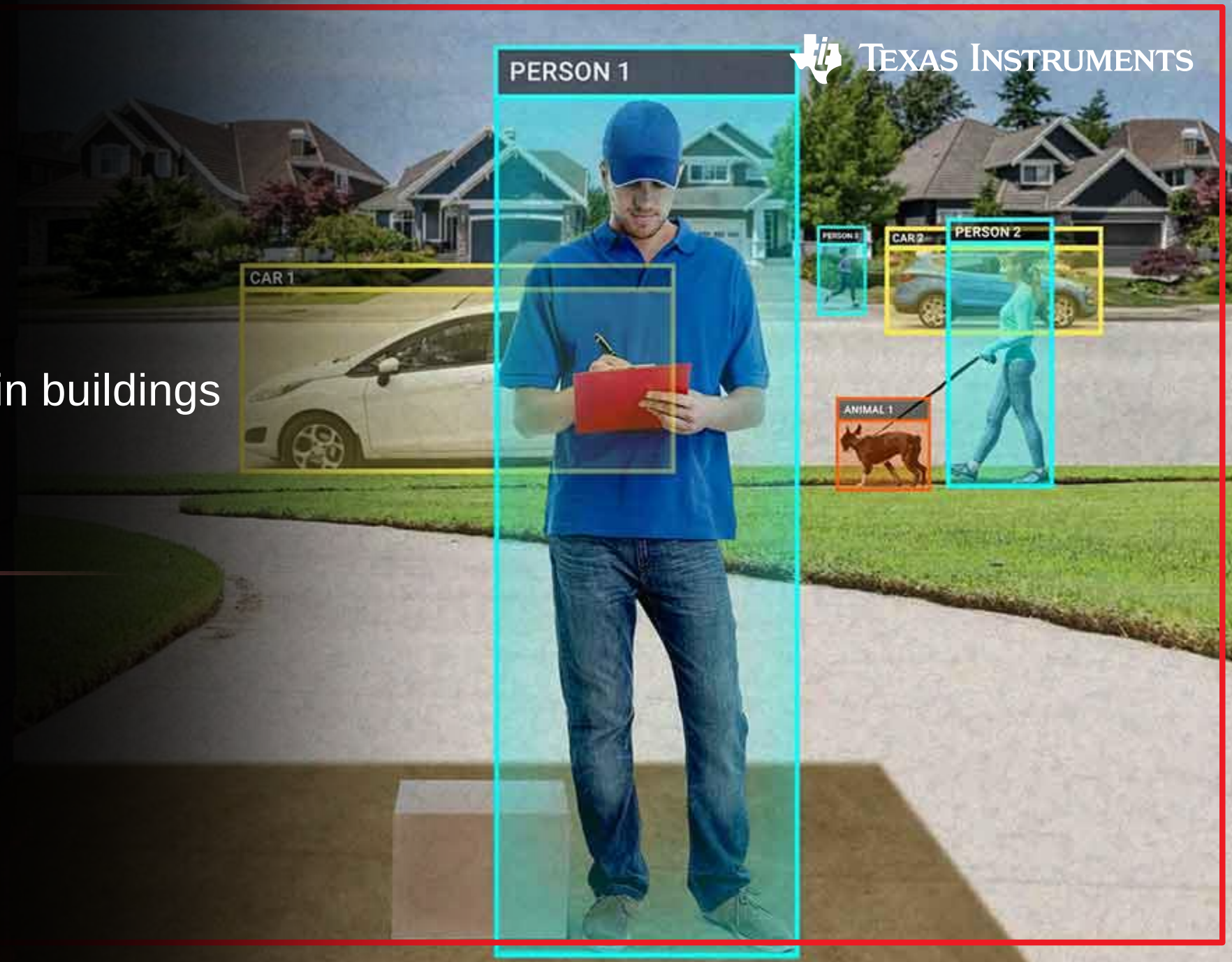
# Webinar

Increasing efficiency in buildings with mmWave radar




**Colin Hice**

Systems engineer

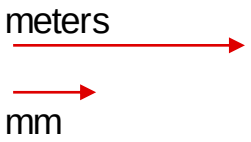
**Kottyn Quintanilla**

Product marketing engineer

# What is mmWave technology?

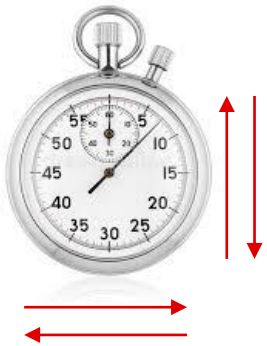
Repeatable, Dependable, Accurate Sensing…

**Range**



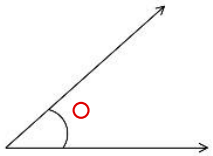

Measuring distance or change in distance of object from the sensor

**Velocity**



Displacement or motion signature for classification and monitoring

**Angle**



Azimuth & Elevation for localization

…in challenging conditions


**Camera-less**

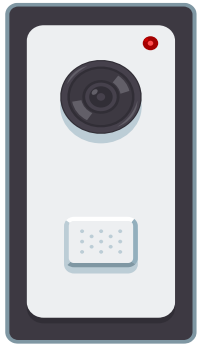
**Contact-less**

# Radar | building automation

- Presence Detection
- Major / Minor Motion Detection
- Localization
- Counting / Tracking
- Static Object Detection
- Velocity and Direction Detection
- Stance / Fall Detection
- Heart & Breath Rate Detection
- Human vs non-Human Classification

# Building automation using TI mmWave

Sensing that guarantees timely door opening, enhanced pedestrian safety, and reduced building energy losses



## Surveillance Applications

- Robust in conditions such as rain and snow
- Reduce false detections to reduce power consumption

## Commercial Doors

- Efficiently detect objects walking towards the door and ignore objects whose trajectory is not towards the door

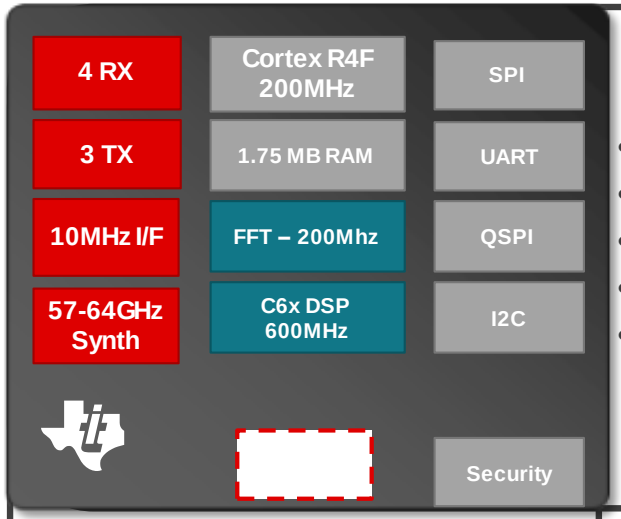

## Thermostats/HVAC

- Detect, track and count the number of people in an area to improve space utilization and for more efficient use of HVAC

| TI mmWave Features | Sensing Benefits |
|---|---|
| 3D Presence + Static Object Detection +Tracking | High accuracy 3D detection of multiple people/objects (moving) in the area of interest. Detect static objects/people in the door pathway |
| Object's Velocity Information | Adapt to the speed of approaching people/objects to make intelligent decision as to when to open the door and when to close the door |
| Immune to Environmental Conditions | Increase reliability over existing PIR /microwave sensors, low false triggers in bright daylight ,dark environments, and other environmental factors such as rain, snow, fog, etc. |
| Increase Battery Life with False Trigger Mitigation | Confirm motion detection events from other sensors with higher accuracy, significantly reducing power consumption by decreasing erroneous system wakeups in battery powered applications. |

