

Getting started with AT32M412CBT7

Introduction

The AT-START-M412 evaluation board is designed to help you experience the high performance of the 32-bit microcontroller, the ARM Cortex®-M4F based AT32M412 with FPU, and expedite development cycles and shorten time to market.

The AT-START-M412 evaluation board is based on the AT32M412CBT7 microcontroller. It features LEDs, buttons and Arduino™ Uno R3 extension connectors. It also comes with a built-in AT-Link-EZ, a tool designed to perform debugging/programming operations, without the need of other extra development tools.

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1 Overview

1.1 Features

The AT-START-M412 board has the following features:

- ARM Cortex®-M4F based 32-bit AT32M412CBT7 microcontroller with FPU that embeds 128 KB Flash memory and 16 KB SRAM, in LQFP48 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-M412, it can be connected with an independent AT-Link for programming and debugging purposes
- Power supply sources:
 - USB bus of AT-Link-EZ
 - External 5 V power supply (E5V)
 - External 3.3 V power supply
- 4 x LED indicators:
 - LED1 (red) indicates that 3.3V power of the board 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
- Rich extension connectors:
 - Arduino™ Uno R3 extension connectors
 - LQFP48 I/O extension connectors

1.2 Definition of terms

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

2 Quick start guide

2.1 Get started

Configure the AT-START-M412 board in the following sequence:

1. Check the Jumper's position on board: JP1 is connected to GND
2. Connect the AT-Link-EZ to PC via 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-M412 board is designed around an AT32M412CBT7 microcontroller in LQFP48 package.

[Figure 1](#) shows the connection between AT-Link-EZ, AT32M412CBT7 and their peripherals (buttons, LEDs and extension connectors) on AT-START-M412 board.

[Figure 2](#) and [Figure 3](#) show their respective locations on the AT-Link-EZ and AT-START-M412 (using AT-START-M412 as an example).

