# *1. Description*

1.1. Project

| Project Name | elastic_actuator_controller |
|---|---|
| Board Name | NUCLEO-F446RE |
| Generated with: | STM32CubeMX 5.6.0 |
| Date | 04/18/2020 |

1.2. MCU

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

# 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 | B1 [Blue PushButton] |
| 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 | | |
| 16 | PA2 | I/O | USART2_TX | USART_TX |
| 17 | PA3 | I/O | USART2_RX | USART_RX |
| 18 | VSS | Power | | |
| 19 | VDD | Power | | |
| 21 | PA5 * | I/O | GPIO_Output | LD2 [Green Led] |
| 22 | PA6 | I/O | TIM3_CH1 | |
| 23 | PA7 | I/O | TIM3_CH2 | |
| 30 | VCAP_1 | Power | | |
| 31 | VSS | Power | | |
| 32 | VDD | Power | | |
| 41 | PA8 | I/O | TIM1_CH1 | |
| 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 |
| 58 | PB6 | I/O | TIM4_CH1 | |
| 59 | PB7 | I/O | TIM4_CH2 | |
| 60 | BOOT0 | Boot | | |
| 61 | PB8 | I/O | I2C1_SCL | |
| 62 | PB9 | I/O | I2C1_SDA | |
| 63 | VSS | Power | | |
| 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*
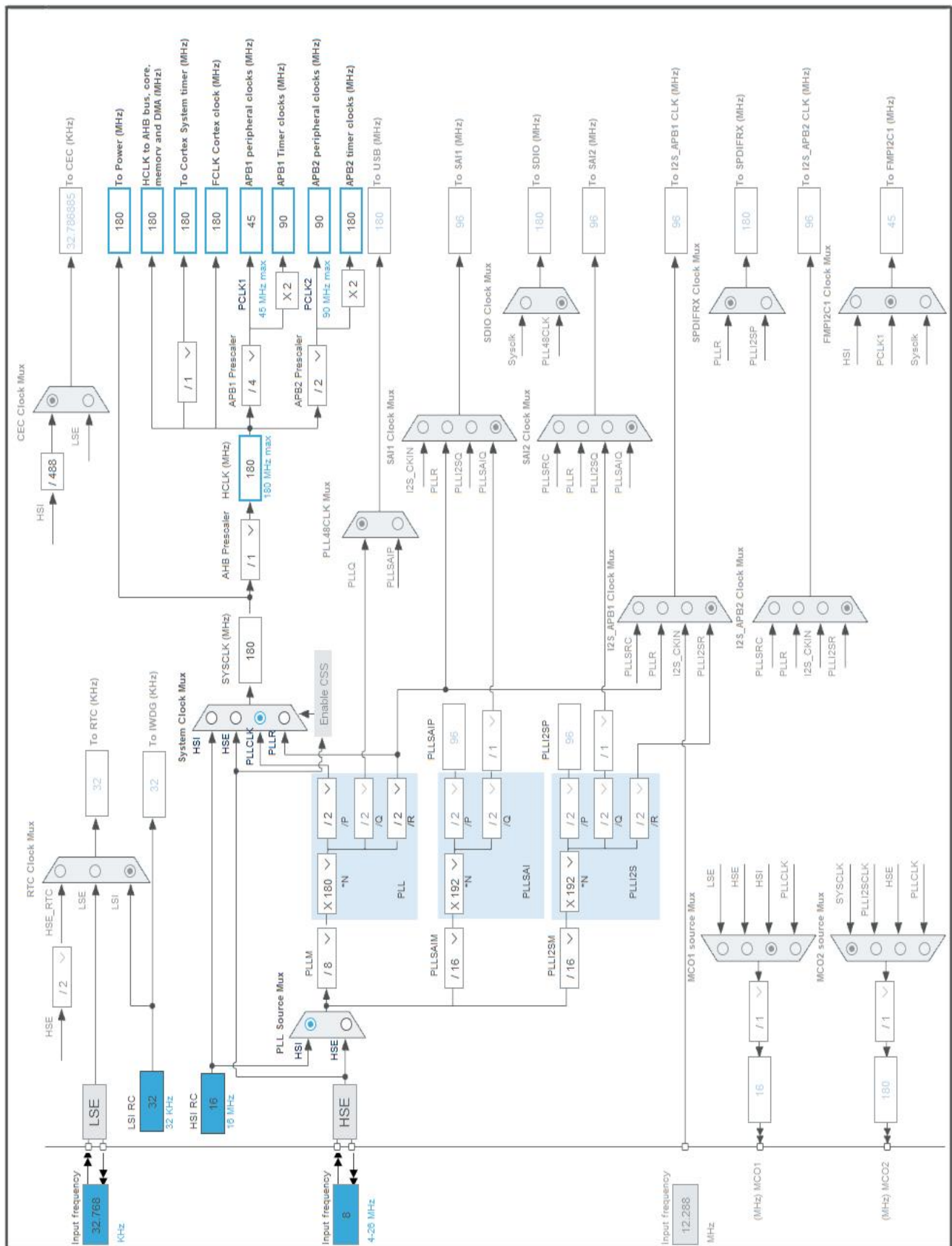
# *5. Software Project*

