ML2400A SERIES
POWER METER

Quick Start Measurement Guide

Originated by Anritsu, EMD, Stevenage, U.K.

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GENERAL INFORMATION

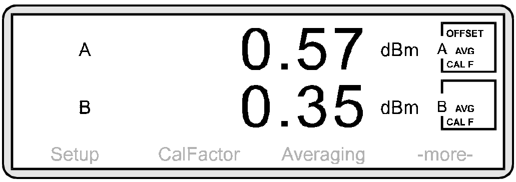
INTRODUCTION

The aim of this guide is to familiarise you with the basic features and capabilities of the Anritsu ML2400A Series Power Meter by the use of working examples. Once you are familiar with these procedures, you may find it useful to refer to the Operations Manual (part number 10585-00001) for more detailed information.

The Power Meters in the ML2400A range covered by this manual are the ML2437A which has one sensor input and the ML2438A which has dual sensor inputs, plus the ML2407A and ML2408A power meters with NCDMA power measurement capability.

USING THIS GUIDE

- The examples in this guide show ML2438A screen displays which refer to two sensors — A and B. The ML2437A displays are similar but do not reflect the second sensor.
- Where a screen is shown, the components of the display relevant to the example are shown in bold type.
- The Measurement screen below shows a reading with both channel 1 and channel 2 activated — in this example, channel 1 is monitoring sensor A and channel 2 is monitoring sensor B. In the examples that follow, the display shows only channel 1. This is the default factory setting. To display two channels, please refer to Example 4.



The Measurement screen

- When using two sensors or channels, make sure that any adjustments are applied to the correct sensor/channel. See Examples 4 and 5 for information.
- To return to the Measurement screen at any point, press a hard key.

CONVENTIONS

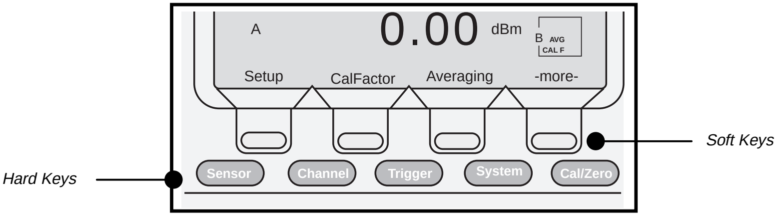
Channel This indicates you need to press the Channel hard key. Pressing a hard key provides access to its associated soft-key menu.

[Setup] This indicates you need to press the Setup soft key. Pressing a soft key provides access to menu options, toggles selections and allows data entry.

> **NOTE**: A routine requiring you to press a combination of hard and soft keys (as in Example 1, Preset), is shown as follows:

System **[Setup] [-more-] [Preset] [Reset]**

HARD AND SOFT KEYS



Hard and Soft Key locations

Sensor The Sensor Menu controls response related functions: sensor set up, entry of calibration factors, averaging, offsets and duty cycle.

Channel The Channel Menu controls display related functions: display channel set up, use of relative power levels and input of high/low level limits.

Trigger The Trigger Menu enables high measurement speeds to be applied precisely when needed. Triggering sources include continuous, internal, external TTL and manual. Triggering delay and the sample integration time are controlled by the operator: trigger set up for channel 1 and channel 2.

System The System Menu controls the operating modes, display visibility, sound, rear panel functions and battery state.

Cal/Zero The Cal/Zero Menu enables measurement errors to be minimised prior to measurement and sensors to be zeroed and/or calibrated.

Soft keys

Having selected a hard key, the various menu options are accessed via soft keys. The figure entitled *Hard and Soft Key locations* shows the Sensor Menu options. Each option is shown on the screen directly above its associated soft key. To access a menu option, press the corresponding soft key.

WORKING EXAMPLES

EXAMPLE 1: STANDARD CW POWER MEASUREMENTS

This first example will explain everything you need to know about the ML2430A Series Power Meter when making standard carrier wave power measurements. However, the Power Meter is capable of much more and examples 2 to 11 explore its functionality in greater depth.

1. Switching on

Turn the ML2430A on using the front panel ON/OFF button.

2. Preset the meter to a known state

A Preset returns the ML2430A to its default settings. It is recommended that this is carried out before each new measurement type and whenever the meter is reconfigured for a new measurement. To preset, press:

System **[Setup] [-more-] [PRESET] [Factory]**

Having performed a Preset, the Measurement screen is displayed:

Select the correct power sensor for your measurement. Consider points such as power range, frequency range, connector type, and speed of response required.

See the appendix for a table of power sensor model numbers, power and frequency ranges.

3. Zero the sensor

Zeroing the power sensor removes any residual DC offset on the sensor/meter combination. After a zero the measurement noise floor is minimised. It is recommended that you always zero the sensor at the beginning of each measurement session and prior to taking important power readings in the bottom 20 dB of its dynamic range.

> **NOTE**: Anritsu recommends that during Zeroing, the sensor is connected to the device under test having ensured it is not emitting any power (*see* **5. Connections**). If this is not possible, then the sensor should be zeroed to the CALIBRATOR socket on the ML2430A front panel. The third option would be to Zero with the sensor in free space i.e. not connected to anything.

Press:

Cal/Zero **[Zero]**

The ML2430A will take a few seconds to perform the Zero and will beep when finished. The Measurement screen is displayed and returns a value of approximately -75 dBm for a standard diode sensor or –40 dBm for a thermal sensor.

4. Calibration

At the beginning of a measurement session, it is good practice to calibrate the sensor. Connect the sensor to the CALIBRATOR connector on the ML2430A front panel and press:

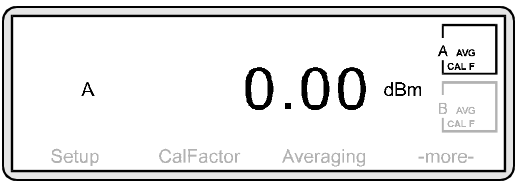
Cal/Zero **[-Cal 0 dBm]**

The ML2430A will take a few seconds to perform the calibration and will beep when finished.

To validate that the meter is working correctly, you may choose to now measure the 0 dB calibration signal. Press

Cal/Zero **[-more-]**

Check that the left-hand soft key reads **RF ON.** If it reads **RF OFF**, press **[RF ON]** to toggle the setting to **RF ON**. A correctly functioning instrument will return the following screen:



5. Connections

Connect the Power Meter to the device under test via the sensor. Ensure:

- you are using the appropriate sensor for the measurement you wish to make
- the sensor is fitted with the correct connector for the device you wish to test.

See the appendix for a table of power sensor model numbers, power and frequency ranges.

> Anritsu do not recommend the use of adapters between the power source and the sensor since this can introduce measurement errors.

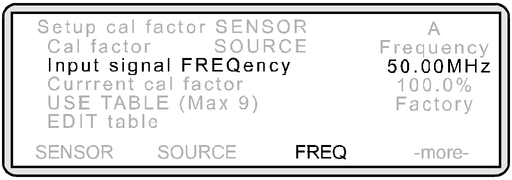
6. Applying a calibration factor

The accuracy of a measurement is affected by the frequency response of the individual sensor. To correct for the sensor frequency response you can enter into the meter the calibration factor for the measurement frequency. This calibration factor data is stored in an EEPROM in the power sensor body.

Press:

Sensor **[Cal Factor]**

The following screen is displayed.

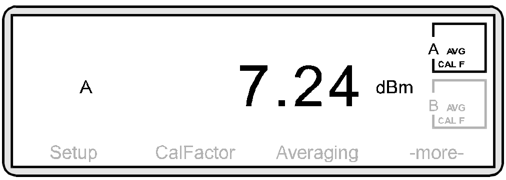


> Some text on the screen appears in upper case. This indicates which soft key to select to change the item's setting. For example, to change the Input signal FREQuency, press the FREQ soft key.

Press **[FREQ]** and using the keypad, input the Input Signal Frequency of the device under test. The soft keys at the bottom of the screen will now change.

Depending on the frequency type, press **[GHz.Entr]** or **[MHz.Entr]**. To return to the Measurement screen, press any hard key.

You are now measuring power! Your Measurement screen should now look something like this:



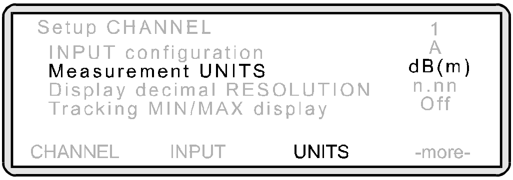
However, you may wish to modify the measurement in the following ways:

7. Changing the way measurement units and decimal resolution are displayed on the screen

The default setting for the ML2430A is to display units in dB[m] and resolution to two decimal places. To change this, press:

Channel **[Setup]**

To change the display units, press **[UNITS]** and toggle the setting by repeatedly pressing the soft key until the measurement unit you require is displayed. Available units are; dBm, W, dBµV and dBmV.



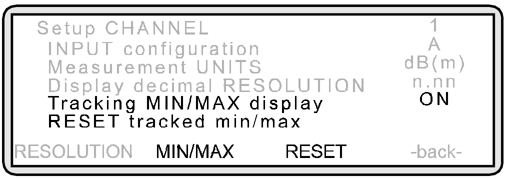
To change the resolution, press **[-more-]** to display further soft keys and then press **[RESOLUTION]**. Toggle this setting until the resolution you require is displayed.

