

User manual

# Getting started with the graphical user interface for the industrial IPS boards for STM32 Nucleo

#### Introduction

The STSW-IFAPGUI is the common graphic user interface designed to facilitate the control of the intelligent power switch (IPS) expansion boards for STM32 Nucleo.

The GUI works in combination with the firmware running on the STM32 Nucleo development board connected to your laptop/PC via USB cable.

The following table lists in the first column the demonstration firmware that the STSW-IFAPGUI is able to automatically detect. A demonstration firmware runs on a STM32 Nucleo and controls the related expansion or evaluation board included in the third column.

Demonstration Firmware	STM32 NUCLEO	Associated Boards
STSW-OUT1F4	NUCLEO-F401RE	
STSW-OUT1G4	NUCLEO-G431RB	X-NUCLEO-OUT01A2
	NUCLEO-F401RE	
STSW-00102	NUCLEO-F446RE	X-NUCLEO-OUT02A1
STSW-OUT3F4	NUCLEO-F401RE	
STSW-OUT3G4	NUCLEO-G431RB	X-NUCLEO-OUT03A1, X-NUCLEO-OUT04A1, STEVAL-IFP043V1, STEVAL-IFP044V1
STSW-OUT3D8F4	NUCLEO-F401RE	
STSW-OUT3D8G4	NUCLEO-G431RB	STDES-00103D08, STDES-00104D08
STSW-OUT5F4	NUCLEO-F401RE	
STSW-OUT5G4	NUCLEO-G431RB	X-NUCLEO-OUT05A1, X-NUCLEO-OUT06A1
STSW-OUT5D4F4	NUCLEO-F401RE	
STSW-OUT5D4G4	NUCLEO-G431RB	STDES-00105D04, STDES-00106D04
STSW-OUT7F4	NUCLEO-F401RE	
STSW-OUT7G4	NUCLEO-G431RB	X-NUCLEO-OUT07A1
STSW-OUT8F4	NUCLEO-F401RE	
STSW-OUT8G4	NUCLEO-G431RB	X-NUCLEO-OUT08A1, X-NUCLEO-OUT10A1
STSW-OUT9F4	NUCLEO-F401RE	
STSW-OUT9G4	NUCLEO-G431RB	X-NUCLEO-OUT09A1, X-NUCLEO-OUT19A1
STSW-OUT11F4	NUCLEO-F401RE	
STSW-OUT11G4	NUCLEO-G431RB	X-NUCLEO-OUTTIAT, X-NUCLEO-OUTT3AT, STEVAL-IFP04TVT, STEVAL-IFP047VT
STSW-OUT12F4	NUCLEO-F401RE	
STSW-OUT12G4	NUCLEO-G431RB	X-NUCLEO-OUT12A1, X-NUCLEO-OUT14A1, STEVAL-IFP042V1, STEVAL-IFP048V1
STSW-OUT15F4	NUCLEO-F401RE	
STSW-OUT15G4	NUCLEO-G431RB	X-NUCLEO-OUT15A1, STEVAL-IFP040V1
STSW-OUT16F4	NUCLEO-F401RE	
STSW-OUT16G4	NUCLEO-G431RB	X-NUCLEO-OUT16A1, X-NUCLEO-OUT17A1
STSW-DO40F4	NUCLEO-F401RE	X-NUCLEO-DO40A1, X-NUCLEO-DO41A1

#### Table 1. Demonstration Firmware



Demonstration Firmware	STM32 NUCLEO	Associated Boards
STSW-DO40G4	NUCLEO-G431RB	X-NUCLEO-DO40A1, X-NUCLEO-DO41A1

The GUI is available free of charge on www.st.com.



# **1** Software installation

The STSW-IFAPGUI software is designed to run on  $\mathsf{Microsoft}^{\textcircled{B}}$  Windows.

To install the GUI:

- Step 1. Run the setup.exe included in the package
- Step 2. Follow the installation instructions

#### Figure 1. STSW-IFAPGUI installation guide

5 STSW-IFAPGUI		-	_		×
Welcome to the STSW-IFA	APGUI Se	etup Wizard	i	(	
The installer will guide you through the steps	required to inst	all STSW-IFAPGUI	l on you	ur comp	uter.
WARNING: This computer program is protec Unauthorized duplication or distribution of thi or criminal penalties, and will be prosecuted	cted by copyrigh is program, or an to the maximum	t law and internation y portion of it, may extent possible un	onal tre result i der the	aties. in sever law.	e civil
	< <u>B</u> ack	<u>N</u> ext >		Cano	el



# 2 Running the graphical user interface

After launching the STSW-IFAPGUI, a splash screen appears during the application components loading.



If a valid firmware is detected a COM port is opened for communication and the user can verify the detected firmware and then can request to launch the proper main control panel for the connected expansion board.

#### 2.1 X-NUCLEO-OUT01A2 expansion board

#### 2.1.1 How to control the expansion board

This application scenario is based on the default configuration of the on-board switch and resistors of the X-NUCLEO-OUT01A2

- Step 1. Stack the X-NUCLEO-OUT01A2 on top of the NUCLEO-F401RE flashed with the STSW-OUT1F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT1G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- Step 3. Connect the load and supply the power stage of the X-NUCLEO-OUT01A2 with a 24 V rail via the CN1 connector.
- **Step 4.** Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

#### Figure 3. STSW-IFAPGUI COM - port opened

STSW-IFAPGUI	
Device : 8200 Port : COM69	Auto detect FW version



Step 5. Click on the GUI STM32 Nucleo icon after it turns blue and after firmware identification the logo will be green.

#### Figure 4. STSW-IFAPGUI identification complete



#### **Step 6.** The STSW-IFAPGUI appears on the screen.



#### Figure 5. STSW-IFAPGUI main control panel



#### Step 7. Use the Command Interface. The main panel is divided into:

- eight channel control sections, one for each channel
- load operating mode section.
- the outputs enable section.
- channels selection section
- selected channels steady state on/off
- selected channels PWM on/off
- a diagnostic section
- commands reset section.

All the buttons with blue text are related to the currently active functions.

 Use the [LOAD] button in the [Load Operating Mode] section to load the control mode (Direct or Synchronous) set for ISO8200BQ.

#### Figure 6. STSW-IFAPGUI Load Operating Mode Section



#### Figure 7. STSW-IFAPGUI Direct Control Mode detected

Load Operating Mode LOAD DIRECT CONTROL MODE

Use the [Output Enable Pin] section to enable the outputs for ISO8200BQ. At the startup the
outputs and all commands into the channels control section are disabled.

#### Figure 8. STSW-IFAPGUI output enable section

Output Enable Pi	n DISABLED
ENABLE	DISABLE

When the output has been enabled the [Output Enable Pin] section will change:

#### Figure 9. STSW-IFAPGUI output enabled

Output Enable Pin	ENABLED
ENABLE	DISABLE

The channel control sections are used to switch on or off the channels in steady state and PWM mode.

- Use the Channel [Steady State] GUI section to manage the channel steady state for ISO8200BQ. The [ON] and [OFF] buttons are used to turn a channel on or off respectively. The [ON] button for each channel is enabled at the startup. When a channel is on in steady state mode the green LED corresponding to that channel will be on, the [OFF] button will be enabled, and the [ON] button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. To use the PWM, the steady state of the channel must first be switched off.
- Use the channel [PWM] GUI section to manage the channel PWM settings and to power on or off the channel input in PWM mode. The [ON] button starting the PWM will be enabled when both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function. The following figures show a detailed view of the GUI Channel section functions.



#### Figure 10. STSW-IFAPGUI channel section, steady state enabled and ready to use



#### Figure 11. STSW-IFAPGUI channel section, steady state on



#### Figure 12. STSW-IFAPGUI channel section, PWM on



Step 8. The [Channels Selection] section allows you to select a set of channels to turn on or off with a single operation in steady state or PWM mode. Click on the [CHECK ALL] button to select all channels and on [UNCHECK ALL] to unselect all the channels. Furthermore, each channel can be selected individually using the related checkbox.

Figure 13. STSW-IFAPGUI Channels Selection Section

Channels Selection								
1	2	3	4	5	6	7	8	
(								

#### Figure 14. STSW-IFAPGUI Channels 1 and 2 selected

Channels Selection								
1	2	<mark>3</mark>	4	5	6	<mark>7</mark> □	8	
C	CHECK ALL UNCHECK ALL							



Step 9. The [Selected Channels Steady State] section allows you to turn on or off the selected channels in steady state mode. However, it should be specified that the command to turn on a selected channel is sent only if that channel is not currently turned on, neither in steady state nor in PWM. The channel off command is given to all selected channels turned on in steady state.

Figure 15. STSW-IFAPGUI Selected Channels Steady State section



Click on the [ON] or [OFF] button to turn on or off the selected channels.

Step 10. The [Selected Channels PWM] is similar the previous section but allows you to turn on or off the selected channels in PWM mode. With the same logic the command to turn on a selected channel in PWM mode is sent only if that channel is not currently turned on, neither in steady state nor in PWM. The PWM off command is given to all selected channels turned on in PWM mode. Unlike the previous case, to be able to see the output switching, you must first set the frequency and duty cycle of the channel, using the corresponding channel section as explained previously.

#### Figure 16. STSW-IFAPGUI Selected Channels PWM



Click on the [ON] or [OFF] button to turn on or off the selected channels in PWM mode.

Step 11. The diagnostic section is related to the thermal shutdown condition check. Click on the [START] button under [Thermal shutdown diagnostic pin Status Check] to monitor the on/off status of the STATUS pins for ISO8200BQ. The STATUS is a diagnostic pin at chip level. The activation of the status pin check is signalized by the bar under the diagnostic LED. When a fault condition is triggered, the red LED will light up. Click on the [STOP] button to stop the STATUS pin check and on the [RESET] button to clear the last pin condition displayed.

#### Figure 17. STSW-IFAPGUI status check



#### Figure 18. STSW-IFAPGUI status check activated





Step 12. Click on the [RESET] button in the [Commands Reset] section to stop all operations in progress, (channels switched on in steady state or PWM, status pin check activated). All frequency and duty cycle values that have been selected are also reset.

#### Figure 19. STSW-IFAPGUI Commands Reset section

Commands Rese	t
RESET	

#### 2.1.2 How to get information about the GUI

Information about the GUI revision is available by clicking at any point on title of the commands interface.

#### Figure 20. STSW-IFAPGUI Commands Interface Title

Graphical Commands Interface for X-NUCLEO-OUT01A2

Then, the following window (in the example related to the first revision) appears:

#### Figure 21. Command interface info



#### 2.1.3 How to get information about the Device Features

Information about the device feature is available by clicking on device picture on the top-left part of the command interface.

#### Figure 22. How to get devices info



Then, the following window appears:

#### Figure 23. Devices info



#### 2.1.4 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the board image.

#### Figure 24. Board Pin Connection



#### 2.1.5 Close the command interface

To close the command interface, use File/Close in the top-left part of the GUI.

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#### Figure 25. STSW-IFAPGUI close the command interface



The command interface can be opened again by clicking on the Nucleo icon as described above.

#### 2.2 X-NUCLEO-OUT02A1 expansion board

#### 2.2.1 How to control a single expansion board

- Step 1. Connect the STM32 Nucleo board flashed with STSW-OUT02 to the X-NUCLEO-OUT02A1 through the Arduino® UNO R3 connectors.
- Step 2. Connect the stacked boards to your PC/laptop USB port through a mini-USB cable. The STM32 is supplied by 3.3 V from the USB supply and the flashed firmware starts running. By default, in the X-NUCLEO-OUT02A1, J8 is closed between pins 5-6 and the ISO8200AQ digital side is supplied by the same 3.3 V of the microcontroller.
- Step 3. Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.
- Step 4. Click on the GUI STM32 Nucleo icon only after it becomes blue (it is green until the firmware identification is completed).
   The following selection window appears.

Figure 26. STSW-IFAPGUI selection window for the number of X-NUCLEO-OUT02A1 expansion boards to control

Device Count	_ 🗖 ×
Please select the number of connected to the communica	devices tion board:



STSW-IFAPGU	II (COM29)						_ □ ×
PARAMETER TCSS	USER SET V	ALUE					
	CHANNEL	Fsw [Hz] min = 0. 1 Hz max = 100 Hz	Duty Cylce [%] min = 0 % max = 100 %		CHA FA	NNEL NULT	
CHIP1	OUT1 OUT2 OUT3 OUT4 OUT5 OUT6 OUT7 OUT8 OUT1 OUT2 OUT3 OUT4 OUT5 OUT6	0 Hz ÷ 0 Hz ÷ 1 ÷	0 % ÷	CHIP1 CHIP2	OUT1 OUT2 OUT3 OUT4 OUT5 OUT6 OUT7 OUT8 OUT7 OUT8 OUT1 OUT2 OUT3 OUT4 OUT5	PGOOD FAULT	Console
OUT_EN2	OUT7 OUT8 SPI Start	SPI Stop			OUT7 OUT8 Refresh		

#### Figure 27. STSW-IFAPGUI control panel, single chip

Step 6. Supply the X-NUCLEO-OUT02A1 power stage with a 24 V rail via J1 connector.

Step 7. Click on the GUI [Refresh] button to align the application board and the GUI status.

Step 8. Select the desired switching frequency and duty cycle of the output channels to be activated (ON/OFF).

- Note: 0 Hz stands for channel OFF; duty cycle 100% stands for channel always ON.
  - Step 9. Tick the OUT\_EN1 to activate the ISO8200AQ output enable signal.
  - Step 10. Click [Start] to activate the SPI communication between the microcontroller and ISO8200AQ.
     Now the activated output channels start switching according to the setup defined in Step 7 (green LED D5 to D12 will be driven accordingly).

When SPI is active, the right side of the GUI (fault monitoring) is automatically updated every 500 ms.

Step 11. The output channels ON/OFF status can be deactivated by unticking the OUT\_EN1 or by clicking [Stop].

In the first case, the SPI communication between microcontroller and ISO8200AQ remains active, while in the second case the SPI communication stops.

Step 12. When the evaluation session finishes, stop the SPI communication, close the GUI, remove the 24 V from J1 and disconnect the USB cable from the STM32 Nucleo development board.

#### 2.2.2 How to control two expansion boards

When two X-NUCLEO-OUT02A1 expansion boards are stacked (daisy chaining), follow the procedure below.

- **Step 1.** Set the proper configuration for J6, J7 and OUT\_EN signal on the twoX-NUCLEO-OUT02A1 to enable daisy chaining configuration.
- Step 2. Connect the NUCLEO-F401RE development board flashed with STSW-OUT02 to the two X-NUCLEO-OUT02A1 boards through the Arduino® UNO R3 connectors.



Step 3. Launch the STSW-IFAPGUI.

When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

- Step 4. Click on the GUI STM32 Nucleo icon only after it becomes blue (it is green until the firmware identification is completed).
- Step 5. Select "2" in the Device Count window and then click OK to activate the control panel.

#### STSW-IFAPGUI (COM29) \_ 🗖 × File PARAMETER USER SET VALUE TCSS Duty Cylce [%] min = 0 % max = 100 % Fsw [Hz] min = 0.1 Hz max = 100 Hz CHANNEL OUT1 0 Hz ÷0% OUT1 + PGOOD + ÷ OUT: OUT2 FAULT 0 Hz OUT3 0 % OUT3 + + ) H: OUT4 CHIP1 CHIP1 0 Hz 0 % OUT5 OUT5 ÷ + ) H: OUT6 OUT7 0 Hz 0 % ÷ OUT EN1 ÷O 0 Hz ÷ 0 % OUT1 OUT1 PGOOD • ÷ ) H FAULT OUT OUT3 0 Hz • OUT3 \* ÷ 0 Hz OUT4 CHIP2 CHIP2 0 Hz -OUT5 . OUT5 • ÷ ) H; OUTE • • OUT7 0 Hz 0 % OUT7 OUT\_EN2 SPI Start Refresh SPI Stop

#### Figure 28. STSW-IFAPGUI control panel, dual chip

**Step 6.** Follow the steps described in Section 2.2.1 (from 6 to 12).

#### 2.2.3 STSW-IFAPGUI control panel for X-NUCLEO-OUT02A1

This control panel (see Figure 27) shows three main function areas:

- Output channel activation (OUT\_EN, switching frequency, duty cycle)
- SPI activation (start/stop)
- Fault monitoring (power good, common fault, per-channel thermal fault)

#### 2.2.3.1 Output channel activation

You can set the switching frequency and duty cycle driving each output channel by editing the text boxes of this section of the GUI.

The switching frequency can be set from 0 Hz (channel always OFF) to 100 Hz.

The duty cycle can be set from 0% (channel always OFF) to 100% (channel always ON).

You can also control the ISO8200AQ output enable signal by ticking the OUE\_ENx box: when ticked, the output enable pin is forced high, otherwise it is off.

Note: the output channel ON/OFF configuration set in the GUI is transferred to the ISO8200AQ only when the SPI communication is activated (see next chapter).





#### 2.2.3.2 SPI activation

The ISO8200AQ output channels are controlled by the microcontroller SPI.

The STSW-IFAPGUI activates/deactivates the STM32 SPI interface by clicking the [SPI Start] or [SPI Stop] buttons.

Although the SPI is activated by the [SPI Start] button, you have to tick the GUI OUT\_ENx box to enable the outputs.

#### 2.2.3.3 Fault monitoring

The ISO8200AQ can report to the microcontroller a wide set of information.

#### Voltage drop on supply rail

The supply voltage is monitored by an embedded circuitry and the power good open drain pin is activated (forced low) when the supply voltage on J1 goes below 16.5 V.

#### SPI communication error (modulo-8 violation)

The internal logic controls if each SPI communication contains 8 bits on the SDI (MOSI) line. In case of violation, the common fault pin is activated (forced low).

#### Communication error internal to ISO8200AQ

The internal logic controls if any communication error occurs between the ISO8200AQ logic and process stage. The common fault is activated (forced low) in case of internal commutation error.

