STDES-WL5xxxxx

Reference designs for STM32WL5x and STM32WLEx microcontrollers

Data brief

Features

Includes ST state-of-the-art patented technology

Reference designs

- Fully open hardware platforms
- Suitable for rapid prototyping of end nodes based on LoRaWAN®, Sigfox™, WM-Bus, and many other proprietary protocols

STM32WL5x or STM32WLEx microcontroller

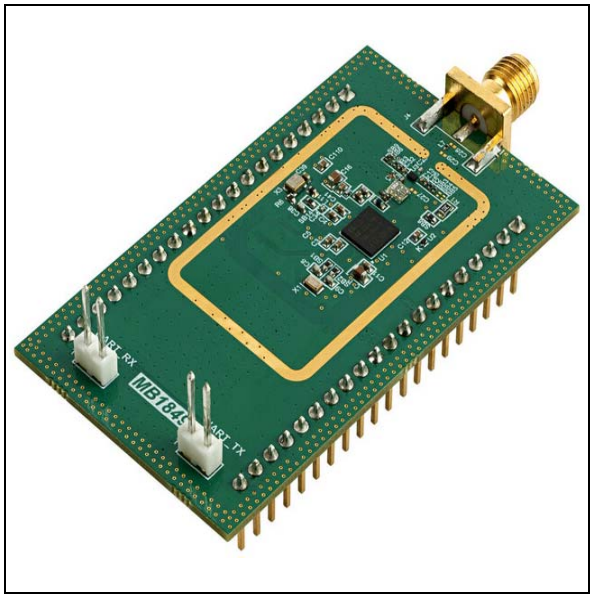
- Multi-protocol LPWAN dual-core 32-bit Arm® Cortex®-M4/M0+ at 48 MHz
- Ultra-low power
- RF transceiver (150 MHz to 960 MHz frequency range) supporting LoRa®, (G)FSK, (G)MSK, and BPSK modulations
- Up to 256-Kbyte flash memory and 64-Kbyte SRAM

Oscillators

- 32.768 kHz LSE crystal
- 32 MHz HSE (on-board TCXO or crystal XO)

Connectors

- 2x HE10-20
- SMA antenna
- 2-point UART



Designs with different references show different layouts.
Picture is not contractual.

Power

- 1.8 V to 3.6 V through external sources

Debug/programming

- Through JTAG/serial-wire debug port to connect an external ST-LINK

Software

- Comprehensive free software libraries and examples available with the STM32CubeWL MCU Package usable with adapted BSP

Table 1. Device summary

Reference	Part numbers
STDES-WL5xxxxx	STDES-WL5I4IHH, STDES-WL5I4IHL, STDES-WL5I4ILH, STDES-WL5I4SBB, STDES-WL5U2IHH, STDES-WL5U2IHL, STDES-WL5U2ILH, STDES-WL5U2SBB, STDES-WL5U4DHB, STDES-WL5U4DLB, STDES-WL5U4IHH, STDES-WL5U4IHL, STDES-WL5U4ILH, STDES-WL5U4SBB, STDES-WL5U4SHW

Contents

List of tables

1 Description

The main objective of the STM32WL5x and STM32WLEx reference designs is to recommend a layout and associated BOM for dedicated applications (these boards are not for sale).

Performance has been assessed and FCC and CE certification checks have been done by an independent company.

These reference designs can be manufactured from files that can be downloaded from the *www.st.com* website. A complete application can be prototyped thanks to the access to all GPIOs.

Sensitive layout parts can be extracted and pasted in any user board design with the same PCB characteristics and feature set.

The STM32WL5x and STM32WLEx reference designs are provided with the STM32WL comprehensive software HAL library. The STM32CubeWL MCU Package contains many software examples developed with the STM32WL Nucleo-64 board (NUCLEO-WL55JC). These examples can be easily adapted for STM32WL5x and STM32WLEx reference designs. A dedicated delivery is provided for radio AT_Slave firmware that is fully compatible with the selected STM32WL5x or STM32WLEx reference board.

The firmware source code corresponding to the selected reference design is available on *www.st.com*. This associated firmware is distributed under license BSD-3-Clause (https://opensource.org/licenses/BSD-3-Clause).

Using the reference designs to design the user application helps to get the right RF performance and to pass certification.

2 General information

These reference designs are based on Arm®(a) Cortex®-M STM32WL5x and STM32WLEx microcontrollers.

arm

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

3 Main features

- STM32WL5x and STM32WLEx MCUs
  - Frequency range: 150 MHz to 960 MHz
  - Modulation: LoRa®, (G)FSK, (G)MSK and BPSK
  - RX sensitivity: -123 dBm for 2-FSK (at 1.2 Kbit/s), 148 dBm for LoRa® (at 10.4 kHz, spreading factor 12)
  - Transmitter high output power, programmable up to +22 dBm
  - Transmitter low output power, programmable up to +15 dBm
- 2 and 4-layer PCBs supported
- Various STM32WL packages supported
- Various frequency ranges supported

