. Now XF7 includes XStream, our GPU acceleration technology, at no additional cost. Using the power and flexibility of NVIDIA's CUDA architecture, XStream tremendously improves EM simulation performance -- from 30 to 300 times faster than a modern 64-bit CPU. Learn more at www.remcom.com/xf7-freespeed.

**Booth No. 303**

Advanced Circuit Materials Division

**Rogers Corp.**
**100 South Roosevelt Avenue**
**Chandler, AZ 85226**
**(480) 961-8256 (ph)**
**(480) 403-5157 (fax)**
www.rogerscorp.com

Rogers is a global technology leader providing high performance laminates and components for use in high frequency and/or high reliability applications. Rogers will be showcasing its recently introduced RO4730™ LoPro™ and RO3730™ 3.0 Dk antenna grade laminates along with its wide range of products including RO4000® with LoPro, RO3000® and RT/duroid® 5880LZ high frequency laminate materials.

**Booth No. 514**

ROHDE & SCHWARZ

**Rohde & Schwarz GmbH & Co. KG**
**Muehldorfstrasse 15**
**81671 Munich**
**Germany**
**+49 89 4129-0 (ph)**
**+49 89 4129-12164 (fax)**
www.rohde-schwarz.com

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. It has approximately 7500 employees and achieved a net revenue of €1.4 billion (US$ 1.9 billion) in fiscal year 2007/2008 (July 2007 to June 2008). Company headquarters are in Munich, Germany.

**Booth No. 739**

Rosenberger

**Rosenberger Hochfrequenztechnik GmbH & Co. KG**
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**D-83413 Fridolfing, Germany**
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Worldwide operating supplier and manufacturer of RF Coaxial connectors, test, measurement and calibration products, automotive connectors, fiber optic products as well as RF coaxial cable assemblies and site solution products. Founded in 1958. Certified by ISO/TS 16949.

**Booth No. 117**

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**Skyworks Solutions Inc.**
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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 include diodes, switches, power amplifiers, low noise amplifiers, filters, mixers, synthesizers, attenuators, front-end modules, RF subsystems and technical ceramics.

**Booth No. 410**

SONNET®

**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 demonstrates the Sonnet Suites Release 12, with up to 30x or faster analysis over the previous release.

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Zeland Software, Inc. 48834 Kato Road, Suite 103a Fremont, CA 94538 510-623-7162
www.zeland.com

# EXHIBITOR PROFILES

**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. 1010**

**Teledyne Cougar**
**927 Thompson Place**
**Sunnyvale, CA 94086**
**(408) 522-3838 (ph)**
**(408) 522-3839 (fax)**

www.teledyne-cougar.com

Teledyne Cougar Inc. a Teledyne Technologies company, designs and manufactures catalog and custom RF and microwave components and integrated assemblies, including frequency locked oscillators, IFM-based receivers as well as IQ demods, coupled detector assemblies, dual-band VCOs and down-converter assemblies. Our 700+ catalog products cover 100 kHz to 20 GHz and are used in the aerospace, defense and industrial markets. We also offer a full range of die and value-add services, including high reliability screening, parametric testing, environmental screening, chip and wire assembly, die and MMIC packaging and testing, and more. We are certified to ISO9001:2000, MIL-PRF-38534, Classes H & K, and AS9100.

**Booth No. 506**

**Teledyne Electronics and Communications**
**9-13 Napier Road**
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**Cumbernauld, G68 0EF, UK**
**+44 1236 733700 (ph)**
**sales_europe@teledyne.com**

www.teledyne-europe.com

Teledyne Coax Switches and Teledyne Reynolds combine to offer microwave solutions for communications, data interconnections and switching systems with a wide offering consisting of coaxial switches, cable sets and switch matrices. Teledyne Coax Switches have high repeatability documented to 10 million operations. The added differentiators of low losses, triboelectric behaviour and unrivalled passive intermodulation provide designers with performance to meet exacting applications. Teledyne Reynolds UK adds the interconnect and next level solutions capability to the package with its Storm microwave cables, standard and custom connectors, complete cable assemblies and next level design & build capability.

**Booth No. 506**

**TriQuint Semiconductor Inc.**
**2300 NE Brookwood Parkway**
**Hillsboro, OR 97124**
**(503) 615-9000 (ph)**

www.triquint.com

TriQuint Semiconductor designs, develops and manufactures advanced, high-performance RF solutions with GaAs, GaN, SAW and BAW technologies for customers worldwide. We are a market diversity leader, serving customers in mobile handset, automotive, base station, Bluetooth®, cable, GPS, optical, PtP backhaul, VSAT, WiMAX, WLAN and defence/aerospace markets. We offer the industry's largest selection of GaAs and GaN foundry processes, plus comprehensive support. Our award-winning solutions -- built with the industry's largest in-house technology portfolio -- enable quicker design turns, higher performance and a smaller bill of materials. Visit us at Stand 323 and discover your next innovative RF solution.

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**Vectron International**
**267 Lowell Road**
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**(888) 328-7661 (ph)**
**(888) 329-8328 (fax)**

www.vectron.com


Vectron International is a world leader in the design, manufacture and marketing of frequency control, sensor and hybrid product solutions. Vectron solves complex timing, filtering and sensor challenges by delivering customized solutions that speed time to market and offer low total cost of ownership. Vectron uses the very latest techniques in both bulk acoustic wave (BAW) and surface acoustic wave (SAW) based designs from DC to microwave frequencies.

**Booth No. 218**

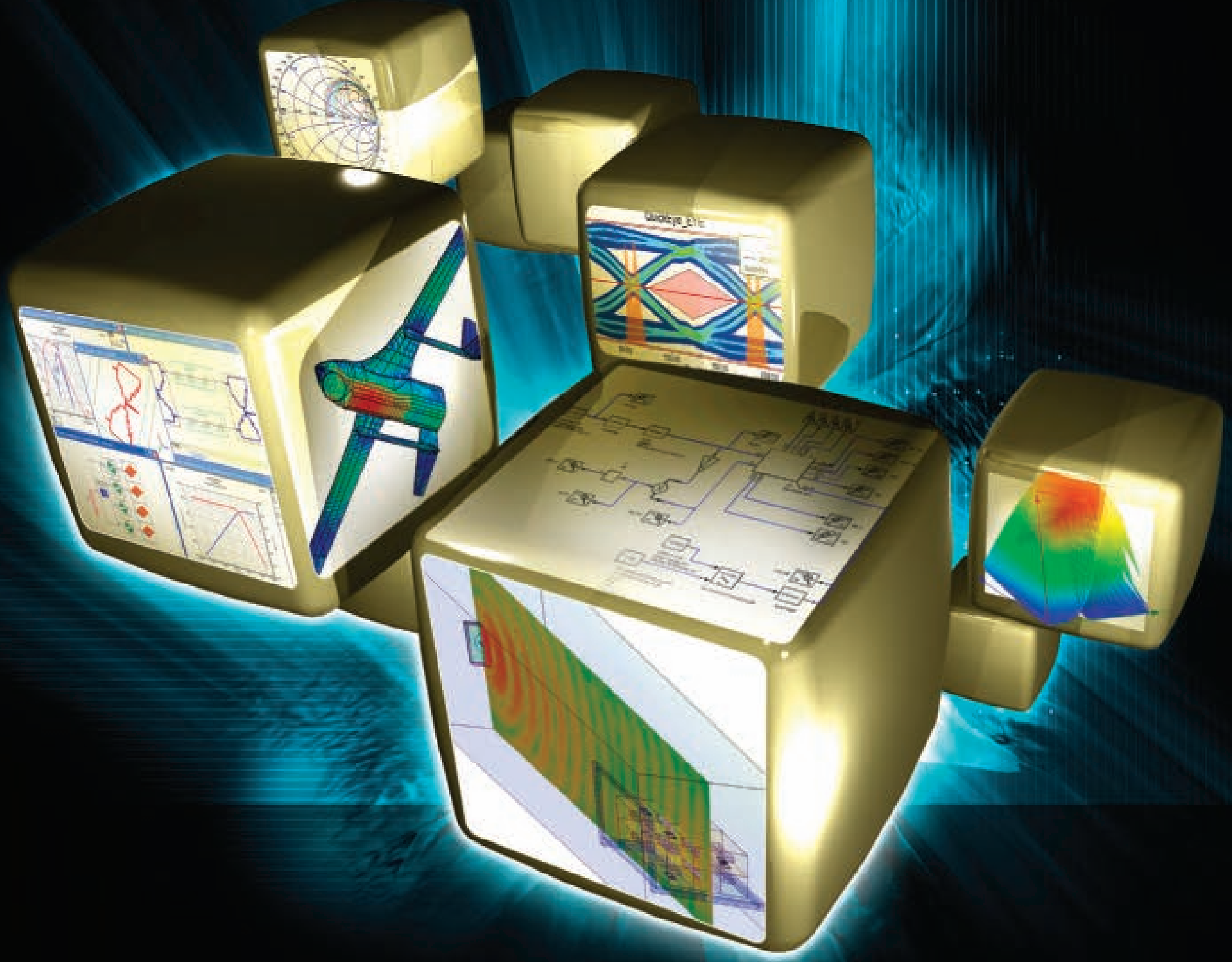
WIN SEMICONDUCTORS CORP.


**WIN Semiconductors Corp.**
**No. 69, Technology 7th Road**
**Hwaya Technology Park**
**Kuei Shan Hisang,**
**Tao Yuan Shien, Taiwan 333**
**+886-3-397-5999 (ph)**
**Info@winfoundry.com**

www.winfoundry.com


WIN Semiconductors Corp., established in October 1999, is the world's first pure-play 6-inch GaAs foundry. WIN has established two advanced GaAs wafer fabs for high volume, RF GaAs MMIC's (monolithic microwave ICs). WIN provides foundry services to fabless design houses and IDM partners. WIN supplies HBT and pHEMT MMIC fabrication services to worldwide IC manufacturers, using state-of-the-art GaAs process technology.

**Booth No. 914**

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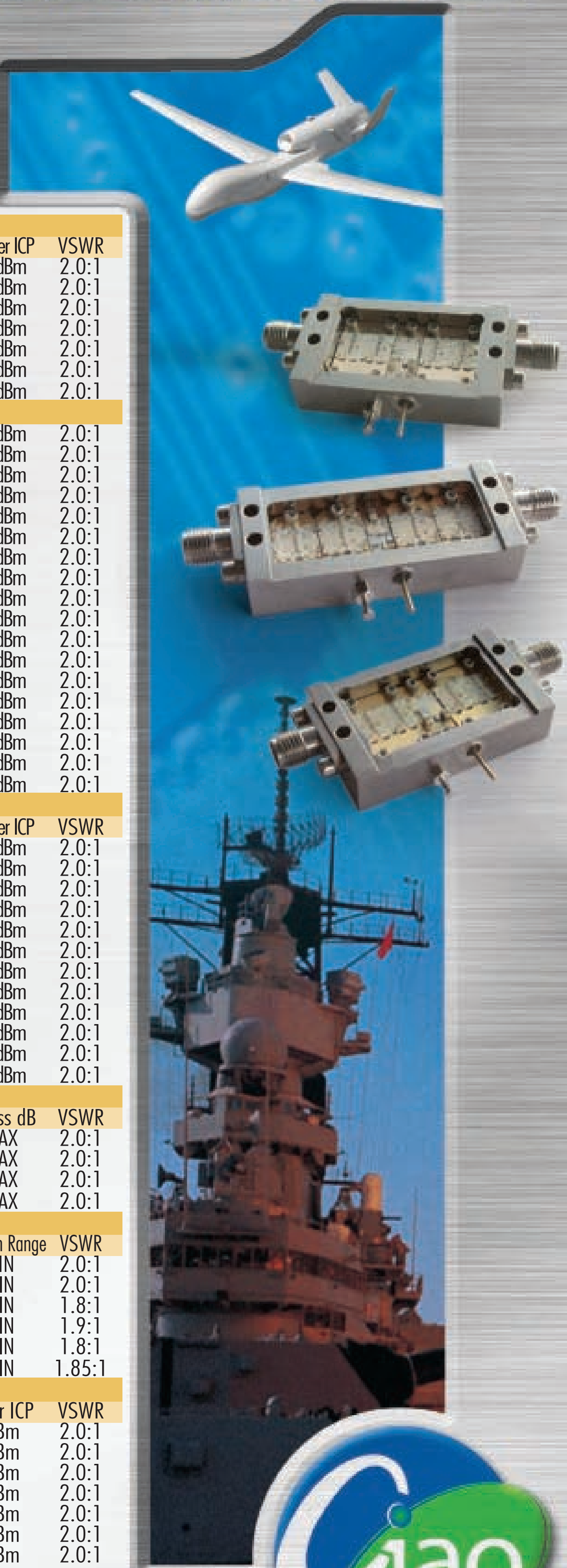

### OCTAVE BAND LOW NOISE AMPLIFIERS

| Model No. | Freq (GHz) | Gain (dB) MIN | Noise Figure (dB) | Power-out @ P1-dB | 3rd Order ICP | VSWR |
|---|---|---|---|---|---|---|
| CA01-2110 | 0.5-1.0 | 28 | 1.0 MAX, 0.7 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA12-2110 | 1.0-2.0 | 30 | 1.0 MAX, 0.7 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA24-2111 | 2.0-4.0 | 29 | 1.1 MAX, 0.95 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA48-2111 | 4.0-8.0 | 29 | 1.3 MAX, 1.0 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA812-3111 | 8.0-12.0 | 27 | 1.6 MAX, 1.4 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA1218-4111 | 12.0-18.0 | 25 | 1.9 MAX, 1.7 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA1826-2110 | 18.0-26.5 | 32 | 3.0 MAX, 2.5 TYP | +10 MIN | +20 dBm | 2.0:1 |

### NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

| Model No. | Freq (GHz) | Gain (dB) MIN | Noise Figure (dB) | Power-out @ P1-dB | 3rd Order ICP | VSWR |
|---|---|---|---|---|---|---|
| CA01-2111 | 0.4 - 0.5 | 28 | 0.6 MAX, 0.4 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA01-2113 | 0.8 - 1.0 | 28 | 0.6 MAX, 0.4 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA12-3117 | 1.2 - 1.6 | 25 | 0.6 MAX, 0.4 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA23-3111 | 2.2 - 2.4 | 30 | 0.6 MAX, 0.45 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA23-3116 | 2.7 - 2.9 | 29 | 0.7 MAX, 0.5 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA34-2110 | 3.7 - 4.2 | 28 | 1.0 MAX, 0.5 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA56-3110 | 5.4 - 5.9 | 40 | 1.0 MAX, 0.5 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA78-4110 | 7.25 - 7.75 | 32 | 1.2 MAX, 1.0 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA910-3110 | 9.0 - 10.6 | 25 | 1.4 MAX, 1.2 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA1315-3110 | 13.75 - 15.4 | 25 | 1.6 MAX, 1.4 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA12-3114 | 1.35 - 1.85 | 30 | 4.0 MAX, 3.0 TYP | +33 MIN | +41 dBm | 2.0:1 |
| CA34-6116 | 3.1 - 3.5 | 40 | 4.5 MAX, 3.5 TYP | +35 MIN | +43 dBm | 2.0:1 |
| CA56-5114 | 5.9 - 6.4 | 30 | 5.0 MAX, 4.0 TYP | +30 MIN | +40 dBm | 2.0:1 |
| CA812-6115 | 8.0 - 12.0 | 30 | 4.5 MAX, 3.5 TYP | +30 MIN | +40 dBm | 2.0:1 |
| CA812-6116 | 8.0 - 12.0 | 30 | 5.0 MAX, 4.0 TYP | +33 MIN | +41 dBm | 2.0:1 |
| CA1213-7110 | 12.2 - 13.25 | 28 | 6.0 MAX, 5.5 TYP | +33 MIN | +42 dBm | 2.0:1 |
| CA1415-7110 | 14.0 - 15.0 | 30 | 5.0 MAX, 4.0 TYP | +30 MIN | +40 dBm | 2.0:1 |
| CA1722-4110 | 17.0 - 22.0 | 25 | 3.5 MAX, 2.8 TYP | +21 MIN | +31 dBm | 2.0:1 |

### ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

| Model No. | Freq (GHz) | Gain (dB) MIN | Noise Figure (dB) | Power-out @ P1-dB | 3rd Order ICP | VSWR |
|---|---|---|---|---|---|---|
| CA0102-3111 | 0.1-2.0 | 28 | 1.6 Max, 1.2 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA0106-3111 | 0.1-6.0 | 28 | 1.9 Max, 1.5 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA0108-3110 | 0.1-8.0 | 26 | 2.2 Max, 1.8 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA0108-4112 | 0.1-8.0 | 32 | 3.0 MAX, 1.8 TYP | +22 MIN | +32 dBm | 2.0:1 |
| CA02-3112 | 0.5-2.0 | 36 | 4.5 MAX, 2.5 TYP | +30 MIN | +40 dBm | 2.0:1 |
| CA26-3110 | 2.0-6.0 | 26 | 2.0 MAX, 1.5 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA26-4114 | 2.0-6.0 | 22 | 5.0 MAX, 3.5 TYP | +30 MIN | +40 dBm | 2.0:1 |
| CA618-4112 | 6.0-18.0 | 25 | 5.0 MAX, 3.5 TYP | +23 MIN | +33 dBm | 2.0:1 |
| CA618-6114 | 6.0-18.0 | 35 | 5.0 MAX, 3.5 TYP | +30 MIN | +40 dBm | 2.0:1 |
| CA218-4116 | 2.0-18.0 | 30 | 3.5 MAX, 2.8 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA218-4110 | 2.0-18.0 | 30 | 5.0 MAX, 3.5 TYP | +20 MIN | +30 dBm | 2.0:1 |
| CA218-4112 | 2.0-18.0 | 29 | 5.0 MAX, 3.5 TYP | +24 MIN | +34 dBm | 2.0:1 |

### LIMITING AMPLIFIERS

| Model No. | Freq (GHz) | Input Dynamic Range | Output Power Range Psat | Power Flatness dB | VSWR |
|---|---|---|---|---|---|
| CLA24-4001 | 2.0 - 4.0 | -28 to +10 dBm | +7 to +11 dBm | +/- 1.5 MAX | 2.0:1 |
| CLA26-8001 | 2.0 - 6.0 | -50 to +20 dBm | +14 to +18 dBm | +/- 1.5 MAX | 2.0:1 |
| CLA712-5001 | 7.0 - 12.4 | -21 to +10 dBm | +14 to +19 dBm | +/- 1.5 MAX | 2.0:1 |
| CLA618-1201 | 6.0 - 18.0 | -50 to +20 dBm | +14 to +19 dBm | +/- 1.5 MAX | 2.0:1 |

### AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

| Model No. | Freq (GHz) | Gain (dB) MIN | Noise Figure (dB) | Power-out @ P1-dB | Gain Attenuation Range | VSWR |
|---|---|---|---|---|---|---|
| CA001-2511A | 0.025-0.150 | 21 | 5.0 MAX, 3.5 TYP | +12 MIN | 30 dB MIN | 2.0:1 |
| CA05-3110A | 0.5-5.5 | 23 | 2.5 MAX, 1.5 TYP | +18 MIN | 20 dB MIN | 2.0:1 |
| CA56-3110A | 5.85-6.425 | 28 | 2.5 MAX, 1.5 TYP | +16 MIN | 22 dB MIN | 1.8:1 |
| CA612-4110A | 6.0-12.0 | 24 | 2.5 MAX, 1.5 TYP | +12 MIN | 15 dB MIN | 1.9:1 |
| CA1315-4110A | 13.75-15.4 | 25 | 2.2 MAX, 1.6 TYP | +16 MIN | 20 dB MIN | 1.8:1 |
| CA1518-4110A | 15.0-18.0 | 30 | 3.0 MAX, 2.0 TYP | +18 MIN | 20 dB MIN | 1.85:1 |

### LOW FREQUENCY AMPLIFIERS

| Model No. | Freq (GHz) | Gain (dB) MIN | Noise Figure dB | Power-out @ P1-dB | 3rd Order ICP | VSWR |
|---|---|---|---|---|---|---|
| CA001-2110 | 0.01-0.10 | 18 | 4.0 MAX, 2.2 TYP | +10 MIN | +20 dBm | 2.0:1 |
| CA001-2211 | 0.04-0.15 | 24 | 3.5 MAX, 2.2 TYP | +13 MIN | +23 dBm | 2.0:1 |
| CA001-2215 | 0.04-0.15 | 23 | 4.0 MAX, 2.2 TYP | +23 MIN | +33 dBm | 2.0:1 |
| CA001-3113 | 0.01-1.0 | 28 | 4.0 MAX, 2.8 TYP | +17 MIN | +27 dBm | 2.0:1 |
| CA002-3114 | 0.01-2.0 | 27 | 4.0 MAX, 2.8 TYP | +20 MIN | +30 dBm | 2.0:1 |
| CA003-3116 | 0.01-3.0 | 18 | 4.0 MAX, 2.8 TYP | +25 MIN | +35 dBm | 2.0:1 |
| CA004-3112 | 0.01-4.0 | 32 | 4.0 MAX, 2.8 TYP | +15 MIN | +25 dBm | 2.0:1 |

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## Harris Receives $44 M from US Air Force

Harris Corp., an international communications and information technology company, has been awarded $44 M in orders to provide JTRS-approved Falcon III AN/PRC-152(C) handheld radios and accessories to the US Air Force. The radios will support the changing communication needs of the entire Air Force enterprise, including Security Forces, Special Operations, Combat Engineers and Air Mobility Command (AMC).

The Air Force is acquiring AN/PRC-152(C) radios along with vehicle adapter amplifiers, base stations and repeater systems for use as core elements of a modern adaptive communications system. The system offers mounted and dismounted forces, secure and reliable extended range communications links among team members and back to the Mission Command Post or Tactical Operations Centers.

The AN/PRC-152(C) offers users a wide range of capabilities such as SINCGARS interoperability, APCO P25, ultra high-frequency (UHF) ground-to-ground line-of-sight communications, HAVEQUICK II, Close-Air Support and programmable encryption. The AN/PRC-152(C) also serves as the handheld-based transceiver of the Falcon III AN/VRC-110, a high-performance, multiband vehicular system that serves as an improved alternative to legacy SINCGARS radios. The radio has been certified as fully compliant with version 2.2 of the JTRS Software Communications Architecture and certified Type-1 compliant by the National Security Agency (NSA).

## Raytheon Awarded Navy Contract for Air and Missile Defense Radar

Raytheon Co. received a $9.9 M contract to perform concept studies for the US Navy's Air and Missile Defense Radar (AMDR).

This radar suite will consist of an S-band radar; X-band radar; and radar suite controller. The system will be scalable to meet the Navy's current and future mission requirements across multiple ship platforms.

AMDR is being developed to fill capability gaps identified by the Joint Requirements Oversight Council in May 2006. A key requirement of the AMDR will be its scalability for installation and integration on multiple platforms. The program will initially support the US Navy's Future Surface Combatant, followed by other ship classes, including the next-generation cruiser, CG(X).

The AMDR S-band component—the initial focus of the concept study—will provide volume search, tracking, ballistic missile defense discrimination and missile communications. The X-band will perform horizon search, precision tracking, missile communications and terminal illumination. The radar suite controller will ensure that both radars operate in coordination across a variety of operational environments.

Under the contract, Raytheon IDS will study the radar's S-band capabilities, as well as the radar suite controller's functionality. IDS will deliver the S-band and radar suite controller conceptual design, systems engineering studies and analyses, and a technology development plan. The majority of work for this contract will be performed at Raytheon IDS' Surveillance and Sensors Center, Sudbury, MA, and is scheduled to be completed by December 2009.

## Space Systems/Loral Selected to Provide Satellite for Telesat Fleet

Space Systems/Loral (SS/L), a subsidiary of Loral Space & Communications and a provider of commercial satellites, announced that it has been selected to provide a satellite for Telesat, one of the world's leading fixed satellite services operators. The new satellite, called Telstar 14R, will replace Telesat's Telstar 14/Estrela do Sul, utilizing SS/L's 1300 bus to deliver high-powered Ku-band services to growing markets throughout the Americas and over the Atlantic Ocean.

"Telstar 14R is the fifth satellite that we will add to our backlog this year, and it demonstrates the versatility of our satellite platform," said John Celli, President and Chief Operating Officer of Space Systems/Loral. "The satellite's five beams and reconfigurable transponder capacity will enable Telesat to address growing demand for broadband and video services in the Americas, and to match satellite capacity to market need."

Space Systems/Loral designed Telstar 14R with five antenna beams that have high-power transponders with substantial on-orbit switching capability. The satellite will provide additional capacity and improved capabilities in its coverage areas, which include: Brazil, the Continental United States (including the Gulf of Mexico and northern Caribbean), the Southern Cone of South America, the Andean region (including Central America and southern Caribbean), and the North and Mid-Atlantic Ocean.

The new Ku-band satellite will replace Telstar 14 at its 63 degrees West orbital location and will have 46 active transponders, of which 27 will be fixed and 19 will be switchable. Telstar 14R is based on the SS/L 1300 platform, which has a long history of reliability and the flexibility for a broad range of applications. Scheduled for launch in the second half of 2011, the satellite is designed to provide service for 15 years or more.

### Advanced Satellite Communications Production Terminals Tested

Raytheon Co. and the US Army recently completed successful testing of the first Advanced Extremely High Frequency, or AEHF, satellite communications production terminals.

Raytheon's Secure Mobile Anti-jam Reliable Tactical Terminal (SMART-T) offers the next generation of protected communications with AEHF satellites. It is the first AEHF system across the US Armed Services to enter production and achieve this first article testing milestone, verifying that it meets all performance, function and production requirements.

The testing follows Raytheon's $97.5 M contract to produce and install AEHF upgrade kits that increase the data rate of existing SMART-T systems four fold. The award, which is part of an indefinite delivery-indefinite quantity contract originally awarded in 2007, increases the total value to $290 M.

"With the cancellation of the Transformational Communications Satellite system, AEHF solutions are more critical than ever," said Jerry Powlen, Vice President, Network Centric Systems Integrated Communications Systems. "Raytheon has shown its commitment to protected satellite communications by providing key AEHF solutions to the US Army, Air Force and Navy."

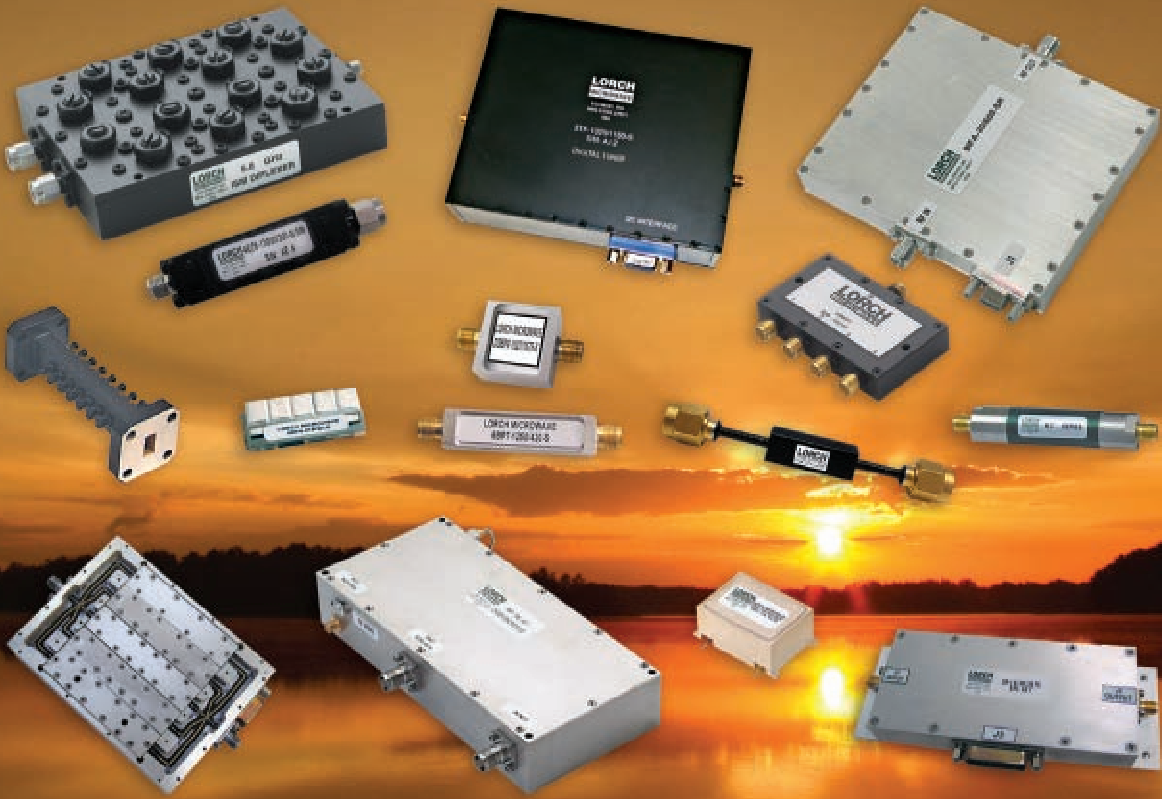
### Herley Awarded IMA Contract for US Electronic Attack Aircraft

Herley Industries Inc. announced that its Herley New England division in Woburn, MA has received an award valued at approximately $16.4 M from a major US prime contractor to manufacture a variety of multi-function integrated microwave assemblies (IMA) for a US Navy electronic attack aircraft.

Richard F. Poirier, CEO and President, commented, "Herley has been producing quality hardware for the US government and its prime contractors for more than 40 years, and Herley New England is a trusted supplier to US prime contractors. This $16.4 M award is the largest single award ever received by Herley. It is the latest in a series of significant orders from this customer for this aircraft, and we look forward to additional annual awards over the next five years."

Poirier continued, "As I assume the role of Chief Executive Officer for Herley, I am very confident that John McClay, Herley New England's new General Manager, and his team will continue to foster and grow this important customer relationship by meeting or exceeding our customer's requirements. John has been the main point of contact on this program for the past three years, and follow-on orders such as this are a clear indication of customer satisfaction."





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| 20 - 75 MHz, minimum | ≥ 40 dB @ 90 MHz & ≥ 50 dB @ 135 - 600 MHz |
| 20 - 115 MHz, minimum | ≥ 40 dB @ 150 MHz & ≥ 50 dB @ 250 - 600 MHz |
| 20 - 150 MHz, minimum | ≥ 40 dB @ 200 MHz & ≥ 50 dB @ 300 - 600 MHz |
| 20 - 220 MHz, minimum | ≥ 40 dB @ 300 MHz & ≥ 50 dB @ 450 - 900 MHz |
| 20 - 335 MHz, minimum | ≥ 40 dB @ 440 MHz & ≥ 50 dB @ 660 - 1400 MHz |
| 20 - 500 MHz, minimum | ≥ 35 dB @ 670 MHz & ≥ 50 dB @ 1005 - 2000 MHz |
| 20 - 700 MHz, minimum | ≥ 40 dB @ 980 MHz & ≥ 50 dB @ 1470 - 2000 MHz |
| 20 - 1010 MHz, minimum | ≥ 35 dB @ 1400 MHz & ≥ 50 dB @ 2100 - 3000 MHz |
| 20 - 1400 MHz, minimum | ≥ 40 dB @ 2000 MHz & ≥ 50 dB @ 3000 - 4200 MHz |
| 20 - 2000 MHz, minimum | ≥ 40 dB @ 2800 MHz & ≥ 50 dB @ 4200 - 5000 MHz |
| 20 - 3000 MHz, minimum | ≥ 40 dB @ 3940 MHz & ≥ 50 dB @ 5910 - 6000 MHz |

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## Global Consortium for European NanoInterface Project

A consortium of leading companies in microelectronics announced a European initiative to improve the efficiency of engineering reliable electronic components as miniaturization reaches the nanoscale. The project, called NanoInterface, has won funding under the Seventh Framework Program for Research and Technological Development (FP7) of the European Union in the Nanosciences, Nanotechnologies, Materials and New Production Technologies programme.

A number of scientific, technological and societal advances are expected, including the development of a multi-scale approach, a shorter time-to-market and fewer redesign cycles for micro-electronic materials, contributions towards the 'zero-defect' objectives of the industry and facilitate the implementation of environmentally friendly materials.

In this multi-scale approach, models at atomic level will be explicitly coupled to state-of-the-art macroscopic (finite element) models. In this 'bottom-up' approach, a user-friendly software tool will be realized, which incorporates chemical, physical and mechanical information from the atomic level directly into the macroscopic models, thereby enabling computational design towards highly reliable metal-oxide-polymer systems for so-called System in Package products: Complex micro-electronic and nano-electronic systems with applications in various industries, such as microelectronics, health and transportation.

The consortium will be led by Philips Applied Technologies and comprises: Accelrys Inc., AMIC GmbH, Centre National de la Recherche Scientifique, Delft University of Technology, Fraunhofer IZM, Georgia Institute of Technology, Honeywell, Infineon Technologies, NXP Semiconductors and St. Petersburg Electrotechnical University.

## TRS Expands NATO Capability

ThalesRaytheonSystems (TRS) has received the approval for replication at eight additional sites across Europe of the NATO Air Command and Control System Level of Operational Capability 1 (ACCS LOC 1) programme.

Currently deployed at five sites in Belgium, France, Germany, Italy and the Netherlands, ACCS LOC 1 will replace NATO's existing air command and control systems in Europe and set new standards of interoperability for air operations with a single, integrated approach to planning, tasking, monitoring and mission execution.

ACCS LOC 1 uses open-system architecture to adapt to changing operational requirements, such as theatre missile defence and network-centric warfare. When fully deployed, NATO member countries will use the same system, and will share operational data over a high-speed communications network.

Air Command Systems International, a ThalesRaytheonSystems company, will deliver the new systems to France, Hungary, the Netherlands, Norway, Poland, Portugal, Spain and Turkey. Work will be performed under two contracts—one for seven sites with the NATO ACCS Management Agency (NACMA), and the other with the French procurement agency—Délégation Générale pour l'Armement (DGA).

"This is a major step toward full deployment of a truly integrated, common air operations management system to support all military air operations across NATO members," said Jack Harrington, Chief Executive Officer of ThalesRaytheonSystems.

## ITU and Qualcomm Provide Emergency Service

The International Telecommunications Union (ITU) and Qualcomm Inc. have reached an agreement to improve emergency communications for disaster preparedness and to coordinate relief activities in the aftermath of a disaster.

Under the agreement, Qualcomm will donate a Qualcomm Deployable Base Station (QDBS), which will enhance the ITU's capacity in deploying mobile telecommunications to assist countries in preparing for disaster and in strengthening response and recovery mechanisms.

Based on 3G CDMA technology, QDBS is a compact, quickly deployable and easy to operate mobile solution for providing first-responder communications. This reliable, responsive and complete cellular system can be forward-deployed to supply vital wireless communications.

"We are delighted by this alliance with one of our development Sector Members," said Sami Al Basheer, Director of ITU's Telecommunication Development Bureau. "QDBS brings with it the wireless technology that is so essential in bridging the telecommunication gap when terrestrial networks are knocked out by natural disasters."

