Product utilizing with SESUB Technology

[SESUB : Semiconductor Embedded in SUBstrate]

Bluetooth V4.0 Low Energy Module

Type : SESUB-PAN-T2541

[EPCOS Code] : B30000P8014Y971

Features

- **General**
  - Bluetooth V4.0 Low Energy Module, its size of 4.6mm x 5.6mm x 1.0mm, only possible using TDK proprietary SESUB technology embedding Texas Instruments CC2541 semiconductor and integrating the function required components.
  - Space saving, <26mm^2 total package size compared with 36mm^2 as discrete solution.
  - Module Height of 1.0mm (typ).
  - 36 user pins with center GND pads, 0.5mm pad pitch with solder bumped LGA.
  - Complete module solution allowing just plug and play to the antenna, giving the designers more flexibility in small area solutions
  - All development tools provided from Texas Instruments for discrete CC2541 package IC can be used for this module without any modification.
  - Embedded Bluetooth-Stack from Texas Instruments available.

- **RF**
  - 2.4GHz Bluetooth Low Energy Mode.
  - Programmable Output Power up to 0 dBm.
  - Accurate Digital RSSI Support.
  - Suitable for Systems Targeting Compliance With Radio Frequency Regulations: ARIB STD-T66 (Japan).

- **Microcontroller**
  - High-Performance and Low-Power 8051 Microcontroller Core with Code Prefetch.
  - 256KB of In-System-Programmable Flash.
  - 8KB RAM.

- **Peripherals**
  - Five-Channel DMA.
  - General-Purpose Timers (One 16-bit, Two 8-bit).
  - I2C Interface.
  - 32kHz Sleep Timer with Capture.
  - Battery Monitor and Temperature Sensor.
  - 12-bit ADC with Eight channels and Configurable Resolution.
  - AES Security Coprocessor.
  - Two UARTs with supporting for Several Serial Protocols.
  - Total 23 General Purpose I/O Pins (21 x 4mA, 2 x 20mA output current capable).
  - Watchdog Timer.
  - Integrated High-Performance Comparator.

- **Development Tools**
  - Pin-Out Compatible with Texas Instruments “CC2541EMK” Evaluation Module Kit.
  - Capable to use Texas Instruments SmartRF™ Software.

- **Applications**
  - Human-Interface Devices (Keyboard, Mouse, Remote Control).
  - Sports and Leisure Equipments.
  - Fitness / Healthcare Products
  - Sensor Monitoring Products
  - Gaming
  - Wearable Products
  - Mobile Phone Accessories
  - Digital Consumer Electronics

Block Diagram

The module block diagram is shown in Figure 1.

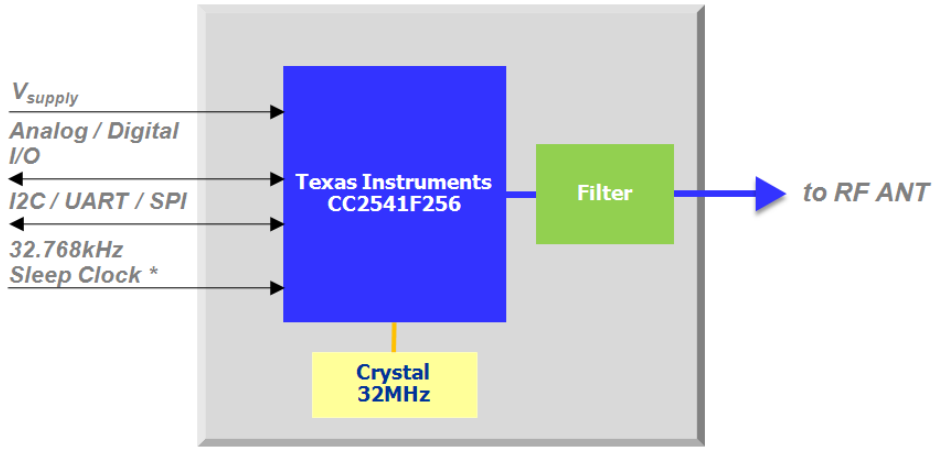


Figure 1 Module Block Diagram

Remark *

External 32.768 kHz crystal or external 32.768 kHz clock input from other device can be used.

Schematic

The module Schematic is shown in Figure 2.

