1. Description

1.1. Project

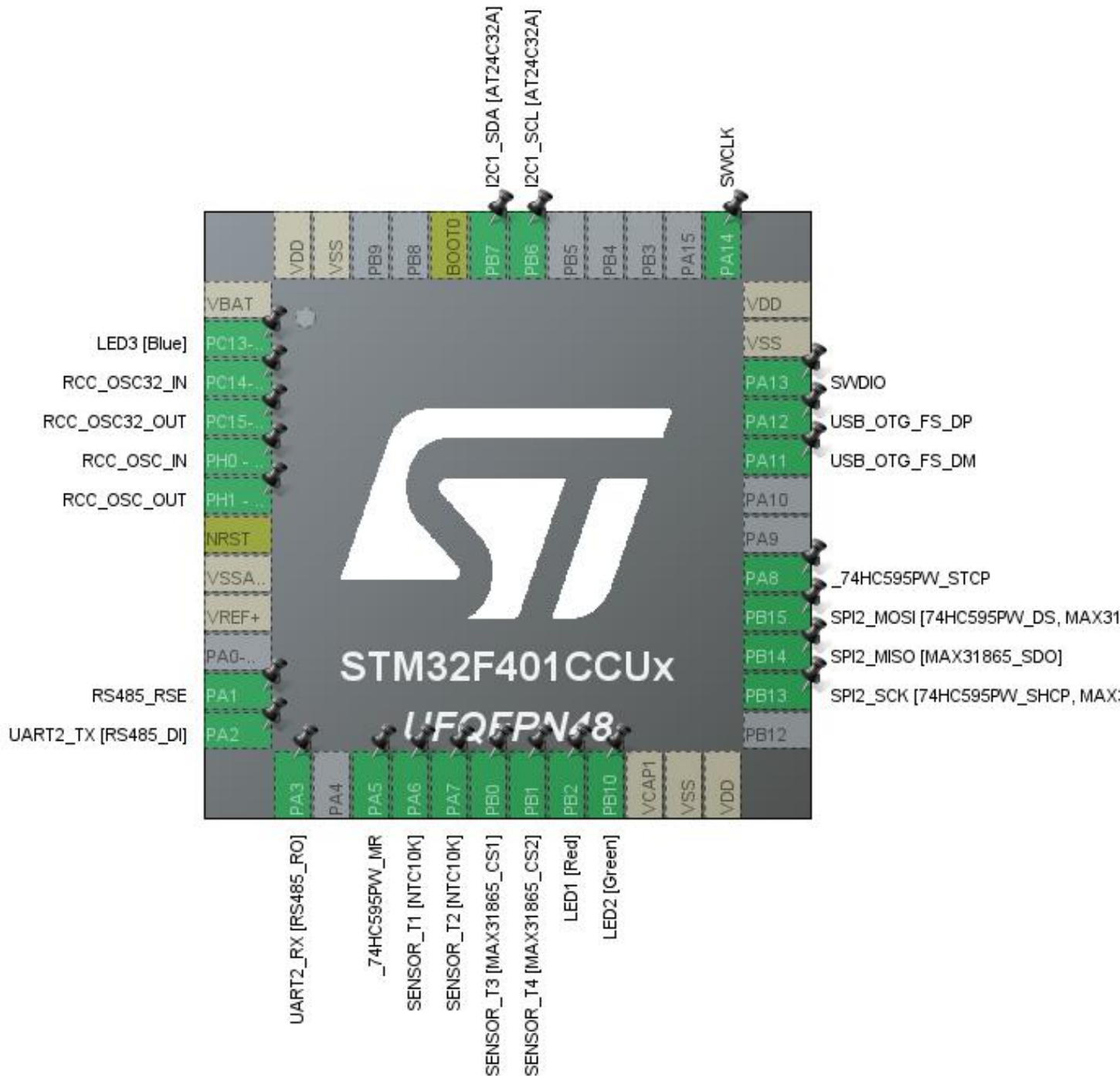|	
Project Name	h-id_heater_sensor_modbus_slave_stm32f401ccu6
Board Name	custom
Generated with:	STM32CubeMX 6.5.0
Date	11/15/2022

1.2. MCU

MCU Series	STM32F4
MCU Line	STM32F401
MCU name	STM32F401CCUx
MCU Package	UFQFPN48
MCU Pin number	48

