Introduction

AT-START-F402 is designed to help you explore the high performance of the 32-bit microcontroller AT32F402 that embeds ARM Cortex®-M4 core, and expedite application development.

AT-START-F402 is an evaluation board based on AT32F402RCT7-7 microcontroller. The device contains such peripherals as LEDs, buttons, USB type-C and USB type-A connectors, Arduino™ Uno R3 extension connectors, and 16 MB SPI Flash memory extended through QSPI1 interface. This evaluation board embeds AT-Link-EZ for debugging/programming without the need of other development tools.

Contents

List of tables

List of figures

1   Overview

1.1   Features

AT-START-F402 has the following characteristics:

- AT-START-F402 has an on-board AT32F402RCT7-7 microcontroller that embeds ARM Cortex®-M4 32-bit core, 256 KB Flash memory and 96+6 KB SRAM, in LQFP64 7x7mm packages.
- On-board AT-Link interface:
  - On-board AT-Link-EZ can be used for programming and debugging (AT-Link-EZ is a simplified version of AT-Link, without offline mode support)
  - AT-Link-EZ can be disassembled from the board by bending it along the joint and connected to an independent AT-Link for programming and debugging purposes
- 16 MB SPI EN25QH128A connected to QSPI interface is used as Flash memory extension
- Various power supply methods:
  - USB bus for AT-Link-EZ
  - OTGFS bus (VBUS_FS)
  - External 5 V power supply (E5V)
  - External 3.3 V power supply
- 4 x LED indicators:
  - LED1 (red) indicates 3.3 V power-on
  - 3 x USER LEDs, LED2 (red), LED3 (yellow) and LED4 (green) indicating operation status
- User button and Reset button
- 12 MHz HEXT crystal oscillator
- 32.768 kHz LEXT crystal oscillator
- USB type-A (host) and type-C connectors (device) to demonstrate OTGFS functions
- A rich choice of extension interfaces for quick prototyping
  - Arduino™ Uno R3 extension connectors
  - LQFP64 I/O extension connectors

1.2   Definition of terms

- **Jumper JPx ON**
  Jumper fitted.
- **Jumper JPx OFF**
  Jumped not fitted.
- **Resistor Rx ON**
  Short by solder or 0Ω resistor.
- **Resistor Rx OFF**
  Connections left open.

2 Quick start

2.1 Get started

Configure the AT-START-F402 board in the following sequence:

1. Check the Jumper's position on board:

    JP1 OFF (BOOT0 = 0, and BOOT0 has an pull-down resistor in the AT32F402RCT7-7);

2. Connect AT_Link_EZ to PC via a USB cable (Type A to type-C), and supply power to the evaluation board via a USB connector CN6. LED1 (red) is always on, and three other LEDs (LED2 to LED4) start to blink in turn.

3. After pressing User button (B2), the blinking frequency of three LEDs are changed.

2.2 AT-START-F402 development toolchains

*   ARM® Keil®: MDK-ARM™
*   IAR™: EWARM
*   AT32 IDE

3 Hardware and layout

AT-START-F402 board is designed around an AT32F402RCT7-7 microcontroller in LQFP64 7x7 mm package.

Figure 1 shows the connections between AT-Link-EZ, AT32F402RCT7-7 and their peripherals (buttons, LEDs, OTGHS and extension connectors)

Figure 2 and *Figure 3* shows their respective locations on the AT-Link-EZ and AT-START-F402 board.

