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RF Explorer®

Signal Generator

User Manual

Updated to Firmware Version 1.17

RF Explorer®

RF Explorer is an affordable Handheld Spectrum Analyzer and Signal Generator family of products with a growing list of features.

This little powerful unit is the tool you need

to reduce the implementation time and cost

of your next wireless project.

Please consider the environment before printing this document.

Table of Contents

Introduction

RF Explorer Signal Generator has been designed to be intuitive and easy to use. There is no need to read large user manuals to get advantage of its advanced functionality.

For simple actions, only a keyboard click is needed to start transmitting signals. For most advanced features like Tracking SNA, the RF Explorer for Windows software will easily guide through steps required so analyzing RF devices becomes a few minutes task for even the most novice users.

We welcome your feedback and look for ideas to make this manual more useful. Please contribute with ideas, suggestions, typo corrections and comments on the official discussion list

www.rf-explorer.com/forum

Description of main features

The RF Explorer Signal Generator is a powerful, wideband fully programmable RF signal generator. It is the perfect companion for Spectrum Analyzer RF Explorer product line.

As a standalone unit, RFE6Gen can generate CW and Sweep signals by selecting embedded menu options. When connected to a PC, it can be fully programmed with the RF Explorer for Windows software tool. Furthermore, the unit can work as a powerful Tracking Generator when used with RF Explorer Spectrum Analyzer connected to the same PC, offering full Scalar Network Analyzer (SNA) capabilities. The SNA feature allows full characterization of filters, amplifiers and any 2-port RF device.

Feature

- ✓ Pocket size and light weight

- ✓ Solid aluminum metal case

- ✓ Lifetime free firmware upgrades available, open to community requested features

- ✓ High capacity Lipo for 10hs+ of continuous run, rechargeable by USB

- ✓ RF Explorer for Windows PC client Open Source

- ✓ Can be extended with internal Expansion Modules for additional future band support and functionality

- ✓ Wide band support

Specification

- Frequency range supported: 23.4 to 6000 MHz

- Frequency step/resolution: 1KHz

- Frequency stability: 0.5ppm

- Temperature compensated (0-45C)

- Backlight for great indoor visibility

- Standard SMA 50 ohms connector

- Programmable Amplitude with included internal programmable attenuator:
  - o -40dBm to -30dBm in 3dB steps
  - o -10dBm to 0dBm in 3dB steps

- Amplitude accuracy: +-0.5dB (normalized) or +-3dB (absolute)

- Sweep measurement point speed < 10ms

- Graphics LCD 128x64 pixels, great visibility outdoors

- PC Windows client supports Windows XP/Vista/Win7 both 32 and 64bits

- Functional modes:

    o CW signal generator at any frequency in the range

    o Tracking generator functionality working together with RF Explorer when connected to the same PC.

    o Sweep generator between any to frequencies in the range, with selectable step size and speed

- Expansion:

    o Expansion port for future enhancements (higher RF power modes, additional frequency bands)

- Weight: 185g

- Size: 113x70x25 mm

www.rf-explorer.com/models

Connecting RF Explorer Signal Generator
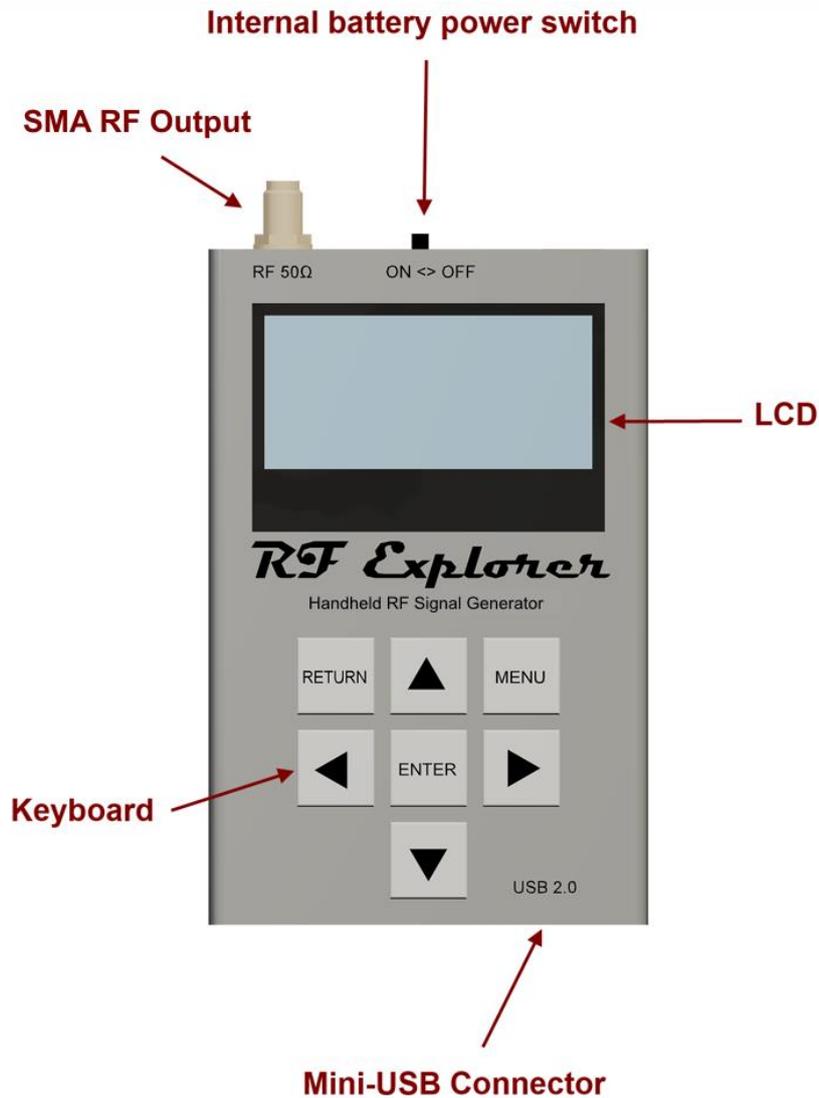
The unit includes 50 ohm impedance RF connector standard SMA format.

