:::measurement INNOVATION

RFT-1000 Rev A.04.60

RF Tools

Operating Manual

MEASUREMENT INNOVATION PTY LTD

RFT-1000 Operating Manual

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Western Australia

Contents

Chapter 1

Installation

Read this chapter if you are about to install the RF Tools software and Agilent IO Libraries for the first time. If the RF Tools software and Agilent IO Libraries are already installed on your PC, skip this chapter and go directly to Chapter 2.

Step 1:

892x - Installing the Agilent 82357A/B GPIB-USB interface cable

The Agilent 82357A or 82357B GPIB-USB interface cable must be installed in order to connect an 8920 and make measurements. However, you can install and run the RF Tools software on your PC without installing the GPIB interface drivers and 82357A/B cable – this will enable you to recall previously saved data and print it out, and use the RF Calculator, but you will not be able to connect an instrument and make new measurements.

Important Note: If you previously used an 82357"A" cable on your PC, and are now about to use one of the newer 82357"B" cables, you will encounter a problem which is easily resolvable. Please refer to Appendix E for details on how to resolve this.

Please follow the instructions in the User's Guide supplied with the Agilent 82357A/B interface. Follow the instructions precisely and you should not have any difficulties. For support and assistance with installing this interface cable, you should contact your local Agilent Technologies office or check their website www.agilent.com.

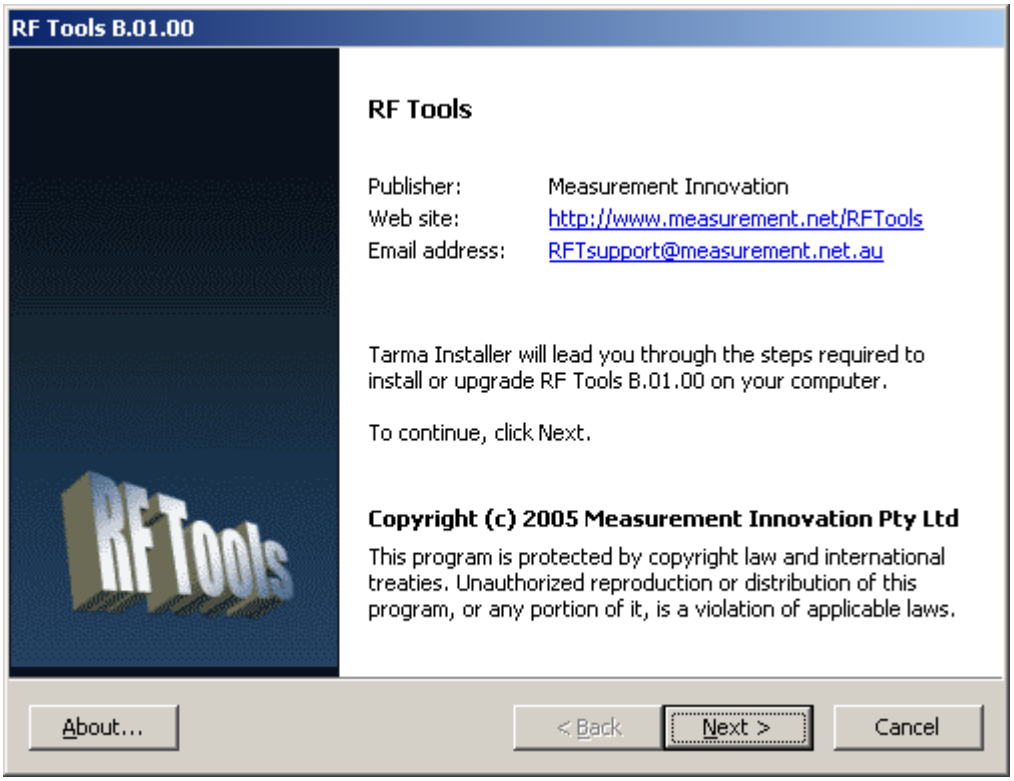
CSA – connecting via an Ethernet cable

The Agilent N1996A "CSA" range of spectrum analysers are connected to RF Tools via an Ethernet cable. As with all Ethernet networking, you can either connect via an Ethernet switch or hub on your corporate network (using standard Ethernet cables), or you can connect directly using a single Ethernet cable that has been wired with a "cross-over" configuration. For most lab or field measurements where the PC is directly connected to the CSA spectrum analyser, using a single cross-over style Ethernet cable that goes directly between the CSA and the PC's Ethernet ports is the simplest method. Please refer to Appendix B for further details on how to connect.

Step 2:

Installing the RF Tools software

Insert the RF Tools CD-ROM into your PC and run "setup.exe" from the CD-ROM. This will prompt you to install the RF Tools software, the Agilent I/O libraries and VEE runtime. All three of these need to be installed in order for the RF Tools software to run. If previous versions of Agilent I/O libraries or VEE runtime are already installed on your PC, you may need to uninstall them first.



By installing this software you agree to the terms of the License agreement.

Chapter 2

Getting Started

Your PC should already have the Agilent I/O Libraries, VEE runtime and RF Tools software installed, and if using an 892x the 82357A/B cable drivers. If not, refer to Chapter 1.

Step 1:

Turn on your PC and connect the hardware

Turn on your PC.

892x: Once Windows is completely loaded, plug your Agilent 82357A/B interface cable into an available USB port on your PC and connect the other end to the GPIB interface on your instrument. You should only have one 892x connected to your PC when using the RF Tools software.

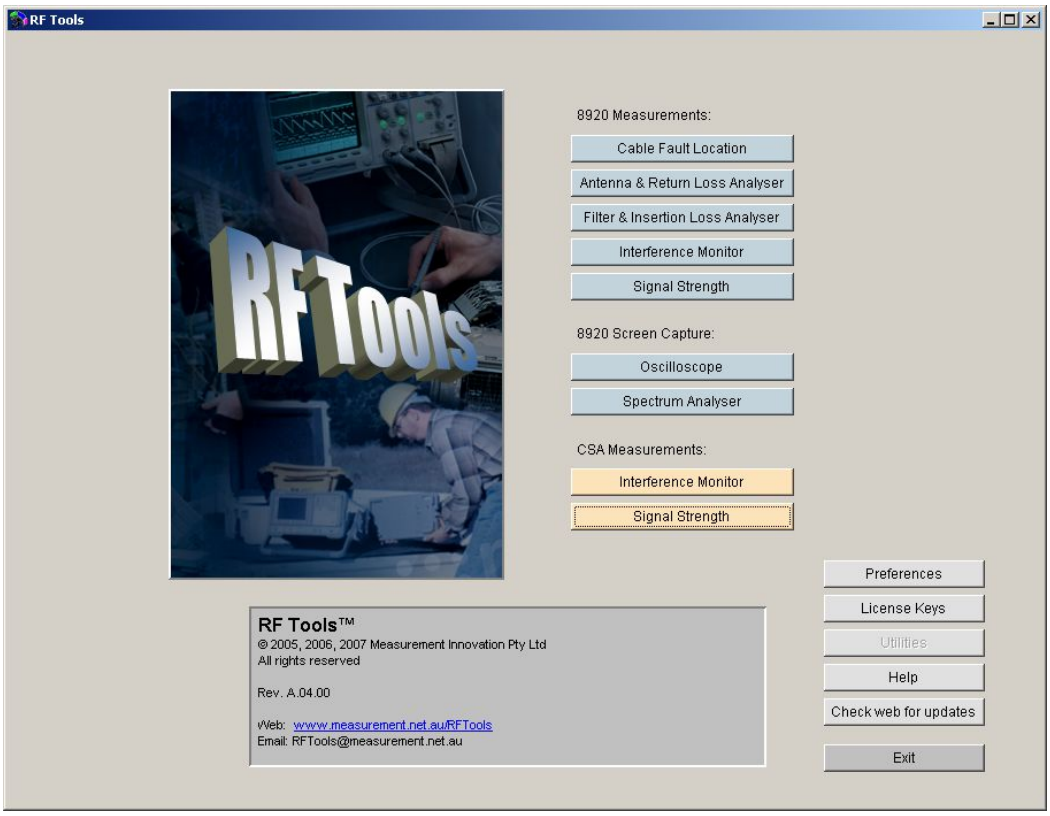
CSA: Connect the cross-over Ethernet cable between your PC and the CSA.

A list of supported instruments is provided in Appendix A of this manual.

Step 2:

Run the RF Tools Software

Double-click the “RF Tools” icon on your desktop, or the “RF Tools.vxe” application icon in the “C:/Programmes/RF Tools” folder. The application should launch and display a screen similar to the one shown below.



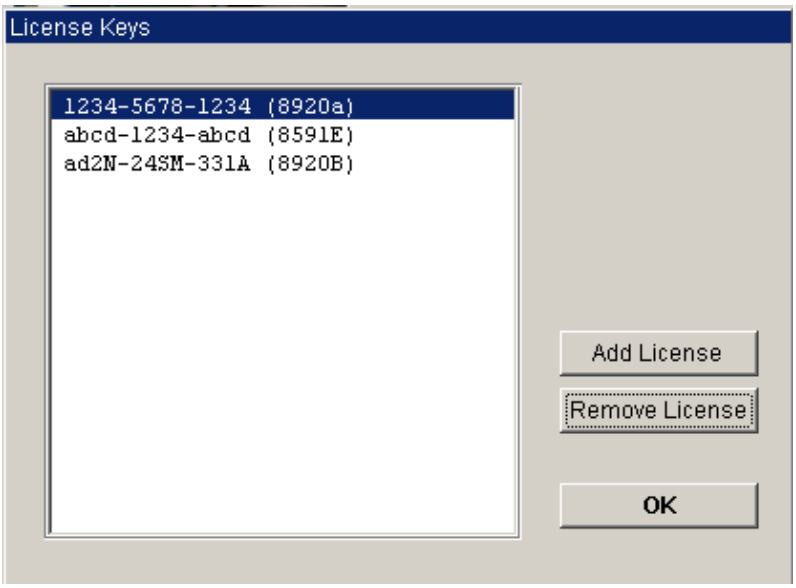
At this stage, no communication has taken place between your PC and your instrument. This will only occur when you click on one of the blue or orange buttons that launches one of the measurement modules. You can now go ahead and click on any of the blue or orange buttons and run one of the modules. However, if you are going to use an instrument to make real measurements, you will first need to install the appropriate License Key(s) for the instrument(s) you plan to use with the RF Tools Software.

Step 3:

Installing License Keys

You only need to install a License key if you plan to make real measurements using an actual instrument. You can run the software without any license keys on any number of PC's, but are limited to recalling and viewing/printing previously saved measurements.

Click on the "License Keys" button and a screen similar to the one shown below will be displayed.



Click the "Add License" button to add a license for an instrument. Follow the prompts – you will be asked to enter the model number of the instrument (for example, 8920A or N1996A) and the License key (for example, 1234-5678-9ABC). Click "OK" and the license key will be added for this instrument. Do this for as many instruments as you have license keys for – every PC in your group can have every license key installed, meaning that you can use any PC with any licensed instrument without having to worry about matching a particular instrument with a particular PC. You can also remove a license by selecting the license key and clicking "Remove License".

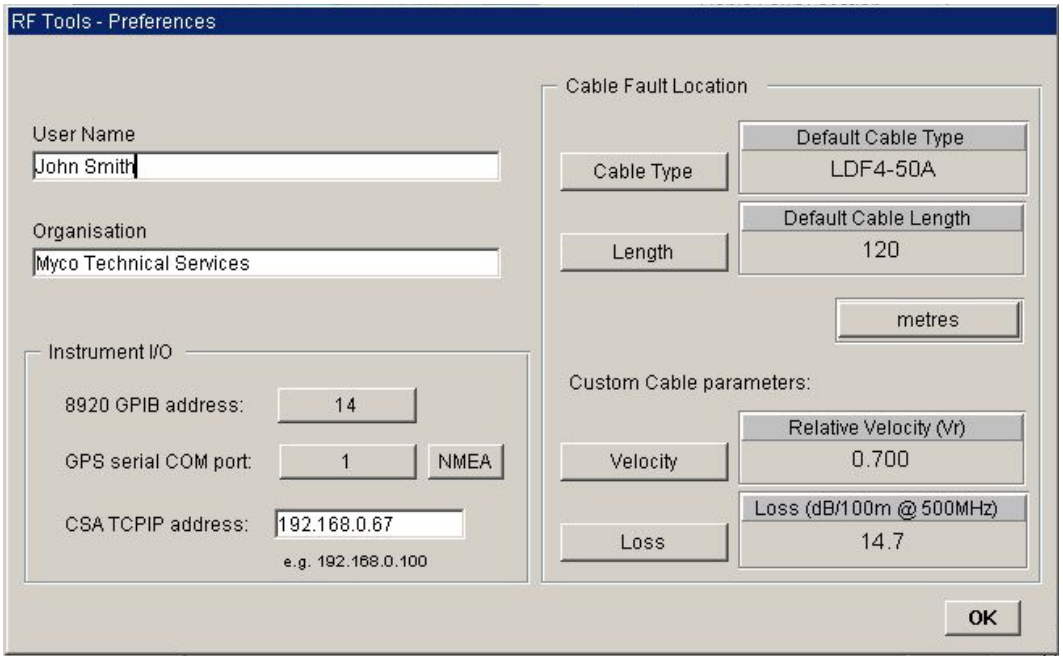
Once you have entered the License key(s), click "OK" and proceed to the next section to set the GPIB address and other user preferences.

License Keys: It's worth spending a moment to emphasise how the RF Tools software is licensed, as it can provide great flexibility to your engineering or workshop team. Because you can install multiple license keys on each PC, a workshop with, say, five 892x's, two CSA's and ten PC's can install the license keys for all seven instruments onto each of the ten PCs. A technician can therefore take any instrument and any PC out on site and know that they will operate together without having to match a specific instrument with a specific PC.

Step 4:

User Preferences & Instrument I/O Settings

Click on the "Preferences" button on the main screen and a dialogue box similar to the one shown below will be displayed.



User Name:
Enter a user name which will be used as the default value in various parts of the programme. In most instances you will be given the opportunity to change the name each time it is used.

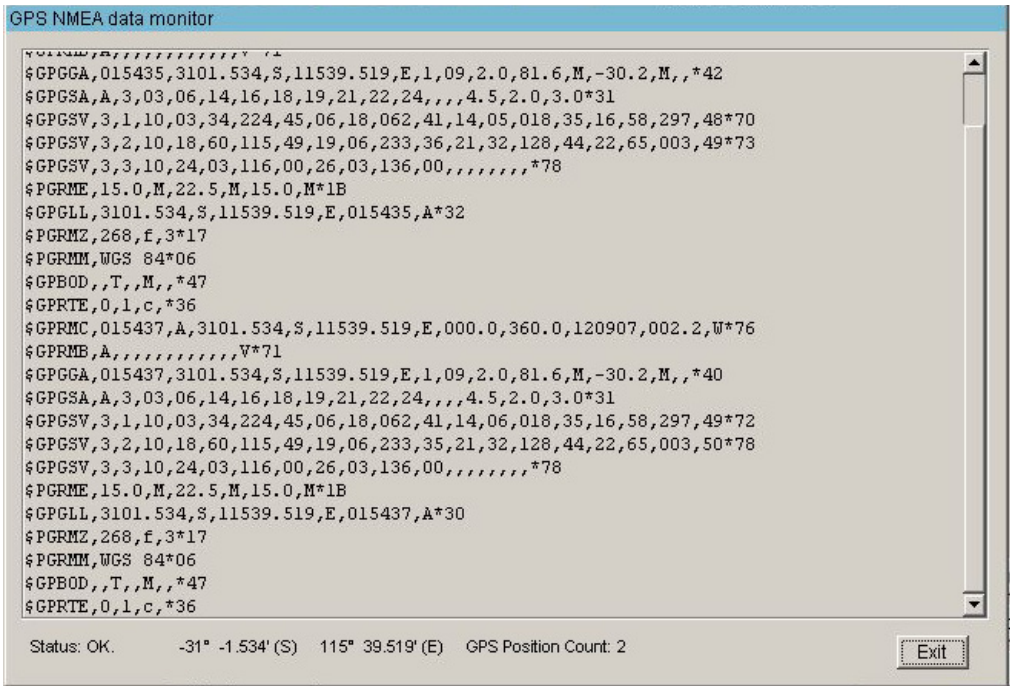
Organisation:
Enter the name of your organisation (company name or whatever). This is used and printed on reports.

Instrument I/O:

892x: Enter the GPIB address that your instrument is set to. Refer to your instrument's operating manual to find out how to do this. You *must* have the correct GPIB address set or the software will not be able to communicate with your instrument. For more information on how to configure the correct settings for your 8920A, 8920B, 8921A or 8924C, refer to Appendix B.

GPS: An optional, user-supplied GPS unit can be connected to log positional information in the Interference Monitor and Signal Strength modules. Enter the number of the COM port of your PC that your serial GPS is connected to. RF-Tools supports standard NMEA protocol from most GPS units that communicate

via RS232/serial. GPS units with USB-only connections are not supported. Click the "NMEA" button to confirm communications with your GPS. You should see bursts of NMEA data scrolling down the screen, similar to that shown below:



GPS com port settings:	Baud rate:	4800
	Byte Length:	8 bits
	Stop bits:	1
	Parity:	None
	Handshake:	None

CSA: If using a CSA spectrum analyser, enter its TCPIP address. The CSA must have a static IP address on the same subnet as your PC. Please refer to Appendix B, or consult your IT person and the CSA Operating Manual for further details.

Default Cable Type and Default Length:
These two settings determine the default cable type, and the length to be measured, which will be recalled whenever you click on the Cable Fault Location measurement button. If the type of cable you use is not listed, just select "Custom" and enter the values as described below.

Metres/Feet:
This button will be labelled either "Metres" or "Feet". If it displays "Metres" and you prefer to measure distance in feet, click the button. The units displayed are what the instrument will use in all its measurements and reports when using Cable Fault Location.

Custom Cable Parameters:
For Cable Fault Location on an RF cable, the only two cable parameters you need to enter are Vr (relative velocity compared with the speed of light) and the Loss in dB/100m at 500MHz. Most cable manufacturers specify Vr and Loss so all you have to do is enter them here and, when making a Cable Fault Location measurement, select "Custom" as the cable type to retrieve these values.

Once you have set all of the above to your preference, click the "OK" button to return to the main screen.

RF signals travel along cables at a speed less than the speed of light. The actual speed depends on a number of factors, including what type of dielectric material the cable is made of. Cable Fault Location relies on the time it takes for the signal to travel along to, and then back from, a fault in the cable. By knowing the speed of travel we can convert this time into the equivalent distance along the cable. If we have the wrong value for Vr entered, then we will get incorrect values of distance. It is worth knowing this since many cable manufacturers specify different values of Vr for apparently the same cable type. The loss (attenuation) of the cable is also important if we want to know the values of return loss or VSWR of these faults (i.e. how bad they are). Because cables are lossy, a reflection that occurs further down the cable will produce a smaller reflection than if the same fault was nearer the test instrument. Knowing the cable's loss, the software can compensate and adjust the values of return loss and VSWR accordingly.

