

Getting started with AT32F456ZET7

The AT-START-F456 evaluation board is designed to help you explore the high performance of the 32-bit microcontroller AT32F456 series, with the ARM Cortex®-M4F core and FPU, and expedite development cycles and shorten time to market.

The AT-START-F456 evaluation board is based on the AT32F456ZET7 microcontroller. It features LEDs, buttons, a USB type-C connector, a USB type-A connector, a CANFD connector, Arduino™ Uno R3 extension connectors and a 16 Mbytes SPI Flash memory (extended through QSPI1). It also comes with a built-in AT-Link-EZ for debugging/programming purposes, without the need of other development tools.

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1 Overview

1.1 Features

The AT-START-F456 board has the following features:

- ARM Cortex®-M4F-based 32-bit AT32F456ZET7 microcontroller with FPU that embeds 512 KB Flash memory and default 144 KB SRAM, in LQFP144 package
- On-board AT-Link connector:
 - On-board AT-Link-EZ for programming and debugging purposes (AT-Link-EZ is a simplified version of AT-Link, without offline mode support)
 - If the AT-Link-EZ is separated from the AT-START-F456, it can be connected with an independent AT-Link for programming and debugging purposes
- 16 Mbytes SPI Flash (EN25QH128A) is used as extended Flash memory
- Power supply source:
 - USB bus of AT-Link-EZ
 - OTGFS1 bus (V_{BUS}) of AT-START-F456
 - External 5 V power supply (E5V)
 - External 3.3 V power supply
- 4 x LED indicators:
 - LED1 (red) indicates that 3.3 V is being supplied
 - 3 x User LEDs, LED2 (red), LED3 (yellow) and LED4 (green) indicate operation status
- User button and Reset button
- 8 MHz HEXT crystal
- 32.768 kHz LEXT crystal
- For OTGFS application, a USB type-A and a type-C connectors on board
- For CAN FD protocol supported by CAN1, a CANFD transceiver (up to 8 Mbit/s) and a bus connector on board
- Rich extension connectors:
 - Arduino™ Uno R3 extension connectors
 - LQFP144 I/O extension connectors

1.2 Definition of terms

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

2 Quick start guide

2.1 Get started

Configure the AT-START-F456 board in the following sequence:

1. Check the Jumper's position on board:
JP1 is connected to GND or OFF (BOOT0 = 0, and BOOT0 has an internal pull-down resistor in the AT32F456ZET7);
JP2 is connected to GND (BOOT1=0)
2. Connect the AT-Link-EZ to PC via a USB cable (type A to type-C) so that the board is powered via USB connector CN6. LED1 (red) is always on, and three other LEDs (LED2 to LED4) start to flash in turn.
3. After pressing User button (B2), the flashing frequency of three LEDs is changed.

2.2 Development toolchains

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

3 Hardware layout and configuration

The AT-START-F456 board is designed around an AT32F456ZET7 microcontroller in LQFP144 package.

[Figure 1](#) shows the connections between AT-Link-EZ, AT32F456ZET7 and their peripherals (buttons, LEDs, USB OTG, CANFD, SPI and extension connectors) on AT-START-F456 board.

[Figure 2](#) and [Figure 3](#) shows their respective locations on the AT-Link-EZ and AT-START-F456 board.

