

# MT8860C

## WLAN Test Set





Operation Manual

# MT8860C

# WLAN Test Set

The Anritsu logo is located in the bottom right corner of the page. It consists of the word "Anritsu" in a bold, sans-serif font. The letter "A" is stylized with a diagonal slash through it.

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<http://www.anritsu.com>

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- The fault is due to use in unusual environments(Note).
- The fault is due to activities or ingress of living organisms, such as insects, spiders, fungus, pollen, or seeds.

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- In dusty places
- Outdoors
- In liquids, such as water, oil, or organic solvents, and medical fluids, or places where these liquids may adhere
- In salty air or in places where chemically active gases (SO<sub>2</sub>, H<sub>2</sub>S, Cl<sub>2</sub>, NH<sub>3</sub>, NO<sub>2</sub>, or HCl, etc.) are present
- In places where high-intensity static electric charges or electromagnetic fields are present
- In places where abnormal power voltages (high or low) or instantaneous power failures occur
- In places where condensation occurs
- In the presence of lubricating oil mists
- At low atmospheric pressure
- In the presence of frequent vibration or mechanical shock, such as in cars, ships, or airplanes

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产品中有毒有害物质或元素的名称及含量

For Chinese Customers Only YLYB

部件名称	有毒有害物质或元素					
	铅 (Pb)	汞 (Hg)	镉 (Cd)	六价铬 [Cr(VI)]	多溴联苯 (PBB)	多溴二苯醚 (PBDE)
印刷线路板 (PCA)	×	○	×	×	○	○
机壳、支架 (Chassis)	×	○	×	×	○	○
LCD	×	×	×	×	○	○
其他(电缆、风扇、 连接器等) (Appended goods)	×	○	×	×	○	○

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 ×：表示该有毒有害物质至少在该部件的某一均质材料中的含量超出 SJ/T11363-2006 标准规定的限量要求。

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WindML Target License  
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NI Device License  
3-2000-1486



WindRiver USB Runtime License  
2000-1421



# DECLARATION OF CONFORMITY

**Manufacturer's Name:** ANRITSU COMPANY

**Manufacturer's Address:** Microwave Measurement Division  
490 Jarvis Drive  
Morgan Hill, CA 95037-2809  
USA

declares that the product specified below:

**Product Name:** WLAN Test Set

**Model Number:** MT8860C

conforms to the requirement of:

EMC Directive: 2004/108/EC  
Low Voltage Directive: 2006/95/EC

**Electromagnetic Interference: EN61326: 1997 +A1: 1998+A2:2002 A3:2003**

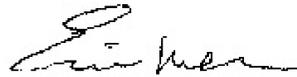
Emissions: EN55011: 1998 +A1: 1999 Group 1 Class A

Immunity: EN 61000-4-2:1995 +A1:1998 +A2:2001 4kV CD, 8kV AD  
EN 61000-4-3:2002 +A1:2002 3V/m  
EN 61000-4-4:1995 +A1:2001 +A2:2001 0.5kV SL, 1kV PL  
EN 61000-4-5:1995 +A1:2001 0.5kV L-L, 1kV L-E  
EN 61000-4-6:1996 +A1:2001 3V  
EN 61000-4-11:2004 100% @ 0.5 cycle

**Electrical Safety Requirement:**

Product Safety: EN61010-1: 2001

Morgan Hill, CA



Eric McLean, Corporate Quality Director

7 Feb 2008  
Date



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## Safety Symbols

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To prevent the risk of personal injury or loss related to equipment malfunction, Anritsu Company uses the following symbols to indicate safety-related information. For your own safety, please read the information carefully *before* operating the equipment.

### Symbols Used in Manuals



This indicates a very dangerous procedure that could result in serious injury or death, or loss related to equipment malfunction, if not performed properly.



This indicates a hazardous procedure that could result in light-to-severe injury or loss related to equipment malfunction, if proper precautions are not taken.



This indicates a hazardous procedure that could result in loss related to equipment malfunction if proper precautions are not taken.

### Safety Symbols Used on Equipment and in Manuals

The following safety symbols are used inside or on the equipment near operation locations to provide information about safety items and operation precautions. Ensure that you clearly understand the meanings of the symbols and take the necessary precautions *before* operating the equipment. Some or all of the following five symbols may or may not be used on all Anritsu equipment. In addition, there may be other labels attached to products that are not shown in the diagrams in this manual.



This indicates a prohibited operation. The prohibited operation is indicated symbolically in or near the barred circle.



This indicates a compulsory safety precaution. The required operation is indicated symbolically in or near the circle.



This indicates a warning or caution. The contents are indicated symbolically in or near the triangle.



This indicates a note. The contents are described in the box.



These indicate that the marked part should be recycled.

## For Safety

### Warning



Always refer to the operation manual when working near locations at which the alert mark, shown on the left, is attached. If the operation, etc., is performed without heeding the advice in the operation manual, there is a risk of personal injury. In addition, the equipment performance may be reduced. Moreover, this alert mark is sometimes used with other marks and descriptions indicating other dangers.

### Warning



or



When supplying power to this equipment, connect the accessory 3-pin power cord to a 3-pin grounded power outlet. If a grounded 3-pin outlet is not available, use a conversion adapter and ground the green wire, or connect the frame ground on the rear panel of the equipment to ground. If power is supplied without grounding the equipment, there is a risk of receiving a severe or fatal electric shock.

### Warning

**WARNING** 

This equipment can not be repaired by the operator. Do not attempt to remove the equipment covers or to disassemble internal components. Only qualified service technicians with a knowledge of electrical fire and shock hazards should service this equipment. There are high-voltage parts in this equipment presenting a risk of severe injury or fatal electric shock to untrained personnel. In addition, there is a risk of damage to precision components.

### Warning



Use two or more people to lift and move this equipment, or use an equipment cart. There is a risk of back injury if this equipment is lifted by one person.

### Caution



Electrostatic Discharge (ESD) can damage the highly sensitive circuits in the instrument. ESD is most likely to occur as test devices are being connected to, or disconnected from, the instrument's front and rear panel ports and connectors. You can protect the instrument and test devices by wearing a static-discharge wristband. Alternatively, you can ground yourself to discharge any static charge by touching the outer chassis of the grounded instrument before touching the instrument's front and rear panel ports and connectors. Avoid touching the test port center conductors unless you are properly grounded and have eliminated the possibility of static discharge.

Repair of damage that is found to be caused by electrostatic discharge is not covered under warranty.

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# Chapter 1 — General Information

## 1-1 About this Manual

This manual provides set-up and operational information for the MT8860C WLAN Test Set. All explanation provided in this manual apply equally to the IEEE802.11b, IEEE802.11g, IEEE802.11a, and IEEE802.11n wireless LAN standards unless otherwise stated.

### Comments on this Manual

Every effort has been made to ensure that this manual is thorough, easy to use, and free from errors. However, to ensure continued improvement, we would welcome your comments on this, or any other Anritsu document.

Please contact us at the address below if you have any comments, good or bad, find any errors or omissions, or have any suggestions on how our documentation could be improved further.

wlan.support@anritsu.com

Your comments will be logged and reviewed, and whenever possible, will be reflected in a subsequent release of the document.

### Software Versions

This manual provides details of the operation and functionality of the following software versions:

MT8860C: 12.0      LANLook: 12.0

Some of the features documented in this manual may not be available to users of software versions prior to those detailed above. Follow the procedure below to check the versions of the software you are using.

1. Start LANLook from the desktop shortcut or by accessing the Windows programs directory and selecting [Anritsu] > [LANLook].
2. Establish a remote connection (GPIB or Ethernet) with the MT8860C. Refer to chapter 5 for details.
3. Select [About Anritsu LANLook] from the LANLook [Help] menu. Check the MT8860C and LANLook version numbers that display in the dialog.

**Note**

A remote connection with the MT8860C is required in order to display the firmware version. The procedure for establishing a remote connection is given in chapter 5.

**Note**

LANLook is provided free of charge on the product CD shipped with the MT8860C. Refer to chapter 3 of this manual for installation details.

## Notification of Software Release

The MT8860C software is periodically updated as new features are added to meet market demands. To receive automatic notification of software releases, send a blank e-mail with the subject heading of "MT8860C Software Notification Request" to wlan.support@anritsu.com. You will receive an e-mail when new software is available to download.

## Associated Documentation

In addition to this manual, the following document is also available on the Product CD shipped with the MT8860C Wireless LAN Test Set.

**Table 1-1.** Associated Documentation

Part number	Document
13000-00259	MT8860C WLAN Test Set Remote Programming Manual

The above document is in pdf format and can be viewed using Adobe Reader™, a freeware program that can be downloaded from <http://www.adobe.com/>.

## Conventions

The following conventions have been adopted in this manual.

**Table 1-2.** Notation Conventions

Item	Convention
MT8860C	The official name of the product detailed in this manual is the MT8860C WLAN Test Set. This name may be shortened to MT8860C throughout this manual.
DUT	The term "DUT" is used to refer to the Device Under Test.
802.11	IEEE802.11 may be shortened to 802.11 throughout this manual.
802.11b/g, 802.11b/g/a/n	Terms such as these may be used when information applies to certain IEEE wireless LAN standards but not to others.
[Anritsu LANLook]	The titles of windows and dialog boxes that appear within LANLook are enclosed in square brackets.
"Ad-Hoc (MT8860C Joins)"	Text that appears in windows or dialog boxes is enclosed in quotation marks when used within a body of text.
"Test Port In/Out"	Text that appears on the MT8860C front or rear panels is enclosed in quotation marks when used within a body of text.
Client software	The term "client software" is used to refer to the software supplied with the WLAN device under test and used to make the mode, connection, and encryption settings for the device.
Test mode software	The term "test mode software" is used to refer to the proprietary software required to control the Tx and Rx operation of the WLAN device under test. This software is supplied by the chipset vendor.

**Table 1-2.** Notation Conventions

Item	Convention
>	A chevron (>) may be used to indicate that the user should select the items or keys in sequential order.
DSSS data rates	This refers to data rates of 1, 2, 5.5, and 11 Mbps.
OFDM data rates	This refers to data rates of 6, 9, 12, 18, 24, 36, 48, and 54 Mbps.

## 1-2 Product Description

The MT8860C is an integrated WLAN test set for testing WLAN devices operating in both the unlicensed Industrial Scientific and Medical (ISM) and 5 GHz frequency bands.

The standard MT8860C is fully compliant with transmitter and receiver testing for both the 802.11b and 802.11g IEEE standards.

Option 14 adds support for 802.11a transmitter and receiver testing.

Option 17 adds support for 802.11n transmitter and receiver testing.

Operation of the MT8860C is controlled from the software packages supplied with the product (LANLook and CombiTest), or from the user's own test program.



**Figure 1-1.** MT8860C with LANLook Software Package

## Option 17

Option 17 adds 802.11n testing capability to the MT8860C. Instruments fitted with option 17 and the MN8861A receiver accessory (sold separately) can perform 802.11n transmitter and receiver testing. Instruments fitted with option 17 but not the MN8861A can perform 802.11n transmitter testing only.



**Figure 1-2.** MT8860C with MN8861A Receiver Accessory

The MN8861A attaches to the “WLAN Reference” input on the front of the MT8860C. It is used to transmit a user-configured 802.11n signal through the MT8860C attenuator to the DUT. Refer to chapter 4 for full details of instrument configurations.

## MT8860C Features

- Two test modes: "Network" and "Direct", allow the user to make both Tx and Rx measurements either with or without a WLAN connection with the DUT.
- Tx and Rx testing of 802.11b and 802.11g standards.
- Tx and Rx testing of 802.11a with the addition of option 14.
- Tx and Rx testing of 802.11n with the addition of option 17.
- Operation in Network mode supports transmitter and receiver testing without use of DUT control software.
- Integrated reference radio for calibrated packet error rate measurements.
- Automatic assignment of DUT IP address using built-in DHCP server.
- Measurement results output to LANLook for graphical and numerical display.
- Supports EVM measurements with constellation diagrams.
- Inputs for external reference radio and interfering signal source.
- Dedicated WLAN signal generator for 802.11b/g/a.
- Supports GPIB and Ethernet remote interfaces.

## Options and Accessories

**Table 1-3.** Options and Accessories

Number	Item
MT8860C-001	Rack mount kit
MT8860C-014	802.11a transmitter and receiver measurements
MT8860C-114	Retrofit 802.11a transmitter and receiver measurements
MT8860C-017 (Option 17)	802.11n transmitter and receiver measurements (Requires MN8861A Receiver Accessory for 802.11n receiver measurement support, sold separately)
MN8861A	Receiver Accessory for MT8860C
MT8860C-117 (Option 117)	Retrofit, 802.11n transmitter and receiver measurements (Requires MN8861A Receiver Accessory for 802.11n receiver measurement support, sold separately)
MT8860C-098	Standard calibration to ANSI/NCSL Z540
MT8860C-099	Premium calibration to ANSI/NCSL Z540 (Test report and uncertainty data)
2000-1548-R	N-type termination plug (6 GHz, 50 $\Omega$ )
2000-1613-R	Bluetooth / dual band WLAN antenna and adapter
2100-2	GPIO cable, 2m
B0329G	Protective cover
2000-1371-R	Ethernet cable
3-806-152	Cat 5E cross-over patch cable
13000-00258	MT8860C WLAN Test Set Operation Manual
13000-00259	MT8860C WLAN Test Set Remote Programming Manual

## Test Methodology Overview

The MT8860C supports two test modes: Network test mode and Direct test mode.

In "Network" test mode, client software is used to control the WLAN device. A network connection between the MT8860C and WLAN device is first established, after which both Tx and Rx testing can be performed.

**Note** Network test mode is not available for testing 802.11n devices.

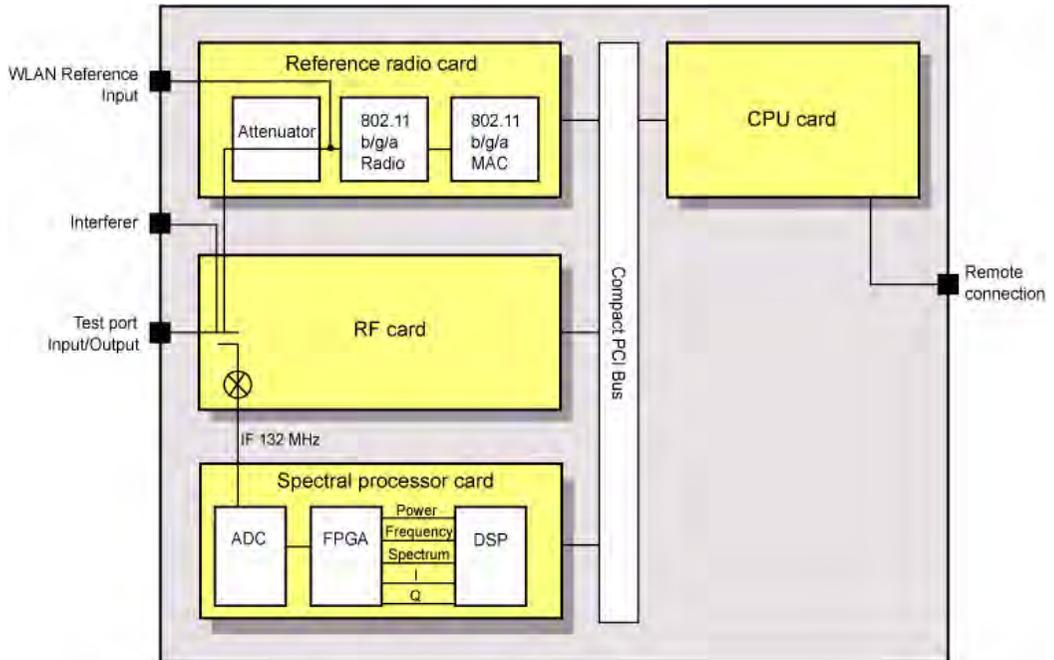
In "Direct" test mode, the test mode software is used to configure and control the WLAN device for Tx and Rx testing without the need to establish a network connection between the MT8860C and WLAN device.

## Technical Overview

The internal structure of the MT8860C is illustrated in the following two figures. The first figure shows the MT8860C with the front panel removed and the four detachable cards visible inside. The second figure is a representation of the interaction and structure of each card.



**Figure 1-3.** MT8860C Internal Structure



**Figure 1-4.** MT8860C Internal Cards

### Reference Radio Card

The reference radio card houses the following three components.

- **Attenuator:** The output from the internal 802.11 reference radio passes through the 80 dB attenuator, allowing the user to set the calibrated signal levels at the test port between 0 and -100 dBm.
- **802.11b/g/a reference radio:** The reference radio provides the correct signal characteristics for receiver testing.
- **MAC:** A WLAN protocol stack enables connection and communication with the DUT using 802.11b/g/a protocol.

### RF Card

The signal from the DUT is fed into the RF/IF card where it is mixed down to an IF of 132 MHz. The RF sample from the attenuator is converted to a suitable IF for AD conversion, and an automatic gain control (AGC) is used to maintain stable input to the ADC and provide a power level signal used in power measurements.

### Spectral Processor Card

The spectral processor card serves the following roles.

- **Analog to Digital Converter (ADC):** The ADC converts the incoming 132 MHz signal to a digital value.
- **Field Programmable Gate Array (FPGA):** The FPGA runs a Pipelined Fourier Transform (PFT), and calculates the power, frequency, spectral content, I, and Q values.

- Digital Signal Processor (DSP): The DSP processes the data from the FPGA to calculate average or peak power and to perform other measurement processing. The output data is then made available to the PC card.

## CPU Card

The CPU card controls all the management functions of the MT8860C. It interprets the commands received over the external interface bus, and formats data for transmission over the bus to LANLook or to the alternative software in use.

## What is LANLook?

LANLook is a PC based software application used to control the MT8860C during testing and graphically display the measurement results. LANLook is supplied as standard with each MT8860C ordered and communicates with the instrument by means of an Ethernet or GPIB interface. The LANLook source code is also supplied and users may wish to use this as a base from which to develop their own program to exactly match requirements.

### Note

It should be noted that all data processing and measurement is performed by the MT8860C. LANLook is simply a tool to configure the test conditions and then read back the measurement results for display.

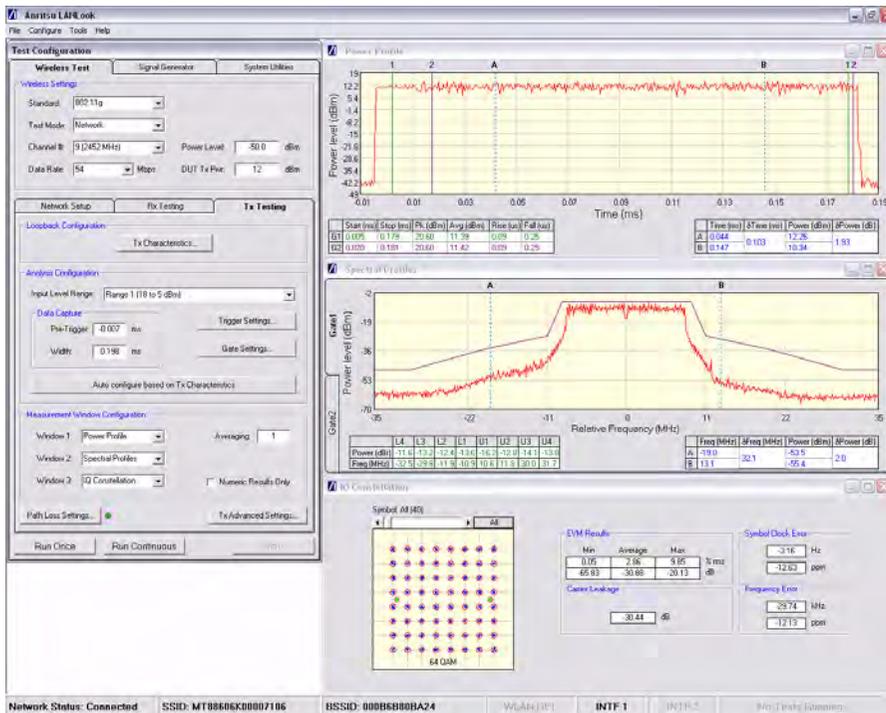


Figure 1-5. LANLook Window Showing Tx Measurement Traces

## LANLook Features

- Performs transmitter and receiver testing with or without a WLAN connection with the DUT.
- Performs testing without the need for user input of remote command strings.
- Configures the MT8860C for testing in an infrastructure or Ad-Hoc connection.
- Monitors measurement results numerically and graphically.
- Runs in either Windows XP or Windows Vista (32 bit) environment.
- Saves traces as image or data files.
- Supplied with source code.
- Provides WLAN signal generator functionality for 802.11b/g/a.

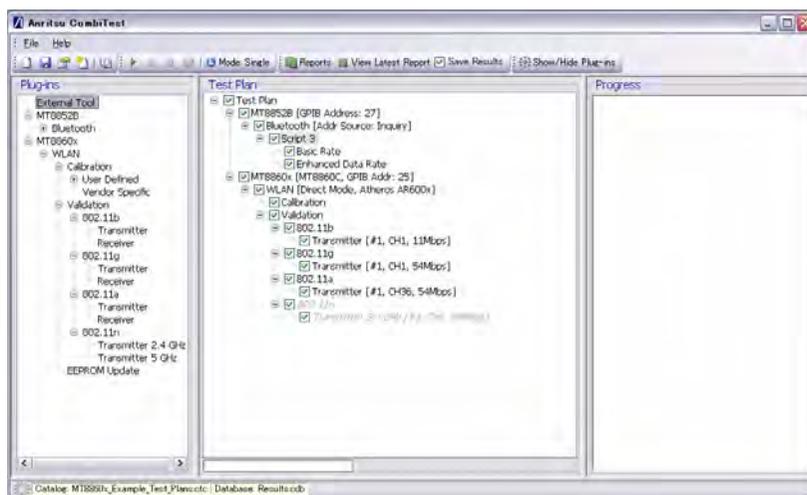
## 1-3 CombiTest

The MT8860C can be used in combination with CombiTest, a powerful PC software application used to remotely control Anritsu WLAN and *Bluetooth* test sets for testing of combo modules incorporating both 802.11 and *Bluetooth* radios.

CombiTest is the ideal tool for design-verification or production testing. It allows users to build a test plan in seconds by simply selecting measurement or calibration tasks from the instrument plug-in and configuring them as required.

When ready, the test plan is executed with a single click and a detailed report of results is output automatically.

CombiTest, and the plug-in for the MT8860C, can be downloaded for free from Anritsu's website. Go to <http://www.anritsu.com/en-gb/products-solutions/products/mt8860c.aspx> and click the [Library] tab. Download the CombiTest software package and the MT8860C plug-in. More information on CombiTest can be found in the CombiTest Product Information Sheet available at the address above. Full instructions are provided in the operation manual available from the CombiTest [Help] menu.



**Figure 1-6.** CombiTest



# Chapter 2 — Preparation for Use

## 2-1 Operating Environment

The MT8860C is designed to function within the temperature range of 5°C to 40°C with a humidity level of <75%, non-condensing.

## 2-2 Power Requirements

The MT8860C is operated from an AC line power. The MT8860C is intended as an Installation (Overvoltage) Category II, Insulation Category I device.

### AC Line Power

The MT8860C operates on AC input power of 85-264V, 47-63 Hz, 100 VA maximum. The MT8860C automatically configures itself for the voltage applied.

### Fuses

The MT8860C AC input line is protected by an externally accessible fuse. This fuse should be replaced only by qualified service personnel, and only with a fuse of the same type and rating (1.25A, 250V, slow blow).

### Grounding

The MT8860C must be properly grounded. Failure to ground the instrument could be hazardous to operating personnel. The instrument is properly grounded during AC line operation when the plug is connected to a properly installed three-prong receptacle.

## 2-3 Unpacking the Product

1. Inspect the shipping container for signs of damage. If the container is damaged, or if the cushioning material shows signs of stress, notify the carrier and your Anritsu Customer Service Center. Retain the shipping materials for inspection.
2. Check the contents of the shipment against the list of shipped items (detailed on the following page). Notify your local sales representative or Anritsu Customer Service Center if anything appears to be missing or damaged. Retain all damaged items for inspection.
3. Check the instrument for mechanical and electrical operation. If the MT8860C is damaged mechanically, notify your local sales representative or Anritsu Customer Service Center.

## Package Contents

Your MT8860C is shipped with the following items. Check that all listed items are present, and contact Anritsu if they cannot be found.

**Table 2-1.** Package Contents

Item	Part number	Quantity
MT8860C		1
Power cable	For US: 800-427 For UK: 800-428 For EU 800-429 For Japan: 1-3566913	1
N-type termination plug (6 GHz, 50 ohm)	2000-1548-R	1
Ethernet cable	2000-1371-R	1
Cat 5E cross-over patch cable	3-806-152	1
Operation manual (hardcopy)	13000-00258	1
Remote Programming manual (hardcopy)	13000-00259	1
Product CD containing :-		1
LANLook software and source code	62157	1
National Instruments VISA run-time engine		1
Ethernet communicator software and source code	70475	1
MT8860C Operation manual (pdf)	13000-00258	1
MT8860C Remote programming manual (pdf)	13000-00259	1

**Note**

The LabView and LabWindows instrument drivers are available for free download from the National Instruments website at the following link.

[http://sine.ni.com/apps/utf8/niid\\_web\\_display.model\\_page?p\\_model\\_id=9940](http://sine.ni.com/apps/utf8/niid_web_display.model_page?p_model_id=9940)

## 2-4 Preparing for Storage

1. Clean the MT8860C prior to storage and pack it using moisture-absorbing desiccant crystals.
2. Store the unit in a temperature controlled environment maintained at between -20°C and 70°C, with a maximum humidity of <75% at 40°C, non-condensing.

## 2-5 Preparing for Shipment

1. Wrap the MT8860C to protect the finish.
2. Position the MT8860C in the original shipping container.

<b>Note</b>	If the original shipping container is no longer available, use a strong corrugated cardboard container that is at least 15 cm larger than the MT8860C.
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3. Insert cushioning material between the MT8860C and the container. Pack the cushioning material tightly.
4. Seal the container carefully; use shipping tape or an industrial stapler.
5. Return the container to the appropriate Anritsu service center. The address of your local service centre can be found at <http://www.anritsu.com/Contact.asp>.



# Chapter 3 — LANLook Installation

## 3-1 Required Operating Environment

The following environment is required to install and run LANLook successfully.

- Intel-based PC with Pentium processor or equivalent.
- Microsoft Windows XP or Windows Vista (32 bit) operating system.
- English, Chinese, or Japanese language environment.
- CD-ROM drive (if installing LANLook from the supplied CD).
- 16 MB RAM minimum.
- PC display settings of 1024 x 768 or greater.
- For GPIB remote interface:
  - National Instruments GPIB interface card (recommended) or GPIB card that is VISA compatible or has NI-488.2 support. (Refer to Appendix B in the Remote Programming Manual for details of the GPIB controller configuration.)
- For Ethernet remote interface:
  - Typically there are four ways in which the MT8860C can be connected to a LAN. Refer to Appendix I for details.

## 3-2 Installation Procedure

**Note**

If using a GPIB remote interface, the GPIB card and drivers must be installed on the PC before installing LANLook.

Previously installed versions of LANLook should be uninstalled before following the procedure below.

1. Insert the Product CD into the drive on the PC. The [MT8860C Applications and Manuals] window displays automatically.
2. Click "LANLook 12.0" in the menu on the left of the window and select "Installation" from the pop-up menu.

3. The “Licence Agreement” dialog displays. Read the agreement and if you agree to the terms select “I agree” and click [Next>].



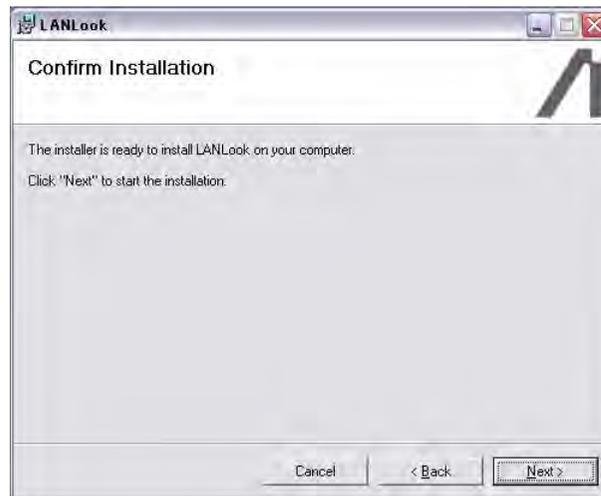
**Figure 3-1.** Licence Agreement

4. A dialog displays to specify the folder for installation. By default, LANLook is installed to C:\Program Files\LANLook. Click [Next>] to install to the specified directory, or click [Browse...] to specify a different location for the installation.



**Figure 3-2.** Install Location

5. Click [Next>] at the “Confirm Installation” dialog to start the installation.



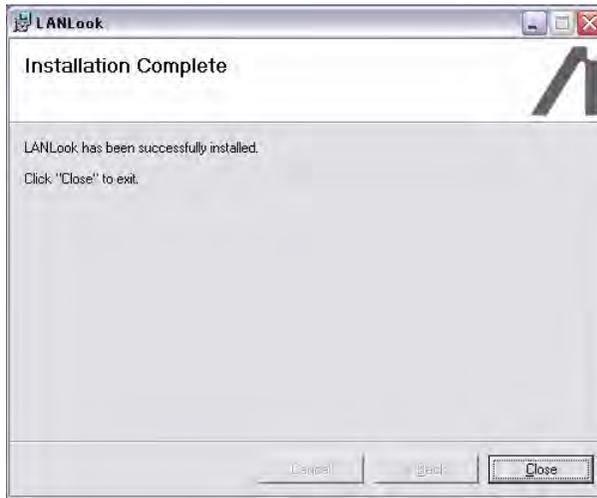
**Figure 3-3.** Confirm Installation

6. The progress of the installation is shown in the dialog below.



**Figure 3-4.** Installing LANLook

7. The dialog shown below displays when the installation is complete.



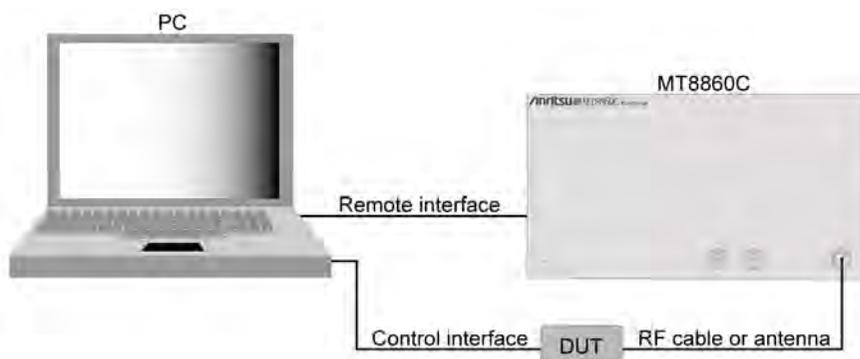
**Figure 3-5.** Installation Complete

**Note**

A message may display during the installation to ask whether the user wishes to overwrite certain .ocx or .dll files. Users are advised not to overwrite any such files.

# Chapter 4 — Instrument Overview

## 4-1 Standard Configuration



**Figure 4-1.** Standard Configuration

Follow the steps below to configure the MT8860C for 802.11b/g/a Tx/Rx testing or 802.11n Tx testing.

**Note**

Refer to the instructions on the following page to configure the MT8860C for 802.11n Rx testing.

1. Install the DUT client software on the PC and configure the channel and operating mode settings in line with the testing requirements.
2. On the PC, set "Wireless Zero Configuration" to "Manual":
  - a. Right-click [My Computer] and select [Manage] from the pop-up menu to display the [Computer Management] window.
  - b. Select [Service and Applications] > [Service] and scroll down to the bottom of the list.
  - c. Double-click "Wireless Zero Configuration", click the [General] tab and set "Startup type" to "Manual".
  - d. Click [Stop] > [Apply] > [OK].
3. Insert the power cable to the rear of the MT8860C (connector L in Figure 4-4) and attach to the mains power supply.
4. Connect the remote interface cable from the rear of the MT8860C to the PC.
  - If using GPIB, connect the GPIB cable from the connector on the MT8860C's rear panel (connector A in Figure 4-4) to the GPIB interface on the PC.
  - If using Ethernet, refer to Appendix I for connection details.

5. Connect an RF cable from the test port on the front of the MT8860C (connector C in Figure 4-4) to the DUT.

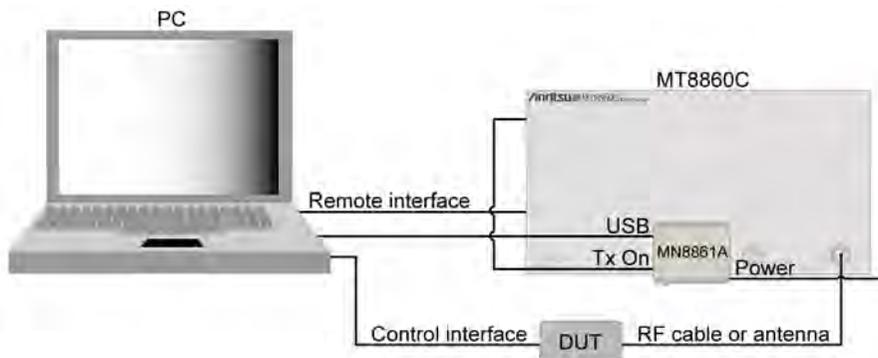
<b>Note</b>	An antenna option (2000-1613-R) is also available as an alternative to an RF cable.
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6. Connect the DUT to the PC using the appropriate interface.
7. Press the power button on the front of the MT8860C. The MT8860C emits a beeping sound to indicate that the internal PC has not located a mouse or keyboard.
8. It takes approximately two minutes for the PC within the MT8860C to boot up. During this time the status of the unit is indicated by the "On" and "Controller Activity" LEDs.
  - a. When the unit is first turned on, both the "On" and "Controller Activity" LEDs are lit.
  - b. After approximately two minutes, the "ON" LED starts to flash with the "Controller Activity" LED still lit.
  - c. The "On" LED stops flashing and turns fully on, and the "Controller Activity" LED turns off.
9. Start LANLook.

## 4-2 Configuration for 802.11n Receiver Testing

Follow the steps below to configure the MT8860C for 802.11n receiver testing.

802.11n receiver testing can be performed on MT8860C units installed with option 17 and fitted with the MN8861A receiver accessory as shown in the figure below. The MN8861A attaches to the "WLAN Reference" input on the MT8860C and transmits a user-configured 802.11n signal through the Test Port to the DUT.



**Figure 4-2.** Configuration for 802.11n Rx Testing

1. Install the DUT client software on the PC and configure the channel and operating mode settings in line with the testing requirements.

2. Install MN8861A control package driver supplied on the option 17 disk. Click "Setup.exe" and follow the prompts that display on screen. If a Windows [Software Installation] warning displays, click [Continue Anyway].
3. On the PC, set "Wireless Zero Configuration" to "Manual":
  - a. Right-click [My Computer] and select [Manage] from the pop-up menu to display the [Computer Management] window.
  - b. Select [Service and Applications] > [Service] and scroll down to the bottom of the list.
  - c. Double-click "Wireless Zero Configuration", click the [General] tab and set "Startup type" to "Manual".
  - d. Click [Stop] > [Apply] > [OK].
4. Attach the MN8861A receiver accessory to the "WLAN Reference" port on the front of the MT8860C. If using the MT8860C in a test rack, attach the MN8861A using the stabilizing bracket provided. Refer to Appendix L for fitting instructions.
5. Insert the power cable to the rear of the MT8860C (connector L in the Rear Panel figure on p4-5) and attach to the mains power supply.
6. Connect the remote interface cable from the rear of the MT8860C to the PC.
  - If using GPIB, connect the GPIB cable from the connector on the MT8860C's rear panel (connector A in the figure on p4-5) to the GPIB interface on the PC.
  - If using Ethernet, refer to Appendix I for connection details.
7. Connect an RF cable from the test port on the front of the MT8860C (connector C in the MT8860C Front Panel figure on p4-4) to the DUT.
8. Connect the DUT to the PC using the appropriate control interface.
9. Connect the Tx On cable from the BNC connector on the left of the MN8861A to the "Digital in 2" port on the rear of the MT8860C.
10. Connect the supplied USB cable from the port on the left of the MN8861A to a port on the PC. If a Windows [Hardware Installation] warning displays, click [Continue Anyway].
11. Connect the supplied power cable from the port on the right of the MN8861A to a mains power source.
12. Press the power button on the front of the MT8860C. The MT8860C emits a beeping sound to indicate that the internal PC has not located a mouse or keyboard.
13. It takes approximately two minutes for the PC within the MT8860C to boot up. During this time the status of the unit is indicated by the "On" and "Controller Activity" LEDs.
  - e. When the unit is first turned on, both the "On" and "Controller Activity" LEDs are lit.
  - f. After approximately two minutes, the "ON" LED starts to flash with the "Controller Activity" LED still lit.
  - g. The "On" LED stops flashing and turns fully on, and the "Controller Activity" LED turns off.
14. Start LANLook and establish a remote connection with the MT8860C.

15. If option 17 is not already installed, select [Option Control...] from the [Configure] menu and enter the option enable code found on the CD label. When entering the option code, set “Instrument/Platform” to “Instrument 1”. Refer to section 5-14 *Options -Enabling and Disabling* for full details.

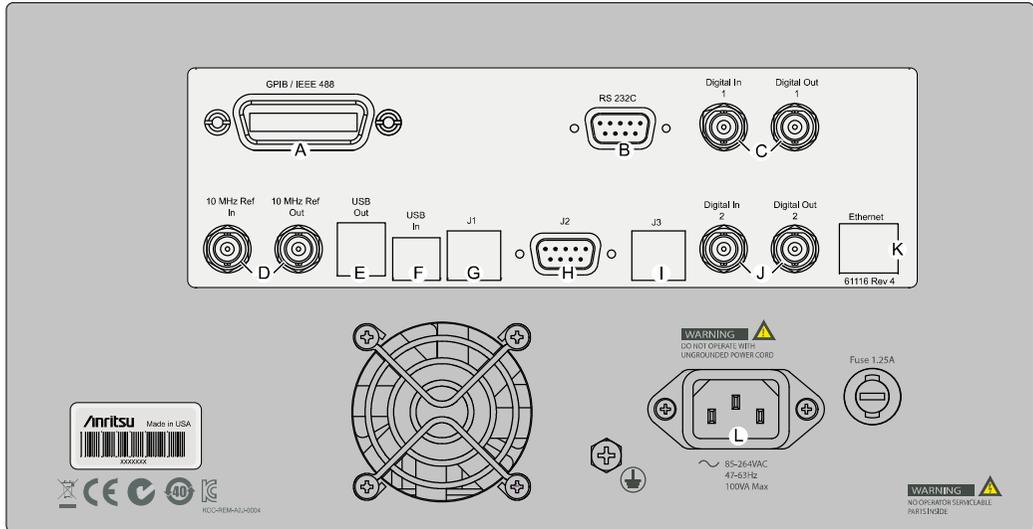
## 4-3 Front Panel Layout



**Figure 4-3.** MT8860C Front Panel

- |   |                          |   |
|---|--------------------------|---|
| A | WLAN Reference Input     | Used for input of an external reference radio.<br><br>When not in use, the WLAN Reference Input should be terminated using the supplied N-type termination plug. This is particularly important when Rx testing is performed with an antenna connection. If the WLAN Reference Input is not terminated, the DUT may detect the signal from the internal reference radio resulting in an erroneous PER result. |
| B | Interferer               | Used for the input of an interference signal when performing receiver adjacent and non-adjacent channel rejection measurements.   |
| C | Test Port Input / Output | Used for connection of the DUT and during use of signal generator mode.   |

## 4-4 Rear Panel Layout



**Figure 4-4.** MT8860C Rear Panel

A	GPIB / IEEE488 connector	Standard General Purpose Interface Bus connector used to connect through GPIB to other test equipment and to a host computer. The MT8860C is compatible with IEEE488.1 and IEEE488.2 requirements.
B	RS232 serial connector	For use in future applications.
C	Digital In / Out 1	Definable digital input and output.
D	10 MHz Ref In / Out	Used for input / output of the external 10 MHz reference signal.
E	USB Out	For use in future applications.
F	USB In	For use in future applications.
G	J1	For use in future applications.
H	J2	For use in future applications.
I	J3	For use in future applications.
J	Digital In / Out 2	Definable digital input and output.
K	Ethernet	Ethernet connector for remote operation.
L	AC main power input	85-264 VAC, 47- 63 Hz, 100 VA maximum. The MT8860C automatically configures itself for the voltage applied. Once connected to the main power the instrument can be switched on using the switch on the front panel.



# Chapter 5 — Remote Connection

A remote connection with the MT8860C can be established using either a GPIB or Ethernet interface.

**Note**

For demonstration purposes LANLook can be run in “Simulation mode” without establishing a remote connection. Simulation mode is activated by default when LANLook is started. A message displays in the LANLook status bar when LANLook is running in simulation mode.

## 5-1 Remote Connection using the GPIB Interface

1. Check that the MT8860C has finished booting up and that the GPIB cable for remote operation is in place between the PC and the MT8860C.
2. Start LANLook and click [System Utilities] tab > [MT8860C Remote] tab.
3. Select “GPIB” at the “Remote Interface” setting as shown in the figure below.



**Figure 5-1.** [System Utilities] Tab for GPIB

4. Select the “Remote Protocol”.  
488.2: Select if using a National Instruments GPIB card.

- VISA: Select “VISA” (Virtual Instrument Software Architecture) to enable use of a non National Instruments GPIB card. Ensure that VISA support has been enabled for the card in use.
5. Click [Scan for Instruments] to acquire a serial number and GPIB address for each of the instruments found on the bus.
  6. Select the required unit from the list and click [Connect].
  7. A connection is established. Check that the connection status reads, “Connection Established”.
  8. Information relating to the GPIB hardware in use can be displayed by clicking [Remote Advanced Settings and Information...] to open the dialog below.



**Figure 5-2.** [Remote Advanced Settings] Dialog

**GPIB Timing:** Users of certain non 488.2 GPIB cards may find that operational difficulties are experienced if the card in question is unable to attain the required operation speed. This can be averted by setting a forced delay in GPIB communication. Select the “Insert delay in GPIB communication” check box and specify the required delay in the entry box below.

## 5-2 Remote Connection using the Ethernet Interface

1. Check that the MT8860C has finished booting up and that the Ethernet cable for remote operation is in place between the PC or hub and the MT8860C.

### Note

If connecting via a hub or switch, connect a standard Ethernet patch cable from the PC to the hub.

If connecting directly to the MT8860C, connect a cross-over patch cable from the PC to the port on the rear of the MT8860C.

Refer to Appendix I for details on setting up the LAN interface.

A VISA installation is required when using LANLook for remote operation over LAN. NI-VISA run-time engine is provided on the MT8860C product CD. Alternatively, visit <http://www.ni.com/support/> for technical support.

2. Start LANLook and click [System Utilities] tab > [MT8860C Remote] tab.
3. Select “LAN” at the “Remote Interface” setting as shown in the figure below.



**Figure 5-3.** [System Utilities] Tab for LAN

### Note

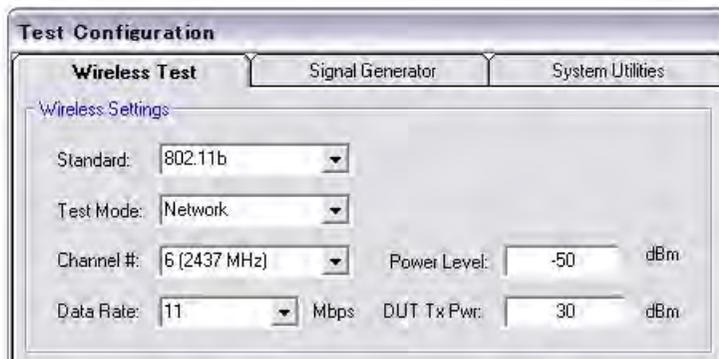
Refer to chapter 14 for information on changing the remote LAN configuration.

Refer to the fault finding section in Appendix I if difficulties are experienced establishing a remote connection.

## 5-3 Test Mode Configuration

With a remote connection established between the MT8860C and the PC as detailed above, the test mode must now be configured.

1. Click the [Wireless Test] tab.
2. The wireless settings display at the top of this tab as shown in the figure below.



**Figure 5-4.** Wireless Settings

The MT8860C supports two test modes:

- Network test mode
- Direct test mode.

### Network Mode

In Network test mode, client software is used to control the WLAN device. A network connection between the MT8860C and WLAN device is first established, after which both Tx and Rx testing can be performed. This mode is also commonly referred to as signalling mode. The following WLAN Standards can be tested in Network test mode:

**Table 5-1.**

WLAN Standard	Additional Comments
802.11b	Tx and Rx
802.11g	Tx and Rx
802.11a	Tx and Rx (option 14 required)

Refer to the following chapters for more information on Network test mode:

- Chapter 6: Establishing an 802.11b/g/a WLAN Connection
- Chapter 7: 802.11b/g/a Transmitter Testing in Network Mode
- Chapter 8: 802.11b/g/a Receiver Testing in Network Mode

## Direct Mode

In Direct test mode, the test mode software is used to configure and control the WLAN device for Tx and Rx testing without the need to establish a network connection between the MT8860C and WLAN device. This mode is also commonly referred to as non-signalling mode.

The following WLAN Standards can be tested in Direct test mode:

**Table 5-2.**

<b>WLAN Standard</b>	<b>Additional Comments</b>
802.11b	Tx and Rx
802.11g	Tx and Rx
802.11a	Tx and Rx (Option 14 required)
802.11n	Tx and Rx (Option 17 required)

Refer to the following chapters for more information on Direct test mode:

- Chapter 9: 802.11b/g/a Transmitter Testing in Direct Mode
- Chapter 10: 802.11b/g/a Receiver Testing in Direct Mode
- Chapter 11: 802.11n Transmitter Testing in Direct Mode
- Chapter 12: 802.11n Receiver Testing in Direct Mode

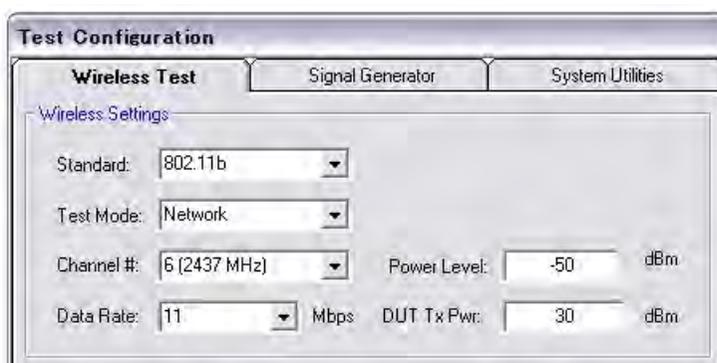


# Chapter 6 — Establishing a WLAN Connection

**Note** As detailed in Chapter 5, a WLAN connection with the DUT is required only when the user has selected “Network” at the LANLook “Test Mode” setting.

## 6-1 Wireless Setup

1. Establish a remote connection between the MT8860C and PC as detailed in chapter 5.
2. Click the [Wireless Test] tab.
3. The wireless settings display at the top of this tab as shown in the figure below.

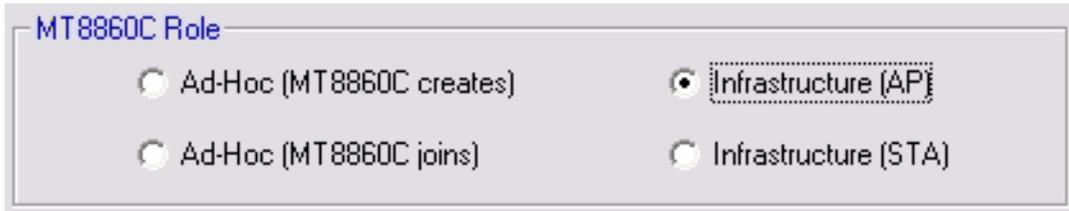


**Figure 6-1.** Wireless Settings

4. At “Standard” select 802.11b, 802.11g, or 802.11a.
5. At “Test Mode” select “Network”.
6. At “Channel #” select the WLAN channel on which measurements will be performed. The supported channels for each WLAN standard are listed in Appendix B.
7. At “Data Rate” select the data rate at which measurements will be performed. The rate can be selected freely from those available but is set by default to the highest rate available in the currently selected IEEE standard (11 Mbps for 802.11b, and 54 Mbps for 802.11g and 802.11a).
8. At “Power Level” specify the “Power Level” that is transmitted by the MT8860C. The value represents the signal level required at the antenna / RF connector of the DUT.
9. At “DUT Tx Power” specify the power that the DUT is expected to transmit. The value represents the signal level at the antenna / RF connector of the DUT.

## 6-2 WLAN Connection with the DUT

In Network mode there are four MT8860C role settings available: two in which a network is created by the MT8860C ('Ad-Hoc (MT8860C creates)' and 'Infrastructure (AP)'), and two in which the MT8860C joins a network already in existence ('Ad-Hoc (MT8860C joins)' and 'Infrastructure (STA)').



