



Application Note

WLAN Output Power Measurement

ML248XA Series
Power Meters



*Understand how to set up and use the Wideband Peak
Power Meter for WLAN measurements*

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

P/N: 1500-00047
REVISION: A
CREATED January 2004
COPYRIGHT 2004
ANRITSU



Measuring the Power of a WLAN Transmitter

Introduction

This application note shows how to set up and measure WLAN transmitters with the ML248XA series wideband peak power meter and MA2490A sensors.

The ML248XA series power meter has a video bandwidth of 20MHz, which makes it ideal for peak and average power measurements on all WLAN signals. The power meter has a selection of trigger and measurement features to select precisely the section of the WLAN signal under test. Higher data rate WLAN signals pose a challenge for conventional power meters as there is considerable AM on the power envelope, which can fool the trigger settings, see Figure 1.

The ML248XA series incorporates a special synchronising feature, frame arming which allows the power meter to detect the off period in the transmission. The power meter can display the results numerically or as a graph, enabling the design or manufacturing engineer to truly see the power profile of the WLAN transmitter.

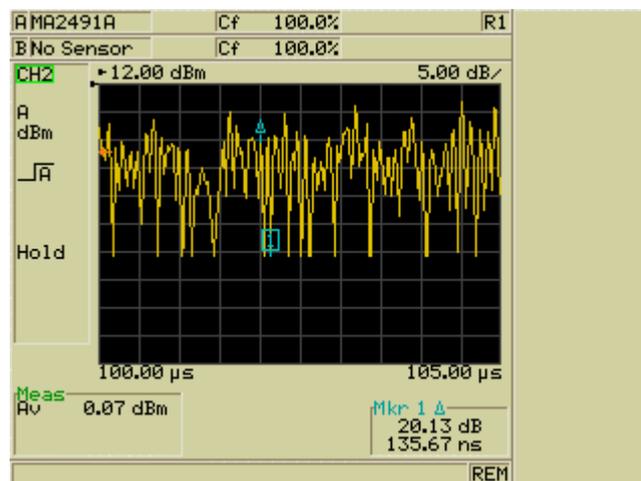


Figure 1. 5µs segment of an 802.11g signal with 64QAM modulation

WLAN 802.11

There are three different variants of WLAN; 802.11b and g which operate in the 2.4GHz ISM band and 802.11a which operates in the 5GHz ISM band. A variety of data rates and modulation techniques are used to encode data rates varying from 1Mb/s to 54Mb/s. All of these systems use Time Division Duplexing, and the data is transmitted in frames of variable length. The IEEE standard also specifies several test modes with fixed times and duty cycle rates but many manufacturers choose to test the transmitters under their own proprietary test signal.

802.11b

The 802.11b transmitter uses BPSK (Binary Phase Shift Keying) or QPSK (Quadrature Phase Shift Keying). The transitions and hence trajectory of the power envelope from one state to the next state will determine the peak to average power ratio.

802.11a,g

The 802.11 a, g transmitters can use a variety of modulation techniques and data rates. Both systems employ OFDM (Orthogonal Frequency Division Multiplexing). In this system the signal is split into 48 separate data sub-carriers (there are also 4 additional pilot carriers), with a correspondingly lower data rate on each carrier. The advantage of this system is that it reduces errors introduced by multi-path propagation at high data rates. Systems based on OFDM can offer higher data rates or longer range at lower data rates compared with conventional single carrier systems.

A variety of modulation schemes are used to convey the data ranging from BPSK at the lowest data rate to 64QAM at 54Mb/s.

The peak power has a significant effect on the design of the Power Amplifier in the transmitter. It is important to test accurately the peak power to ensure that the transmitter is not over-compressing and distorting the transmitter signal. This could lead to higher error rates and lower overall performance of the WLAN signal. It is also important to calibrate the power loop that dynamically controls the power output of the WLAN transmitter. Many transmitters have to co-exist with each other and accurate control of the power is required to do this. A power meter offers the most accurate means of measuring power, which ensures an accurately calibrated WLAN system supporting the highest number of users.

The modulation technique used will have a significant effect of the power envelope of the signal. This application note will show how to measure the peak power and the average power of all these formats.

Notation Conventions Used in this Application Note

The following conventions have been adopted in this Application Note.