Figure 1. Hardware block diagram

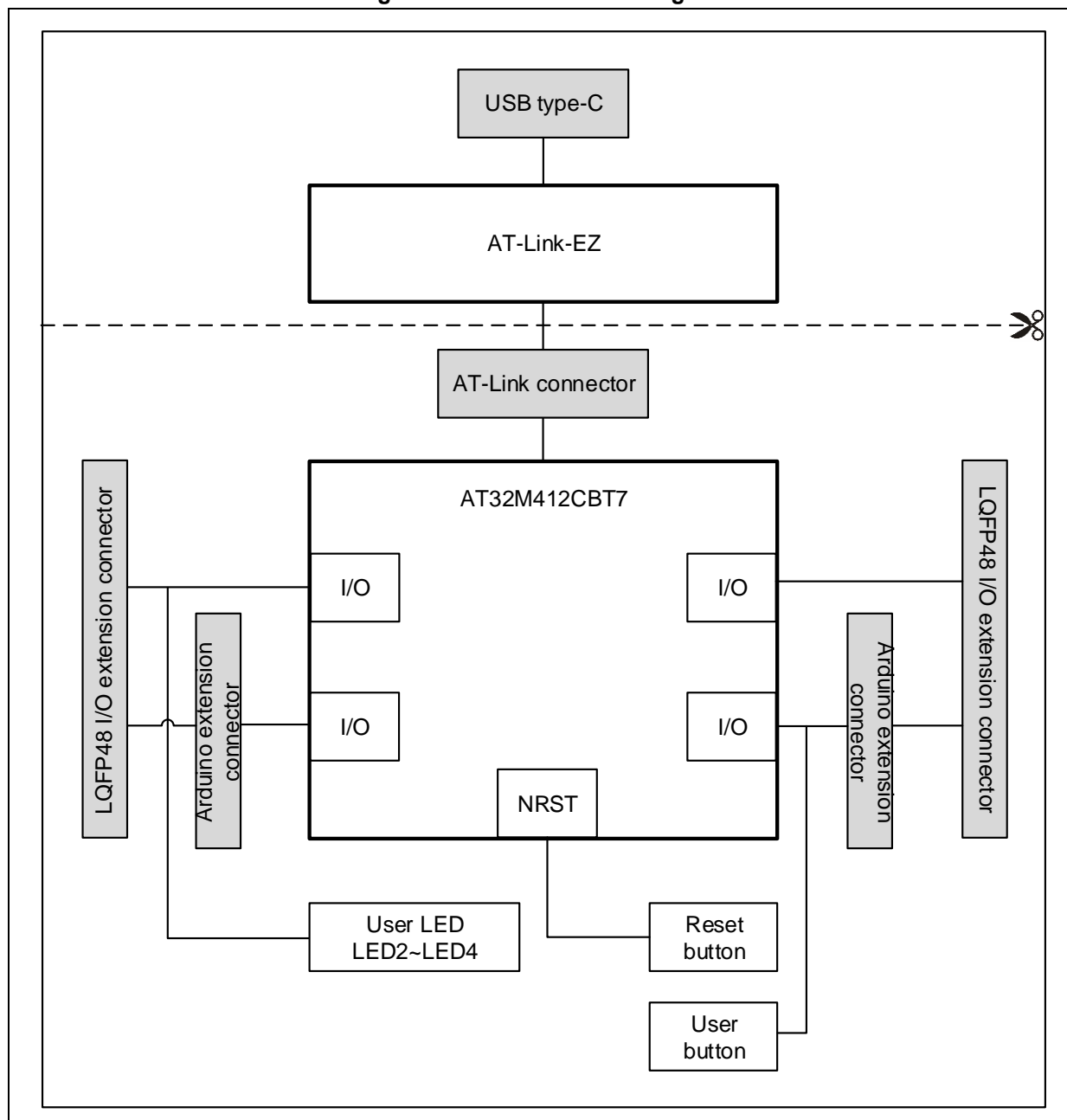


Figure 2. Top layer

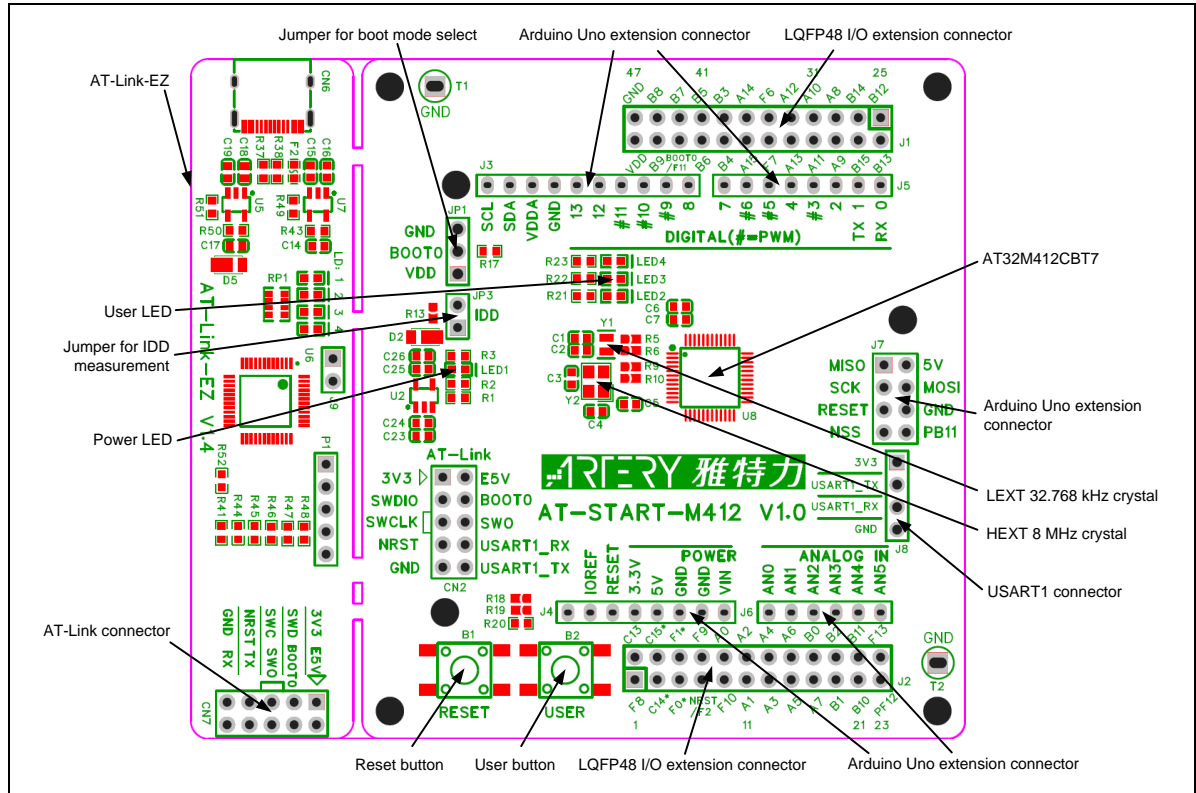
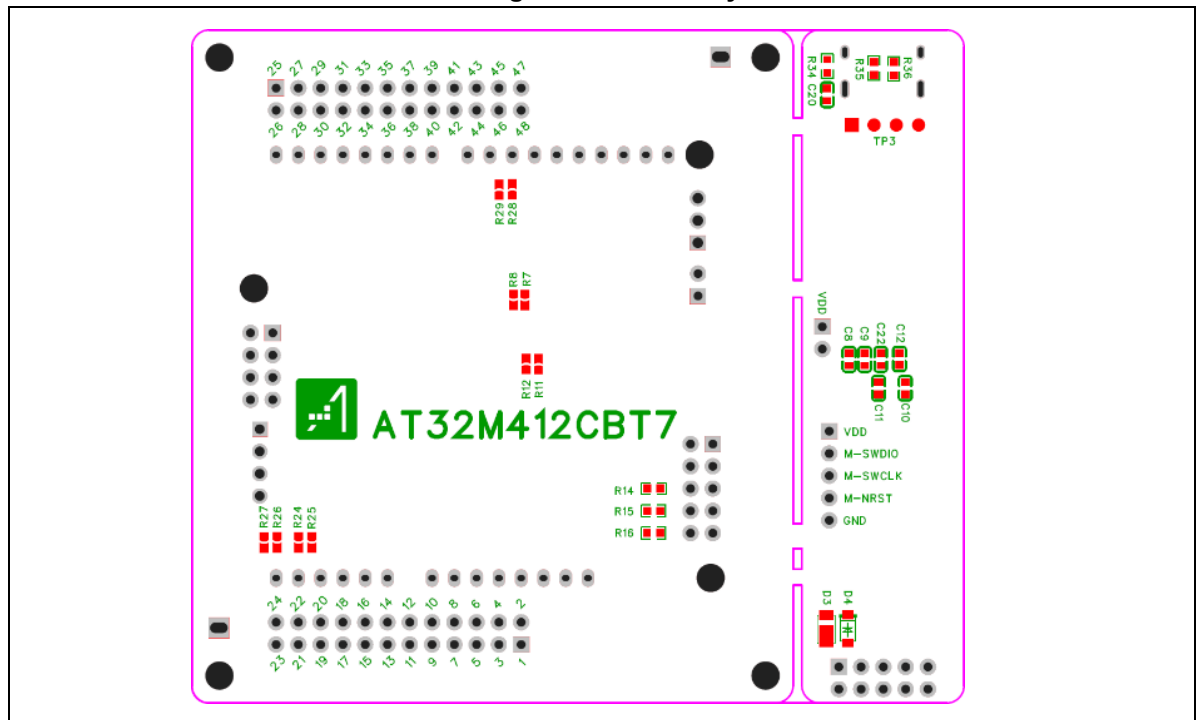


Figure 3. Bottom layer



3.1 Power supply sources

The AT-START-M412 can be supplied with 5 V through a USB cable via USB connector CN6 on the AT-Link-EZ. 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 provided via a 5 V-to-3.3 V voltage regulator (U2).

Additionally, the E5V pin of J4 or J7 can also be used as an input power source to supply the AT-START-M412 board.

