

SMiRF v2

Serial Miniature RF Link

4/1/2005

1 Overview

The SMiRF is a 'black box' wireless serial link operating in the 2.4GHz unlicensed band. The SMiRF base unit attaches to any Windows computer via USB eliminating the need for an external power connection. The remote unit can be powered from 3V up to 10V for easy battery attachment. The SMiRF firmware allows for multiple units (up to 32,000 pairs) to operate in the same environment with virtually no interference. The link can handle half-duplex data rates from 9600bps all the way up to 38400bps with a range of 200-300ft. The SMiRF firmware verifies packet delivery, buffers incoming and outgoing data, and handles all configuration menus. With a built in antenna and real-time, on-the-fly configuration the SMiRF was designed to be a powerful and simple to use wireless link.

less link.

This document was written to explain the interface and protocol requirements for the SMiRF USB Powered Wireless link. Please report typos, inaccuracies, and especially unclear explanations to us at spark@sparkfun.com. Suggestions for improvements are welcome and greatly valued.

Recent wireless technology has come a long way. Unfortunately, this has been limited to the computer market in way of PCMCIA, PCI, and USB based devices. The average embedded hobbyist does not need, and many times has difficulties implementing something as complex as an 802.11g or Blue Tooth stack on their simple design. All one really needs is a 'black box' of sorts to get serial data from point A to point B. That's where the SMiRF shines.

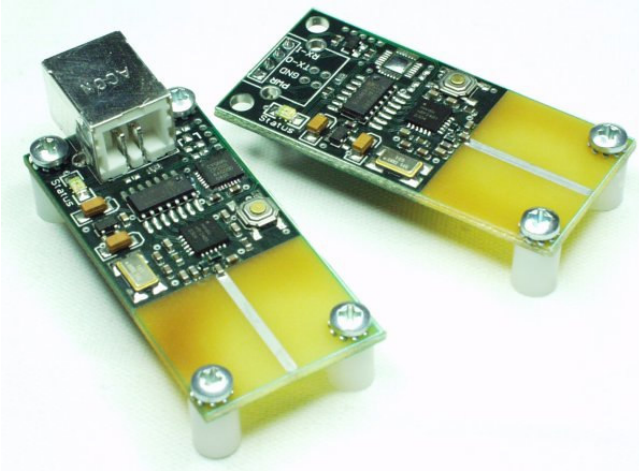
The SMiRF was designed to be as seamless as possible. By plugging in the base unit into any USB port, the base unit gains the needed power and the serial interface connection to the computer. The remote unit can be powered in any system from 3-10V and interfaces at baud rates between 9600-38400bps. Any character you pass into either unit will appear at the output of the opposing unit. No external antenna is needed. No buffering or error detection is needed. It's all built in!

SMiRF v2 offers significant improvements over the original SMiRF. We've incorporated both the transceiver IC and antenna into the main board increasing manufacturability and reducing the cost. We've also added a small button so that different units can 'learn' how to communicate. SMiRF v2 firmware has also had some small improvements which now allow inter-communication between multiple units.

2 Installing the USB SMiRF

This is a standard Windows Driver installation that accompanies almost all Plug and Play devices. The drivers for the CP2101 and an installation tutorial are available from the Spark Fun Electronics' website at <http://www.sparkfun.com>.

The USB SMiRF is recognized under any



Windows installation including Win98, ME, NT, and XP. Drivers are also available upon request for Linux and Mac OS but have not yet been tested.

All power is pulled from the 5V present on the USB bus. Total current consumption during active tx/rx including the USB interface IC is under 40mA.

3 Installing the Remote SMiRF

The remote SMiRF has a standard .1" spaced header located on the bottom of the board for easier insertion into breadboards and sockets. Only four connections are needed:

PWR : 3-10V Power

GND : Ground

TX-0 : Transmit *from* the SMiRF - Serial Output. Normally connected to the RX Pin on any microcontroller or equivalent UART.

RX-I : Receive *into* the SMiRF - Serial Input. Normally connected to the TX Pin on any microcontroller or equivalent UART.

Please note: If you power the remote board with greater than 10V, you will run the risk of damaging the onboard voltage regulator. It may work for awhile, but higher voltages will shorten the life-span of the part.

The remote unit uses no more than 22mA during active tx/rx transport. During standby, the unit uses 19.1mA.

