

User Manual

DA14585 Voice RCU Hardware Manual

UM-B-087

Abstract

This document describes the hardware design of the DA14585 Voice RCU reference design (Rev.B), which is based on the Dialog Semiconductor DA14585 Bluetooth® low energy SoC. This reference design includes an accelerometer/gyro sensor, digital microphone, keypad, and a trackpad which is placed on a separate daughterboard.

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1 Terms and Definitions

APDU	Application Protocol Data Unit
BLE	Bluetooth® low energy
BOM	Bill Of Materials
CIB	Communication Interface Board
DCXO	Digitally Controlled Crystal Oscillator
ESR	Equivalent Series Resistance
HW	hardware
IFA	Inverted-F Antenna
IR	InfraRed
JTAG	Joint Test Action Group (test interface)
LED	Light Emitting Diode\
PCM	Pulse Code Modulation
PDM	Pulse Density Modulation
RCU	Remote Control Unit
RF	Radio Frequency
SoC	System On Chip
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus

2 References

- [1] DA14585 datasheet, Dialog Semiconductor.
- [2] Application Note: "Designing Printed Antennas for Bluetooth® Low Energy"

3 Introduction

Bluetooth® low energy remote control units (RCU) are becoming the standard in next-generation Smart TVs and set-top boxes as they improve the user experience by enabling 2-way communication as well as non-line-of-sight communication to control equipment that is placed behind a door or a piece of furniture, or in another room.

The Dialog Voice RCU reference design builds on its best-in-class Bluetooth® low energy solution, the DA14585, to deliver an RCU with world-leading battery lifetime and a very small Bill of Materials.

4 System Overview

4.1 Features

- Highly integrated Dialog Semiconductor DA14585 Bluetooth® Smart SoC
- Stand-alone module
- Low BOM due to printed antenna
- Low cost PCB
- Integrated keypad
- Combined accelerometer/gyroscope sensor unit
- Separate trackpad/wheel modules
- Access to processor via JTAG and UART from the enclosure

