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MM-Wave Links Are Making Key Connections

With the opening of millimeter-wave spectrum to commercial communications, a number of companies are developing practical solutions for high-speed data access.

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Millimeter-wave frequencies represent the next great frontier for broadband, albeit limited range, communications. Since the United States Federal Communications Commission (FCC) and other global regulatory agencies have designated or freed bandwidth at millimeter-wave frequencies for point-to-point communications links (see Microwaves & RF, August 2007, p. 40), a number of companies at the system level have experienced increased interest in their high-frequency links while some companies at the component level have shared in the enthusiasm. The growing demand for high-speed voice, data, and video interconnections around the world is driving frequency regulators to free up spectrum at millimeter- wave frequencies.

Millimeter-wave frequencies are generally accepted to be in the range from 30 to 300 GHz, with the name coming from the small size of the signal wavelengths at those frequencies. Components for those frequencies are usually based on waveguide interconnections, with the physical size of the waveguide corresponding to the portion of the millimeter-wave spectrum that is passed with minimal signal loss. Of course, many coaxial connector companies now offer connectors with interface dimensions as small as 1 mm for broadband use as wide as DC to 110 GHz (typically for broadband measurement applications), although most millimeter-wave applications fit within a relative small percentage of the total 30-to-300-GHz spectrum.

One of the companies offering complete point-to-point millimeter-wave link solutions is BridgeWave Communications (www.bridgewave.com), with thousands of 60- and 80-GHz wireless gigabit radios deployed worldwide. The firm's millimeter-wave radios support local-area-network (LAN) backbone extensions, mobile-telephone backhaul applications, and high-capacity Internet access. The radio systems are referred to as "wireless fiber" systems for their capability of providing the performance, reliability, and security of a fiber-optic link, but without the installation headaches.

The company's point-to-point, fixed wireless systems employ proprietary AdaptRate™ technology and forward error- correction (FER) techniques to achieve reliable performance over the longest link distances possible for millimeter- wave frequencies. BridgeWave recently announced the additional availability of AdaptPath™ technology to their systems, which allows the integration of their AdaptRate millimeter wave links with secondary connections using complementary wired or wireless technologies. The result is a multiple-technology solution with increased availability and range.

The AdaptPath link switching technology creates an all-weather, dual path data connection by teaming one of the company's 60- or 80-GHz wireless bridges with a lower-speed secondary communications path, such as an unlicensed 5-GHz radio bridge or a licensed 6- or 11-GHz link. Should environmental conditions degrade the performance of the millimeter-wave link, the AdaptPath technology automatically switches data traffic to the secondary path before data errors occur. According to Gregg Levin, senior vice president and chief marketing officer for the company, "AdaptPath is the next step in BridgeWave's strategy to offer enterprises, government entities, and network operators greater flexibility in meeting their network capacity, range, and uptime requirements."

Their customers concur. The combination of technologies has helped broadband service provider Roadstar Internet accelerate the rollout of reliable Internet services in the Washington, DC area. According to the firm's founder and CEO, Marty Dougherty, "Our state-of-the-art GigE wireless backbone enables us to be first to deliver next-generation access services in this fast-growing region. The combination of BridgeWave's AdaptRate and AdaptPath features takes us well beyond what's currently available in the industry."

Roadstar and BridgeWave determined rain fading rates for millimeter-wave signals in the service area and applied the combination of AdaptRate and AdaptPath technologies to deliver the highest-performance service possible even during heavy rainfall. The network employs the AdaptRate feature to switch from a full Gigabit Ethernet (GigE) data rate to a lower 100-Mb/s rate during heavy rains but, if needed, will engage the AdaptPath capability to switch data traffic to a secondary, rain-tolerant 40-Mb/s 5-GHz bridge. Once the rainfall has sufficiently eased, the system quickly reverts to the full GigE rate. Dougherty points out some hidden benefits of the BridgeWave technologies: "AdaptPath also reduces networking equipment costs and complexity since we don't have to provision redundant wireless paths using external Ethernet switches and routers."

Earlier this year, Endwave Corp. (www.endwave.com) introduced a transmitter/receiver module pair for use from 71 to 86 GHz (E-band), nominally for broadband point-to-point radios. The two modules combine the company's MLMS™ (Multilithic Microsystems) and Epsilon™ Packaging technologies to achieve small size and low cost with outstanding performance at millimeter-wave frequencies. The MLMS technology is an alternative to monolithic microwave integrated circuits (MMICs) using flip-chip devices and electromagnetic (EM) coupling methods to minimize circuit-board space and the number of wire bonds.

