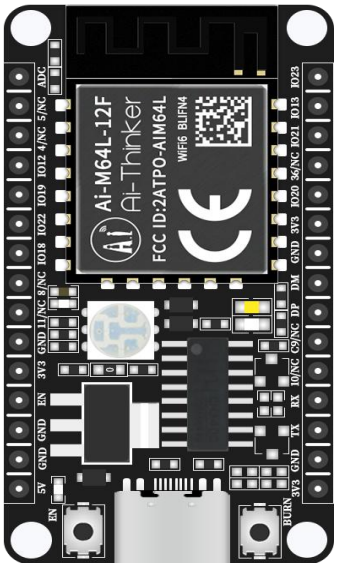
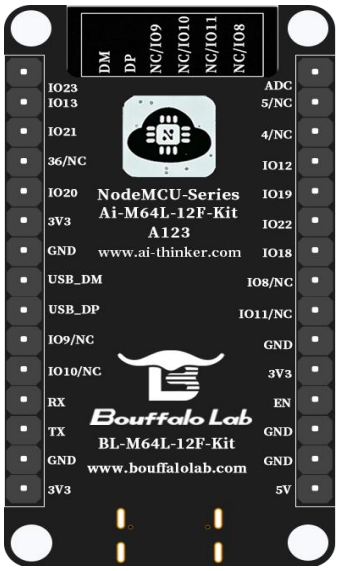
Ai-M64L-12F-Kit Specification





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Contents

List of Figures

List of Tables

1 Product Overview

The Ai-M64L-12F-Kit is a development board developed based on the Ai-M64L-12F module. The Ai-M64L-12F module is a standardized wireless module based on the Bouffalo Lab BL616CL RF chip, specifically designed for ultra-low power, high-performance, and high-security IoT scenarios. The module fully retains the chip-level RF performance and full-function peripherals, and it undergoes rigorous RF matching and reliability verification with plug-and-play capability, significantly reducing the development barriers and mass-production risks of end products. The product has five core features: strong signal performance, low power consumption, high integration, security and reliability, and ultra-compact package, while also supporting backward compatibility.

Figure 1 shows the BL616CL main chip architecture.

