BlueSoleil i410e Datasheet

April 12, 2013

Version 1.7

VERSION HISTORY

REVISION	AMENDMENT	DATE	AUTHOR
1.0	Initial version	2012-10-7	Zhu Yong
1.1	Modify 3, 8, 10 section	2012-10-9	Wan Zhifu Huang Ruixue
1.2	1. Update power consumption; 2. Change PIO4 to GND.	2012-10-29	Li Li
1.3	1. Update power consumption; 2. Update format.	2012-11-29	Li Li
1.4	Update package information. Refer to the chapter 10.	2012-12-12	Li Li
1.5	Update Figure 1 BlueSoleil i410e and Figure 8 i410e Footprint.	2012-12-22	Li Li
1.6	Add FCC, IC, CE certificate	2013-4-3	Li Li
1.7	Add external antenna interface.	2013-4-12	Wan zhifu Li Li

Contents

BlueSoleil i410e

DESCRIPTION

BlueSoleil i410e is a *Bluetooth* 4.0 single-mode module. It provides a *Bluetooth* Low Energy fully compliant system for data communication with IVT BlueSoleil stack. It allows your target devices to send and receive data via *Bluetooth* 4.0 without connecting a serial cable to your computer.

By default, i410e module is equipped with powerful and easy-to-use BlueSoleil firmware. It's easy-to-use and completely encapsulated. BlueSoleil enables users to access *Bluetooth* functionality with simple ASCII commands delivered to the module over serial interface - it's just like a *Bluetooth* modem.

Therefore, BlueSoleil i410e provides an ideal solution for developers who want to integrate *Bluetooth* wireless technology into their design.

FEATURES

- Fully Qualified *Bluetooth* system v4.0
- Low energy
- Support Master or Slave roles
- Integrated layout antenna
- Industrial temperature range from -40^{0}C to +85^{0}C
- RoHS Compliant

APPLICATIONS

- Cable replacement
- Sports and fitness
- Healthcare
- Home entertainment
- Office and mobile accessories
- Automotive
- Commercial
- Watches
- Human interface devices

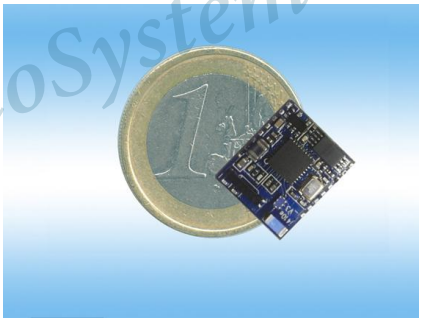


Figure 1 BlueSoleil i410e

1 Block Diagram

BlueSoleil i410e's block diagram is illustrated in Figure 2 below.

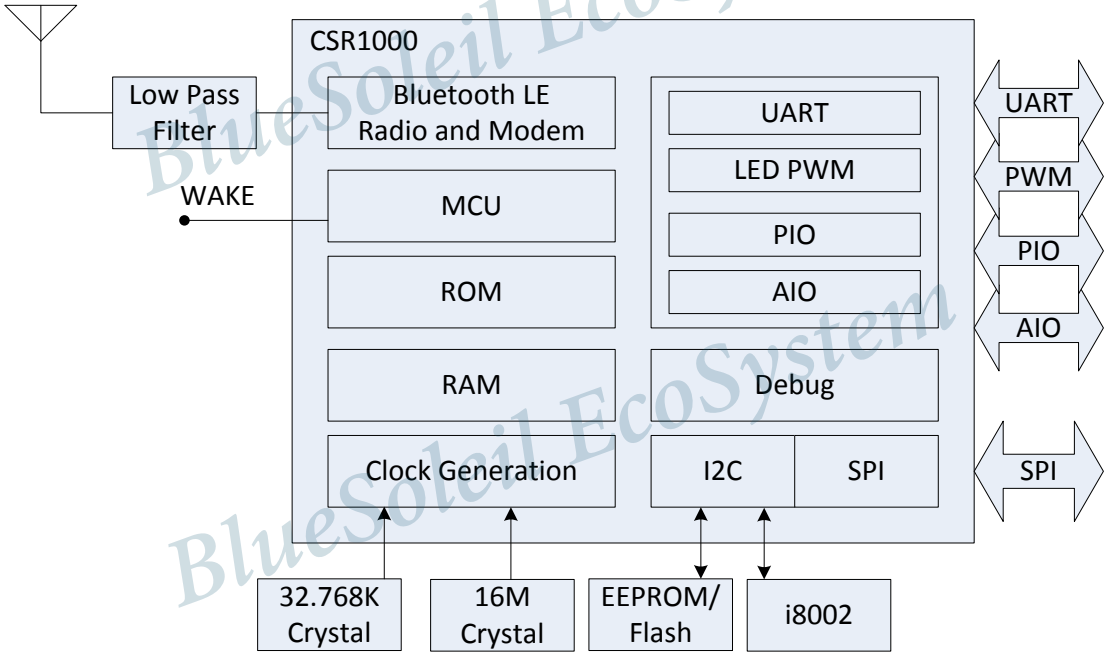


Figure 2 i410e Block Diagram

CSR1000

CSR1000 is a single chip *Bluetooth* 4.0 solution which implements the *Bluetooth* radio transceiver and also an on chip microcontroller. CSR1000 implements *Bluetooth* 4.0 and it can deliver data rates up to 3 Mbps.