4.2 Block Diagram

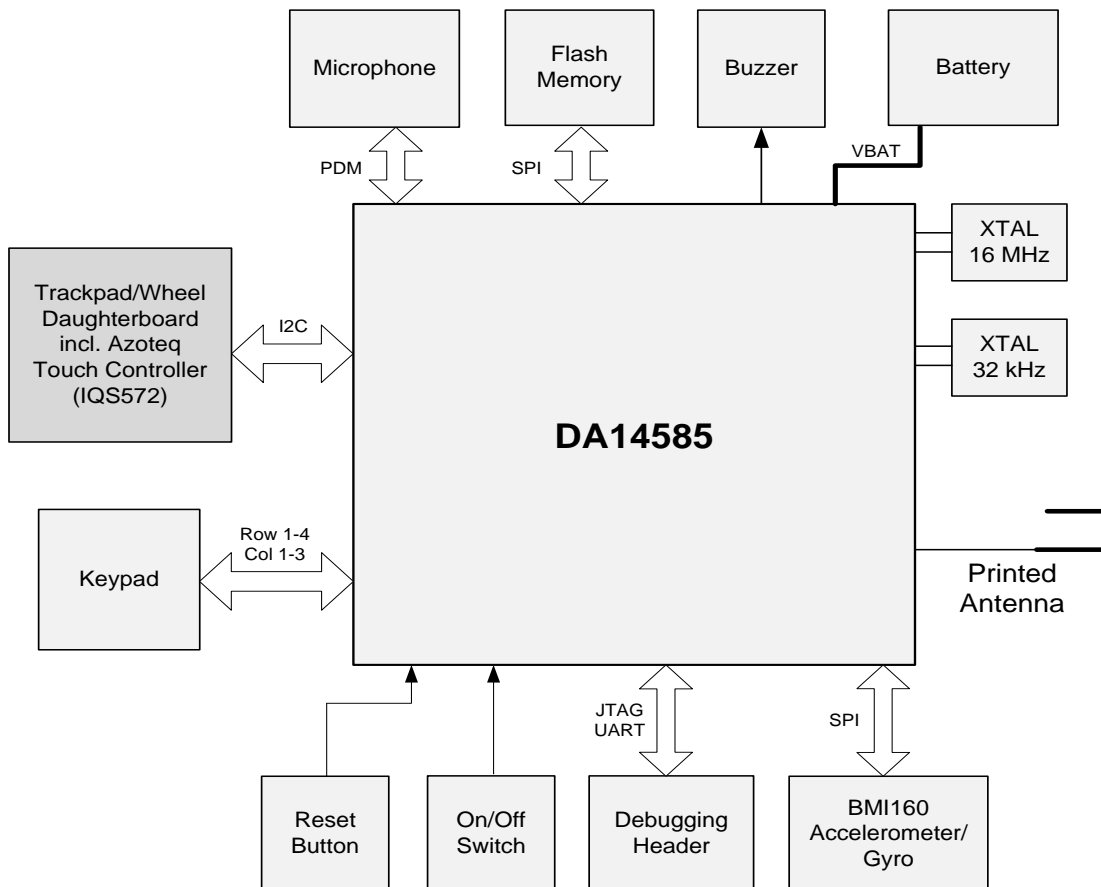


Figure 1: Top Level Block Diagram of the DA14585 Voice RCU Reference Design

4.3 PCBA Overview

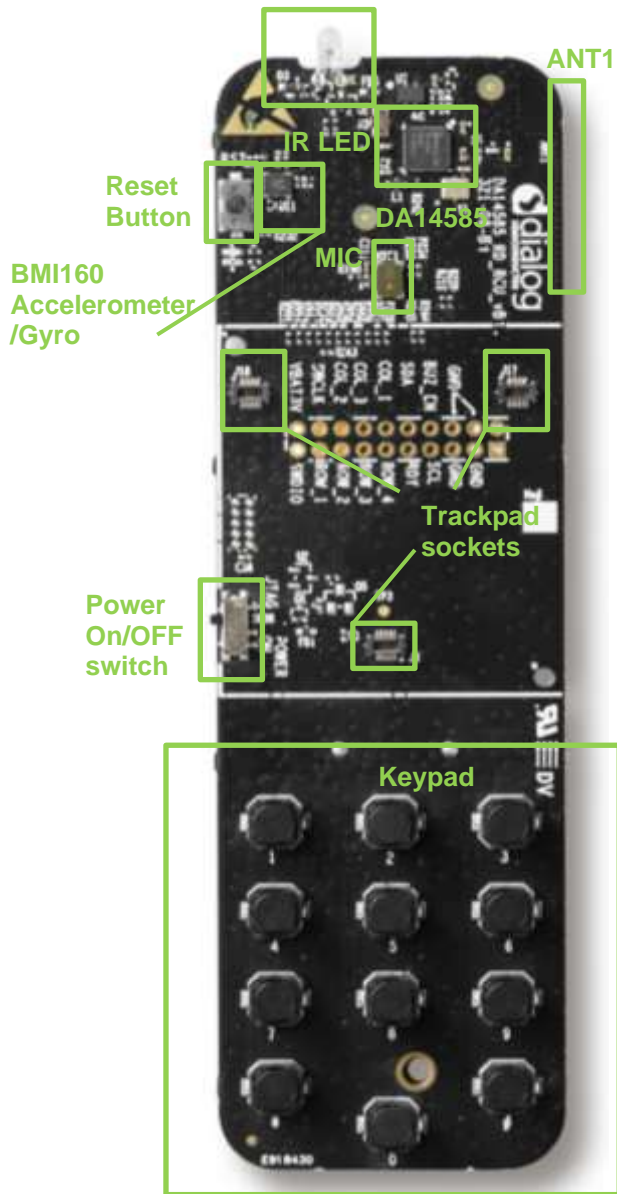


Figure 2: DA14585 Voice RCU Reference Design (Rev B) - Top View

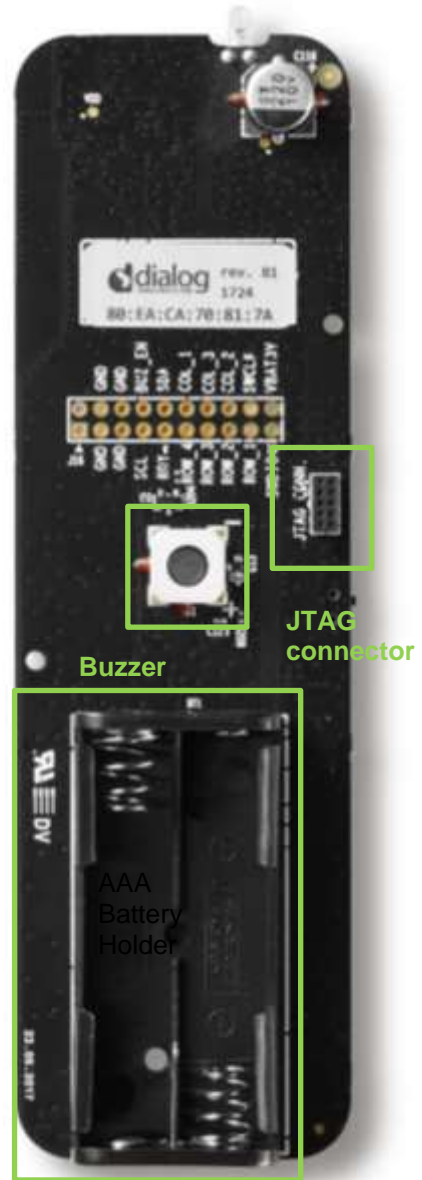


Figure 3: DA14585 Voice RCU Reference Design (Rev B) - Bottom View



Figure 4: Trackpad Daughterboard (Rev B) – Top View



Figure 5: Trackpad Daughterboard (Rev B) – Bottom View



Figure 7: Complete DA14585 Voice RCU Reference Design (Rev B) with Trackpad



Figure 6: Complete DA14585 Voice RCU Reference Design (Rev B) with Track Wheel

5 DA14585 Voice RCU Reference Design

5.1 DA14585 SoC

The DA14585 integrated circuit is an optimized version of the DA14580, offering a reduced boot time and supporting up to eight connections. It has a fully integrated radio transceiver and baseband processor for Bluetooth® low energy. It can be used as a standalone application processor or as a data pump in hosted systems.

The device is optimized for remote control units (RCU) requiring support for voice commands and motion/gesture recognition. Its integrated Audio Unit (AU) offers an easy interface for MEMS microphones over PDM, external codecs over PCM/I2S and a Sample Rate Converter unit.

The Bluetooth® Low Energy firmware includes the L2CAP service layer protocols, Security Manager (SM), Attribute Protocol (ATT), the Generic Attribute Profile (GATT) and the Generic Access Profile (GAP). All profiles published by the Bluetooth® SIG as well as custom profiles are supported.

The transceiver interfaces directly to the antenna and is fully compliant with the Bluetooth® 5.0 standard. The DA14585 has dedicated hardware for the Link Layer implementation of Bluetooth® low energy and interface controllers for enhanced connectivity capabilities.

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DA14585 QFN40 Pin Name	Reference Design Signal	Section
P0_6	SPI_MOSI	SPI data out (Flash memory and accelerometer/gyro)
P0_7	BUZ_EN	Enables buzzer
P1_0	PDM_DATA	Audio interface (Mic)
P1_1	PDM_CLK	Audio interface (Mic)
P1_2	Red LED	Programming LED indication
P1_3	Green LED	Keypad/trackpad operation indication
P2_0	IR LED	IR LED
P2_1	ROW_1	Keypad
P2_2	ROW_1	Keypad
P2_3	ROW_1	Keypad
P2_4	ROW_1	Keypad
P2_5	SDA	I2C data (Touch pad controller)
P2_6	SCK	I2C clock (Touch pad controller)
P2_7	RDY	Data ready (Touch pad controller)
P2_8	COL_1	Keypad
P2_9	SPI_CS1	Accelerometer/gyro chip select
P3_0	INT1_BMI	Accelerometer/gyro interrupt pin

5.3 Power Management

The DA14585 SoC power management subsystem consists of:

- **VBAT1V:** INPUT. Battery connection. Used for an Alkaline or a NiMH battery (1.5 V). Power input in boost configuration only. For buck configuration, this pin is shorted to GND.
- **VBAT3V:** INPUT/OUTPUT. Battery connection for a single coin battery (3 V) or dual AAA batteries (2x 1.5 V). Power input in buck configuration only.
- **SWITCH:** INPUT/OUTPUT. Connection for the external inductor of the DC-DC converter.
- **VDCDC:** Output of the DC-DC converter.
- **VDCDC_RF:** Supply input of the Bluetooth® radio.
- **VDD:** INPUT. This pin is used for testing purposes only.

Power supply of the DA14585 Voice RCU reference design:

- **Battery type:** Two standard AAA batteries (non-rechargeable).
- **DC-DC converter:** The internal DC-DC converter has been configured to operate in Buck mode.
- **Power ON/OFF switch:** This reference design is equipped with a power ON/OFF switch.
- **VDCDC – VDCDC_RF track length:** The PCB track between the VDCDC_RF and VDCDC pins should be at least 7 mm long.

5.4 Flash Memory

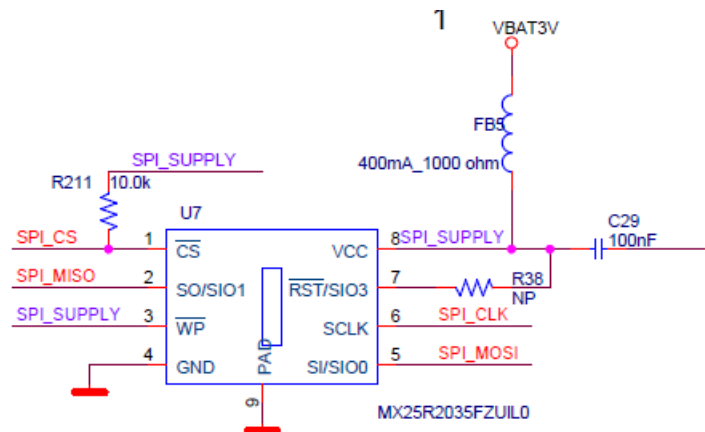


Figure 9: Serial NOR Flash Memory

The DA14585 uses an external Serial NOR Flash memory for mirroring its contents to RAM and execute. The Flash memory type used is MX25R2035:

- 2 Mbit QSPI Flash memory, operated in single I/O mode
- Operating voltage: 1.65 V to 3.6 V for read, erase and program operations

Please notice that a pull-up resistor was added on the chip select pin. The reason is that during power-up and power-down, pin CS# needs to follow the voltage applied to pin VCC to keep the device not selected.

5.5 Crystal Oscillators

The DA14585 SoC has two Digitally Controlled Crystal Oscillators (DCXO), one at 16 MHz (XTAL16M) and a second at 32.768 kHz (XTAL32K). The 32.768 kHz oscillator has no trimming capabilities and is used as the clock for the Extended/Deep Sleep modes. The 16 MHz oscillator can be trimmed.

The crystals used on the DA14585 Voice RCU reference design are specified in [Table 2](#) and [Table 3](#).

Table 2: Y1 (16 MHz Crystal) Characteristics

Reference Designator	Value
Part Number	7M-16.000MEEQ-T
Frequency	16 MHz
Accuracy	±10 ppm
Load Capacitance (CL)	10 pF
Shunt Capacitance (C0)	3 pF
Equivalent Series Resistance (ESR)	100 Ω
Drive Level (PD)	50 μW

Table 3: Y2 (32 kHz Crystal) Characteristics

Reference Designator	Value
Part Number	ABS07-120-32.768KHZ-T
Frequency	32.768 kHz
Accuracy	±20 ppm
Load Capacitance (CL)	6 pF
Shunt Capacitance (C0)	1.2 pF
Equivalent Series Resistance (ESR)	55-60 kΩ
Drive Level (PD)	0.1 to 0.5 μW

5.6 Microphone

The SPK0838HT4H-B from Knowles is a miniature, high performance, low power, top port silicon digital microphone with a single-bit PDM output. Its power consumption during sleep is only 4.6 μ A.