#### Output channel thermal fault

The common fault pin is forced low when one (or more) ISO8200AQ channel has triggered the thermal shutdown threshold. The microcontroller recognizes which channel is in thermal fault by reading the byte sent back by the ISO8200AQ through the SDO (MISO) line.

When SPI is active, the whole status information of the ISO8200AQ is automatically refreshed every 500 ms. When SPI is not active, the status of ISO8200AQ can be showed on the GUI by clicking the [**Refresh**] button.

#### 2.3 X-NUCLEO-OUT03A1 and X-NUCLEO-OUT04A1 expansion boards

#### 2.3.1 How to control a single expansion board

This application scenario is based on the default configuration of the on-board switch and resistors of X-NUCLEO-OUT03A1 (or X-NUCLEO-OUT04A1).

- Step 1. Stack the X-NUCLEO-OUT03A1 (or X-NUCLEO-OUT04A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT3F4 firmware (or NUCLEO-G431RB flashed with STSW-OUT3G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- Step 3. Launch the STSW-IFAPGUI.

When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.



#### Figure 29. STSW-IFAPGUI COM - port opened



Step 4. Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware identification is complete).

A popup window appears to choose the proper system configuration.



Figure 30. System configuration selection panel

Step 5. Select [Single Board System] and the STSW-IFAPGUI appears on the screen.

Step 6.

- Use the left side of the GUI to manage steady state (channel 1 or channel 2, or both) for IPS2050H (or IPS2050H-32).
- Use the right side of the GUI to manage its PWM settings.
- Step 7. Connect the load and supply the power stage of the X-NUCLEO-OUT03A1 (or X-NUCLEO-OUT04A1) with a 24 V rail via the CN1 connector.
- Step 8. Select the desired switching frequency and duty cycle of the output channel through the [PWM SET AND ON/OFF CHANNELS COMMANDS] on the right side of the GUI.



Step 9. To activate the output channel steady state, click on [STEADY STATE CHANNELS COMMANDS]>[CH ON] on the left side of the GUI, for the desired input channel. Use [CH OFF] to deactivate it.





Step 10. Click on the [FAULT CHECK] button on the left side of the GUI for the desired input channel to monitor the on/off status of the FAULT pin on IPS2050H (or IPS2050H-32) (FAULT1 for channel 1, FAULT2 for channel 2).

You can stop monitoring the per-channel fault status by clicking again on the related [FAULT CHECK] button.

Press [FAULT RESET] button to reset the channel fault status.

#### 2.3.2 How to control up to four expansion boards

This application scenario is based on the multiboard configuration of the on-board switch and resistors of STDES-OUT03D08 (or STDES-OUT04D08). Details about how to configure the default board (board 0) and the additional ones (board 1, board 2, and board 3) are available in UM2863 "Getting started with X-CUBE-OUT3 industrial digital output software for STM32 Nucleo". The following table summarizes the multiboard setup.

Board no.	IN1	IN2	FLT1	FLT2
Board 0	R101	R102	R103	R104
Board 1	R131	R132	R133	R134
Board 2	R111	R112	R113	R114
Board 3	R121	R122	R123	R124

#### Table 2. Configuration of a stack of four expansion boards

Note:

When using board 2 and board 3, two jumpers must be used to close the morpho connectors pins in the STM32 Nucleo board: CN7.35-36 and CN10.25-26 closed.

It is also possible to obtain information on the configuration of the resistance connections for each board directly through the GUI by clicking on the image that appears in the window of the respective board (see Figure 38. STSW-IFAPGUI main control panel), as shown in the following figures.







Figure 33. Setup for board 1



#### Figure 34. Setup for board 2



Figure 35. Setup for board 3



- Step 1. Stack up to four X-NUCLEO-OUT03A1 (or X-NUCLEO-OUT04A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT3D8F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT3D8G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB).
   The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.





#### Step 3. Launch the STSW-IFAPGUI.

When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

#### Figure 36. STSW-IFAPGUI COM - port opened

STSW-IFAPGUI	_ 🗆 ×
Nucleo Device : 2050	☑ Auto detect FW version

Step 4. Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware identification is complete).

A popup window appears to choose the proper system configuration.

#### Figure 37. System configuration selection panel





#### Step 5. Select [Multi Board System] and the STSW-IFAPGUI appears on the screen.

W-IFAPGUI (COM29)											
life.augmented		X-NUCLE	0-OUT { <mark>(</mark>	03  4  4	1 based	Ion 丨	ps {	2050H 2050H-32	} Comma	nd Inte	rface
Board 0		Char	nnel O					Ch	annel 1		
	Steady State	Frequency [Hz] min 0.1 max 100	Duty Cycle [%] min 0 max = 100	РИМ	Fault Check	S	teady State	Frequency [Hz] min 0.1 max 100	Duty Cycle [%] min 0 max = 100	РИМ	Fault Check
	ON	and and and and and and	"Judenland"	ON	START		ON	and	"Judinilard"	ON	START
NABLE DISABLE RESET	OFF			OFF	STOP RESET		OFF		and a start	OFF	STOP RESET
Board 1		Char	nel O					Ch	annel 1		
NABLE DISABLE RESET	Steady State ON OFF	Frequency [Hz] min 0.1 max 100	Duty Cycle [%] min 0 max = 100	ON OFF	Foult Check START STOP RESET		ON	Frequency [Hz] min 0.1 max 100 D Hz	Duty Cycle [%] min 0 max = 100	ON OFF	Foult Check START STOP RESET
Peord 2		Cha	mel 0					Ch	onnol 1		
	Steady State	Frequency [Hz] min 0.1 max 100	Duty Cycle [%] min 0 max = 100	РИМ ON	Fault Check	5	State	Frequency [Hz] min 0.1 max 100	Duty Cycle [%] min 0 max = 100	<i>РИМ</i>	Fault Check
NABLE DISABLE RESET	OFF		a strain and a str	OFF	STOP RESET		OFF			OFF -	STOP
Board 3		Char	nel 0					Ch	annol 1		
	Steady State	Frequency [Hz] min 0.1 max 100 Hz +	Duty Cycle [%] min 0 max = 100	PWM ON	Fault Check START	s 	State State ON	Frequency [Hz] min 0.1 max 100	Duty Cycle [%] min 0 max = 100	РИМ ON	Fault Check START STOP

#### Figure 38. STSW-IFAPGUI main control panel

- Step 6. If all four boards are not physically connected, it is possible to disable the commands on the unconnected boards using the [DISABLE] button of the relevant boards.
   By pressing the same button, you can reenable the board once connected.
- Step 7. The main control panel is divided in four rows, one per each board. Each row is divided in two columns, one per each channel of the on-board device.

All the buttons with blue text are related to the currently active functions. For each channel:

- Use the left part of the GUI section to manage the channel steady state for IPS2050H (or IPS2050H-32).
- Use the right part of the GUI section to manage its PWM settings.

The following figure shows a detailed view of the GUI section for each channel.



#### Figure 39. STSW-IFAPGUI channel section

- **Step 8.** Connect the load and supply the power stage of the X-NUCLEO-OUT03A1 (or X-NUCLEO-OUT04A1) with a 24 V rail via the CN1 connector.
- Step 9. Select the desired switching frequency and duty cycle of the output channel through the dedicated controls. Use [ON] and [OFF] buttons under [PWM] to start and stop the PWM function. The button that starts the PWM is activated after selecting a frequency and a duty cycle.



- Step 10. To activate the output channel steady state, use the [ON] button under [Steady State]. Use [OFF] to deactivate it.
- Step 11. Click on the [START] button under [Fault Check] on the right side of the GUI channel section to monitor the on/off status on the per-channel FAULT pin on IPS2050H (or IPS2050H-32).
   You can stop monitoring the fault status by clicking on the related [STOP] button.
   Press the [RESET] button to reset the related fault status.



#### Figure 40. STSW-IFAPGUI in action

#### 2.3.3 How to get information about the GUI

Information about the GUI revision for the multiboard configuration is available by clicking on [**Command** Interface] at the right of the title.

Then, the following window (in the example related to the first revision) appears:

#### Figure 41. Command interface info



### 2.4 X-NUCLEO-OUT05A1 and X-NUCLEO-OUT06A1 expansion boards



#### 2.4.1 How to control a single expansion board

This application scenario is based on the default configuration of the on-board switch and resistors of the X-NUCLEO-OUT05A1 (or X-NUCLEO-OUT06A1).

- Step 1. Stack the X-NUCLEO-OUT05A1 (or X-NUCLEO-OUT06A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT5F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT5G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2.Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for<br/>NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB).<br/>The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.

#### Step 3. Launch the STSW-IFAPGUI.

When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

# STSW-IFAPGUI \_\_ C X

Figure 42. STSW-IFAPGUI COM - port opened

Step 4. Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware identification is complete).

A popup window appears to choose the proper system configuration.







Step 5. Select [X-NUCLEO-OUT05/06A1 Single Board System] and the STSW-IFAPGUI appears on the screen.





Step 6.

- Use the left side of the GUI to manage the channel steady state for the IPS1025H (or IPS1025H-32)
  - Use the right side of the GUI to manage its PWM settings.
- **Step 7.** Connect the load and supply the power stage of the X-NUCLEO-OUT05A1 (or X-NUCLEO-OUT06A1) with a 24 V rail via the CN1 connector.
- Step 8. Select the desired switching frequency and duty cycle of the output channel through the [PWM SET ON/OFF COMMANDS] on the right side of the GUI.





#### Figure 45. STSW-IFAPGUI in action

Step 10. Click on the [FAULT CHECK] button on the left side of the GUI to monitor the on/off status on the desired FAULT pin on IPS1025H (or IPS1025H-32) (FAULT1 for overtemperature, FAULT2 for overload).

You can stop monitoring the fault status by clicking again on the related [FAULT CHECK] button. Press the [FAULT RESET] button to reset the related fault status.

#### 2.4.2 How to control up to four expansion boards

This application scenario is based on the multiboard configuration of the on-board switch and resistors of STDES-OUT05D04 (or STDES-OUT06D04). The following table summarizes the multiboard setup.

Board no.	IN1	FLT1	FLT2
Board 0	R101	R103	R114
Board 1	R102	R104	R117
Board 2	R115	R116	R107
Board 3	R120	R119	R118

#### Table 3. Configuration of a stack of four expansion boards

To get information about the resistance connection configuration for each board directly through the GUI, click on the image that appears in the window of the respective board (see Figure 52. STSW-IFAPGUI main control panel), as shown in the following figures.

57/

#### Figure 46. Setup for board 0 (default setup)



#### Figure 47. Setup for board 1



57

#### Figure 48. Setup for board 2



#### Figure 49. Setup for board 3



- Step 1. Stack up to four X-NUCLEO-OUT05A1 (or X-NUCLEO-OUT06A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT5D4F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT5D4G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB).
   The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.



#### Step 3. Launch the STSW-IFAPGUI.

When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

Figure 50.	STSW-IFAPGUI COM	- port opened
------------	------------------	---------------

	STSW-IFAPGUI	_ 🗆 ×
Wide       1025         Device: 1025       Port: COM17         Image: Comparison of the second s	Evice : 1025 Port : COM17 Evice : 1025	Auto detect FW/ version

Step 4.

Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware identification is complete).

A popup window appears to choose the proper system configuration.

#### Figure 51. System configuration selection panel



# Step 5. Select [X-NUCLEO-OUT05/06A1 Multi Board System] and the STSW-IFAPGUI appears on the screen.





**Step 6.** If all four boards are not physically connected, it is possible to disable the commands on the unconnected boards using the [**Disable**] button of the relevant boards.

By pressing the same button, you can re-enable the board once connected.

- Step 7. The main control panel is divided in four rows, one per each board. Each row is divided in two columns, one per each channel of the on-board device. All the buttons with blue text are related to the currently active functions. For each channel:
  - Use the left part of the GUI section to manage the channel steady state for IPS1025H (or IP1025H-32).
  - Use the right part of the GUI section to manage its PWM settings.

The following figure shows a detailed view of the GUI section for each channel.



#### Figure 53. STSW-IFAPGUI channel section

- **Step 8.** Connect the load and supply the power stage of the X-NUCLEO-OUT05A1 (or X-NUCLEO-OUT06A1) with a 24 V rail via the CN1 connector.
- Step 9. Select the desired switching frequency and duty cycle of the output channel through the dedicated controls. Use [ON] and [OFF] buttons under [PWM] to start and stop the PWM function. The button that starts the PWM is activated after selecting a frequency and a duty cycle.

57/





Step 10. To activate the output channel steady state, use the [ON] button under [Steady State]. Use [OFF] to deactivate it.

You can stop monitoring the fault status by clicking on the related [**STOP**] button. Press the [**RESET**] button to reset the related fault status.

**Step 11.** Click on the [**START**] button under [**Fault Check**] on the right side of the GUI channel section to monitor the on/off status on the per-channel FAULT pins on IPS1025H (or IPS1025H-32).



#### Figure 54. STSW-IFAPGUI in action

#### 2.4.3 How to get information about the GUI

Information about the GUI revision for the multiboard configuration is available by clicking on [**Command** Interface] at the right of the title.

Then, the following window (in the example related to the first revision) appears:

#### Figure 55. Command interface info







#### 2.5 X-NUCLEO-OUT07A1 expansion board

#### 2.5.1 How to control the expansion board

This application scenario is based on the default configuration of the on-board switch and resistors of the X-NUCLEO-OUT07A1.

- Step 1. Stack the X-NUCLEO-OUT07A1 on top of the NUCLEO-F401RE flashed with the STSW-OUT7F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT7G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- Step 3. Connect the load and supply the power stage of the X-NUCLEO-OUT07A1 with a 24 V rail via the CN1 connector.
- **Step 4.** Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

#### Figure 56. STSW-IFAPGUI COM - port opened



Step 5. Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware identification is complete). The GUI automatically identifies the board configuration based on the information provided by the firmware.

#### Figure 57. STSW-IFAPGUI identification complete





**Step 6.** When the board identification phase has been completed the related STSW-IFAPGUI appears on the screen.







Step 7. The main control panel includes the sections:

- four channel control sections, one for each device channel, to control the Steady State or PWM mode.
- six diagnostic sections related to FAULT, OL device pins, and DIAG1, DIAG2, DIAG3 and DIAG4 signals
- a Channels Selection section to perform operation on the selected channels with a single click
- a Command Reset section to restore the main control panel startup status

All the buttons with blue text refer to the functions currently active, when the text is gray the function will be activated after a preliminary action, such as setting the frequency and duty cycle of the PWM.

Use the Channel [Steady State] GUI section to manage the channel steady state for IPS4260LM. The [ON] and [OFF] buttons are used to turn a channel on or off respectively. The [ON] button for each channel is enabled at the startup. When a channel is on in steady state mode the green LED corresponding to that channel will be on, the [OFF] button will be enabled, and the [ON] button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. To use the PWM, the steady state of the channel must first be switched off.



#### Figure 59. STSW-IFAPGUI Channel section, Steady State enabled and ready to use





Use the channel [PWM] GUI section to manage the channel PWM settings and to power on or off the channel input in PWM mode. The button [ON] starting the PWM will be enabled when both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function.





#### Figure 61. STSW-IFAPGUI channel section, PWM ON state



Step 8. The diagnostic sections allow you to check the status of the diagnostic pins and signals available on the board. The pins and signals that is possible to check are:

- FAULT: Cut-off and thermal shutdown pin. Common diagnostic pin both for thermal shutdown and cut-off
- OL: Cumulative power stage open load or short ground common diagnostic
- DIAG1: Channel 1 cut-off and thermal shutdown diagnostic
- DIAG2: Channel 2 cut-off and thermal shutdown diagnostic
- DIAG3: Channel 3 cut-off and thermal shutdown diagnostic
- DIAG4: Channel 4 cut-off and thermal shutdown diagnostic

Use the [FAULT pin status check] section to start and stop the check on the device FAULT pin.

#### Figure 62. STSW-IFAPGUI FAULT pin status check section

FAULT pin status check							
START	STOP	RESET					
			D8				

Click on the [**START**] to monitor the on/off status of the FAULT pin onIPS4260LM. The FAULT is a Common Diagnostic pin, and it is activated (forced low) for both for thermal shutdown and cut-off. When a fault condition is triggered, the red LED into the section will light up. The pin check in progress is signaled by the activation of the progress bar.

#### Figure 63. STSW-IFAPGUI FAULT pin status check in progress



Click on the [**STOP**] button to stop the FAULT pin check and on the [**RESET**] button to clear the last pin condition which is kept displayed after the stop.

Use the [**OL pin status check**] section to start and stop the check on the device OL pin. It is the cumulative power stage open load or short ground common diagnostic, forced low when fault condition occurs.

#### Figure 64. STSW-IFAPGUI OL pin status check section



Click on the [**START**] to monitor the on/off status of the OL pin on IPS4260LM. The OL is a Common Diagnostic pin, and it is forced low when activated. When an OL fault condition is triggered, the red LED into the section will light up, as shown in the following figure. The pin check in progress is signaled by the activation of the progress bar.

#### Figure 65. STSW-IFAPGUI OL pin status check in progress



Click on the [**STOP**] button to stop the OL pin check and on the [**RESET**] button to clear the last pin condition which is kept displayed after the stop.

Below is a description of how to use the monitoring of the DIAG1, DIAG2, DIAG3 and DIAG signals. Since the operation is similar for all four, the operation will be explained only once by generically indicating one of the four signals with DIAGx.

Use the [**DIAGx pin status check**] section to start and stop the check of the device DIAGx diagnostic signal.

#### Figure 66. STSW-IFAPGUI DIAGx signal status check section

DIAG1 pin status check							
START	RESET						

Click on the [**START**] to monitor the on/off status of the DIAGx signal on X-NUCLEO-OUT07A1. The DIAGx is a per-channel diagnostic pin, and it is activated (forced low) in case of thermal shutdown. When a fault condition is triggered, the red LED into the section will light up. The signal check in progress is signaled by the activation of the progress bar.