Channel	Hard keys on the unit are enclosed in a box with a grey background.
Set Up	Soft keys that display on the screen are enclosed in a box with a white background. Pressing a soft key provides access to menu options, toggles selections and allows data entry.
[Exit]	The text that appears on or beneath the keys on the numeric keypad is enclosed in square brackets.
[Channel Set Up]	The titles of input dialogs that appear on the screen are enclosed in square brackets.
“Meas display”	Items or text that display within the main body of the screen are enclosed in quotation marks.
ML248xA	Used throughout this application note to refer to both the ML2487A and the ML2488A power meters.

ML248XA Peak Power Meter

There are two variants of the ML248XA Peak power meter:

- ML2487A single input unit
- ML2488A dual input unit.

Both units have a video bandwidth of 20MHz which means that the peak power on even the highest data rate signal can be measured correctly without resorting to the manual corrections required by lower bandwidth power meters. The ADC samples at 64Ms/s and the WLAN signal is captured in a single sweep. A variety of trigger facilities are available to ensure precise triggering. The power of the WLAN signal can be measured in a gate which defines precise time limits for the measurement. Up to 4 gates can be set on a single display channel set up. 4 Markers are available to measure features of the signal.

Both versions of the power meter support dual display channels. Each display channel can be thought of as a different measurement set-up and the power meter can toggle between them with the **Ch1/Ch2** key or they can be displayed together on the screen. The measurement process will alternate between the two display channels.

The power meter supports 20 settings stores

MA2490A and MA2491A Wideband Sensors

Two versions of the wideband sensor are available.

- MA2490A 50MHz to 8GHz
- MA2491A 50MHz to 18GHz

Both sensors have a 20MHz bandwidth and incorporate a CW mode switch for CW applications.

The sensors' dynamic range is -60dBm to $+20\text{dBm}$ in CW mode and -28dBm to $+20\text{dBm}$ in pulsed modulated mode. The sensors are specified to handle 3dB over range to $+23\text{dBm}$. For signals with a high crest factor, the peak of the power should be kept below $+20\text{dBm}$ for safe and accurate measurements. This may need the addition of an external attenuator and this application note will describe how to automatically offset the reading for the value of the attenuator.

Setting Up the Measurement

To measure WLAN signals follow this procedure.

Set the measurement mode
Select the output parameter
Calibrate and zero the sensor
Set the cal factor for the sensor

Set up the trigger
Set up the timing

Set up the gates
Take the output data.

To start, press the yellow **Preset** key and **select** [Reset]

This will set Channel 1 to pulse modulated mode. Default input is set to A and the output is set to [Avg], the average output power.

Selecting the output parameter

The ML248XA can measure various combinations of output power parameters; the average power only, the average and the peak power or the average power, peak power and crest factor. To select which combination is required press **Channel** and then **Set Up**.

Use the down arrow to move the highlight to [Measurement] and select the appropriate softkey.

The ML248XA has two different signal processing algorithms.

The first algorithm is designed to correctly measure the peak of pseudo random noise like signals such as WLAN and WCDMA, and the second is designed to reduce the effect of noise on a pulsed signal like radar.

The **Avg, Peak** and **Avg, Peak & Crest** selections automatically employ the correct algorithm to measure the peak for pseudo random noise like signals such as WLAN.

The other selection, **Average, Min & Max** employs a different averaging algorithm which reduces the effect of peak impulse noise on radar pulse measurements.

Calibration and Zero

Connect the MA2490A to the Calibrator and the sensor lead to input A.

Press **Cal/Zero** and then **Zero & Cal**

When the cal and zero has finished press **Sensor** and then **Cal Factor**

Use the down arrow to highlight the [Frequency] field.

To enter the frequency, press [Sel] on the numeric keypad and then enter the frequency e.g. 2.45GHz.

Mistakes can be cleared with the [Clr] key. The cal factor for that frequency will be displayed on the upper portion of the screen.

Use [Exit] to close the dialog box.

Connect the power sensor to the WLAN device under test.

Setting up the trigger

In many instances, the exact length of the frame and the off time period are not known. This procedure will help find the optimum trigger and capture time settings.

Many WLAN test signals contain very short off periods and if the modulation is set to QAM then the signal contains many rising edges that can fool the trigger settings on a conventional power meter. The ML248XA contains a special frame arming trigger setting which works as a two stage detection system to detect the off period of the frame signal.