## 5.1. Project Settings

| Name | Value |
|---|---|
| Project Name | elastic_actuator_controller |
| Project Folder | E:\Elastic_robot_arm\firmware\elastic_robot_arm |
| Toolchain / IDE | STM32CubeIDE |
| Firmware Package Name and Version | STM32Cube FW_F4 V1.25.0 |

## 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 |
| Delete previously generated files when not re-generated | Yes |
| Set all free pins as analog (to optimize the power consumption) | No |

# 6. Power Consumption Calculator report

6.1. Microcontroller Selection

| | |
|---|---|
| Series | STM32F4 |
| Line | STM32F446 |
| MCU | STM32F446RETx |
| Datasheet | 027107_Rev6 |

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_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 |

## 6.5. RESULTS

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

## 6.6. Chart

## Consumption Profile by Step



Consumption Profile by Step
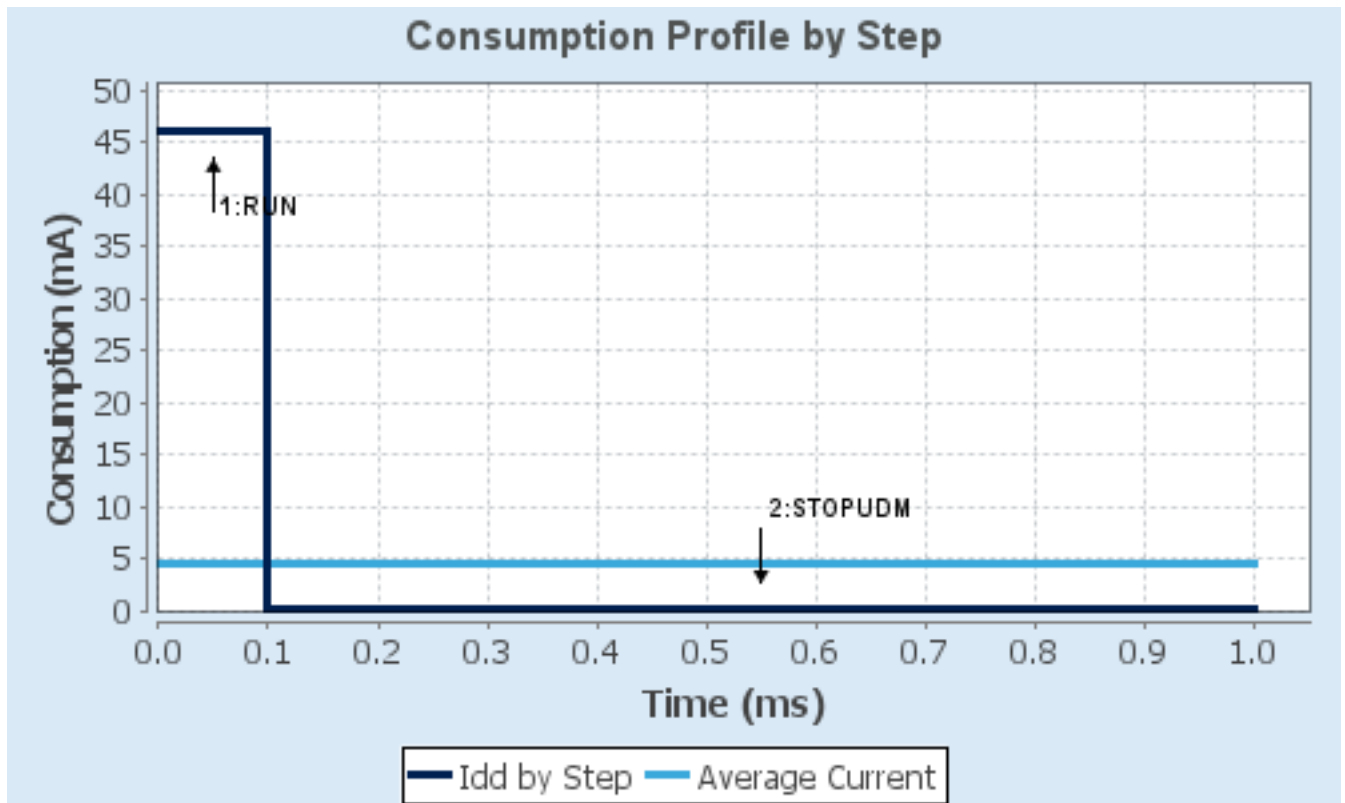
# 7. IPs and Middleware Configuration
## 7.1. GPIO

## 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) | 5 WS (6 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 1 |
| Power Over Drive | Enabled |

## 7.4. SYS

**Debug: Serial Wire**
**Timebase Source: SysTick**

## 7.5. TIM1

**Channel1: PWM Generation CH1**
**7.5.1. Parameter Settings:**

**Counter Settings:**

| | |
|---|---|
| Prescaler (PSC - 16 bits value) | **18-1 \*** |
| Counter Mode | Up |
| Counter Period (AutoReload Register - 16 bits value ) | **400-1 \*** |
| Internal Clock Division (CKD) | No Division |
| Repetition Counter (RCR - 8 bits value) | 0 |
| auto-reload preload | Disable |

