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July 2007

Microwave Journal

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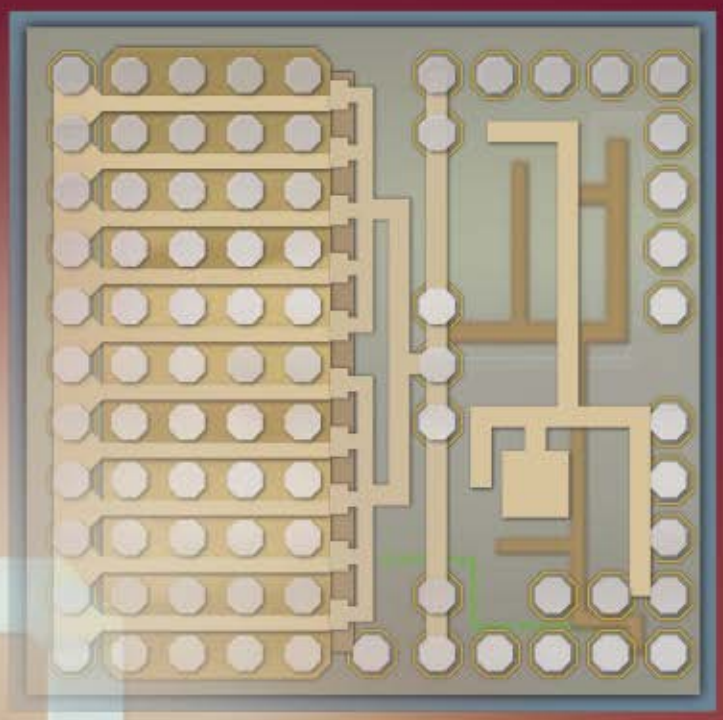
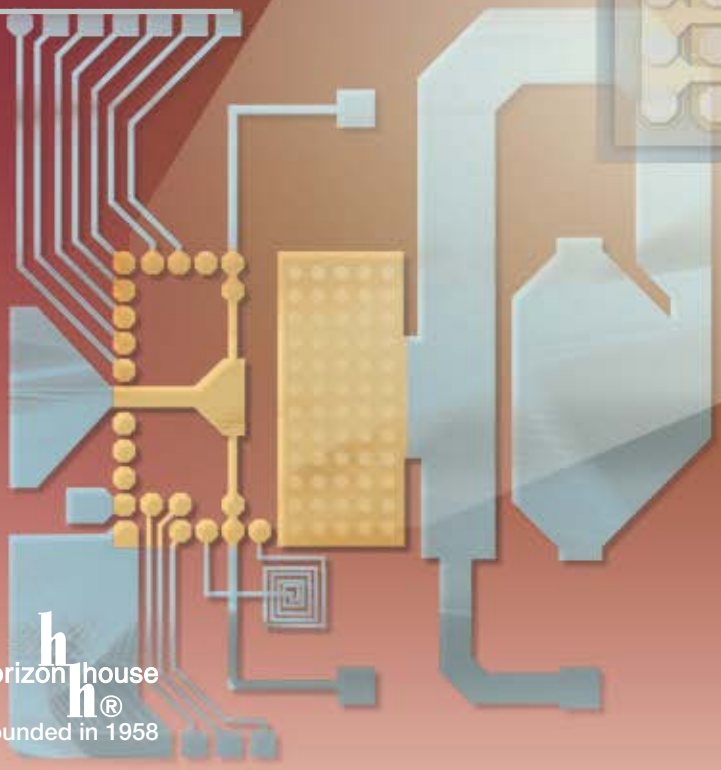
Semiconductors MMICs/RFICs

How Much GaAs Do You Own?

Method to Improve 2G/3G Handset Talk Time

Multiplexers for Multi-band Wireless Handset Applications





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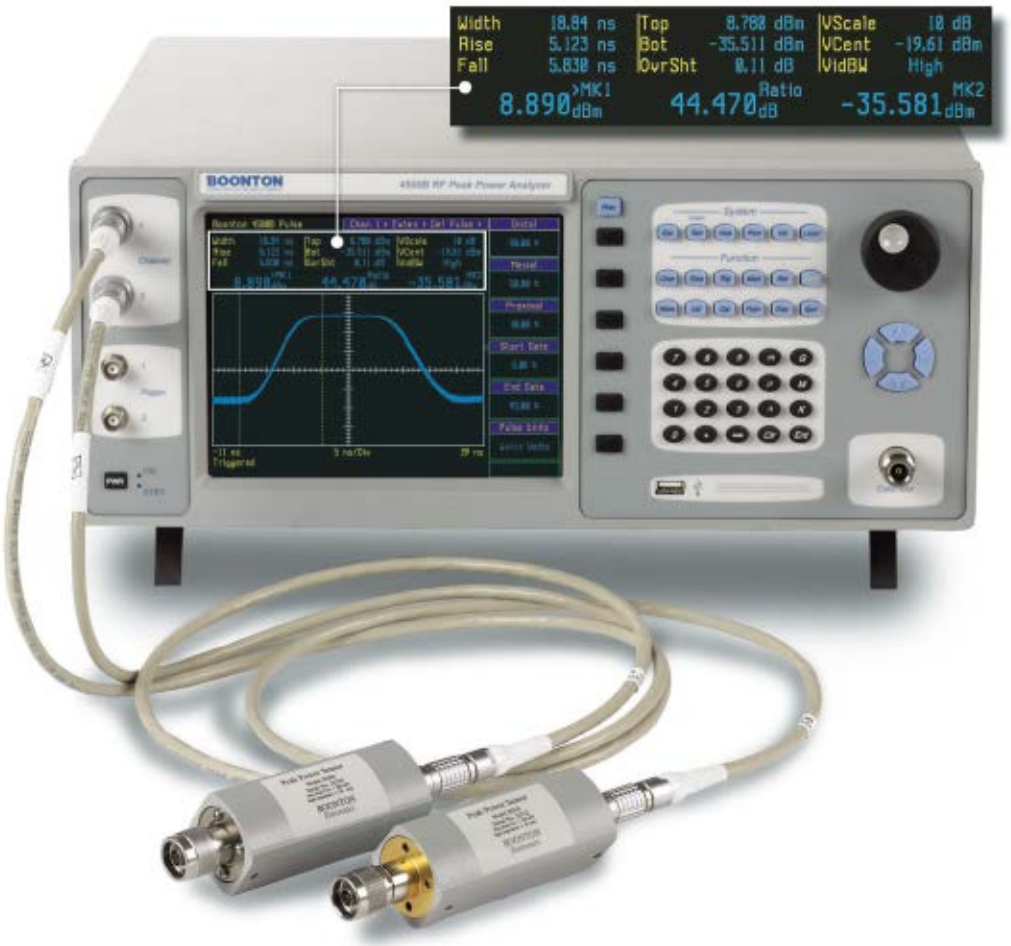

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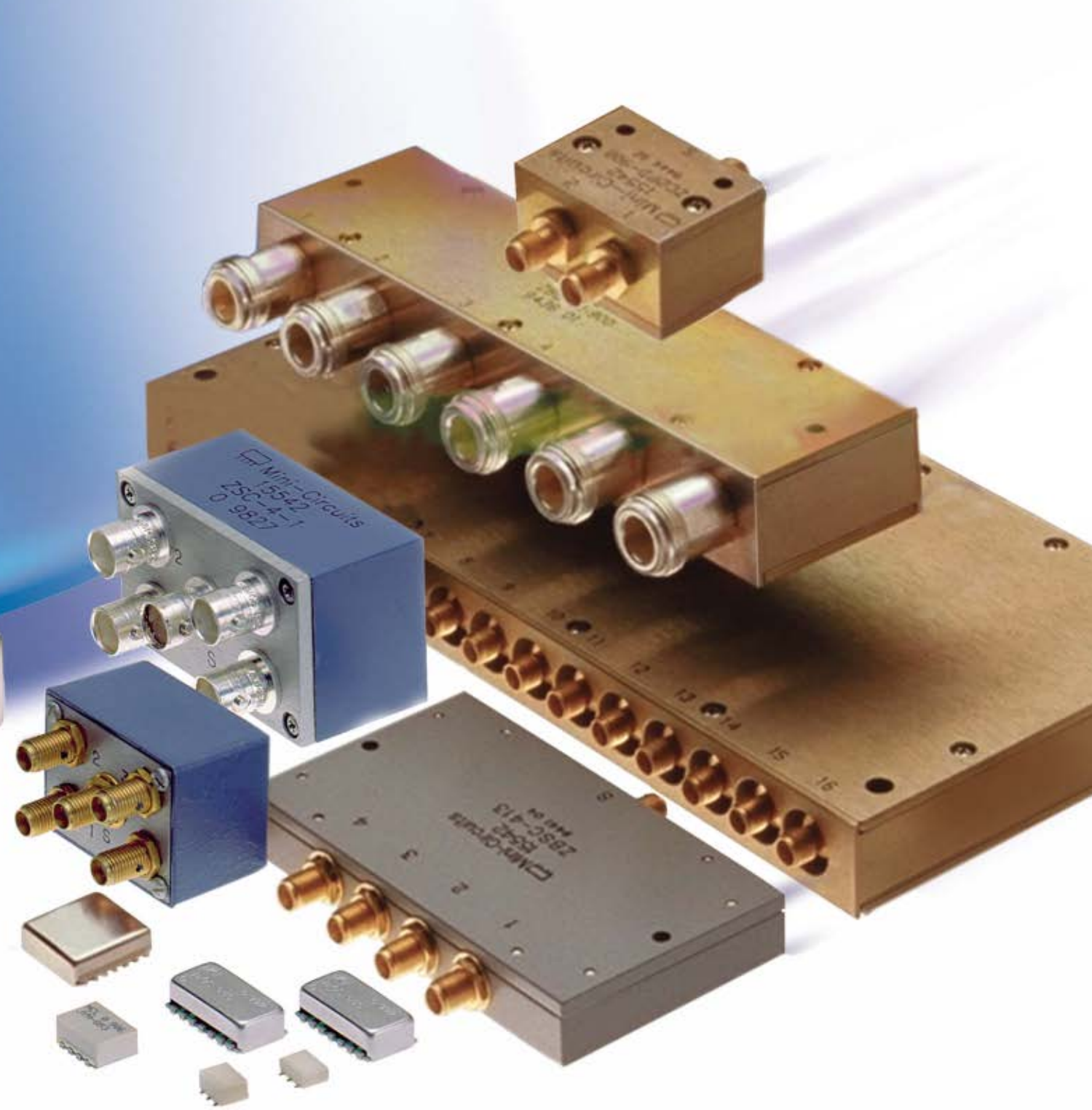

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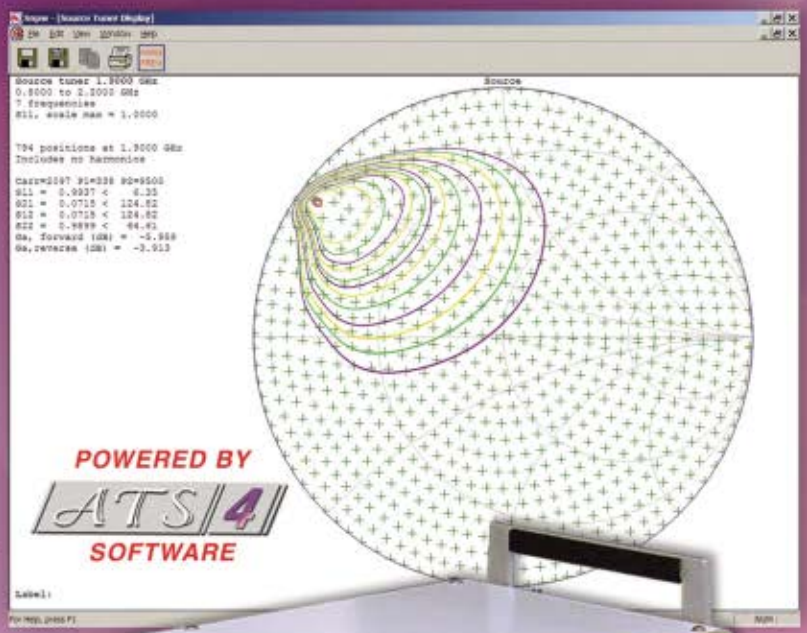

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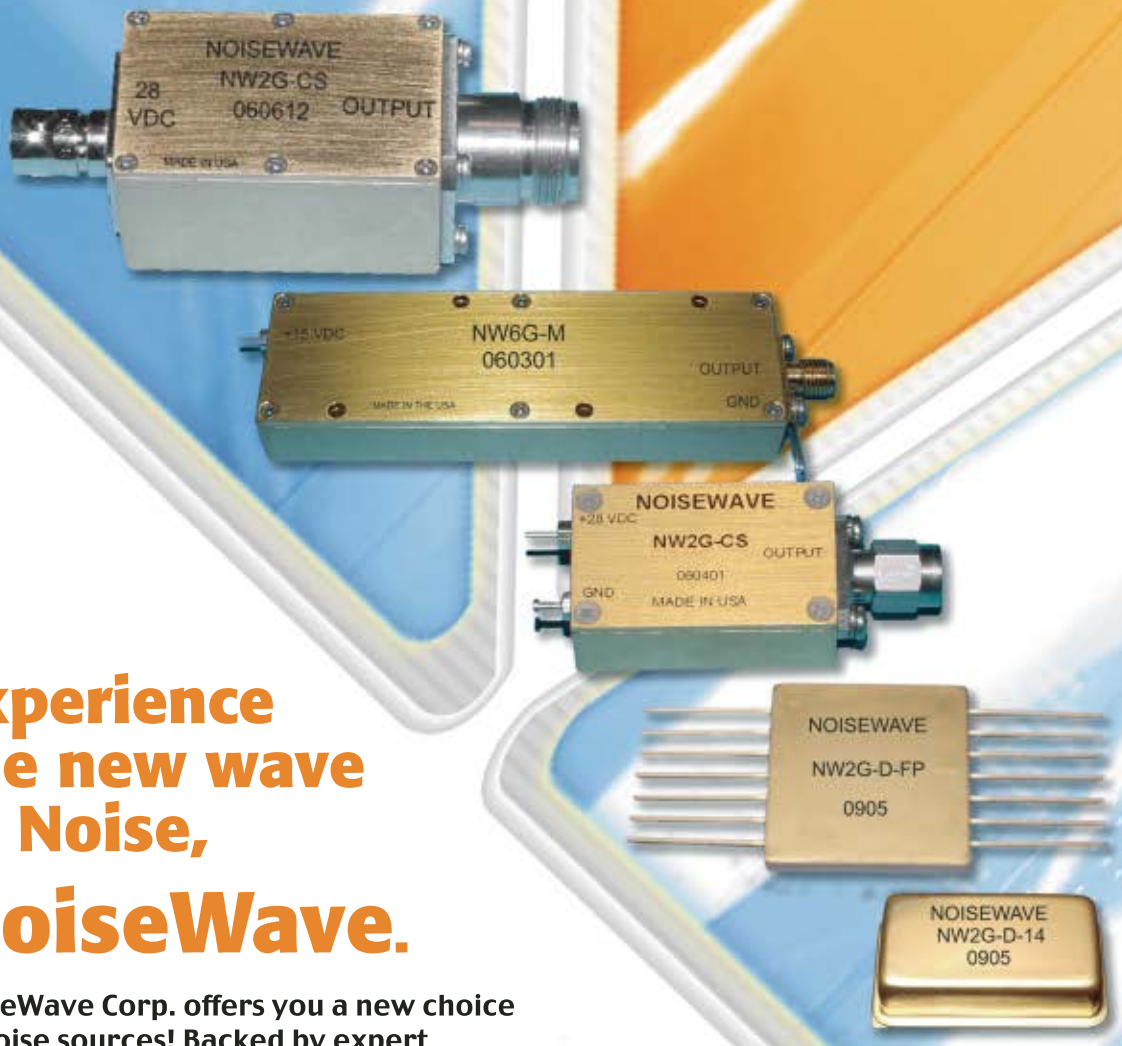

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FEATURES

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Acceleration Sensitivity Characteristics of Quartz Crystal Oscillators

By Steve Fry, Greenray Industries

The resonant frequency of every quartz crystal is affected by acceleration forces. The nature of the effect depends on the type of force that is being applied. Changes in the static gravitational force being experienced such as tilting or rotation will cause a step offset in frequency. Time dependent acceleration or vibration will frequency modulate the output.

LDMOS Technology Solid-State Transmitter for MIDS Communications System

Alberto Asensio, José Luis Serrano, Javier Gismero and Alvaro Blanco, Universidad Politécnica de Madrid, Department of Signals Systems and Radiocommunications

Use of LDMOS technology in the design of a transmitter with an output power of 400 W for the MIDS (Multifunctional Information Distribution System) communication system.

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How it works: Harlan has selected one question from his "Ask Harlan" column to be featured in the magazine. Please visit www.mwjournal.com/askharlan to provide an answer to this month's featured question (see below). Harlan will be monitoring the responses and will ultimately choose the best answer to the question. Although all of the responses to the featured question will be posted on our web site, we plan to publish the winning answer in the September issue. All responses must be submitted by **August 8, 2007**, to be eligible for the participation of the July question.

The winning response will win a free book from Artech House, along with an "I Asked Harlan!" t-shirt. In addition, everyone who submits a legitimate response will be sent an "I Asked Harlan!" t-shirt.

May Question and Winning Response

The May question was submitted by Majeed Ahamad from Urjita Electronics Pvt. Ltd.:

Dear Harlan,

In the case of passive filters (LPF, HPF and BPF), would it be possible that voltage across any component (inductors and capacitors) is more than the input voltage fed to that filter? If yes, then why and how?

The winning response to the May question is from Les Hammer of Smart Sensor Systems:

Yes, the voltage across inductors and capacitors can be more than the input voltage to the filter. The impedance of the inductor is $j\omega L$ and the impedance of the capacitor is $-j/\omega C$; where j is the square root of –1, ω is the radian frequency ($2\pi f$), L is the inductance and C is the capacitance. Put these series with a resistor and compute the voltage across the inductor using the voltage divider equation: v-inductor = $(V\text{-in})*j\omega L/(R+j\omega L-j/\omega C)$. The peak voltage will occur when $\omega L = 1/c\omega$ V-inductor-peak = $(V\text{-in})*j\omega L/R$. If ωL is greater than R, the inductor voltage will be greater than the input voltage. So will the capacitor voltage. They will be just 180 degrees out of phase with each other.

Harlan's response:

Yes, it is definitely possible and very common to have an increase in internal voltages and currents in a filter both due to impedance transformation as well as stored energy as a function of the Q of the circuit. It is important to consider this when choosing the voltage and current ratings of capacitors and inductors.

This Month's Question of the Month
(answer on-line at www.mwjournal.com/askharlan)

George Henry has submitted this month's question:

Dear Harlan,

What is the state-of-the-art in X-band GaN amplifiers in power, efficiency and voltage of operation? How about GaN discrete HFETs?

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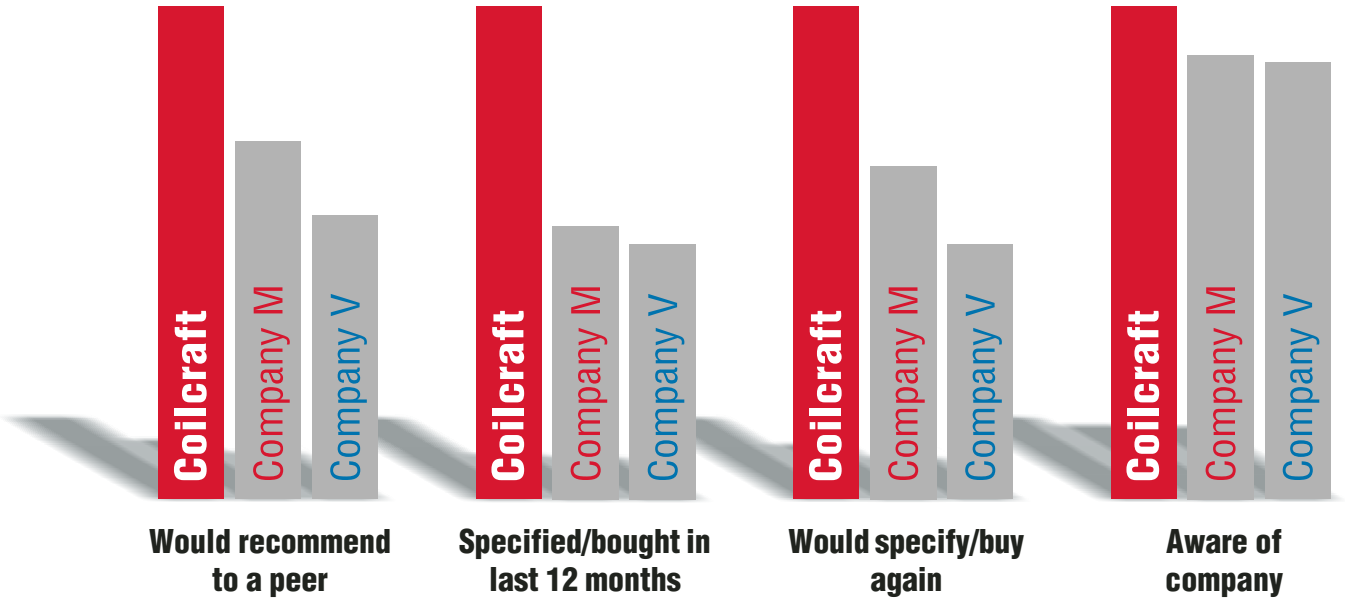

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IEEE INTERNATIONAL CONFERENCE ON ULTRA-WIDEBAND (ICUWB 2007)
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October 4–6, 2007 • Newton, MA
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EUROPEAN MICROWAVE WEEK (EUMW 2007)
October 8–12, 2007 • Munich, Germany
www.eumweek.com

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70TH ARFTG CONFERENCE
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DECEMBER

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IEEE RADIO AND WIRELESS SYMPOSIUM (INCORPORATING WAMICON)
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www.radiowireless.org

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Workshops & Courses

CST User Group Meeting

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■ **Site:** Lake Tegernsee, Germany

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■ **Contact:** CST-Computer Simulation Technology +49 6151 7303-0 or e-mail: info@cst.com.

OPERA-3d Software: Introductory Training Course

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■ **Site:** Aurora, IL

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■ **Site:** Atlanta, GA

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■ **Contact:** Georgia Institute of Technology, Professional Education, PO Box 93686, Atlanta, GA 30377 (404) 385-3500.

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■ **Site:** For location information, please visit url.

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■ **Contact:** Fairchild Semiconductor Corp., 82 Running Hill Road, South Portland, ME 04106 (207) 775-8100, www.fairchildsemi.com.

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■ **Site:** Archived on-line course.

■ **Dates:** Archived on-line for anytime viewing.

■ **Contact:** University of Illinois at Urbana-Champaign, 117 Transportation Bldg., 104 S. Mathews Avenue, Urbana, IL 61801 (217) 333-0897 or e-mail: deg@uiuc.edu.

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■ **Dates:** For date information, please visit url.

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COVER FEATURE
INVITED PAPER

HOW MUCH GaAs DO YOU OWN?

Recently I was asked, "How much GaAs do you own?" This may seem like a strange question and certainly one that I would not have even thought worthy of consideration as little as five years ago. If like me, you remember when the principal drivers for GaAs products were phased-array radar, satellite communications and electronic warfare (EW), then the idea of owning a piece of GaAs may not have entered your mind either. Considering this today and broadening it to the wider RFIC context, however, this simple question actually probes quite deeply into the nature and trends of current business.

In the everyday world, microwaves are no longer synonymous with re-heating food, and the most obvious example of RFICs in your pocket is the ubiquitous mobile phone. But even that contains not one, but at least two microwave bands with associated chips, notably PAs, switches and low noise amplifiers (LNA). Many will also contain a Bluetooth transceiver. In addition, almost all laptops bought in the last year will have an 802.11 interface, usually again with PAs and switches, which, depending on the bands and possible use of multiple antennas, can amount to three or four chips with other features such as Bluetooth becoming more standard.

Many homes now have a wireless Internet router with devices similar to the PCs to complete the radio link. Printers, cameras and a host of other domestic appliances are now sprouting wireless connectivity. If you have satellite TV, there is an LNB containing six or so low noise X-band devices as well as other RFICs in the set top box. There are also devices to transmit signals to the multitude of TV sets in homes today. Going slightly further a field, my car has a built-in Bluetooth interface while others have short-range radar, GPS, security tags and tracking systems.

Against this multitude of consumer applications for RFICs, it seems that the industry and particularly the GaAs segment is at a crossroads. The traditional requirements for RFICs in military, avionics and high value commercial markets have not gone away. They just have not really grown that much. In fact, where there was once a civilian spin off from military

RICHARD G. RANSON
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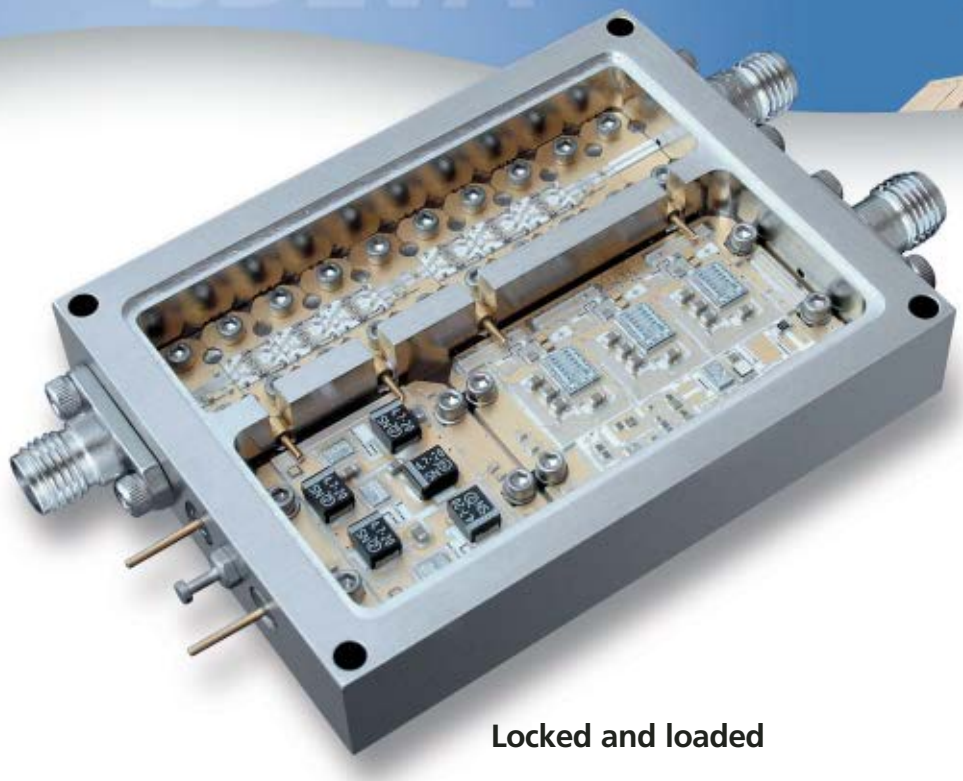

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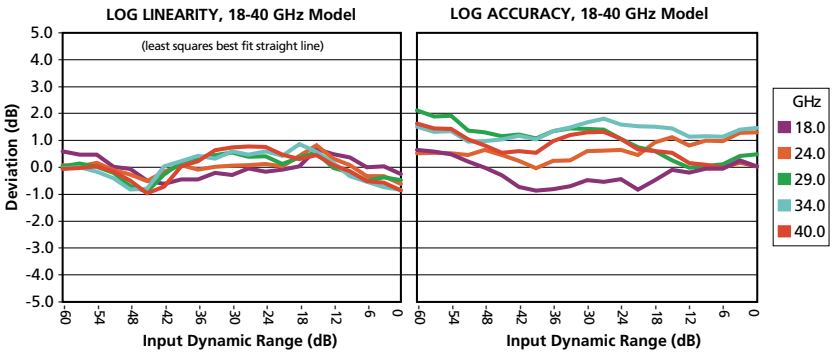

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advances, the position is becoming reversed and military procurement agencies are looking for commercial off-the-shelf (COTS) hardware to address dwindling budgets.

From the manufacturer's perspective, the commercial realities of supporting the consumer market are quite different to those of the traditional military and specialist product business areas. It is not just a matter of volume; it is also time to market, rolling cost reduction programs and product evolution. These are diametrically opposed to the relatively long lead-time, highly controlled design process and long-term product support requirements of military customers.

Faced with these design and production differences, never mind the widely varying customer base, many manufacturers are recognising a need to focus on one market or the other. While the attention is on the newer high volume commercial markets, those who choose to stick to the traditional have an opportunity to rejuvenate fortunes.

TRENDS ON RF AND MICROWAVE ICS

By going to trade shows, conferences and reading journals, one sees a significant move away from advocating highly technical advances like fabrication enhancements and increases in the cut-off frequency or power density. Instead, titles and eye-catching bullets more frequently highlight lower cost, increased functionality or wide application. Of course, there are still notable and ongoing improvements in technological areas. They are, however, less publicised as they are now very commercially sensitive, and secrecy can be even more stringent than for military programs.

Unlike the past, the technological trends are less visible and while it may seem like a cliché to say that the three most important trends are cost, cost and cost, it really is true. Of course, costs come in many forms and that is the interesting part. However, cost, translating into customer value, is still the cornerstone of each of the themes I shall be considering in this article. They include:

- Actual – materials, processing, die shrinkage, advanced modeling and better design.
- Functional – increased functions per die, expansion of the application horizon per die and marriage of mixed technologies on the same die.
- Non-semiconductor – thermal management, packaging and mixed technology integration.

ACTUAL

In response to demand, the industry has seen a significant shift to larger and larger wafers. This trend has been most visible in the silicon world but, in GaAs, for example, while there are still forecasts and budget models built on four-inch wafer figures, the reality is that the majority of parts are now made on six-inch wafers. The significant increase in usable area and hence die per wafer compared to the relatively fixed cost of manufacture makes this an obvious trend.

However, with significant technical challenges in growing eight-inch or larger GaAs bulk material and the lower incremental area increase in going from six- to eight-inch wafer production, there is little prospect of a further jump in wafer sizes in the near future.

Another major trend is the relentless progress of silicon processing and its effects on the RFIC business. While the primary focus of these efforts is in the computer and data applications industry, there are significant side effects in the RF world. The tremendous push towards geometry shrinkage produces transistors with higher and higher frequency capability. It is just a matter of time before this potential is used for actual RF products.

On the more immediate front, the move of mainstream computer chips to sub-90 nm fabrication lines releases fully depreciated manufacturing capacity to address lower volume RF products. For example, for Gen 6 LDMOS devices, companies like NXP have adopted RF power device processing to be made on CMOS lines, putting further downward pressure on the cost per watt of these devices.[1]

Similarly, the handset market is seeing increased competition from silicon devices to established GaAs HBT solutions. ***Figure 1*** shows a BiCMOS power transistor die with integrated biasing and protection circuits, flip-chipped on a passive silicon die with partly integrated input and output matches.[2]

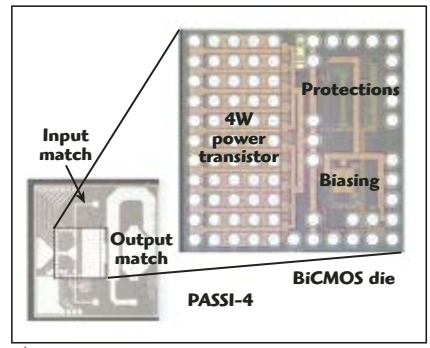
In the HBT and GaAs PHEMT areas, there has been tremendous progress in reducing the cost of materials like MBE wafers, decreasing fabrication cycle times and reducing processing steps. In epitaxial growth, where conventional wisdom dictated inevitable expense from the long cycle times and necessary batch processing through high vacuum equipment, the premium suppliers have combined significant economies of scale with good old manufacturing excellence to consistently reduce costs while maintaining or even increasing uniformity.

Such suppliers have worked with customers to consistently achieve significant price reductions. Also, fabrication engineers have almost halved mask and process steps in recent years for lean manufacturing and better utilisation of expensive capital equipment.

In a similar trend, leading manufacturers such as Skyworks and Anadigics have announced combining PHEMT and HBT processing on a single BiFET wafer.[3] This opens up the possibilities of expanded functional integration in handsets by combining a single supply, high power density HBT, PAs with a low power consumption and low loss PHEMT antenna switches on a single chip.[4,5] There is still some way to go on key issues like isolation and linearity, but this process advancement plays into my next theme in the cost reduction arsenal.

FUNCTIONAL

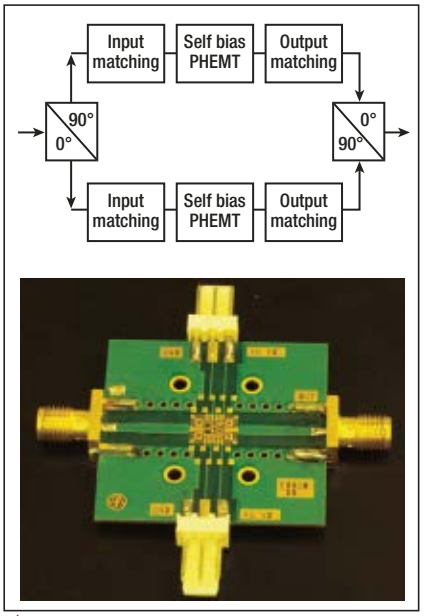
Just like many other markets, after an initial reduction in price for new devices or technologies, there comes a point when further price reduction becomes uneconomic and manufacturers look to retain sales revenue by



▲ *Fig. 1 Flip chip and advanced integrated passive components in RF CMOS. (Courtesy of NXP Semiconductors)*

increasing the function for the same price. The RFIC market is no exception and has certainly reached that point in some sectors. Here, however, because of different relative strengths, the various fabrication technologies approach the issue differently.

The Filtronic FMA3017 shown in ***Figure 2*** is a good example of higher integration in the GaAs PHEMT field. While d-mode devices have generally shown superior performance over the e-mode equivalents, they have always suffered from the need for a negative bias voltage. In most LNA applications, there is still demand for balanced stages, so most designs require two FETs and two hybrid couplers. The Filtronic part integrates both FETs with the couplers and the bias decoupling needed for single supply, self-bias operation into a 4 × 4 QFN.



▲ *Fig. 2 Block diagram and evaluation board of a FMA3017 MMIC balance amplifier. (Courtesy of Filtronic Compound Semiconductors Ltd.)*

▲ *Fig. 3 Complete Bluetooth radio solution. (Courtesy of CSR)*

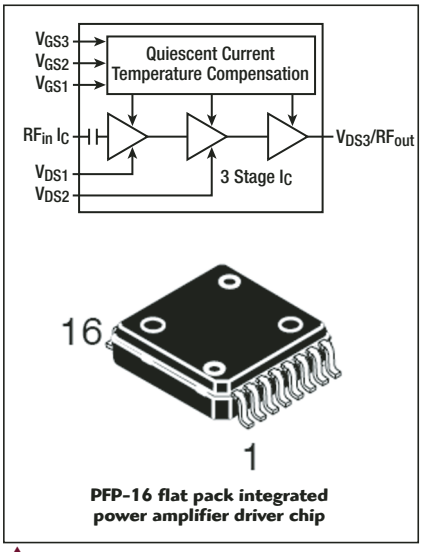
Compared to the board space and cost of the individual parts, this elegant solution illustrates maintaining market share while giving customers better value for their money.

Other examples of this increase in functionality can also be seen in related technologies. QinetiQ and BAE Systems recently published a complete millimetre-wave 62 to 65 GHz transceiver on a chip.[6] Similar advances and complexity were also demonstrated in SiGe technology.[7]

While such high levels of integration are relatively modest in GaAs FET technology, it shows that reliable process and accurate modeling are enabling the realisation of higher-level functions. However, these are very small steps compared to the functional integration achievements in CMOS technologies. Combining the microwave frequency performance that is now possible in CMOS with the traditional capabilities of IF and digital processing produces true systems on a chip (SoC).

For example, the Cambridge Silicon Radio (CSR) BlueCoreX family offers single chip radio and baseband ICs for Bluetooth 2.4 GHz systems, as shown in ***Figure 3***. The low output power of the Bluetooth standard allows huge chunks of the RF and digital requirements to be integrated onto a single 0.13 µm CMOS chip.

Increase in chip functionality is very much a matter of perspective. For GaAs FET-based devices, at high frequencies, integration is in its infancy. There are recognised difficulties



▲ *Fig. 4 Integrated LDMOS drive IC. (Courtesy of Freescale Semiconductor)*

in DC biasing of complex circuits and traditional RF matching elements are quite small, so design approaches are often miniature versions of thin film counterparts.

In contrast CMOS, SiGe and HBT approaches use many transistors, more like op-amps and other low frequency ICs. Complete system integration certainly favours technologies that are compatible with logic. Combining analog with digital capabilities eases integration with system control functions as well as the continual incorporation of RF functions into more and more advanced DSP.

NON-SEMICONDUCTOR

Looking at costs at all levels of the manufacturing process inevitably leads to consideration of the 'other' costs. In the power transistor market, the heat sink material of choice now is copper, with lower cost and higher thermal conductivity than traditional materials.[8] Similarly, the illusion of the hermetic package has been broken at last and various plastic air cavity and over-molded packages are now in the market, removing the relatively expensive ceramic frames and lids. This change really opens the way for further integration of functions into power devices. After all, it was pointless considering a bigger die than necessary when the package was so expensive, but changes in packaging technology enable new solutions.

One example of this can be seen in ***Figure 4***, a Freescale base station LDMOS IC driver. Here, a class AB driver amplifier chain is integrated with other bias control circuits into a single surface-mount package. A diminutive 7 × 9 mm surface-mount package holds up to three amplifier stages and delivers up to 15 W peak RF output. Compared to the cost of individual parts and associated board space, this is a significant cost saver and just a sign of things to come in the integrated power device market.

In low power RF modules, the progress in integration and footprint reduction has been tremendous. Several manufacturers now offer packaged solutions for the whole RF front end of phones, wireless routers and similar products.[9] These advances follow the increased functionality ideas discussed earlier, but in a very different way. Rather than focus on

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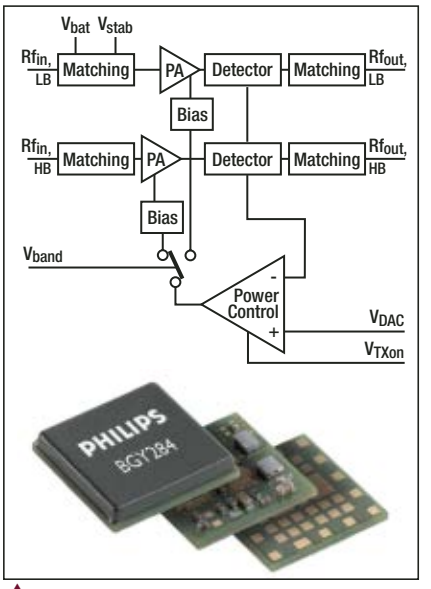
the die level, these solutions are at the package level; by freely mixing active and passive technologies, silicon, SiGe and GaAs dies, as well as surface-mount parts, appropriate cost performance targets are met.

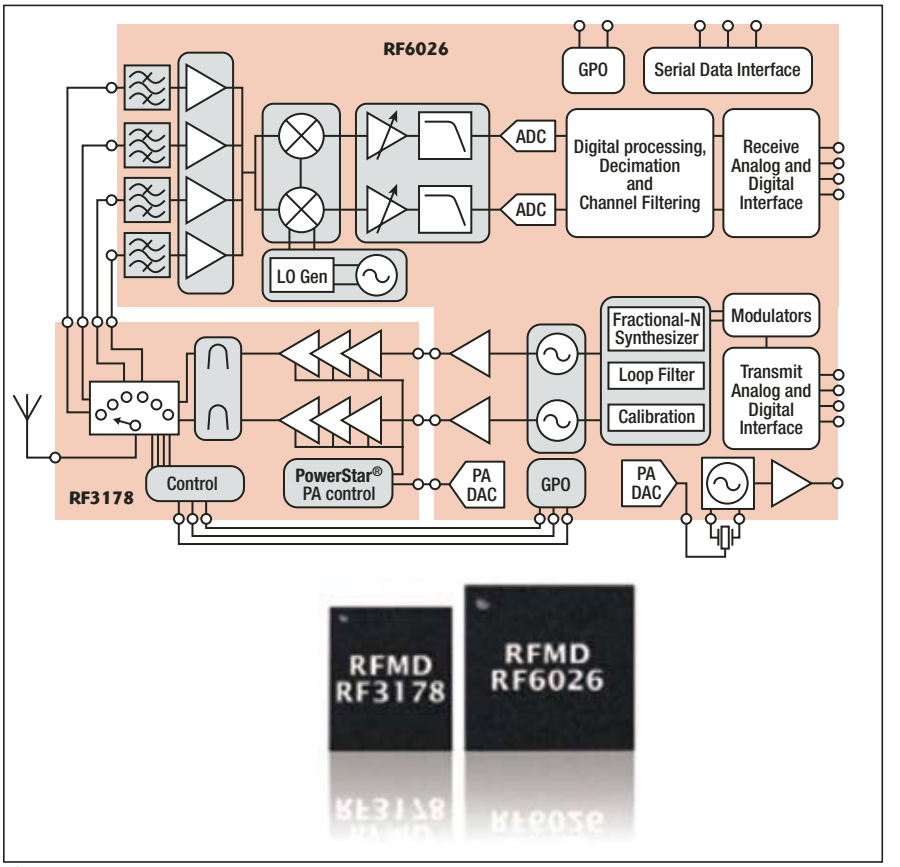
With this 'Optimum Technology Matching' strategy, there is even a trend towards less functionality per die. For example, handset PA die are minimised to just the active components with other functions off-loaded to lower cost passive only substrates in Si or GaAs. This makes sense as long as the fabrication capacity can support such measures, but it does tie up relatively expensive processing equipment on low margin products. With growth still projected in the RFIC market, the future will be for alternatives to present integrated passive die.



▲ *Fig. 5 Philips (now NXP) "Smart Technology Mix." (Courtesy of NXP Semiconductors)*

The NXP example in ***Figure 5*** clearly shows mixed technology integration in the otherwise featureless plastic SMT package. Here, GaAs HBT technology for the PA is combined with Si PASSI substrate for off-chip matching and decoupling, Si BiCMOS for drivers and control functions integrated with SMT parts on a low cost organic substrate.

There are similar products from other manufacturers, with perhaps the most advanced being from RFMD, as shown in ***Figure 6***. This further integrates SAW and baseband devices for a system in a package (actually two packages) and complete RF-to-digital functionality.



▲ *Fig. 6 Polaris™ 2 Total Radio Module Solution.™ (Courtesy of RFMD)*

Advances in packaging technology play a significant role in this trend. With SMT parts now as small as 0201 and innovative uses of organic substrates with hot vias and vertical integration concepts, there is every indication that higher functionality can be achieved with this approach, independent of advances at the die level.

OTHER BUSINESS

Some see a tremendous future in wide bandgap semiconductor-based circuits for RF power applications. Indeed, the attractiveness of the physical properties is indisputable and, particularly in the case of GaN, progress has been remarkable, eclipsing earlier hopes for high voltage GaAs.[10,11] Just like early GaAs developments, the early adopters are the military, where the benefits can be applied to immediate requirements.

However, commercial products are likely to be further away in that highly cost-competitive market. Early claims of greater than 10 W/mm power densities have almost been halved recently, and even then it seems that because of thermal management issues these devices require wider gate-to-gate pitches than GaAs. With the relative high cost and small size of GaN substrates and using the more practical comparison of watts per mm^2, the advantages of GaN compared to established high power technologies, at least for the cellular base station market, are not as clear as initially thought.

CONCLUSION

To answer my original question, I certainly own more RF semiconductor real estate than I realised. Also, as with so many good questions, the interesting part is not so much the numerical result, but more in the way you get to an answer. With mobile handset production predicted to reach one billion this year, uptake of more advanced products in the developing world and demand for greater wireless connectivity almost everywhere, there is clearly scope for further growth. For me, the major trend is that manufacturers are taking the magic out of RF product design, enabling innovation and greater market penetration through wider adoption of the technology. ■

References

1. I.I. Blednov and J. van der Zanden, "High Power LDMOS Integrated Doherty Amplifier for W-CDMA," *2006 Radio Frequency Integrated Circuits Symposium Digest*.
2. A. van Bezooijen. "Over-temperature Protection by Adaptive Output Power Control," *2006 European Conference on Wireless Technology*.
3. "Skyworks Favors Hybrid BiFET Designs," *Compound Semiconductor Magazine*, September 2006.
4. M. Sun, et al., "A High Yield Manufacturable BiFET Epitaxial Profile and Process for High Volume Production," *2006 CS MANTECH Conference Digest*, pp. 149–152.
5. M. Shokrani, "InGaP-Plus™: A Low Cost Manufacturable GaAs BiFET Process Technology," *2006 CS MANTECH Conference Digest*, pp. 153–156.
6. J.R. Powell, P.D. Mundy, W.H. Tang, R.C. Hunt and D.J. Gunton, "MMIC and Module Design and Performance for Millimetric Transceiver Front-ends for Transport Applications," *2006 IEEE MTT-S International Microwave Symposium Digest*, pp. 1497–1500.
7. T. Yao, et al., "65 GHz Doppler Sensor with On-chip Antenna in 0.18 µm SiGe BiCMOS," *2006 European Conference on Wireless Technology*.
8. L. Hamel, "Low Cost Thermally Improved RF Power Transistor Packages," *IWPC Workshop, High Efficiency, High Linearity Semiconductor Devices for Base Station PAs*, November 2005.
9. J. Neal, "The RF Semiconductor Evolution: From Single Components to Systems Solutions," *Microwave Journal*, Vol. 48, No. 2, February 2005, pp. 22–30.
10. A. Maekawa, T. Yamamoto, E. Mitani and S. Sano, "A 500 W Push-pull AlGaN/GaN HEMT Amplifier for L-band High Power Application," *2006 IEEE MTT-S International Microwave Symposium Digest*, pp. 722–725.
11. K. Inoue "A High Gain L-band GaAs FET Technology for 28 V Operation," *2005 IEEE MTT-S International Microwave Symposium Digest*.

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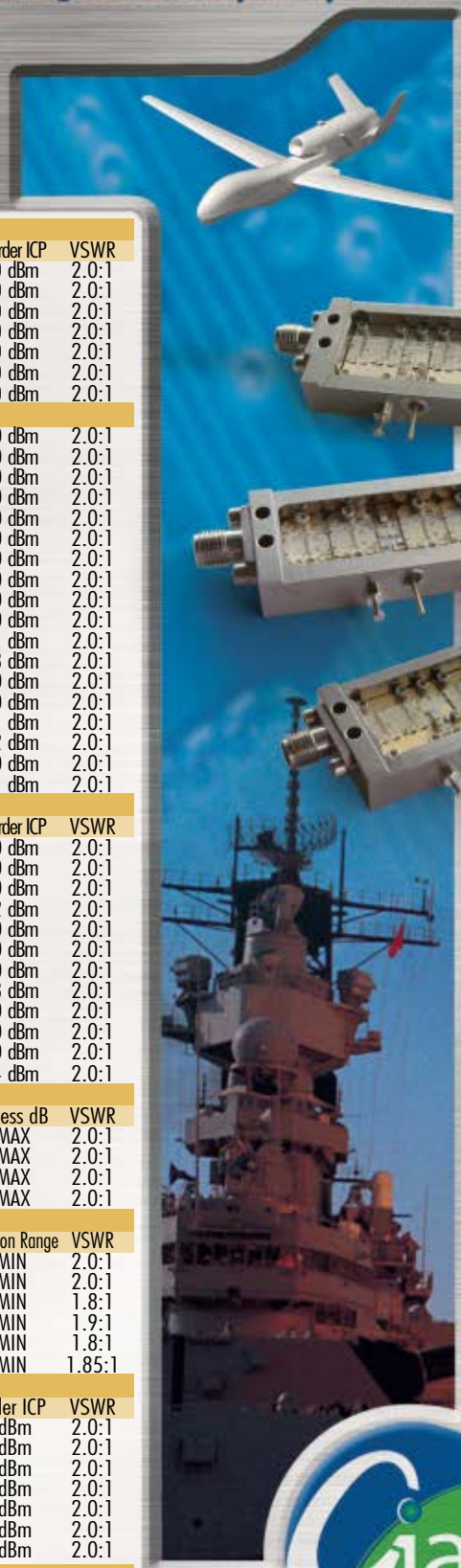

OCTAVE BAND LOW NOISE AMPLIFIERS

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

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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Northrop Grumman Selected for Anti-terrorism Force Protection Contract

Northrop Grumman Corp. was recently awarded a contract potentially valued at $100 M to provide Anti-Terrorism Force Protection (ATFP) systems and capabilities to Navy installations around the world. The contract was awarded by the US Naval Facilities Engineering Command.

Under the terms of the five-year, indefinite-delivery, indefinite-quantity contract, Northrop Grumman will utilize a total systems engineering approach to develop, install, integrate, test and support the fielding of software and hardware that will automate and improve the security and advance warning posture of Navy shore installations worldwide. This contract will emphasize state-of-the-art solutions to meet the requirements for physical security; access control; emergency management; chemical, biological and nuclear protection; and command, control, communications, computers, intelligence, surveillance and reconnaissance. Contracts were awarded March 14 to Northrop Grumman and three other companies. Each company will compete for task orders that have potential overall value of $100 M for each company if all options are exercised. "This contract reinforces Northrop Grumman's already strong position in strategic homeland defense, validates our innovative systems engineering and integration approach and complements our growing set of solutions to protect naval forces and civilians against terrorists threats worldwide," said Zach Parker, ATFP capture manager for Northrop Grumman. The contract includes one base-year and four one-year options with an expected completion date of March 2012, if all options are exercised. Work will be performed at Navy stations worldwide. Northrop Grumman will base its operations from the Washington Navy Yard, Washington, and the Naval Base Ventura County, Camarillo, CA.

Raytheon Wins Navy Multiband Terminal Contract

Raytheon Co. has been awarded the US Navy's Multiband Terminal (NMT) contract, which has a combined value during its lifetime in excess of $1 B for development and production. Raytheon Network Centric Systems will develop, deliver and support an advanced satellite communication system consisting of shipboard and shore-based communication terminals for the transformational communications component of the Navy's FORCEnet architecture. The Navy expects to field the terminals for operational test and evaluation in late 2009, which is consistent with the Department of Defense's plans to have its advanced extremely high frequency satellite constellation in operation in 2010. "This is a tremendous win that recognizes Raytheon's ability to deliver a reliable, innovative, affordable and timely solution to meet the needs of our Navy customer," said Colin Schottlaender, president of Raytheon Network Centric Systems. "We spent over 13,000 hours of shipboard design effort to ensure an easy-to-use and easy-to-maintain system and then demonstrated the system for over 13,700 hours of failure-free operation—far exceeding the Navy's objectives. We are proud to provide this critical communications system to the Navy and we are confident that our terminals will measure up to our highest mission assurance standards."

Harris Corp. Awarded Contract for Falcon High Frequency Tactical Radios

Harris Corp., an international communications and information technology company, has been awarded an indefinite-delivery, indefinite-quantity contract with a maximum value of $422 M to supply the Department of Defense with its Falcon® high frequency multiband radio systems. The contract includes an initial delivery order for the US Army valued at $104 M.

The contract calls for Harris to deliver Falcon II AN/PRC-150(C) HF manpack radios and related vehicular and base station systems, as well as installation and training, over five years. Deliveries will begin later this summer. "This is a great contract award for Harris. We have a long history of supporting the Army with battle-tested, beyond line-of-sight HF radio equipment and we are pleased to continue this relationship," said Dana Mehnert, president, RF Communications Division, Harris Corp. "Harris is committed to providing a wide range of tactical radio solutions and support to the Department of Defense." The falcon line is the most advanced family of radios in the world. Built with features such as embedded communications security certified for transmission of US classified information, the radios are designed to meet the demanding security requirements of military forces around the world.

Lockheed Martin's Trident II Missile Successful in Navy Test

The US Navy conducted a successful test launch, on May 15, of two Trident II D5 Fleet Ballistic Missiles (FBMs) built by Lockheed Martin. The Navy launched the unarmed missiles from the USS Tennessee (SSBN 734) in the Eastern Range in the Atlantic Ocean. With this two-missile Follow-on Commander Evaluation Test, the Trident II D5 missile has achieved 119 consecutive successful test launches since 1989—a record unmatched by any other large ballistic missile or space launch vehicle. The launches are part of a continuing series of operational

system evaluation tests conducted by the Navy to assure the safety, reliability, readiness and performance of the Trident II D5 Strategic Weapon System, as required by the Department of Defense's National Command Authority and conducted under the testing guidelines of the Joint Chiefs of Staff. A new test missile kit design was used for the first time in the test. Produced by Lockheed Martin, the new design uses a combination of custom military and commercial off-the-shelf components. The kits convert operational missiles into test configurations and contain range safety devices and flight telemetry instrumentation. "Consistent with every test launch conducted by the Navy's Strategic Systems Programs, this test was important to ensuring the reliability and credibility of the Fleet Ballistic Missile," said Tory Bruno, vice president of Strategic Missile Programs, Lockheed Martin Space Systems Co. "This test had added significance because the new test missile kits extend the effectiveness of the Navy's rigorous testing program." First deployed in 1990, the D5 missile is currently aboard 12 Trident II Ohio-class submarines. The three-stage, solid propellant, inertial-guided ballistic missile can travel a nominal range of 4000 nautical miles and carries multiple independently targeted reentry vehicles. Lockheed Martin Space System Co., Sunnyvale, CA, is the prime contractor and program manager for the US Navy's Trident Missile. Approximately 2400 Lockheed Martin Space Systems employees, principally in California, Georgia, Florida, Washington and Utah, support the design, development, production, test and operation of the Trident strategic weapon system.

Raytheon Seeks Solutions for Defeating Improvised Explosive Devices

Raytheon Co. is seeking partners to help create innovative solutions to defeat the number one killer of service members in the global war on terror—the improvised explosive device (IED). During the last six months, Raytheon's McKinney, Texas-based Network Centric Systems has led a company-wide drive to rapidly develop and field solutions to defeat IEDs. To broaden the scope of the research, Raytheon is now inviting potential partners to join the effort by registering solutions and ideas at www.raytheon.com. Raytheon will review the registered submissions for feasibility and will contact the appropriate sponsors of those ideas deemed appropriate for further development. Information provided during registration will be treated in a confidential manner and will be subject to reasonable and prudent safeguards against improper disclosure.

Raytheon Co. is a technology leader specializing in defense, homeland security and other government markets throughout the world. The company provides state-of-the-art electronics, mission systems integration and other capabilities in the areas of sensing; effects; and command, control, communications and intelligence systems, as well as a broad range of mission support services. ■

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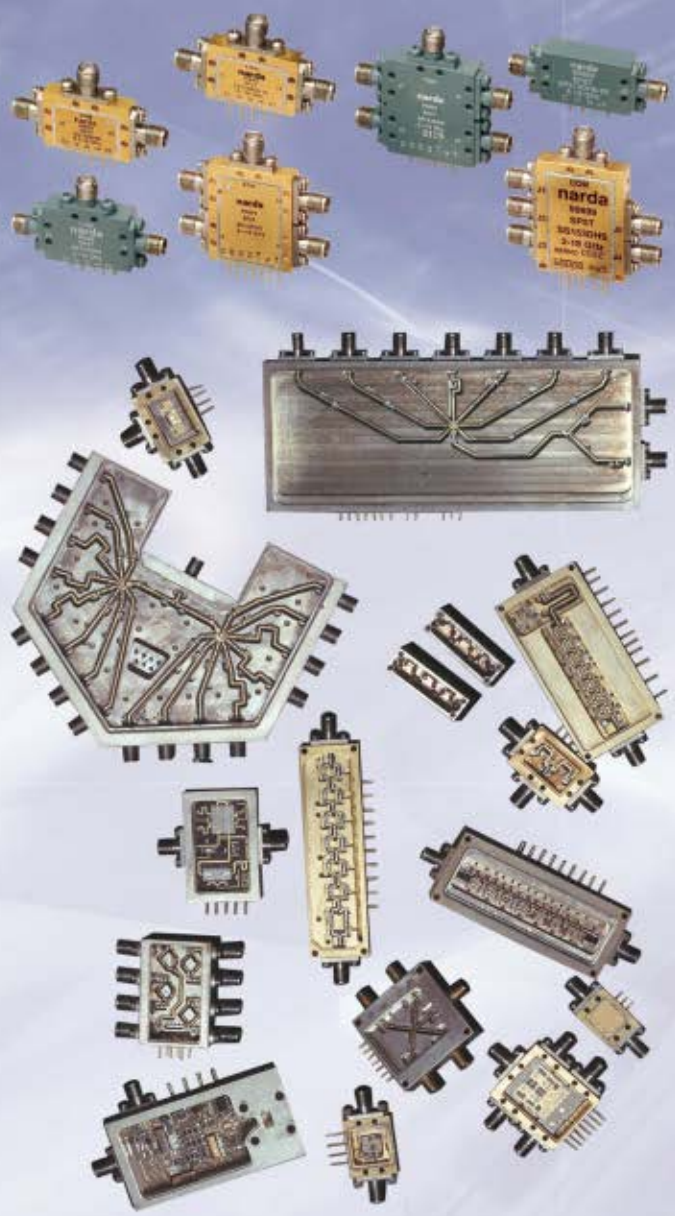

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Nokia and TUT Seek Open Innovation

Nokia Research Centre (NRC) and Tampere University of Technology (TUT) are creating a new framework to tighten open and innovative collaboration in their research activities. Through this initiative TUT will become the first and central collaboration partner in the planned Nokia Innovation Centre Tampere, Finland.

Due to open in September 2007, the centre aims to create a model for research based on open innovation, where information flows freely between collaborators. Past experience indicates that creating common research facilities where researchers from both parties can work together lowers the barrier to collaboration with genuine collaboration being the central target.

When launched, approximately 70 researchers will work together on a weekly basis. Both parties deem it essential that the centre's work has the potential for market impact while also contributing to the state of the art by producing high quality technical publications. Part of the research will be funded by Tekes, the Finnish Funding Agency for Technology. It is envisaged that other research institutions, as well as compatible commercial companies in the Tampere area may eventually participate in the work of the centre.

Professor Jaakko Astola of the Tampere University of Technology, who has been strongly involved in preparing the new framework, commented, "This announcement is about creating impactful results through sharing of information in both directions, not technology transfer. We can discuss together some specific research problem or functional entity without compromising the confidentiality of either party. Researchers from both organizations can share the enthusiasm and work together as one group."

The announcement is just the latest example of NRC's policy of working in close collaboration with respected academic institutions on projects of mutual benefit. It follows on from recent research collaboration agreements with the Massachusetts Institute of Technology (MIT) and Stanford University in the US, the University of Cambridge in the UK and the Helsinki University of Technology in Finland.

NEC Centre's WiMAX Research on Taiwan

The NEC Corp. has signed a Memorandum of Understanding (MoU) with the Taiwan Ministry of Economic Affairs to found a mobile WiMAX research centre in Taiwan. The Multimedia E2E R&D Centre will be established in Taipei during 2007 as part of the M-Taiwan project being lead by the Taiwanese Government.

M-Taiwan is a national project to establish a networked information society and to cultivate IT-related industries in the domestic market. The country aims to upgrade its IT infrastructure based on wireless broadband application technology and cultivate domestic industries related to WiMAX—two major objectives of the M-Taiwan project.

End-to-end live wireless development environments, using NEC's WiMAX base stations and application service platforms, will be provided at the new centre. It will be open to local equipment vendors to enable the implementation of interoperability tests, supporting service providers and software vendors in the development and verification of application services. Demonstration results will be fed back to enable further development by NEC.

Currently, NEC is conducting a WiMAX trial as part of the M-Taiwan project with the Tatung Co. and has demonstrated internet access and video streaming in Hualien city. As a result, Tatung plans to acquire an official WiMAX business license in June. By building on these collaborations with Taiwanese WiMAX-related industries and by leveraging its experience and achievements in the country, NEC plans to pioneer the global expansion of WiMAX business.

Russian/US MoU Sets New Standards

The Russian national standards body, the Russian Federal Agency on Technical Regulating and Metrology, has signed a historic Memorandum of Understanding (MoU) with ASTM International, originally known as the American Society for Testing and Materials. The goals of the MoU are to remove technical barriers in economic and trade relations, create greater efficiency in the development of standards, deliver greater quality products, provide environmental and labour safety, and recognize the mutual benefits to be derived from cooperation in the field of standardization.

Through the MoU, the Russian Federation joins 47 other countries that have signed MoUs with ASTM international and will also give it access to the full collection of ASTM's 12,000 standards. ASTM standards are an important source of technological know-how to advance manufacturing productivity and product quality that will bolster the capability for Russia to export and compete in global markets.

The MoU also allows technical experts from Russian industry and scientific enterprises to influence the technical content of ASTM International standards that are important to Russia's economy through direct free participation in the ASTM standards development process.

James A. Thomas, president of ASTM International, stated, "With Russia's aim to join the World Trade Organization in 2008, the MoU is a timely initiative that will foster much greater cooperation between Russia and ASTM International in the development of international standards."

Alliance Agrees on Semiconductor Development

In a move that signals a firm and ongoing commitment to future technology leadership, IBM and its joint development alliance partners, Infineon Technologies AG and Freescale Semiconductor along with its Common Platform™ technology partners, Chartered Semiconductor Manufacturing and Samsung Electronics, have signed a series of semiconductor process development and manufacturing agreements.

These agreements will now include 32 nm bulk complementary metal oxide semiconductor (CMOS) process technology and joint development of process design kits (PDK) to support that technology. Building on the success of earlier joint development and manufacturing agreements at 90 nm, 65 nm and 45 nm, alliance partners will be able to produce high performance, energy efficient chips at 32 nm.

The partners plan to pool their combined expertise and collaborate to design, develop and manufacture advanced technology through 2010. Those technologies, which are the leading platform for a broad range of systems, may be used by the five partners and other companies to help solve real-life problems in fields such as medicine, communications, transportation and security.

NTT DoCoMo Funds Chinese Venture

NTT DoCoMo will invest $10 M with Gobi Fund II, L.P., a venture capital fund operated by Gobi Partners Inc. The Fund will target cutting-edge venture companies in China working on the convergence of telecommunications, media and technology within the IT and digital media sectors.

Through its involvement with the Fund, the company expects not only to earn a reasonable return on its investment, but also to learn more about opportunities for establishing businesses and forming technical tie-ups in telecom related sectors of China's highly promising economy. DoCoMo's decision to enter the second stage of the Gobi Fund has been prompted, in part, by the successful performance of its investment in the Gobi Fund I in December 2003. The new Fund is targeting a final close of $120 M and is scheduled to operate for ten years. ■

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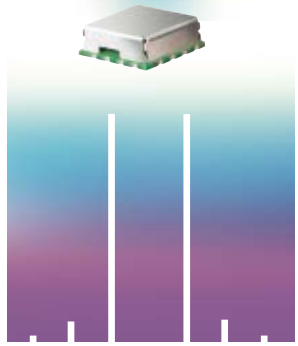

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LAVI-9VH+	820-870	990-1040	120-220	+19	+36	+23	7.2	46	46	15.95
LAVI-10VH+	300-1000	525-1175	60-875	+21	+33	+20	6.3	50	45	22.95
LAVI-17VH+	470-1730	600-1800	70-1000	+21	+32	+20	6.8	52	50	22.95
LAVI-22VH+	425-2200	525-2400	100-700	+21	+31	+20	7.7	50	45	24.95
LAVI-2VH+	2-1100	2-1100	2-1000	+23	+34	+23	7.5	48	47	24.95
LAVI-25VH+	400-2500	650-2800	70-1500	+23	+32	+20	7.5	50	45	24.95

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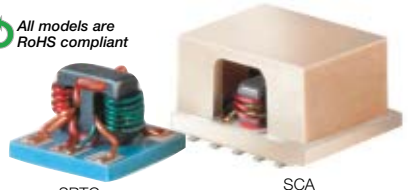

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SBTC-2-20+	200-2000	50 Ω	3.49
SBTC-2-25+	1000-2500	50 Ω	3.49
SBTC-2-10-75+	10-1000	75 Ω	3.49
SBTC-2-15-75+	500-1500	75 Ω	3.49
SBTC-2-10-5075+	50-1000	50/75 Ω	3.49
SBTC-2-10-7550+	5-1000	50/75 Ω	3.49
SCA-4-10+	5-1000	50 Ω	6.95
SCA-4-10-75+	10-1000	75 Ω	6.95
SCA-4-15-75+	10-1500	75 Ω	7.95
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AeA Releases New Report on China 15 Year Science and Technology Plan

AeA, the nation's largest high-tech trade association, released the 14th edition of its ongoing 'Competitiveness Series.' The report outlines the "15 Year Science and Technology Plan" announced by Chinese leaders in January 2006 and analyzes China's capacity to implement the plan. "China's 15 Year Science and Technology Plan looks all too familiar," said William T. Archey, president and CEO, AeA. "It looks remarkably like the blueprint the United States developed in 1958 in response to the Soviet launch of Sputnik. Here we are, months away from the 50th anniversary of Sputnik and the Chinese are cribbing from our playbook. They see how successful it was in making the United States the preeminent scientific, technological and economic power on the planet." China's 15 Year Plan is designed to boost science, technology and innovation with the long-term goal of becoming a preeminent global economic and technological power. It calls for China to raise research and development (R&D) spending from the current 1.4 percent of its economic output to two percent by 2010 and 2.5 percent by 2020. With China's GDP growing by over seven percent per year, these commitments would put Chinese R&D investments above $100 B annually, placing it in the same league as Japan and the United States. Though China already has a growing technology industry, it is largely dominated by multinational companies and much of this is low value-added, labor-intensive manufacturing. The 15 Year Plan intends to change that equation by investing heavily in such cutting-edge areas as nanotechnology and biotechnology to spawn "indigenous innovation."

Mobile Phone Accessories Market Will Generate More Revenue Than Smartphone

The market for mobile phone accessories will generate over $32 B in revenues in 2007, more than the $28 B expected from the Smartphone market. Around 77 percent of these revenues will come from the sales of "after-market" mobile phone accessories and the remaining from "in-box" accessories shipments. According to ABI Research industry analyst Shailendra Pandey, "The number of mobile phone accessory products is expanding with new products driven by technology as well as by customer fashion and personalization needs appearing in the market. Handset vendors and mobile operators are showing greater interest as accessories provide high margins and also opportunities to promote their brand and expand their product offerings. The growing interest among mobile operators is also driven by the realization that mobile phone accessories can lead to higher ARPUs." Handset vendors now recognize that to increase sales of their high-end mobile phone and smartphones, they need to provide accessories that allow users to fully enjoy and benefit from the features provided in those handsets. Nokia is addressing the handset accessory market with a distinctive approach of "Mobile Enhancement" products while Motorola is placing special emphasis on the growing "Personalization" and "Self-Expression" trends. ABI Research expects the market for mobile phone accessories to grow steadily in the next five years and generate over $80 B in revenues in 2012. The continuing innovation and further advancements in technology coupled with the increasing desire of customers to personalize their handsets, bodes well for the future of the market. The firm's recent study, "Mobile Phone Accessories," examines the market landscape and future potential for mobile phone accessory products. It discusses the various types of mobile phone accessories, their features and pricing, key suppliers, market outlook, vendor market share analysis for key accessories, as well as in depth analysis for both in-box and after-market mobile phone accessories. This study forms part of two ABI Research services: Mobile Devices and Mobile Operators, which include a variety of Research Reports, Research Briefs, Market Data, Online Databases, ABI Insights and analyst inquiry support.

Wi-Fi RFID Tag Market to Grow More Than 100 Percent Per Year Through 2010

Despite some hurdles to overcome, Wi-Fi RFID tag shipments will grow at over 100 percent annually through 2010, reports In-Stat. The technology is attractive because Wi-Fi RFID allows businesses to leverage their existing Wi-Fi investments for asset tracking, the high-tech market research firm says. "Historically, one of the key weaknesses of this market has been the short battery life of asset tags," says Daryl Shoolar, In-Stat analyst. "G2 Microsystems, the only tag-specific vendor, has made stride in overcoming this weakness, with multi-year battery life now a reality."

Recent research by In-Stat found the following:

- AeroScout shipments accounted for the majority of all Wi-Fi RFID tags in 2006.
- 2006 worldwide Wi-Fi RFID tags shipments reached 135,000.
- Key verticals for growth will be healthcare, heavy manufacturing, transportation and logistics.

The research, "Where's It At? – The Worldwide Market for RFID," covers the global market for Wi-Fi RFID. It contains forecasts for worldwide Wi-Fi RFID tag shipments and revenue, worldwide PCs embedded with Wi-Fi and worldwide enterprises wireless access point shipments through 2011. It also includes profiles of major vendors and analysis of RFID standards and technologies. Market share information is provided.

3G Cellular to Capture 30 Percent of M2M Market

Cellular Machine-to-Machine (M2M) communications first started in the era of analog cellular connectivity and have largely shifted now to 2G GPRS and CDMA connectivity. Certain M2M applications can benefit from the higher data rates than 3G cellular offers and it is tempting to assume that all M2M communications will be 3G eventually. But a study from ABI Research forecasts that 3G modules will achieve only a 30 percent penetration of the market by 2012 and will become the technology of choice only when the bandwidth demands and economics dictate; "future-proofing" will play a smaller role in 3G M2M market development over the next five years. In addition, according to Sam Lucero, senior analyst, M2M and Wireless Connectivity, "Multiple Wi-Fi and WiMAX will both challenge 3G cellular technology as the most suitable methods to achieve high-speed M2M communications for many applications and in many locales." High-speed wireless M2M will find its natural uses where the need for high bandwidth outweighs the added cost. These include: fixed-wireless terminals that use cellular backhaul; multimedia content delivery to point-of-sale terminals such as digital marketing displays; high-speed telematics connectivity, including real-time navigation information; remote information displays—used, for example, in digital mobile advertising; and video surveillance, where wireless CC backhaul permits camera deployment without the need for cabled connections at each location. In addition to the added cost of 3G modules, says Lucero, wireless network coverage is an issue. "Some think that cellular networks will eventually be all-3G. But ABI Research does not believe that is practical, in terms of cost and power consumption, for all operators in all geographical areas. WiMAX and (especially) municipal Wi-Fi offer attractive alternatives to CDMA 1xEV0DO or HSDPA 3G technologies for wide area wireless M2M," says Lucero. "They are both more cost-effective and operationally efficient. With backing by Intel as well as key carriers worldwide, WiMAX and municipal Wi-Fi will feature as important high-speed wireless M2M networks in the coming years." The new ABI Research study, "3G Machine-to-Machine (M2M) Communications," examines the market for cellular 3G M2M from the perspective of cellular embedded module vendors and analyzes the impact that WiMAX and municipal Wi-Fi will have on market development. ■

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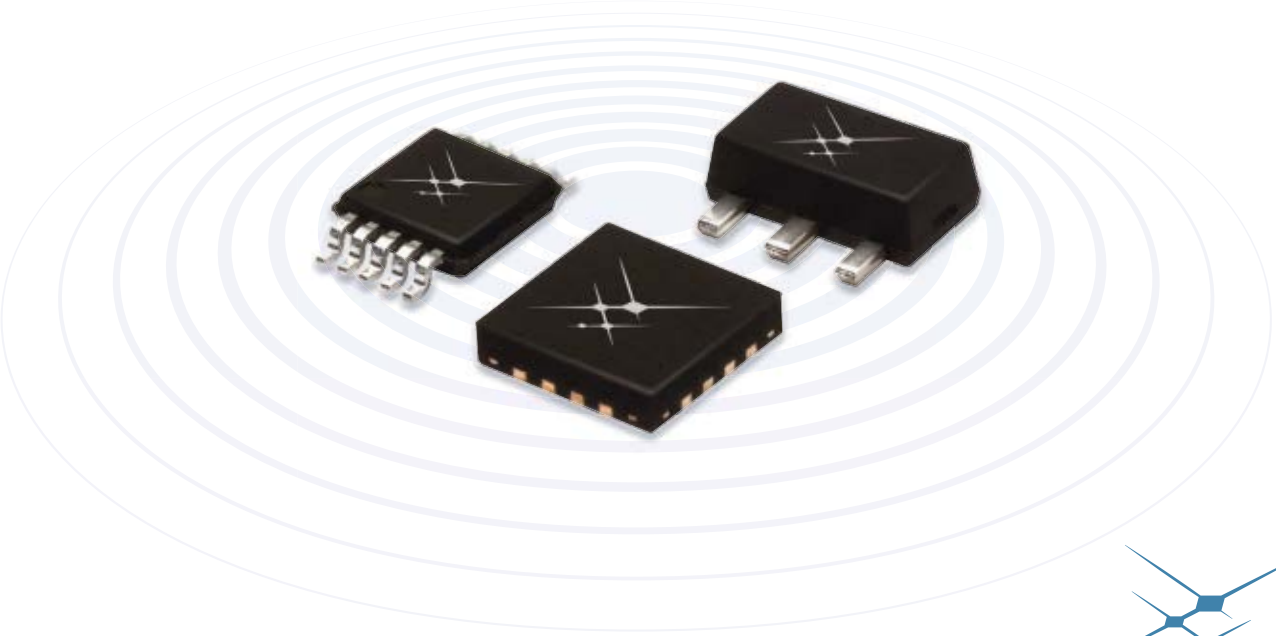

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100 MHz–6 GHz	High Isolation SPDT	0.8–1.5	62–42	49	QFN-16 (4 x 4 mm)

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Frequency Band	Description	Insertion Loss Range (dB) Typ.	Attenuation Range (dB) Typ.	IP3 > 0.5 GHz (dBm) Typ.	Package
500 MHz–3 GHz	5 Bit, LSB 1 dB, Single Positive Control Voltage	1.40–2.30	31	45	MSOP-10EP

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INDUSTRY NEWS

■ **Winchester Electronics Corp.** announced that it has acquired the assets of **Advanced Interconnect Inc.**, Franklin, MA, and **Kings Electronics Co. Inc.**, Rock Hill, SC. Terms of the transactions were not disclosed.

■ **Tyco Electronics** announced a strategic alliance with **KeyTone Technologies** aimed at providing comprehensive solutions to companies who need to meet the Department of Defense's (DoD) mandate on the use of radio frequency identification (RFID) for electronic product codes (ePC) on all products. The expertise of Tyco Electronics in RFID labels, hi-memory tags, readers and antennas combined with the strength of KeyTone Technologies in enterprise-level RFID software enables companies dealing with the DoD to meet the RFID mandate efficiently and cost effectively.

■ **Agilent Technologies Inc.** announced a strategic partnership with **Mentor Graphics**, licensing to Agilent certain products in the Mentor Graphics Volcano® product line. The Agilent LIN Tester, derived from Mentor's Volcano LIN Spector™ product, and the Agilent Vehicle Protocol Tester Series 500, derived from Mentor's Volcano TELLUS® product, help automotive engineers develop electronic products faster and under budget while meeting quality requirements.

■ **Anite**, a leader in testing technology for the wireless industry, and **Beceem Communications Inc.**, a leading provider of chipsets for the mobile broadband market, announced that they have entered into a collaboration to enable customers to more effectively use their respective products. The collaboration is built upon solid foundations with Beceem already using Anite solutions to accelerate the verification of its reference designs. Anite and Beceem will align product roadmaps as part of a deep technical collaboration for WiMAX™ 802.16e and also introduce a dedicated customer support program to ensure that Beceem customers have access to complementary testing tools for subscriber and base station development.

■ **Fujitsu Ltd.** (Fujitsu), **Fujitsu Microelectronics of America Inc.** (FMA) and **Jazz Semiconductor** (Jazz), a wholly owned subsidiary of Jazz Technologies Inc., announced that they will work together to manufacture System-on-Chip (SoC) products for RF CMOS devices. Under a Memorandum of Understanding (MoU) signed by the companies, the collaboration is designed to combine superior RF and mixed-signal expertise from Jazz and leading-edge existing 90 nm and 65 nm manufacturing technology from Fujitsu, enabling both companies to deliver high performance Customer Owned Tooling (COT) foundry services to SoC customers. The alliance will enable Fujitsu to offer Jazz's high precision RF models and design kits using Fujitsu's 90 nm and 65 nm low leakage, leading-edge LSI manufacturing process.

■ **AR RF/Microwave Instrumentation** announced that a new 15,000 square foot building has been completed at the site of AR's worldwide headquarters in Souderton, PA. This $2.2 M building expansion will allow increased production capabilities. AR RF/Microwave Instrumentation will be able to fulfill new orders, as well as perform in-house service and repairs, and manufacture replacement parts quicker and more expediently.

■ **Linear Technology**, a California-based maker of linear integrated circuits, announced that it has opened a new 20,000-square-foot design facility in Manchester, NH. Linear said that it had outgrown its prior New Hampshire design center. The new design center is focused on high performance analog integrated circuits, and includes design facilities, lab and test development floor.

■ **Rohde & Schwarz** was named the Indirect Supplier of the Year 2007 by **Rockwell Collins**. The award was presented by chairman, president and CEO Clay Jones during the Annual Supplier Conference. The Supplier of the Year award is an acknowledgement of significant contributions made during the year by suppliers and is based upon quality, delivery, total cost of ownership, lead time and customer service.

■ **Teledyne Relays** has been recognized as the Relay/Switch Commodity Supplier of the Year by **Rockwell Collins**. Teledyne Relays, producer of industry-leading switching products, was cited for significant contributions made during the year based on quality, delivery, total cost of ownership, lead time and customer service. Rockwell Collins chairman, president and CEO Clay Jones presented the award to Teledyne at the recent Annual Supplier Conference in Cedar Rapids, IA.

■ **Gowanda Electronics**, a manufacturer of high performance electronic inductor components for RF and power applications, announced that the company is now registered as conforming to AS9100 quality management standard. Certification was granted by NSF International Strategic Registrations (NSF-ISR) after completion of an audit earlier this year.

CONTRACTS

■ **LNX Corp.** announced that it has been recently selected by **BAE Systems**, Wayne, NJ, to supply sophisticated solid-state power amplifiers, valued in excess of $4 M, for the F-22 Program.

■ **Merrimac Industries Inc.** announced that it received both an Internal Research And Development (IRAD) and a new co-design contract as a follow-on to the IRAD contract for multi-function integrated modules from **General Dynamics Advanced Information Systems**, a business unit of General Dynamics. The initial design effort is valued at approximately $500,000. Final design and manufacture of the subassembly modules from the IRAD contract was completed and delivered in April 2007.

■ **Richardson Electronics Ltd.** announced that it has received a contract from **Globalstar Inc.**, Milpitas, CA, to produce antenna assemblies for a line of SATCOM asset tracking products. The contract represents a total of 60,000 antennas to be delivered over the next two years.

WIDEBAND

TRANSFORMERS

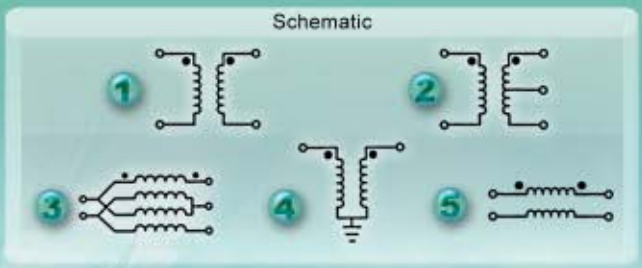
Model #	Z Ratio (50:Z)	Frequency (MHz)	Schematic
Wideband Series			
TM1-0	1:1	0.3 - 1000	1
TM1-1	1:1	0.4 - 500	2
TM1-2	1:1	50 - 1000	2
TM1-6	1:1	5 - 3000	5
TM1.5-2	1:1.5	0.5 - 550	1
TM2-1	1:2	1 - 600	2
TM4-0	1:4	0.2 - 350	2
TM4-1	1:4	10 - 1000	3
TM4-4	1:4	100 - 2500	3
TM2-GT	2:1	5 - 1500	4
TM4-GT	4:1	5 - 1000	4
TM8-GT	8:1	5 - 1000	4

Features

- > Low Cost
- > Wide Bandwidth
- > Good Amplitude / Phase Unbalance
- > Rugged Welded Construction
- > Lead Free RoHS Compliant
- > REL-PRO® Technology
- > Small Size, Surface Mount

Application:

- Impedance Matching
- Phase Shifting/Splitting
- Balance to Unbalance Transformation



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FINANCIAL NEWS

■ **Ansoft Corp.** reports sales of $28.6 M for the fourth quarter of fiscal 2007 ended April 30, 2007, compared to $24.7 M for the same period in 2006. Net income for the quarter was $7.9 M ($0.30/per diluted share), compared to a net income of $8.3 M ($0.32/per diluted share) for the fourth quarter of last year.

■ An impressive series of events appears to have moved **RFID Ltd.** from startup to possible major player in a short time. The company attracted major media and industry attention when it announced its two new niche market RFID tags: the BagChip for lost airline luggage, and the SurvivalTag to monitor firemen at the scene. An LOI with RFID Leasing that offered to establish a $75 M credit facility was reported on March 19, 2007. The company then stated on March 27 that it had teamed up with 3M to pursue medical, legal and government offices.

■ **Endwave Corp.** reports sales of $14.8 M for the first quarter ended March 31, 2007, compared to $13.7 M for the same period in 2006. Net loss for the quarter was $780,000 ($0.07/per share), compared with a net loss of $1.2 M ($0.10/per share) for the first quarter of last year.

■ **Superconductor Technologies Inc.** reports sales of $4.2 M for the first quarter ended March 31, 2007, compared to $4.8 M for the same period in 2006. Net loss for the first quarter was $2.9 M ($0.24/per diluted share), compared with $3.2 M ($0.26/per diluted share) for the first quarter of last year.

NEW MARKET ENTRY

■ **ST Design LLC** specializes in custom-designed quartz crystal-based oscillators and custom-configured automatic test systems. The staff of ST Design has over 55 years' combined experience in the design and manufacture of custom oscillators and test systems. The company has extensive design experience with XOs, VCXOs, TCXOs and OCXOs over the frequency range from less than 1 Hz to greater than 1 GHz. Product capabilities include modest-stability, surface-mount clock oscillators to ultra-high stability, ovenized crystal oscillators. ST Design LLC designs and manufactures automated test systems for multiposition testing at HF, VHF and UHF. These test systems can be stand-alone or networked, open-air or imbedded into environmental chambers. For more information, contact: sales@stdsn.com.

PERSONNEL

▲ Reinhard Ploss

■ **Dr. Reinhard Ploss** has been appointed to the management board of Infineon Technologies AG. He takes responsibility for operations, comprising advanced logic and power logic front-end manufacturing, back-end manufacturing, logistics and quality management units previously assigned to different responsibilities. After receiving undergraduate and doctoral degrees from the Munich University of Technology, he began his career at Siemens. When the company spun off its Semiconductor Group to form Infineon Technologies AG in 1999, Ploss was appointed to manage eupec, a wholly owned subsidiary of Infineon Technologies AG and has since held key positions within the company.

▲ Michael Knopp

■ On August 1, 2007, **Michael Knopp** takes up the post of chief financial officer of SUSS MicroTec AG. He is a business leader with proven financial expertise who is relinquishing his position as managing director of Kemmax GmbH, an industrial chemicals company based in Essen, Germany. It is part of the publicly listed Canadian company Chemtrade Logistics Group that reports annual sales of around €370 M. Previously Knopp worked at REALTECH AG in Walldorf, Germany, first as managing director and then as chief financial officer.

▲ Rich Beeber

■ **Rich Beeber** has joined KOR Electronics as vice president, advanced development. Beeber joins KOR with 39 years of experience having held technical, general management and sales, marketing and business development roles at Raytheon, Hughes Aircraft Co., M/A-COM, Alpha Industries, California Microwave and Crane/Signal Technology. In his new position, Beeber will be focusing on strategy development/deployment and business development.

■ Credence Systems Corp. announced the appointment of **Patrick J. Brady** to senior vice president, engineering. Brady will lead Credence's worldwide engineering organization, with implementation responsibility for all product lines. A 24-year veteran of the semiconductor and capital equipment industry, Brady will report to Lavi Lev, president and chief executive officer of Credence. Previously, Brady was vice president and general manager of the Array Test Division at Photon Dynamics. Prior to that Brady was at KLA-Tencor for over six years.

■ Lark Engineering Co., a manufacturer of RF/microwave filters, announced the appointment of **Javier Merino** to vice president of sales. In his new position, he will manage all domestic and international sales activities. Merino holds BSEE and MBA degrees and has over 20 years experience in the electronics industry with such companies as Xerox and Samsung.

▲ Rajesh Tyagi

■ Sasken Communication Technologies Ltd. has strengthened its senior management team with the appointment of **Rajesh Tyagi** as chief technology officer (products and services). He has more than 20 years of experience in 2.5G/3G/4G wireless, VoIP/VoBB, data and optical networking technologies. Most recently, Tyagi was executive advisor, Technology and Portfolio Strategy at Motorola Inc., where he provided next generation network architecture and technology direction to its Core Networks and Services business units.

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▲ *Doru Roll*

■ Nitronex has named **Doru Roll** as director of RF product development. Specializing in the design and development of high power amplifiers for cellular, wireless and digital radio applications, Roll brings more than twenty years of RF experience to Nitronex. Roll joined Nitronex from BAE Systems in Wayne, NJ, where he led the RF Power Amplifier Development Group, which develops advanced PAs for military applications.

▲ *Todd Newell*

■ Crane Aerospace & Electronics, a segment of Crane Co., announced the appointment of **Todd Newell** as director of operational excellence for the Electronics Group. In this position, Newell will be responsible for driving operational excellence across the Electronics Group. He will be located in Fort Walton Beach, FL. Newell joins Crane Aerospace & Electronics from another Crane business group, Crane Valves North America (CVNA), where he served as its operational excellence director since June 2005.

▲ *Marc Correa*

■ iTerra Communications announced the appointment of **Marc Correa** as director of operations. He will be responsible for leading the introduction of new products to manufacturing, for supply/demand planning, assembly and test, global outsourcing of wafer fabrication, package assembly and test, and for order fulfillment. Correa has more than 25 years of experience in developing global manufacturing capabilities, and in marketing RF devices, analog circuits and mixed-signal ASICs, with a specialty in rapidly transitioning from low volume to high volume production.

▲ *David Moorehouse*

■ Cobham Defense Electronic Systems announced the addition of **David Moorehouse** as general manager of Nurad Technologies Inc. Moorehouse brings more than 20 years of aerospace design and manufacturing experience to Nurad. Most recently, Moorehouse was general manager of MFG Ratech in Sparks, NV, a composite structure manufacturer. He has also held various engineering and management positions with Hexcel Corp., Pratt Whitney and other aerospace contractors.

REP APPOINTMENTS

■ **Richardson Electronics** announced a worldwide partnership to distribute **Radiotronix**'s popular FCC-approved Wi.USB-DTS-R™ base station, which allows quick USB PC-connectivity to a Wi.232DTS-R™ network. The base station units combine a high performance

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HIGH PASS FILTERS *(HFCN)*

Model	Passband MHz	Stopband MHz (Loss >20 dB) Min.	Price $ ea. Qty.10	DESIGNER'S KITS (5 of each model) K1 79.95	K2 99.95
HFCN-650+	710-2490	480	1.99	•	
HFCN-740+	780-2800	550	1.99	•	
HFCN-880+	950-3200	640	1.99		•
HFCN-1200+	1220-4600	910	1.99	•	
HFCN-1300+	1400-5000	930	1.99		•
HFCN-1320+	1400-5000	1060	1.99		•
HFCN-1500+	1600-5500	1250	1.99	•	
HFCN-1600+	1650-5000	1290	1.99		•
HFCN-1760+	1900-5500	1230	1.99	•	
HFCN-1810+	1950-4750	1480	1.99		•
HFCN-1910+	2000-5200	1400	1.99		•
HFCN-2000+	2260-6250	1530	1.99	•	
HFCN-2100+	2200-6000	1530	1.99		•
HFCN-2275+	2450-7000	1770	1.99	•	
HFCN-2700+	2650-6500	1800	1.99	•	
▲HFCN-2700A+	2900-8700	2150	2.99		
▲HFCN-3100+	3400-9900	2450	2.99		
▲HFCN-3500+	3900-9800	2800	2.99		
▲HFCN-3800+	4250-10000	3200	2.49		•
▲HFCN-4400+	5000-10100	3500	2.99		
▲HFCN-4600+	5000-11000	3800	2.99		
▲HFCN-5050+	5500-10000	4200	2.99		•
▲HFCN-5500+	6000-11500	4500	2.99		
▲HFCN-7150+	7900-11000	6150	2.99		
▲HFCN-8400+	9000-13000	6000	2.99		•
			Total number of units in kit:	40	50

HFCN Models: -3800+, -5500+, -8400+ Patent Pending

7 Designer's Kits Available *(see table):*
Order kits by prefix (K1, K2, etc.)
Followed by -LFCN+ or -HFCN+
Example: K1-LFCN+

HFCN+ & LFCN+ ▲HFCN+

LOW PASS FILTERS *(LFCN)*

Model	Passband MHz	Stopband MHz (Loss >20 dB) Min.	Price $ ea. Qty.10	DESIGNER'S KITS (5 of each model) K1 99.95	K2 119.95	K3 109.95	K4 175.95	K5 129.95
LFCN-80+	DC-80	200	3.99			•		
LFCN-95+	DC-95	230	3.99			•		
LFCN-105+	DC-105	250	3.99			•		
LFCN-120+	DC-120	280	3.99			•		
LFCN-160+	DC-160	330	2.99					
LFCN-180+	DC-180	370	2.99					
LFCN-190+	DC-190	400	2.99					
LFCN-225+	DC-225	460	2.99	•		•		
LFCN-320+	DC-320	560	2.99	•		•		
LFCN-400+	DC-400	660	2.99	•		•		
LFCN-490+	DC-490	800	2.99	•		•		
LFCN-530+	DC-530	820	2.99	•		•		
LFCN-575+	DC-575	900	2.99	•		•		
LFCN-630+	DC-630	1000	2.99	•		•		
LFCN-800+	DC-800	1400	1.99		•		•	
LFCN-900+	DC-850	1275	1.99		•		•	
LFCN-1000+	DC-1000	1550	1.99		•		•	
LFCN-1200+	DC-1200	1865	1.99		•		•	
LFCN-1325+	DC-1325	2100	1.99		•		•	
LFCN-1400+	DC-1400	2015	2.99				•	
LFCN-1450+	DC-1450	2025	2.99				•	
LFCN-1500+	DC-1500	2100	2.99				•	
LFCN-1525+	DC-1525	2040	2.99				•	
LFCN-1575+	DC-1575	2175	2.99				•	
LFCN-1700+	DC-1700	2375	1.99		•		•	
LFCN-1800+	DC-1800	2425	2.99				•	
LFCN-2000+	DC-2000	3000	1.99		•		•	•
LFCN-2250+	DC-2200	2900	1.99		•		•	•
LFCN-2400+	DC-2400	3600	1.99		•		•	•
LFCN-2500+	DC-2500	3675	1.99					•
LFCN-2600+	DC-2600	3750	1.99					•
LFCN-2750+	DC-2750	4000	1.99					•
LFCN-2850+	DC-2800	4000	1.99					•
LFCN-3000+	DC-3000	4550	1.99					•
LFCN-3800+	DC-3900	6000	2.99					•
LFCN-4400+	DC-4400	6700	2.99					•
LFCN-5000+	DC-5000	6850	1.99		•		•	•
LFCN-5500+	DC-5500	7200	1.99					
LFCN-5850+	DC-5850	7600	1.99					
LFCN-6000+	DC-6000	8500	1.99		•		•	•
LFCN-6400+	DC-5400	8300	1.99					
LFCN-6700+	DC-6700	9300	1.99		•		•	•
LFCN-7200+	DC-7200	9500	1.99					
			Total number of units in kit:	35	60	55	90	65

LFCN Models: U.S. Patent 6,943,646 except LFCN-800+, -1325+, -2000+ & -2400+.

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■ **TriQuint Semiconductor**, an RF product manufacturer and foundry services provider, announced that it is restructuring its sales coverage and product distribution across Europe. This reorganization is designed to streamline European support to meet growing customer needs for cost-efficient, highly-integrated RF solutions that reduce manufacturing time. **Redtree Solutions** has been named TriQuint's official sales representative for much of Europe, the UK, Ireland and the Nordic countries. TriQuint's existing European distributor, **Avnet Memec**, will now also serve France, Italy, the UK and Ireland after having covered much of Western and Eastern Europe before this most recent expansion announcement.

■ **TRAK Microwave Corp.** announced it has appointed **Sands Technical Sales LLC** to represent the company's products and services in the state of Texas. Contact information: Sands Technical Sales LLC, 16129 East Via De Pa, Gilbert, AZ 85397 (480) 733-4146, fax: (480) 733-4147, ktownsend@sandstechnical.com or visit: www.sandstechnical.com.

■ **BroadWave Technologies** announced the appointment of two new exclusive sales representative firms in the United States and two new exclusive sales representative firms in the Pacific Rim. The new members of the BroadWave Technologies sales representative network are: **CMI Technical Sales Inc.** in the District of Columbia, Maryland, North/South Carolina and Virginia can be contacted at (301) 346-7139 or e-mail: jim@cmitechsales.com; **Thorson West** in northern California and northern Nevada can be contacted at (408) 294-9005 or e-mail: chuck.salsberry @thorsonwest.com; **EM Electronics Corp.** in Taiwan can be contacted at 886-3-318 2878 or visit: www.emec.com.tw and **MRC Tech Co. Ltd.** in South Korea can be contacted at 82-2-417-1750 or visit: www.mrctech.co.kr.

■ **Microsorb Technologies Inc.** announced the appointment of **Midwin & Olifson Inc.** as the company's exclusive sales representative in southern California. Midwin & Olifson will represent and support Microsorb's full line of microwave RF absorbers and dielectric materials to commercial and defense customers. Midwin & Olifson can be reached at 2001 S. Barrington Avenue, Suite 120, Los Angeles, CA 90025-5337 (310) 478-4345, e-mail: reps@mo-rep.com or visit www.mo-rep.com. In related news, Microsorb announced the appointment of **JLF Engineering Inc.** as the company's exclusive sales representative in New England. JLF Engineering will represent and support Microsorb's full line of microwave RF absorbers and dielectric materials to commercial and defense customers. JLF Engineering Inc. can be reached at 66 Bacon Hill Road, Spencer, MA 01562 (508) 769-5035 or e-mail: jlfengineering@charter.net.

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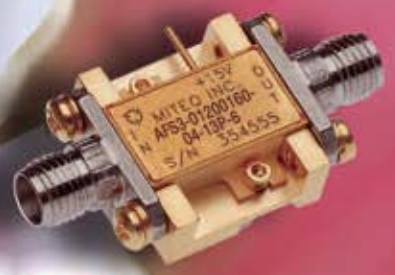

AMPLIFIERS

Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
TEMPERATURE COMPENSATED AMPLIFIERS								
AFS3-01000200-15-TC-6	1–2	36–40	1.00	1.5	2.0:1	2.0:1	+5	125
AFS2-02000400-15-TC-6	2–4	22–26	1.00	1.5	2.0:1	2.0:1	+5	125
AFS3-02000400-15-TC-6	2–4	26–30	1.00	1.5	2.0:1	2.0:1	+5	125
AFS2-04000800-15-TC-2	4–8	17–22	1.00	1.5	2.0:1	2.0:1	+5	100
AFS3-04000800-12-TC-4	4–8	25–30	1.00	1.2	2.0:1	2.0:1	+8	100
AFS2-02000800-30-TC-2	2–8	14–19	1.50	3.0	2.0:1	2.0:1	+5	100
AFS3-02000800-30-TC-4	2–8	22–27	1.50	3.0	2.0:1	2.2:1	+8	150
AFS2-08001200-30-TC-2	8–12	12–16	1.00	3.0	2.0:1	2.0:1	+5	100
AFS3-08001200-22-TC-4	8–12	24–28	1.00	2.2	2.0:1	2.0:1	+8	100
AFS4-12001800-30-TC-6	12–18	22–26	1.00	3.0	2.0:1	2.0:1	+8	150
AFS4-06001800-35-TC-6	6–18	22–26	1.00	3.5	2.0:1	2.0:1	+8	150
AFS6-06001800-35-TC-6	6–18	30–34	1.00	3.5	2.0:1	2.0:1	+8	200
AFS4-02001800-45-TC-6	2–18	18–24	1.50	4.5	2.2:1	2.2:1	+8	120

Note: All specifications guaranteed -54 to +85°C.
Many other frequencies, noise figures and gain windows are available.

Model Number	Frequency Range (GHz)	Gain (Min./Max.) (dB)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
HIGHER POWER AMPLIFIERS								
AFS3-00050100-15-27P-6	0.05–1	36	1.50	1.5*	2.0:1	2.5:1	+27	300
AFS3-00100100-15-27P-6	0.1–1	33	2.00	1.5	2.0:1	2.5:1	+27	300
AFS3-00100200-20-27P-6	0.1–2	34	1.50	2.0	2.0:1	2.0:1	+27**	300
AFS3-00100300-20-23P-6	0.1–3	28	1.50	2.0	2.0:1	2.0:1	+23	275
AFS3-00100400-25-20P-4	0.1–4	24	1.50	2.5	2.0:1	2.0:1	+20	250
AFS4-00100600-24-20P-4	0.1–6	30	1.50	2.4	2.0:1	2.0:1	+20	300
AFS4-00100800-26-20P-4	0.1–8	30	1.50	2.6	2.0:1	2.0:1	+20	300
AFS4-00101200-35-20P-4	0.1–12	27	2.00	3.5	2.0:1	2.0:1	+20	300
AFS4-00501800-40-20P-6	0.5–18***	25	2.75	4.0	2.5:1	2.2:1	+20	350
AFS3-01000200-18-27P-6	1–2	32	1.50	1.8	2.0:1	2.0:1	+27	350
AFS4-02000400-20-25P-6	2–4	36	1.50	2.0	2.0:1	2.0:1	+25	275

* Noise figure degrades below 100 MHz. Please consult MITEQ for details.
** P1 dB spec below 0.2 GHz : +25 dBm.
*** Usable to 0.1 GHz.

Note: Noise figure increases below 500 MHz in bands wider than .1-10 GHz.

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www.miteq.com

Model Number	Frequency Range (GHz)	Gain (Min.) (dB)	Gain Flatness (±dB)	Noise Figure (dB, Max.)	VSWR Input (Max.)	VSWR Output (Max.)	Output Power @ 1 dB Comp. (dBm, Min.)	Nom. DC Power (+15 V, mA)
MODERATE BAND AMPLIFIERS								
AFS2-00700080-06-10P-6	0.7–0.8	28	0.50	0.60	1.5:1	1.5:1	+10	90
AFS2-00800100-05-10P-6	0.8–1	30	0.50	0.50	1.5:1	1.5:1	+10	90
AFS3-01200160-05-13P-6	1.2–1.6	40	0.50	0.50	1.5:1	1.5:1	+13	150
AFS3-01400170-06-13P-6	1.4–1.7	40	0.50	0.60	1.5:1	1.5:1	+13	150
AFS3-01500180-06-13P-6	1.5–1.8	40	0.50	0.60	1.5:1	1.5:1	+13	150
AFS3-01500250-06-13P-6	1.5–2.5	38	1.00	0.60	1.8:1	1.8:1	+13	150
AFS3-01700190-06-13P-6	1.7–1.9	38	0.50	0.60	1.5:1	1.5:1	+13	150
AFS3-01800220-06-13P-6	1.8–2.2	38	0.50	0.60	1.5:1	1.5:1	+13	150
AFS3-02200230-06-13P-4	2.2–2.3	38	0.50	0.60	1.5:1	1.5:1	+13	150
AFS3-02300270-06-13P-6	2.3–2.7	36	0.50	0.60	1.5:1	1.5:1	+13	150
AFS3-02700290-06-13P-6	2.7–2.9	32	0.50	0.60	1.5:1	1.5:1	+13	150
AFS3-02900310-06-13P-6	2.9–3.1	32	0.50	0.60	1.5:1	1.5:1	+13	150
AFS3-03100350-06-10P-4	3.1–3.5	29	0.50	0.60	1.5:1	1.5:1	+10	150
AFS4-03400420-10-13P-6	3.4–4.2	40	0.50	1.00	1.5:1	1.5:1	+13	200
AFS3-04400510-07-S-4	4.4–5.1	30	0.50	0.70	1.5:1	1.5:1	+10	100
AFS3-04500480-07-S-4	4.5–4.8	30	0.50	0.70	1.5:1	1.5:1	+10	100
AFS3-05200600-07-10P-4	5.2–6	30	0.50	0.70	1.5:1	1.5:1	+10	100
AFS3-05400590-07-S-4	5.4–5.9	30	0.50	0.70	1.5:1	1.5:1	+10	100
AFS3-05800670-07-S-4	5.8–6.7	30	0.50	0.70	1.5:1	1.5:1	+10	100
AFS3-07250775-06-10P-4	7.25–7.75	30	0.50	0.60	1.5:1	1.5:1	+10	100
AFS3-07900840-07-S-4	7.9–8.4	30	0.50	0.70	1.5:1	1.5:1	+10	100
AFS4-08500960-08-S-4	8.5–9.6	32	0.75	0.80	1.5:1	1.5:1	+10	125
AFS3-09001100-09-S-4	9–11	26	0.50	0.90	1.5:1	1.5:1	+10	100
AFS4-09001100-09-S-4	9–11	32	0.75	0.90	1.5:1	1.5:1	+10	125
AFS4-10951175-09-S-4	10.95–11.75	32	0.75	0.90	1.5:1	1.5:1	+10	125
AFS4-11701220-09-5P-4	11.7–12.2	32	0.75	0.90	1.5:1	1.5:1	+10	125
AFS2-12201280-14-5P-2	12.2–12.8	14	0.75	1.40	1.4:1	1.5:1	+5	80
AFS4-12201280-13-12P-4	12.2–12.8	25	1.50	1.30	2.0:1	2.0:1	+12	200
AFS4-12701330-15-10P-4	12.7–13.3	30	0.75	1.50	1.5:1	1.5:1	+10	175
AFS4-13201400-16-10P-4	13.2–14	30	0.75	1.60	1.5:1	1.5:1	+10	175
AFS4-14001450-15-10P-4	14–14.5	30	0.75	1.50	1.5:1	1.5:1	+10	175
AFS4-20202120-25-8P-4	20.2–21.2	24	1.00	2.50	1.5:1	1.5:1	+8	175
AFS4-21202400-28-10P-4	21.2–24	23	1.00	2.80	2.0:1	2.0:1	+10	100
OCTAVE BAND AMPLIFIERS								
AFS3-00120025-09-10P-4	0.12–.25	38	0.50	0.9	2.0:1	2.0:1	+10	125
AFS3-00250050-08-10P-4	0.25–0.5	38	0.50	0.8	2.0:1	2.0:1	+10	125
AFS3-00500100-06-10P-6	0.5–1	38	0.75	0.6	2.0:1	1.5:1	+10	150
AFS3-01000200-05-10P-6	1–2	38	1.00	0.5	2.0:1	2.0:1	+10	150
AFS3-01200240-06-10P-6	1.2–2.4	34	1.00	0.6	2.0:1	2.0:1	+10	150
AFS3-02000400-06-10P-4	2–4	32	1.00	0.6	2.0:1	2.0:1	+10	125
AFS3-02600520-10-10P-4	2.6–5.2	28	1.00	1.0	2.0:1	2.0:1	+10	125
AFS3-04000800-07-10P-4	4–8	28	1.00	0.7	2.0:1	2.0:1	+10	125
AFS3-08001200-09-10P-4	8–12	26	1.00	0.9	2.0:1	2.0:1	+10	125
AFS3-08001600-15-8P-4	8–16	28	1.00	1.5	2.0:1	2.0:1	+8	100
AFS4-12001800-18-10P-4	12–18	28	1.50	1.8	2.0:1	2.0:1	+10	125
AFS4-12002400-30-10P-4	12–24	24	2.00	3.0	2.0:1	2.0:1	+10	85
AFS3-18002650-30-8P-4	18–26.5	18	1.75	3.0	2.2:1	2.2:1	+8	125
MULTIOCTAVE BAND AMPLIFIERS								
AFS3-00300140-09-10P-4	0.3–1.4	38	1.00	0.9	2.0:1	2.0:1	+10	125
AFS2-00400350-12-10P-4	0.4–3.5	22	1.50	1.2	2.0:1	2.0:1	+10	80
AFS3-00500200-08-15P-4	0.5–2	38	1.00	0.8	2.0:1	2.0:1	+15	125
AFS3-01000400-10-10P-4	1–4	30	1.50	1.0	2.0:1	2.0:1	+10	125
AFS3-02000800-09-10P-4	2–8	26	1.00	1.0	2.0:1	2.0:1	+10	125
AFS4-02001800-23-10P-4	2–18	25	2.00	2.3	2.0:1	2.0:1	+10	175
AFS4-06001800-22-10P-4	6–18	25	2.00	2.2	2.0:1	2.0:1	+10	125
AFS4-08001800-22-10P-4	8–18	28	2.00	2.2	2.0:1	2.0:1	+10	125
ULTRA WIDEBAND AMPLIFIERS								
AFS3-00100100-09-10P-4	0.1–1	38	1.00	0.9	2.0:1	2.0:1	+10	125
AFS3-00100200-10-15P-4	0.1–2	38	1.00	1.0	2.0:1	2.0:1	+15	150
AFS1-00040200-12-10P-4	0.04–2	15	1.50	1.2	2.0:1	2.0:1	+10	50
AFS3-00100300-12-10P-4	0.1–3	32	1.00	1.2	2.0:1	2.0:1	+10	125
AFS3-00100400-13-10P-4	0.1–4	28	1.00	1.3	2.0:1	2.0:1	+10	125
AFS3-00100600-13-10P-4	0.1–6	28	1.25	1.3	2.0:1	2.0:1	+10	125
AFS3-00100800-14-10P-4	0.1–8	28	1.50	1.4	2.0:1	2.0:1	+10	125
AFS4-00101200-22-10P-4	0.1–12	30	1.50	2.2	2.0:1	2.0:1	+10	150
AFS4-00101400-23-10P-4	0.1–14	24	2.00	2.3	2.5:1	2.5:1	+10	200
AFS4-00101800-25-S-4	0.1–18	25	2.00	2.5	2.5:1	2.5:1	+10	175
AFS4-00102000-30-10P-4	0.1–20	20	2.50	3.0	2.5:1	2.5:1	+10	125
AFS4-00102650-42-8P-4	0.1–26.5	22	2.50	4.2	2.5:1	2.5:1	+8	135

Note: Noise figure increases below 500 MHz in bands greater than 0.1-10 GHz.

LOW COST SIGNAL SOURCES FOR MULTI-BAND, MULTI-MODE WIRELESS COMMUNICATION SYSTEMS

This article focuses on providing a cost-effective solution for multi-band, multi-mode wireless systems in which oscillators simultaneously satisfy the oscillation conditions of two or more signals, thereby obviating the need for several signal sources required for each phone. In multi-band, multi-mode radio architectures, a number of local oscillator (LO) frequencies are required in order to process the information in various frequency bands. It is known that local oscillators exhibit trade-offs between power consumption and phase noise performance. Since oscillators consume a substantial part of the chip area and battery power, this article describes the design approach of a reconfigurable concurrent oscillator (RCO) that simultaneously generates a dual frequency band, with the user having an option of choosing a distinct multiple frequency or a combination of them, which eliminates the need for lossy switches to switch the frequency band, thereby improving the system throughput.

One of the critical building blocks in a multi-mode transceiver system is a multi-band VCO that is required for both up and down conversion. Mobile phones and radios, operating in several modes, are typically switching between receiving and transmitting frequencies, and therefore require low phase noise signal sources (oscillators/VCOs) in each of the respective switched bands. It is known that the oscillators exhibit trade-offs between power consumption and phase noise. To reduce the phase noise, power consumption and real estate area are increased. To miniaturize the system and reduce the power consumption, multi-band, multi-mode system designers are forced to explore a frequency plan that employs one or more oscillators, phase-locked loop (PLL) frequency dividers, buffer amplifiers, filters, switching architectures and multipliers.

The miniaturization and the merging of multi-band systems impose stringent requirements on size, power, performance and configurability of the fully integrated transceiver systems. The technology of the wireless devices also must allow for a smooth migration to future generations of communication standards with higher data rates. Hence, the compact and power-efficient implementation of such multi-standard terminals calls for the need of an intelligent RF front-end that can achieve maximum hardware sharing for various standards. Such a compact RF

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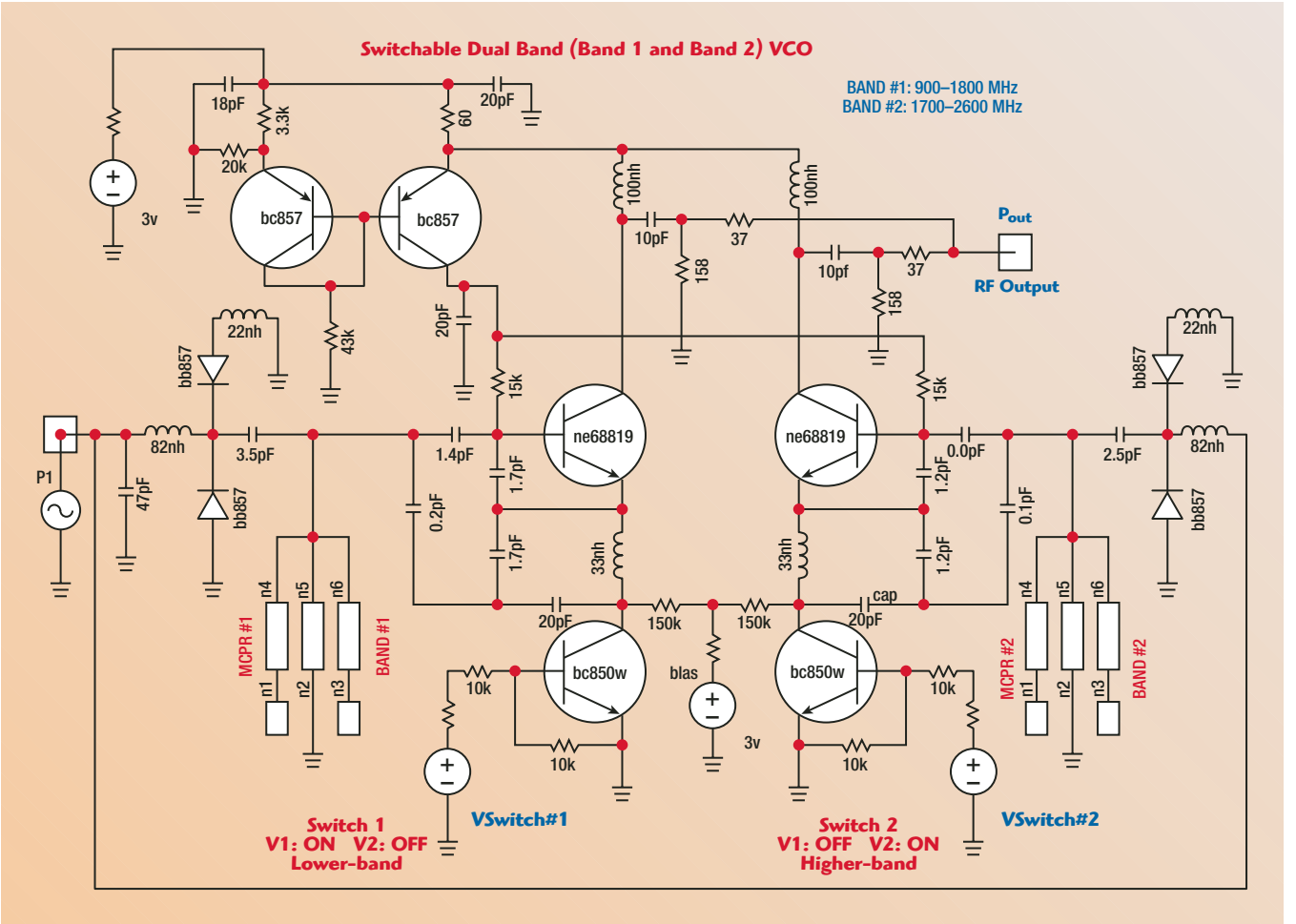
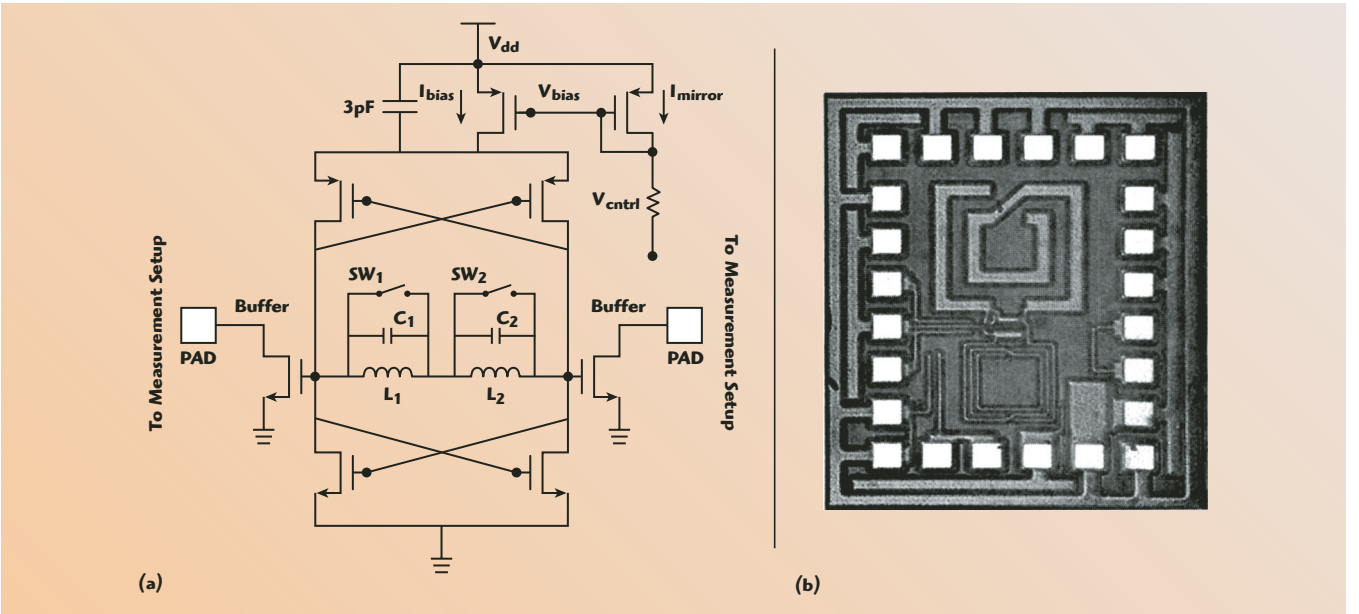


▲ *Fig. 1 Typical schematic of a dual-band switched oscillator.*



▲ *Fig. 2 A dual-mode oscillator's (a) schematic and (b) chip photograph.*

front-end would require reconfigurable multi-band VCO blocks rather than frequency multiplier or divider or switched resonator architectures.

Various techniques, such as switching between VCOs for separate bands, using inter-modal multiple frequencies and switched resonators for band selection have been proposed.[1–25] However, these methods result in circuits of large size, which are current-hungry, narrowband and

with poor phase noise performance. ***Figure 1*** shows the typical schematic of a dual-band (Band 1: 900 to 1800 MHz; Band 2: 1700 to 2600 MHz) switched voltage-controlled oscillator, where the oscillators are alternatively switched with switches 1 and 2 to generate Bands 1 and 2.

Switched resonators (inductors or capacitor banks) suffer from the resistive and capacitive parasitics associated with the switches. A recent paper[2] shows a novel method of mode switching (see ***Figure 2***) in which both switches SW1 and SW2 are open when any of the desired oscillation modes (mode 1: f_1 = 2.398 GHz or mode 2: f_2 = 4.733 GHz) are established. This oscillator uses a cross-coupled CMOS device with L1 = 2.34 nH, L_2 = 0.86 nH, C_1 = 1.6 pF and C_2 = 0.96 pF. ***Figure 3*** demonstrates the concept of mode switching, assuming that both switches SW1 and SW2 are normally open and the circuit is oscillating at f_1. In order to change the oscillation frequency to f_2, SW1 is closed for only a short duration, thereby reducing the region of attraction for f_1 and increasing it for f_2, causing decay of the oscillations at f_1 and growth of the oscillations at f_2. Once the oscillations at f_2 are stabilized, SW1 can be opened again. The system keeps oscillating at f_2 thereafter, since it is one of its steady-state stable modes of oscillation. As shown, SW1 is closed at t_0 for 4 ns, enough for the oscillation at f_2 to stabilize. In order to switch from f_2 to f_1, SW2 is closed for a small duration. It is understood that when the desired oscillation mode (mode 1 or mode 2) is established, both switches are open. Therefore, the loss and nonlinearity of the switches do not degrade the steady-state and phase noise performance of the oscillator. This is fundamentally different from the traditional band-select oscillators, where the dual-band resonances are obtained by alternatively switching oscillators or switching inductors/capacitors (see ***Figure 4***).[10,20] The main drawback of such architecture is that the band-selecting switch is placed in the signal path and thus deteriorates the performance of the oscillator because of its loss and nonlinearity. In the case of the switched mode oscillator, the switching mechanism is limited to a short duration (between the stable modes of oscillations), just to get the desired band, as opposed to switching between two capacitors or inductors. However, the present solutions to the

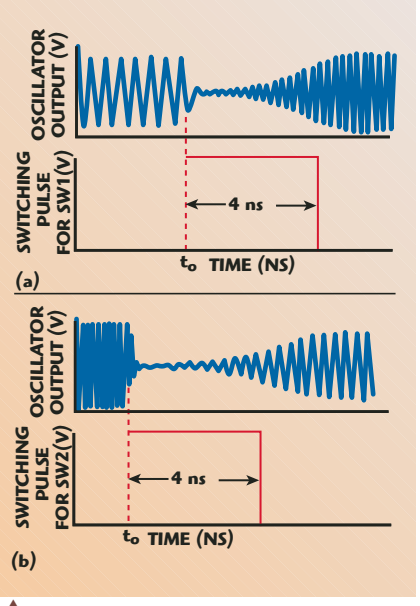


Fig. 3 A dual-mode oscillator's mode 1 and mode 2 outputs.