Figure 1. Hardware block diagram

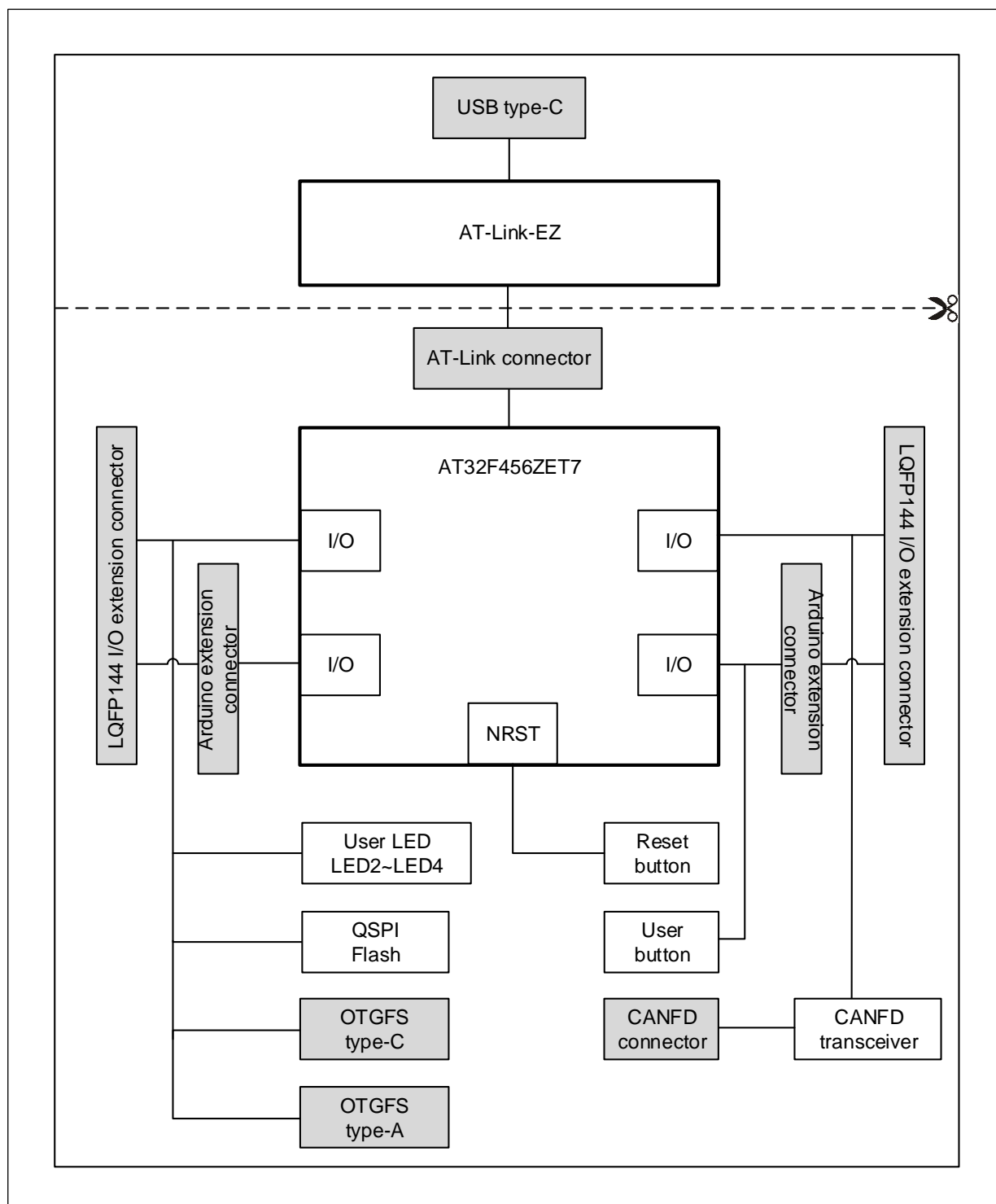


Figure 2. Top layer

