
STM32
CubeMX

1. Description

1.1. Project

Project Name	I2STEST
Board Name	STM32F746G-DISCO
Generated with:	STM32CubeMX 6.10.0
Date	08/21/2024

1.2. MCU

MCU Series	STM32F7
MCU Line	STM32F7x6
MCU name	STM32F746NGHx
MCU Package	TFBGA216
MCU Pin number	216

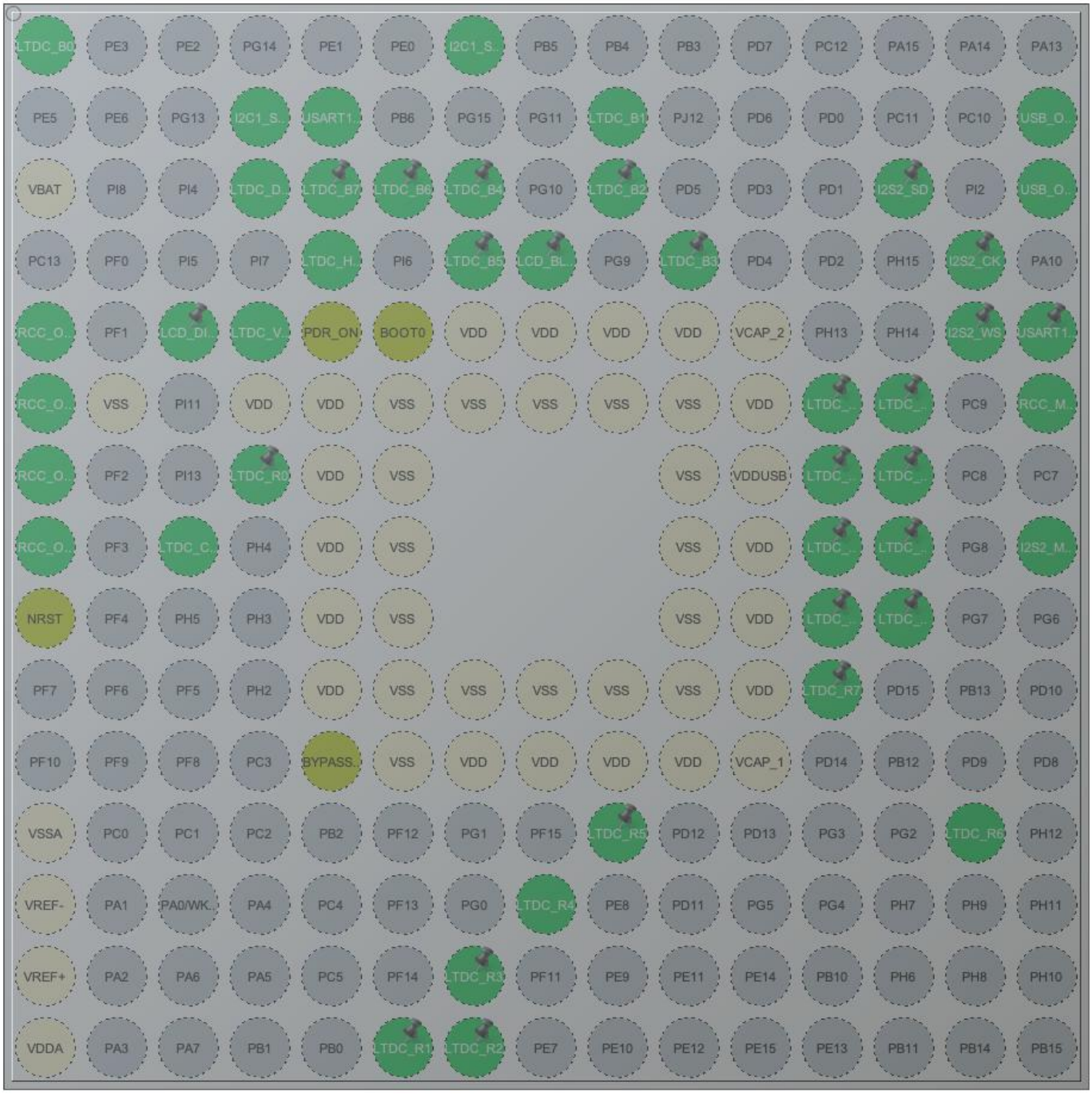
1.3. Core(s) information

Core(s)	Arm Cortex-M7

1.4. Caution

The report was generated although the configuration was in a modified state. It may be not accurate

