



STM32 Based Raayan Mini Development Board

Version 2.0

User's Guide

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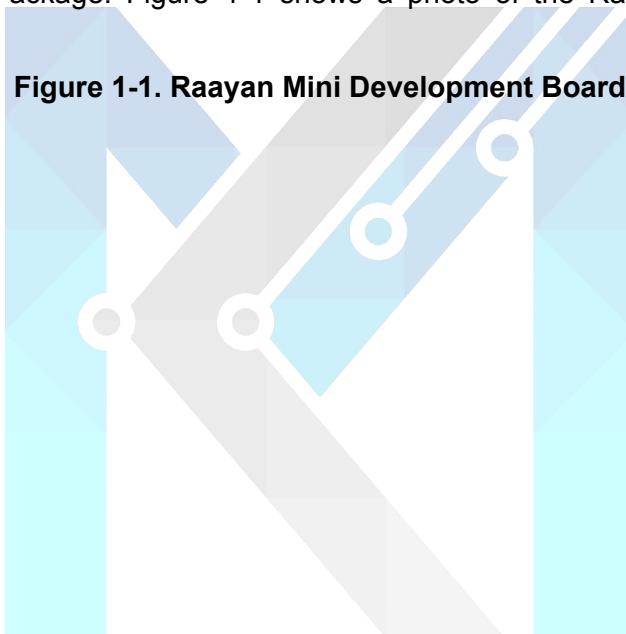
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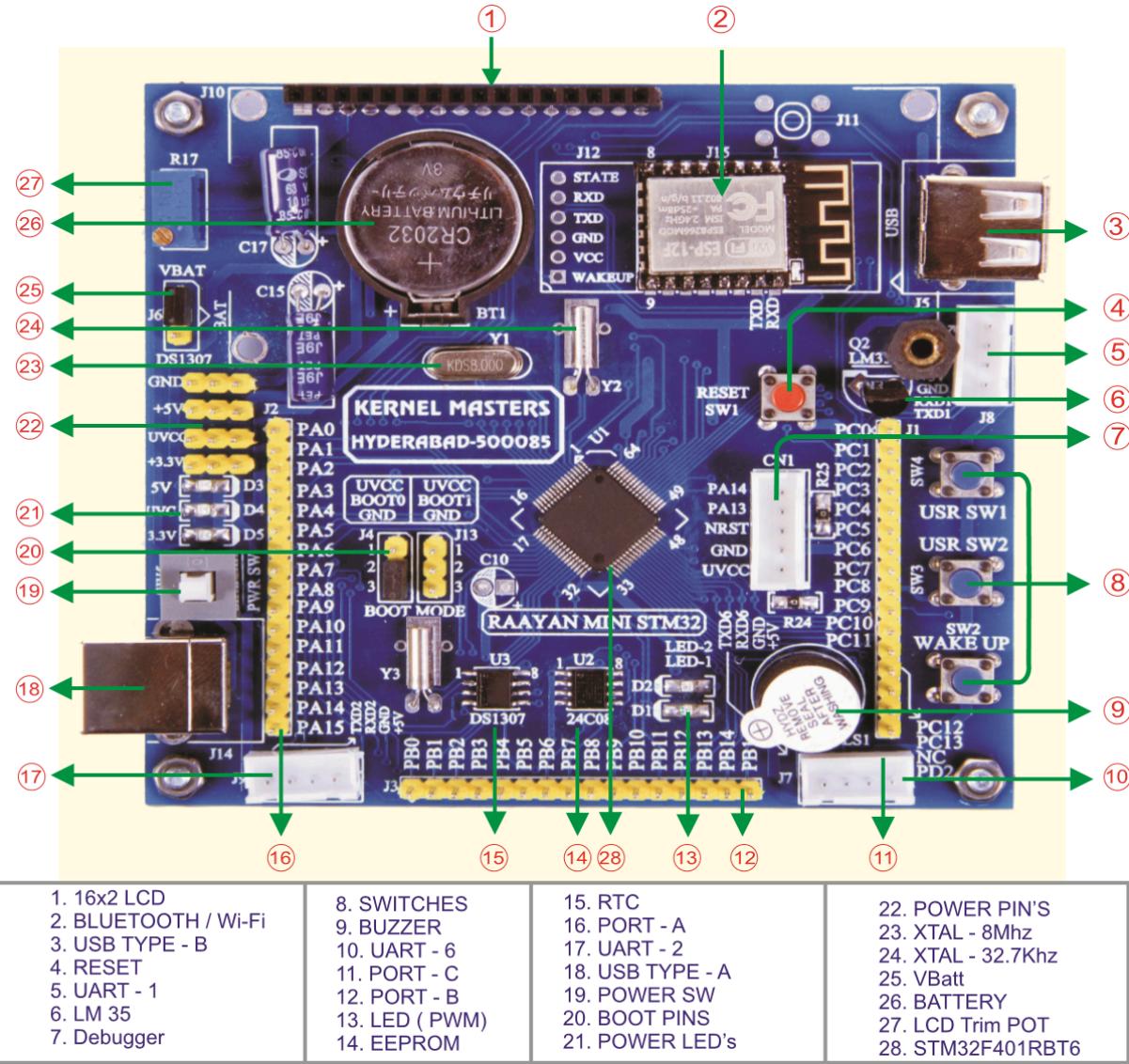
Chapter 1