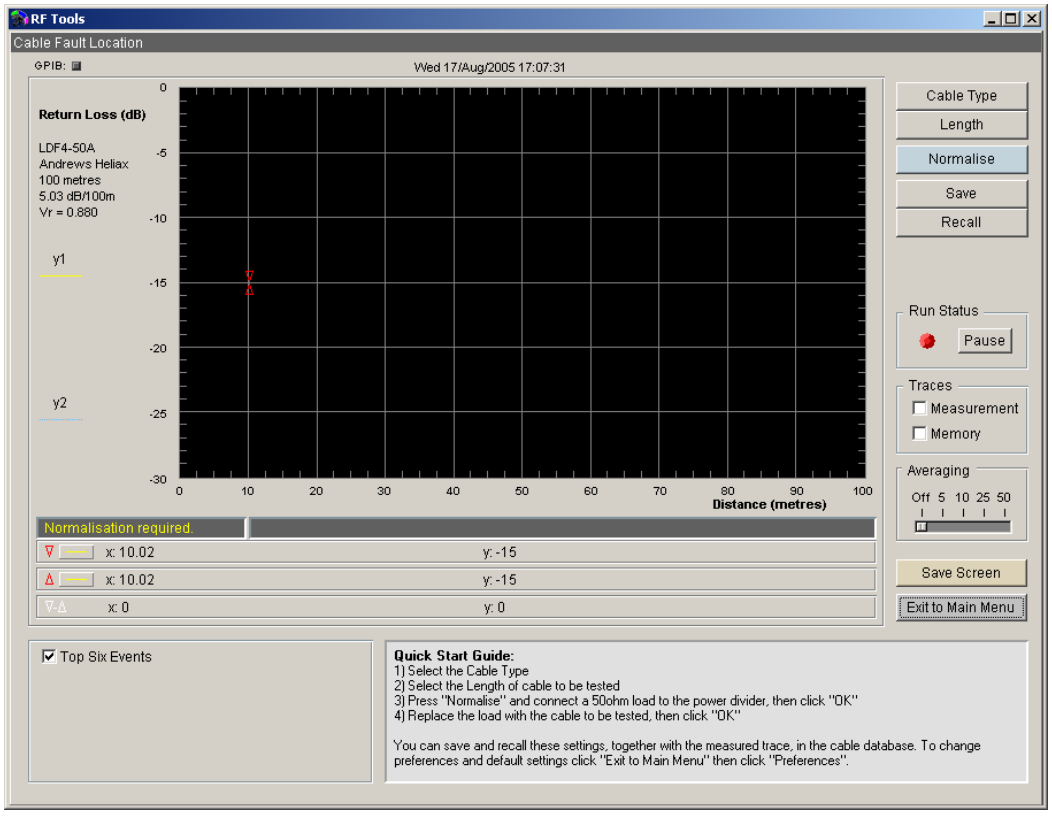
Chapter 3

Cable Fault Location

Use this module to measure the distance to faults along any 50Ω coaxial RF cable.

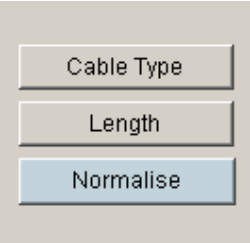
Quick Measurements

Click on the "Cable Fault Location" button on the main screen. A screen similar to the one below will appear.



If instead you get a popup that tells you that no instrument is connected, or that an unlicensed instrument is connected, refer to Chapter 2 on setting the GPIB address and installing License keys.

There are three simple steps to making a cable fault location measurement:

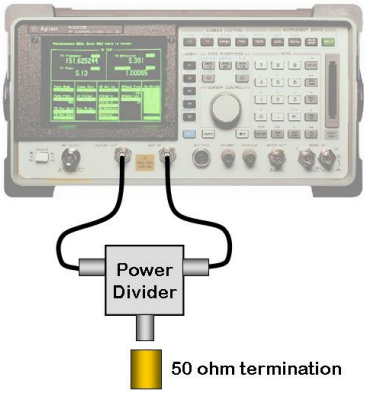


1) Select the Cable Type:
Click the "Cable Type" button and select the type of cable you want to measure (e.g. LDF4-50).

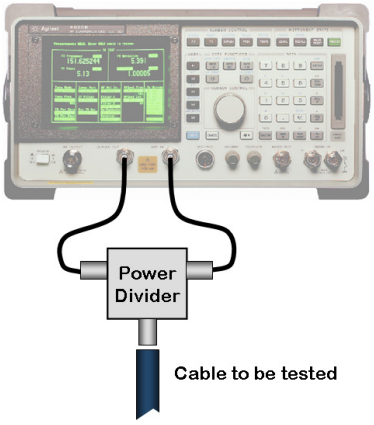
2) Select the Length:
Click the "Length" button and enter the distance over which you want to measure. If you are unsure of the length, just guess a value for now, picking a large value that you can easily reduce later once you have seen what the measurement looks like.

3) Normalise:
Click the "Normalise" button and follow the instructions to normalise the instrument. This involves connecting a precision 50Ω termination to the power divider, and when instructed, replacing the load with the cable to be measured.

Normalise Step 1

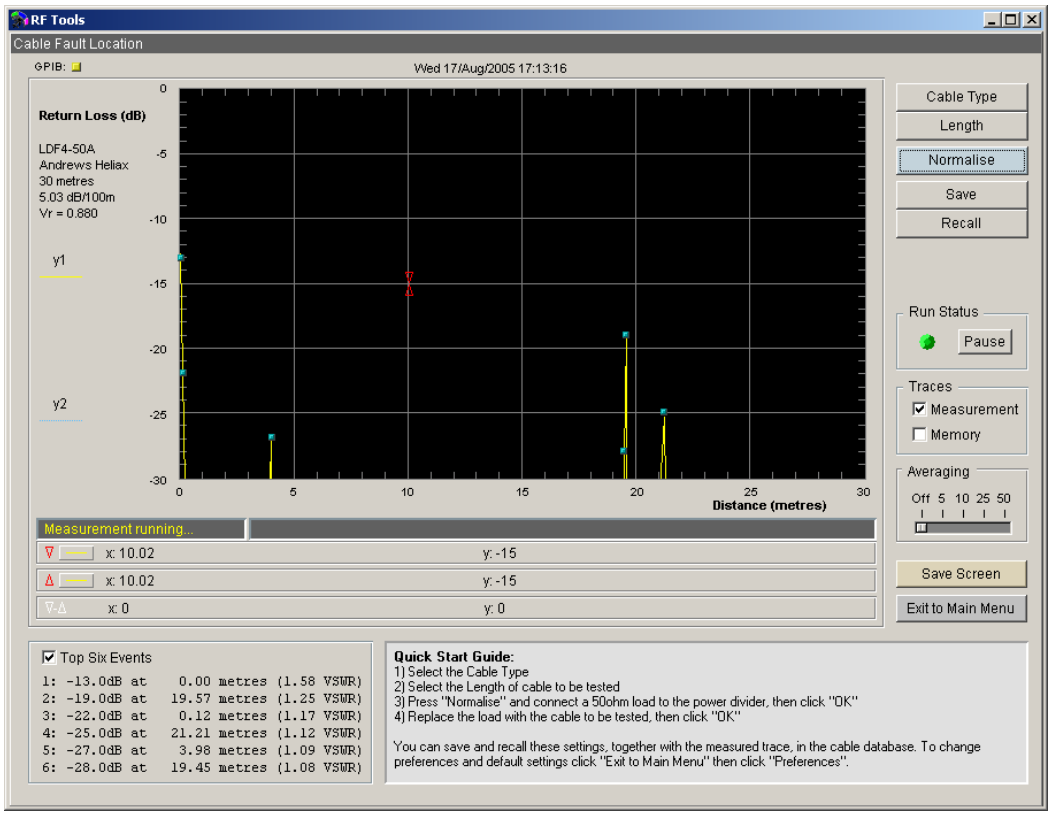


Normalise Step 2



When connecting the cable to the power divider, it is most likely that you will need to use an adapter and perhaps a patch cable.. Adapters can have a significantly detrimental effect on all types of return loss measurements, including Cable Fault Location. Only use the very best quality instrument grade adapters (these are expensive but worth it) and use as few adapters as possible. If you are unsure as to the quality of a particular adapter, connect it between two cables and use this Cable Fault Location software to estimate its return loss!

The screen should now display a Measurement trace similar to the one shown below. Your cable will obviously be different to the one shown here, but there should at least be some peaks at various places along the yellow trace.



If you need to change the Length or the Cable Type, both of these changes send new settings to the instrument and require a re-calibration to be performed. Simply click the “Normalise” button and follow the same procedure as previously.

How to interpret the results

The yellow trace is a measurement of the return loss vs. distance along the cable. A value of 0dB indicates a short or open circuit, meaning that all of the signal is being reflected back at that point; a value of -20dB means that the reflected signal is 20dB less than the level of the forward signal, i.e. 1/100th of the power is being reflected. Return loss is an indication of the match (i.e. how close to 50Ω the measured impedance is). Another unit commonly used to measure match is VSWR (Voltage Standing Wave Ratio). As an example, a VSWR of 1.5 is about the same as a return loss of 14dB. It is frequently considered that a VSWR better than 1.5 (i.e. a return loss better than 14dB) is acceptable. Two red markers are provided to show values of return loss and VSWR at specific distances along the trace.

In the example measurement shown above we measured a length of cable with an antenna at the end. You can see a peak around 3m (an N-type bulkhead connector in a patch panel with a rather poor return loss), another peak around 57m (an N-type joiner that seems to

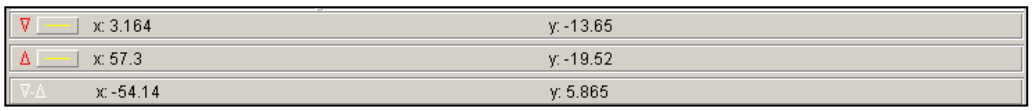
be OK), and some other peaks around 84m that are the responses from the antenna and the balun feeding it.

Run Status and the Pause button

Depending on the cable length (which affects the instrument settings) and how fast your PC is, the yellow Measurement trace updates about once per second. This allows you to watch the effects of any changes you make to the cable under test. If you want to pause the measurement and freeze the screen, click the Pause button. This is particularly useful when you want to move the two red trace markers manually along the trace.

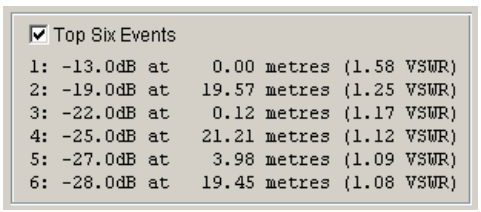
Markers and the "Top six events"

Two red markers are shown that, when the measurement is running, constantly track the two highest peaks of the trace. The x (distance) and y (return loss) values of each are displayed as shown below, along with the difference measurements between the two.



If you press the "Pause" button and freeze the Measurement trace, you can manually move either marker by holding the mouse button down over the marker and dragging it along the trace. (If you don't first press "Pause" then the marker will keep returning to one of the two highest peaks). Later, when we save and recall a trace from memory, you will see how, when we click on the small grey rectangle with the yellow line, the yellow line changes to a blue line. This allows us to move one or both markers on the stored blue trace as well.

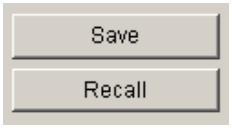
In addition to the markers, the six highest peaks are also measured and listed in the "Top six events" table. The distance (feet or metres), return loss (dB) and VSWR are displayed for each.



Saving, Recalling and Printing

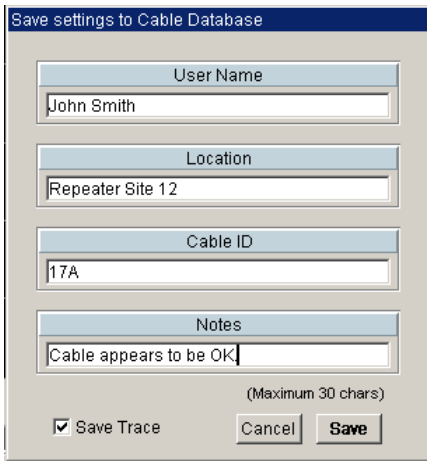
1) Save Screen:
One way record your measurement is to click the "Save Screen" button. This saves a JPG image of the current screen and will prompt you with the usual Windows file dialog so you can choose where you want to save it. You might select the "My Documents" folder, or perhaps a flash memory stick that you have available. This is the simplest and most basic way to save a record of your measurements for pasting into reports etc.

2) Cable Database:



RF Tools has a Cable Database that allows you to keep a record of each of the cables you have tested, and recall them later for comparison. Each record stores all of the measurement parameters, the trace data (optional), plus some extra fields for User Name, Location, Cable ID etc. Each record is automatically time and date stamped.

Saving a Measurement. To save your current measurement, click the "Save" button. The following dialog will be displayed.



You will be prompted with the default User Name as defined in Preferences - you can type over this.

Enter the Location where the measurement is being made, such as the name of the repeater site, or perhaps building address.

Enter a name or number in Cable ID that identifies this particular cable.

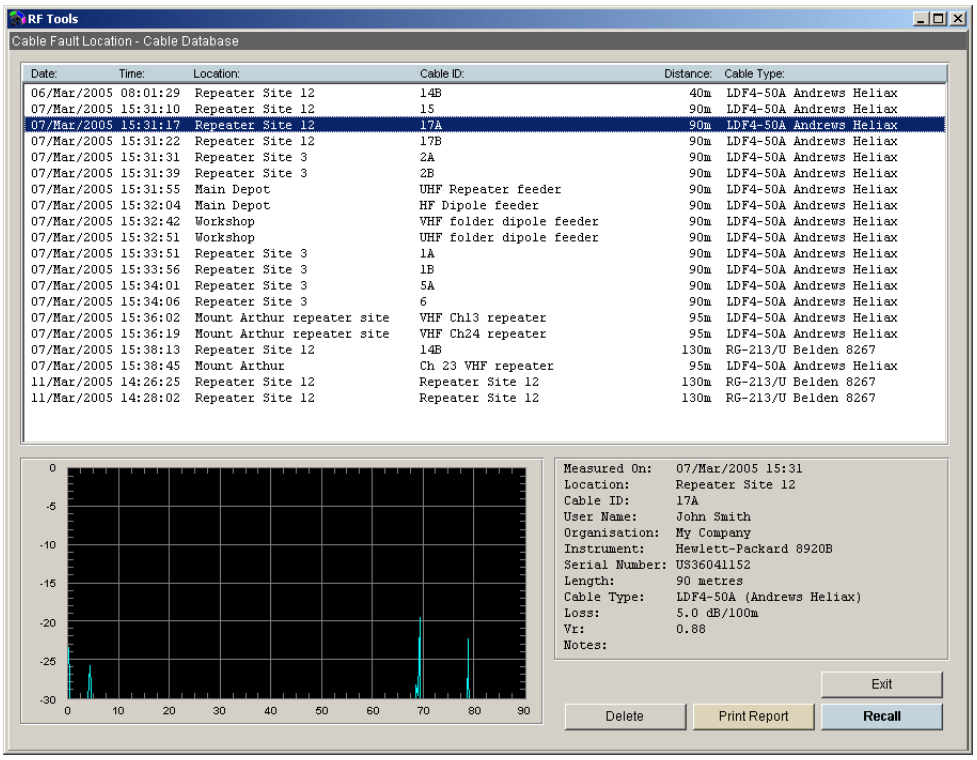
Enter any notes you want to make.

Select whether you want to save the trace data along with all the measurement parameters. (i.e. save "State Only" or "State & Trace").

Click "Save" to save to the Cable Database, or "Cancel" to cancel.

None of these fields are mandatory, but it will be much easier in 12 months time to remember what this measurement relates to if you put something meaningful in the fields provided.

Recalling a Measurement. To recall a previously saved measurement, click the "Recall" button. A list showing all of the previously saved measurements will be displayed, similar to the one shown below.

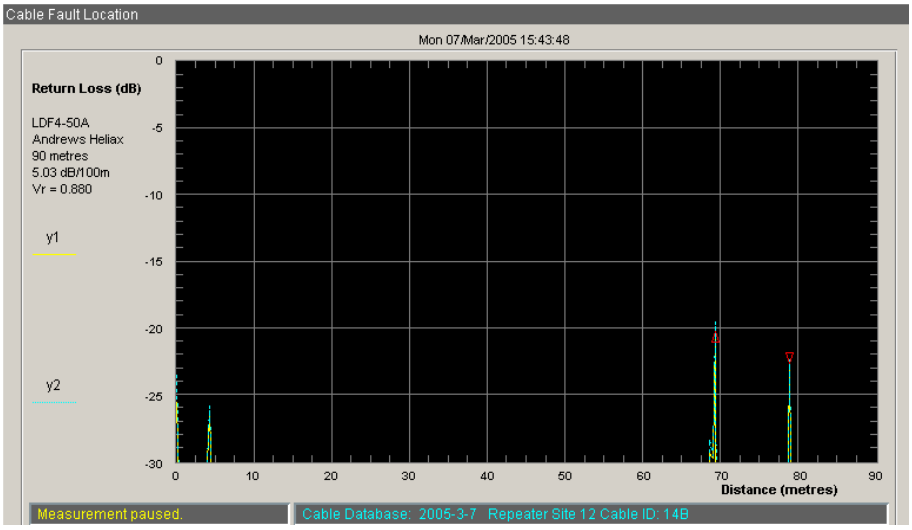


Click on any of the items in the list and you will see a preview of the stored trace, plus a complete list of the various parameters associated with that measurement (Date, Time, User Name, Location, Cable ID etc.) plus the model and serial number of the instrument that was used to make that measurement.

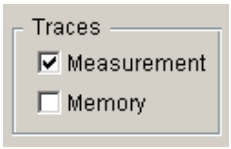
Click "Exit" to exit the screen.

Click "Delete" to delete the selected record. You will be asked to confirm whether you really want to delete this record.

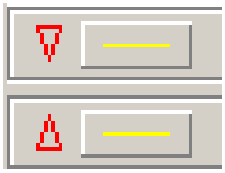
Click "Recall" to recall the measurement parameters for the selected record, including the trace data (assuming you selected "Save Trace" when you originally saved this record). This will return you to the main Cable Fault Location screen, with the cable parameters loaded ready for making a repeat measurement with the recalled settings, and the previously stored trace displayed in blue.



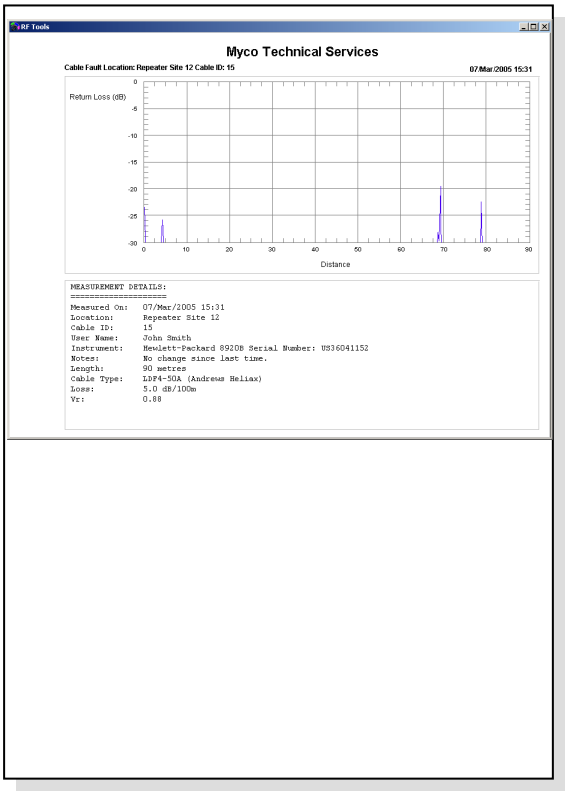
If you want to make a measurement using the new settings, and if any of the cable parameters you recalled are different from those previously being used, you will need to click “Normalise” again and follow the procedure as previously. Once normalised, the screen will show two traces – the live measurement data in yellow and the memory (recall) trace in blue. You can turn either of these On or Off using the “Trace Control” check boxes.



Similarly, you can select whether you want either or both of the markers to be active on the yellow Measured Trace or blue Memory Trace by clicking the respective marker trace buttons. The line colour will change to reflect on which trace the marker is currently active.



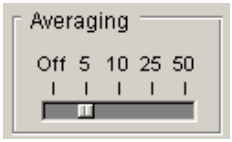
3) Print Report:
Click “Recall” to get back to the Cable Database. Clicking the “Print Report” button will ask whether you want to print a report to your default printer. Click “OK” if you wish to proceed. This report includes all of the measurement data and Measurement trace in a format that suits printing onto paper. Currently there is no ability to select which printer to print to, so if there is more than one printer installed on your PC, you must do the usual thing in Windows and go to Start Menu/Settings/Printers and select the appropriate printer to be your Default Printer. An example report is shown below. The lower portion has been kept blank to allow you to write your own notes and comments.



If you have the full version of an application such as Adobe® Acrobat® installed (not just the free Acrobat Reader version), you can select Acrobat® as your default printer and save the reports in PDF format on your hard drive or a flash memory stick.

Trace Averaging

Turning on averaging may be useful to minimise noise when measuring long cables. The default setting is “Off” which is suitable for most measurements and gives the fastest response when observing changes (such as connecting or disconnecting an antenna). Turning on averaging may reduce the noise in certain situations but bear in mind that the more averages, the longer it will take for the trace to stabilise.



