



FSC-BT645

BLE 4.2 Single Mode Bluetooth Module Datasheet

Version 1.1

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Revision History

Version	Date	Notes	
1.0	2019/10/10	Initial Version	Fish
1.1	2019/12/11	Modify structure and add IO port	Fish

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1. INTRODUCTION

Overview

FSC-BT645 is Bluetooth Low Energy 4.2(BLE4.2) Module. It can be used as an application processor as well as a data pump in fully hosted systems. MCU is 32-bit microcontroller. It supports a wide range of applications from low-end, price sensitive designs to computing-intensive ones and provides advanced high-end features in economical products.

Very low active RF, MCU current and low-power mode current consumption provide excellent battery lifetime and allow for operation on small coin cell batteries and in energy-harvesting applications.

The BLE4.2 firmware includes the L2CAP service layer protocols, Security Manager (SM), At-tribute Protocol (ATT), the Generic Attribute Profile (GATT) and the Generic Access Profile (GAP).

Features

- 2.4-GHz RF Transceiver Compatible With Bluetooth low energy (BLE) 4.2
- Programmable TX power up to 8dBm
- RX sensitivity up to -90dBm@1Mbps
- Postage stamp sized form factor
- Programmable baud-rate generator(baudrate can up to 921600bps)
- UART, I2C,SPI,10-bit ADC,PWM connection interfaces
- Bluetooth stack profiles support: HID
- Operating Voltage:2.2V to 3.6V
- Operating Temperature: -40°C to +85°C

Application

- Health Thermometer
- Heart Rate
- Blood Pressure
- Proximity
- Human Interface Device (HID)

Module picture as below showing



2. General Specification

Table 1: General Specifications

Categories	Features	Implementation
Wireless Specification	Bluetooth Version	Bluetooth low energy 4.2
	Frequency	2.402 - 2.480 GHz
	Transmit Power	+8 dBm (Maximum)
	Receive Sensitivity	-90 dBm (Typical)
	Modulation	GFSK
Host Interface and Peripherals	UART Interface	TX, RX, CTS, RTS
		General Purpose I/O
		Default 115200,N,8,1
	GPIO	Baudrate support from 1200 to 921600
		5, 6, 7, 8 data bit character
		11(maximum – configurable) lines
	I2C Interface	Pull-up resistor (33 KΩ) control
		Read pin-level
	ADC Interface	2(configurable from GPIO total). Up to 400 kbps
		Analog input voltage range: 0.4V ~ 1.4V(or 2.4V) based on configure
		Supports single 10-bit SAR ADC conversion
	PWM	3 channels (configured from GPIO total)
Up to 200MSPS conversion		
Profiles	6 PWM outputs	
	Supports edge-alignment or center-alignment	
Maximum Connections	Supports fault detection	
	Class Bluetooth	No Support
FW upgrade	Bluetooth Low Energy	GATT Client & Peripheral - Any Custom Services
	Classic Bluetooth	No Support
Supply Voltage	Supply	J-Link
Power Consumption		2.2V ~ 3.6V
Physical	Dimensions	Deep Sleep - 8uA(Wake up by wakeup PAD or RESET)
Environmental	Operating	10.8mm X 13.5mm X 2.2mm; Pad Pitch 1mm
	Storage	-40°C to +85°C
Miscellaneous		-40°C to +125°C
	Lead Free	Lead-free and RoHS compliant
Humidity	Warranty	One Year
MSL grade:		10% ~ 90% non-condensing
ESD grade:		MSL 3
	Human Body Model	All pins: ±4000V
	Charged device model	RF pins/ Non-RF pins: ±750V