All models have a SMA left connector installed and, optionally, some future models may have a second SMA connector at the right position for extended range and functionality.

The unit will automatically start running on USB power when a compatible mini-USB cable is connected.

Important: The internal battery power switch must be in the ON position for the battery to charge when the USB cable is connected. The internal battery will not charge when the power switch is in the OFF position.

Note: There are a number of SMA adapters to easily interface RF Explorer SMA connector to any other standard RF connector format, including BNC, N, RP-SMA, etc. For more information of adapters available see section RF Explorer accessories in page 30.

Signal Generator CW mode - Main Screen

Upon start, RF Explorer Signal Generator goes to this mode automatically.

The RF output power is disabled by default and it is important to connect a LOAD in all cases before enabling the RF port.

The below screen is an example of a RF signal generator mode configured at 3.767020GHz. This is organized visually in GHz, MHz and KHz for easy reading.
The internal High Power switch to ON, and the power level in mode 2 (levels are 1-4). This result in (-3.1dBm) output at this frequency.

All elements on screen are important parameters to understand how the Signal Generator is working at any given time.
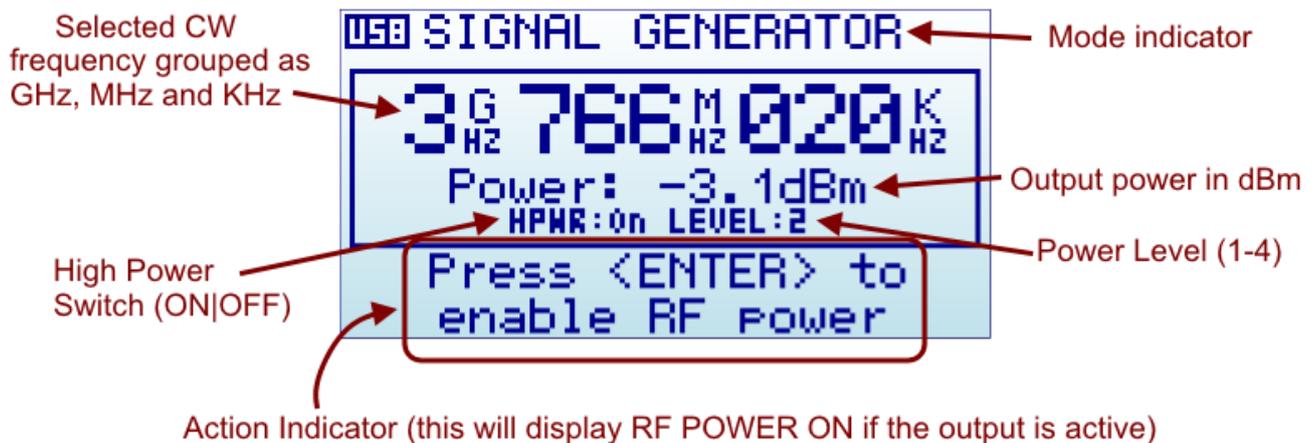
The available indicators are:

- **Selected CW frequency**: This is the currently selected carrier (or CW) frequency, expressed in GHz, MHz and KHz. It can be modified in the FREQUENCY MENU.

- **High Power Switch**: The Signal Generator includes an internal 30dB nominal attenuator. This allows the unit to generate low level signals for multiple purposes. The attenuator is disabled when the High Power Switch is ON.
- **Power Level Switch**: The Signal Generator includes an internal power switch, with a nominal 3dB increment on each step. There are a total of 4 steps. When combined with the internal attenuator, a total of 8 possible power values can be selected.
- **Power mode**: The Signal Generator describe the step required to enable the RF output signal, at the selected frequency and selected power level. By clicking on ENTER key the power signal will be delivered to the RF output port, and the screen will clearly indicate that with RF POWER ON message.

Please note standard precaution of RF power delivered without a connected load.

