RTF OPERATING MANUAL
Passive Intermodulation and Return Loss Fault Ranging Device

an INFINIT@ company

Document Issue	IR	Description of Document Change	Date	Edited By	Authorization
A		Original Issue	03/02/2012		BH
B		Addition of iPA material and menus	21/12/2013		LW
C		Implementation of new Kaelus format.	13/10/2017	SR	LJ

Precautions

⚠ WARNING: INTERFERENCE

This instrument has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in an industrial installation. The instrument generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this instrument does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the instrument and receiver
- Connect the instrument into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TV technician for help

⚠ WARNING: RF HAZARD

This instrument is intended for use with the Kaelus iQA/iPA family of portable PIM analyzers, which are capable of producing up to 50 watts of radio frequency (RF) power in the 700 MHz to 2600 MHz frequency band. Users are reminded that proper precautions must be taken to minimize exposure to these RF fields to the recommended limits. Please pay particular care to the following areas:

- Switch off the RF power from the test equipment before removing or connecting the cables to the test port. Burns to fingers and permanent damage to eyes can result from exposure to connectors carrying high levels of RF power
- Ensure that any antennas being tested are placed so that no personnel are exposed to RF field levels in excess of the maximum exposure limits [Ref ARPANSA RPS No. 3 for Australian Users or Australia]

Also, the unit should be operated by a suitably qualified operator in order to ensure interference is not caused to other spectrum users. Radiation through an antenna requires authorization by the frequency license holder to do so.

DISCLAIMER: INTERFERENCE

When used in conjunction with a Kaelus iQA/iPA portable PIM analyzer, this instrument uses similar frequencies and power levels to several cellular telephone systems. Kaelus and its agents or distributors accept no responsibility for interference to existing communications services as a result of improper operation or misuse. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

GENERAL CONDITIONS OF USE

This equipment should be protected from the ingress of liquids and precipitation such as rain and snow. The equipment must be operated within the environmental conditions specified in Section 4. This equipment is not approved for use in hazardous atmospheres or medical applications.

WARRANTY

Kaelus warranties all of its products and services to be free from defects in material and workmanship for a period of 12 months from first receipt into customer store. The limit of liability under this warranty shall be to repair or replace any product, or part thereof, which proves to be defective after inspection by Kaelus provided that:

- The products are returned properly packed, carriage paid, to Kaelus or their agent or distributor, at the customer's risk within the warranty period
- An adequate description of fault conditions is included with the returned products
- The products have not been misused, mishandled, overloaded, modified or repaired in anyway, or used for any purpose other than that for which they were designed

Kaelus shall be responsible for one way freight charges, from Brisbane to customer store destinations within Australia.

Repair and replacement work carried out by Kaelus on products manufactured by them, shall be warranted against the same defects re-occurring in a period of 12 months, or until the expiration of the original product warranty, which ever shall be the latter.

Kaelus shall not be liable for any direct or consequential injury, loss or damage incurred through the use, or the inability to use, any Kaelus product. Kaelus reserves the right to make design changes to Kaelus product without incurring any obligation to make the same changes to previously purchased products.

UNPACKING

Ensure that the total number of boxes of equipment is checked off against the delivery documentation. At the same time inspect for any obvious transit damage. Should any damage be noted, notify the carrier immediately to file a transit damage claim. Do not discard any packing material until notified by the carrier or Kaelus. Carefully unpack all containers and check that all items listed on the delivery documentation. Please notify Kaelus of any damaged or missing items from the shipment.

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1. Introduction

This manual describes the operation of the Kaelus Range-to-Fault (RTF) system. This system enables the user to pinpoint the locations and magnitudes of PIM and Return Loss faults in RF infrastructure of the type typically found in cellular mobile telephone base stations.

The RTF system comprises an external device called an RTF module connected to a suitably equipped iQA or iPA portable PIM analyzer. Customers can purchase an RTF-ready PIM analyzer from Kaelus, or can arrange a factory upgrade to their existing iQA to become RTF compatible.

2. Functional Description

2.1   Passive Intermodulation Distortion

Passive intermodulation distortion (PIM) is a form of electromagnetic interference that is often encountered in full-duplex radio communications systems such as cellular mobile telephone networks. Its root causes and effects on network performance are described in detail in the iQA/iPA Operating Manuals, but suffice it to say that PIM is an extremely undesirable phenomenon that is of increasing concern to cellular network operators.

2.2   Conventional PIM Testing Equipment

In response to the challenges presented by PIM, a new family of test instruments has come onto the market in recent years. Commonly referred to as "PIM analyzers", these instruments measure the overall PIM performance of the RF infrastructure using the method of Test Setup 1 of IEC62037. The iQA/iPA portable PIM analyzer from Kaelus is one example of this type of instrument.

While useful in determining whether or not a system has a PIM problem, conventional PIM analyzers do not provide any information about the locations of PIM faults in the device under test. Consequently, PIM faults can still be labor-intensive and time-consuming to resolve, especially in complex systems containing many RF cables, components and interconnects.

2.3   RTF Module

The lack of detailed information about where PIM faults are located has previously been a key limitation of conventional PIM analyzers. However, this shortcoming has now been remedied with the development of the Kaelus RTF module.

When attached to an iQA/iPA portable PIM analyzer, the RTF module enables the iQA/iPA to determine the location and magnitude of individual PIM faults in the RF infrastructure.

In addition to this, the RTF module enables the iQA/iPA to pinpoint the location and magnitude of individual Return Loss faults in the RF infrastructure.

2.4   Measurement Process

2.4.1   PIM vs Distance

The RTF system measures the distance to PIM faults by performing a frequency-swept reflected PIM measurement in accordance with Test Setup 1 of IEC62037.

At each point in the sweep, the iQA/iPA generates two high-power synthesized carriers in the transmit band of the instrument. These carriers are emitted from the test port and propagate into the device under test, where PIM is generated by the faulty components and interconnects therein. The resulting 3rd or 5th order intermodulation product is automatically calculated, and the RTF module's receiver is tuned to the required frequency. The RTF module measures the amplitude of the PIM product, and also its phase relative to a local reference tone. This process is repeated at every point in the frequency sweep. Upon completion of the sweep, the measured results are post-processed by the iQA/iPA, and the PIM fault locations and amplitudes are displayed on the screen.

2.4.2   Return Loss vs Distance

The RTF system measures the distance to return loss faults using the well-known technique of Frequency Domain Reflectometry (FDR). This involves measuring the vector reflection coefficient of the device under test over a range of discrete frequencies, and then computing the inverse Fourier transform of the results.

At each point in the sweep, the RTF module generates a single low-power carrier in the transmit band of the iQA/iPA. This tone is emitted from the test port and propagates into the device under test, where reflections are generated by impedance mismatches in the components and interconnects therein. The RTF module then measures the amplitudes of the forward and reflected waves and their relative phase. This process is repeated at every point in the frequency sweep. Upon completion of the sweep, the measured results are post-processed by the iQA/iPA, and the return loss fault locations and amplitudes are displayed on the screen.

3. Features of The RTF System

- Accurately and rapidly measures distance to PIM faults in RF infrastructure
- Also measures distance to Return Loss faults in RF infrastructure
- Multiple display options, including overlay plot of PIM and Return Loss
- Proprietary resolution enhancement algorithm significantly improves effective resolution of system
- Simple sweep setup:
    - Tx start/stop frequencies automatically chosen (within user-defined limits) so that PIM frequencies land in receive band of system
    - Receiver automatically tuned to PIM frequency
- Rapid one-step calibration procedure
- RTF module enclosed in durable, compact housing which attaches directly to output RF connector of iQA/iPA
- All existing iQA/iPA functionality still available, including fixed-tone testing, time trace, frequency sweep and spectrum monitor

4. Specification

PIM Mode	
Measurement Method	Reflected PIM, frequency swept
RF Power	2 x +43 dBm supplied by iQA/iPA
Available PIM Products for RTF Analysis	3rd order (IM3), 5th order (IM5)
Residual PIM	< −115 dBm max (< −125 dBm typ)
PIM vs Distance Measurement Accuracy	Distance: ± 1 m (typ)[1] Magnitude: ± 3 dB (typ)

Return Loss Mode	
Measurement Method	Frequency Domain Reflectometry (FDR)
RF Power	−33 dBm supplied by RTF module
Effective Directivity of Calibrated System	40 dB (approx)

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[1] Assumes input return loss of 10 dB or better for all components & interconnects in device under test. Accuracy specification is applicable to PIM faults with levels of −110 dBm or greater. When multiple PIM faults are present, the stated accuracy is applicable only when adjacent faults are separated by a distance greater than the system resolution.

System	

Results Display Modes	Numeric:
	    Distance to largest PIM fault
	    Magnitude of largest PIM fault
	Graphical:
	    PIM vs Distance
	    Return Loss vs Distance
	    PIM & Return Loss vs Distance

Maximum Alias-Free Range	1500 x vf metres (4950 x vf feet)[2] where vf = cable velocity factor[3]
Ports	Communications (USB Mini-B) Auxiliary Port (Type-N female) iQA/iPA Port (7-16 male) Test Port (7-16 female)

Electrical	
Power	+12V DC @ 400mA (max) supplied via iQA/iPA monitor port +5V DC supplied via iQA/iPA USB port
Power Connector	Coaxial RF connector, Type N female

Mechanical	
Dimensions	127 x 90 x 73 mm
Weight	1.0 kg

Environmental	
Operating Temperature Range	−10°C to +40°C
Storage Temperature Range	−20°C to +60°C
Ingress Protection (IP)	IP50 (operating)
Relative Humidity	5% to 95% RH non-condensing

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[2] Assumes system configured for IM3 sweep with fixed carrier located between Rx band and swept carrier.
[3] Cable velocity factor vf must be greater than zero and less than or equal to one.

5. Construction And Layout

5.1   RTF Module

The external details of the RTF module are shown below in Figure 1 and Figure 2 respectively. Labels may vary slightly from one frequency variant to the next.
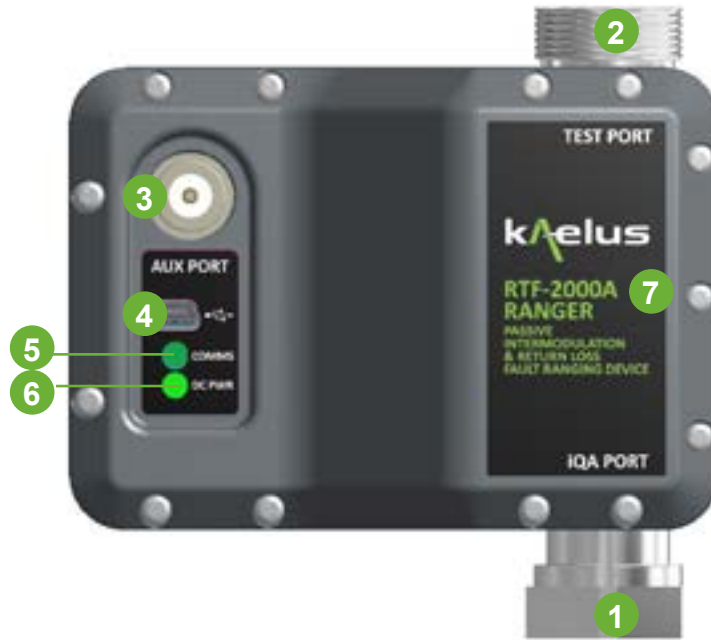
Figure 1   Top view of RTF module.

Figure 2   Side view of RTF module showing RF warning LED

1   iQA/iPA Port

The iQA/iPA Port of the RTF module is connected to the 7-16 test port on the front panel.

2   Test Port

The Test Port of the RTF module is attached to the device under test.

3   Auxiliary Port (AUX Port)

The Auxiliary (AUX) Port is attached to the Monitor Port on the iQA/iPA via a short length of RF cable. The measured PIM signal and 12V DC supply from the iQA/iPA enter the RTF module through this port.

4   USB Port (Type Mini-B)

The USB Port is normally connected to one of the spare ports on the front panel of the iQA or the USB type A connector on the iPA. It allows the iQA/iPA to control the RTF module so that measurements can be made in a synchronized fashion.

5   Communications LED (Green Flashing LED)

The green Communications LED flashes continuously whenever an active communications link exists between the RTF module and the iQA/iPA.

6   DC Power LED (Steady Green LED)

The green DC Power LED will be illuminated whenever 12V DC is present on the AUX Port.

7   RTF Frequency Variant Label

Indicates the frequency variant of the RTF module. The RTF-1000 variant is designed for operation from 698–960 MHz, whereas the RTF-2000 is designed for operation in the range 1710–2170 MHz. The RTF 2600 variant is designed for operation from 2300–2690 MHz

8   Red LED (RF ON indicator)

The high intensity, red LED flashes when RF power is present on the Test port.

5.2   iQA/iPA Front Panel Connectors

The front panel connectors on the C-series iQA and the iPA are identified in Figure 3 below.
In the case of A- and B-series iQAs that have had the RTF upgrade kit installed, the front panel layout is the same except that the third USB port is not provided. iPAs with Firmware version 1.6.1 or later can be upgrade to the latest RTF software via the SD card. iPAs with firmware prior to 1.6.1 MUST upgrade to version 1.6.1 first. Then upgrade to subsequent versions of RTF capable software. Please visit www.kaelus.com to find the service center nearest you for assistance.

Figure 3   C-series iQA and A-series iPA front panel connectors

9. RF Output Port

The RF Output Port on the iQA/iPA front panel is a bidirectional RF port. The pair of high-power carriers are emitted from this port, while the reflected PIM signal from the system under test enter the iQA's receiver via this port.

10. Monitor Port

The Monitor Port is normally connected to the AUX Port of the RTF module. It is used to transmit the measured PIM signal and 12V DC power from the iQA/iPA to the RTF module.

11, 12, 13. USB Port

One of the USB Ports on the iQA/iPA must be connected to the RTF module. For C-series iQAs the preferred choice will usually be USB Port 3, due to its close proximity to the RTF module's point of attachment to the iQA. For the iPA a single Type A USB connector is provided under a protective cover.
Note that USB Port 3 is not provided on A- or B-series iQAs that have had the RTF upgrade kit installed. For those instruments either USB Port 1 or USB Port 2 can be used to connect the iQA to the RTF module.

Cable Assemblies

The RTF module is supplied with the following cable assemblies:

Short USB Cable

The short USB cable is for use with C-series iQAs and the iPA. It connects the RTF module to USB Port 3 on the front panel of the iQA and the Type A USB connector on the iPA.

Long USB Cable

The long USB cable is for use with A- and B-series iQAs that have had the RTF upgrade kit installed. It connects the RTF module to USB Port 1 or USB Port 2 on the front panel of the iQA.

Monitor Cable

The Monitor cable is a low-power RF cable that connects the AUX port on the RTF module to the Monitor port on the front panel of the iQA. Its purpose is to carry the measured PIM signal and 12V DC power from the iQA to the RTF module. Current Production iPAs are shipped with a N Type to SMB cable to connect the RTF module to the iPA. If your N-to-SMB cable has been lost or damaged, a replacement cable can be ordered from Kaelus (part no. R18-0768-500).

6. Getting Started

6.1   Connecting the RTF Module to the iQA

The RTF module can be connected or disconnected from the iQA at any time, without risk of damage to either piece of equipment.

The connection procedure is as follows:

1. Attach the RTF module to the iQA's RF Output port and tighten the RF connector. Do not allow the body of the RTF module to rotate while tightening the connector, as this can cause damage to the 7-16 connector mating surfaces. The recommended orientation of the RTF module is shown in Figure 4.
2. Connect the AUX port of the RTF module to the iQA's Monitor port using the cable provided.
3. Connect the USB port on the RTF module to any one of the USB ports on the iQA's front panel using the cable provided.

Figure 4   Recommended orientation of RTF module when connected to iQA

6.2 Connecting the RTF Module to the iPA

Figure 5 Recommended orientation of RTF module when connected to iPA

1. Attach the RTF module to the iPA's RF Output port and tighten the RF connector. Do not allow the body of the RTF module to rotate while tightening the connector, as this can cause damage to the 7-16 connector mating surfaces. The recommended orientation of the RTF module is shown in Figure 5.
2. Connect the AUX port of the RTF module to the iPA's Monitor port using the cable provided.
3. Connect the USB port on the RTF module to the Type A USB port under the iPA's protective side cover.

