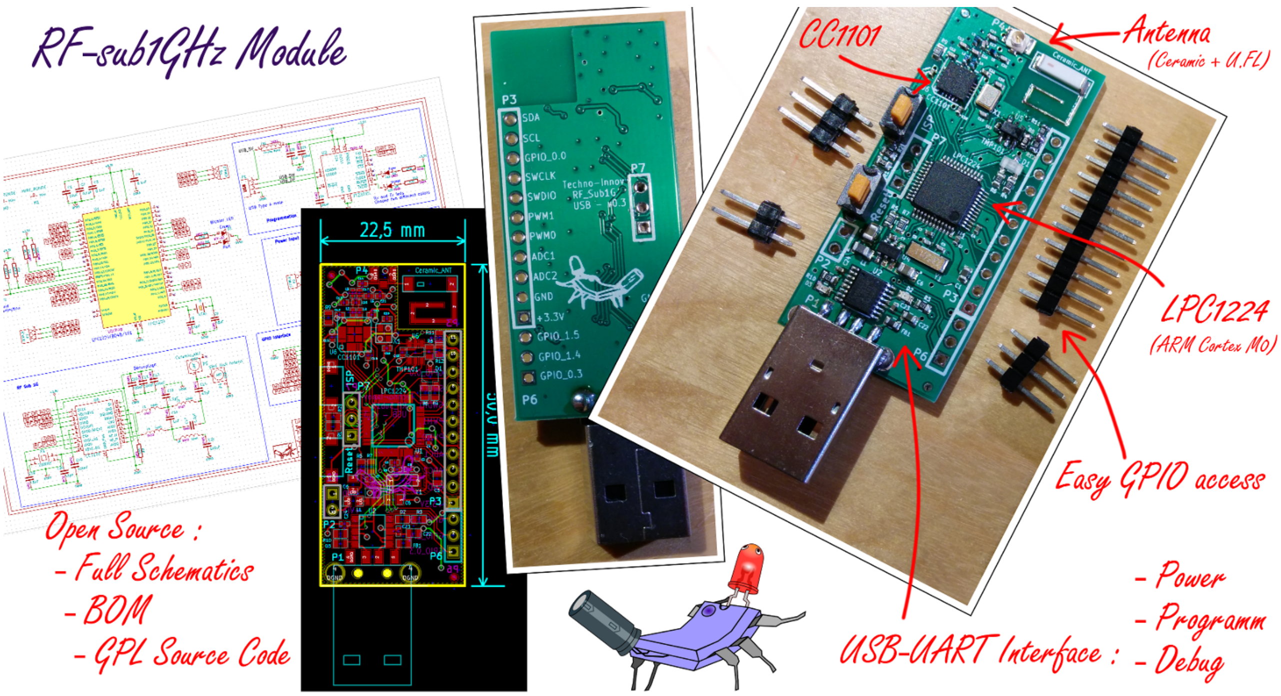


Sub-1GHz RF module
USB version
System Reference Manual

RF_Sub1GHz_mod_USB_SRM for Board v0.3

September 10, 2015 - Doc rev 0.3c

Author: Nathaël Pajani

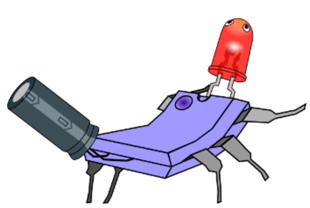


Table des matières

1 Introduction

You are reading the **System Reference Manual** for the Sub-1GHz RF module.
This module has three different form factors : UEXT version for integration in domotics systems, USB version for easy prototyping, development, tests, or use with systems with USB interfaces, and a standalone version for integration in end-user applyances.
This manual covers the board use and design of the USB version.

The Sub-1GHz RF module is an electronics development and prototyping platform for Sub-1GHz communication using the LPC1224 micro-controller from NXP [1] and CC1101 RF Transceiver from Texas Instrument [2].
The LPC1224 micro-controller has a Cortex-M0 ARM core, a minimum of 32KB of flash memory, 4KB of internal SRAM, and multiple interfaces.
The CC1101 RF Transceiver is a low-power sub-1GHz radio frequency transceiver for the 315, 433, 868, and 915 MHz frequency bands, supporting various modulation formats, and data rate up to 600 kbps.
The module also includes a TMP101 temperature sensor, an high efficiency step-up voltage regulator, a bi-color user LED (Red / Green), a reset button, an ISP mode select / User button, 15 GPIO available on 2.54mm pins, an RTC oscilator, and an USB-to-UART bridge (used for programming and easy communication with the module.

Binaries for the Sub-1GHz RF module can be generated using a gcc ARM toolchain and uploaded using the serial line (or over USB for the USB version) and our lpcprog tool (or similar tools).

The Sub-1GHz RF module is designed for users interested in embedded ARM micro-controller development using free, libre and open source softwares only.
Every information about the design is available and all components documentations are freely accessible. You can download the source files for the Sub-1GHz RF module and modify them using KiCad EDA (GPL) according to the license terms found in the license section.
You can create your own Sub-1GHz RF module or a modified version.

In this document the Sub-1GHz RF module will be referred as **the module**.

2 Licenses

2.1 Documentation license

The present document is under Creative Commons CC BY-SA 3.0 License.
It is written in LaTeX and the PDF version is generated using pdflatex.

2.2 Hardware license

The Sub-1GHz RF module hardware and schematics are under Creative Commons CC BY-SA 3.0 License.
You can produce your own original or modified version of the Sub-1GHz RF module, and use it however you like, even sell it for profit.

1. http://www.nxp.com/products/microcontrollers/cortex_m0_m0/LPC1224FBD48.html
2. http://www.ti.com/product/cc1101

2.3 Software license

All the software examples created for the Sub-1GHz RF module are under GPLv3 License.
The lpcprog tool used to program the module is also under GPLv3 License.

3 Hardware

3.1 Dimensions

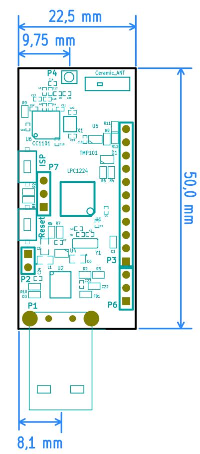


Fig 1 – USB A board type

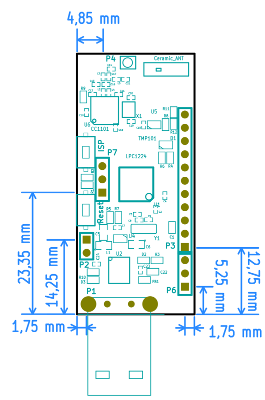


Fig 2 – Headers (2.54mm)

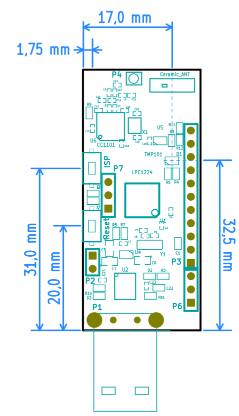


Fig 3 – Buttons and Led

Figures 1, 2 and 3 give the different dimensions and the positions of the main elements (connectors, buttons and user led) of the module.

3.2 Connectors

The module has four 2.54mm pitch headers numbered P2, P3, P6 and P7, and one USB connector numbered P1 and one U.FL connector for external antenna numbered P4. Refer to figure 4 for connectors position and to table 1 for a short description. Detailed description of the signals found on each connector pin follow.