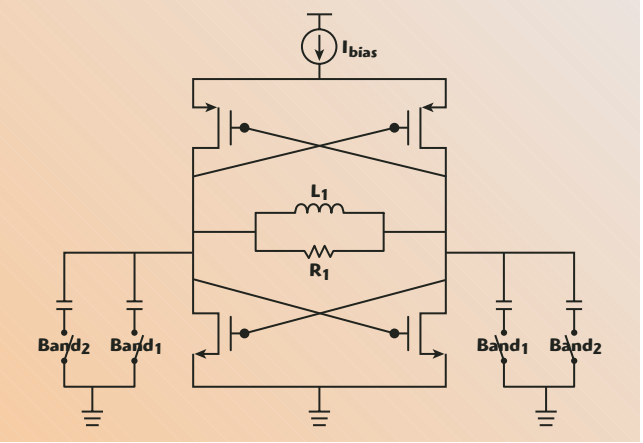
dual-band systems are not concurrent in a real sense, because the oscillators are alternatively switched between different resonators for generating the required different frequencies and the design technique does not allow the signals to be generated at the same time. Therefore, they suffer from power consumption, larger area and design cycle time.

In this work, a novel technique is proposed, based on a dynamically controlled multi-mode oscillation technique using asymmetrical planar-coupled resonator networks to extend the tuning range of the oscillators.[17,24] The proposed topology discussed in this article uses a new class of oscillator that generates multiple synchronous frequencies by using higher order (> 2), multi-coupled planar resonators (MCPR), which offers concurrent solutions by synchronously generating multiple frequencies for different bands without using a multiplier or switching resonators/oscillators network, therefore resulting in a reduction in power consumption, area and design cycle time.[23–25]

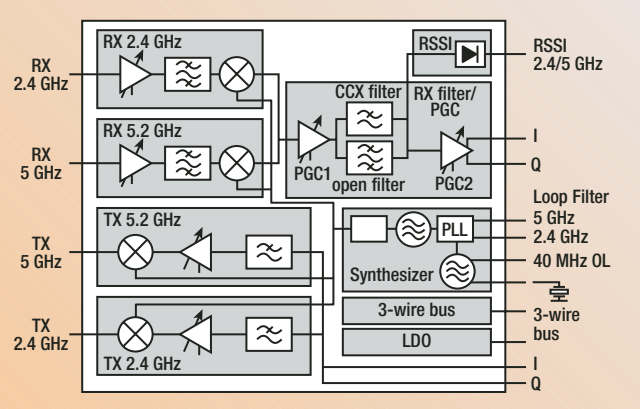
THEORY

The next generation of wireless communication systems is supposed to be frequency agile and must be able to seamlessly span multiple frequency bands dynamically to cover different global standards. Rapid evolution in the field of wireless communication and the convergence of multiple communication protocols has led to the integration of multiple complex functionalities in wireless portable devices. Convergence of various standards, such as WLAN, into a motherboard of a computer or into a cell phone (3G and 4G) has led to added functionality in each system. The most commonly used frequency bands are the 2.4 to 2.5 GHz ISM band and several frequency bands from 5.15 and 5.85 GHz, with several communication standards defined in the IEEE 802.11 standards. In order to give the user more freedom, phones that are able to cover more than one of these bands require reconfigurable concurrent signal sources for multi-band, multi-mode wireless communication systems. ***Figure 5*** shows the typical schematic block diagram of a dual-band (2.4/5.0 GHz) transceiver system, where a single signal source (oscillator) with two or more frequency bands is the first step towards a fully integrated multi-band design.[1] ***Figure 6*** illustrates the divider and the switching-based architecture of the frequency plan for a 2.4/5.0 GHz WLAN transceiver system.[8] As shown, the approach uses a single VCO at 8 GHz with a divider 1 (+ by 2) in a frequency synthesizer to generate a 4 GHz signal, which is followed by a divider 2 (+by 4). The output of divider 1 (4 GHz) and divider 2 (1 GHz) signals are mixed in a QUAD SSB mixer to generate the 5 GHz signal, which is further divided to obtain the required 2.4 GHz signal. The implementation utilizes multiple buffers, filters and divider networks.

Frequency multipliers can be an alternate option, but they are seldom used for the final stage of frequency conversion because of the difficulty in obtaining differential outputs at



▲ *Fig. 4 Typical switched-resonator oscillator.*

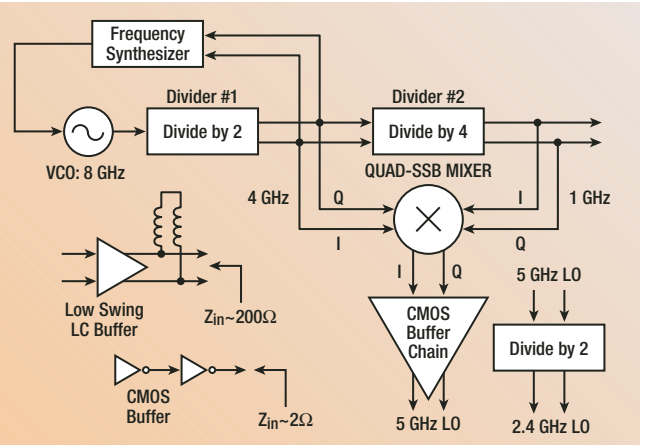


▲ *Fig. 5 Block diagram of a dual-band transceiver.*

higher frequencies, which are required by quadrature converters.[9,10] The basic principle of a multi-mode radio is to process two or more signals of differing frequencies at the same time, but using only one processing Tx-Rx chain.[6,7] The nth-order ($n > 2$) MCPR-based, multi-mode RCO demonstrated in this work can satisfy the present demand for low cost, dual-band, low noise, power efficient, wide tuning range and compact size, and is easily amenable for integration in chip form.

SINGLE FREQUENCY TUNABLE WIDEBAND OSCILLATOR

Typical single frequency tunable oscillators use a grounded base or grounded emitter circuit for generating a negative resistance at one port, which is usually terminated with a parallel or series LC-resonant tuned circuit. For wideband tunability, the required negative resistance over the band is generated by the feedback base-inductance (in the grounded base topology), but the polarity of the reactance may change over the frequency band and can lead to the disappearance of the negative resistance as the operating frequency exceeds its self-resonance frequency (SRF). There are two primary constraints, which limit the oscillator circuit topologies: the first is the transistor and its package; the second is the large capacitance change required to tune the oscillator over an octave band. The common emitter (CE) and common base (CB) are the common topology for a wideband VCO's design. ***Figure 7*** shows the CE topology, which uses a capacitive feedback network with C_1 and C_2 to create the negative resistance looking into the base of the transistor.[3] ***Figure 8*** shows the common base (CB) topology, which uses an inductor L_b in the base of the transistor to gener-



▲ *Fig. 6 Frequency plan for a 2.4/5 GHz WLAN transceiver.*

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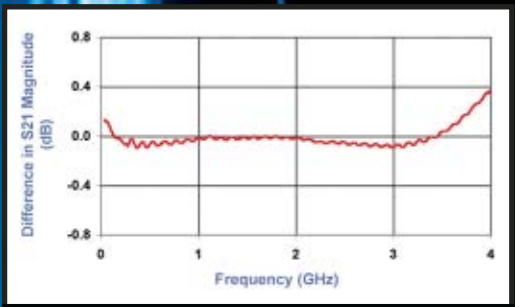

Fig. 1 MODEL 5310 AMPLITUDE BALANCE

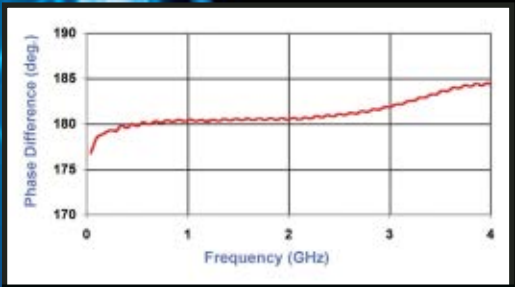

Fig. 2 MODEL 5310 PHASE BALANCE

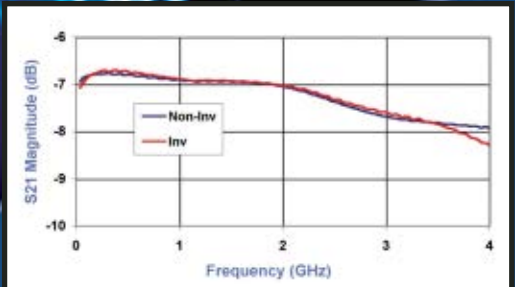

Fig. 3 MODEL 5310 INSERTION LOSS

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Phase Match ± 0.5 degrees

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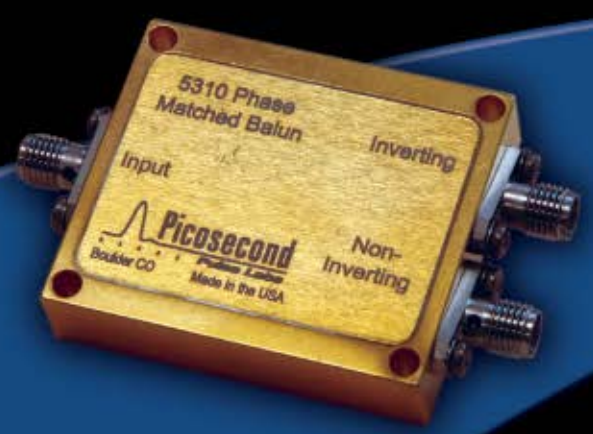

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ate the negative resistance $R_n(t)$ looking into the emitter of the transistor.[4,17] As shown in the CE topology, small values of the feedback capacitances C_1 and C_2 generate a large negative resistance and allows for a wide tuning range at the cost of heavily loading of the resonator and wide conduction angle, hence poor phase noise performance. For optimum phase noise performance, the active device is driven at a large-signal drive level that corresponds to a narrow conduction angle, and this restricts the lower limit of the feedback capacitors.

The drive level is directly proportional to the feedback capacitor C_2[3]; therefore, this topology is best suited for narrow tuning range (10 to 30 percent) VCOs because large values of feedback capacitors C_1 and C_2 will raise the loaded Q of the resonator at the expense of lesser tuning ranges and lower negative resistance. The effective loading of the resonator for the common base (CB) oscillator configuration is due to the series combination of the load resistance and the transconductance of the transistor (the influences of g_{ce}, g_{be} and C_{be} are neglected for simplification). In this case, the loaded Q of the resonator is unaffected by the negative resistance generated by the feedback inductance L_b of the three-terminal device (bipolar/FET) and this configuration is therefore best suited for a wideband (octave-band) VCO application. ***Figures 9*** and ***10*** show the general series feedback topology, and small-signal equivalent circuit for the purpose of the resonance frequency and noise analyses. The steady-state oscillation condition for series feedback CB configuration is given by

$$Z_{osc}\left(I_{L,\omega}\right)+Z_L\left(\omega\right)=0 \qquad (1)$$

$$Z_{osc}\left(I_L,\omega\right)= R_{osc}\left(I_L,\omega\right)+jX_{osc}\left(I_L,\omega\right) \qquad (2)$$

where

$R_{osc}(I_L,\omega)$ = negative resistance components generated by the three-terminal active device (bipolar)
I_L = load current amplitude
ω = resonance frequency
Z_{osc} = current and frequency dependent output impedance
Z_L = only function of frequency

From Equations 1 and 2

$$Z_L\left(\omega\right)=R_L\left(\omega\right)+jX_L\left(\omega\right) \qquad (3)$$

$$Z_{osc}=\left[Z_{22}+Z_2\right] - \frac{\left[Z_{12}+Z_2\right]\left[Z_{21}+Z_2\right]}{\left[Z_{11}+Z_1+Z_2\right]} \qquad (4)$$

where Z_{11}, Z_{12}, Z_{21}, Z_{22} are the [Z] parameters of the transistor. From Equation 4, Z_{osc}, R_{osc}, X_{osc} and R_n can be given by

$$Z_{osc}= \frac{g_m\left(t\right)}{\omega^2 C_{ce}\left[C_{b'e}+C_2-L_1C_2C_{be}\omega^2\right]} -j\left[\left(\frac{C_{ce}+C_2}{\omega C_{ce}C_2}\right) -\left(\frac{1}{\omega\left(\frac{C_2^2}{C_{b'e}}\right)+\omega C_2-L_1C_2^2\omega^3}\right)\right] \qquad (5)$$

$$Z_{osc}=\left[R_{osc}+jX_{osc}\right]\Rightarrow R_{osc}=R_n= -\left[\frac{g_m\left(t\right)}{\omega^2 C_{ce}\left[C_{b'e}+C_2-L_1C_2C_{b'e}\omega^2\right]}\right] \qquad (6)$$

$$X_{osc}=-\left[\left(\frac{C_{ce}+C_2}{\omega C_{ce}C_2}\right) -\left(\frac{1}{\omega\left(\frac{C_2^2}{C_{b'e}}\right)+\omega C_2-L_1C_2^2\omega^3}\right)\right] \qquad (7)$$

$$g_m\left(t\right)=\sum_{n=-\infty}^{n=\infty} g_m^{(n)}\exp(jn\omega t); \quad \text{(n is number of the harmonics)} \qquad (8)$$

where

R_n = negative resistance of the series feedback oscillator
$g_m(t)$ = large-signal transconductance

The total noise voltage power within a 1 Hz bandwidth is[3]

$$\left|\overline{e_N^2(f)}\right|_{\omega=\omega_0} = \overline{e_R^2(f)} + \overline{e_{NR}^2(f)} \quad (9)$$

The first term of Equation 9 is related to the thermal noise, due to the loss resistance of the resonator tank, and the second term is related to the shot noise and flicker noise in the transistor.

From Equation 9, the phase noise can be described by[3]

$$\mathcal{L}(\omega) = \left[4kTR + \frac{\left|g_m^2(t)\right|\left[4ql_c + \frac{K_f I_b^{AF}}{\omega}\right]}{\omega_0^4\beta^2 C_{ce}^2\left(C_2 + C_{b'e} - L_1C_2C_{b'e}\omega_0^2\right)^2 + \left|g_m^2(t)\right|\omega_0^2\left(C_2 + C_{b'e} - L_1C_2C_{b'e}\omega_0^2\right)^2}\right]$$

$$\bullet\left[\frac{\omega_0^2}{4(\omega)^2 V_{cc}^2}\right]\left[\frac{1}{Q_L^2} + \left(1 - \left(\frac{1}{\omega_0^2 L_1}\right)\left(\frac{\left[\left(C_2 + C_{b'e} - L_1C_2C_{b'e}\omega_0^2\right) + C_{ce}\right]}{C_{ce}\left[\left(C_2 + C_{b'e} = L_1C_2C_{b'e}\omega_0^2\right)\right]}\right)\right)^2\right] \quad (10)$$

where

$\mathcal{L}(\omega)$ = ratio of sideband power in a 1 Hz BW
ω = offset frequency from the carrier
ω_0 = resonance frequency
Q_L = loaded Q of the tuned circuit
K_f = flicker noise coefficient
AF = flicker noise exponent
kT = 4.1×10^{-21} at 300K
R = equivalent loss resistance of the resonator circuit
I_c = collector current
I_b = base current
V_{cc} = collector voltage

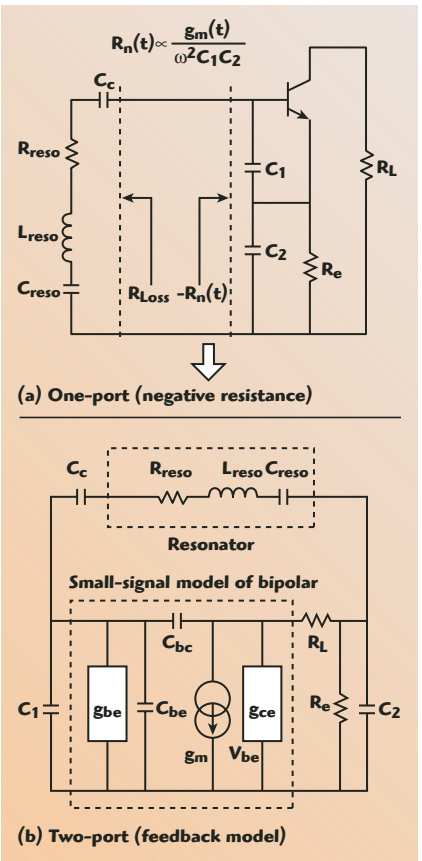
The performance of an oscillator can be evaluated by the figure-of-merit (FOM), and can be described by

$$FOM = \mathcal{L}(\omega) - 20\log\left(\frac{\omega_0}{\omega}\right) + 10\log\left(\frac{P_{DC}}{1mW}\right); \text{dBc / Hz} \quad (11)$$

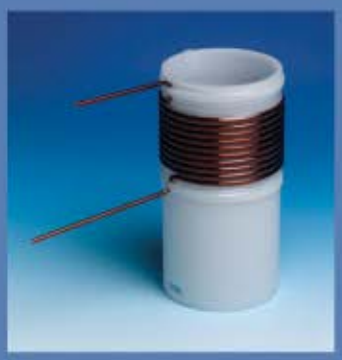
The first and third terms of Equation 11 represent the contributions of phase noise and power consumption (P_{DC}) to FOM, respectively. From Equation 11, the phase noise for a given offset has greater impact on FOM than the power consumption does for a given oscillator frequency f_0 ($\omega_0 = 2\pi f_0$).

MULTI-FREQUENCY (MULTI-BAND AND MULTI-MODE) OSCILLATOR

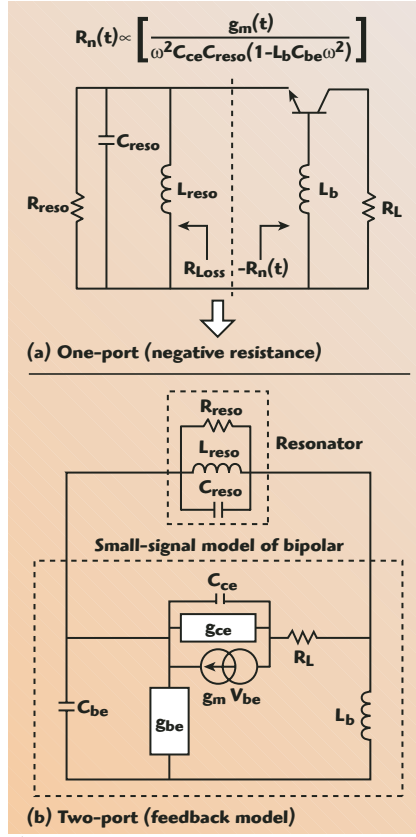
Conventional oscillators are governed by second-order nonlinear differential equations and can only generate periodic waveforms, a single frequency and its harmonics. Oscillators with higher order nonlinear differential equations have multiple modes of oscillations and can generate multiple independent frequencies, individually or simultaneously.[14–16] The paucity of literature on multi-ban, multi-mode oscillators, to-



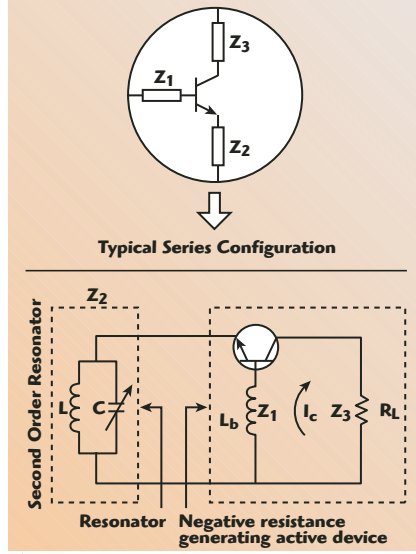
▲ *Fig. 7 One-port (a) and two-port (b) approaches of a CE oscillator.*



gether with a lack of experimental verification of the underlying theories towards achieving the desired mode of oscillations in a controllable way, has been a strong motivator for research work. The phase noise of higher order mode oscillators has not been investigated previously either.[2] A single frequency tunable wideband oscillator utilizes a varactor-tuned, second-order resonator network (parallel LC or series LC network) to generate the desired frequency signal. The impedance response of the parallel LC and series LC resonator networks exhibit an anti-resonance (high parallel resistance: ideally infinite) and resonance (low series resistance: ideally zero resistance), respectively. For simultaneous multi-frequency resonance, the order of the resonator network requires it to be increased, depending upon the number of frequency signals for the respective bands. The main problems in this design are generating simultaneously a negative resistance over the multiple separate distinct bands. ***Figure 11*** shows the typical simplified schematic of a multi-frequency (multi-band and multi-mode) oscillator of nth-order that can be explained with the help of the single band negative



▲ *Fig. 8 One-port (a) and two-port (b) approaches of a CB oscillator.*



▲ *Fig. 9 General topology of the series feedback LC-tuned oscillator.*

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Model	Frequency (GHz)	Gain (dB)	Flatness (dB) max	NF (dB) max	P1dB (dBm) min	VSWR (In/Out)	DC Current @ +12/+15VDC
Broadband Low Noise Amplifiers							
AML016L2802	0.1 – 6.0	28	±1.25	1.3*	+7	2.0:1	190
AML48L3001	4.0 – 8.0	30	±1.0	1.2	+10	1.8:1	150
AML412L3002	4.0 – 12.0	30	±1.5	1.5	+10	1.8:1	150
AML218L0901	2.0 – 18.0	9	±1.0	2.2	+5	2.5:1	60
AML0518L1601-LN	0.5 – 18.0	16	±1.0	2.7	+8	2.2:1	100
AML0126L2202	0.1 – 26.5	22	±2.25	3.5*	+8	2.2:1	170
AML1226L3301	12.0 – 26.5	33	±2.0	2.8	+8	2.5:1	200
Broadband Medium Power Amplifiers							
AML0016P2001	0.01 – 6.0	21	±1.25	3.2*	+23*	2.0:1	480
AML26P3001-2W	2.0 – 6.0	28	±2.5	6	+33	1.8:1	1500
AML28P3002-2W	2.0 – 8.0	30	±2.0	5.5	+33	2.0:1	2000
AML218P3203	2.0 – 18.0	32	±2.5	4	+25	2.0:1	450
AML618P3502-2W	6.0 – 18.0	35	±2.5	4	+33	2.0:1	1850
Narrow Band Low Noise Amplifiers							
AML23L2801	2.8 – 3.1	28	±0.75	0.7	+10	1.8:1	150
AML1414L2401	14.0 – 14.5	24	±0.75	1.5	+10	1.5:1	130
AML1718L2401	17.0 – 18.0	24	±0.75	1.6	+10	1.8:1	150

Low Phase Noise Amplifiers — Phase noise (dBc/Hz) at offset

Part Number	Frequency (GHz)	Gain (dB)	Output Power (dBm)	100Hz	1KHz	10KHz	100KHz
AML811PN0908	8.5 – 11.0	9	17	-154	-159	-167	-170
AML811PN1808	8.5 – 11.0	18	18	-152.5	-157.5	-165.5	-168
AML811PN1508	8.5 – 11.0	15	28	-145.5	-153.5	-158.5	-164.5
AML26PN0904	2.0 – 6.0	9	20	-150	-165	-165	-178
AML26PN1201	2.0 – 6.0	11	15	-155	-160	-160	-175

High Dynamic Range Amplifiers

Part Number	Frequency (MHz)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	DC
AR01003251X	2 – 32	21	32	52	+28V @ 470mA
AFL30040125	50 – 500	23	28	53	+28V @ 700mA
BP60070024X	20 – 2000	32	30	43	+15V @ 1100mA

*Above 500MHz.

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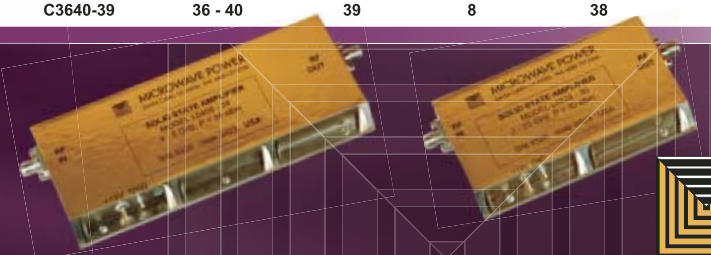
L0104-43	1 - 4	42.5	17.8	41.5	45	14
L0204-44	2 - 4	44	25	42.5	45	14
L0206-40	2 - 6	40	10	38.5	40	8.5
L0208-41	2 - 8	41	12	40	40	17
L0218-32	2 - 18	32	1.4	31	35	5
L0408-43	4 - 8	43	20	41.5	45	17
L0618-43	6 - 18	43	20	41.5	45	22
L0812-46	8 - 12	46	40	45	45	28
Millimeter-Wave Power Amplifiers						
L1826-34	18 - 26	34	2.5	33	35	4
L1840-27	18 - 40	27	0.5	26	30	2
L2240-28	22 - 40	28.5	0.7	27	30	3
L2630-39	26 - 30	39	8.0	38	40	15
L2632-37	26 - 32	37	5.0	36	38	10
L2640-31	26 - 40	31	1.2	30	30	5
L3040-33	30 - 40	33	2.0	32	33	9
L3337-36	33 - 37	36	4.0	35	40	12
L3640-36	36 - 40	36	4.0	35	40	10

High-Power Rack Mount Amplifiers

Model	Frequency (GHz)	Psat (dBm)	Psat (W)	P1dB (dBm)	Pac (kW)	Height (in)
C071077-52	7.1 - 7.7	52.5	170	51.5	1.8	10.25
C090105-50	9 - 10.5	50	100	49	1	8.75
C140145-50	14 - 14.5	50.5	110	49.5	2	10.25
C1416-46	14 - 16	46	40	45	0.35	5.25
C1820-43	18 - 20	43	20	41.5	0.25	5.25
C2326-40	23 - 26	40	10	39	0.25	5.25
C2630-45	26 - 30	45	30	44	0.45	5.25
C3236-40	32 - 36	40	10	39	0.25	5.25
C3640-39	36 - 40	39	8	38	0.24	5.25



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resistance approach. From Equations 1 and 2, the steady-state oscillation condition for multi-band (n^{th}-order) can be explained and described by

$$Z_{osc}\left(I_L,\omega_1,\omega_2,\omega_3\ldots\omega_n\right) + Z_L\left(\omega_1,\omega_2,\omega_3\ldots\omega_n\right)=0 \quad (12)$$

$$Z_{osc}=R_{osc}\left(I_L,\omega_1,\omega_2,\omega_3\ldots\omega_n\right) + jX_{osc}\left(I_L,\omega_1,\omega_2,\omega_3\ldots\omega_n\right) \quad (13)$$

where $R_{osc}(I_L, \omega_1, \omega_2, \omega_3\ldots\omega_n)$ is the negative resistance components generated by the three-terminal active device (bipolar), I_L is the load current amplitude, ω_1, ω_2, $\omega_3\ldots\omega_n$ are n distinct resonance frequencies, Z_{osc} is the current and frequency dependent output impedance and Z_L is only the function of frequency.

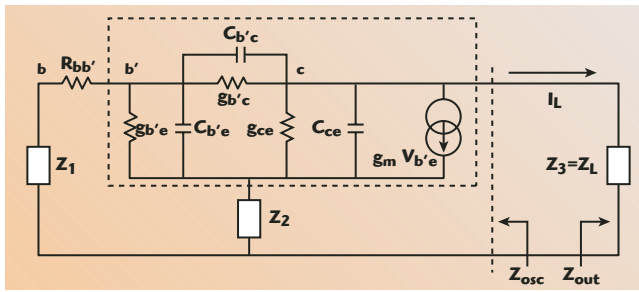


Fig. 10 Small-signal equivalent circuit using a BJT.

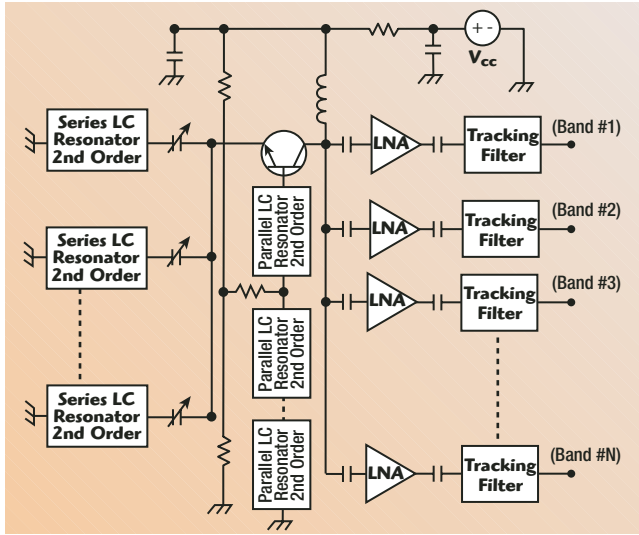


Fig. 11 Multi-band n^{th}-order oscillator (patent pending).

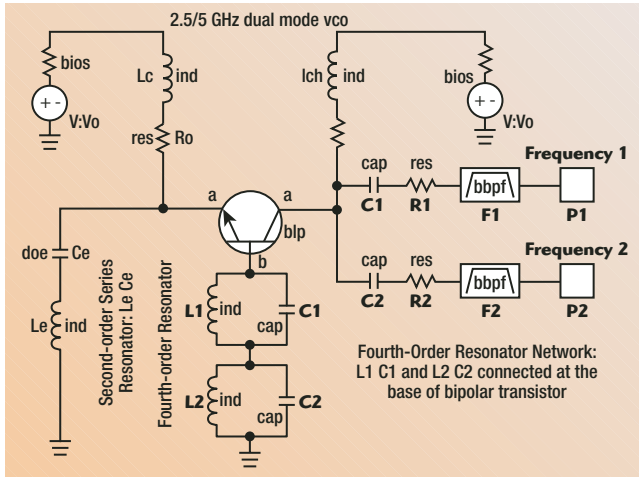
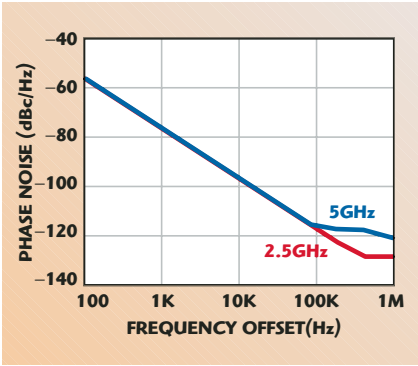


Fig. 12 Typical schematic of a dual-frequency oscillator.

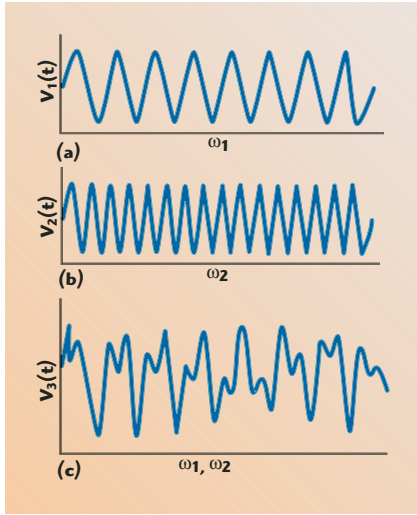
DUAL-BAND, DUAL-MODE OSCILLATOR

The idea of negative resistance in a single band oscillator was extended to a dual-band oscillator by Schaffner,[15,19] where the oscillator has to simultaneously satisfy the resonance conditions for two distinct frequencies f_1 and f_2, respectively. Schaffner[15] investigated mathematically the possibility of simultaneous oscillations at two independent and dependent frequencies based on a nonlinear negative resistance active device connected across a higher order (n = 4) parallel LC resonator network. Schaffner investigated both synchronous (f_2/f_1 = p/q = integer (⇒ rational number) and asynchronous (f_2/f_1 = p/q ≠ integer (irrational number) simultaneous oscillations in oscillators using differential equations. The method is a general method for determining sufficient conditions for the existence and stability of periodic solutions of a class of nonlinear vector differential equations. For transient analysis, the fourth-order system is broken into two second-order systems and the superposi-

tion theorem is applied to obtain the desired solution for dual-mode signal generations at frequencies f_1 and f_2. The independence of the frequencies is related to the irrational ratio of the frequencies ($f_2/f_1 \neq$ integer), whereas a rational ratio between the two frequencies (f_1 and f_2) implies that the signals are dependent on each other through their phase. ***Figure 12*** shows the typical schematic of a dual frequency oscillator that uses a higher order of resonator network (fourth-order instead of second-order, LC resonant circuit, for a single frequency oscillator). From Equations 12 and 13, the oscillator circuit has to satisfy the necessary condition for guaranteed stable oscillations for two frequencies (f_1 and f_2). At a given frequency, the impedance with a negative real part is observed at the emitter terminal by adding an inductor of suitable value at the base terminal. The design philosophy for single frequency oscillation can be extended to apply to dual frequency oscillations. The fundamental criterion is to support simultaneously negative resistance at two distinct frequencies by synthesizing two inductors of different values. For stable oscillations, the resonator network at the base of the transistor terminal should be designed to provide different values of inductance (two degrees of freedom) at the desired center frequencies. Intuitively, a higher inductance value will be needed at f_2 and a relatively lower inductance value is required at f_1 ($f_2 > f_1$). Since a simple parallel LC network is insufficient to provide such a behavior, a fourth-order resonator is synthesized using L_1–C_1 and L_2–C_2. In general, a parallel-connected LC resonator will be inductive before the tank resonance (anti-resonance) and capacitive after the resonant frequency. At a given frequency the effective inductance (L_{eff}) can be determined from a parallel-connected resonator by performing network analysis to calculate the Z_{in} of a resonator. ***Figure 13*** shows the simulated phase noise plot of the dual frequency (2.5/5.0 GHz) oscillator.



▲ *Fig. 13 Simulated phase noise plot of the dual-frequency oscillator.*

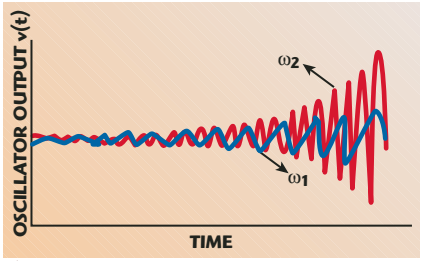


▲ *Fig. 14 Steady-state oscillations at ω_1, (a) and ω_2, (b), and simultaneous oscillations at ω_1 and ω_2 (c).*

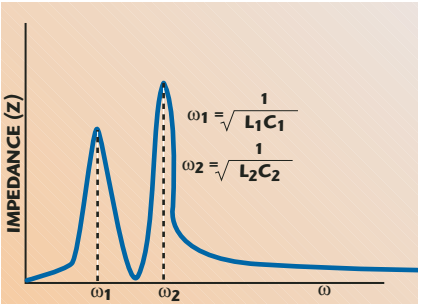
VALIDATION

An oscillator with a high order (> 2) resonator has multiple stable modes of oscillations. By using a proper nonlinear active topology and resonator component values, the higher order oscillator (> 2) can generate more than one resonant frequency. For example, a fourth-order oscillator can generate either of the two distinct frequencies ω_1 or ω_2. ***Figures 14, 15*** and ***16*** show the fourth-order oscillator that can generate either of the two distinct frequencies ω_1 or ω_2 or both ω_1 and ω_2. For validation purposes, the prototype is designed to generate two synchronous bands (fourth-order resonators) by incorporating two second-order parallel resonators in the base of the bipolar transistor.

Figures 17 and ***18*** show the schematic and layout of the reconfigurable dual frequency tunable concurrent oscillator[18,25] that uses a fourth-order resonator network to satisfy the necessary conditions for guaranteed and stable oscillation conditions for two different frequencies (ω_1, ω_2) that can be tuned for two different frequency modes (bands) such as 2.45 to 2.65 GHz and 4.85 to 5.25 GHz. As a result, a simultaneous reduction in power consumption, area and design cycle time can be achieved using a concurrent solution.

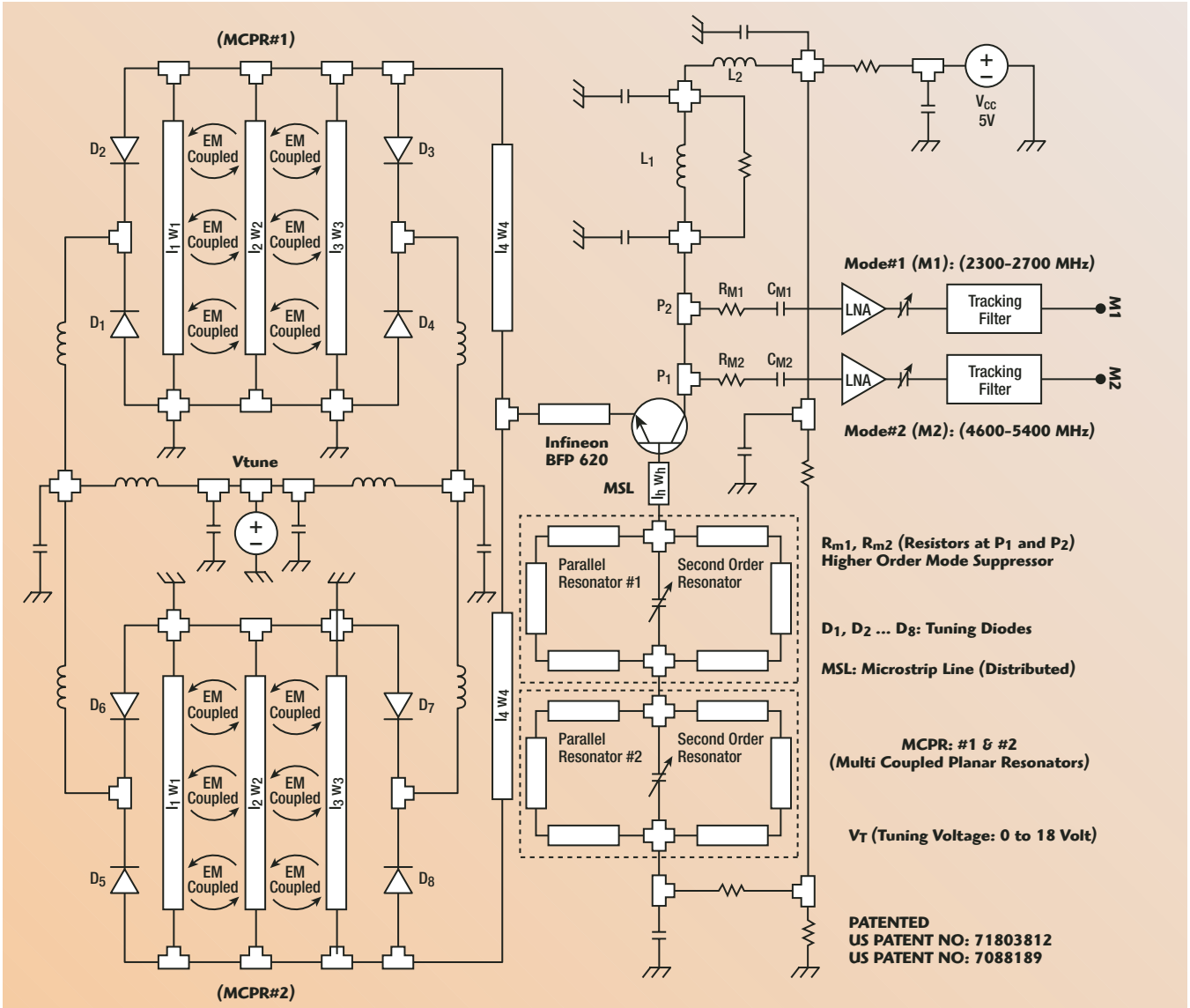


▲ *Fig. 15 Growth of oscillations at ω_1 and ω_2 when the time constant of resonator 1 (τ_1) is greater than the time constant of resonator 2 (τ_2).*



▲ *Fig. 16 Magnitude response of the dual-resonance network.*

The prototype is designed to generate two synchronous bands (fourth-order resonators) by incorporating two second-order parallel resonators in the base of the bipolar transistor. From Equations 12 and 13, the equivalent impedance at the emitter terminal must support a negative real part at two distinct frequencies (ω_1, ω_2). This can be achieved by synthesizing two inductors of different values at the base of the transistor corresponding to (ω_1, ω_2) for simultaneous sustained oscillation conditions. The resonator network at the base of the transistor (Q_1) was designed in a MCPR medium to provide different values of inductance (two degrees of freedom) at the desired center frequencies.[2–7] In general, a parallel LC resonator will be inductive before the tank resonance (anti-resonance)



▲ *Fig. 17 Schematic of a dual-band concurrent oscillator.*

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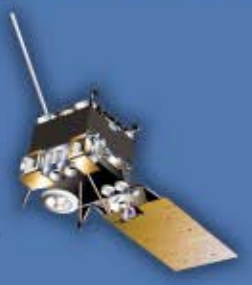

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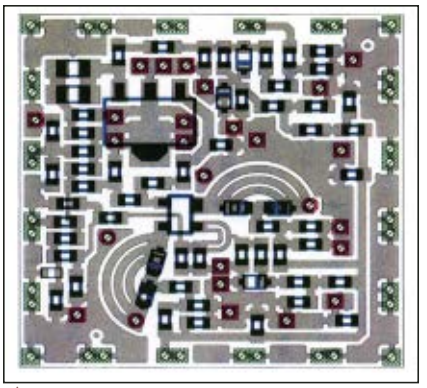
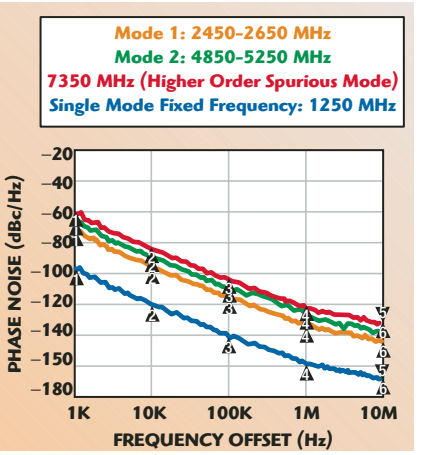
and capacitive after the resonant frequency. At a given frequency the effective inductance can be calculated from a parallel-connected resonator by performing network analysis to calculate the Z_{in} of an equivalent resonator network. Since the active device (Q_1) is sensitive to perturbations at all three nodes (base, emitter and collector) of the BJT, either of them can be tuned to obtain wideband tunability for different bands of oscillations for given values of R_{M1} and R_{M2} at P_1 and P_2. Intuitively, a higher inductance value is needed for Mode 1 (2.45 to 2.65 GHz), and a relatively lower value of inductance is required at Mode 2 (4.85 to 5.25 GHz). For wideband tunability, the effective values of inductance for different modes of oscillation are synthesized by incorporating a tuning capacitor across the resonators network at the base of the transistor Q in such a way that they provide the required negative resistance and reactance (inductive or capacitive) at the emitter terminal of the transistor Q over the required operating bands.[25] ***Figure 19*** shows the measured phase noise plot of the reconfigurable concurrent dual-band oscillators. The measured phase noise performance for Band 1 (2.45 to 2.65 GHz) and Band 2 (4.85 to 5.2 5 GHz) are typically better than –120 dBc/Hz at 1 MHz offset from the respective carrier frequencies. The circuit operates at 5 V, 20 mA and gives a typical output power of 3 dBm over the bands. The phase noise of the fourth-order oscillator, when generating only one of its resonant frequencies, is comparable to the phase noise of a second-order oscillator using the same active topology and resonator quality factor. Furthermore, the fourth-order oscillator has a better phase noise and/or a higher tuning range in VCO implementations, compared to the commonly used switched resonator oscillators.[2] When the system begins to oscillate in dual-mode (Modes 1 and 2), a mode leakage occurs, and therefore how much mode leakage is allowed depends on the spectral selectivity of the succeeding filter and the system requirement.



▲ *Fig. 18 Layout of the dual-band concurrent oscillator (patented).*



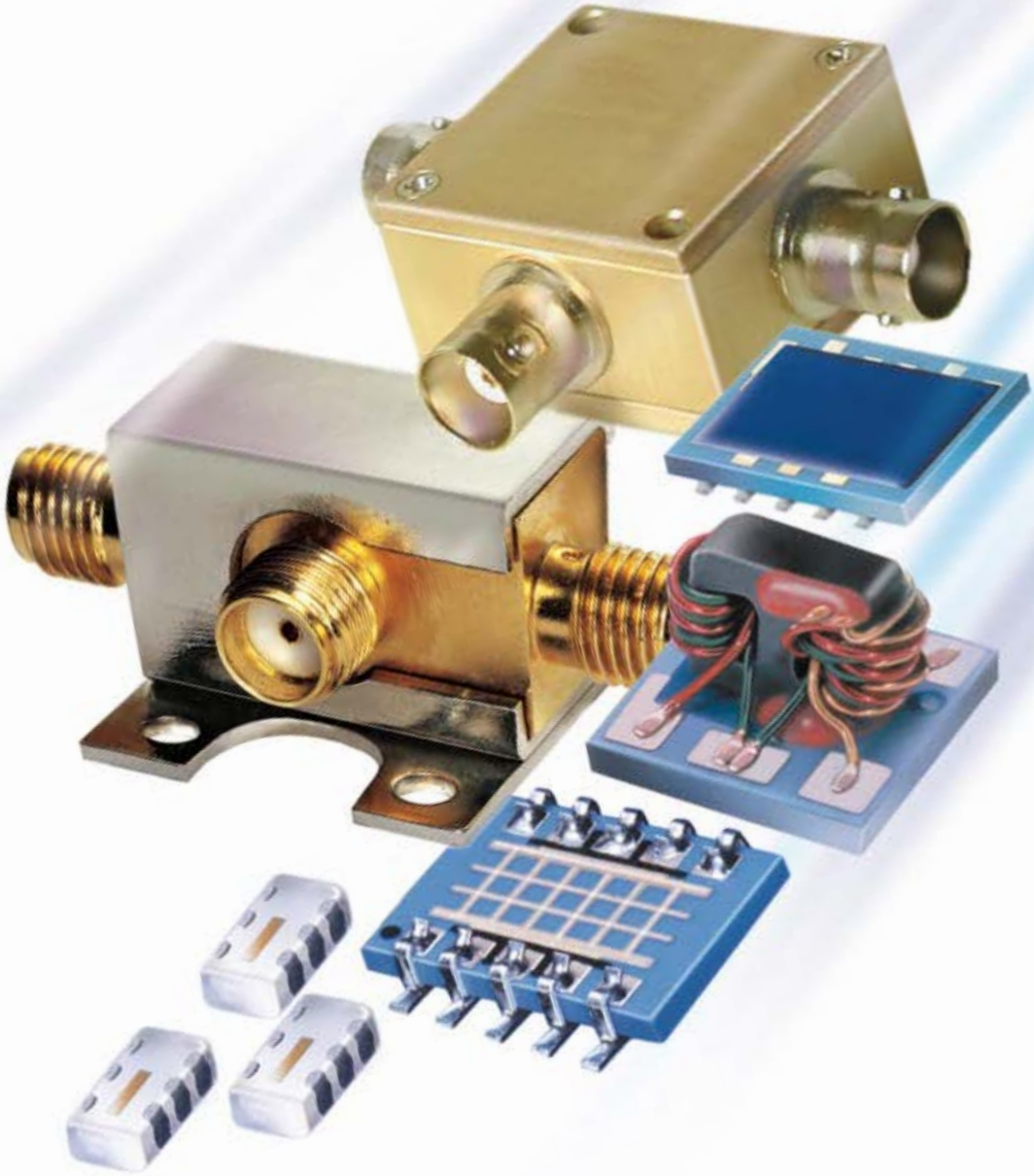
▲ *Fig. 19 Measured phase noise of the dual-band concurrent oscillator.*

CONCLUSION

The state-of-the-art, dual-band, multi-mode RCO reported in this article can be further extended to other higher stable mode such as triple-, quadruple- and n^{th}-order modes. Hence, it can replace traditional multiple oscillators and the technology is compatible with existing IC process. ■

References

1. M. Tiebout, "A CMOS Fully Integrated 1 and 2 GHz Dual-band VCO with a Voltage-controlled Inductor," *2002 IEEE European Solid-State Conference Proceedings*, pp. 799–802.
2. A. Goel and H. Hashrmi, "Frequency Switching in Dual-resonance Oscillators," *IEEE Journal of Solid-State Circuits*, Vol. 42, No. 3, March 2007.
3. U.L. Rohde, A.K. Poddar and G. Boeck, *Modern Microwave Oscillators for Wireless Applications: Theory and Optimization*, John Wiley & Sons Inc., Hoboken, NJ, 2005.
4. A.D. Berny, A.M. Niknejad and R.G. Meyer, "A 1.8 GHz LC VCO with 1.3 GHz Tuning Range and Digital Amplitude Calibration," *IEEE Journal of Solid State Circuits*, Vol. 40. No. 4, April 2005, pp. 909–917.
5. "Low Noise, Low Power Consumption, Configurable, and Adaptable Ultra-wideband VCOs," *2006 IEEE International Conference on Ultra-wideband*.
6. A. Bavisi, "Integrated Multi-mode Oscillators and Filters for Multi-band Radios Using Liquid Crystalline Polymer Based Packaging Technology," PhD thesis, Georgia Institute of Technology, May 2006.
7. A. Ravi, B.R. Carlton, G. Banerjee and K. Soumyanath, "A 1.4 V, 2.4/5.2 GHz, 90 nm



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CMOS System in a Package Transceiver for Next Generation WLAN," *2005 IEEE Symposium on VLSI Technology Proceedings*.
8. C. Lam and B. Razavi, "A 2.6/5.2 GHz Frequency Synthesizer in 0.4µm CMOS Technology," *IEEE Journal of Solid State Circuits*, Vol. 35, No. 5, May 2000, pp. 788–790.
9. B. Razavi, *RF Microelectronics*, Second Edition, Prentice-Hall, Upper Saddle River, NJ, 1998.
10. M.S Yim and K.K. O, "Switched Resonators and Their Applications in a Dual-band Monolithic CMOS LC Tuned VCO," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 54, No. 1, January 2006, pp. 74–81.
11. B. Klepser, M. Punzenberger, T. Ruhlicke and M. Zannoth, "5 and 2.4 GHz Dual-band RF-transceiver for WLAN 802.11a/b/g Applications," *2003 IEEE RFIC Symposium Digest*, pp. 37–40.
12. K. Araki, T. Nakagawa, K. Kawashima, K. Kobayashi, K. Akabane, H. Shiba and H. Hayashi, "Implementation and Performance of a Multi-band Transceiver for Software Defined Radio," *2004 IEEE Radio and Wireless Conference Proceedings*, pp. 207–210.
13. S. Wiggins, *Introduction to Applied Nonlinear Dynamics and Chaos*, Second Edition, Springer-Verlag, New York, NY, 1997.
14. B. Van der Pol, "On Oscillation Hysteresis in a Triode Generator with Two Degrees of Freedom," *Philosophical Magazine*, Vol. 43, 1922, pp. 700–719.
15. J.S. Schaffner, "Simultaneous Oscillations in Oscillators," *IRE Transactions on Circuit Theory*, Vol. 1, No. 2, June 1954, pp. 2–8.
16. T. Endo and S. Mori, "Mode Analysis of a Multimode Ladder Oscillator," *IEEE Transactions on Circuits and Systems*, Vol. 23, No. 2, February 1976, pp. 100–113.
17. A.K. Poddar, "A Novel Approach for Designing Integrated Ultra Low Noise Microwave Wideband Voltage Controlled Oscillators," Dr.-Ing. Dissertation, TU- Berlin, Germany, 14 December 2004.
18. U.L. Rohde, A.K. Poddar and R. Rebel, "Integrated Low Noise Microwave Wideband Push-Push VCO," US Patent No. 7,088189, August 2006.
19. I. Bruyland, "Simultaneous Oscillations at Two Frequencies in RLC Circuits," *Proceedings of the IEEE*, Vol. 1, No, 2, January 1968, pp. 82–83.
20. A.K. Poddar, J.K. Bansal and K.N. Pandey, "Millimeter-wave Evanescent Mode Power Combiner Gunn Oscillator in Suspended Stripline Configuration," *1998 International Conference on Mathematical Methods in Electromagnetic Theory Digest*, pp. 384–386.
21. L. Zhenbiao and K.K. O, "A 1 V Low Phase Noise Multi-band CMOS Voltage-controlled Oscillator with Switched Inductors and Capacitors," *2004 IEEE RFIC Symposium Digest*, pp. 467–470.
22. U.L. Rohde and A.K. Poddar, "Tunable Frequency, Low Phase Noise and Low Thermal Drift Oscillator," US Patent No. 7196591, March 2007.
23. A.K. Poddar and K.N. Pandey, "Evanescent Mode Power Combiner in SSL Configuration," *2000 IEEE International Symposium High Performance Electron Devices for Microwave and Optoelectronic Applications Digest*, pp. 196–201.
24. A.K. Poddar, S.K. Koul and B. Bhat, "Millimeter-wave Evanescent Mode Gunn Diode Oscillator in Suspended Stripline Configuration," *1997 International Conference on IR & MM Waves Digest*, pp. 265–266.
25. U.L. Rohde and A.K. Poddar, "Wideband Voltage-controlled Oscillators Employing Evanescent Mode Coupled Resonators," US Patent No. 71803812, February 2007.
26. U.L. Rohde and A.K. Poddar, "Concurrent Oscillators for Multi-band Wireless Communication Systems," *2007 IEEE Canadian Conference on Electrical and Computer Engineering*.
27. U.L. Rohde and A.K. Poddar, "Reconfigurable Concurrent Oscillators for Multi-band, Multimode Wireless Communication Systems," *2007 IEEE Sarnoff Symposium*.

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SMA CONNECTORS WITH EXTENDED FREQUENCY RANGE

The most common coaxial connector in the microwave market, the Sub-Miniature A connector (SMA), was first introduced by Bendix Corp. in the late 1950s as a connector specially designed for the 0.141" diameter semi-rigid cable. At the SMA connector's inception, the operating frequency did not exceed 12 GHz. As the design matured, the maximum operating frequency was pushed up to 18 GHz and eventually higher. Some years later, higher frequency connector interfaces were introduced with SMA compatible airlines, two examples being the 3.5 mm and 2.9 mm interface connectors. In various applications, the 3.5 mm interface is used to transmit signals at a frequency as high as 36 GHz and the 2.9 mm (SMK) interface as high as 46 GHz.

The theoretical limit of the operating frequency of the SMA connector is restricted by a second mode resonance. The connector will operate at higher frequencies than that of the second mode resonance; however, this would be a dual-mode operation transmission. This is undesirable for most applications, especially in high power applications, where second mode resonances will overheat the SMA connector and cause a voltage breakdown. Theoretically, the second mode can be excited from the so-called cut-off frequency, which depends on the transverse dimensions of the line and the effective dielectric constant. The first waveguide mode in a coaxial line is a magnetic mode, which is identified by TE11 or H11. In this article, either name will be used. The approximate cut-off frequency (in GHz) in a circular coaxial line is given by

$$F_c = \frac{7.514}{(D+d)\sqrt{\varepsilon}} \tag{1}$$

where

d = center conductor diameter in inches
D = dielectric diameter in inches
ε = relative dielectric constant

the "cut-off frequency" F_c can be calculated with an uncertainty of five percent. If a better accuracy is needed, the equation given by Marcuvitz[1] can be used. Note that the mode resonance will typically appear at a frequency greater than that of the cut off. Typical connectors require different sizes of coaxial lines behind the established interface area dimensions to accommodate various sizes of coaxial cable. The exact value of the resonance frequency for a connector depends highly on the length of the coaxial line with the lowest "cut-off frequency." The shorter the length of this limiting

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CMQ1432-QH	Power Amplifier	13.5-15.5	32.0	+32.0 (Psat)
XR1002-BD	Receiver	18.0-34.0	2.0-14.0	NF = 3.0 dB
XL1000-BD	Low Noise Amplifier	20.0-40.0	20.0	NF = 2.0 dB
XP1026-BD	Power Amplifier	27.0-32.0	22.0	+33.0 (Psat)
XP1027-BD	Power Amplifier	27.0-33.0	21.0	+36.0 (Psat)
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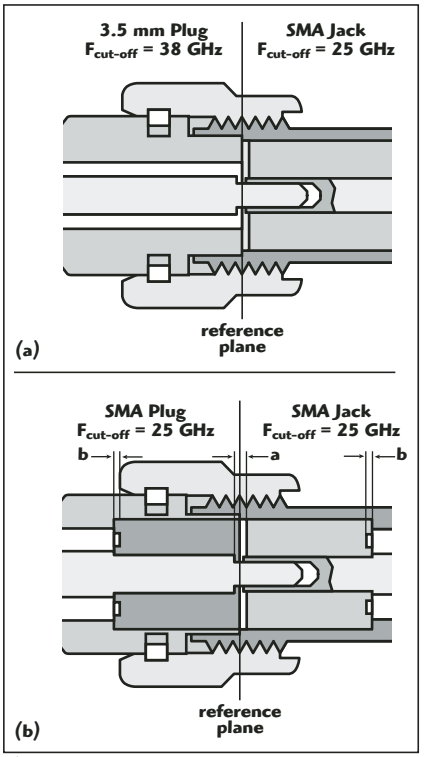
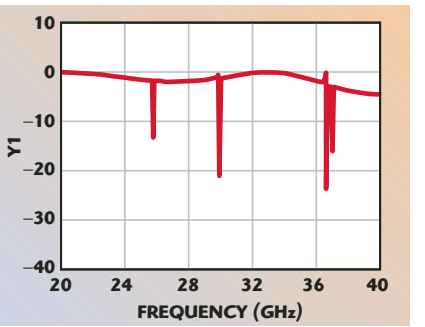
coaxial line, the higher the resonance frequency and the higher the connector operating frequency. This point, while straightforward, has a significant impact on the design and verification of the maximum operating frequency of a connector. When verifying the maximum operating frequency of a connector using a vector network analyzer (VNA), there are cases where the resonance frequency is not clearly visible. However, just because a component does not show a resonance on the VNA, it does not guarantee that there will not be any resonance in actual applications. The SMA connector is an excellent example of this phenomenon. The VNA test port connector has an airline interface (typically 3.5 mm). A 3.5 mm airline interface has a cut-off frequency of approximately 38 GHz, which is much higher than the SMA connector (approximately 25 GHz). While the 3.5 mm connector has an excellent electrical performance, its high cost limits its range of applications outside the test lab. This is significant as it means that in a real application (see ***Figure 1***), the SMA connector will be connected to another SMA interface. Thus, the Teflon dielectric line length, the limiting coaxial line in this case, will be substantially increased as compared to the test situation. The 3.5 mm interface airline can artificially increase the dielectric bead length because the airline has an inductive impedance for the TE11 mode below the cut-off frequency[2,3] (see calculations in the ***Appendix***). However, the airline influence is much smaller when compared to the SMA Teflon line. In this case, the resonance frequency will be lower and its effects easily discerned. Computer simulations were performed for different resonance structures using HFSS from Ansoft. ***Figure 2*** shows a typical simulation of the second mode resonance performed by HFSS for the standard SMA line size with a contact diameter 0.050" and a Teflon diameter of 0.1625". There are several approaches that can be taken to create this resonance frequency simulation. Multiple modeling approaches were used and it was found that there were differences of several percent in the location of the resonance frequency. However, one model in particular proved to be the most repeatable, both in the simulation and the actual performance of the SMA connector while under test. This model was based on a homogeneous dielectric line with three modes on the ports. The blue line in ***Figure 3*** depicts the results of the simulation of the resonance frequency versus the dielectric length of a SMA connector line connected between two 3.5 mm airlines. Note that the Y-axis shows the peak values of the resonance frequency. The maximum operating frequency of the connector must always be lower than the beginning of the resonance.

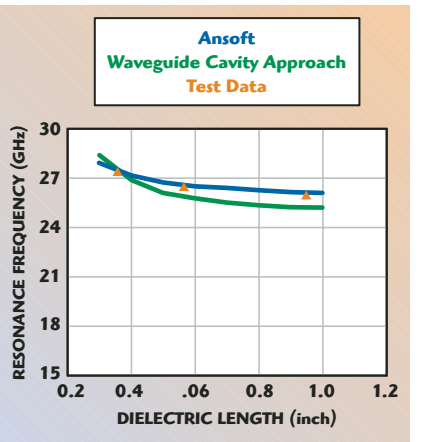
Various SMA components were tested and it was found that the second mode resonance was not always visible even under conditions where it was calculated to occur. Typically, the third and higher modes are much sharper and more discernable. This was the case when testing a SMA plug-to-plug adaptor, where the third mode resonance frequency was clearly visible while the second mode resonance was not. Based on the above formulae and the calculations based upon the length of the Teflon dielectric line, the adaptor should show a second mode resonance at approximately 26 GHz. However, this was not the case. Using several different calibrations and test methods, including special methods for the second mode detection described by the IEC 61141 report,[4] as an Automatic Reflection Measurement Technique, there was still no success in identifying the second mode resonance frequency. The fact that this resonance is not always visible is well known.[5] It is shown that the resonance was unnoticed until provoked by a special exciter. Apparently, under some conditions, the resonance magnitude is so small that it becomes negligible and the resonance issue can be ignored. In cases such as this, it is possible to produce a coaxial component based on a dielectric line of substantial length, which can be used for a single mode transmission at frequencies much higher than the cut off. Is this applicable for RF connector manufacturing? No. In real world applications, the mating connector geometry cannot be predicted. This is an important consideration as the mating connector's dielectric length has a critical influence on the resonance magnitude. In addition to computer simulation and testing, it is always possible to perform some calculations. Typically,



▲ *Fig. 1 Connector junction for 3.5 mm-to-SMA connected to a VNA test port 3.5 mm (a) and a typical SMA-to-SMA connection (b).*



▲ *Fig. 2 Simulation of an SMA connector resonance.*



▲ *Fig. 3 Resonance frequency versus dielectric length for an SMA line connected between two 3.5 mm lines.*

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these calculations have some uncertainty in predicting the actual performance of the component. James Kubota noticed that when comparing calculated and measured results, the "relationship yields an approximate value that is lower than the exact frequency by a few percent."[5] When measuring and verifying the second mode resonance frequency, most references calculate the resonance frequency based on the conjugate impedance, using transmission line equations. However, a simpler method to compute the resonance frequency could be to use a waveguide resonance cavity approach.

The Teflon insulator, or bead, is actually an electrically short piece of a coaxial waveguide. Thus, the bead can be represented as a TE_{11} mode coaxial resonator filled with dielectric. It can be assumed that the connector resonance is related to the cavity resonator. The simple approach to calculate a resonance bead is through the minimum length of a coaxial resonator. According to references, the waveguide or cavity resonator is a piece of waveguide with a height equal to a half-wavelength. The cavity can be based on a circular or rectangular waveguide as well as a coaxial line. In this particular case, the Teflon bead is a coaxial line but with a waveguide mode. This means that the wavelength in the waveguide cavity is greater than in free space. There is an infinite number of resonant modes that may exist in this structure. The lowest mode, TE_{111}, is of interest. The third unit in the mode designation means that one half-wavelength has to be in an axial direction. Thus, the length of the Teflon bead has to reach one half of the wavelength in a coaxial waveguide for TE_{11} mode. The wavelength in the waveguide filled with dielectric (λ_g) can be calculated from

$$\lambda_g = \frac{\lambda}{\sqrt{\varepsilon_r - \left(\frac{\lambda}{\lambda_c}\right)^2}} \qquad (2)$$

where

λ = wavelength in free space, which is actually the TEM wavelength in the coaxial airline

λ_c = cut-off wavelength for the coaxial airline

ε_r = relative dielectric constant of the PTFE bead

The resonance length (l) is a half-wavelength, thus is equal to

$$l = \frac{\lambda_g}{2} = \frac{\lambda}{2\sqrt{\varepsilon_r - \left(\frac{\lambda}{\lambda_c}\right)^2}} \qquad (3)$$

In the case of the SMA connector, the standard SMA line is a PTFE-loaded coaxial line with conductor diameters of 0.050" and 0.1625" and a dielectric constant of approximately 2.03. The cut-off frequency of this line will be approximately 24.82 GHz. To calculate the minimum length of line that can excite resonance at a frequency of 27 GHz, the following parameters need to be calculated:

λ = 1.11 cm at 27 GHz

λ_c = 0.848 cm at 35.36 GHz. (The 'cut-off frequency' of a 0.050/0.1625" coaxial air line without dielectric.)

Introducing these values into Equation 2, the waveguide length λ_g for the TE_{11} mode will be 1.98 cm. The TE_{111} mode resonance is possible at half of the wavelength, which is 0.99 cm or 0.390". This means that an SMA connector junction with an overall Teflon dielectric line length of 0.390" for the mated pair is susceptible to resonance at a frequency equal to or greater than 27 GHz. Note that, if the frequency is gradually reduced to approach the cut-off value for the dielectric loaded line (24.82 GHz in this case), the resonance length will grow and it will approach infinity. This example explains why a component will never resonate at its cut-off frequency. The resonance frequency must be higher than the cut off, otherwise the bead length would be infinite.

Calculations based on Equation 3 closely match the HFSS data and the measured data until the Teflon is shorter than 0.250". At this point, there is a need for additional correction factors for shorter dielectrics. One reason is that the airline, connected to the Teflon bead, creates an inductive impedance at the frequency of interest for TE_{11}.[2,6] In the case of a Teflon dielectric line being connected to a coaxial airline, the effective dielectric length will be increased at both sides of the bead.

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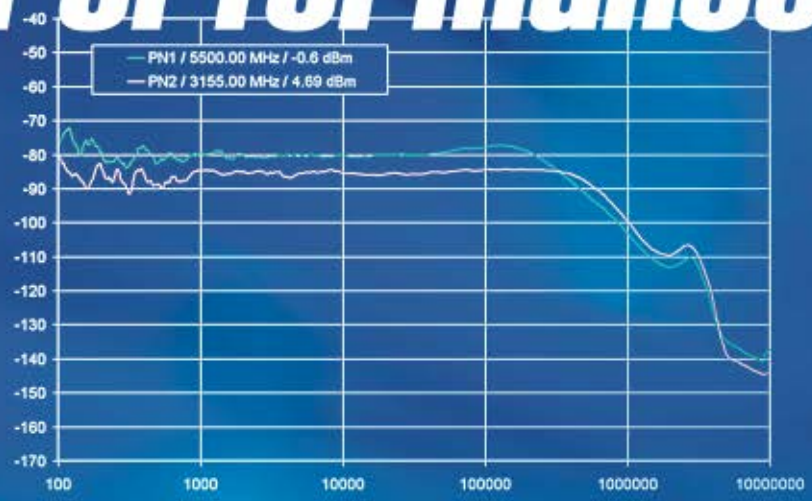

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This means that the physical length of the dielectric needs to be reduced to compensate for the increase in effective length. This length differential for each side of the bead can be approximately calculated as

$$l_{eff} = \frac{c}{2\pi} \frac{\arctan\left(\sqrt{\frac{f^2 - f_{c\xi}^2}{f_c^2 - f^2}}\right)}{\sqrt{f^2 - f_{c\xi}^2}} \qquad (4)$$

(See Equation 9a in the Appendix.)

Here f_c is the cut-off frequency of the connected airline (in this case a 3.5 mm airline) and f_{ct} is the cut-off frequency of the dielectric bead. If there are identical coaxial airlines connected to each side of the Teflon bead, it will be necessary to use twice the value from Equation 4. Another correction factor is caused by the junction between Teflon/airline or Teflon/Teflon. According to references, any such junction has a capacitive impedance. This capacitive impedance is typically compensated by an inductive step of a certain length (see, for example, area "b" on the SMA-to-SMA connection). Additionally, there are air gaps in the Teflon at the reference plane between the mating connectors (see area "a" on the SMA-to-SMA connection). Apparently, these steps push the resonance frequency up, so they have an opposite influence when compared to the length calculated from Equation 4.

The standard SMA line with a length of 0.390", when connected to 3.5 mm airlines at both ends, is susceptible to a mode resonance at 27 GHz. In order to avoid resonance, the physical dielectric line length must be shortened.

There are three important notes:

1. 0.390" is not a connector dielectric line. It is a junction line of two mated connectors.
2. 27 GHz is a center resonance frequency. It cannot be the operational frequency, or, in other words, if there is a need for an SMA connector that is operational up to 27 GHz, the dielectric length needs to be reduced more because the operation frequency should not be at the beginning of resonance. Typically, a few tens of thousandth of an inch should be enough. Suppose there are two mating connectors with dielectric lengths of approximately 0.180" each. In this case, this pair is resonance free up to 27 GHz. Additional safety may be required to guarantee connector performance while allowing for material properties variations and extreme environmental conditions.
3. For SMA connectors with a long dielectric, the resonance length may be calculated from Equation 3. Otherwise, the resonance length could be calculated in three steps:

(a) Calculate the resonance length from the coaxial waveguide approach (Equation 3),

(b) Calculate the length differential caused by a mated airline inductance (Equation 4) and subtract this value from the length calculated in (a). Make this subtraction from both sides.

(c) Add the overall value of all the gaps and setbacks to the length.

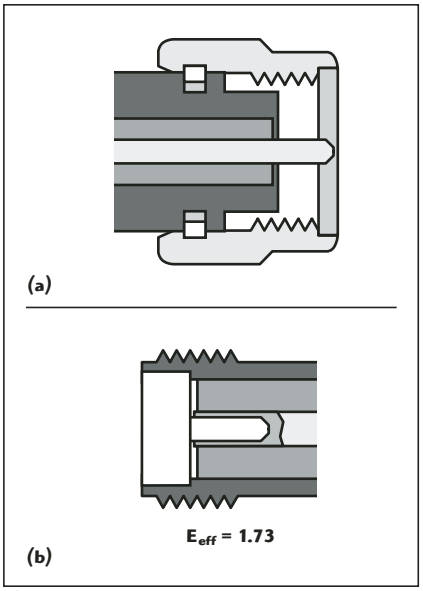
The green line in Figure 3 shows the curve calculated from the waveguide resonator approach. The red triangles show the electrical test data. There are some differences between simulation, calculation and test data but they are not of substantial value. There are other additional factors that can also be considered, such as the slot construction and tolerances, which will also distort the bead effective electrical length, but again, these are not of substantial value. However, the overall field distribution in the area of the dielectric bead is still complicated. There are a few propagating modes at high frequency in the bead area. There is the main TEM wave, there are two TE_{11} modes and, if the bead is partially filled by dielectric, additional mixed modes. Note that there are not one but two TE_{11} modes in cross polarization. This is why, in some references, the TE_{11} (H_{11}) field equation has a component sin x/cos x, (see, for example, Marcuvitz,[1] Equation 44). According to Marcuvitz, "…the Hmn-mode (m > 0) may possess either of two polarizations, each characterized by a different voltage and current." The TE_{11} mode is not symmetrical in a transverse plane and this is the reason for dual-mode extinction (or in other words, the TE_{11} mode is degenerate). It can be seen that the exact location of the resonance frequency is interdependent upon many complicated relationships within the connector mechanical and electrical design. It can be seen from the above

data that a standard SMA connector cannot be used at extended frequencies without some limitations. When designers needed to enhance the component performance of the SMA connector, extended frequency versions of the SMA connector were designed.[7] The resonance frequency in a standard SMA connector is approximately 25 GHz. It can be pushed higher through the incorporation of special design features to create what is known in some companies' catalogues as a "Super SMA." The Super SMA family of connectors has been well known for years. These extended frequency connectors are based on modified transverse dimensions of the SMA plug and jack connectors. For example, if both the outer conductor diameter and the effective dielectric constant are reduced, the connector can maintain a 50 Ω impedance while increasing the frequency at which the second mode resonance will occur. This design optimization allows the outer conductor diameter to be 0.154". If the inner conductor diameter stays the same, the cut-off frequency will be increased from 25 to approximately 27.5 GHz. The resonance frequency will increase to higher than 27.5 GHz. Thus, the Super SMA connectors are rated up to 27 GHz.

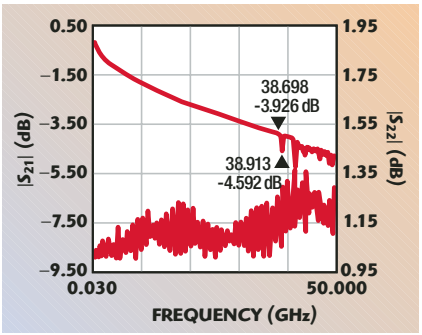
An extended frequency SMA connector product line, called "Premier SMA," has been designed by Astrolab. There are two main differences when compared to a typical Super SMA design:

The SMA jack connector has a slight difference in dimensions. There is no special plug connector for the Premier SMA. The "Premier SMA" plug is based on the thick wall design[8] because it has an increased frequency range. This design also offers a more mechanically reliable connector. ***Figure 4*** shows a thick wall SMA plug on the left.

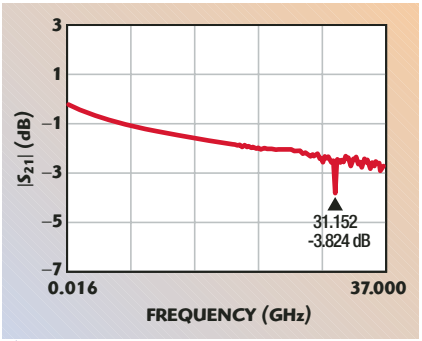
The "Premier SMA" plug utilizing the thick wall design has a cut-off frequency of approximately 33 GHz and therefore does not need any additional features for extended frequency. The resonance frequency is even higher than 33 GHz. ***Figure 5*** shows the typical performance of a test cable with thick wall SMA plug connectors. The cable assembly was connected to 2.9 mm test ports and showed a resonance frequency at approximately 39 GHz (a similar assembly with a shorter Teflon bead showed this resonance at 42 GHz). There is no need to define this connector as a special one because the thick wall plug is the original SMA connector invented by Bendix. The extended frequency SMA



▲ *Fig. 4 Thick wall SMA plug (a) and Premier SMA jack (b).*



▲ *Fig. 5 Assembly with two thick wall SMA plug connected to 2.9 mm test ports.*



▲ *Fig. 6 Resonance in junction between SMA thick wall plug and SMA Premier jack.*

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jack connector is much more complicated. From a mechanical point of view, it is not recommended to reduce the inner conductor diameter to less than 0.050". However, it is possible to reduce both the effective dielectric constant of the Teflon and the outer conductor bore diameter. The Premier SMA design has an effective dielectric constant of 1.73, pushing the 'cut-off frequency' up to 28.5 GHz. The main specification for a Premier SMA connector has the maximum operating frequency as 27.5 GHz because of the safety margin concern. However, the true maximum operating frequency of the Premier SMA connector is found when it is mated with a 2.9 mm connector. In this condition, the maximum operating frequency can reach 36 GHz. ***Figure 6*** shows the second mode resonance in the connector junction between the thick wall SMA plug and Premier SMA jack. With all of the advantages of the extended frequency SMA connectors, what design concerns should one be familiar with in their use? The first consideration is price. The thick wall design of the SMA plug connector is equivalent to standard SMA plug connectors in price. However, the extended frequency SMA jack is more difficult to assemble and therefore is generally more expensive. The second design concern is power handling. The extended frequency connectors have reduced transverse dimensions. Additionally, there are some air gaps in order to reduce the effective dielectric constant. Both factors serve to lower the power handling of the extended frequency connector design. However, in many cases, the cable limits the power handling. The extended frequency connector truly only makes sense for use in high frequency applications, where the cable will be, by necessity, a smaller coaxial line. Thus, in most cases, the cable dimensions are the limiting factor for power handling. Some cables with a low density dielectric can be more powerful than the connector. In this case, special features can increase the connector power handling, but the connector price will be proportionally higher. The design issues involving extended frequency SMA connectors have been discussed in this article and the design guidelines outlined here can open the door as crossover technologies to optimize other industry standard interfaces. Several companies are already applying this technology to the SSMA connector. Using these design tools, the optimized SSMA connector interface can offer design solutions for applications operating up to 60 GHz with great success and reliability.

CONCLUSION

Most standard SMA connectors can be rated up to 25 GHz maximum. SMA plugs of a thick wall design can be used at higher frequencies; in some cases the connector theoretical limit can exceed 40 GHz. SMA jacks and plugs other than the thick wall design with extended frequency of operation require special features, which increase the resonance frequency. Connectors without the special features can operate at frequencies higher than 25 GHz; however, in

this case the dielectric lines must have their length precisely designed for the specific application. The dielectric line length design under consideration must include the mating connector also. A resonance-screening test needs to be done in conditions as close as possible to the real application. The resonance is not always visible. The resonance magnitude and frequency in real connectors may vary as a function of the dielectric line length. The maximum connector operating frequency should have some reasonable safety margin below the resonance value. ■

ACKNOWLEDGMENTS

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References

1. *Waveguide Handbook*, N. Marcuvitz, Ed., McGraw-Hill, New York, NY, 1951.
2. H. Neubauer and F.R. Huber, "Higher Modes in Coaxial RF Lines," *Microwave Journal*, Vol. 12, No. 6, June 1969, pp. 57–66.
3. IEEE P287 Standard for Precision Coaxial Connectors (DC to 110 GHz).
4. IEC 61141 (formerly 1141), *Technical Report Upper Frequency Limit of RF Coaxial Connectors*.
5. J. Kubota, "TNC Connector Meet New Performance Criteria," *Microwaves*, February 1981, pp. 77–79.
6. J.F. Gilmore, "TE11-mode Resonance in Precision Coaxial Connectors," *General Radio Experimenter*, Vol. 40, No. 8, August 1966, pp. 10–13.
7. Southwest Microwave and M/A-COM catalogues.
8. R. Fuks, "Assessing Distortion at Microwave Interface Junctions," *Microwaves & RF*, August 1997, pp. 108–116.
9. T. Moreno, *Microwave Transmission Design Data*, Artech House Inc., Norwood, MA, 1989.
10. MIL-STD-348A Military Standard, Radio Frequency Connector Interfaces.
11. J. Zorzy, "18 GHz Mode-resonant-free Standard MIL-C-39012 TNC Connectors," *Microwave Journal*, Vol. 30, No. 5, May 1987, pp. 365–370.
12. R. Fuks, "New Dielectric Bead for Millimeter-wave Coaxial Components," *Microwave Journal*, Vol. 44, No. 5, May 2001, pp. 318–329.
13. D. Grey, *Handbook of Coaxial Microwave Measurements*, Copyright 1968 by GenRad Inc.; reprinted by Corning Gilbert.

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Rudy Fuks *received his Dipl. Eng degree in radio communication engineering from the Moscow Telecommunications Institute in 1973. He joined the Telecommunications Design Bureau, Moscow, Russia, where he held positions as a lead engineer, chief design engineer and department head. His main interest included the design of passive microwave components, such as coaxial connectors and adaptors, terminations, detectors and antennas. In 1994 he joined Astrolab Inc., Warren, NJ, as an RF design engineer responsible for the design of passive microwave components. He has been director of RF technology since 2002.*

APPENDIX

The coaxial airline connected to the dielectric creates inductive impedance, which will artificially increase the dielectric effective length and therefore shifts the resonance frequency down. Here is a method to calculate this length increase: consider an airline connected to the dielectric. It could be, for example, a 3.5 mm airline connected to the Teflon-loaded line of a SMA connector. Note that this airline operates at a frequency lower than cut off.

The field distribution for a circular waveguide is

$$E_r = -\mu \frac{\omega}{\beta} H_\theta$$

According to the definition of wave impedance, in a circular waveguide Z_w is[9]

$$Z_w = \frac{E_r}{H_\theta} = -\mu \frac{\omega}{\beta} \qquad (1a)$$

Here, β is the propagation constant of the connected airline. Note that Z_w is purely inductive because the airline operates below the cut-off frequency. This wave impedance will be equal to the impedance of the shorted inductance with a length l_{eff}. According to transmission line theory, this impedance will be equal to $jZ_\xi \tanh(\gamma_\xi l_{eff})$, or in the case of small loss $jZ_\xi \tan(\beta_\xi l_{eff})$. Here, Z_ξ and β_ξ are the wave impedance and the propagation constant for a dielectric loaded line. Unlike the airline, this line has a frequency higher than cut off.

$$-\mu \frac{\omega}{\beta} = jZ_\xi \tan\left(\beta_\xi l_{eff}\right) \qquad (2a)$$

Z_ξ can be represented in a form similar to Equation 1a; however, in this case it has to be an absolute value. It means that

$$Z_\xi = \mu \frac{\omega}{\beta_\xi}$$

Equation 2a can thus be written

$$-\mu \frac{\omega}{\beta} = j\mu \frac{\omega}{\beta_\xi}\left(\beta_\xi l_{eff}\right) \qquad (3a)$$

$$-\frac{\beta_\xi}{\beta} = j \tan\left(\beta_\xi l_{eff}\right) \qquad (4a)$$

If phase has a small value, then

$$\tan\left(\beta_\xi l_{eff}\right) \approx \beta_\xi l_{eff} \qquad (5a)$$

Equation 4a can be represented as

$$l_{eff} \approx \frac{j}{\beta} \qquad (6a)$$

The phase constant is equal to

$$\beta = \frac{1}{c}\sqrt{\omega^2 - \omega_c^2}$$

where

ω_c = cut-off angular frequency of the airline

However, the signal in the airline is below cut off, which means that $\omega < \omega_c$. Thus, the phase constant can be represented as

$$\beta = \frac{j}{c}\sqrt{\omega_c^2 - \omega^2}$$

The effective length can be calculated as

$$l_{eff} \approx \frac{c}{\sqrt{\omega_c^2 - \omega^2}} = \frac{c}{2\pi\sqrt{f_c^2 - f^2}} = \frac{1}{2\pi\sqrt{\frac{1}{\lambda_c^2} - \frac{1}{\lambda^2}}} \qquad (7a)$$

Equation 7a shows the increase in the dielectric bead effective length caused by the connection to a coaxial airline. If the bead is installed between two similar airlines the length l_{eff} has to be doubled. If there are different airlines, it is necessary to calculate the length from each side from Equation 7a and add their length.

If the approximation in Equation 5a is not valid, the effective length can be calculated from Equation 4a with better precision

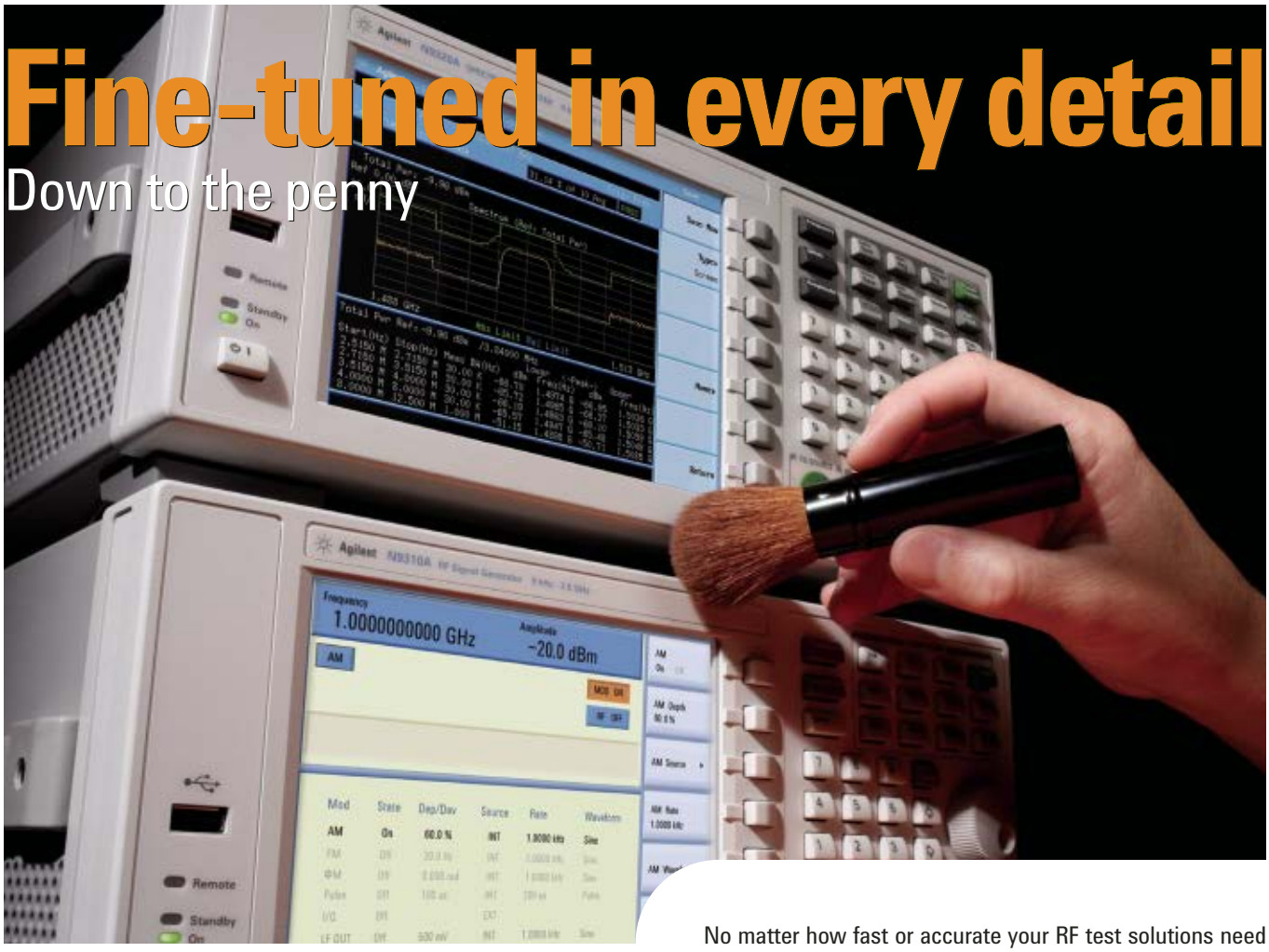
$$l_{eff} = \frac{\arctan\left(-\frac{\beta_\xi}{j\beta}\right)}{\beta_\xi} \qquad (8a)$$

Apparently

$$\beta_\xi = \frac{1}{c}\sqrt{\omega^2 - \omega_{c\xi}^2}$$

where $\omega_{c\xi}$ is the cut-off angular frequency of a Teflon loaded line. Equation 8a can be written as

$$l_{eff} = c\frac{\arctan\left(\frac{\sqrt{\omega^2 - \omega_{c\xi}^2}}{\sqrt{\omega_c^2 - \omega^2}}\right)}{\sqrt{\omega^2 - \omega_{c\xi}^2}} = \frac{c}{2\pi}\frac{\arctan\left(\sqrt{\frac{f^2 - f_{c\xi}^2}{f_c^2 - f^2}}\right)}{\sqrt{f^2 - f_{c\xi}^2}} \qquad (9a)$$



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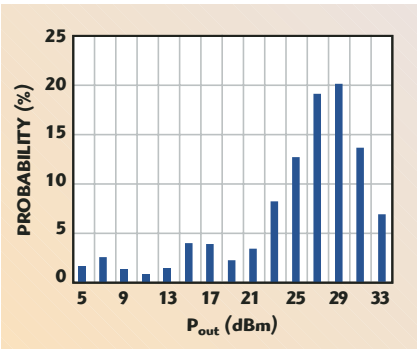
INTELLIGENT POWER MANAGEMENT: A METHOD TO IMPROVE 2G/3G HANDSET TALK TIME

The increasing demand by users and operators for feature rich handsets continues to result in tougher demands on the handset designer in the area of current consumption. With the focus put on reducing this in every aspect of the design, the power amplifier (PA), as a major contributor, can provide some significant savings. This article will discuss power management techniques using PA bias voltage control as a handset talk time enhancement method. The power management techniques will be discussed and demonstrated through the use of experimental data taken on a GSM saturated PA, as well as a WCDMA linear PA. The results will show the expected increase in talk time that can be achieved through the use of intelligent power management.

In the typical GSM handset, the PA consumes approximately 40 percent of the energy stored in the battery during one discharge cycle. For this reason, the handset architect must use care in selecting a PA that will provide the most efficient means of generating the required transmitted RF power while using the least amount of energy from the battery. Handset designers consider several key performance parameters when selecting a PA for GSM handset applications. Maximum output power and peak power efficiency are two of these key parameters. Because talk time, based on one battery charge cycle, is very important to the cell phone end user, the handset designer may select a PA that has the best peak power efficiency (or lowest current consumption at peak power). Though peak power efficiency is a good indicator of the PA impact to talk time, it does not tell the whole story.

Fig. 1 Class 4 GSM probability density function (PDF) curves.



In a GSM network, the handset does not always operate at maximum output power. In fact, the handset only operates at maximum output power about seven percent of the time. Probability density function (PDF) curves have been derived by the service providers to understand the probability versus transmit power level relationship for handset operating under real-life conditions. The Class 4 GSM900 band PDF curve, shown in ***Figure 1***, illustrates the percentage of time that the handset is expected to be transmitting for

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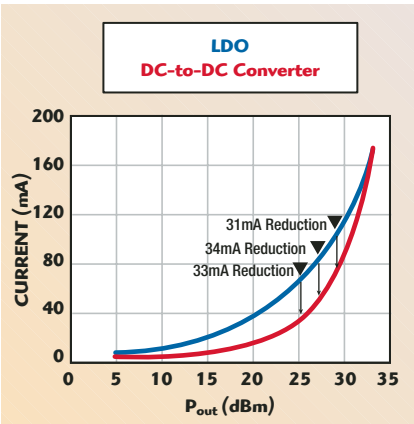
each power control level (PCL) between 5 and 33 dBm. This relationship shows that almost 40 percent of the time the handset will be transmitting at 4 or 6 dB below the maximum output power. Knowing that backed-off transmit power outweighs peak power in actual usage, the opportunity for talk time improvements exists using intelligent power management which improves backed-off PA efficiency.

The RF power amplifier is designed to meet a specified maximum output power level given a certain minimum voltage from the battery. When the PA is not transmitting at maximum output power or when the battery is fully charged, the PA will not be operating at its most efficient point unless power management techniques are used. Power management is implemented through the use of a DC-to-DC buck converter, which ideally steps the battery voltage down without dissipating power in the form of heat. The DC-to-DC converter conserves energy by using a switching function that only draws current from the battery part of the time, thereby reducing the overall current drawn from the battery. The pulsed voltage on the converter output is filtered through a large LC filter network creating a new lower DC voltage. The DC-to-DC converter is properly controlled to set the PA collector voltage in order to establish the proper output power level.

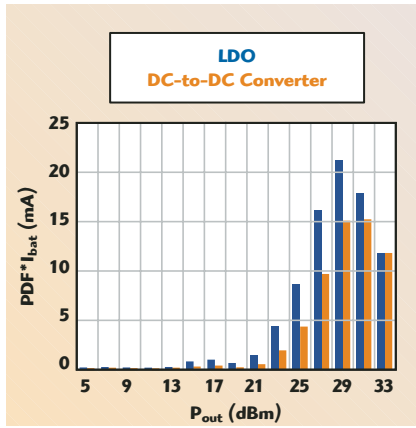
Figure 2 shows a plot of the average battery current consumption for two different transmit modules (TxM). This data was collected at 12.5 percent duty cycle, so peak current would actually be eight times higher. The TxM is a PA plus switchplexer that connects directly to the antenna. TxM1 has a standard PA, which is controlled by a low dropout (LDO) power control circuit, while TxM2 has the same standard PA but uses a DC-to-DC converter as the power control method. The LDO power control method uses a FET to set the proper PA collector voltage for the required RF output power level. The FET acts as a variable resistor, which drops any extra DC voltage and dissipates power in the form of heat. The DC-to-DC converter power control method uses a pulse width modulator (PWM) to control the PA collector voltage. The PWM reduces the pulse width to reduce the DC-to-DC converter output voltage. Since current is drawn from the battery only during the on time of the PWM, the battery current consumption is substantially lower than that of the LDO power control method. The plot shows the dramatic effects on battery current consumption when using the DC-to-DC converter method of power control on a PA. TxM2 average current consumption is more than 31 mA lower than TxM1 for the power levels with the highest operating probability. ***Figure 3*** illustrates the average current drawn from the battery based on the percentage of time the handset is transmitting at each power level.

To show the effects that this new power management technique has on the talk time performance of the GSM handset, an experiment was done to simulate a full battery discharge cycle of an 850 mA lithium ion battery in a simulated phone environment. For this experiment, the current consumption drawn by everything in the phone minus the PA was set at 100 mA continuous draw. This condition was simulated using a PA connected directly to the battery and biased to operate in idle mode at 100 mA. The transmitting TxM was also connected to the battery and operated over the PDF curve in 15-minute cycles. The PDF curve was used to set the percentage of time during the 15-minute cycle that the PA transmitted at each power level. For example, at output power level 29 dBm the probability is 20 percent, so the time spent transmitting at 29 dBm was three minutes (20 percent of 15 minutes) before going to the next operating power level. The test program repeated the 15-minute PDF cycle until the battery voltage dropped below 3.0 V. At that point, the time was recorded. After testing both TxM1 and TxM2, the results proved that TxM2, which used the DC-to-DC converter, operated one hour and 11 minutes longer than TxM1. That is a 21 percent improvement in handset talk time. The actual talk time results, based on operation at 12.5 percent duty, are shown in ***Figure 4***.

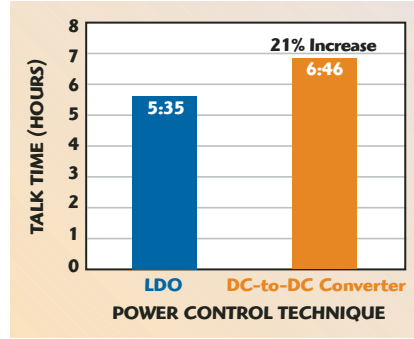
An interesting point to notice when examining maximum RF output power current consumption is that TxM1 had slightly lower current consumption at the same peak power level. Based on the old train of thought about only looking at the peak power efficiency, TxM1 should have enabled the handset to operate with longer talk time than TxM2. This, however, was not the case. Even though peak power efficiency is still



▲ *Fig. 2 Average battery current consumption from two GSM transmit modules utilizing different power control techniques.*



▲ *Fig. 3 Average battery current consumption based on probability from two GSM transmit modules utilizing different power control techniques.*



▲ *Fig. 4 Improvement to talk time using the DC-to-DC converter power control technique.*

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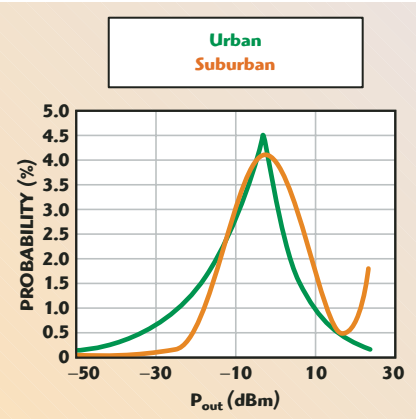
an important parameter to consider when selecting a PA to maximize talk time, proper transmitter power management can have a more substantial effect on talk time.

Like the GSM system, the (W)CDMA system also has a PDF curve for their typical network, which estimates the probability of the handset transmitting at a specified power level. ***Figure 5*** shows the PDF curve for a typical CDMA system operating in two different environments, urban and suburban. In the CDMA case, the handset output power levels with the highest probability occur around –3 dBm. Since the most probable operating power level occurs so far below the +24 dBm maximum output power level, the handset architect must carefully design the transmitter section to focus on minimizing current consumption at the lower power levels in order to optimize talk time.

Once again, the best efficiency enhancement solution for minimizing battery current versus power level is to use a DC-to-DC converter for PA collector voltage control. In a WCDMA system, the PA is required to be linear. In order to maintain linearity, the DC collector voltage must be sufficiently high enough to accommodate the RF signal voltage swing. To achieve the most efficient transmitting system, the DC collector voltage should maintain the PA just slightly beyond the onset of gain compression. WCDMA power amplifiers are capable of transmitting a 0 dBm linear RF signal at a collector voltage of 0.6 V. A DC-to-DC converter supplying 0.6 V from a 3.6 V battery would reduce battery current consumption by 5/6 if the converter was 100 percent efficient. For the case of a standard fixed gain PA, which typically operates at 60 mA at 0 dBm, the current consumption would be reduced to 10 mA. Unfortunately, the converter is not 100 percent efficient, so the current consumption savings will be slightly less. DC-to-DC converters usually exhibit efficiencies in the mid 90 percent range under heavy load. A heavy load occurs when the DC-to-DC converter is sourcing current greater than 50 mA at a voltage level close to 3 V. Having high converter efficiency under heavy load is important to maintain overall PA plus converter system efficiency. In the WCDMA handset however, the PA is typically operating at a light load condition due to higher probabilities for lower power levels. The converter light load operating condition is usually considered to be at an output voltage below 1 V and sourcing current under 50 mA. A typical DC-to-DC converter will, at best, be 50 percent efficient under these operating conditions unless special design techniques are incorporated to improve light load efficiency. Even at a converter efficiency of 50 percent, the DC-to-DC converter solution still provides substantial current reduction benefit. In the example demonstrated earlier, where the current consumption was reduced from 60 to 10 mA with a 100 percent efficient converter, the 50 percent light load efficient converter would still reduce the current from 60 to 20 mA. For a WCDMA handset, the transmitter architect should look closely at the DC-to-DC converter specification for light load performance because in many cases these operating conditions are not included in the data sheet.

Additional current consumption savings can be achieved if the PA includes an analog bias control circuit. In this configuration, the PA base bias is reduced versus power since the PA does not require high collector current in order to remain linear at low power levels. Analog bias controlled WCDMA power amplifiers have been shown to operate linearly with as low as 20 mA quiescent collector current. At 0 dBm, the PA rectified current is only slightly above this quiescent current level. A simple example can demonstrate the reduc-



▲ *Fig. 5 CDMA probability density function (PDF) curves.*

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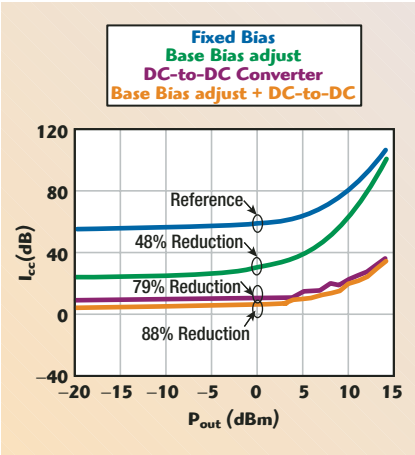
tion of battery current consumption when an analog bias control PA is operated with a DC-to-DC converter. An analog bias control PA operating at 0 dBm at about 24 mA of current would still only need 0.6 V collector voltage. The six times reduction in voltage from the DC-to-DC converter would result in a 5/6 reduction in the current consumption from the battery dropping it down to 4 mA with an ideal converter. Even with the converter at 50 percent efficient, the current consumption would still only be 8 mA.

Figure 6 illustrates measured results of the current drawn from the power supply when using the same WCDMA PA and utilizing different methods of power management. This chart focuses on the highest probable PA operating power levels in a handset and demonstrates the reduction in battery current consumption that can be achieved when using these various power management techniques. The 0 dBm PA operating power was chosen as the reference point because this would be the highest probable PA power level after considering approximately 3 dB of insertion loss in the handset between the PA and antenna. At 0 dBm, this chart illustrates that the DC-to-DC converter power management technique provides the biggest impact on the reduction of battery current consumption with a 79 percent reduction in current versus the PA with no power management. Additional current consumption reduction is achieved when combining the DC-to-DC converter with analog bias control resulting in an 88 percent reduction in current consumption. In a WCDMA handset, a PA operating with no power management can consume up to 40 percent of the available battery energy during one discharge cycle. With the use of intelligent power management and the potential 88 percent reduction in current consumption, the PA contribution to the energy consumed during the discharge cycle can be dramatically reduced.



▲ *Fig. 6 Measured current draw from a power supply using various power management techniques on the same PA.*

CONCLUSION

This article has discussed the transmitter section of the handset and how the PA current consumption affects the handset talk time through one battery charge cycle. Although the PA peak power efficiency is still an important parameter to consider, this article has illustrated through measured results the need for intelligent power management in the handset transmitter section. Utilizing a DC-to-DC converter to properly manage the DC power to the PA is beneficial in both GSM and WCDMA handsets resulting in dramatic reduction in current consumption and thereby increasing the handset talk time. Along with the improvement to handset talk time, the DC-to-DC converter also provides another less recognized benefit in the form of less heat being generated by the PA. The DC-to-DC converter provides an optimal DC environment for the PA to operate with reduced power dissipation and thereby lower operating temperatures. ■

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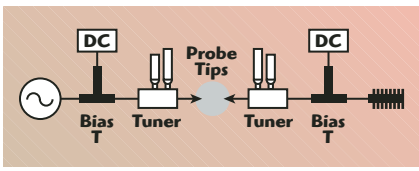
CURRENT SWITCH-OFF SOLUTION TO PROTECT RF POWER TRANSISTORS DURING MEASUREMENTS

A new security switch called "e-fuse" is presented here. It acts as a fuse in the bias feed, providing very fast switch-off times, thus protecting the device under test and the measurement equipment such as probe tips. It can be applied to FET-type transistors as well as to bipolar ones, including HBTs.

Microwave power transistors today can achieve output power levels greater than 100 W and there is more to come. In most cases, these transistors are also high voltage devices based on Si-LDMOS or GaN. In order to characterize such transistors during development, on-wafer measurements (of sub-cells) are an indispensable tool. In this case, however, one faces the problem of how to feed the DC power safely. Typical DC voltages exceed 50 V and currents up to 10 A must be handled. Big power supplies are required, with a high amount of stored energy. Thus, when going to the limits of the transistor, quite often the current limits adjusted by the bias compliance settings do not work properly. As a consequence, the transistors are destroyed during critical measurements. This is true also for parts of the equipment, such as the probe tips. The motivation for the development presented here is to minimize the damage in such situations, thus protecting wafer probes, bias tees, connectors and, as far as possible, the transistors themselves. A typical RF on-wafer measurement setup is shown in ***Figure 1***.

Fig. 1 A typical RF measurement system.



The device-under-test (DUT) is located on the wafer and contacted by suitable probe tips. In the following, the device is assumed to be of the HEMT type. During the measurements, the current or voltage may exceed their maximum tolerated values and a failure in the transistor or at its periphery may occur due to RF and thermal stresses. This will usually result in an excessive DC current into the drain which heats up the device, burning the drain or even causing an explosion in worst cases. Then, in general, not only is the device damaged, but so

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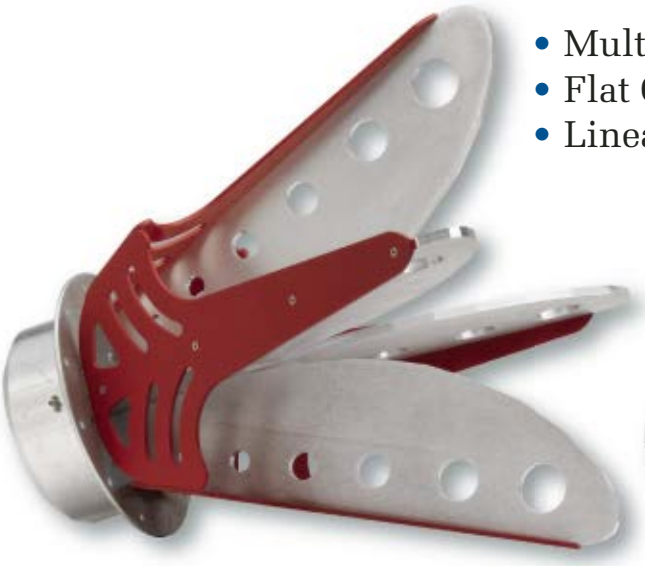

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too the equipment attached, that is the on-wafer probe tips. The proposed drain current e-fuse can avoid these types of accidents in many cases. This inexpensive solution may save a great deal of time and money and avoid the loss of invaluable measurement data. The DUTs and probe tips are then safe from the transient DC peaks of the power supplies usually generated due to the high energy emission of output capacitors of the power supply. Moreover, in cases of device failure, the fast switch-off process of the e-fuse restricts the damage to its origin. Hence, the defective part can be located, which helps in detecting the sources of failure and is very important for device development.

HOW E-FUSING WORKS

As discussed above, the main reason for damage is a high drain current. Thus, if the drain bias is switched off very fast, the damage can be avoided in many cases. For this purpose, two things are needed, the first of which is to follow the instantaneous drain current continuously, and the second is to switch it off very fast and efficiently, that is without any parasitic DC pulse or overshooting. ***Figure 2*** shows a schematic diagram of the circuit realizing these functions. The e-fuse circuit (shown in the shaded area) works as follows: The voltage across the resistor R_m is proportional to the drain current. This voltage is monitored and compared with a variable reference voltage V_{ref}. If the voltage drop across R_m is higher than V_{ref}, the flip-flop will be turned off. The transistor Q1 driven by the flip-flop will cut the drain supply of the DUT very fast. The flip-flop can be turned on or off via the front panel. After a break action, the flip-flop must be reset or switched on for further measurements. The essential feature of the e-fuse is its switching characteristic that should be fast and free from parasitic pulses and peaks. ***Figure 3*** shows data taken from an oscilloscope. The current is shown as a function of time. Switching off 10 A of continuous current takes approximately 150 ns. One can observe that the switching is very clean in terms of unwanted pulses or peaks.

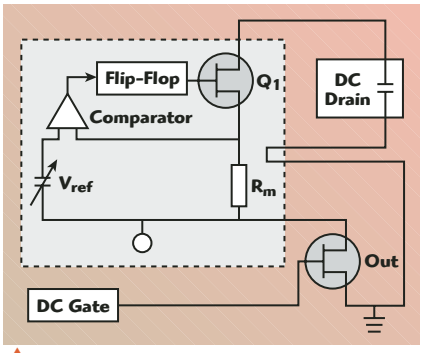


Fig. 2 Schematic diagram of the e-fuse circuit.

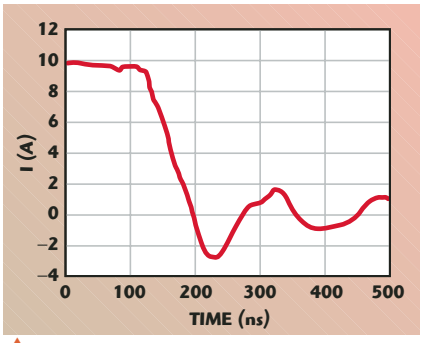


Fig. 3 Oscilloscope trace showing switching action.

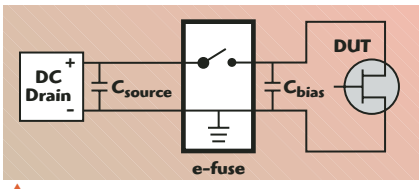


Fig. 4 Typical measurement system connected with an e-fuse.

MEASUREMENT EXAMPLES

In this section, some measurements performed with and without the e-fuse connected at the drain are presented. The output capacitance of common laboratory power supplies, which is shown as C_{source} in ***Figure 4***, is in the range of 1 to 10 µF. If the drain voltage is assumed to be 28 V, the stored energy in the power supplies reaches 0.4 to 4 W. If an e-fuse is connected, C_{source} is isolated from the DUT. Therefore, only the stored energy in the bias tee, that is the energy in C_{bias} and an additional contribution due to the switching action are effective and can damage the DUT. A typical bias tee has a capacitance of 10 to 100 nF, hence the energy stored is approximately 40 to 400 µW. Assuming a total short resistance of 1 Ω and a total switching time of 1 µs, there is an additional switch-off energy of about 400 µW. Therefore, depending on the actual conditions of the devices used, applying an e-fuse drastically reduces the stored energy in the example above by a factor of 500 to 10,000. ***Figure 5*** shows photographs of a GaN HEMT measured without e-fuse before and after a catastrophic failure, which led to excessive drain current causing an explosion of the transistor.

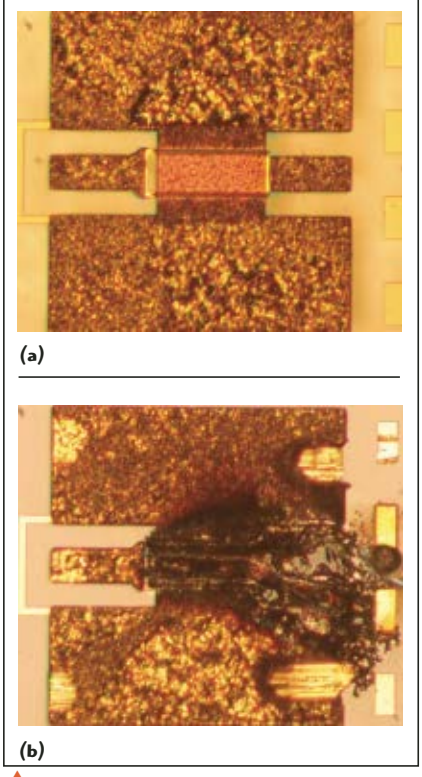


Fig. 5 A GaN HEMT before (a) and after (b) catastrophic failure.

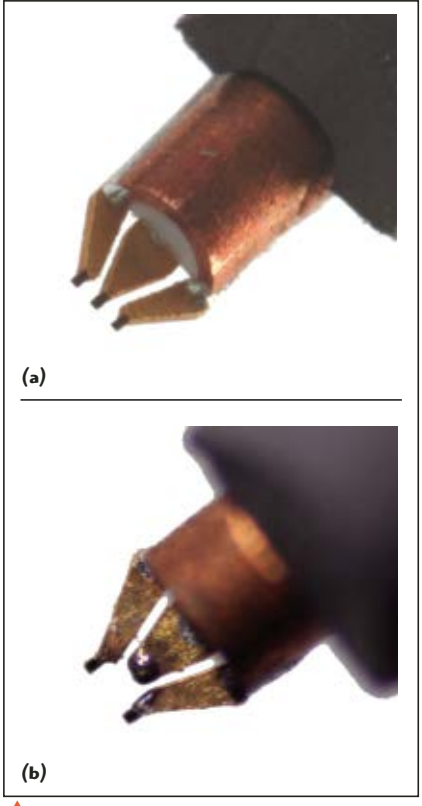
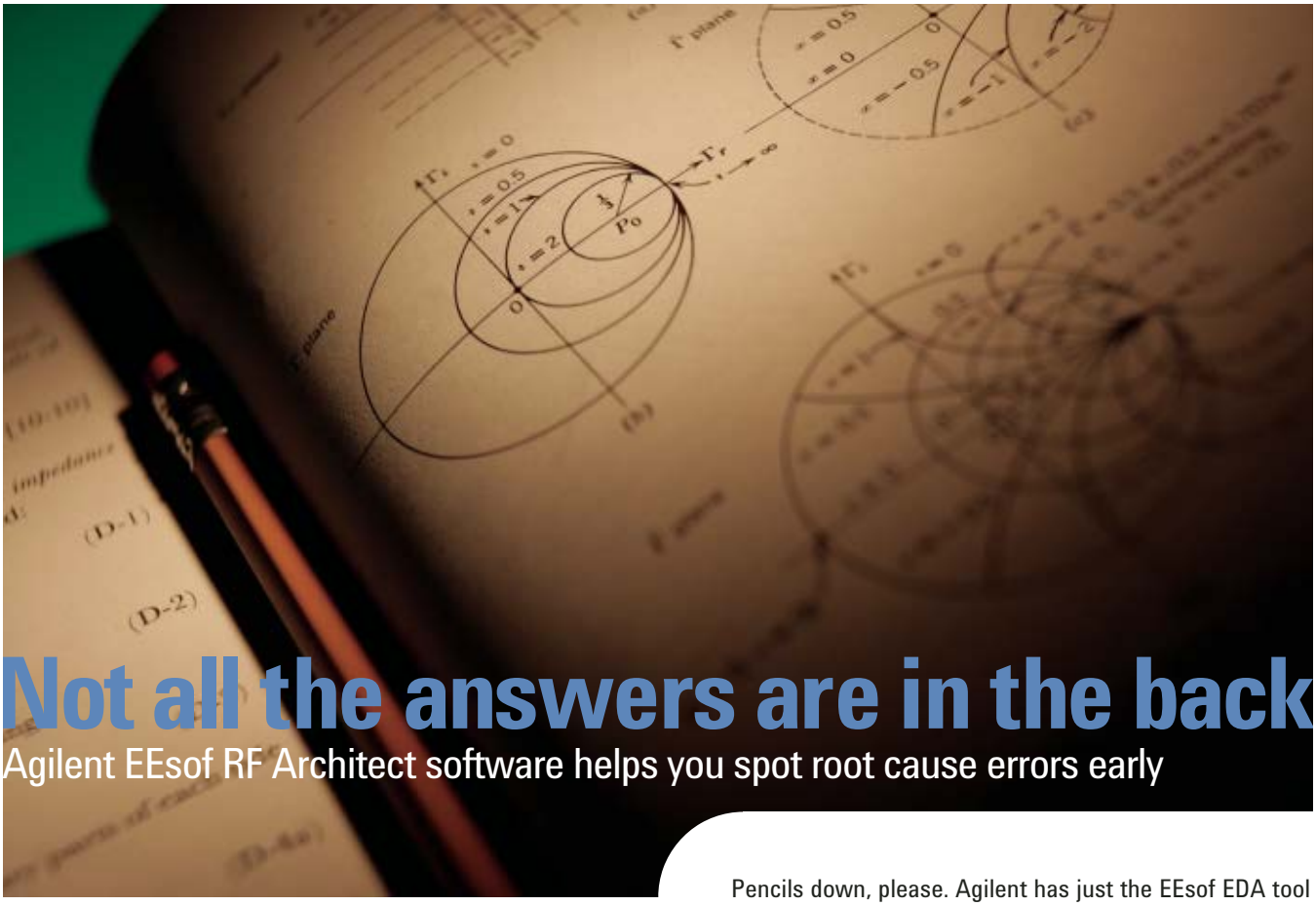


Fig. 6 The probe tip before (a) and after (b) catastrophic failure.



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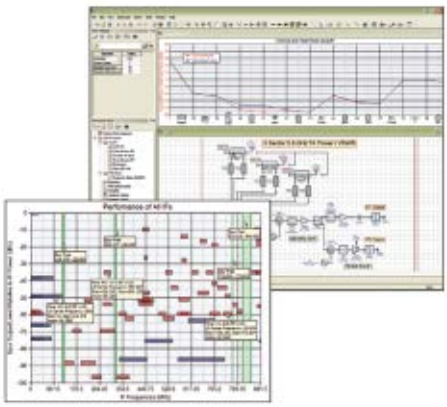

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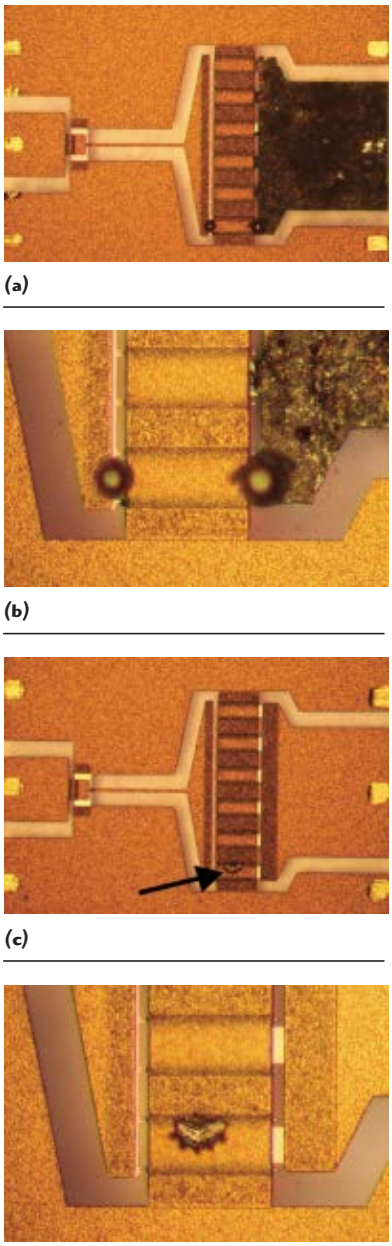
As can be seen the drain side is completely burnt out. Even worse, however, this damaged the probe tips as well. ***Figure 6*** shows the probe before and after the failure. The center finger of the probe tip has simply melted and partially evaporated. This can be avoided by using the e-fuse. In the following, an example will be shown. ***Figure 7*** illustrates the situation. Figures (a) and (b) refer to the case without e-fuse. It can be seen that the drain side of the multi-finger device is burnt completely and the damage extends to the probes causing tip damage. In contrast, Figures (c) and (d) show the results for a similar kind of problem while using the e-fuse. Only a minimum burnout has taken place, where only a single finger is damaged and the drain contact remains intact leaving the tip unaffected. This is important not only in order to save the cost of the measurement equipment, but also because it allows better localization of the origin of the failure within the transistor. Overall, the benefits of the quick drain fusing are obvious.



▲ *Fig. 7 Transistor after failure during RF measurements: (a) and (b) without e-fuse; (c) and (d) using e-fuse.*

CONCLUSION

In this article, a very effective method is presented to perform safe RF power measurements with e-fusing. Using the proposed e-fuse, it is possible to protect the measurement equipment and the devices from burnout due to excessive output current. Thus, in case of damage, the device remains diagnosable, which helps to understand the mechanism of failure. E-fuse also protects devices from unwanted DC peaks generated from DC sources. Such an e-fuse is particularly recommended when employing low cost DC-supplies. ■

References

1. J.D. Brown, et al., "Performance of AlGaN/GaN HEFTs Fabricated on 100 mm Silicon Substrates for Wireless Basestation Applications," *2004 IEEE MTT-S International Microwave Symposium Digest*, Vol. 2, pp. 822–836.
2. B.S. Doyle, D.B. Krakauer and K.R. Mistry, "Examination of Oxide Damage During High Current Stress of n-MOS Transistors," *IEEE Transactions on Electron Devices*, Vol. 40, 1993, pp. 980–985.
3. D. Park, et al., "A Full-process Damage Detection Method Using Small MOSFET and Protection Diode," *IEEE Electron Device Letters*, Vol. 17, December 1996, pp. 563–565.
4. S. Cripps, *RF Power Amplifier for Wireless Communications*, Artech House Inc., Norwood, MA, 1999.
5. G. Gonzalez, *Microwave Transistor Amplifiers Analysis and Design*, Second Edition, Prentice Hall Inc., Upper Saddle River, NJ, 1997.

