MIT technology insider

FROM THE EDITORS OF TECHNOLOGY REVIEW

SPINOFF SPOTLIGHT

Wave of the Future

Active Spectrum is developing a new type of oscillator to improve radio frequency equipment

A new design for a tiny device that is at the heart of all radio equipment may one day allow cell-phone towers to transmit much more data, according to the MIT graduate who created the device and runs the startup trying to commercialize it.

Active Spectrum, of San Carlos, CA, is working on a radio frequency oscillator that could replace the oscillators currently in use. The work, an outgrowth of the PhD thesis of cofounder and CEO James White, could also improve communications test equipment and even help the air force develop better radars.

IMAGE: HOKUSAI

All radio transmission requires an oscillator, which shapes the radio beam into a sine wave, the familiar up-and-down pattern you see in images of radio waves. Without oscillation, radio would be all static and no signal. The standard oscillator, used for the past four decades, is a device commonly known as a YIG, a crystal of yttrium iron garnet surrounded by a copper magnetic coil. This creates an electromagnet that produces radio waves that fluctuate up and down as the electrical input is altered. But that process consumes a lot of power. The magnetic coil also resists miniaturization, and the device produces a certain minimum amount of noise, which limits how much signal it will create.

Active Spectrum's oscillator uses a completely different technology: instead of relying on a magnetic field, it alters the frequency of radio waves through mechanical motion. "Our technology is extremely low power, and we've had good success in making it substantially smaller than a YIG," White says. Because his oscillator uses much less power than a comparable YIG, it winds up costing the user only about a 10th as much to operate. At a size of about 13 by 13 by 3 millimeters, it also has one-30th the volume of a YIG. While the smaller size may not make much difference in ground-based equipment, it could be very helpful in airborne applications, where every ounce counts.

White calls the device a sort of "macro-MEMS." A MEMS, or microelectromechanical system, typically uses small electrical charges to move small mechanical parts. For instance, a MEMS consisting of hundreds of tiny, electrically actuated mirrors is the basis for some projection televisions and portable projectors. White's larger device works on the same principle. At its core, a copper ring acts as an inductor, carrying the magnetic field. The ring is sandwiched between two thin, flexible discs of metal. The discs act as a capacitor, which holds and then releases an electrical charge. When a voltage is applied, they bend inward, until they release their charge and bounce back. The strength of the voltage determines how far the discs bend, controlling the distance between them. In turn, that distance determines what radio frequency the device produces. As the discs flex, the frequency changes, producing a sine wave.

Any oscillator produces some randomness, called phase noise, in its fluctuations. The ratio of signal to noise determines how much data the device can transmit. White says that because his oscillator is essen-

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tially a one-piece device, unlike a YIG, it produces less phase noise, and therefore allows the radio to transmit more data. This is important to operators of cell-phone towers and base stations, who are limited by Federal Communications Commission rules in the power and frequencies at which they can transmit.

Earl Lum, president of the market analysis company EJL Wireless Research, is impressed by Active Spectrum's technology but thinks the company may struggle to get into the very cost-sensitive cell-tower market. The Active Spectrum product may cost more than $100, much more than current oscillators. It is also not packaged to fit easily into existing equipment. Lum says the equation may change as the company develops its technology and as data transmissions become a larger proportion of mobile service, pushing phone companies to move from today's data rates of 14 megabits per second to anywhere from 28 to 100 megabits per second. "If there's a way they can take the gut technology they have and repackage it into an ultralow-cost package, then there's some significant value for them," Lum says.

He's much more enthusiastic about the technology's potential for test and measurement equipment—tools made by companies such as Agilent to test both radio equipment and such devices as the electro-optical modulators that create the signals used in optical telecommunications networks. That market is less sensitive to cost and really needs the high performance Active Spectrum's device supplies, Lum says: "It's a great fit for them."

White says the company is indeed talking to Agilent and other makers of test equipment, in which the oscillator's ability to tune to frequencies across an octave—say, from two to four gigahertz, or five to ten gigahertz—proves quite useful. To test radio equipment, manufacturers need a radio source that can provide a wide range of frequencies at low levels of noise—a task perfectly suited to a series of Active Spectrum oscillators.

The company is also supplying prototypes of its oscillators—and a related device, a tunable frequency filter—to the U.S. Air Force, which has funded the work with Small Business Innovation Research grants. White says the air force won't say exactly what it has in mind for such devices, but he imagines they could be used for a better type of radar that relies on multiple frequencies to build up an image.

