Zigbee Tracker v2.0 Datasheet

Revision A

Table of Contents

1 About This Document

This document outlines the technical details of the Zigbee Tracker v2.0 device. For details on software usage, setting up, or troubleshooting the Zigbee Tracker system, refer to the Zigbee Tracker System User Guide.

2 Revision History

Changes from Original to Revision A

Added Section 5.8 on Charge LED.
Modified specifications on Sleep Current in Section 4.4.
Modified Sensor I2C Addresses in Section 5.
Deleted specifications on Maximum Total Current in Section 4.3.

3 Device Overview and Functions

The Zigbee Tracker v2.0 is designed as a low power wireless device on the IEEE 802.15.4 standard (Zigbee). The Zigbee Tracker v2.0 consists of a Zigbee Module (based on the CC2530 IC), industry standard STM32 microcontroller, single cell Li-ion battery management system, voltage regulator, environment sensor, inertial motion sensor and ambient light sensor on a standard I2C bus. The device functionality is depicted in Figure 3A.
Additionally, the Zigbee Tracker v2.0 has physical dimensions of 35 x 27 x 3.7mm, allowing it to be used in space-limited applications.

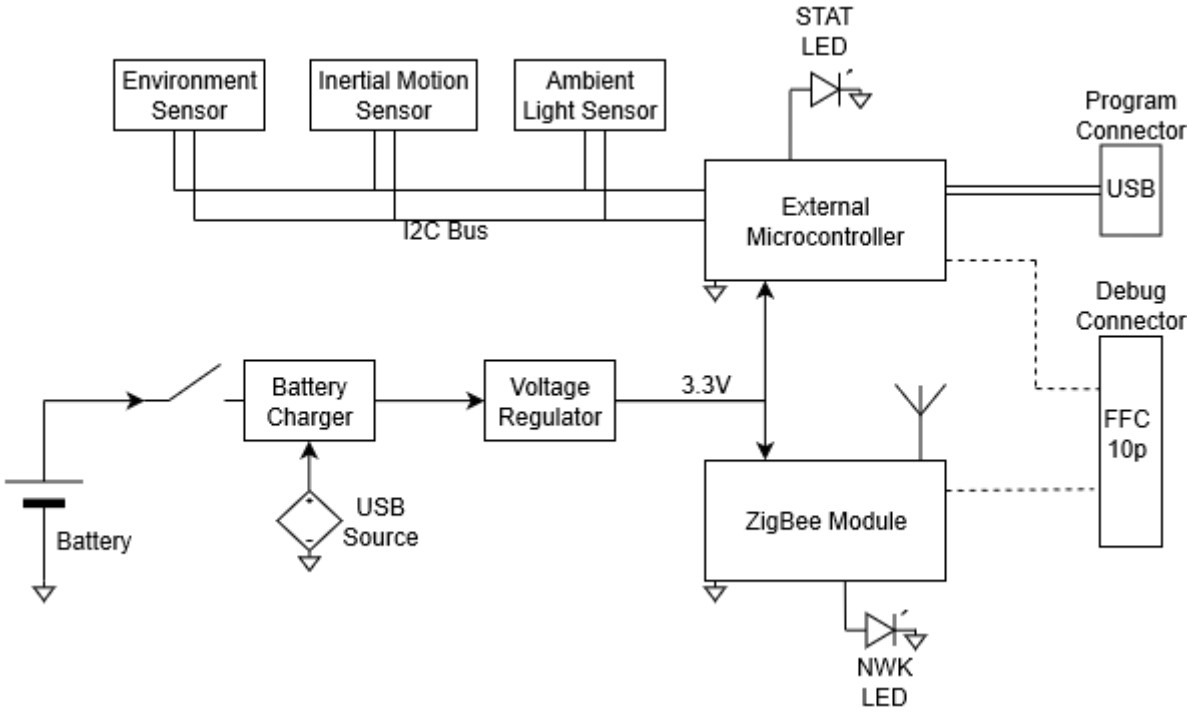

Figure 3A: Simplified Functional Block Diagram

As a low power end device in a Zigbee network, the expected use case is for tracking using RSSI measurements, or as a node in a wireless sensor network. The I2C devices can provide hardware interrupts to the microcontroller. Flashing the microcontroller (factory settings) can be done through the FFC connector. If a bootloader is present, the microcontroller can be programmed through the USB port. The Zigbee Module contains preloaded firmware with AT/HEX command functionality via UART. However, the Zigbee Module can be reprogrammed via the FFC connector. **This will overwrite the existing firmware and is irreversible.** Details on the programming and reflashing of the Zigbee Tracker v2.0 can be found in the User Guide, as well as instructions on the required hardware and connections.