6.3 Calibrating the System

Before the RTF module can be used, it must first be calibrated according to the following procedure:

1. If the iQA/iPA is currently turned off, turn it on now (refer to the relevant iQA/iPA Operating Manual for details concerning the startup procedure).
2. There will be a brief delay while the iQA/iPA connects to the RTF module and searches for a valid calibration. For the iQA, if a valid calibration is found, the following dialogue box is displayed:

Click "Ok" to complete the setup process. The instrument is now ready for use.

For the iPA, if a RTF module is detected then the mode menu selection for RTF will no longer be greyed out.

Shaded Grey = RTF Not Available
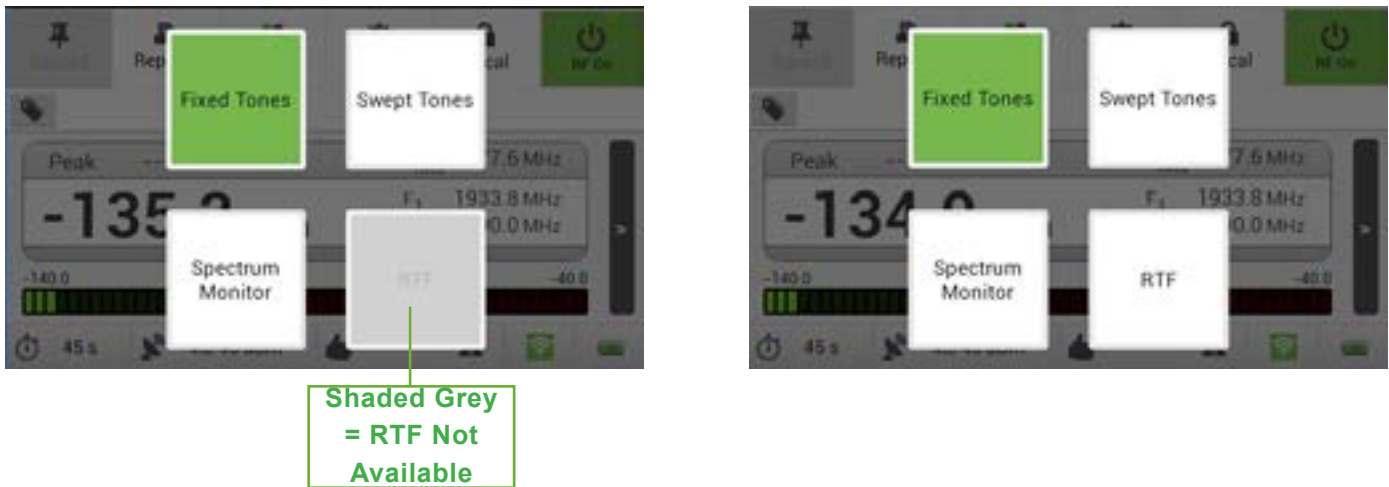
3. If no calibration exists, or the existing calibration is out of date, the iQA/iPA will prompt the user to calibrate the RTF module with the following dialogue box:
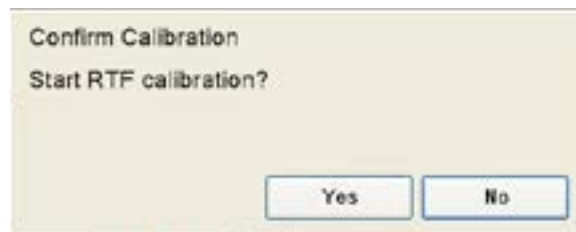
4. Click "Yes" to start the calibration. If you click "No" you will be returned to the main application screen.

Note: Users will not be able to access any of the instrument's PIM vs Distance functions until the unit has been calibrated. However, Return Loss vs Distance functionality is always available, regardless of whether or not the PIM calibration has been performed.

5. The following prompt will now appear on screen, instructing the user to attach the Passive Intermodulation Source (Kaelus part no. CIS-0001A) to the Test port of the RTF module:
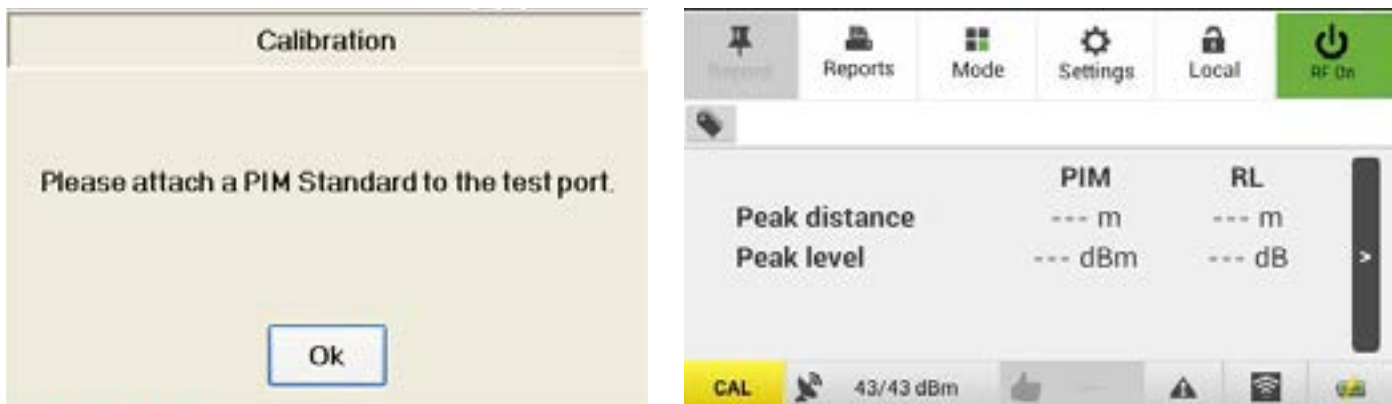
6. Attach the PIM Source to the Test port of the RTF module as shown Figure 7 RTF module attached to iPA with PIM Source attached to Test port (for iQA) or Figure 7 (for iPA), then click "Ok" on the Calibration dialogue box.

Figure 6   RTF module on the iQA (CIS-0001A PIM Source used for 5th order calibration)

Figure 7   RTF module attached to iPA with PIM Source attached to Test port

7.   The system will now perform the RTF calibration sweep. This process can take up to 20 seconds to complete. While the calibration is running, the following progress indicator is displayed:

iPA Remote Display

iPA Local Display
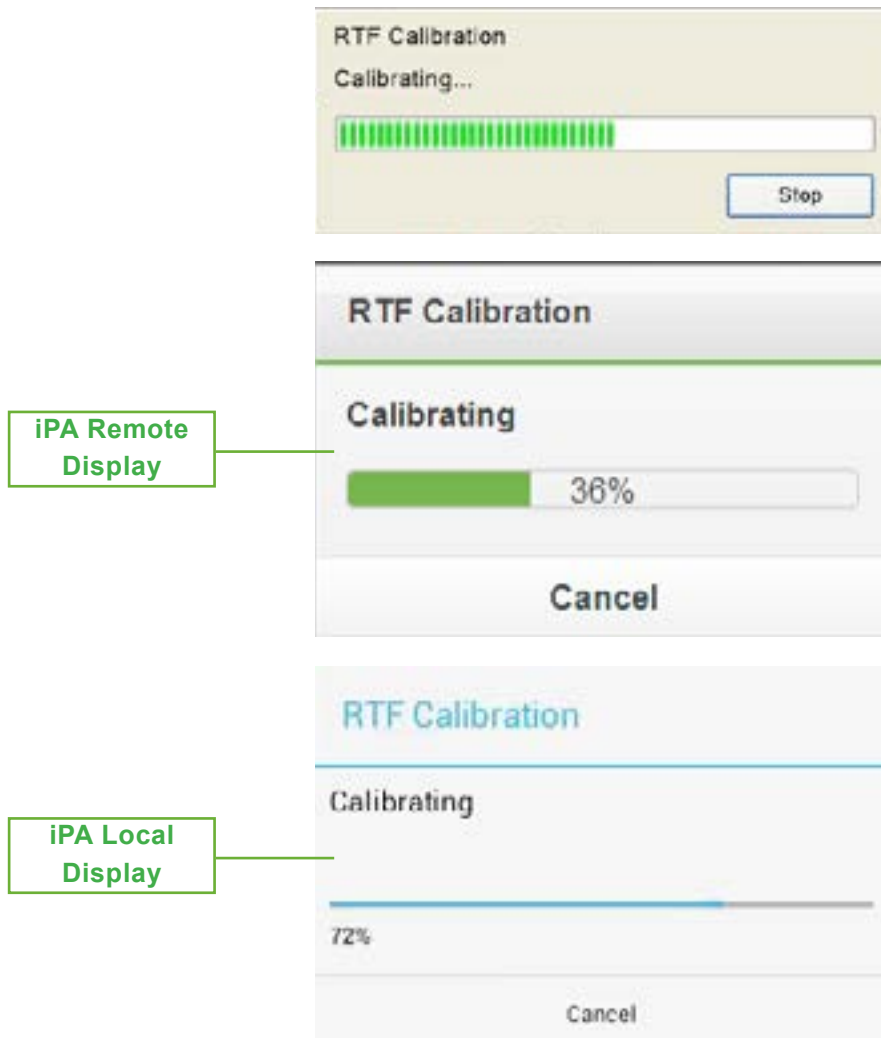
Note: The user can abort the RTF Calibration sequence prematurely by clicking the "Stop" / "Cancel" button if desired. In that case the instrument will use the last valid calibration for subsequent measurements. If no valid calibration exists, the user will not be able to access any of the instrument's PIM vs Distance functions until the unit has been calibrated

8.   Upon completion of the RTF Calibration sweep, the instrument is ready for use.

6.4   Main Application Window

After the RTF module has been successfully calibrated, the instrument will return to the Main Application Window.

The layout of the main application window is described in the iQA/iPA Operating Manuals. When the RTF module is connected, this window remains unchanged except for the new Peak Return Loss indicator and Return Loss indicators. On the iQA these indicators appear beneath the Peak PIM indicator, as shown in Figure 8. The indicators on the iPA are shown in Figure 9. The Peak Return Loss and Return Loss Pass/Fail indicators are visible only when the RTF module is connected; if the RTF module is disconnected, the indicators are removed.

The Peak Return Loss and Return Loss Pass/Fail indicators are discussed further in Section 7. For details on other aspects of the main application window, refer to the iQA/iPA Operating Manuals

Figure 8   Main application window with RTF module connected to iQA
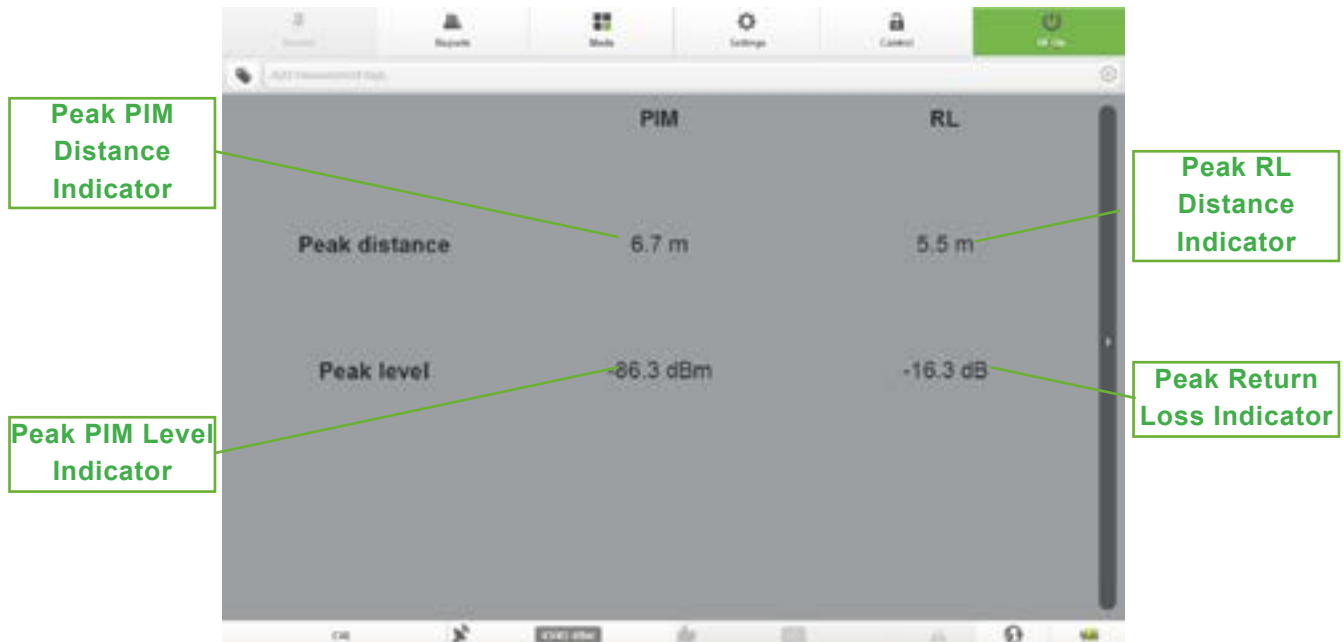
Figure 9   Main application window with RTF module connected to iPA (Remote)
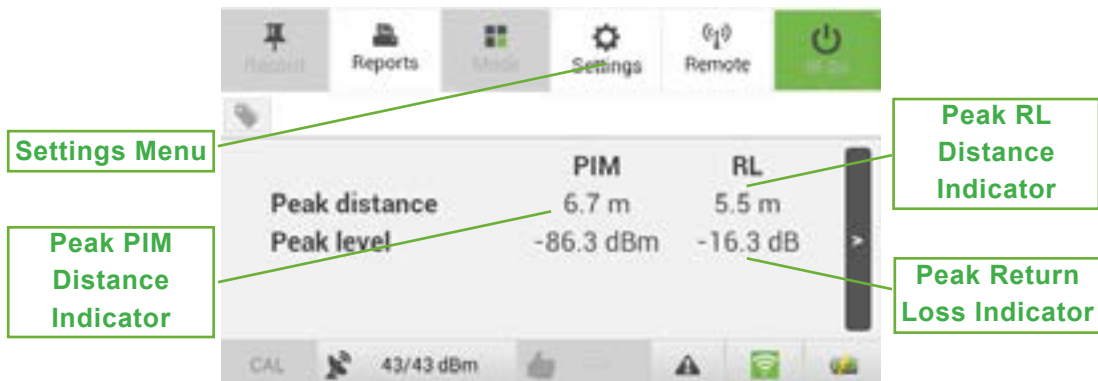
Figure 10   Main application window with RTF module connected to iPA (Local contol)

