Get started with AT32F413RCT7

Introduction

AT-START-F413 is designed to help you explore the high-performance features of the 32-bit microcontroller, AT32F413 embedded with ARM Cortex®-M4F core with FPU, and help develop your applications.

AT-START-F413 is an evaluation board based on AT32F413RCT7 chip with LED indicators, buttons, an USB micro-B connector, Arduino™ Uno R3 extension connector and an expanded 16 MB SPI Flash memory. This evaluation board embeds debugging/programming tool AT-Link-EZ without the need of other development tools

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1 Overview

1.1 Features

AT-START-F413 has the following characteristics:

- AT-START-F413 has an on-board AT32F413RCT7 microcontroller that embeds ARM Cortex®-M4F, 32-bit processor, 256 KB Flash memory and 32 KB SRAM, LQFP64 packages.
- On-board AT-Link connector:
  - The on-board AT-Link-EZ can be used for programming and debugging (AT-Link-EZ is a simplified version of AT-Link, and does not support offline mode)
  - If AT-Link-EZ is separated from this board by bending over along the joint, AT-START-F413 can be connected to an independent AT-Link for programming and debugging
- On-board 20-pin ARM standard JTAG connector (with a JTAG/SWD connector for programming/debugging)
- 16 MB SPI Flash EN25QH128A is used as an expanded Flash memory Bank 3
- Various power supply methods:
  - Through the USB bus of AT-Link-EZ
  - Through the USB bus (V_{BUS}) of AT-START-F413
  - External 7~12 V power supply (VIN)
  - External 5 V power supply (E5V)
  - External 3.3 V power supply
- 4 x LED indicators:
  - LED1 (red) used for 3.3 V power-on
  - 3 x USER LEDs, LED2 (red),LED3 (white) and LED4 (green)
- User button and reset button
- 8 MHz HSE crystal
- 32.768 kHz LSE crystal
- USB micro-B connector
- Varioius extension connectors can be quickly connected into a prototype board and easy to explore:
  - Arduino™ Uno R3 extension connector
  - LQFP64 I/O extension connector

1.2 Definition of terms

- **Jumper JPx ON**

  Jumper installed.

- **Jumper JPx OFF**

  Jumped not installed.

- **Resistor Rx ON**

  Short by solder or 0Ω resistor

- **Resistor Rx OFF**

  Open.

2 Quick start

2.1 Get started

Configure the AT-START-F413 board in the following order to start the application:

1. Check the Jumper position on the board:
   JP1 is connected to GND or OFF (BOOT0 pin is 0, and BOOT0 has an pull-down resistor in the AT32F413RCT7);
   JP4 optional or OFF (BOOT1 is in any state);
   JP8 one-piece jumper is connected to the I/O on the right.
2. Connect the AT-START-F413 board to the PC through an USB cable (Type A to micro-B), and the board will be powered via AT-Link-EZ USB connector CN6. LED1 (red) is always on, and the other three LEDs (LED2 to LED4) start to blink in turn.
3. After pressing the USER button (B2), the blink frequency of three LEDs are changed

2.2 Toolchains supporting AT-START-F413

- ARM® Keil®: MDK-ARM™
- IAR™: EWARM

3 Hardware and layout

AT-START-F413 board is designed around an AT32F413RCT7 microcontroller in LQFP64 package.

Figure 1 shows the connections between AT-Link-EZ, AT32F413RCT7 and their peripherals (buttons, LEDs, USB, SPI Flash memory and extension connectors)

Figure 2 and *Figure 3* shows these features on the AT-Link-EZ and AT-START-F413 board.

