Engineers use 'shaped' laser pulses in 'ultra-wideband' research

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Engineers at Purdue University have developed a technique that could result in more accurate "ultra-wideband" radio signals for ground-penetrating radar, radio communications and imaging systems designed to see through walls.
The researchers first create laser pulses with specific "shapes," which precisely characterize the changing intensity of light from the beginning to end of each pulse. The pulses are then converted into electrical signals for various applications.

By controlling the shapes of laser pulses, the researchers are able to adjust the frequencies of the resulting radio signals and to produce signals with higher frequencies than are otherwise possible. Shorter signals make it easier to screen out interference and enhance image resolution, promising to improve the accuracy of systems used to detect landmines and other underground objects and for newly emerging devices that can look through walls and see what's on the other side.

"You want the best spatial resolution possible if you have two items buried close to one another," said Jason McKinney, a visiting assistant professor of electrical and computer engineering at Purdue. "If your pulse is too long, you get a combined reflection from both items back, but if your pulse is short enough, you get a separate reflection from each."

A similar situation arises in wireless communications. When radio signals are transmitted from one antenna to another, some travel directly to the second antenna while others bounce off of buildings and other objects along the way, causing "noise," or interference. By shaping the laser pulses so they are "narrow," shorter electronic signals can be created. The shorter the signals, the easier it is to pick them out from the noisy, interfering signals by the time they arrive at the receiving end of the transmission.

The researchers' technique will be detailed in a paper to appear in the April issue of IEEE Microwave and Wireless Components Letters, a journal published by the Institute of Electrical and Electronics Engineers. The paper was written by Ingrid S. Lin, a Purdue doctoral student, McKinney and Andrew Weiner, a professor of electrical and computer engineering.

Ultra-wideband technology, commonly referred to as UWB, has numerous potential applications, including high-speed handheld wireless communications for consumer electronics, radar systems in cars that might be used to prevent collisions and the development of "personal area networks," or wireless networks linking computer equipment, personal digital assistants and other devices within a person's workspace.

While commercially available electronic devices produce a fixed set of wideband frequencies, the Purdue team is able to adjust the shapes of optical pulses and the resulting electrical signal, which means more precisely controlled ultra-wideband frequencies can be produced.

"The main innovation is the ability to define what we want," McKinney said. "We're able to say, 'Here is what I want, give it to me, and the system produces the desired signal.'"

The innovation could have laboratory applications in testing and research and in the development of ultra-wideband and wireless radio systems.

Each laser pulse lasts about 300 femtoseconds, or three-tenths of a trillionth of a second. These pulses are processed using "optical arbitrary waveform technology" pioneered by Purdue researchers led by Weiner, which results in a three-nanosecond laser pulse.

"There are commercial boxes that generate pulsed electrical signals, but the user has no control over the shape of these signals," McKinney said. "Because we can create desired shapes of pulsed light, we are able to create electrical signals that you can't buy a commercial box to make. The pulse is designed to produce the desired electrical 'waveform,' or a shaped electrical signal that evolves over time in a user-defined way."

The radio-frequency signal is obtained after a device converts the laser pulse into a radio signal for radar and wireless communications.

"Our goal is to improve radio frequency communications, impulsive radar and other applications in the blossoming area of ultra-wideband radio frequency systems," McKinney said.

Source: Purdue University