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MULTIPLEXERS FOR MULTI-BAND WIRELESS HANDSET APPLICATIONS

Many major RF component suppliers are offering integrated RF front-end modules (FEM), which are rapidly being adopted in today's cell phones. This is due to the fact that handsets do not merely make phone calls anymore; rather they are multimedia systems to be used for taking photos, playing video, games, music, e-mail and surfing the Web. This additional functionality results in less space for the radio front-end, which itself is trending towards increasingly complex multi-band/multi-mode operation. The RF front-end consists of several main building blocks: transceivers, power amplifiers (PA), duplexers (for CDMA/WCDMA systems) and switches (for GSM systems). Various strategies of system-in-package integration in the market include PA plus duplexers, PA plus switches, multiple blocks of filters/duplexers (multiplexers) and switch plus filters (such as antenna switch modules or ASM).[1] CDMA phones are adopting multiplexers and PA and duplexer FEMs, while GSM/WCDMA phones make more use of the PA plus switches and ASM FEMs.[1,2] Each integrated solution presents its own unique performance value proposition, but all offer common size reduction and quicker time-to-market. The integrated solutions produce shorter design cycles because they already handle the interactions between the discrete components such as matching and loading and simply have fewer RF components to put together. This article discusses specifically the multiplexer integration solution: what is it, what is needed to make a good one, provides several examples and speculates on future trends.

There are three main advantages to using multiplexers: size, performance and speed of integration.

WHAT IS A MULTIPLEXER?

A multiplexer is a device that combines multiple frequency band inputs onto a single antenna output. The advantage of this integration strategy is that it uses the same technology, so filter companies are able to parlay their expertise rather than combine unfamiliar technologies together. One clear advantage of a single antenna output is the elimination of additional antennas, which saves hardware cost to the manufacturer. Many examples exist in the worldwide market today, including triplexers and quintuplexers (PCS/Cellular/GPS) for the US market, quadruplexers (WCDMA Band 1+KPCS) for the Korean market and hexaplexers (WCDMA Bands 1,6,9) for the Japanese market.[1–3]

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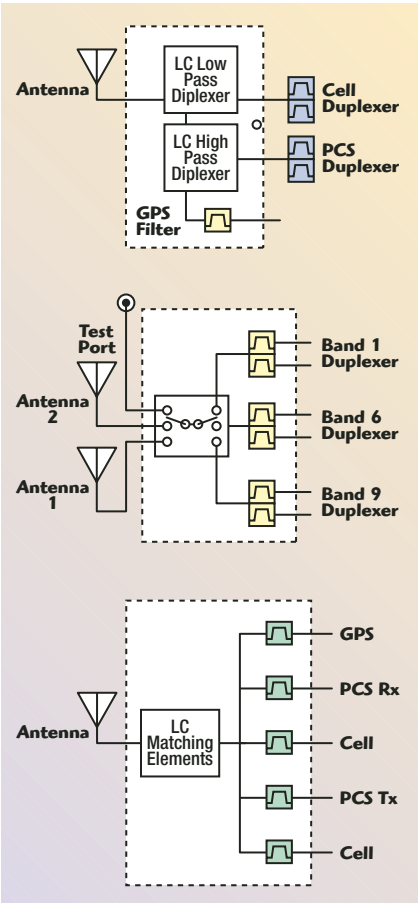
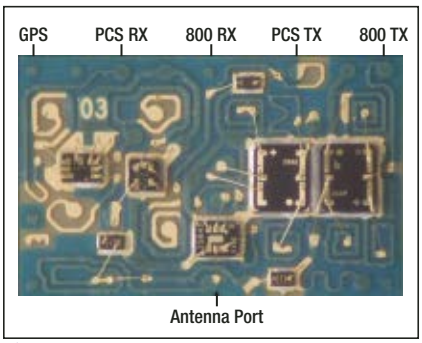
There are three main advantages to using multiplexers: size, performance and speed of integration. Substantial PCB space reductions of up to 70 percent could be realized, while routing and matching losses are reduced or eliminated, improving performance. The improved insertion loss performance is becoming increasingly important in the receive chain, due to the industry migration towards cheaper CMOS chipsets that have worse noise figure and sensitivity and in the transmit chain, due to all the new functionality, which increases power consumption. The ability to drop a single known-good-module onto a phone board rather than integrating many discrete components is attractive as a time saving in the phone design cycle and has improved final phone test yield.



▲ *Fig. 1 Schematics of the various levels of multiplexer integration.*



▲ *Fig. 2 An assembled quintuplexer prior to encapsulation.*

What are the disadvantages? Careful design of the I/O lines and grounding on the phone will be necessary when implementing this solution because the I/O pads are closely spaced and prone to cross talk, which then results in poor sensitivity. Sensitivity should not be an issue with proper PCB design. Since multiplexers are still a relatively new concept, securing multiple sources with expertise in the manufacturing of multiplexers could also be a difficulty. Lastly, antennas for certain duplexer combinations (such as WCDMA Bands 1,4,5) are quite difficult to design and build.

The two main schemes to enable a single antenna output in multiplexers are active switches or passive lumped element (LC) matching circuits. Both schemes serve the same purpose, that is to make the other duplexers/filters look like open circuits while allowing signals in the frequency band of interest to reach the antenna. The advantage of the lumped element matching circuit is that it allows for simultaneous operation of multiple bands, eliminates the need for the control lines needed for switches and provides significant additional wideband rejection. This functionality is very attractive for new CDMA phones, which today use simultaneous GPS operation to comply with the E911 mandate from the FCC. Both triplexers and quintuplexers utilize this totally passive method and are adopted in a majority of new US phones.

Switches are needed when bands overlap, such as in the 1,2,5 WCDMA world phone bands (Band 1 Tx is 1920 to 1980 MHz and Band 2 Rx is 1930 to 1990 MHz), which makes it impossible to use the LC approach. In Japan, switches are used in essentially all the tri-band WCDMA phones because that specific phone architecture demands three different outputs (two for voice/data and one test port). ASM modules have been widely adopted in the GSM world, integrating quad-band GSM Rx filters and switches together. ASMs are now adding on WCDMA ports, but not yet integrating the duplexers within. Switch integration has been accomplished either as a discrete module soldered onto a motherboard or buried into the LTCC cavity substrate.

Figure 1 illustrates different levels of integration for the various multiplexers on the market. The blue color identifies the off modules discrete duplexers; the yellow, discrete filters/duplexers soldered onto the multiplexer motherboard; and the green, the filters mounted on the motherboard. The first level of integration is illustrated with the triplexer (3.2 × 3.2 × 1.6 mm). The triplexer implements the LC matching elements integrated in the LTCC substrate with a GPS filter mounted on top while keeping the PCS and cell band duplexers separate as discrete components. This method has maximum flexibility for the phone manufacturer to use multiple suppliers. However, board space usage is higher because three separate components are used to accomplish the filtering. The second level of integration is to solder the discrete duplexers/filters all on a single motherboard. In Japan, the hexaplexers have three discrete SAW duplexers mounted onto a common motherboard with footprints as small as 6 × 5 × 1.2 mm. Japan has the highest level of WCDMA adoption in the world with tri-band WCDMA operation commonplace. While the size of discrete duplexers is shrinking, currently at 3 × 2.5 mm and with a next target footprint of 2.5 × 2 mm, the size of this type of multiplexer will be limited by the ability of discrete duplexers to shrink. The third and highest level of integration can be seen in the quintuplexer (5 × 8 × 1.2 mm), shown in ***Figure 2***, where the matching and wafer level packaged filters are all integrated onto a single PCB. There are five FBAR die and three capacitors die mounted onto the multiplexer substrate. This provides the maximum level of reduction in x, y and z dimensions of the module and should be the trend as filter integration continues. Currently only film bulk acoustic resonators (FBAR) and solidly mounted resonator (SMR) bulk acoustic wave

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(BAW) are conceptually able to create modules with this level of integration as they already have demonstrated wafer level packaging technologies (microcap for FBAR and bump SiP for BAW) to assure hermeticity.[7,8] Surface acoustic wave (SAW) filters do not yet have wafer level packaging capability and thus are limited to the previous two levels of integration; although a new type of wafer level packaged SAW filter, called interface acoustic wave (IAW), has been demonstrated in literature and could be not far behind commercially.[9] Achieving this level of integration is challenging for several reasons. First, all the individual building blocks need to be available. Then, actually integrating them together requires an accurate EM simulation to successfully control all the interactions of the closely placed of LC components and wire bonds on the module. Finally, and not to be underestimated, is the concatenated yield loss created by putting several duplexers/filters together all on a single PCB.

BUILDING A BETTER MULTIPLEXER

Building good multiplexers relies on good filter components. The qualities to look for in a good filter include high Q, access to high coupling coefficients (kt^2) when needed and low sheet resistance of the electrodes. The filter technologies currently capable for multiplexer integration are bulk acoustic wave (BAW) and surface acoustic wave (SAW). ***Table 1*** shows a table of the Q factors for various technologies.[1,2] SAW filters dominate the GSM and low frequency (< 1 GHz) space. Cost-wise, they have the advantage of low die cost due to simple wafer processing and a large existing fully depreciated manufacturing base. SAW filters can incorporate a single-ended to differential transformation without the need for external baluns, which is a key for GSM Rx applications. BAW technology, which comes in two flavors, FBAR and SMR, has become the standard technology for US PCS duplexer applications.[12] The high Q of the FBAR filters has enabled superior insertion loss (IL) performance, especially when the bands are spaced closely together (see ***Figure 3***). Another of BAW's attractive features is the potential for monolithic or above IC integration with CMOS chips, with filter/LNA/mixer SoC devices already demonstrated in the literature.[1] Ceramic filters, while being very cheap and a well-established technology, are fading away due to larger size and inability to integrate.

However, having good stand-alone filters available does not necessarily guarantee good multiplexer performance. A good out-of-band return loss (RL) is needed from all the filters hooking up to the antenna as out-of-band RL is additive to the IL of each filter in the multiplexer. FBAR technology has the best out-of-band RL (~ –0.2 dB) among the discussed filter technologies, since it uses an air interface on either side of the resonator. The air interface has a very large reflecting bandwidth while SMR-BAW and SAW both use Bragg reflectors, which have a much more limited reflecting bandwidth resulting in less attractive out-of-band (~ –0.6 dB) RL. FBAR multiplexers have been demonstrated in phones to have 1 dB better handset sensitivity and longer battery life than designs using the same duplexers as discrete components. Up to half of the improvement is accounted for by the better out-of-band RL. A design advantage of the multiplexer is that individual duplexers need not have excellent wideband rejection because the LC matching network provides additional wideband rejection for free. This means that the discrete duplexer performance can focus on better IL and near band rejection/isolation specs. A good example is the quintuplexer, where narrowband PCS and cell duplexers are integrated with a GPS filter. As shown in ***Figure 4***, a stand-alone PCS duplexer has very little out of band rejection, but the second harmonic rejection improves by more than 10 dB when incorporated in the multiplexer without any change in the duplexer design.

THE NEXT STEP

While today's WCDMA phones are mostly single or dual-band, the future trend is towards tri-band for worldwide roaming and increased capacity within a country. A multiplexer that utilizes the LC matching scheme should be advantageous in this application because it will allow the addition of more frequency bands without adding more switches. This is helpful because present switches already have difficulty meeting the linearity threshold needed to meet 3GPP blocking specifications without expending exceptions. Each new switch adds more nonlinear capacitance to the module, which will increase distortion even further. For example, tri-band configurations, such as Band 1, 2 and 5 for US-centric and Band 1, 8, (2, 4 or 5) for Europe-centric phones, could use single throw eight pole

TABLE I

Q FACTORS FOR SAW, SMR-BAW AND FBAR TECHNOLOGIES AT US PCS FREQUENCIES

		Q_s	Q_p
BAW	FBAR	2780	2880
BAW	SMR	900	2500
SAW	Leaky mode	310	430
SAW	Raleigh mode	320	1080

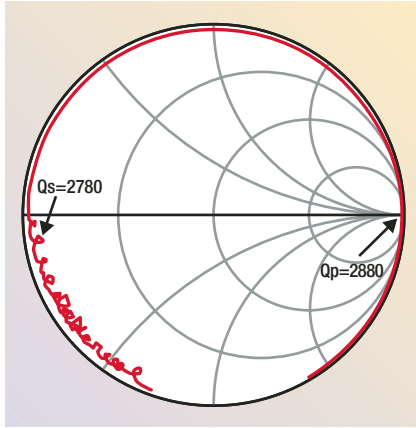


Fig. 3 Q circle plots of a fabricated 2 GHz FBAR.

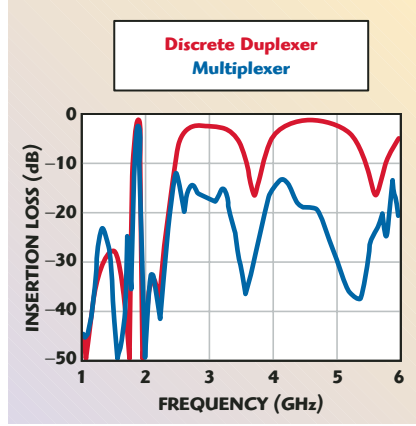
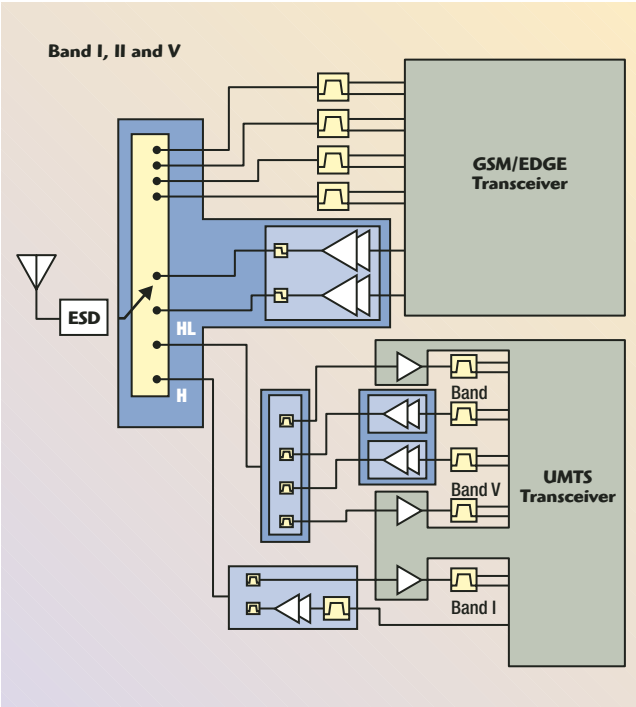


Fig. 4 PCS transmitter to antenna insertion loss for a discrete duplexer and a multiplexer.



▲ *Fig. 5 GSM/WCDMA concept architecture with three FEMs.*

ST8P switches with a multiplexer versus adding 2 to 3 throws with a discrete duplexer solution. ***Figure 5*** shows a GSM/WCDMA concept architecture with three FEMs. A Band 2, 5 multiplexer is used to reduce the number of switches needed. The switch and GSM PA are shown integrated as a FEM. The Band 1 chain is shown as an (input filter/duplexer) FEM. The savings is worthwhile, not only for size (a WCDMA switch is approximately three times the die size of a GSM Rx switch), but also in linearity. The extra wideband rejection from the LC matching network in front of the multiplexer could help to suppress certain jammer signals coming through the antenna before reaching the duplexers and thus improve IMD 2/3. Harmonics performance should also benefit from the extra out-of-band rejection suppressing the harmonics going out the other direction from the Tx chain. Eventually, it makes sense to integrate WCDMA duplexers, GSM Rx filters and the switch to make a single (switch, WCDMA, GSM) FEM even farther down the line. In this configuration, the phase angle between duplexer and switch, which has been shown to influence the amount of IMD generated in the cascaded switch/duplexer chain, can then be controlled and minimized.[1]

CONCLUSION

Multiplexers have made significant penetration in the duplexer market in recent years. The three main benefits of using multiplexers are size reduction, improved performance and speed of integration. It integrates by technology and thus can effectively leverage the expertise of filter companies. Various filter technologies and integration schemes have been presented that work in creating multiplexers with wafer level packaged filters directly attached to a single substrate as the preferred path towards even further size reduction and integration. There is a clear benefit provided by multiplexers in tri-band CDMA phones today and value in applying the same methodology in multi-band WCDMA phones in the future. ■

References

1. F. Van Straten, B. Smolders, A. Van Zuijlen and R. Ooijman, "Multi-band Cellular RF Solutions, *IEEE Journal of Solid-State Circuits*, Vol. 39, No. 10, October 2004, pp. 1598–1604.
2. G. Zhang, S. Chang and A. Wang, "WCDMA PCS Handset Front End Module," *2006 IEEE MTT-S International Microwave Symposium Digest*, Vol. 1, pp. 304–307.
3. H. Mandai and N. Nakajima, "Passive Integration with SAW Filter Using LTCC (Low Temperature Co-fired Ceramics) and Multi-layer Technology," *2002 IEEE Ultrasonics Symposium Proceedings*, Vol. 1, pp. 81–84.
4. T. Jamneala, P. Bradley, D. Feld, D. Clark and A. Chien, "A Generic Passive Matching Network for Multiplexers," *IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control*, June 2007.
5. P. Bradley, J. Kim, S. Ye, B. Yu, K. Grannen, D. Lee, D. Hula and W.K. Kim, "A 6-Port Film Bulk Acoustic Resonator (FBAR) Multiplexer for US CDMA Handsets Permitting Simultaneous Use of PCS, Cellband and GPS with a Single Antenna," *2006 IEEE Ultrasonics Symposium Proceedings*.
6. M. Buchsbaum, C. Korden, E. Leitgeband and H. Faulhaber, "Design of a High Integrated Triplexer Using LTCC Technology," *IEEE MTT-S International Microwave Symposium Digest*, pp. 378–381.
7. K. Wang, W. Mueller, R. Ruby, M. Gat, P. Bradley, A. Barfknecht, F. Geefay, C. Han, G. Gan, A. Chien and B. Ly, "High Rejection Rx Filters for GSM Handsets with Wafer Level Packaging," *2002 IEEE Ultrasonics Symposium Proceedings*, pp. 925–929.
8. M. Franosch, K.G. Oppermann, A. Meckes, W. Nessler and R. Aigner, "Wafer-level Package for Bulk Acoustic Wave (BAW) Filters," *2004 IEEE MTT-S International Microwave Symposium Digest*, Vol. 2, pp. 493–496.
9. H. Kando, D. Yamamoto, M. Mimura, T. Oda, A. Shimizu, K. Shimoda, E. Takata, T. Fuyutsume, R. Kubo and M. Kadota, "6B-4 RF Filter Using Boundary Acoustic Wave," *2006 IEEE Ultrasonics Symposium Proceedings*, pp. 188–191.
10. M. Kadota, T. Nakao, K. Nishiyama, S. Kido, M. Kato, R. Omote, H. Yonekura, N. Takada and R. Kita, "Small SAW Duplexer for W-CDMA Full-band with Good Temperature Characteristics," *Third International Symposium on Acoustic Wave Devices for Future Mobile Communication Systems*, March 2007, Chiba, Japan.
11. T. Nakao, M. Kadota, K. Nishiyama, Y. Nakai, D. Yamamoto, Y. Ishiura, T. Komura, N. Takada and R. Kita, "Smaller SAW Duplexer (32.5 mm^2) for US-PCS Having Good Temperature Characteristics," *Japan-Taiwan Workshop on Future Frequency Control Devices*, March 2007, Chiba, Japan.
12. R. Ruby, P. Bradley, Y. Oshmyansky, A. Chien and J. Larson III, "Thin Film Bulk Wave Acoustic Resonators (FBAR) for Wireless Applications," *2001 IEEE Ultrasonics Symposium Proceedings*, Vol. 1, pp. 813–821.
13. K.M. Lakin "Thin Film Resonator Technology," *IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control*, Vol. 52, No. 5, May 2005, pp. 707–716.
14. P. Ancey, "Above IC RF MEMS and BAW Filters: Fact or Fiction?," *Bipolar/Bi CMOS Circuits and Technology Meeting*, October 2006, pp. 1–5.
15. T. Ranta, J. Ella and H. Pohjonen, "Antenna Switch Linearity Requirements for GSM/WCDMA Mobile Phone Front-ends," *The European Conference on Wireless Technology*, October 2005, pp. 23–26.

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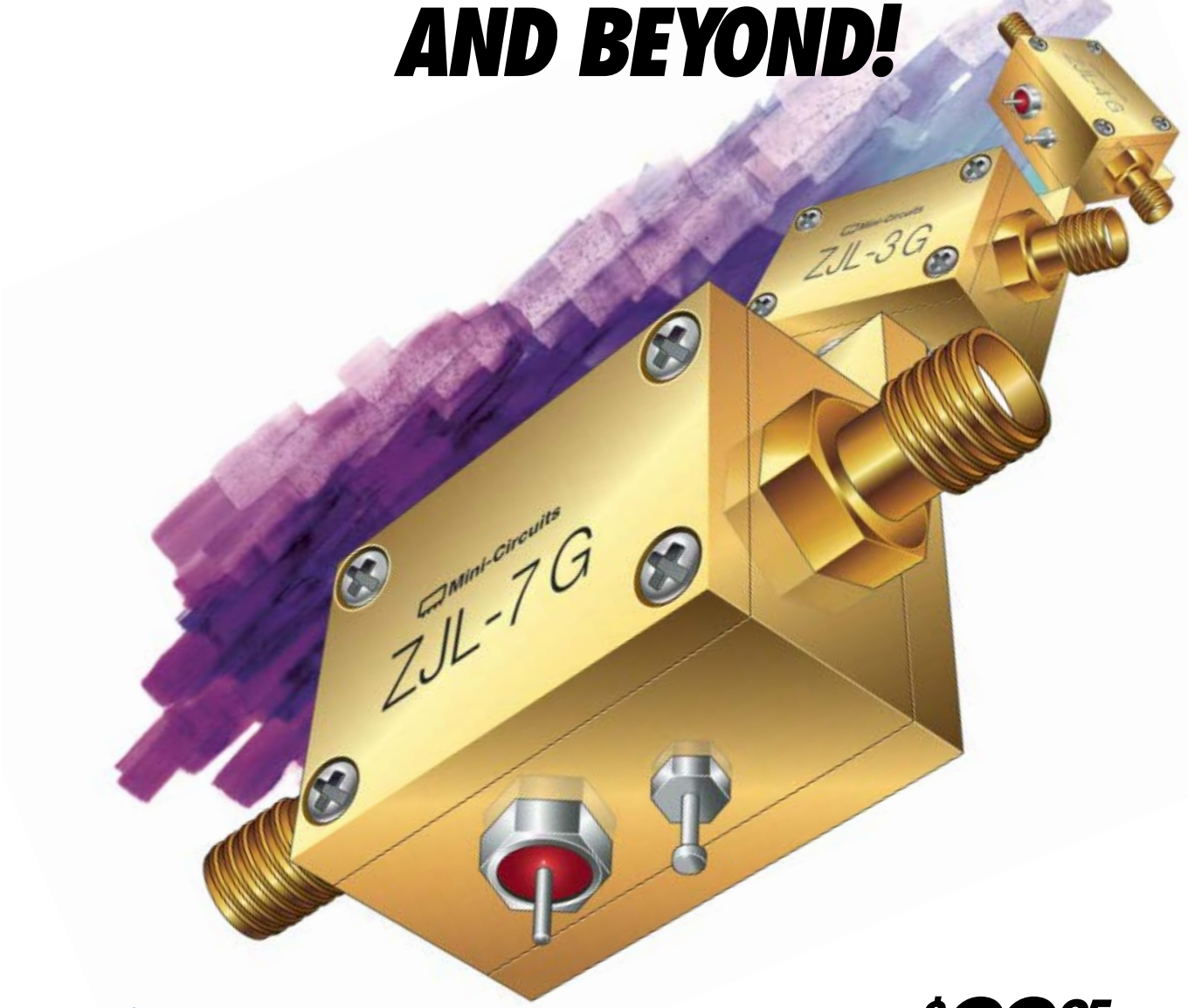

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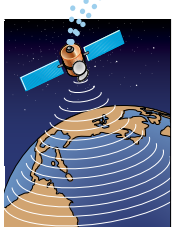

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ZJL-4G	20-4000	12.4	±0.25	13.5	5.5	30.5	75	129.95
ZJL-6G	20-6000	13.0	±1.6	9.0	4.5	24.0	50	114.95
ZJL-4HG	20-4000	17.0	±1.5	15.0	4.5	30.5	75	129.95
ZJL-3G	20-3000	19.0	±2.2	8.0	3.8	22.0	45	114.95
ZKL-2R7	10-2700	24.0	±0.7	13.0	5.0	30.0	120	149.95
ZKL-2R5	10-2500	30.0	±1.5	15.0	5.0	31.0	120	149.95
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A FAMILY OF SILICON CARBIDE UHF AMPLIFIERS

A new class of high power, broadband amplifiers has been developed to utilize the inherent advantages of silicon carbide (SiC). With instantaneous bandwidths of 200 MHz to 1 GHz and exceptional reliability, this new family of amplifiers is highly suited to several markets. In particular, its inherent reflected-power tolerance makes it appropriate for the needs of the EMC test industry (RF immunity testing) and for the testing of high power RF components. High reliability combined with compact size and low weight also make the family suitable for use in commercial applications where space is at a premium and portability can be used to advantage.

The design approach taken when developing this new amplifier family means that it incorporates important key features, including a comprehensive built-in test (BIT) capability included as standard, a large degree of flexibility in the offered output powers, retrospective upgrading of the power level and automatic master/slave control when like amplifiers are interconnected.

TABLE I

KEY PROPERTY DIFFERENCES BETWEEN SILICON AND SILICON CARBIDE USED IN RF TRANSISTORS

	Si	*SiC*
Band gap (eV)	1.1	3.26
Breakdown voltage (kV/cm)	300	2200
Thermal conductivity (W/m.K)	130	370
Maximum operational temperature (°C)	150	600

THE SIC ADVANTAGE

This family of UHF multi-octave power amplifiers has other interesting features facilitated by the inherent properties of the wide band gap silicon carbide technology it utilizes. For instance, the transistor structure enables operation into high VSWR loads, including short and open circuits, without the need for protective circuits. The material's channel-heat conductivity and high channel maximum operational temperature also result in long-term reliability and an improved power handling capability. Importantly too, the utilization of 21st century power transistor technology means a low risk of transistor obsolescence in the foreseeable future.

SiC has power density figures per gate width around eight times those of conventional silicon. This superior power density leads to significant size and weight reduction. For instance, model RF250 (200 to 1000 MHz, 250 W) is 3U high (5¼ inches) and weighs approximately 26 kg (57 lbs). Commercially available silicon-based 250 W UHF amplifiers can be more than three times this size and weight. ***Table 1*** highlights the key property

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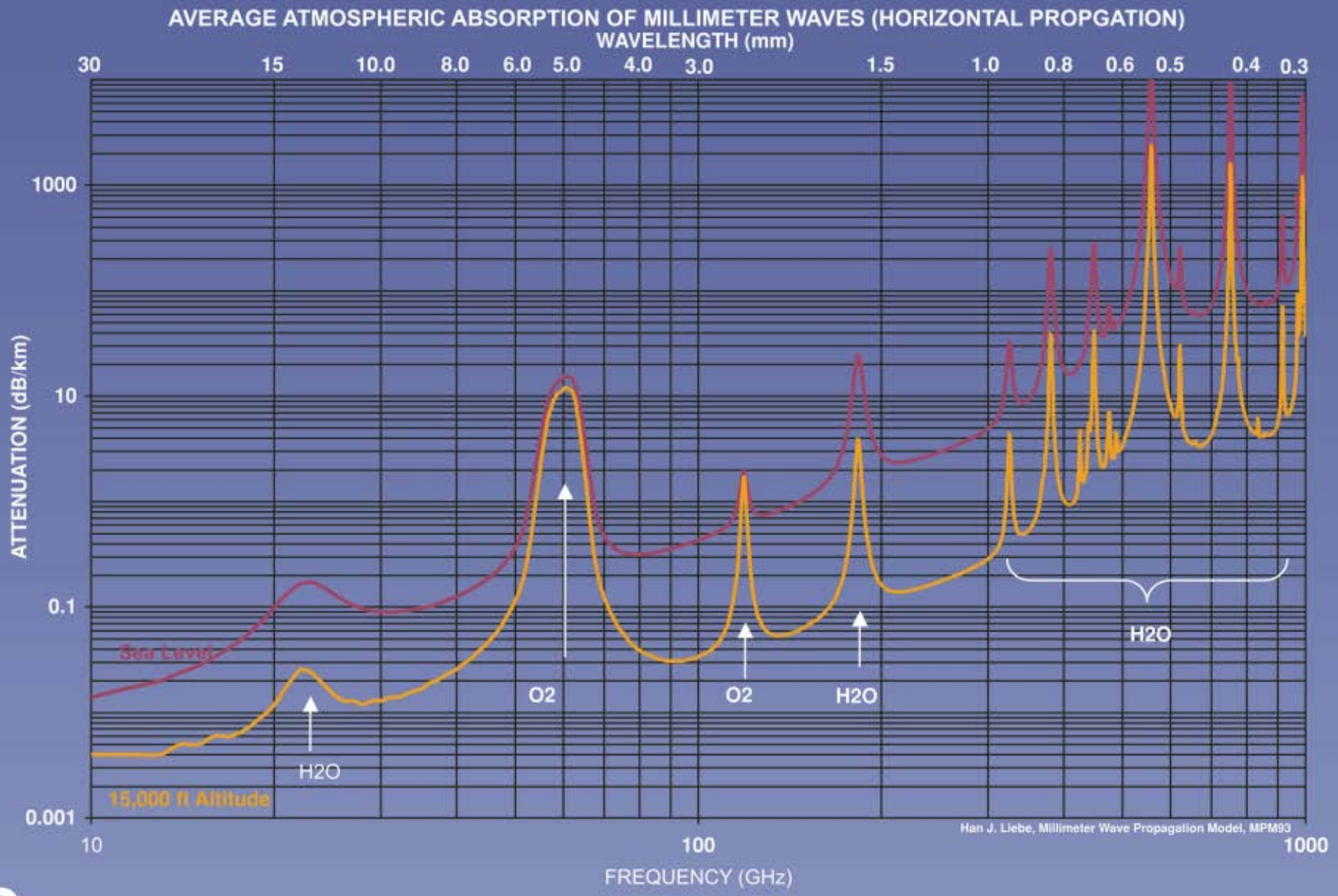
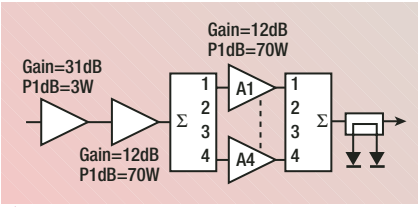


differences between silicon as used in conventional silicon RF transistors and silicon carbide.

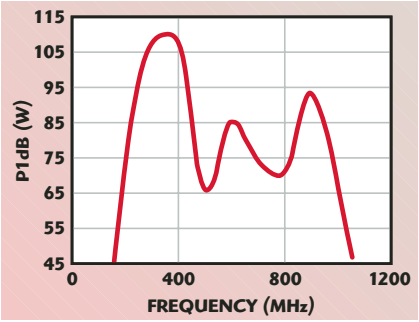
This size/weight factor is of paramount importance for military platforms that need to maximize payload. However, from a commercial perspective, at power levels of 500 W and above, the size and weight constraints associated with conventional power amplifiers force the situation where the majority of power amplifiers in test stations are immobile. With the advent of silicon carbide, portability is an option that can be capitalized on. For instance, sharing high capital cost equipment between test stations and between test sites is now a practicality.

RF250 ARCHITECTURE

The amplifier RF topology follows a Corporate Structure Architecture (CSA) approach, as shown in ***Figure 1***. The name comes from the similarity of the layout of the RF building blocks to that of a corporate organization chart, but turned 90° clockwise. The advantages of the CSA design methodology have been proven in the company's microwave range and are now being exploited in this RF range.



▲ *Fig. 1 RF250 RF topology following a Corporate Structure Architecture approach.*



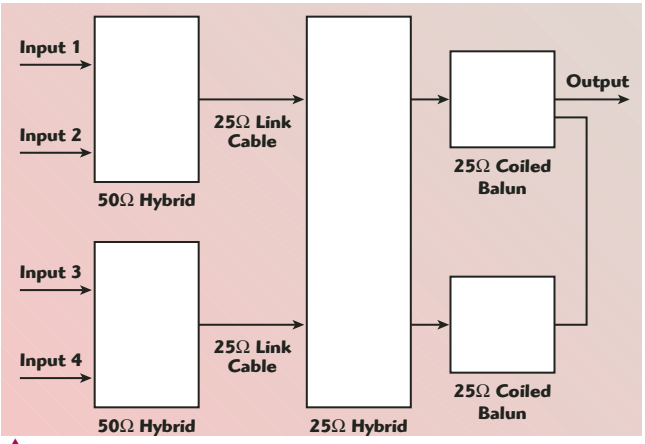
▲ *Fig. 2 P1dB performance of the 70 W module over the band of interest.*

The building block of the amplifier's output rank is a 200 to 1000 MHz, 70 W P1dB power module, with a typical gain of 12 dB. Concentrating on the development of a single common power module has the virtue that a high percentage of engineering resource (microwave, electrical, thermal, mechanical) can be focused to design a component around which a reliable system can be built.

OUTPUT RANK POWER MODULE

The transistor at the heart of this module is the CRF-24060, a silicon carbide MESFET from Cree Inc. A combination of simulation work using the supplied large-signal model, supplemented by load pull data collected within MILMEGA, has brought about the development of high quality matching networks that require minimal tuning to be applied at the manufacturing stage. These matching circuits were optimized for P1dB performance.

Power is developed within the module by combining two transistors in a balanced pair configuration, using one level of quadrature combining. This, in addition to the inherent robustness of the SiC devices, enables the modules to absorb 100 percent reflected power, even when the module is operating at full output power. This can be a significant benefit to the system designer, if the amplifier is required to operate into high VSWR conditions. The P1dB performance of the module over the band of interest is shown in ***Figure 2***.



▲ *Fig. 3 The 4:1 combiner schematic.*

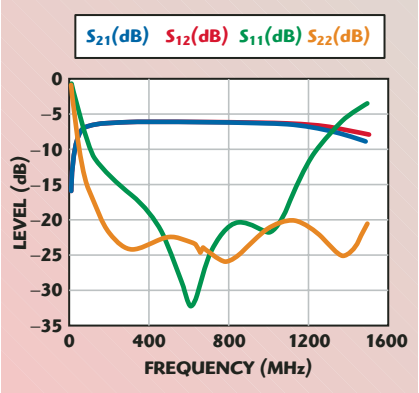
4:1 OUTPUT COMBINER

In designing the final output combiner it was vital that the insertion loss from input to output is an absolute minimum, thus reducing the gain and power requirements on the system preamplifier stages. The major building block of the output combiner is a ferrite-loaded hybrid, which functions as a two-way splitter/combiner. It also provides adequate isolation between its inputs and exhibits low insertion loss. Two versions of these hybrids are used, one a 50 Ω device and the other a 25 Ω device.

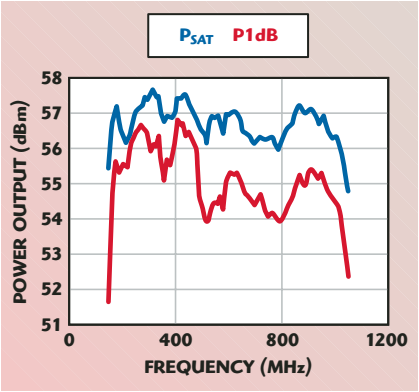
Figure 3 is a representation of this architecture in which two, two-way, 50 Ω hybrids combine the power from four RF inputs, resulting in two 25 Ω outputs. Each 25 Ω output then feeds a 25 Ω hybrid providing isolation between pairs of input sources. A pair of 25 Ω coiled baluns then impedance match to 50 Ω. ***Figure 4*** shows the measured transmission results obtained across the frequency band for this structure. Note the flatness of the amplitude response and the low insertion loss.

CONTROL SYSTEM

The overall control and sensing of the amplifier system is partitioned between three separate processors.



▲ *Fig. 4 The four-way combiner performance.*



▲ *Fig. 5 Final system power performance.*

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FPD1500DFN	18	27	42	1.2	7*	27	40	N/A	5	465
FPD750DFN	20	24	38	0.3	11.5*	24	38	N/A	5	230
FPD750SOT343	18	20	38	0.3	8*	20	38	N/A	3.3	230
FPD6836SOT343	20	20	32	0.5	9*	19	32	1.2	3	105

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First, the central control processor controls and monitors the system modules and provides the BIT functionality. Second, the local control processor acts as the interface between the front panel controls/indicators and the central control processor. It also senses and displays the forward and reflected RF power levels.

Finally, the communications processor acts as the interface between the central control processor and the outside world. Additionally, it permits expanded control and sensing at the next level of system integration, which is when multiple amplifier systems are interconnected. Each processor has in-circuit programming capability, enabling the software to be updated.

To provide BIT functionality, health signs, including voltage and current consumption, are monitored for each module. Key modules such as those in the RF line-up are monitored via direct connections to the central control processor. Less critical modules are monitored every few milliseconds via a multiplexer. A fault causes one of a column of LEDs to light. For convenience, the column is visible through the amplifier front panel.

EXPANDABLE CONTROL CAPABILITY

Initiated by detection of the presence of a specialized interconnecting cable, the expanded control feature permits any amplifier within a combination of amplifiers to be the master or slave in the overall operation of the combined amplifier system. Commands between the separate amplifiers are controlled and synchronized by the communications processors in each amplifier, the protocol being that the initiator of a command becomes the master with the other amplifiers in the system responding as slaves. The BIT functionality passes through to this next level of amplifier integration.

THE FINAL SYSTEM

The efficiency of the output combining circuit is demonstrated by the power achieved in the final system, as shown in ***Figure 5***. The RF250 delivers a P1dB performance of 250 W minimum, peaking at 480 W with P_{sat} a minimum of 410 W, peaking at 585 W. This represents state-of-the-art power density for this type of product resulting in an amplifier, which is approximately three times smaller and lighter than comparable units.

CONCLUSION

The inherent benefits of silicon carbide RF power transistor technology have been combined with the CSA design approach, together with distributed embedded intelligence to create a robust UHF power amplifier family providing high reliability, exceptional power density, ease of power upgrade and portability.

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100 W CLASS GaN POWER HEMTs FOR 2.5 GHz WiMAX APPLICATIONS

The push for mobile WiMAX started in earnest with Korea's announcement of its Wi-Bro (Wireless Broadband) a few years ago. The promise was to deliver to the user a broadband data service similar to DSL or Cable Modems but with all the benefits of mobility. The Wi-Bro standard has been harmonized with the IEEE 802.16 standards body to become what we now call 802.16e or mobile WiMAX.[1] Clearwire took the next steps in terms of mobile service provider adoption of this technology by offering a similar service as envisioned by Wi-Bro. We now see carriers with significant wireless voice businesses (Sprint & KDDI) making the decision to deploy mobile WiMAX technology in their home markets. Along the way, service providers have recognized that high quality coverage is vital to the success of this offering and the RF power amplifier is a key component to quality coverage.

The requirements for these mobile WiMAX amplifiers are among the toughest in the industry as they simultaneously push the boundaries of RF transmit bandwidth (200 MHz), average power out of the antenna (10 and 20 W at 10 dB PAR), efficiency (greater than 20 percent) and linearity (less than 2.5 percent EVM). During this same period of time, power amplifier designers are under demanding schedules as 3G networks around the world move into volume deployment. The available resource pool is very hard pressed to keep up with all the frequencies, bandwidths, power levels and linearity needs of mobile service operators around the globe.

The new NPT25100 GaN HEMT from Nitronex is a high power device based on the NRF1 platform that can be used to address multiple power amplifier scenarios including the demands of 3G and the emerging WiMAX market. The NPT25100 is ideally suited for power amplifiers covering the frequency range specified in WiMAX operations, that is, the 2.5 to 2.7 GHz frequency band, or the 2.3 to 2.5 GHz band being considered by Japanese operators, and at 2.1 GHz, where most WCDMA operators outside the US are transmitting.

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ZX95-100+	50-100	10.0	-110	17	-33	20	37.95
ZX95-535+	300-520	6.0	-101	17	-25	21	39.95
ZX95-1200W+	612-1200	10.0	-96	18	-16	30	49.95
ZX95-2150VW+	970-2150	4.0	-99	25	-22	26	54.95
ZX95-2745+	2000-2745	3.5	-96	24	-25	26	49.95
ZX95-2800+	1400-2800	3.5	-95	25	-15	30	49.95
ZX95-3000W+	2000-3000	5.5	-96	14	-22	35	49.95
ZX95-3360+	2120-3360	8.5	-95	18	-26	45	49.95
ZX95-3555+	3000-3555	5.0	-97	15	-23	41	40.95
ZX95-3760+	3200-3760	7.5	-96	15	-28	48	40.95
ZX95-5150+	4880-5150	3.5	-95	5.0	-30	53	44.95
ZX95-6030C+	5890-6010	2.0	-102	5.0	-22	28	54.95
ZX95-6740C	6640-6740	2.0	-97	5.0	-18	35	54.95

*Phase Noise: SSB at 10 kHz offset, dBc/Hz.

U.S. Patent Number 6,790,049

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VLF-95	DC-95	165	220
VLF-105	DC-105	180	250
VLF-120	DC-120	195	280
VLF-160+	DC-160	230	330
VLF-180+	DC-180	270	370
VLF-190+	DC-190	280	400
VLF-225	DC-225	350	460
VLF-320	DC-320	460	560
VLF-400	DC-400	560	660
VLF-490	DC-490	650	800
VLF-530	DC-530	700	820
VLF-575	DC-575	770	900
VLF-630	DC-630	830	1000
VLF-800	DC-800	1075	1275
VLF-1000	DC-1000	1300	1550
VLF-1200	DC-1200	1530	1865
VLF-1400	DC-1400	1700	2015
VLF-1450	DC-1450	1825	2025
VLF-1500	DC-1500	1825	2100
VLF-1525	DC-1525	1750	2040
VLF-1575	DC-1575	1875	2175
VLF-1700	DC-1700	2050	2375
VLF-1800	DC-1800	2125	2425
VLF-2250	DC-2250	2575	2900
VLF-2500	DC-2500	3075	3675
VLF-2600	DC-2600	3125	3750
VLF-2750	DC-2750	3150	4000
VLF-2850	DC-2800	3300	4000
VLF-3000	DC-3000	3600	4550
VLF-3800+	DC-3900	4850	6000
VLF-4400+	DC-4400	5290	6700
VLF-5000	DC-5000	5580	6850
VLF-5500+	DC-5500	6200	7200
VLF-5850+	DC-5850	6540	7600
VLF-6000	DC-6000	6800	8500
VLF-6400+	DC-6400	7200	8300
VLF-6700	DC-6700	7600	9300
VLF-7200+	DC-7200	8150	9500

U.S. Patent Numbers 6,790,049 & 6,943,646

High Pass *VHF Models $24.95 ea. (1-9)*

Model	Passband (MHz)	fco, Nom. Loss 3 dB (MHz) Typ.	Stopband Loss >20 dB (MHz) Min.
VHF-650	710-2490	650	480
VHF-740	780-2800	740	550
VHF-880	950-3200	880	640
VHF-1200	1220-4600	1180	940
VHF-1300	1400-5000	1300	930
VHF-1320	1400-5000	1320	1060
VHF-1500	1600-5500	1550	1250
VHF-1600	1650-5000	1600	1290
VHF-1760	1900-5500	1760	1230
VHF-1810	1900-4750	1810	1480
VHF-1910	2000-5200	1910	1400
VHF-2000	2260-6250	2000	1530
VHF-2100	2200-6000	2100	1530
VHF-2275	2450-7000	2275	1770
VHF-2700	2650-6500	2500	1800
VHF-2700A+	2900-8700	2700	2150
VHF-3100+	3400-9900	3100	2450
VHF-3500+	3900-9800	3500	2800
VHF-3800	4250-10000	3800	3200
VHF-4400+	5000-10100	4400	3500
VHF-4600+	5000-11000	4600	3800
VHF-5050+	5500-10000	5050	4200
VHF-5500	6000-11500	5500	4500
VHF-7150+	7900-11000	7150	6150
VHF-8400	9000-13000	8400	6000

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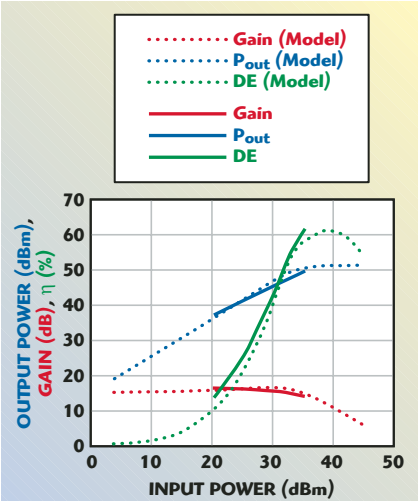
NPT25100 DESIGN AND NONLINEAR SIMULATION

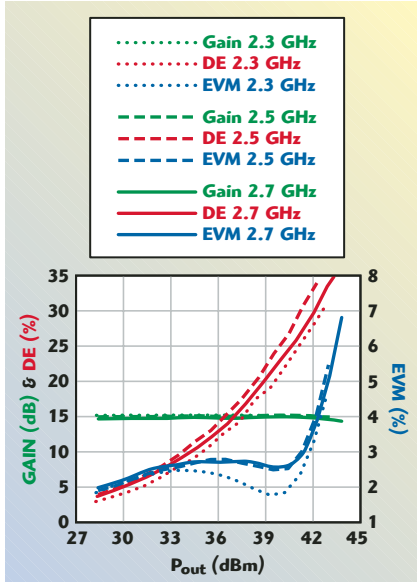
The NPT25100 uses a single GaN die mounted to a thermally enhanced Cu-Mo-Cu single-ended ceramic package using an AuSi eutectic process. The GaN die used to construct the NPT25100 is a 36 mm periphery AlGaN/GaN HFET grown by MOCVD on high resistivity 100 mm silicon substrates. The physical layout of the device consists of 0.5 µm gate length, 30 µm gate pitch and a unit gate width of 200 µm. The source is grounded to the package base using vias through the 100 µm thick Si substrate. The device uses a two-stage input matching network optimized to operate over the 2.3 to 2.7 GHz frequency band and does not contain an output matching network due to GaN's low output capacitance per watt, thus resulting in a broadband device. The design of the NPT25100 was greatly expedited by the availability of an accurate nonlinear GaN device model. Such a model, including device impedance matching networks, and package parasitics has been modeled in both AWR's Microwave Office (MWO) and Agilent's Advanced Design System (ADS). The nonlinear model developed for the GaN HFET is based on the work of Angelov at Chalmers University. The device models are openly available in both MWO and ADS and are known as "Angelov 2C" in MWO and "Angelov 2" in ADS. The model parameters were extracted on the basis of both DC and RF measurements of a 2 mm device and scaled to the required 36 mm gate width. The model accurately simulates forward gate diode conduction, self-heating, and RF performance over temperature and bias. ***Figure 1*** presents the modeled versus measured high power RF performance curves (output power, gain and power-added efficiency) of the NPT25100 device at 2.7 GHz demonstrating good correlation between model and measurement.



▲ *Fig. 1 Simulated and measured swept power curves for the NPT25100 at 2.7 GHz (device and model).*

2.3 TO 2.7 GHz WiMAX PERFORMANCE

The NPT25100 was tested using a 802.16E OFDM compliant waveform (64 QAM 3/4, 8 burst, 3.5 MHz, 10.3 dB PAR at 0.01 percent CCDF, 75 percent full data frame, 20 ms frame length). The device was load-pull tested at 2.3, 2.5 and 2.7 GHz at 28 and 32 V bias and 600 mA I_{DQ}. As evident from the data shown in ***Figure 2***, the device delivers 13 W of average RF power at 3 percent EVM with approximately 15 dB gain and greater than 25 percent drain efficiency. The equivalent source and load impedances presented to the device are provided in ***Table 1***.



▲ *Fig. 2 NPT25100 WiMAX performance at 2.3, 2.5 and 2.7 GHz at V_{DS} = 28 V and 600 mA I_{DQ}.*

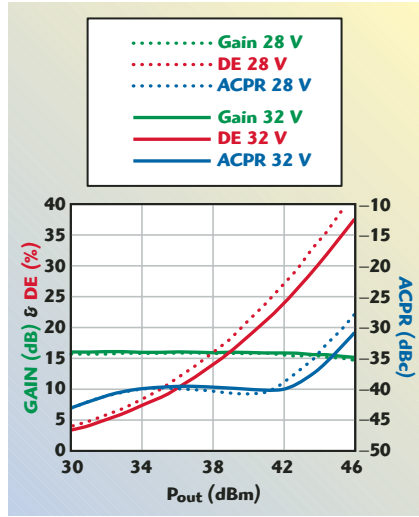
TABLE I

EQUIVALENT SOURCE AND LOAD IMPEDANCES FOR OPTIMUM PERFORMANCE UNDER OFDM

Frequency (GHz)	Z_{source} (Ω)	Z_{load} (Ω)
2.3	15.7 – j4.5	2.9 – j3.0
2.5	7.2 + j1.5	2.4 – j3.8
2.7	5.1 – j1.5	2.5 – j4.5

2.14 GHz WCDMA DATA IN NITRONEX LOAD-PULL SYSTEM

Since the NPT25100 is a broadband device, it was also tested at 2.14 GHz using a 3GPP WCDMA waveform (single carrier WCDMA, 8.5 dB PAR



▲ *Fig. 3 NPT25100 WCDMA performance at 2.14 GHz and V_{DS} of 28 V and 32 V with 600 mA I_{DQ}.*

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The European Microwave Association (EuMA) is an international non-profit association with a scientific, educational and technical purpose. The aim of the Association is to promote European microwaves and to develop networking between microwave scientists and engineers in Europe. EuMA organises European Microwave Week, the most important microwave event in Europe, which comprises, besides the European Microwave Conference (EuMC), three more conferences in related areas — EuMIC, ECWT and EuRAD as well as the largest microwave show in Europe.

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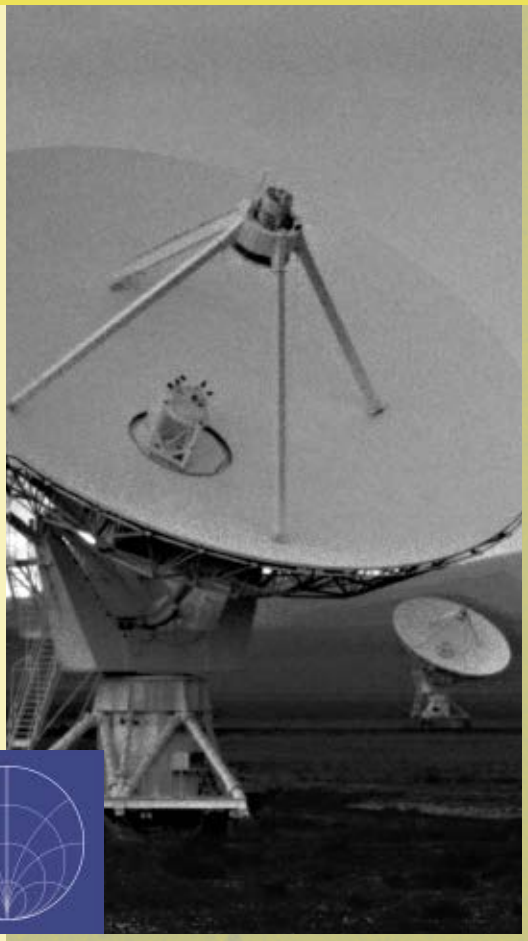

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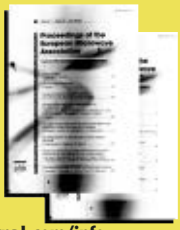
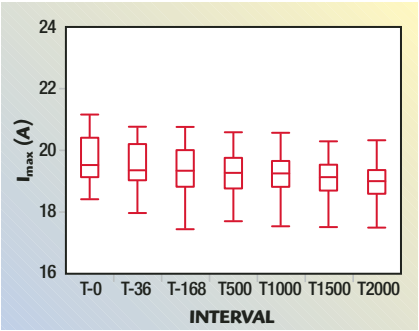


at 0.01 percent CCDF). As evident from the data presented in ***Figure 3***, the device delivers approximately 25 W of average RF power at –35 dBc ACPR with 15 dB gain and greater than 30 percent drain efficiency. Measurements were collected with a drain bias of 28 and 32 V with 600 mA I_{DQ}. The equivalent source and load impedances presented to the device are provided in ***Table 2***.

TABLE II

EQUIVALENT SOURCE AND LOAD IMPEDANCES FOR OPTIMUM WCDMA TUNING

Frequency (GHz)	Z_{source} (Ω)	Z_{load} (Ω)
2.14	14.8 – j17.0	2.1 – j3.1



▲ *Fig. 4 DC-HTOL results for maximum drain current versus test interval out to 2000 hours.*

RELIABILITY OF GaN ON SILICON HEMTs AND 2000 HOUR HTOL

DC-HTOL testing was carried out at V_{DS} of 28 V and T_J of 200°C for 2000 hours. A 45-piece sample was placed under DC-HTOL stress, with results for maximum drain current (I_{MAX}) shown in ***Figure 4***. The box plots show consistent performance between the 45 samples and minimal drift with time recorded at down points of 0, 36, 168, 500, 1000, 1500 and 2000 hours. The median drift data at these down points is fit to a logarithmic relationship versus time and extrapolated forward to 20 years of operation. The projected drift in maximum drain current at 200°C operation is less than 7 percent. Using activation energy (EA) of 2.0eV extracted from three-temperature studies predicts the drift at a more typical operating temperature of 150°C to be less than 3 percent over 20 years.

CONCLUSION

The design and modeling of the Nitronex NPT25100 was presented along with measured RF performance under 802.16E OFDM and 3GPP WCDMA waveforms. The measured performance of the NPT25100 demonstrates it to be a high power, broadband, linear RF transistor, which can address the 2.3 to 2.7 GHz WiMAX and 2.14 GHz 3G BTS (base transceiver station) markets. The broadband performance, relatively high terminal impedance, and available nonlinear transistor models in both Agilent ADS and AWR Microwave Office will benefit engineers developing power amplifiers around these transistors. DC-HTOL reliability testing predicts that performance degradation (based on drift in I_{max}) over a 20-year lifetime is well within an acceptable level, making these devices ready for prime time.

Nitronex Corp.,
Durham, NC (919) 807-9100,
www.nitronex.com.

RS No. 301

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- Chip Attenuators
- Chip Resistors
- Resistor Networks

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www.mwjournal.com

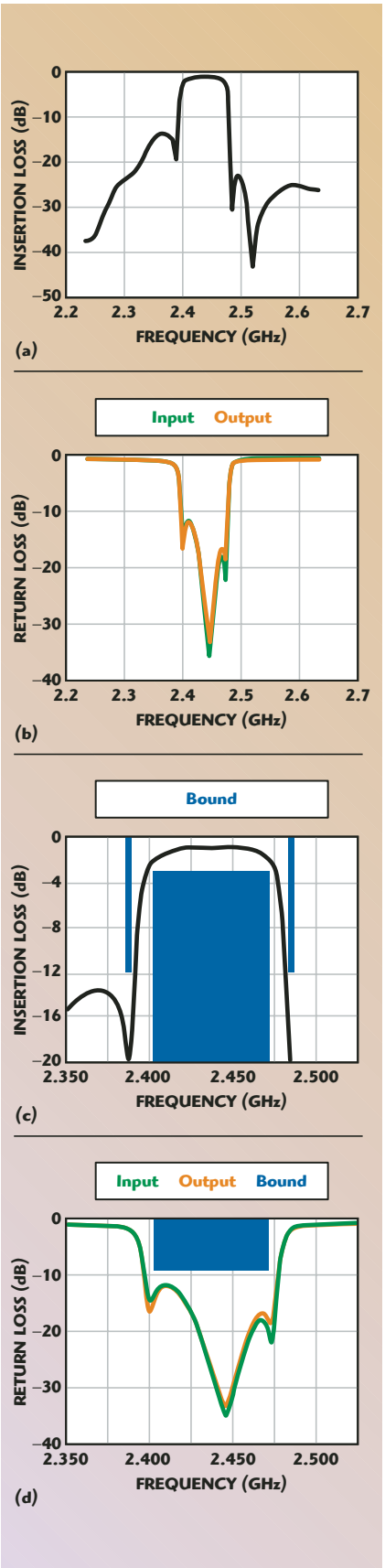
BULK ACOUSTIC WAVE FILTERS FOR 2.4 GHz APPLICATIONS

WLAN access points and routers based on the new 802.11n draft 2.0 standard will have the potential to deliver data throughput at up to five times and twice the range of previous-generation Wi-Fi equipment. In doing so, consumers will have home-wide access to content-rich applications, including streaming high definition video, rapid transfer of data (music, photo, etc.), single network/multiple user online gaming and more. Meanwhile, new 802.11n products will allow enterprise users to increase their network capacity and improve robustness.

The speed and range specifications outlined in the new WLAN standard translate into a demanding set of requirements for individual RF components, particularly calling for small footprint, low profile and high performance. Located directly in the high frequency signal path with the responsibility of blocking unwanted frequencies, RF filters are among the more critical components in the radio front-end. The SKY33100-360LF family of bulk acoustic wave (BAW) bandpass filters from Skyworks, which are now available in volume shipments, deliver the high performance called for in the design of these next generation WLAN, cellular phones, PCIe or mini PCI cards and other 2.4 GHz applications.

As an increasing number of communication systems use RF frequency bands, very high selectivity filters have become more important in ensuring that systems with close frequency bands do not interfere with each other. The technical challenge for RF filters is to reduce the insertion loss in the desired transmission band, and yet provide sufficient rejection at nearby frequencies, such as those just outside the passband. BAW filter technology achieves these two important characteristics by making use of very low loss electromechanical resonators to perform very highly selective RF

SKYWORKS SOLUTIONS INC.
Woburn, MA



▲ *Fig. 1 Wideband insertion loss (a), input and output return loss (b), narrowband insertion loss (c), and input and output return loss (d).*

filtering. The typical configuration for a BAW filter is a ladder network containing series and shunt resonators with slightly differing resonant frequencies to form a bandpass filter with steep near-band roll-off.

BAW filters transduce electrical signals into very low loss resonant acoustic vibrations in piezoelectric structures, similar to what happens in quartz crystals used as electromechanical circuit elements in timing references. BAW resonators consist of a thin film layer of piezoelectric material sandwiched between two metal electrodes. These layers are formed on top of an acoustic mirror, comprised of several alternating layers of high and low acoustic impedance materials, the composition and thickness of which are both very tightly controlled in order to produce the desired filtering.

Electrical signals are coupled into the piezoelectric layer via the electrodes and due to the piezoelectricity, that layer changes dimension, primarily thickness. The longitudinal acoustic wave that is generated is resonant in the layered structure at a frequency of operation dictated by the thickness of the various layers and the acoustic properties of the layers used. The large currents that result at the acoustic resonance produce the sizeable impedance changes that govern the RF filter characteristics.

The SKY33100-360LF bandpass filters are available in a space saving QFN 8L 2 × 2 mm lead (Pb)-free, RoHS-compliant package. The filter is intended for use in the 2.4 GHz WLAN and ISM bands and allows designers to meet all filtering requirements with a single component, significantly reducing the BOM count and cost. Eliminating the need to specifically match each individual filter reduces design cycle time and saves valuable PCB space, resulting in a strategic advantage in terms of pricing, performance, delivery and quality.

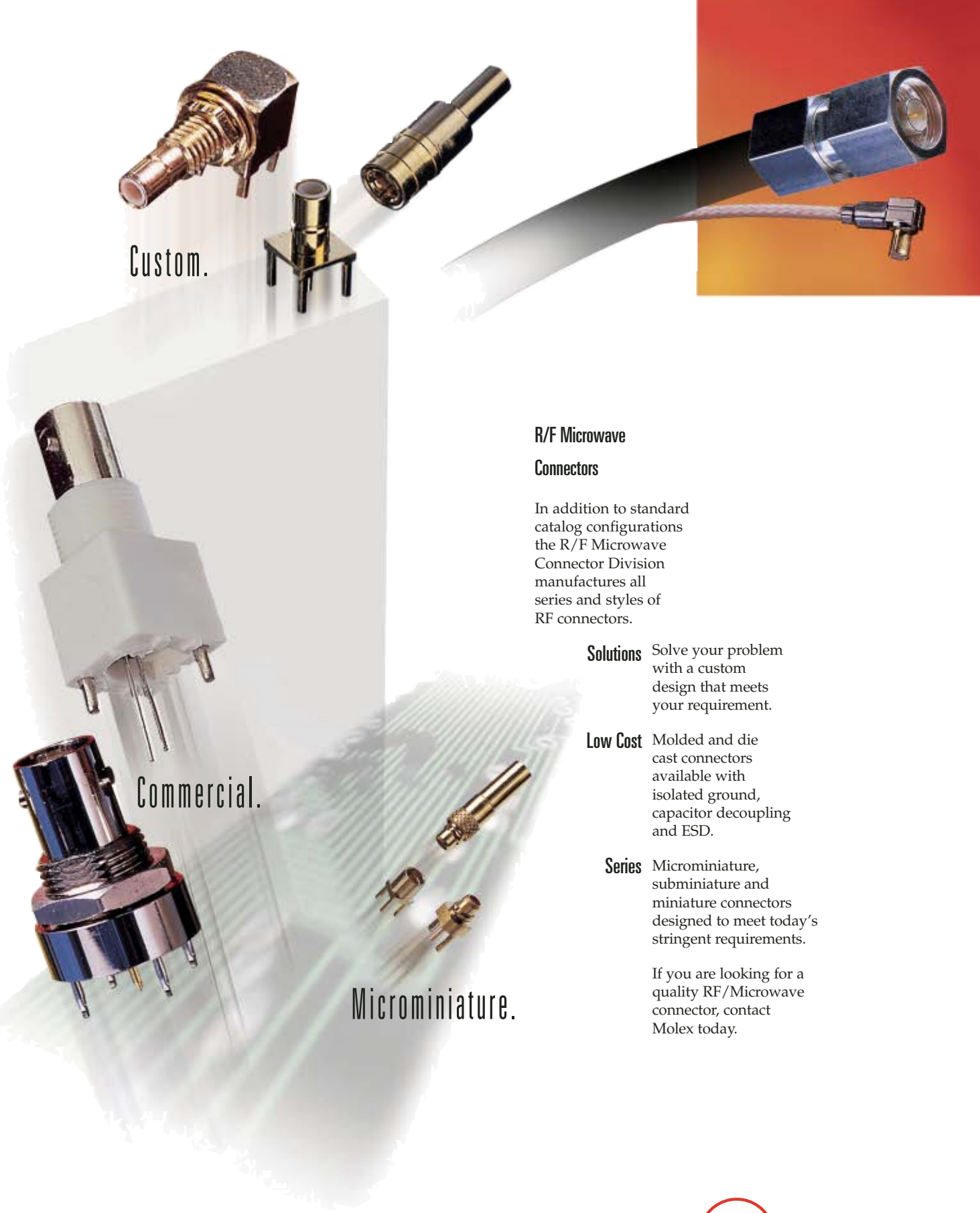
The electrical features include a 70 MHz bandwidth, very low in-band insertion loss with typical values of 1 dB (see ***Figure 1***), steep filter response with excellent near-band rejection that exceeds all other known existing technologies, 50 Ω nominal terminal impedance for very low input and output return loss. The filters offer superior power handling capability, enhanced ESD robustness, stable performance, lower temperature drift and an operating temperature range from –40° to +85°C.

The BAW filters are fabricated using semiconductor wafer fabrication techniques similar to those already used by Skyworks to manufacture heterojunction bipolar transistor (HBT) power amplifiers (PA) and PHEMT switches. In doing so, the manufacturer leverages all of the known benefits of wafer fabrication to achieve the high precision, high repeatability, and large volume capability and manufacturing scalability to address the RF filter needs of the company's wireless communications customers. Device reliability is excellent with no performance degradation over lifetime.

For next generation wireless standards, the BAW filters offer unprecedented frequency selectivity for a dramatic reduction in out-of-band spurious responses, enabling compliance with FCC regulations at a higher-in-band transmission power with improved handling for more robust architectures. Initially being deployed for wireless local area network (WLAN) 802.11 b, g and n access points, Skyworks is also developing BAW filters and duplexers for use in transmit front-end modules for personal communications system (PCS) and universal mobile telecommunications system (UMTS) cellular handsets. The SKY33100-360LF is available for sampling now and is priced at $2.95 for quantities of 10,000.

Skyworks Solutions Inc., Woburn, MA (781) 376-3000, www.skyworksinc.com.

RS No. 302



R/F Microwave Connectors

In addition to standard catalog configurations the R/F Microwave Connector Division manufactures all series and styles of RF connectors.

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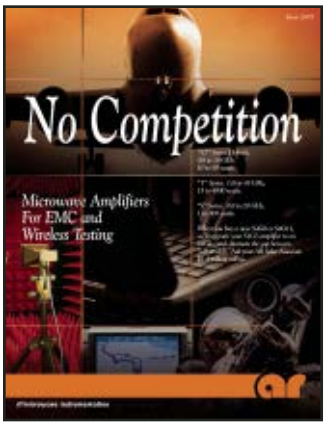
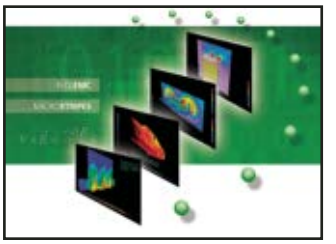


Microwave Amplifier Brochure

The microwave amplifier brochure from AR RF/Microwave Instrumentation features a wide range of microwave amplifiers. The brochure highlights the "S" series (1 to 800 W, 0.8 to 20 GHz) and TWT amplifier series (1 to 4000 W, 0.8 to 45 GHz). The brochure includes photographs, descriptions, specifications and performance graphs for each model.

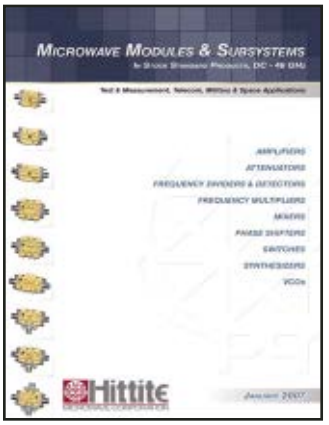
AR RF/Microwave Instrumentation,
Souderton, PA (215) 723-8181, www.ar-worldwide.com.
RS No. 310



MicroStripes/FloEMC Catalog

Predicting 3D high frequency electromagnetic radiation is an increasingly important requirement for many different industries and application areas. Understanding and optimizing the performance of antenna and microwave devices for all types of wireless systems is crucial for the telecommunications, military, automotive and aerospace industries. For the electronics industry, containing electromagnetic emissions from electronic equipment to ensure electromagnetic compatibility (EMC) is also a key legal requirement. The company's MicroStripes and FloEMC products address all of these application areas.

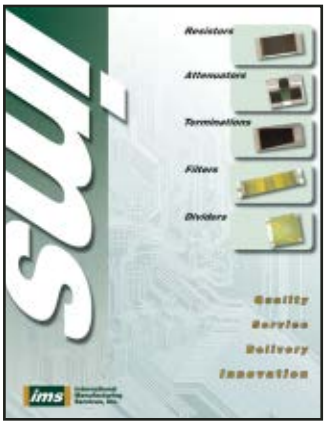
Flomerics Inc.,
Marlborough, MA (508) 357-2012, www.flomerics.com.
RS No. 311



Microwave Modules and Subsystems Catalog

The microwave modules and subsystems catalog features full specifications on 42 microwave components and synthesizers ideal for test and measurement, telecom, military and space applications. This new microwave specialty catalog features a wide variety of connectorized components based on the company's high performance MMICs. To request a 2007 microwave modules and subsystems catalog please visit www.hittite.com and select the "Submit Inquiry" button.

Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343, www.hittite.com.
RS No. 312



Short Form Brochure

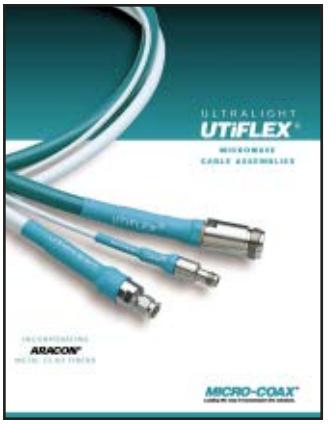
This short form brochure features the company's complete product offering including chip resistors, chip terminations, chip attenuators, planar dividers and planar filters. The brochure highlights key product features, specifications and parameters as well as the company's custom capabilities. It includes IMS's new IMA series attenuators with values to 70 dB and IMF series planar filters.

International Manufacturing Services Inc.,
Portsmouth, RI (401) 683-9700, www.ims-resistors.com.
RS No. 313

Microscope Inspection Data Sheet

This data sheet features complete detail on the company's NAT-31 Microscope Inspection System with Universal Serial Bus (USB) 2.0 camera that resolves 1 micron or less features. High clarity zoom optics use a 0.7X-4.5X objective lens for magnification of 42X-270X with the standard 0.5X auxiliary lens and 84X-540X without. This system is ideal for demanding research environments and teaching facilities.

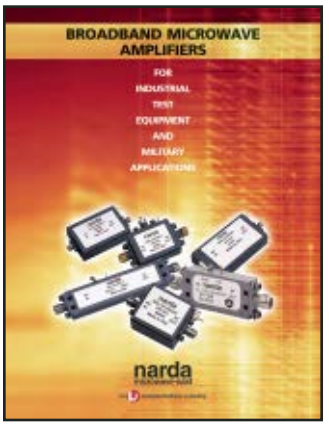
J microTechnology Inc.,
Portland, OR (503) 614-9509, www.jmicrotechnology.com.
RS No. 314



Microwave Cable Assemblies

Micro-Coax's UTiFLEX® Ultralight microwave cable assemblies are outlined in a six-page brochure. Incorporating ARACON® metal clad fibers, UTiFLEX Ultralight cable assemblies provide the lightest weight, lowest insertion loss and best radiation resistance in a flexible cable construction. The cable assemblies are optimized for spaceflight applications.

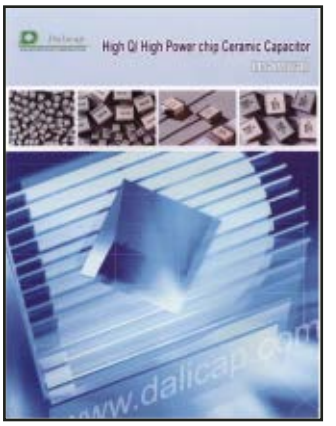
Micro-Coax,
Pottstown, PA (610) 495-0110, www.micro-coax.com.
RS No. 315



Broadband Microwave Amplifiers Catalog

Narda Microwave-East announced that it is adding stocked microwave amplifiers to its portfolio of microwave catalog components. Sub-octave, octave and multi-octave bandwidth models at frequencies between 0.5 and 18 GHz featuring low noise with output power to +30 dBm. Popular models will be available off the shelf. Those not stocked are typically available in less than four weeks ARO.

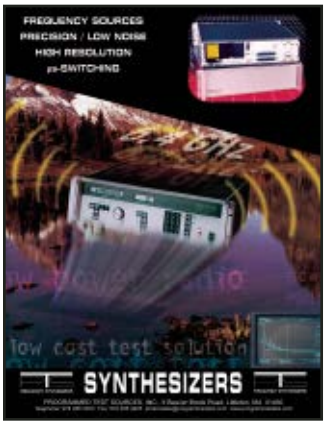
Narda Microwave-East,
Hauppauge, NY (631) 231-1700, www.nardamicrowave.com.
RS No. 316



Hi-Q Capacitor Catalog

This Hi-Q capacitor catalog includes the company's porcelain 10 series (P90), 70 series (NPO) and a new NPO EIA offering. Detailed mechanical and performance data are available for A case: 0.055" × 0.055" operational up to 300 W VDC; B case: 0.110" × 0.110" operational up to 1000 W VDC; C case: 0.225" × 0.225" operational up to 5000 W VDC; E case: 0.390" × 0.390" operational up to 7200 W VDC and a full line of EIA sizes (0402, 0603, 0805). Products are available in various termination styles.

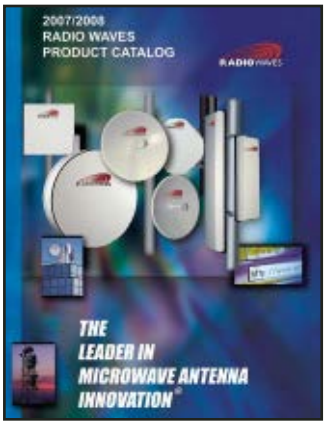
PassivePlus Inc./Dalicap,
Huntington Station, NY (631) 425-0938, www.passiveplus.com.
RS No. 317



Agile Precision Frequency Sources

This catalog describes the company's complete line of PTS frequency synthesizers. These synthesizers produce fast-switching, low phase-noise precision frequencies. With easy remote programming they are vital in advanced measurement or production systems and also serve as stand-alone test equipment. Numerous options and accessories that can be combined to provide a product that will closely match custom specifications. Models ranging from 0.1 to 6400 MHz are available.

Programmed Test Sources Inc.,
Littleton, MA (978) 486-3400, www.programmedtest.com.
RS No. 318



Product Catalog

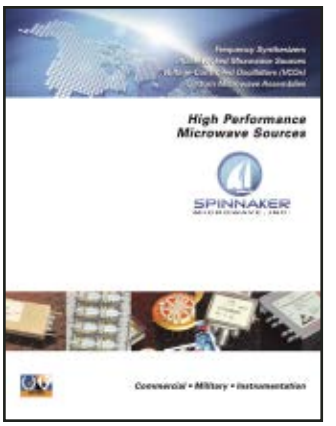
The new 2007/2008 catalog includes new products such as Radio Waves' complete family of WiMAX antennas, new sector antennas for 3.5 GHz fixed wireless networks, new 4.9 GHz series antennas for public safety, new high performance parabolic antennas for 5 GHz and new high frequency licensed band antennas.

Radio Waves Inc.,
N. Billerica, MA (978) 459-8800, www.radiowavesinc.com.
RS No. 319

RFMD® 2007 Designer's Handbook

Available in hard copy and CD, the Designer's Handbook showcases RFMD's broad product portfolio of RF systems and solutions for applications that drive mobile communications. Includes technical data on RFMD's industry-leading power amplifiers, front-end modules, transceivers, SoCs and other integrated components for mobile handset, cellular base station, WLAN and GPS applications—all backed by RFMD's commitment to service, technical support and quality. Visit the company's web site for the most current product information.

RFMD,
Greensboro, NC (336) 678-5570, www.rfmd.com.
RS No. 320



Capabilities Brochure

This four-page color brochure highlights the company's capabilities in the design and manufacture of microwave sources in the 1 to 40 GHz spectrum, including: voltage-controlled oscillators, direct and indirect frequency synthesizers, multi-loop frequency synthesizers, multi-octave broadband frequency synthesizers, phase-locked oscillators and digitally-tuned oscillators. Products are designed to provide solutions to the most difficult requirements facing today's systems engineers.

Spinnaker Microwave Inc.,
Santa Clara, CA (408) 732-9828, www.spinnakermicrowave.com.
RS No. 321

CATALOG UPDATE

Wireless Products Catalog

The 12th edition of the LMR® Wireless Products Catalog includes the entire range of LMR cables including LMR-DB, LMR-FR, LMR-Ultraflex, LMR-LLPL and LMR-75. Also added in this latest edition are LMR-lite, LMR Bundled Cable, SilverLine and TuffGrip test cables and SilverLine QMA Adaptor kits. LMR cables are low loss, flexible, non-kinking RF transmission line cables that utilize easy-to-install connectors and are suitable for use as antenna feeders, system jumpers and interconnects.

Times Microwave Systems,
Wallingford, CT (203) 949-8400, www.timesmicrowave.com.

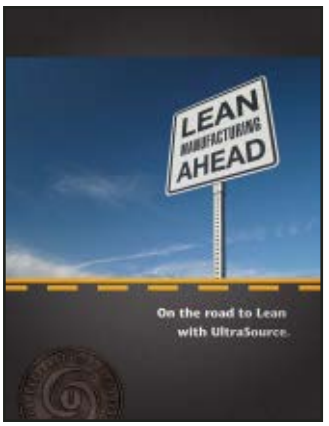
RS No. 322

Product Selection Guide

This product selection guide provides a simple overview of the company's new and existing RF devices for engineers. Products detailed in the guide are designed for a wide range of applications in wireless base stations, WiFi, WiMAX, GPS, cellular, digital cable, satellite and optical communications systems. TriQuint created the guide to support its vision for simplifying connectivity in fixed and mobile environments. Get the guide by visiting www.triquint.com/rf to receive a .pdf download or to order a printed copy.

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

RS No. 323



Brochure Tells Lean Manufacturing Story

This brochure details the company's road to Lean Manufacturing. In it, UltraSource reviews the personal journey towards Lean and outlines some key achievements along the way, including a 475 percent increase in a critical productivity metric. Readers will also learn how documented operational procedures are leveling workloads and visual communication boards and "Kaizen" meetings are revolutionizing the operational culture of the facility.

UltraSource Inc.,
Hollis, NH (800) 742-9410, www.ultrasource.com.

RS No. 324

Agilent N6705A DC power analyzer

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- *Display voltage and current versus time*
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Every function is controlled from the front panel, and a single graphical display reveals all your measurements. Even the controls are designed to save you time. The N6705A includes an easy and intuitive interface, with color-coded controls and convenient button placement to give you quick access to the functions you need.

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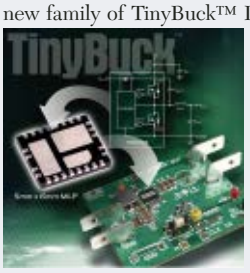
www.agilent.com/find/dcpoweranalyzer

Agilent Technologies

DC-DC Buck Regulators

The model FAN2106 is the first product in a new family of TinyBuck™ DC-DC buck regulators that integrate an advanced analog IC, MOSFETs and a boot diode into an ultra-compact molded leadless package (MLP). Measuring only 5 × 6 mm, the FAN2106 is the industry's smallest 6A, 24 V-input integrated synchronous buck regulator on the market today. This highly integrated low-profile, small-footprint device consumes approximately 50 percent less board space than discrete solutions and facilitates greater design flexibility. Furthermore, the FAN2106 achieves up to 95 percent power efficiency by converting input of 3 V through 24 V input voltages to output voltages as low as 0.8 V while delivering up to 6A output current. This compact, easy-to-use, high-efficiency regulator is ideal in a broad range of point-of-load (POL) applications. Price: $3.78 (1000). Delivery: 10 weeks ARO.



Fairchild Semiconductor Corp., South Portland, ME (207) 775-8100, www.fairchildsemi.com.

RS No. 216

Surface-mount VCOs

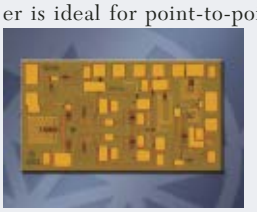
The model ROS-850-319+ is a surface-mount voltage-controlled oscillator (VCO) that offers 5 V tuning for PLL ICs and operates in a frequency range from 800 to 850 MHz. Features include: linear tuning characteristics, low phase noise, low pushing, low pulling and is aqueous washable. Applications include: point-to-point radio and CDMA/TDMA. Price: $19.95 each (5–49).

Mini-Circuits, Brooklyn, NY (718) 934-4500, www.minicircuits.com.

RS No. 219

×2 Active Frequency Multiplier MMIC

This GaAs MMIC ×2 active frequency multiplier is ideal for point-to-point and point-to-multipoint radios, VSAT, telecom, test instrumentation, military, space and fiber optics applications from 8 to 21 GHz. The HMC561 is a broadband ×2 active frequency multiplier die that utilizes GaAs PHEMT technology and accepts input drive levels from 0 to +6 dBm. When driven with a +5 dBm input signal, the HMC561 provides +17 dBm typical output power from 8 to 21 GHz, and the f_o and $3f_o$ isolations are 15 dBc. This compact MMIC multiplier also delivers low additive SSB phase noise of –139 dBc/Hz at 100 kHz offset. The HMC561 is ideal for driving the LO port of many of Hittite's mixers, including the HMC523 GaAs MMIC I/Q mixer, which operates from 15 to 23.6 GHz.

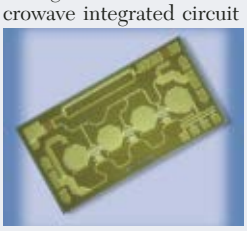


Hittite Microwave Corp., Chelmsford, MA (978) 250-3343, www.hittite.com.

RS No. 217

GaAs MMIC Wideband Buffer Amplifier

This gallium arsenide (GaAs) monolithic microwave integrated circuit (MMIC) wideband buffer amplifier features an on-chip drain bias coil and DC blocking. Using 0.30 micron gate length GaAs pseudomorphic high electron mobility transistor (PHEMT) device model technology, the buffer amplifier covers the 2 to 18 GHz frequency bands and has a small-signal gain of 9 dB with a noise figure of 4.5 dB across the band. Identified as the CMM4000-BD, this device also achieves +19 dBm P1dB compression point and is well suited for fiber optic, microwave radio, military, space, telecom infrastructure, test instrumentation and VSAT applications.

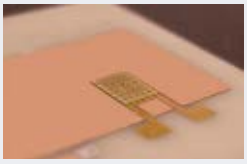


Mimix Broadband Inc., Houston, TX (281) 988-4600, www.mimixbroadband.com.

RS No. 218

Thin Film Embedded Thermoelectric Cooler

This advanced thin film embedded thermoelectric cooler (eTEC™) is designed to address thermal management needs of the electronics, photonics, bio-tech and defense/aerospace industries. Functioning as a miniature, solid-state heat pump, the eTEC is ideal for cooling hot spots that result from localized areas of high heat flux on an IC. The nano-structured thermoelectric thin film device is manufactured using semiconductor processing techniques.

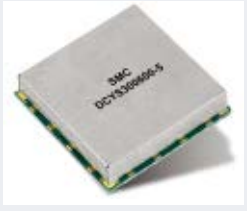


Nextreme, Research Triangle Park, NC (919) 990-8300, www.nextreme.com.

RS No. 221

YIG Replacement VCO

The model DCYS300600-5 is a YIG replacement VCO designed for signal sources operating fundamentally from 3000 to 6000 MHz and fully overcomes the deficiencies of YIG oscillators in power consumption, microphonic effects, tuning speed, size, EMI, integration with current IC technology and cost. Typical applications for this broadband product are test instruments and radar systems. This product is based on Synergy's proprietary patented and other patent pending technology, which increases bandwidth, lowers phase noise, responds to fast tuning and highly improves immunity to phase hits. The phase noise is typically –78 dBc/Hz at 10 kHz offset from the carrier. Size: 0.5" × 0.5" × 0.16".



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

RS No. 222

AGC/Video Amplifier IC

Designers of digital set-top boxes, cable modems and terrestrial receiver systems will be interested in this newest AGC amplifier IC from NEC. The UPC3231GV combines a 30 to 90 MHz AGC amplifier with an on-chip video amplifier that provides output for both ODFM modulators and QPSK/QAM data transmission. High gain and 61 dB of gain control range allows the UPC3231GV to handle a wide range of input signals, while low noise and low distortion ensure the delivery of a clean, accurate signal. Typical performance specifications include: high gain of 65 dB, wide gain control range of 61 dB, low noise of 5 dB, low distortion of 53 dBc IM3 at –20 dBm PIN, 105 µV (0.5 VP-P)/tone and supply voltage of 5 V. Size: 2.9 × 4.9 mm. Priced at $0.99 in 10K.

NEC/California Eastern Laboratories, Santa Clara, CA (408) 919-2500, www.cel.com.

RS No. 220

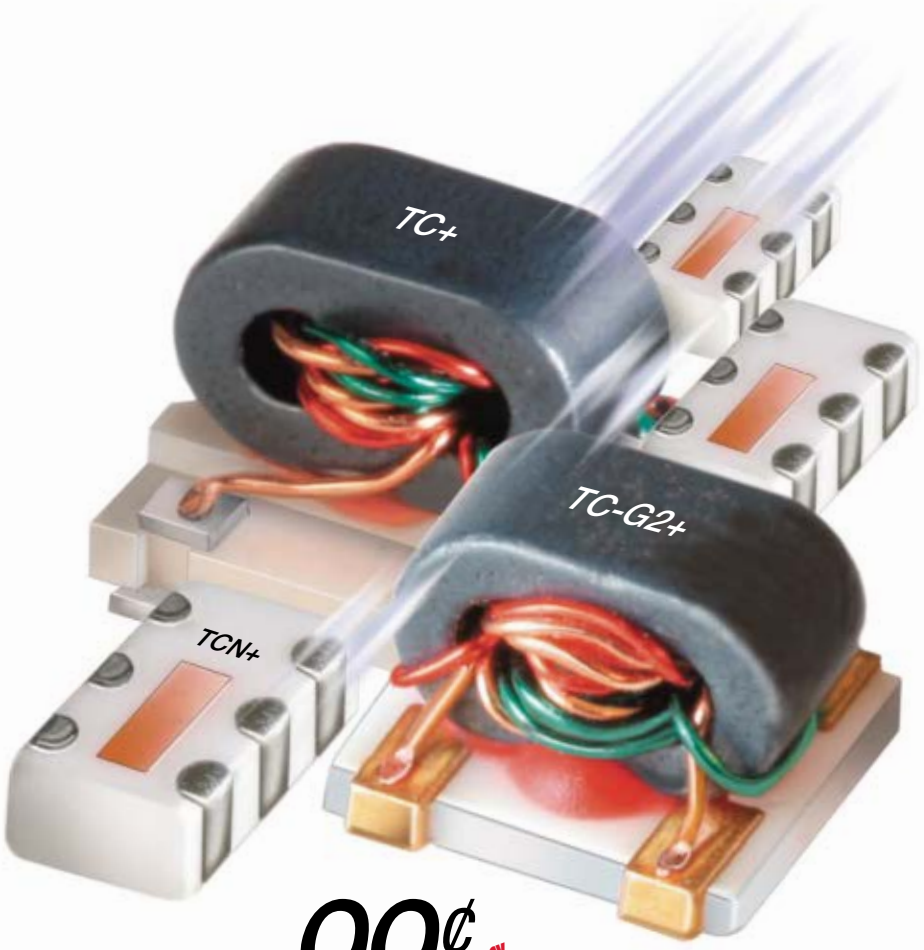
Wideband Voltage-controlled Oscillator

The model V350ME09-LF is a wideband voltage-controlled oscillator (VCO) designed for the VHF band. This wideband VCO product covers the frequency range of 250 to 400 MHz, and offers a low phase noise performance of –109 dBc/Hz at 10 kHz offset. This new model provides an average tuning sensitivity of 16 MHz/V and typical harmonic suppression of –10 dBc. Its output power is 3.5 ± 3.5 dBm over the extended operating temperature range of –40° to 85°C. The tuning voltage is 0.5 to 12 V at DC supply voltage of 5 V drawing 12 mA (typical). This product is lead-free and RoHS-compliant. Size: 0.50" × 0.50" × 0.22". Price: $18.95. Delivery: stock to four weeks.

Z-Communications Inc., San Diego, CA (858) 621-2700, www.zcomm.com.

RS No. 223

TINY RF & MICROWAVE
TRANSFORMERS



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RF/IF MICROWAVE COMPONENTS

377 Rev L

Visit http://mwj.hotims.com/11719-72 or use RS# 72 at www.mwjournal.com/info

COMPONENTS

Ultra Broadband Bias Tee

The model BT-10M18 is a bias tee that is designed to operate in a frequency range from 10 MHz to 20 GHz. The insertion loss is 1.5 dB maximum at 20 GHz, 20 dB of isolation from 10 to 300 MHz and 30 dB from 300 MHz to 20 GHz with a VSWR of 2.0 maximum.
American Microwave Corp., Frederick, MD (301) 662-4700, www.americanmicrowavecorp.com.

RS No. 224

5 W Power Divider/Combiner

This series of high isolation 5 W average power divider/combiners is ideal for antenna sharing, telecommunication infrastructure and test system applications. Model series 152-085XXX* are 50 Ω units available in two-, three- and four-way configurations with typical isolation of 25 dB. Frequency range is 800 to 2700 MHz for two- and four-way configurations and 800 to 2000 MHz for the three-way configuration. RF connectors are N female and delivery is from stock.
BroadWave Technologies Inc., Franklin, IN (317) 346-6101, www.broadwavetech.com.

RS No. 225

Coaxial Terminations

The company has extended its range of coaxial terminations to cover the most common ranges of coaxial connectors such as 1.0/2.3, 1.6/5.6, SMA and BNC, with other types for series N and 7/16 in the pipeline. The terminations have the function of terminating a coaxial line with its characteristic impedance; so 50 and 75 Ω terminations have been developed depending on the connector series it relates to. For the same reason, the working frequencies vary from 1 GHz for the 1.6/5.6 series to 18 GHz for the SMA series. Particular attention has been paid to electrical requirements, particularly the optimization of the reflection value, which is important for laboratory applications where the accuracy of the measurements depends greatly on the accessories being used.

Compel Electronics SpA, Milan, Italy +39 039 61001, www.compel.it.

RS No. 226

Hi-Q Non-magnetic Capacitors

This line of non-magnetic, hi-Q capacitors is available in four case sizes, including: A case: 0.055" × 0.055" operational up to 300 W VDC; B case: 0.110" × 0.110" operational up to 1000 W VDC; C case: 0.225" × 0.225" operational up to 5000 W VDC; and E case: 0.390" × 0.390" operational up to 7200 W VDC. This non-magnetic series is available in two dielectric styles: 10 series (P90) or the 70 series (NPO). Products exhibit excellent performance for non-magnetic body and surface coil applications.
Dalicap Corp., Huntington Station, NY (631) 425-0938, www.dalicap.com.

RS No. 227

Temperature and Frequency Equalizer

The new temperature and frequency equalizer (TFE) is a custom chip made to respond to system changes over temperature and frequency in a single passive chip device measuring only 0.125" × 0.095". Temperature compensation slopes can be tuned to various slope coefficients at specific temperature bands with a fixed amount of frequency change. These devices offer broadband performance from DC to 18 GHz. Once the chip has been tuned to system performance the process is very repeatable such that a system will be optimized for flatness every time. This product is released and available now.
EMC Technology Inc., a Smiths business, Stuart, FL (772) 286-9300, www.emct.com.

RS No. 228

Power Terminations

These ECT terminations absorb average powers ranging from 1 to 800 W with low VSWR and excellent capacity to handle high peak pulse bursts. Various models cover frequency ranges up to 18 GHz. Depending on the average power of the selected device, connector options can include N, BNC, SMA, TNC or 7/16. Delivery: stock to four weeks.

EPX Microwave Inc., San Carlos, CA (650) 692-2198, www.epxmicrowave.com.

RS No. 229

High Power Ceramic Band Reject Filter

The model 4DRN40-422.75/X3-O/O is a high power ceramic band reject filter that has power handling capabilities of 100 W CW. Also, its ultimate return is 1.9 times center frequency, with a lower insertion loss. This filter, which is also called a notch filter, rejects one band of frequencies, and passes higher and lower frequencies. The dimensions are 2.25" L × 1.66" W × 0.60" H–smaller than equivalent cavity filter (4.750" L × 1.13" W × 2.375" H) (both sizes exclude connectors).
K&L Microwave Inc., Salisbury, MD (410) 749-2424, www.klmicrowave.com.

RS No. 230

Dual-band GPS Band Reject Filter

The model 10BRX-1227/1575-S is a dual-band GPS band reject filter with bi-directional inputs. The filter features 50 dB of rejection over each of the central 4 MHz bands. The VSWR is 1.5 from 570 to 1000, 1300 to 1500 and 1600 to 2500 MHz. The physical size is 3.0" × 1.0" × 0.50" excluding SMA female connectors.
Lorch Microwave, Salisbury, MD (410) 860-5100, www.lorch.com.

RS No. 231

X- and Ku-band Isolators/Circulators

These connectorized isolators and circulators are designed for high frequency X- and Ku-band (8 to 18 GHz) applications featuring SMA-female connectors and average power ratings of 2 W. Other specifications include 0.4 dB insertion loss, 1.30 VSWR and 18 dB isolation across the entire band. Units are available from stock to four weeks ARO. Made in the USA.

MECA Electronics, Denville, NJ (973) 625-0661, www.e-meca.com.

RS No. 232

WiMAX/WiFi Diplexer

The model BK-26N is a low cost diplexer designed to separate or combine all the cellular wireless frequency bands from the WiMAX and WiFi bands above 3 GHz. With the 'Tuned-by-Design' approach, unit price is kept low by elimination of the high cost of manual tuning used in conventional designs, while still maintaining low loss and > 50 dB isolation between bands. The low band extends from 380 to 2700 MHz, incorporating TETRA to the proposed new LTE bands up to 2700 MHz. The high band, 3,300 to 6,000 MHz, includes all proposed WiMAX bands and the WiFi to 802.11(a). Passive intermodulation (PIM) is specified at < –150 dBc, and guarantees down to –160 dBc are available with an additional testing charge.

Microlab/FXR,
Parsippany, NJ (973) 386-9696,
www.microlab.fxr.com.

RS No. 233

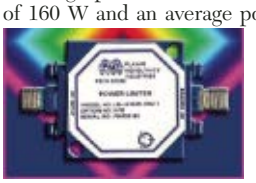
Limiter/Pre-amplifier/Filter Assembly

This line of limiter/pre-amplifier/bandpass filter assemblies is designed to meet a variety of applications. Typical features include: frequency range of 10 to 3000 MHz, ultimate rejection of 2 to 20 GHz, gain of 22 dB, noise figure of overall less than 1.00 dB (typical 0.6 dB), DC power of +5 V (60 mA). Custom designs and package options are available (SMT, GPO, GPPO, SMA interfaces).

Networks International Corp.,
Overland, KS (913) 685-3400,
www.nickc.com.

RS No. 234

40 W High Power Limiter



This high power limiter handles a peak power of 160 W and an average power of 40 W at a frequency of 16 to 16.5 GHz with an insertion loss of only ≤ 1.5 dB and an input and output return loss of ≤ 17 dB. The pulse width is ≤ 15 µs, the duty cycle is ≤ 25 percent and the recovery time is ≤ 1.0 µs. Size: 1.0" × 1.0" × 0.5".

Planar Monolithics Industries Inc.,
Frederick, MD (301) 631-1579,
www.planarmonolithics.com.

RS No. 235

High Power Duplexer

The CH-1100-D series of high power ferrite duplexers operate in 10 percent bandwidths from 400 MHz to 3 GHz. Typical specifications are 20 dB isolation, 0.3 dB insertion loss and 1.25 VSWR. The units can operate at levels up to 10 kW peak and 1 kW average power. Connectors are DIN 7/16 or N depending on power level. Size: 6" × 3½" × 1¼".

UTE Microwave Inc.,
Asbury Park, NJ (732) 922-1009,
www.utemicrowave.com.

RS No. 236

CLASSIFIED

AMPLIFIERS

High Power Amplifiers

This family of broadband linear high power amplifiers is designed with MMIC technology, resulting in an economical and reliable solution. The model AMP2G6-30-33 is a 2 to 6 GHz amplifier that features at least 30 dB gain. The amplifier outputs a minimum of 2 W of power. Current draw is typically 2.5A from +12 V. Connectors are SMA(f) and delivery is typically stock to several weeks. Other models are available that feature additional gain, different input voltages and frequency ranges.

Amplical Corp.,
Verona, NJ (201) 919-2088,
www.amplical.com.

RS No. 237

Subampability Concept

AR RF/Microwave Instrumentation has introduced a new concept called "Subampability" that will enable customers to upgrade some of their existing "S" series (1 to 800 W, 0.8 to 20 GHz) amplifiers to higher power without purchasing new amplifiers. Models 20S4G11A (20 W, 4 to 10.6 GHz) can expand to 40, 60 or 80 W and 35S4G8A (35 W, 4 to 8 GHz) can grow to 60, 90 or 120 W.

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

RS No. 239

Ku-band Amplifier Modules

The first two models in a new range of solid-state microwave amplifier modules are a power amplifier and a low noise amplifier (LNA), which are aimed at satellite communications, point-to-point, radio location and test applications in the defense and wireless communications markets, particularly VSAT satellite communication systems. The LNA module has a class-leading noise level of less than 2.5 B at 250°C while both operate in the Ku-band with the LNA maintaining its performance down to 6 GHz. Both modules incorporate a power enable/disable, making them suitable for portable, battery-powered applications. The devices operate in the –250° to 700°C temperature range and will be qualified to MIL-PRF-38534.

C-MAC MicroTechnology,
Great Yarmouth, Norfolk
+44 (0) 1493 743100, www.cmac.com.

RS No. 240

Responsibility to Safety

NATE
National Association of Tower Erectors ®

NATE reminds the industry to work together to make sure all tower climbers go home safely at the end of every day.

Safety First... Safety Always!

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Email: nate@natehome.com • www.natehome.com

NATE 2008 February 11-14
Safety First...Safety Always • ORLANDO

Low Noise Amplifiers

These PHEMT-based, low noise amplifiers (LNA) operate in a frequency range from 0.5 GHz to 20 GHz and are designed for electronic defense and commercial communication applications. The amplifiers are specifically designed to accommodate numerous and demanding requirements within the homeland security, military and commercial environments for tactical radios, Global Positioning System (GPS) receivers and radar systems. The company's new LNA line-up consists of 30 narrowband and 30 wideband models.

CTT Inc.,
Sunnyvale, CA (408) 541-0596,
www.cttinc.com.

RS No. 241

Low Noise Amplifiers

These low noise amplifier modules cover up to 18 GHz in bands, with noise figures as low as 1.8 dB, gain as high as 28 dB (±2 dB or less) and P1dB output power up to 20 dBm. They are excellent choices for applications ranging from broadband test equipment to various aerospace and defense systems, and meet MIL-STD-883. The NEL-0618T620-5MH low noise broadband amplifier, for example, covers 6 to 18 GHz, with P1dB output power of at least 20 dBm, gain of 28 dB ±2 dB or less, and a noise figure of 4 dB. It operates from a single +12 VDC supply, draws 490 mA or less, and is temperature compensated.

Narda Microwave-East,
Hauppauge, NY
(631) 231-1700,
www.nardamicrowave.com/east.

RS No. 243

Millimeter-wave LNAs

These millimeter-wave JCA Amplifiers™ exhibit exceptionally low noise characteristics over broad bandwidths. This extension of the JCA family of low noise amplifiers features 6 new models from 26 to 40 GHz. Features include a noise figure as low as 3 dB, gain from 27 to 37 dB, gain flatness of 3 dB and a maximum input/output VSWR of 2.5. Additional performance characteristics include a minimum of +10 dBm output power at P1dB, and DC current of 275 mA at +15 VDC. These amplifiers are ideal for broader bandwidth applications where consistent low noise performance is critical such as in receiver front-ends for electronic warfare (EW) applications.

Endwave Corp.,
San Jose, CA (408) 522-3100,
www.endwave.com.

RS No. 242

SAW Replacement VCOs

FEATURED MODELS

Model #	Frequency (MHz)	Tuning Voltage (VDC)	Typical Phase Noise @10 kHz (dBc/Hz)	Bias Voltage (VDC)	Operating Temperature Range (ºC)
DCSO Series					
DCSO1000-12	1000	0.5 to 5	-128	+12	-40 to 85
DCSO1200-12	1200	0.5 to 12	-125	+12	-40 to 85
DCSO1750-12	1750	0.5 to 12	-120	+12	-40 to 85
DCSO2488-12	2488	0.5 to 12	-117	+12	-40 to 85
DCSR Series					
DCSR100-5	100	0.5 to 5	-130	+5	-40 to 85
DCSR1000-12	1000	0.5 to 12	-120	+12	-40 to 85
DCSR2488-12	2488	0.5 to 12	-115	+12	-40 to 85

Other frequencies are available, please call.

Features:

- Planar Non-Ceramic Resonator
- High Immunity to Phase Hits
- Exceptional Phase Noise
- Very Low Post Thermal Drift
- Small Size Surface Mount
- Lead Free - RoHS Compliant
- Patent Pending
- REL-PRO® Technology

RoHS COMPLIANT

For additional information,
contact Synergy's sales and application team.
201 McLean Boulevard, Paterson, NJ 07504
Phone: (973) 881-8800 Fax: (973) 881-8361
E-mail: sales@synergymwave.com

SYNERGY® MICROWAVE CORPORATION

Visit Our Website At WWW.SYNERGYMWAVE.COM

PROCESSING EQUIPMENT

Multi-purpose Power Amplifier

The model SM1822-44 is a GaAs FET amplifier designed for high performance military and commercial markets. The unit operates from 1800 to 2200 MHz with a P1dB of 44 dBm across the band and an OIP_3 of 55+ dBm (typical). Small-signal gain is 45 dB with a flatness of ±0.5 dB across the band. Standard features include a thermal protection with auto reset, over/reverse voltage protection, TTL on/off, FWD and REV power detection, and level control. Most items ship from stock in two weeks.

Stealth Microwave Inc., Trenton, NJ (609) 538-8586, www.stealthmicrowave.com.

RS No. 244

Laser-based PCB

The new ProtoLaser 200 is a versatile state-of-the-art laser system for prototyping and on-demand production of PCBs. This fully enclosed laser-based system works directly off of CAD data to produce circuits on a variety of materials, including ceramic and PTFE based substrates. The protective cabinet allows for a Class 1 laser safety rating and prevents any particles or evaporation from leaving the work area. The ProtoLaser 200 combines advanced laser technology, optics and x/y table mechanisms, resulting in enhanced quality, speed and accuracy. The improved performance and speed of this system makes it an ideal component in any RF and microwave engineering environment including antennas, RFID, filters, and single layer components, among others.

LPKF Laser & Electronics, Wilsonville, OR (503) 454-4212, www.lpkfusa.com.

RS No. 245

Next Generation Wafer Bonder

The ELAN CB8 wafer bonder is based on an entirely new design platform. It exhibits force and temperature uniformity of ±5 percent and ±1° percent, respectively, and has a super clean, high-vacuum environment. It boasts rapid heat up and cool down times to maximize productivity and its Pressure Column Design ensures pressure uniformity, which is con-

firmed via load cell verification. The bonder also incorporates the manufacturer's Wedge Error Compensation function, which ensures true planarity before every single bond. Vacuum isolated heaters allow heat to be directed exactly where it is needed—at the wafer—while the silicon nitride heater material provides strength and conduction over time and under elevated temperatures.

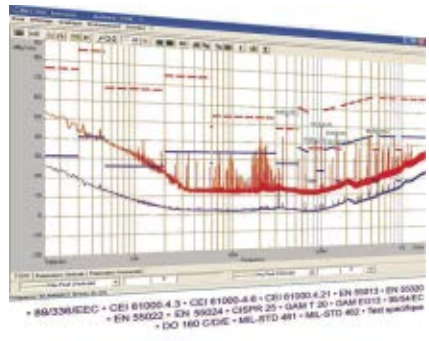
SUSS MicroTec Device Bonder Division,
Saint Jeoire, France
+33 450 35 83 92, www.sussmicrotec.com.

RS No. 248

SOFTWARE

EMC Test Software

The BAT-EMC, all-in-one EMC test software offers twelve different professional test modules including emission, immunity, transient and radiation pattern with particular applications in the aerospace, military, civil, EMC Labs, automotive and IT sectors. Its functions include: EMC test automation (EN, FCC, DO160, CISPR and MIL STD), measuring device management, instrument and bench verification and calibration, test and project configuration management, graphical analysis and automatic report making, and attenuation, transfer curves, amplified harmonics measurements and post treatment. It is also compatible with other EUT control and monitoring tools in the company's range.



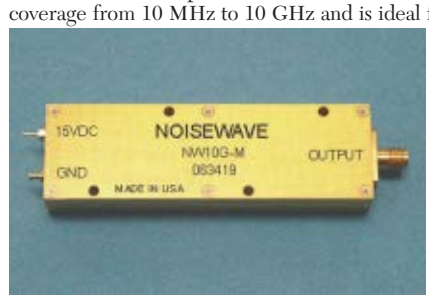
Nexio,
Toulouse, France
+33 (0) 561 440 247, www.nexio.fr.

RS No. 246

SOURCE

Amplified Noise Source

The NW10G-M amplified noise module features broadband frequency coverage from 10 MHz to 10 GHz and is ideal for wireless, CATV, satellite test and broadband high speed data test applications such as 10 Gigabit Ethernet. NoiseWave offers users a uniquely broader bandwidth, making this module practically future proof. The NW10G-M features output power of –17 dBm and spectral flatness of ±3 dB. Internal regulation is standard and the unit operates from +15 VDC typically drawing typically 180 mA. Size: 4" × 1" × 0.5". Utilizing small internal parts count, the unit is economically priced and delivery is typically from stock.



Noisewave Corp.,
East Hanover, NJ
(973) 386-1119, www.noisewave.com.

RS No. 247

TEST EQUIPMENT

TETRA Protocol Analyzer

The 8140 TETRA AirAnalyzer can monitor the quality of service of the TETRA network, evaluate the interoperability between the network and a new TETRA radio, and identify handover problems and dead spots. The analyzer can also help to integrate new terminals into the network or support type approval or fault tracking. It can be used to record, display and evaluate the complex course of the communication between TETRA mobile stations and a TETRA base station in clear or optionally in encrypted mode. It monitors and analyzes the complete up and downlink of one TETRA carrier including all time slots and the two receivers offer a high sensitivity to enable monitoring even in difficult radio environments.

Willtek Communications GmbH, Ismaning, Germany +49 (0) 99641 200, www.willtek.com.

RS No. 250

HSPA Functionality

This HSPA functionality is designed for its MD8470A signaling tester that provides the MD8470A with best-in-class data rate analysis capability for HSPA applications. With the MX847010A-11 (HSDPA) and MX847010A-12 (HSUPA) options, the MD8470A is the only application test solution that can measure full HSPA data rates, making it an excellent verification tool for developers of HSDPA and/or HSUPA applications. The MD8470A, when equipped with the options, supports all HSDPA and HSUPA UE categories specified in 3GPP TS25.306. HSDPA data rates to 14.4 Mbps and HSUPA data rates to 5.76 Mbps can be tested with the MD8470A. With a new built-in Data Throughput Monitor function, the MD8470A supports the monitoring of data throughput performance in real time and provides an efficient test environment for performance optimization.

Anritsu Co., Richardson, TX (972) 644-1777, www.us.anritsu.com.

RS No. 249

Microwave Journal CALL FOR PAPERS

To see one's work in print is the rightful reward of every creative engineer and scientist. The editors of *Microwave Journal* invite you to submit your technical manuscripts for consideration to be published in one of our upcoming issues. Technical articles, application notes and tutorial articles based on the monthly editorial themes are encouraged. Editorial themes include wireless, radar and antennas; RF components and systems; test, measurement and CAD; amplifiers and oscillators; semiconductors, MMICs and RFICs; satellite and mm-wave applications; communications and wireless applications; passive components; and control devices and modulation.

Design features should contain new and innovative technical ideas of practical use and interest to our predominantly engineering readers. Papers should be 14 to 16 double-spaced pages and contain 8 to 12 visual aids in the form of sketches, graphs, photographs or tables.

Papers should be submitted to the attention of the Technical Editor and will be reviewed promptly by our Editorial Review Board prior to acceptance. Articles outside of the monthly themes also will be encouraged.

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MICROWAVE METRICS

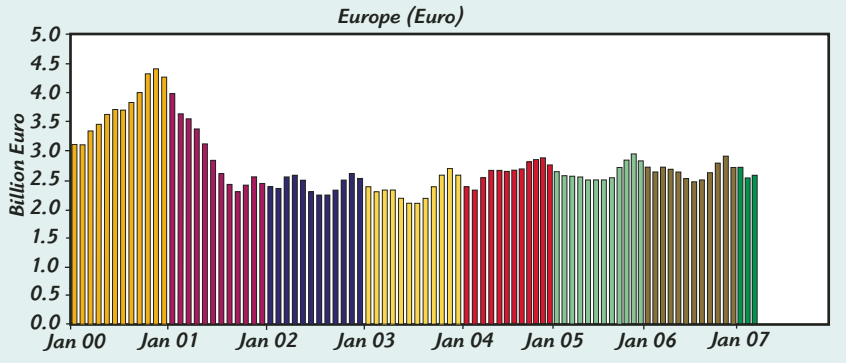
European Semiconductor Market

The March figures for semiconductor sales data have been better than expected. The European market did especially well with a 4.8% increase on a year over year base and in comparison with other regions. Sequentially, the first quarter was down 3.0%, which is in line with the historical pattern. With this value the European market performed better than the world market.

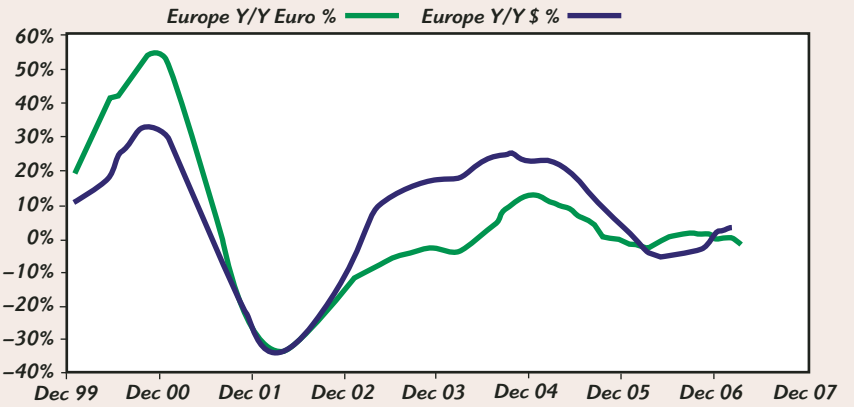
The drivers for these developments have been general purpose products with wide applications like microcontrollers, memories, standard logic and discretes. Microprocessors showed a dip across all regions, still a result of adjustments started in the previous months and which are still happening on the markets. From an application point of view, automotive performed well with increasing sales for both year over year and sequentially. In contrast, lower sales were reported for communication and consumer products sequentially over the last quarter of 2006.

European semiconductor sales in March 2007 amounted to US$ 3.391 B according to the World Semiconductor Trade Statistics (WSTS), up 1.5% versus the previous month. This corresponds to a 4.8% growth compared to the same month last year. On a YTD basis semiconductor sales increased by 4.8% as well as versus the same period in the year 2006.

On a worldwide basis, semiconductor sales in March 2007 were US$ 20.339 B, up 1.0% versus the previous month. This results in an increase of 3.2% versus the same month in 2006 and on a YTD basis it results in a growth rate of 3.2%.



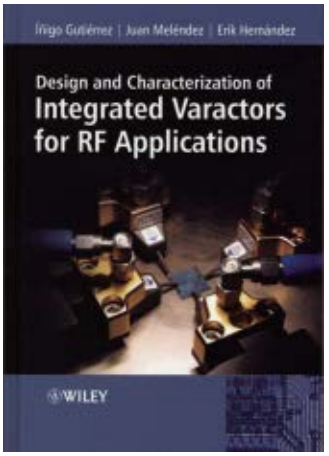
Monthly European Semiconductor Sales in Billion Euro (3-month-average Data)



European Semiconductor Sales Growth in % — Annualized Growth Trend (Y/Y) in Euro and Dollar (12-month-average Data)

Source: European Electronic Component Manufacturers Association, Diamant Building–Bd. A. Reyers 80, B1030 Brussels, Belgium (www.eeca.org)

Design and Characterization of Integrated Varactors for RF Applications



I Gutierrez, J. Melendez and E. Hernandez
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ISBN: 978-0-470-02587-1

This book introduces the reader to varactor design for RF applications in low cost technologies (CMOS, BiCMOS and SiGe) at different levels. It focuses on the design and characterization of integrated varactors. Chapter 1 looks at the general concepts of an integrated varactor, which is characterized by its C-V curve and its figures of merit are the quality factor and the tuning range. Chapter 2 analyses the operating principle of integrated P-N junction varactors and the tools used in their design. Chapter 3 continues along the same lines and looks at MOS varactors. Design rules for the P-N- and MOS-type varactors are extensively described and compared. The experience of different RFIC designers has been summarized to provide the reader with practical knowledge to employ when dealing with challenging VCO designs and others. Some wide band electrical models (up to 5 GHz) are derived, which enable the prediction of their performance in an accurate way. These models are based on physical dimensions and on the properties of the fabrication processes, which provide additional information that is valuable at the design stage. Chapter 4 focuses on the characterization methodology. One specific methodology for integrated varactors is proposed for accurate measurements. It covers the design of on-wafer measurement structures, the calibration process and the detailed description of the equipment required. Chapter 5 looks at the models of varactors and Chapter 6 gives details of the design rules resulting from the work of the previous chapters. Finally, Chapter 7 presents the design of different circuits that use varactors for correct operation, including the design of a voltage-controlled oscillator with a varactor in its LC tank.

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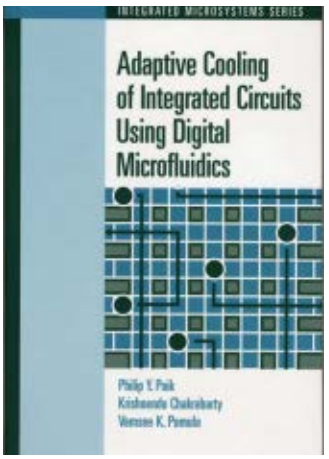

Y. Paik, K. Chakrabarty and V.K. Pamula
Artech House · 203 pages; $89, £41
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Thermal management is a critical issue in integrated circuit design. In this book, alternative cooling architectures, based on a recently invented "digital microfluidic" platform, are introduced. In Chapter 1, the detrimental effects in digital ICs caused by overheating are explained. While many of the same problems are found in analog integrated circuits, they are typically not as extreme. This chapter continues with the study of the sources of power dissipation, followed by descriptions of practical solutions at the microarchitectural level. Chapter 2 provides a number of examples of methods used for cooling integrated circuits, ranging from simple heatsink-fan implementations to complex MEMS structures, used to enhance air flow and heat dissipation. Several microfluidic devices are also discussed. The fundamental principles of how a droplet moves by electro-wetting are described in Chapter 3. Chapter 4 focuses on the development of the basic digital microfluidic platform toward a cooling platform and deals with two main themes: how to measure the temperature across the surface of the chip and identify hot spots, and how to integrate a digital microfluidic chip with an existing device. The temperature effects on moving droplets in a digital microfluidic platform are studied in Chapter 5. Chapters 6 and 7 investigate two methods of chip cooling using digital microfluidic devices. In a flow through approach, cooling droplets are actuated independently via electro-wetting through user-defined reprogrammable flow paths and speeds. The book ends with some concluding remarks summarizing the crucial components that have made the cooling device possible and proposes potential improvements that should be explored in future studies.

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amskatsu@dream.com

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i2i Media
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89# Jian Guo Road
Chaoyang District, Beijing,
China - 100025
Tel: ++86-10-65331960/61
FAX: ++86-10-65331959
aglos@i2i-m.com.cn

If you have to ask how much it costs.....

you can afford it

for synthesizers from PTS, you don't even have to ask,

all our technical information, (web, catalog, data sheets) shows the price of our units. PTS produces fast switching, low noise synthesizers with the best performance/price ratio on the market. Our total installed base, first in the ATE industry, confirms this fact.

41814 units and counting - 3-year warranty since 2003

Are th ere that h ce? Abs ask how much ve think you know th ry...

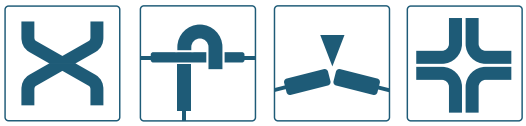
If you should need information on our products, you're free to ask. We shall gladly answer your questions about specs and price.

PROGRAMMED TEST SOURCES, INC.