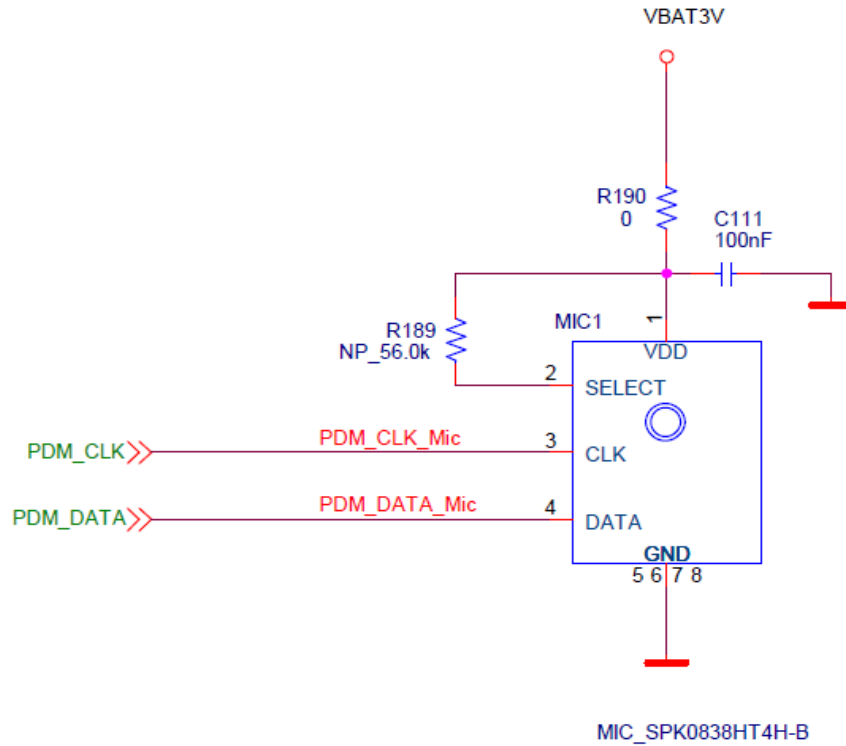
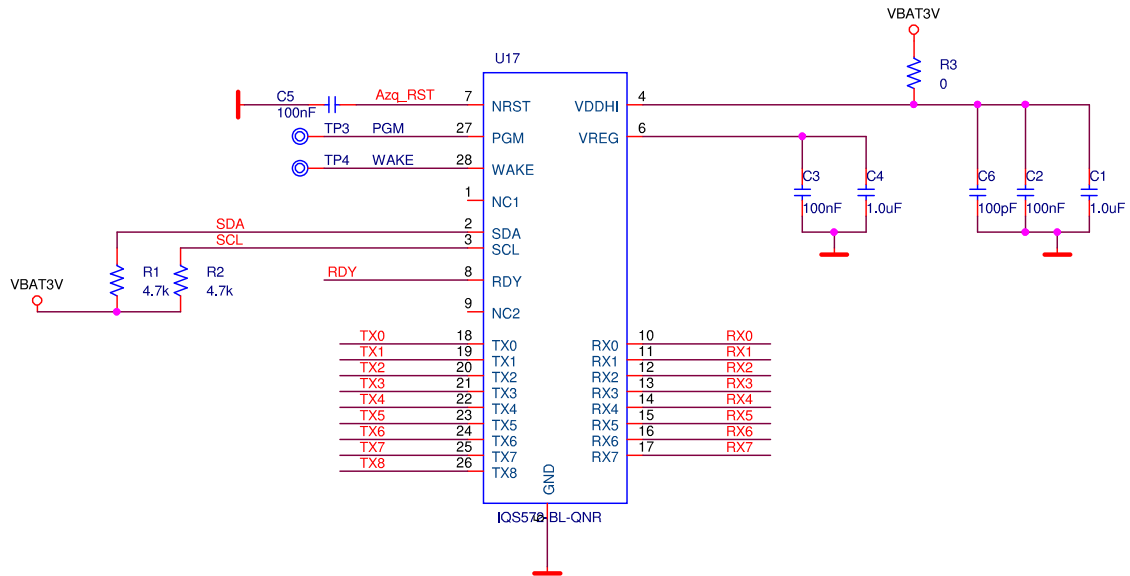


Figure 10: SPK0838HT4H Microphone Schematic

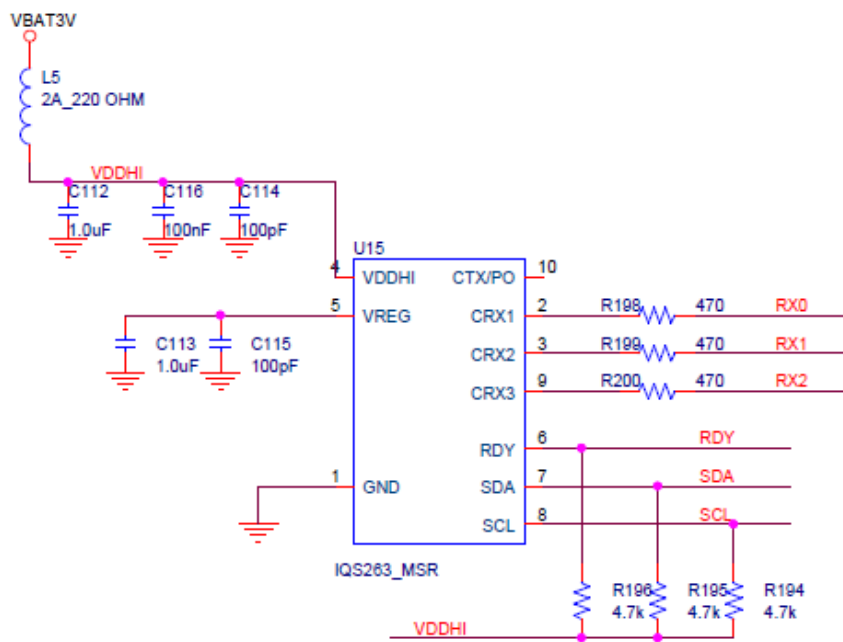
5.7 Capacitive Touch Controller

The trackpad of the DA14585 voice RCU reference design is equipped with a capacitive touch and proximity controller IQS572 from Azoteq while the wheel pad is using the IQS263 from same vendor. These controllers have the ability to sense touch and are accessible by the DA14585 via the I2C interface.