Figure 1. Hardware block diagram

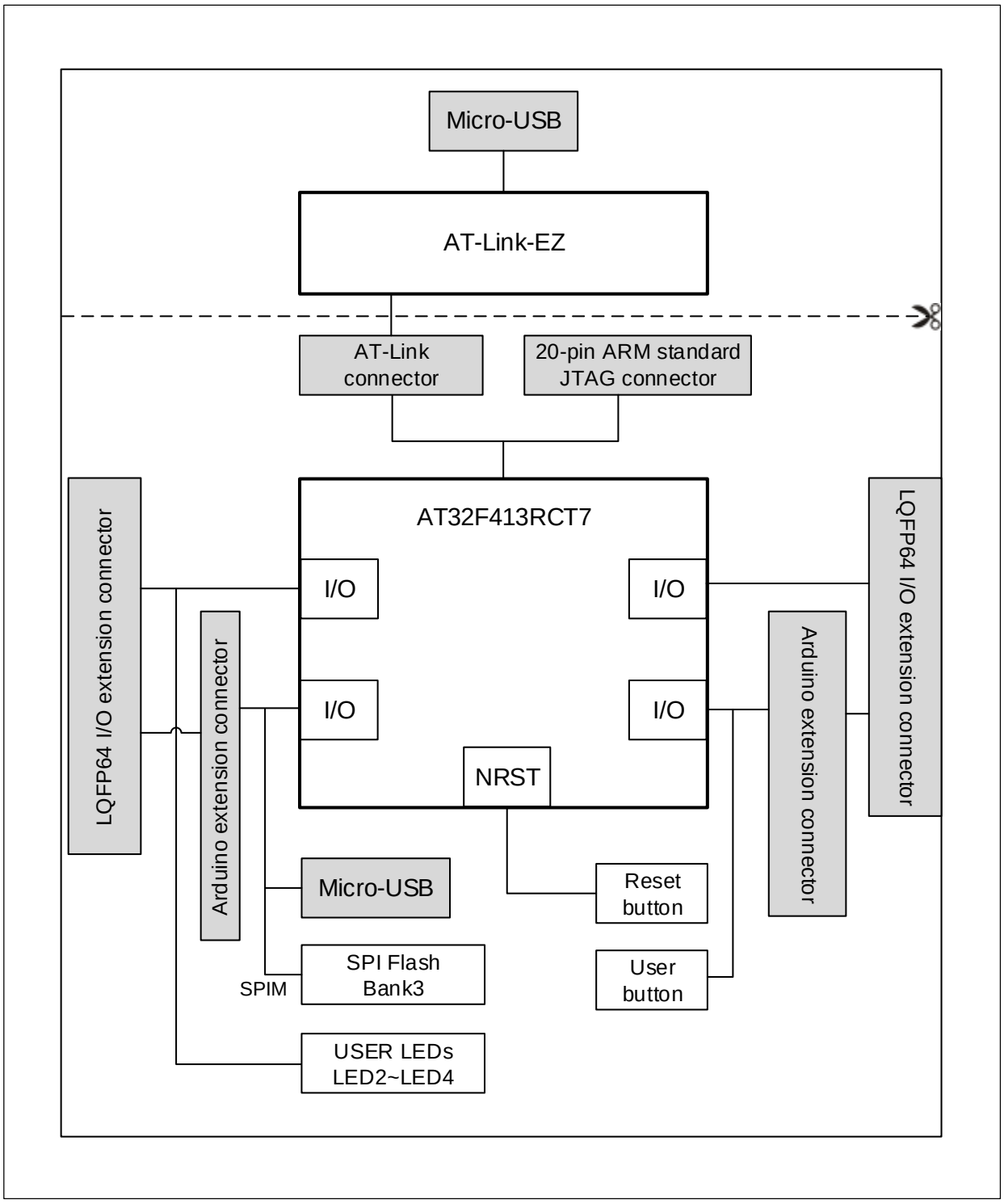


Figure 2. Top layer

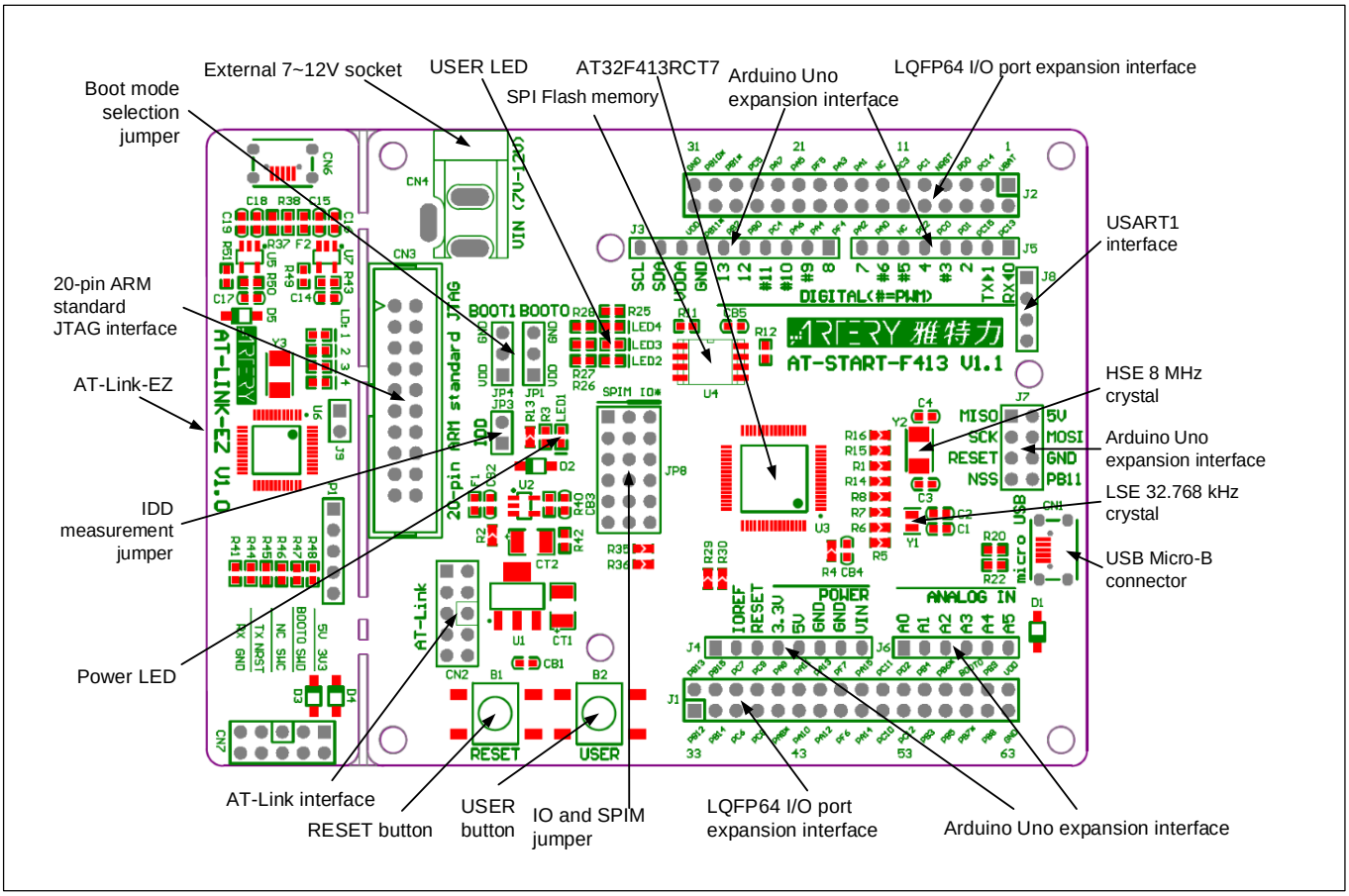
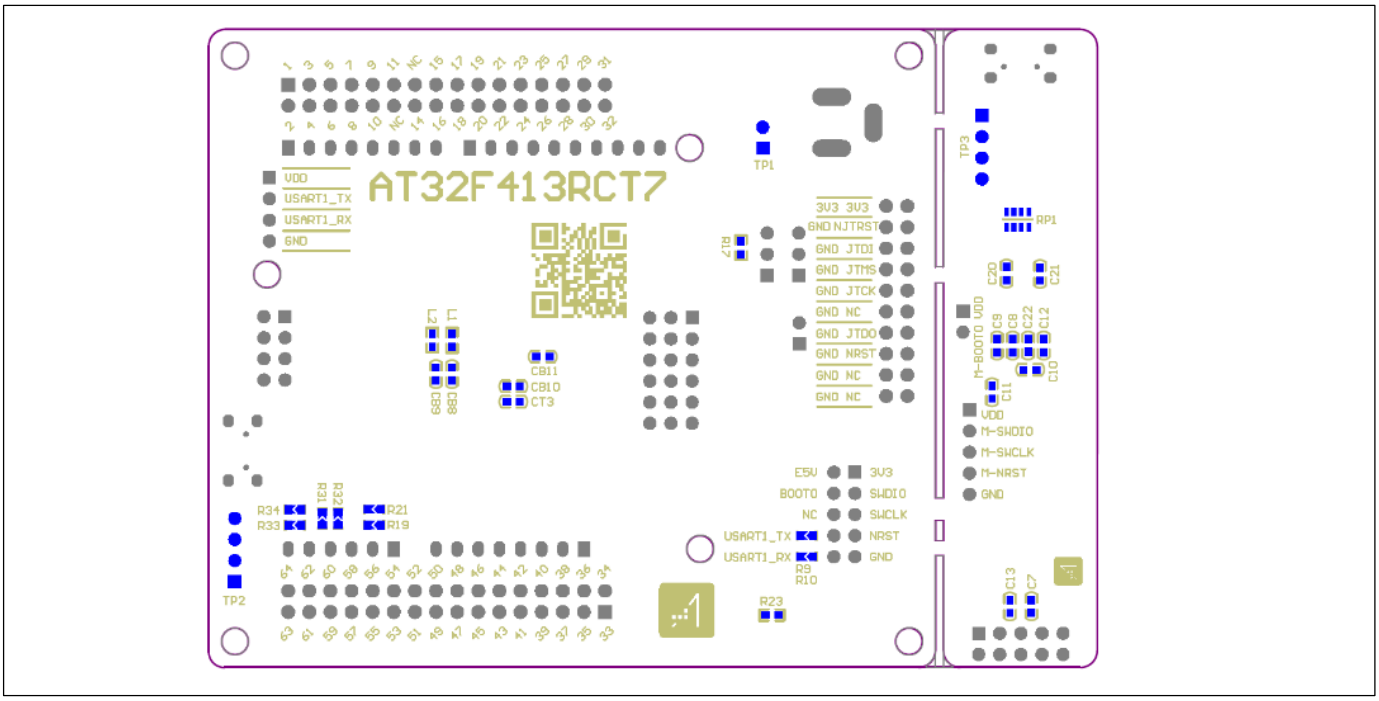


