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# KERNEL MASTERS

## Raayan Mini [ARM Cortex M0/M3/M4] Rev 4.0/4.1

## User Manual

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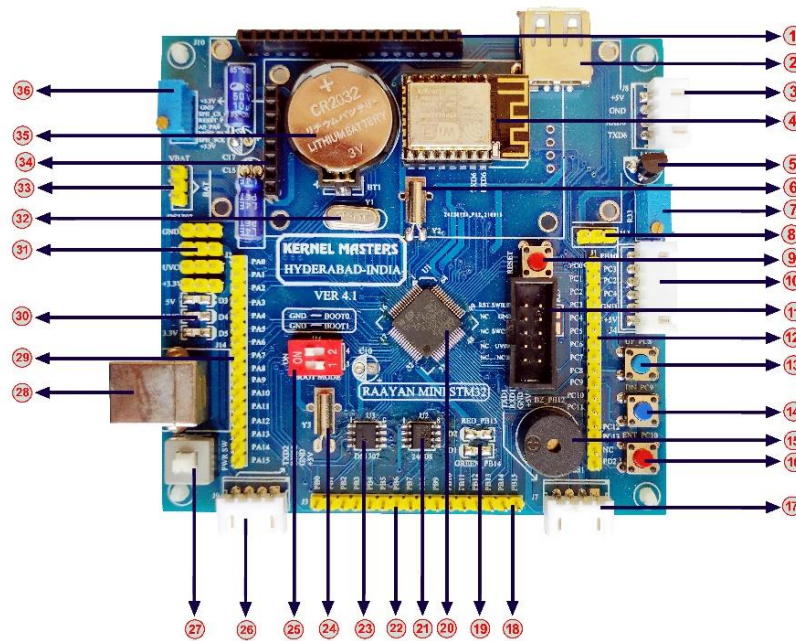


### 1. Introduction to Raayan Mini Board

#### 1.1. Board Overview

The STM32 Based Raayan Mini Development board allows users to easily develop applications with the STM32F401RBTx high-performance microcontroller with the Arm® Cortex®-M4 32-bit core. It includes everything required either for beginners or experienced users to get started quickly. The Raayan Mini Development board also features programmable user buttons and an RG LED for custom applications. STM32 Based Raayan Mini Development board comes with the STM32 comprehensive free software libraries and examples available with the STM32CubeF4 MCU Package. Figure 1-1 shows a photo of the Raayan Mini Development Board.

**Figure 1-1. Raayan Mini Development Board**



|                       |               |                  |                 |                 |
|-----------------------|---------------|------------------|-----------------|-----------------|
| 1.16x2 LCD            | 9.Reset       | 17.Uart - 1      | 26.Uart_2       | 33.VBat         |
| 2.USB                 | 10.CAN_out    | 18.Port_B        | 27.Power Switch | 34.TFT_Lcd      |
| 3.Uart - 6            | 11.Debugger   | 19.User_LED      | 28.USB-A        | 35.Battery      |
| 4.Bluetooth / Wi-fi   | 12.Port_C     | 20.STM32F401RBT6 | 29.Port_A       | 36.LCD Trim POT |
| 5.LM35                | 13.Switch_UP  | 21.EEPROM        | 30.Power_LED's  |                 |
| 6.XTAL-32.7 kHz       | 14.Switch_DN  | 23.RTC           | 31.Power_Pin's  |                 |
| 7.ADC POT             | 15.Buzzer     | 24.XTAL-32.7 kHz | 32.XTAL_8Mhz    |                 |
| 8.Pull_UP / Pull_Down | 16.Switch_ENT | 25.Boot Switch   | 33.VBat         |                 |

### 1.2. Kit Contents

The Raayan Mini STM32 Development Board Kit contains the following items:

- Raayan Mini Development Board (STM32F401RBTx)
- ST-Link Serial wire Debugger
- USB – TTL module
- USB Type A to B cable
- Jumper wires
- User manual

### 1.3. Getting Started

Follow the sequence below to configure the Raayan Mini STM32F4 Development Board and launch application:

1. Check the switch positions of BOOT0, BOOT1 pins on the board.
2. Connect the STM32F4 Development board to a PC with a USB cable Type-A to B through USB connector J14 to power the board.
3. Press the push button SW5 (PWR SW). LEDs D3, D4, D5 then lights up.
4. The board runs a preloaded Board test application. The 16 X 2 LCD or the TFT display shows “Welcome to KM” followed by some test cases for testing the board and peripherals. Perform each test cases as shown in the display until all the peripherals are tested OK.
5. Discover the STM32F401RBT6 features and develop the application using available source code and libraries.
6. Connect the ST LINK to CN1 before flashing your application code to the microcontroller.

### 1.4. Features

Your Raayan Mini Development board includes the following features:

- STM32F401RBT6 microcontroller featuring 32-bit Arm® Cortex®-M4 with FPU core, Up to 128-Kbytes of Flash memory and 64-Kbytes of RAM.
- On-board ST-LINK Serial wire debugger/programmer
- 5 LEDs:
  - 3 Power LEDs and 2 user LEDs
- On-board Buzzer
- 16 X 2 Monochrome LCD interface with GPIO
- TFT LCD interface with SPI
- DS1307 RTC interface with I2C
- AT24C02 EEPROM interface with I2C
- LM35 Temperature Sensor interface with ADC
- ESP Wi-Fi module interface with UART

- USB Type A interface
- Flexible power-supply options: ST-LINK, USB Type B connector
- Expansion Headers supports,
  - GPIO ports with interrupt capability
  - I2C interface (1Mbit/s, SMBus/PMBus)
  - Up to 3 USARTs (2 x 10.5 Mbit/s, 1 x 5.25 Mbit/s), ISO 7816 interface, LIN, IrDA, modem control)
  - SPI interface (up to 42 Mbits/s at fCPU= 84 MHz), SPI2 and SPI3 with muxed full-duplex I2S to achieve audio class accuracy via internal audio PLL or external clock
- External application power supply: 3 V and 5 V
- Support of a wide choice of Integrated Development Environments (IDEs) including IAR Embedded Workbench®, MDK-ARM, and STM32CubeIDE.

### 1.5. Specifications

Table 1-1 summarizes the specifications for the Raayan Mini STM32F4 Development Board.

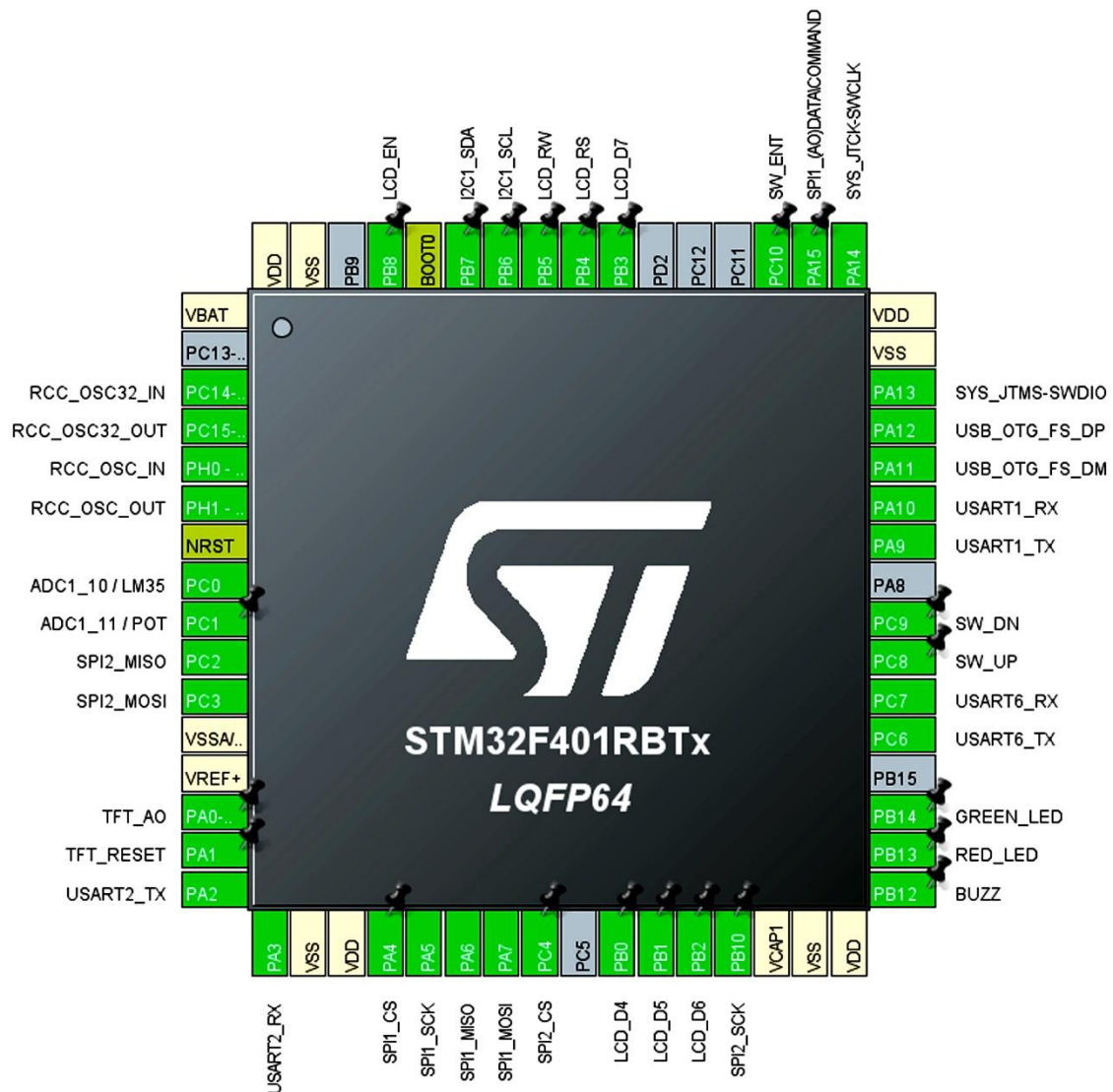
**Table 1-1. Raayan Mini STM32F4 Development Board Specifications**