Azoteq's IQS572 (QFN28- 4X4mm)

Figure 11: Capacitive Touch Controller Schematic (Trackpad)



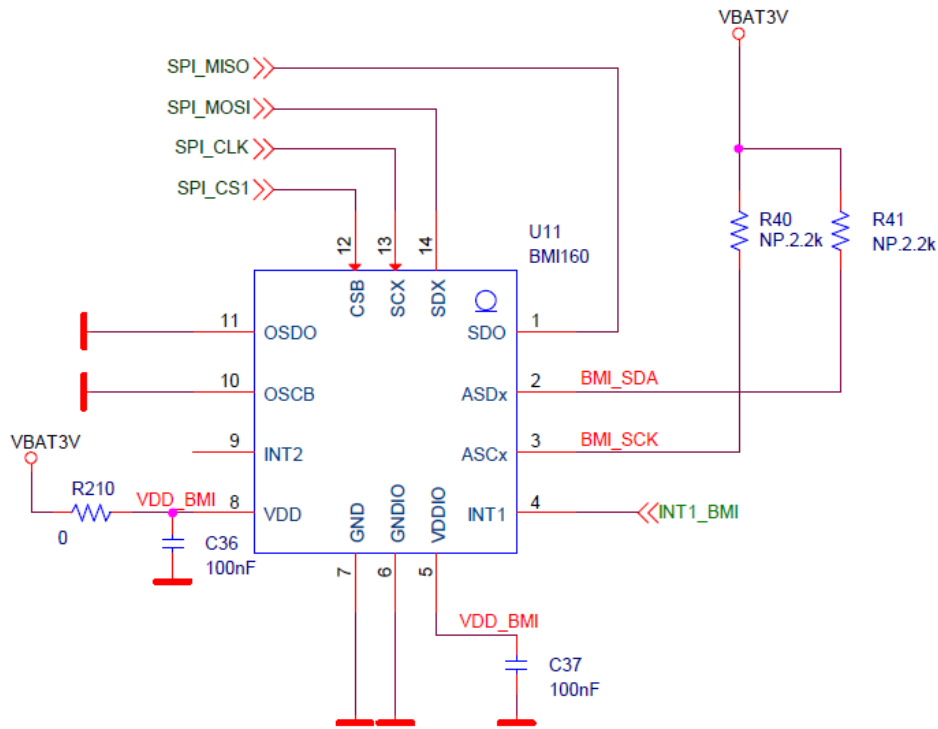
Azoteq's IQS263

Figure 12: Capacitive Touch Controller Schematic (Wheel)

5.8 Accelerometer/Gyroscope Sensor

The DA14585 Voice RCU reference design includes the **BMI160** Combined Inertial Measurement Unit and Accelerometer sensor module from Bosch SensorTec.

The BMI160 is a low-power, low-noise inertial measurement unit, designed for use in mobile and indoor applications which require highly accurate, real-time sensor data. In full operation mode, with the accelerometer and gyroscope enabled, the current consumption is typically 950 μ A, while this is dropped down to 3 μ A in suspend mode. The BMI160 module is connected to the DA14585 via an SPI interface.



Accelerometer/Gyro

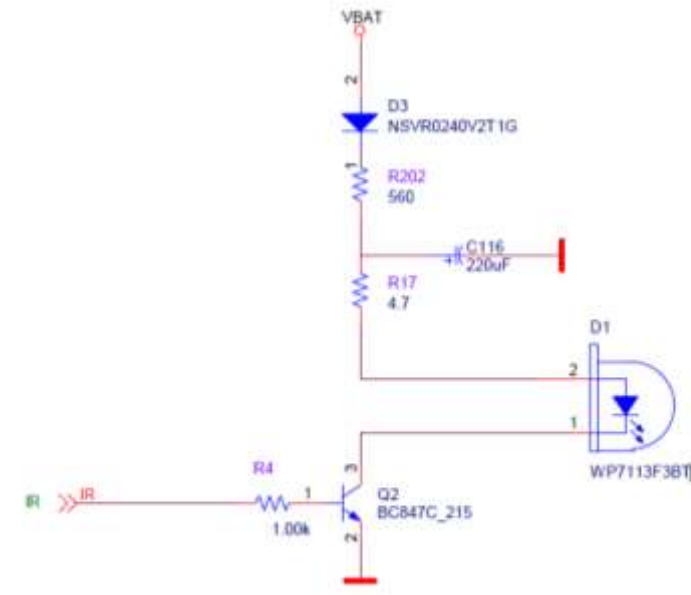
Figure 13: BMI160- Inertial Sensor Schematic

Table 4: BMI160 Inertial Sensor - Electrical Characteristics

Parameter	Min	Typ	Max	Unit
Supply Voltage (VDD)	1.71	3.0	3.6	V
Supply Voltage (VDD I/O)	1.2	2.4	3.6	V
Voltage Input Low Level			0.3*VDD I/O	V
Voltage Input High Level	0.7*VDD I/O			V
Voltage Output Low Level			0.2*VDD I/O	V
Voltage Output High Level			0.23*VDD I/O	V
Operating Temperature	-40		85	°C

5.9 Infrared LED

The DA14585 voice RCU reference design employs the WP7113F3BT IR LED from Kingbright. A Schottky diode NSVR0240V2T1G is used to ensure that no current will be reflected back to battery. The IR LED is driven by the P2_0 GPIO via a transistor switch.

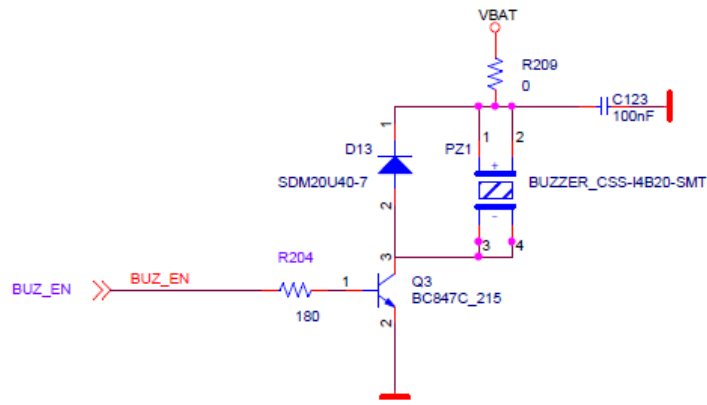


IR

Figure 14: IR LED Schematic

5.10 Buzzer

The DA14585 Voice RCU reference design employs the CSS-I4B20-SMT magnetic buzzer transducer from CUI INC. The buzzer is driven by the P0_7 GPIO via a transistor switch.



BUZZER

Figure 15: Buzzer Schematic

5.11 ON/OFF Switch

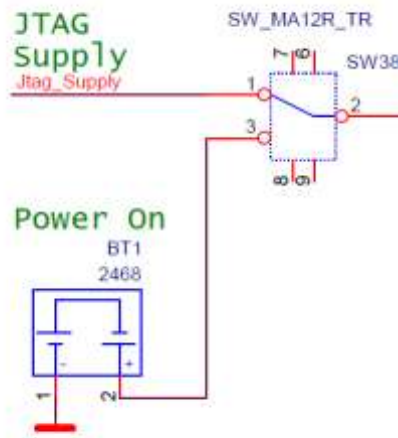


Figure 16: Power ON/OFF Switch Schematic

The DA14585 Voice RCU reference design is equipped with a two-position ON/OFF switch, which selects the system to be powered by the battery or via the JTAG supply.

5.12 LEDs

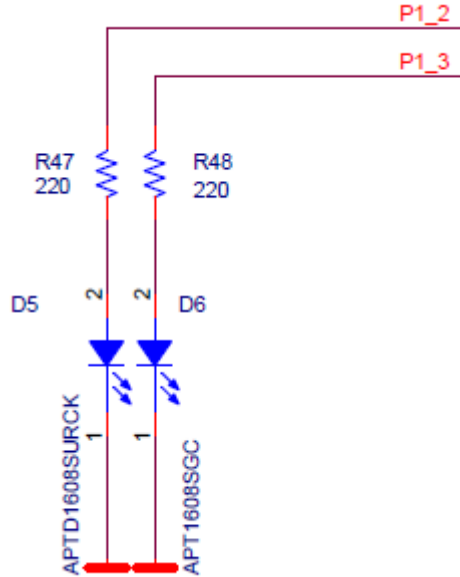


Figure 17: Indication LEDs Schematic

The DA14585 Voice RCU reference design is equipped with a Red LED (D5) and a Green LED (D6), which are used to indicate programming and keypad/trackpad operations, respectively. The Red LED is controlled by GPIO P1_2, the Green LED by GPIO P1_3.

