# User manual

## DA14580 Antenna module for QFN48 package

### UM-B-036

**Abstract**

*This document describes the Bluetooth® Smart antenna module, based on the DA14580 SoC. Target hardware: da14580_rd_module_qfn48_vD, board number: 078-28-D.*

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# 1 Terms and definitions

| | |
|---|---|
| BLE | Bluetooth Low Energy (now: Bluetooth Smart) |
| BOM | Bill Of Materials |
| DUT | Device Under Test |
| ERP | Effective Radiated Power |
| GPIO | General Purpose Input/Output |
| PCBA | Printed Circuit Board Assembled |
| PCB | Printed Circuit Board |
| RF | Radio Frequency |
| Rx | Receive |
| SoC | System on Chip |
| Tx | Transmit |
| VSWR | Voltage Standing Wave Ratio |

# 2 References

1. DA14580 Low Power Bluetooth Smart SoC, Datasheet, Dialog Semiconductor
2. AN-B-020: End product testing and programming guidelines, Application note, Dialog Semiconductor

# 3 Introduction

The DA14580 QFN48 antenna module is based on the Dialog Semiconductor DA14580 Bluetooth® Smart SoC. It is a stand-alone system consisting of the DA14580 SoC in a QFN48 package, 16 MHz and 32 kHz crystals, a DC/DC converter and a printed antenna. The module was successfully tested for FCC/IC certification and CE marking. This document presents the module system, its technical specifications, physical dimensions and test results.

# 4 System overview

## 4.1 Features

- Highly integrated Dialog Semiconductor DA14580 *Bluetooth® Smart SoC*
- Module can be used stand-alone or as a data pump in a system with an external processor
- Antenna module in buck configuration certified according to FCC/IC and CE marking
- Module meets all Bluetooth Smart requirements
- No external crystal or additional passive components required for module operation
- Access to processor via JTAG, SPI, UART or $I^2C$
- 32 GPIOs available on module at a 1.27 mm pitch, suitable for keyboard designs
- Operating voltage: 2.4 V to 3.6 V, suitable for operation from a single cell coin battery
- On-board printed inverted F-type antenna
- Up to 0 dBm RF transmitted power
- Receiver sensitivity: better than -92 dBm
- Supply current:
  - Transmit/Receive mode: typ. 5 mA peak current @ 3.0 V
  - Sleep mode: typ. 2 µA average current
- 17.89 mm x 25.4 mm, 38 pins, two layer PCBA

## 4.2 Electrical characteristics

**Table 1: QFN48 antenna module characteristics`**

| Parameter | Description | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{BAT}$ | battery supply voltage | | 2.4 | 3.0 | 3.3 | V |
| $f_{OPER}$ | operating frequency | | 2400 | | 2483.5 | MHz |
| $P_O$ | output power | conducted; $V_{BAT}$ = 3 V, $T_A$ = 25 °C | | 0 | | dBm |
| $P_{SENS}$ | sensitivity level | $V_{BAT}$ = 3 V, $T_A$ = 25 °C | | -92 | | dBm |
| $I_{BAT\_TX}$ | battery supply current | transmit mode; peak value; $V_{BAT}$ = 3 V, $T_A$ = 25 °C | | 5 | | mA |
| $I_{BAT\_SLP}$ | battery supply current | sleep mode; average value; $V_{BAT}$ = 3 V, $T_A$ = 25 °C | | 2 | | µA |

## 4.3 General description

The DA14580 QFN48 antenna module consists of the DA14580 Bluetooth Smart SoC, RF section, GPIOs, crystals, power management, debugging/testing and OTP programming. Only one external power supply is required for operating the module.

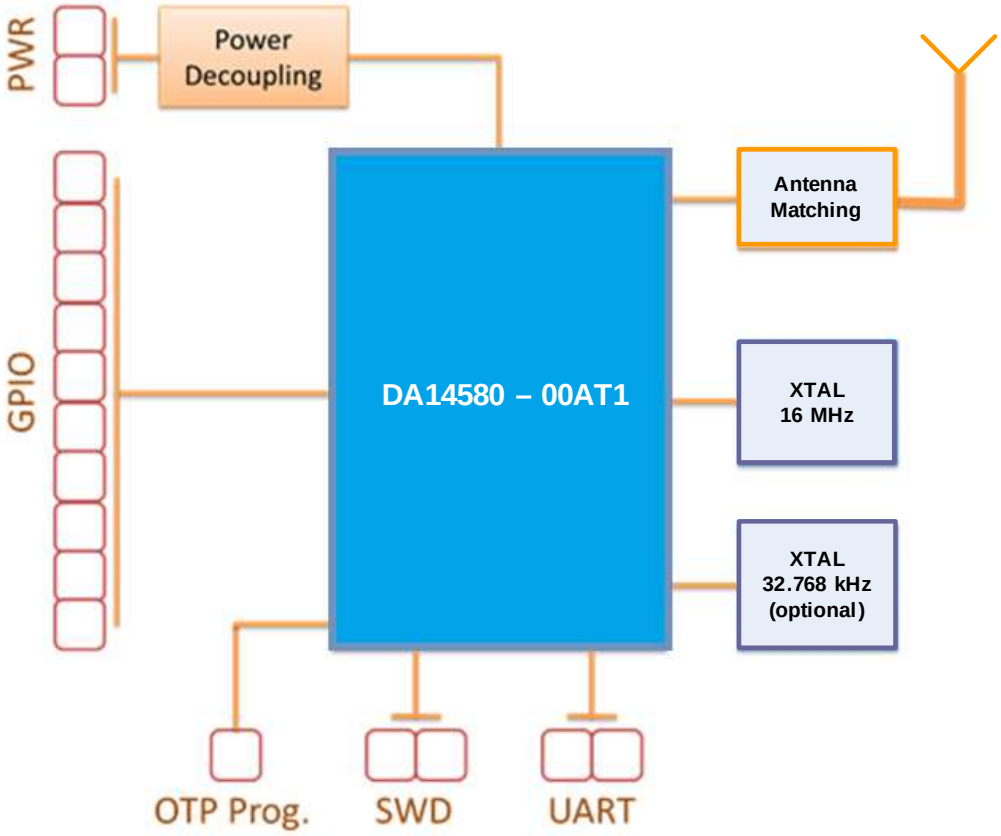



**Figure 1: Antenna module block diagram**

## 4.4 Bluetooth Smart SoC

The DA14580 integrated circuit has a fully integrated radio transceiver and baseband processor for *Bluetooth® Smart*. It can be used as an application processor as well as a data pump in systems with an external processor.

The DA14580 contains an embedded One-Time-Programmable (OTP) memory for storing Bluetooth profiles as well as custom application code. The qualified Bluetooth Smart protocol stack which is stored in a dedicated ROM, and the customer application software which is stored in system RAM, both run on the embedded ARM® Cortex®-M0 processor. Low leakage Retention RAM is used to store sensitive data and connection information while in Deep Sleep mode.

The radio transceiver implements the RF part of the Bluetooth Smart protocol. Together with the Bluetooth 4.0 PHY layer, it provides a 93 dB RF link budget for reliable wireless communication. All RF blocks are supplied by on-chip low drop out regulators (LDOs). The RF port is single ended 50 Ω, so no external balun is required.

The DA14580 has dedicated hardware for the Link Layer implementation of Bluetooth Smart and interface controllers for enhanced connectivity capabilities.

The DA14580 is equipped with a DC/DC converter that can be configured either for buck or boost mode operation. On this module both configurations are available. The default configuration is a buck mode DC/DC converter. Also, the FCC/ETSI certification is valid only for the buck configuration.

## 4.5 Schematic diagram

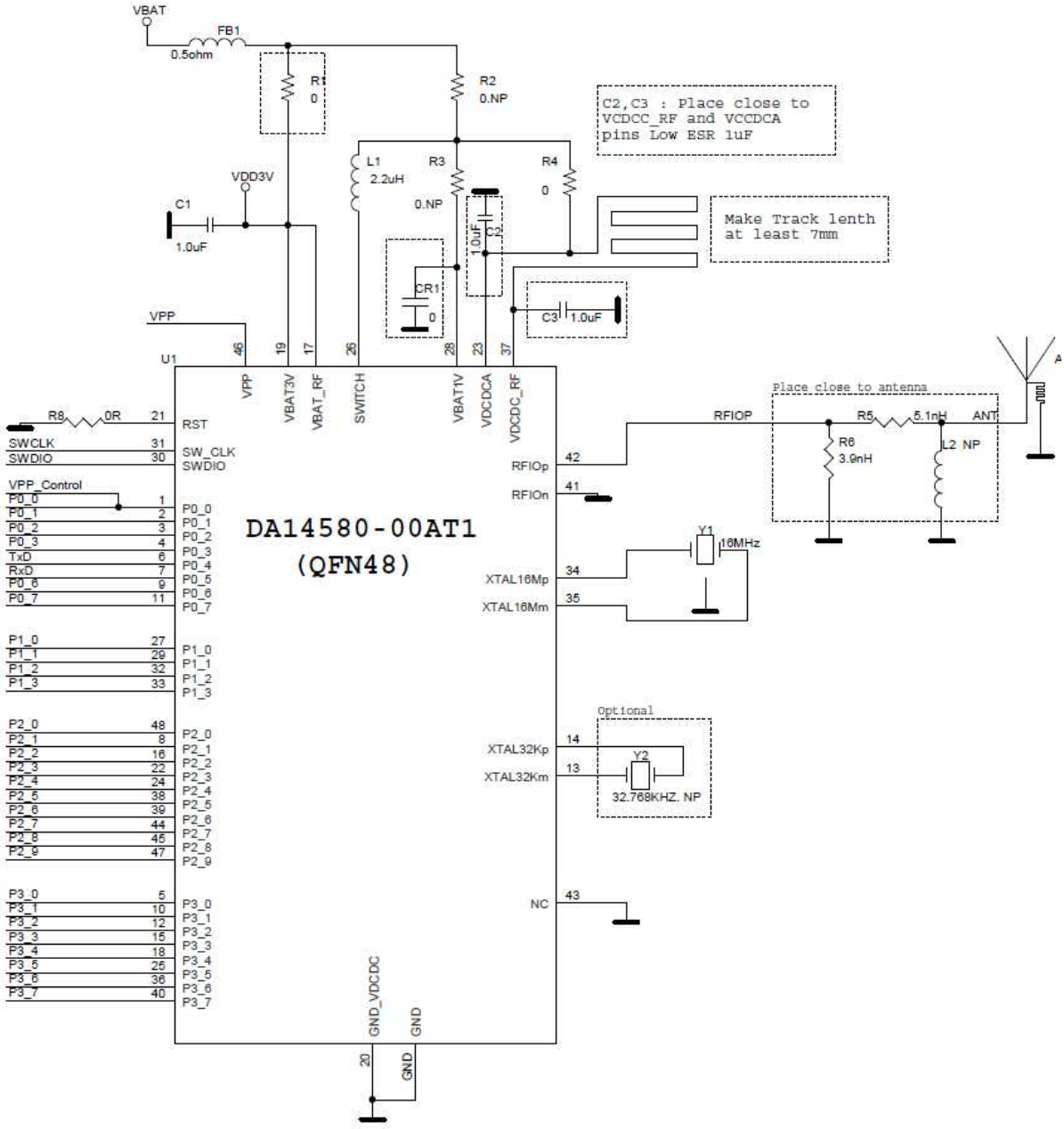



**Figure 2: Schematic diagram of the DA14580 QFN48 antenna module**

## 4.6 Module pinout

All available pins of the DA14580 SoC are routed out to the pins of the QFN48 antenna module. Module pin numbers and names are given in Figure 3 and Table 2. The module pins use the corresponding names of the DA14580 QFN48 integrated circuit.

