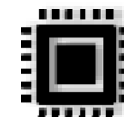


HopeRF Bluetooth Products Introduction

Cheng Yuan

Manufacturer of IoT Key Components



RF IC
射频芯片

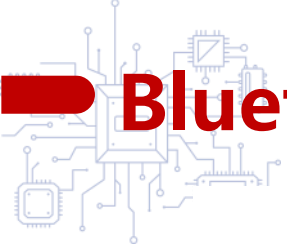


IoT Module
无线



Signal Chain
信号链产品

*Customized Solutions -
RF Modules & Wireless Networking
& More IoT Products*



Bluetooth Market Today

HOPERF



AUDIO STREAMING

- **2024 Market Shipments**
 - 1.01 billion
 - Bluetooth Classic today

Use Cases

- Calling
- Listening
- Watching

Sample Devices (LE Audio)

- Smart Watches
- Headphones
- Hearing Aids
- TVs



DATA TRANSFER

- **2024 Market Shipments**
 - 1.35 billion
 - 35% IOT devices rely on BT

Use Cases

- Sports & Fitness
- Health & Wellness
- Input & Control

Sample Devices

- Fitness & smartwatches
- Portable Medical Devices
- PC Peripherals
- Small Appliances
- Power Tools
- Access Points



DEVICE NETWORKS

- **2024 Market Shipments**
 - 850 million
 - Bluetooth mesh

Use Cases

- Automation Systems
- Control Systems
- Monitoring Systems

Sample Devices

- Lighting
- Sensors (lighting, temp, etc)
- Control
- HVAC
- Access Control



LOCATION SERVICES

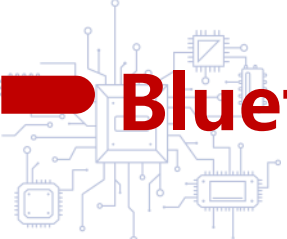
- **2024 Market Shipments**
 - 255 million
 - Presence, distance, direction

Use Cases

- Item Finding
- Asset Tracking
- Access Control

Sample Devices

- Asset Tags
- Beacons
- Locators
- Access Controls
- Smart Speakers
- Power



Bluetooth Product Roadmap

HOPERF

Product



2018



2019



2021



2023



Developing

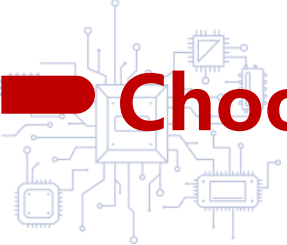
Key Features

- First generation of BLE SoC supports BLE 5.0
- Up to +10dBm tx power

- Upgrade for better RF performance
- 138KB SRAM / 512KB Flash and QFN48 package for complicated application
- QFN32/QFN48 package

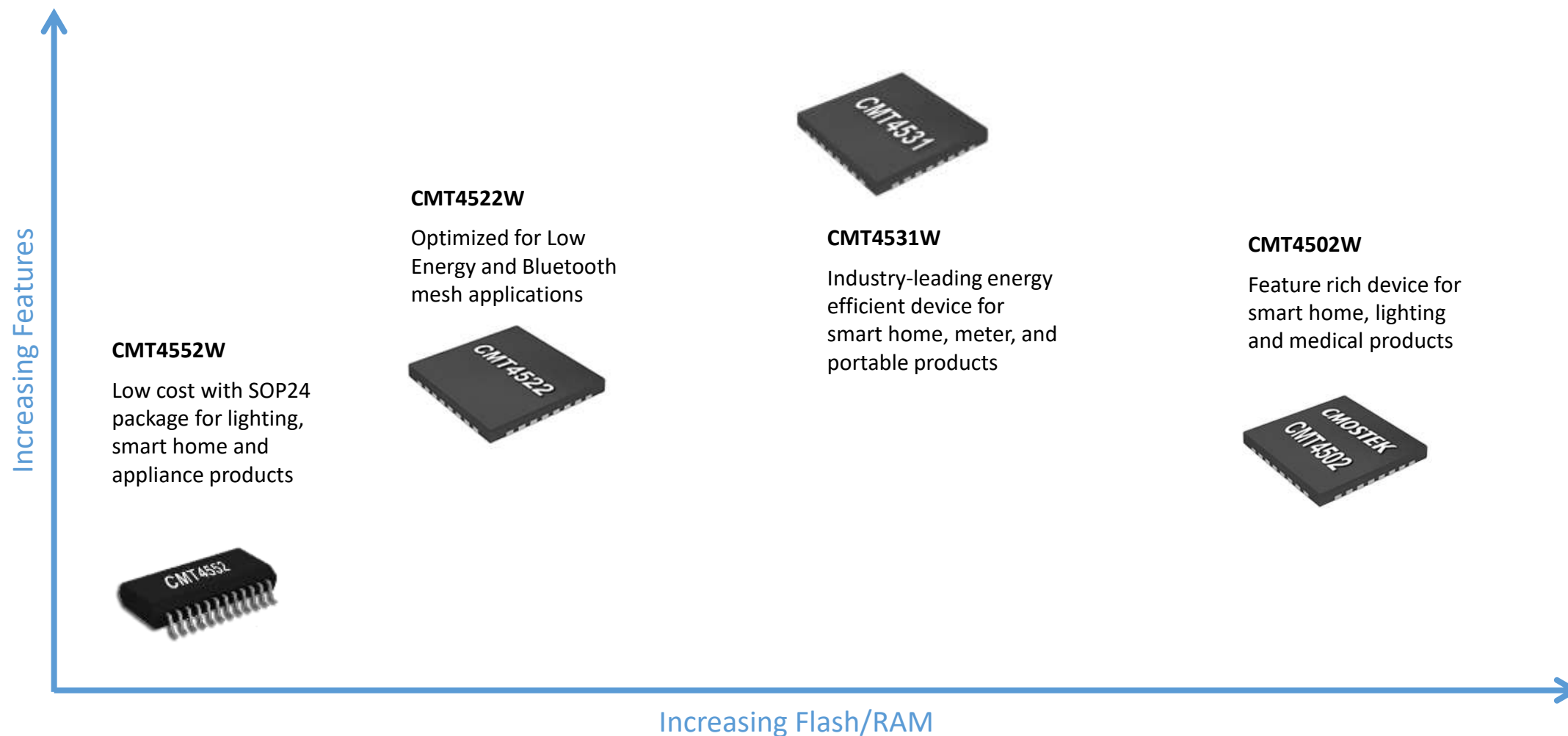
- Next generation of BLE SoC with optimized current consumption
- Support BLE 2Mbps and LE Coded PHY
- QFN32 package

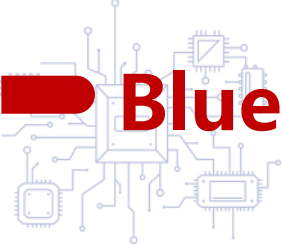
- New design for Industry-leading energy efficient
- Ultra low power consumption
- QFN32 package



Choosing a CMT BLE Device

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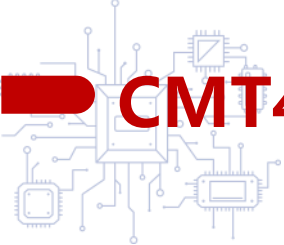