1.3. Core(s) information

Core(s)	Arm Cortex-M4

2. Pinout Configuration

3. Pins Configuration

Pin Number UFQFPN48	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
1	VBAT	Power		
2	PC13-ANTI_TAMP *	I/O	GPIO_Output	LED3 [Blue]
3	PC14-OSC32_IN	I/O	RCC_OSC32_IN	
4	PC15-OSC32_OUT	I/O	RCC_OSC32_OUT	
5	PH0 - OSC_IN	I/O	RCC_OSC_IN	
6	PH1 - OSC_OUT	I/O	RCC_OSC_OUT	
7	NRST	Reset		
8	VSSA/VREF-	Power		
9	VREF+	Power		
11	PA1 *	I/O	GPIO_Output	RS485_RSE
12	PA2	I/O	USART2_TX	UART2_TX [RS485_DI]
13	PA3	I/O	USART2_RX	UART2_RX [RS485_RO]
15	PA5 *	I/O	GPIO_Output	_74HC595PW_MR
16	PA6	I/O	ADC1_IN6	SENSOR_T1 [NTC10K]
17	PA7	I/O	ADC1_IN7	SENSOR_T2 [NTC10K]
18	PB0 *	I/O	GPIO_Output	SENSOR_T3 [MAX31865_CS1]
19	PB1 *	I/O	GPIO_Output	SENSOR_T4 [MAX31865_CS2]
20	PB2 *	I/O	GPIO_Output	LED1 [Red]
21	PB10 *	I/O	GPIO_Output	LED2 [Green]
22	VCAP1	Power		
23	VSS	Power		
24	VDD	Power		
26	PB13	I/O	SPI2_SCK	SPI2_SCK [74HC595PW_SHCP, MAX31865_SCLK]
27	PB14	I/O	SPI2_MISO	SPI2_MISO [MAX31865_SDO]
28	PB15	I/O	SPI2_MOSI	SPI2_MOSI [74HC595PW_DS, MAX31865_SDI]
29	PA8 *	I/O	GPIO_Output	_74HC595PW_STCP
32	PA11	I/O	USB_OTG_FS_DM	
33	PA12	I/O	USB_OTG_FS_DP	
34	PA13	I/O	SYS_JTMS-SWDIO	SWDIO
35	VSS	Power		

Pin Number UFQFPN48	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
36	VDD	Power		
37	PA14	I/O	SYS_JTCK-SWCLK	SWCLK
42	PB6	I/O	I2C1_SCL	I2C1_SCL [AT24C32A]
43	PB7	I/O	I2C1_SDA	I2C1_SDA [AT24C32A]
44	BOOT0	Boot		
47	VSS	Power		
48	VDD	Power		

