

# New Opportunities for Sustainable Interaction Using Backscatter Sensors

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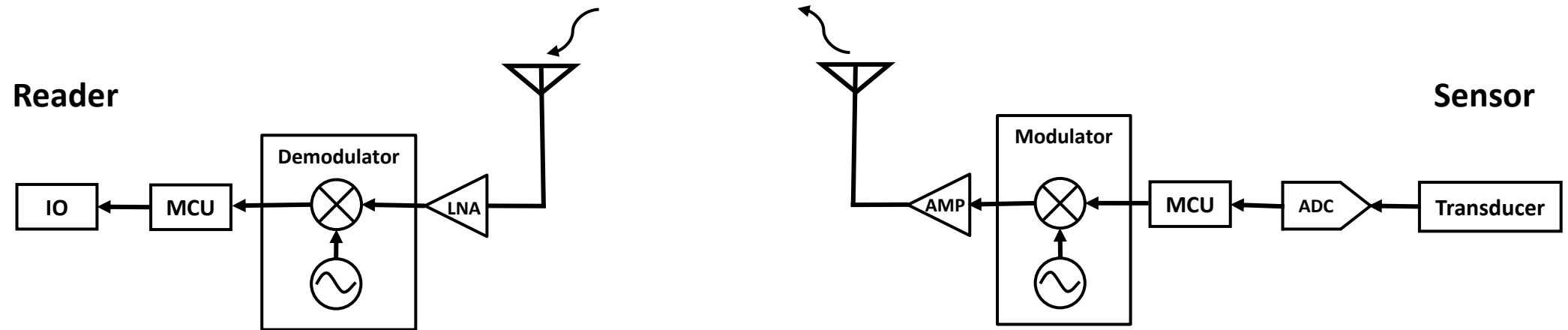
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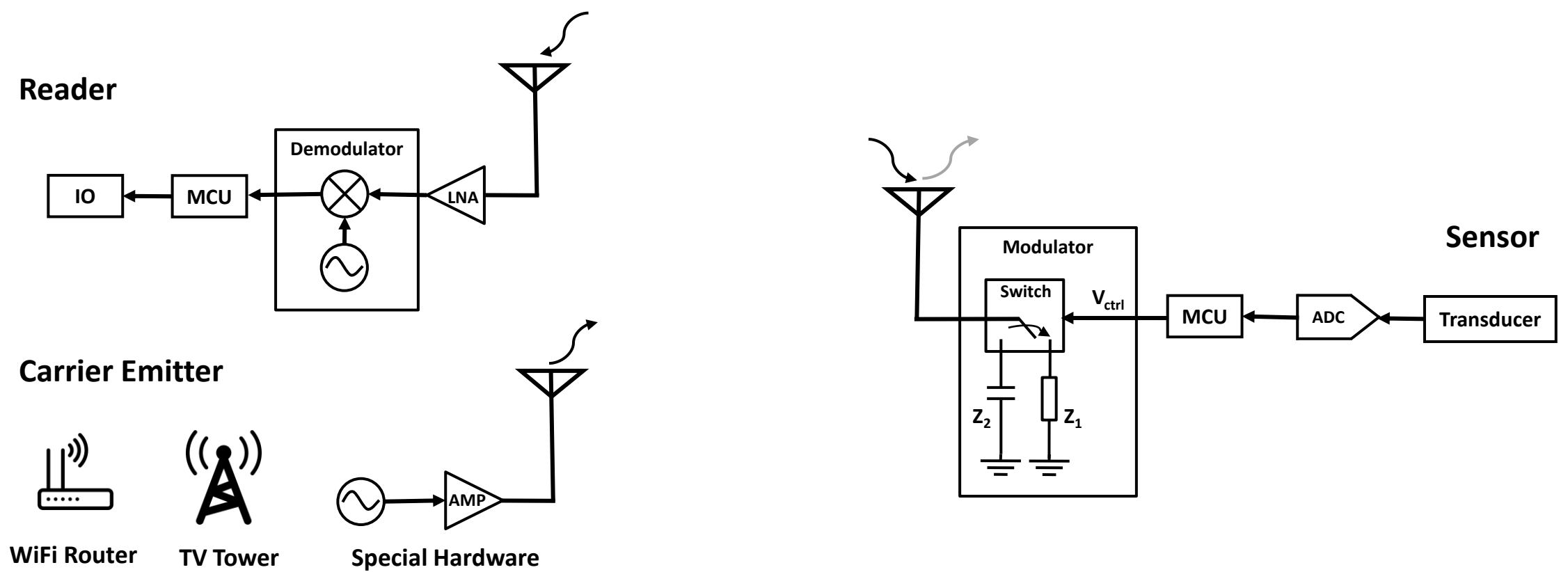
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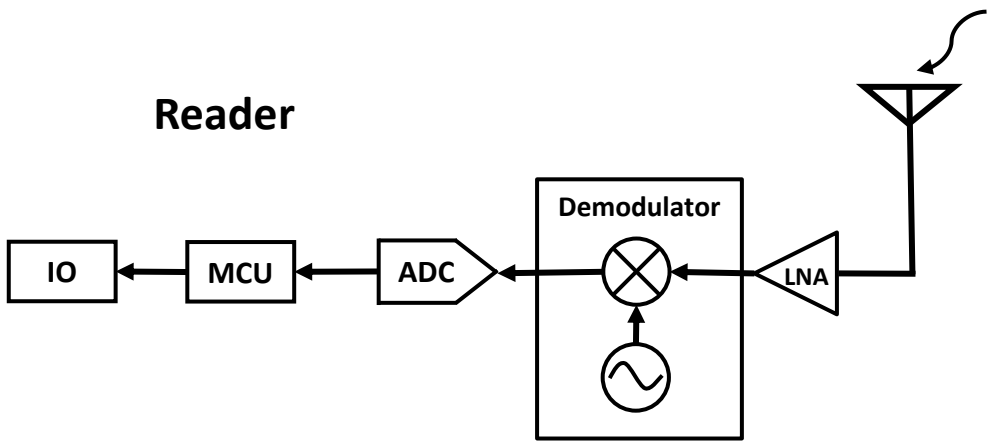
# Conventional Wireless Sensing Systems



