Get started with AT32F403ZGT6

Introduction

AT-START-F403 is designed to help you explore the high-performance features of the 32-bit microcontroller, AT32F403 embeded with ARM Cortex®-M4 core with FPU, and help develop your applications.

AT-START-F403 is an evaluation board based on AT32F403ZGT6 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 Features

AT-START-F403 has the following characteristics:

- AT-START-F403 has an on-board AT32F403ZGT6 microcontroller that embeds ARM Cortex®-M4F, 32-bit processor, 1024 KB Flash memory and 96+128 KB SRAM, LQFP144 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-F403 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-F403
  - External 7 V~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 LED indicators: LED2 (red), LED3 (white) and LED4 (green)
- 2 x buttons (user button and reset button)
- 8 MHz HSE crystal
- 32.768 kHz LSE crystal
- USB micro-B connector
- Various extension connectors can be quickly connected into a prototype board and easy to explore:
  - Arduino™ Uno R3 extension connector
  - LQFP144 I/O extension connector

2 Conventional terms

Table 1 shows the definitions of some conventional terms used in this document.

Table 1. ON/OFF definition

Conventional terms	Definition
Jumper JPx ON	Jumper installed
Jumper JPx OFF	Jumped not installed
Resistor Rx ON	Short by solder or 0Ω resistor
Resistor Rx OFF	Open

3 Quick start

AT-START-F403 is a low-cost and easy-to-use development kit that is designed for quick evaluating and using the high-performance AT32F403 microcontrollers to develop applications.

3.1 Get started

Configure the AT-START-F403 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 is 0, and BOOT0 has an pull-down resistor in the AT32F403ZGT6);

   JP4 optional or OFF (BOOT1 is in any state);

   JP8 one-piece jumper is connected to the USB on the right.

2. Connect the AT-START-F403 board to the PC through a 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 other three LEDs (LED2 to LED4) start to blink in turn.
3. After pressing the user button (B2), the blinking frequency of three LEDs are changed.

3.2 Toolchains supporting AT-START-F403

- ARM® Keil®: MDK-ARM™
- IAR™: EWARM

4 Hardware and layout

AT-START-F403 board is designed around an AT32F403ZGT6 microcontroller in LQFP144 package.

Figure 1 shows the connections between AT-Link-EZ, AT32F403ZGT6 and their peripherals (buttons, LEDs, USB, SPI Flash memory and extension connectors)

Figure 2 and *Figure 3* show these features on the AT-Link-EZ and AT-START-F403 board.