Name	Description
P1	USB A male connector.
P2	2 pins, 2.54mm pitch header. +Vin and ground input.
P3	11 pins, 2.54mm pitch header. Provides +3.3V, ground, I2C, ADC, PWM, SWD and GPIO from port 0 and 1.
P4	U.FL external antenna connector.
P6	3 pins, 2.54mm pitch header. Provides GPIO from port 0 and 1.
P7	3 pins, 2.54mm pitch header. Provides SPI.

TABLE 1 – Module Connectors Description

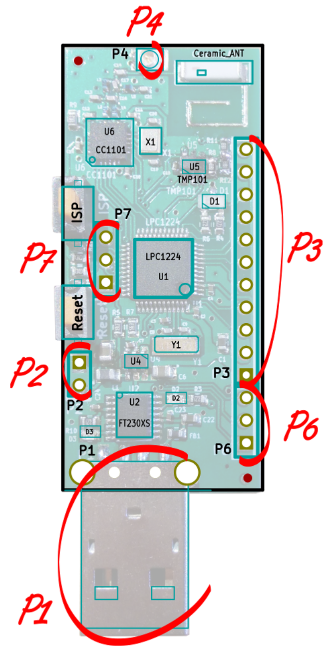


Fig 4 – Module Connectors

3.2.1 P1 Connector

P1 is a male USB-A port.
Refer to the Universal Serial Bus (USB) [3] page on Wikipedia for pinout and more information on the USB bus and connectors.

3.2.2 P2 Connector

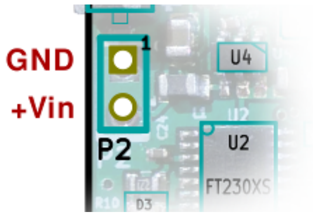


Fig 5 – P2 Connector

Pin #	Description	LPC Pin
1	GND : Ground	-
2	+Vin : External unregulated input, +0.9V to +3.6V	-

TABLE 2 – P2 Connector Pinout

P2 connector is a standard 2.54mm (0.1 inch) pitch header, with 2 pins, and can be populated using either male or female header, and mounted either on top or on bottom of the board.
P1 connector provides access to +Vin and Ground for the onboard step-up regulator. This lets you power the board using a large variety of power sources.
Note : it is also possible to power the board from +4.2V LiPo batteries, though this is not recommended without the use of an LDO or step down regulator.

3. http://fr.wikipedia.org/wiki/Universal_Serial_Bus

3.2.3 P3 Connector

P3 connector is a standard 2.54mm (0.1 inch) pitch header, with 1 row of 11 pins, and can be populated using either male or female header, and mounted either on top or on bottom side of the board.
P3 connector provides access to +3.3V, Ground, I^{2}C, ADC, and GPIO pins from port 0 and 1 of the LPC micro-controller.

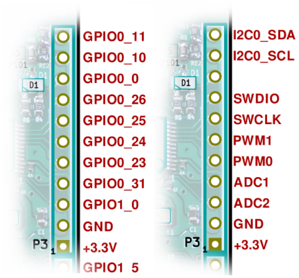


Fig 6 – P3 Connector

Pin #	Description	LPC Pin
1	+3.3V : +3.3 Volt	-
2	GND : Ground	-
3	ADC2	LPC pin 36 : PIO1_0
4	ADC1	LPC pin 35 : PIO0_31
5	PWM0	LPC pin 8 : PIO0_23
6	PWM1	LPC pin 9 : PIO0_24
7	SWDIO	LPC pin 10 : PIO0_25
8	SWDCLK	LPC pin 11 : PIO0_26
9	GPIO_0.0	LPC pin 15 : PIO0_0
10	SCL : Clock for I^{2}C bus	LPC pin 25 : PIO0_10
11	SDA : Bidirectional Serial Data for I^{2}C bus	LPC pin 26 : PIO0_11

Table 3 – P3 Connector Pinout

Note : Most P3 pins also provide alternate GPIO, input or output functions. Refer to the LPC1224 documentation from NXP for full documentation of the alternate functions.

Note : When the board is not connected to a power source (USB or P1), the +3.3V is not present on pin 1 of P3 connector. It must then be connected to a +3.3V supply.

3.2.4 P4 Connector

P4 connector is a standard U.HF Hirose connector[4] available for use of an external antenna.
Refer to Hirose documentation for more information on the U.FL connector.

3.2.5 P6 Connector

P6 connector is a standard 2.54mm (0.1 inch) pitch header, with 1 row of 3 pins, and can be populated using either male or female header, and mounted either on top or on bottom side of the board.
P6 connector provides access to GPIO pins from port 0 and 1 of the LPC micro-controller.

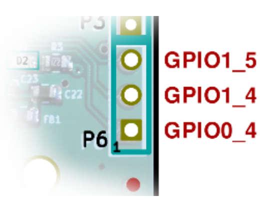


Fig 7 – P6 Connector

Pin #	Description	LPC Pin
1	GPIO_0.4	LPC pin 18 : PIO0_4
2	GPIO_1.4	LPC pin 40 : PIO1_4
3	GPIO_1.5	LPC pin 41 : PIO1_5

Table 4 – P6 Connector Pinout

4. https://en.wikipedia.org/wiki/Hirose_U.FL

Note : P3 and P6 are aligned and joined, so they appear to be one single connector on the module, but they are two separate connectors on the schematics and identified as such in this manual and on the board printing.

Note : P6 is present only on the USB version of the Sub-1GHz RF module. The signals are provided for ease of development of applications which target the UEXT version, which have the signals fond on P6 routed to the UEXT connector. These may be removed in future versions, or replaced with UART1 signals

3.2.6 P7 Connector

P7 connector is a standard 2.54mm (0.1 inch) pitch header, with 1 row of 3 pins, and can be populated using either male or female header, and mounted either on top or on bottom side of the board.
P7 connector provides access to GPIO pins from port 0 of the LPC micro-controller.

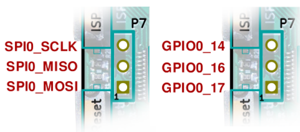


Fig 8 – P7 Connector

Pin #	Description	LPC Pin
1	MOSI : Master Out Slave In for SPI bus	LPC pin 32 : PIO0_17
2	MISO : Master In Slave Out for SPI bus	LPC pin 31 : PIO0_16
3	SCK : Clock for SPI bus	LPC pin 29 : PIO0_14

Table 5 – P7 Connector Pinout

Note : SPI is used in master mode for communication with the CC1101 RF transceiver and cannot be used as slave. Use a GPIO from P3 or P6 as slave select if you need to connect to another device using SPI.

4 Electronics

The Sub-1GHz RF module has been created using KiCad [5] EDA software suite for the creation of the schematics and printed circuit boards.

See page 21 in the annexes for the full schematics. The sources for the schematics are available for download from the RF sub1GHz module page [6] on Techno-Innov.fr.