Figure 1. Hardware block diagram

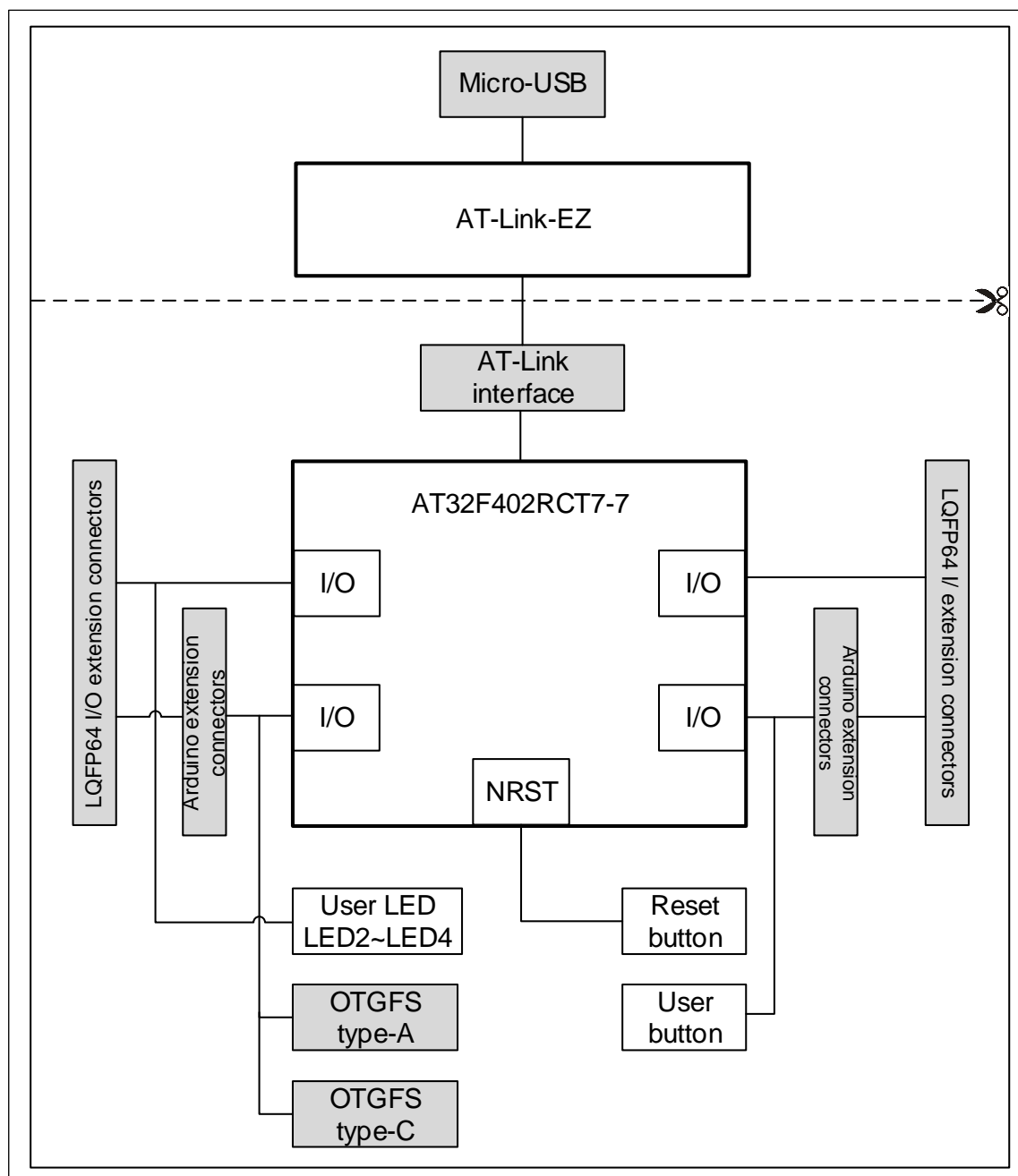## Figure 2. Top layer

