UM2140
User manual

Discovery kit with STM32F723IE MCU

Introduction

With the STM32F723 Discovery kit (32F723EDISCOVERY), users develop applications easily on the STM32F7 Series high-performance microcontrollers based on Arm® Cortex®-M7 core. The Discovery kit combines the STM32F723 features with 240x240 pixel LCD with touch panel, SAI audio codec, MEMS microphones, USBs OTG HS and OTG FS, Quad-SPI NOR Flash memory, and microSD™ card connector.

An embedded ST-LINK/V2-1 debugger/programmer is included. Specialized add-on boards can be connected through the ARDUINO® Uno V3, Pmod™, or STMod+ expansion connectors.

Figure 1. 32F723EDISCOVERY (Top view)

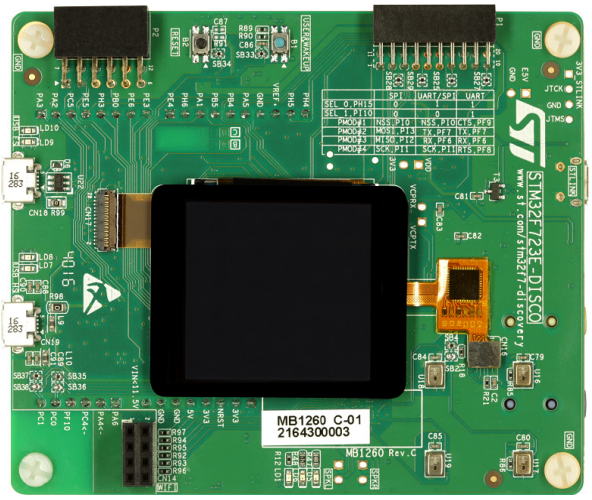
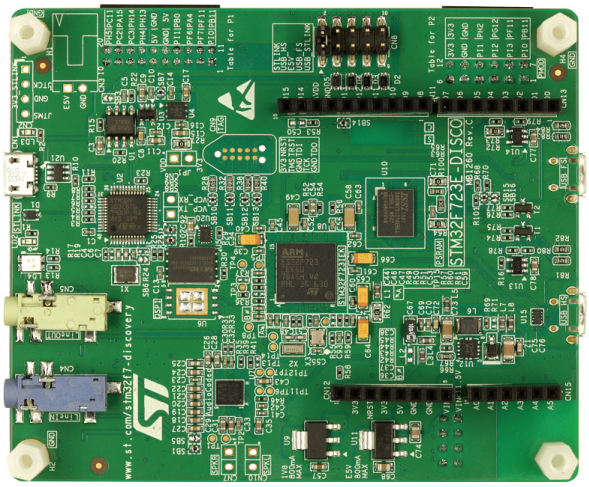


Figure 2. 32F723EDISCOVERY (Bottom view)



Pictures are not contractual.

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1 Features

- STM32F723IEK6 microcontroller with 512 Kbytes of Flash memory and 176+16 Kbytes of SRAM, in a BGA176 package
- 240x240-pixel TFT LCD with a parallel interface and capacitive touch panel
- USB OTG HS and OTG FS
- SAI audio codec
- Four digital ST-MEMS microphones
- 8-Mbit 16-bit wide PSRAM
- 512-Mbit Quad-SPI NOR Flash memory
- User and reset push-buttons
- Board connectors:
  - ESP-01 Wi.Fi® module connector
  - Two user USB with Micro-AB
  - Jack for audio line with stereo input and output
  - Stereo speaker output
  - Pmod™ connector
  - STMod+ connector to embedded fanout daughterboard compatible with MikroElektronika mikroBUS™ adapter Click boards™, ESP-01, and Seeed Studio™ Grove modules. Provision for headers for direct breadboard plug-in
  - ARDUINO® Uno V3 expansion connectors
  - 3.3 or 5.0 V power supply output for external applications
- Flexible power-supply options: ST-LINK USB V_{BUS}, user USB HS and FS connectors, or external sources
- Comprehensive free software libraries and examples available with the STM32Cube MCU Package
- On-board ST-LINK/V2-1 debugger/programmer with USB re-enumeration capability: mass storage, Virtual COM port, and debug port
- Support of a wide choice of Integrated Development Environments (IDEs) including IAR Embedded Workbench®, MDK-ARM, and STM32CubeIDE

2 Ordering information

To order the 32F723EDISCOVERY Discovery kit, refer to *Table 1*. Additional information is available from the datasheet and reference manual of the target microcontroller.

Table 1. Ordering Information

Order code	Board reference	Target STM32
STM32F723E-DISCO	MB1260(1) MB1280(2)	STM32F723IEK6

1. Mother board
2. Fanout daughterboard

2.1 Codification

The meaning of the codification is explained in *Table 2*.

Table 2. Codification explanation

STM32F7XXY-DISCO	Description	Example: STM32F723E-DISCO
STM32F7	MCU series in STM32 32-bit Arm Cortex MCUs	SRM32F7 Series
XX	MCU product line in the series	STM32F723
Y	STM32 Flash memory size: E for 512 Kbytes	512 Kbytes
DISCO	Discovery kit	Discovery kit

3 Development environment

The 32F723EDISCOVERY Discovery kit runs with the STM32F413ZHT6 32-bit microcontroller based on the Arm®(a) Cortex®-M7 core.

3.1 System requirements

- Multi-OS support: Windows® 10, Linux®(b) 64-bit, or macOS®(c)(d)
- USB Type-A or USB Type-C® to Micro-B cable

3.2 Development toolchains

- IAR Systems® - IAR Embedded Workbench®(e)
- Keil® - MDK-ARM(e)
- STMicroelectronics - STM32CubeIDE

4 Conventions

Table 3 defines some conventions used in the present document.

Table 3. ON/OFF conventions

Convention	Definition
Jumper JPx ON	Jumper fitted
Jumper JPx OFF	Jumper not fitted
Jumper JPx [1-2]	Jumper fitted between Pin 1 and Pin 2
Solder bridge SBx ON	SBx connections closed by solder
Solder bridge SBx OFF	SBx connections left open
Resistor Rx ON	Resistor soldered
Resistor Rx OFF	Resistor not soldered

a. Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

b. Linux is a registered trademark of Linus Torvalds.

c. macOS is a trademark of Apple Inc. registered in the U.S. and other countries.

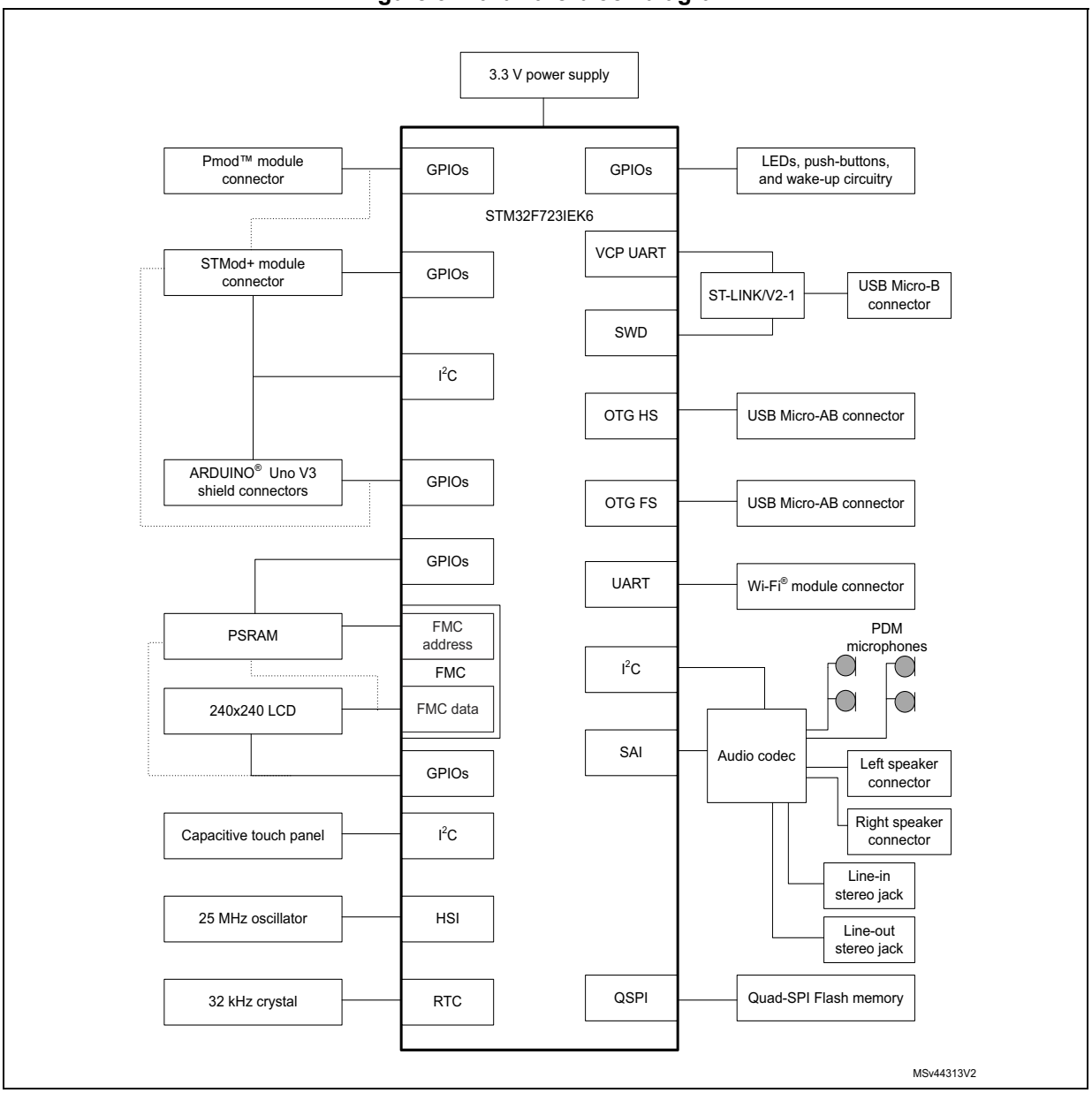
d. All other trademarks are the property of their respective owners.

e. On Windows® only.

5 Hardware layout and configuration

The 32F723EDISCOVERY Discovery kit is designed around the STM32F723IEK6 (176-pin in UFBGA package). The hardware block diagram shown in *Figure 3* illustrates the connection between STM32F723IEK6 and peripherals (PSRAM, Quad-SPI Flash memory, LCD connector, USB OTG HS and FS connectors, USART, Audio, ARDUINO® Uno V3, Pmod™ and STMod+ shields, and embedded ST-LINK). *Figure 4* and *Figure 5* help users to locate these features on the 32F723EDISCOVERY board. The mechanical dimensions of the 32F723EDISCOVERY board are shown in *Figure 6*.

