General Description

The DA14531 TINY™ Module, is the first Dialog Bluetooth® Low Energy module based on world's lowest power DA14531 SoC.
The module offers a unique combination of lowest power, integration of all external components including antenna at a very affordable cost.
It is designed to enable use of Bluetooth Low Energy in applications where BLE was prohibitive so far because of cost or complexity. The bigger picture is to drive Bluetooth Low Energy technology into every application, turning every product into a connected IoT node driving the next 1 billion IoT devices in the market.
The SmartBond TINY module is supported by easy to work with software to lower the threshold of using BLE technology or speeding up design time significantly.
It comes with configurable DSPS (serial port service) and a next generation Codeless software to design Bluetooth applications without Bluetooth knowledge or advanced programming skills.
The combination of affordable cost, lowest power and ease of use makes it an ideal product for the mass market, including the makers community.

Key Features

- Bluetooth
  - Compatible with Bluetooth v5.1, ETSI EN 300 328 and EN 300 440 Class 2 (Europe), FCC CFR47 Part 15 (US) and ARIB STD-T66 (Japan) core
  - Supports up to 3 BLE connections
- Processing and memories
  - 16 MHz 32-bit Arm® Cortex® M0+ with SWD interface
  - 128 Kbytes internal FLASH
  - 48 Kbytes RAM
  - 144 Kbytes ROM
  - 32 Kbytes OTP
- Current Consumption
  - 2 mA RX at VBAT=3V
  - 4 mA TX at VBAT=3V and 0 dBm
  - 1.8 uA at sleep with all RAM retained
- Radio
  - Programmable RF transmit power from -19 to +2.2 dBm
  - -93 dBm receiver sensitivity
- Interfaces
  - Quadrature decoder with 3 channels
  - 4 channel 11-bit ENOB ADC
  - 2 general purpose timers with PWM capabilities
  - Built in temperature sensor
  - 9 GPIOs
  - SPI
  - 2x UART, 1wire UART support
  - I2C
- Power Management
  - Operating range (1.8V - 3.3V)
  - Inrush current control
- Other
  - Real Time Clock
- Packaging
  - 12.5 mm x 14.5 mm x 2.8 mm package
- Module Software Development Kit
  - Configurable DSPS
  - Codeless v2.0
  - SDK6 support
- Module Software Tools
  - Flash/OTP programmer
  - SUOTA support
  - Battery Life Estimation
  - Data Rate Monitoring
  - Real-Time Power Profiling
  - Production Line Testing
- Standards Conformance
  - IEC 62368-1
  - EN 62368-1
  - FCC PART 15 C:2017
  - RSS-247 Issue 2
  - RSS-Gen Issue 4

Applications

- Beacons
- Remote Controls,
- Proximity tags
- Low Power Sensors
- Commissioning/Provisioning
- RF pipe
- Toys

Contents

Figures

Tables

1 References

[1] DA14531, Datasheet, Revision 3.0, Dialog Semiconductor.

[2] DA14585/DA14531 SW Platform Reference Manual (can be retrieved via web from https://www.dialog-semiconductor.com/products/connectivity/bluetooth-low-energy/products/da14531)

2 Block Diagram

SmartBond TINY™ module is based on the Dialog Semiconductor DA14531 SoC configured in buck mode. With an integrated 1Mbit flash, 32MHz XTAL and a printed antenna, it allows faster time to market at reduced development cost.

The module, as seen in Figure 1, comprises of:

- 1 Mbit SPI FLASH
- 32MHz XTAL
- 2 decoupling capacitors
- a power inductor
- a CLC filter and matching components for the printed antenna.

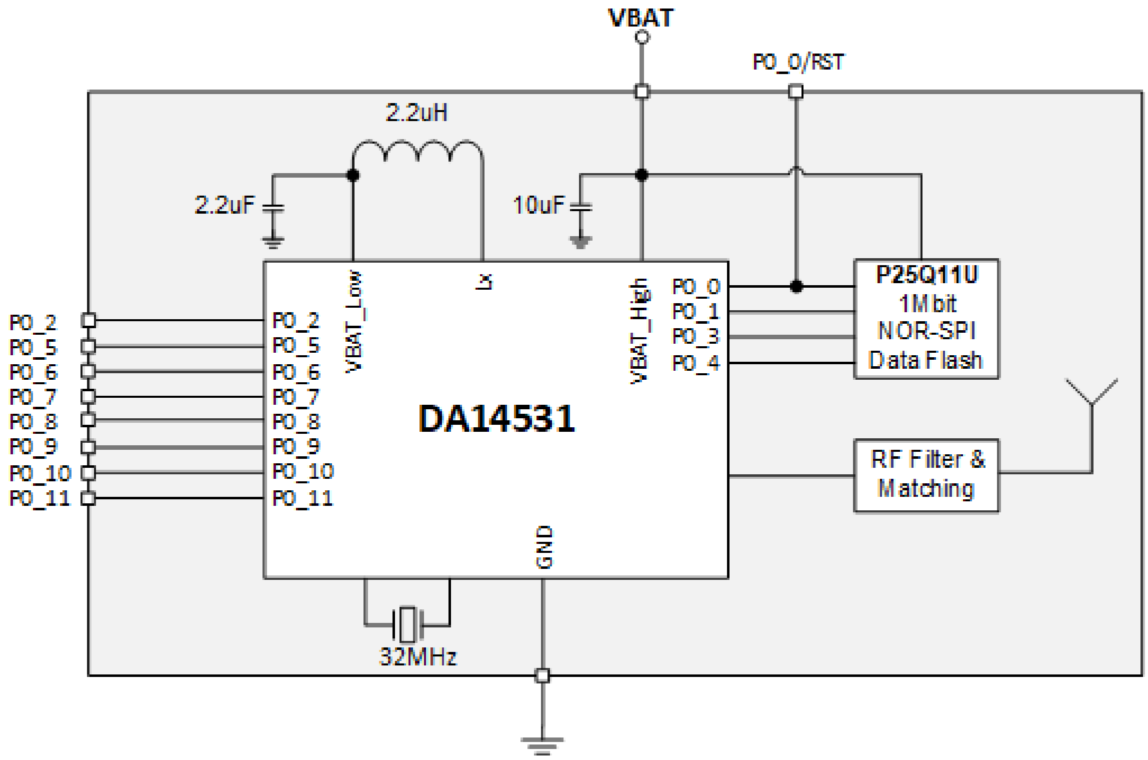


Figure 1: SmartBond TINY Module Block Diagram

SmartBond TINY™ is fully certified across regions.