Bluetooth SoC Portfolio

HOPERF

| | CMT4531W | CMT4502W | CMT4522W (EOL) | EFR32BG22 |
|-----------------------|---|------------------------------------|------------------------------------|----------------------------------|
| Protocols Core | Bluetooth LE 5.2 | Bluetooth LE 5.0 | Bluetooth LE 5.2 | Bluetooth LE 5.2 |
| | Cortex-M0@64MHz | Cortex-M0@48MHz | Cortex-M0@48MHz | Cortex-M33@76.8MHz |
| Flash/RAM | 256KB/512KB FLASH | 512KB FLASH | W04: 512KB FLASH W16: 2MB FLASH | 512KB FLASH |
| | 48KB RAM | 138KB RAM | 64KB RAM | 32KB RAM |
| Peripheral | 21 GPIO | 33 GPIO (QFN48) 19 GPIO (QFN32) | 22 GPIO | 18 GPIO(QFN32) 26 GPIO(QFN40) |
| | USART, SPI, I2C, I2S, PWM, AMIC, KEYSKAN, IRC | UART, SPI, I2C, PWM, PDM, KEYSKAN | UART, SPI, I2C, PWM, PDM, KEYSKAN | UART, SPI, I2C, I2S, IrDA, PDM |
| Operating Voltage | 1.8~3.6v | 1.8~3.6V | 1.8~3.6V | 1.71~3.8V |
| Sleep Current | 1.4uA | 13uA | 13uA | 1.40 uA |
| Active Current | Tx 4.2mA @0dBm | 6.7 mA@0dBm | 4.6mA@0dBm | 4.1 mA @0dBm |
| | Rx 3.8mA@3.3V | 6.7 mA | 4mA @3.3V | 3.6 mA |
| PHY | 1M/2M/125K/500K | 1M/2M | 1M/2M/125K/500K | 1M/2M/125K/500K |
| Max TX Output Power | +6 dBm Max | +10 dBm Max | +10 dBm Max | +6 dBm Max |
| RX Sensitivity | -96 dBm@1Mbps | -97 dBm@1Mbps | -97 dBm@1Mbps | -98.9dBm @ 1Mbps |
| | -103 dBm@125Kbps | | | |
| Operating temperature | -40~+85°C | -40~+85°C | -40~+85°C | G:-40~+85°C I:-40~+125°C |
| Package | QFN32(4x4mm) | QFN32(5x5mm) QFN48(7x7mm) | QFN32(4x4mm) | QFN32(4x4mm) QFN40(5x5mm) |

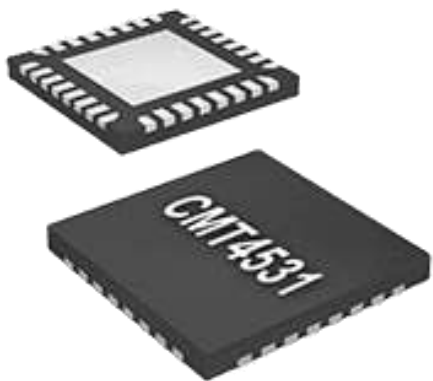


CMT4531W Introduction

HOPERF

■ Target Markets

- Smart Home
- Smart Lighting
- Smart appliance
- Asset Tags and Beacons
- Data transmission module



■ BLE

- BLE 5.2
- Supports 1 Mbps BLE mode, enhanced 2 Mbps BLE mode, 125 Kbps / 500 Kbps BLE long range mode

■ CPU Core

- 32-bit ARM Cortex-M0 core
- Frequency up to 64 MHz

■ Storage

- 256 KB/512KB Flash (192KB ROM)
- 48 KB SRAM

■ Low Power Consumption

- Radio RX current: 3.8 mA@3.3 V
- Radio TX current: 4.2 mA @0 dBm/3.3 V
- Sleep mode (48 KB RAM retention): 1.4μA@3 V
- PD (power down) mode: 130 nA

■ RF Specification

- RX sensitivity: -96 dBm @BLE 1 Mbps
- RX sensitivity: -93 dBm @BLE 2 Mbps
- Power of programmable transmitter: up to +6 dBm
- Single end antenna

■ Peripherals

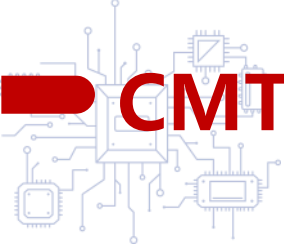
- 2xUSART
- LPUART supports low-power mode
- 2xSPI supports up to 16MHz
- I2C
- 10bit ADC@1.33Mbps
- 16bit ADC@16Kbps
- 21 GPIO