Figure 3. Bottom layer



3.1 Power supply selection

The 5 V power supply of AT-START-F413 can be provided through a USB cable (either through the USB connector CN6 on the AT-Link-EZ or USB connector CN1 on the AT-START-F413), or through an external 5 V power supply (E5V), or by an external 7~12 V power supply (VIN) via 5V voltage regulator (U1) on the board. In this case, the 5 V power supply provides the 3.3 V power required by the microcontrollers and peripherals by means of the 3.3 V voltage regulator (U2) on the board.

The 5 V pin of J4 or J7 can also be used as an input power source. The AT-START-F413 board must be powered by a 5 V power supply unit.

The 3.3 V pin of J4 or the VDD pin of J1 and J2 can also be directly used as 3.3 V input power supply. AT-START-F413 board must be powered by a 3.3 V power supply unit.

Note: Unless 5 V is provided through the USB connector (CN6) on the AT-Link-EZ, the AT-Link-EZ will not be powered by other power supply methods.

When another application board is connected to J4, the pin VIN, 5 V and 3.3 V can be used as output power; J7 5V pin used as 5 V output power; the VDD pin of J1 and J2 used as 3.3 V output power.

3.2 IDD

In the event of JP3 OFF (symbol IDD) and R13 OFF, it is allowed to connect an ammeter to measure the power consumption of AT32F413RCT7.

- **JP3 OFF, R13 ON**

  AT32F413RCT77 is powered (Default setting, and JP3 plug is not mounted before shipping).
- **JP3 ON, R13 OFF**

  AT32F413RCT7 is powered.
- **JP3 OFF, R13 OFF**

  An ammeter must be connected to measure the power consumption of AT32F413RCT7 (if there is no ammeter, the AT32F413RCT7 cannot be powered).