3 Pinout

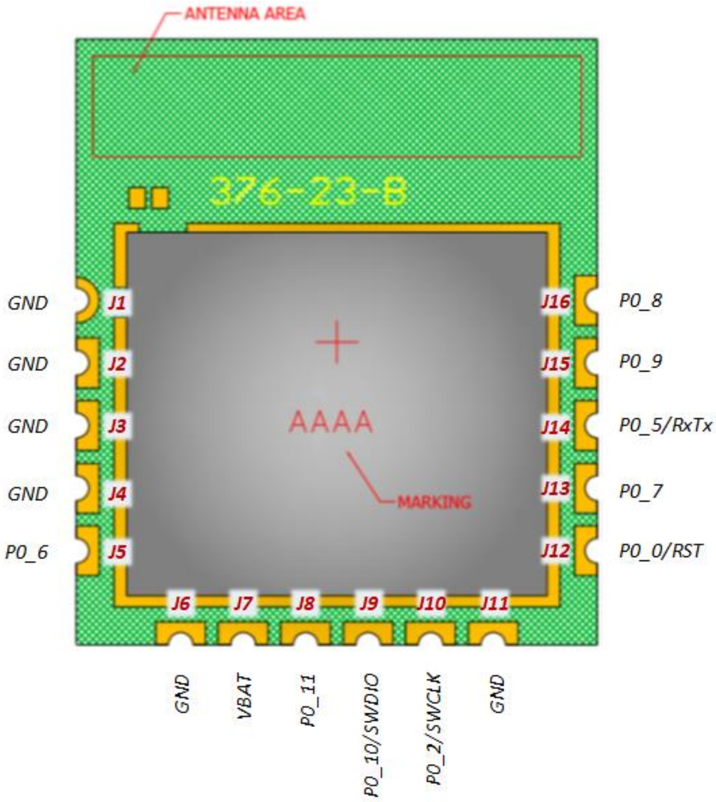


Figure 2: Pinout Diagram Top and Bottom View

Note that, J1 has no internal connection and for this reason presents a difference pad shape. It was used ONLY for providing RF signal for certification purposes.

Table 1: Pin Description

Pin #	Pin Name	Type	Reset State	Description
J1	GND	GND		Ground
J2	GND	GND		Ground
J3	GND	GND		Ground
J4	GND	GND		Ground
J5	P0_6	DIO (Type A) Note[1]	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power down.
J6	GND	GND		Ground

[1] There are two types of pads, namely Type A and Type B. Type A is a normal IO pad with a Schmitt trigger on input while Type B has an extra RC Filter with a cutoff frequency of 100 kHz.

Pin #	Pin Name	Type	Reset State	Description
J7	VBAT	PWR		INPUT. Battery connection. IO supply.
J8	P0_11	DIO (Type A)	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power down.
J9	P0_10	DIO (Type A)	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power down.
	SWDIO			INPUT/OUTPUT. JTAG Data input/output. Bidirectional data and control communication (by default).
J10	P0_2	DIO (Type B)	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power-down.
	SWCLK			INPUT JTAG clock signal (by default).
J11	GND	GND		Ground
J12	P0_0	DIO (Type B) Note [2]	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power-down
	RST			RST active high hardware reset (default).
J13	P0_7	DIO (Type A)	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power down.
J14	P0_5	DIO (Type B)	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power down.

[2] This pin is also used for the communication to the internal SPI FLASH

Pin #	Pin Name	Type	Reset State	Description
J15	P0_9	DIO (Type A)	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power down
J16	P0_8	DIO (Type A)	I-PD	INPUT/OUTPUT with selectable pull up/down resistors. Pull-down enabled during and after reset. General purpose I/O port bit or alternate function nodes. Contains state retention mechanism during power down.

I-PD stands for Input-Pulled Down while I-PU stands for Input-Pulled Up.

DIO stands for Digital Input-Output, PWR stands for power and GND stands for Ground.

4 Characteristics

All MIN/MAX specification limits are guaranteed by design, production testing and/or statistical characterization. Typical values are based on characterization results at default measurement conditions and are informative only.

Default measurement conditions (unless otherwise specified): VBAT= 3.0 V, TA = 25 °C. All radio measurements are performed with standard RF measurement equipment.

4.1 Absolute Maximum Ratings

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, so functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification are not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

Table 2: Absolute Maximum Ratings

Parameter	Description	Conditions	Min	Max	Unit
V_{BAT_LIM}	limiting battery supply voltage		-0.1	3.6	V
T_{STG}	storage temperature		-40	125	°C

4.2 Recommended Operating Conditions

Table 3: Recommended Operating Conditions

Parameter	Description	Conditions	Min	Typ	Max	Unit
V_{BAT}	battery supply voltage	Allowing FLASH programming	1.65		3.3	V
V_{PIN}	voltage on a pin		-0.1		3.3	V
T			-40		85	°C

Parameter	Description	Conditions	Min	Typ	Max	Unit
V_{IH}	HIGH level input voltage	V_{DD}=0.9V	0.7*VDD			V
V_{IL}	LOW level input voltage	V_{DD}=0.9V			0.3*VDD	V

