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# FR5082 Datasheet

Dual Mode Bluetooth Stereo Audio Speaker SOC

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## DESCRIPTION

FR5082 is a family of SoC (system on chip) for rapid development of Bluetooth audio related products. With Freq-chip's innovational technology, FR5082 integrates RF, CODEC, PMU, Baseband, Cortex-M3 CPU and Audio DSP all in a single chip, which provides customer with:

1. competitive power consumption
2. outstanding wireless sound quality
3. remarkable Bluetooth range
4. low-cost BOM

FR5082 contains a Dual Mode Bluetooth V5.0 (BR/EDR/LE Mode) fully compliant system with Freq-chip designed Firmware and software stack in ROM. The firmware can be upgraded or customized in order to reduce the production risk and shorten the time to market.

New advanced technology is implemented like: noise suppression, multipoint (2 devices connected), true wireless.

## FEATURES

- Extremely low power design
- Bluetooth Dual Mode 5.0 Specification Radio
  - RX sensitivity -90dBm @1Mbps for BR
  - RX sensitivity -92dBm @2Mbps for EDR
  - RX sensitivity -93.5dBm @1Mbps for BLE
  - TX Power -20dBm ~ 8dBm
- Bluetooth Dual Mode 5.0 Specification Controller
  - BR/EDR 1Mbps/2Mbps/3Mbps support
  - LE 1Mbps support
- Dedicated Dual-Core processor architecture
  - 32-bit Cortex-M3 CPU inside for communication and application subsystem, frequency is 48MHz.
  - Floating point DSP for audio & other algorithm, frequency is 156MHz.
- Embedded 96KB+416KB SRAM.
- XIP Flash 1MB for Coretex-M3.

- Up to 104 x4 Mbps QSPI interface.
- High performance low power audio
  - 2-ch DAC SNR@96dB
  - 1-ch ADC SNR @84dB
  - 48kHz 24-bit I2S/PCM interfaces
  - Full band configurable EQ
- SoC Peripherals on
  - 4-ch PDM interface for Digital Mic
  - 2 x I2C
  - Up to 2 x QSPI
  - 2 x UART
  - Configurable GPIO x22
  - SDC
  - USB-OTG
  - 6 x PWM
  - Up to 4-ch external SAR-ADC
- Integrated power management unit
  - Dual DC-DC power supply (SISO)
  - On-chip LDO for digital logic & analog
  - Power switch for different power domain
- Bluetooth Audio Application
  - DSP audio decoder support
  - A2DP Source

## TYPICAL APPLICATIONS

- Bluetooth car audio unit
- Bluetooth dongles(USB, TV set, Game player, and Intercom dongle etc)
- Smart Watch
- Device of reception and transmission as one
- Human Interface Devices

## ORDERING INFORMATION

Order code	Temperature rang	Package	Packing
FR5082DM	-40°C ~ +85°C	QFN40 6*4 (P0.4 T0.75)	Tape and reel
FR5082DS	-40°C ~ +85°C	QFN40 6*4 (P0.4 T0.75)	