4 STM32WL5x and STM32WLEx reference designs and codification

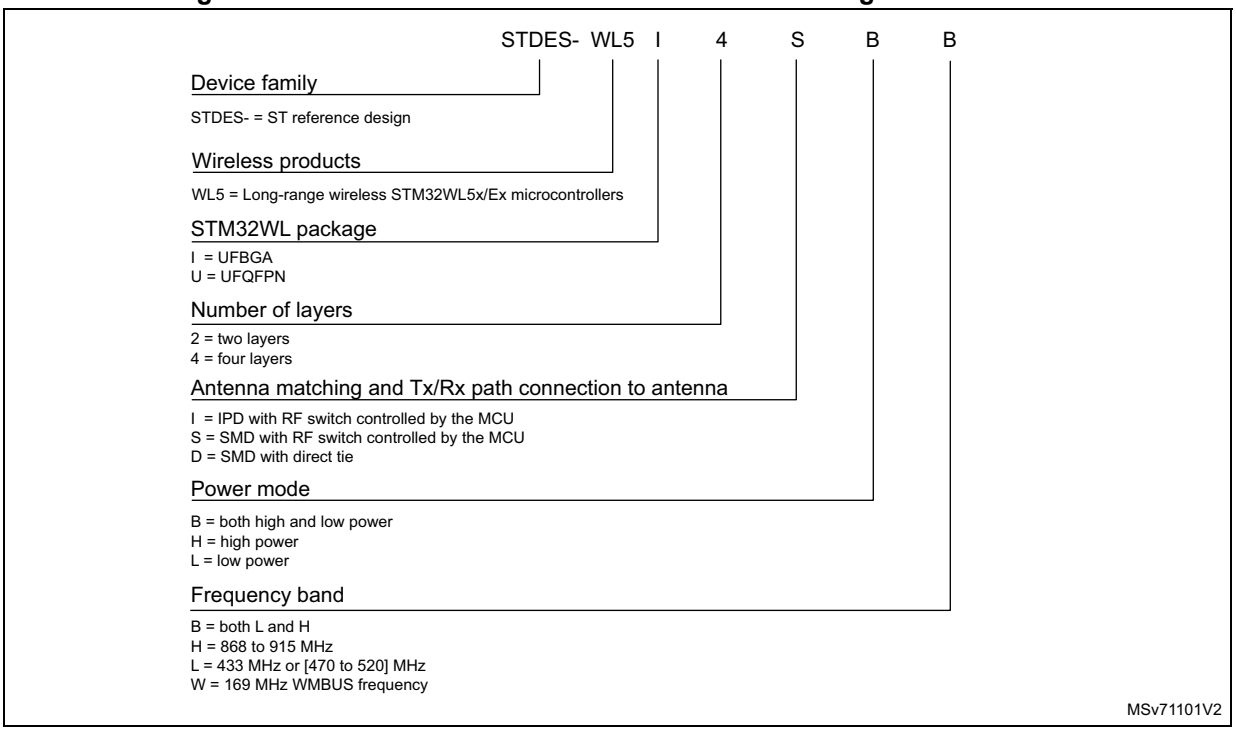
Table 2. STM32WL5x and STM32WLEx reference designs

Web reference	Board reference	MCU package	Number of layers	SMD or IPD	Optimized BOM target	RF switch
STDES-WL5I4SBB	MB1842	UFBGA	4	SMD	[864:928 MHz]/15 dBm	Yes
STDES-WL5I4SBB	MB1842	UFBGA	4	SMD	[864:928 MHz]/22 dBm	Yes
STDES-WL5I4SBB	MB1842	UFBGA	4	SMD	[470:530 MHz]/17 dBm	Yes
STDES-WL5U4SBB	MB1720	UFQFPN	4	SMD	[864:928 MHz]/15 dBm	Yes
STDES-WL5U4SBB	MB1720	UFQFPN	4	SMD	[864:928 MHz]/22 dBm	Yes
STDES-WL5U4SBB	MB1720	UFQFPN	4	SMD	[433 MHz]/15 dBm	Yes
STDES-WL5U4SBB	MB1720	UFQFPN	4	SMD	[470:530 MHz]/17 dBm	Yes
STDES-WL5U4SHW	MB1792	UFQFPN	4	SMD	[168-172 MHz]/22 dBm	Yes
STDES-WL5U2SBB	MB1791	UFQFPN	2	SMD	[864:928 MHz]/15 dBm	Yes
STDES-WL5U2SBB	MB1791	UFQFPN	2	SMD	[864:928 MHz]/22 dBm	Yes
STDES-WL5U2SBB	MB1791	UFQFPN	2	SMD	[470:530 MHz]/17 dBm	Yes
STDES-WL5U4DLB	MB1789-LP	UFQFPN	4	SMD	[864:928 MHz]/15 dBm	No
STDES-WL5U4DLB	MB1789-LP	UFQFPN	4	SMD	[433 MHz]/15 dBm	No
STDES-WL5U4DHB	MB1789-HP	UFQFPN	4	SMD	[864:928 MHz]/22 dBm	No
STDES-WL5U4DHB	MB1789-HP	UFQFPN	4	SMD	[470:530 MHz]/17 dBm	No
STDES-WL5I4ILH	MB1849-LP	UFBGA	4	IPD BALFHB-WL-04D3	[864:928 MHz]/15 dBm	Yes

Table 2. STM32WL5x and STM32WLEx reference designs (continued)

Web reference	Board reference	MCU package	Number of layers	SMD or IPD	Optimized BOM target	RF switch
STDES-WL5I4IHH	MB1849-HP	UFBGA	4	IPD BALFHB-WL-01D3	[915 MHz]/22 dBm	Yes
STDES-WL5I4IHL	MB1849-HP	UFBGA	4	IPD BALFLB-WL-07D3	[490 MHz]/17 dBm	Yes
STDES-WL5U4ILH	MB1848-LP	UFQFPN	4	IPD BALFHB-WL-05D3	[864:928 MHz]/15 dBm	Yes
STDES-WL5U4IHH	MB1848-HP	UFQFPN	4	IPD BALFHB-WL-02D3	[915 MHz]/22 dBm	Yes
STDES-WL5U4IHL	MB1848-HP	UFQFPN	4	IPD BALFLB-WL-08D3	[490 MHz]/17 dBm	Yes
STDES-WL5U2ILH	MB1874-LP	UFQFPN	2	IPD BALFHB-WL-06D3	[864:928 MHz]/15 dBm	Yes
STDES-WL5U2IHH	MB1874-HP	UFQFPN	2	IPD BALFHB-WL-03D3	[915 MHz]/22 dBm	Yes
STDES-WL5U2IHL	MB1874-HP	UFQFPN	2	IPD BALFLB-WL-09D3	[490 MHz]/17 dBm	Yes

Figure 1. STM32WL5x and STM32WLEx reference designs codification



5 Software

STM32CubeWL examples can be used with BSP library adaptation. The software source code corresponding to the selected reference design is available on *www.st.com*.
This associated software is distributed under license BSD-3-Clause (https://opensource.org/licenses/BSD-3-Clause).