| Parameter              | Value                                                                                                            |
|------------------------|------------------------------------------------------------------------------------------------------------------|
| Board supply voltage   | 4.75 VDC to 5.25 VDC from USB Device Type A to B cable (connected to a PC)                                       |
| Dimensions             | (L x W x H)                                                                                                      |
| Break-out power output | <ul style="list-style-type: none"> <li>• 3.3 VDC (current rating)</li> <li>• 5.0 VDC (current rating)</li> </ul> |
| RoHS status            | Compliant                                                                                                        |

## 1.6. Raayan Mini Pin diagram

Figure 1-2. Raayan Mini STM32 Development Board Pin Diagram

# RAAYAN MINI V 4.0

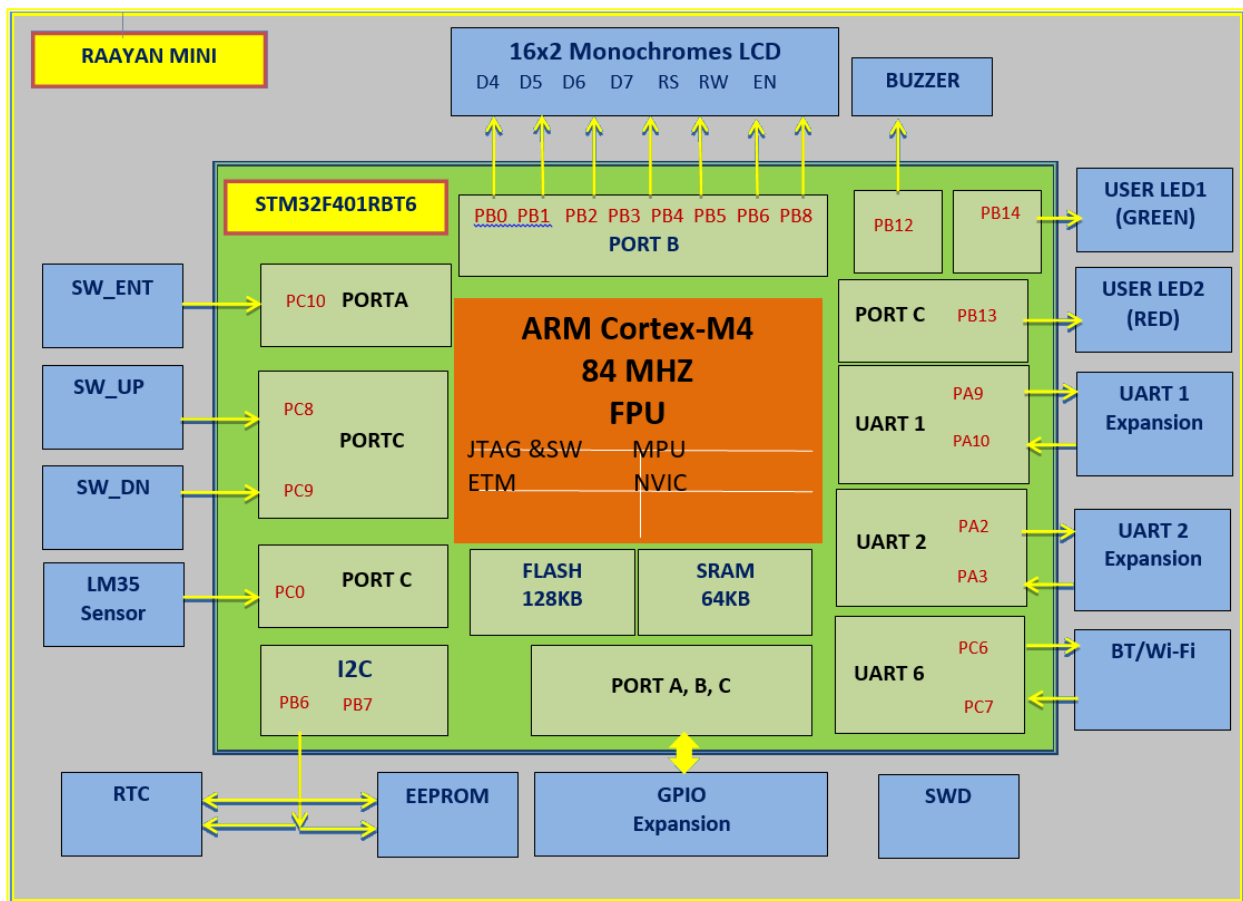


## 2. Hardware Description

### 2.1. Raayan Mini Board Block Diagram

The Raayan Mini STM32F4 Development Board includes a STM32F401RBT6 microcontroller and a serial wire debugger as well as a range of useful peripheral features.

**Figure 2-1. Raayan Mini STM32F4 Development Board Block Diagram**



## 2.2. Functional Description

### 2.2.1. Microcontroller

The STM32F401RBT6 is a high performance 32-bit ARM Cortex-M4 based microcontroller with 128-kB Flash memory, 64-kB SRAM and a frequency of up to 84MHz. The Cortex®-M4 core features a Floating point unit (FPU) single precision which

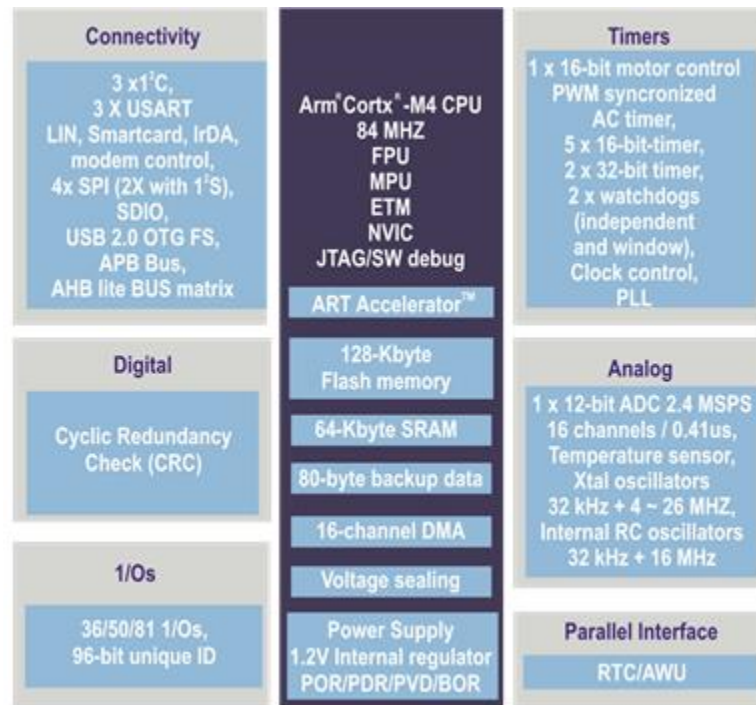
## Raayan Mini [ARM Cortex M0/M3/M4] Rev 4.0/4.1

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supports all Arm single-precision data-processing instructions and data types. (See the STM32F401RBT6 microcontroller data sheet.)

It also implements a full set of DSP instructions and a memory protection unit (MPU) which enhances application security. All devices offer one 12-bit ADC, a low-power RTC, six general-purpose 16-bit timers including one PWM timer for motor control, two general-purpose 32-bit timers. They also feature standard and advanced communication interfaces.

**Figure 2-2. STM32F401RBT6 Specifications**



The STM32F401RBT6 microcontroller is factory-programmed with a Board test program. The Board test program resides in on-chip Flash memory and runs each time power is applied, unless the Board test application has been replaced with a user program.

### 2.2.2. ST-Link V2 Debugger

The ST-LINK/V2 is an in-circuit debugger and programmer for the STM8 and STM32 microcontrollers. Raayan Mini board uses serial wire debugging (SWD) interface to communicate with the STM32 microcontroller located on the development board. The SWD can be connected to CN1 connector on the board.