**Figure 6-2.** MT8860C Role Settings

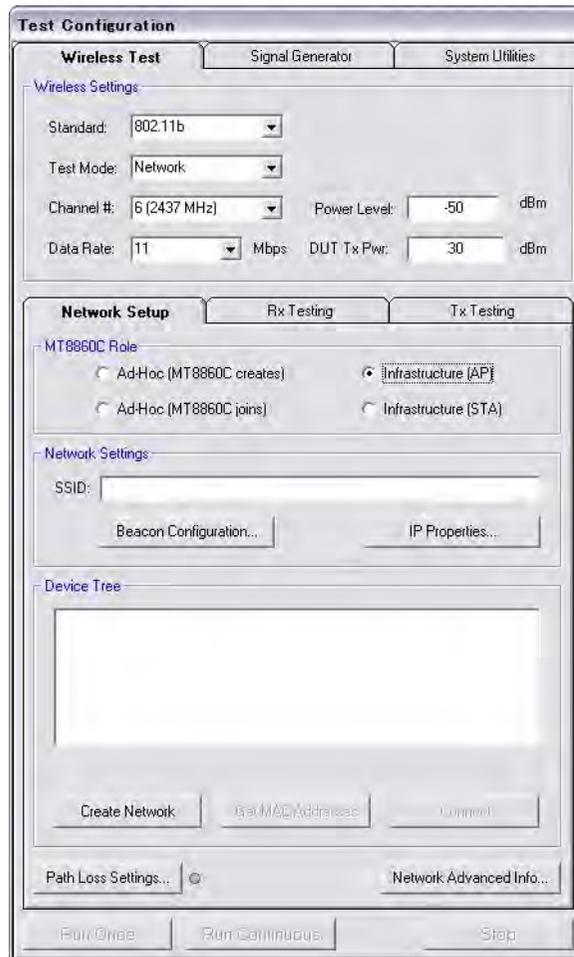
**Note**

Users should note that not all 802.11g/a wireless devices support use of Ad-Hoc mode. When testing 802.11g/a devices Anritsu recommend setting the MT8860C role to one of the infrastructure settings shown on the right in the figure above.

---

**Ad-Hoc (MT8860C creates) / Infrastructure (AP)**

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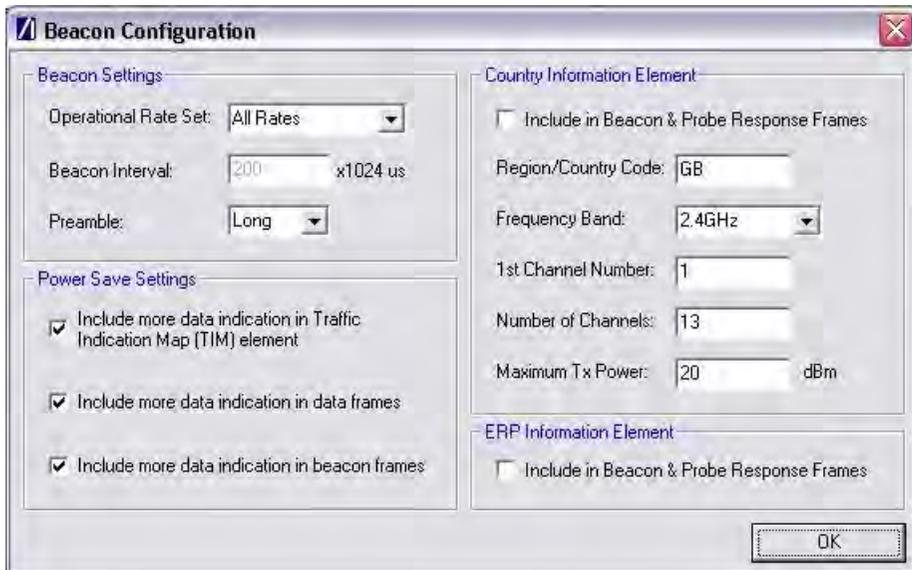


**Figure 6-3.** [Network Setup] Tab

In these modes the MT8860C creates a new WLAN network for the device to join. The difference between the modes lies in the nature of the WLAN architecture. In the “Ad-Hoc (MT8860C creates)” connection there are no access points, in the “Infrastructure (AP)” connection the MT8860C takes on the role of an access point.

1. Click the [Wireless Test] tab and [Network Setup] sub-tab. Select either “Ad-Hoc (MT8860C creates)” or “Infrastructure (AP)” as required.
2. At the “SSID” field, enter a Service Set Identifier for the network to be established. The SSID must be a sequence of no more than 32 letter or numbers. It represents the name of the network to be created and is broadcast to all devices within range.

3. Click [Beacon Configuration...] to display the dialog shown below. Make the required settings as detailed in the table below and click [OK] when complete.



**Figure 6-4.** [Beacon Configuration] Dialog

### Beacon Settings

Operational Rate Set:

This setting is used to select the data rates that the MT8860C is capable of supporting. The three selections (defined below) allow the user to control the data rate table in the beacon management frames. This is particularly useful during transmitter testing in network mode to ensure that data is returned from the DUT at the same rate at which it was sent. By default the DUT will always transmit at the fastest rate in the All Rates table selection. Single Rate selection is recommended if the DUT needs to be tested at rates other than the fastest rate, but the user may need to check whether this or the Multiple Rates setting works best with the DUT.

All Rates: All supported rates are included in the beacon.

Multiple Rates: All rates up to and including the desired data rate are included in the beacon.

Single Rate: Only the desired rate is included in the beacon.

Beacon Interval:

The beacon interval is the amount of time between beacon frame transmissions. The range is 20 to 1000 time units, where one time unit is 1024 microseconds. If the beacon interval is changed the user must press the enter key on the keyboard to enable the new value.

**Preamble:** For data rates of 2, 5.5 and 11 Mbps, long and short preamble options are available. The long setting represents a preamble with 144 bits, and the short with 72. A short preamble setting equates to more payload data being transmitted with each packet for a given timeslot. For 1 Mbps a long preamble is used.

**Note** Preamble settings are not applicable for OFDM data rates.

### Power Save Settings

Many smartphones are configured to enter power save modes when not expecting any more data packets to be sent from the access point. To prevent the DUT entering power save modes during testing, the MT8860C can be configured to state that it has more data to send. Three information bits can be set to indicate that more data is present:

**Include more data in Traffic Indication Map (TIM) element:** When selected, the MT8860C beacon frame TIM Element is configured to indicate that more data is held for the DUT.

**Include more data indication in data frame:** When selected, the 'more data' bit is enabled in the data frames transmitted by the MT8860C.

**Include more data indication in beacon frames:** When selected, the 'more data' bit is enabled in the beacon frames transmitted by the MT8860C.

### Country Information Element

**Include in Beacon & Probe Response Frames:** Select to include the country code information in the beacon.

**Region/Country Code:** Enter a three character region or country code for inclusion in the packet.

**Frequency Band:** Select the frequency band from the drop-down field. Four options are available: 2.4 GHz, 5 GHz Band 1 (5150 to 5350 MHz), 5 GHz Band 2 (5470 to 5725 MHz), or 5 GHz Band 3 (5725 to 5825 MHz).

**1st Channel Number:** Specify the first channel available for use.

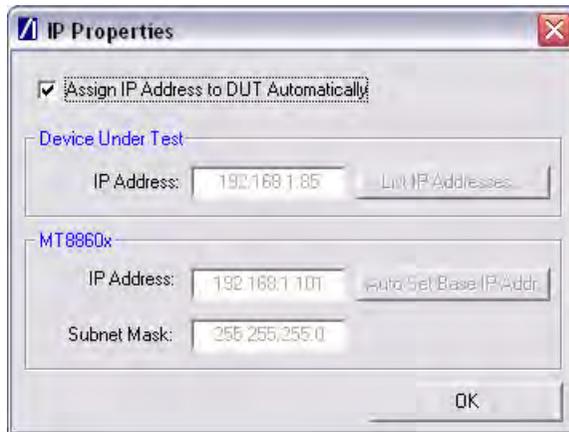
**Number of Channels:** Specify the total number of channels available for use.

**Maximum Tx Power:** Specify the maximum power that should not be exceeded during transmissions from the DUT.

### ERP Information Element

**Include in Beacon & Probe Response Frames:** Select to include Extended Rate Physical (ERP) information in the beacon and probe response frames.

4. Click [IP Properties...] to display the dialog shown below. Make the required settings as detailed in the table below and click [OK] when complete.

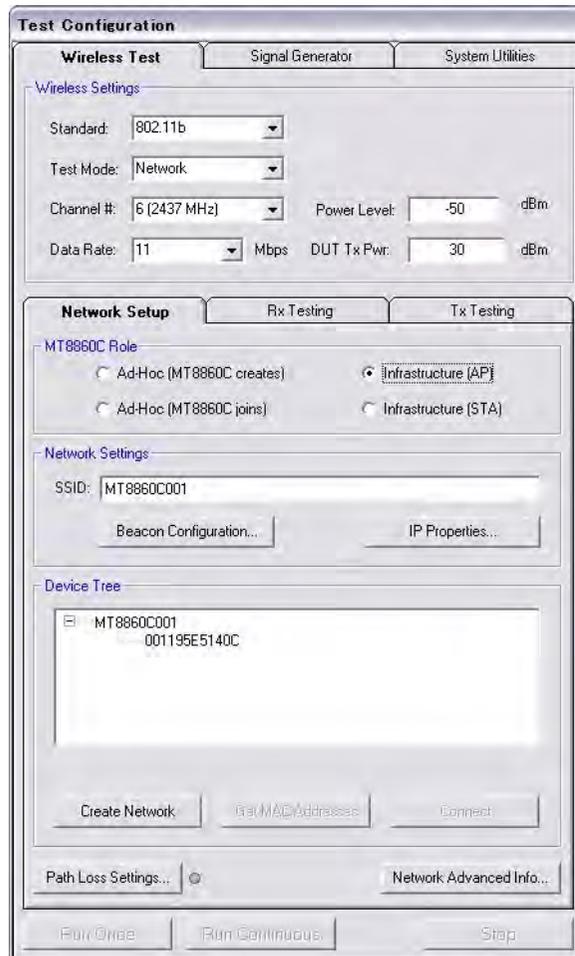


**Figure 6-5.** [IP Properties] Dialog

Assign IP Address to DUT Automatically:	When selected the MT8860C automatically assigns an IP address to the DUT. The assignment process is initiated by the DUT and occurs when a network is established. If the DUT is on a static IP address, the IP properties can be configured manually by clearing this check box. The subnet mask and IP addresses for the MT8860C and DUT can then be entered.
IP Address: (Device Under Test)	Enter the IP address of the DUT. If the address is not known or not currently correct, click [List IP Addresses...] and select the IP address from the list of network devices detected. (Use of [List IP Addresses...] is only possible if the DUT is connected to the same PC as that running LANLook.)
IP Address: (MT8860C)	Specify the IP address of the MT8860C. Ensure that the first three sections of the IP address are the same as those of the DUT IP address (e.g., 192.168.168). If this is not the case, click [Auto Set Base IP Addr.] to reset the address after correctly entering the DUT IP address.
Subnet Mask:	Enter or confirm the subnet mask. The subnet mask is used to determine where the network number in the IP address ends and where the node number begins.

5. If required, a signal level correction table can be used to compensate for test system and cable loss effects. Refer to chapter 13 for details.
6. Press [Create Network] to display the specified SSID address within the “Device Tree” field.
7. Use the client software supplied with the DUT to locate and join the network created.

- When the DUT has joined the network, select the SSID name within the “Device Tree” and click [Get MAC Addresses] to display the MAC address.



**Figure 6-6.** [Network Setup] Tab with MAC Address in Device Tree

9. Select the MAC address and click [Connect] to establish the connection. When a connection is established the word “Connected” appears in the task bar at the bottom of the [Anritsu LANLook] window. The SSID and BSSID also display in the task bar.

**Note** Certain smart phone devices may request specification of a web page as part of the WLAN connection process. If a web page is requested, enter the IP address of the MT8860C (e.g., <http://192.168.1.100>). The IP address can be checked by clicking [IP Properties] on the [Network Setup] tab. When the address is entered, an MT8860C web page displays on the smart phone.

**Note** If “Assign IP Address to DUT Automatically” is selected in the [IP Properties] dialog, an additional progress indicator dialog displays.

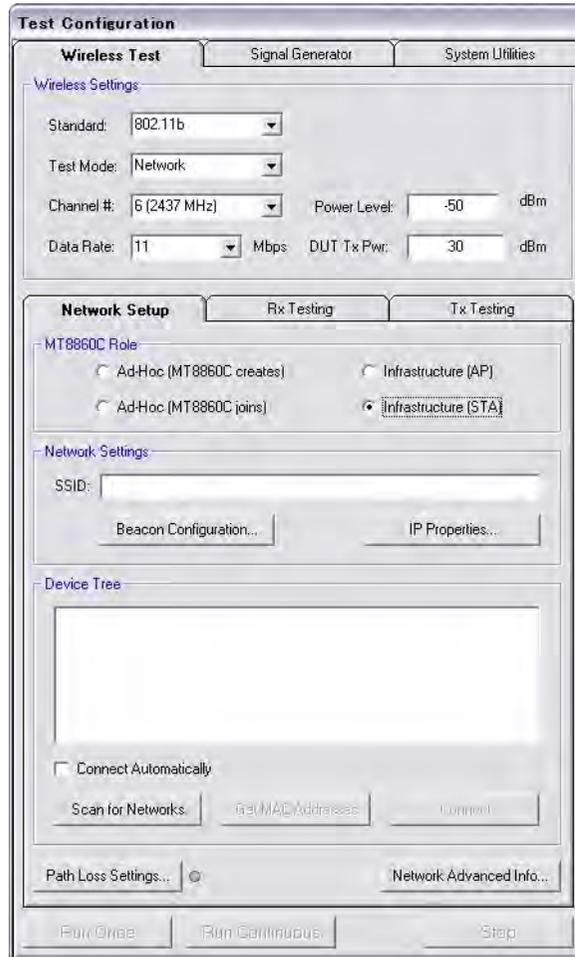


Network Status: Connected    SSID: MT8860C001    BSSID: 000B6B358186

**Figure 6-7.** Task Bar

**Note** The BSSID shown at the right of the task bar above is an address that uniquely identifies each Basic Service Set (BSS). For infrastructure networks, the BSSID is the MAC address of the access point (AP). For Ad-Hoc networks, the BSSID is generated randomly by the station (STA) that creates the network.

## Ad-Hoc (MT8860C joins) / Infrastructure (STA)

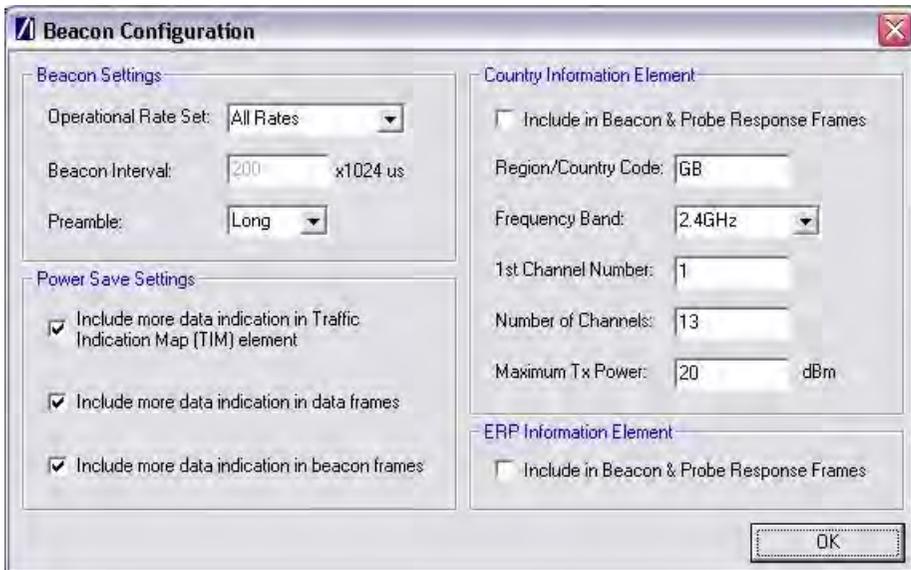


**Figure 6-8.** [Network Setup] Tab

In these modes the MT8860C joins a network created by the DUT. The difference between the modes lies in the nature of the WLAN architecture. In the Ad-Hoc connection there are no access points, in the infrastructure connection the DUT becomes the access point and the MT8860C takes on the role of one of the stations (STA) within the network.

1. Click the [Wireless Test] tab and the [Network Test] sub-tab. Select either “Ad-Hoc (MT8860C joins)” or “Infrastructure (STA)”.

- Click [Beacon Configuration...] to display the dialog shown below. Make the required settings as detailed in the table below and click [OK] when complete.



**Figure 6-9.** [Beacon Configuration] Dialog

### Beacon Settings

**Operational Rate Set:**

This setting is used to select the data rates that the MT8860C is capable of supporting. The three selections (defined below) allow the user to control the data rate table in the beacon management frames. This is particularly useful during transmitter testing in network mode to ensure that data is returned from the DUT at the same rate at which it was sent. By default the DUT will always transmit at the fastest rate in the All Rates table selection. Single Rate selection is recommended if the DUT needs to be tested at rates other than the fastest rate, but the user may need to check whether this or the Multiple Rates setting works best with the DUT.

**All Rates:** All supported rates are included in the beacon.

**Multiple Rates:** All rates up to and including the desired data rate are included in the beacon.

**Single Rate:** Only the desired rate is included in the beacon.

**Beacon Interval:**

The beacon interval is the amount of time between beacon frame transmissions. The range is 20 to 1000 time units, where one time unit is 1024 microseconds. If the beacon interval is changed the user must press the enter key on the keyboard to enable the new value.

**Preamble:** For data rates of 2, 5.5 and 11 Mbps, long and short preamble options are available. The long setting represents a preamble with 144 bits, and the short with 72. A short preamble setting equates to more payload data being transmitted with each packet for a given timeslot. For 1 Mbps a long preamble is used.

**Note** Preamble settings are not applicable for OFDM data rates.

### Power Save Settings

Many smartphones are configured to enter power save modes when not expecting any more data packets to be sent from the access point. To prevent the DUT entering power save modes during testing, the MT8860C can be configured to state that it has more data to send. Three information bits can be set to indicate that more data is present:

**Include more data in Traffic Indication Map (TIM) element:** When selected, the MT8860C beacon frame TIM Element is configured to indicate that more data is held for the DUT.

**Include more data indication in data frame:** When selected, the 'more data' bit is enabled in the data frames transmitted by the MT8860C.

**Include more data indication in beacon frames:** When selected, the 'more data' bit is enabled in the beacon frames transmitted by the MT8860C.

### Country Information Element

**Include in Beacon & Probe Response Frames:** Select to include the country code information in the beacon.

**Region/Country Code:** Enter a three character region or country code for inclusion in the packet.

**Frequency Band:** Select the frequency band from the drop-down field. Four options are available: 2.4 GHz, 5 GHz Band 1 (5150 to 5350 MHz), 5 GHz Band 2 (5470 to 5725 MHz), or 5 GHz Band 3 (5725 to 5825 MHz).

**1st Channel Number:** Specify the first channel available for use.

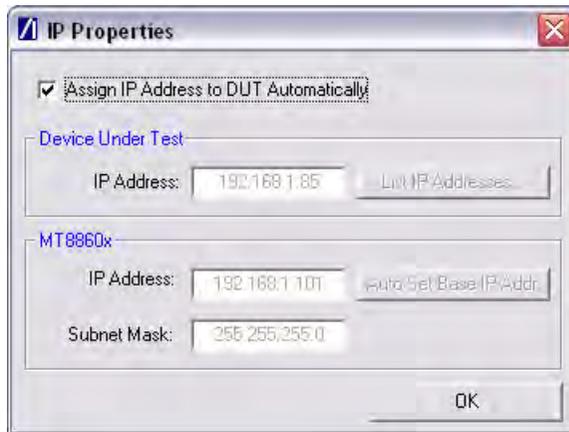
**Number of Channels:** Specify the total number of channels available for use.

**Maximum Tx Power:** Specify the maximum power that should not be exceeded during transmissions from the DUT.

### ERP Information Element

**Include in Beacon & Probe Response Frames:** Select to include Extended Rate Physical (ERP) information in the beacon and probe response frames.

- Click [IP Properties...] to display the dialog shown below. Make the required settings as detailed in the table below and click [OK] when complete.



**Figure 6-10.** [IP Properties] Tab

Assign IP Address to DUT Automatically:	When selected the MT8860C automatically assigns an IP address to the DUT. The assignment process is initiated by the DUT and occurs when a network is established. If the DUT is on a static IP address, the IP properties can be configured manually by clearing this check box. The subnet mask and IP addresses for the MT8860C and DUT can then be entered.
---	---

<b>Note</b>	When the MT8860C Role is configured to Infrastructure (STA), the IP Properties should be configured manually.
-------------	---

IP Address: (Device Under Test)	Enter the IP address of the DUT. If the address is not known or not currently correct, click [List IP Addresses...] and select the IP address from the list of network devices detected. (Use of [List IP Addresses...] is only possible if the DUT is connected to the same PC as that running LANLook.)
---------------------------------	---

IP Address: (MT8860C)	Specify the IP address of the MT8860C. Ensure that the first three sections of the IP address are the same as those of the DUT IP address (e.g., 192.168.168). If this is not the case, click [Auto Set Base IP Addr.] to reset the address after correctly entering the DUT IP address.
-----------------------	--

Subnet Mask:	Enter or confirm the subnet mask. The subnet mask is used to determine where the network number in the IP address ends and where the node number begins.
--------------	--

- Use the client software supplied with the DUT to establish a network at the required transmission rate and on the required channel. The SSID of the network is also specified in the client mode software.

5. Join the network established above using either of the methods detailed below.
  - Select the “Connect Automatically” check box. The MT8860C scans for networks and connects to the first MAC address of the first network that responds. The [Scan for Networks] and [Get MAC Address] buttons are grayed out when “Connect Automatically” is selected.
  - Click [Scan for Networks] to display a list in the “Device Tree” of all addresses found. Select the required network address and click [Get MAC Address]. Double click the MAC address, or select it and click [Connect].
6. When a connection is established the word “Connected” appears in the task bar at the bottom of the [Anritsu LANLook] window. The SSID and BSSID also display in the task bar.



**Figure 6-11.** Task Bar

**Note**

If “Assign IP Address to DUT Automatically” is selected in the [IP Properties] dialog, an additional progress indicator dialog displays.



# Chapter 7 — 802.11b/g/a Transmitter Testing in Network Mode

## 7-1 Test Methodology

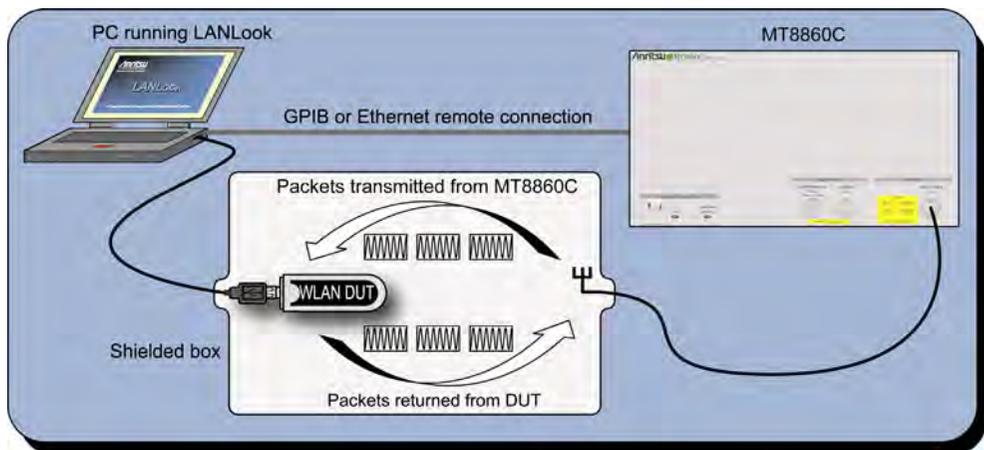
When testing the transmitter characteristics of a WLAN device in Network mode, data frames containing address information that is specific to the DUT are transmitted by the MT8860C. The DUT responds by transmitting frames back to the MT8860C. The frames returned by the DUT are then captured by the MT8860C built-in transmitter analyzer.

The benefit of this method of testing is that the measurement method is greatly simplified and allows any WLAN device to be tested in a mode that closely reflects its native operation. The user is not required to use chipset vendor software to configure the DUT to transmit.

The MT8860C can be configured to capture and analyze data or acknowledgement (ACK) frame types.

### Data Frame Analysis

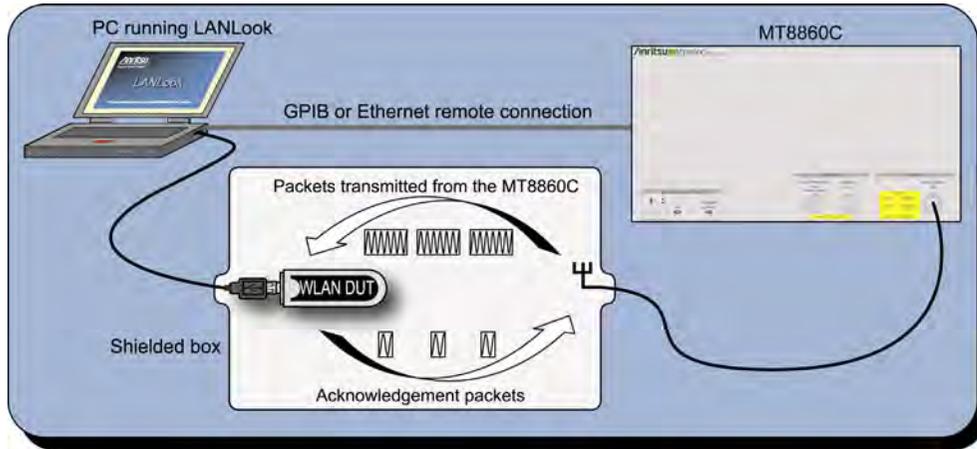
In this configuration, the MT8860C transmits 'ICMP echo request' data packets to the DUT. This packet type contains a control message that instructs the DUT to re-transmit the data received. The 'ICMP echo reply' packets returned by the DUT are then captured by the MT8860C built-in transmitter analyzer. This technique is sometimes referred to as 'Packet Loopback' and allows a complete overview of the power, spectrum and modulation accuracy characteristics of the DUT to be obtained for all data rates.



**Figure 7-1.** Transmitter Testing in Network Mode using Data Frame Analysis

## ACK Frame Analysis

In this configuration, the MT8860C transmits 'Unicast' data packets to the DUT and then analyzes the ACK packets returned by the DUT. This testing methodology is specified by the CTIA and Wi-Fi Alliance in the CWG Test Plan that is used to evaluate the RF Performance of Wi-Fi Mobile Converged Devices.



**Figure 7-2.** Transmitter Testing in Network Mode using ACK Frame Analysis

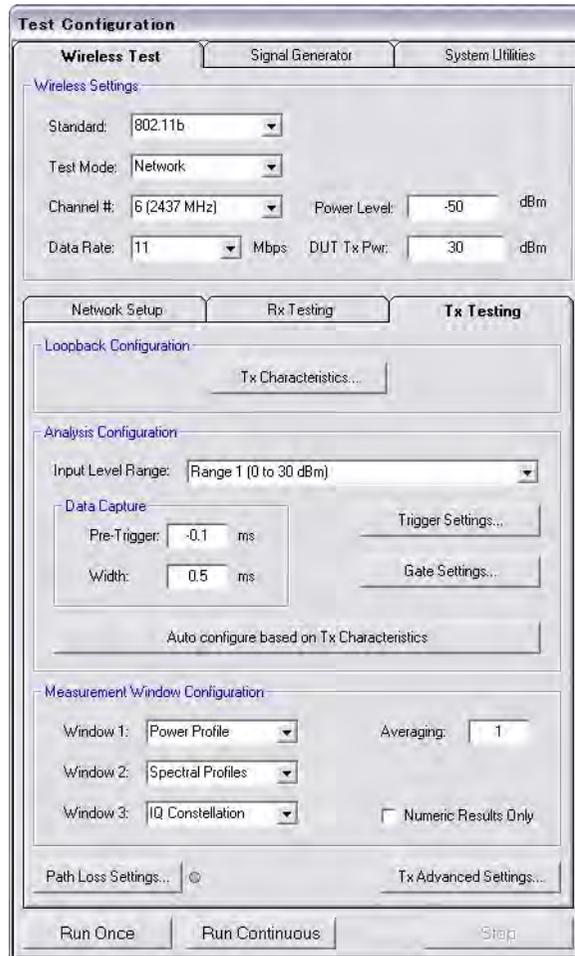
ACK frames are transmitted at the basic data rate at or below the data rate of the received signal. This effectively means that the transmitted data rate from the DUT is 1, 2, 5.5, or 11 Mbps for DSSS rates, and 6, 12, or 24 Mbps for OFDM rates. In addition, as ACK frames have a short time-duration, analysis is limited to the transmitter characteristics shown in the table below.

**Table 7-1.** Transmitter Tests Available During ACK Frame Analysis

DSSS Data Rates	OFDM Data Rates
Average, Peak and Crest Factor Power	Average, Peak and Crest Factor Power
Power-On and Power-Down ramp	Power-On and Power-Down ramp
Spectrum Mask / Mask Segment	CCDF
Occupied Bandwidth (OBW)	
Power Spectrum Density (PSD)	
RF Carrier Suppression	

## Procedure

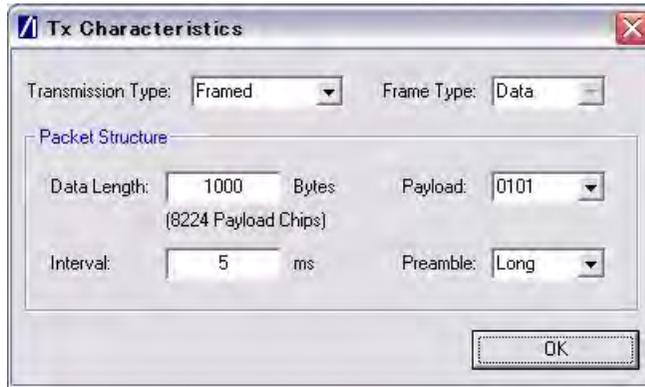
1. Establish a remote connection between the MT8860C and PC as detailed in chapter 5.
2. Establish a WLAN connection between the MT8860C and the DUT as detailed in chapter 6.
3. Click the [Tx Testing] tab shown below.



**Figure 7-3.** [Tx Testing] Tab

## Loopback Configuration

1. Click [Tx Characteristics...] to display the dialog shown below. This dialog is used to specify the expected Tx characteristics of the DUT. The packet structure settings define the data transmitted by the MT8860C which is subsequently looped back from the DUT.



**Figure 7-4.** [Tx Characteristics] Dialog

- Transmission Type:** This function is not applicable in Network Mode. The transmission type will always be framed.
- Frame Type:** Set to “Data” to configure MT8860C for Data Frame Analysis. Refer to page 7-1 for details.  
Set to “ACK” to configure MT8860C for ACK Frame Analysis. Refer to page 7-2 for details.
- Data Length:** If “Frame Type” is set to “ACK”, the “Data Length” must be set to a value between 60 and 1,500 bytes.  
If “Frame Type” is set to “Data”, the maximum and minimum data length is dependent on the data rate as detailed below.

**Table 7-2.** Minimum and Maximum Data Length by Data Rate

Data rate (Mbps)	Minimum data length (bytes)	Maximum data length (bytes)
1	40	600
2	75	1,250
5.5	210	1,500
11	415	1,500
6	50	1,500
9	75	1,500
12	100	1,500
18	145	1,500
24	195	1,500

**Table 7-2.** Minimum and Maximum Data Length by Data Rate

Data rate (Mbps)	Minimum data length (bytes)	Maximum data length (bytes)
36	290	1,500
48	385	1,500
54	435	1,500

**Note**

For DSSS rates, the minimum value equates to 300 us (3300 chips). For OFDM data rates, the minimum value equates to 64 us (16 symbols). The maximum data length values for 1 Mbps and 2 Mbps equate to 5 ms.

- Interval:** The interval specified represents the time between frames transmitted from the MT8860C reference radio to the DUT.
- Payload:** Defines the bit sequence pattern of the dummy data in the payload. There are six options available in the drop down list, ZEROS, 0101, 1010, PN7, RANDOM, and COUNT. The required payload is determined by the test that the user wishes to perform.
- Preamble:** For data rates of 2, 5.5 and 11 Mbps, long and short preamble options are available. The long setting represents a preamble with 144 bits, and the short with 72. A short preamble setting equates to more payload data being transmitted with each packet for a given timeslot. For 1 Mbps a long preamble is used.

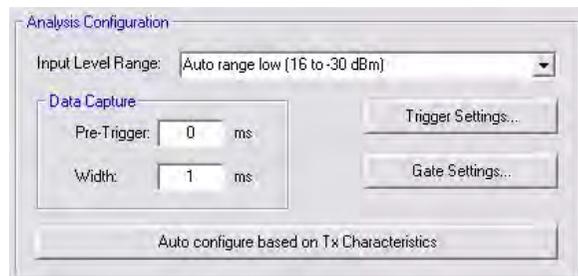
**Note**

Preamble settings are not applicable for OFDM data rates.

## Analysis Configuration

1. Configure the MT8860C as required to allow analysis of the data being looped back from the DUT. Settings can be made in two ways:-

**Manually:** The MT8860C can be configured manually using the “Analysis Configuration” settings.



Refer to steps 2 to 5 below.

Automatically: The Tx analyser settings of the MT8860C can be configured automatically by clicking [Auto configure based on Tx Characteristics].

Auto configure based on Tx Characteristics

When used, all of the settings within “Analysis Configuration” are configured automatically based upon the settings made in the [Tx Characteristics] dialog.

2. Select the power level range at “Input Level Range”.

**Table 7-3.** Input Level Ranges for 802.11b, 802.11g, and 802.11a

	802.11b		802.11g	802.11a
	Low Noise	Low ACP		
Range 1	24 to 11 dBm	20 to 7 dBm	18 to 5 dBm	18 to 7 dBm
Range 1L	12 to 0 dBm	8 to -4 dBm	6 to -6 dBm	8 to -5 dBm
Range 2	1 to -11 dBm	-3 to -15 dBm	-5 to -17 dBm	-4 to -16 dBm
Range 2L	-10 to -24 dBm	-14 to -24 dBm	-16 to -30 dBm	-15 to -26 dBm
Range 3	-23 to -35 dBm	-23 to -35 dBm	-29 to -41 dBm	-25 to -36 dBm
Range 3L	-34 to -55 dBm	-34 to -55 dBm	-40 to -55dBm	-34 to -55 dBm
Auto range low	24 to -24 dBm	20 to -24 dBm	18 to -30 dBm	18 to -26 dBm
Auto range high	24 to -55 dBm	20 to -55 dBm	18 to -55 dBm	18 to -55 dBm

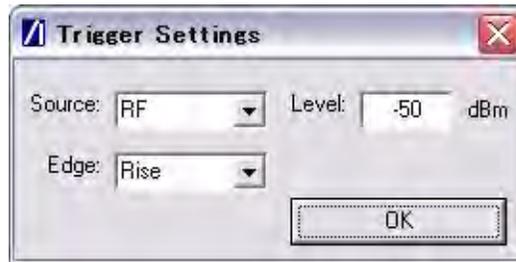
**Note** The user can select “Low Noise” or “Low ACP” by clicking [Tx Advanced Settings...] and selecting the required option on the [Spectral Profile Settings] tab.  
 “Input Level Range” can be set to “Auto Range Low” to prevent damage to the MT8860C input that may be caused when, for example, a sudden power change occurs from range 3 to + 27 dBm.

3. Specify the “Data Capture” settings as detailed below.

**Pre-Trigger:** Enter a value at the “Pre-Trigger” item as required. The “Pre-trigger” item is used to specify the time in milliseconds for which data is captured prior to the trigger point. Enter a negative value between -5.95 and 0.

**Width:** Enter the time period after the pre-trigger during which measurement data is captured. Enter a value in milliseconds within the range of 0.01 to 5.95.

4. Click [Trigger Settings...] to display the dialog below.



**Figure 7-5.** [Trigger Settings] Dialog

**Source:** The trigger source item specifies the mechanism used to trigger measurement within each incoming packet.

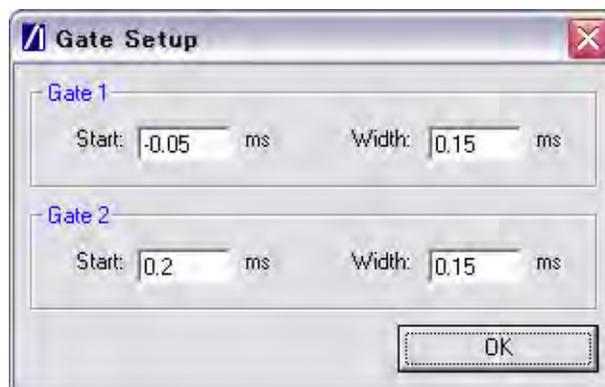
**RF:** Triggering is enabled at the power level specified at the “Level” item.

**Note** There are three other “Source” options available but in Network mode, to ensure analysis is correctly performed on the packet, “Source” must be set to “RF”.

**Edge:** Select whether triggering is performed on the rising or falling edge of the pulse.

**Level:** Specify the power level.

5. Click [Gate Settings...] to display the dialog below.



**Figure 7-6.** [Gate Setup] Dialog

The position of the measurement gates can be defined by entering the start positions and the total gate width.

## Measurement Window Configuration

1. In the “Measurement Window Configuration” frame, select the test results to be displayed in LANLook windows 1 (top), 2 (middle), and 3 (bottom). As shown below, the transmitter tests available differ depending on the selected data rate.

**Table 7-4.** Available Transmitter Tests by Data Rate

DSSS data rates	OFDM data rates
Power profiles	Power profiles
IQ constellation (#1)	CCDF profiles
Spectral profiles	EVM vs Sub-Carrier (#1)
	EVM vs Symbol (#1)
	IQ constellation (#1)
	Spectral profiles (#1)
	Spectral flatness (#1)

(#1) Not supported when MT8860C is configured for ACK frame analysis. Refer to page 7-2 for details.

For Data frame analysis, up to three transmitter measurements can be displayed simultaneously and each of the measurements gives access to a number of different statistics. The user can also select the order in which the individual test result windows display.

For ACK frame analysis, up to two transmitter measurements can be displayed simultaneously and each of the measurements gives access to a number of different statistics. The order in which the individual test result windows display is fixed.

2. At the “Averaging” entry box specify the number of trigger events that are averaged before data is output to LANLook or remote interface.
3. If trace results are not required select “Numeric Results Only” to replace the trace window(s) with a single window of numeric result tables.

## Path Loss Settings

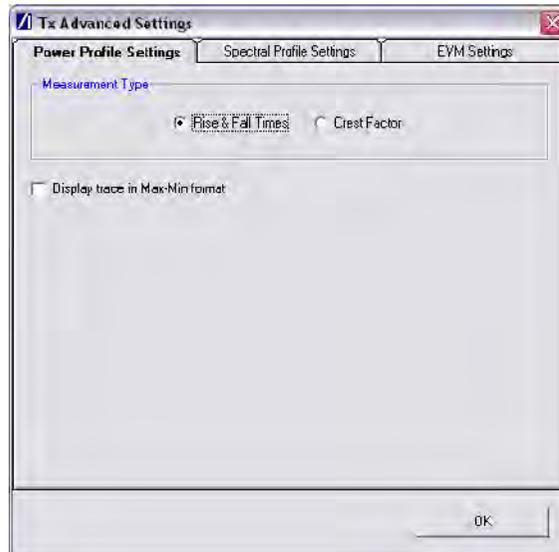
If required, a signal level correction table can be used to compensate for test system and cable loss effects. Refer to chapter 14 (section 14-15) for details.

## Tx Advanced Settings

For Power Profile, Spectrum Profile and EVM related measurements additional configuration settings can be specified. These can be accessed by clicking [Tx Advanced Settings...]

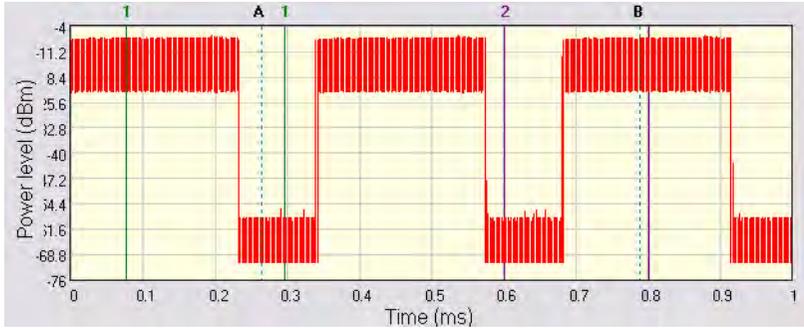
### Power Profile Settings

Click [Power Profile Settings] to display the dialog below.



**Figure 7-7.** Power Profile Settings

- Measurement Type:** When a Power Profile Measurement (see 7.2) is selected, both the Peak and Average power is displayed in a table below the power profile trace. By selecting the Measurement Type to be either 'Rise & Fall Times' or 'Crest Factor', additional rise / fall or crest factor data is included in the numeric results table.
- Display trace in Max-Min format:** When 'Display trace in Max-Min format' is selected, LANLook displays both the maximum and minimum values for each display point on the power profile trace. Each of the maximum and minimum values is joined by a line to give a broad trace such as that shown in the example below

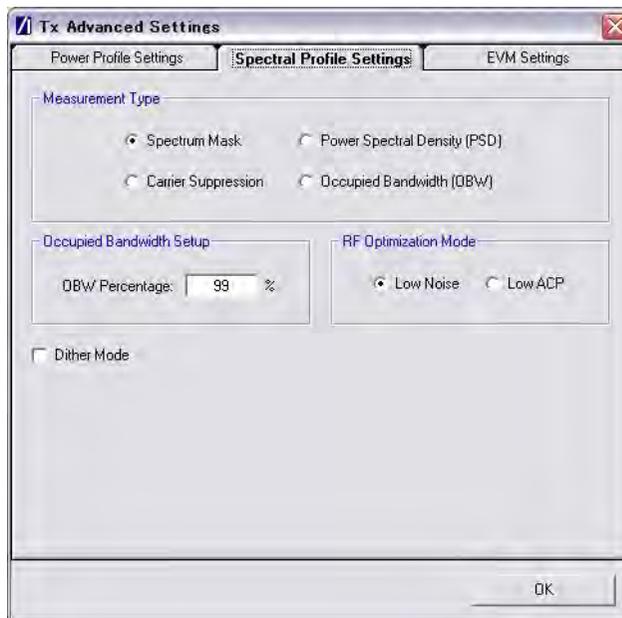


**Figure 7-8.** Max-Min Power Profile

Displaying the max-min data in this way can be useful to monitor the effect that modulation changes between the preamble and payload have on the power level of an OFDM signal.

### Spectral Profile Settings

Click [Spectral Profile Settings] to display the dialog below.

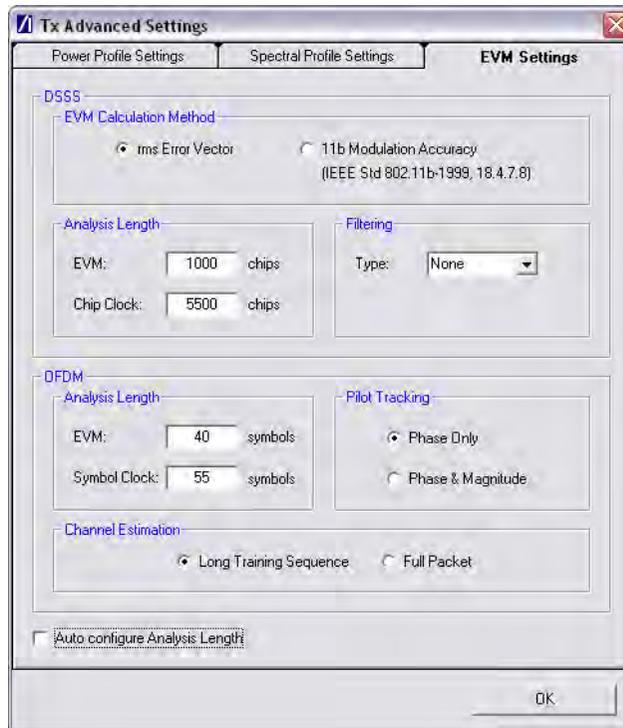


**Figure 7-9.** Spectral Profile Settings

Measurement Type:	Four types of spectral profile data can be individually displayed beneath the spectral profile trace; <ul style="list-style-type: none"><li>• Spectrum Mask</li><li>• Carrier Suppression (DSSS Only)</li><li>• Power Spectral Density (PSD)</li><li>• Occupied Bandwidth (OBW)</li></ul>
Occupied Bandwidth Setup	Set the required power percentage that is to be used when the Occupied Bandwidth Measurement type is selected.
RF Optimization Mode:	Select 'Low Noise' to optimize for signal to noise performance at offsets > 22 MHz from the carrier. This is the default setting. Select 'Low ACP' to optimize for distortion in the adjacent channel.  Note: Only applicable for DSSS data rates
Dither Mode	Dither mode can be used to determine whether spurs in the spectral data are originating from the MT8860C or from the DUT. If generated internally, spurs are removed by making three measurements using differing down conversion offsets.

## EVM Settings

Click [EVM Settings] to display the dialog below.



**Figure 7-10.** EVM Settings

rms Error Vector	The EVM measurement is performed using the 'classic' definition for EVM (rms Error Vector) and is calculated using chips that are transmitted during the PSDU (payload) of the packet.
11b Modulation Accuracy	The EVM measurement is performed using the definition in IEEE Std 802.11b-1999 (18.4.7.8) and is calculated over 1000 chips that are transmitted during the PLCP preamble and header.
Analysis Lengths:	EVM, chip clock and symbol clock measurements are performed over the analysis lengths specified

**Table 7-5.** DSSS and OFDM EVM and Clock Statistics

	Minimum	Maximum	Default
DSSS EVM	220	11000	1000
DSSS Chip Clock	3300	30250	5500
OFDM EVM	16	500	40
OFDM Symbol Clock	16	500	55

Filtering:	Allows the user to specify a filtering type for use during EVM analysis of DSSS modulated signals. Three filter selections are available: <ul style="list-style-type: none"><li>None: No filtering is applied when calculating EVM.</li><li>Gaussian: The Gaussian filter is selected and the user can set the 'BT' value to a value between 0.3 and 1.0 in steps of 0.1.</li><li>Root Nyquist: Root Nyquist (Root Raised Cosine) is selected and the user can set the 'Alpha' value to a value between 0.3 and 1.0 in steps of 0.01.</li></ul>
Pilot Tracking:	For OFDM signals, pilot sub-carriers are used to assist with receiver synchronization. <ul style="list-style-type: none"><li>Phase Only: The demodulation process tracks the pilot phase over the specified EVM analysis length.</li><li>Phase &amp; Magnitude: The demodulation process tracks both the pilot phase and amplitude over the specified EVM analysis length.</li></ul>
Channel Estimation:	For OFDM signals, channel estimation is performed during the initial receiver synchronization process. Long training sequence or full packet channel estimation can be selected.
Auto-configure Analysis Lengths	The analysis length values can be automatically configured by selecting "Auto configure Analysis Length". When selected, the analysis lengths (applicable for the selected WLAN standard) are automatically configured to a valid value when the "Auto configure based on Tx Characteristics" operation is performed.

## 7-2 Running Tests

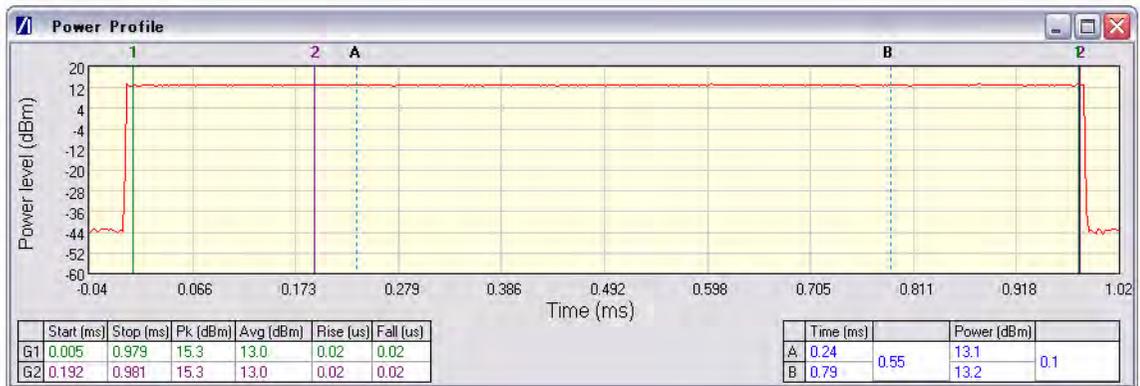
1. Click [Run Once] or [Run Continuous] to display the measurement results within LANLook.
2. Tests can be repeated after changing the “Wireless Mode” settings within LANLook. However, users should understand that the response of the DUT will depend upon the network type selected (infrastructure / Ad-Hoc) and the DUT type (AP / STA). The “Wireless Mode” settings determine the conditions under which the MT8860C performs measurements. The settings are used to configure the internal reference radio and to select the modulation format for EVM analysis. Satisfactory results will not be acquired if the specified conditions do not match those of the DUT transmitter.