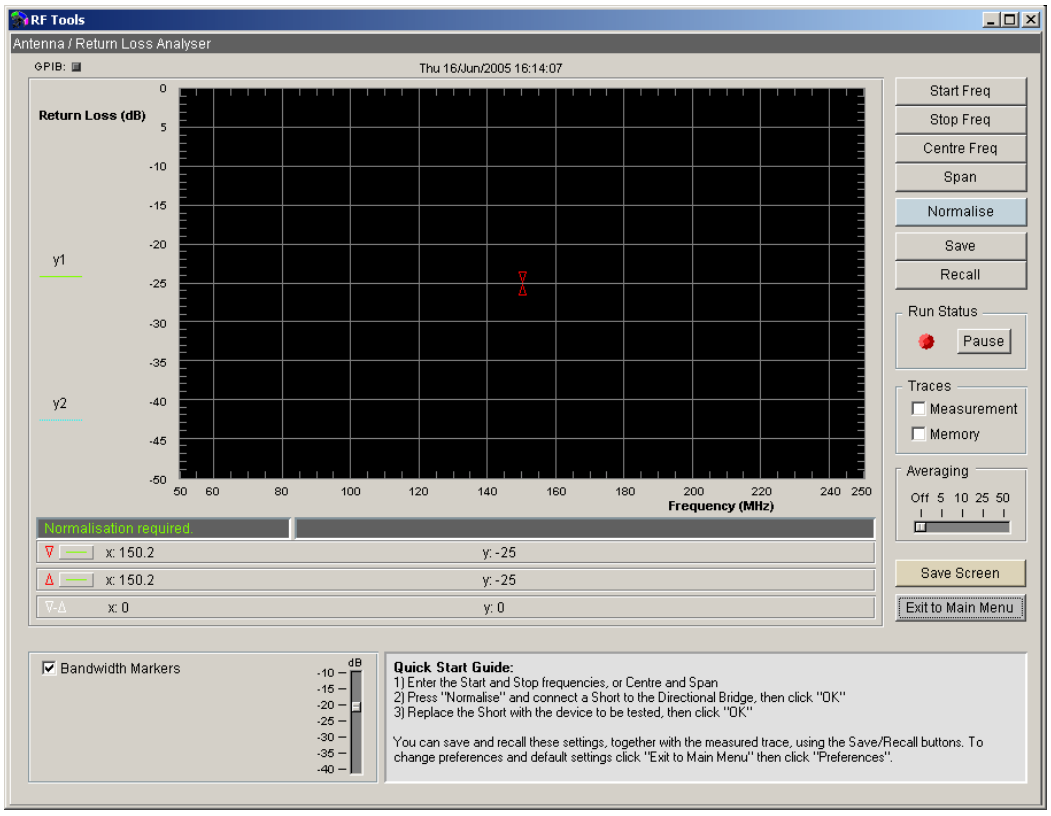
Chapter 4

Antenna & Return Loss Analyser

Use this module to measure the Return Loss of antennas and other 50Ω RF devices.

Quick Measurements

Click on the "Antenna & Return Loss Analyser" button on the main screen. A screen similar to the one below will appear.



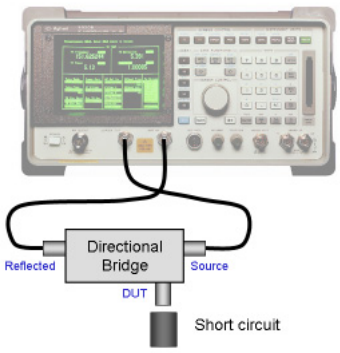
If instead you get a popup that tells you that no instrument is connected, or that an unlicensed instrument is connected, refer to Chapter 2 on setting the GPIB address and installing License keys.

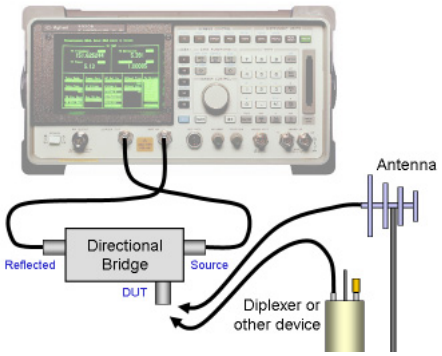
There are two simple steps to making a Return Loss measurement:

1) Select the Frequency Range:
Set the Start and Stop frequencies, or Centre and Span frequencies to suit the device to be measured.

2) Normalise:
Click the "Normalise" button and follow the instructions to normalise the instrument. This involves connecting a precision Short to the directional bridge, clicking "OK", and then replacing the Short with the device to be measured.

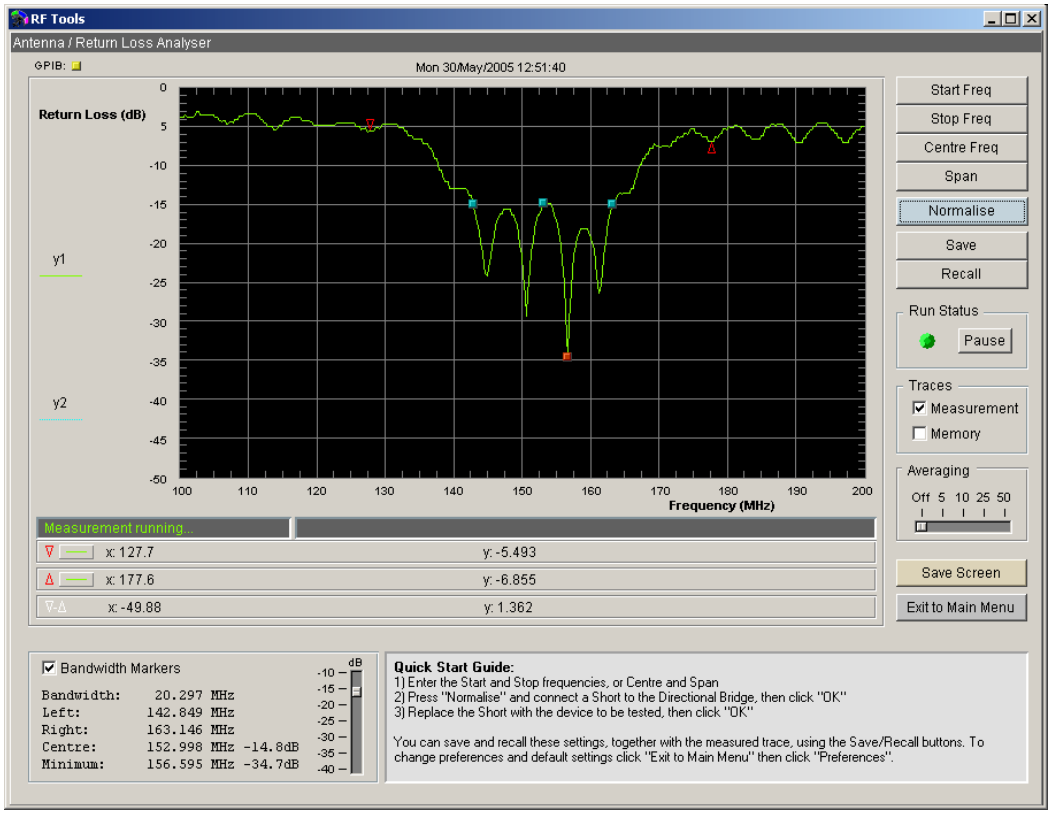
*Please Note that some directional bridges have different connector configurations to those shown in the diagrams below which show those used for the Eagle model RLB150x4. Be sure to connect the **DUPLEX OUT** BNC on the instrument to the "source" or "Input" connector of the bridge, the **ANT IN** BNC to the connector marked "Reflected" on the bridge, and the Short or device to the "DUT" or "Output" connector of the bridge.*





When connecting the antenna or other device to the directional bridge, it is likely that you will need to use a patch cable and perhaps an adapter. Adapters can have a detrimental effect on return loss measurements. Only use the very best quality instrument-grade adapters (these are expensive but worth it) and use as few adapters as possible. If you are unsure as to the quality of a particular adapter, connect it between two cables and use this Cable Fault Location software to estimate its return loss!

The screen should now display a measurement trace similar to the one shown below (in this instance, the return loss of a VHF marine band folded dipole). Your antenna or other device will obviously be different to the one shown here, but assuming you entered an appropriate frequency range and followed the normalisation process, you should see a green trace on the screen that represents the return loss of your device.



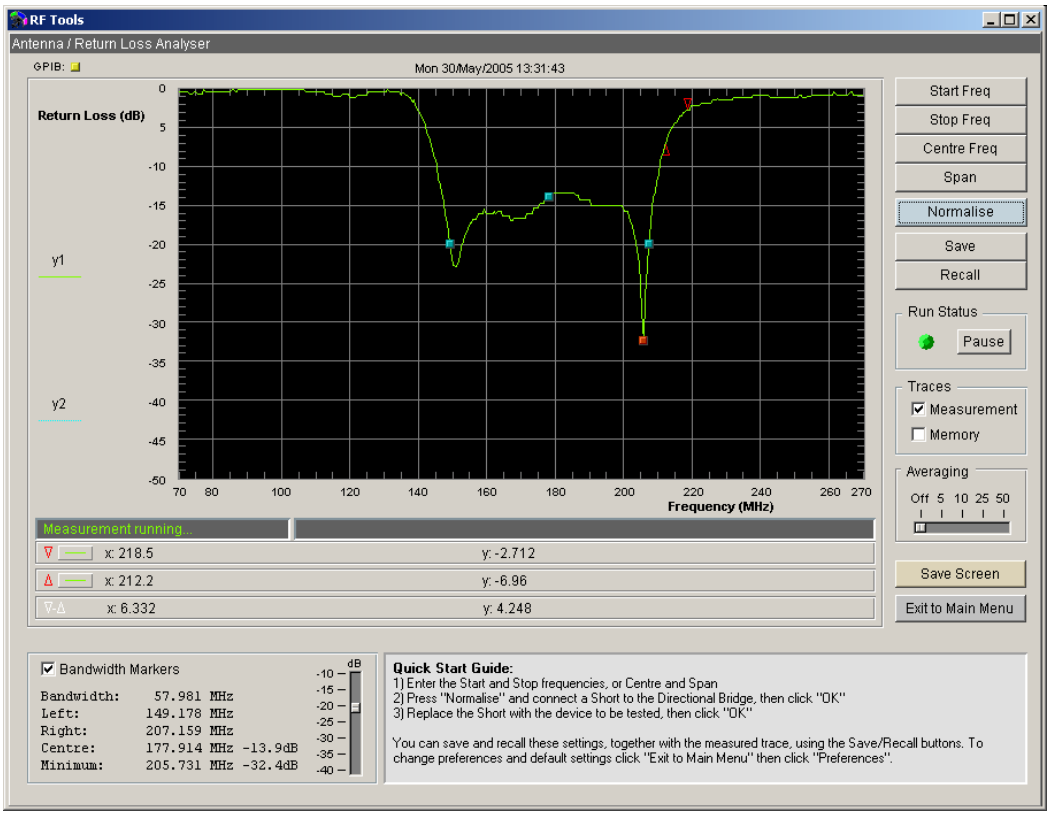
If you need to change the frequency range the instrument will require re-normalising. Simply click the “Normalise” button and follow the same procedure as previously.

How to interpret the results

The green trace is a measurement of the return loss vs. frequency. A value of 0dB indicates a short or open circuit, meaning that the entire signal is being reflected back at that frequency; a value of -20dB means that the reflected signal is 20dB less than the level of the forward signal, i.e. 1/100th of the power is being reflected. Return loss is an indication of the match (i.e. how close to 50Ω the measured impedance is). Another unit commonly used to measure match is VSWR (Voltage Standing Wave Ratio). As an example, a VSWR of 1.5 is about the same as a return loss of 14dB. It is frequently considered that a VSWR better than 1.5 (i.e. a return loss better than 14dB) is acceptable, although others look for a return loss of better than 20dB. Two red markers are provided to show the value of return loss at points along the trace. You can drag these along the trace and read the values directly.

In the example measurement shown above we measured a VHF marine band antenna with quite a long cable attached. Some of the ripples in the measurement are likely to be the result of using such a long cable; using shorter cables may improve the measurement.

Another example shown below is the measurement of the return-loss of a diplexer cavity filter (with a 50Ω termination connected to the un-used port of the filter).

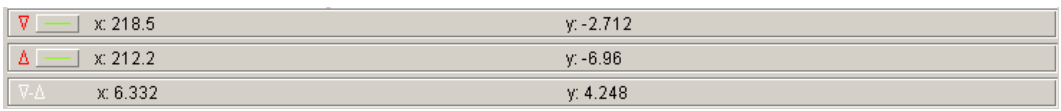


Run Status and the Pause button

Depending on the frequency span selected for the measurement (which affects how long it takes the instrument to sweep) and how fast your PC is, the green Measurement trace updates about twice per second. This allows you to observe the effects of changes you make to the device. If you want to pause the measurement and freeze the screen, click the Pause button. This is particularly useful when you want to move the two red trace User Markers manually along the trace.

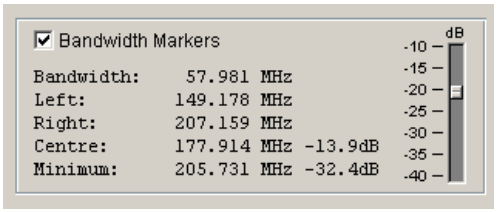
User Markers and Bandwidth Markers

You can drag the two red User Markers anywhere on the trace and read the numeric values of return loss at specific frequencies. The difference between the two markers is also displayed.



Freezing the trace with the "Pause" button can make it easier when dragging the markers. Later, when we save and recall a trace from memory, you can click on the grey rectangle with the green line to swap one or both markers from the green "live" trace onto the blue "stored" trace. This allows you to make difference measurements between stored and live measurement data.

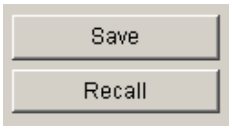
In addition to the User Markers, four automatic Bandwidth Markers can be activated. These try to find the centre frequency (turquoise marker), left and right dB points (turquoise markers) and the minimum return loss (red marker). The dB value is selected using the dB slider. The bandwidth between the left and right markers is also displayed in MHz.

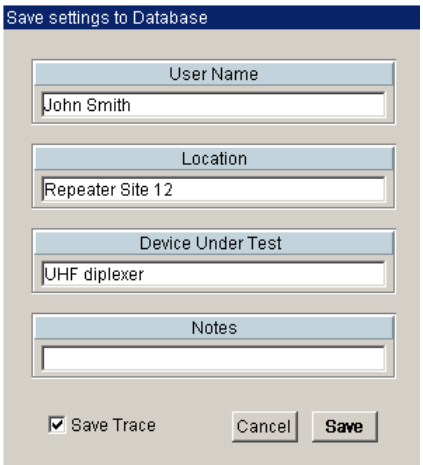


Saving, Recalling and Printing

1) Save Screen:
One way record your measurement is to click the "Save Screen" button. This saves a JPG image of the current screen and will prompt you with the usual Windows file dialog so you can choose where you want to save it. You might select the "My Documents" folder, or perhaps a flash memory stick if you have one. This is the simplest and most basic way to save a record of your measurements for pasting into reports etc.

2) Antenna Database:
RF Tools has a Database that allows you to keep a record of each of the antennas or other devices you have tested, and recall them later for comparison. Each record stores all of the measurement parameters, the trace data (optional), plus some extra fields for User Name, Location, Device ID etc. Each record is automatically time and date stamped.





Saving a Measurement. To save your current measurement, click the "Save" button. The following dialog will be displayed.

You will be prompted with the default User Name as defined in Preferences – you can type over this.

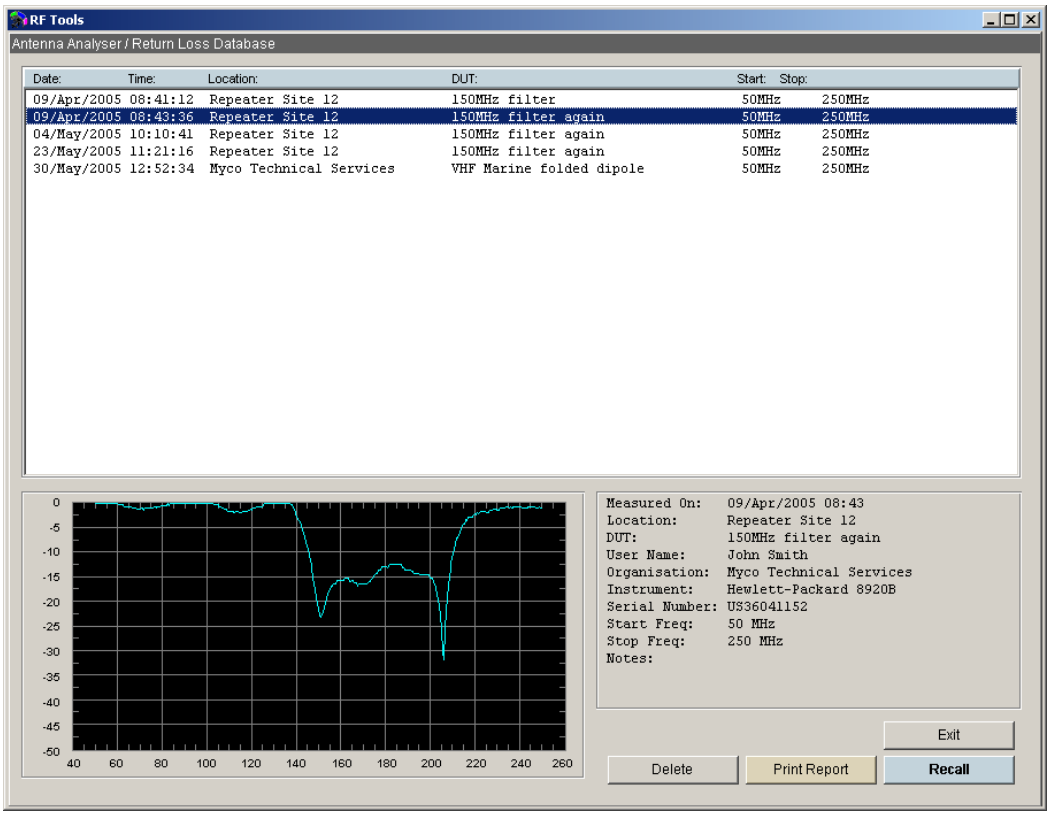
Enter the Location where the measurement is being made, such as the name of the repeater site, or perhaps building address.

Enter a name or number in Device Under Test that identifies this particular device.

Enter any notes you want to make.

Select whether you want to save the trace data along with all the measurement parameters. (i.e. save "State Only" or "State & Trace"). Click "Save" to save to the Database, or "Cancel" to cancel.

Recalling a Measurement. To recall a previously saved measurement, click the "Recall" button. A list showing all of the previously saved measurements will be displayed, similar to the one shown below.

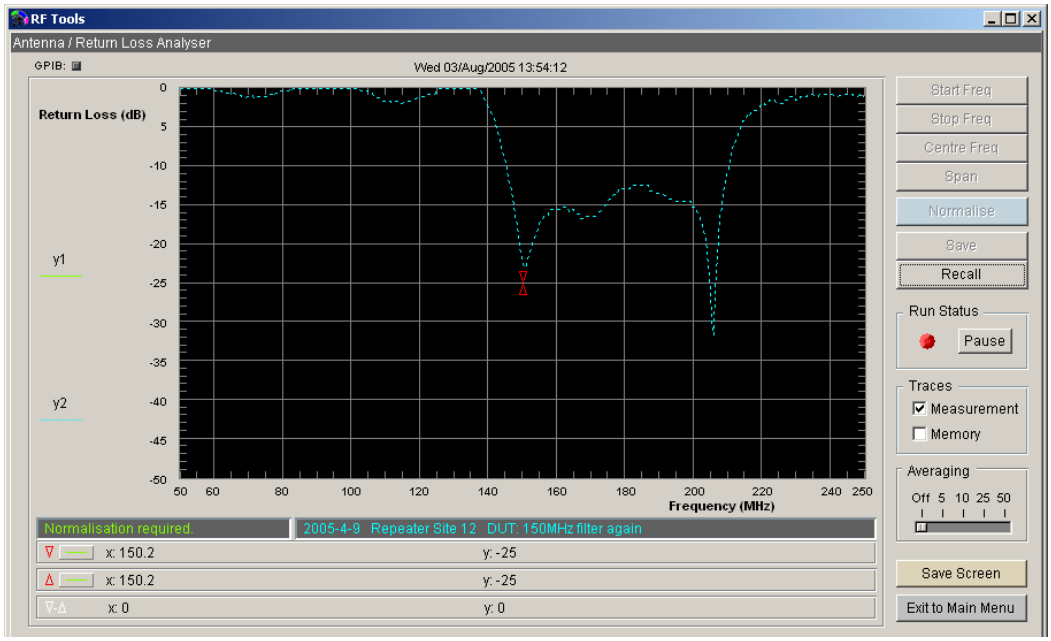


Click on any of the items in the list and you will see a preview of the stored trace, plus a complete list of the various parameters associated with that measurement (Date, Time, User Name, Location, DUT name etc.) plus the model and serial number of the instrument that was used to make that measurement.