1. The frame arming checks that the power level is below the set level for the test time. If this is true then the trigger is armed ready for the next rising edge. The test time and level are set by the user to suit the pulse conditions.
2. The trigger is activated on the next rising edge, which is the start of the WLAN frame.

Once the trigger conditions have been set then the capture time can be set to find the length of the frame.

802.11a example

An 802.11a WLAN card is set up in a test mode. The frame timings are unknown.

Setting up the trigger and frame arming.

Press **Channel**

Then press **Trigger**, **Setup**

Change [Source] from **Cont** to **Internal**

Use the down arrow to select [Arming] and change the Arming from **Automatic** to **Frame**

Use the down Arrow to select [Frame Duration] and after pressing [Sel] enter a time of 2 μ s.

Close the dialog box by pressing [Exit].

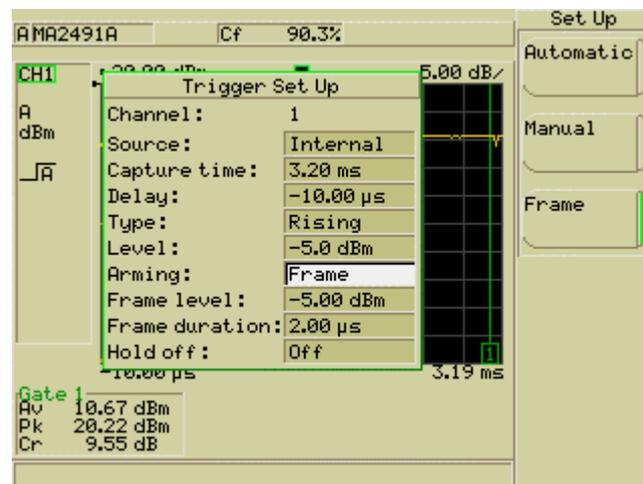


Figure 2. Trigger Set up Menu

Now exit the dialog box and set the Set Capture Time to 20 μ s and the Trigger Delay time to -10 μ s. A -ve value for the delay time will show data before the trigger event and acts as pre-trigger information.

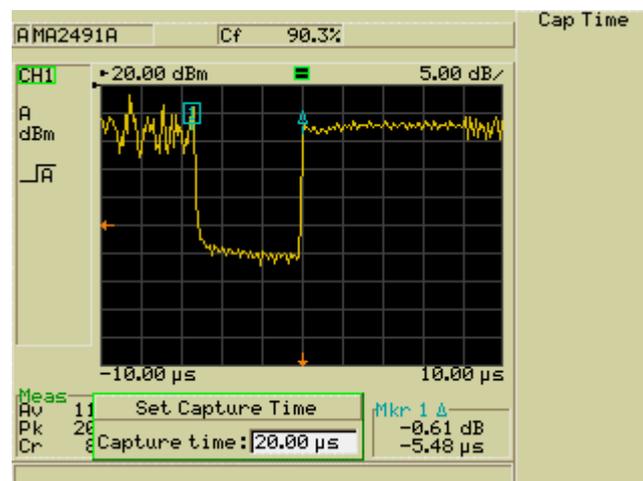


Figure 3. Off Period of 802.11a test signal

Once the trigger has been set, the trigger capture time can be set to a longer time period to see the whole frame. In this example the off period only lasted for approximately 5 μ s, so 2 μ s was a good value to try for the frame arming value. If the Power Meter is not successfully triggering then the error message **Chan 1 -No trigger** is displayed.

The red arrows on the display show the trigger level and the trigger position. The trigger and frame arming test levels should be set to suit the output power of the device under test and the power meter range.

If the scaling factor on the display needs changing then use the scaling keys.

Press **Channel**, **More**, **Scaling**

Autoscale can be used to automatically scale the Y axis of the display.