## BAE Systems Teams with Kongsberg in Australia

BAE Systems and Kongsberg Protech Systems have signed a teaming agreement to sell and support Kongsberg's Remote Weapon Stations (RWS) in Australia. Kongsberg is a market leader in Remote Weapon Stations development and production with more than 10,000 systems sold with deployment in 16 countries, including on the Australian Army's ASLAV. It also supplies the US Army with RWS through the CROWS II programme.

A RWS assembly, integration and test facility will be established at BAE Systems Australia's electro-optic facility at Holden Hill in Adelaide. Heavy grade repairs and calibration of RWS electro-optic sensors, precision mechanisms and electronics will also be conducted at this facility. RWS medium grade repair will be undertaken by BAE Systems at the Albury Wodonga Military Area facility and other customer sites.

BAE Systems combines key skills in engineering and systems integration to provide efficient, value for money solutions that ensure the protection of Australia and its defence forces across the maritime, land, air and security sectors. In Australia, the company employs 6,100 people who support customers at more than 70 locations.

Egil Haugsdal, Executive Vice President Kongsberg Protech Systems, said, "Kongsberg looks forward to expanding its global relationship with BAE Systems through this wide ranging RWS agreement for the Australian market."

## UK Innovation Investment Fund Proposals

The UK Department for Business, Innovation and Skills has taken the next step in setting up the UK Innovation Investment Fund (UK IIF), a venture capital fund of funds to support the UK's technology companies. Capital for Enterprise Ltd. will release the Request for Proposals (RFP) for prospective Fund of Fund managers for the UK IIF. The RFP is a key milestone in delivering the fund as it sets out the parameters for the fund and details the information expected from prospective Fund of Fund managers.

The RFP will ask potential Fund Managers to target the sectors of the future, such as life sciences, low carbon, digital and advanced manufacturing. Success in these sectors is key to the UK Government's industrial strategy to create highly skilled jobs as Britain emerges out of the global downturn. The RFP will also ask Fund Managers how they will raise money from private sector investors to create the largest technology Fund in Europe.

The Departments for Business Innovation & Skills, Energy and Climate Change and Health will invest £150 M alongside private sector investment on a pari-passu basis. It is the Government's ambition to leverage enough private investment to create a £1 B 10-year fund.

The UK Innovation Fund will safeguard the Government's record investment in science over the past decade by demonstrating the wealth-generating potential of the UK research base. It will leverage substantial private sector investment and will boost the venture capital and syndication markets in the UK at a time when they are most vulnerable.



## LTE and Chinese Infrastructure Deployments Offer Hope for RF Power Amplifier Markets

While markets for RF power amplifiers continue their slow decline in developed regions, two new developments—the massive wireless infrastructure rollout in China and the approaching wave of LTE deployments in the West—will provide a temporary lift over the next few years, according to the latest ABI Research forecasts. The Asia-Pacific Region, including Japan, presently accounts for nearly 50 percent of the RF power semiconductor devices that are sold into the mobile wireless infrastructure segment.

Although the market for RF power amplifiers has been less affected by the economic downturn than some other electronics segments, it has not been completely immune. The recession's effects have added to the pre-existing gentle contraction of the market to create a somewhat bleak outlook. But now according to Research Director Lance Wilson, "China 'has the pedal to the metal' in its massive wireless infrastructure rollout, and since only some of the resulting demand for RF power amplifiers is being met domestically, it has been a windfall for international vendors."

That demand is expected to buoy the market until at least sometime in 2010, and probably the Chinese deployments will only start to slow in 2011.

And in a happy coincidence for equipment vendors, 2011 is the expected time-frame for LTE deployments in developed countries to really gather a head of steam. "Although LTE has not significantly impacted RF power amplifier and device sales in the near term," says Wilson, "it is going to bolster RF power sales in the wireless infrastructure space from about 2011 on."

## Satellite Sector Revenue Grows 11 Percent Despite Economic Crisis

Euroconsult announced that growth in the fixed satellite market has remained strong despite the adverse economic environment. According to Euroconsult's soon-to-be released report "Satellite Communications & Broadcasting Markets Survey, Forecasts to 2018," the fixed satellite sector grew in terms of both transponder demand (+9 percent) and overall revenues (+10.7 percent) representing a peak in the current decade. Digital entertainment and emerging digital markets remain the primary growth drivers, with corporate networks, military communications and broadband access uptake also contributing to growth.

"Digital TV broadcasting remains the primary growth engine for the satellite sector. Last year, 18 new satellite pay-TV platforms were launched for a total of 109 platforms now in service. Over 24,000 TV channels are now broadcast by satellite, with more than 2,900 TV channels added last year," said Pacôme Revillon, CEO at Euroconsult. "Transponder demand also remained strong for communication services, particularly corporate networks, government communications and cellular backhaul."

Average fill rate for commercially available satellite capacity currently stands at close to 74 percent and may reach even higher in 2009, following a four-year upward trend. This high fill rate is an important factor as it limits competitive pressure between market players, prevents a drop in capacity prices and protects revenue growth and profit margins.

## Semiconductor Opportunity in Microcells, Picocells and Femtocells Shifts to WiMAX

Semiconductor revenue for WiMAX microcells, picocells and femtocells is on course to a 46 percent compound annual growth rate from 2008 to 2013. The segment will pass $1 B by 2013, reports In-Stat. Cellular femtocell semiconductors will be another growth segment for chip vendors. Worldwide cellular femtocell semiconductor revenue is forecast to grow at a CAGR of 260 percent between 2008 and 2013.

"Cellular microcell semiconductor revenue will fall as base station deployments decline and semiconductor ASPs are pressed downward," says Allen Nogee, In-Stat Analyst. "The key for semiconductor vendors is to focus on the growth. Revenue from femtocell semiconductors, for example, will mirror revenue from the femtocells themselves as mobile operators migrate from larger base stations to smaller access points."

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

## New Antenna Technologies Crucial to Future of Cellular

"Antennas for Mobile Devices: New Technologies, New Opportunities," from the Strategy Analytics RF & Wireless Component market research service, explores new antenna technologies and the companies helping to avert an impending crisis in cellphone antennas.

Christopher Taylor, Director of the RF and Wireless Components service and author of the report, stated, "Future cellular devices will have to handle seven or more primary cellular bands, diversity antennas, and three or more bands for connectivity peripherals, placing difficult performance demands on cellular antennas—among these, the need for several small antennas placed in close proximity to each other and the users' head and hand. Device makers hope to avert an antenna crisis by teaming with antenna specialists, such as Laird, Tyco, Pulse, Ethertronics and Skycross, to make use of new antenna technologies that will include tunable and active antennas. If successful, these technologies and companies will help propel the market for antennas for wireless mobile devices to more than five billion units in 2014."

Asif Anwar, Director of the GaAs and High Speed Semiconductor service, added, "As outlined in the report, the new antenna technologies will add a new dimension to the cellular RF front business, affecting power amp, switch-module, filter and chipset suppliers, as well as the way OEMs do business."

## Wireless Operators to Spend $3.3 B on LTE Base Stations

Wireless operators will spend about $3.3 B building Long Term Evolution (LTE) base stations in 2011, according to the most recent study of LTE from ABI Research. That expenditure will have purchased some 142,000 base stations worldwide. LTE base station equipment spending is expected to rise sharply between 2011 and the end of 2012.

"Vendors will be shipping base station equipment in significant quantities in 2010 ahead of limited trials that typically last about a year, followed by full commercial launches," says Senior Analyst Nadine Manjaro. "Many operators have been talking about re-use of existing equipment, but ABI Research understands that while there may be sharing of masts and cabinets most of those 142,000 base stations will have completely new baseband and RF components, because operators will generally try to keep the new LTE networks separate from their legacy networks."

ABI Research Vice President Jake Saunders also points out that, "Due to LTE's propagation characteristics and higher frequencies, operators will eventually have to deploy extra sites to iron out gaps in coverage."

That is good news for base station equipment vendors. Some contracts have already been announced. As noted previously, Alcatel-Lucent, Ericsson and Starent are the winners of a major set of contracts from Verizon Wireless. In Japan, NTT-DOCOMO, in addition to tapping the world's largest network infrastructure supplier, Ericsson, is also supporting local vendors NEC and Fujitsu.

TeliaSonera has chosen Ericsson and Huawei, while its fellow Scandinavian operators Tele2 and Telenor are also thought likely to settle on Huawei, which is proving a formidable competitor.

"LTE – GSM Long Term Evolution" provides insight into a number of operators' strategies, vendor solutions, frequency bands used and latest development in the IPR analysis. A list of all operators with defined LTE plans is also included, along with potential CAPEX spending and a variety of forecasts.

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| Model | Bands | Step Size | BW (GHz) | Typical Phase Noise 10 | 100 | 1K | 10K | 100K | 1M | Output Frequency | Output Power (dBm, Min.) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BTE | L - Ku | 1 kHz | 2.2 | -73 | -80 | -96 | -96 | -97 | -123 | 12.72 GHz | 13 |
| MFS | L - K | 1 kHz | 2 | -60 | -75 | -90 | -95 | -95 | -120 | 5.3 GHz | 13 |
| CFS | L - K | 1 Hz | 2 | -62 | -75 | -85 | -89 | -97 | -110 | 14.84 GHz | 13 |
| Ku3LS | X - Ku | 1 kHz | 2.2 | -62 | -70 | -75 | -85 | -97 | -115 | 12.50 GHz | 13 |
| C3LS | C | 1 kHz | 1.1 | -63 | -88 | -90 | -100 | -100 | -115 | 5.50 GHz | 13 |
| UWB | S - K | 1 kHz | Multioctave | -60 | -71 | -80 | -90 | -96 | -105 | 12 GHz | 13 |
| MOS | VHF - K | 1 kHz | Multioctave | -55 | -65 | -75 | -85 | -90 | -100 | 20 GHz | 13 |
| SLS | L - Ku | 125 kHz | 1 | -70 | -80 | -86 | -88 | -105 | -115 | 3.3 GHz | 13 |
| SLFS | VHF - Ku | 100 kHz | 2 | -70 | -75 | -80 | -90 | -115 | -125 | 5 GHz | 13 |
| LFTS | VHF - Ku | 100 Hz | 1 | -78 | -88 | -98 | -98 | -110 | -130 | 350 MHz | 13 |
| VFS | L - Ku | >25 MHz | 1.5 | -60 | -80 | -110 | -115 | -115 | -130 | 12.5 GHz | 13 |

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## INDUSTRY NEWS

■ **Agilent Technologies Inc.** and **Varian Inc.** announced that they have signed a definitive agreement for the acquisition by Agilent of Varian, a worldwide supplier of scientific instrumentation and associated consumables for life science and applied market applications. Agilent will pay $52 cash per share of common stock for Varian in a transaction that represents a premium of approximately 35 percent to Varian's closing price on July 24, 2009. Both Agilent's and Varian's Board of Directors have unanimously approved the all-cash offer.

■ Bolstering its commitment to grow its managed network services business, **Harris Stratex Networks Inc.**, a provider of wireless solutions that enable the evolution of next-generation fixed and mobile broadband networks, announced the commissioning of its state-of-the-art network operations center (NOC) at its Morrisville, NC-based headquarters. The NOC was inaugurated by Harris Stratex President and CEO Harald Braun. The center will centrally monitor, manage and control networks for enterprise, carrier, and state and local government customers.

■ **Wurth Electronics Midcom** has expanded into a new office suite. The California office suite increased to five times the size of the original space. The new office, located in Milpitas, CA, is base to three field application engineers and four sales managers. For more information: Wurth Electronics Midcom, 1629A South Main Street, Milpitas, CA 95035 (408) 262-4400 or Wurth Electronics Midcom (Corporate Office), 121 Airport Drive, Watertown, SD 57201 (605) 886-4385, (800) 643-2661, midcom@we-online.com, www.we-online.com.

■ **Cadence Design Systems Inc.**, a leader in global electronic design innovation, and **Taiwan Semiconductor Manufacturing Co.** (TSMC) announced a broad expansion of their collaboration to better enable mutual customers to solve the challenges of their latest custom designs, including RF, mixed-signal and custom digital.

■ **Jazz Semiconductor®**, a Tower Group company, and a leader in analog-intensive mixed-signal (AIMS) foundry solutions, and **Entropic Communications Inc.**, a provider of silicon and software solutions to enable connected home entertainment, announced volume production of Entropic's EN4020, the company's new multi-mode hybrid silicon tuner. The EN4020 uses Jazz's cost-effective 0.18-micron CMOS process (CA18QD) and its RF modeling design kit to develop small yet effective inductors essential for silicon tuner products.

■ **BSC Filters**, a leader in microwave and RF filter technology, will be celebrating its 20th anniversary by showcasing its latest products and innovations at EuMW 2009 (stand 810). The company, servicing the international defense, commercial and aerospace industries, will also have engineers available to talk face to face with existing and prospective clients about product capabilities and their diverse applications.

■ **Nearfield Systems Inc.** (NSI) recently commissioned a NSI-300V-12x12, 12' × 12' (3.7 × 3.7 m) planar near-field scanner as part of its in-house test facilities. Use of a 36" pyramidal absorber on the back wall of the chamber permits high quality measurements down to L-band. This system includes an NSI Panther-based RF subsystem that can take measurements over the 2 to 50 GHz range, and supports both pulse measurement capability and multi-port AUT PIN switching for measurement speeds up to 2 million points per second.

■ **RFaxis**, a fabless semiconductor company focused on innovative, next-generation RF solutions for the wireless and connectivity markets, announced that it has filed three patents for its wireless semiconductor solutions internationally and with the United States Patent and Trademark Office. These solutions are poised to replace the existing front-end module technologies used in devices that incorporate wireless capabilities, specifically mobile platforms (including handsets).

■ **RF Industries Ltd.** (RFI) announced that *Fortune Small Business Magazine* has named RFI as one of America's 100 Fastest Growing Small Public Companies in its July/August 2009 issue. The company was ranked 80th on the publication's list, based on its three-year annualized performance.

## CONTRACTS

■ **Cobham** has been awarded US$14.8 M by the Defense Advanced Research Projects Agency (DARPA) for the Wireless Network after Next (WNaN) program. Under this cost plus fixed fee contract, Cobham Sensor Systems in Lowell, MA, will design, develop and demonstrate low-cost wireless network nodes that support adaptation by means of distributed network processing. A key element of the design is affordability, to allow wide deployment throughout the Armed Services. The radios will be demonstrated during follow-on field trials by the Department of Defense in 2010. The US Air Force Research Lab (AFRL/RIKD) is the contracting activity.

■ **AML Communications Inc.**, a designer, manufacturer and marketer of amplifiers and integrated assemblies for the defense industry, announced it has received a $2.2 M order for integrated microwave assemblies to be deployed in Unmanned Aerial Vehicles (UAV). AML has developed the assemblies exclusively for this specific UAV program and will be the sole source supplier of those components.

■ **Teledyne Coax Switches** announced its selection by **Astrium Ltd.**, Portsmouth, UK, as the supplier for coaxial switch blocks to be used on the Alphasat I-XL satel-

lite programme. Alphasat I-XL, one of the world's largest telecommunications satellites, is being built by Astrium for Inmarsat to augment its Broadband Global Area Network (BGAN).

■ **Elcom Technologies Inc.** announced it has been awarded contracts totaling $1 M for the manufacture of synthesizers and oscillators used in UAV and other airborne applications. Elcom's RS series have been integrated into ECM, ESM, SAR, FCS platforms by both foreign and domestic manufacturers.

■ **Micronetics Inc.** announced that it has received an order in excess of $750K for initial beta testing with a major retailer for its forklift mounted radio frequency identification (RFID) antenna sensor system. The forklift sensor system has recently completed a successful pre-production test phase, and will now begin beta testing with deployments over the next several months. These beta test sites represent approximately 7 percent of the retailer's total locations. This order is a portion of a purchase agreement containing an option for full scale production roll-out upon successful completion of this phase.

■ **Aviel Electronics**, a division of RF Industries Ltd., announced it has been awarded an initial $268,000 production order for a custom designed SMB connector from Zargo Technologies, a Canadian Electro-Mechanical Distributor. The initial order of 10,000 connectors is expected to be substantially delivered in RFI's current fiscal year ending October 31, 2009.

■ Broomfield electronics engineering design firm, **Advantage Electronic Product Development**, has recently begun the first-phase design of an instrument that will be used initially to help protect astronauts on the International Space Station and in later phases, ultimately, astronauts venturing out on deep space flights.

■ **OEwaves Inc.** has been awarded a DARPA contract to develop and demonstrate an all-optical atomic clock with drastically reduced size, weight and power (SWaP) over state-of-the-art primary time and frequency standards. OEwaves will develop the clock with support from the Aerospace Corp. The OEwaves clock will be based on the novel technology of Kerr optical frequency combs generated in a WGM crystalline micro-resonator, recently demonstrated at OEwaves, and will represent a compelling approach to fully meet the stringent performance goals of all three phases of the program. The complete program has a potential total value of approximately $8 M.

## PERSONNEL

■ Custom MMIC Design Services Inc. (CMDS), a designer and developer of custom monolithic microwave integrated circuits, announced **David Folding** has joined the company as its Vice President of Operations. Prior to joining CMDS, Folding was Product Line Manager for the Asia-Pacific

GaAs/SiGe IC Product Line of M/A-COM Inc. In this capacity, he developed key strategic customer relationships that resulted in a substantial increase of market share and profitability within the commercial wireless and infrastructure components business segments. Prior to M/A-COM, Folding served as Manufacturing Manager at Hittite Microwave Corp., where he led the growth of the standard product lines from $2 M/year to $20 M/year over a four-year period.

■ SRC (formerly Syracuse Research Corp.) welcomes **Jack LoSecco** as a new Product and Service Area Director. LoSecco will oversee the management of SRC's defense and intelligence programs focused on chemical/biological defense, counter-improvised explosive devices, cyber security, and decision support systems. In this new position, LoSecco will act as the Strategic Director for multiple business units within SRC. He will oversee technical managers, develop business plans and budgets, and assist with staff management. LoSecco will also participate in opportunity identification and qualification, proposal development, and customer relationship management for the company's information science and engineering programs.

■ Integra Technologies announced that **Brian Battaglia** has joined the company as Sales and Marketing Manager. He comes from HVVi where he was assigned to Applications Engineering and Technical Marketing since 2007. Previously he was with Freescale Semiconductors in a multitude of technical and marketing roles.

■ LadyBug Technologies LLC announced the appointment of **Paul Schmitz** as the company's Vice President of Sales and Marketing. In his new position Schmitz will hold responsibility for LadyBug's overall sales and marketing strategies worldwide, and will oversee the company's direct sales force. Prior to joining LadyBug he served as Senior Product/Platform Manager for Agilent Technologies' Microwave Signal Generator business sector, Santa Rosa, CA.

▲ *Paul Schmitz*

■ Empower RF Systems, a manufacturer of solid-state power amplifiers and amplifier-based solutions, announced the addition of senior level RF talent as part of its ongoing commitment to growth and customer support. **Paulo Correa** will be joining the Empower RF Systems Senior Leadership Team as the Vice President of Engineering. Correa has over 30 years experience in senior leadership, executive and strategic roles, and is bringing special expertise in addressing amplifier requirements for broadband wireless, multimedia and broadcast applications.

■ DYMAX Corp., a manufacturer of advanced light-curable adhesives, coatings and curing equipment, announced the appointment of **Charles Smart** as Director of Engineering in the Curing Equipment Department. In his new position, Smart will be responsible for leading the Engineering Team to continue to support sales and marketing in the design and development of new and innovative light-curing adhesive equipment.

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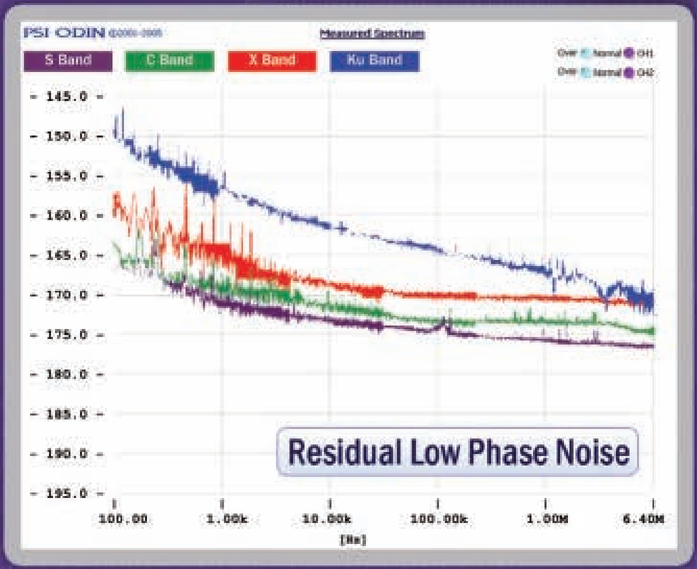


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## REP APPOINTMENTS

■ **RF Monolithics Inc.** (RFM) announced the appointment of **Jay Stone & Associates** as the company's authorized sales representative in northern California and northern Nevada. The addition of Jay Stone & Associates is an action in the RFM sales strategy to penetrate key markets through top high technology sales representation firms. Jay Stone & Associates will be covering all business opportunities for all channels—OEM direct as well as through distribution.

■ **RFMW Ltd.** and **Telemakus LLC** announced a worldwide distribution agreement. Under terms of the agreement, RFMW will market and sell the complete line of Telemakus USB controlled RF test and measurement products. RFMW Ltd. is a specialized distributor that provides customers and suppliers with focused distribution of RF and microwave components as well as customer-specific component-engineering support. Telemakus is an RF design services company with unique insight into customer requirements.

■ **Norden Millimeter Inc.** welcomes **MaxTech Marketing Ltd.** as the company's manufacturer representative for the Ohio Valley territory, including the states OH, MI, IN, KT and western PA. Located in California, Norden's complete line of microwave and millimeter-wave products will be represented. Norden manufactures amplifiers, frequency multipliers, frequency converters, RF switches, switched filters, transceivers, VCOs, DROs and custom integrated assemblies. More information can be obtained at www.nordengroup.com.

■ **Eclipse Microwave Inc.**, a manufacturer of RF and microwave mixers, detectors, limiters and equalizers for the commercial and military industry, announced the appointment of **JayTech Sales** as the New England sales representative. Based in Dracut, MA, JayTech Sales is also a supplier of precision microwave connectors, amplifiers, oscillators, attenuators, couplers, ferrite devices, discrete components, data connectors and specialty microwave materials. JayTech Sales has over 30 years of direct sales and engineering experience in the RF and microwave industry. Contact Rich Jerome at (617) 901-6014 or via e-mail at richjerome@comcast.net.

■ **StratEdge** announced that **Omniscient Electronics Pvt. Ltd.** will represent StratEdge in India. Omniscient is a semiconductor distributor in India, working with semiconductor manufacturers, OEMs and EMS providers on a local and regional basis. Omniscient will handle sales and technical support for StratEdge's complete line of DC to 50+ GHz packages and assembly and test services. For more information, contact Omniscient Electronics Pvt. Ltd., No. 507, 9th Main, Banashankari 2nd stage, Bangalore 560070, India, Tel. 080-26718144 or e-mail: prasad@omniscientelectronics.com.


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| MCA1-85 | 7 | 2800-8500 | 5.6 | 38 | 8.95 |
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# MICROWAVES IN EUROPE: UPBEAT DURING THE DOWNTURN?

*The end of 2008 and the beginning of 2009 saw the global recession take hold. This report considers the current state of the European RF and microwaves sector, how the EU is taking collective responsibility, the technological developments necessary to take the industry forward and asks if there are concrete reasons to be upbeat in the downturn.*

The economic downturn has impacted governments, industries, companies (large and small) and individuals. The RF and microwaves industry is no exception and while its diversity means that some sectors have faired better than others, very few have remained unscathed. Unfortunately, for many companies the terms restructuring, rationalisation and cost cutting have become all too familiar. After a period of sustained prosperity and growth the sudden and widely unpredicted slowdown has meant that the realities of depressed markets, currencies under pressure and a tougher credit environment have hit hard.

However, having survived the body blows, the companies and organisations that have acted quickly to put recovery plans in place, secured the necessary funding and implemented procedures for consolidation are in a position to look forward. Indeed, at the time of going to press, there are signs that the second and third quarters of 2009 have seen improvement and slight but perceptible market growth in some sectors. However, it is too early to say whether the green shoots of recovery have even broken the surface and the blossoming stage is definitely a long way off.

We did not see the recession coming, so predicting the future is difficult and probably foolhardy. That said, from a European perspective, there can be some optimism, mainly because most governments have taken positive action and European Union initiatives that have been put in place over recent years to stimulate and sustain academic and industrial growth are continuing to receive funding and support.

The governments of the major countries have put stimulus packages in place to aid industry in an effort to maintain employment, encourage apprenticeships and training and support the ongoing research and development that is necessary for growth. In recent years, to address increased global competition, especially from mass production, low cost Asian manufacturers, Western Europe in particular, has had to adapt, realign and focus on its strengths. Eastern Europe has evolved at a pace and contributes to the overall European economy, both as a growing consumer market and a competitor to traditional, established companies worldwide.

Although there have been traditional distinctions between east and west, Europe is a union of countries, where links have become stronger and great effort has gone into creating an inclusive,

RICHARD MUMFORD
Microwave Journal *International Editor*

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The latest initiative is to designate 2009 as the European Year of Creativity and Innovation. Its aims include raising awareness of the importance of creativity and innovation for personal, social and economic development; to disseminate good practices and stimulate education and research. Through concrete initiatives the goal is to aid the revival of the EU economy and complement existing programmes. These include the Enterprise Europe Network, aimed at providing funding and support for small to medium-sized enterprises (SME), the European Research Area (ERA) that was set up to provide a coordinated framework for research and the 7th Framework Programme (FP7), which has ongoing and proposed projects, some of which specifically target the RF and microwaves sector.

In the current economic environment, the main priority is survival but once that has been secured, industry and the individual companies and organisations of which it comprises must move forward. And collectively, one of the determinants of the success and progression of any industry is how effectively it develops new technology, exploits it and adapts it to the reality of the marketplace.

A good barometer of the current state of the industry will be European Microwave Week (EuMW) in Rome in September, which will be the first major European RF and microwaves event since the downturn. The indicators from the Week are encouraging with a record number of papers being submitted to the four individual conferences, allied to a fully subscribed European Microwave Exhibition that is sold out.

In this report, the individual conference chairmen each present an overview of their market sectors, complemented by a commercial perspective (published online) as executives of companies that play a key role in the European microwave industry contribute to the Company Survey.

In order to provide a context for these opinions let us first consider the political, commercial, technological and market conditions in which the European microwave industry is operating.

## EUROPEAN PERSPECTIVE

Europe is an amalgamation of different countries whose individual rates and extent of industrial development have been shaped by their unique economic and political circumstances. It has been easy and convenient to polarise the continent as east and west. Due to its high labour and production costs Western Europe struggles to compete with more economically viable locations such as Eastern Europe and the Far East with regards to volume production. Instead it has focused on a rich resource of technical skills and expertise to become a hub for research and development and a source of value added products.

Conversely, the driver in Eastern Europe is manufacturing, which is taking advantage of relatively increased costs in Asia to attract investment in the region, often with the incentives of tax rebates and governments facilitating special economic zone allocations. Add to that the advantages of a trained workforce and reduced working capital. Even in today's marketplace new avenues are opening up as relatively established manufacturing bases such as the Czech Republic, Poland and Hungary are being joined by the likes of Bulgaria, Romania, Belarus, Estonia and Turkey.

Industrially, individual countries plough their own furrows but there is strength in numbers and Europe is a Union of countries that can pool resources and work together for mutual and collective benefit. This is particularly pertinent to the development of technology and research, which is at the core of the EU's strategy to deliver growth, competitiveness and employment while maintaining social and environmental sustainability.

The EU continues to instigate, fund and drive initiatives aimed at invigorating research, technological development and support business, which has never been more needed than in the prevailing climate. One such initiative is the European Research Area, which was established to tackle the problems of insufficient funding, lack of an environment to stimulate research and exploit results, the fragmented nature of activities and the dispersal of resources.

A keystone for the European Research Area, but more specific to industry, is the 7th Framework Programme, which lies at the heart of the European Union's Lisbon Strategy to become the "most dynamic competitive knowledge-

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based economy in the world". FP7 is an umbrella for all research-related EU initiatives to stimulate growth, competitiveness and employment, alongside the Competitiveness and Innovation Framework Programme (CIP) and Education and Training programmes.

The latest EU initiative, launched in 2008, is the Enterprise Europe Network. Its main aim is to inform SMEs of funding opportunities, help them apply for funding and offer advice on EU legislation and policies. The Network brings together business and research, facilitates the search for partners in other countries and promotes the transfer of technology from the drawing board to the marketplace.

To ensure wide coverage, the Network is composed of 600 local partner organisations, including chambers of commerce and industry, research and development organisations, universities, regional development agencies, national SME associations, regional governments and national state banks. Since its foundation it has become a point of reference in cross-border and EU-related matters for companies in more than 40 countries.

## RF & MICROWAVES

RF and microwaves technology is a varied, broad, multidisciplinary field encompassing components, systems and sub-systems, infrastructure, materials, integrated circuits, semiconductors, etc. It serves communications, telecommunications, industrial processing, automotive, satellite, aerospace and defence and security.

Amid such diversity the European initiatives outlined above provide a framework for interaction and cooperation to enable SMEs, large companies, universities and research institutes to have access to the theoretical and practical expertise that will enable technology to be developed and commercially exploited.

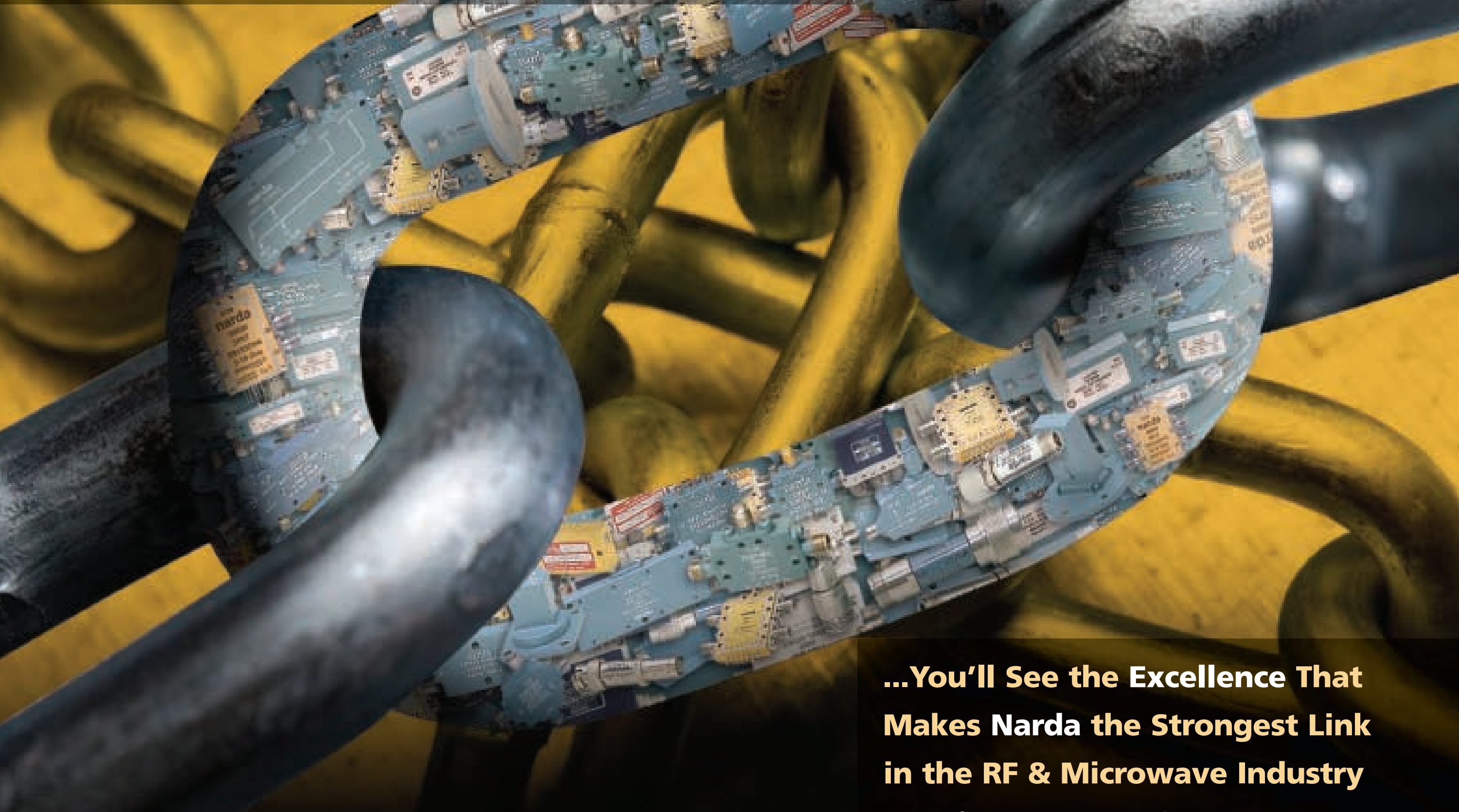
In the present climate market driven products such as sensors, RFID, automotive radar and UWB warrant particular attention, while Europe can use its expertise and development skills to gain a technological advantage and a commercial foothold in emerging markets such as the environment, public safety, security and crisis management, and the life sciences.

These next generation microwave technologies have the potential to create more product and research opportunities and the key drivers for the modern RF and microwaves industry are to increase the overall systems' performance and functionality, while lowering costs.

There are certain areas of development where, with the right investment of effort and resources, Europe can take the lead. Millimetre-wave technology is a prime example—work on integrated solutions that will enable scalable, tuneable multi-band and multi-beam techniques such as phased arrays will have wide applications, as will mm-wave wireless systems for indoor connectivity and high data-rate outdoor communications. Add to that, applications in traffic management, safety systems, RFID and sensor networks. Indeed, the development of intelligent, multifunctional sensors could see sensors working together in advanced networks, creating reconfigurable arrays.

Also, Terahertz systems are beginning to appear on the commercial market, aimed at imaging and spectroscopic

# Take a Closer Look...



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applications for safety, security and environmental surveillance, with the life sciences also being a rich field of application.

In the materials, ICs and semiconductors sector, there have been impressive recent results regarding high frequency CMOS and SiGe semiconductors and devices and the prospective development of these technologies will shape the future of the telecommunications market. In the future low-cost, silicon-based, mass market exploitation of large amounts of bandwidth at 60 GHz and above will influence the advancement of wireless connectivity, sensor networks, traffic management and e-safety.

On a wider, collective front, European fabless companies are developing a common strategy through the constitution of a European Network of Excellence. It is through such action that the RF and microwaves industry as a whole is attempting to weather the economic storm.



## WIRELESS TECHNOLOGIES

In terms of innovation and development the wireless technologies market can be vigorous and exciting, but such dynamism also makes it one of the most difficult to predict. The European mobile communications market is saturated, although there is scope for expansion in parts of Eastern Europe such as Bulgaria, Czech Republic, Hungary and Kazakhstan, while some Central European operators have expanded into Eastern Europe to take advantage of lucrative neighbouring markets.

In general, growth is coming from the 3G sector as operators encourage subscribers to migrate from GSM networks so that they can exploit their investments in high-speed packet access (HSPA) technology and consumers take advantage of faster networks. Operators are expected to maximise their HSPA deployments before deploying 3G LTE, but some might go straight down the 3G LTE path in order to take advantage of the technology's greater potential.

