

STM32G071B-DISCO USB-C Discovery kit

Introduction

The STM32G071B-DISCO USB-C Discovery kit comes on top of the STM32Cube as a firmware package that offers a full set of software components based on a modular architecture allowing each module to be used separately in standalone sink applications.

The STM32G071B-DISCO USB-C Discovery kit may be executed in two different modes depending on the position of the switch: standalone sink mode, or spy mode. The spy mode does not use the USBPD stack. In this mode, the protocol information on the CC lines is decoded, and no protocol action may be triggered. But in the standalone sink mode, some protocol actions may be executed.

In both modes, the UCPD block port 1 is used, and may give an example for a customer application.

The STM32G071B-DISCO USB-C Discovery kit has been designed to run on STM32G071B-DISCO (MB1378).



Figure 1. STM32G071B-DISCO USB-C Discovery kit

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1 Demonstration description

The demonstration has been designed with the following objectives:

- Toolkit with low memory consumption
- Modular applications: independents with high level of reuse
- Basic menu navigation through joystick
- Comprehensive G0 functional coverage

1.1 Demonstration package

Figure 2 shows the demonstration folder organization:



The demonstration sources are located in the "Projects" folder of the STM32Cube package for each supported board, here in STM32G071B-DISCO folder.

The demonstration firmware aims at demonstrating how USB-PD version PD3.0 has been implemented in the context of STM32G0xx devices.

Figure 3 illustrates the organization of the UCPD folder.



rigure 3. Discovery folder organization		
VSBPD_Analyzer		
> 📙 EWARM		
Inc		
> MDK-ARM		
Src Src		
> SW4STM32		

Figure 3. Discovery folder organization

UCPD_Analyzer sub-folders:

- Inc: Analyzer application header files
- Src: Analyzer application implementation
- Software development environments:
 - EWARM: IAR embedded workbench
 - MDK ARM: Keil Microcontroller Development Kit
 - SW4STM32: System workbench for STM32

1.2 Demonstration architecture overview

The top level software architecture of the STM32G071B-DISCO USB-C Discovery kit firmware is represented on Figure 4. The software elements mentioned in this diagram are briefly depicted in dedicated sections.



Figure 4. STM32G071B-DISCO USB-C Discovery kit firmware - Software architecture



1.2.1 Analyzer

The UCPD Analyzer application uses only one G0 port which mainly consists in Type-C connection/disconnection detection and Type-C power contract negotiation.

1.2.2 HAL level

HAL level layer consists in the stm32g0xx.HAL drivers together with the STM32G071B-DISCO board support package (BSP).

1.2.3 Middleware

The middleware provides the following modules:

- FreeRTOS: FreeRTOS open source solution. UCPD application is based on FreeRTOS.
- USBPD: USB-PD software stack



1.3 STM32G071RB resources

1.3.1 Hardware resources used by the UCPD demonstration

Figure 5. STM32G071RBT hardware blocs used by the UCPD demonstration





1.3.2 Peripherals used by the UCPD demonstration



Figure 6. STM32G071RBT peripherals used by the UCPD demonstration

Table 1. STM32G071RBT peripherals used by the UCPD demonstration

Peripheral	Usage description	
SPI	LCD is controlled through SPI1. Write accesses to the LCD are performed to display strings and bitmaps during the UCPD demonstration execution.	
GPIO	The GPIO pins connected to the joystick are used to interact with the UCPD demonstration (e.g. menu navigation). One GPIO pin is used to detect the door position Several GPIOs are used to drive some indication LEDs	
I2C	 I2C1 is used to control 3 different INA230: Two INA230 to detect the voltage level on both CC lines One INA230 to monitor the voltage and the current on VBUS 	
UCPD	UCPD1 is used to manage the USB Type-C communication over the Type-C port.	
DMA	DMA is used for ADC conversions.	

1.3.3 Interrupts

Table 2 shows all the external interrupts used by the demonstration

Table 2. STM32G071RE	T demonstration	interrupts usage
----------------------	-----------------	------------------

Interrupt	Usage description	
Systick	Delay management	
EXTI line 0	Joystick SEL (interrupt mode, rising edge)	

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Interrupt	Usage description
EXTI line 2	Joystick UP (interrupt mode, rising edge)
EXTI line 3	Joystick DOWN (interrupt mode, rising edge)
EXTI line 7	Joystick RIGHT (interrupt mode, rising edge)
EXTI line 1	Joystick LEFT (interrupt mode, rising edge)
EXTI line 13	Tamper (interrupt mode, rising edge)
DMA1 Channel1	DAC/ADC conversions completion
ADC1_COMP	ADC analog watchdogs
UCPD	UCPD related interrupts (e.g. Rx message received, Rx ordered set detected, Transmit message sent,)

Table 2. STM32G071RBT demonstration interrupts usage (continued)



2 Demonstration functional description

2.1 Demo startup

2.1.1 Normal processing

If the STM32G071B-DISCO is powered from the micro USB, after a board reset, at demo startup the welcome screen is displayed.