2. Pinout Configuration



TFBGA216 (Top view)

3. Pins Configuration

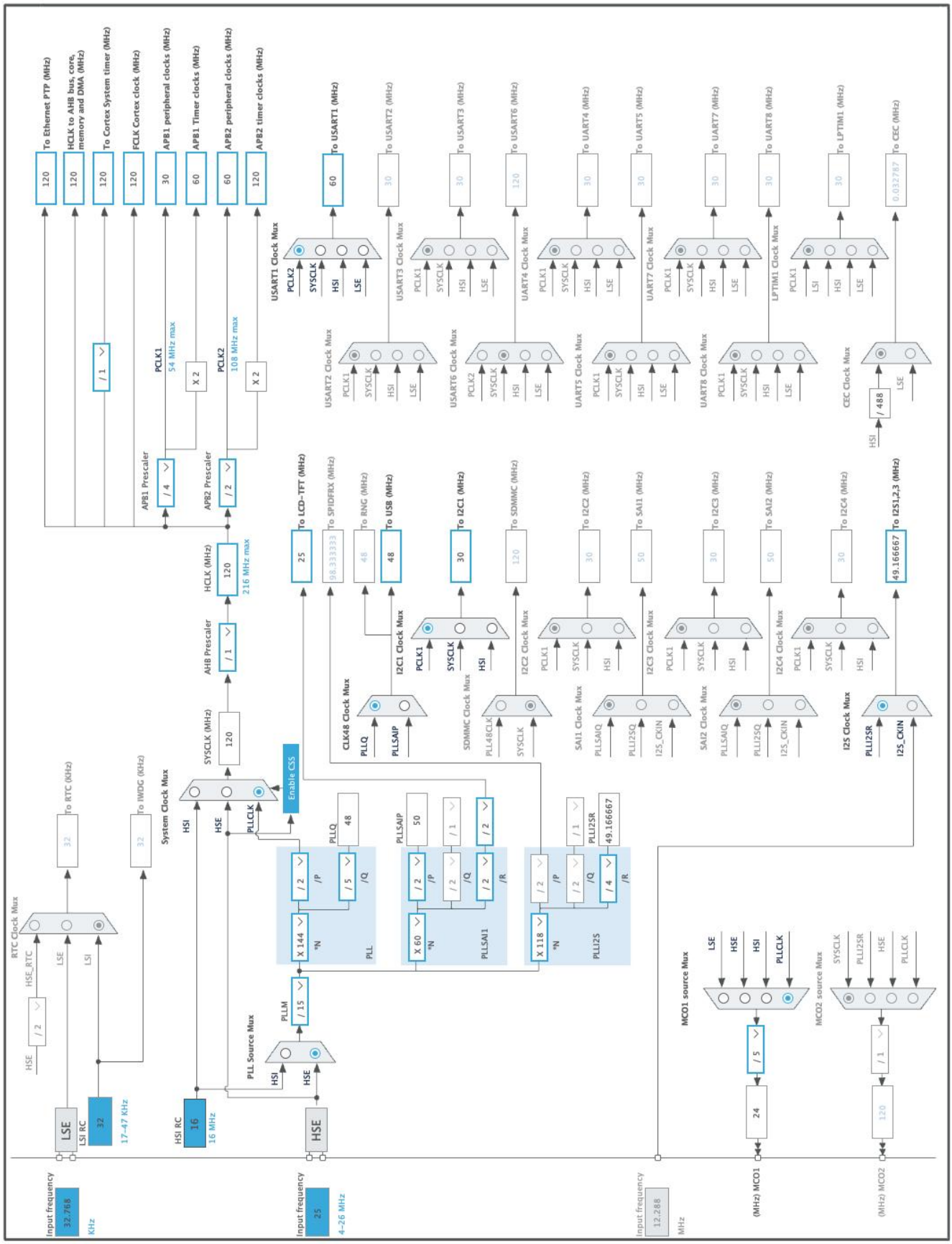
Pin Number TFBGA216	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
A1	PE4	I/O	LTDC_B0	
A7	PB8	I/O	I2C1_SCL	
B4	PB9	I/O	I2C1_SDA	
B5	PB7	I/O	USART1_RX	
B9	PJ13	I/O	LTDC_B1	
B15	PA12	I/O	USB_OTG_FS_DP	
C1	VBAT	Power		
C4	PK7	I/O	LTDC_DE	
C5	PK6	I/O	LTDC_B7	
C6	PK5	I/O	LTDC_B6	
C7	PG12	I/O	LTDC_B4	
C9	PJ14	I/O	LTDC_B2	
C13	PI3	I/O	I2S2_SD	
C15	PA11	I/O	USB_OTG_FS_DM	
D5	PI10	I/O	LTDC_HSYNC	
D7	PK4	I/O	LTDC_B5	
D8	PK3 *	I/O	GPIO_Output	LCD_BL_CTRL
D10	PJ15	I/O	LTDC_B3	
D14	PI1	I/O	I2S2_CK	
E1	PC14/OSC32_IN	I/O	RCC_OSC32_IN	
E3	PI12 *	I/O	GPIO_Output	LCD_DISP
E4	PI9	I/O	LTDC_VSYNC	
E5	PDR_ON	Reset		
E6	BOOT0	Boot		
E7	VDD	Power		
E8	VDD	Power		
E9	VDD	Power		
E10	VDD	Power		
E11	VCAP_2	Power		
E14	PI0	I/O	I2S2_WS	
E15	PA9	I/O	USART1_TX	
F1	PC15/OSC32_OUT	I/O	RCC_OSC32_OUT	
F2	VSS	Power		
F4	VDD	Power		
F5	VDD	Power		
F6	VSS	Power		