Figure 2-3. ST LINK Serial Wire Debugger schematics

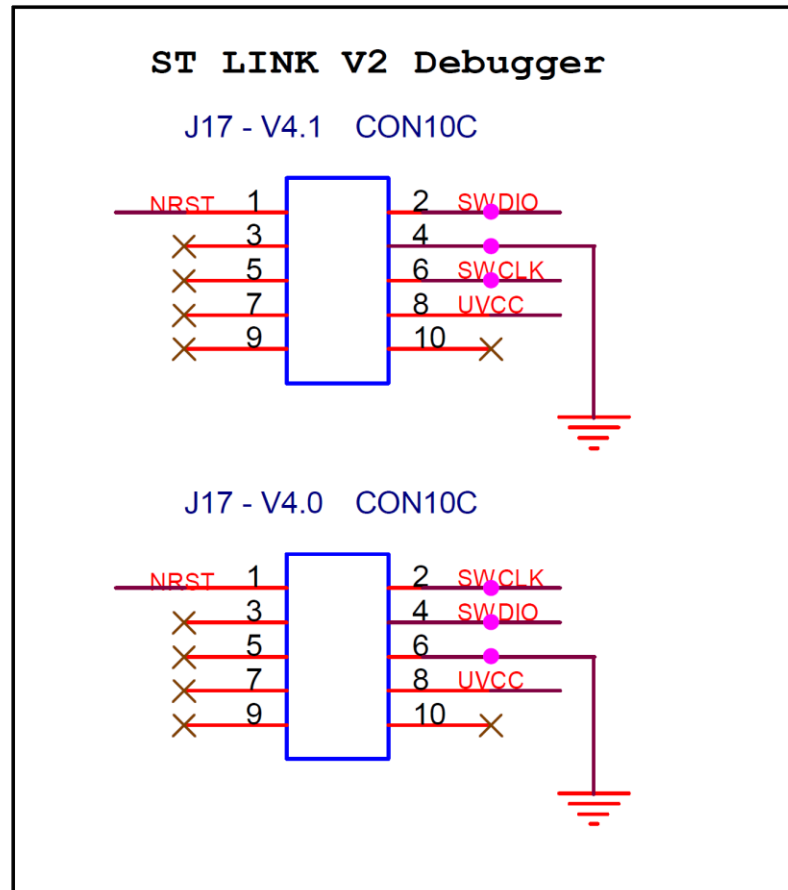


Table 2-1. ST LINK Serial Wire Debugger signals

| GPIO Pin | Pin function | Device |
|----------|--------------|--------|
| PA13     | GPIO         | SWDIO  |
| PA14     | GPIO         | SWCLK  |

The main difference between Raayan Mini board version 4.0 and version 4.1 lies in the SWD interface.

- a) Raayan Mini STM32F4 Development Board version 4.0
- b) Raayan Mini STM32F4 Development Board version 4.1

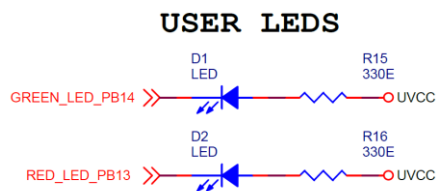
## 2.2.2. User Switches and User LEDs

The Raayan Mini STM32F4 Development Board comes with five LEDs of which two LEDs can be configured for use in custom applications. The other 3 LEDs represent the power input to the board. Three user switches and one buzzer are also included on the board namely SW\_ENT (Enter), SW\_DN and SW\_UP respectively. All these can be used for some purposes in the user's custom application. Table 2-2 shows how these features are connected to the pins on the microcontroller.

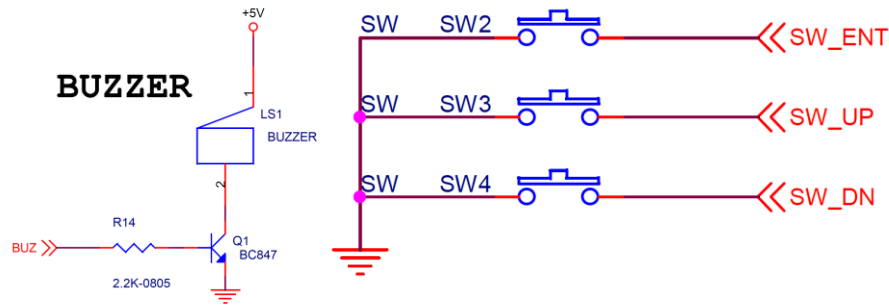
**Figure 2-4. Raayan Mini STM32F4 Development Board LEDs, Switches and Buzzer schematics**

**Table 2-2. User Switches, LED and Buzzer signals**

| GPIO Pin | Pin Function | Device          |
|----------|--------------|-----------------|
| PB12     | GPIO         | BUZZER          |
| PB13     | GPIO         | USR_LED2(Red)   |
| PB14     | GPIO         | USR_LED1(Green) |
| PC8      | GPIO         | SW_UP(SW3)      |
| PC9      | GPIO         | SW_DN(SW4)      |
| PC10     | GPIO         | SW_ENT(SW2)     |



## POWER LEDS



## 2.2.3. Display

The Raayan Mini STM32F4 Development Board version 4.0/4.1 offers two display options.

### a) 16x2 Monochrome LCD Display

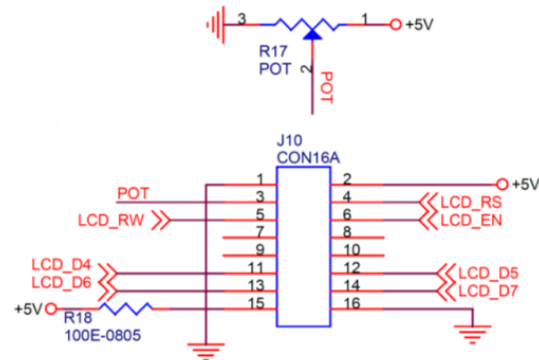
The Raayan Mini STM32F4 Development Board has provision for mounting a 16 x 2 Monochrome LCD display on board and can be used in custom user applications. The LCD can also be removed if it is not required for some application. It is also provided with an LCD trim pot to adjust the brightness/contrast of LCD screen. Only one display can be mounted on board at a time. Table 2-3 shows how the LCD pins are connected to the microcontroller.

**Figure 2-5. Raayan Mini STM32F4 Development Board LCD Display schematics**

**Table 2-3. 16x2 Monochrome LCD signals**

| GPIO Pin | Pin function | Device     |
|----------|--------------|------------|
| PB0      | GPIO         | LCD_DATA_4 |
| PB1      | GPIO         | LCD_DATA_5 |
| PB2      | GPIO         | LCD_DATA_6 |
| PB3      | GPIO         | LCD_DATA_7 |
| PB4      | GPIO         | LCD_RS     |
| PB5      | GPIO         | LCD_RW     |
| PB8      | GPIO         | LCD_EN     |

## 16x2 LCD



### b) TFT-LCD Display

The second option is a 262K-color, graphic type TFT-LCD display. It can also be mounted on top of the board. It consists of 396 source line and 162 gate line driving circuits. This is capable of connecting directly to an external microprocessor, and accepts Serial Peripheral Interface (SPI), 8-bit/9-bit/16-bit/18-bit parallel interface. Table 2-4 shows how these pins are connected to the microcontroller.

**Table 2-4. TFT LCD signals**

| GPIO Pin | Pin function | On-Board Function | Device    |
|----------|--------------|-------------------|-----------|
| PA0      | GPIO         | GPIO              | TFT_A0    |
| PA1      | GPIO         | GPIO              | TFT_RESET |
| PA4      | GPIO         | SPI1_CS           | TFT_CS    |
| PA5      | GPIO         | SPI1_SCK          | TFT_SCK   |
| PA7      | GPIO         | SPI1_MOSI         | TFT_SDA   |

### 2.2.4. Boot Mode Switch

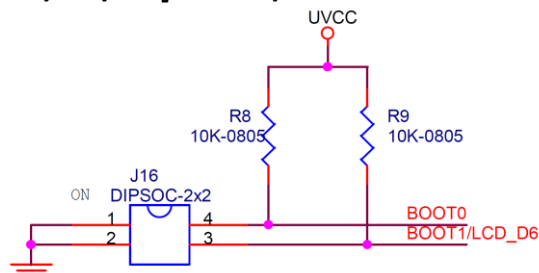
At startup, boot switch is used to select one out of three boot options:

- Boot from user flash
- Boot from system memory
- Boot from embedded SRAM

**Figure 2-6. Raayan Mini STM32F4 Development Board Boot switch schematics**

**Table 2-5. Boot modes**

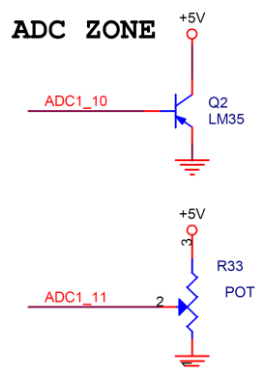
| Boot mode selection pins |       | Boot mode                   | Aliasing                                        |
|--------------------------|-------|-----------------------------|-------------------------------------------------|
| BOOT1                    | BOOT2 |                             |                                                 |
| X                        | 0     | Main Flash memory (default) | Main Flash memory is selected as the boot space |
| 0                        | 1     | System memory               | System memory is selected as the boot space     |
| 1                        | 1     | Embedded SRAM               | Embedded SRAM is selected as the boot space     |



### 2.2.5. Analog to Digital Converter

The Raayan Mini Development board has two on-board analog devices which is one LM35 temperature sensor and one potentiometer. These devices are internally connected to ADC1\_10 and ADC1\_11 analog channels respectively. To convert the sensor output voltage into a digital value, one 12-bit analog-to-digital converter is embedded and shares up to 16 external channels, performing conversions in the single-shot or scan mode.