Figure 1. Hardware block diagram

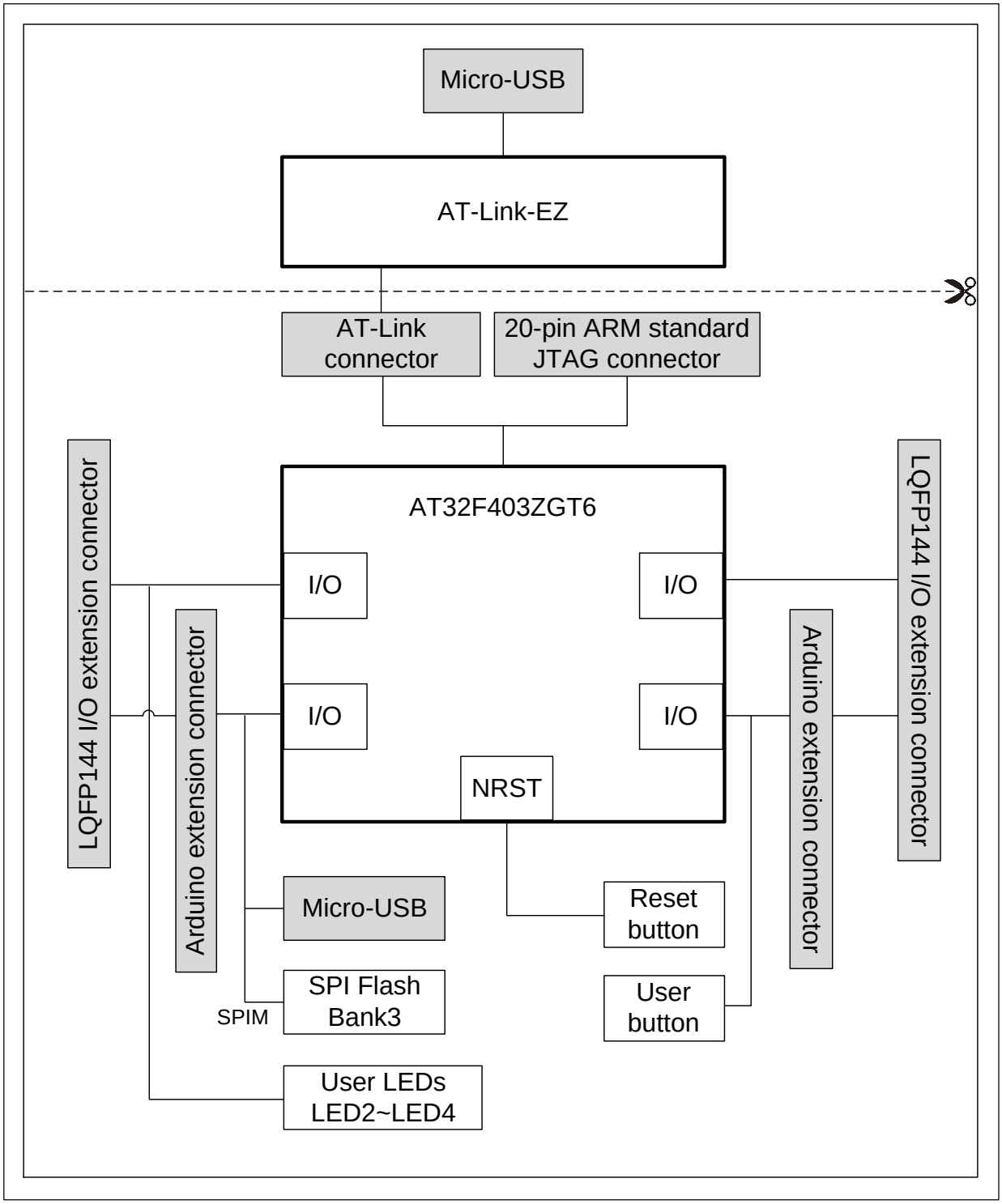


Figure 2. Top layer

