Get started with AT32F407VGT7

Introduction

AT-START-F407 is designed to help you explore the high-performance features of the 32-bit microcontroller, AT32F407 embedded with ARM Cortex®-M4F with FPU, and help develop your applications.

AT-START-F407 is an evaluation board based on AT32F407VGT7 chip with LED indicators, buttons, an USB micro-B connector, an Ethernet RJ45 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-F407 has the following characteristics:

- AT-START-F407 has an on-board AT32F407VGT7 microcontroller that embeds ARM Cortex®-M4F, 32-bit processor, 1024 KB Flash memory and 96+128 KB SRAM, LQFP100 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-F407 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-F407
  - 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 LED indicators, LED2 (red), LED3 (yellow) and LED4 (green)
- 2 x buttons (user button and reset button)
- 8 MHz HSE crystal
- 32.768 kHz LSE crystal
- USB micro-B connector
- Ethernet PHY with RJ45 connector
- Various extension connectors can be quickly connected into a prototype board and easy to explore:
  - Arduino™ Uno R3 extension connector
  - LQFP100 I/O port extension connector

1.2 Definition of terms

- **Jumper JPx ON**
  Jumper installed
- **Jumper JPx OFF**
  Jumped not installed
- **Resistor Rx ON**
  Short circuit by solder or 0Ω resistor
- **Resistor Rx OFF**
  Open

2 Quick start

2.1 Get started

Configure the AT-START-F407 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 AT32F407VGT7);

   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-F407 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-F407

- ARM® Keil®: MDK-ARM™
- IAR™: EWARM

3 Hardware and layout

AT-START-F407 board is designed around an AT32F407VGT7 microcontroller in LQFP100 package.

Figure 1 shows the connections between AT-Link-EZ, AT32F407VGT7 and their peripherals (buttons, LEDs, USB, Ethernet RJ45, SPI Flash memory and extension connectors)

Figure 2 and *Figure 3* shows these features on the AT-Link-EZ and AT-START-F407 board.

