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# Backscatter Modulation based on Chirp Spread Spectrum (CSS) with enhanced processing gain

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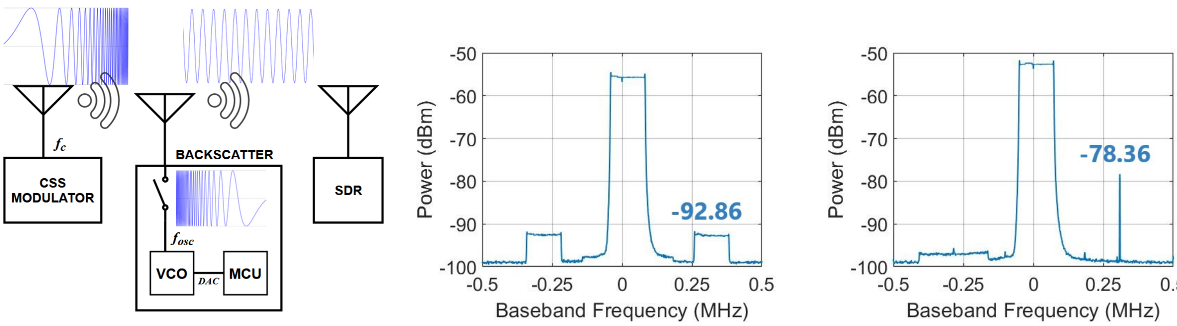
## Extended Abstract

The main barrier to continue spreading IoT wireless nodes worldwide is power consumption. The ability to reduce that consumption will bring about a wide amount of new possible applications and give a boost to the IoT market. At the same time, the relentless reduction in microcontroller power consumption puts the spotlight on radio frequency circuits, which use energy-hungry power amplifiers. The objective is to help provide IoT devices with wireless capabilities without increasing energy consumption at several milliamperes.

This work studies the use of the backscattering technique as a solution to the aforementioned issue. In backscatter transmissions, energy is moved to an external device, just as in conventional RFID communications. Therefore, backscatter devices make use of environment signals as carriers, bouncing them out with new information. This technique replaces standard radio-frequency circuitry with an RF switch with less than one microampere power consumption. The prototype uses the ADG902, an economical reflective switch ideal for wireless applications, connected to a VCO, which in turn is controlled by a microcontroller. The VCO generates the frequency signal $f_{osc}$ that controls the switch. The main drawback of this technique is the trade-off between power consumption and the backscattered signal strength, which is abruptly reduced. To deal with that, a novel backscattering modulation that increases power -an consequently the range- is proposed here. Conventional backscatters bounce the source signal $f_c$, shifting it $f_{osc}$ towards the sidebands, resulting in a copy of the carrier at $f_c \pm f_{osc}$. The backscattered signal strength can be calculated by means of the radar equation. The technique presented in this work consists in using a chirp spread spectrum (CSS) signal as a source to modulate new information acting on the backscatter frequency $f_{osc}$. The microcontroller of the backscatter device modulates $f_{osc}$ with an inverted frequency chirp of duration $T$ from $f_c + BW/2$ to $f_c - BW/2$, being $T$ and $BW$ the period and bandwidth of the source chirp, respectively. The result of this operation is a frequency tone equivalent to concentrating the spread power of the incoming signal, achieving an extra gain of over 10 dB, compared to conventional backscattering. By acting on the backscatter modulation, it is possible to create different modulations, like OOK, FSK, or even a slower CCS. A 13-bit barker sequence with an ideal auto-correlation property has been implemented, providing additional processing gain to the modulation. The processing gain can vary from 6 $dB$ to 22.3 $dB$ depending on the length of the sequence.




(a) (b) (c)

**Figure 1.** (a) Operation diagram; (b) Conventional backscattering of a CSS signal. Source signal: Frequency chirp with $BW$ = 125 $kHz$ and $T$ = 32.77 $ms$ centered at $f_c$ = 868 $MHz$, Backscatter signal: Frequency tone at $f_{osc}$ = 300 $kHz$; (c) Backscattering technique proposed in this work. Source signal: Frequency chirp with $BW$ = 125 $kHz$ and $T$ = 32.77 $ms$ centered at $f_c$ = 868 $MHz$, Backscatter signal: Frequency chirp with $BW$ = 125 $kHz$ and $T$ = 32.77 $ms$ centered at $f_{osc}$ = 300 $kHz$, and reversed with regard to the source signal.