Pin Number TFBGA216	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
F7	VSS	Power		
F8	VSS	Power		
F9	VSS	Power		
F10	VSS	Power		
F11	VDD	Power		
F12	PK1	I/O	LTDC_G6	
F13	PK2	I/O	LTDC_G7	
F15	PA8	I/O	RCC_MCO_1	
G1	PH0/OSC_IN	I/O	RCC_OSC_IN	
G4	PI15	I/O	LTDC_R0	
G5	VDD	Power		
G6	VSS	Power		
G10	VSS	Power		
G11	VDDUSB	Power		
G12	PJ11	I/O	LTDC_G4	
G13	PK0	I/O	LTDC_G5	
H1	PH1/OSC_OUT	I/O	RCC_OSC_OUT	
H3	PI14	I/O	LTDC_CLK	
H5	VDD	Power		
H6	VSS	Power		
H10	VSS	Power		
H11	VDD	Power		
H12	PJ8	I/O	LTDC_G1	
H13	PJ10	I/O	LTDC_G3	
H15	PC6	I/O	I2S2_MCK	
J1	NRST	Reset		
J5	VDD	Power		
J6	VSS	Power		
J10	VSS	Power		
J11	VDD	Power		
J12	PJ7	I/O	LTDC_G0	
J13	PJ9	I/O	LTDC_G2	
K5	VDD	Power		
K6	VSS	Power		
K7	VSS	Power		
K8	VSS	Power		
K9	VSS	Power		
K10	VSS	Power		
K11	VDD	Power		