5.13 Reset Button

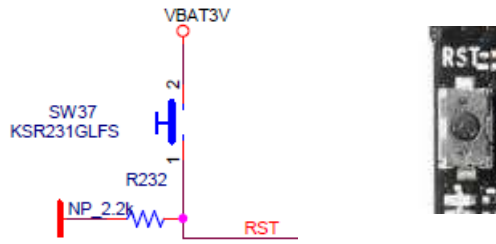
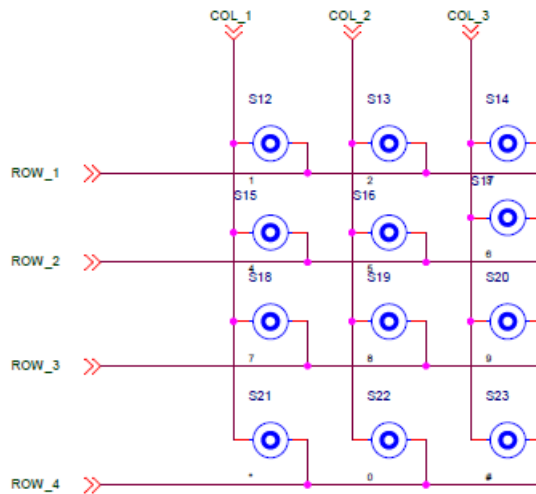


Figure 18: Reset Button Schematic and Actual Illustration

The DA14585 Voice RCU reference design employs a reset button (SW37) for applying a hard reset of the DA14585 SoC.

5.14 Keypad Matrix



KEYPAD

Button type: SKPMBHE010

Figure 19: Keypad Matrix Schematic

The DA14585 Voice RCU reference design uses a fully configurable 3 columns by 4 rows keypad matrix.

5.15 Printed Antenna

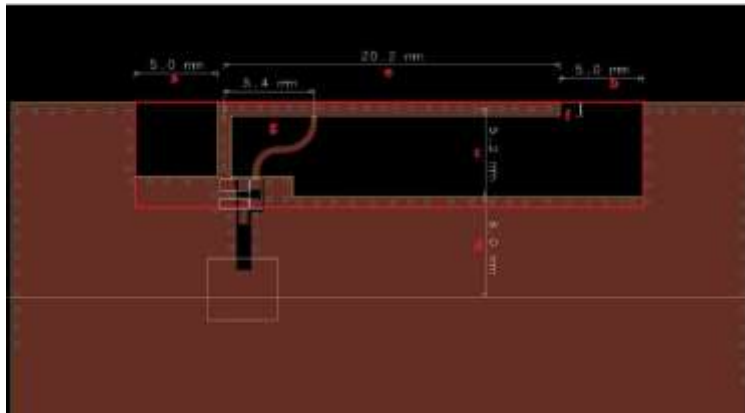


Figure 20: PCB view of a printed antenna

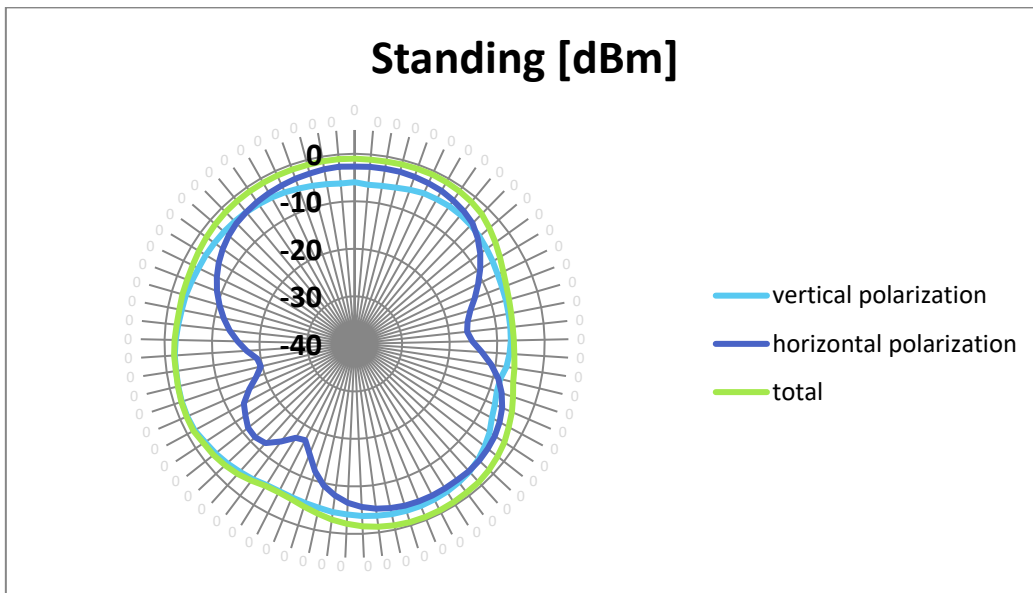


Figure 21: Printed Antenna Radiation Pattern

Printed antennas are low cost, easy to manufacture and provide diversity in polarization.

The antennas used in this reference design was based on the Designing Printed Antennas for Bluetooth® Low Energy application note.

Figure 21 shows the radiation pattern of the printed IFA antenna used in the DA14585 Voice RCU reference design. The antenna performance is summarized in Table 5.

Table 5: Printed Antenna Performance Characteristics

Parameter	Vertical Polarization	Horizontal Polarization
Peak Power [dBm]	-1.617	-2.565
Average EIRP [dBm]	-4.34000333	-6.24978
Total Radiated Power [dBm]	-2.18045194	-1.9

