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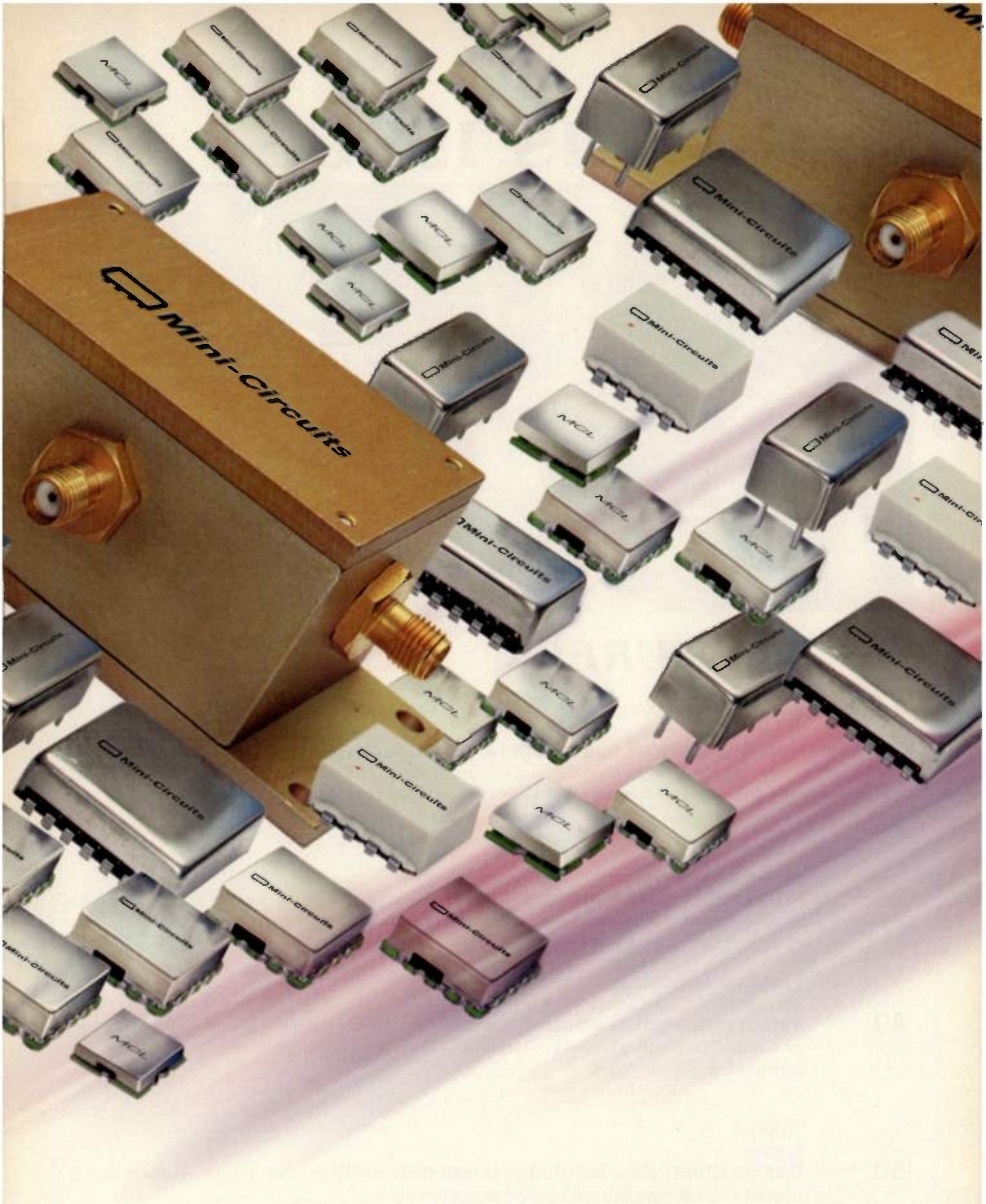
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September 2002

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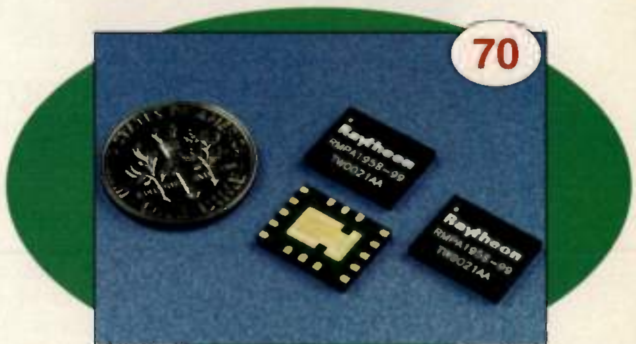
## DEPARTMENTS





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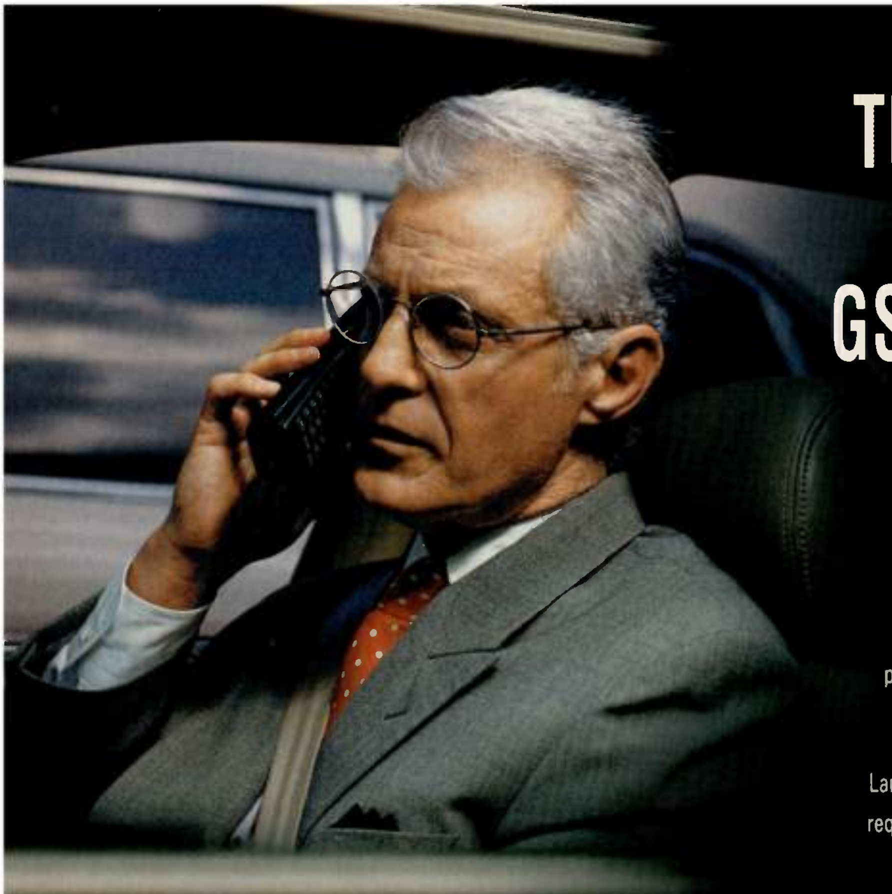

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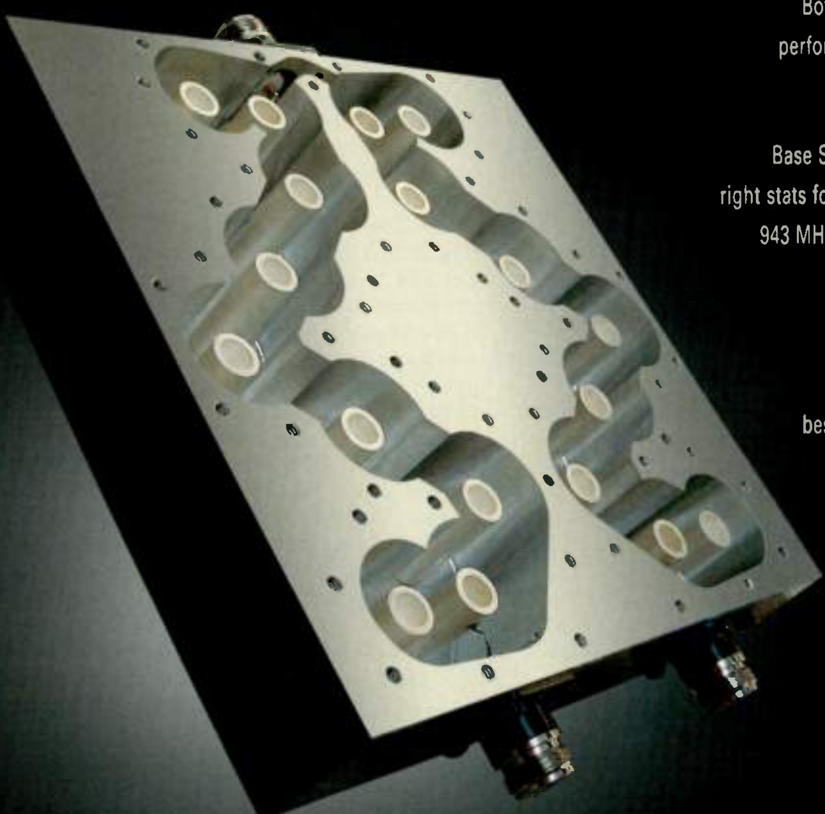

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## RF editorial

# Look to defense for the "killer" app


*By Roger Lesser*
*editor*
*rlesser@primediabusiness.com*


In last months column I addressed how the senior leadership in the government is pushing for more high-tech to fight the war on terrorism. As promised last month, in this column I would like to give you some insight on how to you can contribute to fighting the war on terrorism and contribute to your bottom line. Does this sound like capitalism at it worst? It may, but it is a reality. With every war comes a boon to industry. One needs only look at Krupp, Mitsubishi, General Electric, and General Motors (and on and on). You tell me the war and I'll tell you the company.

### Where's the money?

For too long there has been an assumption that there is no money to be made working with military. And up until 9/11 there was some truth to the assumption. The DoD's budget was cut significantly during the Clinton years. Some cost cutting was warranted and if anything positive came out of the lack of funding it was the DoD's appreciation for high-tech. For the purpose of this column (and the realities of the new kind of war we are fighting) let's refer to not just the military but to the government since there are a number of agencies fighting the war.

Times have changed. Forever. As you many know, President Bush has proposed the establishment of a new cabinet level Department for Homeland Security. As I write this Congress is on vacation so the proposed new department is on hold as is the bill to fund the fight against terrorism. (That's doing the people's business alright.)

If the President gets his way we will see billions spent on the war on terror. $3.5 billion is the current target for spending on first responders to emergencies. We estimate $1 billion will be spent on communications equipment.

Within the DoD, $10 billion is being targeted toward homeland security. The DoD's active involvement can be seen by the recent appointment of Pete Verga as Special Assistant for Homeland Security. He will direct the DoD's Homeland Security Task Force.

While I'm still wading through the FY 2003 budget, it is obvious that the DoD is going to spend significant dollars on communications. A good example is Science Applications International Corp.'s (SAIC) recent award of over $11 million for the engineering of the Submarine Communications/Information and $C^4I$ Systems.

So, the money is going to be there. The only question now is when will government get off the dime and get to work building out new capabilities.

### Is it worth it for you to refocus on government communications?

Yes. The industry is looking for the next "killer application" in the wireless and telecom markets. 3G isn't it. So what is? In my opinion the app is here and it is government communications. If your company is not evaluating entering into government contracts consider this — Your competitors are. I've been in discussions with a number of companies who are creating new units to address government requirements or are returning to the government market.

So, there you have it. You can contribute to your bottom line by evaluating your products and the potential they have for government applications. But how do you start? That will be next month's column.

Roger

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| AP03M | 3 | 2000 | 2300 | +/- 0.2 | 0.20 | 2 | 23 | 1.17 | 60 | 0.56"x 0.20"x 0.072" |
| AW03M | 3 | 2300 | 2700 | +/- 0.2 | 0.20 | 3 | 22 | 1.18 | 60 | 0.56"x 0.20"x 0.072" |
| BC03M | 3 | 3300 | 3700 | +/- 0.2 | 0.20 | 4 | 22 | 1.19 | 60 | 0.56"x 0.20"x 0.072" |
| AH03L | 3 | 815 | 960 | +/- 0.3 | 0.23 | 3 | 22 | 1.18 | 150 | 0.56"x 0.35"x 0.075" |
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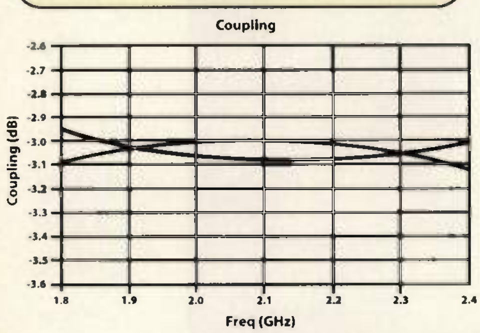
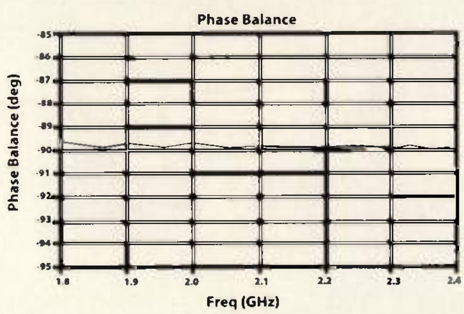
| AV03L | 3 | 1800 | 2700 | +/- 0.5 | 0.30 | 5 | 18 | 1.25 | 60 | 0.56"x 0.35"x 0.075" |
| AS03L | 3 | 1930 | 1990 | +/- 0.15 | 0.23 | 2 | 21 | 1.17 | 100 | 0.56"x 0.35"x 0.075" |
| **AP03L** | **3** | **2000** | **2300** | **+/- 0.2** | **0.20** | **2** | **23** | **1.17** | **60** | **0.56"x 0.35"x 0.075"** |
| AY03L | 3 | 3400 | 3500 | +/- 0.3 | 0.30 | 5 | 21 | 1.25 | 60 | 0.56"x 0.35"x 0.075" |

**Actual data for AP03L**

**Coupling**




**Phase balance**

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## WLAN market growing, opportunity for operators

The Wireless LAN (WLAN) market continued to shine, as unit shipments grew 15 percent overall in 2Q02, bringing some much-needed sunshine to the dreary networking technology industry, according to In-Stat/MDR (**www.instat.com**). However, the high-tech market research firm reports that end-use revenues remained flat, with overall end-use revenues falling 1 percent over the quarter. This tremendous outpacing of equipment volume growth to revenue growth points to the rapid commoditization of the 802.11b equipment market.

"Although the slightly negative revenue growth is troubling for WLAN equipment manufacturers across the board, the falling margins have both driven increased 802.11b volume shipments, as well as spurred vendors to quickly roll out new, high-speed products,"commented Gemma Paulo, a Senior Analyst with In-Stat/MDR. "This is not an industry that is lacking in innovation, as even the low-end vendors are finding ways to differentiate their WLAN products, this is a very good sign that there is still a significant amount of momentum in this market."

In-Stat/MDR also found that:

- Networking giant Cisco continued to dominate the market in terms of overall revenue, although small business and home specialist Linksys topped the market in terms of unit shipments.

- The 802.11a market continued its healthy growth, with players such as Proxim, Intel, Netgear, D-Link, SMC, and Actiontec contributing to this volume and revenue growth. 802.11a newcomer Linksys grabbed 5 percent of the quarterly 802.11a volume share even though it started shipping very late in the second quarter.

- The home market continued to drive overall WLAN market growth, with total home shipments growing 20 percent, spurred on by the popularity of low-cost wireless broadband gateway products (combo AP and router devices often with multiple Ethernet ports and optional print servers). Linksys, D-Link, Buffalo, Apple and Netgear all performed strongly in the home/SOHO market.

- Asia Pacific remained a high-growth market for wireless LAN growth, with Taiwan, South Korea and Hong Kong coming on very strong. D-Link registered impressive growth in Taiwan and AsiaPac in general.

The report, "2Q 2002 WLAN Market Analysis"(#IN020201WL), contains market shares and forecasts for NICs and access points, by technology (802.11b, 802.11a, others), and by market (business and consumer).

In another report, "Public WLAN Service: Mobile Operators Mustn't Miss the Boat," In-Stat/MDR notes that if they don't act quickly, mobile operators may miss their chance to get a critical head start in the burgeoning public Wireless LAN market.

The high-tech market research firm reports that offering WLAN services today will enable mobile operators to experiment with broadband services, to combine them with their GPRS and CDMA 1x RTT offerings, and migrate users to WCDMA when it becomes available. If they delay in implementing WLAN technology, competitors will get a sole head start over mobile operators, covering all the hotspots and competing head-on with their future services.

"Public WLAN services will help educate users on WWAN data usage, thus increasing their usage and adding to overall data ARPU incrementally while helping to alleviate the decline in voice ARPU," says Donald Longueuil, an Analyst with In-Stat/MDR. Mobile operators will be able to contain the potential revenue erosion from competitive WLAN providers by offering public WLAN services themselves.

"Entering this new market will not only provide them with a logical service line extension, but it will also allow them to defend their valuable future next-generation revenues."

In addition, they will be able to address a demand that they currently do not meet, increasing their overall data cash flows. According to Longueuil, "Every mobile operator could achieve increased wireless data revenue if they implement a WLAN solution properly. But to do this, they must start now, either by growing organically or by purchasing a WLAN service provider. Delaying entry into the market will likely prove detrimental in the long run."

In-Stat/MDR has also found that:

- WWAN/WLAN as a combined offering achieves approximately $676 million greater revenues worldwide in 2006 that offering WWAN alone. Mobile operators' overall cash flows could increase 51 percent, as offering WLAN service will not only generate revenue for that service, but will also cause an addition to WWAN usage and cash flow

- In 2006, of the total public WLAN users worldwide, approximately 52 percent will be paying their service bills to WWAN operators. Fairly consistent growth is forecasted throughout the world, particularly in Europe and Asia/Pacific. Growth will be strongest in early years, as the market is being developed, since mobile operators will have the CAPEX and desire to be the first to market, and to attract and solidify a user base.

- Due to the number of mobile operators in Europe and their deployment strategies, Europe should lead the other three regions in total number of mobile operator WLAN users.

- There will be approximately 5,000 hotspots at the end of 2002 worldwide and approximately 41,000 at the end of 2006. Although private non-telecom companies own the majority of public hotspots today, that majority will shift to the mobile operators by 2006.

## Peregrine dedicates unit to space and defense markets

Peregrine Semiconductor, San Diego, Calif., has dedicated a company unit specifically targeted at developing products for the stringent quality needs of the space and defense markets. Peregrine Semiconductor's co-founder and CTO, Ronald E. Reedy, Ph.D. will head the division as vice president of space and defense at the company. Dr. Reedy is a co-inventor of Peregrine's Ultra Thin Silicon (UTSi) technology.

"Working with the military and aerospace markets is nothing new to Peregrine Semiconductor. We have been working with the government for over four years now, and our customers include many of the largest satellite and military manufacturers," commented Reedy. "Introduction of our formalized Space and Defense Business Unit illustrates our contin-

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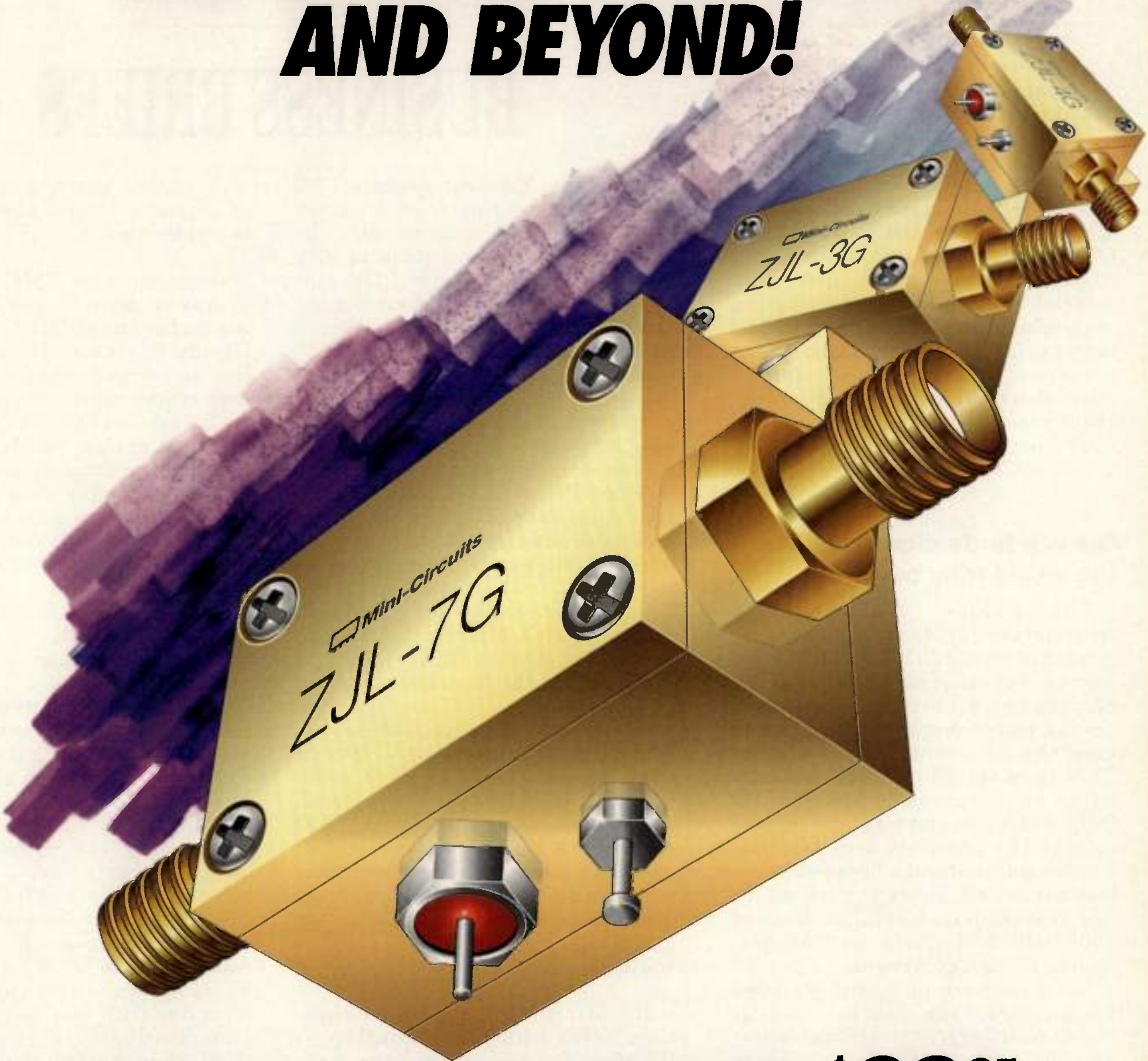


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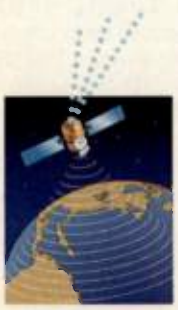

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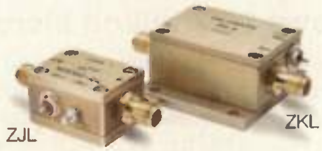
| Model | Freq (MHz) | Gain (typ) Midband (dB) | Gain (typ) Flat (±dB) | Max. $P_{out}$[1] (dBm) | Dynamic Range (Typ @2GHz[2]) NF(dB) | Dynamic Range (Typ @2GHz[2]) IP3(dBm) | I(mA)[3] | Price $ea. (1-9) |
|---|---|---|---|---|---|---|---|---|
| ZJL-5G | 20-5000 | 9.0 | ±0.55 | 15.0 | 8.5 | 32.0 | 80 | 129.95 |
| ZJL-7G | 20-7000 | 10.0 | ±1.0 | 8.0 | 5.0 | 24.0 | 50 | 99.95 |
| 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 |
| ZKL-2 | 10-2000 | 33.5 | ±1.0 | 15.0 | 4.0 | 31.0 | 120 | 149.95 |
| ZKL-1R5 | 10-1500 | 40.0 | ±1.2 | 15.0 | 3.0 | 31.0 | 115 | 149.95 |

NOTES:
1. Typical at 1dB compression.
2. ZKL dynamic range specified at 1GHz.
3. All units at 12V DC.

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"In the past, silicon on sapphire has been in high demand for use in space and military applications, but the cost and lack of high volume requirements of the market prevented the substrate from being readily adopted. By reusing over 90 percent of our commercial design and manufacturing technology, and then customizing products for the higher demands of the aerospace markets, we are able to meet the quality, cost and supply requirements of these markets and introduce more products, more cost effectively," Reedy said.

## Survey finds signs that the worst may be over

The Fabless Semiconductor Association (FSA), announced the release of its 3Q 2002 Wafer Demand Survey Report. The survey noted a significant 9 percent increase in actual wafer demand for Q2 2002 over the 3percent increase in Q1 2002 from Q4 2001. However, compared to the previous forecast, Q2 2002 wafer demand was only 88 percent of the previous forecast. The survey participants lowered their forecast growth in wafer demand for the remainder of 2002 and all of 2003, which is consistent with prevailing market sentiment.

On a positive note, the Q2 2002 9% quarter-over-quarter (Q-o-Q) increase in aggregate actual wafer demand for returning respondents from the 2002 annual survey indicates that recovery will be moderate and gradual, with considerable individual company variability. Overall, the returning respondents from the 2002 annual survey (fabless and integrated device manufacturers) expect steady Q-o-Q wafer demand increases in Q3 2002, Q4 2002, Q1 2003 and Q2 2003.

## Five-year MEMS forecast shows $5.7 billion increase

Despite tough economic conditions overall, MicroElectroMechanical systems (MEMS) continues its upward trek, according to In-Stat/MDR, Scottsdale, Ariz. The market research firm reports that every

# BUSINESS BRIEFS

**Spectrum Control acquire FSY Microwave** — Spectrum Control, Fairview, Pa., has acquired all of the outstanding common stock of FSY Microwave, Columbia, Md. The purchase of FSY allows Spectrum Control to expand it existing Specwave line of ceramic-based wireless products and custom engineered wireless solutions.

**Microsoft selects Taiyo Yuden as Bluetooth supplier** — Microsoft, Seattle, Wash., has selected Taiyo Yuden, Schaumburg, Ill., as its Bluetooth module supplier for the company's next generation wireless keyboard and mouse systems. Under the contract, Taiyo Uden will manufacture Bluetooth modules with Microsoft's human interface device (HID) profile embedded on the flash memory.

**M-tron Industries and Arrow Electronics sign deal** — M-tron Industries, Yankton, S.D., has signed a distribution contract with Arrow Electronics, Melville, N.Y. Arrow is a leading distributor of electronic components and computer products and provides material management programs for active and passive electronic components worldwide.

**RF Micro Devices and Brigh-Com offer Bluetooth solution** — RF Micro Devices, Greensboro, N.C., and Brightcom, Tel Aviv, Israel, have collaborated to offer a complete Bluetooh solution. The solution is comprised of RF Micro Devices' RF2968 transceiver and BrightCom's IntelliBLUE chips and BrightCORE software. Bother companies intend to offer evaluation platforms and reference designs.

**Vishay Intertechnology and Garrett Electronics sign distribution agreement** — Vishay Intertechnology, Malvern, Pa., and Garrett Electronics, Santa Maria, Calif., have signed a distribution agreement. Under terms of the agreement Garrett Electronics will offer Vishay's passive components initially. Garrett anticipates being able to expand it portfolio of Vishay components, pending establishment of inventories and development of marketing plans.