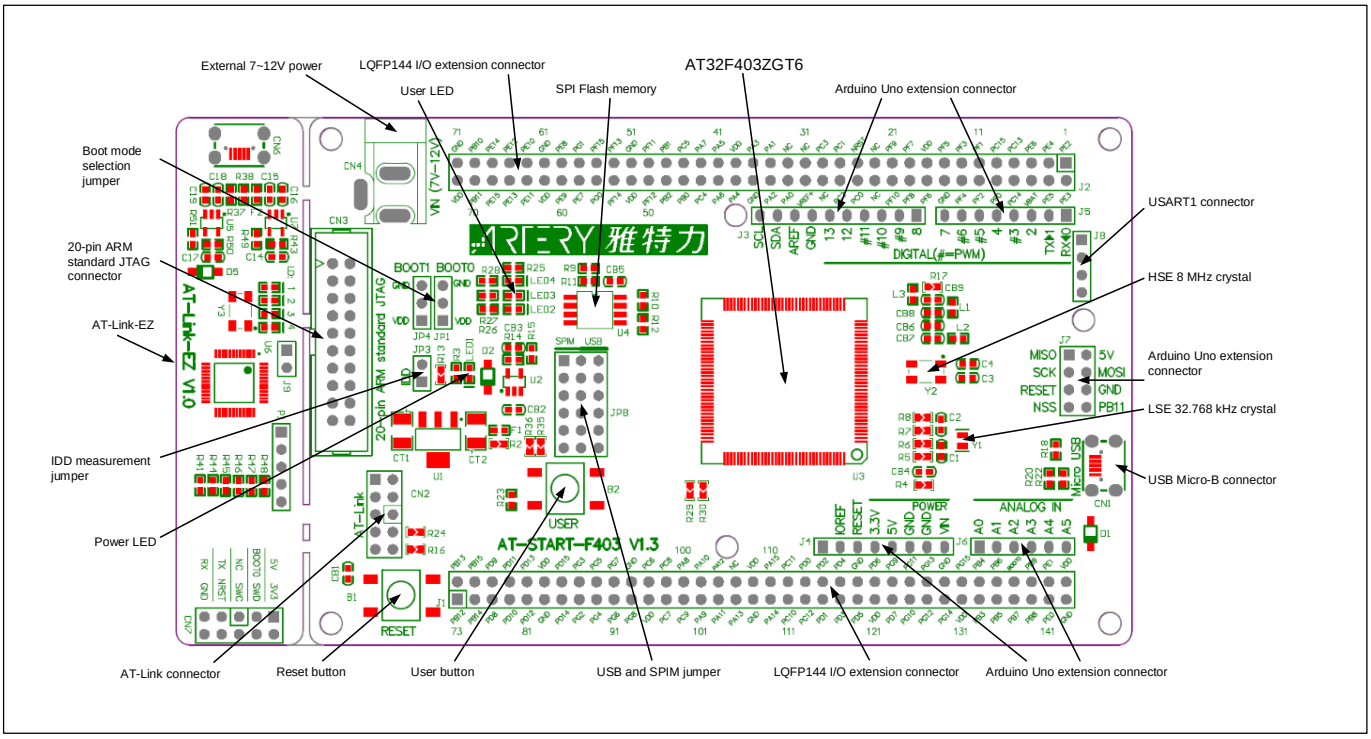
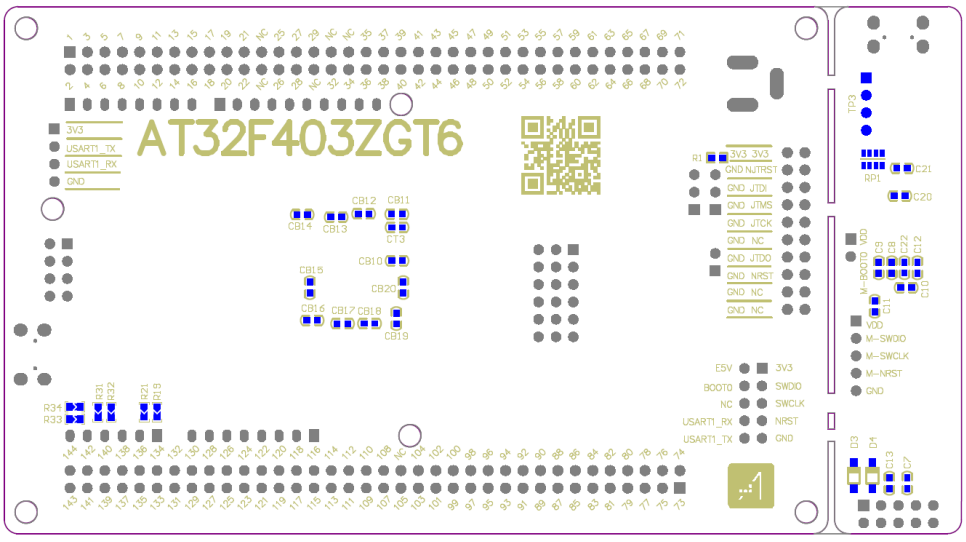


