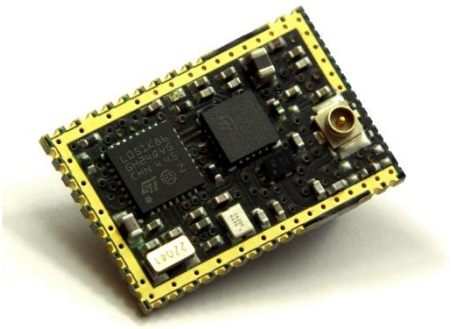
# XLN-RF-C

## Ultra-low power sub-1GHz RF module with integrated microcontroller & U.FL connector

# *DATASHEET*



### FEATURES

- 868 MHz SRD & 915 ISM bands
- Up to 500 kbps data rate
- U.FL connector for external antenna
- Ultra-low power STM32L0 microcontroller
- Simple control with AT command set
- SWD interface for custom firmware development by the user
- USART, $I^2C$, SPI and USB interfaces, up to 16 GPIO pins and up to 6 analog pins (ADC) are available for extended operations
- Real-time clock (RTC)
- CE (R&TTE) certified
- RoHS compliant

### KEY SPECIFICATIONS

- Compact design: 14 x 21 x 2.45 mm
- 1.8 – 3.6V single supply
- Power consumption: 22 mA (Tx @ +11 dBm), 8 mA (Tx @ -7 dBm), 11 mA (Rx)
- 32-MHz Cortex-M0+ microcontroller with 64 kB Flash memory (STM32L0 series)

### APPLICATIONS

- Wireless sensors network
- Battery-powered wireless devices
- Point-to-point serial data link
- Home automation
- Industrial monitoring and control
- Alarm systems
- Wireless metering, Wireless M-Bus

### DESCRIPTION

The XLN-RF-C module is an ultra-low power RF module operating in the 868 MHz SRD band. Thanks to its small footprint, its U.FL connector and its easy-to-use interface, integration of RF connectivity into your design is quick and seamless, reducing time-to-market of RF-enabled products.

The module includes a STM32L0 microcontroller clocked at up to 32 MHz coupled with a SPIRIT1 RF transceiver, with a standard firmware allowing easy RF configuration, transmission and reception through the USART interface. In addition, the microcontroller's standard Serial Wire Debug (SWD) interface is also made available to the user, so that custom applications can also be programmed. The microcontroller's USART, $I^2C$, SPI and USB interfaces are also available to the user, as well as several GPIO and analog input pins to control peripherals, acquire data and communicate with other systems, so that no additional microcontroller is needed in most designs.

The XLN-RF-C module is already CE (R&TTE) certified, so that no costly RF certification is required from the user.



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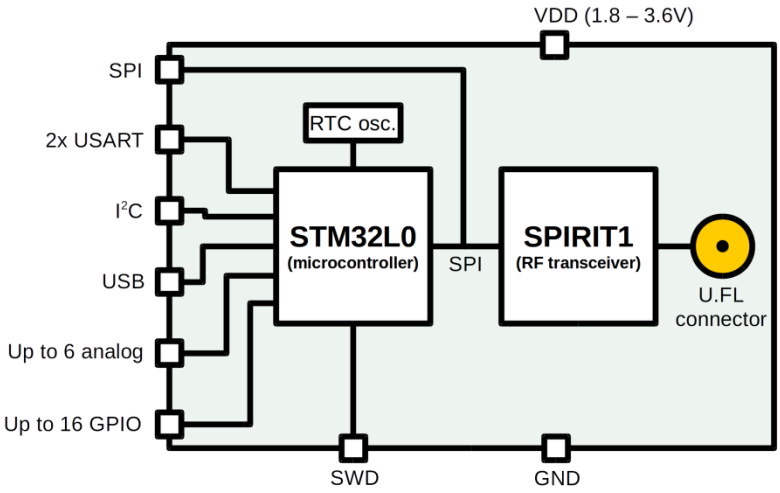


