NoLoRa

Ultra-Low-Power LoRa Transmissions Without Active Radios for Battery-Free Devices

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NoLoRa enables LoRaWAN-compatible communication without dedicated radio transceivers or batteries. It exploits EM emissions from SPI/I2S lines on ultra-low-power MCUs, using the 27th harmonic at 16 MHz to land at 433 MHz within the LoRa EU433 ISM band, decoded by commercial LoRa receivers with no active RF components at the transmitter. Power is harvested from solar energy stored in a supercapacitor.

~10^{-5} W | **>100 m** | LoRaWAN®

Motivation

Traditional RF transceivers draw mA-level current and add complexity. NoLoRa replaces them with direct MCU GPIO emissions to transmit valid LoRa frames.

Contributions

- GPIO harmonic (27th × 16 MHz) as LoRa carrier
- DMA double-buffering — CPU-free TX
- 27 µA avg @ 3 V, 1% duty cycle
- 100+ m LoS range, LILYGO TTGO validated

How it Works

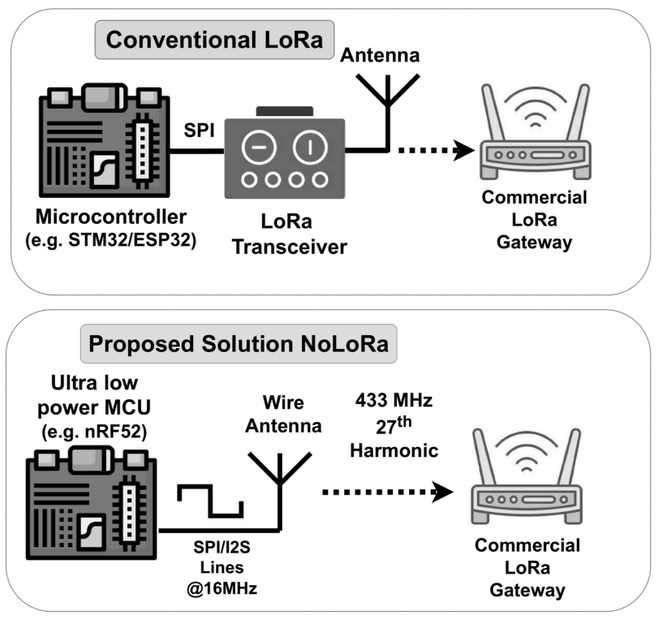
A square wave's odd harmonics roll off as 4/πn. The 27th harmonic at −95 dBm still exceeds LoRa's −130 dBm noise floor by 35 dB.

Results

Outdoor suburban testing achieved successful packet decoding up to 110 m LoS (SF10, BW 125 kHz, 434 MHz), with −121 dBm RSSI and −19 dB SNR at just 27 µA average current.