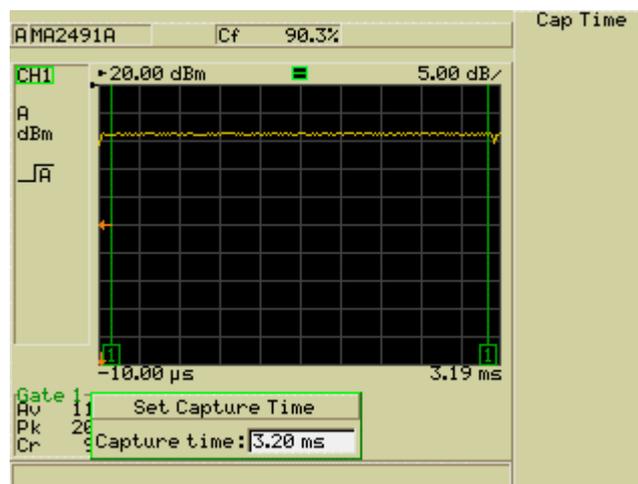


Figure 4. Capture time set to see the whole frame

To set up a Gate to measure the power in the frame

Press **Channel** and then **Gating**, **Set Up**.

The Gating Set Up dialog box appears, see figure 5. Use the up/down and left right keys to navigate in the fields of the gate dialog. Use [Sel] to enter the time values. Timing reference is set from the trigger point.

Press **Enabled** to switch the gate on. Press **Set as Active** to enable the display of the measurement on the screen. The Fence excludes a section of the frame from the calculation of the average and peak power. For WLAN applications you do not need to set a fence.

In this example the gate start was set at 100 μ s and the stop at 3.1 ms as the frame was slightly longer.

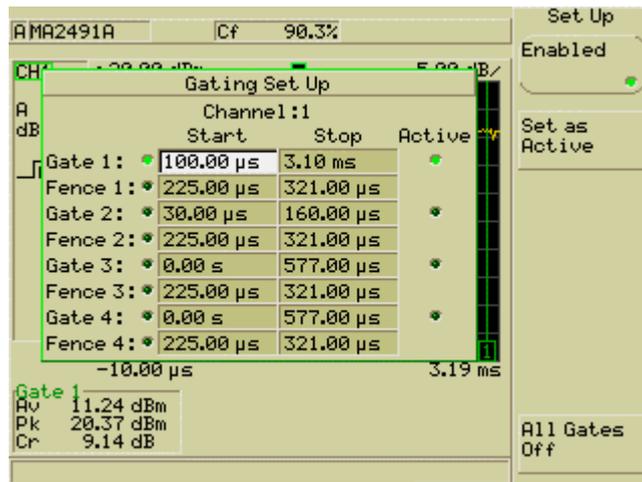


Figure 5. The Gating Set Up Dialog Box

After Gate 1 has been set and enabled then the display should now look like this.

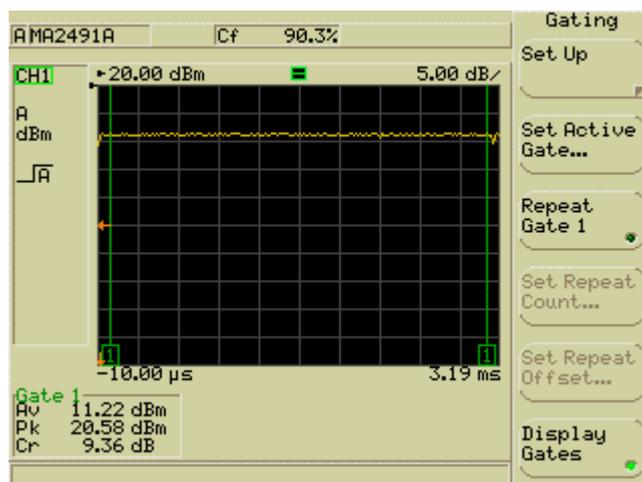


Figure 6. 802.11a Frame showing Average, Peak and Crest Factor display

As an alternative the average, peak and crest factor results can be displayed on their own without the graph.

To do this select **Channel** and then **Set Up**. Move down to [Meas Display] and select **Readout**.

See Figure 7.

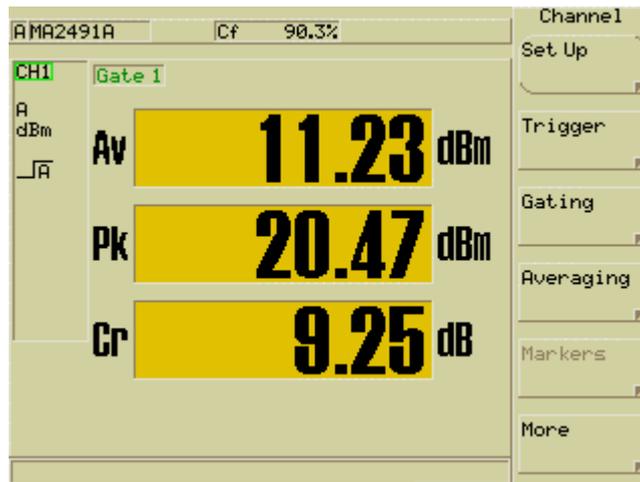


Figure 7. Readout Mode for 802.11a example

This set up can now be saved as a setting store.

