Radio Relays Improve Wireless Products

Originating Technology/NASA Contribution

In order to transmit communications through Earth's atmosphere, satellites and space vehicles need radio equipment that can operate at higher frequencies than on Earth. These higher frequencies, until recently, have demanded mechanical switches in radio relays. Unfortunately, the mechanical switches had some problems with frequency routing, which inspired NASA to seek more rugged, reliable solutions.

NASA began to design new, lightweight, microelectromechanical systems, or MEMS. MEMS are extremely small devices (a fraction of a millimeter long) with moving parts, already used in sensors for airbag accelerometers and video game controllers, as well as radio electronics for cell phones, digital mirror displays, and hand-held radios. Switching to MEMS relays for actuators (and not just sensors) from older mechanical switches offered the Agency improved performance in higher frequencies. A California company helped NASA create new MEMS relays that offer some new benefits as well.

Partnership

After developing a radio frequency (RF) MEMS relay under U.S. Department of Defense contracts, Signal Hill, California-based XCOM Wireless Inc. continued its research with a Phase II **Small Business Innovation Research (SBIR)** contract in 2003 through NASA's Jet Propulsion Laboratory (JPL). In order to improve satellite communication systems, XCOM produced wireless RF MEMS relays and tunable capacitors that use metal-to-metal contact—moving microscopic metal beams into contact with special electrodes—operating much like a light switch small enough to fit on the cross section of a human hair. They have the high speed of solid-state switches, but with mechanical contacts that outperform semiconductor technology. Also, by introducing a MEMS relay with electrostatic—and not electromechanical—actuation, XCOM was able to produce a MEMS relay that consumed less power and was easier to manufacture than earlier relays.

NASA's Lunar Reconnaissance Orbiter, or LRO, and NASA's Lunar Crater Observation and Sensing Satellite, known as LCROSS, shown at top, launched aboard an Atlas V/Centaur rocket in 2009. LCROSS will communicate using radio frequency signals, between antennas on the spacecraft and large dish antennas on Earth, such as the one in Canberra, Australia, shown at bottom. This communication depends on distance, spacecraft orientation, and the physical characteristics of the transmitting and receiving antennas and electronics. Companies such as XCOM Wireless Inc. are working with the Agency to improve these electronics.

These MEMS relays are used for signal tuning, routing, and phase-shifting circuitry, thus enabling wireless systems to adapt to changing operating conditions, radar or communications waveforms, and other mission needs. For its work with NASA, XCOM Wireless concentrated on frequencies in the range of 70 GHz–100 GHz, while most commercial radio frequencies use the range from 0.1 GHz–6 GHz. Despite the difference in bandwidth, XCOM's president, Dr. Daniel Hyman, says that the NASA technology is a "fundamental switching device" now incorporated into all of XCOM's products.

Product Outcome

After designing these improved devices, XCOM entered into a partnership with MEMS manufacturer, Innovative Micro Technology Inc. (IMT), based in Santa Barbara, California. With its NASA-derived design improvements and IMT's manufacturing abilities, XCOM automated its relay manufacturing and testing, and reduced costs to one-tenth the previous amount. This, Hyman says, gave the new relays potential to be "a mainstream product with thousands of solid industrial customers in a stable and growing market."

XCOM has two products made possible by the MEMS technology the company developed under the SBIR from JPL. The first is an industrial relay used for high-frequency test equipment and instrumentation, the XW3100 single pole double throw relay. The second, an RF MEMS tuning circuit, is in development for the wireless communications industry.

The XW3100 relays offer faster performance for automated test equipment, with frequency switching as high as 20 GHz—much more efficient than large electromagnetic relays. Typically the size of sugar cubes, electromagnetic relays consume a lot of power, and because of their large size, they are very slow. Conversely, the XW3100s incorporate gold contacts to offer speed