Figure 3. Bottom layer



4.1 Programming and debugging

4.1.1 Embedded AT-Link-EZ

The evaluation board embeds Artery AT-Link-EZ programming and debugging tool for users to program/debug the AT32F403ZGT6 on the AT-START-F403 board. AT-Link-EZ supports SWD interface mode and a set of virtual COM port (VCP) to be connected to the USART1_TX/USART1_RX (PA9/PA10) of AT32F403ZGT6. In this case, PA9 and PA10 of AT32F403ZGT6 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 R16 and R24 OFF, then the use of PA9 and PA10 of AT32F403ZGT6 is not subject to the above restrictions.

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-F403 by bending over along the joint. In this case, AT-START-F403 can still be connected 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 AT32F403ZGT6.

4.1.2 20-pin ARM® standard JTAG connector

AT-START-F403 also reserves JTAG or SWD general-purpose connectors as programming/debugging tool. If the user want to use this interface to program and debug the AT32F403ZGT6, please seperate the AT-Link-EZ from the board or set R41, R44 and R46 OFF, and connect the CN3 (not mounted before shipping) to the programming and debugging tool.

4.2 Power supply selection

The 5 V power supply of AT-START-F403 can be provided throug a USB cable (either through the USB connector CN6 on the AT-Link-EZ or USB connector CN1 on the AT-START-F403), 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-F403 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-F403 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 VIN, 5 V and 3.3 V pins can be used as output power; the 5 V pin of J7 used as 5 V output power; the VDD pin of J1 and J2 used as 3.3 V output power.

4.3 LED indicators

Power LED1: red indicates that the board is powered by 3.3 V

User LED2: red, connected to the PD13 pin of AT32F403ZGT6

User LED3: white, connected to the PD14 pin of AT32F403ZGT6

User LED4: green, connected to the PD15 pin of AT32F403ZGT6

4.4 Buttons

Reset button B1: connected to NRST to reset AT32F403ZGT6

User button B2: it is, by default, connected to the PA0 of AT32F403ZGT6 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)

4.5 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 AT32F403ZGT6.

- JP3 OFF, R13 ON: AT32F403ZGT6 is powered. (Default setting and JP3 plug is not mounted before shipping)
- JP3 ON, R13 OFF: AT32F403ZGT6 is powered.
- JP3 OFF, R13 OFF: an ammeter must be connected to measure the power consumption of AT32F403ZGT6 (if there is no ammeter, the AT32F403ZGT6 cannot be powered).