3. HARDWARE SPECIFICATION

3.1 Block Diagram and PIN Diagram

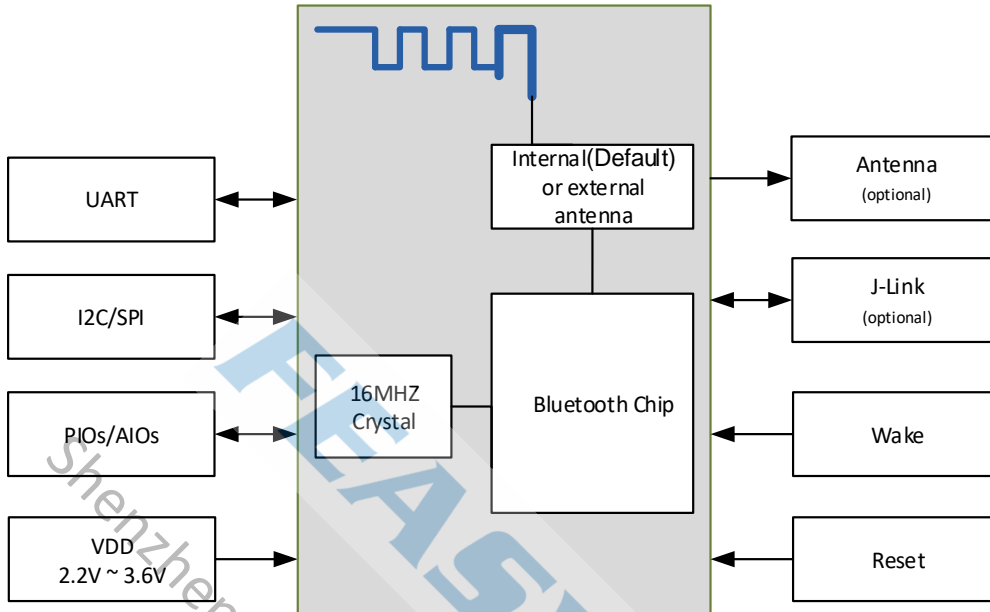


Figure 2: Block Diagram

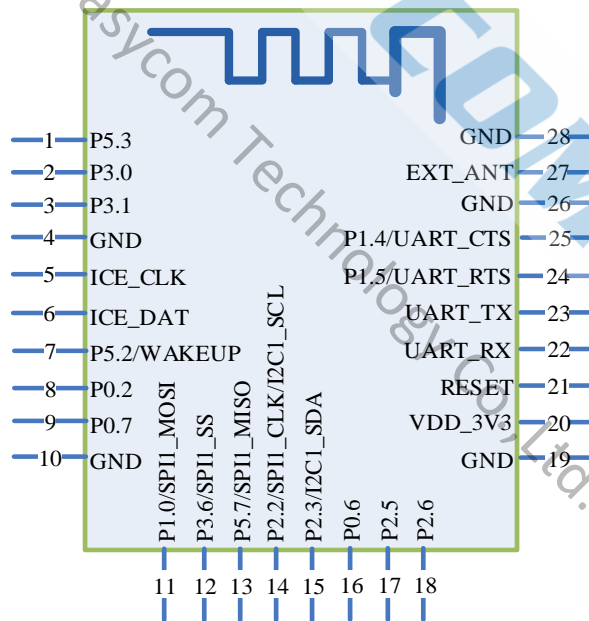


Figure 3: FSC-BT645 PIN Diagram(Top View)

3.2 PIN Definition Descriptions

Table 2: Pin definition

Pin	Pin Name	Type	Pin Descriptions	Notes
1	P5.3	I/O	Programmable input/output line	
2	P3.0	I/O	Programmable input/output line	
3	P3.1	I/O	Programmable input/output line	

4	GND	Vss	Power Ground	
5	ICE_CLK	I/O	Debugging through the CLK line(Default)	Note 1
6	ICE_DAT	I/O	Debugging through the DATA line(Default)	Note 1
7	P5.2/WAKEUP	I/O	Programmable input/output line Alternative Function: Wake up = High level(Default)	
8	P0.2	I/O	Programmable input/output line Alternative Function: LED(Default)	Note 1,4
9	P0.7	I/O	Programmable input/output line Alternative Function: BT Status(Default)	Note 1,2
10	GND	Vss	Power Ground	
11	P1.0/SPI1_MOSI	I/O	Programmable input/output line * The I/O port for reuse.	Note 1,6
12	P3.6/SPI1_SS	I/O	Programmable input/output line * The I/O port for reuse.	Note 1,6
13	P5.7/SPI1_MISO	I/O	Programmable input/output line * The I/O port for reuse.	Note 1,6
14	P2.2/SPI1_CLK/I2C1_SCL	I/O	Programmable input/output line Alternative Function: I2C SCL line (Default) * The I/O port for reuse.	Note 3,6
15	P2.3/I2C1_SDA	I/O	Programmable input/output line Alternative Function: I2C SDA line (Default)	Note 1,3
16	P0.6	I/O	Programmable input/output line	
17	P2.5	I/O	Programmable input/output line	
18	P2.6	I/O	Programmable input/output line	
19	GND	Vss	Power Ground	
20	VDD_3V3	Vdd	Power supply voltage 2.2V ~ 3.6V	
21	RESET	I	External reset input: Active LOW, with an internal pull-up Set this pin low reset to initial state	
22	UART_RX	I	UART data input	Note 1
23	UART_TX	O	UART data output	Note 1
24	UART_RTS/P1.5	I/O	UART request to send active low Alternative Function: Programmable input/output line	Note 1
25	UART_CTS/P1.4	I	UART clear to send active low Alternative Function: Programmable input/output line	Note 1
26	GND	Vss	Power Ground	
27	EXT_ANT	O	RF signal output	Note 5
28	GND	Vss	Power Ground	

Module Pin Notes:

Note 1 For customized module, this pin can be work as I/O Interface.

Note 2 BT Status (Default)-- Disconnected: Low Level; Connected: High Level.

Note 3 I2C Serial Clock and Data.

It is essential to remember that pull-up resistors on both SCL and SDA lines are not provided in the module and MUST be provided external to the module.

Note 4	LED(Default)-- Power On: Light Slow Shinning ; Connected: Steady Lighting.
Note 5	By default, this PIN is an empty feet. This PIN can connect to an external antenna to improve the Bluetooth signal coverage. If you need to use an external antenna, by modifying the module on the OR resistance to block out the on-board antenna; Or contact Feasycom for modification.
Note 6	This I / O port is shared with the internal SPI Flash chip. We do not recommend using this pin, floating processing. This pin is only available when the module is not equipped with air-upgrade function.

4. PHYSICAL INTERFACE

4.1 Power Supply

The transient response of the regulator is important. If the power rails of the module are supplied from an external voltage source, the transient response of any regulator used should be 20μs or less. It is essential that the power rail recovers quickly.

4.2 Reset

The module may be reset from several sources: Power-on Reset (POR), Low level on the nRESET Pin (nRST), Watchdog time-out reset (WDT), Low voltage reset (LVR).