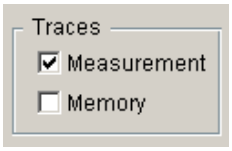
Click "Exit" to exit the screen.

Click "Delete" to delete the selected record. You will be asked to confirm whether you really want to delete this record.

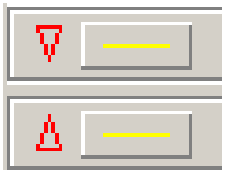
Click "Recall" to recall the measurement parameters for the selected record, including the trace data (assuming you selected "Save Trace" when you originally saved this record). This will return you to the main Antenna & Return Loss Analyser screen, with the measurement parameters loaded ready for making a repeat measurement with the recalled settings, and the previously stored trace shown in blue.



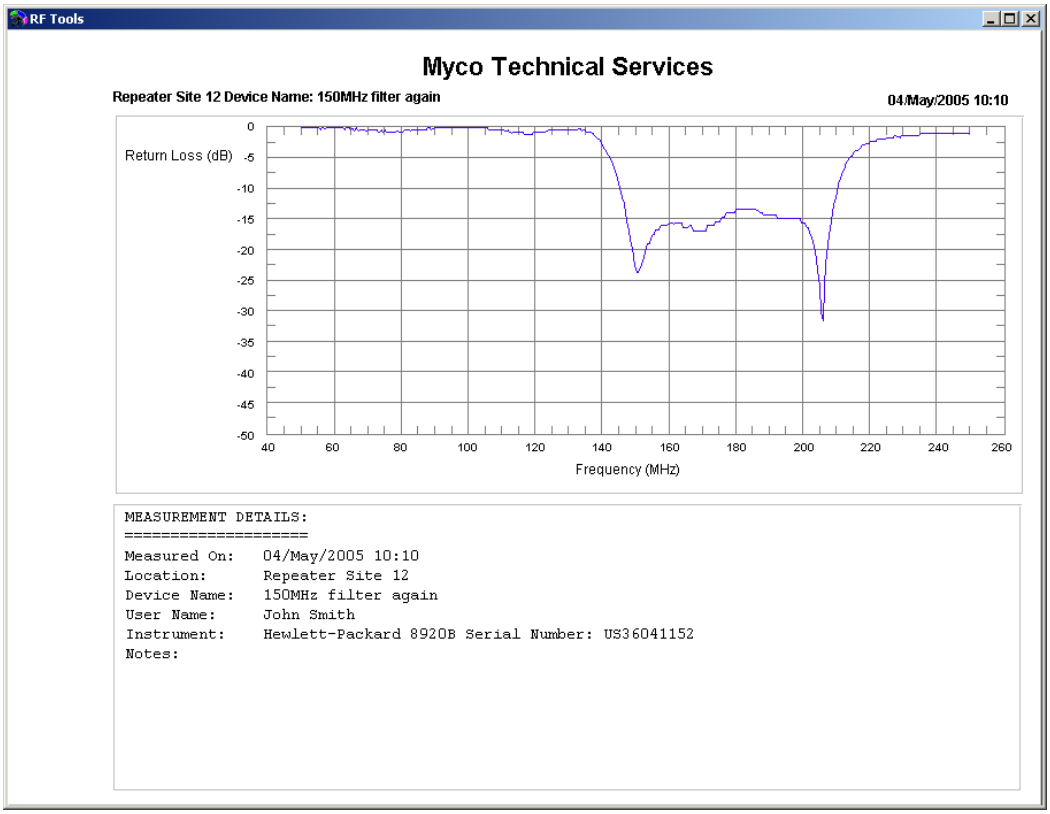
If you want to make a measurement using the new settings, and if any of the parameters you recalled are different from those previously being used, you will need to click “Normalise” again and follow the procedure as previously. Once normalised, the screen will show two traces – the live measurement data in yellow and the memory (recall) trace in blue. You can turn either of these On or Off using the “Trace Control” check boxes.



Similarly, you can select whether you want either or both of the markers to be active on the yellow Measured Trace or blue Memory Trace by clicking the respective marker trace buttons. The line colour will change to reflect on which trace the marker is currently active.

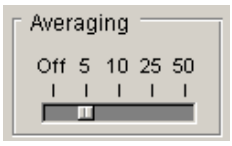


3) Print Report:
Click “Recall” to get back to the Antenna Database. Clicking the “Print Report” button will ask whether you want to print a report to your default printer. Click “OK” if you wish to proceed. This report includes all of the measurement data and Measurement trace in a format that suits printing onto paper. Currently there is no ability to select which printer to print to, so if there is more than one printer installed on your PC, you must do the usual thing in Windows and go to Start Menu/Settings/Printers and select the appropriate printer to be your Default Printer. An example report is shown below. The lower portion has been kept blank to allow you to write your own notes and comments.



If you have the full version of an application such as Adobe® Acrobat® installed (not just the free Acrobat Reader version), you can select Acrobat® as your default printer and save the reports in PDF format on your hard drive or a flash memory stick.

Trace Averaging



Turning on averaging may be useful to minimise noise when measuring long cables. The default setting is “Off” which is suitable for most measurements and gives the fastest response when observing changes (such as connecting or disconnecting an antenna). Turning on averaging may reduce the noise in certain situations but bear in mind that the more averages, the longer it will take for the trace to stabilise.

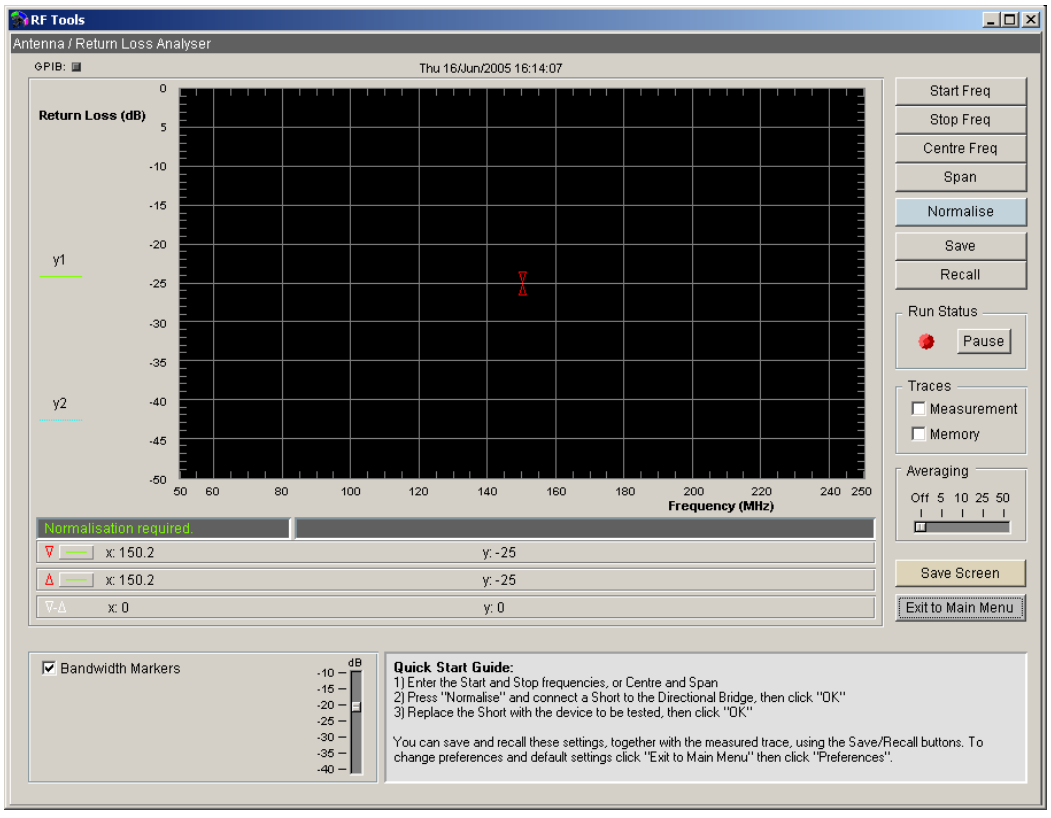
Chapter 5

Filter & Insertion Loss Analyser

Use this module to measure the Insertion Loss of filters, diplexers and other 50Ω RF devices.

Quick Measurements

Click on the "Filter & Insertion Loss Analyser" button on the main screen. A screen similar to the one below will appear.

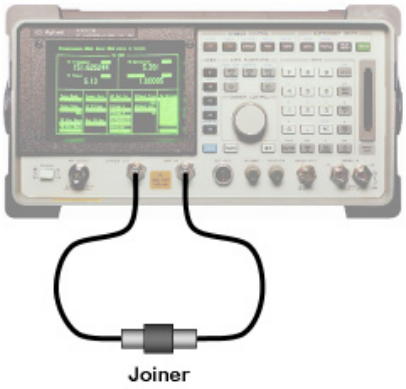


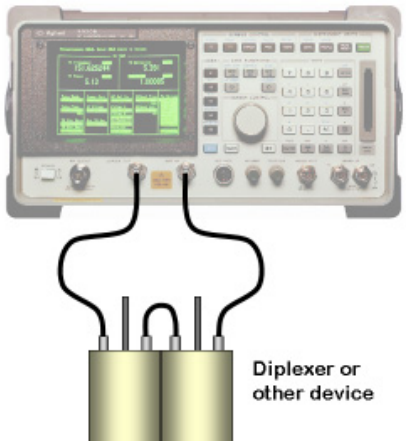
If instead you get a popup that tells you that no instrument is connected, or that an unlicensed instrument is connected, refer to Chapter 2 on setting the GPIB address and installing License keys.

There are two simple steps to making an Insertion Loss measurement:

1) Select the Frequency Range:
Set the Start and Stop frequencies, or Centre and Span frequencies to suit the device to be measured.

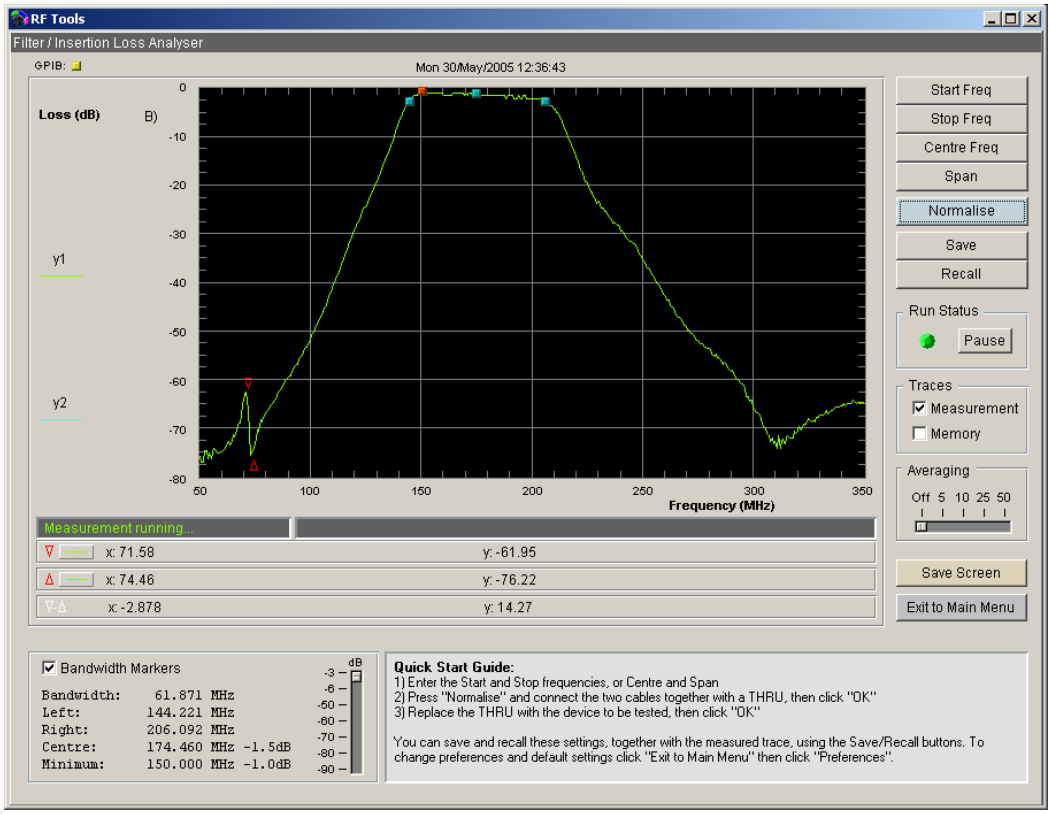
2) Normalise:
Click the "Normalise" button and follow the instructions to normalise the instrument. This involves connecting a precision Thru (coaxial joiner) between the two test cables, clicking "OK", and then replacing the Thru with the device to be measured.





When connecting the diplexer, filter or other device, it is likely that you will need to use a patch cables and adapters. Adapters can have a detrimental effect on measurements so only use the very best quality instrument-grade adapters (these are expensive but worth it) and use as few adapters as possible. If you are unsure as to the quality of a particular adapter, connect it between two cables and use this Cable Fault Location software to estimate its return loss!

The screen should now display a measurement trace similar to the one shown below (in this instance, the insertion loss of a VHF filter). Your antenna or other device will obviously be different to the one shown here, but assuming you entered an appropriate frequency range and followed the normalisation process, you should see a green trace on the screen that represents the insertion loss of your device.



If you need to change the frequency range the instrument will require re-normalising. Simply click the “Normalise” button and follow the same procedure as previously.

How to interpret the results

The green trace is a measurement of the insertion loss vs. frequency. A value of 0dB indicates that the device has no loss, indicating that the signal is passing through the device at that frequency; a value of -20dB means that the device is attenuating the signal by 20dB, i.e. 1/100th of the power passing through the device. Two red markers are provided that show the value of insertion loss at points along the trace. You can drag these along the trace and read the values directly.

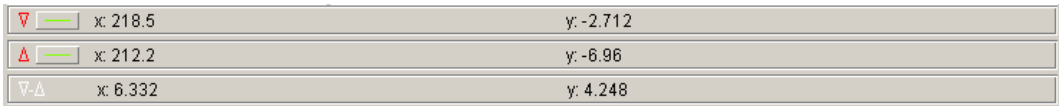
Run Status and the Pause button

Depending on the frequency span selected for the measurement (which affects how long it takes the instrument to sweep) and how fast your PC is, the green Measurement trace updates about twice per second. This allows you to observe the effects of changes you make to the device. If you want to pause the measurement and

freeze the screen, click the Pause button. This is particularly useful when you want to move the two red trace User Markers manually along the trace.

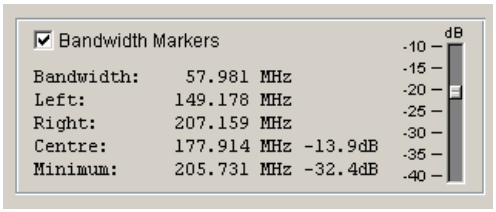
User Markers and Bandwidth Markers

You can drag the two red User Markers anywhere on the trace and read the numeric values of insertion loss at specific frequencies. The difference between the two markers is also displayed.



Freezing the trace with the "Pause" button can make it easier when dragging the markers. Later, when we save and recall a trace from memory, you can click on the grey rectangle with the green line to swap one or both markers from the green "live" trace onto the blue "stored" trace. This allows you to make difference measurements between stored and live measurement data.

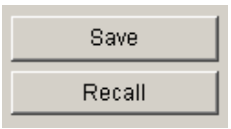
In addition to the User Markers, four automatic Bandwidth Markers can be activated. These try to find the centre frequency (turquoise marker), left and right dB points (turquoise markers) and the minimum return loss (red marker). The dB value is selected using the dB slider. The bandwidth between the left and right markers is also displayed in MHz.



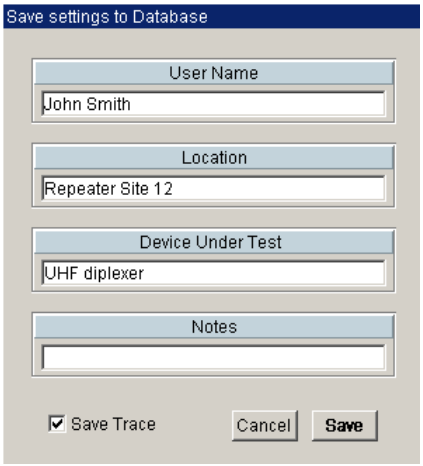
Saving, Recalling and Printing

1) Save Screen:
One way record your measurement is to click the "Save Screen" button. This saves a JPG image of the current screen and will prompt you with the usual Windows file dialog so you can choose where you want to save it. You might select the "My Documents" folder, or perhaps a flash memory stick if you have one. This is the simplest and most basic way to save a record of your measurements for pasting into reports etc.

2) Filter Database:
RF Tools has a Database that allows you to keep a record of each of the filters or other devices you have tested, and recall them later for comparison. Each record stores all of the measurement parameters, the trace data (optional), plus some extra fields for User Name, Location, Device ID etc. Each record is automatically time and date stamped.



Saving a Measurement. To save your current measurement, click the "Save" button. The following dialog will be displayed.



You will be prompted with the default User Name as defined in Preferences – you can type over this.

Enter the Location where the measurement is being made, such as the name of the repeater site, or perhaps building address.

Enter a name or number in Device Under Test that identifies this particular device.

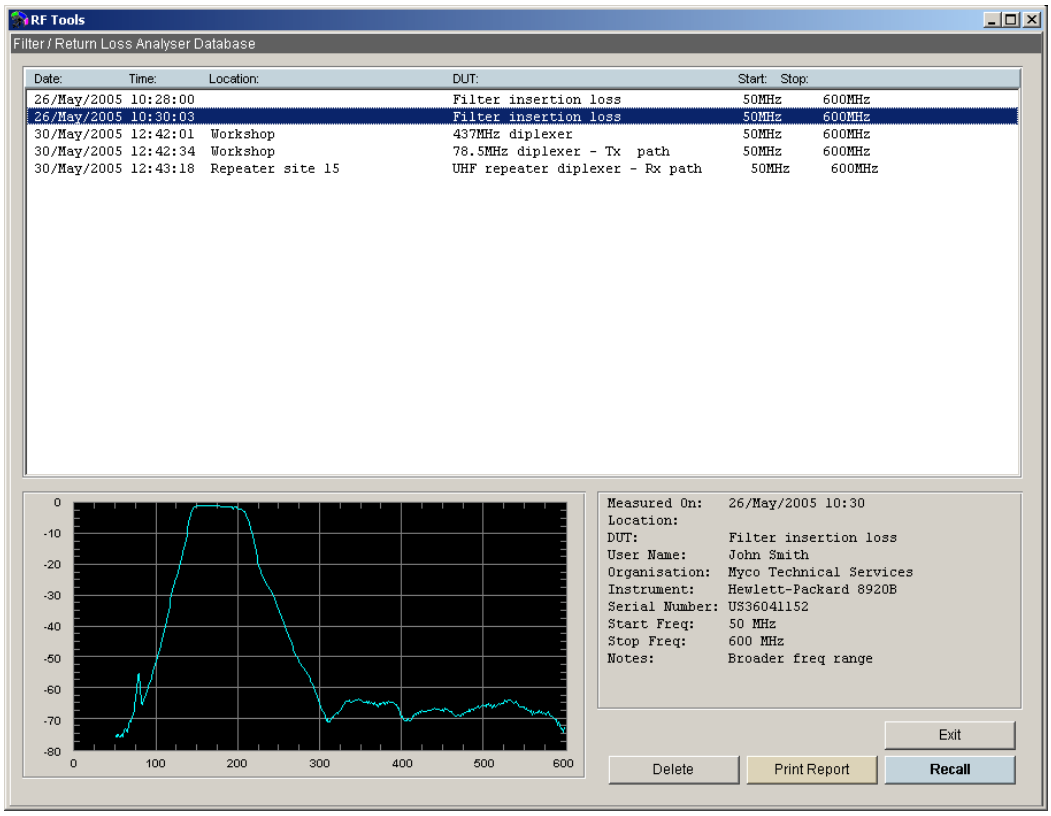
Enter any notes you want to make.