4.6 External clock source

4.6.1 HSE clock source

The 8 MHz crystal on the board is used as HSE clock source.

4.6.2 LSE clock source

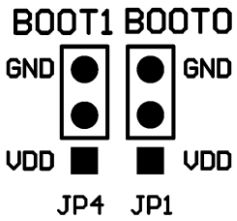
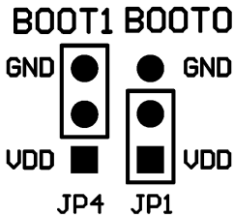
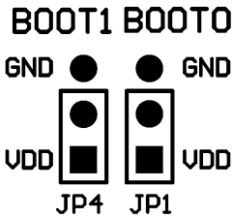
There are three hardware modes to set the external low-speed clock sources:

- **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 pin 3 of J2. 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.

4.7 Boot mode selection

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

Table 2. Boot mode selection jumper setting

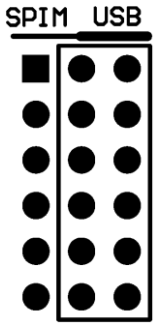
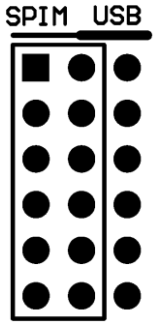
Jumper	Boot mode selection pins		Setting
	BOOT1	BOOT0	
JP1 connected to GND or OFF; JP4 optional or OFF	X	0	Boot from the internal Flash memory with the jumper setting below: (By default, JP1 is connected to GND, and JP4 to GND) 
JP1 connected to VDD JP4 connected to GND	0	1	Boot from the system memory with the jumper setting below: 
JP1 connected to VDD JP4 connected to VDD	1	1	Boot from SRAM with the jumper setting below: 

4.8 USB device

AT-START-F403 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-F403 board.

When using USB, the JP8 one-piece jumper, as shown in *Table 3*, should be selected the right USB side. (Default setting before shipping.)

Table 3. USB and SPIM jumper setting

Jumper	Setting
JP8 connected to USB side	To use the USB function, the jumper is installed as follows: (Default setting before shipping) 
JP8 connected to SPIM side	To use the SPIM function, the jumper is installed as follows: 

4.9 Connect to the Bank3 of Flash memory via SPIM interface

The SPI Flash EN25QH128A on the board is connected to the AT32F403ZGT6 via SPIM interface and used as Bank3 of expanded Flash memory. The pin function is alternate for SPIM and USB interfaces, so the two functions can not be used simultaneously.

When using the Bank3 of the Flash memory via SPIM interface, the JP8 one-piece jumper, as shown in *Table 3*, should be selected the right SPIM side. In this case, PA8, PB1, PB6 and PB7 are not connected to the external LQFP144 I/O extension connector.

4.10 0 Ω resistors

Table 4. 0 Ω resistor setting

Resistors	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 there is no ammeter, the microcontroller cannot be powered)
R4 (V_{BAT} power supply)	**ON**	V_{BAT} must be connected to VDD
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
R17 (V_{REF+})	**ON**	V_{REF+} is connected to VDD
	OFF	V_{REF+} is connected to the J2 pin 32 or Arduino™ connector J3 AREF
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 or SPIM, they are not connected to pin 31 and pin 32 of J1
	ON, ON	When PA11 and PA12 are used as USB or SPIM, they can be connected to pin 31 and pin 32 of J1
R31, R32, R33, R34 (Arduino™ A4, A5)	**OFF, ON, OFF, ON**	Arduino™ A4 and A5 are connected to ADC_IN11 and ADC_IN10
	ON, OFF, ON, OFF	Arduino™ A4 and A5 are 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)
R24 (USART1_RX)	**ON**	USART1_RX of AT32F403ZGT6 is connected to VCP TX of AT-Link-EZ
	OFF	USART1_RX of AT32F403ZGT6 is disconnected from VCP TX of AT-Link-EZ
R16 (USART1_TX)	**ON**	USART1_TX of AT32F403ZGT6 is connected to VCP RX of AT-Link-EZ
	OFF	USART1_TX of AT32F403ZGT6 is disconnected from VCP RX of AT-Link-EZ

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

4.11 Extension connectors

4.11.1 Arduino™ Uno R3 extension connector

Female plug J3~J6 and male J7 support standard Arduino™ Uno R3 connector. Most of the daughter boards designed around Arduino™ Uno R3 are suitable for AT-START-F403.

Note 1: The I/O ports of AT32F403ZGT6 are 3.3 V compatible with Arduino™ Uno R3, but 5V incompatible.