The microcontroller (MCU) on CSR1000 acts as interrupt controller and event timer run the BlueSoleil stack and control the radio and host interfaces. A 16-bit RISC microcontroller is used for low power consumption and efficient use of memory.

CSR1000 has 64Kbytes of on-chip RAM. it supports the RISC MCU and is shared between the ring buffers used to hold data for each active connection and the general-purpose memory required by the BlueSoleil stack.

Crystal

The crystal oscillates include 16MHz and 32.768 KHz. 16MHz is external reference clock source. 32.768 KHz is used during deep sleep and in other low-power modes.

EEPROM/Flash/i8002

Flash /EEPROM is used for storing the *Bluetooth* protocol stack, profile and applications.

Low Pass Filter

The filter is a band pass filter (ISM band).

Antenna

The antenna is meander PCB antenna.

Synchronous Serial Interface

This is a synchronous serial port interface (SPI) for interfacing with other digital devices. The SPI port can be used for system debugging. It can also be used for programming the Flash memory.

UART

This is a standard Universal Asynchronous Receiver Transmitter (UART) interface for communicating with other serial devices.

Programmable I/O

I410e has one digital programmable I/O terminal. It is controlled by firmware running on the device.

AIO

I410e has 3 general-purpose analogue interface pins, AIO[2:0].

PWM

I410e contains a PWM module that works in sleep modes.

WAKE

Wake up input. It wakes i410e from hibernate.

2 Electrical Characteristics

2.1Absolute Maximum Ratings

The module should not continuously run under extreme conditions. The absolute maximum ratings are summarized in Table 1 below. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability and cause permanent damage to the device.

Table 1 Absolute Maximum Ratings

Rating	Min	Max	Unit

Storage temperature	-40	85	℃
Battery (VDD_BAT)operation	1.8	3.6	V
I/O supply voltage	-0.4	3.6	V
Other terminal voltages	VSS-0.4	VDD+0.4	V

2.2Recommended Operating Conditions

Recommended operating conditions are summarized in Table 2 below.

Table 2 Recommended Operating Conditions

	Min	Typ	Max	Unit
Operating temperature	-30	20	85	℃
Battery(VDD_BAT) Operation	1.8	-	3.6	V
I/O supply voltage(VDD_PADS)	1.2	-	3.6	V

.

2.3Input/output Terminal Characteristics

2.3.1 Switch-mode Regulator

Table 3 Switch-mode Regulator

	Min	Typ.	Max	Unit
Switch-mode Regulator				
input voltage	1.8	-	3.6	V
Output voltage	0.65	1.35	1.35	V
Temperature coefficient	-200	-	200	ppm/^{0}C
Normal Operation				
Output noise, Frequency range 100Hz to 100KHz	-	-	0.4	mV rms
Setting time, setting to within 10% of final value	-	-	30	μs
Output current(I_{max})	-	-	50	mA
Quiescent current(excluding load, I_{load}<1mA)	-	-	20	μA
Ultra Low-power Mode				
Output current(I_{max})	-	-	100	μA

Quiescend current	-	-	1	μA

2.3.2 Low-voltage Linear Regulator

Table 4 Switch-mode Regulator

Normal Operation	Min	Typ.	Max	Unit
Input voltage	0.65	-	1.35	V
Output voltage	0.65	-	1.20	V

2.3.3 Digital Terminals

Table 5 Digital Terminals

	Min	Typ.	Max	Unit
Input Voltage Levels				
V_{IL} input Logic level low	-0.4	-	0.4	V
V_{IH} input logic level high	0.7*VDD	-	VDD+0.4	V
T_r/T_f	-	-	25	ns
Output Voltage Levels				
V_{OL} output logic level low, I_{OL} = 4.0mA	-	-	0.4	V
V_{OH} output logic level high, I_{OH}=-4.0mA	0.75*VDD	-	-	V
T_f/T_f	-	-	5	ns
Input and Tristate Currents				
With strong pull-up	-150	-40	-10	μA
I^2C with strong pull-up	-250	-	-	μA
With strong pull-down	10	40	150	μA
With weak pull-up	-5.0	-1.0	-0.33	μA
With weak pull-down	0.33	1.0	5.0	μA
C_I input capacitance	1.0	-	5.0	pF

2.3.4 AIO

Table 6 AIO

Input Voltage Levels	Min	Typ.	Max	Unit
Input voltage	0	-	1.3	V

2.3.5 ESD Protection

Apply ESD static handling precautions during manufacturing. ESD handling maximum ratings are summarized in Table 7 below.

Table 7 ESD Handling Maximum Ratings

Condition	Max	Unit
Human body model contact discharge per JEDEC EIA/JESD22-A114	2	2000V(all pins)
Machine model contact Discharge per JEDEC EIA/JESD22-A115	200V	200V(all pings)
Charged Device Model Contact Discharge per JEDEC EIA/JESD22-C101	III	500V(all pins)

2.4Current Consumption

Table 8 Current Consumption

Operation Mode	Description	Average
Dormant	All functions are shutdown. To wake up toggle the wake pin.	5~6uA
Hibernate	VDD_PADS=ON, REFCLK=OFF, SLEEPCLK+ON, VDD_BAT=ON	5~6μA
Deep Sleep	VDD_PADS=ON, REFCLK=OFF, SLEEPCLK=ON, VDD_BAT=ON, RAM=ON, digital circuits=ON, SMPs=ON(low-power mode), 1ms wake-up time	7~8μA
Connected Standby	-	~1.2mA
RX/TX active	-	~ 4mA

2.5Radio Characteristics

2.5.1 RF Ports

BlueSoleil i410e contains an integrated balun which provides a single-ended RF TX / RX port pin. No matching components are needed as the receive mode impedance is 50Ω and the transmitter has been optimized to deliver power in to a 50Ω load.