Figure 1. Hardware block diagram

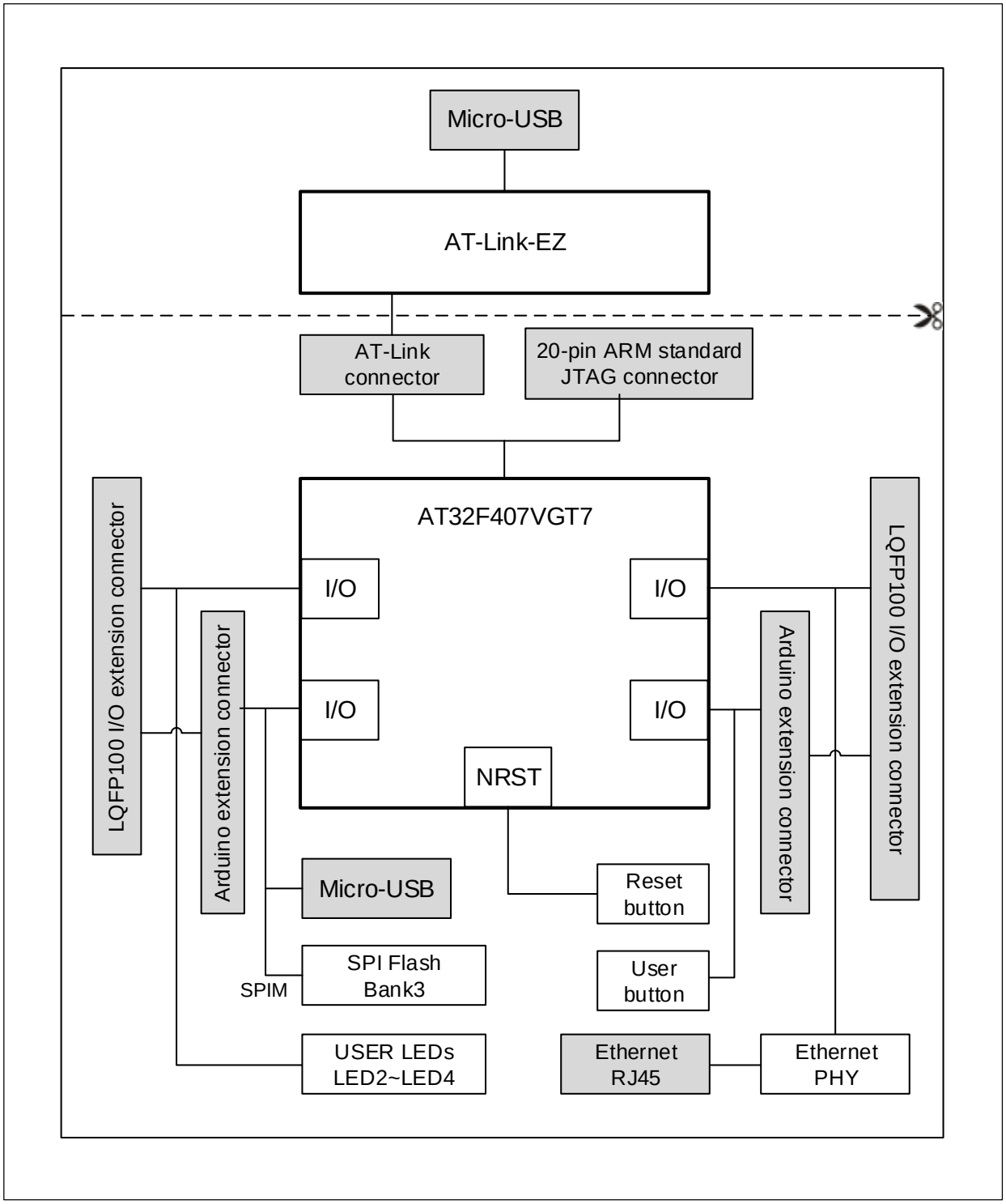


Figure 2. Top layer

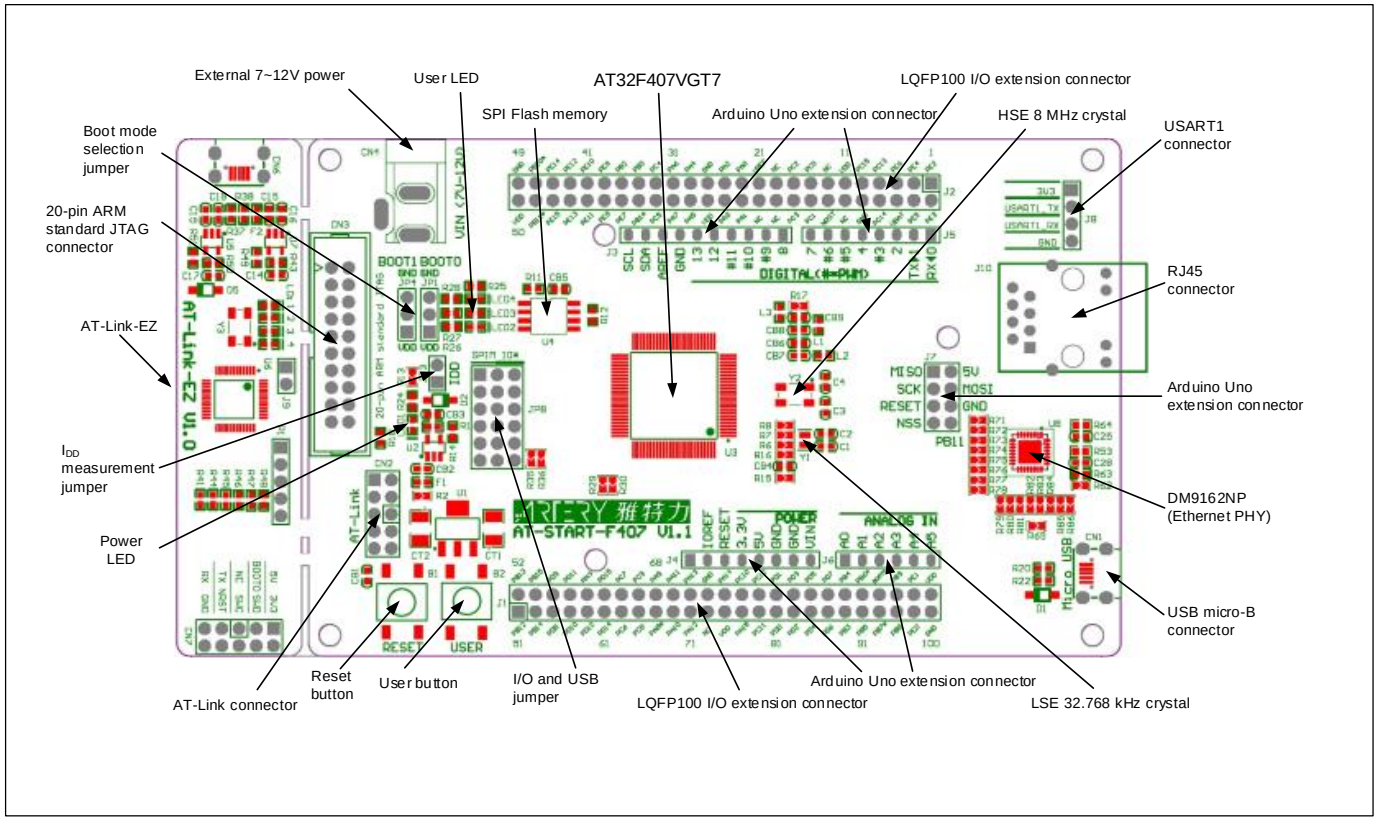
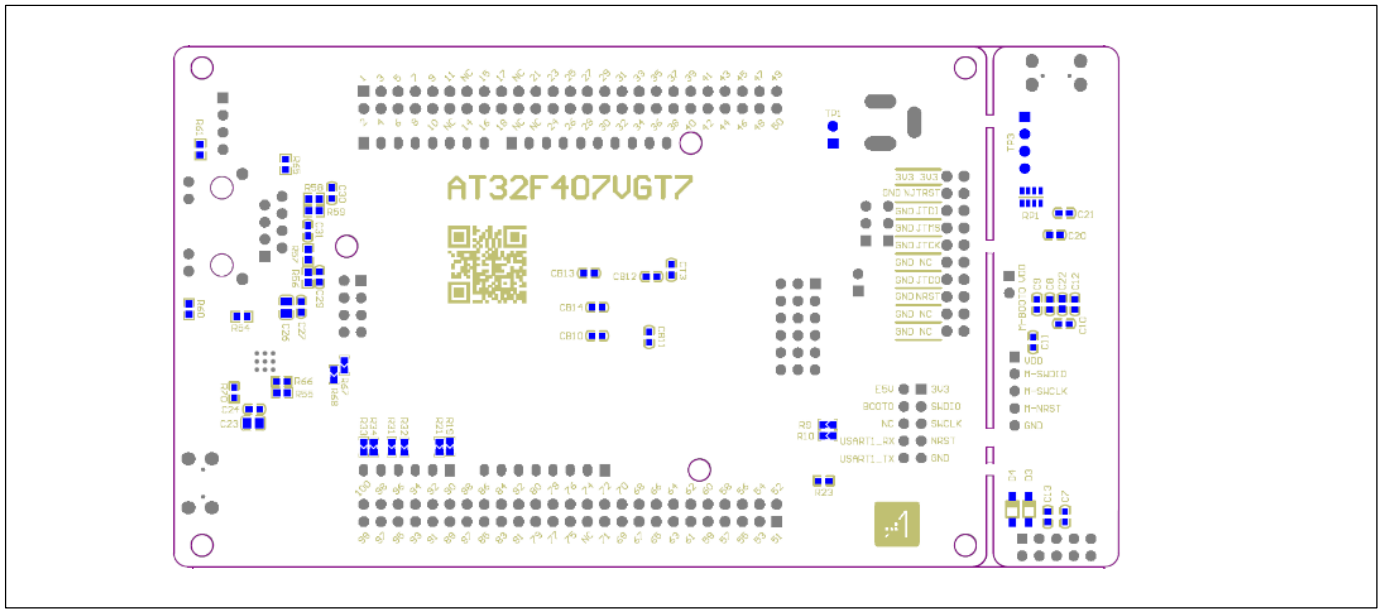