8. Keeping track of minimum and maximum measurements

You may have a requirement to track a device's highest and lowest power measurements over time. Press:

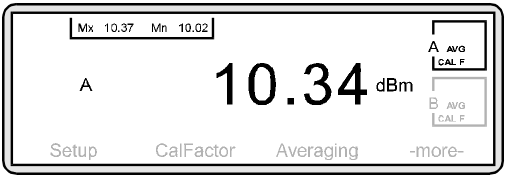
Channel **[Setup]**

The Channel Set Up screen is displayed. Press **[-more-]** to display further soft keys. Press **[MIN/MAX]**. The display changes to:



You will notice the new line "RESET tracked min/max." The Min/Max feature can be reset to record a new time frame at any point — just select **[RESET]** from the Channel Set Up options. To return to the Measurement screen, press any hard key.

The Measurement screen now displays a minimum and maximum range.

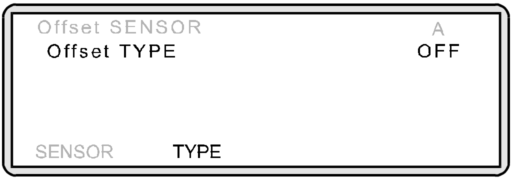


9. Correcting for the effects of an Attenuator or Coupler

Offset values can be either specified in dB or can be obtained from five different Frequency-against-dB Offset Tables. To enter an offset value press:

Sensor **[-more-]** **[Offset]**

The Sensor Offset screen is displayed.

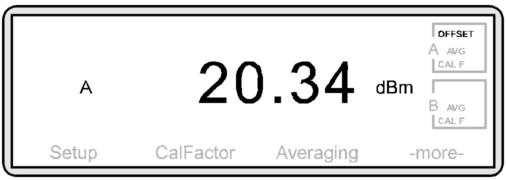


To apply an offset, press **[TYPE]**. Toggle this setting until the offset you require is displayed (see below).

Fixed Offset: If you require a fixed offset, press **[TYPE]** until "Fixed" is displayed. The soft keys at the bottom of the screen will now change. Press **[VALUE]** and using the keypad, input the dB value of the offset. Press **[ENTER]**

Offset from Table: Tables enable an offset to be applied that is frequency dependent. The table must be entered into the memory of the meter before it can be applied. See the Miscellaneous Features section of this guide for further information.

To return to the Measurement screen press any hard key.



Note that box A in the top right hand corner of the screen now indicates that an OFFSET has been applied to the Sensor.

10. Using measurement limits

When using limits, if the power from the device under test falls outside a pre-defined range, the meter will inform you — visually, audibly or both. Press:

Channel **[LIMITS]**

The following screen is displayed:

```
Set limits CHANNEL                          1
  HIGH Limit                        0.00dB(m)
  LOW Limit                         0.00dB(m)
  HIGH enabled                      OFF
  LOW enabled                       OFF
  Fail indicator HOLD               OFF
  Fail BEEP control                 OFF
CHANNEL      HIGH Limit    LOW Limit    -more-
```

Press **[-more-]** to access further soft keys.

```
             HIGH State    LOW State    -more-
```

```
FAIL HOLD    BEEP          -back-
```

[HIGH Limit] The upper test value. If the power remains below this value, the Measurement screen will show PASS alongside display. If the power rises above this value, the screen will show FAIL.

[LOW Limit] The lower test value. If the power remains above this value, the Measurement screen will show PASS alongside the display. If the power drops below this value, the display will show FAIL

[HIGH State] This setting is automatically set to ON when an upper test value is entered. Toggle the setting on or off.

[LOW State] This setting is automatically set to ON when a lower test value is entered. Toggle the setting on or off.

[FAIL HOLD] When set to ON, if the power falls outside the range defined in High Limit and/or Low Limit the Measurement screen will show FAIL alongside the value. This will remain until the setting is toggled off.

[BEEP] When set to ON, if the power falls outside the range defined in High Limit and/or Low Limit, an audible beep will sound. If **[FAIL HOLD]** is ON and a fail has occurred, a beep will sound every second until **[FAIL HOLD]** is turned off or you press:

CLR

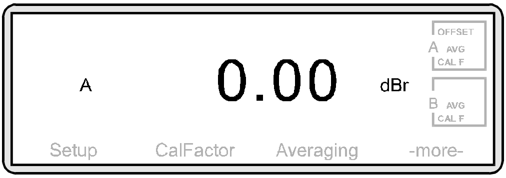
11. Defining a relative power measurement

You may have a requirement not to measure the actual power output of a device but to express the current power relative to a previously measured power. To do this, it is necessary to define an absolute value to reference to.

Let us assume the actual power output at a given time is 10 dBm. You want to track any change in power above or below 10 dBm. Press:

Channel **[Rel 1]**

The display will change to 0.00 dBr and will measure future power LESS the 10 dBm absolute value.



Note that the measurement unit has changed to dBr.

If at any point you wish check the absolute value stored in the meter, press **[Rel 1]** again. If at any point you wish to change the absolute value, press **[Rel 1]** for approximately 2 seconds. This will then replace the stored absolute value with the current measurement.

> To check the absolute value, press **[Rel 1]** once. To re-define the absolute value, press **[Rel 1]** for approximately 2 seconds.

EXAMPLE 2: MEASURING MODULATED CARRIER

The Anritsu power sensors MA2440A and MA2470A are fast responding diode sensors. When measuring signals with an average power greater than –25 dBm and an amplitude modulation component, all diode sensors will normally give incorrect measurement results. This is because the diode is not detecting in its square law region.

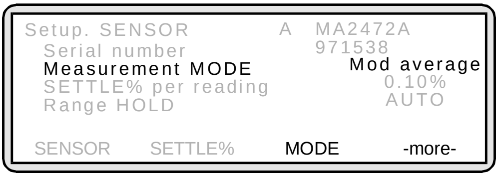
A special feature of the Anritsu diode sensors and power meters is the ability to correctly measure amplitude modulated carriers with average powers greater than –25 dBm. This is possible with MA2470A series standard diode sensors for any signal that has a modulation bandwidth <100 kHz. Universal power sensors will always measure true RMS power (or for NCDMA signals the MA2460A sensors with the ML2407/08A meter can be used). See examples 12 and 13.

This property is used in the modulation average mode to give accurate average power readings at high power levels with modulated signals.

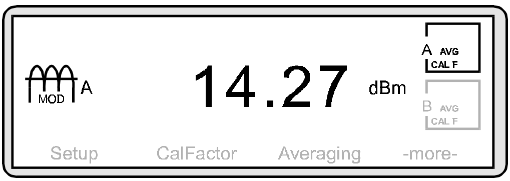
> Modulation average is not required when making measurements with thermal sensors.

To change the measurement mode, press:

Sensor **[Setup] [MODE]**



The Measurement screen will now display a stable reading. A modulation icon reminds you that this mode is active.



EXAMPLE 3: OPTIMISING MEASUREMENTS AT LOW POWER LEVELS

> When measuring power levels in the bottom 20 dB of a sensor’s dynamic range, Anritsu recommends that prior to the measurement, you perform a Zero. If possible, this should be done with the sensor connected to the device under test (having first ensured it is not emitting any power).

When measuring power, readings are subject to a certain amount of noise. To minimise this, averaging increases as the power level reduces. However, at the bottom 20 dB of a sensor’s dynamic range, this effect of noise increases. The meter automatically increases the amount of averaging for low power measurements. However, you may choose to select a high level of averaging. This will be at the expense of measurement speed. To do this, it is necessary to move from Automatic Averaging (the default factory setting) to another method — either **Moving** or **Repeat**.

Moving mode: This mode allows you to manually select the number of averaging readings taken (between 1 reading and 512 readings) regardless of the power level. A reading rate of 512 indicates the highest level of averaging and is recommended when measuring at low power. The display is continually updated whilst averaging.

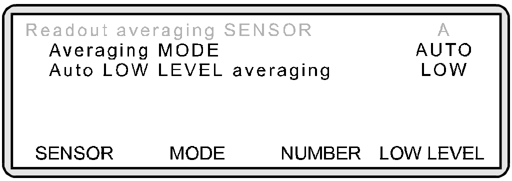
Repeat mode: This mode is similar to Moving Average but the display is only updated once the specified number of readings has been taken. One drawback to this mode is that if the reading rate is set to 512 and the power level changes before all readings have been taken, the display will not reflect the true input power.

1. Changing the averaging mode

To change the averaging mode, press:

Sensor **[AVERAGING]**

The following screen is displayed:



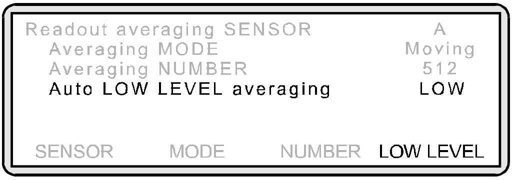
This screen reflects the default factory setting. To change the averaging mode, press **[MODE]**. Toggle this setting until the mode you require is displayed.

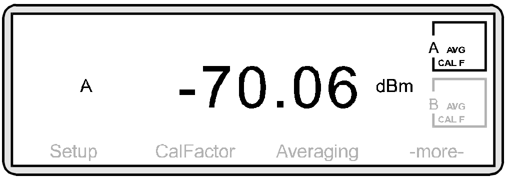
To enter a reading rate, press **[NUMBER]** and using the keypad, input the rate (between 1 and 512). Press **[ENTER]**

2. Apply Automatic Low Level averaging

Automatic Low Level averaging smooths the display but only if the reading is comparatively stable. The default factory setting is LOW and will take out fluctuations of ± 0.01 dB.

To change this setting to MEDIUM (± 0.02 dB), HIGH (± 0.05 dB) or to turn it OFF, press **[LOW LEVEL]**.