Each of the test types available are explained over the following pages.

- Power profile measurements
- CCDF measurements
- Spectral profile measurements
- IQ constellation measurements
- EVM vs sub-carrier measurements
- EVM vs symbol measurements
- Spectral flatness measurements

## 7-3 Power Profile

The power profile utilizes two gates to measure the peak and average power within any section on the trace. The samples within a gate are included in the average and peak power measurements. To see changes in power level due to modulation, a capture time of less than 100  $\mu$ s is required. For longer capture times the displayed data point is an average of all samples within the time period.



**Figure 7-11.** [Power Profile] Window

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
3. Select “Power Profile” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Run Once] or [Run Continuous].

### Peak Transmitter Power

The peak power values display in the “Pk (dBm)” column of the table directly beneath the power profile trace. Peak power is the absolute maximum of the packet within the gate width period.

## Average Transmitter Power

The average values display in the “Avg (dBm)” column of the table directly beneath the power profile trace. The maximum allowable output power is specified by the regulatory body for the region in question. Refer to the table below.

**Table 7-6.** Maximum Transmit Power by Wireless Standard and Regulatory Domain

		<b>US</b>	<b>Europe</b>	<b>Japan</b>
802.11b/g	2412 - 2472 MHz	30 dBm	20 dBm	10 dBm / MHz
	2484 MHz	-	-	10 dBm / MHz
802.11a	5150 - 5250 MHz	16 dBm	23 dBm	10 dBm / MHz
	5250 - 5350 MHz	23 dBm	23 dBm	10 dBm / MHz
	5470 - 5725 MHz	23 dBm	30 dBm	10 dBm / MHz
	5725 - 5825 MHz	29 dBm	-	-
	5825 MHz	30 dBm	-	-

As is the case for all power measurements, the average power is calculated from within the specified gate area only.

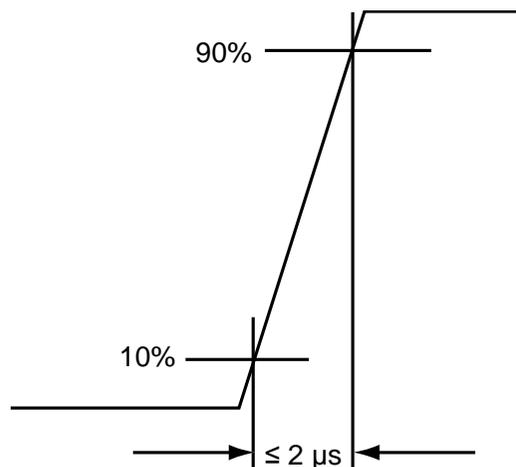
## Transmit Power-On Ramp

The power-on ramp values display in the “Rise (us)” column of the table directly beneath the power profile trace. If the “Rise” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “Rise & Fall Times” from the “Measurement Type” frame.

When making this measurement the entire packet (burst) duration must be contained with the capture period and the measurement gate must be positioned within the burst. The MT8860C locates the rise and fall on either side of the gate.

For IEEE 802.11b, the specification states that the power-on ramp for the region between 10% and 90% of maximum power must not exceed 2  $\mu$ s. This is shown in the figure below.

For IEEE 802.11g / 802.11a the specification does not specifically define any requirements for the power-on or power-down ramps, however, it would be expected that performance would not be worse than that of 802.11b.

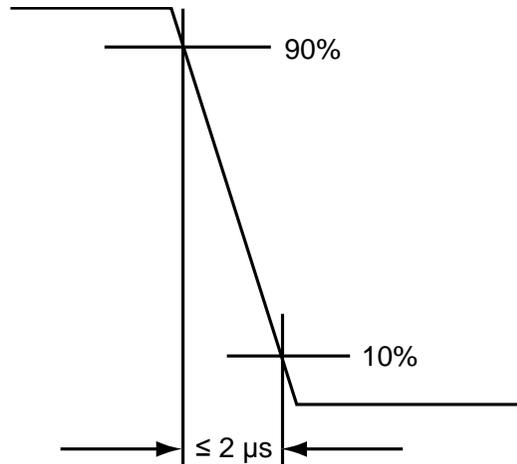


**Figure 7-12.** Transmit Power-On Ramp

## Transmit Power-Down Ramp

The power-down ramp values display in the “Fall (us)” column of the table directly beneath the power profile trace. If the “Fall” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “Rise & Fall Times” from the “Measurement Type” frame.

The IEEE 802.11b specification states that, as shown in the figure below, the power-down ramp for the region between 10% and 90% of maximum power must not exceed 2  $\mu$ s.



**Figure 7-13.** Transmit Power-Down Ramp

**Note**

The minimum capture frame that can be set is 10 $\mu$ s. This is 1  $\mu$ s/division and gives a marker resolution of 0.1 $\mu$ s.

## Crest Factor (OFDM data rates only)

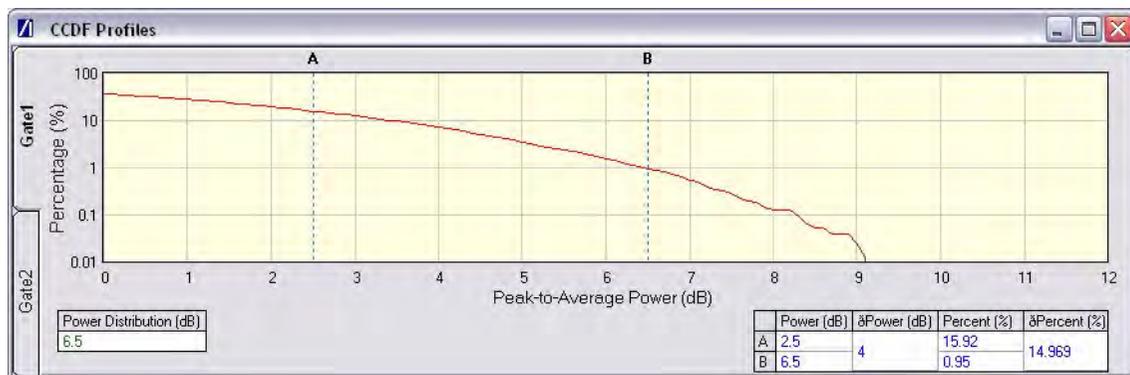
The crest factor values display in the “CF (dB)” column of the table directly beneath the power profile trace. If the “CF” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “CF” from the “Measurement Type” frame.

The crest factor represents the difference in dB between the peak and average power of the signal within the gate.

## 7-4 CCDF Measurements (OFDM Data Rates Only)

The Complementary Cumulative Distribution Function (CCDF) profile allows the user to ascertain the percentage of samples for which the power level specified by the markers is greater than the average power. The profile output contains 120 entries representing the power level (in dB) above the mean in 0.1 dB steps (0-12 dB above the mean). Each entry contains the percentage of time that the signal was less than this number of dB above the mean.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
3. Select “CCDF Profiles” from one of the drop-down fields in the “Measurements” frame.
4. Click [Run Once] or [Run Continuous].



**Figure 7-14.** [CCDF Profiles] Window

## 7-5 Spectrum Profile

The displayed spectrum is a time generated spectrum measurement as defined by gates 1 and 2 in the [Power Profile] trace. Four types of spectral profile data can be individually displayed beneath the profile:

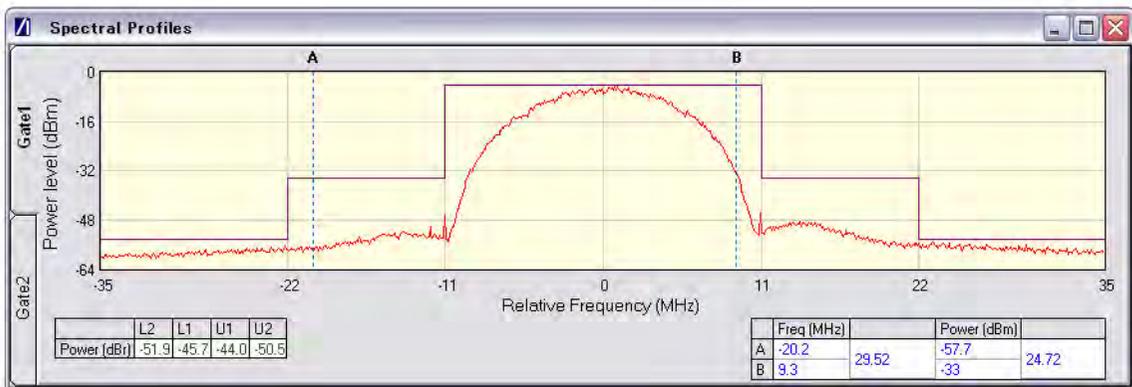
- Spectrum Mask
- Carrier Suppression
- Power Spectral Density (PSD)
- Occupied Bandwidth (OBW)

### Spectrum Mask

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
3. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Tx Testing] tab > [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
5. Select “Spectrum Mask” from the “Measurement Type” frame.
6. Click [Run Once] or [Run Continuous].

The MT8860C applies the spectral mask for the selected WLAN standard. The results tables beneath the trace are used to display the pass / fail status for each of the mask elements. The minimum gate time for spectrum updates is 50 $\mu$ s. Longer gates have more spectrum samples giving the effect of point-to-point averaging.

### 802.11b / 802.11g (DSSS Data Rates)



**Figure 7-15.** [Spectral Profiles] Window with Mask

The figure above shows a typical spectral profile for DSSS data rates.

The “L2”, “L1”, “U1”, and “U2” values that display in the table beneath the spectral profile represent the difference in power level between the maximum point within each segment of the trace and the maximum point of the entire spectrum. The segments on the left side of the trace are, from left to right, “L2” and “L1”. The segments on the right side of the trace are, from left to right, “U1” and “U2”.

### Spectrum mask compliance

The transmitted spectral products must be less than  $-30$  dBr (dB relative to the  $\text{SINx/x}$  peak) for:-

$$f_c - 22 \text{ MHz} < f < f_c - 11 \text{ MHz}; \text{ and}$$

$$f_c + 11 \text{ MHz} < f < f_c + 22 \text{ MHz};$$

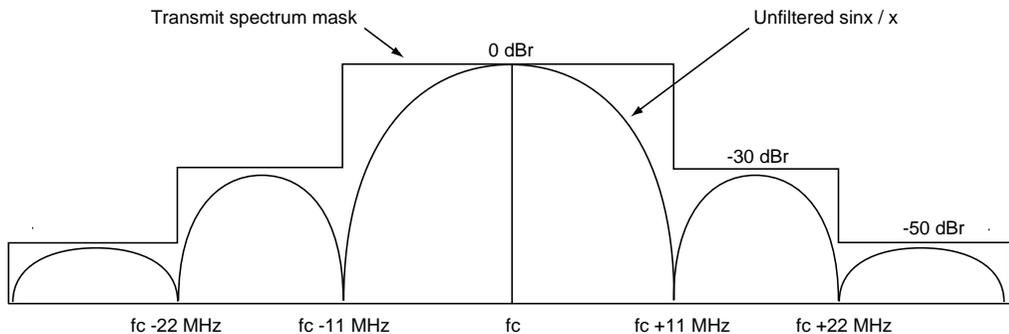
and less than  $-50$  dBr for:-

$$f < f_c - 22 \text{ MHz}; \text{ and}$$

$$f > f_c + 22 \text{ MHz}.$$

Where  $f_c$  is the channel center frequency.

The transmit spectral mask is shown below.

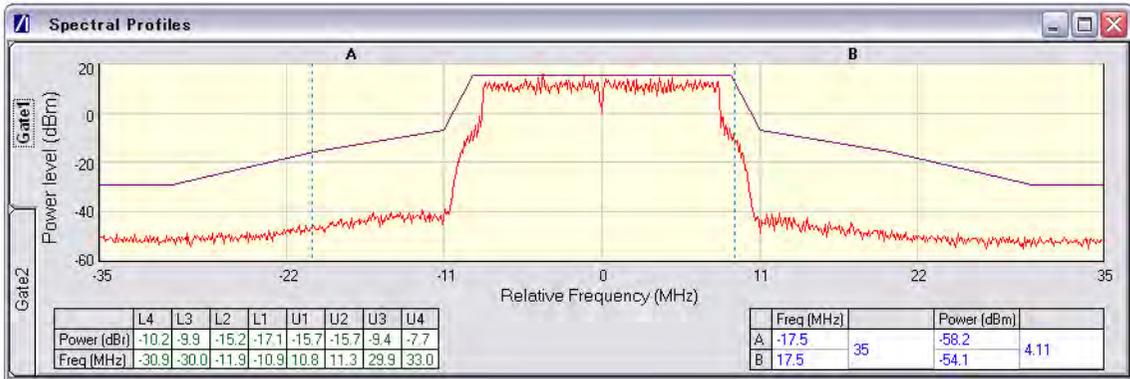


**Figure 7-16.** Spectrum Mask Compliance for DSSS

**Note** Information on how to edit the spectrum mask can be found in chapter 13.

## 802.11g / 802.11a (OFDM Data Rates)

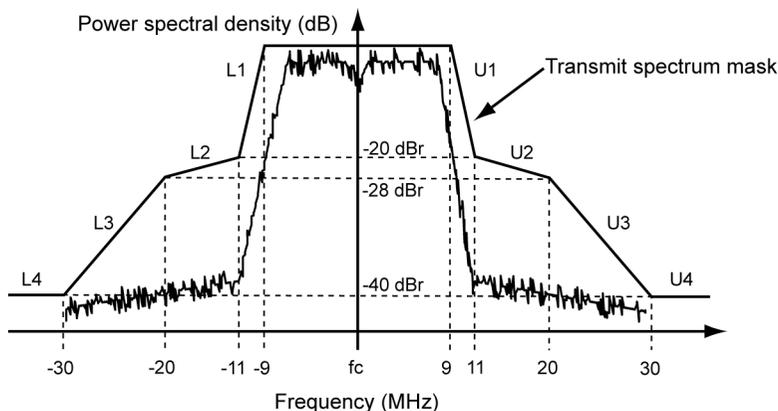
**Note** Not supported when MT8860C is configured for ACK frame analysis. Refer to page 7-2 for details.



**Figure 7-17.** [Spectral Profile] Window

The figure above shows a typical spectral profile for 802.11g / 802.11a. The table below the trace displays the frequency in each of the respective mask sections at which the DUT is closest to the mask or, if the mask is exceeded, the frequency at which the mask is exceeded by the greatest margin.

The transmitted signals must fall within the confines of the mask defined in the figure below.



**Figure 7-18.** Spectral Mask Compliance for OFDM

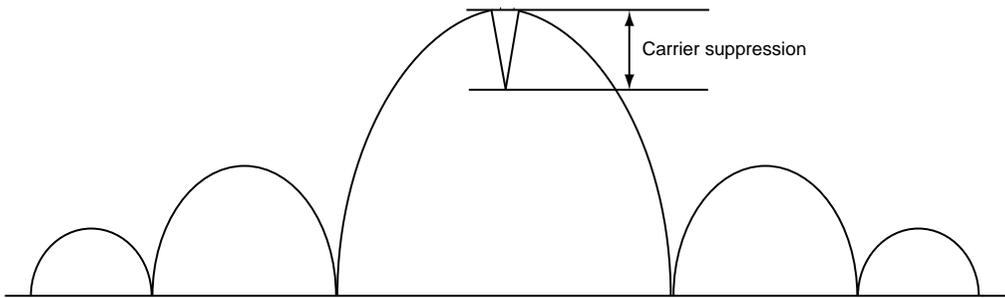
### RF Carrier Suppression (DSSS only)

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).

3. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Tx Testing] tab > [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
5. Select “Carrier Suppression” from the “Measurement Type” frame.
6. Click [Run Once] or [Run Continuous].

The table within the spectral profile window beneath the trace changes to display the carrier suppression results.

The RF carrier suppression, measured at the channel center frequency, must be at least 15 dB below the peak SIN(x)/x power spectrum.



**Figure 7-19.** Carrier Suppression

**Note**

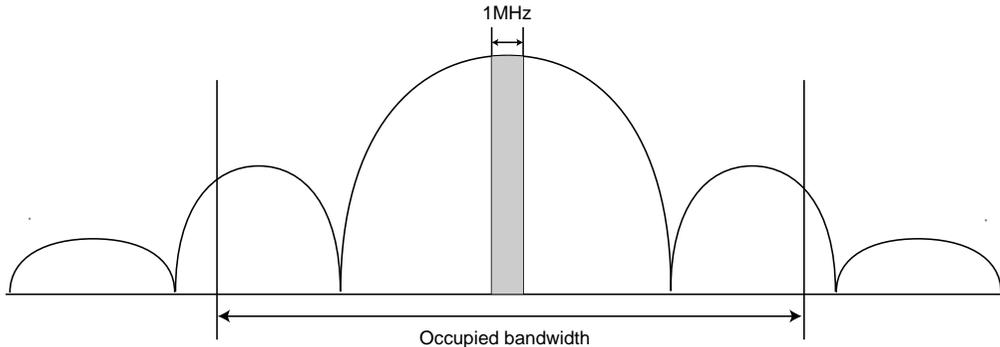
The IEEE standard states that the measurement is made with the DUT configured to transmit DQPSK modulation using a "01" repeating data sequence and with the scrambler disabled. In Network Mode operation it is not possible to disable the scrambler. In order to perform the RF carrier suppression measurement as defined in the IEEE Standard, testing must be performed in Direct Mode with the DUT configured using control software supplied by the chipset vendor. Refer to Chapter 9 - Transmitter Testing in Direct Mode.

As part of the EVM measurement process (see 7-6), the MT8860C includes an IQ offset measurement that returns the actual carrier feedthrough normalized to the mean power at the symbol timings. This measurement does not require a special test signal to be generated by the DUT and so can be performed in Network Mode. Using the IQ offset, an estimate of the RF Carrier Suppression can be made. Refer to Appendix K for details.

## Power Spectral Density (PSD)

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
3. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Tx Testing] tab > [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
5. Select “Power Spectral Density” from the “Measurement Type” frame.

- Click [Run Once] or [Run Continuous].

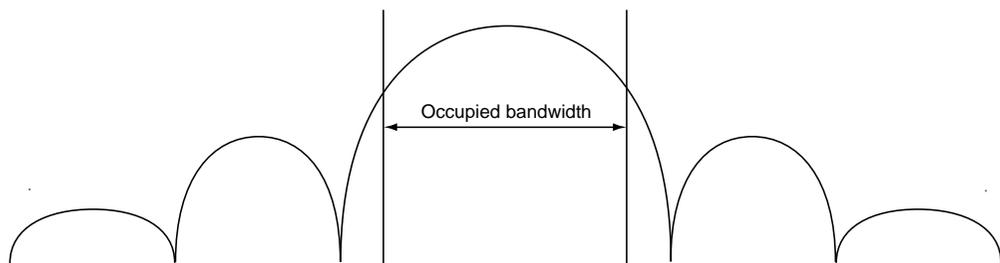


**Figure 7-20.** Power Spectral Density

The table within the spectral profile window changes to display the power spectral density result. The measurement is made according to ETSI EN 300-328 (4.3.2 / 5.7.3) and is defined as the maximum power measured in a 1 MHz bandwidth within the occupied bandwidth of the signal.

### Occupied Bandwidth

- Follow the setup instructions detailed earlier in this chapter.
- Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
- Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
- Click [Tx Testing] tab > [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
- Select “Occupied Bandwidth” from the “Measurement Type” frame.
- Click [Run Once] or [Run Continuous]. The table beneath the trace within the [Spectral Profiles] window changes to display the OBW results. The value within the “OBW” cell of the table indicates the frequency within which the specified percentage of power is contained.



**Figure 7-21.** Occupied Bandwidth

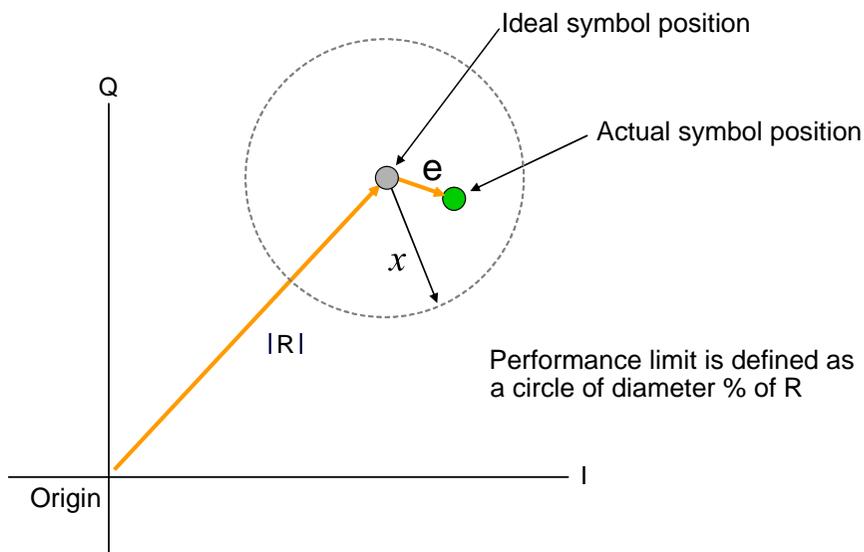
## 7-6 IQ Constellation (EVM Analysis)

**Note**

Not supported (for DSSS or OFDM data rates) when MT8860C is configured for ACK Frame Analysis. Refer to page 7-2 for details.

The IEEE 802.11 specification uses a metric called Error Vector Magnitude (EVM) as a measure of modulation quality. EVM is a measure of the difference between the ideal symbol position and the measured symbol position. The difference between these two positions is referred to as the error vector and is shown in the figure below by the distance “e”.

EVM is an excellent measure of overall transmitter quality and a high EVM reading typically results in similarly high packet error rate.



**Figure 7-22.** EVM Explanation

The following points should be considered when performing IQ constellation / EVM measurements.

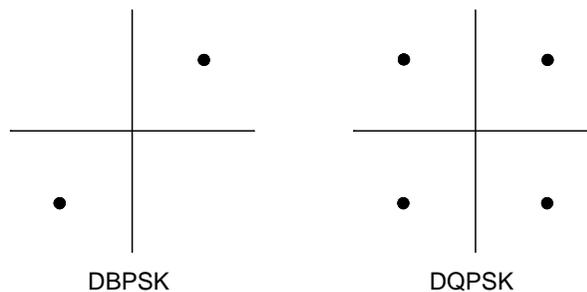
- The transmitted signal must contain an ‘off’ period, i.e. it must not be a continuous transmission.
- The EVM analysis is performed on the first burst found after the trigger, including the pre trigger delay.
- The gate positions do not effect the EVM analysis.
- The EVM analysis is performed over a specified number of chips/symbols. To configure the analysis length, click [Tx Advanced Settings] > [EVM Settings] tab.
- The burst captured must contain at least the specified number of chips/symbols.
- Independent analysis lengths for the DSSS and OFDM data rates are provided.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
3. Select “IQ Constellation” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Run Once] or [Run Continuous] to run IQ constellation measurements on the packet payload.

**Note** The IQ constellation displayed by LANLook is determined by the WLAN Standard and Data Rate settings. If the data rate does not match the rate of transmission from the DUT, it is possible that the analysed data will be mapped onto the wrong constellation.

### 802.11b / 802.11g (DSSS Data Rates)

The 802.11b specification defines two modulation techniques.



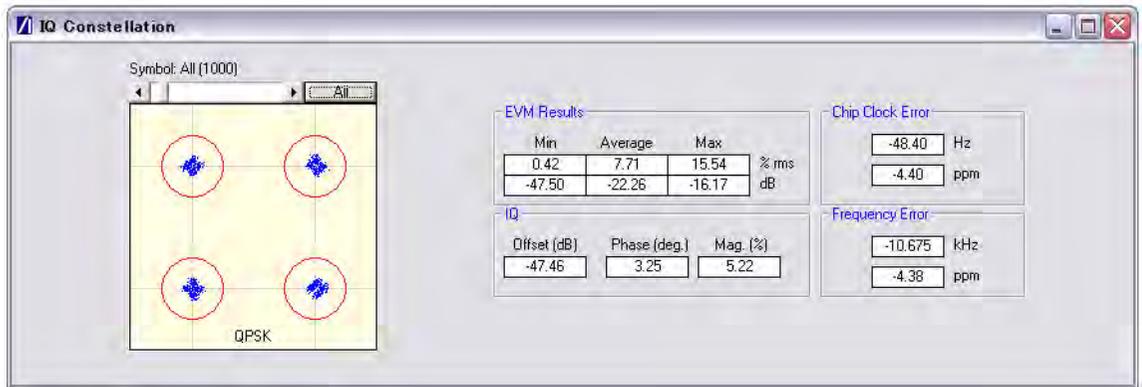
**Figure 7-23.** DSSS Modulation

The DSSS data rates and associated modulation methods are illustrated in the table below.

**Table 7-7.** DSSS Data Rates and Modulation Methods

Data Rate (Mbps)	Modulation	Spreading / coding scheme
1	DBPSK	11 chip Barker sequence
2	DQPSK	11 chip Barker sequence
5.5	DQPSK	CCK
11	DQPSK	CCK

**Note** Users should note that although IQ constellation measurements can be performed at a data rate of 1 Mbps (DBPSK modulation), the IEEE 802.11b specification stipulates that the measurement should be made using DQPSK modulation.



**Figure 7-24.** [IQ Constellation] Window showing DQPSK Constellation

The screen capture above shows a typical DQPSK constellation. The statistic of most interest to the user is the “Max” value that displays at the “EVM Results” field. The 802.11b specification stipulates that the worst-case vector error magnitude should not exceed 35%.

### Chip Clock Error

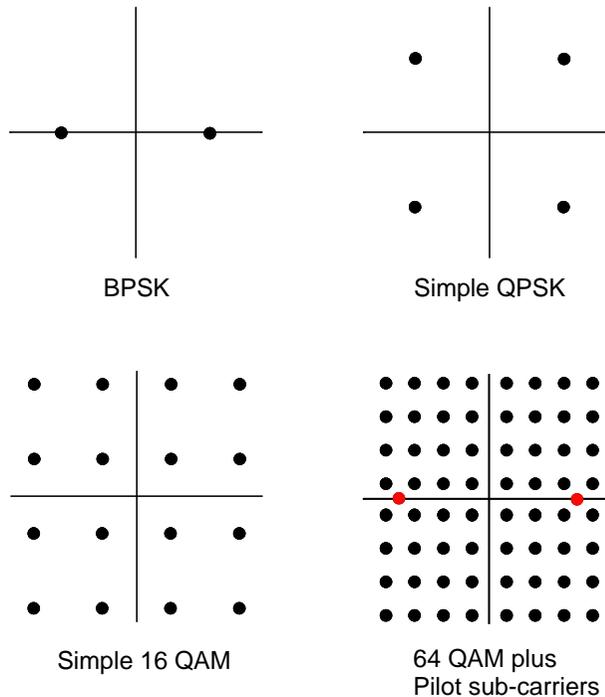
The chip clock error measurement results are also displayed in the dialog above. The 802.11b specification stipulates that the chip clock frequency tolerance shall be better than  $\pm 25$  ppm.

### Frequency Error

The center frequency measurement results are also displayed in the dialog above. The 802.11g specification stipulates that the center frequency tolerance shall be better than  $\pm 25$  ppm. For 802.11a, the specification stipulates that the transmit center frequency tolerance shall be  $\pm 20$  ppm maximum.

## 802.11g / 802.11a (OFDM Data Rates)

Each of the OFDM sub-carriers can be modulated using any of the following four techniques.



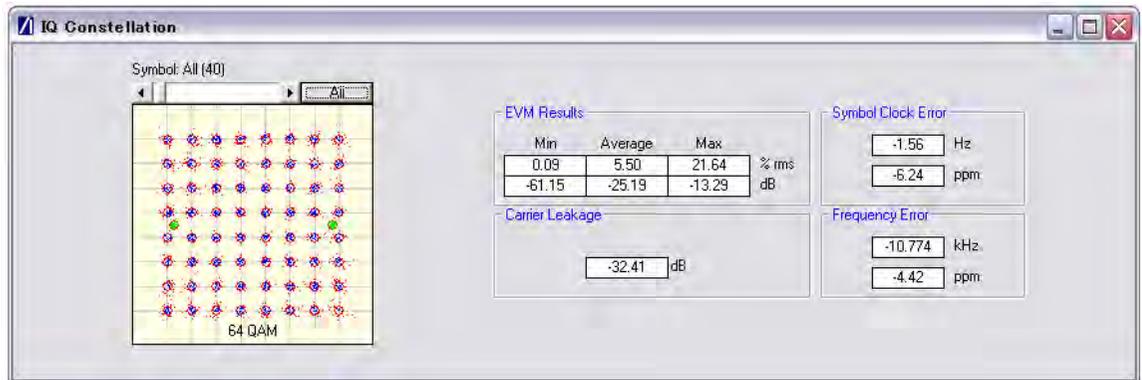
**Figure 7-25.** OFDM Modulation

In addition to the modulation constellations, the MT8860C can be used to display graphical results for EVM vs sub-carrier and EVM vs. symbol . These may be of particular use when a detailed analysis of the cause of distortion is required.

The OFDM data rates and associated modulation methods are illustrated in the table below.

**Table 7-8.** OFDM Data Rates and Modulation Methods

Data Rate (Mbps)	Modulation
6	BPSK
9	BPSK
12	QPSK
18	QPSK
24	16QAM
36	16QAM
48	64QAM
54	64QAM



**Figure 7-26.** [IQ Constellation] Window showing 64 QAM Constellation

The screen capture above shows a 64 QAM constellation. The statistic of most interest to the user is the “Average” value that displays at the “EVM Results” field. The 802.11a specification stipulates that the relative error must not exceed the data rate dependent values specified in the table below. Set the average to 20 to make measurements as specified in the IEEE standard.

**Table 7-9.** Maximum Permissible EVM Values Per Data Rate

Data Rate (Mbps)	EVM (dB)	EVM (% RMS)
6	-5	56.2
9	-8	39.8
12	-10	31.6
18	-13	22.3
24	-16	15.8
36	-19	11.2
48	-22	7.9
54	-25	5.6

### Symbol Clock Error

The symbol clock error measurement results are also displayed in the dialog above. The 802.11g specification stipulates that the symbol clock frequency tolerance shall be  $\pm 25$  ppm maximum. For 802.11a, the specification stipulates that the symbol clock frequency tolerance shall be  $\pm 20$  ppm maximum.

### Frequency Error

The center frequency measurement results are also displayed in the dialog above. The 802.11g specification stipulates that the center frequency tolerance shall be better than  $\pm 25$  ppm. For 802.11a, the specification stipulates that the transmit center frequency tolerance shall be  $\pm 20$  ppm maximum.

**Carrier Leakage**

The carrier leakage measurement results are also displayed in the dialog above.

Carrier leakage is measured during the 8  $\mu$ s channel estimation phase and is relative to the average power of the -16 to +16 sub-carriers. The 802.11a specification stipulates that such leakage shall not exceed -15 dB relative to overall transmitted power.

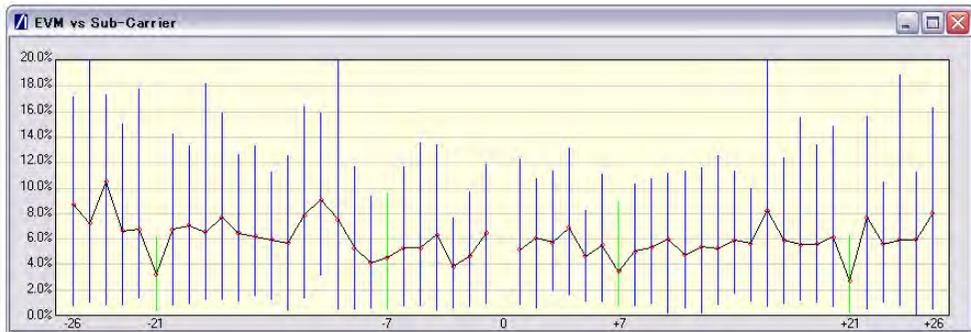
## 7-7 EVM vs Sub-Carrier (OFDM only)

**Note**

Not supported when MT8860C is configured for ACK Frame Analysis. Refer to page 7-2 for details.

Although not a defined measurement of the IEEE, the EVM vs Sub-Carrier measurement is a powerful analysis tool that displays the average and max / min EVM for each OFDM channel.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
3. Select “EVM vs Sub-Carrier” from one of the drop-down fields in the “Measurements Window Configuration” frame.
4. Click [Run Once] or [Run Continuous] to display a trace such as that shown below. The vertical green lines at  $\pm 7$  and  $\pm 21$  are the pilot carriers, the blue bars are the maximum and minimum values and the horizontal trace shows the average EVM.



**Figure 7-27.** [EVM vs Sub Carrier] Window

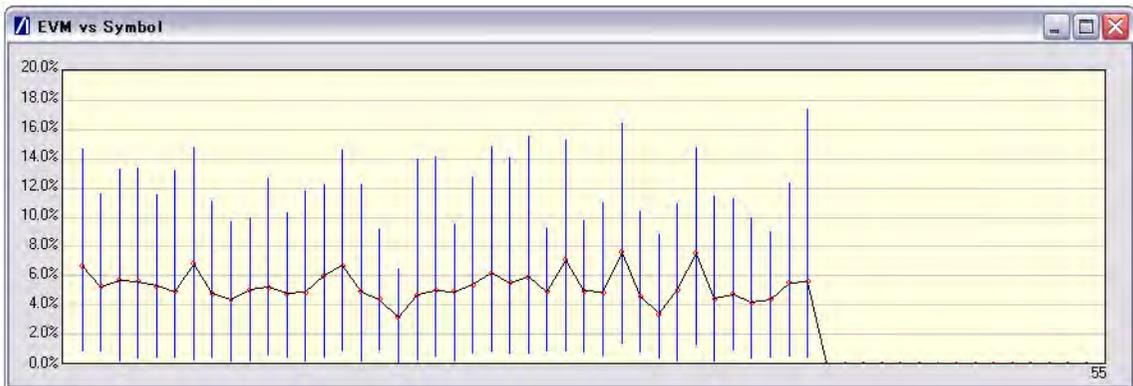
## 7-8 EVM vs Symbol (OFDM only)

**Note**

Not supported when MT8860C is configured for ACK Frame Analysis. Refer to page 7-2 for details.

Although not a defined measurement of the IEEE, the EVM vs Symbol measurement is a powerful analysis tool that displays the average and max / min EVM for each symbol in the gate.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
3. Select “EVM vs Symbol” from one of the drop-down fields in the “Measurements” frame.
4. Click [Run Once] or [Run Continuous] to display a trace such as that shown below.



**Figure 7-28.** [EVM vs Symbol] Window

## 7-9 Spectral Flatness (OFDM only)

**Note**

Not supported when MT8860C is configured for ACK Frame Analysis. Refer to page 7-2 for details.

The spectral flatness measurement provides the user with a display of RF level vs sub-carrier over the measurement range.

The IEEE 802.11a specification stipulates acceptable values for the average energy of the constellations in each of the sub-carriers. For lines -16 to -1 and 1 to 16 the average energy of any individual sub-carrier should deviate no more than  $\pm 2$  dB from their average energy of all 32 central sub-carriers. For lines -26 to -17 and 17 to 26 the average energy of the constellations in each of the spectral lines should deviate no more than  $\pm 2/-4$  dB from the average energy of spectral lines -16 to -1 and 1 to 16. The data for this test is measured over the 8 $\mu$ s channel estimation period of the packet while all 52 sub-carriers are on.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 6.3).
3. Select “Spectral Flatness” from one of the drop-down fields in the “Measurements” frame.
4. Click [Run Once] or [Run Continuous].



**Figure 7-29.** [Spectral Flatness] Window

The spectral mask (shown by the horizontal lines) is split into three sections; an upper limit with a default setting of +2.0 dB, a lower side limit with a default setting of -4.0 dB, and a lower centre limit with a default setting of -2.0 dB. Each of the spectral mask sections can be moved freely to the required position and the dB value appears in a small pop-up next to the cursor when the line is being moved. The new limit values are sent automatically to the MT8860C when the user releases the mouse button. Channel measurements that fall outside of the limits of the mask display in red and also carry a small label that appears near the cursor to say how many times that channel failed.

## 7-10 Numeric Results

Transmitter measurement results can also be viewed as numeric data. Viewing the results in this format is slightly quicker as it requires less remote data than when viewing the traces graphically.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Numeric Results Only” in the “Measurement Window Configuration” frame.
3. Click [Run Once] or [Run Continuous] to view the results. The figure below shows the numeric results window for an OFDM data rate.

Tx Tests Numerical Results								
<b>Power</b>	<b>Start</b>	<b>Stop</b>	<b>Peak</b>	<b>Average</b>	<b>Crest Factor</b>	<b>Rise</b>	<b>Fall</b>	<b>Distribution</b>
Gate 1	0.005 ms	0.179 ms	18.29 dBm	9.50 dBm	8.79 dB	0.07 us	0.27 us	6.50 dB
Gate 2	0.02 ms	0.181 ms	18.29 dBm	9.51 dBm	8.78 dB	0.07 us	0.27 us	6.50 dB
<b>EVM</b>	<b>Minimum</b>		<b>Average</b>		<b>Maximum</b>			
% rms	0.06 %		3.84 %		14.42 %			
dB	-64.75 dB		-28.31 dB		-16.82 dB			
<b>IQ Analysis</b>	802.11g OFDM			802.11 b/g DSSS				
Carrier Leakage / IQ Offset	-30.49 dB			n/a				
Phase Error	n/a			n/a				
Magnitude Error	n/a			n/a				
Frequency Tolerance	-37.88 kHz	-15.54 ppm	n/a		n/a			
<b>Clock Error</b>	802.11g OFDM (Symbol Clock)			802.11 b/g DSSS (Chip Clock)				
Hz	-3.11 Hz			n/a				
ppm	-12.46 ppm			n/a				
<b>Spectrum Mask</b>	<b>Status</b>							
Gate 1	PASS							
Gate 2	PASS							
<b>Spectrum Mask</b>	<b>L4</b>	<b>L3</b>	<b>L2</b>	<b>L1</b>	<b>U1</b>	<b>U2</b>	<b>U3</b>	<b>U4</b>
Gate 1 Power (dBr)	-14.6	-14.0	-13.2	-15.2	-17.2	-15.6	-17.0	-14.1
Gate 2 Power (dBr)	-13.4	-13.5	-12.1	-14.2	-15.8	-13.6	-15.9	-13.8
Gate 1 Frequency (MHz)	-31.6	-20.4	-11.9	-10.7	10.6	11.8	29.6	30.5
Gate 2 Frequency (MHz)	-31.6	-20.4	-11.9	-10.9	10.9	11.8	28.0	31.3
<b>Spectrum Data</b>	<b>Spectral Density</b>		<b>Occupied Bandwidth</b>		<b>Carrier Suppression</b>		<b>Spectral Flatness</b>	
Gate 1	-0.73 dBm/MHz		16.4 MHz		-		PASS	
Gate 2	-0.71 dBm/MHz		16.4 MHz		-		n/a	

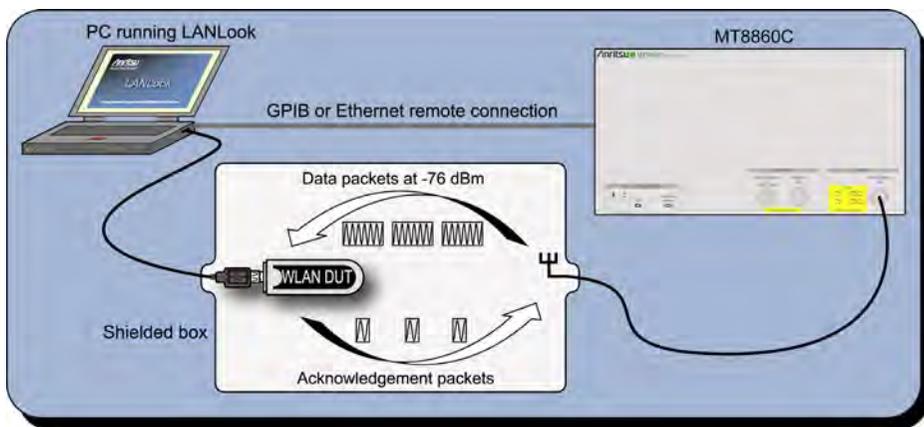
Figure 7-30. [Tx Tests Numerical Results] Window

# Chapter 8 — 802.11b/g/a Receiver Testing in Network Mode

## 8-1 Test Methodology

In Network mode with the packet type set to “Unicast”, packets are transmitted to the DUT under the conditions specified. The DUT returns acknowledgments (ACKs) to notify the MT8860C of the receipt of each packet, and this data is utilized to calculate the sensitivity. This combination of settings has the advantage to the user that receiver sensitivity calculations are made entirely within the MT8860C; it is not necessary to use the DUT client software.

In Network mode with the packet type set to “Broadcast”, packets are transmitted on a fixed channel to all devices in a connection. In broadcast mode the DUT does not return ACKs to the MT8860C and instead the receiver sensitivity is calculated using the DUT client software.



**Figure 8-1.** Receiver Testing in Network Mode (Unicast)

DUT receiver measurements are based on the calculation of Packet Error Rate (PER) or Frame Reception Rate (FRR). In both cases, the MT8860C transmits a defined number of unicast data frames to the DUT and counts the number of ACK control frames returned. PER and FRR calculations differ only in the way in which the results are expressed. PER is an expression of the number of packets there were received in error. FRR is an expression of the number of packets that were successfully received. FRR is specified by the CTIA and Wi-Fi Alliance in the CWG Test Plan used to evaluate the RF Performance of Wi-Fi Mobile Converged Devices.

PER is calculated using the formula below:

$$(1 - (\text{Number of packets correctly received} / \text{Number of packets sent})) \times 100\%$$

FRR is calculated using the formula below:

$$(\text{Number of packets correctly received} / \text{Number of packets sent}) \times 100\%$$

## 802.11 PER Specifications

For DSSS data rates, the IEEE 802.11b specification states that the packet error rate (PER) must not exceed 8% for an input level no greater than -76 dBm measured at the antenna connector. The specification recommends that the test is performed using an 11 Mbps CCK modulated signal with a PSDU length of 1024 bytes.

For the OFDM data rates, the IEEE 802.11g specification states that the packet error rate (PER) shall be less than 10% at a PSDU length of 1000 bytes for the input levels indicated in the table below. Input levels are specific for each data rate and are measured at the antenna connector. A noise figure (NF) of 10 dB and an implementation loss of 5 dB are assumed.

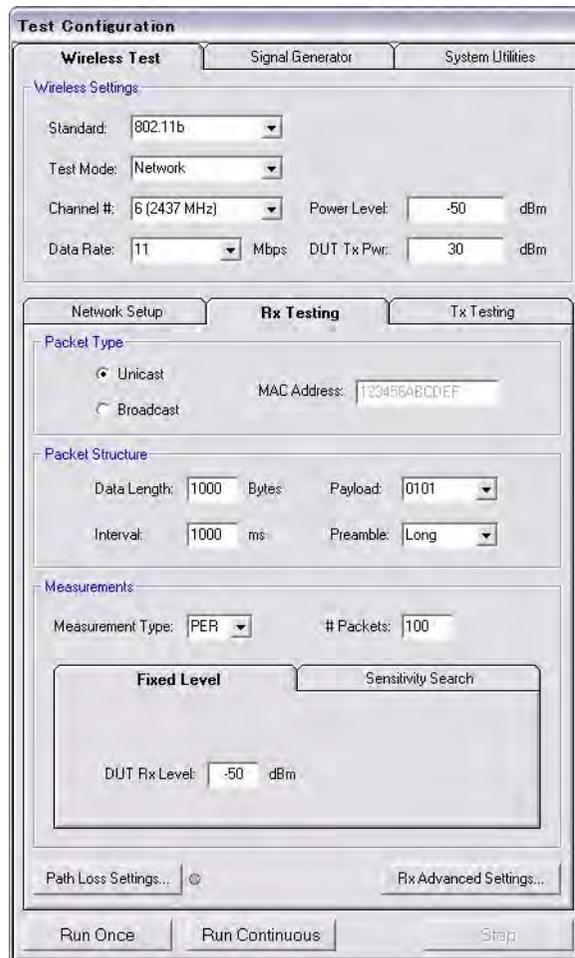
**Table 8-1.** Sensitivity by Data Rate

Data rate (Mbps)	Minimum sensitivity (dBm)
6	-82
9	-81
12	-79
18	-77
24	-74
36	-70
48	-66
54	-65

1. Establish a remote connection between the MT8860C and PC as detailed in chapter 5.
2. Establish a WLAN connection between the MT8860C and the DUT as detailed in chapter 6.

## Packet Type

1. Click the [Rx Testing] tab shown below.



**Figure 8-2.** [Rx Testing] Tab

2. Specify the type of transmission to be sent from the MT8860C to the device.

**Unicast:** This is the default setting in which the MT8860C transmits packets to a single DUT.

When Unicast is selected, the MT8860C transmits data packets that contain the MAC address of the DUT. When the DUT receives the data packet, it responds with an acknowledgement (ACK) packet transmitted at a high power level (e.g. +10 dBm). This power level may saturate the MT8860C reference radio receiver, thus preventing the ACK from being detected, and giving an incorrect measurement result. To prevent this, a programmable attenuator is incorporated inside the MT8860C between the test port connector and the reference radio receiver. The setting of this attenuator is calculated using the 'DUT Tx Pwr' value defined.

**Broadcast:** In broadcast mode the MT8860C transmits packets on a fixed channel to all devices that are in a connection. The 802.11 standard specifies the broadcast address as FF-FF-FF-FF-FF-FF. In broadcast mode the DUT(s) do not return ACKs to the MT8860C. Instead, the PER is calculated using the DUT client software to confirm that the count of received packets has been incremented. Broadcast mode is suitable when connecting to and sequentially testing multiple units in a line. Table and trace PER information is not displayed in broadcast mode and the user is notified of this when [Run Once] is clicked.

## Packet Structure

1. Specify the packet structure at the following items.

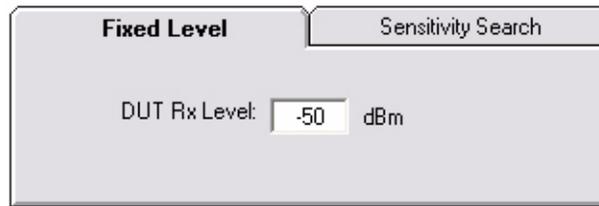
Data Length:	The data length of the packet can be set to any value between 60 and 1500 bytes.
Interval:	The interval specified represents the time in ms between frame transmissions.
Payload:	Defines the bit sequence pattern of the dummy data in the payload. There are six options available in the drop down list, ZEROS, 0101, 1010, PN7, RANDOM, and COUNT.
Preamble:	For data rates of 2, 5.5 and 11 Mbps, long and short preamble options are available. The long setting represents a preamble with 144 bits, and the short with 72. A short preamble setting equates to more payload data being transmitted with each packet for a given timeslot. For 1 Mbps a long preamble is used.

<b>Note</b> Preamble settings are not applicable for OFDM data rates.
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## Measurements

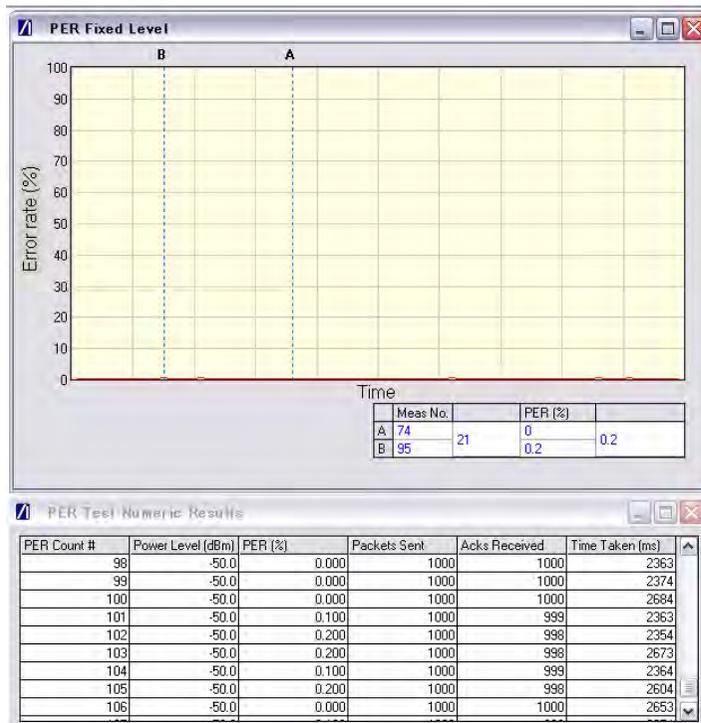
1. At "Measurement Type" specify whether the sensitivity results are shown as PER (packets received in error) or FRR (packets successfully received).
2. At "# Packets" specify the number of packets to be transmitted. Enter a value within the range of 1 and 10,000.
3. If required, a signal level correction table can be used to compensate for test system and cable loss effects. Refer to chapter 14 for details.
4. Follow the instructions over the following pages to perform the required measurements.
  - Measuring PER or FRR at a fixed power level
  - Measuring PER or FRR at a varying power level
  - Measuring PER or FRR in broadcast mode
  - Measuring PER or FRR with co-channel or adjacent channel interference

## 8-2 Fixed Power Level



**Figure 8-3.** PER/FRR Setting

1. Follow the setup instructions detailed at the start of this chapter.
2. Click the [Fixed Level] tab shown above.
3. Set the required MT8860C transmission power level at the “DUT Rx Level” setting.
4. Click [Run Once] to display a table of PER/FRR numeric results, or click [Run Continuous] to display both the numeric results table and a history trace as shown below.



