STM32 CubeMX

1. Description

1.1. Project

Project Name	robotic_arm
Board Name	NUCLEO-F446RE
Generated with:	STM32CubeMX 6.12.1
Date	03/21/2025

1.2. MCU

MCU Series	STM32F4
MCU Line	STM32F446
MCU name	STM32F446RETx
MCU Package	LQFP64
MCU Pin number	64

1.3. Core(s) information

Core(s)	Arm Cortex-M4

2. Pinout Configuration
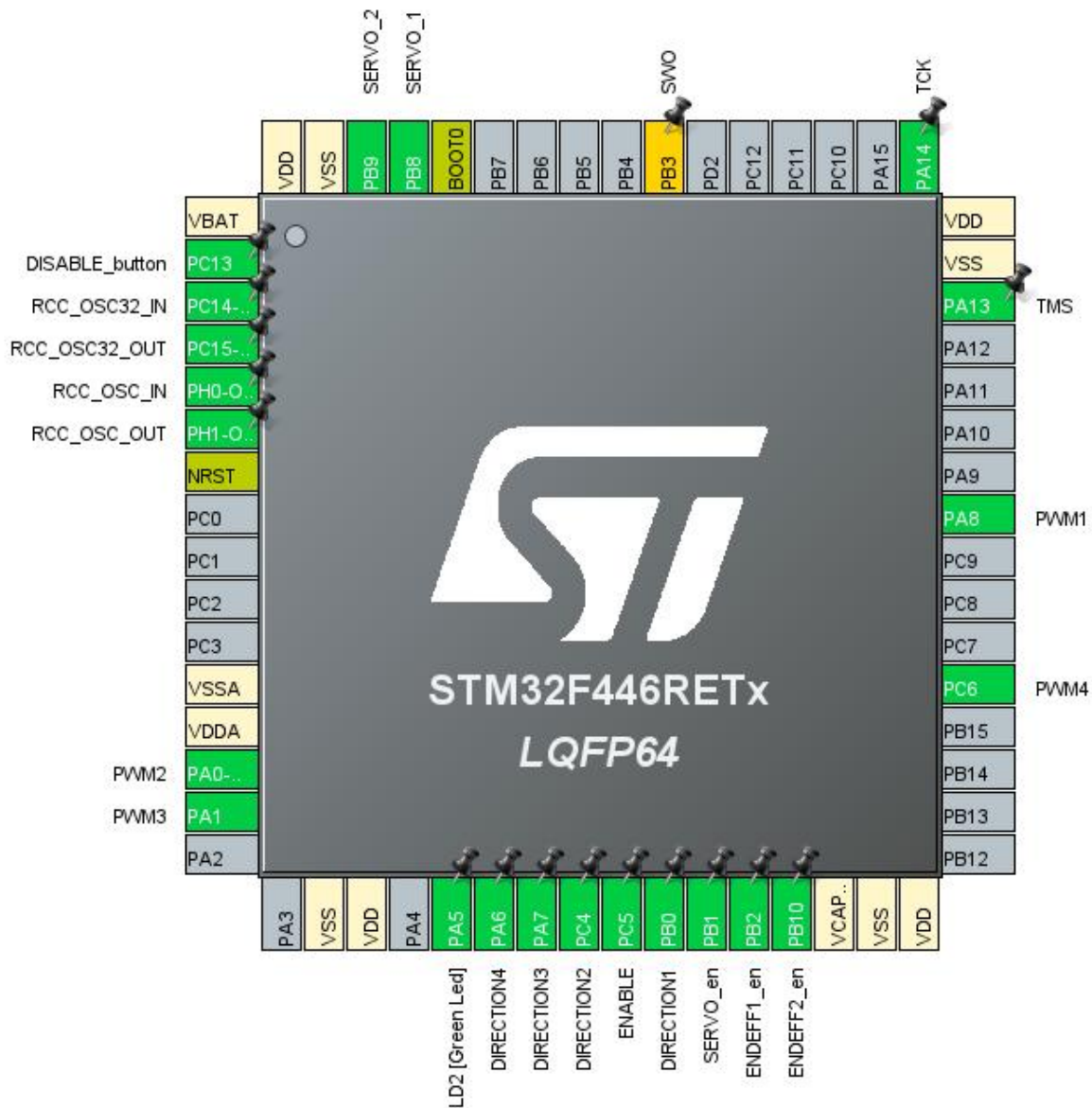
3. Pins Configuration

Pin Number LQFP64	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
1	VBAT	Power		
2	PC13	I/O	GPIO_EXTI13	DISABLE_button
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		
12	VSSA	Power		
13	VDDA	Power		
14	PA0-WKUP	I/O	TIM2_CH1	PWM2
15	PA1	I/O	TIM2_CH2	PWM3
18	VSS	Power		
19	VDD	Power		