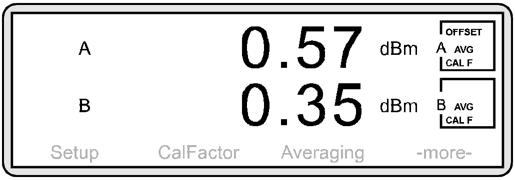


Typical display for measurement of low power levels

EXAMPLE 4: USING BOTH CHANNELS

In the previous examples, measurements have been made on only one channel — channel 1. However, it is possible to measure power on two channels. Possible applications for this feature when using only one sensor might be to display the measurement in dBm on channel 1 and Watts on channel 2 or with two sensors to measure power at different points in a test system.

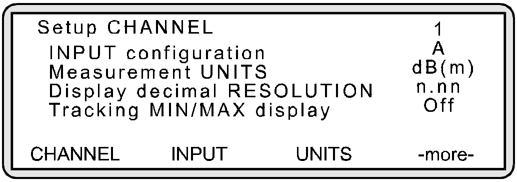
When two channels are in operation, the displays are aligned one above the other.



To activate channel 2, press:

Channel **[Setup]**

The following screen is shown:



Press **[CHANNEL]**. The screen now shows the configuration for channel 2. Note that the Input Configuration is set to OFF and is therefore inactive.

In order to activate channel 2, it is necessary to specify the type of input (sensor, combination of sensors or rear panel BNC input) that will be used. This will vary depending on the model of Power Meter you are using. To allocate an input for channel 2, press **[INPUT]**. Toggle the setting until the input type you require is displayed.

Input options for the ML2437A

A	Take input from sensor A
External Volts	Take input from rear panel BNC, “Input 2, Analog”
OFF	Default value – Channel is inactive

Input options for the ML2438A

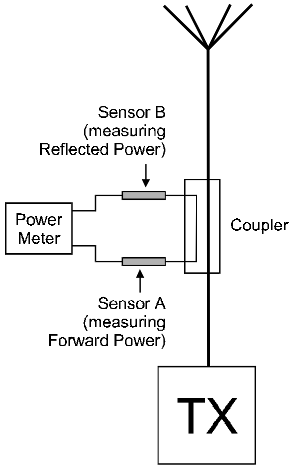
A	Take input from sensor A
B	Take input from sensor B
A-B	Subtract sensor measurement B from sensor measurement A and display result on current channel *
B-A	Subtract sensor measurement A from sensor measurement B and display result on current channel *
A/B	Divide sensor measurement A by sensor measurement B and display result on current channel.*
B/A	Divide sensor measurement B by sensor measurement A and display result on current channel.*
External Volts	Take input from rear panel BNC, “Input 2, Analog”
OFF	Default value – channel is inactive

* These ratios are expressed in either logarithmic or linear terms but the mathematical calculation is always performed on the linear values. Please refer to the Operation Manual for further details.

When using the Channel Menu options to change settings such as Units, Resolution, Min/Max etc. make sure that you are effecting the changes on the correct channel. Change from channel 1 to channel 2 by using the **[CHANNEL]** soft key.

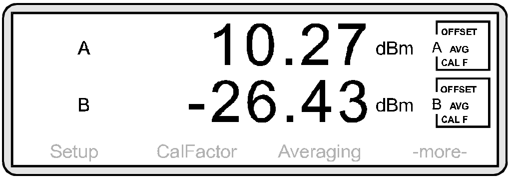
A preset will return the power meter back to its default setting i.e. one channel only.

EXAMPLE 5: USING TWO SENSORS



The Dual Input ML2438A allows for two sensors to be used simultaneously with the Measurement screen showing both readings one above the other. One possible application for this feature might be to measure the forward and reflected power on an antenna.

Channel 1 might be configured to show the measurement from sensor A with channel 2 showing the measurement from sensor B. The resulting Measurement screen may look like this:



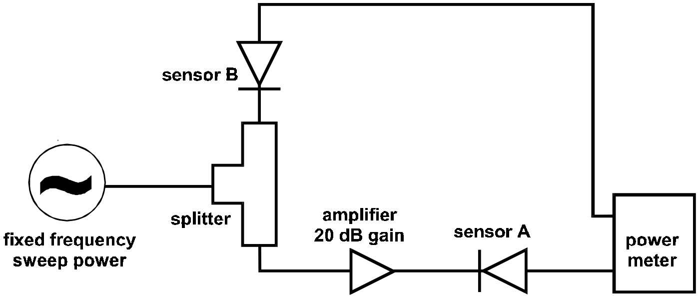
An offset has been applied to compensate for the coupling factor of the through line coupler.

In this example, sensor A is allocated to channel 1 and sensor B is allocated to channel 2. This allocation can be changed as shown in Example 4.

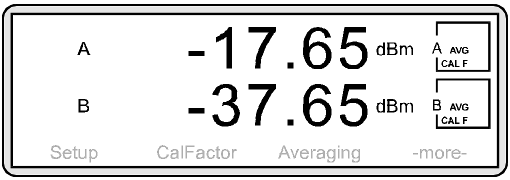
> When using the Sensor Menu options to change settings such as Mode, Calibration Factor, Averaging etc. make sure that you are effecting the changes on the correct sensor. Change from sensor A to sensor B by using the **[SENSOR]** soft key.
>
> Additional soft keys are included in the Cal/Zero Menu options — **[Sensor A]** and **[Sensor B]**. Select as appropriate.
>
> After a Preset, channel 1 is allocated to sensor A and channel 2 is inactive.

EXAMPLE 6: GAIN COMPRESSION MEASUREMENT

A common application for a two input power meter is for gain compression measurements on amplifiers. In this example, we will measure the 1 dB compression point for an amplifier with 20 dB gain.



Connect your measurement system as shown above. Allocate sensor A to channel 1 and sensor B to channel 2 (see Example 4 and 5) The signal source should be set to a suitable CW frequency to test the amplifier. Follow the procedures described in Example 1 to zero and calibrate the sensor and to enter the correct calibrator factor frequency for this measurement. The source power level should initially be set to a power at which the amplifier is on its linear, small signal gain region. In this case, -30 dBm. Your measurement screen may look something like this:

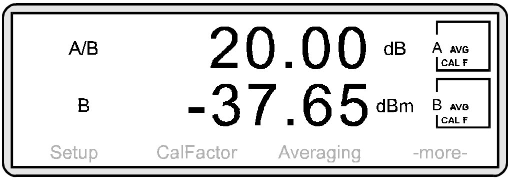


A is displaying the output power of the amplifier. B is displaying the input power to the amplifier. (Note a signal splitter has a nominal path loss of 6 dB.)

We can display the gain of the amplifier directly if we set channel 1 to A/B (see Example 4). Press:

Channel **[Setup] [Input]**

Your Measurement screen will now display the following:



Note the small signal gain of the amplifier. Now increase the signal source power slowly. When the amplifier begins to compress the displayed gain will start to decrease. Increase the source power until the gain has dropped by 1 dB, in this example to 19 dB.

Channel 2 now shows the input power at which the amplifier is in 1 dB compression. To display the amplifiers output power at 1 dB compression, press:

Channel **[Setup] [Input]**

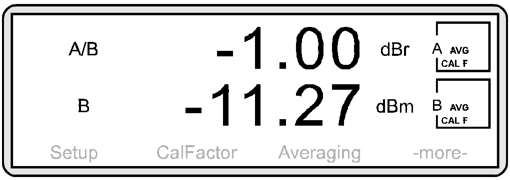
and select Input A .

The above routine can be simplified by defining the A/B small signal gain reading to be 0.00 dBr.

Return the source to –30 dBm. Now set the A/B display of gain to 0 dB by pressing:

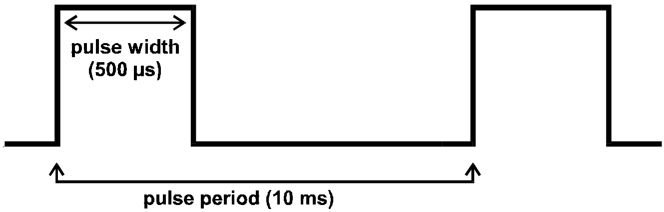
Channel **[Rel 1]**

Increase the power of the signal source until the display reads –1.00 dBr. The amplifier is now at its 1 dB compression point. Input and output powers at 1 dB compression can be viewed as before.



EXAMPLE 7: MEASURING PULSE SIGNALS WITH A DUTY CYCLE

In this example, we will be measuring the power output of a repetitive 500 µs pulse with a 10 ms pulse period.



In normal measurement mode the ML2430A power meter measures and displays average power. When the signal to be measured is a repetitive pulse, an average power reading will display average power over time and not the pulse power. By entering the duty cycle of the pulse, the meter can mathematically correct to display the pulse power. This technique assumes rectangular pulses with flat pulse tops.

$$\text{Duty Cycle} = \frac{\text{Pulse Width}}{\text{Pulse Period}} \times 100\%$$

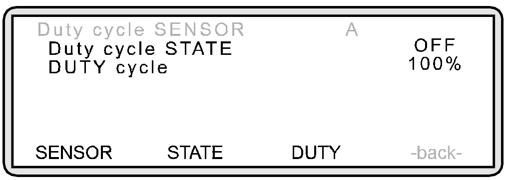
In the above example:

$$\text{Duty Cycle} = \frac{0.5\text{ ms}}{10\text{ ms}} \times 100\% = 5\%$$

Press:

Sensor **[-more-]** **[Duty cycle]**

The following screen is displayed:



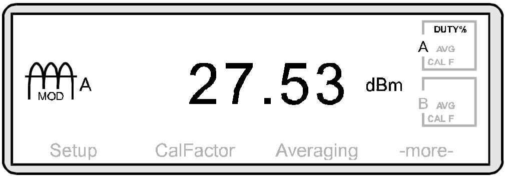
Press **[STATE]** and toggle the setting by pressing the soft key until the display reads ON. Press **[DUTY]** and using the keypad, input a duty cycle of 5%. Press **[Enter]**. To return to the Measurement screen press any hard key.