5. http://www.kicad-pcb.org/display/KICAD/
6. http://www.techno-innov.fr/technique-rf-sub1ghz/

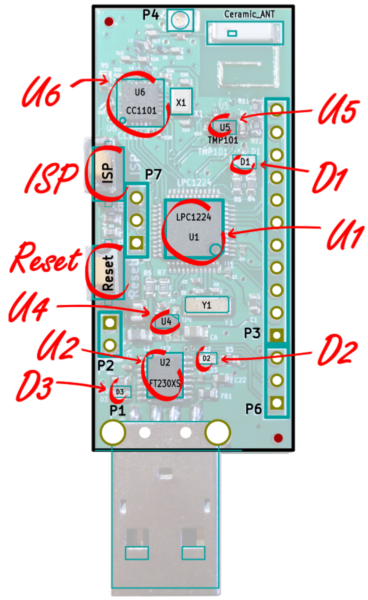


Fig 9 – Module Main Components

Name	Description
U1	LPC1224 ARM Cortex-M0 micro-controller.
U2	FTDI FT230XS USB to UART bridge.
U4	AP1603 3.3V step-up voltage regulator.
U5	TMP101 I²C temperature sensor.
U6	CC1101 RF sub-1GHz transceiver.
D1	User led, bicolore (red / green).
D2	Green led : FTDI Rx activity.
D3	Orange led : FTDI Tx activity..
Reset	Reset button for LPC1224 (SW2).
ISP	ISP mode select button for LPC1224 (SW1).

Table 6 – Module Main Components Description

4.1 Micro-controller LPC1224

The module's micro-controller is a LPC1224 from NXP[7]. The LPC1224 version used on the module is the LPC1224FBD48/101. All LPC1224 have an ARM Cortex-M0 core running at up to 45 MHz.

The module uses the internal 12 MHz RC Oscillator as main clock. Its 1% accuracy is suitable for most applications.

Note : Refer to the LPC1224 documentation from NXP for full list and documentation of the LPC1224 features. Here are only the descriptions of the features used on the module.

7. http://www.nxp.com/products/microcontrollers/cortex_m0_m0/LPC1224FBD48.html

4.1.1 Internal RAM

The LPC1224FBD48/101 has 4kB of internal SRAM mapped in one block at address 0x1000 0000.

4.1.2 Internal Flash

The LPC1224FBD48/101 has 32kB of internal FLASH memory, mapped at address 0x0000 0000. The flash memory programming requires no additional hardware thanks to the In-System Programming (ISP) and In-Application Programming (IAP) on-chip bootloader software.

See section 4.1.6 (Reset and ISP mode) or sections 5.2 (Code Compilation) and 5.3 (Uploading binary on target) for more information on internal FLASH memory.

4.1.3 Communication interfaces

The module makes use of the following communication interfaces found on the LPC1224 :

- **One UART** : UART0 is connected to the USB to UART bridge.
  UART0 is used for In-System Programming of the LPC1224.
- **One I²C bus interface** supporting full I²C-bus specification and Fast-mode Plus with a data rate of 1 Mbit/s. I²C is connected to P3 header. See section 4.5 for more information.
- **One SSP/SPI controller** with FIFO and multi-protocol capabilities. The SPI bus is connected to P7 header.

4.1.4 GPIO

The module gives access to 15 GPIO pins dispatched on P3, P6 and P7 connectors.

Refer to tables 3, 4 and 5 for details about the signals available on these GPIO and to the LPC1224 documentation from NXP for full list of features for each GPIO.

Note : Signals found on P6 are not available on the standalone version of the Sub-1GHz RF module.

4.1.5 ADC

GPIO pins 3 and 4 on P3 connector are inputs channels 2 and 1 for the 10-bit ADC of the LPC1224 micro-controller.

The internal ADC uses the voltage on the Vref pin as reference voltage for the conversion which is the same as the supply voltage from the +3.3V pin on P3.

ADC input 0 is connected to a voltage divider (resistors R5 and R7) allowing input voltage tracking when running on battery.

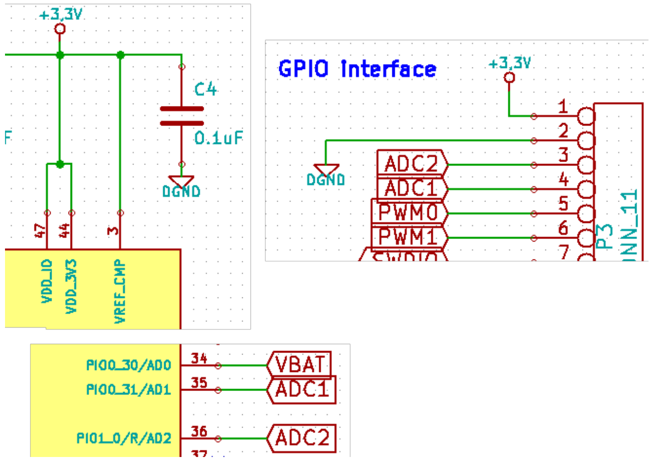


Fig 10 – ADC Input Pins

4.1.6 Reset and ISP mode

Reseting the LPC1224 without removing the power can be done with the Reset button (SW2).

To enter In-System Programming (ISP) mode after reset you must hold the ISP button (SW1) when you release the reset button. The LPC1224 bootloader considers a LOW level on the PIO0_12 pin as an external hardware request to enter ISP mode and start the ISP command handler. The sampling of the GPIO0_12 pin may take up to 3ms.

Refer to section 5.3 (Uploading binary on target) or to the LPC1224 user manual for more information on ISP mode.

If the ISP button is not held when th Reset button is released (and a valid user code is found in Flash memory) then the execution is transfered to the user program.

4.2 RF transceiver

The Sub-1GHz RF module uses the CC1101 RF Transceiver from Texas Instrument [8] as RF transceiver.

8. http://www.ti.com/product/cc1101

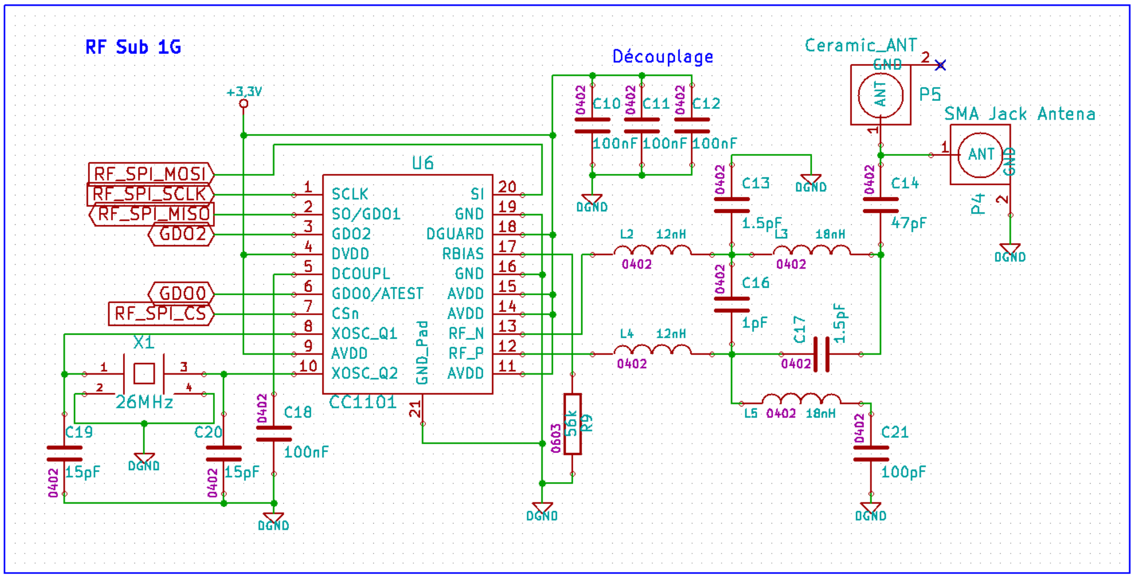


Fig 11 – RF Transceiver

The CC1101 is connected to the LPC1224 micro-controller using the SPI interface. It shares the SPI signals found on P7 (refer to 3.2.6) with any SPI device you would connect, but has a dedicated chip-select signal (PIO0_15). It also has the last two "GDO" (GDO0 and GDO2) signals connected to GPIO on the LPC1224 micro-controller (GDO1 is also the SPI_MISO signal).
GDO0 is connected to PIO0_6 and GDO2 is connected to PIO0_7. Prefer the use of these GDO signals to GDO1 as it will simplify software development of applications when other SPI devices are connected to the Sub-1GHz RF module.