4.3 Device Characteristics

Table 4: DC Characteristics

Parameter	Description	Conditions	Min	Typ	Max	Unit
I_{BAT_ACTIVE}	battery supply current with CPU running CoreMark from RAM at 16MHz			0.42		mA
$I_{BAT\_BLE\_ADV\_100ms}$	Average battery supply current with system in Advertising state (3 channels) every 100ms and extended sleep with all RAM retained. TX output power at 2dBm. FLASH is off.			90		µA
$I_{BAT\_BLE\_CONN\_30ms}$	Average battery supply current with system in a connection state with 30ms connection interval and extended sleep with all RAM retained. TX output power at 2dBm. FLASH is off.			100		µA
I_{BAT_FLASH}	battery supply current with CPU fetching code from serial FLASH. RF is off.			0.24		mA
I_{BAT_HIBERN}	battery supply current with system shut down (Hibernation or shipping mode). FLASH is off.			0.48		µA
I_{BAT_IDLE}	battery supply current with CPU in Wait for Interrupt Mode. FLASH is off.			0.24		mA
$I_{BAT\_SLP\_20KB}$	battery supply current with system in extended sleep mode and 20KB RAM retained			1.5		µA
$I_{BAT\_SLP\_48KB}$	battery supply current with system in extended sleep mode and all RAM retained			1.8		µA

Parameter	Description	Conditions	Min	Typ	Max	Unit
$I_{BAT\_RF\_RX}$	battery supply current	Continuous RX; VBAT=3V; FLASH in sleep mode; DCDC converter is on; T_A = 25 °C		2		mA
$I_{BAT\_RF\_TX\_0dBm}$	battery supply current	Continuous TX;VBAT=3V; FLASH in sleep mode; DCDC converter is on; Output power at 0 dBm; T_A = 25 °C		4		mA
$I_{BAT\_RF\_TX\_+3dBm}$	battery supply current	Continuous TX; VBAT=3V; FLASH in sleep mode; DCDC converter is on; Output power at 3 dBm; T_A = 25 °C		5		mA
$I_{BAT\_RF\_TX\_-3dBm}$	battery supply current	Continuous TX;VBAT=3V; FLASH in sleep mode; DCDC converter is on; Output power at -3 dBm; T_A = 25 °C		3		mA
$I_{BAT\_RF\_TX\_-6dBm}$	battery supply current	Continuous TX;VBAT=3V; FLASH in sleep mode; DCDC converter is on; Output power at -6 dBm; T_A = 25 °C		2.3		mA
$I_{BAT\_RF\_TX\_-12dBm}$	battery supply current	Continuous TX;VBAT=3V; FLASH in sleep mode; DCDC converter is on; Output power at -12 dBm; T_A = 25 °C		1.8		mA
$I_{BAT\_RF\_TX\_-18dBm}$	battery supply current	Continuous TX;VBAT=3V; FLASH in sleep mode; DCDC converter is on; Output power at -18 dBm; T_A = 25 °C		1.5		mA

Table 5: XTAL32MHz - Recommended Operating Conditions

Parameter	Description	Conditions	Min	Typ	Max	Unit
f_{XTAL_32M}	crystal oscillator frequency			32		MHz
Δf_{XTAL}	crystal frequency tolerance	After trimming; including aging and temperature drift	-25		25	ppm

Table 6: Digital IO - Recommended Operating Conditions

Parameter	Description	Conditions	Min	Typ	Max	Unit
V_{IH}	HIGH level input voltage	V_{DD}=0.9V	0.52			V
V_{IL}	LOW level input voltage	V_{DD}=0.9V			0.27	V

Table 7: Digital IO - DC Characteristics

Parameter	Description	Conditions	Min	Typ	Max	Unit
I_{IH}	HIGH level input current	V_I=V_{BAT_HIGH}=3.0V	-10		10	µA
I_{IL}	LOW level input current	V_I=V_{SS}=0V	-10		10	µA
I_{IH_PD}	HIGH level input current	V_I=V_{BAT}=3.0V	60		180	µA
I_{IL_PU}	LOW level input current	V_I=V_{SS}=0V, V_{BAT}=3.0V	-180		-60	µA
V_{OH}	HIGH level output voltage	I_O=3.5mA, V_{BAT}=1.8V	0.8*VBAT			V
V_{OL}	LOW level output voltage	I_O=3.5mA, V_{BAT}=1.8V			0.2*VBAT	V
V_{OH_LOWDRV}	HIGH level output voltage	I_O=0.3mA, V_{BAT}=1.8V	0.8*VBAT			V
V_{OL_LOWDRV}	LOW level output voltage	I_O=0.3mA, V_{BAT}=1.8V			0.2*VBAT	V
C_{IN}	input capacitance			TBD		pF

Table 8: Radio 1Mbps - Recommended Operating Conditions

Parameter	Description	Conditions	Min	Typ	Max	Unit
f_{OPER}	operating frequency		2400		2483.5	MHz
N_{CH}	number of channels			40		1
f_{CH}	channel frequency	K = 0 to 39		2402+K*2		MHz

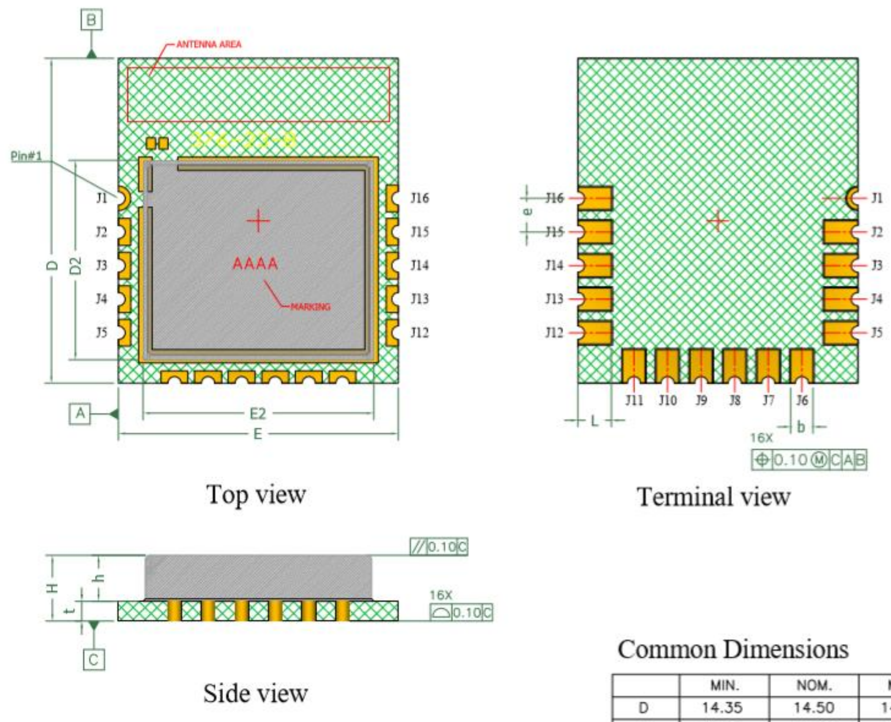
Table 9: Radio 1Mbps - AC Characteristics