# IWR6843 | IWRL6432 performance / power

## IWR6843 / AOP




Fully integrated
4Rx, 3Tx
1-patch antennae
on package
(AOP)

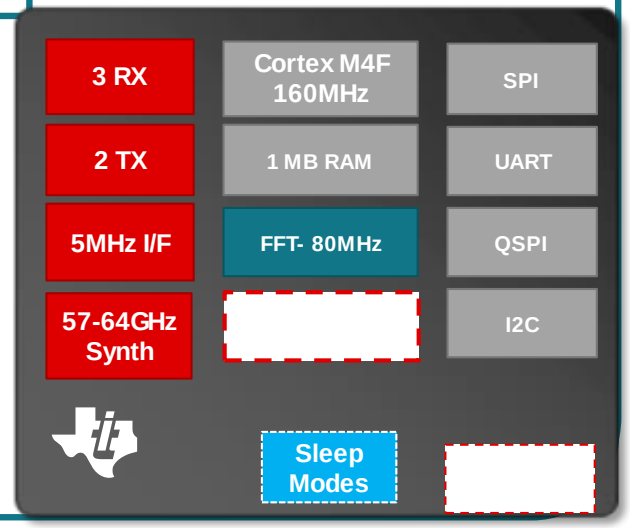
**Performance**

- Tracking: up to 10 people w/ 85% accuracy
- Max range: up to 100 meters
- Classification: advanced human / non-human
- Heart rate / Breathing rate accuracy: ±5bpm / ±2bpm
- Power consumption: up to 2W

**Power**

- FCCSP
  - Samples: Now
  - Production: 1Q24

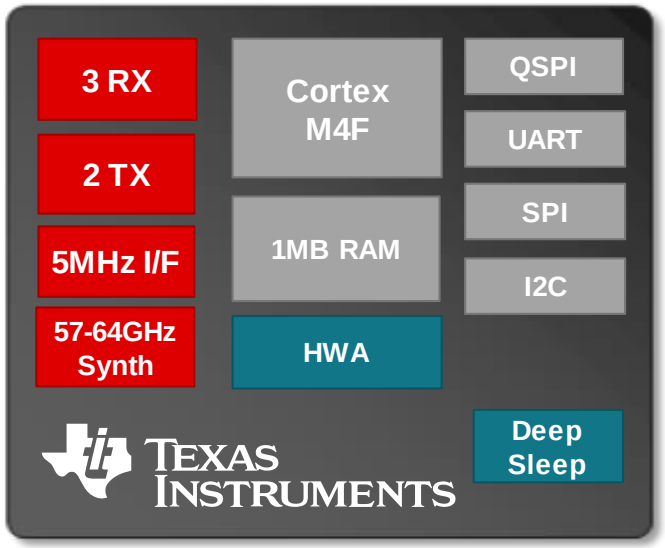
## IWRL6432




- Tracking: up to 5 people w/ 85% accuracy
- Max range: up to 20 meters
- Classification: human / non-human
- Heart rate / Breathing rate accuracy: ±10bpm / ±4bpm
- Power consumption: < 2mW

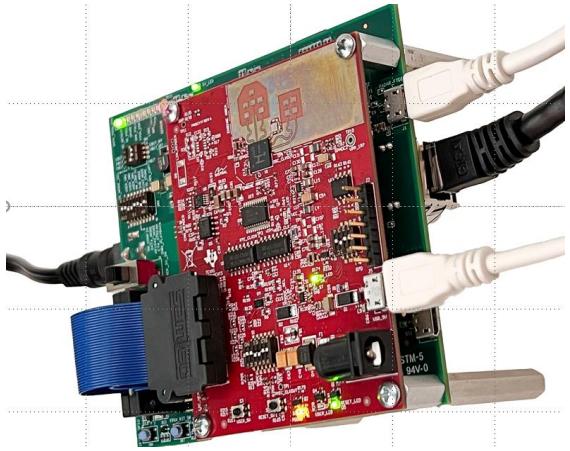
# IWRL6432 | product overview

- **Designed for small form factor, low BOM cost and lower power applications**
- **Integrated transceivers :** 3 Rx and 2 Tx
- **Integrated frequency synthesizer:** 57GHz to 64GHz
- **Processing:**
  - Arm® Cortex®-M4F MCU @ 160 MHz
  - Integrated FFT, CFAR-CA HWAs
- **Memory:** 1.0 MB SRAM
- **Interfaces:** SPI, UART, I2C, QSPI, GPIOs
- **System simplification**
  - Multiple power modes to enable ultra-low power
  - One, two or three power-rail topologies (1.8V, 1.2V, 3.3V)
- **Package:**
  - 6.45 x 6.45 mm FCCSP (0.5mm pitch) -- Samples Now



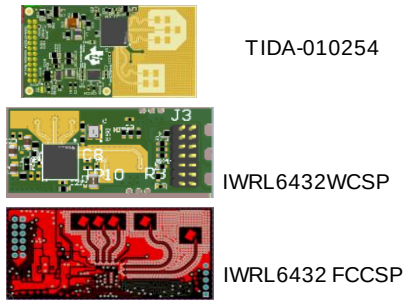

Sample/EVM: Now

Production: Q1 2024



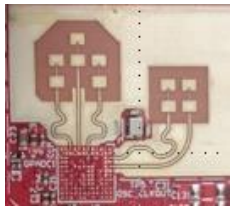
# IWRL6432 | Design Options

## Reference design



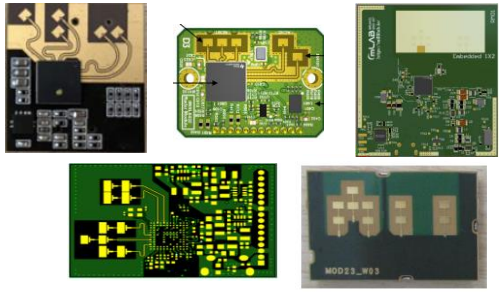

- Full reference design including radar, power management, passives, antenna etc.
- TI provides design files, layout, gerber, pcb stack, simulation and test results
- IWRL6432WCSP reference design (today)
- IWRL6432 FCCSP reference design (today)
- IWRL6432AOP reference design (in design)
- TIDA-010254 reference design (November)