> ### *IMPORTANT*
>
> **You must have connected a 50 ohm antenna or RF load before you switch your transmitter ON.**
>
> If you switch the transmitter ON without a proper load, you may damage the RF module of your RF Explorer Signal Generator, as the power amplifier will not have a load to feed. Think of the equivalent to an audio amplifier running at full power with no speakers connected: you are likely damaging the power transistors.
>
> You can use any kind of RF 50 ohm load, including a dummy load, a coaxial with a 50 ohm termination, an antenna, etc. If you use a load different than 50 ohm, the reflected wave may also damage the power amplifier.

- **Using the keyboard**: In the RF SIGNAL GENERATOR mode screen, the keyboard can be used for easy and convenient tasks as described below:
  - Using buttons LEFT and RIGHT on this screen will increase or decrease the selected frequency by the amount expressed on the *Freq Step* value configured in the FREQUENCY MENU.

For instance, if the Freq Step is configured to 100MHz, clicking on RIGHT will increase the CW frequency in 100MHz increments everytime the key is pressed, and similarly clicking on LEFT button will decrease the CW frequency by 100MHz.

An example of increment from 3,766,020KHz using 1MHz increment step, RIGHT button click will increase to 3,767,020KHz and then LEFT button click will decrease it back to 3,766,020KHz:

o Using buttons UP and DOWN on this screen will increase or decrease the selected RF power, one step at a time.

For instance if the unit is in *High Power:OFF* and *Level:1* (lowest possible power) a press on the UP button will increase into *High Power:OFF* and *Level:2*. Another press will increase to *Level:3*, etc.

The Level is sequentially increased up to the max level Level:4 and, if the High Power is OFF at that point, it will be set to ON to increase the power in the next increment with UP button. For instance if the unit is in *High Power:OFF* and *Level:4*, the press of UP button will increase to *High Power:ON* and *Level:1*. See RF power section *Understanding RF Power Modes* on page 18 for more details on power level modes.

o Using ENTER key enables and disables RF output power

o Using MENU key goes to the last used menu. Note: if the RF power was enabled, MENU will automatically disable it to avoid unattended power signal to be active. You can re-enable power once you get back from MENU configuration.

Using menus

There are several menus in RF Explorer Signal Generator. They are organized on different screens, which you can iterate through by using the [Menu] key. If you click [Menu] button multiple times, you will visit every one of them:

```
FREQUENCY MENU

CW Freq: 3767.020
Freq Step: 0001.000
Start Freq: 1100.000
 Stop Freq: 1101.000
Step Delay: 01.000
```

```
POWER MENU

CW Power:-3.1dBm
Start Power:-28.1dBm
 Stop Power:-2.1dBm
Power Steps:7
```

```
CONFIG MENU

Backlight: Med
Contrast: 3
USB Bauds: 500Kbps
```

```
OPERATIONAL MODE

RF Generator
Frequency Sweep
Amplitude Sweep
RF Connections
Battery
About
```
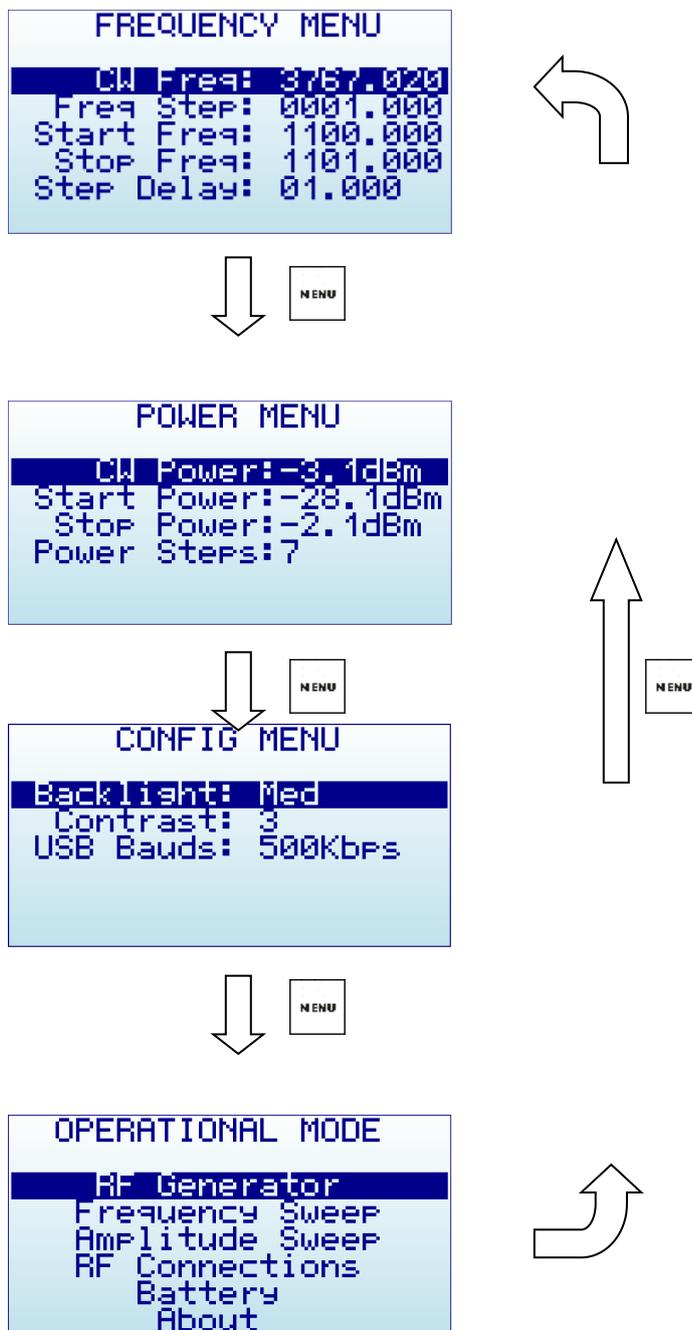
Optionally, you can use the [Left] and [Right] keys to go from one screen to another.