Parameter	Description	Conditions	Min	Typ	Max	Unit
P_{SENS_EPKT}	sensitivity level	Extended packet size (255 octets)		-91		dBm

5 Mechanical Specifications

5.1 Dimensions

The module dimensions are presented in the following figure:



NOTE :
ALL DIMENSION ARE IN mm. ANGLES IN DEGREES.
COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
COPLANARITY SHALL NOT EXCEED 0.10 mm.
WARPAGE SHALL NOT EXCEED 0.10 mm.

Common Dimensions

	MIN.	NOM.	MAX.
D	14.35	14.50	14.65
E	12.35	12.50	12.65
D2	8.80	8.90	9.00
E2	10.20	10.30	10.40
b	0.90	1.00	1.10
L	1.40	1.50	1.60
e		1.50 BSC	
H	2.85	2.90	3.05
t		1.0 Max	
h		2.0 REF	

Figure 3: Mechanical Drawing

5.2 PCB Footprint

The footprint for the PCB is presented in the following figure:

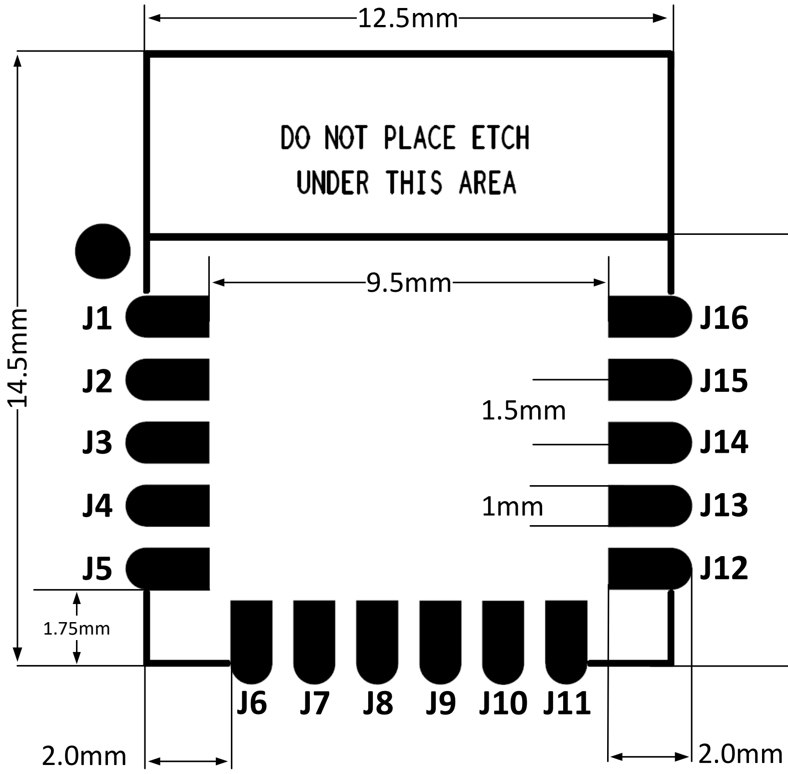


Figure 4: Module Footprint Top View

5.3 Marking

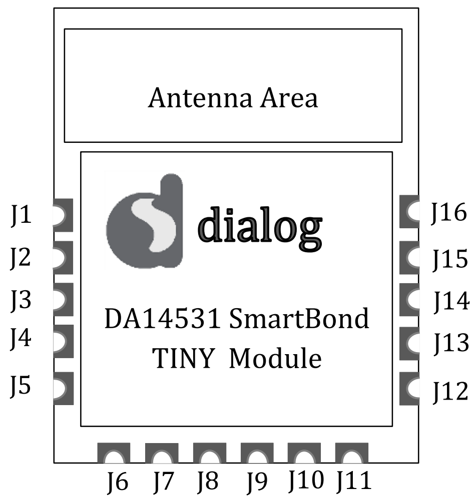


Figure 5: Indicative Module Shield Marking

6 Packaging Information

6.1 Tape & Reel

To be defined

6.2 Labeling

To be defined

7 Application Information

A typical reference diagram of the TINY module is presented in the following figure:

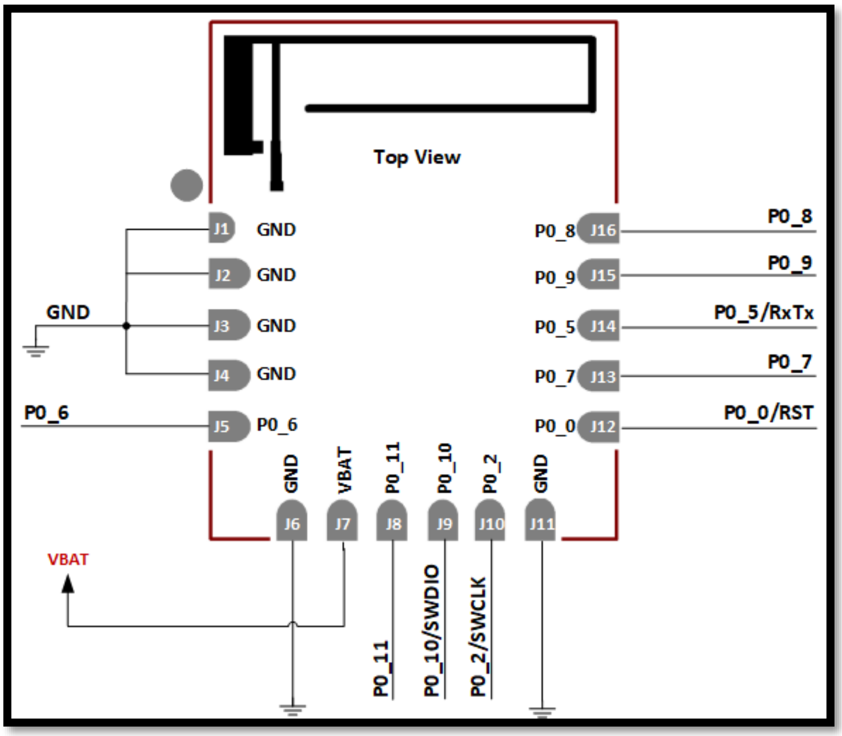


Figure 6: Reference Diagram

There are some special considerations regarding using the TINY module, namely:

- RST signal is shared with the MOSI input of the NOR flash. For this reason, RST must not be driven to GND. When internal Flash is in use, reset functionality is not available.
- The SPI Bus of DA14531 is used for the communication of the BLE SoC with the NOR Flash at boot time. Three of the four signals are not driven to external module pins. For this reason, a sensor that utilizes the SPI bus must be assigned (by software) on to the module pins to communicate with after booting and when NOR Flash is no longer in use. An example is presented in the following figure.

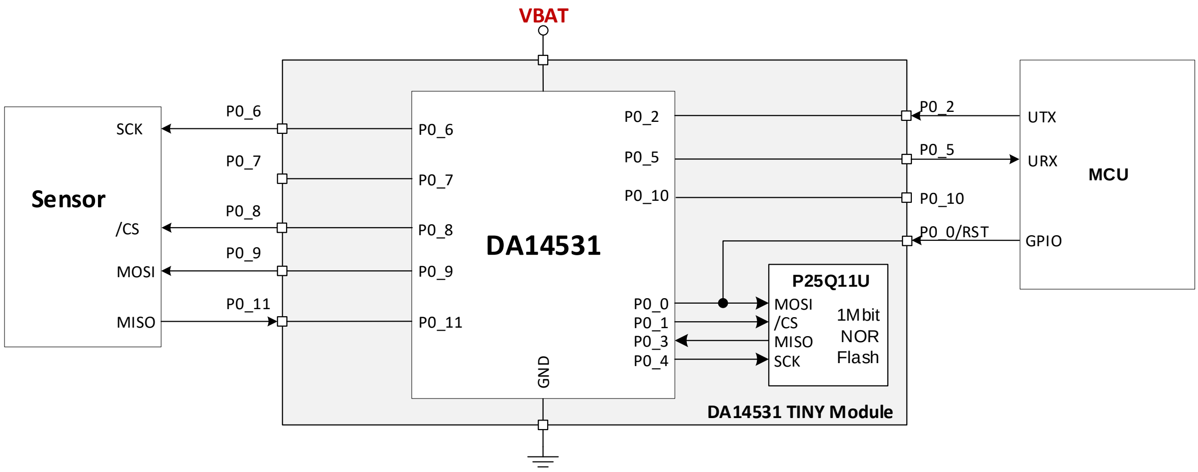


Figure 11: Example of connecting a sensor to the SPI bus and an MCU to RST and UART

Note that P0_0/RST pin should not be driven while the TINY module is booting from its internal SPI FLASH.

8 Design Guidelines

DA14531 SmartBond TINY™ Module comes with an integrated PCB trace antenna. Antenna area is 12x4 mm. The antenna is characterized in terms of Voltage Standing Wave Ratio (VSWR) and efficiency.

The PCB trace antenna radiated performance depends on the host PCB layout. The Antenna gain is better than -3.5 dBi when mounted on a 50x50 mm reference board. Radiation pattern is omnidirectional. The RF front end has been optimized to achieve the maximum possible efficiency for various mounting positions of the module on a host PCB. To obtain similar performance, guidelines described in the following sections should be followed.

8.1 Placement

For optimum performance, the module should be placed at the edge of a host PCB with the antenna edge facing out. The module can be located on either of the outer corners or the middle of the host PCB with equivalent performance.

Proximity with copper or laminate next to the PCB trace antenna affects the efficiency of the antenna. The antenna should have 4 mm free space in all directions. Laminate or copper under the antenna should be avoided as it severely affects the performance of the antenna. Antenna keep-out area can be seen in Figure 8.

Metals close to the antenna will cause degradation on antenna performance. The amount of degradation depends on the host system characteristics.

Following table summarizes antenna efficiency for different placements on a host PCB as indicated in Figure 7.

Table 10: Antenna efficiency vs Tiny Module positions

	Position # 1 (Left)		Position # 2 (Middle)		Position # 3 (Right)	
Freq	Antenna efficiency		Antenna efficiency		Antenna efficiency	
[MHz]	[%]	[dB]	[%]	[dB]	[%]	[dB]
2405	52	-2,8	40	-4,0	40	-4,0
2440	46	-3,4	34	-4,7	41	-3,9
2480	50	-3,0	40	-4,0	52	-2,8

