

Document: Summary STM32F4	Date:	05/04/22
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	Prepared by:	Flávio Cavaliari

Mastering STM32F4 Microcontrollers

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Summary

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Document History

Rev.	Date	Comments	Rev. by
1	05.04.22	Initial document	FGC

Trainer

Name	Company	Email
Flávio Cavalieri	Eletrocurcos	flavio.cavalieri@eletrocurcos.net

Training hours

Video Lessons
16 h

Goals

1. Explore the features of the STM32F407 microcontrollers by knowing its electrical characteristics, its main registers and applications;
2. Explore many resources of the STM32CubeIDE as well as software libraries, HAL API, and a bunch of middlewares to accelerate the development task;
3. Provide practical skills for diagnosing common programming failures through the use of STM32CubeIDE embedded debugger tools, or even by monitoring and terminal tools as STM32CubeMonitor;
4. Develop applications integrating microcontroller peripherals such as ADC, USART, USB, TIM, RTC, SPI, GPIO, IWDG, etc. With those peripherals and their software resources, develop solutions for Graphic Display and Touch controller, uSD Cards, Ethernet interface and much more.

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<p>Video lesson 1</p>	<p style="text-align: center;">INITIAL CONSIDERATIONS</p> <p style="text-align: center;">Introduction – Goals – Hardware and Software resources</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p style="text-align: center;">Complementary material / software:</p> <ul style="list-style-type: none"> • STM32CubeIDE • STM32CubeMonitor • STM32Cube MCU Firmware Examples • Termitte 3.1 terminal Ethernet/Serial • Hercules 3.2.8 terminal Ethernet/Serial <ul style="list-style-type: none"> • TFTP64 TFTP tool • DevBoard • ST-Link V2 Programmer • LAN8720 ETH Board • 320 x 240 LCD DISPLAY - ILI9341 SPI • XPT2046 Touch Controller • Dupont FxF Jumpers • Potentiometer </div>
<p>Video lesson 2</p>	<p style="text-align: center;">MCU CONCEPTS</p> <p style="text-align: center;">Explore important microcontroller hardware and software documentation. Find in firmware examples and it's reference documentation a great starting point for your project development process.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • AN4488 Getting started with STM32F4xxx MCU hardware development <ul style="list-style-type: none"> • AN4739 STM32Cube firmware examples for STM32F4 Series • UM1730 Getting started with STM32CubeF4 MCU Package • ES0182 STM32F405/407xx and STM32F415/417xx device limitations • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs <ul style="list-style-type: none"> • STM32F405xx STM32F407xx Datasheet </div>
<p>Video lesson 3</p>	<p style="text-align: center;">GPIO CMSIS</p> <p style="text-align: center;">Explore CMSIS concepts and implement a solution interfacing GPIO and TIM peripherals using microcontroller registers.</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs </div>
<p>Video lesson 4</p>	<p style="text-align: center;">GPIO HAL</p> <p style="text-align: center;">Explore HAL and LL reference document. Create na application mixing a delay solution implemented with register direct manipulation and a GPIO solution using HAL API functions instead.</p>

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	<p>Complementary material: (st.com)</p> <ul style="list-style-type: none"> UM1725 Description of STM32F4 HAL and low-layer drivers
Video lesson 5	<p style="text-align: center;">EXTI HAL</p> <p>Understand External Interrupt main features and it's concept. Implement a EXTI solution and use IDE embedded debugging features in order to solve common software issues. Install STM32CubeMonitor tool and set it for working as a debugger auxiliary graphical tool.</p> <p>Complementary material: (st.com)</p> <ul style="list-style-type: none"> RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs UM1725 Description of STM32F4 HAL and low-layer drivers <ul style="list-style-type: none"> Installing STM32CubeMonitor
Video lesson 6	<p style="text-align: center;">PWM</p> <p>Explore PWM features and implement a solution to control LED brightness.</p> <p>Complementary material: (st.com)</p> <ul style="list-style-type: none"> RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs UM1725 Description of STM32F4 HAL and low-layer drivers
Video lesson 7	<p style="text-align: center;">IC</p> <p>Explore Input Capture features and implemente a frequencimeter solution, capable to retrieve frequency and pulse width values. Using PWM output as a generator signal source. Graphical monitoring option is possible with STM32CubeMonitor tool.</p> <p>Complementary material: (st.com)</p> <ul style="list-style-type: none"> RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs UM1725 Description of STM32F4 HAL and low-layer drivers
Video lesson 8	<p style="text-align: center;">TIM</p> <p>Explore general-purpose timer concepts in order to create and understand a timer period elapsed interruption application.</p> <p>Complementary material: (st.com)</p> <ul style="list-style-type: none"> RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs UM1725 Description of STM32F4 HAL and low-layer drivers AN4476 General-prupose timer cookbook for STM32 microcontrollers
Video lesson 9	<p style="text-align: center;">IWDG</p> <p>Explore Independent Watchdog basis and create a sample application.</p> <p>Complementary material: (st.com)</p> <ul style="list-style-type: none"> RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs UM1725 Description of STM32F4 HAL and low-layer drivers