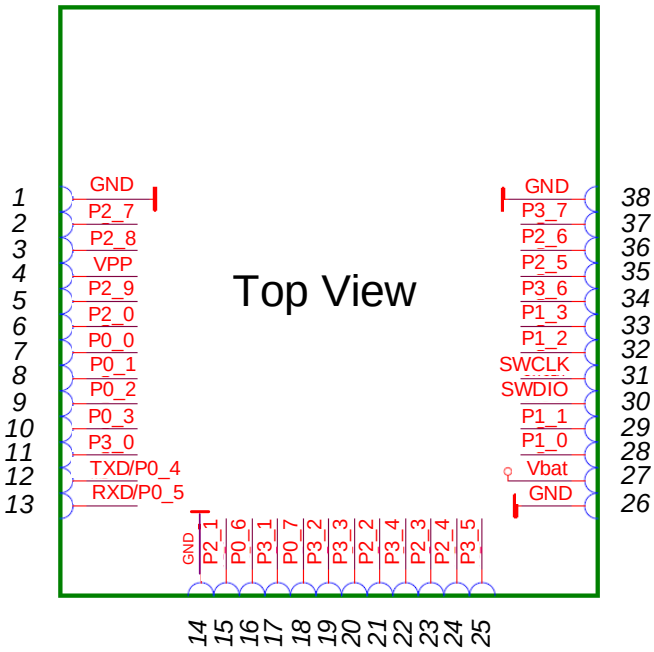



**Figure 3: Module pin locations**

**Table 2: Module pin assignment (top view)**

| Pin no. | Pin name (PCB left side) | Pin no. | Pin name (PCB bottom side) | Pin no. | Pin name (PCB right side) |
|---|---|---|---|---|---|
| 1 | GND | 14 | GND | 26 | GND |
| 2 | P2_7 | 15 | P2_1 | 27 | VBAT |
| 3 | P2_8 | 16 | P0_6 | 28 | P1_0 |
| 4 | VPP | 17 | P3_1 | 29 | P1_1 |
| 5 | P2_9 | 18 | P0_7 | 30 | SWDIO |
| 6 | P2_0 | 19 | P3_2 | 31 | SW_CLK |
| 7 | P0_0 | 20 | P3_3 | 32 | P1_2 |
| 8 | P0_1 | 21 | P2_2 | 33 | P1_3 |
| 9 | P0_2 | 22 | P3_4 | 34 | P3_6 |
| 10 | P0_3 | 23 | P2_3 | 35 | P2_5 |
| 11 | P3_0 | 24 | P2_4 | 36 | P2_6 |
| 12 | P0_4 (TxD) | 25 | P3_5 | 37 | P3_7 |
| 13 | P0_5 (RxD) | | | 38 | GND |

## 4.7 Module GPIOs

The QFN48 antenna module provides 32 general purpose input/output pins (including JTAG signals). The interfaces are multiplexed with the GPIOs and can be enabled by appropriate programming. The available GPIO functions are presented in Table 3.

The following digital interfaces are available externally to the module:

- Two UARTs with hardware flow control up to 1 MBd
- SPI interface
- $I^2C$ bus at 100 kHz, 400 kHz
- 3-axis capable quadrature decoder

In addition, a 4-channel 10-bit ADC is also available externally to the module.

**Table 3: GPIO pins: available functions**

| Interface | Description | Pins | Comments |
|---|---|---|---|
| UART1 (UTX, URX) | Bootable UART | P00, P01 | 57.6 kBd on booting |
| | | P02, P03 | 115.2 kBd on booting |
| | | P04,P05 | 57.6 kBd on booting.<br>This combination is selected for the UART on this module. |
| | | P06, P07 | 9.6 kBd on booting |
| UART1 (RTS, CTS) | Bootable UART | P02, P03 | |
| | | P06, P07 | |
| UART1 or UART2 | UART debug port | Any port and any pin combination | |
| SPI | Bootable SPI | P00, P03, P05, P06 | Up to 8 MHz. |
| | Non-bootable SPI | Any port and any pin combination | |
| I2C | Bootable $I^2C$ | P00, P01 | 100 kHz on booting for all combinations |
| | | P02, P03 | |
| | | P04, P05 | |
| | | P06, P07 | |
| | Non-bootable $I^2C$ | Any port, any pin | |
| ADC | | P00, P01, P02, P03 | The voltage on these pins must be lower than $V_{BAT}$. |
| Test points | Frequency calibration | P05 | 16 MHz oscillator output. Can be used for clock calibration. |
| Interrupts | | Any port and any pin combination | |
| Keypad | | Any port , any pin | column or row |

### 4.7.1 Reset

The reset signal of the DA14580 (pin RST) is active high. On the QFN48 antenna module the RST pin of the DA14580 is connected to GND via a resistor R8 (0 Ω). Consequently, the only way to perform a hardware reset of the DA14580 on the antenna module is by switching off the power.

## 4.8 Power management

The QFN48 antenna module is supplied by a single power supply via pin 27 (VBAT). The supply voltage of the module follows the specification of the DA14580 IC in buck configuration. The supply voltage ranges from 2.4 V to 3.6 V.

Embedded in the DA14580, the DC/DC converter and LDOs produce all voltages required for the system operation. The DC/DC converter is supplied from $V_{BAT}$ through a bead (FB1) and produces 1.4 V that feeds the internal LDOs. The LDOs supply the digital, analog and RF sections of the chip with 1.2 V. Finally, the I/O ring is supplied from $V_{BAT}$.

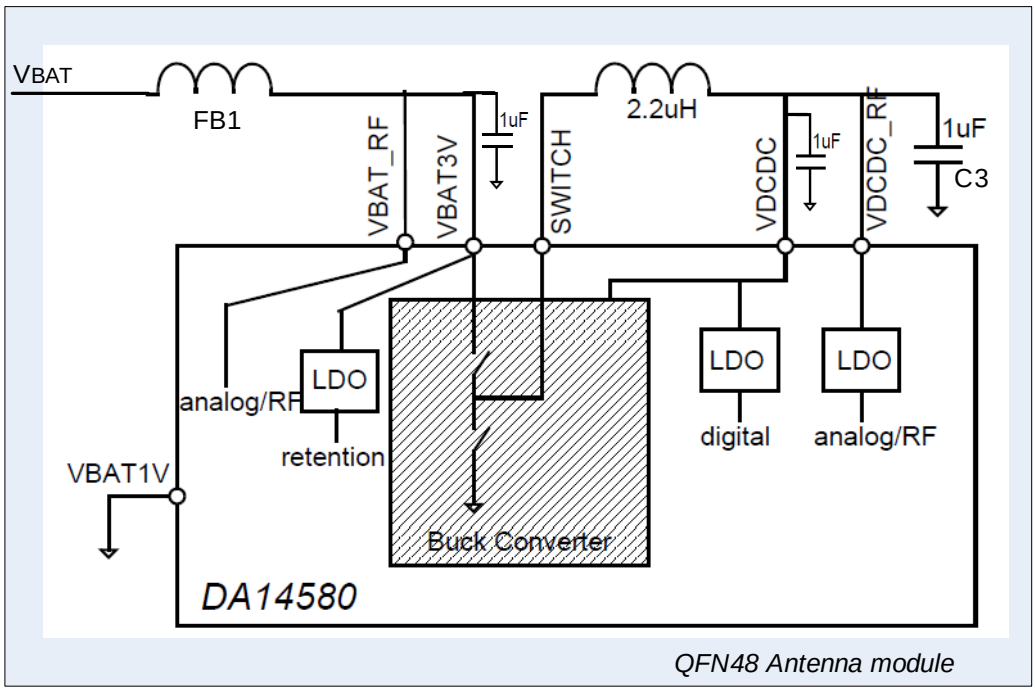



**Figure 4: Power management, DC/DC converter in buck configuration**

The overall current consumption of the QFN48 antenna module in transmit mode is in the range of 5 mA, whereas in sleep mode the consumption is in the range of 2 µA. See Figure 5.

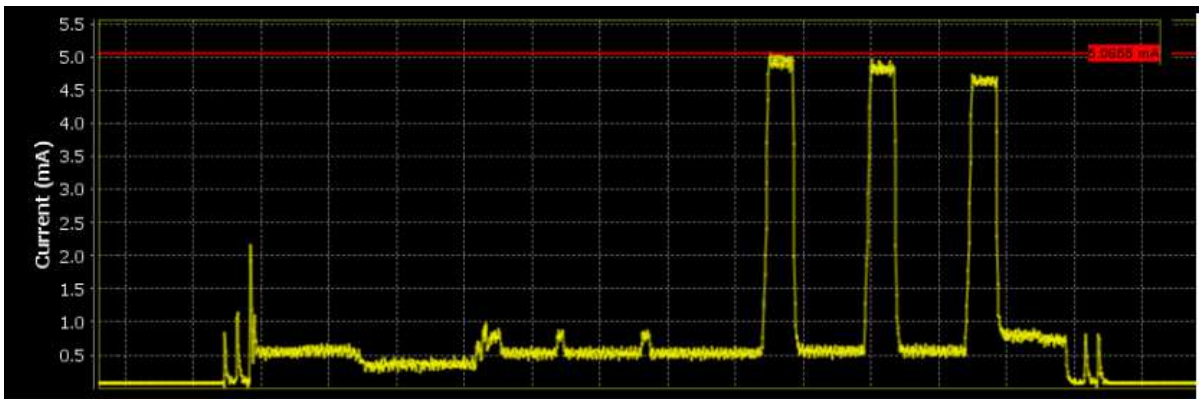



**Figure 5: Current consumption during an Advertising frame**

### 4.8.1 DC/DC converter in boost configuration

Supplying the QFN48 antenna module at a lower voltage (down to 0.9 V) is feasible, but modification of the module's components is needed. Please note that this configuration has not been used in the tests for the FCC/ETSI certification.