**Cadence and UMC partner to enhance nanometer design for manufacturability** — Cadence Design Systems, San Jose, Calif., has announced a joint initiative to help customers facilitate the smooth transition to fabrication through physical design verification using Cadence's technology for nanometer designs. Under this initiative, Cadence Assura physical verification solution DRC decks for 0.25-, 0.18- and 0.13-micron CMOS logic technologies are now available for download free-of-charge on UMC's, Taiwan, "My UMC" customer Web site (**www.umc.com**).

**Avestor to start production of new battery for telecom applications** — Avestor, Canada, has announced that it is now ready to commercially produce the first generation of its lithium-metal-polymer battery, the SE 48S70, specifically designed for the telecommunications industry. The SE48S70 battery provides operates in ambient temperatures ranging from -40° C to 65° C (-40° F to 149° F) using one-third the space and with one-fifth the weight of traditional valve-regulated lead-acid (VRLA) batteries. The SE 48S70 battery has an expected service life of approximately 10 years. The SE 48S70 will be built in a new 130,000-square-foot facility located in Boucherville (Quebec, Canada). The plant will have a rated capacity of 120 megawatthours. Production is expected to start this fall. Avestor is accepting advanced orders for the new battery.

**Hittite Microwave names two new representatives** — Hittite Microwave, Chelmsford, Mass, announced the appointment of two new sales representative firms to serve customers in India and Taiwan. Syratron Marketing Private Ltd., headquartered in Bangalore, will handle sales in India, while Bandtek International Co., Ltd. will

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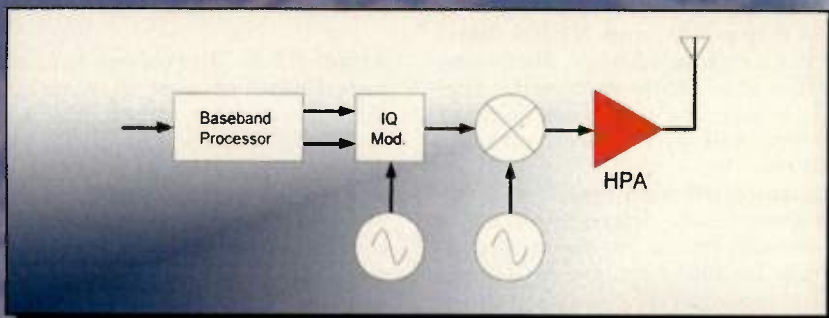
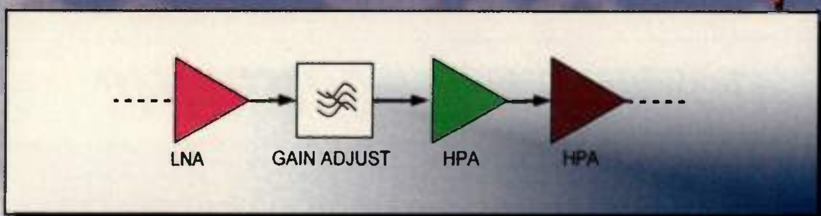



## Cellular/PCS Base Station Rx Amp

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- LP1500SOT89 •
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- LMA411 •
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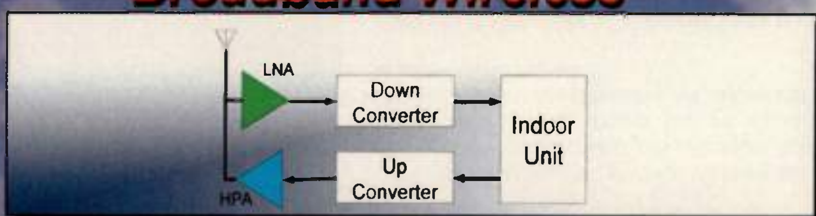
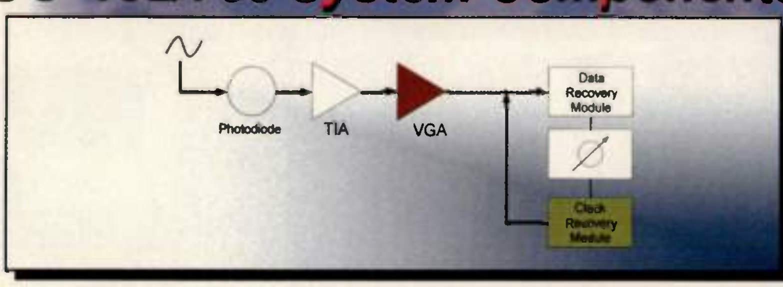



## OC-192/768 System Components

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major market has now embraced the technology and that mature segments will see relatively low compound annual growth rates (CAGRs), and that in others, such as the communications and consumer markets, MEMS has only just begun to scratch the surface. As a result, worldwide revenues for MEMS are forecast to grow from $3.9 billion in 2001 to $9.6 billion in 2006.

In-Stat/MDR reports that while VC funding is certainly down, it is by no means out, and MEMS start-ups continue to emerge. However, considerable fab overcapacity currently exists, and it appears that the situation will only worsen over the next year.

In-Stat/MDR also found that the shift from sensor-driven revenues to non-sensor-driven revenues is continuing. In 2001, non-sensor devices comprised nearly a third of total MEMS revenues, whereas by 2006, they will account for almost half.

# BUSINESS BRIEFS

cover the market in Taiwan. Syratron specializes in the sales and distribution of RF/microwave components, and has strong ties with local defense, space, and communications companies. Bandtek has developed a close working relationship with defense and wireless customers in Taiwan.

**Avnet RF & Microwave launches new business unit** – Avnet RF & Microwave, San Diego, Calif., has launched Wavelength Design Solutions (WDS), a new business unit, which will provide services and products to customers incorporating wireless technology into their end products. According to Avnet RF & Microwave, WDS was created to assist original equipment manufacturers (OEMs), original design manufacturers (ODMs), and enterprises that plan to incorporate wireless technology into their end products, but do not necessarily have the technical expertise and or resources to do the job internally.

**Companies to jointly offer DC/RF parametric test solution** – Agilent Technologies, Palo Alto, CA has announced a new parametric test platform, developed in cooperation with ACCRETECH, Japan, and Cascade Microtech, Japan. The Agilent 4070 DC/RF parametric test solution is a complete, integrated test solution for direct current (DC) and radio frequency (RF) testing of RF-CMOS devices used in wireless, consumer electronics, high-speed Internet and other applications.

## Satellite radio not cutting it with consumers

While telecom is seeing a continued down turn, many have looked at commercial satellite applications as potential new markets for components and subsystems. One application that showed promise was satellite radio. However, after less than a year on the market the nation's only two satellite radio companies, Sirius and XM are attempting to get new financing before they run out of money.

According to the Associated Press, shares of Sirius Satellite Radio fell significantly after the company said it was not signing up subscribers as fast as predicted. XM Satellite has exceeded early subscription forecast by signing up 136,000 customers. XM had forecast 130,000.

Even with the somewhat better than forecast signups, XM said it would run out of cash early next year and would have to discontinue operations if it did not raise additional funds.

Sirius has reported it needs another $300 million by the middle of 2003 or it would have to file for bankruptcy.

Sirius spent $1.9 billion on its network of three satellites and 92 land basestations. Sirius reported a second quarter loss of $124.6 million, or $1.62 per share, on revenue of $70,000.

XM satellite spent about $1 billion on its satellite and ground station network.

## Harris selected for U.S. Army's WIN-T Program

Harris, Melbourne, Fla., announced that it anticipates the immediate award of a major subcontract from Lockheed Martin Mission Systems, Gaithersburg, Md., for the design and test of the wireless transmission system architecture as part of the three-year competitive downselect for phase one of the U.S. Army's Warfighter Information Network—Tactical (WIN-T) program. WIN-T is the next generation of military tactical communications systems, featuring an integrated framework of standards and protocols that will optimize offensive military communications. The production phase of the program, if awarded to the Lockheed Martin team in 2005, could increase the total value of the program for Harris to $1 billion over a 15-year period.

The WIN-T will bringing enhanced mobile bandwidth and networking capability to the battlefield, and will provide modern networking technology to U.S. Army warfighters. It will enable battlefield situational awareness on-the-move and give commanders new capabilities to synchronize combat power. The system will provide a highly secure network backbone for high-speed communications for voice, data and video.

# How Bluetooth's unusual operating characteristics impact test decisions

*Specialized test cases play a significant role in the testing and performance strategies of the design, manufacturing and after-market phases of Bluetooth transceivers.*

**By Teit Poulsen**

Bluetooth wireless technology is an open specification for a wireless personal area network that provides limited-range, wireless communications for voice and data transmissions between information appliances. It is a promising solution for portable devices and for interconnecting computer and communications devices via a radio link, rather than with cumbersome cables. The Bluetooth module includes a radio transceiver that can be built into various host devices with a need to communicate with other devices.

Mainstream applications include mobile phones, laptop PCs and personal digital assistants (PDAs). All connections are real-time, fast and secure.

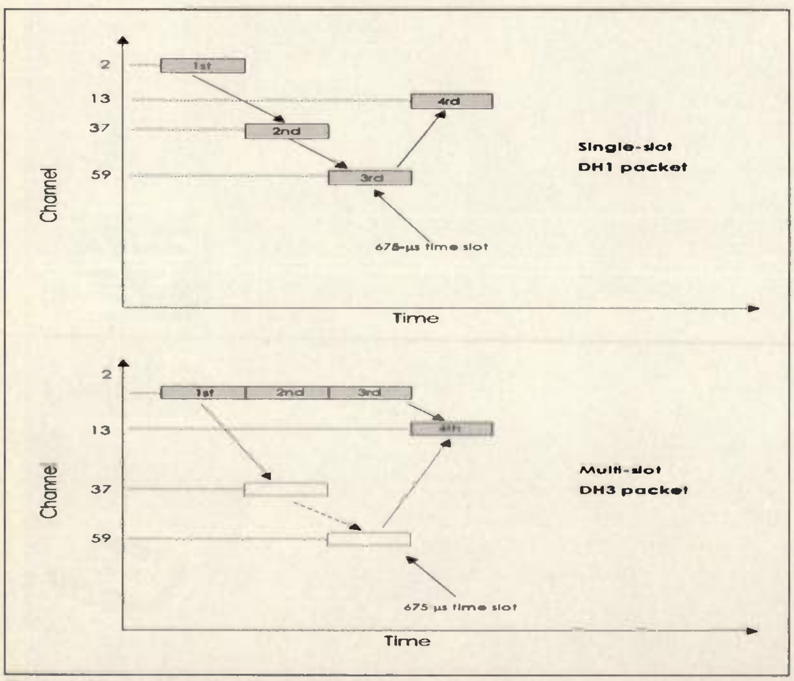


Figure 1. Single-slot and multiple-slot behavior.

### Interference – the great equalizer

Operating in the 2.4 GHz industrial/scientific/medical (ISM) band, interference can occur between Bluetooth and other devices such as wireless local area networks (LAN) services and appliances such as microwave ovens.

To help Bluetooth operate successfully in the crowded environment of the ISM band, modulation is based on frequency-shift keying (FSK). FSK modulation is used because it has reduced susceptibility to interference. However, Bluetooth goes a step further by employing a spread-spectrum frequency-hopping scheme.

### Spread-spectrum – the great enabler

Operating at 1.6 khops/sec in a pseudorandom sequence, the transmitter alternates among 79 carrier frequencies over the range 2.4 to 2.4835 GHz, with channels spaced 1 MHz apart. This eliminates the need to perform rigorous radio planning and improves link reliability in the presence of other ISM spectrum users.

Governed by the pseudorandom generator in the master device, the signal sent to the slave hops from channel to channel. The signal dwells at each channel frequency for a 675 ms interval in what is called a 'time slot'. The master transmits during even-numbered time slots and is the slave during odd-numbered time slots. Voice bits and data bits are transmitted in packets. These packets may straddle one, three, or five of the 675 ms time slots.

In single-slot mode, the slots are frequency hopped in accordance with the pseudorandom sequence governed by the master (see Figure 1). Notice that in multi-slot mode, the signal dwells at the same frequency for two intervals (2 x 675 ms) and then does a 'catch up', returning to the governing pseudorandom sequence.

A Bluetooth radio can be implemented with a number of system architectures, from direct frequency-modulated, voltage-controlled oscillator/analog discriminator to IQ modulated/digital demodulator designs. Figure 2 shows a typical block diagram of a Bluetooth device in which the transceiver employs an IQ modulator/demodulator. This figure depicts the RF transmitter, the receiver and the controller/processor.

Typically, designs employ a single local oscillator — such as the voltage-controlled oscillator/phase lock loop (VCO/PLL) shown in this figure — that switches between receive and transmit functions. The transmitter up-converts the baseband information arriving at the digital-to-analog converter(s)

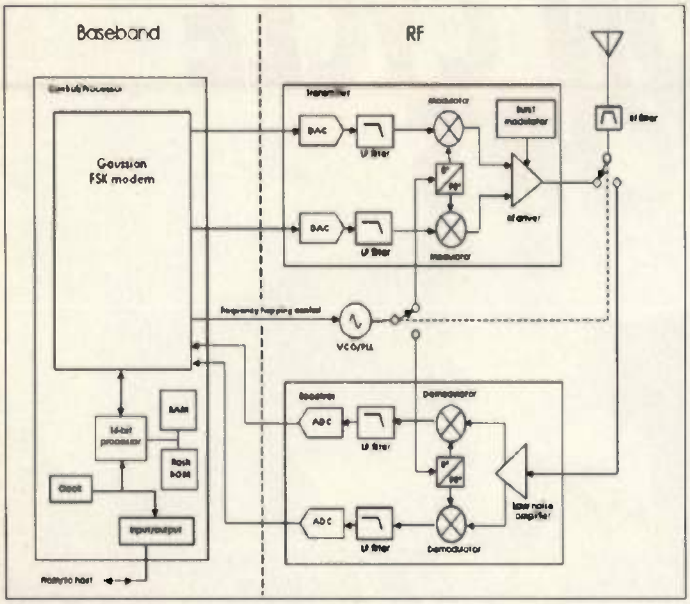

Figure 2. Block diagram of a Bluetooth device.

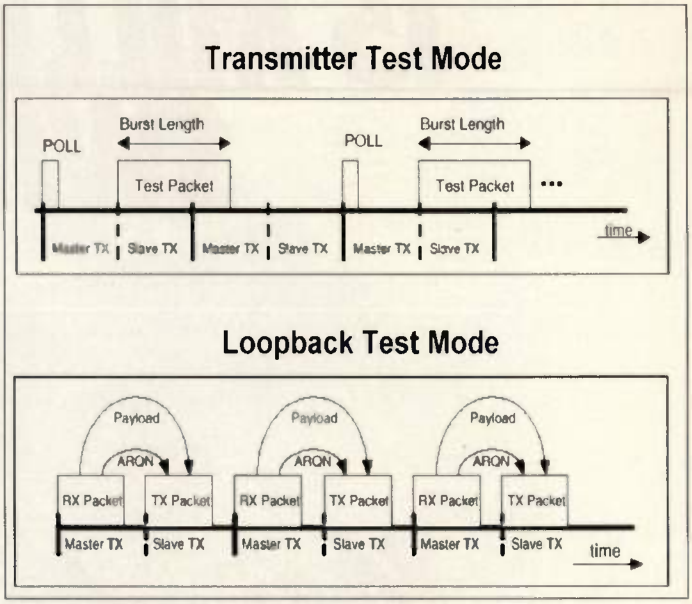

Figure 3. Loopback and transmitter test modes.

(DAC) to the frequency-modulated carrier. Frequency hopping and bursting are performed at this level.

Likewise, the receiver downconverts and demodulates the RF signal and feeds the baseband signal to the Gaussian FSK modem.

## GFSK – the next level

The scheme relies on GFSK using two closely-spaced frequencies to represent a '0' or '1'. The peak allowable frequency deviation from the carrier center frequency is 175 kHz. Unlike standard FSK, GFSK employs a Gaussian filter prior to modulation and transmission. This filter rounds each transmitted pulse, thereby reducing spectral width and enabling the signal to fit more efficiently into a narrower frequency band.

## In Bluetooth terms

The term BT = 0.5, with reference to Bluetooth modulation, refers to the bandwidth-time product, a design parameter that dictates the time spread of the frequency-shaping pulse. It is the product of the 3 dB baseband bandwidth of the Gaussian filter and the bit duration. A value of 0.5 results in a relatively small pulse width and thereby reduces the amount of intersymbol interference.

As for data throughput, the base rate is 1M symbols/s. The effective data throughput is somewhat lower, however, because of protocol overhead. The asynchronous channel supports an asymmetric link of 721 kb/s, maximum, in either direction while enabling 57.6kb/s in the return direction. The alternative is a 432.6 kb/s symmetric link.

## Power to the Bluetooth

With regard to power and depending on the class of service, the transmitter output ranges from 0.25 to 100 mW. The maximum permissible level is Class 1 at 100 mW (+20 dBm). At this power level, the operating range is approximately 100 meters.

## Bluetooth's test modes

The Bluetooth device can operate in different modes: normal, transmitter (TX) test and loopback test (illustrations of the loopback and transmitter mode appear in Figure 3). Transmitter Mode is the normal mode (the same mode in which standard Bluetooth communication occurs). In this mode, if a test system is programmed to function as a master and sends POLL packets to the Bluetooth device (slave), the device will confirm the reception of these packets by sending back a NULL packet. (The description of POLL and NULL packets can be found in readily availble documents).

In this mode the test equipment is able to examine test packets and determine characteristics such as initial carrier frequency tolerance.

The loopback test mode is where the Bluetooth device (slave) is asked to decode the packets sent by the test system (master) and respond by sending back the payload using the same packet type. The bit error rate test requires such loopback capability. The tester sends a packet such as a PN9 sequence. The device under test will then sends back those same packets. The tester compares what is received with what was sent. If they are all the same, the bit error rate is zero. If 1% of the bits are wrong, the BER is 1%.

## Test set-ups

Different set-ups may be used for Bluetooth transmitter tests, depending on whether one is testing an entire Bluetooth device, an RF transmitter or an RF component of the transmitter.

One way to test the transmitter performance of a full Bluetooth device is to use a Bluetooth test set. The test set and device under test (DUT) form a piconet where the tester acts as master and the DUT acts as slave. The test set establishes a link with the device in either the normal or test mode using the standard Bluetooth protocol. With the device in test mode, the test set will acquire complete control of DUT operation.

For instance, the test set can put the device into loopback mode or transmit mode, disable frequency hopping and ask the device to transmit at specific frequencies as required by the Bluetooth RF test specification.

Three other types of transmitter measurement set-ups are illustrated in Figure 4. These three set-ups require

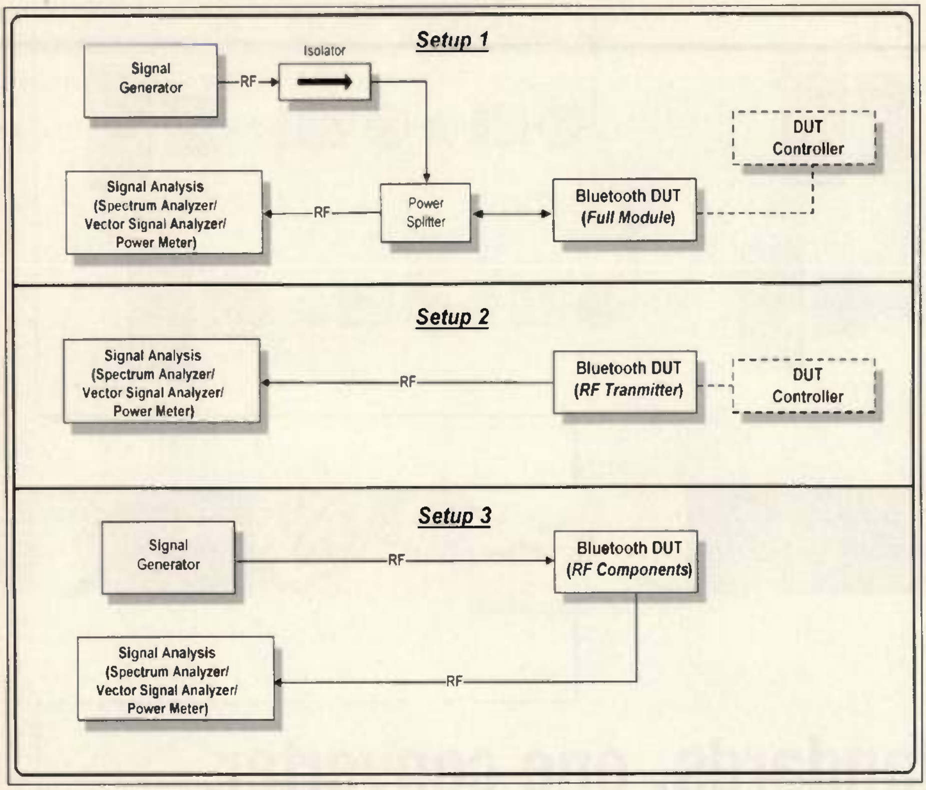

**Figure 4. Three transmitter measurement set-ups**

the use of a signal analyzer, which could be a spectrum analyzer or a vector signal analyzer. Additional equipment includes signal generators and possibly a power meter, power supply, oscilloscope and network analyzer.

Set-up 1 is an example of a set-up to test the transmitter performance of a full Bluetooth module, while set-up 2 is used for testing only a Bluetooth transmitter. Set-up 3 is for testing RF components of a transmitter.

Set-up 1 differs from the set-up of Figure 3 in that there is no Bluetooth communication established between the device and the test equipment, so the test equipment doesn't have any control of the DUT operation. For this set-up, a special internal test facilities utility must be implemented in the device. This utility must have the ability to instruct the device to transmit the packets it receives. This will enable a Bluetooth signal from the signal generator to be fed to the Bluetooth device receiver and then be looped back through its own transmitter for analysis.

In set-up 2, the utility must have the capability to control the type of transmission — frequency hopping on or off, different types of packets, etc. — to provide the right conditions to test the Bluetooth transmitter.

Set-up 3 can be used in testing the amplifier of a Bluetooth transmitter, as well as in a variety of other tests.

If a direct cable connection is not possible between the Bluetooth device and the measurement equipment, a suitable coupling device, such as an antenna, will be necessary. The path loss between antennas must be accounted for in the calculations. This can be evaluated using a network analyzer.

*RF*

## Conclusions

This article has discussed the tests required for Bluetooth devices in a highly abbreviated fashion. Given the enormous growth expected in the near future for Bluetooth-enabled devices, regulatory standards are adapting and changing to meet the safety and technical challenges of new Bluetooth features and products. Developers should consult the latest standard information to ensure proper compliance.

## References

[1] "Bluetooth RF Measurement Fundamentals," Agilent Application Note 1333-1.

[2] "Specification of the Bluetooth System – Version 1.1, Volume 1 "Core," February 22, 2002 – Bluetooth SIG.

[3] "Mobile Communications," Jochen H. Schiller, Addison-Wesley, 2000.

## About the author

For additional information, go to the Agilent Website at **www.get.agilent.com.find/bluetooth/**. For full information on the tests required, refer to the Bluetooth RF Test Specification, prepared by the Bluetooth SIG at **www.Bluetooth.org**. Synopses of the specific tests discussed in this article are available from Agilent's Web site under "Transmitters Measurements," "Transceiver Tests" and Receiver Measurements."

# Home networking leaps to digital

*Keeping up with the demand and proliferation of technologies and applications, home networking breaks the analog barriers.*

**By Guillaume Bichot, Louis Litwin and Kumar Ramaswamy**

With the proliferation of digital technologies and digital content, today's home networking techniques are jumping on the digital bandwagon as well. The biggest driver of networking in the home is the Internet and broadband connectivity, and the desire to access the Internet from multiple points in the home.

## Two options — wired and wireless

Present key technologies for home networking are:

• Wired Connectivity — Today's homes typically have power line, telephone wiring and cable wiring that can be used for home networking. However, access to these wires is restrictyed or inconvienient. Also, it is not desirable to expose to a neighbor (both for reasons of coexistent resource sharing and privacy) the data carried on a shared wire (such as the power line).

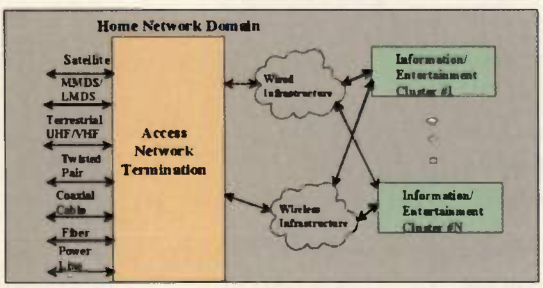


Figure 1. Logical Representation of the elements of a home network.

• Wireless connectivity — Wireless solutions are elegant in the fact that they do not require any modification to the existing infrastructure. Therefore, the installation and maintenance of this technology is easier.

However, wireless technologies tend to be more expensive than wired technologies for a given capability. With emerging high-speed silicon integration, this disadvantage starts to fade, making the case stronger for investment into wireless technologies for the home.

## Key issues for digital home networking:

Digital home netoworking has many dependent and independent issues. Among them are:

• Network and access protocols — Network and access control protocols are an important element of the overall home networking system. These provide the rules, or the etiquette, for sharing the underlying resources among various devices in the network. There is a further problem of making sure that these rules are consistent among the various wired and wireless physical layers, which will be addressed later. Because these standards are developed in diverse industrial groups, ensuring network interoperability is often a challenge.

• Security, privacy and content protection — In addition to making sure that content is seamlessly available within the home it is also important to ensure that this is done securely and maintains privacy. It is also important, from the viewpoint of a content provider, that, whenever content is consumed, there must be a mechanism to monetize the transaction.

• Coexistence, interactivity and interoperability — Given the number of possible options on technologies and competing standards, it is important that these standards and technologies coexist. The average consumer would expect "plug and play" operation on most devices and applicances, hence it is important to guarantee this by design. In practice, however, due to the emergence of competing technolgies, this is often done as an afterthough.

## Interoperability — a must have

Interoperability assumes direct interaction between devices to enable a certain functionality. It is easier to explain this with an example.

Consider a user who wishes to record a specific program on a digital video recorder from a television set that is connected to the recorder. The user starts with the interface of the television to pick the specific channel of interest. The next step would be to interact with the user interface of the recording device and request a recording. This is the interactivity paradigm, which should be replaced by interoperability. In the interoperability paradigm, the user simply requests a recording of a program (for example, using the user interface of the television set). The television set is responsible for coordinating the recording of the program in an available storage device anywhere in the network. This will clearly require an additional layer of sophisticated protocols among the devices involved.

## Services for a home network

A typical list of services that may reside in a home network is shown in Table 1. It is obvious that several services with different constraints on delay and bit rates are possible. It must also be noted that the error rates at which these services need to be delivered are also different for each application.