*XLN-RF-C module block diagram*

# SPECIFICATIONS

| | |
|---|---|
| RF band | 868 MHz (SRD860), 915 MHz ISM |
| RF modulations | ASK, 2-FSK, GFSK, GMSK, MSK, OOK |
| Data rate | 1 to 500 kb/s |
| Rx sensitivity | -118 dBm (2-FSK at 1.2 kb/s), -95 dBm (MSK at 250 kb/s) |
| Tx output power | -30 to +11 dBm |
| RF connector | U.FL connector for remote antenna |
| Encryption | 128-bit AES (hardware accelerated) |
| Power consumption | Sleep: 2 µA<br>Tx: 8 mA @ -7 dBm, 22 mA @ +11 dBm<br>Rx: 11 mA |
| Supply voltage | 1.8 – 3.6V (single supply) |
| RF transceiver | SPIRIT1 (ST Microelectronics) |
| Microcontroller | STM32L052 (ST Microelectronics)<br>Cortex-M0+, up to 32 MHz, 64 kB Flash, 8 kB RAM |
| Included functionalities | Real-time clock (20 ppm accuracy) |
| Interfaces | 1x $I^2C$, 1x SPI, 2x USART, 1x USB 2.0, 1x SWD<br>Up to 16 GPIO pins<br>Up to 6 analog pins (ADC) |
| RF standards compatibility | EN13757-4 (Wireless M-BUS) |
| Dimensions | 14 x 21 x 2.45 mm |
| Operating temperature | -30 to +85 °C |
| Certifications | CE (R&TTE, EN 300 220), 868 MHz SRD only |
| Environmental compliance | RoHS |

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# 1 Hardware specifications

## 1.1 Absolute maximum ratings

| *Symbol* | *Description* | *Min.* | *Max.* | *Unit* |
|---|---|---|---|---|
| $T_a$ | Ambient operating temperature | -40 | 85 | °C |
| $T_s$ | Storage temperature | -40 | 85 | °C |
| $V_{DD}$ | Supply voltage | -0.3 | 3.9 | V |
| $V_{IOst}$ | STM32 I/O pins voltage | -0.3 | 5.5 | V |
| $V_{IOsp}$ | SPIRIT1 I/O pins voltage | -0.3 | 3.9 | V |
| $I_{IO}$ | I/O pins current | -16 | 16 | mA |

***Table 1 - Absolute maximum ratings***

## 1.2 Normal operating conditions

| *Symbol* | *Description* | *Min.* | *Typ.* | *Max.* | *Unit* |
|---|---|---|---|---|---|
| $V_{DD}$ | Supply voltage | 1.8 | 3.0 | 3.6 | V |
| $V_{IL}$ | Input low level voltage | -0.3 | 0 | 0.3 $V_{DD}$ | V |
| $V_{IH}$ | Input high level voltage | 0.7 $V_{DD}$ | $V_{DD}$ | $V_{DD}$ + 0.3 | V |
| $I_{IO}$ | I/O pins current | -16 | - | 16 | mA |

***Table 2 - Normal operating conditions***

## 1.3 Pinout

The pinout of the XLN-RF-C module is described on Figure 1 and Table 3.