2.2 UCPD demonstration

2.2.1 Mode selection

Depending on the position of the switch, the analyzer may run in two modes:



Figure 7. Mode selection

2.2.2 LED indications

The mode selection is confirmed by the LED LD6:



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Beforence Oolen Name					
Reference	Color	Name	Function		
LD1	Green	POWER 5V	5V present onto the board		
LD4	Orange	SINK mode	Attached to a power source		
LD5	Orange	SOURCE mode	Attached to a device as source		
LD6	Green	SPY mode	SPY mode active		
LD7	Green	сс	CC1 active line		

Table 3. LED assignation



3 Hardware settings

On this kit, no particular setting must be configured.

The G0 Discovery kit may be powered on with a micro USB cable, or it may power itself using the VBUS, when connected to a type C Source.

For detailed information on the hardware part, please check *STM32G0 Discovery kit for USB Type-C*[™] *and Power Delivery* user manual (UM2401)

3.1 STM32G071B-DISCO board

The STM32Cube demonstration supports STM32G071RB device and runs on STM32G071B-DISCO board from STMicroelectronics.





4 Software settings

4.1 Clock Control

STM32G071 internal clocks are derived from the HSI running at 16Mhz.

In this demo application, the various system clocks are configured as follows:

- System clock is set to 64 MHz: the PLL is used as the system clock source.
- HCLK frequency is set to 64 MHz.

4.2 **Programming the demonstration**

The user may program the demonstration using two methods:

4.2.1 Using Binary file

To program demonstration's binary image into the internal Flash memory, the user may exercise STM32G071B-DISCO_USBPD_Analyzer.hex file, thanks to ST-Link Utility or STM32CubeProgrammer.

Please refer to the Binary Resources Demo in the Board web page STM32G071B-DISCO (https://www.st.com/en/evaluation-tools/stm32g071b-disco.html).

4.2.2 Using preconfigured projects

Select the folder corresponding to the preferred toolchain (MDK-ARM, EWARM or SW4STM32).

- Open USBPD_Analyzer project and rebuild all sources.
- Load the project image through the debugger.
- Restart the evaluation board (press B1: reset button).



5 Software description



Following sections detail:

- Application: in charge to initialize demo application, HAL, interrupt handler and launch the main module
- Middleware: FreeRTOS, USBPD

5.1 Demonstration Application

The application goal is to prepare demonstration startup, by initializing all the HW/SW.

Table below provides a description of all the actions performed by the different functions in main.c

Functions (Main.c)	Description
Main	Initialize the HAL, configure the clock and the power MOS, depending on the door position, initialize the responder for the STM32CubeMonitor USB Type-C PD tool (GUI_Init), start the stack (USBPD_DPM_InitCore), the UCPD application (USBPD_DPM_UserInit), start the OS (USBPD_DPM_InitOS), and then start the demonstration
SystemClock_Config	Set the right clocks for flash and RCC

Table 4. Main application functions description



The file "stm32g0xx_it.c" is also part of the application and is used, as usual, to map the interrupt vector on the driver HAL driver, depending on the module requirement (for debug trace, and joystick management)

Main demonstration functionalities are in the file demo_disco.c.

Functions (demo_disco.c)	Description
DEMO_Manage_spy	This is the main spy function. It gets the VBUS voltage and current from the INA230, and gets the voltage level of both CC lines. If the message queue has some messages to process, Display_add_spymsg is called
DEMO_Manage_event	Main function for standalone mode.
Display_add_spymsg	Function goal is to fill the USB PD data structures with the information received from the CC lines. These structures are then used by the application, to feed the G0 disco information display.
DEMO_SPY_Handler	This function is called on any UCPD event thanks to an interrupt. It posts the USBPD protocol message seen from the CC lines to a queue. Later, the application reads this queue and decode the protocol messages. We don't decode the message under interrupt state, to be ready as soon as possible to see the next messages on the CC lines.
DEMO_InitBSP	Initialise the LCD, and the voltage monitoring of VBUS and CC lines.
Check_cc_attachement	Used in case of spy mode: to detect which CC line is used for power delivery protocol exchanges.
DEMO_PostMMIMessage	Function that posts the joystick press event in a FreeRTOS queue, thanks to HAL_GPIO_EXTI_Rising_Callback function.
*_menu_nav	Function that is used to manage the joystick up and down press to navigate into a specific menu (source power profiles, sink power profiles, extended capabilities, command)
*_menu_exec	Function that executes the selected specific action (select power profile, command)
Intialize_RX_processing	Configures the UCPD IP (DMA, Interrupts) to be ready to capture UCPD messages.