Also, the data rates and constraints for Internet content are dictated by the type of service exercised. For example, if a video stream is being downloaded for immediate viewing, the delay constraints can be important, while they may be less important while viewing a Web page. Clearly, the design of the protocol and the digital communication technology itself is to be guided by the choice of intended appli-

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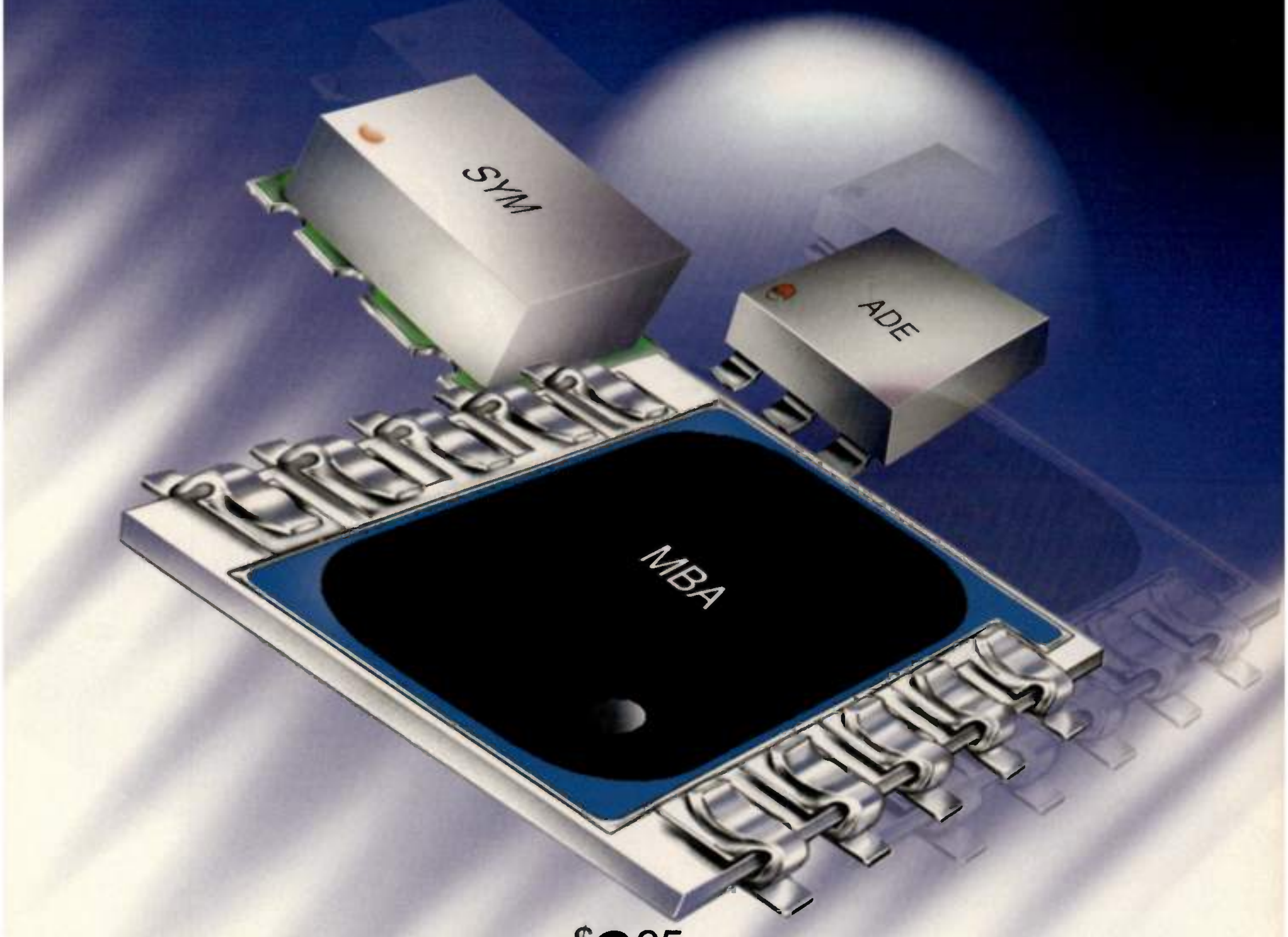


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|---|---|---|---|---|---|---|
| ADE-10MH | 800-1000 | +13 | 26 | 1.3 | 7.0 | 6.95 |
| ADE-12H | 500-1200 | +17 | 28 | 1.1 | 6.7 | 8.95 |
| • MBA-591L | 4950-5900 | +4 | 15 | 1.1 | 7.0 | 6.95 |
| SYM-25DLHW | 40-2500 | +10 | 22 | 1.2 | 6.3 | 7.95 |
| SYM-25DMHW | 40-2500 | +13 | 26 | 1.3 | 6.6 | 8.95 |
| SYM-24DH | 1400-2400 | +17 | 29 | 1.2 | 7.0 | 9.95 |
| SYM-25DHW | 80-2500 | +17 | 30 | 1.3 | 6.4 | 9.95 |
| SYM-22H | 1500-2200 | +17 | 30 | 1.3 | 5.6 | 9.95 |
| SYM-20DH | 1700-2000 | +17 | 32 | 1.5 | 6.7 | 9.95 |
| SYM-18H | 5-1800 | +17 | 30 | 1.3 | 5.75 | 9.95 |
| SYM-14H | 100-1370 | +17 | 30 | 1.3 | 6.5 | 9.95 |
| SYM-10DH | 800-1000 | +17 | 31 | 1.4 | 7.6 | 9.95 |

*E Factor = [IP3 (dBm) - LO Power (dBm)] ÷ 10. See web site for E Factor application note. ADE models protected by U.S. patent [illegible]

• MBA Blue Cell™ model protected by U.S. patents 5,534,830 5,640,132 5,640,099.

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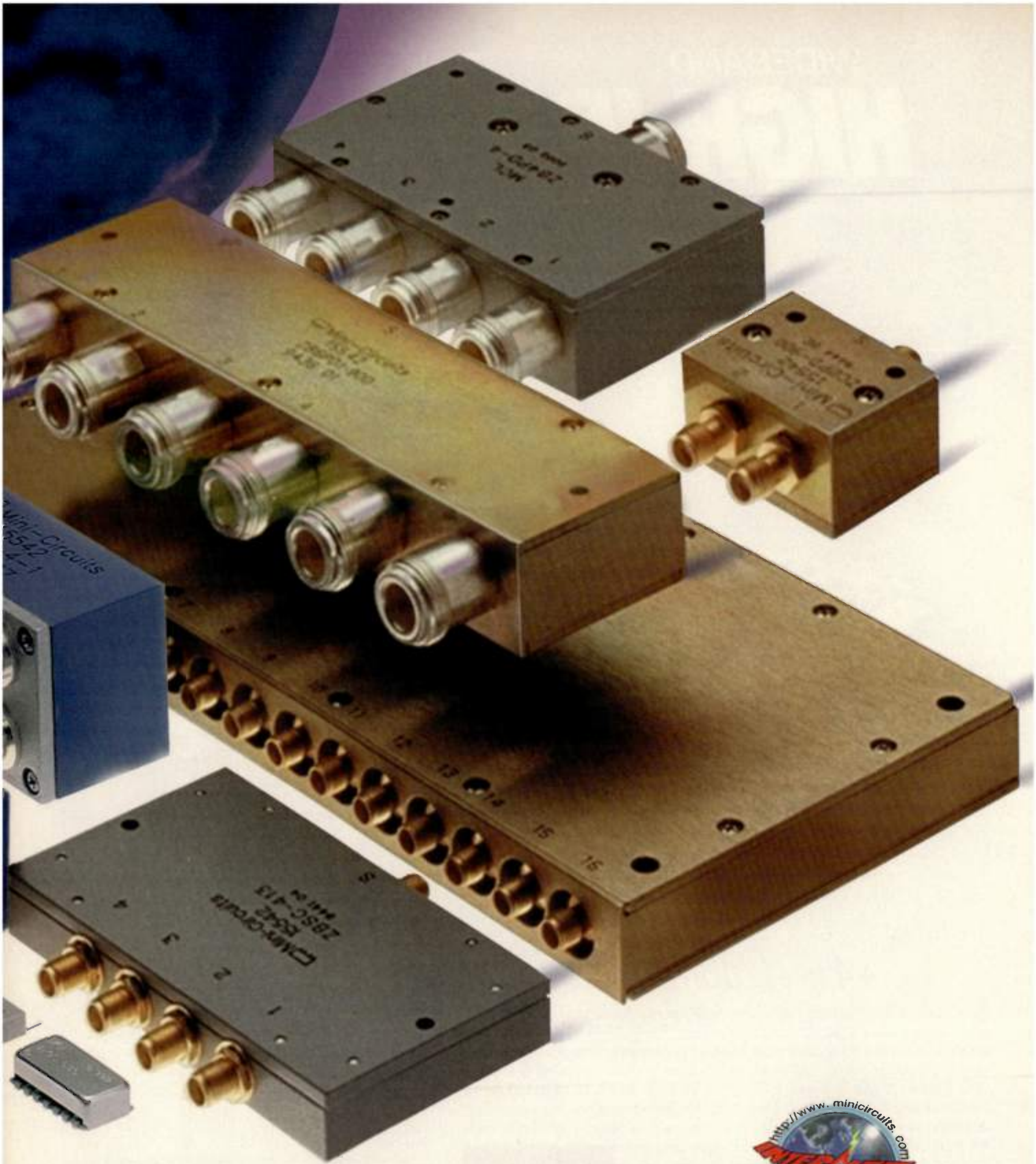


| Type of Service | Data Rate Range | Type of Communication | Delay Constraints? |
|---|---|---|---|
| Voice | 8- 64 Kbps | Bi-directional | Yes |
| Hi-Fi Audio | 64 Kbps- 4 Mbp/s | Unidirectional | None |
| Video Telephony | 384 Kbps-1.5 Mbp/s | Bi-directional | Yes |
| Broadcast Video - Standard Definition | 1.5 Mbp/s - 6 Mbp/s | Unidirectional | None |
| Broadcast Video - High Definition | 12 Mbp/s - 18 Mbp/s | Unidirectional | None |
| Computer/Internet Data | Varies | Bi-directional | Depends on Application |
| Home Automation | Several Kbps | Bi-directional | Depends on Application |

**Table 1. Potential application services for distribution in a home network.**

| | Bluetooth | 802.11b | 802.11a |
|---|---|---|---|
| Max power level: | 1 W | 1 W | 800 mW |
| Frequency band: | 2.4 to 2.483 GHz | 2.4 to 2.483 GHz | 5.15 to 5.35 GHz, and 5.725, to 5.825 GHz |
| Data rate: | 1 Mbp/s | 1 to 11 Mbp/s | 12 to 72 Mbp/s |
| Modulation: | FHSS | IR, FHSS, DSSS | OFDM |
| Range: | 10 m, 100 m with external power amp | 100 m | 15 - 30 m |

**Table 2. Summary of several wireless digital home networking standards.**

cations over different home networking technologies.

## Elements of a home network

A logical representation of a home network domain is shown in Figure 1. Several possible broadcast and interactive mechanisms exist to access the outside world through the access network termination. It is also possible that some of these mechanisms function cooperatively. For example, a digital broadcast satellite and a digital subscriber loop (DSL) services.

As alluded to earlier, the existing wiring infrastructure in the home includes the power line, cable and twisted pair wiring. The power line medium is a harsh medium with large variations in dynamic characteristics. Furthermore, due to radiation regulations, the operational frequencies are restricted to below about 30 MHz, with limited power. The power line medium is likely to find a niche in data redistribution — especially from broadband modems — but is unlikely to be a solution for high-speed video streaming applications.

The twisted pair wiring in the home carries plain old telephone service (POTS) in the 0 to 4 KHz band. The frequency band up to 1.1 MHz is allocated for digital subscriber loop (DSL) applications. The Home Phone Network Allicance (HPNA) developed the technology to carry digital data in the home phone copper wires above the DSL band. But given the limited number of phone access points in an average home, this technology is not expected to play a major role in home networking.

Cable wiring for redistributing content also has a limited appeal due to the number of available cable TV outlets in the average home.

Furthermore, the channels that are allocated for television on the cable network are dependent on the local service provider. So, it is difficult to design a home network to share the cable resource with a service provider.

## The physical layers

This section of the article will examine some of the physical layer aspects of wireless digital home networking, problems and issues faced when operating a wireless device in the home. It will describe some techniques for handling those problems. In particular, we will use examples from three popular wireless digital home networking standards: Bluetooth, IEEE 802.11b, and IEEE 802.11a.

## Spectrum allocation

Most wireless digital home networks (WDHNs) operate in one of the frequency ranges that belong to the unlicensed industrial/scientific/medical (ISM) bands. The FCC has designated the ISM bands as license-free as long as devices stay below the specified transmit power level. In the United States, there are three sections of the ISM bands: 902 to 928 MHz, 2.4 to 2.483 GHz, and 5.725 to 5.850 GHz.

Most WDHNs operate in the 2.4, 5.7 and 5.15 to 5.35 GHz unlicensed unlicensed national information infrastructure (UNII) bands. Both the Bluetooth and IEEE 802.11b standards use the 2.4 GHz band and the IEEE 802.11a standard uses the 5.7 GHz band.

## The wireless home environment

Many factors make the home a difficult environment in which to operate a wireless communications system. Interference from man-made sources is a major issue. Many devices in the home radiate energy (either intentionally or unintentionally) in the ISM bands.

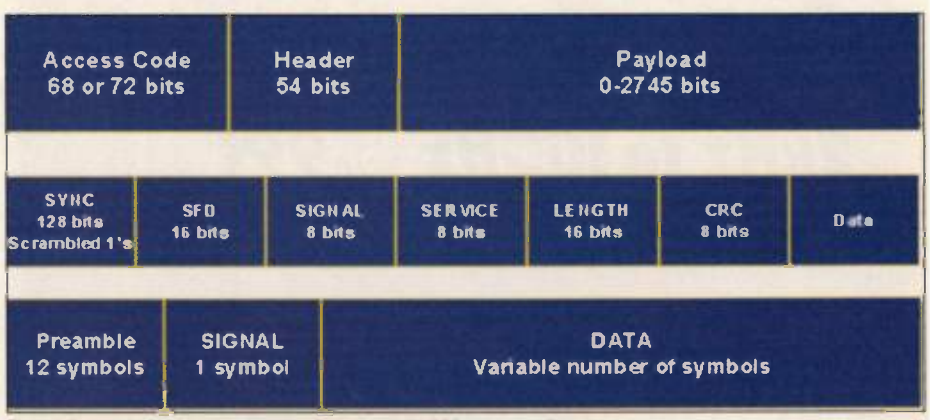
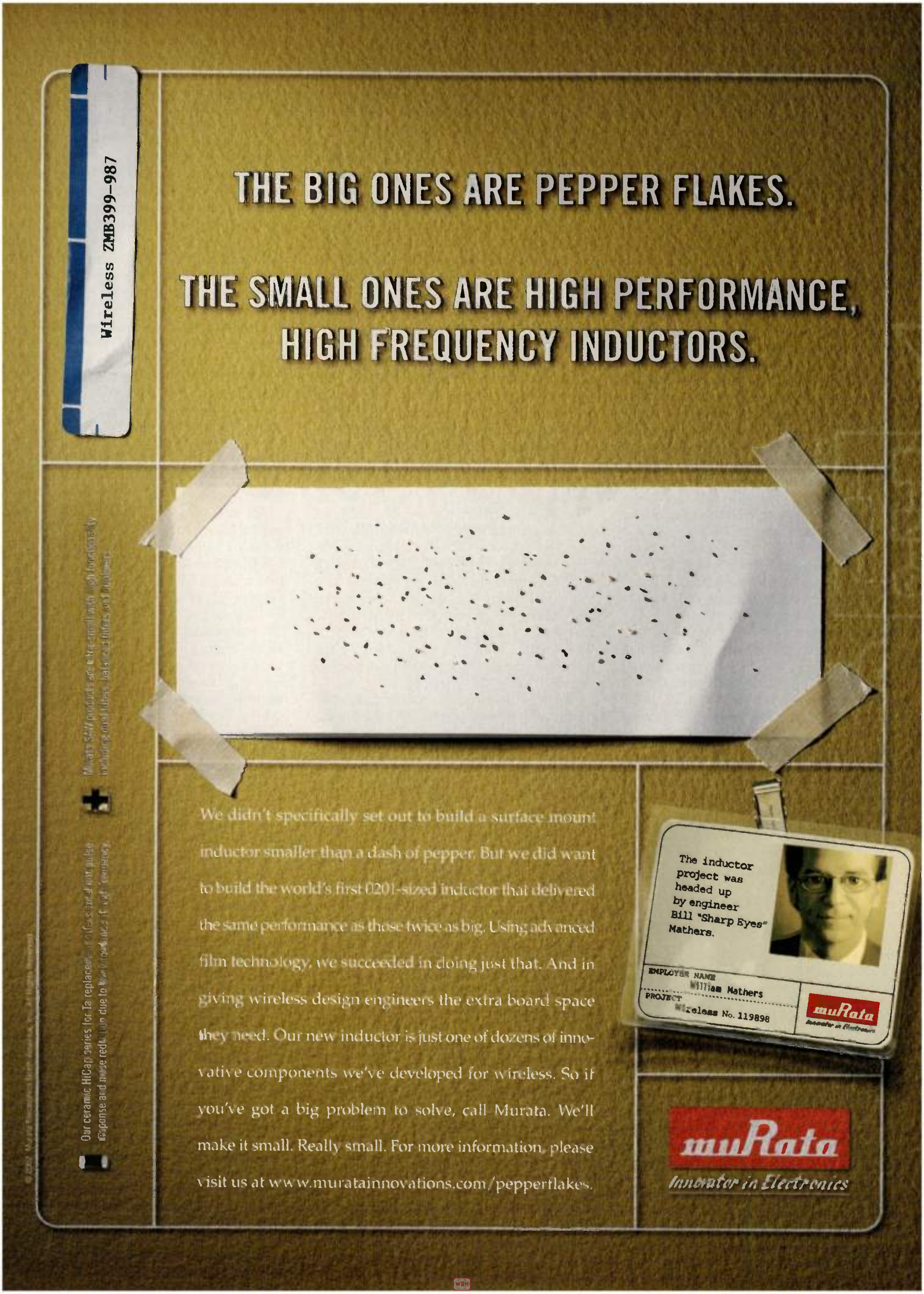



Figure 2 Burst formats for Bluetooth (top), IEEE 802.11b, and 802.11a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Examples include interference from microwave ovens, cordless phones, amateur radio transmissions and radar. Because several WDHN devices operate in the ISM bands, there will also be interference in areas where multiple networks are being operated with devices from different standards.

Because the home is essentially an enclosed box, WDHN devices must cope with frequency-selective channels caused by a multipath environment. The effect of a frequency-selective channel is intersymbol interference (ISI). ISI occurs when the in-home reflections cause several delayed versions of a signal to arrive at the receiver. Typical delay spreads of an indoor channel are between 100 to 200 ns within a room and greater than 300 ns in hallways. These delay spreads can be even greater when using WDHNs in office or factory environments. The dynamic environment of the home, such as moving people and animals, as well as moving objects such as ceiling fans, means that the in-home channel is rapidly time-varying as well.

Another problem faced when operating in the home is that of path loss. Severe signal attenuation occurs when trying to pass the signal through the walls of a home at high frequencies. This attenuation can range from about 1 dB for plywood to more than 20 dB for metal walls. Thus, the material that a house is made out of can greatly affect the useful range of a WDHN device.

## ISM band power limits

The FCC limits the transmitted power sent to the antenna in the ISM bands to 1 W. Spectral density limits also restrict the power density in any 3 kHz bandwidth region to 6.3 mW. By placing these requirements on the ISM band usage, the FCC prevents a user from severly degrading the performance of neaby wireless devices.

To stay below these limits, many WDHN radios, such as Bluetooth and IEEE 802.11b, use spread-spectrum (SS) modulation where the transmitted signal spectrum is significantly wider than the original data bandwidth. Instead of SS modulation, IEEE 802.11a uses orthogonal frequency division multiplex (OFDM) modulation (OFDM is described in detail later).

## Basics of spread-spectrum

Two basic types of spread-spectrum modulation exist. Frequency-hopping spread spectrum (FHSS) is used by Bluetooth. The Bluetooth spectrum is divided up into 79 channels of 1 MHz each. After transmitting a burst on one channel, the transmitter hops to another channel and transmits the next burst at that frequency. The Bluetooth radio hops over these channels at a rate of 1.6 khops/s. By transmitting at relatively high power for only a short period on any given frequency, the signal's average power is kept below the FCC's limit. In addition, the radio is able to hop around interfering signals. Thus, a narrowband interferer will only be a problem during the short time that the radio is using that 1 MHz channel.

IEEE 802.11b radios support both FHSS and direct sequence spread spectrum (DSSS). In contrast to FHSS, a DSSS radio sends a signal that is spread over a wide bandwidth, but the spectral density at any given frequency is very low. The signal in DSSS is spread by multiplying the data signal by a wide bandwidth spreading sequence. Each bit in the spreading sequence is known as a chip. IEEE 802.11b uses an 11-chip Barker code as the spreading sequence for its 1 and 2 Mb/s modes.

To send information, the transmitter takes either one or two bits and uses those values to differentially modulate the spreading sequence using either binary phase-shift keying (BPSK) or quadrature phase-shift keying (QPSK). Thus, the information is conveyed in the phase of the spreading sequence.

The higher date rate modes of 5.5 and 11 Mb/s use a different type of modulation known as complementary code keying (CCK). In addition to using two bits of the symbol to perform differential QPSK modulation, the remaining bits of the symbol are used to choose from a set of either four or 64 complex orthogonal spreading sequences. This selection is performed on a symbol-by-symbol basis. Thus, in CCK modulation, information is contained in both the phase of the spreading sequence and in the choice of the spreading sequence used. By using a wide bandwidth signal, a DSSS signal will interfere with all frequencies in the channel. However, the low spectral density means that the interference will be small.

The DSSS radio has the drawback that it must always transmit on the entire channel as opposed to having the flexibility to hop around other interfering signals.

## OFDM and ISI

WDHN radios use different techniques to cope with the severe frequency-selective channels that occur in the gigahertz bands within the home. FHSS systems such as Bluetooth are able to hop around channel nulls so that such nulls will only distort the received signal for a brief amount of time. IEEE 802.11a radios take a different approach by using OFDM. The 20 MHz spectrum is broken down into 64 sub-bands of 312.5 kHz each. The user data are modulated onto 48 subcarriers and four subcarriers are used to carry known pilot sequences that aid in signal recovery. The remaining band-edge and DC subcarriers are zeroed out to reduce the effects of co-channel interference.

An advantage of using a multicarrier modulation such as OFDM is that it takes 64 symbols that have a short symbol duration and it combines them all into a single OFDM symbol. This OFDM symbol has a symbol duration 64 times as long as the original symbol duration. In single-carrier systems, the time span of the channel is typically much longer than the symbol period. Hence, ISI occurs due to interference from a large number of adjacent symbols. However, the long symbol period in OFDM means that the symbol duration is longer than the timespan of the channel. The ISI in an OFDM system is due to the previous symbol, and this ISI will only affect the first few samples of a given OFDM symbol.

To combat the effect of this ISI a cyclic prefix is used. The cyclic prefix is formed by taking 16 samples from the end of the OFDM symbol and prepending a copy of those samples in front of the symbol. Because ISI is only due to the previously transmitted symbol, only the cyclic prefix will be corrupted. Because the cyclic prefix contains redundant information, it can be discarded at the receiver and thus the effects of ISI are essentially thrown out.

Another type of interference known as intrasymbol interference occurs when delayed versions of a given transmitted symbol cause the symbol to interfere with itself at the receiver. Intrasymbol interference is corrected by using a frequency-domain equalizer that has a single complex equalizer tap for each subcarrier.

## Bursty communications

Unlike a broadcast system such as dig-

ital television, WDHNs are bursty communications systems. Because the receiver only has a short burst of data to work with, it must quickly perform functions such as carrier and timing recovery and channel equalization to be able to successfully recover the entire burst of data.

To aid the receiver in this process, preambles are prepended to the beginning of a burst. The preambles contain known sequences that the receiver can use to synchronize itself prior to the reception of the user data part of the burst. The preambles will also contain information about the length of the user data payload as well as the data rate of the payload. To ensure good reception of the preamble, it is typically transmitted using the most robust format available in a given system. Many systems send the preamble using BPSK modulation and rate 1/2 convolutional coding.

## Applications

The three standards used as examples are suited for different applications. Bluetooth is typically used as a cable replacement solution to wirelessly connect devices that were previously connected using a cable.

An example is connecting a laptop to a cell phone. Bluetooth's low cost and low power consumption allow it to be integrated in a variety of products that need a low data rate (1 Mb/s) and short range (10 m) wireless link. IEEE 802.11b's higher data rate (11 Mb/s) and longer range (100 m) make it better suited for use as a wireless data network.

A typical application uses the 802.11b link to give devices such as laptops and PDAs mobility while still retaining the ability to connect to a wired data network or a phone line. IEEE 802.11a radios provide a high data rate (72 Mb/s) over a range of between 15 to 30 m. The high throughput of this link allows audio and video to be wirelessly sent throughout the home or office.

## Link layer protocols

The link layer is the layer between the physical layer and the network layer according to the open software interconnection (OSI) layering model specified by the International Standard Organization (ISO). The physical layer allows the bit coding and transport of the information over the wireless medium. The link layer provides protocols to enable communications between two devices interconnected through the medium.

When the medium is shared among several interconnected devices, the layer is split into two sub-layers. The lowest sub-layer (directly over the physical layer) is called medium access control (MAC) and it controls and arbitrates the access to the shared medium. The highest sub-layer is called logical link control (LLC) and provides the protocols to ensure the communication between two devices directly connected to the medium. Typically, the service offered by the LLC sub-layer, and hence by the link layer, is either a reliable (or acknowledge) service where the receiver acknowledges each data frame or packet, or a non-reliable service where a data frame or packet is sent without guarantee that it has been received by the destination device.

## Wireless link

From the link layer point of view, a wireless link is no different than a wired except for the issue of reliability. The bit error rate may be over $10^{-3}$ which can increase packet loss and implies dedicated strategies such as forward error correction (FEC) and/or retransmission.

Another issue is the way a device has to be connected to the medium. In a wired medium, the physical connection consists of plugging the device into the medium. In a wireless medium, the device has to automatically perform certain operations called scanning and joining to recognize (and be associated with) the network. The wireless nature of a link implies some inherent problems such as the hidden node problem.

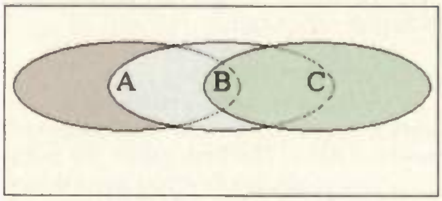

Figure 3. Illustration of a hidden node.

| | IEEE 802.11 | Hiperlan2 | Bluetooth |
|---|---|---|---|
| Network mode | Ad-hoc Infrastructure | Ad-hoc Infrastructure | Ad-hoc |
| MAC | Distributed: CSMA/CA | Centralized: scheduler | Centralized: polling |
| QOS | No | Yes: unicast + multicast | Yes |
| Multimedia | Near isochronous service | Fixed slot allocation | Circuit switched service Near isochronous service |
| Handover | Inter-base stations protocol not specified | Inter-base stations protocol not specified | |
| Security | Basic | Ok | Ok |
| Error correction | Retransmission | Retransmission FEC (home extension) | Retransmission FEC |
| Misc | Interferences within the 2.4 *GHz* band Mounted attacks against the security barrier | Difficult to implement the Scheduler | Limited set of active device within the scatter-net Interference within the 2.4 *GHz* band Limited interactions between slaves in a scatter-net |

Table 3. Wireless LAN comparison.

A wireless link is characterized by the maximum range within two devices can communicate. Consider the case in which three devices (A, B and C) are located in such a way that A and B are in range together, and B and C are in range together, but A and C are not in range (see Figure 3).