The RESET pin is an active low reset and is internally filtered using the internal low frequency clock oscillator. A reset will be performed between 1.5 and 4.0ms following RESET being active. It is recommended that RESET be applied for a period greater than 5ms.

4.3 General Purpose Analog IO

- 10-Bit ADC
- Analog input voltage range: 0.4~1.4 or 0.4~2.4V based on configure
- Up to eight single-end analog input channels
- Two operating modes
 - Single mode: A/D conversion is performed one time on a specified channel
 - PWM sequence mode: When PWM trigger, two of three ADC channels from 0 to 2 will automatically convert analog data in the sequence of channel [0,1] or channel[1,2] or channel[0,2] defined by MODESEL (ADC_SEQCTL[3:2])
- An A/D conversion can be started by
 - Software write 1 to SWTRG bit
 - External pin STADC
 - PWM trigger with optional start delay period
- Each Conversion result is held in data register with valid and overrun indicators
- Conversion results can be compared with specified value and user can select whether to generate an interrupt when conversion result matches the compare register setting
- Channel 8 supports 2 input sources: External analog voltage and internal fixed band-gap voltage

4.4 General Purpose Digital IO

There are 11 general purpose digital IOs defined in the module. All these GPIOs can be configured by software to realize various functions, such as button controls, LED drives or interrupt signals to host controller, etc. Do not connect them if not use.

The I/O type of each I/O pins can be configured by software individually as Input or Push-pull output mode. After the chip is reset, the I/O mode of all pins is input mode with no pull-up and pull-down enable. Each I/O pin has an individual pull-up and pull-down resistor which is about 30 k Ω ~ 50 k Ω for VDD and Vss.

4.5 RF Interface

For This Module, the default mode for antenna is internal ,it also has the interface for external antenna. If you need to use an external antenna, by modifying the module on the 0R resistance to block out the on-board antenna; Or contact Feasycom for modification.

The user can connect a 50 ohm antenna directly to the RF port.

- 2402–2480 MHz BLE4.2
- TX output power of +8dBm.
- RX sensitivity up to -90dBm

4.6 Serial Interfaces

4.6.1 UART

FSC-BT645 provides one channels of Universal Asynchronous Receiver/Transmitters (UART)(Full-duplex asynchronous communications). The UART Controller performs a serial-to-parallel conversion on data received from the peripheral and a parallel-to-serial conversion on data transmitted from the CPU.

This is a standard UART interface for communicating with other serial devices. The UART interface provides a simple mechanism for communicating with other serial devices using the RS232 protocol.

When the module is connected to another digital device, UART_RX and UART_TX transfer data between the two devices. The remaining two signals, UART_CTS and UART_RTS, can be used to implement RS232 hardware flow control where both are active low indicators.

This module output is at 3.3V CMOS logic levels (tracks VCC). Level conversion must be added to interface with an RS-232 level compliant interface.

Some serial implementations link CTS and RTS to remove the need for handshaking. We do not recommend linking CTS and RTS except for testing and prototyping. If these pins are linked and the host sends data when the FSC-BT645 deasserts its RTS signal, there is significant risk that internal receive buffers will overflow, which could lead to an internal processor crash. This drops the connection and may require a power cycle to reset the module. We recommend that you adhere to the correct CTS/RTS handshaking protocol for proper operation.

Table 3: Possible UART Settings

Parameter	Possible Values	
Baudrate	Minimum	1200 baud ($\leq 2\%$ Error)
	Standard	115200bps($\leq 1\%$ Error)
	Maximum	921600bps($\leq 1\%$ Error)
Flow control	RTS/CTS, or None	
Parity	None, Odd or Even	
Number of stop bits	1 /1.5/2	
Bits per channel	5/6/7/8	

When connecting the module to a host, please make sure to follow .

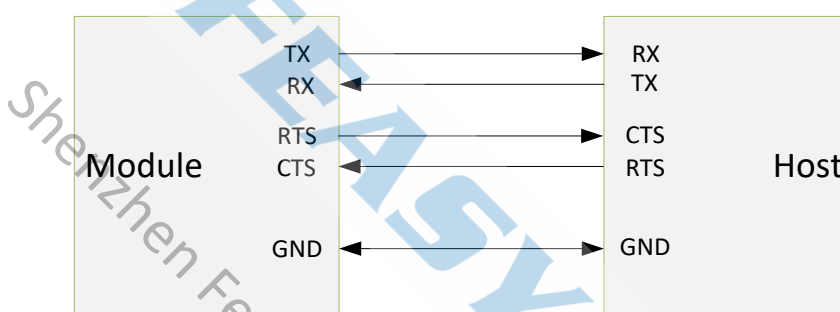


Figure 4: UART Connection

4.6.2 I²C Interface

- Two I2C master and slaver devices with DMA
- Bidirectional data transfer between masters and slaves
- Multi-master bus Arbitration between simultaneously transmitting masters without corruption of serial data on the bus
- Serial clock synchronization allowing devices with different bit rates to communicate via one serial bus
- Serial clock synchronization can be used as a handshake mechanism to suspend and re-sume serial transfer
- Built-in 14-bit time-out counter that requests the I2C interrupt if the I2C bus hangs up and timer-out counter overflows
- Programmable clocks allow for versatile rate control
- Supports multiple address recognition

4.7 PWM Interface

- Up to six built-in 16-bit PWM generators
- Individual clock source, clock divider, 8-bit pre-scalar and dead-time generator for each PWM generator
- PWM interrupt synchronized to PWM period
- Supports edge-alignment or center-alignment
- Supports fault detection

5. ELECTRICAL CHARACTERISTICS

5.1 Absolute Maximum Ratings

Absolute maximum ratings for supply voltage and voltages on digital and analogue pins of the module are listed below. Exceeding these values causes permanent damage.