2.5.2 RF Receiver

The receiver features a near-zero IF architecture that allows the channel filters to be integrated onto the die. Sufficient out-of-band blocking specification at the LNA input allows the receiver to be used in close proximity to GSM and W-CDMA cellular phone transmitters without being significantly desensitized.

An ADC digitizes the IF received signal.

Low Noise Amplifier

The LNA operates in differential mode and takes its input from the balanced port of the integrated balun.

RSSI Analogue to Digital Converter

The ADC samples the RSSI voltage on a packet-by-packet basis and implements a fast AGC. The front-end LNA gain is changed according to the measured RSSI value, keeping the first mixer input signal within a limited range. This improves the dynamic range of the receiver, improving performance in interference-limited environments.

2.5.3 RF Transmitter

IQ Modulator

The transmitter features a direct IQ modulator to minimize frequency drift during a transmit packet, which results in a controlled modulation index. Digital baseband transmit circuitry provides the required spectral shaping.

Power Amplifier

The internal PA has a maximum 7.5dBm output power without needing an external RF PA.

2.5.4 *Bluetooth* Radio Synthesizer

The *Bluetooth* radio synthesizer is fully integrated onto the die with no requirement for an external VCO screening, can varactor tuning diodes, LC resonators or loop filter. The synthesizer is guaranteed to lock in sufficient time across the guaranteed temperature range to meet *Bluetooth* v4.0 specification.

2.5.5 Baseband

Physical Layer Hardware Engine

The hardware supports all optional and mandatory features of *Bluetooth* v4.0 specification. It performs the following features:

- Cyclic redundancy check
- Encryption
- Data whitening
- Access code correlation

3 Pin Description

BlueSoleil i410e's PIN descriptions are summarized in Figure 3 and Table 9 below.

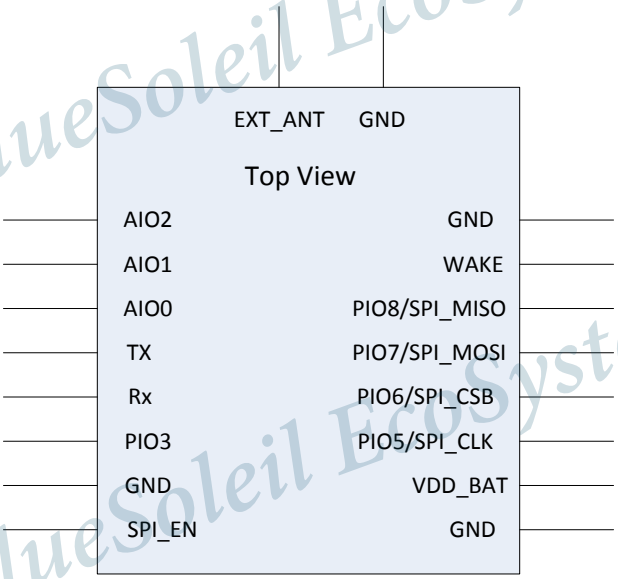


Figure 3 i410e PIN diagram

Table 9 PIN Description

PIN NO.	Name	Type	Function
1	AIO[2]	Bidirectional analogue	Analogue programmable I/O line. General-purpose analogue interface pins.
2	AIO[1]	Bidirectional analogue	Analogue programmable I/O line. General-purpose analogue interface pins.
3	AIO[0]	Bidirectional analogue	Analogue programmable I/O line. General-purpose analogue interface pins.

4	Tx	CMOS Output	TXD is used to implement UART data transfer from i410e to another device.
5	Rx	CMOS Input	RXD is used to implement UART data transfer from another device to i410e.
6	PIO3	Bidirectional with programmable strength internal pull-up/down	Programmable I/O line
7	GND	Ground	Ground
8	SPI_EN	Input with strong internal pull-down	This pin foot pulls high to SPI mode, pulled low for programmable I/O port mode.
9	GND	GND	Ground
10	VDD_BAT	POWER	+1.8V To +3.3V Supply
11	PIO5 / SPI_CLK	Bidirectional with programmable strength internal pull-up/down	Programmable I/O line or debug SPI CLK selected by SPI_EN#.
12	PIO6 / SPI_CSB	Bidirectional with programmable strength internal pull-up/down	Programmable I/O line or debug SPI CSB selected by SPI_EN#.
13	PIO7 / SPI_MOSI	Bidirectional with programmable strength internal pull-up/down	Programmable I/O line or debug SPI MOSI selected by SPI_EN#.
14	PIO8 / SPI_MISO	Bidirectional with programmable strength internal pull-up/down	Programmable I/O line or debug SPI MISO selected by SPI_EN#.
15	WAKE	WAKE	External wake-up function. When WAKE Pin pulled low(To Ground), wake-up module!
16	GND	GND	Ground
17	GND	GND	Ground
18	EXT_ANT	EXT_ANT	The external antenna interface

GND

Connect GND pins to the ground plane of PCB.