Figure 2-7. Raayan Mini STM32F4 Development Board ADC Schematic



| GPIO Pin | Pin function | On-Board Function | Device        |
|----------|--------------|-------------------|---------------|
| PC0      | GPIO         | ADC1 IN10         | LM35 sensor   |
| PC1      | GPIO         | ADC1 IN11         | Potentiometer |

Table 2-6. Analog devices pin configuration

### 2.2.6. USART Zone

The Development Board provides three dedicated UART headers which helps in communicating various peripherals or sensors that may be used in your custom projects. UART headers are named J7, J8 AND J9 respectively. J7 is UART1, J8 is UART6 and J9 is UART2 respectively. In Raayan Mini board versions 3.0, 4.0 and 4.1, UART6 is internally connected to the Wi-Fi module (ESP8266) provided on board. These STM32F4 microcontroller, ADC, UART and Wi-Fi combination can also be used as a platform for making many IoT projects.

Figure 2-8. Raayan Mini STM32F4 Development Board UART schematics

## USART ZONE

### USART OUPUTS

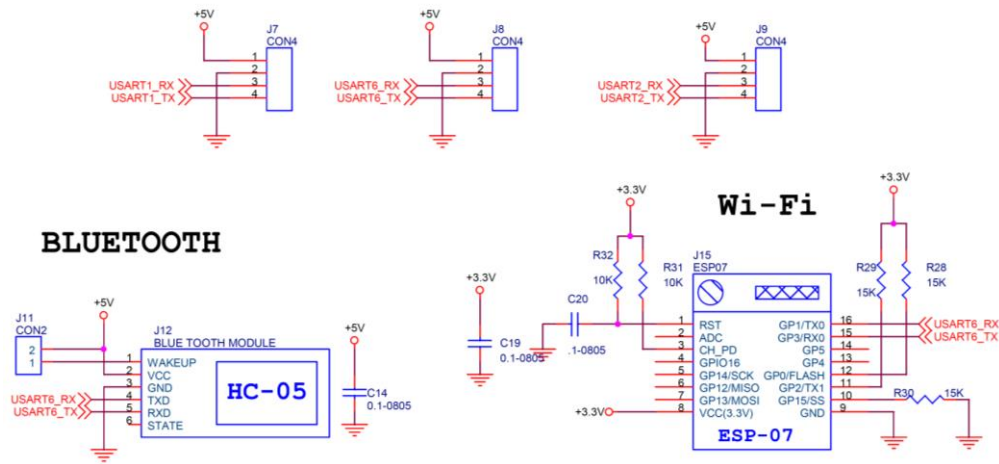


Table 2-7. USART Pin configuration

| GPIO Pin | Pin Function | On-Board Function |
|----------|--------------|-------------------|
| PA9      | GPIO         | UART1_TX          |
| PA10     | GPIO         | UART1_RX          |
| PA2      | GPIO         | UART2_TX          |
| PA3      | GPIO         | UART2_RX          |
| PC6      | GPIO         | UART6_TX          |
| PC7      | GPIO         | UART6_RX          |

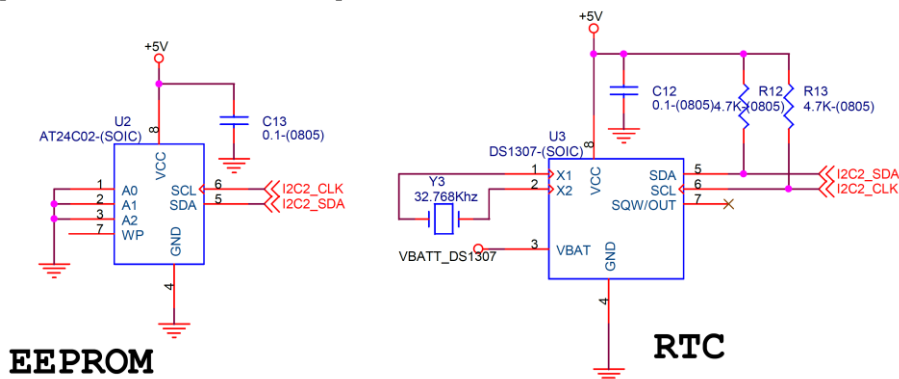
### 2.2.7. I2C Zone

The Raayan Mini Development Board has extended one I2C bus for connecting slaves. I2C2 is the master and is already connected to two slaves on the board. One is EEPROM (slave address is 0X50H) and the second slave is RTC (slave address is 0X68H).

Figure 2-9. Raayan Mini STM32F4 Development Board I2C schematics

Table 2-8. I2C Pin Configuration

| GPIO Pin | Pin Function | On-Board Function |
|----------|--------------|-------------------|
| PB6      | GPIO         | I2C1_CLK          |
| PB7      | GPIO         | I2C1_SDA          |



### 2.2.8. SPI Zone

The SPI interface can be configured for communication in master mode and slave mode. The Raayan Mini Development board provides SPI1 as master which can be interfaced to another SPI device. The Table 2-9 shows the pin configuration for SPI.

**Table 2-9. SPI Pin Configuration**

| GPIO Pin | Pin Function | On-Board Function |
|----------|--------------|-------------------|
| PA4      | GPIO         | SPI1_NSS          |
| PA5      | GPIO         | SPI1_SCK          |
| PA6      | GPIO         | SPI1_MISO         |
| PA7      | GPIO         | SPI1_MOSI         |

### 2.2.9. CAN Zone

Raayan Mini STM32F4 Development Board version 4.0/4.1 offers the option for connecting an external Controller Area Network (CAN) controller that implements the CAN specification, Version 2.0B. It is capable of transmitting and receiving both standard and extended data and remote frames. This CAN controller interfaces with microcontrollers (MCUs) via an industry standard Serial Peripheral Interface (SPI).

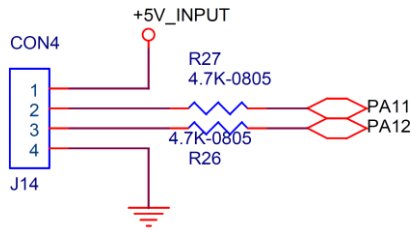
**Table 2-10. CAN-SPI Pin Configuration**

| GPIO Pin | Pin function | On-Board Function | Device  |
|----------|--------------|-------------------|---------|
| PB10     | GPIO         | SPI2_SCK          | CAN_SCK |
| PC2      | GPIO         | SPI2_MISO         | CAN_SO  |
| PC3      | GPIO         | SPI2_MOSI         | CAN_SI  |
| PC4      | GPIO         | SPI2_CS           | CAN_CS  |

### 2.2.9. Power supply

The power supply is provided by the host PC through the USB cable, or by an external 5V power supply. 5V and 3V3 can be used as output power supplies when another application board is connected to the corresponding pins, power consumption must be lower than 100 mA.

## POWER SUPPLY



**Figure 2-10. Raayan Mini STM32F4 Development Board Power supply schematics**

### 2.2.10. Oscillators

The Raayan Mini STM32F4 Development Board provides an external 32.768-KHz crystal (Y3) as the clock source for external RTC. Another 32.768-KHz crystal (Y2) serves as clock for internal RTC. This board also uses an 8 MHz crystal (Y1) to complete the STM32F401RBT6 microcontroller main internal clock circuit.

