FR20xx Datasheet

Bluetooth Low Energy SOC with SIG Mesh integrated

Version:v0.1

Release Date:2022.11

FREQCHIP

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Description

FR20xx is a family of SOC (system on chip) for rapid development of Bluetooth Low Energy related products. It contains Bluetooth V5.1 (LE Mode) fully compliant system with Freqchip designed firmware and software stack. Users can develop various applications based on embedded 32-bits high performance MCU.

The Bluetooth Smart firmware includes the L2CAP service layer protocols, Security Manager (SM), Attribute Protocol (ATT), the Generic Attribute Profile (GATT) and the Generic Access Profile (GAP). Furthermore, application profiles such as Proximity, Health Thermometer, Heart Rate, Blood Pressure, Glucose, Human Interface Device (HID) and SDK (include drivers, OS API, etc.) are supported. The SDK has integrated SIG Mesh for networking application.

With Freqchip's innovational technology, FR20xx integrates, PMU, QSPI flash ROM with XIP mode, I2C, UART, GPIO, ADC, USB OTG, PWM all in a single chip, which provides customer with:

1. competitive power consumption
2. stable connection
3. low-cost BOM

Features

CPU and On-chip Memory

- Embedded 32-bits Arm Cortex-M3 CPU
  - floating point operation unit
  - Running at a frequency of up to 48MHz
- Memory
  - 256KB/512KB Flash
    for user space software and data
  - up to 56KB SRAM
  - Internal mask 128KB ROM
    - BOOT Code
    - Controller protocol stack
  - ROM Software:
    - BLE Profile & Protocol: GATT, LM, LC
    - Driver API
    - SIG Mesh

Bluetooth

- Compliant with Bluetooth Specification V5.1 LE
- support 2M, 1M, 500K and 125K data rate

PMU

- Integrated Battery Charger
- Integrated DC-DC Regulator

Interface

- Digital Interface:
  - GPIO
  - Timer *2
  - Efuse 128bit
  - SPIM *2
  - SPIS
  - UART
  - SPI/QSPI
  - I2C
  - PWM
  - PDM
  - USB OTG
  - 8080 parallel interface
- Analog Interface:
  - 8-channel 10bit SAR ADC
  - Maximum sampling data rate 1Mbp
  - Sampling trigger follows PWM pulse

Operating Conditions:

- Operating ambient temperature:
  -40°C ~ +105°C

Applications

- Smart Mouse
- Bluetooth Wearable
- SIG Mesh Application
- Smart Locks
- Domestic Appliance

Ordering Information

Part Number	Embedded Flash	GPIO	Operating temperature	Operating Power supply	Package	size
FR2002BS8	256KB	2	-40°C ~ +105°C	2.5V~3.3V	SOP8	4.9*6.0*1.55,1.27pitch
FR2002BS16	256 KB	10	-40°C ~ +105°C	2.5V~3.3V	SOP16	10.0*6.0*1.55,1.27pitch
FR2012A	512KB	25	-40°C ~ +105°C	1.8V~4.3V	QFN32	4.0*4.0*0.75, 0.4 pitch
FR2002B	256 KB	25	-40°C ~ +105°C	1.8V~4.3V	QFN32	4.0*4.0*0.75, 0.4 pitch