White started the company in 2002, along with his brother Chris, who earned a PhD from Caltech and is now the company's chief technology officer, and Alexander Slocum, a professor of mechanical engineering at MIT who supervised James's doctorate. The original idea was to commercialize a technology James developed as part of his thesis work, a MEMS that could tune cell phones to different frequencies. MIT's Deshpande Center for Technological Innovation gave the company a grant of $250,000 to do just that, and Active Spectrum also made it to the finals of the $50K business plan competition in 2004. The team eventually realized that it would be competing with a lot of less expensive alternatives, and that even a shot at being successful would require a great deal of venture capital, which would mean giving up a lot of control of the company.

Eventually, he and his colleagues switched to the oscillator, a device inspired by, but not directly developed from, the original work, White says. They're also developing technology from Chris's thesis project, a device that measures free radicals in various substances. They'll probably sell that to the army as a way to precisely measure the quality of motor oil; as long as oil is changed before it breaks down, leading to engine failure, not changing it too early can save money. The same technology might also be used to detect drugs in blood, saliva, and urine.

Active Spectrum employs three full-time engineers and five part-time consultants, and hopes to be able to start selling both the sensor and the oscillator by early 2008. It licenses the sensor technology from Caltech and has developed two of its own patents—one issued, one pending—on the oscillator. Funding, from friends, family, and various grants, is just shy of $2 million.

White is determined not to take money from venture capitalists. "We feel that we can organically grow the company to the point where it's profitable, and where it would be interesting to people looking to acquire the various technologies we have," he says.

IN BRIEF

NAME
Active Spectrum

CEO
James White

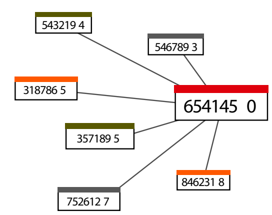
CONTACT
www.activespectrum.com

MAJOR PRODUCTS
Tunable oscillator
Tunable frequency filter
Mini electron spin resonance spectrometer

FUNDING
Funding: Less than $2 million

PATENT STRENGTH
Core protection

TIME TO MARKET
1 to 3 years



PATENT MAP
For a graphical analysis of Active Spectrum's patent position, go to www.ipvisioninc.com/techinsider/05/07.

Deciphering Cellular Cross-Talk

Communications between living cells are important for everything from development to immune response. The communication typically happens either through direct contact between cells or by means of chemical signals they release into their surroundings. But researchers trying to understand which type plays a role in a particular process haven't been able to tease them apart. Now, scientists at the Harvard-MIT Division of Health Sciences and Technology have developed a device that allows them to control how close together cells grow. Sangeeta Bhatia, an associate professor in HST and of electrical engineering and computer science, and postdoctoral associate Elliot Hui built a micromechanical culture system that they can reconfigure even as cells grow. The system consists of comb-shaped cartridges with interlocking teeth that can be placed at three different settings: closed, for direct cell-to-cell contact; detached, with a gap that prevents physical contact but still allows the transmission of chemical signals; and separated, in which the two combs are far enough apart to prevent any communication at all. Using this system, the team has already discovered that the function of liver cells depends on the help of fibroblast support cells, but that the two types of cells need to touch for only 18 hours before the liver cells can thrive on their own—a finding important to the researchers' work on engineering replacement organs. The device can be used to study development, stem cell maturation, and other processes, Hui says.

Mixing It Up

Physicists and engineers have traditionally viewed turbulence as an irregular, unpredictable flow. But in a finding that has the potential to help aeronautical, automotive, and nautical engineers, researchers at MIT have visualized the complicated pattern of motion that underlies turbulent flows. Colleagues at the University of Texas at Austin used lasers to follow the paths of buoyant, luminescent particles in a rotating tank of turbulent water. Led by mechanical-engineering professor George Haller, the MIT team analyzed the velocity of individual particles and found a compelling pattern: some sets of particles attracted other particles intensely, even as other groups repelled them with the same intensity. The ever-evolving flow patterns were being driven by these two competing sets of particles, pushing and pulling each other. Understanding turbulence might prove useful in a number of ways, Haller says. For example, pilots could use lasers to scan a plane's path in order to predict and avoid clear-air turbulence, engineers could increase the efficiency of air-fuel mixing in jet engines, and scientists could predict and abort the spread of oil and chemical spills in the ocean.