# Backscatter Sensing Systems without HFOSC



# Backscatter Sensing Systems without HFOSC and ADC



## Carrier Emitter



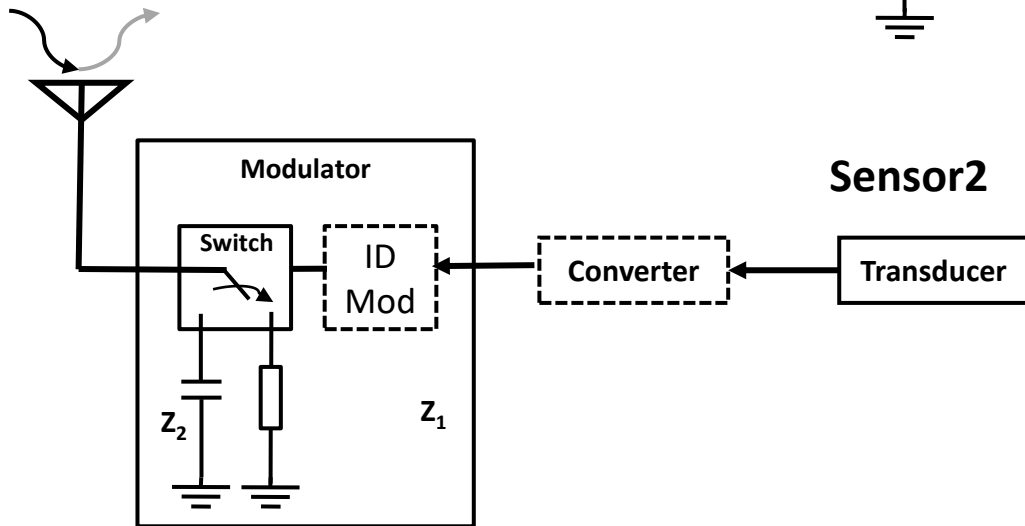
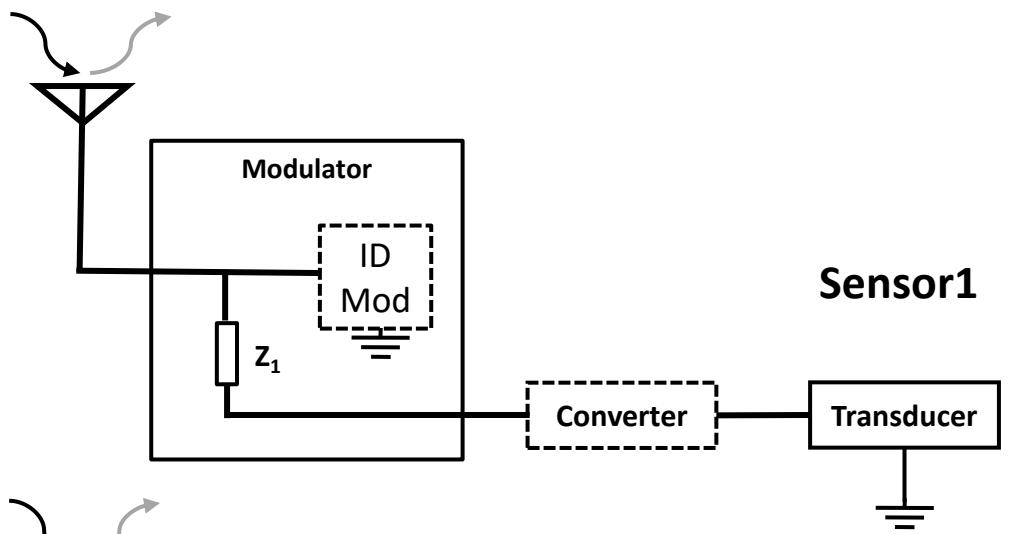
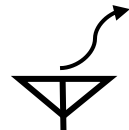
WiFi Router