6.5 Measurement Configuration Menu (iPA)
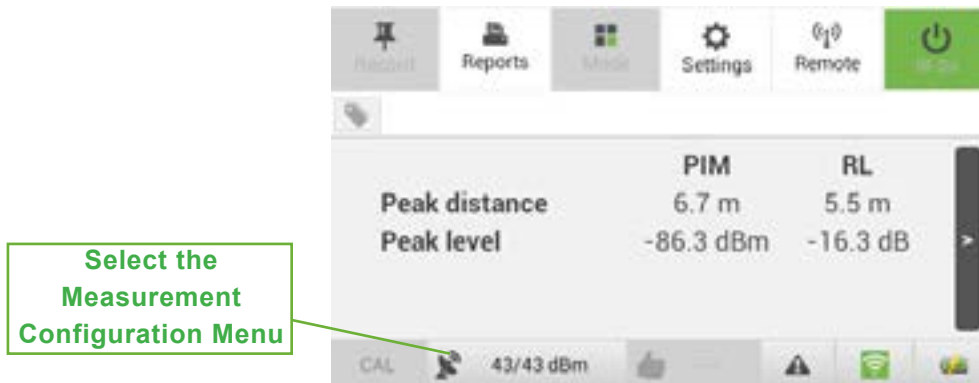
Figure 11   Selecting the Measurement configuration Menu iPA (Local control)
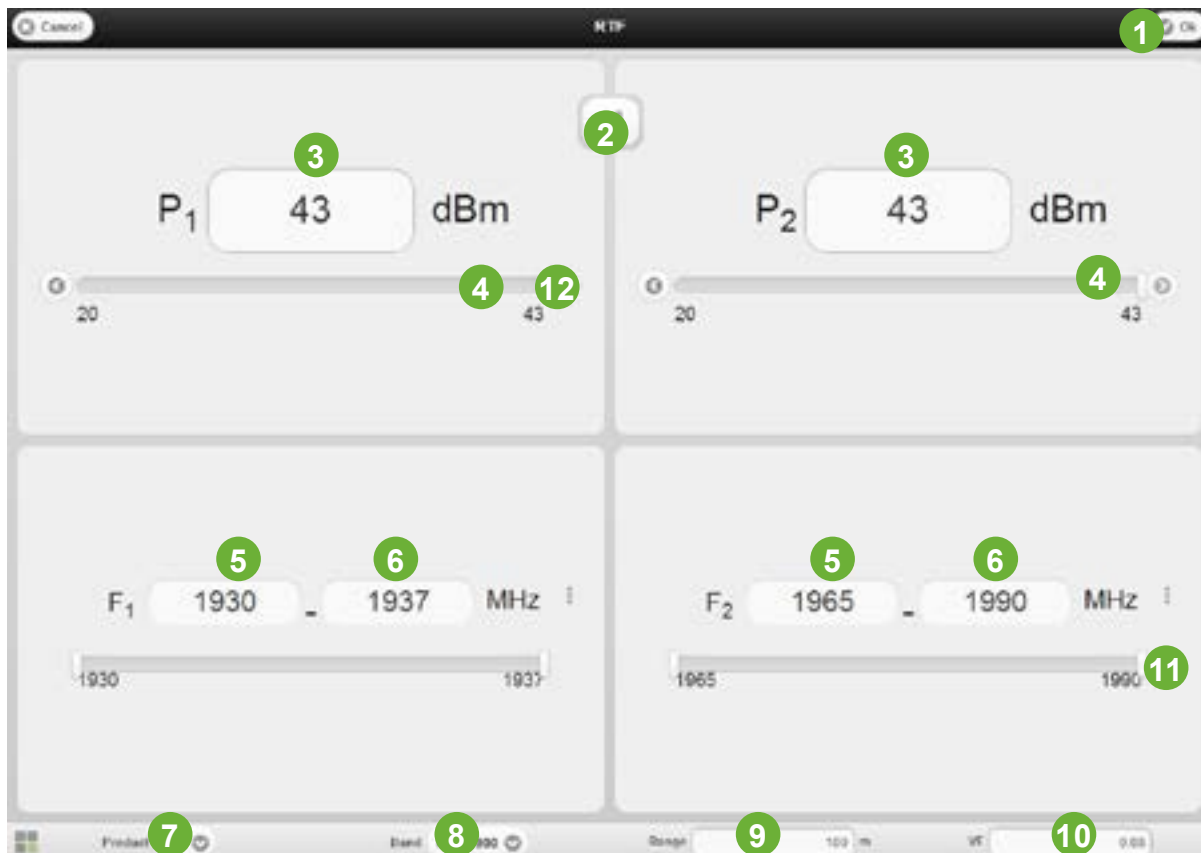
Figure 12   Measurement Configuration Menu iPA (Remote Control)
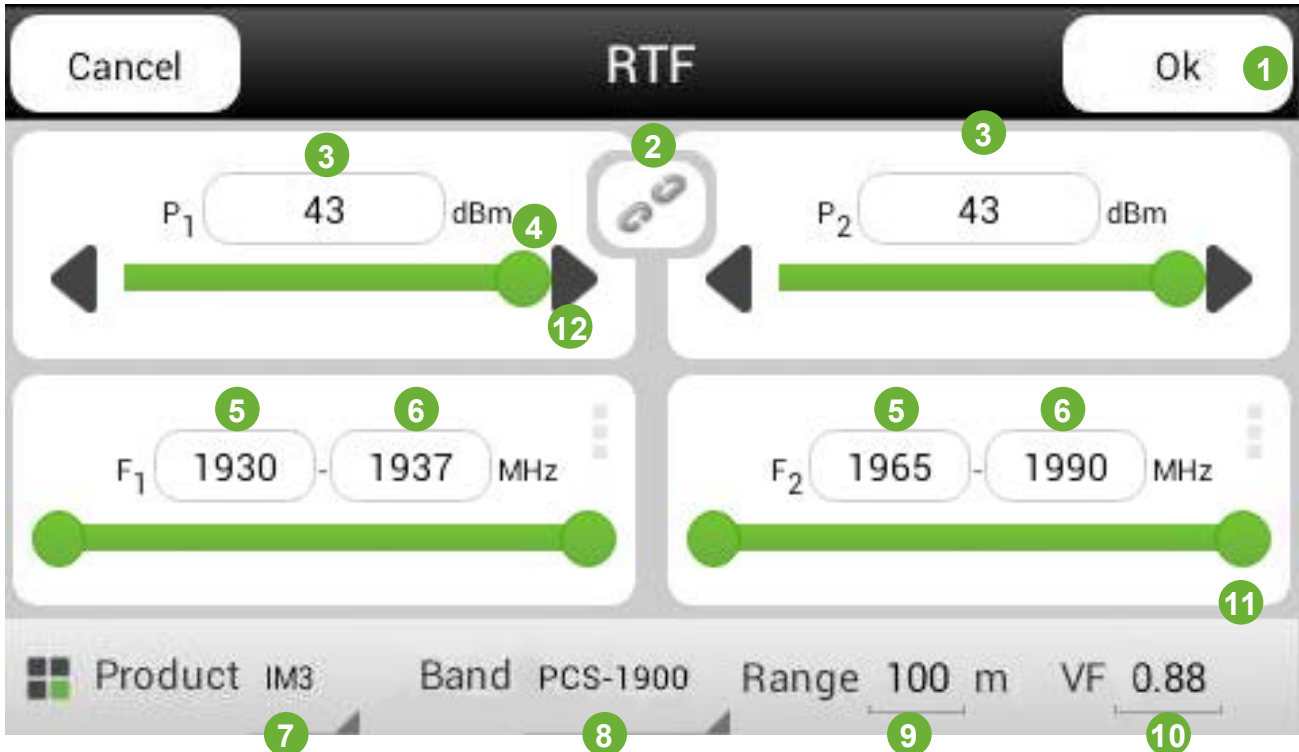
Figure 13   Measurement Configuration Menu iPA (Local Control)

1   OK

When this button is selected the iPA will accept the user's measurement configuration values and exit from the menu. If the OK button is greyed out, this indicates that another device has control of the instrument. (Only the controlling display can update the measurement configuration values.)

2   Linked Power Control

When selected (chain links closed) one of the power control panels will be grayed out and the left hand control sets the power of both test tones.

3   Power level Set 1,2

This field can be highlighted and the Power level required entered in via the keyboard. How the field is selected will depend on whether you using a touch screen or PC.

4   Power Adjust Slider

When touched the slider can be moved to adjust the Tx Power. When Power Adjust is unlinked each tone can be adjusted separately. When linked, both tone levels are adjusted together.

5   Lower Sweep Frequency Tone 1,2

The lower end of the frequency sweep is set either by the appropriate left slide control or by highlighting the left numeric field and entering the frequency via the keyboard.

6   Upper Sweep Frequency Tone 1,2

The upper end of the frequency sweep is set either by the appropriate right slide control or by highlighting the right numeric field and entering the frequency via the keyboard

7   Intermodulation Product Select

Activates a pull down menu allowing a selection between IM3 or IM5 Products.

8   Band selection for multiband units

If you are using a multiband unit this pull down menu allows you to select between the available operating bands.

9   Maximum Range

This sets the maximum distance of the PIM and Return Loss Measurement to be used. Depending on the distance units settings this can be in either meters or feet. Units settings are under Settings Miscellaneous menu settings.

10   Velocity Factor

The velocity factor (VF) is a fundamental property of the RF cables in the system under test, which affects the speed at which signals travel through the system. The velocity factor varies from cable to cable, but its value is always greater than zero and less than or equal to one.

11   Frequency Adjust Slider

12   Power Step Arrow

7. Standard iQA/iPA Measurement Modes

7.1   Introduction

The full suite of standard (i.e. non-RTF) iQA/iPA operating modes is still available when the RTF module is connected, including:
- Fixed frequency PIM measurement
- Time trace
- Frequency sweep
- Spectrum monitor

The only difference with the RTF module at present is the addition of a Return Loss pre-test, which is automatically performed before commencing PIM testing in Fixed Frequency mode.

Time Trace, Frequency Sweep and Spectrum Monitor modes are all unchanged with the RTF module present.

7.2   Fixed Frequency PIM Measurements with RTF Module Connected to iQA/ iPA

The procedure for performing a fixed frequency PIM test with the RTF module connected to the iQA/iPA is as follows:
1. Configure the instrument for a fixed frequency PIM test as described in the iQA/iPA Operating Manual.
2. Press the green RF ON/OFF button to start the test.
3. The instrument now performs a low-power return loss sweep across the transmit band of the iQA/iPA. While the sweep is running the following progress indicator is displayed:
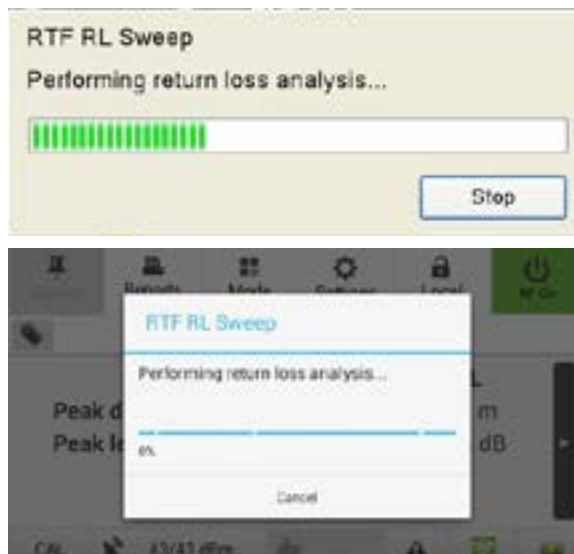
Note: While the Return Loss sweep is in progress, the high-power transmit carriers from the iQA/iPA are turned off.

4.   Upon completion of the Return Loss sweep, the instrument checks the peak return loss level against the Return Loss Pass/Fail threshold. (This threshold is defined in the Settings screen, which is discussed in Section 8.6.8.)

5.   If the return loss satisfies the Pass/Fail threshold, the instrument will turn on the two high-power transmit carriers and display the measured PIM level as described in the iQA/iPA Operating Manual. On the iQA, the peak return loss measurement from the pre-test will be displayed underneath the peak PIM result, as shown in Figure 14

Figure 14   Fixed-tone PIM test running with RTF module connected

If the return loss fails the Pass/Fail threshold, the following warning message is displayed:
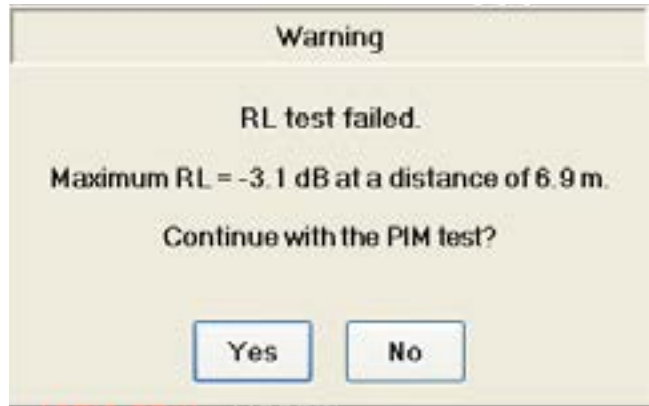
The user can now choose to abort the measurement and return to the main application window, or continue with the PIM test. If the user chooses to continue, the instrument will turn on the two high-power transmit carriers and display the measured PIM level as described in the iQA/iPA Operating Manual. On the iQA, the peak return loss measurement from the pre-test will be displayed underneath the peak PIM result, as shown in Figure 14.

Note that on the iQA the return loss pass/fail threshold can be adjusted by the user. However, on the iPA the threshold is fixed at −5 dB.

6.   The RF power can be switched off by either pressing the red RF ON button, or waiting for the Power Timer to time out.

7.3   Time Trace, Frequency Sweep and Spectrum Monitor

7.4   Measurements with RTF Module Connected to iQA/iPA

The Time Trace, Frequency Sweep and Spectrum Monitor modes are unchanged with the RTF module connected to the iQA/iPA. The return loss pre-test is not performed in these modes.

8. RTF Analysis

8.1   Activating the RTF Analysis Window

When the RTF module is connected to the iQA/iPA a new screen becomes available. This screen is referred to as the RTF Analysis window.

To navigate to the RTF Analysis window from the iQA/iPA's main application window, use the softkey menu sequence Mode → RTF, as shown in Figure 15.
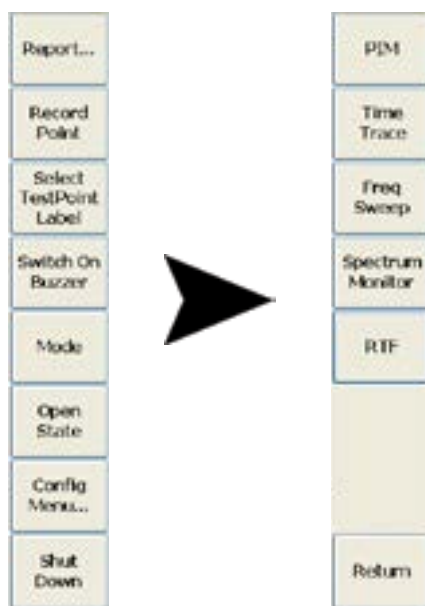
Figure 15   Softkey menu path to RTF Analysis screen (iQA)
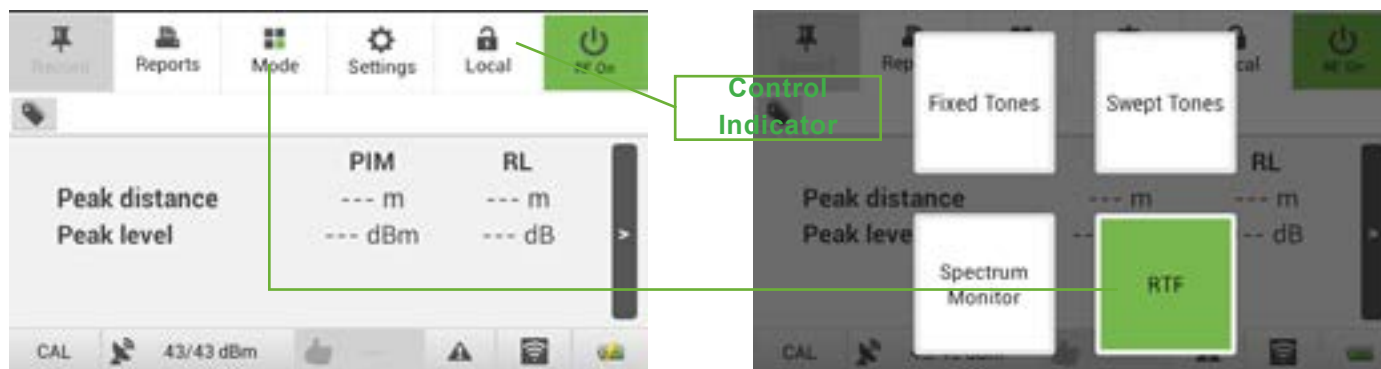
Figure 16   Softkey menu path to RTF Analysis screen (iPA)

Note : As it is possible to control the iPA from multiple points, the local or remote point that is in control has the power to change modes . See the iPA operating manual for more details.