BSP adaptation

The BSP adaptation versus the STM32WL Nucleo board NUCLEO-WL55JC concerns the RF switch control as the available GPIOs depend on the board.

Table 3. RF switch per reference board(1)

Reference board	SW_CTRL2	SW_CTRL3
MB1720	PC13	PA11
MB1791, MB1848-LP/HP, MB1874-LP/HP	PA9	PA0
MB1792	PC13	PA9
MB1842, MB1849-LP/HP	PC4	PC3

1. No RF switch on the MB1789 board.

Other optional configurations associated with hardware board solder bridges exist. Make sure to use the firmware configuration associated with the hardware board configuration (see *Section 6.4*).

6 Hardware layout and configuration

6.1 Schematics and BOM (bill of material)

A zip file including the following items is available for download:

- board schematic
- board Gerber file
- BOMs for selected frequencies and output power

6.2 HSE 32 MHz XO or TCXO selection

The reference boards for UFQFPN packages are designed to be populated either for a XTAL or for a TCXO. The reference boards for UFBGA packages are designed only for the TCXO solution (X_{OUT} not connected).

The XO can anyway be implemented with the UFBGA, and the final frequency drift can be improved by means of a serial capacitor.

Possible implementations are shown in the table below.

Table 4. HSE XO/TCXO reference board implementation(1)

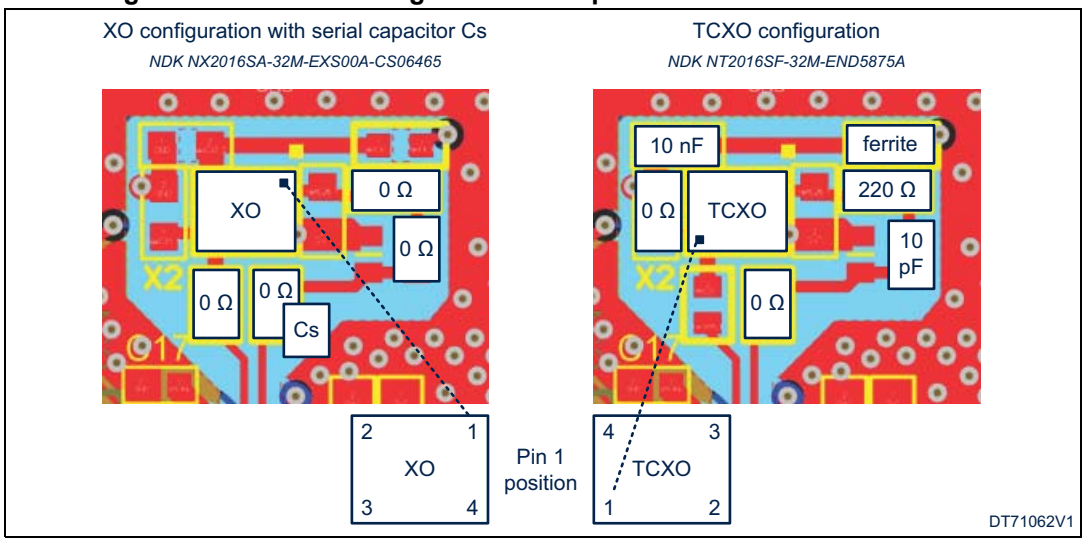
Reference board	XO + serial	TCXO
MB1720	X	-
MB1791	X	X
MB1792	X	X
MB1842	-	X
MB1789	X	X
MB1848-LP/HP	X	X
MB1849-LP/HP	-	X
MB1874-LP/HP	X	X

1. X: implementation possible.

Note: The XO solution, with a serial capacitor on Xin pin, can also be implemented on a board with the UFBGA package.

The figure below shows the two possible implementations on the reference board MB1848.

Figure 2. XO/TCXO configuration example on reference board MB1848



Note: The solution presented in Figure 2 is patented. It must not be implemented in association with another product from another company without STMicroelectronics agreement.

6.3 IPD (integrated passive device)

STMicroelectronics develops integrated passive device (IPD) companion chips for optimized matching, filtering, and balun. The IPD is an all-in-one very compact solution covering each package and each of the main use cases (22 dBm at 915 MHz, 14 dBm at 868 MHz, 17 dBm at 490 MHz).

IPD-based reference boards give a better overall performance than equivalent SMD solutions and facilitate the board design.

6.4 Solder bridges

The reference designs can be configured versus the application needs.

Note: VDDPA must be connected to VDDRF only in the high output power configuration. If the associated solder bridge is wrongly configured, it can be destructive for the STM32WL device.

Table 5. Solder bridge configurations

Solder bridge	Board reference								Solder bridge	Description
	MB1720	MB1842	MB1791	MB1792	MB1789	MB1848	MB1874	MB1849		
LSE control	SB1/SB2	SB1/SB2	-	-	-	-	-	SB1/SB2	ON	LSE provided by external LSE 32.768 kHz CLK X2(1)
									OFF	LSE not provided by external LSE 32.768 kHz CLK X2
VDD RF switch	SB3	SB3	SB3	SB3	-	SB3	SB3	SB3	ON	VDD RF switch supplied by VDD (general VDD)
									OFF	VDD RF switch NOT supplied by VDD (general VDD)(1)
	SB4	SB4	SB4	SB4	-	SB4	SB4	SB4	ON	VDD RF switch supplied by MCU (STM32WL I/O)(1)
									OFF	VDD RF switch NOT supplied by MCU (STM32WL I/O)
	SB5	SB5	SB5	SB5	-	-	-	-	ON	VDD RF switch supplied by external signal
									OFF	VDD RF switch NOT supplied by external signal(1)
CTRL RF switch	SB6	SB6	SB6	SB6	-	SB6	SB6	SB6	ON	CTRL RF switch controlled by MCU (STM32WL I/O)(1)
									OFF	CTRL RF switch NOT controlled by MCU (STM32WL I/O)
	SB9	SB9	SB9	SB9	-	SB9	SB9	SB9	ON	CTRL RF switch controlled by external signal(1)
									OFF	CTRL RF switch NOT controlled by external signal