21	PA5 *	I/O	GPIO_Output	LD2 [Green Led]
22	PA6 *	I/O	GPIO_Output	DIRECTION4
23	PA7 *	I/O	GPIO_Output	DIRECTION3
24	PC4 *	I/O	GPIO_Output	DIRECTION2
25	PC5 *	I/O	GPIO_Output	ENABLE
26	PB0 *	I/O	GPIO_Output	DIRECTION1
27	PB1 *	I/O	GPIO_Output	SERVO_en
28	PB2 *	I/O	GPIO_Output	ENDEFF1_en
29	PB10 *	I/O	GPIO_Output	ENDEFF2_en
30	VCAP_1	Power		
31	VSS	Power		
32	VDD	Power		
37	PC6	I/O	TIM8_CH1	PWM4
41	PA8	I/O	TIM1_CH1	PWM1
46	PA13	I/O	SYS_JTMS-SWDIO	TMS
47	VSS	Power		
48	VDD	Power		
49	PA14	I/O	SYS_JTCK-SWCLK	TCK
55	PB3 **	I/O	SYS_JTDO-SWO	SWO
60	BOOT0	Boot		
61	PB8	I/O	TIM10_CH1	SERVO_1
62	PB9	I/O	TIM11_CH1	SERVO_2
63	VSS	Power		

Pin Number LQFP64	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
64	VDD	Power		