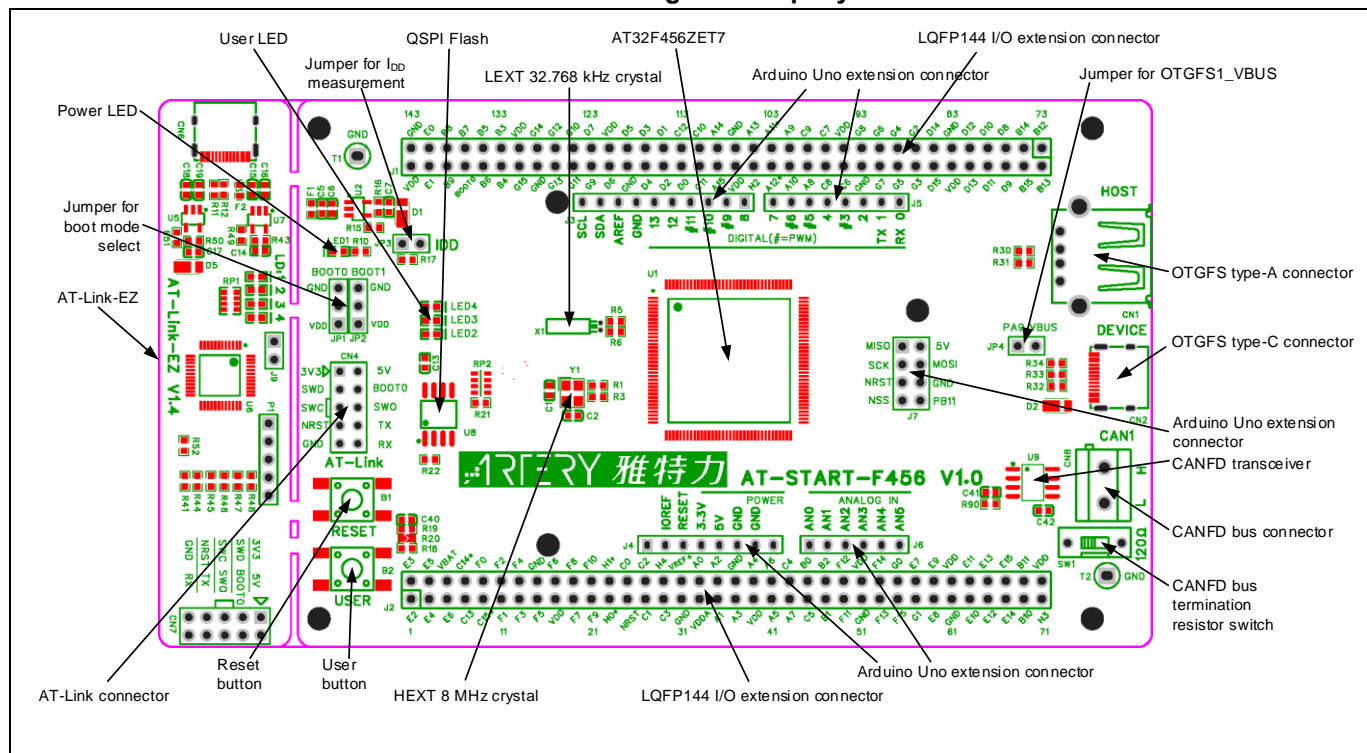
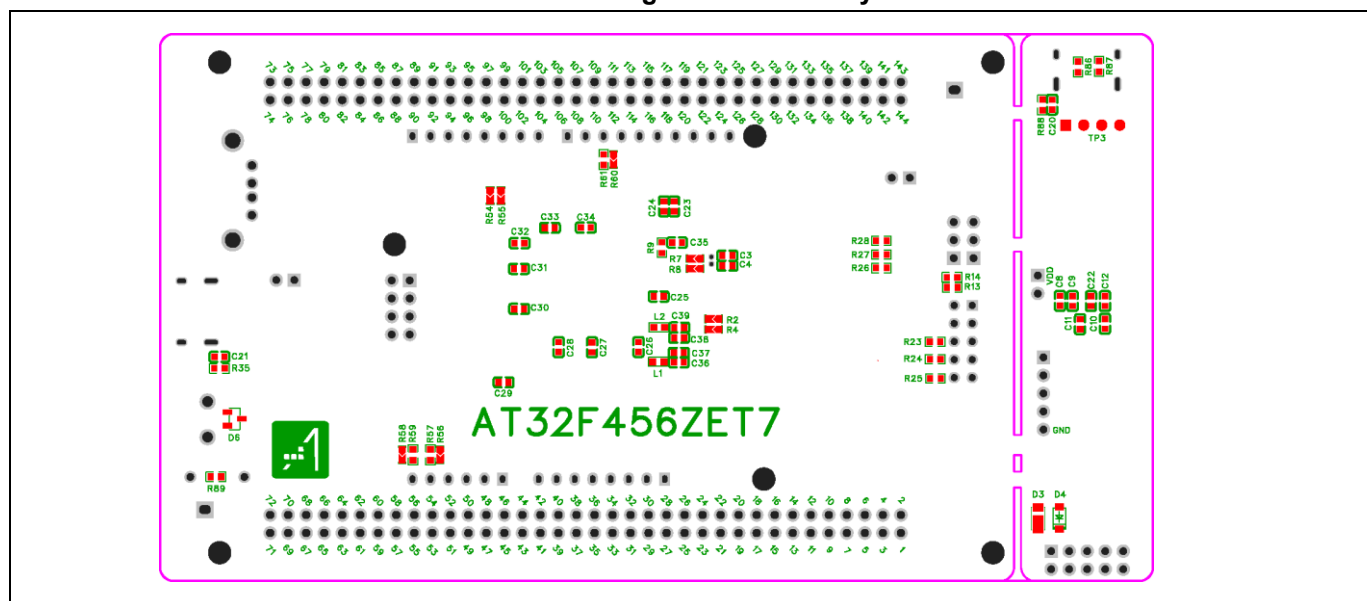