The average PIO pin output current is defined as the average current value flowing through any one of the corresponding pins for a 100mS period. The total average PIO pin output current is defined as the average current value flowing through all of the corresponding pins for a 100mS period. The maximum output current is defined as the value of the peak current flowing through any one of the corresponding pins.

Table 4: Absolute Maximum Rating

Symbol	Description	Min	Trp	Max	Unit
VDD	BT Input voltage	-0.3	-	3.6	V
VI	Input voltage	-0.3	-	VDD	V
VO	Output voltage	VSS	-	VDD	V
TOP	Operating Temperature	-40	-	85	°C
TSTG	Storage Temperature	-40	-	125	°C

Note: Exceeding one or more of the limiting values may cause permanent damage to FSC-BT645.

Caution: Electrostatic sensitive device, comply with protection rules when operating.

5.2 DC Electrical Characteristics

Table 5: Voltage and current

Symbol	Parameter	Min	Type	Max	Unit	Test Conditions
V _{DD} -V _{SS}	DC Power Supply	2.2	3	3.6	V	TA=25°C
T _A	Operating Temperature	-40	25	+85	°C	-
I ₁	Standby Current in Sleep mode	-	8	-	uA	Wakeup PAD or RESET
VOH	Output high level voltage	VDD-0.3	-	VDD	V	-
VOL	Output low level voltage	VSS	-	VSS+0.3	V	-
VIH	Input high level voltage	2.0	3	3.6	V	-
VIL	Input low level voltage	VSS	-	VSS+0.3	V	-

5.3 AC Electrical Characteristics

Table 6: RF

Symbol	Parameter	Min	Type	Max	Unit
General frequency					
Fop	Operating frequency	2402	-	2480	MHz
PLLres	PLL Programming resolution	-	1	-	MHz
Fxtal	Crystal frequency	-	16	-	MHz

DR	Data rate	-	1	-	Mbps
Δf_{1M}	Frequency deviation	225	250	275	KHz
FCH1M	Channel spacing	-	2	-	MHz
Transmitter					
PRF	Output power	-18	-	13	dBm
PBW	20dB Bandwidth for Modulated Carrier at 1Mbps	-	1.5	-	MHz
Receiver					
RXmax	Maximum received signal at <0.1% BER	-	-10	-	dBm
RXSENS	Sensitivity (0.1%BER) @1Mbps	-	-90	-	dBm
C/I _{CO}	C/I Co-channel interference	-	11	-	dB
C/I _{1MHz}	Adjacent 1MHz interference	-	-2	-	dB
C/I _{2MHz}	Adjacent 2MHz interference	-	-22	-	dB
C/I _{3MHz}	Adjacent ≥ 3 MHz interference	-	-38	-	dB
C/I _{image}	Image frequency interference	-	-12	-	dB
C/I _{image} ± 1 MHz	Adjacent 1MHz interference to in-band image freq	-	-24	-	dB

Table 7: ADC

Symbol	Parameter	Min	Type	Max	Unit
Resolution	-	-	12	-	Bit
Enob	-	-	10	-	Bit
IOT	Operation Current	880	1000	1660	uA
Pclk	System Clock	-	-	52	MHz
FS	Sample Rate	-	-	0.5	MHz
Fin	-	0	-	40	KHz
Vrefp-Vrefn	Analog input voltage, Reference voltage V _{bg}	1	2	2	V
Cin	Input Capacitance	-	10	-	pF
VCM	-	0.9	-	1.4	V
DATA	ADC Output	000	-	FFF	HEX
SFDR	Spurious Free Dynamic range	-	72	-	dB

6. MSL & ESD

Table 8: MSL and ESD

Parameter	Test Conditions	Value	
MSL grade:	MSL 3 ⁽¹⁾		
ESD grade:	Human body model (HBM), per ANSI/ESDA/JEDEC JS001 ⁽²⁾	All pins	$\pm 4000V$
		RF pins	$\pm 750V$
	Charged device model (CDM), per JESD22-C101 ⁽³⁾	Non-RF pins	$\pm 750V$

(1)The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(2) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(3) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7. RECOMMENDED TEMPERATURE REFLOW PROFILE

Prior to any reflow, it is important to ensure the modules were packaged to prevent moisture absorption. New packages contain desiccant (to absorb moisture) and a humidity indicator card to display the level maintained during storage and shipment. If directed to bake units on the card, please check the Picture below and follow instructions specified by IPC/JEDEC J-STD-033.

Note: The shipping tray cannot be heated above 65°C. If baking is required at the higher temperatures displayed in the Picture below, the modules must be removed from the shipping tray.

Any modules not manufactured before exceeding their floor life should be re-packaged with fresh desiccant and a new humidity indicator card. Floor life for MSL (Moisture Sensitivity Level) 3 devices is 168 hours in ambient environment 30°C/60%RH.