■ Operating Conditions

- Operating voltage: 1.8 V~3.6 V
- Operating temperature: -40°C~85°C

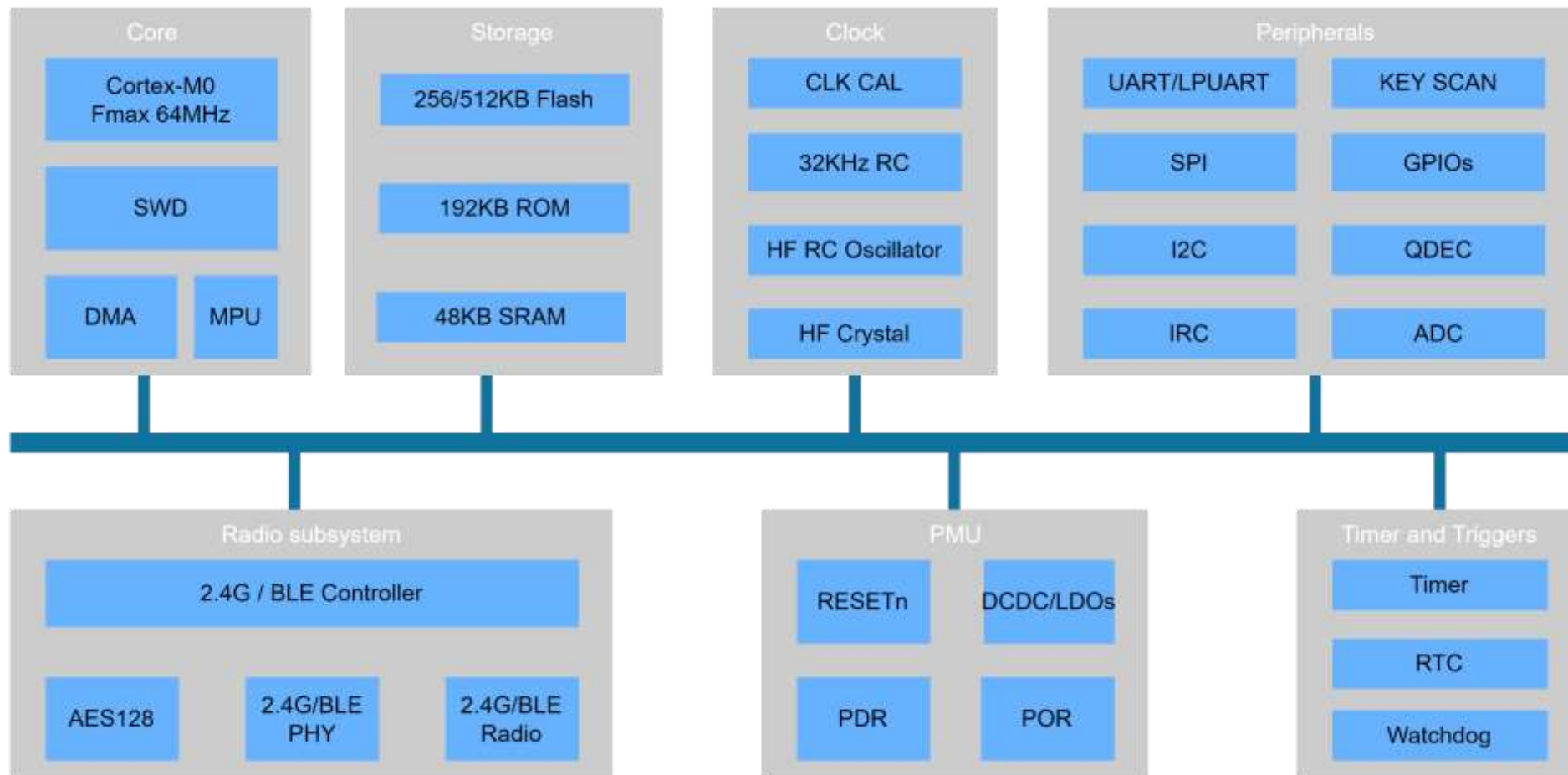
■ SoCs Package

- 4x4 QFN32



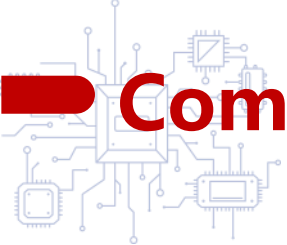
CMT4531W Block Diagram

HOPERF



192KB ROM is reserved for BLE stack

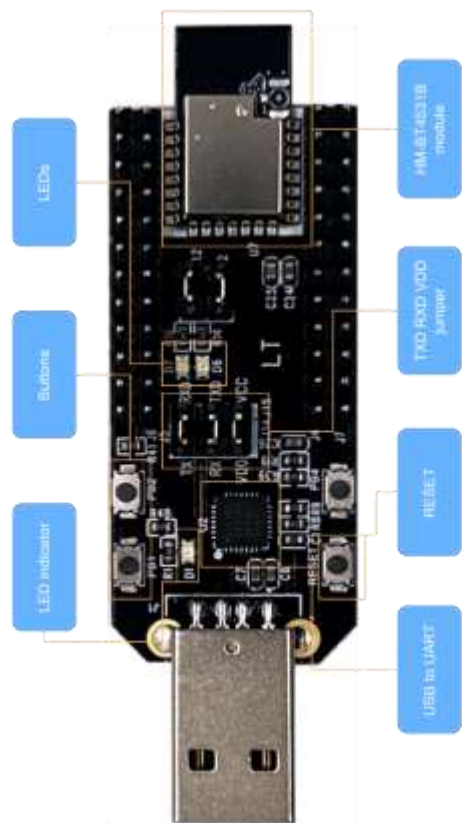
LPUART can work in sleep mode with the 32.768KHz LSE clock source



Complete Bluetooth solution

HOPERF

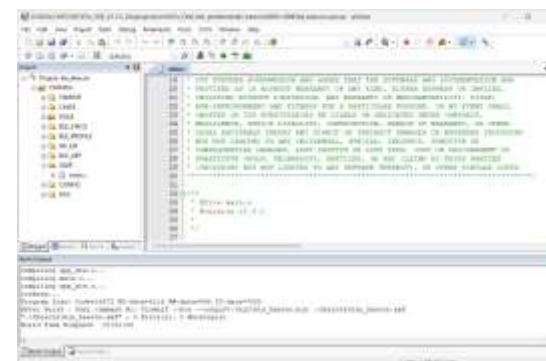
sales@hoperf.com



Evaluation Board

- documentation
- firmware
- middlewares
- projects
- utilities
- release_notes.txt

SDK
Development User Guide



Development Tool



Android Mobile App

| | | | | | | | | |
|---------------------------|---|---|---|---|---|---|---|---|
| |  |  |  |  |  |  |  |  |
| Module | HM-BT4502W HM-BT4502AW | HM-BT4502BW HM-BT4502BW-1 | HM-BT4531W | HM-BT4531BW | HM-BT4531CW | HM-BT2201W HM-BT2204W | HM-BT2101W HM-BT2102W | HM-BT2401DAW |
| Dimensions L x W x H (mm) | 17*12.5*2.5 | 15.1*11.2*2.6 | 17*12.5*2.6 | 19.02*11.22 | 16*10.5*2.4 | 17*12*2.1 | 20*12*2.6 | 29*26*2.6 |
| SoC | CMT4502-EQR | CMT4502-EQR | CMT4531-EQR | CMT4531-EQR | CMT4531-EQR | BG22C112 BG22C224 | BG21A010F768 BG21A020F768 | BG24A010F1024IM40 |
| Flash/RAM | 512K / 138K | 512K / 138K | 256K / 48K | 256K / 48K | 256K / 48K | 512K / 32K | 768K / 64K | 1024K / 128K |
| Protocols | BT5.0 (1M, 2M) | BT5.0 (1M, 2M) | BLE 5.1 (1M, 2M, Coded PHY) | BLE 5.1 (1M, 2M, Coded PHY) | BLE 5.1 (1M, 2M, Coded PHY) | BLE5.2 BT2201: (1M, 2M) BT2204: (1M, 2M, Coded PHY) | BLE5.2 (1M, 2M, Coded PHY) | BLE6.0 CS (1M, 2M, Coded PHY) |
| Max TX power | +8 dBm | +8 dBm | +6 dBm | +6 dBm | +6 dBm | 0/+6 dBm | +10/+20 dBm | +10 dBm |
| Sensitivity (1M) | -97 dBm | -97 dBm | -96 dBm | -96 dBm | -96 dBm | -98.9 dBm | -97.5 dBm | -97.6 dBm |
| Tx Current@0dBm | 8 mA | 8 mA | 4.2 mA | 4.2 mA | 4.2 mA | 4.1 mA | 9.3 mA | 5 mA |
| Rx Current | 8 mA | 8 mA | 3.8 mA | 3.8 mA | 3.8 mA | 3.6 mA | 8.8 mA | 4.4 mA |
| Sleep Current | 13 uA | 13 uA | 1.4 μA | 1.4 μA | 1.4 μA | 1.4 uA | 5.0 uA | 1.3 uA |
| GPIO (user available) | 5 | 17 | 5 | 15 | 9 | 14 | 16 | |
| Operating Voltage | 1.8V~3.6V | 1.8V~3.6V | 1.8V/2.32V~3.6V | 1.8V/2.32V~3.6V | 1.8V~3.6V | 1.71V-3.8V | 1.71V-3.8V | 1.71V-3.8V |
| Operating Temp | -20℃~+85℃ | -20℃~+85℃ | -20℃~+85℃ | -20℃~85℃ | -40℃~85℃ | -40℃~+85℃ | -40℃~+85℃ | -40℃~+85℃ |
| Certifications | BQB FCC / CE / IC /SRRC | NA | BQB FCC / CE / IC /SRRC | NA | NA | BQB FCC / CE / IC / SRRC | CE | NA |
| Comments | NRND | NRND | Low Power Low Cost | More GPIO | Small Size | FCC/CE /ISED/SRRC BQB | CE | Channel Sounding |