Figure 3. Bottom layer



3.1 Power supply selection

The 5 V power supply of AT-START-F407 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-F407), 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-F407 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-F407 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; 5V pin of J7 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 AT32F407VGT7.

- **JP3 OFF, R13 ON**

  AT32F407VGT7 is powered. (Default setting, and JP3 plug is not mounted before shipping)

- **JP3 ON, R13 OFF**

  AT32F407VGT7 is powered.

- **JP3 OFF, R13 OFF**

  An ammeter must be connected to measure the power consumption of AT32F407VGT77 (if there is no ammeter, the AT32F407VGT7 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 AT32F407VGT7 on the AT-START-F407 board. AT-Link-EZ supports SWD interface mode and supports a set of virtual COM ports (VCP) to connect to the USART1_TX/USART1_RX (PA9/PA10) of AT32F407VGT7. In this case, PA9 and PA10 of AT32F407VGT7 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

Note: The user can set R9 and R10 OFF, then the use of PA9 and PA10 of AT32F407VGT7 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-F407 by bending over along the joint. In this case, AT-START-F407 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 AT32F407VGT7.

3.3.2 20-pin ARM® standard JTAG connector

AT-START-F407 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 AT32F407VGT7, 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.

It is recommended to use AT-Link series development tools to experience the best debugging environment despite Artery MCUs compatible with most of the 3rd party development tools.

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		Setting
	BOOT1	BOOT0	
JP1 connected to GND or OFF; JP4 optional or OFF	X(1)	0	Boot from the internal Flash memory (Factory default setting)
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 the PB2 function is not used.

3.5 External clock source

3.5.1 HSE clock source

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

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 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 settings 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 PD13 pin of AT32F407VGT7.

- **User LED3**

  Yellow, connected to the PD14 pin of AT32F407VGT7.

- **User LED4**

  Green, connected to the PD15 pin of AT32F407VGT7.

3.7 Buttons

- **Reset button B1**

  Connected to NRST to reset AT32F407VGT7

- **User button B2**

  It is, by default, connected to the PA0 of AT32F407VGT7, 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-F407 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-F407 board.

3.9 Connect to Bank3 of Flash memory via SPIM interface

The SPI Flash EN25QH128A on the board is connected to the AT32F407VGT7 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 LQFP100 I/O extension connector. These 6 pins are marked by adding [*****] after the pin name of extension connector on the PCB silkscreen.

Table 2. GPIO and SPIM jumper setting

Jumper	Settings
JP8 connected to I/O	Use I/O and Ethernet MAC function (Default setting before shipping)
JP8 connected to SPIM	Use the SPIM function

3.10 Ethernet

AT-START-F407 embeds an Ethernet PHY DM9162NP (U8) and RJ45 connector (J10, internal isolation transformer), supporting 10/100 Mbps dual-speed Ethernet communication.

When using Ethernet MAC, the JP8 one-piece jumper, as shown in *Table 2,* should select the right I/O. In this case, PA8, PB10 and PB11 are connected to the external LQFP100 I/O extension connectors.

Ethernet PHY is connected to the AT32F407VGT7 in RMII mode by default. In this case, the 25 MHz clock required by PHY is provided by the CLKOUT (PA8) pin of AT32F407VGT7 to the XT1 pin of PHY, while the 50 MHz clock required by RMII_REF_CLK (PA1) of the AT32F407VGT7 is provided by the 50MCLK pin of PHY. The 50MCLK pin must be pulled up at power-on.

Ethernet PHY and AT32F407VGT7 can be connected in MII mode. The user needs to follow the notes in the lower left corner of *Figure 8*. At this time, the TXCLK and RXCLK of PHY are connected to the MII_TX_CLK (PC3) and MII_RX_CLK (PA1) of AT32F407VGT7, respectively.

Note that AT32F407VGT7 is connected to the PHY with the pin of remapping 1 configuration.

To simplify the PCB design, the PHY does not have an external Flash memory to allocate the PHY address [3:0] at power-on, and the PHY address [3:0] is set to 0x0 by default. After power-on, the software can re-assign the PHY address via the SMI connector of PHY.

For complete information on Ethernet MAC and DM9162NP of the AT32F407VGT7, please refer to their respective technical manual and data sheet.

If the user does not use the DM9162NP on the board but select LQFP100 I/O extension connectors J1 and J2 to connect to other Ethernet application boards, please refer to *Table 3* to disconnect AT32F407VGT7 from DM9162NP.

3.11 0 Ω resistors

Table 3. 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 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 pin_6 V_{BAT} of J2
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_21 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 PA12used as USB, they are not connected to pin-20 and pin_21 of J1
	ON, ON	When PA11 and PA12 are not used as USB, they are connected to pin_20 and pin_21 of J1
R62 ~ R64, R71 ~ R86 (USB PHY DM9162)	**See notes in the lower left corner of *Figure 8***	Ethernet MAC of AT32F407VGT is connected to DM9162 through RMII mode (R66 and R70 are 4.7 kΩ)
	See notes in the lower left corner of *Figure 8*	Ethernet MAC of AT32F407VGT is connected to DM9162 through MII mode
	All OFF except R66 and R70	Ethernet MAC of AT32F407VGT7 is disconnected from DM9162 (in this case, AT-START-F403A board is a better choice)
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)
R9 (USART1_RX)	**ON**	USART1_RX of AT32F407VGT7 is connected to VCP TX of AT-Link-EZ
	OFF	USART1_RX of AT32F407VGT7 is disconnected from VCP TX of AT-Link-EZ
R10 (USART1_TX)	**ON**	USART1_TX of AT32F407VGT7 is connected to VCP RX of AT-Link-EZ
	OFF	USART1_TX of AT32F407VGT7 is disconnected from VCP RX of AT-Link-EZ

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

3.12 Extension connectors

3.12.1 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-F407.

Note 1: The I/O ports of AT32F407VGT7 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-F407 to the V_{REF+} of AT32F407VGT7 by means of Arduino™ Uno R3 daughter board.

Table 4. Arduino™ Uno R3 extension connector pin definition

Connector	Pin number	Arduino pin name	AT32F407 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	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 or 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	AT32F407 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 in *Table 3*.
(2) SPIM must be disabled and JP8 one-piece jumper must select I/O, otherwise PA8 and PB6 cannot be used.

3.12.2 LQFP100 I/O extension connector

The extension connectors J1 and J2 can connect the AT-START-F407 to external prototype/packing board. The I/O ports of AT32F407VGT7 are available on these extension connectors. J1 and J2 can also be measured with the probe of oscilloscope, logic analyzer or voltmeter.

Note 1: *Set R17 OFF* if it is necessary to supply power through the J2 pin_21 V_{REF+} *of AT-START-F407 by and external power supply,*

4 Schematic

Figure 4. Schematic (AT-Link-EZ)