4 Specifications

4.1 Absolute Maximum Ratings

PARAMETER		MIN	MAX	UNIT
Pin Voltage		-0.3	3.6	V
Device Temperature		-25	115	°C
USB Supply Voltage, V_{bus}		-0.3	6	V
Battery Input Voltage, V_{bat}			5	V

The device is not guaranteed to function within these ratings. Exceeding these ratings may cause permanent damage to the device.

4.2 Recommended Operating Conditions

PARAMETER		MIN	MAX	UNIT
Pin Voltage		0	3.3	V
Operating Temperature	Excluding battery charger	-5	85	°C
USB Supply Voltage, V_{bus}		4.75	5.25	V
Battery Input Voltage, V_{bat}		3.0	4.2	V

4.3 Electrical Characteristics

PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
System Voltage, $V_{3.3}$	$V_{proc} > 3.52V$	3.29	3.32	V
	$V_{proc} < 3.52V$	2.1	3.49	V
Max. Charge Current, I_{batmax}	Sum of I_{battyp} and $I_{3.3}$ and $R_{LIM} = 2.2k$	0	704	mA
Fast Charge Current, I_{battyp}	$R_{SET} = 2k$	0	445	mA
Charge Input UVLO, V_{UVLO-}	Charge input voltage falling	3.2	3.4	V
Regulation Efficiency, η	$V_{in} = 5.0V$, $0.1mA < I_{3.3} < 100mA$	90		%
100% Mode Entry, $V_{TH\_100\%-}$	Input voltage falling	3.49	3.56	V
100% Mode Exit, $V_{TH\_100\%+}$	Input voltage rising	3.44	3.51	V
Battery Charge Voltage, $V_{batterm}$	$T_{JUNCTION} = T_A =$ 25°C at terminating voltage level	4.16	4.23	V

4.4 Operating Characteristics

PARAMETER	TEST CONDITIONS	MIN	MAX	UNIT
Operating Current, I_{op}	RF transmission active at 4.5dBm, microcontroller moderate usage	58.8	59.2	mA
	RF inactive, microcontroller moderate usage	12.5	16.1	
Sleep Current, I_{sp}	Significant Motion detector @ 12.5Hz, gyroscope suspended, other sensors forced mode. Microcontroller CPU, HSE/HSI, LSE, PLL, GPIO_CLK, PVD OFF. Internal regulator low power mode.	33.7	41.2	µA
Complete Standby Current, I_{sb}	All devices in lowest valid power state		29.8	µA
Maximum RF Transmit Power	Configured in Zigbee Module		4.5	dBm
Maximum RF Receive Sensitivity	Configured in Zigbee Module		-97.5	dBm

All voltages are measured with respect to V_{ss}

5 Detailed Description and Functionality

5.1 Microcontroller

The Zigbee Tracker v2.0 is controlled primarily by the onboard STM32F103C8T6 microcontroller. This microcontroller provides a 32-bit ARM core at low cost and low power.
The microcontroller's BOOT0 pin is connected to GND with a 10k resistor. A stronger pull to VDD via the DEBUG FFC connector will force the microcontroller to boot to either SRAM or the system memory, depending on the state of BOOT1 (PB2). More details can be found in the microcontroller documentation.
The microcontroller's PD0/PD1 HSE clock pins are connected to an 8MHz crystal, and the PC14/PC15 LSE clock pins are connected to a 32.768kHz crystal. The hardware I2C pins PB6/PB7 are used to communicate with all sensors in the system. 10k pull-up resistors are present on the bus.
The microcontroller is also connected to the ambient light sensor and inertial motion sensor via two hardware interrupt pins PA15/PB15 respectively. These can be used to wake the microcontroller from sleep or trigger RTC events. More details regarding interrupt pin functionality and priority can be found in the microcontroller documentation.
The microcontroller's inbuilt USB module differential PA11/PA12 pins are connected to the USB socket. This method can only be used to program the microcontroller if a USB bootloader is present and the BOOT pins are set correctly.
The microcontroller's hardware UART2 PA2/PA3 pins are connected to the Zigbee Module for issuing commands. UART3 is connected to the DEBUG FFC connector and is used to flash the microcontroller directly.
Pins PB10/PB11/PB12 are connected to the Zigbee Module as control pins.
Further information can be derived from the circuit schematics provided.