1. Hardware Details

1.1 Block Diagram

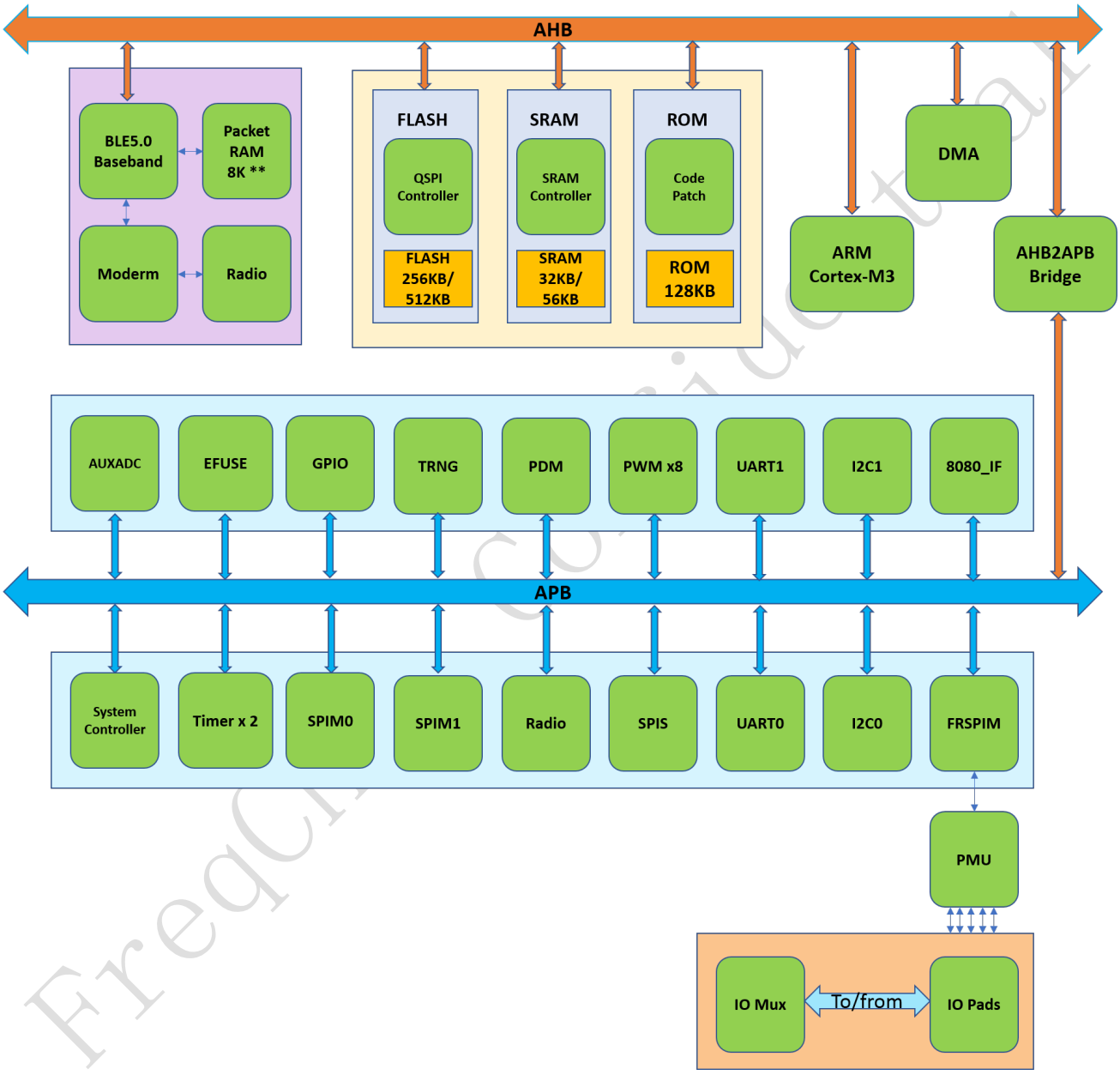


Figure 1-1 Block Diagram

1.2 Hardware Resources

Hardware resources of FR20xx series are shown in the following table:

table 1-1 FR20xxH Hardware Resources

Series	Part NO.	FLASH(KB)	RAM(KB)	GPIO	Timer	RTC	UART	I2C	SPI	QSPI	I2S	ADC	Charge	LVD	PDM	AES	TRNG
FR20xx	FR2002BS8	256	32	2	2	√	1	1	-	-	-	-	-	√	-	AES-128	1
	FR2002BS16	256	32	10	2	√	2	2	1	-	-	8ch	-	√	1	AES-128	1
	FR2016B	256	56	25	2	√	2	2	1	-	1	8ch	-	√	1	AES-128	1
	FR2016A	512	56	25	2	√	2	2	1	-	1	8ch	-	√	1	AES-128	1

1.3 Bluetooth Radio

- On-chip balun (50Ω impedance in TX and RX modes)
- No external trimming is required in production
- Qualified to Bluetooth v5.0 LE specification
- Up to 8dBm(FR2002BS8/FR2002BS16) 10dBm(FR2012A/FR2012B) RF transmit power
- -94dBm(FR2002BS8/FR2002BS16) -97dBm (FR2012A/FR2012B) (1M) receiver sensitivity in LDO mode
- Integrated channel filters
- Digital demodulator for improved sensitivity and co-channel rejection
- Real time digitized RSSI

1.4 Bluetooth Controller

- All device classes support (Broadcaster, Central, Observer, Peripheral)
- All packet types (Advertising / Data / Control)
- Encryption (AES / CCM)
- Bit stream processing (CRC, Whitening)
- Frequency hopping calculation
- Supports power down of the baseband during the protocol's idle periods

1.5 Peripheral Interfaces

- UART port for Debugging and AT Commands
- I2C interface to support external EEPROM or other devices (like G-SENSOR)
- Up to 25 general purpose IOs (25 IOs can be set in interrupt mode)
- General purpose 10-bits ADC used for basic analog signal measurement
- 8-channel PWM controller, with dead time control (FR2002B/FR2002BS16)
- General purpose programmable timer for various task
- Watchdog used for tracking unexpected exception

1.6 Integrated Power Control and Regulation

- Embedded Power-On-Reset
- On-chip high efficiency switch-mode power supply, 1.8v to 4.3v（FR2012A/FR2012B）2.5v to 3.3v（FR2002BS8/FR2002BS16）input direct from battery and programmable output voltage
- On-chip Low Dropout (LDO) Linear Regulator for internal Digital, RF and Analog circuit
- Power management features include software shutdown and hardware wake-up
- Power-on-reset cell detects low supply voltage
- Internal voltage level detector