**Table 4: DA14580 DC/DC converter configurations**

| | |
|---|---|
| **Buck configuration (default)** | |
| Supply voltage | 2.4 V to 3.6 V |
| Populated components | R1 = 0 Ω, R4 = 0 Ω, CR1 = 0 Ω |
| Not populated components | R2, R3 |
| FCC/CE certification | Yes |
| **Boost configuration** | |
| Supply voltage | 0.9 V to 2.0 V (single cell alkaline battery) |
| Populated components | R2 = 0 Ω, R3 = 0 Ω, CR1 = 1 µF |
| Not populated components | R1, R4 |
| FCC/CE certification | No |

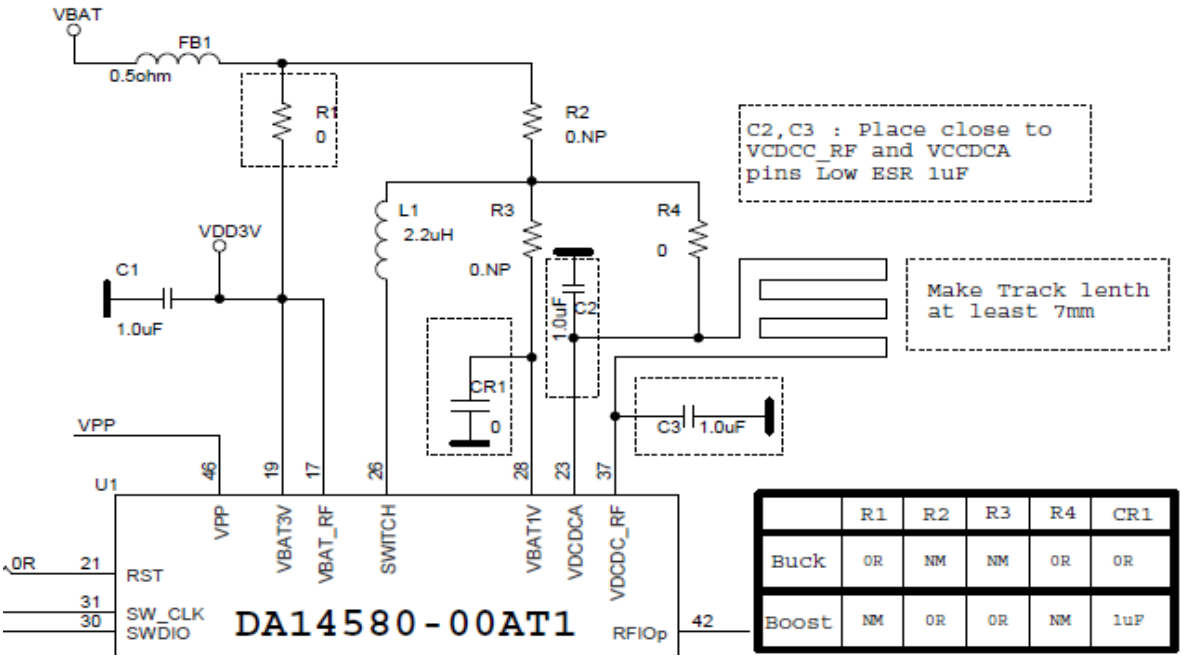



**Figure 6: DA14580 DC/DC converter circuit**

## 4.9 Crystals

The frequency tolerance specification for BLE is ±50 ppm. To compensate for ageing and offset effects, the external crystal of 16 MHz must have an accuracy of ±20 ppm or better. On the QFN48 antenna module the 16 MHz crystal (Y1) has a fundamental frequency of 16 MHz ±10 ppm and a load capacitance of 10 pF. The crystal is located on the module itself. The crystal oscillator frequency can be tuned using a programmable capacitance bank that is embedded in the DA14580.

For sleep mode the on-chip RCX oscillator is used (typ. 10 kHz). In addition, a 32.768 kHz crystal (Y2) with a tolerance of ±50 ppm can be mounted on the module.

**Table 5: Crystal characteristics**

| Frequency | Accuracy | Load capacitance | Size | Placement |
|---|---|---|---|---|
| 16 MHz | ±10 ppm | 10 pF | 2.5 mm x 2.0 mm | Populated |
| 32.768 kHz | ±20 ppm | 7 pF | 3.2 mm x 1.5 mm | Optional |

**Note:** When the DC/DC converter configuration is changed to boost mode, a 32.768 kHz crystal must be mounted. The on-chip RCX oscillator can only be used in buck mode.

## 4.10 OTP programming

For programming the OTP memory of the DA14580, a DC voltage of 6.7 V (typ.) must be applied to pin 4 (VPP).

## 4.11 Debugging/testing ports

Two ports are available for testing/debugging or software development: JTAG and UART: The pin assignments of these ports are given in Table 6.

**Table 6: QFN48 antenna module debug ports**

| Function | QFN48 antenna module | | DA14580 | |
|---|---|---|---|---|
| | Pin name | Pin no. | Pin name | Pin no. |
| UART transmit (UTX) | TxD | 13 | P0_5 | 7 |
| UART receive (URX) | RxD | 12 | P0_4 | 6 |
| JTAG data | SWDIO | 30 | SWDIO | 30 |
| JTAG clock | SWCLK | 31 | SWCLK | 31 |

## 4.12 RF section

The DA14580 has a single pin RF input/output port. The RF section of the QFN48 antenna module consists of a printed antenna and the matching network of R5, R6 and L2. L2 is not populated. See Figure 7.

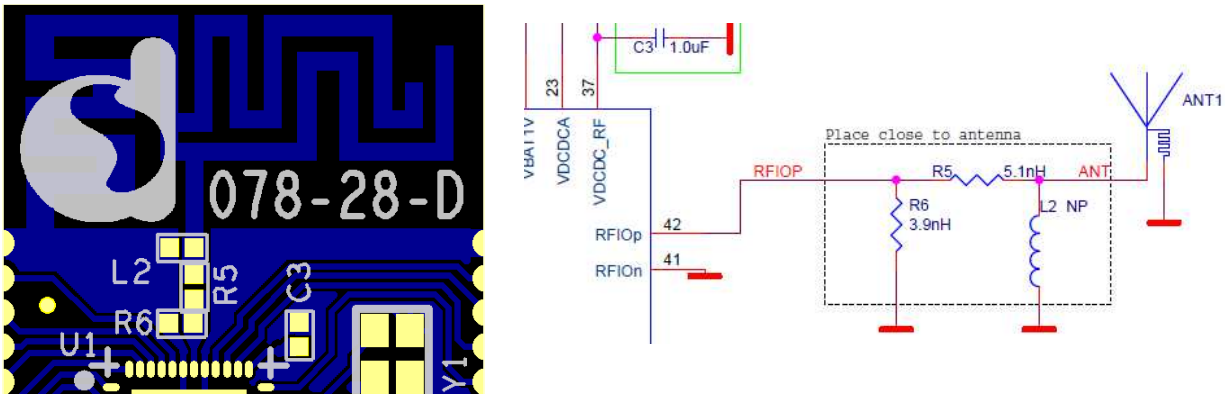



**Figure 7: RF section: PCB layout (left) and schematic (right)**

### 4.12.1 Antenna

A broadband variant of a printed F-antenna is used. A matching network is required for achieving the maximum power transfer possible. The matching network consists of two inductances: R5 (series coil: 5.1 nH, 0402, LQP series) and R6 (shunt coil: 3.9 nH, 0402, LQP series).

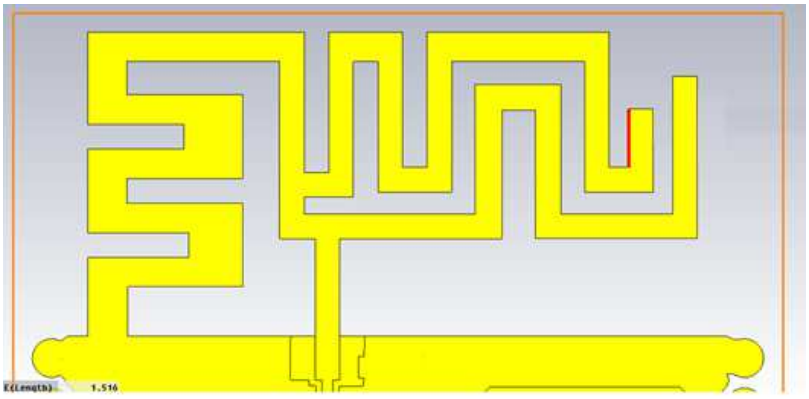


**Figure 8: Antenna geometry**

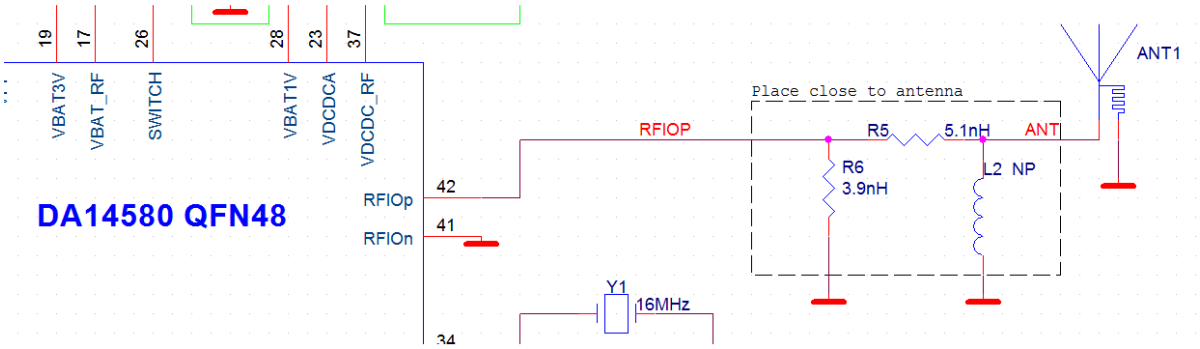
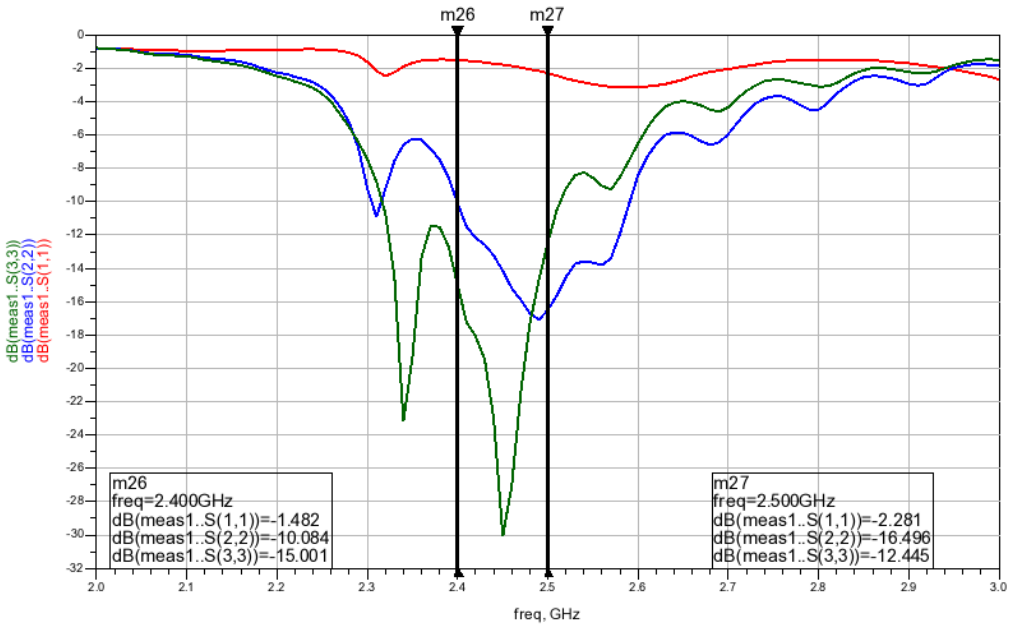



**Figure 9: Matching network: R5 (5.1 nH) and R6 (3.9 nH)**




**Red**: no matching
**Blue**: R5 = 4.7 nH, R6 = 3.9 nH
**Green**: R5 = 5.1 nH, R6 = 3.9 nH

**Figure 10: Antenna VSWR measurements**

#### 4.12.1.1 Radiation diagrams

Gain calculations were performed. The maximum gain was measured at 2.225 dBi. See Table 7.