The CC1101 has a dedicated 26MHz oscilator (identified as X1 on the schematics and BOM), and is connected to an onboard 868MHz ceramic antenna and a U.FL connector (standard Hirose connector, found on many devices which allow the use of an external antenna).

Note : For use at 915MHz the chip antenna should be replaced by the 915MHz corresponding part : 0915AT43A0026E from Johanson Technology, available under reference 1885494 from Farnell.

4.3 RTC

The Sub-1GHz RF module includes a 32.768kHz oscilator for RTC operation during deep sleep.
Refer to section 5 (Software) and the software interface (API) manual on our Wiki for more information on the use of the RTC.

4.4 Step-up voltage regulator

The Sub-1GHz RF module has a integrated Step-Up voltage regulator which allows operation from a wide range of batteries. This circuit was mainly intended for the standalone version of the Sub-1GHz RF module but has been kept for testing purposes.
The Step-Up voltage regulator is able to function from voltages as low as 0.9V and can provide up to 150mA of current, which should be enough for most applications.

Note : The voltage regulator used (AP1603 from Diodes Inc.) is only a Step-Up regulator, which means that if you power your module with a 4.2V LiPo or equivalent the supply voltage provided to the LPC1224 micro-controller and available on the +3.3V pin will be 4.2V (exact voltage depending on the battery charge state). This has been tested and works, but with no warranty, and note also that ADC conversions are made with this voltage as reference voltage.

4.5 I²C

The Sub-1GHz RF module only has the temperature sensor on the I²C bus. The Sub-1GHz RF module provides two 1.5kOhms pull-up resistors on both SDA and SCL lines.

4.5.1 I²C Addresses

I²C Component	I²C Address R / W
Temperature sensor	0x94 / 0x95

TABLE 7 – I²C Addresses

Table 7 shows all the possible I²C Addresses for the components used on the module.

4.5.2 Temperature sensor

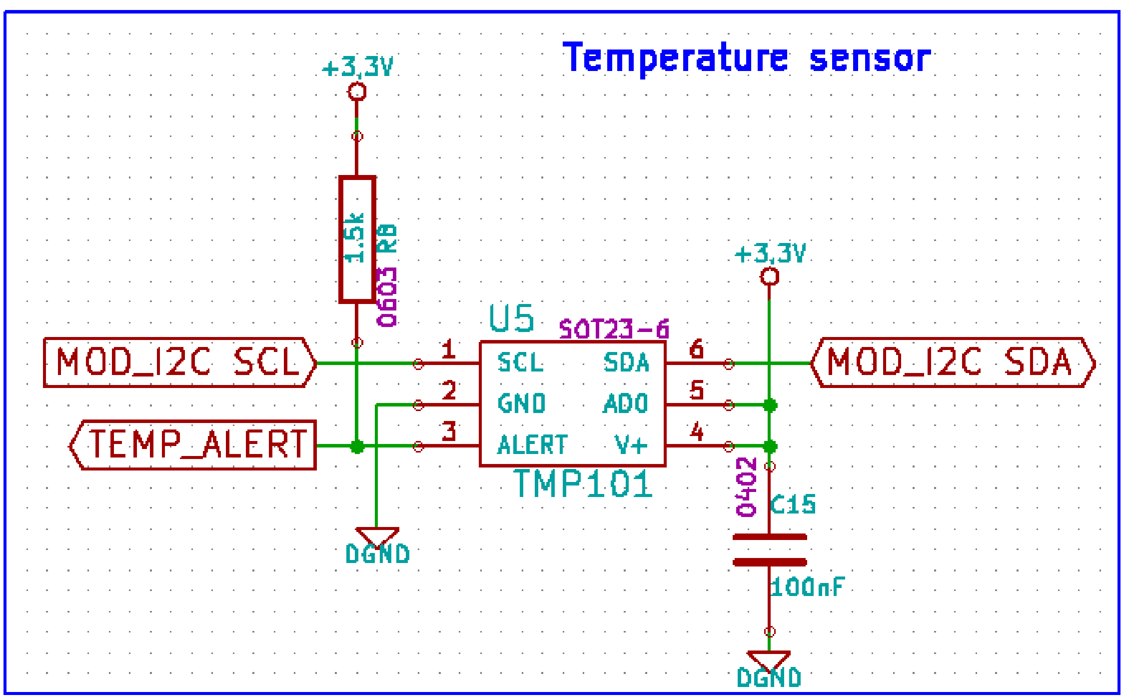


Fig 12 – Temperature sensor

The module has a TMP101 temperature sensor (from Texas Instrument) on the I²C bus (address 0x94 / 0x95).

This temperature sensor has an "alert" function available through a dedicated pin. This pin is routed to a wake-up capable pin of the LPC1224 micro-controller : GPIO0_3 (pin 18) which allows the temperature sensor to wake the micro-controller from "Deep-sleep" mode.
Refer to the LPC1224 User Manual from NXP for more information on the "Deep-sleep" mode and to the TMP101 documentation for the temperature alert signal.

4.6 User Led and Button

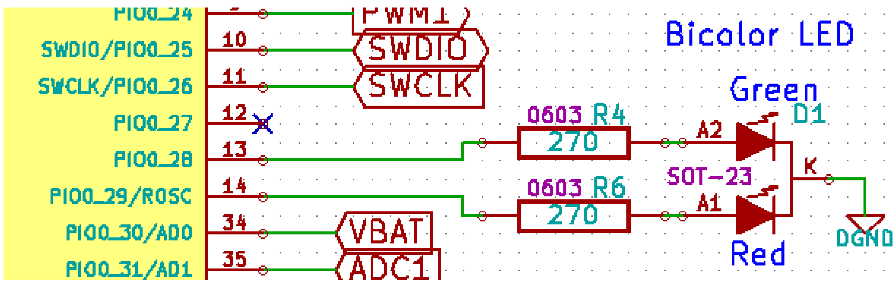


Fig 13 – User Led

The module has three leds and two buttons. The two leds connected to the USB to UART bridge (D2 and D3) and the Reset button have dedicated functions and cannot be assigned other functions.
The remaining led (D1) and button (ISP) can be used as the user wishes.

The D1 led is a bi-color red / green led connected to PIO0_28 (pin 13) and PIO0_29 (pin 14). Both can be turned on at the same time, providing a third color (orange).