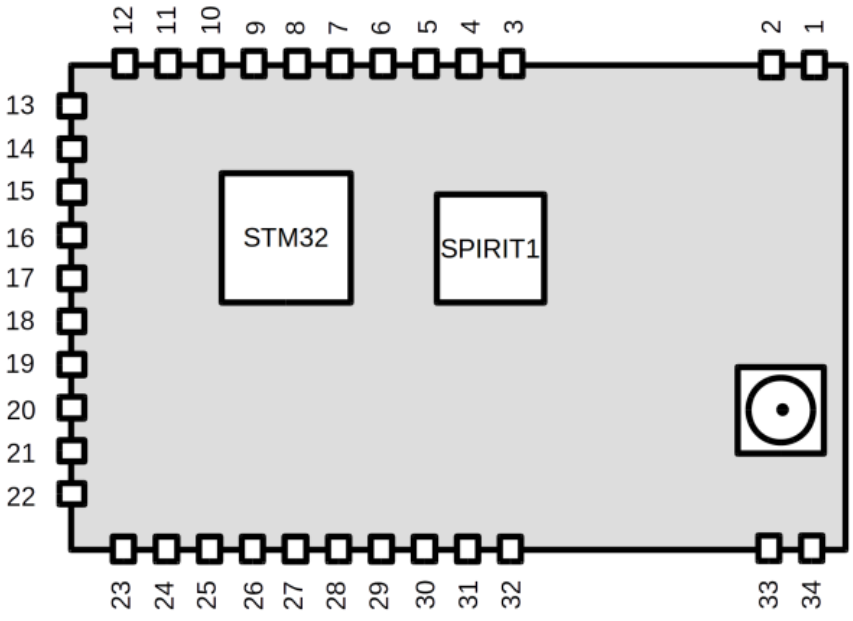


***Figure 1 - XLN-RF-C module pinout***



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| *Pin #* | *Pin name* | *Type* | *SPIRIT1 pin* | *STM32L0 pin* | *Functions* |
|---|---|---|---|---|---|
| 1 | GND | Supply | - | - | Ground |
| 2 | GND | Supply | - | - | Ground |
| 3 | RF.GPIO3 | I/O | GPIO_3 | PB2 | SPIRIT1 GPIO / STM32 GPIO |
| 4 | GPIO1.PA8 | I/O | - | PA8 | STM32 GPIO |
| 5 | USART1.TX | I/O | - | PA9 | USART1 TX / STM32 GPIO |
| 6 | USART1.RX | I/O | - | PA10 | USART1 RX / STM32 GPIO |
| 7 | USB1.DM | I/O | - | PA11 | USB1 Data – / STM32 GPIO |
| 8 | USB1.DP | I/O | - | PA12 | USB1 Data + / STM32 GPIO |
| 9 | SWDIO | I/O | - | PA13 | Serial Wire Debug I/O / STM32 GPIO |
| 10 | GND | Supply | - | - | Ground |
| 11 | SWCLK | I/O | - | PA14 | Serial Wire Debug CLK / STM32 GPIO |
| 12 | VCC | Supply | - | - | Supply Voltage (1.8 – 3.6V) |
| 13 | RF.SDN | I/O | SDN | PA15 | SPIRIT1 Shutdown Pin / STM32 GPIO |
| 14 | BOOT0 | I/O | - | BOOT0 | STM32 Bootloader Mode (BOOT0) |
| 15 | GPIO1.PB3 | I/O | - | PB3 | STM32 GPIO |
| 16 | GPIO1.PB4 | I/O | - | PB4 | STM32 GPIO |
| 17 | GPIO1.PB5 | I/O | - | PB5 | STM32 GPIO |
| 18 | I2C1.SCL | I/O | - | PB6 | I2C Clock / STM32 GPIO |
| 19 | I2C1.SDA | I/O | - | PB7 | I2C Data / STM32 GPIO |
| 20 | VCC | Supply | - | - | Supply Voltage (1.8 – 3.6V) |
| 21 | VCC | Supply | - | - | Supply Voltage (1.8 – 3.6V) |
| 22 | GND | Supply | - | - | Ground |
| 23 | GPIO1.PB8 | I/O | - | PB8 | STM32 GPIO |
| 24 | RF.GPIO2 | I/O | GPIO_2 | PA0 | SPIRIT1 GPIO / STM32 GPIO |
| 25 | GPIO1.PA1 | I/O | - | PA1 | STM32 GPIO |
| 26 | USART2.TX | I/O | - | PA2 | UART2 TX / STM32 GPIO |
| 27 | NRST | RST | - | NRST | STM32 reset pin (active low) |
| 28 | USART2.RX | I/O | - | PA3 | UART2 RX / STM32 GPIO |
| 29 | SPI1.CLK | I/O | SCLK | PA5 | SPI clock |
| 30 | SPI1.MOSI | I/O | MOSI | PA7 | SPI Master Out-Slave In |
| 31 | SPI1.MISO | I/O | MISO | PA6 | SPI Master In-Slave Out |
| 32 | SPI1.CS1 | I/O | CSn | PA4 | SPI Chip Select |
| 33 | GND | Supply | - | - | Ground |
| 34 | GND | Supply | - | - | Ground |

***Table 3 - Module pinout details***



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## 1.4 Simplified schematics

A simplified schematic of the module is shown on Figure 2.