Saving Settings

Press **System** , **Save/Recall** and then **Save Settings**. Select the store and use **Save as** to save for the first time. The numeric keypad can be used to title the store settings. Use the **Next** key to set consecutive letters that are on the same key. For example 'adg' can be set directly by pressing keys 8,9,4 , but to set 'abc' requires 8, **Next** , 8, **Next** , 8.

Press **Enter** when finished, this will store the setting.

Setting an Offset

If the peak power is above +20dBm then an external attenuator should be used to keep the peak power in the operating region of the diode sensor.

To set an offset press **Sensor** and then **Offset** . Select **Fixed** and use the down key to select **[Offset]**. Enter the value of the attenuator directly as a positive value. E.g. a 10.56dB attenuator should be entered directly as 10.56.

The power meter will now automatically correct for the value of the attenuator, giving the true power reading at the test port which is the input to the attenuator.

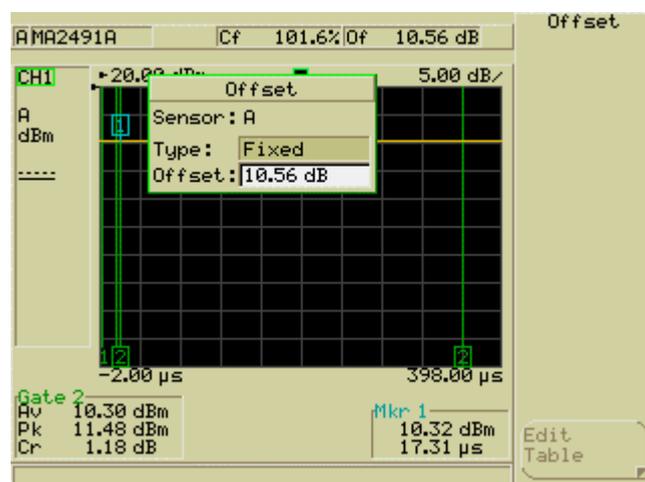


Figure 8. Entering the offset value

802.11g example

In this example an 802.11g signal with 54Mb/s, 64QAM will be measured.

Both g and a frames include a BPSK modulated 16 μ s preamble/training sequence and an 8 μ s header at the start of each frame. The training sequence has a relatively low crest factor and is suitable for use as calibration points for the power control loop in the WLAN transmitter.

Use the same trigger set up method as the previous example, the lower data rate 802.11a signal. Set the frame arming duration to arm the trigger during the brief off period.

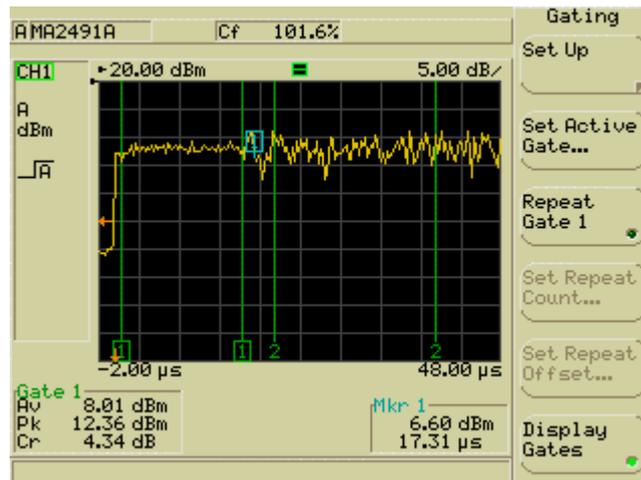


Figure 9. The start of an 802.11g frame showing the 16 μ s preamble sequence

To set two gates up, go to the gate menu (**Channel**, **Gating**, **Set Up**) and enable two gates.