Table 5.	Main	applications	functions	description

5.2 Application overview

Depending on the door position (GPIO DOOR_SENSE_PIN: PC8), two different subapplications may be executed.

In the spy case, USBPD stack is not launched. INA230 is used to know which CC line is selected for communication, and then decode the messages on it.

In the standalone mode, the full USBPD stack is running.



5.2.1 Spy mode case

In spy mode, the door is open, and the Discovery kit may receive a second plug to spy the messages exchanges.

In spy mode, the Discovery kit must not interfere with the two type C devices to which it is connected.

This is why, as soon as open door is detected, T2, T3 and T5 MOSFETs are turned ON.

Table 6. Code example: MOSFET control in spy mode

BSP_MOSFET_On(MOSFET_ENCC1);	
BSP_MOSFET_On(MOSFET_ENCC2);	

Door is open, RD56 (5K1 Ohms) is ignored (needed only for standalone mode to be seen as a sink), and CC1 and CC2 pins are connected from the G0 UCPD IP.



Figure 12. CC lines isolation/pull down

if no micro USB is plugged, as soon as the source device detects the sink device, VBUS is driven, and the G0 Discovery kit is powered on.

Here are the menus sequence. Details on the menus in following Section 5.2.3





Figure 13. Menu sequence in spy mode

5.2.2 Standalone sink case

In standalone mode, the board is in captive cable configuration. Only CC1 line is used for power delivery protocol exchanges.

In this mode, application may boot from the VBUS provided by the source. So dead battery indication may be provided and Rd resistors on the CC1 line must be shown.

This is why when the door is closed, the T5 MOSFET is enabled and RD CC1 signal is driven so that the resistor R56 is set between CC1_P and GND. See details in Figure 12.

In the standalone spy case, some specific actions may be requested using the joystick (select the power profile...), thus menus sequence is a little bit different from the one in spy mode configuration.

Details on the menus in following Section 5.2.3





5.2.3 Demonstration menu details

Figure 15. Welcome screen

STM32G0 Disco Kit SINK	
------------------------------	--

When the G0 disco is powered on (if micro USB is plugged or VBUS driven on the type C cable) this screen is visible.

Figure	16.	Attach	screen
--------	-----	--------	--------

Attached to a Dual Role Power Source	
--	--

Whenever a VBUS is present on the type C cable, this information is displayed. Then, depending on the source capabilities seen, dual role information may be displayed.

Figure 17. PD capability screen

USB Type-C
PD3 capable

If USBPD protocol exchanges are seen over the CC lines, the power delivery specification version is displayed. This information may appear in spy mode, even if one device doesn't support power delivery

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Figure 18. Power screen

1 pov	er
profi	e
max 15	0 W

When the source capabilities are seen over the CC lines, the maximum power profile is displayed.

Figure 19. Power role screen

Dual Role Power (DRP): YES
YES

This screen will indicate if the power role swap is supported by the connected source device.

Unchunked	
Mode (UNCKD):	
YES	

Figure 20. Unchunked mode support screen

This screen will indicate if the connected source device supports unchunked messages.

- - -

Figure 21. Data role screen
Dual Role Data (DRD): NO

This screen will indicate if the connected source device supports data role swap.

Figure 22. Display Port screen (only standalone mode)

Display Port Support: YES	
---------------------------------	--

If the source is capable of using the super speed lines to send display port video signal, the information is displayed. This screen also displays if Thunderbolt capability is available. This information is gathered only in standalone sink mode, because the G0 issues a Discovery identity message. In some case, the source may not respond to this message, and therefore no information may be retrieved.

Figure 23. Power delivery information screen

	5.125 V	
	0,001 A	
	0,005 W	



This screen displays the current VBUS power: voltage and current, and calculated power.



This screen displays all source power profiles. The user scrolls the list via the joystick. In case of standalone sink mode, he may request a dedicated power profile using the joystick (center click on the desired profile)



D	Distant Sink capa:
F	FIXED: 5V 3.0A
	V: 4.7-21.0V 3.0A B: 4.7-21V 60.0W

This screen displays the sink profiles. This information is retrieved only in standalone sink mode, because a dedicated command (get sink capabilities) is sent by the G0 disco application. No actions or selection may be triggered here on a distant sink profile.