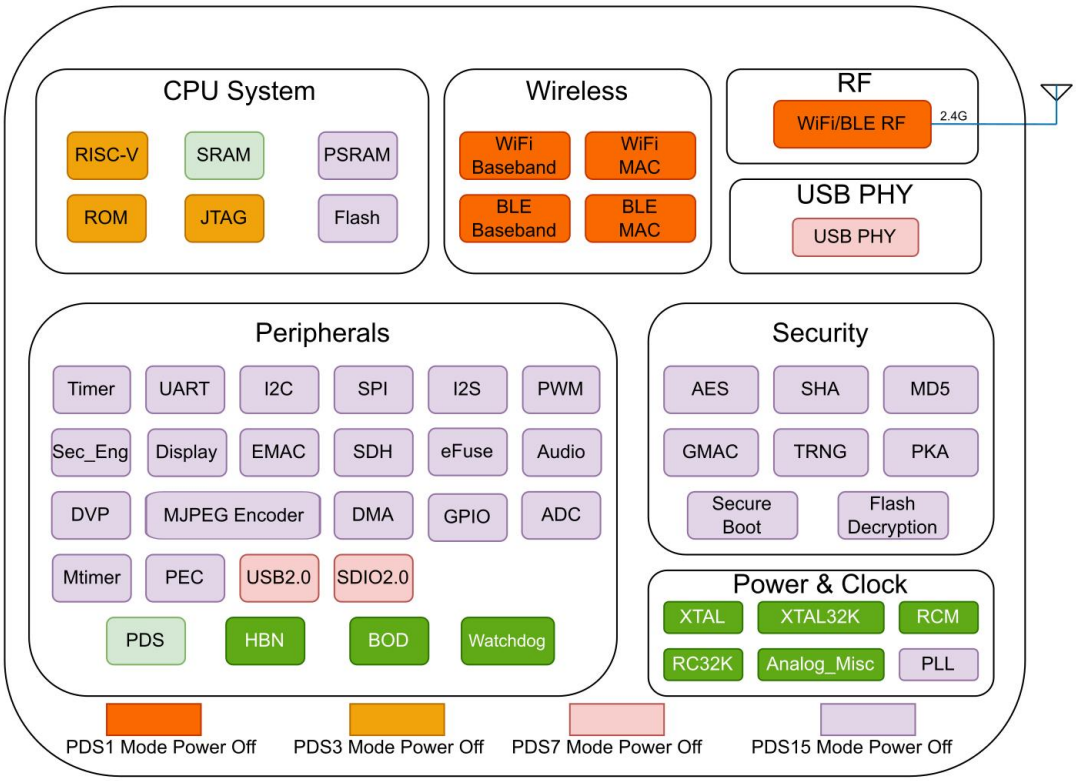


Figure 1 Main Chip Architecture Diagram

1.1 Features

Wireless

- 2.4 GHz RF transceiver
- Wi-Fi 6 (IEEE 802.11b/g/n/ax), 20MHz bandwidth, 1T1R
- Bluetooth® 5.3, multi-rate: 2Mbps/1Mbps/500kbps/125kbps
- Wi-Fi/BLE coexistence, supports BLE-assisted Wi-Fi fast connection
- Supports LDPC, STBC, Beamformee, DL/UL OFDMA, MU-MIMO, TWT (Target Wake Time), SR (Spatial Reuse), DCM (Dual Carrier Modulation), ER (Extended Range)
- Supports aggregation (AMPDU, AMSDU), immediate block ACK, fragmentation and defragmentation
- Supports RX diversity
- Supports IEEE 802.11e QoS WMM (Wi-Fi Multimedia), IEEE 802.11w PMF (Protected Management Frames)
- STA, SoftAP, STA+SoftAP, and Sniffer modes
- Integrated RF balun, PA/LNA, supports external PA/LNA

Microcontroller Subsystem

- 32-bit RISC-V CPU, supports RISC-V RV32IMAFCP instruction set
- Dynamic frequency from 1MHz to 320MHz
- Integrated FPU

Memory

- 388KB SRAM
  - 224KB OCRAM
  - 160KB WRAM
  - 4KB HBN RAM
- BL616CL chip embedded with 2/4/8MB Flash (optional)
- Supports external Flash expansion (customized)

Security

- Secure boot (supports firmware encryption & signing)
- Supports Anti-Rollback
- XIP On-The-Fly AES Decryption (OTFAD)
- Supports TrustZone
- AES-ECB/CBC/CTR/GMAC/XTS modes
- MD5, SHA-1/224/256/384/512
- TRNG (True Random Number Generator)
- PKA (Public Key Accelerator) for RSA/ECC
- Total 1024 bits eFuse

Peripherals

- USB, UART, I2C, SPI, PWM, GPTimer, Watchdog, ADC, etc.

Operating Frequency Band

- 2.4GHz band: 2400 – 2483.5MHz

Power Consumption

- Supports PDS power-down sleep and HBN hibernation
- PDS mode: 194.46μA
- HBN mode: 6.42μA

Physical Characteristics

- Package: DIP-30
- Development Board Dimensions (L × W): 48.26 × 25.40mm
- Antenna Type: On-board antenna
- Operating Temperature: -40 – 85°C
- Storage Conditions: -40 – 125°C, < 90% RH
- On-board RGB LED, warm/cool dual-color LED, reset button, Flash button

Electrical Characteristics

- Three power supply modes: Type-C, 3V3 header pin, 5V header pin

- Supply Voltage: 3.3V or 5V
- Supply Current: > 500mA
- Available I/Os: 19 by default

Note: For features not marked, please refer to the Bouffalo BL616CL chip datasheet.

1.2 Application Scenarios

- Audio and Video Multimedia
- Internet of Things (IoT)
- Mobile Devices
- Smart Home
- Central Control Equipment

2 Key Specifications

Table 1 summarizes the key electrical and physical parameters of the Ai-M64L-12F-Kit development board.