A starts to transmit information to B. C senses the medium and assumes that the medium is free (A being out of range). It consequently starts to transmit to B as well. The consequence is interference at B. The MAC protocol needs to provide some means to solve this problem.

Another important issue is power management. There are a few fundamental issues to be resolved in relation to power management. The first one is related to the power of the transmitter that has to be adjusted according to the distance between the transmitter and the receiver. The physical layer usually performs this function. The second function relates to the power consumption of the devices. The mobile device is battery operated. Therefore, it must be power efficient. The MAC sub-layer may provide some mechanisms to control and limit the power consumption by allowing the device to be in "sleep" mode and to be awakened when some message is intended specifically for it.

The final important issue is that of security. Wireless links are prone to eavesdropping. Also, unauthorized users could access the network unless there are explicit mechanisms that prevent them from doing so. Consequently, the link protocol usually has some security mechanisms such as authentication and encryption.

## Wireless architecture

Two types of architectures are commonly found in wireless local area networks (LANs). The first, called the infrastructure mode, implies that some device which forms the network infrastructure is required. Such a device is called a base station (or access point). This device provides some additional intelligence and memory resources to extend the wireless interconnections and to help coordinate bandwidth management.

A network may contain several base stations. The base stations may be interconnected through either a wired or wireless link. In this mode, a wireless device is said to be attached to a base station, meaning all transmissions coming from or to be sent to this device go through the base station. The base station acts as a relay and can buffer some data when the destination device is temporatily unavailable. If the wireless device is mobile, one base station may perform a handoff to another base station seamlessly. The process or protocol that provides this function is usually implemented within the wireless link layer and is called handover.

The second network architecture is called ad-hoc mode. In that mode, no infrastructure device exists such as a base station. Two devices may establish a communication relationship autonomously when they are in range of each other. It is also possible for a device be identified as a controller after an automatic initialization to control the medium access for instance. However, it is still in an ad-hoc mode because any device can potentially play that role.

## MAC protocol

Two types of MAC protocols exist. The first type, called a distributed MAC, includes the protocols where the control of the access to the medi-

um is distributed. This implies that all devices participate in that control and that there is not a central controller. Thus, all contender devices have the same chance to gain access to the medium. The second class of MAC protocols are called centralized MAC protocols in which one device controls and manages the access to the medium.

## Wireless LANs

IEEE 802.11 specifies one MAC layer and several different physical layers. The LLC sub-layer is already specified by the IEEE 802.2 group and used over Ethernet (802.3) for instance. The obvious consequence is that the interconnection between an IEEE 802.11 sub-network and an Ethernet LAN, for instance, is natural. IEEE 802.11 defines two network modes, an ad-hoc mode and an infrastructure mode as defined above. IEEE 802.11 defines the service offered by the distribution system that consists of the set of interconnected access points (through either wired or wireless links), but doesn't specify the protocols to ensure handoff between these base stations.

The MAC protocol is carrier sense multiple access/collision avoidance (CSMA/CA) and it is a distributed protocol. All stations, regardless of architecture (ad-hoc or infrastructure), have the same status and the same priority regarding the medium access. The method in itself is based on a random process where a station that wants to acquire the medium first senses the medium. If some activity is detected (the medium is busy), the station has to wait a certain time corresponding to a certain number of time slots randomly chosen. After this waiting time, the station attempts to get access again. If it is still busy, the station has to double the time it waited before this attempt and so on.

This process is known as the binary exponential back-off mechanism. If no activity is detected during a certain gap then the medium is seen as free and the station may start to transmit. The basic transmission is called a transaction and it consists of sending a data packet to the receiver and waiting for the acknowledgement from the same receiver. To avoid the hidden node problem, the transaction may contain a short handshake before sending the data packet. This handshake is called request-to-send/clear-to-send (RTS/CTS) and it allows all other stations, in the range of the receiver (which will send back CTS) to detect the upcoming transaction. Embedded within each packet of the transaction (RTS, CTS, DATA, ACK) is a duration parameter, which informs all other stations waiting to acquire the medium about the duration of the transaction. This is the collision avoidance part of the MAC protocol.

Hiperlan2 also specifies two network modes: ad-hoc and infrastructure. The stack includes (from bottom to top) the physical layer, a data link control (DLC) layer comprising the MAC sub-layer, the radio link control (RLC) sub-layer and some convergence layers.

A convergence layer gathers specification to adapt other link protocols such as ATM, IEEE 802.3 (Ethernet), and IEEE 1394 over the Hiperlan2 protocol stack. The MAC protocol is a centralized one. A

*Continued on page 58*

# Indoor propagation issues for wireless LANs

*It looks good on paper, but the actual variations of propagation caused by absorption, scattering and multipath make for large variations in path loss from the free space.*

**By Dan Dobkin**

Wireless local area networks (WLANs) are rapidly gaining popularity. These networks are primarily targeted for indoor use, and are most often based on either the IEEE 802.11 Ethernet-type protocols or the Bluetooth Special Interest Group (SIG), both using the unlicensed bands at 2.4 to 2.5 GHz (IEEE 802.11b – "WiFi" — and Bluetooth) or at 5.15 to 5.85 GHz (IEEE 802.11a – "WiFi5"). The European HiperLAN standard is also designed for operation around 5.2 to 5.8 GHz.

It is often said that the higher-frequency unlicensed national information infrastructure (U-NII) band at 5.15 to 5.85 GHz will be intrinsically limited to shorter ranges than the industrial/scientific/medical (ISM) band due to higher path loss, limiting the utility of 802.11a relative to that of 802.11b.

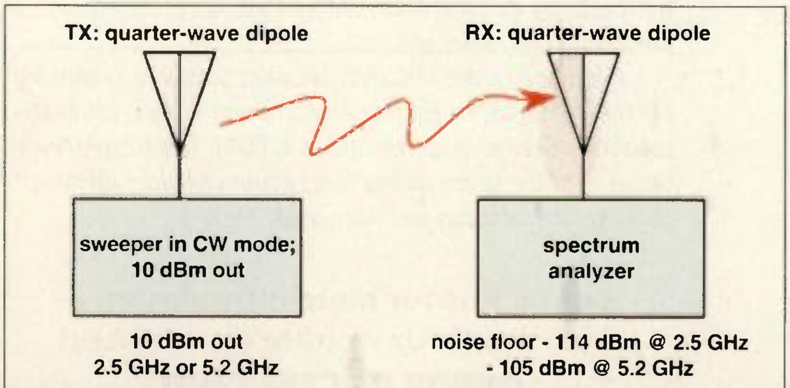


Figure 1. Measurement schematic.

The purpose of this investigation was to examine that claim. It was found, at least in the test environment discussed in this article, to be unfounded.

## Experimental method and results

The propagation of a continuous-wave (CW) signal at either 2.5 or 5.2 GHz from place to place within a typical light industrial environment was measured. The 10 mW signal was generated using a sweeper in CW mode and radiated from a fixed vertically oriented $\lambda/4$ dipole constructed from a coaxial line with exposed center conductor of appropriate length, soldered to a copper ground plane 15 cm on a side.

The signal was received by an identical dipole and monitored with a spectrum analyzer. The receive antenna was moved to various locations throughout the facility. At each nominal location, at least five measurements were taken, in which the exact position was moved randomly in 10 to 20 cm increments to sample possible signal variations due to shadowing and multipath fading. Nominal locations were the same for the 2.5 and 5.2 GHz measurements to within about 1 meter.

The experimental setup is shown schematically in Figure 1, and the measured points in Figures 2(a) and (b). The transmitter was located on the second floor (the red dot in Figure 2(a)) and receive locations on both floors 1 and 2 were tested. The building is typical of Silicon Valley construction, with an open central area occupied by cubicles or engineering test benches, offices and conference rooms along the perimeter, and a thin steel-supported concrete floor. The cubicle adjacent to the transmitter contained several large sheet-metal bookshelves, acting as the sort of internal obstacle one might typically expect to encounter in an indoor environment.

Short distance measurements (0.6 ±0.05 and 1.2 ±0.05 meters) provide a rough calibration for the longer distances, because multipath effects are generally minimal at these distances. Distance from transmitter to receiver was estimated from building plans to the nearest meter, accounting for the 3 meter height of the floor 1 ceiling when applicable.

Figure 3 shows the results for both frequencies and both floors. The dots connected by a bar represent the highest and lowest values measured at the same nominal location. It is seen that local fades of anywhere from 5 to 25 dB are common, with one instance of 45 dB. Average values fall as much as 30 dB below ideal free-space [$1/r^2$] propagation. Finally, it is apparent that there is little statistically significant distinction between the path loss for the 2.5 and 5.2 GHz signals.

To further emphasize this point, a joint fit to all of the data points was performed, finding a best-fit propagation model as defined by:

$$\text{model signal (dBm)} = -38 - \left[10\log(\textit{distance})\right] - 8.95\begin{Bmatrix}1 \text{ if floor } 1\\ 0 \text{ if floor } 2\end{Bmatrix} \quad (1)$$

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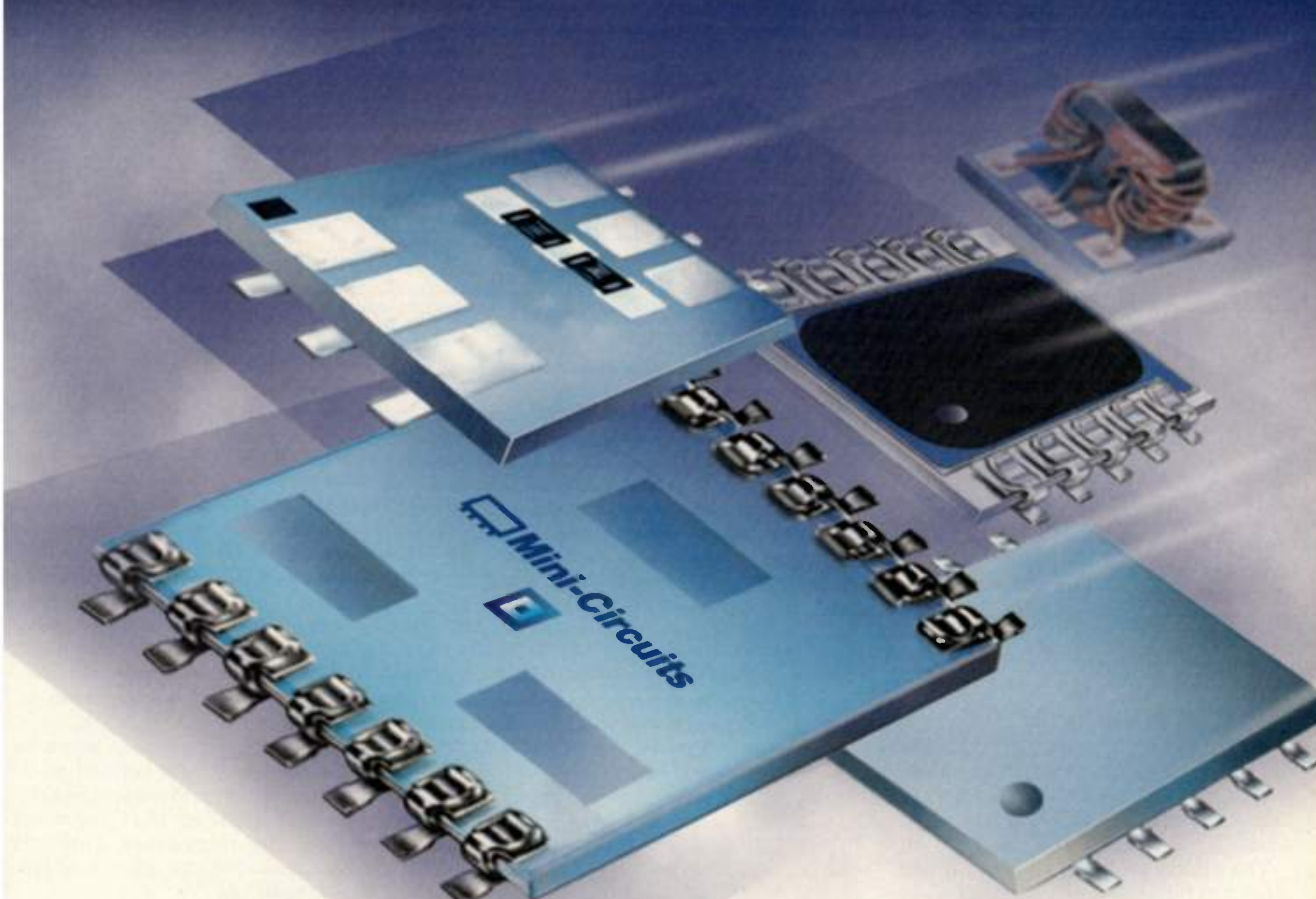


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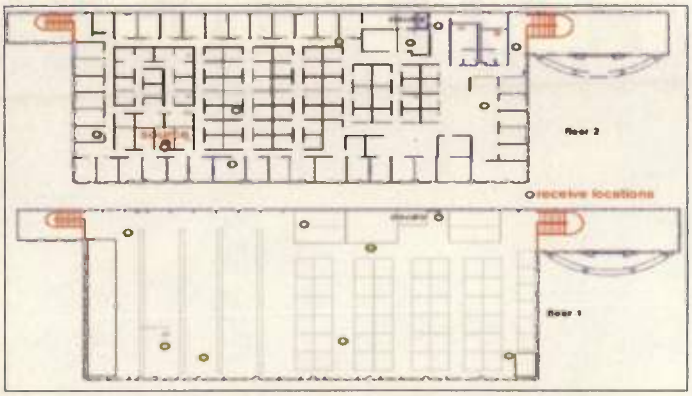


Figure 2. Transmit and receive locations overlaid on a building layout.

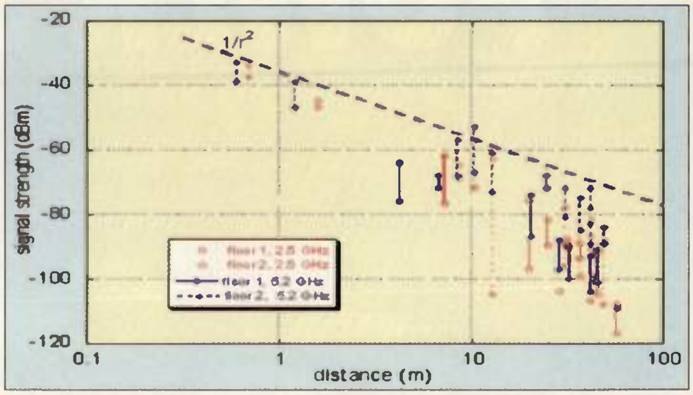


Figure 3. Results of propagation measurements, floors 1 and 2, 2.5 and 5.2 GHz.

(That is, the propagation exponent is about 3.0 and the floor loss about 9 dB.)

The results for each measured data point from the modeled value for that nominal location for 2.5 and 5.2 GHz, is shown in Figures 4(a) and (b) as histograms. While there is a modest difference in the exact shape of the distributions, the difference of the averages (1.7 – 1.4 = 0.3) is much less than the standard deviations of the distributions. There is no statistically significant difference between 2.5 and 5.2 GHz link losses in the facility.

## A bit more detail

• *Free Space* — It is a common misconception that free space propagation is wavelength-dependent. It is timely to examine how this misunderstanding arises.

The signal strength received by an ideal receiving antenna from an ideal transmitting antenna over a free-space distance "*d*" can be expressed as:

$$P_{rec} = P_{trans}\left(\frac{1}{4\pi d^2}\right) g_{trans} A_{rec} \qquad (2)$$

where *P*s are transmitted and received powers, $g_{trans}$ is the directivity of the transmitting antenna, and $A_{rec}$ is the effective collecting area of the receiving antenna. Note that there is no explicit dependence of the propagation on wavelength[1].

The received signal strength is, however, more often written in terms of antenna directivity[2]. To arrive at this form one must impose the reciprocity condition : *transmitting from antenna 1 to antenna 2 should give the same result as transmitting from antenna 2 to antenna 1 in free space* (that is, space is isotropic, at least in the absence of an overall magnetic field and orbiting charges) by:

$$P_{trans}\left(\frac{1}{4\pi d^2}\right) g_1 A_2 = P_{trans}\left(\frac{1}{4\pi d^2}\right) g_2 A_1 \qquad (3)$$

And, a bit of algebra shows that:

$$g_1 A_2 = g_2 A_1 \rightarrow \frac{g_1}{g_2} = \frac{A_1}{A_2} \qquad (4)$$

That is, the directivity is monotonically related to the effective collecting area of the antenna. An ideal isotropic radiator (directivity = 1) has an effective collecting area proportional to the square of the wavelength, therefore:

$$A_{iso} = \frac{\lambda^2}{4\pi} \rightarrow A_{rec} = g_{rec}\left(\frac{\lambda^2}{4\pi}\right) \qquad (5)$$

Substituting this in the link loss expression gives the more commonly observed form:

$$P_{rec} = P_{trans}\left(\frac{1}{4\pi d^2}\right) g_{trans} g_{rec}\left(\frac{\lambda^2}{4\pi}\right) \qquad (6)$$

Note that, although the term in wavelength is often folded into the term in distance for dimensional convenience, it is actually a statement about antenna size. A nearly isotropic antenna must get smaller as the wavelength shrinks. It is the reduced collecting area of the receiving antenna, not any mysterious wavelength-dependent propagation behavior, that causes free-space link losses to increase with frequency when antennas of a given directivity are specified.

Therefore, higher frequencies induce one to use not shorter ranges, but more directional antennas with larger collection area to maintain a constant link budget.

• *Indoor propagation* — The situation is, of course, more complex in practical indoor environments, where numerous objects may scatter, diffract, reflect, and absorb radiation.

Numerous experimental and theoretical studies of indoor propagation have been performed ([3] and [6-11]). The effects of the environment are often absorbed into a modified propagation exponent, ranging from 2.7 to 5, and a floor loss factor of 3 to 12 dB, generally in agreement with the empirical expression we arrived at for our data.

However, there does not seem to exist a specific comparison of unlicensed frequencies, under identical circumstances, such as that reported above, or any suggested analytic approximation for the effects of frequency on path loss

• *Scattering* — The effects of scattering and diffraction have been studied for many years. It is well-known that objects whose dimensions are small compared to a wavelength act as weak scattering centers, with effective scattering cross-section proportional to the fourth power of the impinging wavelength (Rayleigh scattering)[4]. Objects much larger than a wavelength can be treated by the familiar approach of phase-insensitive ray tracing learned in classical optics, and encountered every day in our visual world: they absorb, reflect and cast geometric shadows.

The dominant scatterers in indoor environments fall into neither of these simplistic categories: their typical sizes are from 2 to 3 cm to human dimensions of 2 to 3 meters vs. wavelengths of roughly 12 cm in the 2.4 to 2.5 GHz ISM band and around 5.5 cm in the 5.2 to 5.8 GHz UNII band. Most of these objects fall into the Mie scattering

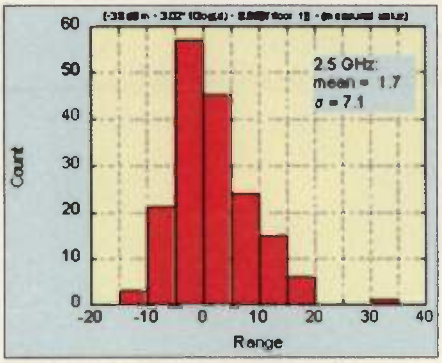


Figure 4(a). 2.5 GHz data vs. joint model.

regime from 1 to 10 wavelengths, in which complex behavior depending on the shape and characteristics of the scatterer is expected[5]. Obstacles much smaller than a wavelength "disappear" from view. Thus FM at 100 MHz ($\lambda = 3$ meters) is undisturbed by cars and people, but suffers reflections and diffraction from buildings. This leads to multipath fade in urban environments. The situation is depicted qualitatively in Figure 5, showing scattering cross-section as a function of size for a perfectly reflecting sphere, for frequencies of 2.45 and 5.2 GHz.

It is expected to find a strong monotonic wavelength dependence in indoor propagation when there are important scatterers at sizes between the cutoffs of the high and low frequency waves.

For example, if the environment were populated with lots of metal spheres (ball bearings) of 2 cm diameter, a 5.2 GHz transmission would be scattered 10 times more effectively than a 2.45 GHz transmission. However, a quick look around an office environment will disclose that human beings mostly populate their world with larger objects; the "disappearance" of 2-cm scattering centers at ISM band relative to UNII band has

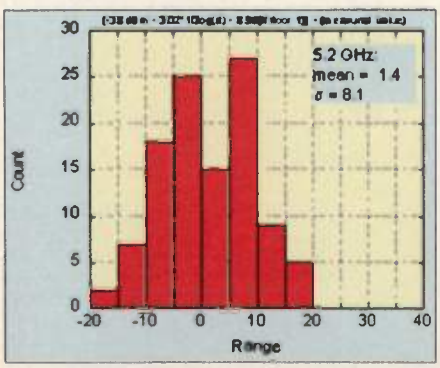


Figure 4(b). 5.2 GHz data vs. joint model.

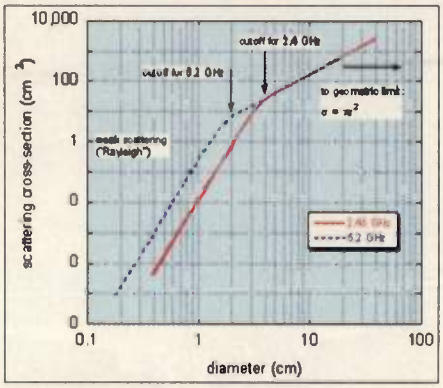


Figure 5. Scattering cross-section vs. diameter for perfectly reflecting spheres, after[5].

little effect on the overall path loss. For larger objects (of size larger than a wavelength), the diffracted intensity must be examined in more detail. Investigation of a typical two-dimensional obstacle of short dimension 0.5 meter, located 5 meters from a source of either 2.4 or 5.25 GHz radiation, was performed using the Fresnel integrals. The diffracted minima at e.g. 12 meters from the obstacle, are 5 dB deeper at 5.25 GHz than at 2.4 GHz, though only 30 cm wide; the on-axis maxima only differ by about 2 dB between the high and low frequencies. Based upon this rationale, it can be concluded that the experimental results are reasonable and may be typical of indoor environments.

• *Multipath and delay spread* – Multipath propagation leads both to fading and to variations in path delay of transmitted signals. Delay spread and number of significant paths increase gradually with distance in indoor environments; a typical range appears to be about 20 to 80 nsec for 5 to 15 meter distances at 5 GHz[8].

An 802.11a signal contains 48 active carriers[12]. At the minimum overall data rate of 6 Mb/s each carrier has a data rate of 125 Kb/s or a bit time of 8 μseconds. Even during the PLCP preamble, signal transmission uses 12 subcarriers for an effective rate of 500 KHz. It seems unlikely that the bit error rate would be extremely sensitive to the 10 to 30 nanosecond variations in the multipath delay distribution that one would expect at these ranges.

While there has been no explicit examination of the effects of multipath propagation, it can be noted that the magnitude of multipath propagation should be reflected in the variation about the mean of path loss (see Figures 4(a) and (b)). Similar standard deviations for CW propagation suggest qualitatively similar multipath / delay effects.

## Conclusions

As a result of this experiment, it is suggested that no intrinsic impairment exists in 5.2 to 5.8 GHz propagation vs. 2.4 to 2.5 GHz propagation in office/light manufacturing environments. Thus, no intrinsic impediment to roughly equivalent deployment of 802.11a and 802.11b wireless LAN systems exists.

Note, however, that this does not imply equivalence of practical systems: higher frequencies suffer higher losses in cables and circuit boards, and low-cost devices may suffer from reduced gain or lower output power at higher frequencies. Further, to achieve equivalent collecting area, higher-frequency antennas become more directional, which may be inconvenient for end-users.

RF

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Dobkin received his B.S. degree from the California Institute of Technology, and a Ph.D. from Stanford University, both in Applied Physics. His career has spanned development of compound semiconductor devices and circuits, capital equipment and processes for semiconductor manufacturing, and expert testimony in contract and patent litigation. He is currently Director of Technical Marketing for WJ Communications. He can be reached at: *daniel.dobkin@wj.com*

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# Design Chebychev bandpass filters efficiently

*Get optimum results in days by teaming a 3D full-wave field solver with a circuit simulator.*

**By B. Mayer, PhD, M.H. Vogel, PhD**

Designing filters is not an easy talk, despite the fact that the technology involved is mature and understood. Modern software tools are available that provide the circuits in terms of lumped electrical components, but designing the actual 3D microwave structure can take weeks. This article shows how a circuit simulator and a 3D field solver can work together to reduce the design time from weeks to days.

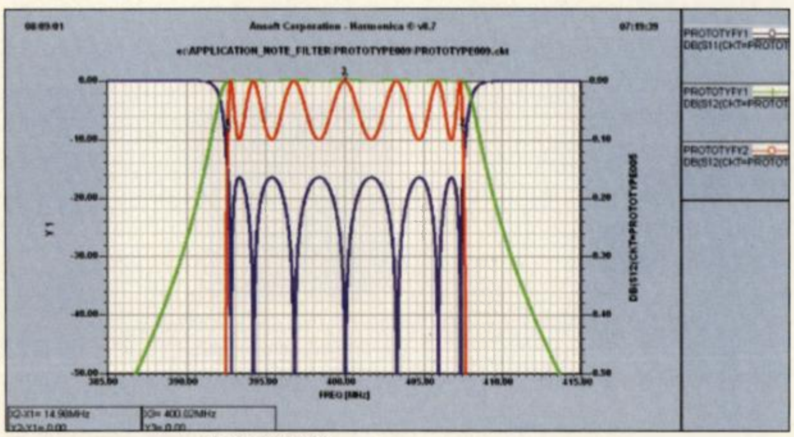


Figure 1. Desired filter characteristics.

While others have explored the basic idea[1], they used different circuits. This method, through an example, will design a Chebychev band pass filter with the following specifications:

*Center frequency : 400 MHz*
*Ripple bandwidth: 15 MHz*
*Ripple: 0.1 dB*
*Out-of-band rejection: 24 dB at 390 MHz and 410 MHz*

To achieve out-of-band rejection, seven poles will be required. The desired filter characteristic is shown in Figure 1.

As the basic geometry for this filter, a cavity was chosen with seven coaxial resonators (see Figure 2). In the figure, the "buckets" have been drawn as wire frames for clarity to show that the cylinders, which form the inner conductors of the individual coaxial resonators, don't extend all the way to the bottom.

This geometry is symmetrical with respect to the central cylinder. In this kind of filter, the walls of the cavity, the long cylinders, the buckets under the cylinders and the disk-shaped objects near the first and last cylinder are all made of metal. Cylinders and buckets don't touch. This way, each cylinder-bucket combination is a resonating structure. The disk-shaped objects near the first and last resonator are connected to the input and output transmission lines and provide the necessary coupling to the source and the load. For the purpose of clarity, the objects will be referred to as antennas in this document. They are near the first and last cylinders, but never touch them.