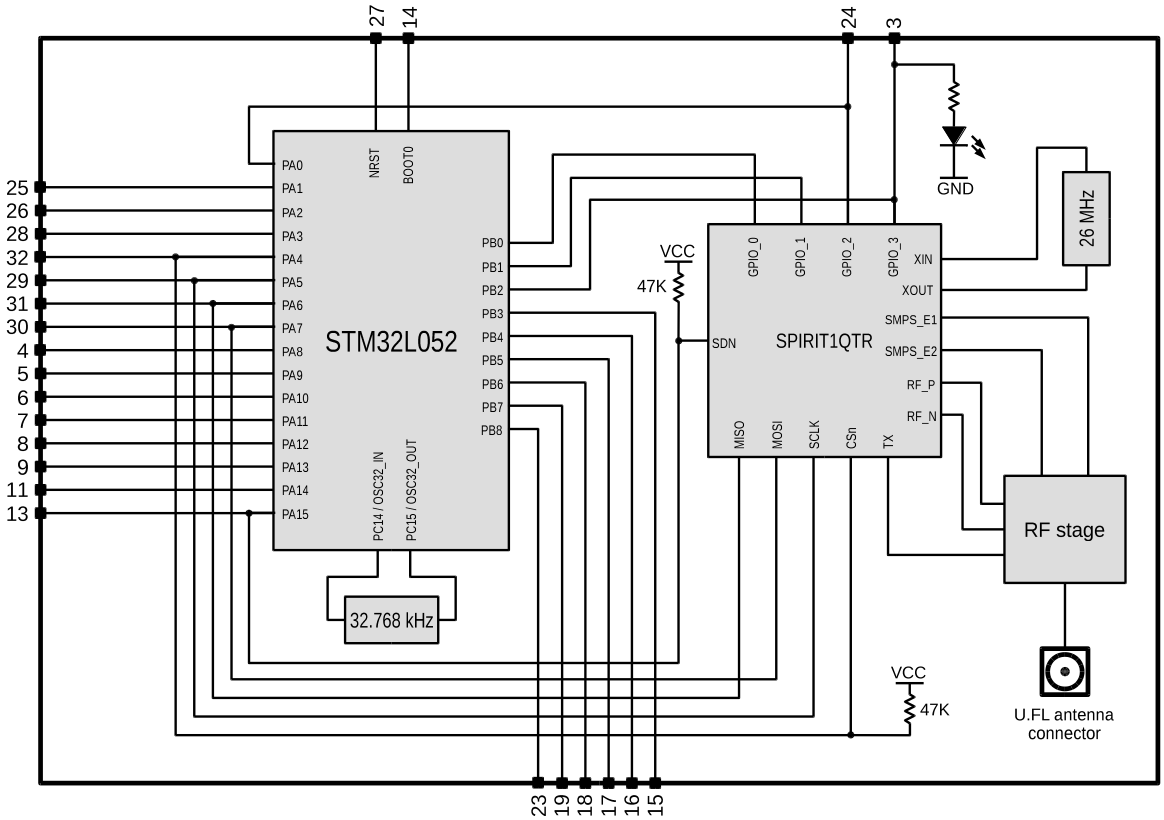


***Figure 2 - Simplified schematic of XLN-RF-C module***

## 1.5 Recommended PCB footprint

The recommended PCB footprint for the XLN-RF-C module is shown on Figure 3.