Pin Number TFBGA216	Pin Name (function after reset)	Pin Type	Alternate Function(s)	Label
K12	PJ6	I/O	LTDC_R7	
L5	BYPASS_REG	Reset		
L6	VSS	Power		
L7	VDD	Power		
L8	VDD	Power		
L9	VDD	Power		
L10	VDD	Power		
L11	VCAP_1	Power		
M1	VSSA	Power		
M9	PJ4	I/O	LTDC_R5	
M14	PJ5	I/O	LTDC_R6	
N1	VREF-	Power		
N8	PJ3	I/O	LTDC_R4	
P1	VREF+	Power		
P7	PJ2	I/O	LTDC_R3	
R1	VDDA	Power		
R6	PJ0	I/O	LTDC_R1	
R7	PJ1	I/O	LTDC_R2	

* The pin is affected with an I/O function

4. Clock Tree Configuration



5. Software Project

5.1. Project Settings

Name	Value
Project Name	I2STEST
Project Folder	/Users/iebe/Documents/aaSchool/2dejaarThomasMore/prattische enterprice
Toolchain / IDE	STM32CubeIDE
Firmware Package Name and Version	STM32Cube FW_F7 V1.17.2
Application Structure	Basic
Generate Under Root	Yes
Do not generate the main()	No
Minimum Heap Size	0x2000
Minimum Stack Size	0x4000

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	SystemClock_Config	RCC
2	MX_GPIO_Init	GPIO
3	MX_USB_DEVICE_Init	USB_DEVICE
4	MX_LTDC_Init	LTDC
5	MX_USART1_UART_Init	USART1
6	MX_I2C1_Init	I2C1
7	MX_I2S2_Init	I2S2

1. Power Consumption Calculator report

1.1. Microcontroller Selection

Series	STM32F7
Line	STM32F7x6
MCU	STM32F746NGHx
Datasheet	DS10916_Rev4

1.2. Parameter Selection

Temperature	25
Vdd	3.3

1.3. Battery Selection

Battery	Alkaline(9V)
Capacity	625.0 mAh
Self Discharge	0.3 %/month
Nominal Voltage	9.0 V
Max Cont Current	200.0 mA
Max Pulse Current	0.0 mA
Cells in series	1
Cells in parallel	1