3.3 Programming and debugging

3.3.1 Embedded AT-Link-EZ

The evaluation board embeds Artery AT-Link-EZ programming and debugging tool for users to program/debug the AT32F413RCT7 on the AT-START-F413 board. AT-Link-EZ supports SWD interface mode, SWO debug, and supports a set of virtual COM ports (VCP) to connect to the USART1_TX/USART1_RX (PA9/PA10) of AT32F413RCT7. In this case, PA9 and PA10 of AT32F413RCT7 will be affected by AT-Link-EZ as follows:

- PA9 is weakly pulled up to high level by the VCP RX pin of AT-Link-EZ;
- PA10 is strongly pulled up to high level by the VCP TX pin of AT-Link-EZ

The user can set R9 or R10 OFF, then the use of PA9 and PA10 of AT32F413RCT7 is not subject to the above restrictions.

The SWO of AT-Link-EZ is connected to the TRACESWO (PB3) of AT32F413RCT7 through R18, and will be set in floating state when the SWO debug is not enabled, which would not affect the use of PB3. If you have any concerns in use, please set R18 OFF.

Please refer to AT-Link User Manual for complete details on the operations, firmware upgrade and precautions of AT-Link-EZ.

The AT-Link-EZ PCB on the evaluation board can be separated from AT-START-F413 by bending over along the joint. In this case, AT-START-F413 can still be connected to the CN7 of AT-Link-EZ through CN2 (not mounted before shipping), or can be connected with another AT-Link to continue the programming and debugging on the AT32F413RCT7.

3.3.2 20-pin ARM® standard JTAG connector

AT-START-F413 also reserves JTAG or SWD general-purpose connectors as programming/debugging tools. If the user wants to use this interface to program and debug the AT32F413RCT7, please separate the AT-Link-EZ from this board or set R41, R44 and R46 OFF, and connect the CN3 (not mounted before shipping) to the programming and debugging tool.

Although Artery microcontrollers can be compatible with most third- party development tools in the market, it is still recommended to use AT-Link series tools to experience the best debug environment.

3.4 Boot mode selection

At startup, three different boot modes can be selected by means of the pin configuration.

Table 1. Boot mode selection jumper setting

Jumper	Boot mode selection		Settings
	BOOT1	BOOT0	
JP1 connected to GND or OFF; JP4 optional or OFF	X(1)	0	Boot from the internal Flash memory (Factory default)
JP1 connected to VDD JP4 connected to GND	0	1	Boot from the system memory
JP1 connected to VDD JP4 connected to VDD	1	1	Boot from SRAM

(1) It is recommended that JP4 selects GND when PB2 is not enabled.

3.5 External clock source

3.5.1 HSE clock source

There are three hardware modes to set the external high-speed clock sources:

- **On-board crystal (default setting)**
  The 8 MHz crystal on the board is used as HSE clock source. The hardware setting must be: R1 and R15 ON, R14 and R16 OFF
- **Oscillator from external PD0**
  External oscillator is injected from the 5th pin of J2. The hardware setting must be: R14 and R16 ON, R1 and R15 OFF.
- **HSE not used**
  PD0 and PD1 are used as GPIO. The hardware setting must be: R14 and R16 ON, R1 and R15 OFF.

3.5.2 LSE clock source

There are three hardware modes to set the external low-speed clock sources:

- **On-board crystal (default setting)**

  The 32.768 kHz crystal on the board is used as LSE clock source. The hardware setting must be: R6 and R7 ON, R5 and R8 OFF

- **Oscillator from external PC14:**

  External oscillator is injected from the J2 pin_3. The hardware setting must be: R5 and R8 ON, R6 and R7 OFF.

- **LSE not used**

  PC14 and PC15 are used as GPIO. The hardware setting must be: R5 and R8 ON, R6 and R7 OFF.

3.6 LED indicators

- **Power LED1**

  Red indicates that the board is powered by 3.3 V.

- **User LED2**

  Red, connected to the PC2 pin of AT32F413RCT7.

- **User LED3**

  Yellow, connected to the PC3 pin of AT32F413RCT7.

- **User LED4**

  Green, connected to the PC5 pin of AT32F413RCT7.

3.7 Buttons

- **Reset B1: reset button**

  Connected to NRST to reset AT32F413RCT7.

- **User B2: user button**

  It is, by default, connected to the PA0 of AT32F413RCT7, and alternatively used as a wake-up button (R19 ON, R21 OFF); Or connected to PC13 and alternatively used as TAMPER-RTC button (R19 OFF, R21 ON)

3.8 USB device

AT-START-F413 board supports USB full-speed device communication through an USB micro-B connector (CN1). V_{BUS} can be used as 5 V power supply of AT-START-F413 board.

3.9 Connect to Bank3 of Flash memory via SPIM interface

The SPI Flash EN25QH128A on the board is connected to the AT32F413RCT7 via SPIM interface and used as Bank 3 of expanded Flash memory.

When using the Bank 3 of the Flash memory via SPIM interface, the JP8 one-piece jumper, as shown in *Table 2*, should select the left SPIM side. In this case, PB1, PA8, PB10 PB11, PB6 and PB7 are not connected to the external LQFP64 I/O extension connector. These 6 pins are marked by adding [*****] after the pin name of extension connector on the PCB silkscreen.

