

Release notes for RSP-Spectrum Analyser V1.0a

Please read the following as it contains important information regarding known problems with this release.

Known problems

1 – Slow start-up. The analyser can take several seconds to load and display. The cause has been identified.

2 – Intermittent display freezing. On occasion, the analyser display may stop updating, all other functions are unaffected. Either stop and re-start the analyser or re-select the span. This will usually unfreeze the display.

3 – Gain settings changing. Sometimes, the noise floor will drop several dB's when a sweep is restarted, although the signal magnitude is not affected. It seems to be caused by incorrect gain settings being sent to the RSP. To restore the correct gain settings, change the reference level, and then set it back to the original setting.

4 – Trackgen connection. There are still ongoing problems with the comms link.

On my development PC, if I try to connect to the Arduino for the first time after a total (mains-plug-out-the-wall) power down then although the comms port connects and the analyser sends the connect request to the Arduino. The Arduino sends back a connection confirmation but the PC serial receive port does not see the incoming data. If I then re-select the port, connection is established. I can then continue to make and break connections at any time, until I perform a total power down again. This problem does not occur when running on an Asus laptop under Windows Vista.

I have a solution to this problem and it will be included in the final release. In the meantime, if you experience this problem, try re-selecting the comms port. Also, try connecting the Arduino to a terminal program and confirm that the Trackgen firmware is loaded and running.

The above problems will be addressed and rectified for the next (beta) release. Apart from the following additions, no further additions or changes (bugs excepted) will be made, so the time taken to reach the beta release should be relatively short.

To be added

The following will be added for the final release.

1 – Optional dBm offset on the input panel. This will be added to the signal level so that compensation for attenuators or gain blocks may be offset. This setting will be saved at shut-down.

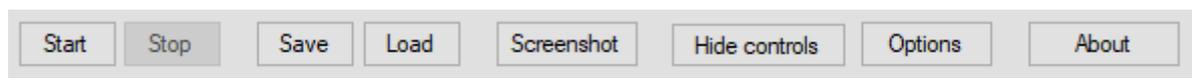
2 – Optional on-screen data display showing various sweep and span parameters, as well as marker calculations. This may be useful if screen shots are taken as all pertinent data will be available.

RSP-Spectrum Analyser V1.0a

Interim user manual

The analyser requires access to an SDRplay API DLL in order to control the RSP device. The API is installed as part of the analyser's installation procedure.

Top Panel



The **Start** button starts the analyser. Some controls will be disabled while the analyser is running.

The **Stop button** stops the analyser and enables any controls that were disabled while the analyser was running.

The **Save** button is used to save the current analyser settings to a custom set-up file. Users may specify a name for the setting so that multiple set-ups may be saved, and later re-loaded. This button is disabled when the analyser is running. Settings files are stored in the user's Documents folder under RSP-Spectrum Analyser/SpecSettings. The folder is automatically created when the analyser is run for the first time. In addition default settings and current settings files are generated and stored in the SpecSettings folder.

The **Load** button is used to load a previously saved set-up. This button is disabled when the analyser is running.

The **Screenshot button** allows a screen shot of the main spectrum display be taken at any time by a single click of the button. The screenshot is saved in bitmap format in the user's Documents folder under RSP-SAS Spectrum Analyser/Screenshots. Each screenshot is numbered, with the number automatically incrementing with each screenshot taken. The folder is created automatically when the analyser is run for the first time. The default file name for screen shots may be changed in the options dialogue box. The start number may also be set in the options dialogue. The current screenshot file name and number are saved in the CurrentSettings file when the analyser is closed. They are also saved in the user-specified settings file if one has been loaded.