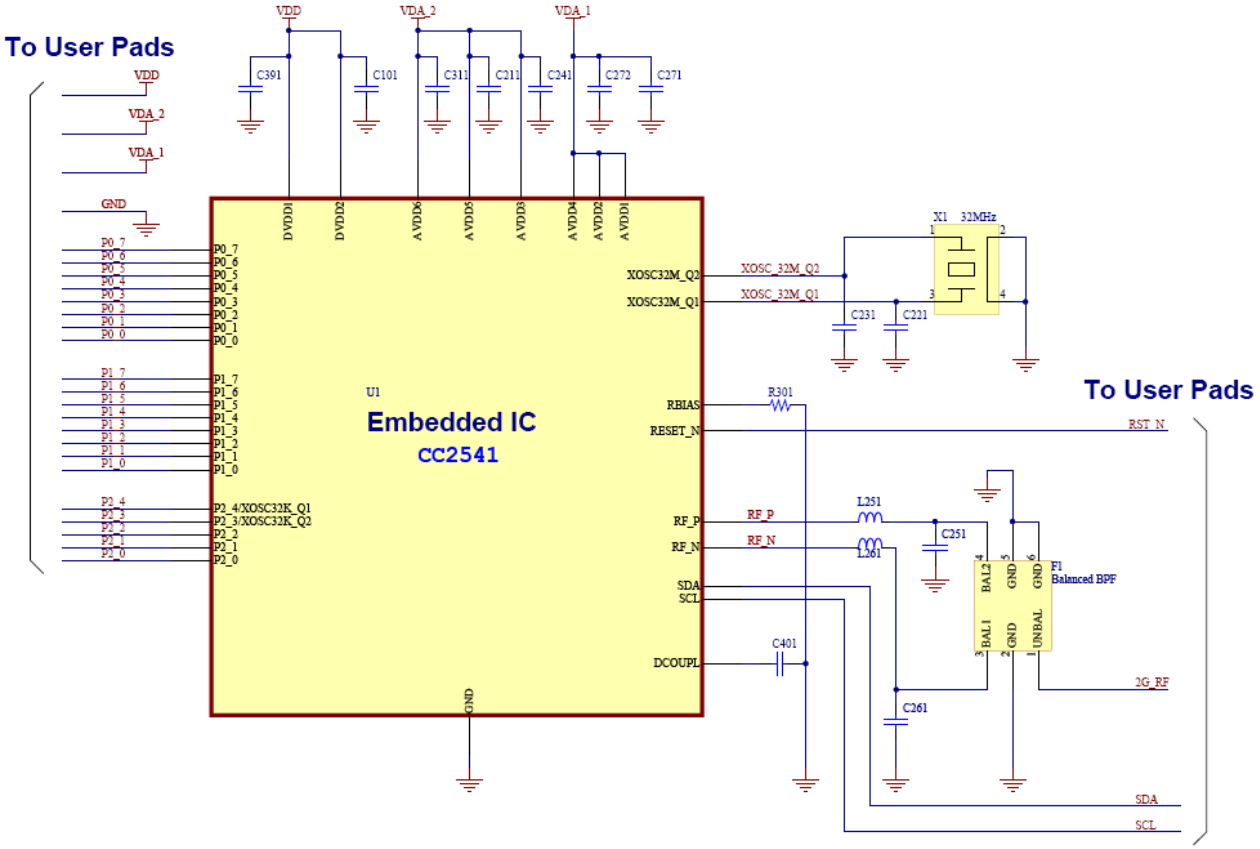


Figure 2 Module Schematic

Absolute Maximum Ratings

Over operating room temperature range (unless otherwise noted)

Item	VALUE	UNIT
Supply voltage range	-0.3 to 3.9	V
Voltage range to any of digital pins	-0.3 to VDD + 0.3, <3.9	V
Storage temperature range	-40 to +85	℃
Radio input power level	+10	dBm
ESD (Charged Device Model)	500	V
ESD (Human Body Model)	1000	V

Operating Conditions

Over operating room temperature range (unless otherwise noted)

Item	Min	Typ	Max	UNIT
Supply voltage range	2.0		3.6	V
Operational temperature range	-20		+70	℃

Electrical Characteristics

Measured on SP13801 EM board with the condition of Ta=25℃+/-10℃ and VDD = 3V

PARAMETER	Conditions	Value			UNIT
		Min	Typ	Max	
Rx mode Current	RF input PWR level: -70dBm Packet type: RF_PHY_TEST Payload Data Pattern: PRBS9 Payload Data Length: 37bytes		19.8		mA
Tx mode Current	RF output PWR level: 0dBm Payload Data Pattern: PRBS9 Payload Data Length: 37bytes		20.6		mA
Standby mode Current	PM2 (Sleep Timer On) *refer IC datasheet in detail*		1.2		μA

General RF Characteristics

Measured on SP13801 EM board with the condition of Ta=25℃+/-10℃ and VDD = 3V

PARAMETER	Conditions	Value			UNIT
		Min	Typ	Max	
Center Frequency		2402		2480	MHz
Channel Spacing			2		MHz
RF Port Impedance			50		Ohm

RF Characteristics

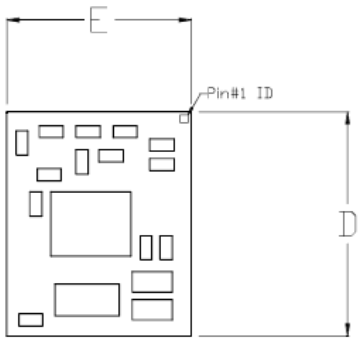
Measured on SP13801 EM board with the condition of Ta=25℃+/-10℃ and VDD = 3V

fc=2440MHz

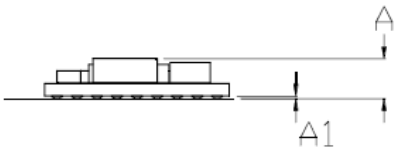
PARAMETER	Conditions	Value			UNIT
		Min	Typ	Max	
Tx Output Power	Maximum output power setting	-6	0	-	dBm
Tx Frequency accuracy	Maximum output power setting XOSC32M_TUNE[3:0]= 0x0F	-150	0	+150	kHz
Tx modulation characteristics					
Delta F1		225		275	kHz
Delta F2/F1		0.8			-
Delta F2 Max		99.9			%
Receiver Sensitivity max input level [measured by Packet Error Rate]	Packet error rate : ≤ 30.8%	-10			dBm
Receiver Sensitivity level [measured by Packet Error Rate]	Packet error rate : ≤ 30.8%			-70	dBm

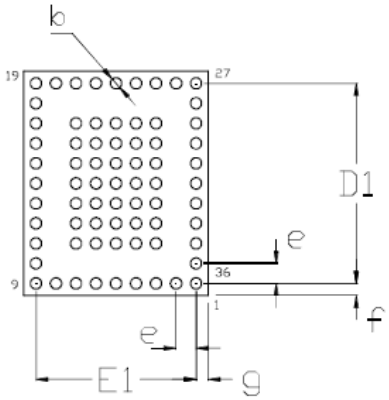
Mechanical Dimensions

The module mechanical dimensions are shown in Figure 3.



TOP VIEW





BTTOM VIEW

Symbol	Dimmension in mm		
	MIN	TYP	MAX
A		1.0	1.2
A1	---	(0.06)	---
b	---	ø0.28	---
D	5.5	5.6	5.7
E	4.5	4.6	4.7
D1		5.0	
E1		4.0	
e		0.5	
f	---	0.3	---
g	---	0.3	---

Figure 3 Module Mechanical Dimensions

Module Pin-Out

The module Pin-Out and names are shown in Figure 4 and Table 1.

