

Circuit Principle and Operational Description for Bluetooth Module based on Bluetrum PTSA15E5B

1.0 Introduction

This document describes the circuit principles and operational characteristics of the Bluetooth module. The core component of this module is the Bluetrum PTSA15E5B system-on-chip (SoC), which integrates RF transceiver, baseband processor, memory, and application peripherals for Bluetooth audio applications.

2.0 Functional Block Diagram

A high-level block diagram of the module is provided, please see the **Block Diagram**

3.0 Circuit Schematic Overview

The detailed circuit schematic accompanies this description. Key sections are summarized below:

3.1 Power Supply:

- * External DC power input at 3.3V is supplied to the module via pin VBAT.
- * On-board decoupling capacitors 1uF filter noise on power rails near the PTSA15E5B and other ICs.

3.2 Bluetrum PTSA15E5B SoC:

- * **Core:** The integrated RISC-V CPU handles protocol stack and application functions.
- * **Memory:** The SoC contains embedded RAM/ROM
- * **Clock:** An external 26.000 MHz crystal oscillator provides the reference clock for the system and RF circuitry.
- * **RF Interface:** The differential RF output pins of the PTSA15E5B connect directly to the

matching network.

3.3 RF Front-End & Antenna:

* **Matching Network:** A Pi-type or similar matching network ([C7 10pF], [L3 NC], [L4 NC]) matches the chip's RF output impedance (typically differential) to the characteristic impedance of the antenna feedline (typically 50Ω single-ended). This network includes a BALUN Balanced function.

* **Antenna:** The module employs a PCB trace antenna.

4.0 Operational Description

4.1 General Function:

The SDC-LE-05 is a Bluetooth dual-mode module. Its primary function is to perform BLE data transmission/reception via the UART interface and Bluetooth audio playback.

4.2 Modes of Operation:

* **BLE Transmit (TX) Mode:** When data is initiated:

1. Data is processed by the PTSA15E5B's internal processor and baseband.
2. The baseband signal modulates the 2.4 GHz carrier using GFSK for BLE as per Bluetooth specifications.
3. The modulated RF signal is amplified by the internal PA and output differentially from the PTSA15E5B's RF pins.
4. The external BALUN and matching network convert the differential signal to single-ended and provide impedance matching to the antenna.
5. The antenna radiates the RF signal within the 2.4 GHz ISM band (2402 – 2480 MHz).

* **BLE Receive (RX) Mode:**

1. RF signals in the 2.4 GHz band are received by the antenna.
2. The signal passes through the matching network (providing reciprocity) to the PTSA15E5B's RF input.
3. The internal LNA and receiver down-convert, demodulate, and decode the signal.
4. The retrieved digital audio/data is then processed further output via UART.

* **Low Power/Sleep Mode:** The PTSA15E5B employs various low-power states controlled by its internal firmware to conserve energy when not actively transmitting or receiving.

* **Bluetooth Classic (BR/EDR) RF Operation Mode:** This module operates under the Bluetooth Classic protocol (also known as Basic Rate/Enhanced Data Rate, BR/EDR), compliant with Bluetooth Core Specification v2.1+EDR or later. It utilizes the 2.4 GHz Industrial, Scientific, and Medical (ISM) band, spanning from 2402 MHz to 2480 MHz.

4.3 RF Parameters:

* **Frequency Range:** 2402 – 2480 MHz (Bluetooth ISM Band).

* **Number of Channels:**

- 1) BLE Mode: 40 channels for BLE 1 MHz. Adaptive Frequency Hopping (AFH) is used.
- 2) Bluetooth Classic Mode: A total of 79 RF channels are employed, each with a 1 MHz channel spacing.

* **Modulation Type:** GFSK, Optional support for $\pi/4$ -DQPSK and 8DPSK.

* **Output Power:** The maximum conducted output power from the module antenna port is typically < 9 dBm. Power control is implemented as per Bluetooth requirements.

* **Antenna Gain:** The antenna gain used is 1.39 dBi. This is a integral antenna.

* **Power Source:** Powered by 3.3V DC.

FCC Statement

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help important announcement

Important Note:

Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator and your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Country Code selection feature to be disabled for products marketed to the US/Canada.

This device is intended only for OEM integrators under the following conditions:

1. The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2. The transmitter module may not be co-located with any other transmitter or antenna,
3. For all products market in US, OEM has to limit the operation channels in CH1 to CH11 for 2.4G band by supplied firmware programming tool. OEM shall not supply any tool or info to the end-user regarding to Regulatory Domain change. (if modular only test Channel 1-11)

As long as the three conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Important Note:

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End Product Labeling

The final end product must be labeled in a visible area with the following"

Contains FCC ID:**2BT3H-SDC-LE-05** "

Manual Information to the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

Integration instructions for host product manufacturers according to KDB 996369 D03 OEM Manual v01r01

2.2 List of applicable FCC rules

CFR 47 FCC PART 15 SUBPART C has been investigated. It is applicable to the modular transmitter

2.3 Specific operational use conditions

This module is stand-alone modular. If the end product will involve the Multiple simultaneously transmitting condition or different operational conditions for a stand-alone modular transmitter in a host, host manufacturer have to consult with module manufacturer for the installation method in end system.

2.4 Limited module procedures

Not applicable

2.5 Trace antenna designs

Not applicable

2.6 RF exposure considerations

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.

2.7 Antennas

This radio transmitter **FCC ID:2BT3H-SDC-LE-05** has been approved by Federal Communications Commission to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Antenna No.	Model No. of antenna:	Type of antenna:	Gain of the antenna (Max.)		Frequency range:
			Antenna 1	Antenna 2	
Bluetooth	/	PCB Antenna	1.39	N/A	2402-2480MHz

2.8 Label and compliance information

The final end product must be labeled in a visible area with the following" Contains **FCC ID:2BT3H-SDC-LE-05**".

2.9 Information on test modes and additional testing requirements

Host manufacturer is strongly recommended to confirm compliance with FCC requirements for the transmitter when the module is installed in the host.

2.10 Additional testing, Part 15 Subpart B disclaimer

Host manufacturer is responsible for compliance of the host system with module installed with all other applicable requirements for the system such as Part 15 B.

2.11 Note EMI Considerations

Host manufacture is recommended to use D04 Module Integration Guide recommending as "best practice" RF design engineering testing and evaluation in case non-linear interactions generate additional non-compliant limits due to module placement to host components or properties.

2.12 How to make changes

This module is stand-alone modular. If the end product will involve the Multiple simultaneously transmitting condition or different operational conditions for a stand-alone modular transmitter in a host, host manufacturer have to consult with module manufacturer for the installation method in end system. According to the KDB 996369 D02 Q&A Q12, that a host manufacture only needs to do an evaluation (i.e., no C2PC required when no emission exceeds the limit of any individual device (including unintentional radiators) as a composite. The host manufacturer must fix any failure.