Table 1 Key Specifications

Model	Ai-M64L-12F-Kit
Package	DIP-30
Dimensions	48.26 × 25.40mm
Antenna Type	On-board antenna
Frequency Range	2400 – 2483.5MHz
Operating Temperature	-40 – 85℃
Storage Conditions	-40 – 125℃, <90% RH
Power Supply Range	Supply voltage: 3.3V or 5V; supply current >500mA
Available I/Os	19 by default
UART Rate	115200bps by default

2.1 Power Supply Selection

The Ai-M64L-12F-Kit supports three power supply modes:

- Type-C interface (recommended)
- 3V3 and GND pin header
- 5V and GND pin header

3 Electrical Characteristics

3.1 Recommended Operating Conditions

Table 2 lists the recommended operating electrical parameters of the Ai-M64L-12F-Kit development board. Operating outside these ranges may cause device damage.

Table 2 Recommended Operating Conditions

Parameter	Condition	Min	Typ	Max	Unit
Interface Power Supply	Type-C	4.5	5	5.3	V
Pin Header Power Supply	3V3	2.97	3.3	3.63	V
	5V	4.5	5	5.3	V

3.2 I/O DC Electrical Characteristics

Table 3 lists the I/O DC characteristics of the Ai-M64L-12F-Kit development board. These parameters are mainly used for external interface level matching and GPIO circuit design.

Table 3 I/O DC Electrical Characteristics

Symbol	Parameter	Min	Typ	Max	Unit
VIH	High-level Input Voltage	2	-	-	V
VIL	Low-level Input Voltage	-	-	0.8	V
VOH	High-level Output Voltage	-	0.9 × VCC	-	V
VOL	Low-level Output Voltage	-	0.1 × VCC	-	V

3.3 Electrostatic Discharge

Figure 2 shows the ESD protection diagram. Ai-M64L-12F-Kit is an ESD-sensitive device and requires special precautions during handling.

Figure 2 ESD Protection Diagram

3.4 Wi-Fi RF Performance

Table 4 lists the Wi-Fi RF performance parameters of the Ai-M64L-12F module. RF performance parameters are measured under typical test conditions. Actual performance may be affected by the antenna, power supply, PCB layout, test environment, and other factors.

Table 4 Wi-Fi RF Performance

Description	Typ			Unit
Frequency Range	2400 – 2483.5			MHz
Output Power				
Mode	**Min**	**Typ**	**Max**	**Unit**
802.11b, 11Mbps	-	19	-	dBm
802.11g, 54Mbps	-	18	-	dBm
802.11n, HT20 (MCS7)	-	18	-	dBm
802.11ax, HE20 (MCS9)	-	15	-	dBm
Receiver Sensitivity				
Mode	**Min**	**Typ**	**Max**	**Unit**
802.11b, 1Mbps	-99	-	-	dBm
802.11b, 11Mbps	-90	-	-	dBm
802.11g, 6Mbps	-93	-	-	dBm
802.11g, 54Mbps	-78	-	-	dBm
802.11n, HT20 (MCS7)	-75	-	-	dBm
802.11ax, HE20 (MCS9)	-67	-	-	dBm

3.5 BLE RF Performance

Table 5 lists the BLE RF performance parameters of the Ai-M64L-12F module. RF performance parameters are measured under typical test conditions. Actual performance may be affected by the antenna, power supply, PCB layout, test environment, and other factors.

Table 5 BLE RF Performance

Description	**Typ**			**Unit**
Frequency Range	2400 – 2483.5			MHz
Output Power				
Rate Mode	**Min**	**Typ**	**Max**	**Unit**
1Mbps	-	10	15	dBm
2Mbps	-	10	15	dBm
Receiver Sensitivity				
Rate Mode	**Min**	**Typ**	**Max**	**Unit**
1Mbps Sensitivity@30.8% PER	-97	-	-	dBm
2Mbps Sensitivity@30.8% PER	-95	-	-	dBm

3.6 Power Consumption

Table 6 lists the power consumption data of the Ai-M64L-12F module in different modes. The following power consumption data are measured under a 3.3V power supply and 25℃ ambient temperature.