**Table 7: Far field antenna parameters @ 2.44 GHz**

| Parameter | Value |
|---|---|
| Frequency | 2.44 GHz |
| Radiation efficiency | -1.882 dB |
| Total efficiency | -6.662 dB |
| Directivity | 2.225 dBi |

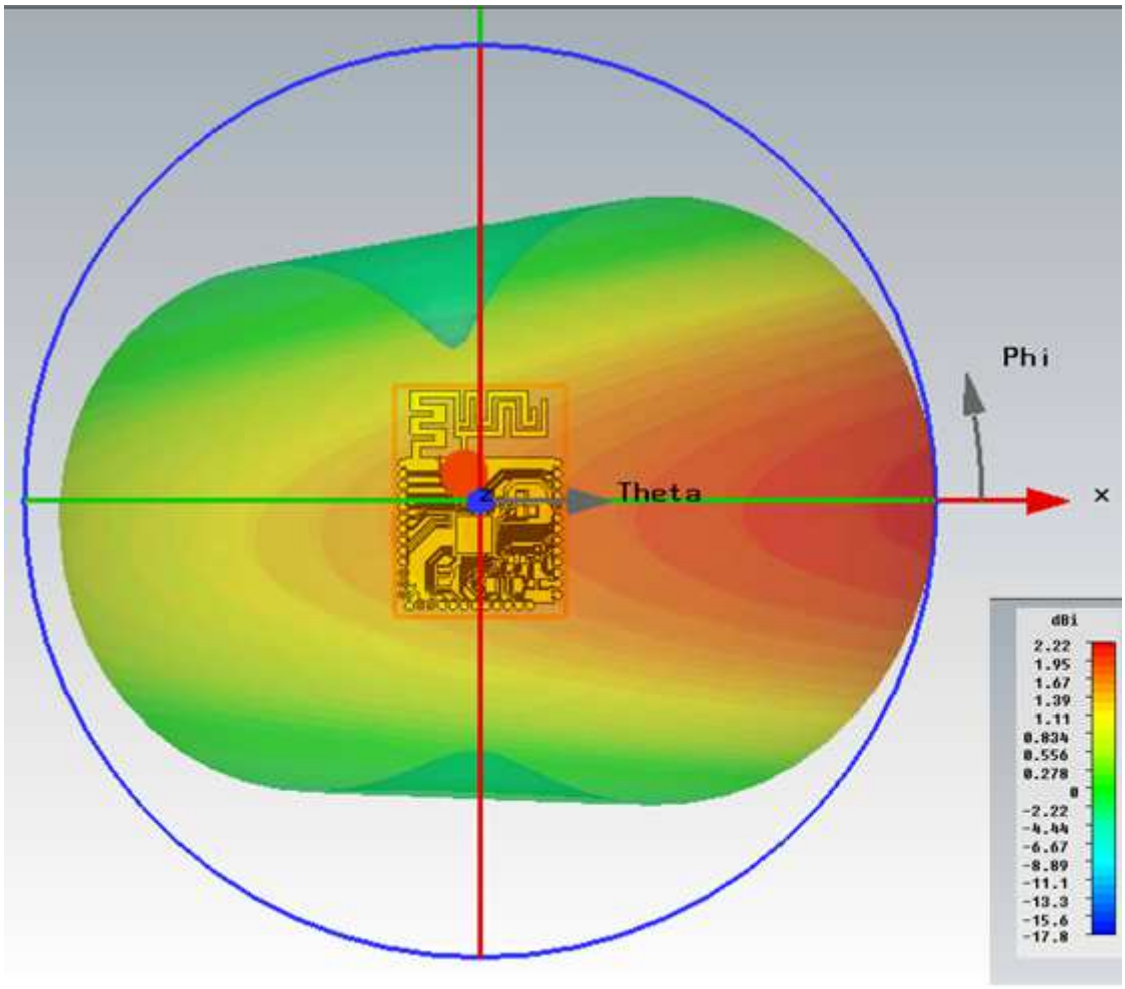



**Figure 11: Far field antenna directivity @ 2.44 GHz**

#### 4.12.1.2 Radiation pattern measurements

Measurements of the radiation pattern in an anechoic chamber for vertical and horizontal positions of the module are given in Figure 12 and Figure 13, respectively.

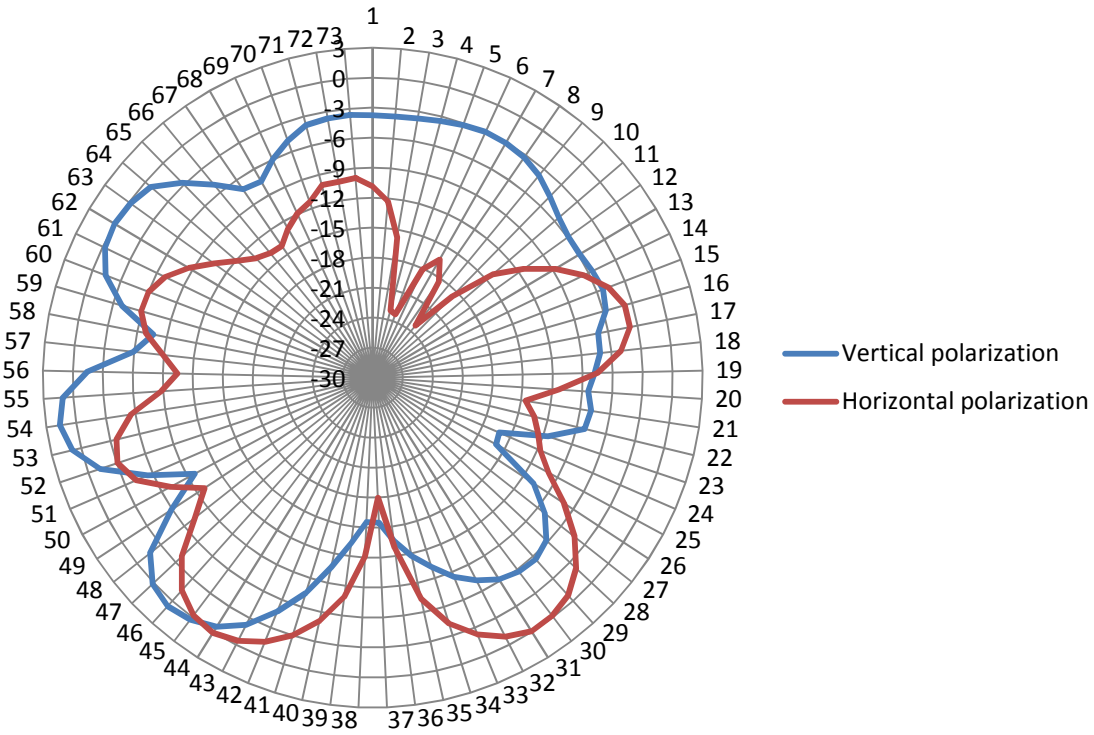



**Figure 12: Radiation diagram for the module placed vertically on the long edge**

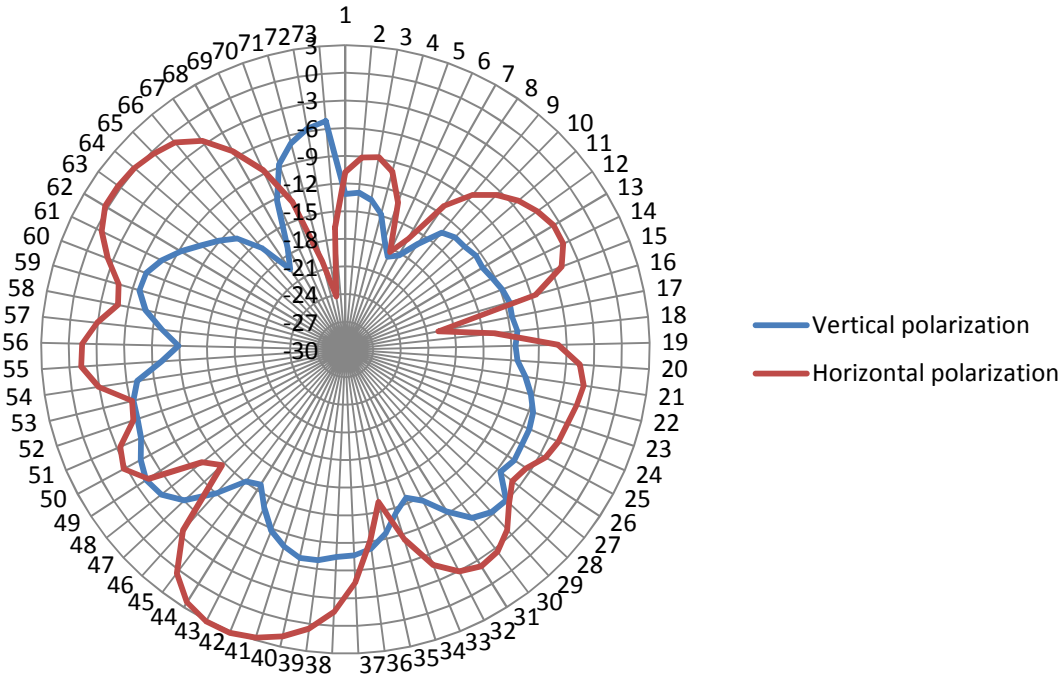



**Figure 13: Radiation diagram for the module placed horizontally**

## 4.13 Tuning the 16 MHz crystal

The accuracy of the 16 MHz crystal (±10ppm) guarantees the 'in spec' operation of the QFN48 antenna module. However, further trimming of the 16 MHz crystal is possible using the procedure that is described in *AN-B-020 End product testing and programming guidelines*. See Ref.[2].

## 4.14 Software

The standard SDK release software, without modifications, can be used for testing or operating the QFN48 antenna module.

## 4.15 Test platform

An interposer (078-46-A) was built for hardware interfacing the Expert DK Motherboard (580-MB-vC2 / 078-10-C2) to the QFN48 antenna module. The interposer can be used as a stand-alone platform, as it has a debug port (J39). The debug port consist of JTAG, UART, VPP, VBAT and GND signals.