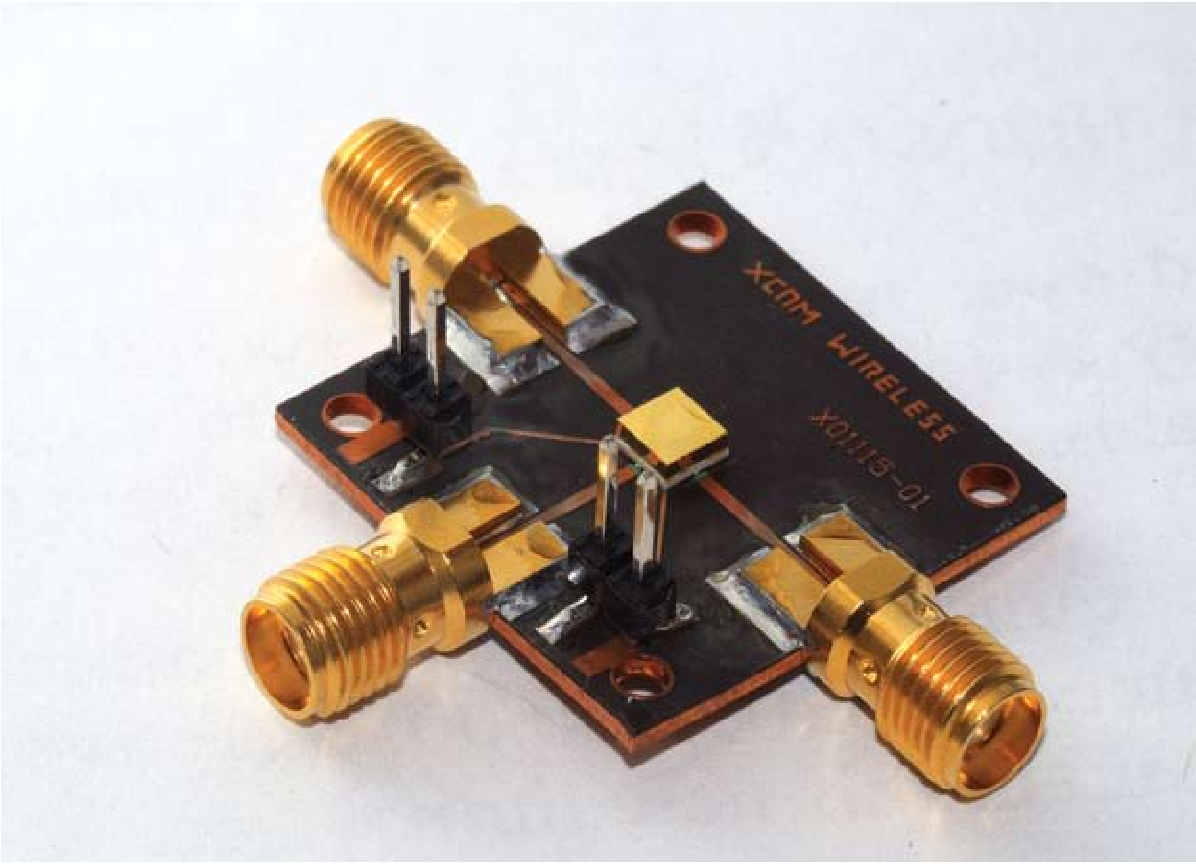

Image courtesy of XCOM Wireless Inc.

The XCOM Wireless XW3100 microelectromechanical single pole double throw relay, mounted on a radio frequency test coupon. According to the company, the XW3100 relays offer faster performance for automated test equipment, with frequency switching as high as 20 gigahertz.

in a small footprint. Industrial systems that reconfigure different testing for computer chips or cell phones, for instance, depend on the speed of these relays. Reconfiguration speed can account for half of the total cost of testing final products, so companies are able to cut costs by having faster, smaller relays. "Fifty percent improvement in profits to the chipset makers is our compelling value and why our parts are so desirable," Hyman says. The XW3100 relays also offer other advantages, such as linearity, lifetime, and bandwidth, but Hyman suggests that the most attractive features are the reduced power consumption and significantly higher switching speed, especially when contrasted with electromagnetic relays. The relays offer a continuous RF current of 400 milliamps.

Although early interest for the RF MEMS technology was primarily for instrumentation for aerospace and defense industries, the opportunities are now far more varied. Newer applications include fixed and wireless broadband data link equipment, wireless network hardware, cell phones, laptop computers, and personal digital assistants.

The second product, which will be available in 2010, is an RF MEMS tuning circuit for use in hand-held radios and cell phones. These circuits use the low-loss switch technology developed with the NASA funding, and Hyman expects the technology will greatly improve interoperability and power consumption in tactical radios. Miniaturizing the circuits and integrating them with filter and antenna subsystems allow older and newer radios to communicate seamlessly, making multi-agency operations more efficient. Hyman also expects XCOM's relays will be incorporated into multiband third generation (3G) cellular systems because they enable cell phones to have better worldwide service, improved simultaneous data and voice use, and better wireless local network service. American cell phones typically do not work in Europe, for example, but the relays can make the numerous waveforms all compatible, thus enabling seamless global coverage. The relays can also switch a phone call from a cellular network to an available broadband wireless network automatically, thereby reducing the use of cell phone minutes and reducing dependence on overloaded cellular infrastructure. Lastly, the technology can also extend battery life and reduce dropped calls.

Hyman expects more commercial broadband companies will take advantage of the technology soon. The applications are still growing today as consumer wireless companies continue to reduce cost while increasing functionality in each new model. "These are the technologies and opportunities that will shape the next generation of wireless," Hyman concludes. ❖