Note : The PIO0_28 and PIO0_29 pins are PWM capable so it's possible to create shades between red and green without using a lot of processing power.

After reset the ISP button can be used by the user to any purpose. It's state can be read on pin PIO0_12 (pin 27).

4.7 USB to UART bridge

In order to ease the development process and the use of the module we added a USB to UART bridge on-board. This bridge is made by a FTDI FT230XS chip. It provides a 3.3V regulated voltage for the module and is well supported on most operating systems so there is usually no configuration required to use it as a serial line on the host development system, removing the need of any additional power source or of specific hardware to program the LPC1224 micro-controller and communicate with the module.

The FTDI chip controls two "activity" leds for Rx (D2, the green one) and Tx (D3, orange one) data over the serial link.

It is not possible to disconnect the USB to UART bridge from UART0 on the LPC1224 micro-controller.

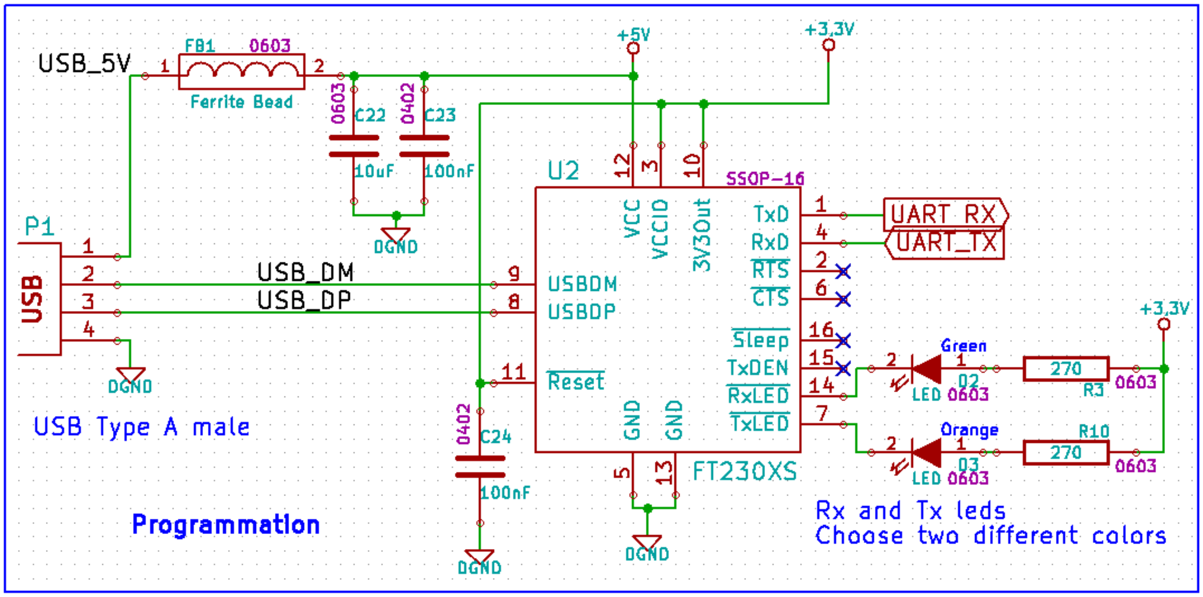


Fig 14 – USB to UART bridge

5 Software

The LPC micro-controller family uses ARM cores, which make them very easy to use. Apart from a few wrappers, all the code can be written in C and compiled using gcc.

ARM, NXP and other vendors provide sample code, but published under many different licences. The code we provide for the Sub-1GHz RF module is published under the well known GPLv3 licence.

5.1 Sample Source Code

5.1.1 Grab the sources

An example application code can be downloaded from our git repository [9] using the following clone command :

```
user@host:~/sw$ git clone http://gitclone.techno-innov.fr/modules
```

The code for the applications specific to the GPIO Demo module is in the `apps/base/` directory. Code for other modules may be found in other `apps/` sub-directories.
The code specific to the RF sub1GHz modules is in the `apps/rf_sub1G` sub-directory.

The Sub-1GHz RF module can also use the code from the GPIO Demo module as all the drivers and core code is common to both modules.
The differences are the external components present on the modules, and is reflected in the examples present in the apps sub-directories for each module. If using code from examples for the GPIO Demo module, remember that access to the I²C on the GPIO Demo module require additionnal steps which are not necessary on the Sub-1GHz

9. http://git.techno-innov.fr/?p=modules;a=summary

RF module.

5.1.2 Sample code content

This code provides the micro-controller definitions (Cortex-M0 specific definitions, registers, interrupts ...) and the routines required to start the micro-controller (bootstrap, vector table, power state, flash, clocks).

At the time of writing it also provides a basic set of library functions and the drivers for the interfaces found on the module. The list of supported features and interfaces is updated as the development goes on, so read the README file for the full list of supported features and interfaces.

The code has been split in five parts : `core/`, `drivers/`, `extdrv/`, `apps/` and `lib/` (with the associated directories under `include/` for the headers) :

- `core` : Contains all the required parts and system initialisations. Many functions in there are defined as weak aliases of dummy functions, so the code compiles even if no drivers are used. When these functions are redefined in the driver code they override the weak definition.
- `lib` : Contains the implemented parts of the small C library for our code. The micro-controller does not run a full Linux system, so the gnu libc must not be used, and even a µClibc is much more than what's required. Most of the code in these files come from the kernel implementations of libc parts.
- `drivers` : Contains the drivers for the different interfaces found on the module.
- `extdrv` : Provides drivers for external components, either on the module (status led, tmp101 temperature sensor, CC1101 RF transceiver, ...), or to be purshased separately and connected to the module.
  The number of external parts supported will grow with time. Note that it may not be possible to use all of them at the same time.
- `apps` : Provides sample applications for the different modules made by Techno-Innov which demonstrate either LPC1224 interfaces or external drivers, which can be used as base for your own developments.
  Most modules will have their own directory under `apps/`. The Sub-1GHz RF module uses the `rf_sub1G/` subdirectory. Creating a new app is as easy as creating a new sub-directory under `apps/rf_sub1G/` (with no spaces or special caracters in the name), copying the `Makefile` from one of the other apps in your new app directory, and creating your own C source file(s) (maybe starting with a copy of an existing example).
  If you created a new module, you should consider creating a new "module" directory under `apps/` with it's own sub-directories for specific apps.

5.1.3 Sample code entry point

The main loop is in `main.c` in function `main()`, as with any C program, though `main()` is called by the bootstrap code (`Reset_Handler()` in `core/bootstrap.c`) and could have any name.
The calls to the system initialisation routines have been put together in the `system_init()` function.
`SELECTED_FREQ` must be set to one of the `FREQ_SEL_**MHz` defined in `include/core/system.h` :

- `FREQ_SEL_12MHz`
- `FREQ_SEL_24MHz`
- `FREQ_SEL_36MHz`
- `FREQ_SEL_48MHz`
- `FREQ_SEL_60MHz`

Note : The frequency can go up to 60MHz despite what is said in the documentation, but the micro-controller needs much more power at higher frequencies.

Note : `system.h` provides two sleep functions (`msleep()` and `usleep()`). These will activate the systick with a 1ms tick if it has not been done yet.