Table 5. Solder bridge configurations (continued)

Solder bridge	Board reference								Solder bridge	Description
	MB1720	MB1842	MB1791	MB1792	MB1789	MB1848	MB1874	MB1849		
V_{DDPA} supply	SB7	-	SB7	SB7	-	-	-	-	ON	VDDPA supplied by VDDRF (high output power configuration)
									OFF	VDDPA not supplied by VDDRF (high output power configuration)(1)
	SB8	-	SB8	SB8	-	-	-	-	ON	VDDPA supplied by VDDRF1V55 (low output power configuration)(1)
									OFF	VDDPA not supplied by VDDRF1V55
	-	SB7	-	-	-	-	-	-	ON (2-1)	VDDPA supplied by VDDRF1V55 (low output power configuration)(1)
									ON (2-3)	VDDPA supplied by VDDRF (high output power configuration)
RF output	SB10	SB10	-	SB10	-	-	-	-	ON(2-1)	RF: high output power
									ON (2-3)	RF: low output power(1)
	-	-	SB1	-	-	-	-	-	ON (2-1)	RF: high output power
									ON (2-3)	RF: low output power(1)
BOOT0	SB11	SB8	SB11	SB11	SB11	SB11	SB11	SB8	ON	BOOT0 connected to pull-down resistor(1)
									OFF	BOOT0 not connected to pull-down resistor

Table 5. Solder bridge configurations (continued)

Solder bridge	Board reference								Solder bridge	Description
	MB1720	MB1842	MB1791	MB1792	MB1789	MB1848	MB1874	MB1849		
HSE XO/ TCXO(2)	SB12	-	-	-	-	-	-	-	ON	HSE external input connected
									OFF	HSE external input not connected(1)
	SB13	-	-	SB13	-	-	-	-	ON	HSE XO input connected(1)
									OFF	HSE XO/TCXO input not connected
	SB14	-	-	SB14	-	-	-	-	ON	HSE XO output connected(1)
									OFF	HSE output not connected
	-	-	SB13	-	SB13	SB13	SB13	SB13	ON	HSE XO/TCXO input connected(1)
									OFF	HSE XO/TCXO input not connected
HSE XO/ TCXO	-	-	SB15	-	SB15	SB15	SB15	SB15	ON	HSE XO output connected (XO mode)(1)
									OFF	HSE output not connected (TCXO mode)
	-	-	SB14	-	SB14	SB14	SB14	SB14	ON	HSE TCXO supplied (TCXO mode)(1)
									OFF	HSE TCXO not supplied (XO mode, except MB1842)
	-	SB14	-	-	-	-	-	-	ON	HSE TCXO input connected(1)
									OFF	Not supported

1. Default low output power configuration.
2. Other modifications must be done in the BOM. See schematic notes.

7 Firmware programming

To download firmware, it is enough to connect a serial-wire debug port from an external probe. For example, the STLINK-V3SET can be used to easily perform the connection.

SWDIO is linked to PA13 and SWCLK to PA14.

The figures below show the JTAG and power-supply connections on the reference boards (top view).