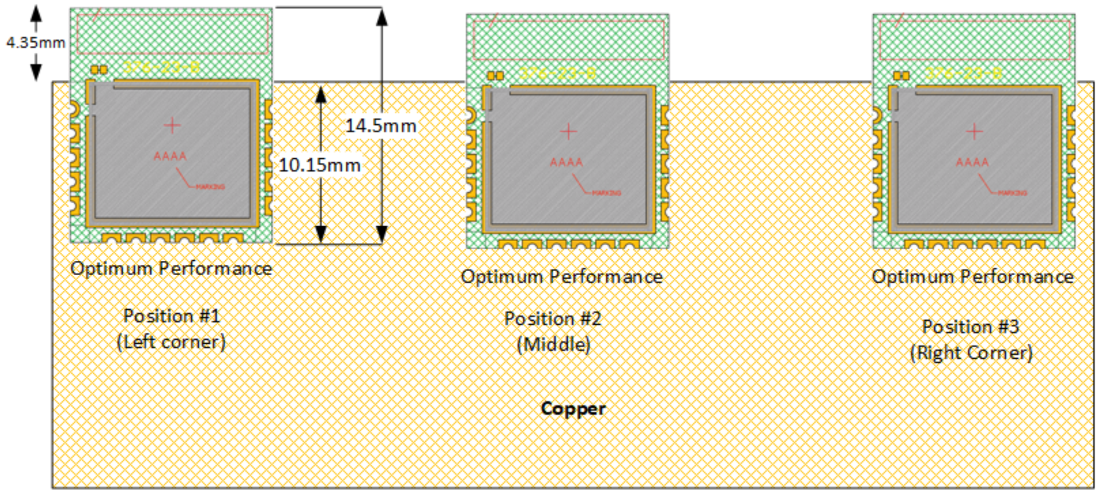


Figure 7: Mounting positions for optimum Antenna Performance

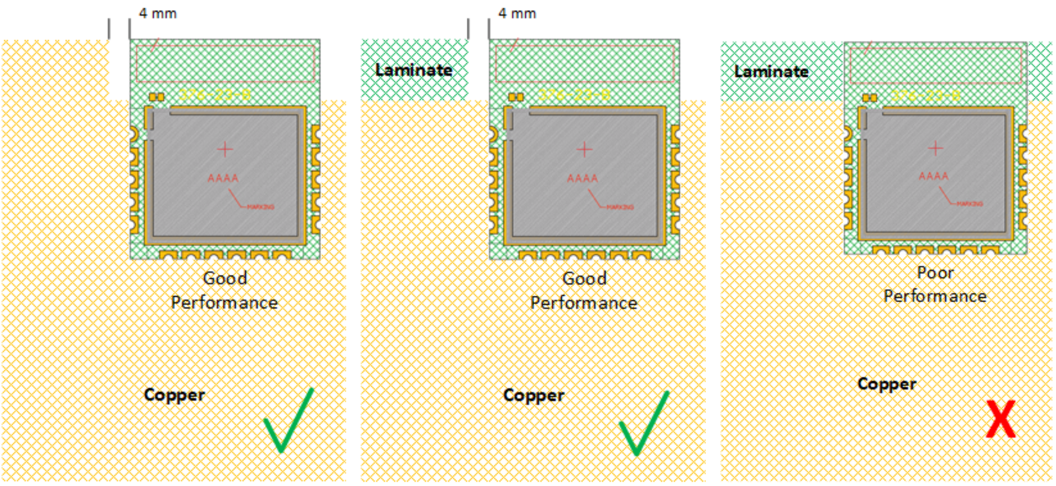


Figure 8: Antenna Performance proximity with copper(left), laminate(middle) and laminate under antenna (right)

The actual Tiny module evaluation board layout that has been used to conduct all measurements is presented in the following figure:

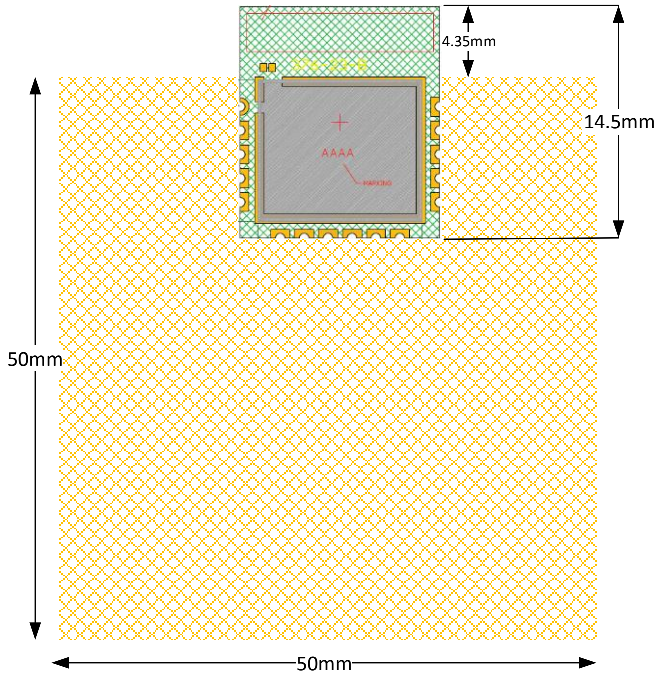


Figure 9: Tiny Module Evaluation Board

8.2 Antenna graphs

Antenna VSWR measurements for the three mounting positions are described in the following figures.

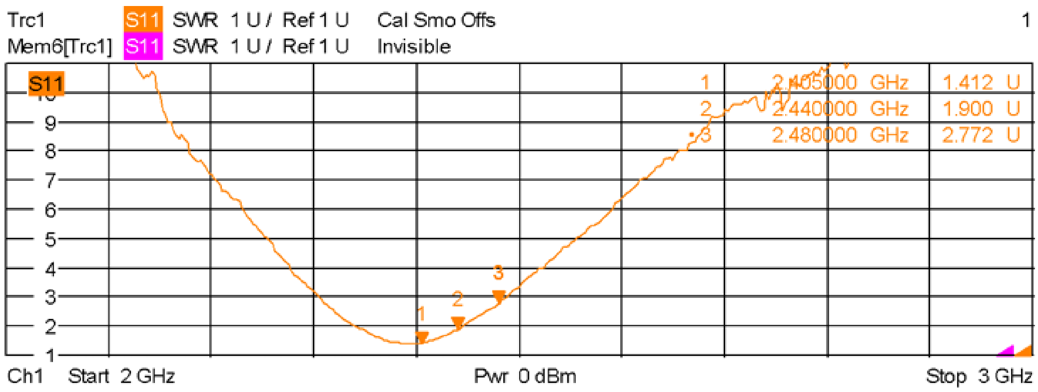


Figure 10: VSWR mounted in the upper left corner (Position #1) of evaluation board