The first networks based on LTE technology are predicted to become commercial at the end of 2009 and into 2010, with the latest analysis from Frost & Sullivan predicting that, in Western Europe, by 2013 there will be around 22.4 million 3G LTE subscribers with service revenues totalling €9,685.4 million.

However, such growth raises technological issues with operators needing to upgrade their backhaul in order to supply greater capacity, with the deployment of high-capacity point-to-point microwave links and relays for backhaul being one option. Another is to employ 3G LTE-enabled femtocells, but there would be issues concerning interference levels between the femtocell and macrocell and such next-generation multi-hopping wireless networks will require low-power low-cost transceivers that can operate in a high interference environment. Also, backhaul for wideband access is an issue in regions where fixed cable solutions are not available, which has opened up a market for low cost equipment.

Other emerging technologies receiving attention include cognitive radio, the deployment of which will require fully flexible self-tuning RF transceivers, Ultra Wideband (UWB) and MIMO. The latter, for example, offers the possibility of achieving significant increases in data throughput and link range without ad-

ditional bandwidth or transmit power, which would enable next generation wireless systems. Even more futuristic, but on the development agenda, is Body-Area Networks deployed on the human body for communication and monitoring purposes.

## ICS & SEMICONDUCTORS

The European semiconductor market has been hard hit by the economic downturn, with the exchange rate imbalance of the Euro against the US dollar having significant impact in this sector. At the time of going to press the latest figures from World Semiconductor Trade Statistics (WSTS) were for April 2009 and showed that for that month European semiconductor sales amounted to $2.168 B, which corresponds to a decline of 35 percent compared to the same month last year and is down 0.9 percent on the previous month. On a YTD basis semiconductor sales declined by 34.3 percent in 2009 compared to the same period in 2008.



Measured in Euros, semiconductor sales of €1.666 B in April 2009 were down 0.6 percent on the previous month and down 23.5 percent compared to the same month last year. On a YTD basis semiconductor sales declined by 24 percent in 2009 compared to the same period in 2008. The only encouraging results concerned communications and automotive applications specific analogue chips that grew by 19 and 6 percent, respectively.

To offer a global context, worldwide semiconductor sales in April 2009 were $15.638 B, up 6.4 percent on the previous month. Compared to the same month in 2008, there was a decline of 25.1 percent and on a YTD basis there was a decline of 26.5 percent. The WSTS expects the market to have reached the bottom of the current cycle during the first half of 2009 and sees positive growth beginning in the first quarter of 2010.

With regards to materials, GaAs microwave ICs will capitalise on their high voltage, high power and wide bandwidth capabilities to remain the key building blocks for microwave electronics and millimetre-wave systems. GaN combines high breakdown voltages at high temperatures with high carrier mobility and this combination of frequency and power properties makes it particularly suitable for military and defence applications. Silicon-based processes and devices combine low cost and ease of on chip integration of analogue and digital functions, while the automotive industry is looking to Silicon Carbide technology to replace silicon bipolar junction transistors.

## DEFENCE

The defence sector operates under different criteria to other sectors, which, to a certain extent, can protect it from the vagaries of the economic downturn. It may be true that military contracts tend to be long-term and driven more by the objective rather than commercial considerations but value for money has become increasingly important. The military has been affected by pressures on public spending and defence is constantly under review.

Recent history has shaped Europe as an eclectic mix of established military powers, combined with emerging nations that have resulted from the break up of the Europe Block. Global terror-

ism, regional conflicts and peace keeping engage coalition forces and their allies, while home and border security are a concern for all.

At the forefront of European defence is the European Security Strategy document in which the EU clarifies its security strategy, which is aimed at achieving a secure Europe, identifying the threats facing the Union, defining its objectives and setting out the political implications for Europe. Key objectives include, addressing threats, building security in the EU and an international order based on effective multilateralism.

Allied to this strategy is the European Security and Defence Policy (ESDP), which is celebrating its tenth anniversary. It aims to allow the Union to develop its civilian and military capacities for crisis management and conflict prevention at international level, thus helping to maintain peace and international security, in accordance with the United Nations Charter. Over the last decade the ESDP has developed as a means of enabling Europe to project itself through action in response to crises and play an important role in the management of global challenges.

To face such challenges Europe must use its technological strengths to build the capability for deploying significant resources for peacekeeping, humanitarian aid and military support. To achieve this requires an optimal use of resources, the development of European industrial capabilities and a collective approach. The 7th Framework Programme and the European Security Research Programme (ESRP) are specific EU initiatives that will help achieve that.

In modern combat, technology has become a weapon that is increasingly being investigated and deployed, often utilising methods and systems developed for the commercial market. Network-centric operations are to the fore and communication technology is playing a significant role on the battlefield, where the information advantage is being exploited for Intelligence, Surveillance and Reconnaissance (ISR). Communication architectures, which interconnect intelligence sources, decision makers and units in the field in a system of systems offer increased situational awareness and simplify the transfer of information.

Today's military also demands communications-on-the-move (COTM) and the utilisation of military satellites to facilitate enhanced situational awareness in real time, while in transit, has become critical for mobile command and control operations. Prevalent issues include the reduction of size, weight and power consumption and the need to ensure interoperability. Technology is also moving COTM solutions on through the improvement of satellite network communications protocols and the development of antennas.

## MICROWAVES IN EUROPE ONLINE

The Chairmen of the four individual EuMW conferences offer overviews of their particular market sectors, examining how technology is currently developing and identifying likely future areas of activity. A view from the 'coal face' of current market conditions is offered via the Company Survey of executives from companies representing a wide cross section of the European RF and microwaves industry. Go to www.mwjournal.com/mweu09 to read the overviews and surveys. ■

# A NEEDLE IN A HAYSTACK: OPTIMIZING MIXER SELECTION USING PROGRESSIVE NEW TOOLS

**EXECUTIVE INTERVIEW SERIES**

**HARVEY KAYLIE, MINI-CIRCUITS. VISIT WWW.MWJOURNAL.COM FOR MORE INFORMATION.**

*Bob is asked to develop a new radio system design, with some tough goals on RF performance and power consumption. Like many RF engineers, Bob has never really been comfortable with mixers. There is something mysterious about how they convert one frequency to another, and his formal education only covered them briefly; you know, the Taylor series expansion of the diode curve with two sine waves. His design experience and wisdom of his colleagues leads him to a simple rule of thumb: If you need good linearity and IMD performance, use a high LO mixer. But a high LO mixer requires a big LO booster amplifier, and that means more power consumption. Bob's problem is how to distribute the gain and power in his radio design to get the needed linearity and still use the lowest power.*

*Bob's design (see* ***Figure 1****) has goals that include frequency response and IMD performance; his key goal is +22 dBm IP3 at a frequency of 2.5 GHz. He starts with a Web search for mixers, and finds a lot of results, so he picks a few sites and starts looking over spec sheets. He is determined that he can only afford around +7 dBm from his LO drive, but needs good IP3 for his application. He starts to search through data sheets and nothing really meets his needs; all the level 7 mixers have low IP3. What he finds is that he needs high level mixers, +13 dBm or higher, to achieve his IP3 specs, but that is going to require an additional amplifier and he cannot afford the power.*

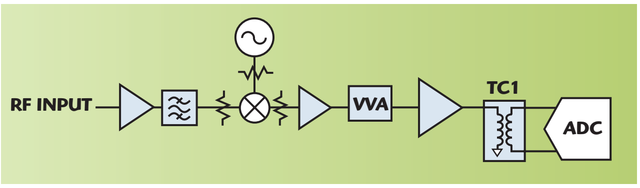


*Fig. 1 System block diagram of a receiver.*

Let us talk about the skills and knowledge needed to work out a design; the skills required depend upon a wealth of experience in device or components selection, which not all designers possess. For example:

- The ability to predict how components perform given the stimulus of the specific system, understanding that some of the parameters do not change as you may think (this might be particularly troublesome for distortion parameters).
- Even components with similar or the same high level specifications, e.g. "level 7 mixer", or "double balanced mixer", may have very different internal designs, use different internal components (diodes, FETs, baluns) so that their behavior vs. RF and especially LO drive may be quite different, even if they show similar behavior at one specified RF or LO drive point.
- Often, performance other than what is contained in a spec sheet is required to understand behavior in a system and therefore data and the ability to characterize components beyond the specified range is a benefit.

JOEL DUNSMORE
*Agilent Technologies Inc., Santa Clara, CA*
TED HEIL AND HARVEY KAYLIE
*Mini-Circuits, Brooklyn, NY*

IKE Micro

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## Our Productivity Goals

**IKE Micro owner Scott MacKenzie discusses his latest fashion choices.**

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

**SM:** I promised to dress up like a woman if we beat our productivity goal in 2008. We did, so here I am in all my glory!

**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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Characterization beyond the spec sheet will also allow one to discover how robust a design implementation is with respect to mix-and-match of parts and the performance of parts over time and temperature.

*In Bob's search, some of the mixers he found were on the Mini-Circuits website, which also includes a progressive new tool: The Yoni2™ search engine, which searches an extensive database of measured performance of all the mixers in the database. He tries the Yoni2 search engine, puts in an LO power range of 5 to 10 dBm, with his IP3 spec of +22 dBm, and decides he can accept about 9 dB conversion loss if he can get the distortion he needs (see* ***Figure 2****). Yoni2 returns the choices (see* ***Figure 3****).*

*Bob sees three options, and looks at the data sheet for each. It turns out that the first two options are really the same device—the SIM-722MH+—but the second entry represents the results of a special test of that device.*

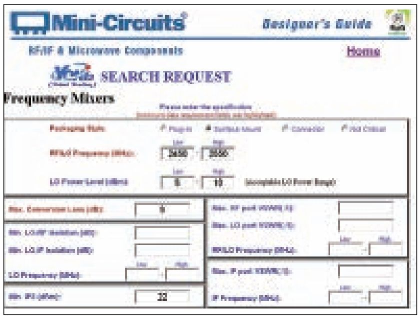



Fig. 2 Yoni2 search request page.

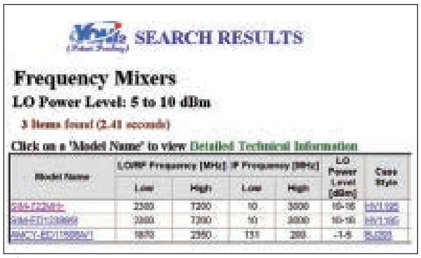


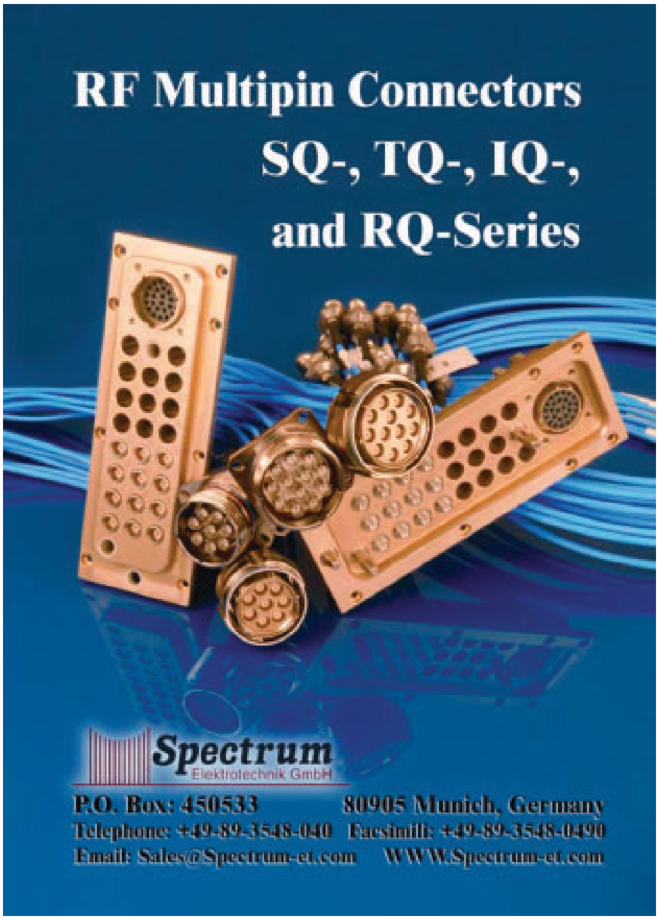

Fig. 3 Yoni2 search results.

*The third choice was a mixer with an integrated amplifier, so it may consume too much power. From here, Bob clicks on the data sheet page (see* ***Figure 4****), looks at the measured IP3 data and sees that at his frequency of interest (2500 MHz), the IP3 at lower LO drive (+10) is actually better than at higher LO drive, which is not what he expects. He thought all mixers had better IP3 with higher LO drive, but the data shows that sometimes this commonly held idea is not true, and the normal behavior reverses. Even though this mixer is a level 13 mixer, it looks like it might work in the level 7 design. Although the data directs Bob to a good choice for the right mixer, it does not provide all the information he needs to validate his choice. He needs to see how this mixer behaves at a lower power level.*

A design problem starts with objectives and constraints, e.g. the RF Receiver Chain:

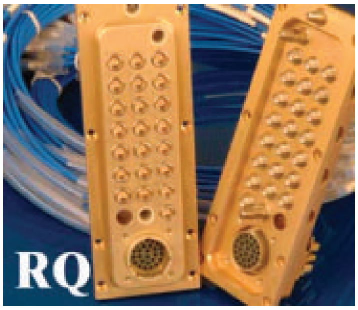
- Objective: Develop a system architecture including the allocation of amplification, filtering and frequency conversion
- Constraints: Power, dynamic range (min and max levels), frequency of operation. To achieve the goals, a designer has a number of tradeoffs available
- Allocation of gain and power stages depends on distribution of noise figure and distortion characteristics

The reality is that tradeoffs may be more complex than what is described

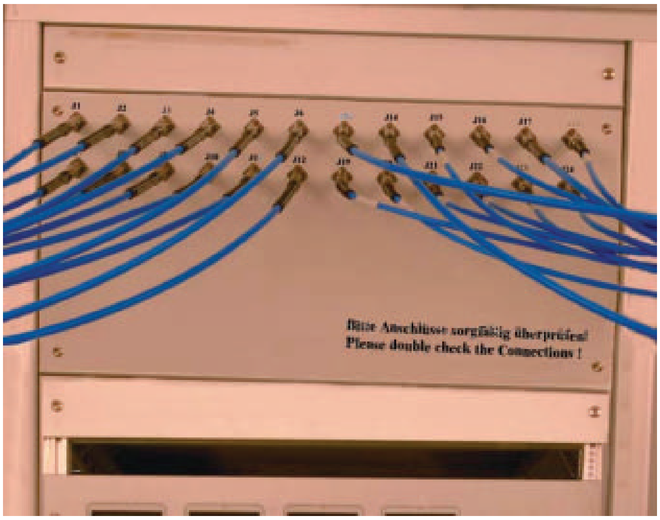



## Catalogue RF Multipin Connectors

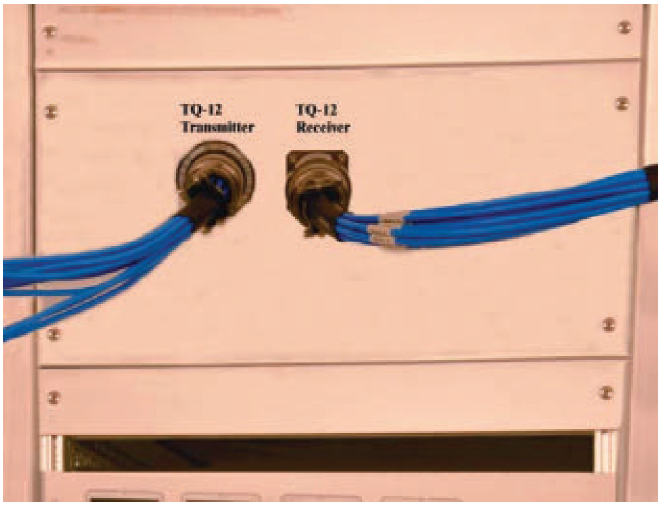
52 pages showing in detail 4 coaxial Multipin Connector Series, demonstrating how to connect and disconnect up to 23 coaxial lines in seconds and saving space.




**The Problem:** In various applications many coaxial microwave links have to be connected and disconnected. This means threadening and unthreadening, torquing and untorquing. Very dense packaging is not possible, as there is still room needed for manual threadening and for the use of a torque wrench. In helicopters and aircrafts all connectors usually have to be safely secured, wiring the coupling nuts of the connectors, using wire holes, a time-consuming process.




**The Solution:** Spectrum's Multipin Connectors are available with four (4), seven (7), eight (8), twelve (12) and twenty three (23) coaxial inserts (terminating the coaxial cable assemblies) at the Multipin end, and connecting all the coaxial cable assemblies at once and in seconds with no need of a torque wrench, no need for safety wires and using minimum space.

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in school or conventional data books.

Tradeoffs include: noise floor, noise figure, power consumption, power handling and distortion performance.

One tradeoff not often considered is the power consumed by the LO drive amplifier versus the mixer distortion and gain properties. Can a "starved LO" mixer operate with much lower total power consumption in the converter chain? How should one determine the tradeoffs in mixer LO drive level for different class of mixers?

*Bob knows that making IP3 versus LO power measurements can be pretty daunting, but he needs to know the details of this curve to ensure that if his LO drive to the mixer varies due to battery voltage or temperature it will still perform. Traditional methods to test this include using a signal generator to get the two tones, another one to get the LO drive, and a spectrum analyzer to read the results, but then he has to write some code to control everything, calibrate everything and plot the curves. Fortunately for Bob, he has a newer VNA, with integrated sources, and integrated applications, such as IMDX, which allows direct measurement of mixer IP3 characteristics: The PNA-X. Bob sets up a swept-frequency, IMD-X measurement of the SIM-722MH+ mixer, and makes measurements to confirm the Yoni2 data, and see how conversion loss behaves versus LO drive level. (see swept frequency input IP3 in **Figure 5**).*

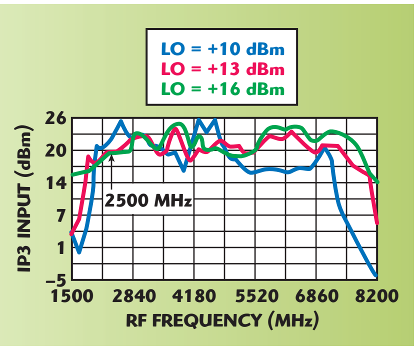


*Fig. 4 Data Sheet from the Yoni2 search.*

## STANDARD CHARACTERIZATION VERSUS EXTENDED CHARACTERIZATION

New characterization tools and techniques can efficiently provide the wealth of data the engineer can use to optimize his/her component selection and system architecture. A new instrument, the PNA-X with the new mixer IMD measurement application (IMD-X), provides for the first time an integrated calibration and measurement suite that simplifies these complex measurements. As shown in Figure 5, the conversion loss and IP3 results for a particular SIM-722MH+ mixer closely match the results of the data sheet, but the PNA-X has the capability to extend the measurements beyond the data sheet to match the requirements of a design. In this case, it is clear that for the frequency of interest, 2.5 GHz, the conversion loss does not change much with LO drive, but the IP3 appears to change significantly. This change versus LO drive power can be displayed directly in a LO power sweep.

*These results show that at level +10 dBm, the mixer has better IP3 than at +13 dBm, and might be very suitable for the design. But he still needs to see how the mixer behaves versus LO drive power. Fortunately, with the PNA-X, he can simply change the*

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| | Frequency | Function | Maximum PFD Frequency (MHz) | Maximum Reference Frequency (MHz) | Figure of Merit (Frac / Int) (dBc/Hz) | Frequency Resolution w/ 50 MHz Ref. | Bias Supply | Package | Part Number |
|---|---|---|---|---|---|---|---|---|---|
| NEW! | 10 kHz to 8 GHz | Fractional-N w/ Int. Sweeper | 75 | 200 | -221 / -227 | 3 Hz | +5V @ 37mA +3.3V @ 90mA | LP6C | HMC701LP6CE |
| NEW! | 10 kHz to 14 GHz | Fractional-N w/ Int. Sweeper | 75 | 200 | -221 / -227 | 6 Hz | +5V @ 37mA +3.3V @ 136mA | LP6C | HMC702LP6CE |
| | 10 MHz to 8 GHz | Fractional-N | 70 | 200 | -221 / -226 | 3 Hz | +5V @ 7mA +3.3V @ 95mA | LP4 | HMC700LP4E |
| | 80 MHz to 7 GHz | Integer-N | 1300 | 1300 | -233 | 50 MHz | +5V @ 310mA | LP5 | HMC698LP5E |
| | 160 MHz to 7 GHz | Integer-N | 1300 | 1300 | -233 | 50 MHz | +5V @ 310mA | LP5 | HMC699LP5E |
| | 10 MHz to 2.8 GHz | Integer-N | 1300 | 1300 | -233 | 50 MHz | +5V @ 250mA | QS16G | HMC440QS16GE |

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- 50% Duty Cycle Outputs

### IN-STOCK FREQUENCY DIVIDERS (PRESCALERS)

| | Input Freq. (GHz) | Function | Input Power (dBm) | Output Power (dBm) | 100kHz SSB Phase Noise (dBc/Hz) | Bias Supply | Package | Part Number |
|---|---|---|---|---|---|---|---|---|
| NEW! | 0.1 - 6.5 | Programmable Divider (N= 1 to 17) | -15 to +10 | 0 | -153 | +5V @ 190mA | LP4 | HMC705LP4E |
| NEW! | 0.2 - 2.0 | Programmable Divider (N= 1 to 4) | -2 to +10 | 10 | -155 | +5V @ 135mA | LP3 | HMC794LP3E |
| | 0.5 - 18 | Divide-by-2 | -15 to +10 | -4 | -150 | +5V @ 75mA | C-1 / SMA | HMC-C005 |
| | 0.5 - 18 | Divide-by-4 | -15 to +10 | -4 | -150 | +5V @ 93mA | C-1 / SMA | HMC-C006 |
| | 0.5 - 8 | Divide-by-5 | -15 to +10 | -1 | -155 | +5V @ 80mA | C-1 / SMA | HMC-C039 |
| | 0.5 - 18 | Divide-by-8 | -15 to +10 | -4 | -150 | +5V @ 98mA | C-1 / SMA | HMC-C007 |
| | 0.5 - 17 | Divide-by-10 | -15 to +10 | -1 | -155 | +5V @ 152mA | C-1 / SMA | HMC-C040 |
| | DC - 2.2 | 5-Bit Counter (N= 2 to 32) | -15 to +10 | 4 | -153 | +5V @ 194mA | LP4 | HMC394LP4E |

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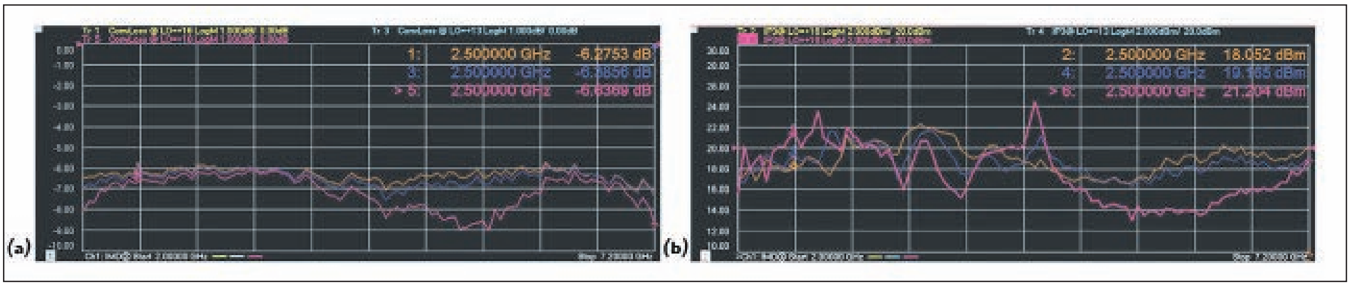


▲ *Fig. 5 Measurements of a real SIM-722MH+ mixer, at +10, +13 and +16 dBm LO drive for conversion loss (a) and IP3 (b).*

*sweep type to power sweep, and with a couple of keystrokes, set the LO start and stop powers, to plot the IP3 versus LO drive power. To make it even easier, the automatic calibration he did for the swept frequency IP3 measurement can be used for this measurement as well.* ***Figure 6*** *shows what Bob saw, that the IP3 for the mixer does have a peak value with lower LO drive power, and is pretty well controlled around his desired power range. He can also see the behavior of the conversion loss versus LO drive level. Just to be thorough, Bob tests a level 7 version of the same family, a SIM-83+. This mixer has the same pin-out, but a lower drive level. Yoni2 did not select it, but Bob was curious. The plot shows the results of the SIM-83+ versus power level, and he sees that it is very well controlled, and has slightly better conversion loss, but just does not have enough IP3, confirming the recommendations from the Yoni2 selection tool.*

*With these results, Bob can continue his design with a new understanding of the tradeoffs available to him when it comes to mixer performance. In this case, it is clear that 8.5 dBm is the optimum drive, but the IP3 is reasonably controlled at a lower power level, and the conversion loss is also reasonably controlled. Bob can now make intelligent tradeoffs between LO drive, IP3 and conversion loss with data that was previously insufficient or just too difficult to obtain. This understanding might allow him to completely eliminate an LO gain stage, saving power and cost. The realization of using components beyond their data sheet values, and the willingness of part manufacturers to provide a database of characteristics, provides insights into design options that were not possible to see in the past.*

The results of Figure 6 provide compelling evidence that many aspects of mixer design contribute to the overall performance, especially in the nonlinear domain. To many engineers, it would be unexpected that a high drive (level 13) mixer might per-

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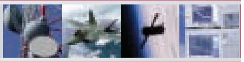

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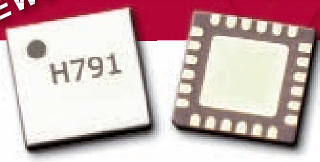


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|---|---|---|---|---|---|---|---|---|---|
| | 13 / 13 | Fast Rise Time 1:2 Fanout Buffer* | 22 / 20 | 2 | 0.6 - 1.2 | 290 | +3.3 | LC3C | **HMC744LC3C** |
| | 13 / 13 | 2:1 Selector* | 22 / 22 | 2 | 0.6 - 1.2 | 250 | +3.3 | LC3C | **HMC748LC3C** |
| | 13 / 13 | Fast Rise Time AND/NAND/OR/NOR* | 22 / 21 | 2 | 0.6 - 1.2 | 230 | +3.3 | LC3C | **HMC746LC3C** |
| *NEW!* | 28 / 28 | Clock Divider: Divide-by-2, Divide-by-4 | 12 / 14 | n/a | 0.6 | 660 | -3.3 | LC4B | **HMC791LC4B** |
| | 13 / 13 | Fast Rise Time D-Type Flip-Flop* | 22 / 20 | 2 | 0.7 - 1.2 | 264 | +3.3 | LC3C | **HMC747LC3C** |
| | 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** |

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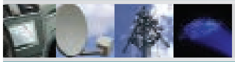
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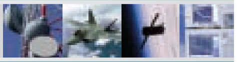


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- *Minimum Pulse Width: 60 ps*
- *Low Power Dissipation: 150 mW*

## IN-STOCK HIGH SPEED COMPARATORS

| | Input Bandwidth (GHz) | Function | Deterministic Jitter (ps) | Propagation Delay (ps) | Output Voltage Swing (Vdc) | DC Power Consumption (mW) | Vcco / $V_{term}$ * Power Supply (Vdc) | Package | Part Number |
|---|---|---|---|---|---|---|---|---|---|
| *NEW!* | 10 | Clocked Comparator - RSPECL | <3 | 120 | 0.4 | 150 | +3.3 / +1.3 | LC3C | **HMC874LC3C** |
| *NEW!* | 10 | Clocked Comparator - RSCML | <3 | 120 | 0.4 | 130 | 0 / 0 | LC3C | **HMC875LC3C** |
| *NEW!* | 10 | Clocked Comparator - RSECL | <3 | 120 | 0.4 | 150 | 0 / -2.0 | LC3C | **HMC876LC3C** |
| | 9.3 | Latched Comparator - RSPECL | 2 | 85 | 0.4 | 140 | +3.3 / +1.3 | LC3C | **HMC674LC3C** |
| | 10 | Latched Comparator - RSCML | 2 | 100 | 0.4 | 100 | 0 / 0 | LC3C | **HMC675LC3C** |
| | 10 | Latched Comparator - RSECL | 2 | 100 | 0.35 | 120 | 0 / -2.0 | LC3C | **HMC676LC3C** |

** Note that Vee = -3.0V & Vcci = +3.3V*

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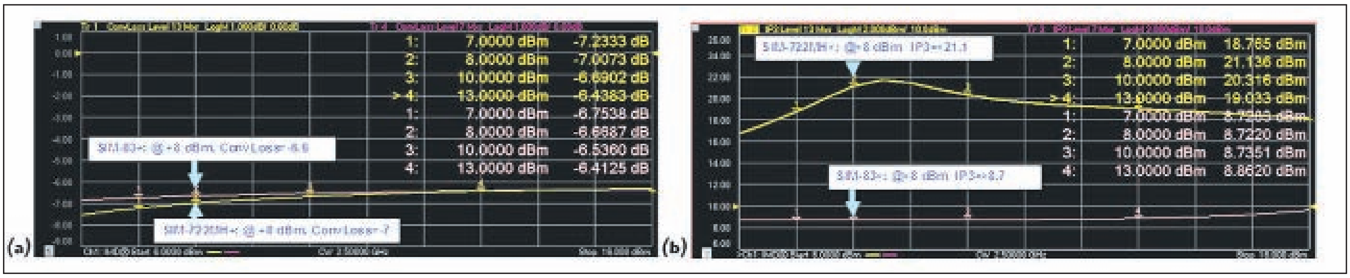
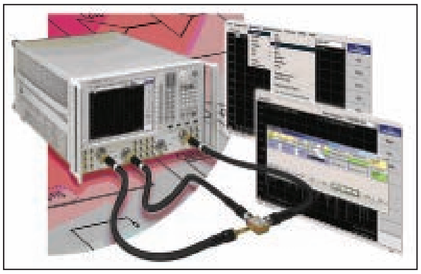



▲ *Fig. 6 Conversion loss (a) and IP3 (b) for the SIM-722MH+ and SIM-83+ vs. LO power drive.*

form better at lower drive than a lower drive mixer (level 7), but the data from Figure 6 shows this is true. In addition, the conversion loss versus LO





▲ *Fig. 7 Agilent PNA-X configured for mixer measurements.*

drive level data provides very useful information on system design tradeoffs. Without this data, "common wisdom" would say that one would risk getting poor nonlinear performance if one used too low a LO drive, a conclusion that is in fact wrong for this mixer type.

This article points to a new direction in the component specification and circuit design. Current practice limits a designer to sorting through physical or virtual (web-based) data sheets to infer from them the parts that might be usable in a design task. Unfortunately, most data sheets are not sufficiently detailed, and even if they were, sorting through tens or hundreds of pages of data sheets to find the one "needle-in-the-haystack" component is just not feasible.

However, there are new progressive data mining tools like Yoni2, which through access to new dimensions in selecting off-the-shelf components, enable designers to select a part that conventional search engines or websites cannot locate. When coupled with progressive measurement and analysis tools like the PNA-X (see ***Figure 7***), which can characterize components in multiple dimensions to support these search tools, it enables designers to validate this data, and support the designers' ability to meet more challenging system requirements in a fast, repeatable method that is beyond the normal "rule-of-thumb" design wisdom that might limit innovation. This ensures the operational attributes are fully understood and the optimum operating point is clear for the designer to use. ■

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# NONLINEAR EXTENSIONS FOR VNAs: QUID PRO QUO?

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To keep up with the growing needs of business sectors such as telecommunications, automotive, domotics, medical, aerospace and defense, the performance requirements of RF and HF transistors and amplifiers are increasing sharply. These products need to be affordable, and they must be able to handle more complex information, consume less power and still remain reliable. As a consequence, the design and performance tests of such devices are not a trivial task: It is time consuming, and the number of parameters that need to be tuned and checked are increasing exponentially. Several test and measurement manufacturers are vying for a share of this market. Indeed, there is a growing need for extensive RF and HF characterization capabilities of components operating under realistic conditions. Furthermore, the price must be affordable, even in situations where the S-parameters fail to do their job.

## "QUID PRO QUO?"

Starting from regular DC and S-parameters, this article introduces more advanced applications by gradually extending commercially available vector network analyzers (VNA). The objective of these applications is to fully characterize active components, from small-signal to large-signal behavior under realistic excitations in a single connection. The article answers the questions, "Which nonlinear extensions should I buy first on my limited budget so that I can add more nonlinear capabilities when additional budget becomes available?" and "What do I gain with these extensions?"

## FROM DC AND S-PARAMETERS TO COMPLETE LARGE-SIGNAL CHARACTERIZATION

### DC Characterization

When characterizing active components, a DC source is typically used to bias the device under test (DUT). This allows one to characterize the behavior of the device by performing a DC voltage/current sweep at the device's input and output and by measuring the corresponding DC voltage-current relationship (see ***Figure 1***). If necessary, calibration techniques can be applied to compensate for the losses of the bias tees and other cabling.