 * The pin is affected with an I/O function

4. Clock Tree Configuration
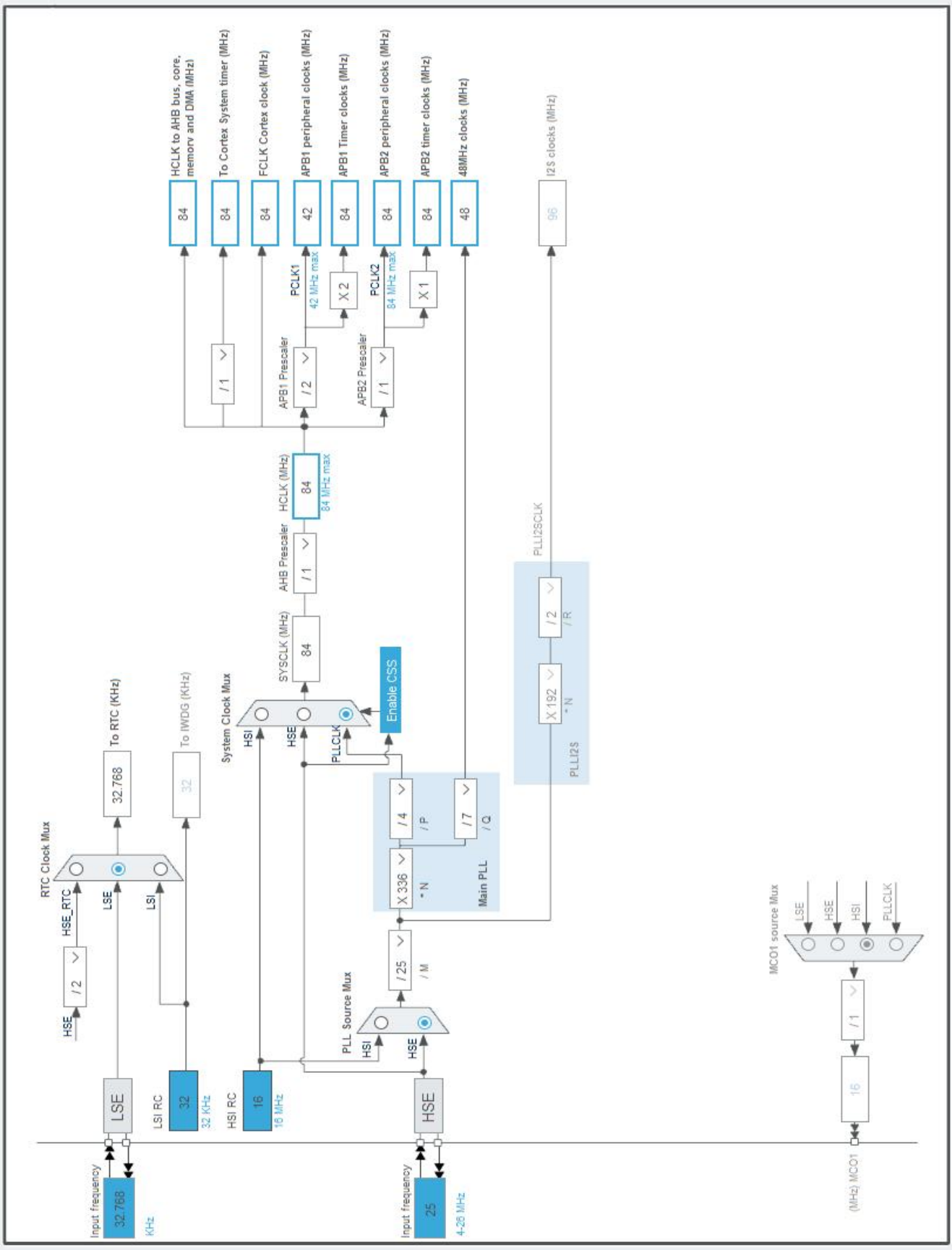
5. Software Project

5.1. Project Settings

Name	Value
Project Name	h-id_heater_sensor_modbus_slave_stm32f401ccu6
Project Folder	C:\Users\Dobord\Documents\h-id_heater_sensor_modbus_slave_stm32f401ccu6
Toolchain / IDE	SW4STM32
Firmware Package Name and Version	STM32Cube FW_F4 V1.27.0
Application Structure	Advanced
Generate Under Root	Yes
Do not generate the main()	No
Minimum Heap Size	0x300
Minimum Stack Size	0x500

5.2. Code Generation Settings

Name	Value
STM32Cube MCU packages and embedded software	Copy only the necessary library files
Generate peripheral initialization as a pair of '.c/.h' files	No
Backup previously generated files when re-generating	No
Keep User Code when re-generating	Yes
Delete previously generated files when not re-generated	Yes
Set all free pins as analog (to optimize the power consumption)	No
Enable Full Assert	No

5.3. Advanced Settings - Generated Function Calls

Rank	Function Name	Peripheral Instance Name
1	MX_GPIO_Init	GPIO
2	MX_DMA_Init	DMA
3	SystemClock_Config	RCC
4	MX_ADC1_Init	ADC1
5	MX_I2C1_Init	I2C1
6	MX_SPI2_Init	SPI2
7	MX_USART2_UART_Init	USART2
8	MX_RTC_Init	RTC
9	MX_USB_DEVICE_Init	USB_DEVICE

6. Power Consumption Calculator report

6.1. Microcontroller Selection

Series	STM32F4
Line	STM32F401
MCU	STM32F401CCUx
Datasheet	DS9716_Rev8

6.2. Parameter Selection

Temperature	25
Vdd	3.3

6.3. Battery Selection

Battery	Li-SOCL2(A3400)
Capacity	3400.0 mAh
Self Discharge	0.08 %/month
Nominal Voltage	3.6 V
Max Cont Current	100.0 mA
Max Pulse Current	200.0 mA
Cells in series	1
Cells in parallel	1

6.4. Sequence

Step	Step1	Step2
Mode	RUN	STOP
Vdd	3.3	3.3
Voltage Source	Battery	Battery
Range	Scale2-Medium	No Scale
Fetch Type	FLASH/ART/PREFETCH	n/a
CPU Frequency	84 MHz	0 Hz
Clock Configuration	HSE PLL	Regulator_LPLV Flash-PwrDwn
Clock Source Frequency	4 MHz	0 Hz
Peripherals		
Additional Cons.	0 mA	0 mA
Average Current	21.2 mA	10 µA
Duration	0.1 ms	0.9 ms
DMIPS	105.0	0.0
Ta Max	102.76	105
Category	In DS Table	In DS Table