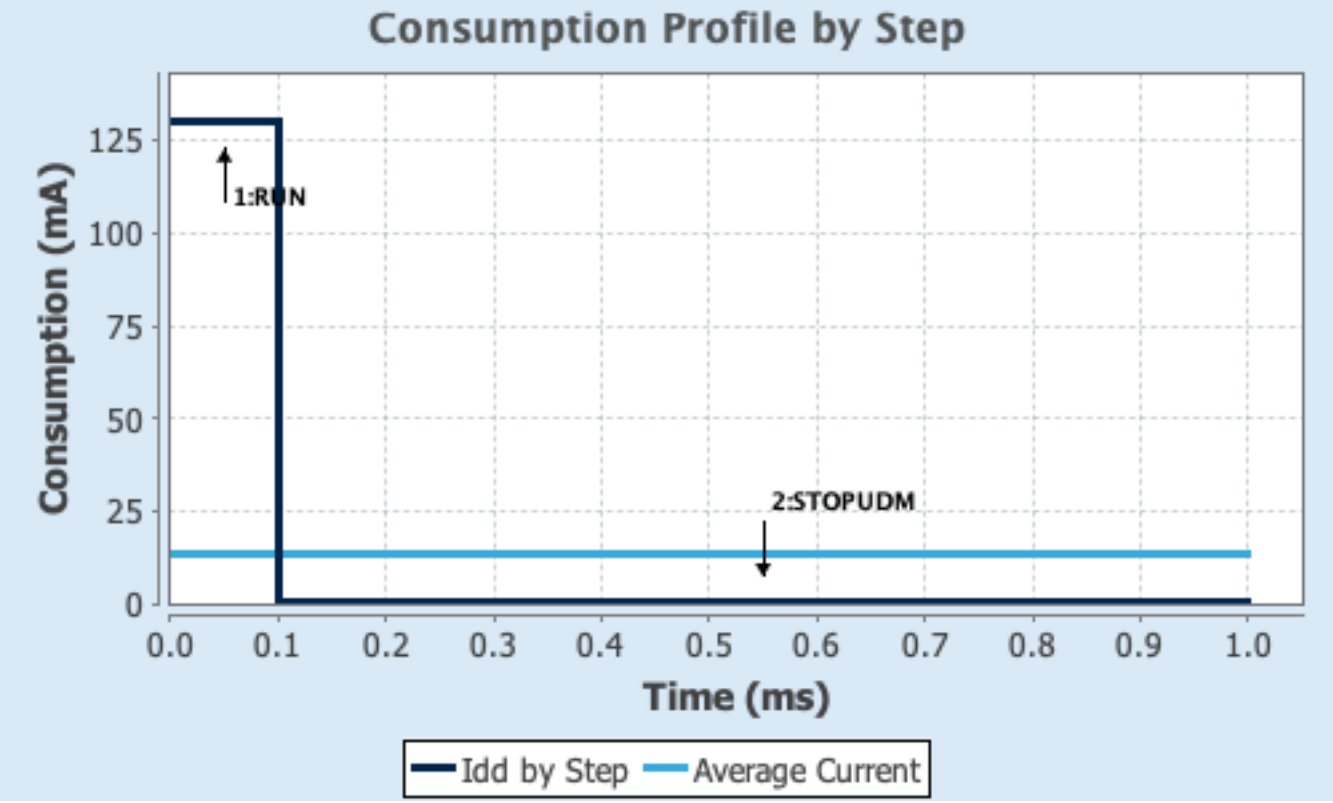
1.4. Sequence

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	ITCM/FLASH/REGON	n/a
CPU Frequency	216 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	130 mA	100 µA
Duration	0.1 ms	0.9 ms
DMIPS	462.0	0.0
Ta Max	92.56	104.99
Category	In DS Table	In DS Table

1.5. Results

Sequence Time	1 ms	Average Current	13.09 mA
Battery Life	1 day, 23 hours	Average DMIPS	462.24005 DMIPS

1.6. Chart


Consumption Profile by Step
Consumption (mA)
125
100
75
50
25
0
1:RUN
2:STOPUDM
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Time (ms)
Idd by Step
Average Current

2. Peripherals and Middlewares Configuration

2.1. I2C1

I2C: I2C

2.1.1. Parameter Settings:

Timing configuration:

I2C Speed Mode	Standard Mode
I2C Speed Frequency (KHz)	100
Rise Time (ns)	0
Fall Time (ns)	0
Coefficient of Digital Filter	0
Analog Filter	Enabled
Timing	**0x007074AF ***

Slave Features:

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

2.2. I2S2

Mode: Half-Duplex Master

mode: Master Clock Output

2.2.1. Parameter Settings:

Generic Parameters:

Transmission Mode	Mode Master Transmit
Communication Standard	I2S Philips
Data and Frame Format	**32 Bits Data on 32 Bits Frame ***
Selected Audio Frequency	**48 KHz ***
Real Audio Frequency	**48.014 KHz ***
Error between Selected and Real	**0.02 % ***

Clock Parameters:

Clock Source	PLL I2SR Clock
Clock Polarity	Low

2.3. LTDC

Display Type: RGB888 (24 bits)

2.3.1. Parameter Settings:

Synchronization for Width:

Horizontal Synchronization Width	**41 ***
Horizontal Back Porch	**13 ***
Active Width	**480 ***
Horizontal Front Porch	**32 ***
HSync Width	40
Accumulated Horizontal Back Porch Width	53
Accumulated Active Width	533
Total Width	565

Synchronization for Height:

Vertical Synchronization Height	**10 ***
Vertical Back Porch	2
Active Height	**272 ***
Vertical Front Porch	2
VSync Height	9
Accumulated Vertical Back Porch Height	11
Accumulated Active Height	283
Total Height	285

Signal Polarity:

Horizontal Synchronization Polarity	Active Low
Vertical Synchronization Polarity	Active Low
Data Enable Polarity	Active Low
Pixel Clock Polarity	Normal Input

Layer Default Color:

Red	0
Green	**255 ***
Blue	**255 ***

2.3.2. Layer Settings:

Layer Default Color:

Layer 0 - Alpha	0
Layer 0 - Blue	0
Layer 0 - Green	0

Layer 0 - Red	0
Layer 1 - Alpha	0
Layer 1 - Blue	0
Layer 1 - Green	0
Layer 1 - Red	0

Number of Layers:

Number of Layers	2 layers

Windows Position:

Layer 0 - Window Horizontal Start	0
Layer 0 - Window Horizontal Stop	**480 ***
Layer 0 - Window Vertical Start	0
Layer 0 - Window Vertical Stop	**272 ***
Layer 1 - Window Horizontal Start	0
Layer 1 - Window Horizontal Stop	**480 ***
Layer 1 - Window Vertical Start	0
Layer 1 - Window Vertical Stop	**272 ***

Pixel Parameters:

Layer 0 - Pixel Format	**ARGB1555 ***
Layer 1 - Pixel Format	**ARGB1555 ***

Blending:

Layer 0 - Alpha constant for blending	**255 ***
Layer 0 - Blending Factor1	**Alpha constant x Pixel Alpha ***
Layer 0 - Blending Factor2	**Alpha constant x Pixel Alpha ***
Layer 1 - Alpha constant for blending	**255 ***
Layer 1 - Blending Factor1	**Alpha constant x Pixel Alpha ***
Layer 1 - Blending Factor2	**Alpha constant x Pixel Alpha ***

Frame Buffer:

Layer 0 - Color Frame Buffer Start Adress	0
Layer 0 - Color Frame Buffer Line Length (Image Width)	**480 ***
Layer 0 - Color Frame Buffer Number of Lines (Image Height)	**272 ***
Layer 1 - Color Frame Buffer Start Adress	0
Layer 1 - Color Frame Buffer Line Length (Image Width)	**480 ***
Layer 1 - Color Frame Buffer Number of Lines (Image Height)	**272 ***

2.4. RCC

High Speed Clock (HSE): Crystal/Ceramic Resonator

Low Speed Clock (LSE) : Crystal/Ceramic Resonator

mode: Master Clock Output 1

2.4.1. Parameter Settings:

System Parameters:

VDD voltage (V)	3.3
Flash Latency(WS)	3 WS (4 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 Over Drive	Disabled
Power Regulator Voltage Scale	Power Regulator Voltage Scale 3

2.5. SYS

Timebase Source: SysTick

2.6. USART1

Mode: Asynchronous

2.6.1. 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
Single Sample	Disable

Advanced Features:

Auto Baudrate	Disable
TX Pin Active Level Inversion	Disable
RX Pin Active Level Inversion	Disable

Data Inversion	Disable
TX and RX Pins Swapping	Disable
Overrun	Enable
DMA on RX Error	Enable
MSB First	Disable

2.7. USB_OTG_FS

Mode: Device_Only

2.7.1. Parameter Settings:

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

2.8. USB_DEVICE

Class For FS IP: Audio Device Class

2.8.1. 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
USBD_LPM_ENABLED (Link Power Management)	1: Link Power Management supported

Class Parameters:

USBD_AUDIO_FREQ (Audio sample frequency rate)	**48000 ***

2.8.2. 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 Audio Class
CONFIGURATION_STRING (Configuration Identifier)	AUDIO Config
INTERFACE_STRING (Interface Identifier)	AUDIO Interface