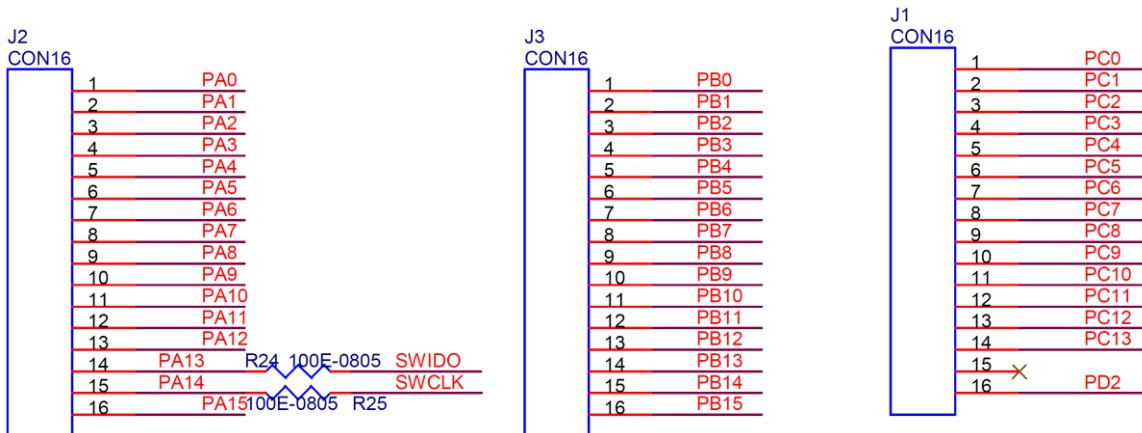
### 2.2.11. Electrically Erasable and Programmable Read-Only Memory (EEPROM)

The Raayan Mini STM32F4 Development Board provides an EEPROM of size 8K with 2-wire serial interface bus, I2C compatible. It is internally Organized 128 x 8 (1K), 256 x 8 (2K), 512 x 8 (4K), 1024 x 8 (8K) or 2048 x 8 (16K). It also has a write Protect Pin for Hardware Data Protection.

### 2.2.12. Real Time clock (RTC)

The Raayan Mini STM32F4 Development Board provides an external RTC. It is a low power, full binary-coded decimal (BCD) serial Real Time Clock. Address and data are transferred serially through an I2C, bidirectional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. An external crystal (32.7 KHz) is also provided exclusively for RTC.

### 2.2.13. Expansion Headers



**Figure 2-11. Raayan Mini STM32F4 Development Board GPIO Header schematics**

The three rows of stackable headers are mapped to most of the GPIO pins of the STM32F401RBT6 microcontroller. These rows are labeled as connectors J1, J2, and J3. Each pin has to be configured in their respective GPIO Port Mode register as shown below as per your requirement of your project.

**Table 2-11. STM32F401 MuX/Pad Configuration**

| GPIOIX_MODER |   |                    |
|--------------|---|--------------------|
| 0            | 0 | GPIO - Input       |
| 0            | 1 | GPIO - Output      |
| 1            | 0 | Alternate Function |
| 1            | 1 | Analog mode        |

All 48 header pins represents the GPIO Port C, Port A and Port B respectively. These GPIO pins can be configured according to the functionality required by the users.

**Table 2-12. J1 Connector**

## Raayan Mini [ARM Cortex M0/M3/M4] Rev 4.0/4.1

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| J1 Pin | STM32F4 MCU Pin | Port   | GPIO | On-board Function | Analog Function | AF00<br>SYS_AF | AF01<br>TIM1/TIM2 | AF02<br>TIM3/TIM4 / TIM5 | AF03<br>TIM9/TIM10/TIM11 | AF04<br>I2C1/I2C2 / I2C3 | AF05<br>SPI1/SPI2/I2S2/SPI3/I2S3/SPI4 | AF06<br>SPI2/I2S2/SPI3/I2S3 | AF07<br>SPI3/I2S3 /USART1 /USART2 | AF08<br>USART6 | AF09<br>I2C2/I2C3 | AF10<br>OTG1_FS | AF11<br>SDIO | AF12     | AF13 | AF14 | AF15      |
|--------|-----------------|--------|------|-------------------|-----------------|----------------|-------------------|--------------------------|--------------------------|--------------------------|---------------------------------------|-----------------------------|-----------------------------------|----------------|-------------------|-----------------|--------------|----------|------|------|-----------|
| 1.01   | 8               | Port C | PC0  | -                 | ADC1_IN10       | -              | -                 | -                        | -                        | -                        | -                                     | -                           | -                                 | -              | -                 | -               | -            | -        | -    | -    | EVENT OUT |
| 1.02   | 9               |        | PC1  | -                 | ADC1_IN11       | -              | -                 | -                        | -                        | -                        | -                                     | -                           | -                                 | -              | -                 | -               | -            | -        | -    | -    | EVENT OUT |
| 1.03   | 10              |        | PC2  | CAN_SO            | ADC1_IN12       | -              | -                 | -                        | -                        | -                        | SPI2_MISO                             | I2S2ext_SD                  | -                                 | -              | -                 | -               | -            | -        | -    | -    | EVENT OUT |
| 1.04   | 11              |        | PC3  | CAN_SI            | ADC1_IN13       | -              | -                 | -                        | -                        | -                        | SPI2_MOSI /I2S2_SD                    | -                           | -                                 | -              | -                 | -               | -            | -        | -    | -    | EVENT OUT |
| 1.05   | 24              |        | PC4  | CAN_CS            | ADC1_IN14       | -              | -                 | -                        | -                        | -                        | -                                     | -                           | -                                 | -              | -                 | -               | -            | -        | -    | -    | EVENT OUT |
| 1.06   | 25              |        | PC5  | -                 | ADC1_IN15       | -              | -                 | -                        | -                        | -                        | -                                     | -                           | -                                 | -              | -                 | -               | -            | -        | -    | -    | EVENT OUT |
| 1.07   | 37              |        | PC6  | USART6_TX         | -               | -              | -                 | TIM3_CH1                 | -                        | -                        | I2S2_MCK                              | -                           | -                                 | USART6_TX      | -                 | -               | -            | SDIO_D6  | -    | -    | EVENT OUT |
| 1.08   | 38              |        | PC7  | USART6_RX         | -               | -              | -                 | TIM3_CH2                 | -                        | -                        | -                                     | I2S3_MCK                    | -                                 | USART6_RX      | -                 | -               | -            | SDIO_D7  | -    | -    | EVENT OUT |
| 1.09   | 39              |        | PC8  | SW_UP             | -               | -              | -                 | TIM3_CH3                 | -                        | -                        | -                                     | -                           | -                                 | USART6_CK      | -                 | -               | -            | SDIO_D0  | -    | -    | EVENT OUT |
| 1.1    | 40              |        | PC9  | SW_DN             | -               | MCO_2          | -                 | TIM3_CH4                 | -                        | I2C3_SDA                 | I2S_CKIN                              | -                           | -                                 | -              | -                 | -               | -            | SDIO_D1  | -    | -    | EVENT OUT |
| 1.11   | 51              |        | PC10 | SW_ENT            | -               | -              | -                 | -                        | -                        | -                        | -                                     | SPI3_SCK/I2S3_CK            | -                                 | -              | -                 | -               | -            | SDIO_D2  | -    | -    | EVENT OUT |
| 1.12   | 52              |        | PC11 | -                 | -               | -              | -                 | -                        | -                        | -                        | I2S3ext_SD                            | SPI3_MISO                   | -                                 | -              | -                 | -               | -            | SDIO_D3  | -    | -    | EVENT OUT |
| 1.13   | 53              |        | PC12 | -                 | -               | -              | -                 | -                        | -                        | -                        | -                                     | SPI3_MOSI /I2S3_SD          | -                                 | -              | -                 | -               | -            | SDIO_CK  | -    | -    | EVENT OUT |
| 1.14   | 2               | Port D | PC13 | -                 | -               | -              | -                 | -                        | -                        | -                        | -                                     | -                           | -                                 | -              | -                 | -               | -            | -        | -    | -    | EVENT OUT |
| 1.15   |                 |        | NC   | -                 | -               | -              | -                 | -                        | -                        | -                        | -                                     | -                           | -                                 | -              | -                 | -               | -            | -        | -    | -    | -         |
| 1.16   | 54              | Port D | PD2  | -                 | -               | -              | -                 | TIM3_ETR                 | -                        | -                        | -                                     | -                           | -                                 | -              | -                 | -               | -            | SDIO_CMD | -    | -    | EVENT OUT |