Select whether you want to save the trace data along with all the measurement parameters. (i.e. save "State Only" or "State & Trace").

Click "Save" to save to the Filter Database, or "Cancel" to cancel.

None of these fields are mandatory, but it will be much easier in 12 months time to remember what this measurement relates to if you put something meaningful in the fields provided.

Recalling a Measurement. To recall a previously saved measurement, click the "Recall" button. A list showing all of the previously saved measurements will be displayed, similar to the one shown below.

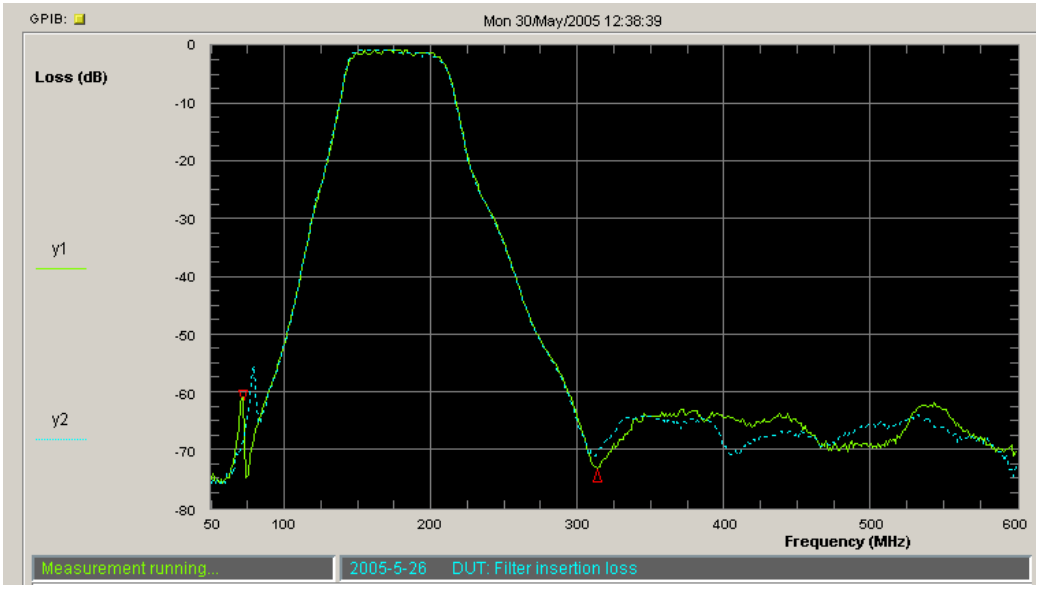


Click on any of the items in the list and you will see a preview of the stored trace, plus a complete list of the various parameters associated with that measurement (Date, Time, User Name, Location, Device ID etc.) plus the model and serial number of the instrument that was used to make that measurement.

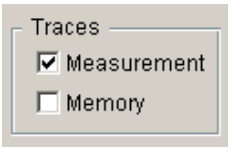
Click “Exit” to exit the screen.

Click “Delete” to delete the selected record. You will be asked to confirm whether you really want to delete this record.

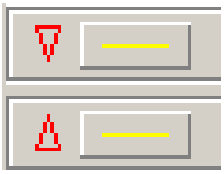
Click “Recall” to recall the measurement parameters for the selected record, including the trace data (assuming you selected “Save Trace” when you originally saved this record). This will return you to the main Filter & Insertion Loss Analyser screen, with the measurement parameters loaded ready for making a repeat measurement with the recalled settings, and the previously stored trace shown in blue.



If you want to make a measurement using the new settings, and if any of the parameters you recalled are different from those previously being used, you will need to click “Normalise” again and follow the procedure as previously. Once normalised, the screen will show two traces – the live measurement data in yellow and the memory (recall) trace in blue. You can turn either of these On or Off using the “Trace Control” check boxes.

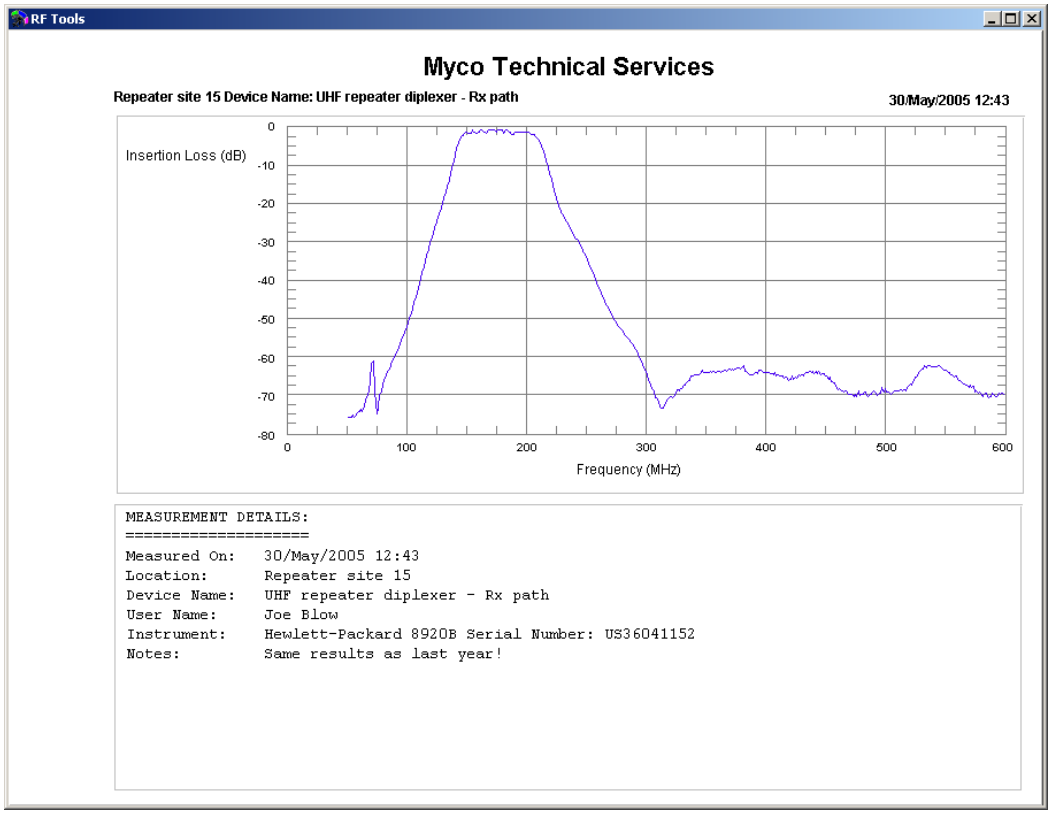


Similarly, you can select whether you want either or both of the markers to be active on the yellow Measured Trace or blue Memory Trace by clicking the respective marker trace buttons. The line colour will change to reflect on which trace the marker is currently active.



3) Print Report:
Click “Recall” to get back to the Filter Database. Clicking the “Print Report” button will ask whether you want to print a report to your default printer. Click “OK” if you wish to proceed. This report includes all of the measurement data and Measurement trace in a format that suits printing onto paper. Currently there is no ability to select which printer to

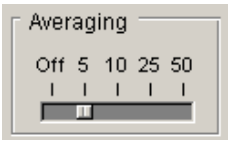
print to, so if there is more than one printer installed on your PC, you must do the usual thing in Windows and go to Start Menu/Settings/Printers and select the appropriate printer to be your Default Printer. An example report is shown below. The lower portion has been kept blank to allow you to write your own notes and comments.



If you have the full version of an application such as Adobe® Acrobat® installed (not just the free Acrobat Reader version), you can select Acrobat® as your default printer and save the reports in PDF format on your hard drive or a flash memory stick.

Trace Averaging

Turning on averaging may be useful to minimise noise when measuring long cables. The default setting is "Off" which is suitable for most measurements and gives the fastest response when observing changes (such as tuning up a cavity filter). Turning on averaging may reduce the noise in certain situations but bear in mind that the more averages, the longer it will take for the trace to stabilise.



Chapter 6

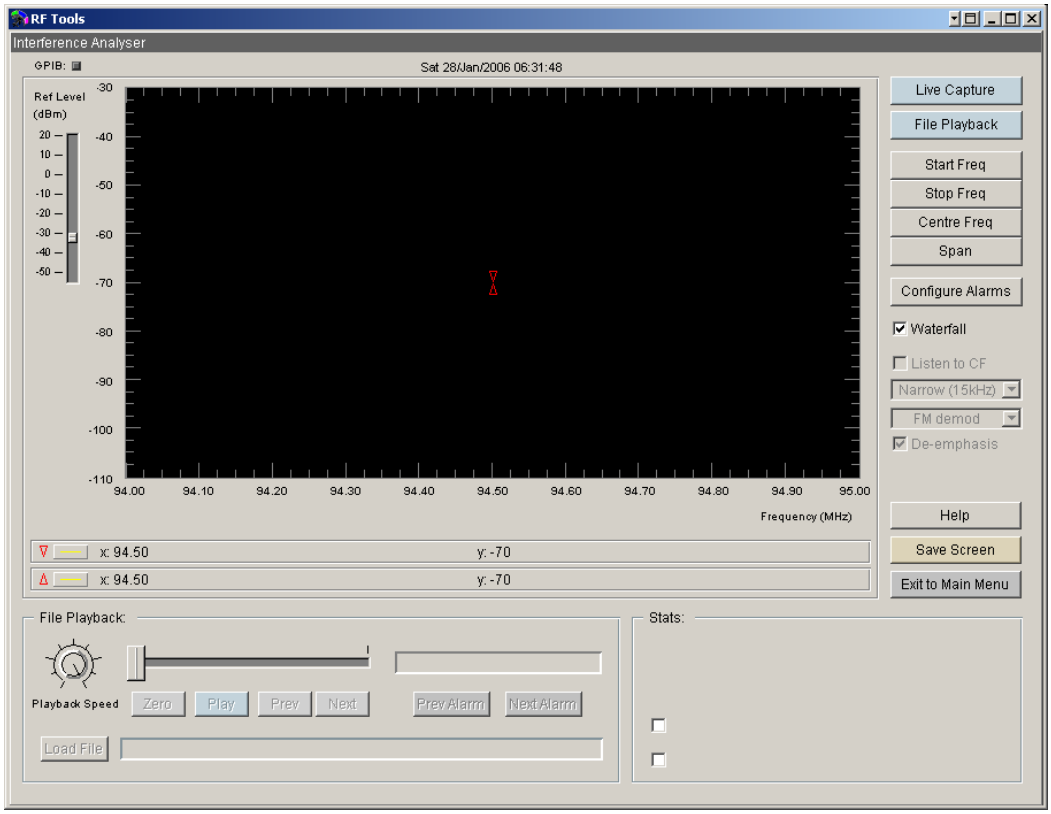
Interference Monitor

This module is used to monitor and record the RF spectrum.

Off-air signals can be monitored using a suitable antenna connected to the 892x or CSA to identify interfering signals or monitor RF activity within certain portions of the spectrum. A suitable antenna should be connected to the "Antenna" port of the 892x or CSA's RF Input. **Live Capture** mode is used for real-time monitoring and recording of the spectrum (requires a licensed 892x or CSA connected to your PC); **File Playback** mode is used to play back and observe spectral data previously recorded during Live Capture.

Getting Started

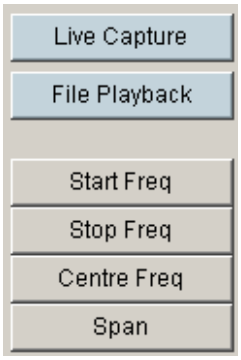
Click on the "Interference Monitor" button on the main screen. A screen similar to the one below will appear.



If instead you get a popup that tells you that no instrument is connected, or that an unlicensed instrument is connected, refer to Chapter 2 on setting the IO address and installing License keys.

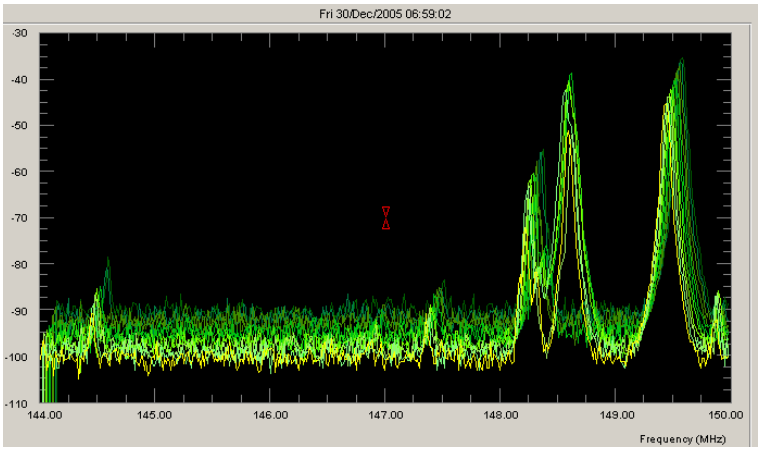
Live Capture

There are two simple steps to start capturing the spectrum:



1) Select the Frequency Range:
Set the Start and Stop frequencies, or Centre and Span frequencies, to suit the portion of spectrum you wish to monitor.

2) Activate Live Capture:
Click the "Live Capture" button. Within a few seconds you should start to see spectrum traces appear on the display (similar to that shown below).



As soon as the "Live Capture" button is pressed, spectrum recording is also activated. All spectrum traces (as well as settings such as frequency range and zone alarms) are time and date stamped and recorded to a file on your PC's hard disk. A filename is automatically generated according to the following naming convention so that each recording can clearly be identified as to the date and time it was started.

`YYYY-MM-DD from HHMM.gnt` (for 892x captures)

`YYYY-MM-DD from HHMM.cnt` (for CSA captures)

Filenames can later be changed to something more meaningful if you wish, but be sure not to change the ".gnt" or ".cnt" file extension.

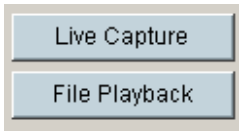
The time between trace updates will vary depending on the speed of your PC, which instrument you are using (892x or CSA), and the various span/RBW settings.

Frequency range and alarm settings can be changed "on the fly" while in Live Capture mode, so you can zoom in on a signal of interest or change to a completely different frequency range without having to stop and restart the measurement. This is particularly useful when trying to track down and identify unknown signals.

To stop the Live Capture process (and at the same time stop recording to disk) click the Live Capture button. This closes the *.gnt* or *.cnt* capture file and makes it available for playback using File Playback mode.

File Playback

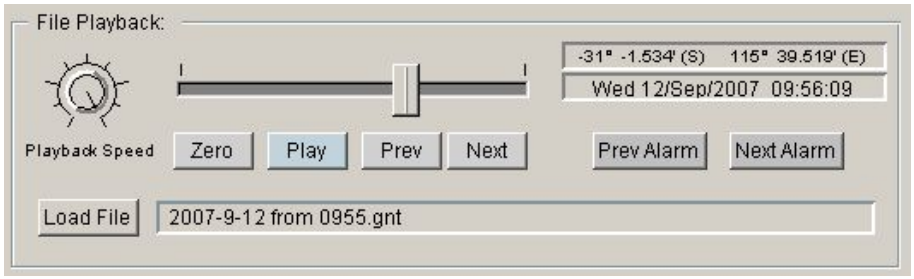
There are three simple steps to playback previously captured spectrum data:



1) Activate File Playback:
Click the "File Playback" button.

2) Load File:
Click the "Load File" button and select any visible file using the standard Windows dialog box that appears and click "Open".

3) Play:
Click "Play" to see your previously captured spectrum data played back (at super-fast speed!)



Each trace is date and time stamped, and the date and time stamp for the currently displayed active trace is displayed. If the waterfall display is being used, the date and time displayed relates to the front-most (yellow) trace. The date and time recorded for each trace is taken from the PC's internal clock at the time the trace was captured. If an optional GPS was connected during the measurement, positional information is also displayed for each trace. You can change the way the recorded spectrum data is played back using the File Playback controls as follows:

Play:	Starts and pauses the playback of the file.
Zero:	Returns to the start of the file, i.e. to the first trace. The same can also be achieved by moving the slider fully to the left.
Prev:	When paused (i.e. the *Play* button is not pressed), use the *Prev* button to step backwards to the previous trace.
Next:	When paused (i.e. the *Play* button is not pressed), use the *Next* button to step forwards to the next trace.
Playback Speed:	Rotate this knob to adjust the speed at which recorded data is played back. Fully clockwise plays back "as fast as possible" and is useful for quickly reviewing long capture periods. Turning the knob anticlockwise slows down the trace update rate allowing more detailed analysis.
Prev Alarm:	When paused (i.e. the *Play* button is not pressed), pressing the *Prev Alarm* button skips backwards to the first occurrence of the previous new alarm. (Alarms must have been activated during Live Capture, and an alarm must have occurred, in order for this button to do anything).

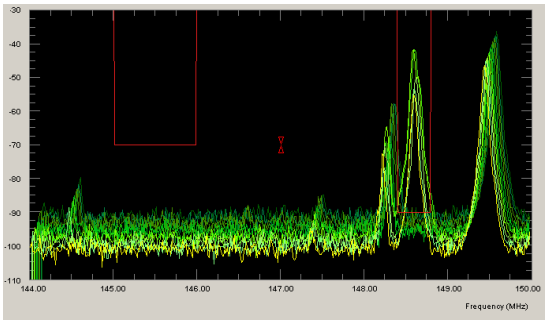
Next Alarm: When paused (i.e. the *Play* button is not pressed), pressing the *Next Alarm* button skips forwards to the first occurrence of the next new alarm. (Alarms must have been activated during Live Capture, and an alarm must have occurred, in order for this button to do anything).

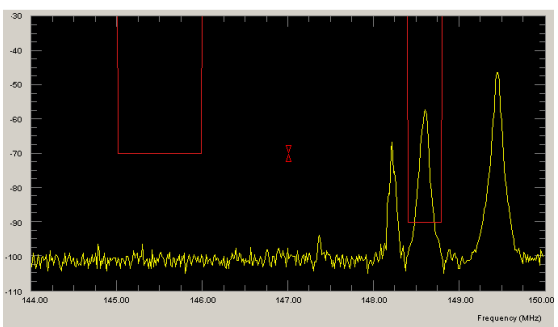
Export to CSV: Once a file has been loaded for playback, all captured data (time, GPS coords, alarm settings/status and trace levels, can be exported to a CSV (comma separated variable) file. Two export formats are available: a) Standard CSV (each value for each record is separated by a comma); b) Excel Compatible (time/GPS/alarms are comma-separated, but all trace values are stored in a single column with a semi-colon ";" as the separator between each value). Excel only supports 256 columns so is unable to display the full 417 (892x) or 401 (CSA) trace data points if each point is saved in a separate comma-separated field/column.

Waterfall

A waterfall display can be extremely helpful when trying to visually observe changes to the spectrum over a period of time. The current (active) trace is shown at the front of the waterfall in yellow. The previous 10 traces are shown in varying shades of green and slightly offset in both the x and y axes. A transmitter that intermittently turns on and off can more easily be observed using a waterfall display than the normal single-trace display on a spectrum analyser. This is especially true if the transmitter's signal is low and very close to the noise floor. The waterfall display can be turned on/off using the *Waterfall* check box.

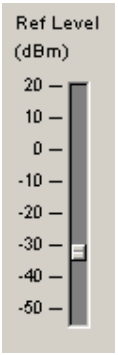
Note that your selection will only become apparent the next time the trace is updated i.e. if the display is paused then the display will not change from waterfall to normal or vice versa until another trace is displayed by pressing Play or the Next/Prev buttons.