# 1. Hardware Details

## 1.1 Application Diagram

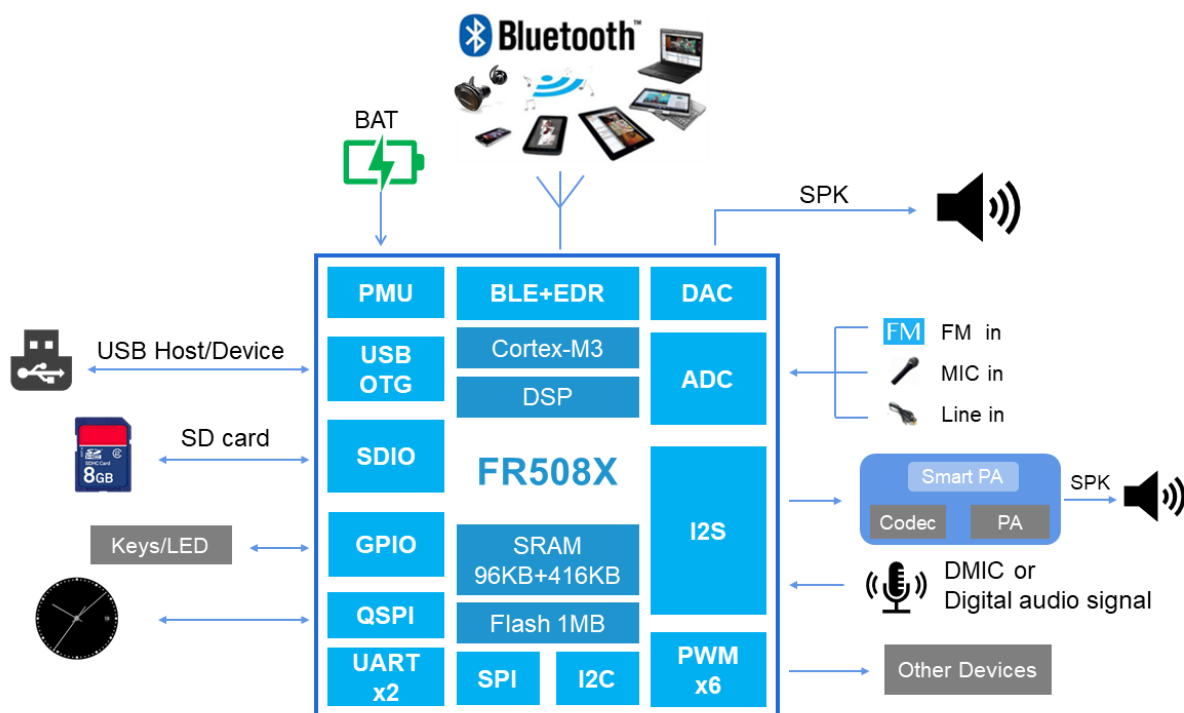


Figure 1-1 Application Diagram



## 1.2 Block Diagram

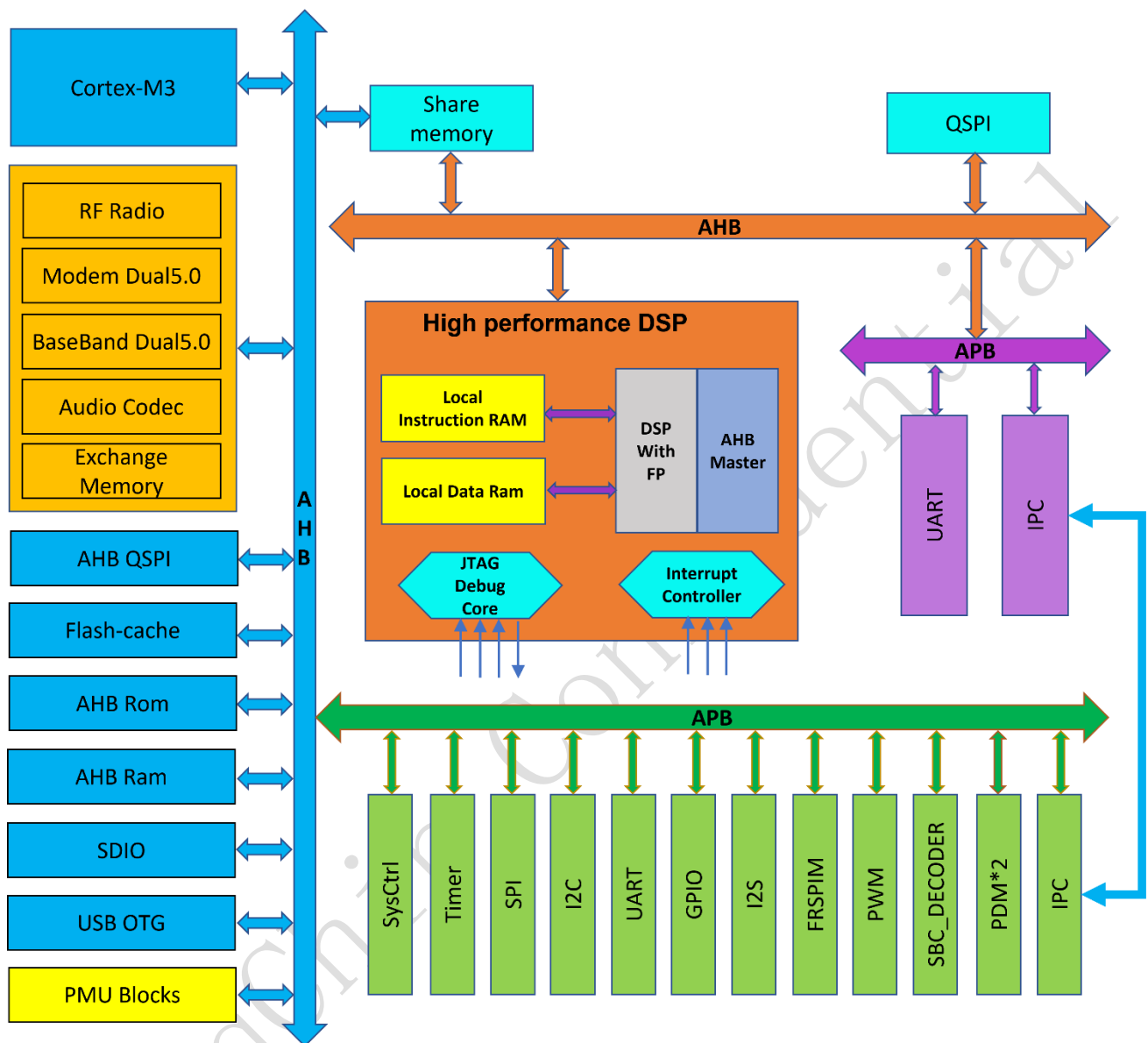


Figure 1-2 Block Diagram

## 1.3 Bluetooth Radio

- On-chip balun (50Ω impedance in TX and RX modes)
- No external trimming is required in production
- Qualified to Bluetooth Dual Mode V5.0 BR/EDR/BLE specification

## 1.4 Bluetooth Transmitter

- Configurable RF transmit power -20dBm ~ 8dBm
- Class 2 and Class 3 support without need for external power amplifier or TX/RX switch

## 1.5 Bluetooth Receiver

- Integrated channel filters
- Digital demodulator for improved sensitivity and co-channel rejection
- Real time digitized RSSI
- Fast AGC for enhanced dynamic range
- Channel classification for AFH

## 1.6 Bluetooth Controller

- Embedded 32-bits low power processor with on-chip ROM and RAM
- Embedded 24Mhz Crystal Oscillator Driver
- Embedded low frequency RC Crystal Oscillator for Bluetooth sleep communication
- Processor in 16~48Mhz speed
- Support SCO/eSCO link
- Support Secure Simple Pairing
- Bluetooth 5.0 BR/EDR/BLE Mode support

## 1.7 Audio Interface

- Embedded 16-bit Audio CODEC
- DAC SNR 96dB, THD -86dB
- ADC SNR 84dB, THD -83dB
- DAC/ADC Support 8k/16k/44.1k/48kHz sample rate
- Full Band configurable EQ
- One analog MIC amplifier, build-in MIC bias generator
- Support 4-ch PDM with Digital microphones input
- One channel Stereo analog MUX
- Output earphone PA with 50mW output power

## 1.8 Physical Interfaces

- UART port for Debugging and AT Commands
- 1/2/4-bit SPI flash memory interface to support external SPI flash
- I2C interface to support external EEPROM or other devices (like FM Receiver)
- QSPI interface support up to 104x4Mbps data rate.
- Up to 22 general purpose IOs (5082DM has 22 IOs, 5082DS has 18 IOs)
- SDIO card interface supports either 1-bit mode, 2-bit mode or 4-bit mode, can support SD nand flash or EMMC
- USB interface support OTG can work in host and device mode