Visit http://mwj.hotims.com/11719-87 or use RS# 87 at www.mwjournal.com/info

Wide bandwidth, HIGH POWER DEVICES

Unsurpassed quality + on-time delivery, is the Werlatone promise

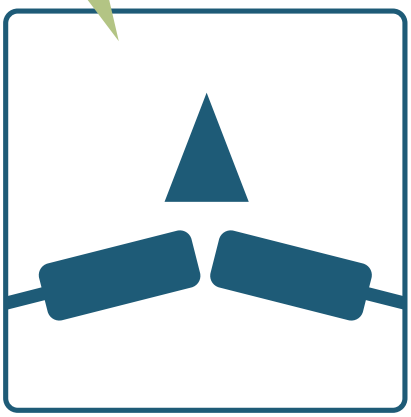


WERLATONE

Breaking all the Rules

High Power Combiners

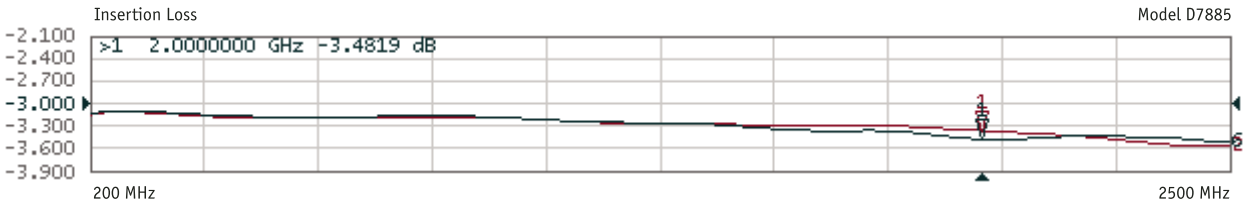
- 10:1 + Bandwidth
- Full Input Failure Protection
- Capable of Non-Coherent Combining

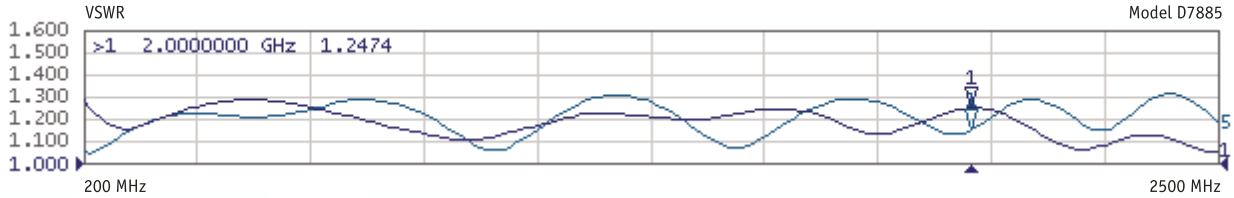


COMBINERS

**Multi-Section Power Dividers, first described by Seymour Cohn, employ a large number of floating, high value resistors, resulting in excessive high frequency roll-off and low unbalanced power capability.

Werlatone's, Patent Pending **"Collapsed Cohn" design requires only one or two, low value, high power resistors to provide the same port-to-port isolation and higher unbalanced power protection, while eliminating high frequency roll-off.





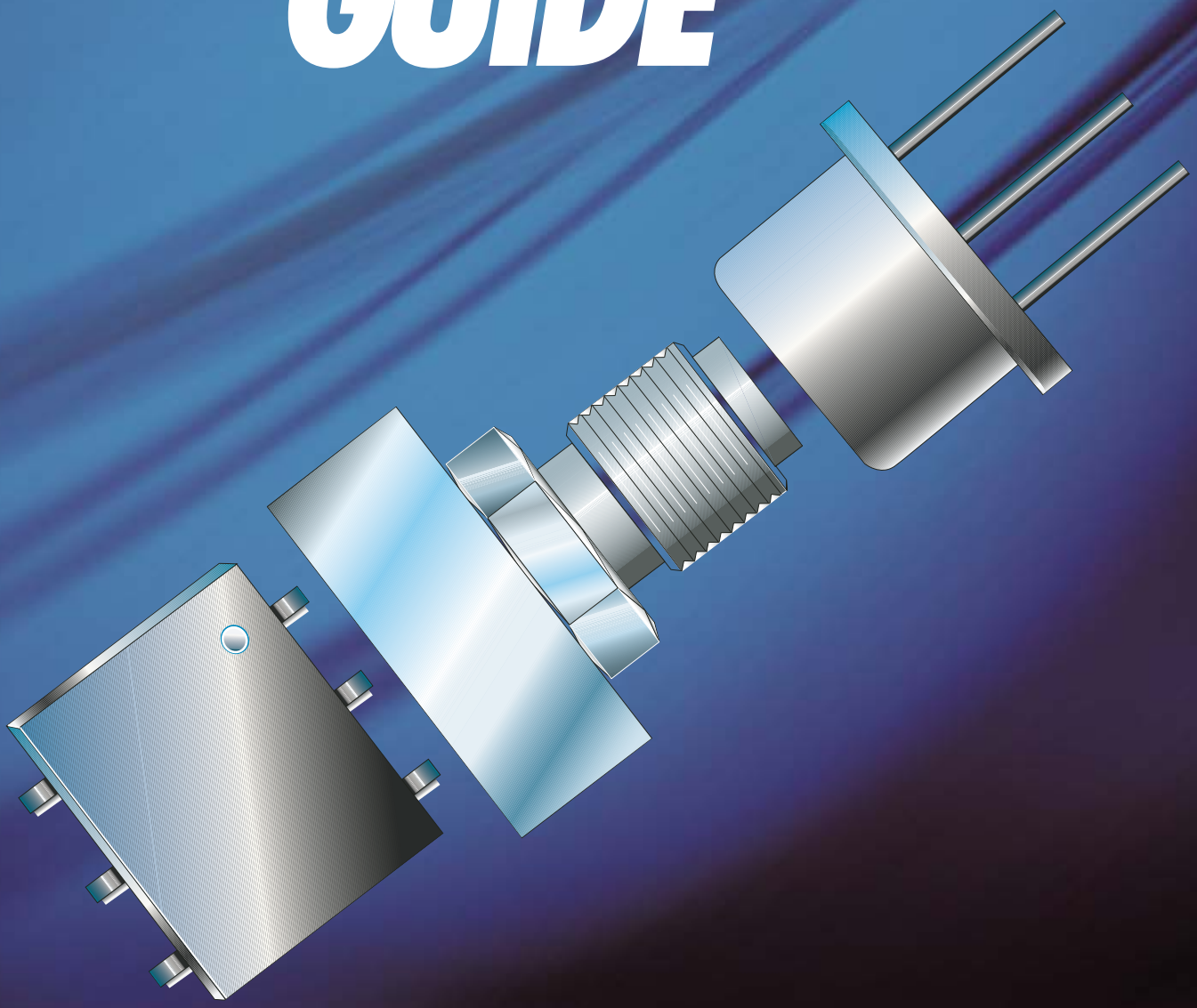
www.werlatone.com

Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	VSWR	Isolation (dB)	Size (Inches)
D7885	2-Way	200-2500	200	0.65	1.40:1	15	7.7 x 1.6 x 1.1
D7823	2-Way	500-2500	200	0.4	1.35:1	15	4.7 x 2.0 x 0.8
D7630	2-Way	800-3000	200	0.4	1.35:1	15	3.7 x 1.9 x 0.87
D7539	4-Way	800-2800	200	0.6	1.35:1	17	5.5 x 4.1 x 1.1
D7695	4-Way	900-1300	100	0.4	1.30:1	20	4.0 x 3.3 x 0.8

SF/2007

IF/RF Microwave

SIGNAL PROCESSING COMPONENTS GUIDE



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ISO 9001 ISO 14001 CERTIFIED

Mini-Circuits...the solid source for

Mini-Circuits®
2007

IF/RF Microwave components

Signal Processing Solutions For:

COMMUNICATIONS • WIRELESS & CELLULAR PRODUCTS
MEDICAL • TEST INSTRUMENTATION • SATELLITE LINKS • RECEIVERS
PC ASSEMBLIES • COMPUTER • DIGITAL & ANALOG DATA ACQUISITION • MILITARY
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For pricing/availability, and complete specifications, performance data and curves, data sheets, pcb layouts, outline drawings & shopping online, see Mini-Circuits website.

Mini-Circuits commitment

QUALITY POLICY Mini-Circuits quality policy is to provide products and services to our internal and external customers that will:

- *Meet Stated Requirements*
- *Exceed Expectations*
- *Continuously Be Improved*

ENVIRONMENTAL COMMITMENT Mini-Circuits has developed an environmental policy that commits to the following:

- *Regulatory Compliance*
- *Pollution Prevention*
- *Continual Improvement*

CORPORATE VISION To continue to be a world preferred company for IF/RF Microwave products.

MISSION STATEMENT Our mission is to provide our customers with products of superior value while promoting growth and prosperity for our members, suppliers, community, and company.

HARVEY KAYLIE
President
Mini-Circuits Worldwide

to quality and customer satisfaction


KEMA
Affiliate with the N.V. KEMA in the Netherlands
A member of the International Network for Quality System Assessment and Certification "IQNet"

CERTIFICATE

Number: 10584.01

The Quality System of:

Mini-Circuits
13 Neptune Avenue
Brooklyn, NY 11235

161 Industry Court
Deer Park, NY 11729

Branson Site
188-194 Symington Place
Hollister, MO 65672

including its implementation, meets the requirements of the standard:

ISO 9001:2000

Scope:

Design, development, manufacture, and distribution of RF, IF and Microwave products for communication systems: commercial, industrial, and military applications. Over 20 product lines, including frequency mixers, power splitters/combiners, attenuators, amplifiers, directional couplers, filters, switches, bias tees, voltage controlled oscillators (VCO's), transformers, monolithic amplifiers, monolithic integrated circuits, frequency synthesizers, I&Q modulators and demodulators.

This Certificate is valid until: April 28, 2006
Renewal Date: April 28, 2003
Issued for the first time: April 28, 1997

H. Pierre Sallé
President
KEMA-Registered Quality

The method of operation for quality system and environmental management system certification is defined in the KRQ General Terms and Conditions for Quality System Certification. Integral publication of this certificate and adjoining reports is allowed.

KEMA-Registered Quality, Inc.
4377 County Line Road
Chalfont, PA 18914
Ph: (215)997-4519
Fax: (215)997-3809

Accredited By:
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The Dutch Council for Accreditation (RvA)

ISO 9001 & ISO 14001 CERTIFICATION AND REGISTRATION

ISO 9001 enhances our devotion to quality. Through a process of planning and prevention, it helps assure customer satisfaction today and in the future.

ISO 14001 is the centerpiece of Mini-Circuits commitment to compliance with environmental regulations. It assures conformance with our stated environmental policies, and demonstrates our passion to implement, maintain, and continually improve our environmental management system.

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WELCOME TO MINI-CIRCUITS SIGNAL PROCESSING COMPONENTS GUIDE

Contents

RoHS Compliant Product availability is listed on our website.

For our complete product selection of more then
10,000 IF/RF Microwave Products
please visit our new website
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Mini-Circuits commitment to innovation

In The Beginning *in 1969, Mini-Circuits founder Harvey Kaylie started the company with a simple formula for success: Manufacture quality products, sell them at a very competitive price, and provide fast delivery. Time would prove Mr. Kaylie's formula was right!*

Today, *Mini-Circuits has grown into the world's largest manufacturer of double balanced mixers, and offers the most diversified selection of IF/RF and microwave products in the marketplace. But in today's world of rapid advances in wireless communications, we must stay extraordinarily focused on long term achievement to defend our position as a market leader. To meet the challenge, aggressive deployment of new technologies continue to penetrate our company with the aim of delivering tangible customer benefits in areas such as new product introduction, lower costs, state-of-the-art manufacturing, high volume production capability, fast turn-around, test and inspection, product reliability, and fast shipment, as well as providing a high level of customer service, communication, and support!*

In The Future, *advanced technologies, sophisticated new products, and novel applications for wireless communications will open challenging new frontiers. As in the past, Mini-Circuits will be there to meet the challenges each step of the way by providing leading-edge solutions and superb value for our customers worldwide!*

Our Guiding Principles

Our Commitment To You Never Ends

Mini-Circuits...

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The Design Engineers Search Engine Provides ACTUAL Data Instantly From MINI-CIRCUITS At: ***www.minicircuits.com***

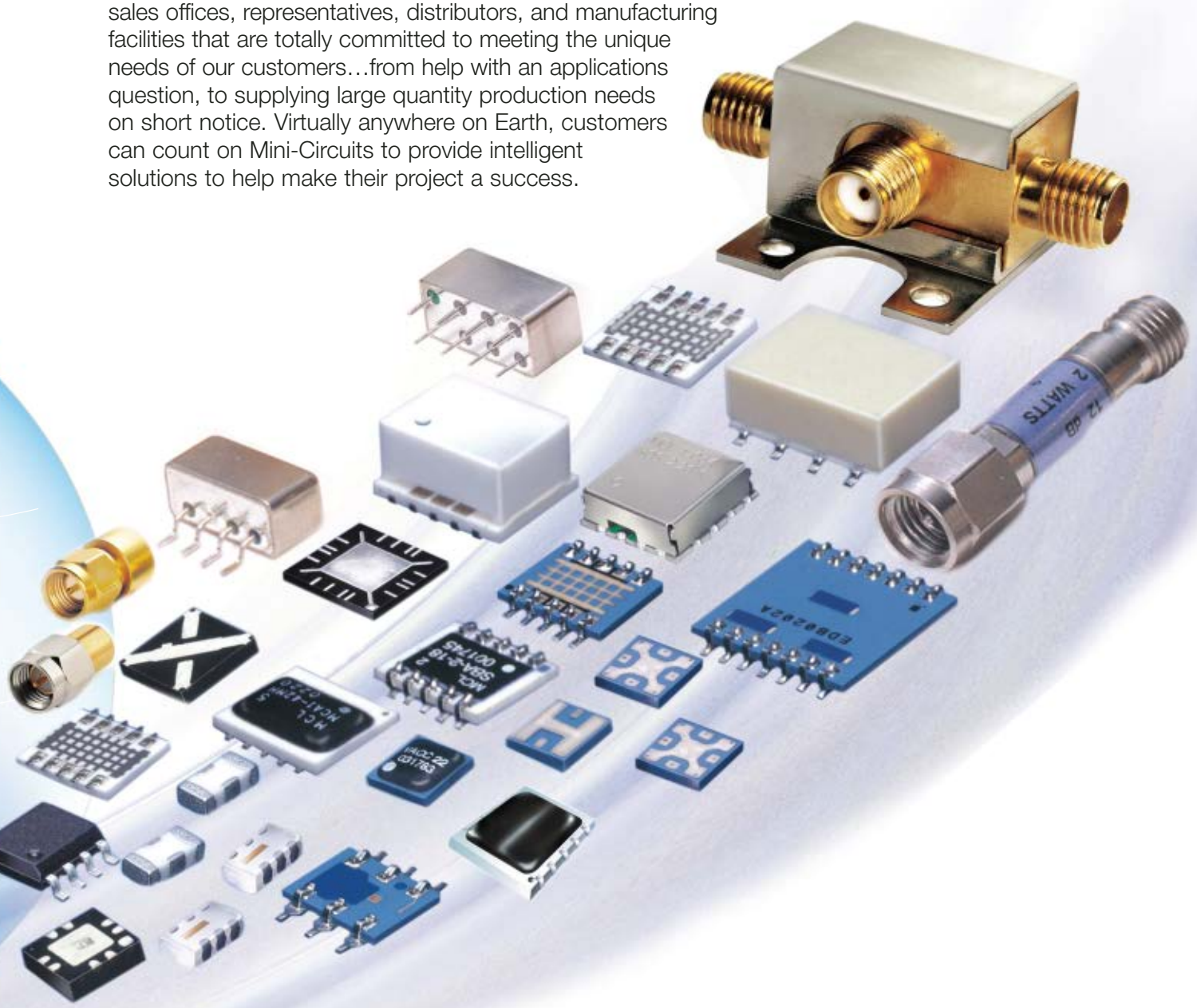
Patent Pending

ISO 9001 ISO 14001 CERTIFIED *RoHS compliant*

Mini-Circuits®
2007

serving your needs worldwide!

As a global leader in IF/RF Microwave signal processing components, Mini-Circuits maintains easily accessible international sales offices, representatives, distributors, and manufacturing facilities that are totally committed to meeting the unique needs of our customers…from help with an applications question, to supplying large quantity production needs on short notice. Virtually anywhere on Earth, customers can count on Mini-Circuits to provide intelligent solutions to help make their project a success.



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For Mini-Circuits products, Our Customers

service & reliability year after year

Say It Best!

Consistently Recognized for…

- *Excellent performance in the area of quality, delivery accuracy, and service*
- *Strategic supplier • Preferred supplier • Supplier of the year*
- *100% quality acceptance • Continuous process improvement*
- *Extraordinary commitment to excellence*
- *Meeting stringent customer service, product quality, and on time delivery standards*
- *Fast shipment and meeting critical needs*
- *Teamwork, top preferred supplier*

MINI-CIRCUITS…honored by these and numerous other satisfied customers.

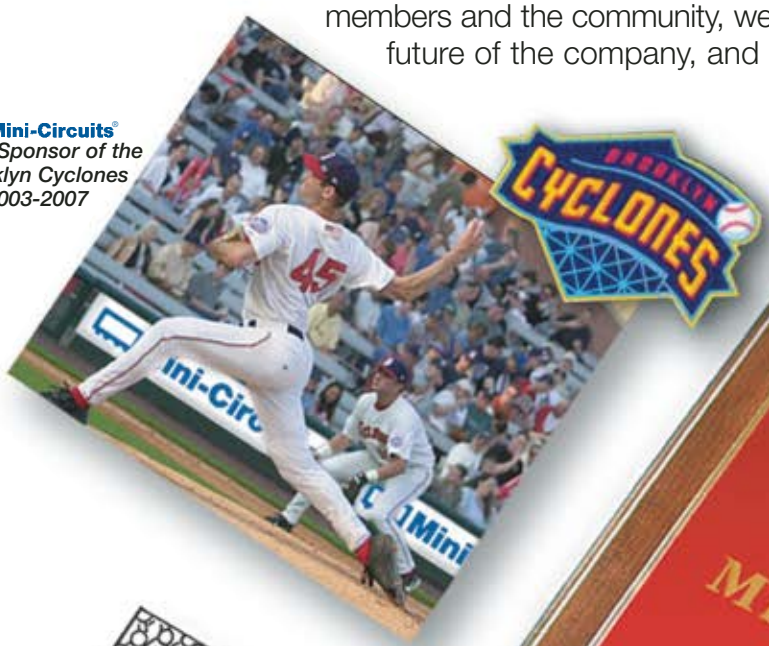
For IF/RF Microwave Components

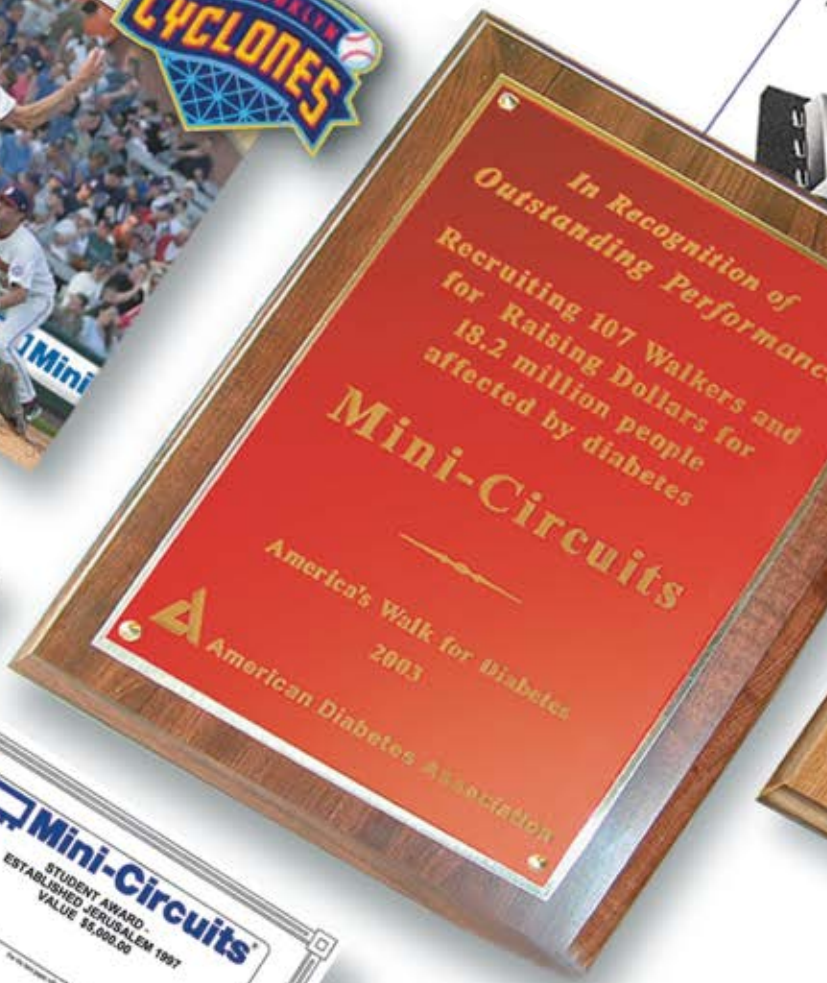
Mini-Circuits commitment to

Building community partnerships is a cornerstone value at Mini-Circuits. We're dedicated to making a positive impact on the communities in which we are doing business by using our unique resources to support neighborhood activities and non-profit organizations.

As a leader in promoting continuing education, Mini-Circuits offers a number of programs that enable our members to further their training and professional skills. We also sponsor an educational scholarship fund for engineering students in the wireless communications field. By promoting continuing educational opportunities for Mini-Circuits members and the community, we help prepare for the future of the company, and industry as well.

Mini-Circuits®
Proud Sponsor of the Brooklyn Cyclones 2003-2007





School Contest
Brooklyn, NY

local communities worldwide!

After School Youth Soccer Sponsorship
Penang, Malaysia

Mini-Circuits Employees Generously Contributed To Tsunami Relief Fund

Mini-Circuits Funds Wisma Yatim Orphanages Ability To House More Children

Mini-Circuits Penang Donates
To Cerebal Palsy Children's Association

Factory donates RM100,000 to group

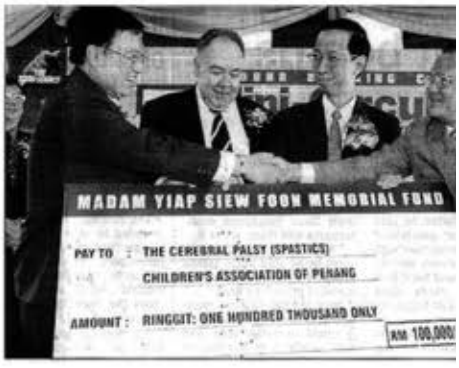
CARING CORPORATE ... Mini-Circuits Technology (M) Sdn Bhd president Kelvin Kiew (*left*) presenting a donation of RM100,000 to Penang Cerebral Palsy (Spastics) Children's Association vice-president Saw Hock Eng.

Looking on are Mini-Circuits Corporation president Harvey Kaylie (*second left*) and Penang Chief Minister Tan Sri Dr Koh Tsu Koon.

Four other organisations in Penang also received donations in conjunction with the ground-breaking ceremony of Mini-Circuits' manufacturing facility at Bayan Lepas Free Industrial Zone yesterday.

The Salvation Army received (RM40,000) while the Lions Club of Georgetown Mutiara, Wisma Yatim Pulau Pinang and Ramakrisna Orphanage each received RM20,000.

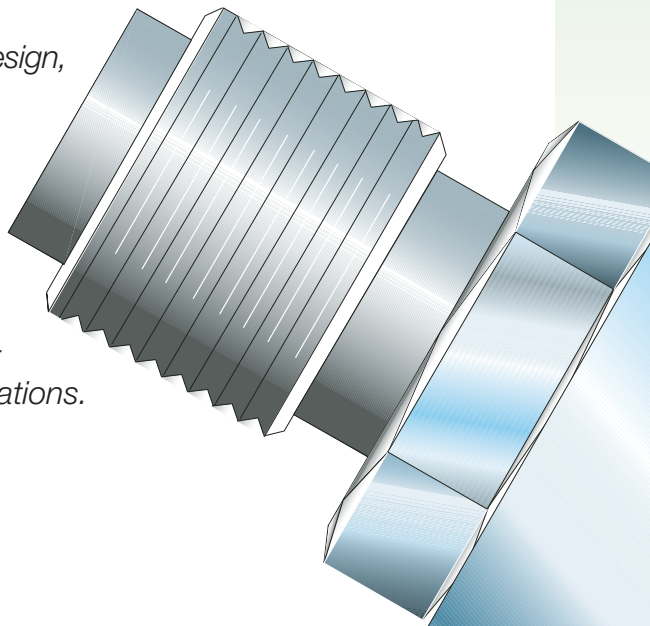
Mini-Circuits Incorporated of the United States plans to invest RM500mil to set up Malaysia's first radio frequency and microwave design centre in Penang.




OUTPUT
+24V
GND
Mini-Circuits
OUTPUT
+15V
GND
Mini-Circuits
15542
ZN2PD-20
0 0203
Mini-Circuits

COAXIAL

With the proliferation of new wireless products on the market today, the demand for coaxial IF/RF Microwave components for use in design, test, R&D, laboratory, and manufacturing environments is at an all time high! To meet this demand, Mini-Circuits offers the world's widest array of high quality, high performance, highly reliable solutions immediately available off-the-shelf. Our products are built to meet or beat our customer's stringent requirements for commercial, industrial, and military applications.



ADAPTERS 50 Ω

DC-18000 MHz

SMA to SMA

SF-SF50 Case DJ952 | SM-SM50 Case DJ951 | SF-SM50 Case DJ836 | SF-MQK50 Case DJ836

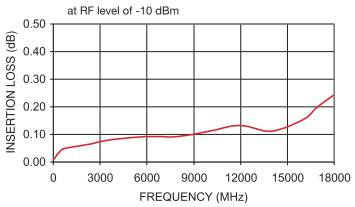
SMA to BNC

SM-BM50 Case DJ1022 | SF-BM50 Case DJ1023 | SM-BF50 Case DJ1024 | SF-BF50 Case DJ1025

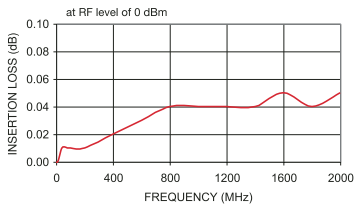
MODEL PREFIX	CONNECTOR TYPE		FREQUENCY RANGE (MHz)	INSERTION LOSS (dB)	VSWR Typ. (:1)
	CONNECTOR 1	CONNECTOR 2	f_L-f_U	Typ.	
SMA/SMA					
SF-SF50	SMA-Female	SMA-Female	DC-18000	0.1	1.10
SM-SM50	SMA-Male	SMA-Male	DC-18000	0.05	1.10
SF-SM50	SMA-Female	SMA-Male	DC-18000	0.1	1.05
Quick Connect					
SF-MQK50	SMA-Female	SMA-Male	DC-18000	0.1	1.10
SMA/BNC					
SM-BM50	SMA-Male	BNC-Male	DC-2000	0.05	1.04
SF-BM50	SMA-Female	BNC-Male	DC-2000	0.05	1.04
SM-BF50	SMA-Male	BNC-Female	DC-2000	0.05	1.04
SF-BF50	SMA-Female	BNC-Female	DC-2000	0.05	1.04

INSERTION LOSS vs. FREQUENCY

SMA/SMA
INSERTION LOSS



SMA/BNC
INSERTION LOSS



Type-N to SMA

NF-SF50 Case DJ827 | NF-SM50 Case DJ826 | NM-SF50 Case DJ825 | NM-SM50 Case DJ824

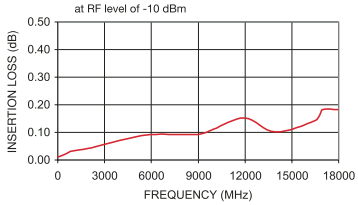
Type-N to Type-N

NF-NF50 Case DJ1092

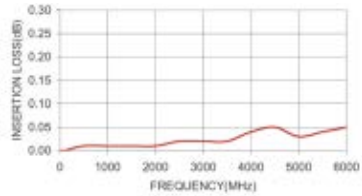
MODEL PREFIX	CONNECTOR TYPE		FREQUENCY RANGE (MHz)	INSERTION LOSS (dB)	VSWR Typ. (:1)
	CONNECTOR 1	CONNECTOR 2	f_L-f_U	Typ.	
Type-N/SMA					
NF-SF50	N-Female	SMA-Female	DC-18000	0.1	1.10
NF-SM50	N-Female	SMA-Male	DC-18000	0.1	1.10
NM-SF50	N-Male	SMA-Female	DC-18000	0.1	1.05
NM-SM50	N-Male	SMA-Male	DC-18000	0.15	1.05
Type-N/Type-N					
NF-NF50	N-Female	N-Female	DC-6000	0.05	1.05

INSERTION LOSS vs. FREQUENCY

TYPE-N/SMA
INSERTION LOSS



TYPE-N/TYPE-N
INSERTION LOSS



AMPLIFIERS *Broadband, Linear 50 Ω*

50 kHz to 14000 MHz

ZX60 Case GC957 | ZEL Case EEE132 | ZJL Case BW459 | ZFL Case Y39/Y460 | ZKL Case BY493 | ZX60 Case GA955 | ZQL Case CW686 | ZRL Case FJ893 | ZQLSC Case GZ1067

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	GAIN, (dB) Min.	GAIN, (dB) Flatness Max.	MAXIMUM POWER (dBm) Typ. Output (1 dB Comp.) Total Range	MAXIMUM POWER (dBm) Typ. Input (no damage)	NOISE FIGURE (dB) Typ.	IP3 (dBm) Typ.	VSWR Typ. (:1) In	VSWR Typ. (:1) Out	ACTIVE DIRECTIVITY (dB) Typ. Midband	DC POWER VOLT (V) Nom.	DC POWER CURRENT (mA) Max.
LOW NOISE *up to +26 dBm output NF 0.4 dB to 2.0 dB*												
ZRL-700	250-700	27.0	±1.0	+24.8	+10	2.0	+46.0	1.20	1.10	16	12	575
ZQL-900LN	824-849	15.0	±0.5	+21.0	+10	0.9	+35.0	1.2	1.1	7	15	160
ZQL-900MLN	824-849	25.5	±0.5	+24.5	+3	1.2	+41.0	1.3	1.4	22	15	230
ZQL-900LNW	800-900	13.0	±1.6	+21.0	+10	0.9	+35.0	1.2	1.1	7	15	160
ZQL-900MLNW	800-900	22.0	±2.2	+23.0	+3	1.2	+41.0	1.3	1.4	24	15	230
ZQLSC-1100	600-1100	15.0	±2.5	+19.0	+10	0.6	+35.0	1.5	1.5	11	24	185
ZEL-0812LN	800-1200	20.0	±1.0	+8.0	+13	1.3	+18.0	1.8	1.6	11	15	70
ZHL-0812HLN	800-1200	30.0	±1.0	+26.0	+10	1.2	+36.0	1.8	1.6	27	15	725
ZHL-0812MLN	800-1200	28.0	±1.0	+20.0	0	1.4	+33.0	1.4	1.7	35	15	300
ZRL-1200	650-1200	25.0	±1.0	+24.3	+10	2.0	+46.0	1.2	1.2	17	12	575
ZRL-1150LN	650-1400	25.0	—	+24.0	+10	0.8	+40.0	1.2	1.2	17	12	500
ZX60-1215LN	800-1400	11.0	±3.0	+12.5	+13	0.4	+26.7	1.65	1.4	13	12	50
ZX60-1614LN	1217-1620	11.0	±2.0	+13.5	+13	0.5	+30.0	1.3	1.3	11.7	12	50
ZEL-1217LN	1200-1700	20.0	±1.0	+8.0	+13	1.5	+25.0	2.0	1.4	11	15	70
ZHL-1217HLN	1200-1700	30.0	±1.0	+26.0	+10	1.2	+36.0	1.8	1.4	20	15	725
ZHL-1217MLN	1200-1700	30.0	±1.0	+20.0	0	1.5	+34.0	1.8	1.4	34	15	300
ZQL-1900LN	1850-1910	15.0	±0.5	+19.0	+10	1.3	+37.0	1.15	1.25	10	15	160
ZQL-1900LNW	1700-2000	14.0	±1.8	+18.5	+10	0.8	+37.0	1.15	1.25	10	15	160
ZQL-1900MLN	1850-1910	25	±0.7	+26.0	+3	1.15	+41.0	1.25	1.2	19	15	310
ZQL-1900MLNW	1800-2000	23.0	±2.0	+25.0	+3	1.2	+41.0	1.4	1.25	17	15	310
ZRL-2150	950-2150	22.5	±1.8	+22.0	+10	1.5	+33.0	1.3	1.2	26	12	300
ZEL-1724LN	1700-2400	20.0	±1.0	+8.0	+13	1.5	+22.0	1.6	1.6	12	15	70
ZHL-1724HLN	1700-2400	30.0	±1.0	+26.0	+10	1.2	+36.0	1.6	1.6	17	15	725
ZHL-1724MLN	1700-2400	28.0	±1.0	+20.0	0	1.1	+32.0	1.6	1.6	32	15	300
ZQLSC-2400	1400-2400	10.5	—	+20.0	+10	1.1	+36.0	1.5	1.6	9	24	185
ZRL-2400LN	1000-2400	23.0	±4.0	+23.0	+10	1.0	+44.0	1.5	1.35	15	12	500
ZQL-2700MLNW	2200-2700	25.0	±3.0	+25.0	+3	1.0	+38.0	1.25	1.15	31	15	325
ZX60-33LN	50-3000	13.0	—	+17	+13	1.1	+32.0	2.0	1.6	10	5.0	80
ZX60-3011	400-3000	7.5	—	+19.5	+15	1.6	+31.0	1.7	1.6	11	12	120
LOW POWER *up to +12 dBm output*												
ZFL-500	0.05-500	20.0	±1.0	+9.0	+5	5.3	+18.0	1.9	1.9	16	15	80
ZFL-500LN	0.1-500	24.0	±0.5	+5.0	+5	2.9	+14.0	1.5	1.6	25	15	60
ZFL-750	0.2-750	18.0	±0.5	+9.0	+5	6.0	+18.0	1.5	2.0	22	15	90
ZFL-1000	0.1-1000	17.0	±0.7	+9.0	+5	6.0	+18.0	1.5	2.1	23	15	105
ZFL-1000LN	0.1-1000	20.0	±0.5	+3.0	+5	2.9	+14.0	1.5	2.0	23	15	60
ZFL-2AD	2-1000	9.0	±0.5	-3.5	+10	6.5	+14.0	2.0	2.0	21	15	22
ZFL-11AD	2-2000	8.0	±1.3	-3.5	+10	6.5	+14.0	2.5	2.0	18	15	22
ZKL-2R7	10-2700	20.0	±0.7	+12.0	+13	5.0	+30.0	1.3	1.4	11	12	120
ZJL-3G	20-3000	14.0	±2.9	+8.0	+13	3.8	+22.0	1.4	1.6	3	12	45
ZJL-4G	20-4000	10.0	±0.6	+12.0	+20	5.5	+30.5	1.4	1.6	6	12	75
ZJL-6G	20-6000	10.0	±1.9	+10.0	+15	4.5	+24.0	1.5	1.4	6	12	50
ZJL-7G	20-7000	7.5	±1.2	+9.0	+15	5.0	+24.0	1.5	1.5	7	12	50
ZX60-8008E	20-8000	8.4	—	+10.8	+15	4.1	+24.0	1.5	1.9	8	12	50
ZX60-14012L	0.3-14000	9.0	±2.0	+11.0	+10	5.5	+20.0	1.3	1.7	5	12	68

ZFL Case SS98 | ZRON Case AV243 | ZHL Case S32 | ZHL-HLN, ZHL-1042J Case NN92 | ZHL-42 Case U36 | ZVE-8G Case BN333

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	GAIN, (dB) Min.	Flatness Max.	MAXIMUM POWER (dBm) Typ. Output (1 dB Comp.) Total Range	Input (no damage)	NOISE FIGURE (dB) Typ.	IP3 (dBm) Typ.	VSWR Typ. (:1) In	Out	ACTIVE DIRECTIVITY (dB) Typ. Midband	DC POWER VOLT (V) Nom.	CURRENT (mA) Max.
MEDIUM POWER *up to +21 dBm output*												
ZFL-1HAD	10-500	10.0	±1.0	+20.0	+17	7.5	+30.0	1.3	1.35	33	15	115
ZFL-500HLN	10-500	19.0	±0.4	+16.0	+15	3.8	+30.0	2.0	2.0	15	15	110
ZFL-1000H	10-1000	28.0	±1.0	+20.0	+5	5.0	+33.0	2.0	2.0	15	15	160
ZFL-2HAD	50-1000	11.0	±1.0	+20.0	+15	5.0	+33.0	2.0	2.0	25	15	110
ZKL-1R5	10-1500	36.0	±1.2	+15.0	+13	3.0	+31.0	1.4	1.6	7	12	115
ZFL-2000	10-2000	20.0	±1.5	+16.0	+5	7.0	+25.0	2.0	2.0	12	15	120
ZKL-2	10-2000	29.0	±1.5	+15.0	+13	4.0	+31.0	1.4	1.4	10	12	120
ZKL-2R5	10-2500	26.0	±1.5	+13.0	+13	5.0	+31.0	1.4	1.4	10	12	120
ZFL-2500	500-2500	28.0	±1.5	+15.0	+5	8.0	+27.0	2.5	2.5	32	5	220
ZX60-2510M	500-2500	12.9	—	+16.2	+10	5.4	+28.8	1.5	1.6	20	5	95
ZX60-2514M	500-2500	16.4	—	+17.5	+10	4.8	+30.3	1.5	1.7	17	5	90
ZX60-2522M	500-2500	23.5	—	+19.2	+10	3.0	+30.6	1.5	1.7	17	5	95
ZX60-2531M	500-2500	31.0	—	+18.2	+10	3.5	+28.4	1.3	1.6	25	5	130
ZX60-2534M	500-2500	34.0	—	+18.0	+10	3.1	+30.0	1.3	1.5	20	5	185
ZX60-3018G	20-3000	18.0	—	+12.8	+13	2.7	+25.0	1.3	1.4	4	12	45
ZJL-4HG	20-4000	13.0	±2.4	+15.0	+13	4.5	+30.5	1.5	1.4	5	12	75
ZX60-4016E	20-4000	15.7	—	+17.4	+13	3.9	+30.0	1.25	1.3	4	12	75
ZX60-43	0.5-4000	17.0	—	+17.3	+13	5.4	+33.0	1.2	2.0	8	5	110
ZHL-1042J	10-4200	25.0	±1.5	+20.0	+10	6.0	+30.0	2.5	2.5	26	15	330
ZJL-5G	20-5000	7.0	±0.55	+15.0	+20	8.5	+32.0	1.6	1.3	8	12	80
ZX60-5916M	1500-5900	17.2	—	+15.7	+10	6.4	+28.3	2.2	1.2	22	5	96
ZX60-6013E	20-6000	13.0	—	+13.4	+15	3.3	+28.7	1.4	1.2	6	12	50
ZRON-8G	2000-8000	20.0	±1.5	+20.0	+10	6.0	+30.0	2.0	2.0	43	15	310
MEDIUM HIGH POWER *up to +30 dBm output*												
ZHL-32A	0.05-130	25.0	±1.0	+29.0	+10	10.0	+38.0	2.0	2.0	13	24	600
ZHL-3A	0.4-150	24.0	±1.0	+29.5	+10	11.0	+38.0	2.0	2.0	12	24	600
ZRL-400	150-400	27.0	±1.0	+25.0	+10	2.5	+42.0	1.25	1.35	19	12	575
ZHL-6A	.0025-500	21.0	±1.2	+22.0	+10	9.5	+34.0	1.8	2.0	30	24	350
ZHL-1A	2-500	16.0	±1.0	+28.0	+20	11.0	+38.0	2.0	2.0	14	24	600
ZHL-211	800-950	20.0	±0.4	+29.0	+15	8.0	+38.0	1.8	1.8	24	24	600
ZFL-1000VH	10-1000	20.0	±1.0	+25.0	+15	4.5	+38.0	2.0	2.5	17	15	320
ZFL-1000VH2	10-1000	26.0	±1.0	+25.0	+15	5.0	+38.0	2.0	2.5	17	15	320
ZHL-2	10-1000	16.0	±1.0	+29.0	+15	9.0	+38.0	2.0	2.0	27	24	600
ZHL-2-8	10-1000	27.0	±1.0	+29.0	+5	10.0	+38.0	2.0	2.0	31	24	600
ZHL-1010	50-1000	9.5	±0.6	+26.0	+22	3.5	+46.0	2.0	2.0	7	12	525
ZHL-1010-75	50-1000	9.5	±0.7	+26.0	+20	3.5	+47.0	1.5	1.5	6	12	525
ZHL-2010	50-1000	20.0	±0.8	+26.0	+11	3.7	+46.0	2.0	2.0	11	12	900
ZHL-3010	50-1000	30.0	±1.0	+26.0	-3	5.5	+46.0	2.5	2.0	16	12	1000
ZHL-2-12	10-1200	24.0	±1.0	+29.0	+10	4.0	+38.0	2.0	2.0	25	24	750
ZRL-2300	1400-2300	21.0	±1.0	+24.6	+10	2.5	+42.0	1.2	1.16	21	12	575
ZX60-2411BM	800-2400	9.0	±2.2	+24.0	+14	3.5	+46.5	1.2	1.2	9	5	360
ZFL-2500VH	10-2500	20.0	±1.5	+23.0	+10	5.5	+35.0	1.7	2.0	15	15	300
ZRL-3500	700-3500	11.0	—	+24.0	+10	2.4	+45.0	1.40	1.30	22	12	575
ZHL-4240W	10-4200	40.0	±1.5	+28.0	-5	8.0	+38.0	2.5	2.5	19	15	900
ZHL-42W	0-4200	30.0	±1.5	+28.0	0	8.0	+38.0	2.5	2.5	26	15	880
ZHL-42	700-4200	30.0	±1.0	+28.0	+5	10.0	+38.0	2.5	2.5	31	15	880
ZHL-4240	700-4200	40.0	±1.5	+28.0	-5	8.0	+38.0	2.5	2.5	18	15	900
ZVE-8G	2000-8000	30.0	±2.0	+30.0	+20	4.0	+40.0	2.0	2.0	17	12	1200

AMPLIFIERS *High Power, Variable Gain, RF Instrument, Pulse 50 Ω*

2.5 kHz to 2000 MHz

LZY-1X Case BT412
LZY-2X Case BT451
ZHL-10W-2GX Case BT1204
ZHL-50W-52X Case BT1165
ZHL-100W-52X Case BT1165

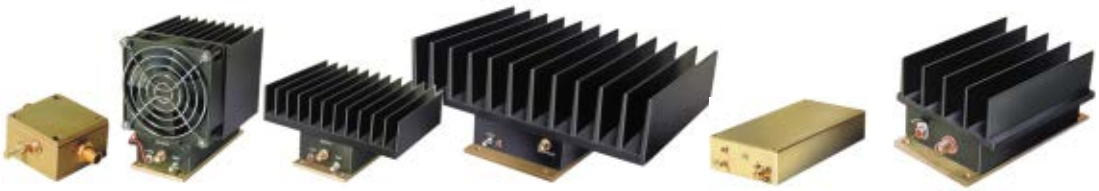
LZY-1 Case BT412
LZY-2 Case BT451
ZHL-10W-2G Case BT1204
ZHL-50W-52 Case BT1165
ZHL-100W-52 Case BT1165

TIA-1000-1R8
Case AP175

TIA-1000-4
Case AP176

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	GAIN, (dB) Min.	Flatness Max.	MAXIMUM POWER (dBm) Output (1 dB Comp.) Min.	Input (no damage)	NOISE FIGURE (dB) Typ.	IP3 (dBm) Typ.	VSWR Typ. (:1) In	Out	ACTIVE DIRECTIVITY (dB) Typ. Midband	DC POWER VOLT (V) Nom.	CURRENT (mA) Max.
HIGH POWER *above +30 dBm output NF from 3.0 dB*												
ZHL-03-5WF	60-300	30.0	±1.0	+36.0	+10	3.0	+49.0	1.4	1.5	29	24	2800
ZHL-5W-1	5-500	40.0	±1.7	+37.0	0	4.0	+49.0	2.0	2.5	16	24	3300
ZHL-1-2W	5-500	29.0	±1.0	+33.0	+10	12.0	+44.0	2.0	2.0	20	24	900
ZHL-50W-52	50-500	46.0	±2.8	+43.0	2	6.0	+55.0	1.6	2.0	24	24	9300
ZHL-50W-52X	50-500	46.0	±2.8	+43.0	2	6.0	+55.0	1.6	2.0	24	24	9000
ZHL-100W-52	50-500	47.0	±1.8	+45.0	3	6.5	+57.0	1.45	2.5	28	24	9300
ZHL-100W-52X	50-500	47.0	±1.8	+45.0	3	6.5	+57.0	1.45	2.5	28	24	9000
LZY-1	20-512	39.0	±1.5	+44.0	+10	8.6	+54.0	2.0	—	20	26	7300
LZY-1X	20-512	39.0	±1.5	+44.0	+10	8.6	+54.0	2.0	—	20	26	7300
ZHL-20W-13	20-1000	46.0	±1.8	+39.0	0	3.5	+50.0	1.7	2.5	20-30	24	2800
ZHL-20W-13X	20-1000	46.0	±1.8	+39.0	0	3.5	+50.0	1.7	2.5	5-19	24	2800
LZY-2	500-1000	40.0	±1.5	+43.0	+10	8.0	+54.0	2.0	3.5	6	26	8000
LZY-2X	500-1000	40.0	±1.5	+43.0	+10	8.0	+54.0	2.0	3.5	6	26	8000
ZHL-1000-3W	500-1000	38.0	±1.5	+35.0	0	3.5	+45.0	2.0	2.5	36	24	2250
ZHL-5W-2G	800-2000	40.0	±2.1	+36.0	+1	8.0	+44.0	1.7	1.5	40	24	2000
ZHL-5W-2GX	800-2000	40.0	±2.1	+36.0	+1	8.0	+44.0	1.7	1.5	40	24	2000
ZHL-10W-2G	800-2000	40.0	±2.0	+39.0	+1	7.0	+50.0	1.3	1.3	40	24	5000
ZHL-10W-2GX	800-2000	40.0	±2.0	+39.0	+1	7.0	+50.0	1.3	1.3	40	24	5000
VARIABLE GAIN *up to +13 dBm output NF from 12 dB, Control Range 30 dB*												
ZFL-1000G	10-1000	17	±1.5	+3.0	+10	12.0	+13.0	2.0	2.0	30	15	100
ZFL-1000GH	10-1200	24	±1.5	+13.0	+10	15.0	+25.0	2.2	2.0	24	15	170

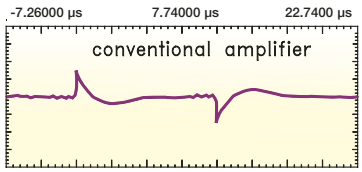
MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	GAIN, (dB) Min.	Flatness Max.	MAXIMUM POWER (dBm) Output (1 dB Comp.) Min.	Input (no damage)	NOISE FIGURE (dB) Typ.	IP3 (dBm) Typ.	VSWR Typ. (:1) In	Out	ACTIVE DIRECTIVITY (dB) Typ. Midband	AC POWER (50/60 Hz) VOLT (V)	CURRENT (mA) Max.
RF INSTRUMENT												
TIA-1000-1R8	0.50-1000	35.0	±2.0	+32.0	+7	8.0	+45.0	1.9	2.5	44	110	1300
TIA-1000-1R8-2	0.50-1000	35.0	±2.0	+32.0	+7	8.0	+45.0	1.9	2.5	44	220	650
TIA-1000-4	100-1000	19.0	±1.5	+36.0	+25	12.0	+48.0	2.5	2.5	38	110	3700
TIA-1000-4-2	100-1000	19.0	±1.5	+36.0	+25	12.0	+48.0	2.5	2.5	38	220	1850



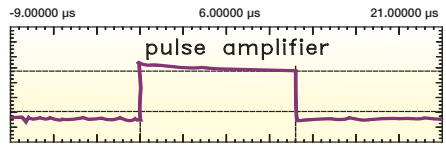
ZFL Case Y39 | ZHL-03-5WF Case CP641 | ZHL-1-2W Case T35 | ZHL-5W-1, ZHL-1000-3W, ZHL-5W-2G Case DDD131 | ZHL-5W-2GX Case DDD131 (no heatsink) | ZPUL Case S32

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	GAIN, (dB) Min.	GAIN, (dB) Flatness Max.	RISE/ FALL TIME (ns) Max.	PULSE WIDTH (µs) Max.	MAXIMUM POWER (dBm) Typ. Output (1 dB Comp.)	MAXIMUM POWER (dBm) Typ. Input (no damage)	NOISE FIGURE (dB) Typ.	IP3 (dBm) Typ.	VSWR Typ. (:1) In	VSWR Typ. (:1) Out	ACTIVE DIRECTIVITY (dB) Typ. Midband	DC POWER VOLT (V) Nom.	DC POWER CURRENT (mA) Max.
PULSE AMPLIFIERS *Inverting and Non-Inverting +22 dBm output NF from 7.2 dB*														
ZPUL-21	0.0025-700	21	±1.0	1.5	6	22.0	+10	7.3	+34.0	2.0	2.0	27	24	350
ZPUL-30P	0.0025-700	29	±1.0	1.5	6	22.0	+10	7.2	+34.0	2.0	2.0	37	24	400

TYPICAL AMPLIFIER RESPONSE TO PULSE INPUT



Ch.1=500.0 mvolts/div
Timebase=3.00 µs/div
offset=8.200 volts
Delay=7.74000 µs



Ch.1=500.0 mvolts/div
Timebase=3.00 µs/div
Start=0.00000 µs
Vmarker1-193.0 mvolts
Stop-10.7400 µs
Vmarker2=1.577 volts
offset=1.190 volts
Delay=6.00000 µs
Delta T=10.7400 µs
Delta V=1.384 volts

ADAPTENUATORS *Attenuators, between different series connectors*

DC to 2000 MHz 3,6,10, 20 dB 50 Ω

MODEL PREFIX	CONNECTOR TYPE		FREQ. RANGE (MHz)	ATTENUATION (dB)							VSWR (:1)						INPUT POWER (W)
					Flatness												
					L		M		U		L		M		U		
	CONNECTOR 1	CONNECTOR 2	f_L-f_U	Nom.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Max.
SMA to BNC Connectors																	
SF-BM-3	SMA-Female	BNC-Male	DC-2000	3±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
SF-BM-6	SMA-Female	BNC-Male	DC-2000	6±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
SF-BM-10	SMA-Female	BNC-Male	DC-2000	10±0.3	0.05	0.15	0.10	0.15	0.10	0.20	1.1	1.2	1.1	1.3	1.2	1.25	0.5
SM-BM-3	SMA-Male	BNC-Male	DC-2000	3±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
SM-BM-6	SMA-Male	BNC-Male	DC-2000	6±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
SM-BM-10	SMA-Male	BNC-Male	DC-2000	10±0.3	0.05	0.10	0.10	0.15	0.10	0.20	1.1	1.2	1.1	1.3	1.2	1.25	0.5
SF-BF-3	SMA-Female	BNC-Female	DC-2000	3±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
SF-BF-6	SMA-Female	BNC-Female	DC-2000	6±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
SF-BF-10	SMA-Female	BNC-Female	DC-2000	10±0.3	0.05	0.10	0.10	0.15	0.10	0.20	1.1	1.2	1.1	1.3	1.2	1.25	0.5
SM-BF-3	SMA-Male	BNC-Female	DC-2000	3±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
SM-BF-6	SMA-Male	BNC-Female	DC-2000	6±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
SM-BF-10	SMA-Male	BNC-Female	DC-2000	10±0.3	0.05	0.15	0.10	0.15	0.10	0.20	1.1	1.2	1.1	1.3	1.2	1.25	0.5

Type-N to BNC Connectors																	
NF-BM-3	N-Female	BNC-Male	DC-2000	3±0.3	0.05	0.15	0.10	0.25	0.17	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
NF-BM-6	N-Female	BNC-Male	DC-2000	6±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
NF-BM-10	N-Female	BNC-Male	DC-2000	10±0.3	0.05	0.15	0.10	0.25	0.15	0.30	1.1	1.2	1.1	1.3	1.2	1.25	0.5
NM-BM-3	N-Male	BNC-Male	DC-2000	3±0.3	0.10	0.20	0.20	0.25	0.20	0.30	1.1	1.2	1.1	1.2	1.2	1.30	0.5
NM-BM-6	N-Male	BNC-Male	DC-2000	6±0.3	0.05	0.15	0.15	0.25	0.20	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
NM-BM-10	N-Male	BNC-Male	DC-2000	10±0.3	0.05	0.15	0.15	0.25	0.20	0.25	1.1	1.2	1.1	1.3	1.2	1.25	0.5
NF-BF-3	N-Female	BNC-Female	DC-2000	3±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
NF-BF-6	N-Female	BNC-Female	DC-2000	6±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
NF-BF-10	N-Female	BNC-Female	DC-2000	10±0.3	0.05	0.15	0.10	0.15	0.10	0.20	1.1	1.2	1.1	1.3	1.2	1.25	0.5
NM-BF-3	N-Male	BNC-Female	DC-2000	3±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
NM-BF-6	N-Male	BNC-Female	DC-2000	6±0.3	0.05	0.15	0.10	0.20	0.15	0.25	1.1	1.2	1.1	1.2	1.2	1.25	0.5
NM-BF-10	N-Male	BNC-Female	DC-2000	10±0.3	0.05	0.15	0.15	0.25	0.20	0.30	1.1	1.2	1.1	1.2	1.2	1.25	0.5
Type-N to SMA Connectors																	
NM-SF-20	N-Male	SMA-Female	DC-3000	20±0.3	0.05	0.15	0.10	0.30	0.60	1.0	1.01	1.20	1.04	1.20	1.09	1.25	0.5

L = low range (DC to 500 MHz) M = mid range (DC to 1000 MHz) U = upper range (DC to f_U MHz)

What is an Adaptenuator? *Our new line of Adaptenuators is simply an attenuator with different connector types at the input and output. The benefits of using Mini-Circuits Adaptenuators are, improved interface matching and eliminating the hassle of working with, misplacing and stocking all different types of adapters to fit your attenuators. Based on the* ***attenuation*** *value you require you can now order the attenuator you need with the* ***connectors*** *you need. These are the new Adaptenuators from Mini-Circuits, designed with an ultra wideband frequency response, usable to 4 GHz with a super flat frequency response. Durably built with solid unibody construction.*

ATTENUATORS, ELECTRONIC 50 Ω

3.5 dB to 40 dB

Mini-Circuits® 2007

ZX73-M
Case GD1163

ZX73
Case GD958

ZFAT
Case SSS173

ZSAT
Case AR214

ZX76
Case HK1149, HK1172

MODEL PREFIX	FREQUENCY RANGE (MHz)		INSERTION LOSS (dB) @ 15 V control voltage		ATTENUATION (dB) @ 0 V control voltage		IP3 (dBm)	RETURN LOSS (dB)	POWER SUPPLY		CONTROL	
	Min.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Typ.	Voltage (V)	Current (mA) Max.	Voltage (V)	Current (mA) Max.
VOLTAGE VARIABLE *10 MHz to 2500 MHz*												
ZX73-2500M	10	2500	3.3	6.2	40	25	+43	20	+3 to +5	5	0-17	30
ZX73-2500	10	2500	3.3	6.2	40	25	+43	20	+3 to +5	5	0-17	30

MODEL PREFIX	FREQUENCY (MHz)		PRIMARY ATTENUATION STEPS (dB) @TTL CONTROL PORT			ATTENUATION (dB) Typ.		VSWR (:1) Max.		
	f_L	f_U	#1	#2	#3	Attenuation Above insertion loss at (1,1,1) state	Max. Insertion loss at (0,0,0) state	L	M	U
DIGITAL STEP *Pin Diode 10 MHz to 1000 MHz*										
ZFAT-R512	10	1000	0.5±0.18	1±0.25	2±0.25	3.5	4.0	1.6	1.4	1.5
ZFAT-124	10	1000	1±0.25	2±0.25	4±0.3	7.0	4.0	1.6	1.4	1.5
ZFAT-3610	10	1000	3±0.3	6±0.4	10±0.4	19.0	4.0	1.6	1.4	1.5
ZFAT-4816	10	1000	4±0.4	8±0.4	16±0.5	28.0	4.0	1.6	1.4	1.5
ZFAT-51020	10	1000	5±0.4	10±0.4	20±0.5	35.0	4.0	1.6	1.4	1.5
				SIX CONTROL PORTS		LOGIC STATE (1,1,1,1,1,1)	(0,0,0,0,0,0)			
ZSAT-31R5	10	1000	(1) 0.5±0.18 (4) 4±0.3	(2) 1±0.25 (5) 8±0.4	(3) 2±0.25 (6)16±0.5	31.5	7.0	2.0	1.5	1.6

L = low range (10 to 100 MHz) M = mid range (100 to 500 MHz) U = upper range (500 to 1000 MHz)

MODEL PREFIX	FREQUENCY RANGE (MHz)	TOTAL STEP ATTENUATION (dB) Typ.	LOWEST ATTENUATION STEP (dB) Typ.	INPUT IP3 (dBm) Typ.	SINGLE POWER SUPPLY Typ. (V_{DD})	DUAL POWER SUPPLY Typ. (V_{DD}, V_{SS})	SWITCHING SPEED (µSec.) Typ.	INPUT PWR. @ 0.2 dB COMPRESSION Typ. dBm	CONTROL INTERFACE	No. OF BITS
DIGITAL STEP *CMOS DC-2400 MHz*										
ZX76-31R5-PN	DC-2400	31.5	0.5	+52	—	+3 V, -3 V	1.0	+24	Parallel	6
ZX76-31R5-PP	DC-2400	31.5	0.5	+52	+3 V	— —	1.0	+24	Parallel	6
ZX76-31R5-SN	DC-2400	31.5	0.5	+52	—	+3 V, -3 V	1.0	+24	Serial	6
ZX76-31R5-SP	DC-2400	31.5	0.5	+52	+3 V	— —	1.0	+24	Serial	6
ZX76-31-PN	DC-2400	31.0	1.0	+52	—	+3 V, -3 V	1.0	+24	Parallel	5
ZX76-31-PP	DC-2400	31.0	1.0	+52	+3 V	— —	1.0	+24	Parallel	5
ZX76-31-SN	DC-2400	31.0	1.0	+52	—	+3 V, -3 V	1.0	+24	Serial	5
ZX76-31-SP	DC-2400	31.0	1.0	+52	+3 V	— —	1.0	+24	Serial	5
ZX76-15R5-PN	DC-4000	15.5	0.5	+52	—	+3 V, -3 V	1.0	+24	Parallel	5
ZX76-15R5-PP	DC-4000	15.5	0.5	+52	+3 V	— —	1.0	+24	Parallel	5
ZX76-15R5-SN	DC-4000	15.5	0.5	+52	—	+3 V, -3 V	1.0	+24	Serial	5
ZX76-15R5-SP	DC-4000	15.5	0.5	+52	+3 V	— —	1.0	+24	Serial	5

ATTENUATORS, FIXED General Response /DC Passing

1 dB to 30 dB, DC-6000 MHz

VAT Case FF704
SMA

HAT Case FF747
BNC

VAT Case DC1066
SMA (2W)

UNAT Case FF779
Type N

NAT Case FF57
Type N

MODEL PREFIX	FREQ. RANGE (MHz) f_L-f_U	ATTENUATION (dB) Nom.	L Typ.	FLATNESS M Typ.	U Typ.	Total Band Typ.	VSWR (:1) TYP. L Typ.	M Typ.	U Typ.	INPUT POWER (W) Max.
SMA *(VAT) 0.5 W / 1 W 50 Ω*										
VAT-1	DC-6000	1±0.3	0.20	0.20	0.20	0.60	1.05	1.10	1.40	1.0
VAT-2	DC-6000	2±0.3	0.20	0.20	0.25	0.65	1.05	1.20	1.50	1.0
VAT-3	DC-6000	3±0.3	0.20	0.15	0.15	0.45	1.05	1.15	1.40	1.0
VAT-4	DC-6000	4±0.3	0.20	0.15	0.20	0.55	1.05	1.15	1.45	1.0
VAT-5	DC-6000	5±0.3	0.10	0.10	0.10	0.25	1.05	1.15	1.40	1.0
VAT-6	DC-6000	6±0.3	0.15	0.10	0.20	0.45	1.05	1.15	1.50	1.0
VAT-7	DC-6000	7±0.3	0.10	0.10	0.10	0.10	1.05	1.15	1.40	1.0
VAT-8	DC-6000	8±0.3	0.10	0.10	0.15	0.20	1.05	1.20	1.60	1.0
VAT-9	DC-6000	9±0.3	0.10	0.10	0.10	0.10	1.05	1.15	1.60	1.0
VAT-10	DC-6000	10±0.3	0.10	0.20	0.15	0.35	1.05	1.20	1.90	1.0
VAT-12	DC-6000	12±0.3	0.10	0.10	0.10	0.30	1.05	1.20	1.65	1.0
VAT-15	DC-6000	15±0.3	0.20	0.30	0.30	0.80	1.05	1.40	1.75	1.0
VAT-20	DC-6000	20±0.3	0.45	0.55	0.35	0.85	1.05	1.20	1.30	0.5
VAT-30	DC-6000	30±0.3	1.10	0.70	0.35	1.30	1.05	1.15	1.25	0.5
SMA *(VAT) 2 W 50 Ω*										
VAT-1W2	DC-6000	1±0.3	0.20	0.20	0.20	0.60	1.10	1.30	1.55	2.0
VAT-2W2	DC-6000	2±0.3	0.20	0.20	0.25	0.65	1.10	1.30	1.50	2.0
VAT-3W2	DC-6000	3±0.3	0.20	0.15	0.15	0.45	1.05	1.30	1.45	2.0
VAT-4W2	DC-6000	4±0.3	0.20	0.15	0.20	0.55	1.05	1.30	1.50	2.0
VAT-5W2	DC-6000	5±0.3	0.20	0.10	0.15	0.35	1.10	1.40	1.65	2.0
VAT-6W2	DC-6000	6±0.3	0.20	0.10	0.20	0.45	1.10	1.30	1.50	2.0
VAT-7W2	DC-6000	7±0.3	0.25	0.15	0.10	0.45	1.10	1.25	1.40	2.0
VAT-8W2	DC-6000	8±0.3	0.15	0.10	0.15	0.25	1.10	1.25	1.60	2.0
VAT-9W2	DC-6000	9±0.3	0.15	0.10	0.10	0.15	1.10	1.15	1.50	2.0
VAT-10W2	DC-6000	10±0.3	0.10	0.20	0.15	0.35	1.15	1.35	1.60	2.0
VAT-12W2	DC-6000	12±0.3	0.10	0.15	0.10	0.30	1.20	1.50	1.70	2.0
VAT-15W2	DC-6000	15±0.3	0.20	0.30	0.30	0.80	1.30	1.60	1.75	2.0
VAT-20W2	DC-6000	20±0.3	0.50	0.45	0.20	1.05	1.35	1.70	1.95	2.0
VAT-30W2	DC-6000	30±0.3	0.70	0.45	0.20	1.30	1.25	1.45	1.60	2.0

VAT Models: L = low range (DC to 3000 MHz) M = mid range (3000 to 5000 MHz) U = upper range (5000 to 6000 MHz)

Type-N *(UNAT) 0.5 W / 1 W 50 Ω*										
UNAT-1	DC-6000	1±0.3	0.20	0.15	0.10	0.45	1.10	1.40	1.0	1.0
UNAT-2	DC-6000	2±0.3	0.20	0.25	0.15	0.50	1.07	1.22	1.50	1.0
UNAT-3	DC-6000	3±0.3	0.20	0.10	0.10	0.35	1.05	1.22	1.50	1.0
UNAT-4	DC-6000	4±0.3	0.15	0.15	0.10	0.40	1.05	1.10	1.50	1.0
UNAT-5	DC-6000	5±0.3	0.15	0.15	0.10	0.35	1.05	1.10	1.50	1.0
UNAT-6	DC-6000	6±0.3	0.15	0.15	0.15	0.40	1.05	1.20	1.50	1.0
UNAT-7	DC-6000	7±0.3	0.10	0.10	0.15	0.20	1.05	1.10	1.50	1.0
UNAT-8	DC-6000	8±0.3	0.10	0.10	0.10	0.10	1.05	1.10	1.50	1.0
UNAT-9	DC-6000	9±0.3	0.15	0.10	0.10	0.15	1.05	1.10	1.50	1.0
UNAT-10	DC-6000	10±0.3	0.10	0.20	0.20	0.40	1.15	1.20	1.50	1.0
UNAT-12	DC-6000	12±0.3	0.15	0.20	0.15	0.35	1.15	1.20	1.80	1.0
UNAT-15	DC-6000	15±0.3	0.20	0.35	0.20	0.60	1.15	1.20	1.70	1.0
UNAT-20	DC-6000	20±0.3	0.45	0.45	0.40	0.75	1.15	1.20	1.30	0.5
UNAT-30	DC-6000	30±0.3	1.20	0.70	0.40	2.30	1.04	1.07	1.10	0.5

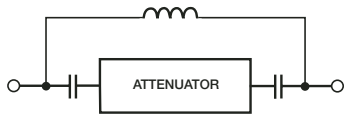
UNAT Models: L = low range (DC to 3000 MHz) M = mid range (3000 to 4500 MHz) U = upper range (4500 to 6000 MHz)

MODEL PREFIX	FREQ. RANGE (MHz) f_L-f_U	ATTENUATION (dB) Nom.	FLATNESS L Typ.	FLATNESS M Typ.	FLATNESS U Typ.	Total Band Typ.	VSWR (:1) TYP. L Typ.	VSWR (:1) TYP. M Typ.	VSWR (:1) TYP. U Typ.	INPUT POWER (W) Max.
BNC (HAT) 0.5 W / 1 W 50 Ω						**Max.**				
HAT-1	DC-2000	1±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-2	DC-2000	2±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-3	DC-2000	3±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-4	DC-2000	4±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-5	DC-2000	5±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-6	DC-2000	6±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-7	DC-2000	7±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-8	DC-2000	8±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-9	DC-2000	9±0.2	0.05	0.10	0.15	0.25	1.05	1.10	1.10	1.0
HAT-10	DC-2000	10±0.2	0.05	0.10	0.10	0.25	1.05	1.10	1.10	1.0
HAT-12	DC-2000	12±0.2	0.05	0.10	0.10	0.25	1.05	1.10	1.15	1.0
HAT-15	DC-2000	15±0.2	0.05	0.10	0.20	0.30	1.05	1.10	1.15	1.0
HAT-20	DC-2000	20±0.2	0.05	0.15	0.25	0.40	1.05	1.10	1.15	0.5
HAT-30	DC-2000	30±0.2	0.30	0.60	0.80	1.30	1.05	1.10	1.15	1.0
BNC (HAT) 0.5 W 75 Ω										
HAT-3-75	DC-2000	3±0.2	0.05	0.10	0.15	0.30	1.05	1.15	1.22	0.5
HAT-6-75	DC-2000	6±0.2	0.05	0.10	0.15	0.3	1.03	1.05	1.15	0.5
HAT-10-75	DC-2000	10±0.2	0.05	0.05	0.05	0.15	1.03	1.04	1.10	0.5
HAT-15-75	DC-2000	15±0.2	0.05	0.05	0.05	0.15	1.03	1.04	1.10	0.5
HAT-20-75	DC-2000	20±0.2	0.05	0.05	0.05	0.15	1.03	1.04	1.10	0.5

HAT Models: L = low range (DC to 500 MHz) M = mid range (DC to 1000 MHz) U = upper range (DC to 2000 MHz)

MODEL PREFIX	FREQUENCY (MHz)	ATTENUATION (dB) Nom.	ATTENUATION (dB) Flatness, Max.	VSWR (:1) Max.	POWER (mW) Max.	DC CURRENT (AMPS) Max.	DC BREAKDOWN (Volts) Max.
Type-N (NAT) DC Passing 50 Ω							
NAT-3DC	200-2500	3±0.5	±0.8	1.25	500	1	60
NAT-6DC	200-2500	6±0.5	±0.8	1.40	375	1	60
NAT-10DC	200-2500	10±0.3	±1.0	1.60	600	4	125
NAT-20DC	500-2300	20±0.5	±1.2	1.80	400	4	125
NAT-3DC-1A	650-3500	3±0.5	±0.7	1.6	1000	1	50
NAT-3DC-2A	1000-3500	3±0.5	±0.8	1.7	1000	2	50
NAT-3DC-3A	1700-3300	3±0.7	±0.7	1.6	1000	3	50
NAT-6DC-1A	600-4000	6±0.7	±0.8	1.7	1000	1	50
NAT-6DC-2A	1000-3750	6±0.7	±0.8	1.6	1000	2	50
NAT-6DC-3A	1700-3500	6±0.5	±0.8	1.5	1000	3	50
NAT-10DC-1A	600-4000	10±0.6	±0.6	1.6	1000	1	50
NAT-10DC-1.5A	1000-4000	10±0.5	±0.6	1.6	1000	1.5	50
NAT-10DC-2.5A	1700-4000	10±0.5	±0.6	1.6	1000	2.5	50
NAT-15DC-1A	650-4000	15±0.7	±0.8	1.7	1000	1	50
NAT-15DC-1.5A	950-4000	15±0.7	±0.6	1.6	1000	1.5	50
NAT-15DC-2.5A	1700-4000	15±0.8	±0.6	1.5	1000	2.5	50

ELECTRICAL SCHEMATIC



ATTENUATORS, FIXED PRECISION 50 Ω

1 to 40 dB, DC to 18000 MHz

BW-SW2 Case FF658/FF659
SMA, 2 W

BW-SW5 Case DC737
SMA, 5 W

BW-NW5 Case DC736
Type N, 5 W

BW-40N100W Case GH986
Type N, 100 W

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ATTENUATION (dB) Nominal	Accuracy	VSWR (:1) Max. L	M	U
SMA 2 W						
BW-S1W2	DC-18000	1	±0.40	1.20	1.25	1.30
BW-S2W2	DC-18000	2	±0.40	1.20	1.25	1.30
BW-S3W2	DC-18000	3	±0.40	1.20	1.25	1.30
BW-S4W2	DC-18000	4	±0.40	1.20	1.25	1.30
BW-S5W2	DC-18000	5	±0.40	1.20	1.25	1.30
BW-S6W2	DC-18000	6	±0.40	1.20	1.25	1.30
BW-S7W2	DC-18000	7	-0.4, +0.9	1.20	1.25	1.30
BW-S8W2	DC-18000	8	±0.60	1.20	1.25	1.30
BW-S9W2	DC-18000	9	-0.4, +0.8	1.20	1.25	1.30
BW-S10W2	DC-18000	10	±0.60	1.20	1.25	1.30
BW-S12W2	DC-18000	12	±0.60	1.20	1.25	1.30
BW-S15W2	DC-18000	15	±0.60	1.20	1.25	1.30
BW-S20W2	DC-18000	20	-0.5, +0.8	1.20	1.25	1.30
BW-S30W2	DC-18000	30	±0.85	1.20	1.25	1.30
BW-S40W2	DC-18000	40	-0.5, +1.5	1.20	1.25	1.30
SMA 5 W						
BW-S1W5	DC-18000	1	±0.40	1.20	1.25	1.30
BW-S2W5	DC-18000	2	±0.40	1.20	1.25	1.30
BW-S3W5	DC-18000	3	±0.40	1.20	1.25	1.30
BW-S4W5	DC-18000	4	±0.40	1.20	1.25	1.30
BW-S5W5	DC-18000	5	±0.40	1.20	1.25	1.30
BW-S6W5	DC-18000	6	±0.40	1.20	1.25	1.30
BW-S7W5	DC-18000	7	-0.4, +0.9	1.20	1.25	1.30
BW-S8W5	DC-18000	8	±0.60	1.20	1.25	1.30
BW-S9W5	DC-18000	9	-0.4, +0.8	1.20	1.25	1.30
BW-S10W5	DC-18000	10	±0.60	1.20	1.25	1.30
BW-S12W5	DC-18000	12	±0.60	1.20	1.25	1.30
BW-S15W5	DC-18000	15	±0.60	1.20	1.25	1.30
BW-S20W5	DC-18000	20	-0.5, +0.8	1.20	1.25	1.30
BW-S30W5	DC-18000	30	±0.85	1.20	1.25	1.30
BW-S40W5	DC-18000	40	-0.5, +1.5	1.20	1.25	1.30
Type-N 5 W						
BW-N1W5	DC-18000	1	±0.40	1.20	1.25	1.30
BW-N2W5	DC-18000	2	±0.40	1.20	1.25	1.30
BW-N3W5	DC-18000	3	±0.40	1.20	1.25	1.30
BW-N4W5	DC-18000	4	±0.40	1.20	1.25	1.30
BW-N5W5	DC-18000	5	±0.40	1.20	1.25	1.30
BW-N6W5	DC-18000	6	±0.40	1.20	1.25	1.30
BW-N7W5	DC-18000	7	-0.4, +0.9	1.20	1.25	1.30
BW-N8W5	DC-18000	8	±0.60	1.20	1.25	1.30
BW-N9W5	DC-18000	9	-0.4, +0.8	1.20	1.25	1.30
BW-N10W5	DC-18000	10	±0.60	1.20	1.25	1.30
BW-N12W5	DC-18000	12	±0.60	1.20	1.25	1.30
BW-N15W5	DC-18000	15	±0.60	1.20	1.25	1.30
BW-N20W5	DC-18000	20	-0.5, +0.8	1.20	1.25	1.30
BW-N30W5	DC-18000	30	±0.85	1.20	1.25	1.30
BW-N40W5	DC-18000	40	-0.5, +1.5	1.20	1.25	1.30

L = low range (DC to 4000 MHz) M = mid range (4000 to 8000 MHz) U = upper range (8000 to 12400 MHz)

Type-N 100 W

BW-40N100W	DC-4000	40	±1.6	1.15	1.35	1.40

L = low range (DC to 500 MHz) M = mid range (500 to 2000 MHz) U = upper range (2000 to 4000 MHz)

BIAS-TEES *Wideband, High DC Current 50 Ω*

100 kHz to 12000 MHz

Mini-Circuits® 2007

ZX85-12G
Case GC957

ZFBT
Case K18

ZFBT-FT
Case Y460

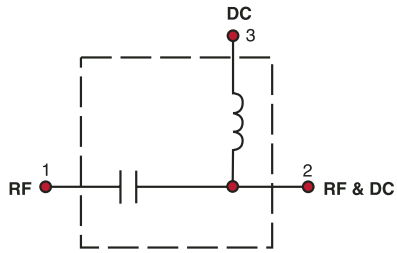
ZNBT
Case K558

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	INSERTION LOSS (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	ISOLATION, (dB) (RF port to DC port) (RF & DC port to DC port) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	VSWR (:1) L Typ.	M Typ.	U Typ.	RF POWER OPERATING Max. (dBm)	DC CURRENT OPERATING Max. (mA)
0.1 to 12000 MHz																		
ZFBT-4R2GW	0.1-4200	0.15	0.8	0.6	1.2	0.6	1.6	25	15	40	20	50	20	1.06	1.13	1.13	20	200
ZFBT-4R2GW-FT	0.1-4200	0.15	0.8	0.6	1.2	0.6	1.6	—	—	—	—	—	—	1.06	1.13	1.13	20	200
ZFBT-4R2G	10-4200	0.15	0.6	0.6	1.2	0.6	1.6	32	20	40	20	50	20	1.06	1.13	1.13	20	200
ZFBT-4R2G-FT	10-4200	0.15	0.6	0.6	1.2	0.6	1.6	—	—	—	—	—	—	1.06	1.13	1.13	20	200
ZFBT-6GW	0.1-6000	0.15	0.8	0.6	1.4	1.0	2.2	25	15	40	20	30	17	1.06	1.13	1.13	20	200
ZFBT-6GW-FT	0.1-6000	0.15	0.8	0.6	1.4	1.0	2.2	—	—	—	—	—	—	1.06	1.13	1.13	20	200
ZNBT-60-1W	2.5-6000	0.2	0.9	0.6	2.0	1.6	2.2	75	45	45	25	35	20	1.1	1.1	1.35	20	200
ZFBT-6G	10-6000	0.15	0.6	0.6	1.4	1.0	2.2	32	20	40	20	30	17	1.06	1.13	1.13	20	200
ZFBT-6G-FT	10-6000	0.15	0.6	0.6	1.4	1.0	2.2	—	—	—	—	—	—	1.06	1.13	1.13	20	200
ZX85-12G	0.2-12000	0.10	0.5	0.6	1.5	1.0	2.5	—	—	—	—	—	—	1.10	1.20	1.20	20	200

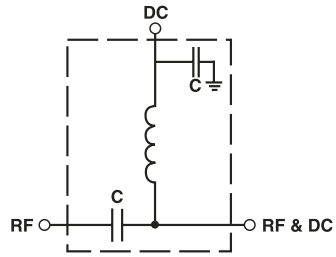
L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

ELECTRICAL SCHEMATICS

For ZFBT models



For ZX85-12G, ZNBT-60-1W models



CABLES, FLEXIBLE TEST 50 Ω

DC to 18 GHz

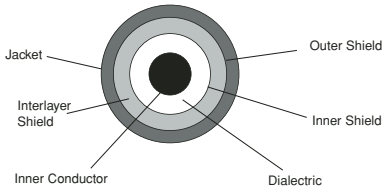
RUGGED CABLES

FLEX TEST™

RUGGED QUICK TURN CABLES *TIME SAVERS!*

MODEL PREFIX	FREQ. (GHz) f_L-f_U	LENGTH (Feet)	INSERTION LOSS (dB) DC - 2.5 GHz Typ.	DC - 2.5 GHz Max.	2.5 - 6 GHz Typ.	2.5 - 6 GHz Max.	6 - 12 GHz Typ.	6 - 12 GHz Max.	12 - 18 GHz Typ.	12 - 18 GHz Max.	RETURN LOSS (dB) DC - 2.5 GHz Typ.	DC - 2.5 GHz Min.	2.5 - 6 GHz Typ.	2.5 - 6 GHz Min.	6 - 12 GHz Typ.	6 - 12 GHz Min.	12 - 18 GHz Typ.	12 - 18 GHz Min.
SMA Male to Male																		
CBL-1.5FT-SMSM	DC-18	1.5	0.25	0.6	0.4	0.85	0.7	1.2	1.0	1.4	30	23	30	20	27	17	27	17
CBL-2FT-SMSM	DC-18	2	0.4	0.6	0.7	0.95	1.1	1.35	1.4	1.75	30	23	30	20	27	17	27	17
CBL-3FT-SMSM	DC-18	3	0.6	0.8	1.0	1.3	1.5	1.9	1.9	2.45	30	23	30	20	27	17	27	17
CBL-4FT-SMSM	DC-18	4	0.55	0.9	1.0	1.65	1.6	2.45	2.25	3.15	30	23	30	20	27	17	27	17
CBL-6FT-SMSM	DC-18	6	1.2	1.4	2.0	2.35	3.0	3.5	3.8	4.55	30	23	30	20	27	17	22	17
CBL-10FT-SMSM	DC-18	10	1.8	2.1	3.1	3.8	4.8	5.7	6.1	7.4	30	23	30	20	27	17	22	17
CBL-12FT-SMSM	DC-18	12	2.0	2.45	3.8	4.4	5.9	6.7	7.3	8.7	30	23	30	20	27	17	22	17
CBL-15FT-SMSM	DC-18	15	2.5	2.95	4.7	5.5	7.3	8.35	9.25	10.8	30	23	30	20	27	17	22	17
SMA Male to Type-N Male																		
CBL-2FT-SMNM	DC-18	2	0.4	0.6	0.7	0.95	1.1	1.4	1.4	1.75	30	23	30	20	27	17	27	17
CBL-3FT-SMNM	DC-18	3	0.6	0.8	1.0	1.3	1.5	1.95	1.9	2.45	30	23	30	20	27	17	27	17
CBL-4FT-SMNM	DC-18	4	0.55	0.95	1.0	1.65	1.6	2.45	2.25	3.15	30	23	30	20	27	17	27	17
CBL-6FT-SMNM	DC-18	6	1.2	1.4	2.0	2.35	3.0	3.55	3.8	4.55	30	23	30	20	27	17	22	17
CBL-15FT-SMNM	DC-18	15	2.5	2.95	4.94	5.5	7.32	8.35	9.25	10.8	30	23	30	20	27	17	22	17
Type-N Male to Male																		
CBL-2FT-NMNM	DC-18	2	0.4	0.6	0.7	1.0	1.1	1.4	1.4	1.8	30	23	30	20	27	17	27	17
CBL-3FT-NMNM	DC-18	3	0.6	0.8	1.0	1.35	1.5	1.95	1.9	2.5	30	23	30	20	27	17	27	17
CBL-6FT-NMNM	DC-18	6	1.2	1.4	2.0	2.4	3.0	3.55	3.8	4.6	30	23	30	20	27	17	22	17
CBL-15FT-NMNM	DC-18	15	2.5	2.95	4.94	5.5	7.32	8.35	9.25	10.85	30	23	30	20	27	17	22	17
CBL-20FT-NMNM	DC-18	20	3.3	3.85	6.2	7.25	9.4	11.05	12.0	14.3	30	23	30	20	27	17	22	17
CBL-25FT-NMNM	DC-18	25	4.1	4.8	7.8	9.0	11.7	13.7	15.0	17.8	30	23	30	20	27	17	22	17
SMA Female to Male																		
CBL-3FT-SFSM	DC-18	3	0.6	0.8	1.0	1.3	1.5	1.9	1.9	2.45	30	23	30	20	27	17	27	17
SMA Female to Type-N Male																		
CBL-2FT-SFNM	DC-18	2	0.4	0.6	0.7	1.0	1.1	1.40	1.4	1.8	30	23	30	20	27	17	27	17
CBL-3FT-SFNM	DC-18	3	0.6	0.8	1.0	1.35	1.5	1.95	1.9	2.45	30	23	30	20	27	17	27	17
CBL-6FT-SFNM	DC-18	6	1.1	1.4	2.0	2.35	3.0	3.55	3.8	4.55	30	23	30	20	27	17	22	17
Quick Turn *Type-N Male to* ***Quick Turn*** *SMA Male*																		
CBL3NMQ-SMQ+	DC-18	3	0.6	0.8	1.0	1.3	1.5	1.95	1.9	2.45	30	23	30	20	27	17	27	17
Quick Turn *SMA Male to SMA Male*																		
CBL2SMQ-SM+	DC-18	2	0.4	0.6	0.7	0.95	1.1	1.35	1.4	1.75	30	23	30	20	27	17	27	17
CBL3SMQ-SM+	DC-18	3	0.6	0.8	1.0	1.3	1.5	1.9	1.9	2.45	30	23	30	20	27	17	27	17
CBL6SMQ-SM+	DC-18	6	1.2	1.4	2	2.35	3	3.5	3.8	4.55	30	23	30	20	27	17	22	17
CBL10SMQ-SM+	DC-18	10	1.8	2.1	3.1	3.8	4.8	5.7	6.1	7.4	30	23	30	20	27	17	27	17
Quick Turn *SMA Male to Type-N Male*																		
CBL2SMQ-NM+	DC-18	2	0.4	0.6	0.7	0.95	1.1	1.4	1.4	1.75	30	23	30	20	27	17	27	17
Quick Turn *Type-N Male to Type-N Male*																		
CBL3NMQ-NM+	DC-18	3	0.6	0.8	1.0	1.3	1.6	1.9	2.0	2.45	30	23	30	20	27	17	27	17
CBL6NMQ-NM+	DC-18	6	1.2	1.4	2.0	2.4	3.0	3.55	3.8	4.6	30	23	30	20	27	17	27	17
Quick Turn *Type-N Male to SMA Male*																		
CBL3NMQ-SM+	DC-18	3	0.6	0.8	1.0	1.3	1.5	1.95	1.95	2.45	30	23	30	20	27	17	27	17
CBL6NMQ-SM+	DC-18	6	1.2	1.4	2.0	2.35	3.0	3.55	3.8	4.55	30	23	30	20	27	17	27	17

CABLE CROSS SECTION



CABLE CONSTRUCTION

Inner Conductor
Solid Silver-Plated Copper Clad Steel

Dielectric
Solid PTFE

Shield
Silver-Plated Copper Flat Ribbon Braid
Aluminum-Polymide Tape Interlayer 36 GA
Silver-Plated Copper Braid (90%k)

Jacket
Clear FEP

CONNECTORS

Passivated stainless steel
Captive contact
Thick wall interface (SMA)
Gold plated beryllium copper center contacts
PTFE dielectric

FLEX TEST™ CABLES

DC to 18 GHz from $68.95 ea. (qty.1-9) IN STOCK

Strength, ruggedness, and reliability…*supercharged!* That's what you get when you choose Mini-Circuits ultra-flexible precision test cables. Engineered to be a workhorse for your day-to-day test operations, these triple shielded cable assemblies are qualified to at least 20,000 bends, employ an advanced strain relief system, and are equipped with passivated stainless steel connectors, *so you can rely on them to* ***flex, connect and disconnect over and over and over again!*** They're so rugged, each test cable is backed by our 6 month guarantee*! With low insertion loss and very good return loss, you can also rely on getting good performance over the wide DC-18 GHz band. Need them right away? Overnight shipment is available. So make Mini-Circuits your test cable connection! *Mini-Circuits…we're redefining what VALUE is all about!*

Custom sizes available, consult factory.

SMA Female | SMA Male | N-Type Male

RoHS COMPLIANT™

Frequency Range: DC-18 GHz, Impedance: 50 ohms

Models	Connector Type	Length (Ft.)	Inser. Loss (dB) Midband Typ.	Return Loss (dB) Midband Typ.	Price $ ea. Qty.(1-9)
Male to Male					
CBL-1.5FT-SMSM+	SMA	1.5	0.7	27	68.95
CBL-2FT-SMSM+	SMA	2	1.1	27	69.95
CBL-3FT-SMSM+	SMA	3	1.5	27	72.95
CBL-4FT-SMSM+	SMA	4	1.6	27	75.95
CBL-6FT-SMSM+	SMA	6	3.0	27	79.95
CBL-10FT-SMSM+	SMA	10	4.8	27	87.95
CBL-12FT-SMSM+	SMA	12	5.9	27	91.95
CBL-15FT-SMSM+	SMA	15	7.3	27	100.95
CBL-2FT-SMNM+	SMA to N-Type	2	1.1	27	99.95
CBL-3FT-SMNM+	SMA to N-Type	3	1.5	27	104.95
CBL-4FT-SMNM+	SMA to N-Type	4	1.6	27	112.95
CBL-6FT-SMNM+	SMA to N-Type	6	3.0	27	114.95
CBL-15FT-SMNM+	SMA to N-Type	15	7.3	27	156.95
CBL-2FT-NMNM+	N-Type	2	1.1	27	102.95
CBL-3FT-NMNM+	N-Type	3	1.5	27	105.95
CBL-6FT-NMNM+	N-Type	6	3.0	27	112.95
CBL-15FT-NMNM+	N-Type	15	7.3	27	164.95
CBL-20FT-NMNM+	N-Type	20	9.4	27	178.95
CBL-25FT-NMNM+	N-Type	25	11.7	27	199.95
Female to Male					
CBL-3FT-SFSM+	SMA-F to SMA-M	3	1.5	27	93.95
CBL-2FT-SFNM+	SMA-F to N-M	2	1.1	27	119.95
CBL-3FT-SFNM+	SMA-F to N-M	3	1.5	27	124.95
CBL-6FT-SFNM+	SMA-F to N-M	6	3.0	27	146.95

6 mo. GUARANTEE*

Mini-Circuits will repair or replace your test cable at its option if the connector attachment fails within **six months of shipment. This guarantee excludes cable or connector interface damage from misuse or abuse.*

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For pricing/availability, and complete specifications, performance data and curves, data sheets, pcb layouts, outline drawings & shopping online, see Mini-Circuits website.

DIRECTIONAL COUPLERS, 6.7 to 40 dB Coupling

5 kHz to 2575 MHz

ZX30-BD Case GW1052 | ZX30 Case FL905 | ZEDC Case V37 | ZFDC, Z30 Case K18 | ZFBDC ZFDC-20-1H Case J17 | ZNDC Case FM587 | ZADC Case F14 | ZADC Case CC51-1 | ZMDC Case M21 | ZDC Case M22 | ZABDC Case DD477 | ZBDC Case HT1180

MODEL PREFIX	FREQUENCY (MHz)	COUPLING (dB)		MAINLINE LOSS (dB)						DIRECTIVITY (dB)						VSWR (:1)	POWER INPUT, W	
				L		M		U		L		M		U			L	MU
	f_L-f_U	Nom.	Typ. Flatness	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Max	Max.
DIRECTIONAL COUPLERS 50 Ω																		
ZADC-6-2G-5W	800-2000	6.7±1.0	±1.3	1.6	1.9	1.6	1.9	1.6	1.9	25	17	25	17	25	17	1.15	5.0	5.0
ZX30-9-4	5-1200	8.9±0.5	±0.1	1.10	1.4	1.1	1.4	1.3	1.8	21	19	20	15	16	12	1.20	0.5	1.0
ZADC-10-17	1000-1700	9.8±0.5	±1.0	0.8	1.3	0.8	1.3	0.8	1.3	25	17	25	17	25	17	1.20	5.0	5.0
ZADC-10-10	800-1000	10±0.6	±1.0	0.8	1.2	0.8	1.2	0.8	1.2	22	17	22	17	22	17	1.16	5.0	5.0
ZADC-10-17W	800-1900	10.2±1.0	±1.5	0.8	1.3	0.8	1.3	0.8	1.3	24	14	24	14	24	14	1.20	5.0	5.0
ZFDC-10-1	1-500	10.5±0.25	±0.6	1.00	1.3	0.8	1.1	1.0	1.3	32	25	33	25	22	15	1.20	1.5	3.0
ZFDC-10-2	10-1000	10.75±0.5	±0.5	1.50	2.0	1.2	1.8	1.5	2.0	35	28	30	25	27	20	1.50	1.5	3.0
ZFDC-10-5	1-2000	10.8±0.5	±0.5	1.20	1.9	1.2	1.8	1.8	2.5	38	25	30	18	22	18	1.30	0.5	0.5
ZFDC-10-6	0.005-20	11±0.5	±0.5	0.40	1.2	0.4	0.8	0.4	1.0	40	30	40	30	35	25	1.30	1.5	3.0
ZFDC-10-22	1-750	11±0.5	±0.5	1.10	1.9	1.2	1.7	1.4	1.9	35	30	25	20	25	20	1.25	1.0	2.0
ZEDC-10-2B	1-1000	11±0.5	±0.75	1.30	1.8	1.5	1.8	1.5	1.8	35	30	30	20	18	13	1.30	1.5	3.0
ZFDC-10-21	1-1000	11±0.5	±0.5	1.20	2.1	1.2	1.7	1.60	2.0	40	30	25	20	25	20	1.20	1.0	2.0
ZDC-10-1	0.5-500	11.5±0.5	±0.6	0.85	1.3	0.6	1.0	0.85	1.3	32	25	32	25	22	15	1.20	1.5	3.0
ZMDC-10-1	0.5-500	11.5±0.5	±0.6	0.85	1.3	0.6	1.0	0.85	1.3	32	25	32	25	22	15	1.20	1.5	3.0
ZX30-12-4	5-1000	12.0±0.5	±0.3	0.70	1.0	0.75	1.0	0.90	1.2	35	28	25	20	20	13	1.15	0.5	1.0
ZX30-13-4	5-1200	13.0±0.5	±0.3	0.60	0.9	0.7	1.1	0.90	1.5	21	18	19	15	15	10	1.15	0.5	1.0
ZNDC-13-2G	800-2000	13.0±0.5	±0.35	0.8	1.3	0.8	1.3	0.8	1.3	20	14	20	14	20	14	1.20	3.0	3.0
ZFDC-15-6	0.03-35	15±0.5	±0.5	0.30	0.6	0.2	0.4	0.30	0.6	38	30	35	25	28	20	1.15	2.0	4.0
ZEDC-15-2B	1-1000	15±0.5	±0.5	0.50	1.4	0.8	1.2	1.00	1.4	35	30	30	20	25	15	1.15	1.5	3.0
ZFDC-15-10	800-1000	15±1.0	±1.0	0.3	0.7	0.3	0.7	0.3	0.7	23	17	23	17	23	17	1.20	5.0	5.0
ZNDC-15-2G	800-2000	15±0.5	±0.3	0.8	1.3	0.8	1.3	0.8	1.3	23	14	23	14	23	14	1.20	3.0	3.0
ZFDC-15-5	1-2000	15.5±0.5	±1.0	1.20	1.8	1.2	1.8	1.30	2.3	30	20	25	20	18	11	1.30	0.5	2.0
ZADC-17-14HP	500-1350	16.4±0.9	±1.3	0.8	1.5	0.8	1.5	0.8	1.5	29	16	29	16	29	16	1.06	10.0	10.0
ZX30-17-5	5-2000	17.5±0.9	±0.4	0.7	1.7	0.7	1.7	0.7	1.7	16	9	16	9	16	9	1.30	0.5	1.0
ZNDC-18-2G	800-2000	18.2±0.5	±0.4	0.5	1.1	0.5	1.1	0.5	1.1	25	14	25	14	25	14	1.20	3.0	3.0
ZDC-20-3	0.2-250	19.5±0.5	±0.5	0.35	0.6	0.2	0.5	0.35	0.6	36	30	33	25	25	20	1.20	1.5	4.0
ZFDC-20-3	0.2-250	19.5±0.5	±0.25	0.35	0.6	0.2	0.5	0.35	0.6	36	25	33	25	25	20	1.20	1.5	4.0
ZMDC-20-3	0.2-250	19.5±0.5	±0.5	0.35	0.6	0.35	0.5	0.35	0.6	36	30	33	25	25	20	1.20	1.5	4.0
ZFDC-20-4	1-1000	19.5±0.5	±0.5	0.40	1.2	0.4	0.8	0.80	1.5	36	28	27	20	23	18	1.10	0.5	2.0
ZFDC-20-5	0.1-2000	19.5±0.5	±0.5	0.30	1.0	0.7	1.4	1.50	2.3	30	20	27	20	22	10	1.20	0.5	2.0
ZFDC-20-50	20-2000	19.5±0.5	±0.8	0.80	1.3	0.7	1.3	1.00	1.6	30	20	25	20	22	10	1.25	1.0	1.0
ZDC-20-1	25-400	20±0.5	±0.5	0.20	0.25	0.3	0.35	0.35	0.5	25	20	35	25	25	20	1.25	3.0	5.0
ZADC-20-10	800-1000	20±0.6	±1.2	0.4	0.7	0.4	0.7	0.4	0.7	21	17	21	17	21	17	1.18	5.0	5.0
ZNDC-20-2G	800-2000	20±0.5	±0.5	0.5	1.1	0.5	1.1	0.5	1.1	25	14	25	14	25	14	1.15	3.0	3.0
ZFDC-20-4L	10-1000	20.2±0.5	±0.5	0.20	0.5	0.3	0.7	0.70	1.2	40	20	30	16	20	14	1.10	1.0	1.0
ZX30-20-4	5-1000	20.5±0.6	±0.5	0.30	0.5	0.3	0.6	0.60	0.9	21	19	22	19	19	11	1.11	1.0	1.0
ZADC-6-2G-5W	800-2000	6.7±1.0	±0.7	1.3	1.9	1.3	1.9	1.3	1.9	22	20	22	20	22	20	1.15	5.0	5.0
ZNDC-23-2G	800-2000	23.0±0.5	±0.4	0.5	1.1	0.5	1.1	0.5	1.1	25	14	25	14	25	14	1.20	3.0	3.0
ZMDC-30-1	0.1-250	30±0.5	±0.5	0.40	0.6	0.5	0.8	0.55	0.85	23	18	20	15	17	10	1.50	1.0	3.0
ZADC-30-10	800-1000	30±0.6	±1.4	0.4	0.7	0.4	0.7	0.4	0.7	21	16	21	16	21	16	1.15	5.0	5.0
DIRECTIONAL COUPLERS 75 Ω																		
ZDC-2375	50-100	10.5±0.3	±0.2	—	—	—	—	1.10	1.3	—	—	—	—	35	30	1.30	4.0	4.0
ZDC-10-1-75	1-250	10.5±0.5	±0.75	1.10	1.5	1.1	1.5	1.10	1.5	30	20	30	20	30	20	2.00	2.0	4.0
ZFDC-10-1-75	1-400	10.5±0.5	±0.5	1.00	1.7	1.1	1.5	1.10	1.6	46	30	44	28	34	20	1.30	2.0	4.0
Z30-10-4-75	5-1000	10.5±0.5	±0.3	1.50	2.5	1.5	2.3	1.50	2.2	22	16	21	14	19	—	1.30	0.5	1.0
ZADC-10-4-75	10-1000	10.7±0.5	±0.5	1.18	1.9	1.2	1.9	1.32	1.9	27	20	22	15	18	13	1.17	1.0	1.0
ZFDC-10-21-75	10-750	11±0.5	±0.75	1.50	1.8	1.5	1.9	1.70	2.1	36	30	30	20	26	20	1.40	1.0	2.0
Z30-13-5-75	5-1500	13.5±0.5	±0.7	0.85	1.4	0.9	2.2	1.00	1.7	22	17	20	14	19	—	1.30	0.5	1.0
Z30-16-5-75	5-1500	16.5±0.5	±0.9	1.10	2.0	1.1	1.1	1.20	1.9	22	16	24	—	24	—	1.30	0.5	1.0
Z30-18-4-75	5-1000	18.5±0.5	±0.5	0.80	1.5	0.85	1.5	0.95	1.6	28	17	23	16	15	—	1.30	1.0	1.0
ZDC-20-3-75-1	55-90	18.6±0.5	±0.3	0.40	0.6	0.4	0.6	0.40	0.6	35	30	35	30	35	30	1.20	4.0	4.0
ZFDC-20-3-75	10-250	19.3±0.5	±0.3	0.25	0.4	0.3	0.5	0.40	0.6	29	25	29	25	28	24	1.20	1.0	2.0
ZDC-20-3-75	1-150	19.5±0.5	±0.75	0.35	0.8	0.35	0.8	0.35	0.8	25	20	25	20	25	20	2.00	2.0	4.0
ZADC-20-18-75	800-1750	19.8±0.6	±0.7	0.4	0.9	0.4	0.9	0.4	0.9	22	13	22	13	22	13	1.20	4.0	1.0
ZFDC-20-5-75	100-1500	20.5±0.5	±0.75	0.90	1.3	0.9	1.2	1.10	1.5	30	20	25	18	22	13	1.30	1.0	1.0
BI-DIRECTIONAL COUPLERS 50 Ω																		
ZABDC10-25HP	1500-2500	10.0±1.0	±0.5	0.55	0.9	0.55	0.9	0.55	0.9	26	18	26	18	26	18	1.10	10	10
ZABDC20-2400	1500-2400	19.5±1.0	±1.0	0.3	0.5	0.3	0.5	0.3	0.5	25	18	25	18	25	18	1.20	10	10
ZFBDC20-970HP	860-970	20.4±0.6	±0.6	0.1	0.4	0.1	0.4	0.1	0.4	28	20	28	20	28	20	1.10	10	10
ZFDC-20-1H	30-400	20.5±0.5	±0.4	0.15	0.4	0.15	0.4	0.3	0.4	30	25	30	25	30	23	1.20	25	25
ZFBDC20-900HP	800-900	20.7±0.6	±0.6	0.1	0.4	0.1	0.4	0.1	0.4	28	20	28	20	28	20	1.10	10	10
ZX30-20-20BD	500-2000	21.0±1.0	±2.2	0.2	0.5	0.2	0.5	0.2	0.5	21	14	21	14	21	14	1.20	2.0	2.0
ZBDC25-2575W	1270-2575	24.9±1.1	±0.8	0.3	0.5	0.3	0.5	0.3	0.5	28	20	28	20	28	20	1.05	20	20
ZBDC40-1450W	550-1450	39.9±1.5	±1.5	0.15	0.4	0.15	0.4	0.15	0.4	24	18	24	18	24	18	1.12	50	50

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

DC BLOCKS *Very Wideband, 50 Ω*

0.1 MHz to 18000 MHz

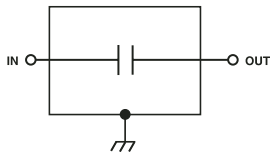
Mini-Circuits® 2007

SMA BLK-18, BLK-89 Case FF888

Type-N BLK-6 Case FF779

MODEL PREFIX	FREQUENCY RANGE (GHz)	INSERTION LOSS (dB) Typ.	INSERTION LOSS (dB) Max.	RETURN LOSS (dB) Typ.	RETURN LOSS (dB) Min.
SMA					
BLK-18	***0.01-18***				
	0.01-0.1	0.02	0.2	26	20
	0.1-1.0	0.07	0.3	36	20
	1.0-4.0	0.15	0.5	24	20
	4.0-8.0	0.38	1.0	18	15
	8.0-18	1.00	—	12	—
BLK-89	***0.0001-8.0***				
	0.0001-0.1	0.010	0.09	40	20
	0.1-1.0	0.10	0.3	36	25
	1.0-4.0	0.15	0.8	24	18
	4.0-8.0	0.5	0.9	20	13
Type-N					
BLK-6	***0.01-6.0***				
	0.01-1.0	0.05	0.20	45	30
	1.0-3.0	0.12	0.40	30	18
	3.0-4.0	0.25	0.60	22	14
	4.0-6.0	0.50	1.00	17	—

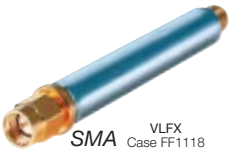
ELECTRICAL SCHEMATIC



FILTERS *Low Pass 50 Ω*

DC to 7200 MHz

SMA VLF, VLP Case FF704



SMA VLFX Case FF1118

MODEL PREFIX	PASSBAND (MHz) (Loss <1 dB) Max.	fco, (MHz) NOMINAL (Loss 3 dB) Typ.	STOPBAND, (MHz) (loss, dB) f20 Min.	40 Typ.	fr20 Typ.	VSWR (:1) STOPBAND Typ.	PASSBAND Typ.	POWER INPUT (W) Max.
SMA								
VLF-80	DC-80	145	200	225-1550	4500	20	1.2	8.5
VLF-95	DC-95	165	230	225-1600	4500	20	1.2	8.5
VLF-105	DC-105	180	250	265-1650	4750	20	1.2	8.5
VLF-120	DC-120	195	280	300-1850	4750	20	1.2	8.5
VLF-160	DC-160	230	330	480-2700	6100	17	1.2	8.0
VLF-180	DC-180	270	370	525-2350	6400	17	1.2	8.0
VLF-190	DC-190	280	400	510-2850	6550	17	1.2	8.0
VLF-225	DC-225	350	460	510-2500	5500	20	1.2	8.5
VLF-320	DC-320	460	560	640-2500	5300	20	1.2	8.5
VLF-400	DC-400	560	660	680-3000	5500	20	1.2	8.5
VLF-490	DC-490	650	800	880-2500	6000	20	1.2	8.5
VLF-530	DC-530	700	820	945-3000	6000	20	1.2	8.5
VLF-575	DC-575	770	900	1050-3200	5500	20	1.2	8.5
VLF-630	DC-630	830	1000	1050-3500	6000	20	1.2	8.5
				30 dB Typ.				
VLF-800	DC-800	1075	1275	1350-4850	5100	20	1.2	10
VLF-1000	DC-1000	1300	1550	1900-5000	5500	20	1.3	10
VLF-1200	DC-1200	1530	1865	2000-5000	6200	20	1.2	10
VLF-1400	DC-1400	1700	2015	2100-6600	6800	20	1.2	10
VLF-1450	DC-1450	1825	2025	2050-6600	6700	20	1.2	10
VLF-1500	DC-1500	1825	2100	2150-6600	6800	20	1.2	10
VLF-1525	DC-1525	1750	2040	2120-6600	6700	20	1.2	10
VLF-1575	DC-1575	1875	2175	2225-6800	7100	20	1.2	10
VLF-1700	DC-1700	2050	2375	2500-6500	7000	20	1.2	10
VLF-1800	DC-1800	2125	2425	2500-7200	8600	20	1.2	10
VLF-2250	DC-2250	2575	2900	3000-5000	7200	20	1.2	10
VLF-2500	DC-2500	3075	3675	3800-6100	8000	20	1.2	10
VLF-2600	DC-2600	3125	3750	3900-6600	8400	20	1.2	10
VLF-2750	DC-2750	3150	4000	4150-6800	8400	20	1.2	10
VLF-2850	DC-2800	3300	4000	4200-7400	9000	20	1.2	10
VLF-3000	DC-3000	3600	4550	4780-7500	10000	20	1.2	10
VLF-3800	DC-3900	4850	6000	5700-8300	13000	17	1.3	8
VLF-4400	DC-4400	5290	6700	6280-9800	13000	17	1.2	8
VLF-5000	DC-5000	5580	6850	7050-10000	18000	20	1.2	9
VLF-5500	DC-5500	6200	7200	6770-9500	12100	17	1.3	8
VLF-5850	DC-5850	6540	7600	7100-9900	12500	17	1.3	8
VLF-6000	DC-6000	6800	8500	8700-10500	18000	20	1.3	9
VLF-6400	DC-6400	7200	8300	7770-10200	12500	17	1.2	8
VLF-6700	DC-6700	7600	9300	9500-11000	18000	20	1.3	9
VLF-7200	DC-7200	8150	9500	8850-9800	12300	17	1.3	8
	(Loss <1.2 dB Max.)			***40 dB Typ.***				
VLFX-80	DC-80	145	195	220-20000	—	10	1.2	10
VLFX-105	DC-105	165	250	400-20000	—	10	1.2	10
VLFX-225	DC-225	350	460	520-20000	—	10	1.15	10
VLFX-300	DC-300	450	580	650-20000	—	10	1.15	10
VLFX-400	DC-400	540	670	700-20000	—	10	1.15	10
VLFX-450	DC-450	640	800	900-20000	—	10	1.15	10
VLFX-470	DC-470	675	820	1000-20000	—	10	1.15	10
VLFX-500	DC-500	750	900	1100-20000	—	10	1.15	10
VLFX-540	DC-540	810	1000	1100-20000	—	10	1.2	10
VLFX-650	DC-650	1025	1275	1450-20000	—	10	1.2	10
VLFX-780	DC-780	950	1450	1600-20000	—	10	1.25	10
VLFX-825	DC-825	1275	1550	1850-20000	—	10	1.20	10
VLFX-950	DC-950	1400	1750	2250-20000	—	10	1.3	10
VLFX-1050	DC-1050	1675	1990	2100-20000	—	10	1.4	10
VLFX-1100	DC-1100	1750	2070	2300-20000	—	10	1.4	10
VLFX-1125	DC-1125	1825	2125	2300-20000	—	10	1.4	10
VLFX-1300	DC-1300	1925	2300	2500-20000	—	10	1.2	10
VLFX-1350	DC-1350	2050	2425	2600-20000	—	10	1.3	10
	(Loss <1 dB Max.)		***Loss > 20 dB***	***Loss > 40 dB***	***fr 20 dB Typ.***			
VLP-11	DC-850	1078	1500	2000-3500	5500	20	1.2	16
VLP-16	DC-1350	1550	2100	2700-4000	7000	20	1.1	15
VLP-20	DC-1700	1980	2700	3300-3880	7200	20	1.1	14
VLP-24	DC-2000	2430	3400	4400	8000	20	1.2	10
VLP-41	DC-3300	4100	5500	5600	10000	20	1.2	10
VLP-54	DC-4000	5400	7100	—	9500	20	1.2	10
VLP-64	DC-5400	6410	9000	—	18000	20	1.1	19

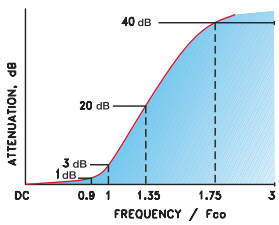
SMA Case FF99 *SLP, SBLP* | *BNC* Case FF55 *BBLP* | *Type-N* Case FF57 *NBLP*

MODEL PREFIX	PASSBAND, (MHz) (Loss < 1 dB)	fco, (MHz) NOMINAL (Loss 3 dB)	STOPBAND, (MHz) (Loss > 20 dB)	STOPBAND, (MHz) (Loss > 40 dB)	VSWR PASSBAND Typ.	VSWR STOPBAND Typ.	POWER INPUT (W) Max.
SMA							
SLP-1.9	DC-1.9	2.5	3.4-4.7	4.7-200	1.7:1	18:1	0.5
SLP-2.5	DC-2.5	2.75	3.8-5.0	5.0-200	1.7:1	18:1	0.5
SLP-5	DC-5	6	8-10	10-200	1.7:1	18:1	0.5
SLP-10.7	DC-11	14	19-24	24-200	1.7:1	18:1	0.5
SLP-15	DC-15	17	23-32	32-200	1.7:1	18:1	0.5
SLP-21.4	DC-22	24.5	32-41	41-200	1.7:1	18:1	0.5
SLP-30	DC-32	35	47-61	61-200	1.7:1	18:1	0.5
SLP-50	DC-48	55	70-90	90-200	1.7:1	18:1	0.5
SLP-70	DC-60	67	90-117	117-300	1.7:1	18:1	0.5
SLP-90	DC-81	90	121-157	157-400	1.7:1	18:1	0.5
SLP-100	DC-98	108	146-189	189-400	1.7:1	18:1	0.5
SLP-150	DC-140	155	210-300	300-600	1.7:1	18:1	0.5
SLP-200	DC-190	210	290-390	390-800	1.7:1	18:1	0.5
SLP-250	DC-225	250	320-400	400-1200	1.7:1	18:1	0.5
SLP-300	DC-270	297	410-550	550-1200	1.7:1	18:1	0.5
SLP-450	DC-400	440	580-750	750-1800	1.7:1	18:1	0.5
SLP-550	DC-520	570	750-920	920-2000	1.7:1	18:1	0.5
SLP-600	DC-580	640	840-1120	1120-2000	1.7:1	18:1	0.5
SLP-750	DC-700	770	1000-1300	1300-2000	1.7:1	18:1	0.5
SLP-800	DC-720	800	1080-1400	1400-2000	1.7:1	18:1	0.5
SLP-850	DC-780	850	1100-1400	1400-2000	1.7:1	18:1	0.5
SLP-1000	DC-900	990	1340-1750	1750-2000	1.7:1	18:1	0.5
SLP-1200	DC-1000	1200	1620-2100	2100-2500	1.7:1	18:1	0.5
SLP-1650	DC-1400	1650	2300-2900	2900-6000	1.3:1	18:1	0.5
SLP-2400	DC-2200	2400	3150-4000	4000-6000	1.3:1	18:1	0.5
SLP-2950	DC-2700	2950	3700-4500	4500-6000	1.3:1	18:1	0.5

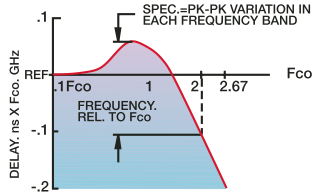
MODEL PREFIX	PASSBAND (MHz) (Loss <1.2 dB) Min.	fco, (MHz) NOMINAL (Loss 3 dB)	STOP BAND, (MHz) Loss > 10 dB	STOP BAND, (MHz) Loss > 20 dB	VSWR DC-0.2fco $\overline{X}$	VSWR DC-0.6fco $\overline{X}$	GROUP DELAY VARIATION, ns DC-fco $\overline{X}$	GROUP DELAY VARIATION, ns DC-2fco $\overline{X}$	GROUP DELAY VARIATION, ns DC-2.67fco $\overline{X}$	RF POWER INPUT (W) Max.
***SMA** Flat Time Delay*										
SBLP-39	DC-23	39	78-117	117	1.3:1	2.3:1	0.70	4.00	5.00	0.5
SBLP-117	DC-65	117	234-312	312	1.3:1	2.4:1	0.35	1.40	1.90	0.5
SBLP-156	DC-94	156	312-416	416	1.3:1	1.1:1	0.30	1.10	1.50	0.5
SBLP-200	DC-120	200	400-534	534	1.6:1	1.9:1	0.40	1.30	1.60	0.5
SBLP-300	DC-180	300	600-801	801	1.25:1	2.2:1	0.20	0.60	0.80	0.5
SBLP-467	DC-280	467	934-1246	1246	1.25:1	2.2:1	0.15	0.40	0.55	0.5
SBLP-933	DC-560	933	1866-2490	2490	1.3:1	2.2:1	0.09	0.20	0.28	0.5
SBLP-1870	DC-850	1870	3740-5000	5000	1.45:1	2.9:1	0.05	0.10	0.15	0.5
***Type-N** Flat Time Delay*										
NBLP-39	DC-23	39	78-117	117	1.3:1	2.3:1	0.70	4.00	5.00	0.5
NBLP-300	DC-180	300	600-801	801	1.25:1	2.2:1	0.20	0.60	0.80	0.5
***BNC** Flat Time Delay*										
BBLP-39	DC-23	39	78-117	117	1.3:1	2.3:1	0.70	4.00	5.00	0.5

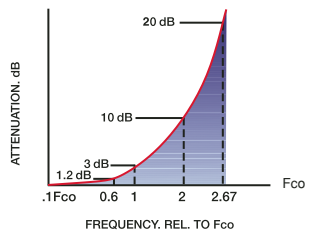
TYPICAL FREQUENCY RESPONSE

SLP SERIES



BLP SERIES





FILTERS *Low Pass*

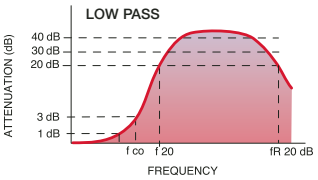
DC to 7200 MHz

BNC BLP Case FF55

Type-N NLP Case FF57

MODEL PREFIX	PASSBAND, (MHz) (Loss < 1 dB)	fco, (MHz) NOMINAL (Loss 3 dB)	STOPBAND, (MHz) (Loss > 20 dB)	STOPBAND, (MHz) (Loss > 40 dB)	VSWR (:1) PASSBAND Typ.	VSWR (:1) STOPBAND Typ.	POWER INPUT (W) Max.
BNC *50 Ω*							
BLP-1.9	DC-1.9	2.5	3.4-4.7	4.7-200	1.7	18	0.5
BLP-2.5	DC-2.5	2.75	3.8-5.0	5.0-200	1.7	18	0.5
BLP-5	DC-5	6	8-10	10-200	1.7	18	0.5
BLP-10.7	DC-11	14	19-24	24-200	1.7	18	0.5
BLP-15	DC-15	17	23-32	32-200	1.7	18	0.5
BLP-21.4	DC-22	24.5	32-41	41-200	1.7	18	0.5
BLP-30	DC-32	35	47-61	61-200	1.7	18	0.5
BLP-50	DC-48	55	70-90	90-200	1.7	18	0.5
BLP-70	DC-60	67	90-117	117-300	1.7	18	0.5
BLP-90	DC-81	90	121-157	157-400	1.7	18	0.5
BLP-100	DC-98	108	146-189	189-400	1.7	18	0.5
BLP-150	DC-140	155	210-300	300-600	1.7	18	0.5
BLP-200	DC-190	210	290-390	390-800	1.7	18	0.5
BLP-250	DC-225	250	320-400	400-1200	1.7	18	0.5
BLP-300	DC-270	297	410-550	550-1200	1.7	18	0.5
BLP-450	DC-400	440	580-750	750-1800	1.7	18	0.5
BLP-550	DC-520	570	750-920	920-2000	1.7	18	0.5
BLP-600	DC-580	640	840-1120	1120-2000	1.7	18	0.5
BLP-750	DC-700	770	1000-1300	1300-2000	1.7	18	0.5
BLP-800	DC-720	800	1080-1400	1400-2000	1.7	18	0.5
BLP-850	DC-780	850	1100-1400	1400-2000	1.7	18	0.5
BLP-1000	DC-900	990	1340-1750	1750-2000	1.7	18	0.5
BLP-1200	DC-1000	1200	1620-2100	2100-2500	1.7	18	0.5
BNC *75 Ω*							
BLP-7-75	DC-7	8	11-15	15-200	1.7	18	0.5
BLP-10.7-75	DC-11	14	19-24	24-200	1.7	18	0.5
BLP-15-75	DC-15	17	23-32	32-200	1.7	18	0.5
BLP-21.4-75	DC-22	24.5	32-41	41-200	1.7	18	0.5
BLP-30-75	DC-32	35	47-61	61-200	1.7	18	0.5
BLP-50-75	DC-48	55	70-90	90-200	1.7	18	0.5
BLP-70-75	DC-60	67	90-117	117-300	1.7	18	0.5
BLP-100-75	DC-98	108	146-189	189-400	1.7	18	0.5
BLP-600-75	DC-580	640	840-1120	1120-2000	1.7	18	0.5
BLP-850-75	DC-750	850	1150-1490	1490-2000	1.7	18	0.5
Type-N *50 Ω*							
NLP-1.9	DC-1.9	2.5	3.4-4.7	4.7-200	1.7	18	0.5
NLP-2.5	DC-2.5	2.75	3.8-5.0	5.0-200	1.7	18	0.5
NLP-5	DC-5	6	8-10	10-200	1.7	18	0.5
NLP-10.7	DC-11	14	19-24	24-200	1.7	18	0.5
NLP-15	DC-15	17	23-32	32-200	1.7	18	0.5
NLP-21.4	DC-22	24.5	32-41	41-200	1.7	18	0.5
NLP-30	DC-32	35	47-61	61-200	1.7	18	0.5
NLP-50	DC-48	55	70-90	90-200	1.7	18	0.5
NLP-70	DC-60	67	90-117	117-300	1.7	18	0.5
NLP-90	DC-81	90	121-157	157-400	1.7	18	0.5
NLP-100	DC-98	108	146-189	189-400	1.7	18	0.5
NLP-150	DC-140	155	210-300	300-600	1.7	18	0.5
NLP-200	DC-190	210	290-390	390-800	1.7	18	0.5
NLP-250	DC-225	250	320-400	400-1200	1.7	18	0.5
NLP-300	DC-270	297	410-550	550-1200	1.7	18	0.5
NLP-450	DC-400	440	580-750	750-1800	1.7	18	0.5
NLP-550	DC-520	570	750-920	920-2000	1.7	18	0.5
NLP-600	DC-580	640	840-1120	1120-2000	1.7	18	0.5
NLP-750	DC-700	770	1000-1300	1300-2000	1.7	18	0.5
NLP-800	DC-720	800	1080-1400	1400-2000	1.7	18	0.5
NLP-850	DC-780	850	1100-1400	1400-2000	1.7	18	0.5
NLP-1000	DC-900	990	1340-1750	1750-2000	1.7	18	0.5
NLP-1200	DC-1000	1200	1620-2100	2100-2500	1.7	18	0.5
NLP-1750	DC-1500	1750	2400-3000	3000-6000	1.3	18	0.5
NLP-2400	DC-2200	2400	3150-4000	4000-6000	1.3	18	0.5
NLP-2950	DC-2700	2950	3700-4500	4500-6000	1.3	18	0.5

TYPICAL FREQUENCY RESPONSE



FILTERS Bandpass

9.5MHz to 4500 MHz

SMA Case FF99 — SBP, SIF | BNC Case FF55 — BBP | Type-N Case FF57 — NBP | SMA Case H16 — ZFB | SMA Case FF1145 — VBFZ

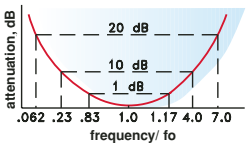
MODEL PREFIX	CENTER FREQUENCY MHz	PASSBAND (MHz) (Loss <1 dB)	STOP BANDS (Loss > 10 dB) at MHz	STOP BANDS (Loss > 20 dB) at MHz	VSWR 1.3:1, TYP. TOTAL BAND (MHz)	RF POWER INPUT (W) Max.
BANDPASS *Constant Impedance* 50 Ω						
SIF-21.4	21.4	18-25	4.9 & 85	1.3 & 150	DC-220	0.5
SIF-30	30	25-35	7 & 120	1.9 & 210	DC-330	0.5
SIF-40	42	35-49	10 & 168	2.6 & 300	DC-400	0.5
SIF-50	50	41-58	11.5 & 200	3.1 & 350	DC-440	0.5
SIF-60	60	50-70	14 & 240	3.8 & 400	DC-500	0.5
SIF-70	70	58-82	16 & 280	4.4 & 490	DC-550	0.5

MODEL PREFIX	CENTER FREQUENCY MHz	PASSBAND Loss < 1.5 dB MHz	3 dB BANDWIDTH TYPICAL MHz	STOP BANDS #1 (Loss > 20 dB) at MHz	STOP BANDS #2 (Loss > 35 dB) at MHz	VSWR (:1) PASSBAND Max.	VSWR (:1) STOP BAND Typ.	RF POWER INPUT (W) Max.
BANDPASS *Elliptic Response* 50 Ω								
BBP-10.7	10.7	9.5-11.5	8.9-12.7	7.5 & 15	0.6 & 50-1000	1.7	16	0.5
BBP-21.4	21.4	19.2-23.6	17.9-25.3	15.5 & 29	3.0 & 80-1000	1.7	16	0.5
BBP-30	30	27.0-33.0	25-35	22 & 40	3.2 & 99-1000	1.7	16	0.5
BBP-60	60	55.0-67.0	49.8-70.5	44 & 79	4.6 & 190-1000	1.7	16	0.5
BBP-70	70	63.0-77.0	58.0-82.0	51 & 94	6.0 & 193-1000	1.7	16	0.5
NBP-10.7	10.7	9.5-11.5	8.9-12.7	7.5 & 15	0.6 & 50-1000	1.7	16	0.5
NBP-70	70	63.0-77.0	58.0-82.0	51 & 94	6.0 & 193-1000	1.7	16	0.5
SBP-10.7	10.7	9.5-11.5	8.9-12.7	7.5 & 15	0.6 & 50-1000	1.7	16	0.5
SBP-21.4	21.4	19.2-23.6	17.9-25.3	15.5 & 29	3.0 & 80-1000	1.7	16	0.5
SBP-30	30	27.0-33.0	25-35	22 & 40	3.2 & 99-1000	1.7	16	0.5
SBP-60	60	55.0-67.0	49.8-70.5	44 & 79	4.6 & 190-1000	1.7	16	0.5
SBP-70	70	63.0-77.0	58.0-82.0	51 & 94	6.0 & 193-1000	1.7	16	0.5

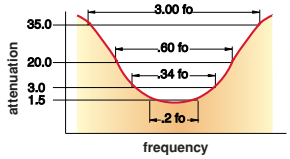
MODEL PREFIX	CENTER FREQUENCY MHz	PASSBAND (MHz) F1 - F2	LOSS (dB)	STOP BANDS #1 (Loss > 20 dB) @ MHz F3	STOP BANDS #1 F4	STOP BANDS #2 (Loss > 30 dB) @ MHz F5	STOP BANDS #2 F6	VSWR (:1) PASSBAND Typ.	VSWR (:1) STOP BAND Typ.	RF POWER INPUT (W) Max.
BANDPASS SMA 50 Ω										
ZFBP-70	70	69-71	7.0	66	75	64	78-1000	1.35	18	0.5
VBFZ-780	780	710-850	2.5	460	1300	440	1320-16000	1.6	20	7.0
VBFZ-925	925	800-1050	2.4	530	1550	500	1620-18000	1.6	20	7.0
VBFZ-1065	1065	980-1150	2.3	630	1800	600	1800-16000	1.4	20	7.0
VBFZ-1400	1400	1350-1450	2.6	890	1965	870	1965-6600	1.6	20	7.0
VBFZ-1690	1690	1455-1925	2.3	930	2600	860	2600-9000	1.5	20	7.0
VBFZ-2000	2000	1730-2270	2.3	1210	2960	1200	2960-16000	1.6	20	7.0
VBFZ-2130	2130	2000-2260	2.6	1420	2950	1400	2950-18000	1.6	20	7.0
VBFZ-2340	2340	2020-2660	2.2	1450	3750	1400	3800-8500	1.5	20	7.0
VBFZ-2575	2575	2350-2800	2.2	1390	3850	1275	3900-9000	1.9	20	7.0
VBFZ-4000	2575	3500-4500	—	2550	5700	2750	5720-16000	1.6	20	7.0
BANDPASS BNC 75 Ω						(Loss > 40 dB)				
ZFBP-13-75	13	12.3-13.8	4.0	10.6	16	10	17.5-300	1.4	18	0.5

TYPICAL FREQUENCY RESPONSE

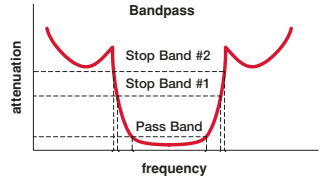
Bandpass Constant Impedance



Bandpass Elliptic Response



Bandpass



For pricing/availability, and complete specifications, performance data and curves, data sheets, pcb layouts, outline drawings & shopping online, see Mini-Circuits website.