Note 2: Set R17 OFF if it is needed to supply power through the J3 pin 8 AREF of AT-START-F403 to the V_{REF+} of AT32F403ZGT6 by means of Arduino™ Uno R3 daughter board.

Table 5. Arduino™ Uno R3 extension connector pin definition

Connector	Pin number	Arduino pin name	AT32F403 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	-	5 V input/output
	6	GND	-	Ground
	7	GND	-	Ground
	8	VIN	-	7~12V input/output
J6 (Analog input)	1	A0	PA0	ADC123_IN0
	2	A1	PA1	ADC123_IN1
	3	A2	PA4	ADC12_IN4
	4	A3	PB0	ADC12_IN8
	5	A4	PC1 or PB9(1)	ADC123_IN11 or I2C1_SDA
	6	A5	PC0 ro PB8(1)	ADC123_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	TMR3_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	AREF	-	V_{REF+} input/output
	9	SDA	PB9	I2C1_SDA
	10	SCL	PB8	I2C1_SCL

Connector	Pin number	Arduino pin name	AT32F403 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) 0 Ω resistor setting is shown *Table 4.*
(2) SPIM must be disabled and JP8 one-piece jumper must select USB side, otherwise PA8 and PB6 cannnot be used.

4.11.2 LQFP144 I/O extension connector

The extension connectors J1 and J2 can connect the AT-START-F403 to external prototype/packing board. The I/O ports of AT32F403ZGT6 are available on these extension connectors. J1 and J2 can also be measured with the oscilloscope, logic analyzer or voltmeter probe.

Note: Set R17 OFF if it is necessary to supply power through the J2 pin 32 V_{REF+} of AT-START-F403 with an external power supply.

5 Schematic

Figure 4. Schematic (AT-Link-EZ)