When measuring duty cycles with long pulse repetition frequencies, it may be necessary to apply the Modulated Average mode (see Example 2, Measuring Modulated Carrier). Press:

Sensor **[Setup] [MODE]**

Toggle this setting until Mod Average is displayed.

The following screen is displayed:

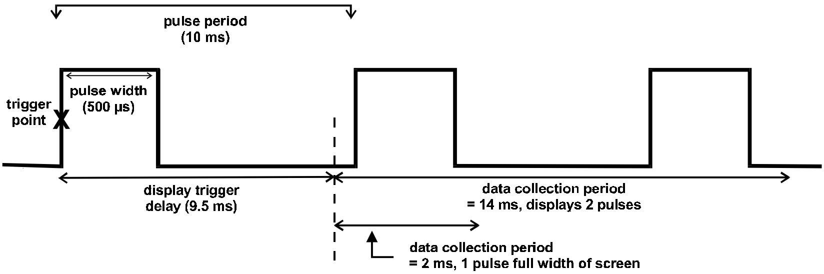


Note that box A in the top right hand corner of the screen now indicates that a Duty Cycle percentage has been applied to the Sensor.

EXAMPLE 8: PROFILING PULSE SIGNALS

The ML2430A Series Power Meter can be used to view signals graphically as well as digitally.

In this example, we will measure a pulse with a duration of 500 µs and a pulse period of 10 ms.



Display trigger delay is a time delay from the trigger point to the time when the power meter starts to collect data. It can be used to view the complete rising edge of a pulse which would otherwise be on the extreme left of the instrument display.

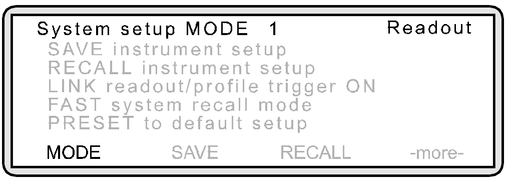
Data collection period is the length of time for which data is captured. It also defines the time axis settings.

1. Changing from Readout to Profile mode

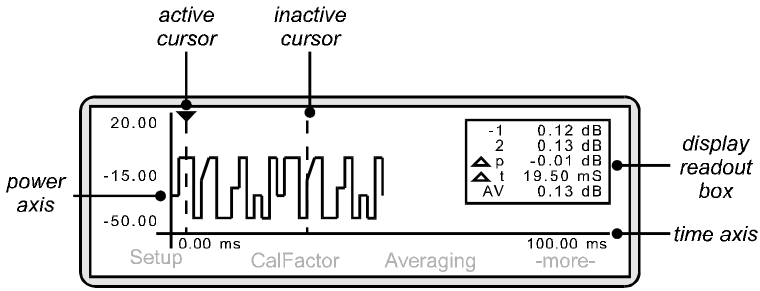
Press:

System **[Setup]**

The following screen is displayed:



Press **[MODE]** and toggle this setting until "Profile" is displayed. Press any hard key to display the Measurement screen.



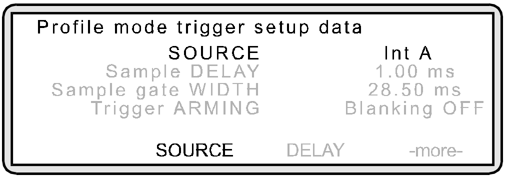
Default continuous trigger results in unstable display

2. Set up the triggering attributes

Press:

Trigger **[Setup]**

The following screen is displayed:



Press **[SOURCE]** and toggle this setting until the trigger source you require is displayed:

Int A	Take trigger from sensor A
Int B	Take trigger from sensor B (ML2438A only)
EXTTTL	Take trigger from an external source
MANUAL	User triggers measurement from front panel soft key
CONTINUOUS	Automatic continuous trigger on completion of measurement cycle

For this example, toggle this setting until "Int A" is displayed.

To set the trigger for a falling edge, press **[-more-] [TYPE]** and toggle this setting until "Fall (Int A)" is displayed. Press **[LEVEL]** if you wish to change from the default trigger level of –15 dB.

To display the Measurement screen, press any hard key.

The pulse is displayed on the screen and the display readout box on the right-hand side shows:

1	the power measurement at cursor 1
2	the power measurement at cursor 2
Δp	the power difference between cursors 1 and 2
Δt	the time difference between cursors 1 and 2
AV	the average power between cursors 1 and 2

3. Changing the axis scaling

In order to display the waveform clearly, it may be necessary to amend the X and Y axis settings. To change the time axis, press:

System **[Profile] [Period]**

The entered value of Data Collection Period determines the time axis scaling. Using the keypad, input a period value that will result in the display of the required number of pulses. Press either **[ms.Enter]** or **[us.Enter]**. In this example, a period of 10 ms will result in the display of one pulse cycle. To change the power axis, press:

System **[Control] [-more-] [SCALE]**

Press **[TOP]** and/or **[BOTTOM]** to set the dB values as required. Press **[Enter]** to accept the values. Alternatively, rather than entering top and bottom values, you can select **[AUTO SCALE]**.

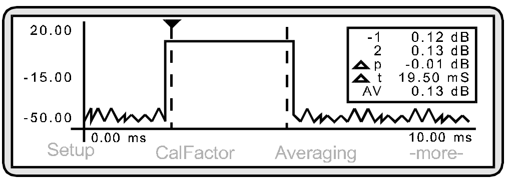
4. Introducing a delay to the trigger point display

The Measurement screen currently shows the trigger point of the pulse as occurring on the extreme left-hand side of the graph. It may be useful to show a leading edge to the pulse thus displaying activity prior to the trigger point.

Press:

System **[Profile] [Delay]**

and using the keypad, input a delay of 9.5 ms. Press **[Enter]** to accept the value. The Measurement screen now shows activity prior to the trigger point.



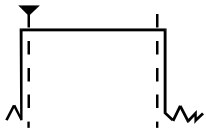
Using the cursors

Cursors are used to define the points at which or between which power is measured. To take a measurement at a single point, position one cursor. To take a measurement between two points, use both. They are depicted as vertical dashed lines. The active cursor is depicted in two ways:

- by a triangular end cap on the end of the dotted line
- by a hyphen against the cursor number in the display readout box (see Components of the Profiling Screen).

By positioning the cursors, the display readout box will show the average power measured between the two cursors.

Position the cursors approximately 10% inside the start and finish of the pulse — see opposite. This will help to stabilise the reading.



When Profile mode is first used, both cursors sit at the extreme right hand side of the display. To move a cursor, press:

System **[Control]**

To move the active cursor, press **[<<]** or **[>>]**. To activate the other cursor, press **[SWAP]**.

If you had multiple pulses displayed on the screen and wished to compare identical timed power readings, the cursors can be linked and then moved as a pair along the waveform. To link the cursors, press:

System **[Control] [-more-] [-more-] [LINK CURSR]**

If the cursors are now moved using **[<<]** or **[>>]**, they move as a pair.

5. Displaying the Readout box

This box can be toggled on and off by pressing:

System **[Control] [-more-] [READOUT]**

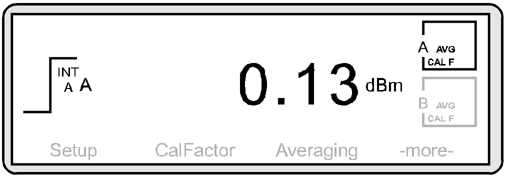
6. Displaying the average power in readout mode

The average power between a set of cursors is shown at the bottom of the Display Readout box. However, to display the average power in readout mode, press:

System **[Setup] [-more-]**

Press **[LINK]** and toggle this setting until "ON" is displayed.

To return to readout mode, press **[-back-] [MODE]**. Toggle this setting until "Readout" is shown. To display the resulting screen, press any hard key.



EXAMPLE 9: DISPLAYING GSM-TDMA BURSTS

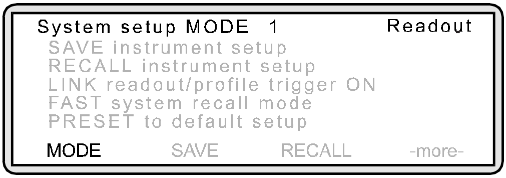
The principle for viewing and measuring GSM-TDMA bursts is similar to that for profiling pulse signals. In this example, we will be measuring three GSM-TDMA bursts in an eight-slot frame.

1. Changing from Readout to Profile mode

Press:

System **[Setup]**

The following screen is displayed:



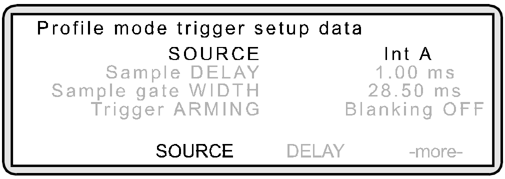
Press **[MODE]** and toggle this setting until "Profile" is displayed.