8.2   Layout of the RTF Analysis Window

8.2.1   iQA Analysis Window

The RTF Analysis window is shown in Figure 17 in its default display mode. This window is available only when the RTF module is connected to the iQA.
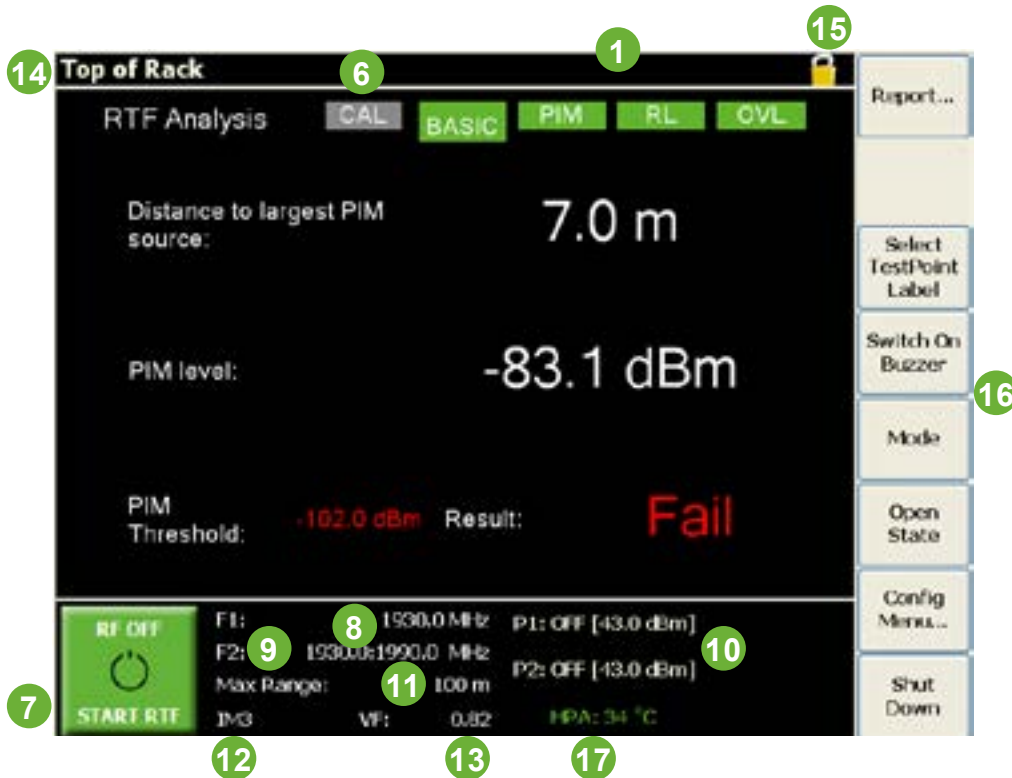
Figure 17   RTF Analysis Window - Basic Display Mode (Default) iQA

8.2.1.1   Results Display Mode Buttons (iQA)

The results display mode buttons allow the user to switch between the different results formats in the RTF Analysis window. The different display modes are discussed in detail in sections to follow, but in summary:

8.2.1.2   Basic Mode (iQA)

This is the default results display mode. It is a simple numerical readout of the location and amplitude of the largest PIM fault in the device under test.

8.2.1.3   PIM vs Distance Plot (iQA)

This mode plots PIM amplitude as a function of distance. Sources of PIM in the device under test show up as peaks on the plot.

8.2.1.4   Return Loss vs Distance Plot (iQA)

This mode plots return loss as a function of distance. Sources of poor return loss in the device under test show up as peaks on the plot.

8.2.1.5   Overlay Plot (iQA)

This mode plots the PIM and Return Loss vs Distance traces on the same set of axes.

8.2.1.6   Calibrate Button (iQA)

The calibrate button triggers an RTF PIM calibration.

8.2.1.7   RF ON/OFF Button (iQA)

The RF ON/OFF button is used for triggering an RTF sweep. As a visual aid, this button will turn red whenever the high-power RF carriers have been switched on. In the default state (RF OFF) this button will be green. Additional text appears on this button to show the state of the button (RF OFF or RF ON).

8.2.1.8   F1 Tone Frequency (iQA)

The F1 tone is fixed in frequency. The frequency is user-adjustable and can be set to any value within the instrument's Tx band. It can be greater than or less than the F2 tone frequency.

Note that not all F1 frequencies will generate a PIM product of the desired order in the instrument's Rx band. An error message will appear when the associated PIM product does not fall within the applicable Rx band and the user will have the opportunity to correct the tone placement.

8.2.1.9   F2 Tone Frequency Range

The F2 tone is swept across a range of frequencies. The frequency range is user-adjustable and can be set to any range within the instrument's Tx band. The range can be greater than or less than the F1 tone frequency.

Note that not all F2 frequency ranges will generate a PIM product of the desired order in the instrument's Rx band. In such cases the instrument will sweep the F2 tone over the widest possible bandwidth within the specified frequency range for which a PIM product lands in the Rx band.

If the instrument cannot find any combination of frequencies that generate a PIM product in the Rx band, an error message will appear and the user will have the opportunity to correct the tone placement.

8.2.1.10   Tone Output Powers

The default Tx tone output power is +43 dBm (20W) per tone, but the power is adjustable to as low as +33 dBm (2W) per tone.

8.2.1.11   Maximum Range

The maximum range setting determines the largest distance at which the instrument can detect faults without error.

Note: It is very important to choose a value of Max Range that is greater than the length of the device under test. The accuracy of the instrument cannot be guaranteed if this condition is not met.

A good rule of thumb for the value of Max Range is:

Max Range = Estimated length of device under test + 10%.

8.2.1.12   PIM Product

PIM Product determines which intermodulation product is measured by the instrument when performing a PIM vs Distance sweep. Two choices are available: 3rd order (IM3), or 5th order (IM5). The desired product can be manually changed at any time. During a PIM vs Distance sweep the PIM frequency is automatically calculated, taking into account the Tx tone frequencies, the order of the IM product and the instrument's Rx band.

In practice, IM3 is usually the preferred product as it has the largest amplitude. However, in some cases it may be necessary to switch to the IM5 product, for example when it is not possible to find a combination of frequencies that generates an IM3 product in the Rx band, or when a higher resolution plot is desired.

8.2.1.13   Velocity Factor (VF)

The velocity factor (VF) is a fundamental property of the RF cables in the system under test, which affects the speed at which signals travel through the system. The velocity factor varies from cable to cable, but its value is always greater than zero and less than or equal to one.

If the system under test contains multiple cables of different velocity factors, the velocity factor of the longest cable should be chosen for the VF setting.

8.2.1.14   Test Point Label

The user-changeable Test Point Label appears at the top left-hand corner of the application window. This label will appear in the test report when the associated test point is recorded. The default label is "Top of Rack".

8.2.1.15   Config Lock (iQA only)

The "Config Lock" icon shows whether the configuration mode is accessible or not.

8.2.1.16   Button Bar

The button bar is the main user-instrument interface.

8.2.1.17   HPA Temperature

This temperature display area doubles as an alarm status indicator. As soon as an instrument alarm is triggered it will show an alarm message in red text in place of the temperature display. Press on the alarm message and the alarm screen will be displayed. The description of an alarm can be seen by pressing on the specific alarm indicator. The HPA temperature alarm is activated at 70°C and a soft cut-out occurs at 75°C, until temperature is restored to below 70°C.

8.2.2   iPA ANalysis Window (Local Control)
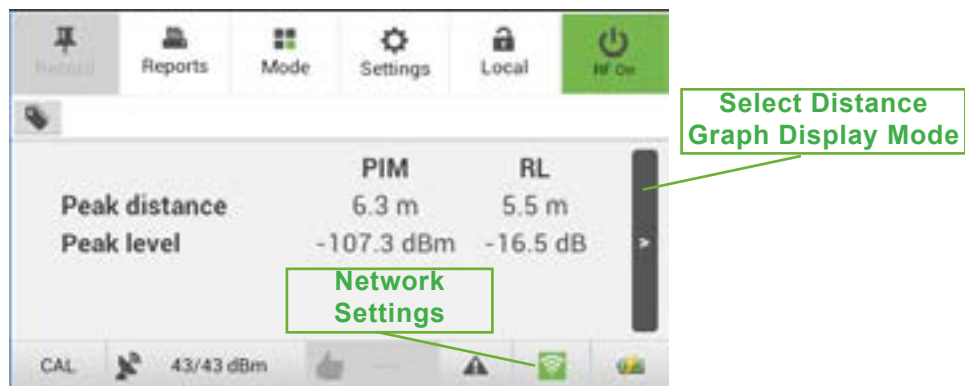
Figure 18   RTF Analysis Window - Basic Display Mode (Default) With Instrument Under Local Control

8.2.3   iPA Analysis Window (Remote Control)
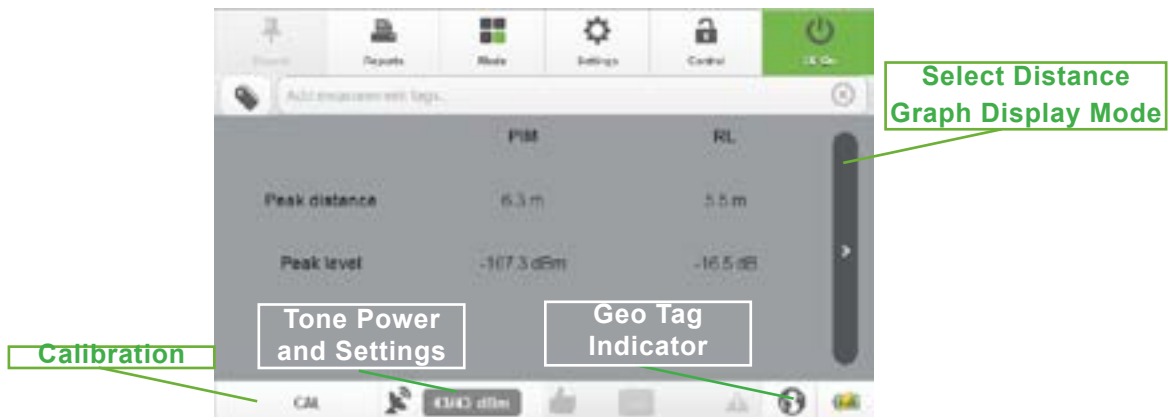
Figure 19   RTF Analysis Window - Basic Display Mode (Default) Under Remote Control

Operation of the remote control keys is almost identical to local operation, with a few important exceptions.

1. A wireless network connection must first be established between the iPA and the remote control device before any RF testing can be performed. The most common approach is to configure the iPA as a Hotspot and connect the remote device to it via WiFi. The factory defaults for this configuration are:

*   IP address of iPA: 192.168.0.1
*   SSID: Serial number of iPA (i.e. TX**********)
*   Password: kaelusap

Note: The iPA's networking parameters can only be changed on the local machine, as changing them remotely could cause you to lose contact with the iPA.

2. A Geo Tag Icon has been added to the screen, as the location services function of the remote control device can be used to record the location at which each test is performed.

8.3   Performing an RTF Measurement

8.3.1   Calibrating the Instrument

Before performing an RTF measurement the instrument must be calibrated using the process described in Section 6.3. The user will be prompted to perform a calibration when either of the following conditions exists:

*   More than 12 hours have elapsed since the instrument was last calibrated
*   The RTF sweep settings have been changed, and no valid calibration exists that matches the new settings

Calibrations may also be manually initiated by the user at any time. To trigger a manual calibration, press the CAL button at the top of the RTF Analysis screen. From this point on the process is the same as that described in Section 6.3.

The results of the calibration process are automatically stored to file. Multiple calibrations for different sweep settings are permissible. Calibration data is automatically stored and retrieved by the instrument as needed.

8.3.2   Starting an RTF Sweep

To start a new RTF sweep, the following procedure should be used:

1. Connect the device under test to the Test Port connector of the RTF module, and tighten firmly using a torque wrench.
2. Press the green RF ON/OFF button.
3. The instrument will now perform a low-power return loss sweep. During the sweep the following progress indicator is displayed on screen:

4.   Upon completion of the Return Loss sweep, the instrument checks the peak return loss level against the Return Loss Pass/Fail threshold. (This threshold is defined in the Settings screen, which is discussed further in Section 8.6.8.)

If the return loss satisfies the Pass/Fail threshold, the instrument will turn on the two high-power transmit carriers and perform a swept PIM measurement. During the sweep the following progress indicator is displayed on screen:
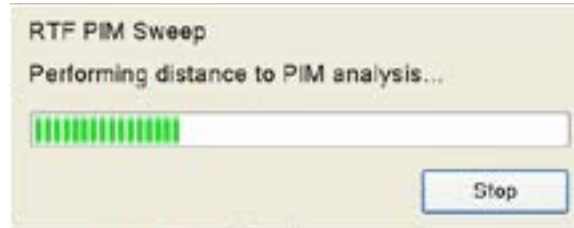
RTF PIM Sweep

Performing distance to PIM analysis...

[||||||||||||]

Stop

If the return loss fails the Pass/Fail threshold, the following warning message is displayed:

Warning

RL test failed.

Maximum RL = -3.1 dB at a distance of 6.9 m.

Continue with the PIM test?

Yes   No
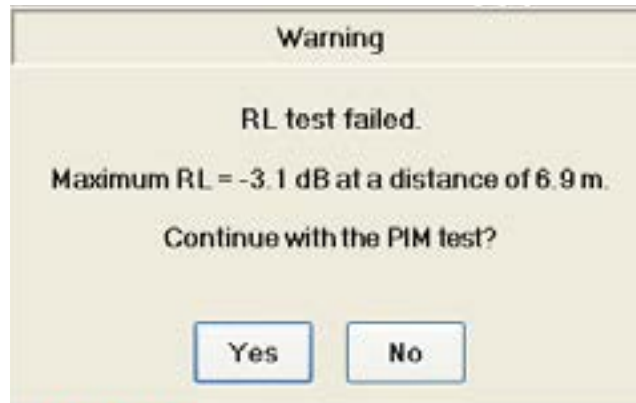
The user can now choose to abort the measurement and return to the RTF Analysis window, or continue with the PIM sweep. If the user chooses to continue, the instrument will turn on the two high-power transmit carriers and perform the sweep.

Note: The accuracy of PIM vs Distance measurements can be adversely affected by large return loss faults in the device under test. Therefore it is strongly recommended that any large return loss faults be repaired prior to performing PIM vs Distance measurements.

5.   Upon completion of the PIM sweep, the high-power transmit carriers are automatically turned off, and the results of the sweep are displayed on the screen.

8.4   Analyzing the Results of an RTF Sweep

The results of an RTF measurement can be viewed in four different display modes:

• Basic Display
• PIM vs Distance Plot
• Return Loss vs Distance Plot
• Overlay of PIM & Return Loss vs Distance Plots

Details of these display modes are provided in the following sections.

8.4.1   Basic Display Mode

Basic display mode is the default results screen. It is activated by pressing the BASIC button at the top of the RTF Analysis window. The format is a simple numerical readout of the location and amplitude of the largest PIM fault in the device under test, as shown in Figure 20

Figure 20   Basic Display Mode

Key features of this screen are as follows:

1   Distance to Largest PIM Source Indicator

The distance to largest PIM source indicator is a numerical readout of the location of the worst PIM fault in the device under test. The units can be toggled between metres and feet by touching the units label.

2   Level of Largest PIM Source Indicator

The level of largest PIM source indicator is a numerical readout of the amplitude of the worst PIM fault in the device under test. The units can be toggled between dBm and dBc by touching the units label.

3   PIM Pass/Fail Threshold

The PIM Pass/Fail threshold is the test limit against which the PIM vs Distance results are compared. Its value can be changed by touching the on-screen value and typing in the new value at the prompt.

Note that the PIM Pass/Fail Threshold should not be confused with the Pass/Fail threshold on the main application window, as described in the iQA/iPA Operating Manual. The threshold on the main application window is a customer-specified value that is used for acceptance testing at a site. The threshold on the RTF Analysis screen is used purely for troubleshooting purposes – it does not appear on any reports, and should not be used for final site approval.

4   PIM Pass/Fail Indicator

The PIM Pass/Fail indicator displays whether or not the measured results meet the PIM Pass/Fail threshold.

8.4.2   PIM , RL Marker, Zoom Functions and Enhanced Display (iPA)

The iPA provides trace peak markers and 2 other markers that can be used on either Passive Intermodulation or Return Loss. Depending how the 2 other markers are used, Delta distances can be measured between Return Loss peaks , PIM Peaks or between a RL Peak and PIM peak using both traces, or from a peak and an entered distance.

As the iPA can have several screens attached as a hotspot client, each device can operate their own markers to look at different PIM or RL peaks.

Note that control of the instrument, including max range setting, measurement and calibration, is governed by the controlling device. However each of the viewing devices can zoom, pan, move traces and markers to their individual needs within the maximum range of the measurement. Enhanced display mode can also be selected per individual client.