### Small-signal Characterization

Next, one can analyze the dynamic linear behavior of the component using small-signal characterization techniques. The S-parameters

GUILLAUME PAILLONCY, FRANS VERBEYST AND MARC VANDEN BOSSCHE
*NMDG NV, Bornem, Belgium*

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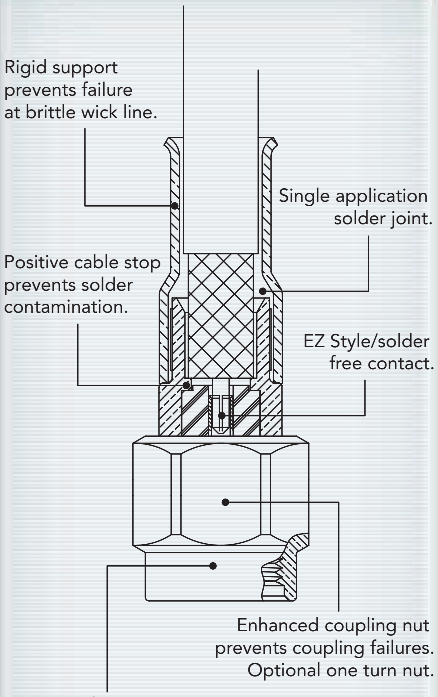


## Cable Assembly Performance

| | |
|---|---|
| **Frequency:** | DC to 20 GHz |
| **VSWR:** | 1.17:1 |
| **Intermodulation:** | < -150 dBc Typ. (2 x 20 watt carriers) |
| **DWV:** | 750 Vrms |
| **Insulation Resistance:** | 10,000 megohms |
| **Temperature Range:** | - 40°C to +125°C |

## Mechanical Performance

| | |
|---|---|
| **Interfaces:** | Per MIL-STD-348 |
| **Coupling Proof Torque:** | 15 inch lbs |
| **Coupling Nut Retention:** | 60 lbs axial |
| **Durability:** | 100 cycles |

## Connector Materials

| | |
|---|---|
| **Contact:** | BeCu, Au/Ni plate |
| **Locking Ring:** | BeCu |
| **Coupling Nut:** | Stainless steel |
| **Crimp Ferrule:** | Soft Cu, Au/Cu plate |
| **Body:** | Brass, Au/Cu plate |
| **Insulator:** | PTFE |
| **Gasket:** | Si Rubber |


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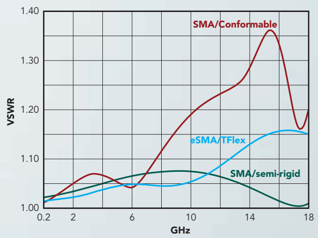


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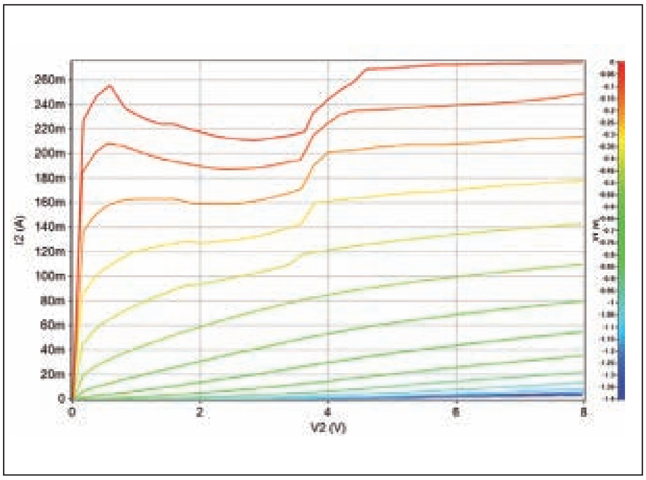



▲ *Fig. 1 DC IV output characteristics.*

provide a uniform approach for adequately describing the linear behavior, relating the incident and reflected waves at both ports of the device. Today, vector network analyzers are commonly used instruments for performing small-signal measurements and for extracting the S-parameters at both ports of the device under test, as illustrated in ***Figure 2***.

When designing a linear HF system, it is possible to use S-parameters as a model in combination with circuit-level models and tune certain parameters to achieve the design goal. Once the circuit is manufactured, it is measured using a VNA. The VNA provides S-parameters, which can easily be compared to simulation results. The loop from characterization, modeling, design and testing is closed using the same equipment. This avoids any discussions that may arise due to different equipment being utilized, as the vector network analyzer is used to share information across the complete cycle.

## ENHANCEMENT OF VNA WITH NONLINEAR CAPABILITIES

Triggered by the growing need for better insight into the nonlinear behavior of components, VNA manufacturers are adding various "nonlinear" features to some of their VNA models. These competitive features include AM-to-AM, AM-to-PM, harmonic power measurements and mixer characterization.[1] Unfortunately, these features characterize the nonlinear behavior only partially as one essential piece of information is missing: The phase relationship between the different spectral components.

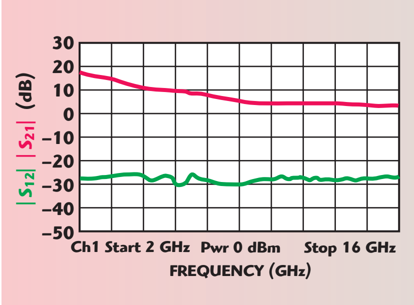
Indeed, mixer-based network analyzers do not allow one to measure the phase relationship between different tones. One frequency is measured at a time, and while stepping or sweeping the internal local oscillator from one frequency to the next, an arbitrary phase is introduced. In fact, the network analyzer is missing a phase reference in order to consistently capture the phase relationship between different tones.[2,3]

Starting with commercially available network analyzers with the appropriate options (four-port, frequency offset measurement capability and direct access to the receivers), different extension kits exist, transforming the VNA into a mixer-based large-signal network analyzer (LSNA) and allowing complete harmonic characterization of active high-frequency components. ***Figure 3*** shows such an example, combining a four-port R&S ZVA24 with the corresponding NMDG ZVxPlus add-on kit.

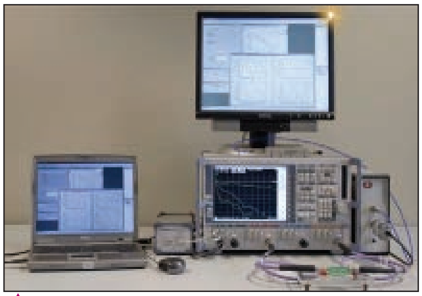
These extension kits include a synchronizer to add the missing phase reference to the VNA. The synchronizer is a very stable periodic pulse generator that generates a comb of harmonically related spectral components, which have a fixed phase relationship, in the frequency domain.

Four receivers of the VNA simultaneously capture a given harmonic of the incident and reflected waves at the input and output ports of the DUT, and—at the same time—a fifth receiver is used to measure the corresponding harmonic of the synchronizer. You can then reference the phase of the different harmonics at the DUT level to the phase of the corresponding harmonics of the synchronizer. Based on the fixed phase relationship of the output signal of the synchronizer, although not yet calibrated, the phase of all signals at the DUT level can be measured in a consistent way.

To eliminate the systematic errors of the measurement system, proper




▲ *Fig. 2 S-parameters vs. frequency.*



▲ *Fig. 3 The NMDG ZVxPlus add-on kit on top of the R&S ZVA24.*

calibration techniques must be applied. In addition to a standard VNA calibration, two further calibration steps are required for accurate large-signal behavior analysis. First, a power calibration using a power meter is performed at fundamental and harmonics to take into account the amplitude distortion of the system. Next, the add-on kit includes an additional calibration element—a harmonic phase reference (HPR). This unique device enables the broadband harmonic phase calibration of the system and deals with the phase distortion of the measurement system.

Using de-embedding of extrinsic parasitics such as package or launcher pads, measurements close to the intrinsic nonlinearities of the device can be performed. The complete spectrum—in amplitude and phase—of incident and reflected waves, both at fundamental and harmonics, can then be acquired and the time waveforms reconstructed.

## LARGE-SIGNAL CHARACTERIZATION

Small-signal network analysis implies that the signal levels are sufficiently small such that the device behaves linearly. Many applications today require signal levels that are significantly higher, driving the RF ICs in their nonlinear region of operation.

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Even more difficult, transistors are driven in a highly nonlinear manner to transmit signals with high efficiency but low distortion.

At this stage, S-parameters are no longer adequate and there is a need to "go beyond S-parameters." Indeed, as soon as the device behaves nonlinearly, the superposition principle is no longer valid. Therefore, it is crucial to be able to put the DUT under realistic large-signal operating conditions and to acquire complete and accurate information about its electrical behavior for different classes of signals.

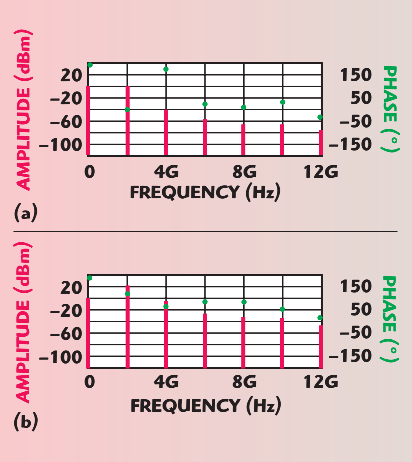
Possible candidates are either voltage and current or incident and reflected waves. Depending on the application, one will use the representation that provides the best insight. For example, process engineers and transistor modelers tend to use the voltage and current formalism, while system engineers generally prefer the wave quantities.

Moreover, signals can be visualized both in the time and frequency domain. Again, process and transistor modeling engineers tend to prefer the time domain because their models are formulated in that domain, while system engineers prefer the frequency domain, as the system level specifications such as adjacent channel power ratio (ACPR) or spectral re-growth are expressed in this domain. All these different data representations and visualizations are possible with a mixer-based LSNA.

## CONTINUOUS WAVES CHARACTERIZATION CLOSE TO 50 Ω ENVIRONMENT

Now assume that one wants to characterize the large-signal HF behavior of a biased FET transistor, using a continuous wave (CW) excitation (for example at 2 GHz) at the gate, and terminated close to 50 Ω at the drain. If the device is stable (not oscillating) and does not exhibit sub-harmonic or chaotic behavior, all currents and voltages (or wave quantities) will have the same periodicity as the drive signal (in this case 0.5 ns).

Presently, large-signal network analysis is limited to CW or periodic modulated signals where the fundamental carrier and fundamental modulation frequency do not have to be commensurate. Like a spectrum analyzer, the LSNA allows you to visualize the spectral data of the measured quantities in the frequency domain. The unique feature here is that the spectral data includes calibrated phase information (see ***Figure 4***).



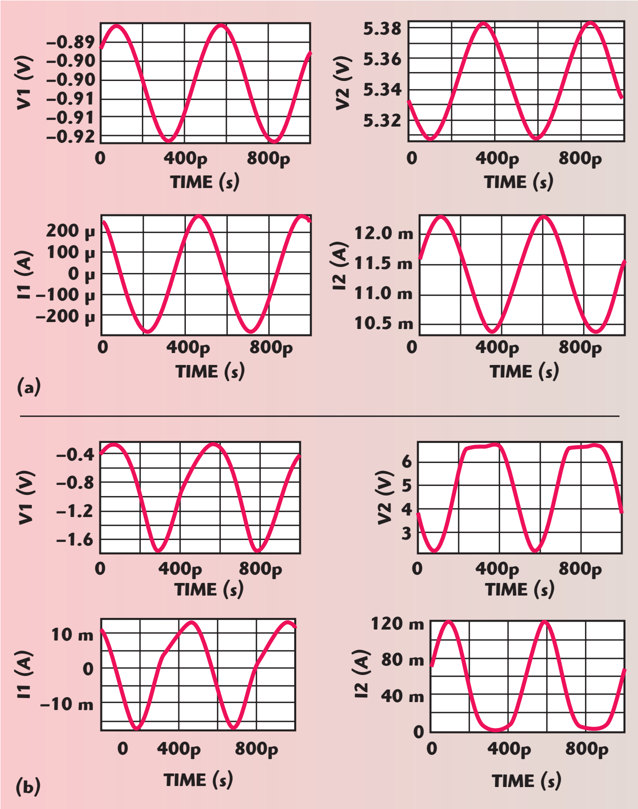

▲ *Fig. 4 Incident (a) and transmitted (b) wave quantities in the frequency domain.*

An oscilloscope is an indispensable tool on the lab bench for probing signals and for checking the proper behavior of circuits. Today, sampling scopes with a real-time bandwidth higher than 10 GHz are available. However, voltage information alone is not enough, and one needs to add a proper test set and calibration techniques to accurately measure the component behavior. The advantages of using vector network analyzers instead of oscilloscopes have clearly been proven for linear RF and HF applications.

The LSNA can provide the voltage and current waveforms at the input and output ports of a device under test, as illustrated in ***Figure 5*** under both small- and large-signal conditions. When the input power is low, one can observe sine waves for all quantities. For high input power—due to nonlinear behavior of the device—one will start to observe distortion of the waveforms such as the clipping effect of the output current.

Using the above voltage and current waveforms in the time domain, one can display the dynamic trajectories:

- Dynamic source line, i.e. $i_1(t)$ as function of $v_1(t)$ (see ***Figure 6a***)
- Dynamic transfer line or dynamic $g_m$, i.e. $i_2(t)$ as function of $v_1(t)$ (see ***Figure 6b***)




▲ *Fig. 5 Input and output voltages and currents in the time domain for small-signal (a) and large-signal (b) conditions.*

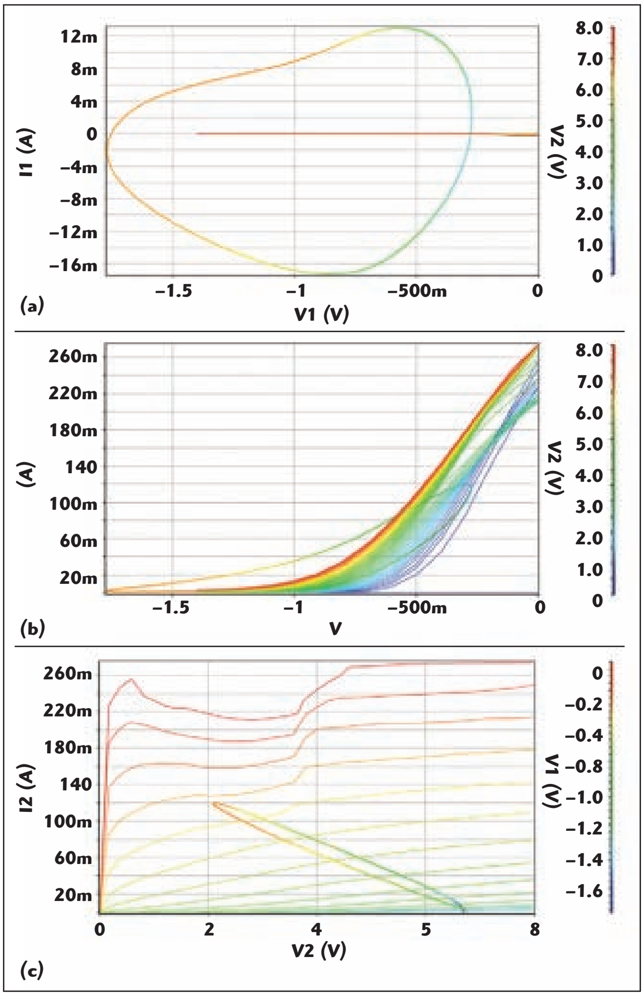
- Dynamic load line, i.e. $i_2(t)$ as function of $v_2(t)$ (see ***Figure 6c***)

Furthermore, as both quantities at the input and output of the device are measured simultaneously, the mixer-based LSNA allows one to map the dynamic excursion of the input voltage $v_1(t)$ to the static input voltage using, for example, gradient colors as a 3rd dimension, resulting in a 3D dynamic load line. If the color of the input voltage $v_1(t)$ does not match that of the DC input voltage, it indicates that the measurements do not correspond to the intrinsic static nonlinear behavior of the component and that other phenomena are present, such as delay between input and output or trapping and memory effects.

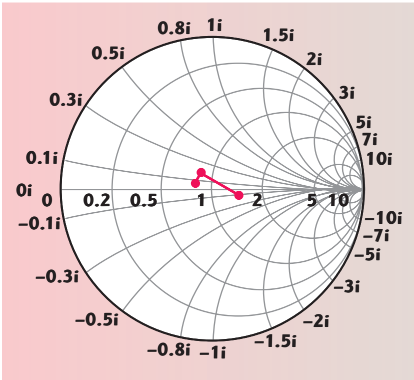
Using the basic information, one can also calculate the input reflection coefficient of the device and the load reflection coefficient, presented at the output of the device, both at fundamental and harmonics. Typically, these quantities are visualized using a Smith Chart (see ***Figure 7***).

## CHARACTERIZATION IN A NON-50 Ω ENVIRONMENT

Today, power amplifier (PA) designers mainly use load-pull systems to extract specifications such as output power or power added efficiency (PAE) under different source and load impedance conditions. Such a system, based on passive (mechanical or electrical) or active (active loop or injection of power using an external source) tuning, has several drawbacks: Preparing the setup with the tuners is time-consuming and cumbersome, while the tuning process is slow due to the power meters which are typically used and the precise movement of the passive tuners. Furthermore, the broadband power measurements do not differentiate between fundamental and harmonics. As a result, one cannot be sure that the amplifier is being used exactly in the desired class of operation.

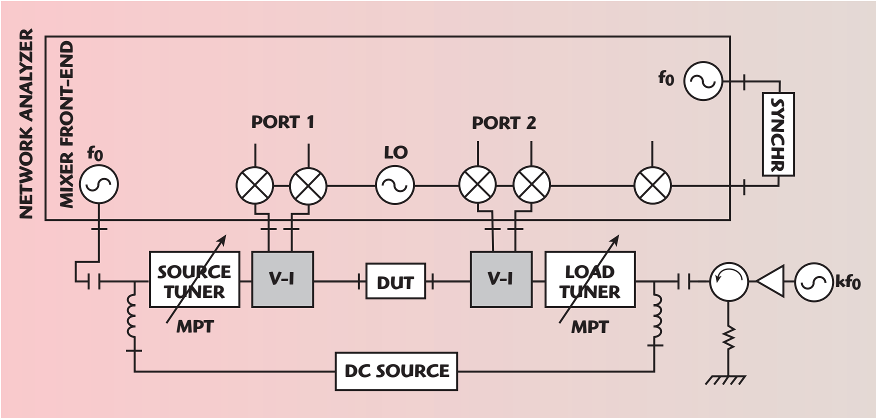



▲ *Fig. 6 Dynamic source (a), transfer (b) and load (c) lines on top of DC voltage-current characteristics.*

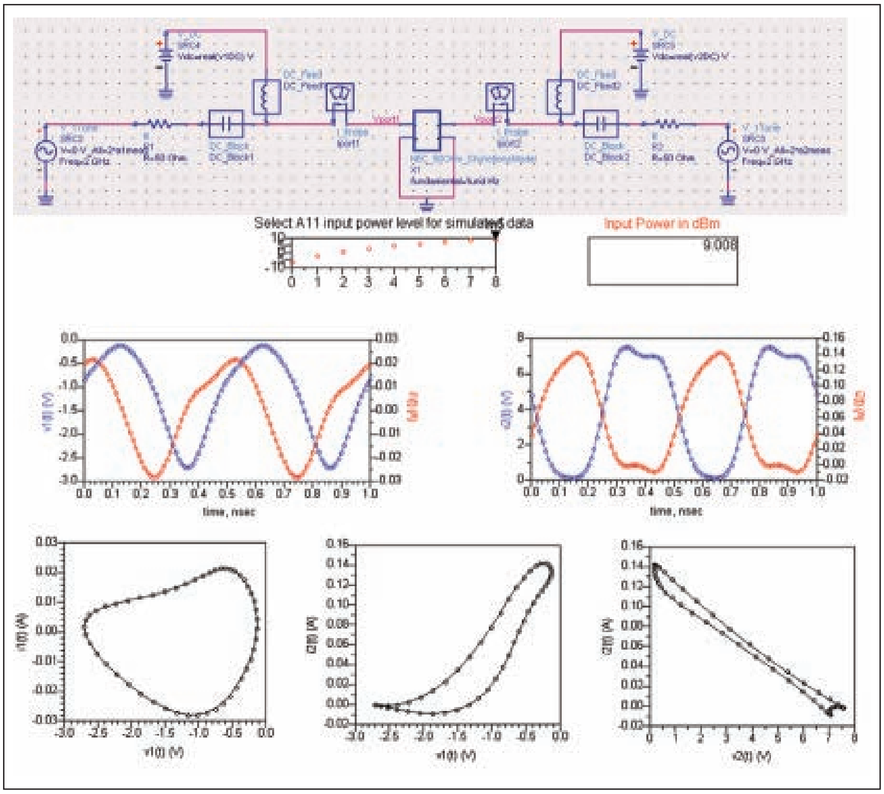


▲ *Fig. 7 Fundamental, second and third harmonic impedances presented at the device output.*

While the calibration of a classic load-pull system[4] requires off-line characterization of all parts of the measurement setup, one can (re)-configure the stimuli at the input and output of the LSNA without recalibration. One can then study the DUT behavior under realistic conditions with a single device connection and without the need to calibrate the tuner. For highly mismatched components, this setup is not adequate because the couplers used to capture incident and reflected waves are lossy components and they will degrade the tuner performance




▲ *Fig. 8 Device characterization in non-50 Ω conditions: combining LSNA with harmonic tuners and new probing solutions.*




▲ *Fig. 9 Model verification using large-signal measurements.*

in terms of highest possible gamma presented to the DUT. One solution is to put the tuner between the DUT and the couplers. However, changing the tuner position invalidates the calibration, and one still needs to characterize the tuners separately and use an S-parameter-based de-embedding technique for each tuner position.

Another issue appears as soon as one wants to perform harmonic tuning using a passive tuner. Indeed, since one generally wants to present a high reflection coefficient for the harmonics, most if not all of the harmonic energy will be reflected back to the DUT before reaching the reflectometers. As such, the VNA will not be able to accurately measure the harmonic behavior.

In recent years, research has focused on overcoming these various drawbacks.[5] New probing solutions were introduced for harmonic tuning using a quasi-lossless coupler-like structure to be inserted between the DUT port and the tuner hardware. If one combines the LSNA with this new probing solution and a multi-harmonic tuner[6] (see ***Figure 8***), one can ac-

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| ZHL-10W-2G+ | 800-2000 | 43 | +40 | +41 | 7.0 | +50 | 24 | 5.0 | 1295 | 1220 |
| ZHL-16W-43+ | 1800-4000 | 45 | +41 | +42 | 6.0 | +47 | 28 | 4.3 | 1595 | 1545 |
| • ZHL-20W-13 | 20-1000 | 50 | +41 | +43 | 3.5 | +50 | 24 | 2.8 | 1395 | 1320 |
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curately characterize the component in a harmonic non-50 Ω environment while controlling independently the fundamental up to the 3rd harmonic impedances presented at both its input and output port.

## CHARACTERIZATION UNDER PULSE AND MODULATION CONDITIONS

Using the pulse capability of some VNAs such as the R&S ZVA, the nonlinear extension kits can be used to perform these large-signal measurements under pulsed conditions, both in average pulse and pulse profile mode. Combined with pulsed DC equipment, one can then extract the nonlinear behavior of the component while avoiding contributions of heating and trapping effects. Moreover, due to the large IF bandwidth of the R&S ZVA, large-signal measurements under modulation conditions can be performed efficiently by capturing the full IF bandwidth around each harmonic.[7]

## DESIGN

### Improvement of Large-signal Transistor Models

One should notice that the voltage and current quantities contain both the amplitude and phase information at fundamental and harmonics. This is essential for process and transistor modeling engineers as these quantities are directly usable in the harmonic-balance simulation tools. Using the mixer-based LSNA, model verification in 50 Ω conditions can already be performed by using the measured voltages at the input and output ports of the device as stimuli in the simulation and comparing the measured currents to the simulated ones. A more realistic model verification can also be done in non-50 Ω conditions by combining LSNA with one of the tuning techniques. In both cases, one can be sure that they tested the model under the same realistic conditions as during the measurement of the "real" component (see ***Figure 9***).

### Power Amplifier Design Made Easy

When you combine the LSNA with new quasi-lossless probing solution and multi-harmonic tuning techniques (see ***Figure 10***), the design of an amplifier in the desired class of operation using waveform engineering becomes almost as easy as in the theoretical textbooks.[8] Indeed, amplifier designers can now on-the-fly visualize the dynamic load line and voltage and current waveforms as close as possible to the intrinsic level of the amplifier. They can also monitor different figures of merit such as output delivered power or PAE, while controlling independently the fundamental up to 3rd harmonic impedances presented to the device output.

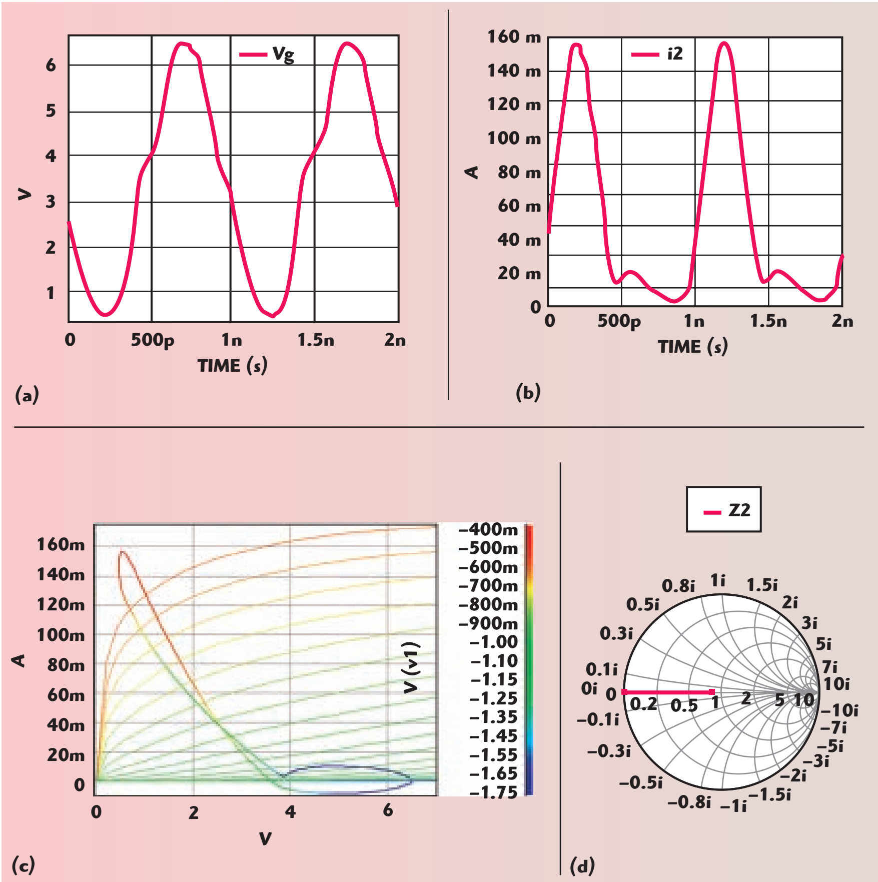
Using this unique measurement solution, excellent agreements with theoretical performance have been observed on a commercially available high-efficiency heterojunction power FET[9] by optimizing fundamental and harmonic output impedances for different classes of operation. ***Figure 11*** shows the measurement results with the device optimized for class B. The optimization only took a couple of minutes, and the obtained PAE of 74 percent is very close to the theoretical PAE of 78.5 percent.

### Behavioral Modeling

The S-parameters can be regarded as a measurement-based small-signal behavioral model of the DUT. Moreover, the small-signal network analysis is independent of the type of component and independent of the process technology. This explains the success of S-parameters for passive or active components used in their linear mode of operation.

Unfortunately, there is as yet no such uniform approach for dealing with nonlinear RF and microwave problems. One can deal with a subset of these phenomena in a uniform way using existing modeling techniques such as the describing functions in-

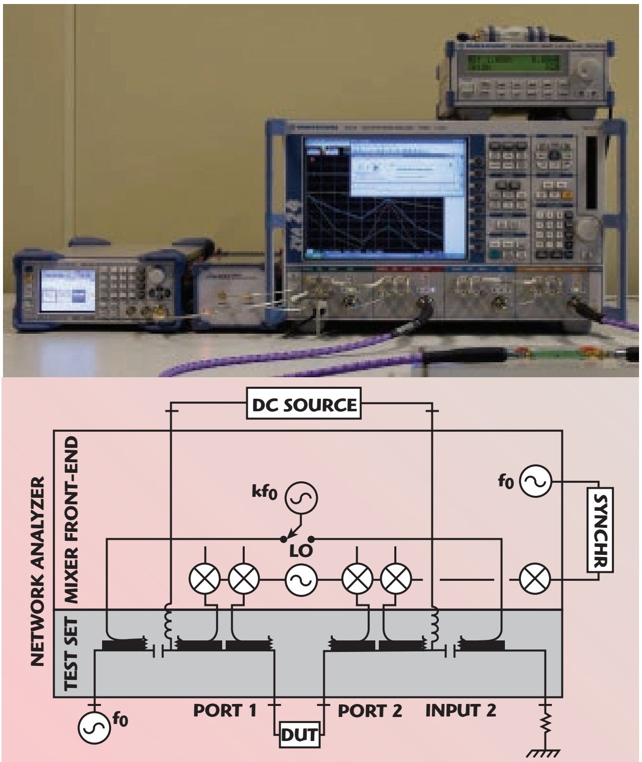
▲ *Fig. 10 Setup combining R&S ZVA24 with Focus V-I Probes and MPT multi-harmonic tuner.*




▲ *Fig. 11 Visualizations of a high-efficiency heterojunction power FET device optimized in class B: output voltage waveform (a), output current waveform (b), dynamic load line (c) and fundamental up to 3rd harmonic impedances presented at output of the device (d).*

troduced in the late '90s,[10] a natural extension of S-parameters to model the nonlinear behavior of active components.[11] To extract a small-signal behavioral model, the S-parameters can be measured at different DC bias points. One should notice that while they correctly describe the small-signal behavior of the component at each of these DC bias points, the S-parameters themselves become a nonlinear function of the DC operating points.

Under large-signal conditions, the above DC-bias-dependent S-parameters do not correctly describe the behavior of the component. To describe the nonlinear behavior of the component, an additional "bias" point is required: The large-signal input tone. Because the component is driven by this large-signal input tone, the reflected and transmitted waves will also contain harmonics. Considering both the DC bias and fundamental tone as part of the large-signal operating point (LSOP), one can already describe the nonlinear relationship between incident and reflected waves at both the input and output port of the device. In addition, one can measure the "S-parameters" as a function of frequency by performing a forward and reverse measurement. Beyond the fundamental and harmonics at $k.f_0$ resulting from the large-signal input tone and the small-signal input tone at frequency f, additional tones will show up at $k.f_0 \pm f$. A linear relationship does exist between the small-signal input tone and the resulting output tones. This linear relationship also depends on the large-signal operating point and describes the behavior of the component due to perturbations on top of the large-signal input tone. The combination of both the nonlinear and linear relationships is referred to as S-functions instead of S-parameters because of their dependency on the LSOP.[11]




▲ *Fig. 12 S-functions extraction setup (a) and corresponding block diagram (b).*

When applying the large-signal tone using an external source, the LSNA can be reconfigured to extract the S-functions using the internal source of the VNA to apply the small-signal input tone at the fundamental and at harmonics $k.f_0$ either at the input or output of the DUT (see ***Figures 12*** and ***13***). One can also use the different tuning techniques to extract the S-functions in non-50 Ω conditions. Like the S-parameters, S-functions can be cascaded. Imported in CAE tools, S-functions can then predict both harmonic and modulation behavior, under quasi-static assumption, from the component level up to the system level under non-50 Ω conditions in a uniform manner.

## CONCLUSION

If one wishes to extend the capabilities of network analyzers at an affordable price, add-on kits are available to provide unique insight into the behavior of active components. By setting up a single connection, engineers can now visualize the linear and nonlinear behavior of their components and also verify and certify their models against large-signal network analysis techniques.

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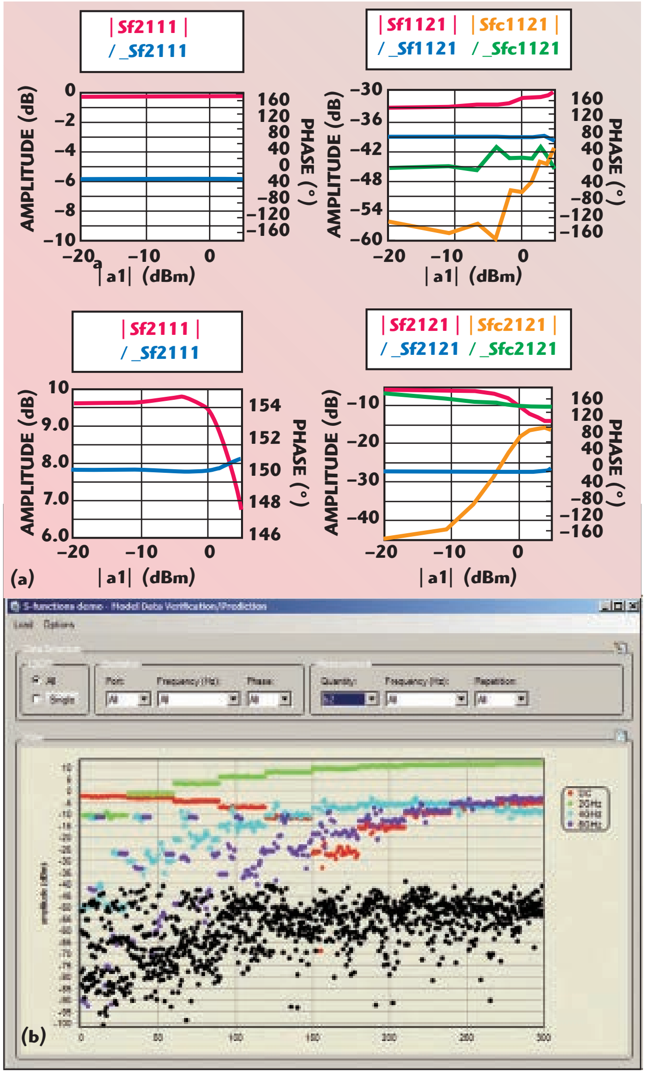
tuning technologies, it is now possible to match transistors at both fundamental and harmonics to optimize their performance based on instantaneous feedback provided by the voltage and current waveform measurements. By extracting measurement-based behavioral models via the S-functions, engineers can improve and speed up their design process by measuring and directly simulating RF systems under large-signal conditions. Manufacturers can also provide more complete system-level models of their RF devices. Starting with a set of commercially available vector network analyzers, one can gradually add nonlinear measurement and modeling capabilities under realistic conditions, including fundamental and harmonic mismatch. This approach will surely open new frontiers. ■




▲ *Fig. 13 S-functions visualization (a) and verification using an independent set of measurements (b): The measured DC (red), fundamental (green), second (blue) and third (purple) harmonic spectral components of the transmitted wave b2 are shown. Black dots: amplitude in dB of complex difference between measured and predicted b2.*

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# A HIGHLY MINIATURIZED ACTIVE 90° POWER COMBINER MMIC EMPLOYING CE AND CC CIRCUITS

*In this work, a highly miniaturized active 90° power combiner, employing InGaP/GaAs heterojuntion bipolar transistors (HBT), was fabricated on a GaAs substrate for MMIC applications. A novel composite structure employing common-emitter (CE) and common-collector (CC) circuits is proposed for 90° power combining. The size of the active 90° power combiner is approximately 2.2 percent of a conventional passive combiner. The active 90° power combiner showed good RF performance, comparable to a passive combiner at S-band. This work is the first 90° power combiner reported employing active devices.*

A 90° power combiner has been used for signal mixing at the intermediate frequency (IF) output port of an image rejection mixer.[1,2] Until now, a passive branch-line coupler was mainly employed for 90° power combining.[1,3] However, the passive branch-line coupler occupies a very large circuit area. For example, if the branch-line coupler is fabricated on a GaAs substrate with a thickness of 100 μm, for a signal mixing with an IF of 2.4 GHz, the size will be approximately 10.92 × 10.54 mm. Therefore, passive power combiners cannot be integrated on MMICs due to their very large size.[4] To reduce the size of the 90° power combiner,[6] it has to be fabricated using an active device. However, no study of a 90° power combiner employing an active device has been reported yet. In this work, for integration of the 90° power combiner on a MMIC, a highly miniaturized active 90° power combiner employing CE and CC circuits with InGaP/GaAs heterojunction bipolar transistors (HBT) is proposed.

## DESIGN OF AN ACTIVE 90° POWER COMBINER EMPLOYING CE AND CC WITH INGAP/GAAS HBT

***Figure 1*** shows the schematic circuit of an active 90° power combiner employing CE and CC circuits. As shown, a novel composite structure employing common-emitter (CE) and common-collector (CC) circuits was used, with the output ports of the CE and CC circuits connected to each other. To compensate for the insertion loss of the active 90° power combiner, an amplifier was added at the output port.