2. Package and Pin Information

2.1 Package

2.1.1 FR2002BS8 Package

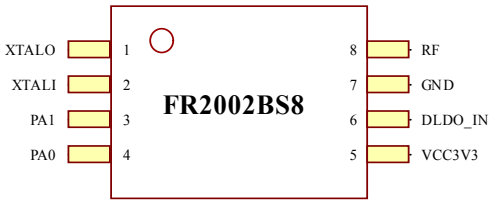


Figure 2-1 FR2002BS8 Package Pinout

2.1.2 FR2002BS16 Package

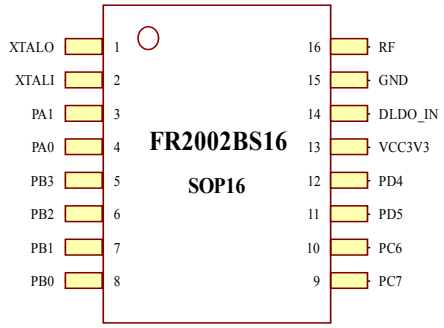


Figure 2-2 FR2002BS16 Package Pinout

2.1.3 FR2012A Package

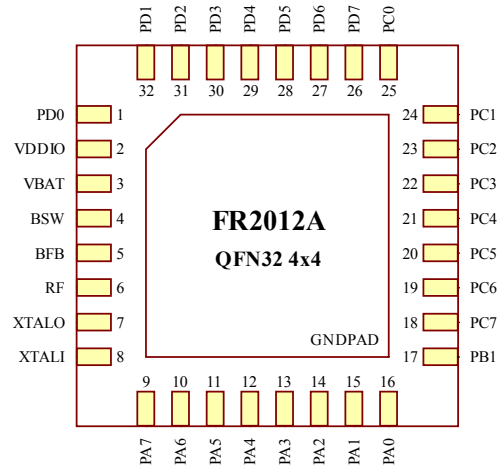


Figure 2-3 FR2012A Package Pinout

2.1.4 FR2012B Package

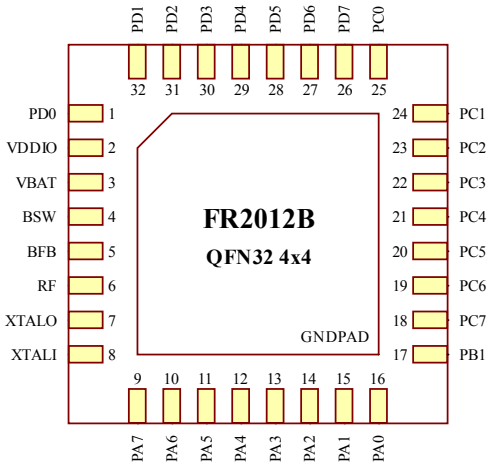
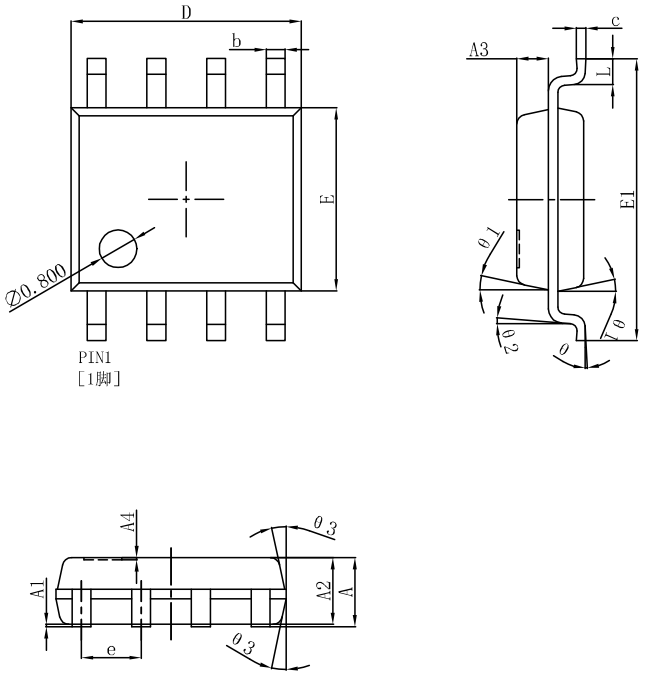


Figure 2-4 FR2012B Package Pinout

2.2 Package Physical Dimensions

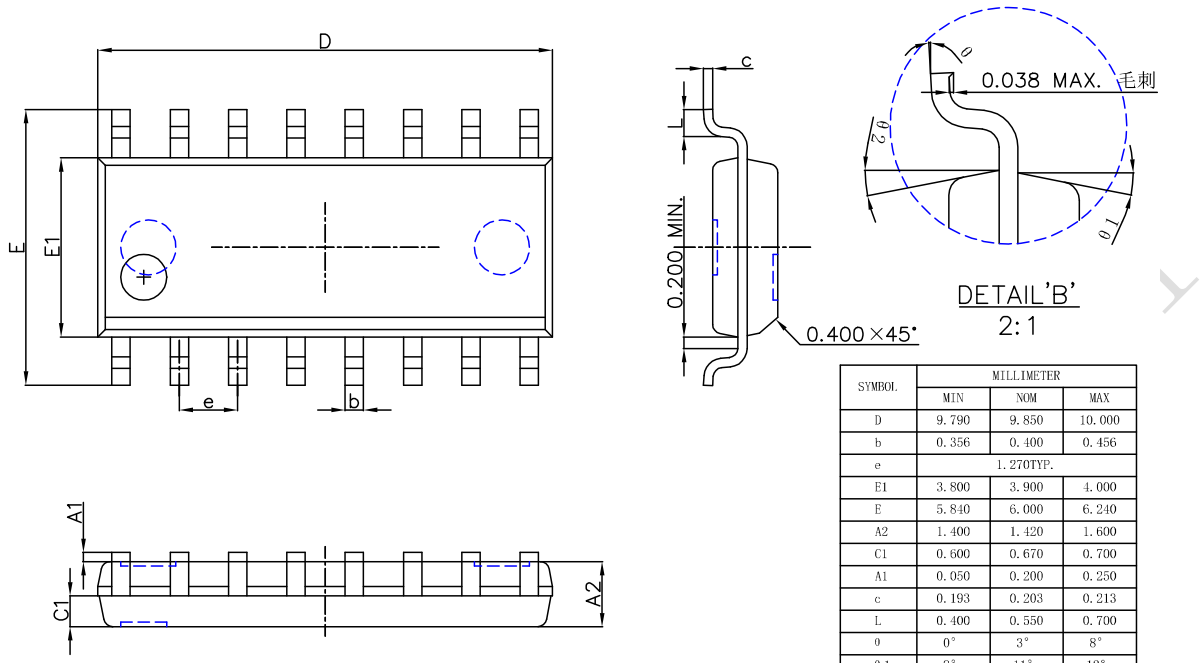
2.2.1 FR2002BS8 Package Physical Dimensions