 * The pin is affected with an I/O function

** The pin is affected with a peripheral function but no peripheral mode is activated

4. Clock Tree Configuration
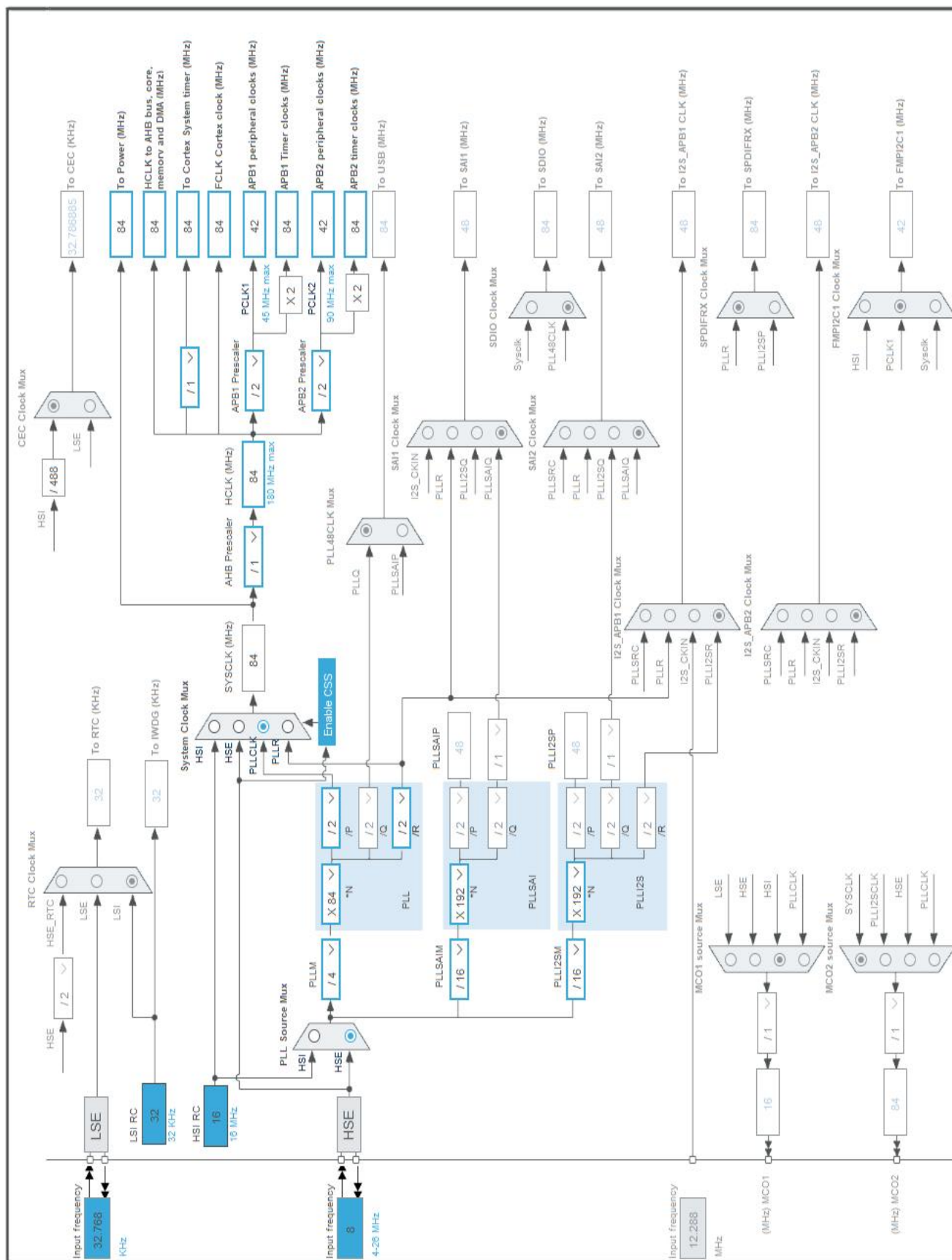
1. Power Consumption Calculator report

1.1. Microcontroller Selection

Series	STM32F4
Line	STM32F446
MCU	STM32F446RETx
Datasheet	DS10693_Rev6

1.2. Parameter Selection

Temperature	25
Vdd	3.3

1.3. 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

1.4. Sequence

Step	Step1	Step2
Mode	RUN	STOP_UDM (Under Drive)
Vdd	3.3	3.3
Voltage Source	Battery	Battery
Range	Scale1-High	No Scale
Fetch Type	RAM/FLASH/REGON/ART/PREFETCH	n/a
CPU Frequency	180 MHz	0 Hz
Clock Configuration	HSE PLL	Regulator_LP Flash-PwrDwn
Clock Source Frequency	4 MHz	0 Hz
Peripherals		
Additional Cons.	0 mA	0 mA
Average Current	46 mA	55 µA
Duration	0.1 ms	0.9 ms
DMIPS	225.0	0.0
Ta Max	98.02	104.99
Category	In DS Table	In DS Table

1.5. Results

Sequence Time	1 ms	Average Current	4.65 mA
Battery Life	1 month	Average DMIPS	225.0 DMIPS