VDD_BAT

3.3 V supply voltage connection. Battery input and regulator enables (active high).

PIO3

Programmable digital I/O line.

AIO0 – AIO2

Analog programmable I/O lines.

Rx

CMOS input with weak internal pull-down. RXD is used to implement UART data transfer from another device to i410e.

Tx

CMOS output with weak internal pull-up. TXD is used to implement UART data transfer from i410e to another device.

PIO6 / SPI_CSB

Programmable digital I/O lines. / CMOS input with weak internal pull-up. Active low chip select for SPI (serial peripheral interface).

PIO5 / SPI_CLK

Programmable digital I/O lines. / CMOS input for the SPI clock signal with weak internal pull-down. I410e is the slave and receives the clock signal from the device operating as a master.

PIO8 / SPI_MISO

Programmable digital I/O lines. / SPI data output with weak internal pull-down.

PIO7 / SPI_MOSI

Programmable digital I/O lines. / SPI data input with weak internal pull-down.

WAKE

Inputs to wake i410e from hibernate. Input has no internal pull-up or pull-down, use external pull-down.

EXT_ANT

If use the external antenna interface, the on-board antenna need to be removed.

4 Physical Interfaces

4.1 UART Interface

BlueSoleil i410e Universal Asynchronous Receiver Transmitter (UART) interface provides a simple mechanism for communicating with other serial devices using the RS232 standard. The UART interface of I410E uses voltage levels of 0 to VDD and thus external transceiver IC is required to meet the voltage level specifications of UART.

In order to communicate with the UART at its maximum data rate using a standard PC, an accelerated serial port adapter card is required for the PC.

Table 10 Possible UART Settings

Parameters		Possible Values
Baud rate	Minimum	1200 baud (≤2%Error)
		9600 baud (≤1%Error)
	Maximum	2Mbaud (≤1%Error)
Flow control		RTS/CTS, none
Parity		None, Odd, Even
Number of stop bits		1 or 2
Bits per channel		8

NOTE: The maximum baud rate is 9600bps during deep sleep.

4.2 SPI Interface

The synchronous serial port interface (SPI) is for interfacing with other digital devices. The SPI port can be used for system debugging. SPI interface is connected using the MOSI, MISO, CSB and CLK pins. It uses a 16-bit data and 16-bit address programming and debug interface. Transaction occurs when the internal processor is running or is stopped.

The module operates as a slave and receives commands on MOSI and outputs data on MISO. Table 11 shows the instruction cycle for a SPI transaction.

Table 11 Instruction Cycle for a SPI Transaction

Step	Operation	Description
1	Reset the SPI interface	Hold CSB high for 2 CLK cycles
2	Write the command word	Take CSB low and clock in the 8-bit command
3	Write the address	Clock in the 16-bit address word
4	Write or read data words	Clock in or out 16-bit data words
5	Termination	Take CSB high

With the exception of reset, CSB must be held low during the transaction. Data on MOSI is clocked on the rising edge of the clock line CLK. When reading, i410e replies to the master on MISO with the data changing on the falling edge of the CLK. The master provides the clock on CLK. The transaction is terminated by taking CSB high.

The auto increment operation on the i410e cuts down on the overhead of sending a command word and the address of a register for each read or write, especially when large amounts of data are to be transferred. The auto increment offers increased data transfer efficiency on the i410e. To invoke auto increment, CSB is kept low, which auto increments the address, while providing an extra 16 clock cycles for each extra word written or read.

5 Software Stacks

BlueSoleil i410e is supplied with *Bluetooth* v4.0 compliant stack firmware, which runs on the internal RISC microcontroller. The i410e software architecture allows *Bluetooth* processing and the application program to be shared in different ways between the internal RISC microcontroller and an external host processor (if any).