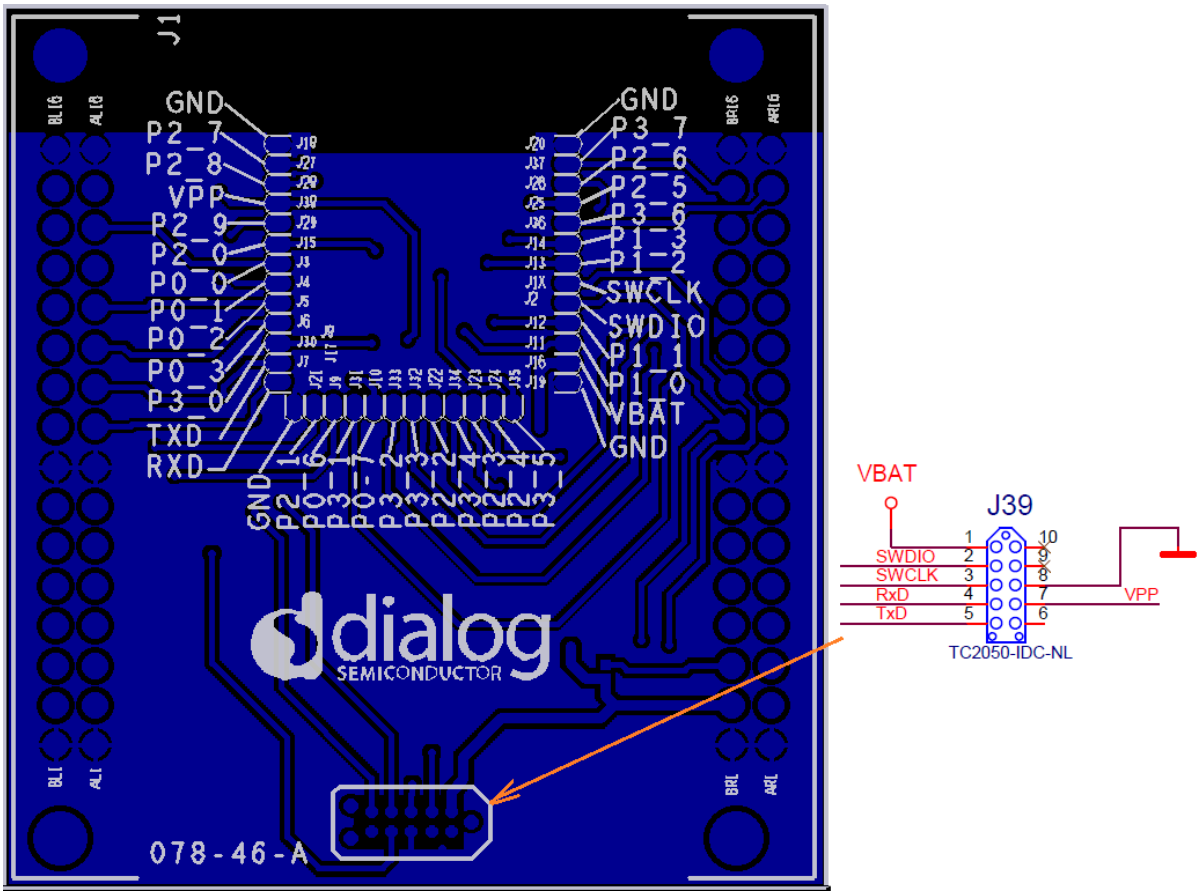



**Figure 14: Interposer (078-46-A) for the QFN48 antenna module**

## 4.16 PCBA

A two-layer FR4 PCB with 1 mm standard thickness is used. The PCB size is 25.4 mm x 17.9 mm. There are 38 connection pads which are made as castellation (1/2 open drill) with 1.27 mm pitch. The PCB layout is shown in Figure 15 and the fabrication parameters are given in Table 8.

The schematic diagram and BOM of the QFN48 antenna module are presented in Figure 16 and Table 9, respectively.

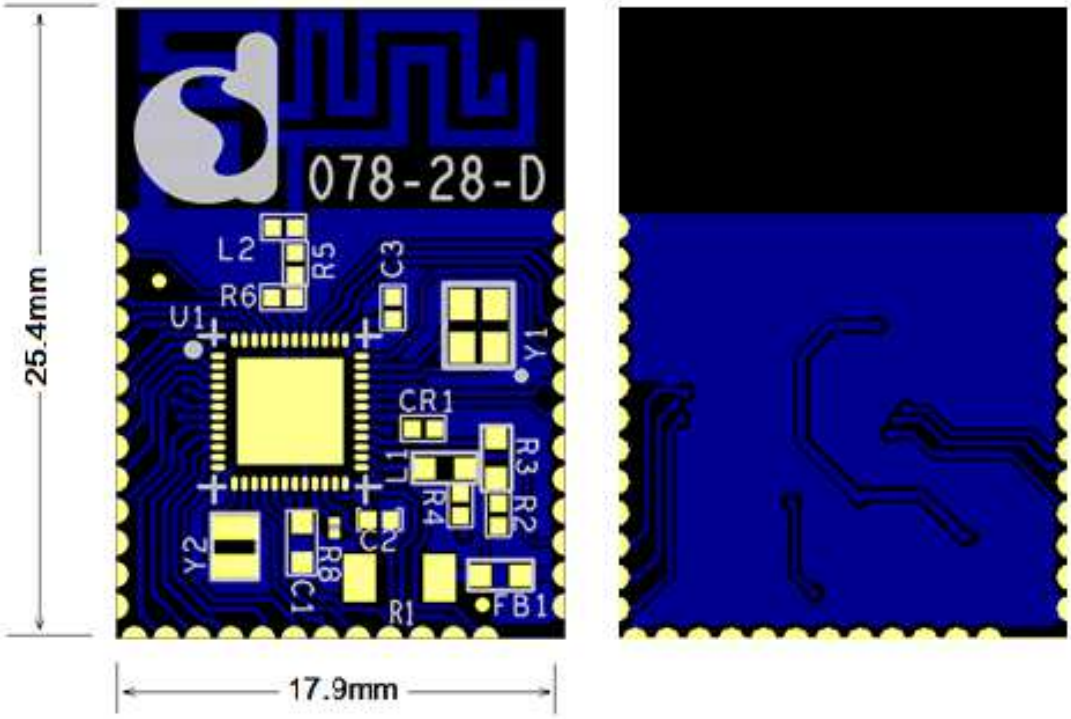



**Figure 15: Top view (left) and bottom view (right) of PCBA**

**Table 8: PCB fabrication parameters**

| | |
|---|---|
| **Number of layers** | 2 |
| **Core material** | FR4 IMP – 1.0 mm |
| **Top copper thickness** | 0.018 mm |
| **Bottom copper thickness** | 0.018 mm |
| **Outer layer track width** | 0.100 mm |
| **Hole density** | <1000 per $dm^2$ |
| **Outer layer isolation distance** | 0.125 mm |
| **Hole diameter** | 0.45 mm |
| **Outer layer annular ring** | 0.100 mm |