1.6. Chart

Consumption Profile by Step
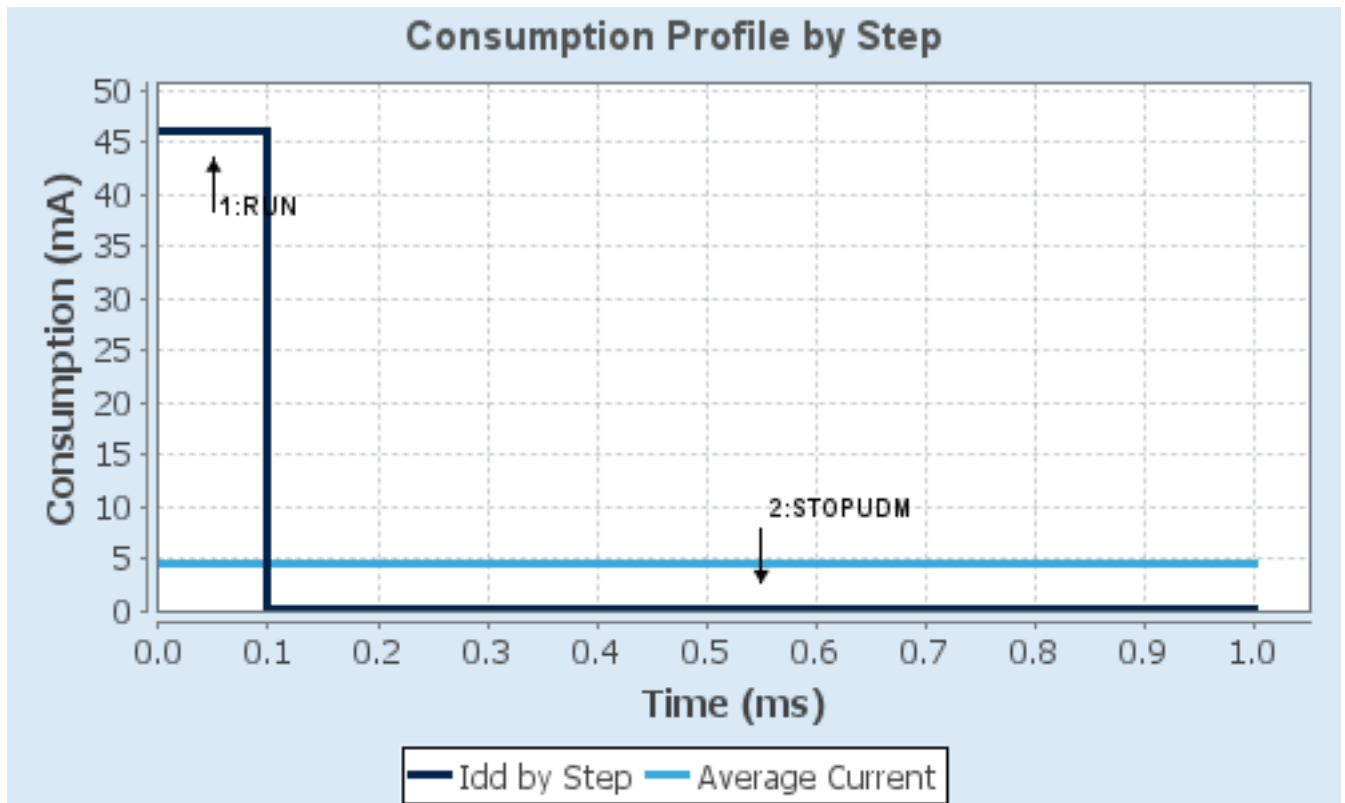
2. Software Project

2.1. Project Settings

Name	Value
Project Name	robotic_arm
Project Folder	C:\Users\david\Desktop\v1.0_gripper\Main\robotic_arm
Toolchain / IDE	STM32CubeIDE
Firmware Package Name and Version	STM32Cube FW_F4 V1.28.1
Application Structure	Advanced
Generate Under Root	Yes
Do not generate the main()	No
Minimum Heap Size	0x200
Minimum Stack Size	0x400

2.2. 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	Yes
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

2.3. Advanced Settings - Generated Function Calls

Rank	Function Name	Peripheral Instance Name
1	SystemClock_Config	RCC
2	MX_GPIO_Init	GPIO
3	MX_TIM3_Init	TIM3
4	MX_TIM5_Init	TIM5
5	MX_TIM1_Init	TIM1
6	MX_TIM2_Init	TIM2
7	MX_TIM4_Init	TIM4
8	MX_TIM8_Init	TIM8
9	MX_TIM10_Init	TIM10
10	MX_TIM11_Init	TIM11
11	MX_TIM6_Init	TIM6

3. Peripherals and Middlewares Configuration

3.1. RCC

High Speed Clock (HSE): Crystal/Ceramic Resonator

Low Speed Clock (LSE) : Crystal/Ceramic Resonator

3.1.1. 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 3
Power Over Drive	Disabled

3.2. SYS

Debug: Serial Wire

Timebase Source: SysTick

3.3. TIM1

Clock Source   : Internal Clock

Channel1: PWM Generation CH1

3.3.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	**4 ***
Counter Mode	Up
Counter Period (AutoReload Register - 16 bits value)	65535
Internal Clock Division (CKD)	No Division
Repetition Counter (RCR - 8 bits value)	0
auto-reload preload	**Enable ***

Trigger Output (TRGO) Parameters:

Master/Slave Mode (MSM bit)	**Enable (Trigger delayed for master/slaves simultaneous start) ***
Trigger Event Selection	**Update Event ***

Break And Dead Time management - BRK Configuration:

BRK State	Disable
BRK Polarity	High

Break And Dead Time management - Output Configuration:

Automatic Output State	Disable
Off State Selection for Run Mode (OSSR)	Disable
Off State Selection for Idle Mode (OSSI)	Disable
Lock Configuration	Off