## Antenna-only reference design



- Pre-validated antenna design from IWRL6432BOOST EVM (2-patch)
- Use simulated antenna designs from TI catalog
- TI provides
  - Layout
  - Dfx files
  - Simulation results
  - PCB stackup
  - Design reviews
  - Radome reviews
  - Test results (EVM only)

## System-on-Module



- Pre-qualified module including power management, passives, PCB, Xtal etc.
- Customizable antenna designs
- Various sizes and radar performance

SMART RADAR SYSTEM

muRata INNOVATOR IN ELECTRONICS

JORJIN TECHNOLOGIES

AVDS Technology

D3

…more

## 3rd party network

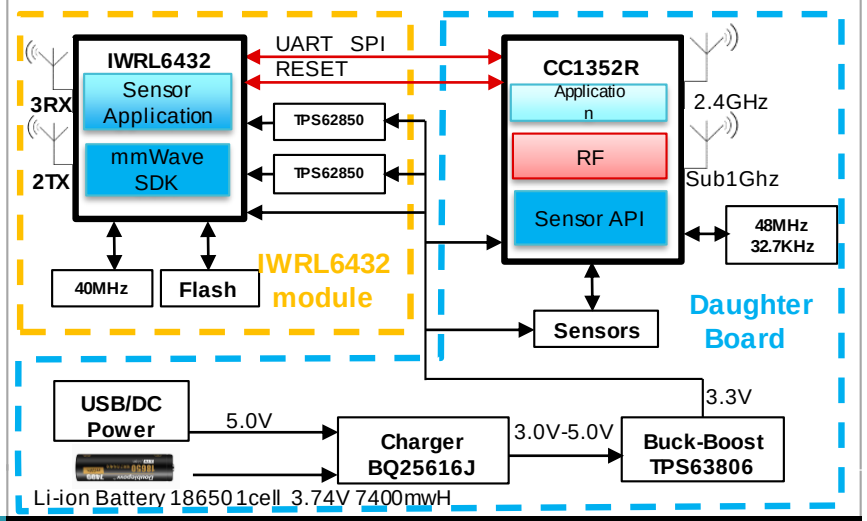
- New ti.com tool to help customers find radar partners to fill development gaps and accelerate time to market
- Select from multiple categories of capabilities and end applications
- Partners Include:
  - Turnkey designs – complete hardware & software
  - Evaluation – hardware & demo software
  - Services – hardware & software design services

# Battery Powered low-cost TI mmWave radar reference design

## Design challenge/problem statement

- Battery powered **standalone** demo board has high privacy in home use cases.
- **Detection** is independent of **area conditions** like light, dust, smoke, etc.
- **Ultra low-power** mmWave sensor that enables longer operation time in battery powered applications.
- Communications with smart home system by **wired or wireless** interfaces.

## Block diagram/schematic




## Additional resources

| | 60GHz mmWave | Wireless MCU |
|---|---|---|
| GPN | IWRL6432 | CC1352R |
| Description | Low-power, low cost mmWave sensor + HWA +MCU | Arm Cortex M4F, sub-1 GHz and 2.4-GHz wireless Bluetooth5.2, Zigbee |
| Technical resources | • Sensor Sequencing Using the CC13x2 and CC26x2 Sensor Controller<br>• Low Power mmWave radar enables new functionality in battery powered proximity se | |

## What differentiates this subsystem solution

- Precise minor motions, person sitting detection indoor.
- Determine if motion detected in coarse region of interest.
- Location of up to 3 people walk tracking.
- Patient vital signs and position signs detection.
- External processor: Classification of human vs non-human objects.
- External processor: Classification of human stance/behavior.

## Sims/measurements

| | TI (demo board) |
|---|---|
| Power source | 18650 Li-battery |
| Comm Mode | UART, SPI |
| Antenna | PCB layout |
| Wireless Protocols | Bluetooth 5.2 LE Zigbee |
| Sensors | Temp & Humi **HDC3020** Hall effect **DRV5032** Light **OPT3004** PIR **IRA-S210** |


IWRL6432 module Daughter Board

| Device Mode | Power (mW, 25deg) |
|---|---|
| Deep Sleep | 0.583 (1.8V IO) |
| | 1.226 (3.3V IO) |
| Idle | 11.99 (3.3V IO) |
| Processing | 144.6 |

Early power test

## EEs benefitting from this subsystem

- Appliances > Major appliance > Refrigerator & freezer
- Appliances > Service robot > Robotic lawn mower
- Building automation > Building Security System > Video doorbell
- Building automation > Building Security System > Motion detector (PIR, mmWave, etc.)
- Building Automation > Building Security System > Occupancy detection (people tracking & counting)
- Building Automation > Video surveillance > IP network camera

# Power consumption optimization

| Debug steps | Related part | I @ 3.3V Board A |
|---|---|---|
| Remove R179 | LED | 1888 uA |
| Remove IIC pull up R4/R75 | IIC | 1710 uA |
| Remove UART pull up R73/R74 | UART | 1118 uA |
| Remove GPADC2 pull up R67 | GPADC2 | 1078 uA |
| Remove BUCK MODE pull up R238/R244/Q3, shut MODE to GND | BUCK MODE | 1020 uA |
| J10 change to input in SW | BUCK MODE | 854 uA |
| SW set FLASH in SHUTDOWN mode | Need double check the code change | -- |
| Change R49/R44 to 2M | FLASH pull up | 665 uA |
| Set RAM retention in OOB demo | RAM | 588 uA |

Deep sleep mode
Sleep current

| | | |
|---|---|---|
| Deep sleep + motion detection demo running with 1 chirp per frame @ 1Hz | | 350uA (average current)<br>~1.15mW |