At this stage, without design restrictions, the option to choose many dimensions of the filter is available. For this case, the following choices were made:

*Cavity dimensions: 280 x 30 x 120 mm*
*Resonator diameter: 10 mm*
*Buckets' inner diameter: 12 mm*
*Buckets' outer diameter: 16 mm*
*Buckets' height: 15 mm*
*Antennas' diameter: 26 mm*
*Antennas' thickness: 4 mm*

Once the above has been determined, six dimensions remain. They will be crucial in obtaining the desired filter characteristic. They are:

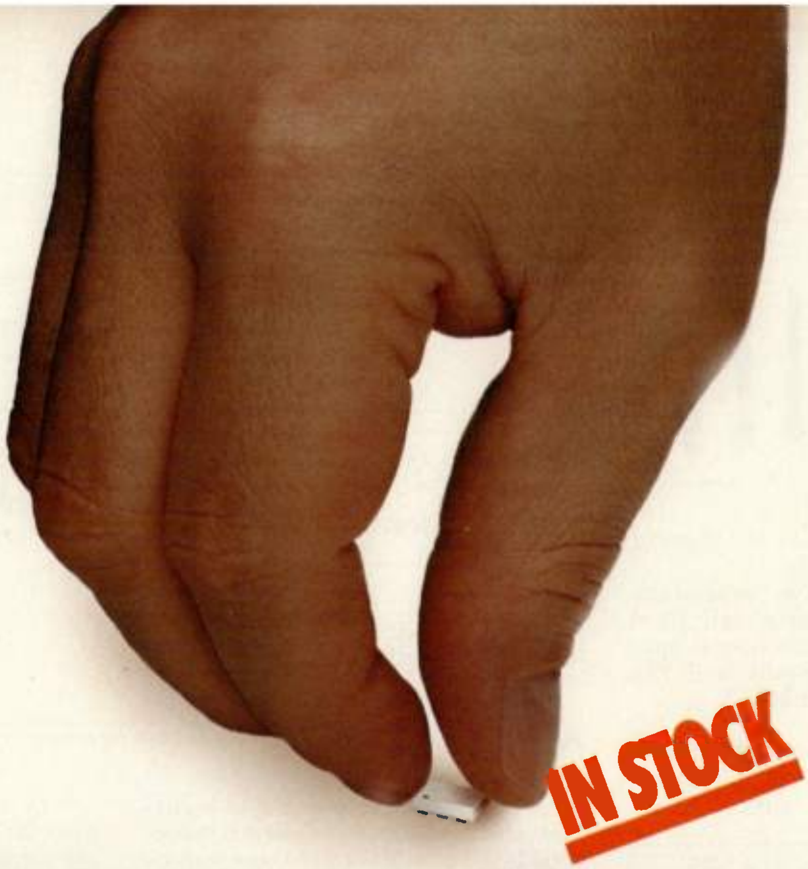
- *The length of the first and last resonating cylinder (both have equal length)*
- *The length of the five interior cylinders (all five have equal length)*
- *The distance between an antenna and its nearest cylinder*
- *Three distances between neighboring cylinders (remember the filter is symmetric)*

## Steps in the design process

With traditional filter design methods, obtaining the correct dimensions is a time-consuming task that commonly takes several weeks. Filter design with a circuit simulator, on the other hand, is relatively straightforward. Filter theory provides the values for the lumped inductors and capacitors that are needed to obtain the desired filter characteristic.

First, it will be shown how to design a circuit that not only has the desired filter characteristic, but also lends itself to implementation with microwave components. In such a circuit, we use series $L$ and $C$ for each resonator, i.e. the cylinder-and-bucket combinations, and impedance inverters to represent the distances between adjacent resonators.

Second, relationships between components in the

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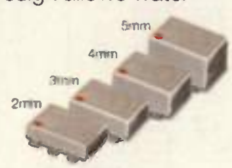

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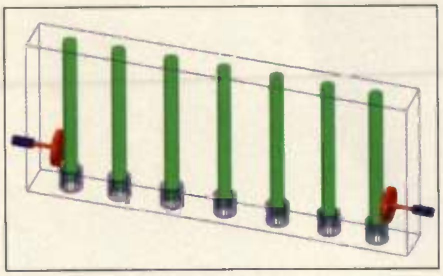

Figure 2. Basic filter geometry.

circuit and dimensions in the physical filter will be determined.

Third, an iterative procedure between the electromagnetic field solver and the circuit simulator to optimize the design will be presented. The procedure converges quickly.

## Circuit representation of the filter

To design an order-seven band-pass filter around 400 MHz with a 0.1 dB

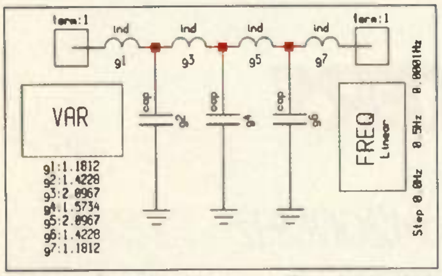


Figure 3. Normalized low-pass filter circuit, starting point for design procedure.

ripple, filter theory[2] tells us to start with an order-seven low-pass filter, normalized to 1 radian/s. The normalized filter is to have a 0.1 dB ripple like the desired band-pass filter. The source and load impedances of the normalized low-pass filter are normalized to 1Ω (see Figure 3).

Filter theory provides us with the values for the inductors and the capacitors, denoted by $g_1$ through $g_7$ in the figure. These values in this case are:

$g_1 = g_7 = 1.1812$ H
$g_3 = g_5 = 2.0967$ H
$g_2 = g_6 = 1.4228$ F
$g_4 = 1.5734$ F.

An important step is the replacement of shunt capacitors by series inductors and impedance inverters.

Basically, an impedance inverter transforms impedances in the same way as a λ/4 transmission line, but independent of frequency. The resulting circuit is shown in Figure. 4. This is still a normalized low-pass filter with the same characteristic as the circuit in Figure 3. Taking advantage of imped-

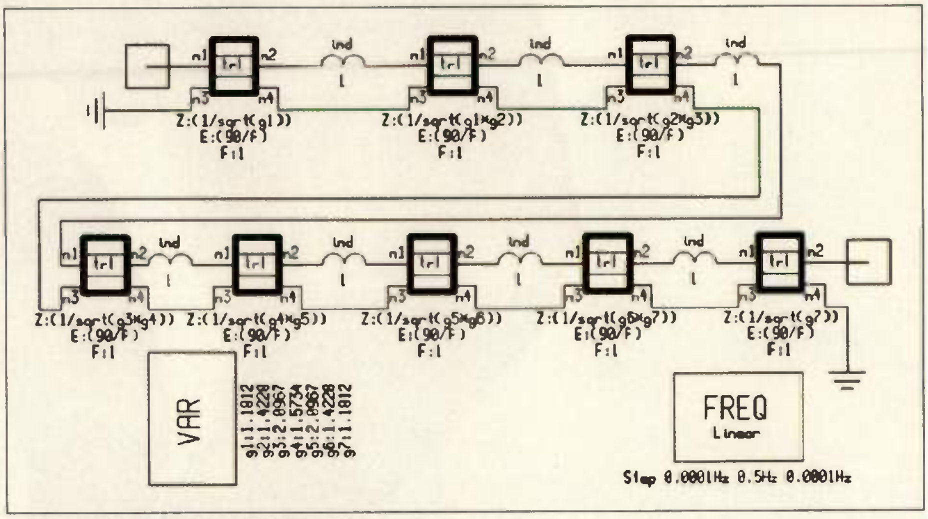


Figure 4. Normalized low-pass filter without shunt capacitors.

ance inverters, it is possible to transform shunt capacitors into series inductors. In the physical filter these impedance inverters will be realized by couplings between the coaxial resonators.

Following a standard procedure[2], the following steps are taken to derive the desired band-pass filter model:

- *De-normalize the low-pass cut-off angular frequency from 1 rad/s to bw rad/s.*
- *Transform the low-pass filter to a band-pass filter with a relative bandwidth of bw and a center angular frequency of 1 rad/s by inserting a 1 F capacitor in series with every 1 H inductor.*
- *De-normalize the center frequency to 400 MHz by choosing* $L = 1/(2\pi 4^8)$ H and $C = 1/(2\pi 4x10^8)$ F.
- *De-normalize the port impedances from 1Ω to the usual 50Ω by introducing impedance inverters at the input and output with coupling coefficients of √50.*
- *Introduce finite quality factors to the individual resonators by adding a series resistor to each resonator.*
- *Introduce individual resonant frequencies to the first and last resonators to be able to take the frequency shift due to the coupling antennas into account.*
- *Add a homogeneous transmission line of length* ZUL *between filter input/output and port 1/port 2 to be able to adjust the phase due to the connectors.*

The result is the filter shown in Figure 5.

In this circuit, every *LC* pair res-

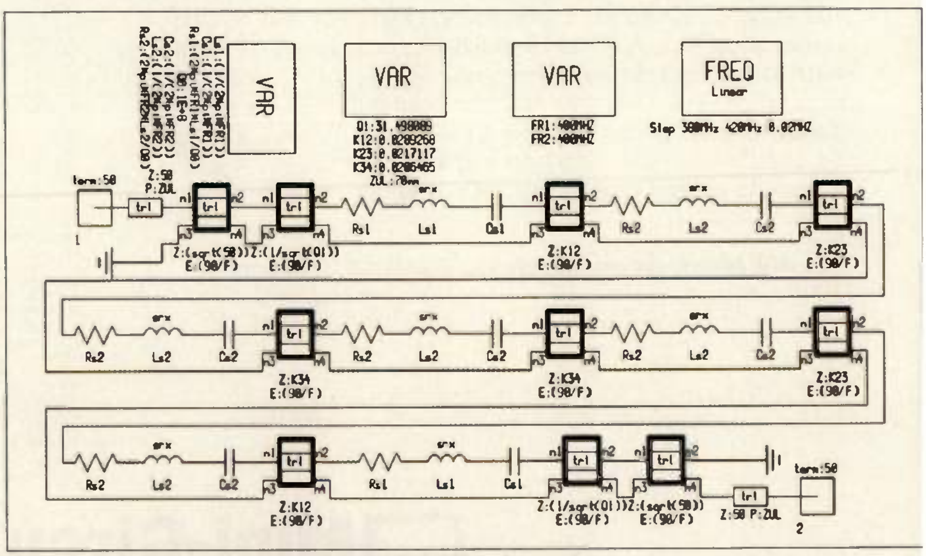


Figure 5. Final filter circuit, representing the desired band-pass filter.

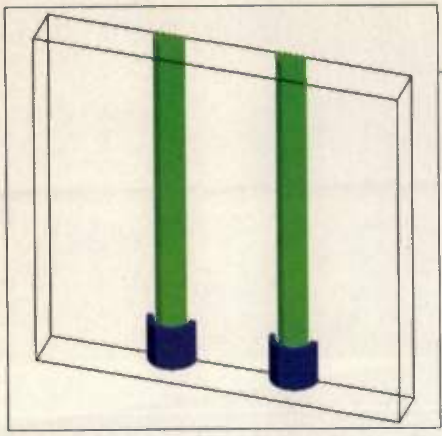

Figure 6. Model used to determine the coupling coefficient K.

onates at 400 MHz. Further $K_{12}$, $K_{23}$, $K_{34}$ and $Q_L$ have been defined as:

$$K_{i} = \frac{bw}{\sqrt{gg}} \quad (1)$$

and:

$$Q = \frac{g_{1}}{bw} \quad (2)$$

where $bw$ is the relative bandwidth and $g_i$ is the $i^{th}$ $g$ value from filter theory.

Notice that, because the $g$ values are known from filter theory, the values of all the components in the circuit are still known, even though the components have changed considerably in the process.

Filter theory[3] tells us that $K_{i,\,i+1}$ and $Q_L$ have important physical meanings. $K_{i,\,i+1}$ is known as the coupling constant between adjacent resonators. If there are only two resonators in the cavity with a very light, ideally zero, coupling to the source and the load, then the relation between coupling constant $K_{12}$ and resonant frequencies $f_1$ and $f_2$ is given by:

$$K_{12} = \frac{2(f_2 - f_1)}{f_2 + f_1} \quad (3)$$

$Q_L$ is known as the loaded $Q$ of the circuit. If there is just one resonator in the cavity, coupled to source and load, the relation between $Q_L$, resonant frequency $f_R$ and 3 dB band width $BW_{3dB}$ is given by:

$$Q_L = \frac{f_R}{BW_{3dB}} \quad (4)$$

In the next section, the components of this circuit will be linked to the dimensions in the physical geometry of the filter.

## Making the links

The software model that was used to determine the coupling coefficient $K$ as a function of resonator spacing is shown in Figure. 6. Two resonators have been placed in a closed metal cavity. As can be seen in the figure, symmetry has been exploited. Further, because we want to determine resonances in the ideal case of zero coupling to source and load, there are no transmission lines nor ports for signal input and output. The resonances of this structure are to be determined through an eigenmode simulation.

By embedding the project in an optimizer, its dimensions can be easily varied.

First, the length of the cylinders was adjusted such that the resonances are centered at 400 MHz. Then, the distance between the resonators was varied and, for each distance, the eigenmode solver computed the two eigen frequencies and obtained $K$. The relation between the resonator spacing and $K$ is shown graphically in Figure 7.

With this graph, for any coupling coefficient required by filter theory, the spacing to be applied between resonators in the physical model can be readily determined.

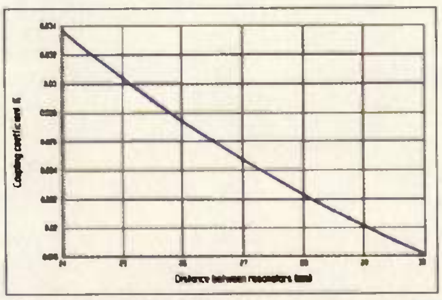

Figure 7. Relation between resonator spacing and coupling coefficient K.

## Antenna distance and loaded Q

The model that was used to determine the loaded $Q$ as a function of antenna spacing is shown in Figure 8. An antenna-resonator combination has been placed in a closed metal cavity. The 50Ω transmission line is present. However, we have chosen to determine $Q$ through an eigenmode analysis rather than through a frequency sweep. Therefore, the transmission line has been terminated by a perfectly matched layer (PML) of absorbing material. The power dissipation in the PML takes the place of power dissipation in a 50Ω load.

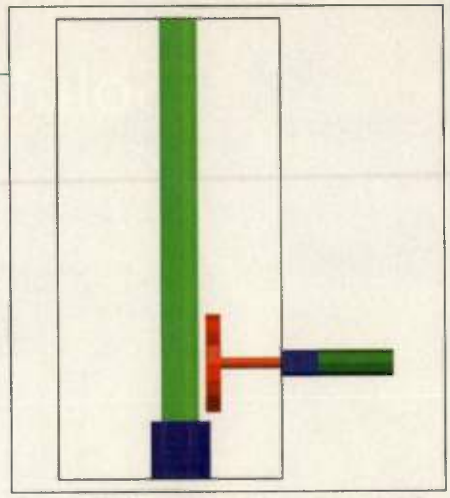

Figure 8. Model used to determine the loaded Q.

Because this project has been embedded in an optimizer, the antenna distance and the cylinder length were varied simultaneously and independently (since both influence the resonant frequency and the loaded $Q$). As an example of the results, the relation between antenna spacing and loaded $Q$ is shown graphically in Figure 9 for a constant cylinder length of 113.4 mm.

With results like these, for any loaded $Q$ and resonant frequency required by filter theory, the antenna spacing and cylinder length to be applied in the physical model can be readily determined.

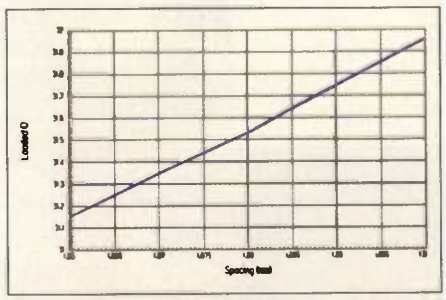

Figure 9. Relation between antenna spacing and loaded Q at a resonator length of 113.4 mm.

## Initial filter design

Now that the circuit is defined and the relations between circuit components and physical dimensions are known, it is possible to construct the filter in the field solver. Filter theory tells us we need to achieve the following parameters:

*Resonant frequency of the outermost resonators: fR1 = 400 MHz.*

*Resonant frequency of the inner resonators*: $f_{R2}$ = 400 MHz.

*Loaded Q*: $Q_L$ = 31.498.

*Coupling coefficients*: $K_{12}$ = 0.02893, $K_{23}$ = 0.02171, $K_{34}$ = 0.02065.

The calibration projects above indi-

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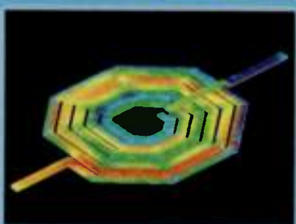

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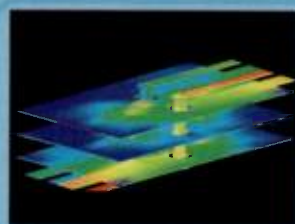

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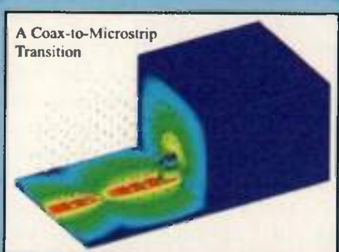

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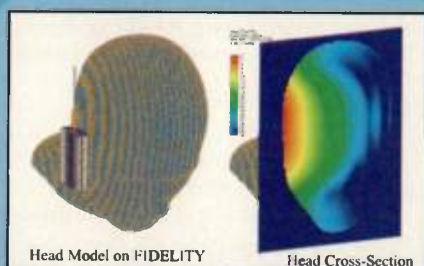

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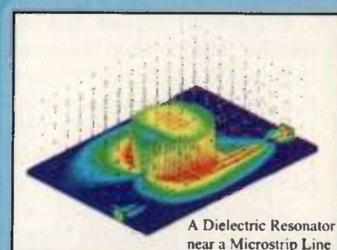

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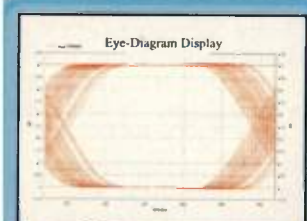

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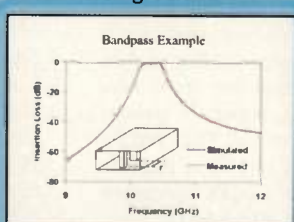


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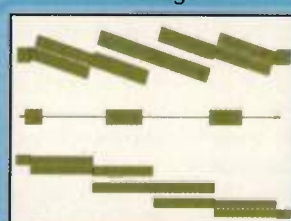

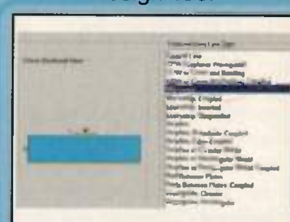

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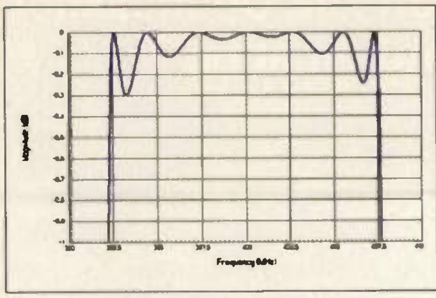

Figure 10. $S_{21}$ results for the initial design.

cate that the dimensions of the filter, as shown in Figure 2, are to be:

*Length of the two outermost resonators*: 113.399 mm.

*Length of the five inner resonators:* 114.69 mm

*Antenna distance*: 1.879 mm.

*Distances between resonators*: 25.513 mm , 28.291 mm and 28.767 mm.

The resulting filter characteristic is shown in Figure 10. Notice that the center frequency and the ripple bandwidth are almost perfect. While the correct number of ripples is shown, the actual value is 0.3 dB rather than 0.1 dB.

## Curve Fitting

The simulator results shown in the previous section have been exported to the circuit simulator, in which we can determine, through curve fitting, what the actual parameters of this initial design are.

Figure 11 shows the curve-fitting results. Notice that there are still a few hundredths of a dB difference between the simulator results and the best fit in the circuit simulator. This indicates that this design method is accurate to a few hundredths of a dB.

The curve fitting procedure indicates that a filter has been constructed with a resonant frequency of the outermost resonators $f_{R1}$ = 400.058 MHz; a resonant frequency of the inner resonators of $f_{R2}$ = 399.926 MHz, a loaded *Q of* $Q_L$ = 30.368, and coupling coefficients of, $K_{12}$ = 0.02825, $K_{23}$ = 0.02173 and $K_{34}$ = 0.02068.

The calibration projects will indicate how much correction is needed to achieve the desired characteristic. For example, noticing that $Q_L$ is 1.132 lower than the desired value of 31.5, the next iteration will aim for a $Q_L$ that is 1.132 higher. This procedure produces a filter with the dimensions of : *length of the two outermost resonators*: 113.44 mm; *length of the five inner resonators*: 114.684 mm; *antenna distance*: 1.928 mm; *distances between resonators*: 25.286 mm, 28.3 mm and 28.78 mm.

Hence, the dimensions that undergo the largest changes are the antenna

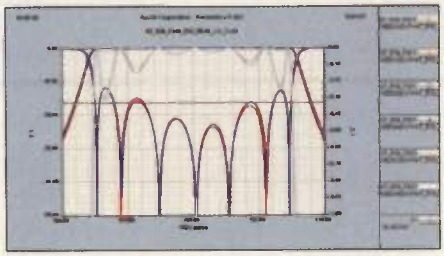

Figure 11. Result of curve fitting, magnitude.

distance and the distance between the first and second resonator.

## Corrected filter design

The corrected filter was again modeled and simulated. The resulting characteristic is shown in Figure 12. Note that the ripple, which was 0.3 dB in the initial design, is better than 0.13 dB now. The target is 0.1 dB.

In most practical cases, this corrected design can be considered good enough to serve as the final design. Notice that it took only one iterative step to get here from the initial design. In case more improvement is desired, the results in Figure 12 can be exported to the circuit simulator for another iterative step.

Once the final design is known, the field solver easily produces additional information: the effects of internal losses, the maximum power handling capability and the effects of mechanical tolerances.

## Conclusion

An efficient method to design microwave filters with modern simulation software, using standard techniques as resonating *LC* combinations separated by impedance inverters has been presented. Then, through a series of calibration projects with the software, relationships are established between components in the circuit simulator and in the circuit solver.

Next, an iterative procedure involving simulation in the solver and curve fitting in the circuit simulator yields the optimum dimensions for the microwave filter. The iterative procedure converges in one step. This entire process can be carried out in a matter of days, as opposed to weeks for more traditional filter design methods.

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[3] Randall W. Rhea, "HF Filter Design and Computer Simulation," McGraw-Hill, Inc., 1995, ISBN 0-07-052055-0.

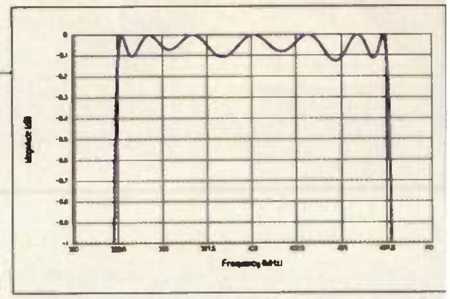

Figure 12. $S_{21}$ results in HFSS for the corrected design.

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station has the responsibility to manage/schedule the access to the medium. This station is the base station for the infrastructure mode and the central controller (decided on automatically by auto-configuration) for the ad-hoc mode. The time is divided into frames. Each frame gathers a set of time slots that correspond to transport channels. A transport channel contains either signaling information or data currently transmitting between the controller and a station. A station that wants to use the medium sends a signaling message (resource request) to the controller. The controller processes the request, allocates some radio resources (a set of time slots) to the requester and sends back the signaling response message. The station can then use these dedicated time slots to send data.

The DLC sub-layer includes some signaling protocols for power control, scanning and joining, and to set up some logical connections where a certain quality of service may be negotiated between the station and the controller. This QOS implies the reservation of time slots for several frames in order to provide an isochronous service.

The Bluetooth protocol stack is composed of the physical layer, the baseband sub-layer (MAC) a logical link control (LLC) sub-layer and a set of application-oriented protocols. Bluetooth proposes only the ad-hoc network architecture mode. However, this may be divided into two different sub-modes. The first defines a peer-to-peer relationship between two stations, whereas the second defines some one-to-multiple stations relationship to provide multicast service. The latter mechanism forms a so-called "scatter-net".

A controller named the master has the responsibility to control the medium access. Any Bluetooth device has the ability to be a master. In fact, the master is the device that initiates the connection during the scanning/joining phase. In case of a scatter-net, the master may control as many as eight "slave" stations simultaneously.

The MAC protocol is a centralized one in which the master controls the medium access by a polling method. The time is divided in time slots. The even slots are dedicated to the master and the odd slots to the slaves. The master polls any slave station sending data and/or signaling information; the slave sends back its response and/or other signaling/data information through the following time slots. The master then polls the following station and so on.

Bluetooth specifies two services: an isochronous service (based on the reservation of dedicated slots) where up to three isochronous connections may be established between a master and one or several slaves, and an asynchronous service allowing only one connection between the master and its slaves. The master poll interval may be negotiated providing a certain level of quality of service (QoS).

## Comparison

Table 3 points out the differences, drawbacks and advantages of the three protocols focusing on audio/video services within home networks. The security drawback for IEEE 802.11 is related to the size of the encryption key which is too small and the authentication nechanism which is not mutual. Hiperlan2 and Bluetooth both specify ın FEC mechanism that might be useul for video transmission.

With its lower bit rates and lower ɔower, Bluetooth is intended to be prinarily a solution for a lower speed data ɔonnectivity between devices in a room. t is not expected to provide complete ıome coverage which may limit its use, ɛspecially for video based applications. The master/slave model has an impact ɔn how the application is designed that mplies some limitations regarding nteractions between stations.

## Conclusions

Wireless Home Networks are driven ɔy applications. The primary driver for he first wave of applications is the sharng of broadband access to the home. There are several solutions from the corɔorate LAN space that can fit in home ıpplications bearing in mind that home ıpplications are cost sensitive. Given the elative complexity of the protocols and he diverse products in the home space, t is also a challenge to guarantee interoperability between devices and services. It is expected that as digital video content becomes more prevalent and available with acceptable business models for distribution, home networks will be needed to make the content available throughout the home in a cost-effective manner. Wireless technologies are expected to coexist with existing home wiring based technologies. As they become more cost-effective, it is expected that home electronics will be sold network-enabled out of the box.