Figure 3. MB1842 - JTAG and power supply connections

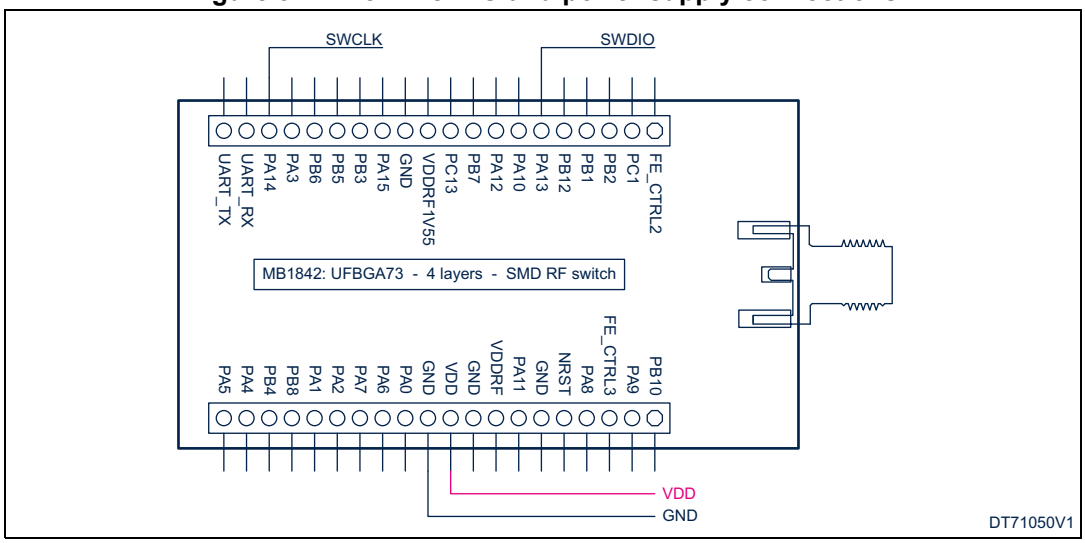


Figure 4. MB1720 - JTAG and power supply connections

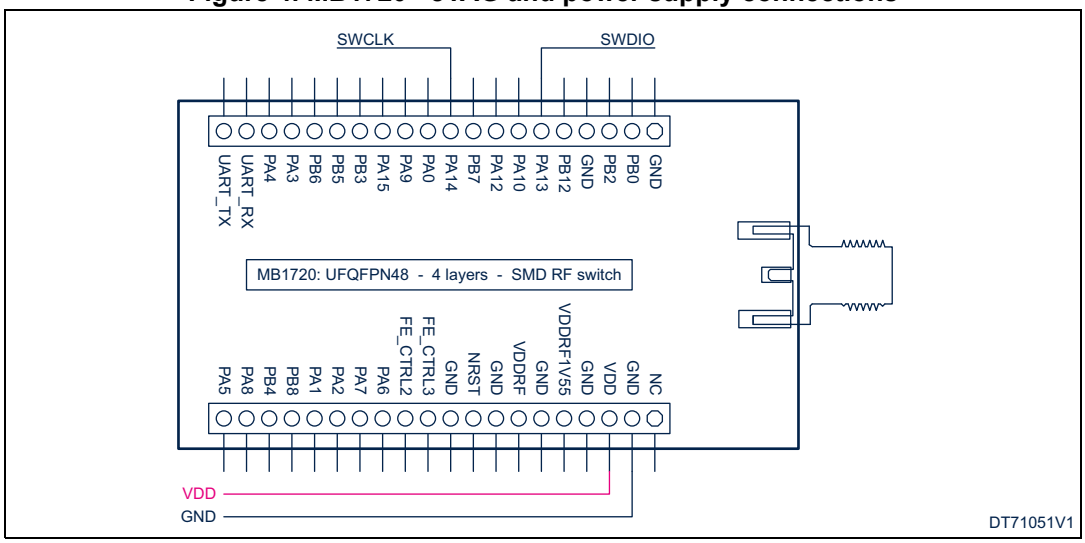


Figure 5. MB1789 - JTAG and power supply connections

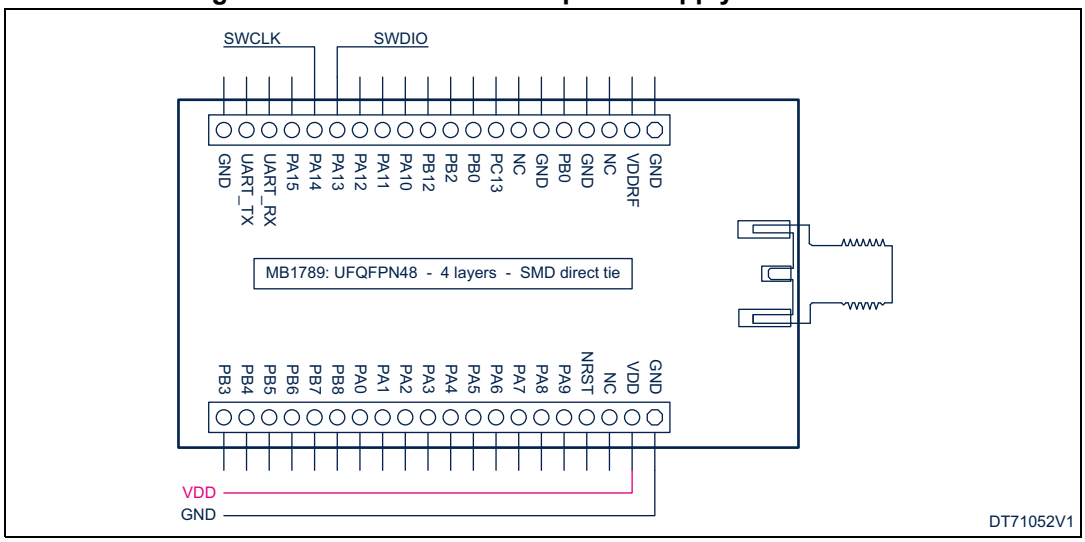


Figure 6. MB1791/MB1792 - JTAG and power supply connections

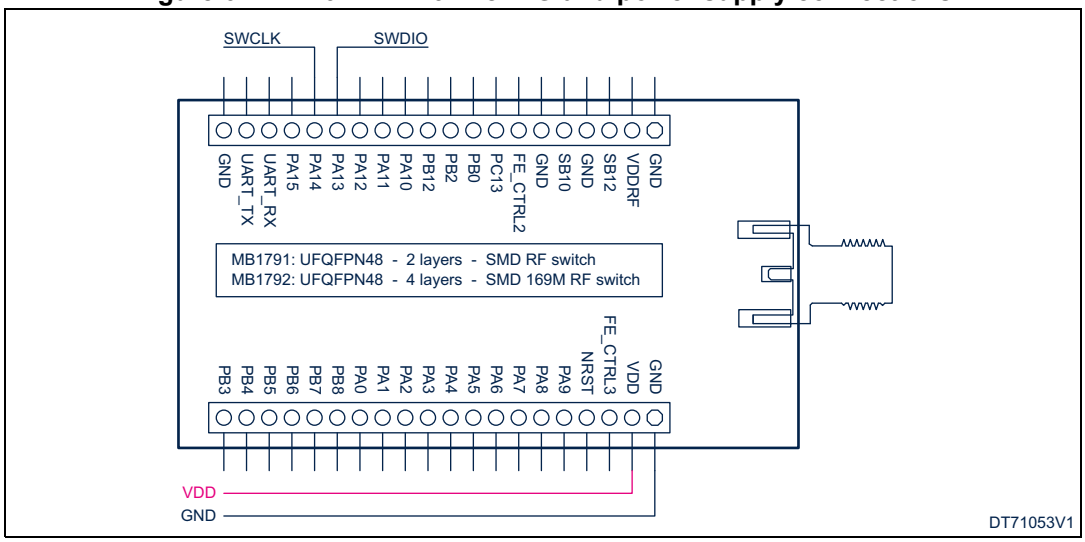


Figure 7. MB1848/MB1874-LP/HP - JTAG and power supply connections

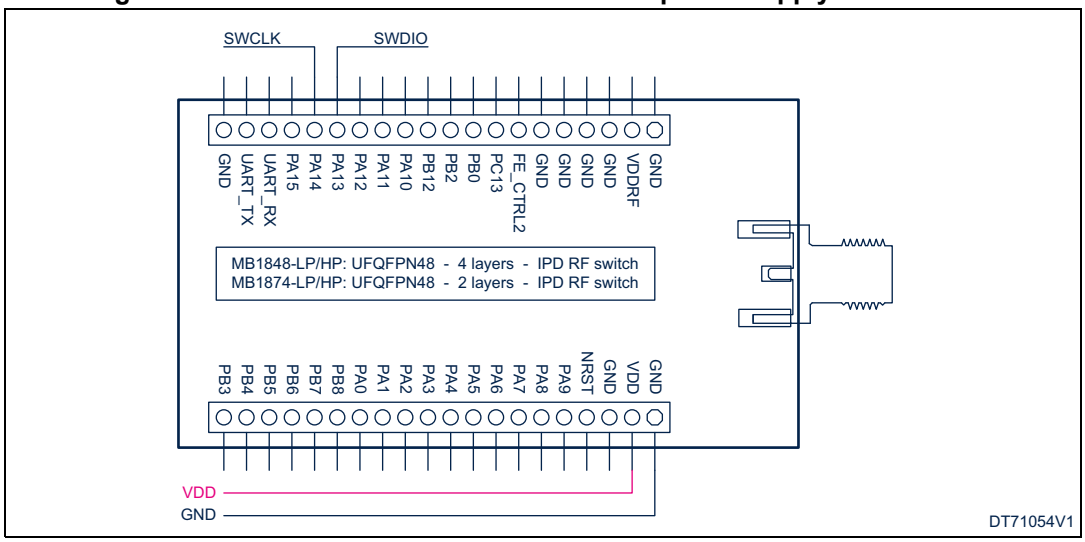
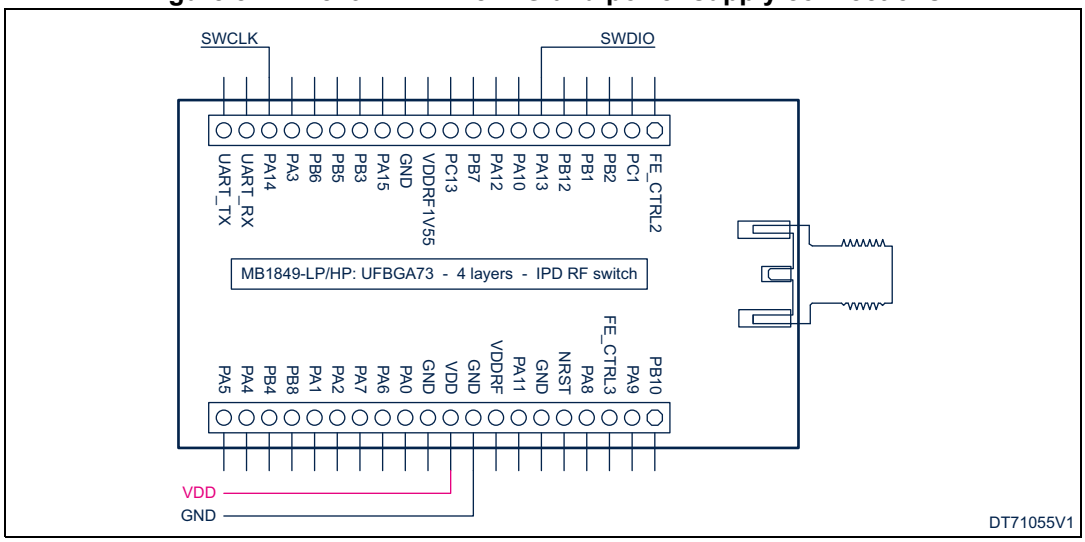


Figure 8. MB1849-LP/HP - JTAG and power supply connections



8 AT_Slave and UART pins

To test the RF performance using the AT_Slave firmware, a UART must be connected. AT_Slave uses LPUART1.

The following pins must be used:

- PA3 is connected to LPUART1_RX.
- PA2 is connected to LPUART1_TX.

For more informations about the AT commands, refer to the application note *LoRaWAN® AT commands for STM32CubeWL* (AN5481).

The figures below show the UART and power supply connections on the reference boards (top view).