Even though the waterfall display is extremely useful when visually identifying transmitters and other intermittent RF signals, it can appear confusing when trying to compare the active trace against alarm zones due to the X/Y shifting of the previous 10 traces as shown here. Similarly it may sometimes be useful to turn off the waterfall display when capturing the screen image for documentation purposes.

Reference Level



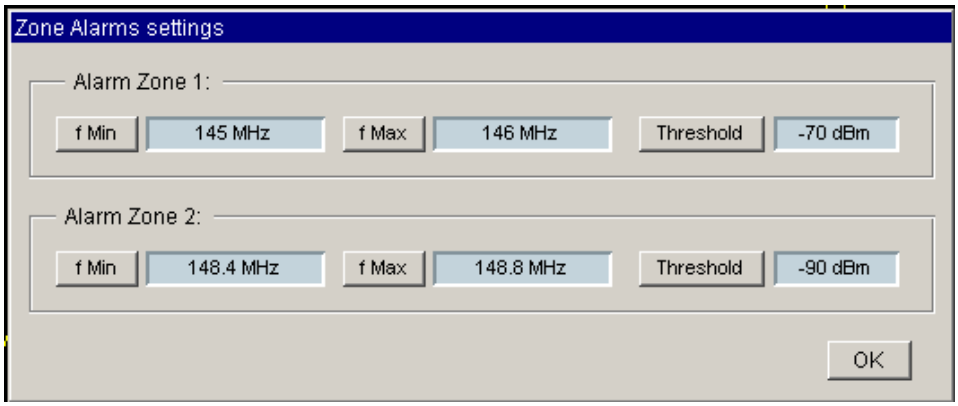
The *Ref Level* slider sets the reference level (y-axis position) of the displayed spectrum traces.

In Live Capture mode it sets the actual reference level of the spectrum analyser. On an 892x it directly affects the attenuator settings, so for maximum sensitivity with an 892x use a reference level of -30dBm or -40dBm (this sets the internal attenuator in the 892x to 0dB). For a CSA, RF Tools holds the attenuator at 0dB for maximum sensitivity. Additional sensitivity can be obtained on the CSA by activating the "Preamp" check box (for CSA's with Opt P03 or Opt P06 preamplifiers installed0.

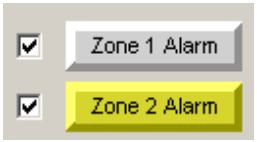
In File Playback mode, the *Ref Level* slider adjusts the position of the trace on the y-axis and obviously does not affect the sensitivity of previously captured traces.

Zone Alarms

Two zone alarms can be defined which, if a signal occurs within one of the zones, an alarm is raised and recorded. This feature is especially useful when leaving the system unattended to search for infrequent signals. Rather than having to visually observe long periods of live or recorded spectrum, each zone infringement is automatically logged and can quickly be located using the *Prev Alarm* and *Next Alarm* buttons. The total number of infringements is also displayed in the Stats section (see below). Alarm Zones are configured using the Configure Alarms button.



Minimum and maximum frequencies, and a threshold level in dBm, can be set for each of the two alarms. These alarm zone settings can be changed at any time during Live Capture; the changes are logged and recorded along with the spectrum trace data. Either or both of the two alarms can be activated during Live Capture by clicking their respective check boxes as shown below. Zone Alarms cannot be activated during File Playback.



Alarm status is indicated by the colour of the Zone Alarm boxes. The meaning is slightly difference between Live Capture and File Playback modes

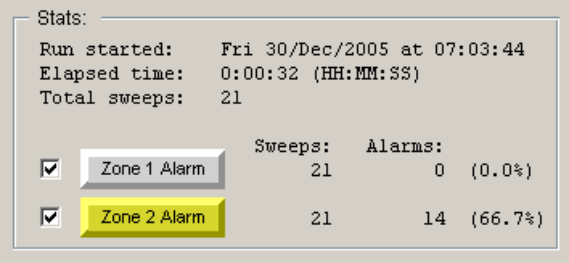
During Live Capture: A grey box indicates that a particular alarm has not yet been infringed; a red box indicates that the current (active) trace is infringing that particular

alarm; yellow box indicates that an infringement occurred previously but is not occurring at present.

During File Playback: A grey box indicates that the current (active) trace is did not infringe that particular alarm; a red box indicates that the current (active) trace did infringe that particular alarm.

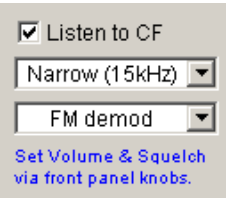
Statistics

The Stats section provides a statistical summary of the current run (Live Capture mode) or the entire recorded file (File Playback mode).



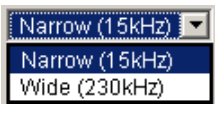
Most of the data displayed is self explanatory, but it is worth pointing out why separate *Sweeps* figures are provided for each of the Zone Alarms. Because each Zone Alarm can be turned on or off at any time during Live Capture, the number of sweeps while a particular Zone Alarm is active may be different (but always less than) the value of *Total Sweeps*. The ratio of *Alarms* vs. *Sweeps* for each Zone Alarm is indicated as a percentage and gives a good indication of utilisation within each alarm zone.

Listen to CF (892x only)

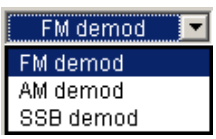


This allows the operator to listen to whatever signal is present at the Centre Frequency (CF) of the display, provided the Span is ≤ 1MHz. The demodulated audio can be heard through the 892x's internal loudspeaker. To listen to a particular frequency, the Centre Frequency must be set to that frequency. The Volume and Squelch knobs on the 892x front panel may need to be adjusted manually to obtain the desired audio output.

Two IF bandwidths are available via the popup menu: Narrow (15kHz) which suits most narrow band transmissions; Wide (230kHz) suitable for most FM broadcast transmissions.



Three demodulation types are available via the popup menu: FM, AM and SSB.



De-emphasis can be turned off or on as required.

Save Screen

The Save Screen button is used to save a screen capture in .jpg format to your PC's hard disk. This button can be pressed at any time, during Live Capture or File Playback.

Chapter 7

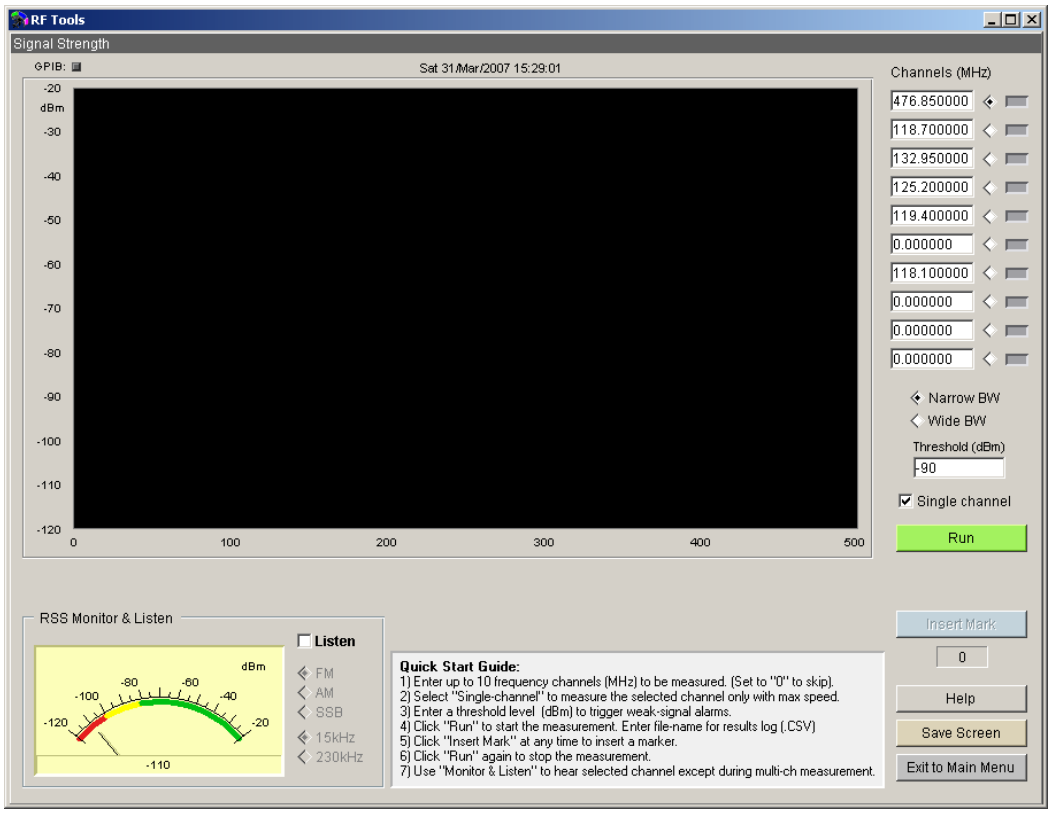
Signal Strength

This module is used to monitor and record the Received Signal Strength (RSS) of up to 10 radio channels.

A typical application is to verify that a transmitter or group of transmitters in a repeater network is providing sufficient coverage to all users. The instrument automatically tunes to each of a series of radio channels and records the measured signal strength in dBm.

Getting Started

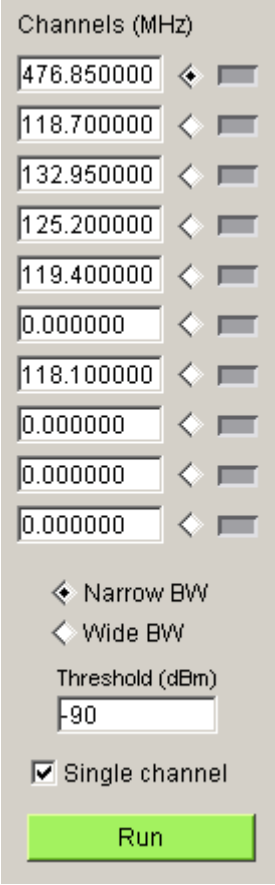
Connect a suitable antenna to the "Antenna" port of the 892x or the RF input of the CSA, and click on the "Signal Strength" button on the main screen. A screen similar to the one below will appear.



If instead you get a popup that tells you that no instrument is connected, or that an unlicensed instrument is connected, refer to Chapter 2 on setting the IO configuration and installing License keys.

Making an RSS measurement

These are the steps required to make a Received Signal Strength measurement:



1) Enter the frequency channels to be measured:
Double-click the frequency field and type in a new frequency (MHz). Press TAB or ENTER to enter the value. Repeat this for as many channels as you like. Enter a value of "0" in any field to skip this channel during a multi-channel measurement.

2) Select the measurement bandwidth:
Select "Narrow BW" for all normal narrow-band signals such as two-way radio systems. This selects a 3kHz RBW filter in the 892x. For broadcast transmitters such FM Stereo radio stations and TV stations where wideband modulation is used, select "Wide BW" which selects a 300kHz RBW filter in the 892x.

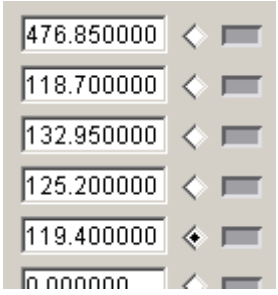
3) Enter a Threshold Value (optional):
The threshold value (dBm) is used to trigger a weak-signal notification in the stored results. If the received signal level of any channel drops below the threshold, a "1" is stored in the corresponding record in the CSV log file.

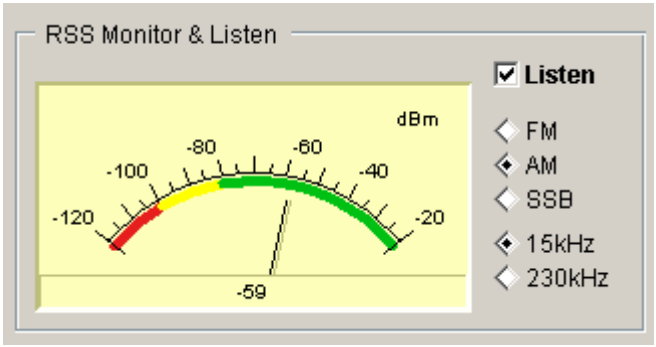
4) Select Single or Multi-channel:
With "Single Channel" ticked, just one of the ten channels will be measured. Use the radio buttons to select which channel is to be measured (channel 1 in this instance). Single-channel mode is far quicker than Multi-channel as no retuning of the 892x is required between measurements. With "Single Channel" unticked, all channels will be scanned except those with a frequency of "0 MHz". We recommend you leave "Single Channel" ticked while learning how to use the software.

CSA users: Note that the optional preamplifier (if installed) can be turned on from here to increase measurement sensitivity.

RSS Monitor & Listen

A useful feature while setting up your frequency channels is to be able to listen to the demodulated audio. It's just like having an FM/AM/SSB radio built-in. Use the channel-select buttons to select which channel you want to listen to (Channel 5 in this instance, an AirBand channel with AM modulation from the local airport), then click "Listen" and select the required demodulation type (FM, AM, SSB) and demodulation bandwidth (e.g. 15kHz for two-way radio communications, or 230kHz for broadcast FM stations). Adjust the Volume and Squelch knobs on the 892x to set the desired audio level and muting.

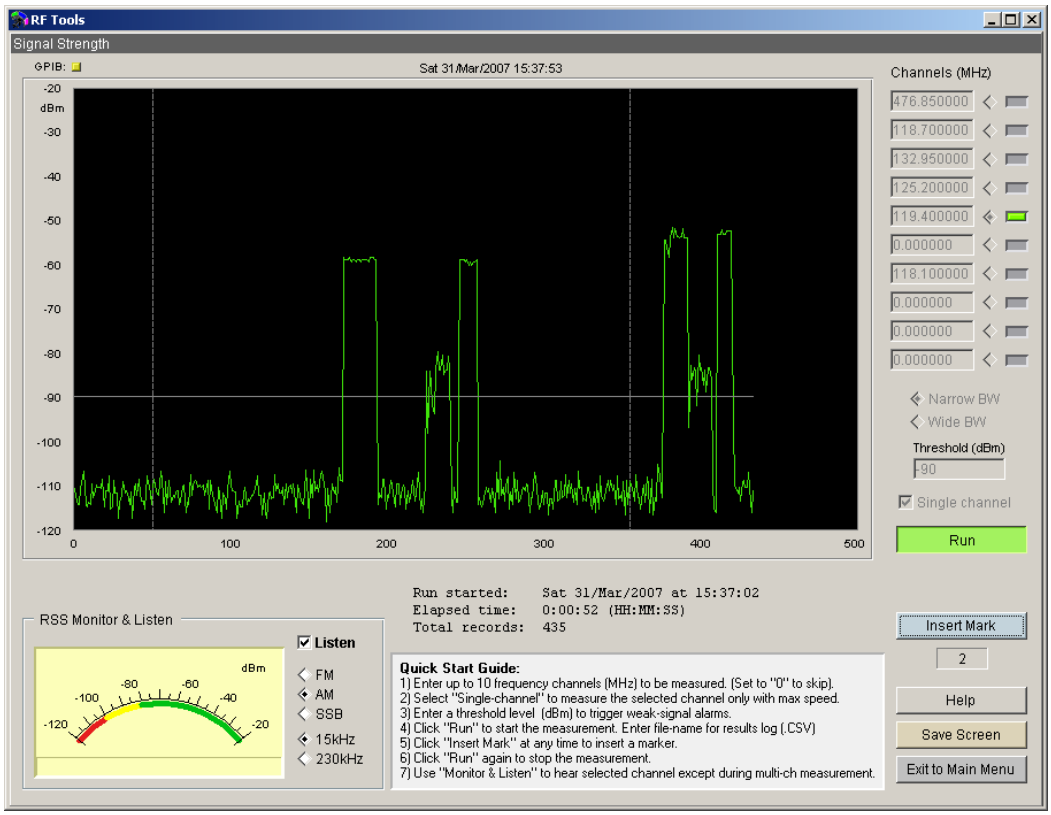




CSA users: Note that Monitor & Listen functions differently on a CSA since it only has one receiver. This means that the instrument can either Listen or Measure, but not both at the same time. When Listen is activated, the instrument pauses at the end of each sweep and demodulates the audio for a short period, then performs another sweep.

Once you have completed all the above steps, click the green "Run" button. You will be prompted with a filename (which you can change if you like) which is where the results will be stored. The measurement will commence shortly after you click "SAVE".

Assuming you are making a single-channel measurement you should start to see a screen such as that shown below. This measurement was made from a fixed location in our workshop, measuring the RSS from transmissions between aircraft and the control tower at the local airport. The control tower transmissions are at around -85dBm and the two aircraft were received at approximately -60dBm and -50dBm. In a real-life RSS measurement situation, you might have your 892x and laptop PC in a vehicle while driving around making measurements, but whilst learning how to use the software it's probably easier to make some measurements while stationary.

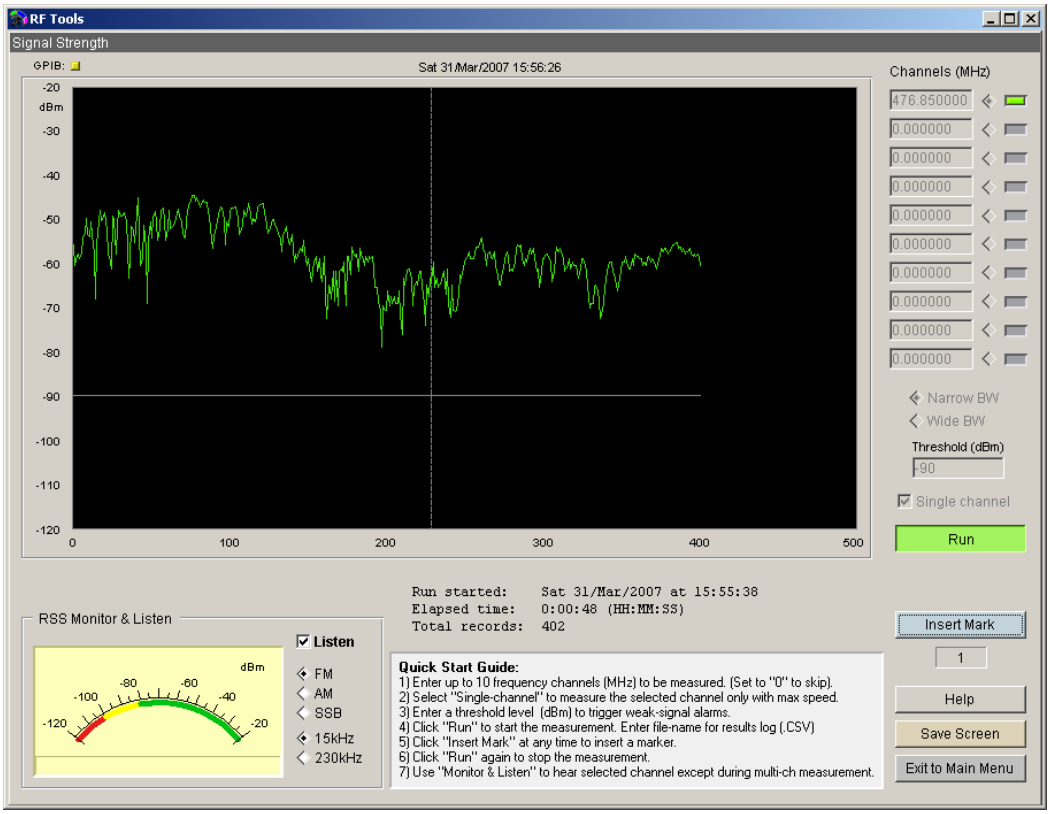


Once 500 measurement points (records) have been recorded, the screen will start to scroll from right to left automatically like a strip-chart recorder. The most recent 500 measurement points are always displayed on the screen. You cannot manually scroll backwards to see previous data while the measurement is running as this would interrupt the measurement process. Previously recorded data can be viewed after the measurement has stopped by opening the CSV log file where all measurement data is recorded. To stop the measurement, click the "Run" button again.