## 1.9 Integrated Power Control and Regulation

- Embedded Power-On-Reset
- Support ONKEY (switch or long press) power on and power off logic
- Low power core voltage
- On-chip high efficiency switch-mode power supply, 2.5v to 4.3v 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

## 1.10 Package

- QFN40 6\*4 (P0.4 T0.75)

## 2. Solution Details

### 2.1 Embedded Bluetooth Protocols and Profiles

- Bluetooth Dual Mode V5.0 BR/EDR/BLE specification compliant
- Low level Bluetooth protocols embedded (LMP, L2CAP, RFCOMM, SDP, etc.)
- A2DP V1.3 and AVRCP V1.6 supported
- HFP V1.8 supported
- SPP V1.2 supported

### 2.2 Music Enhancements and Features

- Configurable full-band EQ for music/voice playback
- Embedded SBC hardware decoder

### 2.3 AEC/NS Features

- AEC (acoustic echo cancellation) up to 60dB
- Superior full-duplex
- Support one microphone mode, ease for application
- Support dual-microphone mode
- Acoustic echo tail length coverage: up to 64ms ~128ms
- Fast AGC control to improve dynamic range
- Noise suppression up to 20 dB

### 2.4 Additional Functionality

- Support Alarm Clock
- Support up to 454\*454\*24bits OLED panel with QSPI port

## 2.5 System Configuration and Upgrading

- Flexible configuration data (pskeys) and PC helper tools
- Auto reconnection (e.g. power-on or RF signal lost)
- Configurable Button events mapping to specific functions. (e.g. double press on PIO for last number redial)
- User-defined indication tones for events and ringtones
- Software Code Patch (including Firmware upgrading, bug-fix or customized codes)
- Support upgrading by UART or SPP over air
- XIP support for customer application

## 2.6 Solution Development Support

- FR5082 Reference Design Circuits and Documents
- Configuration Tool and Documents
- Indication Tone maker Tool
- Application Notes

### 3. RF Radio Characteristics

#### 3.1 Enhanced Data Rate

##### 3.1.1 Receiver Specifications

Table 3-1 Receive Specifications

Description	Condition	Min	Typ	Max	Unit
Frequency range	Min - Max	2402	-	2480	MHz
Sensitivity with dirty off	$\pi/4$ DQPSK, BER < 0.01%	-	-92	-	
Maximum received signal	$\pi/4$ DQPSK, BER < 0.01%	-20	0	-	dBm
	8PSK, BER ≤ 0.01%	-20	-2	-	dB
C/I co-channel selectivity	$\pi/4$ DQPSK, BER < 0.01%	-	10	13	dB
	8PSK, BER ≤ 0.01%	-	19	21	dB
C/I 1MHz adj. channel selectivity	$\pi/4$ DQPSK, BER < 0.01%	-	-10	0	dB
	8PSK, BER ≤ 0.01%	-	-1	5	dB
C/I 2MHz adj. channel selectivity	$\pi/4$ DQPSK, BER < 0.01%	-	-44	-30	dB
	8PSK, BER ≤ 0.01%	-	-25	-25	dB
C/I ≥3MHz adj. channel selectivity	$\pi/4$ DQPSK, BER < 0.01%	-	-40	-40	dB
	8PSK, BER ≤ 0.01%	-	-41	-33	dB
C/I image channel selectivity	$\pi/4$ DQPSK, BER < 0.01%	-	-29	-7	dB
	8PSK, BER ≤ 0.01%	-	-19	0	dB
C/I image 1MHz adj. channel selectivity	$\pi/4$ DQPSK, BER < 0.01%	-	-34	-20	dB
	8PSK, BER ≤ 0.01%	-	-25	-13	dB

### 3.1.2 Transmitter Specifications

Table 3-2 Transmitter Specifications

Description	Condition	Min	Typ	Max	Unit
Frequency range	Min - Max	2402	-	2480	MHz
Maximum transmit power	$\pi/4$ DQPSK	-	4	8	dBm
	8PSK	-	4	8	dBm
Relative transmit power	$\pi/4$ DQPSK	-4	-3	1	dB
	8PSK	-4	-3	1	dB
Freq. stability $\omega_0$	$\pi/4$ DQPSK	-10	-1	10	KHz
	8PSK	-10	-1	10	KHz
Freq. stability $\omega_1$	$\pi/4$ DQPSK	-75	11	75	KHz
	8PSK	-75	11	75	KHz
$ \omega_0 + \omega_1 $	$\pi/4$ DQPSK	-75	11	75	KHz
	8PSK	-75	11	75	KHz
RMS DEVM	$\pi/4$ DQPSK	-	5	20	%
	8PSK	-	4	13	%
99% DEVM	$\pi/4$ DQPSK	-	11	30	%
	8PSK	-	10	20	%
Peak DEVM	$\pi/4$ DQPSK	-	8	35	%
	8PSK	-	8	25	%
In-band spurious emission	$\pi/4$ DQPSK, $\pm 1$ MHz offset	-	-36	-26	dBm
	8PSK, $\pm 1$ MHz offset	-	-37	-26	dBm
	$\pi/4$ DQPSK, $\pm 2$ MHz offset	-	-36	-20	dBm
	8PSK, $\pm 2$ MHz offset	-	-35	-20	dBm
	$\pi/4$ DQPSK, $\pm 3$ MHz offset	-	-42	-40	dBm
	8PSK, $\pm 3$ MHz offset	-	-42	-40	dBm