You can exit from a menu anytime by using the [Return] key.

The first time you click on [Menu] button in a RF Explorer session, Frequency Menu will open. This may change as we will see later, so every time you click on [Menu] from Signal Generator main screen, you actually re-open the last menu you were working with. In this way you save time by not having to navigate through all the menus to go the same place you were before.

Operational Mode menu

The menu display different functional modes available in your Analyzer.

Use [Up] and [Down] arrow keys to select the desired mode and click on [Enter] to activate it immediately.

- **RF Generator** mode is the default mode, this is used for carrier CW signals

- **Frequency Sweep** allows iterative hops over Start Frequency and Stop Frequency defined by a Step Frequency and a Step delay.

- **Amplitude Sweep** allows iterative amplitude change at CW frequency.

- **RF Connections** enumerates the installed RF modules and how each one is connected to each SMA RF port. This example below shows a standard RFE6GEN model with 24 to 6000MHz. Click on any key to get out of this screen.
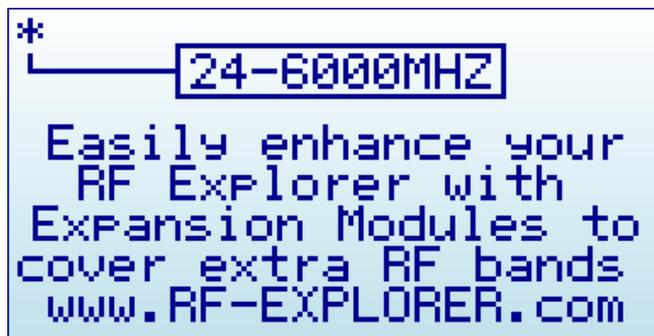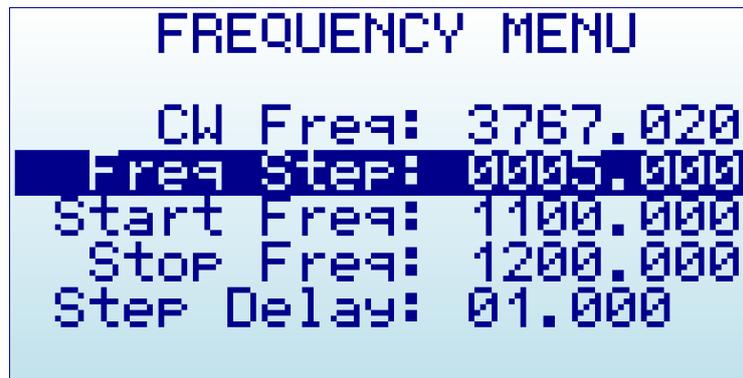

- **Battery** includes details on internal battery charge level, and assist you on charging the unit when connected to USB. For more details read section *Charging the internal battery* in page 23.

- **About** displays information about installed firmware and versioning. Use any key to get out of this screen.

Frequency Menu

- **CW Freq**: CW frequency selected for transmission in MHZ
- **Freq Step**: Frequency step in MHZ used in Frequency Sweep mode and when using LEFT-RIGHT button increments in CW mode.
- **Start Freq**: Lower frequency in MHZ used in Frequency Sweep mode
- **Stop Freq**: Higher frequency in MHZ used in Frequency Sweep mode
- **Step Delay**: Selected step delay for Amplitude / Frequency Sweep in seconds (with millisecond resolution)

To navigate through the menu, just use [Up] and [Down] keys to go to the option you want, then click on [Enter] to edit that option, [Left] or [Right] to go to the digit you want to change, and [Enter] to confirm or [Return] to cancel.

In above example screen:

- CW frequency is 3,767.020 MHz
- Frequency sweep will run from 1,100.000 MHz to 1,200.000 MHz with a 5 MHz step and 1 second delay

Power Menu
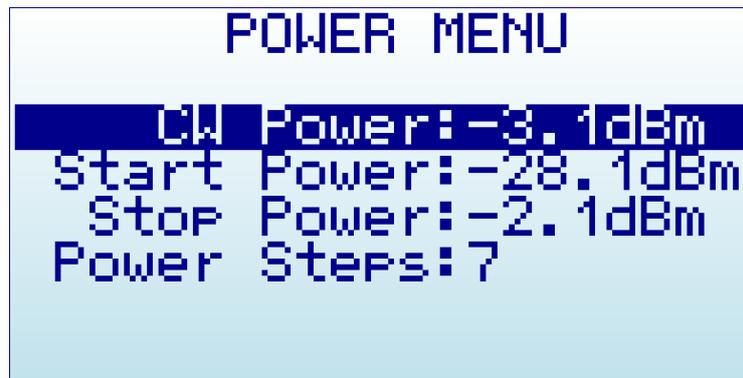
- **CW Power**: Power level used for Generator CW mode and Frequency Sweep mode.
- **Start Power**: Lower power level for Amplitude Sweep
- **Stop Power**: Higher power level for Amplitude Sweep
- **Power Steps**: number of steps used in Amplitude Sweep, automatically calculated based on Start/Stop power settings.