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	1.300	1.500	1.700
A1	0.100	0.150	0.200
A2	1.350	1.420	1.550
A3	0.645	0.670	0.695
A4	0.020	--	0.050
c	0.170	0.203	0.250
E	3.800	3.900	4.000
E1	5.800	6.000	6.200
L	0.450	0.600	0.750
b	0.330	0.400	0.510
D	4.800	4.900	5.000
e	1.270BSC		
θ	0°	3°	8°
θ1	12° REF.		
θ2	5° REF.		
θ3	12° REF.		

Figure 2-5 FR2002BS8 Package Physical Dimensions

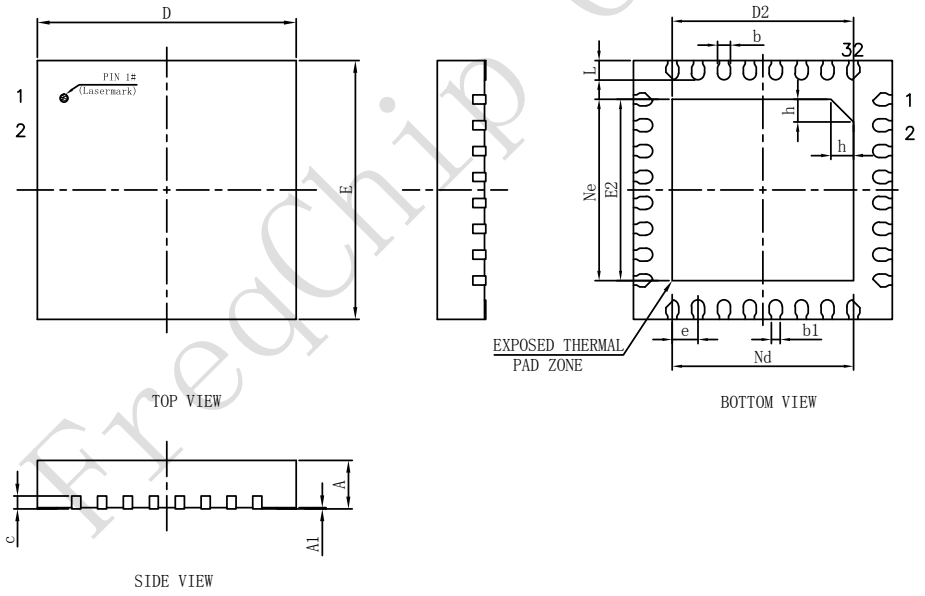
2.2.2 FR2002BS16 Package Physical Dimensions



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
D	9.790	9.850	10.000
b	0.356	0.400	0.456
e	1.270TYP.		
E1	3.800	3.900	4.000
E	5.840	6.000	6.240
A2	1.400	1.420	1.600
C1	0.600	0.670	0.700
A1	0.050	0.200	0.250
c	0.193	0.203	0.213
L	0.400	0.550	0.700
θ	0°	3°	8°
θ1	8°	11°	12°
θ2	8°	11°	12°

Figure 2-6 FR2002BS16 Package Physical Dimensions

2.2.3 FR2012A/FR2012B Package Physical Dimensions



SYMBOL	MILLIMETER			
	MIN	NOM	MAX	
A	0.70	0.75	0.80	
	0.80	0.85	0.90	⚠
	0.85	0.90	0.95	⚠
A1	0	0.02	0.05	
b	0.15	0.20	0.25	
b1	0.14REF			
c	0.18	0.20	0.25	
D	3.90	4.00	4.10	
D2	2.70	2.80	2.90	
e	0.40BSC			
Ne	2.80BSC			
Nd	2.80BSC			
E	3.90	4.00	4.10	
E2	2.70	2.80	2.90	
L	0.25	0.30	0.35	
h	0.30	0.35	0.40	
L/F载体尺寸	122X122			

Figure 2-7 FR2012A/FR2012B Package Physical Dimensions

2.3 Pins Description

FR200xx series are CMOS devices. Floating level on input signals will cause unstable device operation and abnormal current consumption. Pull-up or Pull-down resistors should be used appropriately for input or bidirectional pins.

Table 2-1 pin abbreviations

Notation	Description
AI	Analog input
AO	Analog output
IO	Bidirectional(digital)
OD	Open drain
PWR	Power
GND	Ground

Table 2-2 shows pin descriptions of FR2002BS8 package.

Table 2-2 FR2002BS8 pins description

Pin No.	Pin Name	Type	Description
1	PA1	IO	PA1 / I2C0.DAT / SPIM0.CSN / SPIS.CSN / UTXD0 / USBDM / PWM1 / PDM.DAT / BLE.RX / SIROUT / I2S.FRM
2	PA0	IO	PA0 / I2C0.CLK / SPIM0.CLK / SPIS.CLK / URXD0 / USBDP / PWM0 / PDM.CLK / BLE.TX / SIRIN / I2S.BCLK
3	GND	G	Ground
4	VCC3V3	PWR	Power supply for chip
5	DLDO_IN	AI	Digital Low-Dropout regulator input
6	RF	AI/O	RF input and output
7	XTALI	AI	Crystal oscillator input
8	XTALO	AO	Crystal oscillator output

Table 2-3 shows pin descriptions of FR2002BS16 package.