The 3V pin of J4, or VDD pin of J1 and J2, can also be used as 3.3 V input power source of the AT-START-M412 board.

Note: Unless 5 V is provided via 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 E5V and 3V3 can be used as output power supply, the E5V pin of J7 as 5 V output power supply, the VDD pin of J1 and J2 as 3.3 V output power supply.

3.2 IDD

When JP3 OFF (symbol IDD) and R13 OFF, an ammeter can be connected to measure the power consumption of AT32M412CBT7.

- **JP3 OFF, R13 ON**

AT32M412CBT7 is being powered. (Default setting, and JP3 connector is not mounted before shipping)

- **JP3 ON, R13 OFF**

AT32M412CBT7 is being powered.

- **JP3 OFF, R13 OFF**

An ammeter must be connected to measure the power consumption of AT32M412CBT7 (if there is no ammeter, the AT32M412CBT7 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 AT32M412CBT7 on the AT-START-M412 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 the AT32M412CBT7.

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-M412 board. In this case, the CN2 connector (not mounted before shipping) of the AT-START-M412 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 AT32M412CBT7.

3.4 Boot mode selection

At startup, the board boots from the following memory locations according to the BOOT configuration. BOOT0 pin is used as PF11 after startup.

Table 1. Boot mode selection

| Jumper | BOOT0 pin configuration | Description |
|----------------------|-------------------------|--|
| JP1 connected to GND | 0 | Boot from the Flash memory (Factory default settings) |
| JP1 connected to VDD | 1 | Boot from the system memory or SRAM ⁽¹⁾ |

(1) It depends on the nBOOT1 bit in the User System Data.

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: R9 and R10 must be ON, and R11, R12 OFF

- **External oscillator from PF0**

External oscillator is injected from the pin 5 of J2. Hardware settings: R11 and R12 must be ON, and R9, R10 OFF.

- **HEXT not used**

PF0 and PF1 are used as GPIOs. Hardware settings: R11 and R12 must be ON, and R9, R10 OFF.

3.5.2 LEXT clock sources

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

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

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

- **External oscillator from PC14**

External oscillator is injected from the pin 3 of J2. Hardware settings: R7 and R8 must be ON, and R5, R6 OFF.

- **LEXT not used**

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

3.6 LEDs

- **Power LED1**
Red color, indicates that the 3.3 V of AT-START-M412 board is being powered.
- **User LED2**
Red color, controlled with the PF6 pin of AT32M412CBT7. The User LED lights up when PF6 outputs low.
- **User LED3**
Yellow color, controlled with the PF7 pin of AT32M412CBT7. The User LED lights up when PF7 outputs low.
- **User LED4**
Green color, controlled with the PF8 pin of AT32M412CBT7. The User LED lights up when PF8 outputs low.

3.7 Buttons

- **Reset button B1**
Connected to NRST to reset AT32M412CBT7 microcontroller.
- **User button B2**
By default, it is connected to the PA0 of AT32M412CBT7 and used as a WKUP1/TAMP2 button (R18 ON, R19 OFF); it can also be connected to PC13 and used as WKUP2/TAMP1 button (R18 OFF, R19 ON).

3.8 0 Ω resistors

Table 2. 0 Ω resistor settings

| Resistors | State ⁽¹⁾ | Description |
|--|----------------------|--|
| R13 (Microcontroller power consumption measurement) | ON | When JP3 OFF, the microcontroller is powered by 3.3 V. |
| | OFF | When JP3 OFF, an ammeter can be connected to 3.3 V or to measure the power consumption of microcontroller. (The microcontroller cannot be powered without ammeter) |
| R9, R10, R11, R12 (HEXT) | ON, ON, OFF, OFF | The crystal Y2 on board is used as HEXT clock source |
| | OFF, OFF, ON, ON | HEXT clock source is from external PF0, or PF0 and PF1 are used as GPIOs |
| R5, R6, R7, R8 (LEXT) | ON, ON, OFF, OFF | The crystal Y1 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 |
| R18, R19 (User button B2) | ON, OFF | User button B2 is connected to PA0 |
| | OFF, ON | User button B2 is connected to PC13 |