2. Set up the triggering attributes

Press:

Trigger **[Setup]**

The following screen is displayed:



Press **[SOURCE]** and toggle this setting until the trigger source you require is displayed:

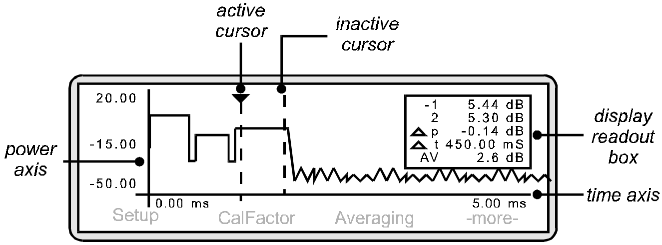
Int A	Take trigger from sensor A
Int B	Take trigger from sensor B (ML2438A only)
EXTTTL	Take trigger from an external source
MANUAL	User triggers measurement from front panel soft key
CONTINUOUS	Automatic continuous trigger on completion of measurement cycle

In this example, the power meter is triggered from a TTL pulse which must be connected to rear panel connector marked INPUT 1 DIGITAL. This pulse is generated by the base station, or signal source, at the start of each 8-burst frame.

To set the trigger for a TTL pulse, press:

Trigger **[Setup] [SOURCE]**

and toggle this setting until "EXTTTL" is displayed. To display the Measurement screen, press any hard key.



The frame is displayed on the screen and the display readout box on the right-hand side shows:

1	the power measurement at cursor 1
2	the power measurement at cursor 2
Δp	the power difference between cursors 1 and 2
Δt	the time difference between cursors 1 and 2
AV	the average power between cursors 1 and 2

3. Changing the axis scaling

In order to display the waveform clearly, it may be necessary to amend the X and Y axis settings. To change the time axis, press:

System **[Profile] [Period]**

The entered value of Data Collection Period determines the time axis scaling. Using the keypad, input a period value that will result in the display of the required number of time slots. Press either **[ms.Enter]** or **[us.Enter].** In this example, a period of 5 ms will result in the display of one frame (equals eight time slots).

To change the power axis, press:

System **[Control] [-more-] [SCALE]**

Press **[TOP]** and/or **[BOTTOM]** to set the dB values as required. Press **[Enter]** to accept the values.

Alternatively, rather than entering top and bottom values, you can select **[AUTO SCALE]**.

4. Introducing a delay to the trigger point display

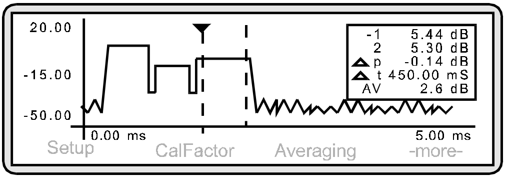
The Measurement screen currently shows the trigger point of the pulse as occurring on the extreme left-hand side of the graph. It may be useful to show a leading edge to the pulse thus displaying activity prior to the trigger point.

Press:

System **[Profile]** **[Delay]**

and using the keypad, input a delay of 4.5 ms. Press **[Enter]** to accept the value.

The Measurement screen now shows activity prior to the trigger point.

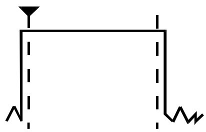


5. Using the cursors

Cursors are used to define the points at which or between which power is measured. To take a measurement at a single point, position one cursor. To take a measurement between two points, use both cursors. They are depicted as vertical dashed lines. The active cursor is depicted in two ways:

- by a triangular end cap on the end of the dotted line
- by a hyphen against the cursor number in the display readout box (see Components of the Profiling Screen).

By positioning the cursors, the display readout box will show the average power measured between the two cursors.



Position the cursors approximately 10% inside the start and finish of the pulse — see opposite. This will help to stabilise the reading.

When Profile mode is first used, both cursors sit at the extreme right hand side of the display. To move a cursor, press:

System **[Control]**

To move the active cursor, press **[<<]** or **[>>]**. To activate the other cursor, press **[SWAP]**.

If you wish to compare the different burst power readings, the cursors can be linked and then moved as a pair along the waveform. To link the cursors, press:

System **[Control] [-more-] [-more-] [LINK CURSR]**

If the cursors are now moved using **[<<]** or **[>>]**, they move as a pair.

6. Displaying the Readout box

This box can be toggled on and off by pressing:

System **[Control] [-more-] [READOUT]**

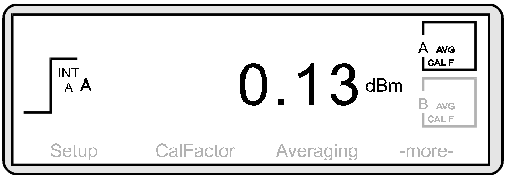
7. Displaying the average power in readout mode

The average power between a set of cursors is shown at the bottom of the Display Readout box. However, to display the average power in readout mode, press:

System **[Setup] [-more-]**

Press **[LINK]** and toggle this setting until "ON" is displayed.

To return to readout mode, press **[-back-] [MODE]**. Toggle this setting until "Readout" is shown. To display the resulting screen, press any hard key.

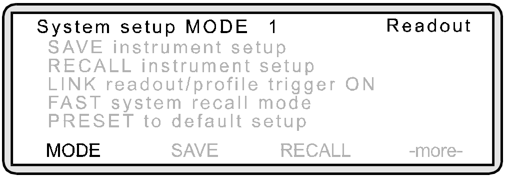


EXAMPLE 10: POWER VERSUS TIME DATA LOGGING

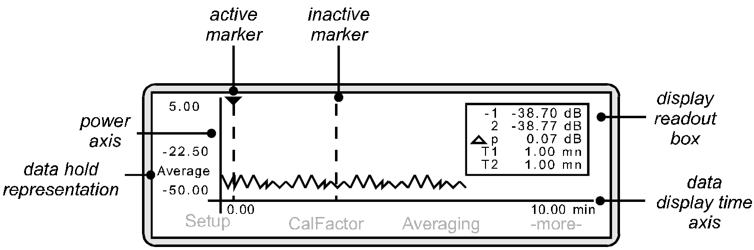
To take power measurements over a user-defined period of time, press:

System **[Setup]**

The following screen is displayed:



Press **[MODE]** and toggle this setting until “Power v Time” is displayed. Press any hard key to display the Measurement screen.



Components of the Power versus Time Measurement screen

1. Changing the axis scaling

The data display time axis shows the length of time over which you wish to take measurements. Press:

System **[PwrVsTime] [TIME]**

Using the keypad, enter the required time. Press either **[hr.Enter]** or **[min.Entr]**.

To change the power axis, press:

System **[Control] [-more-] [SCALE]**

Press **[TOP]** and/or **[BOTTOM]** to set the dB values as required. Press **[Enter]** to accept the values.

Alternatively, rather than entering top and bottom values, you can select **[AUTO SCALE]**.

2. Selecting the data hold representation

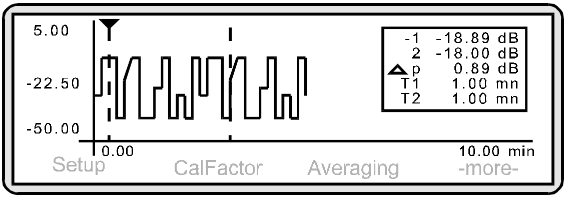
The data hold representation allows you to specify how you would like these measurements displayed on the screen. Press:

System **[PwrVsTime]**

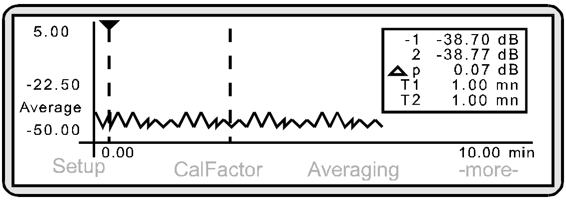
The way the power meter measures power versus time is to divide the data display time period into 200 blocks of time. For example, with a data display time period of 200 minutes, the duration of each block of time would be 1 minute. If the display time were 100 minutes, each block of time would be of 30 seconds duration.

Press **[DATA HOLD]** and toggle the setting by repeatedly pressing the soft key until the representation type you require is displayed.

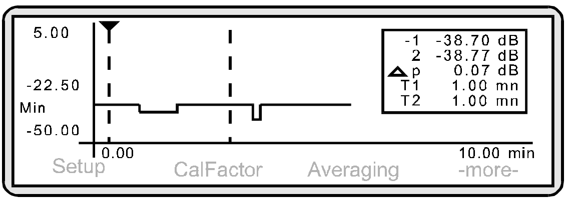
Normal This is the default setting and returns the last measurement taken within each block of time.



Average This looks at all the measurements within the block of time and returns the average power.



Min This looks at all the measurements within the block of time and returns the minimum power.



Max	This looks at all the measurements within the block of time and returns the maximum power. The Measurement screen is similar to that achieved with Min.
Min/Max	This looks at all the measurements within the block of time and returns both the minimum and the maximum power. Both readings are connected on the graph by a line which results in a similar display to that shown below.

Press any hard key to return to the Measurement screen. The display readout box on the right-hand side shows a combination of:

1	the power measurement at cursor 1
2	the power measurement at cursor 2
Δp	the power difference between cursors 1 and 2
Δt	the time difference between cursors 1 and 2
T1	the time at cursor 1
T2	the time at cursor 2

3. Using the cursors

Cursors are used to define the points at which or between which power is measured. To take a measurement at a single point, use one cursor. To take a measurement between two points, use linked cursors (see below). They are depicted as vertical dashed lines. The active cursor is depicted in two ways:

- by a triangular end cap on the end of the dotted line
- by a hyphen against the cursor number in the display readout box (see Components of the Profiling Screen).

By positioning the cursors, the display readout box will show the power or time measured at each cursor and also the power or time difference between the cursors, depending upon the data hold mode selected.

To move a cursor, press:

System **[Control]**

To move the active cursor, press **[<<]** or **[>>]**. To activate the other cursor, press **[SWAP]**.

If you wished to compare identical time duration power readings, the cursors can be linked and then moved as a pair along the waveform. To link the cursors, press:

System **[Control] [-more-] [-more-] [LINK CURSR]**

If the cursors are now moved using **[<<]** or **[>>]**, they move as a pair.