Figure 26. Action screen (only standalone mode)

	Select a command:			
	HARD RESET			
	GET SRC CAPA			
	GET SNK CAPA			
	DATA ROLE SWAP			

On this screen, the user may execute the displayed commands using the joystick. (center to select). He may scroll up or down to access all possible actions.

Figure 27. Version screen

Connect STM32Cube- MonitorUCPD	
W50.2 C GUI TRACE	

This screen displays the current G0 Discovery demonstration version.

We remind the user that the STM32CubeMonitor USB Type-C PD tool application may be run on a PC to get more details about the USBPD protocol messages that are exchanged. See chapter 5.2.4.

5.2.4 STM32CubeMonitor USB Type-C PD tool with G0 Discovery kit

We recommend to always plug the micro USB cable so that the disco is powered on, and have the possibility to see the details on the USBPD protocol exchanges.

In case of spy mode, as no action may be requested using the G0 disco, only the trace is available.





Figure 28. STM32CubeMonitor USB Type-C PD tool debug trace selection







The user gets such a screen:

STM32Cube	eMonitor_USBCPD	0.19.1	- 🗆 >	<			
STN	M32CubeMc	onitor US	SB Type-C PD Configurator English 🗸 🔽 🕞 🏹 🔆 🧲	-			
				'			
COM17							
T	T'01	Dent	Harris				
Туре	nmest	POR	Message				
OUT	12258	1	GOODCRC SOP H:0x0A01				
NOTIF	12259	1	GETSNKCAP_ACCEPTED				
PE	12259	1	PE_STATE_READY				
NOTIF	12261	1	STATE_SNK_READY				
PE	12261	1	PE_STATE_READY_WAIT				
PE	12264	1	PE_SVDM_REQ_GET_SVID				
OUT	12264	1	SVDM_DISCOVER_SVIDS DATA:02A000FF VDM : INIT SOP PD3 H:0x188F VENDOR_DEFINED				
OUT	12265	1	SVDM_DISCOVER_SVIDS DATA:02A000FF VDM : INIT SOP PD3 H:0x188F VENDOR_DEFINED				
IN	12267	1	GOODCRC SOP H:0x0921				
PE	12267	1	PE_SVDM_WAIT_GET_SVID				
GUI	0		Trace Not Decoded : 32001301EE2F00000000000AAF2D42A000FF000001FF				
OUT	12270	1	GOODCRC SOP H:0x0C01				
NOTIF	12271	1	VDM_SVID_RECEIVED				
PE	12271	1	PE_STATE_READY				
NOTIF	12273	1	STATE_SNK_READY	1			
PE	12273	1	PE_STATE_READY_WAIT				
CAD	16129	1	USBPD_CAD_STATE_SWITCH_TO_SRC				
EVENT	16129	1	EVENT_DETACHED				
NOTIF	16129	1	POWER_STATE_CHANGE				
PE	16129	1	PE_SNK_STARTUP				
CAD	16129	1	USBPD_CAD_STATE_DETACHED				
		_	× ピー 通 DISCONNECT TRACES COPY TRACES CLEAR TRACES				

Figure 30 Trace example

When the G0 disco application is used in standalone sink mode, the full STM32CubeMonitor USB Type-C PD tool application (GUI) may be used to issue some commands like a data role swap for example.