To navigate through the menu, just use [Up] and [Down] keys to go to the option you want, then click on [Enter] as many times as required to change the power value. The Power Steps setting is not editable (automatically calculated).

Understanding RF Power Modes

The RF Explorer Signal Generator delivers 8 different power levels, nominally specified as per table below:

RF output power (nominal)	High Power	Power Switch
0dBm (1mW)	ON	4
-3dBm (0.5mW)	ON	3
-6dBm (0.25mW)	ON	2
-9dBm (0.125mW)	ON	1
-30dBm (1uW)	OFF	4
-33dBm (0.5uW)	OFF	3
-36dBm (0.25uW)	OFF	2
-39dBm (0.125uW)	OFF	1

These are ideal power levels that are not actually constant with frequency. Actual power levels are a function of frequency, as depicted in graph below. This graph is generic but every RF Explorer Signal Generator includes an internal calibration table, produced in the factory at calibration time, with actual values for accurate reading on screen.

RF Explorer Signal Generator RFE6GEN output power typical response
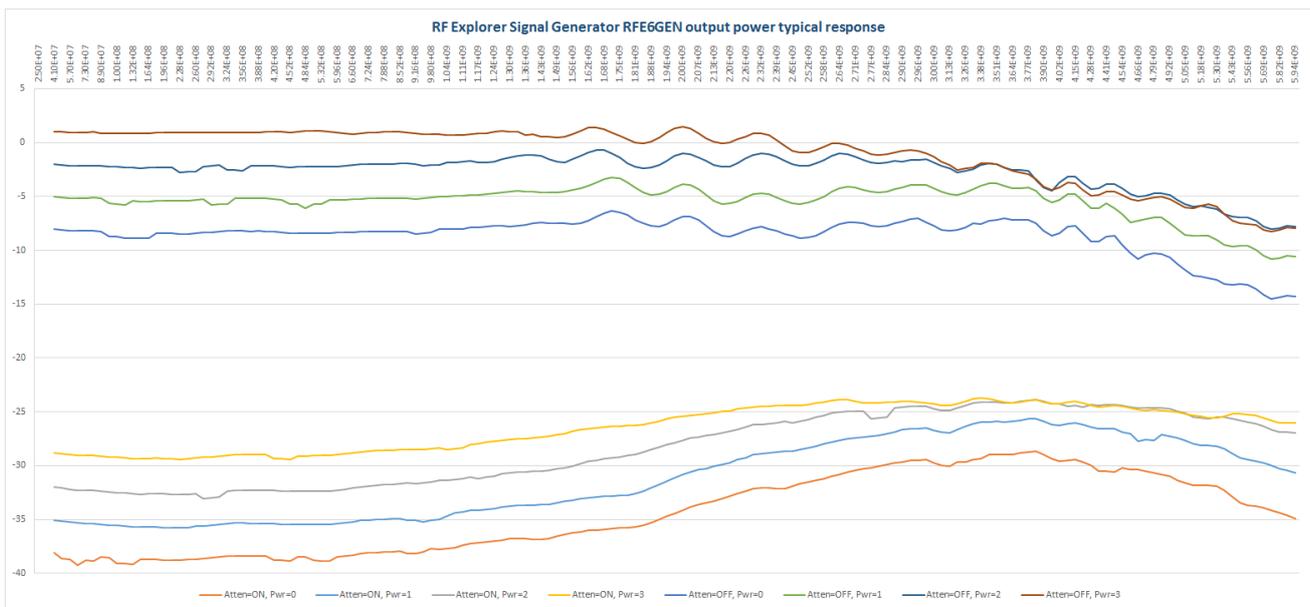
The delivered power levels have a linear response up to about 2GHz, for higher frequencies there are some roll off and power becomes predictable but not constant. The unit is fully calibrated and includes an internal amplitude calibration table to allow accurate power normalization and measurement done in Tracking mode.

The exact power level available on each frequency point is available on screen, as well as in the RF Explorer for Windows application. If you need more details or power level accuracy is important to you, please contact us.

A future Hardware module upgrade, available for connection on the internal expansion port, will allow for additional power modes with finer granularity, higher power values and flat frequency response as an option.

Configuration Menu

- **Backlight**: Several levels of display backlight. RF Explorer has good visibility indoor and outdoor, including direct sunlight. The level of backlight should be the appropriate for each condition, and you may want to limit backlight brightness to preserve battery capacity.
- **Contrast**: There are 10 different display contrast levels to choose from.
- **USB Bauds**: Default is 500Kbps, which is also the recommended setting. In the rare case you experience a problem when connecting with the PC, you may want to change this to 2400bps slower speed. However, this is not recommended as the connection will go really slow, so do this only if there is a good reason to. The port speed in the RF Explorer and PC Client settings must match to properly establish a connection.