- The P_{OUT} power for all transmit modes is measured at the antenna interface.
- All transmission data are measured at 100% duty cycle in continuous transmit mode.

Table 6 Power Consumption

Mode	Min	Avg	Max	Unit
TX 802.11b, 11Mbps, POUT = +23dBm	-	410.52	-	mA
TX 802.11g, 54Mbps, POUT = +20dBm	-	337.71	-	mA
TX 802.11n, MCS7, POUT = +19dBm	-	322.60	-	mA
TX 802.11ax, MCS9, POUT = +17dBm	-	276.75	-	mA
RX 802.11b, Packet Length 1500 bytes	-	70.60	-	mA
RX 802.11g, Packet Length 1500 bytes	-	70.67	-	mA
RX 802.11n, Packet Length 1500 bytes	-	69.07	-	mA
RX 802.11ax, Packet Length 1500 bytes	-	69.82	-	mA
PDS Power Consumption, DTIM Level 10	-	194.46	-	μA
HBN Mode	-	6.42	-	μA

4 Mechanical Specifications

4.1 Development Board Dimensions

Figure 3 shows the outline dimensions of the Ai-M64L-12F-Kit development board. The outline dimensions (L × W) are 48.26 × 25.40mm. The dimensional tolerance is ±0.20mm.

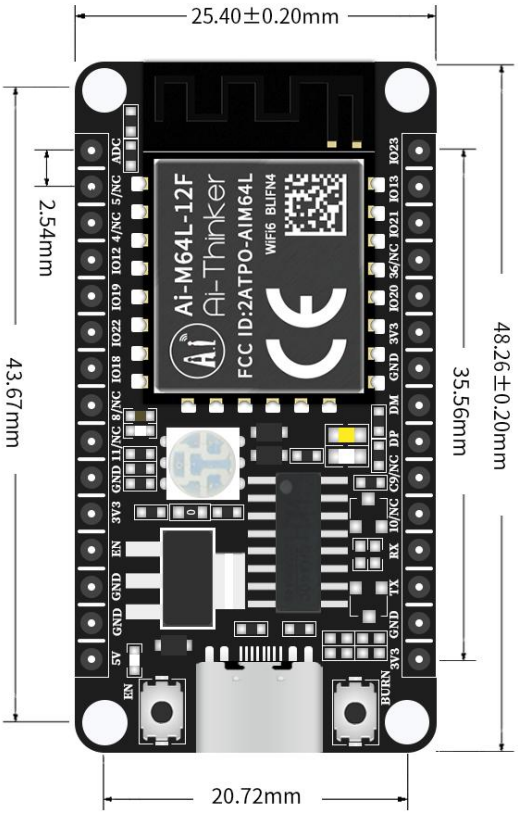


Figure 3 Development Board Dimensions

5 LED and Button Description

Figure 4 shows the onboard layout of LED indicators and buttons for the Ai-M64L-12F-Kit development board.