Table 2-13. J2 Connector

## Raayan Mini [ARM Cortex M0/M3/M4] Rev 4.0/4.1

## User Manual

| J2 Pin | STM32F4<br>MCU Pin | Port   | GPIO | On-board<br>Function | Analog<br>Function | AF00<br>SYS_AF | AF01<br>TIM1/TIM2     | AF02<br>TIM3/TIM4/<br>TIM5 | AF03<br>TIM9/TIM10/<br>TIM11 | AF04<br>I2C1/I2C2<br>/I2C3 | AF05<br>SPI1/SPI2/<br>I2S2/SPI3/I2<br>S3/SPI4 | AF06<br>SPI2/I2S2/<br>SPI3/I2S3 | AF07<br>SPI3/I2S3<br>/USART1<br>/USART2 | AF08<br>USART6 | AF09<br>I2C2/<br>I2C3 | AF10<br>OTG1_FS | AF11 | AF12<br>SDIO | AF13 | AF14 | AF15         |
|--------|--------------------|--------|------|----------------------|--------------------|----------------|-----------------------|----------------------------|------------------------------|----------------------------|-----------------------------------------------|---------------------------------|-----------------------------------------|----------------|-----------------------|-----------------|------|--------------|------|------|--------------|
| 2.01   | 14                 | Port A | PA0  | TFT_A0               | ADC1_IN0           | -              | TIM2_CH1/<br>TIM2_ETR | TIM5_CH1                   | -                            | -                          | -                                             | -                               | USART2_<br>CTS                          | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.02   | 15                 |        | PA1  | TFT_RESET            | ADC1_IN1           | -              | TIM2_CH2              | TIM5_CH2                   | -                            | -                          | -                                             | -                               | USART2_<br>RTS                          | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.03   | 16                 |        | PA2  | USART2_TX            | ADC1_IN2           | -              | TIM2_CH3              | TIM5_CH3                   | TIM9_CH1                     | -                          | -                                             | -                               | USART2_<br>TX                           | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.04   | 17                 |        | PA3  | USART2_RX            | ADC1_IN3           | -              | TIM2_CH4              | TIM5_CH4                   | TIM9_CH2                     | -                          | -                                             | -                               | USART2_<br>RX                           | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.05   | 20                 |        | PA4  | TFT_CS               | ADC1_IN4           | -              | -                     | -                          | -                            | -                          | SPI1_NSS                                      | SPI3_NSS/<br>I2S3_WS            | USART2_<br>CK                           | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.06   | 21                 |        | PA5  | TFT_SCK              | ADC1_IN5           | -              | TIM2_CH1/<br>TIM2_ETR | -                          | -                            | -                          | SPI1_SCK                                      | -                               | -                                       | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.07   | 22                 |        | PA6  | SPI1_MISO            | ADC1_IN6           | -              | TIM1_BKIN             | TIM3_CH1                   | -                            | -                          | SPI1_MISO                                     | -                               | -                                       | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.08   | 23                 |        | PA7  | TFT_SDA              | ADC1_IN7           | -              | TIM1_CH1<br>N         | TIM3_CH2                   | -                            | -                          | SPI1_MOSI                                     | -                               | -                                       | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.09   | 41                 |        | PA8  | -                    | -                  | MCO_1          | TIM1_CH1              | -                          | -                            | I2C3_SCL                   | -                                             | -                               | USART1_<br>CK                           | -              | -                     | OTG_FS_<br>SOF  | -    | -            | -    | -    | EVENT<br>OUT |
| 2.10   | 42                 |        | PA9  | USART1_TX            | -                  | -              | TIM1_CH2              | -                          | -                            | I2C3_SM<br>BA              | -                                             | -                               | USART1_<br>TX                           | -              | -                     | OTG_FS_<br>VBUS | -    | -            | -    | -    | EVENT<br>OUT |
| 2.11   | 43                 |        | PA10 | USART1_RX            | -                  | -              | TIM1_CH3              | -                          | -                            | -                          | -                                             | -                               | USART1_<br>RX                           | -              | -                     | OTG_FS_<br>ID   | -    | -            | -    | -    | EVENT<br>OUT |
| 2.12   | 44                 |        | PA11 | -                    | -                  | -              | TIM1_CH4              | -                          | -                            | -                          | -                                             | -                               | USART1_<br>CTS                          | USART6_<br>TX  | -                     | OTG_FS_<br>DM   | -    | -            | -    | -    | EVENT<br>OUT |
| 2.13   | 45                 |        | PA12 | -                    | -                  | -              | TIM1_ETR              | -                          | -                            | -                          | -                                             | -                               | USART1_<br>RTS                          | USART6_<br>RX  | -                     | OTG_FS_<br>DP   | -    | -            | -    | -    | EVENT<br>OUT |
| 2.14   | 46                 |        | PA13 | -                    | -                  | JTMS_S<br>WDIO | -                     | -                          | -                            | -                          | -                                             | -                               | -                                       | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.15   | 49                 |        | PA14 | -                    | -                  | JTCK_S<br>WCLK | -                     | -                          | -                            | -                          | -                                             | -                               | -                                       | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |
| 2.16   | 50                 |        | PA15 | -                    | -                  | JTDI           | TIM2_CH1/<br>TIM2_ETR | -                          | -                            | -                          | SPI1_NSS                                      | SPI3_NSS/<br>I2S3_WS            | -                                       | -              | -                     | -               | -    | -            | -    | -    | EVENT<br>OUT |

Table 2-14. J3 Connector

| J3 Pin | STM32F4 MCU Pin | Port   | GPIO | On-board Function | Analog Function | AF00     | AF01      | AF02           | AF03             | AF04           | AF05                          | AF06                | AF07                    | AF08   | AF09      | AF10    | AF11 | AF12    | AF13 | AF14 | AF15      |
|--------|-----------------|--------|------|-------------------|-----------------|----------|-----------|----------------|------------------|----------------|-------------------------------|---------------------|-------------------------|--------|-----------|---------|------|---------|------|------|-----------|
|        |                 |        |      |                   |                 | SYS_AF   | TIM1/TIM2 | TIM3/TIM4/TIM5 | TIM9/TIM10/TIM11 | I2C1/I2C2/I2C3 | SPI1/SPI2/I2S2/SPI3/I2S3/SPI4 | SPI2/I2S2/SPI3/I2S3 | SPI3/I2S3/USART1/USART2 | USART6 | I2C2/I2C3 | OTG1_FS |      | SDIO    |      |      |           |
| 3.01   | 26              | Port B | PB0  | LCD_DATA_4        | ADC1_IN8        | -        | TIM1_CH2N | TIM3_CH3       | -                | -              | -                             | -                   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.02   | 27              |        | PB1  | LCD_DATA_5        | ADC1_IN9        | -        | TIM1_CH3N | TIM3_CH4       | -                | -              | -                             | -                   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.03   | 28              |        | PB2  | LCD_DATA_6        | -               | -        | -         | -              | -                | -              | -                             | -                   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.04   | 55              |        | PB3  | LCD_DATA_7        | -               | JTDO-SWO | TIM2_CH2  | -              | -                | -              | SPI1_SCK                      | SPI3_SCK/I2S3_CK    | -                       | -      | I2C2_SDA  | -       | -    | -       | -    | -    | EVENT OUT |
| 3.05   | 56              |        | PB4  | LCD_RS            | -               | JTRST    | -         | TIM3_CH1       | -                | -              | SPI1_MISO                     | SPI3_MISO           | I2S3ext_SD              | -      | I2C3_SDA  | -       | -    | -       | -    | -    | EVENT OUT |
| 3.06   | 57              |        | PB5  | LCD_RW            | -               | -        | -         | TIM3_CH2       | -                | I2C1_SMBA      | SPI1_MOSI                     | SPI3_MOSI/I2S3_SD   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.07   | 58              |        | PB6  | I2C1_SCL          | -               | -        | -         | TIM4_CH1       | -                | I2C1_SCL       | -                             | -                   | USART1_TX               | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.08   | 59              |        | PB7  | I2C1_SDA          | -               | -        | -         | TIM4_CH2       | -                | I2C1_SDA       | -                             | -                   | USART1_RX               | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.09   | 61              |        | PB8  | LCD_EN            | -               | -        | -         | TIM4_CH3       | TIM10_CH1        | I2C1_SCL       | -                             | -                   | -                       | -      | -         | -       | -    | SDIO_D4 | -    | -    | EVENT OUT |
| 3.10   | 62              |        | PB9  | -                 | -               | -        | -         | TIM4_CH4       | TIM11_CH1        | I2C1_SDA       | SPI2_NSS/I2S2_WS              | -                   | -                       | -      | -         | -       | -    | SDIO_D5 | -    | -    | EVENT OUT |
| 3.11   | 29              |        | PB10 | CAN_SCK           | -               | -        | TIM2_CH3  | -              | -                | I2C2_SCL       | SPI2_SCK/I2S2_CK              | -                   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.12   | 30              |        | PB11 | -                 | -               | -        | TIM2_CH4  | -              | -                | I2C2_SDA       | -                             | -                   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.13   | 33              |        | PB12 | BUZZER            | -               | -        | TIM1_BKIN | -              | -                | I2C2_SMBA      | SPI2_NSS/I2S2_WS              | -                   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.14   | 34              |        | PB13 | USER_LED2 (RED)   | -               | -        | TIM1_CH1N | -              | -                | -              | SPI2_SCK/I2S2_CK              | -                   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.15   | 35              |        | PB14 | USER_LED1 (GREEN) | -               | -        | TIM1_CH2N | -              | -                | -              | -                             | I2S2ext_SD          | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |
| 3.16   | 36              |        | PB15 | -                 | -               | RTC_REFN | TIM1_CH3N | -              | -                | -              | SPI2_MISO                     | SPI2_MOSI/I2S2_SD   | -                       | -      | -         | -       | -    | -       | -    | -    | EVENT OUT |

## 3. Software Development

This chapter provides general information on software development as well as instructions for Flash memory programming.