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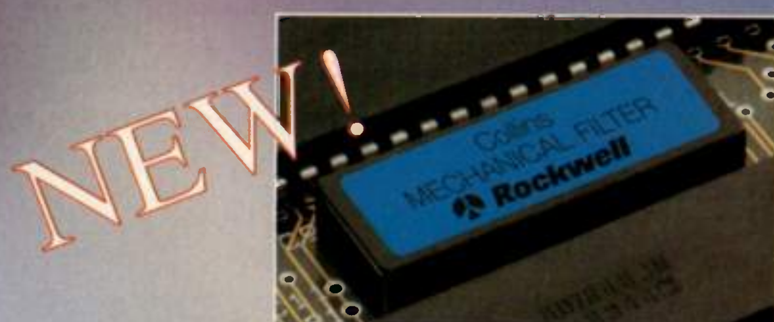

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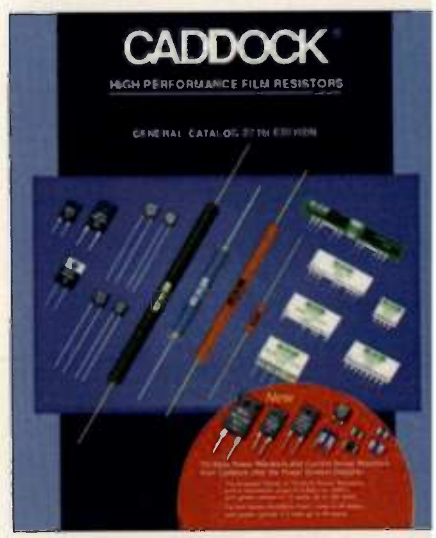


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## New SystemView supports S-parameters

SystemView by **Elanix** is a Windows-based tool for system-level design: mixed signal, system-on-a-chip, communications, RF/analog, and DSP. SystemView is used throughout the design cycle by manufacturers and universities around the world as a multi-disciplinary tool that spans the needs of DSP, Analog, and System designers. SystemView integrates bit-true DSP (including TI eXpressDSP-compliant C code generator), distortion true RF, extensive communication models, full-range filter design, and now S-parameters. S-parameters are modeled as a two-port system including network parameters, source impedance, load impedance and transmission line delay. Frequency gain and phase values are input to S-parameter tokens using the industry standard Touchstone format.
**Elanix**
**www.elanix.com.html**

## Package includes modeling capabilities, DC-to-RF

**Agilent Technologies** introduces an RF extension to the BSIM4 modeling package for deep sub-micron CMOS devices used in wireless and wireline communication products. The RF extraction module, now included within the open Integrated Circuit Characterization and Analysis Program (IC-CAP) modeling software, enables accurate simulation of RF CMOS devices and reduces overall design time. The module is an update to the Agilent 85194K BSIM4 Modeling Package, a leading modeling solution for CMOS devices with ultra-short channel lengths that are well below 0.18 microns. The BSIM4 Modeling Package key features and benefits include the following: a DC extraction module that provides fast and accurate measurement-based extraction of DC, CV, temperature and noise model, with one set of parameters to fit a wide range of device geometries; an RF extraction module that provides highly accurate, high-frequency model parameters; a built-in user interface that enables the whole measurement and extraction process to be fully automated with the push of a button; software that is easy to enhance and customize to accommodate specific processes and requirements; and fast and easy-to-use extraction methodologies, based on direct measurements, that provide a high level of model accuracy across DC, CV and RF BSIM4 model parameters.
**Agilent Technologies**
**www.agilent.com**

## Automated intermodulation test software

**IFR** announces new intermodulation application software for the 2.4 GHz 2309 signal analyzer. The 2309 signal analyzer is suitable for RF designers and production ATE engineers who must measure intermodulation distortion of wireless systems and components such as receivers, amplifiers, frequency converters and mixers. The 2309 intermodulation software uses FFT analysis to perform fast and accurate measurements of intermodulation with dynamic range beyond the capability of conventional swept spectrum analyzers and does so at speeds formerly unachievable by conventional methods. The new application software equips the 2309 with a powerful, fast and accurate method for making intermodulation distortion measurements. For the first time, complex and time consuming intermodulation measurements have been simplified to allow the tests to be automated. The new software builds on the 2309's existing intermodulation distortion measurement capability to provide a user interface that requires very little setup by the user.
**IFR**
**www.ifrsys.com**

## Simulation software for LTCC, 3G and WLAN

With version 6.0, **AC Microwave** has accommodated LINMIC+/N to the increasing needs of multilayer circuit design and to designing circuits with complex excitations. Completely revised 2.5D PEEC simulation engine for multilayer components with extended layout library from basic elements up to complete baluns, transformers etc. and with orders of magnitude speed advantage compared to 3D planar or 3D tools; extended Harmonic Balance algorithm for nonlinear circuits with digitally modulated excitation signals; new nonlinear MESFET/ HEMT/MOSFET models for Harmonic Balance simulation including model parameter extraction from measured data. Additionally, the functions and look-and-feel of the GUI have been further improved: managing design projects is simplified and auxiliary EM information is generated automatically; easy access to internet resources is implemented.
**AC Microwave GmbH**
**www.linmic.com**


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## Bluetooth-enabled modular product family

**SMART Modular Technologies** debuts its latest offering of wireless solutions that transmit and receive Bluetooth RF data. These solutions are available in an assortment of modular form factors, including a Type II PC card, a USB dongle, a serial port adapter, and a mini-module. These Bluetooth modules retrofit current and legacy machines to enable instant access to Bluetooth functionalities for mobile and desktop computer markets. For the small form-factor applications including personal digital assistants (PDAs), cellular telephones and similar portable devices, the company has developed the Bluetooth Mini Module. The Mini Module offers a system solution in a small (12.5 x 21.6mm) form factor allowing designers to significantly reduce time-to-market without comprising crucial board space.
**SMART Modular Technologies**
**www.smartmodulartech.com**

## Cost/space-efficient Bluetooth solutions

**Motorola** has developed a comprehensive Bluetooth RF transceiver in a 6 mm x 7 mm x 1.3 mm low temperature co-fired ceramic (LTCC) module; and a stacked die RF-plus-baseband Bluetooth solution, that includes RF transceiver and baseband ICs. This highly integrated 2.4 GHz RF transceiver module is designed to provide a comprehensive, low-power Bluetooth 1.1 radio for Class 2 systems. The module's receiver features a low-noise amplifier, high/low image reject mixer, complete VCO, post mixer amplifier, self-adjusting channel filter, limiting amplifier, demodulator, and an A/D block. The transmitter function includes a direct modulation FM transmitter controlled by a dual-port fractional-N synthesizer


and VCO, a low power amplifier (0 dBm), and a transmit/receive control function. Low current drain of 27 mA (transmit) and 33 mA (receive), with multiple power down modes conserve power; while an integrated electronic crystal trim provides the capability to compensate for as much as 50 ppm of crystal tolerance.
**Motorola**
**www.motorola.com**

## PC/104 carrier board for GPS, wireless modems

**Diamond Systems** announces the introduction of the PC/104 carrier board, Pyxis-MM. It provides a low-cost, compact solution for embedding a GPS receiver module, a wireless modem module, and/or a landline modem module into a PC/104 embedded system. It offers the advantage of two modules on a single carrier (GPS and wireless

modem), saving critical space for mobile applications. When used with GPS receiver and 2.4 GHz worldwide license-free wireless modem modules, it provides location identification and communications features for vehicle-based embedded systems around the world, such as vehicle tracking, navigation, and precision farming. It can also be configured for standalone operation without a CPU for low-cost applications. In this mode, all that is required is the carrier board, the modules, and a power supply. The GPS receiver and wireless modem are directly connected to each other, allowing the automatic real-time broadcast of GPS data to enable a base station to monitor the whereabouts of a vehicle. It includes all the necessary I/O circuitry to interface the selected modules onto the PC/104 bus, including serial ports and power supplies. A backup power connector is provided to maintain GPS almanac and minimize time-to-first-fix The board runs on +5V and operates over the industrial temperature range of –40 to +85° Model PXMM-XT is the full-featured carrier board for GPS, wireless, and/or landline modem. Pricing is $160 in single quantity and $136 in 100-499 (not including add-on modules). Modules and antennas are available from Diamond Systems or direct from their respective manufacturers.
**Diamond Systems**
**www.diamondsystems.com**

## New Bluetooth design solution

**Royal Philips Electronics** has added a low power Bluetooth system solution to its existing portfolio. The system enables wireless technology designers to focus on taking product functionality to the next level without worrying about complex design issues The solution consists of the Blueberry DATA baseband IC (PCF87752) and its


TrueBlue radio module (BGB101). Thi system makes Bluetooth wireless tech nology a practical option for communi cation, computing and consumer appli cations at home, in the office or on th

# MNA AMPLIFIERS

## MMICs from 500MHz to 5.9GHz

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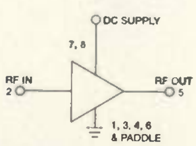


## Built-In RF Choke, Resistors, Bypass & Coupling Capacitors

Simplify your 500MHz to 5.9GHz designs with Mini-Circuits easy to use MNA amplifiers. With DC blocking capacitors and a biasing network built-in, all you do is drop the amplifier in place on your PC board, connect, and the job is done! There's no biasing to figure out and no external components to connect. Broadband, low and high power models offer 10 to 23dB (typ) gain, 7 to 18dBm (typ) power output, and more than 40dB isolation, which makes them terrific for use as an isolator. But these

amplifiers go on to feature a minuscule ***3x3mm MCLP™ SM package with exposed metal bottom for excellent grounding and heat dissipation.*** If you're looking for versatility, MNAs operate from a +5V to 2.8V DC supply, making them indispensable for use in today's miniature battery operated hand-held devices. And if you're looking for value, prices start ***from only $1.60 ea.*** (qty. 30). *So simplify your design, your manufacturing, and your life with Mini-Circuits all-in-one MNAs!*

| MODEL | Freq. (GHz) | DC Volts (V) | Gain Midband (dB) Typ. | Pwr. Out 1dB Comp. (dBm) Typ. | Price $ea. (qty.30) |
|---|---|---|---|---|---|
| MNA-2 | 0.5-2.5 | 5.0<br>2.8 | 12.8<br>11.5 | 17.7<br>12.9 | 1.90 |
| MNA-3 | 0.5-2.5 | 5.0<br>2.8 | 16.2<br>15.2 | 11.4<br>9.7 | 1.60 |
| MNA-4 | 0.5-2.5 | 5.0<br>2.8 | 16.6<br>14.6 | 17.0<br>13.4 | 1.90 |
| MNA-5 | 0.5-2.5 | 5.0<br>2.8 | 22.8<br>21.4 | 12.2<br>10.1 | 1.60 |
| MNA-6 | 0.5-2.5 | 5.0<br>2.8 | 23.5<br>21.5 | 18.0<br>14.1 | 2.25 |
| MNA-7 | 1.5-5.9 | 5.0<br>2.8 | 17.2<br>15.4 | 15.6<br>12.7 | 2.25 |

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move. Blueberry DATA is a new baseband family member suitable for hosted and several embedded applications for mobile communications, consumer and computing. It combines low power consumption levels with 224K bytes embedded flash and a USB 1.1 interface with embedded transceiver. The PCF87752 supports a wide range of discrete radio ICs and radio modules. Blueberry DATA's recognized Bluetooth core will help ensure interoperability with all major mobile phone and PC manufacturers' Bluetooth compliant devices. The BGB101 is a pre-qualified, fully tested and plug-and-play Bluetooth radio module.
**Royal Philips Electronics**
**www.semiconductors.philips.com**

## Onboard micro-controller with radio transceiver

**Honeywell** has announced a transceiver module, the Radio-On-Chip System-in-Package (ROC SIP), developed for battery powered wireless applications in digital data communications. The device combines a radio transceiver and a micro-controller for a single system-in-a-package unit offering wireless designers high levels of integration and a shortened, simpler transceiver design process. The chip design includes a half-duplex radio on a chip, a 900 MHz transceiver and a built-in 8051 based Cygnal C8051F300 micro-controller integrated into a single 52-pin leadless TAPP package. Customers can re-use their existing 80C51 code, without modification, in the ROC SIP product. The micro-controller and transceiver pair is a highly functioning set guaranteed to operate together. The micro-controller has an 8K ISP flash memory, a high-speed pipelined 8051 CPU, and on-chip JTAG based debug in each device. It's configurable with two flexible user inputs for easy connectivity. The transceiver has a high number of built-in digital features including Manchester encoder and decoder and message storage.
**Honeywell**
**www.honeywell.com**

## Wireless bi-directional repeater

**ADTRAN** announces its new wireless bi-directional repeater 2400 (BDR 2400). The BDR 2400 allows ADTRAN's T1 or E1 TRACER systems to transmit over and around microwave path obstacles, cutting the cost of additional equipment required for a repeated circuit by as much as 50 percent. Previously, obstacles to wireless signals were dealt with by deploying complete back-to-back radio systems. By combining two transceivers into one housing, TRACER can now relay voice and data through just one repeater, saving valuable networking dollars. TRACER features direct sequence spread spectrum digital technology for point-to-point wireless connectivity. It operates in the 2.4 GHz band, license-free band. The TRACER product line is available in mastmount and rackmount configurations to provide E1 or dual T1 communication links.
**Adtran**
**www.adtran.com.**


# MEMS FOR WIRELESS APPS

## 300 kHz to 6 GHz RF MEMS single-pole, double-throw (SPDT) switch

**Teravicta** has developed the TT612, an ultra-low loss, 300 kHz to 6 GHz RF MEMS single-pole, double-throw (SPDT) switch.

RF MEMS switches combine the performance advantages of electromechanical relays with the manufacturability advantages of solid state switches. MEMS switches also provide ultra-low losses, high isolation, and high linearity of relays, but with the significant size, power consumption, and cost advantages of high volume wafer fabricated solid state switches such as GaAs FETS and PIN diodes. MEMS-based technology has inherent performance advantages for wireless applications in that they are broadband.

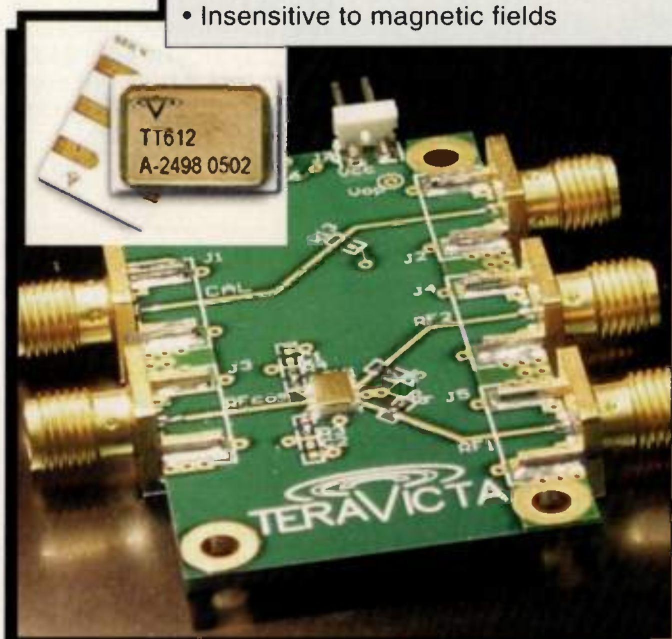
MEMS-based products synergistically combine both mechanical and electronic devices on a monolithic microchip to provide tremendous performance advantages over solid-state components, especially for wireless applications. The immediate benefits of RF MEMS switches for end-users are longer battery life and greater connection quality as well as extended range of communication, fewer dropped calls, enhanced call quality, and increased bandwidth for wireless data applications. RF MEMS will also more easily meet the requirements placed on them by the need to deliver high-quality broadband data in 3G systems.

The key advantage of the TT612 is its extremely low insertion loss. switches have losses of 0.15 dB to 0.3 dB (or 1% to 4%) at frequencies from 2 GHz to 6 GHz. Traditional GaAs switches and PIN diodes have losses of 0.6 dB to 1.5 dB (10 to 35%) depending on frequency and power. This allows MEMS switches to significantly increase the range (20 to 30%) or battery life (15 to 25%) of radios.

This switch combines ultra-low losses with flat linearity (IP3 >65 dBm) and high-power handling capability (3 W continuous RF power), encased in a surface-mount package. Applications include multi-band/multi-mode switching, diversity switch, CDMA systems, CATV set top boxes, cellular/wireless handsets, smart antennas, and general RF signal routing & switching.

**Terravicta**
**www.teravicta.com**

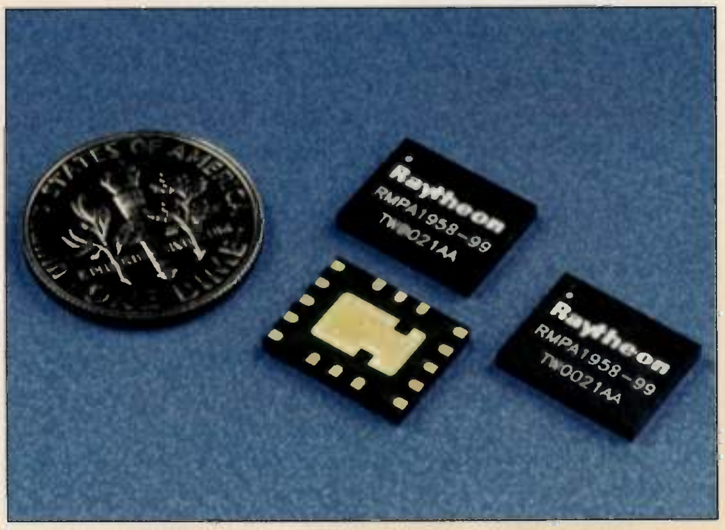
**Device highlights:**
- Low-loss – 0.1 dB @ 900MHz, 0.3 dB @ 6 GHz
- 300 kHz to 6 GHz RF frequency response
- High linearity, IP3 >65 dBm
- Insensitive to magnetic fields




**Ultra-low loss, DC to 6 GHz RF MEMS single-pole, double-throw (SPDT) switch**

## High-efficiency GSM/GPRS power amplifier

**Raytheon** has introduced RMPA1958-99, a high efficiency power amplifier module for GSM/GPRS quad-band applications. The module, which has an overall frequency range of 824 to 1910 MHz, uses InGaP MMIC technology with a CMOS control circuit in an integrated design, affording greater flexibility and user convenience. Features include internal 50Ω input and output matching with internal DC-blocking, and a leadless chip-carrier module with on-board band select and output power control, reducing handset design complexity and minimizing loss. The device operates at a supply voltage of 3.5 VDC and delivers an output power of 35 dBm for GSM applications and, 32.5 and 31.5 dBm, respectively, for DCS and PCS. Its power-added efficiency is 55% for US cell/GSM and 50% for DCS/PCS. The full range of output power control is set with a variable power control voltage of 1.9 VDC max, and the total leakage current at shutoff is in the uA range. The InGaP GaAs HBT-process offers an inherently lower temperature sensitivity, easier manufacturability and higher reliability. The unit is packaged in an 11.6 X 9.1 X1.6 mm leadless chip-carrier (LCC) module to maximize available handset board.
**Raytheon**
**www.raytheonrf.com**




## MILITARY/SPACE

### Phase matched military multiplexer

**K&L Microwave** has unveiled a low-profile multiplexer with an ultra wide usable passband from 500 MHz to 2000 MHz. Units can be purchased as stand-alone units, matched pairs or

matched sets with a maximum of six units per set. Sets can be phase matched to within ±15° across the entire passband. Units are designed to withstand stringent military requirements and are fully spec compliant over the operating temperature range of –55° to +55° C. This device features a 6061 aluminum housing that is laser welded to meet hermeticity specifications in addition to various environmental conditions of MIL-STD-202.
**K&L Microwave**
**www.klmicrowave.com**

### Digitally tuned oscillator product line

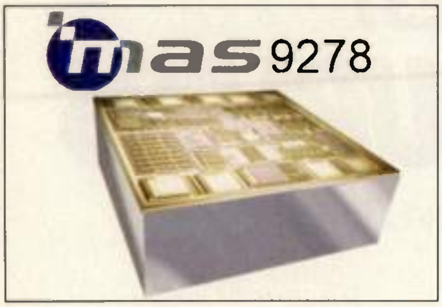
**Signal Technology** has released a line of digitally tuned oscillators (DTO) developed primarily for military digital receiver front ends for radar applications and for electronic warfare (EW) simulator markets. These components are designed for applications that

require speed, broadband jamming, and fast frequency hopping. The DTO design incorporates a custom integrated assembly architecture using a dual source approach with hybrid and monolithic multi function microwave and control component circuitry. This achieves the broadband tuning and stability required. The dual source approach allows for lower operating power consumption, improved reliability and smaller package size. Designs with continuous frequency coverage from 2 to 18 GHz with 2 to 6 GHz, 2 to 9 GHz, and 6 to 18 GHz options covering full military temperature ranges are currently available.
**STC**
**www.sigtech.com**

## SIGNAL SOURCES

### Tiny IC for cellular phone VCXO modules

**MAS** has launched the MAS9278, a miniature IC less than 1.5 mm$^2$. It is designed for VCXO modules used in high-volume markets like cell phones as a low cost replacement for more expensive VCTCXO modules. Because it does not include temperature compensation its small size offers OEMs a low system solution cost. It has a memory for the offset trimming of the crystal tolerance making it possible to achieve high stability at room tempera




ture. It features a typical power consumption of only <0.9 mA for extended battery time, low phase noise of <–130 dBc/Hz at 1 kHz and is delivered in as die form. Price for 1000 pcs is $0.82 each.
**Micro Analog Systems**
**www.mas-oy.com**
*info@mas-oy.com*

# AMPLIFIERS

## Feature-improved 2.4 GHz ISM band amplifier

**Ophir$_{RF}$** has redesigned the model 5302015 ISM band amplifier primarily for video transmission in the 2.4 GHz unlicensed band. This module has been redesigned to make it smaller, lighter, and operate up to +80° C. Added features include forward power monitoring and an enable/disable control. It features a minimum small signal gain of 41 dB and 8 W of linear output power. Operating off of a single 13 VDC supply, this module has

fixing holes for mounting to a cold plate, or it can be provided complete with a heat-sink and cooling fans. When provided in system form, an Ethernet connectivity option allows remote control and monitoring of the amplifier from anywhere. suitable applications include wireless LAN backhaul, cell site interconnectivity, and testing products for susceptibility to 802.11b and Bluetooth signal radiation. Priced at less than $1,200.
**Ophir**
**www.ophirrf.com**

## Dual 400MHz, 2500V/µs voltage feedback Amp

**Linear Technology** has released the LT1819 is a dual, high-speed (gain bandwidth product = 400MHz, slew rate = 2500V/$\mu$s), unity gain stable, voltage feedback op amp with low total harmonic distortion of –85dB at f = 5MHz and $V_{OUT}$ = 2Vpp, RL = 500Ω. Supply current is 9 mA/amplifier. In addition, the amplifier features low noise (6 nV/Hz @10 kHz), 1.5 mV max input offset voltage and a guaranteed minimum output current of 50 mA. This combination of features makes the LT1819 applicable for use in high-speed filters, ADC drivers and DAC buffers as well as in high-end video and wireless base station amplifiers.
**Linear Technology**
**http://www.linear.com**

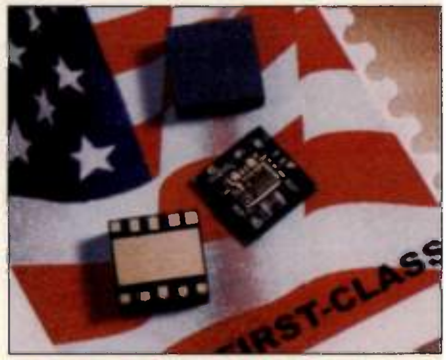
## Compact 8 W class A amplifier

**Stealth Microwave** has released the SM0822-39, a compact class A amplifier operating from 800 to 2200 MHz. Output power, at P1dB, is +39 dBm (min.) with a +53 dBm (min.) OIP3. Linear gain is 45 dB with 1.5 dB peak to peak flatness. Supply voltage is

+12 VDC @ 3.5 Amps. Features include mismatch protection, temperature compensation, over/reverse voltage protection, thermal protection with auto reset, and logic on/off control. Forward Power Detection is also available.
**Stealth Microwave**
**www.ssbtech.com**
*sales@ssbtech.com*

## Linear PAmodule for CDMA 3G handset applications

**Celeritek** has debuted a new 4mm square, linear, power amplifier module designed for transmit functions in CDMA2000 cellular multimode, data-enabled handset applications. The model CHP0205-QM operates from 824 to 849 MHz and offers 36% linear power added efficiency, +28 dBm out-



put power, lower RF power efficiency enhancement, 50Ω internal matching and on-board DC power down mode. The device is packaged in a 4mm x 4mm x 1.5mm power module.
**Celeritek**
**www.celeritek.com**

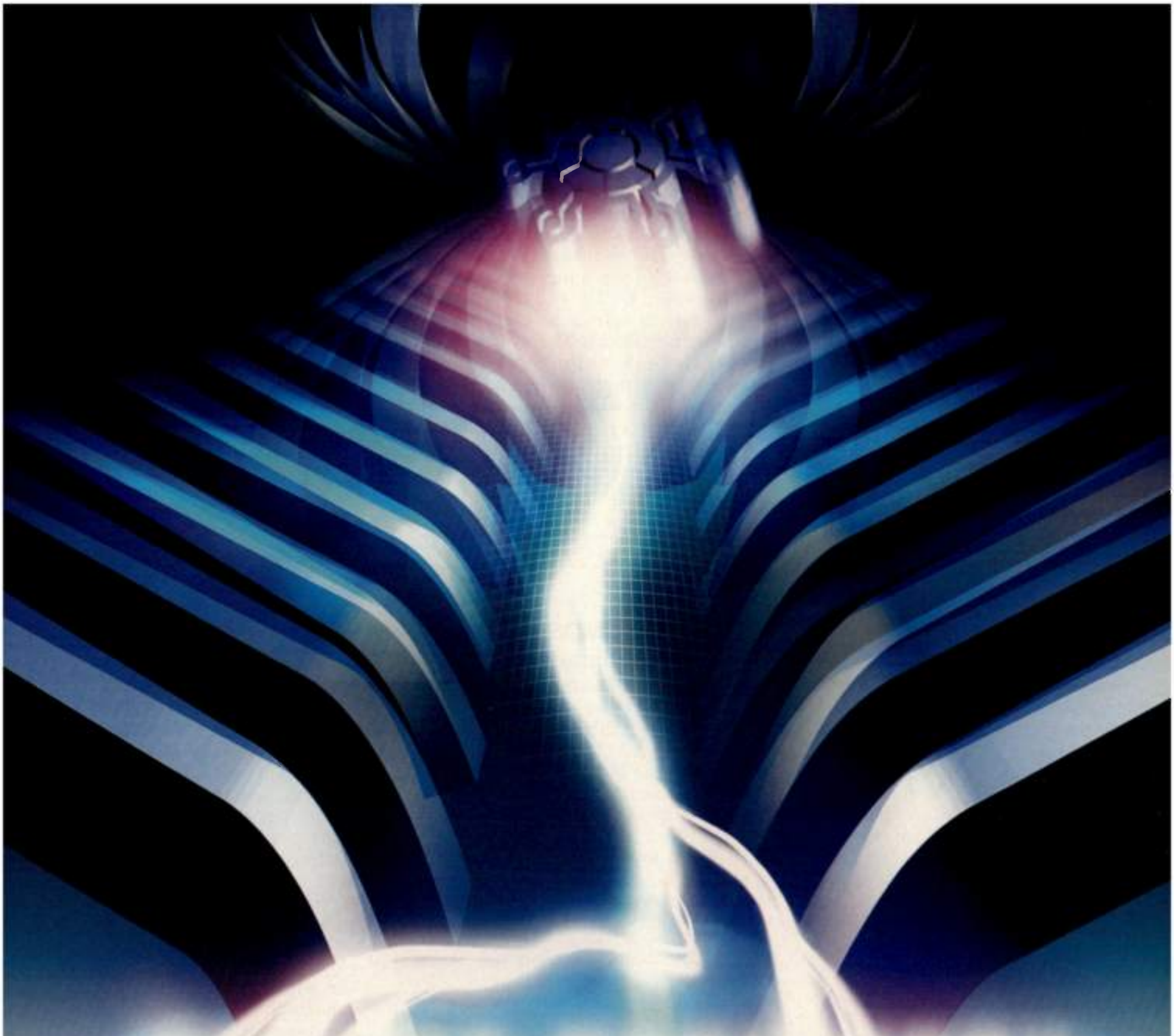
## WJ expands the AG series low-cost gain blocks

**WJ Communications** offers five new AG Series low-cost gain block amplifier models. The AG201, AG202, AG203, AG503, and AG604 are the next installment in a broad family of general-purpose buffer amplifiers. They are designed to provide broadband gain at frequencies from DC to 3 GHz. The family covers 11 performance combinations spanning 10 to 20 dB gain, +6 to +19 dBm P1dB, and +20 to +34 dBm OIP3. While targeted at telecommunications infrastructure and CATV markets, the series will work for other applications within the DC to 3 GHz operating range. They can be directly applied to various current and next generation wireless technologies such as GSM, CDMA, W-CDMA, UMTS and GPRS. Unit prices for the AG Series models purchased in 10,000 piece order quantities are less than $1 each.
**WJ Communications**
**www.wj.com**

# TEST AND MEASUREMENT

## Wireless Internet protocol test solution

**Anritsu Company** has introduced the cdma2000 1xRTT wireless Internet protocol (IP) test solution designed specifically to help wireless Internet application developers create, troubleshoot, and verify application



# ANSOFT DESIGNER™

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designs. By using the wireless IP test solution, engineers can accelerate the development cycle. The test set model number MX880121A-02, is a software option to the 1xRTT version of Anritsu's MT8801C radio communication analyzer. A variety of functions can be performed using Anritsu's cdma2000 1xRTT wireless IP solution.