Table 2. IO and SPIM jumper setting

Jumper	Settings
JP8 is connected to IO	Use GPIO function (Factory default)
JP8 is connected to SPIM	Use SPIM function

3.10 0 Ω resistors

Table 3. 0 Ω resistor setting

Resistor	State(1)	Description
R13 (Microcontroller power consumption measurement)	**ON**	When JP3 is OFF, 3.3V is connected to the microcontroller to provide power supply
	OFF	When JP3 is OFF, 3.3V allows an ammeter to be connected to measure the power consumption of microcontroller (If no ammeter, the microcontroller cannot be powered)
R4 (V_{BAT} power supply)	**ON**	V_{BAT} must be connected to VDD
	OFF	V_{BAT} can be powered by the 1st pin VBAT of J2
R1, R14, R15, R16 (HSE)	**ON, OFF, ON, OFF**	HSE clock source uses crystal Y2 on the board
	OFF, ON, OFF, ON	HSE clock source is from external PD0 or PD0 and PD1 are used as GPIO.
R5, R6, R7, R8 (LSE)	**OFF, ON, ON, OFF**	LSE clock source uses crystal Y1 on the board
	ON, OFF, OFF, ON	LSE clock source is from external PC14 or PC14 and PC15 are used as GPIO.
R19, R21 (USER button B2)	**ON, OFF**	User button B2 is connected to PA0
	OFF, ON	User button B2 is connected to PC13
R29, R30 (PA11, PA12)	**OFF, OFF**	When PA11 and PA12 are used as USB, they are not connected to pin_12 and pin_13 of J1
	ON, ON	When PA11 and PA12 are not used as USB, they can be connected to pin_12 and pin_13 of J1
R31, R32, R33, R34 (Arduino™ A4, A5)	**OFF, ON, OFF, ON**	Arduino™ A4 and A5 is connected to ADC_IN11 and ADC_IN10
	ON, OFF, ON, OFF	Arduino™ A4 and A5 is connected to I2C1_SDA and I2C1_SCL
R35, R36 (Arduino™ D10)	**OFF, ON**	Arduino™ D10 is connected to SPI1_SS
	ON, OFF	Arduino™ D10 is connected to PWM (TMR4_CH1)
R9 (USART1_RX)	**ON**	USART1_RX of AT32F413RCT7 is connected to VCP TX of AT-Link-EZ
	OFF	USART1_RX of AT32F413RCT7 is disconnected from VCP TX of AT-Link-EZ
R10 (USART1_TX)	**ON**	USART1_TX of AT32F413RCT7 is connected to VCP RX of AT-Link-EZ
	OFF	USART1_TX of AT32F413RCT7 is disconnected from VCP RX of AT-Link-EZ
R18 (SWO)	**ON**	The TRACESWO of AT32F413RCT7 is connected to the SWO of AT-Link-EZ.
	OFF	The TRACESWO of AT32F413RCT7 is disconnected from the SWO of AT-Link-EZ.

(1) The factory default Rx state is shown in BOLD.

3.11 Extension connectors

3.11.1 Arduino™ Uno R3 extension connector

Female plug J3~J6 and male J7 support standard Arduino™ Uno R3 connector. Most of the daughter boards designed abround Arduino™ Uno R3 are suitable for AT-START-F413.

Note 1: The I/O ports of AT32F413RCT7 are 3.3 V compatible with Arduino™ Uno R3, but 5V incompatible.

Note 2: The pin_8 of J3 is VDDA, which has the same level as VDD, without AFEF function defined by Arduino™ Uno R3

Table 4. Arduino™ Uno R3 extension connector pin definition

Connector	Pin number	Arduino pin name	AT32F413 pin name	Functions
J4 (Power supply)	1	NC	-	-
	2	IOREF	-	3.3V reference
	3	RESET	NRST	External reset
	4	3.3V	-	3.3V input/output
	5	5V	-	5V input/output
	6	GND	-	Ground
	7	GND	-	Ground
	8	VIN	-	7~12V input/output
J6 (Analog input)	1	A0	PA0	ADC12_IN0
	2	A1	PA1	ADC12_IN1
	3	A2	PA4	ADC12_IN4
	4	A3	PB0	ADC12_IN8
	5	A4	PC1 or PB9(1)	ADC12_IN11 or I2C1_SDA
	6	A5	PC0 or PB8(1)	ADC12_IN10 or I2C1_SCL
J5 (Logic input/output low byte)	1	D0	PA3	USART2_RX
	2	D1	PA2	USART2_TX
	3	D2	PA10	-
	4	D3	PB3	TMR2_CH2
	5	D4	PB5	-
	6	D5	PB4	TMR3_CH1
	7	D6	PB10	TMR2_CH3
	8	D7	PA8(2)	-
J3 (Logic input/output high byte)	1	D8	PA9	-
	2	D9	PC7	TMR8_CH2
	3	D10	PA15 or PB6(1)(2)	SPI1_NSS or TMR4_CH1
	4	D11	PA7	TMR3_CH2 or SPI1_MOSI
	5	D12	PA6	SPI1_MISO
	6	D13	PA5	SPI1_SCK
	7	GND	-	Ground
	8	VDDA	-	VDDA output
	9	SDA	PB9	I2C1_SDA
	10	SCL	PB8	I2C1_SCL

Connector	Pin number	Arduino pin name	AT32F413 pin name	Functions
J7 (Others)	1	MISO	PB14	SPI2_MISO
	2	5V	-	5V input/output
	3	SCK	PB13	SPI2_SCK
	4	MOSI	PB15	SPI2_MOSI
	5	RESET	NRST	External reset
	6	GND	-	Ground
	7	NSS	PB12	SPI2_NSS
	8	PB11	PB11	-

(1) 0Ω resistor setting is shown in *Table 3*.
(2) SPIM must be disabled and JP8 one-piece jumper must select I/O, otherwise PA8 and PB6 cannot be used.

3.11.2 LQFP64 I/O port extension connector

The extension connectors J1 and J2 can connect the AT-START-F413 to external prototype/packing board. The I/O ports of AT32F413RCT7 are available on these extension connectors. J1 and J2 can also be measured with the probe of oscilloscope, logic analyzer or voltmeter.