Figure 3. Bottom layer



3.1 Power supply sources

The AT-START-F456 can be supplied with 5 V through a USB cable (either via USB connector CN6 on the AT-Link-EZ or USB connector CN2 on the AT-START-F456 board). It can also be supplied with an external 5 V power supply (E5V). The 3.3 V required for the microcontroller and its peripherals is then provided via a 5 V-to- 3.3 V voltage regulator (U2).

Additionally, the 5 V pin of J4 or J7 can also be used as an input power source to supply the AT-START-F456 board.

The 3.3 V pin of J4, or the VDD of J1 and J2 can be used as 3.3 V input power source of the AT-START-F456 board.

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

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

3.2 IDD

When JP3 OFF (symbol IDD) and R17 OFF, an ammeter can be connected to measure the power consumption of AT32F456ZET7.

- **JP3 OFF, R17 ON:**

AT32F456ZET7 is being powered. (Default setting, and JP3 connector not mounted before shipping)

- **JP3 ON, R17 OFF:**

AT32F456ZET7 is being powered.

- **JP3 OFF, R17 OFF:**

An ammeter must be connected to measure the power consumption of the. AT32F456ZET7. If there is no ammeter available, the AT32F456ZET7 cannot be powered.

3.3 Embedded AT-Link-EZ for programming and debugging

The evaluation board integrates Artery AT-Link-EZ for users to program/debug the AT32F456ZET7 on the AT-START-F456 board. AT-Link-EZ supports SWD interface mode and SWO debugging. It also offers a virtual COM port (VCP) to be connected to the USART1_TX/USART1_RX (PA9/PA10) of AT32F456ZET7.

Please refer to [AT-Link User Manual](#) for complete details on AT-Link-EZ.

The AT-Link-EZ can be separated from the AT-START-F456 board. In this case, the CN4 connector (not mounted before shipping) of the AT-START-F456 can still be connected to the CN7 connector (not mounted before shipping) of the AT-Link-EZ to reestablish connection between them. Alternatively, the evaluation board can be connected to AT-Link via AT-Link connector to continue programming and debugging the AT32F456ZET7.

3.4 Boot mode selection

At startup, three different boot modes are available for selection through pin configuration.

Table 1. Boot mode selection

Jumper	Pin configuration		Boot mode
	BOOT1	BOOT0	
JP1 to GND or be OFF JP2 to arbitrary position or be OFF	X	0	Boot from Flash memory (factory default setting)
JP1 to VDD JP2 to GND	0	1	Boot from system memory
JP1 to VDD JP2 to VDD	1	1	Boot from internal SRAM

3.5 External clock sources

3.5.1 HEXT clock sources

There are three hardware methods to configure the external high-speed clock sources.