## 3.2 LE 1M Data Rate

### 3.2.1 Receiver Specifications

Table 3-3 Receiver Specifications

Description	Condition	Min	Typ	Max	Unit
Frequency range	Min – Max	2402	-	2480	MHz
Receiver sensitivity	PER < 30.8%	-	-93.5	-89	dBm
Max. detectable input power	PER < 30.8%	-	0	-	dBm
C/I co-channel selectivity	PER < 30.8%	-	6	21	dB
C/I 1MHz adj. channel selectivity	PER < 30.8%	-	0	15	dB
C/I 2MHz adj. channel selectivity	PER < 30.8%	-	-22	-17	dB
C/I 3MHz adj. channel selectivity	PER < 30.8%	-	-45	-27	dB
C/I image channel selectivity	PER < 30.8%	-	-23	-9	dB
C/I image 1MHz adj. channel selectivity	PER < 30.8%	-	-22	-15	dB
Out-of-band blocking	30MHz ~ 2000MHz	-	-	-30	dBm
	2001MHz ~ 2399MHz	-	-	-35	dBm
	2501MHz ~ 3000MHz	-	-	-35	dBm
	3001MHz ~ 12.75GHz	-	-	-30	dBm

### 3.2.2 Transmitter Specifications

Table 3-4 Transmitter Specifications

Description	Condition	Min	Typ	Max	Unit
Frequency range	Min - Max	2402	-	2480	MHz
transmit power	Min - Max	-20	4	8	dBm
Gain Step	-	0.5	1	2	dB
Modulation characteristic	$\Delta f_{1avg}$	225	262	275	KHz
	$\Delta f_{2max}$	185	222	-	KHz
	$\Delta f_{1avg} / \Delta f_{2avg}$	0.8	0.88	-	
Carrier frequency offset & drift	Frequency offset	-150	12	150	KHz
	Frequency drift	-50	4	50	KHz
	Maximum drift rate	-20	4	20	KHz/uS



Description	Condition	Min	Typ	Max	Unit
In-band spurious emission	$\pm 2$ MHz offset	-	-42	-20	dBm
	$\pm 3$ MHz offset	-	-42	-30	dBm
	$>\pm 3$ MHz offset	-	-52	-30	dBm

## 4. Audio CODEC Characteristics

Table 4-1 Audio CODEC Characteristics

Digital to Analogue Converter (Stereo)					
Parameter	Conditions	Min	Typ	Max	Unit
Resolution	-	-	-	20	Bits
Sampling frequency (Fs)*	The synchronized clock signal	8	-	48	kHz
SNR (Signal to Noise Ratio)	Fin=1kHz B/W=20Hz—20KHz A-Weighted THD_N<0.01% Fs(8K,16K,32K,44.1K,48K)	-	96	-	dB
Digital Gain	Digital Gain Resolution=1/48dB	-48	-	32	dB
Analogue Gain	Analog Gain Resolution = 3dB	0	-	-30	dB
Output voltage full-scale	AU_BFB=2.3V	-	1.15	-	V
Stopband attenuation	Min - Max	65	-	-	dB
Analog to Digital Converter (Mono)					
Parameter	Conditions	Min	Typ	Max	Unit
Resolution	-	-	-	16	Bits
Sampling frequency (Fs)*	The synchronized clock signal	8	-	48	kHz
Signal to Noise Ratio	A-weighted	-	79	-	dBFS
	W/O weighting	-	79	-	dBFS
Digital Gain	Digital Gain Resolution=1/48dB	-48	-	32	dB
Analogue Gain	Analog Gain Resolution = 3dB	0	-	30	dB
Microphone Bias					
Bias Voltage	MBVSEL=0	-	0.6*AU_BFB	-	V
	MBVSEL=1	-	0.9*AU_BFB	-	V
Bias Current Source	VMICBIAS within +/-3%	-	-	3	uA
Output Noise Voltage	1kHz to 20kHz	-	15	-	nV/sqrt(Hz)

## 5. Electrical Characteristics

### 5.1 Absolute Maximum Ratings

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

Table 5-1 Absolute Maximum Ratings

Rating		Min	Max	Unit
Storage Temperature		-55	125	°C
I/O Voltage	VDDIO	1.8	3.3	V
Supply Voltage	VBAT	2.5	4.3	V
	VCHG	4.5	5.5	V

### 5.2 IOLDO Characteristics

Table 5-2 IOLDO Characteristics

Parameter	Min	Typ	Max	Unit
Input voltage	2.5	3.7	4.3	V
Output voltage	1.8	2.9	3.3	V
Max Output current	-	120	-	mA
Ripple	-	25	-	mV

### 5.3 System DC-DC Characteristics

Table 5-3 System DC-DC Characteristics

Parameter	Min	Typ	Max	Unit
Input voltage	2.5	3.7	4.3	V
Output voltage	1.2	1.4	1.6	V
Max Output current	80	-	-	mA
Switch frequency	-	2.5	-	MHz
PWM Mode Ripple	-	10	-	mV
PFM Mode Ripple	-	30	-	mV
Efficiency(PWM)	-	85	-	%
Efficiency(PFM)	-	85	-	%
Leakage current (Power down)	-	< 25	-	nA

## 5.4 Audio DC-DC Characteristics

Table 5-4 Audio DC-DC Characteristics

Parameter	Min	Typ	Max	Unit
Input voltage	2.5	3.7	4.3	V
Output voltage	1.65	1.8	2.5	V
Max Output current	80	-	-	mA
Switch frequency	-	2.5	-	MHz
PWM Mode Ripple	-	10	-	mV
PFM Mode Ripple	-	30	-	mV
Efficiency (PWM)	-	85	-	%
Efficiency (PFM)	-	85	-	%
Leakage current (Power down)	-	< 15	-	nA

## 5.5 Recommended Operating Conditions

Table 5-5 Recommended Operating Conditions

Operating Condition		Min	Typ	Max	Unit
Operating Temperature Range		-40	25	85	°C
Core Supply Voltage	/	0.9	1.2	1.3	V
I/O Voltage	VDDIO	1.8	2.9	3.3	V
Audio Voltage	AU_BFB	1.2	2.3	2.6	V
Supply Voltage	VBAT	2.5	3.7	4.3	V
Charge input voltage	VCHG	4.5	5	5.25	V