#### Figure 67. STSW-IFAPGUI DIAGx signal status check in progress



Click on the [**STOP**] button to stop the DIAGx signal status check and on the [**RESET**] button to clear the last signal condition which is kept displayed after the stop.

Step 9. Click on the [RESET] button in the bottom-right part of the main control panel to stop all operations in progress (channels switched on in steady state or PWM mode, diagnostic checks on going). All frequency and duty cycle values selected for the PWM are also reset.

#### Figure 68. STSW-IFAPGUI Commands Reset button

Commands Reset RESET





#### 2.5.2 How to get information about the GUI

Information about the GUI revision is available by clicking on the interface title (See Figure 58. STSW-IFAPGUI main control panel). Then, the following window (in the example related to the first revision) appears:

#### Figure 69. Command interface info



#### 2.5.3 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the yellow info logo on the left of the board image (See Figure 58. STSW-IFAPGUI main control panel). The following figure shows the Board Connections window shown after the click for X-NUCLEO-OUT07A1.



#### Figure 70. Board Pin Connections

#### 2.5.4 Information about the device

It is also possible to obtain information on the features of the device mounted on the board. Simply with a click on the device package picture (See Figure 58. STSW-IFAPGUI main control panel).


#### Figure 71. Get Command Interface info



Then, the following window appears:

#### Figure 72. Device Features







# 2.5.5 Close the command interface

To close the command interface, use File/Close in the top-left part of the GUI.

#### Figure 73. STSW-IFAPGUI close the command interface



The command interface can be opened again by clicking on the Nucleo icon as described above.

# 2.6 X-NUCLEO-OUT08A1 and X-NUCLEO-OUT10A1 expansion boards

# 2.6.1 How to control a single expansion board

In this application scenario, the default X-NUCLEO-OUT08A1 (or X-NUCLEO-OUT10A1) on-board switch and resistor configuration is applied.

- Step 1. Stack the NUCLEO-F401RE board flashed with the STSW-OUT8F4 firmware (or NUCLEO-G431RB flashed with STSW-OUT8G4) on the X-NUCLEO-OUT08A1 (orX-NUCLEO-OUT10A1) through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC/laptop USB port through a mini-USB (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB).
- Step 3. Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.
- Step 4. Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware identification has completed).

COMMANDS     COMMANDS     DEFAULT     Image: Command comm	STSW-IFAPGUI (COM36) i File			_ 🗆 ×
BOARD       COMMANDS       PWM COMMANDS         DEFAULT       INPUT	life.augmented X-NU	ICLEO-OUT $\left\{ \begin{array}{c} 08\\ 10 \end{array} \right\}$ -A1 based on IPS	160 161     HF Commands Console 1.2.1	
DEFAULT       INPUT       ON       OFF         INPUT       ON       OFF       Inmax 100       Duty Cycle P2, min0 max 100         INPUT       ON       OFF       Inmax 100       Inmax 100       Inmax 100         INPUT       ON       OFF       Inmax 100       Inmax 100       Inmax 100       Inmax 100         INPUT       Neh DRV       DAG       START       RESET       Inmax 100       Inmax 100 </th <th>BOARD</th> <th>COMMANDS</th> <th>PWM COMMANDS</th> <th>IPS</th>	BOARD	COMMANDS	PWM COMMANDS	IPS
INPUT Nch DRV DIAG OUTFB       INPUT       ON       OFF       OFF       OFF         ALTERNATE       INPUT       ON       OFF       ON       OFF         INPUT Nch DRV DIAG OUTFB       INPUT       ON       OFF       ON       OFF         INPUT Nch DRV DIAG OUTFB       INPUT       ON       OFF       ON       OFF         INPUT Nch DRV DIAG OUTFB       INPUT       ON       OFF       ON       OFF         INPUT Nch DRV DIAG OUTFB       START       RESET       ON       OFF       ON	DEFAULT	INPUT ON OFF Nch DRV ON OFF DIAG START RESET	Frequency [H2] min 0.1 max 100     Duty Cycle [%] min 0 max = 100       0 Hz     0 %       1 min 0 max = 100     0	Console
ALTERNATE INPUT ON OFF Neh DRV DIAG OUT FB START RESET OUT FB START RESET OUT FB START RESET	INPUT Nch DRV DIAG OUT FB		OFF Lenght % 0	
	ALTERNATE	INPUT     ON     OFF       Nch DRV     ON     OFF       DIAG     START     RESET       OUT FB     START     RESET	Image: Note of the second s	

#### Figure 74. STSW-IFAPGUI main control panel



Figure 75. STSW-IFAPGUI single chip control panel



- Connect the load and supply the power stage of the X-NUCLEO-OUT08A1 (or X-NUCLEO-OUT10A1) Step 6. with a 24 V rail via CN1 connector.
- Step 7. Select the desired switching frequency and duty cycle of the output channel through the [PWM COMMANDS] on the top right side of the GUI.
- Click the [ON/OFF] button (just below the Frequency Selection area) to activate or deactivate the Step 8. output channel.
- Note: The output channel steady state can be activated by clicking on the [ON] button on the right of the [INPUT] label.
  - Click on the [START] button on the right of the [DIAG] and [OUT FB] labels to monitor the on/off status Step 9. of the DIAG pin on IPS160HF (or IPS161HF) and the output voltage status (if activated by setting J13 appropriately).

You can stop monitoring these feedback signals by clicking on the [STOP] button.

- Note: In some cases it may be necessary to supply the board 30 V for proper activation of the signals on the GUI.
  - Step 10. Use one of the following options to test Q1 and the on-board circuit for the fast discharge of high capacitive load:
    - Click on the [ON/OFF] button on the right of the [NchDRV] label to activate Q1 in steady state.
    - Tick the box on the left of the [Nch Enable] label and then select its activation delay after the output gets inactive and its activation length during the output deactivation window.

Both timing parameters are defined as a percentage of the deactivation window of the output channel by the [Delay %] and [Length %] selectors.

#### 2.6.2 How to control two expansion boards

The STSW-IFAPGUI and the STSW-OUT8F4 or STSW-OUT8G4 firmware can also control two stacked shields (two X-NUCLEO-OUT08A1, or two X-NUCLEO-OUT10A1 expansion boards, or one of each).

Configure the jumper and resistors of the second (ALTERNATE) board as described in UM2715 (for X-Step 1. NUCLEO-OUT08A1) and UM2716 (for X-NUCLEO-OUT10A1), freely available on www.st.com.



STSW-IFAPGUI (COM36) \_ 🗆 × File  $I_{\text{life.ougmented}} X-\text{NUCLEO-OUT} \left\{ \begin{matrix} 08\\ 10 \end{matrix} \right\} -\text{A1} \quad \text{based on} \quad \text{IPS} \left\{ \begin{matrix} 160\\ 161 \end{matrix} \right\} \text{HF}$ 1SOIe 1.2.1 DEFAULT Frequency [Hz] min 0.1 max 100 INPUT ON OFF Enabled ON OFF DIAG START RESET Nch Er ON Delay % OUTFB START RESET OFF Lenght % INPUT Nch DRV DIAG OUT FB 0 ALTERNATE Frequency [Hz] min 0.1 max 100 INPUT ON OFF Nch DRV ON OFF DIAG START RESET Nch Enable ON Delay % OUT FB START RESET DIAG OUT FB INPU Lenght % OFF 0 Na

Figure 76. STSW-IFAPGUI dual chip control panel

The control panel of the ALTERNATE board is a clone of the DEFAULT one, so you can follow the steps described in Section 2.6.1.

# 2.7 X-NUCLEO-OUT09A1 and X-NUCLEO-OUT19A1 expansion boards

## 2.7.1 How to control the expansion board

This application scenario is based on the default configuration of the on-board switch and resistors of the X-NUCLEO-OUT09A1 (or X-NUCLEO-OUT19A1).

- Step 1. Stack the X-NUCLEO-OUT09A1 (or X-NUCLEO-OUT19A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT9F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT9G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB).
   The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- **Step 3.** Connect the load and supply the power stage of the X-NUCLEO-OUT09A1 (or X-NUCLEO-OUT19A1) with a 24 V rail via the CN1 connector.



#### **Step 4.** Launch the STSW-IFAPGUI.

When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

Figure 77. STSW-IFAPGUI COM - port opened

STSW-IFAPGUI	_ 🗆 ×
Nucleo	☑ Auto detect FW version
Perts : COM17	

- Step 5. Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware Identification is complete).
- Step 6. The STSW-IFAPGUI appears on the screen.







#### Step 7. The main panel is divided into:

- eight channel control sections, one for each channel
- a diagnostic section
- a command reset section

All the buttons with blue text are related to the currently active functions.

The channel control sections are used to switch on or off the channels in steady state and PWM mode.

 Use the Channel [Steady State] GUI section to manage the channel steady state for IPS8160HQ (or IPS8160HQ-1). The [ON] and [OFF] buttons are used to turn a channel on or off respectively. The [ON] button for each channel is enabled at the startup.

When a channel is on in steady state mode the green LED corresponding to that channel will be on and the **[OFF]** button will be enabled, and the **[ON]** button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. In order to use the PWM, the steady state of the channel must first be switched off.

Use the channel [PWM] GUI section to manage the channel PWM settings and to power on or off the channel input in PWM mode. The [ON] button starting the PWM will be enabled when both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function.

The following figures show a detailed view of the GUI Channel section functions.

# Figure 79. STSW-IFAPGUI channel section, Steady State enabled and ready to use



#### Figure 80. STSW-IFAPGUI channel section, Steady State ON



#### Figure 81. STSW-IFAPGUI channel section, PWM ON





**Step 8.** The diagnostic section is related to the thermal shutdown condition check. Click on the [**START**] button under [**Thermal shutdown diagnostic pin Status Check**] to monitor the on/off status of the STATUS pins on IPS8160HQ (or IPS8160HQ-1). The STATUS is a diagnostic pin at chip level. The activation of the status pin check is signalized by the bar under the diagnostic LED. When a fault condition is triggered, the red LED will light up. Click on the [**STOP**] button to stop the STATUS pin check and on the [**RESET**] button to clear the last pin condition displayed

#### Figure 82. STSW-IFAPGUI status check



#### Figure 83. STSW-IFAPGUI status check activated (no fault condition triggered)



Step 9. Click on the [RESET] button in the [Commands Reset] section to stop all operations in progress (channels switched on in steady state or PWM, status pin check activated). All frequency and duty cycle values that have been selected are also reset.

#### Figure 84. STSW-IFAPGUI commands reset

Commands Reset	
RESET	

Step 10. To close the command interface, use File/Close in the top-left part of the GUI. The command interface can be opened again by clicking on the Nucleo icon as described above.



# 2.7.2 How to get information about the GUI

Information about the GUI revision is available by clicking on [**Command Interface**] at the right of the title. Then, the following window (in the example related to the first revision) appears:

#### Figure 85. Command Interface info



# 2.7.3 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the board image.



#### Figure 86. Board setup

# 2.7.4 Close the command interface

To close the command interface, use File/Close in the top-left part of the GUI.

#### Figure 87. STSW-IFAPGUI close the command interface

	STSW-IFAPGUI (COM58)				
	File				
Π		Close	1		

The command interface can be opened again by clicking on the Nucleo icon as described above.



# 2.8 X-NUCLEO-OUT11A1 and X-NUCLEO-OUT13A1 expansion boards

# 2.8.1 How to control the expansion board

This application scenario is based on the default configuration of the on-board switch and resistors of the X-NUCLEO-OUT11A1 (or X-NUCLEO-OUT13A1).

- Step 1. Stack the X-NUCLEO-OUT11A1 (or X-NUCLEO-OUT13A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT11F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT11G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- Step 3. Connect the load and supply the power stage of the X-NUCLEO-OUT11A1 (or X-NUCLEO-OUT13A1) with a 24 V rail via the CN1 connector.
- **Step 4.** Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

# STSW-IFAPGUI

# Figure 88. STSW-IFAPGUI COM - port opened



Step 5. Click on the GUI STM32 Nucleo icon after it turns blue. After the click a system selection windows are shown, because there are more than one system using device of the same 808 family.



Figure 89. System configuration selection panel

In this case the option one must be selected. It is necessary to have flashed the correct firmware (STSW-OUT11F4 or STSW-OUT11G4) in the microcontroller to avoid errors when opening the command interface, in fact if the firmware is not the correct one an error message will be shown. After the system selection and firmware identification the logo will be green.

# Figure 90. STSW-IFAPGUI identification complete











#### Step 7. Use the Command Interface.

#### The main panel is divided into:

- eight channel control sections, one for each channel
- control mode section
- the outputs enable section
- a diagnostic section
- commands reset section

All the buttons with blue text are related to the currently active functions.

Use the [Control Mode Used] section to choose the control mode state for ISO808 or ISO808-1 or ISO808Q or ISO808Q-1. The [SCM] button selects the Direct Control Mode, the [DCM] button selects the Synchronous Control Mode. At the command interface startup, the default mode is Synchronous, so the change mode to [DCM] button is enabled.

#### Figure 92. STSW-IFAPGUI control mode selection



Use the [Output Enable Pin] section to enable the outputs for ISO808 or ISO808-1 or ISO808Q or ISO808Q-1. At the startup the outputs and all commands into the channels control section are disabled.

## Figure 93. STSW-IFAPGUI Output Enable Pin control



The channel control sections are used to switch on or off the channels in steady state or PWM mode

- Use the Channel [Steady State] GUI section to manage the channel steady state for ISO808 or ISO808-1 or ISO808Q or ISO808Q-1. The [ON] and [OFF] buttons are used to turn a channel on or off respectively. The [ON] button for each channel is not enabled after the commands interface startup until the outputs are enabled. When a channel is on in steady state mode the green LED corresponding to that channel will be on, the [OFF] button will be enabled, and the [ON] button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. In order to use the PWM, the steady state of the channel must first be switched off.
- Use the channel [PWM] GUI section to manage the channel PWM settings and to power on or off the channel input in PWM mode. The [ON] button starting the PWM will be enabled when the outputs are enabled and both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function.

The following figures show a detailed view of the GUI Channel section functions.



# Figure 94. STSW-IFAPGUI channel section, Steady State control enabled and ready to use



#### Figure 95. STSW-IFAPGUI channel section, Steady State on



# Figure 96. STSW-IFAPGUI channel section, PWM on





**Step 8.** The diagnostic section is related to the thermal shutdown condition check. Click on the [**START**] button under [**Thermal shutdown diagnostic pin Status Check**] to monitor the on/off status of the STATUS pins on ISO808 or ISO808-1 or ISO808Q or ISO808Q-1. The STATUS is a diagnostic pin at chip level. The activation of the status pin check is signalized by the bar below the diagnostic LED. When a fault condition is triggered, the red LED will light up. Click on the [**STOP**] button to stop the STATUS pin check and on the [**RESET**] button to clear the last pin condition displayed.

#### Figure 97. STSW-IFAPGUI status check before activation

Thermal shu Si	ıtdown di tatus che	iagnostic pin ck
START	STOP	RESET
[		

#### Figure 98. STSW-IFAPGUI status check activated, no fault

Thermal shutdown diagnostic pin					
Status check					
START	START <b>STOP</b> RESET				

Step 9. Click on the [RESET] button in the [Commands Reset] section to stop all operations in progress, (channels switched on in steady state or PWM, status pin check activated). All frequency and duty cycle values that have been selected are also reset.

#### Figure 99. STSW-IFAPGUI commands reset

Commands Reset	
RESET	

#### 2.8.2 How to get information about the GUI

Information about the GUI revision for the system you are using is available by clicking on [**Command Interface**] at the left part of the title.Then, the following window (in the example related to the first revision) appears:

#### Figure 100. Command interface info

Grie About Command Interface - X
life.augmented
X-NUCLEO-OUT11A1, X-NUCLEO-OUT13A1 STEVAL-IFP041V1, STEVAL-IFP047V1 System Command Interface
Revision 1.0.0



## 2.8.3 How to get information about the Device Features

Information about the device feature is available by clicking on devices pictures on the top-left part of the command interface.

#### Figure 101. How to get devices info



Octal channel high side drivers

#### Then, the following window appears:

#### ISO808, ISO808-1,ISO808Q, ISO808Q-1 Features and Applications Х ISO808, ISO808-1 ISO808Q, ISO808Q-1 Galvanic isolated octal high side power solid state relay for high inductive loads TFQFPN3 Features V<sub>CC(AMR)</sub> = 45 V . Over-voltage protection (V<sub>CC</sub> clamping) - Wide process side op. range V<sub>CC</sub> = 9.2 to 36 V - Loss of GND and $\mathsf{V}_{\mathsf{CC}}$ protections R<sub>DS</sub>(on) = 0.125 Ω per channel (TYP) Very low process and logic sides supply current + Fast demagnetization of inductive loads V<sub>DEMAG(TYP)</sub> = V<sub>CC</sub> - 54 V Logic side 5 V and 3.3 V TTL/CMOS and MCU compatible I/Os Common output enable/disable pin Per channel process side op. current - ISO808/ISO808Q IOUT < 0.7 A Under-voltage shut down with auto restart and hysteresis Common fault open drain diagnostic ISO808-1/ISO808Q-1 I<sub>OUT</sub> < 1 A</li> Reset function for IC outputs disable Short circuit protection on output channels High common mode transient immunity ISO808/ISO808Q I<sub>LIM(MIN)</sub> = 0.7 A . Designed to meet IEC 61000-4-2, IEC 61000- 4-4, IEC 61000-4-5 and IEC 61000-4-8 ISO808/ISO808Q I<sub>LIM(MIN)</sub> = 1 A Per-channel over-temperature protection with thermal independence of separate UL1577 and UL508 certified channel Safety limits according to VDE 0844-11 . Case over-temperature protection PowerSO-36, TFQFPN32 9x11 Applications Programmable logic control • Industrial PC peripheral input/output Numerical control machines Drivers for all type of loads (resistive, capacitive, inductive)

# Figure 102. Devices info

# 2.8.4 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the board image.



#### Figure 103. Board setup



# 2.8.5 Close the command interface

To close the command interface, use File/Close in the top-left part of the GUI.