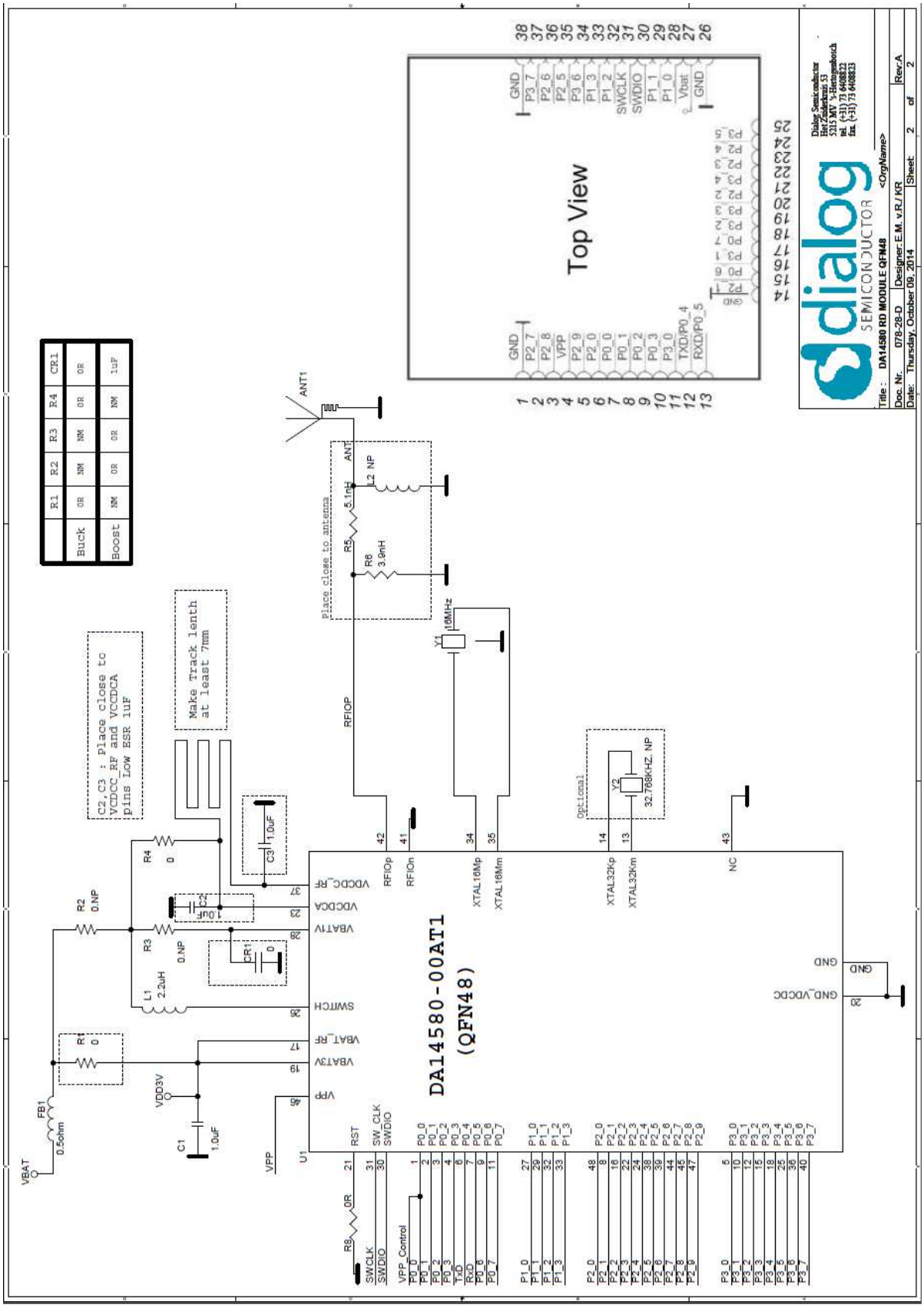



**Figure 16: Schematic of the DA14580 QFN48 antenna module**

**Table 9: Bill of Materials**

| No | Qty | Description | Part Ref | Value | Part Number | Package | Manufacturer |
|---|---|---|---|---|---|---|---|
| 1 | 1 | CAP CERM 1.0uF 16V X7R 0603 | C1 | 1.0 µF | 0603YC105K AT2A | 0603 | AVX Corporation |
| 2 | 2 | CAP MLCC, 0204, 1UF, 6.3V, 20%, X5R | C2 C3 | 1.0 µF | GRM155R70 G105KA12D | 0402 | Murata Electronics |
| 3 | 2 | RES 0.0 OHM 1/16W 5% 0402 SMD | CR1 R4 | 0 Ω | CRCW04020 000Z0ED | 0402 | Vishay/Dale |
| 4 | 1 | FILTER CHI0.5ohm 0.4A 0603 | FB1 | | BLM18AG102 SN1D | 0603 | Murata Electronics |
| 5 | 1 | INDUCTOR Power 2.2uH, 500mA, 400MHz | L1 | 2.2 µH | BRL1608T 2R2M | 0603 | Taiyo Yuden |
| 6 | 1 | RESISTOR, THICK FILM, 0 OHM, 250mW, 5% | R1 | 0 Ω | RC1206JR- 070RL | 1206 | YAGEO |
| 7 | 1 | INDUCTOR RF, 0402, 5.1NH, ±0.3NH, 0.26ohm | R5 | 5.1 nH | L-07C5N1 SV6T | 0402 | JOHANSON TECHNOLOGY |
| 8 | 1 | RF INDUCTOR 0402 3.9NH, ±0.3NH 0.22ohm | R6 | 3.9 nH | L-07C3N9 SV6T | 0402 | Johanson Technology Inc |
| 9 | 1 | RESISTOR, 0201, 0R0 | R8 | 0 Ω | CRCW02010 000Z0ED | 0201 | VISHAY DRALORIC |
| 10 | 1 | DA14580 Bluetooth Low Energy SOC – QFN48 | U1 | | DA14580-00AT1 | QFN48, 6x 6 x 0.9mm | DIALOG SEMI |
| 11 | 1 | CRYSTAL 16.000MHZ 10PF SMT | Y1 | 16 MHz | 7M-16.000 MEEQ-T | xtal4p 25x20 | TXC |
| **Not Populated** | | | | | | | |
| 1 | 1 | Inductor | L2 | NM | | 0402 | |
| 2 | 1 | Resistor | R3 | 0 Ω | | 0603 | |
| 3 | 1 | crystal 32.768KHZ, ±20ppm, 7PF | Y2 | 32.768 kHz | ABS06-32.768KHz-7-T | 2x1.2mm | Abracon Corporation |
| 4 | 1 | Resistor | R2 | 0 Ω | CRCW0402 0000 Z0ED | 0402 | Vishay/Dale |

# 5 Measurements

## 5.1 Receiver sensitivity (conducted)

### 5.1.1 Test description

In this test the conducted RF sensitivity of the QFN48 antenna module was measured.

### 5.1.2 Test setup

The supply voltage (3.0 V DC) was connected between the PCB pads 27 (VBAT) and 26 (GND). The R&S®CBT Bluetooth® Tester from Rohde & Schwarz was used. Component R5 was removed. The semi-rigid cable was soldered at this pad. See Figure 17.

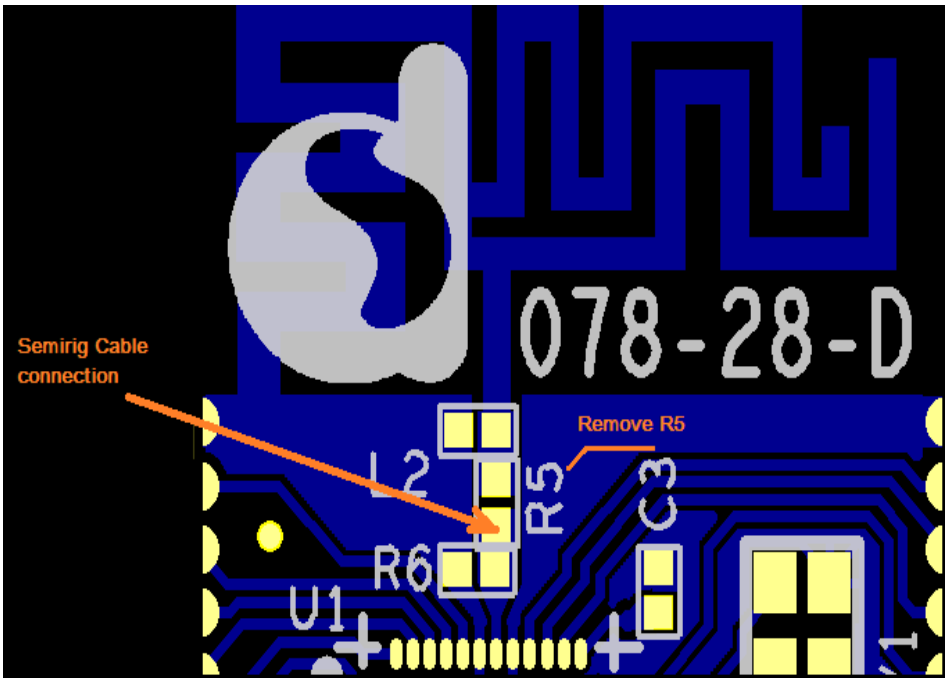



**Figure 17: Test setup for the conducted RF measurements**

### 5.1.3 Test results

The conducted RF sensitivity using a ‘dirty’ transmitter is better than -90 dBm for most channels. Lower sensitivity has been noticed on some channels. This is caused by harmonics of the 16 MHz oscillator. The results for one of the modules are shown Table 10.

### Table 10: Conducted receiver sensitivity

**Bluetooth Low Energy PER Search**

*TX Start Level: -96.0 dBm, Packets: 1000, Payload: PRBS 9, Length: 37 Bytes, Dirty Transmitter: specification table*

*Channelscan: from Ch. 00 to Ch. 39, with detailed values*

| Test Name and Condition | Lower Limit | Upper Limit | Measured Value | P/F |
|---|---|---|---|---|
| RX Level @ *Ch: 00, PER: 29.60%, Count: 08* | | | -91.50 dBm | ✔ |
| RX Level @ *Ch: 01, PER: 30.00%, Count: 17* | | | -91.60 dBm | ✔ |
| RX Level @ *Ch: 02, PER: 31.20%, Count: 10* | | | -91.60 dBm | ✔ |
| RX Level @ *Ch: 03, PER: 29.80%, Count: 15* | | | -91.40 dBm | ✔ |
| RX Level @ *Ch: 04, PER: 28.90%, Count: 14* | | | -91.40 dBm | ✔ |
| RX Level @ *Ch: 05, PER: 30.90%, Count: 12* | | | -91.40 dBm | ✔ |
| RX Level @ *Ch: 06, PER: 30.50%, Count: 05* | | | -91.20 dBm | ✔ |
| RX Level @ *Ch: 07, PER: 28.80%, Count: 14* | | | -89.00 dBm | ✔ |
| RX Level @ *Ch: 08, PER: 30.60%, Count: 07* | | | -91.50 dBm | ✔ |
| RX Level @ *Ch: 09, PER: 29.00%, Count: 09* | | | -91.60 dBm | ✔ |
| RX Level @ *Ch: 10, PER: 30.60%, Count: 16* | | | -91.50 dBm | ✔ |
| RX Level @ *Ch: 11, PER: 29.70%, Count: 12* | | | -91.10 dBm | ✔ |
| RX Level @ *Ch: 12, PER: 30.20%, Count: 08* | | | -91.00 dBm | ✔ |
| RX Level @ *Ch: 13, PER: 29.70%, Count: 10* | | | -90.90 dBm | ✔ |
| RX Level @ *Ch: 14, PER: 30.70%, Count: 11* | | | -91.00 dBm | ✔ |
| RX Level @ *Ch: 15, PER: 30.10%, Count: 12* | | | -88.80 dBm | ✔ |
| RX Level @ *Ch: 16, PER: 29.10%, Count: 09* | | | -90.80 dBm | ✔ |
| RX Level @ *Ch: 17, PER: 29.60%, Count: 12* | | | -91.10 dBm | ✔ |
| RX Level @ *Ch: 18, PER: 29.60%, Count: 11* | | | -90.50 dBm | ✔ |
| RX Level @ *Ch: 19, PER: 28.80%, Count: 13* | | | -90.70 dBm | ✔ |
| RX Level @ *Ch: 20, PER: 29.40%, Count: 12* | | | -91.10 dBm | ✔ |
| RX Level @ *Ch: 21, PER: 29.70%, Count: 13* | | | -91.20 dBm | ✔ |
| RX Level @ *Ch: 22, PER: 29.90%, Count: 10* | | | -91.20 dBm | ✔ |
| RX Level @ *Ch: 23, PER: 30.20%, Count: 07* | | | -88.30 dBm | ✔ |
| RX Level @ *Ch: 24, PER: 30.90%, Count: 05* | | | -91.20 dBm | ✔ |
| RX Level @ *Ch: 25, PER: 29.40%, Count: 07* | | | -91.50 dBm | ✔ |
| RX Level @ *Ch: 26, PER: 29.70%, Count: 11* | | | -91.20 dBm | ✔ |
| RX Level @ *Ch: 27, PER: 29.70%, Count: 09* | | | -90.80 dBm | ✔ |
| RX Level @ *Ch: 28, PER: 28.90%, Count: 08* | | | -90.70 dBm | ✔ |
| RX Level @ *Ch: 29, PER: 30.40%, Count: 13* | | | -90.70 dBm | ✔ |
| RX Level @ *Ch: 30, PER: 29.30%, Count: 18* | | | -90.50 dBm | ✔ |
| RX Level @ *Ch: 31, PER: 31.40%, Count: 06* | | | -88.20 dBm | ✔ |
| RX Level @ *Ch: 32, PER: 28.90%, Count: 24* | | | -90.70 dBm | ✔ |
| RX Level @ *Ch: 33, PER: 30.00%, Count: 07* | | | -90.60 dBm | ✔ |
| RX Level @ *Ch: 34, PER: 29.00%, Count: 13* | | | -90.70 dBm | ✔ |
| RX Level @ *Ch: 35, PER: 28.80%, Count: 07* | | | -90.00 dBm | ✔ |
| RX Level @ *Ch: 36, PER: 28.90%, Count: 07* | | | -90.60 dBm | ✔ |
| RX Level @ *Ch: 37, PER: 30.80%, Count: 11* | | | -91.00 dBm | ✔ |
| RX Level @ *Ch: 38, PER: 31.80%, Count: 15* | | | -90.90 dBm | ✔ |
| RX Level @ *Ch: 39, PER: 31.00%, Count: 09* | | | -87.60 dBm | ✔ |

## 5.2 Transmitter output power (conducted)

### 5.2.1 Test description

In this test the conducted RF output power of the QFN48 antenna module was measured.