5.1 BlueSoleil Stack

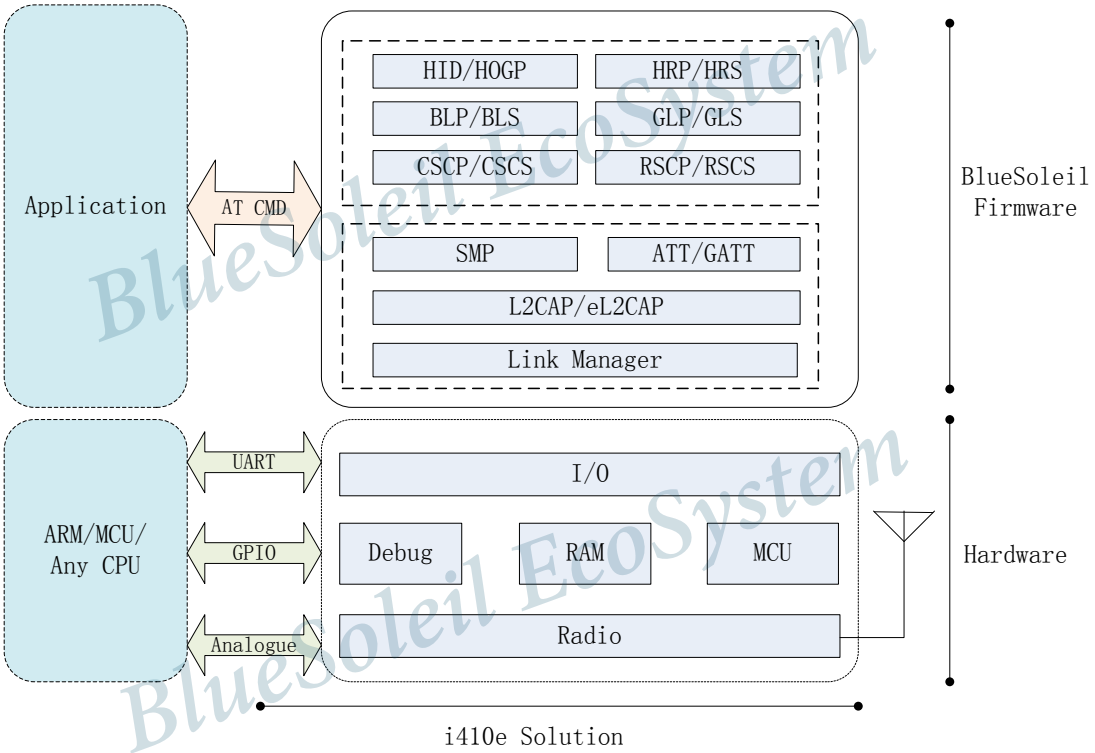


Figure 4 BlueSoleil Stack

As illustrated in Figure 4 above, no host processor is required to run the *Bluetooth* protocol stack. All BlueSoleil stack layers, including application software, run on the internal RISC processor.

The MCU interfaces to BlueSoleil i410e via one or more of the physical interfaces, which are also shown in the figure 4. The most common interfacing is done via UART interface using the ASCII commands supported by the BlueSoleil stack. With these ASCII commands the user can access *Bluetooth* functionality without paying any attention to the complexity, which lies in the *Bluetooth* protocol stack.

The user may write applications code to run on the MCU to control BlueSoleil stack with ASCII commands and to develop *Bluetooth* powered applications. Please refer to BlueSoleil_i410e_Programming_Manual.pdf.

6 Re-flow Temperature-time Profile

The re-flow profiles are illustrated in Figure 5 and Figure 6 below.