*** User modified value**

3. System Configuration

3.1. GPIO configuration

IP	Pin	Signal	GPIO mode	GPIO pull/up pull down	Max Speed	User Label
I2C1	PB8	I2C1_SCL	Alternate Function Open Drain	No pull-up and no pull-down	**Very High ***	
	PB9	I2C1_SDA	Alternate Function Open Drain	No pull-up and no pull-down	**Very High ***	
I2S2	PI3	I2S2_SD	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PI1	I2S2_CK	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PI0	I2S2_WS	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PC6	I2S2_MCK	Alternate Function Push Pull	**Pull-up ***	**Very High ***	
LTDC	PE4	LTDC_B0	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ13	LTDC_B1	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PK7	LTDC_DE	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PK6	LTDC_B7	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PK5	LTDC_B6	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PG12	LTDC_B4	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ14	LTDC_B2	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PI10	LTDC_HSYNC	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PK4	LTDC_B5	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ15	LTDC_B3	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PI9	LTDC_VSYNC	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PK1	LTDC_G6	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PK2	LTDC_G7	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PI15	LTDC_R0	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ11	LTDC_G4	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PK0	LTDC_G5	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PI14	LTDC_CLK	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ8	LTDC_G1	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ10	LTDC_G3	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ7	LTDC_G0	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ9	LTDC_G2	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ6	LTDC_R7	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ4	LTDC_R5	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ5	LTDC_R6	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ3	LTDC_R4	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ2	LTDC_R3	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PJ0	LTDC_R1	Alternate Function Push Pull	No pull-up and no pull-down	Low	

IP	Pin	Signal	GPIO mode	GPIO pull/up pull down	Max Speed	User Label
	PJ1	LTDC_R2	Alternate Function Push Pull	No pull-up and no pull-down	Low	
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	
	PA8	RCC_MCO_1	Alternate Function Push Pull	No pull-up and no pull-down	Low	
	PH0/OSC_IN	RCC_OSC_IN	n/a	n/a	n/a	
	PH1/OSC_OUT	RCC_OSC_OUT	n/a	n/a	n/a	
USART1	PB7	USART1_RX	Alternate Function Push Pull	No pull-up and no pull-down	**Very High ***	
	PA9	USART1_TX	Alternate Function Push Pull	No pull-up and no pull-down	**Very High ***	
USB_OTG_FS	PA12	USB_OTG_FS_DP	Alternate Function Push Pull	No pull-up and no pull-down	**Very High ***	
	PA11	USB_OTG_FS_DM	Alternate Function Push Pull	No pull-up and no pull-down	**Very High ***	
GPIO	PK3	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	LCD_BL_CTRL
	PI12	GPIO_Output	Output Push Pull	No pull-up and no pull-down	Low	LCD_DISP

3.2. DMA configuration

nothing configured in DMA service

3.3. NVIC configuration

3.3.1. 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
USB On The Go FS global interrupt	true	0	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		
USART1 global interrupt	unused		
FPU global interrupt	unused		
LTDC global interrupt	unused		
LTDC global error interrupt	unused		