Table 2-3 FR2002BS16 pins description

Pin No.	Pin Name	Type	Description
1	XTALO	AO	Crystal oscillator output
2	XTALI	AI	Crystal oscillator input
3	PA1	I/O	PA1 / I2C0.DAT / SPIM0.CSN / SPIS.CSN / UTXD0 / USBDM / PWM1 / PDM.DAT / BLE.RX / SIROUT / I2S.FRM
4	PA0	I/O	PA0 / I2C0.CLK / SPIM0.CLK / SPIS.CLK / URXD0 / USBDP / PWM0 / PDM.CLK / BLE.TX / SIRIN / I2S.BCLK

Pin No.	Pin Name	Type	Description
5	PB3	I/O	PB3 / I2C1.DAT / SPIM0.IO1 / SPIS.MISO / UCTS0 / UTXD1 / PWM3 / PDM.DAT / WLAN.RX / LCD.CSX / BURN.SPIMISO
6	PB2	I/O	PB2 / I2C1.CLK / SPIM0.IO0 / SPIS.MOSI / URTS0 / URXD1 / PWM2 / PDM.CLK / WLAN.TX / RS485.EN / BURN.SPIMOSI
7	PB1	I/O	PB1 / I2C0.DAT / SPIM0.CSN / SPIS.CSN / UTXD0 / USBDM / PWM1 / PDM.DAT / BLE.RX / SIROUT / BURN.SPICSN
8	PB0	I/O	PB0 / I2C0.CLK / SPIM0.CLK / SPIS.CLK / URXD0 / USBDP / PWM0 / PDM.CLK / BLE.TX / SIRIN / BURN.SPICLK
9	PC7	I/O	PC7 / I2C1.DAT / SPIM1.CSN / SPIS.MISO / UCTS0 / UTXD1 / PWM7 / PDM.DAT / SWDIO / RS485.EN / I2S.MISO
10	PC6	I/O	PC6 / I2C1.CLK / SPIM1.CLK / SPIS.MOSI / URTS0 / URXD1 / PWM6 / PDM.CLK / SWTCK / SIROUT / I2S.MOSI
11	PD5	I/O	PD5 / I2C0.DAT / SPIM1.IO3 / SPIS.CSN / UTXD0 / PWM5 / PDM.DAT / SARADC5 / SIRIN / I2S.FRM
12	PD4	I/O	PD4 / I2C0.CLK / SPIM1.IO2 / SPIS.CLK / URXD0 / PWM4 / PDM.CLK / SARADC4 / I2S.BCLK
13	VCC3V3	PWR	Power supply for chip
14	DLDO_IN	AI	Digital Low-Dropout regulator input
15	GND	G	Ground
16	RF	AI/O	RF input and output

table 2-4 shows pin descriptions of FR2012A/FR2012B package.

table 2-4 FR2012A/FR2012B pins description

Pin No.	Pin Name	Type	Description
1	PD0	I/O	PD0 / I2C0.CLK / SPIM1.CLK / SPIS.CLK / URXD0 / PWM0 / PDM.CLK / SARADC0 / SIRIN / I2S.BCLK
2	VDDIO	PWR	Power supply for IO
3	VBAT	PWR	Battery positive supply input or charger output
4	BSW	AO	BUCK Switch output
5	BFB	AI	BUCK feedback input
6	RF	AI/O	RF input and output
7	XTALO	AO	Crystal oscillator output
8	XTALI	AI	Crystal oscillator input
9	PA7	I/O	PA7 / I2C1.DAT / SPIM0.CSN / SPIS.MISO / UCTS0 / UTXD1 / PWM7 / PDM.DAT / CLK.OUT / RS485.EN / I2S.MISO
10	PA6	I/O	PA6 / I2C1.CLK / SPIM0.CLK / SPIS.MOSI / URTS0 / URXD1 / PWM6 / PDM.CLK / ANT.RX / SIROUT / I2S.MOSI