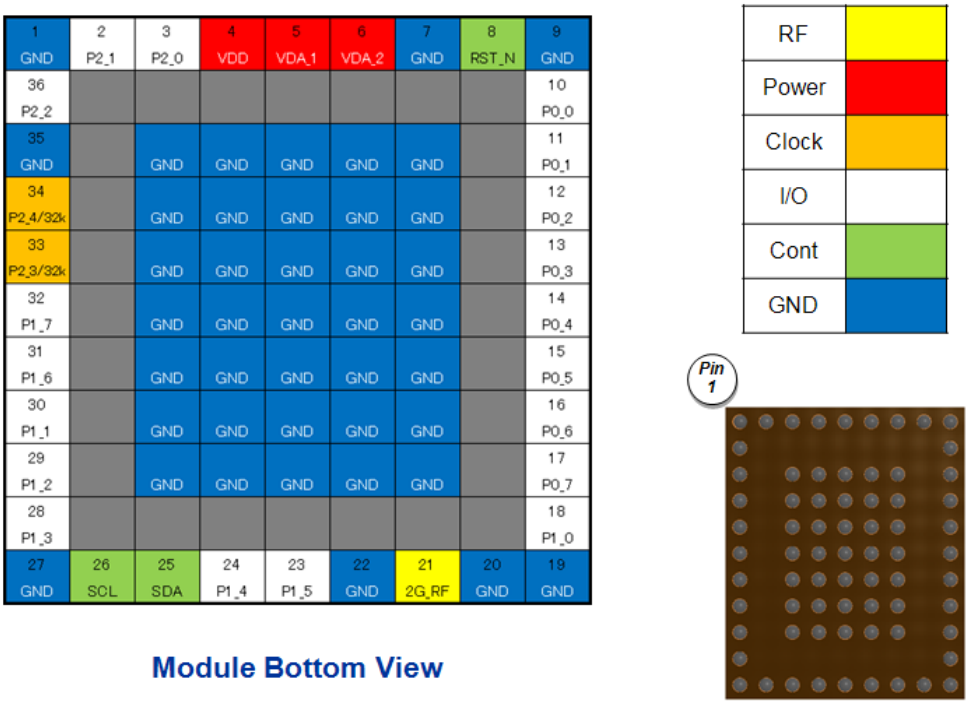


Figure 4 Module Pin-Out & Color Definition

Table 1 PIN Descriptions

Pin Nr	Pin Name	Pin Type	Description
1	GND	Ground	Connect to Ground
2	P2_1/DD	Digital I/O	Port2.1 / Programming I/F DD
3	P2_0	Digital I/O	Port2.0
4	VDD	Power	2V-3.6V digital power supply
5	VDA_1	Power	2V-3.6V analog power supply
6	VDA_2	Power	2V-3.6V analog power supply
7	GND	Ground	Connect to Ground
8	RST_N	Digital I/O	Reset in active low
9	GND	Ground	Connect to Ground
10	P0_0	Digital I/O	Port0.0
11	P0_1	Digital I/O	Port0.1
12	P0_2	Digital I/O	Port0.2 / UART RX / SPI MISO
13	P0_3	Digital I/O	Port0.3 / UART TX / SPI MOSI
14	P0_4	Digital I/O	Port0.4 / UART CTS / SPI CS
15	P0_5	Digital I/O	Port0.5 / UART RTS / SPI CLK
16	P0_6	Digital I/O	Port0.6

Pin Nr	Pin Name	Pin Type	Description
17	P0_7	Digital I/O	Port0.7
18	P1_0	Digital I/O	Port1.0 – 20mA drive capability
19	GND	Ground	Connect to Ground
20	GND	Ground	Connect to Ground
21	2G_RF	RF I/O	Connect to RF antenna
22	GND	Ground	Connect to Ground
23	P1_5	Digital I/O	Port1.5
24	P1_4	Digital I/O	Port1.4
25	SDA	Digital I/O	I2C SDA // Leave floating if not used.
26	SCL	Digital I/O	I2C SCL // Leave floating if not used.
27	GND	Ground	Connect to Ground
28	P1_3	Digital I/O	Port1.3
29	P1_2	Digital I/O	Port1.2
30	P1_1	Digital I/O	Port1.1 – 20mA drive capability
31	P1_6	Digital I/O	Port1.6
32	P1_7	Digital I/O	Port1.7
33	P2_3/32k-1	I/O / Clock	Port2.3 / 32.768kHz crystal1
34	P2_4/32k-2	I/O / Clock	Port2.4 / 32.768kHz crystal2
35	GND	Ground	Connect to Ground
36	P2_2/DC	Digital I/O	Port2.2 / Programming I/F DC

Table 2 Peripheral I/O Pin Mapping

Periphery/ Function	P0								P1								P2				
	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	4	3	2	1	0
ADC	A7	A6	A5	A4	A3	A2	A1	A0													T
Operational amplifier						O	–	+													
Analog comparator			+	–																	
USART 0 SPI			C	SS	MO	MI															
Alt. 2											M0	MI	C	SS							
USART 0 UART			RT	CT	TX	RX															
Alt. 2											TX	RX	RT	CT							
USART 1 SPI			MI	M0	C	SS															
Alt. 2									MI	M0	C	SS									
USART 1 UART			RX	TX	RT	CT															
Alt. 2									RX	TX	RT	CT									
TIMER 1		4	3	2	1	0															
Alt. 2	3	4												0	1	2					
TIMER 3												1	0								
Alt. 2									1	0											
TIMER 4															1	0					
Alt. 2																		1			0
32-kHz XOSC																	Q1	Q2			
DEBUG																			DC	DD	
OBSSEL											5	4	3	2	1	0					

Notes:

This table is referred from the “CC2541 User Guide” (swru191). See description about I/O Pins in section 7. SESUB-PAN-T2541 has same I/O Pin structure with CC2541 SoC.

Evaluation Board Information

SP13801 EM Board is fully pins compatible to Texas Instruments Smart RF Studio Evaluation Board. The SP13801 board can be connected to TI's SmartRF05 Evaluation Board. (see reference information in following section.)

