Low Cost Ambient Backscatter for Agricultural Applications

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In our days, the massive growth of Internet-of-Things related applications has required the design and fabrication of low-cost and low-power wireless sensors. The last decade, backscatter communication has been introduced as a cutting-edge technology that could address the above limitations. In high precision agricultural applications, the monitoring of plant-water-stress (PWS) is of high importance for smart sensing. Instead of the traditional ground soil moisture sensing, leaf sensing is an old technology, which is used for the detection of PWS. Considering the above topics, this work aims to mention the development of a novel sensor node/tag for environmental leaf sensing which uses backscattering communication over ambient frequency modulated signals (FM music signals). The work is based on our previous works [1], [2] and it is described how ambient backscatter technology could be exploited for the "one sensor/plant" concept in precision agriculture applications.

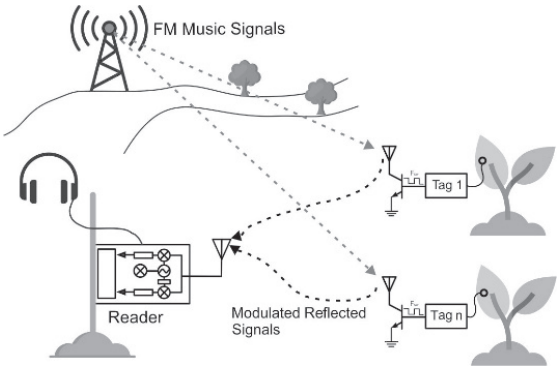

Figure 1. Backscatter communication using ambient Frequency Modulated (FM) signals. A commecrial FM receiver can be used for collecting the data.

Ambient backscattering is a novel idea based on the bistatic backscatter philosophy and has become a very promising approach for extremely low-power and low-cost communication. Cellular, TV, FM radio and Wi-Fi signals that are typically available in urban areas indoors and outdoors for 24 hours a day. In our case, as the application is outdoors, far away from industrial centers, only the powerful FM signals are suitable for communication. The tags, shown in Fig. 1, can reflect the ambient music signals from nearby FM stations to communicate with a FM receiver. By using the reflections of FM signals, the "reader" system is simplified, and its power consumption is reduced dramatically since it does not need a dedicated transmitter but only a receiver part. The receiver consists of a commercial low-cost software defined radio which captures the received signal and decodes with an appropriate signal processing algorithm.

The work is based on our recent work [1] that was presented for the first time a novel plant leaf sensor based on a low-cost and low-power backscatter tag. The proof-of-consent prototype is batteryless and was powered by a flexible solar panel consuming around 20 uW of power. The sensor measures the T_{leaf}-T_{air} which is strictly related to the PWS. The prototype cost was estimated under 15 USD and was demonstrated in monostatic architecture with operation up to 2 m distance. Binary amplitude shift keying (ASK) modulation are commonly used for the communication between the tag and reader, such that information is encoded using two states of the amplitude of the reflected carrier wave (CW). The tag uses ambient FM signals as a carrier instead of an unmodulated CW signal [2]. Each tag consists of a micro-controller (MCU) with an analog-to-digital converter (ADC) and a super capacitor charging circuit. The tag could collect readings from analog sensors through the ADC and process them. After that MCU internally, converts the sensor values to modulation pulses and controls the RF front-end transistor.

[1] S. N. Daskalakis, G. Goussetis, S. D. Assimonis, M. M. Tentzeris, and A. Georgiadis, "A uW backscatter-morse-leaf sensor for low-power agricultural wireless sensor networks," IEEE Sensors J., vol. 18, no. 19, pp. 7889–7898, Oct. 2018.
[2] S. N. Daskalakis, J. Kimionis, A. Collado, G. Goussetis, M. M. Tentzeris, and A. Georgiadis, "Ambient backscatterers using FM broadcasting for low cost and low power wireless applications," IEEE Trans. Microw. Theory Techn., vol. PP, no. 99, pp. 1–12, Nov. 2017.

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