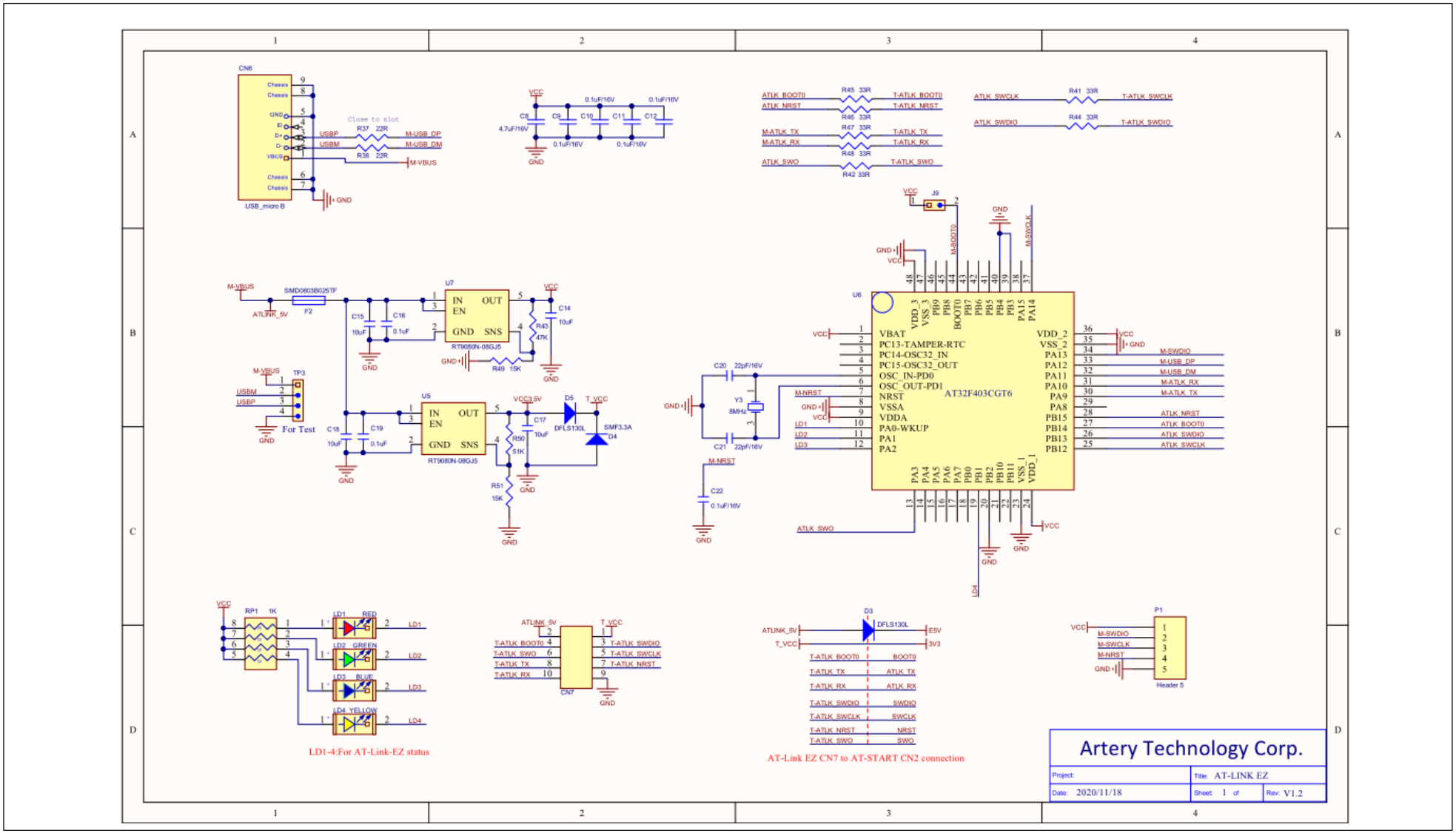


Figure 5. Schematic (microcontroller)