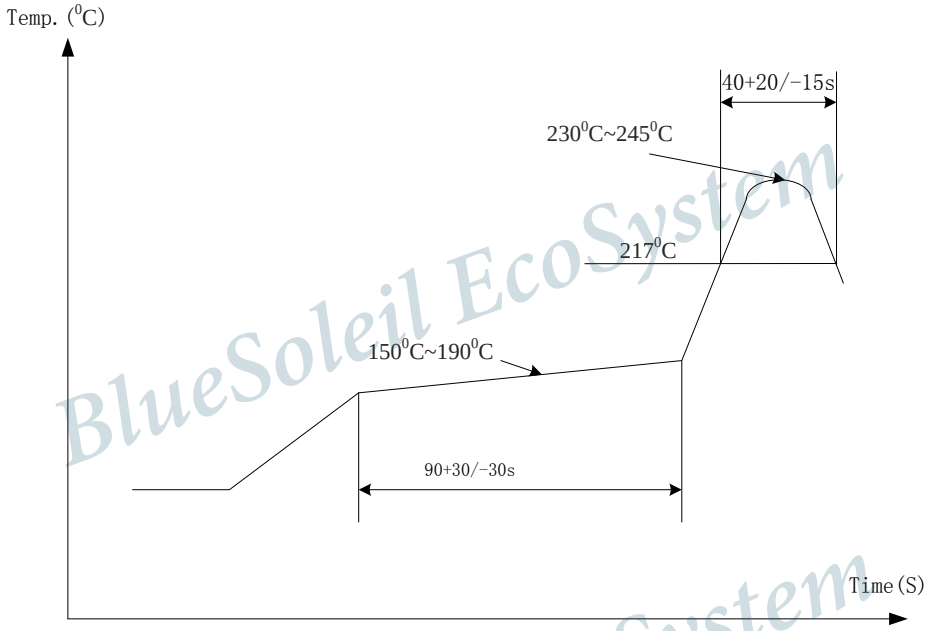


Figure 5 Typical Lead-Free Re-flow Solder Profile

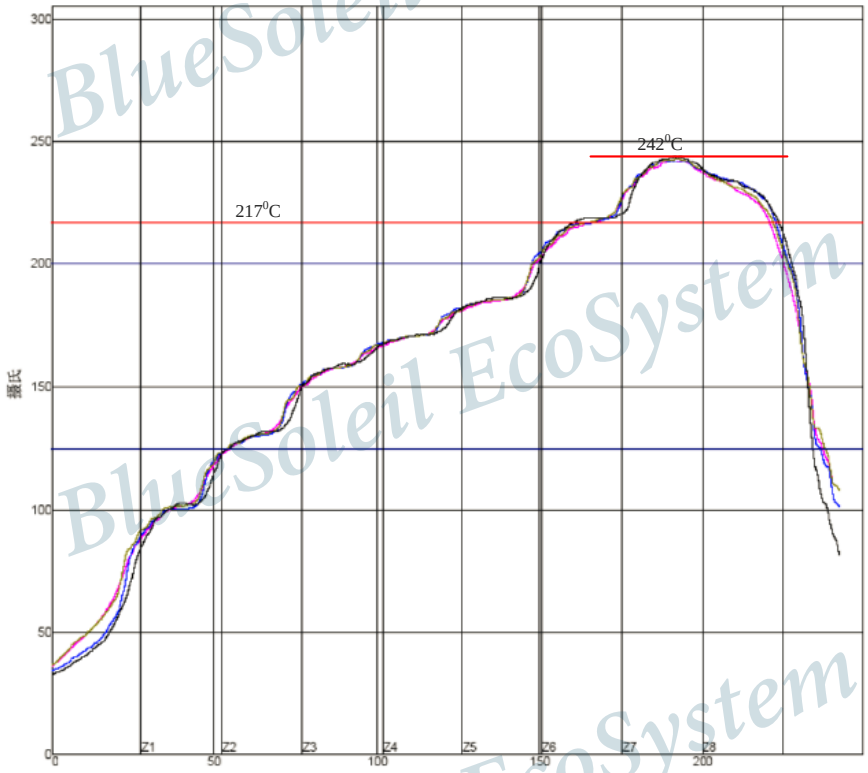


Figure 6 Typical Lead-free Re-flow

The soldering profile depends on various parameters according to the use of different solder and material. The data here is given only for guidance on solder re-flow.

i410e will withstand up to two re-flows to a maximum temperature of 245°C.

7 Reliability and Environmental Specification

7.1Temperature test

Put the module in demo board which uses exit power supply, power on the module and connect to mobile. Then put the demo in the -40℃ space for 1 hour and then move to +85℃ space within 1minute, after 1 hour move back to -40℃ space within1 minute. This is 1 cycle. The cycles are 32 times and the units have to pass the testing.

7.2Vibration Test

The module is being tested without package. The displacement requests 1.5mm and sample is vibrated in three directions(X,Y,Z).Vibration frequency set as 0.5G , a sweep rate of 0.1 octave/min from 5Hz to 100Hz last for 90 minutes each direction. Vibration frequency set as 1.5G, a sweep rate of 0.25 octave/min from 100Hz to 500Hz last for 20 minutes each direction.

7.3Desquamation Test

Use clamp to fix the module, measure the pull of the component in the module, make sure the module`s soldering is good.

7.4Drop Test

Free fall the module (condition built in a wrapper which can defend ESD) from 150cm height to cement ground, each side twice, total twelve times. The appearance will not be damaged and all functions OK.

7.5Packaging Information

After unpacking, the module should be stored in environment as follows:

- Temperature: 25℃ ±2℃
- Humidity: <60%
- No acidity, sulfur or chlorine environment

The module must be used in four days after unpacking.

8 Layout and Soldering Considerations

8.1Soldering Recommendations

BlueSoleil i410e 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.

IVT Corporation 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.

8.2Layout Guidelines

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 via 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 via all around the PCB edges.

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

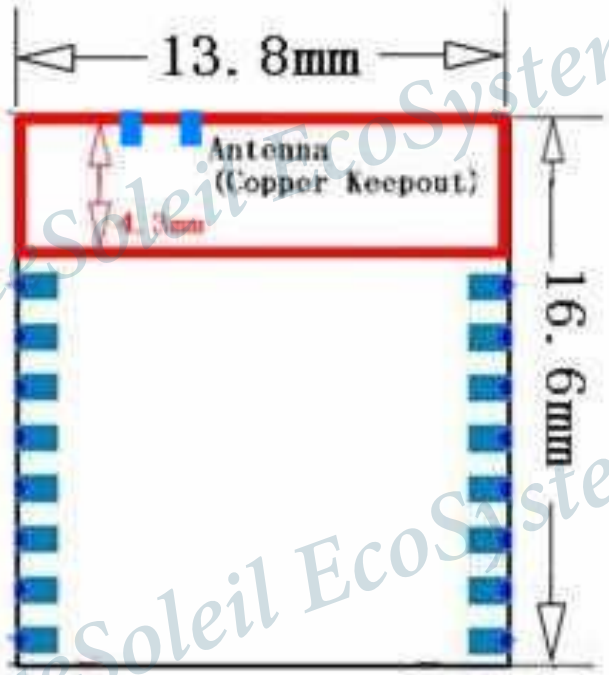


Figure 7 i410e Restricted Area

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 via around it. Locate them tightly and symmetrically around the signal via. 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 Physical Dimensions

BlueSoleil i410e's dimension is 16.6mm (L) *13.8mm (W)* 2.5mm (H).