## 5.6 Power Consumption

Table 5-6 Power Consumption

Operation Mode	Average	Max	Unit
Bluetooth A2DP (SBC Audio )	<6.5	-	mA
Bluetooth ESCO +AEC/NS(Phone call)	<8	-	mA
Standby(500ms Sniff, 1 attempt, 0 timeout, 3.3V supply voltage)	<70	-	uA
Power off	<3	-	μA

## 5.7 IO Electrical Logical Characteristics

Table 5-7 IO Electrical Logical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit	Test Conditions
VIL	Low-Level Input Voltage	-0.3	-	0.3* VDDIO	V	VDDIO=3V
VIH	High-Level Input Voltage	0.7*VDDIO	-	VDDIO+0.3	V	VDDIO=3V
VOL	Low-Level Output Voltage	-	-	0.3	V	VDDIO=3V
VOH	High-Level Output Voltage	2.7	-	-	V	VDDIO=3V

## 5.8 Internal Resistor Characteristics

Table 5-8 Internal Resistor Characteristics

Port	General Output	Internal Pull-Up Resistor	Internal Pull-Down Resistor
All GPIOs	8mA	50K	30K
USB_DP/USB_DM	8mA	1.5K	15K

## 5.9 Inductance

Table 5-9 Inductance

Parameter	Min	Typ	Max	Unit
Saturated Current	80	-	-	mA
Self Resonant Frequency	10	-	-	MHz
Direct Current Resistance	-	-	1	ohm

## 5.10 Crystal oscillator

Table 5-10 Crystal oscillator

Parameter	Min	Typ	Max	Unit
Clock Frequency	24	24	24	Mhz
CL Load capacitance	-	9	12	pF
Tolerance	-	+/-10	-	ppm
Motional resistance	-	-	60	R
Shunt capacitance	-	-	2	pF