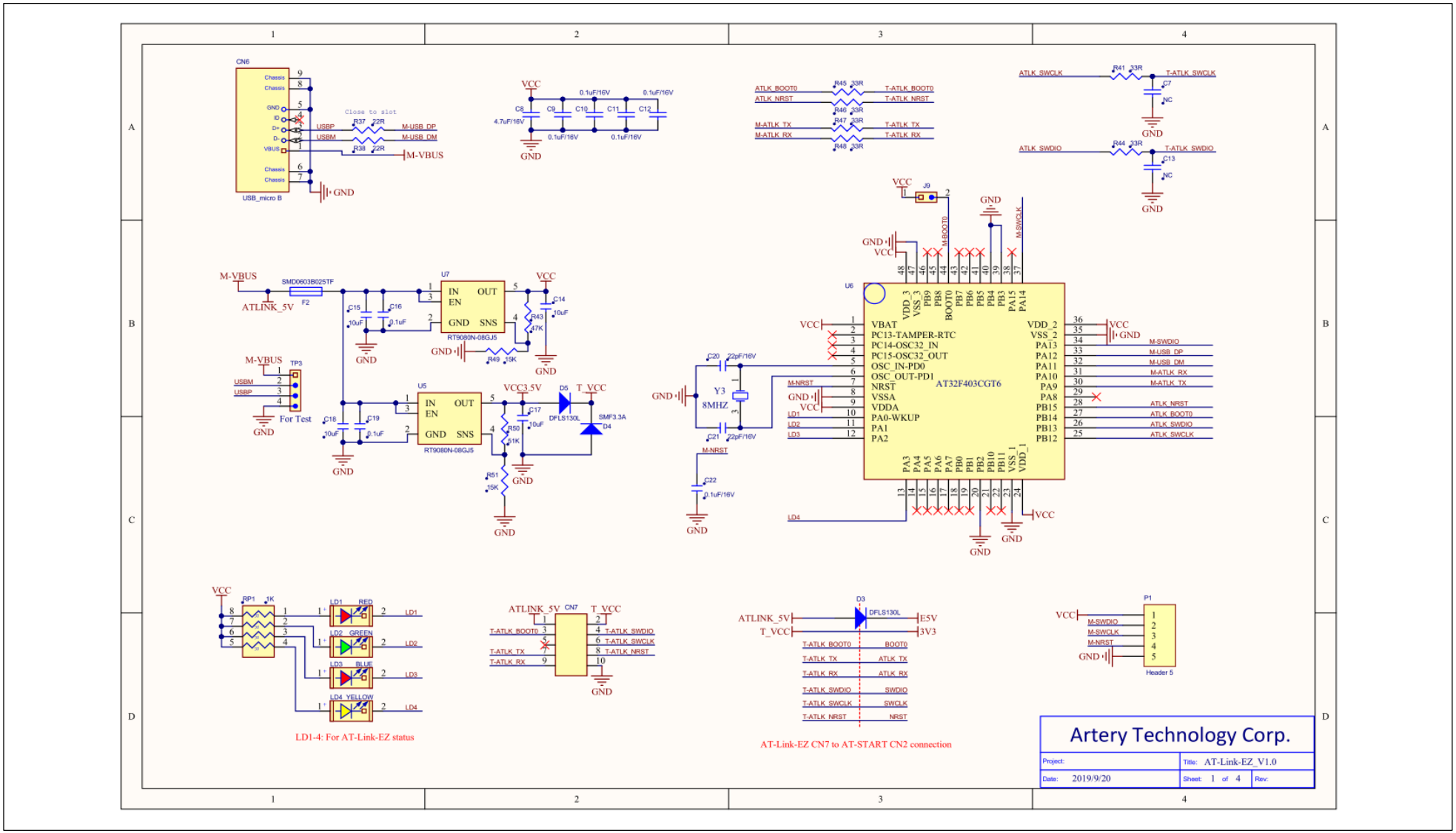


Figure 5. Schematic (microcontroller)

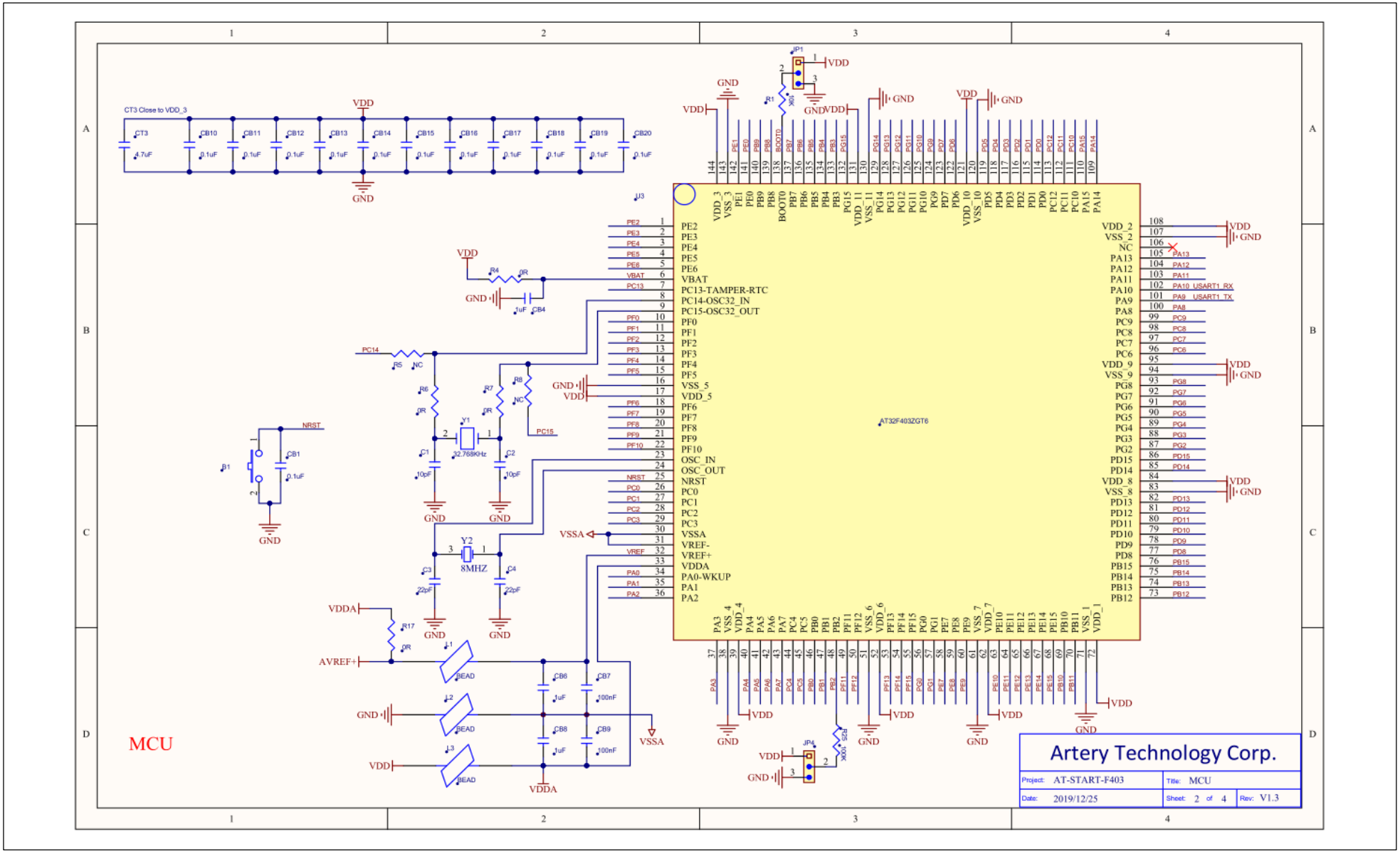


Figure 6. Schematic (power supply and peripherals)