Figure 9. MB1842 - UART and power supply connections

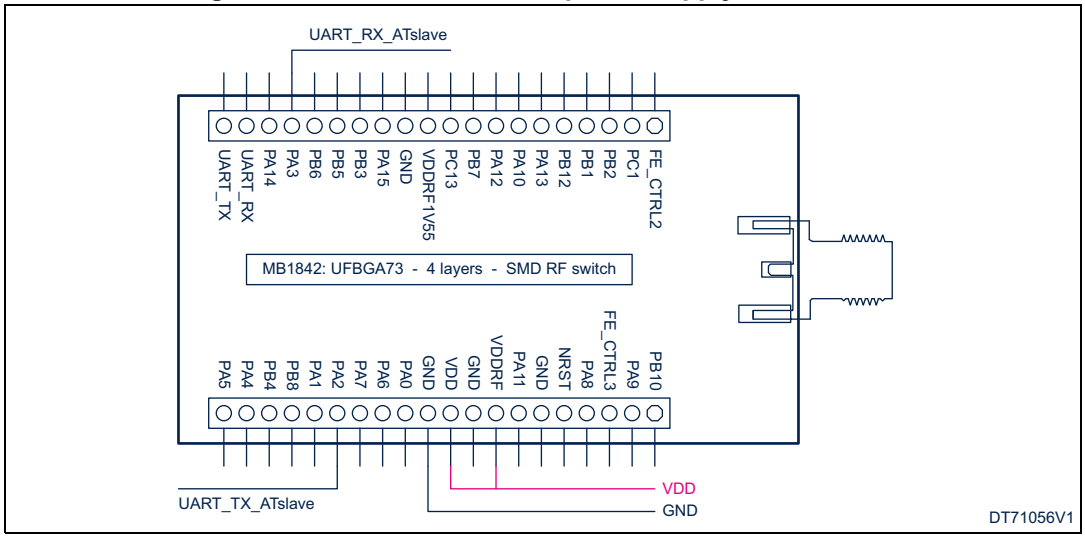


Figure 10. MB1720 - UART and power supply connections

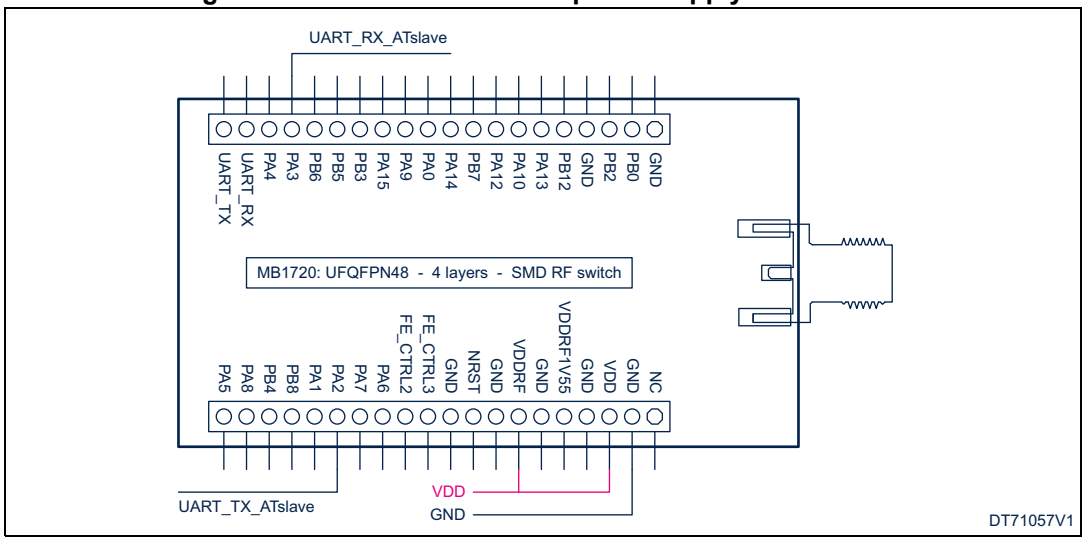


Figure 11. MB1789 - UART and power supply connections

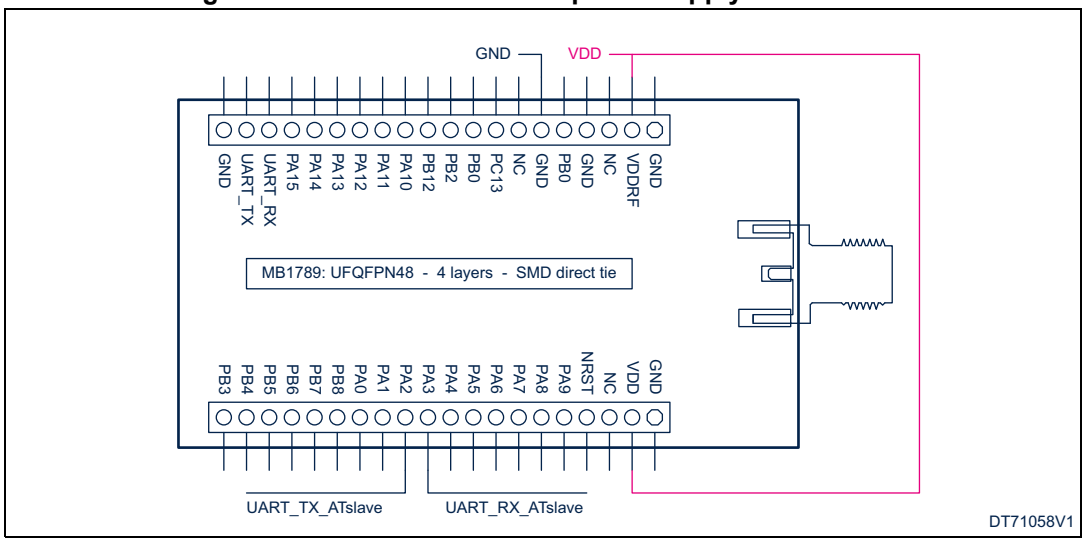


Figure 12. MB1791/MB1792 - UART and power supply connections

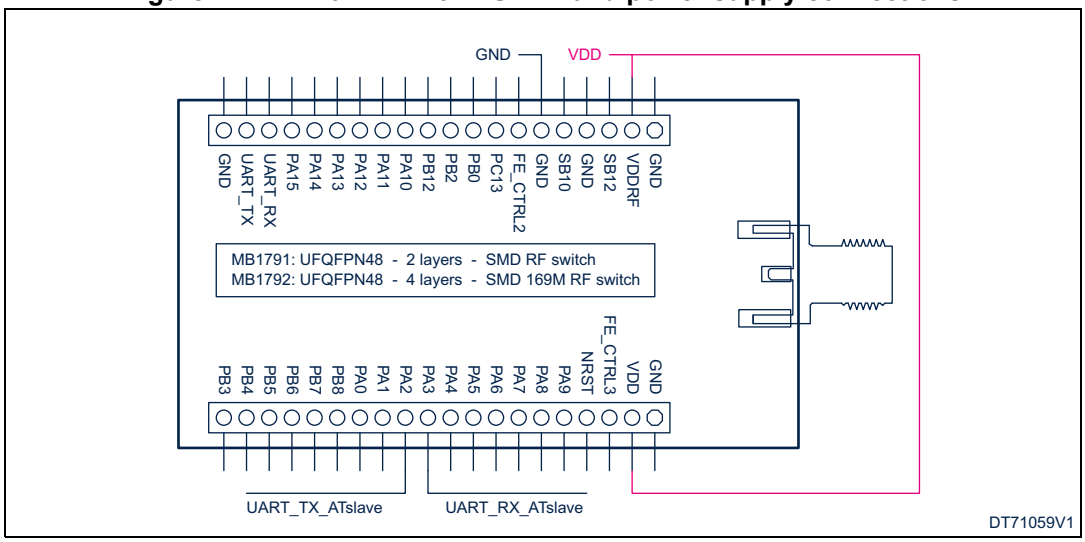


Figure 13. MB1848/MB1874-LP/HP - UART and power supply connections

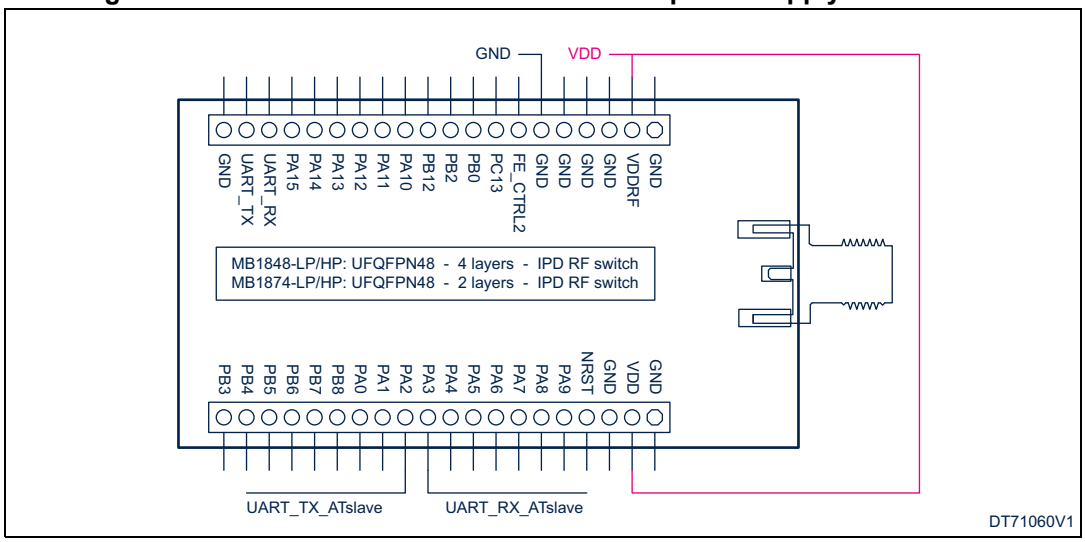
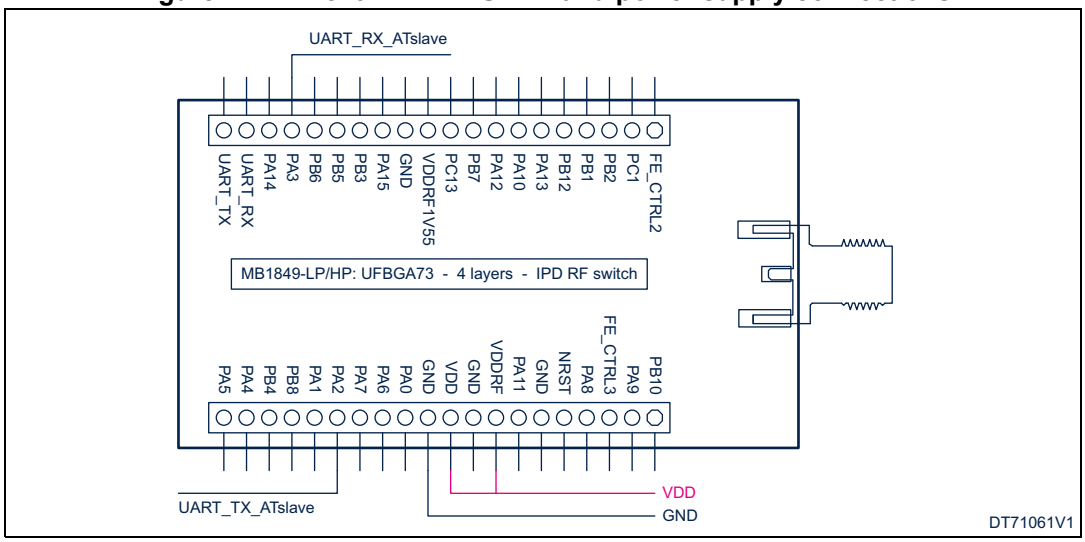


Figure 14. MB1849-LP/HP - UART and power supply connections



9 Conventions

Table 6. Conventions for solder bridges

Configuration	Description
Solder bridge SBx ON	SBx connections closed by 0 Ω resistor
Solder bridge SBx OFF	SBx connections left open

10 Revision history

Table 7. Document revision history

Date	Revision	Changes
8-Dec-2021	1	Initial release.
20-Apr-2022	2	Updated: – *Table 1: Device summary* – New *Section 2: General information* and *Section 3: Main features* – *Section 4: STM32WL reference designs and codification* – *Table 3: RF switch per reference board* – *Table 4: Solder bridge configurations* – New *Section 7: Firmware programming* – New *Section 8: AT_Slave and UART pins*