### 3.1. Software Description

### 3.2. Source Code

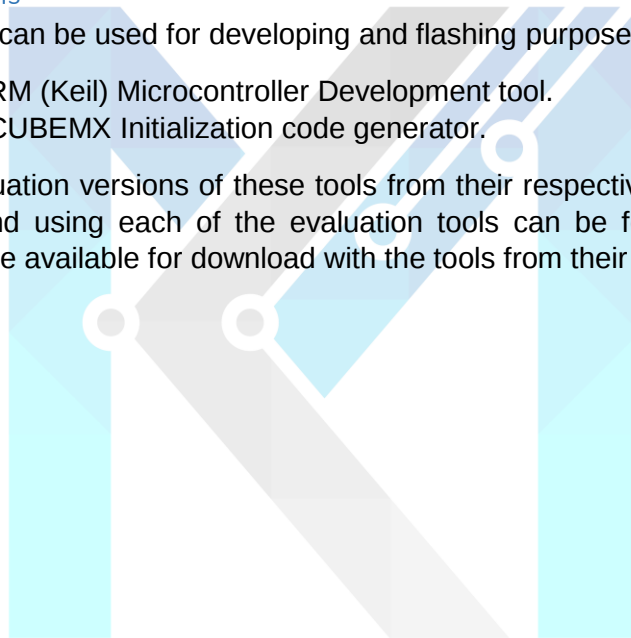
<https://github.com/raayanmini>

### 3.3. Tool Options

Following tools can be used for developing and flashing purpose.

1. MDK-ARM (Keil) Microcontroller Development tool.
2. STM32CUBEMX Initialization code generator.

Download evaluation versions of these tools from their respective websites. Instructions on installing and using each of the evaluation tools can be found in the Quick start guides which are available for download with the tools from their respective websites.



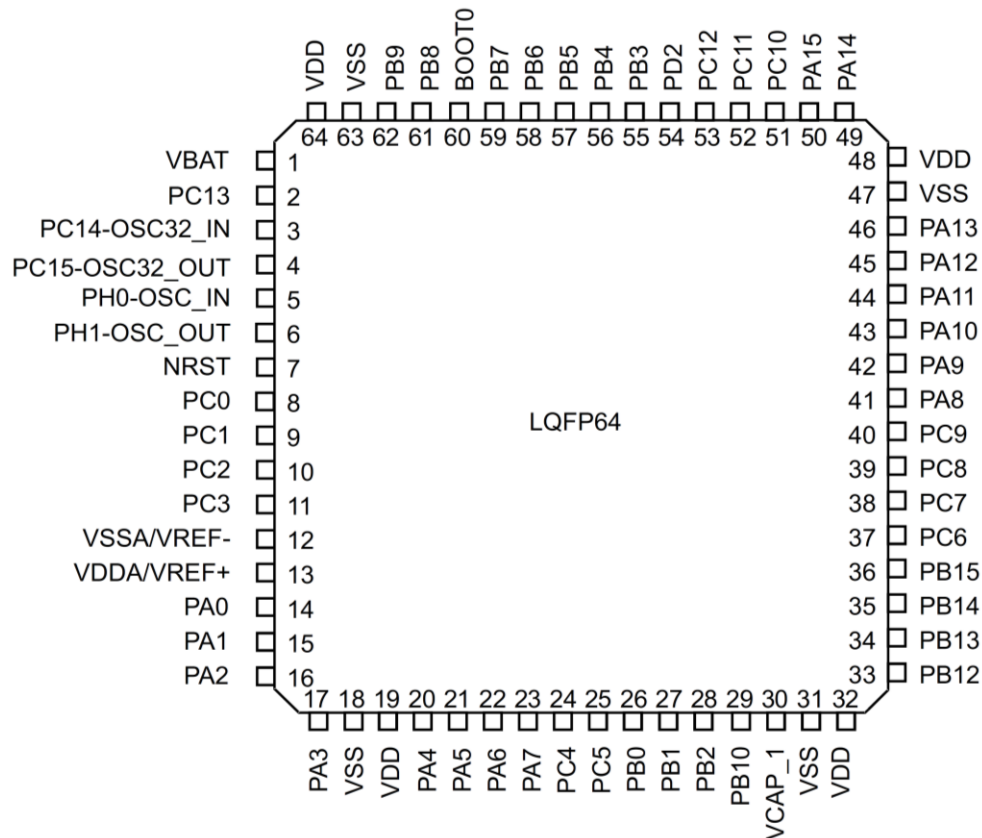
## 4. References, PCB Layout, and Bill of Materials

### 4.1. References

- MDK-ARM ([www.keil.com/arm/rvmdkkit.asp](http://www.keil.com/arm/rvmdkkit.asp))
- STM32CubeMX([www.st.com/en/development-tools/stm32cubemx.html](http://www.st.com/en/development-tools/stm32cubemx.html))

### 4.2. Pin out Diagram

Figure 4-1. STM32F401RBT6 LQFP64 pin out



## 4.3. Component Locations

Figure 4-2. Raayan Mini STM32F4 Development Board Component Locations (Top View)

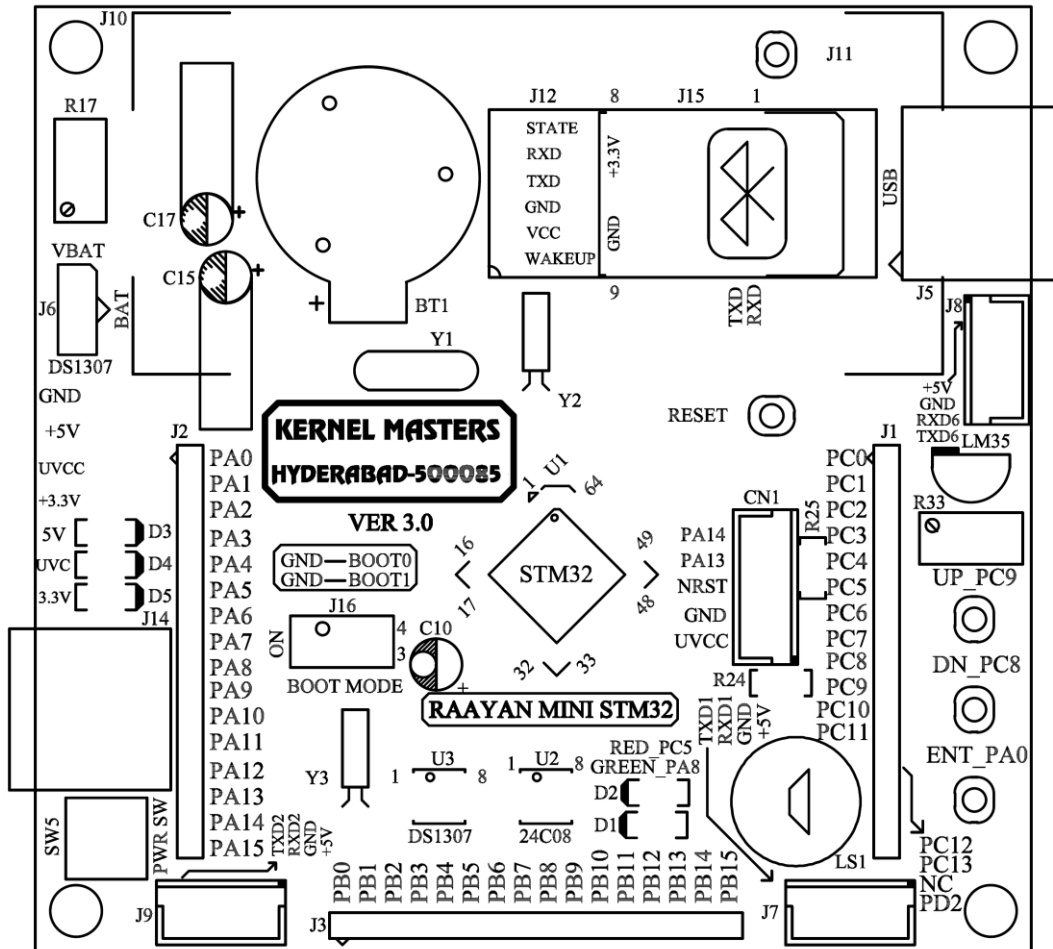


Figure 4-3. Raayan Mini STM32F4 Development Board Component Locations (Bottom View)