8.4.2.1   Setting Enhanced Mode on the Local Display (iPA)
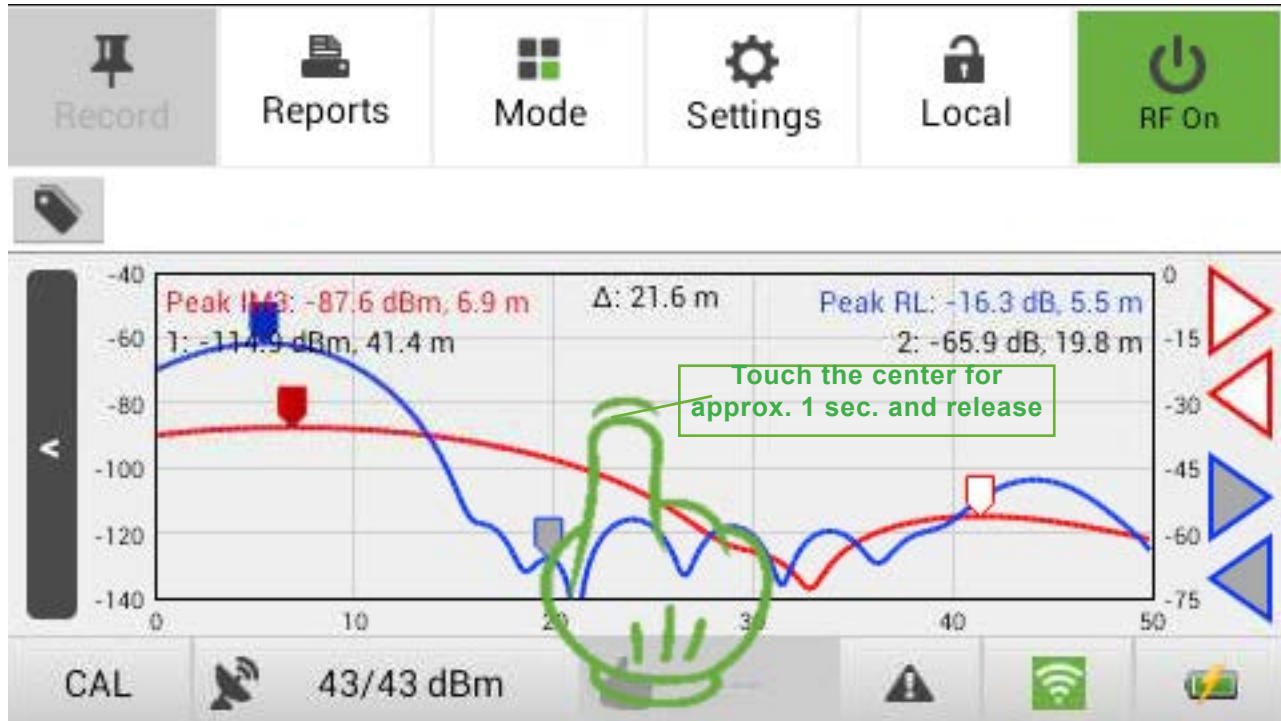
Figure 21   Enable Enhanced Display and Trace Menu (iPA Local Screen)
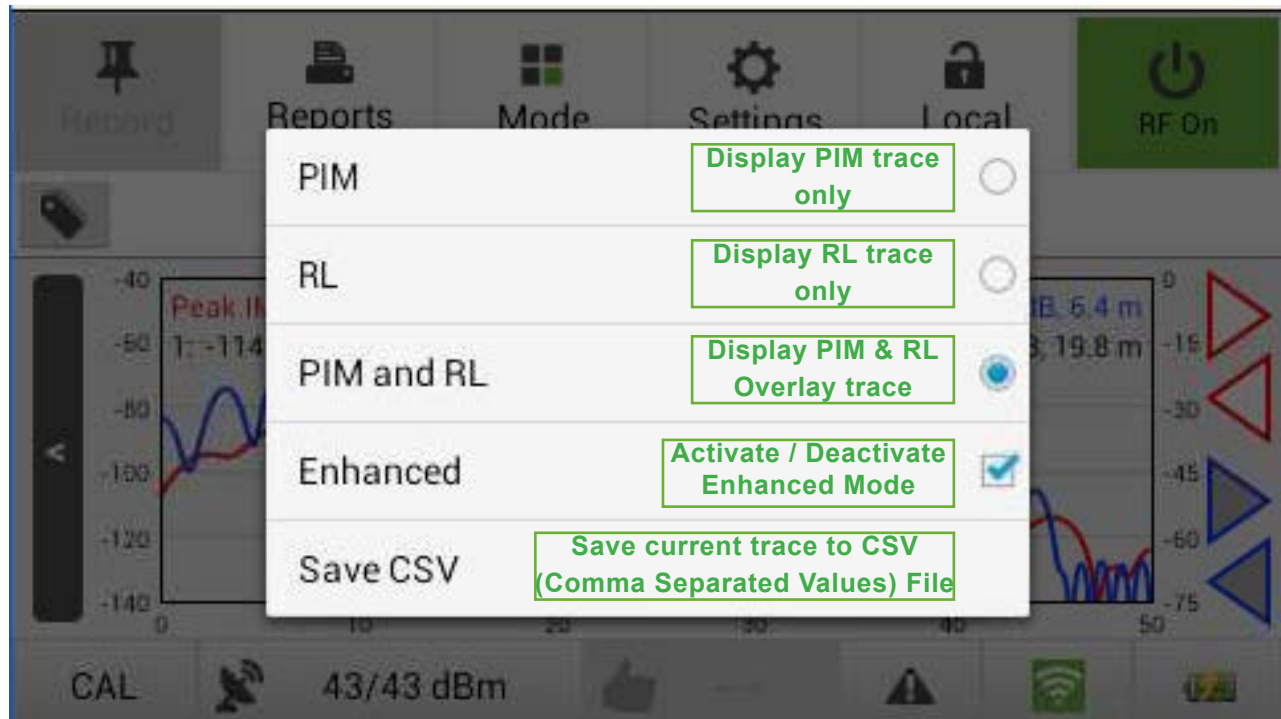
Figure 22   Enhanced Display Trace Menu (iPA Local Screen)

8.4.2.2 Setting Enhanced Mode on the Remote Display (iPA)

Figure 23   Enable Enhanced Display and Trace Menu (iPA Remote Screen)

If you are using a touch screen device. Touch where indicated, click with the mouse pointer or touchpad where indicated.
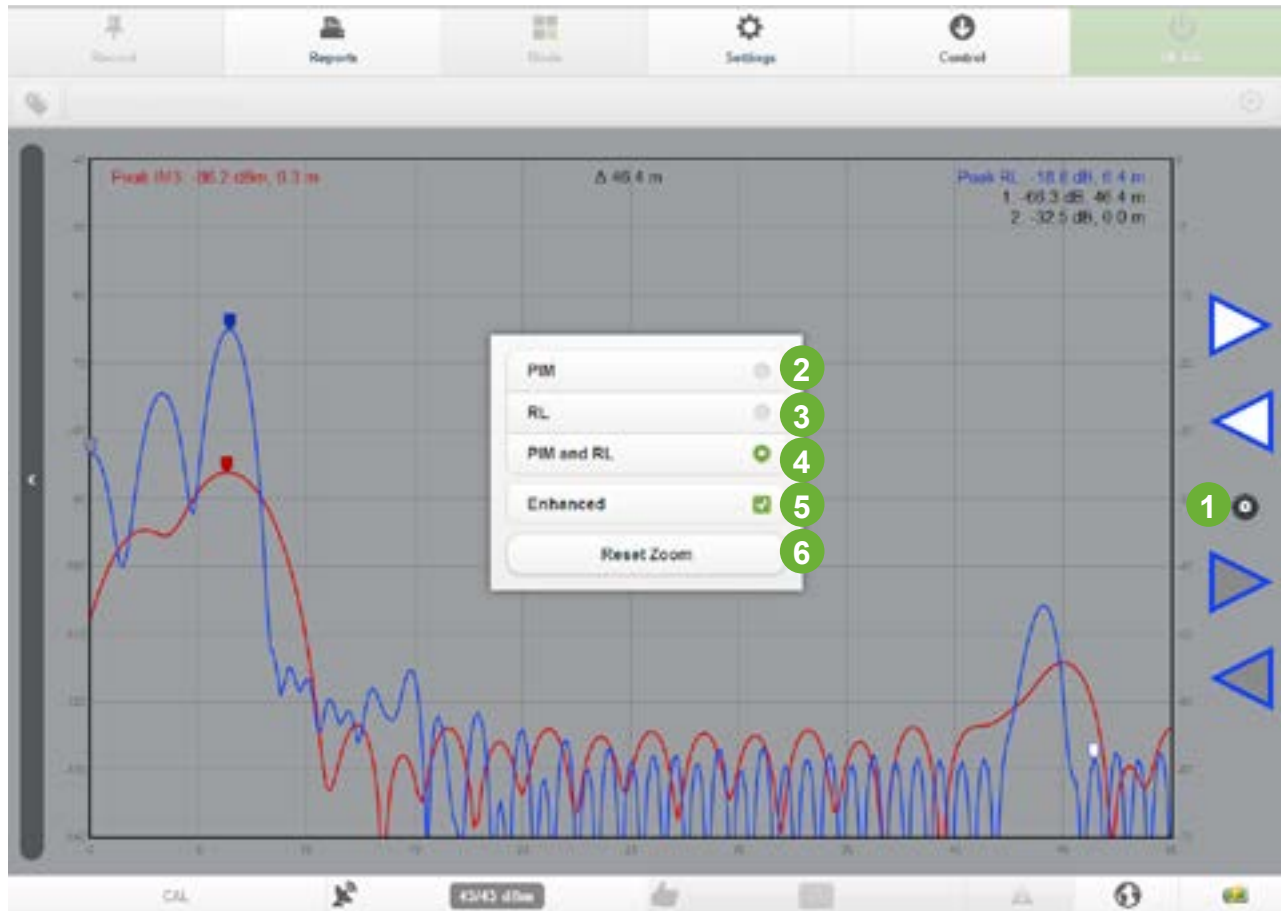
Figure 24   Enhanced Display and Trace Menu (iPA Remote Screen)

1   **Touch here to bring up the Menu**

2   **Display PIM trace only**

3   **Display RL trace only**

4   **Display PIM & RL Overlay trace**

5   **Activate / Deactivate Enhanced Mode**

6   **Reset Zoom to full scale**

8.4.2.3 Zoom and Pan Control (iPA Local Display)

The local zoom function for PIM and Return Loss is almost identical to that described in the *iPA Operating Manual* except that there is now slide control on each side of the display. The right hand side is for the RL vertical scale and the left hand side is for the PIM vertical scale.

At the top of the screen is combo window containing a red and blue rectangle. By sliding this rectangle around in the combo window, the user can move the main plot window to a different part of the trace while keeping the zoom level unchanged.
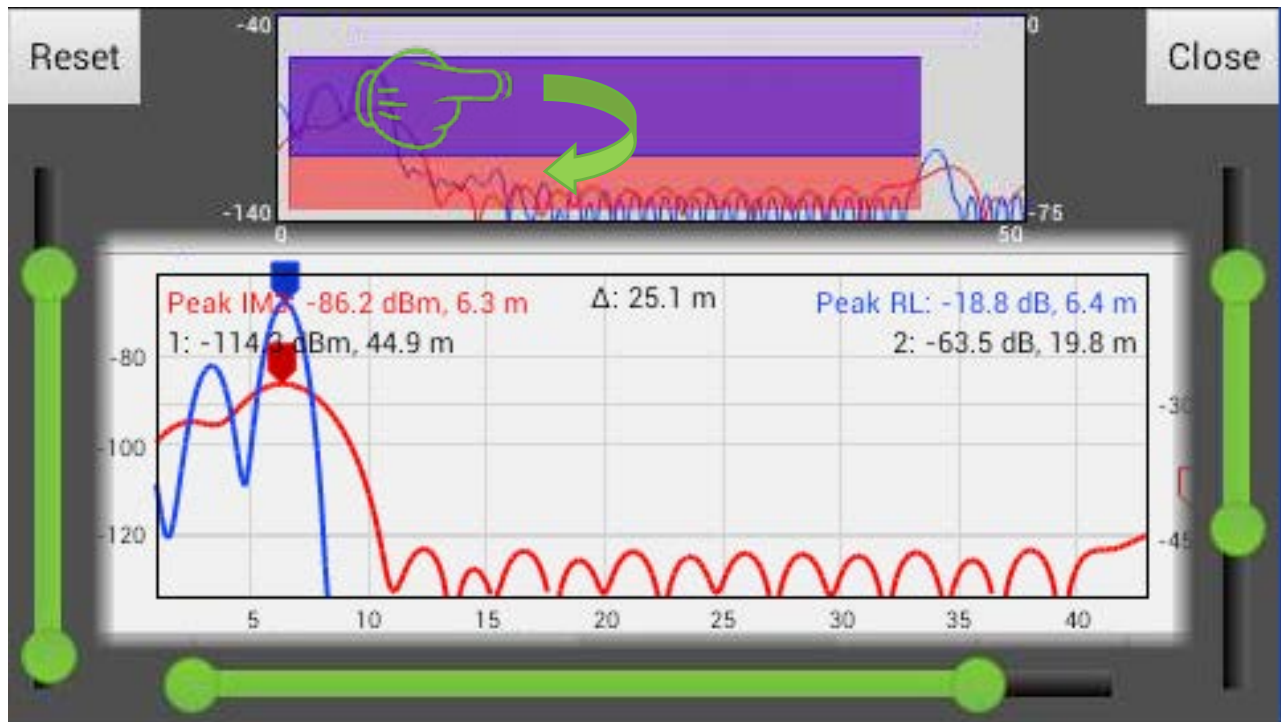
Figure 25   Zoom control window (iPA local screen)

8.4.2.4 Zoom Control (iPA Remote Control using PC with Mouse)

Figure 26 Zoom control window with mouse wheel (iPA Remote PC Screen)

1   **When pointed here Zoom In / Out with Mouse wheel Return Loss only**

2   **When pointed here Zoom In / Out with Mouse wheel PIM and Return loss**

3   **When pointed here Zoom In / Out with Mouse wheel PIM only**

4   **When pointed here Zoom In / Out with Mouse wheel distance only**

Figure 27   Zoom control window with duoble mouse click or touch pad (iPA Remote PC Screen)

Figure 28   Zoom control window with multi-touch tablet (iPA Remote Touch Screen)

8.4.2.5 Pan Control (iPAd Remote Control using Touch Screen Device)

Figure 29   Pan control touch pad (iPA remote touch screen)

When controlling the iPA remotely using a touch-screen device, the user can pan the PIM and Return Loss traces either separately or together, depending on which part of the screen is touched. Details of the available panning modes are as follows:

•   By touching the center of the screen, the user can pan the PIM and Return Loss traces together. The traces can moved in both a vertical and horizontal direction.

•   By touching the vertical axis on the left side of the screen, the user can slide the PIM trace up or down while leaving the Return Loss trace unchanged.

•   By touching the vertical axis on the right side of the screen, the user can slide the Return Loss trace up or down while leaving the PIM trace unchanged.

•   By touching the horizontal axis at the bottom of the screen, the user can slide both the PIM and Return Loss traces left or right while leaving their vertical positions unchanged.

8.4.3 PIM vs Distance Plot (iQA)

The PIM vs Distance plot is shown in Figure 30. This view is activated by pressing the PIM button at the top of the RTF Analysis window.
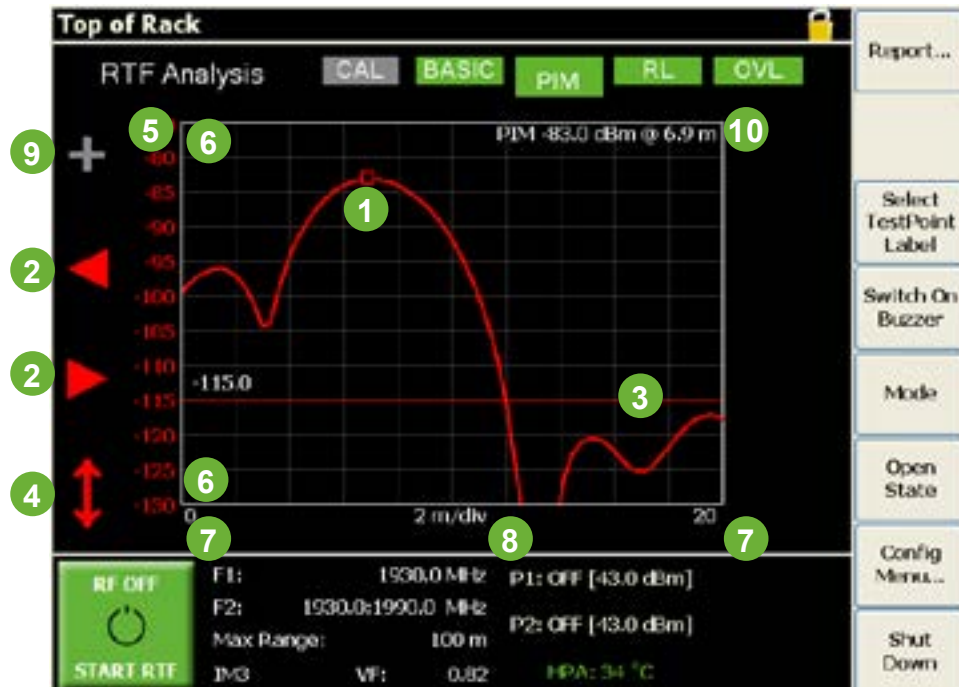
Figure 30   PIM vs Distance plot

Key features of this screen are as follows:

1   Peak Marker

The peak marker is aligned with the largest peak on the trace by default, although it can be moved to neighboring peaks using the Peak Search controls. The amplitude and location of the peak marker are printed in the top right hand corner of the graticule.