4. Displaying the Readout box

This box can be toggled on and off by pressing:

System **[Control] [-more-] [READOUT]**

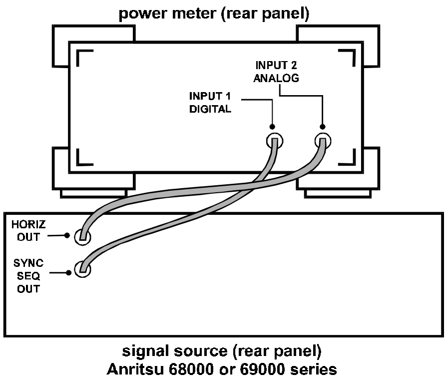
EXAMPLE 11: FREQUENCY MEASUREMENTS USING A SEPARATE SOURCE

In the previous examples, we have been working with variable power on a fixed frequency. In this example, we will be measuring power against swept frequency.

Between the frequency start point and the frequency stop point (i.e. 1 GHz to 2 GHz), you can take a power measurements at each point and plot the power between them. This is a frequency response measurement.

1. Connecting the meter to the device under test

Prior to starting this type of measurement, it is necessary to connect the power meter to the signal source using BNC cables.

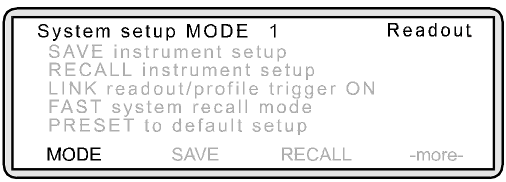


2. Selecting Source Sweep mode and defining frequencies

Press:

System **[Setup]**

The following screen is displayed:



Press **[MODE]** and toggle this setting until "Source Sweep" is displayed.

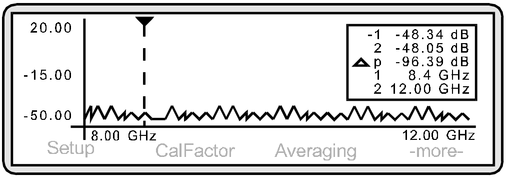
Press:

System **[Source sweep] [-more-]**

Press **[START]** and using the keypad, input the frequency at which the sweep starts. Press **[Enter]** to accept the value.

Press **[STOP]** and using the keypad, input the frequency at which the sweep stops. Press **[Enter]** to accept the value.

The following screen is displayed:



> Note that the frequency axis reflects the Start and Stop settings. Each time you measure at different frequencies, it is necessary to re-input the **[START]** and **[STOP]** values.

To achieve the maximum dynamic range, apply the highest levelled output power for the source as possible i.e. +20 dBm.

3. Changing the power axis

To change the power axis, press:

System **[Control] [-more-] [SCALE]**

Press **[TOP]** and/or **[BOTTOM]** to set the dB values as required. Press **[Enter]** to accept the values.

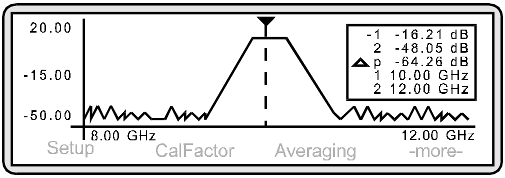
> In Source Sweep mode, you are unable to measure levels of less than -50 dBm.

In Source Sweep mode, the calibration factor is handled in a different manner since it is defined by the current frequency of the source. Press:

Sensor **[Cal Factor]**

Press **[SOURCE]** and toggle the setting by repeatedly pressing the soft key until the V/GHz is displayed.

To display the Measurement screen, press any hard key.



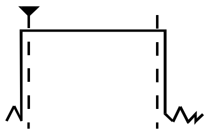
The response of the device under test is displayed on the screen and the display readout box on the right-hand side shows:

1	the power measurement at cursor 1
2	the power measurement at cursor 2
∆p	the power difference between cursors 1 and 2
x1	the frequency at cursor 1
x2	the frequency at cursor 2

4. Using the cursors

Two cursors are used to define the points at which or between which power is measured. They are depicted as vertical dashed lines. The active cursor is depicted in two ways:

- by a triangular end cap on the end of the dotted line
- by a hyphen against the cursor number in the display readout box (see Components of the Profiling Screen).



By positioning the cursors, the display readout box will show the average power measured between the two cursors.

When Profile mode is first used, both cursors sit at the extreme right hand side of the display. To move a cursor, press:

System **[Control]**

To move the active cursor, press **[<<]** or **[>>]**. To activate the other cursor, press **[SWAP]**.

To measure the power difference between the cursors, link them first. Press:

System **[Control] [-more-] [-more-] [LINK CURSR]**

If the cursors are now moved using **[<<]** or **[>>]**, they move as a pair.

EXAMPLE 12: : NCDMA MEASUREMENTS USING THE ML2407/08A

Note: This example is based on power meter software version 3.00 or above. For a free software upgrade contact your local Anritsu service centre.

CDMA as implemented in the IS-95 standard uses QPSK (mobile) and OQPSK (base station) modulation. A spectral display of the signal shows that it has a modulation bandwidth of 1.2288MHz and that the spectrum is very peaky. Measurement of average power requires the sensor to capture the true magnitude of all the transmitted peaks. For a power meter to measure average power and peak power of an NCDMA signal correctly, the sensor and power meter signal channel must have a bandwidth of at least 1.25MHz. The measurement of crest factor is also common. Crest factor is defined as the peak to average power ratio. It is important because any components in a CDMA signal path, especially amplifiers, must be linear enough to cope with any peaks in the waveform over and above the average power.

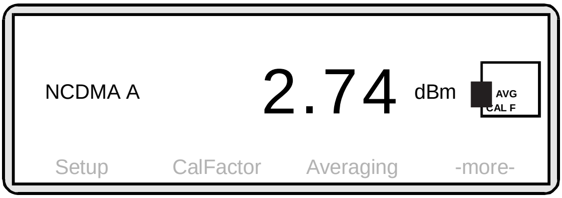
The Anritsu ML2407A and ML2408A power meters when used with the ML2469A power sensor, measure the average and peak power, as well as crest factor on NCDMA signals.

1. Putting the ML2407A into CDMA mode

To measure NCDMA signals the power meter must be put into CDMA mode.

Sensor **[Set up] [Mode]**

Press the mode key until NCDMA is displayed. Follow the procedures described in Example 1 to zero and calibrate the sensor and to enter the correct calibration factor for this measurement.



The meter is now measuring NCDMA average power.

2. Displaying average power and crest factor simultaneously

To simultaneously measure both the average power and the crest factor of a NCDMA signal on channels 1 and 2.

Channel **[Setup]**

Now toggle the **[CHANNEL]** key until channel 2 is selected. Next toggle the **[INPUT]** key until input A is selected.

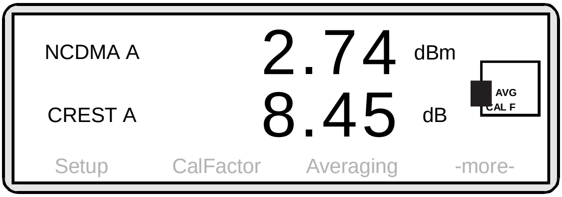
To change the channel measurement

Channel **[Setup] [-more-]** and toggle the **[NCDMA]** key.

CDMA measurement options for the ML2407A

AVERAGE	*Average power of a CDMA signal*
PEAK	*Maximum peak power measured since the function was last reset*
CREST	*Display of the peak to average power ratio*

Select CREST



3. Modifying the peak reset condition

In the default condition, the peak value is held until it is manually reset. A manual reset can be performed by

System **[Readout] [RESET]**

Or alternatively by pressing the **CLR** key at any time.

It is also possible to put the meter into a continuous reset mode. In this mode the crest factor peak value is reset every 5 seconds. This enables the user to see how the crest factor varies with changing input signal levels in near real time. To put the power meter into continuous reset mode

System **[Readout] [HOLD]**

Toggle Hold until TIME is displayed. The default period of time for automatic resettings is 5 seconds. This is a good compromise between measurement stability and speed of response. The time period can be user set if required using the TIME key.

EXAMPLE 13: MEASUREMENTS ON WCDMA, COMPLEX MODULATED AND MULTI-TONE SIGNALS USING A UNIVERSAL POWER SENSOR

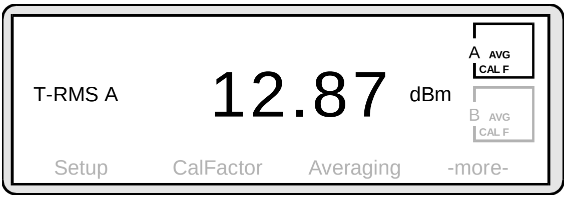
Note: This example is based on power meter software version 3.00 or above. For a free software upgrade contact your local Anritsu service centre.

Anritsu's MA2480A Univeral Power Sensors will measure the True RMS Power of any modulated or multi-tone carrier. Universal sensors deliver over 80dB of dynamic range with speed and accuracy. They are ideal for WCDMA, HDTV, N-QAM, DAB, GSM-EDGE and other carriers with complex or wide bandwidth modulation. Universal sensors are not bandwidth limited and are therefore ideal for multi-tone or intermodulation measurements, regardless of tone spacing.

The basic principle of operation is that the sensor has three diode pairs internally. The input signal passes through dividers and attenuators such that each diode pair receives a different power level for a given input signal. The meter is able to determine which diode pair is operating within its square law region. Power measurements are always made using the diode pair in their square law region and therefore always measures True RMS power.