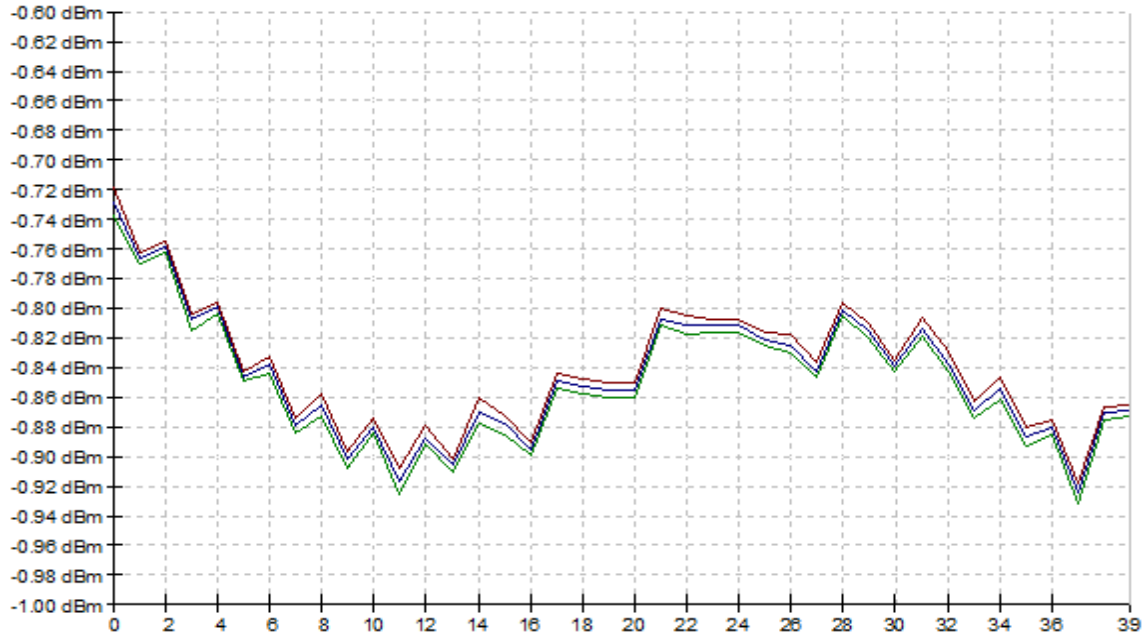
### 5.2.2 Test setup

The supply voltage (3.0 V DC) was connected between the PCB pads 27 (VBAT) and 26 (GND). The integrated antenna was bypassed by removing component R5. A short RF semi-rigid cable was connected to this pad. See Figure 17.

The R&S®CBT Bluetooth® Tester from Rohde & Schwarz was used. Bursts of 10 packets were transmitted by the DA14580. The packet length was 37 bytes and the pattern was '01010101'.

### 5.2.3 Test results

The results of the output power measurements for one of the modules are given in Figure 18.




**Red:** maximum
**Blue:** average
**Green:** minimum

**Figure 18: Conducted output power per channel**

## 5.3 Current consumption

### 5.3.1 Test setup

The board used in the test presented has optimal RF performance. The following instruments were used for the test:

- Multimeter
- 3 V, 100 mA power source for peak current
- 3 V, 10 µA power source for sleep current

- Agilent N6705B DC Power Analyzer

Power consumption was measured using beacon firmware. During this test the transmit peak current (in Advertising mode) and the sleep current were measured.

### 5.3.2 Test results

For this measurement the DUT was supplied by 3 V. Firmware was downloaded and the JTAG programmer was disconnected. The firmware was controlling the RF switches.

**Table 11: Peak current during Advertising mode**

| Parameter | Value |
|---|---|
| $I_{BAT\_TX}$ | 4.62 mA |

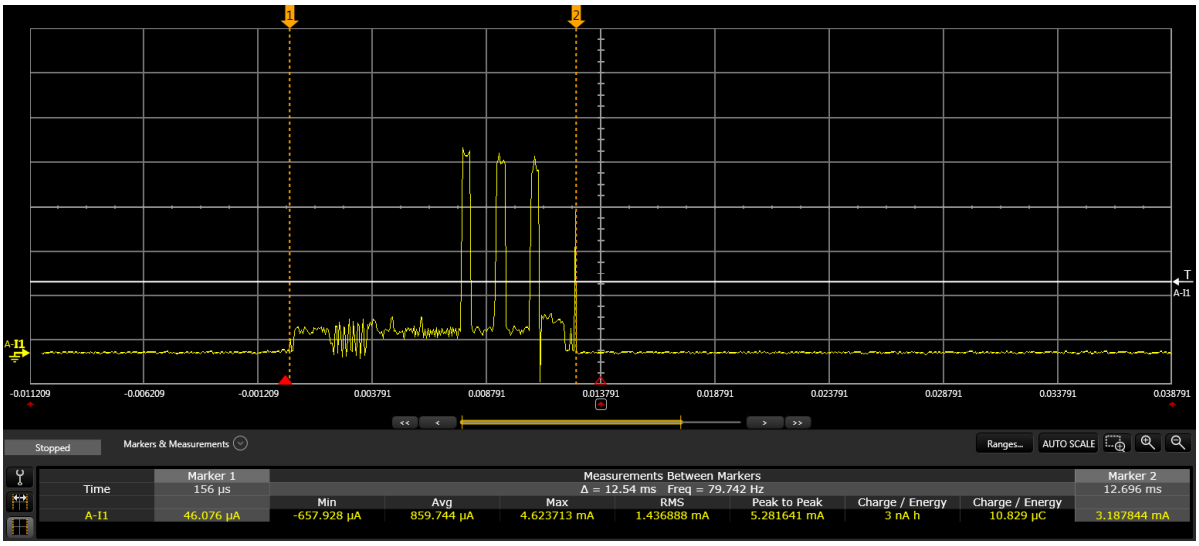



**Figure 19: Supply current during an Advertising frame**

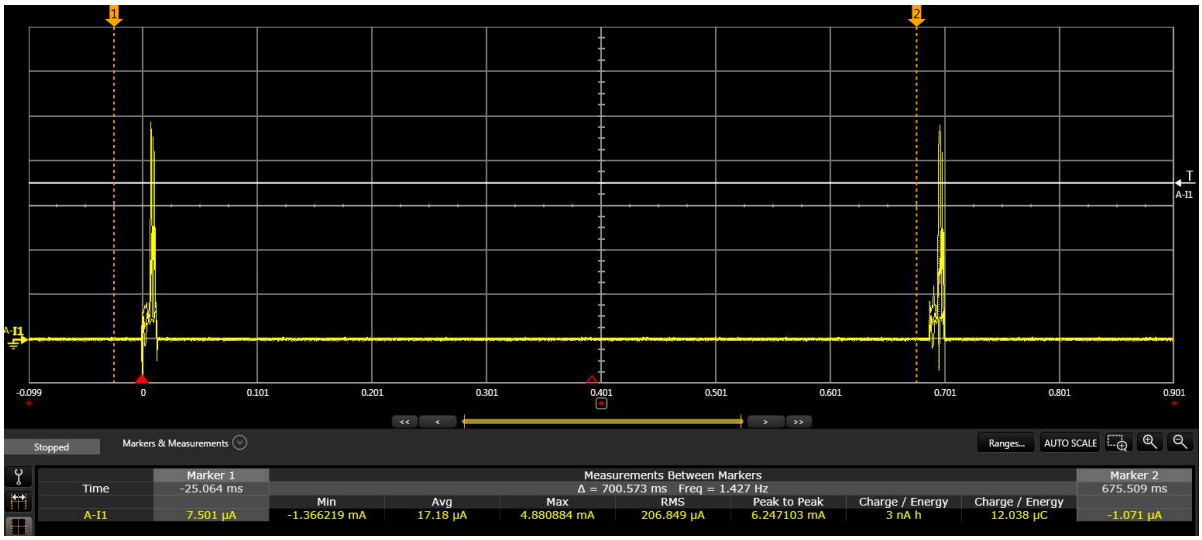



**Figure 20: Supply current during periodic transmissions every 700 ms**

**Table 12: Average current in Extended Sleep mode**

| Parameter | Value |
|---|---|
| $I_{BAT\_SLP}$ | ~ 2 µA |

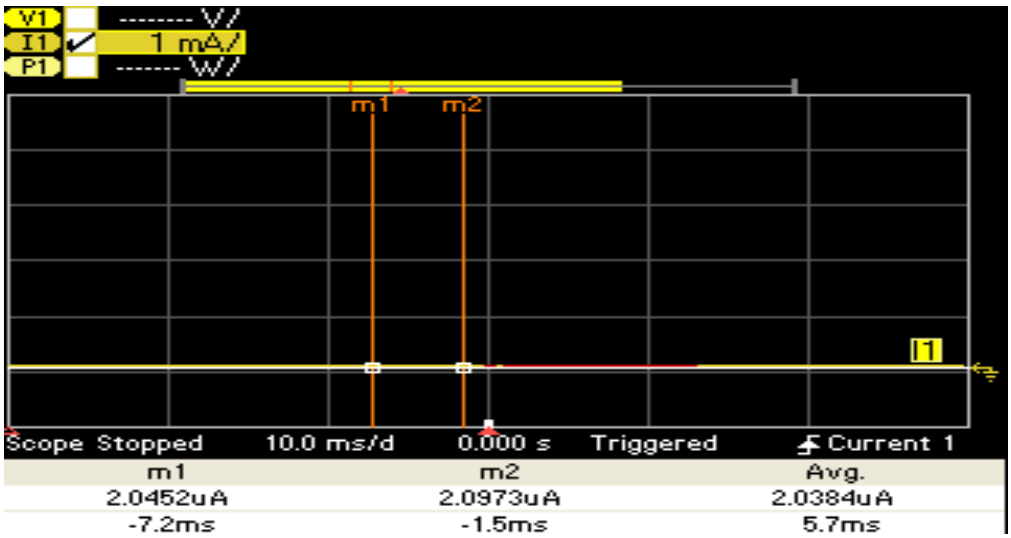



**Figure 21: Supply current during Extended Sleep mode**

# 6 FCC/IC Certification and CE marking

## 6.1 Standards and conformity assessment

The QFN48 antenna module was tested and found compliant by a qualified laboratory to the following standards:

**For FCC/IC certification:**

- Complete RF testing according to FCC part 15.247, 15.209.
- FCC Rules and Regulations 47 CFR Chapter I Part 15 Subpart B (10-01-12 Edition) and ICES-003 ISSUE 5. This covers:
  - Continuous Conducted Emission of Power Leads, frequency range 0.15 ÷ 30 MHz.
  - Radiated Emission – Electromagnetic field, frequency range 30 MHz ÷ 26 GHz

**For CE marking:**

- Complete RF testing according to ETSI EN 300 328 v1.8.1
- EMC testing according to EN 301 489-1 V.1.9.2 & EN 301 489-17 V2.2.1
  - Radiated Emission- Electromagnetic Field measure. Frequency Range 30 MHz ÷ 6 GHz. Test standard EN 55022 (2010)/ AC(2011).
  - Radiated RF Electromagnetic Field Immunity Test. Frequency Range 80 MHz ÷ 2.7 GHz. Test standard, EN 61000-4-3 (2006) / A1 (2008) / A2 (2010).
- Electrical Safety testing according to EN 61010-1: 2010
  - Electrostatic Discharge Immunity Test. Test standard EN 61000-4-2
- RoHS 2011/65/CE (includes screening for 20 elements).

## 6.2 FCC requirements regarding the end product and end user

### 6.2.1 End product marking

The end product that the module is integrated into must be marked as follows:

“Contains Transmitter Module FCC ID: Y82DA14580REFANT / IC: 9567A-DA14580REFANT”

“Module transmetteur ID IC: 9567A-DA14580REFANT”

### 6.2.2 End product literature

The literature that is provided to the end user must include the following wording:

“Dialog Semiconductor does not approve any changes or modifications made to this device by the user. Any changes or modifications could void the user’s authority to operate the equipment.