HM-BT4531W Module

HOPERF

■ Target Markets

- Smart Home
- Smart appliance
- Building Automation
- Data transmission module



■ BLE

- CMT4531 inside
 - BLE 5.2
 - 1Mbps / 2Mbps / 125 Kbps / 500 Kbps PHY
 - Operating Frequency: Up to 64MHz

■ Features

- 5 GPIOs
- Provides rich AT commands for configuring module and data transmission
- Simple to use, no any BLE development experience required
- Support UART interface with baud rate 9600bps to 500000bps
- Can be used as a transparent transmission module and supports secondary development
- Supports anti-hijacking password setup for secure connection

■ Characteristic

- Operating Voltage: 1.8V - 3.6V
- Operating Temperature: -40°C to 85°C
- Receive Current: 3.8mA @ 3.3V
- Transmit Current: 4.2mA @ 3.3V @ 0dBm
- Sleep Current (with 48KB RAM retention): 1.4μA @ 3V
- Transmit Power: -20dBm to +6dBm
- Receive Sensitivity: -94dBm @ BLE 1Mbps data rate

■ Module Package

- 17*12.5*2.6mm

■ Certification and Qualification

- FCC/CE/ISED/SRRC/BQB



HM-BT220XW Module

HOPERF

■ Target Markets

- Smart Home
- Smart appliance
- Building Automation
- Data transmission module

■ Ordering information

- HM-BT2201
- HM-BT2204



■ BLE

- SiliconLabs EFR32BG22 inside
 - BLE 5.2
 - Operating Frequency: up to 76.8MHz
 - Flash up to 512KB
- Features
 - 14 GPIOs
 - Rich AT command set.
 - Simple to use, no any BLE development experience required
 - Can be used as a transparent transmission module, or can also function as an MCU.
 - Supports BLE & 2.4G multi-protocol.

■ Electrical Characteristics

- Operating Voltage: 1.8V - 3.6V
- Operating Temperature: -40°C to 85°C
- Receiving Current: 3.6mA@3.3V
- Transmitting Current: 4.1mA@3.3V@0dBm
- Sleep Current: 1.4uA@3V
- Transmit Power: -20dBm to +6dBm
- Receiver Sensitivity: -98.9dBm

■ Module Package

- 17*12*2.1mm

■ Certification and Qualification

- FCC/CE/IC/SRRC/BQB



HM-BT2401DAW Module

HOPERF

■ Target Markets

- Smart Home
- Building Automation
- Indoor positioning
- Trackers
- PKE or PEPS



■ BLE

- Silicon Labs EFR32BG24A010F1024
 - BLE 6.0
 - Operating Frequency: Up to 78MHz
 - 1024KB Flash, 128KB RAM
- Features
 - Up to 4 connections support for tracking simultaneously
 - Dual-antenna solution with four antenna paths design for higher CS accuracy
 - Good performance even in the Back Pocket scenario
 - Provides rich AT commands for configuring module and data transmission

■ Electrical Characteristics

- Operating Voltage: 1.71V - 3.8V
- Operating Temperature: -40°C to 125°C
- Receiving Current: 4.4mA@3.3V
- Transmitting Current: 5mA@3.3V@0dBm
- Sleep Current: 1.3uA@3V
- Transmit Power: -20dBm to +10dBm
- Receiver Sensitivity: -97.6dBm

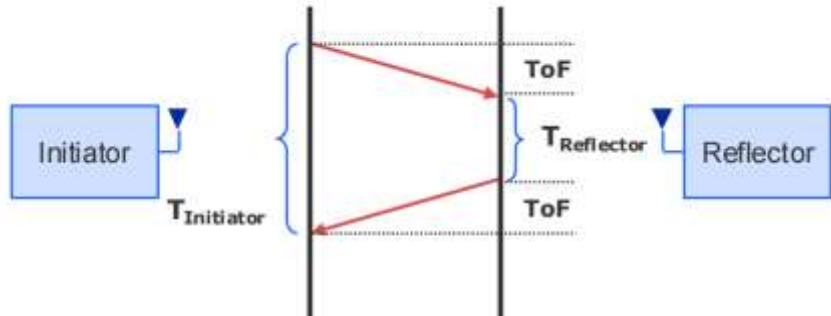
■ Module Package

- 29*26*2.6mm

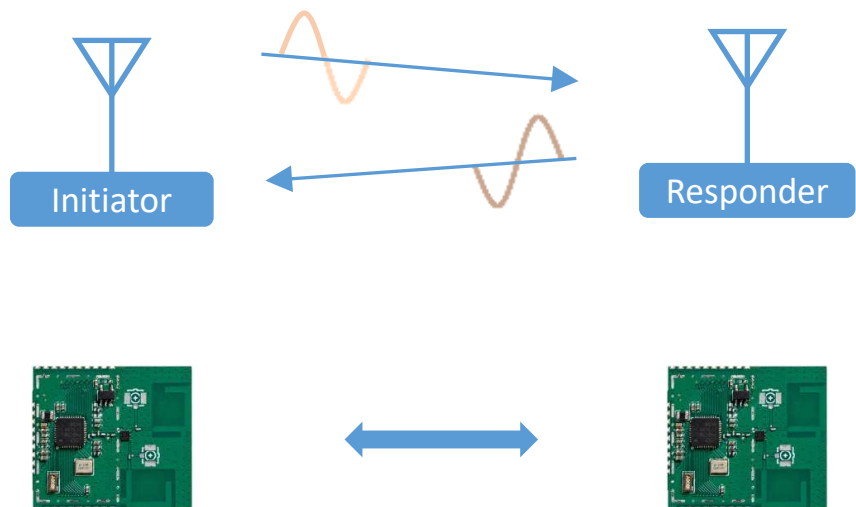


Channel Sounding

- **MODE: RTT(Round Trip Time)**

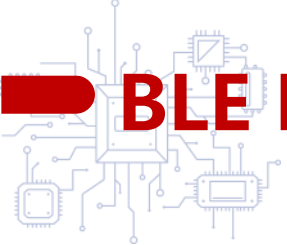


- **MODE: PBR(Phase Based Ranging)**



Sequence

- Initiator start advertising
- Reflector device scans and initiates a connection with the Initiator device.
- After establishing a connection, secure communication is enabled, and both sides exchange supported ranging features.
- The Initiator device sends a ranging data packet first.
- The Reflector returns the ranging packet (using the same phase in PBR mode).
- The Initiator calculates the distance using the returned ranging data with the algorithm library.