6 Schematics

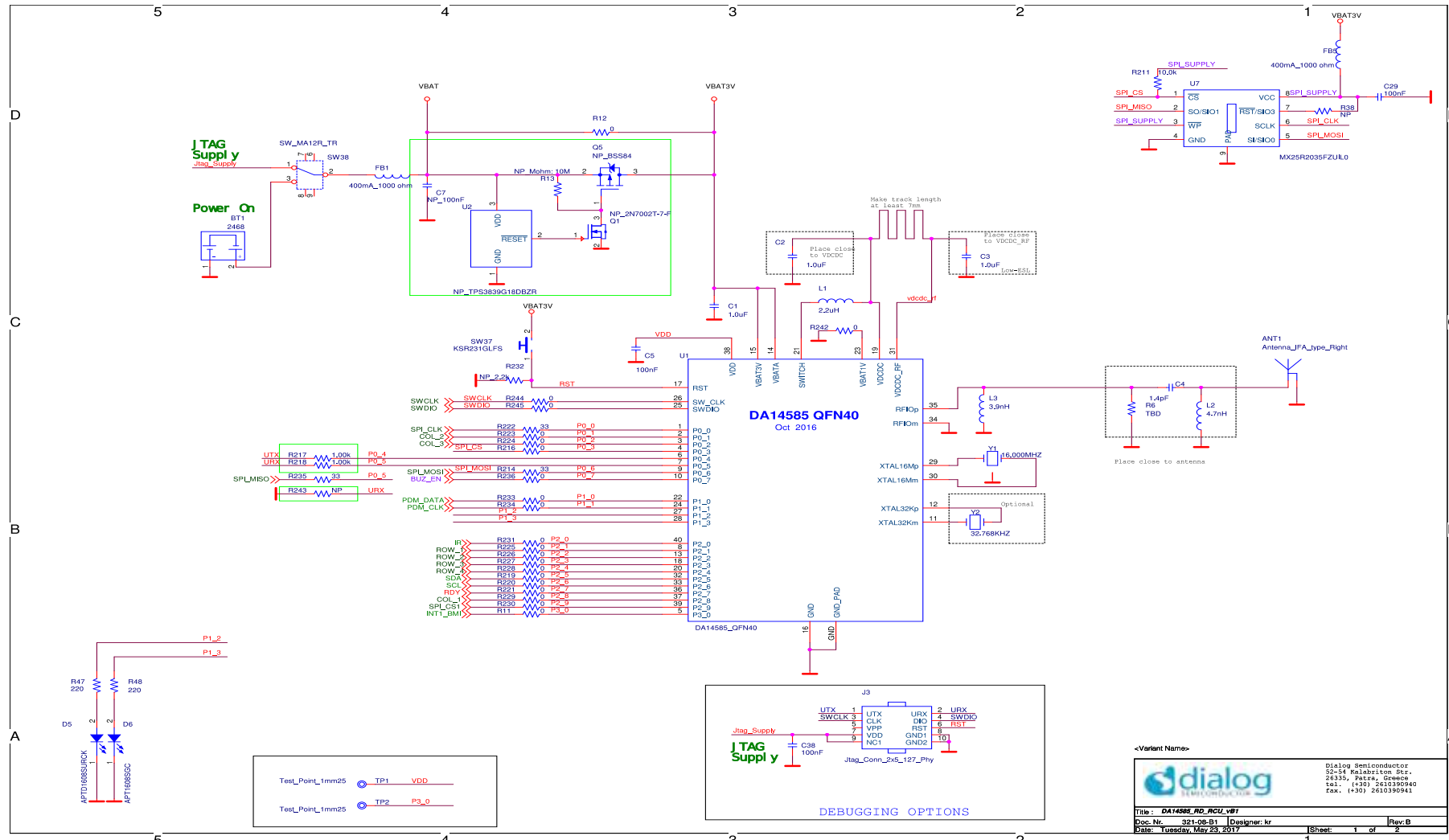


Figure 22: DA14585 Voice RCU Reference Design Rev. B1 - SoC, Flash Memory, Debugging Port

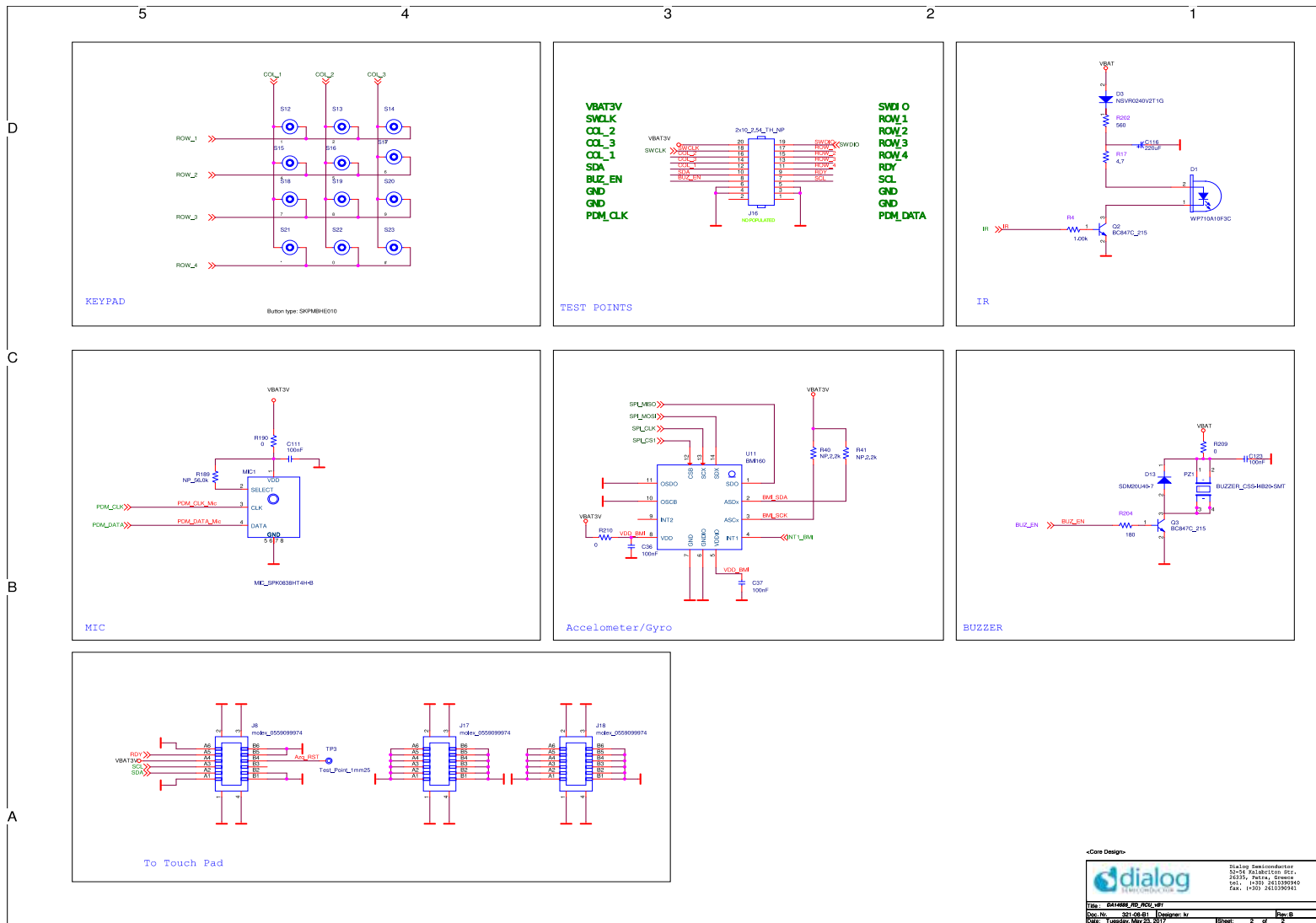


Figure 23: DA14585 Voice RCU Reference Design Rev. B1 – Peripherals, Sensors

7 PCB Layout

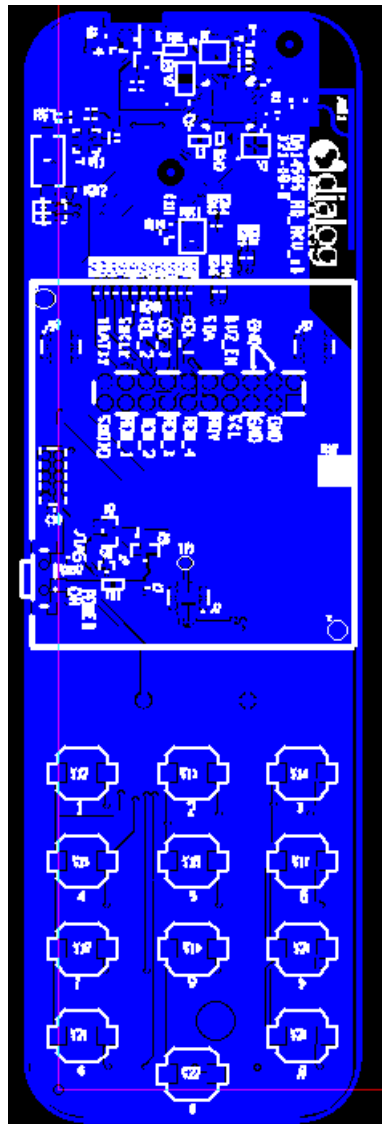


Figure 24: DA14585 Voice RCU Reference Design Rev. B - Top View

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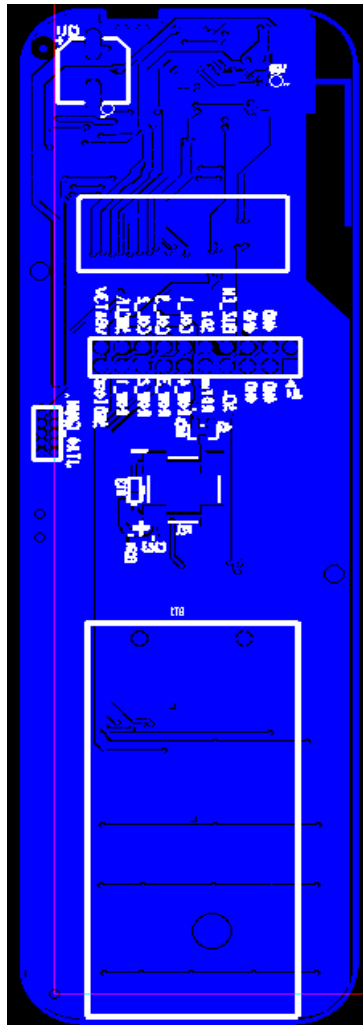