Table 9: Recommended baking times and temperatures

MSL	125°C Baking Temp.		90°C/≤ 5%RH Baking Temp.		40°C/ ≤ 5%RH Baking Temp.	
	Saturated @ 30°C/85%	Floor Life Limit + 72 hours @ 30°C/60%	Saturated @ 30°C/85%	Floor Life Limit + 72 hours @ 30°C/60%	Saturated @ 30°C/85%	Floor Life Limit + 72 hours @ 30°C/60%
3	9 hours	7 hours	33 hours	23 hours	13 days	9 days

Feasycom surface mount modules are designed to be easily manufactured, including reflow soldering to a PCB. Ultimately it is the responsibility of the customer to choose the appropriate solder paste and to ensure oven temperatures during reflow meet the requirements of the solder paste. Feasycom surface mount modules conform to J-STD-020D1 standards for reflow temperatures.

The soldering profile depends on various parameters necessitating a set up for each application. The data here is given only for guidance on solder reflow.

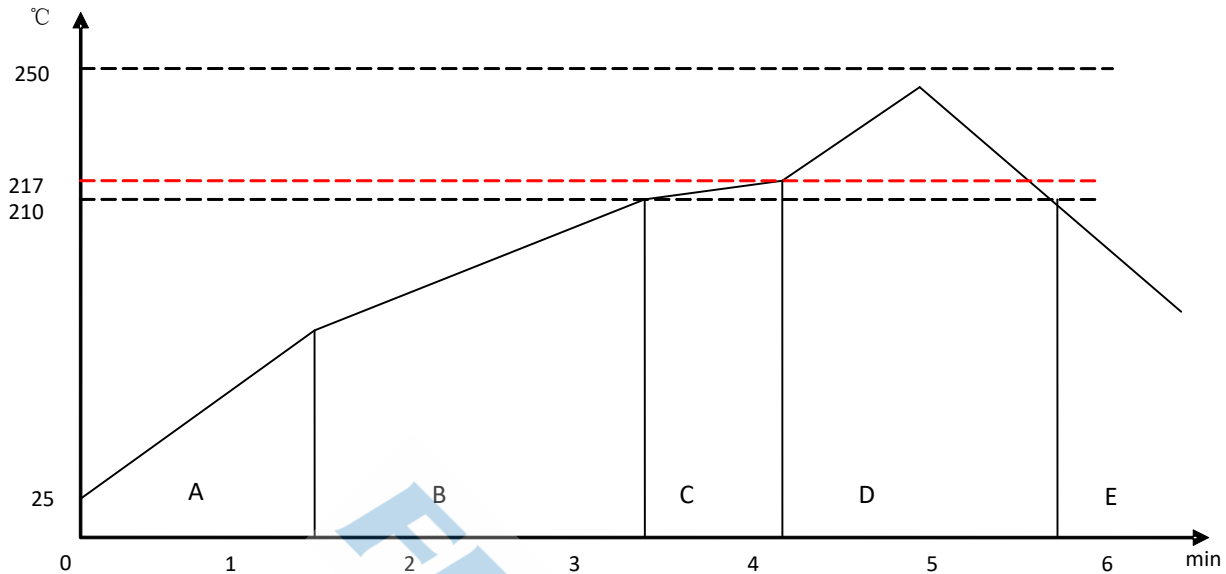


Figure 5: Typical Lead-free Re-flow

Pre-heat zone (A) — This zone raises the temperature at a controlled rate, **typically 0.5 – 2 °C/s**. The purpose of this zone is to preheat the PCB board and components to 120 ~ 150 °C. This stage is required to distribute the heat uniformly to the PCB board and completely remove solvent to reduce the heat shock to components.

Equilibrium Zone 1 (B) — In this stage the flux becomes soft and uniformly encapsulates solder particles and spread over PCB board, preventing them from being re-oxidized. Also with elevation of temperature and liquefaction of flux, each activator and rosin get activated and start eliminating oxide film formed on the surface of each solder particle and PCB board. **The temperature is recommended to be 150° to 210° for 60 to 120 second for this zone.**

Equilibrium Zone 2 (C) (optional) — In order to resolve the upright component issue, it is recommended to keep the temperature in 210 – 217 ° for about 20 to 30 second.

Reflow Zone (D) — The profile in the figure is designed for Sn/Ag3.0/Cu0.5. It can be a reference for other lead-free solder. The peak temperature should be high enough to achieve good wetting but not so high as to cause component discoloration or damage. Excessive soldering time can lead to intermetallic growth which can result in a brittle joint. The recommended peak temperature (T_p) is 230 ~ 250 °C. The soldering time should be 30 to 90 second when the temperature is above 217 °C.

Cooling Zone (E) — The cooling rate should be fast, to keep the solder grains small which will give a longer-lasting joint. **Typical cooling rate should be 4 °C.**

8. MECHANICAL DETAILS

8.1 Mechanical Details

- Dimension: 10.8mm(W) x 13.5mm(L) x 2.2 mm(H) Tolerance: ±0.1mm
- Module size: 10.8mm X 13.5mm Tolerance: ±0.2mm
- Pad size: 2mmX0.6mm Tolerance: ±0.1mm
- Pad pitch: 1mm Tolerance: ±0.1mm