Note : `usleep()` ma

The pins used by your application should be configured using either the `set_pins()` function and `pio_config` structures (see `common_pins[]` in most examples) or the `config_gpio()` function for each used pin.

5.2 Building the binary

5.2.1 Get a toolchain

Build has been tested using gcc, and only gcc, in the version provided by the Debian project [10], but any ARM gcc toolchain should do.

In order to get the Debian ARM gcc cross-toolchain you must install package `gcc-arm-none-eabi`.
There's no need for the related libc package here, the libc does not fit in our micro-controller memory. Instead have a look at the content of the `lib/` directory, and add stuff there.

Alternatively you can download pre-compiled gcc toolchains (many different projects provide their own), or build your own one using crosstool-ng [11] or similar projects. For more information on what is a (cross-)toolchain, have a look at this information page on elinux.org [12].

5.2.2 Build command and options

Once done with the toolchain installation (or if you already have one) you should build using the provided `Makefile` by running the simple "`make`" command from any of the `apps/rf_sub1G/` sub-directory.
You can also build all apps by running "`make`" from repository root directory or "`make rf_sub1G/my_app`" to compile "`my_app`" from the `apps/rf_sub1G/` sub-directory only. (`rf_sub1G` may be replaced by any other module name). NoteYou may want to change the `CROSS_COMPILE` variable from the main `Makefile` (in the repository root directory) and set it to the prefix of your toolchain.

5.2.3 Build process

The specific information about the target (LPC1224 micro-controller) memory (Flash and RAM) used by the linker is in the `lpc_link_lpc1224.ld` linker script.

The vector table is defined in the `core/bootstrap.c` file, but the checksum of the first seven entries in the vector table is left unmodified. This checksum must be computed and placed in the eighth vector entry as the bootloader needs to find a valid checksum in the eighth entry to consider the user code as valid and transfer execution to the reset handler (first vector table entry).
This is done by the lpcprog tool before sending the binary to the target.

10. http://www.debian.org/
11. http://crosstool-ng.org/
12. http://elinux.org/Toolchains

5.3 Uploading binary on target

5.3.1 Tools

To flash the binary (the one with .bin) to the LPC Flash you can use our lpctools package, packaged for Debian as of 2014-09-10 and available in jessie or newer versions, or available in the lpctools git repository [13].
Lpctools is released under GPLv3 licence.
Clone the repository using :

```
user@host:~/sw$ git clone http://gitclone.techno-innov.fr/lpctools
```

Then build (`make`) the tools.

Note : Other tools may be used but have not been tested. No tools were found to be open source when we looked for tools to upload the binaries to the micro-controller. You must check that the tool you chose to use can take care of the checksum computation.

5.3.2 Enter ISP mode

In order to allow flashing of the micro-controller it must be placed in "In-System Programming (ISP) mode after reset. Refer to section 4.1.6 (Reset and ISP mode) for more information on how to enter ISP mode on the Sub-1GHz RF module.

5.3.3 Connection with target and upload

Usual command line to upload a binary to the micro-controller :

```
user@host:~/sw$ lpcprog -d /dev/ttyUSB0 -c flash mod_gpio.bin
Part ID 0x3640c02b found on line 18
Flash now all blank.
Checksum check OK
Flash size : 32768, trying to flash 8 blocks of 1024 bytes : 8192
Writing started, 8 blocks of 1024 bytes ...
user@host:~/sw$
```

If you want to get information on the connected device use the **id** command of **lpcprog** :

```
user@host:~/sw$ lpcprog -d /dev/ttyUSB0 -c id
Part ID 0x3640c02b found on line 18
Part ID is 0x3640c02b
UID: 0x1228f5f5 - 0x4b324307 - 0x08333834 - 0x4d7b2c1a
Boot code version is 1.6
user@host:~/sw$
```

Note : The part information definition for each supported micro-controller is in the lpctools package. See lpctools readme and lpcprog or lpcisp help (-h option) or manpages for more information.

13. http://git.techno-innov.fr/lpctools

6 Board revisions history

6.1 v01

This board revision has not been sold.
First prototype version, only in UEXT connector form factor, with footprint error for the LPC1224 package.

6.2 v02

This board revision has not been sold.
First prototype version with USB. Missing I²C pullups and Rx and Tx signals to USB-to-UART bridge crossed.

6.3 v03

Actual version sold as of writting of this documentation.
Fixes the v02 mistakes.

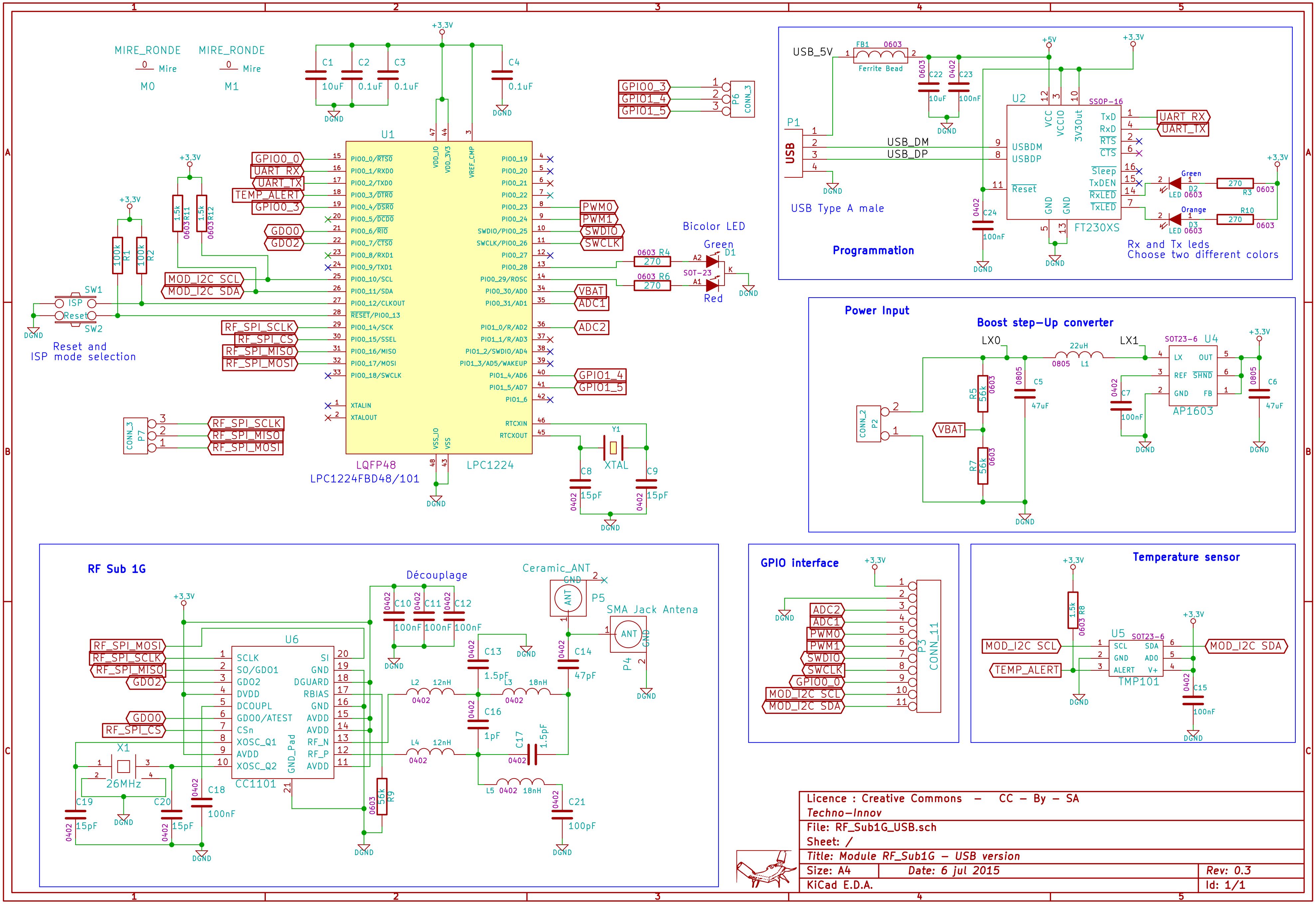
7 Annexes

7.1 Schematics

The board schematics and PCB layout have been created using KiCad[14] EDA software suite. You can download the sources on the module page[15] on Techno-Innov.fr.

