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●インターネット・オブ・シングス (IoT) に不可欠な省電力型トランスミッタ

【MIT News Office, 2015/02/22】

インターネット・オブ・シングス (IoT) を実現するにあたっては、数ヤード離れた機器と通信できる性能を持ちながら、数か月にわたって駆動できる、あるいは熱・振動などを電力に変換できる電力効率の高いトランスミッタが必要となる。

マサチューセッツ工科大学 (MIT) のアナンサ・チャンドラカサン教授は、その中でも最も大きな課題はスタンバイ時の電力を極限まで抑えることだという。

同教授の研究グループは、今週開かれる IEEE の「International Solid-State Circuits Conference」で、この課題に取り組んだ成果を発表する予定。

この席で、オフ時の消費電力を従来の 100 分の 1 に抑える一方、Bluetooth や 802.15.4 による通信が可能なトランスミッタを公開する。

チャンドラカサン教授によると、このトランスミッタはトランジスタの漏れ電力を減らす手法を応用しているとのこと。

トランジスタは半導体に 2 本の電極を接続し、これに対して垂直に取り付けられたゲートに正電荷をかけることで電極間に電流を流すが、ゲートに電荷がかかっていない状態でも微小な電流は流れ、これが消費電力の増加につながる。

チャンドラカサン教授のチームは、トランスミッタがアイドル時には逆に負電荷をかけることで、より積極的に半導体を絶縁化している。

この場合、負電荷の消費電力がアイドル時の漏れ電力よりも小さければ、電力消費は抑えられることになるが、TSMC の研究プログラムを通じて製造された試作品のテストでは、20 ピコワットの消費で 1 万ピコワット分の漏れ電力節減に成功した。

今回の研究には、テキサス・インスツルメンツ (TI) とシェルが資金を提供している。

記事入手元：

<http://newsoffice.mit.edu/2015/low-power-radio-chip-internet-of-things-0222>

(参考) 本件報道記事

Radio chip for the “Internet of things”

Circuit that reduces power leakage when transmitters are idle could greatly

extend battery life.

Larry Hardesty | MIT News Office

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At this year's Consumer Electronics Show in Las Vegas, the big theme was the "Internet of things" - the idea that everything in the human environment, from kitchen appliances to industrial equipment, could be equipped with sensors and processors that can exchange data, helping with maintenance and the coordination of tasks.

Realizing that vision, however, requires transmitters that are powerful enough to broadcast to devices dozens of yards away but energy-efficient enough to last for months - or even to harvest energy from heat or mechanical vibrations.

"A key challenge is designing these circuits with extremely low standby power, because most of these devices are just sitting idling, waiting for some event to trigger a communication," explains Anantha Chandrakasan, the Joseph F. and Nancy P. Keithley Professor in Electrical Engineering at MIT. "When it's on, you want to be as efficient as possible, and when it's off, you want to really cut off the off-state power, the leakage power."

This week, at the Institute of Electrical and Electronics Engineers' International Solid-State Circuits Conference, Chandrakasan's group will present a new transmitter design that reduces off-state leakage 100-fold. At the same time, it provides adequate power for Bluetooth transmission, or for the even longer-range 802.15.4 wireless-communication protocol.

"The trick is that we borrow techniques that we use to reduce the leakage power in digital circuits," Chandrakasan explains. The basic element of a digital circuit is a transistor, in which two electrical leads are connected by a semiconducting material, such as silicon. In their native states, semiconductors are not particularly good conductors. But in a transistor, the semiconductor has a second wire sitting on top of it, which runs perpendicularly to the electrical leads. Sending a positive charge through this wire - known as the gate - draws electrons toward it. The concentration of electrons creates a bridge that current can cross between the leads.

But while semiconductors are not naturally very good conductors, neither are they perfect insulators. Even when no charge is applied to the gate, some current still leaks across the transistor. It's not much, but over time, it can make a big difference in the battery life of a device that spends most of its time sitting idle.

Going negative

Chandrakasan - along with Arun Paidimarri, an MIT graduate student in electrical engineering and computer science and first author on the paper, and Nathan Ickes, a research scientist in Chandrakasan's lab - reduces the leakage by applying a negative charge to the gate when the transmitter is idle. That drives electrons away from the electrical leads, making the semiconductor a much better insulator.

Of course, that strategy works only if generating the negative charge consumes less energy than the circuit would otherwise lose to leakage. In tests conducted on a prototype chip fabricated through the Taiwan Semiconductor Manufacturing Company's research program, the MIT researchers found that their circuit spent only 20 picowatts of power to save 10,000 picowatts in leakage.

To generate the negative charge efficiently, the MIT researchers use a circuit known as a charge pump, which is a small network of capacitors - electronic components that can store charge - and switches. When the charge pump is exposed to the voltage that drives the chip, charge builds up in one of the capacitors. Throwing one of the switches connects the positive end of the capacitor to the ground, causing a current to flow out the other end. This process is repeated over and over. The only real power drain comes from throwing the switch, which happens about 15 times a second.

Turned on

To make the transmitter more efficient when it's active, the researchers adopted techniques that have long been a feature of work in Chandrakasan's group. Ordinarily, the frequency at which a transmitter can broadcast is a function of

its voltage. But the MIT researchers decomposed the problem of generating an electromagnetic signal into discrete steps, only some of which require higher voltages. For those steps, the circuit uses capacitors and inductors to increase voltage locally. That keeps the overall voltage of the circuit down, while still enabling high-frequency transmissions.

What those efficiencies mean for battery life depends on how frequently the transmitter is operational. But if it can get away with broadcasting only every hour or so, the researchers' circuit can reduce power consumption 100-fold.

“Ultralow leakage energy is critical for future sensor nodes that need the transmitter to be on only a very small percentage of time,” says Baher Haroun, director of the Embedded Processing Systems Labs at Texas Instruments (TI), which helped fund the MIT researchers' work. “Working with Anantha's research team on ultralow-power circuit and system ideas has always been beneficial to TI. We learn from his team's novel approaches and depth of understanding of the ultralow-power methods that apply to multiple functions, from digital to [radio frequency].”

The research was also funded by Shell.

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