6.5. Results

Sequence Time	1 ms	Average Current	2.13 mA
Battery Life	2 months, 5 days, 14 hours	Average DMIPS	105.0 DMIPS

6.6. Chart

Consumption Profile by Step
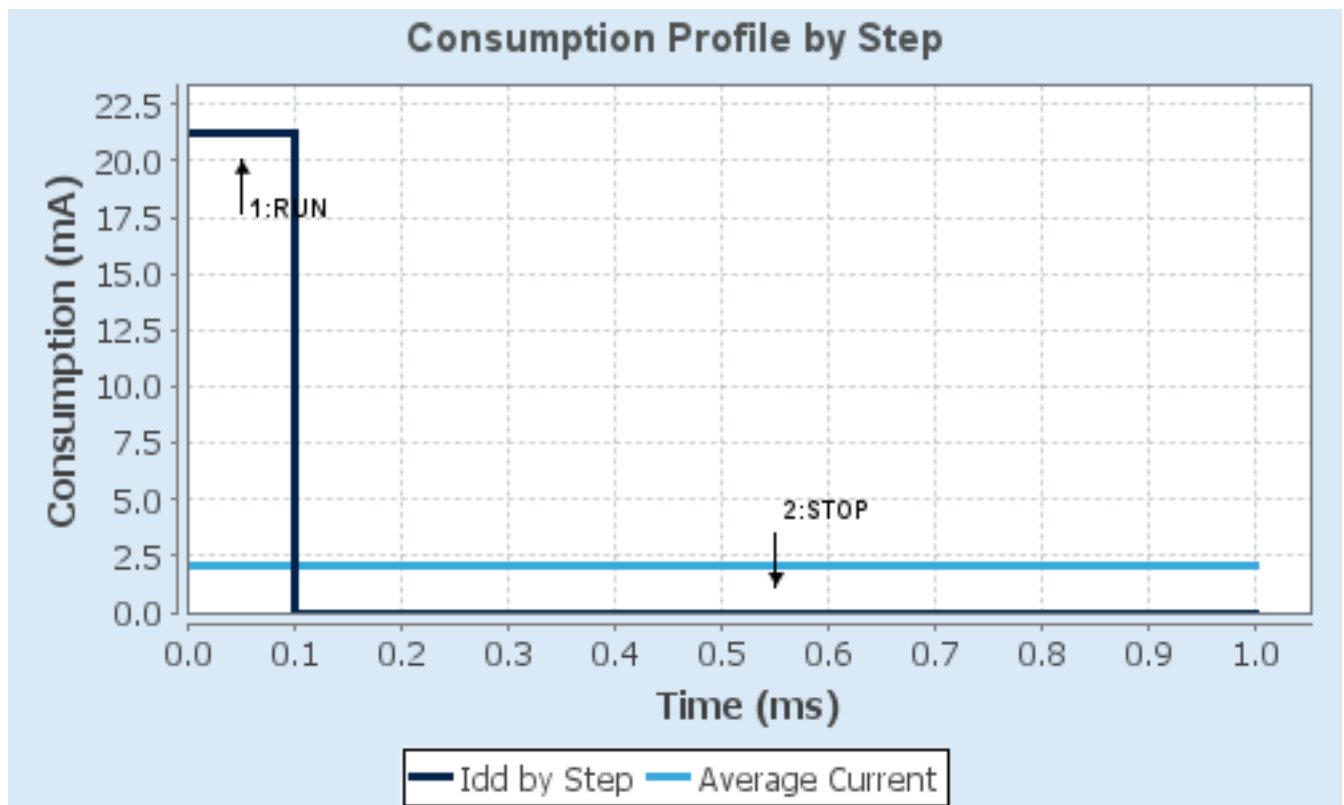
7. Peripherals and Middlewares Configuration

7.1. ADC1

mode: IN6

mode: IN7

mode: Temperature Sensor Channel

mode: Vrefint Channel

7.1.1. Parameter Settings:

ADCs_Common_Settings:

Mode	Independent mode

ADC_Settings:

Clock Prescaler	PCLK2 divided by 4
Resolution	12 bits (15 ADC Clock cycles)
Data Alignment	Right alignment
Scan Conversion Mode	Enabled
Continuous Conversion Mode	**Enabled ***
Discontinuous Conversion Mode	Disabled
DMA Continuous Requests	**Enabled ***
End Of Conversion Selection	**EOC flag at the end of all conversions ***