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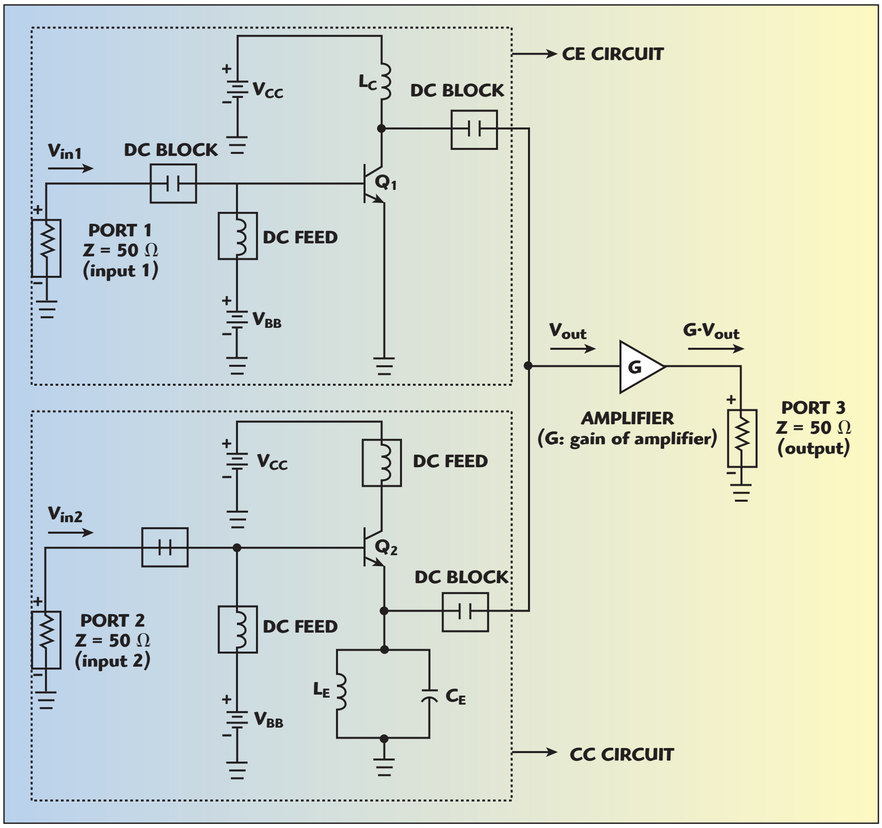


*Fig. 1 Schematic of the active 90° power combiner.*

The output voltage gain and output phase of the CE circuit are given by[7]

$$A_{v1} = \frac{V_{out}}{V_{in1}} = \frac{-jX_C}{r'_e}, (X_c = \omega L_c) \quad (1.1)$$

$$\angle A_{v1} = -90° \quad (1.2)$$

where r'$_e$ is the emitter resistor of the transistor.

The output voltage gain and output phase of the CC circuit are given by[7]

$$A_{v2} = \frac{V_{out}}{V_{in2}} = \frac{jX_E}{r'_e + jX_E},$$

$$\left( X_E = \frac{\omega L_E}{1-\omega^2 L_E C_E} \right) \quad (2.1)$$

$$\angle A_{v2} = \tan^{-1}\left( \frac{r'_e}{X_E} \right) \quad (2.2)$$

where ω is the operating frequency.

Ideal characteristics of the 90° power combiner employing CE and CC circuits require that the output signal from the incoming port 1 ($S_{31}$) and the incoming port 2 ($S_{32}$) should have a 90° phase difference and equal power. Thus, the circuit elements were determined to obtain the required relationship. In other words, for a 90° phase difference between output signal $S_{31}$ and $S_{32}$, the following equation should be satisfied using Equations 1.2 and 2.2

$$\angle A_{v1} - \angle A_{v2} = -90° - \tan^{-1}\left( \frac{r'_e}{X_E} \right) \quad (3)$$

In the above equation, $X_E$ must be infinite ($X_E = \infty$) in order that the phase difference be -90°. Thus, from Equation (2.1), the following relationship must be satisfied

$$\omega = \frac{1}{\sqrt{L_E C_E}} \quad (4)$$

If $X_E = \infty$, from Equation 2.1, $A_{v2} = 1$. Therefore, from Equations 1.1 and 2.1, for an equal power of the output signals $S_{31}$ and $S_{32}$, the following equation should be satisfied

$$|A_{v1}| - |A_{v2}|, \left| \frac{-jX_C}{r'_e} \right| = \left| \frac{jX_E}{r'_e + jX_e} \right| \approx 1 \quad (5)$$


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From the above equation, the following relation is given

$$X_C = \omega L_C = r_e' \quad (6)$$

Finally, the circuit elements $L_E$, $C_E$ and $L_C$ were determined from Equations 4, 5 and 6.

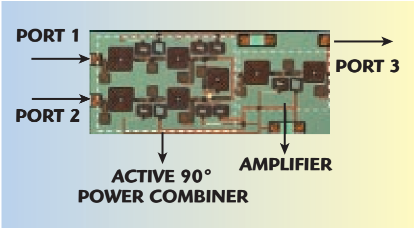
## MEASUREMENT OF AN ACTIVE 90° POWER COMBINER EMPLOYING CE AND CC WITH INGAP/GAAS HBT

***Figure 2*** shows a photograph of the active 90° power combiner MMIC employing CE and CC InGaP/GaAs HBTs, which was fabricated on a GaAs substrate. The size of the fabricated chip, including the active 90° power combiner and amplifier, is 2.42 × 1.05 mm, which is 2.2 percent of the size of a conventional branch-line coupler fabricated on a GaAs MMIC (as mentioned previously, the size of a passive coupler is 10.54 × 10.92 mm).

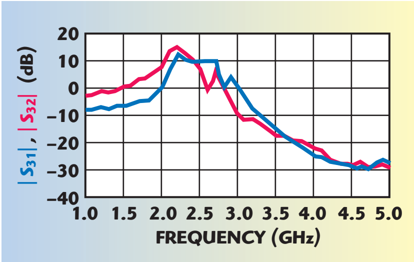
***Figure 3*** shows the output gain characteristics ($S_{31}$ and $S_{32}$) of the active 90° power combiner. As shown, an equal output gain characteristic is observed from 2.3 to 2.5 GHz. Specifically, the proposed active 90° power combiner shows a gain of 10 ± 1 dB from 2.3 to 2.5 GHz due to the amplifier integrated on the MMIC. ***Figure 4*** shows the phase difference characteristic of the active 90° power combiner. A phase difference characteristic of -90 ± 2.5° is observed from 2.3 to 2.5 GHz. ***Figure 5*** shows the isolation characteristic between ports 1 and 2 of the active 90° power combiner. As shown, an isolation better than -25 dB is observed from 2.3 to 2.5 GHz. ***Figure 6*** shows the output power characteristic of the active 90° power combiner. As shown, P1dB is approximately -3 dBm. The active 90° power combiner shows a power saturation level higher than -3 dBm due to the nonlinear characteristic of the InGaP/GaAs HBT. Therefore, the proposed active 90° power combiner can be used for a receiver or medium power transmitter of a wireless communication system. The characteristics of the active 90° power combiner are summarized in ***Table 1*** for a comparison with the characteristics of a conventional 90° passive coupler.

## CONCLUSION

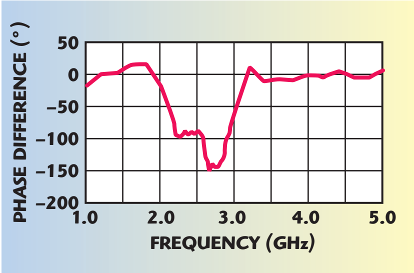
In this work, a highly miniaturized active 90° power combiner employing CE and CC with InGaP/GaAs HBT was fabricated on a GaAs substrate for MMIC applications. For a 90° phase difference and equal power



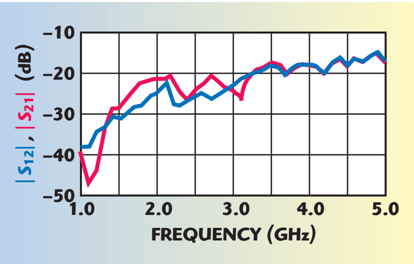

▲ *Fig. 2 Photograph of the fabricated active 90° power combiner.*



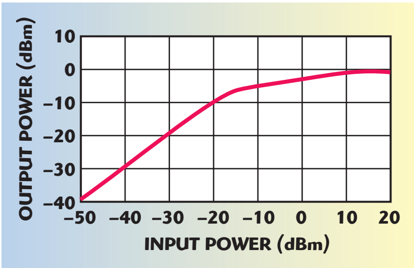

▲ *Fig. 3 Measured $S_{31}$ and $S_{32}$ characteristics.*



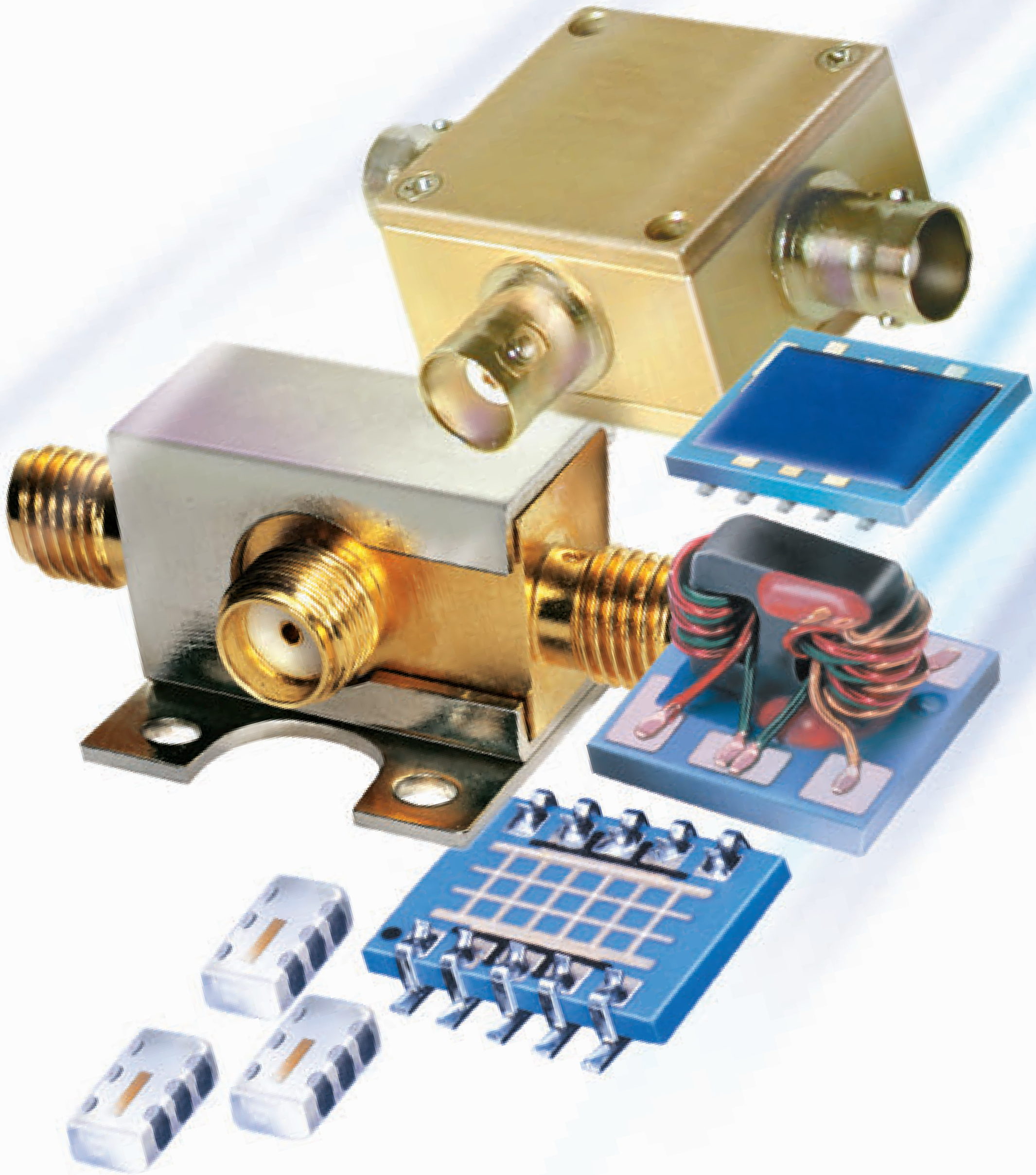

▲ *Fig. 4 Measured phase difference between $S_{31}$ and $S_{32}$.*




▲ *Fig. 5 Measured isolation characteristics.*




▲ *Fig. 6 Output power characteristics.*



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coupling, a novel composite structure is proposed, employing CE and CC circuits. The size of the active 90° power combiner including amplifier is 2.42 × 1.05 mm, which is 2.2 percent of the size of a conventional passive coupler. The active 90° power combiner showed good RF performances, comparable to those of a conventional passive coupler at S-band, and also showed a gain, due to the amplifier integrated on a MMIC. This work is the first report known of a 90° power combiner employing active devices. ■

**TABLE I**

**COMPARISON OF THE CHARACTERISTICS OF A CONVENTIONAL, PASSIVE AND ACTIVE COMBINER**

| | Passive Branch-line Coupler | Active 90° Power Combiner |
|---|---|---|
| Circuit size | 10.56 × 10.92 mm | 2.42 × 1.05 mm |
| Size comparison | 100% | 2.2% |
| Power loss | -3.65 dB | × |
| Linearity | ∞ | -3 dBm |
| Isolation | -30.2 dB | -26.6 dB |
| Amplitude balance | -3.65 dB/-3.6 dB | 10.5 dB/10.3 dB |
| Power consumption | × | 187 mW |
| Bandwidth | 640 MHz | 330 MHz |


## ACKNOWLEDGMENTS

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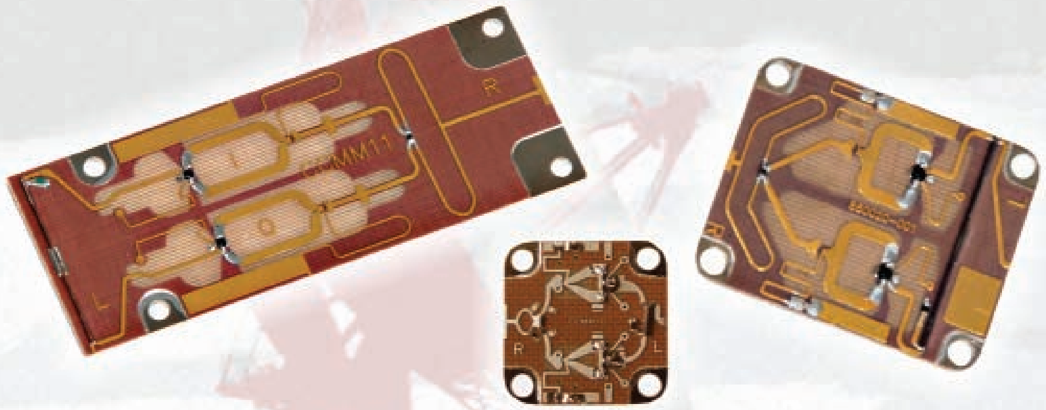

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| IQM4221 | 2.1-4.1 | 2.1-4.1 | DC-500 | 10 | 9.0 | 10.0 | 40 | 33 | 42 | 35 | 25 | 20 |
| IQM11621 | 6.0-10.8 | 6.0-10.8 | DC-500 | 10 | 8.5 | 10.0 | 25 | 20 | 40 | 33 | 28 | 23 |
| IQM18621 | 15.0-18.0 | 15.0-18.0 | DC-500 | 13 | 10.0 | 12.0 | 25 | 20 | 30 | 23 | 23 | 18 |
| IQM15101 | 10.5-14.5 | 10.5-14.5 | DC-500 | 10 | 6.3 | 8.0 | 25 | 20 | 28 | 22 | 23 | 18 |
| IQM15103 | 10.5-14.5 | 10.5-14.5 | DC-500 | 13 | 6.3 | 8.0 | 25 | 20 | 28 | 22 | 23 | 18 |
| IQM17131 | 13.2-16.8 | 13.2-16.8 | DC-500 | 10 | 6.5 | 8.0 | 25 | 20 | 30 | 23 | 23 | 18 |
| IQM17133 | 13.2-16.8 | 13.2-16.8 | DC-500 | 13 | 6.5 | 8.0 | 25 | 20 | 30 | 23 | 23 | 18 |

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# S-BAND LOW-LOSS WIDE-BANDWIDTH MICROWAVE SURFACE ACOUSTIC WAVE FILTER

*A novel S-band low-loss wide-bandwidth microwave microstrip, surface acoustic wave (SAW) filter used in spread spectrum communication systems was designed and implemented. The 16 micron input/output interdigital transducer (IDT) on the 64°-rotated Y-cut $LiNbO_3$ 69.0 MHz SAW filter, with microwave square open-loop resonators, has an insertion loss of 3.987 dB. This device is also a 2.5 GHz microwave microstrip SAW filter, with four cross-coupled microstrip square open-loop resonators and two planar interdigital capacitors, with an insertion loss as low as 2.41 dB and a 3 dB bandwidth as wide as 450 MHz (18 percent). The characteristics of these low-loss wide-bandwidth microwave microstrip SAW filters are influenced by the interaction between electromagnetic waves and the piezoelectric SAW.*

Recently, many types of wireless communication systems have rapidly developed and the demand for bandwidth has increased. The spread spectrum communication systems, such as the code division multiple access (CDMA) systems have attracted increasing attention because of their unique features that make it possible to transmit signals through noisy communication channels with a high degree of security. Therefore, high-performance microwave devices having low insertion loss and wide bandwidth are required.

The filter is an important component for radio frequency integrated circuits (RFIC) in wireless communication systems and used in both receivers and transmitters. The reduction of filter size has been the focus of several studies. The problems caused by the larger, heavier and discrete conventional filters can be solved by using a planar filter. Many forms of the planar filter exist; therefore, surface acoustic wave (SAW) filters[1,2] and microwave microstrip filters[3-12] are small, light and simply fabricated. No convenient and low cost resonators for high-frequency applications are better than planar resonators such as microstrip resonators. The microstrip version is the most popular structure of a planar transmission line. Moreover, cross-coupled microstrip filters have attracted much attention in recent years due to their quasi-elliptical function or flat group delay responses. This type of microstrip resonator with appropriately designed circuits, effectively reduces the volume of circuits by using ULSI techniques.

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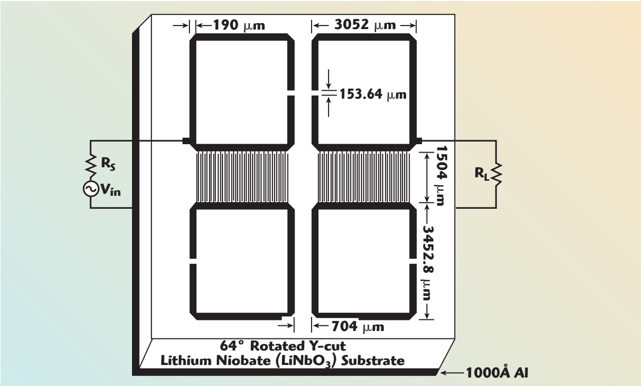
In addition, SAW filters are currently available for mobile and wireless applications in frequency ranges from 800 to 1500 MHz for personal communications services (PCS) and wide area networks (WAN) in a small form factor and can be mass produced by high volume fabrication processes. Generally, some factors can easily increase the insertion loss for conventional SAW filters such as bi-directional loss, electrical mismatch loss, propagation loss in the substrate, bulk wave problems, parasitic resistance of an interdigital transducer (IDT), and scatter capacitance of the delay line.[13] The insertion loss usually exceeds 6 dB (3 dB per transducer).[14] The central frequency of a conventional SAW filter is determined by the width of the IDT finger and the phase velocity that excites the SAW on the piezoelectric materials ($V_s = \lambda_o f_o$, where $V_s$ is the phase velocity of the acoustic wave, $\lambda_o$ is the wavelength of the acoustic wave and $f_o$ is the central frequency of the SAW filter).[15] For gigahertz range applications, it is necessary to develop new high velocity SAW materials or use a process with submicron design-rules. The width of the designed IDT finger must be less than 1 micron to yield a working high frequency device in the gigahertz range. Such a finger is hard to fabricate on a standard piezoelectric material such as the 64°-rotated Y-cut lithium niobate ($LiNbO_3$). Besides, conventional SAW filters generally have a narrow bandwidth, but greater bandwidth is required to meet the demand of communication systems. Generally, bandwidth can be increased by redesigning the IDT circuits,[16] but the fabrication becomes more complex and difficult. The high insertion loss and the narrow bandwidth will limit the usage of SAW devices so performance improvement is an important issue.

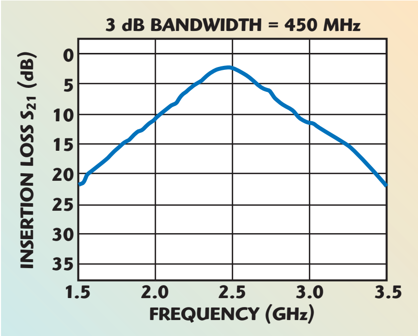
Fundamental ideas on the usefulness of combining of a SAW and bulk piezoelectric phenomena were already proposed in the last decade, but nobody has tried to design the novel combination circuit of microwave microstrip and SAW interdigital transducers. Moreover, nobody has analyzed the interrelationship between electromagnetic (EM) waves and SAWs. In this article, a novel microwave device including both the four cross-coupled microstrip square open-loop resonators and the SAW filters with 16 micron input/output IDTs of 42 pairs is designed and fabricated using the semiconductor process including photolithography and evaporation on the piezoelectric substrates. The working frequency of this novel filter can be easily increased up to 2.5 GHz without reducing the width of the IDT finger below 1 micron. It is found that this proposed filter has a lower insertion loss and a wider bandwidth due to the interaction between electromagnetic waves and the piezoelectric SAWs, substantially improving the characteristics of the conventional SAW filters. To confirm the SAW is still excited in this proposed device, four cross-coupled microstrip square open-loop resonators without SAW IDTs are designed and fabricated on the same $LiNbO_3$. Moreover, the proposed filter is also fabricated on the non-piezoelectric substrate in order to identify how the piezoelectric effect is affecting the performance. This article will also use the principle of SAW and equivalent circuit of IDT to prove the experimental results. The difference will be obtained by these comparisons to distinguish the contribution of SAW effect.

## EXPERIMENT

Based on the device specifications and design principles determined by the requirements of the circuit, four cross-coupled microstrip square open-loop resonators and the input/output IDTs of the SAW were designed and fabricated. A detailed fabricating process is shown in a previous report.[17] The techniques for fabricating planar microwave devices and SAW devices are similar to ULSI techniques. ULSI technology used in conventional photolithography and the evaporation techniques for metal patterns were used to fabricate novel microstrip SAW devices on the 64°-rotated Y-cut lithium niobate ($LiNbO_3$) piezoelectric material and the non-piezoelectric $SiO_2/Si$ material with a thickness of 9000 Å. After the normal cleaning process for these wafers, the conventional photolithography and lift-off techniques were applied for metal

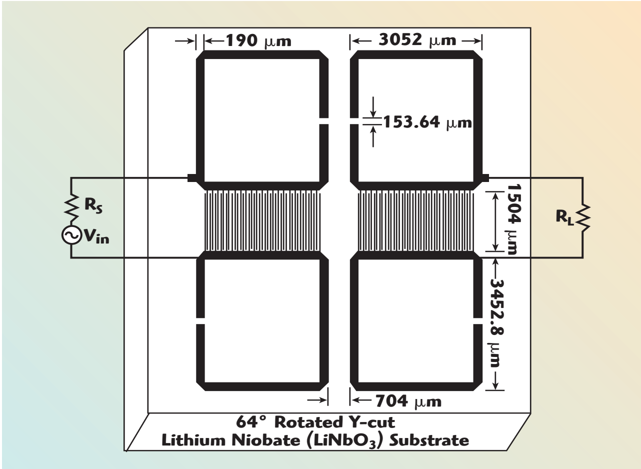



▲ *Fig. 1 Configuration of a novel microstrip SAW filter.*




▲ *Fig. 2 Frequency response of the novel microstrip SAW filter fabricated on $LiNbO_3$ substrate.*

pattern fabrication on the two substrates. An aluminum electrode with thickness of 1000 Å was deposited on the substrates by using vacuum evaporation. Due to the addition of the microstrip lines in the microwave SAW filter, the backside of the substrate was covered with the aluminum electrode. The four cross-coupled microstrip square open-loop resonators based on the same specifications were fabricated by the same methods. It requires only one mask step to fabricate this device during the experimental procedure. It is suitable for mass-produce because of its simple processing. The performance of the designed SAW filter was characterized on a HP 8722ET network analyzer.




▲ *Fig. 3 A 16 micron IDT conventional SAW filter without a metal ground on the back of the substrate.*

## RESULTS AND DISCUSSION

According to the device design, the microstrip structure with four cross-coupled microstrip square open-loop resonators was combined with a conventional SAW filter using 16 micron input/output IDTs of 42 pairs fabricated on the 64°-rotated Y-cut lithium niobate ($LiNbO_3$) with a higher electromechanical coupling coefficient ($K^2$=11.3 percent). An aluminum layer was also deposited for the ground plane on the back of the substrate. The configuration of the novel microstrip SAW filter is shown in ***Figure 1*** (sample A). ***Figure 2*** shows the frequency response of this device that is a wide-bandwidth and low-loss filter with a central frequency of 2.5 GHz, a 3 dB bandwidth of 450 MHz (BW = 18 percent) and an insertion loss $S_{21}$ of 2.41 dB. When this novel filter is fabricated on the 64°-rotated Y-cut $LiNbO_3$, the absence of an aluminum metal layer to ground the back of the piezoelectric substrate yields a conventional SAW bandpass filter with the structure shown in ***Figure 3*** (sample B). A central frequency $f_o$ of 69 MHz, a 3 dB bandwidth of 1 MHz (BW = 1.4 percent), a reflection loss $S_{11}$ of 20.191 dB and an insertion loss $S_{21}$ of 3.987 dB are obtained for sample B, as shown in ***Figure 4***. Comparison of

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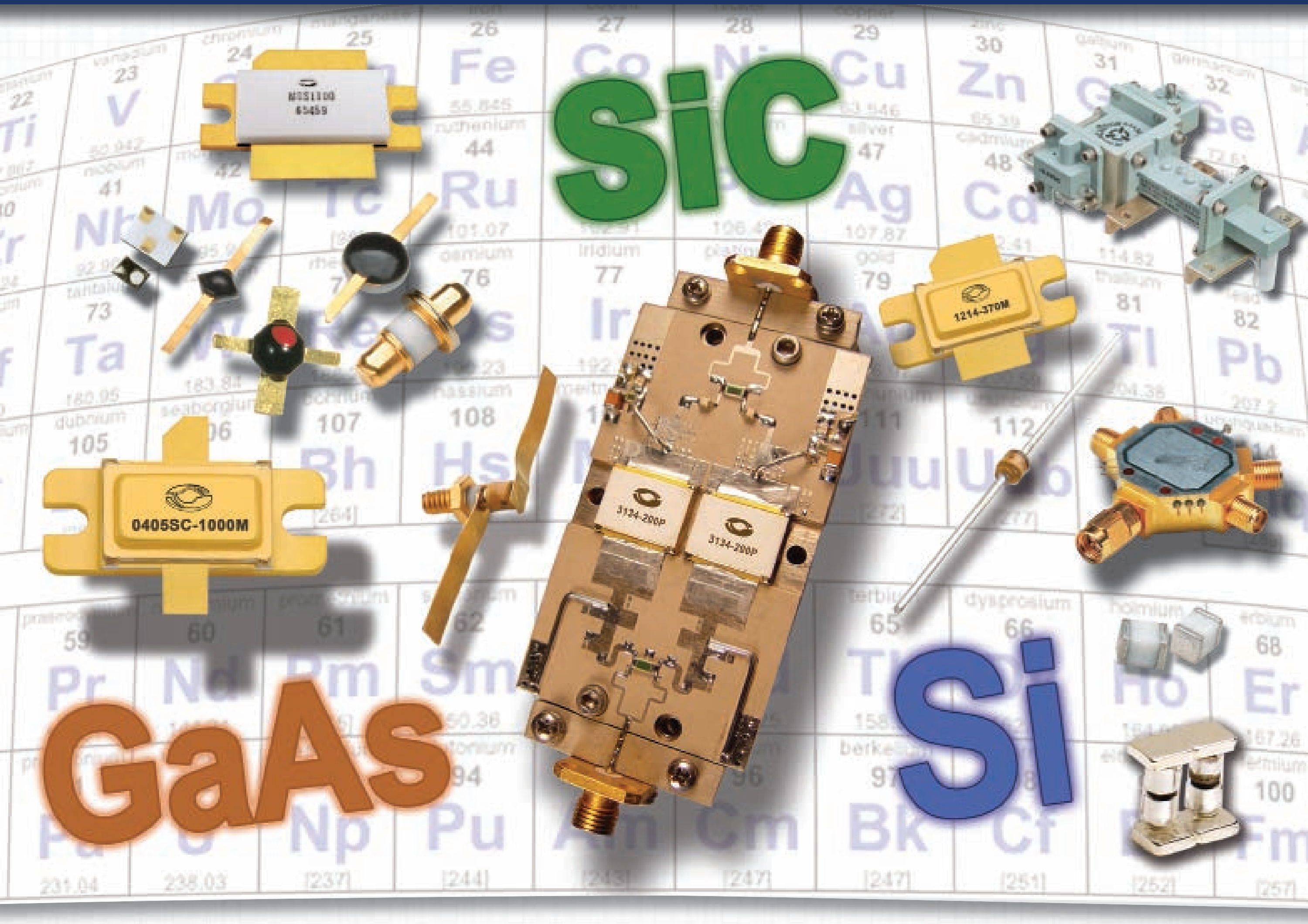


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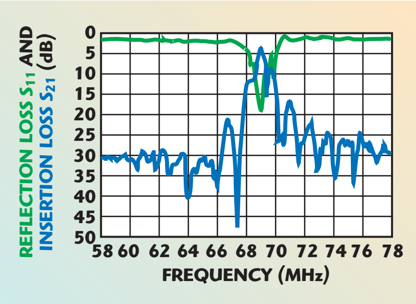
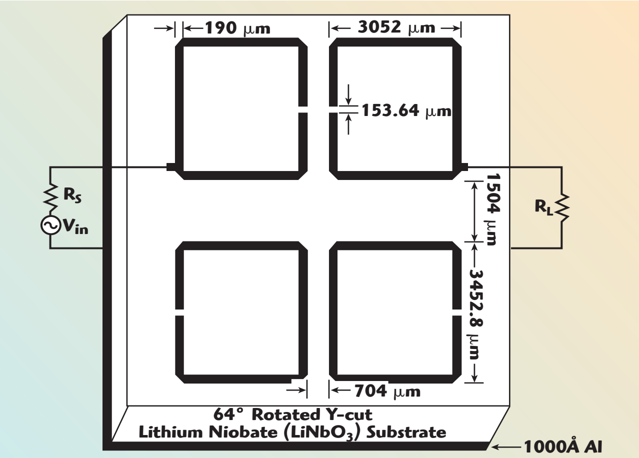


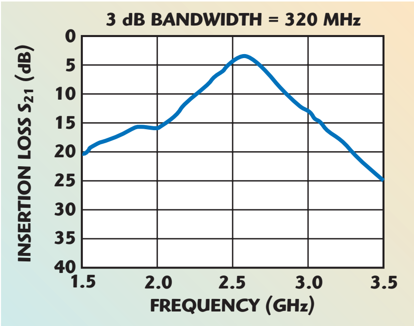

▲ *Fig. 4 Frequency responses of the 16 micron IDT conventional SAW filter fabricated on the $LiNbO_3$ substrate.*

the novel microstrip SAW filter and the conventional SAW filter, as shown in Figures 2 and 4, reveals that a central frequency of 69 MHz is increased to 2.50 GHz; an insertion loss of 3.987 dB is reduced to 2.41 dB without adding reflection gratings; and a bandwidth of 1 MHz (BW = 1.4 percent) is increased to 450 MHz (BW = 18 percent). In addition, the configuration of the four cross-coupled microstrip square open-loop resonators is fabricated on the same $LiNbO_3$ without IDTs, as shown in ***Figure 5*** (sample C). ***Figure 6*** shows the performance of sample C that has a central frequency of 2.51 GHz, a 3 dB bandwidth of 320 MHz (BW = 12.7 percent) and an insertion loss $S_{21}$ of 3.59 dB. From the results of Figures 2 and 6, the variation of the bandwidth and the insertion loss between the novel microstrip SAW filter and the four cross-coupled microstrip square open-loop resonators is observed. The bandwidth of Sample A and Sample C is 450 MHz (18 percent) and 320 MHz (12.7 percent), respectively, and the insertion loss of Sample A and Sample C is 2.41 and 3.59 dB, respectively. Comparisons of the characteristics of these devices are summarized in ***Table 1***. However, the SAW propagates on the piezoelectric substrate not only due the elastic wave movement in the medium, but also due to the time-dependent electric field and magnetic field effects that are produced on the piezoelectric substrate.[18] In the microwave frequency domain, the IDTs of the SAW devices are also regarded as electromagnetic microwave lumped-element devices as well as piezoelectric transducers that operate by two different mechanisms. Therefore, the relationships and interactions between the SAW and EM waves are produced on the piezoelectric substrates for the novel SAW microstrip filters. It is concluded that this microstrip device fabricated on the $LiNbO_3$ substrate is capable of interacting with piezoelectric SAW and acts as a high-performance, low-loss, wide-bandwidth microwave filter.




▲ *Fig. 5 Configuration of the four cross-coupled microstrip square open-loop resonators without IDTs.*

To confirm the existence of the interaction between the EM and SAW waves, devices with the same design have been fabricated on a non-piezoelectric (9000 Å $SiO_2$/Si) substrate. ***Figure 7*** shows the frequency response of the four cross-coupled microstrip square open-loop resonators




▲ *Fig. 6 Frequency response of the four cross-coupled microstrip square open-loop resonators without IDTs on the $LiNbO_3$ substrate.*



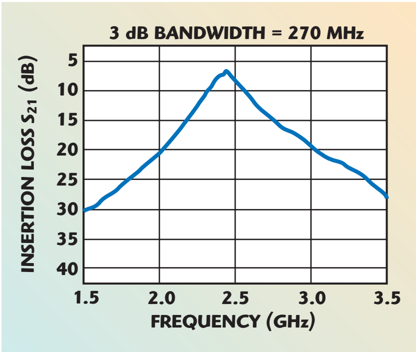
  

with IDTs on 9000 Å $SiO_2$ deposited on a (100) Si substrate (sample D). It has a central frequency ($f_o$) of 2.43 GHz, a 3 dB bandwidth of 270 MHz (BW = 11.1 percent) and an insertion loss $S_{21}$ of 7.01 dB. ***Figure 8*** shows the frequency response of the four cross-coupled microstrip square open-loop resonator without IDTs on 9000 Å $SiO_2$ deposited on the (100) Si substrate (sample E). It has a central frequency ($f_o$) of 2.46 GHz, a 3 dB bandwidth of 230 MHz (BW = 9.3 percent) and an insertion loss $S_{21}$ of 8.09 dB. From the above results, the bandwidth of sample D and sample E is 270 MHz (11.1 percent) and 230 MHz (9.3 percent), respectively. Because these two devices were fabricated on the 9000 Å $SiO_2$/Si substrate without the piezoelectric property, the interdigital electrodes just function as coupling capacitors. No matter if the device has interdigital transducers or not, the SAW will not be excited by the devices fabricated on the 9000 Å $SiO_2$/Si substrate. Consequently, the bandwidths of the sample D and sample E are almost the same.