4 Schematic

Figure 4. Schematic (AT-Link-EZ)

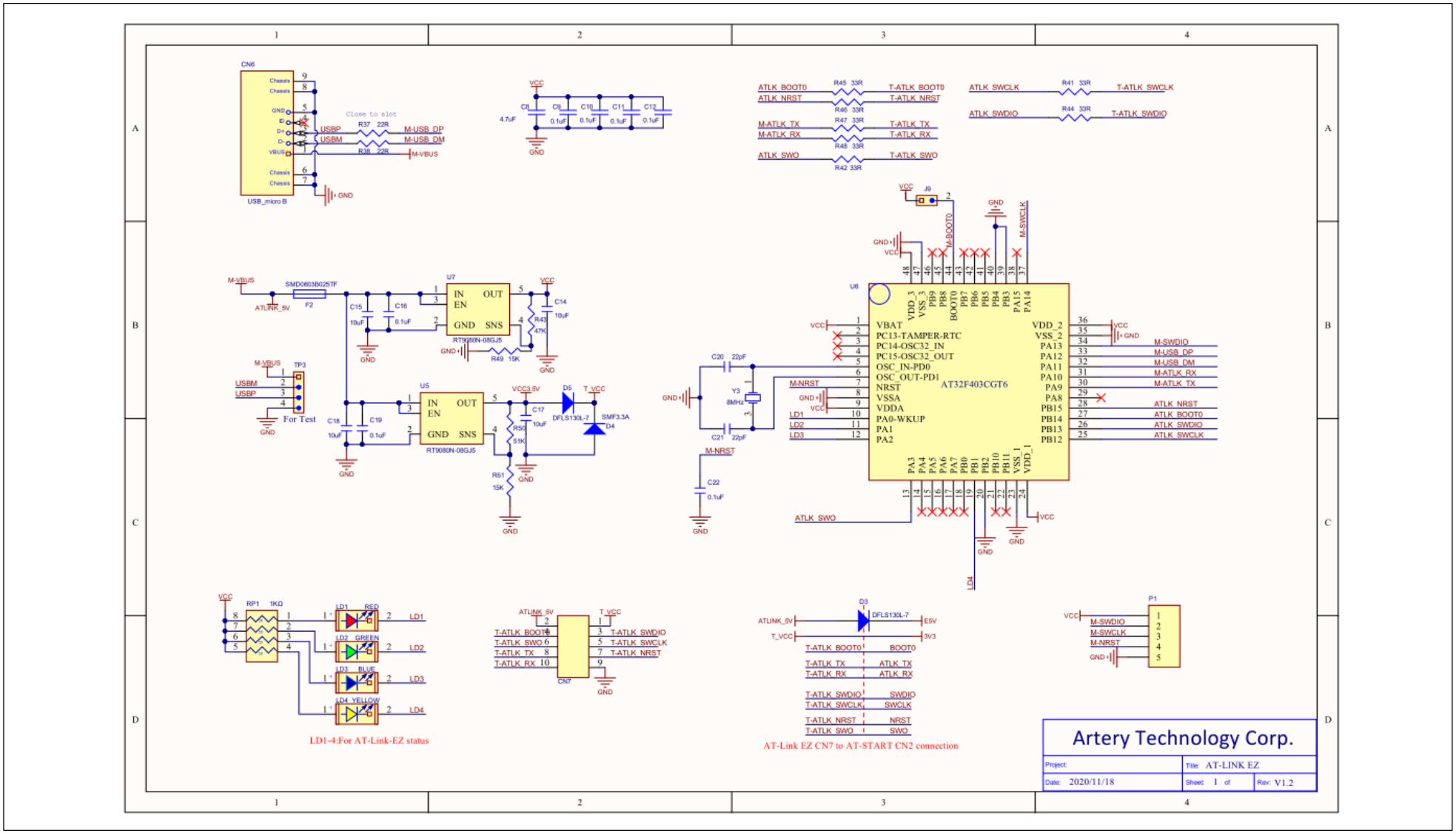


Figure 5. Schematic (microcontroller)