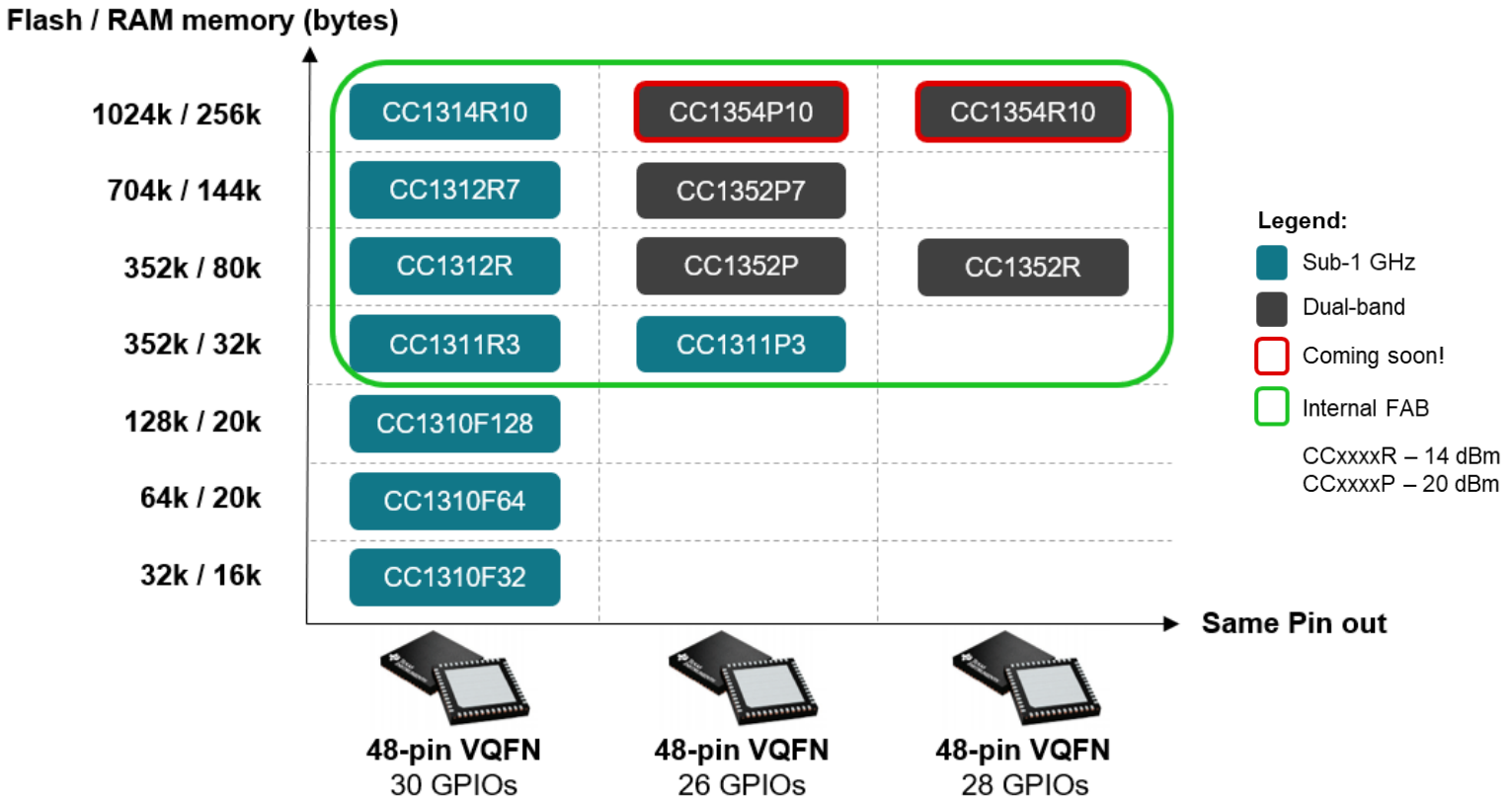
Deep sleep + motion detection
Average current

# CC13xx Wireless MCUs

Robust. Long Range. Low Power.

Scale your application with pin-to-pin, software compatible options and the industry's lowest power technology


| Parameter | 0-series | 1-series | 2-series | 4-series |
|---|---|---|---|---|
| Arm Cortex | M3 | M4 | M4F | M33 |
| Dual-band | - | - | Optional | Optional |
| Radio | Gen. 1 | Gen. 2 | Gen. 2 | Gen. 3 |
| High Power PA | - | Optional | Optional | Optional |
| Security | Mid | Mid | Mid+ | High |
| Sensor Controller | Gen. 1 | - | Gen. 2 | Gen. 2 |
| SDK | Fam. 1 | Fam. 2 | Fam. 2 | Fam. 2 |
| Standby current | 0.7 µA | 0.7 µA | 0.8 µA | 0.9 µA |



# CC1352P and CC1352P7 product overview

*48 MHz MCU with up to 704 kB flash, dual-band and 20 dBm PA*

## Features

**Ultra-low Power Consumption**
- MCU Current: 60 µA/MHz
- 0.85 µA standby with full RAM retention and RTC
- 5.8 mA RX
- 24.9 mA TX at +14 dBm
- 63.0 mA TX at +20 dBm

**MCU**
- 48 MHz Arm® Cortex®-M4F
- 352/704 KB Flash w/ 8KB cache
- 80/144 KB ULL RAM
- 1.8 – 3.8 V supply range

**Security**
- AES-128/256, SHA-256/512, ECC

**RF Key Features**
- Output power:
  - Up to +14 dBm on Sub-1 GHz
  - Up to +5 dBm on 2.4 GHz
  - Up +20 dBm on both bands
- Sensitivity:
  - -110 dBm (50kbps GFSK)
  - -121 dBm (2.5kbps SL-LRM)
- Down to 4 kHz RX BW (narrowband)

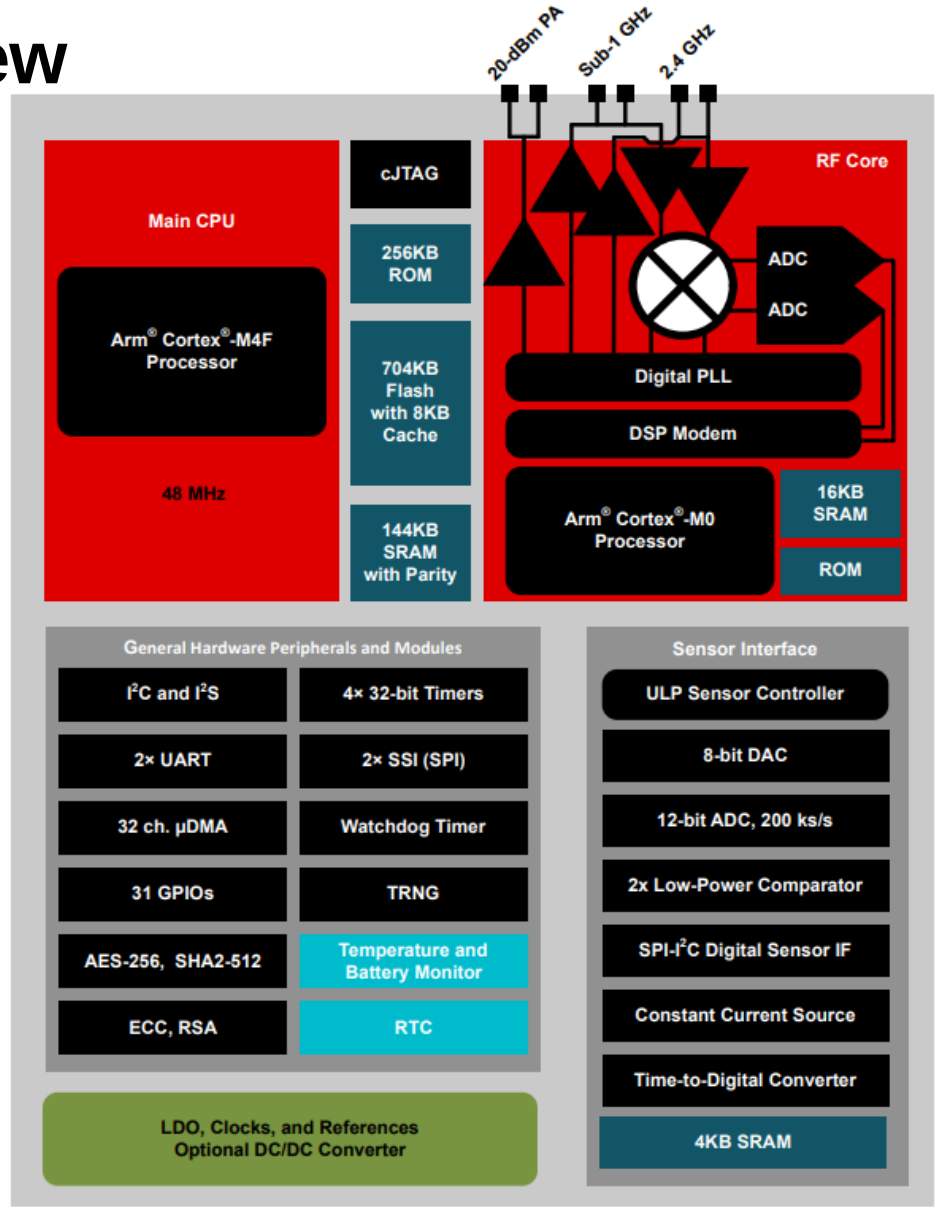
**Peripherals**
- All Digital Peripheral Pins Can Be Routed to Any GPIO
- Programmable Sensor Controller