Figure 3. Hardware block diagram



1. Dotted lines identify the shared signals.

5.1 32F723EDISCOVERY Discovery kit layout

Figure 4. 32F723EDISCOVERY top layout

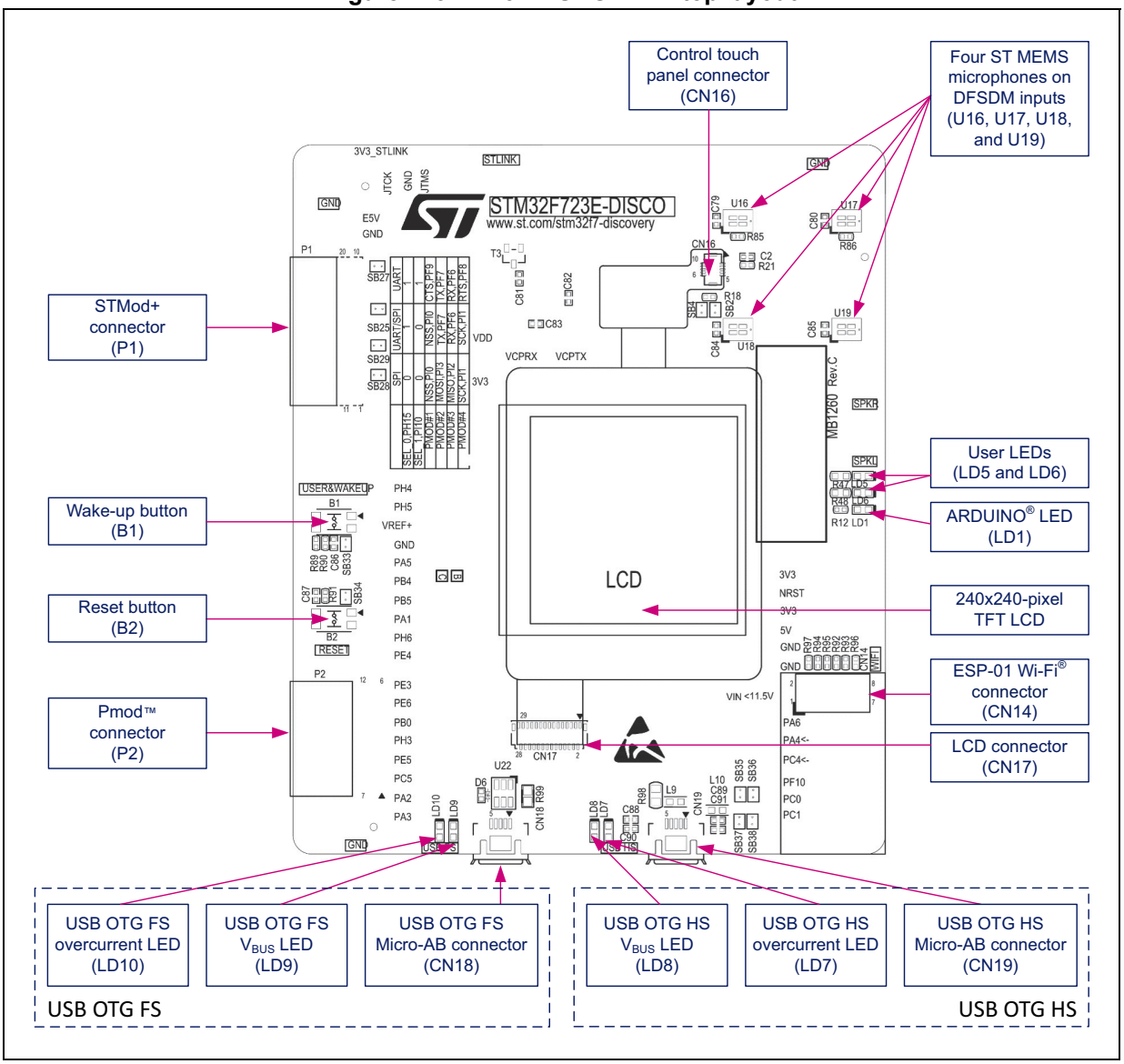
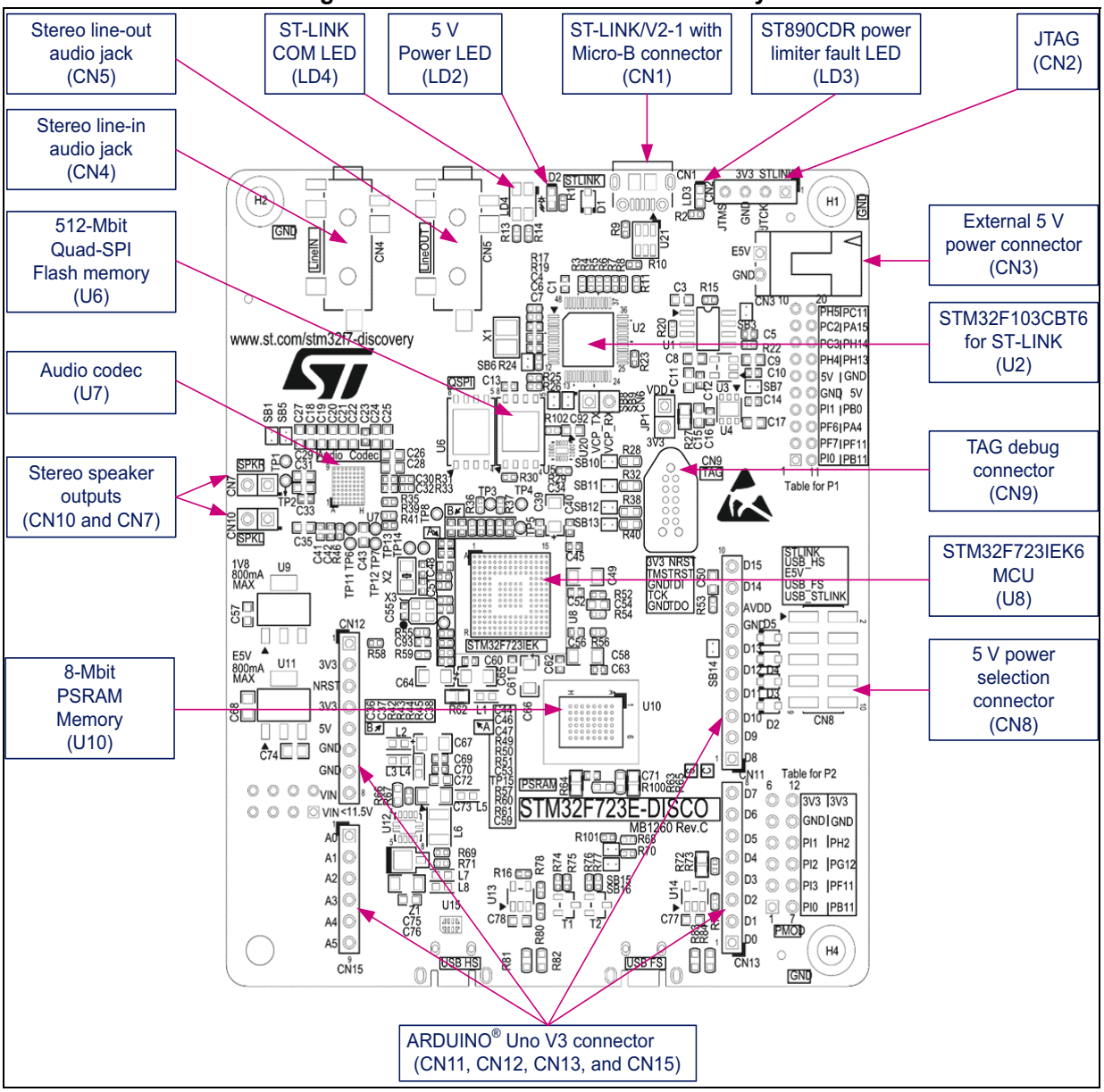
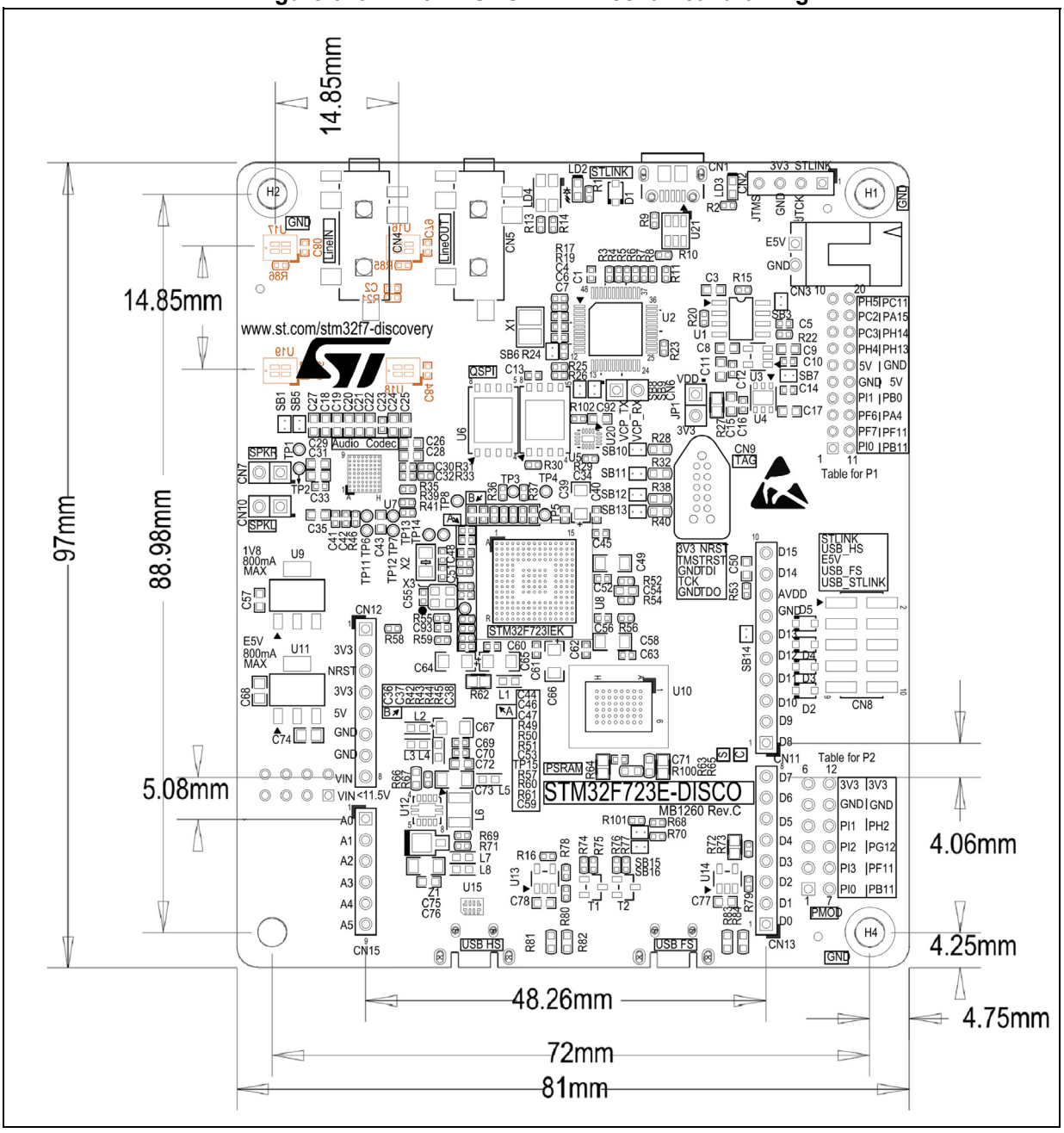


Figure 5. 32F723EDISCOVERY bottom layout



5.2 32F723EDISCOVERY Discovery kit mechanical drawing

Figure 6. 32F723EDISCOVERY mechanical drawing



1. The digital microphones marked in orange (U16, U17, U18, and U19) are placed on the bottom side of the board.

5.3 Embedded ST-LINK/V2-1

The ST-LINK/V2-1 programming and debugging tool is integrated on the 32F723EDISCOVERY board. Compared to ST-LINK/V2 the changes are listed below.

The new features supported on ST-LINK/V2-1 are:

- USB software re-enumeration
- Virtual COM port interface on USB
- Mass storage interface on USB
- USB power management request for more than 100mA power on USB

These features are no more supported on ST-LINK/V2-1:

- SWIM interface
- Application voltage lower than 3V

For general information concerning the debugging and programming features that are common to both versions V2 and V2-1, refer to the user manual *ST-LINK/V2 in-circuit debugger/programmer for STM8 and STM32* (UM1075).