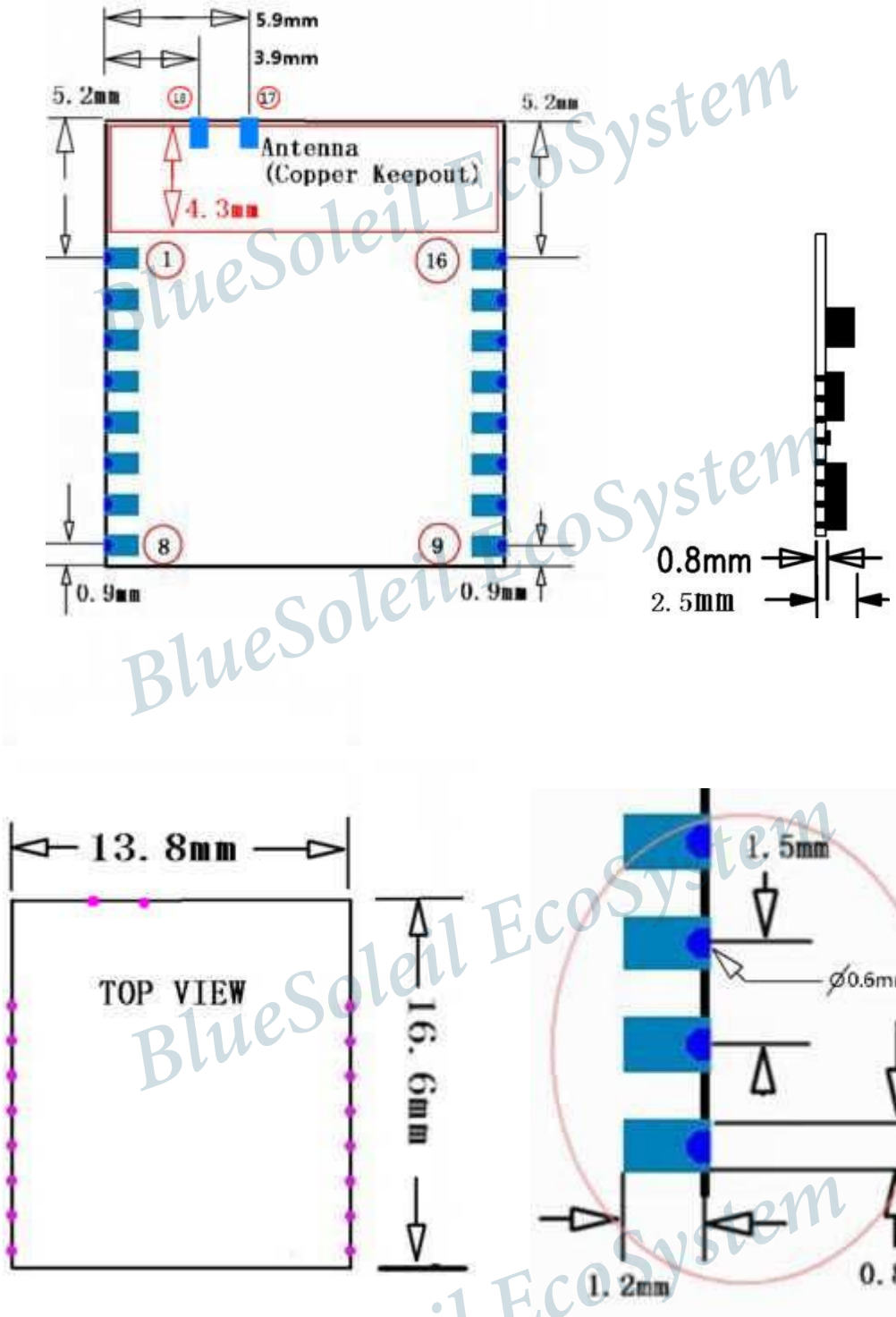
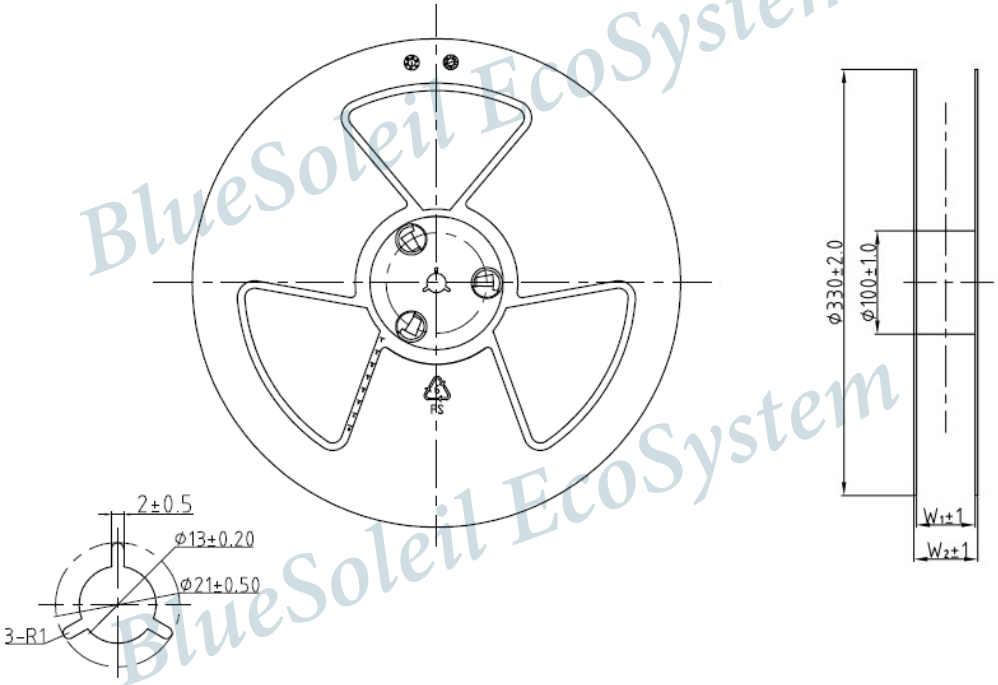


Figure 8 i410e Footprint

10 Package



MATERIAL ; PS COLOR : BLUE

Width	12mm	16mm	24mm	32mm	44mm	56mm	72mm	88mm
W1	13.5	17.5	25.5	33.5	45.5	57.5	74.0	90
W2	17.5	21.5	29.5	37.5	49.5	61.5	78.0	94