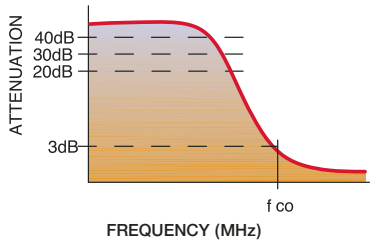
FILTERS, HIGH PASS, 50 Ω

27.5 MHz to 13000 MHz

MODEL PREFIX	STOPBAND, (MHz) (Loss > 40 dB)	STOPBAND, (MHz) (Loss > 20 dB)	fco, (MHz) NOMINAL (Loss 3 dB)	PASSBAND, (MHz) (Loss <1 dB)	VSWR (:1) STOPBAND Typ.	VSWR (:1) PASSBAND Typ.	RF POWER (W) Max.
BNC							
BHP-25	DC-13	13-19	25	27.5-800	18	1.7	0.5
BHP-50	DC-20	20- 26	37	41-800	17	1.5	0.5
BHP-100	DC-40	40- 55	82	90-2000	17	1.5	0.5
BHP-150	DC-70	70- 95	120	133-1000	17	1.8	0.5
BHP-175	DC-70	70-105	140	160-1200	17	1.5	0.5
BHP-200	DC-90	90-116	164	185-3000	17	1.6	0.5
BHP-250	DC-100	100-150	205	225-3000	17	1.3	0.5
BHP-300	DC-145	145-190	245	290-3000	17	1.7	0.5
BHP-400	DC-210	210-290	360	395-3200	17	1.7	0.5
BHP-500	DC-280	280-365	454	500-3200	17	1.9	0.5
BHP-600	DC-350	350-440	545	600-3000	17	2.0	0.5
BHP-700	DC-400	400-520	640	700-3000	17	1.6	0.5
BHP-800	DC-445	445-570	710	780-3000	17	2.1	0.5
BHP-900	DC-520	520-660	820	910-3000	17	1.8	0.5
BHP-1000	DC-550	550-720	900	1000-3000	17	1.9	0.5
Type-N							
NHP-25	DC-13	13- 19	25	27.5-800	18	1.7	0.5
NHP-50	DC-20	20- 26	37	41-800	17	1.5	0.5
NHP-100	DC-40	40- 55	82	90-2000	17	1.5	
NHP-150	DC-70	70- 95	120	133-1000	17	1.8	0.5
NHP-175	DC-70	70-105	140	160-1200	17	1.5	0.5
NHP-200	DC-90	90-116	164	185-3000	17	1.6	0.5
NHP-250	DC-100	100-150	205	225-3000	17	1.3	0.5
NHP-300	DC-145	145-190	245	290-3000	17	1.7	0.5
NHP-400	DC-210	210-290	360	395-3200	17	1.7	0.5
NHP-500	DC-280	280-365	454	500-3200	17	1.9	0.5
NHP-600	DC-350	350-440	545	600-3000	17	2.0	0.5
NHP-700	DC-400	400-520	640	700-3000	17	1.6	0.5
NHP-800	DC-445	445-570	710	780-3000	17	2.1	0.5
NHP-900	DC-520	520-660	820	910-3000	17	1.8	0.5
NHP-1000	DC-550	550-720	900	1000-3000	17	1.9	0.5
SMA							
SHP-25	DC-13	13- 19	25	27.5-800	18	1.7	0.5
SHP-50	DC-20	20- 26	37	41-800	17	1.5	0.5
SHP-100	DC-40	40- 55	82	90-2000	17	1.5	0.5
SHP-100A	DC-77	77-82	92	110-3000	13	1.6	0.1
SHP-150	DC-70	70- 95	120	133-1000	17	1.8	0.5
SHP-175	DC-70	70-105	140	160-1200	17	1.5	0.5
SHP-200	DC-90	90-116	164	185-3000	17	1.6	0.5
SHP-250	DC-100	100-150	205	225-3000	17	1.3	0.5
SHP-300	DC-145	145-190	245	290-3000	17	1.7	0.5
SHP-400	DC-210	210-290	360	395-3200	17	1.7	0.5
SHP-500	DC-280	280-365	454	500-3200	17	1.9	0.5
SHP-600	DC-350	350-440	545	600-3000	17	2.0	0.5
SHP-700	DC-400	400-520	640	700-3000	17	1.6	0.5
SHP-800	DC-445	445-570	710	780-3000	17	2.1	0.5
SHP-900	DC-520	520-660	820	910-3000	17	1.8	0.5
SHP-1000	DC-550	550-720	900	1000-3000	17	1.9	0.5

MODEL PREFIX	STOP BAND, (MHz) (Loss > 40 dB)	STOP BAND, (MHz) (Loss > 20 dB)	fco, (MHz) NOMINAL (Loss 3 dB) Typ.	PASSBAND, (MHz) (Loss <1.3 dB) Max.	PASSBAND, (MHz) (Loss <2 dB) Typ.	VSWR (:1) Stopband Typ.	VSWR (:1) Passband Typ.	POWER INPUT (W) Max.
***SMA** Miniature package*								
VHP-9R5	DC-600	750	950	1300-3500	_	18	1.5	14
VHP-16	DC-1030	1300	1580	1900-2700	_	18	1.5	14
VHP-19	DC-1450	1650	1995	2300-5500	_	18	1.5	10
VHP-26	DC-1500	2000	2570	3000-7000	_	18	1.4	10
VHP-39	DC-2000	3050	3900	4600-5500	_	18	1.5	10
VHF-650	390	480	650	850-2000	710-2490	20	1.5	7
VHF-740	430	550	740	900-2200	780-2800	20	1.5	7
VHF-880	500	640	880	1060-2500	950-3200	20	1.5	7
VHF-1200	750	910	1180	1380-4000	1220-4600	20	1.5	7
VHF-1300	680	930	1300	1510-4000	1400-5000	20	1.5	7
VHF-1320	880	1060	1320	1700-3800	1400-5000	20	1.5	7
VHF-1500	1090-1060	1250	1550	1850-4400	1600-5500	20	1.5	7
VHF-1600	1090	1290	1600	1950-4000	1650-5000	20	1.5	7
VHF-1760	950	1230	1760	2100-5200	1900-5500	20	1.5	7
VHF-1810	1100	1480	1810	2250-4000	1900-4750	20	1.5	7
VHF-1910	1075	1400	1910	2200-4400	2000-5200	20	1.5	7
VHF-2000	1300	1530	2000	2410-5550	2260-6250	20	1.5	7
VHF-2100	1050	1530	2100	2500-5000	2200-6000	20	1.5	7
VHF-2275	1400	1770	2275	2640-6230	2450-7000	20	1.5	7
VHF-2700	1500	1800	2500	3000-5700	2650-6500	20	1.5	7
	Loss >30 dB Typ.			***Loss <1.5 dB Max.***	***Loss <2 dB Max.***			
VHF-2700A	2270	2150	2700	3070-8500	2900-8700	20	1.5	7
VHF-3100	2500	2450	3100	3500-9500	3400-9900	20	1.5	7
VHF-3500	2900	2800	3500	4000-8800	3900-9800	20	1.5	7
VHF-3800	3100	3200	3800	4500-9000	4250-10000	20	1.5	7
VHF-4400	3600	3500	4400	5000-9900	5000-10100	20	1.5	6
VHF-4600	3700	3800	4600	5200-10500	5000-11000	20	1.5	7
VHF-5500	4000	4500	5500	6600-11000	6000-11500	20	1.5	7
VHF-5050	3600	4200	5050	5650-9700	5500-10000	20	1.5	7
VHF-7150	5100	6150	7150	8500-10500	7900-11000	20	1.5	6
				Loss <2.5 dB Max.	***Loss <3 dB Max.***			
VHF-8400	5700	6000	8400	9500-13000	9000-13000	20	1.5	7

TYPICAL FREQUENCY RESPONSE



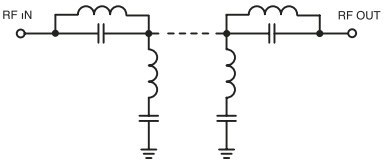
FILTERS Band Stop 50 Ω

88 MHz to 108 MHz

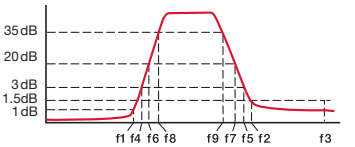
NSBP
Case FF967

MODEL PREFIX	STOP BAND, (MHz)		Loss 3 dB	PASSBAND, (MHz)		VSWR (:1)	
	(Loss > 20 dB) f6-f7	(Loss > 35 dB) f8-f9	Typ. f4, f5	(Loss <1 dB) f1	(Loss <1.5 dB) f2, f3	Stopband Typ.	Passband Typ.
NSBP-108	88-108	89-105	81 & 120	65	140-1000	3.4	1.3

FUNCTIONAL SCHEMATIC



TYPICAL FREQUENCY RESPONSE



VLM
Case FF704

MODEL PREFIX	FREQUENCY (MHz)	INPUT POWER (dBm)		OUTPUT POWER (dBm)	LIMITING	
					Input Power Range (dBm)	△Output / 1 dB △Input
		Min.	Max.	Typ.		dB/dB
VLM-52	10-500	+10	+20	+9.5	+9.5 to +12.5	0.30
					+12.5 to +15	0.20
					+15 to +20	0.14

MIXERS, FREQUENCY 50 Ω

500 Hz to 10000 MHz

ZX05 Case FL905 | ZMX Case BU413 | ZEM Case V37 | ZFM Case K18 | ZAM Case F14

MODEL PREFIX	FREQUENCY (MHz) LO/RF f_L-f_U	IF	CONVERSION LOSS (dB) MID-BAND m $\bar{x}$	σ	Max.	TOTAL RANGE Max.	LO-RF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	LO-IF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	SCHEMATIC
LEVEL 3	**+3 dBm LO**	**up to 0 dBm RF**																	
ZX05-1L	2-500	DC-500	5.2	0.1	7.2	8.0	68	50	55	30	44	30	55	40	45	30	35	25	1
LEVEL 4	**+4 dBm LO**	**up to +1 dBm RF**																	
ZX05-10L	10-1000	DC-800	7.2	0.1	8.2	8.8	70	55	60	40	47	37	40	26	37	20	24	13	1
LEVEL 7	**+7 dBm LO**	**up to +1 dBm RF**																	
ZAD-8	0.0005-10	DC-10	5.79	0.05	7.5	8.5	60	50	50	40	45	35	60	50	50	40	45	35	1
ZAD-6	0.003-100	DC-100	4.65	0.08	7.5	8.5	60	50	45	30	35	25	60	45	40	25	30	20	1
ZLW-6	0.003-100	DC-100	4.58	0.05	7.5	8.5	60	50	45	30	35	25	60	45	40	25	30	25	1
ZAD-3	0.025-200	DC-200	4.61	0.06	7.5	8.5	60	50	45	35	35	25	45	35	40	30	30	20	1
ZLW-3	0.025-200	DC-200	4.61	0.06	7.5	8.5	60	50	45	35	35	25	45	35	40	30	30	20	1
ZFM-3	0.04-400	DC-400	4.78	0.03	7.0	8.0	60	50	50	35	35	25	55	40	45	30	35	25	1
ZP-3	0.15-400	DC-400	4.70	0.10	7.0	8.0	60	50	46	30	35	25	60	40	47	25	35	20	1
ZAD-1-1	0.1-500	DC-500	4.83	0.04	7.5	8.5	50	45	45	30	35	25	45	30	40	25	30	20	1
ZLW-1-1	0.1-500	DC-500	4.82	0.07	7.5	8.5	50	45	45	30	35	25	45	30	40	25	30	20	1
ZP-10514	0.2-500	DC-500	5.18	0.10	7.0	8.5	55	45	50	35	35	30	50	40	36	30	30	20	1
ZAD-1	0.5-500	DC-500	5.24	0.10	7.0	8.5	50	45	45	30	35	25	45	35	40	25	30	20	1
ZLW-1	0.5-500	DC-500	5.81	0.08	7.0	8.5	50	45	45	30	35	25	45	35	40	25	30	20	1
ZX05-1	0.5-500	DC-500	5.00	0.10	6.5	7.8	70	50	55	35	45	30	65	45	40	25	30	20	1
ZP-1	2-600	DC-600	5.85	0.10	7.0	8.0	60	50	42	30	37	25	60	45	47	30	36	22	1
ZLW-1W	1-750	DC-750	5.74	0.05	7.5	8.5	50	45	45	30	35	25	45	30	40	25	30	20	1
ZFM-1W	10-750	DC-750	5.42	0.14	7.0	8.0	50	45	45	30	35	25	45	40	40	25	27	20	1
ZAD-2	1-1000	0.5-500	5.66	0.07	7.5	8.5	45	30	35	20	30	20	45	30	35	20	30	20	1
ZFM-2	1-1000	DC-1000	5.72	0.06	7.5	8.5	50	45	40	25	30	25	45	40	35	25	25	20	1
ZLW-2	1-1000	DC-1000	5.68	0.08	7.5	9.5	55	45	40	25	35	20	50	40	40	25	30	20	1
ZX05-2	5-1000	DC-1000	6.67	0.26	8.0	9.5	65	50	47	25	35	22	62	35	45	25	32	20	1
ZEM-2B	10-1000	DC-1000	5.74	0.07	7.0	8.5	55	50	30	25	25	20	55	45	30	20	25	20	1
ZX05-10	10-1000	DC-800	6.80	0.10	7.8	8.3	80	50	60	40	47	37	40	26	33	20	24	13	1
ZP-2	50-1000	DC-1000	5.85	0.10	7.5	9.0	58	40	47	30	42	25	50	35	44	20	29	18	1
ZFM-4	5-1250	DC-1250	5.70	0.34	7.5	8.5	50	45	40	30	30	25	45	40	35	25	25	20	1
ZFM-12	800-1250	50-90	5.67	0.12	—	7.5	35	25	35	25	35	25	30	20	30	20	30	20	1
ZFM-5X	1-1500	1-1000	5.90	0.10	7.0	9.0	60	40	40	20	28	17	60	45	45	25	38	20	1
ZP-5X	1-1500	1-1000	5.90	0.10	7.0	9.0	60	40	40	20	28	17	60	45	45	25	38	20	1
ZLW-5	5-1500	10-600	5.81	0.08	7.5	8.5	55	40	35	25	30	20	50	40	35	25	30	20	1
ZX05-5	5-1500	DC-1000	6.60	0.10	7.5	9.3	50	40	40	25	33	23	50	40	30	20	20	10	1
ZP-5	20-1500	DC-1000	5.70	0.10	9.0	9.0	54	40	42	30	39	25	40	25	32	18	23	8	1
ZFM-11	1-2000	5-600	7.03	0.17	8.5	9.0	50	45	35	25	25	20	45	40	27	20	25	20	1
ZAD-11	5-2000	10-600	7.12	0.12	8.5	9.0	50	45	35	25	30	20	45	40	30	20	25	15	1
ZLW-11	5-2000	10-600	6.85	0.10	8.5	9.0	50	45	35	25	30	20	45	40	30	20	25	15	1
ZX05-11X	10-2000	5-1000	7.10	0.10	8.2	9.8	62	45	36	20	27	18	60	45	37	20	38	20	1
ZFM-2000	100-2000	DC-600	7.49	0.20	9.5	9.5	37	20	37	20	37	20	30	20	30	20	30	20	1
ZX05-C24	300-2400	DC-700	6.10	0.10	8.9	—			40 (typ.)		25 (min.)				25 (typ.)		15 (min.)		1
ZX05-30W	300-4000	DC-950	6.80	0.20	9.0	9.8			35 (typ.)		17 (min.)				16 (typ.)		7 (min.)		1
ZX05-C42	1000-4200	DC-1500	6.10	0.10	—	8.9			35 (typ.)		23 (min.)				20 (typ.)		12 (min.)		1
ZAM-42	1500-4200	DC-500	5.67	0.11	—	8.5	25	14	25	14	25	14	18	10	18	10	18	10	1
ZFM-4212	2000-4200	DC-1300	5.44	0.088	—	8.5	25	17	25	17	25	17	18	10	18	10	18	10	1
ZEM-4300	300-4300	DC-1000	6.65	0.06	—	9.5	40	20	—	—	30	17	15	8	—	—	15	8	1
ZX05-C60	1600-6000	DC-2000	6.20	0.30	—	8.5	—	—	28 (typ.)		17 (min.)	—	—	—	18 (typ.)		—	—	
ZMX-7GR	3700-7000	DC-1000	5.00	0.30	—	8.2	—	—	30 (typ.)		20 (min.)	—	—	—	36 (typ.)		20 (min.)	—	1
ZMX-10G	3700-10000	DC-2000	5.00	0.10	—	8.5	—	—	30 (typ.)		20 (min.)	—	—	—	17 (typ.)		8 (min.)	—	1

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)
m = mid band ($2f_L$ to $f_U/2$)

ZP
Case GG60

ZLW
Case M21

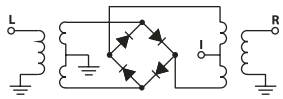
ZAD
Case M22

MODEL PREFIX	FREQUENCY (MHz) LO/RF f_L-f_U	FREQUENCY (MHz) IF	CONVERSION LOSS (dB) MID-BAND m $\bar{x}$	σ	Max.	TOTAL RANGE Max.	LO-RF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	LO-IF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	SCHEMATIC
LEVEL 10	***+10 dBm LO***	***up to +5 dBm RF***																	
ZP-3LH	0.15-400	DC-400	4.8	0.37	7.0	8.0	67	50	51	30	40	25	67	40	45	25	34	20	1
ZP-1LH	2-600	DC-600	6.0	0.17	7.0	8.0	70	50	50	30	42	25	65	45	50	30	41	22	1
ZX05-1LHW	2-750	DC-750	5.3	0.10	6.8	8.5	66	50	52	35	46	27	64	40	50	27	40	20	1
ZP-5LH	20-1500	DC-1000	6.9	0.27	8.5	9.0	53	40	42	30	38	25	40	25	30	18	22	8	1
ZP-11ALH	1400-1900	40-500	7.0	0.20	8.6	8.6			36	20					28	15			1
ZFM-150	10-2000	DC-1000	6.05	0.12	8.0	8.0	32	25	35	25	35	20	33	20	30	20	25	20	2
ZX05-C24LH	300-2400	DC-700	6.5	0.10	—	8.9			40 (typ.)		25 (min.)				30 (typ.)		15 (min.)		1
ZFM-15	10-3000	10-800	6.13	0.14	8.0	8.5	35	25	35	25	35	25	30	20	30	20	30	20	2
ZX05-C42LH	1000-4200	DC-1500	6.0	0.10	—	8.9			38 (typ.)		23 (min.)				20 (typ.)		11 (min.)		1
ZX05-C60LH	1600-6000	DC-2000	6.1	0.10	8.5	—			30 (typ.)		20 (min.)				21 (typ.)		—		1
ZMX-7GLHR	3700-7000	DC-1500	5.4	0.30	—	9.8	33	20	33	20	33	20	35	20	35	20	35	20	1
ZMX-8GLH	3700-8000	DC-2000	5.5	0.20	—	9.8	40	20	40	20	40	20	18	8	18	8	18	8	1
LEVEL 13	***+13 dBm LO***	***up to +9 dBm RF***																	
ZP-3MH	0.15-400	DC-400	5.0	0.33	7.0	8.0	60	50	46	30	35	25	60	40	42	25	35	20	1
ZX05-1MHW	0.5-600	DC-600	5.2	0.10	6.9	8.0	63	50	53	32	43	20	56	40	44	25	30	20	1
ZP-1MH	2-600	DC-600	6.3	0.12	7.0	8.0	68	50	50	30	43	25	65	45	48	30	37	22	1
ZP-2MH	50-1000	DC-1000	6.0	0.25	7.5	9.0	58	40	47	30	37	25	55	35	47	20	32	18	1
ZX05-12MH	10-1200	DC-1200	6.3	0.10	8.0	9.3	62	45	45	32	40	26	68	40	42	27	30	20	1
ZP-5MH	20-1500	DC-1000	7.0	0.25	8.5	9.0	50	40	41	30	35	25	38	25	28	18	20	8	1
ZEM-M2TMH	10-2400	10-1000	6.9	0.10	9.0	9.5	49	40	43	35	42	35	49	40	44	30	40	30	2
ZX05-C24MH	300-2400	DC-700	6.1	0.10	—	8.6			40 (typ.)		20 (min.)				25 (typ.)		14 (min.)		1
ZLW-186MH	2-2500	2-1000	6.9	0.11	8.5	9.5	33	25	35	25	30	20	42	25	49	25	32	20	2
ZX05-25MH	5-2500	5-1500	6.9	0.10	8.8	9.8	47	28	34	23	34	23	34	23	32	18	23	17	2
ZX05-42MH	5-4200	5-3500	7.5	0.20	9.8	11.8	47	28	29	20	30	15	34	23	26	17	23	17	2
ZX05-C42MH	1000-4200	DC-1500	6.2	0.10	—	8.9			35 (typ.)		15 (min.)				20 (typ.)		10 (min.)		1
ZEM-4300MH	300-4300	DC-1000	6.42	0.15	—	8.5	40	20	—	—	40	20	14	7	—	—	12	7	1
ZX05-C60MH	1600-6000	DC-2000	6.4	0.10	—	8.5			28 (typ.)		18 (min.)				17 (typ.)		—		1
ZMX-7GMH	3700-7000	DC-2000	4.7	0.20	—	8.0	37	20	37	20	40	20			17 (typ.)		8 (min.)		1

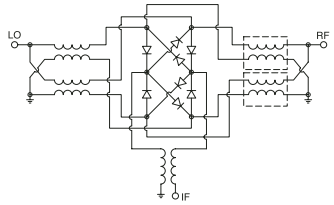
L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)
m = mid band ($2f_L$ to $f_U/2$)

ELECTRICAL SCHEMATICS

1 DOUBLE BALANCED MIXER



2 TRIPLE BALANCED MIXER



MIXERS, FREQUENCY 50 Ω

50 kHz to 8000 MHz

ZX05
Case FL905

ZMX
Case BU413

ZFM, ZFY
Case K18

ZP
Case GG60

ZLW, ZMY
Case M21

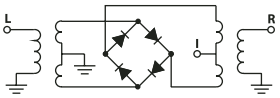
ZAD, ZAY
Case M22

MODEL PREFIX	FREQUENCY (MHz)		CONVERSION LOSS (dB)				LO-RF ISOLATION (dB)						LO-IF ISOLATION (dB)						SCHEMATIC
	LO/RF f_L-f_U	IF	MID-BAND m $\bar{x}$	σ	Max.	TOTAL RANGE Max.	L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	
LEVEL 17 +17 dBm LO up to +14 dBm RF																			
ZAD-3H	0.05-200	DC-200	4.89	0.09	7.0	7.5	55	45	45	30	35	25	45	35	40	30	30	2	1
ZFM-3H	0.05-300	DC-300	5.18	0.11	7.0	8.5	55	45	40	30	30	25	50	40	35	25	25	20	1
ZP-3H	0.15-400	DC-400	5.00	0.33	7.0	8.0	60	50	50	35	40	30	60	40	45	25	35	20	1
ZAD-1H	0.5-500	DC-500	6.16	0.08	7.5	8.5	50	45	45	30	35	25	45	35	40	30	30	20	1
ZLW-1H	0.5-500	DC-500	6.13	0.08	7.5	8.5	55	45	45	30	35	25	45	35	40	30	30	20	1
ZLW-1SH	2-500	DC-500	5.9	0.08	7.5	8.5	50	40	40	30	30	25	45	35	35	25	25	20	1
ZFM-1H	2-500	DC-500	6.14	0.11	7.5	8.5	50	45	40	30	30	25	45	35	35	25	25	20	1
ZP-1H	2-600	DC-600	5.90	0.18	7.0	8.0	68	50	50	30	43	25	62	45	48	30	33	22	1
ZLW-1WSH	5-750	DC-750	5.83	0.07	7.5	9.0	50	45	40	30	30	20	45	40	35	25	30	20	1
ZX05-1HW	5-750	DC-750	6.0	0.10	8.6	9.0	64	45	48	35	42	28	50	35	40	30	30	20	1
ZLW-2H	2-1000	DC-1000	6.34	0.14	7.5	10.0	50	40	35	25	35	25	45	35	30	20	25	20	1
ZFM-2H	5-1000	DC-1000	6.12	0.12	7.0	10.0	50	40	40	30	30	20	45	40	35	25	25	17	1
ZX05-10H	10-1000	DC-800	7.0	0.10	8.5	9.5	68	52	55	38	47	25	46	30	32	20	26	13	1
ZP-2H	50-1000	DC-1000	6.20	0.22	7.5	9.0	58	40	47	30	42	25	58	35	44	25	28	18	1
ZFM-4H	5-1200	DC-1200	4.97	0.11	8.0	9.0	50	40	35	25	30	20	50	40	35	20	30	20	1
ZP-5H	20-1500	DC-1000	7.50	0.17	8.5	9.0	62	55	50	40	38	25	40	25	29	18	20	8	1
ZX05-17H	100-1700	50-1500	7.2	0.10	8.5	9.5	32	20	—	—	36	22	32	20	—	—	37	22	2
ZP-11AH	1400-1900	40-500	7.30	0.28	9.0	9.0			35 (typ.)		25 (min.)				30 (typ.)		15 (min.)		1
ZX05-20H	1500-2000	DC-300	5.2	0.20	7.8	7.8			31 (typ.)		22 (min.)				34 (typ.)		20 (min.)		1
ZAD-11H	10-3000	10-1000	6.83	0.09	10.0	12.0	27	20	25	18	23	16	27	20	25	18	23	16	2
ZLW-11H	10-3000	10-1000	6.83	0.09	10.0	12.0	27	20	25	18	23	16	27	20	25	18	23	16	2
ZMX-7GHR	3700-7000	DC-1000	5.3	0.30	—	8.5			33		20				34	20			1
ZMX-8GH	3700-8000	DC-2000	5.8	0.30	—	8.5			40		20				18	8			1
LEVEL 23 +23 dBm LO up to +20 dBm RF																			
ZAY-3	0.07-200	DC-200	5.53	0.08	7.5	8.0	55	45	40	30	30	25	55	45	40	30	30	20	1
ZMY-3	0.07-200	DC-200	5.53	0.08	7.5	8.0	55	45	40	30	30	25	55	45	40	30	30	20	1
ZFY-1	0.1-500	0.01-500	4.85	0.18	6.0	7.5	40	20	46	35	40	30	37	23	46	35	40	30	2
ZAY-1	5-500	DC-500	6.57	0.09	7.5	8.5	55	45	40	30	30	25	55	45	40	30	30	20	1
ZMY-1	5-500	DC-500	6.62	0.10	7.5	8.5	55	45	40	30	30	25	55	45	40	30	30	20	1
ZFY-2	0.1-1000	0.01-500	5.40	0.24	7.5	9.5	40	20	40	30	30	25	37	23	40	25	25	15	2
ZAY-2	10-1000	DC-1000	6.89	0.22	8.5	10.0	50	35	40	30	35	25	50	35	35	25	25	20	1
ZMY-2	10-1000	DC-1000	6.89	0.22	8.5	10.0	50	35	40	30	35	25	50	35	35	25	25	20	1
ZFY-11	10-2400	5-1000	7.40	0.09	8.5	10.0	28	20	25	20	25	20	28	20	26	20	25	20	2

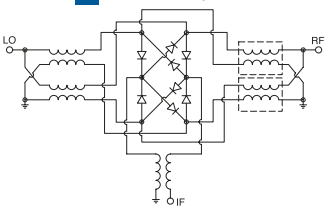
L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)
m = mid band ($2f_L$ to $f_U/2$)

ELECTRICAL SCHEMATICS

1 DOUBLE BALANCED MIXER



2 TRIPLE BALANCED MIXER



MODULATORS/DEMODULATORS 50Ω

9 MHz to 1050 MHz QPSK, I&Q

ZFMIQ
Case J17

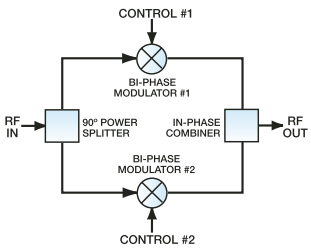
ZMQ, ZAMIQ
Case HHH141

MODEL PREFIX	FREQUENCY (MHz)	INSERTION LOSS (dB) Typ.	INSERTION LOSS (dB) Max.	AMPLITUDE UNBALANCE (dB) Typ.	AMPLITUDE UNBALANCE (dB) Max.	PHASE UNBALANCE (Deg.)± With reference to 90° Typ.	PHASE UNBALANCE (Deg.)± With reference to 90° Max.	1dB COMPR. (dBm) Typ.	VSWR (:1) TYP. In	VSWR (:1) TYP. Out
QPSK Modulators *wideband 360º in 90º steps Control current ±20 mA*										
ZMQ-1050	800-1050	5.5	7.5	0.5	1.0	3	7	4	2.0	2.0

MODEL PREFIX	FREQUENCY (MHz) RF (signal)/ LO (carrier) f_L	f_U	I&Q Min.	I&Q Max.	CONVERSION LOSS (dB) $\bar{X}$	σ	Max.	CARRIER REJECTION (-dBc) Typ.	Min.	SIDEBAND REJECTION (-dBc) Typ.	Min.	HARMONIC SUPPRESSION (-dBc) 3XI/Q Typ.	3XI/Q Min.	5XI/Q Typ.	5XI/Q Min.
I&Q Modulators *High Rejection of Carrier and Sideband LO = 10 dBm IF up to 0 dBm*															
ZFMIQ-10M	9	11	DC	2	5.8	0.20	7.0	41	30	40	30	58	45	68	58
ZFMIQ-70ML	66	73	DC	5	5.7	0.10	6.5	38	30	38	30	48	43	58	55
ZFMIQ-91M	86	95	DC	5	5.5	0.17	6.5	38	30	38	30	48	45	58	55
ZFMIQ-100M	95	105	DC	5	5.5	0.17	6.5	38	30	38	30	48	45	58	55
ZAMIQ-895M	868	895	DC	5	8.0	0.10	10.5	40	30	40	30	52	35	58	50

MODEL PREFIX	FREQUENCY (MHz) RF (signal)/ LO (carrier) f_L	f_U	I&Q Min.	I&Q Max.	CONVERSION LOSS (dB) $\bar{X}$	σ	Max.	AMPLITUDE UNBALANCE (dB) Typ.	Max.	PHASE UNBALANCE (Deg.)± With reference to 90° Typ.	Max.	HARMONIC SUPPRESSION (-dBc) 3XI/Q Typ.	3XI/Q Min.	5XI/Q Typ.	5XI/Q Min.
I&Q Demodulators *LO = 10 dBm RF up to 4 dBm*															
ZFMIQ-10D	9	11	DC	2	6.0	0.10	7.0	0.15	0.3	1.0	3.0	50	35	35	55
ZFMIQ-70D	66	73	DC	2	6.2	0.10	7.0	0.15	0.5	0.7	3.0	56	45	58	55
ZAMIQ-895D	868	895	DC	5	8.0	0.20	10.5	0.15	0.3	1.5	4.0	52	35	58	50

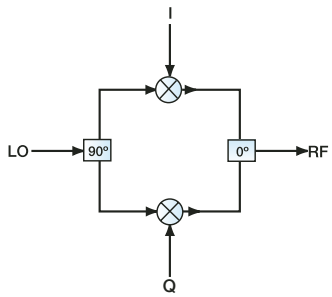
QPSK Block Diagram



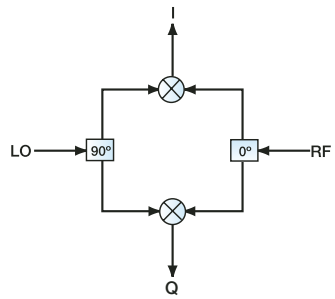
Phase Shift VS. Control Current

Cont-1 (mA)	Cont-2 (mA)	Phase Shift (Deg.)
+20	+20	0
+20	-20	90
-20	-20	180
-20	+20	270

I&Q Modulator Block Diagram



I&Q Demodulator Block Diagram



MATCHING PADS, IMPEDANCE 50 to 75 Ω

DC to 3000 MHz Resistive minimum loss

BMP
Case FF55

UNMP
Case FF779

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L - f_U	ATTENUATION (dB) Nom.	Flatness Max. L	M	U	VSWR (:1) Max. L	M	U	CONNECTORS Impedance	Type
BMP-5075	DC-2000	5.7±0.1	0.2	0.3	0.4	1.06	1.22	1.4	75 Ω 50 Ω	Male BNC Female BNC
BMP-5075R	DC-2000	5.7±0.1	0.2	0.3	0.4	1.06	1.22	1.4	75 Ω 50 Ω	Female BNC Male BNC
UNMP-5075	DC-3000	5.7±0.15	0.2	0.3	0.4	1.10	1.30	1.5	75 Ω 50 Ω	Male Type-N Female Type-N

L = low range (DC to 100 MHz) M = mid range (100 to 1000 MHz) U = upper range (1000 MHz to f_U)

MULTIPLIERS FREQUENCY 50 Ω

0.1 MHz to 8100 MHz

Mini-Circuits® 2007

FK
Case H16

MK
Case L19

GK
Case L20

FD
Case FF55

ZX90
Case JA1242

MODEL PREFIX	FREQUENCY (MHz) Input	FREQUENCY (MHz) Output	RF INPUT POWER (dBm) Min.	RF INPUT POWER (dBm) Max.	CONVERSION LOSS (dB) Typ.	CONVERSION LOSS (dB) Max.	HARMONIC OUTPUT (dBc) F1 Typ.	F1 Min.	F3 Typ.	F3 Min.	F4 Typ.	F4 Min.
X 2							BELOW F2					
MK-3	0.05-50	0.1-100	0	13	11.0	17.0	40	28	45	30	16	12
	50-150	100-300	0	13	11.5	15.0	35	20	40	20	16	12
FD-2	5-100	10-200	1	15	13.0	16.0	40	30	50	40	16	12
	100-300	200-600	1	15	13.5	15.5	25	20	40	30	16	12
	300-500	600-1000	1	15	14.0	16.5	20	15	30	25	16	12
MK-2	5-100	10-200	1	15	13.0	16.0	40	30	50	40	16	12
	100-300	200-600	1	15	13.5	15.5	25	20	40	30	16	12
	300-500	600-1000	1	15	14.0	16.5	20	15	30	25	16	12
FK-5	10-600	20-1200	13	20	13.0	15.0	20	10	26	20	15	10
	600-1000	1200-2000	10	20	14.0	17.0	20	10	25	20	25	15
GK-5	10-600	20-1200	13	20	13.0	15.0	20	10	26	20	15	10
	600-1000	1200-2000	10	20	14.0	17.0	20	10	25	20	25	15
MK-5	10-600	20-1200	13	20	13.0	15.0	20	10	26	20	15	10
	600-1000	1200-2000	10	20	14.0	17.0	20	10	25	20	25	15
FK-3000	70-1000	140-2000	12	15	11.0	14.0	31	20	40	25	15	10
	1000-1500	2000-3000	12	15	12.0	17.5	22	15	30	20	30	14
ZX90-2-11	500-1100	1000-2200	5	10	10.5	13.5	27	21	34	25	21	12
	550-750	1100-1500	5	10	10.0	13.5	30	21	34	25	21	12
ZX90-2-19	1100-1900	2200-3800	5	10	10.5	14.5	27	20	30	23	17	11
ZX90-2-36	1700-3600	3400-7200	8	13	11.0	15.0	18	11	32	22	17	10
	2100-2700	4200-5400	8	13	10.0	14.0	23	14	35	22	17	10
X 3							F1 Typ.	F1 Min.	F2 Typ.	F2 Min.	F4 Typ.	F4 Min.
							BELOW F3					
ZX90-3-452	1000-1500	3000-4500	10	16	14.7	18.0	40	30	55	40	55	38
ZX90-3-692	1700-2300	5100-6900	9	13	14.7	20.0	40	29	40	25	40	25
ZX90-3-812	2000-2700	6000-8100	0	5	15.0	22.0	30	21	48	30	48	27

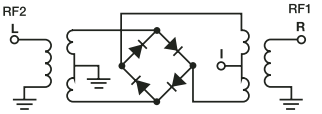
PHASE DETECTORS *High Output 50 Ω*

1 MHz to 100 MHz

ZRPD
Case M22

MODEL PREFIX	FREQUENCY (MHz) RF1 RF2	I	POWER IN RF1 RF2 (dBm)	SCALE FACTOR mV/deg.	IMPEDANCE (OHMS) output load I	ISOLATION (dB) RF1-RF2 Min.	OUTPUT POLARITY RF1/RF2 In-phase	DC OUTPUT (mV) note 2 Typ.	Max. Min.	Offset Typ.	Offset Max.	FIGURE-OF-MERIT M Typ.
ZRPD- 1	1- 100	DC- 50	7	8	500	40	neg.	1000	700	0.2	1	143

ELECTRICAL SCHEMATIC



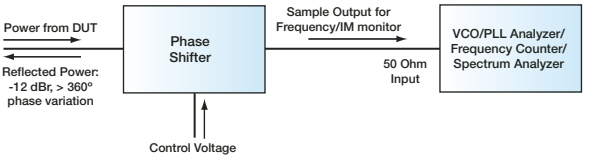
PHASE SHIFTERS *360° VOLTAGE VARIABLE 50 Ω*

80 MHz to 1300 MHz

ELS
Case K18

MODEL PREFIX	FREQUENCY RANGE, (MHz) f_L-f_U	INPUT POWER (dBm) Max.	PHASE RANGE Degrees Min.	RETURN LOSS (dB) Typ.	CONTROL VOLTAGE (V)
FIXED MAGNITUDE MISMATCH	***RF up to 13 dBm***				
ELS-210	80-210	10	360	10-12	0.5-25
ELS-450	180-450	10	360	10-12	0.5-25
ELS-950	400-950	10	360	10-12	0.5-25
ELS-1300	750-1300	10	360	10-12	1-25

APPLICATION BLOCK DIAGRAM VCO (DUT) Load Pull Test



POWER DETECTORS 50 Ω

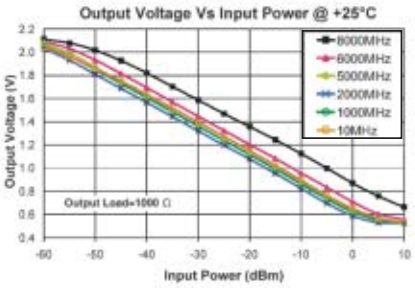
10 MHz to 8000 MHz -60 dBm to+20 dBm

Mini-Circuits® 2007

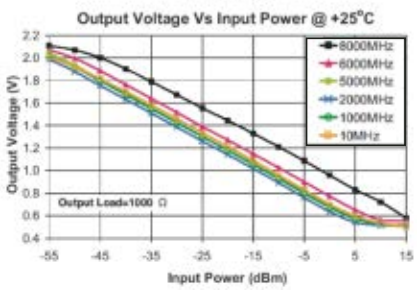
ZX47
Case HN1173

MODEL PREFIX	FREQUENCY (MHz) Min.	FREQUENCY (MHz) Max.	DYNAMIC RANGE @ ± 1dB Error (dBm) Typ.	OUTPUT VOLTAGE RANGE (V) Typ.	SLOPE (mV/dB) Typ.	VSWR (:1) Typ.	PULSE RESPONSE TIME Rise (nsec) Typ.	PULSE RESPONSE TIME Fall (nsec) Typ.	TEMP. SENSOR OUTPUT SLOPE (mV/°C) Typ.	DC OPERATING POWER Vcc (volts) Min.	DC OPERATING POWER Vcc (volts) Typ.	DC OPERATING POWER Vcc (volts) Max.	DC OPERATING POWER Current (mA) Typ.
ZX47-60	10 1000 5000 6000	1000 5000 6000 8000	-55 to 0 -60 to -5 -55 to +5 -50 to +5	0.50-2.10	-25	1.1 1.8 1.7 1.4	400	10	2.00	4.5	5.0	5.5	100
ZX47-55	10 1000 5000 6000	1000 5000 6000 8000	-50 to +5 -55 to 0 -50 to +5 -45 to +10	0.50-2.10	-25	1.05 1.40 1.50 1.30	400	10	2.00	4.5	5.0	5.5	100
ZX47-50	10 1000 5000 6000	1000 5000 6000 8000	-45 to +10 -50 to +5 -45 to +10 -40 to +15	0.50-2.10	-25	1.05 1.20 1.30 1.20	400	10	2.00	4.5	5.0	5.5	100
ZX47-40	10 1000 5000 6000	1000 5000 6000 8000	-40 to +20 -40 to +15 -35 to +20 -30 to +20	0.50-2.10	-25	1.03 1.10 1.20 1.40	400	10	2.00	4.5	5.0	5.5	100

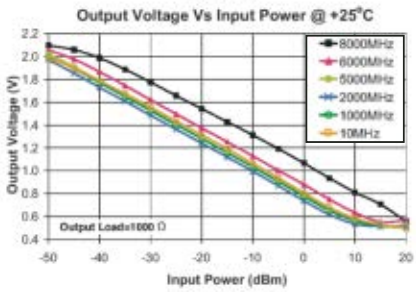
ZX47-60



ZX47-55



ZX47-50



POWER SPLITTERS/COMBINERS

DC to 12600 MHz

ZX10 Case FL905 | ZX10Q Case GW1052 | ZESC-2 Case V37 | IZY2PD Case JJJ245 | ZFSC, ZFSCJ, ZFRSC, ZFSC-2 Case K18 | ZC2PD Case F183 | ZN2PD Case VVV180, VVV845

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS, (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBAL., degrees L Max.	M Max.	U Max.	AMPLITUDE UNBAL. (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
2 WAY - 0° 50 Ω								*Insertion Loss Above 3 dB*													
ZFSC-2-6	0.002-60	27	20	30	20	27	20	0.3	0.6	0.3	0.6	0.6	1.0	2	3	4	0.15	0.20	0.30	1.0	0.125
ZMSC-2-2	0.002-60	27	20	30	20	27	20	0.3	0.6	0.3	0.6	0.6	1.0	2	3	4	0.15	0.25	0.30	1.0	0.125
ZSC-2-2	0.002-60	25	20	30	20	27	20	0.3	0.6	0.3	0.6	0.6	1.0	2	3	4	0.15	0.25	0.30	1.0	0.125
ZMSC-2-1	0.1-400	20	15	25	20	25	20	0.2	0.5	0.4	0.75	0.6	1.0	2	3	4	0.15	0.20	0.30	1.0	0.125
ZSC-2-1	0.1-400	20	15	25	20	25	20	0.2	0.5	0.4	0.75	0.6	1.0	2	3	4	0.15	0.20	0.30	1.0	0.125
ZFSC-2-1	5-500	30	25	28	20	25	20	0.2	0.5	0.3	0.6	0.6	0.8	2	4	4	0.15	0.15	0.30	1.0	0.125
ZMSC-2-1W	1-650	25	20	35	20	25	20	0.3	0.5	0.5	0.8	0.7	1.0	2	3	4	0.15	0.20	0.30	1.0	0.125
ZSC-2-1W	1-650	25	20	35	25	25	20	0.3	0.5	0.5	0.8	0.7	1.0	2	3	4	0.15	0.20	0.30	1.0	0.125
ZFSC-2-1W	1-750	30	20	28	20	25	20	0.2	0.5	0.4	0.8	0.8	1.0	2	4	4	0.15	0.15	0.30	1.0	0.125
ZAPD-900-5W	100-900	23	18	23	18	23	18	0.3	1.0	0.3	1.0	0.3	1.0	3	3	3	0.30	0.30	0.30	5.0	1.000
ZC2PD-900	800-900	30	20	30	20	30	20	0.1	0.4	0.1	0.4	0.1	0.4	2	2	2	0.20	0.20	0.20	10.0	0.125
ZN2PD-920	800-920	30	20	30	20	30	20	0.15	0.4	0.15	0.4	0.15	0.4	2	2	2	0.20	0.20	0.20	10.0	0.125
ZFSC-2-4	0.2-1000	20	15	25	20	23	18	0.2	0.8	0.5	1.0	0.9	1.2	2	4	4	0.15	0.15	0.30	1.0	0.125
ZAPD-1	500-1000	25	19	25	19	25	19	0.25	0.6	0.25	0.6	0.25	0.6	2	2	2	0.20	0.20	0.20	10.0	0.125
ZFSC-2-2	10-1000	30	20	25	20	23	18	0.2	0.5	0.5	1.0	0.9	1.2	2	4	4	0.15	0.15	0.30	1.0	0.125
ZSC-2-4	10-1000	25	20	35	20	25	20	0.2	0.5	0.5	0.8	0.7	1.3	2	4	6	0.15	0.20	0.30	1.0	0.125
ZN2PD-920W	700-1050	22	15	22	15	22	15	0.15	0.5	0.15	0.5	0.15	0.5	3	3	3	0.30	0.30	0.30	10.0	0.125
ZX10-2-12	2-1200	21	16	21	16	21	16	0.5	1.5	0.5	1.5	0.5	1.5	3	3	3	0.50	0.50	0.50	0.5	0.125
ZFSC-2-5	10-1500	25	15	30	20	25	18	0.25	0.6	0.5	1.0	0.8	1.5	2	3	4	0.15	0.20	0.50	1.0	0.125
ZAPD-1750	950-1750	30	22	30	22	30	22	0.2	0.4	0.2	0.4	0.2	0.4	4	4	4	0.50	0.50	0.50	10.0	0.125
ZN2PD-1900	1600-1900	30	20	30	20	30	20	0.18	0.4	0.18	0.4	0.18	0.4	2	2	2	0.20	0.20	0.20	10.0	0.125
ZESC-2-11	10-2000	19	10	18	13	20	11	0.5	0.9	0.5	1.0	0.6	1.2	1	3	6	0.20	0.30	0.50	1.0	0.125
ZFSC-2-11	10-2000	14	10	16	14	20	15	1.2	1.5	1.2	1.5	1.0	2.0	1	2	4	0.20	0.30	0.50	1.0	0.125
ZX10-2-20	200-2000	20	16	20	16	20	16	0.8	2.2	0.8	2.2	0.8	2.2	6	6	6	4.00	4.00	4.00	0.5	0.125
ZAPD-21	500-2000	25	18	25	18	25	18	0.25	1.0	0.25	1.0	0.25	1.0	3	3	3	0.20	0.20	0.20	10.0	0.125
ZAPD-20	700-2000	30	20	30	20	30	20	0.30	0.7	0.30	0.7	0.30	0.7	3	3	3	0.40	0.40	0.40	10.0	0.125
ZAPD-23	700-2000	27	20	27	20	27	20	0.4	0.8	0.4	0.8	0.4	0.8	2	2	2	0.20	0.20	0.20	10.0	0.5
ZN2PD-20	750-2000	18	15	25	20	18	15	0.2	0.5	0.2	0.5	0.2	0.5	4	4	4	0.30	0.30	0.30	5.0	0.725
ZAPD-2	1000-2000	25	19	25	19	25	19	0.25	0.6	0.25	0.6	0.25	0.6	2	2	2	0.20	0.20	0.20	10.0	0.125
ZN2PD-1900W	1500-2000	24	15	24	15	24	15	0.2	0.5	0.2	0.5	0.2	0.5	3	3	3	0.30	0.30	0.30	10.0	0.125
ZFSC-2-2500	10-2500	16	11	17	14	17	14	0.5	0.8	0.6	1.4	0.8	1.5	1	4	8	0.20	0.30	0.40	10.0	0.5
ZX10-2-25	100-2500	20	14	20	14	20	14	1.2	2.2	1.2	2.2	1.2	2.2	10	10	10	1.20	1.20	1.20	5.0	0.725
ZAPD-30	20-3000	14	12	16	12	20	14	1.1	1.5	1.1	1.8	1.4	2.3	3	5	9	0.30	0.40	0.80	1.0	0.125
ZX10-2-42	1900-4200	23	10	23	10	23	10	0.2	1.0	0.2	1.0	0.2	1.0	3	3	3	0.30	0.30	0.30	1.0	0.10
ZAPD-4	2000-4200	25	19	25	19	25	19	0.4	0.8	0.4	0.8	0.4	0.8	6	6	6	0.40	0.40	0.40	10.0	0.125
ZN2PD2-50	500-5000	25	15	25	15	25	15	0.8	1.4	0.8	1.4	0.8	1.4	4	4	4	0.50	0.50	0.50	10.0	0.250
ZAPD-50	4400-5000	26	20	26	20	26	20	0.3	0.8	0.3	0.8	0.3	0.8	5	5	5	0.50	0.50	0.50	10.0	0.125
ZAPD-50W	4200-6000	26	16	26	16	26	16	0.3	0.8	0.3	0.8	0.3	0.8	5	5	5	0.70	0.70	0.70	10.0	0.125
IZY2PD-64	5800-6400	35	24	35	24	35	24	0.2	0.5	0.2	0.5	0.2	0.5	5	5	5	0.30	0.30	0.30	1.0	0.125
ZX10-2-71	2950-7100	23	10	23	10	23	10	0.25	0.9	0.25	0.9	0.25	0.9	3	3	3	0.40	0.40	0.40	1.0	0.125
IZY2PD-86	7000-8600	30	18	30	18	30	18	0.1	0.5	0.1	0.5	0.1	0.5	6	6	6	0.25	0.25	0.25	1.0	0.125
ZN2PD-9G	1700-9000	22	15	22	15	22	15	0.5	1.4	0.5	1.4	0.5	1.4	4	4	4	0.60	0.60	0.60	10.0	0.125
ZFSC-2-9G	3500-9000	18	12	—	—	20	12	0.5	1.5	—	—	0.6	1.2	7	—	10	0.30	—	0.50	1.0	0.125
ZX10-2-98	4750-9800	23	10	23	10	23	10	0.3	1.2	0.3	1.2	0.3	1.2	9	9	9	0.50	0.50	0.50	1.0	0.125
ZFSC-2-10G	2000-10000	15	9	—	—	20	12	0.5	1.5	—	—	0.6	1.6	7	—	12	0.60	—	0.50	1.0	0.125
ZX10-2-126	7400-12600	23	10	23	10	23	10	0.3	1.3	0.3	1.3	0.3	1.3	10	10	10	0.50	0.50	0.50	1.0	0.100

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

ZAPD, ZAPO, ZAOQ, ZAPOJ
Case F14, F53

ZMSC-2, ZMSC-J, ZMSC-Q
Case M21

ZSC-2
Case M22

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS, (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBAL., degrees L Max.	M Max.	U Max.	AMPLITUDE UNBAL. (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
2 WAY - 0° 75 Ω								*Insertion Loss Above 3 dB*													
ZSC-2-2-75	0.002-60	25	20	30	20	27	20	0.3	0.6	0.3	0.6	0.6	1.0	2.0	3.0	4.0	0.15	0.25	0.30	1.0	0.125
ZFSC-2-6-75	0.004-60	30	20	35	20	25	20	0.5	0.8	0.4	0.8	0.7	1.0	1.0	2.0	3.0	0.15	0.20	0.30	1.0	0.125
ZSC-2375	55-85	35	25	35	25	35	25	0.3	0.5	0.3	0.5	0.3	0.5	1.0	1.0	1.0	0.10	0.10	0.10	1.0	0.125
ZFSC-2-1-75	0.25-300	20	15	30	25	25	20	0.4	0.75	0.4	0.75	0.4	1.0	2.0	3.0	5.0	0.15	0.20	0.30	1.0	0.125
ZSC-2-1-75	0.25-300	20	15	30	20	20	15	0.4	0.75	0.4	0.75	0.4	1.0	2.0	3.0	5.0	0.15	0.20	0.30	1.0	0.125
ZFSC-2-1W-75	5-600	44	26	45	30	31	20	0.22	0.6	0.27	0.7	0.46	0.9	1.0	2.0	3.0	0.20	0.30	0.40	1.0	0.125
ZAPD-2-22-75	910-2150	30	20	30	20	30	20	0.2	0.7	0.2	0.7	0.2	0.7	2.0	2.0	2.0	0.40	0.40	0.40	5.0	0.250
2 WAY - 0° Resistive 50 Ω								*Insertion Loss Above 6 dB*													
ZFRSC-2050	DC-2000	6.2	6.2	6.6	6.6	7.0	7.0	0.1	0.2	0.3	0.6	0.5	1.4	1.0	2.0	5.0	0.1	0.2	0.5	0.75	0.35
ZFRSC-42	DC-4200	6.2	6.2	6.5	6.6	7.0	7.0	0.1	0.2	0.1	0.5	0.4	1.4	1.0	3.0	5.0	0.1	0.2	0.5	0.75	0.35
2 WAY - 0° Resistive 75 Ω																					
ZFRSC-2075	DC-2000	6.2	6.2	6.6	6.6	7.0	7.0	0.1	0.2	0.3	0.6	0.5	1.4	1.0	2.0	5.0	0.1	0.2	0.5	0.75	0.35
2 WAY - 90° 50 Ω								*Avg. of Coupled Outputs less 3 dB*													
ZMSCQ-2-50	25-50	27	20	27	20	27	20	0.3	0.7	0.3	0.7	0.3	0.7	3.0	3.0	3.0	1.5	1.5	1.5	1.0	0.062
ZMSCQ-2-90	55-90	30	20	30	20	30	20	0.3	0.7	0.3	0.7	0.3	0.7	3.0	3.0	3.0	1.2	1.2	1.2	1.0	0.062
ZSCQ-2-90	55-90	30	20	30	20	30	20	0.3	0.7	0.3	0.7	0.3	0.7	3.0	3.0	3.0	1.2	1.2	1.2	1.0	0.062
ZMSCQ-2-120	80-120	21	18	21	18	21	18	0.3	0.7	0.3	0.7	0.3	0.7	3.0	3.0	3.0	1.5	1.5	1.5	1.0	0.062
ZMSCQ-2-180	120-180	23	15	23	15	23	15	0.3	0.7	0.3	0.7	0.3	0.7	4.0	4.0	4.0	1.2	1.2	1.2	1.0	0.125
ZX10Q-2-3	220-470	24	18	24	18	24	18	0.6	0.8	0.6	0.8	0.6	0.8	8.0	8.0	8.0	1.3	1.3	1.3	7.0	3.5
ZX10Q-2-5	330-580	22	14	22	14	22	14	0.4	0.9	0.4	0.9	0.4	0.9	5.0	5.0	5.0	1.3	1.3	1.3	8.6	4.3
ZX10Q-2-7	425-675	17	11	17	11	17	11	0.4	1.0	0.4	1.0	0.4	1.0	8.0	8.0	8.0	1.0	1.0	1.0	8.6	4.3
ZX10Q-2-12	800-1250	17	13	17	13	17	13	0.35	0.7	0.35	0.7	0.35	0.7	5.0	5.0	5.0	0.8	0.8	0.8	8.6	4.3
ZX10Q-2-19	1100-1925	26	19	26	19	26	19	0.4	0.9	0.4	0.9	0.4	0.9	4.0	4.0	4.0	1.1	1.1	1.1	8.6	4.3
ZAPDQ-2	1000-2000	22	16	22	16	22	16	0.4	1.4	0.4	1.4	0.4	1.4	6.0	6.0	6.0	0.8	0.8	0.8	1.0	0.125
ZX10Q-2-25	1350-2450	25	17	25	17	25	17	0.4	0.9	0.4	0.9	0.4	0.9	5.0	5.0	5.0	1.1	1.1	1.1	8.6	4.3
ZX10Q-2-27	1700-2700	23	18	23	18	23	18	0.4	0.7	0.4	0.7	0.4	0.7	5.0	5.0	5.0	1.0	1.0	1.0	8.6	4.3
ZX10Q-2-34	2500-3400	29	20	29	20	29	20	0.4	0.7	0.4	0.7	0.4	0.7	4.0	4.0	4.0	1.2	1.2	1.2	8.6	4.3
ZAPDQ-4	2000-4200	22	16	22	16	22	16	0.4	0.9	0.4	0.9	0.4	0.9	8.0	8.0	8.0	1.0	1.0	1.0	1.0	4.3
2 WAY - 180° 50 Ω								*Insertion Loss Above 3 dB*													
ZFSCJ-2-2	0.01-20	35	25	30	25	25	18	0.3	0.8	0.2	0.5	0.3	0.6	1.0	2.0	2.5	0.1	0.1	0.2	1.0	0.125
ZMSCJ-2-2	0.01-20	35	25	30	25	25	18	0.3	0.8	0.2	0.5	0.3	0.6	1.0	2.0	2.5	0.1	0.1	0.2	1.0	0.125
ZSCJ-2-2	0.01-20	35	25	30	25	25	18	0.3	0.8	0.2	0.5	0.3	0.6	1.0	2.0	2.5	0.1	0.1	0.2	1.0	0.125
ZMSCJ-2-1	1-200	35	30	35	25	30	23	0.75	1.0	0.6	0.8	0.75	1.2	2.0	2.5	4.0	0.3	0.15	0.3	1.0	0.125
ZSCJ-2-1	1-200	35	30	35	25	30	23	0.75	1.0	0.6	0.8	0.75	1.2	2.0	2.5	4.0	0.3	0.15	0.3	1.0	0.125
ZFSCJ-2-3	5-300	30	20	33	25	30	18	1.0	1.5	1.0	1.5	1.0	1.5	2.0	4.0	6.0	0.15	0.2	0.5	1.0	0.125
ZFSCJ-2-1	1-500	30	20	33	25	30	18	1.0	1.5	1.0	1.5	1.0	1.5	2.0	4.0	7.0	0.5	0.2	0.5	1.0	0.125
ZFSCJ-2-4	50-1000	30	20	—	—	25	18	1.2	1.9	—	—	1.6	2.4	6.0	—	7.0	0.6	—	0.6	1.0	0.125
ZAPDJ-2	1000-2000	22	18	22	18	22	18	1.3	1.8	1.3	1.8	1.3	1.8	6.0	6.0	6.0	0.8	0.8	0.8	1.0	0.125

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

POWER SPLITTERS/COMBINERS

2 kHz to 8400 MHz


ZCSC-3
Case UU233


ZB3PD1
Case UU188-1


ZFSC-3
Case J17


ZMS
Case P26


ZSC-3
Case P25


ZA3PD
Case CC51


ZN3PD
Case UU181


ZB3PD
Case UU182

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS, (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBAL., degrees L Max.	M Max.	U Max.	AMPLITUDE UNBAL. (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
3 WAY - 0° 50 Ω								*Insertion Loss Above 4.8 dB*													
ZSC-3-2	0.01-30	35	30	40	25	30	25	0.25	0.45	0.15	0.45	0.45	0.75	1	2	4	0.2	0.3	0.4	1.0	0.187
ZFSC-3-13	1-200	45	30	48	35	37	30	0.25	0.5	0.35	0.6	0.35	0.6	1	3	5	0.1	0.2	0.2	1.0	0.187
ZMSC-3-1	1-200	45	35	40	25	40	25	0.3	0.5	0.4	0.7	0.6	1.0	1	2	4	0.15	0.2	0.3	1.0	0.187
ZSC-3-1	1-200	45	30	40	25	40	25	0.3	0.5	0.4	0.7	0.6	1.0	1	2	4	0.15	0.2	0.3	1.0	0.187
ZCSC-3-R3	2-300	32	28	31	28	32	22	0.3	0.8	0.4	1.0	0.8	1.2	1	2	3	0.1	0.3	0.3	1.0	0.187
ZFSC-3-1	1-500	30	20	30	20	25	18	0.4	0.75	0.5	0.9	0.8	1.2	2	3	4	0.2	0.3	0.4	1.0	0.187
ZFSC-3-1W	2-750	30	20	30	20	25	18	0.4	0.75	0.5	1.0	1.0	1.6	3	5	7	0.2	0.3	0.5	1.0	0.187
ZN3PD-900	800-900			30	20					0.2	0.4				—			0.5		10.0	0.187
ZFSC-3-4	1-1000	35	20	20	18	20	17	0.2	0.5	0.7	1.4	1.0	2.0	3	6	10	0.2	0.4	0.9	1.0	0.187
ZA3PD-1	500-1000	20	14	20	14	20	14	0.3	0.6	0.3	0.6	0.3	0.6	—	—	—	0.4	0.4	0.4	10.0	0.187
ZN3PD-900W	650-1050	22	15	22	15	22	15	0.3	0.8	0.3	0.8	0.3	0.8	—	—	—	0.8	0.8	0.8	10.0	0.187
ZA3PD-1.5	750-1500	20	14	20	14	20	14	0.3	0.7	0.3	0.7	0.3	0.7	—	—	—	0.4	0.4	0.4	10.0	0.187
ZA3PD-2	1000-2000	20	15	20	15	20	15	0.3	0.6	0.3	0.6	0.3	0.6	—	—	—	0.3	0.3	0.3	10.0	0.187
ZB3PD1-222	500-2200	25	14	25	14	25	14	0.3	1.0	0.3	1.0	0.3	1.0	—	—	—	0.7	0.7	0.7	10.0	0.187
ZB3PD-2400W	700-2400	25	17	25	17	25	17	0.5	1.2	0.5	1.2	0.5	1.2		8		0.9	0.9	0.9	1.0	0.125
ZA3PD-4	2000-4200	18	14	18	14	18	14	0.7	1.0	0.7	1.0	0.7	1.0	—	—	—	0.9	0.9	0.9	10.0	0.187
3 WAY - 0° 75 Ω																					
ZSC-3-1-75	1-200	35	30	35	25	35	25	0.6	1.0	0.4	0.7	0.6	1.0	2	3	4	0.15	0.2	0.3	1.0	0.187
ZFSC-3-4-75	1-1000	34	22	27	17	23	15	0.2	0.5	0.4	1.2	1.2	2.0	3	6	10	0.5	0.7	0.9	1.0	0.25


ZFSC-4
Case G15


ZMSC-4
Case N24


ZSC-4
Case N27


ZA4PD
Case DD52


ZX10-4
Case GR1026


ZX10-4A
Case GY1065


ZBSC-4
Case UU102


ZC4PD
Case Z184

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS, (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBAL., degrees L Max.	M Max.	U Max.	AMPLITUDE UNBAL. (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
4 WAY - 0° 50 Ω								*Insertion Loss Above 6 dB*													
ZMSC-4-2	0.002-20	30	20	33	25	33	25	0.45	0.75	0.3	0.5	0.7	1.0	4	6	8	0.15	0.20	0.25	1.0	0.083
ZSC-4-2	0.002-20	30	20	33	25	33	25	0.45	0.75	0.3	0.5	0.7	1.0	4	6	8	0.15	0.20	0.25	1.0	0.083
ZMSC-4-1	0.1-200	33	20	30	20	27	20	0.4	0.6	0.5	0.75	0.7	1.0	4	6	8	0.15	0.20	0.25	1.0	0.083
ZSC-4-1	0.1-200	33	20	30	20	27	20	0.4	0.6	0.5	0.75	0.7	1.0	4	6	8	0.15	0.20	0.25	1.0	0.083
ZMSC-4-3	0.25-250	33	20	30	20	27	20	0.4	0.7	0.5	0.75	0.7	1.2	4	6	10	0.15	0.20	0.25	1.0	0.083
ZSC-4-3	0.25-250	33	20	30	20	27	20	0.4	0.7	0.5	0.75	0.7	1.2	4	6	10	0.15	0.20	0.25	1.0	0.083
ZFSC-4-3	10-300	32	28	38	30	38	30	0.5	0.8	0.6	0.9	0.9	1.2	4	6	8	0.10	0.10	0.20	1.0	0.083
ZB4PD1-500	5-500	34	20	34	20	28	20	0.4	1.0	0.5	0.9	0.9	1.5	1	3	6	0.20	0.20	0.40	1.0	0.083
ZFSC-4-1W	10-500	23	20	23	20	23	20	0.6	1.5	0.6	1.5	0.6	1.5	4	8	8	0.20	0.30	0.40	1.0	0.083
ZBSC-413	10-800	26	20	18	15	18	15	0.6	1.0	1.0	1.5	1.6	2.0	4	8	8	0.20	0.40	0.60	1.0	0.083
ZC4PD-900	800-900	30	20	30	20	30	20	0.3	0.6	0.3	0.6	0.3	0.6	3	3	3	0.20	0.20	0.20	10.0	0.083
ZN4PD-920	800-920	30	20	30	20	30	20	0.25	0.5	0.25	0.5	0.25	0.5	2	2	2	0.20	0.20	0.20	10.0	0.083
ZB4PD1-930	850-930	30	20	30	20	30	20	0.3	0.5	0.3	0.5	0.3	0.5	5	5	5	0.25	0.25	0.25	10.0	0.083
ZFSC-4-1	1-1000	25	20	23	18	20	15	0.4	1.2	0.6	1.5	1.6	2.5	4	8	8	0.20	0.40	0.70	1.0	0.083
ZN4PD-920W	670-1000	22	15	22	15	22	15	0.3	0.6	0.3	0.6	0.3	0.6	3	3	3	0.20	0.20	0.20	10.0	0.083
ZB4PD1-930W	725-1050	22	15	22	15	22	15	0.3	0.8	0.3	0.8	0.3	0.8	5	5	5	0.40	0.40	0.40	10.0	0.083
ZX10-4-11	800-1125	20	15	20	15	20	15	0.6	1.3	0.6	1.3	0.6	1.3	3	3	3	0.70	0.70	0.70	2.5	0.125
ZX10-4A-11	800-1125	20	14	20	14	20	14	0.6	1.1	0.6	1.1	0.6	1.1	4	4	4	0.70	0.70	0.70	2.5	0.125
ZX10-4-14	1100-1450	20	15	20	15	20	15	0.8	1.3	0.8	1.3	0.8	1.3	7	7	7	0.80	0.80	0.80	2.5	0.125
ZX10-4A-14	1100-1450	25	16	25	16	25	16	0.6	1.0	0.6	1.0	0.6	1.0	4	4	4	0.70	0.70	0.70	2.5	0.125
ZC4PD-18	1000-1800	32	18	32	18	32	18	0.3	0.8	0.3	0.8	0.3	0.8	6	6	6	0.40	0.40	0.40	10.0	0.125
ZX10-4-19	1425-1900	20	16	20	16	20	16	0.75	1.0	0.75	1.0	0.75	1.0	6	6	6	0.90	0.90	0.90	2.5	0.08
ZX10-4A-19	1425-1900	20	16	20	16	20	16	0.75	1.1	0.75	1.1	0.75	1.1	5	5	5	0.70	0.70	0.70	2.5	0.08
ZB4PD1-2000	800-2000	25	18	25	18	25	18	0.6	1.2	0.6	1.2	0.6	1.2	—	—	—	0.30	0.30	0.30	10.0	0.125
ZA4PD-2	1000-2000	25	16	25	16	25	16	0.3	1.0	0.3	1.0	0.3	1.0	6	6	6	0.70	0.70	0.70	10.0	0.125
ZN4PD-20	1800-2000	31	20	31	20	31	20	0.3	0.7	0.3	0.7	0.3	0.7	4	4	4	0.50	0.50	0.50	10.0	0.125
ZX10-4-24	1675-2350	20	17	20	17	20	17	0.9	1.1	0.9	1.1	0.9	1.1	5	5	5	0.70	0.70	0.70	2.5	0.08
ZX10-4A-24	1675-2350	20	18	20	18	20	18	0.8	1.2	0.8	1.2	0.8	1.2	7	7	7	0.60	0.60	0.60	2.5	0.08
ZX10-4-27	2225-2700	20	16	20	16	20	16	1.0	1.5	1.0	1.5	1.0	1.5	9	9	9	1.20	1.20	1.20	2.5	0.08
ZX10-4A-27	2225-2700	20	16	20	16	20	16	1.0	1.3	1.0	1.3	1.0	1.3	6	6	6	0.90	0.90	0.90	2.5	0.08
ZB4PD-42	1700-4200	23	16	23	16	23	16	0.5	1.4	0.5	1.4	0.5	1.4	8	8	8	0.80	0.80	0.80	10.0	0.125
ZA4PD-4	2000-4200	25	16	25	16	25	16	0.5	1.0	0.5	1.0	0.5	1.0	16	16	16	0.80	0.80	0.80	10.0	0.125
ZB4PD-4	3700-4200	24	15	24	15	24	15	0.6	1.1	0.6	1.1	0.6	1.1	8	8	8	0.80	0.80	0.80	10.0	0.125
ZN4PD1-50	500-5000	23	13	23	13	23	13	0.9	1.8	0.9	1.8	0.9	1.8	8	8	8	0.60	0.60	0.60	10.0	0.25
ZB4PD1-5.8	4600-5800	25	16	25	16	25	16	0.4	0.9	0.4	0.9	0.4	0.9	5	5	5	0.40	0.40	0.40	10.0	0.125
ZN4PD1-63	2000-6000	26	17	26	17	26	17	0.7	1.3	0.7	1.3	0.7	1.3	5	5	5	0.40	0.40	0.40	10.0	0.33
ZB4PD-6.4	5400-6800	25	18	25	18	25	18	0.6	1.2	0.6	1.2	0.6	1.2	9	9	9	0.90	0.90	0.90	10.0	0.125
ZB4PD1-8.4	6700-8400	29	18	29	18	29	18	0.5	1.3	0.5	1.3	0.5	1.3	9	9	9	0.90	0.90	0.90	10.0	0.125

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

ZB4PD / ZB4PD 1Case UU188 | ZB4PD Case Z54 ZB4PD1 Case UUU188 | ZN4PD Case UU182 | ZN4PD1 Case UU846 | ZFSC-5 Case G1170 | ZBSC-5 Case UU102

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS, (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBAL., degrees L Max.	M Max.	U Max.	AMPLITUDE UNBAL. (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
4 WAY - 0° 75 Ω								*Insertion Loss Above 6 dB*													
ZFSC-4375	50-90	34	30	34	30	34	30	0.3	0.8	0.3	0.8	0.3	0.8	4	4	4		0.15		1.0	0.08
ZSC-4-1-75	1-200	30	20	25	20	25	20	0.4	0.7	0.5	0.8	0.7	1.2	4	6	10	0.15	0.20	0.30	1.0	0.08
ZSC-4-3-75	0.25-250	28	20	30	20	27	20	0.4	0.8	0.3	0.7	0.5	1.0	1	2	3	0.15	0.20	0.25	1.0	0.08
ZB4PD1-500-75	5-500	34	20	34	20	30	20	0.45	1.0	0.6	0.9	1.0	1.5	1	3	6	—	0.20	—	1.0	0.08
ZFSC-4-175W	5-1000	34	22	36	22	27	20	0.5	0.8	0.5	1.2	0.9	1.9	1	3	5	0.20	0.20	0.50	1.0	0.17
ZFSC-4-175	10-1000	35	25	38	20	22	18	0.5	0.8	0.6	1.2	0.9	2.0	—	—	—	0.20	0.30	0.60	1.0	0.08
ZB4PD-1750-75	875-1750	30	20	30	20	30	20	0.4	0.8	0.4	0.8	0.4	0.8		3		—	0.40	—	10.0	0.25
5 WAY - 0° 50 Ω								*Insertion Loss Above 7 dB*													
ZFSC-5-1	1-300	25	20	23	18	20	17	0.2	0.5	0.6	1.0	1.5	2.0	2	4	8	0.20	0.30	0.60	1.0	0.125
ZBSC-5-1	120-520	25	18	25	18	25	18	1.0	2.0	1.0	2.0	1.0	2.0	8	8	8	—	0.90	—	1.0	0.156

ZBSC-6 Case UU102 | ZB6PD-17 Case UU586 | ZFSC-6 Case Q28 | ZB6PD1 Case UU187 | ZC6PD Case AB185 | ZB6PD-1700 Case AB1232 | ZB6PD-2 Case Z59

6 WAY - 0° 50 Ω								*Insertion Loss Above 7.8 dB*													
ZFSC-6-1	1-175	27	22	26	20	26	20	0.75	1.0	0.75	1.2	0.8	1.2	2	6	12	0.20	0.40	0.60	1.0	0.10
ZBSC-611	10-200	28	22	26	20	23	20	0.5	0.8	0.7	1.0	0.9	1.2	4	5	6	0.20	0.30	0.50	1.0	0.10
ZBSC-615	1-500	30	25	26	18	24	18	0.5	0.8	0.7	1.2	1.0	2.2	4	8	20	0.20	0.40	1.20	1.0	0.10
ZFSC-6-110	1-500	35	25	26	20	25	20	0.5	0.8	0.6	1.1	1.0	1.7	2	6	12	0.30	0.30	0.80	1.0	0.10
ZB6PD1-900	800-900	32	20	32	20	32	20	0.3	0.7	0.3	0.7	0.3	0.7	—	—	—	0.50	0.50	0.50	10.0	0.10
ZB6PD1-960	890-960	35	20	35	20	35	20	0.3	0.8	0.3	0.8	0.3	0.8	—	—	—	0.60	0.60	0.60	10.0	0.10
ZC6PD-960	890-960	30	20	30	20	30	20	0.4	0.8	0.4	0.8	0.4	0.8	—	—	—	0.40	0.40	0.40	10.0	0.175
ZC6PD-960W	700-1000	28	15	28	15	28	15	0.4	1.0	0.4	1.0	0.4	1.0	—	—	—	0.60	0.60	0.60	10.0	0.175
ZB6PD-17	600-1700	25	18	25	18	25	18	0.35	0.9	0.35	0.9	0.35	0.9		7		0.50	0.50	0.50	10.0	0.175
ZB6PD-1700	1500-1700	30	20	30	20	30	20	0.5	1.0	0.5	1.0	0.5	1.0	—	—	—	0.60	0.60	0.60	10.0	0.150
ZB6PD1-1900	1700-1900	32	20	32	20	32	20	0.4	0.8	0.4	0.8	0.4	0.8	—	—	—	0.60	0.60	0.60	10.0	0.10
ZC6PD-1900	1700-1900	30	20	30	20	30	20	0.4	0.8	0.4	0.8	0.4	0.8	—	—	—	0.50	0.50	0.50	10.0	0.175
ZB6PD-2	800-2000	27	17	27	17	27	17	0.7	1.7	0.7	1.7	0.7	1.7	—	—	—	0.70	0.70	0.70	10.0	0.175
ZC6PD-1900W	1500-2000	30	15	30	15	30	15	0.5	1.0	0.5	1.0	0.5	1.0	—	—	—	0.60	0.60	0.60	10.0	0.175
6 WAY - 0° 75 Ω								*Insertion Loss Above 7.8 dB*													
ZFSC-6-1-75	1-200	30	25	30	22	20	18	0.75	1.0	0.75	1.0	0.9	1.2	2	6	12	0.20	0.40	0.60	1.0	0.10

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

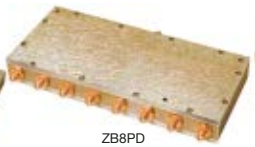
POWER SPLITTERS/COMBINERS

10 kHz to 8400 MHz


ZCSC-8
Case UU215


ZFSC-8
Case R29


ZC8PD
Case AB186


ZB8PD
Case Z41


ZC8PD1
Case DE749

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS, (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBAL., degrees L Max.	M Max.	U Max.	AMPLITUDE UNBAL. (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
8 WAY - 0° 50 Ω								*Insertion Loss Above 9 dB*													
ZFSC-8-1	0.5-175	30	25	30	20	25	18	0.8	1.2	0.8	1.2	1.0	1.6	1.0	2.5	5.0	0.2	0.2	0.3	1.0	0.089
ZCSC-8-1	2-250	37	27	30	20	24	18	0.65	1.2	0.8	1.2	1.0	1.6	2.0	4.0	8.0	0.2	0.3	0.5	1.0	0.089
ZFSC-8-4	5-700	35	20	25	17	20	17	0.8	1.2	1.2	1.8	1.8	2.5	2.0	5.0	15.0	0.2	0.4	0.7	1.0	0.089
ZC8PD-900	800-900	30	20	30	20	30	20	0.4	0.7	0.4	0.7	0.4	0.7	5.0	5.0	5.0	0.4	0.4	0.4	10.0	0.125
ZB8PD-1	800-960	30	20	30	20	30	20	0.4	0.9	0.4	0.9	0.4	0.9	8.0	8.0	8.0	0.4	0.4	0.4	10.0	0.125
ZFSC-8-43	10-1000	23	20	25	20	26	20	1.0	1.6	1.4	2.1	2.1	2.9	5.0	10.0	20.0	0.4	0.4	0.7	1.0	0.089
ZC8PD1-10	300-1000	27	17	27	17	27	17	0.6	1.4	0.6	1.4	0.6	1.4	8.0	8.0	8.0	0.7	0.7	0.7	10.0	0.286
ZB8PD-2000	800-2000	26	18	26	18	26	18	0.8	1.7	0.8	1.7	0.8	1.7	—	—	—	0.7	0.7	0.7	10.0	0.125
ZB8PD-2	1000-2000	24	17	24	17	24	17	0.8	1.3	0.8	1.3	0.8	1.3	18.0	18.0	18.0	0.8	0.8	0.8	10.0	0.125
ZB8PD-4	2000-4200	23	16	23	16	23	16	0.8	1.8	0.8	1.8	0.8	1.8	10.0	10.0	10.0	1.2	1.2	1.2	10.0	0.125
ZB8PD-6.4	5600-6800	26	18	26	18	26	18	0.8	1.7	0.8	1.7	0.8	1.7	15.0	15.0	15.0	0.7	0.7	0.7	10.0	0.125
ZB8PD-8.4	7200-8400	25	20	25	20	25	20	0.9	1.6	0.9	1.6	0.9	1.6	15.0	15.0	15.0	0.8	0.8	0.8	10.0	0.125
8 WAY - 0° 75 Ω																					
ZFSC-8375	50-90	30	25	30	25	30	25	1.0	1.3	1.0	1.3	1.0	1.3	2.0	2.0	2.0	0.2	0.2	0.2	1.0	0.089
ZFSC-8-1-75	0.5-175	25	20	30	20	25	20	0.5	1.0	0.6	1.1	0.7	1.3	1.0	2.5	5.0	0.2	0.3	0.5	1.0	0.089
ZFSC-84-75	1-300	26	20	30	25	30	23	0.8	1.5	0.7	1.1	0.9	1.5	4.0	3.0	8.0	0.2	0.2	0.4	1.0	0.089
ZFSC-8-4-75	5-1000	35	20	25	16	20	15	0.4	1.0	0.6	1.6	1.6	2.7	2.0	7.0	13.0	0.3	0.5	1.2	1.0	0.089
ZB8PD-22-75	950-2200	24	16	24	16	24	16	0.7	1.6	0.7	1.6	0.7	1.6	—	—	—	0.7	0.7	0.7	10.0	0.125

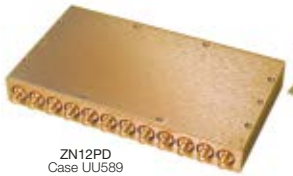

ZC9PD
Case AB204


ZC10PD
Case AB204


ZFSC-10
Case RR93

9 WAY - 0° 50 Ω								*Insertion Loss Above 9.6 dB*													
ZC9PD-1000	800-1000	30	20	30	20	30	20	0.6	1.2	0.6	1.2	0.6	1.2	—	—	—	0.6	0.6	0.6	10.0	0.080
10 WAY - 0° 50 Ω								*Insertion Loss Above 10 dB*													
ZFSC-10-1	0.5-100	28	20	30	24	27	20	0.5	0.8	0.4	1.0	0.8	1.5	3	6	10	0.2	0.3	0.4	1.0	0.10
ZC10PD-900W	750-900	30	20	30	20	30	20	0.4	1.0	0.4	1.0	0.4	1.0	—	—	—	0.6	0.6	0.6	10.0	0.167
ZC10PD-900	800-900	25	20	25	20	25	20	1.5	2.0	1.5	2.0	1.5	2.0	—	—	—	0.8	0.8	0.8	10.0	0.167
ZC10PD-26	2300-2600	35	20	35	20	35	20	0.7	1.9	0.7	1.9	0.7	1.9	15	15	15	1.1	1.1	1.1	10.0	0.089

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)



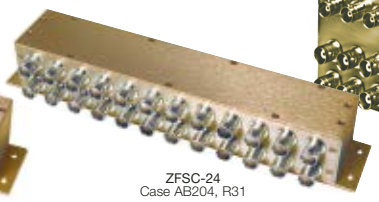
ZN12PD
Case UU589

ZFSC-12
Case R67

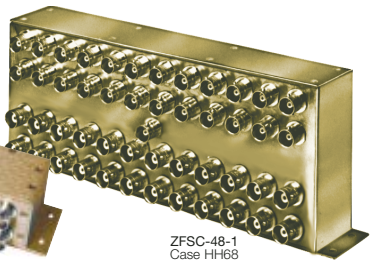
MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS, (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBAL., degrees L Max.	M Max.	U Max.	AMPLITUDE UNBAL. (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
12 WAY - 0° 50 Ω								*Insertion Loss Above 10.8 dB*													
ZFSC-12-1	1-200	30	25	35	20	28	20	0.8	1.2	1.1	1.4	1.3	1.6	4	8	16	0.3	0.2	0.3	1.0	0.08
ZFSC-12-11	10-300	28	20	33	25	28	20	1.1	1.3	1.1	1.5	1.5	1.8	2	4	6	0.2	0.3	0.4	1.0	0.08
ZN12PD-17	800-1700	30	18	30	18	28	20	0.45	1.2	0.45	1.2	0.45	1.2	14	14	14	0.7	0.7	0.7	5.0	0.182
12 WAY - 0° 75 Ω																					
ZFSC-12-1-75	10-200	35	27	—	—	27	20	0.5	0.8	—	—	0.8	1.3	—	—	—	0.25	—	0.4	1.0	0.08
ZFSC-12-175	10-500	23	20	24	20	22	18	0.9	1.2	1.0	1.3	1.2	2.0	—	—	—	0.4	0.5	0.8	1.0	0.08
ZFSC-12-1W-75	5-860	33	22	30	20	26	18	0.5	1.2	0.8	2.5	1.6	4.2	2	8	20	0.7	0.8	1.5	1.0	0.08

ZC16PD
Case UU179, UU640

ZFSC-16
Case R30



ZFSC-24
Case AB204, R31



ZFSC-48-1
Case HH68

16 WAY - 0° 50 Ω								*Insertion Loss Above 12 dB*													
ZFSC-16-3	1-30	45	28	45	28	45	28	0.5	0.9	0.5	0.9	0.5	0.9	1	2	3		0.1		1.0	0.0
ZFSC-16-1	0.5-125	30	24	25	18	20	15	1.0	1.2	1.1	1.3	1.2	1.4	1	3	5	0.3	0.2	0.5	1.0	0.0
ZFSC-16-12	0.1-200	33	20	27	20	26	20	0.6	1.5	0.7	1.0	0.9	1.5	2	6	9	0.4	0.2	0.4	1.0	0.0
ZC16PD-900	800-900	30	20	30	20	30	20	0.5	1.0	0.5	1.0	0.5	1.0				0.5	0.5	0.5	10.0	0.16
ZC16PD-960	890-960	28	20	28	20	28	20	0.5	1.0	0.5	1.0	0.5	1.0	—	—	—	0.5	0.5	0.5	10.0	0.16
ZC16PD-960W	700-1000	26	15	26	15	26	15	0.5	1.3	0.5	1.3	0.5	1.3	—	—	—	0.6	0.6	0.6	10.0	0.16
ZC16PD-1900	1700-1900	30	20	30	20	30	20	0.5	1.0	0.5	1.0	0.5	1.0	—	—	—	0.8	0.8	0.8	10.0	0.16
ZC16PD-1900W	1500-2100	30	15	30	15	30	15	0.7	1.4	0.7	1.4	0.7	1.4	—	—	—	0.8	0.8	0.8	10.0	0.16
ZC16PD-23	1500-2300	32	20	32	20	32	20	0.8	1.4	0.8	1.4	0.8	1.4	11	11	11	0.6	0.6	0.6	10.0	0.13
ZC16PD-24	650-2400	25	14	25	14	25	14	0.8	2.25	0.8	2.25	0.8	2.25	14	14	14	0.9	0.9	0.9	10.0	0.16
ZC16PD-2185	1800-2600	30	16	30	16	30	16	0.5	1.4	0.5	1.4	0.5	1.4	6	6	6	0.7	0.7	0.7	10.0	0.117
16 WAY - 0° 75 Ω																					
ZFSC-16-675	0.01-25	25	20	40	25	25	20	0.8	1.1	0.4	0.8	1.0	1.6	4	3	5	0.4	0.2	0.4	1.0	0.06
ZFSC-16-1-75	1-150	30	25	30	25	25	20	0.8	1.1	0.7	1.1	1.0	1.3	3	6	10	0.4	0.2	0.4	1.0	0.06
24 WAY - 0° 50 Ω								*Insertion Loss Above 13.8 dB*													
ZFSC-24-1	0.2-100			25	20					1.0	2.0			—	—	—	0.6	0.4	0.5	1.0	0.037
ZFSC-24-11	1-200	33	25	22	20	20	17	0.9	1.7	1.0	1.8	1.3	2.2	—	—	—	0.6	0.8	0.8	1.0	0.037
24 WAY - 0° 75 Ω																					
ZFSC-24-11-75	1-200	35	25	33	20	27	20	0.6	1.3	0.8	1.5	1.1	2.0	—	—	—	0.6	0.4	0.6	1.0	0.037
48 WAY - 0° 50 Ω								*Insertion Loss Above 16.8 dB*													
ZFSC-48-1	10-3300	30	25	28	20	23	20	1.2	2.0	2.1	2.5	2.8	4.0	—	—	—	0.8	0.9	1.2	1.0	0.018

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

POWER SPLITTERS/COMBINERS *High Power 50 Ω*

2 MHz to 2100 MHz up to 50 Watts

2 WAY

ZAPD-2-21-3W Case F53 | ZA2CS Case AW254

3 WAY

ZA3CS-400-3W Case CC51 | ZA3CS Case AX255 | ZB3CS-920-15W Case AW256 | ZB3CS-900-6W Case Z667

4 WAY

ZB4CS-700-10W ZB4CS-870-10W Case Z689 | ZB4CS-700-10W Case Z689

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ISOLATION (dB) Typ.	ISOLATION (dB) Min.	INSERTION LOSS (dB) Typ.	INSERTION LOSS (dB) Max.	PHASE UNBALANCE Degrees Typ.	PHASE UNBALANCE Degrees Max.	AMPLITUDE UNBALANCE (dB) Typ.	AMPLITUDE UNBALANCE (dB) Max.	INPUT RF Power Max (W) Output ports (Matched S port)	INPUT RF Power Max (W) S-Port (Matched output ports)
2 WAY				*Insertion Loss Above 3.0 dB*							
ZA2CS-500-15W	200-500	31	20	0.3	1.0	0.3	3.0	0.10	0.4	7.5	15
ZA2CS-600-10W	100-600	27	15	0.4	1.3	0.4	3.0	0.15	0.5	5.0	10
ZA2CS-10-20W	900-1000	38	20	0.2	0.5	0.5	3.0	0.11	0.3	10.0	20
ZA2CS-2G-20W	1800-2000	30	20	0.2	0.5	0.5	4.0	0.05	0.2	10.0	20
ZAPD-2-21-3W	700-2100	25	20	0.4	1.2	0.7	3.0	0.05	0.3	1.25	10
3 WAY				*Insertion Loss Above 4.8 dB*							
ZA3CS-400-3W	2-400	25	17	0.5	1.2	0.2	3.0	0.15	0.5	1.0	10
ZA3CS-450-9W	100-450	22	15	0.9	1.8	2.5	8.0	0.20	0.7	3.0	12
ZB3CS-900-6W	440-900	24	17	0.2	1.0	3.0	6.0	0.10	0.4	2.0	20
ZB3CS-920-15W	825-920	27	17	0.2	0.8	1.7	6.0	0.11	0.5	5.0	15
4 WAY				*Insertion Loss Above 6.0 dB*							
ZB4CS-440-12W	100-440	27	17	0.6	1.2	0.8	4.0	0.15	0.5	3.0	10
ZB4CS-700-10W	400-700	25	20	0.35	0.8	0.6	4.0	0.10	0.3	2.5	20
ZB4CS-870-10W	570-870	28	20	0.35	0.8	0.6	3.0	0.10	0.3	2.5	20
ZB4CS-960-12W	820-960	28	17	0.3	0.8	2.0	6.0	0.20	0.6	3.0	12

5 WAY

ZB5PD Case BV278

ZB5CS-920-10W Case Z668

6 WAY

ZB6CS-150-12W Case Z259

8 WAY

ZB8CS Case AW257

5 WAY				*Insertion Loss Above 7.0 dB*							
ZB5PD-894-50W	800-894	32	20	0.4	0.8	—	—	0.15	0.45	10	50
ZB5CS-920-10W	450-920	26	18	0.4	1.0	2.0	7.0	0.10	0.6	2	20
6 WAY				*Insertion Loss Above 7.8 dB*							
ZB6CS-150-12W	50-150	32	20	0.5	1.2	3.0	9.0	0.15	0.5	2	10
8 WAY				*Insertion Loss Above 9.0 dB*							
ZB8CS-950-32W	800-950	30	18	0.4	1.0	2.0	6.0	0.10	0.5	4	32

SWITCHES, MECHANICAL 50 Ω

DC to 18000 MHz up to 10,000,000 cycles

Mini-Circuits® 2007

MSP2T-18
Case FK811

MSP2TA-18
Case FP914

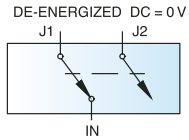
MTS-18B
Case DS810

MODEL PREFIX	FREQUENCY (MHz)	INSERTION LOSS (dB)		ISOLATION (dB)		VSWR (:1)		DC CURRENT @+24 V (mA)		RF POWER (W)
	f_L-f_U	Typ.	Max.	Typ.	Min.	Typ.	Max.	Typ.	Max.	Max.
SPDT *DC to 18000 MHz*										
MSP2T-18 *(reflective)*	DC-1000	0.10	0.15	100	85	1.05	1.10	80	115	10
	1000-8000	0.20	0.30	90	75	1.20	1.35			
	8000-12000	0.25	0.35	80	70	1.20	1.35			
	12000-18000	0.30	0.45	66	60	1.15	1.40			
MSP2TA-18 *(absorptive)*	DC-1000	0.10	0.15	100	85	1.05	1.10	175	215	10
	1000-8000	0.15	0.30	90	70	1.20	1.30			
	8000-12000	0.25	0.40	80	70	1.20	1.35			
	12000-18000	0.30	0.50	66	60	1.25	1.40			
TRANSFER *DC to 18000 MHz*										
MTS-18B	DC-1000	0.10	0.15	100	85	1.05	1.10	175	215	10
	1000-8000	0.10	0.25	90	75	1.15	1.20			
	8000-12000	0.20	0.36	86	70	1.15	1.25			
	12000-18000	0.25	0.45	76	60	1.15	1.30			

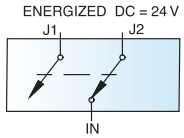
SWITCHING STATES

MSP2T-18

DE-ENERGIZED DC = 0 V

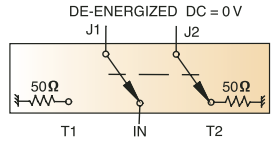


ENERGIZED DC = 24 V

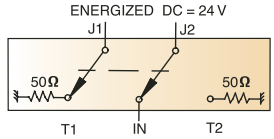


MSP2TA-18

DE-ENERGIZED DC = 0 V

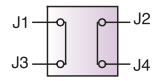


ENERGIZED DC = 24 V

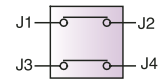


MTS-18B

DE-ENERGIZED DC = 0 V



ENERGIZED DC = 24 V



SWITCHES, PIN DIODE 50 Ω

DC to 5000 MHz

ZMSW
Case JJ77

ZSDR-230
Case CCC127

ZSDR-425
Case GGG126

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	TYPE	TTL DRIVER	INSERTION LOSS (dB) Low-band l w Typ.	Low-band l w Max.	Upper band U Typ.	Upper band U Max.	IN-OUT ISOLATION (dB) Frequency Band L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	RISE TIME (µsec) Typ.	SWITCHING TIME (µsec) Typ.	SWITCHING TIME (µsec) Max.	CONTROL LOGIC	SUPPLY VOLTAGE (V)
SPDT/SP4T *With TTL Drivers*																		
ZSDR-230	10-3000	SPDT	•	1.3	1.9	1.8	2.7	60	40	40	28	35	22	—	2.0	4.0	G	+5
ZSDR-425	10-2500	SP4T	•	1.1	1.7	1.5	2.5	60	40	40	30	35	22	—	2.0	4.0	H	+5
SPST/SPDT *Without TTL Drivers*																		
ZMSW-1111	10-2500	SPST		1.1	1.9	1.9	2.7	50	45	35	28	28	22	2	—	4.0	I	—
ZMSW-1211	10-2500	SPDT		1.1	1.9	1.9	2.7	50	45	35	28	28	22	2	—	4.0	J	—

L = low range (f_L to $10f_L$) l w = low band (f_L to $f_U/2$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

CONTROL LOGIC

G

SPDT Switch: ZSDR-230

TTL	RF Out port 1	RF Out port 2
Low	ON	OFF
High	OFF	ON

Low: 0 to 0.8 V
High: 2 to 5 V

H

SP4T Switch: ZSDR-425

TTL-1	TTL-2	RF Out port 1	2	3	4
High	Low	ON	OFF	OFF	OFF
High	High	OFF	ON	OFF	OFF
Low	High	OFF	OFF	ON	OFF
Low	Low	OFF	OFF	OFF	ON

Low: 0 to 0.8 V
High: 2 to 5 V

I

SPST Switch: ZMSW-1111

Control Ports 1	2	RF Out port 2
0	V	ON
V	0	OFF

V = 5 V

J

SPDT Switch ZMSW-1211

Control Ports 1	2	RF Out port 1	2
0	V	OFF	ON
V	0	ON	OFF

V = 5 V

ZFAS
Case K18

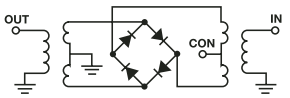
ZMAS
Case M21

ZAS
Case M22

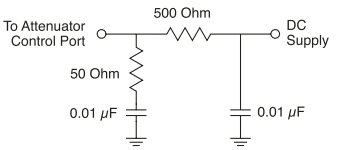
MODEL PREFIX	FREQUENCY (MHz) IN f_L	CON f_U	INSERTION LOSS, dB (±20 mA) Mid-Band m Typ.	Mid-Band m Max.	Total Range Typ.	Total Range Max.	MAX. INPUT PWR (dBm) (±20 mA) 1 dB compr.	no damage	IN-OUT ISOLATION, dB (0 mA) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	BI-PHASE X̄ (±20 mA) Typ. Δ AMP, dB m	Total Range	Phase (deg) deviation from 180° m	Total Range
BI-PHASE																		
ZAS-3	1-200	DC-0.05	1.4	2.0	1.6	2.5	15	30	65	50	50	40	50	35	0.10	0.1	0.5	1.0
ZMAS-3	1-200	DC-0.05	1.4	2.0	1.6	2.5	15	30	65	50	50	40	50	35	0.10	0.1	0.5	1.0
ZAS-1	5-450	DC-0.05	3.5	4.0	3.5	4.7	20	30	65	50	55	40	35	25	0.10	0.1	0.5	1.2
ZMAS-1	5-450	DC-0.05	3.5	4.0	3.5	4.7	20	30	65	50	55	40	35	25	0.10	0.1	0.5	1.2
ZFAS-2000	100-2000	DC-0.5	4.2	6.5	5.4	7.5	19	25	30	22	—	—	26	20	0.30	0.4	5.0	8.0

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) m = mid band ($2f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

ELECTRICAL SCHEMATIC



SUGGESTED CONTROL PORT BIASING CONFIGURATION



ZYSW, ZYSWA
Case ZZ121

ZFSW, ZFSWA
Case G144

ZSWA
Case CV665

ZFSWHA
Case J17

ZASW, ZASWA
Case CY353

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	TTL DRIVER	ABSORPTIVE	REFLECTIVE	INSERTION LOSS (dB) Typ.	INSERTION LOSS (dB) Max.	1 dB COMPR. (dBm) Typ.	1 dB COMPR. (dBm) Min.	IN-OUT ISOLATION (dB) Typ.	IN-OUT ISOLATION (dB) Min.	RISE/FALL TIME (10% TO 90%), ns Typ.	RISE/FALL TIME (10% TO 90%), ns Max.	SWITCHING TIME 50% OF CONTROL TO: 90% RF (Turn-on), ns Typ.	90% RF (Turn-on), ns Max.	10% RF (Turn-off), ns Typ.	10% RF (Turn-off), ns Max.	CONTROL LOGIC
SPDT *With/Without TTL Drivers*																	
ZFSW-2-46	DC-4600			•	1.0	2.8	17	—	50	28	2	—	—	—	—	—	K
ZFSWA-2-46	DC-4600		•		0.9	2.6	17	—	50	25	2	—	—	—	—	—	K
ZYSW-2-50DR	DC-5000	•		•	1.3	2.4	23	15	38	22	6	12	20	40	20	40	M
ZYSWA-2-50DR	DC-5000	•	•		1.4	2.1	20	13	31	19	6	12	20	40	20	40	M
SP4T *With TTL Drivers*																	
ZSWA-4-30DR	DC-3000	•	•		1.5	3.9	25	—	37	26	25	—	45	—	45	—	N
SPST *High Isolation Without TTL Drivers*																	
ZFSWHA-1-20	DC-2000		•		1.3	1.7	19	—	65	58	3	5	7	10	3	10	L
SPDT *High Isolation With TTL Drivers*																	
ZASW-2-50DR	DC-5000	•		•	1.8	4.5	20	—	82	46	5	15	10	20	10	20	M
ZASWA-2-50DR	DC-5000	•	•		1.8	4.5	20	—	82	46	5	15	10	20	10	20	M

CONTROL LOGIC

K

SPDT Switches: ZFSW, ZFSWA

Control Ports 1	Control Ports 2	RF outputs 1	RF outputs 2
-V	0	ON	OFF
0	-V	OFF	ON

V = 5 to 8 V

L

SPST Switch: ZFSWHA

Control Ports 1	Control Ports 2	RF outputs
-V	0	ON
0	-V	OFF

V = 5 to 8 V

M

SPDT Switch with Drivers: ZYSW, ZYSWA, ZASW, ZASWA

Control Port	RF outputs 1	RF outputs 2
Low	ON	OFF
High	OFF	ON

Low: 0 to 0.8 V
High: 2 to 5 V

N

SP4T Switch: ZSWA-4-30DR

Control Ports 1	Control Ports 2	Control Ports 3	Control Ports 4	RF outputs 1	RF outputs 2	RF outputs 3	RF outputs 4
Low	High	High	High	ON	OFF	OFF	OFF
High	Low	High	High	OFF	ON	OFF	OFF
High	High	Low	High	OFF	OFF	ON	OFF
High	High	High	Low	OFF	OFF	OFF	ON

Low: 0 to 0.8 V
High: 2 to 5 V

TERMINATIONS

DC to 20000 MHz


ROSE
Case LL604


LOUIS
Case LL987


ANNE
Case LL561


ANNE-50CN Case LL561


BTRM
Case LL85

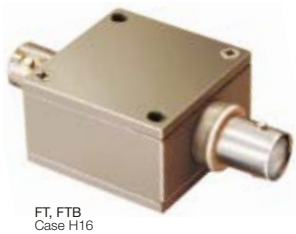

KARN
Case LL718


KARN-50CN
Case LL718

MODEL PREFIX	FREQUENCY RANGE (MHz)	RETURN LOSS, dB (MHz) Min.								POWER RATING (W)	CONNECTOR
		DC-1000	DC-2000	DC-4000	DC-6000	DC-8000	DC-12000	DC-18000	DC-20000		
50 Ω											
BTRM-50	DC-2000	30	21	—	—	—	—	—	—	0.5	Male-BNC
LOUIS-50	DC-2000	28	21	—	—	—	—	—	—	0.125	DIN Male w/retaining sleeve
KARN-50	DC-8000	30	29	27	—	20	—	—	—	2.0	Male-TYPE N
KARN-50CN	DC-8000	30	29	27	—	20	—	—	—	2.0	Male-TYPE N
KARN-50-18	DC-18000	35	30	30	—	26	20	18	—	2.0	Male-TYPE N
ROSE-50	DC-6000	33	30	23	20	—	—	—	—	0.5	SMB-PLUG
ANNE-50	DC-18000	30	30	30	28	28	26	20	—	1.0	Male-SMA
ANNE-50CN	DC-18000	30	30	30	28	28	26	20	—	1.0	Male-SMA
ANNE-50L	DC-12000	26	26	26	21	21	18	—	—	1.0	Male-SMA
ANNE-50X	DC-20000	30	30	30	30	30	30	26	20	1.0	Male-SMA
75 Ω											
BTRM-75	DC-1000	20	—	—	—	—	—	—	—	0.5	Male-BNC, 75Ω

TRANSFORMERS, IF/RF MICROWAVE

10 kHz to 500 MHz

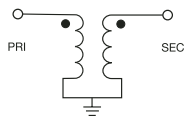


FT, FTB
Case H16

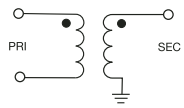
MODEL PREFIX	Ω RATIO (Secondary/Primary)	FREQUENCY (MHz)	INSERTION LOSS (dB) 3 dB (MHz)	2 dB (MHz)	1 dB (MHz)
D *Unbalanced to Unbalanced 50 Ω*					
FT-1.5-1	1.5	0.1-400	0.1-400	0.5-200	1-100
E *Balanced to Single-ended 50 Ω*					
FTB-1-1	1.0	0.2-500	0.2-500	0.5-300	1-100
FTB-1-6	1.0	0.01-125	0.01-125	0.05-50	0.1-25
E *Balanced to Single-ended 75 Ω*					
FTB-1-1-75	1.0	0.5-500	0.5-500	5-300	10-100

ELECTRICAL SCHEMATICS

D



E



VOLTAGE CONTROLLED OSCILLATORS 50 Ω

25 MHz to 5150 MHz

ZOS
Case BR386

ZX95
Case GB956

DUAL OUTPUT 25 MHz to 1025 MHz

MODEL PREFIX	FREQUENCY (MHz) Min.	FREQUENCY (MHz) Max.	POWER OUTPUT (dBm) Typ. Main.	POWER OUTPUT (dBm) Typ. Aux.	TUNE VOLTAGE (V) Min.	TUNE VOLTAGE (V) Max.	PHASE NOISE (dBc/Hz) SSB@ offset frequencies: Typ. 10 kHz	PHASE NOISE 100 kHz	PHASE NOISE 1 MHz	PULLING (MHz) pk-pk (open/short) Typ.	PUSHING (MHz/V) Typ.	TUNING SENSITIVITY (MHz/V) Typ.	HARMONICS (dBc) Typ.	HARMONICS (dBc) Max.	3 dB MOD. BANDWIDTH (MHz) Typ.	DC OPERATING POWER Vcc (Volts)	DC OPERATING POWER Current (mA) Max.
ZOS-50	25-50		+9	-12	1	16	-107	-126	-141	0.012	0.08	2.5	-22	-12	0.1	12	140
ZOS-75	37.5-75		+9	-12	1	16	-110	-128	-142	0.016	0.15	3.5	-26	-20	0.1	12	140
ZOS-100	50-100		+9	-12	1	16	-111	-131	-143	0.026	0.25	4.5	-29	-20	0.1	12	140
ZOS-150	75-150		+9	-12	1	16	-107	-127	-142	0.017	0.39	5.8	-23	-17	0.1	12	140
ZOS-200	100-200		+10	-11	1	16	-106	-126	-141	0.015	0.42	7.7	-25	-20	0.1	12	140
ZOS-300	150-280		+9	-13	1	16	-103	-123	-142	0.017	0.50	11	-27	-20	0.1	12	140
ZOS-400	200-380		+10	-13	1	16	-100	-120	-136	0.021	0.50	15	-24	-18	0.1	12	140
ZOS-535	300-525		+9	-13	1	16	-96	-118	-131	0.018	0.50	18	-27	-20	0.1	12	140
ZOS-765	485-765		+8.5	-14	1	16	-96	-117	-132	0.033	0.72	22	-27	-17	0.1	12	140
ZOS-1025	685-1025		+8	-13	1	16	-92	-112	-136	0.051	1.00	30	-25	-18	0.1	12	140

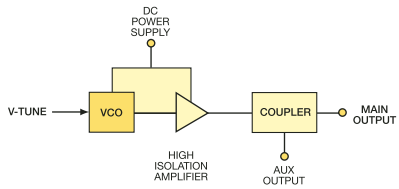
5 V TUNING for PLL IC's 410 MHz to 5150 MHz

MODEL PREFIX	FREQUENCY (MHz) Min.	FREQUENCY (MHz) Max.	POWER OUTPUT (dBm) Typ.	TUNING VOLTAGE RANGE (V) Min.	TUNING VOLTAGE RANGE (V) Max.	PHASE NOISE (dBc/Hz) SSB@ offset frequencies (kHz): Typ. 1	PHASE NOISE 10	PHASE NOISE 100	PHASE NOISE 1000	PULLING pk-pk @ 12 dBr (MHz) Typ.	PUSHING (MHz/V) Typ.	TUNING SENSITIVITY (MHz/V) Typ.	HARMONICS (dBc) Typ.	HARMONICS (dBc) Max.	3 dB MODULATION BANDWIDTH (MHz) Typ.	DC OPERATING POWER Vcc (Volts)	DC OPERATING POWER Current (mA) Max.
ZX95-445	410	445	+0.0	0.5	5	-91	-115	-135	-155	0.4	0.20	11-12	-20	-11	60	5.0	16
ZX95-470	435	470	-0.5	0.5	5	-89	-114	-135	-155	0.4	0.20	11-13	-21	-13	80	5.0	16
ZX95-485	450	485	-1.0	0.5	5	-91	-114	-134	-153	0.3	0.20	11	-21	-13	80	5.0	15
ZX95-505	470	505	+0.5	0.5	5	-89	-114	-135	-154	0.2	0.30	11-13	-21	-13	80	5.0	17
ZX95-520	485	520	-0.0	0.5	5	-90	-115	-135	-154	0.2	0.10	12	-22	-14	70	5.0	17
ZX95-530	500	530	-0.5	0.5	5	-90	-111	-132	-151	0.4	0.10	10-11	-23	-15	80	5.0	15
ZX95-550	515	550	-1.0	0.5	5	-90	-112	-132	-151	0.2	0.20	12-13	-23	-14	60	5.0	17
ZX95-570	535	570	-0.5	0.5	5	-90	-114	-135	-155	0.4	0.40	13	-18	-10	60	5.0	15
ZX95-585	550	585	-0.0	0.5	5	-90	-114	-135	-152	0.4	0.20	13	-19	-11	50	5.0	16
ZX95-590	555	590	-0.0	0.5	5	-87	-111	-132	-152	0.4	0.20	11-12	-18	-9	60	5.0	17
ZX95-595	560	595	-0.5	0.5	5	-89	-112	-132	-151	0.4	0.10	12-13	-19	-10	80	5.0	17
ZX95-615	580	615	-0.5	0.5	5	-90	-113	-133	-153	0.2	0.20	12-13	-21	-13	19	5.0	17
ZX95-630	595	630	0.0	0.5	5	-90	-113	-133	-153	0.4	0.10	11-12	-23	-15	80	5.0	18
ZX95-645	610	645	0.0	0.5	5	-88	-112	-132	-151	0.4	0.10	12-13	-24	-16	50	5.0	17
ZX95-665	630	665	0.0	0.5	5	-98	-113	-133	-153	0.4	0.10	12-13	-24	-16	60	5.0	18
ZX95-680	650	680	+0.5	0.5	5	-91	-114	-134	-154	0.3	0.20	11-12	-24	-16	50	5.0	18
ZX95-690	655	690	-1.0	0.5	5	-89	-111	-131	-151	0.4	0.40	12-13	-24	-16	50	5.0	17
ZX95-700	665	700	0.0	0.5	5	-89	-113	-133	-153	0.4	0.10	12-13	-21	-13	80	5.0	17
ZX95-715	680	715	-0.5	0.5	5	-90	-113	-133	-152	0.5	0.20	12-13	-22	-14	60	5.0	16
ZX95-730	695	730	0.0	0.5	5	-90	-114	-134	-153	0.5	0.20	11-12	-21	-13	90	5.0	18
ZX95-745	710	745	+1.0	0.5	5	-88	-113	-133	-153	0.8	0.30	12	-22	-14	60	5.0	17
ZX95-755	720	755	-0.5	0.5	5	-89	-113	-133	-147	0.4	0.10	12-13	-23	-15	80	5.0	17
ZX95-766	730	766	+0.5	0.5	5	-91	-113	-134	-154	0.5	0.10	12-13	-23	-15	80	5.0	18
ZX95-810	775	810	+0.5	0.5	5	-88	-112	-131	-151	0.9	0.80	12-13	-19	-12	60	5.0	18
ZX95-835	800	835	-0.5	0.5	5	-89	-110	-130	-150	1.0	0.50	12-13	-21	-13	60	5.0	15
ZX95-870	840	870	+1.0	0.5	5	-89	-111	-132	-151	1.1	1.00	11-12	-19	-12	90	5.0	17
ZX95-928C	902	928	+10.0	0.5	5	-89	-117	-138	-157	1.0	0.2	18.0	-22	-15	130	12.0	32
ZX95-1000C	1000	1000	+1.0	0.5	5	-96	-126	-146	-162	0.1	0.04	5.0	-22	-14	150	6.0	35
ZX95-2660	2620	2660	+2.5	0.5	5	-83	-108	-129	-148	0.4	0.3	17-20	-19	-10	200	5.0	45
ZX95-2930	2840	2930	+7.0	0.5	5	-69	-96	-117	-138	1.3	2.70	85	-29	-20	450	5.0	40
ZX95-3000	2800	3000	+10.0	0.5	5	-74	-102	-123	-144	4.0	0.10	59-65	-25	-15	280	5.0	36
ZX95-3080	2920	3080	+3.0	0.5	5	-71	-95	-116	-136	2.0	3.00	90	-22	-11	4	5.0	37
ZX95-3146	3000	3110	+9.0	0.5	5	-73	-102	-123	-144	4.5	2.50	56-64	-25	-15	200	5.0	43
ZX95-3214C	3074	3200	+2.0	0.5	4.5	-77	-102	-123	-143	2.5	0.30	45-57	-21	-15	20	5.0	40
ZX95-3220	3050	3220	+2.5	0.5	5	-71	-96	-117	-137	1.0	2.50	74	-20	-10	340	5.0	37
ZX95-3270	3150	3270	+2.5	0.5	5	-71	-96	-116	-137	2.5	4.50	82	-20	-12	340	5.0	33
ZX95-3550	3350	3550	+3.5	0.5	5	-71	-97	-118	-139	1.5	0.70	77-82	-23	-13	720	5.0	42
ZX95-3610	3500	3610	+3.5	0.5	5	-73	-97	-118	-138	1.5	2.50	80	-19	-10	320	5.0	37
ZX95-3800	3630	3800	+5.0	0.5	5	-72	-97	-119	-139	1.5	2.00	73-78	-31	-22	500	5.0	40
ZX95-3970	3790	3970	+3.5	0.5	5	-71	-96	-117	-137	1.5	4.00	77-85	-23	-16	30	5.0	31
ZX95-4300	4150	4300	+4.5	0.5	5	-65	-91	-112	-132	9.5	2.00	68-77	-26	-18	330	5.0	34
ZX95-5150	4880	5150	+3.5	0.5	5	-69	-95	-116	-136	1.0	2.00	74-90	-30	-20	500	5.0	53

LINEAR TUNING WIDEBAND 50 MHz to 4720 MHz

MODEL PREFIX	FREQUENCY (MHz)		POWER OUTPUT (dBm)	TUNING VOLTAGE RANGE (V)		PHASE NOISE (dBc/Hz) SSB@ offset frequencies (kHz): Typ.				PULLING pk-pk @ 12 dBr (MHz)	PUSHING (MHz/V)	TUNING SENSITIVITY (MHz/V)	HARMONICS (dBc)		3 dB MODULATION BANDWIDTH (MHz)	DC OPERATING POWER	
	Min.	Max.	Typ.	Min.	Max.	1	10	100	1000	Typ.	Typ.	Typ.	Typ.	Max.	Typ.	Vcc (Volts)	Current (mA) Max.
ZX95-100	50	100	+10.0	0.5	17.0	-86	-110	-131	-151	0.4	0.1	3.5-4.5	-33.0	-24.0	0.18	12.0	20
ZX95-200	100	200	+10.0	1.0	17.0	-86	-106	-128	-148	0.5	0.2	7.0-10.0	-30.0	-20.0	0.12	12.0	20
ZX95-400	200	380	+10.0	0.5	17.0	-83	-104	-125	-145	0.5	0.2	10.0-18.0	-25.0	-18.0	0.13	12.0	21
ZX95-535	300	520	+6.0	1.0	17.0	-79	-101	-120	-140	0.5	0.2	12.0-23.0	-25.0	-15.0	0.18	12.0	21
ZX95-765	485	765	+8.0	1.0	16.0	-77	-98	-118	-138	1.0	0.5	28.0-33.0	-35.0	-24.0	0.60	12.0	22
ZX95-1200W	612	1200	+10.0	0.5	18.0	-71	-96	-117	-139	11.0	0.9	35.0-50.0	-16.0	—	40.0	12.0	30
ZX95-1410	850	1410	+8.0	0.5	11.0	-74	-101	-123	-143	10.0	0.5	57.0-95.0	-17.0	-10.0	100.0	12.0	30
ZX95-1600W	800	1600	+9.0	0.5	24.0	-72	-99	-122	-143	10.0	0.3	35.0-58.0	-22.0	-15.0	90.0	11.5	35
ZX95-1700W	770	1700	+9.0	1.0	24.0	-74	-100	-121	-143	7.0	0.5	30.0-60.0	-25.0	-14.0	20.0	12.0	35
ZX95-1900V	1450	1900	+8.0	0.5	20.0	-79	-104	-125	-145	10.0	1.0	25.0-41.0	-20.0	-10.0	70.0	5.0	25
ZX95-2150VW	970	2150	+4.0	0.5	25.0	-74	-99	-120	-140	4.0	1.5	32.0-78.0	-22.0	—	15.0	5.0	26
ZX95-2500	1600	2500	+7.5	0.5	14.0	-64	-91	-112	-132	20.0	2.0	72.0-107.0	-17.0	—	4.0	12.0	28
ZX95-2650	2165	2650	+5.0	0.5	19.0	-75	-101	-117	-142	3.0	1.0	29.0-40.0	-12.0	—	200.0	12.0	25
ZX95-2700	2500	2700	+6	0.5	8.0	-74	-98	-119	-139	2.0	4.5	40-45	-18	-10	30	5.0	36
ZX95-2705	1950	2705	+8.5	0.5	10	-64	-90	-112	-132	14.0	4.0	91-156	-27	-12	340	8.5	29
ZX95-2740	2700	2740	+3.5	0.5	5.5	-83	-106	-127	-146	0.7	2.0	17	-19	-12	150	5.0	36
ZX95-2745	2000	2745	+3.5	1	24	-71	-96	-117	-137	4.0	3.0	25-56	-25	-10	45	5.0	26
ZX95-2750	2350	2750	+5.5	0.5	14.5	-78	-105	-126	-146	2.0	0.3	32-42	-22	-12	120	6.0	35
ZX95-2755	2300	2755	+8.0	0.5	13.0	-74	-100	-120	-140	9.0	1.5	40-55	-17	-10	600	5.0	30
ZX95-2760	2660	2760	+5.5	0.5	12.0	-83	-107	-127	-147	1.0	1.5	16-19	-27	-20	200	8.0	41
ZX95-2770	1970	2770	+6.0	1.0	28.0	-74	-101	-122	-143	4.5	1.5	24-56	-27	-15	250	10.0	32
ZX95-2795	2600	2795	+5.0	0.5	10.0	-76	-99	-120	-140	1.5	4.0	35-39	-32	-22	250	5.0	42
ZX95-2800	1400	2800	+3.5	0.5	25	-69	-95	-116	-137	6.0	2.5	42-107	-15	—	130	5.0	30
ZX95-2920C	2500	2920	+7.0	0.5	16.0	-79	-107	-128	-147	2.0	0.2	34-42	-25	-15	150	8.0	38
ZX95-3000W	2000	3000	+5.5	0.5	14	-71	-96	-117	-138	13.5	1.5	84-125	-22	-10	140	12.0	35
ZX95-3005	2850	3005	+5.5	0.5	10.0	-77	-100	-121	-142	2.0	1.5	37	-30	-20	10	5.0	42
ZX95-3015	2570	3015	+9.0	0.5	24.0	-72	-99	-120	-140	17.0	0.8	30-43	-14	—	60	10	35
ZX95-3050	2850	3050	+6.0	0.5	12.0	-73	-99	-120	-141	1.0	3.0	35-42	-21	-12	20	5.0	44
ZX95-3075	2920	3075	+3.0	0.5	11.0	-78	-102	-123	-143	0.7	2.5	24-28	-19	-10	30	8.0	40
ZX95-3100	2300	3100	+9.0	0.5	11.0	-66	-92	-113	-133	5.0	4.0	92.0-124.0	-20.0	-10.0	160.0	10.0	46
ZX95-3245	3100	3245	+6.0	0.5	10.0	-72	-98	-119	-139	2.0	4.0	27-32	-26	-18	30	5.0	40
ZX95-3250	2550	3250	+2.0	0.5	24.0	-74	-99	-120	-140	0.6	3.0	27-46	-22	-12	160	5.0	42
ZX95-3350	3200	3350	+5.0	0.5	10.0	-73	-97	-118	-138	1.0	2.0	33	-30	-20	250	5.0	40
ZX95-3360	2120	3360	+8.5	0.5	18	-68	-95	-116	-137	3.0	1.0	65-113	-26	-12	170	12.0	45
ZX95-3450	3250	3450	+5.0	0.5	10.0	-73	-98	-119	-139	1.8	1.7	28-36	-19	-13	12	5.0	40
ZX95-3490	3340	3490	+0	0.5	12.0	-75	-98	-119	-139	0.8	1.0	28-32	-35	-22	220	8.0	40
ZX95-3500	3090	3500	+3.0	0.5	11.0	-70	-96	-117	-137	1.0	2.0	64.0-71.0	-24.0	-14.0	500.0	10.0	41
ZX95-3555	3000	3555	+5	0.5	15.0	-71	-97	-118	-138	1.5	3.0	60-70	-23	-15	600	5.0	41
ZX95-3600	2950	3600	+3.0	0.5	24.0	-73	-98	-119	-139	0.8	2.0	23-46	-33	-23	100	5.0	40
ZX95-3605	3300	3605	+8.5	0.5	8.0	-71	-97	-118	-138	3.5	0.6	47-64	-20	-15	550	5.0	46
ZX95-3760	3200	3760	+7.5	0.5	15.0	-69	-96	-117	-138	3.0	1.0	56.0-67.0	-28.0	-18.0	600.0	5.0	48
ZX95-3900	3750	3900	+4.5	0.5	10.0	-76	-97	-118	-138	2.0	3.5	25-40	-28	-18	260	5.0	40
ZX95-4000	3850	4000	+5.0	0.5	10.0	-72	-96	-117	-137	3.0	2.5	26-36	-26	-15	20	5.0	40
ZX95-4100	3950	4100	+5.5	0.5	10.0	-71	-96	-117	-137	2.0	1.5	25.0	-90.0	—	10.0	5.0	35
ZX95-4720	4680	4720	+7.5	0.5	11.0	-70	-96	-117	-138	2.5	0.7	15.0	-26.0	-16.0	120.0	5.0	50

ELECTRICAL SCHEMATIC DUAL OUTPUT VCO'S

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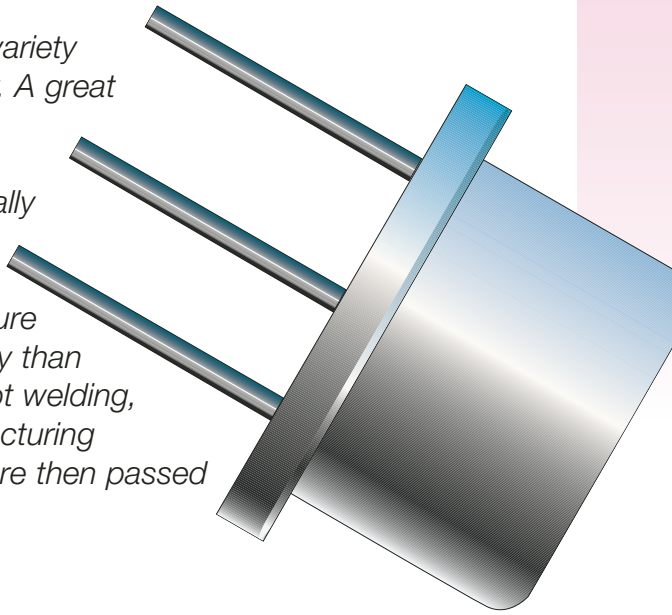
PLUG-IN

Mini-Circuits offers the world's largest assortment of Plug-in components in a variety of package styles for thru-hole assembly. A great majority of these products are shielded, and utilize our proprietary laser welding process to hermetically seal the package. This automated laser sealing procedure offers higher reliability than solder sealing or spot welding, and reduces manufacturing costs. The savings are then passed on to you!