Board Overview

The STM32 Based Raayan Mini Development board allows users to easily develop applications with the STM32F401RBT6 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





1.1. Kit Contents

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

- Raayan Mini Development Board (STM32F401RBT6)
- ST-Link Serial wire Debugger
- USB – TTL module
- USB Type A to B cable
- Jumper wires
- User manual

1.2. Getting Started

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

1. Check the jumper 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 screen shows "Welcome to KM" followed by some test cases for testing the board and peripherals. Perform each test cases as shown in the LCD screen 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.

1.3. 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, Adaptive real-time accelerator (ART Accelerator™) allowing 0-wait state execution from Flash memory, frequency up to 84 MHz, memory protection unit, 105 DMIPS/1.25 DMIPS/MHz (Dhrystone 2.1), and DSP instructions
- On-board ST-LINK Serial wire debugger/programmer
- 1×12-bit, 2.4 MSPS A/D converter: up to 16 channels
- One PWM timer for motor control
- GPIO ports with interrupt capability
 - All IO ports 5 V tolerant
 - Up to 3 UART Headers
 - Up to 78 fast I/Os up to 42 MHz
- Communication interfaces
 - 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
- Up to 8-Kbytes of On – board EEPROM
- On – board temperature sensor
- On-board Buzzer
- 16 X 2 LCD interface
- On-board Wi-Fi interface.
- USB Type A interface
- Flexible power-supply options: ST-LINK, USB Type B connector
- External application power supply: 3 V and 5 V
- User (application/wake) and reset push-buttons
- On - board RTC

- 5 LEDs:
 - 3 Power LEDs and 2 user LEDs
- Support of a wide choice of Integrated Development Environments (IDEs) including IAR Embedded Workbench®, MDK-ARM, and STM32CubeIDE.

1.4. Specifications

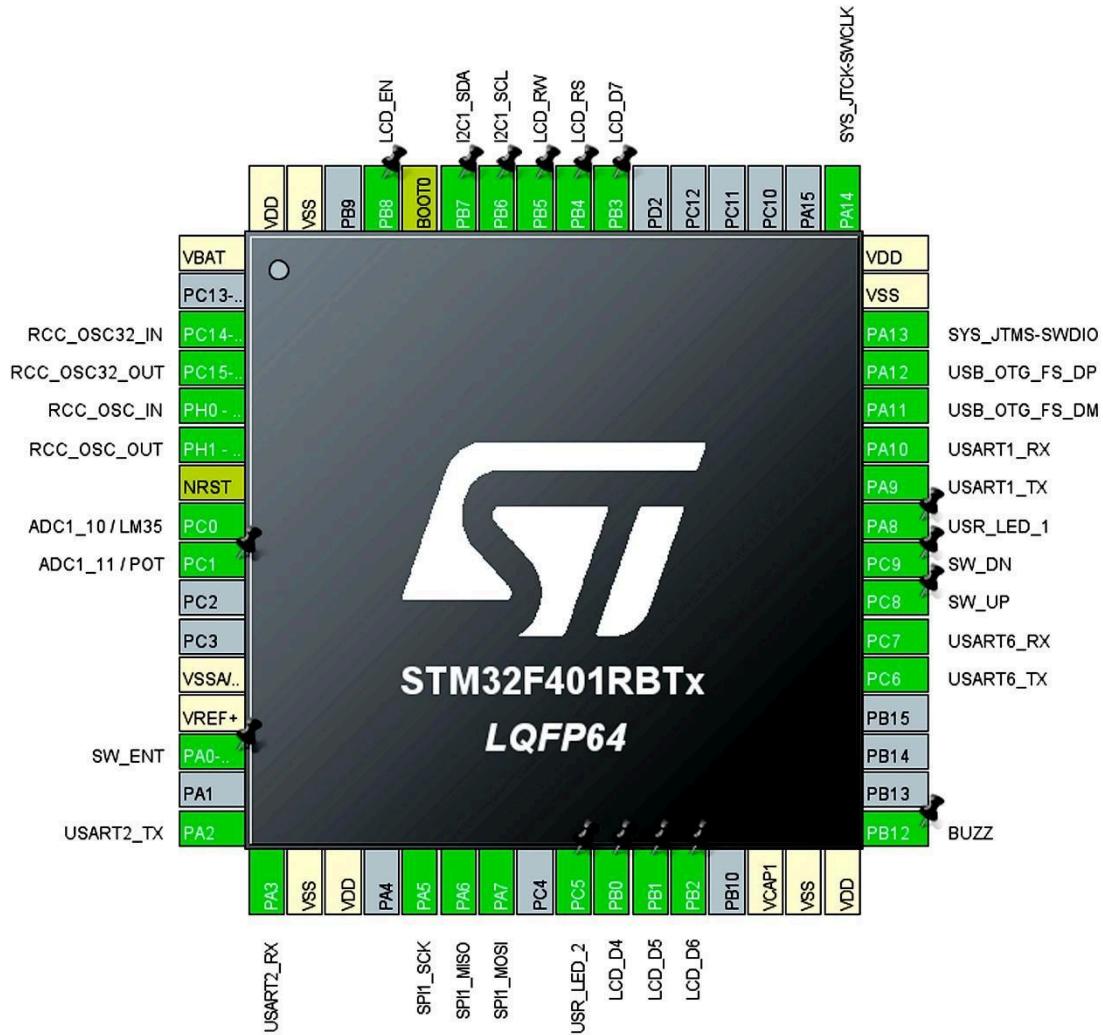
Table 1-1 summarizes the specifications for the Raayan Mini STM32F4 Development Board.