BLE Position solutions

HOPERF

| | RSSI | AOA/AOD | Channel Sounding |
|----------------------|---|--|--|
| Fundamental | Distance estimation from transmitter signal strength | Calculate relative angle between two points | distance measure between two points using time of flight and phase-based ranging |
| Accuracy | +/-5m | +/-3m | +/-0.5m |
| Antenna Requirements | Single antenna | Multi-antenna required by spec | Multi-antenna not required, but useful for optimal position resolution |
| Performance | high susceptibility to multipath interference | +/- 5 degrees accuracy | +/- 0.3 m < 5m with PBR ranging +/- 0.5 m > 5m with PBR ranging |
| Advantage | Easy to deploy Support for RSSI measurements in existing Bluetooth Low Energy products | Scalable solution for real time position tracking Supports 5-10 year battery life | High accuracy and security Small form factor with flexible antenna design |



HM-BT2401DA Performance

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| Distance | 1m | 2m | 3m | 4m | 5m | 7m | 9m |
|----------|------|------|------|------|------|------|-------|
| AVG | 1285 | 2146 | 2907 | 4110 | 5214 | 7516 | 9882 |
| Min | 1096 | 1835 | 2755 | 3814 | 4722 | 6852 | 9070 |
| Max | 1441 | 2475 | 3101 | 4322 | 5727 | 8155 | 10613 |

Test Environment

Office Indoor Environment Testing

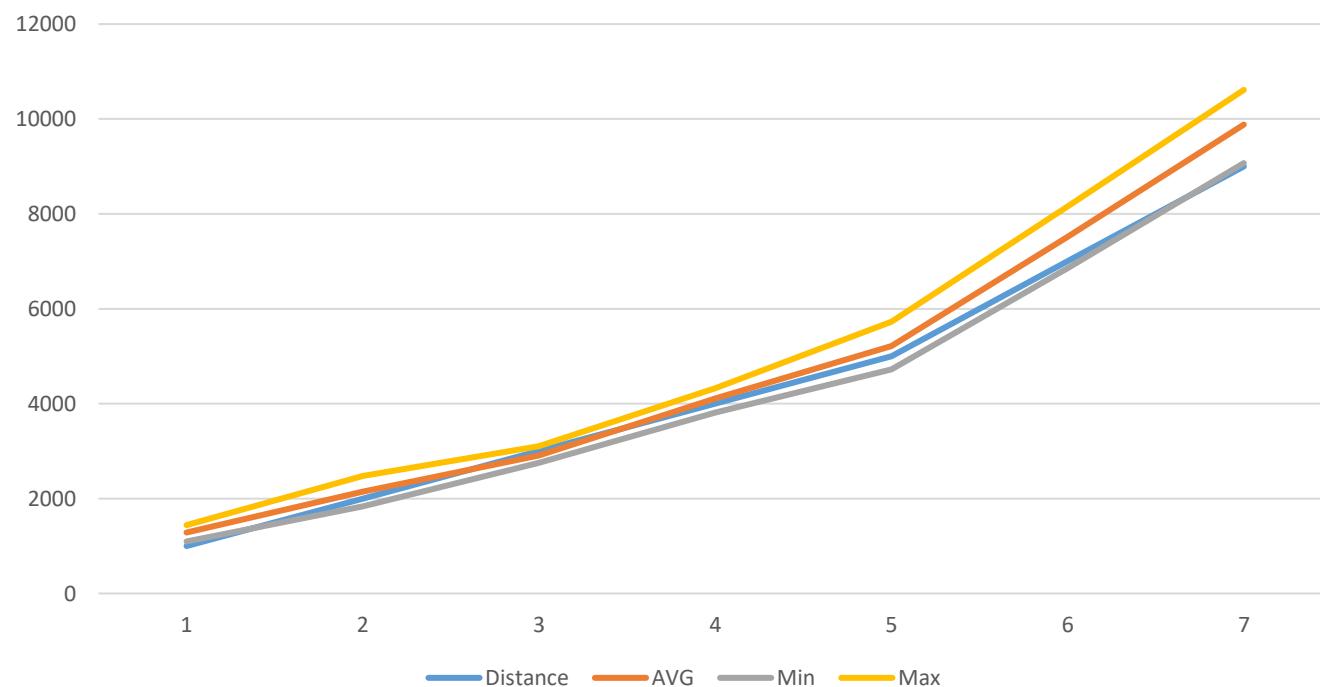
Two HM-BT2401DA Modules (Dual Antenna)

No Obstacles Between Modules, 1 Meter Above the Ground

Using PBR Mode, Real-time Tracking Algorithm

Collect 300 Data Sets Continuously for Each Distance,

Calculate AVG, MIN, and MAX Values





Target Applications

HOPERF

Smart Home



Smart Appliances



Smart Lighting



Smart Plug



Smart Lock



Smoke Alarm



Voice Remote



Automotive



TPMS



PKE



Smart Key



Industries



Electric meter



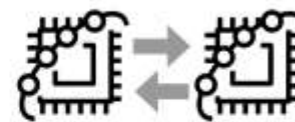
Gas meter



Water meter



Data transmission



Wearable & Health care



Heart rate



Body temperature



Smart Band



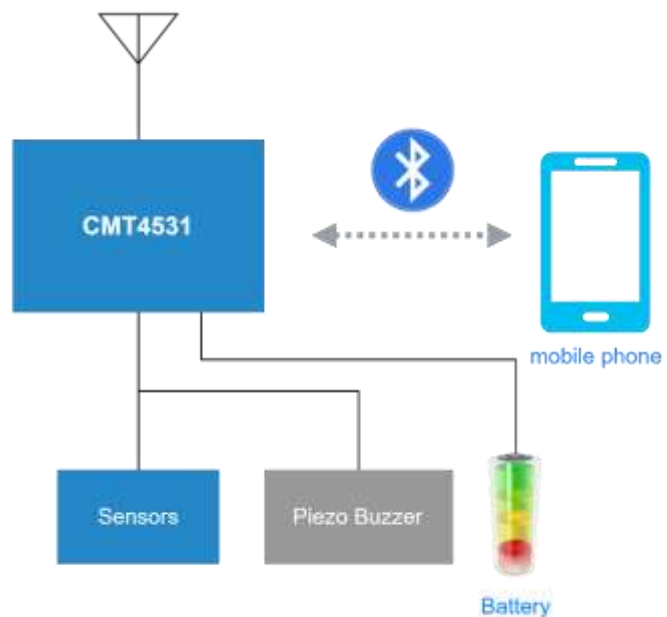
Fitness equipment





Asset Tags and Beacons

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HopeRF Technology

Features

- Ultra Low power consumption, Cost-effective solution
- Excellent RF performance