3.3.2. NVIC Code generation

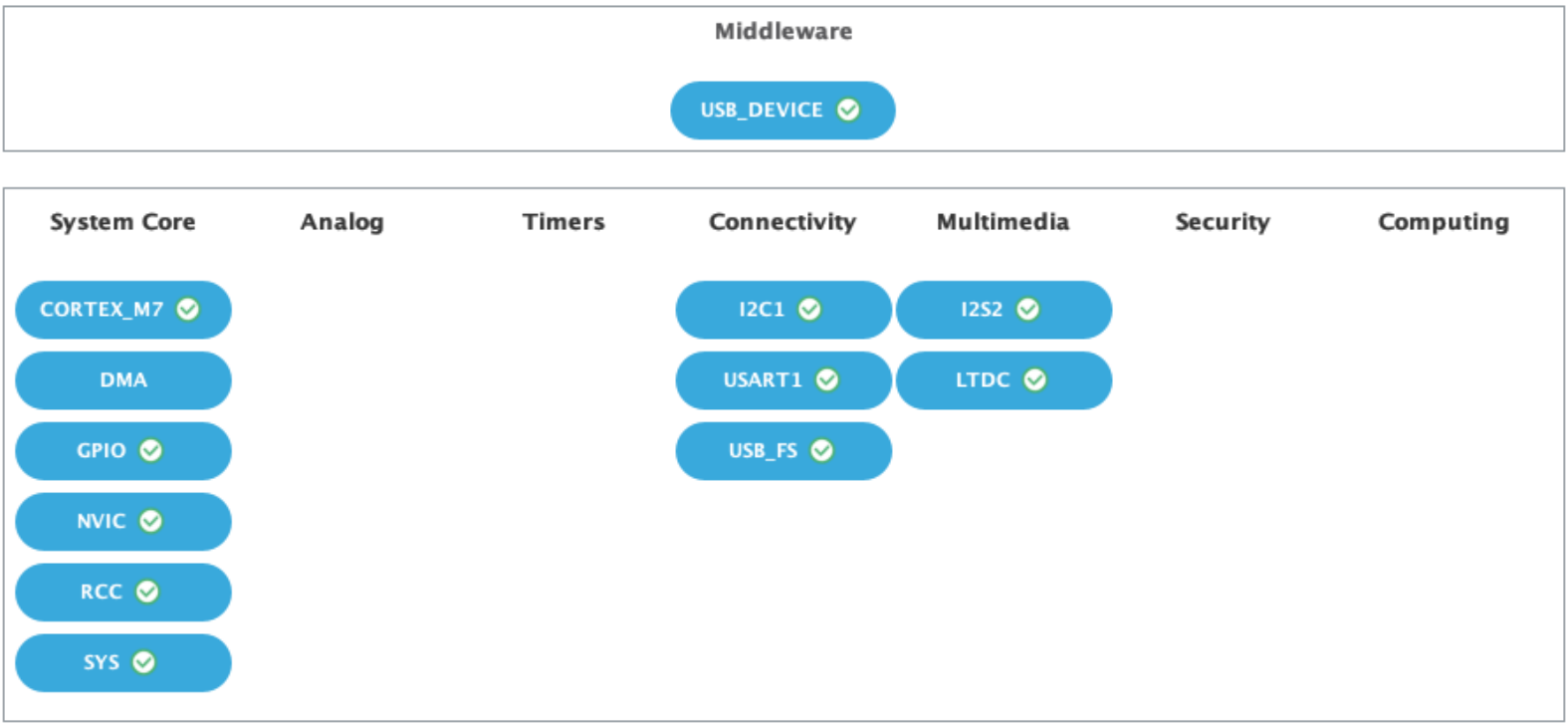
Enabled interrupt Table	Select for init sequence ordering	Generate IRQ handler	Call HAL handler
Non maskable interrupt	false	true	false
Hard fault interrupt	false	true	false
Memory management fault	false	true	false
Pre-fetch fault, memory access fault	false	true	false
Undefined instruction or illegal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

*** User modified value**

4. System Views

4.1. Category view

4.1.1. Current



5. Docs & Resources

Type	Link
BSDL files	https://www.st.com/resource/en/bsdl_model/stm32f7_bsdl.zip
IBIS models	https://www.st.com/resource/en/ibis_model/stm32f7_ibis.zip
System View Description	https://www.st.com/resource/en/svd/stm32f7-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
Presentations	https://www.st.com/resource/en/product_presentation/microcontrollers-stm32h7rs-lines-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/flstmcsuite.pdf
Flyers	https://www.st.com/resource/en/flyer/flstm32trust.pdf
Flyers	https://www.st.com/resource/en/flyer/flstm32gui.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/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/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/an4286-spi-protocol-used-in-the-stm32-bootloader-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/an4655-virtually-increasing-the-number-of-serial-communication-peripherals-in-stm32-applications-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4660-migration-of-microcontroller-applications-from-stm32f42xxxf43xxx-devices-to-stm32f7-series-devices-stmicroelectronics.pdf
Application Notes	https://www.st.com/resource/en/application_note/an4661-getting-started-with-stm32f7-series-mcu-hardware-development-stmicroelectronics.pdf
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