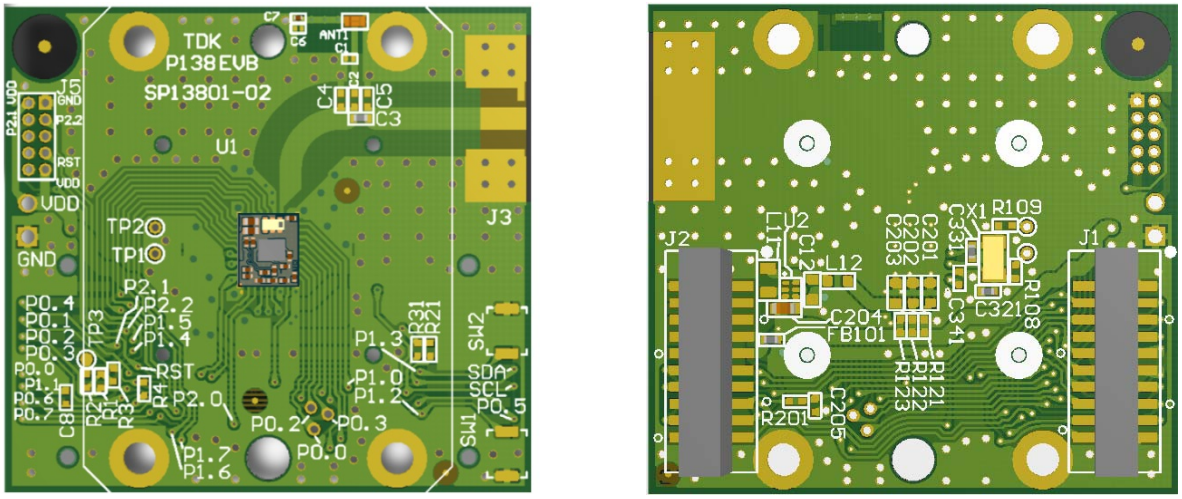


Figure 5 SP13801 EM Board

SP13801 evaluation board has two options for 32.768kHz clock source.

a) External 32.768kHz sleep clock input

External 32.768 kHz clock can be input from other microcontroller as for sleep clock.

To enable the clock input from other clock source, R109 must be jumper and input clock at the TP2.

b) 32.768kHz crystal Unit mounting

A 32.768 kHz crystal Unit can be mounted on SP13801 EM Board stand alone operation without other microcontroller output clock signal as optional.

Testing Condition:

When testing the module, the following parts are mounted to the SP13801 EM Board.

Table 3 SP13801 BOM list

Designator	Part Type	Manufacturer Part Number	Manufacturer
X1	32.768kHz, 12.5pF, +/-20ppm	FC-135 32.768kHz 12.5/20	EPSON
C321, C331	18pF, 50V, +/-5%, C0G	C1005C0G1H180J	TDK-EPC
C3	10pF, 50V, +/-5%, C0G	C1005C0G1H100D	TDK-EPC
C204	2.2uF, 10V, +/-10%, X5R	C1608X5R1A225K	TDK-EPC
J1, J2	Board to Board Connector	SFM-110-02-SM-D-A-K	SAMTEC
FB101	1000ohm, 250mA	BLM15HG102SN1D	MURATA
J3	SMA RF connector	---	---

External 32.768 kHz Crystal Unit

Item	Conditions	Value			UNIT
		Min	Typ	Max	
Crystal frequency			32.768		kHz
Crystal frequency accuracy requirement *		-40		+40	ppm
ESR Equivalent series resistance			40	130	kΩ
Co Crystal shunt capacitance			0.9	2	pF
CL Crystal load capacitance			12	16	pF
Start-up time			400		mS

Remark*

Including aging and temperature dependency

Module Pick & Place Point

This module can be handled at the area where shown in red colored break during assembling.
The area is 2.0x1.6mm. (Picking up with top of the crystal Unit)

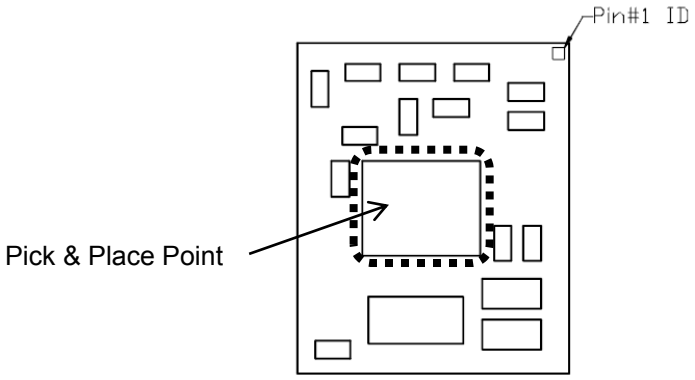


Figure 6 Module Pick & Place Point

Marking

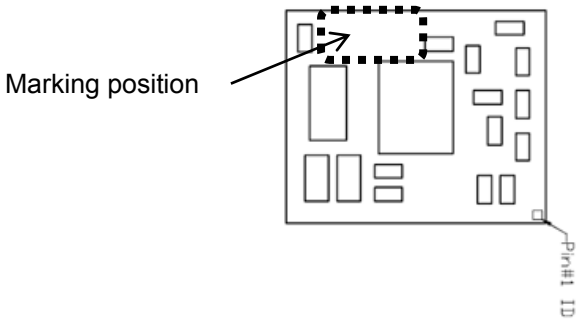
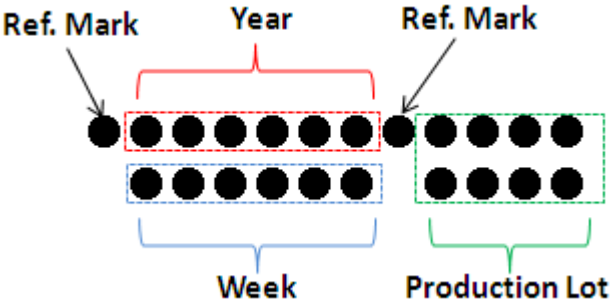


Figure 7 Module Marking Position

	Dot					
Year (Last 2 digits)	● 1	● 2	● 4	● 8	● 16	● 32
	Dot					
Week	● 1	● 2	● 4	● 8	● 16	● 32



	Dot			
Production Lot	● 1	● 2	● 4	● 8
	● 16	● 32	● 64	● 128

(Maximum Production = 225 Lots)

Example

Year : 2013

Week : 45

Production Lot : 25

Figure 8 Module lot code

Recommended PWB Footprint

The recommended PWB foot print for the module is shown in Figure 9.