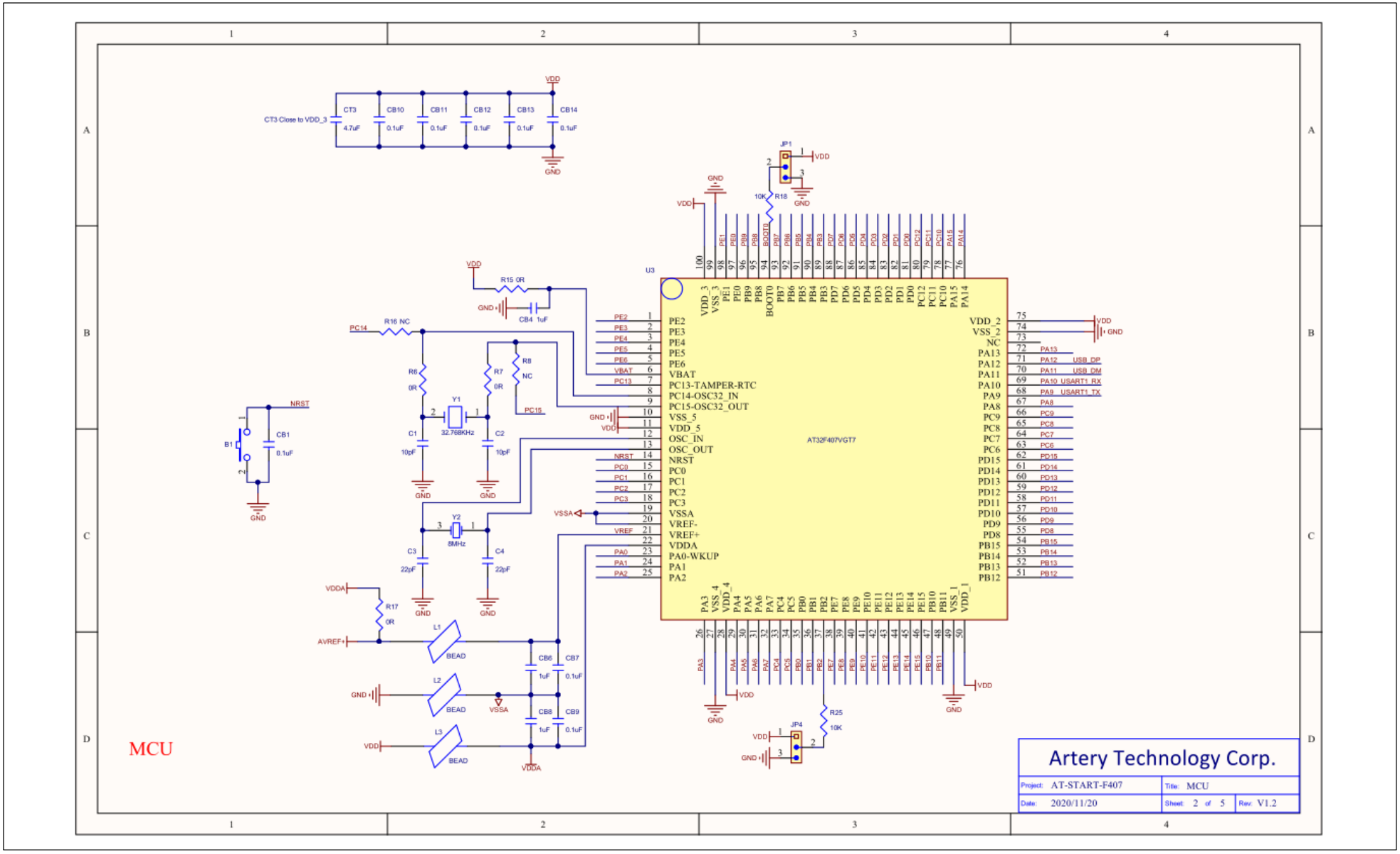


Figure 6. Schematic (power supply and peripherals)