Useful tips:

1. Frequency channels cannot be changed while the measurement is running.
2. RSS Monitor & Listen allows you to continue listening during single-channel measurements, but not during multi-channel measurements. The RSS meter is always inactive during measurements (to maximise the logging speed)
3. Click “Insert Mark” to add markers at any time during the measurement.
4. The multi-coloured LED’s show which channel is currently being measured.

In a real measurement situation where one might be in a vehicle measuring RSS while traveling, a display such as the one shown below might be more like what you’d see. In this instance, the RSS of a citizens band transmitter was measured. You can also see the weak-signal Threshold line (horizontal grey line), and one “Mark” (vertical, dashed grey line) that was inserted by the operator at the furthest point from the transmitter. You can also see that the operator was listening to the demodulated audio of the transmission during the measurement (the “Listen” button is ticked).



Statistics

Basic statistics are displayed showing at what time the measurement began, the elapsed time since the start, and the total number of records (measurements).

Insert Mark

The “Insert Mark” button can be clicked at any time while a measurement is running. Two things occur when this button is clicked: 1) A dashed, grey, vertical line is displayed on the display at the point where you clicked the button; 2) A numerical value (starting at 1 and incrementing each time “Insert Mark” is clicked) is stored in the log file next to the associated measurement record. This feature allows the operator to make a note of specific points of specific interest during the course of the measurement. For example, if making a measurement while traveling in a vehicle, one might want to insert a mark as one passes key locations such as “top of the hill” or “entering a tunnel”.

Threshold

The threshold level (dBm) is displayed as a grey horizontal line while the measurement is running. Each measured value of RSS is compared with this threshold and a “1” is recorded for any frequency channel where the RSS level fell below the threshold. This provides a simple method to search for problem areas (e.g. locations where the signal may be too weak to be received) when later reviewing the recorded data in the CSV log file.

Opening the log file (CSV)

All measurement results are stored in a CSV (comma separated variable) file which can be opened with many PC applications such as spreadsheets, databases and the like. Using the example of a single-channel measurement, a typical set of results might appear as follows when opened in a spreadsheet such as Excel.

	A	B	C	D	E	F	G	H	I	J
1	**Date & Time**	**Latt (deg)**	**Latt (min)**	**Long (deg)**	**Long (min)**	**Elapsed Secs**	**119.4**	**Mark**	**Threshold**	**Alarm**
2	Sat 31/Mar/2007 17:40:47	0	0	0	0	0.00000000	-83.0		-90	0
3	Sat 31/Mar/2007 17:40:48	0	0	0	0	0.10900116	-112.0		-90	1
4	Sat 31/Mar/2007 17:40:48	0	0	0	0	0.23400116	-107.3		-90	1
5	Sat 31/Mar/2007 17:40:48	0	0	0	0	0.35900116	-82.2		-90	0
6	Sat 31/Mar/2007 17:40:48	0	0	0	0	0.46900177	-62.4		-90	0
7	Sat 31/Mar/2007 17:40:48	0	0	0	0	0.59400177	-63.0		-90	0
8	Sat 31/Mar/2007 17:40:48	0	0	0	0	0.71900177	-63.0		-90	0
9	Sat 31/Mar/2007 17:40:48	0	0	0	0	0.95300293	-63.0	1	-90	0
10	Sat 31/Mar/2007 17:40:48	0	0	0	0	0.96900177	-63.8		-90	0
11	Sat 31/Mar/2007 17:40:49	0	0	0	0	1.09400177	-60.8		-90	0
12	Sat 31/Mar/2007 17:40:49	0	0	0	0	1.21900177	-63.8		-90	0
13	Sat 31/Mar/2007 17:40:49	0	0	0	0	1.32800293	-63.8		-90	0
14	Sat 31/Mar/2007 17:40:49	0	0	0	0	1.56300354	-63.8	2	-90	0
15	Sat 31/Mar/2007 17:40:49	0	0	0	0	1.57800293	-62.4		-90	0
16	Sat 31/Mar/2007 17:40:49	0	0	0	0	1.70300293	-61.5		-90	0
17	Sat 31/Mar/2007 17:40:49	0	0	0	0	1.82800293	-60.8		-90	0
18	Sat 31/Mar/2007 17:40:49	0	0	0	0	1.93800354	-64.5		-90	0
19	Sat 31/Mar/2007 17:40:50	0	0	0	0	2.06300354	-64.5		-90	0
20	Sat 31/Mar/2007 17:40:50	0	0	0	0	2.18800354	-64.5		-90	0

The column widths have been widened appropriately, the top row set to “bold”, and the number format for columns F and G has been set to show a consistent number of decimal places.

Each row from Row 2 downwards is an individual measurement record. From left to right, the columns are as follows:

Date & Time:
Displays the Date & Time of each record. Detailed timing information is now shown here - refer to “elapsed secs” below.

Lat (deg), Lat (min), Long (deg), Long (min):
If a GPS was connected during the measurement process, GPS coordinates are shown as Latitude and Longitude values for each record. The values are shown as zeros if a GPS was not connected at the time of the measurement, or if the GPS lost fix or any other GPS error occurred during the measurement.

Elapsed Secs:
This shows the elapsed time since the Signal Strength measurement started for each record starting from t = 0. All time values are generated from the PC's internal clock.

119.4 (Channel 1 Frequency):
This column shows the frequency being measured in Row 1 (119.4MHz in this instance), and the RSS (dBm) for each measurement in Row 2 downwards. In multi-channel mode, there are 9 additional columns (one per frequency channel) with the corresponding RSS values for each. Converting from dBm to dBµV can easily be performed by inserting additional column(s) and applying the formula:

$$dB\mu V = dBm + 107dB$$

If using a calibrated antenna, antenna factors can also be included in the formula to calculate calibrated field-strength values in dBµV/m.

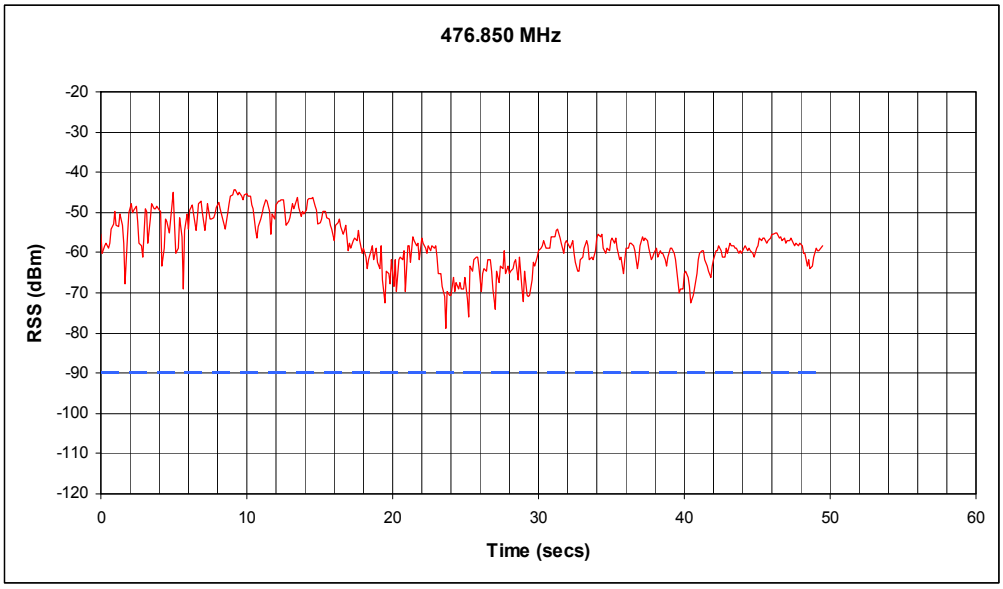
Mark:
This column shows the numerically incrementing marks as inserted by the operator when clicking the "Insert Mark" button during the measurement.

Threshold:
This column shows the threshold level - the same value for every record. Despite the seemingly unnecessary repetition of this parameter, it is included as it makes it simpler to create a horizontal threshold line when using the graphing tools in a spreadsheet having this value repeated for each record.

Alarm:
A "0" in this column tells us that the RSS for the particular channel was above the threshold (i.e. no alarm). A "1" indicates that the RSS fell below the threshold level (i.e. an alarm condition).

Graphing the results

The data in the CSV file can be graphed in any way that best suits the particular measurement requirements. For example, the X-Y Scatter Graph tool in Excel could be used to produce a simple graph of the results such as that shown below. The red trace is the measured data; the blue dashed line shows the threshold level.



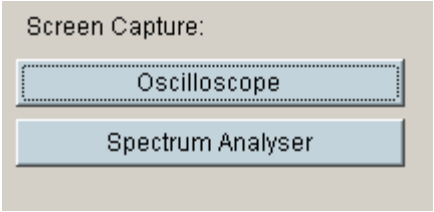
Chapter 8

892x Screen Capture

This module can be used to record traces and data from selected 892x screens.

The 892x series of instruments has no built-in capability (or GPIB programmable capability) to capture the screen image to a graphics file. These utilities are therefore provided as a method of capturing a few of the more important 892x screens (notably those with a measurement trace) to a .jpg file which can be saved, and later recalled and printed or pasted into other applications for documentation purposes. Additional screen capture utilities may be added later (check www.measurement.net.au for updates).

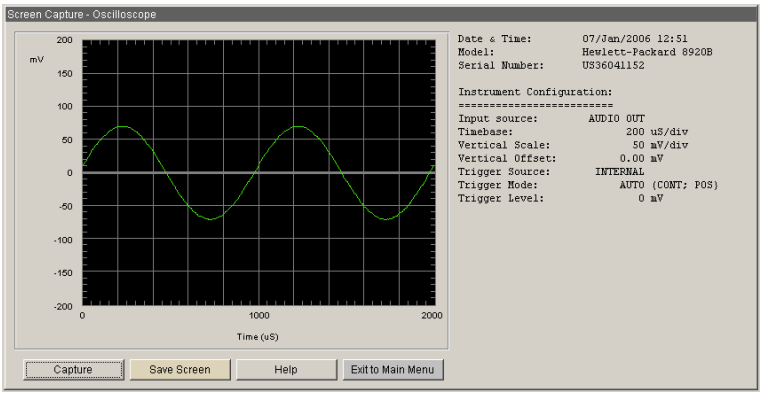
How to use



These utilities can only be used when a licensed 892x is connected. Click one of the screen capture buttons on the main screen as show. Clicking one of these buttons performs a number of tasks:

- Switches to the corresponding "Screen Capture" utility within RF Tools.
- Forces the 892x to the corresponding screen (e.g. Oscilloscope).
- Triggers another measurement (e.g. another sweep on the osilloscope)
- Retrieves the measured trace and all related measurement settings and displays them on the PC screen.
- Returns the 892x to "Local" mode (i.e. no longer under GPIB control, and available for manual adjustment of the 892x's front panel controls by the operator).

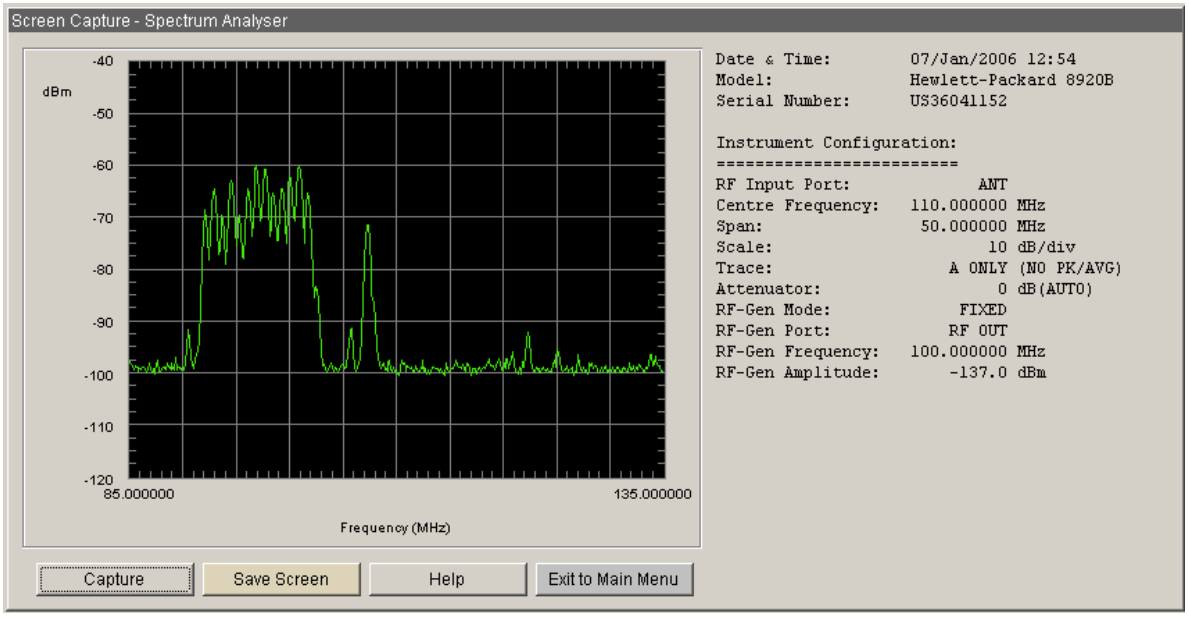
A screen similar to the one shown below should be displayed:



Four buttons are available:

- **Capture:** Triggers another measurement and displays the new data on the screen, and returns the 892x to "Local" mode once again.
- **Save Screen:** Saves the screen image as a .jpg file via the normal Windows "Save" dialog box.
- **Help:** Opens the Operating Manual PDF file (this document)
- **Exit to Main Menu:** Closes the Screen Capture window and returns to the Main Menu.

Below is another example of a screen capture, this time using the Spectrum Analyser utility:



Chapter 9

Appendix A

Instruments supported

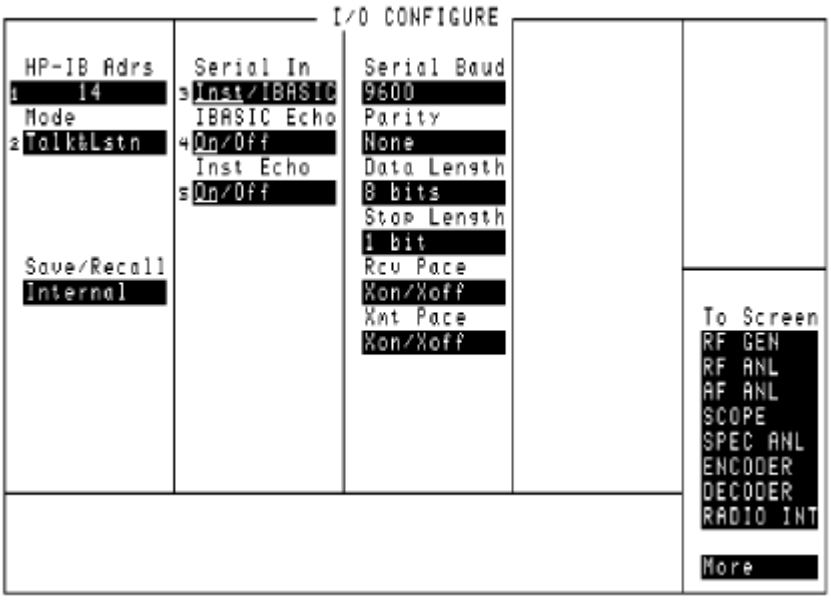
Make	Model	Options required	Firmware Revision
HP/Agilent	8920A	002 or 102; 003 or 103	A.14.07 and above
HP/Agilent	8920B	102	Any
HP/Agilent	8921A	Any	A.14.07 and above
HP/Agilent	8924C	Any	A.06.00 and above
Agilent	N1996A (CSA)	Any	Any

Appendix B

Instrument I/O Configuration

HP/Agilent 892x:

Whichever 892x instrument you are using, the instrument's I/O settings must be set correctly to enable communications with the PC and the RF Tools software. To check the settings on your instrument, go to the I/O CONFIGURE screen on your instrument. This screen is accessed by selecting the *More* field (directly below the *To Screen* menu), and selecting *IO CONFIG*.



The *HP-IB Adrs* field can be set to any valid address number. This number is the address value that you must enter into the GPIB Address field in the RF Tools software Preferences screen. By default, RF Tools uses an GPIB address value of 14. The *Mode* field must be set to "Talk&Lstn", which means that the instrument is configured to receive commands from an external PC.

Provided the GPIB address matches the value set in the RF Tools software Preferences, and provided the Mode setting is correct, communications with your PC and RF Tools software should occur. If they don't, and provided you have all the software and 82357A cable drivers installed correctly, you should suspect a hardware fault.

Note – the terms "HP-IB" and "GPIB" are synonymous. They are both common terms used to describe the IEEE-488 interface standard, originally invented by the Hewlett-Packard™ company.

Agilent N1996A "CSA":

RF Tools communicates to the CSA via Ethernet. The most common connection method for a standalone PC directly to the CSA will be via an Ethernet "cross-over" cable, cheaply available from most general computer and electronics stores. But connecting your CSA to RF Tools via a network is equally simple provided you get the IP settings correct.

Configuring your PC and the CSA should be a relatively straightforward process, but if you experience any difficulties, please get your friendly IT specialist involved who will be familiar with TCP/IP addressing, subnets etc.

Step 1:

Tell RF Tools what TCP/IP address you have set your CSA to. This is done within the "Preferences" panel as shown here. This is the only setting required within RF Tools, but do bear in mind that RF Tools will assume that your CSA is on the same subnet as your PC.

Step 2:

Set the TCP/IP settings of your CSA by pressing the "System" button, then "Controls", then "IP-Admin". The parameters that need to be set are as follows:

- Host Name: Anything you like.
- IP Config: Static
- IP Address: A valid TCP/IP address on the same subnet as your PC
- Net Mask: A valid subnet mask that matches the subnet of your PC
- Gateway: The address of your server/gateway PC

For simple configurations involving just one PC and a CSA, try using the following settings which should work just fine. You will need Administrator privileges on your PC in order to change its TCP/IP configuration:

- Set you PC's TCP/IP address to 192.168.0.100, subnet mask 255.255.255.0
- Set your CSA IP Config to "Static"; IP Address to 192.168.0.101; Net Mask to 255.255.255.0; Gateway to 192.168.0.100

For large organisations where the allocation of IP addresses is handled centrally, the best solution is to talk to your IT department and get a fixed IP address allocated to the CSA which will be one from your organisation's range of available network addresses. This will be a far better solution in the longer term, and avoid the need to change the IP configuration of your laptop/PC when running RF Tools. That's what we do here at Measurement Innovation and it works extremely well.

Appendix C

Hardware Requirements

What you need…

- A Windows® PC with a USB port
- 892x RF Communications Test Set with GPIB and Spectrum Analyser options, or N1996A "CSA" spectrum analyser.
- RF Tools Software plus one license key for each 892x or N1996A "CSA"
- Agilent Technologies™ 82357A or 82357B USB to GPIB interface cable
- Various RF cables & accessories, depending on what measurements you want to make

You must supply a suitable PC and 8920A, 8920B, 8921A, 8924C or CSA to make live measurements, or purchase directly from Measurement Innovation. You can supply your own 82357A or 82357B interface cable and RF accessories, or purchase them as options with the RF Tools software from Measurement Innovation.

User-supplied PC:

The following lists the minimum requirements for the PC; higher performance PC's are strongly recommended.

- Pentium 120 MHz processor (266 MHz Pentium II or higher recommended)
- Windows® 2000(SP4), or Windows XP™(SP1)
- 256 MB RAM
- Hard disk free space: 500 MB minimum
- CD-ROM drive
- Monitor resolution 1024x768 or greater
- One available USB Port (required for instrument control)

User-supplied 892x:

Most 8920A, 8921A, 8920B and 8924C models are supported provided they have the required options and firmware (Table 1 shows supported configurations). Each must have a GPIB interface (opt 003 or 103) and Spectrum-Analyser/Tracking-Generator (opt 002 or 102). Firmware upgrades are available if required.

Additional options already installed in your 892x will not adversely affect the operation of the RF Tools software.

Table 1	Options required:	Firmware:
8920A	Options 002 and 003	Rev. A.14.07 and above
8920A	Options 002 and 103	Rev. A.14.07 and above
8920A	Options 102 and 003	Rev. A.14.07 and above
8920A	Options 102 and 103	Rev. A.14.07 and above
8921A	Any	Rev. A.14.07 and above
8920B	Option 102	Any
8924C	Any	Rev. A.06.00 and above

User-supplied CSA:

Any Agilent N1996A "CSA" spectrum analyser can be used. Note that RF Tools only supports the Interference Monitor & Signal Strength modules when using a CSA spec-an.

RF Cables & Accessories:

Table 2 shows which accessories are required for each task or measurement. If you intend to supply your own RF Accessories, please note that:

- Most 3-resistor power dividers or combiners can be used for Cable Fault Location measurements. 2-resistor power splitters are not the same and are not suitable.
- All RF accessories should be high-performance, instrument grade devices covering the full frequency range of the 892x (minimum 30MHz to 1GHz).
- Measurement performance is solely dependent on the quality and specifications of these devices and of your 892x.

Table 2	Licensed 892x + 82357A/B	Licensed CSA + Ethernet cable	Bridge and Short	Power Divider & Termination	Attenuators (for improved match)	Thru adapter (user-supplied)	Antenna
Review & Print test results	-	-	-	-	-	-	-
Interference Monitor	Yes	Yes	-	-	-	-	Yes
Signal Strength	Yes	Yes	-	-	-	-	Yes
Return Loss measurements	Yes	Not supported	Yes	-	Optional	-	-
Insertion Loss measurements	Yes	Not supported	-	-	Optional	Yes	-
Cable Fault Location	Yes	Not supported	-	Yes	Optional	-	-
Screen Capture	Yes	Not supported	-	-	-	-	-

A suitable antenna is required for the Interference Monitor and this is not included in any of the optional kits or accessories provided with RF Tools.

Software Licenses

RF Tools can be installed on as many PC's as you like for the purpose of viewing and printing previously stored measurement results. A licensed 892x must be physically connected to the PC running the RF Tools software to make new measurements. Each time

you purchase the RF Tools software you must provide the model number and serial number of a specific instrument. The license key supplied is locked to that instrument and will not work with any other unit. License keys are neither transferable nor refundable under any circumstances.

Multiple license keys can be entered onto multiple PCs. This means that any licensed instrument can be used with any PC without having to match one with another. This simplifies the task of dispatching staff with instruments.

Appendix D

Logging GPS positional data

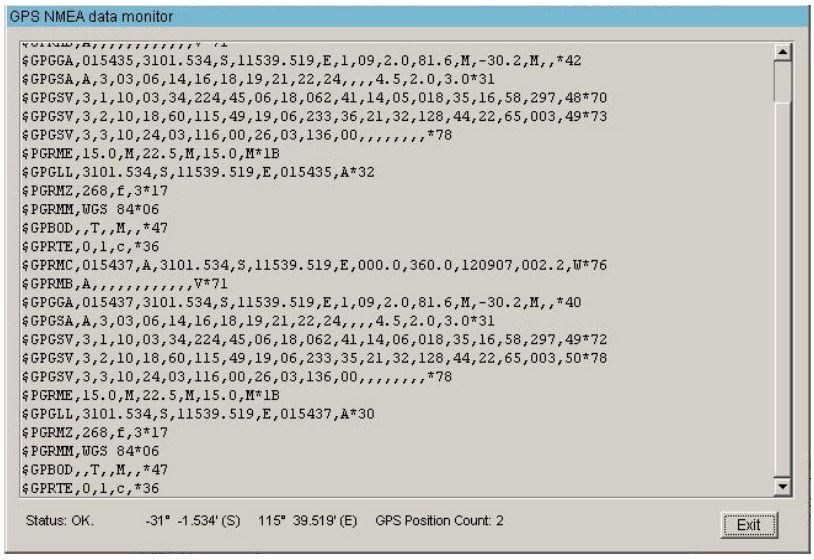
An optional, user-supplied GPS receiver that communicates over a standard RS232/serial port can be used with RF Tools. Positional data can then be logged when using the Signal Strength or Interference modules. Standard NMEA data is supported and has been tested using various models of Garmin GPS units. Due to the variations in GPS design and data formats, no guarantee is given as to the suitability or compatibility of any particular make or model. GPS receivers with USB-only connectivity are not supported.

The COM port number of your PC that the GPS is connected to must be entered into the Instrument IO section of the Preferences control panel in RF-Tools.

The GPS must be configured to output NMEA data on its serial/RS232 port with the following settings:

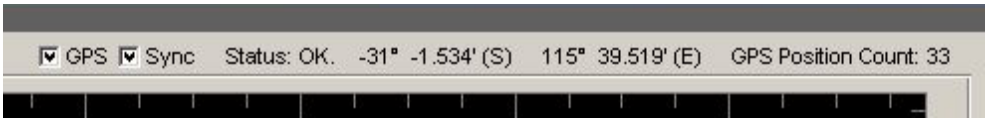
Baud rate:	4800
Byte Length:	8 bits
Stop bits:	1
Parity:	None
Handshake:	None

Communication between the GPS and the PC can be verified by clicking the "NMEA" button in the Preferences panel. Bursts of NMEA should scroll down the screen every few seconds. The "Status" indicator shows "OK" when valid data is being received, or alternative messages such as "No Fix" while the GPS is acquiring satellites or is unable to fix a location (e.g. when operating inside a building).



For PC's that do not have a serial/RS232 port (this is especially common with modern laptop PC's) one of the many available RS-232 to USB converters can be used. No guarantee is made as to the suitability of any of these, so some degree of trial and experimentation may be required to find one that suits your particular situation.

The top panel of the Interference and Signal Strength modules has two checkboxes for controlling how the GPS data is going to be used during a measurement.



GPS: Turns on/off the reading of the GPS data. When "on", the Status indicator shows the current validity of the incoming GPS data stream, followed by the current position (Lat/Long) if available.

Sync: This is a very useful control and it is important to understand its purpose. NMEA data from a GPS is transmitted in bursts, with new positional information sent every second or two. There are many situations where RF Tools is able to make measurements much faster than the rate at which the GPS updates its position, which would result in many measurements being made for (at least as far as the GPS is concerned) the same location. Activating the "Sync" control forces RF Tools to wait for the GPS to send another position before making its next measurement – i.e. the measurement rate is synchronized with each new burst of GPS data. Or to be more precise, once RF Tools has finished one set of measurements (e.g. a single sweep in Interference Monitor, or a set of signal-strength measurements in Signal Strength), it waits for the next valid burst of NMEA data before starting the next sweep or set of measurements.

So what may have been very fast sweeps/measurements with GPS "off", may now appear to run quite slowly once "GPS" and "Sync" are active, but you can be sure that with Sync active you will not be collecting large amounts of redundant data for the same set of GPS coordinates.

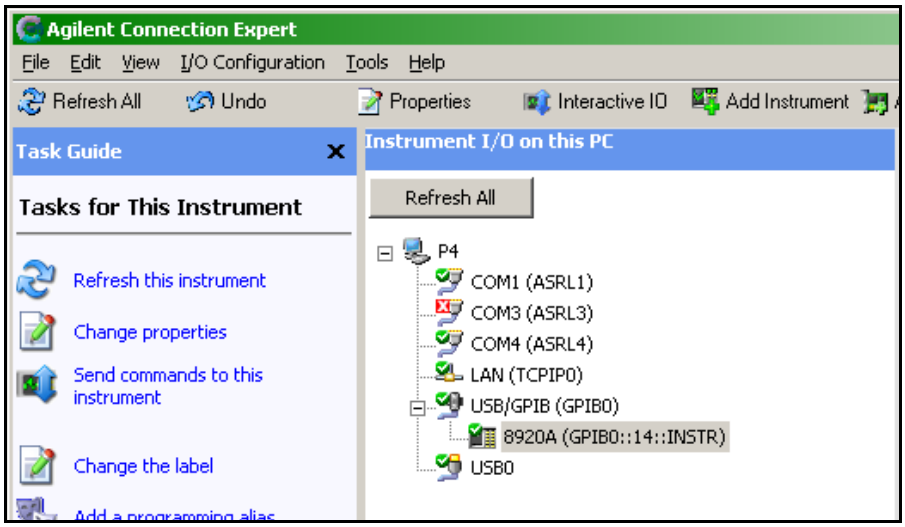
Some points for consideration:

- With Sync active, RF Tools will of course continue to make a new measurement even if the GPS is stationary and repeatedly sending the same coordinates.
- Certain measurements such as Interference measurements with very wide Spans or narrow RBW settings, or multi-channel Signal Strength measurements scanning many channels, may take many seconds to complete. If the time taken is longer than the update rate from the GPS, then clearly one or more GPS readings may be ignored while each long measurement is in progress.
- Setting "GPS" to Off does not stop the flow of NMEA data into your PC's serial port. Windows/RF Tools will continue to buffer this data all the while your GPS is physically turned on and connected to the PC. It is therefore worthwhile activating the "GPS" control prior to initiating a critical measurement to ensure that the NMEA buffer has been cleared of data prior to any measurements commencing.
- As with all RF measurements, none are instantaneous and always involve a certain measurement time. Similarly, GPS data is sent in bursts and there is a time taken for the data to be communicated to the PC. Therefore absolute time synchronisation between a specific set of GPS coordinates and any given measurement is always, on any system, not going to be possible.

Appendix E

Installing an 82357"B" cable

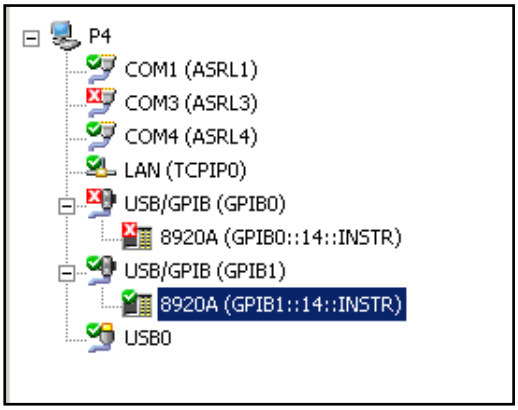
If you have previously used an 82357"A" cable on your PC, you are very likely to experience difficulties when installing one of the new Agilent 82357"B" cables onto the same PC. These difficulties are not due to any fault in the software drivers or the RF Tools software, and can be easily resolved.



With just the 82357"A" cable installed, you should see just one USB/GPIB interface displayed in the Agilent Connection Expert, labelled (GPIB0), as shown above.

The "Agilent Connection Expert" is accessed by right-clicking the small Agilent "IO" icon (shown here circled in red) on the toolbar of your PC, and selecting the topmost menu item.

After installing the new Agilent IO Libraries and Drivers for the 82357"B" cable, you will see an additional USB/GPIB interface displayed, labeled (GPIB1) as shown here. What's happened is that Windows has created another completely separate GPIB bus for the new "B" cable, and this is what causes RF Tools not to recognise your 892x. RF Tools (like most programs) expects all instruments to be connected to bus GPIB0, but your new cable is connected to bus GPIB1 which is why RF Tools cannot see your 892x.

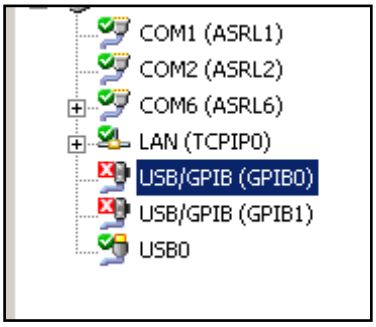


In summary, RF Tools always talks over GPIB0 interface bus, and expects the cable you have connected to be on this bus.

Solution:

Not yet installed the 82357“B” cable?

If you have not already installed the new 82357”B” cable, delete the one and only USB/GPIB interface (GPIB0) from within Agilent Connection Expert. This is easily done by right-clicking on the interface and selecting “delete”, and can be done without any of the cables connected as shown in the picture where the red/white crosses indicates that the cables are physically not connected. Now install the new Agilent IO libraries and 82357B driver software, then connect the new 82357B cable. The drivers will automatically install and configure it to GPIB0.



Already installed the 82357“B” cable?

You should have two USB/GPIB interfaces showing in the Agilent Connection Expert. Disconnect all USB/GPIB cables to ensure the red/white crosses are displayed, then right-click and “delete” each of the installed USB/GPIB interfaces (GPIB0 and GPIB1). Reconnect the “B” cable and it will automatically install and configure itself to GPIB0.

Appendix F

Frequently Asked Questions

Why does the trace on the RF Tools software screen not appear to be the same as on my 892x?

In Cable Fault Location mode, the RF Tools screen shows an inverse Fourier Transform (time domain) version of the 892x's trace (frequency domain), hence the two screen's will of course always look different. When making Return Loss or Insertion Loss measurements, there will always be slight differences between the 892x's trace and the RF Tools trace since RF Tools displays normalized trace data, whereas the 892x only displays the raw measured data without any correction from the normalization process.

Why do I get multiple images of the cable's response when performing Cable Fault Location measurements with my 892x?

High return-loss events such as shorts or opens reflect a large signal back towards the 892x. As with all instruments, the source and receiver in the 892x (along with the power divider, cables, connectors and any adapters being used) do not have exactly 50Ω impedance. Small amounts of these signals will therefore be re-reflected back up the cable from these slight mismatches. If large enough, and because of the good sensitivity of the measuring system, these signals may appear as images at multiples of the actual distance. For example, the 100% reflection from an open circuit at the end of a 20m cable may also show as a small reflection at 40m. This is completely normal and typical of most Time Domain Reflectometry systems. The effect can be reduced by inserting attenuators (typically 3dB or 6dB) in the circuit.

What if the cable I am using is not listed in the Cable Type list? Can I still use the RF Tools software?

Any 50Ω coaxial cable type can be measured with RF Tools, even if it is not in the list, provided that the Relative Velocity (Vr) and Attenuation (dB/100m at 500MHz) are known. Go to the Preferences dialog from the main screen and enter the custom cable type values. Then select "Custom" from the popup list of cable types in the Cable Fault Location Screen.

Why does the Return Loss of an Antenna at the end of a cable during Cable Fault Location measurements give a different (and incorrect) reading of Return Loss (VSWR) compared with when I measure it with the Return Loss Analyser or my SWR meter?

This is a common mistake made by operators of Time Domain tools. All distance to fault instruments, whether swept FFT type or the older "pulsed" type, send a very broad spectrum of RF frequencies up the cable. In the case of a pulsed TDR (Time Domain Reflectometer), the breadth is determined by the width of the pulse. For a swept FFT

system, such as that used by the RF Tools Software and 892x, the start and stop frequencies are determined by the software. Most antennas are highly frequency selective and only have a low or VSWR over a very narrow frequency range (usually centred on the transmit frequency they were designed to operate at). Antennas typically have a very poor match at all other frequencies, including the majority of frequencies being sent up the cable by a TDR system, and hence have a high return loss everywhere except at the resonant frequency(s) of the antenna.

The return loss of an antenna (or any other narrow-band device such as a filter or diplexer) when measured by a TDR therefore has little bearing on the actual return loss at its resonant frequency. A TDR will give a good indication of the location/distance of an antenna or other devices along a cable, and will give a good indication of return loss values for broadband devices (such as the cable, connectors and joiners), but one needs to use a return loss analyser such as that provided by the RF Tools software to measure the actual return loss or VSWR of an antenna. This is true for all Time Domain measurement systems.

Why do the front panel buttons on the 892x not work while I'm running the RF Tools software?

RF Tools takes control of the 892x while running and disables all of the front panel buttons (except for the *LOCAL* button). You cannot make changes to the 892x settings from the front panel while the RF Tools software is running and controlling the instrument. Generally, "Exit to Main Menu" returns the instrument to Local mode (i.e. not under GPIB control), allowing the operator to manually control the 892x via its front panel without having to exit the RF Tools software. The only exception to this is when in Screen Capture mode, which puts the 892x back into Local mode immediately after every capture so that the 892x settings can be adjusted manually.

How do I revert the 892x back to normal front panel operation after I've finished using the RF Tools Software?

Exiting RF Tools by clicking the *Exit* button on the main startup screen will automatically revert the instrument to local, front panel operation. If the application has been exited through some other means, pressing the *LOCAL* button on the front panel of the instrument will bring the unit back to local, front panel operation. The *LOCAL* button should not be pressed while the RF Tools is running otherwise an error may result.

How do I revert the CSA back to normal front panel operation after I've finished using the RF Tools Software?

Press the "Cancel (Esc)" button on the CSA to put the instrument back into LOCAL mode once you've finished using RF Tools. This button should not be pressed while the RF Tools is running otherwise an error may result.

Is there any way to monitor a spectrum using the Interference Monitor without storing the captured data to a file?

No. Starting a Live Capture automatically initiates the recording of spectrum data to a file.

How long can I capture data for using the Interference Monitor?

Theoretically there is no limit other than the amount of free space on your hard disk. However, the longer the capture period, the larger the capture file becomes. Eventually the file size will become unmanageable and take an inordinate amount of time to load, and dramatically slow down the playback process. A future revision of RF Tools may limit the capture period to, say, 24 hours and automatically create a new file every 24 hours to permit indefinite capture periods. As a guide, captures have been performed over 3 to 4 days quite easily and, apart from the long time taken to load the file for playback (it may appear that the PC has frozen!), no problems should be encountered.

Why doesn't the "Listen to CF" button ever become active in the 892x Interference Monitor?

You can only demodulate and listen to the demodulated signal at the centre frequency of the display when the Span is ≤ 1MHz. Demodulation cannot be performed when the Span is > 1MHz (this is a limitation of the 892x). To listen to, say, a local FM radio station on 96.1MHz, set the Centre Frequency to 96.1; set the Span to 1 (the "Listen to CF" button should now become active); click "Listen to CF"; select "Wide (230kHz)"; select "FM". Finally, turn the Volume knob clockwise and the Squelch knob anti-clockwise on the 892x until you can hear the signal.

Listen to CF is not available when using the CSA for Interference Monitoring.

Why do I see no signals on the display when using the Interference Monitor?

- Make sure you have a licensed 892x connected to your PC before running the RF Tools software.
- Ensure you have a suitable antenna connected to the "Antenna" BNC socket on the 892x's front panel. An antenna is not supplied with the RF Tools software or RF Tools kit – you must provide the antenna.
- Ensure you have selected a suitable frequency range (in most places, setting the Start Frequency to 88MHz and the Stop Frequency to 108MHz will display many large FM Broadcast signals – if not, suspect a faulty antenna, antenna cable or a faulty 892x)
- Ensure that the "Live Capture" button is selected.

Appendix G

Transferring Data between PC's

Even though there is no real limit to the number of measurement traces that can be stored on a single PC (other than available disk space), sometimes it may be useful to be able to transfer measured data to another PC for safe keeping, sharing instrument setups with colleagues, or perhaps the viewing or printing of measured data at a remote location.

Saved measurement data can be transferred between PC's by locating the database or capture files and copying them to another PC (via LAN, email attachments, memory stick, floppy or any other available file transfer mechanism). The files containing measurement data are:

cabDB	contains measured data from Cable Fault Location measurements
RLDUTDB	contains measured data from Antenna/Return Loss measurements
ILDUTDB	contains measured data from Filter/Insertion Loss measurements
xxxxx.gnt	contains recorded spectrum data from the Interference Monitor (892x). Each Live Capture creates a separate *.gnt* file. Similarly if making Interference measurements with a CSA spectrum analyser, except the file extension is *.cnt*.

These files are all contained in the following directory:

C:\Program Files\Measurement Innovation\RF Tools.

You can drag, copy or paste these files between PC's to allow you to share, copy or backup measured data. To keep multiple database files in one single directory, you can change the name of, say, the *RLDUT* file to something like *RLDUT_Bill_August_2005*. When wanting to revisit the measured data in this file at a later date, just change its name back to *RLDUT* and place it back in the RF Tools directory and run the RF Tools Application.

Note: RF Tools will error if you run the application with any or all of these files missing from the RF Tools directory.

The file containing your License Key(s) is:

license	contains the license keys that you have purchased

This file is contained in the following directory:

C:\Program Files\Measurement Innovation\RF Tools.

There are probably few situations where you'd want to copy the *license* file, other than perhaps in a large workshop with many licensed 892x's when it may be more convenient to enter all the license keys once onto one PC, and then copy the file to all the other PC's. Sharing your license keys is not a security issue since they can only be used with the specific licensed 892x's they relate to. The 892x, in effect, acts as the "dongle" or hardware security key to enable the full capability of the software.

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RF Tools Rev A.04.60
Operating Manual
March 2009

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