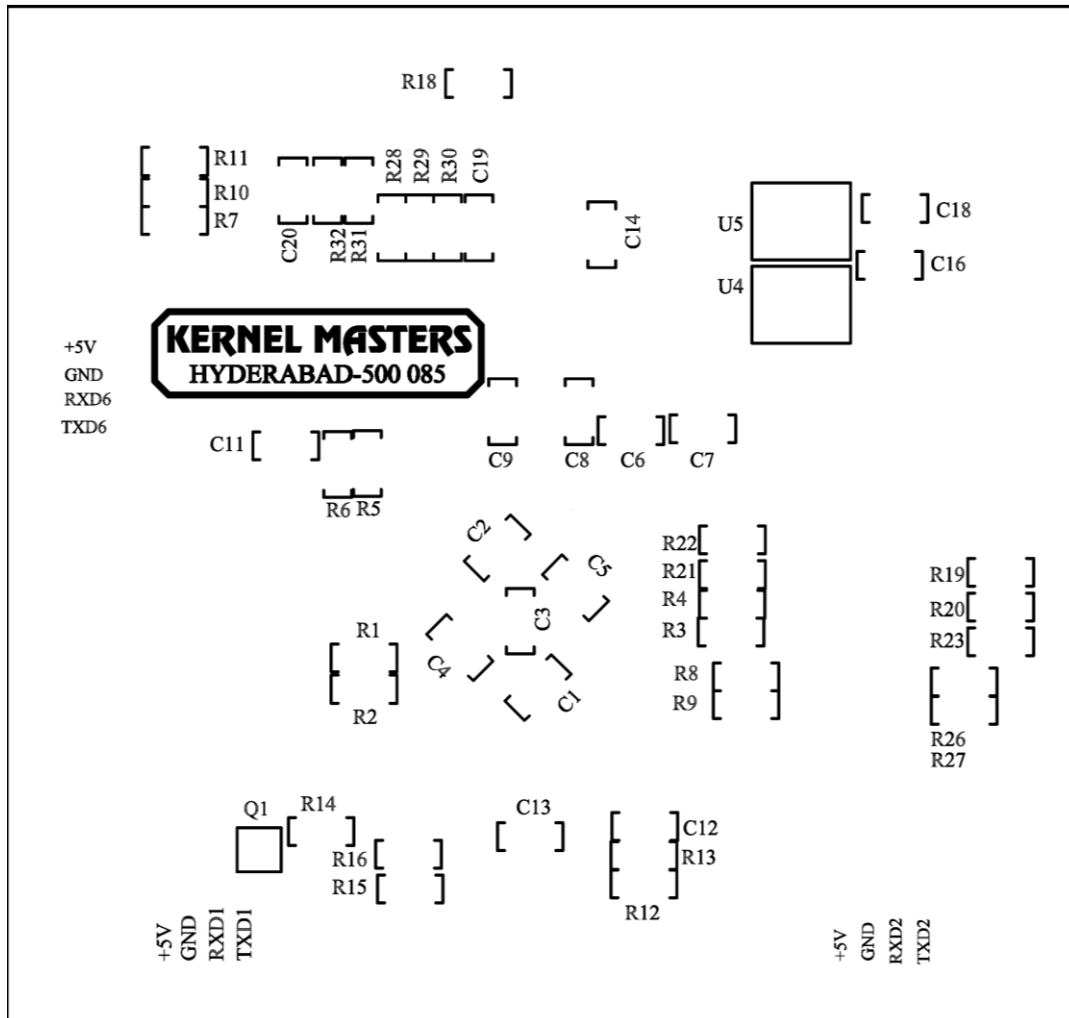
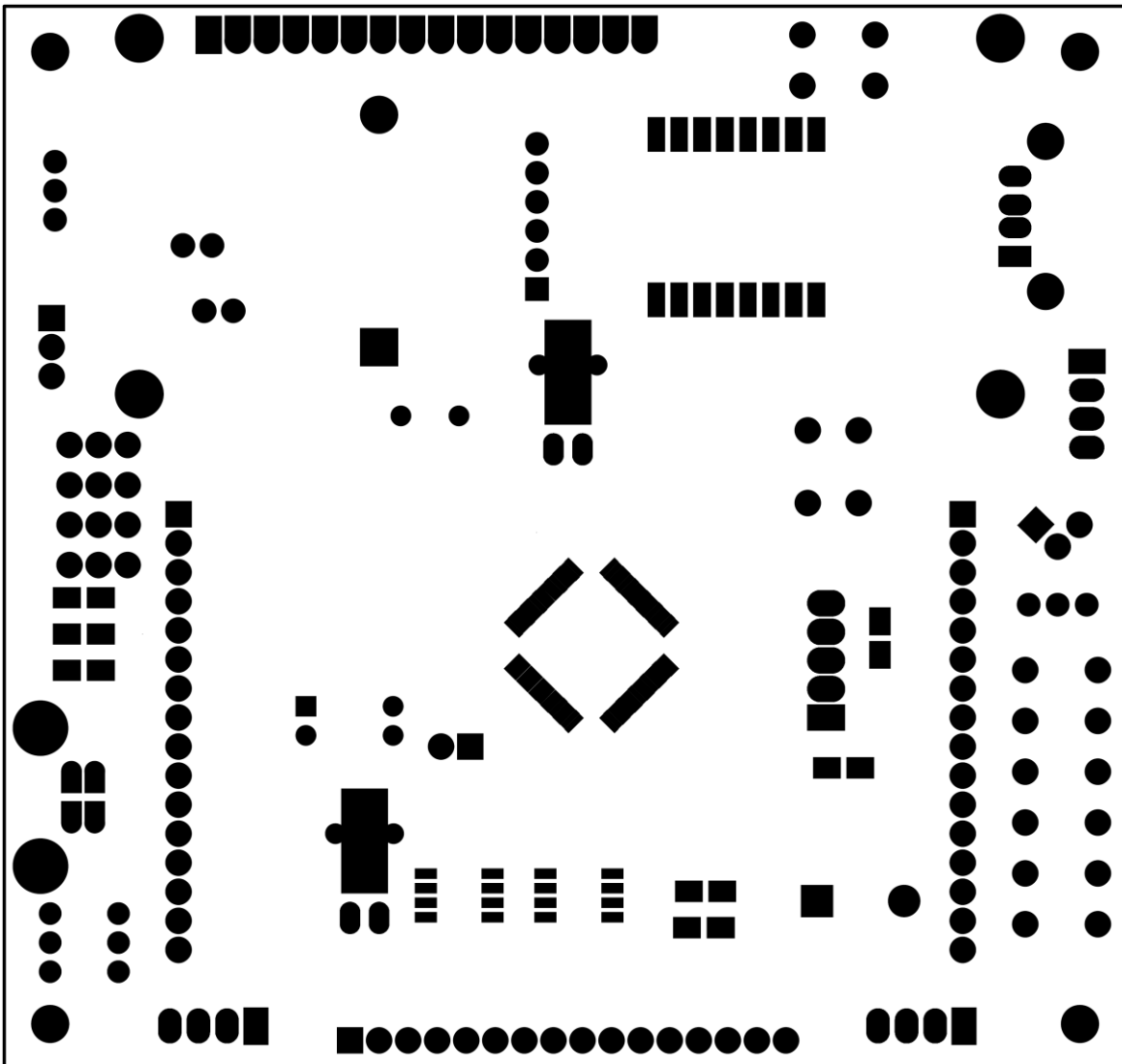


Figure 4-4. Raayan Mini STM32F4 Development Board



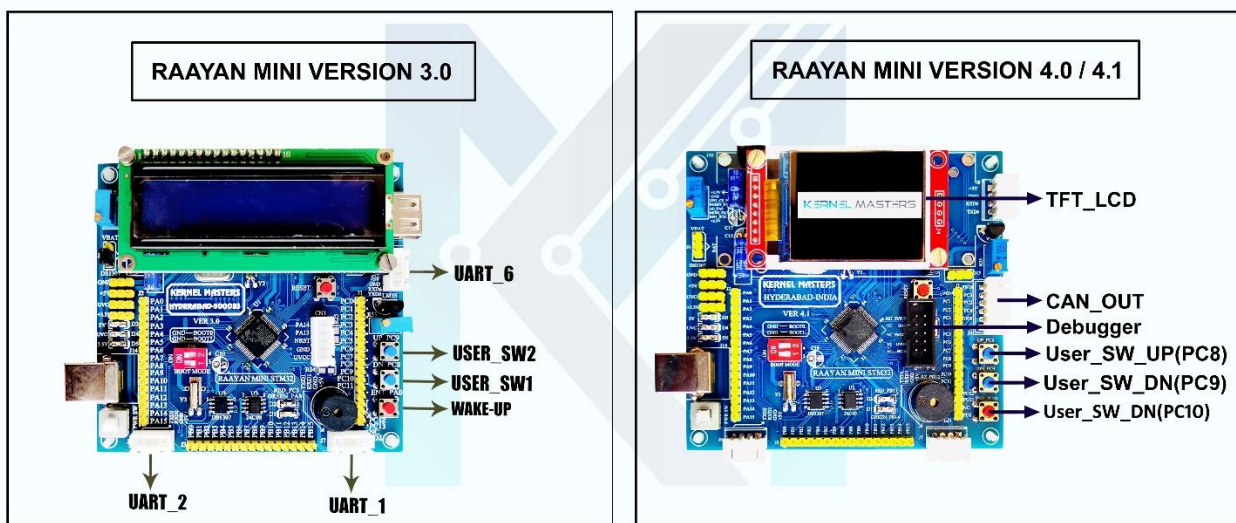
## 4.4 Bill of Materials (BOM)

Table 4-1 shows the bill of materials for the Raayan Mini STM32F4 Development board.



## Appendix A

Raayan Mini board version 3.0 vs version 4.0/4.1



## Appendix B

### Schematics



This section contains the complete schematics for the Raayan Mini STM32F4 Development board.