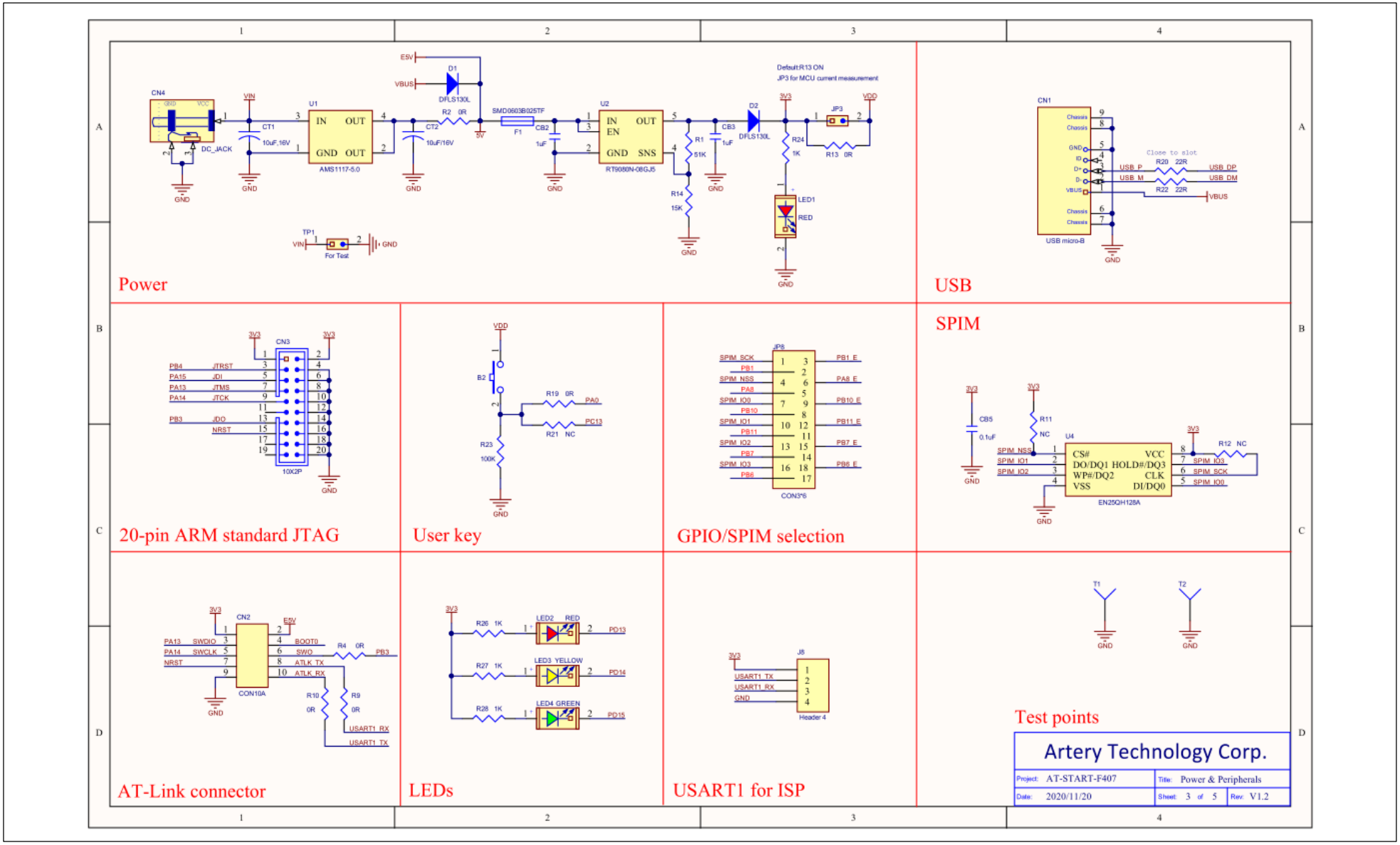


Figure 7. Schematic (extension connectors)

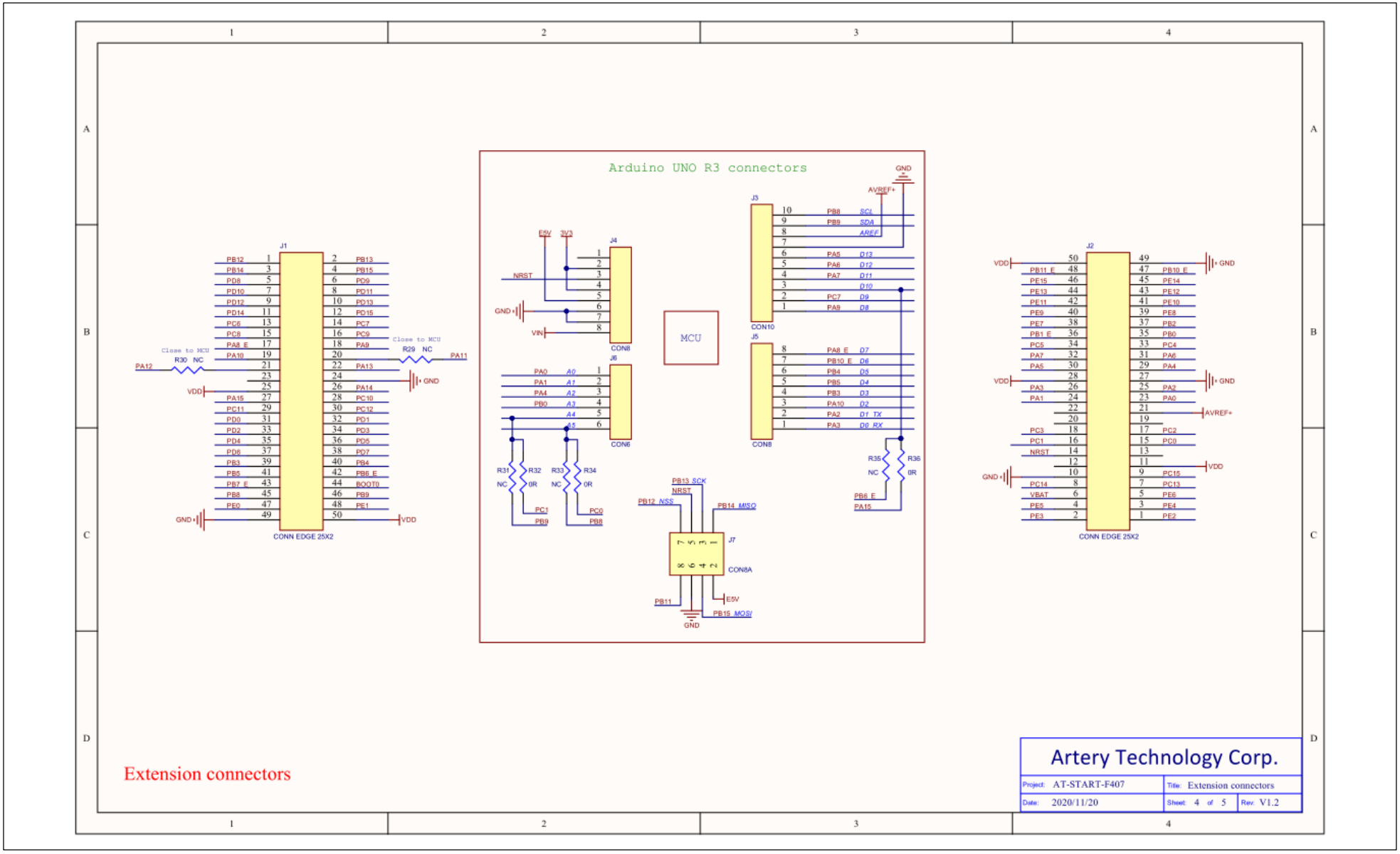
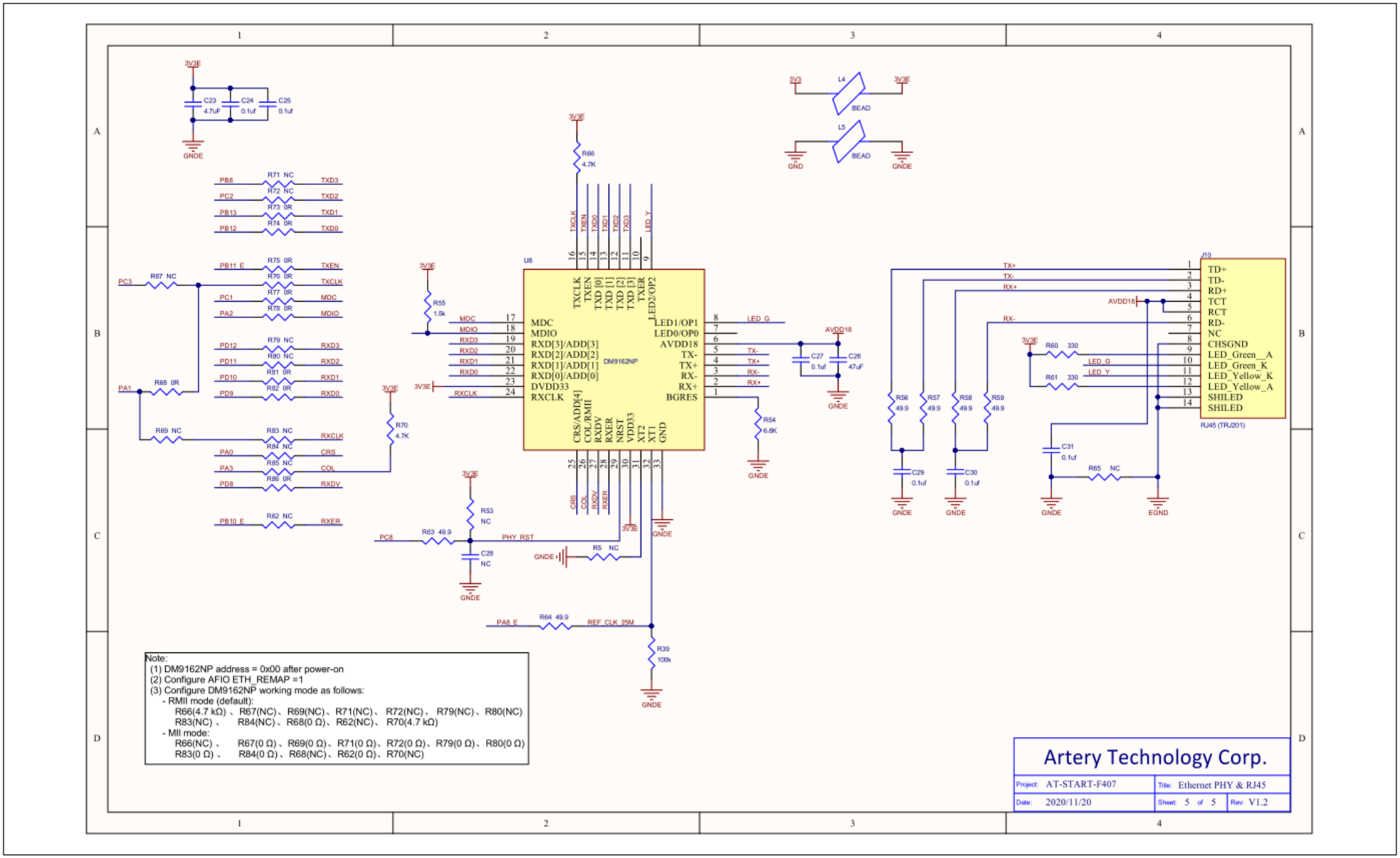


Figure 8. Schematic (Ethernet PHY and RJ45 connector)



5 Revision history

Table 5. Document revision history

Date	Revision	Changes
2020.2.14	1.0	Initial release
2020.5.12	1.1	1. Modified LED3 to yellow 2. Connected the TXEN of DM916 to PB11_E, not directly linked to AT32F407 3. Modified the 51 Ω wire-wound resistor between AT32F407 and DM9162 to 0 Ω bridge so that AT32F40 can be completely disconnected from DM9162.
2020.9.23	1.11	1. Changed the revision code of this document to 3 digits, with the first two for AT-START hardware version, and the last one for the document version. 2. Added Section 3.9.
2020.11.20	1.20	1. Updated the version of AT-Link-EZ to 1.2, and adjusted two rows of CN7 signals, and modified the silkscreen. 2. Modified the CN2 silkcreen in accordance with Artery development tools. 3. Added GND test pin ring to facilitate measurement. 4. Optimized power layout and added the pull-down resistor of DM9162 XT1 pin to eliminate the disturbance from TXCLK clock. 5. Removed the 0 Ω resistor between the unused pins and microcontrollers when DM9051 is operated in RMII mode.

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