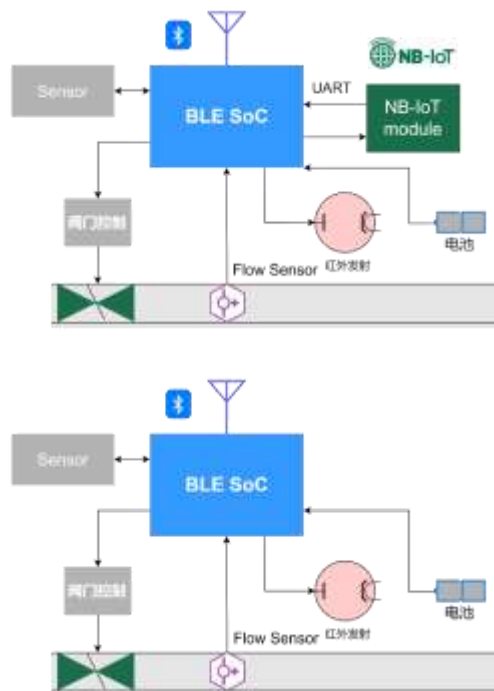
Advantages

- Ultra-low power consumption, sleep current $\leq 1.4\mu A$, 0dBm transmission power is 4.1mA
- Wide Selection of Peripherals such as ADC, GPIOs, I2C, SPI, TIMERS for interfacing sensor
- Complete Bluetooth and regulatory certification, reducing the certification process for end customer



Smart Metering

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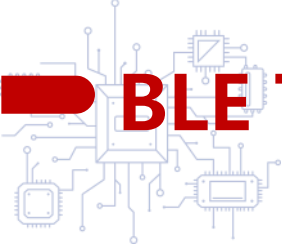


Features

- Low power consumption
- High security
- Excellent RF performance

Advantages

- Ultra-low power consumption, sleep current $\leq 1.4\mu A$, 0dBm transmission power is 4.1mA
- Single module with maximum +20dBm transmission power, meeting long-distance meter reading requirements
- Support up to 32 simultaneous connections
- Complete Bluetooth and regulatory certification, reducing the certification process for end customer



BLE TPMS & Passive Key Entry

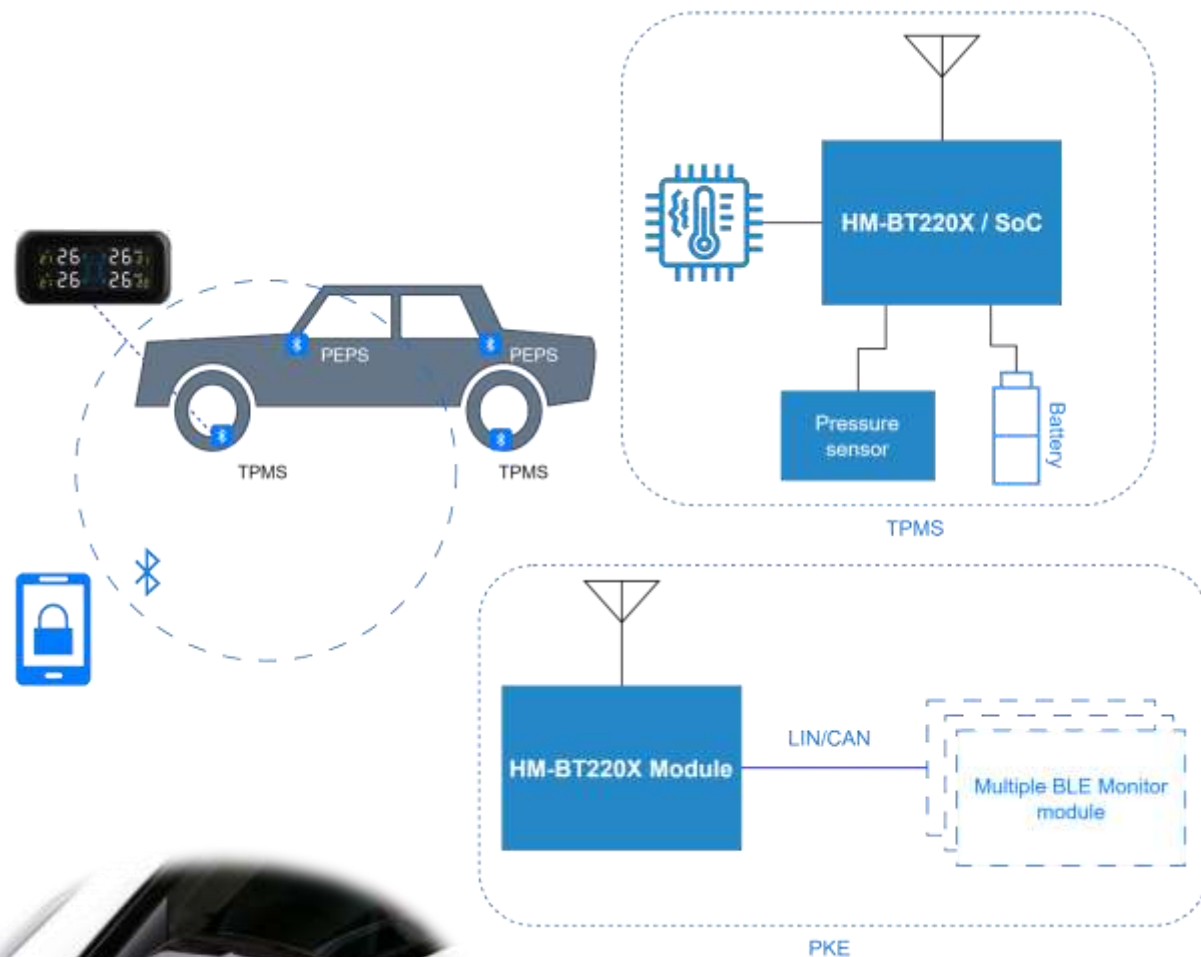
HOPERF

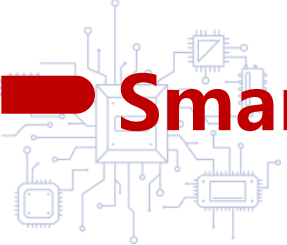
System Features

- Using a mobile phone as a digital key
- High security
- Automatic unlock when near, automatic lock when far away
- Users can configure the unlocking and locking range
- Low standby power consumption of the system
- Main chip meets AEC-Q100 certification