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

The on-board 8 MHz crystal is used as HEXT clock source. Hardware settings: R1 and R3 must be ON, R2 and R4 OFF.

- **External oscillator from PH0**

External oscillator is injected from the pin_23 of J2. Hardware settings: R2 must be ON, R1 and R3 OFF. To use PH1 as GPIO, R4 ON is connected to the pin_24 of J2.

- **HEXT not used**

PH0 and PH1 are used as GPIOs. Hardware settings: R2 and R4 must be ON, R1 and R3 OFF.

3.5.2 LEXT clock source

There are three hardware methods to configure the external low-speed clock sources.

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

The on-board 32.768 kHz crystal is used as LEXT clock source. Hardware settings: R5 and R6 must be ON, R7 and R8 OFF

- **External oscillator from PC14**

External oscillator is injected from the pin_3 of J2. Hardware settings: R7 and R8 must be ON, R5 and R6 OFF.

- **LEXT not used**

PC14 and PC15 are used as GPIOs. Hardware settings: R7 and R8 must be ON, R5 and R6 OFF.

3.6 LEDs

- **Power LED1**
Red LED indicates that the 3.3 V of AT-START-F456 board is being powered.
- **User LED2**
Red LED is connected to the PD13 pin of AT32F456ZET7. The User LED lights on when PD13 outputs low.
- **User LED3**
Yellow LED is connected to the PD14 pin of AT32F456ZET7. The User LED lights on when PD14 outputs low.
- **User LED4**
Green LED is connected to the PD15 pin of AT32F456ZET7. The User LED lights on when PD15 outputs low.

3.7 Buttons

- **Reset B1: Reset button**
It is connected to NRST to reset AT32F456ZET7 microcontroller.
- **User B2: User button**
By default, it is connected to the PA0 of AT32F456ZET7 and used as a WKUP button (R19 ON and R20 OFF); it can also be connected to the PC13 and used as TAMPER button (R19 OFF and R20 ON)

3.8 OTGFS configuration

The AT-START-F456 board supports OTGFS1 full-speed/low-speed host or full-speed device mode via a USB type-C connector (CN2). In device mode, the AT32F456ZET7 can be directly connected to the host through a USB type-C cable, and V_{BUS} can be used as 5 V input of the AT-START-F456 board. The AT-START-F456 board also offers a USB type-A connector (CN1) which is used as OTGFS host interface to connect to USB disk and other devices.

If the PA9 of the AT32F456ZET7 is to be used as OTGFS1_VBUS, the JP4 jumper must be ON (it is OFF by default and without jumper cap attached) so that the PA9 is connected to the USB type-C CN2 connector.

3.9 CANFD communication

The AT-START-F456 board supports CAN FD protocol communication with CAN1 through a connector which features a CAN FD transceiver. The transceiver U9 (MCP2562FD-E/SN) supports up to 8Mbit/s transfers. The CANH/CANL is connected to external devices via a connector CN8. A switch button (SW1) is used to control whether CAN1 bus is tied to a 120 Ω termination resistor. In other words, when SW1 is placed to its ON side, the CANH/CANL is connected to 120 Ω . As the STBY pin of the transceiver (MCP2562FD-E/SN) is connected to the CAN1_STB (PB7) of the AT32F456ZET7, the transceiver enters Standby mode when the STBY is active high.

3.10 QSPI Flash memory

The on-board SPI Flash (EN25QH128A), connected to the AT32F456ZET7 via QSPI1 interface, is used as an extended Flash memory.

The QSPI1 interface is connected to Flash memory through PF6~10 and PG6. If these GPIOs are to be used for other purposes, it is recommended to set RP2, R21 and R22 OFF in advance.