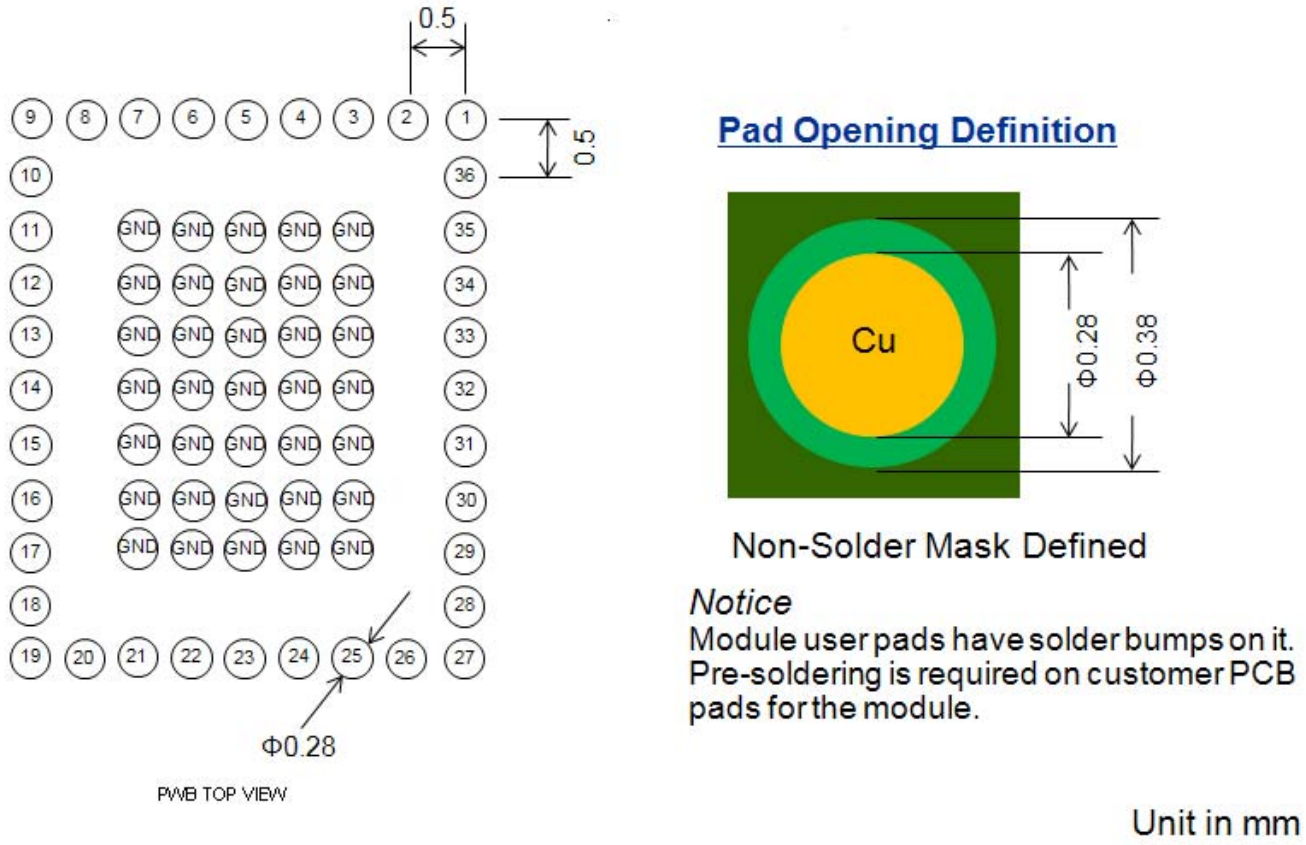


Figure 9 Recommended PWB Footprints

Recommended Metal Mask Design

The recommended metal mask design for the module is shown in Figure 10.

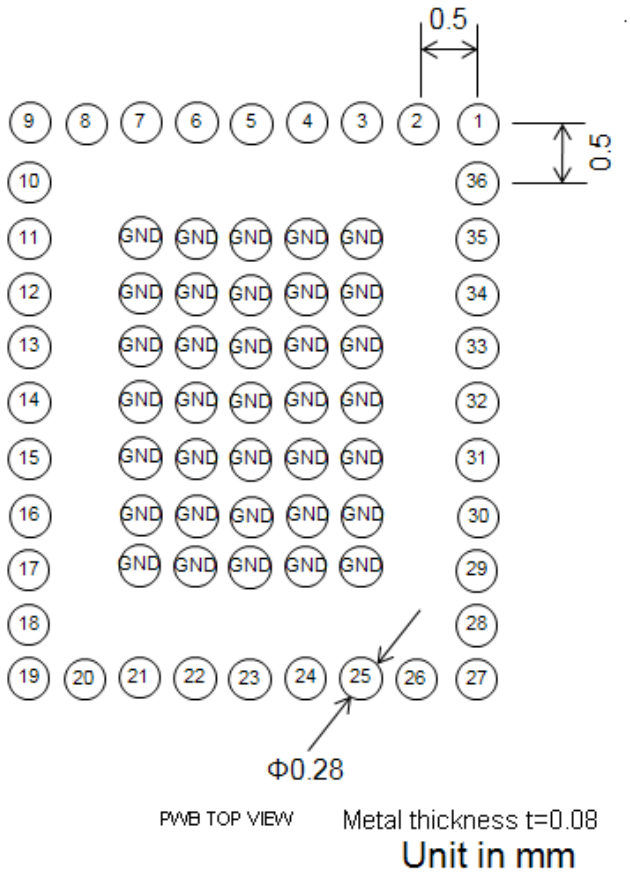


Figure 10 Recommended Metal Mask Design

Recommended Reflow Profile

The recommended reflow profile for the module is shown in Figure 11.