**Package**
- 7x7 mm packaging

## Benefits

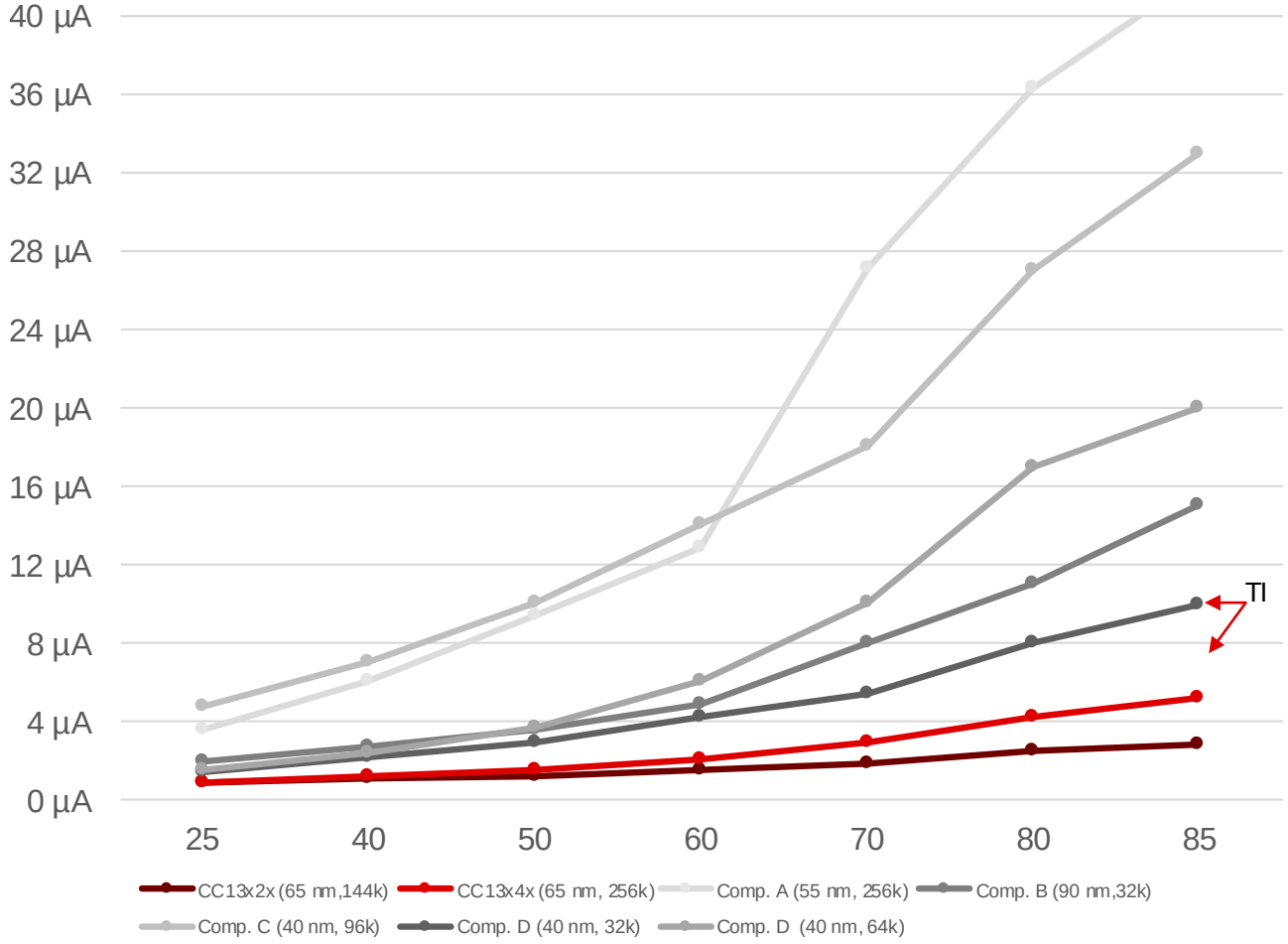
- Run larger stacks like Amazon Sidewalk or Wi-SUN
- Enable easy network commissioning with Bluetooth 5.2
- SoC offering long battery lifetime for the complete system (RF and application combined)

Sub-1GHz Proprietary | TI-15.4 Stack | M-Bus wireless | mioty | Wi-SUN | amazon sidewalk | zigbee



# Low power consumption

*True low power wireless solutions*



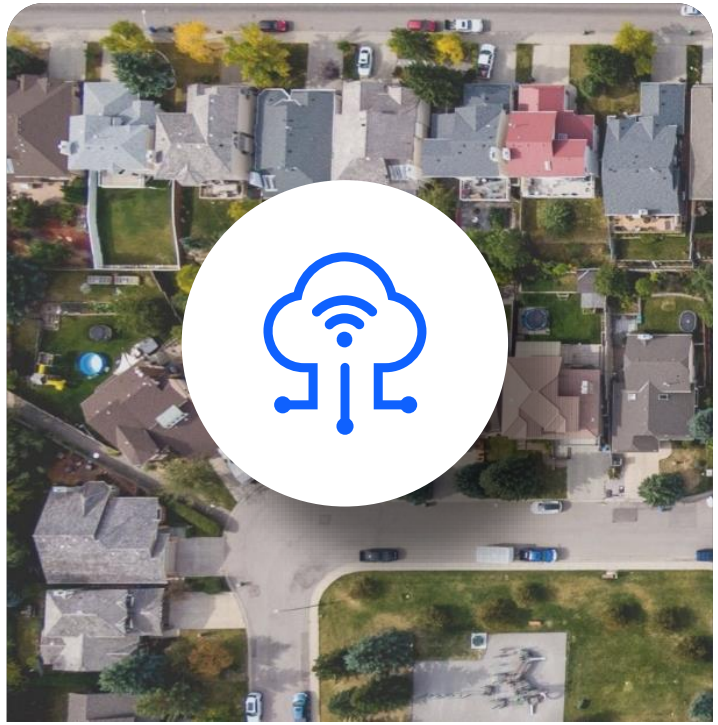

## Key Features

- Sub-1 uA standby current even at 256 kB RAM retention
- Low standby current over temperature
- Integrated high power PA 63 mA @ 20 dBm TX
- Sensor Controller