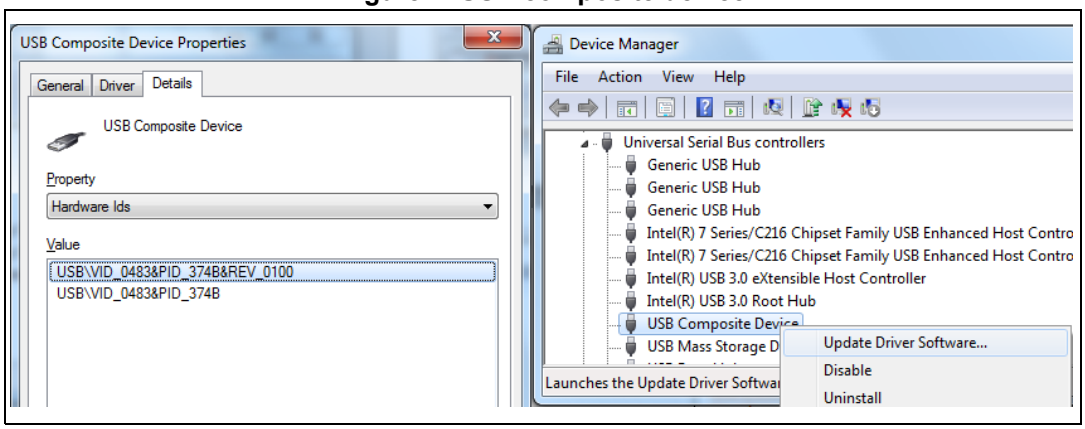
5.3.1 Drivers

Before connecting the 32F723EDISCOVERY board to a Windows® PC via USB, a driver for ST-LINK/V2-1 must be installed. It can be downloaded from the *www.st.com* website.

In case the 32F723EDISCOVERY board is connected to the PC before installing the driver, the PC device manager may report some 32F723EDISCOVERY board interfaces as “Unknown”. To recover from this situation, after installing the dedicated driver, the association of “Unknown” USB devices found on the 32F723EDISCOVERY board to this dedicated driver, must be manually updated in the device manager.

Note: It is recommended to proceed using USB Composite Device, as shown in Figure 7.

Figure 7. USB composite device



5.3.2 ST-LINK/V2-1 firmware upgrade

The ST-LINK/V2-1 embeds a firmware upgrade mechanism for in-situ upgrades through the USB port. As the firmware may evolve during the lifetime of the ST-LINK/V2-1 product (for example a new functionality, bug fixes, support for new microcontroller families), it is recommended to visit the *www.st.com* website before starting to use the 32F723EDISCOVERY board and periodically, to stay up-to-date with the latest firmware version.

5.4 Power supply

The 32F723EDISCOVERY board is designed to be powered from a 5 V DC power source. It is possible to configure the 32F723EDISCOVERY board to use any of the sources described in the following *Table 4*.

Table 4. 32F723EDISCOVERY board power configuration

CN8 configuration	Power connector	Voltage
ST-LINK	CN1	5 V
USB_STLINK	CN1	5 V
E5V	CN3	5 V
E5V	CN12	7 V-12 V => 5 V
USB_HS	CN19	5 V
USB_FS	CN18	5 V

Note: The Discovery board must be powered by a power supply unit or by auxiliary equipment complying with the standard EN-60950-1: 2006+A11/2009, and must be Safety Extra Low Voltage (SELV) with limited power capability.

5.4.1 Supplying the board through the ST-LINK USB port (default setting)

To power the 32F723EDISCOVERY board in this way the host PC USB gets connected with the ST-LINK USB port through a USB Type-A to Micro-B cable.

5 V DC power is provided by V_{BUS} from the CN1 USB type Micro-B connector of ST-LINK/V2-1 (USB 5 V power source on ST-LINK silkscreen, refer to *Figure 8*). If the USB enumeration succeeds (as explained below), the ST-LINK 5 V link power is enabled by asserting the PWR_ENn signal. This pin is connected to the U1 ST890 power switch, which powers the board. This power switch also features a current limitation to protect the PC in case of a short-circuit on the board (current demand exceeding 700 mA).

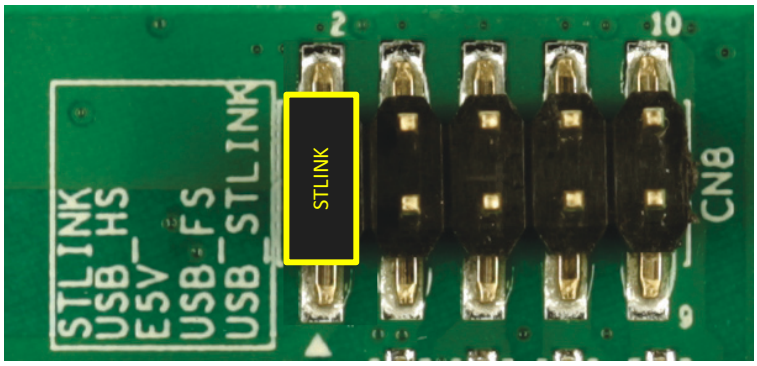
The 32F723EDISCOVERY board can be powered from the CN1 ST-LINK USB connector, but only the U2 STM32F103CBT6 is powered before USB enumeration because the host PC only provides 100 mA to the board at that time. During the USB enumeration, the 32F723EDISCOVERY board asks for the 500 mA power to the host PC. Two events can happen:

- If the host can provide the required power, the enumeration finishes by a *SetConfiguration* command and then, the power transistor ST890 is switched ON, the

red LED LD2 is turned ON, thus the 32F723EDISCOVERY board consumes maximum 500 mA current, but no more.

- If the host is not able to provide the requested current, the enumeration fails. Therefore the ST890 remains OFF and the STM32 part including the extension board is not powered. As a consequence, the LD2 red LED remains turned OFF. In this case, it is mandatory to use an external power supply.

Figure 8. CN8 ST-LINK connector



Note: In case the 32F723EDISCOVERY board is powered by a USB charger, there is no USB enumeration, so the led LD2 remains set to OFF permanently and the board is not powered. Only in this specific case, the resistor R5 needs to be ON, to allow the board to be powered anyway.

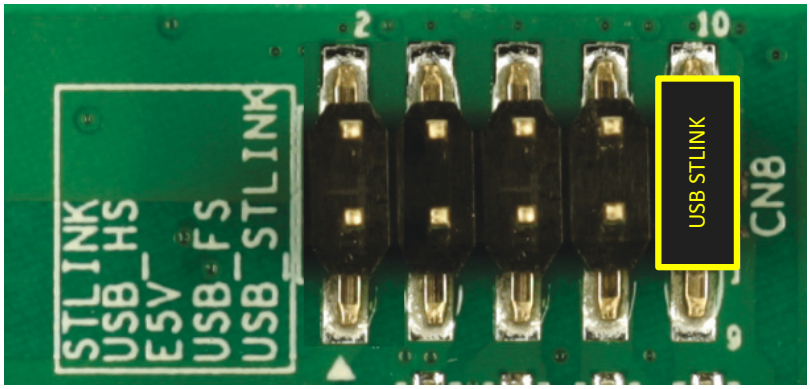
The LED LD2 is lit when the 32F723EDISCOVERY board is powered by the 5 V correctly.

Caution: Do not connect a PC to the CN1 ST-LINK connector when R5 is ON. The PC may be damaged or the board not powered correctly.

5.4.2 Supplying the board through a charger connected to ST-LINK

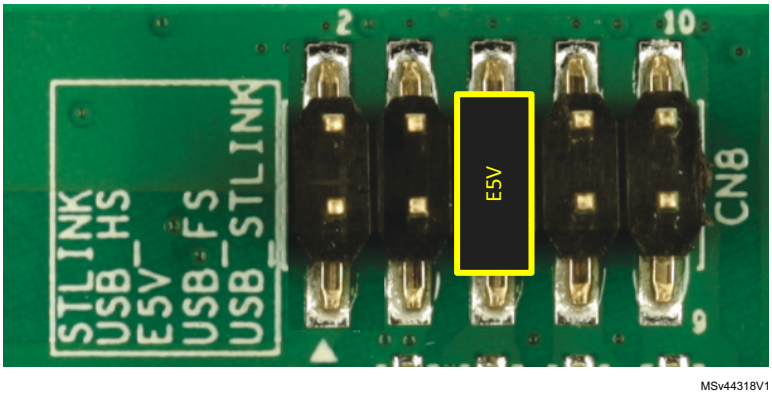
The 5 V DC power charger is connected to the CN1 USB_STLINK. In this case, if the 32F723EDISCOVERY board is powered by an external USB charger then the debug is not available. If the PC is connected instead of the charger, then the limitation is no more effective and the PC could be damaged (5 V power source on USB_STLINK silkscreen, refer to *Figure 9*).

Figure 9. CN8 USB_STLINK connector



5.4.3 Supplying the board from E5V (On CN3 or CN12 connector)

Figure 10. CN8 external 5 V supply



From E5V: 5V DC power adapter connected to CN3

In this case, the 32F723EDISCOVERY board must be powered by a power supply unit or by auxiliary equipment complying with standard EN-60950-1: 2006+A11/2009 connected to CN3 and be Safety Extra Low Voltage (SELV) with limited power capability (5 V power source on E5V silkscreen, refer to *Figure 10*).

From E5V: 7-12V DC power from CN12 VIN

7-12 V DC power supply is provided by an ARDUINO® Uno V3 compatible shield connected to CN11, CN12, CN13, and CN15 connectors.

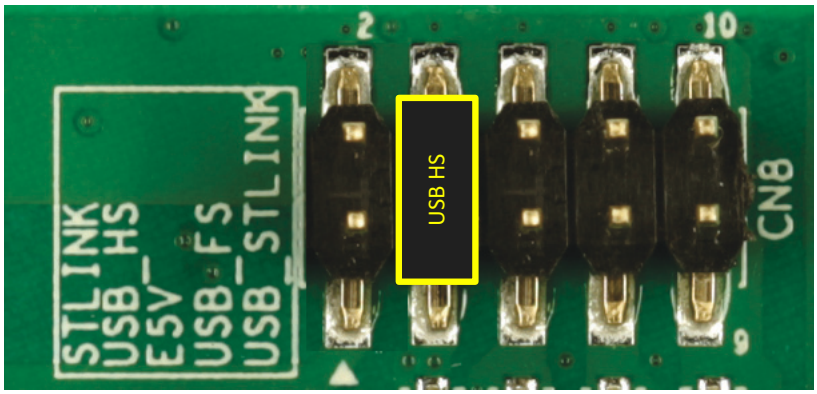
This 7-12 V VIN voltage is then converted to 5 V by U11 LDO.

Finally, the user must fit the jumper on the E5V position on the CN8 connector, to select this E5V LDO output as the main power supply for the board. Refer to *Figure 10*.

5.4.4 Supplying the board from an external power supply through USB HS

A 5 V DC external power supply is connected to the CN19 USB OTG HS Micro-AB connector (5 V power source on USB_HS silkscreen, refer to *Figure 11*).