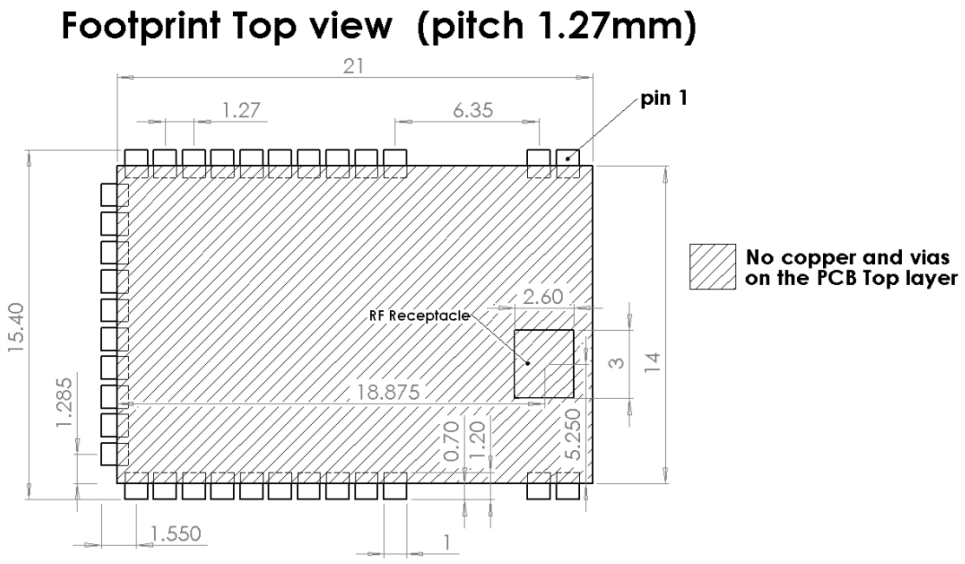


***Figure 3 - Recommended PCB footprint***



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# 2 Module operation

The XLN-RF-C module can be operated either with the included firmware, which offers basic operations, or with a custom user firmware.

## 2.1 Operation with included firmware

The firmware included in the XLN-RF-C module allows basic radio configuration and data transmission/reception over the UART1 interface of the STM32 microcontroller (pins 5 and 6 of the XLN-RF-C module).

### 2.1.1 UART1 configuration

At power up or after a reset, the UART interface has the following configuration:

- Data bits: 8
- Stop bit: 1
- Parity: none
- Bitrate: 115200
- Flow control: disabled

The bitrate and the flow control can be changed by changing the corresponding S register (see Table 4).

### 2.1.2 Operating modes

The firmware operates in two distinct modes: the command mode (for configuration) and the data mode (for data transmission and reception), described below.

#### *2.1.2.1 Command mode*

This is the mode in which the module's firmware boots into after power up or reset.

The command mode allows the user to configure the module by using Hayes-like AT commands.

An AT command is a character string starting with the characters "AT" and ending with a CR-LF (carriage return, line feed) sequence.

Examples of AT commands:

| | |
|---|---|
| `ATE1` | *Enables local echo of characters in command mode* |
| `ATS1=10000` | *Sets S register 1 (RF bitrate) to value 10000* |
| `ATS2?` | *Reads the value of S register 2 (RF modulation)* |
| `ATO` | *Enter data mode* |

The list of supported AT commands is shown in Table 4.



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| ***Command*** | ***Description*** |
|---|---|
| ATE<n> | Echo on/off. When echo is on, the XLN-RF-C module will transmit back to the host every character received on the UART interface when in AT commands mode.<br>Possible values for <n> :<br>• 0 : echo off<br>• 1 : echo on<br>Example:<br>ATE1<br>Reply from module:<br>OK |
| ATI<n> | Returns information about the module<br>Possible values for <n> :<br>• 0 : module type<br>• 1 : module manufacturer<br>• 2 : firmware revision<br><br>Example :<br>ATI1<br>Reply from module:<br>Exelen GmbH |
| ATO | Leaves command mode and enters data mode.<br>After this command is received, the module will be in data mode, meaning that data received on the UART interface will be transmitted by radio.<br>To return to command mode from data mode, the escape sequence shall be sent to the module. See section 2.1.2.2 for more details.<br>Example :<br>ATO<br>Reply from module: none |
| ATR | Loads and applies the default settings.<br>Example:<br>ATR<br>Reply from module:<br>OK |
| ATS<n>?<br>ATS<n>=<x> | Reads or writes configuration registers.<br><br>ATS<n>? reads and returns the value of register <n>.<br>ATS<n>=<x> sets the value of register <n> to <x>.<br><br><n> and <x> shall be in decimal format.<br><br>Example:<br>ATS1=200000<br>Reply from module:<br>OK<br><br>Example:<br>ATS0?<br>Reply from module:<br>115200<br><br>See Table 5 for a list and a detailed description of configuration registers. |