**Figure 8-4.** PER at Fixed Power Level

**Note** The MT8860C does not retry packets for which an ACK is not returned.

The trace generated shows how the PER/FRR fluctuates over time for each measurement at the specified power. This is useful in analysis of performance over time or to monitor DUT resilience whilst applying conditions such as extreme temperatures or channel noise.

## 8-3 Varying Power Level

In this test the transmission power from the MT8860C is stepped down by a specified amount to find the point at which an acceptable threshold is reached.

Fixed Level		Sensitivity Search	
Start Level:	-60 dBm	Stop Level:	-100 dBm
Step:	1 dB	Threshold:	95 %

**Figure 8-5.** PER Setting for Sensitivity Search

1. Follow the setup instructions detailed at the start of this chapter.
2. Click the [Sensitivity Search] tab shown above and enter appropriate values as explained below.

**Start Level:** Specify the initial power transmitted to the DUT.  
**Stop Level:** Specify the final power transmitted to the DUT.  
**Step:** Specify the power step between the start and stop levels. The specified number of packets are transmitted at each power level before stepping on to the next level.  
**Threshold:** Specify a percentage limit at which testing will be stopped as the receiver sensitivity level has exceeded the defined limit.

3. Click [Run Once] to display a plot such as that shown below.

**Note** The [Run Continuous] button is not available when performing a sensitivity search.

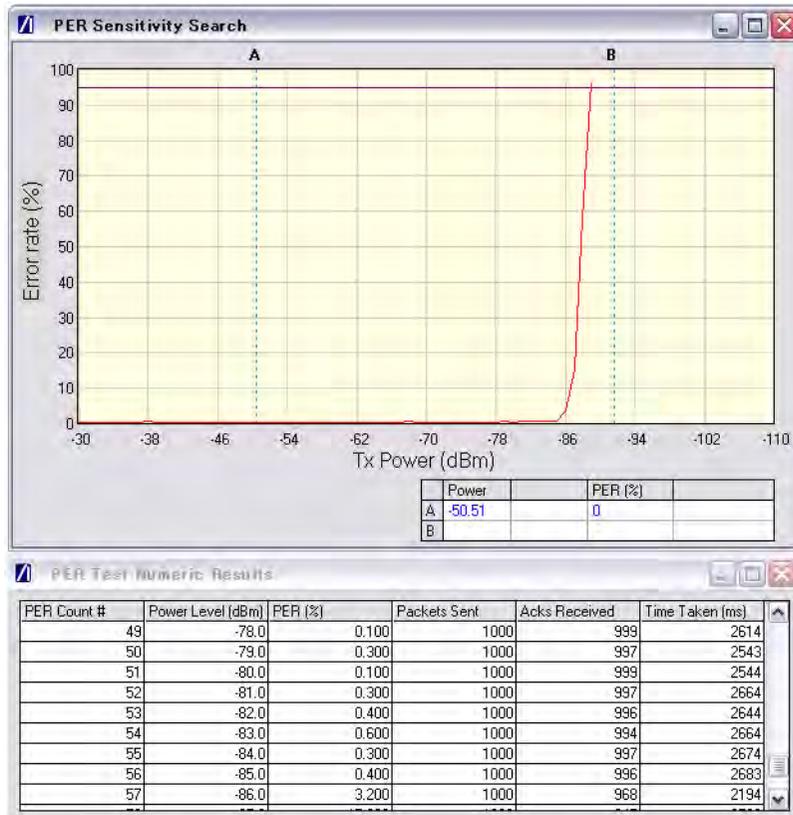
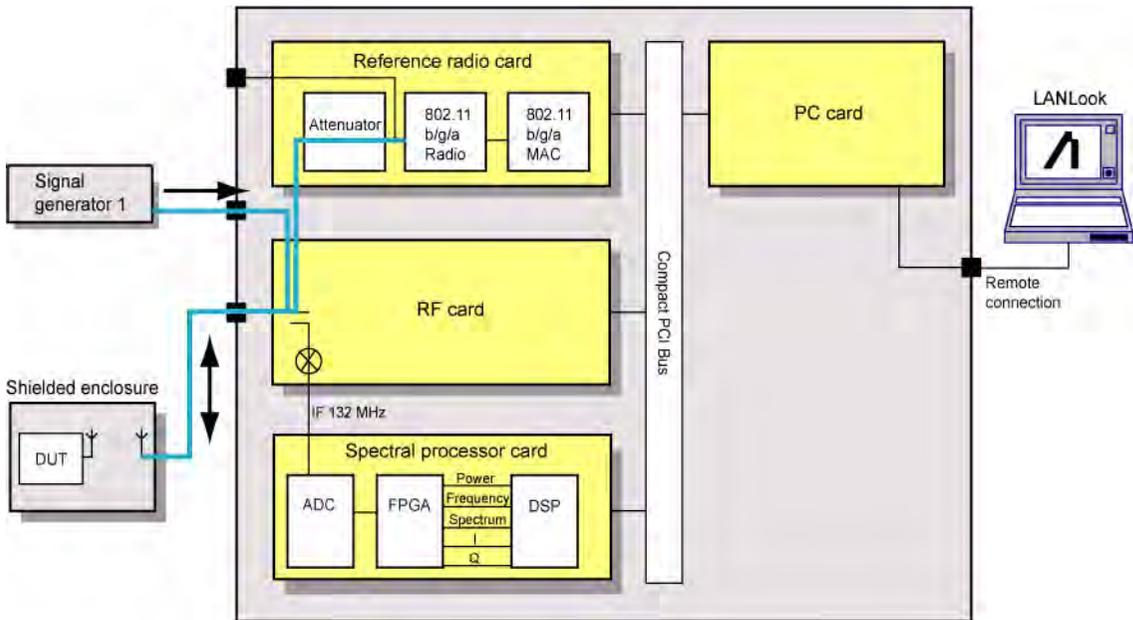


Figure 8-6. PER Sensitivity Search

## 8-4 Interference

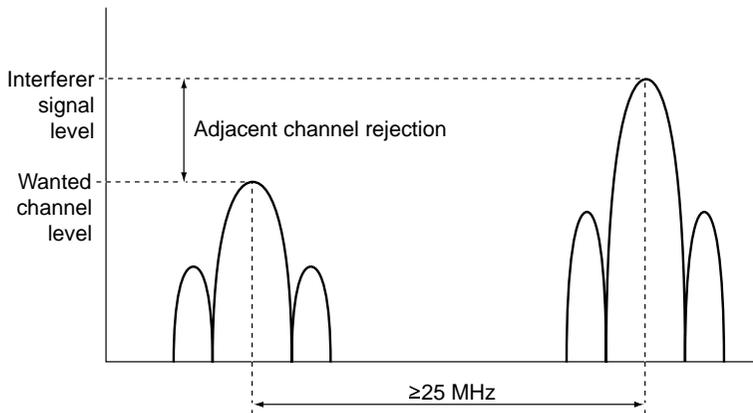


**Figure 8-7.** PER with Channel Interference

In addition to the normal test configuration detailed earlier, an external signal generator can be coupled to the MT8860C to measure adjacent or alternate channel rejection.

### Adjacent Channel Rejection Specifications

For DSSS data rates, adjacent channel rejection is defined between any two channels with 25 MHz separation. The adjacent channel rejection must be equal to or better than 35 dB, with a PER of 8% using 11 Mbps CCK modulation and a PSDU length of 1024 bytes.



**Figure 8-8.** Adjacent Channel Rejection

For OFDM data rates, the adjacent channel rejection shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in the table below and raising the power of the interfering signal until 10% PER is caused for a PSDU length of 1000 bytes. The power difference between the interfering and the desired channel is the corresponding adjacent channel rejection. The interfering signal in the adjacent channel shall be a conformant OFDM signal, unsynchronized with the signal in the channel under test.

**Table 8-2.** Rejection Values Per Data Rate

Data rate (Mbps)	Adjacent channel rejection (dB)	Alternate adjacent channel rejection (dB)
6	16	32
9	15	31
12	13	29
18	11	27
24	8	24
36	4	20
48	0	16
54	-1	15

1. Connect a signal generator to the interferer input on the front of the MT8860C.
2. Set the signal generator to transmit on the required channel.
3. Follow the setup instructions detailed in “” at the start of this chapter.
4. Set the required transmission power level on the [Fixed Level] tab in the “Measurements” frame.
5. Click [Run Once].

**Note**

When performing adjacent channel testing, it is necessary to know the path loss from the interferer input to the test port. The path loss for each instrument is measured in the production process and the value is stored in non-volatile memory. The path loss can be read by the user by sending the INTFLOSS command from the LANLook [Diagnostics] tab. The INTFLOSS command returns the insertion loss for the channel requested. The returned value should be used as an offset for the interfering signal when making adjacent channel measurements. The typical path loss from the interferer input to the test port is 22 dB.

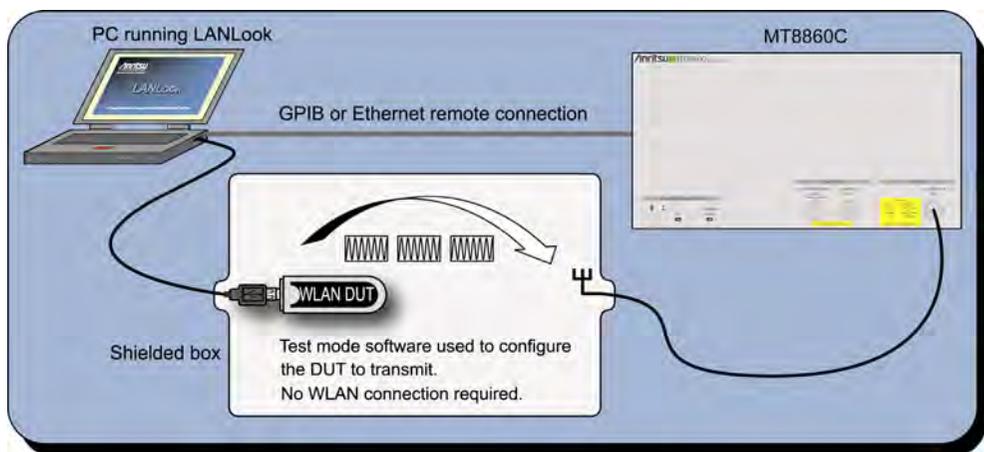


# Chapter 9 — 802.11b/g/a Transmitter Testing in Direct Mode

A WLAN connection with the DUT is not required in order to perform Tx testing in Direct mode. When Direct mode is selected the Network setup settings within LANLook are no longer applicable and are replaced by a message to this end.

## 9-1 Test Methodology and Settings

In Direct mode, control software supplied by the chipset vendor is used to configure the DUT to transmit continuously on a defined channel and data rate. The MT8860C spectral processor is then tuned to the same channel and triggers continuously or from the power burst rising edge. The advantage to the user of testing in the mode is that tests can be conducted without the need to establish a WLAN connection between the MT8860C and the DUT.

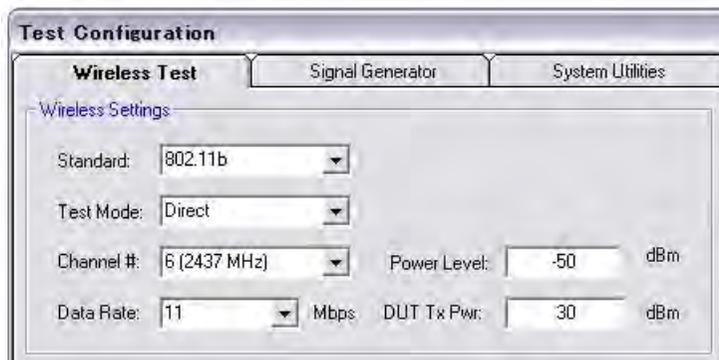


**Figure 9-1.** Transmitter Testing in Direct Mode

## 9-2 Wireless Settings

Set the standard, channel, data rate, and power to match the required DUT transmission characteristics. Satisfactory test results will not be achieved if the MT8860C performs measurements on a different channel or at a different data rate to that of the signal being transmitted by the DUT.

1. Establish a remote connection between the MT8860C and PC as detailed in chapter 5.
2. Click the [Wireless Test] tab.
3. The wireless settings display at the top of this tab as shown in the figure below.



**Figure 9-2.** Wireless Settings

4. At “Standard” select the IEEE standard to be used during testing. Users should note that 802.11a is available only on units for which option 14 has been enabled.
5. At “Test Mode” select ”Direct”.

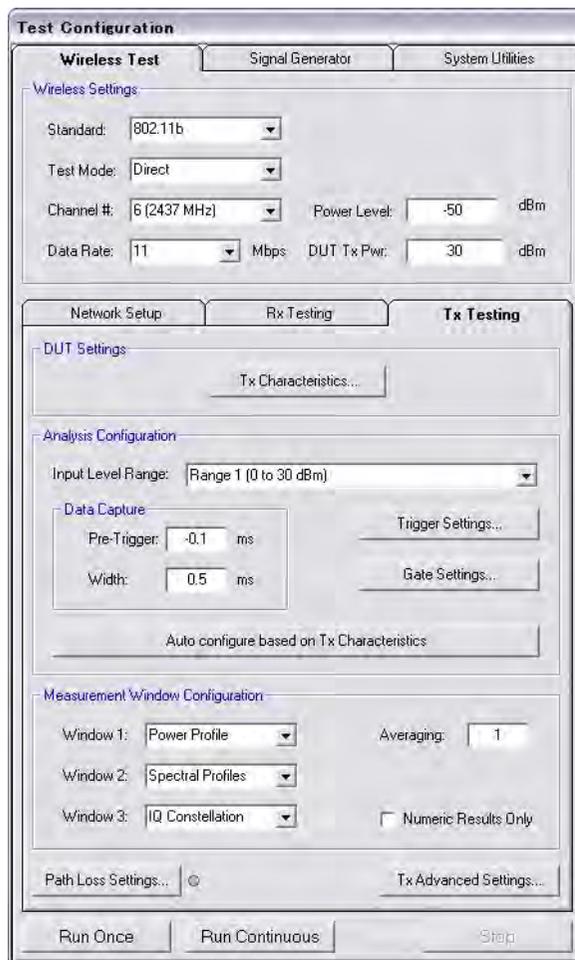
Selecting “Direct” allows the user to perform testing without the need to establish a WLAN connection with the DUT.

6. At “Channel #” select the WLAN channel on which measurements will be performed. The channels for each of the WLAN standards are shown in the table on the following page.
7. At “Data Rate” select the data rate at which measurements will be performed. The rate can be selected freely from those available but is set by default to the highest rate available in the currently selected IEEE standard (11 Mbps for 802.11b and 54 Mbps for 802.11g and 802.11a).
8. At “Power Level” specify the “Power Level” that is transmitted by the MT8860C. The value should represent the signal level required at the antenna / RF connector of the DUT.
9. At “DUT Tx Power” specify the power that the DUT is expected to transmit. The value should represent the signal level at the antenna / RF connector of the DUT.

## 9-3 Configuring Test Settings

### DUT Settings

1. Click the [Tx Testing] tab shown below.



**Figure 9-3.** [Tx Testing] Tab

- Click [Tx Characteristics...] to display the dialog shown below. This dialog is used to specify the expected Tx characteristics of the DUT.

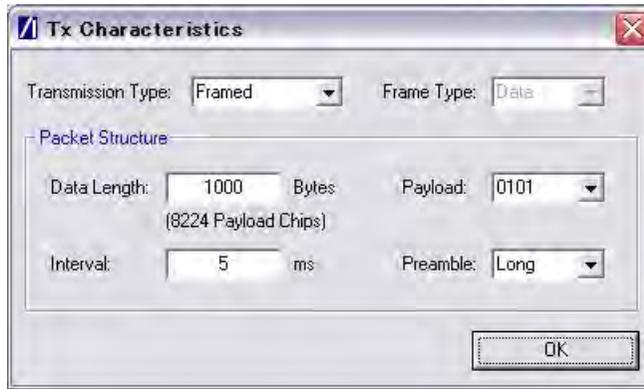


Figure 9-4. [Tx Characteristics] Dialog

- Transmission Type: Select either a “framed” or “continuous” transmission type.
- Frame Type: Not available in Direct mode. Set by default to data frame analysis.
- Data Length: The maximum and minimum packet length is dependent upon the data rate as detailed below.

Table 9-1. Minimum and Maximum Data Length by Data Rate

Data Rate	Minimum data length (bytes)	Maximum data length (bytes)
1	40	600
2	75	1,250
5.5	210	3,440
11	415	6,875
6	50	3,750
9	75	5,625
12	100	7,500
18	145	11,250
24	195	15,000
36	280	22,500
48	385	30,000
54	435	33,750

**Note** For DSSS rates, the minimum value equates to 300 us (3300 chips). For OFDM data rates, the minimum value equates to 64 us (16 symbols). The maximum data length values for 1 Mbps and 2 Mbps equate to 5 ms.

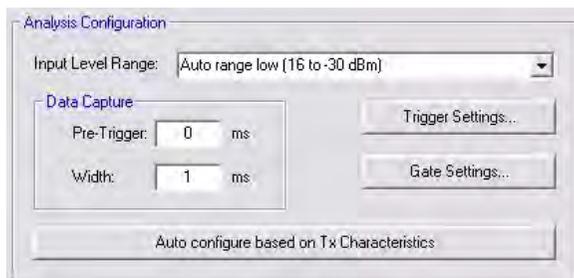
- Interval: The interval specified represents the time between frames transmitted by the DUT.
- Payload: Defines the bit sequence pattern of the dummy data in the payload. There are six options available in the drop down list, ZEROS, 0101, 1010, PN7, RANDOM, and COUNT. The required payload is determined by the test that the user wishes to perform.
- Preamble: For data rates of 2, 5.5 and 11 Mbps, long and short preamble options are available. The long setting represents a preamble with 144 bits, and the short with 72. A short preamble setting equates to more payload data being transmitted with each packet for a given timeslot. For 1 Mbps a long preamble is used.

**Note** Preamble settings are not applicable for OFDM data rates.

### Analysis Configuration

1. Configure the MT8860C as required to allow analysis of the data being transmitted from the DUT. Settings can be made in two ways:-

**Manually:** The MT8860C can be configured manually using the “Analysis Configuration” settings.



Refer to steps 2 to 5 below.

**Automatically:** The Tx analyser settings of the MT8860C can be configured manually by clicking [Auto configure based on Tx Characteristics].



When used, all of the settings within “Analysis Configuration” are configured automatically based upon the settings made in the [Tx Characteristics] dialog.

2. Select the power level range at “Input Level Range”.

**Table 9-2.** Input Level Ranges for 802.11b, 802.11g, and 802.11a

	802.11b		802.11g	802.11a
	Low Noise	Low ACP		
Range 1	24 to 11 dBm	20 to 7 dBm	18 to 5 dBm	18 to 7 dBm
Range 1L	12 to 0 dBm	8 to -4 dBm	6 to -6 dBm	8 to -5 dBm
Range 2	1 to -11 dBm	-3 to -15 dBm	-5 to -17 dBm	-4 to -16 dBm
Range 2L	-10 to -24 dBm	-14 to -24 dBm	-16 to -30 dBm	-15 to -26 dBm
Range 3	-23 to -35 dBm	-23 to -35 dBm	-29 to -41 dBm	-25 to -36 dBm
Range 3L	-34 to -55 dBm	-34 to -55 dBm	-40 to -55dBm	-34 to -55 dBm
Auto range low	24 to -24 dBm	20 to -24 dBm	18 to -30 dBm	18 to -26 dBm
Auto range high	24 to -55 dBm	20 to -55 dBm	18 to -55 dBm	18 to -55 dBm

**Note** If using Auto range high, the DUT should be configured to transmit before the MT8860 is asked to perform a measurement. Failure to do so will result in invalid first measurement results.

The user can select “Low Noise” or “Low ACP” by clicking [Tx Advanced Settings...] and selecting the required option on the [Spectral Profile Settings] tab.

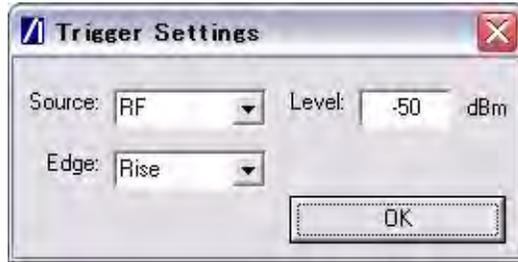
“Input Level Range” can be set to “Auto Range Low” to prevent damage to the MT8860C input that may be caused when, for example, a sudden power change occurs from range 3 to + 27 dBm.

3. Specify the “Data Capture” settings as detailed below.

**Pre-Trigger:** Enter a value at the “Pre-Trigger” item as required. The “Pre-trigger” item is used to specify the time in milliseconds for which data is captured prior to the trigger point. Enter a negative value between -5.95 and 0.

**Width:** Enter the time period after the pre-trigger during which measurement data is captured. Enter a value in milliseconds within the range of 0.01 to 5.95.

4. Click [Trigger Settings...] to display the dialog below.



**Figure 9-5.** [Trigger Settings] Dialog

Source: The trigger source item specifies the mechanism used to trigger measurement within each incoming packet. There are four options available.

RF: Triggering is enabled at the power level specified at the “Level” item.

External: The signal to trigger measurement is supplied from the external BNC connect (“Digital In 1”) on the rear of the MT8860C.

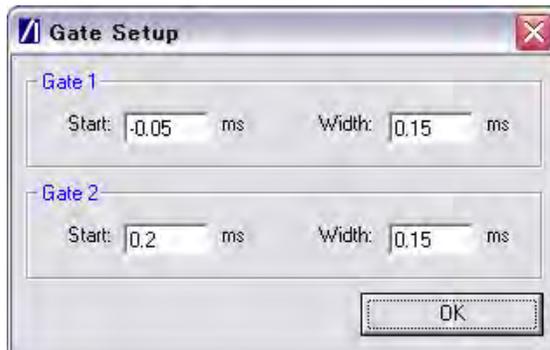
Free run: Triggering is performed continuously.

Video: Auto trigger from the RF power at the IF of the MT8860C.

Edge: Select whether triggering is performed on the rising or falling edge of the pulse.

Level: Specify the power level.

5. Click [Gate Settings...] to display the dialog below.



**Figure 9-6.** [Gate Setup] Dialog

The position of the measurement gates can be defined by entering the start positions and the total gate width.

## Measurement Window Configuration

1. In the “Measurement Window Configuration” frame, select the test results to be displayed in LANLook windows 1 (top), 2 (middle), and 3 (bottom). As shown below, the transmitter tests available differ depending on the selected wireless standard and data rate.

**Table 9-3.** Available Transmitter Tests by Wireless Standard

802.11b / 802.11g (DSSS data rates)	802.11g / 802.11a (OFDM data rates)
Power profile	Power profile
IQ constellation	CCDF profiles
Spectral profiles	EVM vs Sub-Carrier
	EVM vs Symbol
	IQ constellation
	Spectral profiles
	Spectral flatness

Up to three transmitter measurements can be displayed simultaneously and each of the measurements gives access to a number of different statistics. The user can also select the order in which the individual test result windows display.

2. At the “Averaging” entry box specify the number of trigger events that are averaged before data is output to LANLook or remote interface.
3. If trace results are not required select “Numeric Results Only” to replace the trace window(s) with a single window of numeric result tables.

## Path Loss Settings

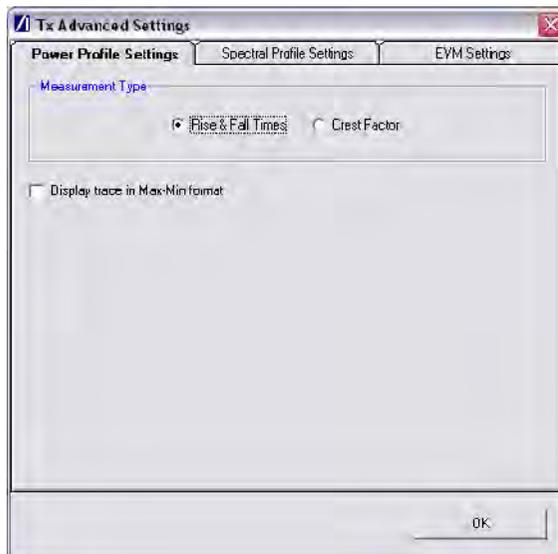
If required, a signal level correction table can be used to compensate for test system and cable loss effects. Refer to chapter 14 (section 14-15) for details.

## Tx Advanced Settings

For Power Profile, Spectrum Profile and EVM related measurements additional configuration settings can be specified. These can be accessed by clicking [Tx Advanced Settings...]

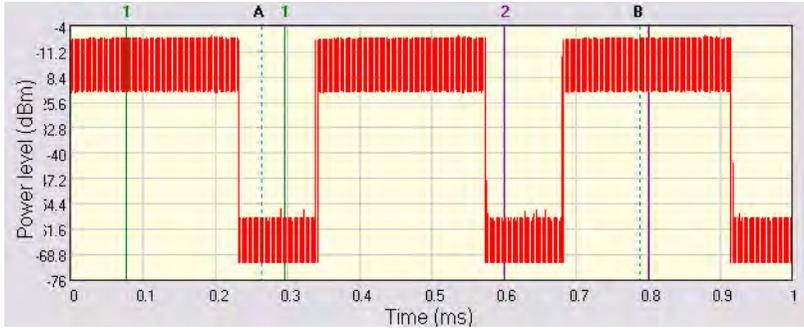
### Power Profile Settings

Click [Power Profile Settings] to display the dialog below.



**Figure 9-7.** Power Profile Settings

- |                                  |  |
|----------------------------------|--|
| Measurement Type:                | When a Power Profile Measurement (see 7.2) is selected, both the Peak and Average power is displayed in a table below the power profile trace. By selecting the Measurement Type to be either 'Rise & Fall Times' or 'Crest Factor', additional rise / fall or crest factor data is included in the numeric results table. |
| Display trace in Max-Min format: | When 'Display trace in Max-Min format' is selected, LANLook displays both the maximum and minimum values for each display point on the power profile trace. Each of the maximum and minimum values is joined by a line to give a broad trace such as that shown in the example below                                       |

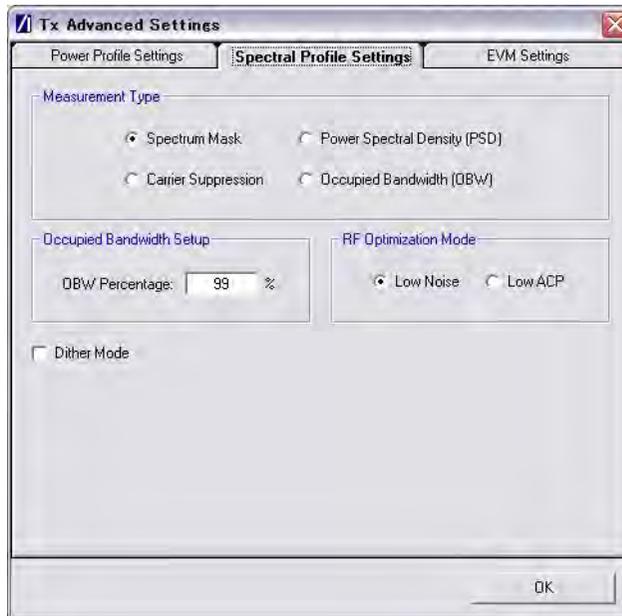


**Figure 9-8.** Max-Min Power Profile

Displaying the max-min data in this way can be useful to monitor the effect that modulation changes between the preamble and payload have on the power level of an OFDM signal.

### Spectral Profile Settings

Click [Spectral Profile Settings] to display the dialog below.

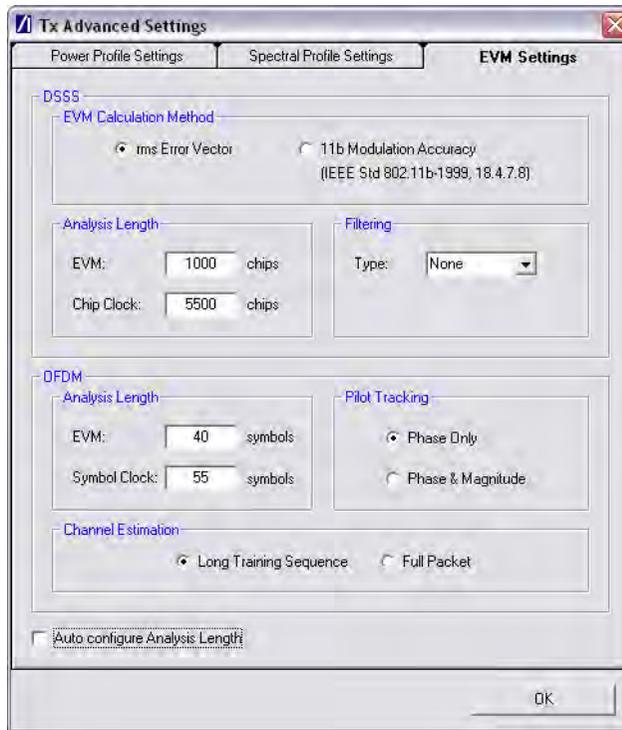


**Figure 9-9.** Spectral Profile Settings

Measurement Type:	Four types of spectral profile data can be individually displayed beneath the spectral profile trace; <ul style="list-style-type: none"><li>• Spectrum Mask</li><li>• Carrier Suppression (DSSS Only)</li><li>• Power Spectral Density (PSD)</li><li>• Occupied Bandwidth (OBW)</li></ul>
Occupied Bandwidth Setup	Set the required power percentage that is to be used when the Occupied Bandwidth Measurement type is selected.
RF Optimization Mode:	Select 'Low Noise' to optimize for signal to noise performance at offsets > 22 MHz from the carrier. This is the default setting. Select 'Low ACP' to optimize for distortion in the adjacent channel.  Note: Only applicable for DSSS data rates
Dither Mode	Dither mode can be used to determine whether spurs in the spectral data are originating from the MT8860C or from the DUT. If generated internally, spurs are removed by making three measurements using differing down conversion offsets.

## EVM Settings

Click [EVM Settings] to display the dialog below.



**Figure 9-10.** EVM Settings

- rms Error Vector: The EVM measurement is performed using the 'classic' definition for EVM (rms Error Vector) and is calculated using chips that are transmitted during the PSDU (payload) of the packet.
- 11b Modulation Accuracy: The EVM measurement is performed using the definition in IEEE Std 802.11b-1999 (18.4.7.8) and is calculated over 1000 chips that are transmitted during the PLCP preamble and header.
- Analysis Lengths: EVM, chip clock and symbol clock measurements are performed over the analysis lengths specified

**Table 9-4.** DSSS and OFDM EVM and Clock Statistics

	Minimum	Maximum	Default
DSSS EVM	220	11000	1000
DSSS Chip Clock	3300	30250	5500
OFDM EVM	16	500	40
OFDM Symbol Clock	16	500	55

Filtering:	Allows the user to specify a filtering type for use during EVM analysis of DSSS modulated signals. Three filter selections are available;
None:	No filtering is applied when calculating EVM.
Gaussian:	The Gaussian filter is selected and the user can set the 'BT' value to a value between 0.3 and 1.0 in steps of 0.1.
Root Nyquist:	Root Nyquist (Root Raised Cosine) is selected and the user can set the 'Alpha' value to a value between 0.3 and 1.0 in steps of 0.01.
Pilot Tracking:	For OFDM signals, pilot sub-carriers are used to assist with receiver synchronization.
Phase Only:	The demodulation process tracks the pilot phase over the specified EVM analysis length.
Phase & Magnitude	The demodulation process tracks both the pilot phase and amplitude over the specified EVM analysis length.
Channel Estimation:	For OFDM signals, channel estimation is performed during the initial receiver synchronization process. Long training sequence or full packet channel estimation can be selected.
Auto-configure Analysis Length	The analysis length values can be automatically configured by selecting “Auto configure Analysis Length”. When selected, the analysis lengths (applicable for the selected WLAN standard) are automatically configured to a valid value when the "Auto configure based on Tx Characteristics" operation is performed.

## 9-4 Running Tests

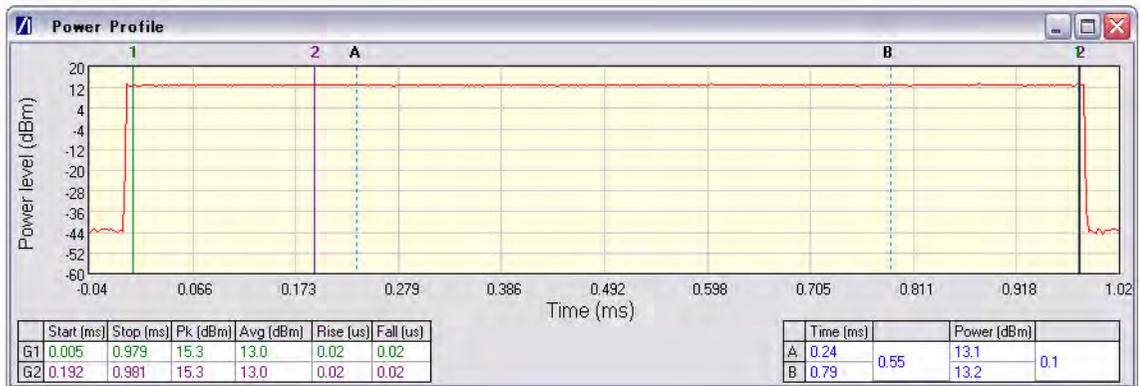
1. Click [Run Once] or [Run Continuous] to display the measurement results within LANLook.
2. Tests can be repeated after changing the “Wireless Mode” settings within LANLook. However, users should understand that the response of the DUT will depend upon the network type selected (infrastructure / Ad-Hoc) and the DUT type (AP / STA). The “Wireless Mode” settings determine the conditions under which the MT8860C performs measurements. The settings are used to configure the internal reference radio and to select the modulation format for EVM analysis. Satisfactory results will not be acquired if the specified conditions do not match those of the DUT transmitter.

Each of the test types available are explained over the following pages.

- Power profile measurements
- Frequency measurements
- CCDF measurements
- Spectral profile measurements
- IQ constellation measurements
- EVM vs sub-carrier measurements
- EVM vs symbol measurements
- Spectral flatness measurements

## 9-5 Power Profile

The power profile utilizes two gates to measure the peak and average power within any section on the trace. The samples within a gate are included in the average and peak power measurements. To see changes in power level due to modulation, a capture time of less than 100  $\mu$ s is required. For longer capture times the displayed data point is an average of all samples within the time period.



**Figure 9-11.** [Power Profile] Window

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select “Power Profile” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Run Once] or [Run Continuous].

### Peak Transmitter Power

The peak power values display in the “Pk (dBm)” column of the table directly beneath the power profile trace. Peak power is the absolute maximum of the packet within the gate width period.

## Average Transmitter Power

The average values display in the “Avg (dBm)” column of the table directly beneath the power profile trace. The maximum allowable output power is specified by the regulatory body for the region in question. Refer to the table below.

**Table 9-5.** Maximum Transmit Power by Wireless Standard and Regulatory Domain

		US	Europe	Japan
802.11b/g	2412 - 2472 MHz	30 dBm	20 dBm	10 dBm / MHz
	2484 MHz	-	-	10 dBm / MHz
802.11a	5150 - 5250 MHz	16 dBm	23 dBm	10 dBm / MHz
	5250 - 5350 MHz	23 dBm	23 dBm	10 dBm / MHz
	5470 - 5725 MHz	23 dBm	30 dBm	10 dBm / MHz
	5725 - 5825 MHz	29 dBm	-	-
	5825 MHz	30 dBm	-	-

As is the case for all power measurements, the average power is calculated from within the specified gate area only.

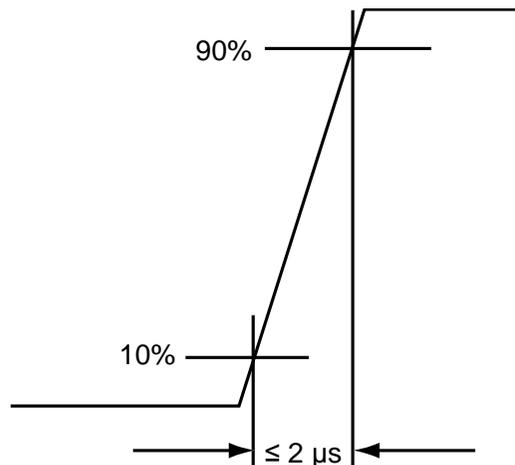
## Transmit Power-On Ramp

The power-on ramp values display in the “Rise (us)” column of the table directly beneath the power profile trace. If the “Rise” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “Rise & Fall Times” from the “Measurement Type” frame.

When making this measurement the entire packet (burst) duration must be contained with the capture period and the measurement gate must be positioned within the burst. The MT8860C locates the rise and fall on either side of the gate.

For IEEE 802.11b, the specification states that the power-on ramp for the region between 10% and 90% of maximum power must not exceed 2  $\mu$ s. This is shown in the figure below.

For IEEE 802.11g / 802.11a the specification does not specifically define any requirements for the power-on or power-down ramps, however, it would be expected that performance would not be worse than that of 802.11b.

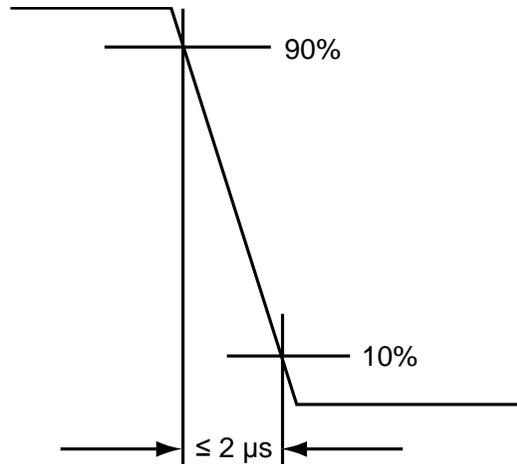


**Figure 9-12.** Transmit Power-On Ramp

## Transmit Power-Down Ramp

The power-down ramp values display in the “Fall (us)” column of the table directly beneath the power profile trace. If the “Fall” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “Rise & Fall Times” from the “Measurement Type” frame.

The IEEE 802.11b specification states that, as shown in the figure below, the power-down ramp for the region between 10% and 90% of maximum power must not exceed 2  $\mu$ s.



**Figure 9-13.** Transmit Power-Down Ramp

**Note**

The minimum capture frame that can be set is 10 $\mu$ s. This is 1  $\mu$ s/division and gives a marker resolution of 0.1 $\mu$ s.

## Crest Factor (OFDM data rates only)

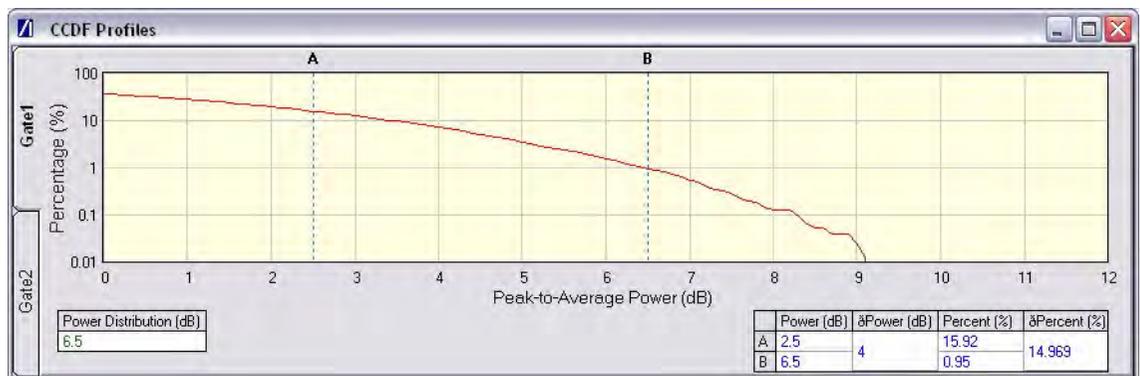
The crest factor values display in the “CF (dB)” column of the table directly beneath the power profile trace. If the “CF” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “CF” from the “Measurement Type” frame.

The crest factor represents the difference in dB between the peak and average power of the signal within the gate.

## 9-6 CCDF Measurements (OFDM Data Rates Only)

The Complementary Cumulative Distribution Function (CCDF) profile allows the user to ascertain the percentage of samples for which the power level specified by the markers is greater than the average power. The profile output contains 120 entries representing the power level (in dB) above the mean in 0.1 dB steps (0-12 dB above the mean). Each entry contains the percentage of time that the signal was less than this number of dB above the mean.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select “CCDF Profiles” from one of the drop-down fields in the “Measurements” frame.
4. Click [Run Once] or [Run Continuous].



**Figure 9-14.** [CCDF Profiles] Window

## 9-7 Spectrum Profile

The displayed spectrum is a time generated spectrum measurement as defined by gates 1 and 2 in the [Power Profile] trace. Four types of spectral profile data can be individually displayed beneath the profile:

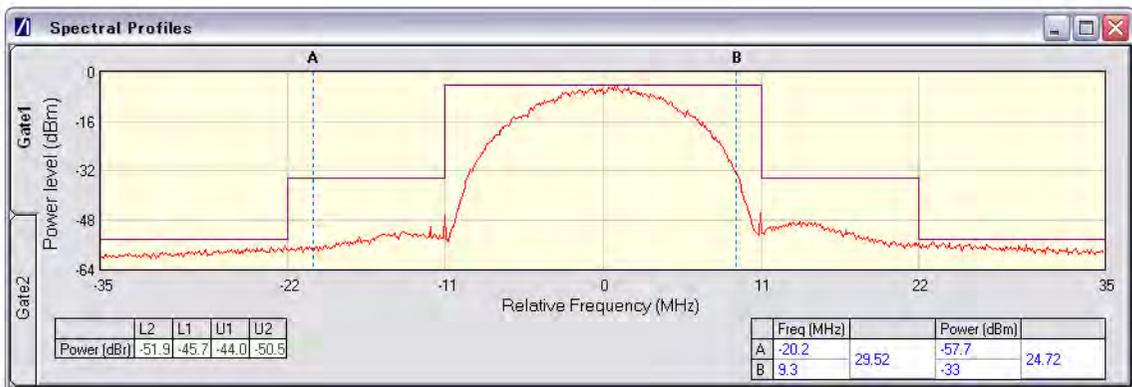
- Spectrum Mask
- Carrier Suppression
- Power Spectral Density (PSD)
- Occupied Bandwidth (OBW)

### Spectrum Mask

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Tx Testing] tab > [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
5. Select “Spectrum Mask” from the “Measurement Type” frame.
6. Click [Run Once] or [Run Continuous].

The MT8860C applies the spectral mask for the selected WLAN standard. The results tables beneath the trace are used to display the pass / fail status for each of the mask elements. The minimum gate time for spectrum updates is 50 $\mu$ s. Longer gates have more spectrum samples giving the effect of point-to-point averaging.

### 802.11b / 802.11g (DSSS Data Rates)



**Figure 9-15.** [Spectral Profiles] Window with Mask

The figure above shows a typical spectral profile for DSSS data rates.

The “L2”, “L1”, “U1”, and “U2” values that display in the table beneath the spectral profile represent the difference in power level between the maximum point within each segment of the trace and the maximum point of the entire spectrum. The segments on the left side of the trace are, from left to right, “L2” and “L1”. The segments on the right side of the trace are, from left to right, “U1” and “U2”.

### Spectrum mask compliance

The transmitted spectral products must be less than  $-30$  dBr (dB relative to the  $\text{SINx/x}$  peak) for:-

$$f_c - 22 \text{ MHz} < f < f_c - 11 \text{ MHz}; \text{ and}$$

$$f_c + 11 \text{ MHz} < f < f_c + 22 \text{ MHz};$$

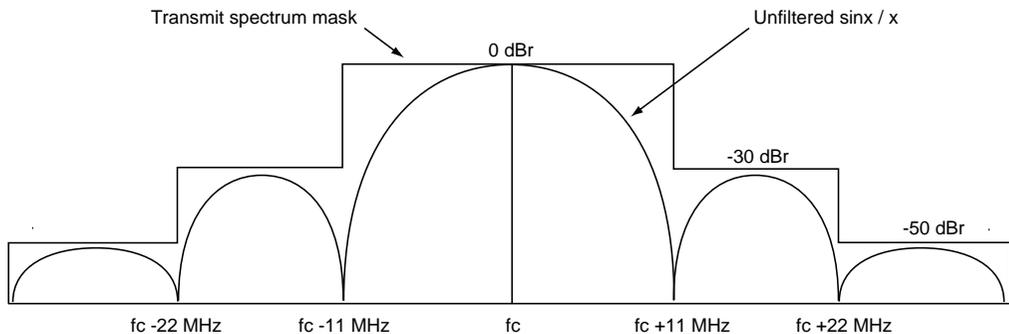
and less than  $-50$  dBr for:-

$$f < f_c - 22 \text{ MHz}; \text{ and}$$

$$f > f_c + 22 \text{ MHz}.$$

Where  $f_c$  is the channel center frequency.

The transmit spectral mask is shown below.



**Figure 9-16.** Spectrum Mask Compliance for DSSS

**Note** Information on how to edit the spectrum mask can be found in chapter 13.

802.11g / 802.11a (OFDM Data Rates)

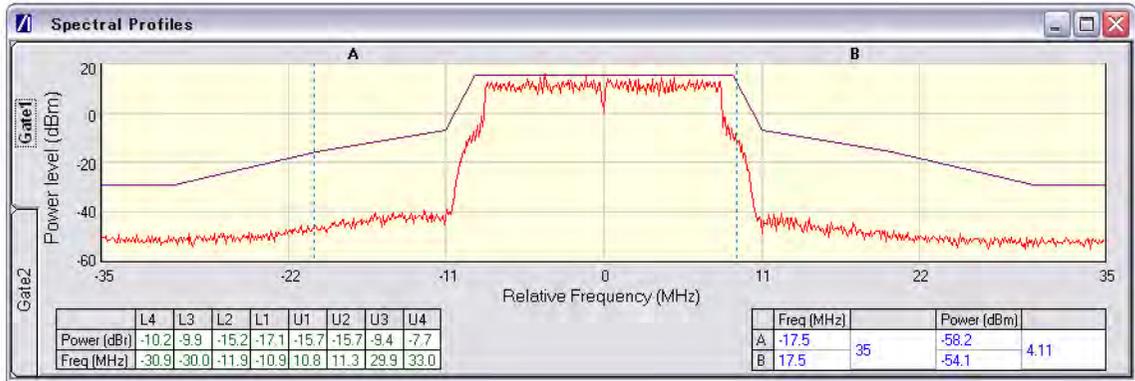


Figure 9-17. [Spectral Profile] Window

The figure above shows a typical spectral profile for 802.11g / 802.11a. The table below the trace displays the frequency in each of the respective mask sections at which the DUT is closest to the mask or, if the mask is exceeded, the frequency at which the mask is exceeded by the greatest margin.

The transmitted signals must fall within the confines of the mask defined in the figure below.

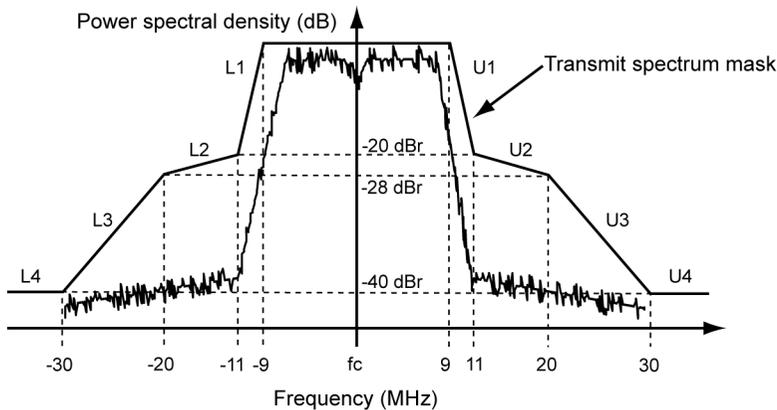


Figure 9-18. Spectral Mask Compliance for OFDM

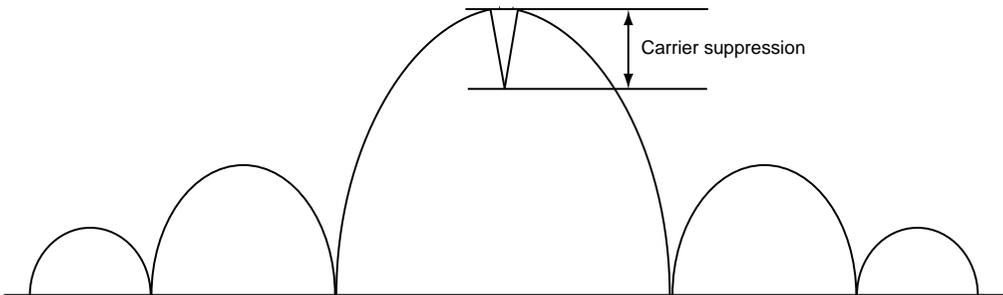
**RF Carrier Suppression (DSSS only)**

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select "Spectral Profiles" from one of the drop-down fields in the "Measurement Window Configuration" frame.
4. Click [Tx Testing] tab > [Tx Advanced Settings...] > [Spectral Profile Settings] tab.