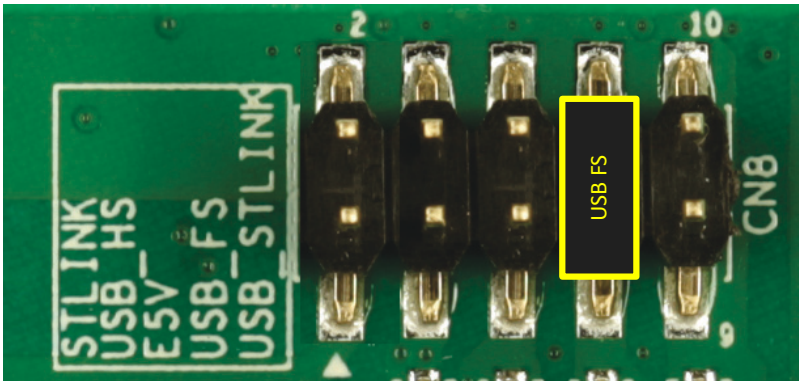
Figure 11. CN8 external USB_HS supply



5.4.5 Supplying the board from an external power supply through USB FS

A 5 V DC external power supply is connected to USB OTG FS Micro-AB connector CN18 (5 V power source on USB_FS silkscreen, refer to *Figure 12*).

Figure 12. CN8 external USB_FS supply



5.5 Programming/debugging when the power supply is not from ST-LINK

It is mandatory to power the board first using CN3 E5V, or CN12 VIN, or CN18 USB FS, or CN19 USB_HS, then connect the USB cable to the PC. Proceeding this way ensures that the enumeration succeeds thanks to the external power source.

The following power sequence procedure must be respected:

1. Connect the CN8 jumper on E5V or USB_HS or USB_FS.
2. Connect the external power source to CN3, or CN12, or CN18, or CN19.
3. Check that the LD2 red LED is turned ON.
4. Connect the PC to the CN1 USB connector.

If this order is not respected, the 32F723EDISCOVERY Discovery board may be powered by V_{BUS} first from ST-LINK and the following risks may be encountered:

1. If more than 500 mA current is needed by the board, the PC may be damaged or the current can be limited by the PC. As a consequence, the board is not powered correctly.
2. 500 mA is requested at the enumeration: if the PC cannot provide such a current, there is a risk that the request is rejected and the enumeration does not succeed.

5.6 Clock sources

Up to 2 clock sources as described below:

- X2 25 MHz oscillator for STM32F723IEK6 microcontroller
- X3 32 KHz crystal for the STM32F723IEK6 embedded RTC

5.7 Reset sources

The reset signal of the 32F723EDISCOVERY board is active LOW and the reset sources include:

- Reset button B2
- ARDUINO® Uno V3 shield board from CN12
- Embedded ST-LINK/V2-1

5.8 Audio

An audio codec with 4 DACs and 2ADCs is connected to the SAI interface of STM32F723IEK6. It communicates with STM32F723IEK6 via I^2C bus:

- The analog line input is connected to the audio codec ADC through the CN4 blue audio jack.
- The analog line output is connected to the audio codec DAC via the CN5 green audio jack.
- Two external speakers can be connected to the audio codec via CN10 for the left speaker and CN7 for the right speaker.
- Four digital ST-MEMS microphones are on the 32F723EDISCOVERY board. They are connected to the digital microphone inputs of the audio codec.

5.9 USB OTG HS

The 32F723EDISCOVERY board supports USB OTG high-speed communication via a USB Micro-AB connector.

A USB power switch is also connected to V_{BUS} and provides power to CN19. The LD8 green LED is lit in one of these cases:

- Power switch is ON and the 32F723EDISCOVERY board works as a USB host.
- V_{BUS} is powered by another USB host when the 32F723EDISCOVERY board works as a USB device.

The LD7 red LED is lit when an overcurrent occurs.

Note:1 When the 32F723EDISCOVERY board is powered by the ST-LINK then the OTG function can provide up to 100 mA.

Note:2 When the 32F723EDISCOVERY board is powered by an external power supply then the OTG function can provide more than 100 mA, according to the external power supply capability.

Note:3 When the 32F723EDISCOVERY board is powered by an external power supply through the CN19 USB HS connector in device mode, do not use a PC as the power source. Refer to Section 5.4.4.

5.10 USB OTG FS

The 32F723EDISCOVERY board supports USB OTG full-speed communication via a USB Micro-AB connector.

A USB power switch is also connected to V_{BUS} and provides power to CN18. The green LED LD9 is lit in one of these cases:

- Power switch is ON and the 32F723EDISCOVERY board works as a USB host
- V_{BUS} is powered by another USB host when the 32F723EDISCOVERY board works as a USB device.

The red LED LD10 is lit when an overcurrent occurs.

Note:1 When the 32F723EDISCOVERY board is powered by the ST-LINK then the OTG function provides up to 100 mA.

Note:2 When the 32F723EDISCOVERY board is powered by an external power supply then the OTG function provides more than 100 mA, according to the external power supply capability.

Note:3 When the 32F723EDISCOVERY board is powered by an external power supply through the CN18 USB FS connector in device mode, do not use a PC as the power source. Refer to Section 5.4.5.

Note:4 On Rev.C boards (MB1260 C01) in device mode, the path to the U22 ESD protection from USB data pins causes a raised voltage on USB V_{BUS} after disconnection. As a result, the device disconnect event is not detected and the BCD capability cannot be used.

Note:5 On Rev.D boards (MB1260 D01), there is no more limitation. The device disconnect event is detected and BCD capability can be used.

5.11 PSRAM memory

An 8-Mbit PSRAM is connected to the FMC interface of the STM32F723IEK6 with 16 bits of data and 18 bits of addresses (4-Mbit memory accessible).

5.12 Quad-SPI NOR Flash memory

A 512-Mbit Quad-SPI NOR Flash memory is connected to the Quad-SPI interface of STM32F723IEK6.

5.13 Virtual COM port

The serial interface USART6 is directly available as a virtual COM port of the PC connected to the CN1 ST-LINK/V2-1 USB connector. The Virtual COM port settings are configured with 115200 bps, 8-bit data, no parity, 1 stop bit, and no flow control.

5.14 TFT LCD 240x240 pixels

A 240x240-pixel TFT LCD is connected to FMC data interface of STM32F723IEK6.

It uses a controller for 262K-color, TFT-LCD graphic type. Display data are stored in the on-chip display data RAM of 240x320x18 bits. It performs display data RAM read/write operation with no external operation clock to minimize power consumption.

External PSRAM can also be used to store display data.

LCD_RS signal is used to determine whether the bus is carrying data or control and command registers.

5.15 Capacitive control touch panel

Capacitive Control Touch Panel is controlled by STM32F723IEK6 through I^2C.

5.16 Buttons and LEDs

The B2 black button located on the LCD side is the reset of the STM32F723IEK6 microcontroller.

The B1 blue button also located on the LCD side is available to use as a digital input or as an alternate wake-up function. When the button is pressed the logic state is HIGH, otherwise, the logic state is LOW.

Three LEDs located on the LCD side are available for the user. The LEDs are the LD1 blue ARDUINO®, the LD5 red User1, and the LD6 green User2.To light a LED a LOW logic state must be written in the corresponding GPIO.

Table 5 gives the assignment of control ports to the LED indicators.

Table 5. Control port assignment

Reference	Color	Name	Comment
B1	BLUE	USER	Alternate function Wake-up
B2	BLACK	RESET	-
LD1	BLUE	ARDUINO	PA5
LD2	RED	5 V Power	-
LD3	RED	Fault Power	Current upper than 625 mA
LD4	RED/GREEN	ST-LINK COM	Green during communication
LD5	RED	USER1	PA7
LD6	GREEN	USER2	PB1
LD7	RED	USB OTG HS OVCR	PH10
LD8	GREEN	V_{BUS} USB HS	PB13
LD9	RED	USB OTG FS OVCR	PB10
LD10	GREEN	V_{BUS} USB FS	PA9

6 Connectors

6.1 Wi-Fi® ESP-01 compatible connector

Figure 13. CN14 Wi-Fi® connector (Front view)

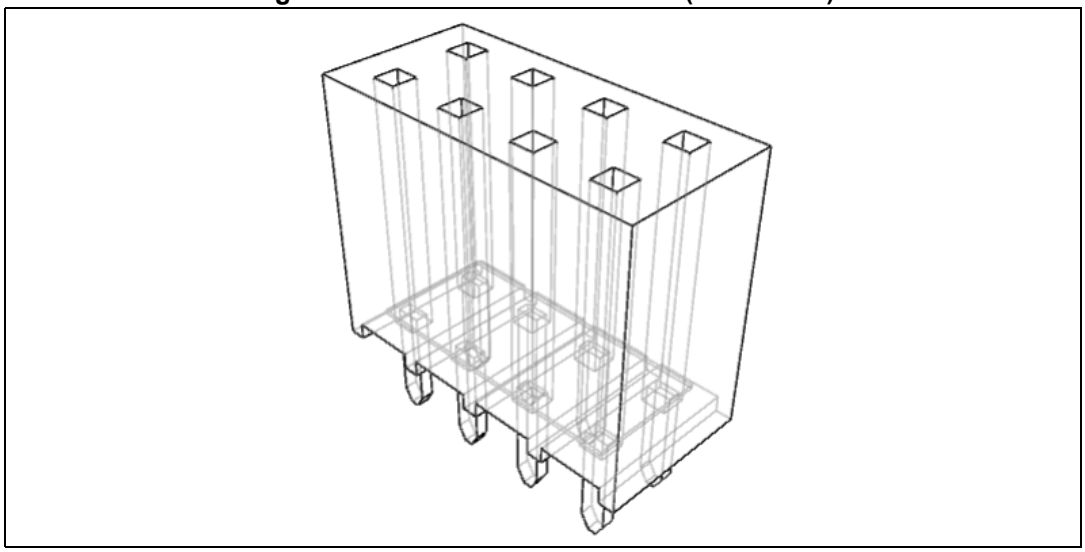


Table 6. CN14 Wi-Fi® module connector

Pin number	Wi-Fi® description
1	WIFI_RX
2	3.3 V
3	GPIO0
4	WIFI-RST
5	GPIO2
6	CH_PD
7	GND
8	WIFI_TX

6.2 ARDUINO® Uno V3 compatible connectors

CN11, CN12, CN13, and CN15 are female connectors compatible with ARDUINO® Uno V3 standard. Most shields designed for ARDUINO® Uno V3 are also supported by the 32F723EDISCOVERY board.

The ARDUINO® connectors on the 32F723EDISCOVERY board support the ARDUINO® Uno V3.

Caution: The STM32 microcontroller I/Os are 3.3 V compatible instead of 5 V for ARDUINO® Uno V3.

Table 7. GPIO assignment for ARDUINO® pins

I/O	Name	Pin number		Name	I/O
-	-	-	CN11.10	SCL2	PH4(1)
-	-	-	CN11.9	SDA2	PH5(1)
-	-	-	CN11.8	V_{REF+}	-
-	-	-	CN11.7	GND	-
-	NC	CN12.1	CN11.6	SCK1	PA5
-	3.3 V	CN12.2	CN11.5	MISO1	PB4
-	NRST	CN12.3	CN11.4	MOSI1	PB5
-	3.3 V	CN12.4	CN11.3	NSS1	PA1
-	5 V	CN12.5	CN11.2	TIM12_CH1	PH6
-	GND	CN12.6	CN11.1	GPIO	PE4
-	GND	CN12.7	-	-	-
-	V_{IN}	CN12.8	CN13.8	GPIO	PE3
-	-	-	CN13.7	TIM9_CH2	PE6
PA6	ADC1_IN6	CN15.1	CN13.6	TIM3_CH3(2)	PB0
PA4	ADC1_IN4	CN15.2	CN13.5	GPIO	PH3
PC4(2)	ADC1_IN14	CN15.3	CN13.4	TIM9_CH1	PE5
PF10	ADC3_IN8	CN15.4	CN13.3	GPIO	PC5
PC0	ADC1_IN10	CN15.5	CN13.2	TX2	PA2
PC1	ADC1_IN11	CN15.6	CN13.1	RX2	PA3

1. Shared between ARDUINO® and STMod+.
2. Exclusive use: ARDUINO® or STMod+.

6.3 P2 Pmod™ and P1 STMod+ connectors

On the 32F723EDISCOVERY board, Pmod™ and STMod+ connectors are providing flexibility in small form factor applications.