## 6. FR5082 QFN40 Package and Pin Information

### 6.1 Package

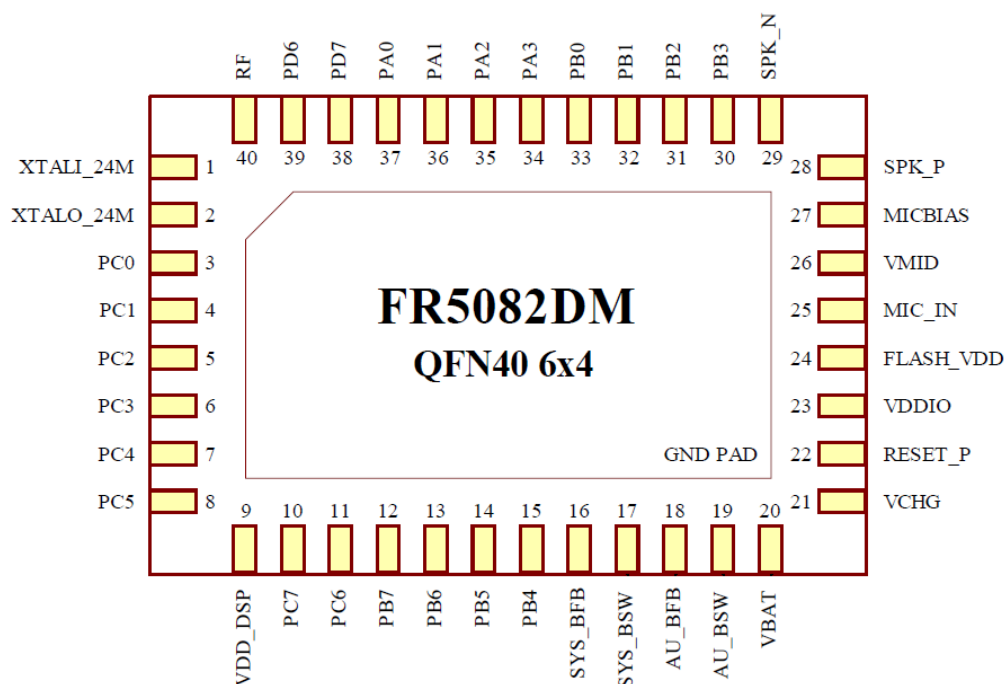


Figure 6-1 FR5082DM pin information

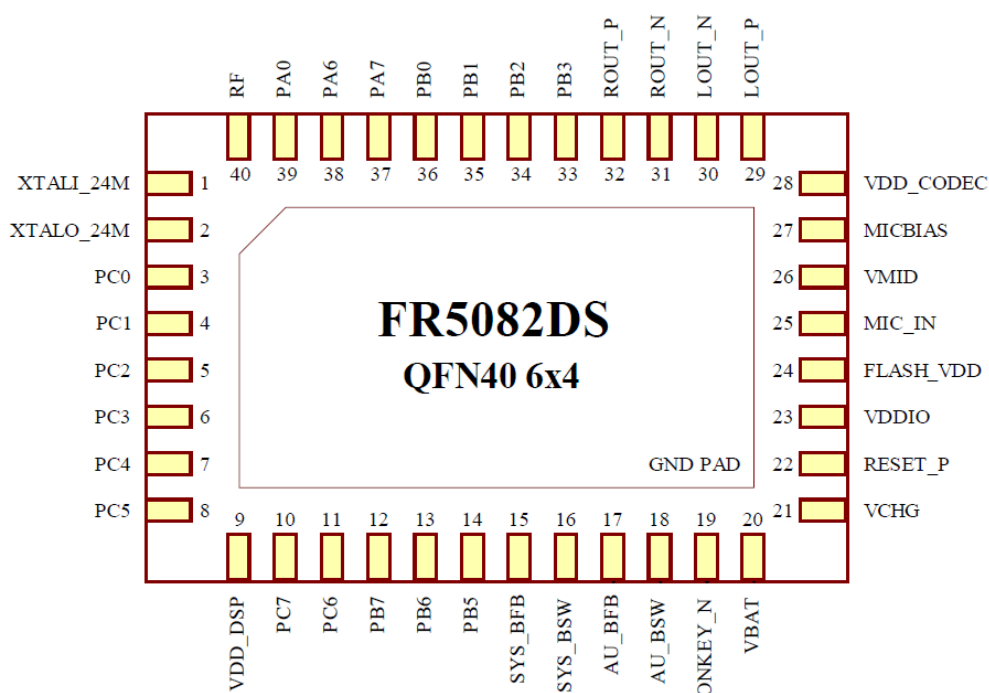


Figure 6-2 FR5082DS pin information

## 6.2 Package Physical Dimensions

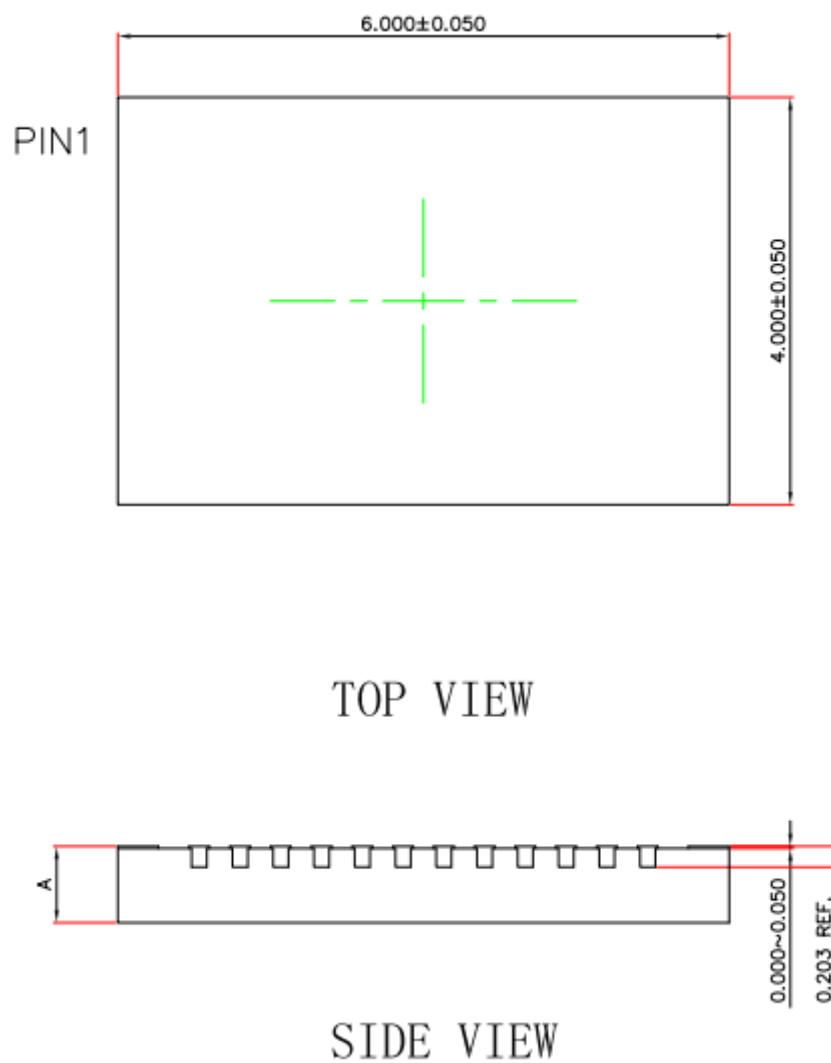
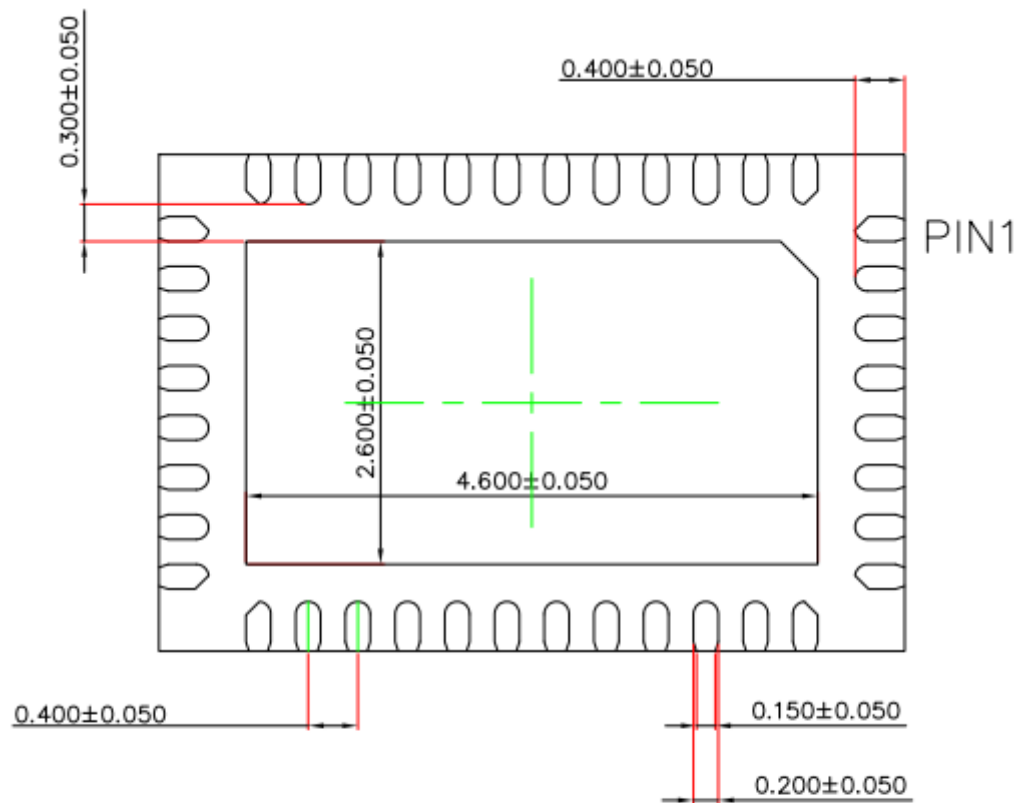