5. Select “Carrier Suppression” from the “Measurement Type” frame.
6. Click [Run Once] or [Run Continuous].

The table within the spectral profile window beneath the trace changes to display the carrier suppression results.

The RF carrier suppression, measured at the channel center frequency, must be at least 15 dB below the peak SIN(x)/x power spectrum.



**Figure 9-19.** Carrier Suppression

**Note**

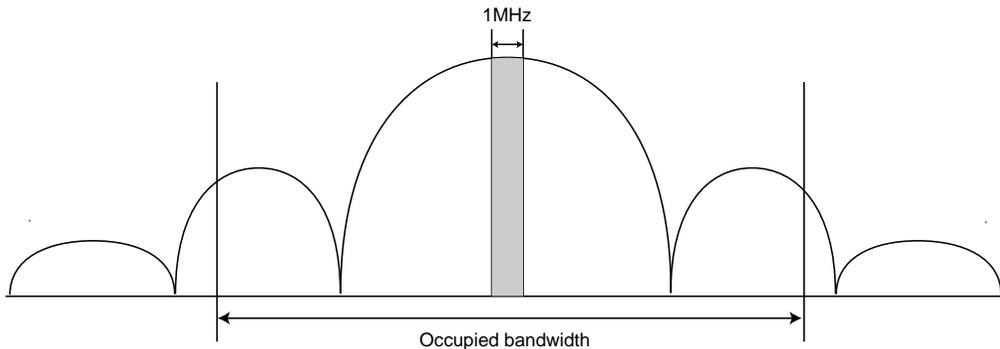
The IEEE standard states that the measurement is made with the DUT configured to transmit DQPSK modulation using a "01" repeating data sequence and with the scrambler disabled. In order to perform the RF carrier suppression measurement as defined in the IEEE Standard, the DUT is configured using control software supplied by the chipset vendor.

As part of the EVM measurement process (see 9-8), the MT8860C includes an IQ offset measurement that returns the actual carrier feedthrough normalized to the mean power at the symbol timings. Using the IQ offset, an estimate of the RF Carrier Suppression can be made. Refer to Appendix K for details.

## Power Spectral Density (PSD)

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Tx Testing] tab > [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
5. Select “Power Spectral Density” from the “Measurement Type” frame.

- Click [Run Once] or [Run Continuous].

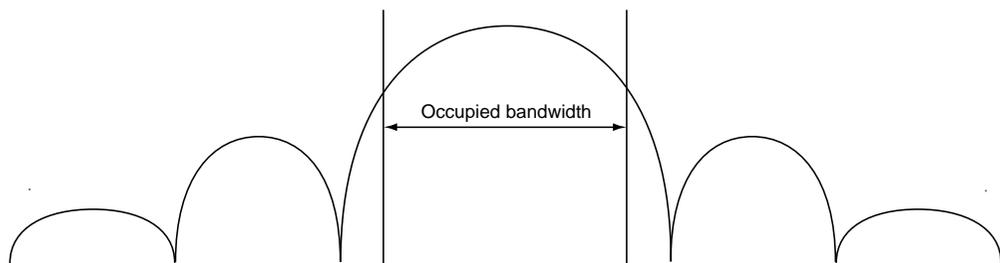


**Figure 9-20.** Power Spectral Density

The table within the spectral profile window changes to display the power spectral density result. The measurement is made according to ETSI EN 300-328 (4.3.2 / 5.7.3) and is defined as the maximum power measured in a 1 MHz bandwidth within the occupied bandwidth of the signal.

### Occupied Bandwidth

- Follow the setup instructions detailed earlier in this chapter.
- Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
- Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
- Click [Tx Testing] tab > [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
- Select “Occupied Bandwidth” from the “Measurement Type” frame.
- Click [Run Once] or [Run Continuous]. The table beneath the trace within the [Spectral Profiles] window changes to display the OBW results. The value within the “OBW” cell of the table indicates the frequency within which the specified percentage of power is contained.

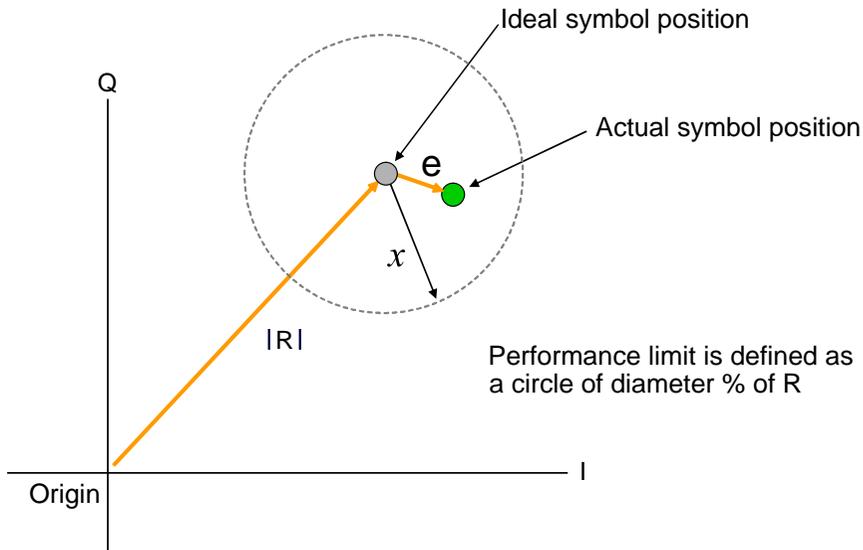


**Figure 9-21.** Occupied Bandwidth

## 9-8 IQ Constellation (EVM Analysis)

The IEEE 802.11 specification uses a metric called Error Vector Magnitude (EVM) as a measure of modulation quality. EVM is a measure of the difference between the ideal symbol position and the measured symbol position. The difference between these two positions is referred to as the error vector and is shown in the figure below by the distance “e”.

EVM is an excellent measure of overall transmitter quality and a high EVM reading typically results in similarly high packet error rate.



**Figure 9-22.** EVM Explanation

The following points should be considered when performing IQ constellation / EVM measurements.

- The transmitted signal must contain an ‘off’ period, i.e. it must not be a continuous transmission.
- The EVM analysis is performed on the first burst found after the trigger, including the pre trigger delay.
- The gate positions do not effect the EVM analysis.
- The EVM analysis is performed over a specified number of chips/symbols. To configure the analysis length, click [Tx Advanced Settings] > [EVM Settings] tab.
- The burst captured must contain at least the specified number of chips/symbols.
- Independent analysis lengths for the DSSS and OFDM data rates are provided.

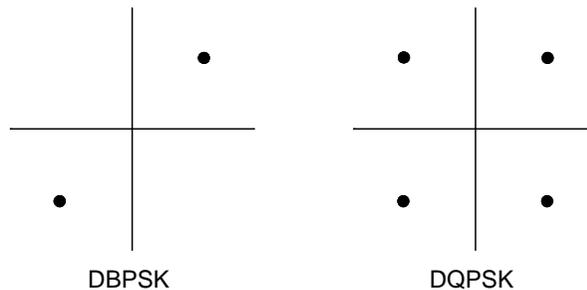
1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select “IQ Constellation” from one of the drop-down fields in the “Measurement Window Configuration” frame.
4. Click [Run Once] or [Run Continuous] to run IQ constellation measurements on the packet payload.

**Note**

The IQ constellation displayed by LANLook is determined by the WLAN Standard and Data Rate settings. If the data rate does not match the rate of transmission from the DUT, it is possible that the analysed data will be mapped onto the wrong constellation.

### 802.11b / 802.11g (DSSS Data Rates)

The 802.11b specification defines two modulation techniques.



**Figure 9-23.** DSSS Modulation

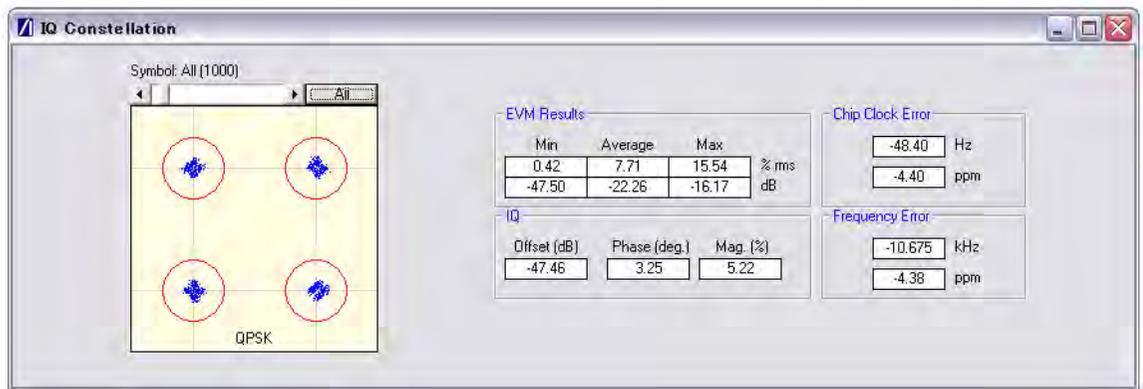
The DSSS data rates and associated modulation methods are illustrated in the table below.

**Table 9-6.** DSSS Data Rates and Modulation Methods

Data Rate (Mbps)	Modulation	Spreading / coding scheme
1	DBPSK	11 chip Barker sequence
2	DQPSK	11 chip Barker sequence
5.5	DQPSK	CCK
11	DQPSK	CCK

**Note**

Users should note that although IQ constellation measurements can be performed at a data rate of 1 Mbps (DBPSK modulation), the IEEE 802.11b specification stipulates that the measurement should be made using DQPSK modulation.



**Figure 9-24.** [IQ Constellation] Window showing DQPSK Constellation

The screen capture above shows a typical DQPSK constellation. The statistic of most interest to the user is the “Max” value that displays at the “EVM Results” field. The 802.11b specification stipulates that the worst-case vector error magnitude should not exceed 35%.

### Chip Clock Error

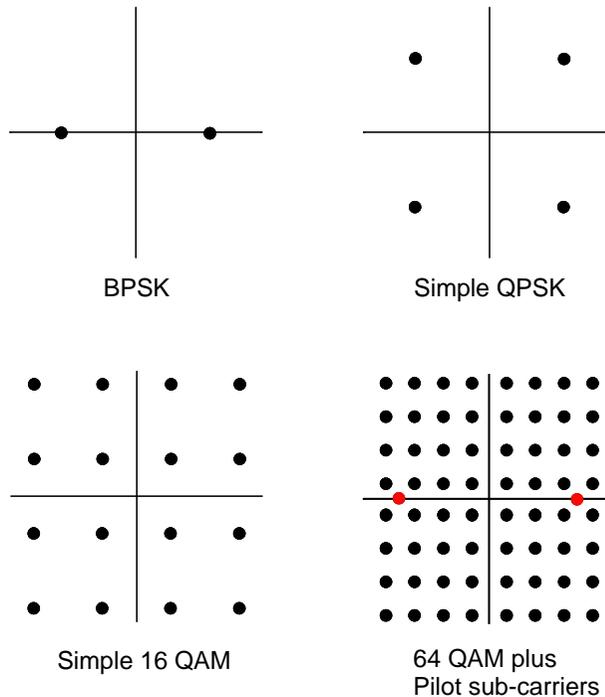
The chip clock error measurement results are also displayed in the dialog above. The 802.11b specification stipulates that the chip clock frequency tolerance shall be better than  $\pm 25$  ppm.

### Frequency Error

The center frequency measurement results are also displayed in the dialog above. The 802.11g specification stipulates that the center frequency tolerance shall be better than  $\pm 25$  ppm. For 802.11a, the specification stipulates that the transmit center frequency tolerance shall be  $\pm 20$  ppm maximum.

## 802.11g / 802.11a (OFDM Data Rates)

Each of the OFDM sub-carriers can be modulated using any of the following four techniques.



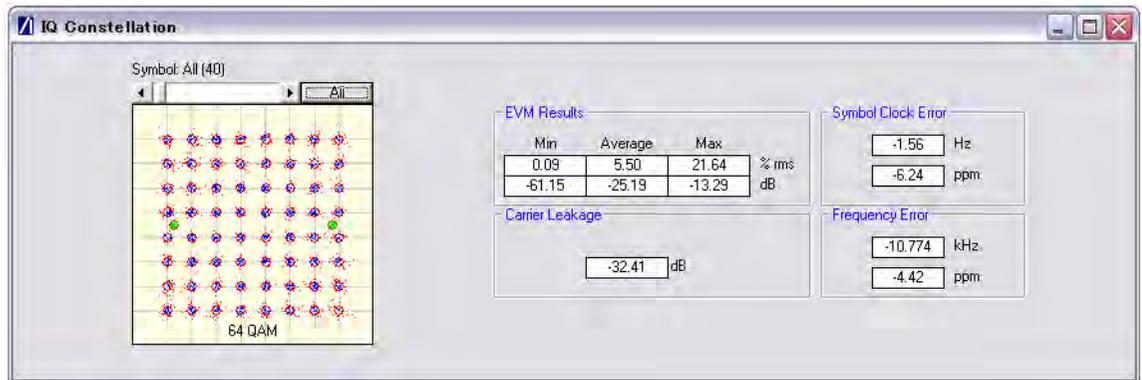
**Figure 9-25.** OFDM Modulation

In addition to the modulation constellations, the MT8860C can be used to display graphical results for EVM vs sub-carrier and EVM vs. symbol . These may be of particular use when a detailed analysis of the cause of distortion is required.

The OFDM data rates and associated modulation methods are illustrated in the table below.

**Table 9-7.** OFDM Data Rates and Modulation Methods

Data Rate (Mbps)	Modulation
6	BPSK
9	BPSK
12	QPSK
18	QPSK
24	16QAM
36	16QAM
48	64QAM
54	64QAM



**Figure 9-26.** [IQ Constellation] Window showing 64 QAM Constellation

The screen capture above shows a 64 QAM constellation. The statistic of most interest to the user is the “Average” value that displays at the “EVM Results” field. The 802.11a specification stipulates that the relative error must not exceed the data rate dependent values specified in the table below. Set the average to 20 to make measurements as specified in the IEEE standard.

**Table 9-8.** Maximum Permissible EVM Values Per Data Rate

Data Rate (Mbps)	EVM (dB)	EVM (% RMS)
6	-5	56.2
9	-8	39.8
12	-10	31.6
18	-13	22.3
24	-16	15.8
36	-19	11.2
48	-22	7.9
54	-25	5.6

### Symbol Clock Error

The symbol clock error measurement results are also displayed in the dialog above. The 802.11g specification stipulates that the symbol clock frequency tolerance shall be  $\pm 25$  ppm maximum. For 802.11a, the specification stipulates that the symbol clock frequency tolerance shall be  $\pm 20$  ppm maximum.

### Frequency Error

The center frequency measurement results are also displayed in the dialog above. The 802.11g specification stipulates that the center frequency tolerance shall be better than  $\pm 25$  ppm. For 802.11a, the specification stipulates that the transmit center frequency tolerance shall be  $\pm 20$  ppm maximum.

**Carrier Leakage**

The carrier leakage measurement results are also displayed in the dialog above.

Carrier leakage is measured during the 8  $\mu$ s phase and is relative to the average power of the -16 to +16 sub-carriers. The 802.11a specification stipulates that such leakage shall not exceed -15 dB relative to overall transmitted power.

## 9-9 EVM vs Sub-Carrier (OFDM only)

Although not a defined measurement of the IEEE, the EVM vs Sub-Carrier measurement is a powerful analysis tool that displays the average and max / min EVM for each OFDM channel.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select “EVM vs Sub-Carrier” from one of the drop-down fields in the “Measurements Window Configuration” frame.
4. Click [Run Once] or [Run Continuous] to display a trace such as that shown below. The vertical green lines at  $\pm 7$  and  $\pm 21$  are the pilot carriers, the blue bars are the maximum and minimum values and the horizontal trace shows the average EVM.

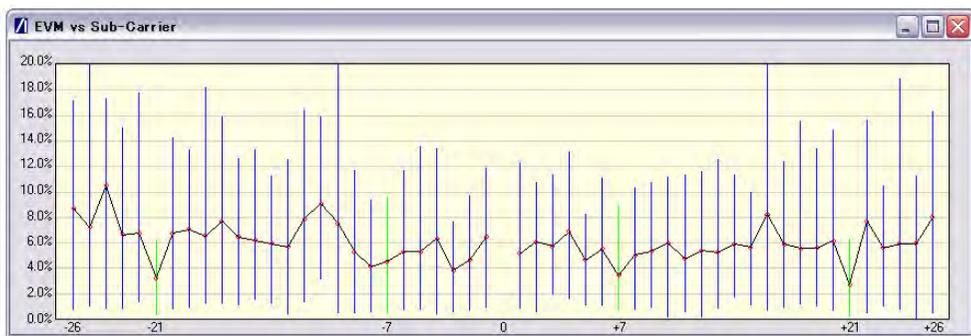
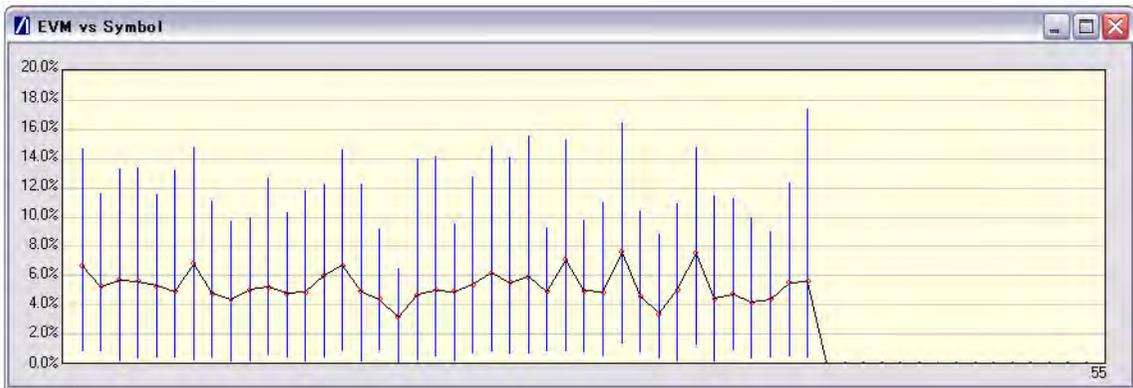


Figure 9-27. [EVM vs Sub Carrier] Window

## 9-10 EVM vs Symbol (OFDM only)

Although not a defined measurement of the IEEE, the EVM vs Symbol measurement is a powerful analysis tool that displays the average and max / min EVM for each symbol in the gate.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select “EVM vs Symbol” from one of the drop-down fields in the “Measurements” frame.
4. Click [Run Once] or [Run Continuous] to display a trace such as that shown below.



**Figure 9-28.** [EVM vs Symbol] Window

## 9-11 Spectral Flatness (OFDM only)

The spectral flatness measurement provides the user with a display of RF level vs sub-carrier over the measurement range.

The IEEE 802.11a specification stipulates acceptable values for the average energy of the constellations in each of the sub-carriers. For lines -16 to -1 and 1 to 16 the average energy of any individual sub-carrier should deviate no more than  $\pm 2$  dB from their average energy of all 32 central sub-carriers. For lines -26 to -17 and 17 to 26 the average energy of the constellations in each of the spectral lines should deviate no more than  $\pm 2/-4$  dB from the average energy of spectral lines -16 to -1 and 1 to 16. The data for this test is measured over the  $8\mu\text{s}$  channel estimation period of the packet while all 52 sub-carriers are on.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select the appropriate WLAN standard from the [Wireless Test] tab (see Table 8.3).
3. Select “Spectral Flatness” from one of the drop-down fields in the “Measurements” frame.
4. Click [Run Once] or [Run Continuous].



**Figure 9-29.** [Spectral Flatness] Window

The spectral mask (shown by the horizontal lines) is split into three sections; an upper limit with a default setting of +2.0 dB, a lower side limit with a default setting of -4.0 dB, and a lower centre limit with a default setting of -2.0 dB. Each of the spectral mask sections can be moved freely to the required position and the dB value appears in a small pop-up next to the cursor when the line is being moved. The new limit values are sent automatically to the MT8860C when the user releases the mouse button. Channel measurements that fall outside of the limits of the mask display in red and also carry a small label that appears near the cursor to say how many times that channel failed.

## 9-12 Numeric Results

Transmitter measurement results can also be viewed as numeric data. Viewing the results in this format is slightly quicker as it requires less remote data than when viewing the traces graphically.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Numeric Results Only” in the “Measurement Window Configuration” frame.
3. Click [Run Once] or [Run Continuous] to view the results. The figure below shows the numeric results window for an OFDM data rate.

Tx Tests Numerical Results								
<b>Power</b>	<b>Start</b>	<b>Stop</b>	<b>Peak</b>	<b>Average</b>	<b>Crest Factor</b>	<b>Rise</b>	<b>Fall</b>	<b>Distribution</b>
Gate 1	0.005 ms	0.179 ms	18.29 dBm	9.50 dBm	8.79 dB	0.07 us	0.27 us	6.50 dB
Gate 2	0.02 ms	0.181 ms	18.29 dBm	9.51 dBm	8.78 dB	0.07 us	0.27 us	6.50 dB
<b>EVM</b>	<b>Minimum</b>		<b>Average</b>		<b>Maximum</b>			
% rms	0.06 %		3.84 %		14.42 %			
dB	-64.75 dB		-28.31 dB		-16.82 dB			
<b>IQ Analysis</b>	<b>802.11g OFDM</b>				<b>802.11 b/g DSSS</b>			
Carrier Leakage / IQ Offset	-30.49 dB				n/a			
Phase Error	n/a				n/a			
Magnitude Error	n/a				n/a			
Frequency Tolerance	-37.88 kHz	-15.54 ppm		n/a		n/a		
<b>Clock Error</b>	<b>802.11g OFDM (Symbol Clock)</b>				<b>802.11 b/g DSSS (Chip Clock)</b>			
Hz	-3.11 Hz				n/a			
ppm	-12.46 ppm				n/a			
<b>Spectrum Mask</b>	<b>Status</b>							
Gate 1	PASS							
Gate 2	PASS							
<b>Spectrum Mask</b>	<b>L4</b>	<b>L3</b>	<b>L2</b>	<b>L1</b>	<b>U1</b>	<b>U2</b>	<b>U3</b>	<b>U4</b>
Gate 1 Power (dBr)	-14.6	-14.0	-13.2	-15.2	-17.2	-15.6	-17.0	-14.1
Gate 2 Power (dBr)	-13.4	-13.5	-12.1	-14.2	-15.8	-13.6	-15.9	-13.8
Gate 1 Frequency (MHz)	-31.6	-20.4	-11.9	-10.7	10.6	11.8	29.6	30.5
Gate 2 Frequency (MHz)	-31.6	-20.4	-11.9	-10.9	10.9	11.8	28.0	31.3
<b>Spectrum Data</b>	<b>Spectral Density</b>		<b>Occupied Bandwidth</b>		<b>Carrier Suppression</b>		<b>Spectral Flatness</b>	
Gate 1	-0.73 dBm/MHz		16.4 MHz		-		PASS	
Gate 2	-0.71 dBm/MHz		16.4 MHz		-		n/a	

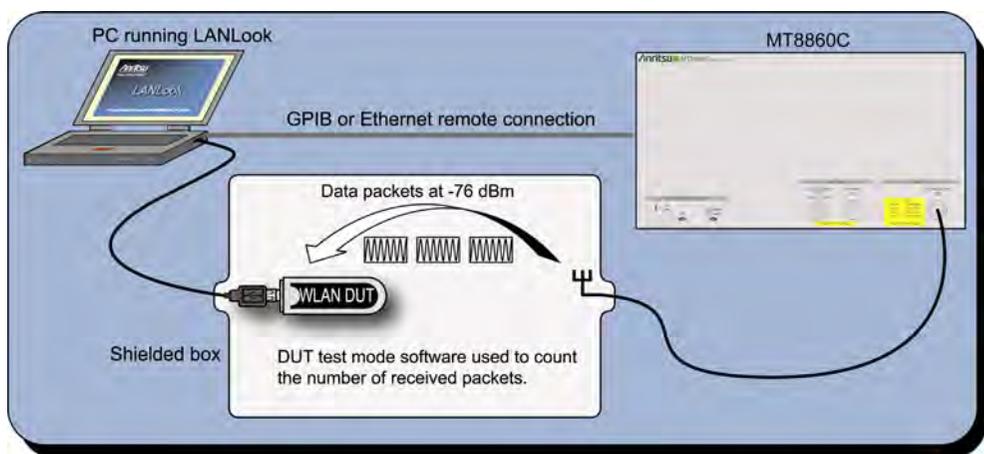
Figure 9-30. [Tx Tests Numeric Results] Window

# Chapter 10 — 802.11b/g/a Receiver Testing in Direct Mode

A WLAN connection with the DUT is not required in order to perform Rx testing in Direct mode. When Direct mode is selected the Network setup settings within LANLook are no longer applicable and are replaced by a message to this end.

## 10-1 Test Methodology

When testing the Rx sensitivity of a device in Direct Mode, the MT8860C is configured to transmit a specified number of data packets. After the final packet has been transmitted, a baseband register (internal to the DUT) is read. This register contains the number of packets received without error. Calculations are then made based on the number of packets sent by the MT8860C and the number received without error.



**Figure 10-1.** Receiver Testing in Direct Mode

DUT receiver measurements are based on the calculation of Packet Error Rate (PER) or Frame Reception Rate (FRR). PER is an expression of the number of packets there were received in error. FRR is an expression of the number of packets that were successfully received. FRR is specified by the CTIA and Wi-Fi Alliance in the CWG Test Plan used to evaluate the RF Performance of Wi-Fi Mobile Converged Devices.

PER is calculated using the formula below:

$$(1 - (\text{Number of packets correctly received} / \text{Number of packets sent})) \times 100\%$$

FRR is calculated using the formula below:

$$(\text{Number of packets correctly received} / \text{Number of packets sent}) \times 100\%$$

## 802.11 PER Specifications

For DSSS data rates, the IEEE 802.11b specification states that the packet error rate (PER) must not exceed 8% for an input level no greater than -76 dBm measured at the antenna connector. The specification recommends that the test is performed using an 11 Mbps CCK modulated signal with a PSDU length of 1024 bytes.

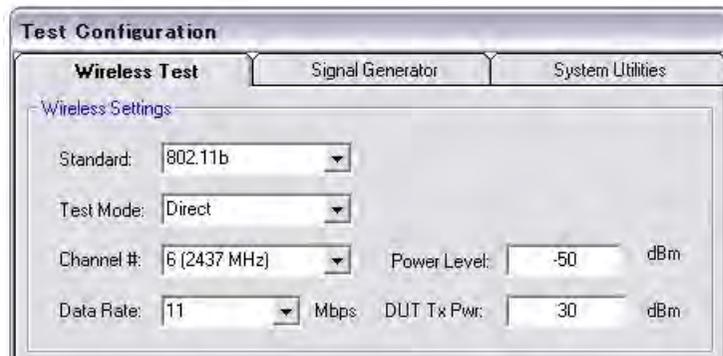
For the OFDM data rates, the IEEE 802.11b specification states that the packet error rate (PER) shall be less than 10% at a PSDU length of 1000 bytes for the input levels indicated in the table below. Input levels are specific for each data rate and are measured at the antenna connector. A noise figure (NF) of 10 dB and an implementation loss of 5 dB are assumed.

**Table 10-1.** Sensitivity by Data Rate

Data rate (Mbps)	Minimum sensitivity (dBm)
6	-82
9	-81
12	-79
18	-77
24	-74
36	-70
48	-66
54	-65

## 10-2 Wireless Settings

1. Establish a remote connection between the MT8860C and PC as detailed in chapter 5.
2. Click the [Wireless Test] tab.
3. The wireless settings display at the top of this tab as shown in the figure below.



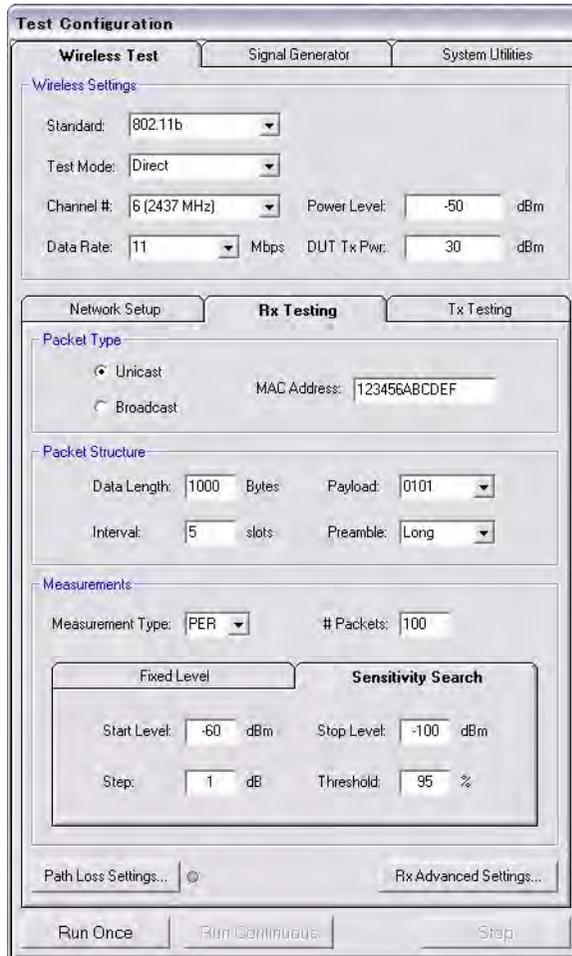
**Figure 10-2.** 802.11b/g/a Wireless Settings

4. At “Standard” select the IEEE standard to be used during testing. Users should note that 802.11a is only available on units for which option 14 has been enabled.
5. At “Test Mode” select “Direct”.  
Selecting “Direct” allows the user to perform testing without the need to establish a WLAN connection with the DUT.
6. At “Channel #” select the WLAN channel on which measurements will be performed. The channels for each of the WLAN standards are shown in the table on the following page.
7. At “Data Rate” select the data rate at which measurements will be performed. The rate can be selected freely from those available but is set by default to the highest rate available in the currently selected IEEE standard (11 Mbps for 802.11b and 54 Mbps for 802.11g and 802.11a).
8. At “Power Level” specify the “Power Level” that is transmitted by the MT8860C. The value should represent the signal level required at the antenna / RF connector of the DUT.
9. At “DUT Tx Power” specify the power that the DUT is expected to transmit. The value should represent the signal level at the antenna / RF connector of the DUT.

## 10-3 Configuring Test Settings

### Packet Type

1. Click the [Rx Testing] tab shown below.



**Figure 10-3.** [Rx Testing] Tab

2. Specify the type of transmission to be sent from the MT8860C to the device.

- Unicast:** This is the default setting in which the MT8860C transmits packets with a unique MAC address specified by the user.
- Broadcast:** In broadcast mode the MT8860C transmits packets using the broadcast address (FF-FF-FF-FF-FF-FF).
- MAC Address:** The unique 12 digit hexadecimal MAC address.

## Packet Structure

1. Specify the packet structure at the following items.

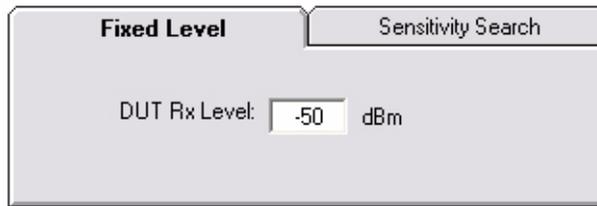
Data Length:	The data length of the packet can be set to any value between 60 and 1500 bytes.
Interval:	The interval specified represents the number of slots between frame transmissions. For transmission of DSSS modulated data, each slot is equal to 20 $\mu$ s, for transmission of OFDM modulated data, each slot is equal to 9 $\mu$ s.
Payload:	Defines the bit sequence pattern of the dummy data in the payload. There are six options available in the drop down list, ZEROS, 0101, 1010, PN7, RANDOM, and COUNT. The required payload is determined by the test that the user wishes to perform.
Preamble:	For data rates of 2, 5.5 and 11 Mbps, long and short preamble options are available. The long setting represents a preamble with 144 bits, and the short with 72. A short preamble setting equates to more payload data being transmitted with each packet for a given timeslot. For 1 Mbps a long preamble is used.

<p><b>Note</b> Preamble settings are not applicable for OFDM data rates.</p>
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## Measurements

1. At “Measurement Type” specify whether the sensitivity results are shown as PER (packets received in error) or FRR (packets successfully received).
2. At “# Packets” specify the number of packets to be transmitted. Enter a value within the range of 1 and 10,000.
3. If required, a signal level correction table can be used to compensate for test system and cable loss effects. Refer to chapter 14 for details.
4. Follow the instructions over the following pages to perform the required measurements.
  - Measuring PER or FRR at a fixed power level
  - Measuring PER or FRR at a varying power level
  - Measuring PER or FRR in broadcast mode
  - Measuring PER or FRR with co-channel or adjacent channel interference

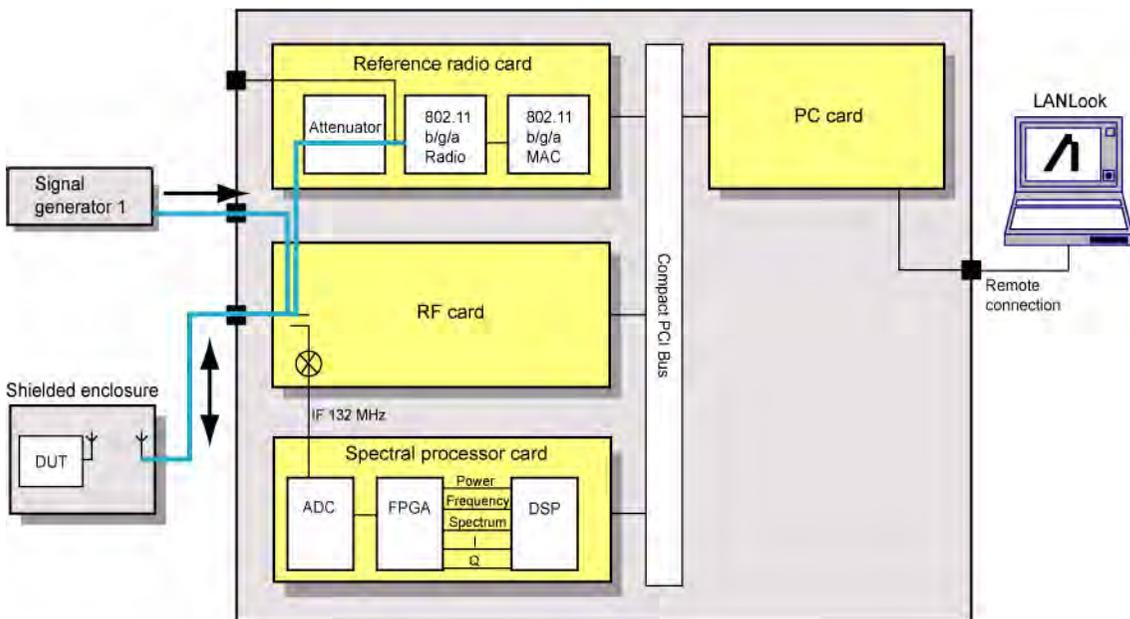
## 10-4 Fixed Power Level



**Figure 10-4.** PER/FRR Setting

1. Follow the setup instructions detailed at the start of this chapter.
2. Click the [Fixed Level] tab shown above.
3. Set the required MT8860C transmission power level at the “DUT Rx Level” setting.
4. Click [Run Once] to initiate the transmission of packets.
5. Use the chipset vendor’s test mode software to read the number of packets successfully received by the DUT.

## 10-5 Channel Interference

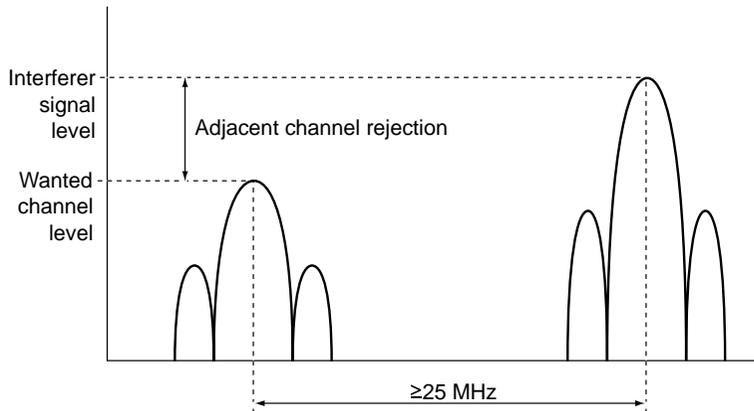


**Figure 10-5.** PER with Channel Interference

In addition to the normal test configuration detailed earlier, an external signal generator can be coupled to the MT8860C to measure adjacent or alternate channel rejection.

## Adjacent Channel Rejection Specifications

For DSSS data rates, adjacent channel rejection is defined between any two channels with 25 MHz separation. The adjacent channel rejection must be equal to or better than 35 dB, with a PER of 8% using 11 Mbps CCK modulation and a PSDU length of 1024 bytes.



**Figure 10-6.** Adjacent Channel Rejection

For OFDM data rates, the adjacent channel rejection shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in table 10-1 and raising the power of the interfering signal until 10% PER is caused. The power difference between the interfering and the desired channel is the corresponding adjacent channel rejection. The interfering signal in the adjacent channel shall be a conforming OFDM signal, unsynchronized with the signal in the channel under test.

**Table 10-2.** Rejection Values Per Data Rate

Data rate (Mbps)	Adjacent channel rejection (dB)	Alternate adjacent channel rejection (dB)
6	16	32
9	15	31
12	13	29
18	11	27
24	8	24
36	4	20
48	0	16
54	-1	15

1. Connect a signal generator to the interferer input on the front of the MT8860C.
2. Set the signal generator to transmit on the required channel.
3. Follow the setup instructions detailed at the start of this chapter.

4. Set the required transmission power level on the [Fixed Level] tab in the “Measurements” frame.
5. Click [Run Once].

**Note**

When performing adjacent channel testing, it is necessary to know the path loss from the interferer input to the test port. The path loss for each instrument is measured in the production process and the value is stored in non-volatile memory. The path loss can be read by the user by sending the INTFLOSS command from the LANLook [Diagnostics] tab. The INTFLOSS command returns the insertion loss for the channel requested. The returned value should be used as an offset for the interfering signal when making adjacent channel measurements. The typical path loss from the interferer input to the test port is 22 dB.

# Chapter 11 — 802.11n Transmitter Testing in Direct Mode

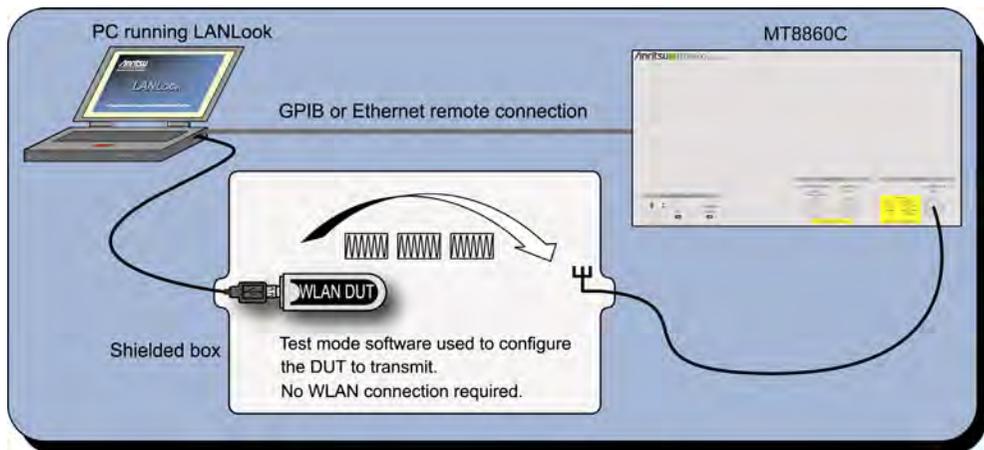
MT8860C units installed with option 17 can perform 802.11n transmitter measurements.

**Note** The MN8861A receiver accessory (purchased separately) is not required for 802.11n transmitter testing.

A WLAN connection between the MT8860C and the DUT is not required in order to perform 802.11n Tx testing.

## 11-1 Test Methodology

For 802.11n testing, control software supplied by the chipset vendor is used to configure the DUT to transmit continuously on a defined channel and data rate. The MT8860C spectral processor is then tuned to the same channel and triggers continuously or from the power burst rising edge.



**Figure 11-1.** Transmitter Testing in Direct Mode

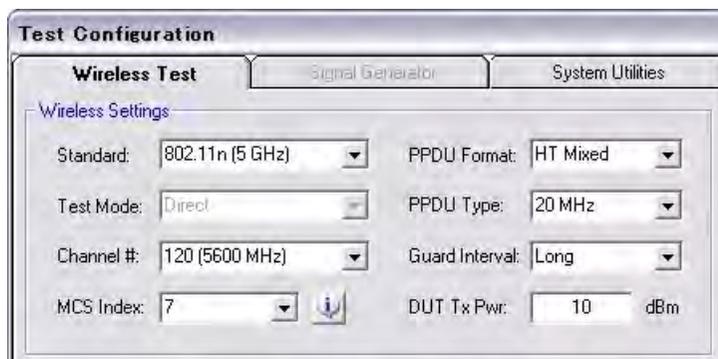
## 11-2 802.11n Overview

The 802.11n standard differs from the 802.11b/g/a standards in a number of ways. Users are recommended to read and digest the four key differences outlined below, before attempting to configure the wireless setup.

- 802.11n data can be transmitted in either the 2.4 GHz ISM frequency band, or in the 5.0 GHz UNII band.
- 802.11n data can be transmitted over a signal with a 20 MHz or 40 MHz bandwidth.
- 802.11n data can be transmitted using any of three PPDU formats (Non-HT, HT Mixed, HT Greenfield). The format is selected as required to maximize throughput, or provide full or partial backwards compatibility with 802.11b/g/a legacy devices.
- 802.11n data rates for high-throughput transmissions are determined by a Modulation and Coding Scheme (MCS). MCS values were defined in the IEEE standard to simplify the numerous factors that can influence achievable data rates. An MCS value selected by the user is plotted against variables such as modulation and guard interval to determine the effective data rate. Refer to the tables in Appendix B for full details of MCS data rates for long and short guard intervals.

## 11-3 Wireless Setup

1. Establish a remote connection between the MT8860C and PC as detailed in chapter 5.
2. Click the [Wireless Test] tab.
3. Click the [Tx Testing] tab.
4. The wireless settings display as shown in the figures below.



**Figure 11-2.** 802.11n Wireless Settings for HT (High-Throughput) Mixed Transmissions

5. At "Standard" select "802.11n (2.4 GHz)" or "802.11n (5 GHz)".

**Note** Note 802.11n (5 GHz) selection is only available on MT8860C units fitted with option 14.

6. At "Channel #" select the WLAN channel(s) on which measurements will be performed. The channels available for selection from the "Channel #" drop-down vary depending on the "Freq Band" and "PPDU Type" settings.

If “PPDU Type” is set to “20 MHz”, the “Channel #” drop-down displays a simple list of available channels: 1 to 13 in the 2.4 GHz band, or 36 to 165 in the 5.0 GHz band.

If “PPDU Type” is set to “40 MHz”, “40 MHz Upper”, “40 MHz Lower”, or “40 MHz Duplicate”, the “Channel #” drop-down displays a list of channels appended with “+1” or “-1”: e.g., “2, +1 (2427 MHz)”.

802.11n operation at 40 MHz is achieved using a combination of two adjacent 20 MHz channels. The first value within the “Channel #” drop-down indicates the primary 20 MHz channel, the second value (+1 or -1) indicates whether the secondary channel is sequentially above or below the primary channel.

7. Select the “MCS Index” or “Data Rate” at which measurements will be performed. The name of this field is determined by the “PPDU Format” setting.

If “PPDU Format” is set to “HT Mixed” or “HT Greenfield”, an “MCS Index” drop-down setting displays. Due to the numerous factors that can influence data rates, the 802.11n standard uses a “Modulation and Coding Scheme” (MCS) for high-throughput data transmissions. The selected MCS value is plotted against variables such as modulation and guard interval, to determine the effective data rate. The data rate and modulation scheme can be verified by clicking the information button (i) to the right of the drop down. The available MCS values and their associated data rates are detailed in the tables in Appendix B.

If “PPDU Format” is set to “Non-HT”, the data rate can be selected directly from the “Data Rate” drop-down.

8. At “PPDU Format” select the format at which measurements will be performed. The items within the drop-down are defined below.

Non-HT:	All data is transmitted in the 802.11b/g/a format to ensure backwards compatibility with legacy devices.
HT Mixed:	Data is transmitted with both legacy formatted and HT formatted preambles. Legacy devices receiving the data are unable to read the payload but can avoid collision by knowing when the channel is busy. Ensuring backwards compatibility in this manner reduces data throughput considerably.
HT Greenfield:	All data is transmitted in high-throughput format and cannot be read by 802.11b/g/a legacy devices.

9. At “PPDU Type” select the channel bandwidth at which data will be transmitted from the DUT. The items within the drop-down are detailed below.

20 MHz:	Data is transmitted over a signal with 20 MHz bandwidth.
40 MHz:	Data is transmitted over two adjacent signals with 20 MHz bandwidth.
40 MHz Upper:	Data is transmitted over a signal with 20 MHz bandwidth in the upper side band of a 40 MHz channel.
40 MHz Lower	Data is transmitted over a signal with 20 MHz bandwidth in the lower side band of a 40 MHz channel.

40 MHz Duplicate Data is transmitted twice using two adjacent signals with 20 MHz bandwidth.

10. At “Guard Interval” select the long or short guard interval. This is applicable only if “PPDU Format” is set to “HT Mixed”.

**Note** For "HT-Greenfield" a long guard interval is used.

11. At “DUT Tx Power” specify the power that the DUT is expected to transmit. The value should represent the signal level at the antenna / RF connector of the DUT.

## 11-4 Configuring Test Settings

### DUT Settings

1. Display the [Tx Testing] tab for 802.11n as shown in the figure below.

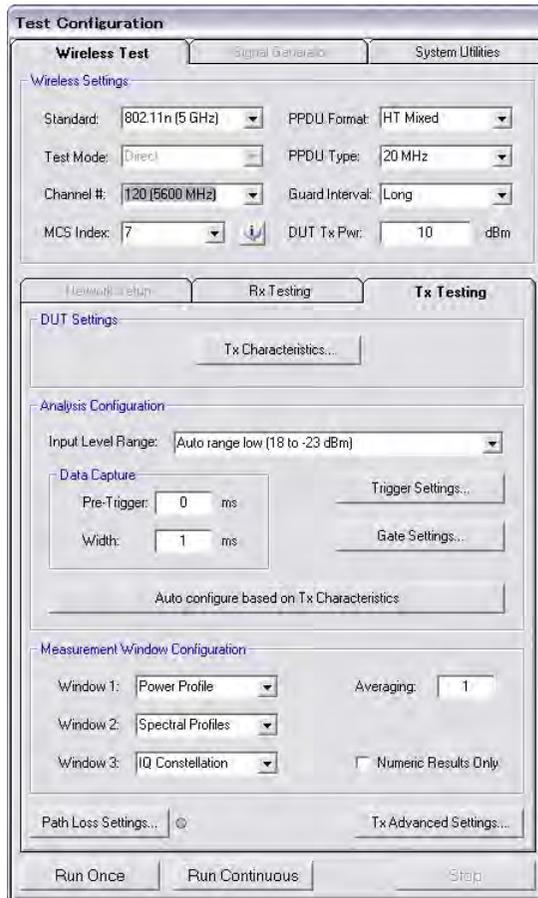
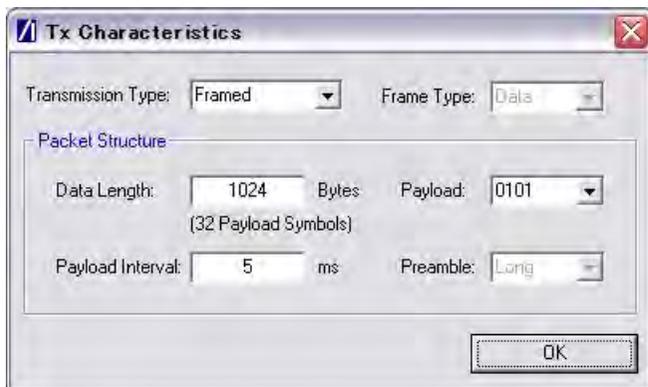


Figure 11-3. [Tx Testing] Tab

2. Click [Tx Characteristics...] to display the dialog shown below. This dialog is used to specify the expected Tx characteristics of the DUT.