1. Basic WCDMA average power measurements

Connect the sensor to Input A of the power meter (or Input B on a two channel version of the meter if desired). The meter immediately display the average power of the source under test.

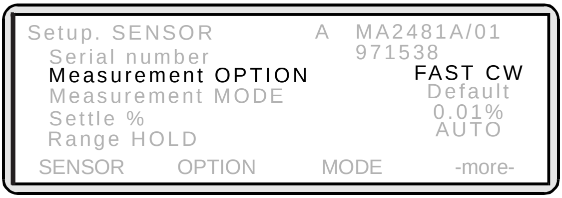


2. Using Universal Power Sensors in Profile and Source sweep modes

Note: Universal power sensors must be calibrated with option 1 data to be used in Profile or Source Sweep modes (part number MA2480/01). If option 1 data is installed the sensor is supplied with a label “with Option 1” adhered, below the serial number.

The user must select to use the sensor in its Fast CW mode for profiling and source sweep measurements. In Fast CW mode, the sensor always uses the diode pair with the least input attenuation regardless of the input signal level. In this case the sensor has the same performance and specification as a standard MA2470A series diode sensor. The sensitivity is limited to –60dBm as the first input divider remains in the signal path.

Sensor [Setup] [OPTION]



Select Fast CW.

System [Setup] [MODE]

Select Profile or Source Sweep as required.

The configuration of the meter for profile measurements and source sweep measurements is then the same as described in examples 8 and 11 respectively.

When in Fast CW mode the user also has access to Mod average and Custom sensor settings. These have exactly the same functionality as when using other Anritsu MA2470A series sensors. Only Default sensor mode is available unless Option 1, Fast CW mode data is installed and active.

MISCELLANEOUS FEATURES

SAVE AND RECALL INSTRUMENT SETTINGS

You can save up to 10 of your favourite measurement settings by pressing:

System **[Setup] [SAVE] [LIST]**

The screen will show a list of used and unused "Save Stores" and prompt you to enter a setup number. Using the keypad, input a store number between 1 and 10 and press **[Enter]**.

To recall a previously saved setting, press:

System **[Setup] [RECALL] [LIST]**

Using the keypad, input the store number of your setting and press **[Enter]**.

> When controlling the power meter over the GPIB, alpha numeric labels can be allocated to each store location.

PRINTING RESULTS

To print results, press:

System **[-more-] [Print]**

To change the printer driver, press:

System **[-more-] [-more-] [Rear panel] [PRINTER]**

At this point, **[down]** and **[up]** may be used to select from the available printer types.

USING THE POWER METER WITH A MODEM

In certain circumstances, it is possible to relay a measurement result to a remote PC via a modem. To set this up, press:

System **[-more-] [-more-] [Rear panel] [RS232] [MODEM]**

To enter the phone number, press **[PHONE]** and input the number using the keypad. Set the number of times the power meter tries to connect to the remote PC by pressing **[COUNT]** and input the number using the keypad.

The power meter can be configured to dial the entered number on various conditions.

To select the conditions, press:

System **[-more-] [-more-] [Rear panel] [RS232] [AUTO]**

and select from Limits Fail, Power Range Fail or AC Mains Power Failure.

PRESETTING THE METER TO A KNOWN STATE

A Preset returns the ML2430A to its default settings. It is recommended that this is carried out before each new measurement type and whenever the meter is reconfigured for a new measurement. To preset to factory default settings, press:

System **[Setup] [-more] [PRESET] [FACTORY]**

To preset without clearing offset tables or resetting the instrument GPIB address, press:

System **[Setup] [-more] [PRESET] [RESET]**

ADJUSTING THE DISPLAY CONTRAST

To adjust the display contrast, press:

System **[-more] [Display]**

Press **[DOWN]** or **[UP]** as required.

DISPLAYING MEASUREMENTS WITH THE PEAKING METER

The meter can also display an analog peaking meter alongside the numeric measurement. Press:

System **[-more] [Display] [-more-] [PEAKMETER]**

USER DEFINED OFFSET TABLES

The ML2430A Series Power Meters have a capability to define sets of offset data and store them in the meter. A user-defined offset table can be used on its own, or in conjunction with the factory-defined calibration factor table.

To define your own offset table, press:

Sensor **[-more-] [Offset] [TYPE]**

and toggle this setting until "Offset from Table" is displayed. Press **[-more-]** **[EDIT]**. Use **[Freq]** and **[Offset]** to enter the data required in the calibration table.

SAMPLE GPIB CODE FRAGMENTS

Note: All examples are in visual basic

Taking a single reading in readout mode

```
Public Function Take_Reading(channel as integer) as single
    Dim buf as string * 20
    ' Ask for a reading
    Call Send(0, 13, "O " & channel, NLend)
    Call Receive(0, 13, buf, STOPend)
    Take_Reading = val(buf)
End Function
```

Maximising GPIB measurement speed in readout mode

This shows how you use the GPIB command set to read back readings from the Power Meter in Fast Mode. In this mode you can get up to 650 readings per second. – Readout mode only.

```
Public Sub Fast_Demo

    Dim buf as String * 20
    Dim Reading as single

    ' configure the Power Meter for fast mode
    Call Send(0, 13, "FAST ON", NLend)


    Call ReceiveSetup(0, 13)

    Do
        Call RcvRespMsg(0, buf, STOPend)
        Reading = val(buf)
    Loop until stop_flag

End Sub
```

Reading trace data from profile mode

```
Public Function Get_Graph_Data(graph_data() as single)

    ‘ graph_data is an array of 200 elements of type single

    Dim buf as String * 1000
    Dim previous as Integer
    Dim nextcomma as Integer

    ‘ ask for the graph data
    Call Send(0, 13, “OGD”, NLend)
    Call Receive(0, 13, buf, STOPend)

    ‘ extract each reading from the string returned and place in our array
    previous = InStr(buf, ",")
    For I = 1 To 200
        nextcomma = InStr(previous + 1, buf, ",")
        If nextcomma = 0 Then
        nextcomma = Len(buf)
        End If

        sample = Val(Mid(buf, previous + 1, nextcomma - previous))
        graph_data(I) = sample
        previous = nextcomma
    Next I
End Function
```

Reading GSM burst average power

This example shows how to trigger the power meter on a GSM burst with external triggering, gate width set to 5ms, delay to .25ms and then to read back the average burst power.Public Function GSM_burst() as single.

```
Public Function SGM_burst() as single
    ‘ set up Power Meter
    Call Setup_GSM_Application()

    GSM_burst = Take_Reading(1)

End Function

Public Sub Setup_GSM_Application()

    ‘ Setup Sensor
    Call Send(0, 13, “SENMM A, CUSTOM”, NLend)

    ‘ Setup Trigger
    Call Send(0, 13, “TRGSRC 1, EXTTTL”, NLend)
    Call Send(0, 13, “TRGDLY 1, .25ms”, NLend)
    Call Send(0, 13, “TRGGW   1, 5ms”, NLend)

End sub
```

APPENDIX A

POWER SENSOR TABLE

Model	Frequency Range	Dynamic Range (dBm)	Rise Time (ms)	RF Conn.
Diode Power Sensors				
MA2468A	10 MHz - 6 GHz	-60 to +20	< 0.0006	N (m)
MA2469A	10 MHz - 14 GHz			N (m)
MA2469B	10 MHz – 18 GHz			N (m)
MA2472A	10 MHz - 18 GHz	-70 to +20	< 0.004	N (m)
MA2473A	10 MHz - 32 GHz			K (m)
MA2474A	10 MHz - 40 GHz			K (m)
MA2475A	10 MHz - 50 GHz			V (m)
Thermal Power Sensors				
MA2421A	0.1 MHz - 18 GHz	-30 to +20	< 4.0	N (m)
MA2422B	10 MHz - 18 GHz			N (m)
MA2423B	10 MHz - 32 GHz			K (m)
MA2424B	10 MHz - 40 GHz			K (m)
MA2425B	10 MHz - 50 GHz			V (m)
High Accuracy Diode Sensors				
MA2442A	10 MHz - 18 GHz	-67 to +20	< 0.004	N (m)
MA2444A	10 MHz - 40 GHz			K (m)
MA2445A	10 MHz - 50 GHz			V (m)
Universal Power Sensors				
MA2481A	10 MHz – 6 GHz	-60 to +20	N/A	N (m)
MA2480/01	10 MHz – 6 GHz	-60 to +20	< 0.004	N (m)

ACCURACY

Power measurement accuracy is a straightforward concept. It has several component parts. Some can be substantially reduced through judicious measurement practice. In the table below, a classic example of measurement practice is detailed for each MA2400A Series power sensor type. The 16 GHz, 12.0 dBm signal is presumed to have a source SWR of 1.5:1.0.

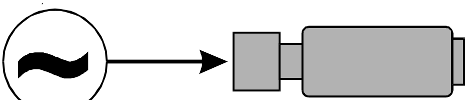
Instrument accuracy is the accuracy of the meter. Typically the specification is 0.5% – a very small component of overall measurement accuracy. The error sources, which comprise instrumentation accuracy, are largely related to linear voltage measurement.

Sensor linearity and temperature linearity describe the relative power level response over the sensor's dynamic range. When measuring a power level at other than the power level of the absolute reference, which is typically the meter's 0.0 dBm reference “calibrator", sensor linearity is included in measurement accuracy. Temperature linearity is included when operating in the sensor at other than room temperatures. The best way to reduce this error is to first choose power sensors with clearly specified linearity performance.