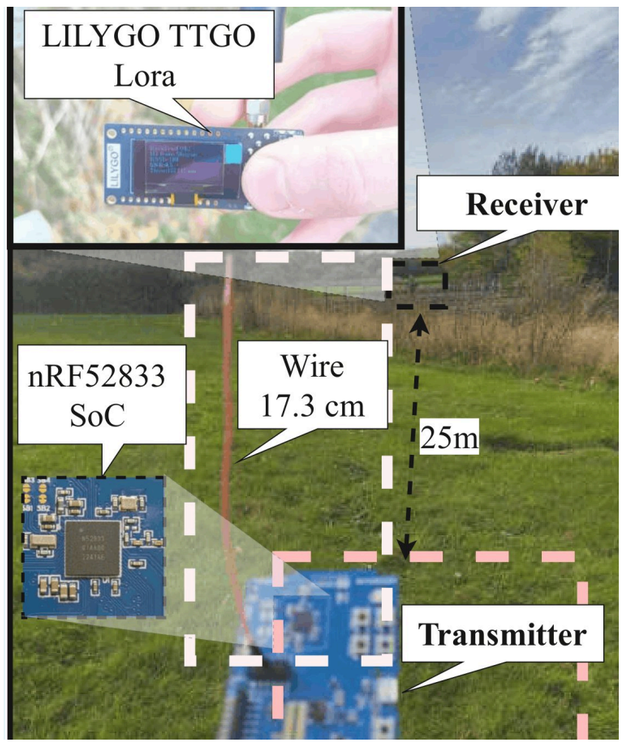
System Architecture

Conventional LoRa (top) requires a dedicated transceiver IC connected via SPI. NoLoRa (bottom) uses an nRF52 MCU's SPI/I2S lines directly as the radiating element at 433 MHz via the 27th harmonic.

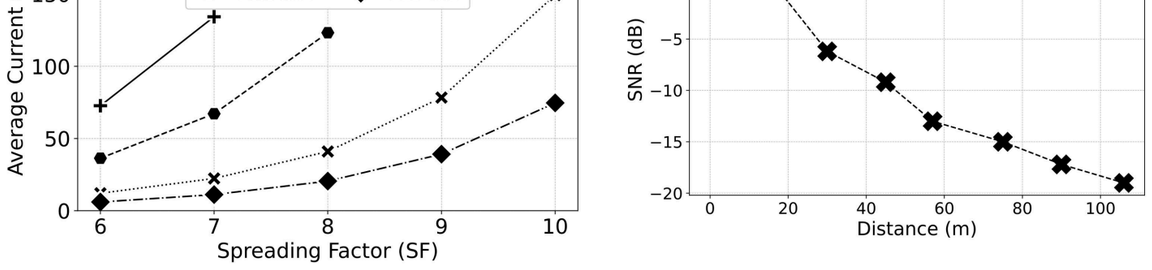


Field Experiment Setup

Outdoor test at Heriot Watt University. Transmitter: nRF52833 + 17.3 cm quarter-wave wire monopole (no matching). Receiver: LILYGO TTGO LoRa. Initial separation 25 m, extended to 110 m.

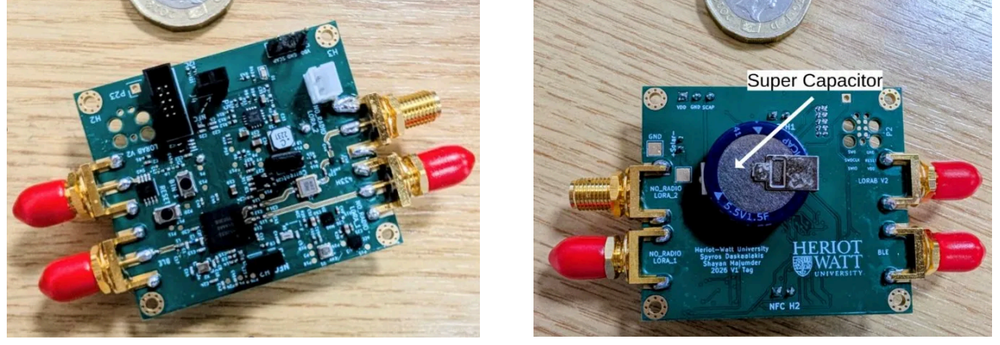


Results



(Left) Average current stays in the tens-of-µA across all SF/BW combinations — wider BW and lower SF reduce consumption, but all remain harvest-compatible. (Right) SNR stays above the −20 dB demodulation threshold out to 110 m, with RSSI = −121 dBm at maximum range.

Custom PCB



PCB V2 (S. Daskalakis & S. Majumder) adds NFC, BLE, and LoRa TX paths, improved RF routing, filters, matching, and amplifier. A 5.5 V / 1.5 F supercap enables fully battery-free solar-harvested LoRa transmission.

Conclusion

NoLoRa demonstrates that LoRa-compatible communication is achievable with no active RF hardware, at harvest-compatible power levels. Next steps include validation of the fabricated PCB V2, EMC compliance, and deployment in IoT applications such as smart agriculture, asset tracking, and environmental sensing.

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