**Figure 11-4.** [Tx Characteristics] Dialog

- Transmission Type: Select either a “framed” or “continuous” transmission type.
- Frame Type: Not available for 802.11n. Set by default to data frame analysis.
- Data Length: The maximum and minimum packet length is dependent upon the data rate. The tables below detail the maximum and minimum data lengths for Non-HT and HT data rates.

**Table 11-1.** Non-HT Minimum and Maximum Data Length by Data Rate

Data Rate (Mbps)	Minimum data length (bytes)	Maximum data length (bytes)
1	40	600
2	75	1,250
5.5	210	3,440
11	415	6,875
6	50	3,750
9	75	5,625
12	100	7,500
18	145	11,250
24	195	15,000
36	280	22,500
48	385	30,000
54	435	33,750

**Table 11-2.** HT Minimum and Maximum Data Length by Data Rate

Data Rate (Mbps)	Minimum data length (bytes)	Maximum data length (bytes)	Data Rate (Mbps)	Minimum data length (bytes)	Maximum data length (bytes)
6	50	3,750	43.3	350	27,060
6.5	55	4,060	45	360	28,125
6.7	55	4,185	52	420	32,500
7.2	60	4,500	54	435	33,750
13	105	8,125	57.8	465	36,125
13.5	110	8,435	58.5	470	36,560
14.4	120	9,000	60	480	37,500
15	120	9,375	65	520	40,625
19.5	160	12,185	72.2	580	45,125
21.7	175	13,560	81	650	50,625
26	210	16,250	90	720	56,250
27	220	16,875	108	864	65,535
28.9	235	18,060	120	960	65,535
30	240	18,750	121.5	972	65,535
39	315	24,375	135	1080	65,535
40.5	325	25,310	150	1200	65,535

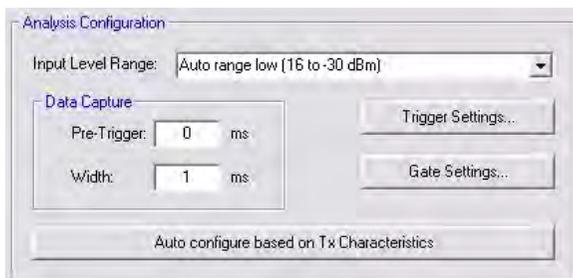
- Payload Interval:** The interval specified represents the time between frames transmitted by the DUT.
- Payload:** Defines the bit sequence pattern of the dummy data in the payload. There are six options available in the drop down list, ZEROS, 0101, 1010, PN7, RANDOM, and COUNT. The required payload is determined by the test that the user wishes to perform.
- Preamble:** For data rates of 2, 5.5 and 11 Mbps, long and short preamble options are available. The long setting represents a preamble with 144 bits, and the short with 72. A short preamble setting equates to more payload data being transmitted with each packet for a given timeslot. For 1 Mbps a long preamble is used.

**Note** Preamble settings are not applicable for OFDM data rates.

## Analysis Configuration

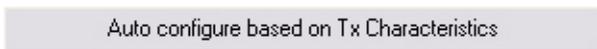
1. Configure the MT8860C as required to allow analysis of the data being transmitted from the DUT. Settings can be made in two ways:-

Manually: The MT8860C can be configured manually using the “Analysis Configuration” settings.



Refer to steps 2 to 5 below.

Automatically: The Tx analyser settings of the MT8860C can be configured manually by clicking [Auto configure based on Tx Characteristics].



When used, all of the settings within “Analysis Configuration” are configured automatically based upon the settings made in the [Tx Characteristics] dialog.

2. Select the power level range at “Input Level Range”.

**Table 11-3.** Input Level Ranges for 802.11n by PPDU Type

	<b>20 MHz, 40 MHz Upper, 40 MHz Lower</b>	<b>40 MHz, 40 MHz Duplicate</b>
Range 1	18 to 5 dBm	16 to 5 dBm
Range 1L	6 to -6 dBm	6 to -6 dBm
Range 2	-5 to -17 dBm	-5 to -17 dBm
Range 2L	-16 to -30 dBm	-16 to -30 dBm
Range 3	-29 to -41 dBm	-29 to -41 dBm
Range 3L	-40 to -50 dBm	-40 to -50 dBm
Auto range low	18 to -30 dBm	16 to -30 dBm
Auto range high	18 to -50 dBm	16 to -50 dBm

**Note** “Input Level Range” can be set to “Auto Range Low” to prevent damage to the MT8860C input that may be caused by a sudden power change.

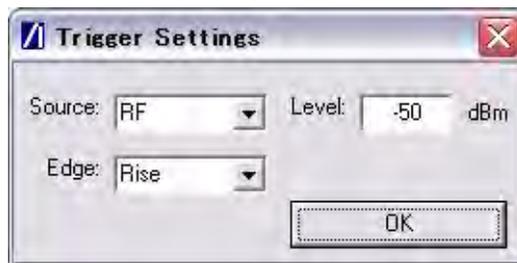
3. Specify the “Data Capture” settings as detailed below.

**Pre-Trigger:** Enter a value at the “Pre-Trigger” item as required. The “Pre-trigger” item is used to specify the time in milliseconds for which data is captured prior to the trigger point. Enter a negative value between -5.95 and 0.

**Width:** Enter the time period after the pre-trigger during which measurement data is captured. Enter a value in milliseconds within the range of 0.01 to 5.95.

4. Click [Trigger Settings...] to display the dialog below.

---



**Figure 11-5.** [Trigger Settings] Dialog

---

**Source:** The trigger source item specifies the mechanism used to trigger measurement within each incoming packet. There are four options available.

**RF:** Triggering is enabled at the power level specified at the “Level” item.

**External:** The signal to trigger measurement is supplied from the external BNC connect (“Digital In 1”) on the rear of the MT8860C.

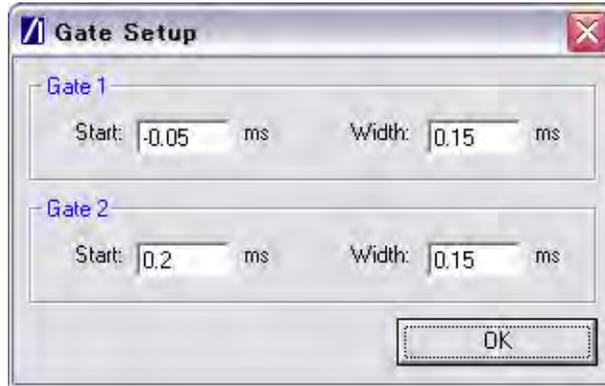
**Free run:** Triggering is performed continuously.

**Video:** Auto trigger from the RF power at the IF of the MT8860C.

**Edge:** Select whether triggering is performed on the rising or falling edge of the pulse.

**Level:** Specify the power level.

5. Click [Gate Settings...] to display the dialog below.



**Figure 11-6.** [Gate Setup] Dialog

The position of the measurement gates can be defined by entering the start positions and the total gate width.

### Measurement Window Configuration

1. In the “Measurement Window Configuration” frame, select the test results to be displayed in LANLook windows 1 (top), 2 (middle), and 3 (bottom). The transmitter tests available are listed below.

**Table 11-4.** Available Transmitter Tests for 802.11n Standard

802.11n
Power profile
CCDF profiles
EVM vs Sub-Carrier
EVM vs Symbol
IQ constellation
Spectral profiles
Spectral flatness

Up to three transmitter measurements can be displayed simultaneously and each of the measurements gives access to a number of different statistics. The user can also select the order in which the individual test result windows display.

2. At the “Averaging” entry box specify the number of trigger events that are averaged before data is output to LANLook or remote interface.
3. If trace results are not required select “Numeric Results Only” to replace the trace window(s) with a single window of numeric result tables.

## Path Loss Settings

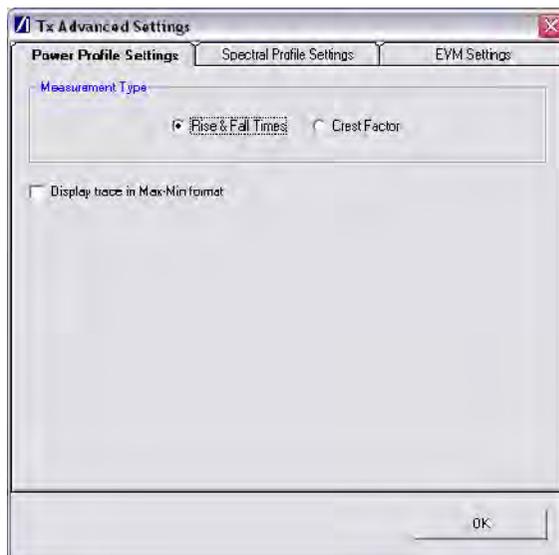
If required, a signal level correction table can be used to compensate for test system and cable loss effects. Refer to chapter 14 (section 14-15) for details.

## Tx Advanced Settings

For Power Profile, Spectrum Profile and EVM related measurements additional configuration settings can be specified. These can be accessed by clicking [Tx Advanced Settings...]

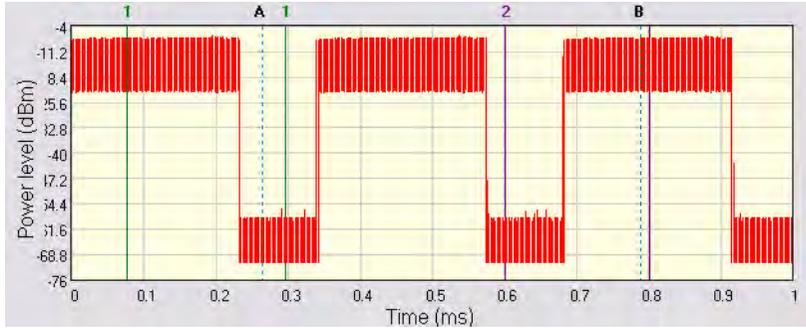
### Power Profile Settings

Click [Power Profile Settings] to display the dialog below.



**Figure 11-7.** Power Profile Settings

- |                                  |   |
|----------------------------------|---|
| Measurement Type:                | When a Power Profile Measurement is selected, both the Peak and Average power display in a table below the power profile trace. By selecting the Measurement Type to be either 'Rise & Fall Times' or 'Crest Factor', additional rise / fall or crest factor data is included in the numeric results table. |
| Display trace in Max-Min format: | When 'Display trace in Max-Min format' is selected, LANLook displays both the maximum and minimum values for each display point on the power profile trace. Each of the maximum and minimum values is joined by a line to give a broad trace such as that shown in the example below                        |



**Figure 11-8.** Max-Min Power Profile

Displaying the max-min data in this way can be useful to monitor the effect that modulation changes between the preamble and payload have on the power level of an OFDM signal.

### Spectral Profile Settings

Click [Spectral Profile Settings] to display the dialog below.

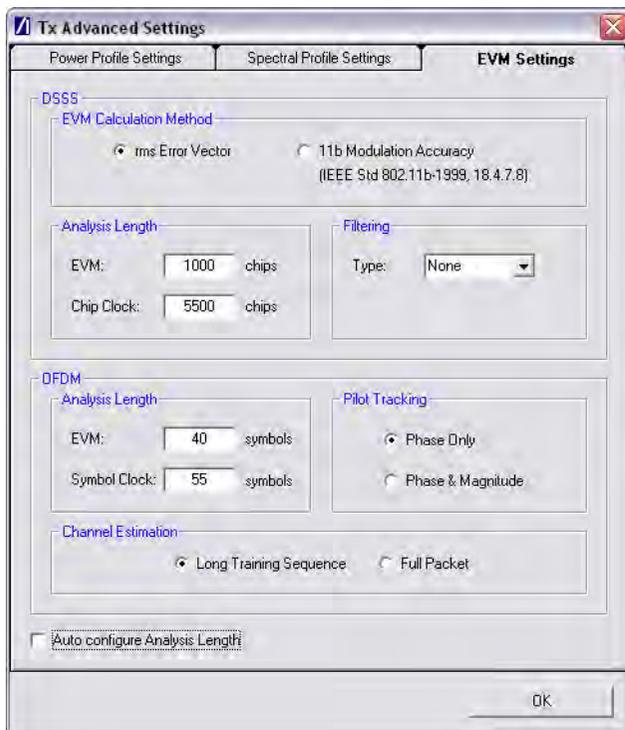


**Figure 11-9.** Spectral Profile Settings

Measurement Type:	Four types of spectral profile data can be individually displayed beneath the spectral profile trace; <ul style="list-style-type: none"><li>• Spectrum Mask</li><li>• Carrier Suppression (DSSS Only)</li><li>• Power Spectral Density (PSD)</li><li>• Occupied Bandwidth (OBW)</li></ul>
Occupied Bandwidth Setup	Set the required power percentage that is to be used when the Occupied Bandwidth Measurement type is selected.
RF Optimization Mode:	Select 'Low Noise' to optimize for signal to noise performance at offsets > 22 MHz from the carrier. This is the default setting. Select 'Low ACP' to optimize for distortion in the adjacent channel.  Note: Only applicable for DSSS data rates
Dither Mode	Dither mode can be used to determine whether spurs in the spectral data are originating from the MT8860C or from the DUT. If generated internally, spurs are removed by making three measurements using differing down conversion offsets.

### EVM Settings

Click [EVM Settings] to display the dialog below.



**Figure 11-10.** EVM Settings

- rms Error Vector: The EVM measurement is performed using the 'classic' definition for EVM (rms Error Vector) and is calculated using chips that are transmitted during the PSDU (payload) of the packet.
- 11b Modulation Accuracy: The EVM measurement is performed using the definition in IEEE Std 802.11b-1999 (18.4.7.8) and is calculated over 1000 chips that are transmitted during the PLCP preamble and header.
- Analysis Lengths: EVM, chip clock and symbol clock measurements are performed over the analysis lengths specified

**Table 11-5.** DSSS and OFDM EVM and Clock Statistics

	Minimum	Maximum	Default
DSSS EVM	220	11000	1000
DSSS Chip Clock	3300	30250	5500
OFDM EVM	16	500	40
OFDM Symbol Clock	16	500	55

Filtering:	Allows the user to specify a filtering type for use during EVM analysis of DSSS modulated signals. Three filter selections are available; None: No filtering is applied when calculating EVM. Gaussian: The Gaussian filter is selected and the user can set the 'BT' value to a value between 0.3 and 1.0 in steps of 0.1. Root Nyquist: Root Nyquist (Root Raised Cosine) is selected and the user can set the 'Alpha' value to a value between 0.3 and 1.0 in steps of 0.01.
Pilot Tracking:	For OFDM signals, pilot sub-carriers are used to assist with receiver synchronization. Phase Only: The demodulation process tracks the pilot phase over the specified EVM analysis length. Phase & Magnitude: The demodulation process tracks both the pilot phase and amplitude over the specified EVM analysis length.
Channel Estimation:	For OFDM signals, channel estimation is performed during the initial receiver synchronization process. Long training sequence or full packet channel estimation can be selected.
Auto-configure Analysis Length	The analysis length values can be automatically configured by selecting "Auto configure Analysis Length". When selected, the analysis lengths (applicable for the selected WLAN standard) are automatically configured to a valid value when the "Auto configure based on Tx Characteristics" operation is performed.

## 11-5 Running Tests

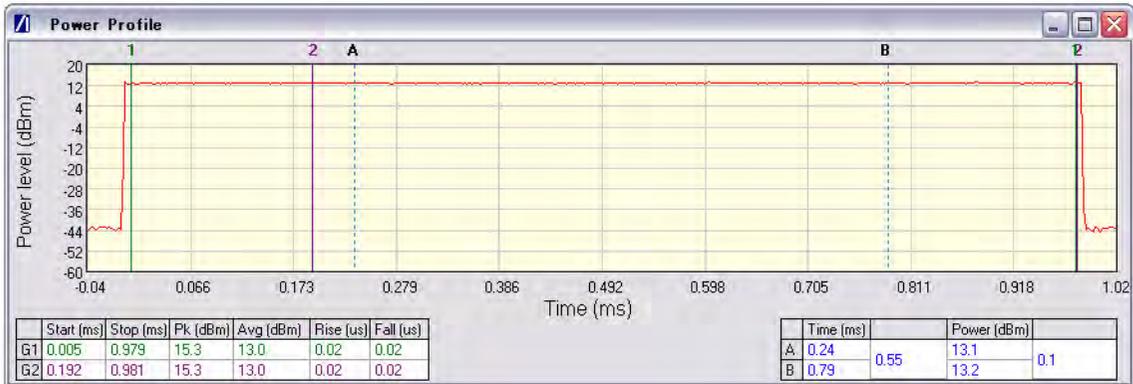
1. Click [Run Once] or [Run Continuous] to display the measurement results within LANLook.
2. Tests can be repeated after changing the “Wireless Mode” settings within LANLook. However, users should understand that the response of the DUT will depend upon the network type selected (infrastructure / Ad-Hoc) and the DUT type (AP / STA). The “Wireless Mode” settings determine the conditions under which the MT8860C performs measurements. The settings are used to configure the internal reference radio and to select the modulation format for EVM analysis. Satisfactory results will not be acquired if the specified conditions do not match those of the DUT transmitter.

Each of the test types available are explained over the following pages.

- Power profile measurements
- CCDF measurements
- Spectral profile measurements
- IQ constellation measurements
- EVM vs sub-carrier measurements
- EVM vs symbol measurements
- Spectral flatness measurements

## 11-6 Power Profile

The power profile utilizes two gates to measure the peak and average power within any section on the trace. The samples within a gate are included in the average and peak power measurements. To see changes in power level due to modulation, a capture time of less than 100  $\mu$ s is required. For longer capture times the displayed data point is an average of all samples within the time period.



**Figure 11-11.** [Power Profile] Window

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Power Profile” from one of the drop-down fields in the “Measurement Window Configuration” frame.
3. Click [Run Once] or [Run Continuous].

### Peak Transmitter Power

The peak power values display in the “Pk (dBm)” column of the table directly beneath the power profile trace. Peak power is the absolute maximum of the packet within the gate width period.

## Average Transmitter Power

The average values display in the “Avg (dBm)” column of the table directly beneath the power profile trace. The maximum allowable output power is specified by the regulatory body for the region in question. Refer to the table below.

**Table 11-6.** Maximum Transmit Power by Wireless Standard and Regulatory Domain

		US	Europe	Japan
802.11n (20 MHz)	2412 - 2472 MHz	30 dBm	20 dBm	10 dBm / MHz
	5150 - 5250 MHz	16 dBm	23 dBm	10 dBm / MHz
	5250 - 5350 MHz	23 dBm	23 dBm	10 dBm / MHz
	5470 - 5725 MHz	23 dBm	30 dBm	10 dBm / MHz
	5725 - 5825 MHz	29 dBm	-	-
	5825 MHz	30 dBm	-	-
802.11n (40 MHz)	2412 - 2472 MHz	30 dBm	20 dBm	7 dBm / MHz
	5150 - 5250 MHz	16 dBm	23 dBm	7 dBm / MHz
	5250 - 5350 MHz	20 dBm	23 dBm	7 dBm / MHz
	5470 - 5725 MHz	20 dBm	30 dBm	7 dBm / MHz
	5725 - 5825 MHz	30 dBm	-	-
	5825 MHz	-	-	-

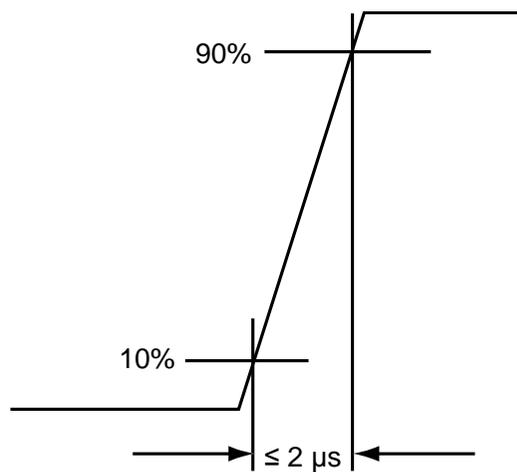
As is the case for all power measurements, the average power is calculated from within the specified gate area only.

## Transmit Power-On Ramp

The power-on ramp values display in the “Rise (us)” column of the table directly beneath the power profile trace. If the “Rise” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “Rise & Fall Times” from the Measurement Type frame.

When making this measurement the entire packet (burst) duration must be contained with the capture period and the measurement gate must be positioned within the burst. The MT8860C locates the rise and fall on either side of the gate.

The IEEE specification states that the power-on ramp for the region between 10% and 90% of maximum power must not exceed 2  $\mu$ s. This is shown in the figure below.

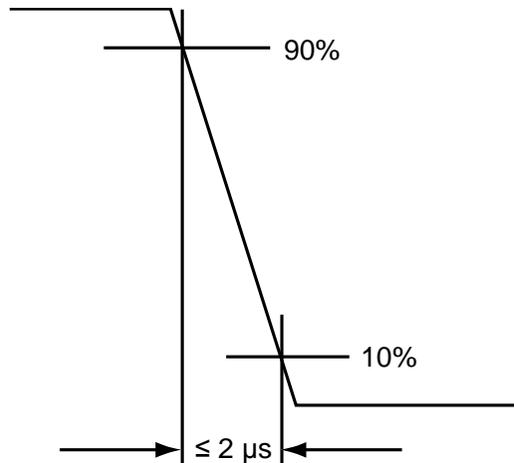


**Figure 11-12.** Transmit Power-On Ramp

## Transmit Power-Down Ramp

The power-down ramp values display in the “Fall (us)” column of the table directly beneath the power profile trace. If the “Fall” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “Rise & Fall Times” from the Measurement Type frame.

The IEEE specification states that, as shown in the figure below, the power-down ramp for the region between 10% and 90% of maximum power must not exceed 2  $\mu$ s. This is shown in the figure below.



**Figure 11-13.** Transmit Power-Down Ramp

**Note** The minimum capture frame that can be set is 10 $\mu$ s. This is 1  $\mu$ s/division and gives a marker resolution of 0.1 $\mu$ s.

## Crest Factor (OFDM data rates only)

The crest factor values display in the “CF (dB)” column of the table directly beneath the power profile trace. If the “CF” column does not appear in the table, click [Tx Advanced Settings...], click the [Power Profile Settings] tab and select “CF” from the Measurement Type frame.

The crest factor represents the difference in dB between the peak and average power of the signal within the gate.

## 11-7 CCDF (OFDM Only)

The Complementary Cumulative Distribution Function (CCDF) profile allows the user to ascertain the percentage of samples for which the power level specified by the markers is greater than the average power. The profile output contains 120 entries representing the power level (in dB) above the mean in 0.1 dB steps (0-12 dB above the mean). Each entry contains the percentage of time that the signal was less than this number of dB above the mean.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “CCDF Profiles” from one of the drop-down fields in the “Measurements” frame.
3. Click [Run Once] or [Run Continuous].

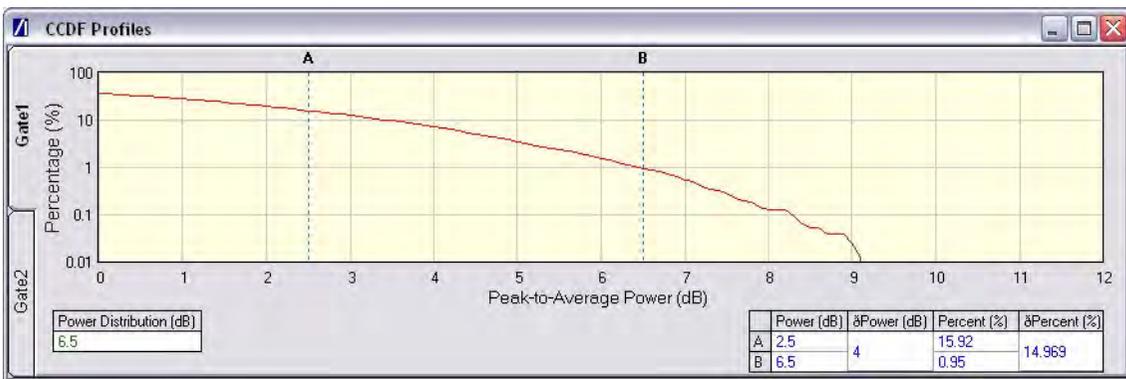


Figure 11-14. [CCDF Profiles] Window

## 11-8 Spectrum Profile

The displayed spectrum is a time generated spectrum measurement as defined by gates 1 and 2 in the [Power Profile] trace. Four types of spectral profile data can be individually displayed beneath the profile:

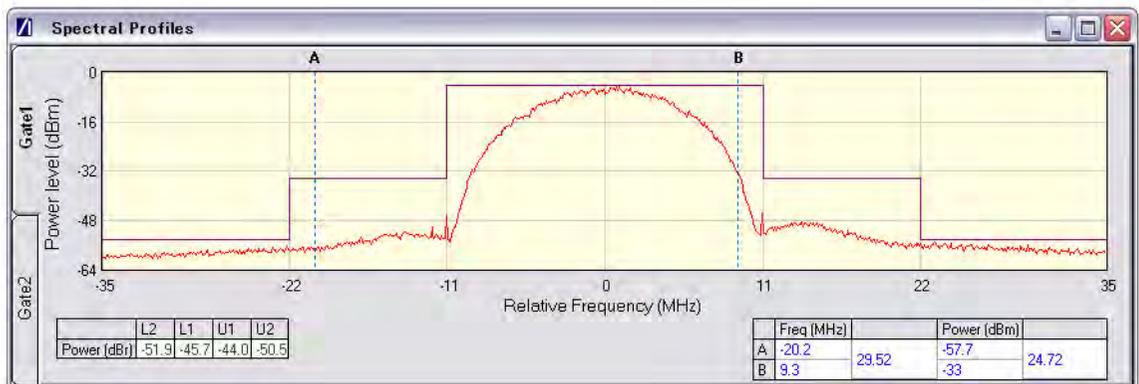
- Spectrum Mask
- Carrier Suppression
- Power Spectral Density (PSD)
- Occupied Bandwidth (OBW)

### Spectrum Mask

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
3. Click [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
4. Select “Spectrum Mask” from the “Measurement Type” frame.
5. Click [Run Once] or [Run Continuous].

The MT8860C applies the spectral mask for the selected WLAN standard. The results tables beneath the trace are used to display the pass / fail status for each of the mask elements. The minimum gate time for spectrum updates is 50 $\mu$ s. Longer gates have more spectrum samples giving the effect of point-to-point averaging.

### DSSS Data Rates (20 MHz, Non-HT)



**Figure 11-15.** [Spectral Profiles] Window with Mask

The figure above shows a typical spectral profile for DSSS data rates.

The “L2”, “L1”, “U1”, and “U2” values that display in the table beneath the spectral profile represent the difference in power level between the maximum point within each segment of the trace and the maximum point of the entire spectrum. The segments on the left side of the trace are, from left to right, “L2” and “L1”. The segments on the right side of the trace are, from left to right, “U1” and “U2”.

### Spectrum mask compliance

The transmitted spectral products must be less than  $-30$  dBr (dB relative to the  $\text{SINx/x}$  peak) for:-

$$f_c - 22 \text{ MHz} < f < f_c - 11 \text{ MHz}; \text{ and}$$

$$f_c + 11 \text{ MHz} < f < f_c + 22 \text{ MHz};$$

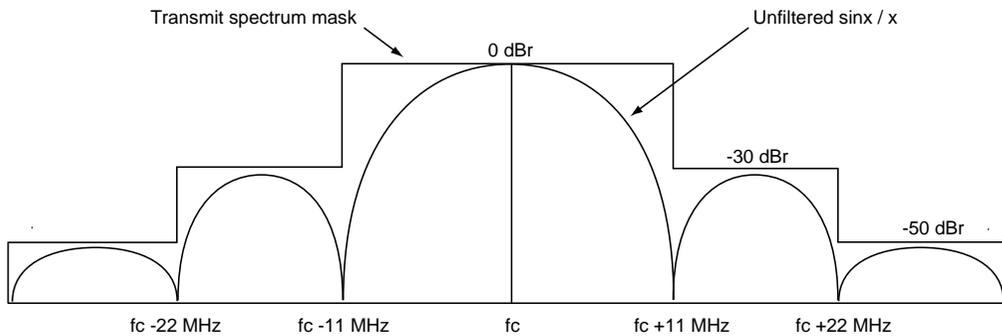
and less than  $-50$  dBr for:-

$$f < f_c - 22 \text{ MHz}; \text{ and}$$

$$f > f_c + 22 \text{ MHz}.$$

Where  $f_c$  is the channel center frequency.

The transmit spectral mask is shown below.



**Figure 11-16.** Spectrum Mask Compliance for DSSS

**Note** Information on how to edit the spectrum mask can be found in chapter 13.

OFDM Data Rates (20 MHz)

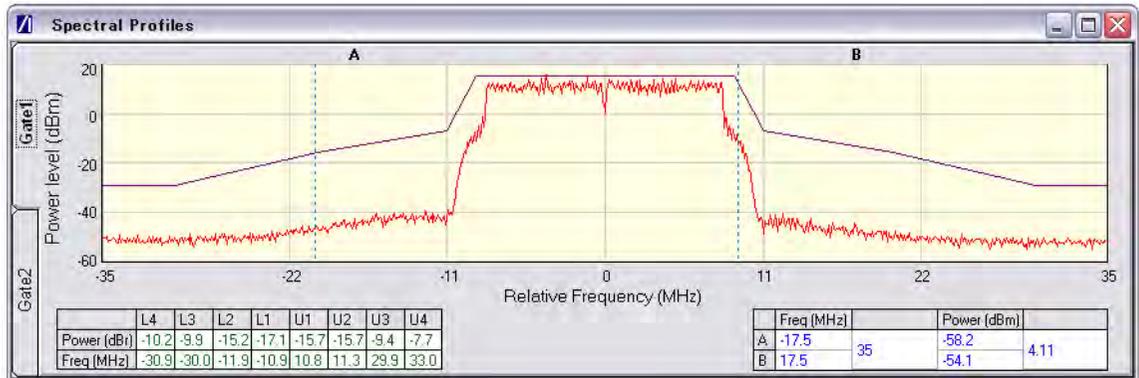


Figure 11-17. [Spectral Profile] Window

The figure above shows a typical spectral profile for 802.11n at 20 MHz. The table below the trace displays the frequency in each of the respective mask sections at which the DUT is closest to the mask or, if the mask is exceeded, the frequency at which the mask is exceeded by the greatest margin.

The transmitted signals must fall within the confines of the mask defined in the figure below.

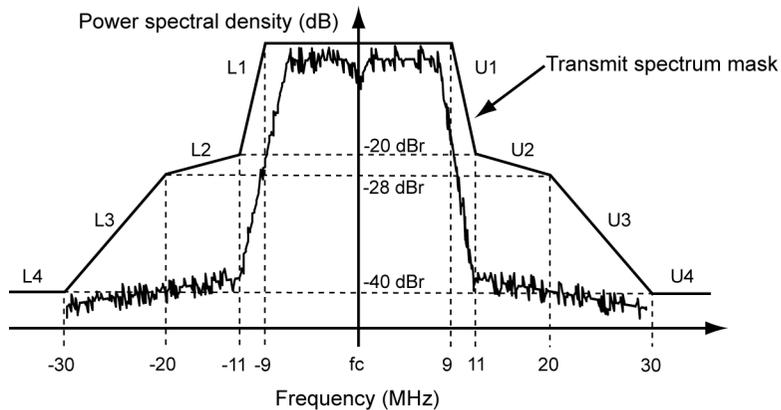


Figure 11-18. Spectral Mask Compliance for OFDM 20 MHz

OFDM Data Rates (40 MHz, HT)

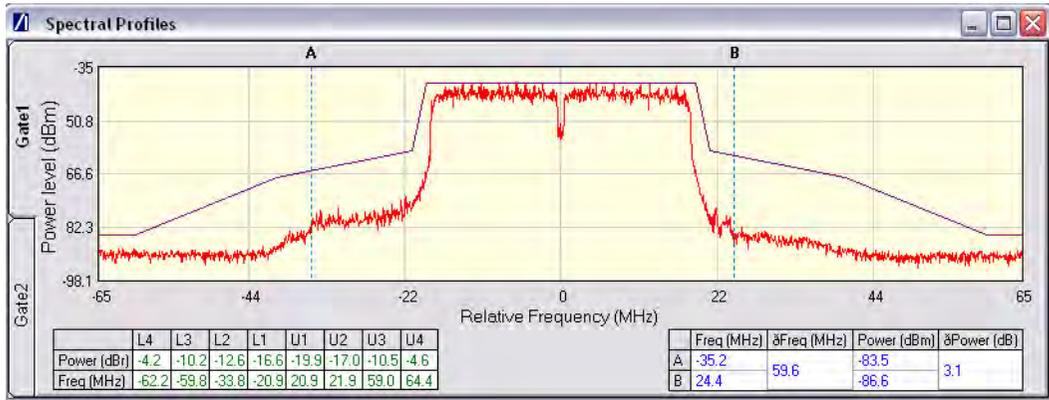


Figure 11-19. [Spectral Profile] Window

The figure above shows a typical spectral profile for 802.11n at 40 MHz. The table below the trace displays the frequency in each of the respective mask sections at which the DUT is closest to the mask or, if the mask is exceeded, the frequency at which the mask is exceeded by the greatest margin.

The transmitted signals must fall within the confines of the mask defined in the figure below.

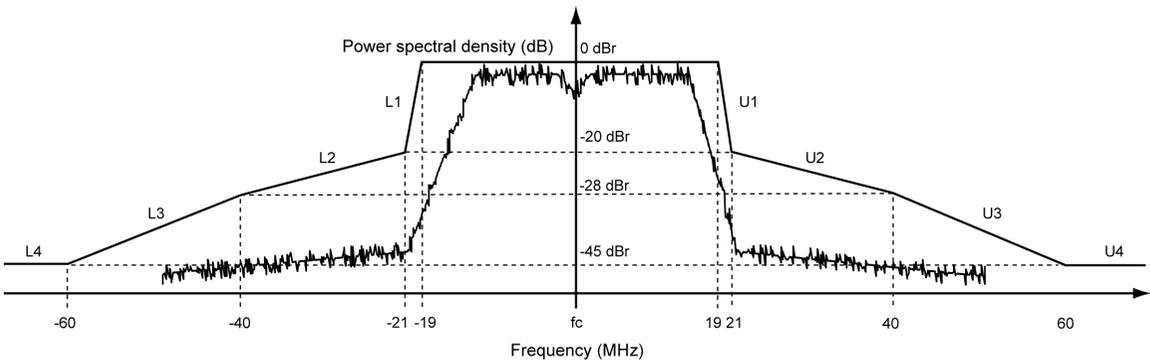


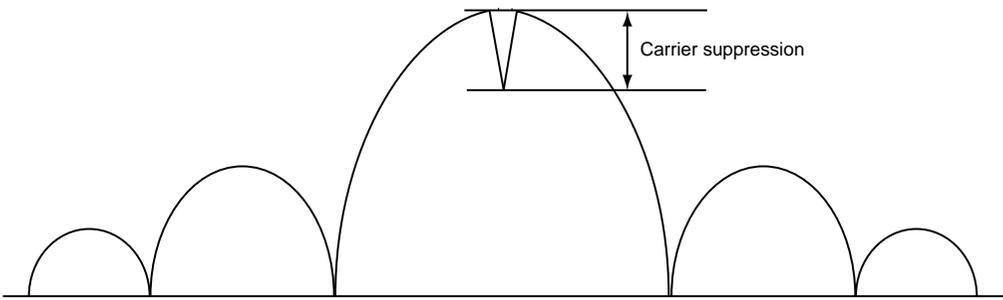
Figure 11-20. Spectral Mask Compliance for OFDM 40 MHz

## RF Carrier Suppression (DSSS only) (20 MHz, Non-HT)

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
3. Click [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
4. Select “Carrier Suppression” from the “Measurement Type” frame.
5. Click [Run Once] or [Run Continuous].

The table within the spectral profile window beneath the trace changes to display the carrier suppression results.

The RF carrier suppression, measured at the channel center frequency, must be at least 15 dB below the peak SIN(x)/x power spectrum.



**Figure 11-21.** Carrier Suppression

### Note

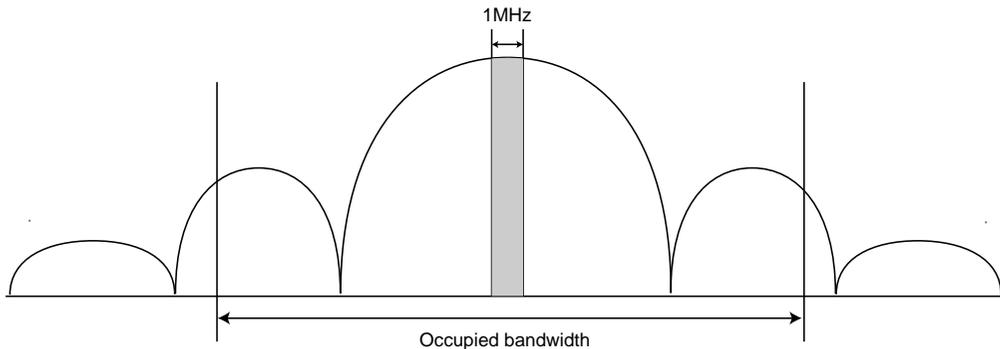
The IEEE standard states that the measurement is made with the DUT configured to transmit DQPSK modulation using a "01" repeating data sequence and with the scrambler disabled. In order to perform the RF carrier suppression measurement as defined in the IEEE Standard, the DUT is configured using control software supplied by the chipset vendor.

As part of the EVM measurement process (see 11-9), MT8860C includes an IQ offset measurement that returns the actual carrier feedthrough normalized to the mean power at the symbol timings. Using the IQ offset, an estimate of the RF Carrier Suppression can be made. Refer to Appendix K for details.

## Power Spectral Density (PSD)

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
3. Click [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
4. Select “Power Spectral Density” from the “Measurement Type” frame.

5. Click [Run Once] or [Run Continuous].

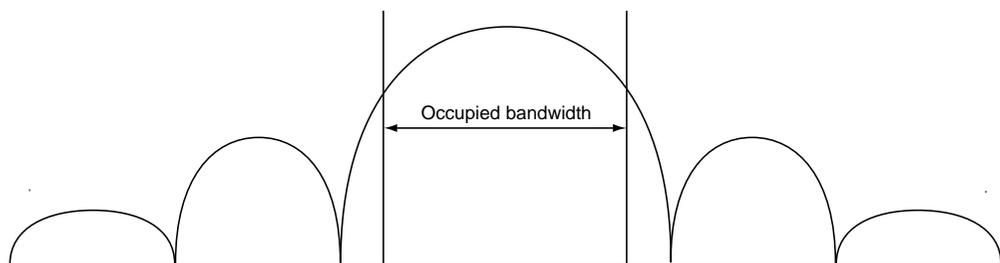


**Figure 11-22.** Power Spectral Density

The table within the spectral profile window changes to display the power spectral density result. The measurement is made according to ETSI EN 300-328 (4.3.2 / 5.7.3) and is defined as the maximum power measured in a 1 MHz bandwidth within the occupied bandwidth of the signal.

### Occupied Bandwidth

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Spectral Profiles” from one of the drop-down fields in the “Measurement Window Configuration” frame.
3. Click [Tx Advanced Settings...] > [Spectral Profile Settings] tab.
4. Select “Occupied Bandwidth” from the “Measurement Type” frame.
5. Click [Run Once] or [Run Continuous]. The table beneath the trace within the [Spectral Profiles] window changes to display the OBW results. The value within the “OBW” cell of the table indicates the frequency within which the specified percentage of power is contained.

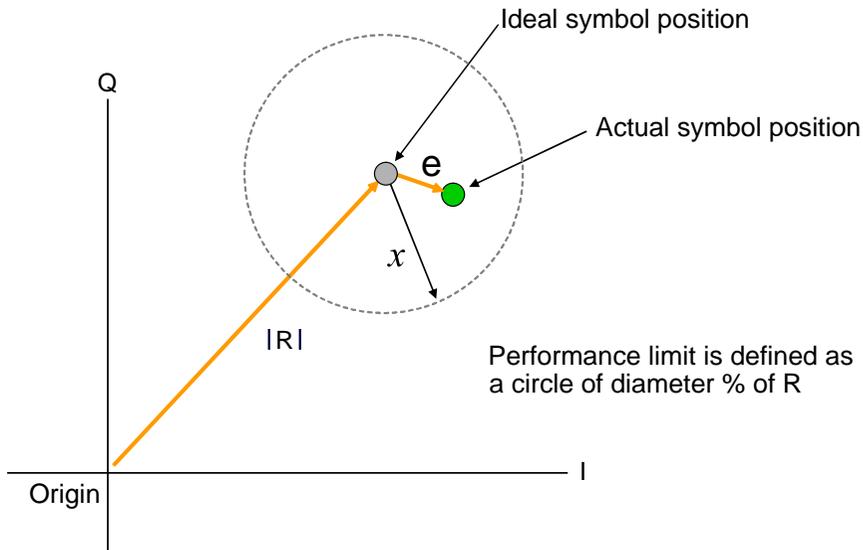


**Figure 11-23.** Occupied Bandwidth

## 11-9 IQ Constellation

The IEEE 802.11 specification uses a metric called Error Vector Magnitude (EVM) as a measure of modulation quality. EVM is a measure of the difference between the ideal symbol position and the measured symbol position. The difference between these two positions is referred to as the error vector and is shown in the figure below by the distance “e”.

EVM is an excellent measure of overall transmitter quality and a high EVM reading typically results in similarly high packet error rate.



**Figure 11-24.** EVM Explanation

The following points should be considered when performing IQ constellation / EVM measurements.

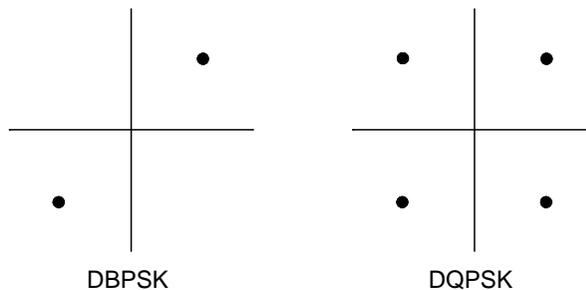
- The transmitted signal must contain an ‘off’ period, i.e. it must not be a continuous transmission.
- The EVM analysis is performed on the first burst found after the trigger, including the pre trigger delay.
- The gate positions do not effect the EVM analysis.
- The EVM analysis is performed over a specified number of chips/symbols. To configure the analysis length, click [Tx Advanced Settings...] > [EVM Settings] tab.
- The burst captured must contain at least the specified number of chips/symbols.
- Independent analysis lengths for the DSSS and OFDM data rates are provided.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “IQ Constellation” from one of the drop-down fields in the “Measurement Window Configuration” frame.
3. Click [Run Once] or [Run Continuous] to run IQ constellation measurements on the packet payload.

**Note** The IQ constellation displayed by LANLook is determined by the WLAN Standard and Data Rate settings. If the data rate does not match the rate of transmission from the DUT, it is possible that the analysed data will be mapped onto the wrong constellation.

### DSSS Data Rates (20 MHz, Non-HT)

The IEEE specification defines two modulation techniques.



**Figure 11-25.** DSSS Modulation

The DSSS data rates and associated modulation methods are illustrated in the table below.

**Table 11-7.** DSSS Data Rates and Modulation Methods

Data Rate (Mbps)	Modulation	Spreading / coding scheme
1	DBPSK	11 chip Barker sequence
2	DQPSK	11 chip Barker sequence
5.5	DQPSK	CCK
11	DQPSK	CCK

**Note** Users should note that although IQ constellation measurements can be performed at a data rate of 1 Mbps (DBPSK modulation), the IEEE 802.11b specification stipulates that the measurement should be made using DQPSK modulation.



**Figure 11-26.** [IQ Constellation] Window showing DQPSK Constellation

The screen capture above shows a typical DQPSK constellation. The statistic of most interest to the user is the “Max” value that displays at the “EVM Results” field. The 802.11b specification stipulates that the worst-case vector error magnitude should not exceed 35%.

### Chip Clock Error

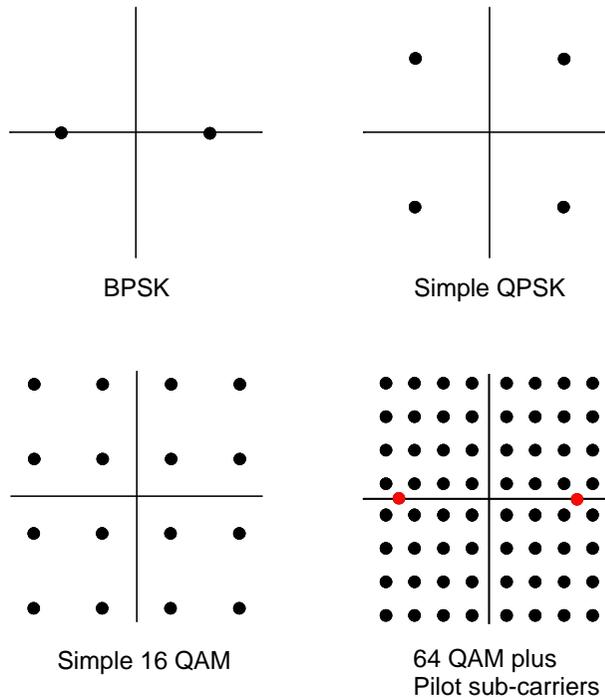
The chip clock error measurement results are also displayed in the dialog above. The 802.11b specification stipulates that the chip clock frequency tolerance shall be better than  $\pm 25$  ppm.

### Frequency Error

The center frequency measurement results are also displayed in the dialog above. The 802.11g specification stipulates that the center frequency tolerance shall be better than  $\pm 25$  ppm. For 802.11a, the specification stipulates that the transmit center frequency tolerance shall be  $\pm 20$  ppm maximum.

## OFDM Data Rates (20 MHz or 40 MHz, Non-HT or HT)

Each of the OFDM sub-carriers can be modulated using any of the following four techniques.



**Figure 11-27.** OFDM Modulation

The OFDM packet structures are shown in Appendix C. In addition to the modulation constellations, the MT8860C can be used to display graphical results for EVM vs sub-carrier and EVM vs. symbol. These may be of particular use when a detailed analysis of the cause of distortion is required.

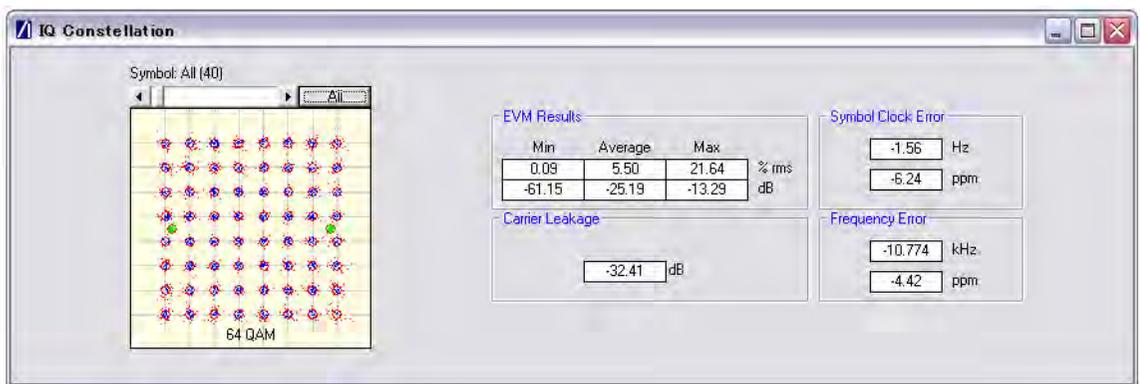
The OFDM data rates and associated modulation methods are illustrated in the tables below.

**Table 11-8.** Non-HT OFDM Data Rates and Modulation Methods

Data Rate (Mbps)	Modulation
6	BPSK
9	BPSK
12	QPSK
18	QPSK
24	16QAM
36	16QAM
48	64QAM
54	64QAM

**Table 11-9.** HT OFDM Data Rates and Modulation Methods

MCS	Modulation
0	BPSK
1	QPSK
2	QPSK
3	16QAM
4	16QAM
5	64QAM
6	64QAM
7	64QAM
32	BPSK

**Figure 11-28.** [IQ Constellation] Window showing 64 QAM Constellation

The screen capture above shows a 64 QAM constellation. The statistic of most interest to the user is the “Average” value that displays at the “EVM Results” field. The 802.11n specification stipulates that the relative error must not exceed the data rate dependent values specified in the table below. Set the average to 20 to make measurements as specified in the IEEE standard.