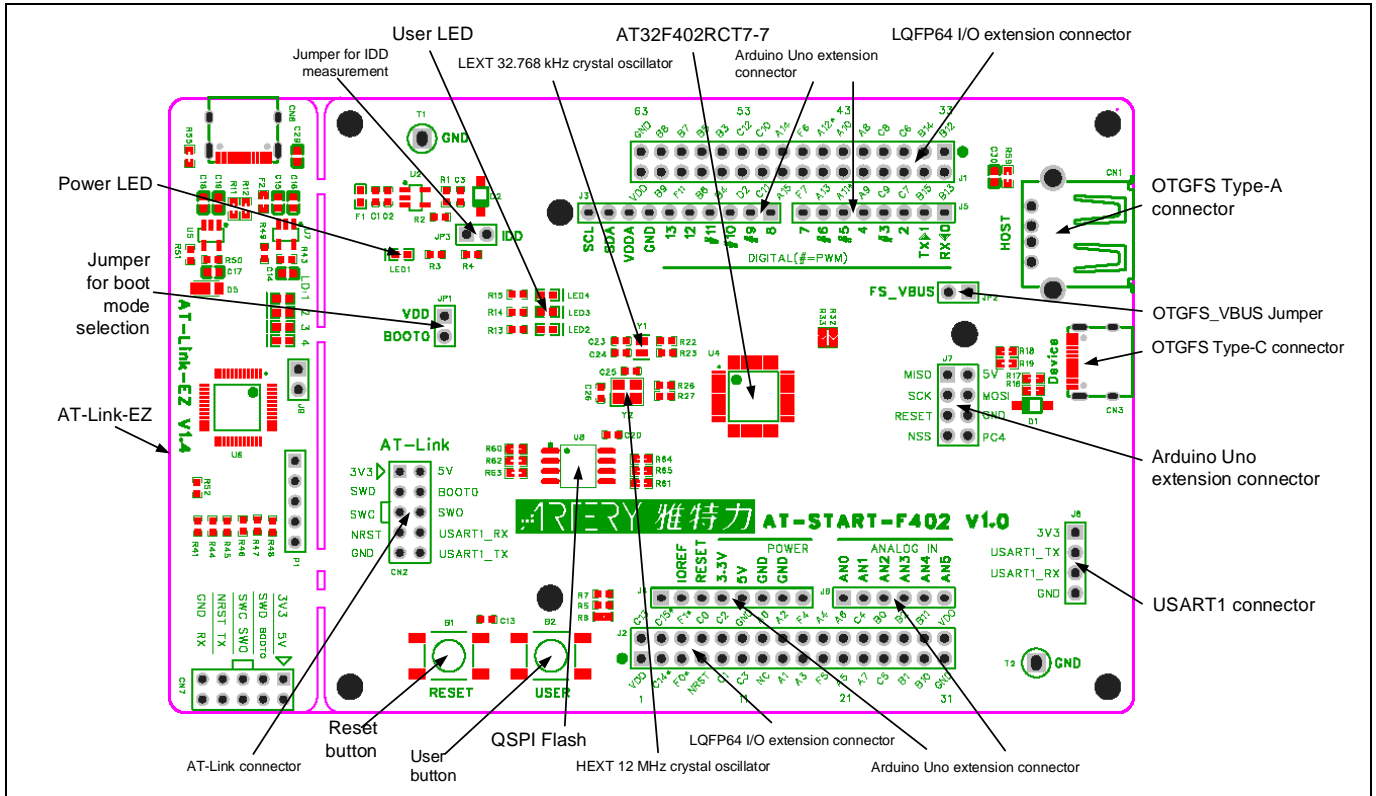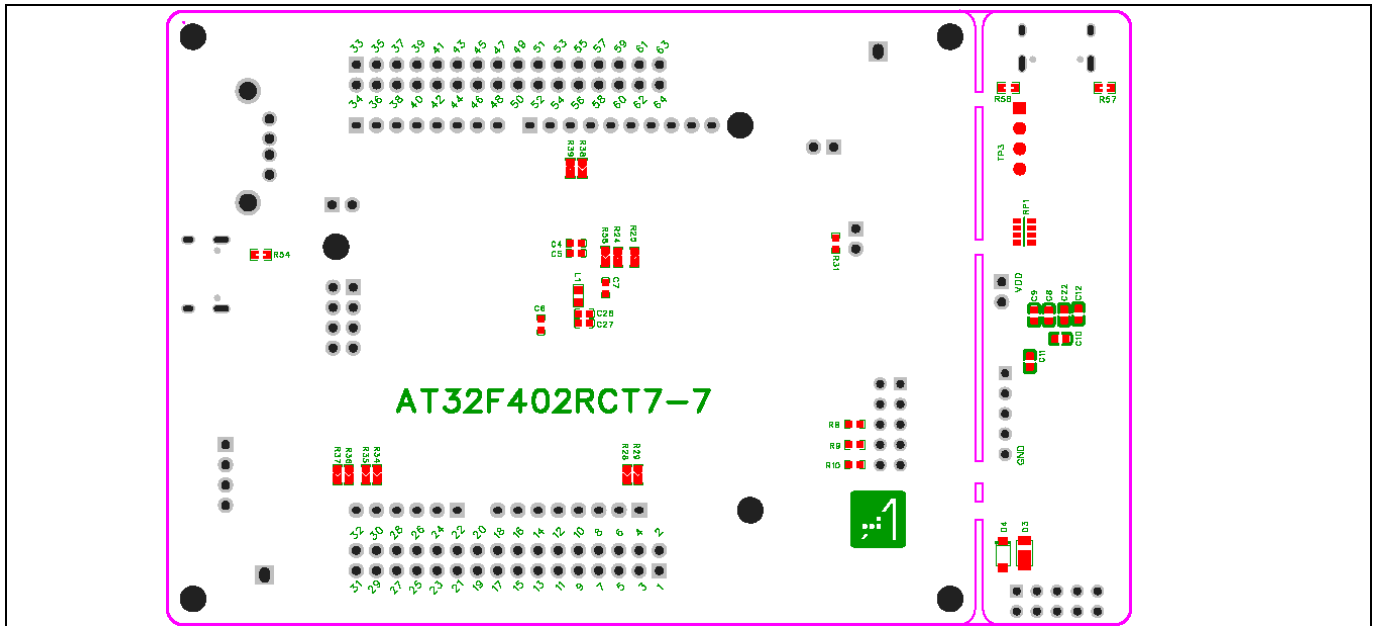Figure 2. Top layer