## Application Benefits

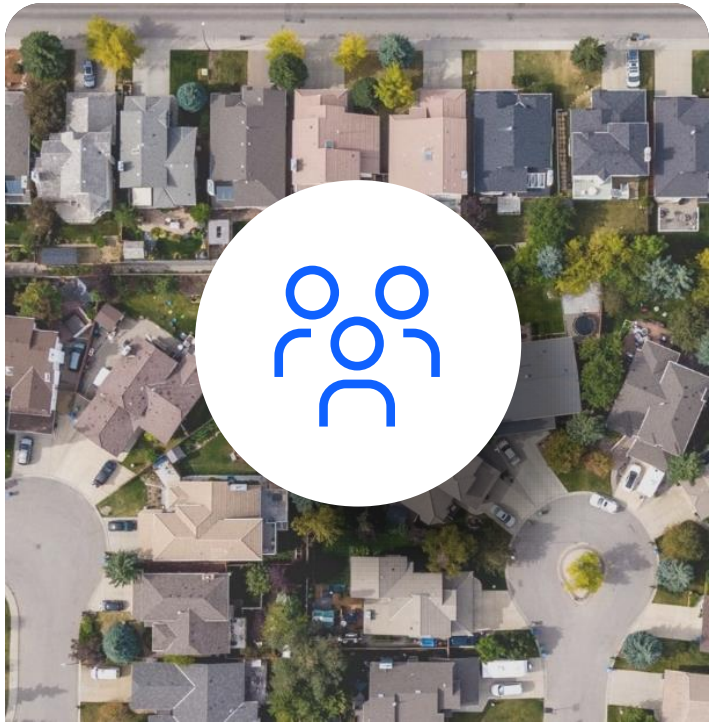
- Longer product lifetime
- Reduce cost with lower peak currents
- Longer battery replacement intervals
- … even at high temperatures

# What is Amazon Sidewalk?



DATA FROM DEVICE TO CLOUD

Sidewalk is a wireless IoT network comprised of millions of Ring and Echo devices



SERVING THE COMMUNITY

It's a public network that is powered by the community and whose devices are meant to better serve the community

DIVERSE USE CASES

Sidewalk combines short and long range wireless technologies to accommodate a variety of use cases

# Sidewalk use cases

**Inside the home**

'Things' that are difficult to connect or remain connected

- Appliances (e.g., laundry)
- Air conditioning filters
- Medical devices (e.g. glucose monitoring)

**At the home-edge**

'Things' that have issues in staying connected

- Appliances (e.g., HVAC)
- Pool pumps
- Water leak sensors
- Mailbox sensors
- Pathway lights

**In the neighborhood**

'Things' that move around and need continuous connectivity

- Last mile delivery trackers
- Car tags
- Cold-chain tracker for food
- Cold chain tracker for pharma

# How Amazon Sidewalk Works

**Scale to be supported**

**Cloud Service**

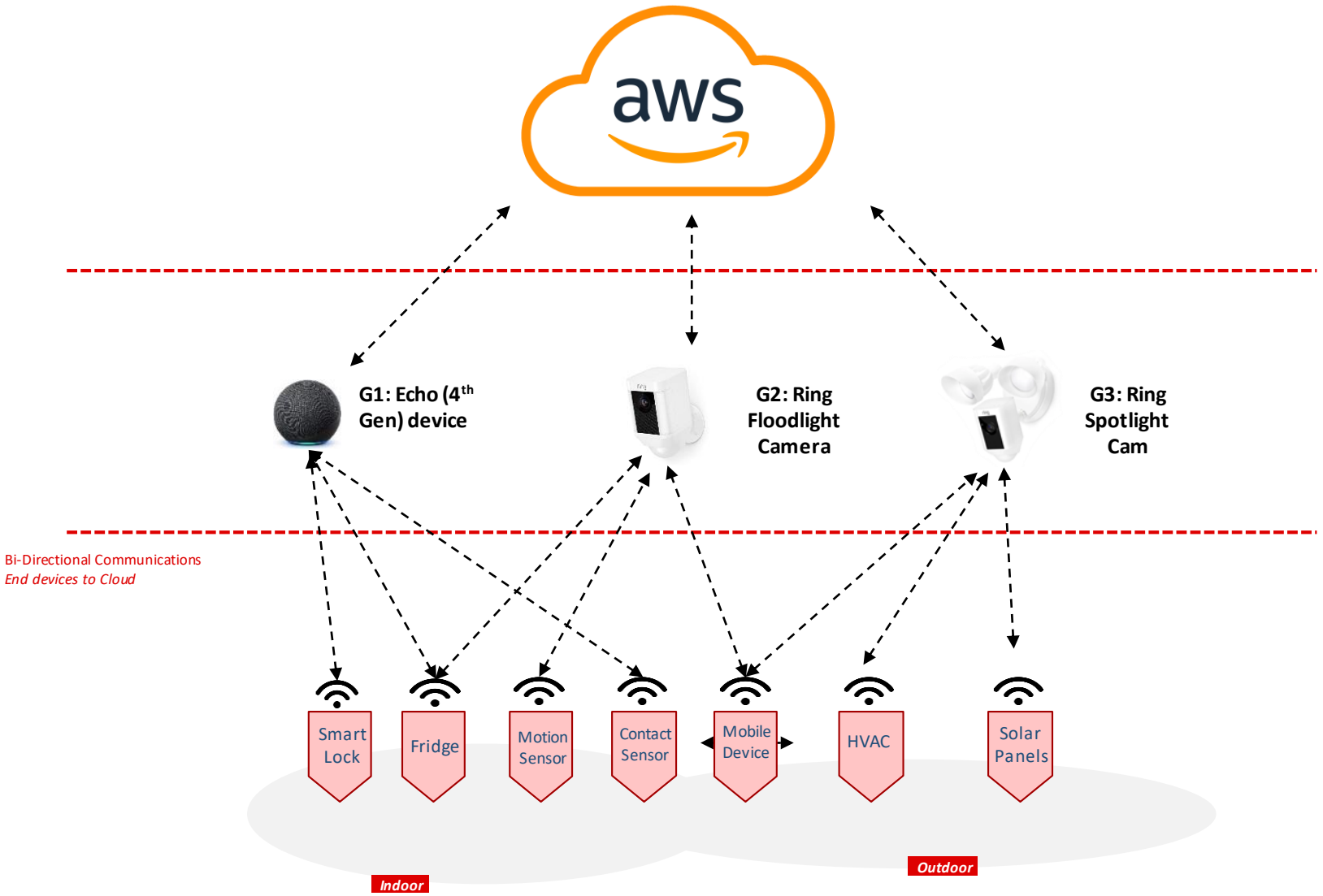
Tens of billions of messages

**Sidewalk Bridge Devices**

Millions of gateways

**3rd party IoT devices**

Billions of devices



# Amazon Sidewalk | TI is your main partner

## What is Sidewalk?

- Sidewalk is a ready-to-use stack with security leveraging the 900MHz band
- Extends connectivity beyond Bluetooth and your home Wi-Fi
- Leverages Amazon's existing infrastructure for a crowdsourced network