Figure 6-3 Package physical dimensions TOP and SIDE view



BOTTOM VIEW

	MIN.	NORM.	MAX.
A	0.700	0.750	0.800
	0.800	0.850	0.900

Figure 6-4 Package physical dimensions Bottom view



### 6.3 Pins Description

FR5082 is a CMOS device. 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 6-1 Pin Abbreviations

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

Table 6-2 pin description

Pin number		Pin name	Type	Description
FR5082DM	FR5082DS			
1	1	XTALI_24M	AI	Crystal oscillator input
2	2	XTALO_24M	AO	Crystal oscillator output
3	3	PC0	IO	Multi-Function GPIO
4	4	PC1	IO	Multi-Function GPIO
5	5	PC2	IO	Multi-Function GPIO
6	6	PC3	IO	Multi-Function GPIO
7	7	PC4	IO	Multi-Function GPIO
8	8	PC5	IO	Multi-Function GPIO
9	9	VDD_DSP	IO	DSP block core power
10	10	PC7	IO	Multi-Function GPIO
11	11	PC6	IO	Multi-Function GPIO
12	12	PB7	IO	Multi-Function GPIO
13	13	PB6	IO	Multi-Function GPIO
14	14	PB5	IO	Multi-Function GPIO
15	/	PB4	IO	Multi-Function GPIO
16	15	SYS_BFB	AI	System DC/DC feedback input terminal
17	16	SYS_BSW	AO	System DC/DC output terminal
18	17	AU_BFB	AI	Audio codec DC/DC feedback input terminal
19	18	AU_BSW	AO	Audio codec DC/DC output terminal

Pin number		Pin name	Type	Description
FR5082DM	FR5082DS			
/	19	ONKEY_N	AI	Always-on input pin
20	20	VBAT	PWR	Chip power
21	21	VCHG	AI	Charger state detection
22	22	RESET_P	AI	Chip Reset Pin (high active)
23	23	VDDIO	AO	Power supply for IO
24	24	FLASH_VDD	AO	Power supply for flash
25	25	MIC_IN	AI	Microphone input
26	26	VMID	AO	The middle voltage of codec
27	27	MICBIAS	AO	Microphone bias voltage
/	28	VDD_CODEC	AO	Audio codec LDO output
28	29	SPK_P / LOUT_P	AO	Audio LR mix / left channel positive output
29	30	SPK_N / LOUT_N	AO	Audio LR mix / left channel negative output
/	31	ROUT_N	AO	Audio right channel negative output
/	32	ROUT_P	AO	Audio right channel positive output
30	33	PB3	IO	Multi-Function GPIO
31	34	PB2	IO	Multi-Function GPIO
32	35	PB1	IO	Multi-Function GPIO
33	36	PB0	IO	Multi-Function GPIO
/	37	PA7	IO	Multi-Function GPIO
/	38	PA6	IO	Multi-Function GPIO
34	/	PA3	IO	Multi-Function GPIO
35	/	PA2	IO	Multi-Function GPIO
36	/	PA1	IO	Multi-Function GPIO
37	39	PA0	IO	Multi-Function GPIO
38	/	PD7	IO	Multi-Function GPIO
39	/	PD6	IO	Multi-Function GPIO
40	40	RF	AI/O	RF input and output