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"> ● 3.3 VDC (current rating) ● 5.0 VDC (current rating)
RoHS status	Compliant

1.5. Pin diagram

RAAYAN MINI PIN DIAGRAM

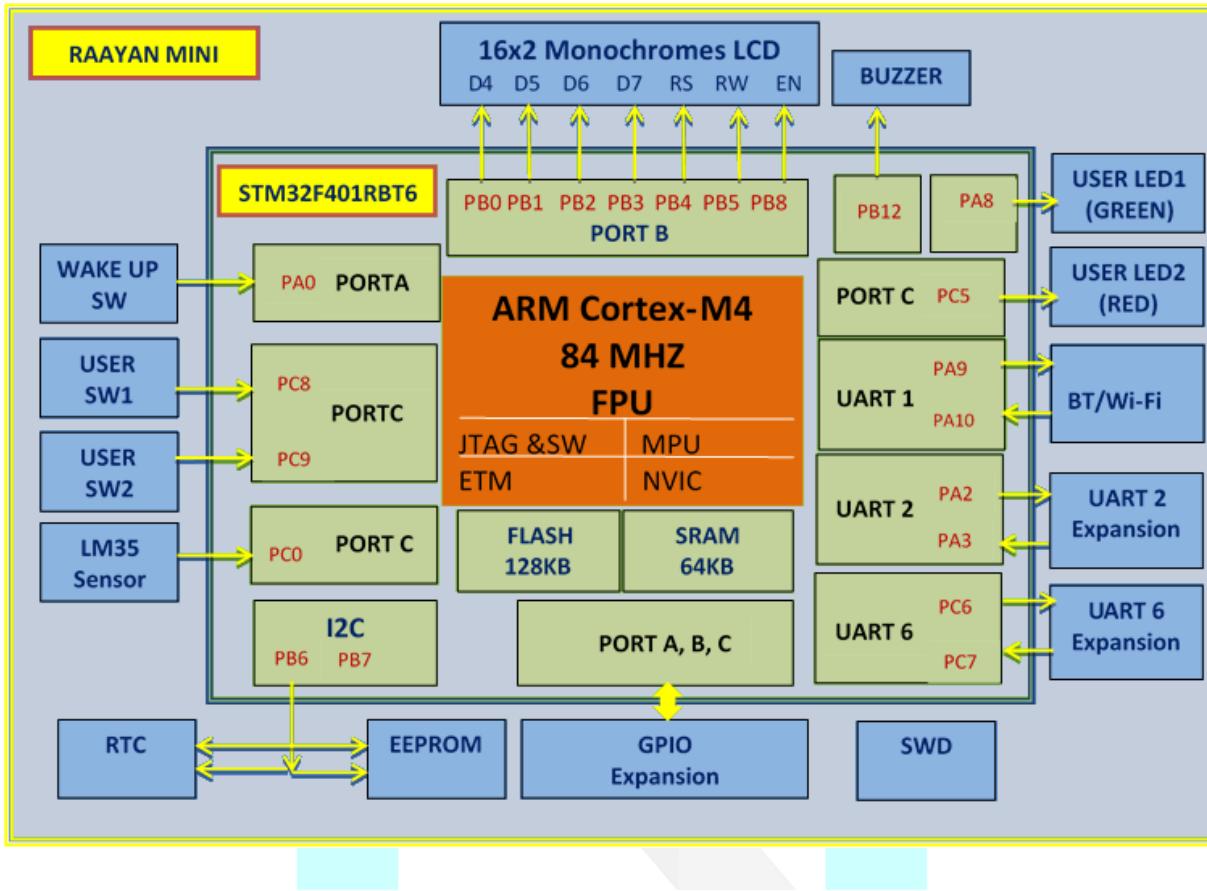


Chapter 2

Hardware Description

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



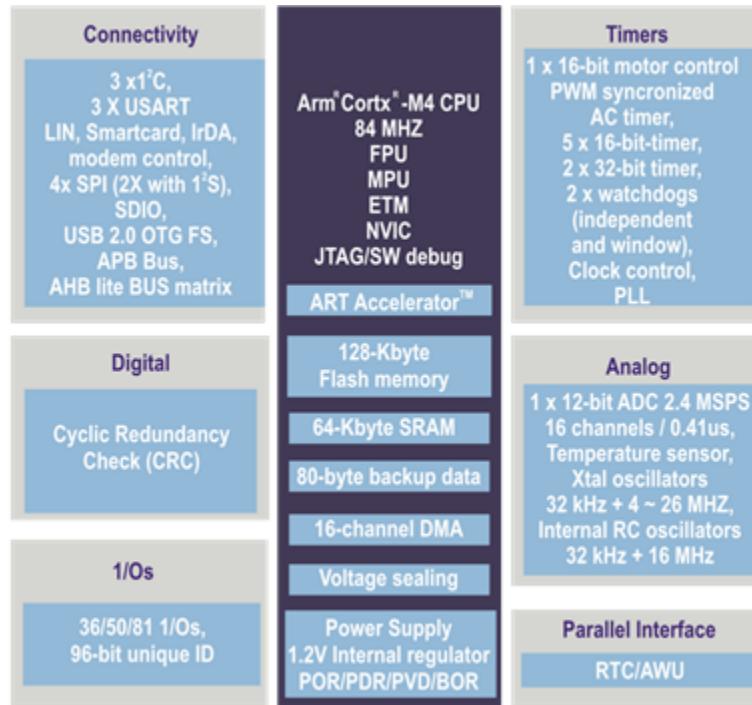
2.1 Functional Description

2.1.1 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 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.

2.1.2 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. SW2, SW3 and SW4 are named SW_ENT(Enter), SW_UP and SW_DN respectively. All these can be used for some purposes in the user's custom application. Table 2-1 shows how these features are connected to the pins on the microcontroller.

Figure 2-3. Raayan Mini STM32F4 Development Board LEDs, Switches and Buzzer schematics