5.2 Zigbee Module

The Zigbee Tracker v2.0 utilizes a low-cost E18-MS1 Zigbee Module based on the CC2530 SoC. The module is preloaded with firmware which allows for AT/HEX UART commands to control the module, bypassing the need for writing code for the CC2530. More information on the commands and their functionality can be found in the E18 Software Datasheet. If the preloaded firmware is deemed unsuitable for the application, the Zigbee Module can be reprogrammed via the DEBUG FFC connector with a Texas Instruments CC debugger. **Reprogramming the Zigbee Module will erase the preloaded firmware and is irreversible.**

5.3 Inertial Motion Sensor

The onboard BMI160 Inertial Motion Sensor (IMU) can provide hardware interrupts to the microcontroller. The BMI160 has many inbuilt functions such as step detector, significant motion, freefall etc. These functions can be set and read via the device registers based on the manufacturer's datasheets. The BMI160 is also capable of high sample rates and direct measurement. For low power

applications, it is generally recommended to use one of the inbuilt functions, setting a low sample rate, and setting the PMU correctly to achieve low power consumption.
There is also an inbuilt temperature sensor in the BMI160 that may be used under certain conditions to confirm the readings by the environment sensor or other purposes as outlined in the manufacturer's datasheets.
The BMI160 is configured in this design to have an I2C address of 0x69.

5.4 Environment Sensor

The onboard BME280 provides humidity, temperature and pressure readings. The BME280 can be used in two modes - interrupt and polling. It is important to note that the interrupts are software interrupts and therefore have limited functionality in low power applications. More details can be found in the manufacturer's datasheets.
The BME280 is configured in this design to have an I2C address of 0x76.

5.5 Ambient Light Sensor

The onboard OPT3001 Ambient Light Sensor (ALS) is used to measure ambient light with a similar spectral response to the human eye, and excellent IR rejection. The OPT3001 can be used in interrupt mode, and is also able to provide a hardware interrupt to the microcontroller.
The OPT3001 is configured in this design to have an I2C address of 0x45.

5.6 Battery Charger

The onboard BQ24072 PMIC is used to charge an external, single cell Li-ion battery, as well as to manage the power path, allowing the Zigbee Tracker v2.0 to be powered from the battery, USB or both. Multiple protections are provided by this IC, such as UVLO, OVP, short-circuit, reverse current, USB inrush and thermal shutdown. The BQ24072 charges the Li-ion battery through a standard precharge-CC-CV cycle, with CC threshold set by the ISET resistor. The total system current is limited by the ILIM resistor. The maximum charge time is set by the TMR resistor. More details can be found in the Specifications and manufacturer's datasheet.

5.7 Voltage Regulator

The onboard TPS62740 PMIC is used to regulate the output of the battery charger to 3.3V. The TPS62740 uses a DCS control topology with extended light-load operation to regulate the output, providing high efficiency even at very low currents. The DCS control topology reduces interference with the onboard Zigbee Module, low output ripple (compared to other switching supplies) and low current consumption. More details can be found in the manufacturer's datasheet.

5.8 Indicator LEDs

The Zigbee Tracker has three indicator LEDs as shown in Figure 5.8A.
The behavior of the LEDs is outlined in Table 5.8A.
The Network LED is connected to pin PA6 of the microcontroller and is user controlled (active high).