(See on next pages)

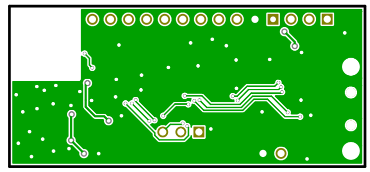
14. http://www.kicad-pcb.org/display/KICAD/
15. http://www.techno-innov.fr/technique-rf-sub1ghz/



MIRE_RONDE
M0
MIRE_RONDE
M1
U1
LPC1224
LQFP48
LPC1224FBD48/101
Reset and
ISP mode selection
Bicolor LED
Programmation
USB Type A male
U2
FT230XS
Rx and Tx leds
Choose two different colors
Power Input
Boost step-Up converter
U4
AP1603
RF Sub 1G
Découplage
Ceramic_ANT
SMA Jack Antena
U6
CC1101
GPIO interface
Temperature sensor
U5
TMP101
Licence : Creative Commons – CC – By – SA
Techno-Innov
File: RF_Sub1G_USB.sch
Sheet: /
Title: Module RF_Sub1G – USB version
Size: A4
Date: 6 jul 2015
Rev: 0.3
KiCad E.D.A.
Id: 1/1

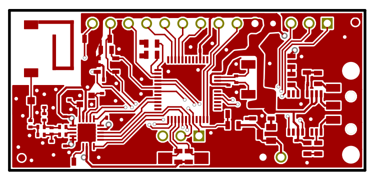
Bottom copper layer

Bottom copper layer



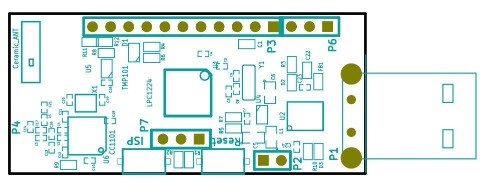
Top copper layer

Top copper layer



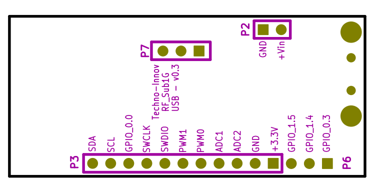
Top silk screen

Top silk screen



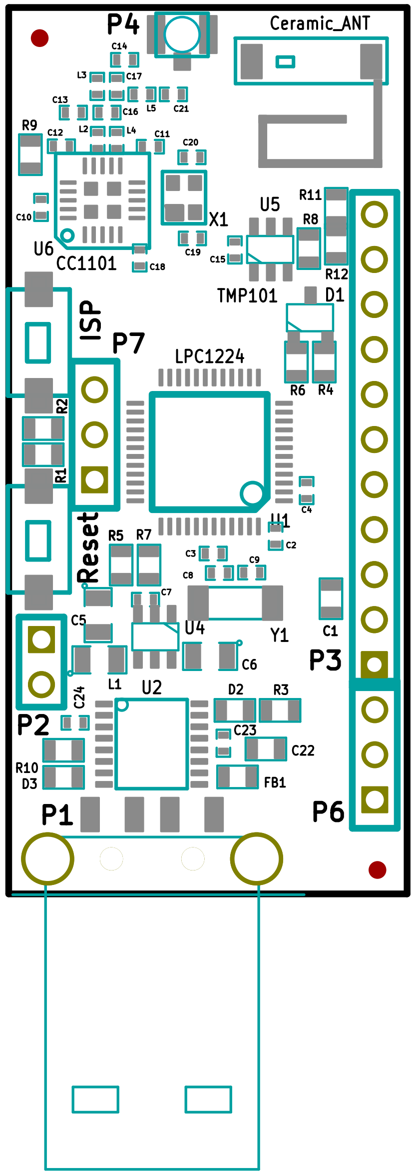
Bottom silk screen

Bottom silk screen



Techno–Innov
File: RF_Sub1G_USB.kicad_pcb
Sheet:
Title: Module RF_Sub1G – USB
Size: A4 Date: 6 jul 2015 Rev: 0.3
KiCad E.D.A. Id: 1/1

Licence : Creative Commons – CC – By – SA
Techno–Innov
File: RF_Sub1G_USB.kicad_pcb
Sheet:
Title: Module RF_Sub1G – USB
Size: A4 Date: 6 jul 2015 Rev: 0.3
KiCad E.D.A. Id: 1/1