Pin No.	Pin Name	Type	Description
11	PA5	I/O	PA5 / I2C0.DAT / SPIM0.IO3 / SPIS.CSN / UTXD0 / USBDM / PWM5 / PDM.DAT / ANT.TX / SIRIN / I2S.FRM
12	PA4	I/O	PA4 / I2C0.CLK / SPIM0.IO2 / SPIS.CLK / URXD0 / USBDP / PWM4 / PDM.CLK / CLK.OUT / I2S.BCLK
13	PA3	I/O	PA3 / I2C1.DAT / SPIM0.IO1 / SPIS.MISO / UCTS0 / UTXD1 / PWM3 / PDM.DAT / WLAN.RX / I2S.MISO
14	PA2	I/O	PA2 / I2C1.CLK / SPIM0.IO0 / SPIS.MOSI / URTS0 / URXD1 / PWM2 / PDM.CLK / WLAN.TX / RS485.EN / I2S.MOSI
15	PA1	I/O	PA1 / I2C0.DAT / SPIM0.CSN / SPIS.CSN / UTXD0 / USBDM / PWM1 / PDM.DAT / BLE.RX / SIROUT / I2S.FRM
16	PA0	I/O	PA0 / I2C0.CLK / SPIM0.CLK / SPIS.CLK / URXD0 / USBDP / PWM0 / PDM.CLK / BLE.TX / SIRIN / I2S.BCLK
17	PB1	I/O	PB1 / I2C0.DAT / SPIM0.CSN / SPIS.CSN / UTXD0 / USBDM / PWM1 / PDM.DAT / BLE.RX / SIROUT / BURN.SPICSN
18	PC7	I/O	PC7 / I2C1.DAT / SPIM1.CSN / SPIS.MISO / UCTS0 / UTXD1 / PWM7 / PDM.DAT / SWDIO / RS485.EN / I2S.MISO
19	PC6	I/O	PC6 / I2C1.CLK / SPIM1.CLK / SPIS.MOSI / URTS0 / URXD1 / PWM6 / PDM.CLK / SWTCK / SIROUT / I2S.MOSI
20	PC5	I/O	PC5 / I2C0.DAT / SPIM1.IO3 / SPIS.CSN / UTXD0 / LCD.RDX / PWM5 / PDM.DAT / SWV / SIRIN / I2S.FRM / PSRAM.IO0 / LCD.D13
21	PC4	I/O	PC4 / I2C0.CLK / SPIM1.IO2 / SPIS.CLK / URXD0 / LCD.WRX / PWM4 / PDM.CLK / ANT.RX / LCD.TE / I2S.BCLK / PSRAM.IO2 / LCD.D12
22	PC3	I/O	PC3 / I2C1.DAT / SPIM1.IO1 / SPIS.MISO / UCTS0 / UTXD1 / PWM3 / PDM.DAT / SWV / I2S.MISO
23	PC2	I/O	PC2 / I2C1.CLK / SPIM1.IO0 / SPIS.MOSI / URTS0 / URXD1 / PWM2 / PDM.CLK / SWV / RS485.EN / I2S.MOSI
24	PC1	I/O	PC1 / I2C0.DAT / SPIM1.CSN / SPIS.CSN / UTXD0 / LCD.DCX / PWM1 / PDM.DAT / SWV / SIROUT / I2S.FRM / PSRAM.CLK / LCD.D9
25	PC0	I/O	PC0 / I2C0.CLK / SPIM1.CLK / SPIS.CLK / URXD0 / LCD.CSX / PWM0 / PDM.CLK / SWV / SIRIN / I2S.BCLK / PSRAM.IO3 / LCD.D8
26	PD7	I/O	PD7 / I2C1.DAT / SPIM1.CSN / SPIS.MISO / UCTS0 / UTXD1 / PWM7 / PDM.DAT / SARADC7 / RS485.EN / I2S.MISO
27	PD6	I/O	PD6 / I2C1.CLK / SPIM1.CLK / SPIS.MOSI / URTS0 / URXD1 / PWM6 / PDM.CLK / SARADC6 / SIROUT / I2S.MOSI

Pin No.	Pin Name	Type	Description
28	PD5	I/O	PD5 / I2C0.DAT / SPIM1.IO3 / SPIS.CSN / UTXD0 / PWM5 / PDM.DAT / SARADC5 / SIRIN / I2S.FRM
29	PD4	I/O	PD4 / I2C0.CLK / SPIM1.IO2 / SPIS.CLK / URXD0 / PWM4 / PDM.CLK / SARADC4 / I2S.BCLK
30	PD3	I/O	PD3 / I2C1.DAT / SPIM1.IO1 / SPIS.MISO / UCTS0 / UTXD1 / PWM3 / PDM.DAT / SARADC3 / I2S.MISO
31	PD2	I/O	PD2 / I2C1.CLK / SPIM1.IO0 / SPIS.MOSI / URTS0 / URXD1 / PWM2 / PDM.CLK / SARADC2 / RS485.EN / I2S.MOSI
32	PD1	I/O	PD1 / I2C0.DAT / SPIM1.CSN / SPIS.CSN / UTXD0 / PWM1 / PDM.DAT / SARADC1 / SIROUT / I2S.FRM