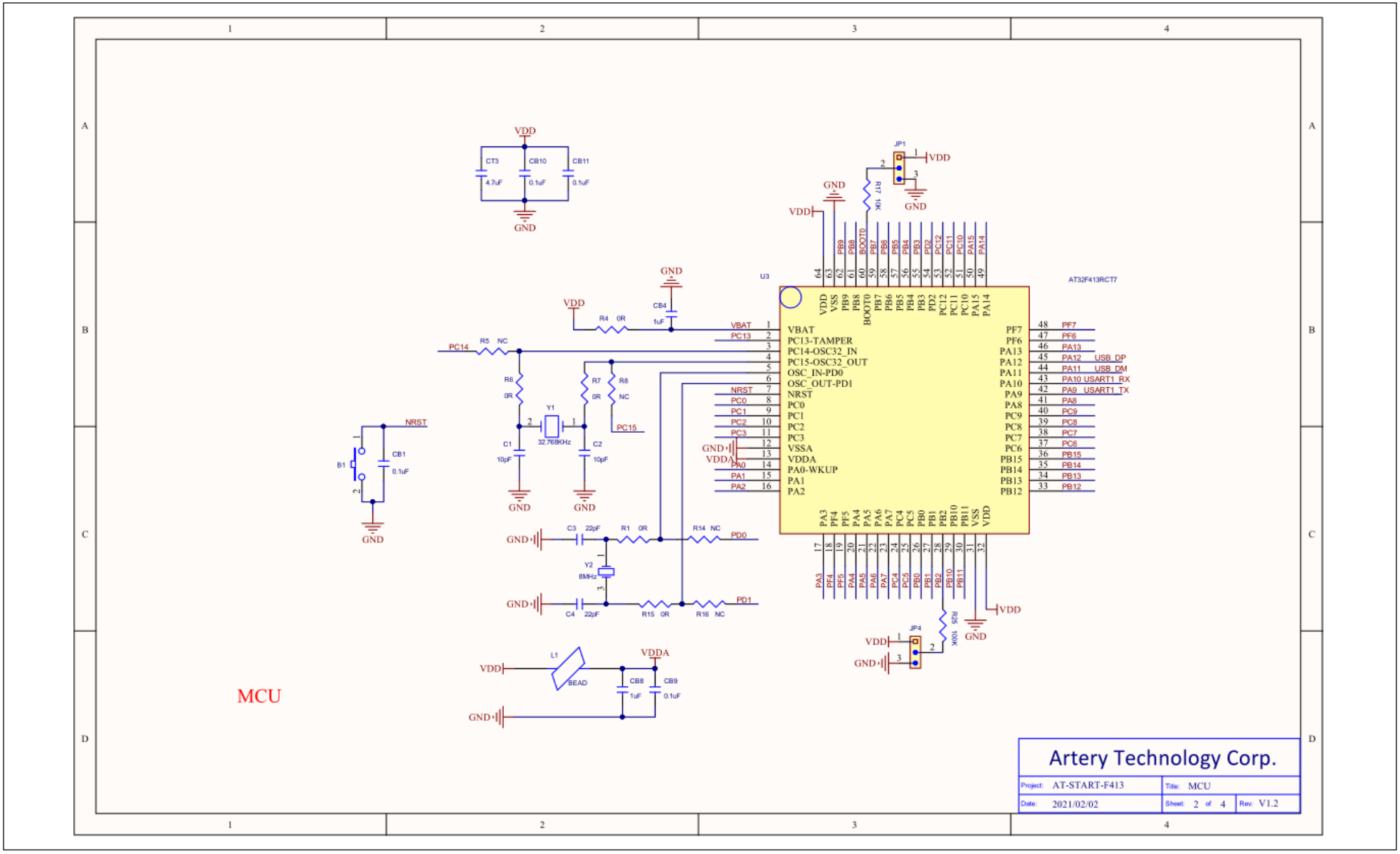


Figure 6. Schematic (power supply and peripherals)