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| ***Command*** | ***Description*** |
|---|---|
| AT&S<n>?<br>AT&S<n>=<x> | Reads or writes SPIRIT1 registers directly.<br>AT&S<n>? reads and returns the value of register <n>.<br>AT&S<n>=<x> sets the value of register <n> to <x>.<br><n> and <x> shall be in decimal format.<br><br>Example:<br>AT&S26=52<br>Reply from module:<br>OK<br><br>Example:<br>AT&S53?<br>Reply from module:<br>64<br><br>WARNING: modifying SPIRIT1 registers may break CE certification compliance. Use at your own risk.<br>See the SPIRIT1 datasheet from STMicroelectronics for a list and a detailed description of configuration registers. |

***Table 4 - AT commands description***



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| *S register id* | *Description* |
|---|---|
| 0 | **UART bitrate**<br>UART bitrate in bits/seconds on the UART1 serial interface.<br>Possible values :<br>• 2400<br>• 9600<br>• 19200<br>• 38400<br>• 57600<br>• 115200<br>• 230400<br>• 460800<br>• 921600 |
| 1 | **RF bitrate**<br>RF bitrate in bits/seconds.<br>Possible values : 1000 to 500000<br>Default value : 10000 |
| 2 | **RF output power**<br>RF output power in dBm * 10.<br>Possible values: 0 to 116 (corresponding to 0 – 11.6 dBm)<br>Default value : 116 |
| 3 | **RF modulation**<br>RF modulation to be used.<br>Possible values:<br>• 0 : 2-FSK<br>• 1 : GFSK (Gaussian filter BT product of 0.5)<br>• 2 : GFSK (Gaussian filter BT product of 1)<br>• 3 : OOK<br>• 4 : MSK<br>Default value : 0 |
| 4 | **RF frequency**<br>RF frequency in Hz.<br>Possible values : 863000000 to 870000000<br>Default value : 868000000 |
| 5 | **RF frequency deviation**<br>RF frequency deviation in Hz (used only for 2-FSK and GFSK modulations).<br>Possible values : 400 to 380000<br>Default value : 20000 |
| 6 | **RX filter cut-off frequency**<br>Cut-off frequency in Hz of the RX digital filter.<br>Possible values :<br>• 0 : automatic cut-off frequency (based on selected modulation parameters)<br>• 1100 to 800000 : cut-off frequency in Hz<br>Default value: 0 |
| 7-30 | **Reserved** |



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| *S register id* | *Description* |
|---|---|
| 31 | **Hardware flow control**<br>Enables/disables hardware RTS/CTS flow control on the UART1 serial interface.<br>Possible values:<br>• 0 : RTS/CTS disabled<br>• 1 : RTS/CTS enabled<br>Default value : 0<br>Note : hardware flow control is strongly recommended to avoid buffer overflows leading to data loss. |

***Table 5 - S registers description***

#### *2.1.2.2 Data mode*

In data mode, data received on the UART1 interface are forwarded to the radio for transmission, and data received from the radio are forwarded to the UART1 interface. Two modules can thus be used to create a wireless serial link.

To enter data mode from command mode, use the ATO command.

The radio interface is configured to use packets carrying at most 48 bytes of payload. This means that as soon as 48 bytes of data are received on the UART interface, they are forwarded to the SPIRIT1 for transmission. In addition, if less than 48 bytes are received on the UART within 50 milliseconds, they are transmitted anyway.

## 2.2 Custom firmware

A custom firmware can be developed by the user and programmed into the microcontroller's FLASH memory through the SWD interface or using the ROM bootloader, through SPI or UART (see STMicroelectronics application note AN2606).

# 3 Revision history

| *Date* | *Version* | *Changes* |
|---|---|---|
| 19.03.2015 | 0.1 | First draft |
| 25.03.2015 | 0.2 | - Improved description of S registers<br>- Added UART configuration |
| 26.03.2015 | 0.3 | - Fixed module dimension<br>- Added document revision history |

***Table 6 - Document revision history***



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The specifications and information provided by STMicroelectronics in the datasheet and errata sheet of the STM32L052 and SPIRIT1 devices are applicable.

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