The MLMS approach supports a mixture of technologies, such as GaAs, indium-phosphide (InP), and silicon-germanium (SiGe) active devices on the same MLMS chip for a true system-on-chip (SoC) design at frequencies to 100 GHz. The company supports its MLMS designs with a growing library of MLMS models, including frequency mixers, multipliers, voltage- variable attenuators (VVAs), filters, and Lange couplers.

Epsilon Packaging replaces high-cost elements, such as machined housings, with lower-cost injection-molded metallized- plastic housing and metallized FR-4 circuit boards. The end result is a package with no machined metal parts that is mass producible with minimal weight and size. The packaging approach allows a combination of assembly techniques, such as surface-mount technology (SMT), chip-on-board, and bare chip-and-wire approaches, to be integrated into a single low-cost module capable of excellent performance at millimeter-wave frequencies.

The transmit module typically provides +16 dBm output power with 15-dB conversion gain. It features an integrated power detector on the transmit output. The receiver features a noise figure of better than 9 dB and better than 25- dB RF-to-IF conversion gain. It has an input 1-dB compression point of -25 dBm. Separate models are available for the 71-to-71-GHz and 81-to-86-GHz bands.

Endwave also offers an example of its millimeter-wave transceiver technology on its website, in the form of the PDH point-to-point transceiver for use at 57 to 59 GHz. The transceiver contains all the transmit, receiver, and source functions needed to assemble a full-featured time-division-duplex (TDD) digital point-to-point radio. Designed for unlicensed use, the half-duplex design employs a modulation bandwidth of 20 MHz with saturated transmit output power of +5 dBm across the frequency range. The receiver section, which operates with in phase (I) and quadrature (Q) intermediate frequency (IF) input range of 0.1 to 50.0 MHz, features a double-sideband (DSB) noise figure of 12 dB (for a 4-MHz bandwidth) and input 1-dB compression point of -20 dBm. The transceiver module measures just 51 X 51 X 8 mm.

Another company making use of the FCC-approved frequency bands at 71 to 76 GHz, 81 to 86 GHz, and 92 to 95 GHz is GigaBeam (www.gigabeam.com). The company's WiFiber® Wireless Fiber link product lines are delivering performance levels to 10 Gb/s at distances to 1 mile using millimeter-wave transceivers. The firm recently received an order for two 100-Mb/s WiFiber links from MetroNext, Inc., a wireless service provider serving Boston and other major metropolitan areas in the Northeast US. The links likely will be deployed as access links for businesses in the downtown Boston area. According to GigaBeam chairman and CEO, Lou Slaughter, "GigaBeam continues to solidify its competitive advantage in the US Northeast, one of the most densely populated and economically active regions in the world." Slaughter adds, "A few months ago, GigaBeam announced an order for a WiFiber link for use in a major university in Spain, marking the company's first penetration into the potential large market for millimeter- wave links in that country."

Of course, not all millimeter-wave applications are for communications systems. Britain's Roke Manor Research (www.roke.co.uk), for example, recently launched their latest generation of miniature radar altimeters (MRAs) for use with autonomous unmanned aerial vehicles (UAVs) for military, paramilitary, civil monitoring, and surveying tasks. Designed for RoHS compliance and meeting applicable military standards, the compact and light-weight designs feature an integrated antenna with radome, low altitude operation, highly precise height positioning, and low probability of intercept waveform (LPI) operation. In contrast to conventional radar altimeters, which are large, heavy, and suffer high power consumption, these compact MRAs are available in a millimeter-wave variant operating at 76 to 77 GHz with medium-to-low altitude above-ground-level (AGL) measurement precision of 0.02 m for heights of 0,2 to 100 m above ground. Along with the lower-frequency variant, which operates at 4.2 to 4.4 GHz, the MRAs are ideal for vertical take-off and landing (VTOL) applications as well as for geophysical, wave height monitoring, airborne mapping, towed airborne targets, traffic monitoring, and collision avoidance applications.