Frequency Sweep mode
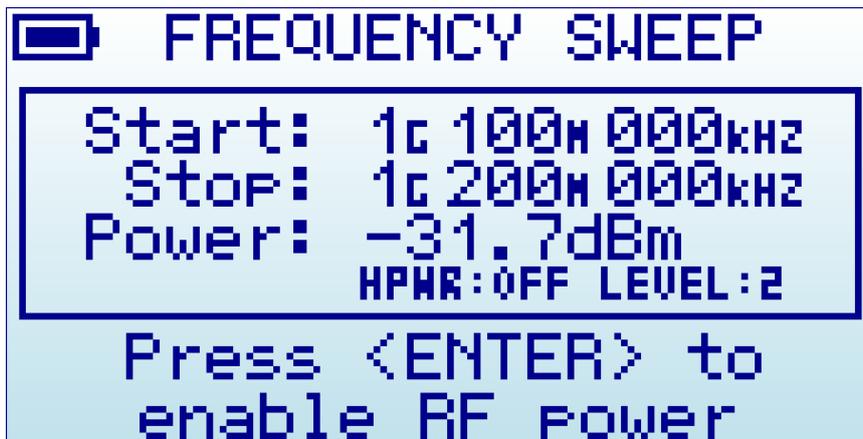
The RF Explorer Signal Generator Frequency Sweep mode allows iterative hops over Start Frequency and Stop Frequency defined by a Step Frequency and a Step delay.

To start the Frequency Sweep, press ENTER key. The Sweep will be active until ENTER is pressed again.
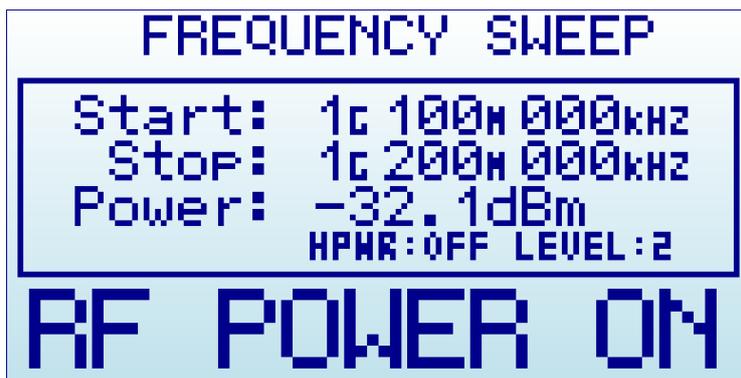
In above example, Frequency Start is 1,100.000MHz and Frequency Stop is 1,200.000MHz. The nominal power level is -31.7dBm with *High Power:OFF* and *Level:2*. Using UP and DOWN button will change power level one step at a time.

The Frequency Step and Step delay used for the sweep is defined in the FREQUENCY MENU.
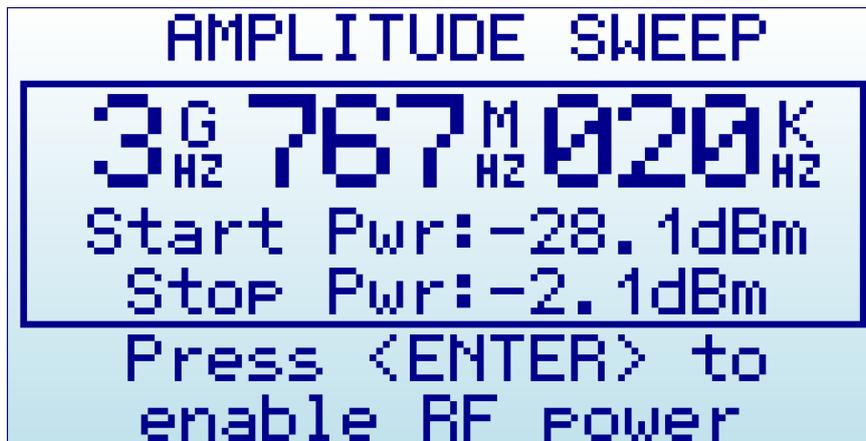
FM modulation

RF Explorer Signal Generator RFE6GEN does not directly create FM or AM modulation signals, but can be easily used to produce low rate modulation including SINAD signals using Frequency Sweep.