Sensor Model Series	MA2420A (%)	MA2440A (%)	MS2470A (%)
Instrumentation accuracy	0.50		
Sensor linearity	1.30	1.80	
Noise, 256 Avg	0.00		
Zero Set and Drift	0.00		
Mismatch uncertainty	3.67	3.84	4.49
Sensor Cal factor uncertainty	0.83	0.79	0.84
Reference power uncertainty	1.20		
Reference to sensor mismatch uncertainty	0.23		
Temperature linearity ± 20°C	1.00		
RSS, Room temp	4.19	4.51	5.09
Sum of uncertainties, Room temp	7.73	8.36	9.06
RSS	4.31	4.62	5.18
Sum of uncertainties	8.73	9.36	10.06

Noise, Zero Set and Zero Drift impact measurement accuracy at the bottom of a power sensor's dynamic range. Different power sensors have different noise characteristics. Noise can be reduced through additional averaging or longer sample integration times. Additionally, low level averaging can be applied to optimise trade-offs between dynamic setting, raw noise power deviation and measuring speed.

Mismatch uncertainty is typically the largest component of measurement uncertainty. The error is caused by the differing impedances between the power sensor and the device to which the power sensor is connected.



reflection coefficient = Γ_1 **reflection coefficient = Γ_2**

% mismatch uncertainty = $100[(1 \pm \Gamma_1 \Gamma_2)^2 - 1]$
dB mismatch uncertainty = $100[(1 \pm \Gamma_1 \Gamma_2)$

Mismatch is easily calculated in either dB or percentage terms from the source's and sensor's respective reflection coefficients

The most convenient method of reducing mismatch uncertainty is to choose power sensors with high return loss; that is, the power sensor's SWR is very close to 1.0. Further improvement results from performing actually measurements of the sensor's return loss with a well-calibrated vector network analyser or other precision return loss measurement technique. Broadband microwave devices like the MA2400A Series sensors are assembled in a manner that typically achieves significantly better SWR performance at some frequencies than the performance specifications indicate.

There are three common techniques of reducing source SWR. If the source's hot S_{22} characteristics can be determined, the mismatch loss can be calculated and the appropriate correction added to the power measurement. Alternatively, a 3.0 dB precision attenuator with high return loss can be attached to the source to improve the effective source impedance. Another common approach is to improve effective source match with external power levelling.

Sensor calibration factor uncertainty identifies the accuracy of the sensor's calibration relative to a recognised standard for absolute power level.

Reference power uncertainty specifies the maximum possible output drift of the power meter's 50 MHz, 0.0 dBm power reference between calibration intervals.

In typical power measurements, test setup and measurement practices often create larger measurement uncertainties. These errors include offset errors, poor connection practice, excessive source harmonics and incorrect calibration factor usage.

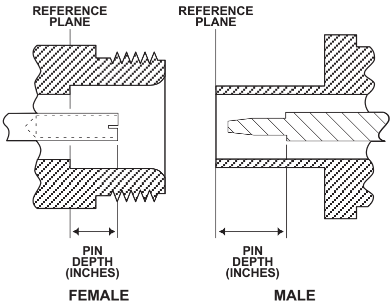
Connector damage has significant accuracy and repeatability effects. It is the most common cause of sensor damage but is frequently undetected. Every MA2400A Series sensor includes a hex nut connection for application of a calibrated torque wrench.

CONNECTOR CARE AND HANDLING

Anritsu MX24XXA Series Power Sensors are high-quality precision laboratory instruments and should receive the same care and respect afforded to such instruments. Follow the precautions listed below when handling or connecting these devices. Complying with these precautions will guarantee longer component life and less equipment down time due to connector or device failure. Also, such compliance will ensure that Power Sensor failures are not due to misuse or abuse – two failure modes not covered under the Anritsu warranty.

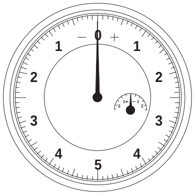
Beware of destructive pin depth mating connectors

Destructive pin depth of mating connectors is the major cause of failure in the field. When an RF component is mated with a connector having a destructive pin depth, damage will usually occur to the RF component connector. A destructive pin depth is one that is too long in respect to the reference plane of the connector (see figure below).



N connector pin depth definition

The centre pin of a precision RF component connector has a precision tolerance. The mating connectors of various RF components may not be precision types. Consequently, the centre pins of these devices may not have the proper pin depth. The pin depth of DUT connectors should be measured to assure compatibility before attempting to mate them with Power Sensor connectors. An Anritsu Pin Depth Gauge or equivalent can be used for this purpose.



Pin depth gauge

If the measured connector is out of tolerance in the "+" region, the centre pin is too long (see Allowable DUT connector pin depth table below). Mating under this condition will likely damage the precision RF component connector. If the test device connector measures out of tolerance in the "-" region, the centre pin is too short. This should not cause damage, but it will result in a poor connection and a consequent degradation in performance.

DUT Connector Type	Anritsu Gauging Set Model	Pin Depth (inches)	Pin Depth Gauge Reading
N - Male N - Female	01-163	207 -0.000 +0.030	207 +0.000 -0.030
WSMA - Male WSMA - Female	01-162	-0.000 -0.010	Same as pin depth
SMA - Male SMA - Female			
3.5mm - Male 3.5mm - Female			
K - Male K - Female	01-162	+0.000 -0.010	Same as pin depth
V - Male V - Female	01-164		

Allowable DUT connector pin depth

Avoid over torquing connectors

Over torquing connectors destructive; it may damage the connector centre pin. Finger-tight is usually sufficient for Type N connectors. *Always* use a connector torque wrench (8 inch-pounds) when tightening WSMA, K or V type connectors. *Never use pliers to tighten connectors.*

Avoid mechanical shock

Precision connectors are designed to withstand years of normal bench handling. However, do not drop or otherwise treat them roughly. Mechanical shock will significantly reduce their service life.

Do not disturb Teflon tuning washers on connector centre pins

The centre conductor on many RF component connectors contains a small Teflon washer that is located near the point of mating. This washer compensates for minor impedance discontinuities at the interface. *Do not disturb this washer.* The location of the washer is critical to the performance of the RF component.

Cleaning connectors

The precise geometry that makes possible the RF component's high performance can easily be disturbed by dirt and other contamination adhering to the connector interfaces. When not in use, keep the connectors covered.

To clean the connector interfaces, use a clean cotton swab that has been dampened with denatured alcohol.

> Most cotton swabs are too large to fit in the smaller connector types. In these cases, it is necessary to peel off most of the cotton and then twist the remaining cotton tight. Be sure that the remaining cotton does not get stuck in the connector. Cotton swabs of the appropriate size can be purchased through a medical laboratory-type supply centre.

The following are some important tips on cleaning connectors:

- Use only denatured alcohol as a cleaning solvent
- Do not use excessive amounts of alcohol as prolonged drying of the connector may be required
- Never put lateral pressure on the centre pin of the connector
- If installed, do not disturb the Teflon washer on the centre conductor pin
- Verify that no cotton or other foreign material remains in the connector after cleaning it
- If available, use compressed air to remove foreign particles and to dry the connector
- After cleaning, verify that the centre pin has not been bent or damaged

ANRITSU CORPORATION
5-10-27, Minamiazabu, Minato-ku,
Tokyo 106, Japan
Phone: +81-3-3446-1111
Telex: J34372
Fax: +81-3-3442-0235

International Subsidiaries

U.S.A.
ANRITSU COMPANY
1155 E. Collins Blvd. Richardson,
TX 75081, U.S.A.
Phone: +1-800-ANRITSU
Fax: +1-972-671-1877

Canada
ANRITSU Instruments LTD.
4-205 Matheson Blvd. East,
Mississauga
Ontario, L4Z 3E3, Canada
Phone: +1-905-890-7799
Fax: +1-905-890-2290

Brazil
ANRITSU ELETRONICA LTDA.
Praia de Botafogo 440, Sala 2401
CEP 22250-040, Rio de Janeiro, RJ,
Brasil
Phone: +55-21-527-6922
Fax: +55-21-537-1456

U.K.
ANRITSU LTD.
Capability Green, Luton,
Bedfordshire
LU1 3LU, United Kingdom
Phone: +44-1582-433200
Fax: +44-1582-731303

Germany
ANRITSU GmbH
Grafenberger Alee 54-56, D-40237
Düsseldorf 1, Germany
Phone: +33-1-60-92-15-50
Fax: +33-1-64-46-10-65

France
ANRITSU SA
9, Avenue du Quebec, ZA de
Courtaboeuf
91951 Les Ullis Cedex, France
Phone: +33-1-60-92-15-50
Fax: +33-1-64-46-10-65

Italy
ANRITSU SpA
Via Elio Vittorini, 129, 00144 Roma
EUR, Italy
Phone: +39-6-502-2666
Fax: +39-6-502-2425
Fax: +968-791697

Sweden
ANRITSU AB
Botvid Center 145 84 Stockholm,
Sweden
Phone: +46-853470700
Fax: +46-853470730
Fax: +91-11-685-2275

Singapore
ANRITSU PTE LTD.
6, New Industrial Rd, #06-01/02, Hoe
Huat
Industrial Building, Singapore
536199
Phone: +65-282-2400
Fax: +65282-2533

Hong Kong
ANRITSU COMPANY LTD.
Suite 812, 8/F, Chinachem Golden
Plaza, 77 Mody Road
Tsimshatsui East, Kowloon, Hong
Kong, China
Phone:+852-2301-4980
Fax: +852-2301-3545

Korea
ANRITSU CORPORATION LTD.
Room No. 901, Daeo Bldg, 26-5,
Yeoido-Dong,
Young Deung Po-Ku, Seoul, Korea
Phone: +82-2-782-7151 to 7156
Fax: +82-2-782-4590