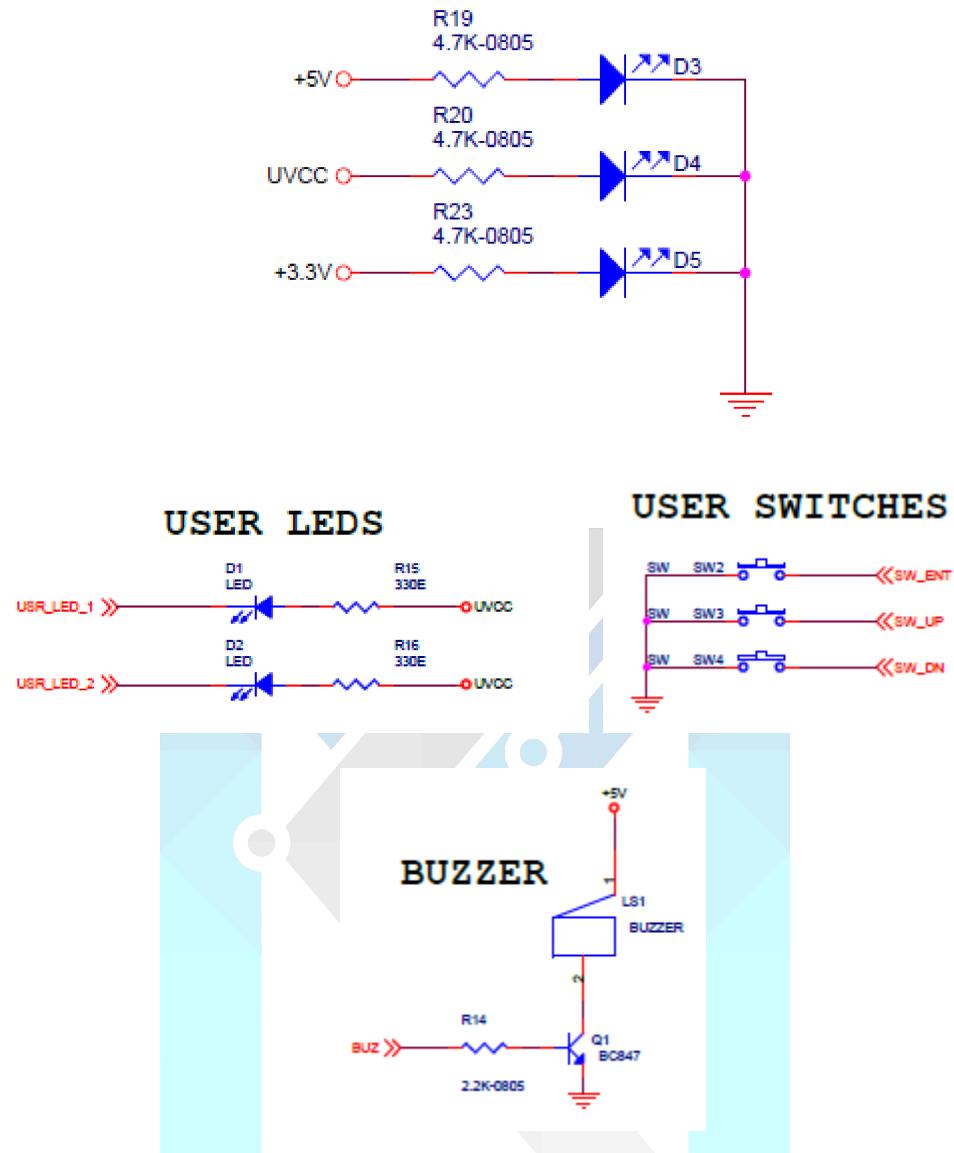


Table 2-1. User Switches, LED and Buzzer signals

GPIO Pin	Pin Function	Device
PA8	GPIO	USR_LED1(Green)
PC5	GPIO	USR_LED2(Red)
PA0	GPIO	SW_ENT(SW2)
PC8	GPIO	SW_UP(SW3)
PC9	GPIO	SW_DN(SW4)
PB12	GPIO	BUZZER

2.1.3 Display

The Raayan Mini STM32F4 Development Board comes with a 16 X 2 Monochrome LCD display that 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 of LCD screen. Table 2-3 shows how these pins are connected to the microcontroller.

Figure 2-4. Raayan Mini STM32F4 Development Board LCD Display schematics

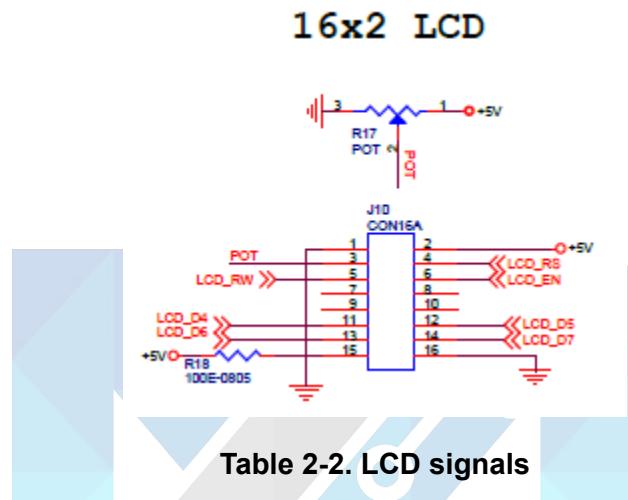


Table 2-2. LCD signals

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

2.1.4 Boot Mode Switch

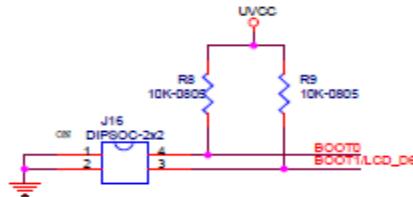
At startup, boot pins are used to select one out of three boot options:

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