For a FM modulation of 1 KHz tone typically used for SINAD, proceed as follows:

- Select the Start Frequency the value you need (e.g. 2.000000GHz)
- Select the Stop Frequency the FM deviation you need. For instance for a 5KHz deviation, set exactly 5KHz above (e.g. 2.000005Ghz)
- Select the Frequency Step same value as FM deviation (e.g. 5KHz)
- Select the Step Delay. For a 1KHz tone, you need 1ms delay, therefore define Step Delay:00.001
- Select RF power you need and start transmission using Frequency Sweep operational mode.
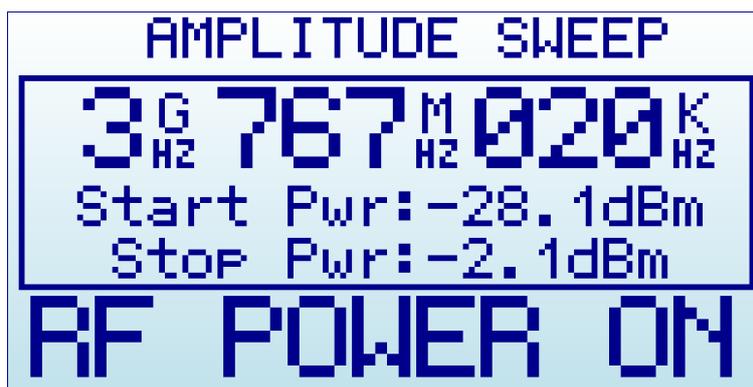
With this technique the highest rate tone generated is 1 KHz (which correspond to 1ms step delay). With a 2ms step delay, frequency tone is 500Hz, etc.

Amplitude Sweep Mode

```
       AMPLITUDE SWEEP
    ┌─────────────────────┐
    │  3 G 767 M 020 K    │
    │    HZ    HZ    HZ   │
    │ Start Pwr:-28.1dBm   │
    │ Stop Pwr:-2.1dBm     │
    └─────────────────────┘
      Press <ENTER> to
      enable RF power
```
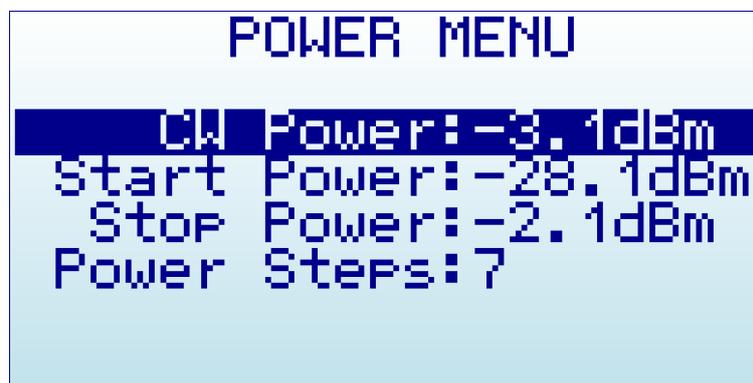
The RF Explorer Signal Generator Amplitude Sweep allows iterative amplitude change at CW frequency using Step delay.

To start the Amplitude Sweep, press ENTER key. The Sweep will be active until ENTER is pressed again.

```
       AMPLITUDE SWEEP
    ┌─────────────────────┐
    │  3 G 767 M 020 K    │
    │    HZ    HZ    HZ   │
    │ Start Pwr:-28.1dBm   │
    │ Stop Pwr:-2.1dBm     │
    └─────────────────────┘
       RF POWER ON
```

Using LEFT and RIGHT buttons the frequency can be decremented/incremented manually, as well as using the Frequency Menu where Step Delay is also configurable.

In above example, amplitude will sweep from -28.1dBm to -2.1dBm at 3,767,020KHz. The amplitude steps used for the sweep is determined for the many power levels between Start/Stop levels, in this case 7 steps total. The number of power levels are displayed in the POWER MENU.

```
         POWER MENU
    ┌─────────────────────┐
    │  CW Power:-3.1dBm   │
    │ Start Power:-28.1dBm │
    │  Stop Power:-2.1dBm  │
    │ Power Steps:7        │
    └─────────────────────┘
```

RF Explorer internal battery

The internal battery is a high capacity Lithium-ion polymer 1000mAh. This is the same battery technology used in cell phones and modern laptops and tablet computers.

The power switch is a *true hard switch* connecting the battery in ON position, fully isolating the battery in the OFF position. As the battery is fully disconnected in the OFF position, you can keep your RF Explorer stored for months and the battery will keep the charge intact, as opposed to cell phones or laptops which typically implement a *soft switch* which slowly discharge the battery by drawing a microamperes continuously from it. This doesn't happen in your RF Explorer.

We designed RF Explorer power circuitry in a way you can always have your RF Explorer ready to use!

Note there is actually a self-discharge effect in the battery but it is so negligible that you can store your device for a year or more and a battery will not be depleted.

IMPORTANT

Never charge your device unattended or in any place where there is a risk of fire.

Never store RF Explorer in a place where temperature may go beyond 50ºC (122F). A car can heat up incredibly quickly in the *sun*, especially in the summer, and damage or reduce the lifetime of your battery if stored in such an environment.

If you manipulate RF Explorer to assemble an Expansion Module, always proceed very carefully with the Lithium Ion battery and make sure it is not punctured, damaged or inflated in any way. A healthy battery is a flat rectangle with no signs of any deformation. If you have any doubt, please take a picture of your unit and send it to us for further help.

If your battery doesn't seem to hold a charge or work properly, or if the unit gets hot when charging, switch the power button OFF immediately and review and/or replace your battery.

Never use RF Explorer with a damaged battery or with a Lithium Ion battery different than the one officially supplied by technical service, which includes a protection circuit for safety. Contact QC@SeeedStudio.com if you have any question on any matter related with your battery or if you need a replacement.