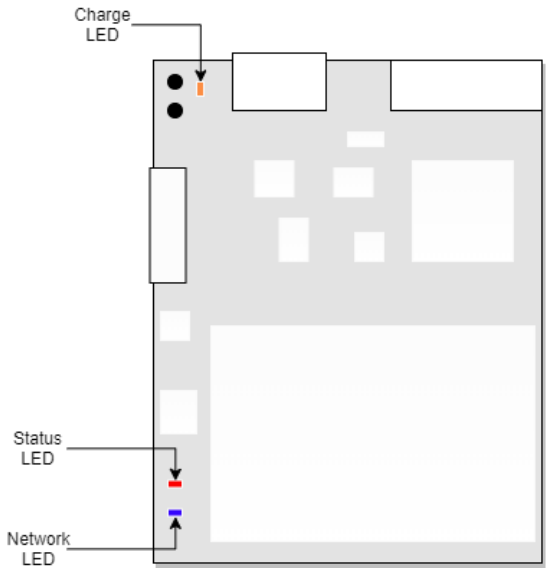

Figure 5.8A: Indicator LEDs on the Zigbee Tracker v2.0

	State	Meaning
Charge LED	Off	Battery not charging
	On	Battery charging
	Flashing at 2Hz	Charger safety timers expired
Network LED	Off	User controlled function
	On	User controlled function
Status LED	Off	Zigbee network connected
	On	Zigbee network disconnected

Table 5.8A: Indicator LED behavior

6 Application and Implementation

6.1 Debugging and Programming

The Zigbee Tracker v2.0, as shown in Figure 6.1B, has an FFC connector which provides connections to the microcontroller hardware UART1 port for flashing of the bootloader or to upload programs without the bootloader, as well as a connection to BOOT0 (pulled down within the system by 10k) as seen in the Microcontroller Flashing Connections in Figure 6.1A.
The FFC connector also provides connections to the Zigbee Module for programming with the CC Debugger as seen the CC Debugger Connections in Figure 6.1A.
It is recommended to use the Zigbee Tracker Debugger Circuit to debug or program the Zigbee Tracker v2.0. Any custom circuits made to fulfill this functionality must observe the design requirements of this device, as well as of any other external debuggers/ICs used. None of the connections on the FFC connector should be exposed to any voltage above the Absolute Maximum Ratings. Additionally, the Zigbee Tracker v2.0 should be **disconnected from both its USB and battery supply**, and be powered through the FFC connector VDD pin with 3.3V to prevent oscillation or surge.

The USB port on the Zigbee Tracker v2.0 in Figure 6.1B is compliant with USB 2.0 and higher. As per USB specifications, the bus voltage should not exceed 5.25V (6V is the Absolute Maximum for this device).