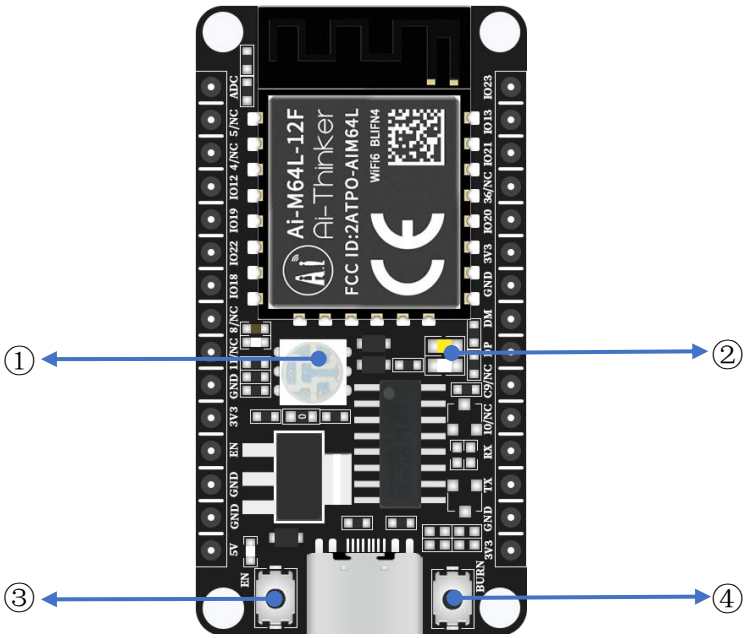


Figure 4 LED and Button Location

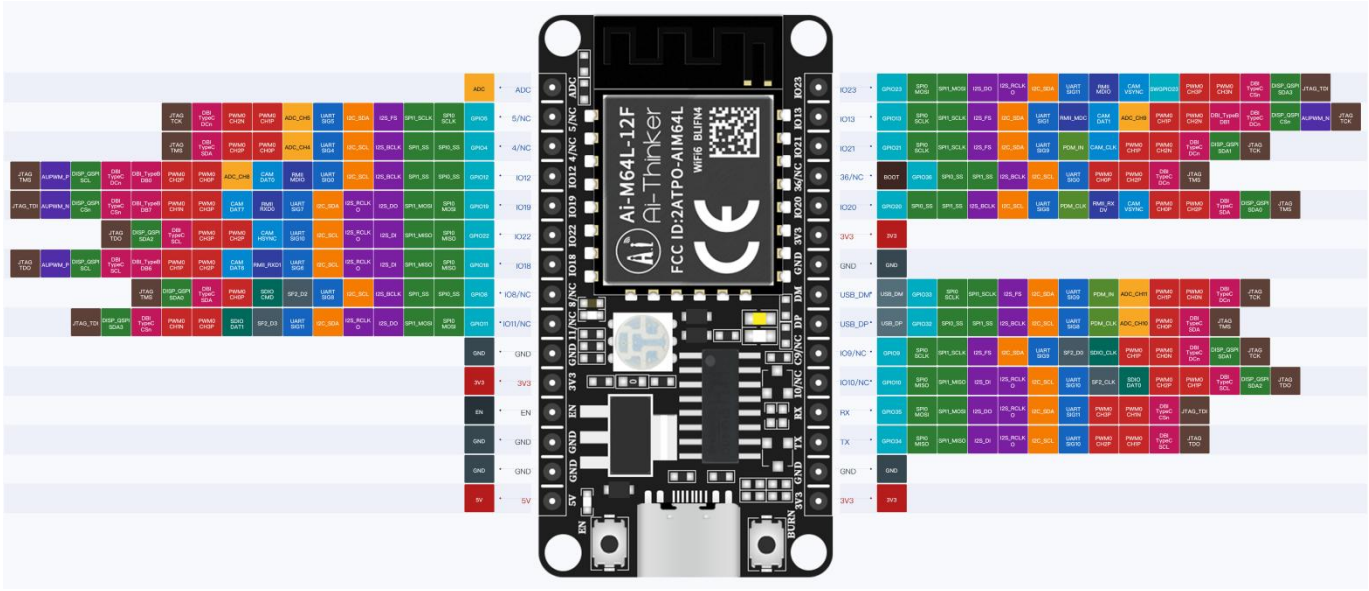
Table 7 provides the detailed functional definitions of the LED indicators and buttons on the Ai-M64L-12F-Kit development board.

Table 7 LED and Button Function Description

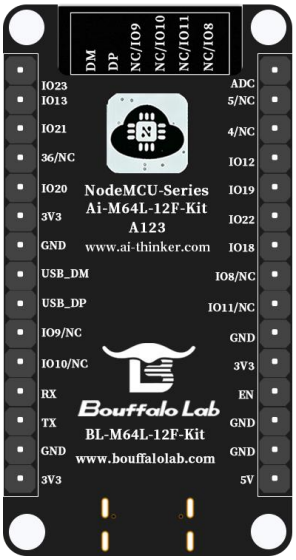
No.	Function Description
①	RGB LED (The red LED is connected to IO19, the green LED is connected to IO22, and the blue LED is connected to IO18. Active high.)
②	LED (The top cool LED is connected to IO13, and the bottom warm LED is connected to IO23. Active high.)
③	Reset button
④	Flash button. When flashing firmware, press and hold the flash button first, then briefly press the reset button at the same time.