AMPLIFIERS Broadband, Linear, 50 Ω (Hermetic)

500 kHz to 3000 MHz

AMP Case PP120 | AMP-3G Case PP230 | TO, AMP-2000 Case QQ96 | MAN Case A05 | MAN-2AD, 11AD, 1HLN Case A06

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	GAIN (dB) Min.	GAIN (dB) Flatness Max.	MAXIMUM POWER (dBm) Output (1 dB Comp)	MAXIMUM POWER (dBm) Input (no damage)	NOISE FIGURE (dB) Typ.	IP3 (dBm) Typ.	VSWR Typ. (:1) In	VSWR Typ. (:1) Out	ACTIVE DIRECTIVITY (dB) Typ. Midband	DC POWER VOLT (V)	DC POWER CURRENT (mA) Max.
LOW POWER *up to +12 dBm output NF from 1.2 dB*												
MAN-1	0.5-500	28	±1.4	+8	+15	4.5	+18	1.8	1.8	11	12	60
MAN-1LN	0.5-500	28	±1.4	+7	+15	3.0	+18	1.8	1.8	10	12	60
AMP-75	5-500	19	±1.0	+12	+13	2.4	+28	2	2	2	15	31
MAN-1AD	5-500	16	±1.0	+7	+15	7.2	+20	1.6	1.7	31	12	85
MAN-2	0.5-1000	18	±1.5	+9	+15	6.0	+19	1.8	1.8	16	12	85
MAN-2AD	2-1000	9	±0.7	-2	+10	6.5	+14	2.0	2.0	20	15	22
AMP-15	5-1000	13	±1.2	+8	+13	2.8	+22	2	2	5	15	29
TO-0812LN	800-1200	20	±1.0	+8	+10	1.2	+22.5	2.5	2.5	21	15	70
TO-1217LN	1200-1700	20	±1.0	+10	+13	1.6	+25	2.5	2.5	11	15	70
MAN-11AD	2-2000	8	±1.5	-2	+10	6.5	+14	3.0	2.0	16	15	22
TO-1724LN	1700-2400	20	±1.0	+10	+13	1.6	+22	2.5	2.5	15	15	70
AMP-3G	30-3000	8	±0.75	+9.5	+13	3.5	+20	2.6	2.5	9	15	55
MEDIUM POWER *up to +16 dBm output NF from 3.0 dB*												
AMP-76	5-500	26	±1.0	+13.5	+6	3.1	+28	2	2	9	15	71
AMP-77	5-500	15	±1.0	+16	+13	3.3	+32	2	2	2	15	56
MAN-1HLN	10-500	10	±0.8	+15	+15	3.7	+30	1.8	1.8	4	12	70
AMP-2000	10-2000	20	±1.5	+15	+5	5.0	+25	2	2	15	15	100
AMP-25G	10-2500	15	±1.6	+12.5	+13	3.0	+26	1.6	1.2	7	15	55

ATTENUATORS, DIGITAL STEP *Precision 50 Ω (Hermetic)*

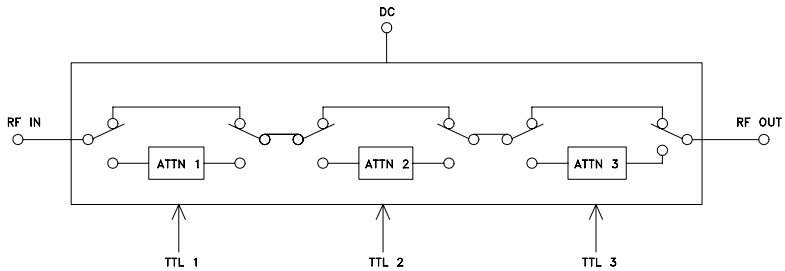
10 MHz to 1000 MHz

TOAT
Case QQ96

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	PRIMARY ATTENUATION STEPS (dB) @TTL CONTROL PORT #1	#2	#3	ATTENUATION (dB) Attenuation Above insertion loss at (1,1,1) state Typ.	Max. Insertion loss at (0,0,0) state	VSWR (:1) Typ. L	M	U	DC POWER VOLT (V)	CURRENT (mA)
DIGITAL STEP *Pin Diode, TTL Control*											
TOAT-R512	10-1000	0.5±0.18	1±0.25	2±0.25	3.5	4.0	1.6	1.4	1.5	5	12
TOAT-124	10-1000	1±0.25	2±0.25	4±0.3	7.0	4.0	1.6	1.4	1.5	5	12
TOAT-3610	10-1000	3±0.3	6±0.4	10±0.4	19.0	4.0	1.6	1.4	1.5	5	12
TOAT-4816	10-1000	4±0.4	8±0.4	16±0.5	28.0	4.0	1.6	1.4	1.5	5	12
TOAT-51020	10-1000	5±0.4	10±0.4	20±0.5	35.0	4.0	1.6	1.4	1.5	5	12

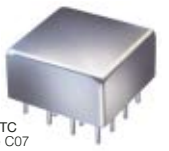
L = low range (10 to 100 MHz) M = mid range (100 to 500 MHz) U = upper range (500 to 1000 MHz)

ELECTRICAL SCHEMATIC



BIAS-TEES *Wideband, High DC Current 50 Ω (Hermetic)*

100 kHz to 3000 MHz

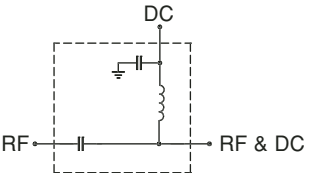


PBTC
Case C07

MODEL PREFIX	FREQUENCY (MHz)	INSERTION LOSS (dB)						ISOLATION (dB) (RF port to DC port) (RF&DC port to DC port)						VSWR (:1)			DC CURRENT OPERATING (mA)	RF POWER OPERATING (dBm)
		L		M		U		L		M		U		L	M	U		
	f_L-f_U	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Typ.	Typ.	Max.	Max.
PBTC-1GW	0.1-1000	0.15	0.8	0.3	0.7	0.3	1.0	25	15	33	20	30	20	1.06	1.06	1.1	200	20
PBTC-1G	10-1000	0.15	0.7	0.3	0.7	0.3	0.7	27	20	33	20	30	20	1.06	1.06	1.1	200	20
PBTC-3GW	0.1-3000	0.15	0.8	0.3	1.5	1.0	2.5	25	15	30	20	35	20	1.06	1.13	1.6	200	20
PBTC-3G	10-3000	0.15	0.7	0.3	1.5	1.0	2.5	27	20	30	20	35	20	1.06	1.13	1.6	200	20

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

ELECTRICAL SCHEMATIC



DIRECTIONAL COUPLERS *(Hermetic)*

5 kHz to 2000 MHz, 6 to 30 dB Coupling

Mini-Circuits® 2007

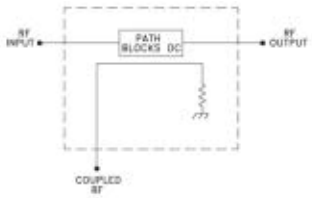
TDC Case B02 | PDC Case A01 | P4DC-30A-2 Case C07, C145

MODEL PREFIX	FREQUENCY (MHz)	COUPLING (dB)		MAINLINE LOSS (dB)						DIRECTIVITY (dB)						VSWR (:1)	POWER INPUT, W	
				L		M		U		L		M		U				
	f_L-f_U	Nom.	Flatness	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	L Max.	MU Max.
DIRECTIONAL 50 Ω																		
TDC-6-1	10-400	6.3±0.4	±0.4	2.0	2.4	2.0	2.4	2.0	2.5	36	30	30	25	20	15	1.5	1.0	2.0
TDC-10-1	1-400	10.0±0.5	±0.5	1.2	1.5	1.0	1.3	1.2	1.5	35	25	30	20	20	15	1.5	1.0	2.0
PDC-10-2	250-1000	10.5±0.5	±0.6	1.4	1.6	—	—	1.6	2.0	30	23	—	—	25	15	1.5	5.0	5.0
PDC-10-54	10-1500	10.5±0.5	±0.7	1.2	1.8	1.3	1.9	1.6	2.3	35	25	28	23	28	23	1.3	0.5	0.5
PDC-10-5	1-2000	10.5±0.5	±1.0	1.2	1.9	1.3	1.9	2.0	2.5	38	25	30	18	22	15	1.3	0.5	0.5
PDC-10-6	0.005-20	11.0±0.5	±0.5	0.4	1.2	0.4	0.8	0.4	1.0	40	30	40	30	35	25	1.3	1.5	3.0
PDC-10-22	5-750	11.0±0.5	±0.5	1.1	1.6	1.2	1.7	1.6	1.9	35	30	25	20	25	20	1.25	1.0	2.0
PDC-10-21	1-1000	11.0±0.5	±0.5	1.2	1.7	1.2	1.7	1.6	2.0	40	30	25	20	25	20	1.3	1.0	2.0
TDC-10-2	5-1000	11.0±0.5	±0.6	1.4	1.8	1.5	1.8	1.6	2.0	50	35	25	20	20	15	1.5	0.5	0.5
PDC-10-1	0.5-500	11.5±0.5	±0.6	0.85	1.3	0.65	1.0	0.85	1.3	32	25	32	25	22	15	1.2	1.5	3.0
PDC-15-21	1-500	14.7±0.5	±0.6	0.7	1.1	0.7	1.1	0.8	1.2	35	30	35	30	30	23	1.4	1.0	2.0
PDC-15-6	0.01-35	15.0±0.5	±0.5	0.3	0.6	0.2	0.4	0.3	0.6	38	30	35	25	28	20	1.15	2.0	4.0
PDC-20-1W	10-700	19.2±0.5	±0.5	0.25	0.5	0.4	0.7	0.7	1.1	34	30	27	23	23	20	1.4	1.0	2.0
PDC-20-3	0.2-250	19.5±0.5	±0.5	0.35	0.6	0.25	0.5	0.35	0.6	36	30	33	25	25	20	1.2	1.5	4.0
PDC-20A-5	0.1-2000	20.0±0.5	±1.0	0.6	1.5	0.6	1.5	1.9	2.9	34	20	25	15	20	10	1.5	0.5	2.0
PDC20-900HP	800-900	20.2±0.6	±0.5			0.25	0.5			24	20	24	20	24	20	1.1	5.0	5.0
PDC20-970HP	860-970	20.2±0.6	±0.5			0.25	0.5			24	20	24	20	24	20	1.1	5.0	5.0
PDC-20-1	25-400	21.0±0.75	±0.5	0.2	0.25	0.3	0.35	0.35	0.5	25	20	35	25	25	20	1.25	3.0	5.0
PDC20-400HP	40-400	21.5±0.5	±0.6	0.1	0.3	0.2	0.4	0.2	0.5	30	20	30	20	27	18	1.1	10.0	10.0
P4DC-30A-2	5-1000	30.5±0.5	±1.0	0.7	1.2	0.7	1.2	0.8	1.5	30	15	32	20	20	10	1.15	1.0	2.0
DIRECTIONAL 75 Ω																		
PDC-10-6-75	0.2-100	10.0±0.5	±0.2	1.2	1.6	0.9	1.2	0.9	1.3	50	30	40	25	37	25	1.5	1.0	2.0
PDC-10-1-75	1-250	10.5±0.5	±0.75	1.1	1.5	1.1	1.5	1.1	1.5	30	20	30	20	30	20	2.0	2.0	4.0
PDC-15-6-75	0.02-35	14.5±0.5	±0.5	0.3	0.7	0.3	0.7	0.3	0.7	35	20	35	20	35	20	1.3	1.5	4.0
PDC-20-3-75	1-150	19.5±0.5	±0.75	0.35	0.8	0.35	0.8	0.35	0.8	25	20	25	20	25	20	2.0	2.0	4.0
PDC-20-6-75	0.05-40	20.4±0.3	±0.25	0.1	0.25	0.1	0.2	0.1	0.3	45	35	35	20	25	18	1.2	1.5	3.0
BI-DIRECTIONAL 50 Ω																		
PDC-10-1BD	1-400	11.5±0.5	±0.5	0.6	0.9	0.8	1.1	0.9	1.3	55	35	35	20	22	15	1.2	2.0	4.0
PDC-20-1BD	0.5-200	19.2±0.5	±0.5	0.3	0.7	0.3	0.5	0.4	0.6	40	30	35	20	22	18	1.1	3.0	5.0
PDC-20-3BD	0.2-250	19.5±0.5	±0.5	0.3	1.0	0.25	0.9	0.35	0.7	47	25	40	25	30	20	1.1	1.5	4.0

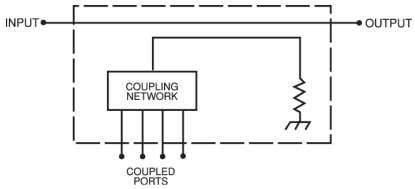
L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

ELECTRICAL SCHEMATICS

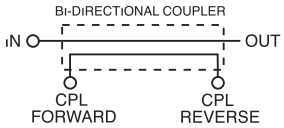
Directional Couplers *(except P4DC-30A-2)*



Model P4DC-30A-2



Bi-Directional Couplers



FILTERS (Hermetic)

DC to 2200 MHz

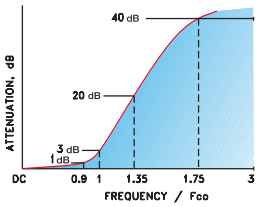
Case A01

MODEL PREFIX	PASSBAND, (MHz) (Loss < 1 dB)	fco, (MHz) NOMINAL (Loss 3 dB)	STOPBAND, (MHz) (Loss > 20 dB)	STOPBAND, (MHz) (Loss > 40 dB)	VSWR (:1) PASSBAND Typ.	VSWR (:1) STOPBAND Typ.	RF POWER Max. (W)
LOW PASS 50 Ω							
PLP-1.9	DC-1.9	2.5	3.4-4.7	4.7-200	1.7	18	0.5
PLP-2.5	DC-2.5	2.75	3.8-5.0	5.0-200	1.7	18	0.5
PLP-5	DC-5	6	8-10	10-200	1.7	18	0.5
PLP-10.7	DC-11	14	19-24	24-200	1.7	18	0.5
PLP-15	DC-15	17	23-32	32-200	1.7	18	0.5
PLP-21.4	DC-22	24.5	32-41	41-200	1.7	18	0.5
PLP-30	DC-32	35	47-61	61-200	1.7	18	0.5
PLP-50	DC-48	55	70-90	90-200	1.7	18	0.5
PLP-70	DC-60	67	90-117	117-300	1.7	18	0.5
PLP-90	DC-81	90	121-157	157-400	1.7	18	0.5
PLP-100	DC-98	108	146-189	189-400	1.7	18	0.5
PLP-150	DC-140	155	210-300	300-600	1.7	18	0.5
PLP-200	DC-190	210	290-390	390-800	1.7	18	0.5
PLP-250	DC-225	250	320-400	400-1200	1.7	18	0.5
PLP-300	DC-270	297	410-550	550-1200	1.7	18	0.5
PLP-450	DC-400	440	580-750	750-1800	1.7	18	0.5
PLP-550	DC-520	570	750-920	920-2000	1.7	18	0.5
PLP-600	DC-580	640	840-1120	1120-2000	1.7	18	0.5
PLP-750	DC-700	770	1000-1300	1300-2000	1.7	18	0.5
PLP-800	DC-720	800	1080-1400	1400-2000	1.7	18	0.5
PLP-850	DC-780	850	1100-1400	1400-2000	1.7	18	0.5
PLP-1000	DC-900	990	1340-1750	1750-2000	1.7	18	0.5
PLP-1200	DC-1000	1200	1620-2100	2100-2500	1.7	18	0.5
LOW PASS 75 Ω							
PLP-7-75	DC-7	8	11-15	15-200	1.7	18	0.5
PLP-10.7-75	DC-11	14	19-24	24-200	1.7	18	0.5
PLP-15-75	DC-15	17	23-32	32-200	1.7	18	0.5
PLP-21.4-75	DC-22	24.5	32-41	41-200	1.7	18	0.5
PLP-30-75	DC-32	35	47-61	61-200	1.7	18	0.5
PLP-50-75	DC-48	55	70-90	90-200	1.7	18	0.5
PLP-70-75	DC-60	67	90-117	117-300	1.7	18	0.5
PLP-100-75	DC-98	108	146-189	189-400	1.7	18	0.5
PLP-600-75	DC-580	640	840-1120	1120-2000	1.7	18	0.5
PLP-850-75	DC-750	850	1150-1490	1490-2000	1.7	18	0.5

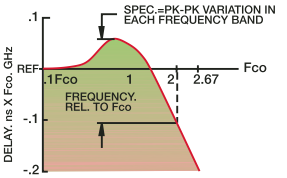
MODEL PREFIX	PASSBAND (MHz) (Loss <1.2 dB) Min.	fco, (MHz) NOMINAL (Loss 3 dB)	STOP BAND, (MHz) Loss > 10 dB	STOP BAND, (MHz) Loss > 20 dB	VSWR (:1) DC-0.2 fco $\bar{X}$	VSWR (:1) DC-0.6 fco $\bar{X}$	GROUP DELAY VARIATION (nsec) DC-fco $\bar{X}$	GROUP DELAY VARIATION (nsec) DC-2 fco $\bar{X}$	GROUP DELAY VARIATION (nsec) DC-2.67 fco $\bar{X}$	RF POWER Max. (W)
LOW PASS, FLAT TIME DELAY 50 Ω										
PBLP-39	DC-23	39	78-117	117	1.3	2.3	0.70	4.0	5.00	0.5
PBLP-117	DC-65	117	234-312	312	1.3	2.4	0.35	1.4	1.90	0.5
PBLP-156	DC-94	156	312-416	416	1.3	1.1	0.30	1.1	1.50	0.5
PBLP-200	DC-120	200	400-534	534	1.6	1.9	0.40	1.3	1.60	0.5
PBLP-300	DC-180	300	600-801	801	1.25	2.2	0.20	0.6	0.80	0.5
PBLP-467	DC-280	467	934-1246	1246	1.25	2.2	0.15	0.4	0.55	0.5

TYPICAL FREQUENCY RESPONSE

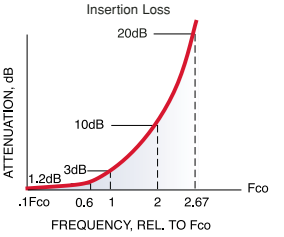
PLP



PBLP Typical Group Delay



PBLP Insertion Loss



BANDPASS Constant Impedance 50 Ω

MODEL PREFIX	CENTER FREQUENCY MHz	PASSBAND (MHz) (Loss <1 dB)	STOP BANDS (Loss > 10 dB) at MHz	STOP BANDS (Loss > 20 dB) at MHz	VSWR 1.3:1, TYP. TOTAL BAND MHz	RF POWER Max. (W)
PIF-21.4	21.4	18-25	4.9 & 85	1.3 & 150	DC-220	0.5
PIF-30	30	25-35	7 & 120	1.9 & 210	DC-330	0.5
PIF-40	42	35-49	10 & 168	2.6 & 300	DC-400	0.5
PIF-50	50	41-58	11.5 & 200	3.1 & 350	DC-440	0.5
PIF-60	60	50-70	14 & 240	3.8 & 400	DC-500	0.5
PIF-70	70	58-82	16 & 280	4.4 & 490	DC-550	0.5

BANDPASS Elliptic Response 50 Ω

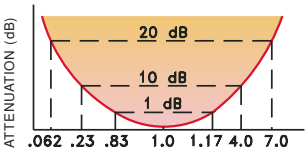
MODEL PREFIX	CENTER FREQUENCY MHz	PASSBAND I.L. 1.5 dB Max. MHz F1 F2	3 dB BANDWIDTH TYPICAL MHz	STOP BANDS (I. Loss > 20 dB) at MHz F3 F4	STOP BANDS (I. Loss > 35 dB) at MHz F5 F6	VSWR (:1) Passband Max.	VSWR (:1) Stop Band Typ.	RF POWER Max. (W)
PBP-10.7	10.7	9.5-11.5	8.9-12.7	7.5 & 15	0.6 & 50-1000	1.7	16	0.5
PBP-21.4	21.4	19.2-23.6	17.9-25.3	15.5 & 29	3.0 & 80-1000	1.7	16	0.5
PBP-30	30	27.0-33.0	25-35	22 & 40	3.2 & 99-1000	1.7	16	0.5
PBP-35N	35	30-40	—	21 & 58	19 & 66-1000	1.5	18	0.5
PBP-35W	35	25-45	—	16 & 70	4 & 80-1000	1.5	18	0.5
PBP-60	60	55.0-67.0	49.8-70.5	44 & 79	4.6 & 190-1000	1.7	16	0.5
PBP-70	70	63.0-77.0	58.0-82.0	51 & 94	6.0 & 193-1000	1.7	16	0.5

HIGHPASS 50 Ω

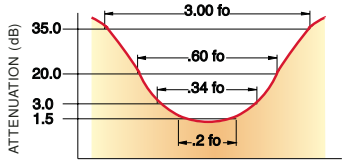
MODEL PREFIX	STOPBAND, (MHz) (Loss > 40 dB)	STOPBAND, (MHz) (Loss > 20 dB)	fco, (MHz) NOMINAL (Loss 3 dB)	PASSBAND, (MHz) (Loss <1 dB)	VSWR (:1) Stopband Typ.	VSWR (:1) Passband Typ.	RF POWER Max. (W)
PHP-25	DC-13	13-19	25	27.5-200	18	1.7	0.5
PHP-50	DC-20	20- 26	37	41-200	17	1.5	0.5
PHP-100	DC-40	40- 55	82	90-400	17	1.5	0.5
PHP-150	DC-70	70- 95	120	133-600	17	1.8	0.5
PHP-175	DC-70	70-105	140	160-800	17	1.5	0.5
PHP-200	DC-90	90-116	164	185-800	17	1.6	0.5
PHP-250	DC-100	100-150	205	225-1200	17	1.3	0.5
PHP-300	DC-145	145-190	245	290-1200	17	1.7	0.5
PHP-400	DC-210	210-290	360	395-1600	17	1.7	0.5
PHP-500	DC-280	280-365	454	500-1600	17	1.9	0.5
PHP-600	DC-350	350-440	545	600-1600	17	2.0	0.5
PHP-700	DC-400	400-520	640	700-1800	17	1.6	0.5
PHP-800	DC-445	445-570	710	780-2000	17	2.1	0.5
PHP-900	DC-520	520-660	820	910-2100	17	1.8	0.5
PHP-1000	DC-550	550-720	900	1000-2200	17	1.9	0.5

TYPICAL FREQUENCY RESPONSE

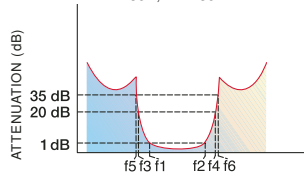
PIF Bandpass, Constant Impedance



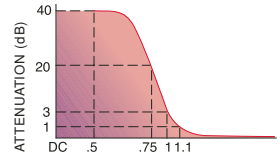
PBP Bandpass, Elliptical (Except PBP-35N, PBP-35W)



PBP Bandpass, Elliptical PBP-35N, PBP-35W



PHP High Pass



LIMITERS Broadband, 50 Ω (Hermetic)

100 kHz to 900 MHz

PLS
Case A01

MODEL PREFIX	FREQUENCY (MHz)	INPUT POWER (dBm)		OUTPUT (dBm)	CONTROL CURRENT mA	LIMITING		
						Input range	△Output / △1 dB	
		Min.	Max.	Typ.	Typ.	dBm	amp	phase deg/dB
PLS-1	0.1 - 150	6	20	-4.0	3	6 to 10	0.10	0.8
						10 to 16	0.15	0.8
						16 to 20	0.15	0.7
PLS-2	100 - 900	3	15	-5.0	5	3 to 8	0.20	2.0
						8 to 12	0.40	2.0
						12 to 15	0.40	2.0

UNCL
Case A01

MODEL PREFIX	FREQUENCY (MHz) LO/RF f_L-f_U	FREQUENCY (MHz) IF	CONVERSION GAIN, (dB) MID-BAND m $\bar{x}$	σ	Min.	TOTAL RANGE Typ.	Min.	LO-RF ISOLATION, (dB) L Typ.	Min.	M Typ.	Min.	U Typ.	Min.	LO-IF ISOLATION, (dB) L Typ.	Min.	M Typ.	Min.	U Typ.	Min.	INPUT POWER (dBm) 1 dB Comp Typ.	DC POWER Volt	Current (mA)
LEVEL 7 +7 dBm LO up to -10 dBm RF Low Noise																						
UNCL-R1	10-500	DC-500	5.53	0.11	2.0	5.0	2.0	65	45	55	40	47	35	40	30	30	20	25	17	-10	12	35

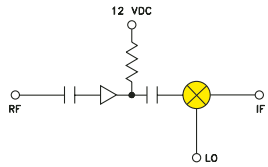
UNCL
Case A01

MODEL PREFIX	FREQUENCY (MHz) LO/RF f_L-f_U	FREQUENCY (MHz) IF	CONVERSION GAIN, (dB) MID-BAND m $\bar{x}$	σ	Min.	TOTAL RANGE Max.	LO-RF ISOLATION, (dB) L Typ.	Min.	M Typ.	Min.	U Typ.	Min.	LO-IF ISOLATION, (dB) L Typ.	Min.	M Typ.	Min.	U Typ.	Min.	INPUT POWER (dBm) 1 dB Comp Typ.	DC POWER Volt	Current (mA)
LEVEL -4 -4 dBm LO up to +1 dBm RF																					
UNCL-L1	10-500	DC-500	5.73	0.08	8.0	8.5	45	30	35	20	25	17	32	20	23	15	18	12	1	12	35
LEVEL 6 +6 dBm LO up to +14 dBm RF																					
UNCL-L1H	10-500	DC-500	5.73	0.07	8.0	8.5	45	25	36	20	24	17	32	18	25	15	18	10	14	12	60

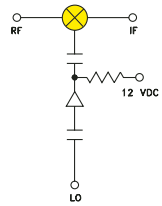
L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)
m = mid band ($2f_L$ to $f_U/2$)

ELECTRICAL SCHEMATICS

Mixer with RF Amplifier
UNCL-R1



Mixer with LO Amplifier
UNCL-L1, UNCL-L1H



MIXERS, FREQUENCY 50 Ω (Hermetic and Non Hermetic)

500 Hz to 4300 MHz

TFM, TUF Case B02 | TFM Case B13 | (Non Hermetic) ASK Case X65 | TSM Case A11 | SAM Case A03 | ROK Case QQ96 | TAK Case A04, A05 | SBL, SRA, SIMA Case A06 | SAY, SRA, RAY, VAY Case A01

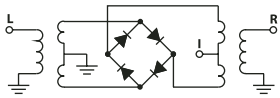
MODEL PREFIX	FREQUENCY (MHz)		CONVERSION LOSS (dB)				LO-RF ISOLATION (dB)						LO-IF ISOLATION (dB)						SCHEMATIC
	LO/RF f_L-f_U	IF	MID-BAND m $\bar{x}$	σ	Max.	TOTAL RANGE Max.	L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	
LEVEL 7 +7 dBm LO up to +1 dBm RF																			
SRA-8	0.0005-10	DC-10	5.69	0.11	7.5	8.5	60	50	50	40	45	35	60	50	50	40	45	35	1
SRA-6	0.003-100	DC-100	4.58	0.05	7.5	8.5	60	50	45	30	35	25	60	45	40	25	30	20	1
SBL-3	0.025-200	DC-200	4.81	0.05	7.5	8.5	55	50	45	30	35	25	45	35	40	30	30	20	1
SRA-3	0.025-200	DC-200	4.61	0.06	7.5	8.5	60	50	45	35	35	25	45	35	40	30	30	20	1
TAK-5	0.01-250	DC-250	4.65	0.02	7.0	8.5	60	50	50	35	40	35	55	45	45	30	35	25	1
TFM-3	0.04-400	DC-400	4.70	0.06	7.0	8.0	60	50	50	35	35	25	55	40	45	30	35	25	1
SBL-1-1	0.1-400	DC-400	4.84	0.04	7.0	8.0	50	45	45	30	35	25	45	30	40	25	30	20	1
TUF-3	0.15-400	DC-400	4.7	0.02	7.0	8.0	60	50	46	30	35	25	60	40	47	25	35	20	1
SRA-1-1	0.1-500	DC-500	4.81	0.11	7.5	8.5	50	45	45	30	35	25	45	30	40	25	30	20	1
TSM-3	0.1-500	DC-500	4.75	0.04	7.5	8.5	60	50	50	35	35	25	55	45	45	30	35	25	1
SRA-1	0.5-500	DC-500	5.11	0.09	7.0	8.5	50	45	45	30	35	25	45	35	40	25	30	20	1
SBL-1	1-500	DC-500	5.60	0.09	7.0	8.0	60	45	45	35	40	25	45	35	40	25	30	20	1
TAK-6	0.5-600	DC-600	5.58	0.04	7.5	8.5	60	50	50	30	40	25	55	45	45	30	30	20	1
ASK-1-X65	1-600	DC-600	5.58	0.06	7.0	8.5	50	30	35	25	30	20	45	35	30	20	25	15	1
SAM-1	1-600	DC-600	5.67	0.05	7.0	8.5	55	45	45	30	35	20	50	40	40	25	30	20	1
TUF-1	2-600	DC-600	5.85	0.04	7.0	8.0	60	50	42	30	37	25	60	45	47	30	36	22	1
SRA-1W	1-750	DC-750	5.80	0.04	7.5	8.5	50	45	45	30	35	25	45	30	40	25	30	20	1
SRA-2	1-1000	0.5-500	5.66	0.07	7.5	8.5	45	30	35	20	30	20	45	30	30	20	30	20	1
TFM-2	1-1000	DC-1000	5.74	0.07	7.5	8.5	50	45	40	25	30	25	45	40	35	25	25	18	1
SRA-2CM	5-1000	DC-1000	5.27	0.04	7.0	8.5	60	50	35	30	30	25	50	45	30	25	25	20	1
SBL-1X	10-1000	5-500	5.88	0.10	7.5	8.0	50	40	40	30	30	20	50	45	40	35	35	25	1
TUF-2	50-1000	DC-1000	5.85	0.07	7.5	9.0	58	40	47	30	42	25	50	35	44	20	29	18	1
TFM-4	5-1250	DC-1250	6.47	0.05	7.5	8.5	50	45	40	30	30	25	45	40	35	25	25	20	1
SRA-12	800-1250	50-90	6.21	0.13	7.5	7.5			35	25					30	20			
TFM-12	800-1250	50-90	5.71	0.14	—	7.5	35	25	35	25	35	25	30	20	30	20	30	20	
SRA-5	5-1500	10-600	6.69	0.07	8.0	8.5	50	45	35	30	30	20	45	40	30	25	25	15	1
TUF-5	20-1500	DC-1000	5.7	0.04	9.0	9.0	54	40	42	30	39	25	40	25	32	18	23	8	1
TFM-11	1-2000	5-600	7.16	0.07	8.5	9.0	50	45	35	25	25	20	45	40	27	20	25	20	1
SBL-11	5-2000	10-600	7.08	0.11	8.5	9.0	50	45	35	25	30	20	45	40	30	20	25	15	1
SRA-11	5-2000	10-600	6.72	0.07	8.5	9.0	50	45	35	25	30	20	45	40	30	20	25	15	1
SRA-2000	100-2000	DC-600	8.60	0.15	9.5	9.5	37	20	37	20	37	20	30	20	30	20	30	20	1
SRA-2400	750-2400	DC-400	5.95	0.26	9.0	9.0	30	20	30	20	30	20	30	8	30	8	30	8	1
TFM-2400	750-2400	DC-400	6.65	0.20	—	9.0	30	20	30	20	30	20	30	10	30	10	30	10	1
SRA-3500	500-3500	DC-1000	7.28	0.31	9.5	9.5	30	17	30	17	30	17	20	8	20	8	20	8	1
TFM-4300	300-4300	DC-800	5.87	0.13	—	10.5	30	20	—	—	30	17	15	7	19	7	10	7	1
LEVEL 10 +10 dBm LO up to +5 dBm RF																			
TUF-3LH	0.15-400	DC-400	4.8	0.37	7.0	8.0	67	50	51	30	40	25	67	40	45	25	34	20	1
TUF-1LH	2-600	DC-600	6.0	0.17	7.0	8.0	70	50	50	30	42	25	65	45	50	30	41	22	1
SBL-2LH	5-1000	DC-1000	5.9	0.09	7.5	9.5	67	45	61	30	57	30	68	40	54	30	43	20	1
SBL-1XLH	10-1000	5-500	6.0	0.12	7.5	8.5	50	40	40	25	30	20	70	45	55	40	45	30	1
TUF-2LH	50-1000	DC-1000	5.2	0.30	7.0	8.5	58	40	44	30	39	25	60	35	50	25	38	20	1
TUF-5LH	20-1500	DC-1000	6.9	0.27	8.5	9.0	53	40	42	30	38	25	40	25	30	18	22	8	1
SRA-220	0.05-2000	0.05-500	5.59	0.11	8.0	9.0	25	20	40	30	30	20	25	20	40	30	25	15	2
TFM-150	10-2000	DC-1000	6.19	0.11	8.0	8.0	32	25	35	25	35	25	33	20	30	20	30	20	2
TFM-15	10-3000	10-800	6.75	0.08	8.0	8.5	35	25	35	25	35	25	30	20	30	20	30	20	2

MODEL PREFIX	FREQUENCY (MHz) LO/RF f_L-f_U	FREQUENCY (MHz) IF	CONVERSION LOSS (dB) MID-BAND m $\bar{x}$	σ	Max.	TOTAL RANGE Max.	LO-RF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	LO-IF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	SCHEMATIC
LEVEL 13	*+13 dBm LO*	*up to +9 dBm RF*																	
SRA-3MH	0.025-200	DC-200	4.77	0.07	7.5	8.5	60	50	45	35	35	25	45	35	40	30	30	20	1
TFM-3MH	1-250	DC-250	4.79	0.23	7.0	8.5	50	45	40	30	28	23	45	40	35	25	26	20	1
SRA-1MH	0.5-500	DC-500	5.65	0.04	7.0	8.5	50	45	45	30	35	25	45	35	40	25	30	20	1
SBL-1MH	1-500	DC-500	5.73	0.08	7.5	8.5	50	35	45	30	35	25	45	30	40	25	30	20	1
TFM-1MH	2-500	DC-500	5.80	0.05	7.5	8.5	50	45	40	30	30	20	45	40	35	25	25	20	1
TUF-1MH	2-600	DC-600	6.3	0.12	7.0	8.0	68	50	50	30	43	25	65	45	48	30	37	22	1
SBL-1ZMH	2-1100	DC-500	6.63	0.10	8.0	9.0	50	40	40	30	30	20	40	30	25	20	25	15	1
TUF-5MH	20-1500	DC-1000	7.0	0.25	8.5	9.0	50	40	41	30	35	25	38	25	28	18	20	8	1
TFM-12MH	0.5-2000	0.2-600	6.99	0.16	8.0	9.5	60	45	35	30	30	25	55	40	30	25	25	20	1
ROK-186MH	5-2500	10-1000	6.57	0.11	8.5	9.5	33	25	35	25	25	20	33	20	31	25	27	20	2
TFM-42MH	10-4200	10-1000	7.46	0.12	8.5	11.0	35	25	40	25	35	25	35	20	35	25	27	20	2
LEVEL 17	*+17 dBm LO*	*up to +14 dBm RF*																	
SRA-3H	0.05-200	DC-200	5.18	0.05	7.0	7.5	50	45	40	30	35	25	45	35	40	30	30	20	1
TFM-3H	0.1-250	DC-250	4.58	0.11	7.0	8.5	50	45	40	30	28	23	45	40	35	25	26	20	1
TAK-3H	0.05-300	DC-300	4.82	0.09	7.0	8.5	55	45	40	30	30	25	50	40	35	25	25	20	1
SRA-1H	0.5-500	DC-500	6.01	0.08	7.5	8.5	55	45	45	30	35	25	45	35	40	30	30	20	1
TAK-1H	2-500	DC-500	5.93	0.08	7.5	8.5	50	40	40	30	30	25	45	35	35	25	25	20	1
TFM-1H	2-500	DC-500	6.14	0.11	7.5	8.5	50	45	40	30	30	20	45	40	35	25	25	20	1
TUF-1H	2-600	DC-600	5.90	0.18	7.0	8.0	68	50	50	30	43	25	62	45	48	30	33	22	1
SRA-1WH	1-750	DC-750	5.85	0.11	7.5	8.5	50	40	45	25	35	25	45	35	40	30	30	20	1
TAK-1WH	5-750	DC-750	5.71	0.08	7.5	9.0	50	40	40	30	30	25	45	35	35	25	30	20	1
SRA-2H	2-1000	DC-1000	6.34	0.14	7.5	10.0	50	40	35	25	35	25	45	30	30	20	25	20	1
TFM-2H	5-1000	DC-1000	6.12	0.12	7.0	10.0	50	45	40	30	30	20	45	40	35	25	25	17	1
SRA-173H	5-1200	DC-1200	5.38	0.05	7.0	8.5	40	35	35	25	35	20	40	35	35	20	30	20	2
SIMA-5H	2-1500	DC-1000	6.94	0.07	8.5	8.5	65	35	44	23	40	22	54	25	30	23	25	13	1
TUF-5H	20-1500	DC-1000	7.50	0.17	8.5	9.0	62	55	50	40	38	25	40	25	29	18	20	8	1
TUF-18DH	100-1800	50-750	7.3	0.15	8.5	9.0	41	23	41	23	41	23	33	20	33	20	33	20	2
SRA-11H	10-3000	10-1000	6.83	0.09	10.0	12.0	27	20	25	18	23	16	27	20	25	18	23	16	2
LEVEL 23	*+23 dBm LO*	*up to +20 dBm RF*																	
RAY-6U	0.01-100	DC-100	5.09	0.15	7.0	8.0	60	50	50	40	40	30	50	45	40	30	35	25	1
RAY-3	0.07-200	DC-200	5.53	0.08	7.5	8.0	55	45	40	30	30	25	55	45	40	30	30	20	1
SAY-1	0.1-500	0.01-500	4.85	0.18	6.0	7.5	40	20	46	35	40	30	37	23	46	35	40	30	2
RAY-1	5-500	DC-500	6.57	0.09	7.5	8.5	55	45	40	30	30	25	55	45	40	30	30	20	1
SAY-11	10-2400	5-1000	7.40	0.09	8.5	10.0	28	20	26	20	25	20	28	20	26	20	25	20	2
RAY-11	100-2500	DC-500	6.23	0.21	9.0	9.0	35	25	32	25	32	25	14	10	20	10	20	10	1
LEVEL 27	*+27 dBm LO*	*up to +24 dBm RF*																	
VAY-1	0.5-500	0.02-500	5.79	0.15	7.5	8.5	47	40	46	35	35	25	35	28	46	35	35	25	2

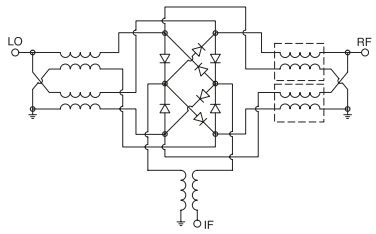
L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)
m = mid band ($2f_L$ to $f_U/2$)

ELECTRICAL SCHEMATICS

1 DOUBLE BALANCED MIXER



2 TRIPLE BALANCED MIXER



MODULATORS/DEMODULATORS 50 Ω (Hermetic)

9 MHz to 1880 MHz

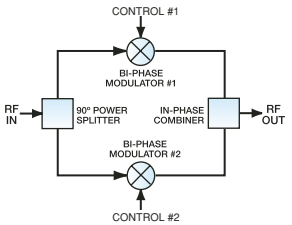
MIQA Case A06 | MIQA Case A01 | MIQC, MIQY, QMC Case C07

MODEL PREFIX	FREQUENCY MHz	INSERTION LOSS (dB) Typ.	INSERTION LOSS (dB) Max.	AMPLITUDE UNBALANCE (dB) Typ.	AMPLITUDE UNBALANCE (dB) Max.	PHASE UNBALANCE (Deg.) ± WITH REFERENCE TO 90° Typ.	PHASE UNBALANCE (Deg.) ± WITH REFERENCE TO 90° Max.	1 dB COMPR. (dBm) Typ.	VSWR (:1) Typ. In	VSWR (:1) Typ. Out
QPSK MODULATORS *Wideband 360° in 90° steps 800 MHz to 1050 MHz*										
QMC-1050	800-1050	5.5	7.5	0.5	1.0	3	7	4	2.0	2.0

MODEL PREFIX	FREQUENCY (MHz) RF (signal)/ LO (carrier) f_L	f_U	I&Q Min.	I&Q Max.	CONVERSION LOSS, (dB) $\bar{X}$	σ	Max.	CARRIER REJECTION (-dBc) Typ.	Min.	SIDEBAND REJECTION (-dBc) Typ.	Min.	HARMONIC SUPPRESSION (-dBc) 3XI/Q Typ.	3XI/Q Min.	5XI/Q Typ.	5XI/Q Min.
I&Q MODULATORS *High rejection of carrier and sideband 9 MHz to 1880 MHz*															
MIQA-10M	9	11	DC	2	5.8	0.20	7.0	41	30	40	30	58	48	68	58
MIQA-21M	20	23	DC	3	6.2	0.14	7.0	50	40	40	30	48	40	65	55
MIQC-88M	52	88	DC	5	5.7	0.10	7.5	41	35	34	30	52	40	66	50
MIQA-70M	66	73	DC	5	6.2	0.10	7.0	38	30	48	30	48	45	58	55
MIQA-70ML	66	73	DC	5	5.7	0.10	6.5	38	30	38	30	48	43	58	55
MIQY-70M	67	73	DC	5	5.8	0.20	7.0	40	35	36	30	47	40	60	50
MIQA-91M	86	95	DC	5	5.5	0.10	6.5	38	30	38	30	48	45	58	55
MIQA-100M	95	105	DC	5	5.5	0.10	6.5	38	30	38	30	48	45	58	55
MIQC-176M	104	176	DC	5	5.5	0.10	7.0	38	30	36	30	47	35	70	50
MIQY-140M	137	143	DC	5	5.8	0.20	7.0	34	30	36	30	45	35	60	50
MIQA-195M	185	205	DC	5	5.6	0.10	6.5	38	30	38	30	48	45	58	55
MIQC-895M	868	895	DC	5	8.0	0.10	10.5	40	30	40	30	52	35	58	50
MIQC-1785M	1710	1785	DC	5	9.0	0.30	10.5	35	25	35	25	40	33	65	50
MIQC-1880M	1805	1880	DC	5	9.0	0.30	10.5	35	25	35	25	40	33	65	50

MODEL PREFIX	FREQUENCY (MHz) RF (signal)/ LO (carrier) f_L	f_U	I&Q Min.	I&Q Max.	CONVERSION LOSS, (dB) $\bar{X}$	σ	Max.	AMPLITUDE UNBALANCE (dB) Typ.	Max.	PHASE UNBALANCE (Deg.) WITH REFERENCE TO 90° Typ.	Max.	HARMONIC SUPPRESSION (-dBc) 3XI/Q Typ.	3XI/Q Min.	5XI/Q Typ.	5XI/Q Min.
I&Q DEMODULATORS *9 MHz to 143 MHz*															
MIQA-10D	9	11	DC	2	6.0	0.10	7.0	0.15	0.3	1.0	3.0	50	35	65	55
MIQA-21D	20	23	DC	3	6.1	0.15	7.0	0.15	0.6	0.7	3.0	64	35	67	50
MIQA-70D	66	73	DC	3	6.2	0.10	7.0	0.15	0.5	0.7	3.0	56	45	58	55
MIQC-60WD	20	60	DC	5	5.3	0.10	7.0	0.15	0.6	1.0	5.0	55	45	67	55
MIQY-70D	67	73	DC	5	5.5	0.25	7.0	0.10	0.6	0.5	3.0	52	40	66	50
MIQY-140D	137	143	DC	5	5.5	0.25	7.0	0.10	0.6	0.5	3.0	47	35	70	50

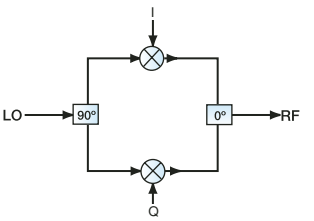
QPSK Modulation block diagram



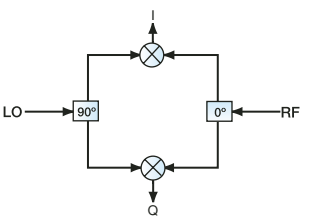
QPSK: Phase Shift vs. Control Current

CONT-1 (mA)	CONT-2 (mA)	PHASE SHIFT (Deg.)
+20	+20	0 (REF)
+20	-20	90
-20	-20	180
-20	+20	270

I&Q Modulator block diagram



I&Q Demodulator block diagram



MULTIPLIERS, FREQUENCY 50 Ω (Hermetic)

0.05 MHz to 3000 MHz

Mini-Circuits® 2007

SK Case B02 | AK Case A03 | RK Case A01

MODEL PREFIX	FREQUENCY (MHz)		INPUT POWER (dBm)		CONVERSION LOSS (dB)		HARMONIC OUTPUT (dBc)					
							F1		F3		F4	
	Input	Output	Min.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.
X 2							*Below F 2*					
RK-3	0.05-50	0.1-100	0	13	11.0	17.0	40	28	45	30	16	8
	50-150	100-300	0	13	11.5	15.0	35	20	40	20	16	12
SK-2	1-100	2-200	1	10	13.0	15.0	40	30	50	40	16	12
	100-300	200-600	1	10	13.5	15.5	25	20	40	30	16	12
	300-500	600-1000	1	10	14.0	16.0	20	15	30	25	16	12
AK-2	1-100	2-200	1	10	13.0	15.0	40	30	50	40	16	12
	100-300	200-600	1	10	13.5	15.5	25	20	40	30	16	12
	300-500	600-1000	1	10	14.0	16.0	20	15	30	25	16	12
RK-2	5-100	10-200	1	15	13.0	16.0	40	30	50	40	16	12
	100-300	200-600	1	15	13.5	15.5	25	20	40	30	16	12
	300-500	600-1000	1	15	14.0	16.5	20	15	30	25	16	12
RK-5	10-100	20-200	10	20	13.0	15.0	20	12	25	20	15	12
	100-400	200-800	10	20	12.5	16.0	20	12	30	20	15	12
	400-800	800-1600	10	20	13.0	16.0	20	12	25	18	15	10
AK-3000	70-1000	140-2000	12	15	10.5	14.0	31	20	40	25	14	10
	1000-1500	2000-3000	12	15	11.5	16.0	22	15	30	20	30	14
RK-3000	70-1000	140-2000	12	15	11.0	14.0	31	20	40	25	15	10
	1000-1500	2000-3000	12	15	12.0	17.5	22	15	30	20	30	14

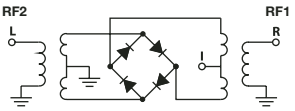
PHASE DETECTORS 50 Ω (Hermetic)

1 MHz to 400 MHz

MPD Case A11 RPD Case A01

MODEL PREFIX	FREQUENCY (MHz) RF1 RF2	FREQUENCY (MHz) I	POWER IN RF1 RF2 (dBm)	SCALE FACTOR mV/deg.	IMPEDANCE (ohms) output load I	ISOLATION (dB) RF1-RF2 Min.	OUTPUT POLARITY RF1/RF2 IN-PHASE	DC OUTPUT (mV) note 1 Max. Typ.	DC OUTPUT (mV) note 1 Max. Min.	DC OUTPUT (mV) note 1 Offset Typ.	DC OUTPUT (mV) note 1 Offset Max.
HIGH OUTPUT *up to 1000 mV DC output*											
MPD-1	1-100	DC- 50	7	8	500	40	neg.	1000	700	0.2	1
RPD-1	1-100	DC- 50	7	8	500	40	neg.	1000	700	0.2	1
RPD-2	5-150	DC- 50	7	8	500	40	neg.	1000	700	0.3	1
MPD-2	10-200	DC- 50	7	8	500	40	neg.	1000	700	0.3	1
MPD-21	50-400	DC- 50	7	7	500	40	neg.	800	500	0.5	1

ELECTRICAL SCHEMATIC



PHASE SHIFTERS 50 Ω (Hermetic)

13 MHz to 16 MHz, 180° Voltage Variable

SPH Case A01

MODEL PREFIX	FREQUENCY (MHz)	PHASE RANGE (DEGREES) Min.	INSERTION LOSS (dB) Typ.	INSERTION LOSS (dB) Max.	CONTROL VOLTAGE (V)	CONTROL BANDWIDTH (kHz) Typ.	VSWR (:1) Typ.	VSWR (:1) Max.	RF POWER (dBm) Max.
SPH-16	13 - 16	180	1.2	2.5	0 - 7	DC- 50	1. 2	1. 7	0

POWER SPLITTERS/COMBINERS *(Hermetic)*

DC to 2000 MHz

TSC Case B02 | MSC Case A03 | PMT Case A04 | PSCQ-2-1000 Case A05 | PQW, PSC, PSCJ, PSCQ Case A01 | PSC, PSCJ Case A06 | PRSC Case C145

MODEL PREFIX	FREQUENCY (MHz)	ISOLATION (dB)						INSERTION LOSS, (dB)						PHASE UNBALANCE DEGREES			AMPLITUDE UNBALANCE (dB)			INPUT RF Power Max (W)	
		L		M		U		L		M		U		L	M	U	L	M	U	S-Port (Matched output ports)	Output ports (Matched S port)
	f_L-f_U	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Max.	Typ.	Max.	Typ.	Max	Max.	Max.	Max.	Max.	Max.	Max.		
2 WAY - 0° 50 Ω								*Insertion Loss Above 3 dB*													
PSC-2-2	0.004-60	27	20	30	20	27	20	0.3	0.6	0.3	0.6	0.6	1.0	2.0	3.0	4.0	0.15	0.25	0.3	1.0	0.125
PSC-2-1	0.1-400	20	15	25	20	25	20	0.2	0.6	0.4	0.75	0.6	1.0	2.0	3.0	4.0	0.15	0.20	0.3	1.0	0.125
TSC-2-1	1-400	30	25	30	25	30	20	0.25	0.5	0.4	0.75	0.8	1.0	2.0	3.0	4.0	0.15	0.20	0.6	1.0	0.125
MSC-2-1	0.1-450	20	15	30	20	30	20	0.3	0.5	0.4	0.75	0.6	1.0	2.0	3.0	4.0	0.15	0.20	0.3	1.0	0.125
PSC-2-1W	1-650	25	20	35	20	25	20	0.3	0.6	0.5	0.9	0.7	1.0	2.0	3.0	4.0	0.15	0.20	0.3	1.0	0.125
MSC-2-1W	2-650	22	18	30	20	22	18	0.3	0.5	0.5	0.8	0.8	1.2	1.0	2.0	4.0	0.30	0.20	0.3	1.0	0.125
PSC-2-45	700-900			20	17			0.2	0.4	0.2	0.4	0.2	0.4	3.0	3.0	3.0	0.20	0.20	0.20	1.0	0.125
PSC-2-4	10-1000	30	25	25	20	25	20	0.6	1.0	0.6	1.2	0.7	1.3	2.0	4.0	8.0	0.15	0.20	0.4	1.0	0.125
TSC-2-1W	200-1000	26	20	—	—	23	14	0.3	0.8	—	—	0.7	1.5	5.0	—	10.0	0.70	—	0.5	1.0	0.125
PSC-2-1000	400-1000	35	25	35	25	35	25	0.5	1.0	0.5	1.0	0.5	1.0	2.0	2.0	2.0	0.30	0.30	0.30	1.0	0.125
PSC-2-5	10-1400	28	18	22	17	24	17	0.3	0.6	0.6	1.0	0.9	1.6	2.0	3.0	4.0	0.15	0.20	0.4	1.0	0.125
MSC-2-5	5-1500	18	16	20	16	20	14	0.6	0.8	0.6	0.8	0.6	1.1	2.0	3.0	5.0	0.20	0.30	0.4	1.0	0.125
MSC-2-11	5-2000	18	16	20	16	18	11	0.6	0.8	0.6	0.8	1.2	1.8	2.0	3.0	5.0	0.20	0.30	0.5	1.0	0.125
PSC-2-11	5-2000	21	16	22	18	19	9	0.5	0.8	0.6	0.9	0.7	1.5	1.0	3.0	6.0	0.20	0.40	1.0	0.5	0.125
2 WAY - 0° 75 Ω																					
PSC-2-2-75	0.008-60	35	20	40	25	30	22	0.1	0.4	0.15	0.4	0.3	0.8	1.0	1.0	1.0	0.15	0.15	0.15	1.0	0.125
PSC-2375	55-85	35	25	35	25	35	25	0.3	0.5	0.3	0.5	0.3	0.5	1.0	1.0	1.0	0.10	0.10	0.10	1.0	0.125
PSC-2-1-75A	1-200	35	27	46	35	36	25	0.1	0.3	0.2	0.4	0.35	0.6	1.0	1.0	2.0	0.10	0.15	0.15	1.0	0.125
PSC-2-1-75	0.25-300	20	15	30	20	20	15	0.4	0.75	0.4	0.75	0.4	1.0	2.0	3.0	5.0	0.15	0.20	0.3	1.0	0.125
PSC-2-4-752	10-850	31	20	32	23	23	15	0.3	0.5	0.4	0.6	0.5	1.0	2.0	5.0	10.0	0.10	0.20	0.5	1.0	0.125
2 WAY - 0° Resistive 50 Ω								*Insertion Loss Above 6 dB*													
PRSC-2050	DC-2000	6.0		6.2		6.5		0.1	0.3	0.2	0.7	0.5	1.0	1.0	3.0	5.0	0.10	0.3	0.5	1.0	0.35
2 WAY - 90° 50 Ω								*Average Insertion Loss Above 3 dB*													
								Typ.	Max.												
PSCQ-2-0.455	0.42-0.51			30	25			0.1	0.5						3.0			1.2		1.0	0.5
PSCQ-2-1.25	1.13-1.38			29	25			0.4	0.7						3.0			1.2		1.0	0.5
PSCQ-2-3.4	3.0-3.8			30	25			0.4	0.7						3.8			1.2		1.0	0.5
PSCQ-2-4	3.5-4.5			36	25			0.4	0.7						3.0			1.5		1.0	0.5
PSCQ-2-7.5	7-8			30	25			0.4	0.7						3.0			1.2		1.0	0.5
PSCQ-2-8	2-8			36	27			0.3	0.7						6.0			0.5		0.05	0.025
PSCQ-2-10.5	9-11			25	20			0.4	0.7						3.0			1.2		1.0	0.5
PSCQ-2-13	12-14			29	25			0.4	0.7						3.0			1.2		1.0	0.5
PSCQ-2-14	12-16			30	25			0.3	0.6						3.0			1.8		1.0	0.5
PSCQ-2-21.4	20-23			30	25			0.4	0.7						3.0			1.2		1.0	0.5
PSCQ-2-26	14-30			25	20			0.4	0.7						3.0			1.5		1.0	0.5
PSCQ-2-32	3.2-32			32	25			0.4	0.8						5.0			0.4		0.05	0.025
PSCQ-2-40	23-40			21	18			0.3	0.7						3.0			1.5		1.0	0.5
PSCQ-2-50	25-50			30	20			0.3	0.7						3.0			1.5		1.0	0.5
PSCQ-2-70	40-70			30	20			0.3	0.7						3.0			1.5		1.0	0.5
PSCQ-2-70N	66-74			22	19			0.2	0.5						0.8			0.25		1.0	0.5
PSCQ-2-85A	55-85			35	20			0.3	0.6						3.0			0.6		1.0	0.5
PQW-2-90	30-90			27	20			0.3	0.6						3.0			1.0		1.0	0.5
PSCQ-2-90	55-90			30	20			0.3	0.7						3.0			1.2		1.0	0.5
PSCQ-2-120	80-120			25	18			0.3	0.7						3.0			1.5		1.0	0.5
PSCQ-2-160	100-160			24	19			0.3	0.7						3.0			1.5		1.0	0.5
PSCQ-2-180	120-180			23	15			0.3	0.7						4.0			1.2		1.0	0.5
PSCQ-2-250	150-250			30	22			0.4	0.8						4.0			1.5		1.0	0.5
PQW-2-270	90-270			20	17			0.4	0.7						4.0			1.4		1.0	0.5
PSCQ-2-400	250-400			23	16			0.5	0.9						4.0			1.5		1.0	0.5
PSCQ-2-450	350-450			23	16			0.5	0.9						5.0			1.5		1.0	0.5
PSCQ-2-550	450-550			19	15			0.4	0.7						5.0			1.5		1.0	0.5
PSCQ-2-1000	800-1000			27	20			0.28	0.6						3.0			1.3		1.0	0.5
2 WAY - 180° 50 Ω								*Insertion Loss Above 3 dB*													
PSCJ-2-2	0.01-20	35	25	30	25	25	18	0.3	0.8	0.2	0.5	0.3	0.6	3.0	2.0	2.5	0.1	0.1	0.2	1.0	0.125
PSCJ-2-1	1-200	35	30	35	25	30	23	0.75	1.0	0.5	0.8	0.75	1.2	2.0	2.5	4.0	0.3	0.15	0.3	1.0	0.125
PSCJ-2-1W	100-600	30	20	30	20	30	20	1.0	1.9	1.0	1.9	1.0	1.9	6.0	6.0	6.0	0.5	0.5	0.5	0.5	0.125
2 WAY - 180° 75 Ω																					
PSCJ-2-1-75	1-200	35	30	31	25	26	20	0.6	1.2	0.8	1.2	1.2	1.8	2.0	4.0	6.0	0.25	0.2	0.5	1.0	0.125
2 WAY - 0°/180° 50 Ω								*Insertion Loss Above 3 dB*													
PMT-1	5-200	22	20	24	20	24	18	0.8	1.0	0.9	1.1	1.0	1.5	2	4	8	0.1	0.2	0.5	1.0	0.125

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

POWER SPLITTERS/COMBINERS *(Hermetic)*

10 kHz to 1000 MHz

MSC
Case A03

PSC, PSCJ
Case A01

PSC-4A, 5, 6
Case C07

PSC-8A, 9, 10, 12
Case E10

MODEL PREFIX	FREQUENCY (MHz)	ISOLATION (dB)						INSERTION LOSS, (dB)						PHASE UNBALANCE DEGREES			AMPLITUDE UNBALANCE (dB)			INPUT RF Power Max (W)	
		L		M		U		L		M		U		L	M	U	L	M	U	S-Port (Matched output ports)	Output ports (Matched S port)
	f_L-f_U	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Max.	Typ.	Max.	Typ.	Max	Max.	Max.	Max.	Max.	Max.	Max.		
3 WAY - 0° 50 Ω								*Insertion Loss Above 4.8 dB*													
PSC-3-2	0.01-30	35	30	40	25	30	25	0.25	0.45	0.15	0.45	0.45	0.75	1	2	4	0.2	0.3	0.4	1.0	0.187
PSC-3-13-39	0.5-50	47	33	46	35	40	33	0.15	0.4	0.15	0.4	0.15	0.4	1	1	2	0.1	0.1	0.1	1.0	0.187
PSC-3-1	1-200	45	30	40	30	40	25	0.6	1.0	0.4	0.7	0.6	1.0	1	2	4	0.15	0.2	0.3	1.0	0.187
PSC-3-13	1-200	45	35	45	30	37	30	0.25	0.5	0.35	0.6	0.35	0.8	1	3	4	0.1	0.2	0.2	1.0	0.187
PSC-3-1A	1-300	38	30	33	23	29	22	0.2	0.5	0.2	0.7	0.6	1.5	1	3	5	0.2	0.3	0.6	1.0	0.187
PSC-3-1W	5-500	25	20	31	15	25	15	0.4	0.8	0.4	1.4	0.8	1.4	2	3	5	0.1	0.3	0.6	1.0	0.187
MSC-3-1W	50-750	22	18	—	—	22	17	0.4	1.0	—	—	0.9	1.5	4	—	7	0.4	—	0.7	1.0	0.09
3 WAY - 0° 75 Ω																					
PSC-3-1-75	1-200	35	23	35	25	35	25	0.6	1.0	0.3	0.7	0.6	1.0	2	3	4	0.15	0.2	0.3	1.0	0.18
4 WAY - 0° 50 Ω								*Insertion Loss Above 6 dB*													
PSC-4-6	0.01-40	35	18	32	25	25	18	0.4	0.8	0.3	0.5	0.5	1.0	2	2	2	0.1	0.15	0.2	1.0	0.083
PSC-4-1	0.1-200	33	20	30	20	27	20	0.4	0.6	0.5	0.75	0.7	1.0	4	6	8	0.15	0.2	0.25	1.0	0.083
PSC-4-3	0.25-250	33	20	30	20	27	20	0.4	0.7	0.5	0.75	0.7	1.2	4	6	8	0.15	0.2	0.25	1.0	0.083
PSC-4-1W	1-500	29	20	27	18	25	18	0.4	0.8	0.5	1.0	0.8	1.5	1	3	5	0.2	0.3	0.5	0.5	0.083
PSC-4-5	1-800	29	20	24	18	25	17	0.4	0.8	0.6	1.5	1.3	2.5	1	4	5	0.2	0.5	0.6	0.5	0.083
PSC-4A-4	10-1000	25	20	21	15	18	15	0.5	0.8	0.8	1.8	1.5	2.5	4	16	20	0.2	0.5	0.7	1.0	0.083
4 WAY - 0° 75 Ω																					
PSC-4-1-75	1-200	30	20	25	20	25	20	0.4	0.7	0.5	0.9	0.7	1.2	2	3	4	0.15	0.2	0.3	1.0	0.083
PSC-4A-1W-75	30-600	27	20	—	—	22	18	0.6	0.8	—	—	0.8	1.1	2	—	5	0.2	—	0.5	1.0	0.083
5 WAY - 0° 50 Ω								*Insertion Loss Above 7 dB*													
PSC-5-1	1-300	25	20	23	18	20	17	0.2	0.5	0.6	1.0	1.5	2.0	2	4	8	0.2	0.3	0.6	1.0	0.125
PSC-5-2	250-750	22	17	22	17	22	17	1.1	2.5	1.1	2.5	1.1	2.5	14	14	14	0.7	0.7	0.7	2.0	0.156
5 WAY - 0° 75 Ω																					
PSC-5-1-75	1-300	35	20	30	18	25	17	0.4	0.6	0.6	0.9	0.9	1.3	2	4	8	0.2	0.3	0.6	1.0	0.125
6 WAY - 0° 50 Ω								*Insertion Loss Above 7.8 dB*													
PSC-6-1	1-175	35	25	30	23	25	18	0.6	1.2	0.6	1.1	0.6	1.3	2	4	8	0.2	0.3	0.6	1.0	0.100
6 WAY - 0° 75 Ω																					
PSC-6-1-75	1-300	35	25	30	23	25	18	0.6	1.2	0.6	1.1	0.6	1.3	2	4	8	0.2	0.3	0.6	1.0	0.100

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

MODEL PREFIX	FREQUENCY (MHz)	ISOLATION (dB)						INSERTION LOSS, (dB)						PHASE UNBALANCE DEGREES			AMPLITUDE UNBALANCE (dB)			INPUT RF Power Max (W)	
		L		M		U		L		M		U		L	M	U	L	M	U	S-Port (Matched output ports)	Output ports (Matched S port)
	f_L-f_U	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Max.	Typ.	Max.	Typ.	Max	Max.	Max.	Max.	Max.	Max.	Max.		
8 WAY - 0° 50 Ω								*Insertion Loss Above 9 dB*													
PSC-8-6	0.01-10	40	20	40	25	28	23	0.3	1.0	0.5	1.0	0.6	1.1	4.0	2.5	4.0	0.4	0.2	0.3	1.0	0.089
PSC-8-1	0.5-175	30	25	30	20	25	18	0.8	1.2	0.8	1.2	1.0	1.6	1.0	2.5	5.0	0.2	0.3	0.5	1.0	0.089
PSC-8A-4	5-500	25	20	23	18	20	15	0.7	1.2	1.0	1.8	1.4	2.5	3.0	8.0	16.0	0.2	0.3	0.5	1.0	0.089
PSC-8-1W	10-600	25	20	23	16	20	16	1.0	1.8	1.2	2.2	1.7	2.8	2.0	4.0	10.0	0.3	0.6	0.9	1.0	0.089
8 WAY - 0° 75 Ω																					
PSC-8-1-75	0.5-175	25	20	30	20	25	20	0.5	1.1	0.6	1.1	0.7	1.3	2.0	2.5	5.0	0.2	0.2	0.3	1.0	0.089
PSC-8A4-75	1-300	26	20	30	25	30	23	0.8	1.2	0.7	1.1	0.9	1.3	1.0	3.0	8.0	0.2	0.2	0.4	1.0	0.089
9 WAY - 0° 50 Ω								*Insertion Loss Above 9.6 dB*													
PSC-9-1	2-300	38	25	26	20	22	15	0.6	1.1	0.9	1.4	1.5	2.0	2.0	5.0	10.0	0.2	0.3	0.8	0.5	0.1
10 WAY - 0° 50 Ω								*Insertion Loss Above 10 dB*													
PSC-10-1	1-150	36	23	27	23	23	18	0.3	0.6	0.4	0.8	1.0	1.3	3	6	10	0.2	0.3	0.4	1.0	0.1
12 WAY - 0° 50 Ω								*Insertion Loss Above 10.8 dB*													
PSC-12-1	1-200	35	30	27	20	21	18	0.5	0.8	0.8	1.2	1.0	1.4	4	8	16	0.2	0.4	0.7	1.0	0.08

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

SWITCHES, PIN DIODE *(Hermetic)*

1 MHz to 3000 MHz

TOSW
Case QQ96

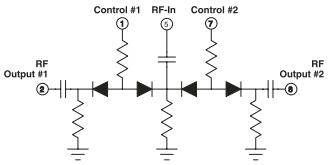
PSW
Case A06

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	TYPE	TTL DRIVER	INSERTION LOSS (dB) low-band lw Typ.	Max.	upper band U Typ.	Max.	IN-OUT ISOLATION (dB) Frequency Band L Typ.	Min.	M Typ.	Min.	U Typ.	Min.	RISE TIME (µsec) Typ.	SWITCHING TIME (µsec) Typ.	Max.
SPDT, SP4T																
PSW-1211	10-2500	SPDT		1.1	1.9	1.9	2.7	50	40	35	28	28	22	2	—	4
TOSW-230	10-3000	SPDT	•	1.3	1.9	1.8	2.7	60	40	40	28	35	22	—	2	4
TOSW-425	10-2500	SP4T	•	1.1	1.7	1.5	2.5	60	40	40	30	35	22	—	2	4

L = low range (f_L to $10f_L$) lw = low band (f_L to $f_U/2$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

ELECTRICAL SCHEMATICS & TRUTH TABLES

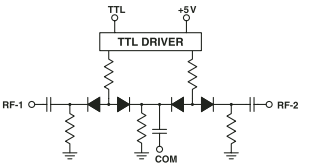
PSW-1211



Control Ports 1	2	RF Out port 1	2
0	V	OFF	ON
V	0	ON	OFF

V = 5 V

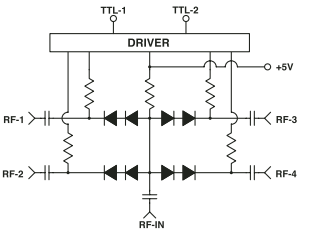
TOSW-230



TTL	RF Out port 1	2
Low	ON	OFF
High	OFF	ON

Low: 0 to 0.8 V
High: 2 to 5 V

TOSW-425



TTL-1	TTL-2	RF Out port 1	2	3	4
High	Low	ON	OFF	OFF	OFF
High	High	OFF	ON	OFF	OFF
Low	High	OFF	OFF	ON	OFF
Low	Low	OFF	OFF	OFF	ON

Low: 0 to 0.8 V
High: 2 to 5 V

TFAS
Case B02

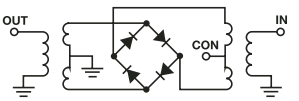
PAS-2000, GAS
Case A05

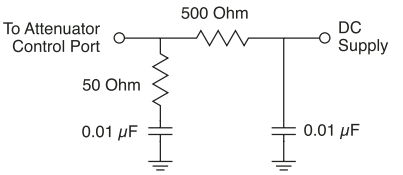
PAS
Case A01

MODEL PREFIX	FREQUENCY (MHz) In	Con	INSERTION LOSS (dB) (±20 mA) Mid-Band m Typ.	Max.	Total Range Typ.	Max.	MAXIMUM INPUT POWER (dBm) (±20 mA) 1 dB compr.	no damage	IN-OUT ISOLATION (0mA) Frequency Band L Typ.	Min.	M Typ.	Min.	U Typ.	Min.	BI-PHASE $\overline{X}$ (±20 mA) Typ. Δ AMP (dB) m	Total Range	Phase (deg) deviation from 180° m	Total Range
BI-PHASE																		
GAS-1	5-450	DC-0.05	3.3	4.0	3.5	5.0	20	25	60	48	45	35	35	25	0.10	0.10	1.0	1.5
GAS-2	10-1000	DC-0.05	4.3	6.0	5.2	8.5	20	25	55	40	35	25	28	20	0.10	0.30	1.5	3.0
PAS-1	5-450	DC-0.05	3.5	4.0	3.5	4.7	20	29	65	50	45	35	35	25	0.10	0.10	0.5	1.2
PAS-2	10-1000	DC-0.05	4.0	6.0	6.5	8.5	20	29	50	40	40	30	35	25	0.10	0.30	0.5	1.0
PAS-3	1-200	DC-0.05	1.4	2.0	1.6	2.5	15	29	65	50	50	40	50	35	0.10	0.10	0.5	1.0
PAS-2000	100-2000	DC-0.50	4.2	6.5	5.4	7.5	19	25	30	22	—	—	26	20	0.30	0.40	5.0	8.0
TFAS-1	2-400	DC-0.05	1.4	2.0	1.6	3.0	20	25	65	45	45	33	35	25	0.10	0.10	1.0	2.0
TFAS-2	10-1000	DC-0.50	3.7	4.5	5.0	8.0	17	25	50	30	42	20	31	20	0.10	0.20	2.0	3.0

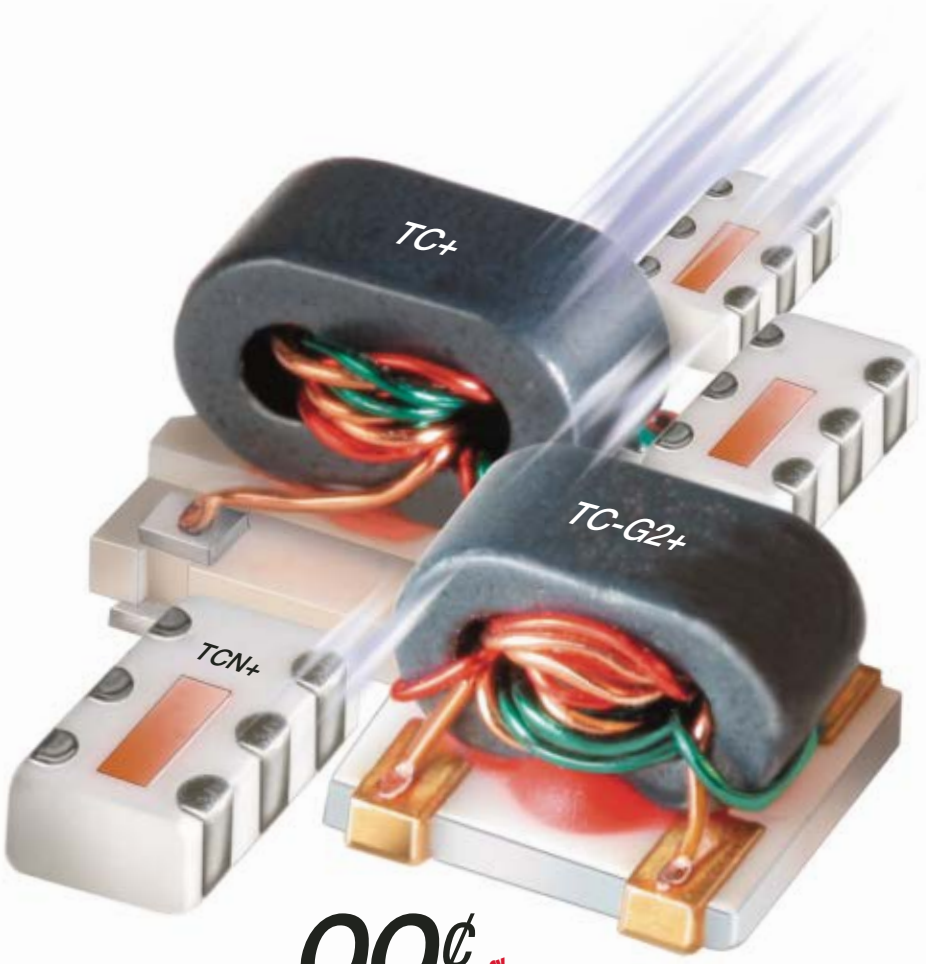
L = low range (f_L to $10f_L$) lw = low band (f_L to $f_U/2$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U) m = ($2f_L$ to $f_U/2$)

ELECTRICAL SCHEMATICS & SUGGESTED CONTROL PORT BIASING CONFIGURATION





TINY RF & MICROWAVE
TRANSFORMERS



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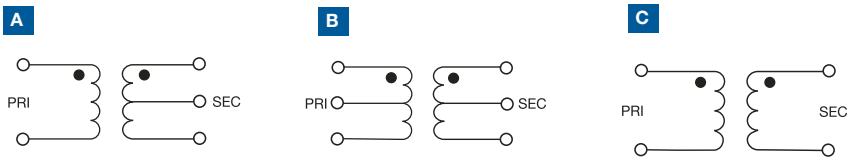
TRANSFORMERS, IF/RF MICROWAVE 50 Ω (Hermetic & Non Hermetic)

4 kHz to 800 MHz

Non Hermetic T, TT Case X65 | TO Case PP94 | TMO Case A11 | TMO, TTMO Case A03

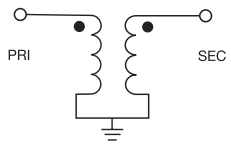
MODEL PREFIX	Ω RATIO (Secondary/Primary)	FREQUENCY (MHz)	INSERTION LOSS 3 dB MHz	2 dB MHz	1 dB MHz
A *Unbalanced to Balanced Center Tap (50 Ω to 800 Ω)*					
TMO1-1T	1	0.05 - 200	0.05 - 200	0.08 - 150	0.2 - 80
T1-1T-X65	1	0.08 - 200	0.08 - 200	0.15 - 150	0.2 - 80
T1-6T-X65	1	0.015 - 300	0.015 - 300	0.21 - 150	0.03 - 50
T2-1T-X65	2	0.07 - 200	0.07 - 200	0.1 - 100	0.5 - 50
TMO2-1T	2	0.07 - 200	0.07 - 200	0.1 - 100	0.5 - 50
T2.5-6T-X65	2.5	0.01 - 100	0.01 - 100	0.02 - 50	0.50 - 20
TMO2.5-6T	2.5	0.01 - 100	0.01 - 100	0.02 - 50	0.05 - 20
T3-1T-X65	3	0.05 - 250	0.05 - 200	0.1 - 200	0.5 - 70
TMO3-1T	3	0.05 - 250	0.05 - 250	0.1 - 200	0.5 - 70
T4-6T-X65	4	0.02 - 250	0.02 - 250	0.05 - 150	0.1 - 100
TMO4-1	4	0.2 - 350	0.2 - 350	0.35 - 300	2 - 100
T4-1-X65	4	0.2 - 350	0.2 - 350	0.35 - 300	2 - 100
T4-1H-X65	4	10 - 350	10 - 350	15 - 300	25 - 200
T5-1T-X65	5	0.3 - 300	0.3 - 300	0.6 - 200	5 - 100
TMO5-1T	5	0.3 - 300	0.3 - 300	0.6 - 200	5 - 100
T8-1T-X65	8	0.3 - 140	0.3 - 140	0.7 - 90	1 - 60
T13-1T-X65	13	0.3 - 120	0.3 - 120	0.7 - 80	5 - 20
TMO13-1T	13	0.3 - 120	0.3 - 120	0.7 - 80	5 - 20
T16-6T-X65	16	0.03 - 75	0.03 - 75	0.06 - 30	0.1 - 20
B *Balanced to Balanced Center Tap at Primary/Secondary (50 Ω to 1250 Ω)*					
TTMO1-1	1	0.005 - 100	0.005 - 100	0.01 - 75	0.05 - 40
TT1-6-X65	1	0.004 - 300	0.004 - 300	0.02 - 200	0.1 - 50
TT1.5-1-X65	1.5	0.075 - 500	0.075 - 500	0.2 - 100	1 - 50
TT2.5-6-X65	2.5	0.01 - 50	0.01 - 50	0.025 - 25	0.05 - 10
TT4-1-X65	3	0.05 - 200	0.05 - 200	0.2 - 50	1 - 30
TT4-1A-X65	4	0.1 - 300	0.1 - 300	0.2 - 250	0.3 - 180
TTMO4-1A	4	0.1 - 300	0.1 - 300	0.2 - 250	0.3 - 180
TT16-1-X65	16	0.1 - 45	0.1 - 45	0.14 - 35	1 - 20
TT25-1-X65	25	0.02 - 30	0.02 - 30	0.05 - 20	0.1 - 10
TTMO25-1	25	0.02 - 30	0.02 - 30	0.05 - 20	0.1 - 10

SCHEMATICS



MODEL PREFIX	Ω RATIO (Secondary/Primary)	FREQUENCY (MHz)	INSERTION LOSS 3 dB MHz	2 dB MHz	1 dB MHz
C *Balanced to Balanced (50 Ω to 1800 Ω)*					
T1-6-X65	1	0.01 - 150	0.01 - 150	0.02 - 100	0.05 - 50
T1-1H-X65	1	8 - 300	8 - 300	10 - 200	25 - 100
T1-1-X65	1	0.15 - 400	0.15 - 400	0.35 - 200	2 - 50
TMO1-1	1	0.15 - 400	0.15 - 400	0.35 - 200	2 - 50
TO-75	1	10 - 500	—	10 - 500	40 - 250
TMO1-02	1	1 - 800	1 - 800	2 - 500	—
T1.18-3-X65	1	0.01 - 250	0.01 - 250	0.02 - 200	0.03 - 50
T1.5-6-X65	1	0.02 - 100	0.02 - 100	0.05 - 50	0.1 - 25
T1.5-1-X65	1	0.1 - 300	0.1 - 300	0.2 - 150	0.05 - 80
T2-1-2W-X65	2	5 - 120	—	—	5 - 120
T2.5-6-X65	2	0.01 - 100	0.01 - 100	0.02 - 50	0.05 - 20
TMO-2.5-6	2	0.01 - 100	0.01 - 100	0.02 - 50	0.05 - 20
T4-6-X65	4	0.02 - 200	0.02 - 200	0.05 - 150	0.1 - 100
TMO4-6	4	0.02 - 200	0.02 - 200	0.05 - 150	0.1 - 100
T4-1-2W-X65	4	10 - 250	—	—	10 - 250
TMO6-1	6	0.3 - 200	0.3 - 200	0.5 - 150	5 - 50
T9-1H-X65	9	2 - 90	2 - 90	3 - 75	6 - 50
T9-1-X65	9	0.15 - 200	0.15 - 200	0.3 - 150	2 - 40
TMO9-1	9	0.15 - 200	0.15 - 200	0.3 - 150	2 - 40
T16-1H-X65	16	7 - 85	7 - 85	10 - 65	15 - 40
T16-1-X65	16	0.3 - 120	0.3 - 120	0.7 - 80	5 - 20
TMO16-1	16	0.3 - 120	0.3 - 120	0.7 - 80	5 - 20
T36-1-X65	36	0.03 - 20	0.03 - 20	0.05 - 10	0.1 - 5
D *Unbalanced to Unbalanced (50 Ω to 700 Ω)*					
T2-1-X65	2	0.050 - 600	0.050 - 600	0.1 - 400	0.5 - 200
TMO2-1	2	0.050 - 600	0.050 - 600	0.1 - 400	0.5 - 200
T3-1-X65	3	0.5 - 800	0.5 - 800	2.0 - 400	—
T4-2-X65	4	0.2 - 600	0.2 - 600	0.5 - 500	2 - 250
TMO4-2	4	0.2 - 600	0.2 - 600	0.5 - 500	2 - 250
T8-1-X65	8	0.15 - 250	0.15 - 250	0.25 - 200	2 - 100
T14-1-X65	14	0.2 - 150	0.2 - 150	0.5 - 100	2 - 50
TMO14-1	14	0.2 - 150	0.2 - 150	0.5 - 100	2 - 50
F *Single-ended to Balanced with Impedance Ratio Selection (50 Ω to 100 Ω)*					
T-622-X65	1:1:1	0.1 - 200	0.1 - 200	0.5 - 100	5 - 80
T-626-X65	1:1:1	0.01 - 10	0.01 - 10	0.02 - 5	0.04 - 2
T2-613-1-X65	1:1:2	0.07 - 200	0.07 - 200	0.1 - 100	0.5 - 50

D



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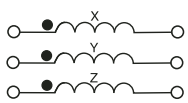

VOLTAGE CONTROLLED OSCILLATORS 50 Ω (Hermetic)

15 MHz to 2120 MHz

POS
Case A06

POSA
Case C07

MODEL PREFIX	FREQUENCY (MHz)		POWER OUTPUT (dBm)	TUNE VOLTAGE (V)		PHASE NOISE (dBc/Hz) SSB@ offset frequencies: Typ					PULLING (MHz) pk-pk @12 dBr	PUSHING (MHz/V)	TUNING SENSITIVITY (MHz/V)	HARMONICS (dBc)		3dB MOD. BANDWIDTH (kHz)	DC OPERATING POWER	
	Min.	Max.	Typ.	Min.	Max.	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz	Typ.	Typ.	Typ.	Typ.	Max.	Typ.	V_{CC} Volts	Current (mA) Max.
LINEAR TUNING WIDEBAND 15 MHz to 2120 MHz																		
POS-26	15	25	+7.0	1	11		-86	-105	-125	-145	0.06	0.04	1–4	-26	-15	60	12	20
POS-50	25	50	+8.5	1	16		-88	-110	-130	-150	0.06	0.04	2.0 –2.6	-19	-12	100	12	20
POS-75	37.5	75	+8.0	1	16		-87	-110	-130	-150	0.15	0.11	3.1–3.8	-27	-16	100	12	20
POS-100	50	100	+8.3	1	16		-83	-107	-130	-150	0.6	0.2	4.2–4.8	-23	-18	100	12	20
POS-150	75	150	+9.5	1	16		-80	-103	-127	-147	0.8	0.3	5.8–6.7	-23	-17	100	12	20
POS-200	100	200	+10.0	1	16		-80	-102	-122	-142	1.0	0.2	7.1–8.6	-24	-20	100	12	20
POS-300	150	280	+10.0	1	16		-78	-100	-120	-140	1.8	0.3	9.5 –13	-30	-20	100	12	20
POS-400	200	380	+9.5	1	16		-76	-98	-120	-140	1.8	0.3	13.7–16.9	-28	-20	100	12	20
POS-500W	250	500	+10.0	1	16		-79	-100	-120	-140	1.5	0.2	17–23	-25	-18	100	12	25
POS-535	300	525	+8.8	1	16		-70	-93	-116	-139	2.0	0.4	10.5–24	-26	-20	100	12	20
POS-765	485	765	+9.5	1	16		-61	-85	-108	-129	5.0	0.4	18–27	-21	-17	100	12	22
POS-800W	400	800	+8.0	0.5	18		-71	-93	-115	-137	3.0	0.5	18–50	-26	-18	100	10	25
POS-900W	500	900	+7.0	1	20		-75	-95	-115	-135	2.0	0.3	16–40	-26	-20	100	12	25
POS-1000W	500	1000	+7.0	1	16		-73	-93	-113	-133	6.0	1.5	30–42	-26	-20	100	12	20
POS-1025	685	1025	+9.0	1	16		-65	-84	-104	-124	5.0	0.6	21–36	-23	-18	100	12	22
POS-1060	750	1060	+12.0	1	20		-65	-90	-112	-132	50	3.0	18–32	-11	—	1000	8	30
POS-1400A	975	1400	+13.0	1	20		-65	-95	-115	-135	14	2.0	25–30	-16	—	4000	8	30
POS-2000A	1370	2000	+11.8	1	20		-73	-97	-117	-137	12	3.0	30–45	-24	-12	4000	8	30
POS-2120W	1060	2120	+8.0	0.5	20		-70	-97	-117	-137	27.0	2.5	35–120	-11	—	1000	12	28
POSA-138	118	138	+5.0	1	16	-72	-100	-125	-145	-163	0.07	0.03	2.3	-40	-30	2000	12	25
POSA-158	138	158	+5.0	1	16	-72	-100	-125	-145	-163	0.07	0.03	2.4	-40	-25	2000	12	25
POSA-960	800	960	+16.0	1	15	—	-84	-112	-130	-150	2.0	0.3	17-22	-30	-16	2000	15	50
5 V TUNING FOR PLL IC'S 24 MHz to 755 MHz																		
POS-50P	24	29	+10.0	0.5	5		-92	-113	-134	-151	0.06	0.04	2-2.5	-18	-12	50	12	20
POS-75P	35	43	+9.0	0.5	5		-91	-113	-135	-151	0.15	0.11	2.5-4	-25	-20	100	12	20
POS-100P	48	59	+9.0	0.5	5		-92	-112	-134	-151	0.8	0.2	3.5-5	-30	-18	100	12	20
POS-150P	72	91	+10.0	0.5	5		-84	-104	-126	-147	0.8	0.3	6-9	-25	-17	100	12	20
POS-200P	95	120	+10.0	0.5	5		-77	-102	-123	-146	1.0	0.2	7-10	-30	-20	100	12	20
POS-300P	148	174	+10.0	0.5	5		-83	-105	-125	-145	1.8	0.3	10-14	-27	-20	100	12	20
POS-400P	194	220	+10.5	0.5	5		-82	-103	-124	-142	1.8	0.3	13-18	-25	-20	100	12	20
POS-535P	278	325	+10.0	0.5	5		-66	-95	-120	-138	2.0	0.4	17-22	-30	-20	100	12	20
POS-765P	486	510	+9.5	0.5	5		-70	-92	-116	-135	5.0	0.4	20-30	-26	-20	100	12	22
POS-1025P	680	755	+8.5	0.5	5		-74	-96	-116	-135	5.0	0.6	30-40	-24	-18	100	12	22

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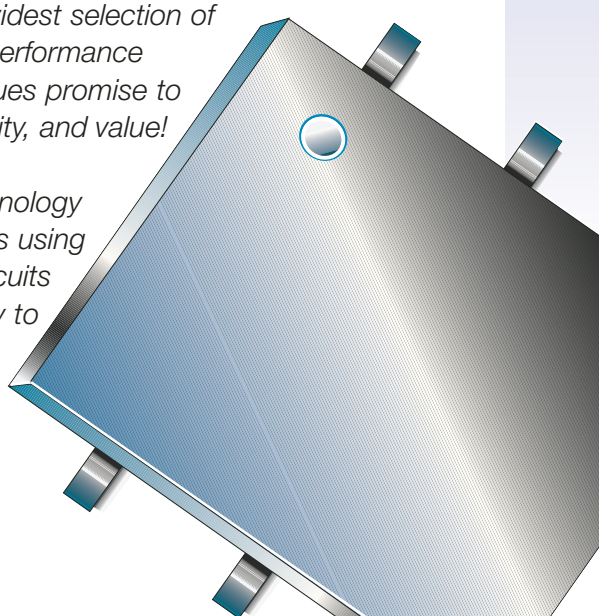


AMPLIFIERS *Monolithic, Broadband 50Ω*

DC to 8000 MHz

ERA-SM
Case WW107

Micro-X Plastic Package

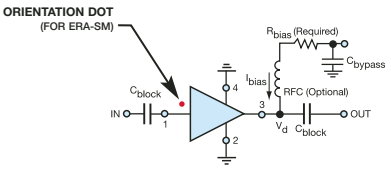
MODEL PREFIX	FREQ. (MHz) f_L-f_U	GAIN, TYPICAL (dB) OVER FREQUENCY, GHz 0.1	1	2	3	4	6	8	MAXIMUM POWER (dBm) Output (1 dB Comp.) Typ.		Input (no dmg)	DYNAMIC RANGE, NF (dB) Typ.	IP3 (dBm) Typ.	VSWR (:1) TYP. In DC-3 GHz	In 3-f_u GHz	Out DC-3 GHz	Out 3-f_u GHz	ABSOLUTE MAX. RATING I (mA)	P (mW)	DC OPERATING POWER @PIN 3 Current (mA)	Device Volt Typ.
LOW POWER *up to +13.5 dBm output NF from 2.8 dB*									*@ 2 GHz*			*@ 2 GHz*									
ERA-8SM	DC-2000	31.5	25.0	19.0	15.0	12.0	—	—	10.5	13		3.1	21.5	1.4	1.8	1.8	2.2	65	250	36	3.7
ERA-33SM	DC-3000	19.3	18.7	17.4	15.9	—	—	—	13.5	13		3.3	30.3	1.2	—	1.25	—	75	330	40	4.3
ERA-3SM	DC-3000	22.1	21.0	18.7	16.4	—	—	—	12.5	13		2.8	25.0	1.25	—	1.3	—	75	330	35	3.2
ERA-2SM	DC-6000	16.4	15.8	14.9	13.9	12.5	10.7	—	13.0	15		3.3	29.0	1.4	1.2	1.2	1.4	75	330	40	3.4
ERA-1SM	DC-8000	12.3	12.1	11.8	10.9	9.7	7.9	8.2	12.0	15		4.3	28.0	1.2	1.3	1.2	1.4	75	330	40	3.4
ERA-21SM	DC-8000	14.2	13.9	13.2	12.2	10.8	8.7	8.9	12.6	15		3.3	28.0	1.1	1.6	1.3	1.9	75	330	40	3.5
MEDIUM POWER *up to +18.4 dBm output NF from 3.5 dB*									*@ 1 GHz*			*@ 1 GHz*									
ERA-50SM	DC-2000	20.7	19.4	18.3	—	—	—	—	17.2	13		3.5	32.5	1.3	—	1.2	—	120	650	60	4.4
ERA-4SM	DC-4000	14.3	14.0	13.4	12.0	11.3	—	—	17.3	20		4.2	34.0	1.2	1.2	1.3	1.8	100	650	65	4.5
ERA-51SM	DC-4000	18.0	17.4	16.1	14.8	12.5	—	—	18.1	13		4.1	33.0	1.1	1.2	1.2	1.4	120	650	65	4.5
ERA-5SM	DC-4000	20.2	19.5	17.6	15.6	13.7	—	—	18.4	13		3.5	33.0	1.3	1.3	1.2	1.3	120	650	65	4.9
ERA-6SM	DC-4000	12.6	12.5	11.7	11.7	10.3	—	—	17.1	20		4.5	35.0	1.3	1.2	1.2	1.2	120	650	70	5.0
ERA-4XSM	DC-4000	14.7	14.2	13.5	12.0	11.3	—	—	17.0	20		4.2	35.0	1.2	1.2	1.2	1.4	100	650	65	4.5
ERA-5XSM	DC-4000	20.5	19.5	17.6	15.5	13.7	—	—	18.4	13		3.5	35.0	1.2	1.3	1.2	1.3	120	650	65	4.9

LEE
Case FG873

Low Profile 3 mm x 3 mm Plastic Package

MODEL PREFIX	FREQ. (MHz) f_L-f_U	GAIN, TYPICAL (dB) OVER FREQUENCY, GHz 0.1	1	2	4	5	8	10	MAXIMUM POWER (dBm) Typ. Output (1 dB Comp.) 2 GHz	f_U	Input (no dmg)	DYNAMIC RANGE, NF (dB) Typ.	IP3 (dBm) Typ.	VSWR (:1) In DC-3 GHz	In 3-f_u GHz	Out DC-3 GHz	Out 3-f_u GHz	MAXIMUM CURRENT RATING I (mA)	DC OPERATING POWER @PIN 3 Current (mA)	Device Volt Typ.
LOW POWER *up to +12 dBm output NF from 4.5 dB*																				
LEE-19	DC-8000	12.1	12.0	12.1	12.0	11.6	10.6	9.0	12.0	12.6	15	6.5	24.5	1.5	1.2	1.4	1.8	55	40	3.6
LEE-29	DC-8000	15.5	15.4	15.4	14.9	14.1	12.5	10.6	11.9	11.5	15	5.5	25.5	1.4	1.3	1.3	1.6	55	40	3.6
LEE-39	DC-8000	21.9	21.4	20.8	18.3	16.6	13.5	10.5	11.6	10.1	13	4.5	23.4	1.3	1.4	1.3	1.6	55	35	3.5
MEDIUM POWER *up to +17.3 dBm output NF from 4.5 dB*																				
LEE-49	DC-5000	14.0	13.9	14.3	14.0	13.1	7.8	-	16.7	10.7	15	5.5	33	1.6	1.2	1.4	1.4	85	65	4.9
LEE-59	DC-5000	20.6	20.3	19.7	15.8	13.8	7.6	-	17.3	11.5	13	4.5	33	1.5	1.5	1.5	1.6	85	65	4.8

ERA, LEE TYPICAL BIASING CONFIGURATION



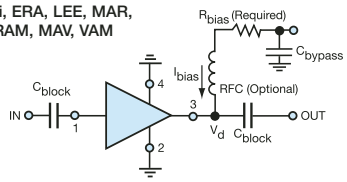
Gali,GVA Case DF782

SOT-89 Plastic Package

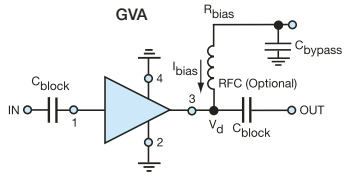
MODEL PREFIX	FREQ. (MHz) f_L-f_U	GAIN, TYPICAL (dB) OVER FREQUENCY, GHz 0.1	1	2	3	4	6	f_u	MAXIMUM POWER (dBm) @ 2 GHz Output (1 dB Comp.) Typ.	Input Typ.	DYNAMIC RANGE, @ 2 GHz NF (dB) Typ.	IP3 (dBm) Typ.	VSWR (:1) TYP In DC-3 GHz	In 3-f_u GHz	Out DC-3 GHz	Out 3-f_u GHz	ABSOLUTE MAX. RATING I (mA)	DC OPERATING POWER @PIN 3 Current (mA)	Device Volt Typ.
LOW POWER *up to +13.4 dBm output NF from 2.7 dB*																			
Gali S66	DC-3000	22.0	20.3	17.3	15.5	—	—	—	2.8	13	2.7	18.0	1.25	—	1.7	—	50	16	3.5
Gali 3	DC-3000	22.4	21.1	19.1	17.3	16.1	15.8	—	12.5	13	3.5	25.0	1.5	—	1.2	—	55	35	3.3
Gali 33	DC-4000	19.3	18.7	17.5	16.3	15.5	15.8	—	13.4	13	3.9	28.0	1.6	2.0	1.2	1.3	55	40	4.3
Gali 1	DC-8000	12.7	12.5	11.8	11.3	10.5	10.5	11.0	12.2	15	4.5	27.0	1.3	1.7	1.4	1.8	55	40	3.4
Gali 2	DC-8000	16.2	15.8	14.8	13.7	12.7	13.2	15.1	12.9	15	4.6	27.0	1.6	2.5	1.6	2.6	55	40	3.5
Gali 21	DC-8000	14.3	13.9	13.1	12.4	11.5	11.9	9.0	12.6	15	4.0	27.0	1.1	1.5	1.3	2.5	55	40	3.5
									@ f_u										
Gali 19	DC-7000	12.1	11.7	11.6	10.7	10.8	10.1	11.0	10.6	15	6.5	23.7	1.6	1.7	1.5	2.3	55	40	3.6
Gali 29	DC-7000	15.4	15.1	14.7	13.7	13.6	12.9	14.2	11.2	15	6.0	24.7	1.5	1.6	1.5	2.3	55	40	3.6
Gali 39	DC-7000	20.8	21.1	19.7	17.7	17.0	16.1	17.6	10.5	13	4.9	22.9	1.6	1.8	1.5	2.3	55	35	3.5
INTERMEDIATE POWER *up to +15.9 dBm output NF from 2.7 dB*																			
									@ 1 GHz		@ 1 GHz								
Gali 52	DC-2000	22.9	20.8	17.8	15.9	14.4	—	—	15.5	13	2.7	32.0	1.35	—	1.4	—	65	50	4.4
Gali 4F	DC-4000	14.3	14.0	13.4	13.0	12.3	13.2	—	15.3	20	4.0	32.0	1.2	1.2	1.5	1.8	65	50	4.4
Gali 51F	DC-4000	18.0	17.3	15.9	14.8	13.4	13.3	—	15.9	13	3.5	32.0	1.2	1.3	1.5	1.7	65	50	4.4
Gali 55	DC-4000	21.9	20.6	18.5	17.0	15.5	15.7	—	15.0	13	3.3	28.5	1.25	1.35	1.3	1.5	65	50	4.3
Gali 5F	DC-4000	20.4	19.3	17.4	16.0	14.8	15.1	—	15.7	13	3.5	31.5	1.2	1.2	1.4	1.4	65	50	4.3
Gali 6F	DC-4000	12.1	12.0	11.6	11.4	10.9	12.3	—	15.8	20	4.5	35.5	1.5	1.5	1.9	2.2	65	50	4.8
MEDIUM POWER *up to +18.3 dBm output NF from 2.7 dB*																			
								7 GHz											
Gali 4	DC-4000	14.4	14.1	13.5	12.9	12.5	13.1	—	17.5	20	4.0	34.0	1.2	1.2	1.4	1.7	85	65	4.6
Gali 5	DC-4000	20.6	19.4	17.5	16.0	14.9	15.1	—	18.0	13	3.5	35.0	1.2	1.2	1.4	1.4	85	65	4.4
Gali 51	DC-4000	18.1	17.5	16.1	14.7	13.7	—	—	18.0	13	3.5	35.0	1.3	1.2	1.5	1.7	85	65	4.5
Gali 6	DC-4000	12.2	12.2	11.8	11.3	11.4	12.3	—	18.2	20	4.5	35.5	1.5	1.4	1.8	2.0	85	70	5.0
Gali 49	DC-5000	14.0	13.7	13.6	13.7	13.3	13.1	10.7	16.4	20	5.5	33.3	1.7	1.2	1.5	1.4	85	65	5.0
Gali 59	DC-5000	20.6	19.7	18.3	16.7	15.4	—	10.2	17.6	13	4.3	33.3	1.6	1.5	1.5	1.7	85	65	4.8
											@ 0.1 GHz								
Gali 74	DC-1000	25.1	21.8	18.0	15.3	13.4	—	—	18.3	10	2.7	38.0	1.2	—	1.6	—	130	80	4.8
HIGH POWER *up to +21.2 dBm output NF from 4.2 dB*																			
									@ 2 GHz		@ 2 GHz								
Gali 24	DC-6000	25.3	22.6	19.1	16.6	14.9	12.4	—	19.4	13	4.2	36.3	1.25	1.4	1.9	2.2	160	80	5.8
Gali 84	DC-6000	25.6	22.7	19.2	16.7	15.0	11.8	—	21.2	13	4.4	38.0	1.2	1.4	1.9	2.2	160	100	5.8
																		TYP	*NOM.*
GVA-84+	DC-6000	24.1	21.7	18.4	16.0	14.6	12.5	—	20.6	13.0	5.5	36.6	1.2	1.3	2.0	3.0	160	108	5.0

RECOMMENDED APPLICATION CIRCUITS

Gali, ERA, LEE, MAR, RAM, MAV, VAM



GVA



AMPLIFIERS *Monolithic, Broadband 50 Ω*

DC to 2000 MHz

RAM
Case AF190

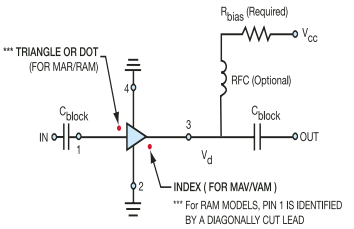
MAR-SM
Case WW107, WW107-1

MAV-SM
Case RRR137, RRR137-1

VAM
Case MMM168

MODEL PREFIX	FREQ. (MHz) f_L-f_U	GAIN (dB) TYPICAL at (MHz) 100	1000	2000	MAXIMUM POWER (dBm) Output (1 dB Comp.) Typ.	Input (no damage)	DYNAMIC RANGE NF (dB) Typ.	IP3 (dBm) Typ.	VSWR, (:1) Typ. In	Out	ABSOLUTE MAX. RATING (25°C) I (mA)	P (mW)	DC OPERATING POWER @PIN 3 Current (mA)	Device Volt Typ.
CERAMIC MICRO-X PACKAGE up to 12.5 dBm output NF from 2.8 dB														
RAM-1	DC-1000	19.0	15.5	—	+1.5	+13	5.5	+14.0	1.3	1.3	40	200	17	5.00
RAM-2	DC-2000	12.5	11.8	11.0	+4.5	+13	6.5	+17.0	1.2	1.4	60	325	25	5.00
RAM-3	DC-2000	12.5	12.0	10.5	+10.0	+13	6.0	+23.0	1.6	1.7	80	425	35	5.00
RAM-4	DC-1000	8.5	8.0	—	+12.5	+13	6.5	+25.5	1.4	1.9	100	540	50	5.25
RAM-6	DC-2000	20.0	16.0	11.0	+2.0	+13	2.8	+14.5	1.4	1.3	50	200	16	3.50
RAM-7	DC-2000	13.5	12.5	11.0	+5.5	+13	4.5	+19.0	2.0	1.8	60	275	22	4.00
RAM-8	DC-1000	32.5	23.5	—	+12.5	+13	3.0	+27.0	#	#	65	420	36	7.80
MICRO-X PLASTIC PACKAGE up to 18.5 dBm output NF from 3.0 dB														
MAR-1SM	DC-1000	17.8	16.5	—	+2.5	+13	3.3	+14.0	1.3	1.2	40	200	17	5.00
MAR-2SM	DC-2000	12.5	12.0	11.0	+7.0	+13	3.7	+22.0	1.3	1.3	60	325	25	5.00
MAR-3SM	DC-2000	12.5	12.0	10.5	+10.0	+13	3.7	+28.0	1.3	1.3	70	400	35	5.00
MAR-4SM	DC-1000	8.3	8.0	—	+12.5	+13	6.0	+25.5	1.5	1.9	85	500	50	5.25
MAR-6SM	DC-2000	22.0	20.0	17.0	+3.0	+13	3.0	+14.5	1.3	1.3	50	200	16	3.50
MAR-7SM	DC-2000	13.5	12.5	11.0	+5.5	+13	3.5	+19.0	1.3	1.3	60	275	22	4.00
MAR-8ASM	DC-1000	31.5	25.0	—	+12.5	+13	3.1	+25.0	1.4	1.8	65	250	36	3.70
MAR-8SM	DC-1000	32.5	22.5	—	+12.5	+13	3.3	+27.0	#	#	65	500	36	7.80
MAV-11BSM	50-1000	12.7	11.3	9.5	+18.0	+13	4.4	+34.0	1.2	1.2	80	460	60	5.50
MAV-11SM	50-1000	12.7	10.5	—	+17.5	+13	3.6	+30.0	1.5	1.7	80	550	60	5.50
SOT PLASTIC PACKAGE up to 9 dBm output NF from 3.0 dB														
VAM-3	DC-2000	11.5	11.0	9.5	+9.0	+13	6.0	+22.0	1.5	1.7	60	240	35	4.70
VAM-6	DC-2000	19.5	15.0	10.0	+2.0	+13	3.0	+14.0	1.6	1.5	40	125	16	3.30
VAM-7	DC-2000	13.0	12.0	9.8	+5.5	+13	5.0	+18.0	1.5	1.5	50	175	22	3.80

RAM, MAR, MAV, VAM TYPICAL BIASING CONFIGURATION



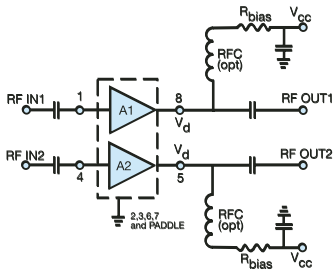
MERA
Case DL805

MERA
Case DL1020

MODEL PREFIX	FREQ. (MHz) f_L-f_U	GAIN TYPICAL, (dB) OVER FREQUENCY, GHz 0.1	1	2	3	4	MAXIMUM POWER (dBm) Output (1 dB Comp.) Typ. 0.1 GHz	1.0 GHz	2.0 GHz	Input (no dmg.)	DYNAMIC RANGE NF (dB) Typ.	IP3 0.1 GHz	(dBm) 0.5 GHz	Typ. 1.0 GHz	VSWR (:1) TYP. In	Out	MAX. RATING I (mA)	P (mW)	DC OPERATING POWER PIN 5, PIN 8 Current (mA)Typ.	Volt Min.Max.	MATCHING Amplitude Match* dB, Typ.		Phase Match* deg., Typ.	
MEDIUM POWER																								
																					DC-1 GHz	1-4 GHz	DC-1 GHz	1-4 GHz
MERA-7456	DC-1000	25.1	22.5	18.6	14.2	9.4	19.0	18.2	14.4	10	2.7	36	35	32	1.3	2.0	130	700	80	4.8	0.10	0.1	0.6	1.0
MERA-7433	DC-1000	25.0	22.4	19.0	16.2	13.4	19.0	18.3	14.8	10	2.7	36	35	32	1.25	1.8	130	700	80	4.8	0.15	0.3	0.5	1.0
																					DC-2.2 GHz	2.2-4 GHz	DC-2.2 GHz	2.2-4 GHz
MERA-556	DC-2200	20.5	20.2	19.0	16.7	13.0	18.0	17.6	16.6	13	3.5	35	35.5	34	1.2	1.4	120	650	65	4.9	0.10	0.1	0.6	1.5
MERA-533	DC-4000	20.5	20.0	18.8	17.5	16.0	17.9	17.5	16.7	13	3.5	35	34	33	1.4	1.5	120	650	65	4.9	0.05	0.1	0.7	2.0

*Matching between the 2 amplifiers

MERA TYPICAL BIASING CONFIGURATION



AMPLIFIERS *High Directivity Supplied Voltage 2.8 to 5.0 Volts, DC 50 Ω*

500 MHz to 5900 MHz

VNA
Case XX211, XX211-1

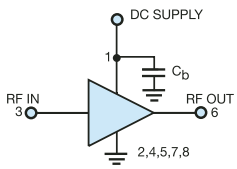
MODEL PREFIX	FREQ. (MHz) f_L-f_U	DC VOLTS (V)	GAIN (dB) TYPICAL OVER FREQUENCY, GHz 0.5	1.0	1.5	2.0	2.5	MAXIMUM POWER (dBm) Output (1 dB Comp.) Typ.	DYNAMIC RANGE NF(dB) @1 GHz Typ.	IP3 (dBm) Typ.	VSWR (:1) Typ. In	Out	DIRECTIVITY (dB) (Isolation-Gain) Typ.	DC OPERATING CURRENT @PIN 3 (mA) Typ.
SOIC-8 LEAD PLASTIC PACKAGE up to 18.2 dBm output NF from 3.7 dB														
VNA-22	500-2500	5.0	10.3	13.3	13.8	13.3	12.2	17.0	6.7	29	1.6	1.4	17-27	80
		2.8	9.6	12.3	12.6	11.9	10.8	14.0	7.0	26	1.6	1.5	17-29	72
VNA-23	500-2500	5.0	15.1	18.6	18.3	16.9	14.6	10.0	4.7	21	1.5	1.3	15-20	32
		2.8	14.6	17.6	17.1	15.9	13.9	8.5	4.7	19	1.5	1.5	14-21	29
VNA-25	500-2500	5.0	15.5	18.0	18.6	17.8	16.0	18.2	5.5	29	1.5	1.6	18-24	85
		2.8	14.5	16.7	17.4	17.0	15.5	12.0	5.5	24	1.5	1.6	16-25	80
VNA-28	500-2500	5.0	18.1	22.4	22.8	21.6	18.3	11.0	3.7	22	1.6	1.5	16-20	33
		2.8	17.5	21.1	21.0	20.1	17.5	9.6	3.7	19.6	1.6	1.6	15-21	30