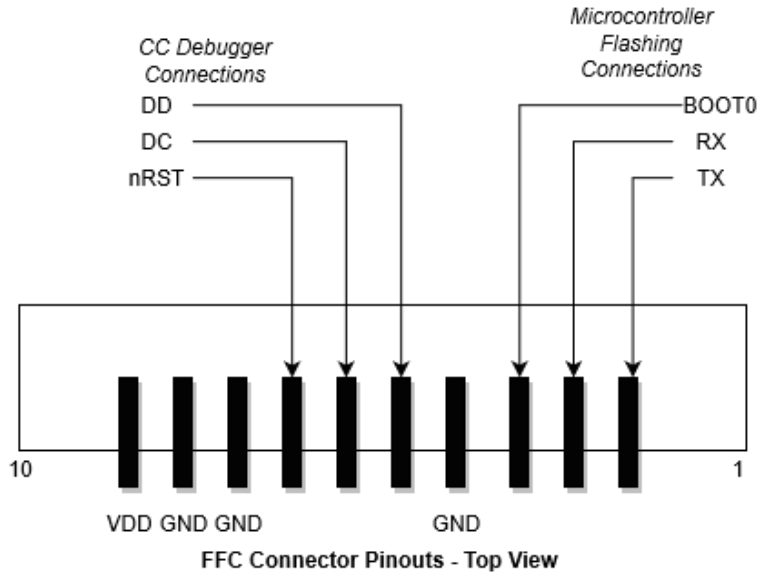

Figure 6.1A: FFC Connector Pinouts

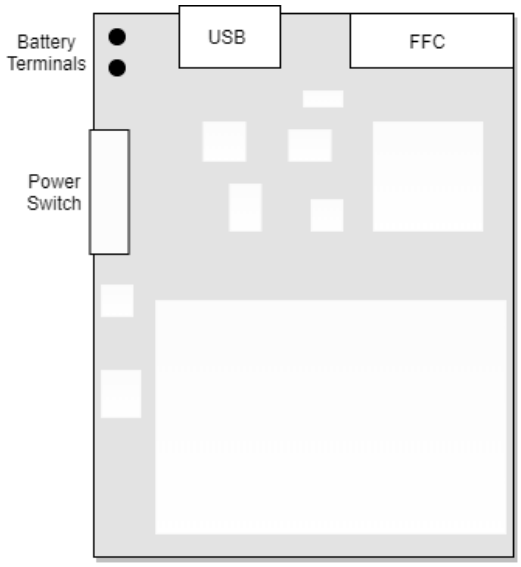

Figure 6.1B: Zigbee Tracker v2.0 user-accessible connectors and switch

6.2 External Enclosures

As with any wireless device, it is highly inadvisable to use metal enclosures without substantial research on its effects on device performance. Placing any metal or conductor directly above or around the region in Figure 6.2A is likely to detune and absorb RF transmissions from the Zigbee Module PCB antenna.

It is also recommended to have clear sections of the enclosure for the indication LEDs in Section 5.8 to be visible to the user.
Depending on the purpose of the device, vents for thermal dissipation may be necessary. Generally, if the device is in sleep mode most of the time, no thermal considerations are required. However, it should be noted that during charging, the device dissipates a nontrivial amount of heat.

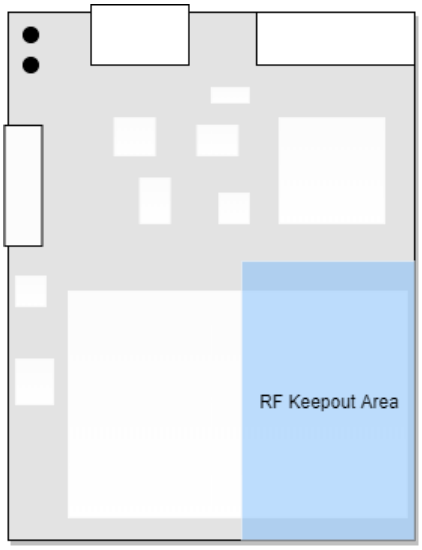

Figure 6.2A: Zigbee Tracker v2.0 RF Keepout Area

6.3 Battery

The Zigbee Tracker v2.0 is only compatible with a single cell, standard 3.7V (nom.) Li-ion battery. Any other types of batteries may cause the system to function incorrectly and run the risk of fires or explosions. The recommended capacity of the Li-ion battery is between 800-2000mAh, though larger capacities may be used at the expense of compactness. The battery should be soldered to the two battery terminals shown in Figure 6.1B, with the correct polarity indicated on the Zigbee Tracker v2.0 silkscreen.

6.4 ESD Protection

The Zigbee Tracker v2.0 has no dedicated ESD protection, besides the inbuilt protection in the ICs with a minimum of +-250V CDM, allowing manufacturing with a standard ESD process (JEP157).
It is recommended to take the necessary precautions to protect the device from ESD.

7 Related Documentation

Documents related to the Zigbee Tracker v2.0

Zigbee Coordinator v2.0 Datasheet
Technical documentation of the Zigbee Coordinator v2.0 device.

Zigbee Tracker System User Guide
User-friendly set-up guide for Zigbee Tracker system (including Zigbee Tracker v2.0 as both end device and router nodes, and Zigbee Coordinator v2.0 as coordinator node).

Documents related to the hardware components of the Zigbee Tracker v2.0

TPS62740
Low-power buck converter
BQ24072
USB-friendly lithium-ion charger
STM32F103C8T6
Medium-density performance ARM microcontroller
E18-MS1-PCB
CC2530 module with PCB antenna
OPT3001
Ambient light sensor with IR rejection
BMI160
Low-power inertial motion sensor
BME280
Low-power environment sensor