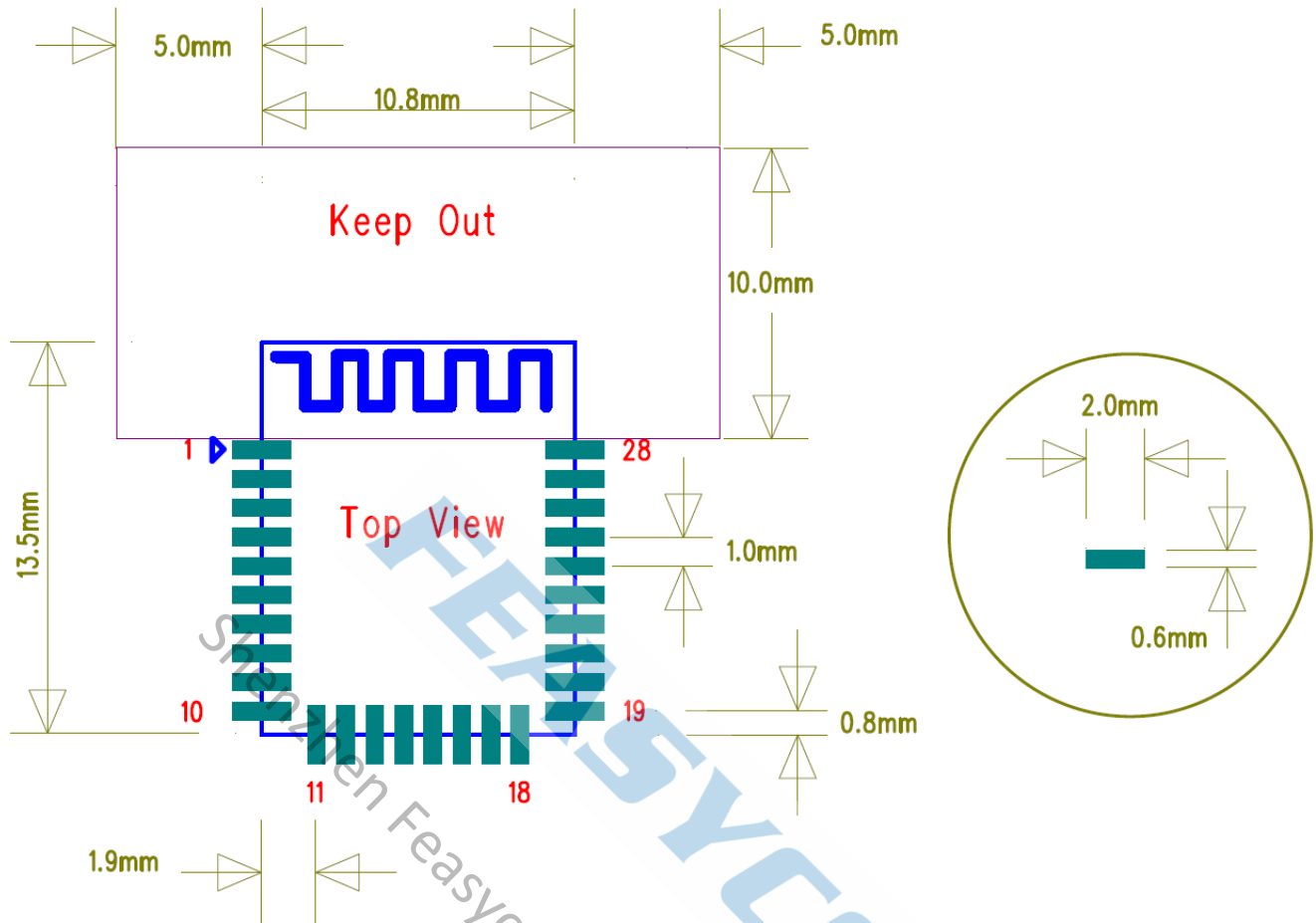


Figure 6: FSC-BT645 footprint

9. HARDWARE INTEGRATION SUGGESTIONS

9.1 Soldering Recommendations

FSC-BT645 is compatible with industrial standard reflow profile for Pb-free solders. The reflow profile used is dependent on the thermal mass of the entire populated PCB, heat transfer efficiency of the oven and particular type of solder paste used. Consult the datasheet of particular solder paste for profile configurations.

Feasycom will give following recommendations for soldering the module to ensure reliable solder joint and operation of the module after soldering. Since the profile used is process and layout dependent, the optimum profile should be studied case by case. Thus following recommendation should be taken as a starting point guide.

9.2 Layout Guidelines(Internal Antenna)

It is strongly recommended to use good layout practices to ensure proper operation of the module. Placing copper or any metal near antenna deteriorates its operation by having effect on the matching properties. Metal shield around the antenna will prevent the radiation and thus metal case should not be used with the module. Use grounding vias separated max 3 mm apart at the edge of grounding areas to prevent RF penetrating inside the PCB and causing an unintentional resonator. Use GND vias all around the PCB edges.

The mother board should have no bare conductors or vias in this restricted area, because it is not covered by stop mask print. Also no copper (planes, traces or vias) are allowed in this area, because of mismatching the on-board antenna.