Core Values

New images, produced using data from earthquakes, show the earth's inner structure with the highest degree of resolution ever achieved. Until now, researchers had been able to examine only tiny swatches of the boundary where the planet's solid mantle layer meets its liquid outer core, some 2,900 kilometers beneath the surface. But Rob van der Hilst, director of MIT's Earth Resources Laboratory, took seismic data amassed from more than 100,000 earthquakes and processed it in such a way that the planet's core-mantle boundary beneath Central America could be mapped out in incredible detail. Earthquakes send out shock waves in all directions; this energy propagates down to the center of the earth and then bounces back upward, where seismograph stations on the surface record it. Van der Hilst, together with a colleague from Purdue University, used the resulting data to describe the mantle-core interface. "In the future, we may be able to do this over the entire globe," he says. The advance in mapping technology can also be used by the gas and oil industry to improve the imaging of complex areas of the ocean floor that are difficult to explore.

Super Cool

In intro physics classes, students are taught that quantum mechanics is important at the molecular but not the visible scale. But because quantum behavior is exposed only when all thermal energy is gone, it's an open question whether large objects actually have the same quantum behavior as small ones—no one has been able to get large objects cold enough to tell. Quantum behavior doesn't appear until objects are cooled to near absolute zero (0 Kelvin, or -237 °C), a temperature thought too low for anything bigger than molecules to reach. But now assistant physics professor Nergis Mavalvala, graduate student Thomas Corbitt, and their colleagues at Caltech and the Max Planck Institutes have laser-cooled a mirror about the size of an M&M to just 0.8 degrees Kelvin. That temperature is still too warm for researchers to see quantum behavior, but it's a huge step in the right direction. "What's more remarkable," Mavalvala says, "is how quickly we're finding ways to improve it."

NEWS LINKS

Computer model mimics blink of a human eye
web.mit.edu/newsoffice/2007/vision-0404.html

MIT neuroengineers' pulsing light silences overactive neurons
web.mit.edu/newsoffice/2007/brain-block.html

Natural polyester makes new sutures stronger, safer
web.mit.edu/newsoffice/2007/sutures.html

Engineers create SpaceNet—the supply chain
web.mit.edu/newsoffice/2007/spacenet.html

MULTIMEDIA LINKS

Building Technology that Matters: Global Opportunities in Engineering
mitworld.mit.edu/video/439/

Financial Markets: Outlook 2007
mitworld.mit.edu/video/440/

How the Cookie Cutter Crumbles

House_n Research Consortium aims to let any buyer design a customized home

These days, consumers can order a variety of personalized products, from computers preloaded with favorite applications to cars customized with preferred detailing and upgrades. These products are preassembled in factories and shipped directly to the doorstep. Kent Larson, director of MIT's House_n Research Consortium, wants to apply this same concept to our homes.

"[In] most housing today, the end user or the homeowner is not even in the process," says Larson, a principal research scientist in the Department of Architecture. "They either buy an existing house, which usually doesn't fit their needs, or they go to a new subdivision and buy some generic drywall box that the local developer has just thrown up. But when all the design decisions are being made, the person who will actually live there is not even in the process. And that's dysfunctional."

Larson envisions the following alternative: Homeowners would download software that walked them through the process of designing their future house. They could specify the dimensions of each room, the embedded wiring for a home entertainment system, and maybe even more sophisticated technology, like automated lighting and temperature control. Once finalized, the plans would be sent electronically through a chain of "integrators"—manufacturers that prefabricate parts of the house, such as walls with windows and wiring systems fully installed. These prefabricated parts would be transported to the building site, eliminating a lot of on-site construction. Meanwhile, local "assemblers" might bid on a contract to fit the parts together into a finished house. Larson believes that not only would these houses be tailored to the owner's exact preferences, but they'd be built in less than half the time of a traditional construction project.

Dutch architect N. John Habraken, who headed MIT's architecture department in the 1970s, created this concept, originally known as "open building." Larson has transformed this into open-source building, a term that refers to a web of coöperating industries—design, manufacturing, supply, and distribution—all working to create personalized living spaces. Today Larson has dedicated sections of his 14-person lab toward the goal of open building; the group is developing computer models, fabrication materials, and technologies for each step of the proposed scenario.

Currently, Larson is working with graduate student Giles Phillips to design software that would allow people to in effect become their own architects. The duo will soon solicit volunteers to go through various exercises that will help researchers correlate certain activity sequences with various room and house layouts. While most people might not be trained in architectural principles, Phillips says, a program that asks about a person's preferences and daily activities may narrow a range of blueprints down to a few that a customer can choose from. Phillips and Larson hope to produce a prototype software tool in the next year.

Meanwhile, Larson has teamed up with Bensonwood Homes, a company based in Walpole, NH, to build four customized prototype houses, one every 18 months. Each house will be designed to fit the needs of its particular occupants and will be assembled from specially designed, prefabricated parts. For example, Larson's team will design entire walls with custom wiring, plumbing, and insulation; the walls will be assembled in the factory and then transported to the building site, where they will be lowered by crane and attached to a timber frame. What's more, both electrical and plumbing systems will be easily accessible to the homeowners in case repairs are needed.