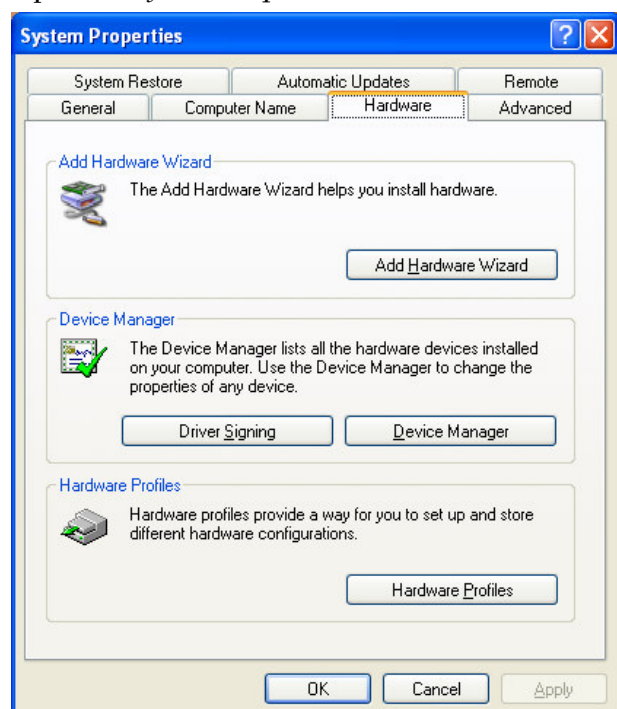
4 Configuration

4.1 Connecting via HyperTerminal

Configuring the units (base/remote) can be done from either unit - they will communicate with each other to reconfigure the link. The easiest way to do this is to install both units with the base unit attached to the USB port and the remote unit powered. You can verify that the link is activated by power cycling the units and viewing the status LED. If the LED turns on at all, the unit is up and running.

Once both units are powered, configuration can be done through HyperTerminal - the serial terminal application provided with all Windows environments. HyperTerminal is normally found under the *Accessories* menu of Windows.

You will need to create a connection to the Com Port on which the SMiRF base unit resides. This is different in every case as the USB interface IC will attach itself to the first available Com Port. To find out where the SMiRF ended up, right click on 'My Computer' and click on *Properties*. This will open the *System Properties* window:



Next, click on the **Hardware** tab and then **Device Manager** button. This will open the Device Manager:



Scroll down to 'Ports' and open the branch. In this example, the **SFE - SMiRF Controller** is located on Com Port 3. Close these windows and return to your terminal program. Open a new connection using the Com Port you found earlier. The SMiRF units ship at default 9600bps connection speed. Open a connection to the SMiRF USB at 9600bps and press Ctrl-S more than 5 times. This series of non-visible characters will cause the SMiRF configuration menu to appear:

SMiRF Firmware v01 - Configuration Menu:

- [1] Channel Select (2407MHz)
- [2] Address Select (57)
- [3] Output Power (-10 dBm)
- [4] Baud Rate
- [5] View Packet Statistics
- [6] Scan for remote units
- [x] Exit

:

Each option will be discussed in detail in the following sections.

Note: All configuration data is saved internally. Upon power loss, all previous user settings are restored. While in configuration mode, the unit's Status LED will be lit, and all packets being sent to or from the unit **will be dropped**.

4.2 Channel Selection

The SMiRF utilizes a transceiver based on the nRF2401 chipset from Nordic Semiconductor. This chipset allows for 120 different channels in the world-wide recognized, unlicensed 2.4GHz band. The SMiRF firmware further divides these individual channels into 256 separate addresses. This allows for a theoretical limit of approximately 30,000 paired units to operate in the same environment.

While multiple units can reside on the same channel, heavy traffic can cause degraded performance. Tune the units to a given channel and watch the Status LED. If it is blinking fairly regularly without external input, the unit is receiving invalid packets - a channel change may be worth while.

The current channel is shown within the Configuration Menu. Pressing **1** from the Configuration Menu will bring up the Channel Selection Menu:

Channel Select:

- [1] Increase
- [2] Decrease
- [x] Exit

Channel Number = 2407MHz

Pressing **1** and **2** will control the shown Channel. Upon pressing **x**, the current unit will communicate the new channel selection to the remote unit, wait for the 'Ok' response from the remote unit, and then proceed to the new channel where the remote unit will join. The user will then be brought back to the Configuration Menu.