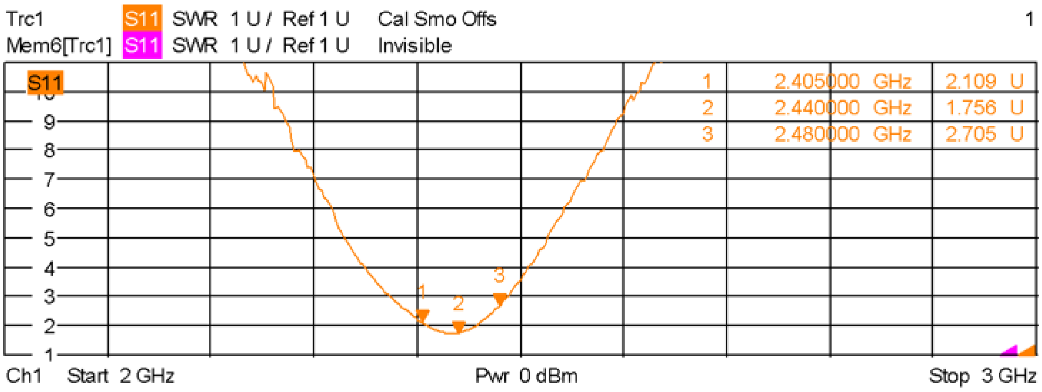


Figure 11: VSWR with module mounted in center (Position #2) of the evaluation board

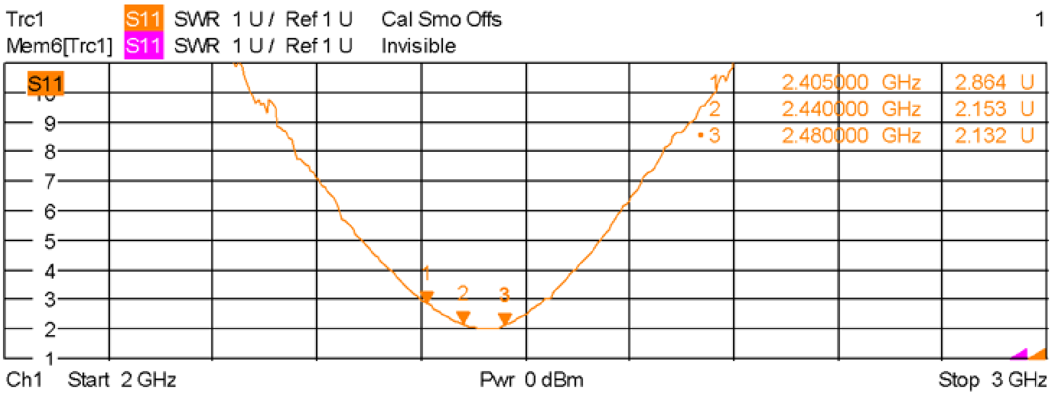


Figure 12: VSWR with module mounted in the upper right corner (Position #3) of the evaluation board

8.3 Radiation pattern

The antenna radiation pattern measurements are carried out in an anechoic chamber. Radiation patterns are presented for three measurement planes: XY-, XZ- and YZ- planes with horizontal and vertical polarization of the receiving antenna.

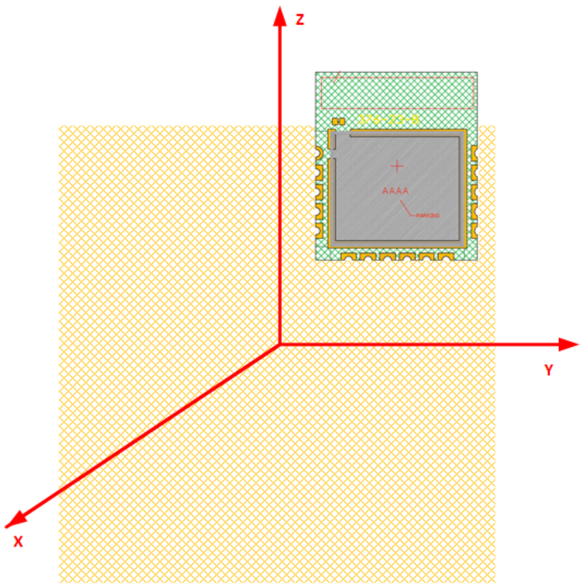


Figure 13: Measurement plane definition

Measurements are carried out for the module mounted in the upper right corner on the reference board with no laminate below antenna trace.

Radiation pattern for antenna trace

Horizontal polarization	Vertical polarization

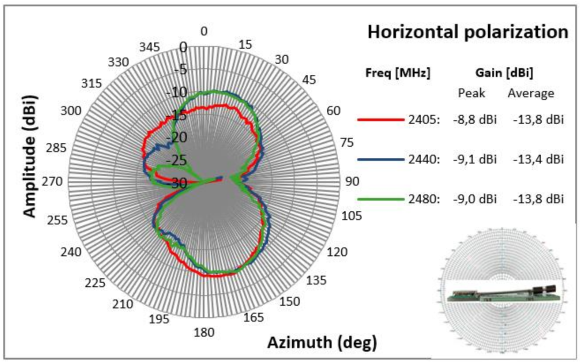


Figure 14: Radiation pattern for XY-plane, horizontal polarization.

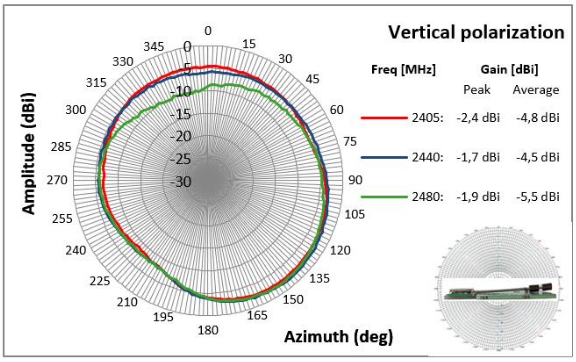


Figure 15: Radiation pattern for XY-plane, vertical polarization.