Table 2-3. 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

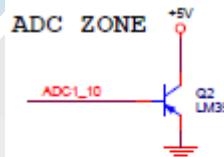
Figure 2-4. Raayan Mini STM32F4 Development Board Boot switch schematics



2.1.5 Analog to Digital Converter

The Raayan Mini Development board have an on-board LM35 temperature sensor. The sensor is internally connected to ADC1_10 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 2-5. Raayan Mini STM32F4 Development Board ADC to LM35 and LCD POT

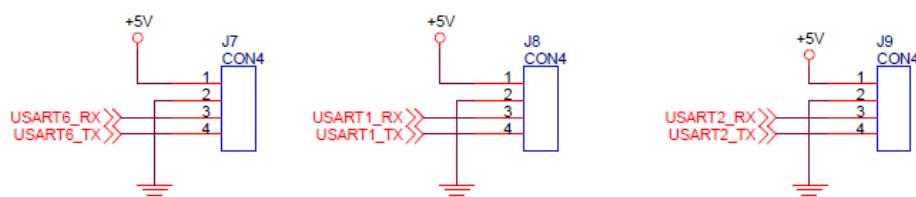


2.1.6 USART Zone

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 UART6, J8 is UART1 and J9 is UART2 respectively. UART1 is directly connected to the BLUETOOTH / Wi-Fi module (ESP8266) provided on the board. These STM32F4 microcontroller, ADC, UART and Bluetooth/Wi-Fi combination can also be used as a platform for making many IoT projects.