Figure 9 Reel Information

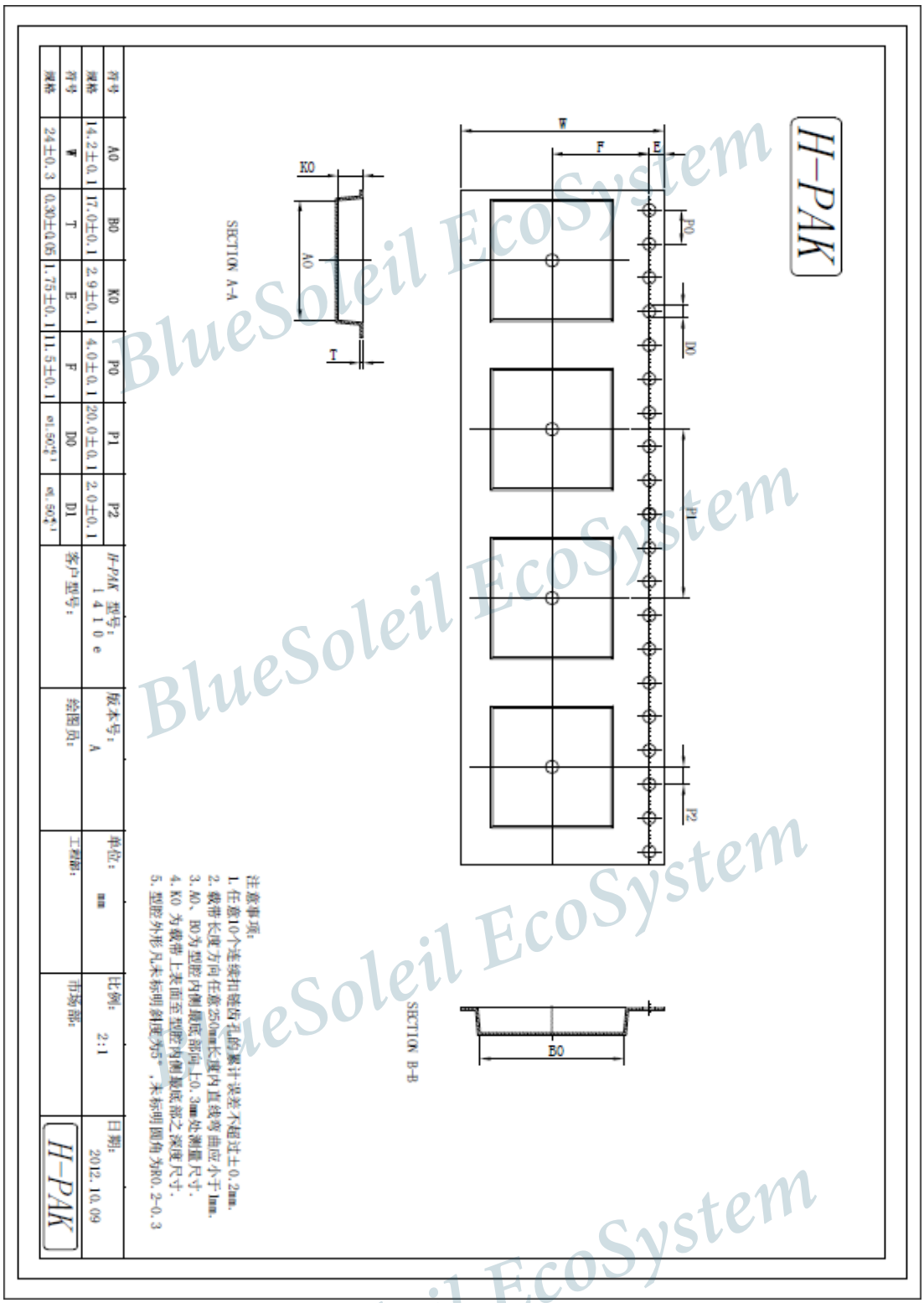


Figure 10 Tape Information

11 Certification

11.1 Bluetooth

BlueSoleil i410e module is qualified as a *Bluetooth* controller subsystem and it fulfills all the mandatory requirements of Bluetooth 4.0 core specification. If not modified in any way, it is a complete Bluetooth entity, containing software and hardware functionality as well as the whole RF-part including the antenna. This practically translates to that if the module is used without modification of any kind, it does not need any Bluetooth approval work for evaluation on what needs to be tested.

i410e Qualified Design ID (QDID): B020729

11.2 CE 0700

Hereby, IVT Corporation declares that this device is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.

CE 0700

11.3 FCC

Host manufacturer: IVT Corporation

Host Brand name: BlueSoleil

Host model number: i410e

FCC ID: S78-IVTI410E

11.4 IC

Host manufacturer: IVT Corporation

Host Brand name: BlueSoleil

Host model number: i410e

IC: 11004A-IVTI410E

The output power of this device is less than 20mW. The SAR test is not required. When using it, ensure that the antenna of the device is at least 20cm away from all persons.

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.

This device complies with Part 15 of the FCC Rules and with RSS-210 of Industry Canada. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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 Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

NOTE: The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications or changes to this equipment. Such modifications or changes could void the user's authority to operate the equipment.

NOTE: 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.

12 *Bluetooth* Technology Best Developed Corporation

IVT Corporation is one of Bluetooth technology BEST developed together which is authenticated by The Bluetooth SIG. See Figure 11 below.

Figure 11 IVT is one of *Bluetooth* technology BEST developed together

13 Contact Information

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