ADC_Regular_ConversionMode:

Number Of Conversion	**4 ***
External Trigger Conversion Source	Regular Conversion launched by software
External Trigger Conversion Edge	None
Rank	1
Channel	**Channel Vrefint ***
Sampling Time	**480 Cycles ***
Rank	**2 ***
Channel	**Channel Temperature Sensor ***
Sampling Time	**480 Cycles ***
Rank	**3 ***
Channel	Channel 6
Sampling Time	**480 Cycles ***
Rank	**4 ***
Channel	**Channel 7 ***
Sampling Time	**480 Cycles ***

ADC_Injected_ConversionMode:

Number Of Conversions	0

WatchDog:

Enable Analog WatchDog Mode   false

7.2. I2C1
I2C: I2C
7.2.1. Parameter Settings:

Master Features:

I2C Speed Mode   Standard Mode
I2C Clock Speed (Hz)   100000
Slave Features:

Clock No Stretch Mode   Disabled
Primary Address Length selection   7-bit
Dual Address Acknowledged   Disabled
Primary slave address   0
General Call address detection   Disabled

7.3. RCC
High Speed Clock (HSE): Crystal/Ceramic Resonator
Low Speed Clock (LSE) : Crystal/Ceramic Resonator
7.3.1. Parameter Settings:

System Parameters:

VDD voltage (V)   3.3
Instruction Cache   Enabled
Prefetch Buffer   Enabled
Data Cache   Enabled
Flash Latency(WS)   2 WS (3 CPU cycle)
RCC Parameters:

HSI Calibration Value   16
TIM Prescaler Selection   Disabled
HSE Startup Timout Value (ms)   100
LSE Startup Timout Value (ms)   5000
Power Parameters:

Power Regulator Voltage Scale   Power Regulator Voltage Scale 2

7.4. RTC
mode: Activate Clock Source
7.4.1. Parameter Settings:

General:

Hour Format	Hourformat 24
Asynchronous Predivider value	127
Synchronous Predivider value	255

7.5. SPI2
Mode: Full-Duplex Master
7.5.1. Parameter Settings:

Basic Parameters:

Frame Format	Motorola
Data Size	8 Bits
First Bit	MSB First

Clock Parameters:

Prescaler (for Baud Rate)	2
Baud Rate	**21.0 MBits/s ***
Clock Polarity (CPOL)	Low
Clock Phase (CPHA)	1 Edge

Advanced Parameters:

CRC Calculation	Disabled
NSS Signal Type	Software

7.6. SYS
Debug: Serial Wire
Timebase Source: TIM1

7.7. USART2
Mode: Asynchronous
7.7.1. Parameter Settings:

Basic Parameters:

Baud Rate	115200
Word Length	8 Bits (including Parity)
Parity	None
Stop Bits	1

Advanced Parameters:

| Data Direction | Receive and Transmit |
| Over Sampling | 16 Samples |

7.8. USB_OTG_FS
Mode: Device_Only
7.8.1. Parameter Settings:

Speed	Device Full Speed 12MBit/s
Low power	Disabled
Link Power Management	Disabled
VBUS sensing	Disabled
Signal start of frame	Disabled

7.9. FREERTOS
Interface: CMSIS_V2
7.9.1. Config parameters:

API:

| FreeRTOS API | CMSIS v2 |

Versions:

| FreeRTOS version | 10.3.1 |
| CMSIS-RTOS version | 2.00 |

MPU/FPU:

| ENABLE_MPU | Disabled |
| ENABLE_FPU | **Enabled *** |

Kernel settings:

USE_PREEMPTION	Enabled
CPU_CLOCK_HZ	SystemCoreClock
TICK_RATE_HZ	1000
MAX_PRIORITIES	56
MINIMAL_STACK_SIZE	128
MAX_TASK_NAME_LEN	16

USE_16_BIT_TICKS	Disabled
IDLE_SHOULD_YIELD	Enabled
USE_MUTEXES	Enabled
USE_RECURSIVE_MUTEXES	Enabled
USE_COUNTING_SEMAPHORES	Enabled
QUEUE_REGISTRY_SIZE	8
USE_APPLICATION_TASK_TAG	Disabled
ENABLE_BACKWARD_COMPATIBILITY	Enabled
USE_PORT_OPTIMISED_TASK_SELECTION	Disabled
USE_TICKLESS_IDLE	Disabled
USE_TASK_NOTIFICATIONS	Enabled
RECORD_STACK_HIGH_ADDRESS	Disabled