2   Peak Search Controls

The Peak Search controls allow the user to move the peak marker left or right to the next peak on the trace.

Note: When using the Peak Search controls, only those peaks that are above the PIM reference line are considered. Any peaks below the PIM reference line are ignored.

3   PIM Reference Line

The PIM reference line determines the sensitivity of the Peak Search controls. Any peaks below the reference line are ignored when moving the marker from peak to peak. To change the PIM reference line setting, touch the numeric label immediately above the reference line and type in the desired value.

4   Autoscale Control

The autoscale control allows the user to turn autoscaling on and off on the vertical axis. When the control is colored red, autoscaling is active and the instrument adjusts the limits on the vertical axis so that the trace occupies as much of the screen as possible. The axis limits are updated automatically after every sweep. When the autoscale control is colored light grey, autoscaling is turned off and the axis limits remain the same until changed by the user.

5   PIM Units

The units on the vertical axis of the plot can be toggled between dBm and dBc by touching the units tag at the top of the axis.

6   Vertical Axis Limits

The start and stop limits on the vertical axis can be changed by touching each limit and typing in the desired value.

Note: The limits on the vertical axis can only be changed if autoscaling is turned OFF.

7   Horizontal Axis Limits

The start and stop limits on the horizontal axis can be changed by touching each limit and typing in the desired value.

8   Distance Units

The units on the horizontal axis of the plot can be toggled between metres and feet by touching the units tag in the middle of the axis.

9   Resolution Enhancement On / Off Control

The resolution enhancement control allows the user to toggle between standard resolution mode and enhanced resolution mode, as shown in Figure 31. When the control is colored light grey, the standard resolution results are plotted. When the control is colored red, the resolution-enhanced results are plotted.

Note: In some cases the instrument may be unable to compute a resolution-enhanced plot. This can occur in high-noise environments, or with unstable PIM faults. In such situations the resolution enhancement control will be colored dark grey, and only the standard resolution results will be available.

10   Peak Marker Value

Figure 31   Resolution-enhanced plot of PIM vs Distance (iQA)

8.4.4 PIM vs Distance Plot (iPA Remote Display)

Figure 32   Resolution-enhanced plot of PIM vs Distance (iPA)

1   **PIM Units**

2   **Peak Marker Value**

3   **Vertical Axis Limit (Upper) PIM**

4   **Distance Between Markers 1,2**

5   **Peak Marker**

6   **Vertical Axis Limit (Lower) PIM**

7   **Horixontal Axis Limit (Lower)**

8   **Distance Units**

9   **Peak Search Controls Marker 1**

10   **Trace Select Enhanced Display Zoom Reset Menu**

11   **Peak Search Controls Marker 2**

12   **Horizontal Axis Limit (Upper)**

8.4.5 Return Loss vs Distance Plot

The Return Loss vs Distance plot is shown in Figure 33. This view is activated by pressing the RL button at the top of the RTF Analysis window.
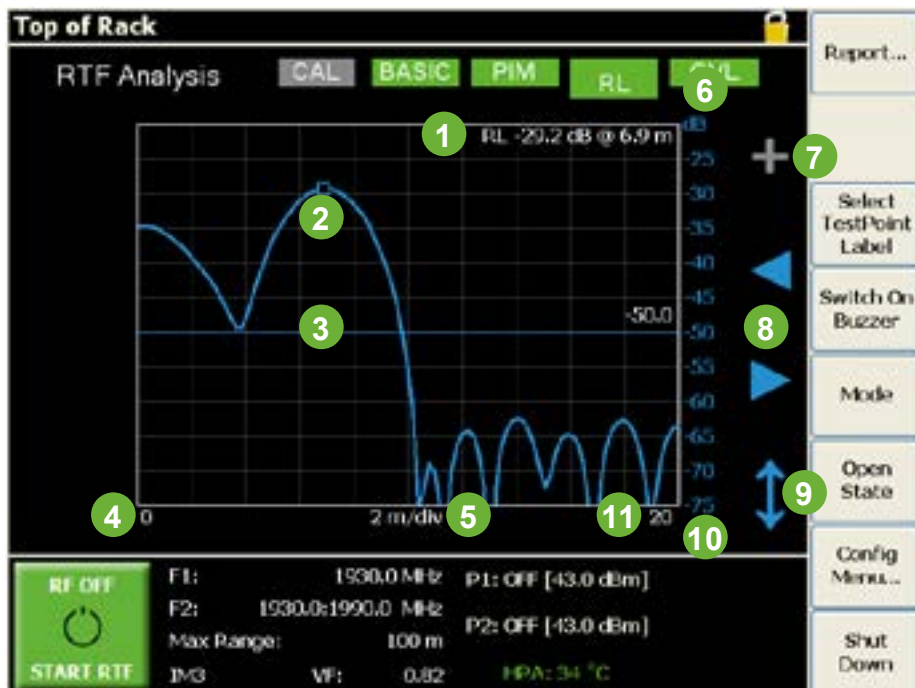
Figure 33   Return Loss vs Distance plot (iQA)

1   **Peak Marker Value**

2   **Peak Marker**

3   **Return Loss Reference Line**

4   **Horizontal Axis Limit (Lower)**

5   **Distance Units**

6   **Vertical Axis Limit (Upper)**

7   **Resolution Enhancement On / Off Control**

8   **Peak Search Controls**

9   **Autoscale Control**

10   **Vertical Axis Limit (Lower)**

11   **Horizontal Axis Limit (Upper)**

Figure 34   Return Loss vs Distance plot (iPA)

1	**Distance Units**
2	**Distance Between Markers 1 & 2**
3	**Peak Marker**
4	**Horizontal Axis Limit (Lower)**
5	**Peak Marker Value**
6	**RL Scale**
7	**Peak Search Controls Marker 1**
8	**Trace Select Enhanced Display Zoom Reset Menu**
9	**Peak Search Controls Marker 2**
10	**Horizontal Axis Limit (Upper)**

Key features of this screen are as follows:

Peak Marker

The peak marker is aligned with the largest peak on the trace by default, although it can be moved to neighboring peaks using the Peak Search controls. The magnitude and location of the peak marker are printed in the top right hand corner of the graticule.

Peak Search Controls

The Peak Search controls allow the user to move the peak marker left or right to the next peak on the trace.

Note: When using the Peak Search controls, only those peaks that are above the return loss reference line are considered. Any peaks below the return loss reference line are ignored.

Return Loss Reference Line

The return loss reference line determines the sensitivity of the Peak Search controls. Any peaks below the reference line are ignored when moving the marker from peak to peak. To change the return loss reference line setting, touch the numeric label immediately above the reference line and type in the desired value.

Autoscale

The autoscale control on the iQA allows the user to turn autoscaling on and off on the vertical axis. When the control is colored blue, autoscaling is active and the instrument adjusts the limits on the vertical axis so that the trace occupies as much of the screen as possible. The axis limits are updated after every sweep. When the autoscale control is colored light grey, autoscaling is turned off and the axis limits remain the same until changed by the user. The iPA autoscales by default and can be adjusted by Zooming and Panning. See Sections 8.4.2.3, 8.4.2.4 and 8.4.2.5 .

Vertical Axis Limits

The start and stop limits on the vertical axis can be changed by touching each limit and typing in the desired value.

Note: The limits on the vertical axis can only be changed if autoscaling is turned OFF.

Horizontal Axis Limits

The start and stop limits on the horizontal axis can be changed by touching each limit and typing in the desired value.

Distance Units

The units on the horizontal axis of the plot can be toggled between metres and feet by touching the units tag in the middle of the axis.

Resolution Enhancement On/Off Control

The resolution enhancement control allows the user to toggle between standard resolution mode and enhanced resolution mode, as shown in Figure 35. When the control is colored light grey, the standard resolution results are plotted. When the control is colored blue, the resolution-enhanced results are plotted.

Note: In some cases the instrument may be unable to compute a resolution-enhanced plot. This can occur in high-noise environments, or with unstable return loss faults. In such situations the resolution enhancement control will be colored dark grey, and only the standard resolution results will be available.
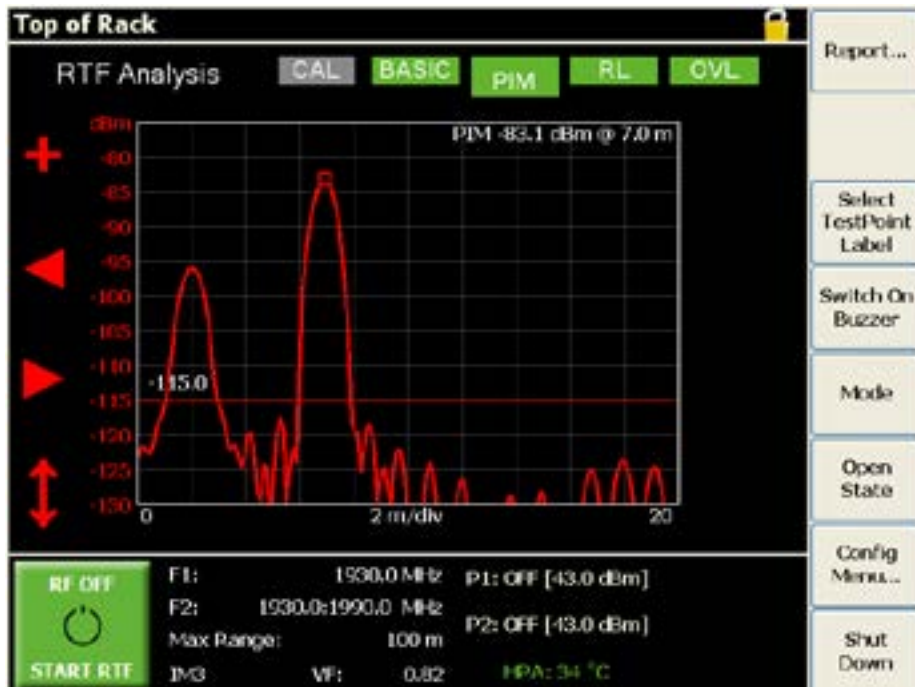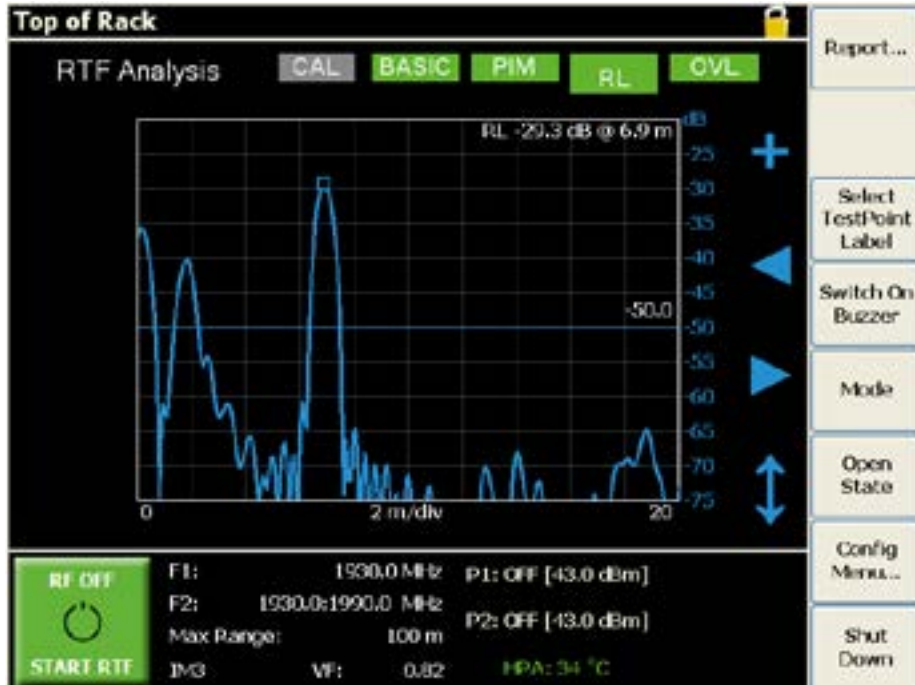
Figure 35   Resolution-enhanced plot of Return Loss vs Distance

8.4.6   Overlay of PIM and Return Loss vs Distance Plots

The overlay plot displays both the PIM and Return Loss vs Distance traces on the same set of axes, as shown in Figure 36. This view is activated by pressing the OVL button at the top of the RTF Analysis window.
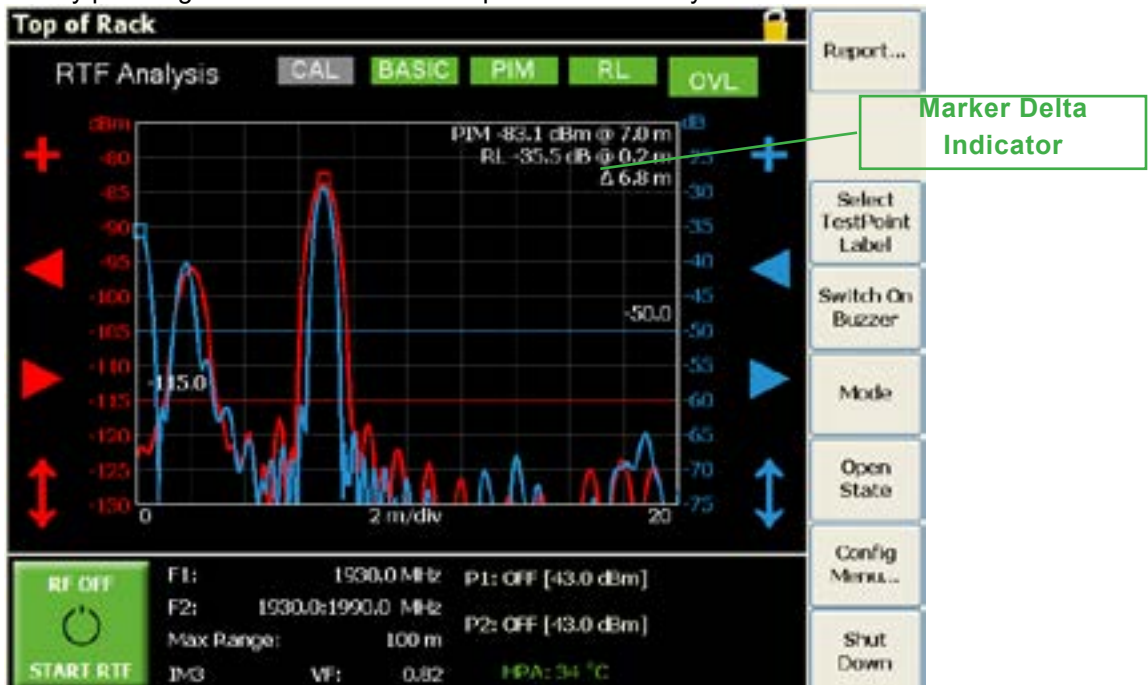
**Figure 36   Overlay of PIM & Return Loss vs Distance plots**

The controls and settings on this screen are identical to those of the PIM vs Distance and Return Loss vs Distance plots described in Sections 8.4.2 and 8.4.5 respectively. The only new feature is the Marker Delta Indicator Δ, which is displayed in the top right corner of the graticule underneath the PIM and Return Loss marker values. The Marker Delta is a relative measurement giving the difference between the locations of the PIM and Return Loss peak markers. This difference is given as an absolute value, hence it is always positive.

