New Ultra-Wideband Radio Design Hurdles Traditional Challenges

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A working prototype of an ultra-wideband digital wireless radio, a feat that the electronics industry has struggled to accomplish, has been built by four undergraduates from the University of Massachusetts Amherst. The device could have applications in industrial monitoring and medical sensing by providing a cheap and reliable way of transferring data between electronic devices. A team of faculty and graduate students in the electrical and computer engineering department developed the novel approach to creating the prototype.

Qu Zhang, a doctoral student in electrical and computer engineering at UMass Amherst, will present the new circuitry and experimental results on Sept. 26 at the 2006 International Conference on Ultra-Wideband in Waltham, Mass.

Ultra-wideband radio has been attractive to industry for some time, as it circumvents a tricky problem, says UMass Amherst's Dennis Goeckel, lead faculty member on the project. The radio frequency spectrum is crowded with radio, television and other bandwidth allocations. Ultra-wideband however, spreads the signal power across a wide number of frequency bands so the effect on any given frequency band is negligible.

"The basic idea is to override everybody out there on the spectrum – radio, TV, cell phones, everybody," says Goeckel. "So it causes each person only a little bit of pain."

Another appealing aspect of ultra-wideband is that it provides a very high resolution of the signal at the receiver. This makes for extremely reliable communications and makes it easy for the system to determine where the transmitter is located, important when tracking something carrying the transmitter, such as patients in a hospital or parts in a factory. But this benefit is also ultra-wideband's bane— the high resolution means that the receiver sees in great detail all of the distortion caused by the signal bouncing off metal structures.

"The resolution is great—but you see all these bounces, and if you can't process them, it hurts," explains Goeckel. "In our lab, for example, there are all these metal benches and file cabinets. So, because of that interference, the data are smeared and your receiver gets what appears to be a bunch of garbage."

Engineers have tried to address this problem in ultra-wideband by including a device known as a delay-line in the receiver, says Goeckel. The delay-line allows for recombining the radio signal that was subdivided at the transmitter, making it possible to compare and interpret all the data being transmitted, despite the reflections from the metal objects.

But the delay line for an ultra-wideband radio has proven incredibly hard to build. One solution in a previous industrial prototype was to employ a 20-foot-long cable, which is terribly unwieldy compared to the anticipated thumbnail-sized receiver to which it will be attached.

"It's a clever idea and has been studied like crazy in the literature, but you just can't build it, you just can't," says Goeckel. "People have been working very hard on this—but they aren't getting close to what's needed."

So the UMass Amherst team came up with an elegant solution that doesn't take the delay-line route. Instead of separating the two pulses by time as the delay-line does, the team decided to separate the pulses by frequency. It's a clever idea that requires only a mixer, a component that can be bought right off the shelf.

"We changed the system," says Goeckel. "By sending the reference signal and the data at the same time but at different frequencies, we can line everything up at the receiver without the need for the delay-line."

Armed with this new concept and design, a team of undergraduates took just nine months to construct a working prototype of an ultra wide-band digital radio, which they first unveiled in April at the Ultra-Wideband Workshop sponsored by University of Southern California. Members of the undergraduate team, under the leadership of Robert W. Jackson, electrical and chemical engineering, included then seniors Justin Burkhart, Brandon Mui, Matt Carrier and Nick Merrill.

"This is not the whole solution that people have historically been looking for to the ultra-wideband receiver design," notes Goeckel. "But it is part of the solution. What we're talking about here is a solution for radio devices with low data rates, lots of metal interference, things moving very quickly, really harsh environments. Ours is a good solution to that part of the problem."

Source: University of Massachusetts Amherst

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