Figure 25: DA14585 Voice RCU Reference Design Rev. B - Bottom View

This is a 2-layer FR-4 PCB with approx. 1.6 mm thickness as can be seen from the stack-up figure below:

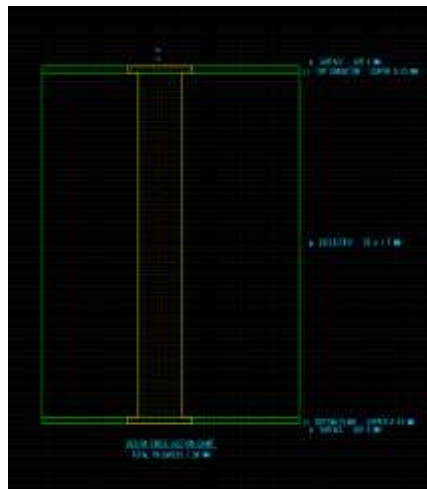


Figure 26: DA14585 Voice RCU Reference Design - PCB Stack-Up

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8 Power Measurements

This chapter contains current consumption measurement results for the DA14585 Voice RCU Reference Design. These measurements were conducted using the Agilent DC power analyzer N6705B with the reference design connected to a mobile phone application.



Figure 27: DA14585 Voice RCU Reference Design – Average Operating Current



Figure 28: DA14585 Voice RCU Reference Design – Average Sleep Current



Figure 29: DA14585 Voice RCU Reference Design – Average Touch Pad Scanning Current

Figure 29 shows the average current consumption of the DA14585 Voice RCU reference design, emphasizing the scanning pulse generated by the touch pad controller.



Figure 30: DA14585 Voice RCU Reference Design – Current during Touch Pad Scan Pulse

Table 6: DA14585 Voice RCU Reference Design

Current consumption type	Value
Average Operating Current consumption (uA) - Normal mode	113.412
Average Operating Current consumption (uA) - Sleep mode	13.73
Average Operating Current consumption (uA) - Touch scanning event	108.509

9 Enclosure



Figure 31: DA14585 Voice RCU Reference Design Enclosure – Top View



Figure 32: DA14585 Voice RCU Reference Design Enclosure – Bottom View



Figure 33: Connection of JTAG Cable with DA14585 Voice RCU PCB Inside Enclosure

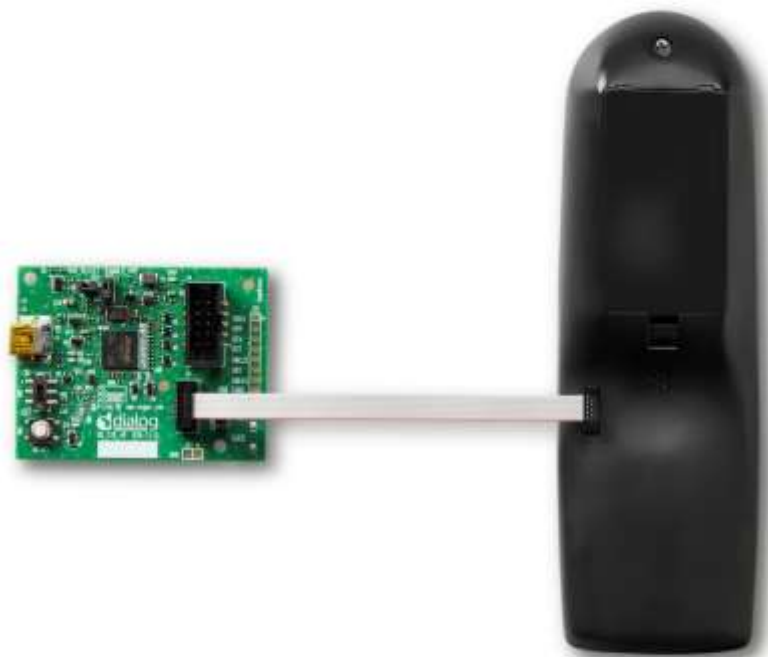


Figure 34: Connection of CIB Board with DA14585 Voice RCU PCB inside the Enclosure



Figure 35: DA14585 Voice RCU Reference Design Enclosure – Top Exploded View

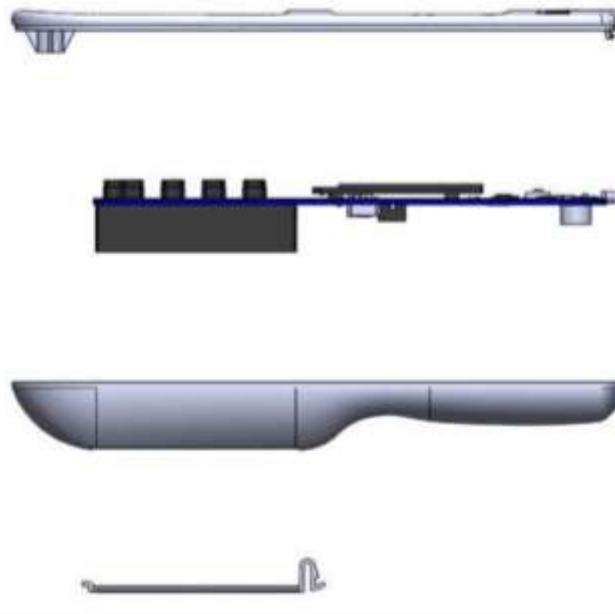


Figure 36 : DA14585 Voice RCU Reference Design Enclosure - Side Exploded View

10 Configuration of the Debugging Interface

The DA14585 voice RCU reference design has a dedicated debugging port as shown in [Figure 37](#) . Two debugging ports are used on the DA14585 SoC: JTAG and UART.

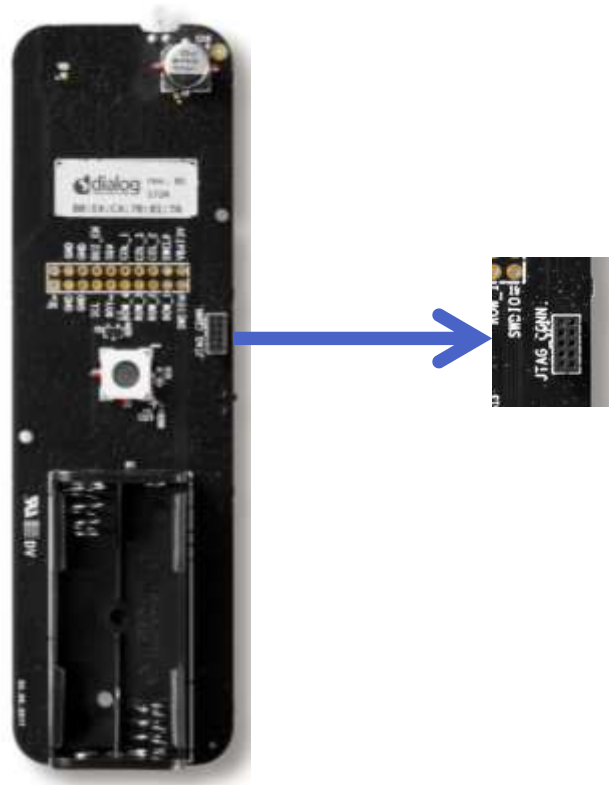


Figure 37: Debug Interface

[Figure 38](#) illustrates the proper way of connecting an IDC-10 programming/debugging cable coming from the CIB programming board.