#### Figure 104. STSW-IFAPGUI close the command interface

STSW-IFAPGUI (COM58)			
	Close		

The command interface can be opened again by clicking on the Nucleo icon as described above.

# 2.9 X-NUCLEO-OUT12A1 and X-NUCLEO-OUT14A1 expansion boards

#### 2.9.1 How to setup a multiboard system

This application scenario is based on the multiboard configuration using the on-board jumpers and resistors of the X-NUCLEO-OUT12A1 (or X-NUCLEO-OUT14A1).

There are two different scenarios:

- Parallel Independent Mode
- Daisy Chain Mode

In the parallel independent mode, it is possible to drive up to two boards independently to get an 8+8 channels system. The board resistors must be properly configured. The first board, called Board 0 has the default resistor configuration and you don't have to do anything. For the second, called Board 1, it is necessary to unsolder some resistor and solder them in a new position as described in the following table:

Table 4. Resistors configuration of two stacked expansion boards in Parallel Independent Mode

Board no.	SPI_CLK	DaisyChain	SPI_MISO	SPI_MOSI	SPI_SS	OUT_EN	STATUS	PGOOD
Board 0	R106	_	R105	R104	R103	R119	R108	R107
Board 1	R106	_	R105	R104	R114	R109	R113	R111

To use the command interface, it's not necessary to have booth boards. Can be stacked on the nucleo board only one of the two X-NUCLEO, but it is necessary to refer to the board number accordingly to the resistors configuration. Furthermore, the correct jumper setup must be used:

J5 open

J3 Closed 1-2, 3-4, 5-6

J4 Closed 5-6

J6 Closed 1-2, 3-4, 5-6, 7-8 to enable active state led for OUT1-4

J7 Closed 1-2, 3-4, 5-6, 7-8 to enable active state led for OUT5-8

J9, J10 closed

J12: Closed 1-2

J13: Closed 1-2

In Daisy Chan mode the two board connections create a unique system. So, the two boards are not independent and must always be stacked together on the Nucleo board. In this case two stacked boards using Daisy Chain implement a 16 channels system.

#### Table 5. Configuration of a stack of two expansion boards in Daisy Chain Mode

Board no.	SPI_CLK	DaisyChain	SPI_MISO	SPI_MOSI	SPI_SS	OUT_EN	STATUS	PGOOD
Board 0	R106	R102	-	R104	R103	R119	R108	R107
Board 1	R106	R102	R105	-	R103	R119	R113	R111

The jumper setup for the Daisy Chain Mode is: J5 open J3 Closed 1-2, 3-4, 5-6 J4 Closed 5-6 J6 Closed 1-2, 3-4, 5-6, 7-8 to enable active state led for OUT1-4 J7 Closed 1-2, 3-4, 5-6, 7-8 to enable active state led for OUT5-8 J9, J10 closed

- Board 0:
  - J12: Closed 1-2
  - J13: Closed 3-4
- Board 1:
  - J12: Closed 3-4
  - J13: Closed 1-2





## 2.9.2 How to control the expansion boards

- Step 1. Stack the X-NUCLEO-OUT12A1 (or X-NUCLEO-OUT14A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT12F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT12G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- Step 3. Connect the load and supply the power stage of the X-NUCLEO-OUT12A1 (or X-NUCLEO-OUT14A1) with a 24 V rail via the CN1 connector.
- **Step 4.** Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

STSW-IFAPGUI	_ 🗆 ×
Perice: 808 Peric: COMSS	☑ Auto detect FW version

#### Figure 105. STSW-IFAPGUI COM - port opened



Step 5. Click on the GUI STM32 Nucleo icon after it turns blue. After the click a system selection windows are shown, because there is more than one system using device of the same 808 family.





In this case there are two options selectable:

- 2: Parallel Independent Mode
- 3: Daisy Chain Mode

The firmware to be flashed in the microcontroller must be STSW-OU12F4 or STSW-OUT12G4, a not corrected firmware will generate an error message in command interface opening phase. After the system selection and firmware identification the logo will be green.

#### Figure 107. STSW-IFAPGUI identification complete





**Step 6.** The STSW-IFAPGUI appears on the screen. The following figures show the command interface startup window for parallel independent and daisy chain mode.





Figure 109. STSW-IFAPGUI – daisy chain system main control panel

	Comn	nand In	terface for )	(-NUCLEC	D-OUT	{ <u>12</u>	} A1	and STEVA	L-IFP { 04	2 8 7 1	5
DARD 0 BOARD 1				Daisy Chai	n Syster	п Соп	- figuration		- 0-	-	IP
BOARD 0 X-NUCLEO-DUTIZAT STEVAL-FORMT X-NUCLEO-DUTIAT STEVAL-FORMT		Steady State	Channel T Frequency [Hz] min 0.1 max 100	Duty Cycle [74] min 0 max = 100			Steady State	Channel 2 Frequency (Hz) min 0.1 max 100	Duty Cycle [%] min 0 max 100	<i>РИМ</i> ОN	C
ISO RODA Powe90-36 Galvanic Isolated Octal High Side Drivers System Enable		Steady State ON OFF	Channel 3 Frequency (Hz) min 0.1 max 100 D Hz	Duty Cycle [%] min 0 max 100	РИМ ON OFF		Steady State ON OFF	Channel 4 Frequency (Hz) min 0.1 max 100 D Hz	Duty Cycle [%] min 0 max 100		
			Channel					Channel f	5		
Power Good Pin Status Check		Steady State ON OFF	Frequency (Hz)	Duty Cycle [%] min 0 max 100	ON OFF		Steady State ON OFF	Frequency (Hz) min 0.1 max 100	Duty Cycle (%) min 0 max 100	ON OFF	
Internal Communication Error Status Pin Check			Channel 7	7				Channel 8	3		
START STOP RESET		Steady State ON OFF	Frequency (Hz) min 0.1 max 100	Duty Cycle [%] min 0 max 100	ON OFF		Steady State ON OFF	Frequency (Hz) min 0.1 max 100 D Hz	Duty Cycle [%] min 0 max 100	ON OFF	



#### Step 7. Use the Command Interface.

The main panel for Parallel Independent and Daisy Chain mode are quite similar. The differences using the two interfaces will be described later. The main panel contains two tabs related to Board 0 and 1 respectively. Each tab is divided into sections: For the **Parallel Independent** Command Interface:

an Output Enable Pin section.

- eight channel control sections, one for each channel.
- a diagnostic section to check the Power Good Pin.
- a diagnostic section to check the Status Pin.
- a commands reset section.

For the Daisy Chain Command Interface:

- a System Enable section.
- eight channel control sections, one for each channel.
- a diagnostic section to check the Power Good.
- a diagnostic section to check the Status Pin
- a commands reset section.
- **Step 8.** Use the [**ENABLE**] button int the [**Output Enable Pin**] section to enable the outputs for ISO808A or ISO808A-1 or ISO808AQ or ISO808AQ-1. At the startup the outputs and all commands into the channels control section are disabled, and the yellow led will be on. After the click on the [**ENABLE**] button LED will be switched off. The two boards outputs can be enabled and disabled independently.

#### Figure 110. STSW-IFAPGUI Output Enable for Parallel Independent configuration



# **Daisy Chain System Configuration**

Use the [ENABLE] button int the [System Enable] section to enable the outputs for ISO808A or ISO808A-1 or ISO808AQ or ISO808AQ-1. At the startup the outputs and all commands into the channels control section are disabled, and the yellow led will be on. After the click on the [ENABLE] button LED will be switched off. In the Daisy Chain connections, the operation on the two boards are not independent, so each enabling command on one board affects also the other. The same behavior for the disable.

Figure 111. STSW-IFAPGUI SYSTEM Enable for Daisy Chain configuration



**Step 9.** The command interface can be used to drive up to board in parallel independent mode and two board in daisy chain mode. To address a board, use the tab in the upper-left part of the interface.

#### Figure 112. STSW-IFAPGUI board selection





Step 10. Control the channel in steady state or PWM mode using the related Control sections.

Use the Channel [**Steady State**] GUI section to manage the channel steady state for ISO808A or ISO808A-1 or ISO808AQ or ISO808AQ-1. The [**ON**] and [**OFF**] buttons are used to turn a channel on or off respectively. The [**ON**] button for each channel is not enabled at the command interface startup. To enable it will be necessary to enable the outputs using the [**Output Enable Pin**] section for a parallel independent system or the [**System Enable**] section for Daisy Chain mode.

When a channel is on in steady state mode the green LED corresponding to that channel will be on and the **[OFF]** button will be enabled, and the **[ON]** button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. In order to use the PWM, the steady state of the channel must first be switched off.

Use the channel [PWM] GUI section to manage the channel PWM settings and to power on or off the channel input in PWM mode. The [ON] button starting the PWM will be enabled when both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel and the system was initially enabled using the [Output Enable Pin] section for a parallel independent system or the [System Enable] section for Daisy Chain mode. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function.

The following figures show a detailed view of the GUI channel section functions.

#### Figure 113. STSW-IFAPGUI channel section, Steady State enabled and ready to use







#### Figure 115. STSW-IFAPGUI channel section, PWM on





Step 11. Diagnostic section related to the [Thermal Shutdown or Internal Communication Error] condition. Click on the related [START] button to monitor the on/off status of the STATUS pins on ISO808A or ISO808A-1 or ISO808AQ or ISO808AQ-1. The STATUS is a diagnostic pin at chip level. The activation of the status pin check is signalized by the bar under the diagnostic LED. When a fault condition is triggered, the red LED will light up. Click on the [STOP] button to stop the STATUS pin check and on the [RESET] button to clear the last pin condition displayed.

#### Figure 116. STSW-IFAPGUI status check before activation



#### Figure 117. STSW-IFAPGUI status check activated, no fault



Step 12. A diagnostic section to check the power Good Pin.is available. Click on the [START] button in [Power Good Pin Status Check] to monitor the on/off status of the power good pin on ISO808A or ISO808A-1 or ISO808AQ or ISO808AQ-1. The STATUS is a diagnostic pin at chip level. A power good check fail condition is signalized by the red LED on into the section.

#### Figure 118. STSW-IFAPGUI Power Good Pin check before activation



#### Figure 119. STSW-IFAPGUI power pood pin check activated, fail signalization

Power Good Pin Status Check						
	START	STOP	RESET			

Click on the [STOP] button to stop the Power Good pin check and on the [RESET] button to clear the last pin condition displayed.



Step 13. There are dedicated sections to reset the ongoing operations and restore the command interface initial state. There are differences between parallel independent and daisy chain mode:

**Parallel Independent**: for the two board refers to the following sections available respectively in the BOARD 0 and 1 tabs:

#### Figure 120. STSW-IFAPGUI commands reset for BOARD 0 and 1

BOARD 0 Commands Reset	BOARD 1 Commands Reset
RESET	RESET

In this mode the reset works independently on the two boards.

Click on the [**RESET**] button in the [**BOARD 0 Commands Reset**] or [**BOARD 1 Commands Reset**] sections to stop all operations in progress, (channels switched on in steady state or PWM, status pin, power good check activated). All frequency and duty cycle values that have been selected are also reset. The output enable will be also switched off.

Daisy Chain: for the two board refers to the following section available in the BOARD 0 and 1 tabs:

### Figure 121. STSW-IFAPGUI System Commands Reset



In this mode the two boards must be considered as a unique system so the reset works on both boards simultaneously. Click on the [**RESET**] button in the [**System Commands Reset**] section to stop all operations in progress, (channels switched on in steady state or PWM, status pin, power good check activated). All frequency and duty cycle values that have been selected are also reset. The output enable will be also switched off and the system will be disabled.

#### 2.9.3 How to get information about the GUI

Information about the GUI revision for the is available by clicking on [**Command Interface**] at the left part of the title. Then, the following window (in the example related to the first revision) appears:

#### Figure 122. Command Interface info





# 2.9.4 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the board image.



Figure 123. BOARD 0 setup for parallel independent mode

Figure 124. BOARD 1 setup for parallel independent mode











57





#### 2.9.5 How to get information about the Device Features

Information about the device feature is available by clicking on devices pictures on the top-left part of the command interface.

Figure 127. How to get devices info



Then, the following window appears:



#### 2.9.6 Close the command interface

To close the command interface, use File/Close in the top-left part of the GU:.

#### Figure 129. STSW-IFAPGUI close the command interface

	STSV	/-IFAPGUI (C	:OM58)	
	File		_	
Π	Close			

The command interface can be opened again by clicking on the Nucleo icon as described above.

## Figure 128. Devices info



# 2.10 X-NUCLEO-OUT15A1 expansion board

## 2.10.1 How to control a single expansion board

This application scenario is based on the default configuration of the on-board switch and resistors of the X-NUCLEO-OUT15A1.

- Step 1. Stack the X-NUCLEO-OUT15A1 on top of the NUCLEO-F401RE flashed with the STSW-OUT15F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT15G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.

Step 3. Launch the STSW-IFAPGUI.

When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

#### Figure 130. STSW-IFAPGUI COM - port opened

STSW-IFAPGUI	_ 🗆 ×
Received to the second s	Auto detect FW version
Device: 1025 Port: COM17	

Step 4. Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware identification is complete).

A popup window appears to choose the proper system configuration.

#### Figure 131. System configuration selection panel





Fault Check

START

STOP

RESET

Check

START

STOP

RESET

#### Step 5. Select [X-NUCLEO-OUT15A1 Single Board System] and the STSW-IFAPGUI appears on the screen.

 

 SWHEARQUI (COMIT)
 X-NUCLEO-OUT 15 A1 based on IPS 1025HF Command Interface
 Image: Command Interface

w

NCh D

Delay [%]

Lenght [%]

Pulse Width Modulation

ON

OFF

#### Figure 132. STSW-IFAPGUI main control panel

Step 6.

- Use the bottom left side of the GUI to manage the channel steady state for the IPS1025HF.
- Use the bottom right side of the GUI to manage its PWM settings.

ty Cycle [%]

÷

÷ 0 %

ON

OF

- Step 7. Connect the load and supply the power stage of the X-NUCLEO-OUT15A1 with a 24 V rail via the CN1 connector.
- Step 8. Select the desired switching frequency and duty cycle of the output channel through the [Pulse Width Modulation] controls on the bottom right side of the GUI.
- Step 9. To activate the output channel steady state, click on the [ON] button on the bottom left side of the GUI in the [Steady State] controls. Use [OFF] to deactivate it.



#### Figure 133. STSW-IFAPGUI in action



Step 10. Use the proper [Fault Check] [START/STOP/RESET] controls on the bottom right side of the GUI to monitor the on/off status on the desired FAULT pin on IPS1025HF (FAULT1 for overtemperature, FAULT2 for overload).

You can stop monitoring the fault status by clicking on the related [**STOP**] button. Press the proper [**RESET**] button to reset the related fault status.

- Step 11. Click on [ON/OFF] buttons in the top right side of the GUI in the [NCh Drv] section to activate/ deactivate the output fast discharge.
- Step 12. Click on [START], [STOP] and [RESET] buttons in the [Out FB] section to start, stop and reset the output feedback monitoring.

## 2.10.2 How to get information about the GUI

Information about the GUI revision for the current configuration is available by clicking on [**Command Interface**] just below the title.

Then, the following window (in the example related to the first revision) appears:

#### Figure 134. Command interface info





# 2.11 X-NUCLEO-OUT16A1 and X-NUCLEO-OUT17A1 expansion boards

The X-NUCLEO-OUT16A1 or X-NUCLEO-OUT17A1 boards can be used in different configurations to create single or dual board systems. The possible configurations are related to the configuration of the jumpers and switches on the used boards. In particular, the configurations that can be created are:

- Single board parallel mode
- Single board 8-bit SPI mode
- Single board 16-bit SPI mode
- Daisy Chain 8-bit SPI mode
- Daisy Chain 16-bit SPI mode

Each configuration consists of a common setting and a setting specific for the configuration (Parallel 8 Ch, SPI 8Ch 8-bit, SPI 8 Ch 16-bit, Daisy Chain 16 Ch 8-bit, Daisy Chain 16 Ch 16-bit)). The set of all possible configurations is described below:

Item	Common settings	Parallel 8 Ch	SPI 8 Ch 8-bit	SPI 8 Ch 16-bit	Daisy Chain 16 Ch 8-bit	Daisy Chain 16 Ch 16-bit
SW1	Closed 1-2	0.0				
SW3	Closed 1-2	1				
SW17	Closed 1-2	1				
JP1, JP2, JP3, JP4, JP5,	Closed to enable OUT1-8	1				
JP6, JP7, JP8	output lines					
JP9	Closed	1				
JP10	Open	1				
JP11	Not mounted	1				
JP12	Closed	1				
JP13	Closed	1				
JP14	Open	]				
JP15	Closed	]				
JP16	Open					
JP17	Open					
JP18	Open					
JP19	Open	]				
JP20	Closed					
JP23	Closed	]				
JP24	Closed					
JP25	Closed					
JP27	Closed	]				
JP28	Closed 2-4	]				
JP29	Closed 1-2, 3-4, 5-6, 7-8 to					
	enable active state led for					
	OUT1-4					
JP30	Closed 1-2, 3-4, 5-6, 7-8 to					
	enable active state led for					
ID21	Classed	{				
SW4	Closed	Closed 1.2	Closed 2	22	Class	100
SW5		Closed 1-2	Closed 2	2-3	Close	12-3
SW6		Closed 1-2	Closed 2	2-3	Board 0	Board 1
(DAISY CHAIN/MOSI)		010300 1-2	0.0300		Olevert 0.0	Observed 4.0
					Closed 2-3	Closed 1-2
SW7		Closed 1-2	Closed 2	2-3	Close	d 2-3
SW9		Closed 1-2	Closed 2	2-3	Close	d 2-3
SW10		Closed 1-2	Closed	2-3	Close	d 2-3
SW11		Closed 1-2	Closed 2	2-3	Close	d 2-3
SW12		Closed 1-2	Closed 2	2-3	Close	d 2-3
SW13		Closed 1-2	Closed 2	2-3	Close	12-3
SW14		Closed 1-2	Closed	2-3	Closed	42.2
SW13		Olosed 1-2	Closed	1.0	Board 0	Board 1
(SPI MISO/DAISY CHAIN)		Open	Ciosed	1-2	Closed 2.2	Closed 4.2
SW20		Closed 1.2	Closed	13	Closed 2-3	123
JD21		Onen	Closed (SE	12 H)	Closed /	SEI 2 H)
0121		(SEL2 L)	Ciused (SE		Ciused (a	
JP22		Open	Open (SEL1 L)	Closed (SEL1 H)	Open (SEL1 L)	Closed (SEL1 H)
	-	-	-			

## Figure 135. Configurations

The use of the graphical interface for all these configurations will be described below.



