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3Qs: Could circuits' face-lift mean faster, smaller phones?

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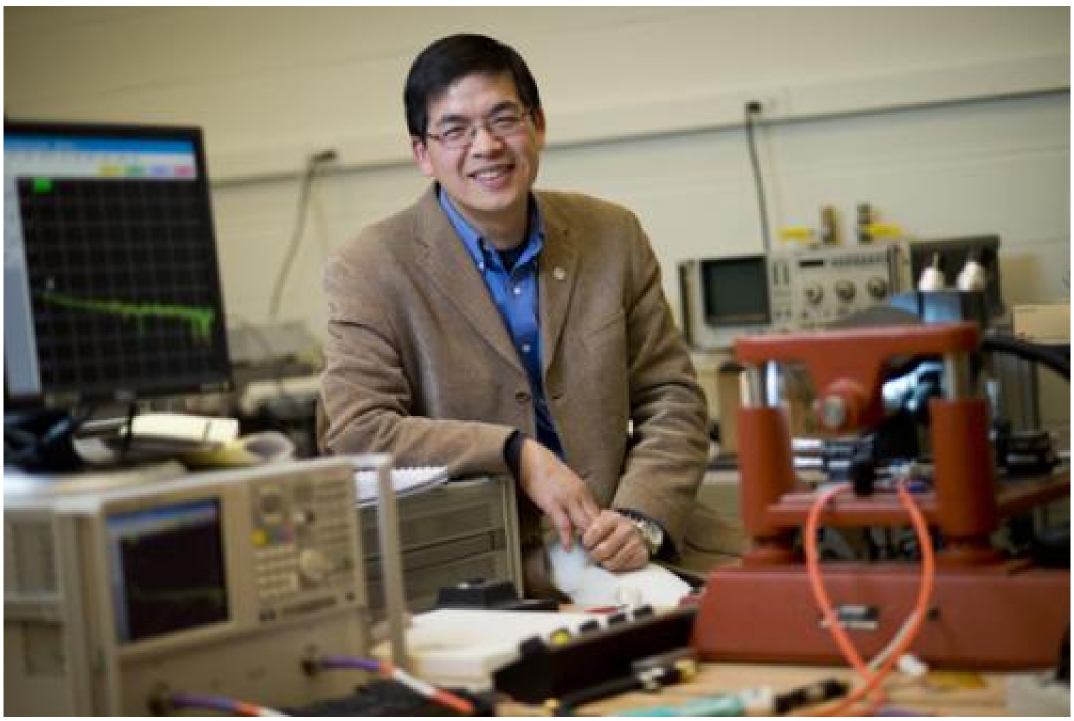

Associate professor of electrical and computer engineering Nian Sun works on the interface of radio-frequency devices and the magnetic field. Credit: Brooks Canaday.

Imagine a cell phone that's half the size with longer battery time and better performance. That could become a reality thanks to new research by Nian Sun, associate professor of electrical and computer engineering at Northeastern. Sun's team recently presented work that could significantly improve the functionality and efficiency of our smartphones and other radio-frequency devices. We asked him to explain the research and discuss what sort of impact it might have on the telecommunication devices we've all come to rely on.

How do cell phones currently achieve multimodal functionality, and what are the limitations to this method?

Every time we switch between operations on our cell phones—going to GPS, cellular, wifi, Bluetooth or even switching among different cellular bands and wifi bands—we are switching between radio-frequency channels that the phone is handling automatically and seamlessly. So, how does it switch from one channel to another? It can either use an electronic switch to choose different circuits that operate different channels, or it can use tunable components that can operate on different channels simultaneously.

Every radio-frequency resonance circuit has two components: an inductor and a capacitor. For the many decades that we've been using RF devices, we've only been able to tune the capacitor.

Every cell phone now can have up to about 20 channels distributed across the capacitors of a handful of circuit modules. The challenge is to minimize the number of circuit modules in a cell phone, which could make these devices smaller, lead to less radio frequency interference, and allow the batteries to last longer. This is because circuit components dissipate a lot of energy into heat instead of being used to carry data. It's why your cell phone gets hot.

What is the innovation you have introduced with your recent research?

It's more difficult to tune the other half of the circuit module—the inductor—because the only method involves using a strong magnetic field. This is not really viable with a cell phone. In the lab, producing a tuning magnetic field requires kilowatts of power, which is not feasible to realize this in mobile system because the battery isn't large enough to produce a strong enough current.

So we tried something different. Instead of using a current, we used voltage to tune inductance, a much more power efficient approach. You have to constantly drive a current in order to achieve magnetic field tuning of inductance, but with voltage tuning you can just charge it and inductance change will stay. This means RF circuits can be tunable on both the capacitor and inductor side. It's the missing link for tunable RF circuits.

How will this innovative approach change our cell phones?

There are currently multiple radio frequency circuit modules in a cell phone. This number could be reduced by half because right now tunability is quite limited since only capacitors or half of each circuit module is being tuned.

Right now, cellphones have to use multiple modules to operate on different RF channels, but if they used our components instead, they could realize the same number of channels with fewer circuit modules since we can pack more channels into one module by tuning both sides—the capacitor and the inductor. This means that the number of circuit modules can be significantly reduced. Cell phones could be much more compact than they are right now and still be very powerful both in their performance and data rate, while also achieving a clearer signal.

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