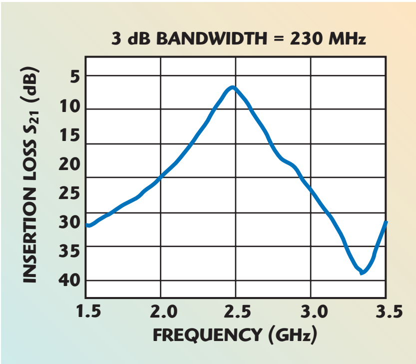
**TABLE I**

**COMPARISON OF THE CHARACTERISTICS OF THE DIFFERENT STRUCTURES FABRICATED ON THE $LiNbO_3$ SUBSTRATE**

| *Filter Structures* | *Central Frequency (GHz)* | *Insertion Loss $S_{21}$ (dB)* | *Bandwidth (MHz)* |
|---|---|---|---|
| This proposed microstrip SAW filter (sample A) | 2.50 | 2.41 | 450 |
| Conventional SAW filter (sample B) | 0.069 | 3.987 | 1 |
| Four cross-coupled microstrip square open-loop resonators (sample C) | 2.51 | 3.59 | 320 |
| Comparison of these results | Up to GHz-band for conventional SAW filter | Obvious decrease | Substantial increase |




▲ *Fig. 7 Frequency response of the four cross-coupled microstrip square open-loop resonators with IDTs on $SiO_2$ deposited on Si substrate.*




▲ *Fig. 8 Frequency response of the four cross-coupled microstrip square open-loop resonators without IDTs on $SiO_2$ deposited on Si substrate.*

In addition, the relative permittivity $\varepsilon_r$ is related to the electric susceptibility $\chi_e$, as follows:

$$\varepsilon_r = 1 + \chi_e, \qquad (1)$$

and the piezoelectric equation is

$$P = Z\,d + E\chi_e \qquad (2)$$[19]

However, the SAW propagates on the piezoelectric substrate not only does the elastic wave movement in the medium, but also due to the time-dependent electric field and magnetic field effects that are produced on the piezoelectric substrate.[18]

where:
P = polarization
Z = stress
d = piezoelectric strain constant
E = electric field

In the presented devices, the piezoelectric wave propagating in piezoelectric substrate influences the polarization, and the dielectric polarization is changed under the influence of the surface acoustic mechanical wave. Consequently, the dielectric constant changes, and the wavelength of the EM wave varies with the dielectric constants. The perturbation of the dielectric constant of the quasi-TEM

wave that propagates in the microstrip lines on the piezoelectric substrate strains the frequency response of this device due to the interaction between the EM wave and the piezoelectric surface acoustic mechanical wave.

The coupling coefficient of piezoelectric electromechanical $K^2$ can be defined in terms of the piezoelectric coefficient e, the elastic constant c and the dielectric permittivity ε. This equation has already been given as

$$K^2 = e^2 / c\varepsilon^{15} \quad (3)$$

The dielectric permittivity is changed since the electric field of the quasi-TEM wave that propagates in the microstrip influences the piezoelectric polarization. The electromechanical coupling coefficient $K^2$ is related to the dielectric permittivity and can be improved. The insertion loss of the device is reduced as $K^2$ increases. The increased $K^2$ increases the vibrations of the acoustic mechanical wave on the piezoelectric substrate and the strength of the polarization. Therefore, the characteristics of the device are changed by the interaction between the EM wave and the piezoelectric surface acoustic mechanical wave.

As demonstrated above, it can be seen that the characteristics of the devices on the 9000 Å $SiO_2$/Si substrates are different from those of the devices on the piezoelectric substrates with same design. The electromagnetic wave does not interact with the piezoelectric SAW in the non-piezoelectric material $SiO_2$/Si, 9000 Å thick. The bandwidth will be the same as that of the microwave planar bandpass filter that is composed of the four electromagnetic wave cross-coupled microstrip square open-loop resonators, as shown in Figures 7 and 8. Moreover, the EM wave did not interact with the SAW for the four cross-coupled microstrip square open-loop resonators without the input/output IDTs of the conventional SAW filters, as indicated in Figure 6. Therefore, it can be concluded that the characteristics of the microstrip filters on the piezoelectric substrates are due to the interaction of the EM wave and piezoelectric surface acoustic mechanical wave. Based on these reasons, it is known that the proposed microstrip SAW filters have an extra capacitive coupling effect by the IDTs configuration, resulting in lower insertion loss than that without IDTs. Moreover, it also gives an additional SAW to cause variation on piezoelectric effect, resulting in the bandwidth increasing.

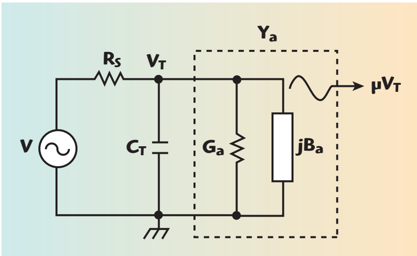



*Fig. 9 Equivalent circuit of IDT.*

Besides, the principle of SAW and equivalent circuit of IDT is used to prove our experimental results. ***Figure 9*** shows the equivalent circuit of an IDT.[14]

$$C_T = N \cdot C_S \cdot W \quad (4)$$

$$G_a(f) = 2 \cdot (0.8)^2 \cdot (K^2)^2 \cdot N^2 \cdot y_0 \cdot \frac{W}{\lambda} \cdot$$

$$\sin^2\left[\frac{\pi f}{2f_0}\right] \cdot \frac{\sin^2 \frac{N\pi(f-f_0)}{f_0}}{\frac{N^2\pi^2(f-f_0)^2}{f_0^{\,2}}} \quad (5)$$

$$B_a(f) = 2 \cdot (0.8)^2 \cdot (K^2)^2 \cdot N^2 \cdot y_0 \cdot \frac{W}{\lambda} \cdot$$

$$\frac{\sin \frac{2N\pi(f-f_0)}{f_0} - 2\frac{N\pi(f-f_0)}{f_0}}{2\frac{N^2\pi^2(f-f_0)^2}{f_0^{\,2}}} \quad (6)$$

where:

$C_T$ = total capacitance of the IDT finger

$G_a(f)$ = radiation conductance

$B_a(f)$ = radiation susceptance

N = number of IDT electrode pairs

$C_S$ = static capacitance of one pair IDT

W = IDT finger apodization overlap

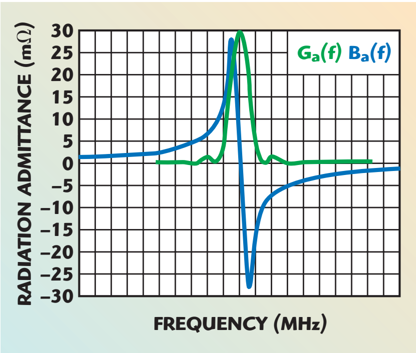
$K^2$ = electromechanical coupling coefficient

$y_0$ = electrical characteristic admittance of the equivalent SAW transmission line

λ = wavelength of the surface acoustic wave

$f_0$ = center frequency of the SAW filter

***Figure 10*** shows the simulation




▲ *Fig. 10 $G_a(f)$ and $B_a(f)$ simulations of conventional SAW filter with IDTs on a $LiNbO_3$ substrate.*

results for $G_a(f)$ and $B_a(f)$ on the 64°-rotated Y-cut $LiNbO_3$ substrate. It indicates that when the operating frequency is less than the central frequency, the wavelength is larger than one IDT period and the phase of the current is ahead of the voltage, so $B_a(f)$ represents a capacitance. When the operating frequency exceeds the central frequency, the wavelength is less than one IDT period and an extra delay occurs so the current phase falls behind the voltage and $B_a(f)$ represents an inductance.

When the operating frequency is the central frequency, if the structure were a typical SAW filter, the radiation susceptance $B_a(f)$ would be zero, as shown in Figure 10. Thus, the quality factor $Q_{01}$ of the typical SAW filter is

$$Q_{01} = \frac{2\pi f_{o1} C_T}{G_a(f_{o1})} = \frac{f_{o1}}{\Delta f} = \frac{f_{o1}}{BW} \qquad (7)$$

where:

$G_a(f_{o1})$ = radiation conductance at the central frequency

$f_{o1}$ = central frequency

$\Delta f$ = BW (that is the 3 dB bandwidth of the conventional SAW filter)

The conventional SAW filter with the narrower bandwidth is also described by Equation 7, as same as the experimental results, as shown in Figure 4.

The central frequency of the novel microstrip SAW filter is much larger than that of the SAW filter, so the radiation susceptance $B_a(f)$ of the conventional SAW filter is regarded as an inductance. The quality factor $Q_{02}$ of the novel microstrip SAW filter is

$$Q_{02} = \frac{1}{G_a(f_{o2}) \cdot 2\pi f_{o2} \cdot B_a(f_{o2})} = \frac{f_{o2}}{\Delta f} = \frac{f_{o2}}{BW} \qquad (8)$$

where:

$G_a(f_{o2})$ = radiation conductance at the central frequency

$B_a(f_{o2})$ = radiation susceptance at the central frequency

$f_{o2}$ = central frequency

$\Delta f$=BW (that is the 3 dB bandwidth of the novel microstrip SAW filter)

Figure 10 shows that the $G_a(f)$ and $B_a(f)$ values of the 64°-rotated Y-cut $LiNbO_3$ are high enough due to the higher electromechanical coupling coefficient ($K^2$ = 11.3 percent) as compared with the other piezoelectric materials. The result implies that the novel microstrip SAW filter has a wider bandwidth from Equation 8, as same as the experimental results, as shown in Figure 2.

## CONCLUSION

A novel S-band low-loss wide-bandwidth microstrip SAW filter combined with a 16 micron input/output interdigital transducer (IDT) of 42 pairs with four cross-coupled microstrip square open-loop resonators on the 64°-rotated Y-cut lithium niobate ($LiNbO_3$) was designed and fabricated. The working frequency of this novel filter can be easily increased up to 2.5 GHz without reducing the width of the IDT finger below 1 micron. Due to the interaction between the EM waves and the piezoelectric surface acoustic waves, the performance of this proposed microstrip SAW filter shows a wider bandwidth of 450 MHz and a lower insertion loss of 2.41 dB, and is better than a conventional SAW and microstrip filters, resulting in the bandwidth expansion and the insertion-loss reduction. The four cross-coupled microstrip square open-loop resonators without the IDTs of conventional SAW filters are used to prove these effects. Moreover, the devices on piezoelectric substrates are found to be superior to those on non-piezoelectric substrates with the same metal pattern. Therefore, it is proven that the EM

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| PLD | 30-130 MHz | P.L. Crystal | -95 | -115 | -140 | -155 | -155 | - | 100 MHz | 13 |
| PLD-1C | 130-1000 MHz | P.L. Mult. Crystal | -80 | -100 | -120 | -130 | -135 | - | 560 MHz | 13 |
| BCO | .100-16.5 GHz | P.L. Single Loop | -65 | -75 | -80 | -90 | -115 | - | 16.35 GHz | 13 |
| VFS | 1-14 GHz | Multiple Freq. Dual Loop | -60 | -75 | -110 | -115 | -115 | - | 12.5 GHz | 13 |
| DLCRO | .8-26 GHz | P.L. CRO Dual Loop | -60 | -85 | -110 | -115 | -115 | -138 | 10 GHz | 13 |
| PLDRO | 2-40 GHz | P.L. DRO Single/Dual | -60 | -80 | -110 | -115 | -120 | -145 | 10 GHz | 13 |
| CP | .8-3.2 GHz | P.L. CRO Single Loop | -80 | -110 | -120 | -130 | -130 | -140 | 2 GHz | 13 |
| CPM | 4-15 GHz | P.L. Mult. Single Loop | -60 | -90 | -105 | -110 | -115 | -130 | 12 GHz | 13 |
| ETCO | .1-24 GHz | Voltage Tuned CRO | - | - | -70 | -100 | -120 | -130 | 2-4 GHz* | 13 |

* Octave band.

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wave indeed interacts with the piezoelectric surface acoustic mechanical wave in this proposed microstrip SAW filter. The principle of the SAW and equivalent circuit of IDT are used to prove the experimental results. Further study is required to elucidate the mechanism of the interaction between the EM wave and SAW in the proposed devices. The device can be easily and inexpensively fabricated using conventional photolithography, a normal lift-off technique and standard piezoelectric materials. ■


## ACKNOWLEDGMENT

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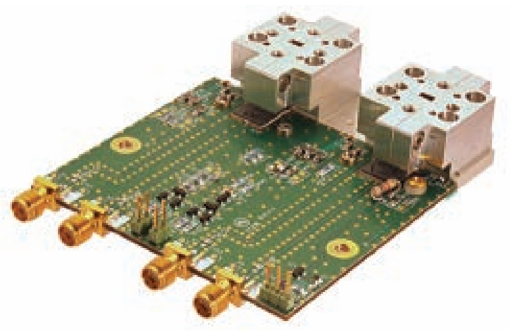

# A VERSATILE BROADBAND 60 GHZ CONVERTER FOR MULTI-PURPOSE USE

In recent years, the 60 GHz band has gained increased interest due to the large amount of license-free and little used frequency spectrum located in the vicinity of 60 GHz. A particular feature of this band is the high attenuation in air, close to 15 dB/km, regardless of weather conditions. This high attenuation makes the 60 GHz band less suitable for some applications, but for many other systems it is beneficial. Today, the most common commercial 60 GHz product takes the form of license-free and high-speed (1.25 Gbps) wireless Ethernet links.

Due to the high attenuation these links benefit from reduced co-channel interference, and thus shorter cell re-use distance, which is of the utmost importance in a dense urban environment. Another application where the high attenuation is beneficial is secure communication, when the transmitted signal will vanish in the noise floor after a controlled distance determined by the user. Thus, in practice, it will be impossible to overhear the communication outside a well defined range of operation.

To address such applications, Sivers IMA has developed a new broadband 60 GHz converter that is a very versatile building block for high-performance 60 GHz applications. The converter is linear and can thus accommodate almost any modulation scheme that the user desires. It is capable of 64QAM transmission at 60 GHz and consists of one up-converter and one down-converter in a single unit. These two converters work independently and can thus be used in both frequency multiplexed and time multiplexed applications.

## FEATURES AND PERFORMANCE

The 60 GHz converter employs single-chip transmitter (up-converter) and receiver (down-converter) MMICs for reliable and consistent performance. The chip-set used allows for high-volume production of the converter with minimal manual tuning of the individual modules required. A block diagram of the standard FC1001V/00 60 GHz converter is shown in ***Figure 1***.

As a unique feature, the user has full control of frequency selection by choosing an appropriate external LO source. Frequency multipliers (×8) are integrated in both the up-converter and down-converter. The LO injection is effected at 7 GHz with +0 dBm power. The unit has two separate inputs for the LO signal, one for the up-converter and one for the down-converter.

Each input accepts an input signal in the range between 6.75 and 7.625 GHz. With this range it is possible to fully cover 57 to 63 GHz, while maintaining a full operational IF bandwidth of 1 GHz centered around 2.5 GHz. The up-converter and down-converter accepts LO power levels between -4 to +10 dBm. Howev-

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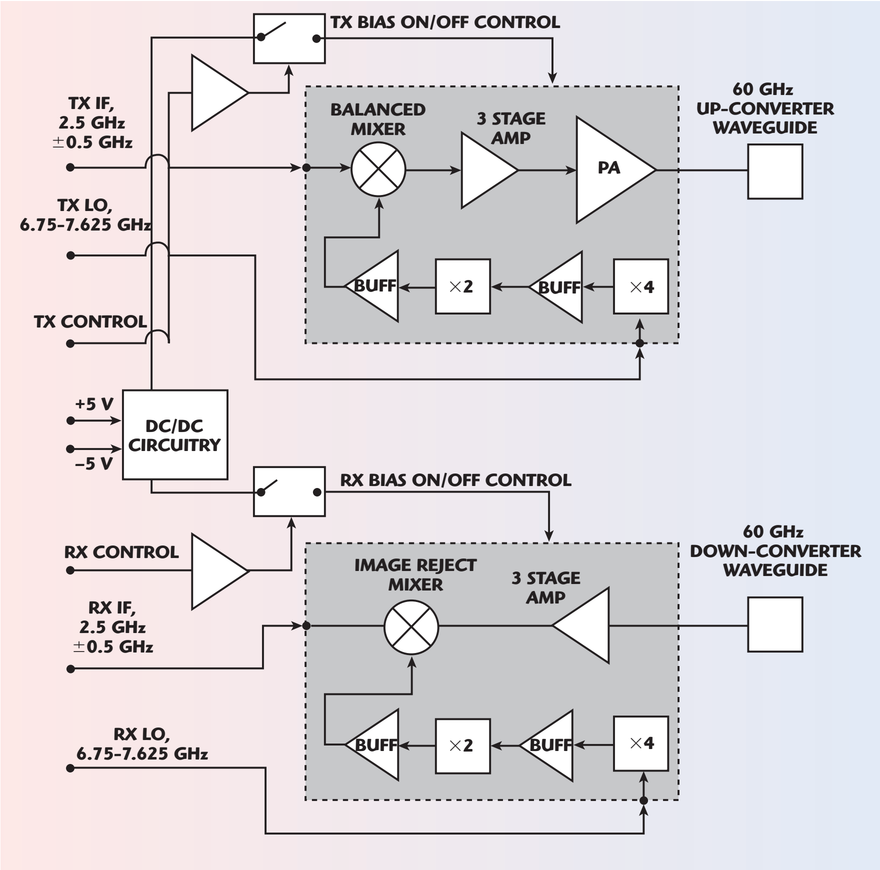



▲ *Fig. 1 Block diagram of standard FC1001V/00 60 GHz converter.*

**TABLE I**

**SUMMARY OF THE PERFORMANCE OF THE UP-CONVERTER OF THE FC1001V/00 60 GHz CONVERTER**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Nominal gain IF/RF | | 15 | | dB |
| Output power | | +10 | +12 | dBm |
| 1 dB output comp. point | | +10 | | dBm |
| ON/OFF ratio | | 40 | | dB |
| LO rejection | | 20 | | dB |
| LO input power | -4 | +2 | +10 | dBm |
| Added phase noise over LO @ 7 GHz | | 18.1 | | dB |
| RF output frequency range | 57 | | 63 | GHz |
| IF input frequency range | 2 | | 3 | GHz |
| IF input return loss | | -10 | | dB |
| Switching delay, bias control | | | 100 | ns |
| Bias current ON state | | | 350 | mA |
| Bias current OFF state | | | 50 | mA |
| All data given for ambient temperature of +25°C | | | | |

er, a nominal level of +2 dBm ±2 dB is recommended for best performance.

The applied LO signals determine much of how the converter is implemented in a system. Some systems require very low phase noise, while others must be frequency agile (Frequency Division Duplex (FDD) requires a different LO for the up-converter and down-converter, etc.). The user needs to select the output or input operating frequency and choose a LO source with 1/8th of that frequency. The phase noise at 60 GHz band is readily calculated as the phase noise at the applied 7 GHz LO frequency +18.1 dB, due to the ×8 frequency multiplication within the converter. By using a high-quality LO synthesizer provided by Sivers IMA, 64QAM transmission has been demonstrated with the standard 60 GHz converter.

A set of two identical FC1001V/00 converters can be used in a full duplex configuration by the appropriate choice of LO signals for the up-converter and down-converter modules, respectively. The user also has access to a bias control input for both the up-converter and down-converter. This feature enables Time Division Duplex (TDD) operation by independently turning OFF the up-converter and down-converter when not in use. The bias can be turned ON and OFF in less than 100 ns from a CMOS gate, operational amplifier or comparator. The user may also use this control to save DC power by switching off the up-converter and/or down-converter when in idle mode.

The FC1001V/00 is intended as a sub-unit to be integrated into a user application. For easy handling, the unit is furnished with standard SMA connectors for IF and LO signals. The output is a standard WR-15 waveguide flange UG385/U for easy connection to other equipment or antennas. It is also possible for the user to remove the waveguide adapter flange and use the waveguide exciters (probes) as low gain antennas.

A summary of the performance for the up-converter (transmitter, Tx) and down-converter (receiver, Rx) part of the standard FC1001V/00 60 GHz converter is shown in ***Tables 1*** and ***2***, respectively.

## VARIANTS OF THE STANDARD CONVERTER

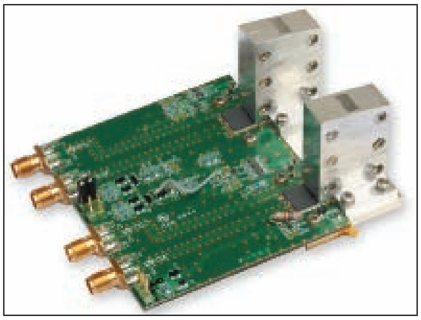
Sivers IMA has a long history of designing and manufacturing custom-made systems. Thus, the standard FC1001V/00 60 GHz converter can be tailored to fit the specific needs of the customer. One straight-forward example is shown in ***Figure 2*** where the standard FC1001V/00 is equipped with +10 dBi horn antennas. In this configuration the product number is FC1001V/01. Apart from the functionality found in the standard FC1001V/00 converter, additional functionality such as a mechanical housing, high-quality LO synthesizer, additional DC circuitry, and gain-control circuitry may be ordered and included.

**TABLE II**

**SUMMARY OF THE PERFORMANCE OF THE DOWN-CONVERTER OF THE FC1001V/00 60 GHz CONVERTER**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Nominal gain RF/IR | | 5 | | dB |
| Noise figure | | 11 | | dB |
| Image rejection ratio | 10 | 20 | | dB |
| 1 dB input comp. point | | -18 | | dBm |
| LO input power | -4 | +2 | +10 | dBm |
| Added phase noise over LO @ 7 GHz | | 18.1 | | dB |
| RF input frequency range | 57 | | 63 | GHz |
| IF output frequency range | 2 | | 3 | GHz |
| IF input return loss | | -10 | | dB |
| Switching delay, bias control | | | 100 | ns |
| Bias current ON state | | | 350 | mA |
| Bias current OFF state | | | 50 | mA |
| All data given for ambient temperature of +25°C | | | | |

The mechanical housing is typically designed according to the needs of the customer and provides efficient dust and weather protection. The integrated high quality synthesizer may result in a frequency resolution as small as 0.1 kHz of the 60 GHz signal. The additional DC circuitry allows for a single-input DC feed between +10 to +18 V, which makes the handling of the module even simpler. The gain-control circuitry allows for gain and output power variation over a 32 dB range or more.



▲ *Fig. 2 60 GHz converter with optional +10 dBi horn antennas (FC1001V/01).*

## CONCLUSION

The standard FC1001V/00 60 GHz converter is a broadband, versatile 60 GHz converter for multi-purpose use. It can be utilized in all applications where a seamless 60 GHz converter is needed. Applications include diverse areas such as high speed (several Gbps) point-to-point links, secure communication, measurement systems, electronic warfare and lab usage. Furthermore, the converter can be customized to fit the exact needs of the customer.

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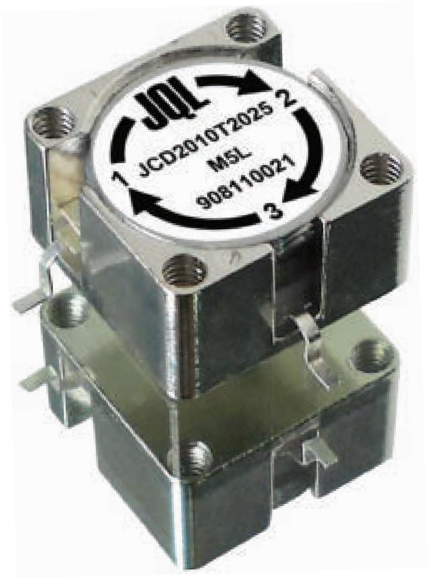


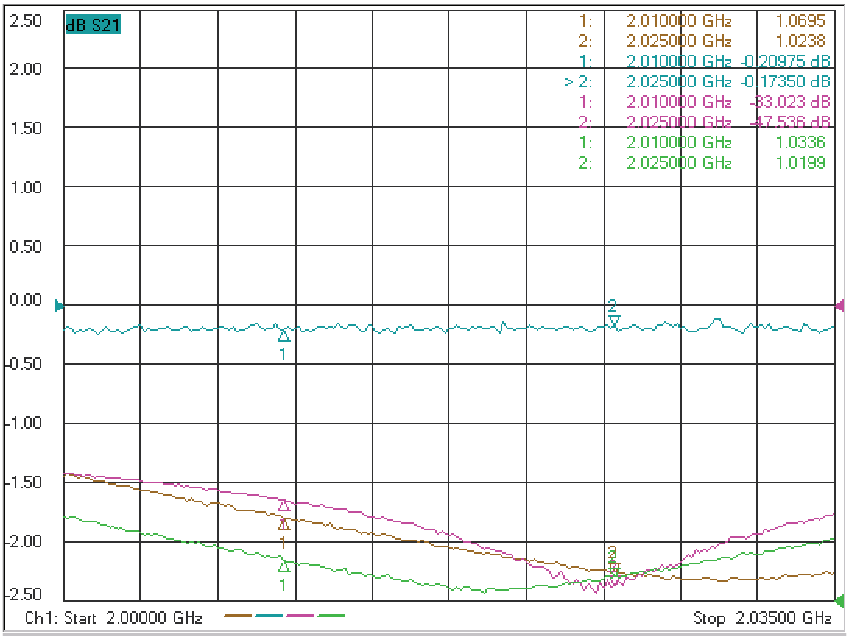


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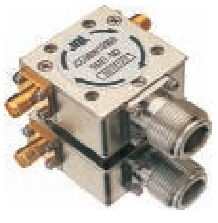

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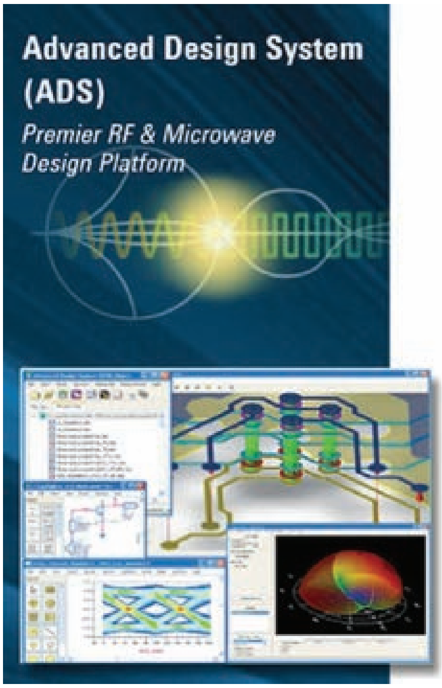
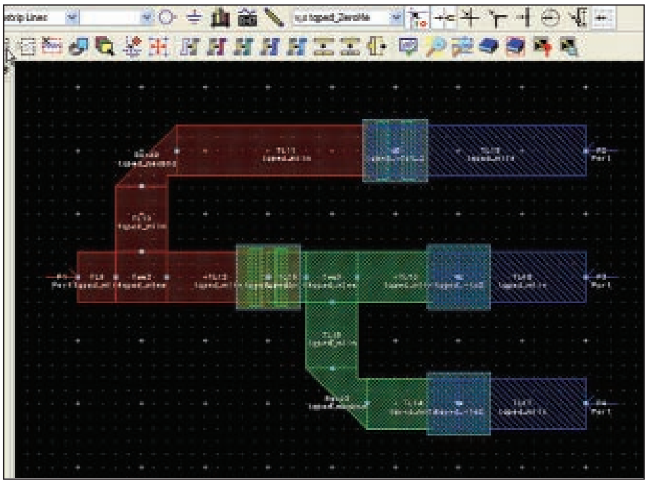



# ACCELERATING MMIC, RF MODULE DESIGN WITH ADS 2009 UPDATE 1

Agilent's Advanced Design System (ADS) 2009 Update 1 is a complete front-to-back solution for MMIC and RF module design. This includes a complete flow to manufacturing: Enhanced PDKs, Desktop LVS & DRC and Calibre LVS integration; full support for X-parameters*; enhanced integrated 3D EM analysis; and an easy-to-use Optimization Cockpit. This combination of capabilities enables designers to stay within a single design platform throughout their development cycle (design, simulation and manufacturing output), eliminating the time and expense integrating disparate point-tools.



▲ *Fig. 1 In MMIC design, the PDK-specific tool bar can be used to convert selected traces into transmission lines.*

## COMPLETE MMIC MANUFACTURING DESIGN FLOW

Agilent ADS accelerates design with capabilities such as a customized MMIC layout tool bar. Built on top of foundry-approved PDKs (currently available for TriQuint, Win Semiconductor and UMS), the tool bar allows one-click access to process-specific functions for layout creation and editing (see ***Figure 1***). Example functions include automatic via insertion; the conversion of trace structures to transmission lines; and splitting, joining, stretching and tapping into transmission lines. Easy access to these capabilities improves productivity and also helps eliminate layout-versus-schematic errors early in the design process.

For improved synchronization, ADS 2009 Update 1 includes multiple options that go well beyond the typical "always on" tools that are often inflexible and may lead to design errors that are difficult to correct without damaging or discarding an entire design. One such capability is the continuously updated "Design Differences" window, which provides either a single or a dual representation of schematic and layout. In this mode, the designer can choose to place specific schematic components onto the layout or, at will, update the entire layout from the schematic.

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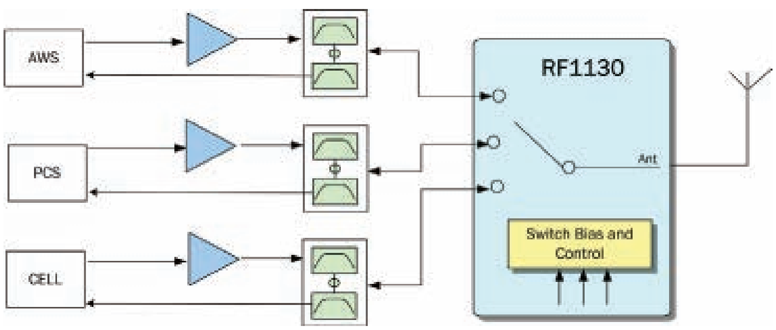
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SPDT | RF1200 | 2 | DC to 2500 | 37 | 0 / +2.6 | 0.30 | 26 | 118 | — | 2 x 2 x 0.85 | NOW | — |
| | RF1201 | 2 | DC to 2500 | 41 | 0 / +2.6 | 0.30 | 26 | 118 | — | 2 x 2 x 0.85 | NOW | — |
| | RF1120 | 1 | DC to 3500 | 32 | 0 / +1.8 | 0.45 | 29 | 100 | — | 2 x 2 x 0.55 | NOW | — |
| | RF1121 | 2 | DC to 3500 | 23 | 0 / +2.6 | 0.33 | 25 | 107 | 64 | 1 x 1 x 0.40 | NOW | — |
| | RF1126 | 2 | DC to 6000 | 23 | 0 / +3.0 | 0.26 | 27 | 96 | 62 | 2 x 1.3 x 0.38 | NOW | — |
| | RF1127 | 1 | DC to 3500 | 23 | 0 / +1.8 | 0.45 | 29 | 100 | 65 | 2 x 1.3 x 0.38 | NOW | — |
| | RF1128 | 2 | DC to 3500 | 32 | 0 / +2.85 | 0.35 | 27 | 111 | 67 | 2 x 1.3 x 0.38 | NOW | — |
| SP3T | RF1130 | 2 | DC to 2500 | 38 | 0 / +1.8 | 0.30 | 29 | 114 | 70 | 3 x 3 x 0.55 | NOW | No DC blocks required |
| | RF1131 | 3 | DC to 2500 | 37 | 0 / +2.6 | 0.30 | 32 | — | 62 | 2 x 2 x 0.55 | NOW | — |
| | RF1132 | 3 | DC to 2500 | 37 | 0 / +2.6 | 0.48 | 30 | — | 67 | 2 x 2 x 0.55 | NOW | — |
| | RF1136 | 2 | DC to 3500 | 29 | 0 / +1.8 | 0.25 | 28 | 110 | 63 | 2.5 x 2.5 x 0.55 | NOW | No DC blocks required |
| SP4T | RF1450 | 2 | DC to 2500 | 38 | 0 / +1.8 | 0.40 | 29 | 128 | — | 3 x 3 x 0.9 | NOW | — |
| | RF1140 | 2 | DC to 2500 | 38 | 0 / +1.8 | 0.30 | 28 | 110 | 70 | 3 x 3 x 0.55 | NOW | No DC blocks required |
| | RF1146 | 2 | DC to 2500 | 29 | 0 / +1.8 | 0.30 | 29 | 106 | 63 | 3 x 3 x 0.45 | NOW | No DC blocks required |
| | RF1147 | 2 | DC to 3500 | 29 | 0 / +1.8 | 0.30 | 29 | 106 | 63 | 3 x 3 x 0.45 | NOW | No DC blocks required |
| SP5T | RF1156 | 3 | DC to 2500 | 28 | 0 / +1.8 | 0.35 | 29 | 108 | 60 | 3 x 3 x 0.85 | NOW | No DC blocks required |

**Typical Application: Tri-band CDMA Band Switch**

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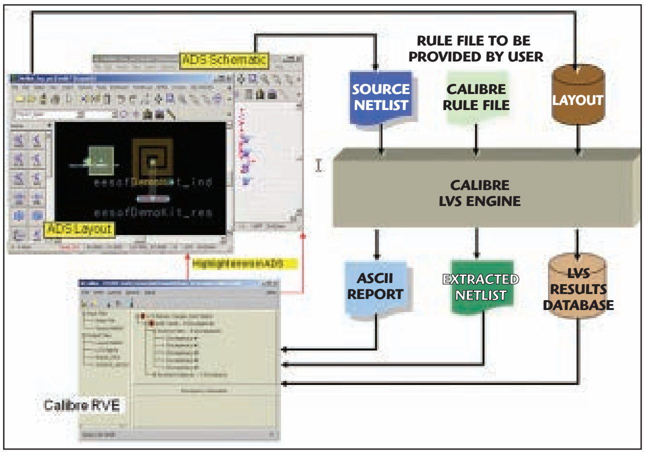


▲ *Fig. 2 Integration of Calibre LVS into the layout environment equivalency of schematic and layout.*

Once an initial MMIC design is complete, a full LVS check will ensure that the layout is electrically equivalent to the schematic prior to wafer fabrication. This is simplified by integration of tools such as Mentor Graphics™ Calibre LVS into the layout portion of ADS, as shown in ***Figure 2***.