PWM Generation Channel 1:

Mode	PWM mode 1
Pulse (16 bits value)	**32768 ***
Output compare preload	Enable
Fast Mode	**Enable ***
CH Polarity	High
CH Idle State	Reset

3.4. TIM2
Clock Source   : Internal Clock
Channel1: PWM Generation CH1
Channel2: PWM Generation CH2
3.4.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	**4 ***
Counter Mode	Up
Counter Period (AutoReload Register - 32 bits value)	**65535 ***
Internal Clock Division (CKD)	No Division
auto-reload preload	**Enable ***

Trigger Output (TRGO) Parameters:

Master/Slave Mode (MSM bit)	**Enable (Trigger delayed for master/slaves simultaneous start) ***
Trigger Event Selection	**Update Event ***

PWM Generation Channel 1:

Mode	PWM mode 1
Pulse (32 bits value)	**32768 ***
Output compare preload	Enable
Fast Mode	**Enable ***
CH Polarity	High

PWM Generation Channel 2:

Mode	PWM mode 1
Pulse (32 bits value)	**32768 ***
Output compare preload	Enable
Fast Mode	**Enable ***
CH Polarity	High

3.5. TIM3
Slave Mode: Trigger Mode
Trigger Source: ITR1
Clock Source   : Internal Clock

3.5.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	**65535 ***
Counter Mode	Up
Counter Period (AutoReload Register - 16 bits value)	**199 ***
Internal Clock Division (CKD)	No Division
auto-reload preload	**Enable ***
Slave Mode Controller	Trigger Mode

Trigger Output (TRGO) Parameters:

Master/Slave Mode (MSM bit)	Disable (Trigger input effect not delayed)
Trigger Event Selection	Reset (UG bit from TIMx_EGR)

3.6. TIM4
Slave Mode: Trigger Mode
Trigger Source: ITR0
mode: Clock Source

3.6.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	**65535 ***
Counter Mode	Up
Counter Period (AutoReload Register - 16 bits value)	**199 ***
Internal Clock Division (CKD)	No Division
auto-reload preload	**Enable ***
Slave Mode Controller	Trigger Mode

Trigger Output (TRGO) Parameters:

Master/Slave Mode (MSM bit)	Disable (Trigger input effect not delayed)
Trigger Event Selection	Reset (UG bit from TIMx_EGR)

3.7. TIM5
Slave Mode: Trigger Mode
Trigger Source: ITR3
mode: Clock Source
3.7.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	**65535 ***
Counter Mode	Up
Counter Period (AutoReload Register - 32 bits value)	**199 ***
Internal Clock Division (CKD)	No Division
auto-reload preload	Disable
Slave Mode Controller	Trigger Mode

Trigger Output (TRGO) Parameters:

Master/Slave Mode (MSM bit)	Disable (Trigger input effect not delayed)
Trigger Event Selection	Reset (UG bit from TIMx_EGR)

3.8. TIM6
mode: Activated
3.8.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	**27 ***
Counter Mode	Up
Counter Period (AutoReload Register - 16 bits value)	**1400 ***
auto-reload preload	Disable

Trigger Output (TRGO) Parameters:

Trigger Event Selection	Reset (UG bit from TIMx_EGR)

3.9. TIM8
Clock Source   : Internal Clock
Channel1: PWM Generation CH1
3.9.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	**4 ***
Counter Mode	Up
Counter Period (AutoReload Register - 16 bits value)	65535
Internal Clock Division (CKD)	No Division
Repetition Counter (RCR - 8 bits value)	0
auto-reload preload	**Enable ***

Trigger Output (TRGO) Parameters:

Master/Slave Mode (MSM bit)	**Enable (Trigger delayed for master/slaves simultaneous start) ***
Trigger Event Selection	**Update Event ***

Break And Dead Time management - BRK Configuration:

BRK State	Disable
BRK Polarity	High

Break And Dead Time management - Output Configuration:

Automatic Output State	Disable
Off State Selection for Run Mode (OSSR)	Disable
Off State Selection for Idle Mode (OSSI)	Disable
Lock Configuration	Off

PWM Generation Channel 1:

Mode	PWM mode 1
Pulse (16 bits value)	**32768 ***
Output compare preload	Enable
Fast Mode	**Enable ***
CH Polarity	High
CH Idle State	Reset