Charging the internal battery

To charge the internal battery, plug it in to a powered USB port or USB wall-wart charger via the USB mini socket. For the internal charger to access the battery, you must set the power switch to ON position, otherwise the device will be running from USB but will not use or charge the internal battery.

RF Explorer may draw up to 500mA according to USB standard, and may take up to 3hs max to charge a fully discharged battery in normal conditions. We recommend the first time to be charged for up to 8hs.

It is ok having the battery connected forever to the USB port, the internal charger will stop and start the charge when needed.

If your USB port is unpowered it may not be capable of delivering more than 100mA; the battery may not be charged at all. If you have no other option available than a 100mA USB port, set the LCD backlight to OFF in the OPTIONS MENU and keep charging for as long as needed (it may take up to 24hs in these conditions so you should use a powered USB port whenever possible).

## Using the Battery dedicated screen

In latest firmware versions, you can use the specific Battery menu option for better battery charge control. Note: As long as the USB is connected and the power switch is in the ON position, the battery will charge. However, you can get additional information when using the Battery specific menu.


Inside this INTERNAL BATTERY charger screen, it is easier to realize if the battery is being charged. In this case below, it clearly indicates the power switch is not in the ON position and, therefore, battery is not being charged.
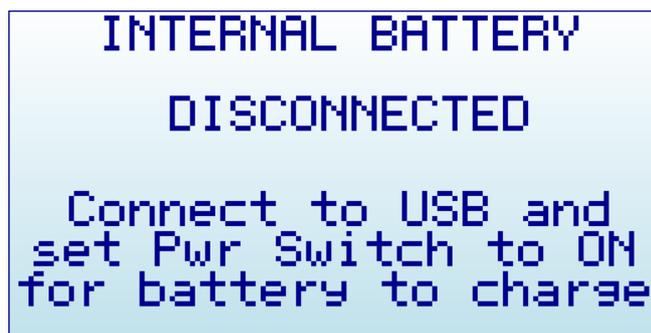

As soon as the power switch is set to the correct position, the screen will display correct charging status.

```
        INTERNAL BATTERY
       BATTERY LEVEL:73%
          CHARGING
```

At this point you can close this screen pressing ENTER or RETURN. If you keep it active for more than 15 seconds, it automatically sets the device in SLEEP MODE - all internal circuits and LCD backlight go off, except for charging and minimal CPU monitoring - This is the recommended procedure to charge the device overnight. Note: for the sake of clarity, below black/white screen images are depicted when LCD backlight is OFF.

```
       INTERNAL BATTERY
      BATTERY LEVEL:99%
         CHARGING
         SLEEP MODE
```
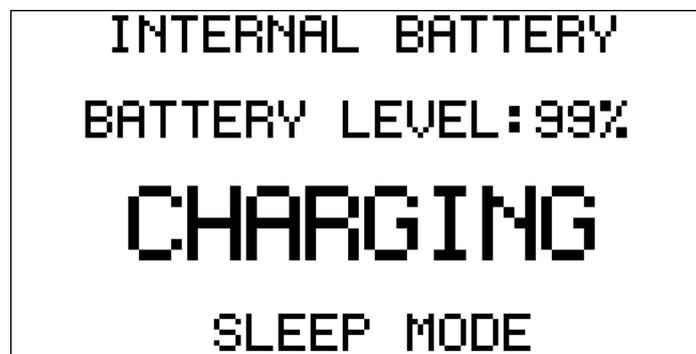
In this mode you can stop charging whenever the device reaches 99% or 100%, which may take up to 2 or 3 hours under normal condition and depending on initial battery charge level. When the charging algorithm detects the battery fully charged and a minimum of 2hs connected, it will suggest disconnecting the USB cable.

```
       INTERNAL BATTERY
      BATTERY LEVEL:99%
        DISCONNECT USB

         SLEEP MODE
```
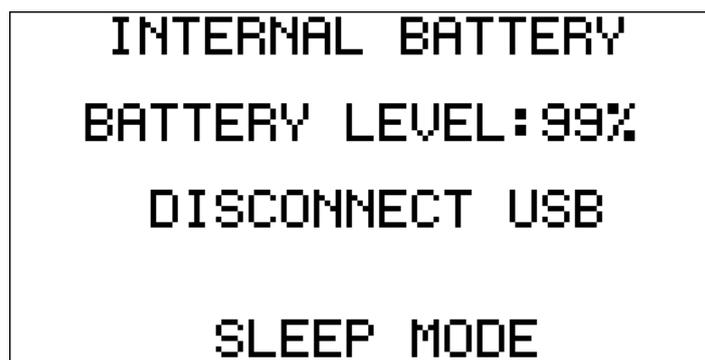
Calibrating the battery capacity

The INTERNAL BATTERY screen, at this point, can re-calibrate the available battery power level. This is a useful feature to adjust what reference voltage the internal charger considers 100% capacity. This reference is subject to change over time as the internal battery reduces total capacity over many charge cycles. As a reference, 500 charge cycles will typically reduce the total battery capacity about 30% - in order for this new