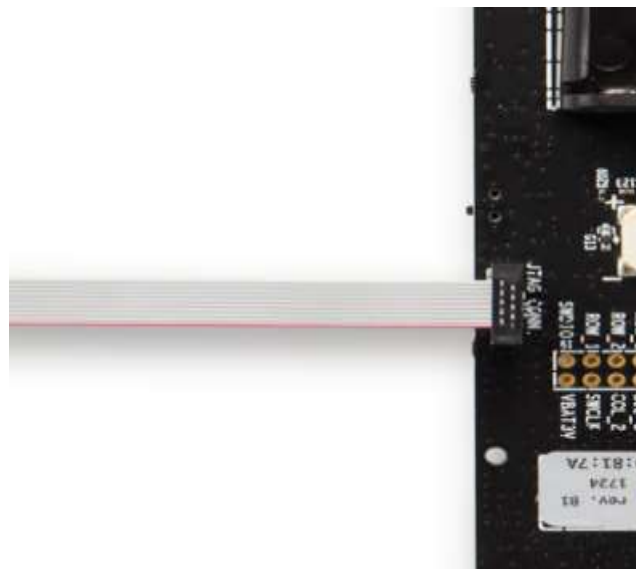


Figure 38: IDC-10 Programming/Debugging Cable Installation

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Debugging Using the CIB

The DA14585 Voice RCU reference design has a dedicated debugging port as shown in . Two debugging ports are used on the DA14585 SoC: JTAG and UART.

The USB-to-JTAG and USB-to-UART functions are implemented by an external Communication Interface Board (CIB) as shown in [Figure 39](#). This interface board has a SEGGER chip running the JLink-OB firmware.

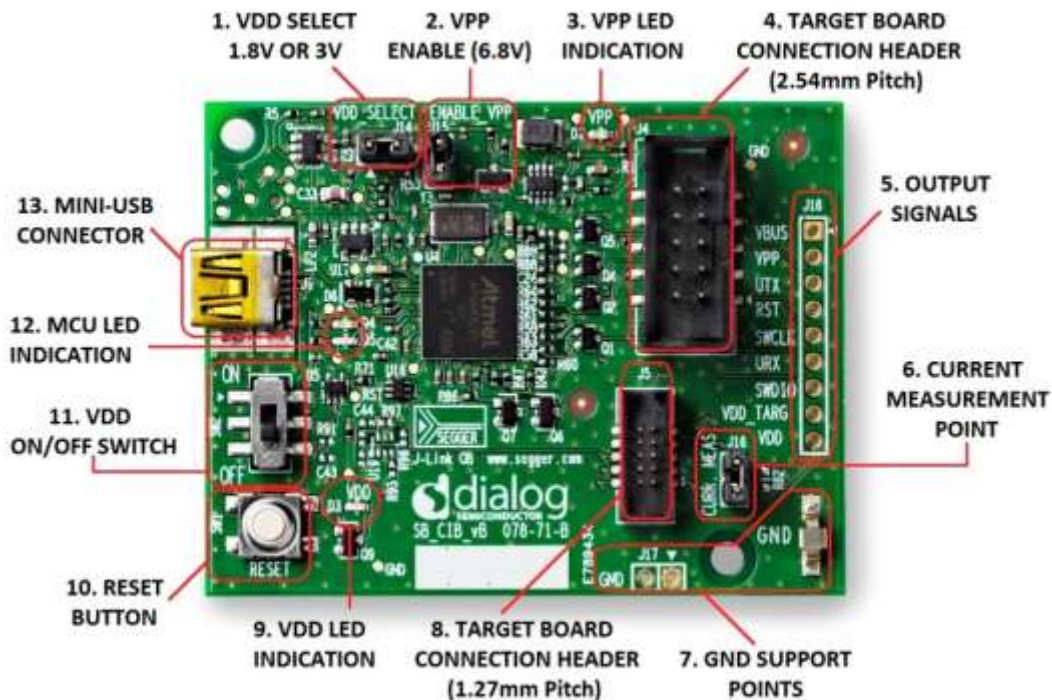


Figure 39: Communication Interface Board (CIB)

The following functions are performed by the interface board:

- Connectivity of PC to the DA14585 JTAG port
- Connectivity of PC to the DA14585 UART port (full UART is possible but it must be enabled on the PC driver)
- Hardware RESET capability. Note that the RESET signal is active high.

The following on-board settings have to be enforced in order to be able to program /debug the DA14585 voice RCU reference design board:

Interface board settings (see [Figure 39](#)):

- ON-OFF switch set to ON
- USB cable connected at the mini USB connector
- IDC-10 cable from the 1.27 mm pitch header to the target board
- IDC-10 cable from interface board is connected at the **bottom** of the voice RCU reference design board
- ON-OFF switch has to be switched to ON position in order to be powered by the communication interface board
- Jumper at J16 header should be populated

The connection between the interface board and the DA14585 voice RCU reference design board is shown in [Figure 40](#).

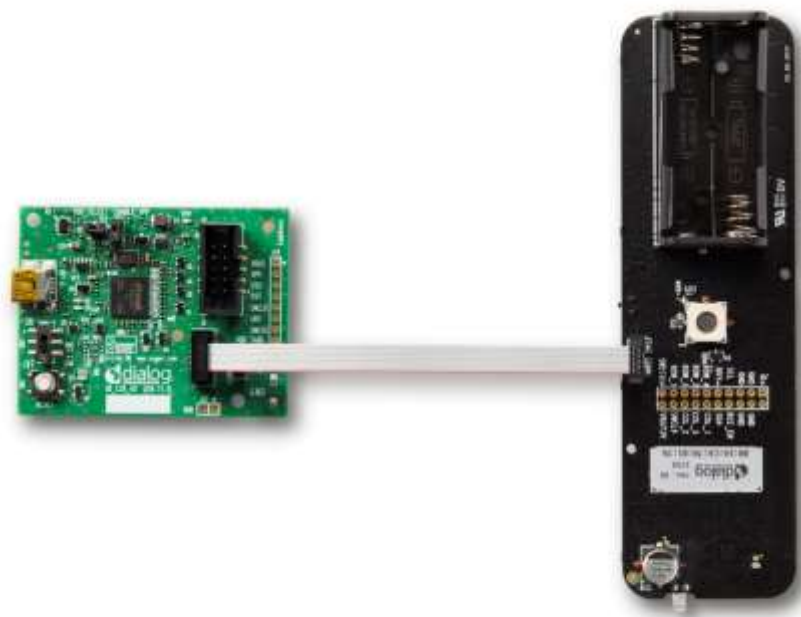


Figure 40: Connection of the DA14585 Voice RCU PCB to the CIB Programming Board

10.1 Debug/Programming Interface Scenarios

The following two scenarios are targeted to help the user to successfully debug/program the DA14585 Voice RCU reference design.

10.1.1 Scenario 1: RCU Inside the Enclosure

In this case the user must have the batteries installed before connecting the CIB programming/ debugging board, because the power ON/OFF switch is placed in ON position by default, prior to shipping the reference design to the customer (see [Figure 41](#)). The debugging port of the enclosure can be seen in [Figure 32](#).

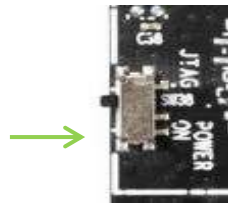


Figure 41: Power ON/OFF Switch Position for Scenario 1 (Green Arrow: ON)

10.1.2 Scenario 2: RCU Outside the Enclosure

In this case the user must either have the batteries installed before connecting the CIB programming/ debugging board or (when there are no batteries available) the reference design must be powered by the CIB interface board, hence the power ON/OFF switch must be placed in the JTAG position (see [Figure 42](#)).

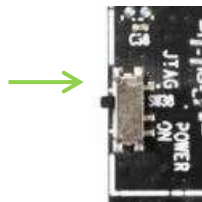


Figure 42: Power ON/OFF Switch Position for Scenario 2 (Green Arrow: JTAG)

Revision History

Revision	Date	Description
1.1	24-Dec-2021	Updated logo, disclaimer, copyright.
1.0	09-Jun-2017	Initial version.

Status Definitions

Status	Definition
DRAFT	The content of this document is under review and subject to formal approval, which may result in modifications or additions.
APPROVED or unmarked	The content of this document has been approved for publication.