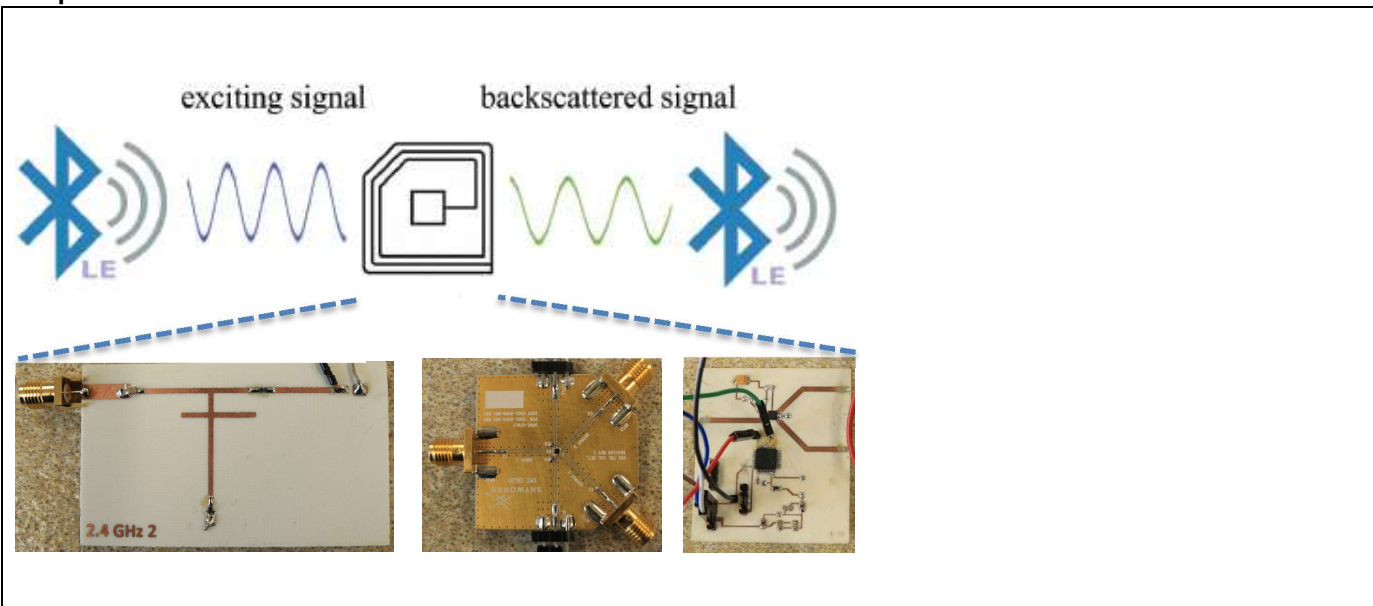


Radio Frequency and Physical-layer Designs for Backscatter Communications

Abstract:

In this short course, we will start from the basic principle of backscatter communications, especially its unique features that are favorable for ultra-low-power Internet of Things (IoT) applications. It will then focus on the recent development on ambient backscatter communications. In the first part, the radio frequency designs for different backscatter modulation schemes will be presented, as well as the associated energy harvesting modules. In the second half, we will dedicate to Bluetooth Low Energy (BLE) backscatter communications, from physical-layer protocol designs to practical implementations. A number of prototypes will be demonstrated lively.

Graphical abstract*:



Recommended prerequisites for attendees:

The course requires a basic knowledge of wireless communications and microwave & radio frequency engineering.

Learning objectives:

After the course the participant will be able to

- Understand the principle of backscatter communications, and especially the ambient backscatter communications;
- Understand the design criteria on radio frequency circuits for backscatter tags;
- Understand the energy harvesting designs and its interaction with backscatter modulation circuits;

- Understand the challenges and state-of-the-art on ambient Bluetooth Low Energy backscatter communications;
- Understand the experiment setups and system prototyping.

Course outline:

The course will be organized in two sections, delivered by two organizers.

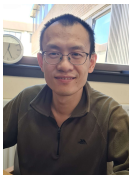
The first section will present the basic principle of backscatter communications, and especially the challenges and recent development on ambient backscatter communications. The radio frequency design examples, as well as prototypes, will be discussed. A demo on either FM backscatter communications or WiFi backscatter communications will be shown lively.

The second section will be dedicated to Bluetooth Low Energy backscatter communications, from excitor design, tag designs, and commercial BLE compatible physical-layer designs. Some live demonstrations will be presented in the short course.

Below topics will be covered:

1. Backscatter Principle
 - Dedicated backscatter & ambient backscatter;
 - Monostatic backscatter & bistatic backscatter;
2. Backscatter modulation
 - Amplitude, phase and frequency-domain modulations;
 - Sideband and harmonic suppression;
 - Other advanced receiver processing;
3. Backscatter circuits
 - RF switch based;
 - RF transistor based;
 - Digital pin based;
 - Tunnel diode based;
4. Powering
 - RF energy harvesting;
 - Power management;
 - Interaction among powering and backscattering;
5. Waveform designs for compatibility with commercial transceivers, using Bluetooth Low Energy as example.
 - Excitor designs;

- Protocol and waveform designs;
 - Preamble detection;
 - Synchronization;
6. Live demonstration
- In-band ambient WiFi backscatter communications;
 - Commercial-BLE compatible backscatter communications



YUAN DING received his Bachelor's degree from Beihang University (BUAA), Beijing, China, in 2004, received his Master's degree from Tsinghua University, Beijing, China, in 2007, and received his Ph.D. degree from Queen's University of Belfast, Belfast, UK, in 2014, all in Electronic Engineering.

He was a radio frequency (RF) Engineer in Motorola R&D Centre (Beijing, China) from 2007 to 2009, before joining Freescale Semiconductor Inc. (Beijing, China) as an RF Field Application Engineer, responsible for high power base-station amplifier design, from 2009 to 2011. He is now an Associate Professor at the Institute of Sensors, Signals and Systems (ISSS) in Heriot-Watt University, Edinburgh, UK. His research interests are in backscatter communications, antenna array, physical layer security, and 5G related areas.

Dr. Ding was the recipient of the IET Best Student Paper Award at LAPC 2013 and the recipient of the Young Scientists Awards in General Assembly and Scientific Symposium (GASS), 2014 XXXIst URSI.



WEI GONG is a professor in the School of computer science and Technology at the University of Science and Technology of China. His research focuses on battery-free sensors, backscatter networks, and green computing. His group has pioneered the research on backscatter communications and networks. His works have led the world's efforts to develop general-purpose backscatter on many research fronts, including Bluetooth, cellular, and WiFi backscatter networks. Also, his group has invented several novel backscatter architectures, such as multi-hop, multi-carrier, and multi-frequency backscatter paradigms. Previously, he had worked at SFU, UOttawa, and Tsinghua University. After receiving his B.E. in computer science at HUST, he attended Tsinghua University, where he was awarded his M.E. in software engineering and Ph.D. in computer science.

Key bibliography

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