| Resistors | State ⁽¹⁾ | Description |
|---|-------------------------|---|
| R24, R25, R26, R27 (Arduino™ AN4, AN5) | OFF, ON, OFF, ON | Arduino™ AN4 and AN5 are connected to ADC12_IN6 and ADC12_IN9 |
| | ON, OFF, ON, OFF | Arduino™ AN4 and AN5 are connected to I2C1_SDA and I2C1_SCL |
| R28, R29 (Arduino™ D10) | OFF, ON | Arduino™ D10 is connected to SPI1_SS |
| | ON, OFF | Arduino™ D10 is connected to PWM (TMR4_CH1) |

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

3.9 Extension connectors

3.9.1 Arduino™ Uno R3 extension connectors

Female connectors J3~J6 and male J7 support standard Arduino™ Uno R3 connectors. Most of the daughter boards built on Arduino™ Uno R3 are suitable to the AT-START-M412 board.

Note 1: The I/O ports of AT32M412CBT7 are 3.3 V compatible with Arduino™ Uno R3, but 5 V not.

Note 2: The pin 8 of J3 is VDD, without AFEF function of Arduino™ Uno R3.

Table 3. Arduino™ Uno R3 extension connectors

| Connectors | Pin No. | Arduino pin name | AT32M412 pin name | Function |
|-------------------------------------|---------|------------------|---------------------------|-------------------------|
| J4 (Power supply) | 1 | NC | - | - |
| | 2 | IOREF | - | 3.3 V reference voltage |
| | 3 | RESET | NRST/PF2 | External reset |
| | 4 | 3.3V | - | 3.3 V input/output |
| | 5 | E5V | - | 5 V input/output |
| | 6 | GND | - | Ground |
| | 7 | GND | - | Ground |
| | 8 | NC | - | - |
| J6 (Analog input) | 1 | AN0 | PA0 | ADC12_IN0 |
| | 2 | AN1 | PA1 | ADC2_IN1 |
| | 3 | AN2 | PA4 | ADC12_IN4 |
| | 4 | AN3 | PB0 | ADC2_IN8 |
| | 5 | AN4 | PA6 or PB9 ⁽¹⁾ | ADC12_IN6 or I2C1_SDA |
| | 6 | AN5 | PB1 or PB8 ⁽¹⁾ | ADC12_IN9 or I2C1_SCL |
| J5 (Logic input/output low byte) | 1 | D0 | PA3 | USART2_RX |
| | 2 | D1 | PA2 | USART2_TX |
| | 3 | D2 | PA10 | - |
| | 4 | D3 | PB5 | TMR3_CH2 |
| | 5 | D4 | PB3 | - |
| | 6 | D5 | PB4 | TMR3_CH1 |
| | 7 | D6 | PA8 | TMR1_CH1 |
| | 8 | D7 | PB10 | - |

| Connectors | Pin No. | Arduino pin name | AT32M412 pin name | Function |
|--------------------------------------|---------|------------------|----------------------------|----------------------|
| J3 (Logic input/output high byte) | 1 | D8 | PA9 | - |
| | 2 | D9 | PB7 | TMR4_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 | VDD | - | 3.3 V input/output |
| | 9 | SDA | PB9 | I2C1_SDA |
| | 10 | SCL | PB8 | I2C1_SCL |
| 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/PF2 | External reset |
| | 6 | GND | - | Ground |
| | 7 | NSS | PB12 | SPI2_CS |
| | 8 | GPIO | PB11 | - |

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

3.9.2 LQFP48 I/O extension connectors

The extension connectors J1 and J2 are used to connect the I/O ports of the AT-START-M412 to external devices. All the I/O of AT32M412CBT7 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 |
|-----------|----------|---|
| 2024.8.5 | 1.00 | Initial release |
| 2025.1.17 | 1.01 | Removed descriptions related to AT-START-M416 evaluation board from this document as this only deals with AT-START-M412 board. AT-START-M416 board functions can be found in another separate document “AT-START-M416 User Manual”. |

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