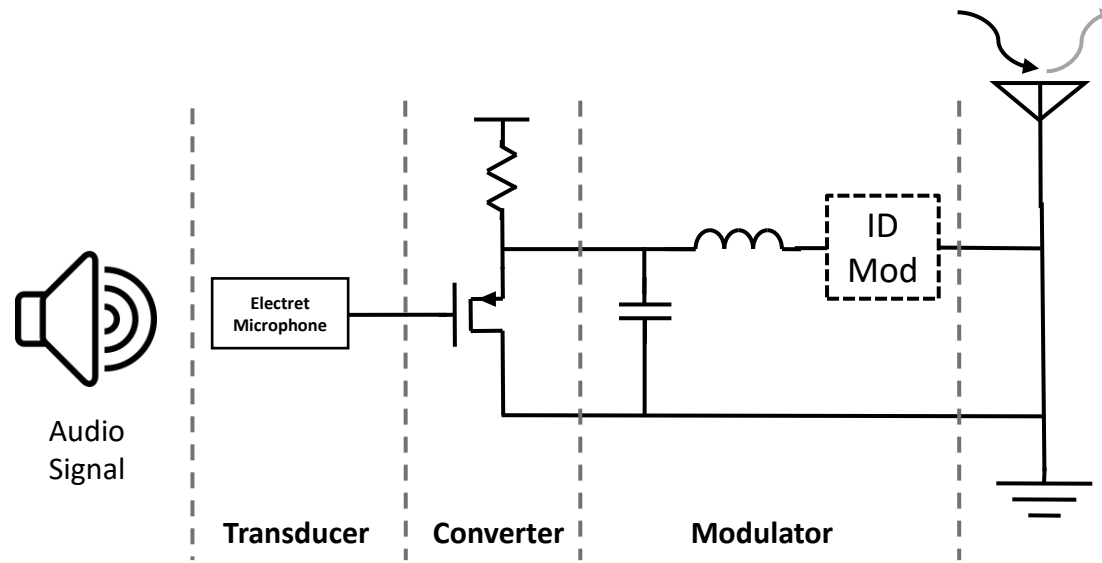
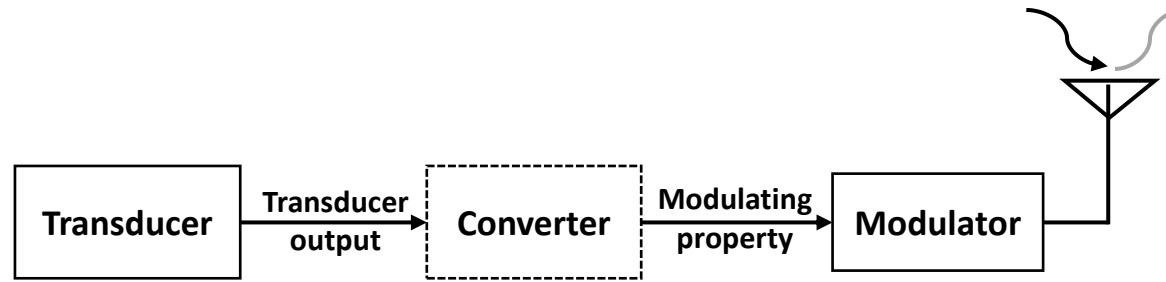
TV Tower



