New chip design delivers better performance, longer battery lilfe

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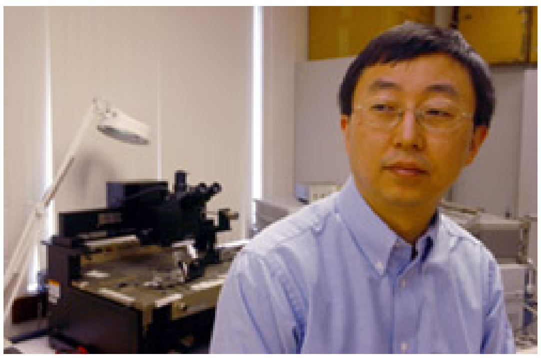

Hui Wu, professor of electrical and computer engineering (PHOTO CREDIT: University of Rochester)

Anyone who uses a cell phone or a WiFi laptop knows the irritation of a dead-battery surprise. But now researchers at the University of Rochester have broken a barrier in wireless chip design that uses a tenth as much battery power as current designs and, better yet, will use much less in emerging wireless devices of the future.

Hui Wu, professor of electrical and computer engineering at the University of Rochester, a pioneer in a circuit design called an "injection locked frequency divider," or ILFD, has solved the last hurdle to making the new method work. Wireless chip manufacturers have been aware of ILFD and its ability to ensure accurate data transfer using much less energy than traditional digital methods, but the technique had two fatal flaws: it could not handle a wide range of frequencies, and could not ensure a fine enough resolution within that range. Wu, together with Ali Hajimiri, associate professor of electrical engineering at California Institute of Technology, surmounted the first problem in 2001, and has now found a solution for the latter.

When a cell phone or a laptop using WiFi or Bluetooth communicates wirelessly, the data is transmitted at very specific frequencies. One person can talk on a cell phone at a frequency of 2.0001 gigahertz, and someone else nearby can talk at 2.0002 gigahertz, and neither one will pick up the other's conversation. In order to make sure it is both listening for and sending information on exactly the right frequency at all times, the phone must maintain a very accurate and stable clock, which is generated by a special circuit called "phase-locked loop." This circuit consumes a dramatic portion of the battery usage on wireless devices.

Wu's ILFD method uses less power than conventional digital methods because the tiny "ones" and "zeroes" that comprise digital information waste energy. Digital circuitry checks the frequency by counting each pulse of the clock one at a time. When a one is needed, the system sends electricity to the right node on a chip, and that node then represents a one. When the system then calls for a zero, that stored energy is simply released from the circuit as heat, and the node resets to a low-energy state. Do this several billion times a second, and quite a bit of energy in the form of those dissipated ones is simply wasted. An ILFD device, on the other hand, does not use a brute-force approach of counting each pulse. To gauge and stabilize the generated frequency, a phase-locked loop multiplies the pulse from a highly-stable reference clock, such as a quartz crystal oscillator, up to the desired frequency. To check if the output frequency is correct, a frequency divider essentially undoes the multiplying process, and the result can then be compared to the initial clock, with adjustments made as needed.

ILFDs use an analog method that requires less power, but the Achilles' heel of ILFDs has always been their inability to efficiently and reliably divide the frequency by anything but two--a serious drawback to achieve fine frequency resolution, which is a must for modern communication systems.

This is where Wu's new design makes the practical application of ILFDs possible. He introduced a new topology into this circuitry--instead of the old three-transistor design, his has five transistors--creating what he calls "differential mixing." The new circuitry topology allows the ILFD to divide by three as well as two.

This tiny change has huge ramifications. A circuit design that can divide by two or three can, for instance, divide 9,999 clock pulses by two, and the 10,000th by 3, giving an average of 2.0001, which could be the frequency at which the cell phone is trying to communicate. Should the phone need to communicate at 2.0002 gigahertz, the ILFD could divide 9,998 clock pulses by two, and the 9,999th and 10,000th by three, yielding an average of 2.0002. By varying how many clock pulses are divided by two or by three, any frequency can be selected, making the power-saving ILFD method viable for the first time.

Wu has demonstrated another benefit of his "Divide-by-Odd-Number ILFD." In an effort to move more data faster, wireless manufacturers are looking to move to ever-higher frequencies. A 900-megahertz cordless phone, for instance, was once considered state of the art, but soon cordless phones migrated to 2.4 gigahertz, and now 5.8 gigahertz. Likewise, WiFi and other wireless networking devices will soon be pushing into the proposed 60 gigahertz band. At such high frequencies, a digital frequency divider will be hard pressed to keep up such speed, and will demand ever-more power to do so, but Wu's ILFD will be much less demanding and will use proportionately less power as the frequency increases.

Wu's group has designed and fabricated several prototype chips, and the results successfully demonstrated his concepts. One of them, an 18 gigahertz divide-by-3 ILFD, was recently presented at this year's International Solid-State Circuits Conference, the premiere technical conference in semiconductor industries. Wu is also working on other power-saving aspects of chip design that he hopes can be used to stretch the battery life of wireless devices even further.

Source: University of Rochester

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