## 6.4 Application circuit

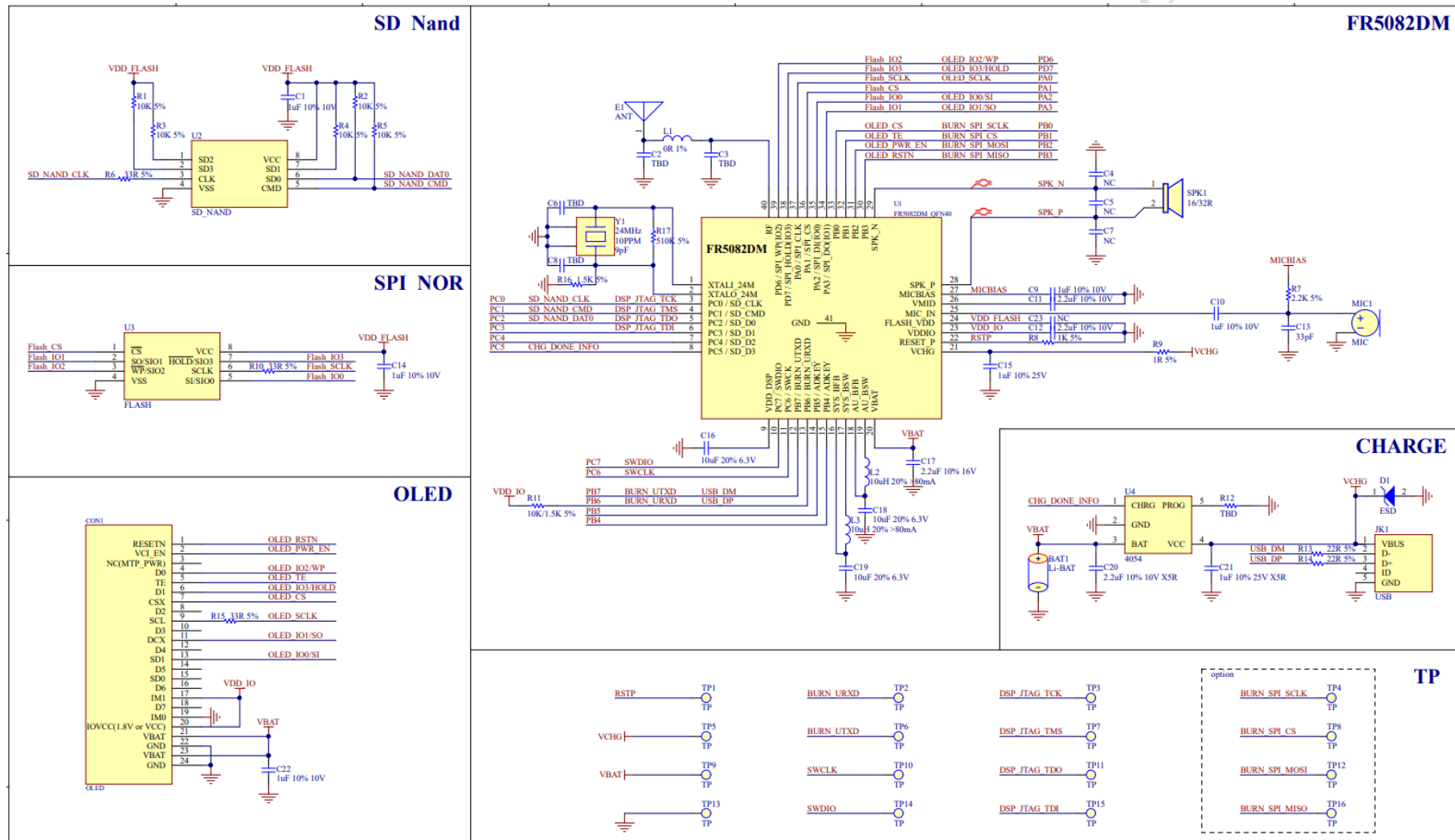


Figure 6-5 FR5082DM application circuit

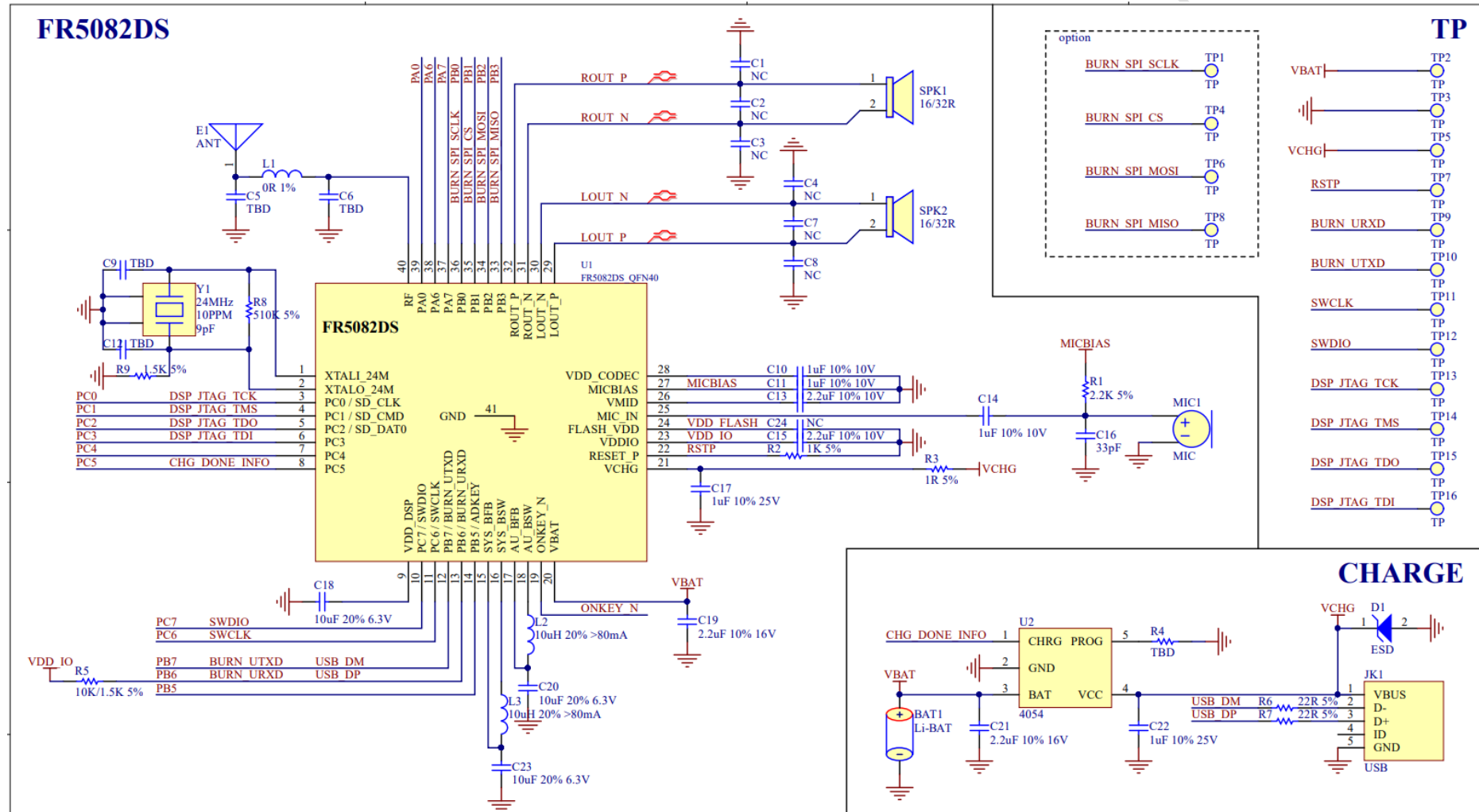


Figure 6-6 FR5082DS application circuit

## 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
Codec	Coder-Decoder

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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](mailto:docs@freqchip.com).

Reversion Number	Reversion Date	Description
V1.0	2020.12.11	Initial Draft
V1.3	2021.09.10	Delete Charger Function
V1.3.1	2021.09.18	Update AU_BFB Voltage Range
V1.3.2	2021.12.02	The Crystal XI is connected with the XO terminal with 510K resistance, and the XO terminal with 1.5K resistance is added to ground
V1.3.3	2021.12.17	Update application circuit
V1.3.4	2022.02.11	V3.1.1 Modify Receive Specifications About Sensitivity with dirty off