**Table 11-10.** Maximum Permissible EVM Values Per Data Rate, Non-HT

Data Rate (Mbps)	EVM (dB)	EVM (% RMS)
6	-5	56.2
9	-8	39.8
12	-10	31.6
18	-13	22.3
24	-16	15.8
36	-19	11.2
48	-22	7.9

**Table 11-10.** Maximum Permissible EVM Values Per Data Rate, Non-HT

Data Rate (Mbps)	EVM (dB)	EVM (% RMS)
54	-25	5.6

**Table 11-11.** Maximum Permissible EVM Values Per Data Rate, HT

MCS	EVM (dB)	EVM (% RMS)
0	-5	56.23
1	-10	31.62
2	-13	22.39
3	-16	15.85
4	-19	11.22
5	-22	7.94
6	-25	5.62
7	-28	3.98
32	-5	56.23

### Symbol Clock Error

The symbol clock error measurement results are also displayed in the dialog above. The 802.11n specification stipulates that the symbol clock frequency tolerance for the 2.4 GHz frequency band shall be  $\pm 25$  ppm maximum. For the 5 GHz band, the specification stipulates that the symbol clock frequency tolerance shall be  $\pm 20$  ppm maximum.

### Frequency Error

The center frequency measurement results are also displayed in the dialog above. The 802.11n specification stipulates that the center frequency tolerance for the 2.4 GHz frequency band shall be better than  $\pm 25$  ppm. For the 5 GHz frequency band, the specification stipulates that the transmit center frequency tolerance shall be  $\pm 20$  ppm maximum.

### Carrier Leakage

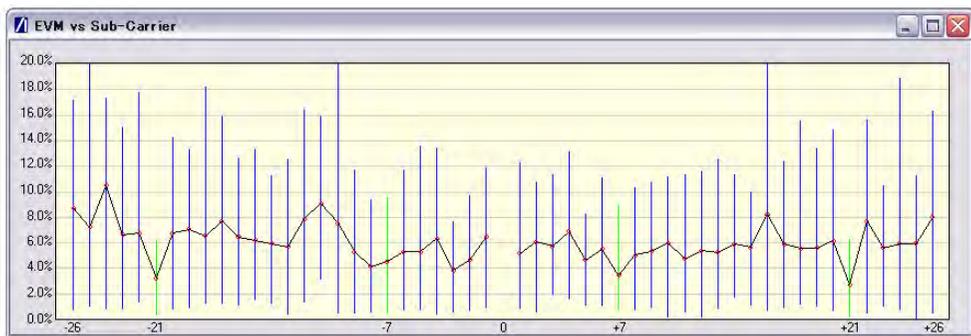
The carrier leakage measurement results are also displayed in the dialog above. The 802.11n specification stipulates that:

- for transmissions in a 20MHz channel width, the center frequency leakage shall not exceed -15 dB relative to overall transmitted power.
- for transmission in a 40 Mhz channel width, the center frequency leakage shall not exceed -20 dB relative to overall transmitted power.
- for upper or lower 20 MHz transmissions in a 40 MHz channel, the center frequency leakage (center of a 40 MHz channel) shall not exceed -17 dB relative to overall transmitted power.

## 11-10 EVM vs Sub-Carrier (OFDM only)

Although not a defined measurement of the IEEE, the EVM vs Sub-Carrier measurement is a powerful analysis tool that displays the average and max / min EVM for each OFDM channel.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “EVM vs Sub-Carrier” from one of the drop-down fields in the “Measurements Window Configuration” frame.
3. Click [Run Once] or [Run Continuous] to display a trace such as that shown below. The vertical green lines at  $\pm 7$  and  $\pm 21$  are the pilot carriers, the blue bars are the maximum and minimum values and the horizontal trace shows the average EVM.

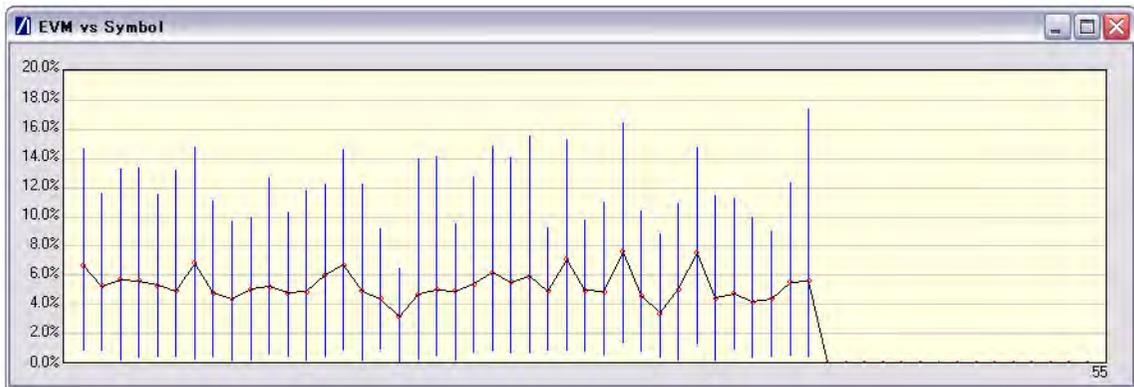


**Figure 11-29.** [EVM vs Sub Carrier] Window: Example for 20 MHz Non-HT

## 11-11 EVM vs Symbol (OFDM only)

Although not a defined measurement of the IEEE, the EVM vs Symbol measurement is a powerful analysis tool that displays the average and max / min EVM for each symbol in the gate.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “EVM vs Symbol” from one of the drop-down fields in the “Measurements” frame.
3. Click [Run Once] or [Run Continuous] to display a trace such as that shown below.



**Figure 11-30.** [EVM vs Symbol] Window: Example for 20 MHz Non-HT

## 11-12 Spectral Flatness (OFDM only)

The spectral flatness measurement provides the user with a display of RF level vs sub-carrier over the measurement range.

The IEEE 802.11a specification stipulates acceptable values for the average energy of the constellations in each of the sub-carriers. For lines -16 to -1 and 1 to 16 the average energy of any individual sub-carrier should deviate no more than  $\pm 2$  dB from their average energy of all 32 central sub-carriers. For lines -26 to -17 and 17 to 26 the average energy of the constellations in each of the spectral lines should deviate no more than  $\pm 2/4$  dB from the average energy of spectral lines -16 to -1 and 1 to 16. The data for this test is measured over the  $8\mu\text{s}$  channel estimation period of the packet while all 52 sub-carriers are on.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Spectral Flatness” from one of the drop-down fields in the “Measurements” frame.
3. Click [Run Once] or [Run Continuous].



**Figure 11-31.** [Spectral Flatness] Window: Example for 20 MHz Non-HT

The spectral mask (shown by the horizontal lines) is split into three sections; an upper limit with a default setting of +2.0 dB, a lower side limit with a default setting of -4.0 dB, and a lower centre limit with a default setting of -2.0 dB. Each of the spectral mask sections can be moved freely to the required position and the dB value appears in a small pop-up next to the cursor when the line is being moved. The new limit values are sent automatically to the MT8860C when the user releases the mouse button. Channel measurements that fall outside of the limits of the mask display in red and also carry a small label that appears near the cursor to say how many times that channel failed.

## 11-13 Numeric Results

Transmitter measurement results can also be viewed as numeric data. Viewing the results in this format is slightly quicker as it requires less remote data than when viewing the traces graphically.

1. Follow the setup instructions detailed earlier in this chapter.
2. Select “Numeric Results Only” in the “Measurement Window Configuration” frame.
3. Click [Run Once] or [Run Continuous] to view the results. The figure below shows the numeric results window for an OFDM data rate.

Tx Tests Numerical Results								
Power	Start	Stop	Peak	Average	Crest Factor	Rise	Fall	Distribution
Gate 1	0.005 ms	0.271 ms	-7.80 dBm	-17.25 dBm	9.45 dB	0.02 us	0.05 us	6.00 dB
Gate 2	0.036 ms	0.273 ms	-8.99 dBm	-17.25 dBm	8.25 dB	0.02 us	0.05 us	5.90 dB

EVM	Minimum	Average	Maximum
% rms	0.05 %	2.91 %	10.11 %
dB	-65.51 dB	-30.72 dB	-19.91 dB

IQ Analysis	802.11g/a/n OFDM	802.11 b/g/n DSSS
Carrier Leakage / IQ Offset	-36.96 dB	n/a
Phase Error	n/a	n/a
Magnitude Error	n/a	n/a
Frequency Tolerance	-3.35 kHz	-1.36 ppm

Clock Error	802.11g/a/n OFDM (Symbol Clock)	802.11 b/g/n DSSS (Chip Clock)
Hz	-0.36 Hz	n/a
ppm	-1.45 ppm	n/a

Spectrum Mask	Status
Gate 1	PASS
Gate 2	PASS

Spectrum Mask	L4	L3	L2	L1	U1	U2	U3	U4
Gate 1 Power (dBr)	-3.7	-9.4	-12.7	-16.5	-17.5	-14.6	-9.9	-4.4
Gate 2 Power (dBr)	-3.7	-9.4	-12.7	-16.5	-17.9	-14.8	-10.3	-4.6
Gate 1 Frequency (MHz)	-61.9	-59.5	-34.4	-20.9	20.8	21.8	59.0	60.1
Gate 2 Frequency (MHz)	-61.9	-59.5	-32.8	-20.9	20.7	21.8	59.0	60.1

Spectrum Data	Spectral Density	Occupied Bandwidth	Carrier Suppression	Spectral Flatness
Gate 1	-31.25 dBm/MHz	35.8 MHz	-	PASS
Gate 2	-31.10 dBm/MHz	35.9 MHz	-	n/a

Figure 11-32. [Tx Tests Numerical Results] Window

# Chapter 12 — 802.11n Receiver Testing in Direct Mode

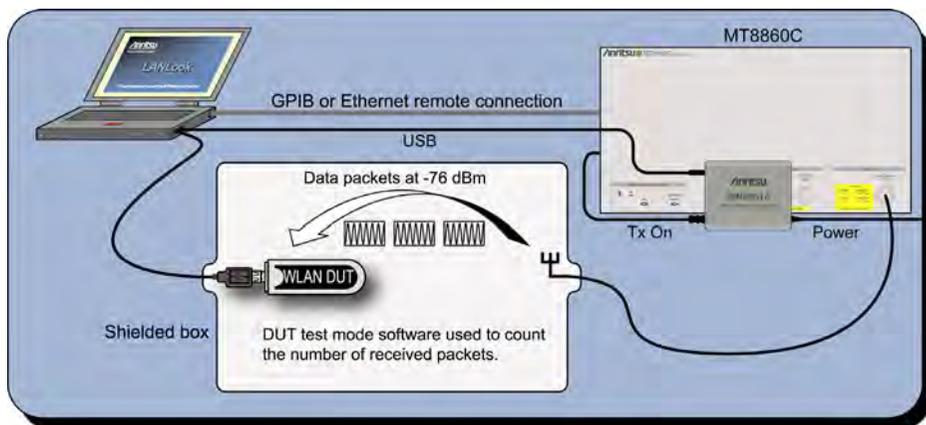
## Note

802.11n receiver testing can be performed on MT8860C units installed with option 17 and fitted with the MN8861A receiver accessory. The MN8861A receiver accessory attaches to the front of the MT8860C and sends 802.11n signals through the attenuator to the DUT.

A WLAN connection with the DUT is not required in order to perform Rx testing in Direct mode. When Direct mode is selected, the Network setup settings within LANLook are no longer applicable.

## 12-1 Test Methodology

When testing the Rx sensitivity of a device in Direct Mode, the MN8861A is configured to transmit a specified number of 802.11n data packets. After the final packet has been transmitted, a baseband register (internal to the DUT) is read. This register contains the number of packets received without error. Calculations are then made based on the number of packets sent by the MT8860C and the number received without error.



**Figure 12-1.** Receiver Testing in Direct Mode

DUT receiver measurements are based on the calculation of Packet Error Rate (PER) or Frame Reception Rate (FRR). PER is an expression of the number of packets that were received in error. FRR is an expression of the number of packets that were successfully received. FRR is specified by the CTIA and Wi-Fi Alliance in the CWG Test Plan used to evaluate the RF Performance of Wi-Fi Mobile Converged Devices.

PER is calculated using the formula below:

$$(1 - (\text{Number of packets correctly received} / \text{Number of packets sent})) \times 100\%$$

FRR is calculated using the formula below:

$$(\text{Number of packets correctly received} / \text{Number of packets sent}) \times 100\%$$

## 802.11 PER Specifications

The IEEE 802.11n specification states that the packet error rate (PER) shall be less than 10% for the input levels indicated in the table below.

**Table 12-1.** Sensitivity by MCS

MCS	Minimum sensitivity 20 MHz (dBm)	Minimum sensitivity 40 MHz (dBm)
0	-82	-79
1	-79	-76
2	-77	-74
3	-74	-71
4	-70	-67
5	-66	-63
6	-65	-62
7	-64	-61
32	Not specified	Not specified

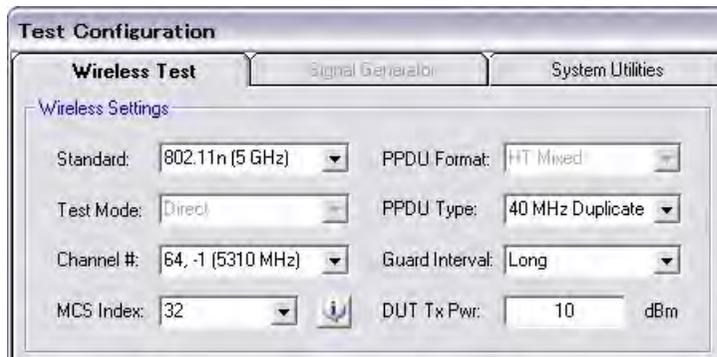
## 12-2 802.11n Overview

The 802.11n standard differs from the 802.11b/g/a standards in a number of ways. Users are recommended to read and digest the four key differences outlined below before attempting to configure the wireless setup.

- 802.11n data can be transmitted in either the 2.4 GHz ISM frequency band, or in the 5.0 GHz UNII band.
- 802.11n data can be transmitted over a signal with a 20 MHz or 40 MHz bandwidth.
- 802.11n data can be transmitted using any of three PPDU formats (Non-HT, HT Mixed, HT Greenfield). The format is selected as required to maximize throughput, or provide full or partial backwards compatibility with 802.11b/g/a legacy devices.
- 802.11n data rates for high-throughput transmissions are determined by a Modulation and Coding Scheme (MCS). MCS values were defined in the IEEE standard to simplify the numerous factors that can influence achievable data rates. An MCS value selected by the user is plotted against variables such as modulation and guard interval to determine the effective data rate. Refer to the tables in Appendix B for full details of MCS data rates for long and short guard intervals.

## 12-3 Wireless Setup

1. Establish a remote connection between the MT8860C and PC as detailed in chapter 5.
2. Click the [Wireless Test] tab.
3. Click the [Rx Testing] tab.
4. The wireless settings display as shown in the figures below.



**Figure 12-2.** 802.11n Wireless Settings for HT (High-Throughput) Mixed Transmissions

5. At “Standard” select “802.11n (2.4 GHz)” or “802.11n (5 GHz).”

**Note** Note 802.11n (5 GHz) selection is only available on MT8860C units fitted with option 14.

6. At “Channel #” select the WLAN channel(s) on which measurements will be performed. The channels available for selection from the “Channel #” drop-down vary depending on the “Freq Band” and “PPDU Type” settings.

If “PPDU Type” is set is set to “20 MHz”, the “Channel #” drop-down displays a simple list of available channels: 1 to 13 in the 2.4 GHz band, or 36 to 165 in the 5.0 GHz band.

If “PPDU Type” is set is set to “40 MHz”, or “40 MHz Duplicate”, the “Channel #” drop-down displays a list of channels appended with “+1” or “-1”: e.g., “2, +1 (2427 MHz)”.

802.11n operation at 40 MHz is achieved using a combination of two adjacent 20 MHz channels. The first value within the “Channel #” drop-down indicates the primary 20 MHz channel, the second value (+1 or -1) indicates whether the secondary channel is sequentially above or below the primary channel.

7. Select the “MCS Index” at which measurements will be performed.

Due to the numerous factors that can influence data rates, the 802.11n standard uses a “Modulation and Coding Scheme” (MCS) for high-throughput data transmissions. The selected MCS value is plotted against variables such as modulation and guard interval, to determine the effective data rate. The data rate and modulation scheme can be verified by clicking the information button (i) to the right of the drop down. The available MCS values and their associated data rates are detailed in the tables in Appendix B.

If “PPDU Type” is set to 20 MHz or 40 MHz, select an MCS Index between 0 and 7.

If “PPDU Type” is set to 40 MHz Duplicate, the MCS Index is set automatically to 32.

8. At “PPDU Type” select the channel bandwidth at which data will be transmitted from the DUT. The following items are supported and listed in the drop-down.

20 MHz: Data is transmitted over a signal with 20 MHz bandwidth.

40 MHz: Data is transmitted over two adjacent signals with 20 MHz bandwidth.

40 MHz Duplicate Data is transmitted twice using two adjacent signals with 20 MHz bandwidth.

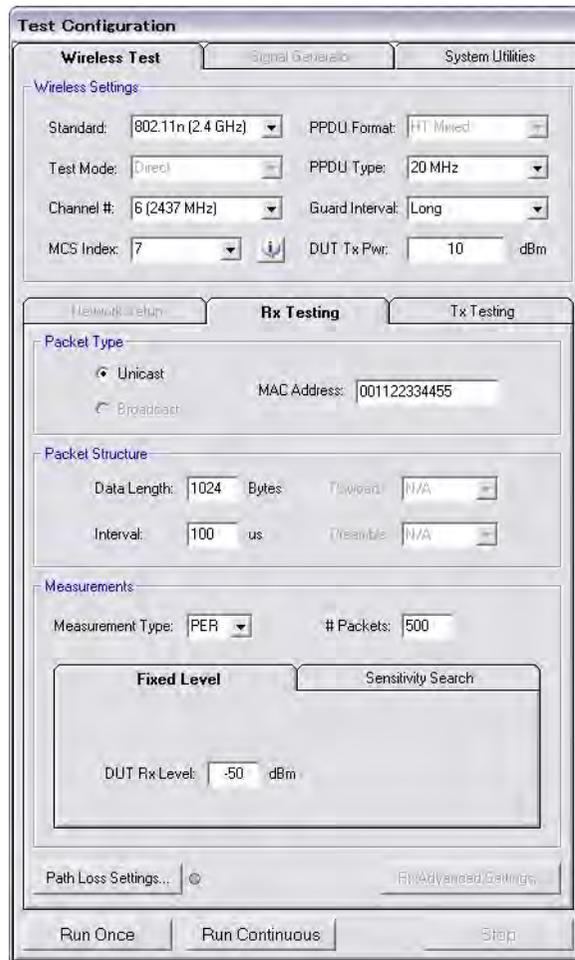
9. At “Guard Interval” select the long or short guard interval.

10. At “DUT Tx Pwr” specify the power that the DUT is expected to transmit. The value should represent the signal level at the antenna / RF connector of the DUT.

## 12-4 Configuring Test Settings

### Packet Type

1. Click the [Rx Testing] tab shown below.



**Figure 12-3.** [Rx Testing] Tab

2. Specify the MAC address of the packets transmitted by the MT8860C. The MN8861A can transmit Unicast packets. Broadcast and Multicast packets are not supported.

### Packet Structure

1. Specify the packet structure at the following items.

**Data Length:** The data length of the packet can be set to any value between 50 and 1772 bytes.

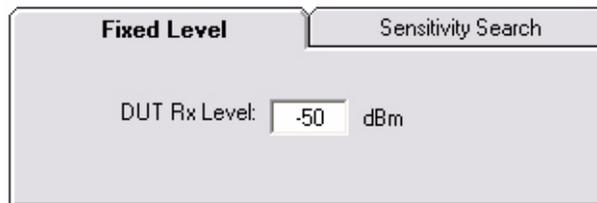
Interval: The interval specified represents the time in microseconds from the end of one packet to the beginning of the next. The range is 100 to 1000 microseconds. For transmission of 802.11n modulated data, each slot is equal to 9  $\mu$ s.

## Measurements

1. At “Measurement Type” specify whether the sensitivity results are shown as PER (packets received in error) or FRR (packets successfully received).
2. At “# Packets” specify the number of packets to be transmitted. Enter a value within the range of 1 and 10,000.
3. If required, a signal level correction table can be used to compensate for test system and cable loss effects. Refer to chapter 14 for details.
4. Follow the instructions over the following pages to perform the required measurements.
  - Measuring PER or FRR at a fixed power level
  - Measuring PER or FRR at a varying power level
  - Measuring PER or FRR with co-channel or adjacent channel interference

## 12-5 Fixed Level Measurements

---



**Figure 12-4.** PER/FRR Setting

1. Follow the setup instructions detailed at the start of this chapter.
2. Click the [Fixed Level] tab shown above.
3. Set the required MT8860C transmission power level at the “DUT Rx Level” setting.

- Click [Run Once] to display a table of PER/FRR numeric results, or click [Run Continuous] to display the numeric results table below.

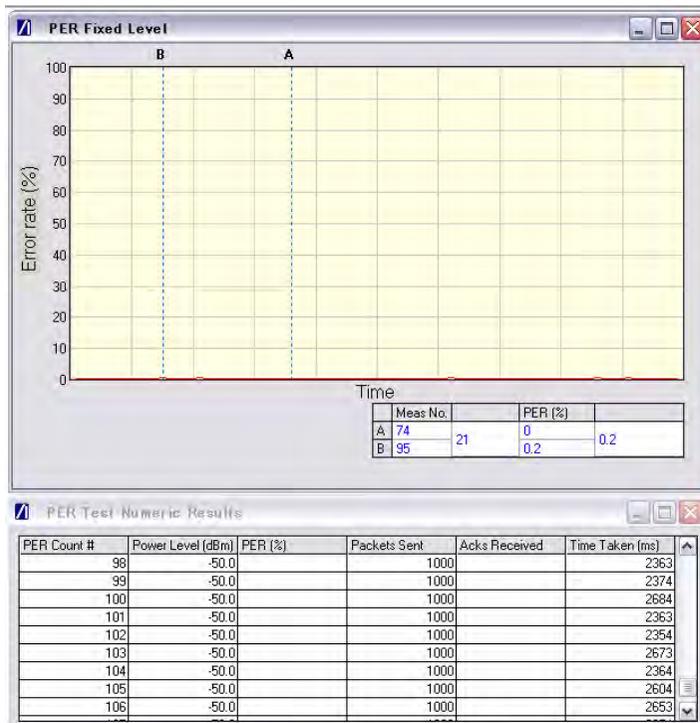


Figure 12-5. PER at Fixed Power Level

## 12-6 Varying Level Measurements

In this test the transmission power from the MT8860C is stepped down by a specified amount to find the point at which an acceptable threshold is reached.

Fixed Level		Sensitivity Search	
Start Level:	-60 dBm	Stop Level:	-100 dBm
Step:	1 dB	Threshold:	95 %

Figure 12-6. PER Setting for Sensitivity Search

- Follow the setup instructions detailed at the start of this chapter.

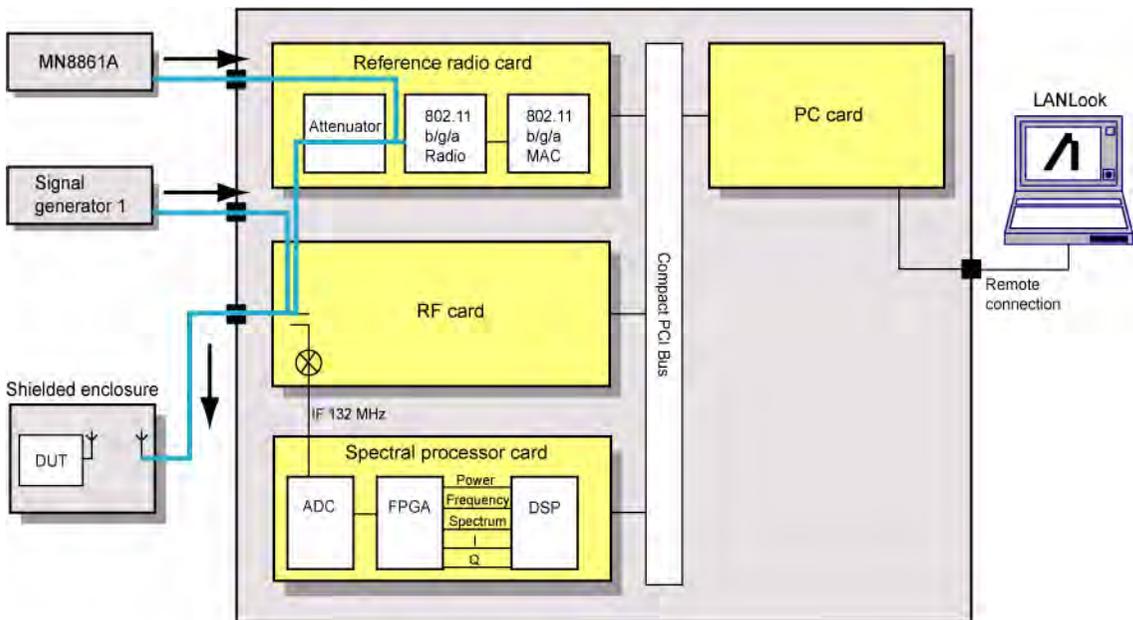
- Click the [Sensitivity Search] tab shown above and enter appropriate values as explained below.

Start Level:	Specify the initial power transmitted to the DUT.
Stop Level:	Specify the final power transmitted to the DUT.
Step:	Specify the power step between the start and stop levels. The specified number of packets are transmitted at each power level before stepping on to the next level.
Threshold:	Specify a percentage limit at which testing will be stopped as the receiver sensitivity level has exceeded the defined limit.

- Click [Run Once] to display a plot of packets sent.

**Note** The [Run Continuous] button is not available when performing a sensitivity search.

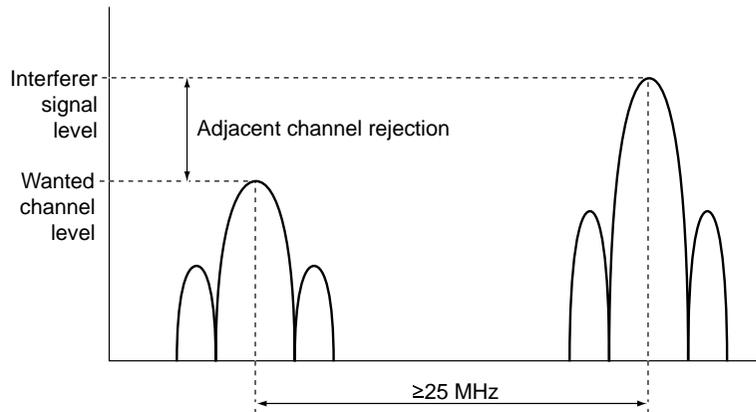
## 12-7 Channel Interference



**Figure 12-7.** PER with Channel Interference

In addition to the normal test configuration detailed earlier, an external signal generator can be coupled to the MT8860C to measure adjacent or alternate channel rejection.

## Adjacent Channel Rejection Specifications



**Figure 12-8.** Adjacent Channel Rejection

For 802.11n data rates, the adjacent channel rejection shall be measured by setting the desired signal's strength 3 dB above the rate-dependent sensitivity specified in table 12-1 and raising the power of the interfering signal until 10% PER is caused. The power difference between the interfering and the desired channel is the corresponding adjacent channel rejection. The interfering signal in the adjacent channel shall be an OFDM signal, unsynchronized with the signal in the channel under test.

**Table 12-2.** Rejection Values Per MCS

MCS	Adjacent Channel Rejection (dB)	Alternate Adjacent Channel Rejection (dB)
0	16	32
1	13	29
2	11	27
3	8	24
4	4	20
5	0	16
6	-1	15
7	-2	14
32	Not specified	Not specified

1. Connect a signal generator to the interferer input on the front of the MT8860C.
2. Set the signal generator to transmit on the required channel.
3. Follow the setup instructions detailed at the start of this chapter.
4. Set the required transmission power level on the [Fixed Level] tab in the "Measurements" frame.

5. Click [Run Once].

**Note**

When performing adjacent channel testing, it is necessary to know the path loss from the interferer input to the test port. The path loss for each instrument is measured in the production process and the value is stored in non-volatile memory. The path loss can be read by the user by sending the INTFLOSS command from the LANLook [Diagnostics] tab. The INTFLOSS command returns the insertion loss for the channel requested. The returned value should be used as an offset for the interfering signal when making adjacent channel measurements. The typical path loss from the interferer input to the test port is 22 dB.

# Chapter 13 — Signal Generator (802.11b/g/a only)

## 13-1 Continuous Transmit Mode

The MT8860C provides a signal generator mode of operation whereby a continuous transmit signal is generated at the test port connector. Signal generator mode may be of particular use in calculating the path loss of a test system prior to measurement operation or when testing the receiver of a DUT for RSSI (Received Signal Strength Indicator).

1. Start LANLook and display the [Signal Generator] tab as shown on the following page.

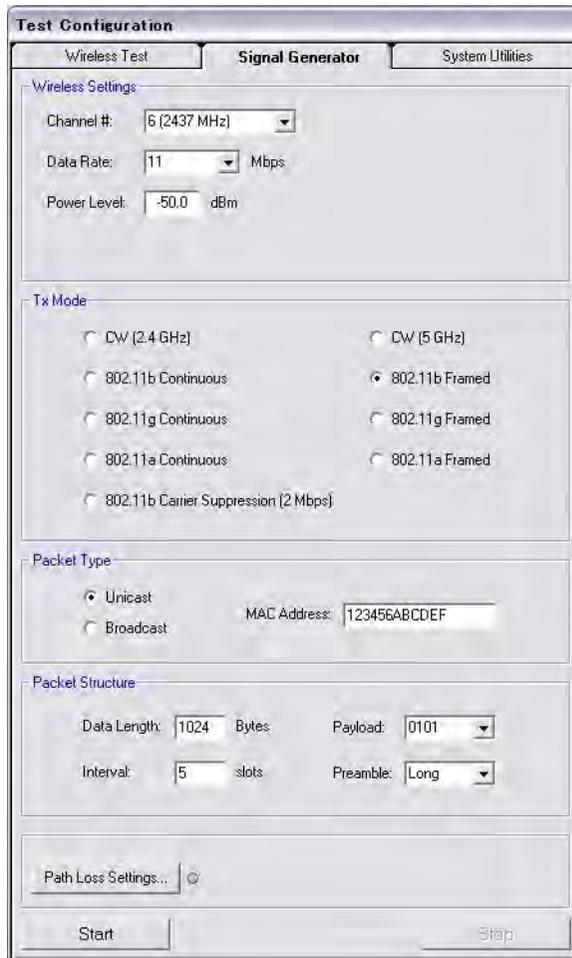
Signal generator mode is unavailable under any of the following conditions:

**Note**

- If the wireless standard is set to 802.11n.
- If test mode is set to “Network”.
- If the reference radio is set to “External”.

2. Select the channel on which data will be output.
3. Select the data rate. The available rates are determined by the “Tx Mode” selection.
4. Specify the required power level between -100 and 0 dBm.
5. Select the required Tx mode. The user can select between:-
  - CW (single carrier) at 2.4 GHz or 5 GHz.
  - Continuous modulated (100% duty cycle) 802.11b, 802.11g or 802.11a.
  - Continuous Framed (dynamic duty cycle) 802.11b, 802.11g or 802.11a.
  - 802.11b carrier suppression at 2 Mbps.

6. If Tx mode is set to one of the framed settings, the packet type and structure can be defined.



**Figure 13-1.** [Signal Generator] Tab

7. Click [Start] to commence the generation of data as defined.

**Note**

The “Channel”, “Data Rate”, “Power Level”, “Packet Type”, and “Packet Structure” parameters are shared between Signal Generator Mode and Wireless Test Mode. Switching between modes may cause some parameters to change in order to maintain consistency. Path Loss settings are applied to the Signal Generator output signal if enabled.

# Chapter 14 — Using the WLAN Reference Input (802.11b/g/a only)

## 14-1 Overview

The MT8860C is provided with a WLAN reference input connector. This allows DUT receiver measurements to be performed using an external WLAN device instead of the internal reference radio. In this mode of operation, only the leveling loop and attenuator hardware of the MT8860C are used to provide a calibrated signal level at the Test Port Connector. In order that the correct signal level is produced at the test port connector, the following test conditions must be used:

- The average power at the WLAN reference input must be in the range +12 dBm to +18dBm.
- The packets generated by the WLAN device must be > 110 us in length.
- The “Tx ON” signal from the WLAN device must be connected to the rear panel BNC connector “Digital 2 In”.

**Note** No measurements are supported by MT8860C in this mode of operation.

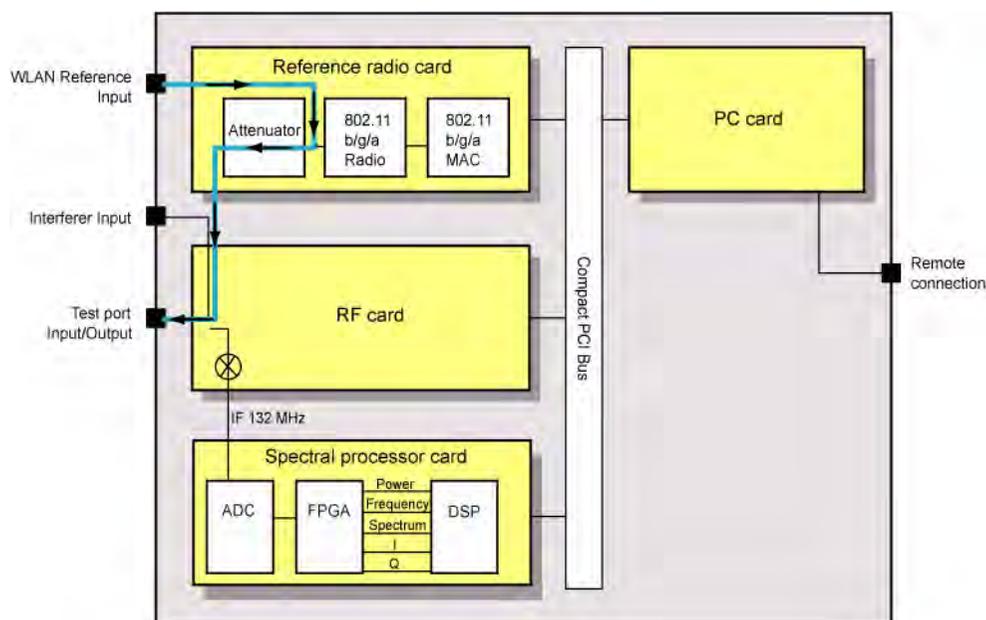


Figure 14-1. WLAN Reference Input

## 14-2 Procedure

1. Establish a remote connection between the MT8860C and the PC as detailed in chapter 5.
2. Make the required wireless test settings.  
The wireless test settings are used to apply the correct calibration for the selected channel number. Ensure that the settings in this pane match the transmission characteristics of the external WLAN device.
3. From LANLook, click the [Rx Testing] tab shown below.

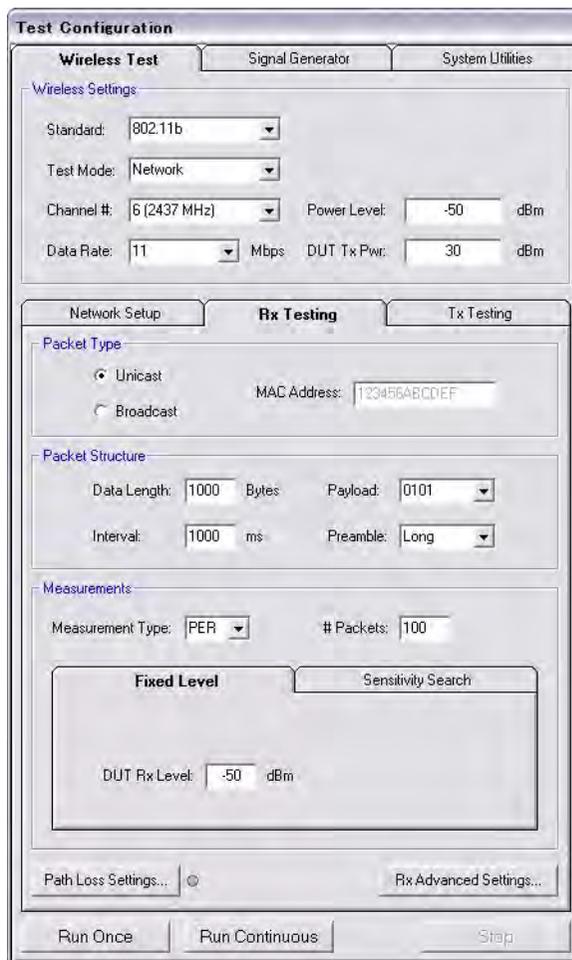


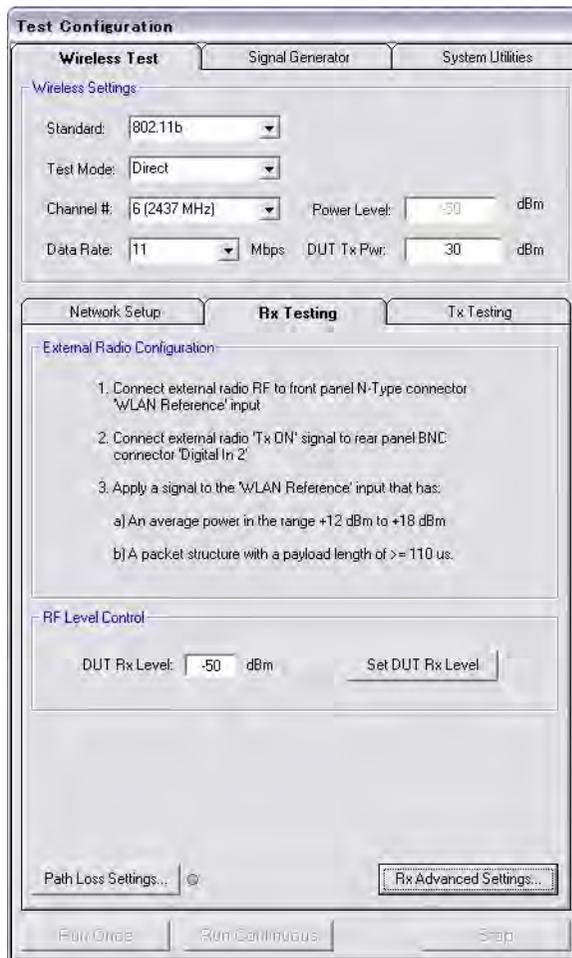
Figure 14-2. [Rx Testing] Tab

4. Click [Rx Advanced Settings...] at the bottom of the page and set the Reference Radio to “External” as shown below.



**Figure 14-3.** [Rx Advanced Settings] Dialog

5. Click [OK]. The Rx testing tab now has the following appearance.



**Figure 14-4.** [Rx Testing] Tab

6. At the “DUT Rx Level” setting, specify the required power level at the test port connector.
7. If required, a signal level correction table can be used to compensate for test system and cable loss effects. Refer to chapter 13 for details.
8. Click the [Set DUT Rx Level] button. The MT8860C performs a leveling operation to produce the power level specified.

# Chapter 15 — Common Procedures

This chapter provides a quick reference to a number of simple procedures with which users will need to gain familiarity. The procedures are listed in alphabetical order based upon the most logical topic heading.

## 15-1 10 MHz Reference Source

The user can choose to use an external reference source by making a connection to the “10 MHz Ref In” port on the rear of the MT8860C and following the procedure below.

1. Open LANLook and click the [System Utilities] tab.
2. The [System Utilities] tab contains three further tabs. Click the [System Settings] tab to display the page shown below.



**Figure 15-1.** [System] Tab

- In the “10 MHz Reference” pane, change the reference source to “External”.

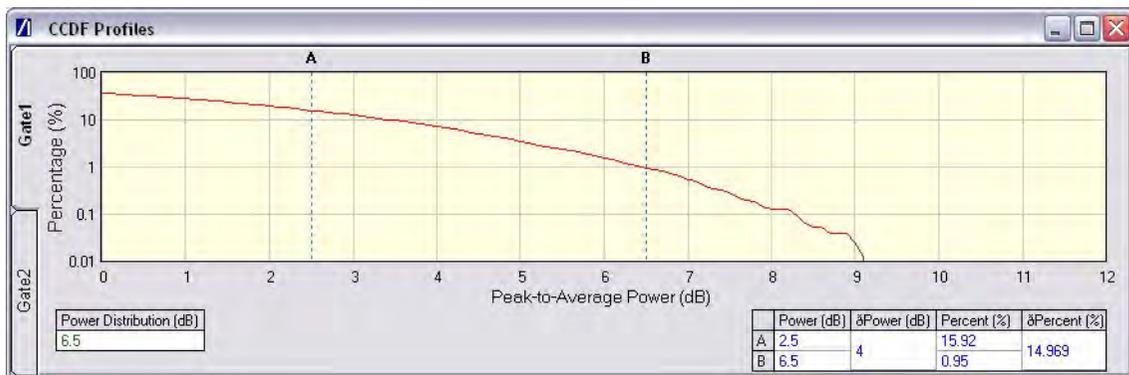
**Note** An external 10 MHz reference source must be applied to the rear panel BNC prior to selecting the external mode of operation. If the external 10 MHz source is selected but not applied the MT8860C uses the internal reference.

## 15-2 CCDF - Setting Percentages (OFDM data rates only)

The CCDF profile (Complementary Cumulative Distribution Function) allows the user to ascertain the percentage of samples for which the power level specified by the markers is greater than the average power. The CCDF percentage is set to 99% by default. This value can be changed as specified below.

**Note** Users should note that in order for the power distribution to be updated correctly, it is necessary to send the new percentage setting to the MT8860C by pressing [Run Once] or [Run Continuous].

- If measurements are in progress, click [Stop].
- Right click the [CCDF profile] plot and select [Set CCDF Percentage] from the pop-up menu that displays.
- Specify the required percentage in the [CCDF Setup] dialog that displays.
- Click [Run Once] or [Run Continuous] to commence measurement and send the new CCDF percentage to the MT8860C.
- The results of the calculation are returned in the “Power distribution” table beneath the CCDF trace. In the example of the figure below, the CCDF setup was left at the default setting of 99% and a power distribution of 6.5 dB was returned. This tells the user that for all the samples captured, 99% were no greater than 6.5 dB above the average power OR 1% exceeded the average power by at least 6.5 dB.



**Figure 15-2.** [CCDF Profile] Window

## 15-3 Crest Factor / Rise/Fall Data - Selecting

The user can display either crest factor or rise/fall data in the [Power Profile] window.

1. Click the [Tx Testing] tab.
2. Click [Tx Advanced Settings...].
3. Click the [Power Profile Settings] tab.
4. Select “Rise & Fall Times” or “Crest Factor”

## 15-4 Default Settings - Returning to

1. Start up LANLook and display the [System Utilities] tab.
2. The [System Utilities] tab contains three further tabs. Click the [System Settings] tab.
3. Click [Preset MT8860C] to return the MT8860C to its default settings.

**Note**

When the [Preset MT8860C] button is clicked the MT8860C is returned to its default settings without further warning. Give due consideration before using this function.

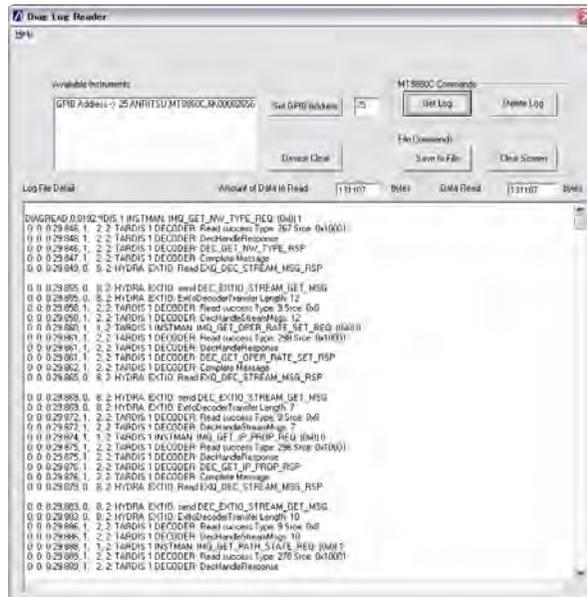
## 15-5 Diagnostics Tool

The diagnostics tool can be used to generate a log of events for analysis if operational difficulties are experienced. The diagnostics tool can be used regardless of whether or not LANLook is being used as the control system. Follow the procedure below to generate a log of GPIB events.

1. Replicate the series of events leading up to the occurrence of the error.
2. Select [Launch Diagnostics Tool] from the [Tools] menu to display the window shown below.
3. Check that the correct instrument has been identified and that the remote address is correct.
4. Click [Get Log] to generate the log in the main “Log file detail” area of the dialog.

**Note**

If problems are experienced during log generation, click [Device clear] to clear the input and output queues and release an abort request to the system.  
If the generated log is too long, click [Delete Log] to delete the current data log from within the MT8860C. Once deleted, replicate the problem again and then click [Get Log] to generate a new, shorter log.



**Figure 15-3.** [Diag Log Reader] Dialog

5. Once the log has been generated, click [Save to File] to save the log as a text file.
6. Send the text file to Anritsu for analysis.

**Note**

For those using an Ethernet remote connection, a diagnostics log can be viewed by opening a web browser and typing <http://A000xxxx/DiagLogFile1.txt> (where xxxx is the four digits after the zeros in the MT8860C serial number). Once generated, the file in the browser can be saved as a text or html file and sent to Anritsu for analysis.

## 15-6 Gates - Positioning

Two gates display on the [Power Profile] and [Frequency Profile] test result windows. The gate start and stop positions are shown by vertical lines denoted by the numbers 1 and 2. The boundaries of gate 1 display in green, and those of gate 2 in purple. Gates can be positioned using either of the methods detailed below.

### Method 1: Dragging Gates

1. Position the mouse pointer directly above any position on any the vertical gate lines.
2. Click and drag the gate as required whilst still holding down the mouse button.
3. The gate values that display in the table beneath the trace are automatically updated.

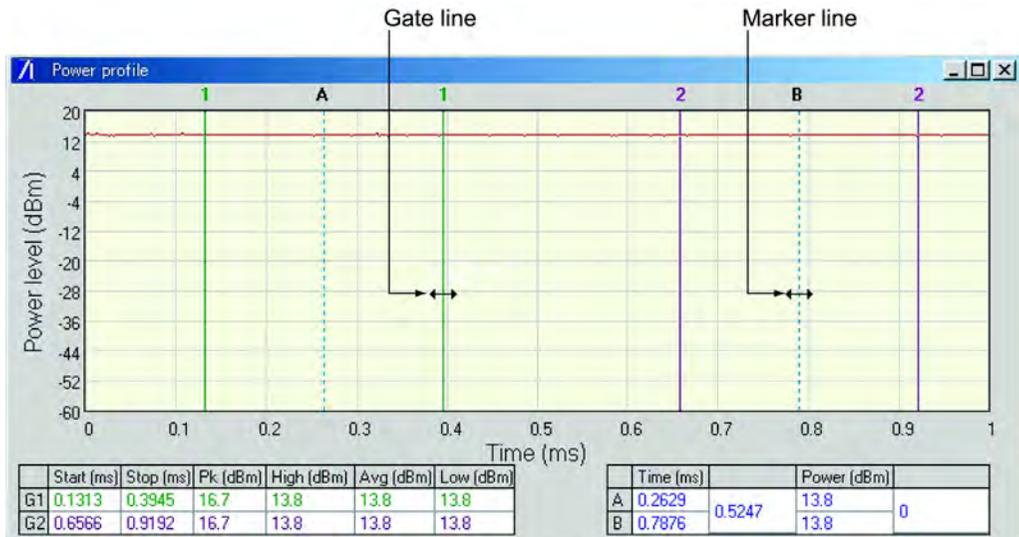
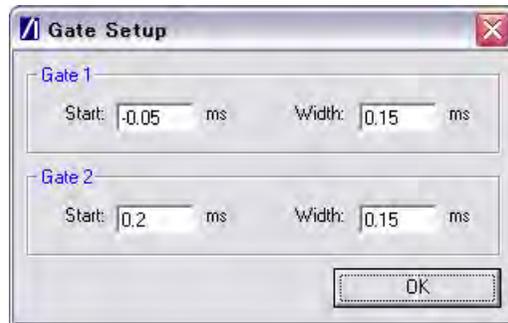


Figure 15-4. Positioning Gates

## Method 2: Entering Gate Width

1. Click [Gate Settings...] on the [Tx Testing] sub-tab to display the dialog below.



**Figure 15-5.** [Gate Setup] Dialog

2. Enter the gate delay position (start) and the total gate width as required in the dialog shown above.

## 15-7 GPIB Address - Changing

1. Start LANLook and click [System Utilities] tab > [MT8860C Remote] tab.
2. Select “GPIB” at the “Remote Interface” setting.
3. Press [Scan for Instruments] to acquire a list of all GPIB addresses found.
4. Select the required address from the list and click [Connect].
5. Click the [System Settings] sub-tab to display the page below.



**Figure 15-6.** [System] Tab

6. Enter the new GPIB address of the MT8860C in the “MT8860C GPIB Address” field.
7. Click [Change] to register the change at the unit.