Set the gate 1 to measure the 16 μ s preamble and gate 2 to measure the power in the data section of the frame. The crest factor in the data section should be much higher, typically about 10dB.

To change which results are displayed on the screen, use the **Set Active Gate** key to change the active gate. The active gate on the screen has boxes around the number.

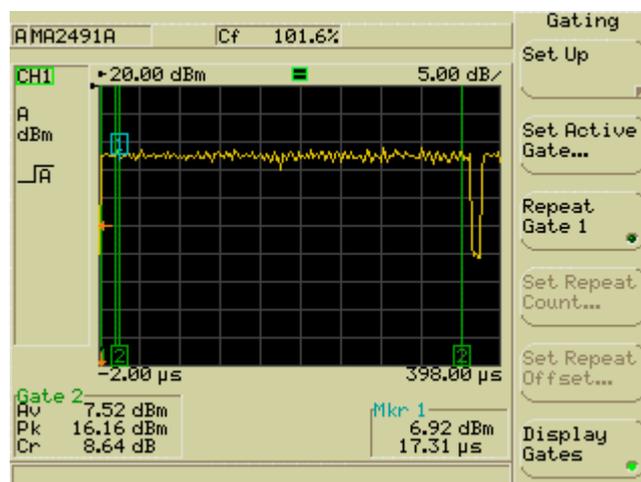


Figure 10. 802.11g Test Frame, showing two enabled gates. Gate 2 is active.

GPIB Tips

Once the settings for the signal set up have been determined then the process of automating the test can start.

Most manual operations have a GPIB command counterpart and in some cases there are additional GPIB commands which help simplify the measurement process.

For example

To calibrate the sensor use the SNCAL A command.

One area where the GPIB offers an enhancement over the display interface is the simultaneous output of measurements from all Gates.

The GPMO command will return the data on all enabled gates.

GPMO 1 Requests the output from all enabled gates on Channel 1

This would return a string for a 2 gate measurement in this format.

GPMO 1,2,3,1,PA,-10.226,PK,-4.873,CF,5.353,2,PA,-10.227,PK,-5.283,CF,4.944

This lists:

The channel no, the no. of gates, the type of measurement (3= Peak, Average and crest), the data values for each gate. (PA= Average Power, PK=Peak Power, CF= Crest Factor)

Readout mode is faster over the GPIB, and the display update can be turned off with the SYDISP command.

Setting stores can be output over the GPIB using the NVOOUT command and then re sent to other power meters over the GPIB using the NVLOAD command. This allows the settings to be determined on one instrument and then copied to other power meters.

For more details on GPIB commands see the ML248XA Wideband Peak Power Meter Remote Programming Manual.

How the Peak Power Meter Display works

The ML248XA profile mode plot uses 200 points as a default setting. The AD converter is running at up to 64Ms/s, the data going directly into a buffer. This data then has to be compressed so that it can be displayed on a 200 point display.

The measurement data is split into 200 display ordinates. For each display ordinate the average, the maximum and minimum of the raw samples is calculated, measured and passed over to the display trace memory. So the display trace memory has three values for each display point, the average, the maximum and the minimum. When the Peak Measurement is selected, the peak value is the largest value of all the maximum values stored for all 200 points.

The default setting for the profile display is to display the average power for each display ordinate. The minimum or maximum power for each display ordinate in the profile can be displayed by the following sequence.

Channel, **More** , **Profile Display** .

Four Selections are available. **Avg** (this is the default) , **Min & Max** , **Min** , **Max**

The Measurement calculations for average, peak and crest factor in the gates are not affected by the choice of display parameter.

Figure 11 shows how this works.