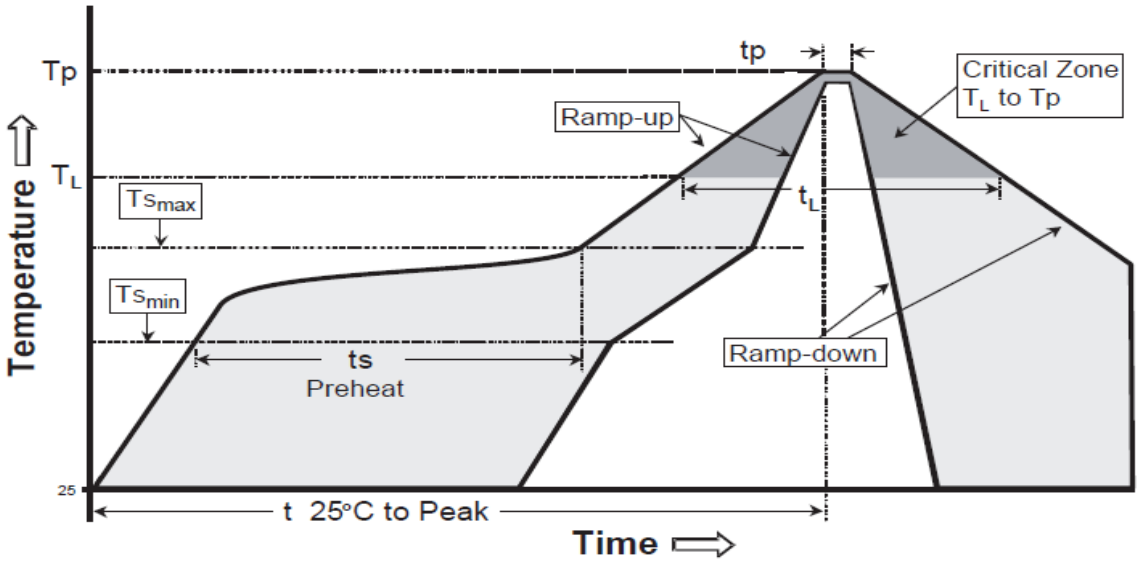


Figure 11 Recommended Reflow Profile

Table 4 Reflow Profile Condition

Profile Feature	Range
Average Ramp-Up Rate (Ts_{max} to Tp)	0.8 °C/seconds
Preheat: -Temperature Min (Ts_{min}) -Temperature Max (Ts_{max}) -Time (ts_{min} to ts_{max})	 150 °C 180 °C 100 +/-10 seconds
Time maintained above: -Temperature (T_L) -Time (t_L)	 220 °C 50 +/-10 seconds
Peak Temperature (Tp)	250 °C
Time within 5°C of actual Peak Temperature (tp)	20-40 seconds
Ramp-Down Rate	6 °C/seconds max.
Time 25°C to Peak Temperature	8 minutes max.

Note:

Solder material used in this product: M705-GRN260K2KJ-V (Senjyu Metal Industry Co., Ltd.)

Permissible maximum reflow cycle: 2

Tape & Reel Specifications

Reel Diameter: 180 mm
Reel Width 13.0mm
Reel Hub Diameter: 21mm
Qty/reel: 1000 pcs

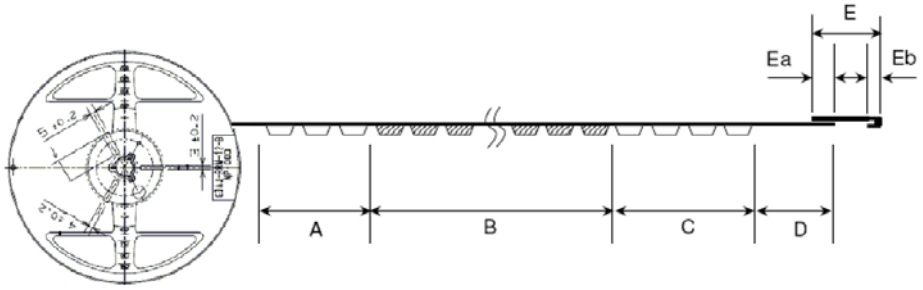


Figure 12 Tape & Reel Definition

Table 5 Taping Length

A	B	C	D	E
Ending pockets	Products pockets	Front pockets	Cover tape	Stop Tape
40mm min	1000pcs	100mm min	250mm min	50mm
		350mm min		70mm

Ea=20mm typ, Eb=10mm typ.

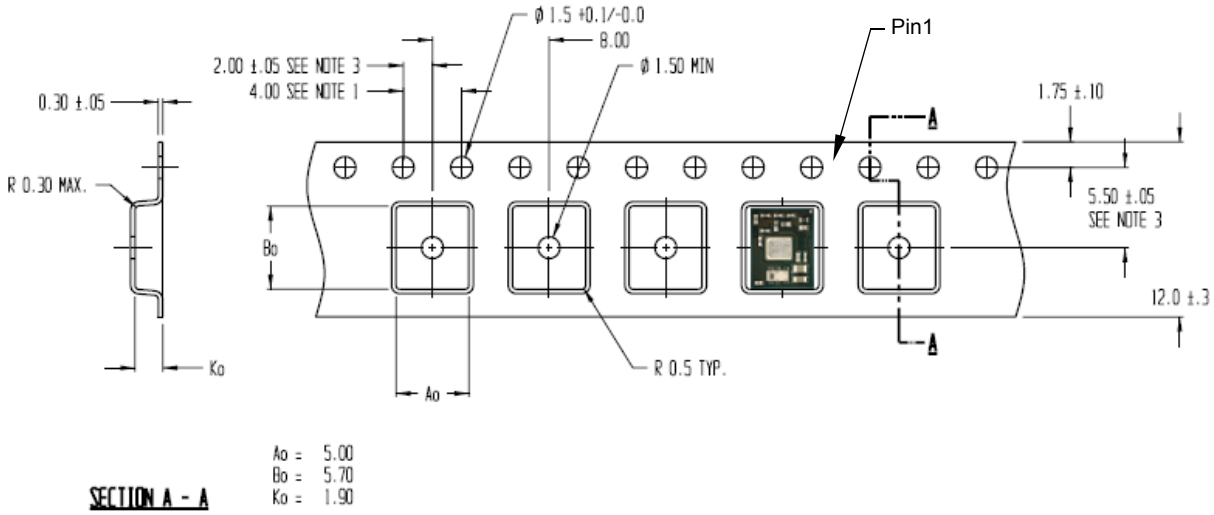


Figure 13 Carrier Tape Dimension

Notes:

1) 10 Sprocket hole pitches cumulative tolerance +/-0.2.
2) Pocket position relative to sprocket hole measured as true position, not pocket hole
3) Ao and Bo are calculated on a plane at a distance “R” above the bottom of the pocket.