Advantages

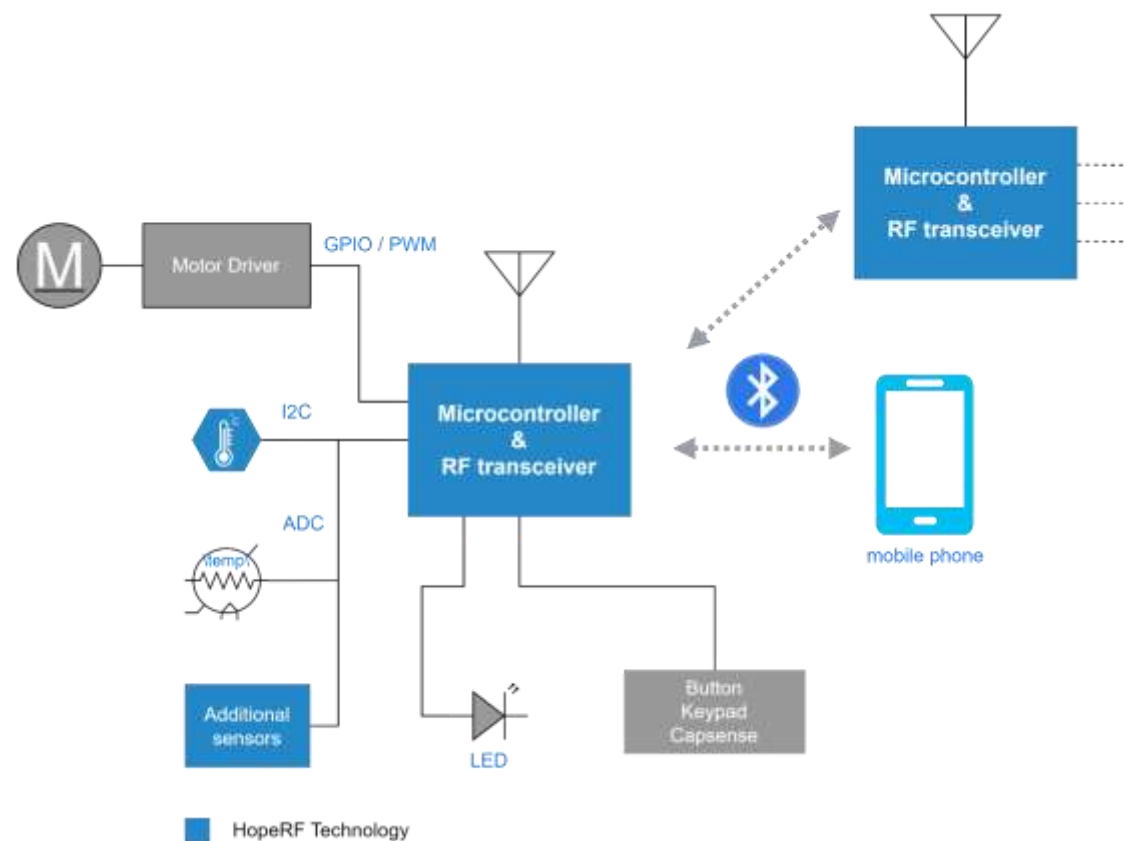
- Ultra-low power consumption, sleep current $\leq 1.4\mu A$
- -98.9 dBm@1Mbit/s GFSK receiving sensitivity
- Multi-channel link monitoring function, achieving accurate positioning
- Automotive-grade Bluetooth SoC (AEC-Q100)
- Compact Bluetooth module

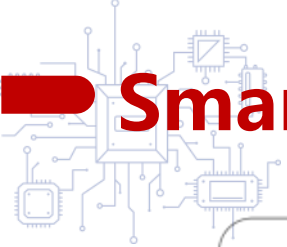




Smart home - Appliances

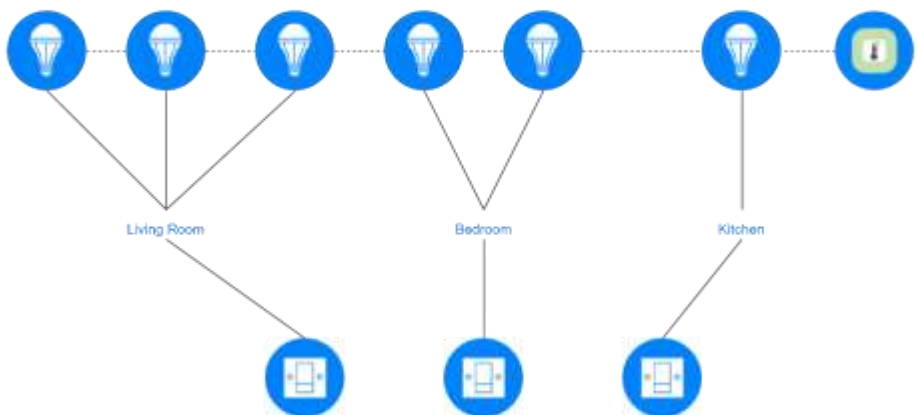
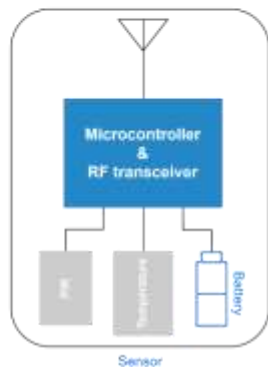
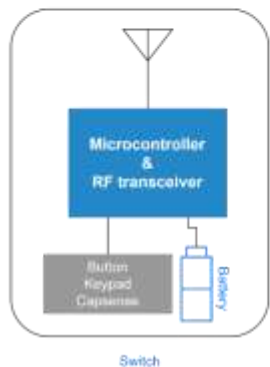
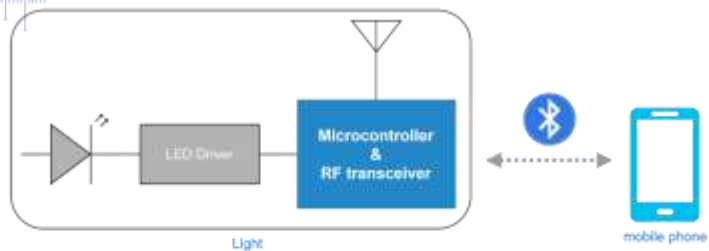
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Smart home - Lighting

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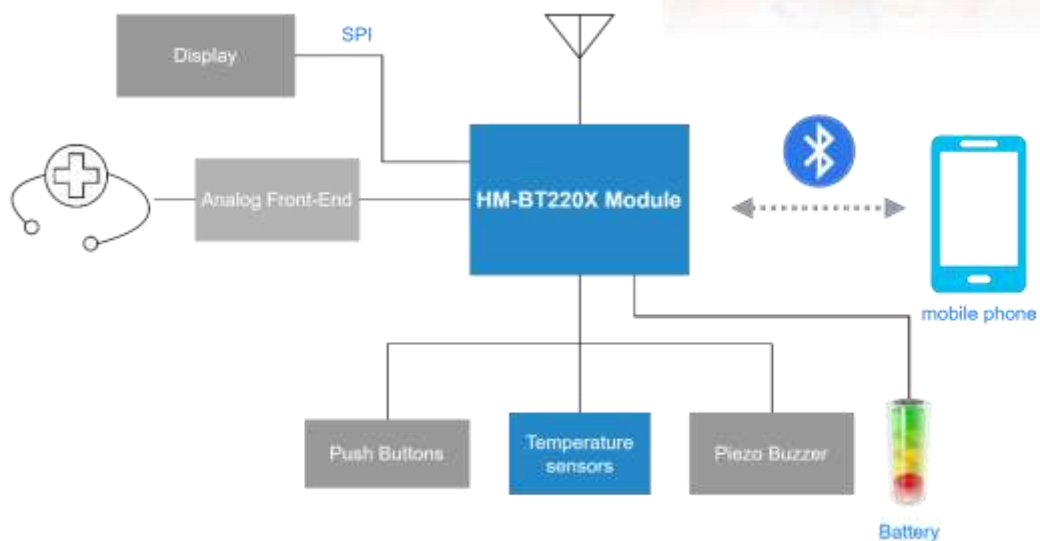
Advantages

- Good interoperability, finished interoperability tests with almost all common mobile phone models
- Support all SIG model defined in the Bluetooth mesh specification
- Open SDK interfaces to support various ecosystem implementations
- Rich peripheral interfaces
- Compact Bluetooth modules suitable for smart home devices



Wearable and medical health

HOPERF



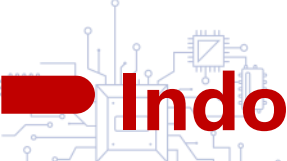
HopeRF Technology

System Features

Wearable and medical health products use low-power Bluetooth technology for data transmission. The system requires Bluetooth solutions to have extremely high security to prevent sensitive data theft. As battery-powered devices, they are highly sensitive to power consumption.