Average Profile Display

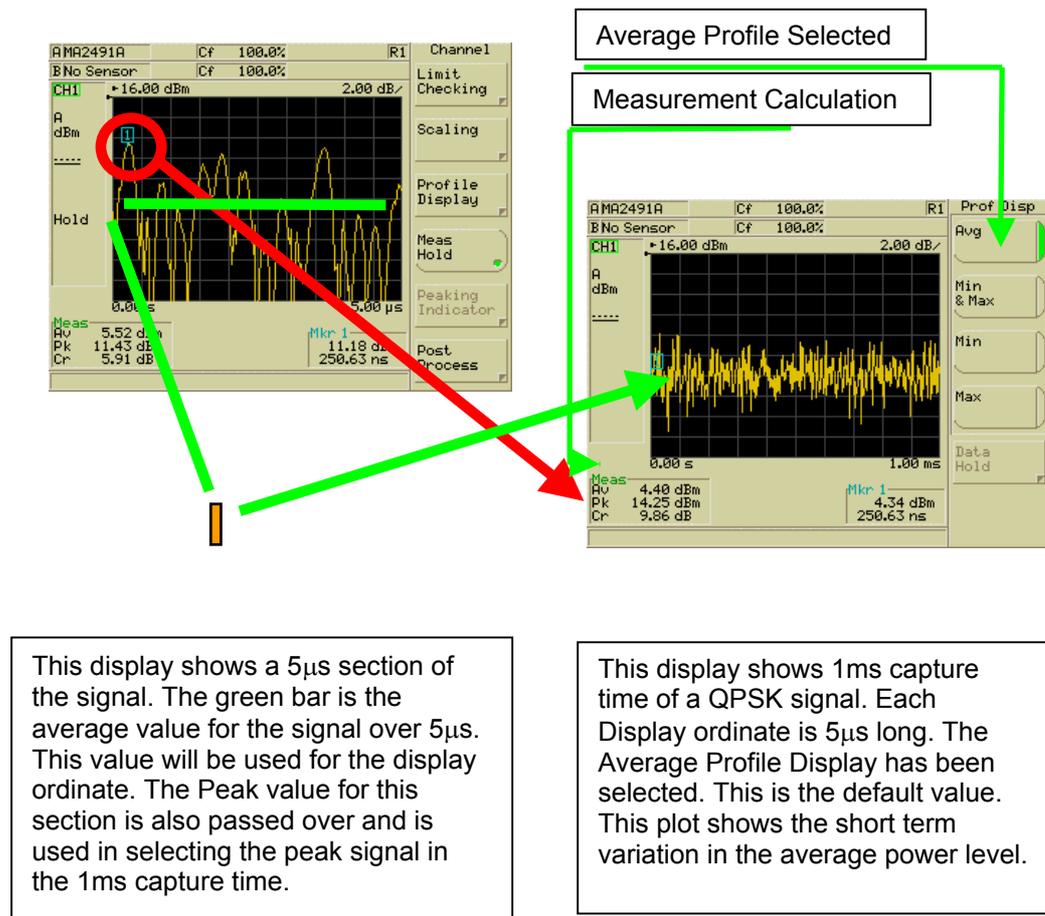
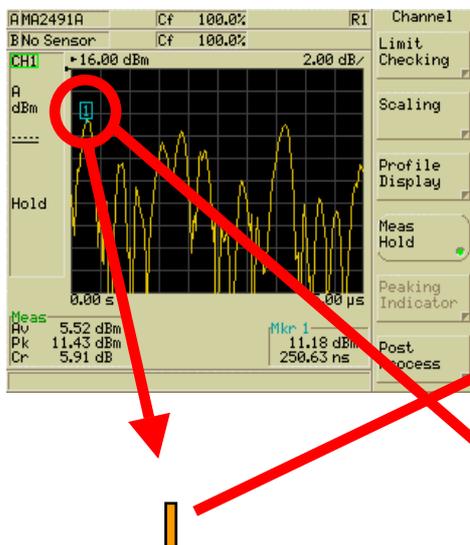
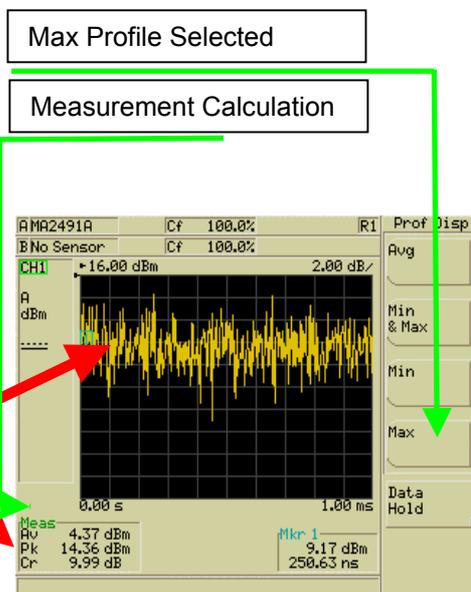


Figure 11. How the Average Profile Display works

Max Profile Display



This display shows a 5µs section of the signal. The Peak signal value for the signal in the 5µs segment value will be used for the display ordinate. The average value for this section is also passed over and is used for the average power calculation.