2.4 Application Circuit

2.4.1 FR2002BS8 Circuit

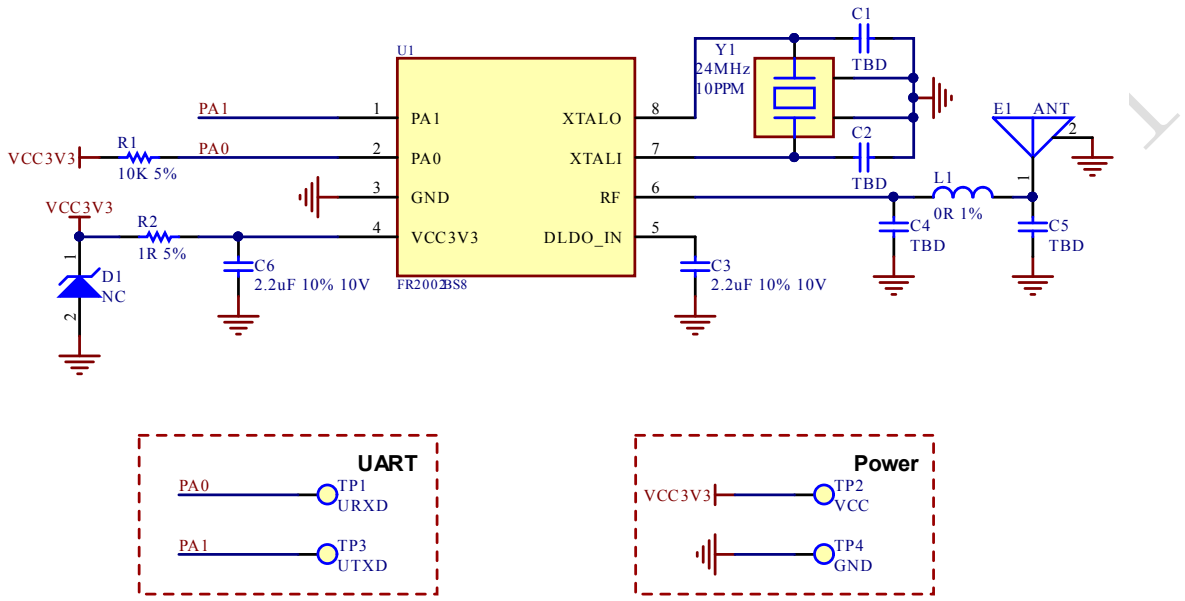


Figure 2-8 FR2002BS8 Circuit

2.4.2 FR2002BS16 Circuit

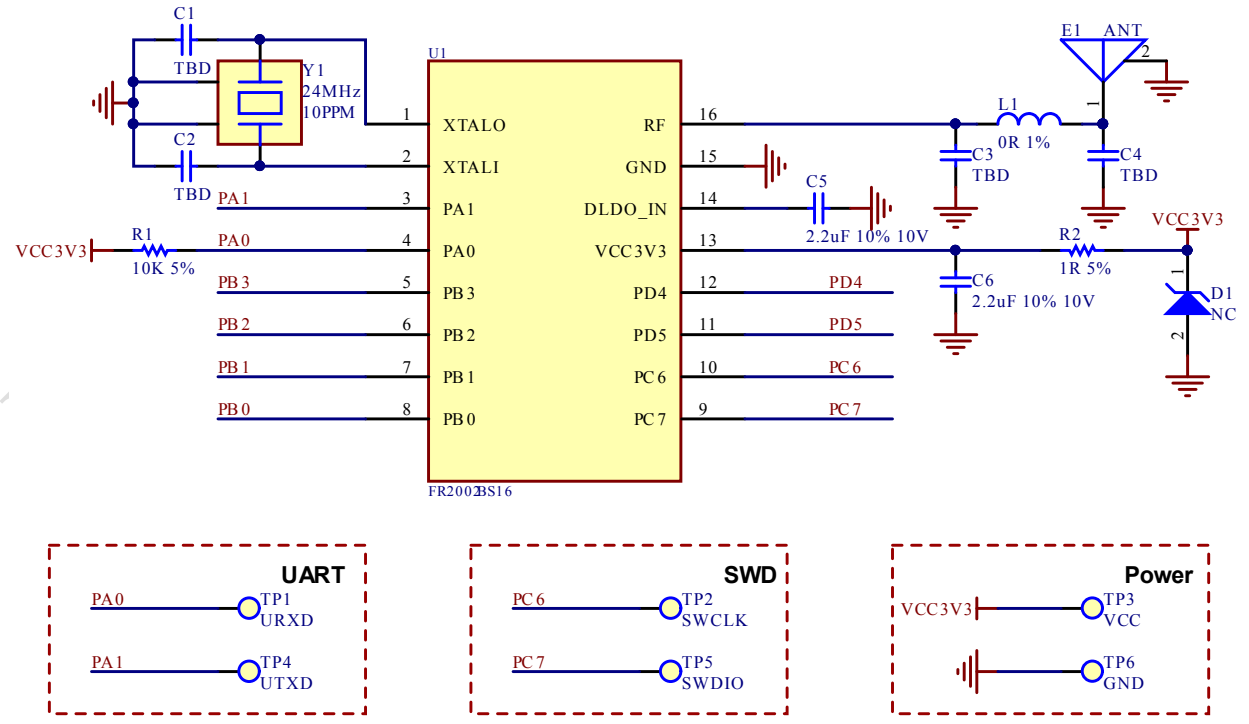


Figure 2-9 FR2002BS16 Circuit

2.4.3 FR2012A/FR2012B Circuit

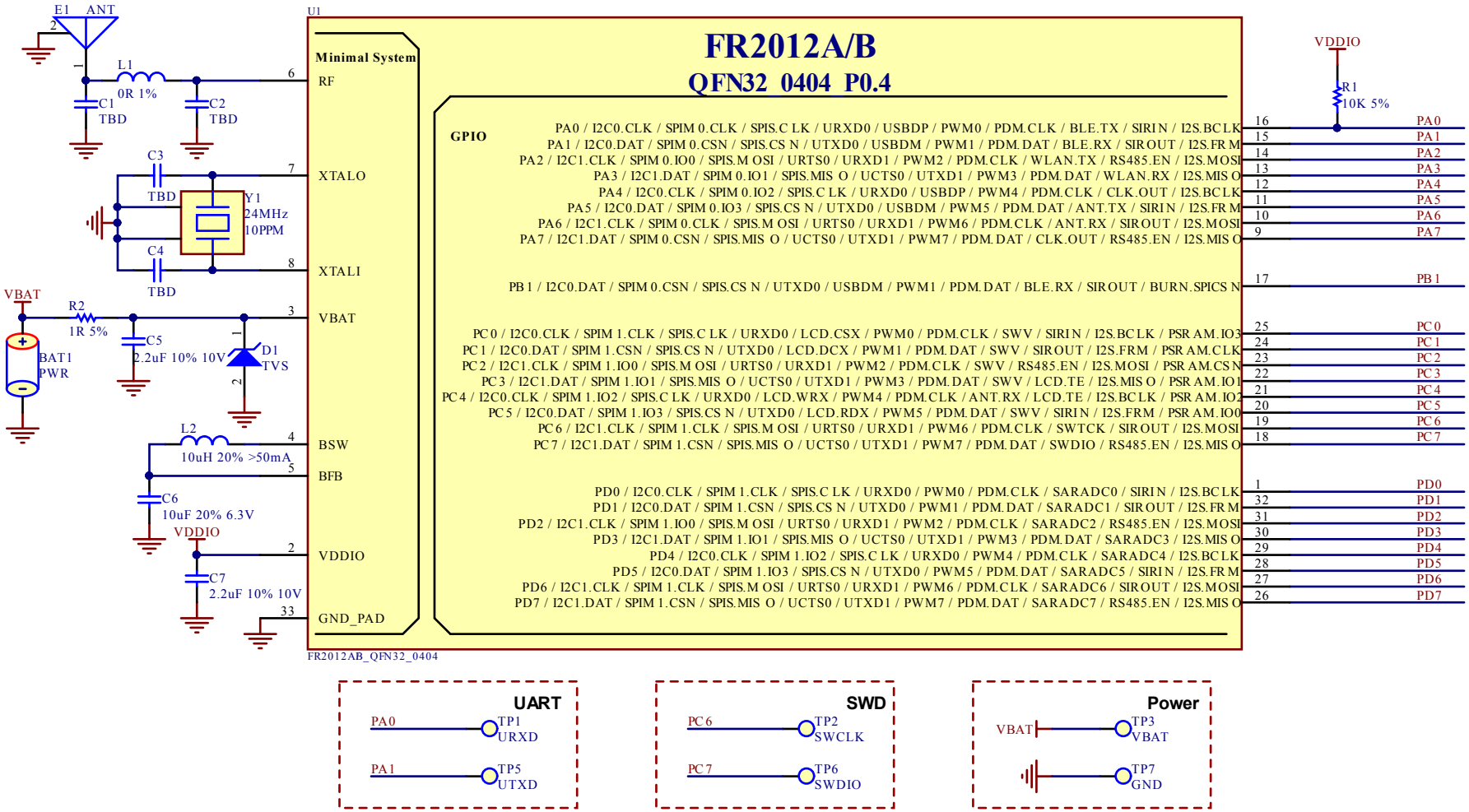


Figure 2-10 FR2012A/FR2012B Circuit

3. Electrical Characteristics

3.1 Absolute Maximum Ratings

Continuous operation at or beyond these conditions may permanently damage the device.

Table 3-1 Absolute Maximum Ratings

Rating		Min	Max	Unit
Storage Temperature		-40	125	℃
Core Supply Voltage		0.9	1.2	V
I/O Voltage	VDDIO	1.6	3.5	V
Supply Voltage	VBAT	1.8	4.3(FR2012A/FR2012B) 3.3(FR2002BS8/FR2002BS16)	V
	VCHG	4.75	5.25	V

3.2 Recommended Operating Conditions

Table 3-2 recommended operating conditions

Operating Condition		Min	Typ	Max	Unit
Operating Temperature Range		-20	25	85	℃
Core Supply Voltage		0.9	1.1	1.2	V
I/O Voltage	VDDIO	1.6	2.9	3.5	V
Supply Voltage	VBAT	1.8	3.3	4.3(FR2012A/FR2012B) 3.3(FR2002BS8/FR2002BS16)	V

VDDIO : Power-on default value is 1.8, user configurable later

3.3 Power Consumption

Table 3-3 power consumption

Operation Mode	Average	Max	Unit
TX peek current (0dB)		6.2	mA
RX peek current		6.5	mA