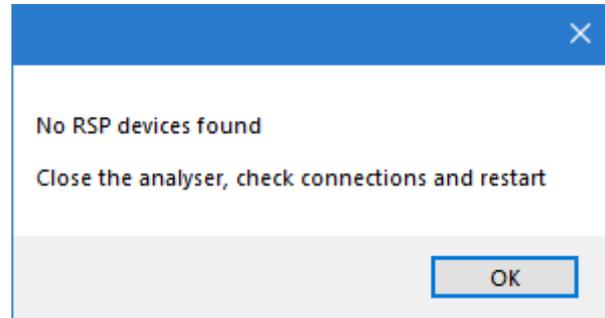
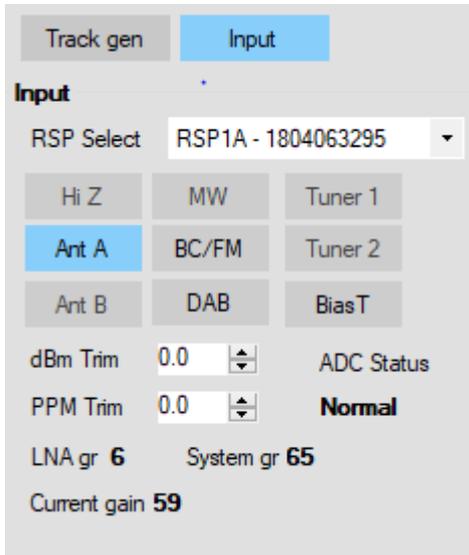
Clicking on the **Hide controls** button hides all control panels, except for the top bar, just the main spectrum and waterfall display are displayed.

The **Options button** displays an options dialogue box, and may be used while the analyser is running.

The **About** button displays an about box, showing the current version and copyright information.

Input Panel

When the analyser is launched, it attempts to find whatever devices are connected. If none are found, a message will be displayed. If this happens, simply close the analyser, check that a device is connect and then re-launch the analyser.



RSP Select lists the available RSP devices and allows the user to select the device to use. Devices that are detected, but are in use by another application, including another instance of the spectrum analyser, will be listed, with the device's name followed by a 'U' to indicate the device is present but unavailable. The device's serial number is also displayed. Note that the RSP1 does not have an embedded serial number, it's serial number will displayed as 0000000001. Access to the device selection list is disabled while the analyser is running.

Antenna selectors **Hi Z**, **Ant A**, **Ant B**, **Bias T**, and filter selectors **BC/FM** and **DAB** buttons will be enabled or disabled depending on the device selected. Full support is offered for the RSPduo operating as a single radio.

dBm Trim may be used to add a fine adjustment to the displayed signal level, in order to compensate for any small gain differences between devices. The control may also used to compensate for FFT windowing loss. Refer to the notes on windowing and FFT averaging at the end of this document.

PPM Trim may be used to correct for any slight frequency differences between radios.

dBm Trim and **PPM Trim** settings are saved when the analyser is closed, and loaded when the analyser is launched.

The **ADC Normal** display is used to indicate when the ADC is overloaded.

LNA gr, **System gr** and **Current gain** displays display the current gain settings.

Span Control Panel

Frequency

Centre freq **10.000000**

Start - MHz **9.950000**

End - MHz **10.050000**

Span

1 kHz	2 kHz	5 kHz
10 kHz	20 kHz	50 kHz
100 kHz	200 kHz	500 kHz
1 MHz	2 MHz	5 MHz
10 MHz	20 MHz	50 MHz
100 MHz	200 MHz	500 MHz
1 GHz	2 GHz	

IF-kHz

2048
450
Zero IF

Window **Blackman**

NFFT **16384** Hz/bin **122.07**

Frequency

Centre freq **10.000000**

Start - MHz **5.000000**

End - MHz **15.000000**

Span

1 kHz	2 kHz	5 kHz
10 kHz	20 kHz	50 kHz
100 kHz	200 kHz	500 kHz
1 MHz	2 MHz	5 MHz
10 MHz	20 MHz	50 MHz
100 MHz	200 MHz	500 MHz
1 GHz	2 GHz	

IF-kHz

2048
450
Zero IF

Sampling rate-Ms/Sec

6 Ms/s	8 Ms/s
10 Ms/s	

Window **Blackman**

NFFT **16384** Hz/bin **488.28**

Centre freq is used to set the centre frequency of the current sweep. A manual entry may be typed into the box, or the mouse scroll wheel may be used to set the required centre frequency. Right-clicking on the box will display a pop-up menu that will allow you to selected the scroll wheel's tuning rate.

If a combination of the selected sweep width and centre frequency results in start frequencies of less than 0kHz, or end frequencies greater than 2GHz, the centre frequency will be automatically adjusted to keeps the start or end frequencies within range.

Start-MHz and **End-MHz** labels display the frequency limits of the currently selected sweep width in conjunction with the centre frequency. The MHz label will be set to kHz when appropriate.

The **Span** buttons are used to select the required frequency span in MHz or kHz. At wider spans, the available ranger of NFFT values may be automatically reduced, and a lower NFFT set. Note that if switching from a wide span, with a reduced NFFT, to a narrow span, the NFFT value is not changed. It is up to the user to selected the required value.

The **IF-kHz** buttons are enabled or disabled depending on the selected span. If **Zero IF** is selected then a range of sampling rate options will be displayed.

The **Window** drop-down box allows the user to selected the required window that will be applied to the signal prior to Fourier processing. The default is set to the Blackman window but this may be changed if required. Users may experiment with the different windows available, but the Blackman window is suitable for most work. There are subtle differences in the way each window type affects the displayed signal, particularly at very high FFT resolutions. Refer to notes on windowing loss at the end of this document.

The **NFFT** drop-box allows the user to select the number of bins used for the Fourier transform, a larger number of bins will result in a higher resolution, or narrower bandwidth but may result in a slower sweep time. Higher resolution is only really required at narrow sweep widths. A higher number of bins will result in an apparent lowering of the noise floor. Refer to the notes on windowing and FFT resolution and averaging at the end of this document.

The figure to the right of the **Hz/bin** label displays the current spectral resolution.

Display scaling panel



Ref – dBm

Sets the reference level at the top of the display screen.

Range – dBm

Sets the range in dBm from the top to the bottom of the display screen, and in conjunction with the Offset – dBm control, may be used to provide a level of vertical zoom.

Offset – dBm Offsets the entire display vertically.

Enable Toggles the offset on or off.

The above controls are only enabled when the analyser is running. Their values are saved at shut-down.

Trace enable panel



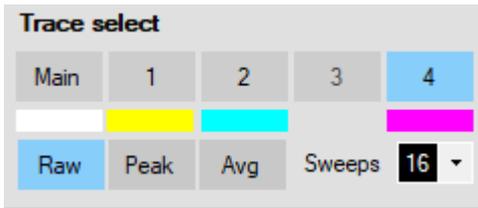
The trace enables panel controls the enabling, displaying and holding of each trace. There are five available traces. The Main trace has the same properties as any of the other traces.

Clicking on **Main**, **1**, **2**, **3**, or **4** will enable the selected trace, and the trace's button will turn green. When a trace is enable, the Hide and Hold buttons for the selected trace are enabled. Clicking on a trace enable button when it is already enabled (green) will disable the trace, and the **Hide** and **Hold** buttons.

The **Hide** button is a toggle action control so clicking it will either hide or show the trace.

Hold is also a toggle control and may be used to either freeze or release the trace.

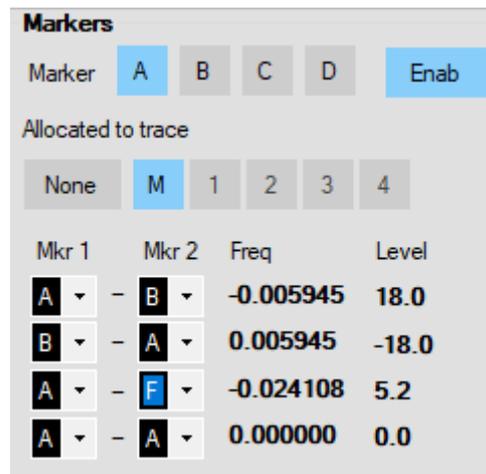
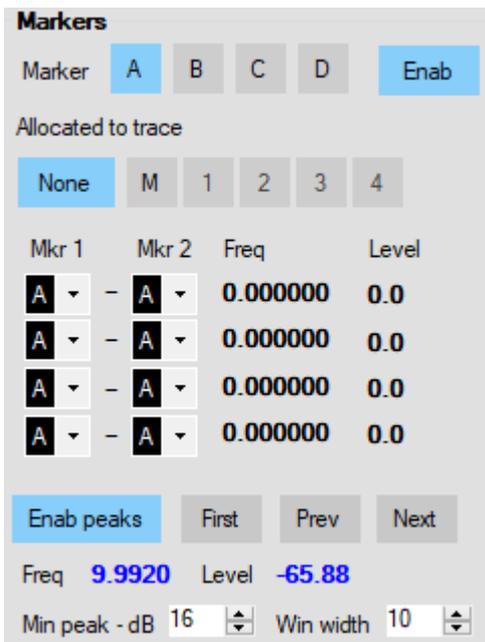
Trace select panel



The Trace select panel is used to set the trace type for the selected trace. Select the required trace by clicking on **Main**, **1**, **2**, **3**, or **4**. If a trace is not enabled, then the relevant trace select button will be disabled as well. The trace colour is displayed below each trace if the trace is enabled,

Select the trace type by clicking on **Raw**, **Peak** or **Avg**. If the trace is to be averaged, select the number of sweeps to average by clicking on the **Sweeps** combo box. Averaging is not currently available for frequency spans greater than 2MHz.

Markers panel



The marker control panel handles the allocation of four markers **A**, **B**, **C** and **D**. Each marker may be allocated to one of the five available traces, provided the trace is enabled. In addition, the panel controls the peak find functions and marker mathematics.

Enable the markers panel by clicking on **Enable**, all controls on the panel will be enabled.

Select a marker you wish to allocate by clicking on **A**, **B**, **C** or **D**. To allocate the selected marker to a trace, click on **M**, **1**, **2**, **3** or **4**. If the selected marker is already allocated to another trace, it can be re-allocated by clicking on the trace you want to allocate the marker too. Selecting a marker and allocating it to **None** will clear the marker's allocated trace. If there is more than one marker on the screen, the active (selected) marker is drawn as a filled inverted triangle, all others are drawn as non-filled.

A marker may be positioned by holding the left mouse button down and dragging the marker to the required frequency. The marker will automatically track the signal amplitude as it is dragged. Place the marker by releasing the mouse button. It may be difficult to place a marker if a signal is noisy. The easiest way is to **Hold** the display, place the marker and then **Release** the display. Using the peak find function is another way to place markers easily and accurately.

To move a marker, select the marker using the **Marker** buttons, and then left-click on the display screen to drag the selected marker to its new position.

Up to four markers may be used, there is no limitation on how many markers may be allocated to a single trace.

Marker maths calculates the difference (delta) between two selected markers. The markers may be allocated to separate traces. Select the required markers by selecting **Mkr 1** and **Mkr 2** from the drop down boxes. **Frequency** and **Level** deltas will be displayed.

Note: There is always a floating or free marker on the screen and it tracks with mouse movement. This marker may be used in calculations and is designated marker **F**. For quick measurements you may only need one marker and the **F** marker.

Peak find



Enab peaks

Enables the peak finder and finds and displays peaks according to the set parameters. Each found peak is marked with a small circle. If there are no markers enabled, a peak marker (inverted unfilled triangle) is displayed at the selected peak. The frequency and level of the selected peak is displayed on this panel. The peak find function may be used without any markers allocated.

First, **Prev** and **Next** buttons are used to select the first, previous or next peaks. If a marker is allocated to the selected trace then the peak marker is not used, the currently selected marker will be used instead.

Min peak - dB

This control sets the minimum peak height threshold. Note, this is not the peak level relative to the noise floor, but peak levels relative to adjacent signals. Reducing the threshold will result in more peaks being found, but they may be nothing more than noise.

Win width

The peak finder algorithm looks for peaks in a window centred on the frequency being tested. Only the highest peak in this window is reported. Using a narrower window may help to resolve some fine peaks.

Min peak – dB and **Win width** are set to defaults of 10. You may want to change these settings to suit the signals you are displaying. These settings are not saved at shut-down.

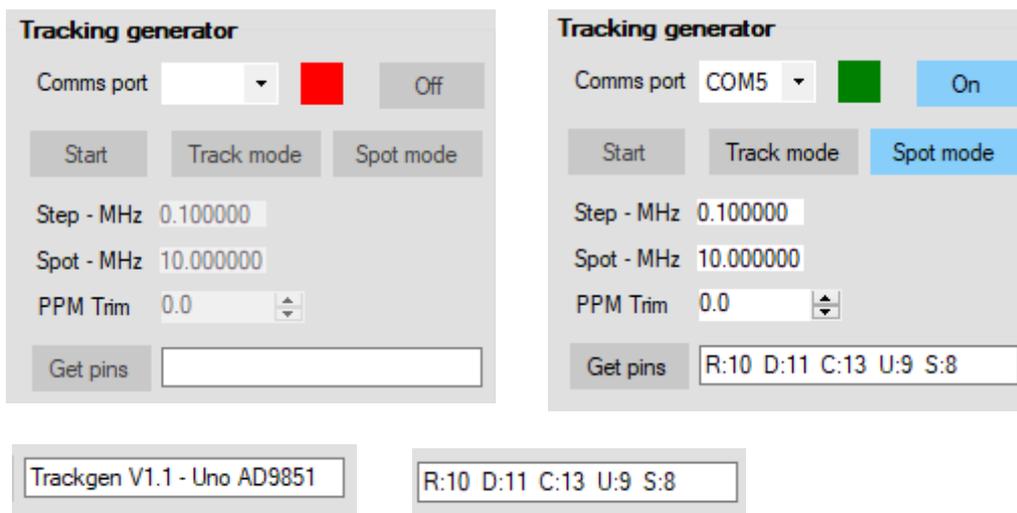
Tracking Generator Panel

The tracking generator system is inactive until an Arduino device running the **Trackgen** firmware is detected. On launching the analyser, the software builds a list of available comms ports but does not display them in the **Comms port** drop down list. A red square to the right of the drop-box indicates that a valid Arduino device is not yet connected.

Click on the Comms port drop-box and select the port that you think the Arduino is connected to. If the correct port is selected, the square will turn green and the message **Trackgen Vn** will be displayed in the text box at the bottom of the panel. If an Arduino is detected but is not running Trackgen firmware, then nothing will be displayed in the message box and the indicator will remain red.

If Trackgen firmware is detected then the **Enable/Disable** control is enabled. If the **Enable** control is clicked, the tracking generator will be enabled. Note that although the analyser detects Trackgen firmware, the Trackgen firmware does not detect the presence of a DDS device.

Clicking the **Get pins** button will display the ports the Arduino is currently using to control the DDS device. The ports used may be changed using the **Options** dialogue box, available on the top panel. The ports are displayed as **R:n D:n C:n U:n and S:n**, where **R** is the **Reset** pin, **D** is the **Data** pin, **C** is the **Clock** pin, **U** is the **Update** pin and **S** is the sync output port.



Clicking on the **On/Off** control will start the generator in spot mode and will set the selected DDS to the spot frequency set in the **Spot - MHz** box. If **Off** is selected, the DDS device frequency is set to 0MHz, effectively turning the generator off. The On/Off button text displays the current generator output status.

The **Step-MHz** control sets the frequency step taken by the DDS when tracking. You may use the mouse scroll wheel to change frequency. Right-click on this control to set the scroll-wheel frequency increment. Numeric text may be typed in followed by pressing the Enter key.

The **Spot-MHz** control sets the spot frequency when in **Spot** mode. You may use the mouse scroll wheel to change frequency. Right-click on this control to set the scroll-wheel frequency increment. Numeric text may be typed in followed by pressing the Enter key.

The **Spot mode** button sets the generator to spot mode. A single frequency is generated and may be varied by using the **Spot-MHz** control. The **Start** sweep button will be disabled.

When **Track mode** is selected, the generator is set to tracking mode, and the **Start** button is enabled. Clicking on the **Start** button will start the sweep generator. The generator start and end frequencies are set automatically according to the centre frequency and span selected in the frequency control panel. Trackgen will ignore frequencies that exceed the maximum output frequency for the selected DDS device.

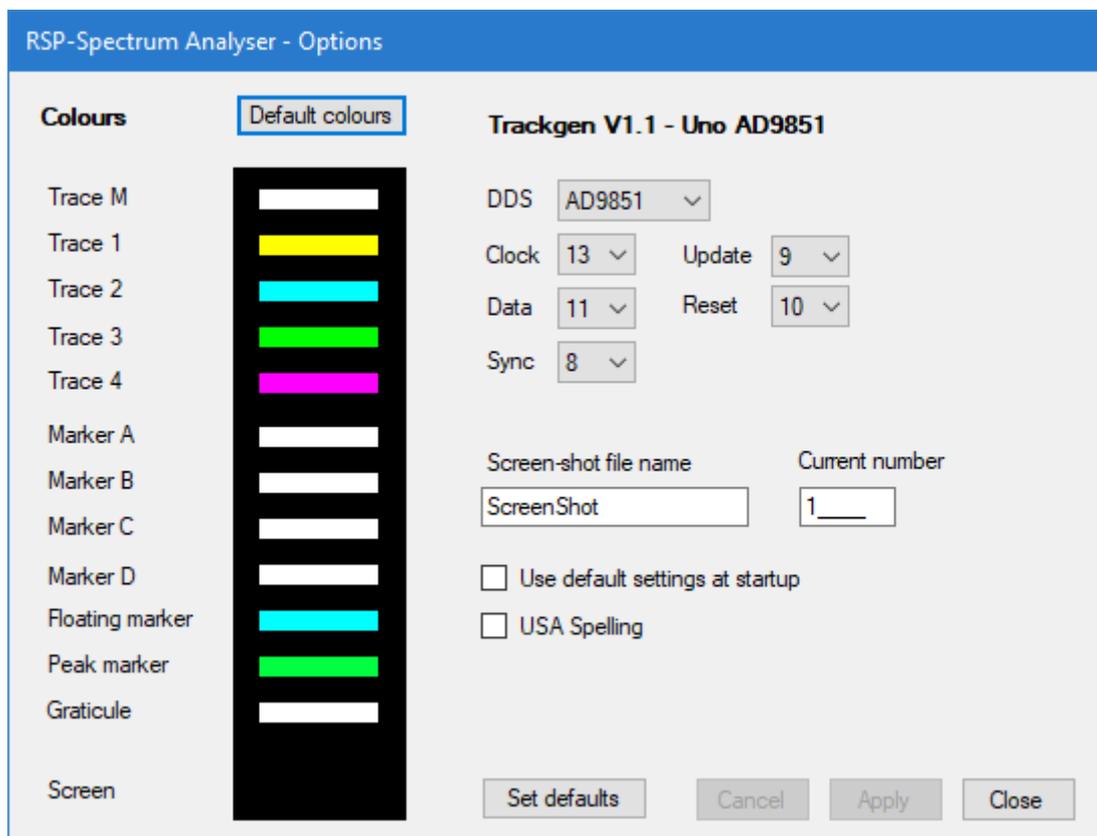
Clicking on the **Start/Stop** button again will stop the sweep and return the generator to spot mode.

Note that a sync pulse is output on the Sync port at the start of every sweep. The port output goes high for around 1ms.

Options Dialogue Box

The options dialogue box is displayed by clicking on the **Options** button on the top control panel. If Trackgen is connected then the current version number, Arduino type and DDS type are displayed. If Trackgen is not connected, a not-connected message is displayed instead.

The dialogue offers the following options.



Colours

The user may optionally change the display colours for the traces, markers, graticule and screen background colours. To edit a colour, click on the colour bar of the item's colour you wish to change. A standard colour picker dialogue will be displayed, select the colour you want and close

the the dialogue. Colour changes will only take effect once the **Apply** button is clicked. To change the colour of the spectrum display screen, click anywhere on the panel containing the colour bars.