This display shows 1ms capture time of a QPSK signal. Each Display ordinate is 5µs. The Max Profile Display has been selected. Note the difference in the display compared with figure 11, both measurements have been made on the same signal and are on the same scaling. This display is showing the short term variation in the maximum. The average power has been calculated from the average power values.

Figure 12. How the Max Profile Display works

Further Information

For more information on the ML248XA Power Meter and the MA2490A sensor please contact your local Anritsu sales office or sales representative.

Anritsu

<p>AUSTRALIA ANRITSU PTY. LTD. Unit 3, 170 Foster Road Mt Waverley, VIC 3149 Australia Telephone: +61-3-9558-8177 Fax: +61-3-9558-8255</p>	<p>Brazil ANRITSU ELETRONICA LTDA. Praia de Botafogo 440, Sala 2401 CEP 22250-040, Rio de Janeiro, RJ, Brasil Telephone: +55-21-5276922 Fax: +55-21-537-1466</p>	<p>CANADA 700 Silver Seven Road, Suite 120, Kanata, ON K2V 1C3, Canada Telephone: +1-613-591-2003 Fax: +1-613-591-1006</p>
<p>CHINA ANRITSU BEIJING SERVICE CENTER 416W Beijing Fortune Building 5 Dong San Huan Bei Lu Chao Yang Qu, Beijing 1000004, China Telephone: +86-1186-1065909237 Fax: +86-1186-1065909236</p>	<p>DENMARK Anritsu ab Tonsbakken 10 DK 2740 Skovlunde Denmark Telephone +45-44502160 Fax +45-44502170</p>	<p>FINLAND Anritsu AB Piispanportti 9, FIN-02240 Espoo, Finland Telephone: +358-9-435-522-0 Fax: +358-9-435-522-50</p>
<p>FRANCE 9, Avenue du Québec Z.A. de Courtabœuf 91951 Les Ulis Cedex, France Telephone: +33-1-60-92-15-50 Fax: +33-1-64-46-10-65</p>	<p>GERMANY Grafenberger Allee 54-56, 40237 Düsseldorf, Germany Telephone: +49-211-96855-0 Fax: +49-211-96855-55</p>	<p>HONG KONG ANRITSU COMPANY LTD. Suite 719, 7/F., Chinachem Golden Plaza, 77 Mody Road, Tsimshatsui East, Kowloon, Hong Kong, China Telephone: +852-2301-4980 Fax: +852-2301-3545</p>
<p>ITALY ANRITSU Sp.A Via Elio Vittorini, 129, 00144 Roma EUR, Italy Telephone: +39-06-509-9711 Fax: +39-06-502-24-25</p>	<p>JAPAN 1800 Onna, Atsugi-shi, Kanagawa prefecture, 243-8555 Japan Telephone: +81-462-239794</p>	<p>KOREA ANRITSU CORPORATION LTD. 14F Hyun Juk Bldg. 832-41, Yeoksam-dong, Kangnam-ku, Seoul, Korea Telephone: +82-2-553-6603 Fax: +82-2-553-6604* 5</p>
<p>SINGAPORE 10, Hoe Chiang Road, # 07-01/02 Keppel Towers Singapore 089315 Telephone: +65-282 2400 Fax: +65-282 2533</p>	<p>SWEDEN Anritsu AB Fågelviksvägen 9A 145 84 Stockholm Sweden Telephone: +46-8-74-05-840 Fax: +46-8-71-09-960</p>	<p>TAIWAN ANRITSU CO., LTD. 7F, NO.316, Sec.1 NeiHu Rd., Taipei, Taiwan, R.O.C Telephone: +886-2-8751-1816 Fax: +886-2-8751-1817</p>
<p>UNITED KINGDOM 200 Capability Green, Luton, Bedfordshire LU1 3LU, U.K. Telephone: +44-1582-433200 Fax: +44-1582-731303</p>	<p>UNITED STATES 1155 East Collins Blvd., Richardson, TX 75081, U.S.A. Toll Free: 1-800-ANRITSU (267-4878) Telephone: +1-972-644-1777 Fax: +1-972-671-1877</p>	