*Dialog Semiconductor n’approuve aucune modification apportée à l’appareil par l’utilisateur, quelle qu’en soit la nature. Tout changement ou modification peuvent annuler le droit d’utilisation de l’appareil par l’utilisateur.*

This device complies with Part 15 of the FCC Rules and Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

*Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.*

This device complies with FCC/IC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines and RSS-102 of the IC radio frequency (RF) Exposure rules. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

*Le présent appareil est conforme à l'exposition aux radiations FCC / IC définies pour un environnement non contrôlé et répond aux directives d'exposition de la fréquence de la FCC radiofréquence (RF) et RSS-102 de la fréquence radio (RF) IC règles d'exposition. L'émetteur ne doit pas être colocalisé ni fonctionner conjointement avec à autre antenne ou autre émetteur.*

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.”

## 6.3 Industry Canada requirements regarding the end product and end user

### 6.3.1 End product marking

The host device shall be properly labelled to identify the modules within the host device. The Industry Canada certification label of a module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the Industry Canada certification number of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

“Contains transmitter module IC: 9567A-DA14580REFANT”

*L'appareil hôte doit être étiqueté comme il faut pour permettre l'identification des modules qui s'y trouvent. L'étiquette de certification d'Industrie Canada d'un module donné doit être posée sur l'appareil hôte à un endroit bien en vue en tout temps. En l'absence d'étiquette,l'appareil hôte doit porter une etiquette donnant le numéro de certification du module d'Industrie Canada, précédé des mots "Contient un module d'émission", du mot "Contient" ou d'une formulation similaire exprimant le même sens, comme suit:*

*“Contient le module d'émission IC: 9567A-DA14580REFANT”*

### 6.3.2 End product literature

The literature that is provided to the end user must include the following wordings:

“This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

*Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.”*

**CAN ICES-3 (B) / NMB-3 (B)**

“This Class B digital apparatus complies with Canadian ICES-003.

*Cet appareil numérique de classe B est conforme à la norme canadienne ICES-003.”*

## 6.4 1999/5/EC Directive

This device has been evaluated against the essential requirements of the 1999/5/EC Directive.

| | |
|---|---|
| Bulgarian | С настоящето Dialog Semiconductor BV декларира, че QFN48 BLUETOOTH MODULE отговаря на съществените изисквания и другите приложими изисквания на Директива 1999/5/ЕС. |
| Czech | Dialog Semiconductor BV tímto prohlašuje, že tento QFN48 BLUETOOTH MODULE je ve shodě se základními požadavky a dalšími příslušnými ustanoveními směrnice 1999/5/ES. |
| Danish | Undertegnede Dialog Semiconductor BV erklærer herved, at følgende udstyr QFN48 BLUETOOTH MODULE overholder de væsentlige krav og øvrige relevante krav i direktiv 1999/5/EF. |

| | |
|---|---|
| Dutch | Hierbij verklaart Dialog Semiconductor BV dat het toestel QFN48 BLUETOOTH MODULE in overeenstemming is met de essentiële eisen en de andere relevante bepalingen van richtlijn 1999/5/EG. |
| English | Hereby, Dialog Semiconductor BV, declares that this QFN48 BLUETOOTH MODULE is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC. |
| Estonian | Käesolevaga kinnitab Dialog Semiconductor BV seadme QFN48 BLUETOOTH MODULE vastavust direktiivi 1999/5/EÜ põhinõuetele ja nimetatud direktiivist tulenevatele teistele asjakohastele sätetele. |
| German | Hiermit erklärt Dialog Semiconductor BV, dass sich das Gerät QFN48 BLUETOOTH MODULE in Übereinstimmung mit den grundlegenden Anforderungen und den übrigen einschlägigen Bestimmungen der Richtlinie 1999/5/EG befindet. |
| Greek | ΜΕ ΤΗΝ ΠΑΡΟΥΣΑ Dialog Semiconductor BV ΔΗΛΩΝΕΙ ΟΤΙ QFN48 BLUETOOTH MODULE ΣΥΜΜΟΡΦΩΝΕΤΑΙ ΠΡΟΣ ΤΙΣ ΟΥΣΙΩΔΕΙΣ ΑΠΑΙΤΗΣΕΙΣ ΚΑΙ ΤΙΣ ΛΟΙΠΕΣ ΣΧΕΤΙΚΕΣ ΔΙΑΤΑΞΕΙΣ ΤΗΣ ΟΔΗΓΙΑΣ 1999/5/ΕΚ. |
| Hungarian | Alulírott, Dialog Semiconductor BV nyilatkozom, hogy a QFN48 BLUETOOTH MODULE megfelel a vonatkozó alapvetõ követelményeknek és az 1999/5/EC irányelv egyéb elõírásainak. |
| Finnish | Dialog Semiconductor BV vakuuttaa täten että QFN48 BLUETOOTH MODULE tyyppinen laite on direktiivin 1999/5/EY oleellisten vaatimusten ja sitä koskevien direktiivin muiden ehtojen mukainen. |
| French | Par la présente Dialog Semiconductor BV déclare que l'appareil QFN48 BLUETOOTH MODULE est conforme aux exigences essentielles et aux autres dispositions pertinentes de la directive 1999/5/CE. |
| Icelandic | Hér með lýsir Dialog Semiconductor BV yfir því að QFN48 BLUETOOTH MODULE er í samræmi við grunnkröfur og aðrar kröfur, sem gerðar eru í tilskipun 1999/5/EC |
| Italian | Con la presente Dialog Semiconductor BV dichiara che questo QFN48 BLUETOOTH MODULE è conforme ai requisiti essenziali ed alle altre disposizioni pertinenti stabilite dalla direttiva 1999/5/CE. |
| Latvian | Ar šo Dialog Semiconductor BV deklarē, ka QFN48 BLUETOOTH MODULE atbilst Direktīvas 1999/5/EK būtiskajām prasībām un citiem ar to saistītajiem noteikumiem. |
| Lithuanian | Šiuo Dialog Semiconductor BV deklaruoja, kad šis QFN48 BLUETOOTH MODULE atitinka esminius reikalavimus ir kitas 1999/5/EB Direktyvos nuostatas. |
| Maltese | Hawnhekk, Dialog Semiconductor BV, jiddikjara li dan QFN48 BLUETOOTH MODULE jikkonforma mal-ħtiġijiet essenzjali u ma provvedimenti oħrajn relevanti li hemm fid-Dirrettiva 1999/5/EC. |
| Norwegian | Dialog Semiconductor BV erklærer herved at utstyret QFN48 BLUETOOTH MODULE er i samsvar med de grunnleggende krav og øvrige relevante krav i direktiv 1999/5/EF. |

| | |
|---|---|
| Polish | Niniejszym Dialog Semiconductor BV oświadcza, że QFN48 BLUETOOTH MODULE jest zgodny z zasadniczymi wymogami oraz pozostałymi stosownymi postanowieniami Dyrektywy 1999/5/EC |
| Portuguese | Dialog Semiconductor BV declara que este QFN48 BLUETOOTH MODULE está conforme com os requisitos essenciais e outras disposições da Directiva 1999/5/CE. |
| Slovak | Dialog Semiconductor BV týmto vyhlasuje, že QFN48 BLUETOOTH MODULE spĺňa základné požiadavky a všetky príslušné ustanovenia Smernice 1999/5/ES. |
| Slovenian | Dialog Semiconductor BV izjavlja, da je ta QFN48 BLUETOOTH MODULE v skladu z bistvenimi zahtevami in ostalimi relevantnimi določili direktive 1999/5/ES. |
| Spanish | Por medio de la presente Dialog Semiconductor BV declara que QFN48 BLUETOOTH MODULE cumple con los requisitos esenciales y cualesquiera otras disposiciones aplicables o exigibles de la Directiva 1999/5/CE. |
| Swedish | Härmed intygar Dialog Semiconductor BV att denna QFN48 BLUETOOTH MODULE står I överensstämmelse med de väsentliga egenskapskrav och övriga relevanta bestämmelser som framgår av direktiv 1999/5/EG. |

In order to satisfy the essential requirements of 1999/5/EC Directive, the product is compliant with the following standards:

| | |
|---|---|
| RF spectrum use (R&TTE art. 3.2) | EN 300 328 v1.8.1 |
| EMC (R&TTE art. 3.1b) | EN 301 489-1 V1.9.2<br>EN 301 489-17 V2.2.1 |
| Health & Safety (R&TTE art. 3.1a) | EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011 + AC:2011<br>EN 62479:2010 |

The conformity assessment procedure referred to in Article 10 and detailed in Annex IV of Directive 1999/5/EC has been followed with the involvement of the following Notified Body Notified Body:

AT4 wireless, S.A.

Parque Tecnologico de Andalucía

C/ Severo Ochoa 2

29590 Campanillas – Málaga

SPAIN

Notified Body No: 1909

Thus, the following marking is included in the product:

CE 1909

Full declaration of conformity can be found can be found on the customer portal https://support.diasemi.com/

There is no restriction for the commercialisation of this device in all the countries of the European Union.

### 6.4.1 RoHS compliance

Dialog Semiconductor complies to European Directive 2001/95/EC and from 2 January 2013 onwards to European Directive 2011/65/EU concerning Restriction of Hazardous Substances (RoHS/RoHS2). Dialog Semiconductor's statement on RoHS can be found on the customer portal https://support.diasemi.com/. RoHS certificates from our suppliers are available on request.

# 7 Revision history

| Revision | Date | Description |
|---|---|---|
| 1.0 | 21-Oct-2014 | Initial version. |
| 2.0 | 10-Dec-2014 | 1999/5/EC Directive added |

## 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. |

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## RoHS Compliance

Dialog Semiconductor complies to European Directive 2001/95/EC and from 2 January 2013 onwards to European Directive 2011/65/EU concerning Restriction of Hazardous Substances (RoHS/RoHS2).
Dialog Semiconductor's statement on RoHS can be found on the customer portal https://support.diasemi.com/. RoHS certificates from our suppliers are available on request.

## Contacting Dialog Semiconductor

United Kingdom (Headquarters)
*Dialog Semiconductor PLC*
Phone: +44 1793 757700

Germany
*Dialog Semiconductor GmbH*
Phone: +49 7021 805-0

The Netherlands
*Dialog Semiconductor B.V.*
Phone: +31 73 640 8822

Email:
enquiry@diasemi.com

North America
*Dialog Semiconductor Inc.*
Phone: +1 408 845 8500

Japan
*Dialog Semiconductor K. K.*
Phone: +81 3 5425 4567

Taiwan
*Dialog Semiconductor Taiwan*
Phone: +886 281 786 222

Web site:
www.dialog-semiconductor.com

Singapore
*Dialog Semiconductor Singapore*
Phone: +65 64 849929

China
*Dialog Semiconductor China*
Phone: +86 21 5178 2561

Korea
*Dialog Semiconductor Korea*
Phone: +82 2 3469 8291