## 2.11.1 Expansion board configured in parallel mode

#### 2.11.1.1 How to control the single expansion board in parallel mode

Step 1.

Stack the X-NUCLEO-OUT16A1 (or X-NUCLEO-OUT17A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT16F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT16G4 firmware), through the Arduino® UNO R3 connectors.

- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- Step 3. Connect the load and supply the power stage of the X-NUCLEO-OUT16A1 (or X-NUCLEO-OUT17A1) with a 24 V rail via the CN1 connector.
- **Step 4.** Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

STSW-IFAPGUI	_ 🗆 ×
Nucleo	Auto detect FW version
Device : 8200 Port : COM91	

# Figure 136. STSW-IFAPGUI COM - port opened

**Step 5.** Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware Identification is complete). The GUI automatically identifies the board configuration based on the information provided by the firmware. The firmware identifies the current configuration of the board by checking the status of the JP21 jumper. When JP21 is open the board is configured in parallel mode while JP21 closed is used for the SPI configuration.







#### Figure 137. STSW-IFAPGUI main control panel



#### Step 7. The main panel is divided into:

- eight channel control sections, one for each channel.
- a Channel Selection section.
- a command section for the Selected Channels.
- a Command Reset section.
- board image: click on it to open a window showing the board connections.
- package image: click on it to open a window showing the device features.

All the buttons with blue text refer to the functions currently active, when the text is gray the function will be activated after a preliminary action, such as setting the frequency and duty cycle of the PWM.

- Use the Channel [Steady State] GUI section to manage the channel steady state for IPS8200HQ (or IPS8200HQ-1). The [ON] and [OFF] buttons are used to turn a channel on or off respectively. The [ON] button for each channel is enabled at the startup. When a channel is on in steady state mode the green LED corresponding to that channel will be on and the [OFF] button will be enabled, and the [ON] button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. To use the PWM, the steady state of the channel must first be switched off.
- Use the channel [PWM] GUI section to manage the channel PWM settings and to power on or off the channel input in PWM mode. The button [ON] starting the PWM will be enabled when both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function.

The following figures show a detailed view of the GUI Channel section functions.



#### Figure 138. STSW-IFAPGUI channel section, Steady State enabled and ready to use

#### Figure 139. STSW-IFAPGUI channel section, Steady State on



#### Figure 140. STSW-IFAPGUI channel section, PWM on







#### Figure 141. Channels Selection section

		Cha	nnel	s Sel	ectio	n		
1	2 □ AL	3 ▼	4 Is	5 V	6 □ 0 CI	7 V	8	

If you want to select all channels, Click on the [**ALL CHs**] button. To deselect all the channels, click on [**NO CHs**]. After selecting the desired channels, you can control them by pressing a single button. To do this you need to use the [**Selected Channels**] section, shown in the following figure.

#### Figure 142. Selected Channels Section



- Step 9. Click on the [ON] button in the Steady State part of the section (left side) to power on in steady state mode the selected channels. Use the [OFF] button to turn off the selected channels. The same behavior for the [ON] and [OFF] buttons on the PWM part of the section (right side). PWM for the selected channels will only be activated if the frequency and duty cycle have been previously set in each related channel section.
- Step 10. Click on the [RESET] button in the [Commands Reset] section to stop all operations in progress, (channels switched on in steady state or PWM). All frequency and duty cycle values that have been selected are also reset.

#### Figure 143. STSW-IFAPGUI commands reset

Co	mmands Reset
	RESET

#### 2.11.1.2 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the board image. The following figure shows the connections for the parallel system.



#### Figure 144. Board pin connections

## 2.11.2 Expansion board configured in 8-bit or 16-bit SPI mode.

This section shows how to control the IPS8200HQ or the IPS8200HQ-1 using the graphic interface in the case of a system with a single board configured in SPI-8 bit or SPI-16 bit. For the 8-bit case the configuration is achieved by enabling the SPI interface with SEL2=H (JP21 closed) and choosing the 8-bits with SEL1=L (JP22 open). For the 16-bit case the configuration is achieved by enabling the SPI interface with SEL2=H (JP22 closed) and choosing the 16-bits with SEL1=H (JP22 closed).

The device configuration is automatically recognized using information from the firmware and is then opened to the correct graphical interface.

## 2.11.2.1 How to control a single expansion board system configuration

This application scenario is based on an X-NUCLEO-OUT16A1 (or X-NUCLEO-OUT17A1) board configured in 8bit or 16-bit SPI mode. The operations to be done now are:

- Step 1. Stack the X-NUCLEO-OUT16A1 (or X-NUCLEO-OUT17A1) on top of the NUCLEO-F401RE flashed with the STSW-OUT16F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT16G4 firmware), through the Arduino® UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- **Step 3.** Connect the load and supply the power stage of the X-NUCLEO-OUT16A1 (or X-NUCLEO-OUT17A1) with a 24 V rail via the CN1 connector.


**Step 4.** Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

### Figure 145. STSW-IFAPGUI COM port opened



Step 5. Click on the GUI STM32 Nucleo icon after it turns blue. It will turn green once it has recognized the correct interface and opened it. The GUI automatically identifies the board configuration based on the jumper and switch configuration and opens the correct GUI.

### Figure 146. STSW-IFAPGUI identification completed





**Step 6.** The STSW-IFAPGUI appears on the screen. In this phase, an interface is shown that allows you to select the physical system you want to use, i.e. a single board system or a system with two boards connected in a daisy chain.





### Figure 148. STSW-IFAPGUI main control panel for 16-bit SPI configuration before single board or daisy chain selection



Step 7. Use the [SINGLE BOARD] or [DAISY CHAIN] buttons to select the configuration. In this case click on [SINGLE BOARD]. The choice must be consistent with the physical system you are using. Otherwise, correct operation will not occur. If you make a mistake, you will need to close the main control panel and reopen it again as previously described. At this point it will be possible to make a new choice.

### Figure 149. STSW-IFAPGUI System configuration selection





Step 8. After the proper system configuration selection, the correct interface will appear on the screen:

### Figure 150. STSW-IFAPGUI main control panel for 8-bit SPI single board configuration

STSW-IFAPGUI (COM94) File		— C
57	Graphical Commands Interface for X-NUCLEO-OUT16A1 and X-NUCLEO-OUT17A1	
merangmenied	8 DII Data Width SINGLE BOAID System Configuration	113
X-NUCLEO-OUT16A1 X-NUCLEO-OUT17A1	Output Enable Pin ENABLE DISABLE DISABLED Watchdog ENABLED	
	All Channel Select/Unselect ALL CHs NO CHs Steedy ON OFF PWM ON OFF	Con
	Channel         1         2         3         4         5         6         7         8           Selection and Output Led         001         002         003         004         006         006         007         008	
	Steady State ON OFF	
D18 🔜 📓 D19	ON OFF	
IPS8200HQ		
IPS8200HQ-1		
Octal channel high side drivers	Faultframe         F7         F6         F4         F2         F1         F0	
QFN &x6	Diagnostic FAULT START STOP RESET D13 FAULT FRAME START STOP RESET	

### Figure 151. STSW-IFAPGUI main control panel for 16-bit SPI single board configuration

STSW-IFAPGUI (COM94) File		– 🗆 ×
life.augmented	Graphical Commands Interface for X-NUCLEO-OUT16A1 and X-NUCLEO-OUT17A1	
X-NUCLEO-OUT16A1 X-NUCLEO-OUT17A1	Output Enable Pin         ENABLE         DISABLE         Watchdag         DISABLED	
	All Channel Select/Unselect ALL CHs NO CHs 5 5 2 8 Steady ON OFF PNM ON OFF	Console
	Channel         1         2         3         4         5         6         7         8           Selection and Output Led         I         001         I         002         I         003         I         006         I         007         I         008	
	Steedy State ON OFF	
D18 🔜 📕 D19	ON OFF	
IPS8200HQ		
IPS8200HQ-1		
1 ST		
Octal channel high side	F7         F6         F3         F2         F1         F0         F6_0X         TWARN         PC         P2         P1         P0         nP0           Fault frame         0 <t< td=""><td></td></t<>	
QFN 8x6	FAULT     F	
Commands RESET	PGOOD pin status check START STOP RESET D12	

The main control panel is composed by:



- a set of columns, one for each channel. Inside each column there are the buttons to turn the channels on and off in Steady State and in PWM mode. There are also the controls used to set the frequency and duty cycle of the PWM mode. At the top of each column there is the LED that shows the status of the channel and the channel selector. On the left of the first column there is the functional description of the controls in the same row.
- the Output Enable Pin section.
- a Watchdog section (related to MCU freeze detection available in IPS8200HQ and IPS8200HQ-1).
- a Channels Selection section to perform operation on the selected channels with a single click.
- the Fault frame section to read the device register bits.
- a diagnostic section to check the FAULT pin.
- a diagnostic section to read the Fault frame.
- for the 16-bit configuration diagnostic sections for TWARN and PGOOD to check these pins.
- a command reset section.
- board image to clicking on to open a window showing the board connections.
- package images to clicking on to open a window showing the device features.

All the buttons with blue text refer to the functions currently active, when the text is gray the function will be activated after a preliminary action, such as enabling the outputs or setting the frequency and duty cycle of the PWM.

### Step 9. Outputs enabling.

 First of all, it is necessary to use the [Output Enable Pin] section to enable the outputs of the IPS8200HQ or the IPS8200HQ-1. At the startup the outputs and all commands to power on the channels are disabled.

### Figure 152. STSW-IFAPGUI Output Enable Pin section at the startup

Output Enable Pin	ENABLE	DISABLE	<b>DISABLED</b>	
-------------------	--------	---------	-----------------	--

The [ENABLE] button enables the outputs, while the [DISABLE] button disables the outputs. After the click on [ENABLE] this is the interface answer:

### Figure 153. STSW-IFAPGUI Outputs Enabled





### Step 10. Use the Command Interface for Steady State and PWM.

Use the Steady State **[ON]** or **[OFF]** buttons related to the desired channel to turn on or off it in Steady State mode. The **[ON]** button for each channel is enabled after the outputs enable. When a channel is on in steady state mode the green LED corresponding to that channel will be on, the **[OFF]** button will be enabled, and the **[ON]** button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. To use the PWM, the steady state of the channel must first be switched off.

### Figure 154. STSW-IFAPGUI channels 1, 3, 5, 7 Steady State ON

Channel	1	2	3	4	5	6	7	8
Selection and Output Led	🗖 📕 D01	🗖 📕 D02	🗖 📕 D03	🗖 📓 D04	🗖 📕 D05	🗖 📓 D06	🗖 📕 D07	🗖 📓 D08
Steady State	ON OFF							

Use the PWM [ON] or [OFF] buttons related to the desired channel to turn on or off it in PWM mode. The [ON] button starting the PWM will be enabled when both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function. During the PWM, the Steady State buttons for the active channels are disabled. Turn off the PWM to have the steady state enabled on these channels. An example of channels 2, 3, 6, 8 active in PWM mode is shown below:



### Figure 155. STSW-IFAPGUI channels 2, 4, 6, 8 PWM ON



- Step 11. The diagnostic sections allow you to check the status of the diagnostic pins to identify the presence of thermal shutdown on one or more channels and to read the bits of the internal register to identify the channels on which it occurred.
  - Use the [FAULT pin status check] section to start and stop the check on the device FAULT pin.

### Figure 156. STSW-IFAPGUI FAULT pin status check section



Click on the [**START**] to monitor the on/off status of the FAULT pin on IPS8200HQ or IPS8200HQ-1. The FAULT is a diagnostic pin at chip level, and it is an active low fault indication pin. The condition that activates the interface signalization is the junction overtemperature of at least one channel. Only in the case of the 16-bit SPI configuration the interface is able to display a failure on this pin also when SPI communication fault event (parity check error or module-8 violation occurs). When a fault condition is triggered, the red LED will light up. The pin check in progress is indicated by the activation of the progress bar.

### Figure 157. STSW-IFAPGUI FAULT pin status check in progress



Click on the **[STOP]** button to stop the FAULT pin check and on the **[RESET]** button to clear the last pin condition which is kept displayed after the stop.

Use the [TWARN pin status check] section to start and stop the check on the device TWARN pin. This section is only available when using the main control panel for the 16-bit SPI configuration. TWARN is the Case Temperature diagnostic pin, and it is activated (forced low) when a case overtemperature event occurs.

### Figure 158. STSW-IFAPGUI TWARN pin status check section



Click on the [**START**] to monitor the on/off status of the TWARN pin on IPS8200HQ or IPS8200HQ-1. When the activation of the TWARM pin occurs, the red LED into the section will light up. The pin check in progress is signaled by the activation of the progress bar.

### Figure 159. STSW-IFAPGUI TWARN pin status check in progress

TWARN	START	STOP	RESET	D11
pin status check				

Click on the [**STOP**] button to stop the TWARN pin check and on the [**RESET**] button to clear the last pin condition which is kept displayed after the stop.

Use the [**PGOOD pin status check**] section to start and stop the check on the device PGOOD pin. This section is only available when using the main control panel for the 16-bit SPI configuration. PGOOD is the Power Good diagnostic pin, and it is activated (forced low) when the voltage on the VCC pin goes below V<sub>PGH2</sub>.

### Figure 160. STSW-IFAPGUI PGOOD pin status check section



Click on the [**START**] to monitor the on/off status of the PGOOD pin on IPS8200HQ or IPS8200HQ-1. When the activation of the PGOOD pin occurs, the red LED into the section will light up. The pin check in progress is signaled by the activation of the progress bar.

### Figure 161. STSW-IFAPGUI PGOOD pin status check ongoing



Click on the [**STOP**] button to stop the PGOOD pin check and on the [**RESET**] button to clear the last pin condition which is kept displayed after the stop.

Use the [FAULT FRAME status check] section to read the channel fault conditions (junction overtemperature) consisting of 8 bits. Each bit, set to '1', indicates an overtemperature condition for the corresponding channel. In the case of the 8-bit SPI configuration the entire fault frame is composed of the 8 bits just described. In the case of the 16-bit configuration, the bits that signal the junction overtemperature are the bits from position 8 to 15.

### Figure 162. STSW-IFAPGUI Fault frame section



Click on the [**START**] button to start the read of Fault frame coming from the IPS8200HQ or IPS8200HQ-1. The [**STOP**] button ends the read. The [**RESET**] button clears the last bit sequence read from the IC. The blue LED blinking signals that the read operation is in progress.

### Figure 163. STSW-IFAPGUI Fault frame read in progress



The read result in case of no channel fault (all bits to zero) for the SPI 8-bit configuration is shown in the following picture:

### Figure 164. STSW-IFAPGUI 8-bit SPI Fault frame, no channel fault

					F7	F6	F5	F4	F3	F2	F1	F0
Faultframe					0 🔘	0 🔘	0	0 🔘	0	0 🕘	0 🕘	0 🔘

The read result in case of no channel fault (all bits to zero) for the SPI 16-bit configuration is shown in the following picture:

Figure 165. STSW-IFAPGUI 16-bit SPI Fault frame, without fault signalization

	F7	F6	F5	F4	F3	F2	F1	FO	FB_OK	TWARN	PC	<u>PG</u>	P2	P1	P0	nP0
Faultframe	0 🔘	0	0	0 🕘	0	0	0 🕘	0 🔘	0 1	0	0	0	0	1	0	1

As can be seen in this configuration, another 8 additional bits are also available, containing diagnostic and parity information. Refer to the IPS8200HQ or IPS8200HQ-1 datasheet for further information.



**Step 12.** The **[Watchdog]** section is useful to verify if the watchdog (MCU freeze detection feature) is enabled on the board. The blue LED indicates that the watchdog is enabled. This is an hardware configuration related to SW3 connection (1-2 WD disabled, 2-3 WD enabled) and it's not possible to change using the interface.

Figure 166.	STSW-IFAPGUI Watchdog section, case of watchdog ENABLED
	Watchdog eNABLED
Figure 167.	STSW-IFAPGUI Watchdog section, case of watchdog DISABLED
	Watchdog DISABLED
The [ <b>All Channel</b> channels to turn or repeating the sam channel is availab	I Select/Unselect] section on the top of the interface is useful to select a on or off in Steady State or PWM mode with a single button click to avoid ne operation for each channel. The selection of a single channel or a groble using the checkbox on the top of each column related to a channel.
F	igure 168. STSW-IFAPGUI All Channel Select/Unselect

All Channel Select/Unselect	ALL CHs NO CHs	1 2 3 4 5 6 7 8	Steady State	ON	OFF	PWM	ON	OFF	

### Figure 169. STSW-IFAPGUI single channel (Ch 1) selection



The **[ALL CHs]** button selects all channels, **[NO CHs]** button deselects all channels. In the Steady State sub-section, the **[ON]** button and **[OFF]** button respectively turn on or off in Steady State mode all the selected (and not already active) channels. In the PWM sub-section, the **[ON]** button and **[OFF]** button respectively turn on or off in PWM mode all the selected (and not already active channels). In the case of PWM, the selected channels for which a frequency and duty cycle other than zero have been set will be turned on.