## X-PARAMETER GENERATION

Many of today's high-frequency designs are nonlinear (e.g. mixers and power amplifiers). The ability to model for nonlinear effects at the system level depends on behavioral models that accurately account for phenomena such as harmonics, frequency mixing and impedance mismatch. To meet this need, Agilent developed X-parameters, a new category of nonlinear network parameters for high-frequency design to accurately model nonlinear behavior. X-parameters help overcome a key challenge in RF design; nonlinear impedance differences, harmonic mixing and nonlinear reflection effects that occur when components are cascaded under large-signal operating conditions. X-parameters can be created from measurements made with a nonlinear vector network analyzer (NVNA) or the new X-parameter Generator in ADS 2009 Update 1. The resulting models enable design houses to provide virtual, simulated samples of power amplifiers (PA), front end-modules (FEM), transceivers and more to their customers before hardware samples are available while protecting the embedded intellectual property.

## OPTIMIZATION COCKPIT

The new Optimization Cockpit provides the designer with greater insight, real-time tuning and optimization control to help produce better designs faster. At a glance, one can identify which variables are constrained at the limits of their allowed ranges and adjust these limits. One can also observe the Pareto of which goals dominate the error function to provide guidance on setting the goal weightings. Error function trends can be monitored, providing guidance on when to choose a new optimization algorithm. The optimization is easily paused at any time (saving the state of component parameters), changes made, then continued from where it left off (see ***Figure 3***).

## ASSESSING EM EFFECTS

As high-frequency end-user devices become more com-


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Fig. 3 The Optimization Cockpit provides a unified interface for managing all settings and results.

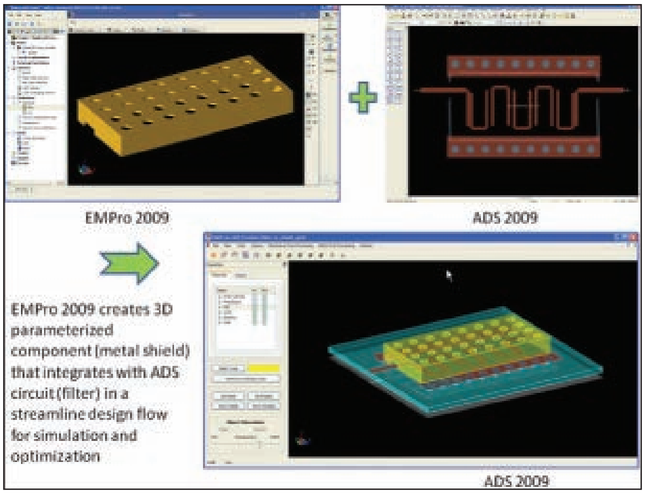


Fig. 4 The perforated metal shield was created in EMPro and placed over a microstrip hair pin in ADS, enabling joint simulation of their combined interaction.

pact, it becomes increasingly important to understand the EM effects of 3D components like interconnects, shielding, packages and on- and off-chip embedded passives. Integrated 3D EM in ADS enables the ability to co-simulate 3D components with 2D layouts to account for EM effects. ADS 2009 Update 1 includes swept simulation and optimization for its 3D FEM solver (EMDS G2). This, along with parameterized 3D components generated in EMPro, as shown in ***Figure 4***, saves time compared to importing static simulation data and manually modifying 3D models in an isolated 3D EM point tool, producing the most accurate simulation results and uncovering interactions before fabrication.

## CONCLUSION

Agilent ADS 2009 Update 1, a complete front-to-back solution for MMIC/RF module design, provides a single, integrated design flow enabling users to stay within a single design platform, eliminating the time and expense integrating disparate point-tools and accelerating the overall development cycle.

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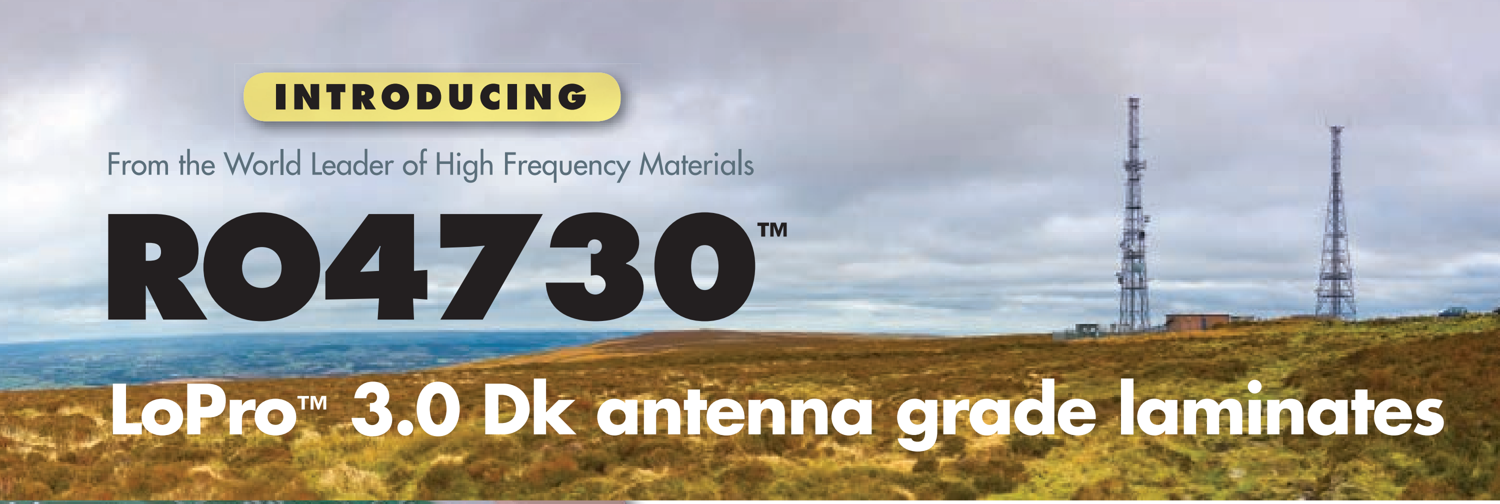

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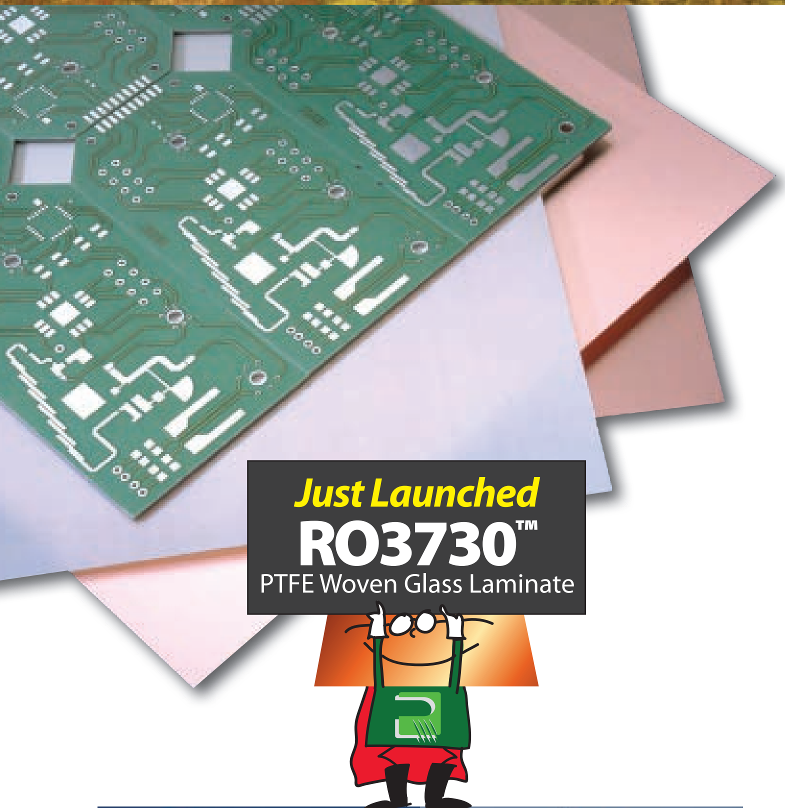


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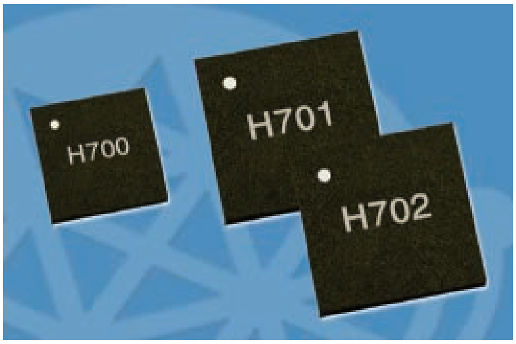


# PLL FRACTIONAL-N SYNTHESIZERS TO 14 GHz

Integration, performance and functionality are three of the most common requests made by RF and microwave designers striving for leading-edge systems with components that can help them deliver that often elusive market edge. In the world of signal generation, Hittite Microwave Corp. is meeting these challenges with the introduction of broadband frequency synthesizers and phase locked loop (PLL) integrated circuits that are designed to deliver superior performance and innovative features, all within a miniature surface-mount package.

Consumer demand for mobile bandwidth and data capacity has pushed mobile backhaul systems to higher levels of digital modulation with more bits/Hertz. These radios require integrated synthesizers that deliver high accuracy and can support signals with exceptional signal-to-noise-ratio (SNR). The phase noise and distortion of the synthesizer can limit the maximum achievable SNR of a modulated signal, while increases in the data throughput of the radio place an even greater demand on the synthesizer phase noise. In addition, synthesizer spurious products and far out noise must be kept to a minimum so as not to impair radios operating in adjacent bands.

## LOW NOISE SYNTHESIZER IC INCLUDES INTEGRATED SWEEPER FUNCTION

Hittite Microwave has developed a core expertise in frequency generation products including MMIC and Silicon VCOs, low noise prescalers, multipliers and now a new line of dual-mode integrated synthesizer solutions. It is important to note that all Hittite synthesizers are designed to work with Hittite's wide selection of high performance VCOs and low noise dividers. This gives Hittite a unique capability to guarantee performance of the PLL and the VCO components together, while offering the flexibility of standalone VCOs.

Hittite synthesizers feature very high reference frequency operation and low noise delta sigma modulator design, two critical factors in achieving ultra-low phase noise.

The HMC702LP6CE is a SiGe BiCMOS fractional-N frequency synthesizer IC that operates in fractional or integer mode over a frequency range of 100 kHz to 14 GHz providing the ability to develop high performance phase locked loops for cellular base stations and point-to-point radio links using the same device. Primarily designed for ultra low phase noise applications, its internal architecture includes a 14 GHz 16-bit RF N-counter, 24-bit delta-sigma modulator, a very low noise digital phase frequency detector (PFD) and a precision controlled charge pump (see ***Figure 1***).

***Figure 2*** shows the exceptional integer and fractional mode phase noise performance of the HMC702LP6CE. Ultra low in-close phase noise allows wider loop bandwidths for

HITTITE MICROWAVE CORP.
*Chelmsford, MA*

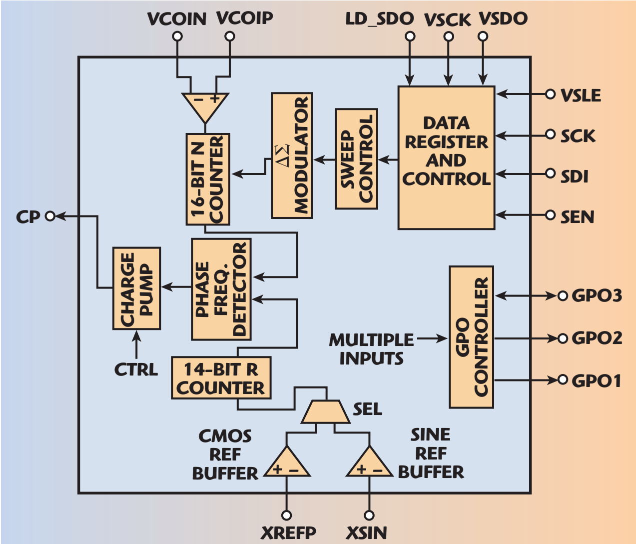


Fig. 1 *Fractional-N frequency synthesizer IC block diagram.*

faster frequency hopping. A Cycle Slip Prevention (CSP) feature can reduce the time to arrive at the new frequency by 50 percent versus conventional PFDs. The HMC702LP6CE also contains a built-in linear sweeper function, which allows it to perform frequency chirps with a wide variety of sweep times, polarities and dwells, all with an external or automatic sweep trigger. Other features include a General Purpose Output (GPO) and square wave and 50 Ohm sinusoidal crystal source buffers in the reference path.

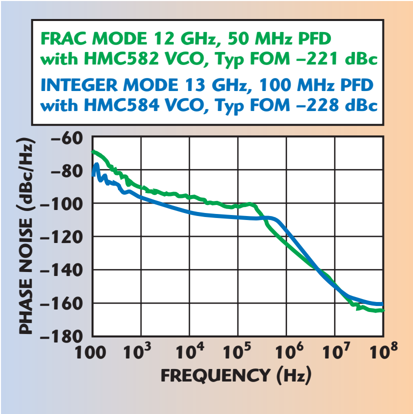


Fig. 2 *Integer and fractional mode phase noise performance of the HMC702LP6CE.*

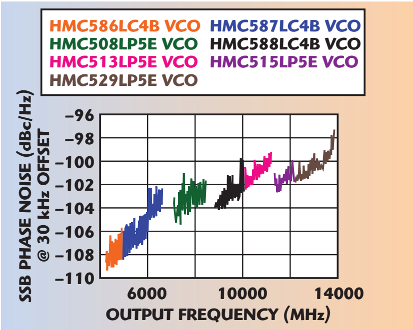


Fig. 3 *HMC702LP6CE phase noise at 30 kHz when combined with various Hittite VCOs (fractional mode).*

The HMC702LP6CE can be combined with many of Hittite's MMIC VCOs to create compact, state-of-the-art PLL synthesizer/VCOs. ***Figure 3*** shows the typical phase noise performance when operating with some of Hittite's most popular VCOs. Performance is shown at 30 kHz offset from the carrier when operating in fractional mode with a wide loop bandwidth. For lower frequency applications, the HMC701LP6CE accepts VCO input frequencies from 100 kHz to 8 GHz (7 GHz fractional)

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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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**TABLE I**

**HITTITE'S FRACTIONAL-N PLL SYNTHESIZER IC PRODUCT LINE**

| Part Number | HMC700LP4E | HMC701LP6CE | HMC702LP6CE |
|---|---|---|---|
| Frequency | 10 MHz to 8 GHz | 10 kHz to 8 GHz | 10 kHz to 14 GHz |
| Max PFD Frequency (MHz) | 70 | 75 | 75 |
| Max. Reference Frequency (MHz) | 200 | 200 | 200 |
| Figure of Merit (Frac/Int) (dBc/Hz) | -221/-226 | -221/-227 | -221/-227 |
| Frequency Resolution with 50 MHz PFD (kHz) | 3 | 3 | 6 |
| Bias Supply | +5V @ 95 mA<br>+3.3V @ 95 mA | +5V @ 37 mA<br>+3.3V @ 90 mA | +5V @ 37 mA<br>+3.3V @ 136 mA |
| Package | LP4 | LP6C | LP6C |

and offers similar performance and features as the HMC702LP6CE.

The HMC700LP4E is a SiGe BiCMOS 8 GHz fractional-N frequency synthesizer IC in a 4×4 mm SMT package. The synthesizer includes a very low noise digital phase PFD and a precision controlled charge pump. The fractional synthesizer features an advanced delta-sigma modulator design that allows both ultra-fine step sizes and low spurious products. The HMC700LP4E PFD features CSP technology that allows faster frequency hopping times. Ultra low in-close phase noise and low spurious also permit architectures with wider loop bandwidths for faster frequency hopping and low micro-phonics. FSK mode allows the synthesizer to be used as a simple low cost direct FM transmitter source.

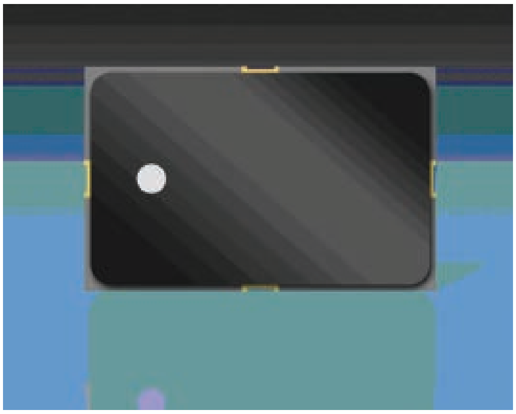
***Table 1*** summarizes Hittite's fractional-N PLL synthesizer IC products. Hittite Microwave is committed to providing superior component solutions and product support that enables customers to be the best in the RF and microwave industry. The company's product strategy is to continue to provide levels of integration that deliver incremental performance and value while maintaining the features that permit user flexibility.

All of Hittite's fractional synthesizers feature built in 5 V charge pumps which can work directly with low voltage VCOs, or drive external op amps for high tuning voltage VCOs. Hittite offers advanced software for modeling both active and passive loop filters. Models are available for all of Hittite's VCOs, and accurately predict phase noise and loop bandwidths for a wide variety of PLL-VCO combinations. Hittite's fractional PLLs are supported with PC control software and simple USB port control.

Samples and evaluation PC boards for all SMT packaged products can be ordered via the company's e-commerce site or direct from the company. Detailed datasheets may be found on the Hittite web site. For design assistance, please contact apps@hittite.com.


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


***RS No. 303***



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Aeroflex / Metelics has introduced a family of RoHS compliant, silicon PIN diode surface-mount high power switches, ideal for high volume, high performance manufacturing in the military and commercial-industrial markets. These switches are ideal for higher power, higher linearity RF and microwave applications for the military radio, IED defeat, MRI and WiMAX markets.

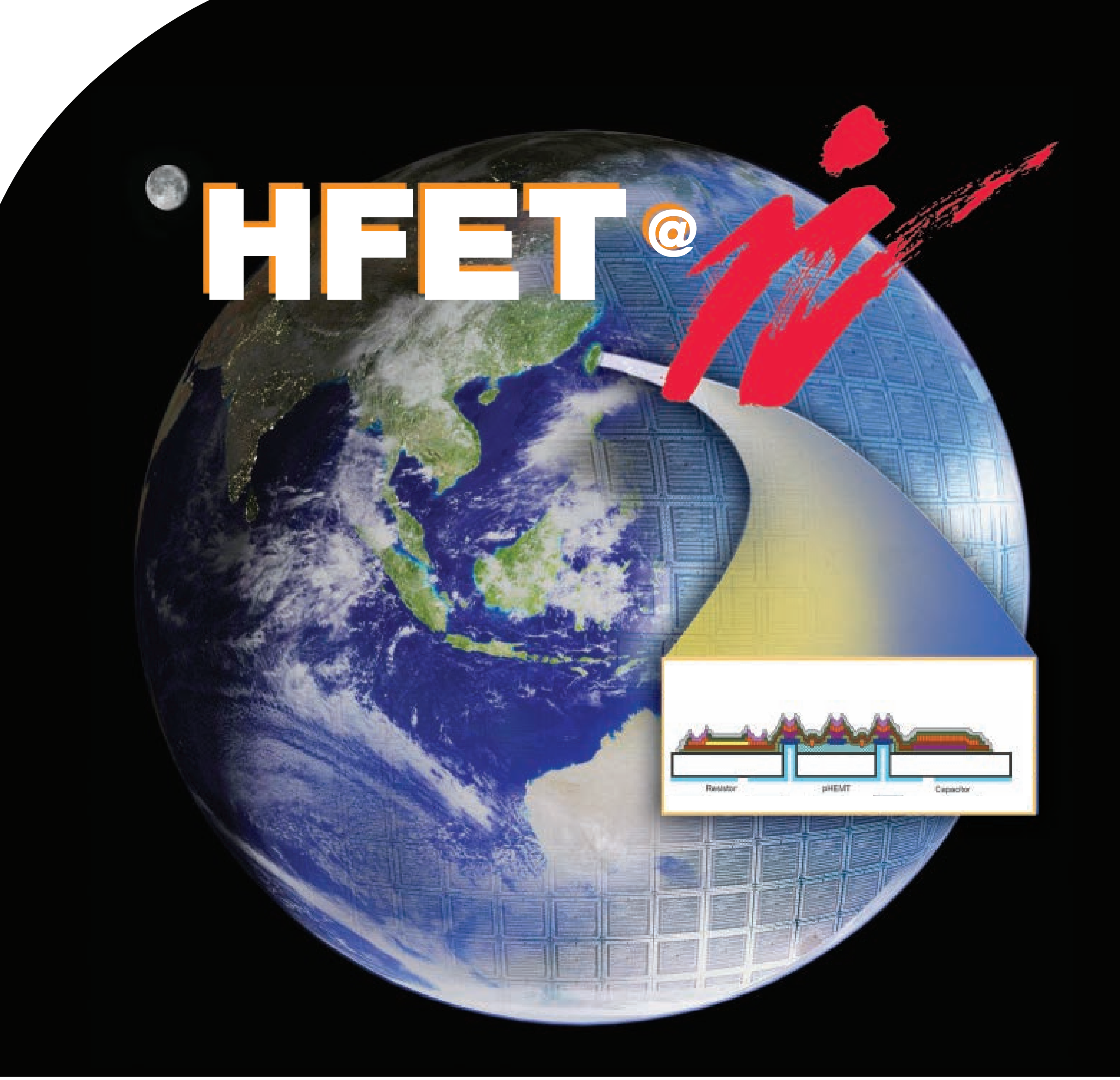
The MSW2000 Series of surface-mount PIN diode SP2T switches is manufactured using Aeroflex / Metelics' proven hybrid manufacturing process incorporating high voltage PIN diodes and passive devices integrated within a ceramic substrate. This low profile, compact, surface-mount component (8 × 5 × 2.5 mm) offers superior low and high signal performance compared to MMIC devices in QFN packages. The RF cover provides a suitable degree of EMI shielding, moisture protection, and a flat surface suitable for high volume, surface-mount manufacturing and test equipment.

The SP2T switches are designed in both asymmetrical and symmetrical topologies. The asymmetrical SP2T's are available as either having the Tx RF port on either the left side of the device (CS200: case style 200) or the right side (CS201: case style 201) for design versatility. The symmetrical configuration consists of a series and shunt PIN diode in both RF ports for improved RF isolation in both ports.

The asymmetrical SP2T design consists of a unique geometry Tx series PIN diode that provides a lower Rs (< 0.7 at 100 mA) for improved power dissipation and higher IIP3 values. The thermal resistance of the Tx PIN diode is on the order of 6° C/W, allowing it to safely handle CW incident power levels exceeding 100 W at +85°C. The Rx port incorporates a series PIN diode in addition to a shunt PIN diode floated on a RF bypass capacitor, allowing for positive voltage only operation. This arrangement provides improved Tx-Rx isolation in excess of 40 dB, or allows less than +10 dBm leakage to the receiver port with a +50 dBm Tx applied signal.

The switches are capable of operating in either a high signal 100 W CW cold switched mode or in a hot switched condition where the RF power state change commutation period from Tx-Ant to Ant-Rx is less than 100 ns. The switches are capable of operating at higher peak RF power levels than comparable surface-mount MMIC switches, since the breakdown voltages of the PIN diodes exceed 1,000 V. Rated RF peak power levels for the SP2T family is 500 W peak power at 50 µS RF pulse width at 5 percent duty cycle at +85°C. This type of high signal switch performance is extremely advantageous

AEROFLEX / METELICS
*Londonderry, NH*




# 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 |

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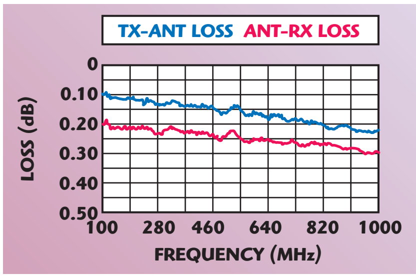
in applications where the peak to average power ratio is greater than 12 dB.

These SP2T switches are optimized in design to function in two frequency bands of interest: Band 1: 10 to 1,000 MHz and band 2: 400 to 4,000 MHz. Typical RF performance for the asymmetrical SP2T switch in band 1 provides Tx-Ant insertion loss of 0.2 dB, with better than 20 dB return loss and 45 dB Tx-Rx isolation. Ant-Rx loss is similar at 0.3 dB with greater than 20 dB return loss and better than 20 dB Rx-Tx isolation. See ***Figures 1, 2*** and ***3*** for graphs of insertion loss, return loss and isolation, respectively, versus frequency.

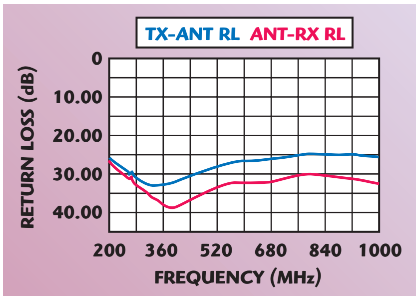
Typical RF performance for the asymmetrical SP2T switch in band 2 provides Tx-Ant insertion loss of 0.3 dB, with better than 17 dB return loss and 40 dB Tx-Rx isolation. Ant-Rx loss is similar at 0.6 dB with 15 dB return loss and greater than 13 dB Rx-Tx isolation. IIP3 is better than +90 dBm. The SP2T switches are capable of operating from positive voltage only: +5, +28 and +50 V DC. Design work is in progress to complete a similar SP2T for the 2 to 6 GHz band.

These SP2T switches are designed to be used in higher power switch applications, operating from 10 MHz to 4 GHz, requiring high volume, surface-mount, solder re-flow manufacturing.

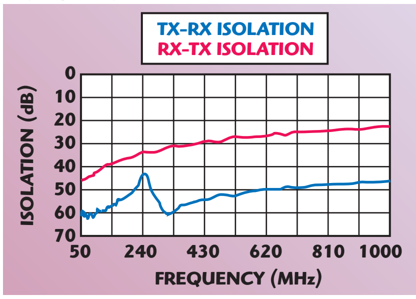
The SP2T ceramic package metallization scheme is compatible with either Sn63/Pb37 or RoHS type solders. They are durable, reliable and capable of meeting all military, commercial and industrial environments. The devices are fully RoHS compliant and are available in high volume tape-reel and tube packaging.




▲ *Fig. 1 MSW2000-200 SP2T insertion loss vs. frequency.*




▲ *Fig. 2 MSW2000-200 SP2T return loss vs. frequency.*




▲ *Fig. 3 MSW2000-200 SP2T isolation vs. frequency.*

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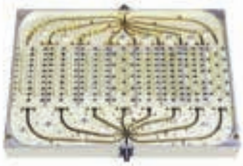


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## Filters and Assemblies

Networks International Corp. has recently updated its website (www.nickc.com), making it more dynamic and user friendly. The updates include a new spotlight feature highlighting NIC's new products and capabilities and improved search for NIC products. Updates have also been made to NIC's product pages to include links to download PDF product catalogs and datasheets.

***Networks International Corp.,***
***15237 Broadmoor,***
***Overland Park, KS 66223***

**www.nickc.com**

## Interactive Product Catalog

This website provides a comprehensive, user-friendly selection of Empower's products and functionality to configure and submit quote requests. The site features a parametric search engine and a collection of RF engineer's applets such as a watts-to-dBm converter, gain calculator and links to contact Empower's sales team. There is also a mobile-friendly version accessible from devices such as a RIM Blackberry.

***Empower RF Systems Inc.,***
***316 West Florence Avenue,***
***Inglewood, CA 90301***

**www.empowerrf.com**


## Global Community

Richardson Electronics announced the release of the company's new website, www.rell.com, a global community for RF, microwave and power conversion engineers. The site features the company's Engineer-Focused Navigation system to make it quicker and easier to find the information you need. Engineer-Focused Navigation™ system offers four interconnected paths to find parts and information based on your particular interest: products, applications, industries and services.

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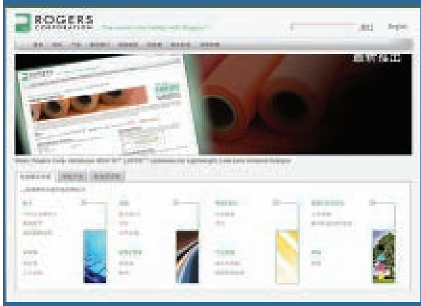

## Chinese Language Website

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Rogers Corp. has launched a new Chinese language website. The comprehensive site provides engineers, product designers and other site visitors with the highest level of regionalized service. The new Rogers' China site, accessible at www.rogerscorp.cn.com or from Rogers' English-lauguage homepage, www.rogerscorp.com, provides streamlined links from markets to applications to products in order to help customers create innovative product designs that deliver high performance and reliability.

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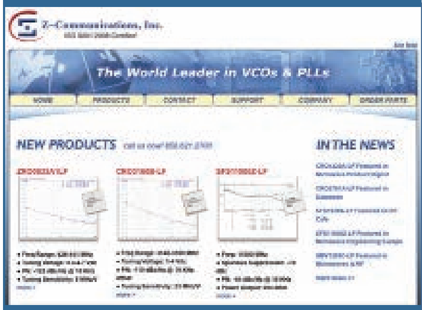

## VCOs and PLLs

Z-Communications Inc. announced a new company website with enhanced functionality and updated navigation. The new site features Z-COMM's entire line of VCO and PLL modules accessible through an easy-to-use product selector. Users can quickly search for parts by center frequency or model number and orders can be placed directly through the web store. Datasheets, mechanical drawings and application notes are provided for download. The company's short form product selection guide is also available.

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Aeroflex/Weinschel's 8314 Series of WLAN System Simulators are specialized subsystems used to simulate the connectivity between a mobile unit running along a line of three base stations spaced from 250 to 1000 meters apart. The test subsystem is able to simulate the variation of the RF signal from the base stations reaching the mobile (as well as the signal from the mobile reaching the base stations) when the mobile is moving at speeds of up to 250 km/h. Several variations of this have been developed and produced. The simulator attenuates the simulated base station signal through three independent attenuators, then combines the signals. Each attenuator has a dynamic range of 60 dB in 1 dB steps.

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## Bluetooth Audio Test Set

VENDORVIEW

Anritsu Co. introduces the MT8855A, an integrated test set capable of measuring the new generation of products using the Bluetooth Advanced Audio Distribution Profile (A2DP), headset profile and hands-free profile. Providing frequency coverage of 20 Hz to 20 kHz, the MT8855A offers lower cost-of-test, significantly reduced development time, and greater confidence in the quality of products shipped compared to alternative multi-instrument test systems consisting of Bluetooth controllers, generators and analyzers. The MT8855A is an ideal instrument for both design verification and manufacturing test of Bluetooth audio products.

***Anritsu Co.,***
***Morgan Hill, CA (408) 778-2000,***
***www.anritsu.com.***
**Booth 335** **RS No. 218**

## High Power Amplifier Modules

VENDORVIEW

AR's new line of wideband, hybrid power amplifier modules (HPM) cover the 6 to 18 GHz frequency range, and are the result of combining Microelectronic technology with the latest developments in thin film substrates. These hybrid modules require a single DC voltage source and are 50 ohm cascadable building blocks with output powers up to 37 dBm. AR offers the in-house capabilities to create custom HPM design solutions with frequencies from DC to 20 GHz.

***AR RF/Microwave Instrumentation,***
***Souderton, PA (215) 723-8181,***
***www.ar-worldwide.com.***
**Booth 707** **RS No. 219**

## Enhanced Polyimide

Arlon's EP2 (Enhanced Polyimide) represents a significant breakthrough in polyimide technology, using proprietary chemistry to provide a highly filled, dimensionally stabilized product with improved copper peel strength and higher thermal conductivity – at a reduction in cost that narrows the gap between pure polyimides and lower cost, but thermally inferior, multifunctional epoxies. This novel Arlon-developed (patent-pending) chemistry that enhances the bond of the polyimide resin to substrate glass, filler materials and copper is the enabling technology in this $4^{th}$ generation polyimide product. Typical properties of this system include: Tg of 250°C, total Z-direction expansion (50 to 260°C) of under 0.75 percent, and lower electrical loss (0.006 to 0.008).

***Arlon Materials for Electronics Division,***
***Rancho Cucamonga, CA***
***(866) 394-6508, www.arlon-med.com.***
**Booth 315** **RS No. 220**

## Microwave Office

VENDORVIEW

Microwave Office® 2009 carries on the AWR tradition of advancing the wireless revolution with powerful new features that enable developers to improve productivity and shorten design cycle time. MRHB™, a groundbreaking new multi-rate harmonic balance technology, dramatically increases the speed and reduces the computer memory required to perform steady-state analysis of complex nonlinear systems with multiple signal sources. A founding member of the Interoperable PDK Library (IPL) alliance, AWR has expanded support for Open Access (OA) process design kits (PDK). A new constant output power simulation capability eliminates manual post-processing steps and reduces simulation iterations. Enhanced load-pull analysis includes dramatic speed improvements as well as the ability to add or remove load-pull data points directly on the Smith Chart.

***AWR UK, Hitchin,***
***Herts, UK +44 (0) 1462 428 428,***
***www.awrcorp.com, www.awr.tv.***
**Booth 339** **RS No. 221**

## Probing Solutions

These two products streamline engineering and production testing of high-bandwidth, short-range RFIC devices for WirelessHD™, automotive radar, and other 60 GHz wireless applications. Using a combination of Cascade Microtech's proprietary thin-film technology and coaxial probe technology from its Infinity Probe® architecture, the 110 GHz Unity-MW millimeter-wave RFIC engineering probe provides the cost-effective answer to the challenges of precision characterization and testing of these multiple-port emerging technologies.

***Cascade Microtech Inc.,***
***Beaverton, OR (503) 601-1000,***
***www.cascademicrotech.com.***
**Booth 539** **RS No. 222**

## Reduced Icing Radome

Cobham Sensor Systems has developed this reduced profile radome (12.5" × 10" × 3") designed to minimize ice build-up while maximizing RF performance; typical loss is less than 1 dB. The radome has an "A" sandwich construction with solid laminate composite mounting flange and is protected with fluoroelastomer rain erosion paint. The radome operates with a wide field-of-view (FOV) and under high power (300 degrees F) with low pattern distortion. The frequency range can be tuned to meet requirements.

***Cobham Sensor Systems,***
***Baltimore, MD (410) 542-1700,***
***www.cobhamdes.com.***
**Booth 935** **RS No. 223**

# NEW WAVES

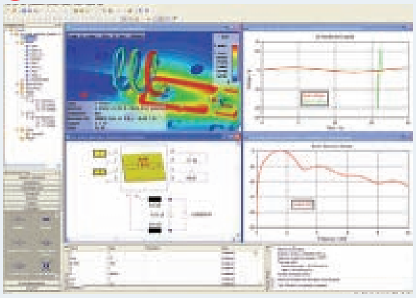
## Broadband Horn Antennas

Cobham Sensor Systems' H-1479 series broadband linear horn antennas provide superior performance for use in a wide variety of laboratory, commercial and military applications. With excellent input VSWR over the 1 to 12 GHz band, these antennas provide high gain across the frequency range and consistent pattern performance. They have become a laboratory standard as a reference horn in anechoic chambers and outdoor ranges. The H-1479 is available with a N-female connector.

***Cobham Sensor Systems,***
***Lansdale, PA (215) 996-2416,***
***www.cobhamdes.com.***
**Booth 935** **RS No. 224**

## CST STUDIO SUITE

VENDORVIEW



CST will be previewing CST STUDIO SUITE™ version 2010 at EuMW, including the industry leading 3D EM tool CST MICROWAVE STUDIO® (CST MWS). CST MWS enables the fast and accurate simulation of high frequency (HF) devices such as antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects. With a user friendly interface, easy data exchange to and from other software tools, a choice of first class solvers and excellent post-processing tools, designers can leverage the latest developments in 3D electromagnetics to bring designs to market faster and with lower risk.

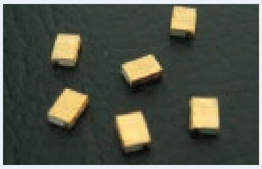
***CST – Computer Simulation Technology,***
***Darmstadt, Germany +49 6151 73030,***
***www.cst.com.***
**Booth 527** **RS No. 225**

## Broadband PCB Probes

This probe is an alternative to high impedance probes for time-domain measurements. Also spectrum analyzer and network analyzer measurements will be supported. ProMic allows measurements of one component of a multi-stage or multi-component design in 50 ohm-environment. The robust design of the ProMic-probe guarantees a long working life. Thin as well as wide microstrip lines can be easily measured. This model NA-PR1 supports SG-contacts.

***Heuermann HF-Technik GmbH,***
***Stolberg, Germany +49 2402/9749764,***
***www.hhft.de.***
**Booth 908** **RS No. 226**

## Foundry Service

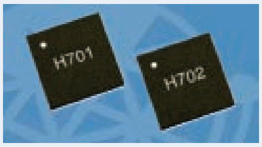


Hirai SK Corp. provides its featured foundry service of multilayered LTCC substrates. Hirai targets higher Q, dimensional precision and the high yield for RF and mm-wave applications. Displayed in the exhibition are miniaturized BPF with low loss, mm-wave antenna integrated LTCC transceiver module, tapered LTCC substrate and hermetically-sealed LTCC package for micro- and mm-wave applications. Hirai ships samples in a week after the design freeze and provides RF test and design services. The design kit CD is also available.

***HIRAI SK Corp.,***
***Shibuya-ku, Tokyo, Japan***
***+81-334991351,***
***www.hirai.co.jp/index_e.html.***
**Booth 200** **RS No. 227**

## PLL Fractional-N Synthesizers

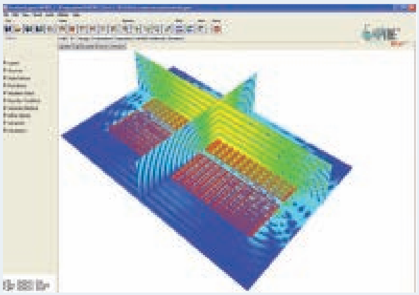
VENDORVIEW




The HMC-702LP6CE is a SiGe BiCMOS Fractional-N Frequency Synthesizer IC that operates in fractional or integer mode over a frequency range of 100 kHz to 14 GHz providing the ability to develop high performance phase locked loops for cellular base stations and point-to-point radio links using the same device. Primarily designed for ultra low phase noise applications, its internal architecture includes a 14 GHz 16-bit RF N-Divider, a 24-bit delta-sigma modulator, a low noise digital phase frequency detector (PFD), and a precision controlled charge pump (see product feature in this issue pg. 172).

***Hittite Microwave Corp.,***
***Chelmsford, MA (978) 250-3343,***
***www.hittite.com.***
**Booth 1010** **RS No. 228**

## EMPIRE XCcel 5.3



The new 3D EM solver EMPIRE XCcel 5.3 will be presented at IMST booth 115b. 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 2000 Million FDTD Cells per second can be achieved on a conventional PC with full access to the built-in memory. Thus complex structures can be modeled fast and highly accurate (e.g. 23 × 16 × 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 115** **RS No. 229**

## Broadband 1000 W Attenuator

VENDORVIEW

The 50FHIE series of fixed attenuators is capable of handling 1000 W of RF power (CW at 25°C) with no liquid cooling or forced-air requirements. Operating frequency range is DC to 3 GHz and the attenuators are available with N connectors in values of 10, 20 and 30 dB.

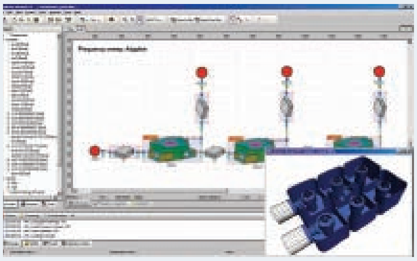
***JFW Industries,***
***Indianapolis, IN (317) 887-1340,***
***www.jfwindustries.com.***
**Booth 804** **RS No. 230**

## 60 MHz Bandpass Filter


KR Electronics introduces part number 2926 bandpass filter. The filter has a minimum 3 dB bandwidth of 3 MHz and > 60 dB at 50 and 70 MHz. Typical insertion loss is 5 dB. The filter is supplied in a surface-mount package measuring 1.5" × 0.5" × 0.5" and can also be supplied connectorized. The filter can be customized for other center frequencies and bandwidths.

***KR Electronics Inc.,***
***Avenel, NJ (732) 636-1900,***
***www.krfilters.com.***
**Booth 915** **RS No. 231**

## EM CAD Tool



The µWave Wizard™ EM CAD tool is a fast and accurate electromagnetic solver that utilizes the well-known Mode-Matching technique and its derivatives (e.g. Boundary-Contour-Mode-Matching) as well as the flexible 2D FE- and 3D FE-Method. In order to solve complex microwave structures, they will be broken down into basic building blocks for ease of computation. For each individual building block, the software computes port scattering parameters before performing multi-modal element connections to simulate the response of the entire structure. This element-based concept eliminates the need for creating and solving a full-up 3D model without sacrificing accuracy.

***Mician GmbH,***
***Bremen, Germany +49 421 168 993 56,***
***www.mician.com.***
**Booth 618** **RS No. 232**

## EM CAD and Optimization Tool

WASP-NET® is a unique hybrid MM/FE/MoM/FD CAD tool that features EM CAD precision in seconds. The newest version provides further speed advancement and convenient synthesis wizards for fast waveguide

# PIN DIODE SWITCHES

## FEATURES:

- *Multioctave bands 0.2 to 18 GHz*
- *Reflective or Absorptive*
- *Current or TTL control*
- *Low insertion loss*
- *High isolation*

Rapid Delivery Parts
**30 Day Delivery**
On Select Models
Rapid Delivery Parts

| Frequency Range (GHz) | Model Number | Insertion Loss (dB, Max.) | Isolation (dB, Min.) | VSWR (Max.) | Rise/Fall Time (ns, Typ.) | On/Off Time (ns, Typ.) | On/Off Time (ns, Max.) | DC Power Positive/Negative (mA, Max.) |
|---|---|---|---|---|---|---|---|---|
| **SPST** | | | | | | | | |
| 0.2 – 2 | SW1-002020RN1NF | 1.7 | 70 | 1.6:1 | 10/10 | 20 | 35 | 35/70 |
| 2 – 8 | SW1-020080RN1NF | 2 | 80 | 1.7:1 | 10/10 | 20 | 35 | 35/70 |
| 4 – 12 | SW1-040120RN1NF | 2.2 | 80 | 1.7:1 | 10/10 | 20 | 35 | 35/70 |
| 2 – 18 | SW1-020180RN1NF | 3 | 80 | 2:1 | 10/10 | 20 | 35 | 35/70 |
| 1 – 18 | SW1-010180RN1NF | 3 | 70 | 2:1 | 10/10 | 20 | 35 | 35/70 |
| **SP2T** | | | | | | | | |
| 0.2 – 2 | SW2-002020RN1NF | 1.5 | 70 | 1.6:1 | 10/10 | 20 | 35 | 60/60 |
| 2 – 8 | SW2-020080RN1NF | 1.8 | 80 | 1.7:1 | 10/10 | 20 | 35 | 60/60 |
| 4 – 12 | SW2-040120RN1NF | 2.2 | 80 | 1.7:1 | 10/10 | 20 | 35 | 60/60 |
| 2 – 18 | SW2-020180RN1NF | 2.8 | 80 | 2:1 | 10/10 | 20 | 35 | 60/60 |
| 1 – 18 | SW2-010180RN1NF | 3 | 70 | 2:1 | 10/10 | 20 | 35 | 60/60 |
| **SP3T** | | | | | | | | |
| 0.2 – 2 | SW3-002020RN1NF | 1.6 | 70 | 1.6:1 | 20/20 | 150 | 180 | 85/85 |
| 2 – 8 | SW3-020080RN1NF | 1.9 | 80 | 1.7:1 | 20/20 | 150 | 180 | 85/85 |
| 4 – 12 | SW3-040120RN1NF | 2.4 | 90 | 1.7:1 | 20/20 | 150 | 180 | 85/85 |
| 2 – 18 | SW3-020180RN1NF | 3 | 80 | 2:1 | 20/20 | 150 | 180 | 85/85 |
| 1 – 18 | SW3-010180RN1NF | 3.1 | 70 | 2:1 | 20/20 | 150 | 180 | 85/85 |

Note: The above models are all reflective switches. Absorptive models are also available, please contact MITEQ.

ISO 9001 Registered ANAB RoHS compliant Available 3 YEAR WARRANTY

**For additional information or technical support, please contact our Sales Department at (631) 439-9220 or e-mail components@miteq.com**

MITEQ®

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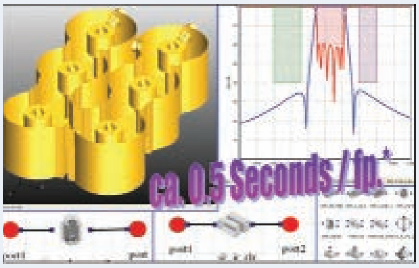
# NEW WAVES




filter, combline filter, horn antenna and slot-array design solutions. WASP-NET proves preferential EM CAD choice of leading space, defense and microwave industry, when efficiency and costs count. Typical CAD examples: All kinds of waveguide and coaxial components, combline/interdigital and dielectric resonator filters, feed systems, aperture and 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.wasp-net.com.***
**Booth 510** **RS No. 233**

## Buffer Amplifier

VENDORVIEW


This buffer amplifier is offered in a standard RoHS compliant 3×3 mm QFN plastic package, making the device easy to implement and handle in volume applications. This buffer amplifier, identified as XB1014-QT, covers 37 to 40 GHz and delivers +19 dBm P1dB compression point and +32 dBm OIP3. The XB1014-QT has 22 dB small-signal gain and is ideal for wireless communications applications such as point-to-point microwave radio. Mimix performs 100 percent RF testing on the XB1014-QT.

***Mimix Broadband Inc., Houston, TX (281) 988-4600, www.mimixbroadband.com.***
**Booth 319** **RS No. 234**

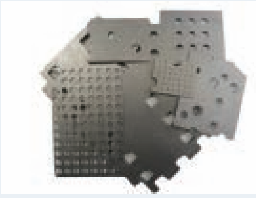
## MMIC Amplifier

VENDORVIEW


Mini-Circuits PHA-1+ Ultra High Dynamic Range MMIC Amplifier supports low Intermodulation amplification over the broad frequency range of 50 MHz to 6 GHz. This design provides a unique combination of high output IP3 (typically +42 dBm) while maintaining a noise figure less than 3 dB up to 4 GHz and typical gain of 14 dB at 2 GHz. Overall performance is comparable to the WJ-AH1 and may be used as a replacement model in high dynamic range systems including linearized transmitters and high dynamic range receivers.

***Mini-Circuits, Brooklyn, NY (718) 934-4500, www.minicircuits.com.***
**RS No. 235**

## Thermal Pyrolytic Graphite



TPG, thermal pyrolytic graphite, is a material pioneered by Momentive Performance Materials. With a thermal conductivity > 1500 W/mK and a density < 2.4 gm/cc, compared to copper TPG has ~4× the conductivity at ~1/4$^{th}$ the weight; a 16 fold weight specific thermal performance advantage. Copper can be too heavy, aluminum does not conduct well enough, and heat pipes can freeze or boil. TPG can be encapsulated with various materials to give structure, and to match thermal expansion.

***Momentive Performance Materials, Strongsville, OH (440) 878-5700, www.momentive.com.***
**Booth 800** **RS No. 236**

## Coaxial Microwave Termination

VENDORVIEW


The model 375BNM coaxial fixed termination operates from DC to 18 GHz and is a rugged, low-cost device that is an excellent choice for a wide array of general-purpose applications. The model 375BNM handles 10 W average and 5 kW peak RF power, has a maximum VSWR of 1.05:1, measures 1.67" long including Type-N connector and 0.72" diameter and weighs 3 oz. (85 g).

***Narda Microwave-East, Hauppauge, NY (631) 231-1700, www.nardamicrowave.com/east.***
**Booth 706** **RS No. 237**

## RF Test Platform

National Instruments will be demonstrating new features for its 6.6 GHz RF test platform that includes the NI PXIe-5663 RF Vector Signal Analyzer and the NI PXIe-5673 RF Vector Signal Generator. This suite of software-defined instrumentation enables engineers to perform many RF measurements 5× to 10× faster than traditional boxes. With the RF list mode feature, customers can program their instruments to deterministically step through pre-configured list of frequencies and RF power levels. Using LabVIEW measurement algorithms, engineers can test devices that used a variety of wireless standards.

***National Instruments, Austin, TX (512) 683-0100, www.ni.com.***
**Booth 604** **RS No. 238**

## EM Simulation Software

VENDORVIEW

Remcom announces that its XStream® GPU acceleration now provides the capacity to solve electromagnetic simulation problems up to 300 times faster than a modern 64-bit CPU. In addition, Remcom announces this updated version of XStream will now be bundled at no additional cost with XFdtd Release 7.0 (XF7), the latest release of Remcom's 3D electromagnetic simulation tool. XStream tremendously improves EM simulation performance by leveraging the powerful NVIDIA graphics processing units (GPU) available on modern video cards to make ultra-fast FDTD numerical computations. Remcom's new generation of XStream enables XF7 calculations to finish in minutes as compared to hours using a CPU only. This solution has the potential to save customers months of simulation time in delivering products to market.

***Remcom Inc., State College, PA (814) 861-1299, www.remcom.com.***
**Booth 303** **RS No. 239**

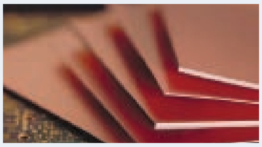
## Medical Treatment Amplifiers

RFHIC Corp. released a hyperthermia treatment or RF ablation purpose RF amplifier. This pallet amplifier uses GaN-on-SiC technology that is robust against back power or other damages, and reduces the need for maintenance. Early stages of a cancer treatment often use this effective RF technology to treat patients. This highly efficient power amplifier use 2.3 to 2.5 GHz frequency, and has a 200 W output power, and three-stage amplifier design totaling 31 dB gain. Final stage amplifier has 55 percent efficiency when operated at AB class amplification. When using the power amplifier on an E-class amplification, the efficiency reaches 90 percent efficiency.

***RFHIC Corp., Suwon, GyeongGi-do, Korea 82-31-250-5011, www.rfhic.com.***
**Booth 910** **RS No. 240**

## High Frequency Laminates

VENDORVIEW



RT/duroid® 5880LZ materials have the lowest Dk for a copper clad laminate available in the market today. Because of its low dielectric constant of 1.96, RT/duroid 5880LZ supports broadband applications at the micro-wave through millimeter-wave frequencies where dispersion and circuit losses must be minimized. It is a lightweight, PTFE-based composite optimized with a unique filler that provides very low density (1.37 gm/$cm^3$) and a low coefficient of thermal expansion (CTE) in the z-axis. This makes 5880LZ well suited for fabricating high-frequency circuits with plated through holes (PTH) and allows higher vehicle payloads.

***Rogers Corp., Advanced Circuit Materials Division, Chandler, AZ (480) 961-1382, www.rogerscorp.com.***
**Booth 514** **RS No. 241**

SKYWORKS

# Ultra Low Noise Amplifiers

## For your demanding receiver applications

### Low Noise Amplifiers

- Noise figure down to 0.6 dB
- Gain adjustable 15 to 25 dB
- OIP3 to 34 dBm with adjustable current
- SiGe product with integrated shutdown mode

| Frequency (MHz) | Technology | Gain Typ. (dB) | Test Freq. (MHz) | NF (dB) [1] | OIP3 Typ. (dBm) | $OP_{1 dB}$ (dBm) | $V_{DD}$ (V) | Quiescent Current Typ. (mA) | Package (mm) | Part Number |
|---|---|---|---|---|---|---|---|---|---|---|
| 700–1200 | pHEMT | 15–25 | 900 | 0.6 | 34 | 18 | 5 | 65 | 8L QFN 2 x 2 | **SKY65037-360LF** |
| 1500–2400 | pHEMT | 15–25 | 1900 | 0.6 | 34 | 18 | 5 | 65 | 8L QFN 2 x 2 | **SKY65040-360LF** |
| 2300–2700 | pHEMT | 15–25 | 2500 | 0.7 | 34 | 18 | 5 | 65 | 8L QFN 2 x 2 | **SKY65066-360LF** |
| 400–3000 | SiGe | 16.5 | 915 | 0.85 | 31.5 | 9.5 | 3.3 | 7.8 | 8L QFN 2 x 2 | **SKY65047-360LF** |

### Low Noise Discrete pHEMT Transistors

- Noise figure as low as 0.55 dB
- Unconditional-stability matching available for popular applications

| Frequency (MHz) | Device Size (µm) | Gain Typ. (dB) | Test Freq. (GHz) | NF (dB) [1] | OIP3 Typ. (dBm) | $OP_{1 dB}$ (dBm) | $V_{DD}$ (V) | Quiescent Current Typ. (mA) | Package (mm) | Part Number |
|---|---|---|---|---|---|---|---|---|---|---|
| 450–6000 | 200 | 16 | 2 | 0.55 | 20 | 8 | 2 | 16 | 4L SC-70 | **SKY65050-372LF** |
| 450–6000 | 200 | 16 | 2 | 0.55 | 20 | 8 | 2 | 16 | 4L QFN 2 x 2 | **SKY65051-377LF** |
| 450–6000 | 400 | 16 | 2 | 0.8 | 31.5 | 18 | 5 | 58 | 4L SC-70 | **SKY65052-372LF** |
| 450–6000 | 400 | 16 | 2 | 0.8 | 31.5 | 18 | 5 | 58 | 4L QFN 2 x 2 | **SKY65053-377LF** |

1. Input connector loss removed from measurement. Unconditional-stability matching used.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# New Waves

## Group Delay Measurement Technique

VENDORVIEW

Rohde & Schwarz will be demonstrating a new technique for measuring the group delay of frequency-converting devices at EuMW 2009. The technique does not require access to the local oscillator (LO) of the device under test. This is extremely useful in applications such as satellite communication links and highly-integrated devices in which the LO cannot be accessed. The solution is extremely fast, easy to use and insensitive against phase and frequency instabilities of the embedded LO. It is available as an option for all four-port R&S ZVA and R&S ZVT Series of vector network analyzers. For more information, visit http://mwjournal.com/RohdeZVA.

***Rohde & Schwarz GmbH & Co. KG, Munich, Germany +49 89 4129 13774, www.rohde-schwarz.com.***
**Booth 739** **RS No. 242**

## Passive Intermodulation Analyzers

The newly developed portable Passive Intermodulation Analyzer (PIA) has been designed for measurements of intermodulation products in passive components. The portable PIA can be used for laboratory and manufacturing applications and is ideally suited for outdoor and field measurements, e.g. the precise analysis of the RF infrastructure quality and performance of radio base stations. The analyzer is delivered in a highly shock-proof, stable transport case. Passive intermodulation analyzers enable quick and accurate measurements of the intermodulation characteristics of passive components.

***Rosenberger Hochfrequenztechnik GmbH Tittmoning, Germany +49 8684-18-263, www.rosenberger.com.***
**Booth 117** **RS No. 243**

## iSAR V2.1

iSAR² performs rapid (within three seconds) and reliable (within 0.5 dB) characterization of the RF performance of wireless transmitters. Version 2.1 extends the capability of iSAR² to effectively support R&D and automated quality control. New features include a new multi-iSAR interface, a smart Combiner feature, and full extension of the software for frequencies up to 6 GHz. It also includes enhancements to its existing features, such as an improved Python interface and enhanced control of base station simulators.

***Schmid & Partner Engineering AG, Zurich, Switzerland +41 44 245 9700, www.speag.com.***
**Booth 516** **RS No. 244**

## Varactor Diodes

Skyworks introduces two new varactor diodes for use in diverse applications such as mobile handset-based DTV receivers, FM tuners and low phase noise voltage-controlled oscillators. Available from stock, these new diodes offer high breakdown voltage, enabling tuning as high as 28 V. In addition, these Pb-free packaging devices offer: low reverse leakage current; wide-tuning range; high-capacitance ratio; low-series resistance and industry standard SC-79 footprint.

***Skyworks Solutions Inc., Woburn, MA (781) 376-3000, www.skyworksinc.com.***
**Booth 410** **RS No. 245**

## Rotary Joints

In order to provide equipment manufacturers with rotary joints tailored to the specific requirements of fixed and mobile SatCom systems, SPINNER has developed two new rotary joint product families – single channel waveguide rotary joints for Ku-band, and dual-channel coaxial rotary joints, which are suitable for Ku-band and intermediate frequency applications. Both product lines follow a common design philosophy that is characterized by well-thought-out modularity that allows a large variety of solutions with a minimum number of different piece parts and excellent electrical and mechanical performance, allied to a simple and highly reliable design.

***SPINNER GmbH, Munich, Germany +49 89 12601-1160, www.spinner.de.***
**Booth 719** **RS No. 246**

## Wafer Probes

The new 1MX Technology combines the |Z| Probe advantages of excellent contact quality and robustness with a higher bandwidth, lower insertion loss less than 0.8 dB at 67 GHz and higher isolation better than 40 dB in contact. The probe is optimized for 50 to 250 µm pitch and comes with a smaller contact footprint compared to the standard |Z| Probe types. This enables fine pitch testing with less over travel by keeping the lifespan of one million touchdowns.

***SUSS MicroTec Test Systems, Dresden, Germany +49 35240 73-0, www.suss.com.***
**Booth 1118** **RS No. 247**

## Miniature Voltage-controlled Oscillators

VENDORVIEW

The new DCO and DXO micro series of miniature voltage-controlled oscillators (VCO) are designed for C- and X-band applications. These VCO's are based on Synergy's proprietary patented technology and patents pending, which enhances bandwidth, reduces phase noise and improves immunity to phase hits. Several models are available with starting frequency at approximately 4 to 10 GHz, in tuning bandwidths of approximately 1000 MHz, and tuning voltages ranging from 0 to a maximum of 24 V DC. Phase noise for 8 to 9 GHz is typically better than -85 dBm at 10 kHz. These new series of VCOs are packaged in Synergy's tiny VCO surface-mount package measuring 0.3" × 0.3" × 0.1", RoHs compliant and can be delivered in tape and reel for automatic assembly processes.

***Synergy Microwave Corp., Paterson, NJ (973) 881-8800, www.synergymwave.com.***
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## Microwave Product Package

Teledyne Electronics and Communications Europe have combined the resources of Teledyne Coax Switches and Teledyne Reynolds through the Teledyne Europe Sales & Marketing Team. The European team is offering a sophisticated package of microwave switching and interconnect products with next level design, manufacture and integration. Each individual product is a leader in its own markets. The combination of those products into an integrated microwave solutions provider adds a new dimension to the Teledyne market presence. Aviation, Space, Military, Data Handling and Communications are the target markets where each of the Teledyne companies is well recognised in its own right.

***Teledyne Electronics and Communications, Cumbernauld, UK +44 1236 733700, www.teledyne-europe.com.***
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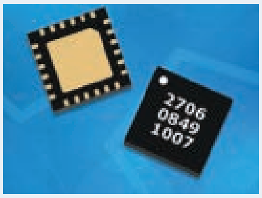
## Linear PA for 3G Microwave Backhaul




Today's high-capacity backhaul networks demand linear power—performance you will find in TriQuint's TGA2706-SM. This new 5.5 to 9 GHz PA supports the increasingly complex modulation schemes typically required by next-generation backhaul radios. Depend on TriQuint's PA heritage, unmatched support and millimeter-wave innovation for your next design. See TriQuint's new point-to-point radio 3G/4G solutions, optical and cable TV network products with other innovations at EuMW: Stand 323. For questions about backhaul/millimeter-wave radio or other networks products, contact: info-networks@tqs.com. For more information, www.mwjournal.com/triquinteumw09.

***TriQuint Semiconductor Inc., Hillsboro, OR (503) 615-9000, www.triquint.com.***
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# MICRO-ADS

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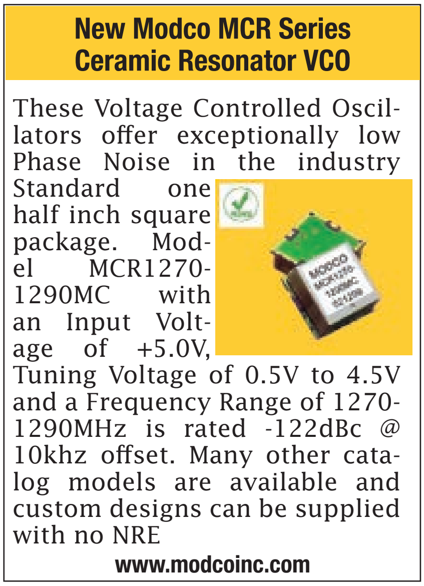


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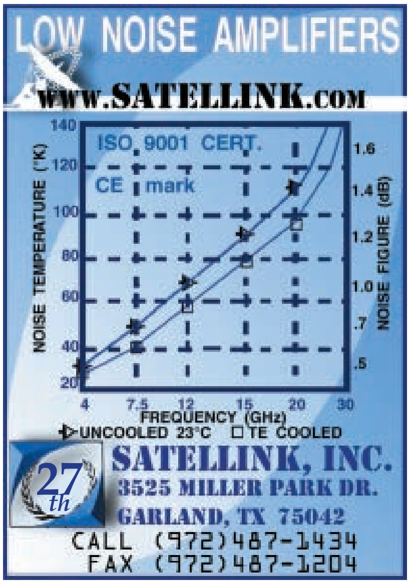
RS 2


RS 131

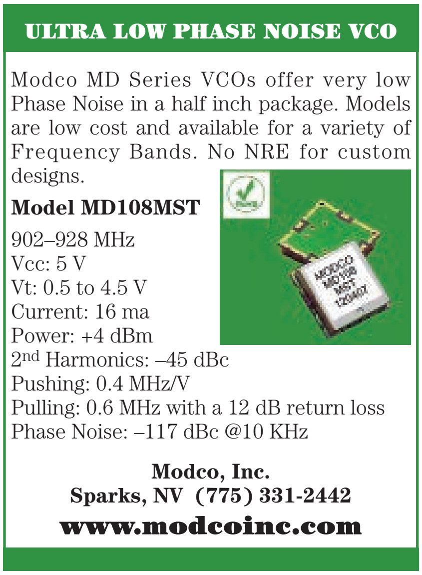



RS 142


RS 32


RS 62 • See us at EuMW Stand 915


RS 143




RS 108

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**The IEEE Microwave Theory & Techniques Society (MTT-S) International Microwave Symposium for 2010 (IMS2010) will be held in Anaheim, California, as the centerpiece of Microwave Week 2010, scheduled from Sunday, May 23 through Friday, May 28, 2010.** IMS2010 offers technical paper sessions, workshops/tutorials, poster sessions (called open forum), applications seminars (called MicroApps), plenary and panel sessions, industrial exhibits, historical exhibits, and a host of other activities including a guest program for the spouses and accompanying family members. The Microwave Week comprises still other activities, including the RFIC Symposium, and the ARFTG conference collocated with IMS2010.

**REQUEST** Authors are invited to submit technical papers describing original research, development, and application work on radio-frequency and microwave theory and techniques, in the various areas within this field; the following list of areas is only suggestive and not intended to exclude other areas:

**Microwave Field and Circuit Techniques**

1. Field Analysis and Guided Waves
2. Frequency-Domain EM Analysis Techniques
3. Time-Domain EM Analysis Techniques
4. CAD Algorithms and Techniques
5. Linear Device Modeling
6. Nonlinear Device Modeling
7. Nonlinear Circuit and System Simulation

**Passive RF and Microwave Components**

8. Transmission Line Elements
9. Passive Circuit Elements
10. Planar Passive Filters and Multiplexers
11. Non-planar Passive Filters and Multiplexers
12. Active, Tunable, and Integrated Filters
13. Ferroelectric, Ferrite, and Acoustic Wave Components
14. MEMS Components and Technologies

**Active RF and Microwave Components**

15. Semiconductor Devices and Monolithic ICs
16. Signal Generation
17. Frequency Conversion and Control
18. HF/VHF/UHF Technologies and Applications
19. Power Amplifier Devices and Circuits
20. High-Power Amplifiers
21. Low-Noise Components and Receivers
22. mm-Wave and THz Components and Technologies

**RF and Microwave Systems and Applications**

23. Microwave Photonics
24. Signal Processing Circuits and GHz speeds
25. Packaging, Interconnects, MCMs and Integration
26. Instrumentation and Measurement Techniques
27. Biological Effects and Medical Applications
28. RF Arrays as Antennas and Power Combiners
29. Radar and Broadband Communication Systems
30. Wireless and Cellular Communication Systems
31. Sensors and Sensor Systems
32. Emerging Technologies

**PAPER SUBMISSION INSTRUCTIONS** Technical papers to be considered for presentation at IMS2010 must be submitted electronically, in pdf format, via the symposium webportal, www.ims2010.org. This website provides complete information on submission procedure, registration, and related items. Paper or printed copies of submissions cannot be accepted. Symposium proceedings are published as a CD ROM by IEEE, and posted in their digital library. Authors of high-quality papers will be invited to submit an extended version of their paper for the Special IMS2010 issue of IEEE Trans. Microwave Theory & Techniques.

**PROPOSAL INVITATION** The Technical Program Committee (TPC) of the Symposium also invites proposals for:

- Workshops (ranging from expert-level to tutorials and short courses), and
- Special Sessions (including focused, honorary, and panel/rump sessions).

Details regarding the types of workshops sought, information requested along with the proposal, and the proposal evaluation criteria, are available on the Symposium website www.ims2010.org. Special sessions on topics that are currently being intensely pursued, contentious, or relevant to the theme of the Symposium or to the microwave community in Southern California, may be proposed for consideration by the Technical Program Committee of the Symposium. For full consideration, all proposals should be received by August 28, 2009.

**SUBMISSION DEADLINES**

| | | |
|---|---|---|
| Workshop and Special Session Proposals | Posted at www.2010.org | |
| Technical Paper Electronic Submission | Monday | November 30, 2009 |
| Notification of Acceptance | Monday | January 18, 2010 |
| Final Manuscript for Accepted Papers | Thursday | March 4, 2010 |
| Final Manuscript of Workshop Notes | Thursday | March 11, 2010 |

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## *New Horizons in Mobile and Wireless Communications, Volume 1: Radio Interfaces*


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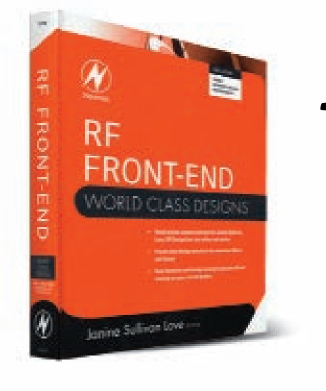
## *RF Front-end: World Class Designs*




### Janine Sullivan Love, Ed.

Janine Sullivan Love has selected the very best RF design material from the Newnes portfolio and has compiled it into this volume. The result is a book covering the gamut of RF front-end design from antenna and filter design fundamentals to optimized layout techniques with a strong pragmatic emphasis. In addition to specific design techniques and practices, this book also discusses various approaches to solving RF front-end design problems and how to successfully apply theory to actual design tasks. The material has been selected for its timelessness as well as for its relevance to contemporary RF front-end design issues.

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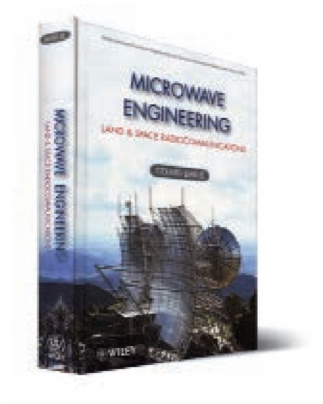
## *Microwave Engineering: Land & Space Radiocommunications*




### Gerard Barue

In *Microwave Engineering: Land & Space Radiocommunications*, find an introduction to the main propagation phenomena vital to the design and planning of any given system type and frequency of operation. This book presents the phenomenon of propagation of electromagnetic waves in frequency bands, wave propagation, antennas, atmospheric and ionospheric influences, terrain influence, and weather conditions and their effect on signal transmission. Practical aspects such as path profiles, link loss budgets, performance predictions, equipment arrangements, and sizing of the required supporting infrastructure to support microwave, space and optical transmission links are covered. This book provides a complete conceptual treatment of securing information and transporting it over a secure network in a manner that does not require a strong mathematical background.

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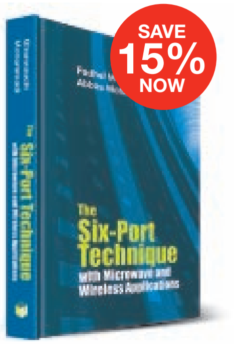


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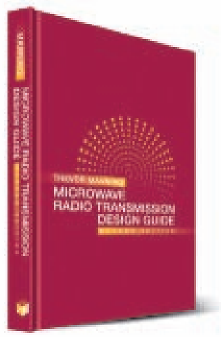


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## ACROSS

**4** British scientist who discovered electromagnetic induction

**6** British physicist who first suggested waveguide concepts and discovered the electron

**8** French physicist who developed the definition of electrostatic forces

**12** French mathematician/physicist who discovered electrodynamics

**13** Danish engineer who was the first to develop the continuous wave transmitter

**15** Self-taught Englishman who expressed Maxwell's equations in vector form and introduced the idea of reactance

**16** Serbian born inventor who was the first to patent a radio transmitter and conceive rotating magnetic fields

**18** Demonstrated first radio transmission near his home in Bolona, Italy

**19** Danish physicist who presented electron theory of electrified matter and the ether

**20** Italian physicist who built a machine to send and receive images over long distances using telegraph called the pantelegraph

## DOWN

**1** German physicist who derived the equation for aerial coaxial cable where the inductance is important

**2** French inventor who transmitted radio signals from the Eiffel tower to a recevier located near the Patheon

**3** German mathematician for which the CGS unit of magnetic induction is named after

**5** English physicist who named the Coherer

**7** German physicist/mathematician who established V=IR

**9** Scottish physicist/mathematician who wrote Treatise on Electricity and Magnetism

**10** Irish physicist/chemist who developed a formula for the power radiated by a small loop antenna

**11** Professor at Copenhagen Denmark who observed that current running through a wire produces a magnetic field

**14** German physicist who proved the existence of radio waves

**17** French mathematician who showed that the electric field is perpendicular to the surface of a conductor


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