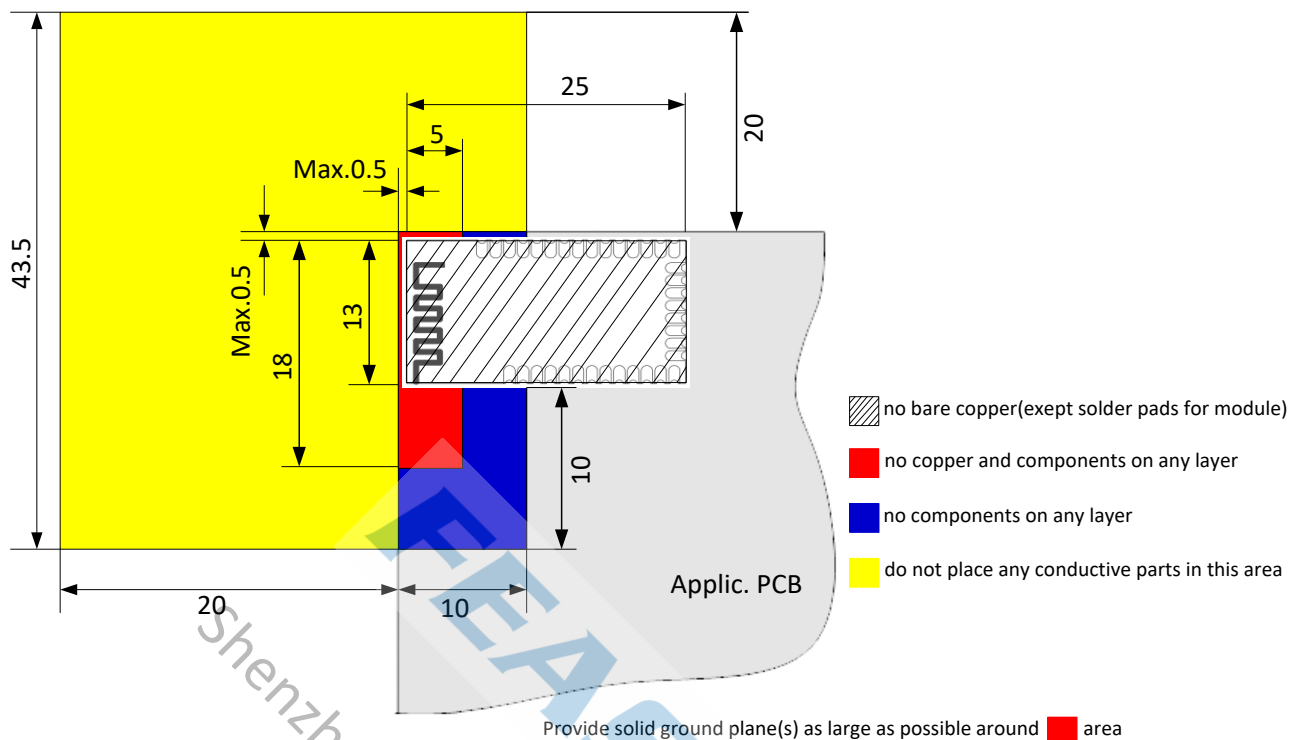


Figure 7: FSC-BT645 Restricted Area

Following recommendations helps to avoid EMC problems arising in the design. Note that each design is unique and the following list do not consider all basic design rules such as avoiding capacitive coupling between signal lines. Following list is aimed to avoid EMC problems caused by RF part of the module. Use good consideration to avoid problems arising from digital signals in the design.

Ensure that signal lines have return paths as short as possible. For example if a signal goes to an inner layer through a via, always use ground vias around it. Locate them tightly and symmetrically around the signal vias. Routing of any sensitive signals should be done in the inner layers of the PCB. Sensitive traces should have a ground area above and under the line. If this is not possible, make sure that the return path is short by other means (for example using a ground line next to the signal line).

9.3 Layout Guidelines(External Antenna)

Placement and PCB layout are critical to optimize the performances of a module without on-board antenna designs. The trace from the antenna port of the module to an external antenna should be 50Ω and must be as short as possible to avoid any interference into the transceiver of the module. The location of the external antenna and RF-IN port of the module should be kept away from any noise sources and digital traces. A matching network might be needed in between the external antenna and RF-IN port to better match the impedance to minimize the return loss.

As indicated in picture below, RF critical circuits of the module should be clearly separated from any digital circuits on the system board. All RF circuits in the module are close to the antenna port. The module, then, should be placed in this way that module digital part towards your digital section of the system PCB.