Step 13. Click on the [RESET] button in the [Commands Reset] section to stop all operations in progress, (channels switched on in steady state or PWM mode). All frequency and duty cycle values that have been selected are also reset.

### Figure 170. STSW-IFAPGUI Commands Reset

Commands	
RESET	

### 2.11.2.2 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the board image. The following figure shows the connections for the system with a single board configure SPI mode.





### Figure 171. Board Pin Connections SPI system configuration

### 2.11.3 Dual Board Daisy Chain 8-bit or 16-bit SPI system

This section shows how to control the IPS8200HQ or the IPS8200HQ-1 using the graphic interface in the case of a dual board 8-bit or 16-bit SPI Daisy Chain system. The configuration is achieved using a combination of switches and jumpers described at the beginning of the paragraph dedicated to the X-NUCLEO-OUT16A1 or X-NUCLEO-OUT17A1 boards.

### 2.11.3.1 How to control a Daisy Chain system

This application scenario is based on the X-NUCLEO-OUT16A1 (or X-NUCLEO-OUT17A1) boards connected in daisy chain and configured in 8-bit or 16-bit SPI mode. In the following notes the two boards will be identified as board 0 the one at the beginning of the chain and board 1 the one at the end.

- Step 1. Configure two X-NUCLEO-OUT16A1 (or X-NUCLEO-OUT17A1) as board 0 and board 1 and stack them on top of the NUCLEO-F401RE flashed with the STSW-OUT16F4 firmware (or NUCLEO-G431RB flashed with the STSW-OUT16G4 firmware), through the Arduino® UNO R3 connectors. Check your switch and jumper configuration carefully as they differ between the two boards.
- Step 2. Connect the three stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- Step 3. Connect the load and supply the power stage of the two X-NUCLEO-OUT16A1 (or X-NUCLEO-OUT17A1) with a 24 V rail via the CN1 connector.



**Step 4.** Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and a COM port is opened for communication.

### Figure 172. STSW-IFAPGUI COM - port opened



Step 5. Click on the GUI STM32 Nucleo icon after it turns blue It will turn green when it has recognized the correct interface and opened it. The GUI automatically identifies the board configuration based on the jumper and switch configuration and opens the correct GUI.

### Figure 173. STSW-IFAPGUI identification complete





**Step 6.** The STSW-IFAPGUI appears on the screen. In this phase, an interface is shown that allows you to select the physical system you want to use, i.e. a single board system or a system with two boards connected in a daisy chain.





### Figure 175. STSW-IFAPGUI main control panel for 16-bit SPI configuration before single board or daisy chain selection



Step 7. Use the [SINGLE BOARD] or [DAISY CHAIN] buttons to select the configuration. In this case click on [DAISY CHAIN]. The choice must be consistent with the physical system you are using. Otherwise, correct operation will not occur. If you make a mistake, you will need to close the main control panel and reopen it again as previously described. At this point it will be possible to make a new choice.

### Figure 176. STSW-IFAPGUI System Configuration Selection





Step 8. After the System Selections, the correct interface will appear on the screen:



STSW-IFAPGUI (COM88)		_ 🗆 ×
57	Graphical Commands Interface for X-NUCLEO-OUT16A1 and X-NUCLEO-OUT17A1	
life.augmented	BOARDO BOARD1 8 bit Data Width DAISY CHAIN System Configuration	IPS
X-NUCLEO-OUT16A1 X-NUCLEO-OUT17A1	BOARD Output Enable Pin ENABLE DISABLE DISABLED Watchdog ENABLED	
	O         All Channel SelectUnselect         ALL CHs         NO CHs         1 2 3 4         Steady         ON         OFF         PVM         ON         OFF	Console
	Channel         1         2         3         4         5         6         7         8           Selection and Ddputted         □ <td□< td=""><td></td></td□<>	
	Steedy Steete ON OFF	
D18 D19	ON OFF	
IPS8200HQ	Frequency [Hz] D Hz + mix 100 m + 2 + mix 10	
IPS8200HQ-1	$\begin{array}{c c c c c c } Duty Cycle [2f] & \underline{z} & \vdots & \underline{0} & \underline{z} & $	
Octal channel high side	Faultiame         F7         F6         F5         F4         F3         F2         F1         F0	
Commands RESET	Diagnostic FAULT FRAME START STOP RESET D13 FAULT FRAME START STOP RESET	

### Figure 178. STSW-IFAPGUI main control panel for 16-bit SPI Daisy Chain configuration

STSW-IFAPGUI (COM88)		– 🗆 ×
57	Graphical Commands Interface for X-NUCLEO-OUT16A1 and X-NUCLEO-OUT17A1	
life.augmented	BOARDO BOARD1 16 bit Data Width DAISY CHAIN System Configuration	
X-NUCLEO-OUT16A1	BOARD Output Enable Pin ENABLE DISABLE DISABLED Watchdog ENABLED	
X-NUCLEO-OUTT/AT	0 All Channel Select Unselect ALL CHs NO CHs S 0 7 6 Steedy ON OFF PWM ON OFF	Console
	Channel         1         2         3         4         5         6         7         8           Selection and Output let         □         □001         □         □002         □         □003         □         □005         □         □006         □         □003         □         □004         □         □         □003         □         □005         □         □006         □         □         □003         □         □005         □         □006         □         □         □003         □         □005         □         □006         □         □         □003         □         □005         □         □007         □         □         □003         □         □005         □         □007         □         □         □003         □         □005         □         □007         □         □         □003         □         □005         □         □007         □         □         □003         □         □         □005         □ </td <td></td>	
	Steedy State ON OFF	
D18 D19	ON OFF	
IPS8200HQ	Frequency [Hz] D Hz + D	
IPS8200HQ-1	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	
FTI Parament		
Octal channel high side drivers	F2         F6         F5         F4         F3         F2         F1         F0         F6_0X[1W]ARN         PC         PG         P2         P1         P0         nP0           Faultframe         0	
QFN 8x6	FAULT pristaus check         START         STOP         RESET         D13         TWARN pin status check         START         STOP         RESET         D11	
Commands RESET	PGOOD pin status check START STOP RESET D12 E FAULT FRAME Status check START STOP RESET	

The main panel is composed of two tabs, one for each system board. Each tab contains:



- a set of columns, one for each channel. Inside each column there are the buttons to turn the channels on and off in Steady State and in PWM mode. There are also the objects used to set the frequency and duty cycle of the PWM. At the top of each column there is the LED that shows the status of the channel and the channel selector. On the left of the first column there is the functional description of the objects in the same row.
- the Output Enable Pin Section.
- a Watchdog section (related to MCU freeze detection available in IPS8200HQ and IPS8200HQ-1).
- a Channels Selection section to perform operation on the selected channels with a single click.
- the Fault frame section to read the device register bits.
- a diagnostic section to check the FAULT pin.
- a diagnostic section to read the Fault frame.
- for the 16-bit configuration diagnostic sections for TWARN and PGOOD to check these pins.
- a command reset section.
- board image to clicking on to open a window showing the board connections.
- package images to clicking on to open a window showing the device features.

All the buttons with blue text refer to the functions currently active, when the text is gray the function will be activated after a preliminary action, such as enabling the outputs or setting the frequency and duty cycle of the PWM.

- Step 9. Board 0 or Board 1 selection.
  - The interface contains two tabs that can be switched to choose which of the two boards to send the commands. The following figures show how to choose one of the two boards.

### Figure 179. STSW-IFAPGUI Board 0 or Board 1 selection



### Step 10. Outputs enabling.

First of all, it is necessary to use the [Output Enable Pin] section to enable the outputs of the IPS8200HQ or IPS8200HQ-1 for the two boards. Since in this case the two boards are a system, the enabling of the outputs can be given indifferently by one of the two boards and will be valid for the entire system. The same concept applies to the outputs disabling. At the startup the outputs and all commands to power on the channels are disabled.

### Figure 180. STSW-IFAPGUI Output Enable Pin section at the startup



The [ENABLE] button enables the outputs, while the [DISABLE] button disables the outputs. After the click on [ENABLE] this is the interface answer:

### Figure 181. STSW-IFAPGUI Outputs Enabled





### Step 11. Use the Command Interface for Steady State and PWM.

Use the Steady State **[ON]** or **[OFF]** buttons related to the desired channel to turn on or off it in Steady State mode. The **[ON]** button for each channel is enabled after the outputs enable. When a channel is on in steady state mode the green LED corresponding to that channel will be on and the **[OFF]** button will be enabled, and the **[ON]** button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. To use the PWM, the steady state of the channel must first be switched off.

### Figure 182. STSW-IFAPGUI channels 1, 3, 5, 7 Steady State ON

Channel	1	2	3	4	5	6	7	8
Selection and Output Led	🗖 📕 D01	🗖 📕 D02	🗖 📕 D03	D04	🗖 📕 D05	🗖 📓 D06	🗖 📕 D07	🗖 📓 D08
Steady State	ON OFF	ON OFF	ON OFF	ON OFF	ON OFF	ON OFF	ON OFF	ON OFF

Use the PWM [ON] or [OFF] buttons related to the desired channel to turn on or off it in PWM mode. The [ON] button starting the PWM will be enabled when both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function. During the PWM the Steady State buttons for the active channels are disabled. Turn off the PWM to have the steady state enabled on these channels. An example of channels 2, 3, 6, 8 active in PWM mode is shown below.



### Figure 183. STSW-IFAPGUI channels 2, 4, 6, 8 PWM ON



- Step 12. The diagnostic sections allow you to check the status of the diagnostic pins to identify the presence of thermal shutdown on one or more channels and to read the bits of the internal register to identify the channels on which it occurred.
  - Use the [FAULT pin status check] section to start and stop the check on the device FAULT pin.

### Figure 184. STSW-IFAPGUI FAULT pin status check section



Click on the [**START**] to monitor the on/off status of the FAULT pin on IPS8200HQ or IPS8200HQ-1. The FAULT is a diagnostic pin at chip level, and it is an active low fault indication pin. The condition that activates the interface signalization is the junction overtemperature of at least one channel. Only in the case of the 16-bit SPI configuration the interface is able to display a failure on this pin also when SPI communication fault event (parity check error or module-8 violation occurs). When a fault condition is triggered, the red LED will light up. The pin check in progress is indicated by the activation of the progress bar.

### Figure 185. STSW-IFAPGUI FAULT pin status check ongoing



Click on the **[STOP]** button to stop the FAULT pin check and on the **[RESET]** button to clear the last pin condition which is kept displayed after the stop.

Use the [TWARN pin status check] section to start and stop the check on the device TWARN pin. This section is only available when using the main control panel for the 16-bit SPI configuration. TWARN is the Case Temperature diagnostic pin, and it is activated (forced low) when a case overtemperature event occurs.

### Figure 186. STSW-IFAPGUI TWARN pin status check section



Click on the [**START**] to monitor the on/off status of the TWARN pin on IPS8200HQ or IPS8200HQ-1. When the activation of the TWARM pin occurs, the red LED into the section will light up. The pin check in progress is signaled by the activation of the progress bar.

### Figure 187. STSW-IFAPGUI TWARN pin status check in progress

TWARN	START	STOP	RESET	D11
pin status check				

Click on the [**STOP**] button to stop the TWARN pin check and on the [**RESET**] button to clear the last pin condition which is kept displayed after the stop.

Use the [**PGOOD pin status check**] section to start and stop the check on the device PGOOD pin. This section is only available when using the main control panel for the 16-bit SPI configuration. PGOOD is the Power Good diagnostic pin, and it is activated (forced low) when the voltage on the VCC pin goes below V<sub>PGH2</sub>.

### Figure 188. STSW-IFAPGUI PGOOD pin status check section



Click on the [**START**] to monitor the on/off status of the PGOOD pin on IPS8200HQ or IPS8200HQ-1. When the activation of the PGOOD pin occurs, the red LED into the section will light up. The pin check in progress is signaled by the activation of the progress bar.

### Figure 189. STSW-IFAPGUI PGOOD pin status check ongoing



Click on the [**STOP**] button to stop the PGOOD pin check and on the [**RESET**] button to clear the last pin condition which is kept displayed after the stop.

Use the [FAULT FRAME status check] section to read the channel fault conditions (junction overtemperature) consisting of 8 bits. Each bit, set to '1', indicates an overtemperature condition for the corresponding channel. In the case of the 8-bit SPI configuration the entire fault frame is composed of the 8 bits just described. In the case of the 16-bit configuration, the bits that signal the junction overtemperature are the bits from position 8 to 15.

### Figure 190. STSW-IFAPGUI Fault frame section



Click on the [**START**] button to start the read of Fault frame coming from the IPS8200HQ or IPS8200HQIPS8200HQ-1. The [**STOP**] button ends the read. The [**RESET**] button clears the last bit sequence read from the IC. The blue LED blinking signals that the read operation is in progress.

### Figure 191. STSW-IFAPGUI Fault frame read in progress



The read result in case of no channel fault (all bits to zero) for the SPI 8-bit configuration is shown in the following picture:

### Figure 192. STSW-IFAPGUI 8-bit SPI Fault frame, no Channel fault

					F7	F6	F5	F4	F3	F2	F1	F0
Faultframe					0	0 🔘	0 🔘	0	0 🔘	0 🔘	0 🔘	0

The read result in case of no channel fault (all bits to zero) for the SPI 16-bit configuration is shown in the following picture:

### Figure 193. STSW-IFAPGUI 16-bit SPI Fault frame, without Channel fault signalization

<b>E</b> 114	F7	F6	F5	F4	F3	F2	F1	F0	FB_OK	TWARN	PC	<u>PG</u>	P2	P1	P0	nP0
Faultframe	0 🔘	0 🔘	0 🔘	0 🔘	0 🔘	0	0 🔘	0 🔘	01	0 🔘	0 🔘	0 🔘	0 🔘	1	0 🔘	1

As can be seen in this configuration, another 8 additional bits are also available, containing diagnostic and parity information. Refer to the IPS8200HQ or IPS8200HQ-1 datasheet for further information.



**Step 13.** The **[Watchdog]** section is useful to verify if the watchdog (MCU freeze detection feature) is enabled on the board. The blue LED Indicates that the watchdog is enabled. This is a hardware configuration related to SW3 connection (1-2 WD disabled, 2-3 WD enabled) and it's no possible to change using the interface.

### Figure 196. STSW-IFAPGUI All Channel Select/Unselect

All Channel Select/Unselect	ALL CHs NO CHs	1 2 3 4 5 6 7 8	Steady State	ON	OFF	PWM	ON	OFF	
-----------------------------	----------------	--------------------	-----------------	----	-----	-----	----	-----	--

### Figure 197. STSW-IFAPGUI single channel (Ch 1) selection



The **[ALL CHs]** button selects all channels, **[NO CHs]** button deselects all channels. In the Steady State sub-section, the **[ON]** button and **[OFF]** button respectively turn on or off in Steady State mode all the selected (and not already active) channels. In the PWM sub-section, the **[ON]** button and **[OFF]** button respectively turn on or off in PWM mode all the selected (and not already active channels). In the case of PWM, the selected channels for which a frequency and duty cycle other than zero have been set will be turned on.

Step 14. Click on the [RESET] button in the [Commands Reset] section to stop all operations in progress, (channels switched on in steady state or PWM mode). All frequency and duty cycle values that have been selected are also reset

### Figure 198. STSW-IFAPGUI Commands Reset

Commands	
RESET	

### 2.11.3.2 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the board image. In case of the Daisy chain the connections are different for the two boards and therefore clicking on the image of the board, the connections of the board selected via one of the two tabs will be displayed.

The following figure shows the connections for Board 0 and Board 1.





### Figure 199. Board pin connections DAISY CHAIN Board 0

Figure 200. Board pin Connections DAISY CHAIN Board 1



### 2.11.4 How to get information about the GUI

Information about the GUI revision for the is available by clicking on interface title. Then, the following window (in the example related to the first revision) appears:



### Figure 201. Command Interface info



### 2.11.5 Information about the device

It is also possible to obtain information on the features of the device mounted on the boards, simply clicking on the image depicting the devices. The following image appears:

Figure 202. Device features

4	life.augmented	IPS8200HQ, IPS8200HQ-
C	Octal high-side smart power solid-state	relay with serial/parallel selectable interface on-chi
De	escription	
l ne	IPS8200HQ and IPS8200HQ -1 are monoliting 8-channel drivers, designed using 31 d with one side connected to the ground. Both ICs operates from 10.5 V to 36 V and fe D matrix, and a micropower step-down switching regulator with a peak current control	Microelectronics <sup>™</sup> VIPower <sup>™</sup> technology, and intended to drive any kind sature a very low supply current, parallel or 4-wire SPI control interface, a loop mode.
Fe	patures	Application
•	Voltage operating range 10.5 V to 36 V	Programmable logic control
•	UVLO with hysteresis	<ul> <li>Industrial PC peripheral input/output</li> </ul>
•	Output current: 0.7 A or 1.0 A (IPS8200HQ or IPS8200HQ-1) per channel	<ul> <li>Numerical control machines</li> </ul>
•	Low supply current in OFF (1 mA) and ON (5.3 mA) states	
•	5 V and 3.3 V compatible I/Os	
•	Selectable interface on logic side SPI or parallel	
	5 MHz SPI (8 or 16-bits) with output enable, daisy chain, and MCU freeze detection	
•	100 mA DC/DC with integrated boot diode and adjustable output voltage	
	4x2 LED matrix for efficient outputs state LEDs driving	
	Can drive all types of loads (resistive, capacitive, and inductive)	Sugar Sugar
	Per-channel overload and short-circuit protection	1PS8200Hu
	Per-channel/independent overtemperature protection	E E E
	Fast demagnetization of inductive loads (Vout clamp)	E TOT E
	Overvoltage protection (VCC clamping)	Employ
	Loss of GND protection	
	Power Good (supply voltage level) diagnostic	
•	Common fault open drain output	
	IC warning temperature detection	
•	VEOEPN-48L (8x6 mm) package	

## 2.11.6 Close the command interface.

To close the command interface, use File/Close in the top-left part of the GUI.

