



# ***RF Explorer®***

## **Signal Generator Combo**

**&**

## **Signal Generator RFE6GEN baseline**

### **User Manual**

**Updated to Firmware Version 1.35**

# *RF Explorer*<sup>®</sup>

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.*

Updates of the RF Explorer User Manual are [available online](#).



*Please consider the environment before printing this document.*

## Table of Contents

Introduction.....	5
Description of main features.....	6
Feature .....	6
Specifications.....	7
Connecting RF Explorer Signal Generator .....	9
Signal Generator CW mode - Main Screen.....	11
Combo enhanced model .....	11
Baseline model .....	13
Using the keyboard.....	14
Using menus.....	16
Operational Mode menu .....	18
Frequency Menu.....	20
Power Menu (Combo model).....	21
Power Levels (Combo model).....	21
Power Menu (baseline model) .....	23
Power Levels (baseline model).....	23
Configuration Menu .....	25
Frequency Sweep mode .....	26
FM modulation .....	27
Amplitude Sweep Mode .....	28
Tracking with Scalar Network Analyzer.....	30
Harmonics filtering.....	32
Spurious and Phase Noise .....	37
RF Explorer internal battery .....	38
Charging the internal battery .....	38
Using the Battery dedicated screen .....	39
Charging a fully depleted battery.....	41
Automatic idle mode with battery charge .....	41
Expansion Modules .....	42
Protecting your instrument from damage .....	43
RF Explorer Holder.....	44
RF Explorer accessories .....	45

SMA-BNC adapter SMA Plug to BNC Jack straight .....	45
SMA-N adapter SMA Plug to N Jack straight .....	45
RF Adapter RP-SMA Jack to SMA Plug straight-long version.....	46
SMA adapter SMA Plug to SMA Jack right angle .....	46
SMA connection cables .....	47
10cm length - SMA male to SMA female 6GHz coaxial cable.....	47
10cm length - SMA male to SMA male 6GHz coaxial cable.....	47
50cm length - SMA male to SMA female RF pigtail Coaxial Cable RG316.....	48
50cm length - SMA male to SMA male plug pigtail cable RG316.....	48
Attenuators.....	49
6GHz SMA Attenuator – 60dB .....	49
6GHz SMA Attenuator - 10dB.....	50
6GHz SMA Attenuator - 30dB.....	50
SMA Male/Female Adaptor .....	51
SMA Termination – 50 ohm dummy load .....	51
Connecting RF Explorer to a computer .....	52
API programming specification for RF Explorer .....	52
RF Explorer for Windows open source code .....	52
Specifications.....	53
Acknowledgments .....	53
FCC and CE regulations.....	53
License .....	53

## 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 support page

[support.rf-explorer.com](http://support.rf-explorer.com)

## 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.

*RF Explorer Signal Generator Combo* extend capabilities of baseline RFE6Gen model by expanding power and frequency range, including efficient wideband harmonic filtering in a compact handheld device. An expansion board is available to easily upgrade baseline RFE6Gen into a Combo model.

## Feature

- ✓ Pocket size and light weight
- ✓ Solid aluminum metal case
- ✓ Lifetime free firmware upgrades available, open to community requested features
- ✓ High capacity Lithium for 10hs+ of continuous run, rechargeable by USB
- ✓ RF Explorer for Windows free software download
- ✓ Can be extended with internal Expansion Modules for additional power range, frequency band support and functionality
- ✓ Wide band support for CW signal, Frequency and Amplitude Sweep, and advanced Tracking SNA.

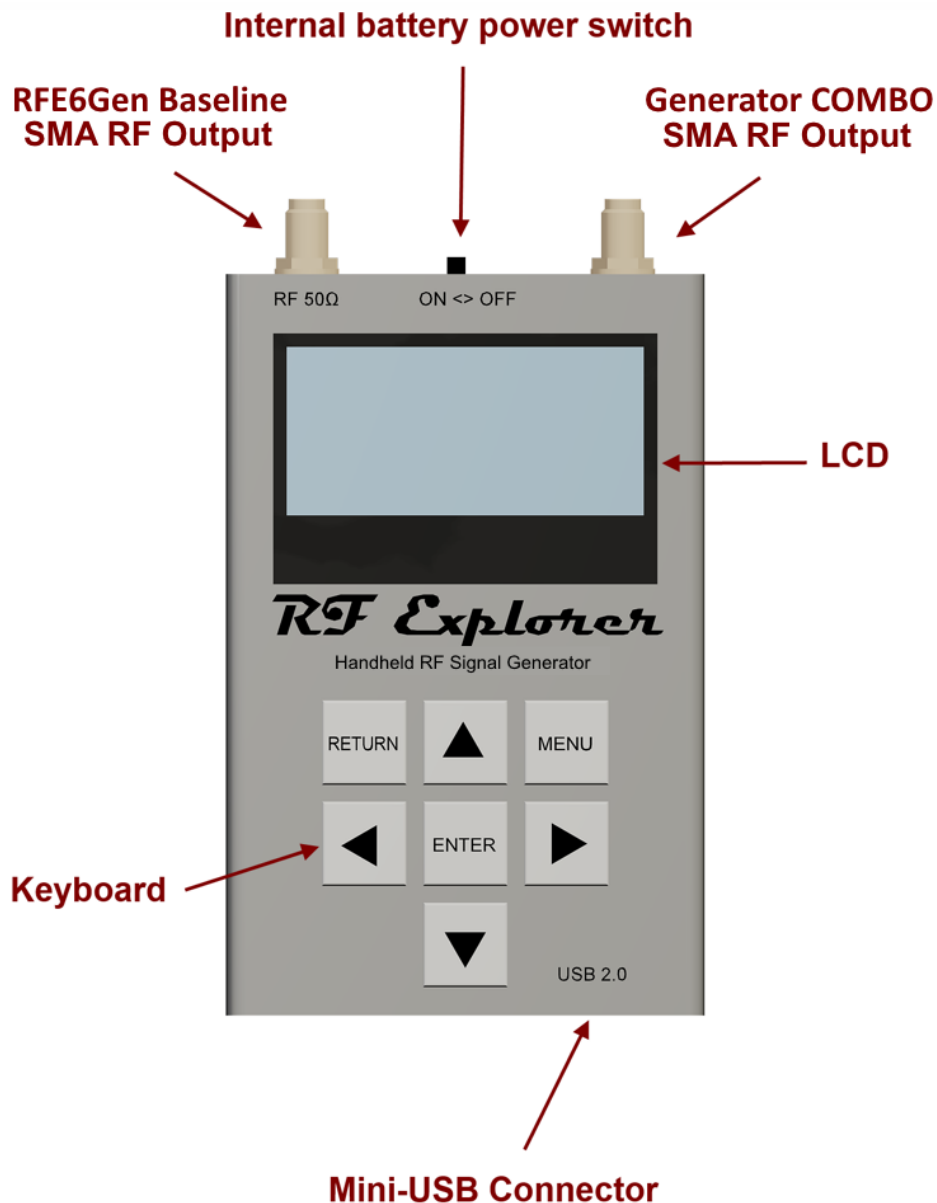
## Specifications

Parameter	Combo Signal Generator	Baseline Signal Generator	Notes
Frequency range	100KHz to 6GHz	23.4MHz to 6GHz	
Frequency step/resolution	1KHz	1KHz	
Frequency stability	100KHz to 250MHz: ±5ppm 250MHz to 6GHz: ±0.5ppm	±0.5ppm	
Frequency accuracy (internal reference)	100KHz to 250MHz: ±10ppm 250MHz to 6GHz: ±1ppm	±1ppm	
Output power range	Calibrated: -40 to +10dBm Uncalibrated: -60 to +18dBm	40dBm to -30dBm in 3dB steps -10dBm to 0dBm in 3dB steps	See section <i>Power Levels (Combo model)</i>
Output power resolution	0.25dB	3dB	
Output power accuracy	Typical ±1.5dB	Typical ±3dB	See section <i>Power Levels (Combo model)</i>
Output power stability	Typical ±0.5dB	Typical ±0.5dB	
Output amplitude settling time	500uS	500uS	Temporary spurious may be present while signal settles
Output protection	25VDC	25VDC	
Harmonics	Typical -40dBc	Typical -10dBc	See section <i>Harmonics filtering</i>
Spurious	Typical less than -52dBc	Typical less than -50dBc	See section <i>Spurious and Phase Noise</i>
Phase Noise	Typical less than -125dBc/Hz on 1MHz at 1GHz	Typical less than -125dBc/Hz on 1MHz at 1GHz	See section <i>Spurious and Phase Noise</i>
Frequency Sweep settling	< 5ms	< 5ms	
Amplitude Sweep settling	< 500uS	< 500uS	
Sweep hops range	unlimited	unlimited	
Functional modes	CW Frequency Sweep Amplitude Sweep Tracking SNA	CW Frequency Sweep Amplitude Sweep Tracking SNA	Tracking requires a Windows PC computer and RF Explorer Spectrum Analyzer
Operating temperature	5-35C	0-45C	

Connector type	SMA 50 ohms	SMA 50 ohms	
Display	Graphics LCD 128x64 pixels	Graphics LCD 128x64 pixels	Excellent visibility outdoors with sunlight
Backlight	5 levels	5 levels	Excellent visibility indoors
Weight	205g	185g	
Size	113x70x25 mm	113x70x25 mm	
Programmable	USB generic API Python API .NET API	USB generic API Python API .NET API	
Software	Windows PC	Windows PC	Free download
Certification	CE/FCC/RoHS/MSDS	CE/FCC/RoHS/MSDS	



## Connecting RF Explorer Signal Generator



The unit includes 50 ohm impedance RF connector standard SMA format.

- The RFE6Gen **baseline model** includes only one connector, the RF SMA on the left in the above image. This manual will indicate specifics for this model whenever is different from Combo model.
- The RF Explorer Signal Generator **Combo model** includes two SMA connectors, but only the enhanced functionality of the SMA connector on the right side is enabled. A future firmware may enable both connectors to allow double signal source but with different capabilities. It is recommended covering the left SMA connector with a dummy load 50ohm for better protection.

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 45.

## 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.

**IMPORTANT**

**You must have connected a 50 ohm antenna or RF load before you switch your transmitter ON.**

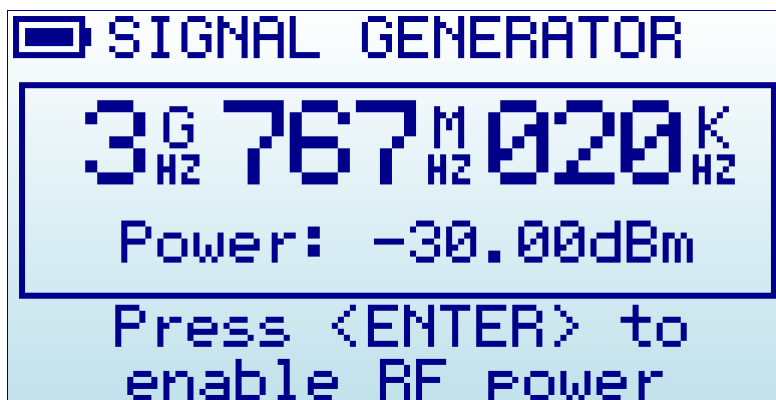
If you switch the transmitter ON without a proper load, you may damage the RF module of your RF Explorer Signal Generator, as the power amplifier will not have a load to feed. Think of the equivalent to an audio amplifier running at full power with no speakers connected: you are likely damaging the power 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.

### Combo enhanced model

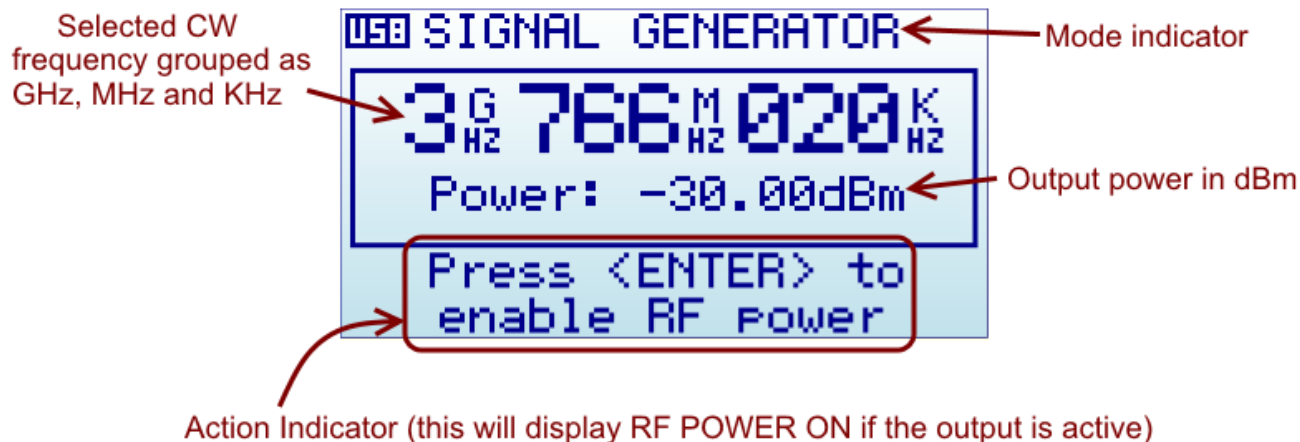
The below screen is an example of a RF signal generator mode configured at 3.767020GHz. This is organized visually in GHz, MHz and KHz for easy reading.

The power level is selectable with 0.25dB precision, amplitude level on screen is fine selectable from Power Menu option.



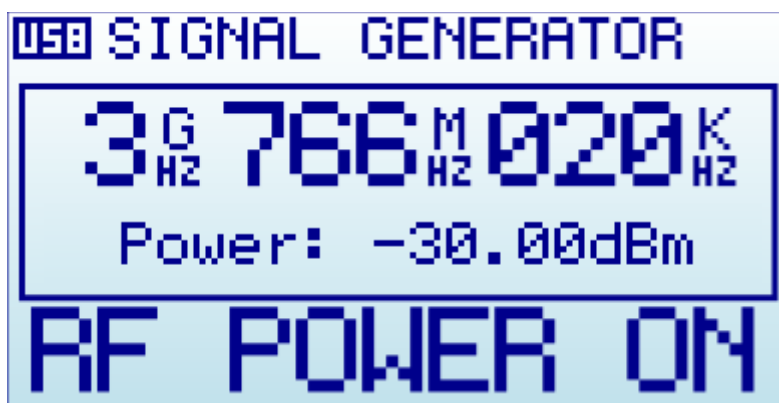
All elements on screen are important parameters to understand how the Signal Generator is working at any given time. In this advanced model the power selected in Menu is exactly the same as shown in screen.

## RF Signal Generator Main Screen



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.
- **Power Level:** This is the actual output power selected in Power Menu for CW. With selective value as fine as 0.25dB this can go in ranges from -60 to +20dBm, but only -40 to +10dBm are calibrated ranges. Note: an upgrade firmware will display a special mark to indicate calibrated vs uncalibrated range.
- **Action Indicator (current power mode):** The Signal Generator display the current status of 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.

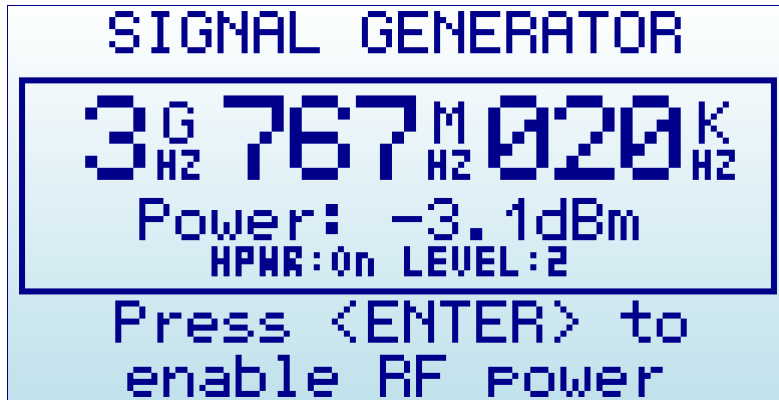


Please note standard precaution of RF power delivered without a connected load.

## Baseline model

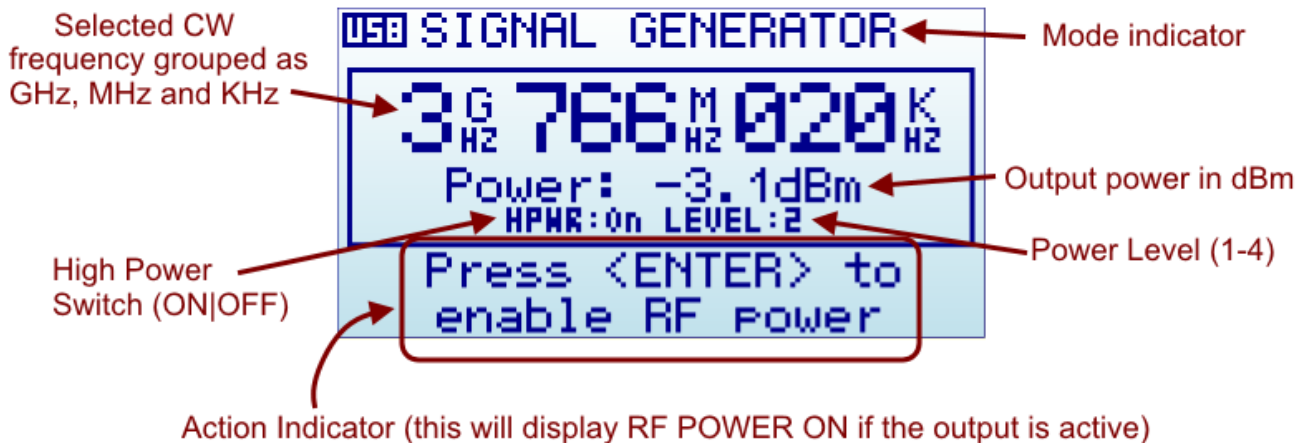
The below screen is an example of a RF signal generator mode configured at 3.767020GHz. This is organized visually in GHz, MHz and KHz for easy reading.

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. In the baseline model (non Combo) model the power level is one of the possible 8 selectable values from Menu.

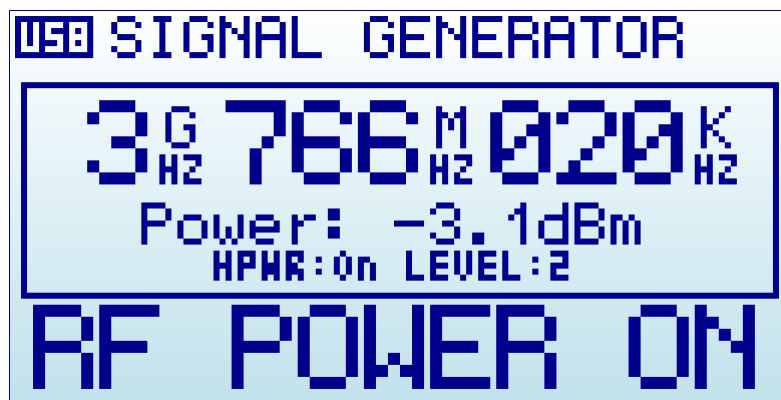
RF Signal Generator Main Screen



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 4 steps available. When combined with the internal attenuator, a total of 8 possible power values can be selected.
- **Action Indicator (current power mode):** The Signal Generator display the current status of 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.

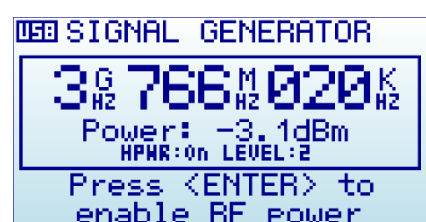
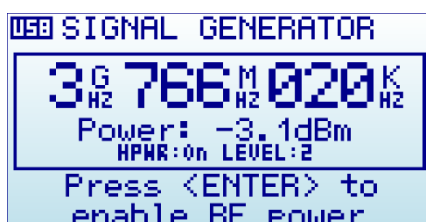
## Using the keyboard

In the RF SIGNAL GENERATOR mode screen, the keyboard can be used for easy and convenient tasks as described below:

- Using ENTER key enables and disables RF output power
- 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 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 every time 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:



- Using buttons UP and DOWN on this screen will increase or decrease the selected RF power, one step at a time. It works slightly different depending on the Signal Generator model.

**Combo model:** For instance, if the unit is at -30.00dBm and the Power Step is defined at 2.5dBm in POWER MENU, click on UP button once will increase to -27.50dBm, a second click will increase to -25.00dBm, etc. A click on DOWN button will decrease power by the defined step.

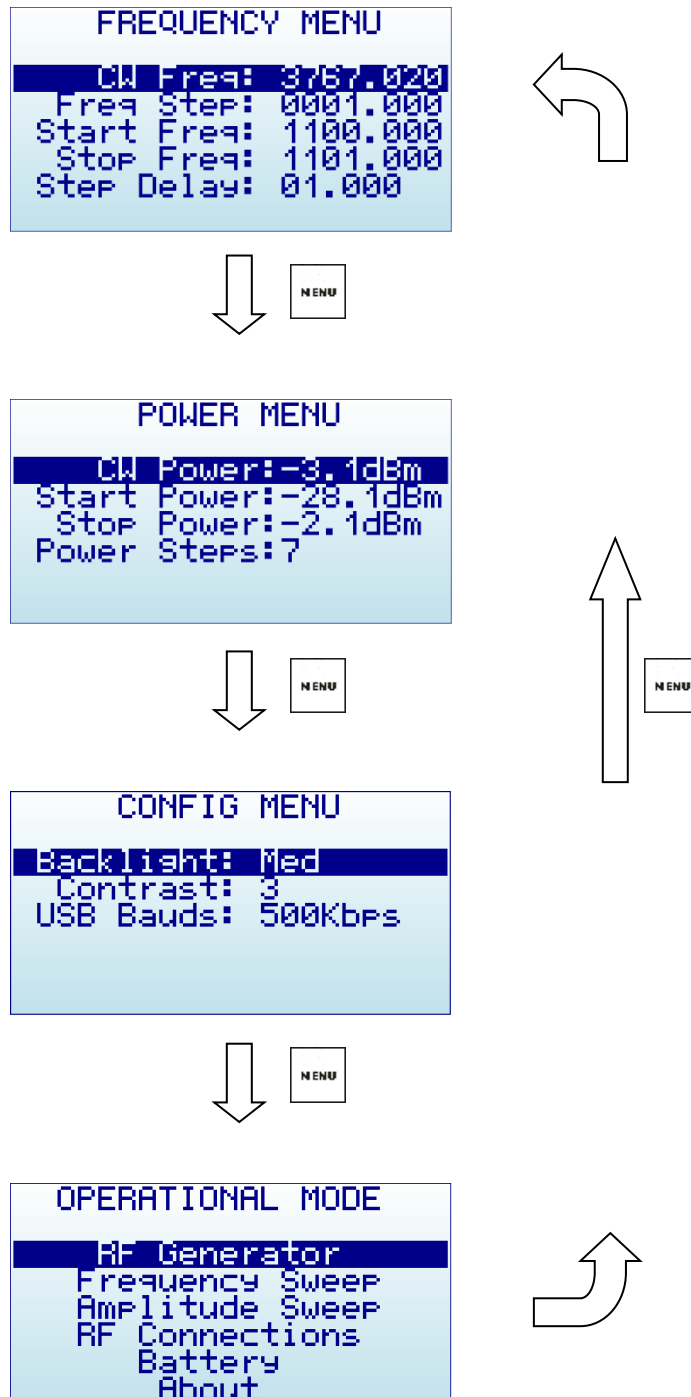
Note: The level is increased up to a maximum of +15dBm and then will circle back to -60dBm. The opposite is also the case when using DOWN button to -60dBm will circle back to +15dBm.

**Baseline model:** 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.

Note: 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 section *Power Menu (baseline model)* on page 23 for more details on power level modes.

## 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:



Optionally, you can use the [Left] and [Right] keys to go from one screen to another.

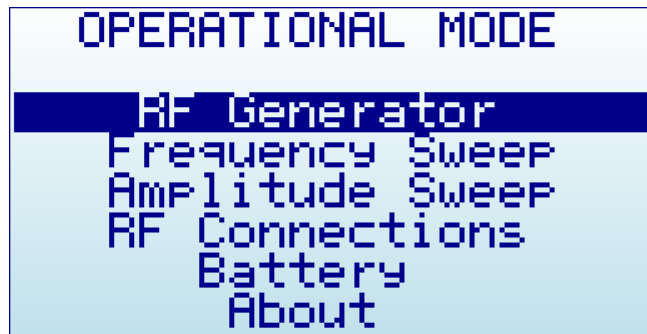
You can exit from a menu anytime by using the [Return] key.



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.

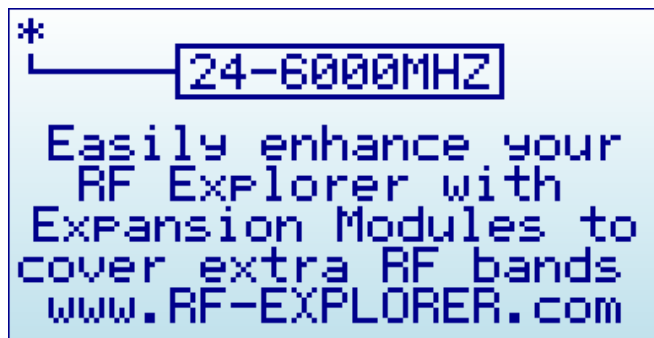
## Operational Mode menu

The menu displays 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 baseline model with 24 to 6000MHz. Click on any key to get out of this screen.



With RF Explorer Signal Generator Expansion board installed (Combo model) the screen will display this information:

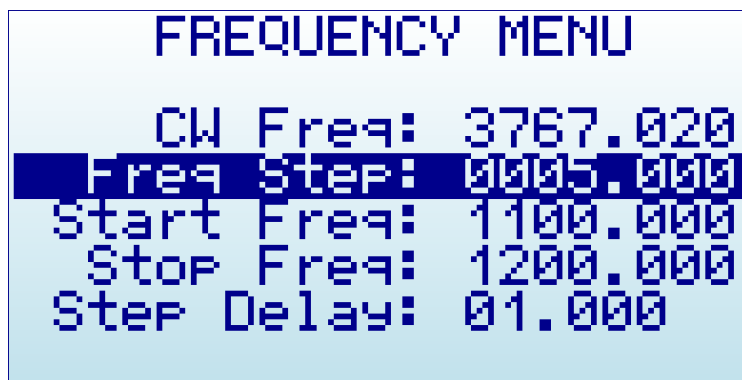


- **Battery** includes details on internal battery charge level, and assist you on charging the unit when connected to USB. For more details read section *Charging the internal battery* in page 38.
- **About** displays information about installed firmware and versioning. Use any key to get out of this screen.



```
RF Explorer  
Signal Generator  
S/N: B3AA76L76MB9BM6E  
ver 01.17 27-Feb-17  
www.rf-explorer.com
```

## 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.

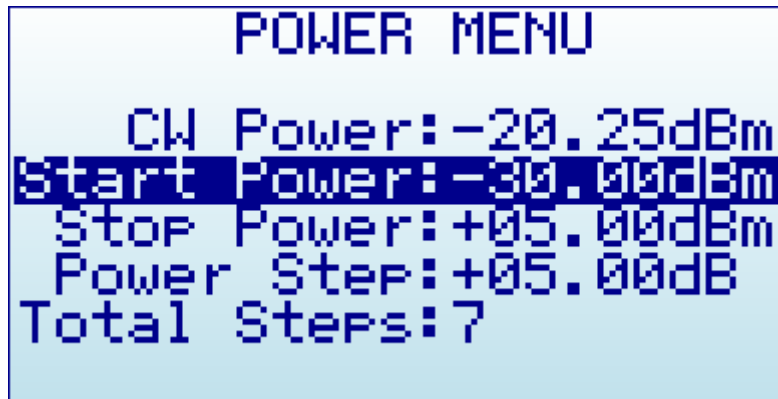
In above example screen:

- 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 (Combo model)

The RF Explorer Signal Generator Combo model is able to specify output power signal with 0.25dB resolution.

Values are selectable from -60 dBm to +15 dBm, but only -40 dBm to +10 dBm are **calibrated** as per description in section below. A future firmware upgrade will show calibration information more explicitly.



- **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 Step:** Selected step in dB
- **Total Steps:** number of steps used in Amplitude Sweep, automatically calculated based on  
$$\text{Total Steps: } (\text{Start} - \text{Stop}) / \text{Step}$$
power settings. As an example, on picture above, the Power step is defined as 5dB, and being Start-Stop = -30 – 5 = -35, therefore 7 steps are automatically calculated.

## Power Levels (Combo model)

The RF Explorer Signal Generator Combo model delivers output power signal in the nominal range -60 to +15dBm. The range is calibrated by bench laboratory grade instruments, sampling 600 measurement points, and is suitable in the range -40 to +10dBm. Output signals outside this range will not perform with the same linearity and accuracy as within the calibrated range.

The calibrated range accuracy is described in next table. Uncalibrated or out-of-range power levels are described as “n/a”. In these ranges the device can be used but output power level may not be accurate.

RF Explorer Signal Generator Combo – output power accuracy			
Frequency range (MHz)	Power range (dBm)	Typical Accuracy (dB)	Worst case Accuracy (dB)
0.1 to 1	-40 to 0	±2	±5
	0 to +10	n/a	n/a
1 to 10	-40 to 0	±1	±2.5
	0 to +10	n/a	n/a
10 to 1950	-40 to -10	±1	±2.5
	-10 to +10	±1.5	±3.5
1950 to 3600	-30 to +10	±1	±2.5
3600 to 5200	-30 to +10	±1.5	±3
5200 to 6000	-30 to 0	±2	±4
	0 to +10	n/a	n/a

Future firmware upgrade will increase accuracy in some frequency and power ranges using internal calibration table adjusted in factory.

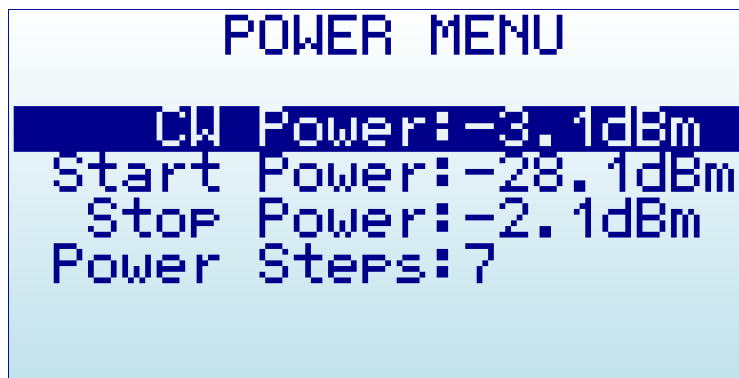
An optional software process will be available to manually calibrate the device and adjust for amplitude deviation. [Contact us](#) for additional details.

Absolute maximum and minimum power levels available are described in next table. Note these levels are not guaranteed and not calibrated.

RF Explorer Signal Generator Combo – Absolute output power range		
Frequency range (MHz)	Minimum output power (dBm)	Maximum output power (dBm)
0.1 to 1	-60	0
1 to 10	-60	+5
10 to 3200	-60	+15
3200 to 3650	-60	+10
3600 to 5200	-60	+15
5200 to 6000	-60	0

## Power Menu (baseline model)

The baseline model has limited power levels available when compared to the Combo model.



- **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.

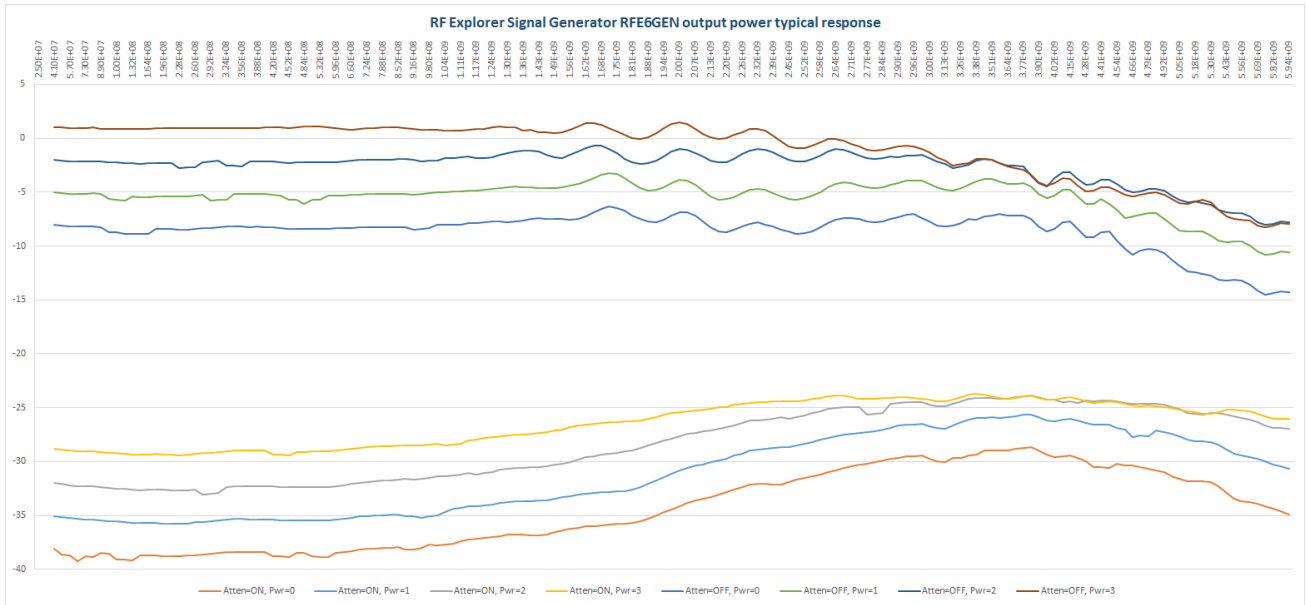
To navigate through the menu, just use [Up] and [Down] keys to go to the option you want, then click on [Enter] as many times as required to change the power value. The Power Steps setting is not editable (automatically calculated).

## Power Levels (baseline model)

The RF Explorer Signal Generator baseline model 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.

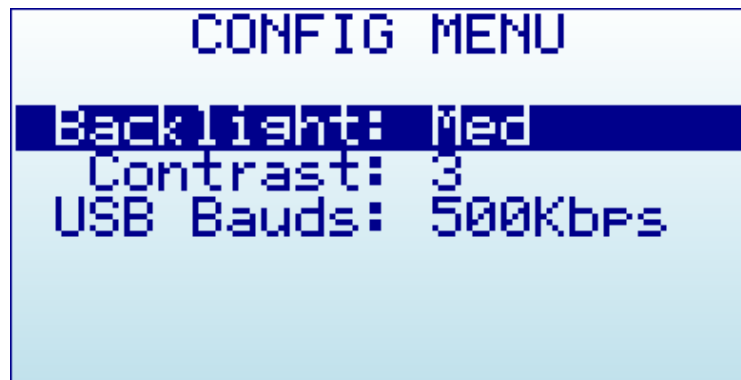


The delivered power levels have a linear response up to about 2GHz, for higher frequencies there are some roll off and power becomes predictable but not constant. The unit is fully calibrated and includes an internal amplitude calibration table to allow accurate power normalization and measurement done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



## Configuration Menu

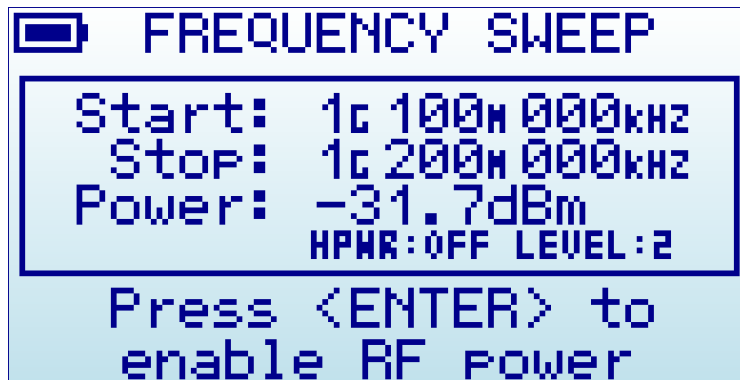


- **Backlight:** Several levels of display backlight. RF Explorer has good visibility indoor and outdoor, including direct sunlight. The level of backlight should be the appropriate for each condition, and you may want to limit backlight brightness to preserve battery capacity.
- **Contrast:** There 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.

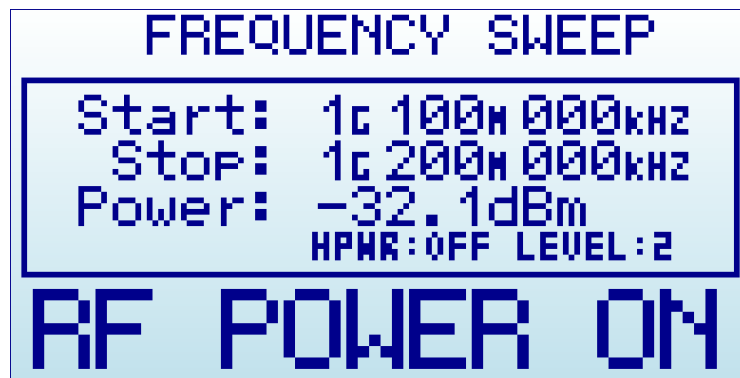
## Frequency Sweep mode

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.

Signal Generator RFE6GEN baseline model offers power levels limited to 8 values, whereas Combo model offers advanced power selection with 0.25dB resolution, as described in *Power Menu (Combo model)* section. Power screens below are depicted for RFE6GEN baseline model but are equivalent for Combo model.

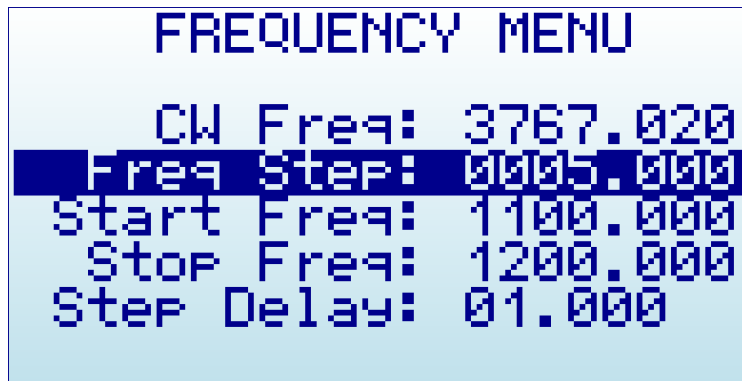


To start the Frequency Sweep, press ENTER key. The Sweep will be active until ENTER is pressed again.



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:

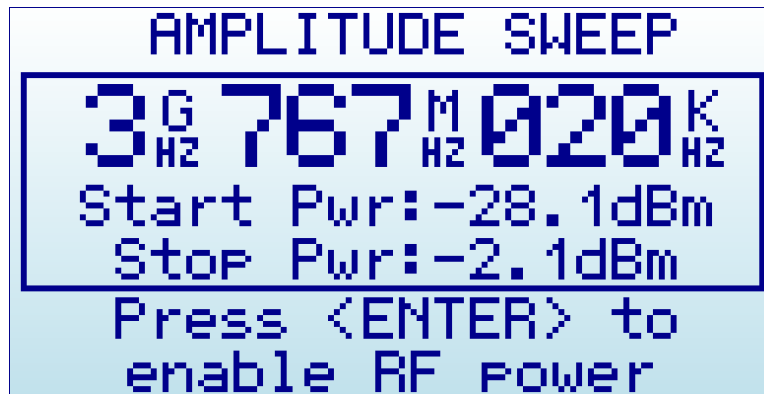
- Select the Start Frequency the value you need (e.g. 2.000000GHz)
- Select the Stop Frequency the FM deviation you need. For instance, for a 5KHz deviation, set exactly 5KHz above (e.g. 2.000005Ghz)
- Select the Frequency Step same value as FM deviation (e.g. 5KHz)
- Select the Step Delay. For a 1KHz 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.

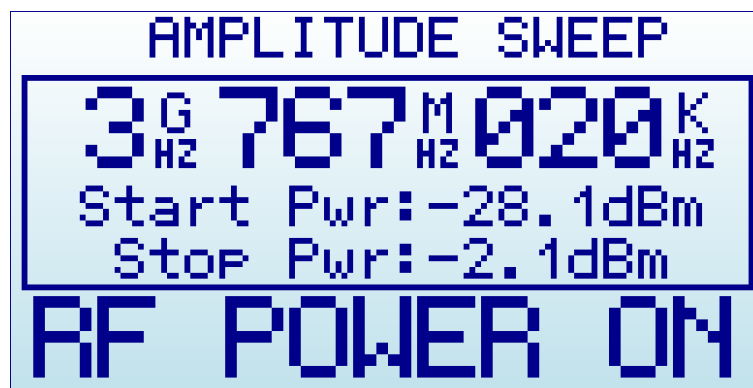
## Amplitude Sweep Mode

The RF Explorer Signal Generator Amplitude Sweep allows iterative amplitude change at CW frequency using Step delay.

Signal Generator RFE6GEN baseline model offers power levels limited to 8 values, whereas Combo model offers advanced power selection with 0.25dB resolution, as described in *Power Menu (Combo model)* section. Power screens below are depicted for RFE6GEN baseline model but are equivalent for Combo model.



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



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

<b>CW</b>	<b>Power: -3.1dBm</b>
Start	Power: -28.1dBm
Stop	Power: -2.1dBm
Power	Steps: 7

## Tracking with Scalar Network Analyzer

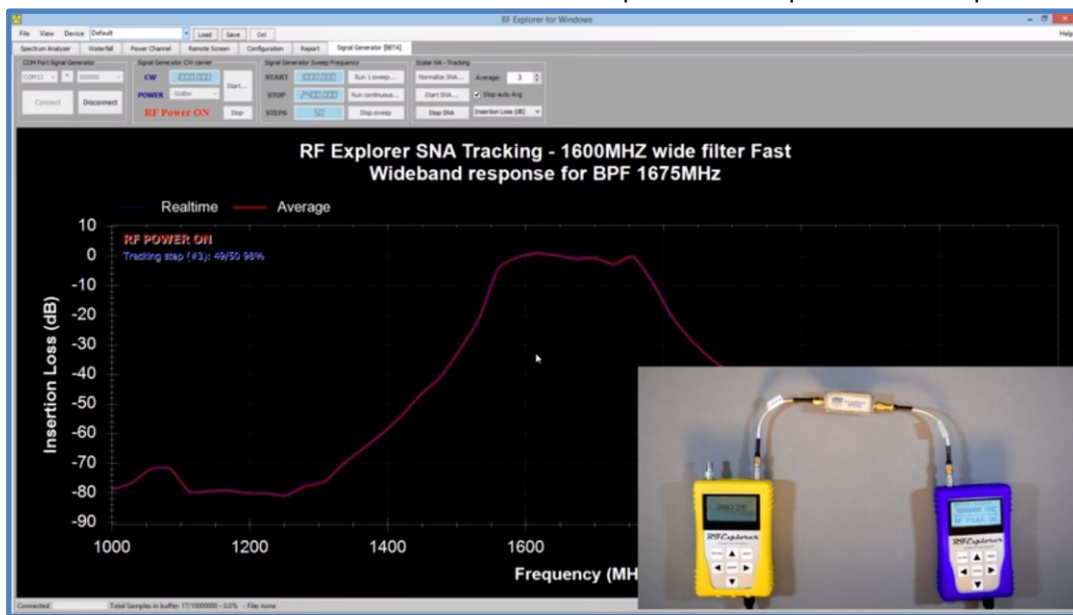
An advanced functionality available when combining RF Explorer Spectrum Analyzer and RF Explorer Signal Generator is to enable Tracking SNA (Scalar Network Analyzer) to efficiently characterize RF devices and circuits such as Filters and Amplifiers.

Both models RF Explorer Signal Generator Combo and RFE6GEN baseline model can be used to perform tracking, but the Combo model can cover lower frequency range starting at 100KHz which makes it an extremely wideband device for a fraction of a bench lab tracking device.

To learn step by step Tracking SNA with RF Explorer please follow these online tutorials:

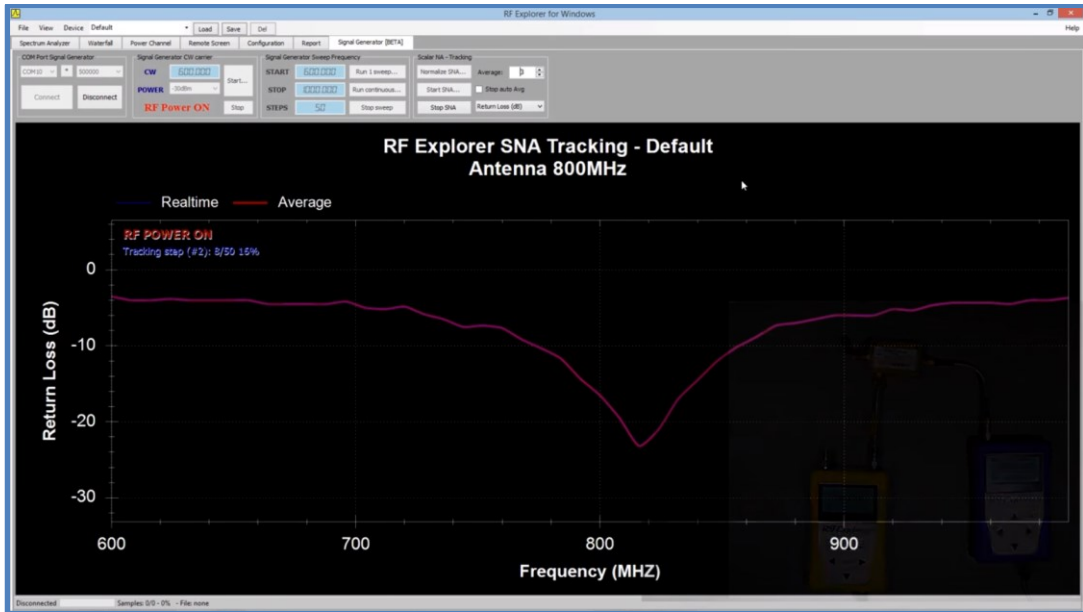
- **SNA Measuring RF Filter response** [link](#)

This tutorial describes how to measure filters or amplifiers and explains how S21 parameter works



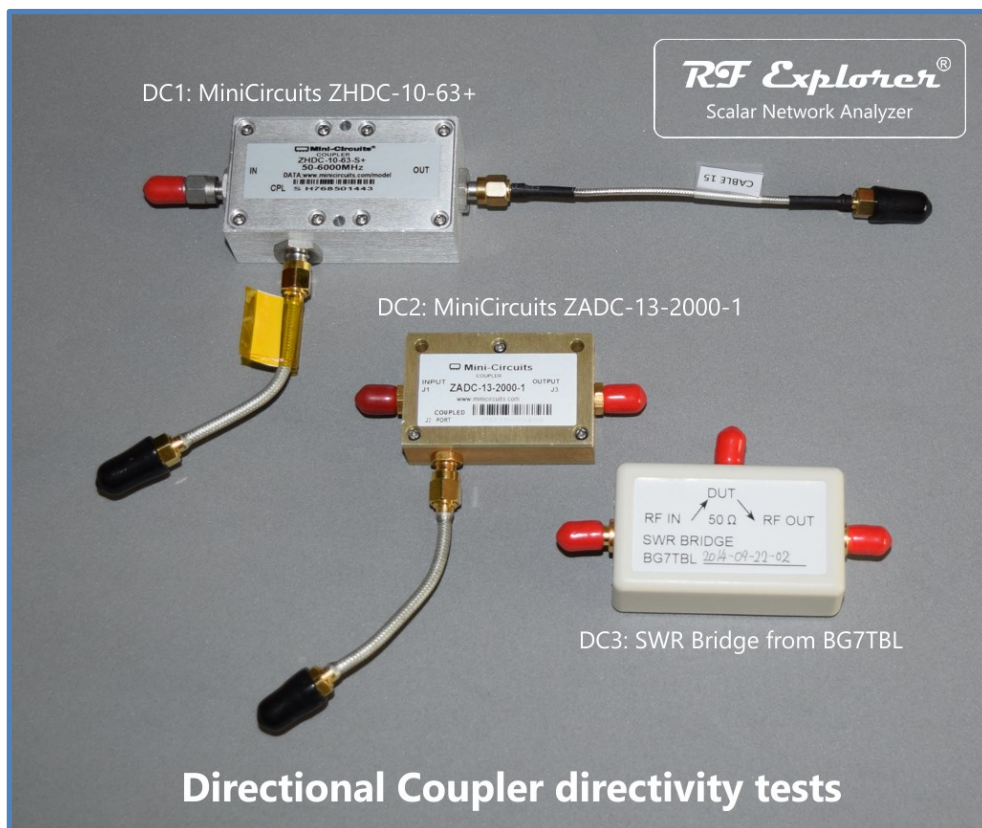
- **SNA Measuring Reflection - Return Loss** [link](#)

This tutorial describes how to use a directional coupler to measure return loss and describe how S11 parameter works



- **Measure Directivity of Directional Couplers** [link](#)

This tutorial walks through different directional coupler options and how to select the best, cost efficient one for the return loss measurement you need



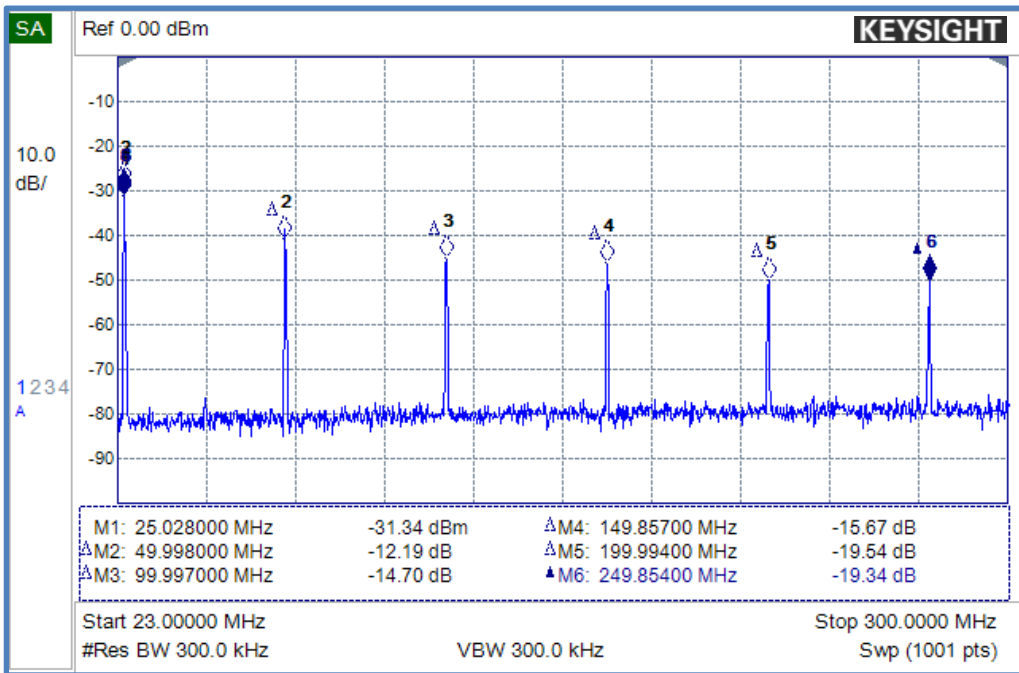
## Harmonics filtering

Harmonics are integer multiple frequencies of the main CW output frequency, and is a common sub-product of RF circuits of all kinds. In some cases, the harmonics are intended useful output signal but, in most cases, they are undesired and can cause intermodulation and false output reading in Spectrum Analyzers.

RF Explorer Signal Generator RFE6GEN baseline includes no internal harmonic filtering, and is intended for use in Tracking SNA and other purposes where harmonics are not an issue. Specifically tracking uses an iterative, computer control sweep where the harmonics are fully ignored and have no side effect, making RFE6GEN the lower cost option to perform these tasks.

For more demanding uses where harmonic signals are not welcome, the RF Explorer Signal Generator Combo model includes a sophisticated yet compact filter bank to significantly reduce the output power of harmonic signals.

An example of the improvement offered by the Combo model is depicted below:



Example output signal including harmonics from a 25MHz CW signal in RFE6GEN baseline model.

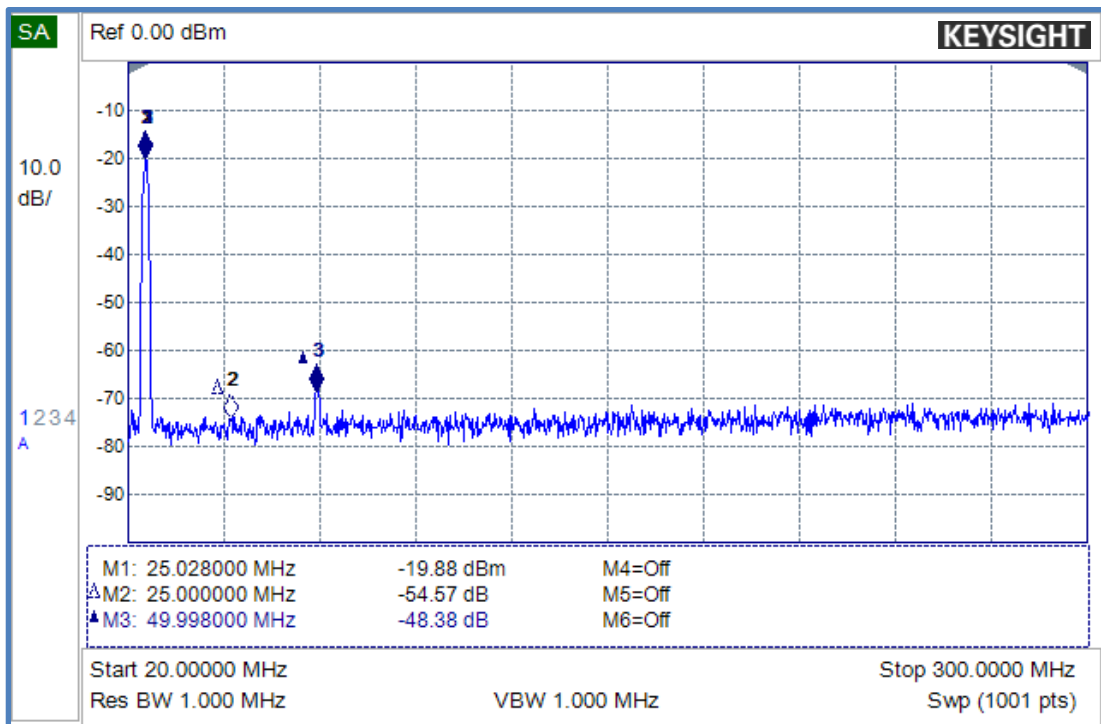
Note odd value harmonics 3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup>, etc are in range of -12 to -19dBc

These signals are not an issue when using Tracking SNA but may be undesired in other scenarios.

As comparison the output signal from the new filtered Combo model is depicted below.

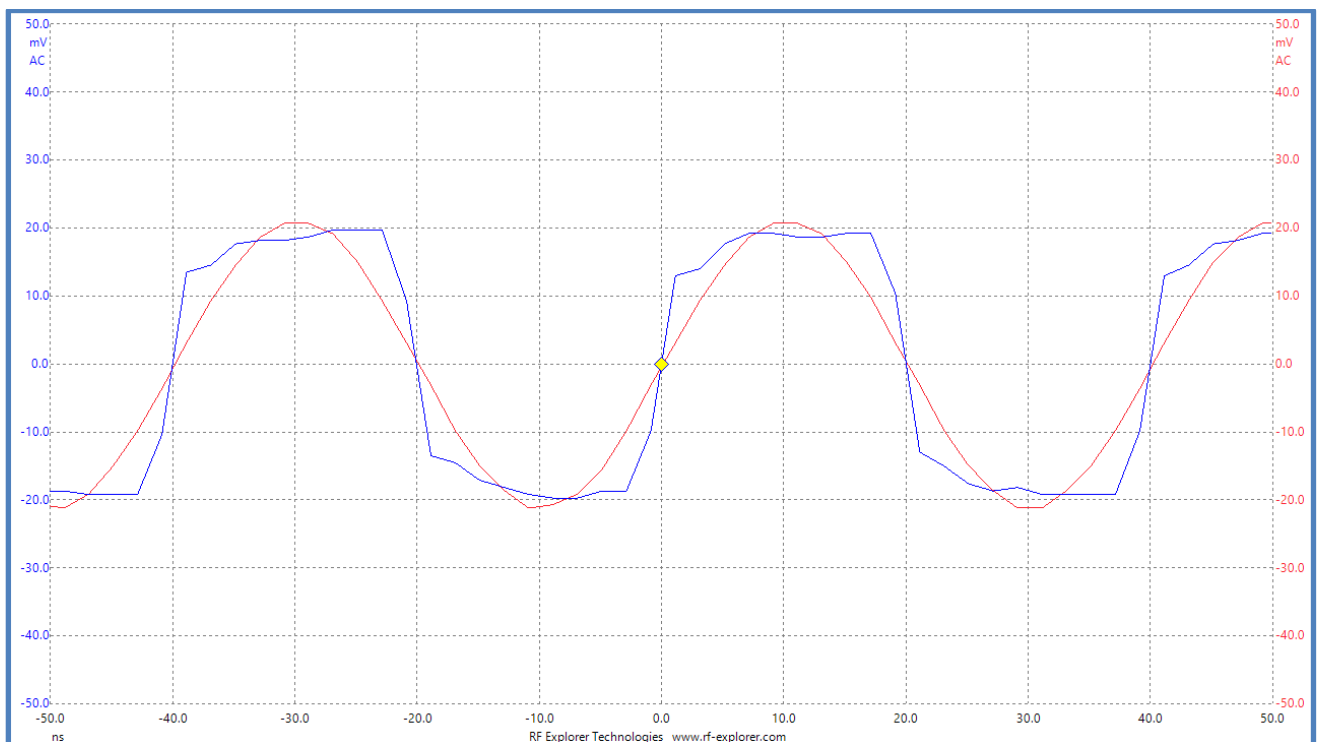
Note with the new Combo model only 3<sup>rd</sup> harmonic is measurable, and attenuated to the range of -50dBc, where other higher order harmonics are no longer above noise floor.





Example output signal including harmonics from a 25MHz CW signal in Combo filtered model with significant improvement over baseline model.

When these results at 25MHz are translated to the time domain the difference between the squarish output signal from the RFE6GEN baseline model (in blue below) and the sine from the Combo model (in red below) are easily identified in a high-speed oscilloscope.



An example at CW 100MHz shows dramatic reduction of 2<sup>nd</sup> and 3<sup>rd</sup> harmonics:

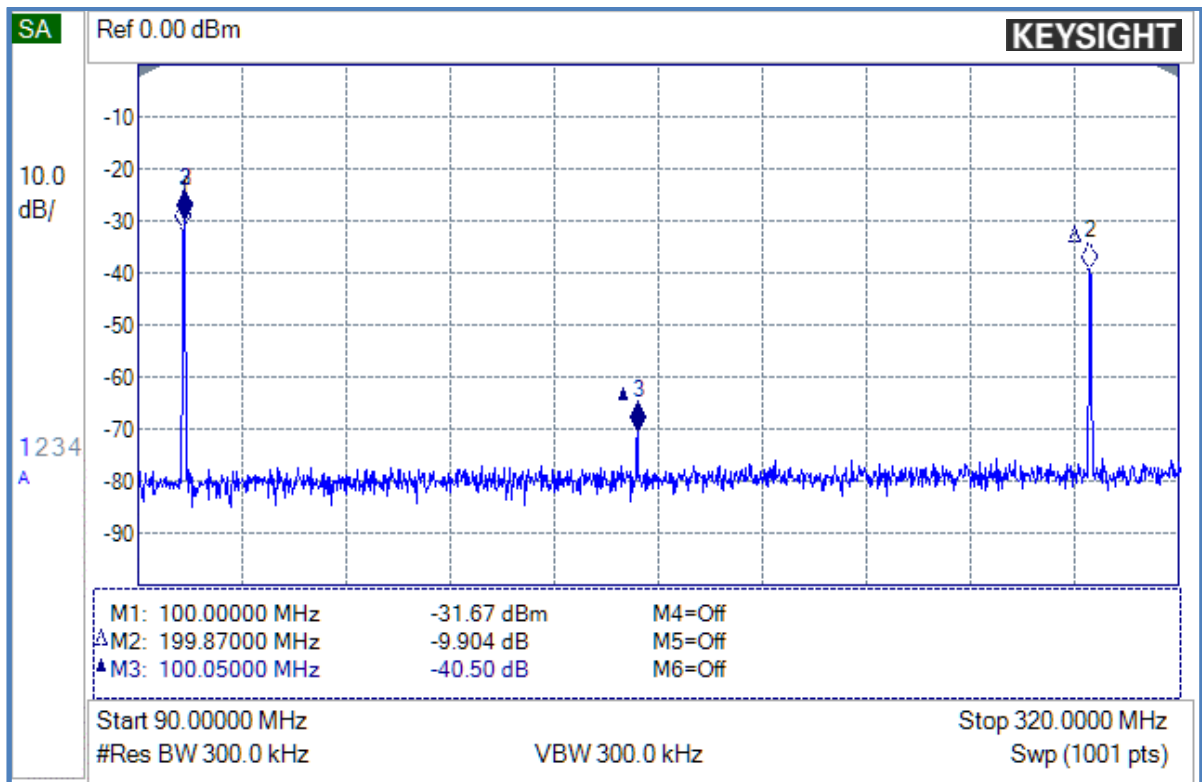


Image above: 100MHz 2<sup>nd</sup> (-40dBc) and 3<sup>rd</sup> (-10dBc) Harmonic using baseline RFE6GEN model

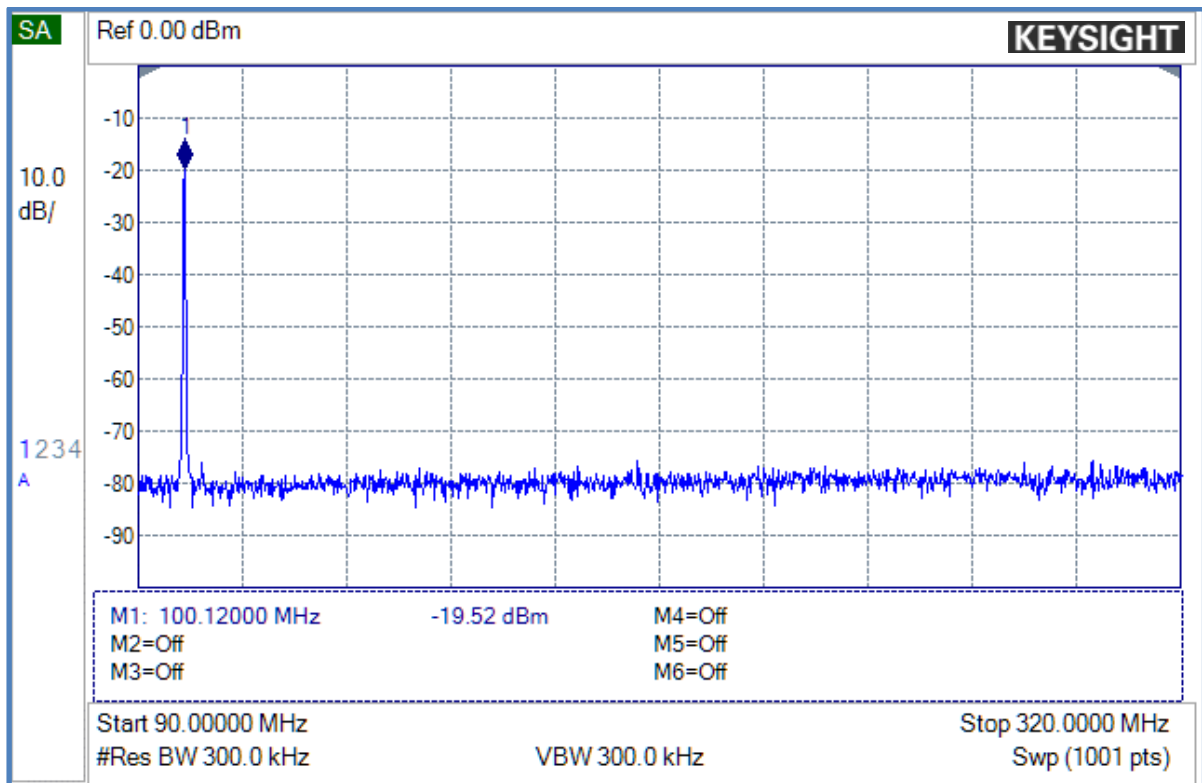


Image above: 100MHz 2<sup>nd</sup> and 3<sup>rd</sup> Harmonic using filtered Combo model.  
 Note output power level is actually 10dB higher than previous measurement  
 with RFE6GEN and still no harmonics are above noise floor

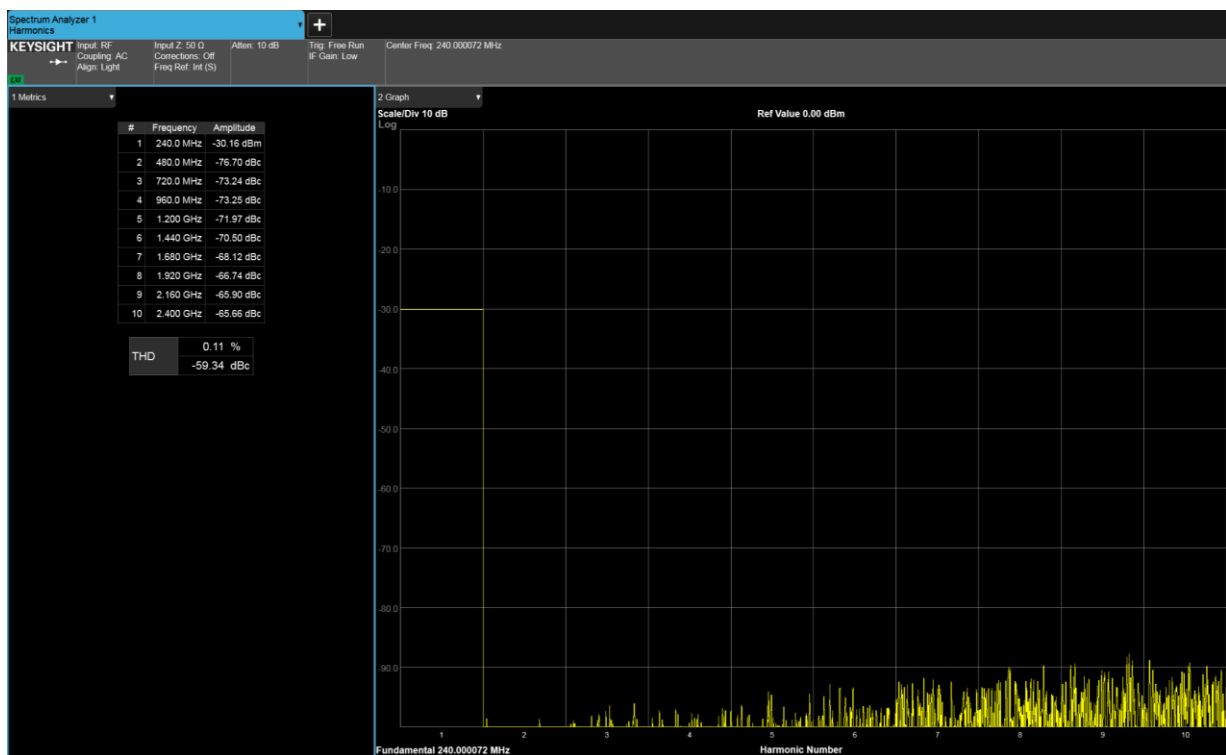
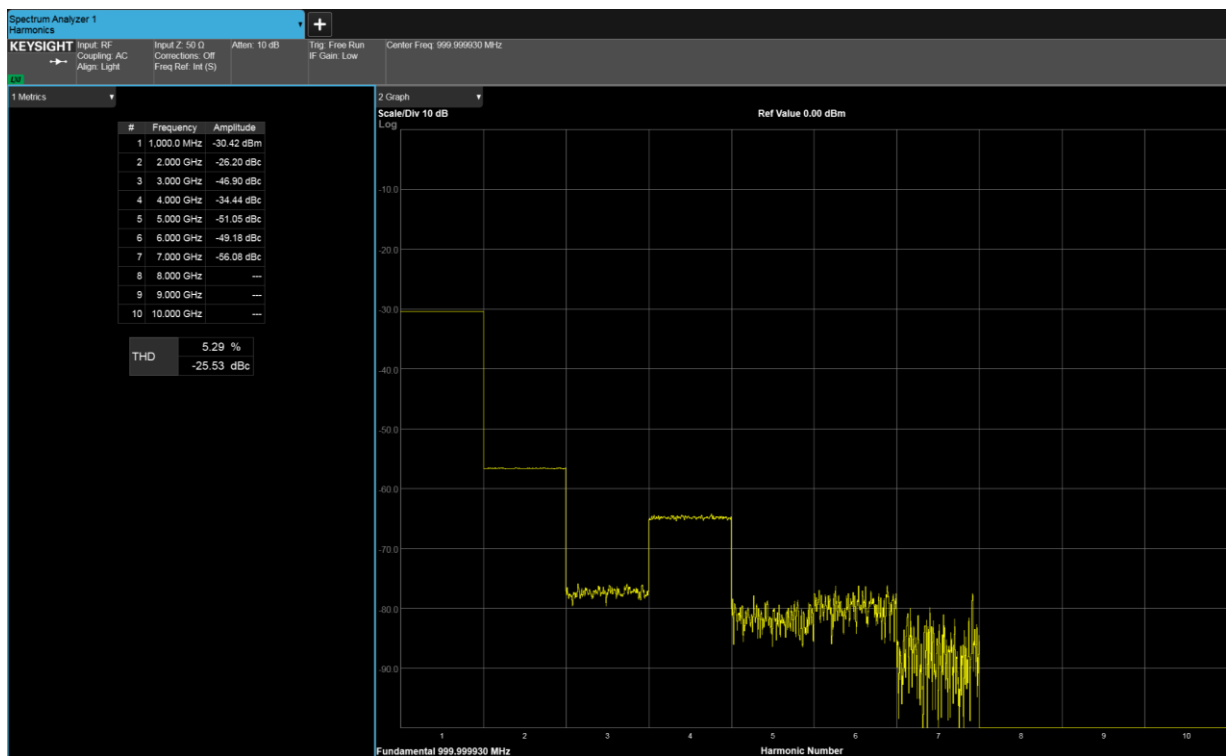
The power and frequency ranges below define the efficiency of the harmonic filtering implemented in the RF Explorer Signal Generator Combo model.

These values are measured at reference output signal at -20dBm, measuring all harmonics order #2 - #10, as this is representative of worst-case scenario.

RF Explorer Signal Generator Combo – Harmonics filtering			
Frequency range (MHz)	Best case (dBc)	Typical (dBc)	Worst case (dBc)
0.1 – 0.5	-42	-40	-20
0.5-250	-59	-57	-42
250-430	-53	-40	-22
430-630	-53	-45	-35
630-820	-39	-37	-22
820-1960	-50	-43	-34
1960-2500	-30	-26	-20
2500-4600	-50	-40	-27
4600-5200	-42	-33	-24
5200-6000	-46	-42	-37

Usually harmonics have better filtering at higher power levels up to +10dBm, and about the same response on lower power levels. Higher signal levels beyond +10dBm may increase harmonics due to saturation of internal power amplifiers.

Example of specific -30dBm harmonics measurement at 1GHz and 240MHz below.



## Spurious and Phase Noise

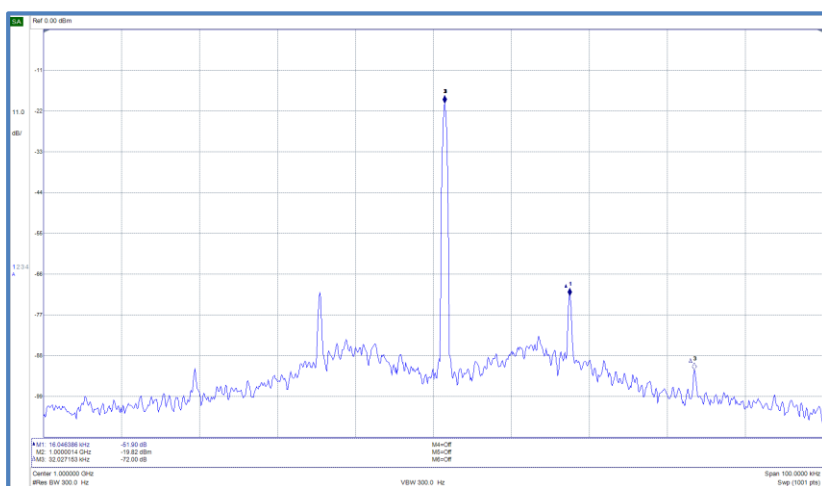
RF Explorer Signal Generator Combo uses a low noise signal source and low noise independent voltage regulators to provide a reduced phase noise output signal.

Below table shows typical values measured at -20dBm output power. These values can slightly increase or decrease at different power levels.

CW Frequency	Phase Noise @ 1KHz	Phase Noise @ 100KHz	Phase Noise @ 1MHz
2MHz	-93 dBc/Hz	-105 dBc/Hz	-122 dBc/Hz
1GHz	-96 dBc/Hz	-108 dBc/Hz	-128 dBc/Hz
5.8GHz	-74 dBc/Hz	-90 dBc/Hz	-115 dBc/Hz

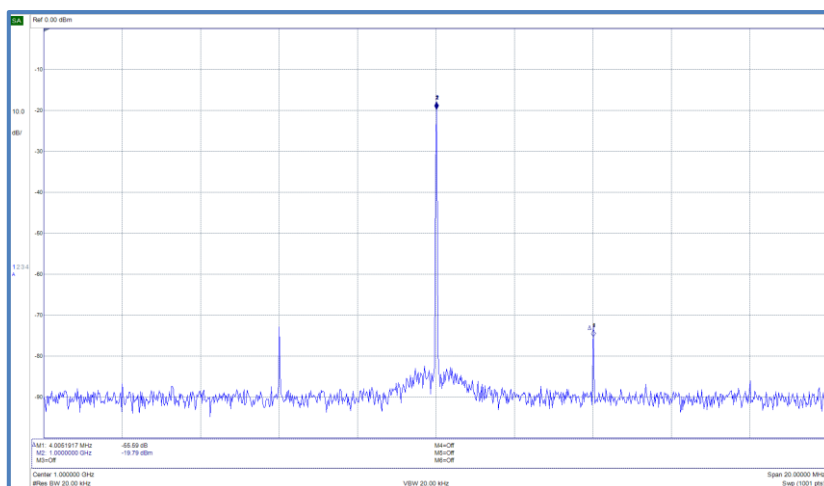
Spurious signals are created by the internal signal source at multiples of the frequency divider and, even though they are filtered, some residues signals may display at 1GHz CW output signal.

Spur @ 16KHz	Spur @ 32KHz	Spur @ 4MHz	Spur @ 8MHz
-52 dBc	-72 dBc	-55 dBc	-68 dBc



Signal measured at 1GHz narrow band displaying spurs at 16KHz and 32KHz.

Signal measured at 1GHz wideband displaying spurs at 4MHz and 8MHz.



## 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 microampere 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 50°C (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@SeedStudio.com](mailto:QC@SeedStudio.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

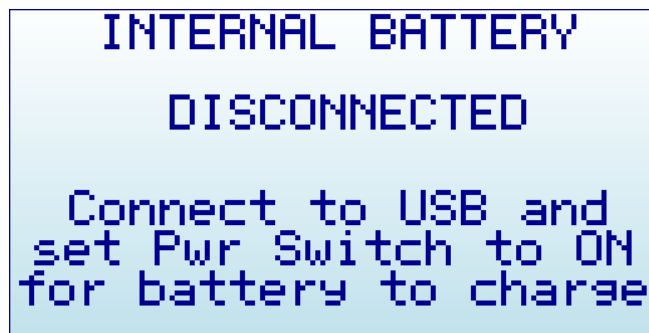
In latest firmware versions, you can use the specific Battery menu option for better battery charge control.

Note: As long as the USB is connected and the power switch is in the ON position, the battery will charge.

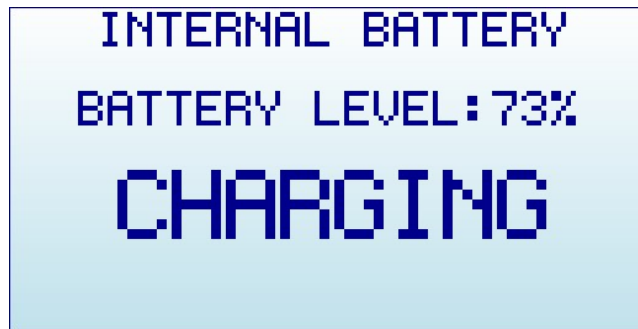
However, you can get additional information when using the Battery specific menu.



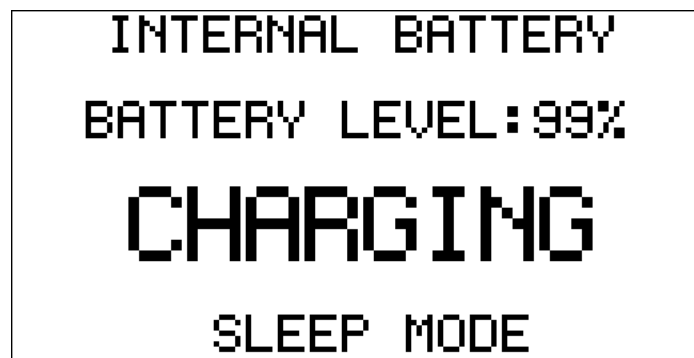
Inside this INTERNAL BATTERY charger screen, it is easier to realize if the battery is being charged. In this case below, it clearly indicates the power switch is not in the ON position and, therefore, battery is not being charged.



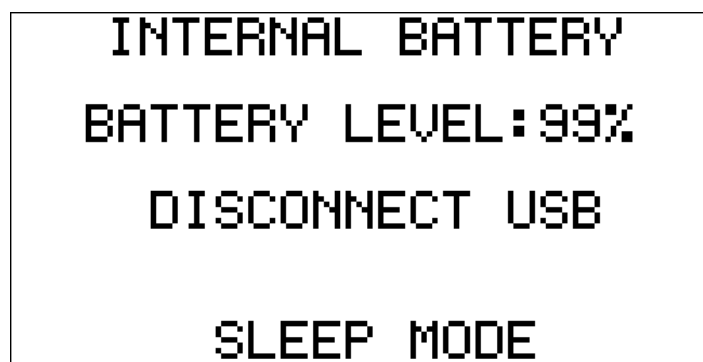
As soon as the power switch is set to the correct position, the screen will display correct charging status.



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.



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.



### **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



capacity to be consistent with the battery icon on screen, you can easily recalibrate after the charge process completed.

In the previous example screen, if the battery charge remains at 99% (or any other level) after the internal charger timer completes 3hs charge process, it will keep asking to DISCONNECT USB.

By doing so, the firmware adjusts for a few seconds the new charge level and save in internal ROM for future use.



After the device recalibrates the internal battery charge reference level, it will automatically restart and you should see the Battery icon (on Spectrum Analyzer screen) showing full charge.

### Charging a fully depleted battery

The firmware includes a protection mechanism to shutdown everything if the battery goes too low, in the range of 3.3V or less. However, this state will still keep drawing about 1mA from the battery. If you keep the power switch to ON forever the battery will be depleted but limited to a safe 3V level where battery protection circuitry will reduce the leakage to about 50uA.

In any case, the internal battery charger will take care of the battery conditions once it gets powered back from the USB and will charge the battery using an internal efficient algorithm. For that to work properly when the battery was fully depleted, you should use the Battery menu option as described.

### Automatic idle mode with battery charge

As described in previous section, you should enable the Battery screen and keep it charging for the device to automatically set internal circuits to Sleep for overnight charge.

Note: A more limited, equivalent functionality was available in old firmware versions prior to v1.16 in the About screen, it has now moved to the new Battery screen. The About screen no longer sets the device to sleep.

## Expansion Modules

RF Explorer Signal Generator includes an internal expansion port to enhance the RF power capabilities and frequency coverage of the main unit with RF Explorer Signal Generator compatible Expansion Modules.

Note: Spectrum Analyzer modules cannot be connected to the Signal Generator, they are incompatibles and have a changed gender connector to avoid any change of connecting incompatible modules.

RF Explorer Signal Generator Expansion is an advanced expansion board. It can be used to easily extend RF Explorer RFE6GEN Signal Generator baseline model into a Combo model.

For more details and assembly information please visit link below.

[www.rf-explorer.com/expansion](http://www.rf-explorer.com/expansion)

## Protecting your instrument from damage

Please protect the RF port from static discharge. This is [ESD](#)<sup>1</sup> sensitive device.



The RF output port is DC decoupled and can sustain up to 25V DC external voltage.

---

<sup>1</sup> [http://en.wikipedia.org/wiki/Electrostatic\\_sensitive\\_device](http://en.wikipedia.org/wiki/Electrostatic_sensitive_device)

## RF Explorer Holder



This is a great accessory for the RF Explorer Signal Generator, a high-quality stand / holder for the desk while USB cable is connected.

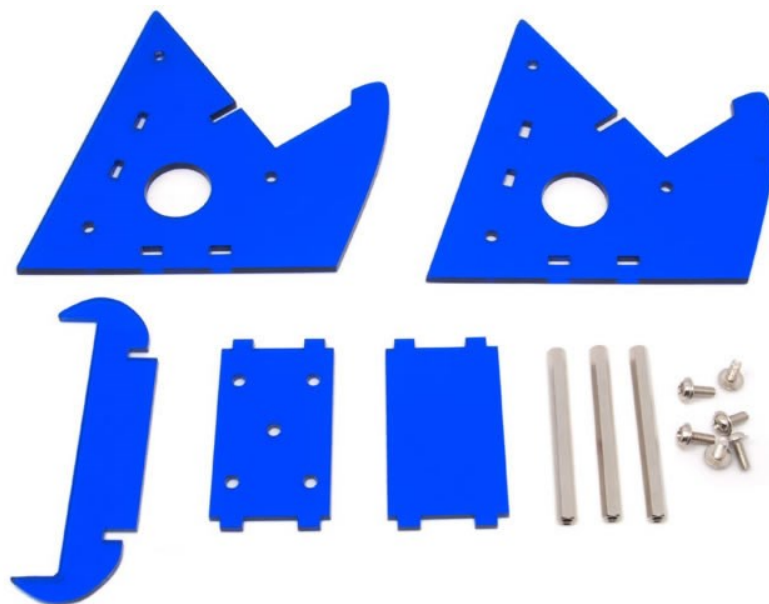
The holder is made of robust laser cut blue acrylic and has provisioned room for a USB cable to connect to a PC.

The USB cable can be connected from behind the holder or any of the two lateral large holes on each side. They're even large enough for bulky USB cables with ferrite beads.

A pre-drilled support bracket at the bottom allows for optionally securing the stand onto a bench for permanent position.

### Feature

- Sturdy 3mm acrylic body
- Color: blue and silver
- Secure support for your RF Explorer Signal Generator for working on the bench
- Nice and practical design
- Comes flat-packed, assembly required.



## RF Explorer accessories

RF Explorer uses standard SMA quality connectors.

By using adapters, you can connect RF Explorer to any RF device or antenna. You can buy SMA adapters and devices on any RF shop, but sometimes is difficult to find what you need and have the certainty the connector you are ordering is the right one. Therefore, we have included a selection of quality connectors, adapters and RF devices that are fully compatible with RF Explorer. You can order them from SeedStudio as well as many of the RF Explorer distributors.

[www.rf-explorer.com/buy](http://www.rf-explorer.com/buy)

### SMA-BNC adapter SMA Plug to BNC Jack straight



Usually HAM and two-way handheld radio antennas and devices are designed for BNC connectors. This BNC-female to SMA-male connector will easily interface your RF Explorer to any other BNC antenna or cable.

### SMA-N adapter SMA Plug to N Jack straight



Laboratory grade RF bench size instruments use N connector size cables in most cases. This N-female to SMA-male connector will easily interface your RF Explorer to any other bench size instrument or cable.

## RF Adapter RP-SMA Jack to SMA Plug straight-long version



Some WiFi antennas and cables are designed for RP-SMA (reverse polarity SMA) and cannot be connected to a standard SMA plug. RP-SMA is a variation of the SMA connector specification which reverses the gender of the interface.

The reason for that was a decision made by FCC in order to prevent end-users from manipulating certified WiFi devices at home, using other available SMA antennas. That led to SMA and RP-SMA devices not being able to connect without an adapter, check [Wikipedia for more details](#)<sup>2</sup>.

If you want to use some standard WiFi antennas you may need this adapter in order to interface them with RF Explorer. By plugin in this adapter your RF Explorer will be able to connect with any RP-SMA antenna, cable or device.

## SMA adapter SMA Plug to SMA Jack right angle



This RF connector is ideal to use RF Explorer deployed horizontally, with any antenna connected onto it.

For instance, when you are on the road and you don't have a RF Explorer Stand, you can still easily fit the USB cable, the antenna and connect to a computer with easy.

It is also useful to create a more reliable ground-effect for a dipole antenna if RF Explorer is over a metallic structure such as a car.

---

<sup>2</sup> [http://en.wikipedia.org/wiki/Reverse\\_polarity\\_SMA](http://en.wikipedia.org/wiki/Reverse_polarity_SMA)

## SMA connection cables

RF cables are an important tool required to directly connect your Spectrum Analyzer to another device (such as a RF transmitter or an antenna) or with a Signal Generator for tracking.

Cables add attenuation to your measurement and, if not correctly connected or if the cable is low quality, it may largely invalidate any measurement. If you use a large cable with known attenuation at a certain frequency, you can compensate that attenuation in the *OffsetDB* parameter in the CONFIG MENU of the RF Explorer device.

Different cables have different purposes. For frequencies up to 2.4GHz, we recommend flexible RG-316 cables, whereas higher quality and shorter lengths are suggested for frequencies up to 6GHz, where semi rigid RG402 is recommended.

### 10cm length - SMA male to SMA female 6GHz coaxial cable



This SMA male to female is a quality cable able to handle 6GHz with very low attenuation. It is the perfect cable to connect the RF Explorer Signal Generator to a device, or to work as a tracking generator.

The semi-rigid nature of the cable allows for stable measurement independently of the position and helps on adding mechanical robustness when using RF Explorer Signal Generator with RF Explorer Spectrum Analyzer as Tracking Generator. You will typically need two of these cables to connect the Tracking Generator to a device (with

two SMA male connectors) or use an equivalent Male to Male version for a device with different SMA gender connectors.

### 10cm length - SMA male to SMA male 6GHz coaxial cable



This SMA male to male is a quality cable able to handle 6GHz with very low attenuation. It is the perfect cable to connect the RF Explorer Signal Generator to a device, or to work as a tracking generator.

The semi-rigid nature of the cable allows for stable measurement independently of the position and helps on adding mechanical robustness when using RF Explorer Signal Generator with RF Explorer Spectrum Analyzer as Tracking Generator. You will typically need two of these cables to connect the Tracking Generator to a device (with two SMA female connectors) or use an

equivalent Male to Female version for a device with different SMA gender connectors.

### 50cm length - SMA male to SMA female RF pigtail Coaxial Cable RG316



RF cables are required when connecting RF Explorer to other instruments or devices.

This 50cm cable is good for any frequency up to 3GHz, and can fit RF Explorer with any external SMA-male device or antenna.

If you need extra length for your connection, you can easily daisy chain two or more of these cables in series.

### 50cm length - SMA male to SMA male plug pigtail cable RG316



RF cables are required when connecting RF Explorer to other instruments or devices.

This 50cm cable is good for any frequency up to 3GHz, and can fit RF Explorer with any external SMA-female device or antenna.



## Attenuators

SMA attenuators are used to reduce the input power, and therefore enable RF Explorer Spectrum Analyzer to measure stronger signals, or in a Signal Generator to accurately reduce the output power. It is also used to protect the input SMA port of RF Explorer when unknown strong signals may be in the environment, so you can use this attenuator on demand. You can easily unplug the attenuator when measurement is for weak signals.

You can also combine multiple attenuators to get additional values. For instance, 10 dB + 30dB attenuators connected in series will give you 40dB total attenuation.

RF Explorer Spectrum Analyzer firmware includes an “Offset DB” feature in the Attenuator Menu, you should specify +0XX dB (where XX is the attenuation value, e.g. 30dB) in this setting when the attenuator is connected in order to get correct readings on screen.

Attenuators recommended by us are high precision mechanical and electrical, working reliably up to 6GHz and supporting continuous input power of up to 2Watt (33dBm). We do not recommend low quality or second-hand attenuators as they may alter amplitude readings and, in worse case low quality SMA mechanical connectors, even damage your analyzer RF SMA ports.

Based on total input power you may need to measure, we recommend the following attenuator values to be added to RF Explorer Spectrum Analyzer input port:

Measurable input range	Recommended external attenuator
Lower than -30dBm / 1 micro Watt	No need
-30 to 0dBm / 1 microwatt to 1 milliwatt	30dB
-30 to 10dBm / 1 microwatt to 10 milliwatt	40dB
0 to 33dBm / 1 milliwatt to 2 Watt	60dB

### 6GHz SMA Attenuator – 60dB



This robust attenuator is custom made, high quality exceptional value 60dB total attenuation. You will not find attenuators of this range anywhere else in the market, the only other option is to daisy chain two 30dB attenuators together.

Therefore, this unit is cost effective option to measure high power RF signals. A 60dB attenuation enables any RF Explorer unit to measure signals of up to 2Watt (33dBm) power without distortion with a single attenuator, as opposed to connecting multiple attenuators in daisy chain.

This precision attenuator can measure up to 6GHz frequency range with high amplitude accuracy. Use OffsetDB: +060 when connected to this attenuator.

### 6GHz SMA Attenuator - 10dB



This precision attenuator can measure up to 6GHz frequency range with high amplitude accuracy.

Use OffsetDB: +010 when connected to this attenuator.

### 6GHz SMA Attenuator - 30dB



This precision attenuator can measure up to 6GHz frequency range with high amplitude accuracy.

Use OffsetDB: +030 when connected to this attenuator.

## SMA Male/Female Adaptor



All RF connectors wear with use. The RF Explorer SMA ports are subject to minimal wear each time the connector interface is coupled and decoupled with an antenna, a SMA Cable, an attenuator or a RF device of any kind.

If you repeat plug/unplug operations over the RF Explorer SMA port hundreds of times, the SMA port may underperform over time and exhibit undesired attenuation.

To protect the SMA port for frequent plug/unplug operations, you can use this adaptor and keep it directly attached to the RF Explorer port. Then you plug/unplug other RF devices into this adaptor, not the original SMA port. After hundreds of operations, if the adaptor wear and show attenuation or reliability problems, you can just replace it by a new one and always keep your original RF Explorer SMA port intact.

## SMA Termination – 50 ohm dummy load



Using SMA termination or Dummy Load is suggested for protection of the SMA port of your RF Explorer when the device is exposed to unwanted high radiation or strong electronic fields.

For instance, if you carry on your RF Explorer that is exposed to an X-Ray scanner in the airport, you should remove the SMA antenna and plug a protection 50 ohm SMA termination.

SMA termination are also required when using Signal Generator while not connected to an antenna; in this way the generator sees a correct load to avoid damage.

## Connecting RF Explorer to a computer

RF Explorer device can be connected to a computer (Windows, Linux, Mac and Android) for additional capabilities, including higher resolution screen, additional features and programmability.

For free, open source RF Explorer for Windows tool, please check this link: [www.rf-explorer.com/windows](http://www.rf-explorer.com/windows)

For additional software options developed by a growing list of 3<sup>rd</sup> party companies, please check this link: [www.rf-explorer.com/software](http://www.rf-explorer.com/software)

## API programming specification for RF Explorer

RF Explorer offers a compact, easy to use, USB / RS232 programming interface. It can be used to automate external solutions when connected to an external computer or device.

For full specification of the current API, check [www.rf-explorer.com/API](http://www.rf-explorer.com/API).

There are [.NET](#) and [Python](#) libraries available in [GITHUB](#) repository, ideal for custom work required by your application.

## RF Explorer for Windows open source code

RF Explorer is a hacker friendly device. Full open source under LPGL license is offered to the community.

As hackers ourselves, we do like customizing, tinkering and expanding gadgets. We certainly designed and built RF Explorer with these factors in mind.

We love and make good use all community contributions, contact us or send us a PULL request if you have source code contributions you want integrated in the final product.

Check our [hacker corner link](#) for more details.

## Specifications

For a complete list of features and RF Explorer Signal Generator models, expansion boards available, and accessories please check the RF Explorer Model Map online.

[www.rf-explorer.com/models](http://www.rf-explorer.com/models)

## Acknowledgments

This product could not be possible without the SeeedStudio Team who manufacture, test and distribute RF Explorer worldwide.

RF Explorer is a reality thanks to the great community behind, always suggesting features and providing useful feedback.

## FCC and CE regulations

RF Explorer is a Test and Measurement device, and therefore compatible with US FCC regulation 47 CFR Part 15.103(c).

RF Explorer is certified for CE compliance under regulations EN/IEC61236 and EN/IEC61000.

## License

RF Explorer embedded firmware is copyrighted © by Ariel Rocholl, 2010-2024

RF Explorer for Windows is Open Source software released under GPL v3, so you are free to modify, distribute and use it based on GPL terms.

RF Explorer is a registered trademark in USA, Australia, China, Japan, Canada and all EU Countries.