**Trigger Output (TRGO) Parameters:**

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

**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) | **200 \*** |
| Output compare preload | Enable |
| Fast Mode | Disable |
| CH Polarity | High |
| CH Idle State | Reset |

## 7.6. TIM2

**Clock Source   : Internal Clock**

**7.6.1. Parameter Settings:**

**Counter Settings:**

| | |
|---|---|
| Prescaler (PSC - 16 bits value) | **9000-1 *** |
| Counter Mode | Up |
| Counter Period (AutoReload Register - 32 bits value ) | **10-1 *** |
| Internal Clock Division (CKD) | No Division |
| auto-reload preload | Disable |

**Trigger Output (TRGO) Parameters:**

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

## 7.7. TIM3

**Combined Channels: Encoder Mode**

**7.7.1. 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 | Disable |

**Trigger Output (TRGO) Parameters:**

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

**Encoder:**

| | |
|---|---|
| Encoder Mode | **Encoder Mode TI1 and TI2 *** |
| _____ Parameters for Channel 1 _____ | |
| Polarity | Rising Edge |
| IC Selection | Direct |
| Prescaler Division Ratio | No division |
| Input Filter | 0 |
| _____ Parameters for Channel 2 _____ | |
| Polarity | Rising Edge |
| IC Selection | Direct |
| Prescaler Division Ratio | No division |

| Input Filter | 0 |
|---|---|

## 7.8. TIM4

**Combined Channels: Encoder Mode**

**7.8.1. 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 | Disable |

**Trigger Output (TRGO) Parameters:**

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

**Encoder:**

| | |
|---|---|
| Encoder Mode | **Encoder Mode TI1 and TI2 \*** |

_____ Parameters for Channel 1 _____

| | |
|---|---|
| Polarity | Rising Edge |
| IC Selection | Direct |
| Prescaler Division Ratio | No division |
| Input Filter | 0 |

_____ Parameters for Channel 2 _____

| | |
|---|---|
| Polarity | Rising Edge |
| IC Selection | Direct |
| Prescaler Division Ratio | No division |
| Input Filter | 0 |

## 7.9. USART2

**Mode: Asynchronous**

**7.9.1. 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

**\* User modified value**

# 8. System Configuration

## 8.1. GPIO configuration

| IP | Pin | Signal | GPIO mode | GPIO pull/up pull down | Max Speed | User Label |
|---|---|---|---|---|---|---|
| I2C1 | PB8 | I2C1_SCL | Alternate Function Open Drain | Pull-up | **Very High \*** | |
| | PB9 | I2C1_SDA | Alternate Function Open Drain | Pull-up | **Very High \*** | |
| 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 | |
| TIM3 | PA6 | TIM3_CH1 | Alternate Function Push Pull | **Pull-up \*** | Low | |
| | PA7 | TIM3_CH2 | Alternate Function Push Pull | **Pull-up \*** | Low | |
| TIM4 | PB6 | TIM4_CH1 | Alternate Function Push Pull | **Pull-up \*** | Low | |
| | PB7 | TIM4_CH2 | Alternate Function Push Pull | **Pull-up \*** | Low | |
| USART2 | PA2 | USART2_TX | Alternate Function Push Pull | No pull-up and no pull-down | **Very High \*** | USART_TX |
| | PA3 | USART2_RX | Alternate Function Push Pull | No pull-up and no pull-down | **Very High \*** | USART_RX |
| Single Mapped Signals | PB3 | SYS_JTDO-SWO | n/a | n/a | n/a | SWO |
| GPIO | PC13 | GPIO_EXTI13 | **External Interrupt Mode with Falling edge trigger detection** | No pull-up and no pull-down | n/a | B1 [Blue PushButton] |
| | PA5 | GPIO_Output | Output Push Pull | No pull-up and no pull-down | Low | LD2 [Green Led] |

## 8.2. DMA configuration

| DMA request | Stream | Direction | Priority |
|:---:|:---:|:---:|:---:|
| USART2_TX | DMA1_Stream6 | Memory To Peripheral | Low |
| I2C1_TX | DMA1_Stream7 | Memory To Peripheral | Low |

### 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 |

### I2C1_TX: DMA1_Stream7 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

| 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 |
| DMA1 stream6 global interrupt | true | 0 | 0 |
| TIM2 global interrupt | true | 0 | 0 |
| I2C1 event interrupt | true | 0 | 0 |
| USART2 global interrupt | true | 0 | 0 |
| DMA1 stream7 global interrupt | 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 | | |
| TIM1 capture compare interrupt | unused | | |
| TIM3 global interrupt | unused | | |
| TIM4 global interrupt | unused | | |
| I2C1 error interrupt | unused | | |
| EXTI line[15:10] interrupts | unused | | |
| FPU global interrupt | unused | | |

**\* User modified value**

# 9. Predefined Views - Category view : Current

# *10. Software Pack Report*