P2, P3, P6 and P7 : top or bottom mount

D2 and D3 :
The cathode (-) is on the U2 side
D2 : Green
D3 : Orange

7.2 BOM

7.2.1 Block version

Part Description	Ref	Module	Nb	Vendor	Vendor ref	Farnell
Micro-controller						
LPC1224	U1	LQFP48	1	NXP	LPC1224FBD48/101	1862465
Decoupling capacitors 100nF	C2, C3, C4	0402	3	Multicomp	MCCA000050	1758896
Filter capacitor 10µF	C1	0603	1	TDK	C1608X5R0J106M	2112705
Pull-Up resistors 100k Ohms	R1, R2	0603	2	Multicomp	MC0063W06031%100K	9330402
Pull-Up resistors 1,5k Ohms	R8, R11, R12	0603	2	Multicomp	MC0063W06031%1K5	9330607
32.768kHz Oscilator	Y1	ABS10	1	ABRACON	ABS10-32.768KHZ-7-T	2101351
Oscilator capacitors 15pF	C8, C9	0402	2	Multicomp	MCMT15N150F160CT	1856050
Bi-color Led resistors 270 Ohms	R4, R6	0603	2	Multicomp	MC0063W06031%270R	9330917
SMD Led Red / Green	D1	SOT-23	1	Kingbright	KM-23ESGW	1142614
SMD switchs	SW1, SW2	SMD	2	Multicomp	DTSM-32S-B	9471898
Temperature sensor						
TMP101 I²C Temperature sensor	U5	SOT23-6	1	Texas instrument	TMP101NA/250G4	1207304
Decoupling capacitors 100nF	C15	0402	1	Multicomp	MCCA000050	1758896
Pull-Up resistors 1,5k Ohms	R8	0603	1	Multicomp	MC0063W06031%1K5	9330607
Step-Up Voltage Regulator						
AP1603 Step-Up voltage regulator	U4	SOT23-6	1	Diodes Inc.	AP1603WL-7	1825335
Decoupling capacitors 100nF	C7	0402	1	Multicomp	MCCA000050	1758896
Step-up inductor 22uH	L1	0805	1	TDK	MLZ2012M220WT	2215653
Step-up capacitor 47uF	C5, C6	0805	2	Murata	GRM21BR60G476ME15	1845737
Voltage divider resistor 56k Ohms	R5, R7	0603	2	Multicomp	MC0063W0603156K	9331360
RF Transceiver						
CC1101 RF transceiver	U6	QFN-20	1	Texas instrument	CC1101RGPR	2422921
Decoupling capacitors 100nF	C10, C11, C12, C18	0402	4	Multicomp	MCCA000050	1758896
26MHz Oscilator	X1	7M	1	TXC	7M-26.000MAAJ-T	1842069
Oscilator capacitors 15pF	C19, C20	0402	2	Multicomp	MCMT15N150F160CT	1856050
Configuration resistor 56k Ohms	R9	0603	1	Multicomp	MC0063W0603156K	9331360
RF tunning capacitor 100pF	C21	0402	1	Multicomp	MC0402N101J500CT	1758969
RF tunning capacitor 47pF	C14	0402	1	Multicomp	MC0402N470J500CT	1758959
RF tunning capacitor 1.5pF	C13, C17	0402	2	Multicomp	MC0402N1R5C500CT	1758931
RF tunning capacitor 1pF	C16	0402	1	Multicomp	MC0402N1R0C500CT	1758930
RF tunning inductors 18nH	L3, L5	0402	2	Murata	LQW15AN18NG00D	1762622
RF tunning inductors 12nH	L2, L4	0402	2	Murata	LQW15AN12NG00D	1762619
Ceramic antenna 868MHz	P5	SMD	1	Johanson Technology	0868AT43A0020E	1885493
U.FL antenna connector	P4	U.FL	1	Hirose	U.FL-R-SMT-1(10)	1688077

TABLE 8 – BOM by functional block

Part Description	Ref	Module	Nb	Vendor	Vendor ref	Farnell
USB Bridge						
Led resistors 270 Ohms	R3, R10	0603	2	Multicomp	MC0063W06031%270R	9330917
Decoupling capacitors 100nF	C23, C24	0402	2	Multicomp	MCCA000050	1758896
Filter capacitor 10µF	C22	0603	1	TDK	C1608X5R0J106M	2112705
SMD chip bead	FB1	0603	1	TDK	MMZ1608R601A	1669700
Rx Led - Green	D2	0603	1	Vishay	VLMG1300-GS08	2251461
Tx Led - Orange	D3	0603	1	Vishay	VLMO1300-GS08	2251473
FT230XS USB to UART	U2	16SSOP	1	FTDI	FT230XS	2081321
USB Type A male	P1	SMD	1	Multicomp	MC32605	1696546
GPIO Connectors						
Male headers GPIO (19 pins)	P2, P3, P6, P7	2,54mm	1	Fischer	SL1.025.36Z	9729038

TABLE 9 – BOM by functional block (continued)

Note : Components used on Board may change for functionnally equivalent references without prior notice

7.2.2 Easy order version

Part Description	Ref	Module	Nb	Vendor	Vendor ref	Farnell
LPC1224	U1	LQFP48	1	NXP	LPC1224FBD48/101	1862465
FT230XS USB to UART	U2	16SSOP	1	FTDI	FT230XS	2081321
AP1603 Step-Up voltage regulator	U4	SOT23-6	1	Diodes Inc.	AP1603WL-7	1825335
TMP101 I²C Temperature sensor	U5	SOT23-6	1	Texas instrument	TMP101NA/250G4	1207304
CC1101 RF transceiver	U6	QFN-20	1	Texas instrument	CC1101RGPR	2422921
32.768kHz Oscilator	Y1	ABS10	1	ABRACON	ABS10-32.768KHZ-7-T	2101351
26MHz Oscilator	X1	7M	1	TXC	7M-26.000MAAJ-T	1842069
SMD chip bead	FB1	0603	1	TDK	MMZ1608R601A	1669700
Decoupling capacitors 100nF	C2, C3, C4, C7, C10, C11, C12, C15, C18, C23, C24	0402	11	Multicomp	MCCA000050	1758896
Filter capacitor 10µF	C1, C22	0603	2	TDK	C1608X5R0J106M	2112705
Step-up capacitor 47uF	C5, C6	0805	2	Murata	GRM21BR60G476ME15	1845737
Oscilator capacitors 15pF	C8, C9, C19, C20	0402	4	Multicomp	MCMT15N150F160CT	1856050
RF tunning capacitor 100pF	C21	0402	1	Multicomp	MC0402N101J500CT	1758969
RF tunning capacitor 47pF	C14	0402	1	Multicomp	MC0402N470J500CT	1758959
RF tunning capacitor 1.5pF	C13, C17	0402	2	Multicomp	MC0402N1R5C500CT	1758931
RF tunning capacitor 1pF	C16	0402	1	Multicomp	MC0402N1R0C500CT	1758930
Step-up inductor 22uH	L1	0805	1	TDK	MLZ2012M220WT	2215653
RF tunning inductors 18nH	L3, L5	0402	2	Murata	LQW15AN18NG00D	1762622
RF tunning inductors 12nH	L2, L4	0402	2	Murata	LQW15AN12NG00D	1762619
Pull-Up resistors 100k Ohms	R1, R2	0603	2	Multicomp	MC0063W06031%100K	9330402
Pull-Up resistors 1,5k Ohms	R8, R11, R12	0603	3	Multicomp	MC0063W06031%1K5	9330607
Led resistors 270 Ohms	R3, R4, R6, R10	0603	4	Multicomp	MC0063W06031%270R	9330917
Configuration resistor 56k Ohms	R5, R7, R9	0603	1	Multicomp	MC0063W0603156K	9331360
SMD Led Red / Green	D1	SOT-23	1	Kingbright	KM-23ESGW	1142614
Rx Led - Green	D2	0603	1	Vishay	VLMG1300-GS08	2251461
Tx Led - Orange	D3	0603	1	Vishay	VLMO1300-GS08	2251473
Ceramic antenna 868MHz	P5	SMD	1	Johanson Technology	0868AT43A0020E	1885493
U.FL antenna connector	P4	U.FL	1	Hirose	U.FL-R-SMT-1(10)	1688077
SMD switchs	SW1, SW2	SMD	2	Multicomp	DTSM-32S-B	9471898
USB Type A male	P1	SMD	1	Multicomp	MC32605	1696546
Male headers GPIO (19 pins)	P2, P3, P6, P7	2,54mm	1	Fischer	SL1.025.36Z	9729038

Table 10 – BOM by reference

Note : Components used on Board may change for functionnally equivalent references without prior notice

7.3 Document revision History

Version	Date	Author	Information
0.3a	July 8, 2015	Nathaël Pajani	Initial revision
0.3b	August 31, 2015	Nathaël Pajani	Fix copy-paste typo in P7 description
0.3c	September 10, 2015	Nathaël Pajani	Changes according to code organisation modifications

7.4 Disclaimer

The Sub-1GHz RF module is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. The entire risk as to the quality and performance of the Sub-1GHz RF module is with you. Should the Sub-1GHz RF module prove defective, you assume the cost of all necessary servicing, repair or correction.