Sleep mode current	＜11(include 56K retention RAM)		μA
	＜10(include 48K retention RAM)		μA
	＜9 (include 32K retention RAM)		μA
Power off mode current	＜3.5		μA

3.4 Crystal oscillator

Clock Source	Min	Typ	Max	Unit
Main Crystal OSC(24MHz) for Bluetooth RF application				
Clock Frequency	24	24	24	MHz
Tolerance		+/-10		Ppm

3.5 IO Resistor

Peripheral	Port Num	Mode	VDD	Value
GPIO	-	Pull-up	3.3V	8.1K
		Pull-down		6.5K
I2C	-	Pull-up	3.3V	3K
		Pull-down		6.5K

3.6 ESD

Pin name	Human body model(HBM)	Charged-device model(CDM)	UNIT
RF	±2000	±200	V
XTALI	±2000	±500	V
XTALO	±2000	±500	V
OTHERS	±2000	±2000	V

Abbreviations

Abbreviations	Descriptions
AEC	acoustic echo cancellers
AGC	Automatic Gain Control
ANS	Automatic Noise Suppression
ADC	Analog-to-Digital-Converter
DAC	Digital-to-Analog-Converter
GPIO	General Purpose Input Output
MIC	Microphone
PMU	Power Management Unit
OSC	Oscillator
PA	Power Amplifier
SoC	system on chip

Contact Information

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Revision History

Feedback:

Freqchip welcomes feedback on this product and this document. If you have comments or suggestions, please send an email to docs@freqchip.com.

Reversion Number	Reversion Date	Description
V0.1	2022.8.16	Initial Draft