Typical applications include mobile device application software evaluation, wireless web development and high-speed data products such as wireless modems or associated application software evaluation The MX880121A-02 is a $5,000 software option to the MT8801C Radio Communication Analyzer equipped with cdma2000(tm) 1xRTT hardware and software. The 1xRTT Wireless IP test system is available for less than $45,000
**Anritsu**
**www.us.anritsu.com.**

## Digital broadband T&M ISM Workstation

**Celerity Systems** has introduced the CS20310C ISM Workstation. The system features 100 MHz of real-time bandwidth and 4 GB of memory. It can monitor and record up to 16 seconds (or 25,600 hops) of all signals within the 2.4 GHz ISM band, including BluetoothTM,

802.11b, 802.11g, and HomeRF signals. The system's high-performance, 300 Ms/s ADC captures all signals in real-time to preserve complete time, frequency, modulation and transient information while delivering 55 dB SFDR. The workstation uses the Windows NT OS, a high-speed Pentium processor, GPIB and 10/100baseT Ethernet to deliver an open workstation environment. The system can be operated manually, automatically, remotely or networked, and is easily upgraded for wider bandwidths, additional memory, and other frequency bands.
**Celerity Systems**
**www.celeritydbt.com**

# *SEMICONDUCTORS/ ICs*

## Versatile LDMOS FET amp for communications

**California Eastern Laboratories** has added another silicon LDMOS FET to its family of NEC low-cost, medium - power devices. Useable from UHF to 2.5 GHz, the NE552R479A is designed as a transmitter output stage for cell phones, two-way radios, wireless LAN, and fixed wireless transceivers. Designed to accommodate battery voltages from 3 to 8 VDC, it's useable in a wide variety of handset and portable applications – plus it does not require a negative supply voltage. It features high output power, high linear gain, and high power-added efficiency in a low-cost plastic, surface-mount package. The design of its miniature 5.7 x 5.7 x 0.9 mm surface mount package results in a low 10° C/W (max) thermal resistance figure. It is priced at $2.00 in 10K piece quantities.
**CEL**
**www.cel.com**

Specifications at a glance:

- Rated at 5VDC, 2.44GHz
- $P_{out}$ +27 dBm
- $G_L$ = 11.5 dB
- Output IP3 = +36 dBm

## Multifunction self-aligned high density MMICs

**M/A-COM**, has announced a family of X-Band MMICs. Two are MMIC low-noise amplifiers covering the 8.5 GHz to 12 GHz frequency range and incorporating on-chip limiters capable of 10 W CW power handling. Two other MMICs offer an integrated 6-bit phase shifter, 5-bit attenuator, buffer amplifier, and on-chip TTL-compatible control logic. All products are fabricated with M/A-COM's Multifunction Self-Aligned Gate (MSAG) GaAs MMIC process. MSAG enables the development of high-performance and low-cost standard products that integrate both microwave and digital circuit functions on high-density die. Contact the factory for volume pricing. Sample availability is from stock.
**M/A-COM**
**www.macom.com**

## High-frequency PWM power supply controller

**Microsemi** has announced a new highly integrated high-frequency power supply controller combining a synchronous PWM switching regulator with an adjustable linear regulator driver. Designated the LX1673, the DC/DC controller is designed to reduce circuit component costs in video card power supplies, double data rate (DDR) memory termination, computer peripherals, computer add-on cards, low voltage applications, and 3.3 VDC power conversion applications. The device features two independently regulated outputs as low as 0.8 VDC from an internal 1% reference. The PWM output is capable of sourcing up to 15 A, while the adjustable low dropout regulator can simultaneously supply up to 5 A for input/output, memory and other supplies surrounding microprocessor designs. It is available for immediate sampling and delivery in a space-saving 20-pin MLP (Jedec MO-229) surface-mount power package, with >10K quantity pricing at $0.99.
**Microsemi**
**www.Microsemi.com**

# *TX/RX*

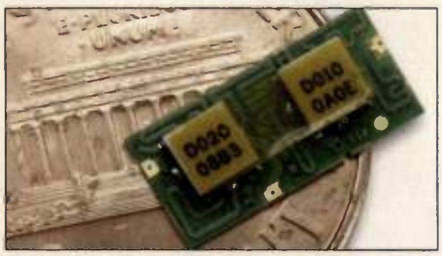
## Combination antenna for 802.11a, b, BTand U-NII

**Centurion** has enhanced its Bluechip antenna so it simultaneously supports all three frequency bands of 802.11(a) as well as Bluetooth, 802.11(b), HyperLan and Unlicensed Network Information Infrastructure (U-NII) broadband applications. The new antenna can be used to access

802.11 (a) and 802.11 (b) networks in North America, Europe and Asia that use different bands within the 2 GHz and 5 GHz ISM bands. The internal antenna offers high-gain 2.0 dBi, and wide bandwidth in a package the size of an eraser tip. The antenna is intended for PCB surface-mounting that can be adjusted to both vertical and horizontal positions without compromising performance. The antenna is available in tape and reel packaging.
**Centurion**
**www.centurion.com**

## Miniature FBAR duplexers for handsets and PDAs

**Agilent** has released a new film bulk acoustic resonator (FBAR) family that allows designers to create ultra-slim cell phones and data cards for PDAs. These duplexers measure 5.6 x 11.9 x 2 mm and are targeted at PCS handset and data card applications operating in the 1900 MHz frequency band. The HPMD-7904 and HPMD-7905 FBAR duplexers enhance the sensitivity and dynamic range of CDMA receivers. They also provide high trans-



mit and receive isolation, offering high sensitivity and excellent desense immunity and low insertion loss. The HPMD-7904 is priced at $3.80 each, while the HPMD-7905 is $3.30 each, in quantities of one million.
**Agilent Technologies**
**www.agilent.com**

## Lightweight and low-cost directional antenna

**Pacific Wireless** has introduced a directional antenna system operating in the 2.4 GHz frequency range for wireless Internet service providers including customer premises equipment (CPE), wireless bridges and point-to-point wireless links. With operating frequencies of 1700 to 2700 MHz available, additional usage of the antenna system includes transmit and

receive applications such as wireless local loop (WLL), point-to-point repeaters, point-to-point receive sites, streaming video and MMDS applications. The Model PAWDCA-24 features 24 dBi gain, 8 degrees of beam width, greater than 24 dB front-to-back ratio, is 42 x 24 inches (including dipole) and weighs 5.5 lbs. Additional specifications include: input return loss of –12 dB; operating temperature of –45 to +70° C; and Pacific Wireless' adjustable tilt attaching hardware for mounting on the customer's pole. Quantities of 1 to 9 are priced at $82 and $57 per unit in 100 piece quantities, and are available from stock.
**Pacific Wireless**
**www.pacwireless.com**

# POWER

## New battery for telecomm Industry

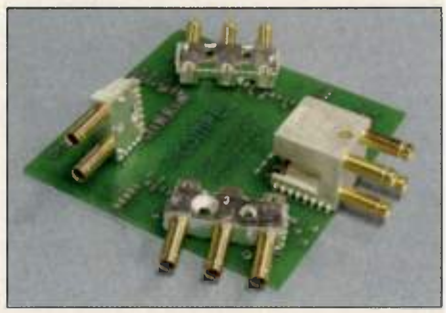
**AVESTOR** has announced that it is ready to commercially produce its first-generation lithium-metal-polymer battery, the SE 48S70, specifically designed for the telecommunications industry. The SE 48S70 battery provides superior performance in ambient temperatures ranging from –40 to +65° C using just one-third the space and with one-fifth the weight of traditional valve-regulated lead-acid (VRLA) bat-


teries. The SE 48S70 battery has an expected service life of about 10 years – even under extreme environmental conditions.
**Avestor**
**www.avestor.com**

# INTERCONNECT/ INTERFACE

## 1.0/2.3 family offers SMT compatibility

**Compel Electronics** is pleased to announce the availability of its 1.0/2.3 SMT-compatible multi-interface connector series. This SMT design facilitates PCB assembly and also accommodates tight packaging density. These new connectors are available with 2-, 3- and 4-coax interface combinations in the same housing. Frequency coverage is from DC to 2 GHz in standard 75Ω impedance value and DC to 10 GHz in optional 50Ω impedance. Custom vari-



ants are available upon request. Standard housings are cast from a light weight alloy, and a liquid crystal polymer housing is also available in the 4-coax version. Units are available in tape and reel packaging.
**Compel**
**www.compelna.com**
*sales@compelna.com*

## 90° 75Ω BNC bulkhead jack

**Trompeter** has introduced the UCBBJR29, a new PCB-mounted right-angle bulkhead BNC jack. This jack is designed for true 75Ω performance and carrier class applications. The jack is applicable to OEM equipment applications that involve high data rates, high bandwidths and/or high frequencies, with low return loss. The bulkhead feature allows torque of the BNC coupling mechanism to be transferred to a panel

front in lieu of the board, ensuring the integrity of the board to connection

junction. The BNC series is capable of 4 GHz of upside frequency in current designs. Pricing is $11.25 each in 5,000 pc quantities.
**Trompeter**
**www.trompeter.com.**

## DC block affords voltage protection To 18 GHz

**Mini-Circuits** BLK-18 coaxial DC block blocks DC in the extremely broad 10 MHz to 18 GHz frequency range. These coaxial DC blocks provide low insertion loss (less than 1 dB up to 18 GHz) and excellent return loss (24 dB typ). The units come with SMA (F) to SMA (M) connectors, measure a small 1.18" in length, and uses Mini-Circuits patent pending unibody construction for rugged applications within the wide –55° C to +100° C temperature range. They are priced from $21.95 ea. (Qty. 1-9).
**Mini-Circuits**
**www.minicircuits.com**

# *DIGITAL HARDWARE/SOFTWARE*

## Power savings in high-performance data converter

**Analog Devices** debuts an advanced CMOS data converter that provides performance typical of bipolar-process converters while achieving 55% lower power consumption than comparable converters. The AD9244 analog-to-digital converter (ADC) provides 14-bits of accuracy at a speed of 65 million samples per second (Ms/s) while consuming only 590 mW of power. It offers cost-effective IF sampling system architectures in wireless base stations by supporting frequencies as high as 200 MHz. Its low power consumption makes it well suited to pico-cell and micro-cell designs with multiple base stations on one tower or location. It uses a multi-stage differential pipelined architecture with output error correction logic to provide 75 dB SNR, 90 dB SFDR and 14-bit accuracy at 65 Ms/s. The AD9244 is available in a 48-pin LFQP package. The 40-/65-Ms/s versions are priced at $20/$29 per unit in 1,000-piece quantities.
**Analog Devices**
**www.analog.com**

## Dual-core processor offers real-time DSP performance

**Texas Instruments** has unveiled the dual-core OMAP5910 embedded processor. It combines, in a single device, the real-time processing capabilities and low power consumption of the TMS320C55x DSP core, the flexibility and scalability of a TI-enhanced ARM925 microprocessor. The device is the newest addition to the family of OMAP processors, which has garnered strong momentum in the 2.5G/3G handset and PDA markets. The single chip delivers system-on-a-chip functionality with peripherals including: 192 KB of RAM, USB 1.1 host and client, MMC/SD card interface, multi channel buffered serial ports, real-time clock, GPIO and UARTs, LCD interface, SPI, µWire and i²s.
**Texas Instruments**
**www.ti.com**

## FPGA delivers new FFT with tenfold speed advantage

**Pentek** has released GateFlow, a family of extendible FPGA products that features a streamlined FFT implemented on its FPGA-based dual-channel wideband receiver and the GateFlow FPGA design kit to facilitate custom algorithm development. Available as a factory-installed option to the Pentek Model 6235 dual channel, 12-bit, 100 MHz Wideband digital receiver, the gateflow FPGA FFT engine offers a powerful front end for many signal processing systems. It includes two complete acquisition and receiver channels in a VIM-2 (velocity interface mezzanine) module compatible with Pentek's 429x series PowerPC and C6000 VME processor boards. With two 100 MHz A/Ds on the model 6235, the GateFlow FFT can handle both A/Ds with 50 percent input overlap processing and zero data loss. The execution speed for the 1k-point complex FFT is 2.56 µsec, also four times faster than real-time at 100 MHz. The model 6235 dual channel receiver with 1k gateflow FFT starts at $11,995. The Model 6235 with 4k GateFlow FFT starts at $12,995.
**Pentek**
**www.pentek.com**

# *EMBEDDED SYSTEMS*

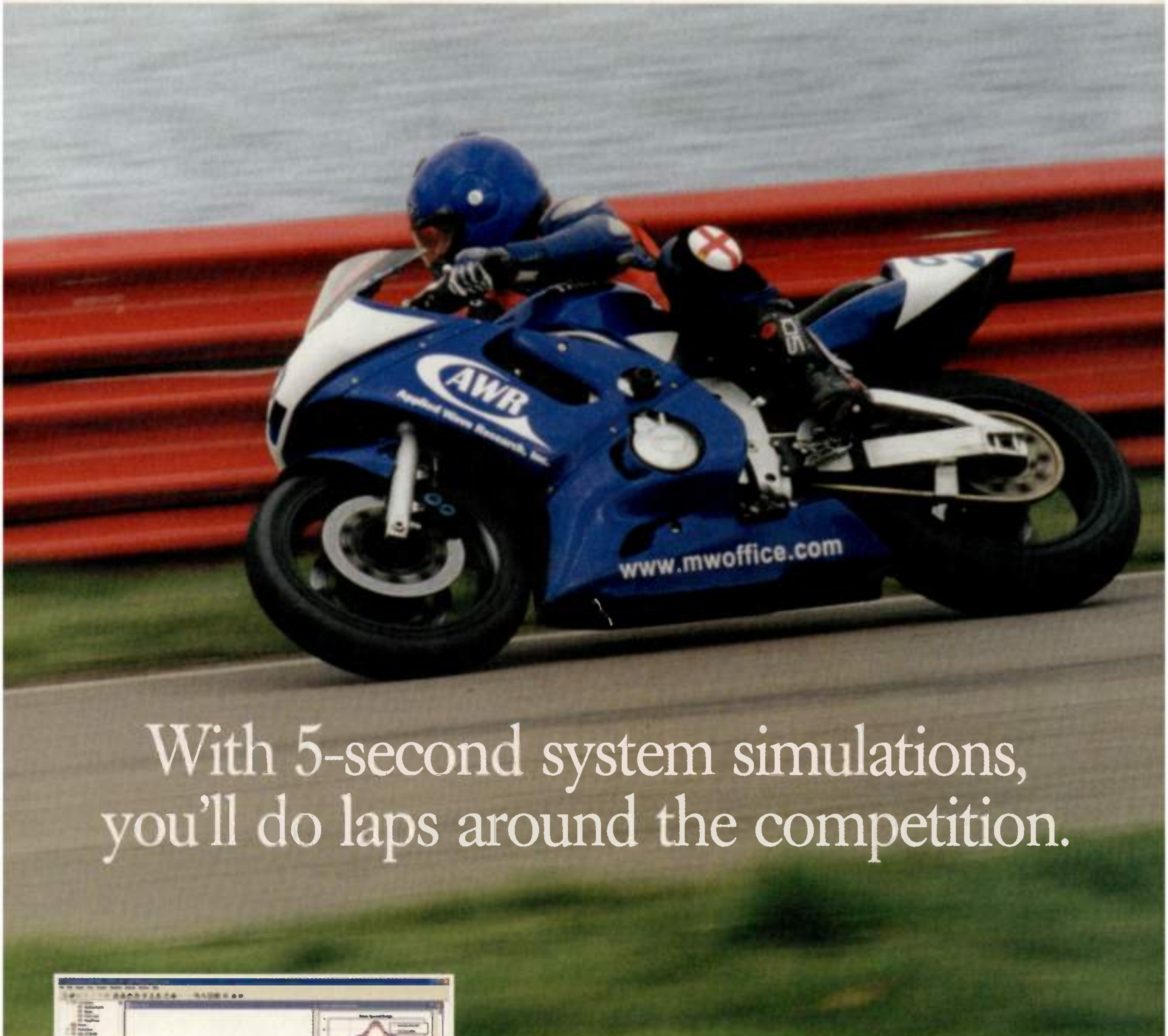
## Probe for the StarCore-based MSC8102 DSP

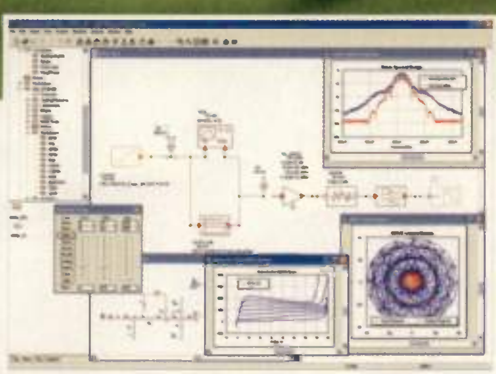
**Green Hills Software** has announced the availability of its MULTI 2000 Integrated Development Environment and high-speed Green Hills Probe for the StarCore-based MSC8102 digital signal processor, Motorola's highest performance DSP. The new IDE, featuring C and C++ optimizing compilers and a multi core debugger, provides a DSP-optimized superset of MULTI's powerful editing, debugging, profiling, and project management capabilities. The MSC8102 combines four StarCore SC140 cores running at speeds of 300 MHz with four enhanced filter coprocessors (EFCOPs), delivering a peak performance of six billion multiply accumulates per second (MMACs). This performance level, coupled with the MSC8102's large on-chip memory (1436 KB), four high-speed TDM interfaces, 16-channel DMA, and high performance system and peripheral bus interface, make it applicable to a wide range of compute-intensive telecommunications applications. MULTI pricing for Windows and Linux hosts starts at $5,900 (US). MULTI for Solaris, and HP-UX starts at $9,900 (US).
**Green Hills Software**
**www.ghs.com**

## Low-power, single-board computer for embedded control

**Z·World's** low-power single-board computer, the LP3500 Fox, is designed to operate in power limited devices such as portable, hand-held, battery-powered, and remote monitoring sys-

AWR



Tune the bias on a transistor. See the effect on the system BER—virtually in real time. That's the speed of the new Visual System Simulator 2002. It's from AWR, so it doesn't demand a month of training or a ton of memory to get up to speed. And the Windows interface is so intuitive you'll have the phase noise specs and amplifier linearity requirements nailed down in no time. Apply complex modulation schemes. Change encoding algorithms. Or throw in a little interference. VSS tells you the impact quickly, efficiently and—most important—accurately. Whether you're simulating an EDGE base station, 802.11 RFIC or OC-768 network, VSS lets you get the high-level perspective while keeping the wheels firmly on the ground. Download a 30-day evaluation from www.appwave.com or call us at 310-726-3000 for more information.

Visual System VSS Simulator 2002

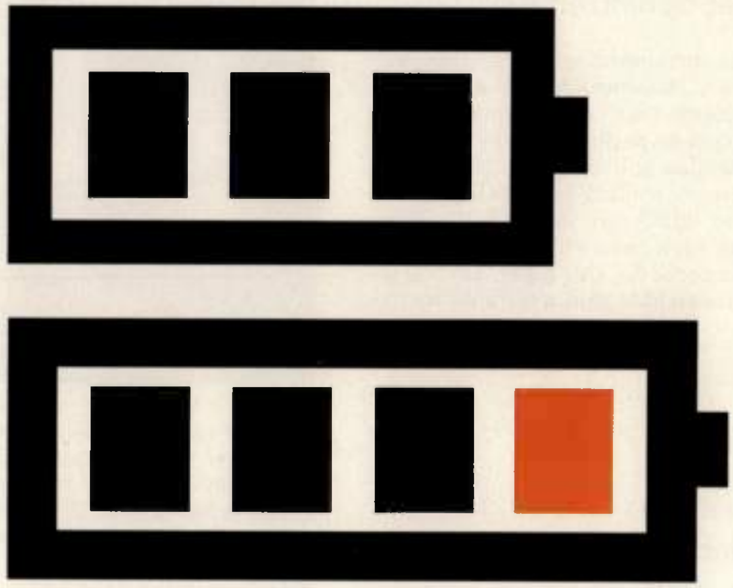
tems. Featuring built-in analog and digital I/O, it consumes less than 20 mA when fully operational and less than 100 $\mu$A in power-save mode. It incorporates the low-EMI Rabbit 3000 microprocessor, up to 512K each of Flash and SRAM, 26 industrialized digital I/O, A/D converter inputs and PWM outputs, six serial ports, one relay, and two dedicated function ports for easy connection to serial Flash cards, keypad/display and other devices. The Fox runs at up to 7.4 MHz at a variety of power levels under software control, thereby accommodating a wide range of operating conditions. The board is equipped with 0.1" connectors, and users can supply their own cables or plug the SBC directly into sockets on their motherboard. It can be used for remote telemetry (RTUs), pipeline monitoring, GPS/asset tracking, handheld wireless devices, remote data acquisition, electrical transmission line monitoring, and other applications that require low power control. An optional 3.3 V keypad/display module is available. LP3500 models arc are priced from $149 (qty. 1) to $122 (qty. 100).

**Z-World**
**zworld@zworld.com**
*www.zworld.com*

## Connectivity for low-power devices

**CMX Systems** and **Cyan Technology**, have launched the CMX-MicroNet TCP/IP stack on the eCOG1 16-bit engine. The **Cyan-CMX** solution sharply reduces the cost of networking devices and Internet connectivity. To facilitate customer support, Designed for the low-power, real-time communications needs of developers, Cyan Technology offers a 16-bit flash microcontroller capable of running code at less than 10 µ and 25 MIPS execution speed. The CMX-MicroNet is a small footprint TCP/IP software stack, developed to provide networking and Internet connectivity for the most stringent real-time communication demands that the 8- and 16-bit designer faces. With the CMX-MicroNet stack and a rich assortment of communication peripherals, serial interfaces and timers, eCOG1 makes an ideal communications engine for Internet-enabled devices, handheld instrumentation, intelligent sensors, and PDA peripherals. The CMX-MicroNet TCP/IP stack is available directly from Cyan Technology starting at $5,500. eCOG1 sells for $10 per 10,000. The comprehensive eCOG1 Development Kit offers an eCOG1 development board priced at $299 and a free set of software development tools that includes an assembler, verified ANSI-C compiler, software simulator and in-circuit emulator/debugger.

**Cyan Technologies**
**www.cyantechnology.com**

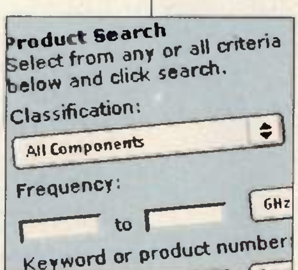


# With up to 25% longer talk time, there's a new icon in handset PAs.

Today's consumers demand extended battery life from their handsets. Now you can give it to them with Raytheon RF Components' PowerEdge power amplifiers, our latest HBT amplifiers with intelligent bias-control technology.

PowerEdge PAs give you up to 25 percent more talk time per battery recharge...as well as greater functionality. These small-outline power amplifier modules feature advanced DC power management to optimize transmitter performance—without sacrificing linearity—while operating at backed-off output levels. In concert with power-sensing and baseband controllers in handsets, PowerEdge PAs automatically adjust amplifier bias in accordance with input signal requirements. This ability to reduce current consumption under certain conditions is critical to extending battery life in the next-generation handsets.

And PowerEdge PAs cover the four CDMA bands around the world.