6 Pin Definition

Figure 5 shows the top and bottom views of the Ai-M64L-12F-Kit development board's pin layout, with a total of 30 pins exposed.



Top View



Bottom View

Figure 5 Pin Diagram

Table 8 defines the pin functions of the Ai-M64L-12F-Kit development board, including pin number, pin name, and function description.

Table 8 Pin Function Definition

No.	Name	Function

1	ADC	ADC pin, voltage-divided with IO12 pin
2	5/NC	GPIO5/SPI0_SCLK/SPI1_SCLK/I2S_FS/I2C_SDA/UART_SIG5/ADC_CH5/PWM0_CH1P/PWM0_CH2N/DBI_TypeC_DCn/JTAG_TCK (Default available; shared with module internal 32.768kHz crystal output pin. NC if custom module with internal SMD 32.768kHz crystal.)
3	4/NC	GPIO4/SPI0_SS/SPI1_SS/I2S_BCLK/I2C_SCL/UART_SIG4/ADC_CH4/PWM0_CH0P/PWM0_CH2P/DBI_TypeC_SDA/JTAG_TMS (Default available; shared with module internal 32.768kHz crystal input pin. NC if custom module with internal SMD 32.768kHz crystal.)
4	IO12	GPIO12/SPI0_SS/SPI1_SS/I2S_BCLK/I2C_SCL/UART_SIG0/RMII_MDIO/CAM_DAT0/ADC_CH8/PWM0_CH0P/PWM0_CH2P/DBI_TypeB_DB0/DBI_TypeC_SDA/DISP_QSPI_SCL/AUPWM_P/JTAG_TMS
5	IO19	GPIO19/SPI0_MOSI/SPI1_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/UART_SIG7/RMII_RXD[0]/CAM_DAT7/PWM0_CH3P/PWM0_CH1N/DBI_TypeB_DB7/DBI_TypeC_CSn/DISP_QSPI_CSn/AUPWM_N/JTAG_TDI
6	IO22	GPIO22/SPI0_MISO/SPI1_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/UART_SIG10/CAM_HSYNC/PWM0_CH2P/PWM0_CH3P/DBI_TypeC_SCL/DISP_QSPI_SDA2/JTAG_TDO
7	IO18	GPIO18/SPI0_MISO/SPI1_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/UART_SIG6/RMII_RXD[1]/CAM_DAT6/PWM0_CH2P/PWM0_CH1P/DBI_TypeB_DB6/DBI_TypeC_SCL/DISP_QSPI_SCL/AUPWM_P/JTAG_TDO
8	IO8/NC	GPIO8/SPI0_SS/SPI1_SS/I2S_BCLK/I2C_SCL/UART_SIG8/SF2_D2/SDIO_CMD/PWM0_CH0P/DBI_TypeC_SDA/DISP_QSPI_SDA0/JTAG_TMS (Default available; shared with module internal Flash pin. NC if custom module with internal SMD Flash.)
9	IO11/NC	GPIO11/SPI0_MOSI/SPI1_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/UART_SIG11/SF2_D3/SDIO_DAT1/PWM0_CH3P/PWM0_CH1N/DBI_TypeC_CSn/DISP_QSPI_SDA3/JTAG_TDI (Default available; shared with module internal Flash pin. NC if custom module with internal SMD Flash.)
10	GND	Ground
11	3V3	3.3V power supply, recommended current ≥ 500mA
12	EN	Default as chip enable, active high
13	GND	Ground
14	GND	Ground
15	5V	5V power supply, recommended current ≥ 500mA
16	IO23	GPIO23/SPI0_MOSI/SPI1_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/UART_SIG11/RMII_MDIO/CAM_VSYNC/SWGPIO[23]/PWM0_CH3P/PWM0_CH3N/DBI_TypeC_CSn/DISP_QSPI_SDA3/JTAG_TDI