Special Hardware



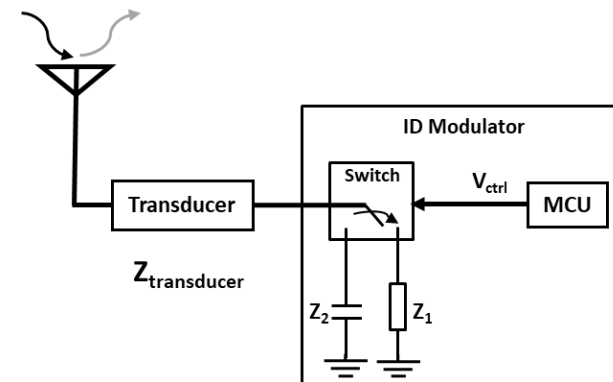
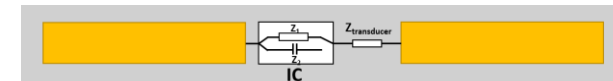
# Backscatter Sensor: Transducer-Converter-Modulator



# Direct Modulation Backscatter Sensors

- The output of Transducer directly modulates the backscattered signal

System	Sensing Task	Transducer	Transducer Output	Modulation	Freq	Power	ID	Multiple Access	Reader
<i><math>\alpha</math>-WISP,2005</i>	Orientation	Mercury Switch	Impedance (Binary)	AM(OOK)	915MHz	RF Harvester	Y	Y (TD)	RFID Reader
WISP,2006	General	NA	NA	ASK/PSK	915MHz	RF Harvester	Y	Y (TD)	RFID Reader
GasSensor,2011	Gas Density	Carbon nanotube	Impedance (Continuous)	AM	915MHz	RF Harvester	Y	Y (TD)	RFID Reader
BendSensor,2012	Bend Angle	Microstrip Transmission Line	Impedance (Continuous)	AM	915MHz	RF Harvester	Y	Y (TD)	RFID Reader
PaperID,2016	Touch	Conductive Material	Impedance (Binary)	AM(OOK)	915MHz	RF Harvester	Y	Y (TD)	RFID Reader
BitID,2017	Contact	Conductive Material	Impedance (Binary)	AM(OOK)	915MHz	RF Harvester	Y	Y (TD)	RFID Reader
RFIBricks,2018	Contact	Magnet	Impedance (Binary)	AM(OOK)	915MHz	RF Harvester	Y	Y (TD)	RFID Reader
Challenge,2018	Light	Phototransistor	Impedance (Continuous)	AM	915MHz	RF Harvester	Y	Y (TD)	RFID Reader
Tip-Tap,2019	Touch	Conductive Tape	Impedance (Binary)	AM(OOK)	915MHz	RF Harvester	Y	Y (TD)	RFID Reader