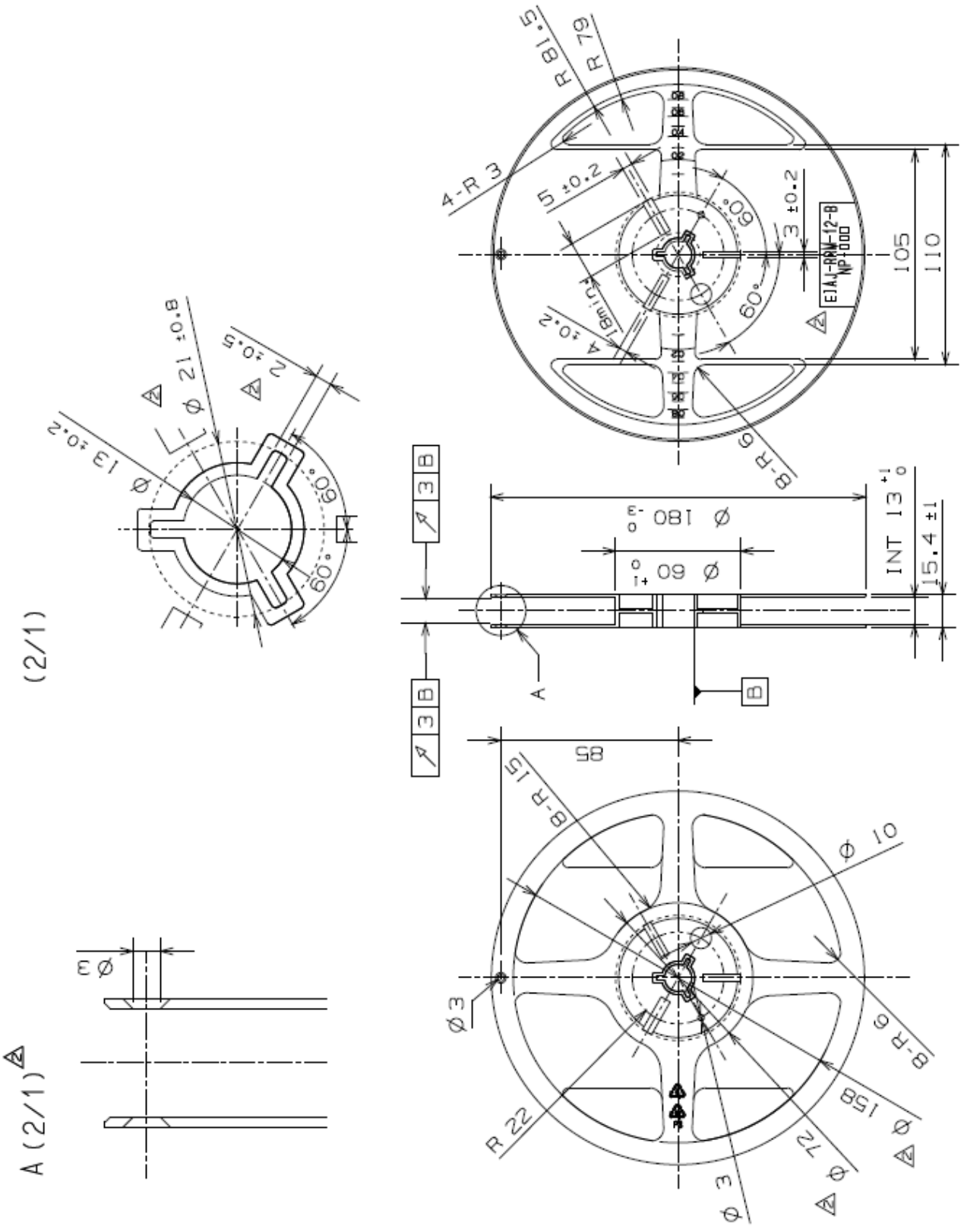


Figure 14 Emboss Definition

Packing Label Specifications

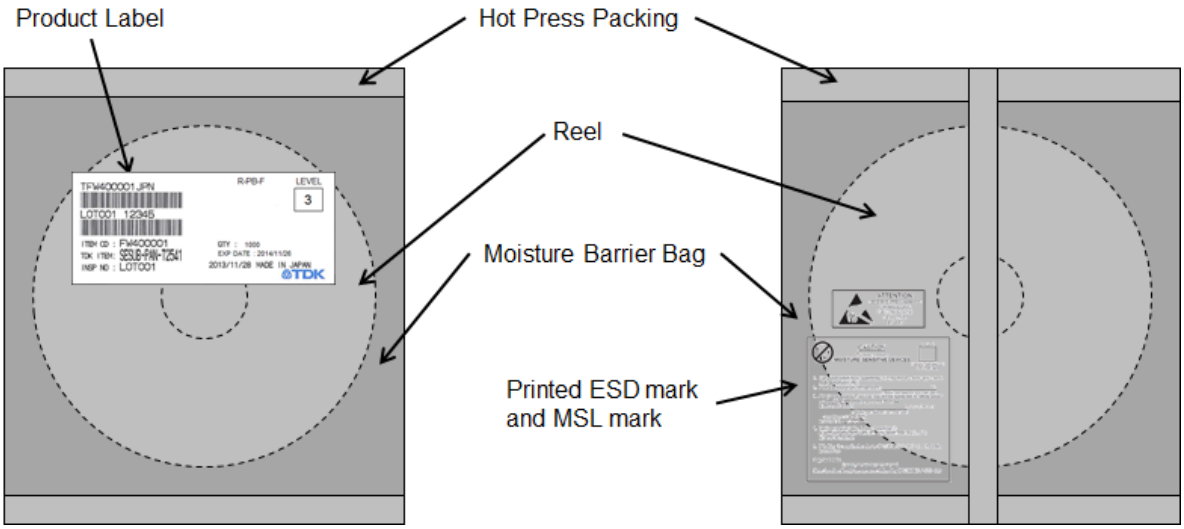
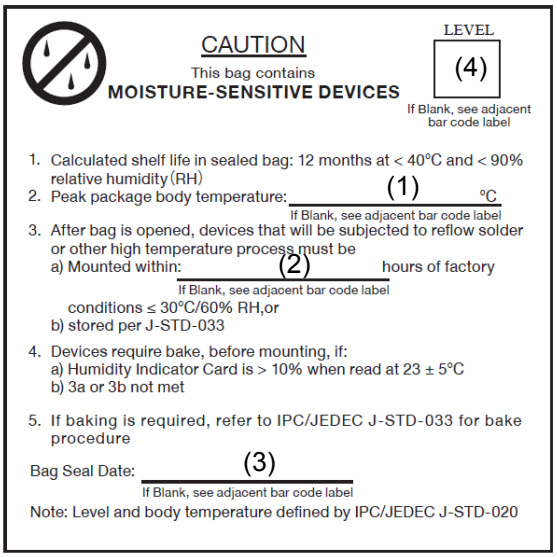


Figure 15 Packing Form

Storage Condition : 5-30℃ / 40-60%RH

The guaranteed term until mounting is 12 months in the above condition.