Figure 2-6. Raayan Mini STM32F4 Development Board UART schematics

USART OUTPUTS



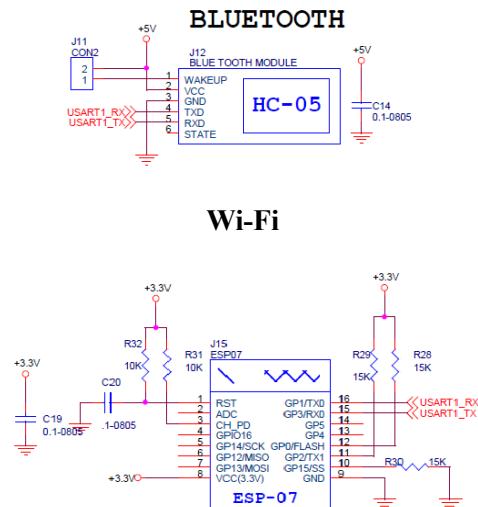


Table 2-4. USART Pin configuration

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

2.1.7 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 2-7. Raayan Mini STM32F4 Development Board I2C schematics

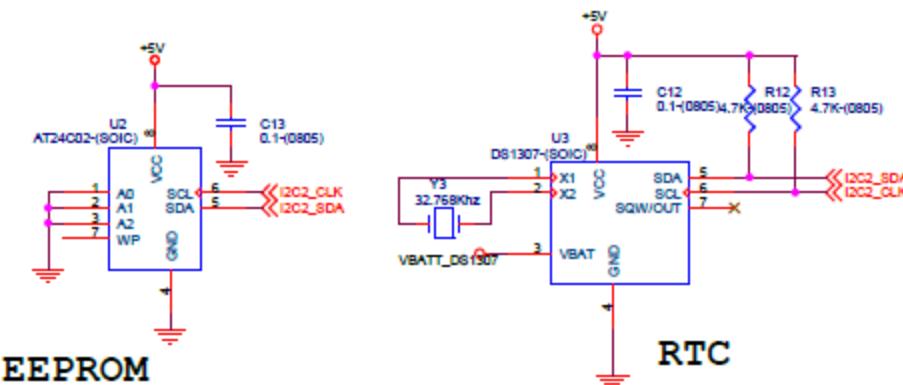


Table 2-5. I2C Pin Configuration

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

2.1.8 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 2-5 shows the pin configuration for SPI.

Table 2-6. 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

2.1.9 Oscillators

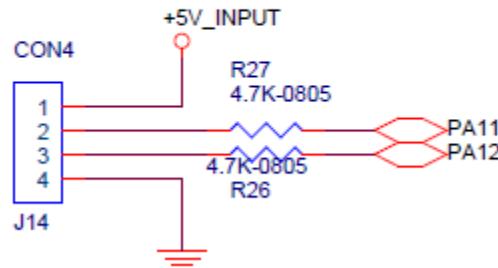
The Raayan Mini STM32F4 Development Board provides an external 32.768-KHz crystal (Y3) as the clock source for external RTC. Another 32.768-KHz crystal (Y2) serves as clock for internal RTC. This board also uses an 8 MHz crystal (Y1) to complete the STM32F401RBT6 microcontroller main internal clock circuit.

2.1.10 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.

Figure 2-8. Raayan Mini STM32F4 Development Board Power supply schematics

POWER SUPPLY



2.1.11 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.

2.1.12 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 for exclusively for RTC.

2.1.13 Expansion Headers

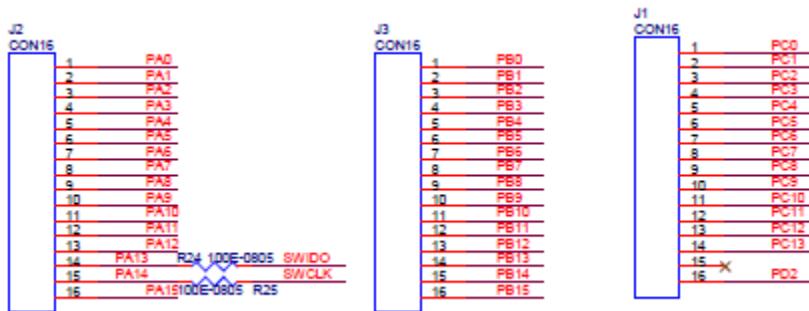
The three rows of stackable headers are mapped to most of the GPIO pins of the STM32F401RBT6 microcontroller. These rows are labeled as connectors J1, J2, and J3. Each pin has to be configured in their respective GPIO Port Mode register as shown below as per your requirement of your project.

Table 2-7. STM32F401 MuX/Pad Configuration

GPIO _I X_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.