4.3 Address Selection

The SMiRF firmware further divides the individual channels into 256 separate addresses. If multiple units are operating on the same channel, the user may choose to use an alternate address. Pressing **2** from the Configuration Menu will bring up the Address Selection Menu:

```
Address Select:
[1] Increase
[2] Decrease
[x] Exit
Address Number = 57
```

Pressing **1** and **2** will control the shown Address. Upon pressing **x**, the current unit will communicate the new address selection to the remote unit, wait for the 'Ok' response from the remote unit, and then proceed to the new address where the remote unit will join. The user will then be brought back to the Configuration Menu.

4.4 Output Power Selection

The nRF2401 chipset allows the user to control the output power. Pressing **3** from the Configuration Menu will bring up the Power Level Selection Menu:

```
Power Level Select:
[1] -20 dBm (Minimum)
[2] -10 dBm
[3] -5 dBm
[4] 0 dBm (Maximum)
[x] Exit
Power Level = -10 dBm
```

Options **1-4** are valid. Upon pressing **x**, the current unit will communicate the new Power Level selection to the remote unit, wait for the 'Ok' response from the remote unit, and then proceed to reconfigure the transceivers with the new power rating. The user will then be brought back to the Configuration Menu.

4.5 Baud Rate Selection

The onboard microcontroller can communicate at the standard 9600, 19200, and 38400 bits per second. Pressing **4** from the Configuration Menu will bring up the Baud Rate Selection Menu:

```
Baud Rate Select:
[1] 9600bps
[2] 19200bps
[3] 38400bps
[x] Exit
Baud Rate = 9600bps
```

Options **1-3** are valid. Upon pressing **x**, the current unit will communicate the new Baud Rate to the remote unit, and wait for the 'Ok' response from the remote unit. The user will then be brought back to the Configuration Menu under the *original baud rate*. The *new* baud rate will not become active until both units are power cycled.

Caution: Be aware of what baud rate you set the link at. The link must communicate at the same speed as the devices they are attached to. The user must also know what speed to connect at via a terminal program to re-configure the link.

4.6 View Packet Statistics

This is just a simple counter that monitors the number of lost packets. This can be used as a traffic indicator: the higher the number of lost packets, the more noisy the environment. You may find better performance by switching to a different channel or by re-locating your system to avoid large EMI/EMF sources such as a microwave without a front door. I always wanted to try a wireless data transfer during a Gaussian cage demonstration.

4.7 Scan For Remote Units

It is quite possible for the base unit to 'loose' the remote unit. When attempting to change the SMiRF configuration, the base unit will attempt to communicate these changes to the re-

mote unit. What happens if the remote unit is out of range? Or is powered off? The SMiRF will let you know this:

```
Remote Configuration Change Failed!
```

```
Would you like this unit to go to  
the new settings anyway? [Y]es or  
[N]o
```

By pressing N, nothing will be changed and the unit will return to the previous setting. By pressing Y, the base unit will go to the new settings, leaving the remote on a different channel and/or address. In order to resolve this, a scanner was designed to scan all available channels and addresses.

To recover a remote unit on which the channel and/or address is unknown, make sure the remote is powered and within 10ft of the base unit. Pressing 6 from the Main Configuration Menu will start the scan:

```
Beginning Scan...  
Press x to stop scan  
Unit found on Channel : 7 Address :  
57  
Channel 11 finished
```

The base unit will proceed to scan each channel looking for available remotes. As you can see in this example, the remote unit was found on Channel 7 (2407MHz) and Address 57. A full scan will take approximately 5 minutes. Pressing x will stop the scanner after the current channel is finished processing and return the SMiRF to its original Channel and Address configuration.

Once you know the remote's Channel and Address, you will need to forcibly attach to it, and then reconfigure it if desired. This sounds worse than it really is!

Again, make sure both base and remote units are powered and near each other. On the base unit, change the Channel to the one found during the scan. In this example, it was 2407MHz. The SMiRF will warn you upon pressing the x key:

```
Remote Configuration Change Failed!
```

We should expect to see this. The base is attempting to communicate with a remote on the previous channel, not the 2407MHz channel that the remote

is actually on. Press Y to force the base unit onto this channel. Repeat with the Address Selection. Once this is complete, the base should now be located on the same Channel and Address as the 'lost' remote. Any further configuration (Channel, Address, Power Level) should complete successfully and you should now have your link back!