Based on the existing Pmod™ Digilent standard popular in connectivity, the 32F723EDISCOVERY board is supporting the Pmod™ type 2A and 4A on the P2 connector.

P1 STMod+ connector uses Pmod™ signals with extended SPI and spare I/Os for different peripheral expansion. The related STM32F723IEK6 I/Os for Pmod™ and STMod+ function are listed in *Table 20: STMod+ connector signals*.

Refer to *Appendix B: Pmod™ and STMod+ schematic table* to find more information about Pmod™ and STMod+ pins. Refer to *Section Appendix C: Fanout board* to find more information about STMod+ compatible fanout board.

The user must select the different configurations using PMOD_SEL_0 (PH15) and PMOD_SEL_1 (PI10) to control the U20 STG3692QTR. This quad analog SPDT (Single Pole Dual Throw) allows to connecting Pmod™ and STMod+, either to UART or SPI, or both in the case of STMod+.

6.3.1 P2 Pmod™ connector

The Pmod™ connector is 2x6 pins with 2.54 mm pitch and a right-angle female connector.

Figure 14. P2 Pmod™ connector

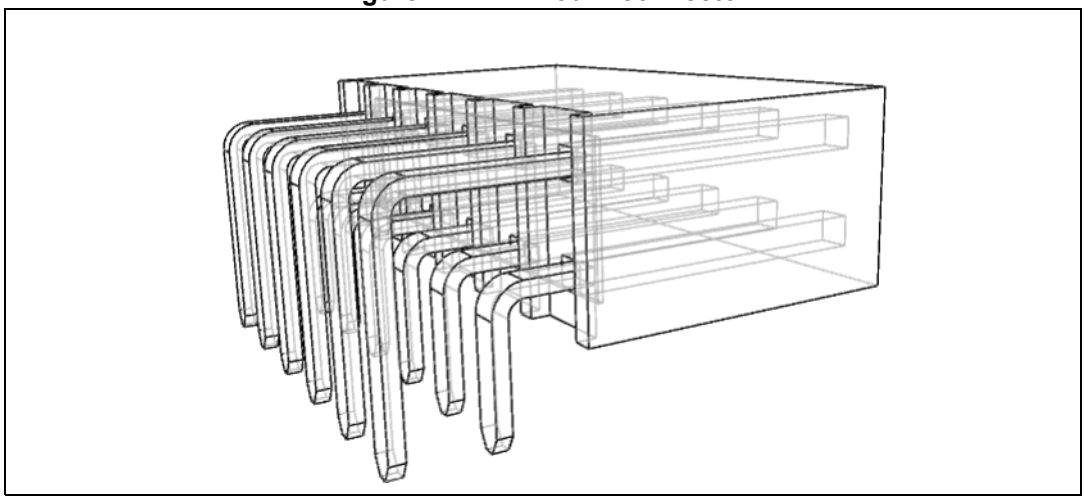


Table 8. GPIO assignment for Pmod™ pins

I/O	Name	Pin number		Name	I/O
PI0 / PF9	NSS2 / CTS7	1	7	INT	PB11
PI3 / PF7	MOSI2p / TX7	2	8	RESET	PF11
PI2 / PF6	MISO2p / RX7	3	9	GPIO0	PG12
PI1 / PF8	SCK2 / RTS7	4	10	GPIO1	PH2
	GND	5	11	GND	
	3.3 V	6	12	3.3 V	

Table 9. Pmod™: SPI or UART configuration selection

Pin name	Pmod™ SPI	Pmod™ UART
PMOD_SEL_0 (PH15)	0	1
PMOD_SEL_1 (PI10)	0	1
PMOD#1	NSS	CTS
PMOD#2	MOSIp	TX
PMOD#3	MISOp	RX
PMOD#4	SCK	RTS

Refer to *Appendix B: Pmod™ and STMod+ schematic table* to find more information about Pmod™ pins.

6.3.2 P1 STMod+ connector

STMod+ connector is 2x10 pins with 2.0 mm pitch and right angle female connector.

Figure 15. P1 STMod+ connector

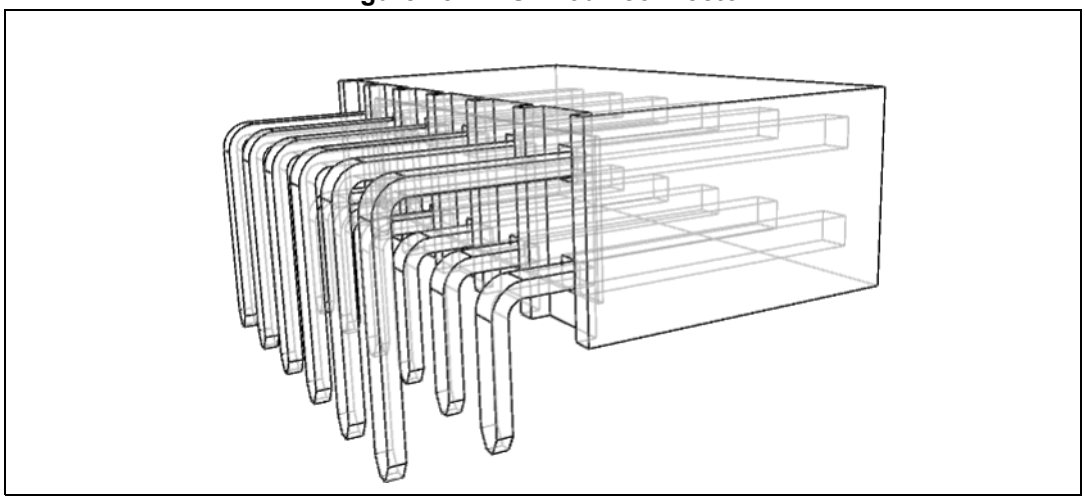


Table 10. GPIO assignment for STMod+ pins

I/O	Name	Pin number		Name	I/O
PI0 / PF9	NSS2 / CTS7	1	11	INT	PB11
PI3 / PF7	MOSI2p / TX7	2	12	RESET	PF11
PI2 / PF6	MISO2p / RX7	3	13	ADC1_IN14	PC4(1)
PI1 / PF8	SCK2 / RTS7	4	14	TIM3_CH3	PB0(1)
-	GND	5	15	5 V	-
-	5 V	6	16	GND	-
PH4(2)	SCL2	7	17	TX4p	PH13
PC3	MOSI2s	8	18	RX4p	PH14
PC2	MISO2s	9	19	PWM	PA15
PH5(2)	SDA2	10	20	RX4s	PC11

1. Exclusive use: ARDUINO® or STMod+.
2. Shared between ARDUINO® and STMod+.

Table 11. STMod+: SPI/UART configuration selection

Pin name	STMod+ SPI	STMod+ UART	STMod+ UART and SPI(1)
PMOD_SEL_0 (PH15)	0	1	1
PMOD_SEL_1 (PI10)	0	1	0
PMOD#1	NSS	CTS	NSS
PMOD#2	MOSIp	TX	TX
PMOD#3	MISOp	RX	RX

Table 11. STMod+: SPI/UART configuration selection (continued)

Pin name	STMod+ SPI	STMod+ UART	STMod+ UART and SPI[1]
PMOD#4	SCK	RTS	SCK
STMod+#8	N/A	N/A	MOSIs
STMod+#9	N/A	N/A	MISOs

1. Default configuration.

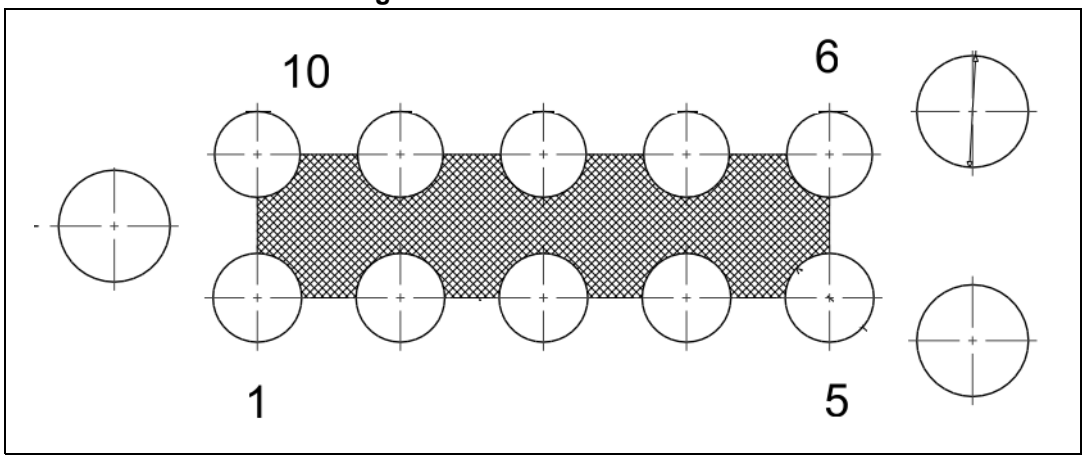
Refer to *Appendix B: Pmod™ and STMod+ schematic table* to find more information about STMod+ signals available on the P1 connector. Refer to *Section Appendix C: Fanout board* to find more information about STMod+ compatible fanout board.

6.4 CN9 TAG connector

TAG connector is a 10-pin footprint supporting SWD mode, which shares the same signals as ST-LINK: PA13 (JTMS / SWDIO), PA14 (JTCLK / SWCLK), PB3 (JTDO / SWO), PB4 (NRST).

A cable is used to link ST-LINK and TAG connectors, so users can easily program and debug the STM32 without using any extra accessories.

Figure 16. CN9 TAG connector



6.5 CN19 USB OTG HS Micro-AB connector

Figure 17. CN19 USB OTG HS Micro-AB connector (Front view)

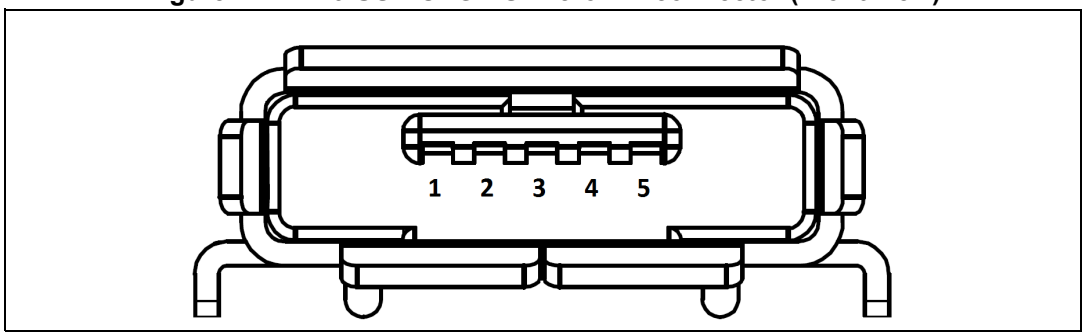


Table 12. CN19 USB OTG HS Micro-AB connector

Pin number	Description	Pin number	Description
1	V_{BUS}	4	ID
2	D-	5	GND
3	D+	-	-

Note: U13 STMPS provides V_{BUS}. It is active high, controlled by PH12. Overcurrent is sent to PH10 interrupt.