3.10. TIM10
mode: Activated
Channel1: PWM Generation CH1
3.10.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	0
Counter Mode	Up
Counter Period (AutoReload Register - 16 bits value)	65535
Internal Clock Division (CKD)	No Division
auto-reload preload	**Enable ***

PWM Generation Channel 1:

Mode	PWM mode 1
Pulse (16 bits value)	**1 ***
Output compare preload	Enable
Fast Mode	**Enable ***
CH Polarity	High

3.11. TIM11
mode: Activated
Channel1: PWM Generation CH1
3.11.1. Parameter Settings:

Counter Settings:

Prescaler (PSC - 16 bits value)	0
Counter Mode	Up
Counter Period (AutoReload Register - 16 bits value)	65535
Internal Clock Division (CKD)	No Division
auto-reload preload	**Enable ***

PWM Generation Channel 1:

|	
Mode	PWM mode 1
Pulse (16 bits value)	**1 ***
Output compare preload	Enable
Fast Mode	**Enable ***
CH Polarity	High

* User modified value

4. System Configuration

4.1. GPIO configuration

IP	Pin	Signal	GPIO mode	GPIO pull/up pull down	Max Speed	User Label
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	
SYS	PA13	SYS_JTMS-SWDIO	n/a	n/a	n/a	TMS
	PA14	SYS_JTCK-SWCLK	n/a	n/a	n/a	TCK
TIM1	PA8	TIM1_CH1	Alternate Function Push Pull	No pull-up and no pull-down	Low	PWM1
TIM2	PA0-WKUP	TIM2_CH1	Alternate Function Push Pull	No pull-up and no pull-down	Low	PWM2
	PA1	TIM2_CH2	Alternate Function Push Pull	No pull-up and no pull-down	Low	PWM3
TIM8	PC6	TIM8_CH1	Alternate Function Push Pull	No pull-up and no pull-down	Low	PWM4
TIM10	PB8	TIM10_CH1	Alternate Function Push Pull	No pull-up and no pull-down	Low	SERVO_1
TIM11	PB9	TIM11_CH1	Alternate Function Push Pull	No pull-up and no pull-down	Low	SERVO_2
Single Mapped Signals	PB3	SYS_JTDO-SWO	n/a	n/a	n/a	SWO
GPIO	PC13	GPIO_EXTI13	External Interrupt Mode with Rising edge trigger detection	No pull-up and no pull-down	n/a	DISABLE_button
	PA5	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	LD2 [Green Led]
	PA6	GPIO_Output	Output Push Pull	**Pull-down ***	Low	DIRECTION4
	PA7	GPIO_Output	Output Push Pull	**Pull-down ***	Low	DIRECTION3
	PC4	GPIO_Output	Output Push Pull	**Pull-down ***	Low	DIRECTION2
	PC5	GPIO_Output	Output Push Pull	**Pull-up ***	**High ***	ENABLE
	PB0	GPIO_Output	Output Push Pull	**Pull-down ***	Low	DIRECTION1
	PB1	GPIO_Output	Output Push Pull	**Pull-down ***	Low	SERVO_en
	PB2	GPIO_Output	Output Push Pull	**Pull-up ***	Low	ENDEFF1_en
	PB10	GPIO_Output	Output Push Pull	**Pull-up ***	Low	ENDEFF2_en

4.2. DMA configuration

nothing configured in DMA service

4.3. NVIC configuration

4.3.1. 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	0	0
System tick timer	true	0	0
TIM1 capture compare interrupt	true	1	0
TIM2 global interrupt	true	1	0
EXTI line[15:10] interrupts	true	0	0
TIM8 break interrupt and TIM12 global interrupt	true	1	0
TIM8 update interrupt and TIM13 global interrupt	true	1	0
TIM8 trigger and commutation interrupts and TIM14 global interrupt	true	1	0
TIM8 capture compare interrupt	true	1	0
TIM6 global interrupt and DAC1, DAC2 underrun error interrupts	true	0	0
PVD interrupt through EXTI line 16	unused		
Flash global interrupt	unused		
RCC global interrupt	unused		
TIM1 break interrupt and TIM9 global interrupt	unused		
TIM1 update interrupt and TIM10 global interrupt	unused		
TIM1 trigger and commutation interrupts and TIM11 global interrupt	unused		
TIM3 global interrupt	unused		
TIM4 global interrupt	unused		
TIM5 global interrupt	unused		
FPU global interrupt	unused		