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<p>Video lesson 10</p>	<p style="text-align: center;">ADC Basis</p> <p>Understand STM32 main ADC characteristics and create a polling application in order to test the peripheral. Explore and observe results using a graphical monitoring interface with STM32CubeMonitor.</p> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers • AN3116 STM32™'s ADC modes and their applications </div>
<p>Video lesson 11</p>	<p style="text-align: center;">ADC DMA</p> <p>Understand STM32 main DMA controller concepts. Use this peripheral to transfer ADC input data directly to RAM memory.</p> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers <ul style="list-style-type: none"> • AN3116 STM32™'s ADC modes and their applications • AN4031 Using the STM32F2, STM32F4 and STM32F7 Series DMA controller </div>
<p>Video lesson 12</p>	<p style="text-align: center;">RTC</p> <p>Understand STM32 main Real-time clock concepts. Follow STM32F4 firmware examples to implement a RTC Calendar application. Comprehend importante registers as the backup one.</p> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers • AN4031 Using the STM32F2, STM32F4 and STM32F7 Series DMA controller • AN3371 Using the hardware real-time clock (RTC) in STM32 F0, F2, F3, F4 and L1 series of MCUs </div>
<p>Video lesson 13</p>	<p style="text-align: center;">USART Basis</p> <p>Understand STM32 main USART characteristics and create a polling application in order to test the peripheral. Use STM32CubeMonitor and Termite 3.1 as serial terminal tool.</p> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers </div>

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Video lesson 14	USART Advanced
	Apply advanced technics using serial port idle interrupt and DMA to create a variable length serial port reception with low MCU processing resources.
	<p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers • AN4031 Using the STM32F2, STM32F4 and STM32F7 Series DMA controller
Video lesson 15	USB HID
	Understand the USB device library concepts. Implement a USB HID application and test it with a demonstrator executable file from ST.
	<p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers <ul style="list-style-type: none"> • UM1734 STM32Cube™ USB device library <ul style="list-style-type: none"> • UM0551 USB HID demonstrator • USB HID Demonstrator V1.0.2
Video lesson 16	EEPROM Emulation
	Implement an EEPROM emulation using microcontroller Flash memory sectors. Fully understand important concepts regarding on-chip Flash memory access and its characteristics.
	<p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers • AN3969 EEPROM emulation in STM32F40x/STM32F41x microcontrollers
Video lesson 17	FATFS uSD
	Develop a FAT file system application using FatFs Middleware. Use SDIO as hardware peripheral connection to uSD card. Perform step by step debugging in order to execute open, read, write and close instructions.
	<p style="text-align: center;">Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers • UM1721 Developing applications on STM32Cube™ with FatFs
Video lesson 18	LWIP
	With a LAN8720 ETH board and using the LwIP Middleware and the TCP/IP stack demonstration project from ST, develop an interesting TCP server project. Use Hercules 3.2.8 as TCP terminal tool.

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	<p>Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs <ul style="list-style-type: none"> • UM1725 Description of STM32F4 HAL and low-layer drivers • AN3966 LwIP TCP/IP stack demonstration for STM32F4x7 microcontrollers <ul style="list-style-type: none"> • LwIP TCP/IP stack demonstration
Video lesson 19	<p style="text-align: center;">ETH IAP</p> <p>Follow STM32F4 firmware examples to implement IAP over the ethernet. Use TFTP64 tool and Hercules 3.2.8 to load MCU program through TFTP protocol.</p> <p>Complementary material: (st.com)</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers <ul style="list-style-type: none"> • AN3968 Implementing IAP over the Ethernet on the STM32F407/STM32F417
Video lesson 20	<p style="text-align: center;">LCD + Touch (ILI9341 + XPT2046)</p> <p>With a touch display based on ILI9341 and XPT2046 controllers, develop a HMI application using TouchGFX Middleware and graphical tool.</p> <p>Complementary material:</p> <ul style="list-style-type: none"> • RM0090 STM32F405/415, STM32F407/417, STM32F427/437 and STM32F429/439 advanced Arm®-based 32-bit MCUs • UM1725 Description of STM32F4 HAL and low-layer drivers <ul style="list-style-type: none"> • TouchGFX Documentation <ul style="list-style-type: none"> • Library Files • ILI9341 Datasheet • XPT2046 Datasheet

Methodology

- STM32F407 Development board + additional peripheral boards and display
- Video lessons, handouts, softwares and manuals;

Necessary resources

- Microcomputer with at least two free USB ports, software and drivers installed: