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## Backscattering Communications

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### Microwaves and Antenna Engineering Group

<https://microwaves.site.hw.ac.uk>

## Motivation

The electromagnetic backscattering phenomenon, underpinning the modern Radar and RFID technologies, has now been employed for wireless communication and sensing purposes, especially under the trend of booming Internet of Things (IoT). It is a preferable solution for future ubiquitous IoT communications and sensing, as it removes the costly and power-hungry RF frontends, e.g., mixers and power amplifiers, which exist in every conventional wireless transmitter. Instead, a backscatter tag relies on modulating the scattered incoming electromagnetic waves. Since backscatter tags do not actively radiate, they generally consume orders of magnitude lower than the common conventional IoT nodes, more precise tens of  $\mu\text{W}$ . This ultra-low power consumption allows the backscatter tags to operate in passive or semi-passive fashion.

## Research Fronts

The group researchers have been leading the backscattering communications in a number of fronts, e.g. ambient backscatter systems, long-range backscatter links, high transmission data-rates, and network spectrum management. In particular, we have successfully demonstrated the backscattering communication systems that can apply different orders of PAM and FSK modulated signals onto ambient FM and WiFi signals. In addition, we synthesised LoRa and OFDM compatible backscatter waveforms that extend the communication ranges to kilometres. In a live award-winning demonstration at Bell Labs NJ, the HWU team achieved Gbps data rate communication across a range of a few metres by virtue of backscattering a 24 GHz signal of an FMCW radar at a record per bit energy consumption of less than 0.15 pJ/bit.

## Achievements

1. Winner of [Proceedings of the IEEE 2023 Best Paper Award](#)
2. [3<sup>rd</sup> place Bell Labs prize \(2016\)](#) on Gbps mmWave backscattering communications.
3. Long-range and high data-rate backscattering communications.

4. [IEEE Graduate Fellowship Award \(2019\)](#)
5. [Coordinating European School of Antennas](#)

## Relevant Demonstration Videos

- [2FSK Ambient FM Demo](#)
- [2FSK Ambient WiFi Demo](#)
- [PAM Ambient FM Demo](#)
- [RFID Ambient Sensing Demo](#)

## Funding Support

Defence and Security Accelerator: 'Exploring ambient signals to stay connected in crowded EM environment'

## Patent

G. Goussetis, et al., Long Range Ambient Backscatter Apparatus, Greece, filing 20200100416, 16 July 2020.

## Selected Publications

Yuan Ding, et al., "Advances in wirelessly powered backscatter communications: From antenna/RF circuitry design to printed flexible electronics," IEEE Proc., 2022. DOI: 10.1109/JPROC.2021.3125285

Yuan Ding, et al., "Backscatter communications," IEEE J. Microw., 2021. DOI: 10.1109/JMW.2021.3110058

Yuan Ding, et al., "FM Rider: Two-FSK Modulation Based Ambient FM Backscatter Over One Hundred Metres Distance," IEEE Trans. Microw. Theory Tech., 2024. DOI: 10.1109/TMTT.2024.3367439

Yuan Ding, et al., "Bitalign: Bit alignment for Bluetooth backscatter communication," IEEE Trans. Mobile Computing, 2024. DOI: 10.1109/TMC.2024.3374815

Yuan Ding, et al., "Embracing self-powered wearables for intelligent healthcare data management," IEEE J. IoT, 2024. DOI: 10.1109/JIOT.2024.3381233

Yuan Ding, et al., "IQ impedance modulator front-end for low-power LoRa backscattering devices," IEEE Trans. Microw. Theory Tech., 2019. DOI: 10.1109/TMTT.2019.2941854

## Researchers

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