## Benefits

- Eliminates the need to build your own gateway
- Added redundancy with neighboring gateways
- Provides extended range (wall penetration) at a lower cost than cellular
- Immunity to interference (outside of 2.4GHz)

## TI Advantage

- Extremely low standby current (0.8uA)
- Highly efficient integrated Power Amplifier (25% lower TX current at +20dBm vs. market)
- Use BLE for easy provisioning & firmware updates with CC1352P7
- Easy to use Sidewalk protocol integrated into TI SDK

## Getting Started

- Build a rapid prototype and expand to full development with LP-CC1352P7 Development kit | TI.com
- Support via local FAEs and TI E2E

# False Trigger Mitigation Tool

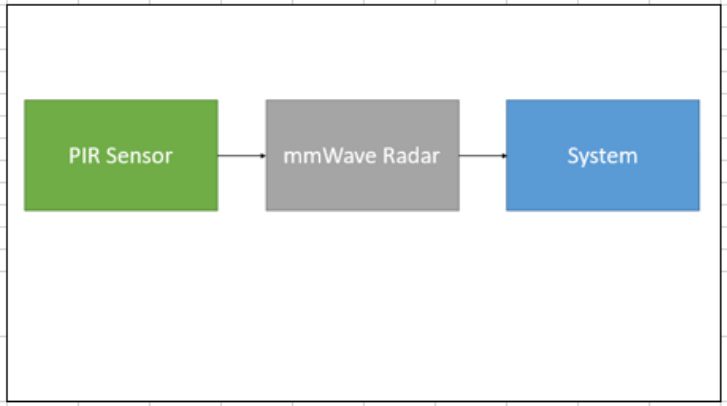
- Uses radar to confirm PIR triggers
- Prevents unnecessary wakeups of camera and system
- Radar can be used for other uses, such as people tracking or gesture control
- High increase in battery life in cases with many false detections

| Power Consumption Comparison | | | |
|---|---|---|---|
| Total Detection Events | % of Events False Triggers | Power Consumption **without** False Trigger Protection (no radar) (mWh) | Power Consumption **with** False Trigger Protection (with radar) (mWh) |
| 60 | 50 | 1333.296 | 666.748 |

| Battery Life Comparison | | | |
|---|---|---|---|
| Detection Events Per Day | % of Events False Triggers | Battery Life **without** False Trigger Protection (days) | Battery Life **with** False Trigger Protection (days) |
| 10 | 50 | 99.9 | 199.8 |