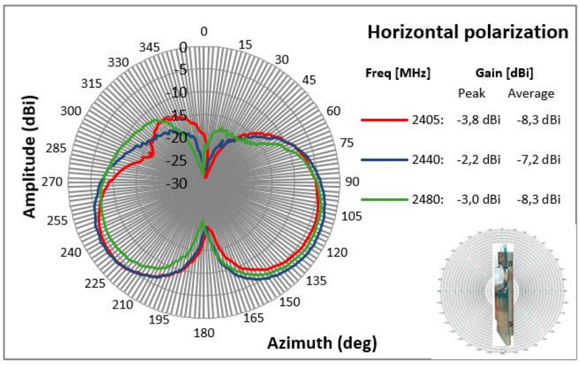


Figure 16: Radiation pattern for XZ-plane, horizontal polarization.

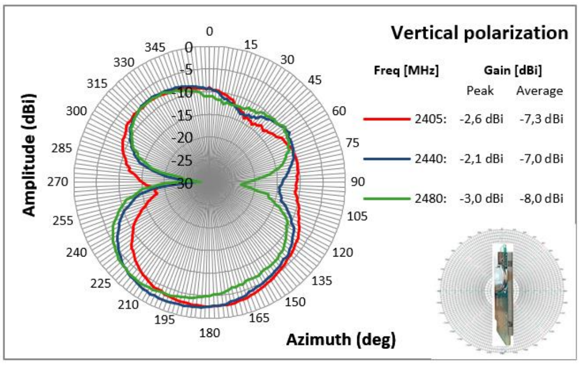


Figure 17: Radiation pattern for XZ-plane, vertical polarization.

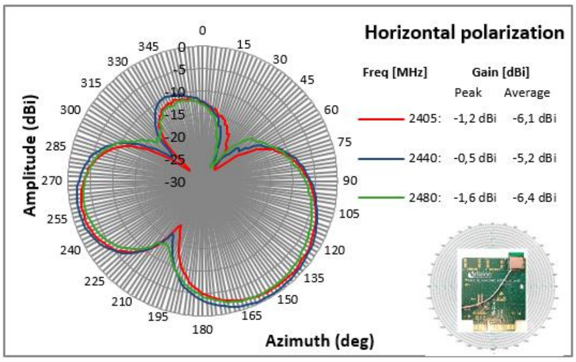


Figure 18: Radiation pattern for YZ-plane, horizontal polarization.

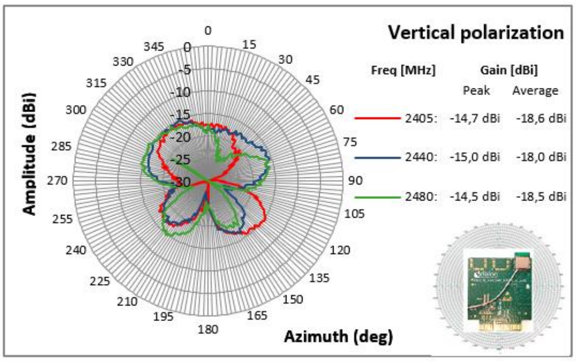


Figure 19: Radiation pattern for YZ-plane, vertical polarization.

9 Soldering

To be defined.

10 Ordering Information

The ordering number consists of the part number followed by a suffix indicating the packing method. For details and availability, please consult your Dialog Semiconductor local sales representative.

Table 11: Ordering Information

Part Number	Size (mm)	Shipment Form	Pack Quantity
DA14531MOD-00F0100	12.5 x 14.5 x 2.8	Reel	1 Kpcs

11 Regulatory Information

This section outlines the regulatory information for DA14531 Tiny Module. The module is certified for a global market. This facilitates the user end-product market entry. Follows a list with the Conformance Standards that DA14531 Tiny Module meets. Please notice that the end-product would need to apply for the end-product certification, however module certification listed below will facilitate this procedure.

Table 12: Standards Conformance

Area	Item	Service	Standard
Global	Safety for module	CB	IEC 62368-1
Europe	Wireless	RED	-
	Safety for module	CE	EN 62368-1
US/CA	Wireless	FCC ID	FCC PART 15 C:2017
		IC ID	RSS-247 Issue 2: February 2017 RSS-Gen Issue 4: November 2014
Japan	Wireless	MIC	JRL
Taiwan	Safety For Module	BSMI	-
	Wireless	NCC	-
South Korea	Wireless	MSIP	-
Australia/New Zealand	Wireless	RCM	-
South Africa	Wireless	ICASA	-
Brazil	Wireless	Anatel	-
China	Wireless	SRRC	-
Thailand	Wireless	NBTC	-

When end user sends end-product to those markets, the end-product may need to follow additional requirement according to specific market regulation.
For example, some markets have additional testing and/or certification like Korea EMC, South Africa SABS EMC and some have requirement on end-product label to put modular approval ID or mark which consists of approved BLE modular ID on host label directly, like Japan, Taiwan, Brazil.

12 Environmental Information

To be defined

Revision History

Revision	Date	Description
1.0	6-March-2020	Initial target datasheet version
○		

Status Definitions

Revision	Datasheet Status	Product Status	Definition
1.<n>	Target	Development	This datasheet contains the design specifications for product development. Specifications may be changed in any manner without notice.
2.<n>	Preliminary	Qualification	This datasheet contains the specifications and preliminary characterization data for products in pre-production. Specifications may be changed at any time without notice in order to improve the design.
3.<n>	Final	Production	This datasheet contains the final specifications for products in volume production. The specifications may be changed at any time in order to improve the design, manufacturing and supply. Major specification changes are communicated via Customer Product Notifications. Datasheet changes are communicated via www.dialog-semiconductor.com.
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