17	IO13	GPIO13/SPI0_SCLK/SPI1_SCLK/I2S_FS/I2C_SDA/UART_SIG1/RMII_MDC/CAM_DAT1/ADC_CH9/PWM0_CH1P/PWM0_CH2N/DBI_TypeB_DB1/DBI_TypeC_DCn/DISP_QSPI_CSn/AUPWM_N/JTAG_TCK
18	IO21	GPIO21/SPI0_SCLK/SPI1_SCLK/I2S_FS/I2C_SDA/UART_SIG9/PDM_IN/CAM_CLK/PWM0_CH1P/PWM0_CH2N/DBI_TypeC_DCn/DISP_QSPI_SDA1/JTAG_TCK
19	36/NC	BOOT/GPIO36/SPI0_SS/SPI1_SS/I2S_BCLK/I2C_SCL/UART_SIG0/PWM0_CH0P/PWM0_CH2P/DBI_TypeB_DCn/JTAG_TMS (Only available on module versions with suffix “A” on the shield can marking, exposed to the module edge castellated pad)
20	IO20	GPIO20/SPI0_SS/SPI1_SS/I2S_BCLK/I2C_SCL/UART_SIG8/PDM_CLK/RMII_RX_DV/CAM_VSYNC/PWM0_CH0P/PWM0_CH2P/DBI_TypeC_SDA/DISP_QSPI_SDA0/JTAG_TMS
21	3V3	3.3V power supply, recommended current ≥ 500mA
22	GND	Ground
23	USB_DM	USB_DM/GPIO33/SPI0_SCLK/SPI1_SCLK/I2S_FS/I2C_SDA/UART_SIG9/PDM_IN/ADC_CH11/PWM0_CH1P/PWM0_CH0N/DBI_TypeC_DCn/JTAG_TCK
24	USB_DP	USB_DP/GPIO32/SPI0_SS/SPI1_SS/I2S_BCLK/I2C_SCL/UART_SIG8/PDM_CLK/ADC_CH10/PWM0_CH0P/DBI_TypeC_SDA/JTAG_TMS
25	IO9/NC	GPIO9/SPI0_SCLK/SPI1_SCLK/I2S_FS/I2C_SDA/UART_SIG9/SF2_D0/SDIO_CLK/PWM0_CH1P/PWM0_CH0N/DBI_TypeC_DCn/DISP_QSPI_SDA1/JTAG_TCK (Default available; shared with module internal Flash pin. NC if custom module with internal SMD Flash.)
26	IO10/NC	GPIO10/SPI0_MISO/SPI1_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/UART_SIG10/SF2_CLK/SDIO_DAT0/PWM0_CH2P/PWM0_CH1P/DBI_TypeC_SCL/DISP_QSPI_SDA2/JTAG_TDO (Default available; shared with module internal Flash pin. NC if custom module with internal SMD Flash.)
27	RX	GPIO35/SPI0_MOSI/SPI1_MOSI/I2S_DO/I2S_RCLK_O/I2C_SDA/UART_SIG11/PWM0_CH3P/PWM0_CH1N/DBI_TypeC_CSn/JTAG_TDI
28	TX	GPIO34/SPI0_MISO/SPI1_MISO/I2S_DI/I2S_RCLK_O/I2C_SCL/UART_SIG10/PWM0_CH2P/PWM0_CH1P/DBI_TypeC_SCL/JTAG_TDO
29	GND	Ground
30	3V3	3.3V power supply, recommended current ≥ 500mA
Note: Both BOOT and the test point on the back of the module can be used as Bootstrap. When the voltage is high at power-up, the module enters flashing mode; when the voltage is low at power-up, the module boots normally. The module internal default is low level.		