Memory management settings:

Memory Allocation	Dynamic / Static
TOTAL_HEAP_SIZE	**65535 ***
Memory Management scheme	heap_4

Hook function related definitions:

USE_IDLE_HOOK	Disabled
USE_TICK_HOOK	Disabled
USE_MALLOC_FAILED_HOOK	Disabled
USE_DAEMON_TASK_STARTUP_HOOK	Disabled
CHECK_FOR_STACK_OVERFLOW	Disabled

Run time and task stats gathering related definitions:

GENERATE_RUN_TIME_STATS	Disabled
USE_TRACE_FACILITY	Enabled
USE_STATS_FORMATTING_FUNCTIONS	Disabled

Co-routine related definitions:

USE_CO_ROUTINES	Disabled
MAX_CO_ROUTINE_PRIORITIES	2

Software timer definitions:

USE_TIMERS	Enabled
TIMER_TASK_PRIORITY	2
TIMER_QUEUE_LENGTH	10
TIMER_TASK_STACK_DEPTH	256

Interrupt nesting behaviour configuration:

LIBRARY_LOWEST_INTERRUPT_PRIORITY	15
LIBRARY_MAX_SYSCALL_INTERRUPT_PRIORITY	5

Added with 10.2.1 support:

MESSAGE_BUFFER_LENGTH_TYPE	size_t
USE_POSIX_ERRNO	Disabled

CMSIS-RTOS V2 flags:

USE_OS2_THREAD_SUSPEND_RESUME	Enabled
USE_OS2_THREAD_ENUMERATE	Enabled
USE_OS2_EVENTFLAGS_FROM_ISR	Enabled
USE_OS2_THREAD_FLAGS	Enabled
USE_OS2_TIMER	Enabled
USE_OS2_MUTEX	Enabled

7.9.2. Include parameters:

Include definitions:

vTaskPrioritySet	Enabled
uxTaskPriorityGet	Enabled
vTaskDelete	Enabled
vTaskCleanUpResources	Disabled
vTaskSuspend	Enabled
vTaskDelayUntil	Enabled
vTaskDelay	Enabled
xTaskGetSchedulerState	Enabled
xTaskResumeFromISR	Enabled
xQueueGetMutexHolder	Enabled
xSemaphoreGetMutexHolder	Disabled
pcTaskGetTaskName	Disabled
uxTaskGetStackHighWaterMark	Enabled
xTaskGetCurrentTaskHandle	Enabled
eTaskGetState	Enabled
xEventGroupSetBitFromISR	Disabled
xTimerPendFunctionCall	Enabled
xTaskAbortDelay	Disabled
xTaskGetHandle	Disabled
uxTaskGetStackHighWaterMark2	Disabled

7.9.3. Advanced settings:

Newlib settings (see parameter description first):

USE_NEWLIB_REENTRANT	**Enabled ***

Project settings (see parameter description first):

Use FW pack heap file	**Disabled ***

7.10. USB_DEVICE

Class For FS IP: Communication Device Class (Virtual Port Com)

7.10.1. Parameter Settings:

Basic Parameters:

USBD_MAX_NUM_INTERFACES (Maximum number of supported interfaces)	1
USBD_MAX_NUM_CONFIGURATION (Maximum number of supported configuration)	1
USBD_MAX_STR_DESC_SIZ (Maximum size for the string descriptors)	512
USBD_SELF_POWERED (Enabled self power)	Enabled
USBD_DEBUG_LEVEL (USBD Debug Level)	0: No debug message

Class Parameters:

USB CDC Rx Buffer Size	**256 ***
USB CDC Tx Buffer Size	**256 ***

7.10.2. Device Descriptor:

Device Descriptor:

VID (Vendor IDentifier)	1155
LANGID_STRING (Language Identifier)	English(United States)
MANUFACTURER_STRING (Manufacturer Identifier)	STMicroelectronics

Device Descriptor FS:

PID (Product IDentifier)	22336
PRODUCT_STRING (Product Identifier)	STM32 Virtual ComPort
CONFIGURATION_STRING (Configuration Identifier)	CDC Config
INTERFACE_STRING (Interface Identifier)	CDC Interface