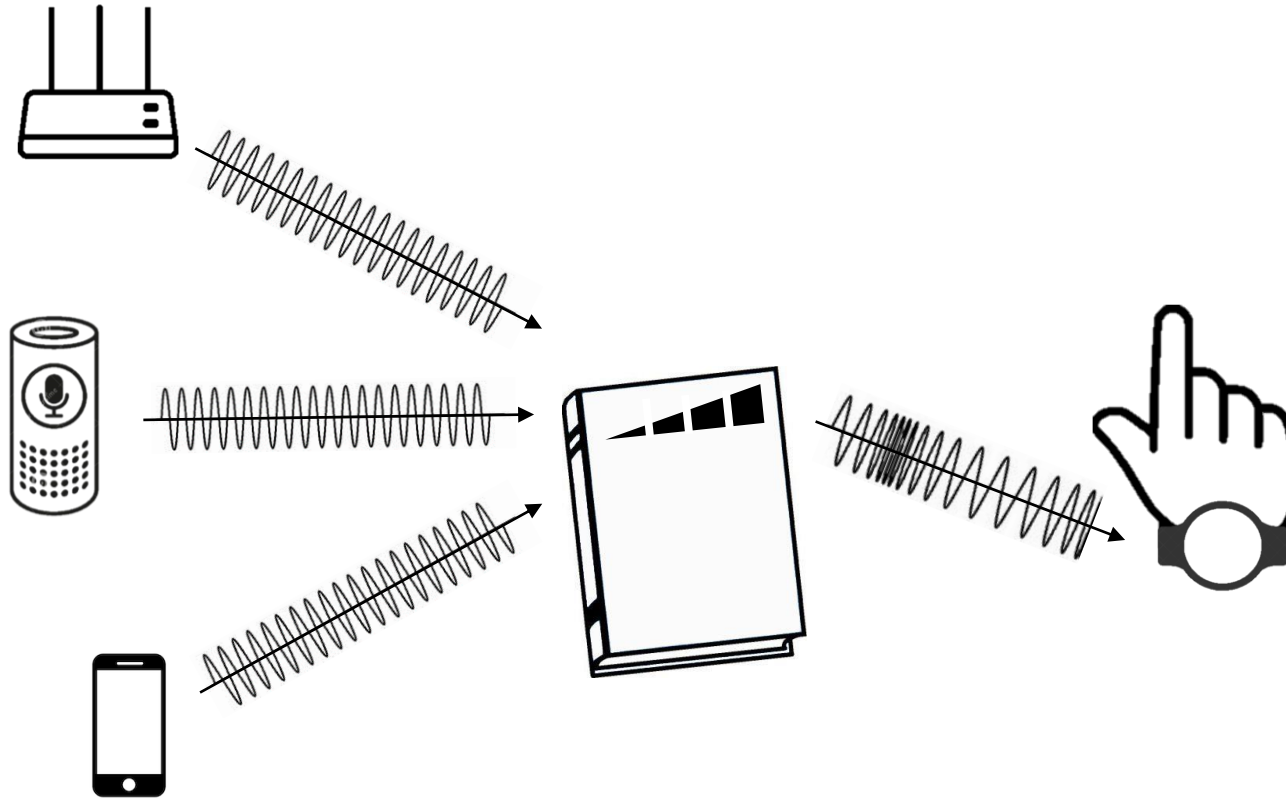


# Adapted Modulation Backscatter Sensors

- The output of Transducer need to be converted to modulates the backscattered signal

	Task	Transducer	Transducer Output	Converter	Converter Output	Modulation	Freq	Power	ID	Multiple Access	Reader
HybridSensor,2013	Audio	Electret Microphone	Voltage	JFET (Triode)	Impedance	AM	915MHz	RF Harvester	Y	Y (TD)	USRP-SDR
HumiditySensor,2014	Humidity	HCH1000	Capacitance	555 Timer	Frequency	FM (FSK)	868MHz	Coin Cell	N	Y (FD)	USRP-SDR
SoilSensor,2016	Soil Moisture	Microstrip Interdigit Cap	Capacitance	555 Timer	Frequency	FM (FSK)	868MHz	Coin Cell	N	Y (FD)	RTL-SDR
Battery-free Cellphone,2017	Audio	Electret Microphone	Voltage	JFET (Triode)	Impedance	AM	915MHz	RF Harvester	N	N	USRP-SDR
ZEUSSS,2018	Audio	Electret Microphone	Voltage	JFET (Triode)	Impedance	AM	915MHz	Triboelectric Nanogenerator	N	N	USRP-SDR
RF Bandit,2018	General	Resistive Sensor	Resistance	LTC6906 OSC	Frequency	FM (FSK)	915MHz	RF Harvester	N	N	USRP-SDR
Battery-free HD Streaming,2018	Video	Camera	Voltage (small)	Comparator	Pulse Width	PWM	915MHz	RF Harvester	N	Y (FD)	USRP-SDR
UbiquiTouch,2020	Touch	Touch Panel	Voltage	TS3002 OSC	Frequency (Binary)	AM (OOK)	87.8MHz-108MHz	Solar Cell	N	N	Smartphone

# BLE Transceiver Compatible Backscatter Touch Sensing System



Thanks