3.11 0 Ω resistors

Table 2. 0 Ω resistor settings

Resistors	State ⁽¹⁾	Description
R17 (Microcontroller power consumption measurement)	ON	When JP3 OFF, the microcontroller is powered by 3.3V.
	OFF	When JP3 OFF, an ammeter can be connected to measure the power consumption of the microcontroller. (The microcontroller cannot be powered without ammeter)
R9 (V _{BAT})	ON	V _{BAT} is connected to VDD
	OFF	V _{BAT} is supplied through the pin_6 (VBAT) of J2.
R1, R2, R3, R4 (HEXT)	ON, OFF, ON, OFF	The crystal Y1 on board is used as HEXT clock source
	OFF, ON, OFF, OFF	HEXT clock source is from external PH0, PH1 is not used.
	OFF, ON, OFF, ON	HEXT clock source is from external PH0, PH1 is used as GPIO; or PH0 and PH1 are used as GPIOs.
R5, R6, R7, R8 (LEXT)	ON, ON, OFF, OFF	The crystal X1 on board is used as LEXT clock source
	OFF, OFF, ON, ON	LEXT clock source is from external PC14; or PC14 and PC15 are used as GPIOs.
R19, R20 (User button B2)	ON, OFF	User button B2 is connected to PA0.
	OFF, ON	User button B2 is connected to PC13.
R54, R55 (PA11, PA12)	OFF, OFF	As OTGFS1, PA11 and PA12 are disconnected from the pin_31 and pin_32 of J1.
	ON, ON	When PA11 and PA12 are not used as OTGFS1, they are connected to the pin_31 and pin_32 of J1.
R56, R57, R58, R59 (Arduino™ AN4, AN5)	OFF, ON, OFF, ON	Arduino™ AN4 and AN5 are connected to ADC12_IN11 and ADC12_IN10.
	ON, OFF, ON, OFF	Arduino™ AN4 and AN5 are connected to I2C1_SDA, I2C1_SCL.
R60, R61 (Arduino™ D10)	OFF, ON	Arduino™ D10 is connected to SPI1_CS.
	ON, OFF	Arduino™ D10 is connected to PVM (TMR4_CH1).

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

3.12 Extension connectors

3.12.1 Arduino™ Uno R3 connectors

Female connectors J3~J6 and male J7 support Arduino™ Uno R3 connectors. Most of the daughter boards built on Arduino™ Uno R3 are suitable to the AT-START-F456 board.

Note: The I/Os of the AT32F456ZET7 are 3.3 V-compatible with Arduino™ Uno R3, but 5 V not.

Table 3. Arduino™ Uno R3 extension connectors

Connector	Pin number	Arduino pin name	AT32F456 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	AN0	PA0	ADC12_IN0
	2	AN1	PA1	ADC12_IN1
	3	AN2	PA4	ADC12_IN4
	4	AN3	PB0	ADC12_IN8
	5	AN4	PC1 or PB9 ⁽¹⁾	ADC12_IN11 or I2C1_SDA
	6	AN5	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	-
J3 (Logic input/output high byte)	1	D8	PA9	-
	2	D9	PC7	TMR3_CH2
	3	D10	PA15 or PB6 ⁽¹⁾	SPI1_CS or TMR4_CH1
	4	D11	PA7	TMR3_CH2 / SPI1_MOSI
	5	D12	PA6	SPI1_MISO
	6	D13	PA5	SPI1_SCK
	7	GND	-	Ground
	8	AREF	-	V _{REF+} output
	9	SDA	PB9	I2C1_SDA
	10	SCL	PB8	I2C1_SCL

Connector	Pin number	Arduino pin name	AT32F456 pin name	Description
J7 (Others)	1	MISO	PB14	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	GPIO	PB11	-

(1) Refer to [Table 2](#) for details on 0Ω resistor settings.

3.12.2 LQFP144 I/O extension connectors

The extension connectors J1 and J2 are used to connect the I/Os of the AT-START-F456 to external devices. All the I/Os of the AT32F456ZET7 are accessible. J1 and J2 can also be measured with oscilloscope, logic analyzer or voltmeter probe.

4 Revision history

Table 4. Document revision history

Date	Revision	Changes
2025.1.20	1.00	Initial release

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