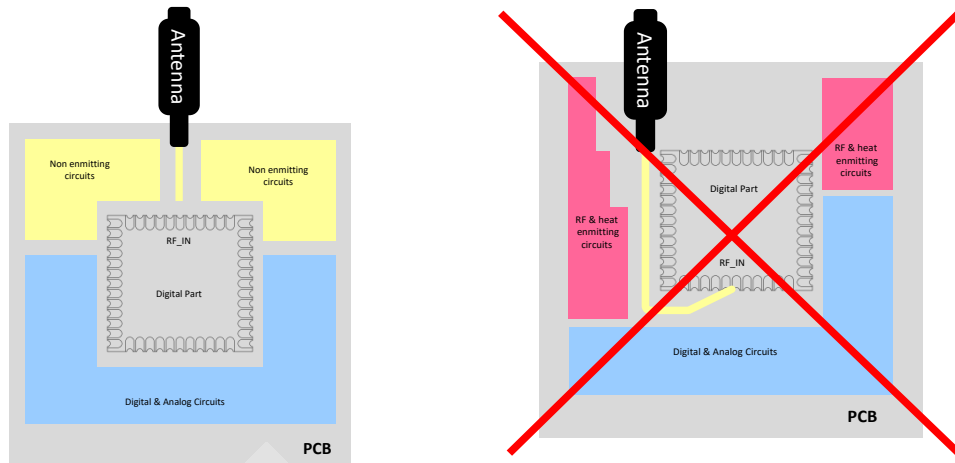


Figure 8: Placement the Module on a System Board

9.3.1 Antenna Connection and Grounding Plane Design

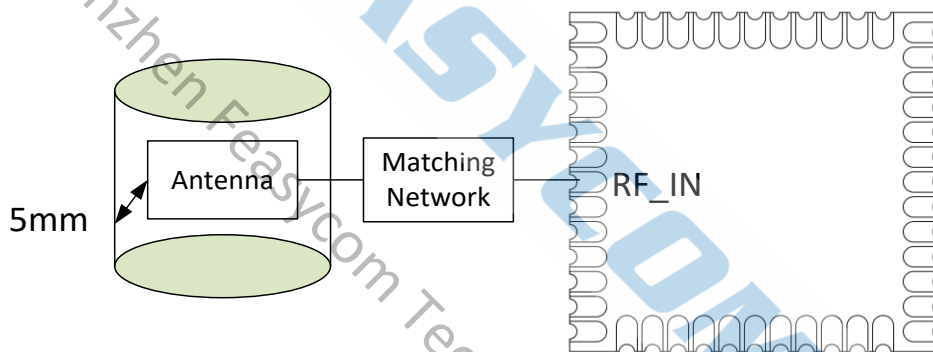


Figure 9: Leave 5mm Clearance Space from the Antenna

General design recommendations are:

- The length of the trace or connection line should be kept as short as possible.
- Distance between connection and ground area on the top layer should at least be as large as the dielectric thickness.
- Routing the RF close to digital sections of the system board should be avoided.
- To reduce signal reflections, sharp angles in the routing of the micro strip line should be avoided. Chamfers or fillets are preferred for rectangular routing; 45-degree routing is preferred over Manhattan style 90-degree routing.

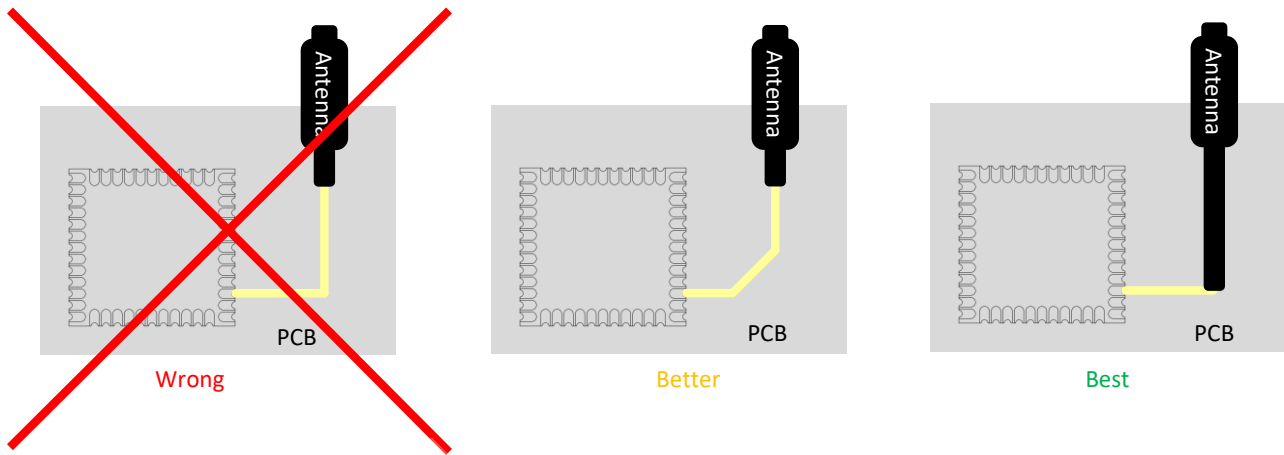


Figure 10: Recommended Trace Connects Antenna and the Module

- Routing of the RF-connection underneath the module should be avoided. The distance of the micro strip line to the ground plane on the bottom side of the receiver is very small and has huge tolerances. Therefore, the impedance of this part of the trace cannot be controlled.
- Use as many vias as possible to connect the ground planes.

10. PRODUCT PACKAGING INFORMATION

10.1 Default Packing

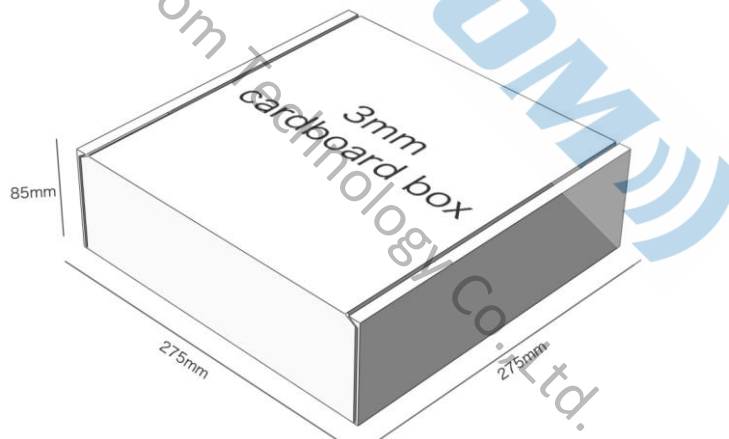
- Tray vacuum
- Tray Dimension: 180mm * 195mm





Figure 11: Tray vacuum

10.2 Packing box(Optional)



* If require any other packing, must be confirmed with customer

* Package: 1000PCS Per Carton (Min Carton Package)

Figure 12: Packing Box

11. APPLICATION SCHEMATIC

