

Radio Modules Offer Embedded Mobility

These compact radios employ MANET technology for scalability and ease of mobility, and plug-in frequency modules to adapt to the spectrum needs of different applications.

Mobility is an important part of modern communications, in both commercial and military applications. Radio users require mobility, not a fixed communications terminal, and radios that can move with them and operate reliably, often across multiple frequency bands to reach different groups of users.

Persistent Systems, with its modular radio designs and use of Mobile Ad Hoc Networking (MANET) technology, provides mobile radio solutions that are as effective for humans as for machines. These solutions deliver easily integrated radio links for frequencies in L-band (1350 to 1390 MHz), BAS (2025 to 2150 MHz), S-band (2200 to 2500 MHz), and C-band (4400 to 6000 MHz) ranges.

MANET radio technology was developed with the encouragement of DARPA, hoping to create a radio technology that would allow mobile communication anywhere in the world without relying on fixed communications infrastructure (e.g., cellular radio towers). Persistent Systems has developed several lines of MANET radios suitable for human as well as robotic users, such as the unmanned aerial vehicles (UAVs) increasingly used for defense ISR operations.

Its Wave Relay MANET technology can be scaled to create large networks by using multiple hops with high throughput and minimal latency. MANET radios apply internet-protocol (IP) communications techniques, with each radio appearing much like a relay or switch within the network. The radios can send and receive voice over IP (VoIP), video, and high-speed data under demanding conditions to meet the requirements for military applications; versions of the radio can serve a wide range of human and machine applications.

For humans, the MPU5 Wave Relay mobile radio (*Fig. 1*) is a portable, battery-powered Android computer, powered by a 1-GHz quad-core processor. The radio, equipped with 2 GB of random-access memory (RAM) and 128 GB of flash memory, can run Android applications and connect and



1. The MPU5 Wave Relay MANET radio can be equipped with different frequency modules for operation at L- through C-band frequencies. (Courtesy of Persistent Systems, LLC)

control as many as three USB devices with three compatible ports. It has a built-in GPS radio for position information, HD video encoder, HD video decoder, 16 channels of push-to-talk voice communications, integrated radio-over-IP (RoIP) functionality, and 10/100 Ethernet connectivity for data rates approaching 100 Mb/s.

The radio's simple modular design features a chassis and plug-in frequency module that determines the operating frequency range. The RF-1100 L-band module runs 1350 to 1390 MHz, the RF-2100 S-band module operates from 2200 to 2500 MHz, and the RF-4100 lower C-band has a frequency range of 4435 to 4980 MHz. At most frequencies, the MPU5 provides as much as 6 W transmit power and is capable of 10 W transmit power at S-band frequencies.

The MPU5 uses software configurable bandwidth of 5, 10, or 20 MHz and a variety of modulation formats, including binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), 16-state quadrature amplitude modulation (16QAM), and 64-state quadrature amplitude modulation. For optimum reception, it operates with a variety of antenna configurations, from single-input, single-output (SISO) through 3×3 multiple-input, multiple-output (MIMO) antenna setups. The radios are RoHS-compliant and screened



2. Embedded Modules are compact versions of the MPU5 Wave Relay radio, using many of the same frequency modules and having many of the same capabilities for UAVs and UGVs. (Courtesy of Persistent Systems, LLC)

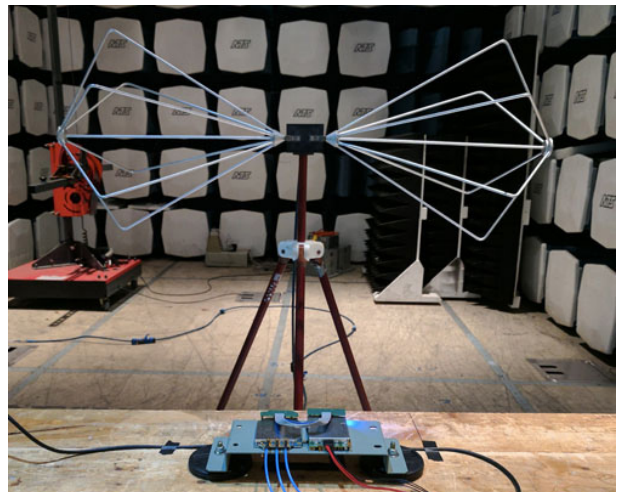
to IP68 for ingress protection from solid objects and liquids. They are designed for operating temperatures from -40 to $+85^{\circ}\text{C}$.

COMPACT MODULES

For machines such as UAVs and unmanned ground vehicles (UGVs), the Embedded Module is a compact version of the MPU5 Wave Relay radio. It has the same choices in frequency bands as the MPU5, but in a format that can readily be integrated into larger systems. (For an example of how these compact MANET radios are employed in UAVs, see “Persistent, Insitu Team on UAV MANET Radios” on www.mwrf.com.)

The interchangeable frequency modules for the Embedded Module (Fig. 2) are available for L-band frequencies from 1350 to 1390 MHz, S-band frequencies from 2200 to 2507 MHz, BAS (broadcast) band frequencies from 2025 to 2150 MHz, lower C-band frequencies from 4400 to 5000 MHz, and upper C-band frequencies from 5100 to 6000 MHz. As with the frequency modules for the MPU5 Wave Relay radio, the modules for the Embedded Module are available for channel bandwidths of 5, 10, and 20 MHz. The Embedded Module radios can also operate with the same RF modulation formats as the MPU5. Both forms of the MANET radios can output 1080-pixel video.

With choice of frequency range, the software-configurable Embedded Module radios support three independent antenna chains, in configurations from SISO to 3×3 MIMO. The Embedded Module radios achieve radio receiver sensitivity of -98 dBm or better for a 5-MHz bandwidth, and peak data throughput of 150 Mb/s when operating at L-band frequencies



3. Pre-certification EMI testing of Embedded Modules is performed according to MIL-STD-461 RE102 standards within this well-equipped facility. (Courtesy of Persistent Systems, LLC)

with a 20-MHz channel; standard and high-power L-band modules are available. For the high-power L-band module, the transmit power can be set from $+16.5$ to $+35.0$ dBm in 0.5-dB steps. Power accuracy is ± 2 dB, while worst-case frequency accuracy is ± 4 ppm.

Since UAVs, UGVs, and other unmanned systems are often subject to strict requirements for electromagnetic interference (EMI) and electromagnetic compatibility (EMC), the Embedded modules are pre-certified for EMI according to MIL-STD-461 RE102 standards (Fig. 3). Given the high integration of function blocks within the Embedded Module, devices such as its on-board computer, video encoders, transmitters, and command and control circuits do not need to be certified separately. To help further speed the adoption of the Embedded Module, it’s available as part of an Embedded Module Development Kit, which also includes cables, an external radio mounting tray, and design documentation/software files.

The Embedded Module MANET radios, for such compact designs, are well-equipped with interconnections: 3G-SDI, composite, and HDMI video input connectors, RS-232 serial interconnection, USB OTG input/output connector, and 10/100 Ethernet input/output connector. Embedded Module radios have main circuit-board dimensions of $2.00 \times 3.29 \times 0.59$ in. and weigh 3.2 oz. The Embedded Modules work with voltages of 8 to 30 V dc and draw 300-mA current from a 12-V dc supply.

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