*Our Web site features a powerful search engine to help you find the right component...right now.*

To receive technical specifications go to: www.raytheonrf.com/talktime or email: talktime@raytheonrf.com

**PowerEdge**

**Raytheon RF Components**

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Circle 39 or visit freeproductinfo.net/rfd

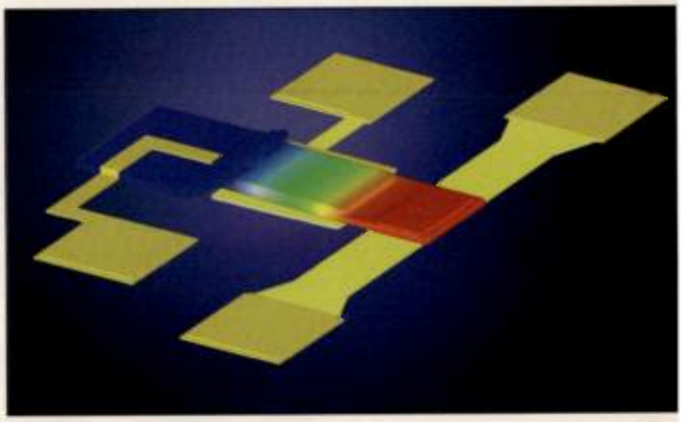
## SOC system controller optimized for MIPS cores

**MIPS Technologies** has developed a new system controller family that enables SOC designers to increase overall system performance and accelerate SOC development. SOC-it system controllers increase system performance by means of an integrated memory controller and multiple, high-bandwidth IP interfaces. The memory controller is optimized for, and closely coupled with, the MIPS core in the SOC. Three dual-port IP interfaces offer high-bandwidth and point-to-point switched bus interconnects for the RAM. IP blocks. SOC-it controllers are synthesizable and available in five upgradable configurations
**MIPS**
**www.mips.com**

# MEMS

## Switch family for rapid mems integration

**Coventor** has unveiled its MEMS switch development platform. MEMS switch technology enables design engineers to create new wireless products featuring low insertion loss and high isolation capabilities in a smaller package. It fosters fast design and prototyping capabilities necessary to bring handset and microwave communications systems to market quickly. The



MEMS switches can be customized and integrated with passive and active components on ICs for RF mixed-signal functions. The family is designed to operate from DC to 40 GHz with a low insertion loss of <0.2 dB for die and <0.4 dB for packaged devices and high isolation of >25dB at 40GHz and >40dB at 2GHz.
**Coventor**
**www.coventor.com**
*sales@coventor.com*



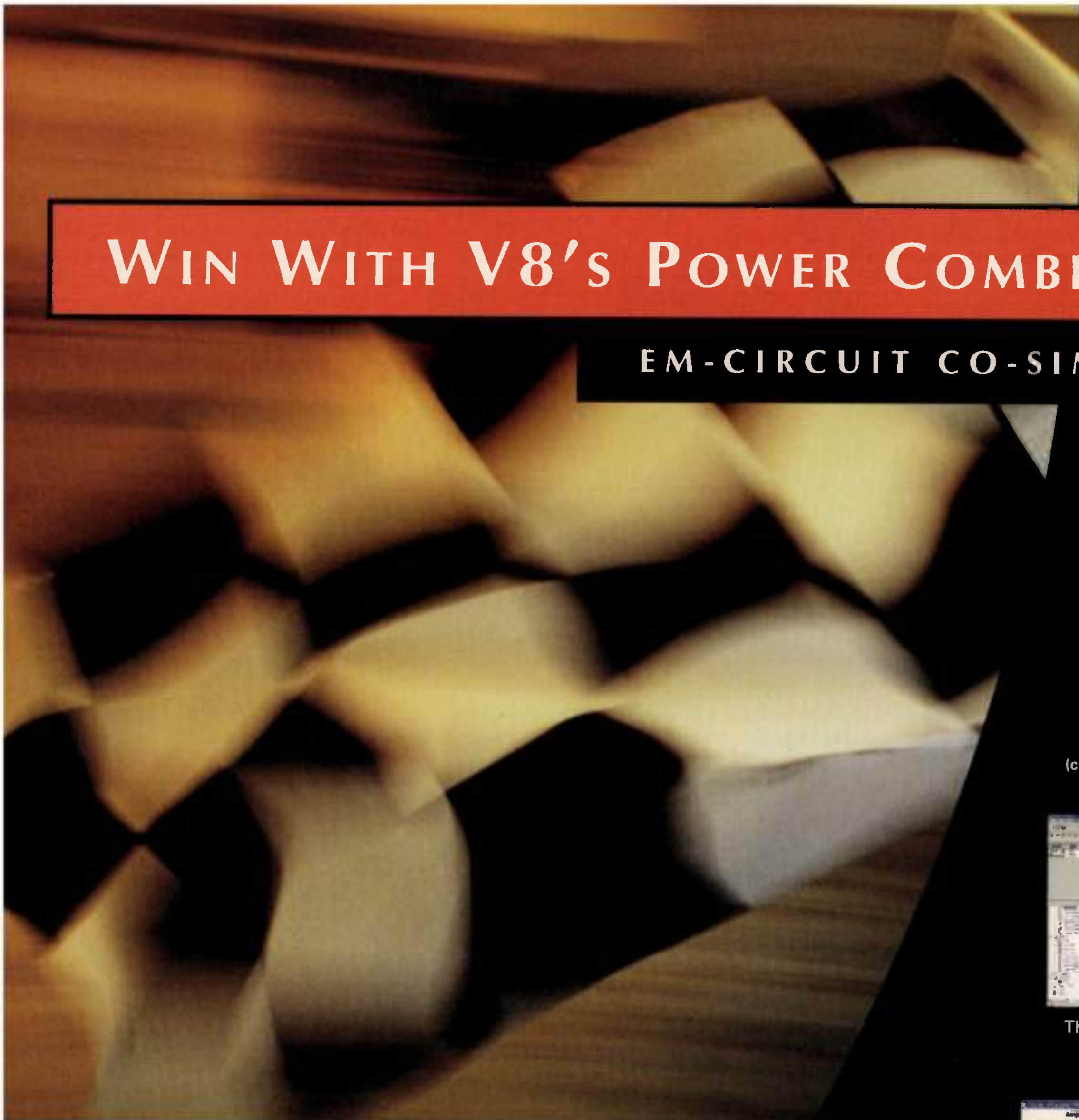
# SUBSYSTEMS

## Highly integrated CDMA front end receiver shipping

**RF Micro Devices** has announced the production availability of the RF2870 front end receiver. The RF2870 is a low-cost, highly integrated single-band front-end solution that features an integrated transmit (TX) local oscillator (LO) buffer amplifier. The device is assembled in a reduced-size 3 mm x 3 mm footprint package and is designed to optimize board space in applications using code division multiple access (CDMA), CDMA IS-95, JCDMA, cdma2000 1x and cdma2000 1x-EVDO standards.
**RFMD**
**www.rfmd.com**

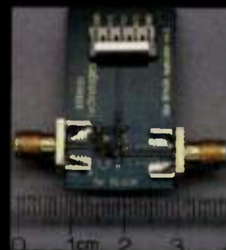
## 105 MHz ADC PMC module for demanding software radio applications

**Interactive Circuits and Systems** has announced the ICS-554 ADC PMC board. Designed for high-performance software radio applications, it pushes the envelope in channel density, speed and performance. The device includes four 14 bit ADCs. Each supports a sample rate of up to 105 MHz and boasts an SNR of greater than 74 dB and an SFDR of close to 100 dB. Each ADC is followed by a quad GC4016 programmable tuner device that supports both wideband and narrowband signal down conversion. A switch network in front of the tuners allows any or all of the 16 tuners to be assigned to any ADC output. An on-board Xilinx XC2V1000 FPGA following the tuner can be programmed for processing base band signals. The ICS-554 also includes a 512K sample on-board buffer and a powerful 66 MHz, 64-bit PCI DMA interface. The device puts 16 FDM receivers into a single width PMC card. With its ability to simultaneously process 4 antenna inputs, it is also ideal for spatial processing. A key feature of the sys

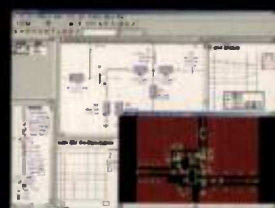


# Win With V8's Power Combination

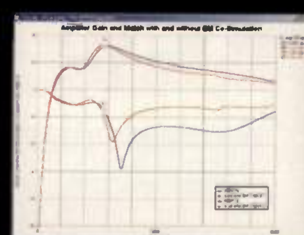
## EM-Circuit Co-Simulation



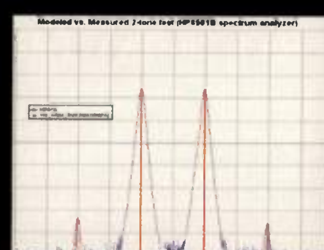
A 1930–1990 MHz LNA
(courtesy: Infineon Technologies)



The schematic and layout of a LNA circuit



S-parameters shift slightly when electromagnetic effects are considered



TEST LINK reads measured data and compares results with your model

**The Right Mix To Win.** GENESYS V8 combines the speed and flexibility of circuit simulation with the accuracy of electromagnetic simulation, allowing you to quickly and easily use the best analysis tool for your designs.

Say goodbye to traditional software that is tedious and error prone when combining EM simulation with circuit simulation.

GENESYS makes it simple. Just ask GENESYS to simulate the layout with the harmonic balance or s-parameter simulator. It automatically runs EM simulation on the layout, runs circuit simulation on the lumped elements, and displays the combined response. Lets you view the effect of layout parasitics quickly and easily. Even better, you can tune the lumped components to compensate for secondary electromagnetic effects in real time.

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www.eagleware.com
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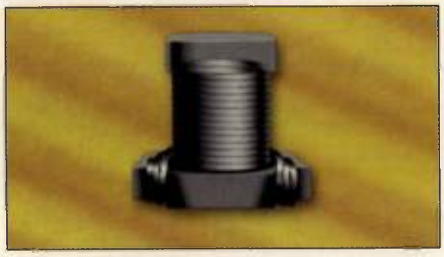
tem is its ability to undersample VHF signals without any degradation of performance. It also allows multiple-board synchronization for higher channel count. The ICS-554 is offered in one, two or four channel versions with or without the tuner modules. The prices begin at $3,995 in single quantity for the 80 MHz grade part.
**ICS**
**www.ics-ltd.com**
*info@ics-ltd.com*

## PASSIVES

### Low cost miniature inductors

**BI Technologies** Magnetic Components Division introduced a new series of SMT inductors featuring a class H design for operation at elevated ambient temperature. Designated the HM61 series, these low-profile form factor inductors feature low DC resistance and high current handling capabilities while offering a wide inductance



range from 1 to 2700 mH. Specially designed for machine placement, the series is compatible with vapor phase and infrared reflow soldering. In addition to providing a wide inductance range and current handling capability as many as 4 amps continuous, this class H design offers a specialized insulation system that designed for a range of demanding applications. The series allows design engineers to incorporate a compact high-current inductor into circuits where temperature and current capacity are critical design criteria. They are suitable for use in radio interference suppression, decoupling in RF and IF circuits and in DC-DC converters. They can also be used in safety devices as well as other applications. The inductors offer inductance ratings from 1 mH to 2700 mH (inductance measured at 1.0 kHz, 0.1V) at up to 4 amps continuous with operating frequencies up to 2MHz. DC resistance ratings range from 0.015 W to 10.5 W with operating temperatures ranging from −40° C to 180° C. The family comes in two footprints (4 x 4.8mm and 8 x 8.5 mm). Typical pricing for the HM61 Series inductors are $0.49 each in quantities of 50,000
**BI Technologies**
**www.bitechnologies.com**

### New capacitors for emi filtering

**Johanson Dielectrics** has introduced a new ceramic filter/decoupling capacitor using X2Y technology. The design incorporates common shielding electrodes that form a Faraday cage around the standard capacitor. The addition of the common electrode creates two matched or balanced capacitors enabling simultaneous line-to-line and line-to-ground filtering. The matched capacitor design also eliminates temperature, voltage and aging differences. This new component virtually eliminates parasitic inductance and provides superior filter and decoupling performance, allowing multiple component replacement and space savings on the PC board. Available in chip sizes 0603 through 1812 and 1410. Price: $0.50 at 1,000 pieces.
**Johanson**
**www.johansondielectricsp.com**

### SMT power iductors

**Coilcraft** debutes the SPT series of high current handling in a low-profile surface-mount part. The self-leaded design ensures rugged reliability and the toroid winding virtually eliminates stray electromagnetic emissions. There are two versions: the standard series with current ratings up to 8 amps, and the high current series that can handle up to 13.9 amps. All are rated for operation from −40° to +130° C and the materials meet UL 94V-0 rating. In addition to the standard values shown Coilcraft can custom engineer parts for specific applications.
**Coilcraft**
**www.coilcraft.com**

# SAWTEK SUPPLIES BROADBAND SOLUTIONS

**BROADER IS BETTER...** and today's broadband market depends on Sawtek's broad range of SAW products for total filtering solutions. Sawtek's patented SAW technology is perfect for every high-speed access application – delivering voice, video, and data to home or office. For wireless and cable connectivity, Sawtek SAW filters offer the heightened sensitivity and flat passbands you need. Our proprietary software delivers shorter turnarounds through highly accurate modeling that helps bring your product to market more quickly, less costly. Call today or visit our website to see why Sawtek is ***the*** broadband access supplier of choice.

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**Sawtek... Your Total SAW Solution!**

**SAWTEK'S BROADBAND ACCESS FILTER FAMILY**

| Frequency (MHz) | Bandwidth (MHz) | Package Size | Part Number |
|---|---|---|---|
| 36.15 | 8.0 | 6/18 DIP | 855748 |
| 43.8 | 5.5 | 6/14 DIP | 851205-3 |
| 44.0 | 6.0 | 6/18 DIP | 855079 |
| 70.0 | 3.5 | 15.3x6.5mm | 855742 |
| 70.0 | 8.0 | 13.3x6.5mm | 855677 |
| 80.0 | 8.0 | 13.3x6.5mm | 855679 |
| 110.59 | 1.0 | 13.3x6.5mm | 855659 |
| 150.0 | 8.0 | 13.3x6.5mm | 855678 |
| 202.75 | 1.2 | 13.3x6.5mm | 855068 |
| 330.0 | 5.45 | 15.3x6.5mm | 855730 |
| 426.0 | 5.16 | 15.3x6.5mm | 855731 |
| 479.5 | 25.5 | 7.0x5.5mm | 855892 |
| 1086.0 | 10.0 | 3.0x3.0mm | 855917 |
| 1090.0 | 10.0 | 3.0x3.0mm | 855989 |
| 1220.0 | 10.0 | 3.0x3.0mm | 855990 |

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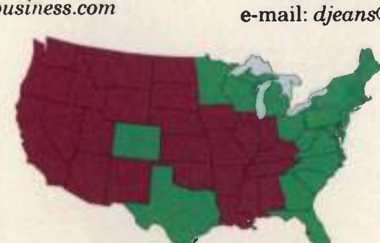

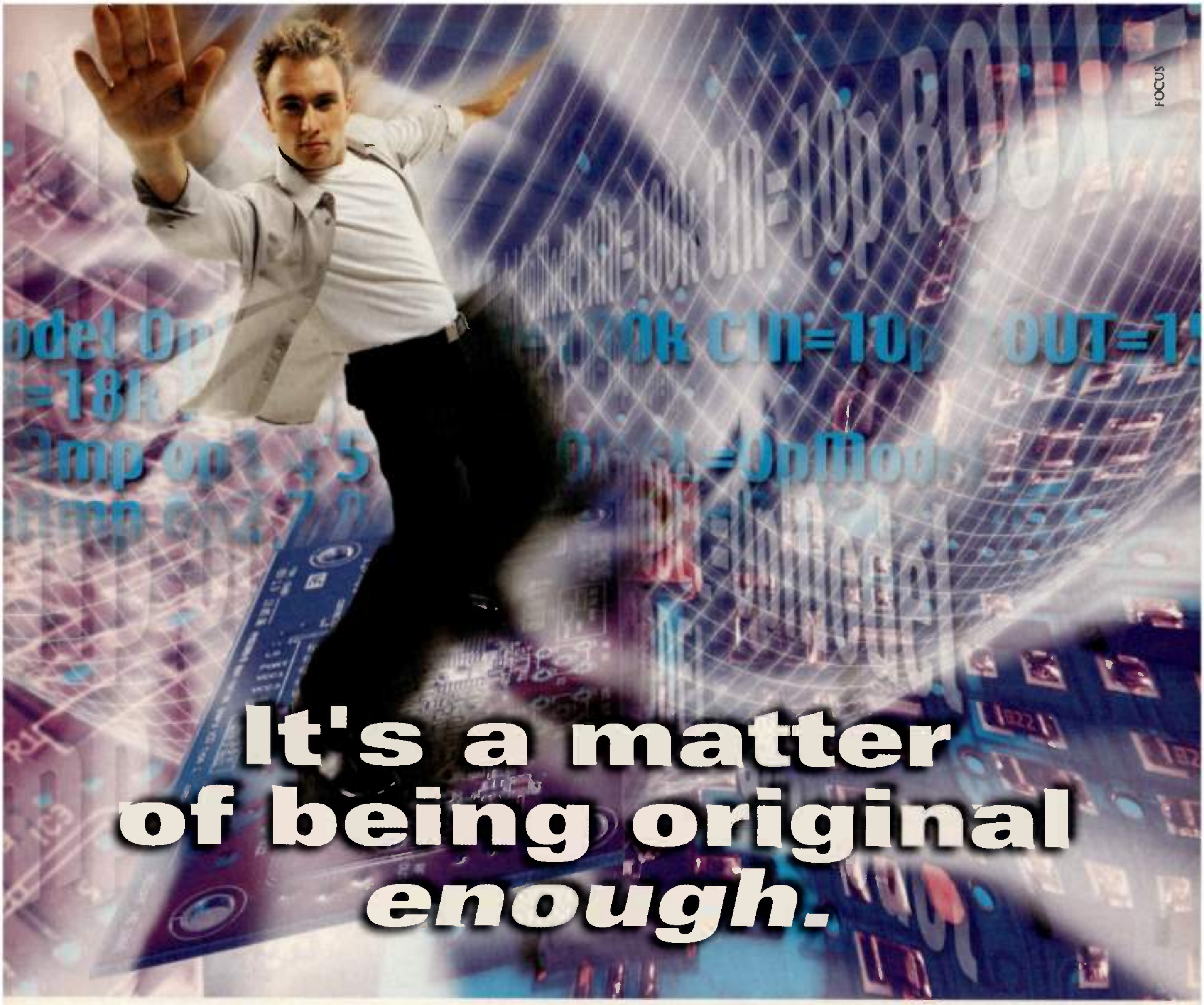
It's a matter
of being original
enough.

# Glossary of terms used in RF Design

**2G** – second generation wireless systems
**3G** – third generation wireless systems
**A/D** – analog-to-digital
**AC** – alternating current
**ACPR** – adjacent–channel power ratio
**ADC** – analog–to–digital converter
**AGC** – automatic gain control
**ALU** – arithmetic logic unit
**AMPS** – advanced mobile phone system
**ANSI** – american national standards inst.
**ASIC** – application–specific integrated circuit
**ASK** – amplitude shift keying
**ASP** – application service provider
**ATM** – asynchronous transfer mode
**AWGN** – additive white gaussian noise
**BER** – bit error rate
**BPSK** – binary phase shift keying
**CCRR** – co–channel rejection ratio
**CDMA** – code–division multiple access
**CDPD** – cellular digital packet data
**CGI** – common gateway interface
**CMOS** – complementary metal-oxide semiconductor
**COTS** – commercial off-of-the-shelf
**CMRR** – common-mode rejection ratio
**CPE** – customer premise equipment
**CW** – continuous wave
**DC** – direct current
**DCS** – distributed communications system or digital cellular system
**DCT** – discrete cosine transfer
**DDS** – direct digital synthesis
**DECT** – digital european cordless telephone
**DSP** – digital signal processor
**DUT** – device under test
**EEPROM** – electrically erasable programmable read-only memory
**EMC** – electromagnetic compatibility
**EMI** – electromagnetic interference
**ESD** – electrostatic discharge
**ETSI** – european telecommunications standards institute
**FCC** – federal communications commission
**FDD** – frequency division duplex
**FEM** – finite-element method
**FER** – frame error rate
**FET** – field-effect transistor
**FFT** – fast fourier transform
**FHSS** – frequency-hopping, spread spectrum
**FIFO** – first-in, first-out
**FIR** – finite impulse response
**FSK** – frequency shift keying
**FPGA** – fine-pitch ball grid array or field programmable gate array
**GaAs** – gallium arsenide
**GaN** – gallium nitride
**Gb** – gigabit
**GB** – gigabyte
**GFSK** – gaussian filtered frequency shift keying
**GMSK** – gaussian minimum shift keying
**GPIB** – general-purpose interface bus
**GPRS** – general packet radio service
**GPS** – global positioning system
**GSM** – global system for mobile communications
**HBT** – heterojunction bipolar transistor
**HDR** – high data rate
**HEMT** – high electron mobility transistor
**HSCSD** – high–speed circuit-switched data
**HTTP** – hypertext transfer protocol
**I and Q** – in–phase and quadrature
**I/O** – input/output
**IC** – integrated circuit
**IF** – intermediate frequency
**IM** – intermodulation
**IMD** – intermodulation distortion
**InP** – indium phosphide
**IP** – internet protocol
**ISM** – industrial, scientific, and medical
**JEDEC** – joint electron device engineers council
**JSP** – java server pages
**LAN** – local area network
**LCC** – leadless chip carrier
**LDMOS** – laterally diffused metal oxide silicon
**LMDS** – local multipoint distribution service
**LNA** – low–noise amplifier
**LO** – local oscillator
**LOS** – line of sight
**LPF** – low–pass filter
**LSI** – large scale integration
**LTCC** – low–temperature co–fired ceramic
**MDS** – multipoint distribution systems
**MMAC** – million multiply accumulate operations
**MMDS** – multichannel multipoint distribution service
**MMIC** – monolithic microwave integrated circuit
**MOSFET** – metal–oxide semiconductor field–effect transistor
**MOU** – minutes of use
**MSPS** – million samples per second
**NRZ** – non–return to zero
**NTC** – negative temperature coefficient
**OEM** – original equipment manufacturer
**PA** – power amplifier
**PAR** – peak-to-average ratio
**PCB** – printed circuit board
**PCM** – pulse code modulation
**PCMCIA** – personal computer memory card interface association (now simply referred to as PC card)
**PCS** – personal communications system
**PDA** – personal digital assistant
**PDC** – pacific digital cellular
**PECL** – positive emitter-coupled logic
**PGA** – pin grid array
**PHEMT** – pseudomorphic high electronmobility transistor
**PIM** – personal information management
**PLL** – phase–locked loop
**PPM** – parts per million
**PSK** – phase shift keying
**QAM** – quadrature amplitude modulation
**QPSK** – quadrature phase shift keying
**RAM** – random access memory
**RFI** – radio frequency interference
**RFIC** – radio frequency integrated circuit
**RFID** – radio frequency identification
**RMS** – root-mean-square
**ROM** – read–only memory
**SAR** – successive approximation register
**SDH** – synchronous digital hierarchy
**SDRAM/SORAM** – synchronous dynamic random access memory
**SiC** – silicon-carbide
**SIR** – serial infrared
**SMA** – standardization management activity
**SMD** – surface mount device
**SMR** –specialized mobile radio
**SMS** – short messaging service
**SMT** – surface–mount technology or surface–mount toroidal
**SNR** – signal–to–noise ratio
**SOIC** – small-outline integrated circuit
**SONET** – synchronous optical network
**SPDT** – single–pole double–throw
**SSPA** – solid state power amplifiers
**TCP** – transmission control protocol
**TCXO** – temperature-compensated crystal oscillator
**TDD** – time division duplex
**TDMA** – time–division multiple access
**TETRA** – trans european trunked radio
**TSOP** – thin small outline package
**TTL** – transistor –transistor logic
**UART** – universal asynchronous receiver transmitter
**UDP** – user datagram protocol
**UMTS** – universal mobile telecommunications service
**UNII** – unlicensed national information infrastructure
**UTRA** – UMTS terrestrial radio access
**VCO** – voltage-controlled oscillator
**VCSEL** – vertical cavity surface-emitting laser
**VCXO** – voltage–controlled crystal oscillator
**VOFDM** – vector orthogonal frequency division multiplexing
**VSAT** – very small aperture terminal (satellite service)
**VSWR** – voltage standing wave ratio
**WAP** – wireless application protocol
**W–CDMA** – wideband code–division multiple access
**WLAN** – wireless local area network
**XDSL** – another name for an ISDN BRI channel


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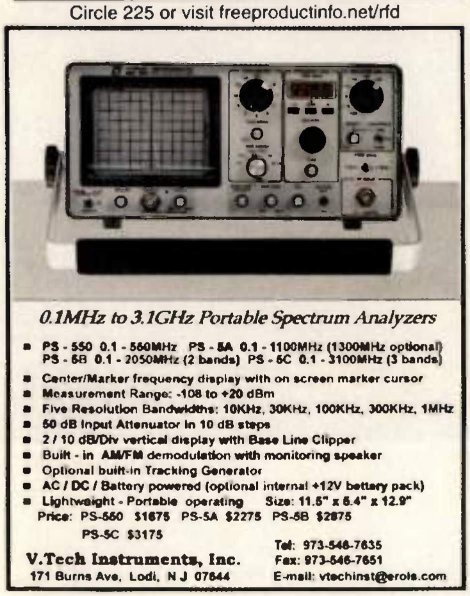


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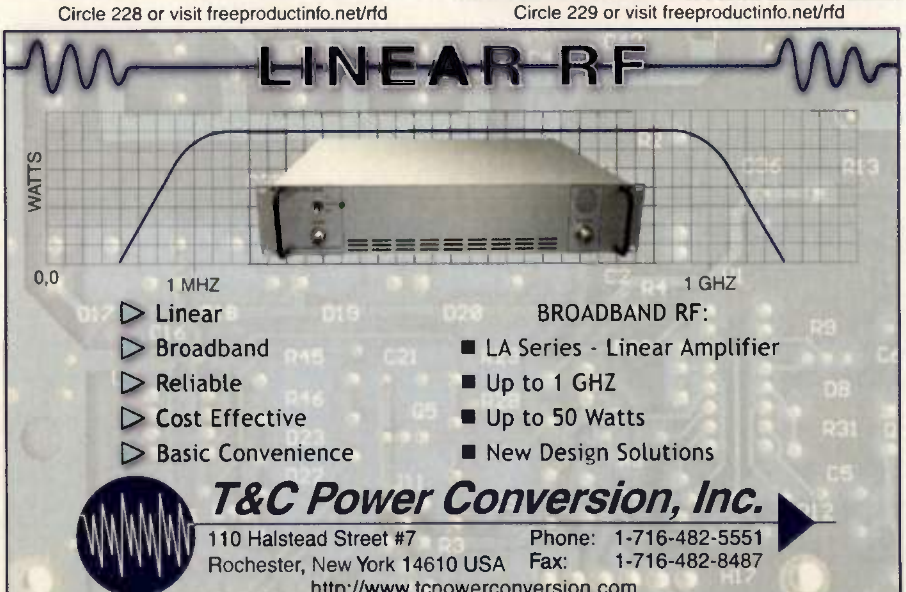


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# Think the unthinkable — abandon 3G

*by Ernest Worthman*
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Recently I was sent a piece from a friend of mine that presented an interesting take on 3G. It was a story printed in the UK's *Financial Times* by Peter Martin, *Financial Times'* senior business columnist, on July 29th. I think this is a topic that deserves serious consideration.

Martin writes, "It is time for the European telecommunications industry to think the unthinkable and abandon 3G - third-generation mobile telephony." Martin further writes, "This [the demand and need for 3G] represents a complete misreading of the future. Instead, networks should abandon the dream that handsets will become mobile media terminals, with lucrative content and e-commerce revenues. In reality, the wireless business will be what it has always been: communication between individual customers." Wow. That takes guts to say, especially in light of the big deal that make of 3G.

**But, you have to have been on the moon... —** Quite frankly, you'd have to have been totally out of communication with the civilized world for this to come as a shocker. The bloodletting of the wireless industry (as well as the overall telecom industry) has been going on for over two-years now. And, there still aren't any real indicators that 3G has an immediate future.

Just recently, the Dutch firm KPN has decided to all but abandon its 3G mobile phone services. This after they posted billion of dollars in net losses for the year.

In Japan, we watched as 3G was constantly delayed as two of the countries telecom giants fought to bring 3G to the Japanese consumer. In the end only NTT DoCoMo roled out 3G. But, only on a limited basis.

Furthermore, Vodaphone, already in a weak financial position has delayed it's decision to launch 3G services in Ireland — the hits just keep coming.

**Take off the shades —** There is a song I know, by a group called Timbuk 3, whose title is "The future's so bright I gotta wear shades." I used to think that was 3G's mantra. Now it appears it may be 3G's swan song. I've said it before, I'll say it again — It's time for the whole world to get realistic about the future of wireless interconnect.

It's becoming a common sense issue. Over the years I've discussed the many shortcomings of wireless communications. You know, system and carrier interoperability, non-ubiquitous coverage, multiple proprietary encoding/modulation technologies...etc. And, I've always said the magic in making any future wireless systems interoperate is some sort of glue technology or a standard platform. Well, it hasn't happened and 3G is quickly becoming an afterthought.

Add to that the evolution and implementation of parallel technologies (WLANs, Bluetooth, WiFi, Home RF,) that can (and are) doing much of what 3G was supposed to do, although on a less global scale. Furthermore, consider the embarrassing bit rates of wireless data over the mobile phone infrastructure and thing get even more depressing.

**"The future of 3G" —** What a statement! Quite frankly, there *is* a 3G in the future. I think everyone involved in the wireless industry believes that. The real question is when and what. We have to get real and take our lumps. We have to get a grip on what the end user wants (and stop looking at NTT DoCoMo as anything other than a novelty). The infrastructure *has* to get built out before the masses will buy into it. We learned that lesson with 2G. And we have to make the technology and interface user friendly and a no-brainer.

We should learn our lessons from past mistakes like the infamous VHS/Betamax wars. But we may never learn. Witness the current SACD and DVD audio wars and the competing DVD-RAM/R and DVD+RW technologies.

Competition is good. But maybe...just maybe, some things should be a monopoly — at least for now.

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| S12W2 | S12W5 | N12W5 | 12 | ±0.60 |
| S15W2 | S15W5 | N15W5 | 15 | ±0.60 |
| S20W2 | S20W5 | N20W5 | 20 | ±0.60 |
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