7 Schematic

Figure 6 shows the schematic of Ai-M64L-12F-Kit development board, including all functional subcircuits such as power supply, USB-to-UART, module, LEDs, buttons, RF, and peripheral interfaces.

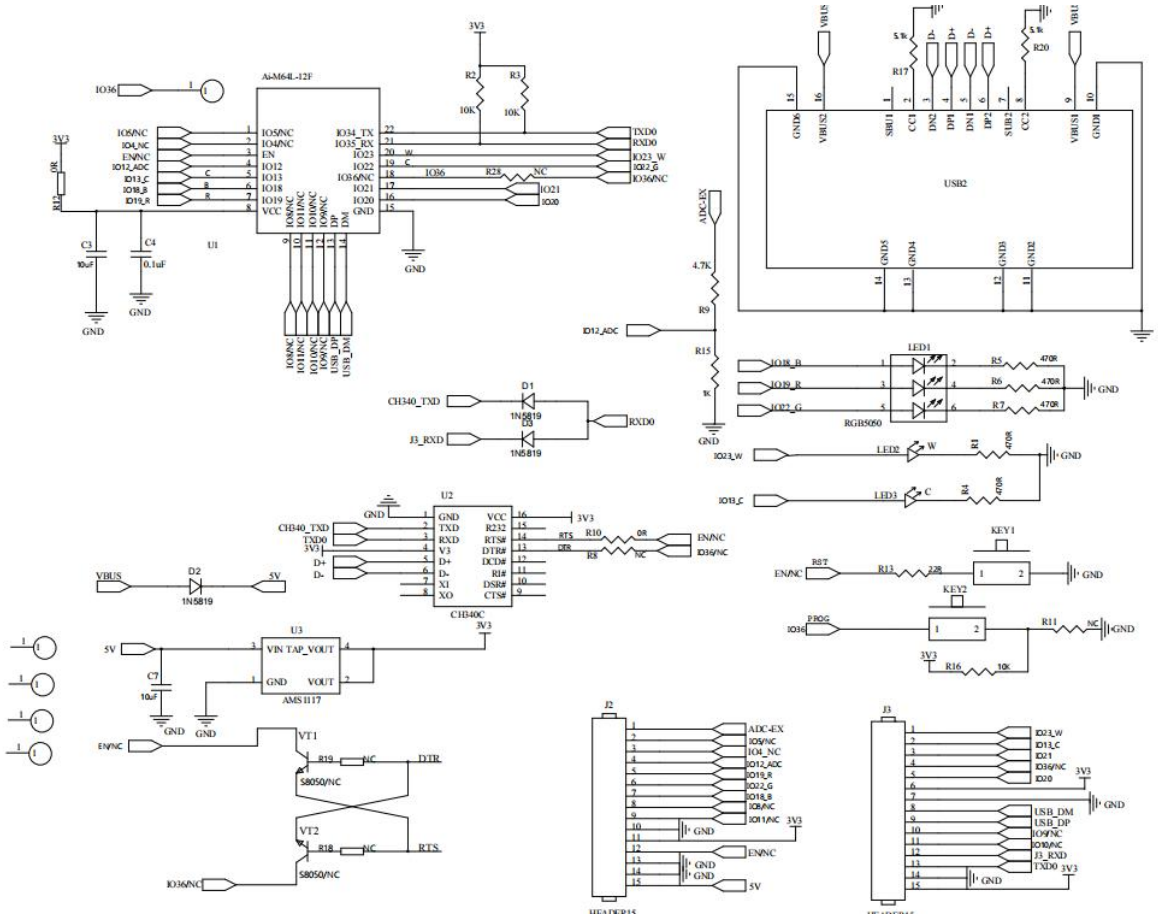


Figure 6 Schematic

8 Packaging Information

Table 9 shows the packaging information for the Ai-M64L-12F-Kit development board.

Table 9 Packaging Information

Packing List	Packaging Method	Quantity per Bag (ESD Bag)	Quantity per Bag (Sealed Bag)
Ai-M64L-12F-Kit	Foam + ESD bag	1pcs	20pcs

9 Contact Us

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