4.3.2. 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

Enabled interrupt Table	Select for init sequence ordering	Generate IRQ handler	Call HAL handler
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	true	false
Debug monitor	false	true	false
Pendable request for system service	false	true	false
System tick timer	false	true	true
TIM1 capture compare interrupt	false	true	true
TIM2 global interrupt	false	true	true
EXTI line[15:10] interrupts	false	true	true
TIM8 break interrupt and TIM12 global interrupt	false	true	true
TIM8 update interrupt and TIM13 global interrupt	false	true	true
TIM8 trigger and commutation interrupts and TIM14 global interrupt	false	true	true
TIM8 capture compare interrupt	false	true	true
TIM6 global interrupt and DAC1, DAC2 underrun error interrupts	false	true	true

* User modified value

5. System Views

5.1. Category view

5.1.1. Current

Middleware

System Core	Analog	Timers	Connectivity	Multimedia	Computing
DMA		TIM1 ✓			
GPIO ⚠		TIM2 ✓			
NVIC ✓		TIM3 ✓			
RCC ✓		TIM4 ✓			
SYS ✓		TIM5 ✓			
		TIM6 ✓			
		TIM8 ✓			
		TIM10 ✓			
		TIM11 ✓			

6. Docs & Resources

Type	Link
BSDL files	https://www.st.com/resource/en/bsdl_model/stm32f446_bsdl.zip
IBIS models	https://www.st.com/resource/en/ibis_model/stm32f446_ibis.zip
System View Description	https://www.st.com/resource/en/svd/stm32f4-svd.zip
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
Presentations	https://www.st.com/resource/en/product_presentation/microcontrollers-stm32-family-overview.pdf
Brochures	https://www.st.com/resource/en/brochure/products-and-solutions-for-plcs-and-smart-i-os.pdf
Flyers	https://www.st.com/resource/en/flyer/flstm32nucleo.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/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/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/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/an4286-spi-protocol-used-in-the-stm32-bootloader-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4488-getting-started-with-stm32f4xxxx-mcu-hardware-development-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4566-extending-the-dac-performance-of-stm32-microcontrollers-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4640-peripherals-interconnections-on-stm32f4057xx-stm32f4157xx-stm32f42xxx-stm32f43xxx-stm32f446xx-and-stm32f469479xx-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4655-virtually-increasing-the-number-of-serial-communication-peripherals-in-stm32-

	applications-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4658-migration-of-applications-from-stm32f429439-lines-to-stm32f446-line-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4739-stm32cube-firmware-examples-for-stm32f4-series-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4750-handling-of-soft-errors-in-stm32-applications-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4776-generalpurpose-timer-cookbook-for-stm32-microcontrollers-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4803-highspeed-si-simulations-using-ibis-and-boardlevel-simulations-using-hyperlynx-si-on-stm32-mcus-and-mpus-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4850-stm32-mcus-spreadspectrum-clock-generation-principles-properties-and-implementation-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4989-stm32-microcontroller-debug-toolbox-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4995-using-an-electromyogram-technique-to-detect-muscle-activity-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an5027-interfacing-pdm-digital-microphones-using-stm32-mcus-and-mpus-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an5073-receiving-spdif-audio-stream-with-the-stm32f4f7h7-series-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4760-quadspi-interface-on-stm32-microcontrollers-and-microprocessors--stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4899-stm32-microcontroller-gpio-hardware-settings-and-lowpower-consumption-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an5612-esd-protection-of-stm32-mcus-and-mpus-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4838-introduction-to-memory-protection-unit-management-on-stm32-mcus-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4879-introduction-to-usb-hardware-and-pcb-guidelines-using-stm32-mcus-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an5225-introduction-to-usb-typec-power-delivery-for-stm32-mcus-and-mpus-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an5537-how-to-use-adc-oversampling-techniques-to-improve-signaltonoise-ratio-on-stm32-mcus-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an5036-guidelines-for-thermal-management-on-stm32-applications-stmicroelectronics.pdf

Application Notes https://www.st.com/resource/en/application_note/an4230-introduction-to-random-number-generation-validation-using-the-nist-statistical-test-suite-for-stm32-mcus-and-mpus-stmicroelectronics.pdf

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