* User modified value

8. System Configuration

8.1. GPIO configuration

IP	Pin	Signal	GPIO mode	GPIO pull/up pull down	Max Speed	User Label
ADC1	PA6	ADC1_IN6	Analog mode	No pull-up and no pull-down	n/a	SENSOR_T1 [NTC10K]
	PA7	ADC1_IN7	Analog mode	No pull-up and no pull-down	n/a	SENSOR_T2 [NTC10K]
I2C1	PB6	I2C1_SCL	Alternate Function Open Drain	No pull-up and no pull-down	Very High *	I2C1_SCL [AT24C32A]
	PB7	I2C1_SDA	Alternate Function Open Drain	No pull-up and no pull-down	Very High *	I2C1_SDA [AT24C32A]
RCC	PC14-OSC32_IN	RCC_OSC32_IN	n/a	n/a	n/a	
	PC15-OSC32_OUT	RCC_OSC32_OUT	n/a	n/a	n/a	
	PH0 - OSC_IN	RCC_OSC_IN	n/a	n/a	n/a	
	PH1 - OSC_OUT	RCC_OSC_OUT	n/a	n/a	n/a	
SPI2	PB13	SPI2_SCK	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	SPI2_SCK [74HC595PW_SHCP, MAX31865_SCLK]
	PB14	SPI2_MISO	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	SPI2_MISO [MAX31865_SDO]
	PB15	SPI2_MOSI	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	SPI2_MOSI [74HC595PW_DS, MAX31865_SDI]
SYS	PA13	SYS_JTMS-SWDIO	n/a	n/a	n/a	SWDIO
	PA14	SYS_JTCK-SWCLK	n/a	n/a	n/a	SWCLK
USART2	PA2	USART2_TX	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	UART2_TX [RS485_DI]
	PA3	USART2_RX	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	UART2_RX [RS485_RO]
USB_OTG_FS	PA11	USB_OTG_FS_DM	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	
	PA12	USB_OTG_FS_DP	Alternate Function Push Pull	No pull-up and no pull-down	Very High *	
GPIO	PC13-ANTI_TAMP	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	LED3 [Blue]

IP	Pin	Signal	GPIO mode	GPIO pull/up pull down	Max Speed	User Label
	PA1	GPIO_Output	Output Push Pull	No pull-up and no pull-down	**High** *	RS485_RSE
	PA5	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	_74HC595PW_MR
	PB0	GPIO_Output	Output Push Pull	No pull-up and no pull-down	**High** *	SENSOR_T3 [MAX31865_CS1]
	PB1	GPIO_Output	Output Push Pull	No pull-up and no pull-down	**High** *	SENSOR_T4 [MAX31865_CS2]
	PB2	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	LED1 [Red]
	PB10	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	LED2 [Green]
	PA8	GPIO_Output	Output Push Pull	No pull-up and no pull-down	**High** *	_74HC595PW_STCP

8.2. DMA configuration

DMA request	Stream	Direction	Priority
ADC1	DMA2_Stream0	Peripheral To Memory	Low
USART2_RX	DMA1_Stream5	Peripheral To Memory	**Medium ***
USART2_TX	DMA1_Stream6	Memory To Peripheral	Low

ADC1: DMA2_Stream0 DMA request Settings:

Mode: **Circular ***

Use fifo: **Enable ***

FIFO Threshold: Full

Peripheral Increment: Disable

Memory Increment: **Enable ***

Peripheral Data Width: Half Word

Memory Data Width: Half Word

Peripheral Burst Size: Single

Memory Burst Size: Single

USART2_RX: DMA1_Stream5 DMA request Settings:

Mode: Normal

Use fifo: Disable

Peripheral Increment: Disable

Memory Increment: **Enable ***

Peripheral Data Width: Byte

Memory Data Width: Byte

USART2_TX: DMA1_Stream6 DMA request Settings:

Mode: Normal

Use fifo: Disable

Peripheral Increment: Disable

Memory Increment: **Enable ***

Peripheral Data Width: Byte

Memory Data Width: Byte

8.3. NVIC configuration

8.3.1. NVIC

Interrupt Table	Enable	Preenmption Priority	SubPriority
Non maskable interrupt	true	0	0
Hard fault interrupt	true	0	0
Memory management fault	true	0	0
Pre-fetch fault, memory access fault	true	0	0
Undefined instruction or illegal state	true	0	0
System service call via SWI instruction	true	0	0
Debug monitor	true	0	0
Pendable request for system service	true	15	0
System tick timer	true	15	0
DMA1 stream5 global interrupt	true	5	0
DMA1 stream6 global interrupt	true	5	0
ADC1 global interrupt	true	5	0
TIM1 update interrupt and TIM10 global interrupt	true	15	0
USART2 global interrupt	true	5	0
DMA2 stream0 global interrupt	true	5	0
USB On The Go FS global interrupt	true	5	0
PVD interrupt through EXTI line 16	unused		
Flash global interrupt	unused		
RCC global interrupt	unused		
I2C1 event interrupt	unused		
I2C1 error interrupt	unused		
SPI2 global interrupt	unused		
FPU global interrupt	unused		

8.3.2. NVIC Code generation

Enabled interrupt Table	Select for init sequence ordering	Generate IRQ handler	Call HAL handler
Non maskable interrupt	false	true	false
Hard fault interrupt	false	true	false
Memory management fault	false	true	false
Pre-fetch fault, memory access fault	false	true	false
Undefined instruction or illegal state	false	true	false
System service call via SWI instruction	false	false	false
Debug monitor	false	true	false
Pendable request for system service	false	false	false
System tick timer	false	false	true

Enabled interrupt Table	Select for init sequence ordering	Generate IRQ handler	Call HAL handler
DMA1 stream5 global interrupt	false	true	true
DMA1 stream6 global interrupt	false	true	true
ADC1 global interrupt	false	true	true
TIM1 update interrupt and TIM10 global interrupt	false	true	true
USART2 global interrupt	false	true	true
DMA2 stream0 global interrupt	false	true	true
USB On The Go FS global interrupt	false	true	true

* User modified value

9. System Views

9.1. Category view

9.1.1. Current

10. Docs & Resources

Type	Link
Presentations	https://www.st.com/resource/en/product_presentation/stm32-stm8_embedded_software_solutions.pdf
Presentations	https://www.st.com/resource/en/product_presentation/stm32_eval-tools_portfolio.pdf
Presentations	https://www.st.com/resource/en/product_presentation/stm32_stm8_functional-safety-packages.pdf
Presentations	https://www.st.com/resource/en/product_presentation/stm32-stm8_software_development_tools.pdf
Training Material	https://www.st.com/resource/en/sales_guide/sg_sc2154.pdf
Flyers	https://www.st.com/resource/en/flyer/flnucleolrwan.pdf
Flyers	https://www.st.com/resource/en/flyer/flstm32f4x1.pdf
Flyers	https://www.st.com/resource/en/flyer/flstm32nucleo.pdf
Flyers	https://www.st.com/resource/en/flyer/flstmcsuite.pdf
Flyers	https://www.st.com/resource/en/flyer/flstm32trust.pdf
Product Certifications	https://www.st.com/resource/en/certification_document/stm32_authentication_can.pdf
Application Notes	https://www.st.com/resource/en/application_note/an1181-electrostatic-discharge-sensitivity-measurement-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an1709-emc-design-guide-for-stm8-stm32-and-legacy-mcus-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an2606-stm32-microcontroller-system-memory-boot-mode-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an2639-soldering-recommendations-and-package-information-for-leadfree-ecopack-mcus-and-mpus-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an2834-how-to-get-the-best-adc-accuracy-in-stm32-microcontrollers-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an2867-oscillator-design-guide-for-stm8afals-stm32-mcus-and-mpus-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an2945-stm8s-and-
stm32-mcus-a-consistent-832bit-product-line-for-painless-migration-
stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an3070-managing-the-
driver-enable-signal-for-rs485-and-iolink-communications-with-the-
stm32s-usart-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an3126-audio-and-
waveform-generation-using-the-dac-in-stm32-products-
stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an3154-can-protocol-
used-in-the-stm32-bootloader-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an3155-usart-protocol-
used-in-the-stm32-bootloader-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an3156-usb-dfu-
protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an3364-migration-and-
compatibility-guidelines-for-stm32-microcontroller-applications-
stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an3997-audio-playback-
and-recording-using-the-stm32f4discovery-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an3998-pdm-audio-
software-decoding-on-stm32-microcontrollers-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4013-stm32-
crossseries-timer-overview-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4031-using-the-
stm32f2-stm32f4-and-stm32f7-series-dma-controller-
stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4221-i2c-protocol-
used-in-the-stm32-bootloader-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4229-how-to-
implement-a-vocoder-solution-using-stm32-microcontrollers-
stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4230-stm32-

microcontroller-random-number-generation-validation-using-the-nist-statistical-test-suite-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4277-using-stm32-device-pwm-shutdown-features-for-motor-control-and-digital-power-conversion-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4286-spi-protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf

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