When the user clicks on **Close**, any colour changes are stored and then used as defaults whenever the analyser is launched. Clicking on the **Default colours** button will restore the colours to their default settings.

The **Use default settings at start-up** allow the user to specify whether the last session settings, or default start-up settings are loaded when the analyser is started. If this box is checked, at next start-up the default ini file will be loaded and the box will be cleared.

Users may check the **USA Spelling** box if they prefer American, rather than European spelling

The **Screen-shot file name** allows the user to set a default name for screen-shot files. The **Current number** box shows the current number append to each screen-shot file. This may be set to whatever the user requires, and is incremented for each screen-shot.

The DDS type drop-box is used to select which DDS type you are using. Currently only the AD9850 and the AD9851 are supported.

The Clock, Data, Update, Reset and Sync drop-boxes allow the user to specify what Arduino I/O ports are used to control the DDS. If the port numbers are changed, they are sent to the Arduino when **Apply** is clicked, and stored in the Arduino's EEPROM. Note that the port numbers refer to the Arduino I/O port pin numbers, and not the device's physical pins.

Clicking on the **Set defaults** button sets all options to the default values.

Clicking on the **Cancel** button, discards any changes made and closes the dialogue box.

The **About** box displays the current version of the analyser and copyright information, and is displayed by clicking on the **About** button on the top control panel.

Arduino Trackgen firmware

Trackgen firmware is used to control a range of DDS (Direct Digital Synthesis) IC's available from Analog Devices. Modules are readily available on Ebay, particularly those using the AD9850 and AD9851 devices. The firmware is fore the Arduino is provide in three hex-format files, one each for the Nano, Uno and Mega-2560

The Trackgen firmware HEX files can be found in the analyser's install directory. The default install directory is:

c:\Program Files\Andrew Developments\RSP-Spectrum Analyser\ (for 32 bit machines)

c:\Program Files(x86)\Andrew Developments\RSP Spectrum Analyser\ (for 64 bit machines)

Trackgen may be used independently of the analyser and can provide a simple, but useful signal or sweep generator. The port edit facility in the options dialogue box will allow you to select whatever ports are convenient to you. When loaded and run for the first time, the firmware sets default ports for DDS control. The same port numbers are used for all three processor variations. Alternately, you

can edit the port settings independently of the analyser application using a standard serials comms application. Note that if connected to the analyser, any changes you make to the port numbers will be overwritten with those saved in the user settings.

The Trackgen firmware uses a simple ASCII-based command interface. You can use any basic serial terminal programme such a PuTTY, or the terminal interface included in the Arduino IDE, or Microsoft's Visual Studio. Set the Baud rate to 115,200. The commands may be in upper or lower case and should be terminated with the newline character (ASCII 10 or '\n') The commands are as follows:

CONNECT	Connect request. Returns “CONNECTED-1” to “CONNECTED-5”
VERSION	Returns the current firmware version, Arduino type and DS type
RESET	Issues a reset sequence to the DDS IC
SPOTF=n	Sets DDS frequency, where n is the required frequency in Hz.
STARTF=n	Sets the sweep start frequency where n is required frequency in Hz.
STOPF=n	Sets the sweep end frequency where n is required frequency in Hz.
STEPF=n	Sets the sweep step frequency where n is required frequency in Hz.
STEPTIME=n	Sets the dwell time between frequency steps in milliseconds
STARTSWEEP	Starts the frequency sweep, sweep will repeat until stopped
STOPSWEEP	Stops the frequency sweep.
RESETPIN=n	Sets the port where n is the port number connected to the DDS Reset pin
DATAPIN=n	Sets the port where n is the port number connected to the DDS Data pin
CLOCKPIN=n	Sets the port where n is the port number connected to the DDS Clock pin
UPDATEPIN=n	Sets the port where n is the port number connected to the DDS Update pin
SYNCPIN=n	Set the port where n is the port number connected to the Arduino sync port
SETDDSTYPE=n	Sets the DS type: 0=AD9850, 1-AD9851
GETDDSTYPE	Returns “0” if AD9850, or “1” if AD9851
PPMTRIM=n	Setrs the PPM trim value
GETPPMTRIM	Returns the PPM trim value
GETPINS	Returns “R:n D:n C:n U:n” where n is the current port number for the Reset, Data, Update, Clock and Sync pins respectively
CLEARSETTINGS	Erases all settings from EEPROM, default values will loaded next time the processor is powered up.

Return strings from Trackgen are terminated with the carriage return character – ASCII 13, or '\r'. The DDS command's maximum frequency is device dependant. For the AD9850 this will be around 40MHZ, for the AD9851, around 80MHz. Be aware that the spectral purity at these frequencies may not be good. You can use the analyser to check the output of these devices.

If you use Microsoft Visual Studio, then a very handy add-on is available from Visual Micro that allows you to edit, compile and download code to a large range of Arduino systems. The system integrates nicely with Visual Studio and includes comprehensive library management, as well as a very handy Arduino reference section that includes documentation for all the available libraries.

I highly recommend Visual Micro as an alternative to the Arduino IDE, particularly if you are working on a project that requires a Windows application that works in conjunction with an Arduino board. Microsoft will allow you to download a free copy of Visual Studio's Community version.

The following are links to where the software mentioned can be downloaded free of charge.

The Arduino IDE

<https://www.arduino.cc/>

Microsoft's Visual Studio Community Edition

<https://www.visualstudio.com/vs/community/>

Visual Micro's add-on for Visual Studio

<https://www.visualmicro.com/>

PuTTY Terminal Application

<https://www.putty.org/>

For further information on the Analog Devices range of DDS ICs, check:

<http://www.analog.com/en/products/rf-microwave/direct-digital-synthesis.html>

Noise source and Return Loss bridge

As an alternative to the tracking generator, a wideband noise source may be used, and in many cases, may be the preferred option. Such a device can be obtained quietly cheaply from Ebay, costing between \$10 and \$20. It's designed to run at 12 Volts, but does get rather hot. It can be powered with 7 Volts, where it runs a lot cooler. For convenience, I have run mine as low as 5V, the output is reduced to around -60dBm, and the broadband frequency distribution is still reasonably flat.

<https://www.ebay.com/itm/171709817697>

The return loss bridge is similarly available on Ebay for around \$10 and is rated from 0.5MHz to 3GHz.

<https://www.ebay.com.au/itm/RF-bridge-0-5-3000-MHz-VNA-Return-Loss-VSWR-SWR-reflection-bridge-antenna/332052527822?hash=item4d4fdf7ace:g:H6IAAOSwnHZYQH0u>

The user can refer to the following for an example of how a noise source and bridge may be used.

<http://www.sdrplay.com/community/viewtopic.php?f=7&t=1562>

Be careful with what you use as a signal source. The front end of the RSP devices can be easily damaged by using excessive levels of input-power. SDRplay recommends +10dBm for short periods, with 0dBm for continuous use. This equates to a voltage of 0.707 Volts RMS at +10dBm, and 223mV RMS at 0dBm. It's far cheaper to buy, or make a simple attenuator, than it is to replace your RSP device.

Windowing and FFT averaging

You will notice that when using a large number of FFT bins, (set on the frequency control panel), that the *apparent* noise floor of the system seems to reduce as the number of FFT bins is increased. This is due to an effect called FFT gain and does not represent the true noise floor of the system. FFT gain increases as the resolution is increased by increasing the number of FFT bins used. The following link gives a good explanation of the effect, and how to correct for it.

<https://kluedo.ub.uni-kl.de/frontdoor/index/index/year/2016/docId/4293>

In addition, selecting various FFT windows on the same control panel appears to apply varying levels of attenuation for the same signal level input. This is referred to as windowing loss. Each type of window, such as Blackman, Hamming, Hanning etc. has a different level of loss associated with it. Spectral power is not really lost, it is just distributed over several bins. The following link to an article by National Instruments gives a good overview of windowing in general, and the losses that might be expected for each window type.

<download.ni.com/evaluation/pxi/Understanding%20FFTs%20and%20Windowing.pdf>