### Figure 203. STSW-IFAPGUI close the command interface



The command interface can be opened again by clicking on the Nucleo icon as described above.



### 2.12 X-NUCLEO-DO40A1 and X-NUCLEO-DO41A1 expansion boards

### 2.12.1 How to control the expansion board

This application scenario is based on the default configuration of the on-board switch and resistors of the X-NUCLEO-DO40A1 and X-NUCLEO-DO41A1.

- Step 1. Stack the X-NUCLEO-DO40A1 (or X-NUCLEO-DO41A1) on top of the NUCLEO-F401RE flashed with the STSW-DO40F4 firmware (or NUCLEO-G431RB flashed with the STSW-DO40G4 firmware), through the Arduino<sup>®</sup> UNO R3 connectors.
- Step 2. Connect the two stacked boards to your PC or laptop USB port through a mini-USB cable (for NUCLEO-F401RE) or micro-USB cable (for NUCLEO-G431RB). The STM32 is supplied via USB (3.3 V) and the flashed firmware starts running.
- Step 3. Connect the load and supply the power stage of the X-NUCLEO-DO40A1 (or the X-NUCLEO-DO41A1) with a 24 V rail via the CN1 connector.
- **Step 4.** Launch the STSW-IFAPGUI. When the application starts, the firmware running on the STM32 is automatically detected and, if a valid firmware is found, a COM port is opened for communication.

### Figure 204. STSW-IFAPGUI COM - port opened



Step 5. Click on the GUI STM32 Nucleo icon after it turns blue (it remains green until the firmware identification is complete). The GUI automatically identifies the board configuration based on the information provided by the firmware.

# STSW-IFAPGUI rev. 2.6.0

### Figure 205. STSW-IFAPGUI identification complete



Step 6. When the board identification phase has been completed the related STSW-IFAPGUI appears on the screen.







Step 7. The main control panel includes the sections:

- four channel control sections, one for each device channel, to control the Steady State or PWM mode.
- four diagnostic sections related to STATUS1, STATUS2, STATUS3 and STATUS4 pins
- a Channels Selection section to perform operation on the selected channels with a single click
- a Command Reset section to restore the main control panel start-up status

All the buttons with blue text refer to the functions currently active, when the text is gray the function will be activated after a preliminary action, such as setting the frequency and duty cycle of the PWM.

Use the Channel [Steady State] GUI section to manage the channel steady state for IPS4140HQ (or IPS4140HQ-1). The [ON] and [OFF] buttons are used to turn a channel on or off respectively. The [ON] button for each channel is enabled at the start-up. When a channel is on in steady state mode the green LED corresponding to that channel will be on, the [OFF] button will be enabled, and the [ON] button disabled. When a channel is turned on in steady state mode it will not be possible to use the PWM mode. To use the PWM, the steady state of the channel must first be switched off.

### Figure 207. STSW-IFAPGUI Channel section, Steady State enabled and ready to use



### Figure 208. STSW-IFAPGUI Channel section, Steady State on



Use the channel [PWM] GUI section to manage the channel PWM settings and to power on or off the channel input in PWM mode. The button [ON] starting the PWM will be enabled when both the frequency and the duty cycle values for the channel have been selected through the dedicated controls and the steady mode is off for the channel. The PWM on will be signalized by the green LED blinking according to the frequency and duty cycle chosen. Use the [OFF] button to stop the PWM function.

### Figure 209. STSW-IFAPGUI channel section, PWM ON state





- **Step 8.** The diagnostic sections allow you to check the status of the diagnostic pins available on the board. The pins that is possible to check are:
  - STATUS1: Channel 1 per-channel over-temperature condition
  - STATUS2: Channel 2 per-channel over-temperature condition
  - STATUS3: Channel 3 per-channel over-temperature condition
  - STATUS4: Channel 4 per-channel over-temperature condition

Below is a description about how to use the monitoring of the STATUS1, STATUS2, STATUS3 and STATUS4 pins. Since the operation is similar for all four, the operation will be explained only once by generically indicating one of the four pins with STATUSx.

Use the [**STATUSx pin status check**] section to start and stop the check of the device STATUSx diagnostic pin.

### Figure 210. STSW-IFAPGUI STATUSx pin status check section

STATU	S1 pin statu	is check	
START	STOP	RESET	
START	STOP	RESET	

Click on the [**START**] to monitor the on/off status of the STATUSx pin on X-NUCLEO-DO40A1 (or X-NUCLEO-DO41A1). The STATUSx is a per-channel diagnostic pin, and it is activated (active low) in case of over-temperature condition. When an over-temperature condition is triggered, the red LED into the section will light up. The pin check in progress is signaled by the activation of the progress bar.

### Figure 211. STSW-IFAPGUI STATUSx pin status check in progress

RESET	STOP	START

Click on the [**STOP**] button to stop the STATUSx pin status check and on the [**RESET**] button to clear the last pin condition which is kept displayed after the stop.

Step 9. Click on the [RESET] button in the bottom-left part of the main control panel to stop all operations in progress (channels switched on in steady state or PWM mode, diagnostic checks on going). All frequency and duty cycle values selected for the PWM are also reset.

Figure 212. STSW-IFAPGUI Commands Reset button

Commands Rese	t
RESET	



### 2.12.2 How to get information about the GUI

Information about the GUI revision is available by clicking on the interface title (See Figure 206. STSW-IFAPGUI main control panel). Then, the following window (in the example related to the first revision) appears:

# Figure 213. Command interface info About Command Interface Company of the About Command Interface If e. augmented Craphical Command Interface for CHUCLEO-DO4OAI and X-NUCLEO-DO4IAI Industrial Digital output expansion boards based on IPS4140HQ and IPS4140HQL2

### 2.12.3 Information about the pin connections

The device pin connections to the microcontroller are shown by clicking on the yellow info logo on the left of the board image (See Figure 206. STSW-IFAPGUI main control panel). The following figure shows the Board Connections window shown after the click for X-NUCLEO-DO40A1 (or X-NUCLEO-DO41A1).



### Figure 214. Board Pin Connections

### 2.12.4 Information about the device

It is also possible to obtain information on the features of the device mounted on the board. Simply with a click on the device package picture (See Figure 206. STSW-IFAPGUI main control panel).

### Figure 215. Get Command Interface info



### Then, the following window appears:

### Figure 216. Device Features







### 2.12.5 Close the command interface

To close the command interface, use File/Close in the top-left part of the GUI.

### Figure 217. STSW-IFAPGUI close the command interface



The command interface can be opened again by clicking on the Nucleo icon as described above.

# **Revision history**

### Table 6. Document revision history

Date	Version	Changes
15-Nov-2018	1	Initial release.
26-Feb-2019	2	Added references to STSW-OUT02 firmware.
		Added references to STSW-OUT8F4, STSW-OUT8G4, X-NUCLEO-OUT08A1 and X-NUCLEO-OUT10A1.
17-Jun-2020	3	Added Section 2.2.1 How to control a single expansion board and Section 2.2.2 How to control two expansion boards.
		Minor text changes.
		Updated Introduction.
15-Nov-2021	4	Added references to STSW-OUT3F4, STSW-OUT3G4, X-NUCLEO-OUT03A1 and X-NUCLEOOUT04A1.
		Added Section 2.2 X-NUCLEO-OUT03A1 and X-NUCLEO-OUT04A1 expansion boards.
		Updated introduction.
		Added references to STSW-OUT5F4, STSW-OUT5G4, STDES-OUT03D08, STDES-OUT04D08, STSW-OUT3D8F4, STSW-OUT3D8G4, X-NUCLEO-OUT05A1, and X-NUCLEO-OUT06A1.
06-Apr-2022	5	Updated Section 2.2.1 How to control a single expansion board.
		Added Section 2.2.2 How to control up to four expansion boards, Section 2.2.3 How to get information about the GUI, and Section 2.3 X-NUCLEO-OUT05A1 and X-NUCLEO-OUT06A1 expansion boards.
		Updated introduction.
26-May-2022	6	Added Section 2.3.2 How to control up to four expansion boards and Section 2.3.3 How to get information about the GUI.
		Added references to STSW-OUT5D4F4, STSW-OUT5D4G4, STDES-OUT05DO4, and STDESOUT06DO4.
		Updated introduction, Section 2.4.1: How to control a single expansion board, and
		Section 2.4.2: How to control up to four expansion boards
22- lun-2022	7	Added Section 2.10: X-NUCLEO-OUT15A1 expansion board, Section 2.10.1: How to control a single
22-0011-2022	, '	expansion board, and Section 2.10.2: How to get information about the GUI
		Section 2.11.4: How to get information about the GUI
		Added references to STSW-OUT15F4, STSW-OUT15G4, and X-NUCLEO-OUT15A1.
		Added Section 2.7: X-NUCLEO-OUT09A1 and X-NUCLEO-OUT19A1 expansion boards,
21-Jun-2023	8	Section 2.8: X-NUCLEO-OUT11A1 and X-NUCLEO-OUT13A1 expansion boards and
		Section 2.9: X-NUCLEO-OUT12A1 and X-NUCLEO-OUT14A1 expansion boards.
24-Oct-2023	Q	Updated Section Introduction.
24 001 2020	0	Added Section 2.1: X-NUCLEO-OUT01A2 expansion board.
04-Oct-2024	10	Added Section 2.5: X-NUCLEO-OUT07A1 expansion board and Section 2.11: X-NUCLEO-OUT16A1
54 001-2024		and X-NUCLEO-OUT17A1 expansion boards.
23- Jan-2025	11	Updated Section Introduction.
20-Jan-2025	11	Added Section 2.12: X-NUCLEO-DO40A1 and X-NUCLEO-DO41A1 expansion boards.

# Contents

1	Soft	ware in	nstallation	3
2	Run	ning th	ne graphical user interface	4
	2.1	X-NU	CLEO-OUT01A2 expansion board	4
		2.1.1	How to control the expansion board	4
		2.1.2	How to get information about the GUI	9
		2.1.3	How to get information about the Device Features	9
		2.1.4	Information about the pin connections	10
		2.1.5	Close the command interface	10
	2.2	X-NU	CLEO-OUT02A1 expansion board	11
		2.2.1	How to control a single expansion board	11
		2.2.2	How to control two expansion boards	12
		2.2.3	STSW-IFAPGUI control panel for X-NUCLEO-OUT02A1	13
	2.3	X-NU	CLEO-OUT03A1 and X-NUCLEO-OUT04A1 expansion boards	14
		2.3.1	How to control a single expansion board	14
		2.3.2	How to control up to four expansion boards	16
		2.3.3	How to get information about the GUI	21
	2.4	X-NU	CLEO-OUT05A1 and X-NUCLEO-OUT06A1 expansion boards	21
		2.4.1	How to control a single expansion board	22
		2.4.2	How to control up to four expansion boards	24
		2.4.3	How to get information about the GUI	29
	2.5	X-NU	CLEO-OUT07A1 expansion board	30
		2.5.1	How to control the expansion board	30
		2.5.2	How to get information about the GUI	36
		2.5.3	Information about the pin connections	36
		2.5.4	Information about the device	36
		2.5.5	Close the command interface	38
	2.6	X-NU	CLEO-OUT08A1 and X-NUCLEO-OUT10A1 expansion boards	
		2.6.1	How to control a single expansion board	38
		2.6.2	How to control two expansion boards	39
	2.7	X-NU	CLEO-OUT09A1 and X-NUCLEO-OUT19A1 expansion boards	40
		2.7.1	How to control the expansion board	40
		2.7.2	How to get information about the GUI	44
		2.7.3	Information about the pin connections	44
		2.7.4	Close the command interface	44
	2.8	X-NU	CLEO-OUT11A1 and X-NUCLEO-OUT13A1 expansion boards	45
		2.8.1	How to control the expansion board	45



### UM2509 Contents

	2.8.2	How to get information about the GUI	50			
	2.8.3	How to get information about the Device Features	51			
	2.8.4	Information about the pin connections	51			
	2.8.5	Close the command interface	52			
2.9	X-NUC	LEO-OUT12A1 and X-NUCLEO-OUT14A1 expansion boards				
	2.9.1	How to setup a multiboard system	52			
	2.9.2	How to control the expansion boards	54			
	2.9.3	How to get information about the GUI	60			
	2.9.4	Information about the pin connections	61			
	2.9.5	How to get information about the Device Features	63			
	2.9.6	Close the command interface	63			
2.10	X-NUC	LEO-OUT15A1 expansion board	64			
	2.10.1	How to control a single expansion board	64			
	2.10.2	How to get information about the GUI	66			
2.11	X-NUC	LEO-OUT16A1 and X-NUCLEO-OUT17A1 expansion boards	67			
	2.11.1	Expansion board configured in parallel mode	68			
	2.11.2	Expansion board configured in 8-bit or 16-bit SPI mode	72			
	2.11.3	Dual Board Daisy Chain 8-bit or 16-bit SPI system	82			
	2.11.4	How to get information about the GUI	92			
	2.11.5	Information about the device	93			
	2.11.6	Close the command interface	93			
2.12	X-NUC	LEO-DO40A1 and X-NUCLEO-DO41A1 expansion boards	95			
	2.12.1	How to control the expansion board	95			
	2.12.2	How to get information about the GUI				
	2.12.3	Information about the pin connections	99			
	2.12.4	Information about the device				
	2.12.5	Close the command interface	101			
Revision	history		102			
List of fig	List of figures					
List of tab	oles		109			