6.6 CN18 USB OTG FS Micro-AB connector

Figure 18. CN18 USB OTG FS Micro-AB connector (Front view)

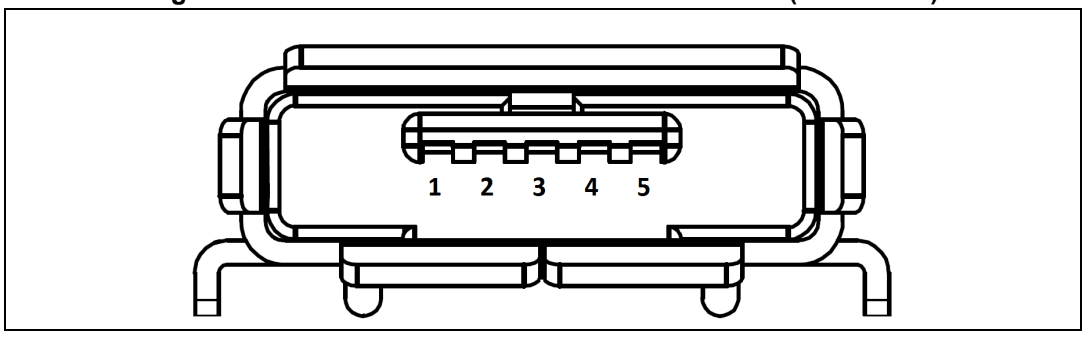


Table 13. CN18 USB OTG FS Micro-AB connector (Front view)

Pin number	Description	Pin number	Description
1	V_{BUS}	4	ID
2	D-	5	GND
3	D+	-	-

Note: U14 STMPS provides V_{BUS}. It is active low, controlled by PG8. Overcurrent is sent to PB10 interrupt.

6.7 LCD connector

Figure 19. CN17 LCD connector (Front view)

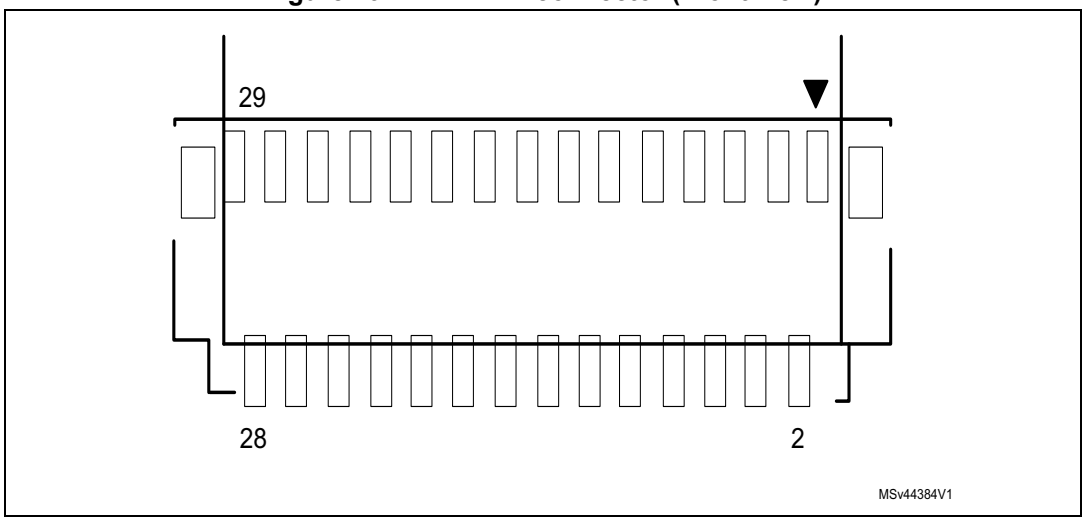


Table 14. Pin description of the CN17 LCD connector

Pin number	Description	Pin connection	Pin number	Description	Pin connection
1	GND	GND	2	FMARK	PC8 (TE INT)
3	DB15	FMC_D15	4	DB14	FMC_D14
5	DB13	FMC_D13	6	DB12	FMC_D12
7	DB11	FMC_D11	8	DB10	FMC_D10
9	DB9	FMC_D9	10	DB8	FMC_D8
11	DB7	FMC_D7	12	DB6	FMC_D6
13	DB5	FMC_D5	14	DB4	FMC_D4
15	DB3	FMC_D3	16	DB2	FMC_D2
17	DB1	FMC_D1	18	DB0	FMC_D0
19	NRD	FMC_NOE	20	NWR	FMC_NWE
21	RS	PF0 (FMC_A0)	22	NCS	PG9 (NE)
23	RESET	PH7 (LCD_RST)	24	IM	VDD
25	IOVCC	VDD	26	VCI	3.3 V
27	GND	GND	28	LEDA	LEDA
29	LEDK	LEDK	-	-	-

Note: LEDA and LEDK backlight are controlled by U12 with PH11 PWM.

6.8 Control Touch Panel (CTP) connector

Figure 20. CN16 CTP connector (Front view)

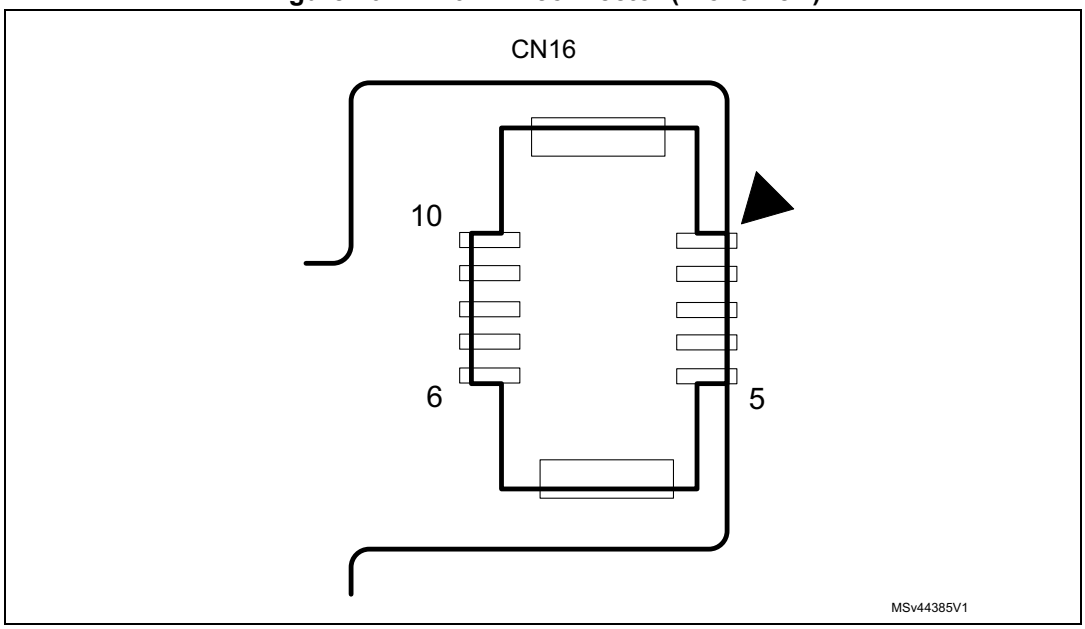


Table 15. Pin description of the CN16 CTP connector

Pin number	Description
1	GND
2	INT
3	GND
4	SDA
5	SCL
6	GND
7	RESET
8	IOVCC
9	VDD
10	GND

6.9 CN1 ST-LINK/V2-1 USB Micro-B connector

The CN1 USB connector is used to connect embedded ST-LINK/V2-1 to the PC for programming and debugging the STM32F723IEK6 microcontroller.

Figure 21. CN1 USB Micro-B connector (front view)

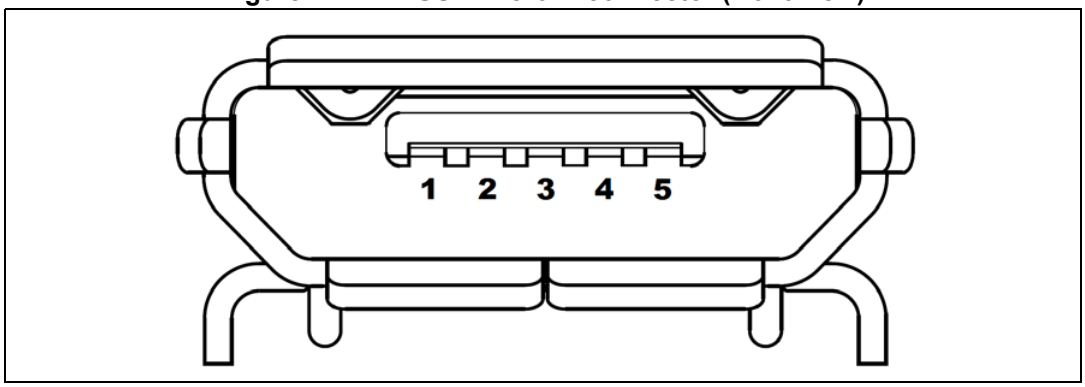


Table 16. CN1 USB Micro-B connector

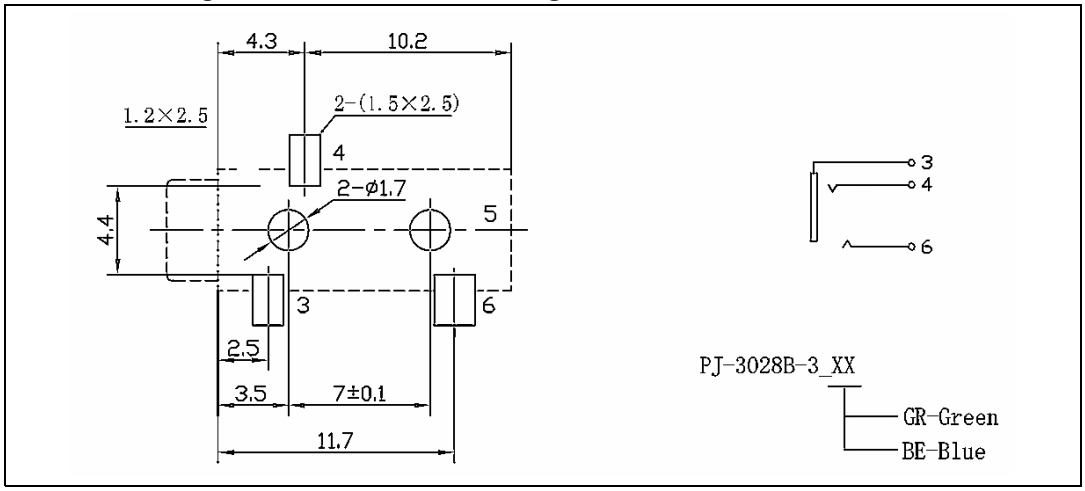
Pin number	Description	Pin number	Description
1	V_{BUS} (power)	4	GND
2	DM	5, 6	Shield
3	DP	-	-

6.10 Audio stereo speakers

The CN10 and CN7 stereo audio outputs are available to support stereo speakers (left and right respectively).

6.11 Audio line connectors

Figure 22. Mechanical drawing of the audio line connector



6.11.1 Audio line output (green jack) connector

A CN5 3.5 mm stereo audio green jack output is available to support the headphone. Refer to *Figure 22*.

Table 17. CN5 audio line output connector

Pin number	Description
3	GND
4	Right
6	Left

6.11.2 Audio line input (blue jack) connector

A CN4 3.5 mm stereo audio blue jack input is available to support the audio line input. Refer to *Figure 22*.

Table 18. CN4 audio line input connector

Pin number	Description
3	GND
4	Right
6	Left

7 32F723EDISCOVERY board information

7.1 Product marking

The stickers located on the top or bottom side of the PCB provide product information:

- Product order code and product identification for the first sticker
- Board reference with revision, and serial number for the second sticker

On the first sticker, the first line provides the product order code, and the second line the product identification.