Figure 2-9. Raayan Mini STM32F4 Development Board GPIO Header schematics


Table 2-8. J1 Connector

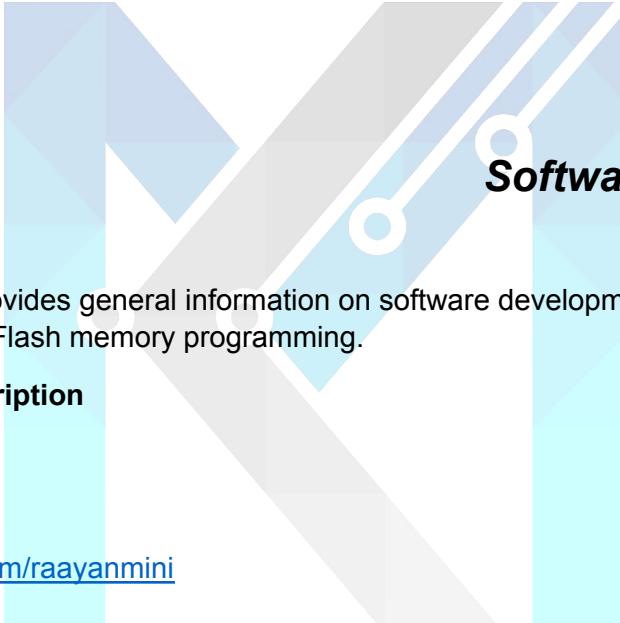
J1 Pin	STM32F4 MCU Pin	Port	GPIO	On-board Function	Analog Function	AF00	AF01	AF02	AF03	AF04	AF05	AF06	AF07	AF08	AF09	AF10	AF11	AF12	AF13	AF14	AF15
						SYS_AF	TIM1/TIM2	TIM3/TIM4 / TIM5	TIM9/TIM10/ TIM11	I2C1/I2C2 /I2C3	SPI1/SPI2/I 2S2/SPI3/I2 S3/SPI4	SPI2/I2S2/S PI3/I2S3	SPI3/I2S3 /USART1 /USART2	USART6	I2C2/I2C3 /USART1 /USART2	OTG1_FS	SDIO				
1.01	8	Port C	PC0	-	ADC1_IN10	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENT OUT		
1.02	9		PC1	-	ADC1_IN11	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENT OUT		
1.03	10		PC2	-	ADC1_IN12	-	-	-	-	-	SPI2_MISO /I2S2_SD	I2S2ext_SD	-	-	-	-	-	-	EVENT OUT		
1.04	11		PC3	-	ADC1_IN13	-	-	-	-	-	SPI2_MOSI /I2S2_SD	-	-	-	-	-	-	EVENT OUT			
1.05	24		PC4	-	ADC1_IN14	-	-	-	-	-	-	-	-	-	-	-	-	EVENT OUT			
1.06	25		PC5	USER_LED_2	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	-	-	-	-	-	-	-	SPI3_SCK/I 2S3_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		PC13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	EVENT OUT			
1.15			NC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
1.16	54	Port D	PD2	-	-	-	-	-	TIM3_ETR	-	-	-	-	-	-	-	SDIO_CMD	-	EVENT OUT		



Table 2-9. J2 Connector



Table 2-10. J3 Connector



Chapter 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.

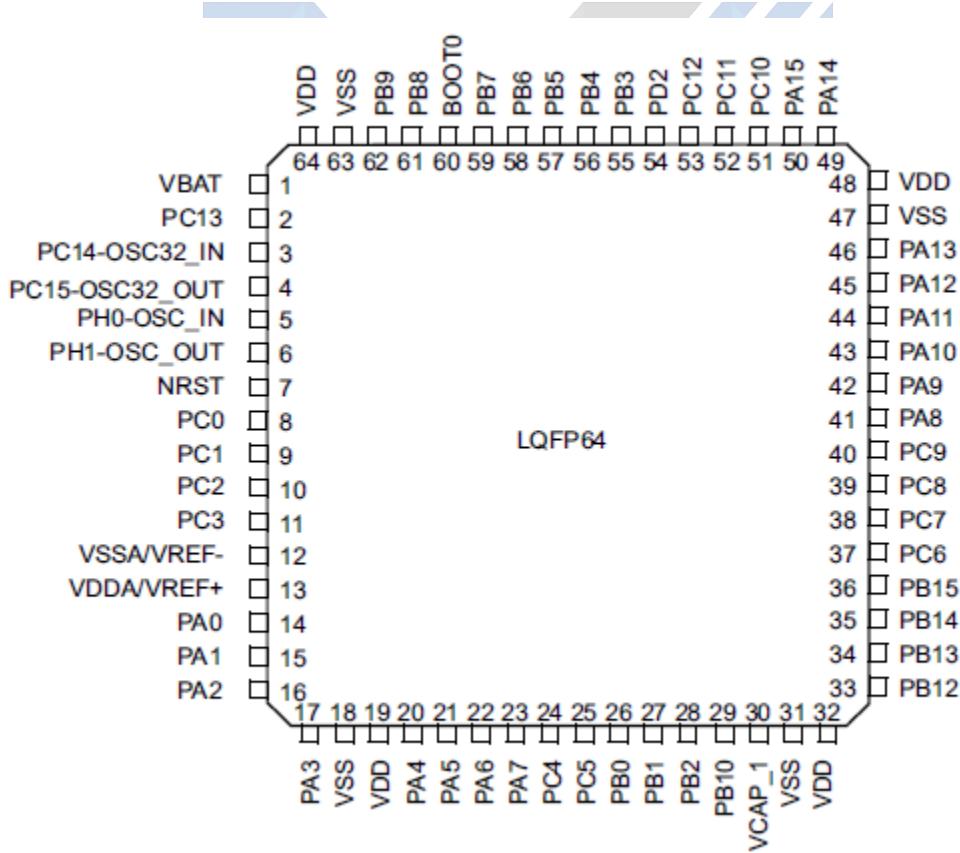
References, PCB Layout, and Bill of Materials