The Irish firm Farran Technology Ltd. (www.farran.com) has a long history of innovation in millimeter-wave component and system design. Working with local academic institutions, such as the Tyndall Institute in Cork, the firm has developed a wide range of millimeter- wave products for space and military applications. The firm recently won a contract with OSIS (www.osis.biz) to supply a millimeter-wave sub-system designed to facilitate enhanced surveillance capabilities. Their customer has developed the Oil Spill Identification System (OSIS) for full-time online surveillance and measurement of oil spilled into the marine environment. Vessels and offshore structures are understood to be two of the major sources of the more than 500,000 tons of oil spilled into the marine environment every year. This surveillance capability makes it possible to closely monitor and control spills to a greater extent than ever before. The hope is that the new technology will allow for the enforcement of applicable environmental regulations and set the stage for future environmental initiatives to control marine oil spills.

In the military area, long-time millimeter- wave technology supplier Millitech (www.millitech.com) recently received a $3.7 million contract from the US Army Communications-Electronics Research, Development, and Engineering Center (CERDEC) for the design and development of a next-generation Satellite Communications on the Move (SOTM) antenna system. The two-year contract includes the delivery of five prototype systems, with an option for a third year for support of the prototypes.

The novel Active Quasioptic Array (AQA) antenna systems, which are designed for use on moving vehicles, will increase the military's communications capabilities. The patent-pending AQA antenna combines the best features of conventional and phased-array antenna technology to provide unprecedented performance at an affordable price. According to Kent Whitney, president and COO of Millitech, "The system is designed to supply crucial information to our soldiers in their vehicles, while moving at full speed over very rough terrain. It is one of the most critical technologies for the next generation of communication systems and has both military and commercial applications."

The Millimeter-Wave Division of ELVA-1 (www.elva-1.com) has developed a 94-GHz frequency-modulated-continuous- wave (FMCW) radar front-end ideal for vehicle collision-warning and construction level-sensing applications. Based on the company's Impatt-diode-based active frequency multiplier (AFM), the FMCW module can be modified for use at frequencies from 20 to 150 GHz. For improved sensitivity and accuracy, the frequency sweep of the transmitter is linearized, with the linearizer being implemented as an open-loop system. Inclusion of the AFM technology allows the use of a low-cost voltage-controlled oscillator (VCO) to ultimately generate the millimeter-wave frequencies. With about 200-mW transmit power and good receiver sensitivity, the FMCW radar module can be used effectively for distances of several hundred meters.

On the component side, ARRA (www.arra.com) offers a wide range of passive microwave and millimeter-wave components including horns from 2.6 through 40 GHz. They are available with minimum gain of 15 dBi and as much as 18 dBi gain. The precisely machined aluminum horns, which are suitable for high-frequency receiving and transmitting applications, exhibit maximum VSWR of 1.25:1. Lower-frequency models are supplied with coaxial connectors while millimeter-wave models are shipped with waveguide flanges.

In addition, the company offers several millimeter-wave crossguide couplers, including the WR-34 model 34-600 with coverage from 22 to 33 GHz and the WR-28 model 28-600 with a frequency range of 26.5 to 40.0 GHz. Both couplers are available with coupling of 20 to 60 dB and provide 15 dB directivity, maximum VSWR of 1.15:1, and maximum frequency sensitivity of ±1.3 dB.

Spacek Labs (www.spaceklabs.com) offers a wide range of components at millimeter- wave frequencies. The firm's model P34-1 low-noise mixer/preamplifier, for example, offers a 26-GHz bandwidth at Ka-band, with 2-GHzwide local oscillator (LO) and RF bandwidths handled by WR-28 waveguide. The multifunction component provides 25-dB typical RF-to-IF gain, with an IF band of 10 to 500 MHz and typical DSB noise figure of 2.5 dB. Recently, the company introduced the model AW- 8X frequency multiplier. The 8X unit translates inputs from 9.35 to 13.75 GHz into outputs from 75 to 110 GHz at 0 dBm or more output power.

Dorado International (www.dorado-intl.com) provides passive millimeter- wave components for most waveguide bands, including attenuators, couplers, and phase shifters for 60-to-90-GHz E-band applications. Full-band 60-to- 90-GHz couplers can be specified with coupling values of 3, 6, 10, and 20 dB and as much as 40 dB directivity and VSWR of less than 1.20:1. Fixed and variable 60-to-90-GHz attenuators provide as much as 30 dB attenuation at millimeter wave frequencies.