On the second sticker, the first line has the following format: “MBxxxx-Variant-yzz”, where “MBxxxx” is the board reference, “Variant” (optional) identifies the mounting variant when several exist, "y" is the PCB revision and "zz" is the assembly revision, for example B01. The second line shows the board serial number used for traceability.

Evaluation tools marked as “ES” or “E” are not yet qualified and therefore not ready to be used as reference design or in production. Any consequences deriving from such usage will not be at ST charge. In no event, ST will be liable for any customer usage of these engineering sample tools as reference designs or in production.

“E” or “ES” marking examples of location:

- On the targeted STM32 that is soldered on the board (For an illustration of STM32 marking, refer to the STM32 datasheet “Package information” paragraph at the *www.st.com* website).
- Next to the evaluation tool ordering part number that is stuck or silk-screen printed on the board.

Some boards feature a specific STM32 device version, which allows the operation of any bundled commercial stack/library available. This STM32 device shows a "U" marking option at the end of the standard part number and is not available for sales.

In order to use the same commercial stack in his application, a developer may need to purchase a part number specific to this stack/library. The price of those part numbers includes the stack/library royalties.

7.2 32F723EDISCOVERY product history

7.2.1 Product identification 32F723EDISCO/

This product identification is based on the MB1260-F723E-D01 mother board.

It embeds the STM32F723IEK6 microcontroller with silicon revision code “A". The limitations of this silicon revision are detailed in the errata sheet *STM32F72xxx and STM32F73xxx device limitations* (ES0360).

Product limitations

No limitation identified for this product identification.

7.2.2 Product identification DK32F723E$AU1

This product identification is based on the MB1260-F723E-D03 mother board.

It embeds the STM32F723IEK6 microcontroller with silicon revision code "A" or “1”. The limitations of this silicon revision are detailed in the errata sheet *STM32F72xxx and STM32F73xxx device limitations* (ES0360).

Product limitations

No limitation identified for this product identification.

7.3 Board revision history

7.3.1 Board MB1260 revision D-01

The revision D-01 of the MB1260 board is the initial release.

Board limitations

No limitation identified for this board revision.

7.3.2 Board MB1260 revision D-03

The revision D-03 of the MB1260 board corresponds to:

- ZZ1 (Touch panel) replaced with FRIDA FRD154B2902-D-CTQ with impact on firmware
- Several part references updated due to obsolescence, such as MEMS microphones or others. Refer to the bill of materials for details.

Board limitations

No demonstration software is provided from this revision.

7.3.3 Board MB1280 revision A-03

The revision A-03[2] is the initial release of the MB1280 fanout daughterboard.

Board limitations

The Grove connector does not support the 5 V I^2C interface.

7.3.4 Board MB1280 revision B-01

The revision B-01 adds layout improvements to the A-03 revision.

Board limitations

The Grove connector does not support the 5 V I^2C interface.

7.3.5 Board MB1280 revision C-01

The revision C-01 removes the limitations of the B-01 revision.

Board limitations

The C-01 revision supports the 5 V I^2C interface for the Grove connector, but the user must solder by himself the MOSFETs and related matched resistors.

Appendix A 32F723EDISCOVERY Discovery board I/O assignment

Table 19. I/O assignment

Pin number	Pin	Function	Label
A1	PE3	GPIO_Output	ARD_D7_GPIO
A2	PE2	QUADSPI_BK1_IO2	-
A3	PE1	FMC_NBL1	-
A4	PE0	FMC_NBL0	-
A5	PB8	I2C1_SCL	-
A6	PB5	SPI1_MOSI	ARD_D11_TIM3_CH2_SPI1_MOSI
A7	PG14	GPIO_Output	WIFI_RST
A8	PG13	GPIO_Output	WIFI_GPIO_0
A9	PB4	SPI1_MISO	ARD_D12_SPI1_MISO
A10	PB3	SYS_JTDO-SWO	-
A11	PD7	FMC_NE1	-
A12	PC12	UART5_TX	UART_TXD_WIFI_RX
A13	PA15	TIM2_CH1	STMOD+_TIM2_CH1_2_ETR
A14	PA14	SYS_JTCK-SWCLK	-
A15	PA13	SYS_JTMS-SWDIO	-
B1	PE4	GPIO_Output	ARD_D8_GPIO
B2	PE5	TIM9_CH1	ARD_D3_TIM9_CH1
B3	PE6	TIM9_CH2	ARD_D6_TIM9_CH2
B4	PB9	I2C1_SDA	-
B5	PB7	FMC_NL	-
B6	PB6	QUADSPI_BK1_NCS	-
B7	PG15	GPIO_EXTI15	SAI2_INT
B8	PG12	GPIO_Output	PMOD_GPIO_0
B10	PG10	SAI2_SD_B	-
B11	PD6	GPIO_Output	WIFI_GPIO_2
B12	PD0	FMC_D2	-
B13	PC11	GPIO_Output	STMOD+_UART4_RXD_s
B14	PC10	QUADSPI_BK1_IO1	-
B15	PA12	USB_OTG_FS_DP	-
C2	PI7	SAI2_FS_A	-
C3	PI6	SAI2_SD_A	-

Table 19. I/O assignment (continued)

Pin number	Pin	Function	Label
C4	PI5	SAI2_SCK_A	-
C10	PG9	FMC_NE2	-
C11	PD5	FMC_NWE	-
C12	PD1	FMC_D3	-
C13	PI3	GPIO_Output	PMOD_SPI2_MOSI
C14	PI2	GPIO_Output	PMOD_SPI2_MISO
C15	PA11	USB_OTG_FS_DM	-
D3	PI9	GPIO_EXTI9	CTP_INT
D4	PI4	SAI2_MCLK_A	-
D10	PD4	FMC_NOE	-
D11	PD3	GPIO_Output	WIFI_CH_PD
D12	PD2	UART5_RX	UART_RXD_WIFI_TX
D13	PH15	GPIO_Output	PMOD_SEL_0
D14	PI1	SPI2_SCK	PMOD_SPI2_SCK
D15	PA10	GPIO_Output	USB_OTG_FS_ID
E1	PC14-OSC32_IN	RCC_OSC32_IN	-
E2	PF0	FMC_A0	-
E3	PI10	GPIO_Output	-
E12	PH13	UART4_TX	STMOD+_UART4_TXD
E13	PH14	UART4_RX	STMOD+_UART4_RXD
E14	PI0	SPI2_NSS	PMOD_SPI2_NSS
E15	PA9	USB_OTG_FS_VBUS	-
F1	PC15-OSC32_OUT	RCC_OSC32_OUT	-
F4	PH2	GPIO_Output	PMOD_GPIO_1
F14	PC9	QUADSPI_BK1_IO0	-
F15	PA8	I2C3_SCL	-
G1	PH0-OSC_IN	RCC_OSC_IN	-
G4	PH3	GPIO_Output	ARD_D4_GPIO
G14	PC8	GPIO_EXTI8	LCD_TE_INT
G15	PC7	USART6_RX	-
H1	PH1-OSC_OUT	RCC_OSC_OUT	-
H2	PF2	FMC_A2	-
H3	PF1	FMC_A1	-
H4	PH4	I2C2_SCL	ARD_D15_STMOD+_I2C2_SCL(1)

Table 19. I/O assignment (continued)

Pin number	Pin	Function	Label
H14	PG8	GPIO_Output	USB_OTGFS_PPWR_EN
H15	PC6	USART6_TX	-
J2	PF3	FMC_A3	-
J3	PF4	FMC_A4	-
J4	PH5	I2C2_SDA	ARD_D14_STMOD+_I2C2_SDA(1)
K1	PF7	UART7_TX	PMOD_UART7_TXD
K2	PF6	UART7_RX	PMOD_UART7_RXD
K3	PF5	FMC_A5	-
K12	PH12	GPIO_Output	USB_OTGHS_PPWR_EN
K13	PG5	FMC_A15	-
K14	PG4	FMC_A14	-
K15	PG3	FMC_A13	-
L1	PF10	ADC3_IN8	ARD_A3_ADC3_IN8
L2	PF9	UART7_CTS	PMOD_UART7_CTS
L3	PF8	UART7_RTS	PMOD_UART7_RTS
L12	PH11	TIM5_CH2	-
L13	PH10	GPIO_Input	USB_OTGHS_OVCR_INT
L14	PD15	FMC_D1	-
L15	PG2	FMC_A12	-
M2	PC0	ADC2_IN10	-
M3	PC1	ADC2_IN11	-
M4	PC2	SPI2_MISO	STMOD+_SPI2_MISOs
M5	PC3	SPI2_MOSI	STMOD+_SPI2_MOSIs
M6	PB2	QUADSPI_CLK	-
M7	PG1	FMC_A11	-
M11	PH6	TIM12_CH1	ARD_D9_TIM12_CH1
M12	PH8	I2C3_SDA	-
M13	PH9	GPIO_Output	CTP_RST
M14	PD14	FMC_D0	-
M15	PD13	QUADSPI_BK1_IO3	-
N2	PA1	TIM2_CH2	ARD_D10_TIM2_CH2_SPI1_NSS
N3	PA0-WKUP	SYS_WKUP1	-
N4	PA4	ADC2_IN4	ARD_A1_STMOD+_ADC_DAC(2)
N5	PC4	ADC2_IN14	ARD_A2_ADC

Table 19. I/O assignment (continued)

Pin number	Pin	Function	Label
N6	PF13	FMC_A7	-
N7	PG0	FMC_A10	-
N11	PE13	FMC_D10	-
N12	PH7	GPIO_Output	LCD_RST
N13	PD12	FMC_A17	-
N14	PD11	FMC_A16	-
N15	PD10	FMC_D15	-
P2	PA2	USART2_TX	ARD_D1_USART2_TX
P3	PA6	ADC2_IN6	-
P4	PA5	SPI1_SCK	ARD_D13_SPI1_SCK
P5	PC5	GPIO_Output	ARD_D2_GPIO
P6	PF12	FMC_A6	-
P7	PF15	FMC_A9	-
P8	PE8	FMC_D5	-
P9	PE9	FMC_D6	-
P10	PE11	FMC_D8	-
P11	PE14	FMC_D11	-
P12	PB12	GPIO_Output	USB_OTG_HS_ID
P13	PB13	GPIO_EXTI13	USB_OTG_HS_VBUS
P14	PD9	FMC_D14	-
P15	PD8	FMC_D13	-
R2	PA3	USART2_RX	ARD_D0_USART2_RX
R3	PA7	GPIO_Output	SYS_LD_USER1
R4	PB1	GPIO_Output	SYS_LD_USER2
R5	PB0	TIM3_CH3	ARD_D5_STMOD+_TIM3_CH3(2)
R6	PF11	GPIO_Input	PMOD_RESET
R7	PF14	FMC_A8	-
R8	PE7	FMC_D4	-
R9	PE10	FMC_D7	-
R10	PE12	FMC_D9	-
R11	PE15	FMC_D12	-
R12	PB10	GPIO_EXTI10	USB_OTGFS_OVCR_INT
R13	PB11	GPIO_EXTI11	PMOD_INT

Table 19. I/O assignment (continued)

Pin number	Pin	Function	Label
R14	PB14	USB_OTG_HS_DM	-
R15	PB15	USB_OTG_HS_DP	-

1. Shared between ARDUINO® and STMod+.
2. Exclusive use: ARDUINO® or STMod+.

Appendix B Pmod™ and STMod+ schematic table

Table 20 describes the signals available on the STMod+ connector. It also shows which signal is shared with other board connectors, such as Pmod™ or ARDUINO® Uno V3.
A switch controlled by software is present to select which function is used (using PI10 and PH15 PIOs). Analog signals are in brackets [xxx]. The I^2C bus is shared with the ARDUINO® Uno V3 connectors. It is recommended to check the device slave address when adding it to the bus. Refer to the following list of acronyms before reading *Table 20*:

- RTS7 stands for USART7_RTS
- ADC2.4 stands for ADC_2_IN4
- T8.4 stands for TIM_8_CH4
- MOSI5 stands for SPI_5_MOSI

Table 20. STMod+ connector signals

-	-	-	STMod+								-	-	-
ARD	**PMOD**	**Some other AF**	**Basic**	**SW**	**Pin**	**Pin number**		**Pin**	**N/A**	**Basic**	**Some other AF**	**PMOD**	**ARD**
-	CTS	MOSI5/[ADC3.7]/T14.1	CTS7	PI10=1	PF9	1	11	PB11	-	INT	SDA2/RX3/T2.4	INT	-
	NSS	T5.4	NSS2	PI10=0	PI0								
-	TX	SCK5/[ADC3.5]/T11.1	TX7	PH15=1	PF7	2	12	PF11	-	RST	MOSI5	RST	-
	MOSI	T8.8ETR	MOSI2p	PH15=0	PI3								
-	RX	NSS5/[ADC3.4]/T10.1	RX7	PH15=1	PF6	3	13	PA4	-	ADC/DAC(1)	NSS1/NSS3/CK2/[ADC2.4]/[DACOUT1.1]	GPIO (PG12)	ADC(1)
	MISO	T8.4	MISO2p	PH15=0	PI2								
-	RTS	MISO5/[ADC3.6]/T13.1	RTS7	PI10=1	PF8	4	14	PB0	-	PWM(1)	CTS4/[ADC1.8]/[ADC2.8]/T1.2N/T3.3/T8.2N	GPIO (PH2)	PWM(1)
	SCK	T8.BKIN2	SCK2	PI10=0	PI1								
-	-	-	GND	-	GND	5	15	+5 V	-	+5 V	-	-	-
-	-	-	+5 V	-	+5 V	6	16	GND	-	GND	-	-	-
SCL2(2)	-	-	SCL2(2)	-	PH4	7	17	PH13	-	GPIO	TX4/TXCAN1/T8.1N	-	-
-	-	[ADC1.13]/[ADC2.13]/[ADC3.13]	MOSI2s	-	PC3	8	18	PH14	-	GPIO	RX4/RXCAN1/T8.2N	-	-
-	-	[ADC1.12]/[ADC2.12]/[ADC3.12]	MISO2s	-	PC2	9	19	PA15	-	GPIO	NSS1/NSS3/RTS4/T2.1/T2.2_ETR	-	-
SDA2 (2)	-	NSS5	SDA2(2)	-	PH5	10	20	PC11	-	GPIO	MISO3/RX3/RX4	-	-

1. Exclusive use: ARDUINO® or STMod+.
2. Shared between ARDUINO® and STMod+.

Appendix C Fanout board

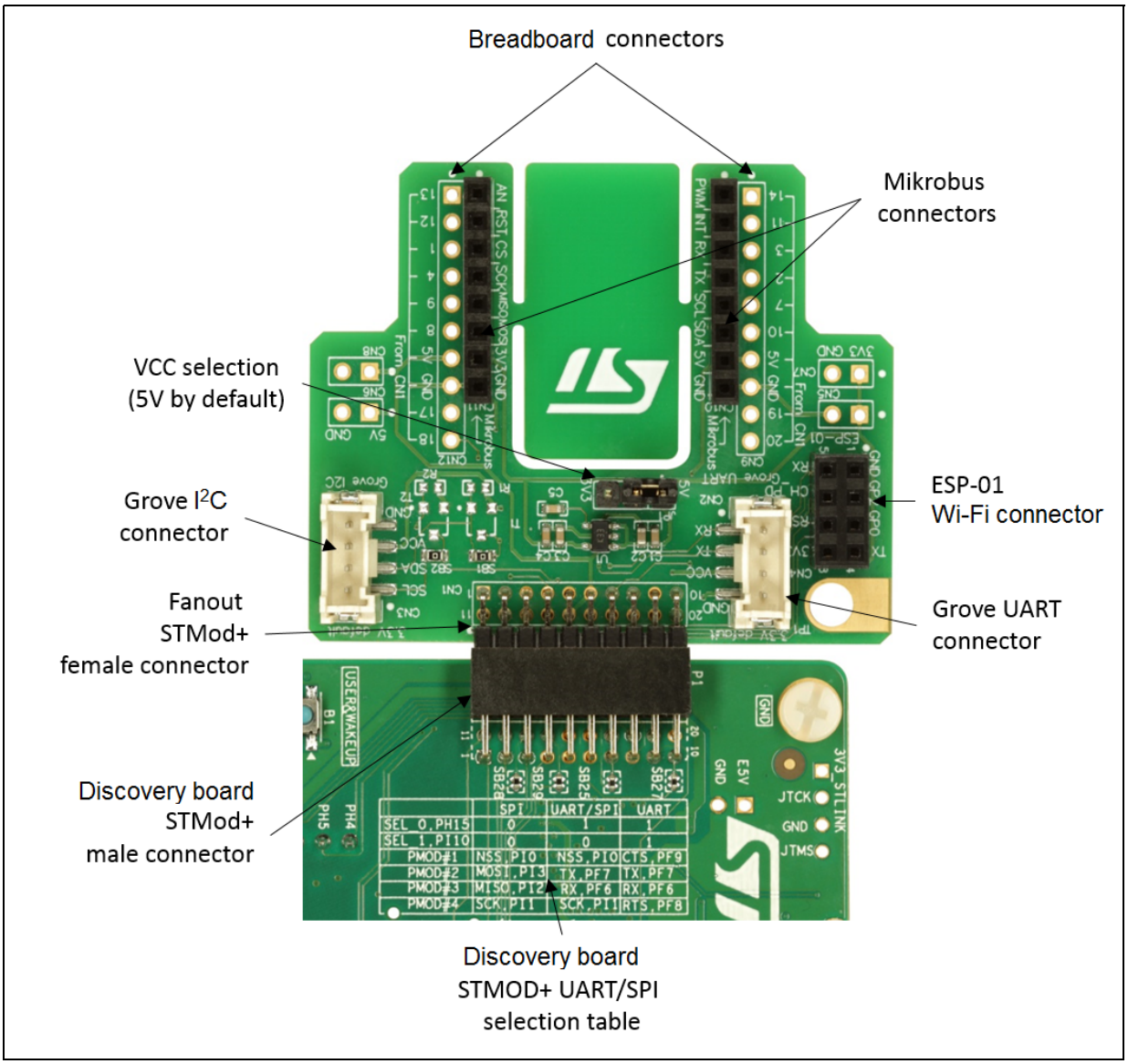
The 32F723EDISCOVERY Discovery board embeds the fanout board. Refer to *Figure 23*.

It is connected via the P1 STMod+ connector and provides access to:

- CN10 and CN11 MikroElektronika Click board compatible 1x8-pin female connectors
- CN4 ESP-01 compatible 2x4-pin female connector
- CN2 and CN3 Seeed Studio™ Grove compatible 1x4-pin male connectors
- Reserved standard 2.54 mm pitch of STMod+ pin header for breadboard

The main active component for this fanout board is the U1 3.3 V / 200 mA regulator.

Figure 23. STMod+ Fanout module plugged into the P1 connector



C.1 MikroElektronika mikroBUS™ compatible connector (Fanout CN10 and CN11)

The mikroBUS™ compatible connector is 2.54" pitch with a pair of 1x8-pin female connectors. *Table 21* below shows the definition of the pins.

Table 21. Description of the mikroBUS™ connector pins

STMod+ connector CN11 number	Function of mikroBUS	Pin number	Pin number	Function of mikroBUS	STMod+ connector CN10 number
STMod+#13-ADC(1)	AN	1	1	PWM	STMod+#14-PWM(1)
STMod+#12-RST	RST	2	2	INT	STMod+#11-INT
STMod+#1-NSS	CS	3	3	RX	STMod+#3-RX
STMod+#4-SCK	SCK	4	4	TX	STMod+#2-TX
STMod+#9-MISOs	MISO	5	5	SCL	STMod+#7-SCL(2)
STMod+#8-MOSIs	MOSI	6	6	SDA	STMod+#10-SDA(2)
-	+3.3 V	7	7	+5 V	-
-	GND	8	8	GND	-

1. Exclusive use: ARDUINO® or STMod+.
2. Shared with ARDUINO®.

The mikroBUS™ pinout assignment is available at the: http://mikroe.com website.

C.2 ESP-01 Wi-Fi® board compatible connector

The ESP-01 Wi-Fi® board connector is 2.54 pitch with 2x4-pin female connectors. *Table 22* shows the definition of the pins.

Table 22. Description of the ESP-01 Wi-Fi® board connector pins

STMod+ connector number	Function of ESP-01	Pin number	Pin number	Function of ESP-01	STMod+ connector number
-	GND	1	8	TXD	STMod+#3-RX
STMod+#14	GPIO2	2	7	CH_PD	STMod+#13
STMod+#11	GPIO0	3	6	RST	STMod+#12-RST
STMod+#2-TX	RXD	4	5	V_{CC}	-

C.3 Compatible connectors for the Grove boards

The two connectors of the Grove board are 2.54 pitch with 1x4-pin male connectors.

C.3.1 Compatible connector for I²C Grove boards (Fanout CN3)

The CN3 connector is compatible with Grove- Barometer sensor and Grove-LCD RGB Backlight boards using cable for connection. *Table 23* shows the definition of the pins.

Table 23. Description of the I²C Grove board connector pins (CN3)

STMod+ connector	Function of Grove CN3	PIN number
STMod+#7-SCL (*)	SCL	1
STMod+#10-SDA (*)	SDA	2
+5 V	VCC	3
-	GND	4

C.3.2 Compatible connector for UART Grove boards (Fanout CN2)

The CN2 connector is compatible with Grove-NFC boards using cable for connection. *Table 24* shows the definition of the pins

Table 24. Description of the UART Grove board connector pins (CN2)

STMod+ connector	Function of Grove CN2	Pin number
STMod+#3-RX	RX (Grove TX)	1
STMod+#2-TX	TX (Grove RX)	2
+5 V	VCC	3
-	GND	4

Appendix D Federal Communications Commission (FCC) and Industry Canada (IC) Compliance Statements

D.1 FCC Compliance Statement

D.1.1 Part 15.19

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

D.1.2 Part 15.105

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

D.1.3 Part 15.21

Any changes or modifications to this equipment not expressly approved by STMicroelectronics may cause harmful interference and void the user's authority to operate this equipment.

D.2 IC Compliance Statement

D.2.1 Compliance Statement

Industry Canada ICES-003 Compliance Label: CAN ICES-3 (A)/NMB-3(A).

D.3 Déclaration de conformité

Étiquette de conformité à la NMB-003 d'Industrie Canada : CAN ICES-3 (A)/NMB-3(A).

Appendix E CISPR32

E.1 Warning

Warning: This device is compliant with Class A of CISPR32. In a residential environment, this equipment may cause radio interference.

Revision history

Table 25. Document revision history

Date	Revision	Changes
10-Feb-2017	1	Initial release.
28-Apr-2017	2	Updated *Section Appendix B: Electrical schematics*.
16-Dec-2021	3	Reshuffle of the document to align with latest standards: – *Introduction* to *Conventions* reordering – New *Table 2: Codification explanation* and *Section 7: 32F723EDISCOVERY board information* Updated: – *Introduction* and *Features* Removed: – *Demonstration software* and *Electrical schematics.*