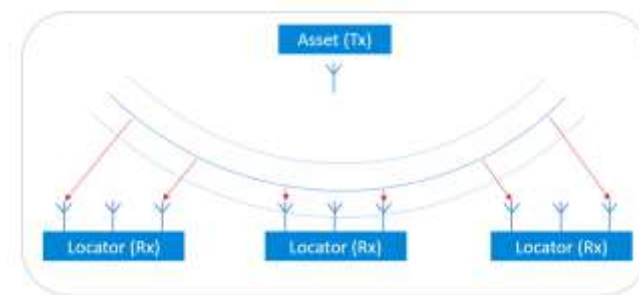
Advantages

- Good interoperability, finished interoperability tests with almost all common mobile phone models
- Ultra-low power consumption, standby current $\leq 1.4\mu\text{A}$, effectively extending battery life
- Up to 16-bit ADC for precise measurement of analog data
- Support for PSA Level 3, the highest security level
- Compact Bluetooth modules



Indoor positioning and Channel sounding

HOPERF

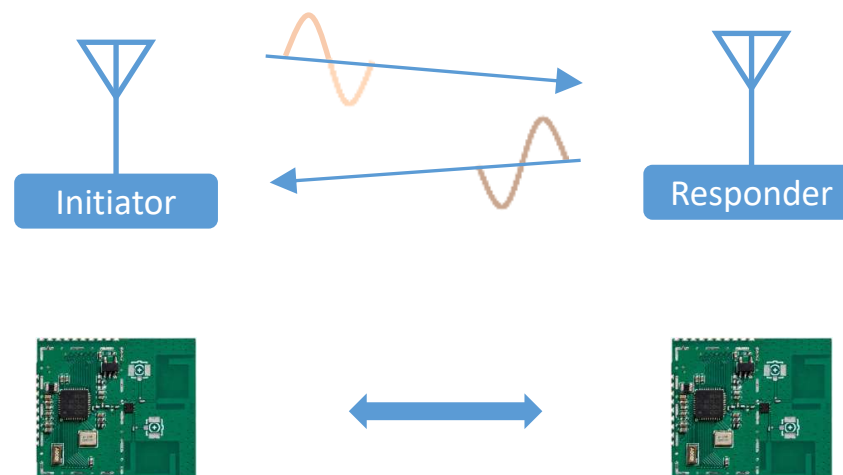


System Features

- Support for Angle of Arrival (AoA) and Angle of Departure (AoD)
- Sub-1m positioning accuracy
- Integrate the AoA/AoD functionality with normal BLE applications.

Advantages

- High security features
- Capable of simultaneously tracking hundreds of tag positions
- Compatible with various antenna array solutions (e.g., Quuppa, CoreHW, etc.)



System Features

- Distance is calculated by the phase difference between transmitted and received signals

Advantages

- High security features
- Distance accuracy of 0.3m
- Support for 1-to-4 connections for distance measurement



Data transmission module

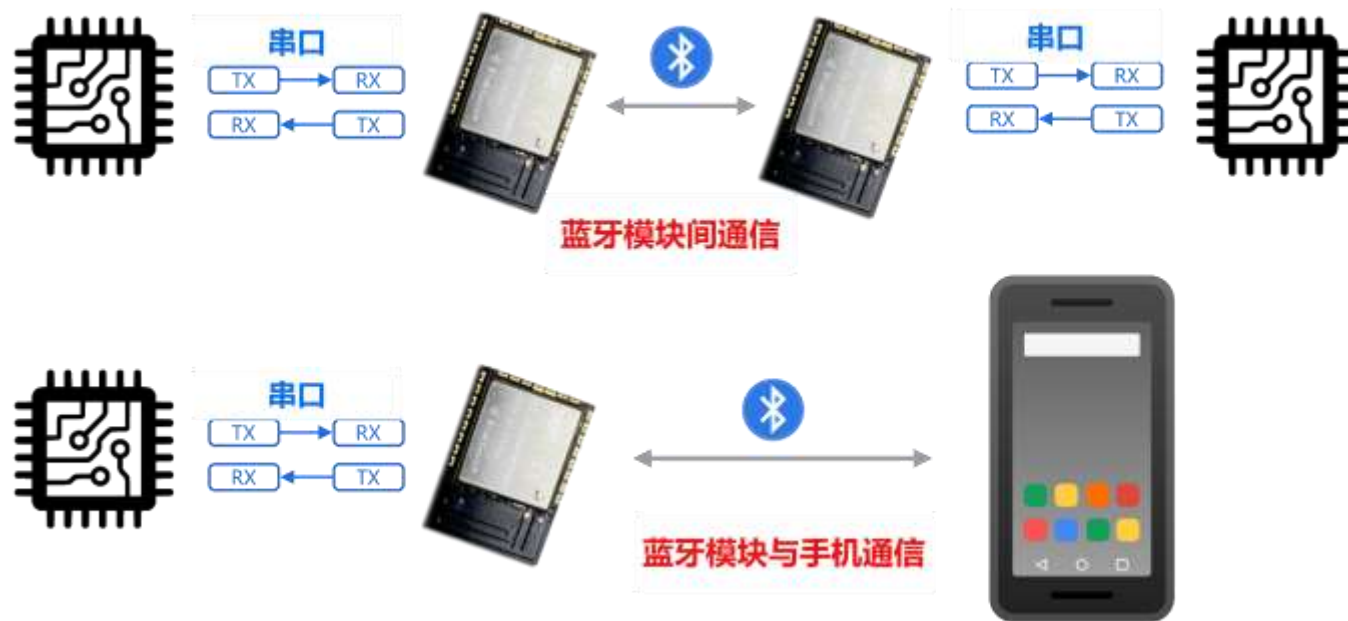
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Features

- With the help of a Bluetooth data transmission module, data received by the UART port will be sent to the smartphone or another BLE module directly.

Advantages


- The module offers a set of AT commands for functionality settings and data transmission
- High system flexibility; the host computer only needs to focus on data processing
- Industry-leading RF performance ensures stable, long-distance data communication
- Compact module size suitable for various application scenarios



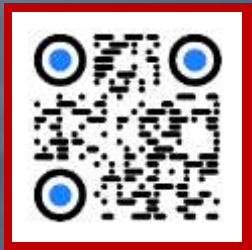
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