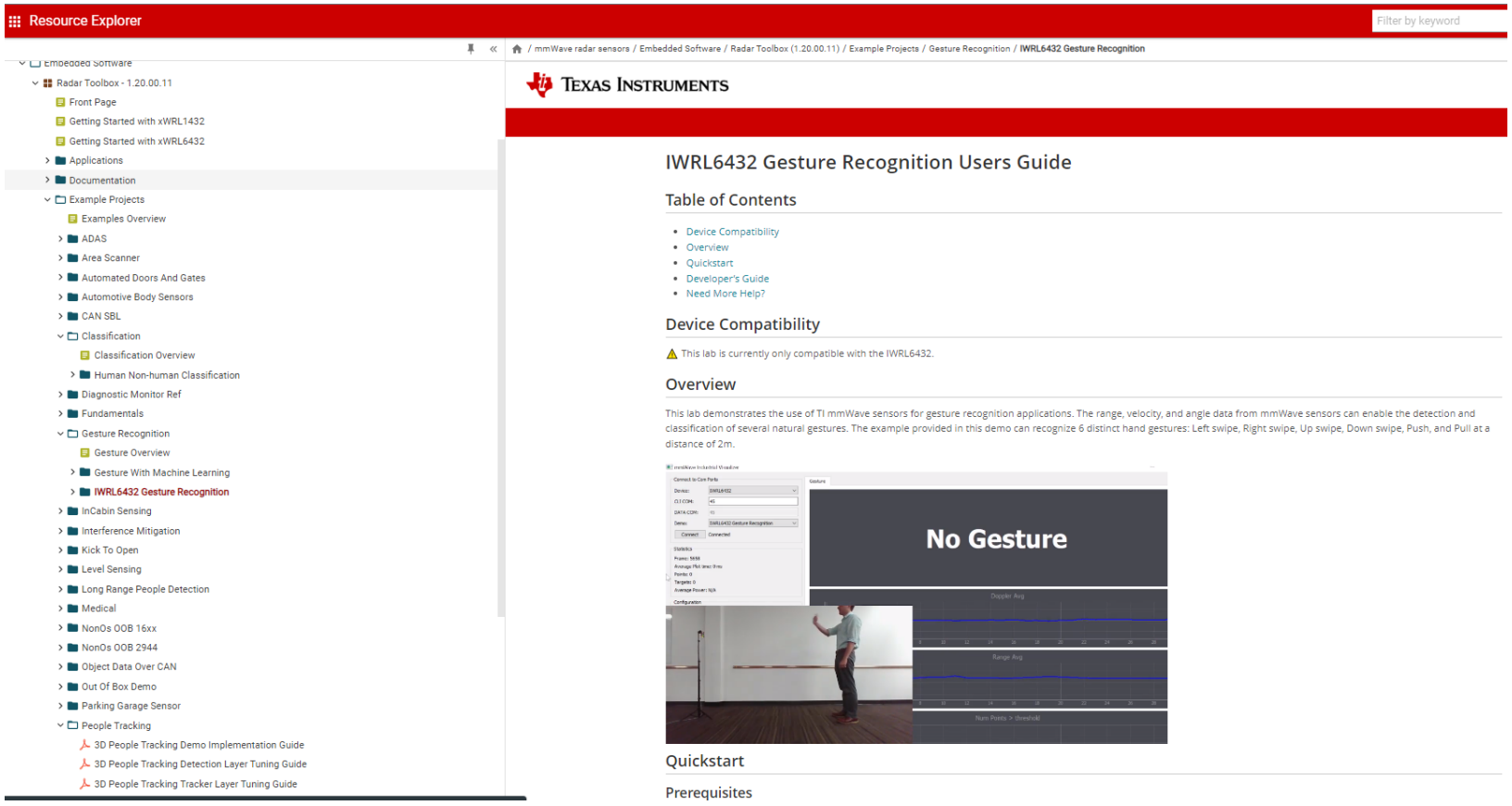
Values in blue cells can be modified

| System Configuration | | | | |
|---|---|---|---|---|
| Default Radar Profile | Select Config: | Presence and Motion | Avg Power (mW): | 15 |
| Custom Radar Power | Enter Custom Avg Power: | 23 | | |
| Radar Time Period | Enter (ms): | 400 | | |
| System Power | Enter Avg Power (mW): | 10000 | | |
| System On-Time (Per detection event) | Enter On-Time (ms): | 8000 | | |
| Radar False Trigger Protection Accuracy (% of false triggers identified correctly): | Enter %: | 100 | Detected False Triggers (Power Consumption | 30 |
| | | | Detected False Triggers (Battery Life Comparison): | 5 |
| Battery Size | Enter mAh: | 6000 | Battery mWh: | 22200 |
| Battery Voltage (Nominal) | Enter V: | 3.7 | | |
| Estimated Battery Life (Events, without radar) | 999 | | | |
| Estimated Battery Life (Events, with radar) | 999 | | | |



# Radar Developer Zone

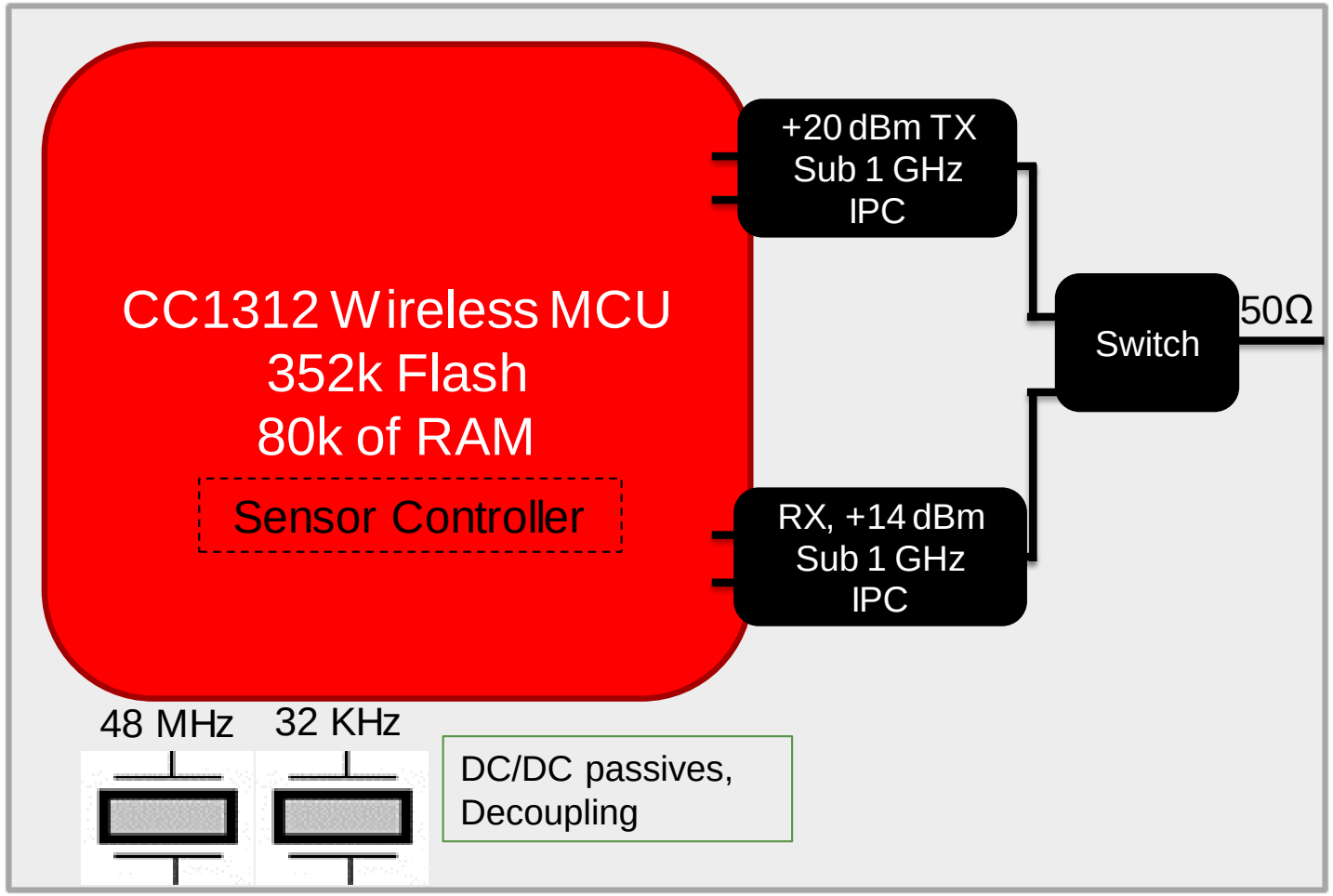
- Example projects including source code, and step-by-step user guides
- Experiments such as radar performance in natural elements, or the testing of other various features
- Direct communication with TI engineers to get support in TI's E2E forums



# CC1312PSIP block diagram

- **Integrated components**
  - 32kHz crystal and software temperature compensated RTC (Real Time Clock)
    - ±50ppm max for -40 to 65 degrees
  - 48 MHz xtal and software temperature compensated RF frequency accuracy:
    - ± 10ppm from -40 to 65 degrees
    - ± 20 ppm for -40 to 105 degrees
  - IPC: Integrated Passive Component for:
    - RX and the +14 dBm TX path (50 Ω)
    - TX:+20 dBm (50 Ω)
  - RX/TX switch
  - DC/DC inductor and capacitor
  - Decoupling capacitors

- The module is shielded
- Ultra Low Power:
  - Standby: 0.9 µA (with RTC and 80k RAM)
  - RX: 5.8 mA
  - TX: 28.7 mA @ +14 dBm, 70mA @ +19 dBm
  - MCU: 2.9 mA (48 MHz running Coremark)



# SIPs/Module | How does it save time to market?

| Design | Certification | Production Test |
| --- | --- | --- |
| **ChipDown:**<br>• RF design takes significant time in order to optimize performance (1-6 months)<br>• Risk of re-spin of the PCB | **ChipDown:**<br>• Failure to certify can be expensive | **ChipDown:**<br>• More advanced production test needed to cover passive components and crystals |
| **Module:**<br>• Less PCB area needed (80% area reduction)<br>• Reduces complexity of layout<br>• Lower manufacturing and assembly cost considering a single component vs multiple components | **Module:**<br>• TI certifies the modules for FCC/IC (saves 2+ months)<br>• TI certifies the CC1312PSIP Launch Pad for CE (ETSI) | **Module:**<br>• The CC1312PSIP has been tested by TI, therefore, a much simpler production test can be implemented<br>• The 48MHz crystal, the RF frequency and the 32kHz crystal have been calibrated |

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