Figure 16 Product Label (Example)



Items	Example
(1) Max Temperature	260
(2) Guarantee time after opening MBB	168
(3) Processing time	2013/11/27
(4) MSL Level	3

Figure 17 Packing Print (Example)

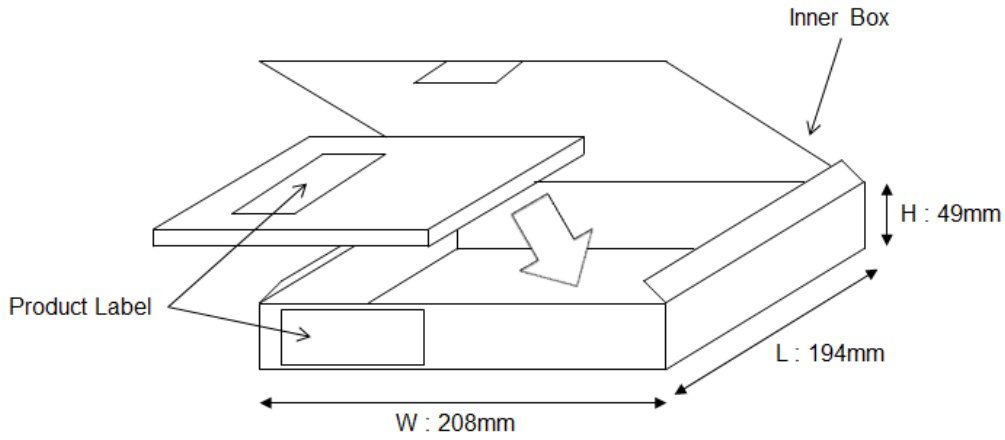


Figure 18 Inner Box

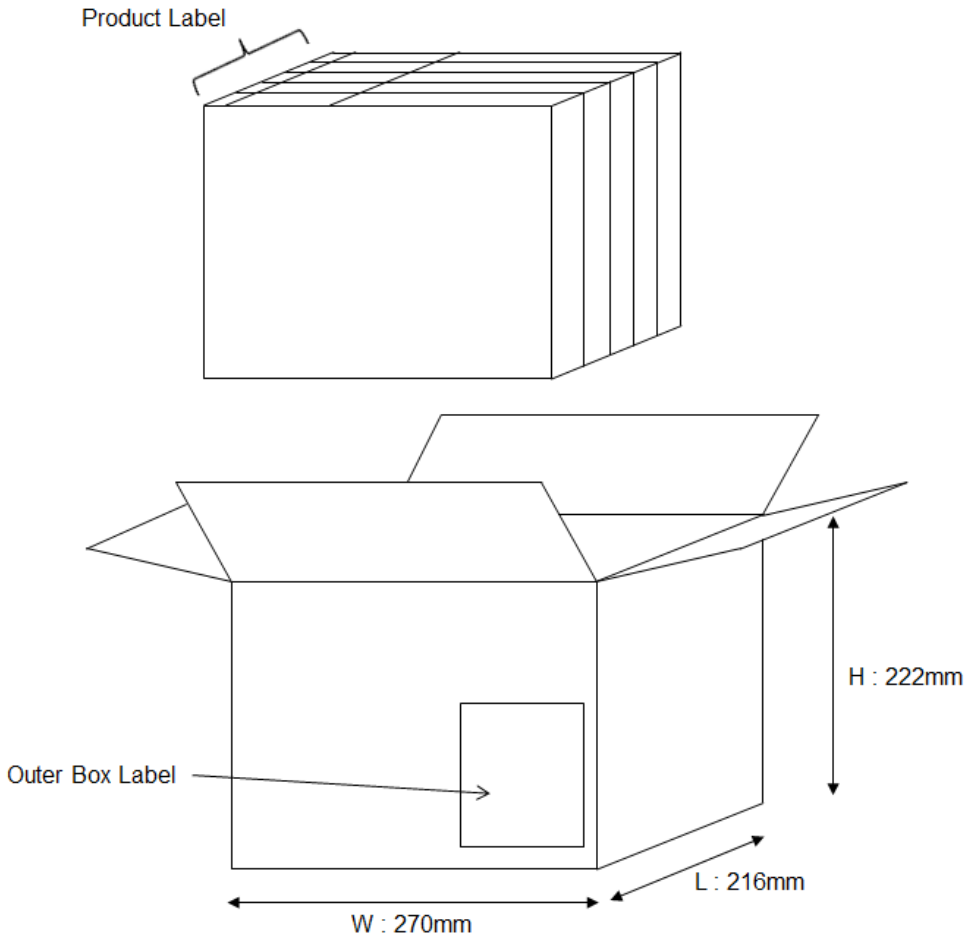


Figure 19 Outer Box

Figure 20 Outer Box Label (Example)

Reference Information

1. Bluetooth Core Technical Specification document, version 4.0
   http://www.bluetooth.com/SiteCollectionDocuments/Core_V40.zip

2. Texas Instruments CC2541 2.4GHz Bluetooth Low Energy System-on-Chip Datasheet (swrs110c)

3. Texas Instruments CC2541 System-on-Chip Solution for 2.4GHz Bluetooth low energy Applications User's Guide (swru191d)

4. Texas Instruments CC2540DK, Development Kit as of evaluation base board for SP13801
   http://www.ti.com/tool/cc2540dk

5. Texas Instruments SmartRF05 Evaluation Board User Guide (swru210a)
   http://www.ti.com/lit/ug/swru210a/swru210a.pdf

6. Texas Instruments CC2541EMK, CC2541 evaluation Module Kit
7. http://www.ti.com/tool/cc2541emk

8. Texas Instruments Bluetooth Low Energy Software Development Kit (SDK)
   http://www.ti.com/tool/ble-stack

9. Texas Instruments SmartRF Studio
   http://focus.ti.com/docs/toolsw/folders/print/smartrftm-studio.html

10. IAR Embedded Workbench for 8051 devices programming
    http://www.iar.com

11. For all other related technical documents, visit Texas Instruments Low-Power RF web site.
    http://www.ti.com/lprf-forum
    http://www.ti.com/lprfnetwork

Lead-free Product Status

Conformity to RoHS Directive: This means that, in conformity with EU Directive 2002/95/EC, lead, cadmium, mercury, hexavalent chromium, and specific bromine-based flame retardants, PBB and PBDE, have not been used except for exempted applications.

A comprehensive qualification for these lead-free module packages has been done. The related AQTP documentation is available from TDK on request.

Definitions

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