MNA
Case DQ849

MODEL PREFIX	FREQ. (MHz) f_L-f_U	DC VOLTS (V)	GAIN (dB) TYPICAL OVER FREQUENCY, GHz 0.5	1.0	1.5	2.0	2.5	MAXIMUM POWER (dBm) Output (1 dB Comp.) Typ. f_L	f_U	DYNAMIC RANGE NF (dB) Typ. @1 GHz	IP3 (dBm) Typ. @1 GHz	@2 GHz	VSWR (:1) Typ. In	Out	DIRECTIVITY (dB) (Isolation-Gain) Typ.	DC OPERATING CURRENT (mA) Typ.
LOW PROFILE PLASTIC PACKAGE 3 mm x 3 mm up to 19.0 dBm output NF from 2.9 dB																
MNA-2	500-2500	5.0	10.6	12.8	12.8	12.3	11.9	17.7	17.9	5.4	26.5	28.0	1.5	1.6	20	76
		2.8	9.6	11.5	11.2	10.7	10.2	12.9	12.4	5.4	23.2	24.2	1.5	1.6	20	60
MNA-3	500-2500	5.0	14.6	16.2	16.1	15.0	11.8	11.4	9.5	4.9	19.6	21.3	1.9	1.5	17	30
		2.8	14.2	15.2	15.0	14.0	11.0	9.7	8.0	4.8	18.0	19.9	1.9	1.5	17	28
MNA-4	500-2500	5.0	15.6	16.6	16.4	15.8	13.3	19.0	17.0	4.8	28.4	29.0	1.5	1.7	20	75
		2.8	14.3	14.6	14.5	14.1	11.7	13.4	13.7	4.8	23.9	24.9	1.5	1.7	20	67
MNA-5	500-2500	5.0	18.5	22.8	21.9	20.6	18.0	12.2	8.0	3.5	19.4	21.0	1.6	1.9	17	28
		2.8	18.0	21.4	20.5	19.4	17.4	10.1	6.5	3.5	18.0	20.0	1.6	1.9	17	26
MNA-6	500-2500	5.0	19.4	23.5	23.6	23.0	20.2	18.0	15.8	2.9	27.1	28.0	1.5	1.6	17	81
		2.8	18.6	21.5	21.2	21.0	19.0	14.1	13.2	2.9	23.4	25.0	1.5	1.9	17	65
				over frequency, GHz												
			1.5	**2.0**	**3.5**	**5.0**	**5.9**			**@2 GHz**	**@2 GHz**	**@5.9 GHz**				
MNA-7	1500-5900	5.0	15.9	17.2	17.4	17.2	10.8	15.6	15.9	6.9	28.4	28.6	2.0	1.5	20	73
		2.8	13.7	15.4	15.8	16.7	9.8	12.7	13.1	6.9	24.1	23.8	2.0	1.5	24	65

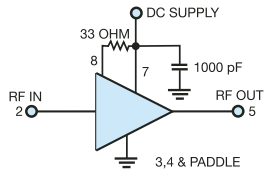
TYPICAL BIASING CONFIGURATIONS

VNA Models



C_b=100 pF to 10nF

MNA Models



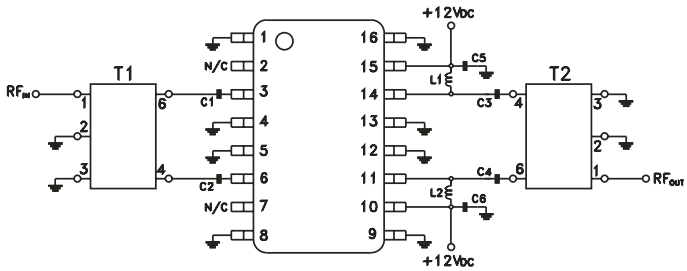
HELA
Case CM624

KIT No. PREFIX*	APPLICATION CHART	FREQUENCY (MHz) f_L-f_U	OHMS	GAIN (dB) TYPICAL at MHz Min.	Typ.	Max.	Typ. Flatness	MAXIMUM POWER (dBm) Output (1 dB Comp.) Typ.	Min.	Input (no damage)	DYNAMIC RANGE NF (dB) Typ.	IP3 (dBm) Typ.	VSWR (:1) Typ. In	Out	DC POWER Volt Typ.	Current (mA)
up to 30 dBm output NF from 3.5 dB																
HELA-10A	A	50-1000	75	9.5	12.0	13.0	±0.4	30	26	20	3.5	47	1.22	1.22	12	525
HELA-10B	B	50-1000	50	9.5	12.0	13.0	±0.4	30	26	20	3.5	47	1.22	1.22	12	525
HELA-10C	C	5-450	75	9.3	11.4	12.5	±0.4	30	26	20	3.5	48	1.30	1.22	12	525
HELA-10D	D	8-300	50	9.3	11.0	12.5	±0.4	30	26	20	3.5	48	1.20	1.20	12	525

*Kit Contains HELA-10 plus Transformers (T1 & T2)

APPLICATION CIRCUIT	T1	T2	C1 to C6	L1, L2	PCB LAYOUT	EVALUATION BOARD
HELA-10A	ADTL1-18-75	ADTL1-18-75	0.01µF	0.75µH	B14-TB-30	TB-16
HELA-10B	ADTL1-12	ADTL1-12	0.01µF	0.75µH	B14-TB-17	TB-17
HELA-10C	ADT1-1WT	ADTL1-4-75	0.039µF	3.3µH	B14-TB-16	TB-30
HELA-10D	ADTL1.5-1	ADTL1.5-1	0.039µF	3.3µH	B14-TB-17	TB-45

APPLICATION SCHEMATIC DIAGRAM *(see table above for values C1 to C6, L1&L2)*



ATTENUATORS, FIXED 50 Ω

0 to 30 dB, DC to 8000 MHz

Low Profile 3 mm x 3 mm Plastic Package 1/2 W

GAT
Case FG873

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ATTENUATION, (dB) Nom.	FLATNESS, Typ. L	M	U	VSWR (:1) TYP L	M	U	MAX. INPUT POWER, W 25°C
GAT-0	DC-8000	0+0.2	0.10	0.20	0.20	1.05	1.15	1.25	0.5
GAT-1	DC-8000	1±0.2	0.10	0.20	0.20	1.05	1.15	1.30	0.5
GAT-2	DC-8000	2±0.2	0.10	0.20	0.20	1.05	1.15	1.30	0.5
GAT-3	DC-8000	3±0.3	0.10	0.20	0.20	1.05	1.15	1.35	0.5
GAT-4	DC-8000	4±0.3	0.10	0.20	0.20	1.05	1.15	1.35	0.5
GAT-5	DC-8000	5±0.3	0.10	0.20	0.20	1.05	1.15	1.35	0.5
GAT-6	DC-8000	6±0.3	0.10	0.20	0.30	1.05	1.15	1.35	0.5
GAT-7	DC-8000	7±0.3	0.10	0.20	0.30	1.05	1.15	1.35	0.5
GAT-8	DC-8000	8±0.4	0.10	0.20	0.30	1.05	1.15	1.35	0.5
GAT-9	DC-8000	9±0.4	0.10	0.20	0.30	1.05	1.15	1.30	0.5
GAT-10	DC-8000	10±0.4	0.15	0.20	0.30	1.05	1.15	1.30	0.5
GAT-12	DC-8000	12±0.4	0.15	0.20	0.30	1.05	1.15	1.30	0.5
GAT-15	DC-8000	15±0.4	0.15	0.30	0.30	1.05	1.15	1.35	0.5
GAT-20	DC-8000	20±0.4	0.15	0.20	0.20	1.05	1.15	1.35	0.5
GAT-30	DC-3000	30±0.9	0.50	1.20	—	1.05	1.15	—	0.5

L = low range (DC to 1000 MHz) M = mid range (1000 to 5000 MHz) U = upper range (5000 to 8000 MHz)

LAT
Case MMM168

PAT
Case AF320

SOT Plastic Package 1/2 W

MODEL PREFIX	FREQUENCY RANGE (MHz) f_L-f_U	ATTENUATION, (dB) Nom.	FLATNESS, Max. L	M	U	VSWR (:1) Max. L	M	U	MAX. INPUT POWER, W 25°C
LAT-0	DC-2500	0±.15	0.3	0.4	0.6	1.2	1.3	1.5	0.5
LAT-1	DC-2500	1±0.3	0.3	0.4	0.7	1.2	1.3	1.5	0.5
LAT-2	DC-2500	2±0.3	0.3	0.4	0.7	1.2	1.3	1.5	0.5
LAT-3	DC-2500	3±0.3	0.3	0.4	0.7	1.2	1.3	1.5	0.5
LAT-4	DC-2500	4±0.3	0.3	0.4	0.7	1.2	1.3	1.5	0.5
LAT-5	DC-2500	5±0.3	0.3	0.4	0.7	1.3	1.3	1.5	0.5
LAT-6	DC-2500	6±0.3	0.3	0.4	0.7	1.3	1.4	1.5	0.5
LAT-7	DC-2500	7±0.3	0.3	0.4	0.7	1.3	1.4	1.5	0.5
LAT-8	DC-2500	8±0.4	0.3	0.5	0.8	1.3	1.4	1.5	0.5
LAT-9	DC-2500	9±0.4	0.3	0.5	0.8	1.3	1.4	1.5	0.5
LAT-10	DC-2500	10±0.5	0.3	0.5	0.8	1.3	1.4	1.5	0.5
LAT-12	DC-2500	12±0.8	0.3	0.5	0.8	1.3	1.4	1.6	0.5
LAT-15	DC-2500	15±0.8	0.3	0.5	0.9	1.3	1.4	1.6	0.5
LAT-20	DC-2500	20±1.5	0.3	0.5	0.9	1.3	1.4	1.6	0.5
LAT-30	DC-1000	30±1.7	0.5	1.2	—	1.2	1.3	—	0.5

L = low range (DC to 500 MHz) M = mid range (DC to 1000 MHz) U = upper range (DC to 2500 MHz)

Ceramic Micro-X Package 1 W

PAT-0	DC-5000	0±0.2	0.2	0.4	0.5	1.2	1.3	1.55	1.0
PAT-1	DC-7000	1±0.2	0.3	0.4	0.7	1.2	1.3	1.5	1.0
PAT-2	DC-7000	2±0.2	0.3	0.5	0.9	1.2	1.3	1.5	1.0
PAT-3	DC-7000	3±0.3	0.3	0.5	0.9	1.2	1.3	1.5	1.0
PAT-4	DC-7000	4±0.3	0.3	0.5	0.9	1.2	1.3	1.4	1.0
PAT-5	DC-7000	5±0.3	0.3	0.5	1.0	1.2	1.3	1.4	1.0
PAT-6	DC-7000	6±0.3	0.3	0.5	1.1	1.2	1.3	1.4	1.0
PAT-7	DC-7000	7±0.3	0.4	0.6	1.3	1.3	1.4	1.5	1.0
PAT-8	DC-7000	8±0.4	0.4	0.6	1.5	1.3	1.4	1.5	1.0
PAT-9	DC-7000	9±0.4	0.4	0.6	1.7	1.3	1.4	1.5	1.0
PAT-10	DC-7000	10±0.4	0.4	0.6	1.7	1.3	1.4	1.5	1.0
PAT-12	DC-7000	12±0.6	0.5	0.6	1.8	1.3	1.4	1.5	1.0
PAT-15	DC-7000	15±0.6	0.5	0.7	2.4	1.3	1.4	1.5	1.0
PAT-20	DC-7000	20±1.3	0.5	0.7	2.6	1.4	1.4	1.5	1.0
PAT-30	DC-7000	30±1.7	0.4	0.9	2.8	1.4	1.4	1.5	1.0

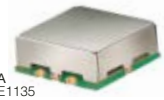
L = low range (DC to 1000 MHz) M = mid range (DC to 2500 MHz) U = upper range (DC to f_U MHz)

ATTENUATORS, VOLTAGE VARIABLE

10 to 3000 MHz

Shielded Metal Package

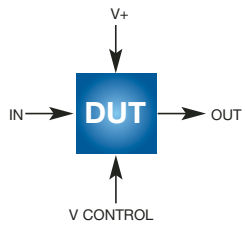

MVA
Case GP1212


EVA
Case HE1135


RVA
Case DV874

MODEL PREFIX	FREQUENCY RANGE (MHz) Min.	Max.	MIN. INSERTION LOSS (dB) @ control voltage Typ.	Max.	MAX. ATTENUATION (dB) @ 0 V control voltage Typ.	Min.	IP3 (dBm) Typ.	RETURN LOSS (dB) Typ.	POWER SUPPLY Voltage (V)	Current (mA) Max.	CONTROL Voltage (V)	Current (mA) Max.
50 Ω												
MVA-1000	***50-1000***		3.6	4.7	13	11.5	+52	20	+5	3	0-5	15
RVA-2000	***150-2000***											
	150-500		2.8	3.5	46	34	+53	23	+5	10	0-17	30
	500-1500		3.0	4.5	35	23	+56	22	+5	10	0-17	30
	1500-2000		3.5	5.0	29	20	+57	21	+5	10	0-17	30
RVA-2500	***10-2500***											
	10-500		3.0	4.6	55	41	+43	20	+3 to +5	5	0-17	30
	500-1500		3.3	5.0	40	30	+43	20	+3 to +5	5	0-17	30
	1500-2500		4.0	6.2	37	25	+44	20	+3 to +5	5	0-17	30
RVA-3000	***20-3000***											
	20-500		2.8	3.5	56	39	+48	23	+5	10	0-17	30
	500-1500		3.0	4.0	40	28	+56	26	+5	10	0-17	30
	1500-3000		3.6	5.0	29	22	+57	21	+5	10	0-17	30
EVA-3000	***50-3000***											
	50-1000		2.5	4.0	43	27	+41	21	+5	5	0-8	40
	1000-2000		3.0	4.5	29	21	+45	22	+5	5	0-8	40
	2000-3000		3.5	5.5	24	17	+44	18	+5	5	0-8	40
75 Ω												
EVA-2-75	***50-2000***											
	50-1000		2.5	3.5	40	25	+48	27	+5	3	0-8	40
	1000-2000		3.0	4.7	24	20	+51	20	+5	3	0-8	40

EVA, RVA, MVA FUNCTIONAL DIAGRAM

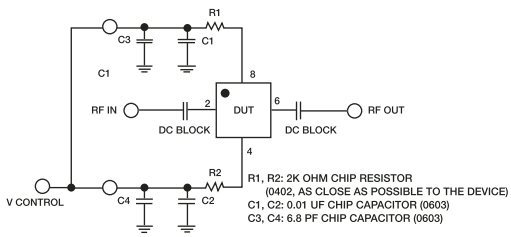


LTCC Miniature Package, 50 Ω


VACC
Case GF995

MODEL PREFIX	FREQUENCY RANGE (MHz) Min.	Max.	INSERTION LOSS (dB) @ 0 V control voltage Typ.	Max.	ATTENUATION (dB) Typ.	Min.	IP3 (dBm) Typ.	Min.	RETURN LOSS (dB) Input Typ.	Output Typ.	CONTROL Voltage (V)	Current (mA) Max.
VACC-09	600-1200		1.0	2.2	25	20	48	40	20	20	0-6	10
VACC-22	1600-2200		1.2	1.5	25	23	42	38	20	20	0-5	10

VACC Recommended Control Port Biasing Configuration



ATTENUATORS *Bi-Phase, Variable*

2 MHz to 1000 MHz

RAS
Case TT240, 241

LRAS
Case QQQ130

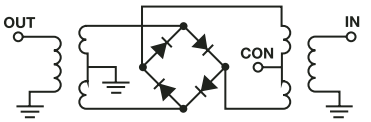
TFAS-SM
Case NNN150

SYAS
Case TTT166, TTT167

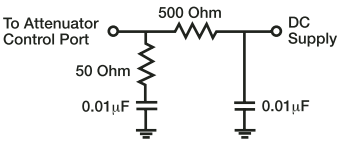
MODEL PREFIX	FREQUENCY (MHz)		INSERTION LOSS, (dB) (±20 mA)				MAX. INPUT PWR. (dBm), (±20 mA)		IN-OUT ISOLATION, (dB) (0 mA)						BI-PHASE $\overline{X}$, (±20 mA) Typ.			
			Mid-Band m		Total Range				L		M		U		Δ AMP (dB)		Phase (deg.) deviation from 180°	
	IN f_L-f_U	CON	Typ.	Max.	Typ.	Max.	1 dB compr. Typ.	no damage	Typ.	Min.	Typ.	Min.	Typ.	Min.	m	Total Range	m	Total Range
50 Ω																		
TFAS-1SM	2-400	DC-0.05	1.4	2.0	1.6	3.0	20	25	65	45	45	33	35	25	0.10	0.1	1.0	2.0
TFAS-2SM	10-1000	DC-0.5	3.7	4.5	5.0	8.0	17	25	50	30	42	20	31	20	0.10	0.2	2.0	3.0
SYAS-1	2-400	DC-0.05	1.4	2.0	1.6	3.0	20	25	65	45	45	33	35	25	0.10	0.1	1.0	2.0
SYAS-2	10-1000	DC-0.05	4.0	6.0	4.5	7.0	17	25	59	40	42	28	28	20	0.10	0.3	2.0	3.0
SYAS-860	600-1000	DC-0.5	—	—	2.7	5.7	14	25	25	(typ.)		18	(min.)		—	0.5	—	4.0
RAS-1	2-400	DC-0.05	1.4	2.4	1.6	3.2	20	25	65	45	45	28	32	22	0.10	0.1	1.0	2.0
75 Ω																		
RAS-2-75	10-1000	DC-0.05	4.1	6.0	4.5	7.5	20	25	58	40	42	28	39	20	0.15	0.3	1.5	3.0
LRAS-2-75	10-1000	DC-0.05	4.1	6.0	4.5	7.5	20	25	58	40	42	28	39	20	0.15	0.3	1.5	3.0

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)
m = mid band ($2f_L$ to $f_U/2$)

ELECTRICAL SCHEMATIC



SUGGESTED CONTROL PORT BIASING CONFIGURATION



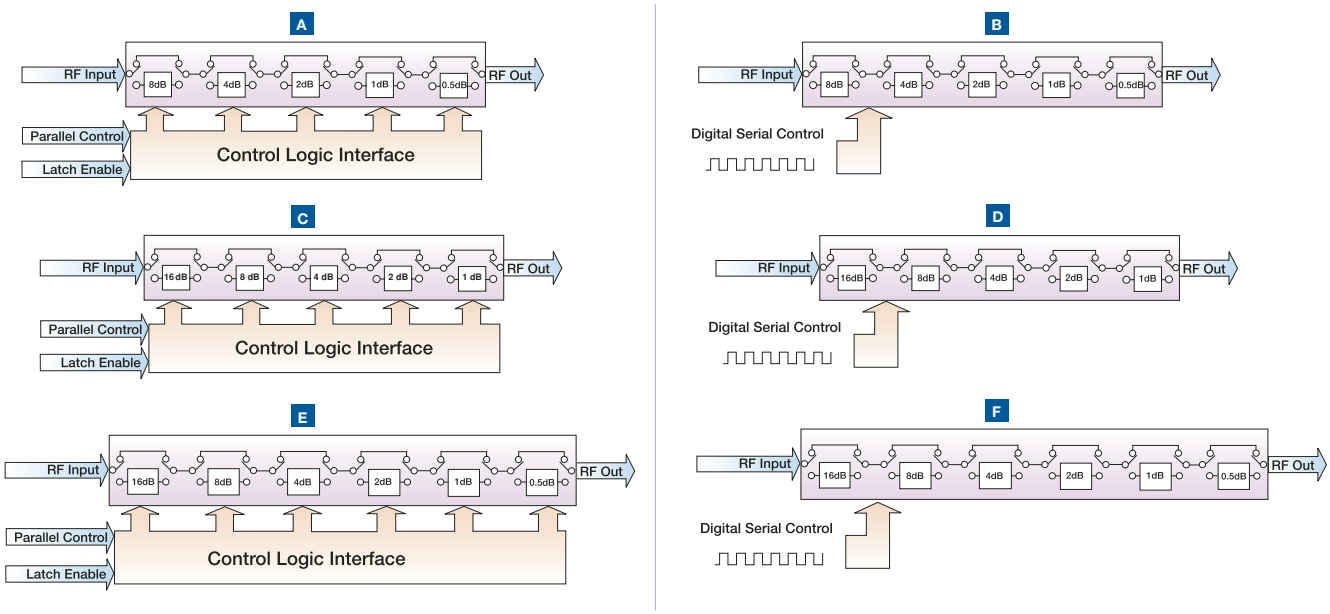
ATTENUATORS, DIGITAL STEP, CMOS

DC to 4000 MHz

DAT
Case DG983-1

MODEL PREFIX	FREQUENCY RANGE (MHz)	ATTENUATION (dB) Typ.	ATTENUATION STEP (dB)	INPUT IP3 (dBm) Typ.	SINGLE POWER SUPPLY (Vdd)	DUAL POWER SUPPLY (Vdd, Vss)	SWITCHING SPEED (µSec.) Typ.	INPUT PWR. 0.2 dB COMPRESSION dBm	CONTROL INTERFACE	No. OF BITS	SCHEMATIC
DC to 4000 MHz 50 Ω											
DAT-15R5-PN	DC-4000	15.5	0.5	+52	-	3 V, -3 V	1	+24	Parallel	5	A
DAT-15R5-PP	DC-4000	15.5	0.5	+52	3 V	-	1	+24	Parallel	5	A
DAT-15R5-SN	DC-4000	15.5	0.5	+52	-	3 V, -3 V	1	+24	Serial	5	B
DAT-15R5-SP	DC-4000	15.5	0.5	+52	3 V	-	1	+24	Serial	5	B
DAT-31-PN	DC-2400	31	1	+52	-	3 V, -3 V	1	+24	Parallel	5	C
DAT-31-PP	DC-2400	31	1	+52	3 V	-	1	+24	Parallel	5	C
DAT-31-SN	DC-2400	31	1	+52	-	3 V, -3 V	1	+24	Serial	5	D
DAT-31-SP	DC-2400	31	1	+52	3 V	-	1	+24	Serial	5	D
DAT-31R5-PN	DC-2400	31.5	0.5	+52	-	3 V, -3 V	1	+24	Parallel	6	E
DAT-31R5-PP	DC-2400	31.5	0.5	+52	3 V	-	1	+24	Parallel	6	E
DAT-31R5-SN	DC-2400	31.5	0.5	+52	-	3 V, -3 V	1	+24	Serial	6	F
DAT-31R5-SP	DC-2400	31.5	0.5	+52	3 V	-	1	+24	Serial	6	F
DC to 2000 MHz 75 Ω											
DAT-15575-PN	DC-2000	15.5	0.5	+52	-	3 V, -3 V	1	+24	Parallel	5	A
DAT-15575-PP	DC-2000	15.5	0.5	+52	3 V	-	1	+24	Parallel	5	A
DAT-15575-SN	DC-2000	15.5	0.5	+52	-	3 V, -3 V	1	+24	Serial	5	B
DAT-15575-SP	DC-2000	15.5	0.5	+52	3 V	-	1	+24	Serial	5	B
DAT-3175-PN	DC-2000	31	1	+52	-	3 V, -3 V	1	+24	Parallel	5	C
DAT-3175-PP	DC-2000	31	1	+52	3 V	-	1	+24	Parallel	5	C
DAT-3175-SN	DC-2000	31	1	+52	-	3 V, -3 V	1	+24	Serial	5	D
DAT-3175-SP	DC-2000	31	1	+52	3 V	-	1	+24	Serial	5	D
DAT-31575-PN	DC-2000	31.5	0.5	+52	-	3 V, -3 V	1	+24	Parallel	6	E
DAT-31575-PP	DC-2000	31.5	0.5	+52	3 V	-	1	+24	Parallel	6	E
DAT-31575-SN	DC-2000	31.5	0.5	+52	-	3 V, -3 V	1	+24	Serial	6	F
DAT-31575-SP	DC-2000	31.5	0.5	+52	3 V	-	1	+24	Serial	6	F

SIMPLIFIED ELECTRICAL SCHEMATICS



BIAS-TEES *Wideband, High DC Current 50 Ω*

100 kHz to 6000 MHz

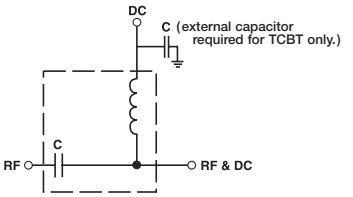
TCBT
Case GU1041

JEBT
Case BL301

MODEL PREFIX	FREQUENCY (MHz)	INSERTION LOSS (dB)						ISOLATION (dB) (RF port to DC port) (RF&DC port to DC port)						VSWR (:1)			DC CURRENT OPERATING (mA)	RF POWER OPERATING (dBm)
		L		M		U		L		M		U		L	M	U		
	f_L-f_U	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Typ.	Typ.	Max.	Max.
TCBT-2R5G	20-2500	0.2	0.8	0.35	0.8	0.7	1.2	65	40	44	25	25	20	1.05	1.05	1.1	100	25
JEBT-4R2GW	0.1-4200	0.15	0.8	0.6	1.2	0.6	1.6	25	15	40	20	40	20	1.05	1.1	1.1	200	20
JEBT-4R2G	10-4200	0.15	0.6	0.6	1.2	0.6	1.6	32	20	40	20	40	20	1.05	1.1	1.1	200	20
TCBT-6G	50-6000	0.2	0.8	0.7	1.8	1.1	2.5	52	38	28	18	19	17	1.05	1.1	1.2	100	25

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

ELECTRICAL SCHEMATIC



CHOKES, RF *50 Ω*

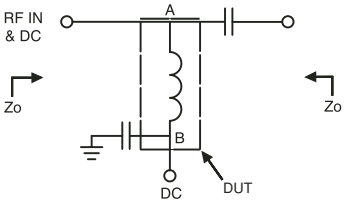
50 MHz to 10000 MHz

TCCH
Case GU1041

ADCH
Case CD542

MODEL PREFIX	FREQUENCY (MHz)	INSERTION LOSS (dB)		VSWR (:1)		DC CURRENT (mA)	INDUCTANCE, µH (Typ.)		
		Typ.	Max.	Typ.	Max.	Max.	@ 0 mA	@ 50 mA	@ 100 mA
TCCH-80	50-8200	0.5	1.1	1.1	1.70	100	4.0	1.3	0.9
ADCH-80	50-8000	0.3	1.0	1.1	1.35	100	7.0	1.8	1.0
	50-10000	0.3	2.0	1.1	1.60	100	7.0	1.8	1.0
ADCH-80A	50-8000	0.3	1.0	1.1	1.35	100	7.0	1.8	1.0
	50-10000	0.3	2.0	1.1	1.60	100	7.0	1.8	1.0

TEST CIRCUIT



DIRECTIONAL COUPLERS

2 MHz to 2600 MHz

D Case CA531 | TCD Case DB714 | DBTC Case AT790-1 | DBTC-L Case AT1030 | JYDC-7-1HP Case BJ1051 | ADC Case CD542 | JDC Case BH292 | LRDC-J Case QQQ569 | SCDC Case YY161 | JYDC-23-1HP Case BJ937

MODEL PREFIX	FREQUENCY (MHz)	COUPLING (dB)		MAINLINE LOSS (dB)						DIRECTIVITY (dB)						VSWR (:1)	POWER INPUT, W	
				L		M		U		L		M		U			L	MU
	f_L-f_U	Nom.	Flatness	Typ.	Max.	Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Max.	Max.
6.2 to 23.5 dB Coupling 50 Ω																		
ADC-6-1R	5-200	6.2±0.3	±0.3	1.6	2.0	1.7	2.0	1.7	2.1	35	22	25	18	17	13	1.33	0.5	0.5
ADC-6-13	200-1300	6.2±0.5	±0.9	1.8	2.5	1.8	2.5	1.8	2.5	17	10	17	10	17	10	1.30	0.5	0.5
JDC-6-1	5-400	6.5±0.5	±0.5	1.6	2.0	1.7	2.4	2.0	2.4	35	30	25	20	20	15	1.25	0.5	0.5
JYDC-7-1HP	30-500	7.3±0.4	±0.2	1.3	1.6	—	—	1.4	1.9	30	22	—	—	20	15	1.25	5.0	5.0
TCD-9-1W	5-1000	8.9±0.5	±0.6	1.2	2.1	1.2	1.8	1.5	2.1	21	17	17	10	13	—	1.30	0.5	1.0
	1000-2000	8.9±0.5	±0.6	—	—	2.5	—	—	—	—	—	10	—	—	—	1.60	1.0	1.0
DBTC-9-4	5-1000	9.0±0.5	±0.5	1.2	2.0	1.2	1.8	1.5	2.0	21	17	18	13	15	—	1.20	0.5	1.0
JDC-10-2	5-750	10.0±0.5	±0.6	1.0	1.5	1.0	1.5	1.0	1.5	20	15	20	17	20	16	1.13	1.0	1.0
TCD-10-1W	10-750	10.3±0.5	±0.8	1.3	2.1	1.2	1.6	1.4	2.0	22	17	18	14	15	—	1.30	0.5	1.0
ADC-10-1R	5-900	10.5±0.5	±0.5	0.7	1.2	0.8	1.2	0.9	1.5	40	25	30	20	18	12	1.30	1.0	1.0
ADC-10-4	5-1000	10.5±0.5	±1.0	0.8	1.3	0.8	1.2	1.0	1.5	40	23	40	20	25	13	1.20	1.0	1.0
JDC-10-4	5-1000	10.5±0.5	±0.6	1.0	1.5	1.0	1.5	1.3	1.8	23	18	23	18	24	15	1.15	1.0	1.0
LRDC-10-1J	5-500	10.7±0.5	±0.5	0.9	1.4	0.9	1.4	1.2	1.9	31	25	30	20	25	16	1.20	1.0	1.0
SCDC-11-2	500-1100	11.3±0.5	±0.6	1.1	1.8	1.1	1.8	1.1	1.8	17	10	17	10	17	10	1.40	2.0	2.0
DBTC-12-4	5-1000	12.2±0.5	±0.9	0.9	1.8	0.7	1.3	1.1	1.6	33	22	21	14	15	—	1.20	0.5	1.0
DBTC-13-4	5-1000	13.0±0.5	±0.6	0.7	1.3	0.7	1.3	1.1	1.6	21	17	18	13	13	—	1.20	0.5	1.0
TCD-13-4	5-1000	13.0±0.5	±0.6	0.7	1.3	0.7	1.3	0.8	1.5	21	17	18	12	15	—	1.20	0.5	1.0
ADC-15-4	5-1000	15.5±0.5	±0.5	0.6	1.0	0.6	1.0	0.8	1.2	23	20	24	20	28	17	1.20	1.0	1.0
D17I	2300-2600	17.5±1.3	—	0.5	0.8	0.5	0.8	0.5	0.8	14	9	14	9	14	9	1.30	1.0	1.0
DBTC-17-5	50-1000	17.0±0.7	±0.9	0.9	1.4	0.9	1.4	0.9	1.4	20	13	20	13	20	13	1.20	2.0	2.0
	1000-1500	17.7±0.9	±1.0	1.0	1.5	1.0	1.5	1.0	1.5	20	10	20	10	20	10	1.20	2.0	2.0
	1500-2000	18.0±1.0	±0.8	1.1	1.6	1.1	1.6	1.1	1.6	14	—	14	—	14	—	1.20	2.0	2.0
TCD-18-4	5-1000	17.9±0.5	±0.6	0.7	1.3	0.7	1.1	1.0	1.4	22	11	20	15	18	—	1.20	1.0	1.0
D18P	1710-1990	18.0±1.8	—	0.3	0.5	0.3	0.5	0.3	0.5	15	10	15	10	15	10	1.20	1.0	1.0
D19G	1420-1660	18.2±1.2	—	0.3	0.5	0.3	0.5	0.3	0.5	15	10	15	10	15	10	1.20	1.0	1.0
D20C	810-960	19.4±1.4	—	0.3	0.5	0.3	0.5	0.3	0.5	15	7	15	7	15	7	1.10	4.0	4.0
JDC-20-1W	50-750	19.5±0.5	±0.5	0.5	0.9	0.5	0.9	0.5	0.9	22	15	22	15	22	15	1.20	0.5	0.5
ADC-20-4	5-1000	20.0±0.5	±0.8	0.4	0.8	0.5	1.0	0.7	1.3	20	18	21	17	21	15	1.10	1.0	1.0
TCD-20-4	5-1000	20.0±0.5	±0.8	0.3	0.9	0.4	0.8	0.7	1.1	20	11	21	15	15	—	1.20	1.0	1.0
ADC-20-12	100-1200	20.0±0.5	±0.7	0.5	1.1	0.5	1.1	0.5	1.1	26	13	26	13	26	13	1.17	1.0	1.0
DBTC-20-4	20-1000	20.4±0.5	±0.8	0.3	1.0	0.4	1.0	0.7	1.3	21	13	21	14	16	—	1.20	1.0	1.0
JDC-20-2	400-900	20.5±1.0	±1.0	0.2	0.6	0.2	0.6	0.2	0.6	19	13	19	13	19	13	1.15	2.0	2.0
LRDC-20-2J	300-1100	20.5±1.0	±1.3	0.25	0.6	0.25	0.6	0.25	0.6	17	10	17	10	17	10	1.20	2.0	2.0
JDC-20-5	50-1500	20.5±0.5	±0.75	0.4	0.8	0.5	0.9	1.0	1.5	25	18	22	16	20	13	1.20	0.5	0.5
JYDC-23-1HP	30-500	23.5±1.0	±1.2	0.1	0.3	—	—	0.2	0.4	26	20	—	—	23	19	1.10	10.0	10.0
6.6 to 20.5 dB Coupling 75 Ω																		
ADC-6-10-75	20-1000	6.6±0.5	±0.5	2.10	2.8	2.1	2.5	2.2	2.8	15	12	15	12	15	9	1.33	0.5	0.5
DBTC-6-4-75	5-1000	6.8±0.3	±0.8	2.20	3.1	2.3	2.9	2.3	2.8	15	13	12	7	16	10	1.40	0.5	1.0
ADC-8-4-75	5-1000	7.9±0.5	±0.5	1.55	2.6	1.6	2.2	2.0	2.7	18	14	17	14	16	10	1.20	1.0	1.0
TCD-9-1W-75	5-1000	8.9±0.5	±0.6	1.30	2.1	1.3	2.0	1.8	2.4	21	17	15	—	10	—	1.30	0.5	1.0
	1000-2000	8.9±0.5	±0.6	—	—	2.5	—	—	—	—	—	10	—	—	—	1.60	—	1.0
LRDC-10-2-75J	30-1000	10.0±0.5	±0.6	1.00	1.5	1.1	1.5	1.3	1.8	21	17	22	17	19	15	1.30	1.0	1.0
LRDC-10-2W-75J	30-1200	10.0±0.5	±0.8	1.00	1.5	1.1	1.6	1.3	2.0	21	17	22	17	18	15	1.30	1.0	1.0
ADC-10-4-75	5-1000	10.5±0.5	±0.5	0.85	1.4	0.9	1.4	1.0	1.4	40	20	18	12	12	8	1.20	1.0	1.0
DBTC-10-4-75	5-1000	10.5±0.5	±0.7	1.50	2.2	1.4	2.0	1.5	2.0	21	16	20	13	16	—	1.30	0.5	1.0
TCD-10-1W-75	10-750	10.5±0.5	±0.7	1.60	2.1	1.4	1.9	1.5	2.0	22	17	18	14	14	—	1.30	0.5	1.0
JDC-10-4-75	10-1000	10.5±0.5	±0.5	1.20	1.6	1.4	1.7	1.6	2.0	27	18	25	18	28	18	1.30	1.0	1.0
LRDC-10-1-75J	5-600	10.7±0.5	±0.5	1.10	1.5	1.0	1.4	1.2	1.8	19	15	21	17	21	16	1.30	1.0	1.0
LRDC-12-1-75J	5-600	12.2±0.5	±0.6	0.40	0.8	0.5	1.0	0.8	1.5	20	17	21	18	20	12	1.30	1.0	1.0
ADC-12-4-75	20-1000	12.6±0.5	±0.5	0.80	1.2	0.9	1.3	1.2	1.8	28	20	23	15	17	10	1.20	1.0	1.0
TCD-13-4-75	5-1000	13.0±0.5	±0.9	1.00	1.8	0.8	1.3	1.1	1.5	22	17	15	—	12	—	1.20	0.5	1.0
DBTC-13-5-75	5-1000	13.2±0.5	±0.6	0.90	1.4	1.0	1.5	1.1	1.6	21	17	19	14	18	—	1.30	0.5	1.0
	1000-1500	13.6±0.5	±0.8	1.4	2.2	1.4	2.2	1.4	2.2	17	—	17	—	17	—	1.30	1.0	1.0
ADC-15-4-75	5-1000	15.5±0.5	±0.5	0.70	1.2	0.7	1.0	0.8	1.2	23	18	20	14	16	11	1.20	1.0	1.0
ADC-16-4-75	5-1000	16.2±0.5	±0.5	0.70	1.2	0.7	1.0	0.8	1.2	38	25	30	16	18	12	1.15	0.5	1.0
DBTC-16-5-75	5-1000	16.3±0.5	±0.7	1.20	2.0	1.0	1.5	1.1	1.6	22	16	21	13	20	—	1.30	1.0	1.0
	1000-1500	16.8±0.7	±0.7	1.3	1.9	1.3	1.9	1.3	1.9	19	—	19	—	19	—	1.30	1.0	1.0
ADC-18-4-75	20-1000	17.4±0.5	±0.5	0.40	0.8	0.4	1.0	0.5	1.2	17	14	18	14	17	12	1.15	1.0	1.0
TCD-18-4-75	10-1000	18.0±0.5	±0.9	0.90	1.3	0.7	1.2	0.8	1.3	20	15	22	15	18	—	1.20	1.0	1.0
DBTC-18-4-75	5-1000	18.2±0.5	±0.7	0.80	1.5	0.8	1.4	1.0	1.6	25	16	21	14	15	—	1.30	1.0	1.0
JDC-20-3-75	2-250	19.2±0.5	±0.5	0.40	0.8	0.3	0.7	0.4	0.7	24	16	30	20	20	15	1.10	0.5	1.0
JDC20-1W-75	50-750	19.5±0.5	±0.5	0.50	0.9	0.5	0.7	0.5	0.9	25	18	23	15	20	15	1.20	0.5	0.5
ADC-20-4-75	5-1000	19.7±0.5	±0.5	0.50	0.8	0.5	1.0	0.6	1.2	22	18	23	15	20	13	1.15	1.0	1.0
DBTC-20-4-75	5-1000	20.5±0.5	±0.9	0.40	0.7	1.1	1.5	0.8	1.2	20	16	9	6	11	7	1.4	1.0	1.0

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

BI-DIRECTIONAL COUPLERS

High Power 50 Ω

1.5 MHz to 6000 MHz

6.0 to 20 dB Coupling

LTCC

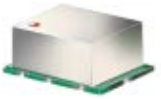
BDCN
Case FV1206-1

LTCC

BDCA/ BDCA1
Case DZ944

LTCC

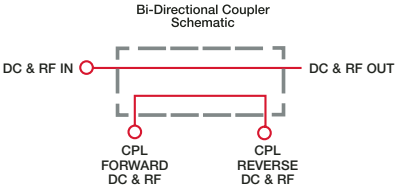
BDCA-10-25
Case SM1L



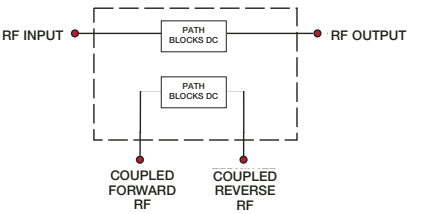
SYDC
Case AH202-1

MODEL PREFIX	FREQUENCY (MHz)	COUPLING (dB)		MAINLINE LOSS (dB)		DIRECTIVITY (dB)		VSWR (:1)	POWER INPUT, W
	f_L-f_U	Nom.	Flatness	Typ.	Max.	Typ.	Min.	Typ.	Max.
DC PASS	*up to 65 W*								
BDCA1-6-11	***600-1100***								
	600-700	6.3±0.5	±0.5	1.5	1.8	23	20	1.05	50
	700-1000	6.0±0.4	±0.3	1.8	2.0	27	19	1.08	42
	1000-1100	6.3±0.5	±0.5	1.8	2.0	21	15	1.10	38
BDCA-6-16	***800-1600***								
	800-960	6.7±0.5	±0.6	1.4	1.8	24	20	1.05	65
	960-1250	6.3±0.5	±0.4	1.6	2.0	23	19	1.05	55
	1250-1600	6.6±0.7	±0.9	1.6	2.0	21	14	1.05	45
BDCA1-6-22	***950-2200***								
	950-1400	6.9±1.0	±1.0	1.4	1.9	23	17	1.20	57
	1400-1900	6.0±0.5	±0.3	1.7	2.1	28	20	1.10	44
	1900-2200	6.5±0.7	±0.7	1.7	2.1	22	15	1.15	37
BDCA-7-25	***1200-2500***								
	1200-1700	7.1±0.8	±0.8	1.5	1.9	22	19	1.08	35
	1700-2100	6.5±0.5	±0.3	1.6	2.0	22	14	1.05	35
	2100-2500	7.0±0.8	±1.0	1.5	2.0	22	12	1.10	27
BDCA1-7-33	***1600-3300***								
	1600-2200	7.0±0.6	±1.0	1.6	1.9	27	22	1.10	32
	2200-2700	6.5±0.5	±0.3	1.6	1.9	23	18	1.15	32
	2700-3300	7.1±0.6	±0.7	1.6	1.9	21	17	1.15	24
BDCA-10-25	***800-2500***	10.1±2.0	±2.0	1.0	1.5	25	11	1.05	24
	800-1000	11.0±0.8	±1.2	0.6	1.0	32	20	1.05	50
	1700-2000	8.5±0.5	±0.6	1.1	1.5	23	16	1.05	34
	2000-2500	9.4±1.2	±1.5	1.0	1.5	22	11	1.05	24
BDCA1-10-40	***1600-4000***								
	1600-1800	10.1±0.7	±0.7	0.8	1.1	21	18	1.10	24
	1800-2200	9.5±0.7	±0.8	1.0	1.3	20	17	1.10	20
	2200-2900	9.1±0.5	±0.5	1.05	1.4	20	16	1.20	16
	2900-3500	9.6±0.9	±1.0	1.15	1.4	22	16	1.20	14
	3500-4000	10.8±1.0	±1.5	1.05	1.4	18	11	1.25	12
BDCN-15-25	***824-2525***	14.5±2.0	±3.0	0.6	0.9	13	8	1.20	16
	824-894	15.0±0.6	±0.6	0.4	0.8	12	8	1.20	16
	880-960	14.5±0.6	±0.6	0.5	0.9	13	8	1.20	16
	1710-1880	12.5±0.6	±0.4	0.6	0.9	22	16	1.20	16
	1850-1990	12.6±0.6	±0.4	0.5	0.9	22	16	1.20	16
	2110-2170	13.3±0.6	±0.5	0.6	1.0	22	16	1.20	16
	2375-2525	15.5±0.6	±1.5	0.6	1.0	12	8	1.20	16
BDCA-15-25	***800-2500***	15.0±1.7	±2.4	0.5	1.0	27	11	1.20	23
	800-1000	16.3±0.8	±1.1	0.35	0.6	27	19	1.15	40
	1800-2000	13.5±0.5	±0.3	0.55	1.0	17	12	1.35	28
BDCA-16-30	***1800-4200***								
	1800-3000	15.2±1.0	±1.2	0.5	0.9	23	13	1.30	24
	1800-2500	15.5±0.7	±1.0	0.4	0.9	22	14	1.30	27
	3000-4200	14.8±0.5	±1.0	0.7	1.2	18	13	1.30	18
BDCN-17-25	***824-2525***	16.8±2.0	±3.0	0.6	0.9	13	10	1.20	16
	824-894	18.3±0.6	±0.6	0.3	0.8	13	10	1.20	16
	880-960	17.6±0.6	±0.6	0.3	0.8	13	10	1.20	16
	1710-1880	14.3±0.6	±0.4	0.5	0.9	22	17	1.20	16
	1850-1990	14.3±0.6	±0.4	0.5	0.9	22	17	1.20	16
	2110-2170	14.3±0.6	±0.5	0.5	0.9	25	20	1.20	16
	2375-2525	15.0±0.6	±0.8	0.5	0.9	15	11	1.20	16
DC BLOCKED	*up to 25 W*								
SYDC-20-62HP	10-540	19.8±0.5	±0.8	0.2	0.6	28	16	1.10	25
SYDC-20-61HP	1.5-60	20.0±0.5	±0.3	0.1	0.4	35	20	1.05	15

ELECTRICAL SCHEMATIC BDCA, BDCN AND SYBD SERIES



ELECTRICAL SCHEMATIC SYDC SERIES



SYBD
Case JB1233

10 to 33 dB Coupling

MODEL PREFIX	FREQUENCY (MHz)	COUPLING (dB)		MAINLINE LOSS (dB)		DIRECTIVITY (dB)		VSWR (:1)	POWER INPUT, W
	f_L-f_U	Nom.	Flatness	Typ.	Max.	Typ.	Min.	Typ.	Max.
DC PASS	***up to 100 W***								
SYBD-10-63HP	***2700-6000***			***0.60***	***1.2***	***20***	***10***	***1.2***	
	2700-3000	12.5±0.8	±0.5	0.40	0.8	23	16	1.1	25
	3000-3600	11.8±0.8	±0.7	0.45	0.9	23	15	1.1	25
	3600-4500	10.8±0.7	±0.6	0.60	1.0	22	12	1.2	20
	4500-6000	10.3±0.7	±0.4	0.75	1.2	18	10	1.3	20
SYBD-13-63HP	***2700-6000***			***0.45***	***0.80***	***20***	***10***	***1.20***	
	2700-3000	15.3±0.8	±0.5	0.25	0.45	23	16	1.15	25
	3000-3600	14.3±0.8	±0.7	0.30	0.50	21	15	1.20	25
	3600-4500	13.3±0.7	±0.7	0.40	0.75	18	13	1.25	20
	4500-6000	12.6±0.7	±0.5	0.45	0.80	17	10	1.25	20
SYBD-14-272HP	***1750-2700***			***0.40***	***0.75***	***23***	***16***	***1.15***	
	1750-1950	15.1±0.7	±0.6	0.25	0.55	23	18	1.10	25
	1950-2300	14.5±0.8	±0.7	0.30	0.65	23	17	1.15	25
	2300-2700	13.5±0.8	±0.7	0.45	0.75	23	16	1.10	25
SYBD-16-172HP	***1400-1750***			***0.22***	***0.5***	***23***	***18***	***1.10***	
	1400-1580	17.0±0.7	±0.7	0.20	0.45	23	18	1.10	50
	1580-1750	16.0±0.7	±0.6	0.22	0.50	23	17	1.10	25
SYBD-16-272HP	***1750-2700***			***0.20***	***0.50***	***30***	***17***	***1.20***	
	1750-1950	18.0±0.7	±0.5	0.13	0.40	30	18	1.10	25
	1950-2300	17.1±0.8	±0.7	0.18	0.45	30	18	1.15	25
	2300-2700	16.1±0.8	±0.7	0.20	0.50	30	17	1.20	25
SYBD-16-53HP	***2700-5000***			***0.20***	***0.70***	***18***	***10***	***1.20***	
	2700-3000	18.1±0.8	±0.5	0.12	0.40	20	13	1.15	25
	3000-3600	17.4±0.8	±0.7	0.15	0.45	18	13	1.15	25
	3600-4500	16.3±0.7	±0.7	0.20	0.50	16	11	1.25	20
	4500-5000	15.7±0.7	±0.3	0.24	0.70	15	10	1.30	20
SYBD-18-142HP	***960-1400***			***0.15***	***0.40***	***26***	***18***	***1.10***	
	960-1240	19.5±0.8	±1.3	0.10	0.35	26	18	1.10	50
	1240-1400	18.0±0.8	±0.7	0.15	0.40	25	18	1.10	50
SYBD-18-172HP	***1400-1750***			***0.10***	***0.35***	***28***	***18***	***1.10***	
	1400-1580	19.5±0.7	±0.7	0.10	0.30	28	18	1.10	50
	1580-1750	18.5±0.7	±0.6	0.12	0.35	30	18	1.05	25
SYBD-20-13HP	***800-1000***	***20.8±0.8***	***±1.3***	***0.12***	***0.35***	***24***	***17***	***1.10***	***100***
	800-900	21.6±0.8	±0.7	0.12	0.35	24	18	1.10	100
	900-1000	20.6±0.8	±0.6	0.12	0.35	24	17	1.10	100
SYBD-20-272HP	***1750-2700***			***0.12***	***0.40***	***22***	***14***	***1.15***	
	1750-1950	20.7±0.7	±0.5	0.11	0.35	23	16	1.10	25
	1950-2300	19.8±0.8	±0.7	0.12	0.35	22	15	1.15	25
	2300-2700	18.8±0.8	±0.6	0.12	0.40	20	14	1.15	25
SYBD-22-82HP	***610-810***	22.8±0.8	±1.5	0.10	0.30	24	19	1.05	100
SYBD-22-172HP	***1400-1750***			***0.09***	***0.30***	***20***	***16***	***1.15***	
	1400-1580	22.3±0.7	±0.7	0.07	0.30	24	17	1.15	50
	1580-1750	21.5±0.7	±0.6	0.09	0.30	23	16	1.15	25
SYBD-23-13HP	***800-1000***	***23.5±0.8***	***±1.3***	***0.06***	***0.25***	***27***	***19***	***1.15***	***100***
	800-900	24.0±0.8	±0.7	0.06	0.25	27	19	1.15	100
	900-1000	23.0±0.8	±0.6	0.06	0.25	27	19	1.15	100
SYBD-24-142HP	***960-1400***			***0.04***	***0.30***	***25***	***17***	***1.15***	
	960-1240	24.8±0.8	±1.2	0.04	0.25	26	18	1.15	50
	1240-1400	23.2±0.8	±0.7	0.05	0.30	24	17	1.15	50
SYBD-25-82HP	***610-810***	***25.5±0.8***	***±1.5***	***0.05***	***0.20***	***28***	***20***	***1.10***	***100***
SYBD-26-62HP	***400-610***			***0.08***	***0.25***	***24***	***20***	***1.05***	
	400-470	27.2±0.8	±0.9	0.08	0.25	24	20	1.05	100
	470-610	25.3±0.8	±1.3	0.09	0.25	24	20	1.05	100
SYBD-26-13HP	***800-1000***	***26.3±0.8***	***±1.1***	***0.03***	***0.25***	***29***	***19***	***1.05***	***100***
	800-900	26.8±0.8	±0.7	0.03	0.20	31	20	1.05	100
	900-1000	25.8±0.8	±0.6	0.03	0.25	29	19	1.05	100
SYBD-28-62HP	***400-610***			***0.03***	***0.20***	***27***	***21***	***1.10***	
	400-470	29.8±0.8	±1.0	0.03	0.20	27	21	1.10	100
	470-610	27.8±0.8	±1.5	0.03	0.20	28	21	1.10	100
SYBD-28-82HP	***610-810***	***28.1±0.8***	***±1.4***	***0.02***	***0.20***	***33***	***21***	***1.05***	***100***
SYBD-30-62HP	***400-610***			***0.02***	***0.20***	***30***	***23***	***1.05***	
	400-470	32.5±0.8	±0.9	0.02	0.20	30	23	1.05	100
	470-610	30.8±0.8	±1.3	0.02	0.20	28	23	1.05	100

FILTERS *Low Pass, 50 Ω*

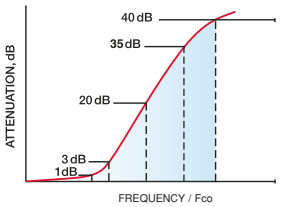
DC to 7200 MHz

SALF, SCLF
Case YY101, YY161

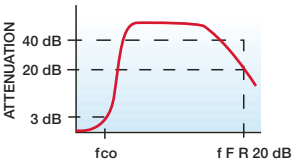
MODEL PREFIX	PASSBAND (MHz) (Loss < 1 dB)	fco (MHz) Nom. (Loss 3 dB)	STOPBAND (MHz) (Loss > 20 dB)	STOPBAND (MHz) (Loss > 40 dB)	VSWR (:1) PASSBAND Typ.
Plastic Package	***0.75" x 0.45" x 0.28" Max.***				
SCLF-4.7	DC-4.7	5.6	6.6-7.4	7.4-600	1.25
SCLF-5	DC-5.0	5.8	8-10	10-200	1.70
SCLF-8	DC-8.0	9.2	12.5-16.5	16.5-200	1.70
SCLF-8.4	DC-8.4	9.4	11.4-12.6	12.6-210	1.25
SCLF-10	DC-10	12.2	14-16	16-230	1.20
SCLF-10.7	DC-11	14	19-24	24-200	1.70
SCLF-21.4	DC-22	24.5	32-41	41-200	1.70
SCLF-23	DC-23	25	31-34	34-320	1.50
SCLF-25	DC-25	28	36-47	47-200	1.70
SCLF-27	DC-27	30	36-41	41-480	1.30
SCLF-30	DC-30	35	47-61	61-200	1.70
SCLF-36	DC-36	40	50-57	57-390	1.30
SCLF-44	DC-44	48.5	59-65.5	65.5-420	1.30
SCLF-45	DC-45	55	70-90	90-200	1.70
SCLF-65	DC-65	71	86-96	96-510	1.30
SALF-78	DC-78	93	120-136	136-550	1.30
SCLF-95	DC-95	108	146-189	189-400	1.70
SALF-116	DC-116	142	178-220	220-825	1.30
SCLF-135	DC-135	155	210-300	300-600	1.70
SALF-146	DC-146	171	210-240	240-850	1.50
SCLF-190	DC-190	210	290-390	390-800	1.70
SCLF-225	DC-225	250	340-440	440-1200	1.70
SALF-265	DC-265	308	390-470	470-1100	1.20
SALF-325	DC-325	383	480-580	580-1300	1.30
				Loss > 35 dB	
SCLF-380	DC-380	440	580-750	750-1800	1.70
SALF-396	DC-396	458	550-620	620-1430	1.30
SCLF-420	DC-420	570	750-920	920-2000	1.70
SALF-490	DC-490	620	800-900	900-1600	1.30
SCLF-550	DC-550	605	800-1050	1050-2000	1.70
SALF-580	DC-580	720	1000-1300	1300-2100	1.50
SALF-680	DC-680	790	1090-1400	1400-2200	1.40
SCLF-700	DC-700	770	1000-1300	1300-2000	1.70
SALF-800	DC-800	935	1200-1300	1300-2550	1.60
SALF-865	DC-865	980	1300-1400	1400-2550	1.40
SCLF-1000	DC-1000	1200	1620-2100	2100-2500	1.70

TYPICAL FREQUENCY RESPONSE

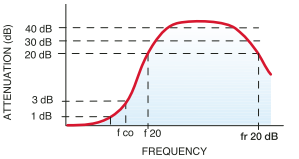
SALF, SCLF MODELS



LFTC MODELS



LFCN MODELS



LTCC

LFTC
Case FR933

MODEL PREFIX	PASSBAND (MHz) (Loss < 1.3 dB) Typ.	fco (MHz) Nom. (Loss 3 dB) Typ.	STOPBAND (MHz) (Loss > 20 dB)	(Loss > 40 dB)	fr 20 dB Typ.	VSWR (:1) PASSBAND Typ.	POWER INPUT (W)	NUMBER OF SECTIONS
LTCC	***0.15" x 0.15" x 0.028"***							
LFTC-850	DC-850	1078	1500	2000-3500	5500	1.2	16	7
LFTC-1350	DC-1350	1550	2100	2700-4000	7000	1.2	15	7
LFTC-1700	DC-1700	1980	2700	3300-3880	7200	1.2	14	7
LFTC-2000	DC-2000	2430	3450	4500-5400	8000	1.2	10	7
LFTC-3300	DC-3300	4100	5600	—	10000	1.2	10	7
LFTC-4000	DC-4000	5325	7250	—	9500	1.2	10	7
LFTC-5400	DC-5400	6410	9000-11000	—	12000	1.1	19	7

LTCC

LFCN
Case FV1206

MODEL PREFIX	PASSBAND (MHz) (Loss < 1.5 dB) Max.	fco (MHz) Nom. (Loss 3 dB) Typ.	STOPBAND (MHz) (Loss, dB) f 20 Min.	40 Typ.	fr 20 Typ.	VSWR (:1) PASSBAND Typ.	POWER INPUT (W) Max.	NUMBER OF SECTIONS
LTCC MINIATURE	***0.126" x 0.063" x 0.037"***							
LFCN-80	DC-80	145	200	225-1550	4500	1.2	8.5	7
LFCN-95	DC-95	165	230	255-1600	4500	1.2	8.5	7
LFCN-105	DC-105	180	250	265-1650	4750	1.2	8.5	7
LFCN-120	DC-120	195	280	300-1850	4750	1.2	8.5	7
LFCN-160	DC-160	230	330	480-2700	6100	1.2	8	7
LFCN-180	DC-180	270	370	525-2350	6400	1.2	8	7
LFCN-190	DC-190	280	400	510-2800	6550	1.2	8	7
LFCN-225	DC-225	350	460	510-2500	5500	1.2	8.5	7
LFCN-320	DC-320	460	560	640-2500	5300	1.2	8.5	7
LFCN-400	DC-400	560	660	680-3000	5500	1.2	8.5	7
LFCN-490	DC-490	650	800	880-2500	6000	1.2	8.5	7
LFCN-530	DC-530	700	820	945-3000	6000	1.2	8.5	7
LFCN-575	DC-575	770	900	1050-3200	5500	1.2	8.5	7
LFCN-630	DC-630	830	1000	1050-3500	6000	1.2	8.5	7
				30 dB Typ.				
LFCN-800	DC-800	990	1400	1500-2000	4500	1.2	9	5
LFCN-900	DC-850	1075	1275	1350-4850	5100	1.2	10	7
LFCN-1000	DC-1000	1300	1550	1900-5000	5500	1.3	10	7
LFCN-1200	DC-1200	1530	1865	2000-5000	6200	1.2	10	7
LFCN-1325	DC-1325	1560	2100	2200	4250	1.4	9	5
LFCN-1400	DC-1400	1700	2015	2100-6600	6800	1.2	10	7
LFCN-1450	DC-1450	1825	2025	2050-6600	6700	1.2	10	7
LFCN-1500	DC-1500	1825	2100	2150-6600	6800	1.2	10	7
LFCN-1525	DC-1525	1750	2040	2120-6600	6700	1.2	10	7
LFCN-1575	DC-1575	1875	2175	2225-6800	7100	1.2	10	7
LFCN-1700	DC-1700	2050	2375	2500-6500	7000	1.2	10	7
LFCN-1800	DC-1800	2125	2425	2500-7200	8600	1.2	10	7
LFCN-2000	DC-2000	2275	3000	3100-3500	4600	1.3	9	5
LFCN-2250	DC-2200	2575	2900	3000-5000	7200	1.2	10	7
LFCN-2400	DC-2400	2800	3600	3700-4000	5000	1.2	9	5
LFCN-2500	DC-2500	3075	3675	3800-6100	8000	1.2	10	7
LFCN-2600	DC-2600	3125	3750	3900-6600	8400	1.2	10	7
LFCN-2750	DC-2750	3150	4000	4150-6800	8400	1.2	10	7
LFCN-2850	DC-2800	3300	4000	4200-7400	9000	1.2	10	7
LFCN-3000	DC-3000	3600	4550	4780-7500	10000	1.2	10	7
LFCN-3800	DC-3900	4850	6000	5700-8300	13000	1.3	8	7
LFCN-4400	DC-4400	5290	6700	6280-9800	13000	1.2	8	7
LFCN-5000	DC-5000	5580	6850	7050	18000	1.2	9	7
LFCN-5500	DC-5500	6200	7200	6770-9500	12100	1.3	8	7
LFCN-5850	DC-5850	6540	7600	7100-9900	12500	1.3	8	7
LFCN-6000	DC-6000	6800	8500	8700-10500	18000	1.3	9	7
LFCN-6400	DC-6400	7200	8300	7770-10200	12500	1.2	8	7
LFCN-6700	DC-6700	7600	9300	9500-11000	18000	1.3	9	7
LFCN-7200	DC-7200	8150	9500	8850-9600	12300	1.3	8	7

FILTERS *High Pass, 50 Ω*

18 MHz to 13000 MHz

SCHF
Case YY161

LTCC

HFTC
Case FR933

LTCC

HFCN 650
thru 2700
Case FV1206

LTCC

HFCN 2700A
thru 8400
Case FV1206-1

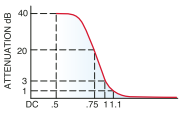
MODEL PREFIX	STOPBAND (MHz) (Loss > 40 dB)	STOPBAND (MHz) (Loss > 20 dB)	fco (MHz) Nom. (Loss 3 dB)	PASSBAND (MHz) (Loss < 1 dB)	VSWR (:1) STOPBAND Typ.	VSWR (:1) PASSBAND Typ.	POWER INPUT (W)
Plastic	***0.75" x 0.45" x 0.28"***						
SCHF-17	DC-9	9-13	16.5	18-200	18	1.25	0.5
SCHF-25	DC-13	13-19	25	27.5-200	18	1.30	0.5
SCHF-300	DC-145	145-190	245	290-1200	18	1.50	0.5

MODEL PREFIX	STOPBAND (MHz) (Loss > 40 dB)	STOPBAND (MHz) (Loss > 20 dB)	fco (MHz) Nom. (Loss 3 dB) Typ.	PASSBAND (MHz) (Loss < 1.3 dB)	VSWR (:1) STOPBAND Typ.	VSWR (:1) PASSBAND Typ.	No. SECTIONS	POWER INPUT (W)
LTCC Ceramic	***0.15" x 0.15" x 0.028"***							
HFTC-9R5	DC-600	750	950	1300-3500	18	1.3	7	14
HFTC-16	DC-1030	1300	1580	1900-2700	18	1.3	7	14
HFTC-19	DC-1450	1650	1995	2300-5500	18	1.3	7	10
HFTC-26	DC-1450	2000	2570	3000-7000	18	1.5	7	10
HFTC-39	DC-1900	3050	3900	4600-5500	18	1.4	7	10

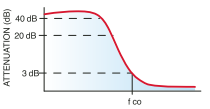
MODEL PREFIX	STOPBAND (MHz) Min. (Loss > 40 dB) F1	STOPBAND (MHz) Min. (Loss > 20 dB) F2	fco (MHz) Nom. (Loss 3 dB) Typ. F3	PASSBAND (MHz) (Loss < 1.3 dB) Max. F4-F5	PASSBAND (MHz) (Loss < 2 dB) Typ.	VSWR Typ. STOPBAND (:1)	VSWR Typ. Frequency (MHz) 1.5:1	No. SECTIONS	POWER INPUT (W) Max.
MINIATURE LTCC Ceramic			***0.126" x 0.063" x 0.037"***						
HFCN-650	390	480	650	850-2000	710-2490	20	760-1700	7	7
HFCN-740	430	550	740	900-2200	780-2800	20	780-1900	7	7
HFCN-880	500	640	880	1060-2500	950-3200	20	970-2400	7	7
HFCN-1200	750	910	1180	1380-4000	1220-4600	20	1300-3200	7	7
HFCN-1300	690	930	1300	1510-4000	1400-5000	20	1400-4000	7	7
HFCN-1320	880	1060	1320	1700-3800	1400-5000	20	1700-3700	7	7
HFCN-1500	1090	1250	1550	1850-4400	1600-5500	20	1620-3450	7	7
HFCN-1600	1090	1290	1600	1950-4000	1650-5000	20	1700-4000	7	7
HFCN-1760	950	1230	1760	2100-5200	1900-5500	20	2200-4500	7	7
HFCN-1810	1100	1480	1810	2250-3850	1950-4750	20	2250-3750	7	7
HFCN-1910	1075	1400	1910	2200-4400	2000-5200	20	2100-4500	7	7
HFCN-2000	1300	1530	2000	2410-5550	2260-6250	20	2400-5600	7	7
HFCN-2100	1050	1530	2100	2500-5000	2200-6000	20	2400-5200	7	7
HFCN-2275	1400	1770	2275	2640-6230	2450-7000	20	2580-6000	7	7
HFCN-2700	1500	1800	2500	3000-5700	2650-6500	20	2900-5500	7	7
	Loss > 30 dB Typ.			***Loss < 1.5 dB Max.***	***Loss < 2 dB Max.***				
HFCN-2700A	2270	2150	2700	3070-8500	2900-8700	20	3400-9000	5	7
HFCN-3100	2500	2450	3100	3500-9500	3400-9900	20	3100-10500	5	7
HFCN-3500	2900	2800	3500	4000-8800	3900-9800	20	3650-9500	5	7
HFCN-3800	3100	3200	3800	4500-9000	4250-10000	20	3950-10000	5	7
HFCN-4400	3600	3500	4400	5000-9900	5000-10100	20	4600-10100	5	7
HFCN-4600	3700	3800	4600	5200-10500	5000-11000	20	4720-11000	5	7
HFCN-5050	3600	4200	5050	5650-9700	5500-10000	20	5200-10000	5	7
HFCN-5500	4000	4500	5500	6600-11000	6000-11500	20	5600-11000	5	7
HFCN-7150	5100	6150	7150	8500-10500	7900-11000	20	7250-11000	5	6
				Loss <2.5 dB Max.	***Loss < 3 dB Max.***				
HFCN-8400	5700	6000	8400	9500-13000	9000-13000	20	9000-13000	5	7

TYPICAL FREQUENCY RESPONSE

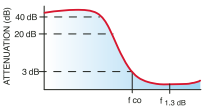
SCHF



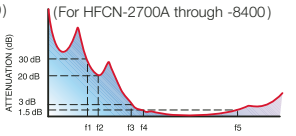
HFTC



HFCN
(Except HFCN-2700A through -8400)



HFCN
(For HFCN-2700A through -8400)



FILTERS *Band pass, Band Stop, Diplexers*

5 MHz to 870 MHz

Mini-Circuits® 2007

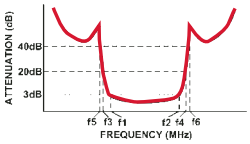
RBP
Case GP731

BPF
Case HQ1157

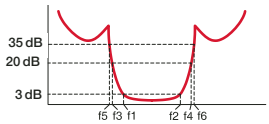
MODEL PREFIX	CENTER FREQUENCY (MHz) Fc	PASSBAND (MHz) (Loss < 3 dB) f1-f2	LINEAR PHASE (MHz) Fc±	LINEAR PHASE Typ. (±deg.)	STOPBANDS (MHz) (Loss > 20 dB) f3	STOPBANDS (MHz) (Loss > 20 dB) f4	STOPBANDS (MHz) (Loss > 35 dB) f5	STOPBANDS (MHz) (Loss > 35 dB) f6	VSWR (:1) PASSBAND Typ.	VSWR (:1) STOPBAND Typ.
Band Pass, 50 Ω										
RBP-98	103	75-131	—	—	55	170	45	210-2000	1.7	18
RBP-160	165	120-210	—	—	85	280	70	340-2000	1.6	18
RBP-220	220	212-228	30	8	150	290	100	320-1000	1.7	18
RBP-253	253	186-340	—	—	140	440	120	500-3000	1.7	18
RBP-263	263.5	230-297	43	8	140	360	80	500-1000	1.7	18
RBP-275	275	268-282	30	8	209	350	120	370-1000	1.7	18
RBP-400	391	292-490	—	—	230	620	200	700-2000	1.5	18
RBP-650	652	624-680	—	—	560	760	520	810-1000	1.5	18
							(Loss >40 dB) f5	*f6*		
BPF-A69	69	55-83	—	—	40	97	32	103-500	1.6	20
BPF-A122	122	119-125	—	—	111	132	105	137-500	1.6	20
BPF-B157	122	119-125	—	—	111	132	105	137-500	1.6	20
BPF-A175	122	119-125	—	—	111	132	105	137-500	1.6	20
BPF-B177	122	119-125	—	—	111	132	105	137-500	1.6	20

TYPICAL FREQUENCY RESPONSE

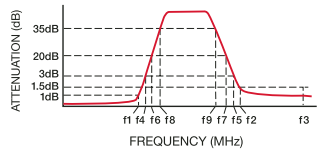
BPF MODELS



RBP MODELS



BSF MODELS



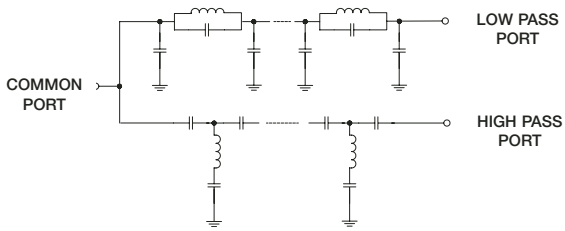
BSF
Case HF1139

MODEL PREFIX	STOPBAND, (MHz) (Loss > 20 dB) f6-f7	STOPBAND, (MHz) (Loss > 35 dB) f8-f9	LOSS 3 dB Typ. f4, f5	PASSBAND, (MHZ) (Loss < 1 dB) f1	PASSBAND, (MHZ) (Loss <1.5 dB) f2, f3	VSWR (:1) PASSBAND Typ.	VSWR (:1) STOPBAND Typ.
Band Stop, 50 Ω							
BSF-108	88-108	90-105	81&102	65	140-1000	1.3	6.0

DPLX
Case HR1176

MODEL PREFIX	INSERTION LOSS (dB) PASSBAND (MHz) Typ.	Max.	Typ.	Max.	ISOLATION (dB) STOPBAND (MHz) Typ.	Min.	Typ.	Min.	CROSSOVER ISOLATION (dB) Typ.	Min.	RETURN LOSS (dB) Low Pass Port Typ.	Min.	High Pass Port Typ.	Min.	Common Port Typ.	Min.	Typ.	Min.
Diplexer, 75 Ω																		
	5-42		*54-870*		*54-870*		*5-42*		*42-54 MHz*		*5-42 MHz*		*54-870 MHz*		*5-42 MHz*		*54-870 MHz*	
DPLX-4254-75	0.5	1.2	0.5	1.4	50	40	60	35	30	17	25	18	20	11	30	22	23	11
			88-1000		*88-1000*				*42-88*				*88-1000*				*88-1000*	
DPLX-4288-75	0.5	1.0	0.5	1.0	60	38	60	50	60	45	25	17	20	13	25	17	20	13

FUNCTIONAL SCHEMATIC



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MATCHING PADS, IMPEDANCE 50 to 75 Ω

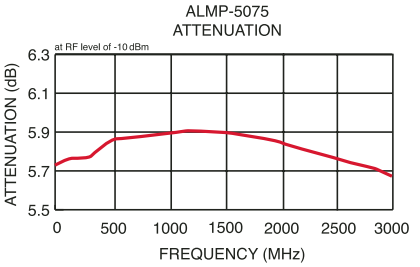
DC to 3000 MHz Resistive minimum loss

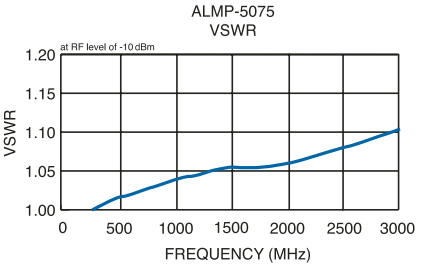
ALMP
Case CB518

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	ATTENUATION (dB) Nom.	Flatness Max L	Flatness Max M	Flatness Max U	VSWR (:1) Max. L	VSWR (:1) Max. M	VSWR (:1) Max. U
ALMP-5075	DC-3000	5.7±0.2	0.2	0.4	0.4	1.06	1.4	1.45

L = DC to 100 MHz M = 100 MHz to 1000 MHz U = 1000 MHz to 3000 MHz

ATTENUATION & VSWR CURVES





WORLD's NO. 1 CHOICE

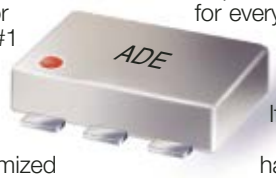
ADE MIXERS

50 kHz-4200 MHz

0.27" x 0.31"

$1.99 from ea. (Qty.100)

With over 72 standard mixer models *IN STOCK*, and over100 more available with optimized performance for specific requirements, the ADE series is the world's #1 choice of high-reliability, high-performance mixers from 50 kHz to 4.2 GHz. Whatever the application, ADE series mixers can meet your frequency conversion requirements. Models are available with a wide range of RF, LO, and IF ranges, and optimized for LO levels from +3 to +20 dBm. ADE series mixers boast conversion loss of less than 6 dB and outstanding LO-to-RF isolation of better than 50 dB. They are designed to fit the tightest designs, supplied in surface-mount packages measuring just 0.27 x 0.31 in. and height as low as 0.080 in. (2 mm).



Full performance data and specifications are available for every model, making it simple to match a mixer to your specific requirements. ADE mixers are competitively priced for even the most demanding budgets. So don't waste time. If you need a mixer from 50 kHz to 4200 MHz, you'll find it in the ADE series, and you won't have to deal with long lead times or uncertain deliveries. Choose an ADE mixer today and we'll have it in your hands as early as tomorrow!

*Available **from stock** and only from Mini-Circuits!*

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MIXERS, ACTIVE 50 Ω

810 MHz to 1940 MHz

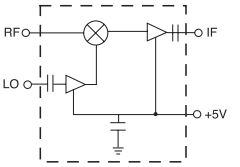
MAX
Case BJ937

High Output IP3

MODEL PREFIX	FREQUENCY (MHz) RF	LO	IF	OUTPUT IP3 (dBm) Typ.	RF INPUT @ 1 dB compression (dBm)	CONVERSION GAIN (dB) Min.	Max.	NOISE FIGURE (dB) Max.	LO-RF ISOLATION (dB) Typ.	Min.	LO-IF ISOLATION (dB) Typ.	Min.	DC POWER Volt	Current (mA) Max.
LEVEL 0 *LO Power 0 dBm up to 8 dBm RF*														
MAX-9H	810-930	570-675	240-260	33	8	8.0	11	11	22	10	2	—	5	165
MAX-19H	1700-1940	1450-1675	240-260	32	7	7.5	10	11	19	10	6	—	5	165

ELECTRICAL SCHEMATIC

MAX MIXER/AMPLIFIER



MIXERS, HIGH RELIABILITY 50 Ω

0.15 to 4000 MHz *(Hermetically Sealed Ceramic Quads)*

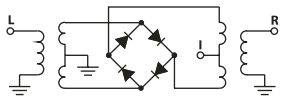
Mini-Circuits® 2007

Plastic case
ADE
Case CD542

Hermetic metal case
TUF-SM
Case NNN150

MODEL PREFIX	LO LEVEL (dBm)	RF IN @ 1 dB comp. Typ. (dBm)	FREQUENCY (MHz) LO/RF	FREQUENCY (MHz) IF	CONVERSION LOSS (dB) MID-BAND x̄	CONVERSION LOSS (dB) MID-BAND σ	CONVERSION LOSS (dB) MID-BAND Max.	CONVERSION LOSS (dB) TOTAL RANGE Max.	LO-RF ISOLATION (dB) L Typ.	LO-RF ISOLATION (dB) L Min.	LO-RF ISOLATION (dB) M Typ.	LO-RF ISOLATION (dB) M Min.	LO-RF ISOLATION (dB) U Typ.	LO-RF ISOLATION (dB) U Min.	LO-IF ISOLATION (dB) L Typ.	LO-IF ISOLATION (dB) L Min.	LO-IF ISOLATION (dB) M Typ.	LO-IF ISOLATION (dB) M Min.	LO-IF ISOLATION (dB) U Typ.	LO-IF ISOLATION (dB) U Min.	IP3 (dBm) Typ.
PLASTIC PACKAGE																					
ADE-R1L	+3	0	2-500	DC-500	5.6	0.10	7.2	8.8	68	55	55	42	44	35	60	45	45	32	35	25	14
ADE-R6	+7	+1	0.15-250	DC-200	4.6	0.05	7.0	7.5	70	50	55	40	42	28	65	45	45	27	32	18	10
ADE-R1	+7	+1	1-500	DC-500	5.0	0.10	6.5	7.8	75	55	60	40	45	33	65	45	45	26	30	18	15
ADE-R2ASK	+7	+1	2-1000	Dc-1000	5.4	0.10	6.8	9.5	65	50	48	32	36	20	55	40	32	22	22	11	14
ADEX-R10	+7	+1	10-1000	DC-800	6.8	0.10	7.8	8.3	70	55	60	40	47	37	40	26	33	20	26	13	16
ADE-R901	+7	+1	300-1000	DC-200	5.9	0.10	7.5	—	38	25	38	25	38	25	28	20	28	20	28	20	13
ADEX-R11X	+7	+1	10-2000	10-1000	7.5	0.10	8.5	9.8	62	45	36	23	30	20	60	45	42	30	33	22	10
ADEX-R20	+7	+1	1500-2800	DC-500	5.8	0.10	8.0	—	30	22	30	22	30	22	28	15	28	15	28	15	12
ADEX-R30W	+7	+1	300-4000	Dc-950	6.8	0.20	9.0	9.8	35	18	35	18	35	18	16	6	16	6	16	6	12
ADE-R1LH	+10	+5	1-500	DC-500	5.2	0.10	6.5	8.2	70	55	60	45	47	32	65	45	45	28	34	20	15
ADE-R2ASKLH	+10	+5	2-1000	DC-1000	5.7	0.10	7.0	9.5	68	45	45	30	36	20	55	40	32	22	22	12	15
ADEX-R10LH	+10	+5	10-1000	DC-800	7.0	0.10	7.8	8.3	70	55	60	40	47	37	40	26	33	20	26	15	16
ADE-R901LH	+10	+5	300-1000	DC-800	6.4	0.10	7.8	—	42	32	42	32	42	32	35	20	35	20	35	20	18
ADE-R5LH	+10	+5	10-1500	DC-1000	7.2	0.10	8.2	9.5	65	50	55	40	42	27	50	37	40	28	30	20	15
ADE-R11XLH	+10	+5	10-2000	10-1000	7.5	0.10	8.6	9.8	55	40	36	23	28	18	65	50	45	30	38	22	11
ADE-R20LH	+10	+5	1500-2600	DC-300	6.0	0.10	8.2	—	35	23	35	23	35	23	26	15	26	15	26	15	14
ADE-R3GLH	+10	+4	2000-2700	DC-700	5.2	0.10	7.0	—	35	24	35	24	35	24	23	9	23	9	23	9	14
ADE-R18WLH	+10	+5	1750-3500	DC-700	5.4	0.30	8.9	—	33	22	33	22	33	22	12	7	12	7	12	7	11
ADE-R35LH	+10	+5	1800-3500	DC-1000	6.8	0.50	9.2	—	25	16	25	16	25	16	22	12	22	12	22	12	14
ADE-R30WLH	+10	+5	300-4000	DC-950	7.5	0.20	9.0	9.8	40	24	40	24	40	24	16	6	16	6	16	6	15
ADE-R1MHW	+13	+9	5-600	DC-600	5.2	0.10	6.9	8.0	63	50	53	35	43	27	56	40	44	28	30	20	18
ADE-R12MH	+13	+9	10-1200	DC-1200	6.8	0.10	8.2	9.5	62	48	50	38	40	28	68	40	42	30	30	21	22
ADE-R272MH	+13	+9	1300-2700	DC-600	5.6	0.10	9.5	—	34	24	34	24	34	24	25	11	25	11	25	11	18
SHIELDED METAL CASE																					
TUF-R3SM	+7	+1	0.25-400	DC-400	5.0	0.06	7.0	8.0	70	55	60	40	55	35	62	45	45	30	38	25	11
TUF-R1SM	+7	+1	5-600	DC-600	5.6	0.2	7.0	8.0	60	45	50	32	42	26	60	43	48	34	40	25	16
TUF-R2SM	+7	+1	50-1000	DC-1000	6.2	0.05	7.5	9.0	60	45	50	38	45	33	52	40	45	25	35	20	16
TUF-R5SM	+7	+1	20-1500	DC-1200	6.5	0.05	9.0	9.0	55	42	48	35	43	32	40	25	30	18	23	10	12
TUF-R3LHSM	+10	+5	0.3-400	DC-400	5.2	0.05	7.0	8.0	62	48	46	30	42	27	62	48	46	30	35	23	15
TUF-R1LHSM	+10	+5	5-600	DC-600	6.2	0.03	7.2	8.5	53	40	48	30	40	24	50	40	45	30	38	21	18
TUF-R2LHSM	+10	+5	50-1000	DC-1000	6.2	0.03	7.5	9.0	55	45	49	38	42	35	52	40	44	30	35	24	17
TUF-R5LHSM	+10	+5	20-1500	DC-650	6.9	0.2	8.8	9.3	55	42	47	35	42	30	40	25	28	16	22	9	13
TUF-R3MHSM	+13	+8	0.3-400	DC-400	5.0	0.03	7.0	8.0	65	50	50	33	43	28	62	48	50	33	38	25	18
TUF-R1MHSM	+13	+9	5-600	DC-600	6.0	0.07	7.0	8.5	55	43	45	33	37	28	55	42	43	32	34	23	20
TUF-R2MHSM	+13	+9	50-1000	DC-1000	6.0	0.1	7.5	9.0	58	40	50	33	42	28	52	38	42	28	32	20	19
TUF-R5MHSM	+13	+9	20-1500	DC-650	7.0	0.1	8.5	9.0	60	45	50	35	46	28	40	27	32	20	22	9	17

ELECTRICAL SCHEMATIC



MIXERS, FREQUENCY 50 Ω

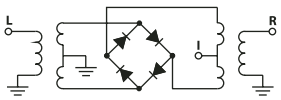
50 kHz to 15000 MHz

SIM Case HV1195 · MCA1 Case DZ885 · MBA Case SM2 · SKY Case BJ398 · ADE /ADEX Cases CD541, CD542, CD636, CD637 · MCA Case DZ883 · RMS Case TT240 · JMS Case BH292

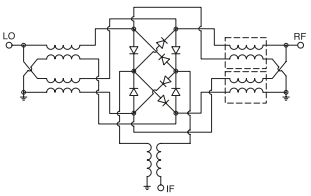
MODEL PREFIX	FREQUENCY (MHz) LO/RF f_L-f_U	IF	CONVERSION LOSS (dB) MID-BAND $\bar{x}$	m σ	Max.	TOTAL RANGE Max.	LO-RF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	LO-IF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	IP3@ center-band TYP. (dBm)	SCHEMATIC
LEVEL 3 +3 dBm LO up to 0 dBm RF																				
ADE-1L	2-500	DC-500	5.2	0.10	7.2	8.0	68	50	55	30	44	30	55	40	45	30	35	25	16	1
MBA-10L	800-1000	DC-200	8.0	0.10	—	9.5			20 (typ.)	13 (min.)					15 (typ.)	8 (min.)			9	1
RMS-5L	400-1400	DC-800	7.0	0.20	—	9.8			22 (typ.)	14 (min.)					22 (typ.)	6 (min.)			9	1
LEVEL 4 +3 dBm LO up to 1 dBm RF																				
ADEX-10L	10-1000	DC-800	7.2	0.10	8.2	8.8	75	55	60	40	47	37	40	26	33	20	24	13	16	1
MBA-15L	1200-2400	DC-600	6.5	0.10	—	8.5			27 (typ.)	15 (min.)					20 (typ.)	10 (min.)			10	1
MBA-25L	2000-3000	DC-600	6.2	0.15	—	8.6			28 (typ.)	18 (min.)					15 (typ.)	7 (min.)			10	1
MBA-591L	4950-5900	DC-1000	7.0	0.10	—	9.0			35 (typ.)	25 (min.)					26 (typ.)	17 (min.)			15	1
SIM-73L	2400-7000	DC-3000	6.3	0.20	—	8.5			32 (typ.)	17 (min.)					26 (typ.)	11 (min.)			12	1
MCA1-85L	2800-8500	DC-1200	6.0	0.30	8.4	—			35 (typ.)	20 (min.)					38 (typ.)	7 (min.)			11	1
MCA1-12GL	3800-12000	DC-1500	6.5	0.30	9.2	—			38 (typ.)	17 (min.)					40 (typ.)	8 (min.)			9	1
LEVEL 7 +7 dBm LO up to +1 dBm RF																				
ADE-6	0.05-250	DC-200	4.6	0.05	7.0	8.4	62	49	40	30	40	20	58	44	45	24	25	15	10	1
TUF-3SM	0.15-400	DC-400	4.7	0.02	7.0	8.0	60	50	46	30	35	25	60	40	47	25	35	20	11	1
ADE-1	0.5-500	DC-500	5.0	0.10	6.5	7.8	70	50	55	35	45	30	65	45	40	25	30	20	15	1
ASK-1-KK81	1-600	DC-600	5.58	0.06	7.0	8.5	50	30	35	25	30	20	45	35	30	20	25	15	14	1
ADE-1ASK	2-600	DC-600	5.3	0.10	6.5	7.5	55	45	50	30	40	25	50	40	45	24	35	18	16	1
TUF-1SM	2-600	DC-600	5.85	0.04	7.0	8.0	60	50	42	30	37	25	60	45	47	30	36	22	16	1
ADE-2ASK	1-1000	DC-1000	5.4	0.10	6.8	9.5	55	45	45	30	36	20	50	40	32	22	22	12	12	1
SYM-2	2-1000	DC-1000	5.4	0.10	7.2	9.5	70	45	50	30	40	25	63	40	48	24	37	20	17	1
ADE-2	5-1000	DC-1000	6.67	0.26	8.0	9.5	65	40	47	25	32	22	62	35	45	25	32	20	20	1
ADEX-10	10-1000	DC-800	6.8	0.10	7.8	8.3	80	55	60	40	47	37	40	26	33	20	24	13	16	1
ADE-12	50-1000	DC-1000	7.0	0.15	8.0	9.0	40	25	—	—	33	22	44	26	—	—	37	20	17	1
TUF-2SM	50-1000	DC-1000	5.85	0.07	7.5	9.0	58	40	47	30	42	25	50	35	44	20	29	18	16	1
ADE-4	200-1000	DC-800	6.8	0.10	—	8.5	60	45	53	40	45	30	45	30	40	22	35	20	15	1
ADE-14	800-1000	DC-200	7.4	0.20	—	8.9			32 (typ.)	22 (min.)					34 (typ.)	20 (min.)			17	1
ADE-901	800-1000	DC-200	5.9	0.10	—	7.3			32 (typ.)	22 (min.)					26 (typ.)	18 (min.)			13	1
SYM-12	5-1200	DC-1000	6.5	0.30	8.0	9.0	68	45	50	30	37	25	56	40	46	25	29	18	16	1
ADE-5	5-1500	DC-1000	6.6	0.10	7.5	9.3	50	40	40	25	33	23	50	40	30	20	20	10	15	1
TUF-5SM	20-1500	DC-1500	5.7	0.04	9.0	9.0	54	40	42	30	39	25	40	25	32	18	23	8	12	1
ADE-13	50-1600	50-1000	8.1	0.10	9.0	9.8	50	25	40	25	33	20	49	30	35	20	32	20	11	1
JMS-11X	5-1900	5-1000	6.7	0.15	8.2	9.8	58	45	35	20	27	18	56	45	37	20	27	20	9	1
ADE-11X	10-2000	5-1000	7.1	0.10	8.2	9.8	62	45	36	20	27	18	60	45	37	20	38	20	9	1
ADE-20	1500-2000	DC-300	5.4	0.10	—	7.8			31 (typ.)	22 (min.)					28 (typ.)	20 (min.)			14	1
MCA1-24	300-2400	DC-700	6.1	0.10	—	8.9			40 (typ.)	25 (min.)					25 (typ.)	15 (min.)			10	1
SYM-2500	1-2500	DC-500	6.5	0.10	8.5	9.8	70	50	50	25	36	20	60	45	30	10	16	8	12	1
MBA-12	800-2500	DC-500	7.5	0.10	—	9.0			30 (typ.)	20 (min.)					15 (typ.)	8 (min.)			12	1
ADE-3GL	2100-2600	DC-600	6.0	0.25	—	8.8			34 (typ.)	25 (min.)					20 (typ.)	7 (min.)			17	1
MBA-26	2200-2700	DC-500	5.7	0.10	—	8.0			40 (typ.)	32 (min.)					33 (typ.)	18 (min.)			9	1
ADE-3G	2300-2700	DC-400	5.6	0.10	—	7.0			36 (typ.)	25 (min.)					26 (typ.)	17 (min.)			13	1
ADE-30	200-3000	DC-1000	4.5	0.20	9.0	9.8			35 (typ.)	20 (min.)					20 (typ.)	7 (min.)			14	1
ADE-35	1600-3500	DC-1500	6.3	0.50	—	9.8			25 (typ.)	16 (min.)					22 (typ.)	12 (min.)			11	1
ADE-18W	1750 -3500	DC-700	5.4	0.30	—	8.9			33 (typ.)	20 (min.)					12 (typ.)	7 (min.)			11	1
ADE-30W	300-4000	DC-950	6.8	0.20	9.0	9.8			35 (typ.)	17 (min.)					16 (typ.)	7 (min.)			12	1
SIM-43	750-4200	DC-1500	6.3	0.20	—	8.6			37 (typ.)	25 (min.)					24 (typ.)	11 (min.)			12	1
MCA1-42	1000-4200	DC-1500	6.1	0.10	—	8.9			35 (typ.)	23 (min.)					20 (typ.)	12 (min.)			10	1
SKY-42	2000-4200	DC-1200	5.0	0.30	—	8.5			31 (typ.)	20 (min.)					17 (typ.)	12 (min.)			9	1
MBA-591	2800-5900	DC-1000	6.5	0.10	—	9.0			36 (typ.)	20 (min.)					26 (typ.)	17 (min.)			10	1
MCA1-60	1600-6000	DC-2000	6.2	0.30	—	8.5			32 (typ.)	17 (min.)					18 (typ.)	—			8	1
MBA-671	2400-6700	DC-1000	6.5	0.10	—	9.2			36 (typ.)	20 (min.)					26 (typ.)	17 (min.)			10	1
SIM-83	2300-8000	DC-3000	6.0	0.20	—	8.9			32 (typ.)	17 (min.)					28 (typ.)	7 (min.)			15	1
MCA1-85	2800-8500	DC-1250	5.5	0.20	—	8.1			40 (typ.)	20 (min.)					40 (typ.)	9 (min.)			13	1
SIM-14	3700-10000	DC-4000	6.3	0.20	—	9.5			36 (typ.)	25 (min.)					16 (typ.)	12 (min.)			13	1
MCA1-12G	3800-12000	DC-1800	6.2	0.10	—	8.5			38 (typ.)	18 (min.)					40 (typ.)	8 (min.)			11	1
SIM-153	3400-15000	DC-4000	8.0	0.40	—	13.2			36 (typ.)	20 (min.)					30 (typ.)	20 (min.)			10	1

ELECTRICAL SCHEMATICS

1 DOUBLE BALANCED MIXER



2 TRIPLE BALANCED MIXER



MODEL PREFIX	FREQUENCY (MHz) LO/RF f_L-f_U	IF	CONVERSION LOSS (dB) MID-BAND m $\bar{x}$	σ	Max.	TOTAL RANGE Max.	LO-RF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	LO-IF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	IP3 @ center-band TYP. (dBm)	SCHEMATIC
LEVEL 10 +10 dBm LO up to +5 dBm RF																				
ADE-1LH	0.5-500	DC-500	5.0	0.10	6.5	8.2	65	50	55	35	47	26	52	40	45	22	34	20	15	1
JMS-1LH	2-500	DC-500	5.75	0.10	7.0	8.0	55	50	45	30	40	25	55	45	45	25	30	20	16	1
RMS-1LH	2-500	DC-500	5.36	0.08	7.0	8.0	58	45	44	25	30	20	55	40	40	25	28	17	15	1
TUF-1LHSM	2-600	DC-600	6.0	0.17	7.0	8.0	70	50	50	30	42	25	65	45	50	30	41	22	17	1
RMS-2LH	5-1000	DC-1000	6.44	0.10	8.0	9.5	58	40	39	20	22	16	52	30	30	17	18	11	18	1
TUF-5LHSM	20-1500	DC-1000	6.9	0.27	8.5	9.0	53	40	42	30	38	25	40	25	30	18	22	8	14	1
SYM-11LH	1-2000	10-600	7.0	0.10	8.3	9.85	60	40	45	25	37	25	59	40	33	20	25	20	14	2
LRMS-20J	1500-2000	DC-500	5.0	0.15	—	7.5			35 (typ.)	22 (min.)					26 (typ.)	18 (min.)			18	1
MCA1-24LH	300-2400	DC-700	6.5	0.10	—	8.9			40 (typ.)	25 (min.)					22 (typ.)	12 (min.)			13	1
MBA-15LH	1200-2400	DC-600	5.6	0.10	—	8.5			26 (typ.)	17 (min.)					22 (typ.)	10 (min.)			15	1
SYM-25DLHW	40-2500	DC-1000	6.3	0.10	7.5	8.8	48	28	40	25	38	22	36	25	33	25	39	21	22	2
SCM-2500LH	500-2500	DC-500	5.6	0.20	6.8	10.0			36 (typ.)	22 (min.)					18 (typ.)	10 (min.)			16	1
LRMS-25J	750-2500	DC-600	5.2	0.15	—	9.5			35 (typ.)	17 (min.)					20 (typ.)	7 (min.)			18	1
SYM-30DLHW	5-3000	5-1500	6.5	0.15	8.4	9.2	36	28	37	29	33	23	41	32	45	37	47	31	19	2
MBA-18LH	1600-3200	DC-500	5.8	0.10	—	8.5			30 (typ.)	17 (min.)					22 (typ.)	10 (min.)			12	1
MCA-35LH	500-3500	10-1500	6.3	0.10	—	8.9			32 (typ.)	11 (min.)					30 (typ.)	15 (min.)			16	2
MBA-25LH	2200-3600	DC-500	7.0	0.10	—	9.2			32 (typ.)	21 (min.)					20 (typ.)	10 (min.)			12	1
SIM-43LH	824-4200	DC-1500	6.3	0.10	—	8.6			37 (typ.)	26 (min.)					24 (typ.)	11 (min.)			14	1
MCA1-42LH	1000-4200	DC-1500	6.0	0.10	—	8.9			38 (typ.)	23 (min.)					20 (typ.)	11 (min.)			12	1
MCA-50LH	1000-5000	10-1500	7.3	0.20	—	9.9			25 (typ.)	11 (min.)					30 (typ.)	15 (min.)			17	2
SKY-53LHR	2800-5300	DC-500	6.2	0.20	—	9.5			28 (typ.)	15 (min.)					12 (typ.)	8 (min.)			14	1
SIM-63LH	750-6000	DC-1500	6.6	0.20	—	9.3			32 (typ.)	22 (min.)					22 (typ.)	12 (min.)			12	1
MCA1-60LH	1700-6000	DC-2000	6.4	0.10	—	8.3			35 (typ.)	20 (min.)					21 (typ.)	—			13	1
SKY-60LH	2500-6000	DC-1500	6.2	0.20	—	9.7			28 (typ.)	17 (min.)					14 (typ.)	8 (min.)			15	1
SIM-83LH	1700-8000	DC-3000	6.0	0.20	—	8.4			31 (typ.)	16 (min.)					28 (typ.)	8 (min.)			18	1
MCA1-80LH	2800-8000	DC-1250	5.9	0.20	8.4	—			35 (typ.)	20 (min.)					40 (typ.)	8 (min.)			12	1
SIM-153LH	3200-15000	DC-4000	7.5	0.30	—	12.4			36 (typ.)	17 (min.)					20 (typ.)	9 (min.)			18	1
SIM-14LH	3700-10000	DC-4000	6.7	0.30	—	8.9			38 (typ.)	21 (min.)					17 (typ.)	10 (min.)			19	1
LEVEL 13 +13 dBm LO up to +9 dBm RF																				
TUF-3MHSM	0.15-400	DC-400	5.0	0.33	7.0	8.0	60	50	46	30	35	25	60	40	42	25	35	20	18	1
ADE-1MHW	0.5-600	DC-600	5.2	0.10	6.9	8.0	63	50	53	32	43	20	56	40	44	25	30	20	17	1
ADE-1MH	2-500	DC-500	5.2	0.10	6.5	8.0	60	45	50	35	48	25	55	40	45	30	40	22	17	1
JMS-1MH	2-500	DC-500	5.75	0.10	7.0	8.0	70	55	60	40	44	25	55	42	45	25	35	20	22	1
RMS-1MH	2-500	DC-500	5.65	0.08	7.0	8.0	58	45	44	25	30	20	55	40	36	25	28	17	26	1
ADE-12MH	10-1200	DC-1200	6.3	0.10	8.0	8.5	62	45	45	32	40	26	68	40	42	27	30	20	22	1
TUF-2MHSM	50-1000	DC-1000	6.0	0.25	7.5	9.0	58	40	47	30	37	25	55	35	47	20	32	18	19	1
ADE-10mh	800-1000	10-200	7.0	0.20	—	8.5			34 (typ.)	20 (min.)					29 (typ.)	20 (min.)			26	2
JMS-5MH	5-1500	DC-1000	5.7	0.10	8.0	9.5	67	40	57	25	35	20	60	40	35	18	15	8	19	1
RMS-5MH	10-1500	DC-900	5.67	0.09	9.0	9.5	58	40	40	20	26	18	50	30	38	18	17	8	17	1
MCA1-24MH	300-2400	DC-700	6.1	0.10	—	8.9			40	20					25	14			13	1
MBA-15MH	1400-2400	DC-600	5.5	0.10	—	8.5			28 (typ.)	16 (min.)					16 (typ.)	8 (min.)			18	1
ADE-25MH	5-2500	5-1500	6.9	0.10	8.5	9.8	47	28	34	23	34	23	34	23	32	20	23	17	18	2
RMS-25MH	5-2500	5-1500	7.0	0.20	8.5	9.8	54	28	32	23	32	20	34	23	32	25	28	17	17	2
SYM-25DMHW	40-2500	DC-1000	6.6	0.10	8.0	9.0	47	32	37	27	35	22	38	28	35	25	38	20	26	2
SYM-30DMHW	5-3000	5-1500	6.5	0.10	8.4	9.3	36	25	39	30	34	23	41	27	42	33	45	30	22	2
MBA-25MH	2000-3000	DC-500	6.5	0.10	—	8.6			36 (typ.)	18 (min.)					20 (typ.)	7 (min.)			18	1
ADE-35MH	5-3500	5-2500	6.9	0.10	9.3	10.5	47	28	33	23	38	18	34	23	28	18	23	17	18	2
MCA-35MH	500-3500	10-1500	6.9	0.10	—	8.7			29	11					29	15			20	2
ADE-42MH	5-4200	5-3500	7.5	0.20	9.8	11.8	47	28	29	20	30	15	34	23	26	17	23	17	17	2
RMS-42MH	800-4200	DC-800	5.3	0.20	9.0	10.8	35	25	—	—	28	17	18	10	—	—	15	7	19	1
SIM-43MH	824-4200	DC-1500	6.3	0.10	—	9.8			37 (typ.)	22 (min.)					24 (typ.)	10 (min.)			20	1
MCA1-42MH	1000-4200	DC-1500	6.2	0.10	—	8.9			35	20					20	10			16	1
MCA-50MH	1000-5000	10-1500	7.3	0.20	—	9.9			25	11					30	20			19	2
SKY-53MHR	2800-5300	DC-500	5.7	0.20	—	9.5			28 (typ.)	15 (min.)					12 (typ.)	8 (min.)			19	1
MCA1-60MH	1600-6000	DC-2000	6.2	0.10	—	8.5			28	18					15	—			15	1
SKY-60MH	2500-6000	DC-1500	6.2	0.20	—	9.5			28 (typ.)	17 (min.)					14 (typ.)	8 (min.)			19	1
MCA1-80MH	2800-8000	DC-1250	5.6	0.20	—	8.7			27 (typ.)	17 (min.)					25 (typ.)	7 (min.)			18	1
SIM-43MH	824-4200	DC-1500	5.7	0.1	—	9.8			37	22					24	10			20	1
SIM-153MH	3200-15000	DC-4000	7.5	0.40	—	11.5			35	21					19	9			17	1

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)
m = mid band ($2f_L$ to $f_U/2$)

MIXERS, FREQUENCY 50 Ω

150 kHz to 10000 MHz

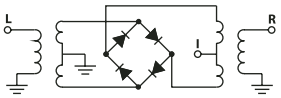
LTCC	LTCC									
SIM Case HV1195	MCA1 Case DZ885	MCA Case DZ883	SKY Case BJ398	ADE /ADEX Cases CD541/542, CD636	RMS Case TT240	JMS Case BH292	LRMS-J Case QQQ569	TUF-SM Case NNN150	SYM Case TTT166	JYM Case BJ293

MODEL PREFIX	FREQUENCY (MHz) LO/RF f_L-f_U	IF	CONVERSION LOSS (dB) MID-BAND m $\bar{x}$	σ	Max.	TOTAL RANGE Max.	LO-RF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	LO-IF ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	IP3 @ center-band TYP. (dBm)	SCHEMATIC
LEVEL 17 +17 dBm LO up to +14 dBm RF																				
TUF-3HSM	0.15-400	DC-400	5.00	0.33	7.0	8.0	60	50	50	35	40	30	60	40	45	25	35	20	22	1
ADE-1H	0.5-500	DC-500	5.30	0.20	6.8	8.0	65	50	52	35	40	26	53	40	42	25	32	20	23	1
JMS-1H	2-500	DC-500	5.90	0.10	7.0	8.5	60	45	50	25	37	22	55	45	50	25	37	22	22	1
RMS-1H	2-500	DC-500	6.25	0.034	7.0	8.5	55	44	44	25	33	20	50	34	45	25	37	22	22	1
LRMS-1HJ	2-500	DC-500	6.25	0.034	7.0	8.5	55	44	44	25	33	20	50	34	45	25	37	22	25	1
TUF-1HSM	2-600	DC-600	5.90	0.18	7.0	8.0	68	50	50	30	43	25	62	45	48	30	33	22	26	1
ADE-1HW	5-750	DC-750	6.00	0.10	7.2	8.8	64	45	48	35	42	28	50	35	40	30	30	18	26	1
RMS-2H	5-1000	DC-900	6.98	0.054	8.5	9.3	55	40	39	22	33	20	52	30	45	22	30	17	23	1
ADEX-10H	10-1000	DC-800	7.00	0.10	8.5	9.5	68	55	55	40	47	31	46	30	32	20	26	13	22	1
JMS-2H	20-1000	DC-1000	7.00	0.15	8.4	9.5	63	40	50	28	35	20	56	30	47	22	37	20	24	1
SYM-10DHW	50-1000	20-800	7.00	—	8.5	9.8			45	30					29	20			25	2
TUF-2HSM	50-1000	DC-1000	6.20	0.22	7.5	9.0	58	40	47	30	42	25	58	35	44	25	28	18	21	1
ADE-10H	400-1000	DC-500	7.00	0.10	—	8.5			39	29					25	17			30	1
SYM-10DH	800-1000	20-200	7.60	—	—	9.3			45	34					29	20			31	2
SIM-14H	3700-1000	DC-4000	7.00	0.30	9.3				38	24					16	8			25	
ADE-12H	500-1200	DC-250	6.70	0.20	—	8.2			34	25					28	20			28	1
SYM-14H	100-1370	10-1000	6.50	0.20	7.4	8.9			36	28					30	24			30	2
JMS-5H	5-1500	DC-1000	5.90	0.10	8.0	9.5	70	50	50	25	35	20	60	40	35	18	20	8	22	1
LRMS-5HJ	10-1500	DC-900	6.36	0.05	8.0	9.8	65	40	36	20	22	15	50	30	30	18	17	7	22	1
RMS-5H	10-1500	DC-900	6.36	0.05	8.0	9.8	65	40	36	20	22	15	50	30	30	18	17	7	24	1
TUF-5HSM	20-1500	DC-1000	7.50	0.17	8.5	9.0	62	55	50	40	38	25	40	25	29	18	20	8	20	1
ADE-17H	100-1700	50-1500	7.20	0.10	8.5	9.5	32	20	—	—	36	22	32	20	—	—	37	22	25	2
SYM-18H	5-1800	10-1500	5.75	0.10	7.6	8.9	50	28	45	35	40	24	39	22	50	30	30	22	30	2
TUF-18DHSM	100-1800	50-750	7.30	0.15	8.5	9.0			41	23					33	20			27	2
SYM-20DHW	10-2000	10-1800	6.20	0.10	7.5	8.8	33	20	40	25	37	22	44	30	42	28	34	22	27	2
SYM-20DH	1700-2000	10-300	6.70	0.16	—	8.2			35	22					34	22			32	2
SYM-22H	1500-2200	DC-200	5.60	0.30	—	8.8			33	22					38	22			30	1
SYM-24DH	1400-2400	10-250	7.00	0.20	—	9.3			32	22					36	23			29	2
SYM-25DHW	80-2500	DC-1000	6.40	0.40	8.0	9.0	46	29	37	25	35	20	38	26	33	24	36	20	30	2
JYM-28H	400-2800	4-700	6.30	0.20	8.0	9.0			40	25					30	15			23	2
JYM-30H	2-3000	4-1400	6.00	0.20	8.9	10.6	40	30	40	25	30	25	40	35	30	20	22	15	24	2
SYM-30DHW	5-3000	5-1500	6.50	0.10	8.3	9.1	36	24	40	30	40	25	42	28	44	36	48	33	29	2
MCA-35H	500-3500	10-1500	6.90	0.10	8.9	—			30	11					27	14			24	2
SYM-36H	1500-3600	DC-600	6.30	0.40	—	9.0			30	20					34	20			25	1
SIM-43H	1000-4000	DC-1500	6.50	0.10	8.6				37	28					24	9			22	
MCA-50H	1000-5000	10-1500	7.30	0.20	10.2	—			25	12					32	18			23	2
SKY-60H	2500-6000	DC-1500	6.20	0.20	—	9.7			28	17					14	8			23	1
SIM-762H	2300-7600	DC-3000	6.00	0.10	9.0				35	17					21	11			25	
MCA1-80H	2800-8000	DC-1250	6.30	0.20	8.9	8.9			35	21					35	8			24	1
MCA1-113H	3800-11000	DC-1800	6.80	0.20	8.8	8.8			35	17					32	8			21	1

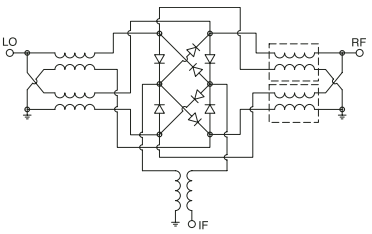
L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)
m = mid band ($2f_L$ to $f_U/2$)

ELECTRICAL SCHEMATICS

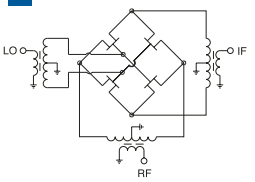
1 DOUBLE BALANCED MIXER



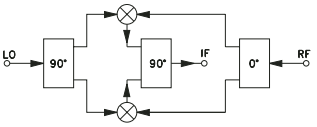
2 TRIPLE BALANCED MIXER



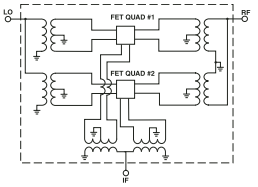
3 HIGH IP3 NARROW BAND MIXER



4 IMAGE REJECT MIXER



5 HIGH IP3 BROADBAND MIXER



HJK Case TTT167, TTT881 | LAVI Case CK605 | JCIR Case BG291

High IP3

MODEL PREFIX	FREQUENCY (MHz) RF	LO	IF	IP3 (dBm) Typ.	RF @1 dB compr. (dBm) Typ.	CONVERSION LOSS (dB) Typ.	σ	Max.	LO-RF ISOLATION (dB) Typ.	Min.	LO-IF ISOLATION (dB) Typ.	Min.	SCHEMATIC
LEVEL 7 +7 dBm LO up to +10 dBm RF													
HJK-9	818-853	753-778	40-100	22	10	7.1	0.3	8.7	36	24	26	20	3
HJK-19	1850-1910	1780-1840	70-130	21	10	8.0	0.2	9.5	30	20	24	16	3
HJK-21	1850-1910	2090-2150	180-300	22	10	7.5	0.3	9.5	28	18	19	13	3
LEVEL 10 +10 dBm LO up to +13 dBm RF													
HJK-9LH	818-853	753-778	40-100	27	13	6.7	0.2	8.0	37	24	27	20	3
HJK-19LH	1850-1910	1750-1840	70-130	25	13	7.5	0.2	9.4	30	20	23	15	3
HJK-21LH	1850-1910	2090-2150	180-300	25	13	7.2	0.3	8.9	28	20	19	13	3
MCA-19FLH	1850-1910	1760-1820	70-130	25	10	6.9	—	8.8	40	22	39	20	3
MCA-30FLH	2960-3060	2780-2880	130-230	25	10	7.5	—	8.9	35	20	27	15	3
MCA-36FLH	3500-3600	3500-3170	380-480	25	10	8.4	—	9.4	40	20	28	15	3
LEVEL 13 +13 dBm LO up to +16 dBm RF													
HJK-9MH	818-853	753-778	40-100	31	16	6.7	0.2	8.0	37	24	27	20	3
HJK-19MH	1850-1910	1780-1840	70-130	30	16	7.4	0.2	8.9	30	20	23	15	3
HJK-21MH	1850-1910	2090-2150	180-300	29	16	7.2	0.2	8.9	29	20	19	13	3
MCA-19FMH	1850-1910	1760-1820	70-130	30	13	6.9	—	8.4	40	22	39	20	3
MCA-30FMH	2960-3060	2780-2880	130-230	30	13	7.4	—	8.9	35	20	27	15	3
MCA-36FMH	3500-3600	3070-3170	380-480	30	13	8.3	—	9.3	42	20	27	15	3
LEVEL 16 +16 dBm LO up to +19 dBm RF													
HJK-3H	140-180	160	0.5-20	37	19	8.0	0.1	9.2	44	35	44	30	3
LEVEL 17 +17 dBm LO up to +20 dBm RF													
HJK-9H	818-853	753-778	40-100	33	20	6.7	0.2	8.0	35	24	31	23	3
HJK-19H	1850-1910	1780-1840	70-130	32	20	8.0	0.2	8.9	26	20	22	16	3
HJK-21H	1850-1910	2090-2150	180-300	36	20	7.6	0.2	8.9	28	20	25	18	3
MCA-19FH	1850-1910	1760-1820	70-130	35	17	6.9	—	8.5	40	22	39	20	3
MCA-30FH	2960-3060	2780-2880	130-230	34	17	7.4	—	8.9	37	20	27	15	3
MCA-36FH	3500-3600	3070-3170	380-480	33	17	8.3	—	9.2	44	20	29	15	3
LEVEL 19 +19 dBm LO up to +23 dBm RF													
LAVI-9VH	820-870	990-1040	120-220	36	23	7.2	0.12	8.5	46	40	46	37	5
LEVEL 20 +20 dBm LO up to +15 dBm RF													
HJK-20VH	1090	1167-1950	77-870	28	15	7.2	0.2	8.5	32	26	34	26	3
LEVEL 21 +21 dBm LO up to +20 dBm RF Wideband													
LAVI-10VH	300-1000	525-1175	60-875	33	20	6.3	0.12	8.0	50	40	45	30	5
LAVI-17VH	470-1730	600-1800	70-1000	32	20	6.8	0.20	8.9	52	38	50	36	5
LAVI-22VH	425-2200	525-2400	100-700	31	20	7.7	0.20	9.6	50	36	45	28	5
LEVEL 23 +23 dBm LO up to +23 dBm RF Wideband													
LAVI-25VH	400-2500	650-2800	70-1500	32	20	7.8	0.25	9.6	50	35	45	30	5
LAVI-2VH	2-1100	2-1100	2-1000	34	23	7.5	0.12	9.5	48	37	47	36	5

Image Reject

MODEL PREFIX	FREQUENCY (MHz) RF f_L-f_U	LO f_L-f_U	IF	CONVERSION LOSS (dB) $\bar{x}$	σ	Max.	IMAGE REJECTION (dBc) RF>LO	LO>RF	Typ.	Min.	LO-RF ISOLATION (dB) Typ.	Min.	LO-IF ISOLATION (dB) Typ.	Min.	RF-IF ISOLATION (dB) Typ.	Min.	IP3 @ centerband (dBm) Typ.	SCHEMATIC
LEVEL 13 +13dBm LO up to +1 dBm RF																		
JCIR-25	2490-2550	2420-2480	57-83	7.0	—	8.5		●	27	17	35	25	26	18	25	—	16	4
LEVEL 15 +15dBm LO up to +1 dBm RF																		
JCIR-4MH	430-930	500-1000	65-75	7.9	0.15	9.0	●		28	18	55	40	25	20	25	15	20	4

Up Converters 0.1 to 7400 MHz

MODEL PREFIX	LO LEVEL (dBm)	RF IN @ 1 dB compr. Typ. (dBm)	FREQUENCY (MHz) IF (IN)	LO	RF (OUT)	CONVERSION LOSS (dB) Typ.	σ	Max.	LO-IF (IN) ISOLATION (dB) Typ.	Min.	LO-RF (OUT) ISOLATION (dB) Typ.	Min.	IP3 @ centerband (dBm) Typ.
SIM-U63	7	+1	1600-2500	3100-5700	3800-6000	6.9	0.3	8.4	16	10	39	29	10
SIM-U742MH	13	+9	0.1-3300	2300-7400	2300-7400	8.0	0.4	9.8	17	11	23	13	20
SIM-U432H	17	+14	0.1-800	1100-4250	1100-3900	7.5	0.2	9.8	24	13	36	28	26
SIM-U712H	17	+14	2600-7100	10-1780	2600-7100	7.3	0.3	9.5	27	14	19	11	27

MODULATORS/DEMODULATORS 50 Ω

52 MHz to 2000 MHz

LTCC

IQBG Case SM20A

JCIQ Case BG291

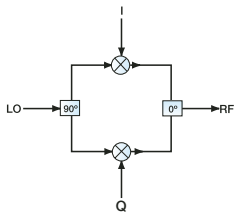
I&Q Modulators

MODEL PREFIX	FREQUENCY (MHz) RF (signal)/ LO (carrier) f_L	f_U	I&Q Min.	Max.	CONVERSION LOSS (dB) $\bar{X}$	σ	Max.	CARRIER REJECTION (-dBc) Typ.	Min.	SIDEBAND REJECTION (-dBc) Typ.	Min.	HARMONIC SUPPRESSION (-dBc) 3XI/Q Typ.	Min.	5XI/Q Typ.	Min.
High rejection of carrier and sideband 52 MHz to 2000 MHz I&Q up to 0 dBm LO Power 10 dBm															
JCIQ-88M	52	88	DC	5	5.6	0.1	7.0	40	32	35	30	45	35	65	50
JCIQ-176M	104	176	DC	5	5.6	0.1	7.0	35	30	35	30	45	35	65	50
IQBG-2000A	1800	2000	DC	10	7.5	—	9.0	30	20	34	28	50	45	70	50

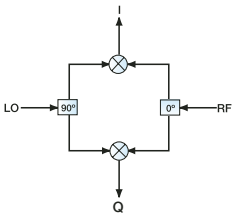
Demodulators

MODEL PREFIX	FREQUENCY (MHz) RF (signal)/ LO (carrier) f_L	f_U	I&Q Min.	Max.	CONVERSION LOSS (dB) $\bar{X}$	σ	Max.	AMPLITUDE UNBALANCE (dB) Typ.	Max.	PHASE UNBALANCE (Degrees) Typ.	Max.	HARMONIC SUPPRESSION (-dBc) 3XI/Q Typ.	Min.	5XI/Q Typ.	Min.
104 MHz to 1880 MHz LO Power 10 dBm RF up to 4 dBm															
JCIQ-176D	104	176	DC	5	5.5	0.1	7.0	0.15	0.6	2	5	52	40	65	50
JCIQ-1880D	1805	1880	DC	5	8.0	0.2	10.5	0.2	0.6	2	5	50	35	65	50

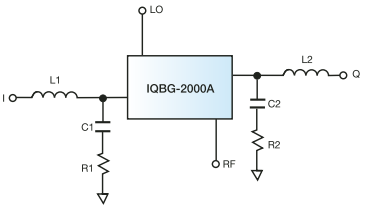
I&Q Modulation Block Diagram



I&Q Demodulation Block Diagram



Recommended IF Diplexer



L1, L2	33 nH	CHIP INDUCTOR (1206)
C1, C2	10 pF	NPO CHIP CAPACITOR (0603)
R1, R2	47 Ω	5% CHIP RESISTOR (0603)

MULTIPLIERS, FREQUENCY 50 Ω

20 MHz to 10000 MHz

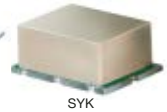
Mini-Circuits® 2007

KC2
Case DZ885

KBA
Case SM2

AMK-2-13+ Case CD542
AMK-3-452+ Case CD636

LK
Case BB48



SYK
Case TTT167

RMK
Case TT1224

MODEL PREFIX	FREQUENCY (MHz)		RF INPUT POWER (dBm)		CONVERSION LOSS (dB)		HARMONIC OUTPUT (dBc)					
							F1		F3		F4	
	Input	Output	Min.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.
X2							B E L O W F 2					
AMK-2-13	10-55	20-1000	4	10	11.4	14.5	45	20	45	25	22	12
SYK-2R	10-500	20-1000	12	16	10.5	14.0	35	25	42	25	20	10
	500-1000	1000-2000	12	16	11.5	16.0	32	20	37	20	20	10
KC2-11	500-1100	1000-2200	5	10	10.5	13.5	27	18	34	20	21	12
KC2-19	1100-1900	2200-3800	5	10	10.5	14.6	24	18	30	18	17	12
KBA-20	1600-2200	3200-4400	11	15	12.0	15.8	12	7	20	13	23	10
LK-3000	70-1000	140-2000	12	15	10.5	14.0	31	20	40	25	15	10
	1000-1500	2000-3000	12	15	11.5	16.0	22	15	35	20	20	14
KC2-36	1700-3600	3400-7200	8	13	11.0	15.5	18	9	30	17	17	8
KBA-40	2700-4800	5400-9600	10	16	12.3	17.6	18	10	26	15	24	14
	2700-4800	5400-9600	5	10	13.0	19.0	15	8	26	16	26	12
KC2-50	3500-5000	7000-10000	7	12	12.5	16.0	15	8	28	20	30	17
X3							B E L O W F 3					
							F1		F2		F4	
AMK-3-452	1000-1500	3000-4500	10	14	14.5	17.5	-2	-10	55	40	55	40
RMK-3-662	1600-2200	4800-6600	9	13	15.0	19.5	6	-4	45	20	38	21
RMK-3-812	1800-2700	5400-8100	0	8	16.0	21.0	6	-6	40	22	37	24