8.5   Verifying the Accuracy of the Calibration

Before commencing an extended round of RTF measurements on the device under test, it is advisable to perform a verification sweep to check the accuracy of the calibration. This entails performing an RTF analysis on a known device, and making sure that the results fall within the expected range. The procedure is as follows:

1. Attach the Passive Intermodulation Source (Kaelus part no. PIS-0002A or CIS-0001A) to the Test port of the RTF module.
2. Press the green RF ON/OFF button. The instrument will now perform a return loss sweep, followed by a PIM sweep.
3. When the measurement sweep is complete, examine the PIM vs Distance plot in standard resolution mode. The plot should consist of a single large peak located at zero metres, as shown in Figure 37. The amplitude of the peak will vary with iQA/iPA frequency variant, tone powers and PIM product, however, the height of the main peak above all the other peaks on the plot should always be between 30 and 40 dB.
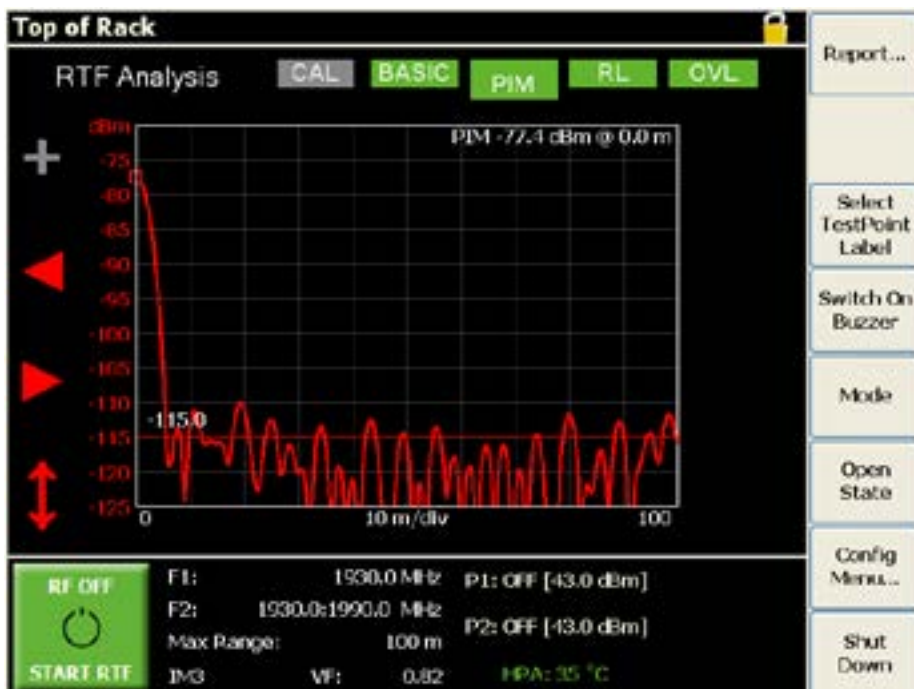
Figure 37   Results of verification sweep (PIM vs Distance screen)

If the PIM vs Distance plot does not satisfy the above criteria, the system should be recalibrated. Simply press the CAL button at the top of the RTF Analysis screen and follow the on-screen prompts.

If the verification sweep is still unsatisfactory after the system has been recalibrated, it is possible that your PIM Source has developed a fault. Contact your local Kaelus representative (see Section 9.8) to discuss a suitable course of action.

4. Now examine the Return Loss vs Distance plot in standard resolution mode. The plot should consist of a single large peak located in the range 0.0 to 0.5 metres, as shown in Figure 38. The amplitude of the peak should be somewhere in the range 18–40 dB, depending on the iQA/iPA frequency variant. The height of the main peak above all the other peaks on the plot should be between 30 and 40 dB.
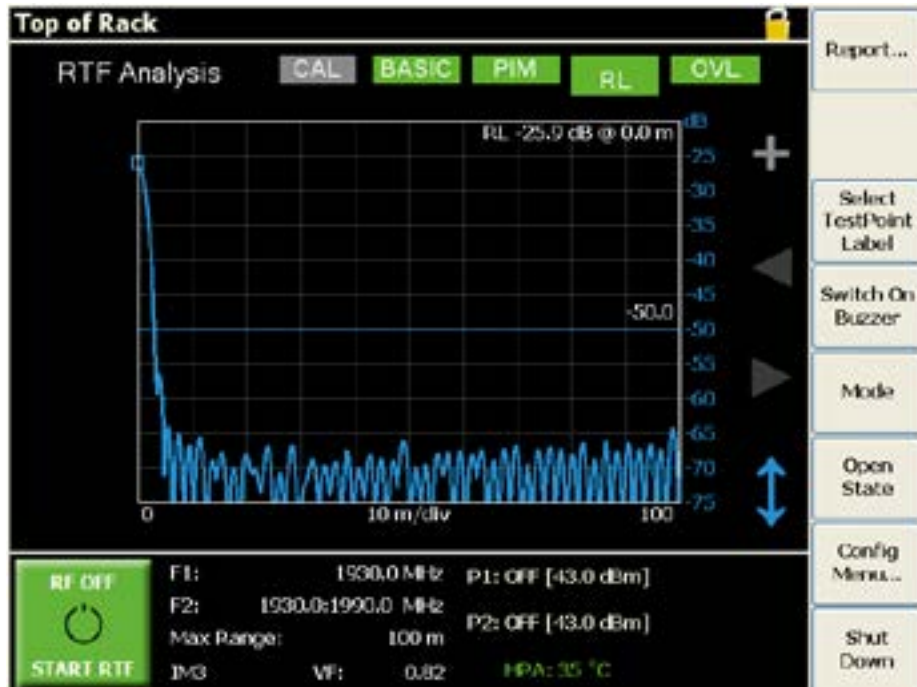
Figure 38   Results of verification sweep (Return Loss vs Distance screen)

If the Return Loss vs Distance plot does not satisfy the above criteria, it is possible that your RTF module requires recalibrating. Contact your local Kaelus representative (see Section 9.8) to arrange this.

8.6   Changing the RTF Sweep Settings (iQA)

The default settings in the RTF Analysis window have been chosen to provide a favorable tradeoff between resolution, sensitivity and measurement speed. However, there may be situations in which the user wishes to change some or all of these settings. The following sections explain how this is done.

8.6.1   Enabling Configuration Mode

The setup of the instrument can be modified via password access to the configuration mode. To access the configuration mode:

1. Press the Config Menu button. A keyboard will be displayed.
2. Type in the password and press Enter. The screen will now switch to Configuration Mode, indicated by the Config Unlocked indicator at the top of the screen, as shown in Figure 39.
3. To return to User mode press the Return button, or the Config Mode indicator.

Figure 39   Configuration Mode window

8.6.2   Modifying the Frequency of the Fixed Tone

1. Press the fixed tone frequency field F1. A numeric keypad is displayed.
2. Input the new test tone frequency in MHz, and press Enter.

8.6.3   Modifying the Frequency Range of the Swept Tone

1. Press the swept tone frequency field F2. A numeric keypad is displayed.
2. Input the new minimum tone frequency in MHz, and press Enter.
3. Input the new maximum tone frequency in MHz, and press Enter.

8.6.4   Modifying the Maximum Range

1. Press the Max Range field. A numeric keypad is displayed.
2. Input the new Max Range setting, and press Enter.

Note: It is very important to choose a value of Max Range that is greater than the length of the device under test. The accuracy of the instrument cannot be guaranteed if this condition is not met.

A good rule of thumb for the value of Max Range is:

Max Range = Estimated length of device under test + 10%.

8.6.5 Changing the PIM Product

1. Press the PIM Product field. The following window will be displayed showing the available PIM products:
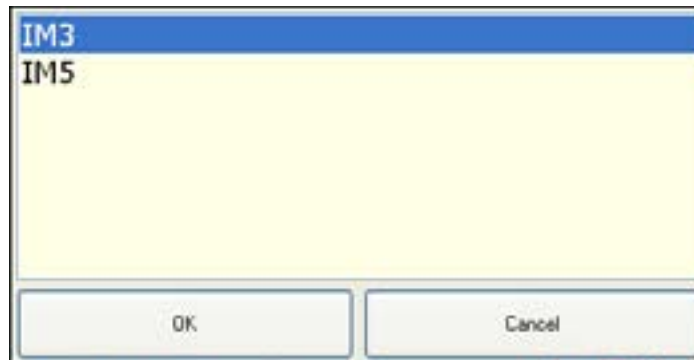
2. Select the desired PIM product and press OK.

8.6.6 Modifying the Velocity Factor

1. Press the velocity factor field VF. A numeric keypad is displayed.
2. Enter the new velocity factor and press Enter. The velocity factor must be greater than zero and less than or equal to one.

8.6.7 Modifying a Test Tone Power Level

1. Press a test tone power field (P1 or P2). A numeric keypad is displayed.
2. Input the new test tone power in dBm, and press Enter.

8.6.8 Modifying the Return Loss Pass/Fail Threshold (iQA)

1. Press the Settings button on the main button bar. A new screen will be displayed as shown in Figure 40.
2. Press the RL Threshold field. A numeric keypad is displayed.
3. Enter the new return loss threshold and press Enter. The new threshold will be applied to subsequent return loss sweeps.
4. To return to the RTF Analysis window press the Return button or the Config Mode Indicator button.

Figure 40   Settings screen

8.6.9   Applying the Factory Reset

1. Press the Settings button on the main button bar. A new screen will be displayed as shown in Figure 40.
2. To reset the instrument to the default factory setup, press the Factory Reset button.
3. To return to the RTF Analysis window press the Return button or the Config Mode Indicator button.

8.7   Changing the RTF Sweep Settings (iPA)

The iPA has a separate menu to adjust the sweep, power, distance and velocity factor settings, this is available as indicated.
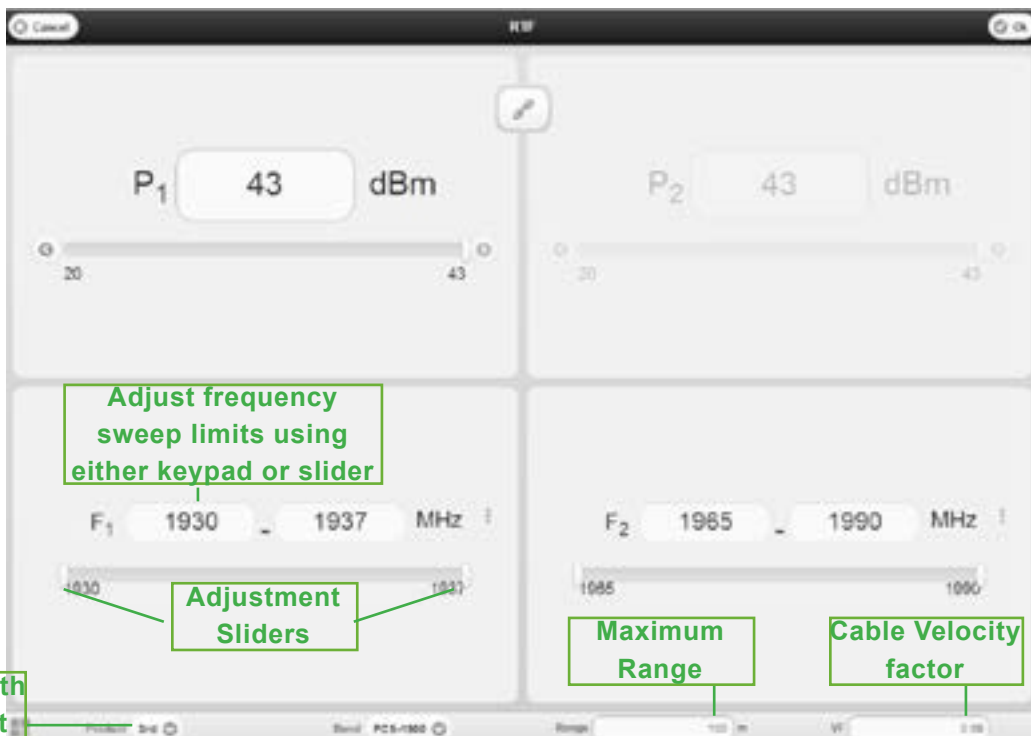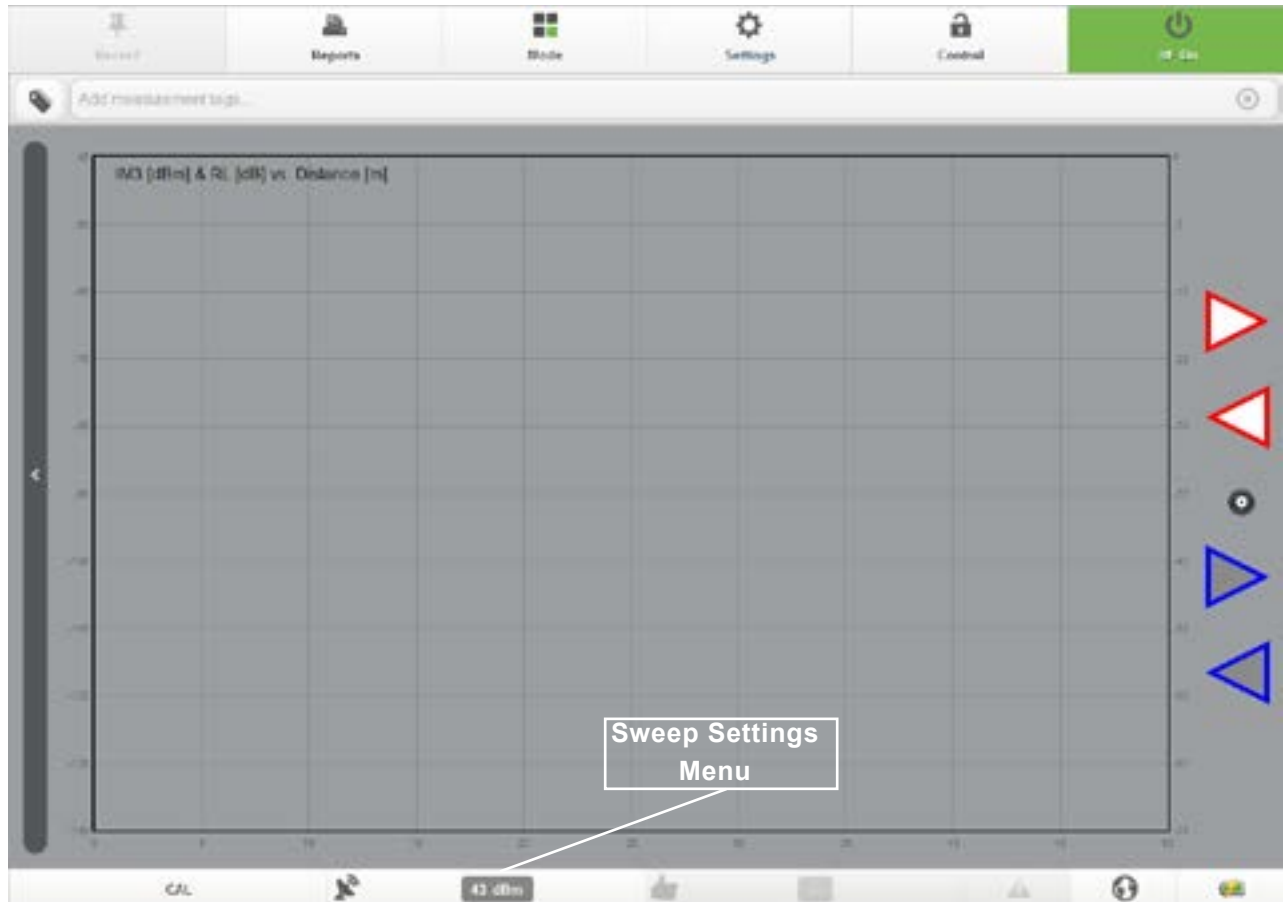
Figure 41   Settings screen (iPA)

Figure 42   iPA RTF Settings screen (Local control)

8.7.1   Slider Controls (iPA)

Slider controls can be touched and moved on touchpad devices or moved with the mouse on PC-based browsers. These change the frequency range that the F1 and F2 tones are swept over.

8.7.2   Adjust Upper and Lower Frequency Limits (iPA)

These can be entered via the touch PC virtual keyboard or the PC keyboard.

8.7.3   Cable Velocity Factor

The velocity factor (VF) is a fundamental property of the RF cables in the system under test, which affects the speed at which signals travel through the system. The velocity factor varies from cable to cable, but its value is always greater than zero and less than or equal to one. An incorrectly specified velocity factor will introduce a distance measurement error into both the PIM vs Distance and Return Loss vs Distance results.

8.7.4   Max Range

This establishes the maximum distance at which the instrument can detect PIM & Return Loss faults without error., Max range can be represented in either meters or feet. The desired measurement units can be selected on the main settings/miscellaneous menu.
To view a sub-range within the maximum range, use the Zoom functions described in Sections 8.4.2.3 and 8.4.2.4, or the Pan Controls described in Section 8.4.2.5. For instructions on changing the max range setting, refer to Section 8.6.4.

8.7.5   PIM Product Menu

Use the Product pull down menu to select the Intermodulation Product to be tested, i.e. IM3 or IM5.