11-May-2022	3	Updated the product references in: – Document title and headers – *Features* and *Description* – *Table 1: Device summary* – *Table 2: STM32WL5x and STM32WLEx reference designs* – *Figure 1: STM32WL5x and STM32WLEx reference designs codification*
14-Oct-2022	4	Expanded the document scope to the reference designs STDES-WL5I4ILH, STDES-WL5I4IHH, STDES-WL5I4IHL, STDES-WL5U4ILH, STDES-WL5U4IHH, STDES-WL5U4IHL, STDES-WL5U2ILH, STDES-WL5U2IHH, and STDES-WL5U2IHL. Updated: – *Table 1: Device summary* – *Table 2: STM32WL5x and STM32WLEx reference designs* – *Table 3: RF switch per reference board* – *Table 5: Solder bridge configurations* – *Figure 3*, *Figure 4*, *Figure 5*, *Figure 6*, *Figure 9*, *Figure 10*, *Figure 11*, and *Figure 12* Added: – *Section 6.2: HSE 32 MHz XO or TCXO selection* – *Section 6.3: IPD (integrated passive device)* – *Figure 7*, *Figure 8*, *Figure 13*, and *Figure 14*
26-Oct-2022	5	Updated the STDES-WL5U4ILH optimized BOM target in *Table 2: STM32WL5x and STM32WLEx reference designs*.
18-Feb-2023	6	Updated the cover picture.