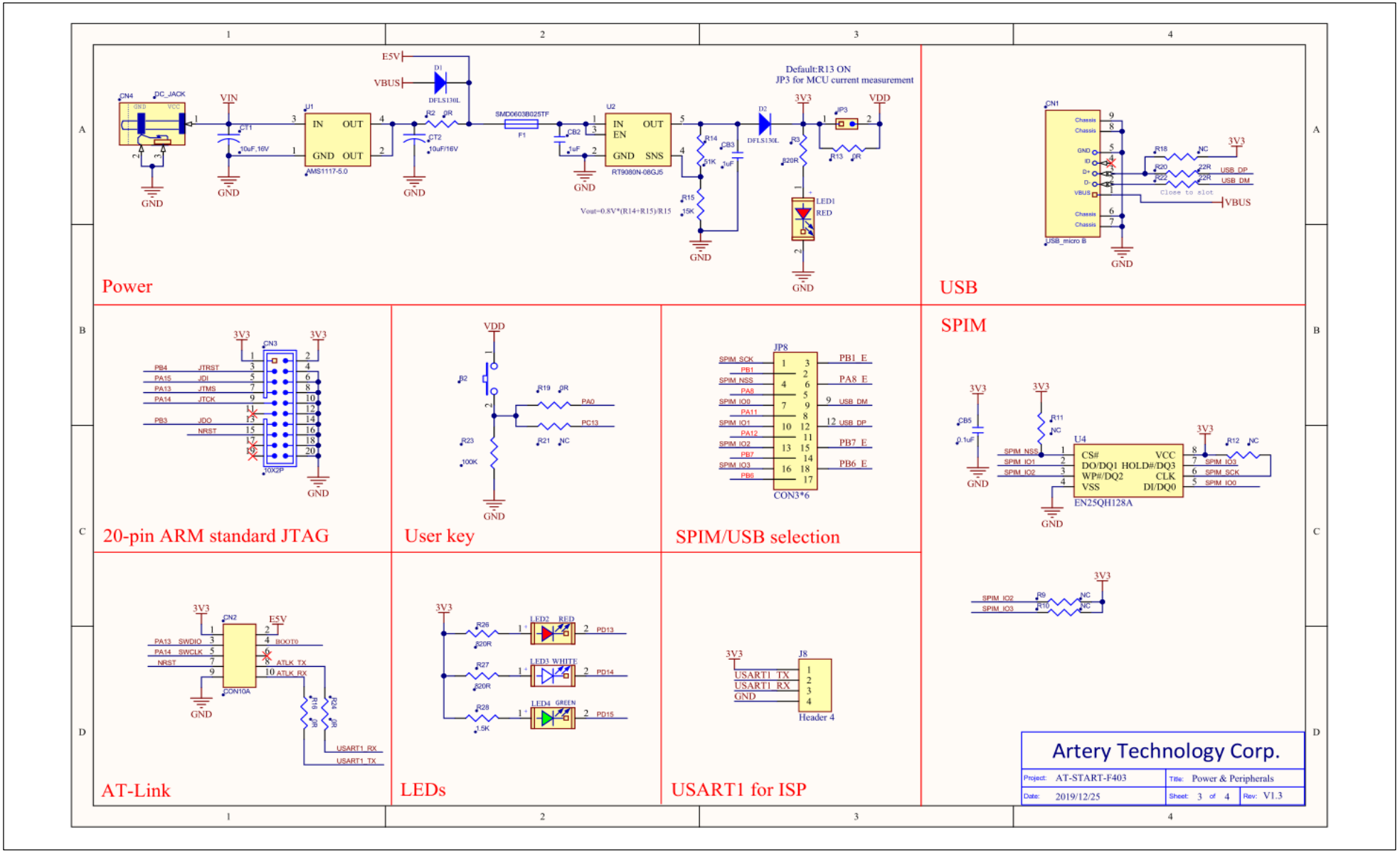
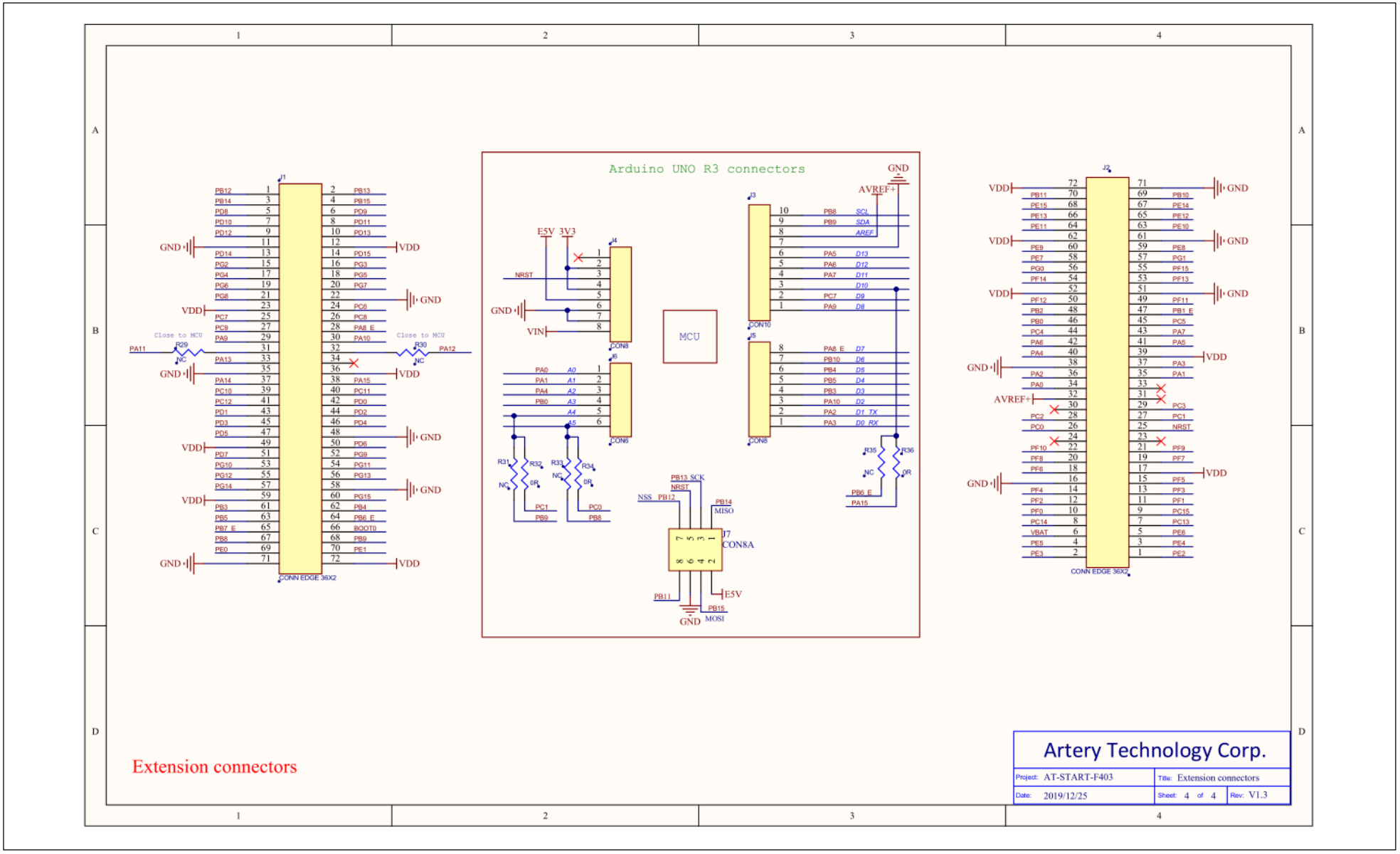


Figure 7. Schematic (extension connectors)



6 Revision history

Table 6. Document revision history

Date	Revision	Changes
2018.1.15	1.0	Initial release
2018.3.19	1.1	1. Modified 5V power selection and canceled 5V power selection jumper 2. Modified LED color, and changed the connecting sequence of PD13~15 to LED2~4 3. Corrected the silkscreen error of BOOT0 and BOOT1
2018.7.23	1.2	1. Modified the main MCU chip U3 to be AT32F403ZGT6 2. Modified JP1 to be optional VDD or GND and removed BOOT0 external pull-down resistor R1 3. Modified J7 pin number increased to 8, additional PB12/SPI2_NSS and PB11 available 4. Modified the default setting before shipping of R35 and R36 OFF and ON 5. Corrected JP8 silkscreen on the PCB V1.1 labelled JP2 by mistaken
2019.12.25	1.3	1. Added AT-Link-EZ 2. Modified 0Ω resistors to solder bridges 3. Modified the voltage regulator (U2) and related external devices

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