4.7.1 Scan Button

SMiRF v2 now utilizes a hardware scan button. Pressing and holding this button will cause the unit to start a scan of the Channels/Addresses for an available link. If it detects any link, it will stop scanning, store the pertinent information, and reside on the discovered channel/address. This is useful if you have a pair of SMiRFs that have lost link or if you have new unit that needs to 'learn' to communicate with another unit.

Scanning can take a long time. By pressing the Scan button, the SMiRF will start with channel 0. Therefore, we recommend the following procedure in the event the link is lost:

You should have direct access to a USB/Base unit through HyperTerminal. Force this unit to a low channel, such as channel 5 (2405MHz). On the remote unit or the 'lost' unit, press and hold the Scan button for 1 second. You will see the status LED turn on - release the Scan button. The remote unit is now scanning each channel. The remote unit should discover the USB/Base unit on Channel 5. Upon completion, you will see the status LED blink quickly for 1 second on the remote unit. Send a character to either unit and you will see both status lights glow briefly indicating the link is now operational. If the remote unit fails to discover the USB/Base unit, power cycle both units and try again.

4.8 Quick Reconfiguration

SMiRF v2 now has a 'Quick Reconfigure' mode that allows the unit to be re-configured via a few serial commands rather than opening the full text-menu. This will allow the SMiRF to be

switched between various channels and addresses from a program application rather than a terminal interface. This menu does not display any text to the user and should only be entered via a software routine where the serial string sent to the SMiRF unit can be closely controlled.

By frequency hopping and/or by changing the destination address, multiple remote units can be communicated with. For example, one base unit can be controlled by a Visual Basic program (or similar program capable of serial port control) to communicate with different robots or sensors, gaining information by passing serial strings back and forth on different channels/address.

The 'Quick Reconfigure' mode is activated in a similar means to the Main Menu. By sending character Ctrl+'t' (decimal 20, 0x14) a series of five times, the SMiRF will go into quick re-configure mode. In this mode, the SMiRF can be reconfigured to any channel, any address, and any power output level, simply by sending a command byte followed by a value byte.

Ctrl+t * 5 will put the unit into quiet menu mode where:

- '1' followed by a 0-120 decimal number will re-assign the channel # and immediately return to the main menu
- '2' followed by a 0-255 decimal number will re-assign the address # and immediately return to the main menu
- '3' followed by a 1-4 decimal number will re-assign the power level and immediately return to the main menu
- '4' followed by a 0 decimal number will save the current quiet configuration to memory (requires 15ms) and return to the main menu
- 'x' will exit quiet config mode returning to normal operation

Multiple commands can follow each other. For example:

```
20 20 20 20 20 '1' 47 '2' 3 '4' 0 'x'
```

This string will cause the unit to go to channel 47 (frequency 2447MHz), address 3, record the new

settings to memory and then exit.

- Please note: A quiet re-configuration is NOT recorded into EEPROM memory to save 15ms of EEPROM writing time. Settings will be lost when powered down. If you wish to make the configuration permanent, you must send the '4' command followed by decimal 0.
- Also note: You must exit out of the quiet configuration menu just like the main menu by sending 'x'.

You can always check which channel/address the SMiRF is operating on by entering into the standard configuration menu by pressing Ctrl-'s' five times.

5 Hardware Layout

5.1 Physical Dimensions

The SMiRF main board measures 2.1" by 1.0" (53x25mm).

Base unit including USB Type-B connector:

- Overall length: 2.2"
- Overall height: 0.65"
- Weight: 11g

Remote unit:

- Overall length: 2.1"
- Overall height: 0.4"
- Weight: 8g

5.2 Transceiver Range

The SMiRF has been tested effective for ranges up to 50ft in doors without problems. The nRF2401 is extremely sensitive and is rated for transmissions up to 500ft. While this is most likely an 'ideal laboratory' setting, we've had very nice results using the units outdoors, up to 300ft. away (line of sight).

SMiRF v2

6 Firmware

6.1 SMiRF Firmware v2

The SMiRF now uses a 16F688 operating at 8MHz for all handshaking. All firmware is freely available and can be found on the Spark Fun website www.sparkfun.com.