4.1 References

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

4.2 Pin out Diagram

Figure 4-1. Raayan Mini STM32F401RBT6 LQFP64 pin out



4.3 Component Locations

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

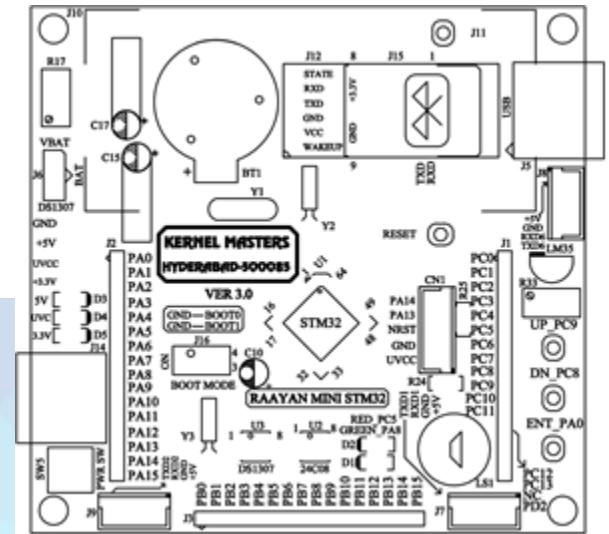


Figure 4-3. Raayan Mini STM32F4 Development Board Component Locations (Bottom View)

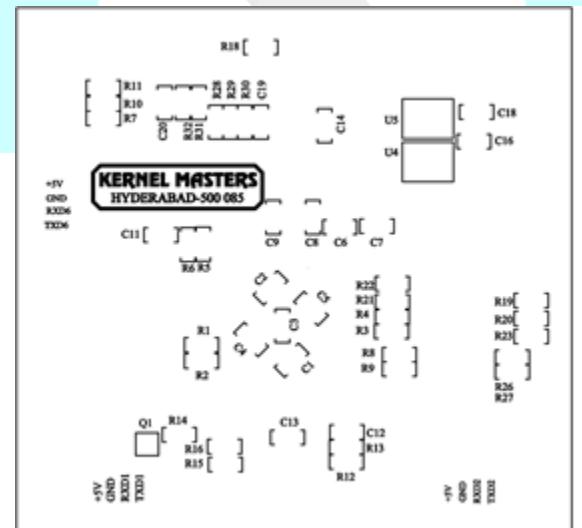
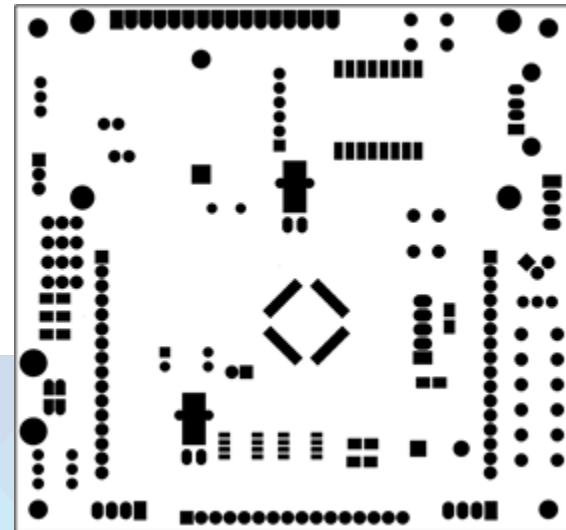


Figure 4-4. Raayan Mini STM32F4 Development Board



4.4 Bill of Materials (BOM)

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

Schematics

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





KERNEL MASTERS