Larson's team completed the first prototype last summer: a three-story transitional housing complex for people recovering from brain injuries. The building, consisting entirely of 40 prefabricated parts (including an elevator), was assembled on-site in less than a month. Larson is already working on the design for the second prototype, a private residence for the president of Unity College in Maine. In accordance with the president's needs, Larson plans to design a modest-sized yet versatile house that can serve as both an intimate home and a place for entertaining large numbers of guests. To that end, the layout will include movable walls that can easily be reconfigured.

Larson hopes that these prototypes will serve as a proof of concept for customizable prefabricated housing. He is already talking with major manufacturers such as Georgia-Pacific and Kohler about open building. However, he may have a long way to go before the housing industry as a whole catches on.

"Getting this framework in place requires lots of convincing and coördinating amongst manufacturers, suppliers, and the distribution chain, who in turn have to buy into the concept," says Mark Gross, professor of architecture and director of the Computational Design Lab at Carnegie Mellon University. "But if the home-building business wants it to happen, it will."

IN BRIEF

NAME
House_n Research Consortium

DIRECTOR
Kent Larson

CONTACT
architecture.mit.edu/house_n/

MAJOR PROJECTS
Open-source building
Designing mass customized homes

Funding Injection

A company that makes implantable devices for the controlled release of drugs over time has completed a Series F round of investment. MicroChips, of Bedford, MA, received $13.4 million in a round led by Novartis Venture Fund. Other funders included new investor CSK Venture Capital of Japan and previous investors Polaris Venture Partners, IDG Ventures, Medtronic, Boston Scientific, Intersouth Partners, and Boston University Community Technology Fund.

MicroChips is developing a silicon-and-glass chip that can be implanted in the body and set to deliver tiny doses of a drug over periods as long as a year. Last year the company published animal data showing that it could use wireless signals to control drug release over a period of six months. Possible applications include delivering drugs to treat osteoporosis or congestive heart failure. The technology could also replace daily insulin injections for diabetics.

MicroChips was cofounded in 1999 by John Santini, now president and CEO, who received his PhD in chemical engineering from MIT that year. Other founders include Institute Professor Robert Langer and Michael Cima, professor of materials science and engineering at MIT.

www.mchips.com

A Zap in the Arm

A company that is developing a better type of cancer treatment has received a $2 million equity investment from a medical-services company. Still River Systems, of Littleton, MA, got the funding from American Shared Hospital Services (AMS), of San Francisco. AMS also bought a $1 million option to acquire two treatment systems from Still River, which are expected to be available in 2008.

Still River is building a device designed to produce beams of protons, the positively charged particles that form the nuclei of hydrogen atoms. Shooting protons at tumors is expected to kill cancer cells while doing less damage to surrounding tissue than x-rays, which are currently used for radiation treatment of cancer. Still River says its device will be smaller and less expensive than existing atomic accelerators, which cost hospitals more than $100 million and take up three rooms. The technology has not yet received approval from the U.S. Food and Drug Administration.

Founded in 2004, Still River has an exclusive license to technology developed by Timothy Antaya, a principal research engineer in MIT's Plasma Science and Fusion Center.

www.stillriversystems.com

Security Check

Passport Systems, an MIT spinoff developing cargo scanners to detect dangerous material and contraband coming into America's ports, has won a nearly $10 million contract from the U.S. Space and Naval Warfare Systems Center. The contract, for a device that can detect nuclear material, calls for work to be completed by March 2009.

The system is based on nuclear resonance fluorescence imaging, which uses x-rays to scan the contents of cargo containers. Instead of just revealing the object's shape, the technique provides information about the elements the x-rays have passed through. It could detect not only nuclear material but chemical weapons and materials used to shield radiation. American Science and Engineering, of Billerica, MA, is working on the system with Passport under a $28.8 million contract from the U.S. Department of Homeland Security's Domestic Nuclear Detection Office.

The technology was developed by William Bertozzi, professor of physics and head of the Nuclear Interactions Group in MIT's Laboratory for Nuclear Science. He founded Passport in December 2002 with Robert Ledoux, former MIT associate professor of physics and now CEO of the company.

www.passportsystems.com

Study Group

Merrimack Pharmaceuticals of Cambridge, MA, has started enrolling candidates in two separate phase II clinical trials of its first drug candidate. To study the compound, which it calls MM-093, the company hopes to enroll 90 to 100 patients with rheumatoid arthritis at 15 centers across the country. Merrimack also plans to test MM-093 in patients with uveitis, an inflammatory disease that damages vision and can lead to blindness. The drug is designed to target the inflammation caused by autoimmune diseases.