STM32CubeMonitor-UCPD 1.0.0					-
FIN32CubeMonitor USB Type-C PD config	uring and monitoring tool				English 🔹 📑 💶 🈏 🛠 🖅
Board Selection	ection O Port Communication O Port Configuration				
General Measurement		Туре	TimeSt	Port	Message
		NOTIF	105014	1	CTRL_MSG_SENT
Distant Capabilities	Message Selector	PC IN	105014	1	PE_STATE_EXTENDED_WATRESPONSE SOP PD3_H:0vF741_EXT_SOURCE_C4PARHITIES_DATA:41F71880FF17FF17000000000101040
 Distant Port 	Filtering messages	ОЛТ	105016	1	GOODCRC SOP H.0x0601
> Generic Settings	P (P P C)	NOTIF	105017	1	SRC_CAP_EXT_RECEIVED
> SVDM	· Request Power Profile	PE	105017	1	PE_STATE_READY
000 000	Request the PE to send a request message.	NOTIF	105019	1	STATE_SNK_READY
· SRC PDU	DODesition 2	PE	105019	1	PE_STATE_READY_WAIT
> SRC 1 (5V - 3A)		PE	137307	1	PE_SNK_SEND_REQUEST
> SRC 2 (9V - 3A) selected PDO	> RequestedVoltage (mV) 9000	001			
SPC 2 (12V - 2.25A)	Sand Alart				GiveBack.0
- SRC 3 (12V - 2.23A)	> Send Alert				
> SRC 4 (15V - 1.8A)	> Get Country Into				NoUSBSuspend:1
> SRC 5 (20V - 1.35A)	Request VDM Discovery				UnchunkedExtendedMessagesSupported:1 SOP PD3 H:0x1482
> SRC 6 ([3V - 11V] - 3A)	Request VDM SVID Discovery	IN	137309	1	GOODCRC
	Request VDM Mode Discovery				SOP H.0x0521
Measurement 🗸	> Enter VDM Mode	PE	137309	1	PE_SNK_SELECT_CAPABILITY
	> Exit VDM Mode	IN	137311	1	ACCEPT SOP PD3 H 0x09A3
Vbus Ibus	VDM Attention	OUT		1	GOODCRC
20,000	 United and APAK 				SOP H.0x0801
2 15,000 4,000 g	> Onstructured vDM	NOTIF	137312	1	POWER_STATE_CHANGE
8 10,000 A 2,000 A 2,000 A 2,000 A	Display Port Status	PF	137312	1	PE SNK TRANSITION SNK
\$ 6,000 £.000 £ 1,000 \$	> Display Port Config	IN	137518	1	PS RDY
0 120 000 130 000 140 000 0	> Hard Reset				SOP PD3 H:0x0BA6
Time (ms)		OUT	137518		GOODCRC CONTRACT
Period 🚯 80 🔲 Stop	Send message to connected Port	NOTIE	137519	1	POWER STATE CHANGE
		NOTIF	137519	1	POWER_EXPLICIT_CONTRACT
Port Contract Power Role Spec Revision	CC Data Role VconnON VBus (mV) Ibus (mA) Selected SRC PDO	PE	137519	1	PE_STATE_READY
Port 1 EXPLICIT CONTRACT SNK PD3	CC2 UFP NO 9014 22 Distant SRC PD02 (9V - 3A)	NOTIF	137519	1	STATE_SNK_READY
Port 2 NO		PE	137519	1	PE_STATE_READY_WAIT
٤	>				i≡ <i>(2</i> n m)
PREVIOUS	NEXT				HIDE TRACES COPY TRACES CLEAR TRACES
Connected To MB1352C-COM13 Board - USB-C Port 1					

Figure 31. Full STM32CubeMonitor USB Type-C PD tool example

For more details see STM32CubeMonitor-UCPD software tool for USB Type-C[™] Power Delivery port management user manual (UM2468).

5.2.5 Dynamic memory use

The demonstration is currently using:

- CSTACK = 0x300
- HEAP = 0x800

5.3 Middlewares

5.3.1 USB PD

In this application the USBPD stack used is delivered as a library.

All information regarding this library may be found in the *STM32Cube USBPD stack* user manual (UM2552).

5.3.2 FreeRTOS

FreeRTOS: FreeRTOS open source solution.

More details may be found at: https://freertos.org



6 Footprint

This chapter sums up Ram / Rom consumption per software blocks. Here is a full demonstration of the software consumption:

Full demonstration software	Read only code memory [Byte]	Read only data [Byte]	Read/write data memory [Byte]
STM32CubeMonitor USB Type-C PD tool responder (GUI)	7682	-	540
Demo Application	13596	2345	842
Policy Engine (PE)	20320	16	20
Stack Protocol layer (PRL)	3000	2	12
Cable detection (CAD)	1484	-	24
Drivers	2254	8802	324
HAL	4706	55	40
Physical	1360	-	72
Debug- Trace	280	-	-
FreeRTOS	5000	1	15628
Standard Libraries	5396	78	5029
G0 Device	1948	22	65
Grand Total	67026	11321	22596

Table 7	RAM/ROM	consumption
		consumption



7 Acronyms

Table	8.	Table	of	acron	vms
10010	•••	Iabio	•••	401011	,

Acronym	-
CC	Configuration channel
USB PD	USB Power Delivery
GUI	Graphical User Interface: UCPD PC monitor application
PD	Power Delivery
DRP	Dual Role Power
FRS	Fast Role Swap
DRD	Dual Role Data
VDM	Vendor Defined Message



8 Table of references

References

USB-IF. (2017). Universal Serial Bus Power Delivery Specification rev 3.0. USB-IF.



Revision history

Table 9	Document	revision	history
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Date	Revision	Changes
20-Feb-2019	1	Initial version
9-Apr-2019	2	Updated: <i>Figure 13</i> , <i>Figure 14</i> and <i>Figure 20</i> Unchunked Mode (UNCKD) replaces Fast Role Swap (FRS)



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