8.7.6   OK Button

Once you have completed adjusting the settings Press OK to enter the new values and return to the previous menu.

8.7.7   Cancel Button

Pressing the Cancel button will allow you to return to the previous menu without using any changes to the settings.

9. Tips for Getting the Best from the RTF System

9.1 RTF System Practices

There are a number of practices that will allow the best to be gained from the RTF system:

9.1.1 Cable & Connector Care

* Good quality connectors and test cables are essential for making accurate PIM vs Distance and Return Loss vs Distance measurements.
* Take good care of the RF connectors on the RTF module and associated cables. Do avoid damaging the connectors in transit.
* Care should be taken when mating the RTF module to the 7-16 Output Port connector on the iQA/iPA, or when mating a cable to the 7-16 Test Port connector on the RTF module. Ensure the mating surfaces line-up correctly, and the coupling nut does not cross thread. Tighten the locking nut by hand initially, and then only do a final torque using a spanner. DO NOT allow the body of the RTF module to rotate. DO NOT over-torque, as this can cause permanent damage to the 7-16 connector.
* Ensure that the 7-16 connectors on the iQA/iPA and RTF module are cleaned regularly, as lack of cleanliness is one of the major causes of PIM problems. A cleaning kit is supplied within the iQA/iPA accessories kit for this purpose. Clean connector mating surfaces using a cotton bud and an isopropyl wipe to remove dirt, dust & small metal filings.
* Keep protective caps installed on all RF connectors whenever they are not in use.

9.1.2 Making PIM vs Distance Measurements

* The accuracy of PIM vs Distance measurements can be adversely affected by large return loss faults in the device under test. Therefore it is strongly recommended that all large return loss faults be repaired prior to performing any PIM vs Distance measurements.
* It is very important to ensure that the Max Distance setting is greater than or equal to the total length of the device under test. The correct operation of the instrument cannot be guaranteed if this condition is not satisfied.
* Be aware that some RF devices like filters, combiners and TMAs can have very long electrical lengths. Therefore the Max Distance setting should be chosen to reflect the "apparent" length of the system, and not simply its physical length. The apparent length can be determined by performing a Return Loss vs Distance measurement with an open circuit termination at the far end of the device under test, and noting the location of the last peak on the trace. The location of the last peak should be used as the Max Distance setting.

9.1.3 Making Return Loss vs Distance Measurements

* The accuracy of Return Loss vs Distance measurements can be adversely affected by the presence of interfering signals in the transmit band of the instrument. This situation frequently arises when performing Return Loss vs Distance measurements on a system with an antenna installed, in which external interferers from other cell sites enter the system through the antenna and cause errors in the measured return loss.
* The presence of external interferers often shows up as a high noise floor on the Return Loss vs Distance trace. As a rule of thumb, if the noise floor of a Return Loss vs Distance trace is less than 20 dB below the largest peak on the trace, there is a good chance that external interferers are to blame.

9.2 Recommended Procedure for PIM Troubleshooting

9.2.1 Static and Dynamic PIM Faults

PIM faults in RF infrastructure generally fall into one of two categories: static or dynamic. The term "static" is used to describe PIM faults that are relatively stable over time, and do not vary greatly when the system is perturbed by mechanical stresses or vibrations. It is primarily this type of fault that the RTF system has been designed to detect.

By contrast, "dynamic" PIM faults are usually highly sensitive to mechanical disturbances, and can produce PIM levels that vary widely from measurement to measurement. The RTF system cannot be relied upon to detect this type of fault. In most cases the only way to detect dynamic faults is to perform a fixed-frequency PIM test on the RF infrastructure while applying a percussive stimulus to each component and interconnect in turn.

9.2.2 Elimination of Multiple Static PIM Faults

In situations where RTF analysis reveals multiple static PIM faults in the system under test, it is strongly recommended that the user repairs only one fault at a time, starting with the largest. When the largest fault has been repaired, a new RTF sweep should be performed and the above process repeated until all faults have been eliminated. DO NOT attempt to repair multiple static PIM faults based on the results of a single RTF sweep.

9.2.3 PIM Testing Flowchart

The diagnosis and repair of PIM faults in the RF infrastructure should be carried out in a methodical manner. A flowchart of the recommended procedure is shown in Figure 43. Steps that involve RTF Analysis are highlighted in yellow.
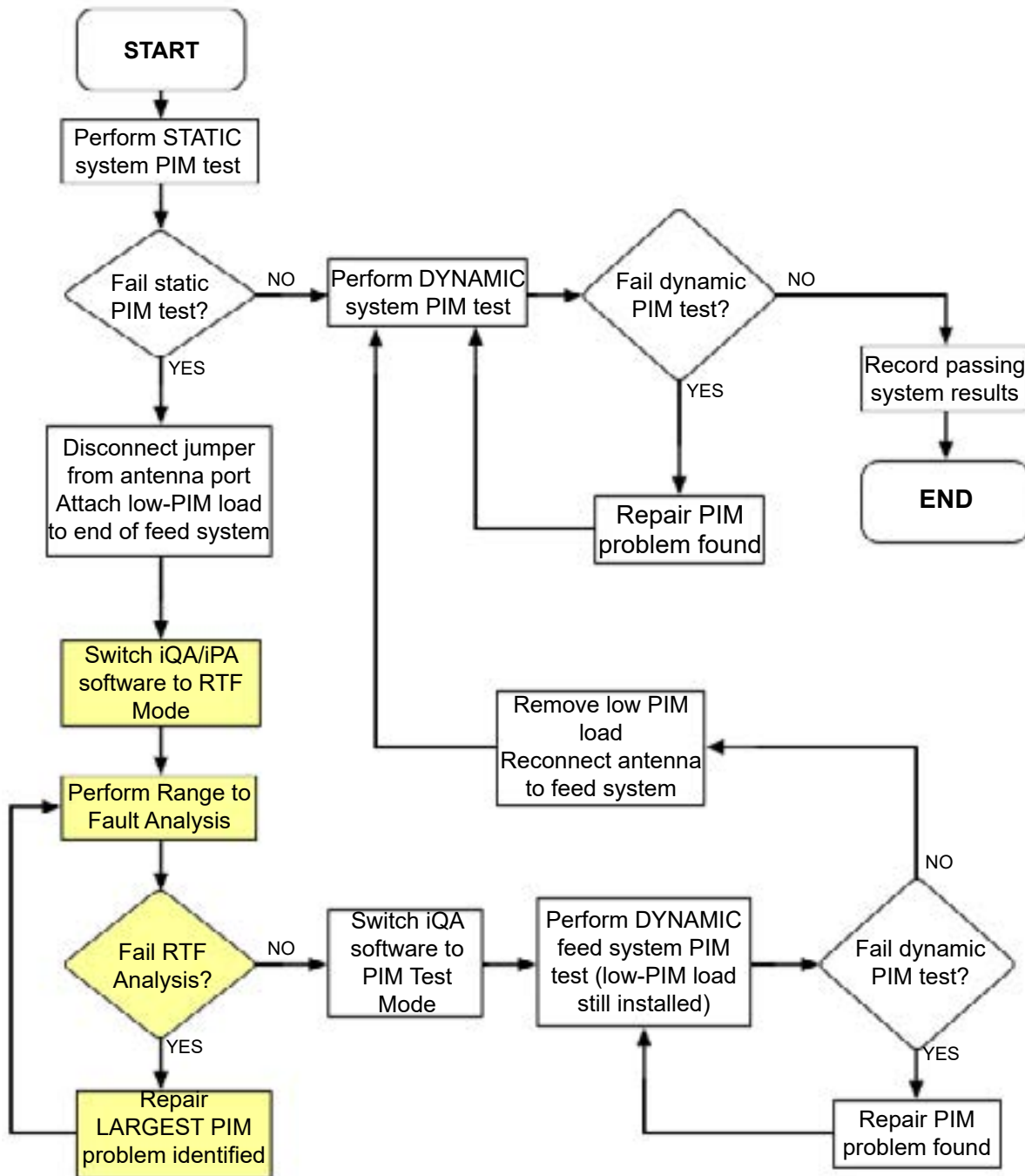

Figure 43   PIM testing flowchart including RTF analysis

9.3　Handling and Transport

- The RTF module is designed for rugged handling, but it remains a precision test instrument and should be handled with care
- Do ship the RTF module in the padded carry case provided where possible
- Airfreight of the RTF module is allowed as there are no dangerous items
- Transport via road freight is preferred to air freight due to care of handling

9.4　Cleaning the RTF Module

Before commencing any cleaning, disconnect the RTF module from the iQA/iPA. We recommend that the exterior surface of the RTF module be cleaned using a soft cloth moistened in water. Do not use aerosol or liquid solvent cleaners.

The 7-16 connector mating surfaces on the RTF module should be cleaned using a cotton bud and an isopropyl wipe to remove dirt, dust & small metal filings. This should be done on a regular basis, as lack of cleanliness is one of the major causes of PIM problems. The cleaning kit supplied with the iQA/iPA accessories kit can be used for this purpose.

9.5　Troubleshooting Guide

If the remedies indicated in the chart below do not solve the problem, consult the manufacturer for further instructions.

Connection Between iQA/iPA and RTF Module

COMMS LED on RTF Module is not flashing

- Ensure iQA/iPA is turned on and ready for use.
- Check that USB cable is connected between RTF module and iQA/iPA.
- Disconnect USB cable from iQA/iPA, wait 5 seconds, then reconnect.
- Check integrity of USB cable.
- If the above actions do not fix the problem the test set should be returned to a Kaelus approved service facility.

DC Power LED on RTF Module is not illuminated

- Ensure iQA/iPA is turned on and ready for use.
- Check that Monitor cable is connected between AUX port of RTF module and Monitor port of iQA/iPA.
- Check that USB cable is connected between RTF module and iQA/iPA.
- Disconnect USB cable from iQA/iPA, wait 5 seconds, then reconnect.
- Check integrity of Monitor cable.
- Check integrity of USB cable.
- If the above actions do not fix the problem the test set should be returned to a Kaelus approved service facility.

Instrument Operation

Instrument will not accept my Max Range setting

There is a limit to how large the value of Max Range can be. This limit is dictated by the minimum frequency step size to which the transmit tones can be programmed (100 kHz on most iQA/iPAs).

In addition to this, Max Range is also affected by the RTF sweep settings. The following guidelines should be followed in order to achieve the largest possible Max Range setting:

- Set the F1 tone frequency to be below the F2 sweep range.
- Change the PIM product to IM3.
- If the above actions do not fix the problem, it is possible you have reached the limit of the instrument's capabilities. The largest value of Max Range that the system can accept (assuming the above guidelines have been followed) is given by the following expression:

1500 x vf metres (4950 x vf feet)
where vf = cable velocity factor

Resolution of PIM vs Distance plot is poor compared with Return Loss vs Distance plot

It will often be the case that the resolution of the PIM vs Distance plot is not as good as the Return Loss vs Distance plot. This is to be expected, due to differences in the sweep bandwidth and signal-to-noise ratio of each measurement.

Nevertheless, several strategies are available to maximize the resolution of the PIM trace:
*   Move the F1 tone frequency to either the very top or very bottom of the instrument's transmit band.
*   Make the F2 sweep range as wide as possible, preferably as wide as the instrument's transmit band.
*   Change the PIM product from IM3 to IM5. (Note: This step should be taken only if the IM5 product is 10–20 dB above the instrument's noise floor.)
*   Make sure resolution enhancement is turned ON for the PIM plot, as described in Section 8.4.2

Instrument will not display resolution-enhanced results on PIM vs Distance plot (or Return Loss vs Distance plot)

In some situations the resolution enhancement mode of the RTF system can fail to return a result, leaving the user with only the standard resolution results. The three most common reasons for this are:
*   **Poor Signal-to-Noise Ratio (SNR):** The resolution enhancement algorithm typically requires an SNR of 20 dB or better. Weak PIM sources (or well-matched devices, in the case of Return Loss measurement) often produce signals that are close to the instrument's noise floor, thereby resulting in poor SNR and a failure of the algorithm to converge.
*   **Unstable Faults:** The resolution enhancement algorithm requires all PIM faults and Return Loss faults in the system under test to be stable for the duration of a measurement. If the magnitude of a fault changes significantly during the course of a measurement sweep (due for example to mechanical instability, micro-arcing or RF heating effects), the resolution enhancement algorithm may fail to converge.
*   **Dispersive Devices:** The resolution enhancement algorithm assumes that all cables and components in the system under test are non-dispersive; that is, that they have a group delay response that is constant over the instrument's transmit and receive bands. Unfortunately, devices like filters and antennas are often highly dispersive, and therefore don't satisfy this requirement. In such cases the resolution enhancement algorithm can fail to return a result.

Note that while the resolution enhancement mode cannot always be guaranteed to converge, the standard resolution mode will produce accurate results in all but the most extreme cases.

Peaks on PIM vs Distance plot do not line up properly (or at all) with peaks on Return Loss vs Distance plot

The accuracy of PIM vs Distance measurements can be adversely affected by the presence of large return loss faults in the device under test. Symptoms include:
*   Peaks on PIM vs Distance plot do not line up properly with peaks on Return Loss vs Distance plot
*   PIM vs Distance plot can contain spurious peaks that do not correspond to any components or interconnects in the device under test

To avoid such problems it is strongly recommended that all major return loss faults in the device under test be repaired before performing any PIM vs Distance measurements.

PIM vs Distance plot has a large peak at zero metres (or feet) which won't go away even after re-working the DUT several times

A persistent PIM fault at zero metres may be due to contamination on the 7-16 connectors of the RTF module or iQA/iPA. Use the following procedure to remedy this problem:
*   Turn off RF power from iQA/iPA.
*   Disconnect RTF module from iQA/iPA.

- Clean 7-16 connector mating surfaces on RTF module and iQA/iPA test set using a cotton bud and an isopropyl wipe to remove dirt, dust & small metal filings. The cleaning kit supplied with the iQA/iPA accessories kit can be used for this purpose.
- Reconnect RTF module to iQA/iPA.
- Clean 7-16 connector mating surface on test cable.
- Re-attach test cable to RTF module.

9.6   CE Declaration of Conformity

Hereby,   Kaelus Pty Ltd
                 34 Corporate Drive
                 Cannon Hill, QLD, 4170
                 AUSTRALIA

declares that the following products are in compliance with the essential requirements of Directive 2004/108/EC (EMC Directive) and Directive 2006/95/EC (LVD Directive) if installed and operated in accordance with manufacturer's instructions.

Part Number	Model Number	Description
RT1000V01A-01N	RTF1000A	Range to Fault Test Set
RT2000V01A-01N	RTF2000A	Range to Fault Test Set
RT2600V01A-01N	RTF2600A	Range to Fault Test Set

These products are in conformity with the following European, harmonised and published standards at the date of this declaration

Referenced EMC Standard	
EN 61326-1:2006	EN 61000-4-4
EN 61326-2-1:2006	EN 61000-4-5
EN 55022:2010 "Class A"	EN 61000-4-6
EN 61000-4-2	EN 61000-4-11
EN 61000-4-3	
Referenced Safety Standard	
EN 61010-1:2010	EN 61010-030:2010

The design, development and manufacturing of Kaelus Pty Ltd products are controlled by an ISO 9001:2008 certified Quality Management System.
Authorised representation within the EU is

Kaelus, 1 Aquarius Court, Viking Way, Rosyth, Scotland, KY11 2DW

Signed by the manufacturer at 34 Corporate Drive, Cannon Hill, QLD, Australia 4170 (the location of the technical file),
…………………………………..
Christine Blair
Engineering Director
Kaelus Pty Ltd
10th September 2013
ID: EUTA2036A1

CE

9.7   End of Life Statement

Equipment marked with the symbol below (Crossed Out Wheelie Bin) complies with the European Parliament and Council Directive 2002/96/EC (the "WEEE Directive") in the European Union.
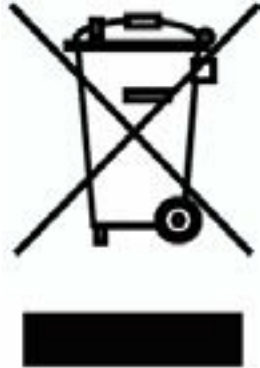
Please contact your local Kaelus representative (see next section) at the end of the product's useful life to arrange its disposal in accordance with your local regulations.

9.8   Contacts

Kaelus has service center locations globally. Please visit http://www.kaelus.com/Contact-Us/Locations/ to find the service center nearest you.

When ringing, ask for IM Tester support (technical or otherwise) & quote the relevant part numbers.

Send feedback to: info@kaelus.com