Merrimack uses microarrays to study how drugs affect interacting proteins. Traditional methods test drugs against one potential target at a time; Merrimack says its method is faster and more accurate.

The company was founded in 2000 by MIT biology professors Michael Cardone, Anthony Sinskey, Peter Sorger, and Michael Yaffe, along with Ulrik Nielsen, then a postdoctoral fellow in MIT's biology department and now Merrimack's vice president of research, and Gavin MacBeath of Harvard. Sorger, Yaffe, and Douglas Lauffenburger, the Uncas and Helen Whitaker Professor of Bioengineering at MIT, sit on the scientific advisory board.

www.merrimackpharma.com

DATEBOOK

May 2-4
Fourth Annual Meeting, MIT Center for Integrated Photonic Systems
MIT
cips.mit.edu/annual07/

May 4
2007 MIT Sloan Sales Conference
Hyatt Regency Cambridge
www.sloansalesconference.com/index.htm

May 9-10
2007 MIT Healthcare Industries Conference
Wong Auditorium, MIT
ilp-www.mit.edu/display_event.a4d?eventId=2345&key=

May 9
h2.0: New minds, new bodies, new identities
Kresge Auditorium, MIT
h20.media.mit.edu/

May 17
Fourth Annual MIT CIO Symposium
Kresge Auditorium, MIT
www.mitcio.com/

May 31-June 1
Inaugural Summit on Behavioral Telehealth: Technology for Behavior Change & Disease Management
The Conference Center at Harvard Medical, Boston, MA
www.tcbi.org/bc2007/index.html

IdeaStream

The IdeaStream Symposium, held annually by the Deshpande Center for Technological Innovation, helps forge connections between MIT innovators and venture capitalists. Students, faculty, and alumni pitch products they believe are marketable. Here is a sampling of some of this year's presentations.

PRESENTER	TECHNOLOGY	IMPACT
Saman Amarasinghe, associate professor, Electrical Engineering and Computer Science	Common machine language that allows existing programs to be adapted for use with any multicore processor	Takes advantage of the speed of new multicore processors by making it easy to rewrite existing software
Mekhail Anwar, graduate student, Electrical Engineering and Computer Science	Implantable computer chip containing a biosensor, signal-processing hardware, and wireless data-transfer capabilities	Measures a diabetic's glucose levels and reports its findings wirelessly, eliminating the need to take blood samples
Erik Bassett , graduate student, Mechanical Engineering	Device for inserting a catheter needle into a patient in a single step	Uses friction sensors to push a needle through hard tissue such as muscle but stop if it hits the empty space inside a vein or between epidural layers, reducing medical errors
François Berthiaume, visiting lecturer, Mechanical Engineering	Skin substitute for burn victims, containing small particles loaded with peptides to reduce inflammation and attract stem cells	Decreases the risk of infection, promotes faster blood vessel growth and better wound healing, and reduces scarring—and medical costs
Shawn K. Kelly, visiting scientist, Research Lab for Electronics	Eye implant that stimulates retinal nerves using images received from a video camera mounted on a pair of glasses	Lets people with retinitis pigmentosa or age-related macular degeneration see well enough to navigate, recognize faces and objects, and perhaps read large print
Nicholas Makris, associate professor, Mechanical Engineering	Device that uses sound waves to image fish populations over thousands of square kilometers	Counts fish more accurately than current methods and over an area one million times the size, improving the efficiency of both commercial fishing and regulatory tracking
Andrew Peterson, graduate student, Chemical Engineering	Process to convert corn or cellulose into propane instead of ethanol	Propane burns cleaner than gasoline or diesel and contains more energy than ethanol, providing a better alternative fuel source
Daniel Pressl, graduate student, Materials Science and Engineering	Endothermic superinsulation combining phase-change materials, which change their state according to energy input, and aerogels, low-density materials consisting mostly of air	The dual-layer insulation efficiently keeps heat out of a building in summer or traps heat inside in winter with less material than current insulation, decreasing insulation costs by an order of magnitude
Henk Wymeersch, postdoc, Electrical Engineering and Computer Science	Algorithm that allows devices using different technologies for determining location, such as RFID, GPS, and 911 systems, to communicate their positions to each other	Overcomes the limitations of individual technologies to create dynamic networks that can provide locations and aid search-and-rescue efforts in areas where GPS is unavailable