# List of figures

Element 4		~
Figure 1.		3
Figure 2.	STSW-IFAPGUI COM - splash screen	4
Figure 3.	STSW-IFAPGUI COM - port opened	4
Figure 4.	STSW-IFAPGUI identification complete	5
Figure 5.	STSW-IFAPGUI main control panel.	5
Figure 6.	STSW-IFAPGUI Load Operating Mode Section.	6
Figure 7.	STSW-IFAPGUI Direct Control Mode detected	6
Figure 8.	STSW-IFAPGUI output enable section.	6
Figure 9.	STSW-IFAPGUI output enabled	6
Figure 10.	STSW-IFAPGUI channel section, steady state enabled and ready to use	7
Figure 11.	STSW-IFAPGUI channel section, steady state on	7
Figure 12.	STSW-IFAPGUI channel section, PWM on	7
Figure 13.	STSW-IFAPGUI Channels Selection Section	7
Figure 14.	STSW-IFAPGUI Channels 1 and 2 selected	7
Figure 15.	STSW-IFAPGUI Selected Channels Steady State section	8
Figure 16.	STSW-IFAPGUI Selected Channels PWM	8
Figure 17.	STSW-IFAPGUI status check	8
Figure 18.	STSW-IFAPGUI status check activated	8
Figure 19.	STSW-IFAPGUI Commands Reset section.	9
Figure 20.	STSW-IFAPGUI Commands Interface Title	9
Figure 21.	Command interface info	9
Figure 22.	How to get devices info	9
Figure 23	Devices info	10
Figure 24	Board Pin Connection	10
Figure 25	STSW/JEADGLUL close the command interface	11
Figure 25.	STSW/IFAPGUI selection window for the number of X NUCLEO. OUT02A1 expansion heards to control	11 11
Figure 20.	STSW-IFAF GOT Selection window for the number of X-NOCLEO-OUTOZAT expansion boards to control	
Eiguro 27	STSW/IEADCI II control papel, single chip	1つ
Figure 27.	STSW/IFAPGUI control panel, single chip	12 12
Figure 27. Figure 28.	STSW-IFAPGUI control panel, single chip	12 13
Figure 27. Figure 28. Figure 29.	STSW-IFAPGUI control panel, single chip	12 13 14
Figure 27. Figure 28. Figure 29. Figure 30.	STSW-IFAPGUI control panel, single chip	12 13 14 15
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI for a single expansion board in action       1	12 13 14 15 16
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup).       1	12 13 14 15 16 17
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup).       1         Setup for board 1       1	12 13 14 15 16 17 17
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup).       1         Setup for board 1       1         Setup for board 2       1	12 13 14 15 16 17 17 18
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup).       1         Setup for board 1       1         Setup for board 3       1	12 13 14 15 16 17 18 18
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         Strow-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup).       1         Setup for board 1       1         Setup for board 3       1         Strow-IFAPGUI COM - port opened       1	12 13 14 15 16 17 18 18 18
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup).       1         Setup for board 1       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1	12 13 14 15 16 17 18 18 19 19
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37. Figure 38.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup).       1         Setup for board 1       1         Setup for board 2       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         Strow-IFAPGUI COM - port opened       1         Setup for board 2       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI main control panel.       1         STSW-IFAPGUI main control panel.       1         STSW-IFAPGUI main control panel.       1	12 13 14 15 16 17 17 18 19 19 20
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37. Figure 38.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup).       1         Setup for board 1       1         Setup for board 2       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI COM - port opened       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI com panel.       1         STSW-IFAPGUI main control panel.       1         STSW-IFAPGUI channel section.       1	12 13 14 15 16 17 17 18 19 19 20 20
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         Stream of the single expansion board in action       1         Setup for board 0 (default setup).       1         Setup for board 1       1         Setup for board 2       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel.       1         STSW-IFAPGUI COM - port opened       1         STSW-IFAPGUI main control panel.       1         STSW-IFAPGUI main control panel.       1         STSW-IFAPGUI in action       1         STSW-IFAPGUI in action       1	12 13 14 15 16 17 18 19 20 20 21
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41.	STSW-IFAPGUI control panel, single chip	12 13 14 15 16 17 18 19 20 20 21 21 21
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 42.	STSW-IFAPGUI control panel, single chip	12 13 14 15 16 17 18 19 20 21 20 21 22 21 22
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 43.	STSW-IFAPGUI control panel, single chip       1         STSW-IFAPGUI control panel, dual chip       1         System configuration selection panel       1         STSW-IFAPGUI for a single expansion board in action       1         Setup for board 0 (default setup)       1         Setup for board 1       1         Setup for board 2       1         Setup for board 3       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel       1         StrsW-IFAPGUI COM - port opened       1         System configuration selection panel       1         StrsW-IFAPGUI COM - port opened       1         System configuration selection panel       1         STSW-IFAPGUI main control panel       1         STSW-IFAPGUI channel section       1         STSW-IFAPGUI in action       1         Command interface info       1         STSW-IFAPGUI COM - port opened       1         System configuration selection panel       1         StrsW-IFAPGUI COM - port opened       1         System configuration selection panel       1         System configuration selection panel       1	12 13 14 15 16 17 18 19 20 21 22 21 22 22 22 22
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 43. Figure 44.	STSW-IFAPGUI control panel, single chip STSW-IFAPGUI control panel, dual chip STSW-IFAPGUI COM - port opened System configuration selection panel. STSW-IFAPGUI for a single expansion board in action Setup for board 0 (default setup). Setup for board 1 Setup for board 2 Setup for board 3 STSW-IFAPGUI COM - port opened System configuration selection panel. STSW-IFAPGUI main control panel. STSW-IFAPGUI channel section. STSW-IFAPGUI in action. Command interface info. STSW-IFAPGUI COM - port opened System configuration selection panel. STSW-IFAPGUI com - port opened STSW-IFAPGUI main control panel. STSW-IFAPGUI main control panel.	12 13 14 15 16 17 18 19 20 21 22 22 22 22 22 22 22 22 22 22
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 43. Figure 44. Figure 45.	STSW-IFAPGUI control panel, single chip       Image: Style sty	12 13 14 15 16 17 18 19 20 21 22 22 22 22 22 22 22 22 22 22 22 22
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 43. Figure 44. Figure 45. Figure 46.	STSW-IFAPGUI control panel, single chip       Image: Style sty	12 13 14 15 16 17 18 19 20 21 22 22 22 22 22 22 22 22 22 22 22 22
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 43. Figure 44. Figure 45. Figure 46. Figure 47.	STSW-IFAPGUI control panel, single chip         STSW-IFAPGUI control panel, dual chip         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI for a single expansion board in action         Setup for board 0 (default setup).         Setup for board 1         Setup for board 2         Setup for board 3         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action         Command interface info.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action         Setup for board 0 (default setup).         Setup for board 1	12 13 14 15 16 17 18 19 20 21 22 22 22 22 22 22 22 22 22 22 22 22
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 42. Figure 43. Figure 44. Figure 45. Figure 45. Figure 48.	STSW-IFAPGUI control panel, single chip         STSW-IFAPGUI control panel, dual chip         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI for a single expansion board in action         Setup for board 0 (default setup).         Setup for board 1         Setup for board 2         Setup for board 3         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action         Command interface info.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action         Command interface info.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action         Command interface info.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action         Setup fo	12 13 14 15 16 17 18 19 20 21 22 22 22 22 22 22 22 22 22 22 22 22
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 42. Figure 43. Figure 44. Figure 45. Figure 45. Figure 48. Figure 49.	STSW-IFAPGUI control panel, single chip         STSW-IFAPGUI control panel, dual chip         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI for a single expansion board in action         Setup for board 0 (default setup).         Setup for board 1         Setup for board 2         Setup for board 3         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action         Command interface info.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI in action.         Command interface info.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI in action.         Command interface info.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action .         Setup for board 0 (default setup).         Setup for board 1 .         Setup for board 1 .         Setup for board 2 .         Setup for board 3 .	12 13 14 15 16 17 18 19 20 21 22 22 22 22 22 22 22 22 22 22 22 22
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 42. Figure 43. Figure 44. Figure 45. Figure 45. Figure 46. Figure 47. Figure 48. Figure 50.	STSW-IFAPGUI control panel, dual chip         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI for a single expansion board in action         Setup for board 0 (default setup).         Setup for board 1         Setup for board 2         Setup for board 3         STSW-IFAPGUI COM - port opened         System configuration selection panel.         Stypem configuration selection panel.         Stystem configuration selection panel.         STSW-IFAPGUI channel section.         STSW-IFAPGUI in action.         Command interface info.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI in action.         Command interface info.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI I commented         STSW-IFAPGUI I naction.         Command interface info.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action nucleon         System configuration selection panel.         STSW-IFAPGUI main control panel.         STSW-IFAPGUI in action nucleon         Setup for board 0 (default setup).         Setup for board 1         Setup for b	12 $13$ $14$ $15$ $17$ $18$ $19$ $20$ $21$ $22$ $23$ $25$ $26$ $27$
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 42. Figure 43. Figure 44. Figure 45. Figure 45. Figure 46. Figure 47. Figure 48. Figure 50. Figure 51.	STSW-IFAPGUI control panel, dual chip         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI for a single expansion board in action         Setup for board 0 (default setup).         Setup for board 1         Setup for board 2         Setup for board 3         STSW-IFAPGUI common selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI channel section         STSW-IFAPGUI in action         Command interface info.         STSW-IFAPGUI common selection panel.         STSW-IFAPGUI in action         Command interface info.         STSW-IFAPGUI in action         STSW-IFAPGUI in action         STSW-IFAPGUI in action         STSW-IFAPGUI in action         Stry-IFAPGUI in action         Stry-IFAPGUI in action         Setup for board 1         Setup for board 1         Setup for board 2         Setup for board 3         Stry-IFAPGUI COM - port opened         System configuration selection panel.         Stry-IFAPGUI com - port opened         System for board 3	12 $13$ $14$ $15$ $17$ $18$ $19$ $20$ $21$ $22$ $23$ $225$ $26$ $27$ $222$ $225$ $26$ $27$ $27$
Figure 27. Figure 28. Figure 29. Figure 30. Figure 31. Figure 32. Figure 33. Figure 34. Figure 35. Figure 36. Figure 37. Figure 38. Figure 39. Figure 40. Figure 41. Figure 42. Figure 42. Figure 43. Figure 44. Figure 45. Figure 45. Figure 46. Figure 47. Figure 48. Figure 50. Figure 51. Figure 52.	STSW-IFAPGUI control panel, dual chip         STSW-IFAPGUI control panel, dual chip         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI for a single expansion board in action         Setup for board 0 (default setup).         Setup for board 1         Setup for board 2         Setup for board 3         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI channel section.         STSW-IFAPGUI in action         Command interface info.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI in action.         Command interface info.         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI in action         Zostwitchapedul in action         Steup for board 1         Setup for board 2         Setup for board 1         Setup for board 3         STSW-IFAPGUI COM - port opened         System configuration selection panel.         STSW-IFAPGUI in action         Setup for board 1         Setup for	12 13 14 15 16 7 18 19 20 21 22 22 22 22 22 22 22 22 22 22 22 22



Figure 54.	STSW-IFAPGUI in action	29
Figure 55.	Command interface info	29
Figure 56.	STSW-IFAPGUI COM - port opened	30
Figure 57.	STSW-IFAPGUI identification complete	30
Figure 58.	STSW-IFAPGUI main control panel	31
Figure 59.	STSW-IFAPGUI Channel section, Steady State enabled and ready to use	32
Figure 60.	STSW-IFAPGUI Channel section, Steady State on	32
Figure 61.	STSW-IFAPGUI channel section, PWM ON state	33
Figure 62.	STSW-IFAPGUI FAULT pin status check section	34
Figure 63.	STSW-IFAPGUI FAULT pin status check in progress	34
Figure 64.	STSW-IFAPGUI OL pin status check section	34
Figure 65.	STSW-IFAPGUI OL pin status check in progress	35
Figure 66.	STSW-IFAPGUI DIAGx signal status check section	35
Figure 67.	STSW-IFAPGUI DIAGx signal status check in progress	35
Figure 68.	STSW-IFAPGUI Commands Reset button	35
Figure 69.	Command interface info	36
Figure 70.	Board Pin Connections	36
Figure 71.	Get Command Interface info	37
Figure 72.	Device Features	37
Figure 73.	STSW-IFAPGUI close the command interface	38
Figure 74.	STSW-IFAPGUI main control panel	38
Figure 75.	STSW-IFAPGUI single chip control panel	39
Figure 76.	STSW-IFAPGUI dual chip control panel	10
Figure 77.	STSW-IFAPGUI COM - port opened	11
Figure 78.	STSW-IFAPGUI main control panel	11
Figure 79.	STSW-IFAPGUI channel section, Steady State enabled and ready to use	12
Figure 80.	STSW-IFAPGUI channel section, Steady State ON 4	12
Figure 81.	STSW-IFAPGUI channel section, PWM ON 4	12
Figure 82.	STSW-IFAPGUI status check	13
Figure 83.	STSW-IFAPGUI status check activated (no fault condition triggered)4	13
Figure 84.	STSW-IFAPGUI commands reset	13
Figure 85.	Command Interface info	14
Figure 86.	Board setup	14
Figure 87.	STSW-IFAPGUI close the command interface	14
Figure 88.	STSW-IFAPGUI COM - port opened	45
Figure 89.	System configuration selection panel	16
Figure 90.	STSW-IFAPGUI identification complete	<del>1</del> 6
Figure 91.	STSW-IFAPGUI main control panel	17
Figure 92.	STSW-IFAPGUI control mode selection	18
Figure 93.	STSW-IFAPGUI Output Enable Pin control	18
Figure 94.	STSW-IFAPGUI channel section, Steady State control enabled and ready to use	19
Figure 95.	STSW-IFAPGUI channel section, Steady State on 4	19
Figure 96.	STSW-IFAPGUI channel section, PWM on	19
Figure 97.	STSW-IFAPGUI status check before activation	50
Figure 98.	STSW-IFAPGUI status check activated, no fault 5	50
Figure 99.	STSW-IFAPGUI commands reset	50
Figure 100.	Command interface info	50
Figure 101.	How to get devices info	51
Figure 102.	Devices info	51
Figure 103.	Board setup	52
Figure 104.	STSW-IFAPGUI close the command interface	52
Figure 105.	STSW-IFAPGUI COM - port opened	54
Figure 106.	System configuration selection panel	55
Figure 107.	STSW-IFAPGUI identification complete	55
Figure 108.	STSW-IFAPGUI – parallel independent system main control panel	56



Figure 109.	STSW-IFAPGUI – daisy chain system main control panel
Figure 110.	STSW-IFAPGUI Output Enable for Parallel Independent configuration
Figure 111.	STSW-IFAPGUI SYSTEM Enable for Daisy Chain configuration
Figure 112.	STSW-IFAPGUI board selection
Figure 113.	STSW-IFAPGUI channel section, Steady State enabled and ready to use
Figure 114.	STSW-IFAPGUI channel section, Steady State on 58
Figure 115.	STSW-IFAPGUI channel section, PWM on
Figure 116.	STSW-IFAPGUI status check before activation
Figure 117.	STSW-IFAPGUI status check activated, no fault 59
Figure 118.	STSW-IFAPGUI Power Good Pin check before activation 59
Figure 119.	STSW-IFAPGUI power pood pin check activated, fail signalization
Figure 120.	STSW-IFAPGUI commands reset for BOARD 0 and 1
Figure 121.	STSW-IFAPGUI System Commands Reset 60
Figure 122.	Command Interface info
Figure 123.	BOARD 0 setup for parallel independent mode
Figure 124.	BOARD 1 setup for parallel independent mode
Figure 125.	BOARD 0 Setup for daisy chain mode
Figure 126.	BOARD 1 setup for daisy chain mode
Figure 127.	How to get devices info
Figure 128.	Devices info
Figure 129.	STSW-IFAPGUI close the command interface
Figure 130.	STSW-IFAPGUI COM - port opened
Figure 131.	System configuration selection panel
Figure 132.	STSW-IFAPGUI main control panel
Figure 133.	STSW-IFAPGUI in action
Figure 134.	Command interface info.
Figure 135.	Configurations
Figure 136.	STSW-IFAPGUI COM - port opened
Figure 137.	STSW-IFAPGUI main control panel
Figure 138.	STSW-IFAPGUI channel section. Steady State enabled and ready to use
Figure 139.	STSW-IFAPGUI channel section. Steady State on
Figure 140.	STSW-IFAPGUI channel section. PWM on
Figure 141.	Channels Selection section
Figure 142.	Selected Channels Section
Figure 143.	STSW-IFAPGUI commands reset
Figure 144.	Board pin connections
Figure 145.	STSW-IEAPGULCOM port opened 73
Figure 146	STSW-IFAPGI II identification completed 73
Figure 147.	STSW-IFAPGUI main control panel for 8-bit SPI configuration before single board or daisy chain selection 74
Figure 148.	STSW-IFAPGUI main control panel for 16-bit SPI configuration before single board or daisy chain selection 75
Figure 149.	STSW-IFAPGUI System configuration selection 75
Figure 150	STSW-IFAPGUI main control panel for 8-bit SPI single board configuration 76
Figure 151	STSW-IFAPGI II main control panel for 16-bit SPI single board configuration 76
Figure 152	STSW-IFAPGI II Output Enable Pin section at the startun
Figure 153	STSW-IFAPGUI Outputs Enabled
Figure 155.	STSW-IFAPGUL channels 1 3 5 7 Steady State ON 78
Figure 155	STSW-IFAPGUL channels 2, 4, 6, 8 PWM ON 78
Figure 156	STSW-IFAF COLCIAINICIS 2, 4, 0, 01 WW CN
Figure 157	STSW-IFAPGUL FAULT nin status check in progress 70
Figure 152	STSW-IFAPGULTWARN nin status check section 70
Figure 150.	STSW-IFAPGUI TWARN nin status check in progress
Figure 160	STSW-IFAPGLII PGOOD nin status check section
Figure 161	STSW-IFAPGUL PGOOD pin status check organing
Figure 162	STSW.IFAPCI II Fault frame section
Figure 462	
Figure 103.	



Figure 164.	STSW-IFAPGUI 8-bit SPI Fault frame, no channel fault	80
Figure 165.	STSW-IFAPGUI 16-bit SPI Fault frame, without fault signalization	80
Figure 166.	STSW-IFAPGUI Watchdog section, case of watchdog ENABLED	81
Figure 167.	STSW-IFAPGUI Watchdog section, case of watchdog DISABLED.	81
Figure 168.	STSW-IFAPGUI All Channel Select/Unselect	81
Figure 169.	STSW-IFAPGUI single channel (Ch 1) selection	81
Figure 170.	STSW-IFAPGUI Commands Reset	81
Figure 171.	Board Pin Connections SPI system configuration	82
Figure 172.	STSW-IFAPGUI COM - port opened	83
Figure 173.	STSW-IFAPGUI identification complete	83
Figure 174.	STSW-IFAPGUI main control panel for 8-bit SPI configuration before single board or daisy chain selection	84
Figure 175.	STSW-IFAPGUI main control panel for 16-bit SPI configuration before single board or daisy chain selection	85
Figure 176.	STSW-IFAPGUI System Configuration Selection.	85
Figure 177.	STSW-IFAPGUI main control panel for 8-bit SPI Daisy Chain configuration	86
Figure 178.	STSW-IFAPGUI main control panel for 16-bit SPI Daisy Chain configuration.	86
Figure 179.	STSW-IFAPGUI Board 0 or Board 1 selection	87
Figure 180.	STSW-IFAPGUI Output Enable Pin section at the startup	87
Figure 181	STSW-IFAPGI II Outputs Enabled	87
Figure 182.	STSW-IFAPGUI channels 1 3 5 7 Steady State ON	88
Figure 183	STSW-IFAPGI II channels 2, 4, 6, 8 PWM ON	88
Figure 184	STSW-IFAPGI II FALUET nin status check section	89
Figure 185	STSW-IFAPGI II FALII T nin status check organing	80
Figure 105.		80
Figure 187		80
Figure 107.		09
Figure 100.		90
Figure 109.		90
Figure 190.		90
Figure 191.		90
Figure 192.	STSW-IFAPGUI 8-bit SPI Fault frame, no Channel Jault	90
Figure 193.		90
Figure 194.		91
Figure 195.		91
Figure 196.		91
Figure 197.		91
Figure 198.		91
Figure 199.	Board pin connections DAISY CHAIN Board 0	92
Figure 200.	Board pin Connections DAISY CHAIN Board 1	92
Figure 201.		93
Figure 202.		93
Figure 203.	STSW-IFAPGUI close the command interface	94
Figure 204.	STSW-IFAPGUI COM - port opened	95
Figure 205.	STSW-IFAPGUI identification complete	95
Figure 206.	STSW-IFAPGUI main control panel	96
Figure 207.	STSW-IFAPGUI Channel section, Steady State enabled and ready to use	97
Figure 208.	STSW-IFAPGUI Channel section, Steady State on	97
Figure 209.	STSW-IFAPGUI channel section, PWM ON state	97
Figure 210.	STSW-IFAPGUI STATUSx pin status check section	98
Figure 211.	STSW-IFAPGUI STATUSx pin status check in progress	98
Figure 212.	STSW-IFAPGUI Commands Reset button	98
Figure 213.	Command interface info.	99
Figure 214.	Board Pin Connections	99
Figure 215.	Get Command Interface info	00
Figure 216.	Device Features	00
Figure 217.	STSW-IFAPGUI close the command interface 1	01
## List of tables

Table 1.	Demonstration Firmware
Table 2.	Configuration of a stack of four expansion boards
Table 3.	Configuration of a stack of four expansion boards
Table 4.	Resistors configuration of two stacked expansion boards in Parallel Independent Mode
Table 5.	Configuration of a stack of two expansion boards in Daisy Chain Mode
Table 6.	Document revision history

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