Figure 3. Bottom layer

Figure 3. Bottom layer

3.1   Power supply selection

The AT-START-F402 can not only be provided with 5 V through a USB cable (either through USB connector CN6 on AT-Link-EZ, OTGFS connector CN3 on AT-START-F402), but also be provided with an external 5 V power supply (E5V). Then 5 V power provides 3.3 V for the microcontroller and its peripherals using on-board 3.3 V voltage regulator (U2).

The 5 V pin of J4 or J7 can also be used as an input power, so the AT-START-F402 board can be supplied through a 5 V power unit.

The 3.3 V pin of J4, or the VDD of J1 and J2 can be used as 3.3 V input directly, which means that AT-START-F402 board can also be supplied by a 3.3 V power unit.

Note: *5 V power supply must be provided through USB connector (CN6) on AT-Link-EZ. Any other methods cannot power the AT-Link-EZ.*

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

3.2   IDD

When JP3 OFF (symbol IDD) and R4 OFF, an ammeter can be connected to measure the power consumption of AT32F402RCT7-7.

- **JP3 OFF, R4 ON:**
  AT32F402RCT7-7 is powered. (Default setting and JP3 plug is not mounted before shipping)

- **JP3 ON, R4 OFF:**
  AT32F402RCT7-7 is powered.

- **JP3 OFF, R4 OFF:**
  An ammeter must be connected to measure the power consumption of AT32F402RCT7-7. If there is no ammeter available, the AT32F402RCT7-7 cannot be powered.

3.3   Programming and debugging: embedded AT-Link-EZ

The evaluation board integrates Artery AT-Link-EZ for users to program/debug the AT32F402RCT7-7 on the AT-START-F402 board. AT-Link-EZ supports SWD interface mode, SWO debug, and virtual COM port (VCP) to be connected to the USART1_TX/USART1_RX (PA9/PA10) of AT32F402RCT7-7.

Please refer to AT-Link User Manual for complete details on AT-Link-EZ.

The AT-Link-EZ on board can be disassembled or separated from the AT-START-F402. In this case, the CN2 (not mounted before leaving factory) of AT-START-F402 can still be connected to the CN7 (not mounted before leaving factory) of AT-Link-EZ, or connected to AT-Link, in order to continue programing and debugging the AT32F402RCT7-7.

3.4　Boot mode selection

At startup, three different boot modes are available for selection through pin configuration. JP1 is not mounted before shipping. After startup, BOOT0 pin is used as PF11.

Table 1. Boot mode selection jumper settings

Jumper	PF11/BOOT0 configuration	Boot mode
JP1 OFF	0	Boot from internal Flash memory (factory default setting)
JP1 to VDD	1	Boot from boot loader code area or internal SRAM [1]

(1)　Depending on the nBOOT1 bit of the user system data area.

3.5　External clock sources

3.5.1　HEXT clock sources

There are three methods to configure the external high-speed clock source by hardware:

● **On-board crystal oscillator (Factory default setting)**

On-board 12 MHz crystal oscillator is used as HEXT clock source. The hardware must be configured: R26 and R27 ON, R28 and R29 OFF.

● **External oscillator from PF0**

External oscillator is injected from the pin_5 of J2. The hardware must be configured: R28 ON, R26 and R27 OFF. To use PF1 as GPIO, R29 ON can be connected to the pin_6 of J2.