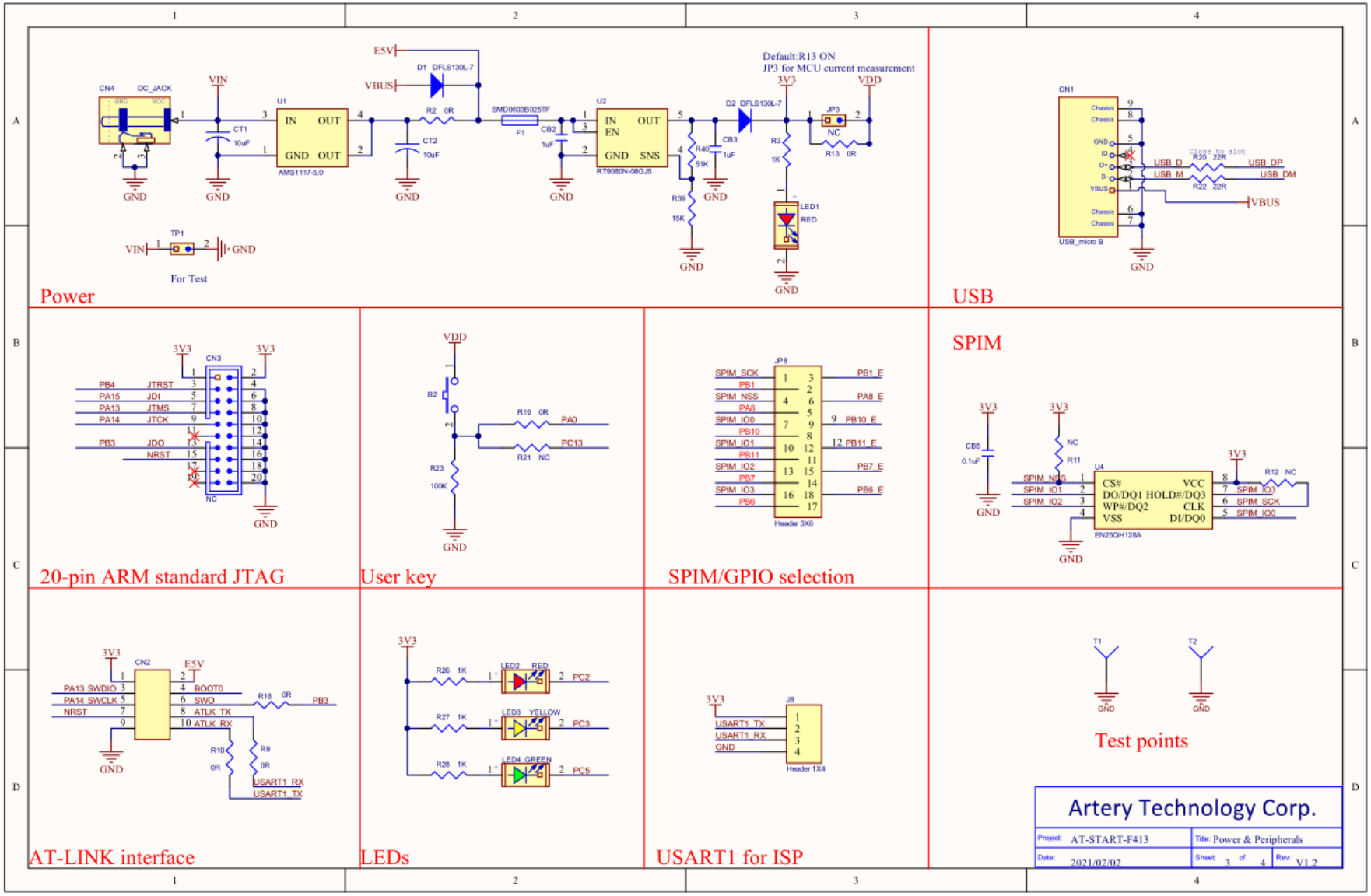
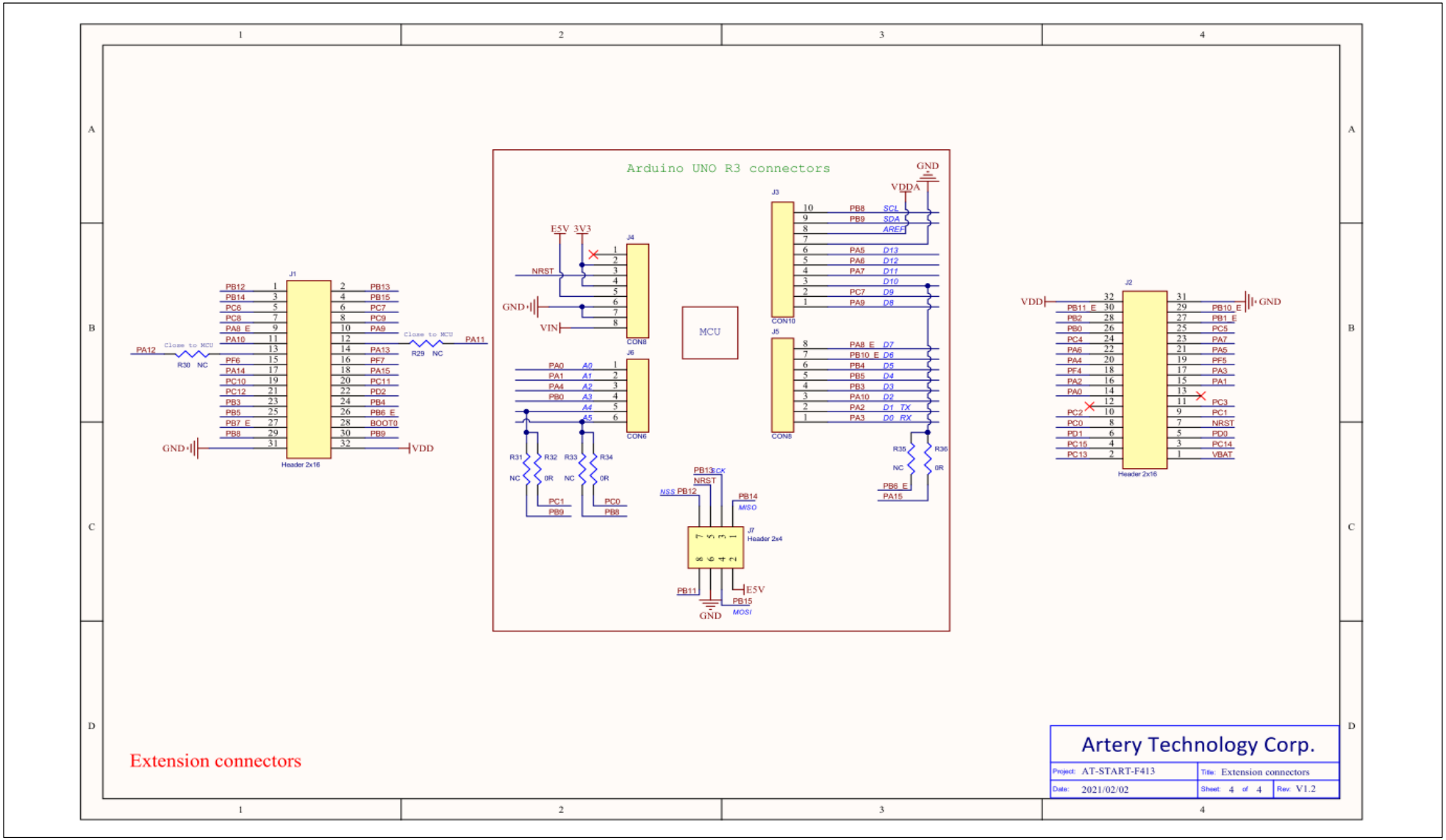


Figure 7. Schematic (extension connectors)



5 Revision history

Table 5. Document revision history

Date	Revision	Changes
2019.2.12	1.0	Initial release
2019.9.20	1.1	1. Added AT-Link-EZ 2. Corrected the silkscreen of CN2 USART1_TX and USART1_RX 3. Modified 0Ω resistor to be solder bridge 4. Modified CB8 to be 1μF 5. Modified voltage regulator (U2) and related external devices
2021.2.2	1.20	1. Changed the revision number of this document to 3 digits, with the first two for the AT-START hardware version, and the last for the document update revision. 2. Updated AT-Link-EZ hardware version to V1.2 to support SWO debug, and added the description of SWO; Adjusted two rows of CN7 signls and corrected the silkscreen to match Artery development tool use habits. 3. Corrected CN2 silkscreen to match Artery development tool use habits. 4. Added GND test pin to faciliate measurement.

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