RKK
Case CK1246

X4							B E L O W F 4							
							F1		F2		F3		F5	
RKK-4-23	320-500	1280-2000	11	15	24.5	30.0	27	21	34	20	38	23	30	24

PHASE DETECTORS 50 Ω

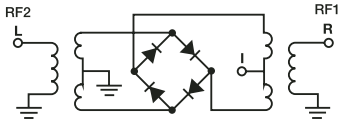
1 MHz to 650 MHz

SYPD
Case TTT167

High Output

MODEL PREFIX	FREQUENCY (MHz) RF1 RF2	FREQUENCY (MHz) I	POWER IN RF1 RF2 (dBm)	SCALE FACTOR mV/deg.	IMPEDANCE (OHMS) output load I	ISOLATION (dB) RF1-RF2 Min.	OUTPUT POLARITY RF1/RF2 In-phase	DC OUTPUT (mV) Max. Typ.	DC OUTPUT (mV) Max. Min.	DC OUTPUT (mV) Offset Typ.	DC OUTPUT (mV) Offset Max.	FIGURE-OF-MERIT M Typ.
SYPD-1	1-100	DC-50	7	8	500	40	neg.	1000	700	0.2	1	143
SYPD-2	10-200	DC-50	7	8	500	40	neg.	1000	700	0.3	1	143
SYPD-52	400-500	DC-50	7	8	500	30	neg.	900	700	0.7	1.2	129
SYPD-52W	300-650	DC-50	7	8	500	28	neg.	850	700	1.0	5.0	129

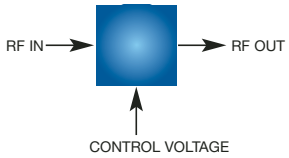
ELECTRICAL SCHEMATIC



JSPHS Case BK276

MODEL PREFIX	FREQUENCY (MHz)	PHASE RANGE (degrees)	INSERTION LOSS (dB)		CONTROL VOLTAGE (V)	CONTROL BANDWIDTH	VSWR (:1)	
		Min.	Typ.	Max.		Typ.	Typ.	Max.
180° VOLTAGE VARIABLE								
JSPHS-12	8-12	180	0.9	2.5	0-15	DC-50 kHz	1. 2	1. 8
JSPHS-26	18-26	180	1.2	3.0	0-12	DC-50 kHz	1. 2	1. 7
JSPHS-150	100-150	180	1.2	2.5	0-12	DC-30 kHz	1. 2	1. 7
JSPHS-446	366-446	180	1.2	2.5	0-12	DC-50 kHz	1. 2	1. 7
JSPHS-1000	700-1000	160	1.2	2.3	0-15	DC-50 kHz	1. 2	2. 6

ELECTRICAL SCHEMATIC



POWER SPLITTERS/COMBINERS

100 kHz to 6500 MHz

SCN, QCN Case FV1206-1 | BP2 Case XX211 | SBB Case SM31 | SBA Case SM1 | SBA Case SM2 | TCP Case DB714 | SBTC Case AT790 | SBTC-L Case AT1029 | ADP, ADPQ Case CD636, CD542 | SP Case CA531 | RPS CaseTT240-1 | JPS Case BH292 | LRPS-J Case QQQ569 | SYPS Case TTT167 | JYPS Case BJ293 | SCP Case YY101

MODEL PREFIX	FREQUENCY RANGE (MHz)	ISOLATION (dB)						INSERTION LOSS, (dB) Above 3 dB						PHASE UNBAL., degrees			AMPLITUDE UNBAL. (dB)			INPUT RF Power Max (W)	
	f_L-f_U	L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	L Max.	M Max.	U Max.	L Max.	M Max.	U Max.	S-Port (Matched output ports)	Output ports (Matched S port)
2 WAY-0° 50Ω																					
SCP-2-1	0.1-400	25	15	30	20	25	20	0.30	1.2	0.2	0.6	0.4	1.1	2.0	2.0	3.0	0.15	0.6	1.2	1.0	0.125
ADP-2-1	0.5-400	25	20	25	20	25	20	0.20	0.4	0.3	0.6	0.5	1.0	1.0	2.0	3.0	0.10	0.2	0.3	0.5	0.125
JPS-2-1	1-500	34	20	30	20	27	20	0.20	0.8	0.25	0.7	0.4	0.9	1.0	2.0	3.0	0.10	0.2	0.3	1.0	0.125
SYPS-2-1	2-500	40	20	32	20	30	20	0.20	0.6	0.3	0.75	0.6	1.0	2.0	3.0	4.0	0.20	0.3	0.5	1.0	0.125
LRPS-2-1J	5-500	50	25	33	24	30	23	0.25	0.5	0.3	0.6	0.5	1.2	1.0	2.0	3.0	0.15	0.2	0.3	1.0	0.125
SCP-2-1A	1-550	25	20	25	20	25	20	0.30	0.6	0.3	0.6	0.7	1.3	2.0	2.0	3.0	0.15	0.2	0.4	1.0	0.125
JPS-2-1N	350-550	30	20	30	20	30	20	0.25	0.5	0.25	0.5	0.25	0.5	3.0	3.0	3.0	0.3	0.3	0.3	1.0	0.125
ADP-2-1W	1-650	30	20	30	20	24	20	0.20	0.8	0.25	0.8	0.5	1.0	2.0	2.0	3.0	0.15	0.2	0.3	2.0	0.125
JPS-2-1W	3-750	36	20	28	17	19	16	0.50	0.8	0.4	1.0	0.9	1.4	1.0	2.0	4.0	0.20	0.3	0.4	1.0	0.125
ADP-2-9	200-900	27	20	27	20	27	20	0.4	0.8	0.4	0.8	0.4	0.8	2.0	2.0	2.0	0.3	0.3	0.3	0.5	0.125
JPS-2-900	400-900	24	18	24	18	24	18	0.5	1.2	0.5	1.2	0.5	1.2	3.0	3.0	3.0	0.4	0.4	0.4	1.0	0.125
SP-2C	780-960	28	17	28	17	28	17	0.4	0.6	0.4	0.6	0.4	0.6	2.0	2.0	2.0	0.2	0.2	0.2	1.5	0.75
BP2C	810-960	25	18	25	18	25	18	0.4	0.9	0.4	0.9	0.4	0.9	3.0	3.0	3.0	0.2	0.2	0.2	1.0	0.75
LRPS-2-980J	800-980	30	18	30	18	30	18	0.5	1.0	0.5	1.0	0.5	1.0	3.0	3.0	3.0	0.5	0.5	0.5	1.0	0.125
ADP-2-10	5-1000	25	15	23	15	20	15	0.30	0.9	0.4	0.9	0.6	1.2	2.0	2.0	3.0	0.20	0.2	0.3	0.5	0.125
SBTC-2-10	5-1000	29	20	25	18	21	16	0.30	0.7	0.3	0.8	0.5	1.4	3.0	3.0	5.0	0.60	0.5	0.5	0.5	0.125
TCP-2-10	5-1000	25	17	25	16	21	16	0.30	0.9	0.5	0.9	0.5	1.4	4.0	4.0	6.0	0.60	0.6	0.3	0.5	0.250
ADP-2-4	10-1000	25	20	23	16	19	14	0.30	0.5	0.4	0.9	0.8	1.5	1.0	3.0	5.0	0.15	0.2	0.4	1.0	0.125
LRPS-2-4J	10-1000	25	20	23	16	19	14	0.30	0.5	0.4	0.9	0.8	1.5	1.0	3.0	5.0	0.15	0.2	0.4	1.0	0.125
JPS-2-4	100-1000	22	16	22	16	22	16	0.5	1.4	0.5	1.4	0.5	1.4	5.0	5.0	5.0	0.4	0.4	0.4	1.0	0.125
SBB-2-10	800-1000	24	15	24	15	24	15	0.6	1.2	0.6	1.2	0.6	1.2	3.0	3.0	3.0	0.3	0.3	0.3	10.0	0.25
SP-2C1	640-1100	20	10	20	10	20	10	0.4	1.0	0.4	1.0	0.4	1.0	2.0	2.0	2.0	0.2	0.2	0.2	1.5	0.75
BP-2C1	650-1100	20	10	20	10	20	10	0.4	1.2	0.4	1.2	0.4	1.2	3.0	3.0	3.0	0.2	0.2	0.2	1.5	0.75
SCN-2-11	800-1175	20	15	20	15	20	15	0.5	0.8	0.5	0.8	0.5	0.8	3.0	3.0	3.0	0.3	0.3	0.3	6.0	3.0
SBB-2-13	950-1300	24	15	24	15	24	15	0.6	1.3	0.6	1.3	0.6	1.3	3.0	3.0	3.0	0.6	0.6	0.6	10.0	0.25
SCN-2-15	1100-1450	23	17	23	17	23	17	0.5	0.8	0.5	0.8	0.5	0.8	3.0	3.0	3.0	0.4	0.4	0.4	6.0	3.0
SBA-2-14	1200-1600	16	10	16	10	16	10	0.6	1.0	0.6	1.0	0.6	1.0	5.0	5.0	6.0	0.5	0.5	0.5	2.0	0.125
BP2G	1420-1660	28	20	28	20	28	20	0.6	1.0	0.6	1.0	0.6	1.0	3.0	3.0	3.0	0.2	0.2	0.2	1.5	0.75
SP-2G	1420-1660	28	19	28	19	28	19	0.4	0.7	0.4	0.7	0.4	0.7	3.0	3.0	3.0	0.2	0.2	0.2	1.5	0.75
SBB-2-18	1425-1800	22	16	22	16	22	16	0.6	1.2	0.6	1.2	0.6	1.2	4.0	4.0	4.0	0.3	0.3	0.3	10.0	0.25
SCN-2-19	1425-1900	23	17	23	17	23	17	0.5	0.9	0.5	0.9	0.5	0.9	4.0	4.0	4.0	0.4	0.4	0.4	6.0	3.0
BP2P	1710-1990	30	18	30	18	30	18	0.5	1.0	0.5	1.0	0.5	1.0	3.0	3.0	3.0	0.2	0.2	0.2	1.5	0.75
SP-2P	1710-1990	28	18	28	18	28	18	0.4	0.8	0.4	0.8	0.4	0.8	3.5	3.5	3.5	0.2	0.2	0.2	1.5	0.75
ADP-2-20	20-2000	18	15	18	15	18	15	0.50	0.8	0.7	1.0	0.8	1.5	2.0	3.0	5.0	0.2	0.3	0.7	1.0	0.125
LRPS-2-11J	20-2000	19	15	21	15	30	15	0.60	0.8	0.7	1.0	0.8	1.5	2.0	3.0	5.0	0.2	0.3	0.7	1.0	0.125
SBTC-2-20	200-2000	20	14	20	14	20	14	0.8	2.2	0.8	2.2	0.8	2.2	10.0	10.0	10.0	0.8	0.8	0.8	0.5	0.125
BP2G1	1200-2000	21	10	21	10	21	10	0.6	1.3	0.6	1.3	0.6	1.3	3.0	3.0	3.0	0.3	0.3	0.3	0.5	0.125
SP-2G1	1200-2000	20	10	20	10	20	10	0.7	1.3	0.7	1.3	0.7	1.3	4.0	4.0	4.0	0.2	0.2	0.2	2.0	0.125
SBA-2-18	1600-2000	19	13	19	13	19	13	0.4	1.0	0.4	1.0	0.4	1.0	6.0	6.0	6.0	0.6	0.6	0.6	2.0	0.125
SBA-2-20	1800-2200	22	13	22	13	22	13	0.5	1.1	0.5	1.1	0.5	1.1	7.0	7.0	7.0	0.7	0.7	0.7	2.0	0.125
SCN-2-22	1850-2200	22	17	22	17	22	17	0.5	0.9	0.5	0.9	0.5	0.9	5.0	5.0	5.0	0.4	0.4	0.4	6.0	3.0
SP-2P1	1350-2250	20	9	20	9	20	9	0.5	1.1	0.5	1.1	0.5	1.1	4.0	4.0	4.0	0.2	0.2	0.2	1.5	0.75
SBB-2-23	2000-2300	24	17	24	17	24	17	0.6	1.0	0.6	1.0	0.6	1.0	3.0	3.0	3.0	0.3	0.3	0.3	10.0	0.25
SP-2U	2100-2300	24	18	24	18	24	18	0.5	0.7	0.5	0.7	0.5	0.7	3.0	3.0	3.0	0.2	0.2	0.2	1.5	0.75
BP2P1	1400-2350	20	10	20	10	20	10	0.5	1.3	0.5	1.3	0.5	1.3	4.0	4.0	4.0	0.3	0.3	0.3	1.5	0.75
SBB-2-21W	1425-2400	22	15	22	15	22	15	0.6	1.1	0.6	1.1	0.6	1.1	4.0	4.0	4.0	0.3	0.3	0.3	10.0	0.25
TCP-2-25	200-2500	18	10	18	10	18	10	0.8	1.3	0.8	1.3	0.8	1.3	6.0	6.0	6.0	0.8	0.8	0.8	0.5	0.25
SBTC-2-25	1000-2500	20	14	20	14	20	14	1.4	2.5	1.4	2.5	1.4	2.5	14.0	14.0	14.0	1.2	1.2	1.2	1.0	0.125
LRPS-2-25J	1700-2500	20	16	20	16	20	16	0.8	1.3	0.8	1.3	0.8	1.3	10.0	10.0	10.0	0.9	0.9	0.9	1.0	0.125
BP2U	2100-2500	30	19	30	19	30	19	0.5	0.8	0.5	0.8	0.5	0.8	2.0	2.0	2.0	0.2	0.2	0.2	1.5	0.75
SP-2U1	2300-2500	22	16	22	16	22	16	0.5	0.9	0.5	0.9	0.5	0.9	3.0	3.0	3.0	0.2	0.2	0.2	1.5	0.75
SBA-2-22	2000-2600	18	10	18	10	18	10	0.8	1.6	0.8	1.6	0.8	1.6	10.0	10.0	10.0	0.8	0.8	0.8	2.0	0.125
SCN-2-27	2225-2700	21	17	21	17	21	17	0.5	1.1	0.5	1.1	0.5	1.1	6.0	6.0	6.0	0.8	0.8	0.8	6.0	3.0
SP-2U2	1720-2850	17	9	17	9	17	9	0.5	1.4	0.5	1.4	0.5	1.4	3.0	3.0	3.0	0.2	0.2	0.2	1.5	0.75
RPS-2-30	10-3000	19	12	22	15	15	9	0.6	1.0	0.9	1.5	1.2	2.5	2.0	4.0	8.0	0.3	0.6	1.2	0.5	0.125
BP2U1	1750-3000	20	10	20	10	20	10	0.5	1.6	0.5	1.6	0.5	1.6	4.0	4.0	4.0	0.3	0.4	0.4	1.5	0.75
SCN-2-35	2825-3700	22	13	22	13	22	13	0.4	1.3	0.4	1.3	0.4	1.3	4.0	4.0	4.0	0.3	0.3	0.3	1.3	0.65
SP-2W	3300-3800	25	16	25	16	25	16	0.5	0.9	0.5	0.9	0.5	0.9	7.0	7.0	7.0	0.2	0.2	0.2	0.75	0.375
SP-2L	2700-4000	18	10	18	10	18	10	0.75	1.4	0.75	1.4	0.75	1.4	8.0	8.0	8.0	0.3	0.3	0.3	0.75	0.375
SP-2W1	2875-4200	20	10	20	10	20	10	0.8	1.4	0.8	1.4	0.8	1.4	8.0	8.0	8.0	0.2	0.2	0.2	0.75	0.375
SCN-2-45	3700-4200	20	13	20	13	20	13	0.7	1.0	0.7	1.0	0.7	1.0	4.0	4.0	4.0	0.4	0.4	0.4	1.3	0.65
SCN-2-65	5500-6500	17	11	17	11	17	11	0.8	1.1	0.8	1.1	0.8	1.1	5.0	5.0	5.0	0.4	0.4	0.4	1.3	0.65
2 WAY-0° 75Ω																					
LRPS-2-1-75J	2-500	35	18	35	25	27	20	0.30	0.8	0.35	0.6	0.5	1.0	1.0	2.0	3.0	0.15	0.2	0.3	1.0	0.125
JPS-2-1-75	5-500	25	18	35	20	20	18	0.15	0.5	0.15	0.7	0.25	0.7	1.0	2.0	3.0	0.10	0.2	0.4	1.0	0.125
LRPS-2-1W-75J	10-650	28	22	29	24	30	20	0.50	1.0	0.6	0.75	0.6	1.2	1.0	2.0	3.0	0.15	0.2	0.3	1.0	0.125
ADP-2-10W-75	5-1000	24	14	23	18	24	18	0.20	0.6	0.3	0.9	0.5	1.1	1.0	3.0	5.0	0.10	0.2	0.3	0.5	0.125
JYPS-2-4-75	5-1000	24	17	25	20	30	18	0.40	0.8	0.4	1.0	0.8	1.5	3.0	4.0	5.0	0.20	0.3	0.4	0.5	0.125
TCP-2-10-75	5-1000	24	14	29	19	30	16	0.30	1.4	0.3	0.9	0.6	1.3	6.0	4.0	3.0	1.20	0.6	0.5	0.5	0.25
SBTC-2-10-75	10-1000	35	20	28	20	21	17	0.70	1.2	0.6	1.2	0.7	1.4	3.0	3.0	5.0	0.70	0.6	0.6	0.5	0.125
JPS-2-4-75	20-1000	27	20	29	20	27	16	0.35	0.7	0.4	0.8	0.45	1.0	2.0	2.0	3.0	0.20	0.2	0.3	1.0	0.125
ADP-2-10-75	50-1000	26	20			22	18	0.60	1.0			0.8	1.4	2.0		3.0	0.15		0.3	0.5	0.125
SBTC-2-15-75	500-1500	28	18	28	18	28	18	0.8	1.5	0.8	1.5	0.8	1.5	5.0	5.0	5.0	0.9	0.9	0.9	0.5	0.125
ADP-2-20-75	5-2000	16	12	16	13	28	15	0.40	0.9	0.5	1.2	0.6	1.4	1.0	4.0	5.0	0.15	0.3	0.6	0.5	0.25
Impedance Matching 50 to 75Ω / 75 to 50Ω																					
SBTC-2-10-7550	5-1000	23	13	24	20	26	20	0.50	1.3	0.6	1.1	0.7	1.5	6.0	3.0	5.0	0.80	0.5	0.5	0.5	0.125
SBTC-2-10-5075	50-1000	25	16	—	—	20	15	0.70	1.2	—	—	1.0	1.6	3.0	—	5.0	0.60	—	0.5	0.5	0.125

L=low range (f_L to $10f_L$) M= mid range ($10f_L$ to $f_U/2$) U= upper range ($f_U/2$ to f_U)

MODEL PREFIX	FREQUENCY RANGE (MHz)	ISOLATION (dB)		INSERTION LOSS (dB) Avg. of Coupled Outputs less 3 dB		PHASE UNBALANCE (Degrees)	AMPLITUDE UNBALANCE (dB)	INPUT RF Power Max (W)	
	f_L-f_U	Typ.	Min.	Typ.	Max.	Max.	Max.	S-Port (Matched output ports)	Output ports (Matched S port)
2 WAY-90° 50Ω									
SCPQ-10.5	9-11	31	20	0.15	0.70	3.0	1.20	1.0	0.50
JYPQ-16	10-16	43	25	0.20	0.60	4.0	0.90	1.0	0.50
SCPQ-21.4	20-23	32	25	0.15	0.50	2.5	1.00	1.0	0.50
JYPQ-30	16-30	28	20	0.20	0.70	3.0	1.50	1.0	0.50
SCPQ-50	25-50	25	20	0.15	0.70	3.0	1.50	1.0	0.50
SCPQ-60	30-60	30	20	0.15	0.70	3.0	1.50	1.0	0.50
LRPQ-70J	65-75	30	20	0.10	0.50	3.0	1.00	1.0	0.50
SYPQ-70	65-75	31	24	0.10	0.40	3.0	1.10	1.0	0.50
JSPQ-80	10-80	44	30	0.45	1.40	6.0	0.60	1.0	0.062
SCPQ-85C	55-85	30	20	0.30	0.60	3.0	0.60	1.0	0.50
ADQ-90	55-90	26	20	0.20	0.70	4.0	1.20	0.5	0.25
SCPQ-90	55-90	26	20	0.20	0.70	3.0	1.20	1.0	0.50
JSPQW-100A	30-100	41	30	0.50	1.10	4.0	0.60	1.0	0.062
JSPQW-100	40-100	24	18	0.20	0.60	3.0	1.20	1.0	0.5
SCPQ-150	95-150	22	18	0.30	0.70	3.0	1.20	1.0	0.5
JYPQ-160	105-160	24	17	0.25	0.60	3.0	1.50	1.0	0.5
ADQ-180	120-180	35	20	0.20	0.70	6.0	1.50	0.5	0.25
SCPQ-180	120-180	20	16	0.30	0.70	3.0	1.20	1.0	0.5
ADPQ-2-250	150-250	24	17	0.20	0.70	4.0	1.40	1.0	0.5
LRPQ-320J	270-320	21	18	0.30	0.60	3.0	1.20	1.0	0.5
JSPQ-350	150-350	20	13	0.50	1.00	5.0	1.50	1.0	0.5
HPQ-04	315-395	24	18	0.20	0.45	3.0	1.60	1.0	0.5
SCPQ-400	250-400	20	16	0.30	0.70	3.0	1.00	1.0	0.5
HPQ-05	410-455	25	20	0.17	0.35	3.0	1.12	1.0	0.5
QCN-3	220-470	24	18	0.60	0.80	8.0	1.30	7.0	3.50
HPQ-05W	380-490	25	20	0.20	0.40	3.0	1.60	1.0	0.5
HPQ-06	510-570	26	18	0.20	0.40	3.0	1.20	1.0	0.5
QCN-5	330-580	20	14	0.40	0.90	5.0	1.10	7.0	3.50
HPQ-06W	480-600	26	18	0.20	0.40	3.0	1.60	1.0	0.50
QCN-7	425-675	17	11	0.40	1.00	8.0	1.00	7.0	3.50
QBA-07	340-680	22	16	0.80	0.80	7.0	2.00	9.0	4.50
LRPQ-700J	500-700	23	18	0.20	0.60	3.0	1.80	1.0	0.50
HPQ-07	580-690	24	18	0.20	0.40	3.0	1.60	1.0	0.50
HPQ-08	680-790	24	18	0.25	0.40	3.0	1.60	1.0	0.50
HPQ-09	730-800	25	20	0.20	0.40	3.0	1.20	1.0	0.50
HPQ-09W	690-830	24	20	0.20	0.40	3.0	1.60	1.0	0.50
RPQ-820	760-860	22	15	0.15	0.70	4.0	1.00	1.0	0.50
QBA-12N	800-900	28	20	0.25	0.30	3.0	1.00	10.0	5.0
HPQ-10	900-970	22	17	0.25	0.45	4.0	1.20	1.0	0.50
HPQ-10W	880-1030	22	16	0.28	0.50	4.0	1.60	1.0	0.50
HPQ-11	980-1070	23	18	0.25	0.50	3.5	1.20	1.0	0.50
HPQ-12	990-1100	21	16	0.25	0.45	4.0	1.20	1.0	0.50
HPQ-12W	940-1130	21	16	0.30	0.50	4.0	1.60	1.0	0.50
QBA-12	800-1200	23	14	0.25	0.44	6.0	1.20	10.0	5.00
QCN-12A	800-1250	17	13	0.30	0.70	5.0	0.80	7.0	3.50
QCN-12	800-1375	19	14	0.40	1.00	13.0	1.00	7.0	3.50
HPQ-15	1320-1430	19	15	0.30	0.50	5.0	1.20	1.0	0.5
HPQ-15W	1240-1460	19	15	0.30	0.60	5.0	1.60	1.0	0.5
RPQ-1495	1400-1600	18	14	0.30	0.80	5.0	1.00	1.0	0.5
JSPQ-1875W	1325-1875	28	18	0.20	0.50	6.0	1.00	1.0	0.5
QCN-19	1100-1925	26	19	0.40	0.90	4.0	1.10	7.0	3.50
QCC-20	1200-2200	32	16	0.40	0.90	5.0	1.00	3.5	1.75
QBA-20W	1500-2200	23	16	0.41	0.58	5.0	1.20	5.0	2.50
QBA-24W	1700-2400	21	15	0.49	0.71	6.0	1.20	5.0	2.50
QBA-20	1800-2000	23	18	0.47	0.54	4.0	0.70	5.0	2.50
QBA-24	1900-2400	21	17	0.54	0.71	6.0	0.80	4.0	2.00
QCN-25	1350-2450	25	18	0.40	0.90	5.0	1.10	7.0	3.5
QCC-22	1500-2500	28	15	0.40	0.80	4.0	1.30	3.5	1.75
QCN-27	1700-2700	30	18	0.40	0.90	6.0	1.00	7.0	3.5
QCN-34	2500-3400	32	20	0.40	0.70	4.0	1.20	7.0	3.5
QCN-45	2500-4500	19	15	0.50	0.80	6.0	2.10	7.0	3.5

POWER SPLITTERS/COMBINERS

1 MHz to 6500 MHz

SCN Case FV1206-1 | BP Case XX211 | SCA Case DZ944 | SBD Case SM34 | SBTCJ Case AT790 | WP Case DQ1225 | AMT Case CD636 | SCA Case DZ943 | JPS Case BH292 | LRPSJ Case QQQ569 | AD3,4,5,6PS Case CJ725 | SYPS-3-12W Case AH202 | SCP Case YY101, YY161

MODEL PREFIX	FREQ. RANGE, (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBALANCE (Degrees) L Max.	M Max.	U Max.	AMPLITUDE UNBALANCE (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
2 WAY-0°/180°								*Insertion Loss Above 3 dB*													
								50 Ω													
AMT-2	50-200	35	20	35	20	35	20	0.8	1.2	0.8	1.2	0.8	1.2	2	2	2	0.3	0.3	0.3	0.5	0.125
2 WAY-180°																					
								50 Ω													
SBTCJ-1W	1-750	23	20	22	20	24	20	0.6	1.7	0.6	1.2	0.9	1.8	3	7	10	0.2	0.4	0.9	0.5	0.125
SCPJ-2-750	30-750	24	18	21	16	20	16	0.7	1.5	1.5	2.2	1.5	2.2	3	4	6	0.8	0.8	0.8	0.5	0.125
SCPJ-2-9	200-900			24	17			1.0	1.8	1.0	1.8	1.0	1.8	6	6	6	0.7	0.7	0.7	1.0	0.125
								75 Ω													
SCPJ-2-1W-75	10-500	30	25	27	20	22	16	1.0	1.5	1.1	1.6	1.5	2.2	3	4	6	0.3	0.5	0.9	0.5	0.125
SCPJ-2-750-75	30-750	26	20	—	—	26	16	1.0	1.5			1.5	2.2	3		6	0.8		0.9	0.5	0.125
3 WAY-0°								*Insertion Loss Above 4.8 dB*													
								50 Ω													
AD3PS-1	1-300	40	23	35	20	27	18	0.3	0.8	0.4	1.0	0.8	1.5	1	4	6	0.2	0.3	0.5	0.5	0.125
SCP-3-1	1-300	30	25	25	20	20	15	0.3	0.6	0.4	0.8	0.7	1.5	1	2	4	0.1	0.15	0.5	1.0	0.187
JPS-3-1	5-300	34	25	33	23	32	20	0.3	0.6	0.3	0.7	0.5	1.4	2	4	6	0.4	0.4	0.6	1.0	0.187
LRPS-3-1J	10-300	25	20	25	20	25	20	0.2	0.6	0.3	0.8	0.5	1.2	2	3	4	0.1	0.3	0.7	1.0	0.187
JPS-3-1W	50-750	23	17	—	—	26	17	0.4	1.0	—	—	0.9	1.4	6	—	7	0.3	—	0.6	1.0	0.25
LRPS-3-850J	500-850	23	16	23	16	23	16	0.7	1.6	0.7	1.6	0.7	1.6	8	8	8	0.9	0.9	0.9	1.0	0.187
SCA-3-11	100-940	20	14	20	14	20	14			0.7	1.5			7	7	7	0.7	0.7	0.7	0.5	0.125
SYPS-3-12W	20-1200			22	15			1.2	2.9	1.2	2.9	1.2	2.9	6	6	6	0.9	0.9	0.9	1.0	0.075
SCN-3-13	750-1325	12.0	10.0	12.0	10.0	12.0	10.0	1.0	1.5	1.0	1.5	1.0	1.5	3	3	3	0.7	0.7	0.7	6.0	2.0
SCN-3-16	950-1600	15.0	11.0	15.0	11.0	15.0	11.0	0.6	1.2	0.6	1.2	0.6	1.2	5	5	5	0.5	0.5	0.5	6.0	2.0
SCN-3-28	1600-2800	12.0	10.0	12.0	10.0	12.0	10.0	0.8	1.2	0.8	1.2	0.8	1.2	8	8	8	0.6	0.6	0.6	6.0	2.0
								75 Ω													
SYPS-3-12W-75	20-1200	22	17	22	17	22	17	1.2	2.2	1.2	2.2	1.2	2.2	5	5	5	0.8	0.8	0.8	1.0	0.075
4 WAY-0°								*Insertion Loss Above 6 dB*													
								50 Ω													
SCP-4-1	1-400	32	23	26	18	21	17	0.4	1.2	0.6	1.2	1.0	1.5	1	4	9	0.2	0.3	0.5	1.0	0.083
AD4PS-1	1-500	32	18	30	20	25	18	0.4	1.2	0.5	1.2	0.8	1.8	2	5	7	0.4	0.5	0.8	0.5	0.083
SCP-4-1W	10-650	34	28	23	18	21	15	0.7	1.0	0.9	1.5	1.1	1.9	3	7	12	0.2	0.4	0.7	1.0	0.083
JS4PS-1	80-750	36	20	36	20	36	20	0.8	1.5	0.8	1.5	0.8	1.5	5	5	5	0.5	0.5	0.5	1.0	0.167
WP4C	810-960	24	18	24	18	24	18	0.8	1.6	0.8	1.6	0.8	1.6	3	3	3	0.5	0.5	0.5	1.5	0.125
BP4C	810-960			22	18			0.7	1.6	0.7	1.6	0.7	1.6	8	8	8	0.6	0.6	0.6	1.5	0.125
SCP-4-4	800-1000	24	17	24	17	24	17	0.7	1.5	0.7	1.5	0.7	1.5	12	12	12	1.0	1.0	1.0	1.0	0.083
SCA-4-10	5-1000	25	15	25	15	25	15	0.8	2.5	0.8	2.5	0.8	2.5	11	11	11	0.9	0.9	0.9	0.5	0.125
JS4PS-1W	5-1000	29	20	26	18	20	15	0.3	1.1	0.8	1.5	1.5	2.4	5	5	12	0.8	0.7	0.7	0.5	0.125
WP4M	720-1125	22	15	22	15	22	15	0.7	1.7	0.7	1.7	0.7	1.7	3	3	3	0.5	0.5	0.5	1.5	0.125
WP4C1	800-1150	22	15	22	15	22	15	0.7	1.6	0.7	1.6	0.7	1.6	4	4	4	0.5	0.5	0.5	1.5	0.125
BP4C1	750-1200	20	13	20	13	20	13	0.7	1.4	0.7	1.4	0.7	1.4	14	14	14	0.6	0.6	0.6	1.5	0.125
WP4G	1400-1660	28	19	28	19	28	19	0.7	1.4	0.7	1.4	0.7	1.4	4	4	4	0.5	0.5	0.5	1.5	0.125
WP4N	1215-1900	23	14	23	14	23	14	0.7	1.9	0.7	1.9	0.7	1.9	5	5	5	0.5	0.5	0.5	1.5	0.125
BP4P	1710-1990	23	18	23	18	23	18	0.8	1.3	0.8	1.3	0.8	1.3	15	15	15	0.5	0.5	0.5	1.5	0.125
WP4G1	1300-2000	26	14	26	14	26	14	0.8	1.9	0.8	1.9	0.8	1.9	5	5	5	0.5	0.5	0.5	1.5	0.125
SCA-4-20	1000-2000	15	8	15	8	15	8	1.0	1.8	1.0	1.8	1.0	1.8	5	5	5	0.9	0.9	0.9	5.0	0.083
WP4P	1710-2025	29	19	29	19	29	19	0.7	1.4	0.7	1.4	0.7	1.4	4	4	4	0.4	0.4	0.4	1.5	0.125
WP4P1	1525-2375	26	15	26	15	26	15	0.9	2.0	0.9	2.0	0.9	2.0	4	4	4	0.5	0.5	0.5	1.5	0.125
WP4U	2100-2500	28	18	28	18	28	18	0.7	1.4	0.7	1.4	0.7	1.4	4	4	4	0.5	0.5	0.5	1.5	0.125
BP4U	2100-2500	23	17	23	17	23	17	0.7	1.2	0.7	1.2	0.7	1.2	20	20	20	1.1	1.1	1.1	1.5	0.125
BP4P1	1500-2500	21	15	21	15	21	15	0.8	1.6	0.8	1.6	0.8	1.6	25	25	25	0.8	0.8	0.8	1.5	0.125
SBD-4-25	1800-2600	20	12	20	12	20	12	1.0	1.9	1.0	1.9	1.0	1.9	8	8	8	0.7	0.7	0.7	10.0	0.125
WP4R	2300-2700	26	18	26	18	26	18	0.7	1.4	0.7	1.4	0.7	1.4	6	6	6	0.4	0.4	0.4	1.5	0.125
WP4U1	1875-2800	24	15	24	15	24	15	0.7	1.9	0.7	1.9	0.7	1.9	5	5	5	0.5	0.5	0.5	1.5	0.125
WP4R1	2000-3000	24	16	24	16	24	16	0.7	2.1	0.7	2.1	0.7	2.1	7	7	7	0.5	0.5	0.5	1.5	0.125
BP4U1	1850-3000	23	13	23	13	23	13	0.7	1.7	0.7	1.7	0.7	1.7	28	28	28	1.3	1.3	1.3	1.5	0.125
WP4W	3300-3800	26	18	26	18	26	18	0.8	1.4	0.8	1.4	0.8	1.4	8	8	8	0.4	0.4	0.4	1.5	0.125
WP4W1	3000-4200	26	17	26	17	26	17	0.9	1.9	0.9	1.9	0.9	1.9	9	9	9	0.5	0.5	0.5	1.5	0.125
WP4S	3400-4600	30	16	30	16	30	16	0.8	1.8	0.8	1.8	0.8	1.8	9	9	9	0.6	0.6	0.6	1.5	0.125
WP4F	5150-5875	29	18	29	18	29	18	1.0	1.8	1.0	1.8	1.0	1.8	7	7	7	0.5	0.5	0.5	1.5	0.125
WP4F1	4750-6200	28	16	28	16	28	16	1.0	2.0	1.0	2.0	1.0	2.0	9	9	9	0.6	0.6	0.6	1.5	0.125
WP4A	5100-6500	25	15	25	15	25	15	0.9	2.0	0.9	2.0	0.9	2.0	8	8	8	0.5	0.5	0.5	1.5	0.125
4 WAY-0°																					
								75 Ω													
JS4PS-1W-75	5-750	34	25	35	25	30	18	0.6	1.2	0.6	1.5	0.8	1.5	3	5	6	0.2	0.3	0.6	0.25	0.083
SCP-4-1W-75	10-750	36	20	32	20	24	15	0.5	1.0	0.65	1.3	0.8	2.0	1.5	3	6	0.2	0.4	0.9	0.50	0.125
JS4PS-9-75	50-860	25	16	25	16	25	16	0.6	1.9	0.6	1.9	0.6	1.9	5	5	5	0.8	0.8	0.8	0.50	0.167
SCA-4-10-75	10-1000	25	15	25	15	25	15	1.5	2.5	1.5	2.5	1.5	2.5	10	10	10	1.2	1.2	1.2	0.50	0.125
SCP-4-4-75	10-1000	36	20	32	18	24	14	0.5	1.0	0.65	1.3	0.8	2.0	3	6	12	0.2	0.4	0.9	1.00	0.125
SCA-4-15-75	10-1500	19	15	19	15	19	15	1.2	2.8	1.2	2.8	1.2	2.8	16	16	16	1.1	1.1	1.1	0.50	0.125

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)


JS4PS
Case BJ360


JS4PS-1W
Case BK377


JCPS
Case BG291


JEPS
Case BL372

MODEL PREFIX	FREQ. RANGE, (MHz) f_L-f_U	ISOLATION (dB) L Typ.	L Min.	M Typ.	M Min.	U Typ.	U Min.	INSERTION LOSS (dB) L Typ.	L Max.	M Typ.	M Max.	U Typ.	U Max.	PHASE UNBALANCE (Degrees) L Max.	M Max.	U Max.	AMPLITUDE UNBALANCE (dB) L Max.	M Max.	U Max.	INPUT RF Power Max (W) S-Port (Matched output ports)	Output ports (Matched S port)
5 WAY-0°			50 Ω							*Insertion Loss Above 7 dB*											
SCP-5-1	2-200	30	20	29	20	30	20	0.2	0.5	0.3	0.75	0.6	1.5	1	3	5	0.2	0.30	0.6	1.0	0.125
AD5PS-1	1-400	35	18	25	20	27	20	0.15	0.5	0.3	1.0	0.8	1.8	1	6	9	0.3	0.40	0.6	0.5	0.10
6 WAY-0°			50 Ω							*Insertion Loss Above 7.8 dB*											
AD6PS-1	2-250	35	17	30	20	27	20	0.2	0.6	0.2	1.0	0.6	1.5	2	6	9	0.3	0.4	0.6	0.5	0.10
JCPS-6-3	75-425	23	18	23	18	23	18	0.9	1.8	0.9	1.8	0.9	1.8	9	9	9	0.7	0.7	0.7	0.25	0.10
8 WAY-0°			50 Ω							*Insertion Loss Above 9 dB*											
JCPS-8-850	10-850	34	20	25	17	20	15	0.8	1.5	1.0	2.5	1.8	3.0	5	10	15	0.6	0.7	1.0	1.0	0.125
JCPS-8-10	5-1000	34	20	22	16	20	15	0.5	1.5	1.2	2.2	1.8	3.0	5	10	15	1.0	0.7	1.3	0.5	0.125
			75 Ω																		
JCPS-8-850-75	10-850	34	20	25	15	20	15	0.7	1.5	1.0	2.0	1.8	3.0	—	—	—	0.6	0.7	1.0	1.0	0.125
JCPS-8-10-75	5-1000	34	20	25	15	20	13	0.8	1.5	1.0	2.5	1.8	3.0	3	8	10	0.4	0.5	1.3	1.0	0.089
12 WAY-0°			50 Ω							*Insertion Loss Above 10.8 dB*											
JEPS-12-10	50-1000	25	16	—	—	23	14	1.6	2.5	—	—	2.2	4.0	10	—	23	0.7	—	1.4	0.5	0.080
16 WAY-0°			50 Ω							*Insertion Loss Above 12 dB*											
JEPS-16-1W	5-1000	36	23	23	17	20	15	0.8	2.0	1.5	2.5	3.0	4.2	8	13	20	1.5	1.2	1.8	0.5	0.125
			75 Ω																		
JEPS-16-1W-75	10-800	32	20	23	15	20	15	1.6	3.5	1.9	3.5	2.2	4.0	10	15	30	0.8	1.2	2.1	0.5	0.018

L = low range (f_L to $10f_L$) M = mid range ($10f_L$ to $f_U/2$) U = upper range ($f_U/2$ to f_U)

$1.29 IN STOCK

from ea. *(Qty. 1,000)*

Mini-Circuits HSWA2-30DR+ SPDT absorptive switches with internal CMOS control driver deliver a giant leap in performance by giving you exceptionally high isolation, very low insertion loss, and high input IP3 over the *entire* DC-3000 MHz band! Operating from a single positive 3V supply voltage, these RoHS compliant switches are totally immune to latch-up so they always work, incorporate our unique design-simultaneous switch-off of RF1 & RF2, and provide super low DC power consumption, essential for today's portable battery operated wireless devices. They're also great solutions for base station infrastructure, CATV, DBS, MMDS, Wireless WLAN, band switching, and more. So resolve your switching needs now and get the most competitive prices in the industry using Mini-Circuits HSWA2-30DR+ high performance switches!

Mini-Circuits…we're redefining what VALUE is all about!

- *Absorptive*
- *High IP3 Performance*
- *Low Insertion Loss*
- *Immune to Latch-Up*
- *Very Linear Performance*

Specifications, Typical (50Ω)

Model	Freq. (MHz)	Isolation (dB)	Ins. Loss (dB)	IP3 (dBm)	Volt (V)	Current (μA)	Price $ea. (Qty.10)
HSWA2-30DR+	DC-3000	50	0.95	+52	+3	8	2.95

Small 4x4 mm Package

Top View Exposed Metal Bottom

Pb RoHS COMPLIANT

Mini-Circuits® P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500 Fax (718) 332-4661

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ISO 9001 ISO 14001 CERTIFIED RoHS compliant

SWITCHES, SEMI-CONDUCTOR *GaAs & CMOS 50 Ω*

DC to 4600 MHz


M3SW
Case DL805


SWM
Case DL1020


HSWA2
Case DG983-1


MSW
Case XX211-1


KSW
Case XX112


RSW
Case CL620


GSWA
Case AN1102

MODEL PREFIX	FREQUENCY (MHz) f_L-f_U	ABSORPTIVE	REFLECTIVE	INSERTION LOSS (dB) Frequency Band Typ.	Max.	1 dB COMPRESSION (dBm) Typ.	IN-OUT ISOLATION (dB) Frequency Band Typ.	Min.
SPST *Without Drivers DC to 2000 MHz*								
KSWHA-1-20	DC-2000	•		1.3	1.7	26	65	58
SPDT *Without Drivers DC to 4600 MHz*								
KSW-2-46	DC-4600		•	1.3	2.8	20	50	28
KSWA-2-46	DC-4600	•		1.5	2.6	20	50	25
RSW-2-25P	DC-2500		•	1.0	1.8	29	48	43
MSW-2-20	DC-2000		•	0.7	1.3	27	34	20
MSWA-2-20	DC-2000	•		1.2	1.5	27	37	25
SPDT *With TTL Drivers DC to 4500 MHz*								
M3SW-2-50DR	DC-4500		•	0.9	1.9	25	50	30
M3SWA-2-50DR	DC-4500	•		0.9	2.0	25	57	30
SWM-2-50DR	DC-4500		•	0.9	1.9	25	50	27
SWMA-2-50DR	DC-4500	•		0.9	1.9	25	55	27
With CMOS Drivers DC to 3000 MHz								
HSWA2-30DR	DC-3000	•		0.9	1.4	31	55	44
TRANSFER *Without Drivers DC to 2000 MHz*								
MSWT-4-20	DC-2000		•	1.25	2.2	28	34	15
SP4T *With TTL Drivers DC to 3000 MHz*								
GSWA-4-30DR	DC-3000	•		2.0	3.9	25	40	26

CONTROL LOGIC

HSWA2-30DR

CONTROL INPUT		RF INPUT/OUTPUT	
Control 1	Control 2	RF1 to RF Common	RF2 to RF Common
Low	Low	OFF	OFF
Low	High	OFF	ON
High	Low	ON	OFF
High	High	N/A	N/A

Low: 0 to 0.3 Vdd
High: 0.7 Vdd to Vd
Vdd: 2.7 to 3.3 V

MSWT-4-20

Control Ports				"On" Path (other paths are ("OFF")
1	2	3	4	
0	-v	-v	-v	T_xJ_2
-v	0	-v	-v	T_xJ_1
-v	-v	0	-v	R_xJ_1
-v	-v	-v	0	R_xJ_2
0	-v	0	-v	T_xJ_2 & R_xJ_1
-v	0	-v	0	T_xJ_1 & R_xJ_2

V= 5 to 8 V

RSW-2-25

Control Ports		RF outputs	
1	2	1	2
LOW	HIGH	ON	OFF
HIGH	LOW	OFF	ON

Low: 0+/-0.2 V
High: Vs -0.2 to Vs
Vs: 5 to 7 V

SPDT and SPST Switches without Drivers

		KSW-2-46 KSWA-2-46 MSW-2-20		MSWA-2-20		KSWHA-1-20
Control Ports		RF outports		RF outports		RF out
1	2	1	2	1	2	
-V	0	ON	OFF	ON	OFF	ON
0	-V	OFF	ON	OFF	ON	OFF

V= 5 to 8 V

SP4T Switch with Driver: GSWA-4-30DR

Control Ports				RF outputs			
1	2	3	4	1	2	3	4
Low	High	High	High	ON	OFF	OFF	OFF
High	Low	High	High	OFF	ON	OFF	OFF
High	High	Low	High	OFF	OFF	ON	OFF
High	High	High	Low	OFF	OFF	OFF	ON

Low: 0 to 0.8 V
High: 2 to 5 V

SPDT Switches with TTL Drivers: M3SW-2-50DR, M3SWA-2-50DR, SWM-2-50DR and SWMA-2-50DR

	RF outports	
Control Port	1	2
Low	ON	OFF
High	OFF	ON

Low: 0 to 0.8 V
High: 2 to 5 V

SYNTHESIZERS

100 MHz to 4.3 GHz

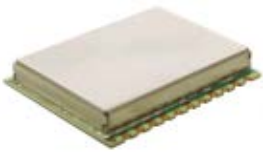
Applications

Mini-Circuits is an industry leader in synthesizer designs, with synthesizers designed in to all the major programs worldwide, including:

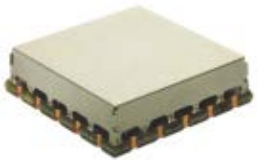
- TDSCDMA
- CDMA Repeaters
- WCDMA
- EDGE
- GSM
- TDMA
- PCS
- UMTS
- Wireless LAN
- Point-to-Point Radio
- Test Equipment
- Microwave Radio High Data Transfer Rate Applications, up to 600 Mbytes/sec
- CATV
- WiMAX
- Military Applications

Our Most Popular Synthesizer Case Styles Are:

KSN
0.584 x 0.800 x 0.154 (14.81 x 20.32 x 3.91 mm)



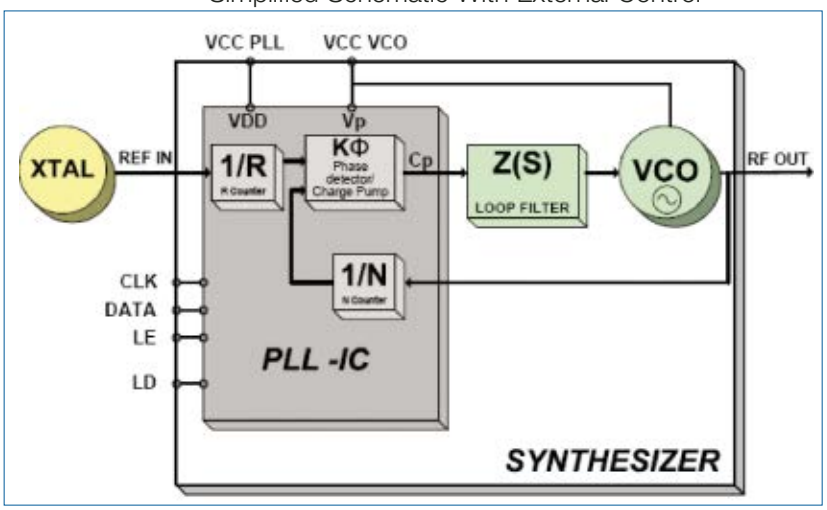
DSN
1.00 x 1.25 x 0.20 (25.40 x 31.75 x 5.08 mm)



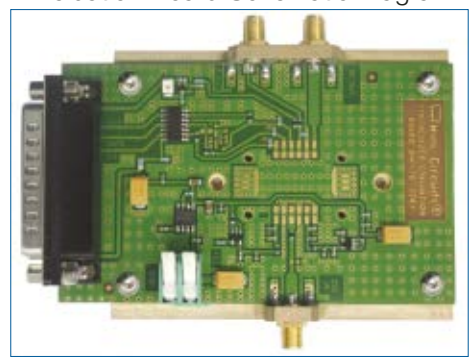
RSN
0.91 x 0.91 x 0.25 (23.11 x23.11 x 6.35 mm)

Our synthesizers provide solutions in a wide range of frequencies from 100 MHz to 4.3 GHz for narrow-band, wide-band, and fixed frequency applications.

Simplified Schematic With External Control



Evaluation Board Schematic Diagram



Features

Mini-Circuits has designed over 150 synthesizer models with very good Phase Noise and Spurious performance, as well as immunity to Phase Hits & Microphonics, that include:

- **Fast settling time (25 microseconds) for Frequency Hopping**
- **Excellent Pulling performance for Frequency Hopping applications**
- **Wideband designs with fast Settling Time (40 microseconds)**
- **Wideband designs using an active loop filter for fast data rate transmission (up to 600 Mbytes/sec)**
- **Narrow-band designs with exceptional Phase Noise performance**
- **Narrow-band designs with excellent integrated Phase Noise performance at low channel spacing**
- **Designs with exceptional Discrete Spurious and Integrated Spurious performance**
- **Channel spacing from 5 kHz to 5 MHz**
- **Fixed frequency synthesizers with internal microcontroller, eliminating the need for an external program control**

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

Working Face-to-Face

Every Mini-Circuits synthesizer is 100% tested during Production, where we perform over 45 electrical tests in automated setups to ensure & guarantee quality and performance repeatability.

Our synthesizer designs are very robust through the use of:

- **High Quality Mini-Circuits VCO designs.**
- **High Quality Tight Tolerance components to ensure Good Repeatability (Skinny Sigma) & immunity to Phase Hits & Microphonic Effects.**
- **Highly reliable structures, in which all components are glued to avoid "tombstoning" resulting from the customer's SMT process, thus making our designs immune to Phase Hits & Microphonics.**

TRANSFORMERS, IF/RF MICROWAVE 50 & 75 Ω

4 kHz to 3000 MHz Wideband 50 to 1800 Ω

TCM
Case DB714

TC
Case AT224-1, AT224-3

ADT
CD542/CD636/CD637

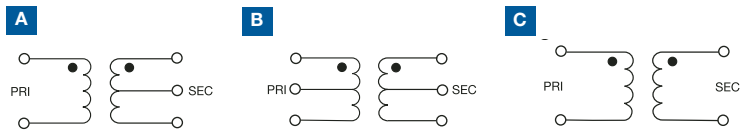
MODEL PREFIX	Ω RATIO (Secondary/Primary)	FREQUENCY (MHz)	INSERTION LOSS (dB) Above mid band 3 dB MHz	2 dB MHz	1 dB MHz
A *SCHEMATIC*	*Unbalanced to Balanced center tap*				
ADT1-6T	1.0	0.03-125	0.03-125	0.04-75	0.05-50
T1-1T	1.0	0.08-200	0.08-200	0.15-150	0.2-80
T1-1T-KK81	1.0	0.08-200	0.08-200	0.15-150	0.2-80
T1-6T	1.0	0.015-300	0.015-300	0.021-150	0.03-50
T1-6T-KK81	1.0	0.015-300	0.015-300	0.021-150	0.03-50
■ ADT1-1WT-1	1.0	1-400	—	—	1-400
TC1-1T	1.0	0.4-500	0.4-500	0.5-300	1-100
TC1-1TG2	1.0	0.4-500	0.4-500	0.5-300	1-100
■ ADT1-1WT	1.0	0.4-800	0.4-800	0.5-700	1-400
TC1.5-52T	1.5	0.5-550	0.5-550	1-350	2-200
TC1.5-52TG2	1.5	0.5-550	0.5-550	1-350	2-200
ADT1.5-1	1.5	0.5-650	0.5-650	0.8-500	1-300
T2-1T	2.0	0.07-200	0.07-200	0.1-100	0.5-50
T2-1T-KK81	2.0	0.07-200	0.07-200	0.1-100	0.5-50
TC2-1T	2.0	3-300	—	—	3-300
TC2-1T G2	2.0	3-300	—	—	3-300
TCM2-1T	2.0	3-300	—	—	3-300
ADT2-1T	2.0	0.4-450	0.4-450	0.6-400	1-200
ADT2-1T-1P	2.0	8-600	8-600	10-400	13-300
■ JTX-2-10T	2.0	50-1000	—	—	50-1000
■ TX-2-5-1	2.0	30-1100	—	30-1100	100-800
JT-1975	2.5	0.04-80	0.04-80	0.05-60	0.1-30
T2.5-6T	2.5	0.01-100	0.01-100	0.02-50	0.50-20
T2.5-6T-KK81	2.5	0.01-100	0.01-100	0.02-50	0.50-20
T3-1T	3.0	0.05-250	0.05-200	0.1-200	0.5-70
T3-1T-KK81	3.0	0.05-250	0.05-250	0.1-200	0.5-70
TC3-1T	3.0	5-300	—	—	5-300
TC3-1TG2	3.0	5-300	—	—	5-300
ADT3-6T	3.0	0.06-400	0.06-400	0.1-290	0.2-250
ADT3-1T	3.0	1-500	—	1-500	2-300
TCM3-1T	3.0	2-500	—	2-500	5-300
T4-6T	4.0	0.02-250	0.02-250	0.05-150	0.1-100
T4-6T-KK81	4.0	0.02-250	0.02-250	0.05-150	0.1-100
ADT4-6T	4.0	0.06-300	0.06-300	0.08-250	0.15-200
TC4-1T	4.0	0.5-300	—	0.5-300	1.5-100
TC4-1TG2	4.0	0.5-300	—	0.5-300	1.5-100
T4-1	4.0	0.2-350	0.2-350	0.35-300	2-100
T4-1-KK81	4.0	0.2-350	0.2-350	0.35-300	2-100
T4-1H	4.0	10-350	10-350	15-300	25-200
T4-1H-KK81	4.0	10-350	10-350	15-300	25-200
ADT4-5WT	4.0	0.3-500	0.3-500	0.5-400	2-250
ADT4-6WT	4.0	0.5-600	0.5-600	0.7-475	2-300
TC4-6T	4.0	1.5-600	1.5-600	2-400	3-350
TC4-6TG2	4.0	1.5-600	1.5-600	2-400	3-350
TCM4-6T	4.0	1.5-600	1.5-600	2-400	3-350
ADT4-1T	4.0	9-625	9-625	10-550	14-500
ADT4-1WT	4.0	2-775	2-775	3-600	6-250
TC4-1W	4.0	3-800	3-800	5-400	10-100
TC4-1WG2	4.0	3-800	3-800	5-400	10-100
TCM4-1W	4.0	3-800	3-800	5-400	10-100
JTX-4-10T	4.0	50-1000	—	—	50-1000
TC4-14	4.0	200-1400	200-1400	300-1300	800-1100
TC4-14G2	4.0	200-1400	200-1400	300-1300	800-1100
TCM4-14	4.0	200-1400	200-1400	300-1300	800-1000
T5-1T	5.0	0.3-300	0.3-300	0.6-200	5-100
T5-1T-KK81	5.0	0.3-300	0.3-300	0.6-200	5-100
ADT8-1T	8.0	0.1-130	0.1-130	0.15-110	0.2-75
T8-1T	8.0	0.3-140	0.3-140	0.7-90	1-60
T8-1T-KK81	8.0	0.3-140	0.3-140	0.7-90	1-60
TCM8-1	8.0	2-500	2-500	5-400	10-100
TC8-1G2	8.0	2-500	2-500	5-400	10-100
TC8-1	8.0	2-500	2-500	5-400	10-100
TC9-1	9.0	2-200	2-200	3-100	5-40
TC9-1G2	9.0	2-200	2-200	3-100	5-40
ADT9-1T	9.0	1-250	—	1-250	2-150
TCM9-1	9.0	2-280	2-280	3-150	5-100
T13-1T	13.0	0.3-120	0.3-120	0.7-80	5-20
T13-1T-KK81	13.0	0.3-120	0.3-120	0.7-80	5-20
ADT16-6T	16.0	0.1-70	0.1-70	0.18-45	0.30-33
T16-6T	16.0	0.03-75	0.03-75	0.06-30	0.1-20
T16-6T-KK81	16.0	0.03-75	0.03-75	0.06-30	0.1-20
ADT16-1T	16.0	1.5-160	1.5-160	3-105	5-65
TC16-161T	16.0	0.6-160	0.6-160	1.5-120	3-80
TC16-161TG2	16.0	0.6-160	0.6-160	1.5-120	3-80
TC16-1T	16.0	20-300	20-300	30-200	50-150
TC16-1TG2	16.0	20-300	20-300	30-200	50-150
TX16-R3T	16.0	40-300	40-300	60-220	70-150

■ Denotes 75 ohm models

TX Case TT240 | JT/JTX Case BH292 | T/TT Case W38 | T Case KK81

MODEL PREFIX	Ω RATIO (Secondary/Primary)	FREQUENCY (MHz)	INSERTION LOSS Above midband loss (dB) 3 dB MHz	2 dB MHz	1 dB MHz
B *SCHEMATIC* *Balanced to Balanced center tap at primary & Secondary*					
ADTT1-6	1	.015-100	.015-100	.02-50	.06-30
ADTT1-1	1	0.3-300	0.3-300	0.4-200	0.5-90
TT1-6-KK81	1	.004-300	.004-300	.02-200	.1-50
TT1-6	1	.004-300	.004-300	.02-200	.1-50
ADTT1.5-1	1.5	0.25-300	0.25-300	0.3-175	0.5-100
TT1.5-1-KK81	1.5	.075-500	.075-500	.2-100	1-50
TT1.5-1	1.5	.075-500	.075-500	.2-100	1-50
TT2.5-6-KK81	2.5	.01-50	.01-50	.025-25	.05-10
TT2.5-6	2.5	.01-50	.01-50	.025-25	.05-10
TT4-1-KK81	3	.05-200	.05-200	.2-50	1-30
TT4-1	3	.05-200	.05-200	.2-50	1-30
ADTT3-2	3	0.2-210	0.2-210	0.3-150	0.5-90
ADTT4-1	4	0.2-120	—	—	0.2-120
TT4-1A-KK81	4	0.1-300	0.1-300	0.2-250	0.3-180
TT4-1A	4	0.1-300	0.1-300	0.2-250	0.3-180
TTCM4-4	4	0.5-400	0.5-400	1.3-160	5-100
TT16-1-KK81	16	0.1-45	0.1-45	0.14-35	1-20
TT16-1	16	0.1-45	0.1-45	0.14-35	1-20
TT25-1-KK81	25	.02-30	.02-30	.05-20	.1-10
TT25-1	25	.02-30	.02-30	.05-20	.1-10
C *SCHEMATIC* *Balanced to Balanced*					
T1-6-KK81	1	.01-150	.01-150	.02-100	.05-50
T1-6	1	.01-150	.01-150	.02-100	.05-50
T1-1H-KK81	1	8-300	8-300	10-200	25-100
T1-1H	1	8-300	8-300	10-200	25-100
ADT1-1	1	0.15-400	0.15-400	0.2-200	0.3-100
T1-1-KK81	1	0.15-400	0.15-400	.35-200	2-50
T1-1	1	0.15-400	0.15-400	.35-200	2-50
TX1-1	1	0.3-400	0.3-400	0.6-200	2-50
TCM1-1	1	1.5-500	1.5-500	2.5-400	5-350
TC1-1	1	1.5-500	1.5-500	2.5-400	5-350
TC1-1G2	1	1.5-500	1.5-500	2.5-400	5-350
TX1-R5	1	0.8-500	0.8-500	1.2-350	3.2-180
T1.18-3-KK81	1.18	0.01-250	0.01-250	0.02-200	0.03-50
T1.18-3	1.18	0.01-250	0.01-250	0.02-200	0.03-50
T1.5-6-KK81	1.5	.02-100	.02-100	.05-50	0.1-25
T1.5-6	1.5	.02-100	.02-100	.05-50	0.1-25
ADT1.5-2	1.5	0.3-225	0.3-225	0.5-140	0.7-80
T1.5-1-KK81	1.5	.1-300	.1-300	.2-150	.5-80
T1.5-1	1.5	.1-300	.1-300	.2-150	.5-80
TX1.5-1	1.5	0.25-300	0.25-300	0.3-150	0.5-80
T2-1-2W-KK81	2	5-120	—	—	5-120
T2-1-2W	2	5-120	—	—	5-120
T2.5-6-KK81	2.5	.01-100	.01-100	.02-50	.05-20
T2.5-6	2.5	.01-100	.01-100	.02-50	.05-20
T4-6-KK81	4	.02-200	.02-200	.05-150	.1-100
T4-6	4	.02-200	.02-200	.05-150	.1-100
ADT4-6	4	0.07-250	.07-250	0.1-220	0.15-150
T4-1-2W-KK81	4	10-250	—	—	10-250
T4-1-2W	4	10-250	—	—	10-250
T9-1H-KK81	9	2-90	2-90	3-75	6-50
T9-1H	9	2-90	2-90	3-75	6-50
T9-1-KK81	9	.15-200	.15-200	.3-150	2-40
T9-1	9	.15-200	.15-200	.3-150	2-40
TX9-1	9	1-200	1-200	1.5-160	3-70
T16-1H-KK81	16	7-85	7-85	10-65	15-40
T16-1H	16	7-85	7-85	10-65	15-40
ADT16-6	16	0.25-105	0.25-105	0.45-75	1-40
T16-1-KK81	16	.3-120	.3-120	.7-80	5-20
T16-1	16	.3-120	.3-120	.7-80	5-20
T36-1-KK81	36	.03-20	.03-20	.05-10	.1-5
T36-1	36	.03-20	.03-20	.05-10	.1-5

SCHEMATICS



TRANSFORMERS, IF/RF MICROWAVE 50 & 75 Ω

10 kHz to 6200 MHz Wideband 8 to 700 Ω

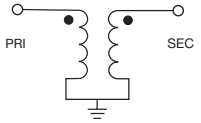
ADT Cases CD542, CD636, CD637 | TX Case TT240 | T Case KK81 | T Case W38

MODEL PREFIX	Ω RATIO (Secondary/Primary)	FREQUENCY (MHz)	INSERTION LOSS Above midband (dB) 3 dB (MHz)	2 dB (MHz)	1 dB (MHz)
D SCHEMATIC *Unbalanced to Unbalanced*					
ADT1.5-17	1.5	.5-1700	.5-1700	1-1500	2-1100
TC1.5-1	1.5	.5-2200	.5-2200	1-2000	2-1100
TC1.5-1G2	1.5	.5-2200	.5-2200	1-2000	2-1100
T2-1-KK81	2	.050-600	.050-600	.1-400	.5-200
T2-1	2	.050-600	.050-600	.1-400	.5-200
T3-1-KK81	3	.5-800	.5-800	2-400	—
T3-1	3	.5-800	.5-800	2-400	—
T4-2-KK81	4	.2-600	.2-600	.5-500	2-250
T4-2	4	.2-600	.2-600	.5-500	2-250
T8-1-KK81	8	.15-250	.15-250	.25-200	2-100
T8-1	8	.15-250	.15-250	.25-200	2-100
T14-1-KK81	14	.2-150	.2-150	.5-100	2-50
T14-1	14	.2-150	.2-150	.5-100	2-50
TC4-11	50/12.5	2-1100	—	2-1100	5-700
TC4-11G2	50/12.5	2-1100	—	2-1100	5-700
■ TC9-1-75	75/8	0.3-475	0.3-475	0.5-450	0.9-370
■ TC9-1-75G2	75/8	0.3-475	0.3-475	0.5-450	0.9-370
F SCHEMATIC *Single-ended to balanced with Impedance ratio selection*					
T-626-KK81	1:1:1	0.01-10	0.01-10	0.02-5	.04-2
T-626	1:1:1	0.01-10	0.01-10	0.02-5	.04-2
T-622-KK81	1:1:1	0.1-200	0.1-200	0.5-100	5-80
T-622	1:1:1	0.1-200	0.1-200	0.5-100	5-80
T2-613-1-KK81	1:1:2	0.07-200	0.07-200	0.1-100	0.5-50
T2-613-1	1:1:2	0.07-200	0 07-200	0.1-100	0.5-50
G SCHEMATIC *Balanced transmission line*					
■ ADTL1-4-75	1	0.5-1000	0.5-1000	1-600	5-400
TCN1-10	1	680-1050	—	—	680-1050
TCL1-11	1	600-1100	—	600-1100	700-1000
TCL1-11G2	1	600-1100	—	600-1100	700-1000
TCML1-11	1	600-1100	—	600-1100	700-1000
ADTL1-12	1	20-1200	—	20-1200	50-1000
TC1-15	1	350-1500	—	350-1000	800-1500
TC1-15G2	1	350-1500	—	350-1000	800-1500
■ ADTL1-18-75	1	5-1800	—	5-1800	25-1200
TCL1-19	1	800-1900	800-1900	—	800-1400
TCL1-19G2	1	800-1900	800-1900	—	800-1400
TCML1-19	1	800-1900	800-1900	—	800-1400
TCN1-23	1	1300-2300	—	—	1300-2300
TC1-1-13M	1	4.5-3000	2000-3000	1000-2000	4.5-1000
TC1-1-13MG2	1	4.5-3000	2000-3000	1000-2000	4.5-1000
TCN2-14	2	700-1400	—	—	700-1400
ADTL2-18	2	30-1800	30-1800	—	100-1500
TCN2-26	2	1600-2600	—	—	1600-2600
TCN3-11	3	600-1100	—	—	600-1100
TCN4-13	4	650-1250	—	—	650-1250

■ Denotes 75 ohm models

SCHEMATICS

D



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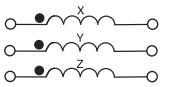

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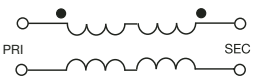


LTCC LTCC


NCS
Case GE0805C-1


TCN
Case FV1206-1

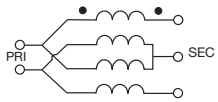

TCM
Case DB714


TC Cases
AT224, AT224-1, AT224-3

MODEL PREFIX	Ω RATIO (Secondary/Primary)	FREQUENCY (MHz)	INSERTION LOSS Above midband (dB) 3 dB (MHz)	2 dB (MHz)	1 dB (MHz)
H SCHEMATIC *Balanced transmission line with secondary center tap*					
TCN-2-45	2	3300-4500	—	—	3300-4500
TC4-19	4	10-1900	10-1900	20-1000	30-700
TC4-19G2	4	10-1900	10-1900	20-1000	30-700
TCM4-19	4	10-1900	10-1900	20-1000	30-700
TC4-25	4	500-2500	500-2500	700-1500	750-1200
TC4-25G2	4	500-2500	500-2500	700-1500	750-1200
TCM4-25	4	500-2500	500-2500	700-1500	750-1200
J SCHEMATIC *Unbalanced to Balanced*					
■ TCN1-152-75	1	950-1450	—	—	950-1450
NCS1-23	1	1300-2000	—	—	1300-2000
NCS1-292	1	1650-2850	—	—	1650-2850
NCS1-422	1	3300-4200	—	—	3300-4200
NCS1-63	1	4900-6000	—	—	4900-6000
TCN2-122	2	600-1200	—	—	600-1200
NCS2-222	2	1275-2200	—	—	1275-2200
NCS2-33	2	1500-3100	—	—	1500-3100
NCS2-392	2	3000-3900	—	—	3000-3900
NCS2-592	2	4900-5875	—	—	4900-5875
NCS2-622	2	5600-6200	—	—	5600-6200
NCS3-272	3	2250-2725	—	—	2250-2725
TCN4-162	4	720-1600	—	—	720-1600
TCN4-22	4	1200-2200	—	—	1200-2200
NCS4-232	4	1600-2300	—	—	1600-2300
NCS4-272	4	2400-2700	—	—	2400-2700
NCS4-442	4	3300-4400	—	—	3300-4400
NCS4-63	4	4500-6000	—	—	4500-6000
K SCHEMATIC *Balanced Transmission Line*					
■ ADTL1-15-75	1	10-1500	—	10-1500	30-1000

SCHEMATICS

H



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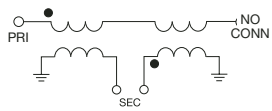

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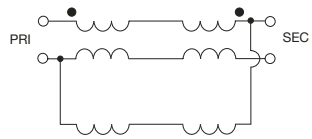

VOLTAGE CONTROLLED OSCILLATORS 50 Ω

12.5 MHz to 6740 MHz

MODEL PREFIX	FREQUENCY (MHz)		POWER OUTPUT (dBm)	TUNE VOLTAGE (V)		PHASE NOISE (dBc/Hz) SSB@ offset frequencies: Typ.				PULLING (MHz) pk-pk @12 dBr	PUSHING (MHz/V)	TUNING SENSITIVITY (MHz/V)	HARMONICS (dBc)		3 dB MOD. BANDWIDTH (kHz)	POWER SUPPLY	
						1 kHz	10 kHz	100 kHz	1 MHz							Voltage (V) Nom.	Current (mA) Max.
	Min.	Max.	Typ.	Min.	Max.					Typ.	Typ.	Typ.	Typ.	Max.	Typ.		
5 V TUNING for PLL IC's 24 MHz to 6740 MHz																	
JTOS-50P	24	29	+9.5	0.5	5.0	-88	-108	-127	-147	0.06	0.04	2-2.5	-14	-12	50	12.0	20
JTOS-75P	35	43	+9.0	0.5	5.0	-89	-110	-130	-140	0.15	0.11	2.5-4	-25	-20	125	12.0	20
JTOS-100P	48	59	+9.0	0.5	5.0	-83	-108	-128	-140	0.6	0.2	3.5-4	-30	-20	100	12.0	18
JTOS-150P	72	91	+9.5	0.5	5.0	-82	-106	-127	-147	0.8	0.3	6-9	-30	-17	112	12.0	20
JTOS-200P	95	120	+8.8	0.5	5.0	-84	-105	-124	-145	1.0	0.2	7-10	-30	-20	110	12.0	20
JTOS-300P	148	174	+10.0	0.5	5.0	-82	-102	-122	-142	1.0	0.2	10-14	-27	-20	120	12.0	20
JTOS-400P	194	220	+11.0	0.5	5.0	-82	-102	-122	-142	1.4	0.4	13-18	-25	-20	130	12.0	20
JTOS-535P	278	325	+9.5	0.5	5.0	-75	-97	-117	-137	2.0	0.5	17-22	-30	-20	115	12.0	20
JTOS-765P	486	510	+9.0	0.5	5.0	-75	-98	-118	-138	2.0	0.5	20-30	-30	-20	100	12.0	20
JTOS-1025P	680	755	+9.0	0.5	5.0	-70	-94	-114	-134	5.0	0.6	30-40	-27	-20	100	12.0	22
JTOS-3000P	2300	2600	+11.0	0.5	5.0	-65	-92	-112	-132	50.0	5.0	120-160	-22	-12	20000	5.0	25
ROS-86-119	80.5	86	+2.0	0.5	5.0	-90	-110	-131	-151	0.05	0.05	7	-28	-20	500	4.6	15
ROS-95-419	91	95	+5.0	0.5	5.0	-97	-125	-146	-162	0.01	0.3	4	-19	-11	7000	5.0	25
ROS-205PV	180	210	+2.0	0.5	5.0	-88	-110	-131	-151	0.4	0.4	10-15	-30	-20	2000	5.0	15
ROS-285PV	245	285	+3.0	0.5	5.0	-80	-100	-120	-140	2.0	0.2	10-20	-20	-10	100	5.0	20
ROS-355-219	381	355	+5.0	0.5	5.0	-87	-113	-133	-153	0.2	0.5	20	-23	-12	3000	5.0	22
ROS-445	410	445	-0.2	0.5	5.0	-91	-115	-135	-155	0.4	0.2	11-12	-20	-11	60000	5.0	16
ROS-470	435	470	-0.3	0.5	5.0	-89	-114	-135	-155	0.4	0.2	11-13	-21	-13	80000	5.0	16
ROS-481	461	481	+6.0	0.5	5.0	-88	-115	-136	-156	0.5	0.7	17	-21	-12	80000	4.75	25
ROS-485	450	485	-1.0	0.5	5.0	-91	-114	-134	-153	0.3	0.2	11	-21	-13	80000	5.0	15
ROS-505	470	505	0.5	0.5	5.0	-89	-114	-135	-154	0.2	0.3	11-13	-21	-13	80000	5.0	17
ROS-520	485	520	-0.2	0.5	5.0	-90	-115	-135	-154	0.2	0.1	12	-22	-14	70000	5.0	17
ROS-530	500	530	-0.4	0.5	5.0	-90	-111	-132	-151	0.4	0.1	10-11	-23	-15	80000	5.0	15
ROS-550PV	450	550	+6.0	0.5	5.0	-81	-104	-124	-144	3.0	0.5	30-60	-15	—	8000	5.0	15
ROS-550	515	550	-1.0	0.5	5.0	-90	-112	-133	-151	0.2	0.2	12-13	-23	-14	60000	5.0	17
ROS-570	535	570	-0.6	0.5	5.0	-90	-114	-135	-155	0.4	0.4	13	-18	-10	60000	5.0	15
ROS-585	550	585	0.2	0.5	5.0	-90	-114	-135	-152	0.4	0.2	13	-19	-11	50000	5.0	16
ROS-590	555	590	0	0.5	5.0	-87	-111	-132	-152	0.4	0.2	11-12	-18	-9	60000	5.0	17
ROS-595	560	595	-0.7	0.5	5.0	-89	-112	-132	-151	0.4	0.1	12-13	-19	-10	80000	5.0	17
ROS-615	580	615	-0.6	0.5	5.0	-90	-113	-133	-153	0.2	0.2	12-13	-21	-13	19000	5.0	17
ROS-630	595	630	0.1	0.5	5.0	-90	-113	-133	-153	0.4	0.1	11-12	-23	-15	80000	5.0	18
ROS-645	610	645	-0.1	0.5	5.0	-88	-112	-132	-151	0.4	0.1	12-13	-24	-16	50000	5.0	17
ROS-660PV	640	660	0	0.5	5.0	-85	-107	-127	-147	0.8	0.6	10-14	-17	-12	2000	5.0	15
ROS-665	630	665	0.2	0.5	5.0	-90	-113	-133	-153	0.4	0.1	12-13	-24	-16	60000	5.0	18
ROS-675PV	655	675	0	0.5	5.0	-85	-107	-127	-145	1.0	0.5	10-14	-23	-10	5000	5.0	15
ROS-680	650	680	0.5	0.5	5.0	-91	-114	-134	-154	0.3	0.2	11-12	-24	-16	50000	5.0	18
ROS-690	655	690	-1.0	0.5	5.0	-89	-111	-131	-151	0.4	0.4	12-13	-24	-16	50000	5.0	17
ROS-700	665	700	-0.1	0.5	5.0	-89	-113	-133	-153	0.4	0.1	12-13	-21	-13	80000	5.0	17
ROS-715	680	715	-0.5	0.5	5.0	-90	-113	-133	-152	0.5	0.2	12-13	-22	-14	60000	5.0	16
ROS-725PV	710	725	0	0.5	5.0	-85	-105	-126	-145	0.9	0.3	8-13	-19	-12	2000	5.0	15
ROS-730	695	730	0.2	0.5	5.0	-90	-114	-134	-153	0.5	0.2	11-12	-21	-13	90000	5.0	18
ROS-740PV	720	740	0	0.5	5.0	-84	-106	-126	-145	1.0	0.8	10-14	-19	-12	5000	5.0	15
ROS-745	71	745	1.2	0.5	5.0	-88	-113	-133	-153	0.8	0.3	12	-22	-14	60000	5.0	17
ROS-750	670	750	+3.0	0.5	5.0	-82	-107	-128	-148	0.3	1.0	27-32	-30	-20	110000	5.0	26
ROS-755	720	755	-0.5	0.5	5.0	-89	-113	-133	-147	0.4	0.1	12-13	-23	-15	80000	5.0	17
ROS-766	730	766	0.4	0.5	5.0	-91	-113	-134	-154	0.6	0.1	12-13	-23	-15	80000	5.0	18
ROS-810	775	810	0.6	0.5	5.0	-88	-112	-131	-151	0.9	0.8	12-13	-19	-12	60000	5.0	18
ROS-835	800	835	-0.4	0.5	5.0	-89	-110	-130	-150	1.0	0.5	12-13	-21	-13	60000	5.0	15
ROS-870	840	870	0.8	0.5	5.0	-89	-111	-132	-151	1.1	0.8	11-12	-19	-12	90000	5.0	17
ROS-900PV	810	900	+1.0	0.5	5.0	-80	-102	-122	-142	3.0	2.0	26-30	-25	-16	1000	4.5	12
ROS-928C-119	902	928	+10	0.5	5.0	-89	-117	-138	-157	1.0	0.2	18	-22	-15	130000	12	32
ROS-960PV	890	960	0	0.5	5.0	-80	-102	-122	-142	2.0	0.2	25-28	-27	-18	1000	5.0	12
ROS-970	830	970	+5.5	0.5	5.0	-80	-107	-128	-148	1.0	1.0	46	-23	-17	80000	5.0	35
ROS-995-119	965	995	+4.5	0.5	5.0	-87	-111	-132	-152	0.8	0.5	16	-24	-10	90000	5.0	32
ROS-1000C-319		1000	+1.0	0.5	5.0	-96	-126	-146	-162	0.1	0.04	5	-22	-14	150000	6	35
ROS-1000PV	900	1000	+6.0	0.5	5.0	-80	-104	-124	-144	2.0	0.7	27-38	-33	-20	1000	5.0	22
ROS-1250W-119	830	1250	+0.5	0.5	5.0	-69	-94	-117	-138	0.5	4.5	74-152	-33	-15	70000	5.0	25
ROS-1270-1PH19	1150	1270	+3.0	0.5	5.0	-80	-105	-126	-146	3.0	0.5	34-40	-18	-10	120000	5.0	35
ROS-1330-1PH19	1210	1330	+3.0	0.5	5.0	-82	-106	-128	-145	2.5	0.5	39-43	-18	-10	100000	5.0	35
ROS-1435PV	1375	1435	+3.0	0.5	5.0	-78	-101	-121	-141	4.0	1.7	20-30	-26	-18	5000	5.0	20
ROS-1540-419	1505	1540	+4.0	0.5	5.0	-83	-110	-131	-152	1.0	0.5	20-30	-16	—	150000	5.0	35
ROS-1600PV	1520	1600	+7.0	0.5	5.0	-75	-100	-120	-140	10.0	3.0	25-38	-26	-16	1000	5.0	25
ROS-1605PV	1500	1605	0	0.5	5.0	-74	-98	-118	-138	6.0	0.8	40-50	-17	-8	8000	3.3	16
ROS-1850-519	1830	1850	-0.5	0.5	5.0	-86	-111	-132	-146	0.1	0.5	17	-29	-20	145000	7.0	35
ROS-2252	2182	2245	+3.0	0.5	5.0	-84	-107	-128	-146	0.5	1.0	21-26	-30	-20	20000	4.75	35
ROS-2470-119	2430	2470	+9.5	0.5	5.0	-81	-106	-126	-146	2.0	0.5	27-31	-22	-11	200000	8.0	40
ROS-2510-219	2250	2510	+4.5	0.5	5.0	-70	-96	-119	-139	5.0	1.5	100	-23	-12	400000	5.0	40
ROS-2930	2840	2930	+7.0	0.5	5.0	-69	-96	-117	-138	1.3	2.7	85	-29	-20	450000	5.0	40
ROS-3080-1PH19	2920	3080	+3.0	0.5	5.0	-71	-95	-116	-136	2.0	3.0	90	-22	-11	4000	5.0	37
ROS-3214-119	3074	3200	+2.0	0.5	4.5	-77	-102	-123	-143	2.5	0.3	45-57	-21	-15	20000	5.0	40
ROS-3270-119	3150	3270	+2.5	0.5	5.0	-71	-96	-116	-137	2.5	4.5	82	-20	-12	340000	5.0	33
ROS-3550	3350	3550	+3.5	0.5	5.0	-71	-97	-118	-139	1.5	0.7	77-82	-22	-13	720000	5.0	42
ROS-5150-319	5020	5145	+3.5	0.5	5.0	-73	-104	-126	-146	0.7	2.5	75-90	-30	-18	120000	5.0	32
ROS-5150-119	4880	5150	+3.5	0.5	5.0	-69	-95	-116	-136	1.0	2.0	74-90	-30	-20	50000	5.0	53
ROS-5490C-119	5340	5490	+0.5	0.5	5.0	-74	-102	-122	-142	0.5	1.5	58-76	-27	-18	175000	5.0	32
ROS-5580-119	5440	5580	-0.5	0.5	5.0	-75	-101	-123	-143	0.3	0.8	68-72	-26	-19	180000	5.0	35
ROS-5776-119	5726	5826	+1.5	0.5	5.0	-75	-102	-122	-142	0.5	3.0	59-78	-28	-18	130000	5.0	33
ROS-6030C-219	5890	6010	+2.0	0.5	5.0	-73	-102	-124	-144	0.7	2.0	62-80	-36	-22	220000	5.0	28
ROS-6740C-119	6640	6740	+2.0	0.5	5.0	-70	-97	-120	-140	1.0	3.0	75-90	-30	-18	300000	5.0	35
MOS-1826PV	1766	1826	+2.0	0.5	5.0	-75	-101	-122	-142	8.0	1.0	21-35	-28	-15	10000	5.0	25
MOS-2033-119	1933	2033	+3.0	0.4	5.0	-78	-103	-124	-144	0.2	0.6	42-47	-23	-13	200000	5.0	37
MOS-2133-219	2033	2133	+2.5	0.5	5.0	-78	-103	-124	-144	0.2	0.5	35-41	-21	-13	200000	5.0	40

SOS
Case FZ990

MOS
Case CZ682

ROS
Case CK605, CK1113, CK829

JTOS
Case BK377

WITH LEADS

JCOS
Case BG419

MODEL PREFIX	FREQUENCY (MHz)		POWER OUTPUT (dBm)	TUNE VOLTAGE (V)		PHASE NOISE (dBc/Hz) SSB@ offset frequencies: Typ.				PULLING (MHz) pk-pk @12 dBr	PUSHING (MHz/V)	TUNING SENSITIVITY (MHz/V)	HARMONICS (dBc)		3dB MOD. BANDWIDTH (kHz)	POWER SUPPLY	
	Min.	Max.	Typ.	Min.	Max.	1 kHz	10 kHz	100 kHz	1 MHz	Typ.	Typ.	Typ.	Typ.	Max.	Typ.	Voltage (V) Nom.	Current (mA) Max.
LINEAR TUNING WIDEBAND 12.5 MHz to 4720 MHz																	
ROS-71-119	62	71	+4.5	0.5	6	-93	-114	-134	-154	0.50	0.5	3.0	-30	-20	200	5.0	15
ROS-100	50	100	+8.3	0.5	17	-75	-105	-125	-145	0.60	0.3	3.0-5.0	-30	-20	100	12.0	20
ROS-150	75	150	+9.5	1.0	18	-80	-103	-127	-144	0.80	0.3	4.0-6.8	-23	-16	100	12.0	20
ROS-200	100	200	+10.0	1.0	17	-80	-105	-125	-145	0.60	0.3	6-11	-30	-20	100	12.0	20
ROS-244	170	244	+10.0	2.0	16	-96	-123	-143	-162	0.10	0.1	6.0	-20	—	50000	12.0	32
ROS-300	150	280	+9.0	1.0	16	-80	-102	-122	-142	0.50	0.3	7-17	-28	-18	100	12.0	20
ROS-400	200	380	+9.5	0.5	17	-80	-100	-120	-140	0.20	0.3	9-22	-24	-18	100	12.0	20
ROS-400-1119	200	400	+6.5	0.5	20	-79	-102	-123	-145	0.60	1.0	10-17	-34	-20	200	5.0	20
ROS-470-319	460	470	+2.5	1.0	10	-94	-118	-138	-150	0.10	0.1	6.0	-21	-15	100000	5.0	22
ROS-535	300	525	+6.0	1.0	17	-75	-98	-118	-138	0.50	0.4	9-27	-20	-15	100	12.0	20
ROS-765	485	765	+6.0	1.0	16	-74	-95	-115	-135	2.00	0.5	10-40	-27	-14	100	12.0	22
ROS-810LN	760	810	+5.0	0.5	10	-90	-115	-135	-155	1.8	0.5	8-10	-24	-18	6000	8.0	20
ROS-950-219	850	950	+6.0	0.5	12	-89	-117	-139	-156	0.50	0.5	9-13	-20	-12	30000	5.5	30
ROS-1000V	900	1000	0.0	0.5	12	-74	-102	-122	-140	1.00	0.4	12-16	-30	-20	8000	5.0	25
ROS-1100V	1000	1100	0.0	0.5	12	-80	-103	-123	-142	1.50	1.5	12-16	-26	-20	8000	5.0	25
ROS-1120-119	610	1120	+13.0	0.5	18	-77	-102	-124	-145	9.0	0.5	40-56	-20	-10	30000	15.0	37
ROS-1121V	1060	1121	+2.5	1.0	11	-88	-111	-131	-149	0.70	0.7	8-13	-11	—	10000	5.0	30
ROS-1150-519	750	1150	+7.0	0.5	13.5	-78	-101	-121	-141	2.0	2.0	38-45	-20	-12	70000	5.0	35
ROS-1200W	612	1200	+10.0	0.5	18	-71	-97	-119	-139	9.0	0.45	26-68	-18	-10	20000	12.0	40
ROS-1340-119	1260	1340	+2.0	2.0	12	-86	-111	-132	-151	0.50	0.2	11-16	-33	-20	270000	5.0	30
ROS-1410	850	1410	+7.0	0.5	11	-73	-99	-119	-138	15.00	1.0	50-80	-8	—	1000	12.0	25
ROS-1455	900	1455	+13.0	0.5	12.0	-72	-100	-126	-146	18.0	0.5	60-71	-15	—	75000	12.0	40
ROS-1480-119	1100	1480	+12.0	1.0	18	-79	-103	-123	-143	20.00	0.5	22-36	-30	-12	70000	15.0	45
ROS-1500	1000	1500	+8.0	0.5	20	-79	-104	-124	-144	10.00	1.2	25-40	-13	—	100000	10.0	26
ROS-1560-1PH19	1260	1560	+3.5	0.5	10	-77	-103	-124	-144	2.00	0.7	35-44	-29	-15	120000	5.0	31
ROS-1600W	800	1600	+9.0	0.5	24	-72	-99	-122	-143	10.0	0.3	35-58	-22	-15	90000	11.5	35
ROS-1700W	770	1700	+8.0	1.0	24	-73	-100	-121	-140	9.0	0.4	26-60	-25	-13	11000	12.0	40
ROS-1707-119	1033	1707	+8.0	0.5	22	-74	-100	-121	-142	10.5	2.0	32-59	-15	—	100000	10.0	35
ROS-1720	1550	1720	+7.0	0.5	12	-73	-101	-121	-141	11.00	1.3	28-34	-17	-10	18000	12.0	25
ROS-1770-1PH19	1710	1800	+3.0	0.5	8	-86	-111	-132	-152	0.10	0.2	18-21	-22	-13	120000	5.0	30
ROS-1862-119	1524	1862	+7.0	1.0	24	-78	-104	-125	-146	4.00	0.5	25-37	-18	—	12000	8.0	30
ROS-1900	1450	1900	+7.0	0.5	20	-80	-106	-126	-146	7.00	0.7	22-34	-15	-7	100000	10.0	25
ROS-1900V	1450	1900	+8.0	0.5	20	-78	-104	-124	-144	7.00	0.7	22-34	-18	-10	100000	5.0	28
ROS-1950-519	1780	1950	+4.0	0.5	11	-84	-110	-130	-150	1.00	0.4	23-25	-18	—	7000	5.0	32
ROS-1990	1800	1990	+6.0	1.0	11	-75	-101	-122	-143	5.00	1.3	37-44	-30	-16	270000	8.0	30
ROS-2000	1350	2000	+7.0	0.5	20	-75	-100	-120	-140	9.0	1.3	30-50	-11	—	2000	12.0	25
ROS-2100-119	1350	2100	+8.5	0.5	18.5	-76	-102	-124	-144	8.5	0.5	46-72	-18	—	60000	8.0	35
ROS-2150VW	970	2150	+4.0	0.5	25	-70	-96	-118	-138	7.0	2.5	30-70	-15	—	6000	5.0	25
ROS-2160W	1160	2160	+5.0	0.5	20	-70	-97	-117	-137	10.0	1.5	30-80	-11	—	12000	10.0	30
ROS-2180-419	2000	2180	+10.0	0.5	6	-73	-102	-124	-144	12.00	1.5	61-75	-21	-10	100000	5.0	40
ROS-2250W-119	1220	2250	+3.5	0.0	20	-73	-99	-120	-142	5.0	1.0	50-75	-18	—	70000	5.0	25
ROS-2345	2295	2345	+5.0	0.5	6	-83	-107	-127	-147	1.00	1.0	19	-22	-13	230000	4.75	35
ROS-2350-519	1960	2350	+7.0	0.5	15	-81	-106	-127	-146	6.00	0.5	33-44	-23	-10	140000	6.0	40
ROS-2350	2160	2350	+5.5	0.5	10	-79	-101	-123	-143	1.0	4.0	27-33	-27	-19	200000	5.0	37
ROS-2400-1019	2100	2400	+6.5	0.5	12	-75	-100	-121	-140	2.50	3.5	42-50	-30	-20	20000	5.0	42
ROS-2432-119	1662	2432	+5.5	1.0	28	-73	-100	-123	-143	6.5	1.0	23-49	-18	—	230000	10.0	30
ROS-2485	2050	2485	+6.5	0.5	16	-77	-105	-126	-146	3.0	0.3	31-59	-30	-15	150000	8.0	32
ROS-2500	1600	2500	+6.5	0.5	14	-66	-90	-113	-133	18.0	5.0	30-180	-14	-8	6000	12.0	25
ROS-2650	2165	2650	+5.0	0.5	19	-75	-101	-121	-141	5.00	1.0	27-36	-12	—	200000	12.0	25
ROS-2700-819	1950	2700	+8.7	0.5	10	-64	-90	-112	-132	21.7	6.0	91-156	-27	-12	340000	8.5	29
ROS-2800-519	2000	2750	+3.5	1.0	24	-71	-96	-117	-137	4.0	3.0	25-56	-25	-10	45000	5.0	26
ROS-2750	2350	2750	+5.7	0.5	14.5	-78	-105	-127	-146	2.00	0.3	32-42	-23	-12	120000	6.0	35
ROS-2770-219	1970	2770	+6.0	1.0	28	-74	-101	-123	-143	4.5	1.5	24-56	-27	-15	250000	10.0	32
ROS-2800-719	1400	2800	+3.5	0.5	25	-69	-95	-116	-137	6.0	2.5	42-107	-15	—	130000	5.0	30
ROS-3000-819	2000	3000	+5.5	0.5	14	-71	-96	-117	-138	13.5	1.5	84-125	-22	-10	140000	12.0	35
ROS-3000V	2400	3000	+9.0	0.5	22	-70	-96	-116	-136	30.00	1.5	20-60	-18	—	20000	5.0	40
ROS-3360	2120	3360	+8.5	0.5	18	-68	-95	-116	-136	3.0	1.0	65-113	-26	-12	170000	12.0	45
ROS-3760	3200	3760	+7.5	0.5	15	-69	-96	-117	-138	3.0	1.0	56-67	-28	-18	600000	5.0	48
ROS-4720-119	4680	4720	+7.5	0.5	11	-70	-96	-117	-138	2.5	0.7	15	-26	-16	120000	5.0	50
JTOS-25	12.5	25	+8.0	1.0	11	-95	-115	-135	-155	0.03	0.02	1.0-4.0	-26	-13	130	12.0	20
JTOS-50	25	47	+8.5	1.0	15	-88	-108	-127	-147	0.06	0.04	2.0-2.6	-19	-12	50	12.0	20
JTOS-75	37.5	75	+8.0	1.0	16	-89	-110	-130	-140	0.15	0.11	2.8-4.0	-27	-20	125	12.0	20
JTOS-100	50	100	+8.3	1.0	16	-83	-108	-128	-140	0.60	0.2	3.7-4.8	-35	-20	100	12.0	18
JTOS-150	75	150	+9.5	1.0	16	-82	-106	-127	-147	0.80	0.3	5.8-6.7	-23	-17	112	12.0	20
JTOS-200	100	200	+10.0	1.0	16	-84	-105	-124	-145	1.00	0.2	6-10	-25	-20	110	12.0	20
JTOS-300	150	280	+9.0	1.0	16	-82	-102	-122	-142	1.00	0.2	9-14	-28	-20	120	12.0	20
JTOS-400	200	380	+9.0	1.0	16	-82	-102	-122	-142	1.40	0.4	10.5-17.1	-25	-20	130	12.0	20
JTOS-535	300	525	+9.5	1.0	16	-75	-97	-117	-137	2.00	0.5	10-24	-28	-20	115	12.0	20
JTOS-765	485	765	+8.0	1.0	16	-75	-98	-118	-138	2.00	0.5	20-30	-30	-20	100	12.0	20
JTOS-850VW	400	850	+6.0	0.5	18	-74	-96	-116	-136	6.0	1.5	15-80	-20	—	185	5.0	20
JTOS-1000W	500	1000	+7.0	1.0	18	-73	-94	-114	-134	5.0	1.0	30-40	-26	-20	100	12.0	25
JTOS-1025	685	1025	+8.6	1.0	16	-70	-94	-114	-134	5.00	0.6	21-36	-28	-20	100	12.0	22
JTOS-1300	900	1300	+7.0	1.0	20	-70	-95	-115	-135	12.00	1.0	25-45	-28	-17	1000	12.0	30
JTOS-1550	1150	1550	+7.0	0.5	20	-73	-101	-121	-141	14.00	0.7	22-32	-20	-10	2700	12.0	30
JTOS-1650	1200	1650	+7.0	1.0	13	-70	-95	-115	-135	15.00	1.5	50-90	-20	-14	1000	12.0	30
JTOS-1750	1350	1750	+7.0	0.5	20	-73	-101	-121	-141	7.00	0.5	26-35	-16	-10	2700	12.0	30
JTOS-1910	1625	1910	+7.0	1.0	12	-69	-97	-117	-137	10.00	1.0	30-60	-20	-15	2500	12.0	20
JTOS-1950	1550	1950	+7.0	0.5	20	-75	-103	-125	-144	7.00	0.6	23-32	-14	-10	8000	12.0	30
JTOS-2000	1370	2000	+12.0	1.0	22	-70	-95	-115	-135	40.0	1.5	30-50	-11	-8	1000	8.0	30
JTOS-2700V	2050	2700	+8.0	0.5	18	-72	-94	-114	-134	5.00	1.0	46-56	-25	-10	8000	5.0	20
JTOS-3000	2300	3000	+10.0	0.5	12	-60	-90	-110	-130	50.00	5.0	50-150	-22	-12	20000	5.0	25
JCOS-175LN	125	175	+3.7	1.0	17	-95	-118	-138	-158	0.08	0.05	3-5	-25	-20	2900	12.0	20
JCOS-820BLN	807	832	+3.0	1.0	14	-88	-112	-132	-151	0.4	0.4	6	-24	-20	2000	10.0	25
JCOS-820WLN	780	860	+9.0	0	20	-90	-112	-132	-150	4.5	0.3	8	-13	-8	2000	9.0	25
JCOS-1100LN	1079	1114	+8.5	0	20	-88	-110	-130	-150	7.5	0.5	4.5	-15	-10	2000	8.0	25
SOS-1505-119	1430	1520	+3.5	0.3	3	-69	-94	-115	-136	1.50	1.0	69-75	-30	-17	160000	3.0	15
MOS-114	57	114	+7.0	0.5	14	-85	-110	-131	-152	0.3	0.1	6	-12	—	2000	15.0	22

National Stock Number (NSN) Guide

NSN	MCL No.
5985-01-483-0465	ADC-10-4
5895-01-514-0619	ADE-13
5950-01-483-0469	ADT1.5-1
5895-01-131-4569	AK-2
5996-01-350-9550	AMP-15
5996-01-350-9551	AMP-75
5996-01-350-9549	AMP-77
5985-01-466-1331	ANNE-50
5985-01-540-6469	ANNE-50L
5895-01-320-0366	ASK-1
5915-01-425-7519	BHP-25
5915-01-454-6890	BLP-5
5915-01-534-2133	BLP-100-75
5915-01-518-7960	BLP-550
5985-01-491-2925	BMP-5075
5985-01-498-2715	BMP-5075R
6625-01-325-7972	BTRM-50
5985-01-328-7420	BTRM-75
5985-01-534-3832	BW-N1W5+
5985-01-538-2245	BW-S1W2
5985-01-538-2194	BW-S2W2
5985-01-535-7292	BW-S3W2
5985-01-538-2187	BW-S4W2
5985-01-538-1141	BW-S5W2
5985-01-535-7294	BW-S6W2
5985-01-524-5984	BW-S10W2
5985-01-525-0443	BW-S12W2
5985-01-525-0445	BW-S20W2
5962-01-459-9075	ERA-1SM
5962-01-459-7410	ERA-2SM
5996-01-516-5438	ERA-3SM
5962-01-459-7410	ERA-4SM
5962-01-459-9314	ERA-5SM
5895-00-087-7925	FD-2
5985-01-204-9746	FK-5
5950-01-325-4686	FT1.5-1
5950-01-132-8034	FTB-1-1-75-A15
5950-01-225-8773	FTB-1-6-A15
5955-01-483-0505	JTOS-200
5955-01-540-7761	JTOS-400P
5955-01-534-2738	JTOS-1025
5955-01-478-7347	JTOS-2000
5985-01-393-7219	KSW-2-46
5995-01-369-4224	KSWA-2-46
5995-01-477-4173	LRMS-1
5995-01-478-7342	LRPS-2-1
5962-01-414-8635	MAR-1SM
5962-01-417-4110	MAR-2
5962-01-339-2933	MAR-3
5962-01-423-1569	MAR-3SM
5962-01-414-8631	MAR-4
5962-01-416-1462	MAR-6
5962-01-460-6063	MAR-6SM
5998-01-360-6957	MAR-8
5895-01-360-6958	MAV-11
5996-01-365-2246	MAV-4
5895-01-361-7477	MK-3
5895-01-332-8582	MK-3BR
6625-01-294-7152	MPD-1
5895-01-389-3572	MPD-21
6625-01-124-8595	MSC-2-1
5985-01-437-3528	MSC-2-1W
5915-01-518-8028	NHP-1000
5915-01-492-3687	NLP-450
5985-01-282-2105	PAS-1
5985-01-192-0100	PAS-2
5895-01-067-3035	PAS-3
5985-01-460-6045	PAT-10
5985-01-460-6043	PAT-15
5985-01-460-6040	PAT-3
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5985-01-178-4406	PDC-10-1

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5985-01-190-7738	PDC-10-22
5985-01-389-9497	PDC-10-5
5985-01-394-6080	PDC-10-54
5985-01-147-0160	PDC-15-6
5985-01-076-8477	PDC-20-3
5915-01-332-1091	PLP-100
5915-01-389-3575	PLP-150
5915-01-355-9433	PLP-30
5915-01-450-7011	PLP-300
5915-01-389-8302	PLP-450
5995-01-105-7820	PLS-1
5895-01-390-0151	PLS-2
6625-01-230-0492	PSC-2-4
6625-01-015-6027	PSC-3-1
6625-01-249-8011	PSC-3-13
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5985-01-381-3835	PSC-3-2
5895-01-065-0106	PSC-4-1
5895-01-105-6189	PSC-4-3
5895-01-423-7929	PSC-4-5
5895-01-332-3086	PSC-4-6
5895-01-347-0205	PSC-4A-4
6625-01-255-3143	PSC-5-1
6625-01-249-8012	PSC-6-1
6625-01-365-5615	PSC-8-1
6625-01-413-2386	PSCJ-2-1
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6625-01-160-0151	PSCQ-2-90
5985-01-328-8006	PSW-1211
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5895-01-143-3726	RK-3
5895-01-415-6798	RMS-1
5895-01-453-9218	RMS-1LH
5895-01-447-3489	RMS-2
5895-01-392-2276	ROK-186MH
5963-01-514-0616	ROS-1410
5895-01-250-8525	RPD-1
5895-01-117-2926	SAM-1
5895-01-199-3893	SAY-11
5895-01-126-4913	SBL-1
6625-01-441-8135	SBL-1-1
5895-01-514-0624	SBL-1MH
5895-01-179-8084	SBL-1X
5895-01-326-6030	SBL-3
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5895-01-374-9561	SCM-1NL
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5915-01-458-5439	SHP-100
5915-01-360-0677	SHP-200
5915-01-530-2149	SHP-300
5915-01-464-8971	SIF-30
6625-01-247-8425	SK-2
5915-01-539-4795	SLP-1.9
5915-01-540-6150	SLP-10.7
5915-01-414-9165	SLP-21.4
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5915-99-244-4808	SLP-450

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5962-01-113-5431	SRA-1-1
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6625-00-594-0223	SRA-1H
5895-01-391-0113	SRA-1MH
5895-01-163-0433	SRA-1W
5895-01-268-1907	SRA-1W
5895-00-576-0716	SRA-1WH
5895-01-063-1078	SRA-2H
5895-01-021-5914	SRA-3
5895-01-117-4537	SRA-3H
5895-01-124-0117	SRA-6
5895-01-081-0977	SRA-8
5895-01-483-0503	SYM-18H
5985-01-456-4751	T0S-W230
5950-01-128-3745	T1-1
5950-01-347-0310	T1-1- KK81
5950-01-409-2785	T1-1H
5950-01-153-0668	T1-1T
5950-01-431-4604	T1-1T- KK81
5950-01-340-7040	T1-1T-X65
5950-01-327-5916	T1-1-X65
5950-01-094-7439	T16-1
5950-01-336-0939	T16-6T
5950-01-258-2173	T1-6T
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5895-01-274-2678	TAK-3H
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5895-01-231-2372	TAK-6
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5950-01-537-9763	TC4-1W
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5895-011-79-5686	TFM-12
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5950-01-215-8697	TM0-2.5-6T
5950-01-183-6414	TM0-2-1
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5950-01-132-8102	TM0-4-6
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5950-01-213-3735	TMO-1-1
5950-01-138-4593	TMO-16-1

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5985-01-416-9020	TOAT-51020
5985-01-456-4751	TOSW-230
5985-01-457-4811	TOSW-425
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5895-01-373-2444	TSM-3
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5950-01-272-2298	TT1-6-X65
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5950-01-415-7145	TTM0-25-1
5985-01-519-7451	VAT-6
5895-01-232-5890	VAY-1
5996-01-460-6044	VNA-25
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5985-01-507-8816	ZA3CS-400-3W
5985-01-357-3919	ZA3PD-2
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5985-00-280-7750	ZAD-1B
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5895-01-229-7431	ZAPD-2-S
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5985-01-476-2218	ZB4PD1-500-S
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5985-01-372-8880	ZB8PD-4-S
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5985-01-370-6145	ZBSC-413-S
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5985-01-417-0065	ZFDC-10-5-S
5985-01-473-9190	ZFDC-10-6
5985-01-298-0144	ZFDC-15-5
5985-01-330-6792	ZFDC-15-6
6130-01-383-9709	ZFDC-20-3-S
5985-01-266-9992	ZFDC-20-4
5985-01-097-2192	ZFDC-20-5
5985-01-542-1840	ZFDC-20-5-S
5985-01-495-8929	ZFDC-20-50B-S
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5996-01-454-6938	ZFL-1000VH
5996-01-220-2213	ZFL-2000B
6625-01-415-2182	ZFM-11-S
5895-01-412-3035	ZFM-15
5895-01-217-6878	ZFM-150-N
5895-01-412-3037	ZFM-1W
6625-01-343-0908	ZFM-2A
5895-01-449-8028	ZFM-2A-S
5895-01-257-9523	ZFM-3
5895-01-381-9289	ZFM-3B
5895-01-290-0300	ZFM-3H
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5985-01-266-6144	ZFRSC-2075
5985-01-332-3083	ZFRSC-42-S
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5895-01-494-8406	ZFSC-2-1B-N
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5895-01-425-7520	ZFSC-2-1W-S
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6625-01-419-4241	ZFSC-2-6
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5895-01-524-8996	ZFSC-2-9G
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5895-01-335-1824	ZFSC-3-13
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5985-01-361-8520	ZFSC-3-1-S
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5985-01-372-6418	ZFSC-4-1W-S
5985-01-253-2843	ZFSC-4-3B-S
6625-01-225-6965	ZFSC-6-1
6625-01-380-5299	ZFSC-6-1-75
6625-01-263-9871	ZFSC-6-1-S
5820-01-136-7244	ZFSC-8-1
5895-01-326-8664	ZFSC-8-1-75
6625-01-223-1235	ZFSC-8-1-S
5895-01-229-0156	ZFSC-8375
5895-01-495-8801	ZFSC-8-43
5985-01-407-7391	ZFSWA-2-46-S
5996-01-453-2464	ZHL-0812HLN

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6130-01-088-2322	ZHL-1A
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5996-01-201-4500	ZHL-1A-S
5996-01-494-6112	ZHL-2010-S
5996-01-400-0753	ZHL-2-12
5895-01-238-7973	ZHL-32A
5895-01-194-1718	ZHL-3A
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5985-01-080-7637	ZLW-1H
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5985-01-140-4291	ZMAS-1
5985-01-437-1502	ZMAS-3
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5895-01-384-7453	ZP-10514
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5985-01-534-3836	ZSDR-230
6625-01-520-6532	ZX10-2-71-S
5895-01-464-8969	ZYSW-2-50DR
4920-01-530-0199	ZYSWA-2-50DR
5985-01-467-3232	ZYSWA-2-50DRB

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CREDIT CARDS WELCOME

AMERICAN EXPRESS MASTER CARD VISA DISCOVER

Mini-Circuits Patent Guide

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ADC-10-1R	6,133,525
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ADC-10-4	6,133,525
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ADC-10-4-75	6,133,525
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ADC-12-4-75	6,133,525
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ADC-15-4-75	6,133,525
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ADC-18-4-75	6,133,525
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ADC-20-12	6,133,525
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ADE-20	6,133,525
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ADE-42MH	6,133,525
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	6,784,521
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	6,784,521
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	6,784,521
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TCD-9-1W	6,140,887
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	6,943,629
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	6,784,531
	6,790,049
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	6,140,887
	6,784,531
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Mini-Circuits Yoni2™

Site Speeds Search For RF/Microwave Components

This upgraded search function supports parametric selection of components based on actual measured data, allowing engineers to quickly match a component to an application.

Matching a component to an application can be tedious and even unnerving at times. No matter how well versed a high-frequency engineer is in terms of the latest components, few if any can understand how some components can fit into a circuit or system better than others. Fortunately, the ready availability of the World Wide Web and high-speed Internet access, coupled with ever-improving high-frequency websites, has made the component search somewhat easier. And with the latest generation of component search tools from Mini-Circuits, the Yoni2 engine, designers can even select specific subbands and performance parameters within a component's total range of operation for that optimum match of component to application.

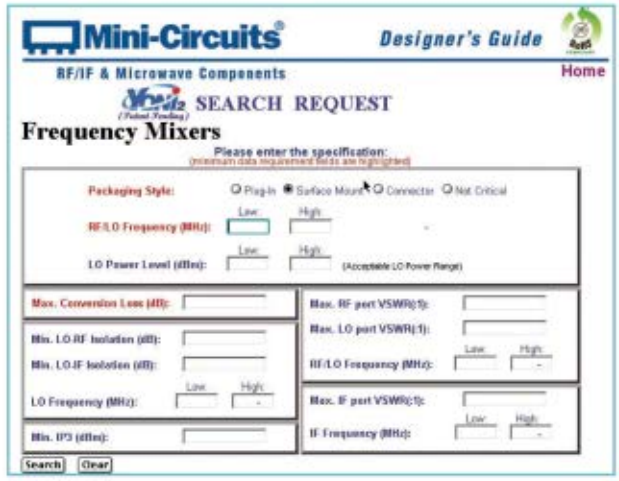
Rather than sorting though copies of data sheets, Yoni2 ***(Fig. 1)*** allows engineers to search through an enormous amount of actual data to find the best component for a particular requirement. In fact, the algorithms with which Yoni2 sorts through the data are so efficient that they represent the unique instance in which one of the functions of a high-frequency website is patent-pending.

1. The opening page of Yoni2 lists the current product lines that are available for a parametric search.

According to Mini-Circuits' president Harvey Kaylie, the development of Yoni2 was spurred by an awareness of how customers were using the company's parts. In some cases, rather than simply selecting, for example, a double-balanced mixer with RF and intermediate-frequency (IF) ranges to translate a desired signal band, engineers were using broader-band mixers over narrower portions of their range to meet a required linearity specification, or conversion-loss level, or optimum local-oscillator (LO) drive level. "Sometimes you don't need the entire usable bandwidth of a component, but just a portion of it, especially where that segment of its operating range gives you better performance than

you might get with a narrow-band solution," says Kaylie.

Constructing the Yoni2 database and search functions was not simply a matter of copying data-sheet files of compiling specifications from existing catalogues. When the Yoni2 search tool triggers on a user's input parameters, it begins a high-speed sort through actual measured data for each component in a category, attempting to match performance limits or a performance window to a customer's request. Collecting this amount of measured data, of course, is extremely time consuming and would have been impractical if not for a major investment on the part of Mini-Circuits in new RF/microwave test systems which include high-performance vector network analyzers and fast-switching synthesized signal sources. Kaylie notes, "We worked very closely with a major international supplier of RF and microwave test equipment, installing quite a few of these test stations in support of Yoni2. It required a cooperative effort to achieve the test performance levels we needed." Kaylie adds, "These are literally millions of points of test data that were compiled in a short time on our existing product lines. And this will be done for all new products—full characterization of performance under different conditions, including temperature, to allow engineers to search for components meeting very specific requirements."



2. The Yoni2 frequency mixer search request screen can be activated with a few simple data entries.

Many companies offer product category searches or the capability of searching for a specific model number. The Yoni2 search tool allows uses to perform a search within a given product category based on their own specifications. How well does it work? During an evaluation of the firm's next-generation website, Yoni2 was used to find components for several typical applications including a microwave mixer.

Although Mini-Circuits is associated with RF components, the firm also offers component beyond 10 GHz for microwave applications. In attempting to find a broadband microwave mixer for applications covering 4 to 12 GHz, Yoni2 was used with its mixer search request screen ***(Fig. 2)*** to search for a mixer that would provide no worse than 10 dB conversion loss and operate with LO drive level of +7 dBm. A word of caution when entering search data: Yoni2 is not all knowing, and upon entering LO drive level in its familiar +7 and +10 configurations (for +7 and +10 dBm), Yoni2 flagged the entry as incorrect (not a number) because of the "plus" sign. Once the plus sign was removed, the search engine quickly jumped to the next screen ***(Fig. 3)***, indicating that a perfect match was not available but that the search would continue based on one or two priorities, such as conversion loss, LO-RF isolation, LO-IF isolation, IP3, VSWR, or none. By leaving the default setting of conversion loss, the search tool quickly found a model MCA1-12GL mixer with LO/RF range of 3.8 to 12.0 GHz and IF range of DC to 1.5 GHz ***(Fig. 4)***.

From the results screen of a mixer search, an operator can click on the model number to show a screen that offers a data sheet as well as choices to view graphs or view data ***(Fig. 5)***. It also shows details about the package, circuit layout, environmental ratings, even information about an evaluation board. Clicking on "View Graphs" brings up on-screen performance plots ***(Fig. 6)*** that include conversion loss, input IP3, LO-to-RF isolation, LO-to-IF isolation, and

3. When Yoni2 cannot find an exact match for a set of requirements, it shows this screen, prompting a user to enter priorities when looking for the next best thing.

4. This screen shows search results for a mixer usable from 4 to 12 GHz with +7 dBm LO power.

VSWR for the LO, RF, and IF ports.

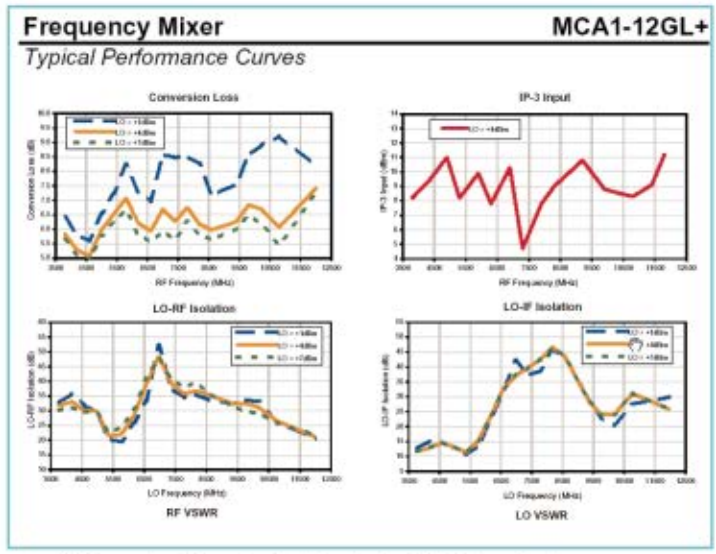
Similar searches were performed using Yoni2 for a voltage-controlled oscillator (VCO), broadband amplifier, and bandpass filter. Each "Search Request" screen is different, customized for the particular component. During the VCO search, for example, the screen permits search parameters to be entered for oscillator frequency range, supply voltage, phase noise at four different offset frequencies (although only one or two of these entries need be completed for a successful search), minimum/maximum output power, minimum/maximum tuning sensitivity, and even harmonic levels.

Using simple search parameters of 1500 to 1600 MHz and phase noise of –86 dBc/Hz offset 1 kHz from the carrier and –140 dBc/Hz offset 1 MHz from the carrier, Yoni2 found a model ROS-EDR5630 VCO. The search engine even shows the elapsed time of the search, in this case a mere 0.02 s. As with the mixer, a user can then save or print a data sheet and quickly view performance data or plots that include tuning linearity, harmonics, output power versus tuning voltage, frequency pushing, and phase noise. Additional information is provided about tape-and-reel packaging, housing dimensions, circuit-board mounting, and an evaluation board.

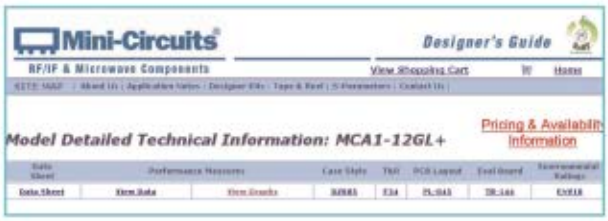
In the case of an amplifier, search parameters include package style, frequency range, minimum gain and isolation, minimum output power, and maximum noise figure. As with the other search mechanisms within Yoni2, a minimum number of these parameters need be entered for a search to be successful. For example, in performing a search by just entering the amplifier frequency range of 2 to 5000 MHz and minimum gain of 10 dB, Yoni2 came up with a model GALI-74 amplifier, although the listed frequency range on the "Search Results" page was DC to 1000 MHz. But clicking on the menu choice to view performance brought up several screens full of actual performance data from 1 to 8835 MHz, complete with measured S-parameters. Plots were also available for power gain, input and output return loss, and isolation. Such S-parameter data are invaluable for modeling commercial components in popular commercial circuit simulators, such as the Advanced Design System (ADS) software simulation suite from Agilent Technologies (www.agilent.com) and Ansoft Designer from Ansoft (www.ansoft.com). Having the actual measured S-parameter data (rather than general parameters) improves simulation accuracy and can reduce the time needed for achieving meaningful simulation results.

Finally, Yoni2 was used to track down a bandpass filter that could be used around a GPS signal at 1575 MHz. Entering a few simple parameters, such as the upper and lower limits of the passband and maximum passband insertion loss, and relaxing the packaging requirement by selecting the "Not Critical" choice, the Search Results screen shows four candidates. Interestingly, the search tool selected Engineering Development Models for these requirements, including the model VBFZ-EDR8448U SMA bandpass filter with a center frequency of 1600 MHz and passband loss of less than 2 dB. Information on the filter notes that it is a non-catalog model, although full information and pricing is available upon request. As with the other searched items, response plots of filter insertion loss and return loss were also available.

At present, Yoni2 supports searches across amplifiers, directional couplers, mixers, power splitters and combiners, RF transformers, VCOs, and filters. Even with the new test equipment, characterization of the company's many product lines takes time, and search capability must still be added for the firm's extensive lines of coaxial adapters, analog and digital attenuators, DC blocks, RF switches, terminations, and test cables. Eventually, all product lines will be supported by the powerful Yoni2 search tool. **Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235-0003; (718) 934-4500, FAX: (718) 332-4661, Internet: www.mini-circuits.com.**



6. By clicking on the "View Graphs" choice, detailed plots of performance are available for the MCA1-12GL+ mixer.



5. This screen provides choices for more detailed information on the searched-for mixer, including options to save or print a data sheet, show performance lots, and study a package style.

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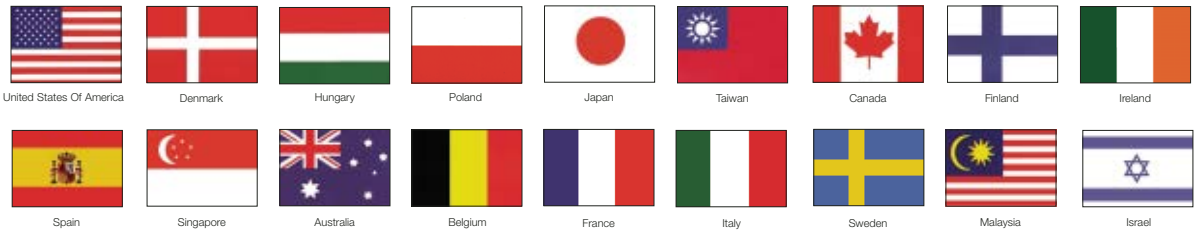

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