● **HEXT unused**

PF0 and PF1 are used as GPIOs. The hardware must be configured: R28 and R29 ON, R26 and R27 OFF.

3.5.2　LEXT clock sources

There are three methods to configure the external low-speed clock source by hardware:

● **On-board crystal oscillator (Factory default setting)**

On-board 32.768 kHz crystal oscillator is used as LEXT clock source. The hardware must be configured: R22 and R23 ON, R24 and R25 OFF

● **External oscillator from PC14**

External oscillator is injected from the pin_3 of J2. The hardware must be configured: R24 and R25 ON, R22 and R23 OFF.

● **LEXT unused**

PC14 and PC15 are used as GPIOs. The hardware must be configured: R24 and R25 ON, R22 and R23 OFF.

3.6   LEDs

- **Power LED1**

  Red LED indicates that the AT-START-F402 is being powered by 3.3 V.
- **User LED2**

  Red LED is connected to the PF4 pin of AT32F402RCT7-7.
- **User LED3**

  Yellow LED is connected to the PF5 pin of AT32F402RCT7-7.
- **User LED4**

  Green LED is connected to the PF6 pin of AT32F402RCT7-7.

3.7   Buttons

- **Reset button B1**

  It is connected to NRST to reset AT32F402RCT7-7 microcontroller.

- **User button B2**

  It is connected to the PA0 of AT32F402RCT7-7 as a wakeup button (R5 ON and R6 OFF), or connected to the PC13 as TAMPER-RTC button (R5 OFF and R6 ON).

3.8   OTGFS

AT-START-F402 board implements USB full-speed device mode via a USB type-C connector (CN3). In device mode, AT-START-F402 can be directly connected to the host through USB type-C connector. The VBUS_FS can be used as 5 V input of AT- START-F402 board.

AT-START-F402 board also offers a USB type-A extension connector (CN1) which is used as USB full-speed/low-speed host interface to be connected to other devices like U-disk or mouse.

If the PA9 of the AT32F402RCT7-7 is to be used as OTGFS_VBUS, JP2 must turn on so that PA9 is connected to USB type-C connector.

3.9   QSPI interface

There is a SPI Flash memory (EN25QH128A) on the board, which is connected to the AT32F402RCT7-7 via QSPI1 interface so that it can be used as extended Flash memory.

Such QSPI1 interface is connected to Flash memory via PC11, PC9, PB7, PC8, PC5 and PC2. If these GPIOs are to be used for other purposes, it is advisable that R60 ~ R65 are turned off first before doing so.

3.10   0Ω resistors

Table 2. 0Ω resistor settings

Resistors	State[1]	Description
R4 (MCU power consumption measurement)	**ON**	When JP3 OFF, the AT32F402RCT7-7 is directly supplied by 3.3V.
	OFF	When JP3 OFF, 3.3V can be connected to an ammeter to measure the power consumption of the AT32F402RCT7-7. (AT32F402RCT7-7cannot be powered without ammeter)
R26, R27, R28, R29 (HEXT)	**ON, ON, OFF, OFF**	HEXT clock source comes from on-board crystal Y2
	OFF, OFF, ON, ON	HEXT clock source: external oscillator from PF0, or when PF0 and PF1 are used as GPIOs.
R22, R23, R24, R25 (LEXT)	**ON, ON, OFF, OFF**	LEXT clock source comes from on-board crystal Y1
	OFF, OFF, ON, ON	LEXT clock source: external oscillator from PC14, or when PC14 and PC15 are used as GPIOs.
R5，R6 (User button B2)	**ON, OFF**	User button B2 is connected to PA0
	OFF, ON	User button B2 is connected to PC13
R32, R33 (PA11, PA12)	**OFF, OFF**	When used as USB, PA11 and PA12 are disconnected from the pin_12 and pin_13 of J1.
	ON, ON	When not used as USB, PA11 and PA12 are connected to the pin_12 and pin_13 of J1.
R34, R35, R36, R37 (Arduino™ A4, A5)	**ON, OFF, OFF, ON**	Arduino™ A4 and A5 are connected to ADC1_IN11 and ADC1_IN10
	OFF, ON, ON, OFF	Arduino™ A4 and A5 are connected to I2C1_SDA and I2C1_SCL
R38, R39 (Arduino™ D10)	**OFF, ON**	Arduino™ D10 is connected to SPI1_CS
	ON, OFF	Arduino™ D10 is connected to PWM (TMR4_CH1)

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

3.11　Extension connectors

3.11.1　Arduino^{TM} Uno R3 connectors

Female plug J3~J6 and male plug J7 support Arduino^{TM} Uno R3 connectors. Most of the daughter boards built on Arduino^{TM} Uno R3 are applicable to AT-START-F402 board.

Note 1:　AT32F402RCT7-7 I/O ports are 3.3 V-compatible with Arduino^{TM} Uno R3, but not 5 V.

Note 2:　The pin_8 of J3 is VDDA, equivalent level to VDD, without Arduino^{TM} Uno R3-defined AREF feature.

Table 3. Arduino^{TM} Uno R3 extension interface pin definition

Connector	Pin number	Arduino pin name	AT32F402 pin name	Description
J4 (Power supply)	1	NC	-	-
	2	IOREF	-	3.3 V reference voltage
	3	RESET	NRST	External reset
	4	3.3V	-	3.3 V input/output
	5	5V	-	5 V input/output
	6	GND	-	Ground
	7	GND	-	Ground
	8	NC	-	-
J6 (Analog input)	1	A0	PA0	ADC1_IN0
	2	A1	PA1	ADC1_IN1
	3	A2	PA4	ADC1_IN4
	4	A3	PB0	ADC1_IN8
	5	A4	PC1 or PB9[1]	ADC1_IN11 or I2C1_SDA
	6	A5	PC0 or PB8[1]	ADC1_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	-
J3 (Logic input/output high byte)	1	D8	PA9	-
	2	D9	PC7	TMR1_CH2
	3	D10	PA15 or PB6[1]	SPI1_CS 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	AT32F402 pin name	Description
J7 (Others)	1	MISO	PC2	SPI2_MISO
	2	5V	-	5 V input/output
	3	SCK	PB13	SPI2_SCK
	4	MOSI	PB15	SPI2_MOSI
	5	RESET	NRST	External reset
	6	GND	-	Ground
	7	NSS	PB12	SPI2_CS
	8	PB11	PC4	-

(1) Refer to *Table 2* for details on 0Ω resistors.

3.11.2 LQFP64 I/O extension connectors

The I/O ports of AT32F402RCT7-7 microcontroller can be connected to external devices through extension connectors J1 and J2. All I/O ports on the AT32F402RCT7-7 are available on these extension connectors. J1 and J2 can be measured with oscilloscope, logic analyzer or voltmeter probe.

4 Revision history

Table 4. Document revision history

Date	Revision	Changes
2023.8.25	1.00	Initial release

IMPORTANT NOTICE – PLEASE READ CAREFULLY

Purchasers are solely responsible for the selection and use of ARTERY's products and services, and ARTERY assumes no liability whatsoever relating to the choice, selection or use of the ARTERY products and services described herein

No license, express or implied, to any intellectual property rights is granted under this document. If any part of this document deals with any third party products or services, it shall not be deemed a license granted by ARTERY for the use of such third party products or services, or any intellectual property contained therein, or considered as a warranty regarding the use in any manner of such third party products or services or any intellectual property contained therein.

Unless otherwise specified in ARTERY's terms and conditions of sale, ARTERY provides no warranties, express or implied, regarding the use and/or sale of ARTERY products, including but not limited to any implied warranties of merchantability, fitness for a particular purpose (and their equivalents under the laws of any jurisdiction), or infringement on any patent, copyright or other intellectual property right.

Purchasers hereby agree that ARTERY's products are not designed or authorized for use in: (A) any application with special requirements of safety such as life support and active implantable device, or system with functional safety requirements; (B) any aircraft application; (C) any aerospace application or environment; (D) any weapon application, and/or (E) or other uses where the failure of the device or product could result in personal injury, death, property damage. Purchasers' unauthorized use of them in the aforementioned applications, even if with a written notice, is solely at purchasers' risk, and Purchasers are solely responsible for meeting all legal and regulatory requirements in such use.

Resale of ARTERY products with provisions different from the statements and/or technical characteristics stated in this document shall immediately void any warranty grant by ARTERY for ARTERY's products or services described herein and shall not create or expand any liability of ARTERY in any manner whatsoever.