**Note**

The MT8860C GPIB address cannot be changed without first establishing a GPIB connection as detailed above.

## 15-8 Graphs - Scaling

### Power, Frequency, and Spectral Profiles

1. Right click the required plot and select either [Default scaling], [Auto scaling], or [Manual scaling] from the pop-up menu that displays.
2. For auto and default scaling, the plot changes as soon as the scaling command is selected. For [Manual scaling], a dialog displays to allow the user to specify the maximum and minimum Y-axis dBm levels. Enter the required values and click [OK].



Figure 15-7. [Y-Axis Settings] Dialog

### EVM Profiles

Right click the required plot and select the 5%, 10%, 20%, or 50% scale command from the pop-up menu that displays.

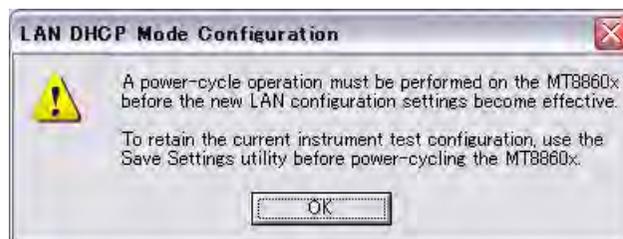
## 15-9 LAN IP Configuration - Changing

1. Start LANLook and click [System Utilities] tab > [MT8860C Remote] tab.
2. Select “LAN” at the “Remote Interface” setting.
3. Enter the IP address or hostname and click [Connect].
4. Click the [System Settings] sub-tab.
5. Click [Change...] in the “LAN DHCP Mode Configuration” frame.
6. Select “Use the following IP Address and Sub Net Mask”.



**Figure 15-8.** LAN DHCP Mode Configuration

7. Enter the required IP address and sub net mask and click [OK]. LANLook displays the following message.



**Figure 15-9.** LAN DHCP Mode Configuration Warning

**Note** Make sure that the new address does not already exist on the network.  
A power cycle operation must be performed before the new LAN configuration settings become effective.

## 15-10 LANLook Software - Upgrading

1. Download the latest software package from the Anritsu website. To do this, go to <http://www.eu.anritsu.com/downloads/>, select “MT8860C” from the drop down list, and click [Show Downloads].
2. Select the LANLook folder, double click the .exe file and follow the instructions that display on screen.

## 15-11 Markers - Positioning

Two markers display on each of the test results windows. The marker positions are shown by vertical dotted lines and the letters A and B. Position the mouse pointer directly above any position on the vertical marker line.

1. Click and drag the marker as required whilst still holding down the mouse button.
2. The values that display in the table beneath the trace are automatically updated.
3. Markers - Zooming
4. Position the markers (the vertical dashed lines labelled “A” and “B” in the Power Profile plot below) on either side of the area to be enlarged.
5. Right click the required plot and select [Zoom to Markers] from the pop-up menu that displays.
6. Select either [Undo Zoom] or [Default Zoom] to zoom out again.

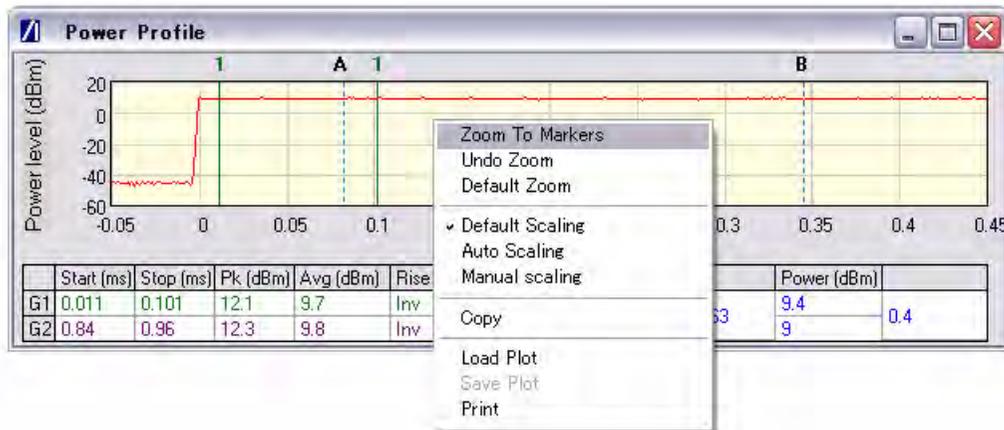
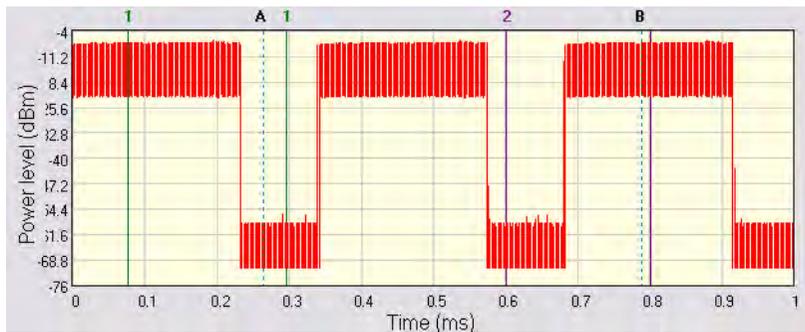


Figure 15-10. Zoom to Markers

## 15-12 Max-Min Power Profile - Displaying

1. Click the [Tx Testing] tab.
2. Click [Tx Advanced Settings...].
3. Click the [Power Profile Settings] tab.
4. Select “Display trace in Max-Min format”.
5. When this command is selected LANLook displays both the maximum and minimum values for each display point on the trace. Each of the maximum and minimum values is joined by a line to give a broad trace such as that shown in the example below.



**Figure 15-11.** Max-Min Power Profile

Displaying the max-min data in this way can be useful to monitor the effect that modulation changes between the preamble and the payload have on the power level of an 802.11g signal.

## 15-13 Occupied Bandwidth - Setting

1. Click the [Tx Testing] tab.
2. Click [Tx Advanced Settings...].
3. Click the [Spectral Profile Settings] tab.
4. Enter a percentage value as required at “OBW Percentage” and click [OK].
5. The value in the “OBW (MHz)” cell of the table beneath the spectral profile trace changes automatically to indicate the frequency within which the specified percentage of power is contained.

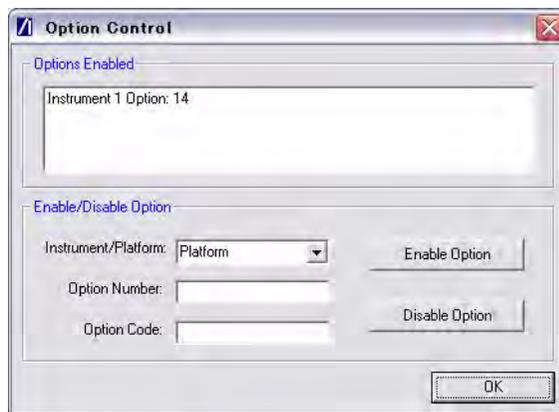
## 15-14 Options - Enabling and Disabling

Options specified at the time of the MT8860C order are installed at Anritsu prior to shipment to the customer. Customers ordering options at a later date should follow the procedure below to enable the selected options upon delivery.

1. Start LANLook and establish a remote connection between the PC and MT8860C as outlined in chapter 5.

**Note** If a remote connection is not established the [Option Control] dialog displays the message, “Option control unavailable on this instrument”.

2. Select [Option Control...] from the [Configure] menu on the main [Anritsu LANLook] window.



**Figure 15-12.**[Option Control] Dialog

3. The option code is required to enable or disable an option. Follow the instructions below to enable a new option.

Instrument/platform: Select “Instrument 1” from the drop-down menu.

Option number: Enter the number of the option, e.g., 14

Option code: Enter the option code specified on the option CD label.

4. Click [Enable Option] and then click [OK] to close the [Option Control] dialog.

Options can be disabled by selecting the required option in the “Options Enabled” list and entering the details used when the option was enabled. Select “Instrument 1”, enter the option number and option code and click [Disable Option].

5. Click [OK] to close the [Option Control] dialog.

## 15-15 Path Loss Table - Configuring

The MT8860C provides a signal level correction table that can be used to compensate for test system and cable loss effects. For each channel, independent Tx and Rx path loss values can be defined. Tx loss values represent loss in the DUT Tx path; Rx loss values represent loss in the DUT Rx path.

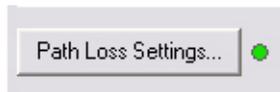
1. Start LANLook and display the [Wireless Test] tab.
2. Click [Path Loss Settings...] at the bottom of any of the three sub-tabs to display the dialog below.



**Figure 15-13.**[Path Loss Table] Tab

3. Use the “Data Entry Mode” setting to select whether the path loss entries are applied to the Tx path only, the Rx path only, or both Tx and Rx paths.
4. Select the required channel from the “Channel” drop-down box.
5. Enter the path loss in the “Path Loss” entry field and press [Add].
6. The specified loss for each channel displays in the table.
7. Repeat steps 3 to 6 above to add additional lines to the table if required.
8. To enable the path loss table, select "Enable Path Loss Correction" and click [OK] when complete.

9. The LED at the side of the [Path Loss Settings...] button is lit when the path loss table is enabled and a path loss value has been specified for the selected channel number.



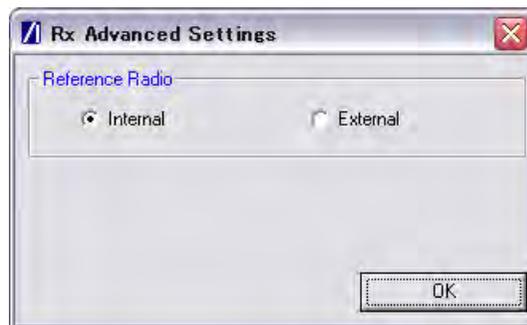
**Figure 15-14.** Path Loss Settings Indicator

- Notes**
- Path loss entries can be deleted from the list by selecting them and clicking [Delete].
  - The MT8860C does not interpolate between loss values specified for non adjacent channels. Each entry within the path loss table applies to the selected channel only.

## 15-16 Reference Radio - Enabling

An external gold card can be used instead of the internal reference radio. Follow the procedure below to select the external card.

1. Start LANLook and display the [Wireless Test] tab.
2. Select the 802.11b, 802.11g, or 802.11a wireless standard.
3. Click the [Rx Testing] tab.
4. Click [Rx Advanced Settings...] at the bottom of the page to display the dialog below.



**Figure 15-15.** [Rx Advanced Settings] Dialog

5. Select the required setting as detailed below.

- Internal: Selects the use of the calibrated reference radio within the MT8860C.
- External: Selects the use of an external gold card.

**Note** Refer to chapter 14 for further information on using an external radio.

## 15-17 Remote Commands - Sending from LANLook

1. Start LANLook, display the [System Utilities] tab and the [MT8860C Remote] sub-tab.
2. Select the required remote interface and establish a remote connection.
3. Click the [Diagnostics] sub-tab to display the page shown below.



**Figure 15-16.** [Diagnostics] Tab

4. Enter the required command in the “Program Message” text box and click [Send] or [Query].

**Note**

Remote commands can be transmitted to the MT8860C regardless of whether using a GPIB or LAN remote interface.

## 15-18 Settings - Saving to the MT8860C

Changes made to the settings within LANLook can be saved to the MT8860C at any time. Saving the settings in this manner ensures that the changes made are retained even when LANLook is closed and subsequently re-started.

1. Open LANLook and click the [System Utilities] tab.
2. The [System Utilities] tab contains three further tabs. Click the [System Settings] tab.
3. Click [Save on MT8860C].

<b>Note</b>	Settings can also be saved from a dialog that displays when the user attempts to close LANLook without having saved changes as detailed above.
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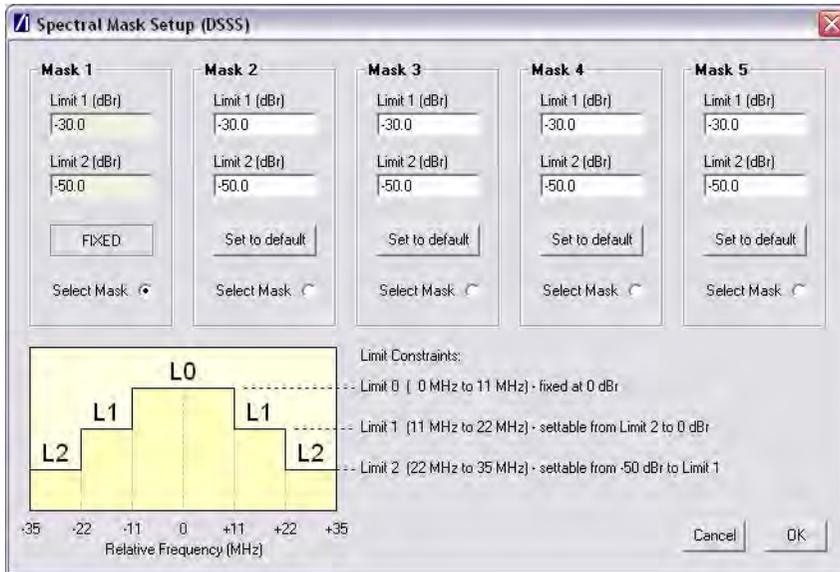
## 15-19 Simulation Mode

Simulation data has been included in LANLook to allow the user to demonstrate or become familiar with the functionality available. Simulation mode is enabled by default until a WLAN connection is established with the DUT. A message displays in the LANLook status bar whenever LANLook is running in simulation mode.

<b>Note</b>	Simulation mode is, as the name suggests, a simulation of actual operation, and as such certain commands or operations are unavailable in this mode. Simulation mode is not currently supported for 802.11a or 802.11n testing. The [Signal Generator] tab is not available in simulation mode.
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## 15-20 Spectral Mask - Editing (DSSS data rates only)

1. Right click in the graph area of the [Spectral Profiles] window and select [Setup Mask] from the pop-up menu to display the dialog shown below.



**Figure 15-17.**[Spectral Mask Setup (DSSS)] Dialog

2. The display area of the dialog is split into sections for each of the masks. Mask 1 is the default mask and cannot be edited.
3. Click “Select Mask” in the “Mask 2” area and enter “Limit 1” (L1) and “Limit 2” (L2) values as required. Both limits can be moved up or down and any changes made are reflected automatically in the associated limit on the opposite side of the mask. As shown in the dialog, the upper limit (shown as “L0” in the figure within the dialog) is fixed at 0 dBr.
4. Repeat this process as required for all required masks.
5. Click [OK] to save the changes and close the dialog.

## 15-21 Test Settings - Saving and Loading

1. To save test settings for future use, select [Save Test Settings..] from the [File] menu of the main [Anritsu LANLook] window.
2. Specify a name and location for the file to be generated in the usual windows manner.
3. Select [Load Test Settings..] from the [File] menu to load the settings saved above back into LANLook.

## 15-22 Traces - Copying to Clipboard

1. Maximize the main [Anritsu LANLook] window.
2. Enlarge the required plot window to the required size. The window can be enlarged to any size, but must remain within the area of the main window.
3. Right click the required plot and select [Copy] from the pop-up menu that displays.
4. The image can now be inserted into any graphical or word processing application using the paste command.

## 15-23 Traces - Loading from Comma Separated Value Data

1. Maximize the required trace.
2. Right click in the graph area of any of the results windows.
3. Select [Load Plot] from the pop-up menu that displays.
4. Locate the CSV file and click [OK] to display the data in the window as a plot.

<b>Note</b>	CSV files must be loaded into the correct window. For example, it is not possible to load the CSV file for a power profile trace into the frequency profile window.
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## 15-24 Traces - Printing

1. Right click the required plot and select [Print] from the pop-up menu that displays.
2. The selected image is printed directly to the default printer.

## 15-25 Traces - Saving as Comma Separated Value Data

1. Right click the image to be saved and select the [Save Plot] command from the pop-up menu. The [Save Plot] command is not available when measurements are in progress.
2. Specify a name and location for the file in the normal Windows manner.
3. Select “CSV file” from the “File type” drop-down menu.
4. Click [Save].

## 15-26 Traces - Saving as Image Files

1. Right click the image to be saved and select the [Save Plot] command from the pop-up menu. The [Save Plot] command is not available when measurements are in progress.
2. Specify a name and location for the file in the normal Windows manner.
3. Select whether the image will be saved as a bitmap or JPEG file.
4. Click [Save].

## 15-27 Version Information - Viewing

1. Select [About Anritsu LANLook] from the [Help] menu of the main [Anritsu LANLook] window. The following window displays showing the software versions and build status.



Figure 15-18.[About Anritsu LANLook] Dialog



# Chapter 16 — LANLook Source Code Guide

The source code for LANLook is available to the end-user for information and development purposes.

This chapter explains the structure of the LANLook source code and provides information necessary for the programmer to deploy all or part of LANLook in their own application for use with the MT8860C.

## 16-1 Overview

LANLook is written in Microsoft Visual Basic 6 (VB6). For most purposes the user should have VB6 installed with the latest service packs in order to view, modify and compile the software. The source code text (.bas, .frm, .cls) can be viewed in a simple text editor (e.g. Notepad) if VB6 is not available.

Ideally, the LANLook source code should be copied in its entirety from the product CD onto the user's PC hard disk. To load the source code into the VB6 development environment open the project file named LANLook.vbp. This will load all required source code files.

LANLook is structured into three layers. These are shown graphically in Figure 14-1 and can be described as follows:

- **Application layer**  
A set of forms and associated modules used for the graphical user interface (GUI) and to define the top-level functionality. The code in this layer is specific to LANLook in its role as a virtual front panel for the MT8860C. It is not intended for re-use.
- **Interface layer**  
A set of modules that provide a high level remote control API and other utility functions required by LANLook. The remote control API supports communication via a GPIB connection (with National Instruments or compatible hardware) using either a basic software driver interface (e.g. NI-488.2) or a VISA-COM interface. Remote control via an Ethernet LAN connection is also supported by the VISA-COM interface using the VXI-11 protocols defined by the IVI Foundation (<http://www.ivifoundation.org>).

### Note

The product CD contains a licensed copy of the NI VISA Runtime Engine which may be installed by the user for use with LANLook if required. Note that the license applies only to software installed by the package on the product CD. The NI-VISA installation includes the VISA COM type libraries provided by the IVI Foundation. LANLook interfaces with the VISA COM libraries, but users developing their own code may prefer to interface directly with the NI VISA library (visa32.dll). Please consult the NI documentation or the NI website (<http://www.ni.com>) for further information.

- System Layer

A set of dynamic link libraries (DLLs) that provide calls to the operating system functions and low-level drivers. These are either part of Microsoft Windows (tm) or provided by a third party vendor (e.g., National Instruments).

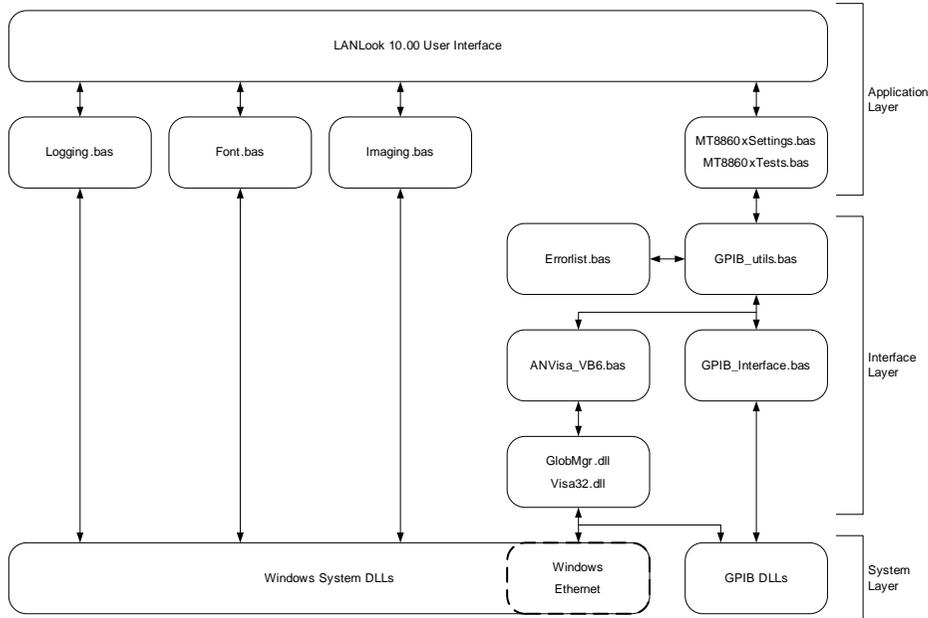


Figure 16-1. LANLook Source Code Structure

## 16-2 Using the LANLook Source Code

The interface layer (in partnership with the system/DLL layer) provides a convenient entry point for the user to begin developing a dedicated application to communicate with the MT8860C. The user can either make calls to the `MT8860xSettings.bas` and `MT8860xTests.bas` modules or more directly to the `GPIB_Utills` module.

The `MT8860xSettings.bas` and `MT8860xTests.bas` modules provide a set of dedicated functions for performing operations on the MT8860C. The `GPIB_Utills.bas` module is lower level and provides for the sending and receiving of data via GPIB or LAN interfaces.

Functions operate on a set of global variables defined in the `Globals.bas` module. Before calling any of the remote control functions, the following global variables should be initialized:

ComInterface [enumerated type COM\_TYPES]

Defines the remote control interface and protocol with the following values:

- `GPIB_4882 = 0` ' GPIB using 488.2
- `GPIB_VISA = 1` ' GPIB using VISA
- `ENET_SOCKET = 2` ' LAN using Sockets (Reserved for future use)
- `ENET_VISA = 3` ' LAN using VXI-11 (VISA)

For GPIB interfaces:

- GPIB\_Address [Integer] Declared in Globals.bas
- GPIB\_BOARD\_NUMBER Declared as a Constant (0) in Globals.bas. This should be changed if a different GPIB board number is used.

For LAN interfaces:

- Rem\_IP\_Hostname [String] Declared in Globals.bas. Derived from the instrument serial number as described in Appendix G.
- Rem\_IP\_Address [String] Declared in Globals.bas. Use standard IPv4 dot notation.
- RemIPAuto [Boolean] Declared in Globals.bas. True = Use DHCP, False = Manual IP address entry.

## 16-3 Using the MT8860xSettings Module

The MT8860xSettings.bas module contains functions for setting and requesting the MT8860C test parameters. New parameter settings are passed in the function calls. For example, the function Set\_DataRate() would be called like this:

```
Call Set_DataRate("11")
```

In this module there is a global variable defined for each of the test parameters.

To request the data rate, the Req\_DataRate() function would be called and the global variable TsetTxDataRate would be updated with the new value. The dialog in the application layer is also updated.

### Note

LANLook performs parameter checking in the application layer. If the values of parameters passed are incorrect the MT8860C will respond with an error. This is handled in the GPIB\_Utils.bas module.

## 16-4 Using the Interface Layer MT8860xTests Module

The MT8860xTests.bas module contains functions for running test sequences. The functions and associated tests are summarised in the table below.

Function	Associated test
Run_Fixed_PER_Test()	Runs one or a number of fixed power level PER tests.
Run_PER_Scan_Test()	Runs a single PER search test.
Run_Tx_Test()	Runs one or a number of transmitter tests.

The functions Run\_Fixed\_PER\_Test() and Run\_Tx\_Test() require one of two run mode parameters that select either a single test or a continuous (repeated) test run. These are constants defined in the Globals.bas module as CONTINUOUS\_TEST and SINGLE\_TEST.

The Run\_Fixed\_PER\_Test() and Run\_PER\_Scan\_Test() functions pass the test results directly to the application layer. The Run\_Tx\_Test() function updates a set of global variables declared in the Globals.bas module.

**Note** None of the test functions provide the facility to set the MT8860C test parameters before running a test. This must be performed by calls to functions in the MT8860xSettings.bas module.

## 16-5 Using the GPIB\_Utills Module

The GPIB\_Utills.bas module allows the user to send and receive GPIB data without the complications of interfacing directly with the GPIB32 dll.

There are five functions of interest in the GPIB\_Utills.bas module. These are described in the table below.

Function	Description
Connect_to_device()	Establishes the GPIB connection and checks the MT8860C IDN string.
data_request()	General ASCII data request and receive.
Request_Profile_Data()	Binary profile data request and receive.
Send_Command()	General ASCII data send.
Close_GPIB()	Closes down the GPIB interface.

The application should call the Connect\_to\_device() function at start up and the Close\_GPIB() function before closing down.

The Send\_Command(), data\_request() and Request\_Profile\_Data() functions require a number of parameters to be passed to them. These parameters are summarised in the table below.

Function(s)	Parameter	Parameter description
Send_Command() and data_request()	brdid	Specifies the GPIB interface number.
Send_Command() and data_request()	addr	Specifies the GPIB address of the MT8860C.
Send_Command() and data_request()	cmd_msg	Specifies the ASCII command for the MT8860C.
data_request() and Request_Profile_Data()	Response()	A string or variable array for return data.
data_request() and Request_Profile_Data()	Count	An integer specifying the number of values returned.
data_request() and Request_Profile_Data()	timeout	A long specifying the GPIB timeout time in ms.
data_request()	Request_Type	An integer specifying the type of data request.

## 16-6 Examples

The `Send_Command()` function is used when the MT8860C is not required to return data. For example when setting the data rate:

```
Command_String="MEASCFG 1, TXRATE, 11"
```

Call `Send_Command(GPIB_BOARD_NUMBER, GPIB_Address, Command_String)`

The `data_request()` function is used when the MT8860C is required to return data. The data received is then returned in the string variable `My_data`. This would be the case when requesting a PER measurement:

```
Command_String="MEASCFG? 1, MEAS, PER"
```

Call `data_request(GPIB_BOARD_NUMBER, GPIB_Address, Command_String, My_data, My_data_cnt, Timeout, Req_Type)`

The `Request_Profile_Data()` function is used specifically to request binary profile data. For example, to request the mean power profile:

```
Call Request_Profile_Data("POWER", "MEAN", My_data [], My_data_cnt, Timeout)
```

The first two parameters define the profile to be requested. The binary data is passed back in the floating-point variable array `My_data`.



# Chapter 17 — Upgrading the MT8860C Firmware

Software upgrades are posted on the Anritsu website at the address given in the procedure below. To receive e-mail notification each time the software is updated, send a blank mail to [wlan.support@anritsu.com](mailto:wlan.support@anritsu.com) with the subject heading of “MT8860C firmware upgrade notification”.

## 17-1 Using the GPIB Bootloader Utility

**Note** The following instructions are applicable when upgrading the firmware to version 12.0 or greater.

The MT8860C is designed to operate with firmware version 8.00 or greater. DO NOT install a firmware version earlier than 8.00.

The firmware upgrade operation will return the instrument to its factory default settings.

1. Remove the existing LANLook installation.
  - a. Go to the Windows [Control Panel] and select [Add or Remove Programs].
  - b. Select LANLook from the list of currently installed programs and click [Remove].
  - c. Close [Add or Remove Programs] when the un-install operation is complete.
2. Install the new version of LANLook.
  - a. On the PC, create the directory C:\temp\LANLook. If a directory with this name already exists, delete the existing contents.
  - b. Copy the zip file containing the new release of LANLook into c:\temp\LANLook.
  - c. Extract the contents of the zip file to c:\temp\LANLook. and delete the zip file. The directory should now contain two files: “LANLook.msi” and “setup.exe”.
  - d. Run the setup.exe to install LANLook as detailed in chapter 3.
3. Bootload the new firmware
  - a. On the PC, create the directory c:\temp\MT8860C Upgrade. If a directory with this name already exists, delete the existing contents.
  - b. Copy the zip file containing the new firmware into c:\temp\MT8860C Upgrade.
  - c. Extract the contents of the zip file to c:\temp\MT8860C Upgrade and delete the zip file. The directory should now contain 35 files.
  - d. Power-on the MT8860C and wait until the boot-up process has completed as detailed in chapter 4.
  - e. Connect a GPIB cable from the GPIB interface on the PC to the MT8860C.



## 17-2 Upgrading Via Ethernet

The following instructions are applicable for instruments that have firmware version 12.0 (or greater) already installed.

For instruments that have firmware version 9.00 (or earlier) installed, refer to the document 'MT8860C firmware bootload (Feb 2009).pdf'

**Note**

The MT8860C is designed to operate with firmware version 8.00 or greater. DO NOT install a firmware version earlier than 8.00.

The firmware upgrade operation will return the instrument to its factory default setting.

The upgrade operation uses the FTP client "FileZilla". The FileZilla client is a free, Open Source FTP client for Windows. It is available for download using the URL: <http://filezilla-project.org/download.php?type=client>

1. Copy the new firmware to the MT8860C bootload folder.
  - a. On the PC, create the directory c:\temp\MT8860C Upgrade. If a directory with this name already exists, delete the existing contents.
  - b. Copy the zip file containing the new firmware into c:\temp\MT8860C Upgrade.
  - c. Extract the contents of the zip file to c:\temp\MT8860C Upgrade and delete the zip file.

The directory c:\temp\MT8860C Upgrade should now contain 35 files.
  - d. Connect the MT8860C to the LAN. Refer to Appendix I for details on setting up the LAN interface.
  - e. Power-on the MT8860C and wait until the boot-up process has completed as detailed in chapter 4.
  - f. Launch the FileZilla Client application. Go to the Windows [Programs] directory and select [FileZilla FTP Client].
  - g. Enter the following details:

Host: <hostname or IP address>

Username: admin

Password: anritsu
  - h. Click Quick connect.
  - i. From 'Local site', select the folder c:\temp\MT8860C Upgrade.
  - j. Select all 35 files that are located in the folder c:\temp\MT8860C Upgrade.
  - k. Perform a Windows style 'Drag and Drop' operation. The file transfer commences.
  - l. When the transfer is complete, a total of 35 files should be listed in the 'Remote Site' folder and the 'Successful transfers' reported should be 35.

**2.** Power-cycle the MT8860C

The firmware upgrade operation is completed when the MT8860C has performed 2 power-on operations.

- a.** Power-on the MT8860C for the first time and wait until the boot-up process is complete. This may take several minutes and is indicated by the "On" LED flashing while the "Controller Activity" LED turns off.
- b.** Power-off the MT8860C and wait approximately 15 seconds.
- c.** Power-on the MT8860C for the second time and wait until the boot-up process is complete. This is indicated by the "On" LED turned fully on (i.e. it is not flashing) and the "Controller Activity" LED turned off.
- d.** The firmware upgrade operation is complete and the instrument can be used normally.

**3.** Confirm that the new firmware has been installed correctly.

- a.** Open a Telnet session. Launch the Command Prompt tool from the Windows Start menu.
- b.** At the command prompt, type telnet <hostname or IP address> 5024.
- c.** The firmware version is displayed on the status line.
- d.** Type exit at the "MT8860 >" prompt to close the Telnet session.

# Appendix A — Specifications

## A-1 MT8860C Specification

Characteristic / Parameter		Specification	
<b>Wireless Test Mode</b>		Standards supported: IEEE Std 802.11b-1999 IEEE Std 802.11g-2003 IEEE Std 802.11a-1999 (Option 14) IEEE Std 802.11n-2009 (Option 17) IEEE Std 802.11-2007	
<b>Supported Channels</b>			
802.11b / 802.11g (DSSS)		Channels 1 to 14 (2412 – 2484 MHz)	
802.11g (OFDM)		Channels 1 to 13 (2412 – 2472 MHz)	
802.11a		Channels 36, 40, 44, 48 (5150 – 5250 MHz) Channels 52, 56, 60, 64 (5250 – 5350 MHz) Channels 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140 (5470 – 5725 MHz) Channels 149, 153, 157, 161, 165 (5725 – 5825 MHz)	
802.11n (20 MHz channel bandwidth)	Frequency Band		
	2.4 GHz	Channels 1 to 13 (2412 – 2472 MHz)	
802.11n (40 MHz channel bandwidth)	5 GHz	Channels 36, 40, 44, 48 (5150 – 5250 MHz) Channels 52, 56, 60, 64 (5250 – 5350 MHz) Channels 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140 (5470 – 5725 MHz) Channels 149, 153, 157, 161, 165 (5725 – 5825 MHz)	
	Frequency Band	40 MHz channels are specified in the format (Primary Channel, Secondary), where Secondary = $\pm 1$	
802.11n (40 MHz channel bandwidth)	2.4 GHz	Primary Channels 1 to 9	Primary Channels 5 to 13
	5 GHz	Primary Channels 36, 44 Primary Channels 52, 60 Primary Channels 100, 108, 116, 124, 132 Primary Channels 149, 157	Primary Channels 40, 48 Primary Channels 56, 64 Primary Channels 104, 112, 120, 128, 136 Primary Channels 153, 161

<b>Data Rates and Modulation</b>		
802.11b / 802.11g (DSSS)	1 Mbps 11-chip Barker DBPSK 2 Mbps 11-chip Barker DQPSK 5.5 Mbps CCK DQPSK 11 Mbps CCK DQPSK	
802.11g (OFDM) 802.11a	6, 9, 12, 18, 24, 36, 48, 54 Mbps OFDM (BPSK, QPSK, 16-QAM, 64-QAM)	
802.11n (non-HT)	PPDU Types: 20 MHz, 40MHz Upper, 40 MHz Lower, 40 MHz Duplicate	
	1 Mbps 11-chip Barker DBPSK 2 Mbps 11-chip Barker DQPSK 5.5 Mbps CCK DQPSK 11 Mbps CCK DQPSK 6, 9, 12, 18, 24, 36, 48, 54 Mbps OFDM (BPSK, QPSK, 16-QAM, 64-QAM)	
802.11n (HT)	PPDU HT Formats: HT-Mixed Mode, (HT-Greenfield: Tx test only)	
	PPDU Types: 20 MHz, 40 MHz, (40 MHz Upper, 40 MHz Lower: Tx test only), 40 MHz Duplicate	
	Modulation & Coding Scheme: MCS Index 0 to 7 and MCS 32 (Duplicate)	
	Guard Interval:	HT-Mixed Mode: Long (800 ns), Short (400 ns)
		HT-Greenfield: Long (800 ns) only
	Data Rates:	20 MHz channel b/w: 6.5, 7.2, 13, 14.4, 19.5, 21.7, 26, 28.9, 39, 43.3, 52, 57.8, 58.5, 65, 72.2 Mbps
		40 MHz channel b/w: 6, 6.7, 13.5, 15, 27, 30, 40.5, 54, 60, 81, 90, 108, 120, 121.5, 135, 150 Mbps
Modulation:	OFDM (BPSK, QPSK, 16-QAM, 64-QAM)	
<b>Operating Modes</b>	Two modes of operation are supported; Network Mode and Direct Mode	

Network Mode (802.11b, 802.11g, 802.11a only)	In Network mode, standard protocol messaging is used to establish a network connection between the MT8860C and a WLAN device. Once a connection is made, the receiver and transmitter characteristics of the device under test (DUT) can be tested	
Receiver Measurements	Packet Error Rate (PER) at defined level Frame Reception Rate (FRR) at defined level	
Unicast Packet Type	<p>The MT8860C transmits data packets containing the MAC address of the DUT and automatically calculates the PER or FRR based on the number of acknowledgement (ACK) packets it receives in response from the DUT.</p> <p>PER (%) = [1 - (ACKs received from DUT / data packets transmitted by MT8860C)] x 100</p> <p>FRR (%) = (ACKs received from DUT / data packets transmitted by MT8860C) x 100</p>	
Broadcast Packet Type	<p>MT8860C transmits data packets containing the broadcast address (FFFFFFFFFFFF). The PER/FRR is calculated externally and requires access to the DUT receive frame registers. These are normally available from the DUT client software under “Advanced Information”.</p> <p>PER (%) = [1 - (good packets reported by DUT / data packets transmitted by MT8860C)] x 100</p> <p>FRR (%) = (good packets reported by DUT / data packets transmitted by MT8860C) x 100</p>	
<b>Transmitter Measurements</b>		
Data Frame Type	The MT8860C transmits ICMP echo request packets and then analyzes the echo reply packets returned by the DUT in response	
	Supported Measurements	All transmitter measurements stated in the 802.11b and 802.11g / 802.11a sections are supported (see below)

ACK Frame Type	The MT8860C transmits Unicast packets and then analyzes the ACK packets returned by the DUT in response. This testing methodology is specified by the CTIA / Wi-Fi Alliance in the CWG Test Plan that is used to evaluate the RF Performance of Wi-Fi Mobile	
	Supported Measurements	ACK frames have a short time duration, As a result, analysis is limited to the following measurements;
	(802.11b / 802.11g DSSS)	Average, Peak and Crest Factor Power Power-On and Power-Down Ramp Spectrum Mask / Mask Segment Occupied Bandwidth (OBW), Power Spectral Density (PSD) RF Carrier Suppression
	(802.11g OFDM / 802.11a)	Average, Peak and Crest Factor Power Power-On and Power-Down Ramp CCDF
<b>Network Mode Configuration Settings</b>		
MT8860C Role (Connection Type)	Infrastructure and Ad-Hoc	
Infrastructure	Supports Access Point and Client (STA) modes	
Ad-Hoc	Supports creating and joining a network	
SSID (Network Name)	Supported in Access Point and Ad-Hoc creation modes (32 characters maximum)	

Beacon Configuration	<p>The MT8860C periodically transmits beacon management frames so that a connection can be established and maintained with a DUT. The following beacon parameters can be adjusted;</p> <p>Beacon Interval: 20 to 1000 (default 200)</p> <p>Operational Rate Set: All Rates, Multiple Rates, Single Rate, User-defined</p> <p>DSSS Preamble Format: Long, Short</p> <p>NOTE: The Beacon Interval represents a number of time units (TU), with 1 TU being equal to 1024<math>\mu</math>s</p> <p>In addition, the following Information Elements can be included in the beacon (and other) management frames;</p> <table border="1"> <tr> <td>ERP Information Element</td> <td></td> </tr> <tr> <td>Country Information Element</td> <td>The parameters regional code, first channel number, number of channels and maximum transmit power level can be specified</td> </tr> <tr> <td>Vendor Specific Information Element</td> <td>Up to 32 characters can be specified in the contents field</td> </tr> </table>	ERP Information Element		Country Information Element	The parameters regional code, first channel number, number of channels and maximum transmit power level can be specified	Vendor Specific Information Element	Up to 32 characters can be specified in the contents field
ERP Information Element							
Country Information Element	The parameters regional code, first channel number, number of channels and maximum transmit power level can be specified						
Vendor Specific Information Element	Up to 32 characters can be specified in the contents field						
IP Properties	The IP settings of the DUT can be assigned manually or automatically via DHCP						
Direct Mode (802.11b, 802.11g, 802.11a, 802.11n)	In Direct mode, the DUT is controlled directly by using the appropriate chipset vendor control software						
Receiver Measurements	The MT8860C transmits a defined number of packets to the DUT. Chipset vendor control software is required to read the DUT receiver packet count register						
Transmitter Measurements	The DUT is configured for continuous transmission using chipset vendor control software. The MT8860C acts as a transmitter analyzer for measurements on the packets received. All transmitter measurements stated in the 802.11b, 802.11g / 802.11a and 802.11n sections are supported (see below)						
<b>802.11b Measurements</b>	The following applies to data rates of 1, 2, 5.5 and 11 Mbps that use DSSS modulation						
<b>Transmit Power Levels</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.7.1)						
Definition	Average, peak and crest factor power measurements derived from gate 1 or 2						
Damage Level	> +27 dBm						
Dynamic Range	<p>Low Noise Mode: +24 dBm to -50 dBm average power (+27 dBm peak)</p> <p>Low ACP Mode: +20 dBm to -50 dBm average power (+23 dBm peak)</p>						

Accuracy (#1)	Data Frame Type:	$\pm 0.6$ dB (+24 dBm to -30 dBm) $\pm 1.0$ dB (-30 dBm to -50 dBm)
	ACK Frame Type:	$\pm 0.8$ dB (+24 dBm to -30 dBm) $\pm 1.2$ dB (-30 dBm to -50 dBm)
Resolution	dBm to 2 decimal places	
Capture Width	10 $\mu$ s to 5.95 ms	
Time Resolution	0.1 $\mu$ s marker resolution with 10 $\mu$ s time window	
<b>Transmit Power Level Control</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.7.2)	
Definition	Peak and Average Power specification as for 18.4.7.1	
<b>Transmit Spectrum Mask</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.7.3)	
Definition	Spectrum measurement derived from gate 1 or 2	
Gate Width	From gate 1 or 2, 50 $\mu$ s to 5.95 ms	
Frequency Span	70 MHz ( $f_c \pm 35$ MHz)	
Flatness over Frequency Span	$\pm 1$ dB	
Linearity	$\pm 0.8$ dB (50 dB dynamic range CW measurements)	
Resolution	dB to 1 decimal place	
Range (modulated carrier power)	Low Noise Mode:	+24 dBm to -40 dBm
	Low ACP Mode:	+20 dBm to -40 dBm
Dynamic Range	>50 dB (usable dynamic range with Dither Mode set to ON)	
Receiver Resolution Bandwidth	Equivalent to 100 kHz Gaussian	
Noise Floor (for all supported channels)	-110 dBm (with Input Level Range 3L selected)	
Spurious Specification (for all supported channels)	<-52 dBc (with Dither Mode set to ON)	
<b>Measurement Configuration</b>		
Dither Mode	OFF	Default mode
	ON	Additional Signal processing removes spurs from the spectral measurement
RF Optimization Mode	User selection of Low Noise or Low ACP (default Low Noise)	
<b>Transmit Center Frequency Tolerance</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.7.4)	
Definition	Average Frequency of the DSSS carrier signal	
Data Output Format	Hz and ppm	
Accuracy	$\pm 1$ kHz $\pm$ reference frequency oscillator error (ppm) for measurement gate >1 ms	
Resolution	Hz to 2 decimal places, ppm to 2 decimal places	

<b>Chip Clock Frequency Tolerance</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.7.5)
Definition	Frequency error relative to 11MHz chip clock. Measurement averaged over a fully coded DSSS packet with minimum payload length of 3,300 chips (300 $\mu$ s)
Data Output Format	Hz and ppm
Range	$\pm$ 50 ppm
Resolution	Hz to 2 decimal places, ppm to 2 decimal places
Analysis Length	3,300 to 30,250 chips (default 5,500 chips)
<b>Transmit Power-On &amp; Power- Down Ramp</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.7.6)
Definition	Time for the burst to transition from 10% to 90% or 90% to 10% of linear power
Resolution	0.1 $\mu$ s
Data Outputs	10%, 90% and delta values
<b>RF Carrier Suppression</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.7.7)
Definition	Relative level of the carrier to highest sideband for a 10101010 test pattern, scrambler disabled, data rate 2 Mbps
Range	As spectral mask range
Dynamic Range	As spectral mask dynamic range
Flatness	As spectral mask flatness
Linearity	As spectral mask linearity
Resolution	As spectral mask resolution
<b>Transmit Modulation Accuracy</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.7.8)
Definition	Peak and Average Error Vector Magnitude measurement performed for DBPSK and DQPSK modulated packets. Measurement averaged over a fully coded DSSS packet with minimum payload length of 220 chips (20 $\mu$ s)
Measurement Accuracy	<10% residual RMS EVM; +24 dBm to -45 dBm
Modulation Setting	Data rate 1, 2, 5.5 or 11 Mbps
Displayed Measurement Range	1% to 100% dependent on modulation
<b>Measurement Configuration</b>	

EVM Calculation Method	rms Error Vector	The EVM measurement is performed using the 'classic' definition for EVM (rms Error Vector) and is calculated using chips that are transmitted during the PSDU (payload) of the packet
	11b Modulation Accuracy	The EVM measurement is performed using the definition in 18.4.7.8 and is calculated over 1,000 chips that are transmitted during the PLCP preamble and header
RX Filter Selection	Selectable between; None Gaussian, BT 0.3 to 1.0 (default 0.5), resolution 0.1 Root Raised Cosine, $\alpha$ 0.30 to 1.00 (default 0.35), resolution 0.01	
Analysis Length	220 to 11,000 chips (default 1,000 chips)	
<b>Receiver Minimum Input Sensitivity</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.8.1)	
Definition	Packet Error Rate (PER) at defined power level	
Power Range	See Reference Radio Transmitter section	
Mode	Network: MT8860C forms a connection with the DUT. Unicast and Broadcast Packets supported  Direct: MT8860C transmits defined number of packets	
Data Packet Structure	Complies with 802.11 specifications for MAC header formatting, scrambling, encoding, interleaving and calculation of the appropriate CRC/FCS checksum	
Number of Transmitted Packets	1 to 10,000 (default 500)	
Payload Length	60 to 1,500 bytes (default 1,024 bytes)	
Preamble Format	Long or Short	
Payload	All 0's, 0101, Counting, PN7, 1010, Random (Payload data scrambled over the air)	
Data Rates	1, 2, 5.5 or 11 Mbps	
<b>Network Mode Settings</b>		
Inter-packet Interval	0 to 65535 ms	
Inter-packet Resolution	1 ms	
DUT TX Power Level	-30 to +30 dBm  This is the expected power level of the ACK packet transmitted by the DUT in response to a correctly received Unicast packet. This value is used by the MT8860C to calculate the amount of return path attenuation required to prevent MT8860C reference radio receiver saturation	
<b>Direct Mode Settings</b>		

Inter-packet Spacing	0 to 200 slots (default 5 slots)	
Inter-packet Resolution	20 $\mu$ s	
DUT MAC Address Range	00-00-00-00-00-00 to FF-FF-FF-FF-FF-FF	
<b>Receiver Maximum Input Level</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.8.2)	
Definition	Receiver PER specification as for 18.4.8.1 (above)	
<b>Receiver Adjacent Channel Rejection</b>	IEEE Std 802.11b-1999 / IEEE Std 802.11-2007 (18.4.8.3)	
Definition	Adjacent Channel measurements made with external modulated signal source (e.g.MG3700A) using Interferer input port	
<b>Additional TX Measurements</b>		
Occupied Bandwidth (OBW)	Measures the frequency range within which the specified percentage power is contained	
Occupied Bandwidth Percentage	1 to 99%	
Power Spectral Density (PSD)	As per ETSI EN 300-328 (4.3.2 / 5.7.3). The maximum power measured in a 1 MHz bandwidth within the occupied bandwidth of the signal	
<b>Additional RX Measurements</b>		
Frame Reception Rate (FRR)	As defined in the CTIA / Wi-Fi Alliance CWG RF Test Plan $FRR (\%) = (\text{ACKs received from DUT} / \text{data packets transmitted by MT8860C}) \times 100$ Specification as for 18.4.8.1 (above)	
<b>802.11g Measurements</b> <b>802.11a Measurements</b>	The following applies to data rates 6, 9, 12, 18, 24, 36, 48 and 54 Mbps that use OFDM modulation (For DSSS data rates, please refer to the 802.11b measurement section above)	
<b>Transmit Power Levels</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.4.7.1) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.9.1)	
Definition	Average, peak and crest factor power measurements on OFDM modulated signals on the supported channels	
Damage Level	> +27 dBm	
Dynamic Range	+18 dBm to -50 dBm average power (+27 dBm peak)	
Accuracy (#1)	Data Frame Type:	$\pm 0.6$ dB (+18 dBm to -30 dBm) $\pm 1.0$ dB (-30 dBm to -50 dBm)
	ACK Frame Type:	$\pm 0.8$ dB (+18 dBm to -30 dBm) $\pm 1.2$ dB (-30 dBm to -50 dBm)
Resolution	dBm to 2 decimal places	
Capture Width	10 $\mu$ s to 5.95 ms	

Time Resolution	0.1 $\mu$ s marker resolution with 10 $\mu$ s time window
<b>Transmit Spectrum Mask</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.5.4) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.9.2)
Definition	Display of Spectrum measurement derived from gate 1 or 2
Gate Width	From gate 1 or 2, 50 $\mu$ s to 5.95ms
Frequency Span	70 MHz ( $f_c \pm 35$ MHz)
Flatness over Frequency Span	$\pm 1$ dB
Linearity	$\pm 0.8$ dB (50 dB dynamic range CW measurements)
Resolution	dBr to 1 decimal place
Range (modulated carrier power)	+18 dBm to -40 dBm
Dynamic Range	(Usable dynamic range for signals with 8 dB crest factor and Dither Mode set to ON) $\pm 11$ MHz from $f_c$ ; 30 dB (typical 46 dB) $\pm 20$ MHz from $f_c$ ; 40 dB (typical 48 dB) $\pm 30$ MHz from $f_c$ ; 43 dB (typical 50 dB)
Receiver Resolution Bandwidth	Equivalent to 100 kHz Gaussian
Noise Floor (for all supported channels)	(With Input Level Range 3L selected)
802.11g	-110 dBm
802.11a	-105 dBm
Spurious Specification (for all supported channels)	(With Dither Mode ON)
802.11g	< -45 dBc
802.11a	< -43 dBc
<b>Measurement Configuration</b>	
Dither Mode	OFF Default mode ON Additional Signal processing removes spurs from the spectral measurement
<b>Transmit Center Frequency Tolerance</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.4.7.2) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.9.4)
Definition	Average Frequency of the OFDM carrier signal
Data Output Format	Hz and ppm
Accuracy	$\pm 1$ kHz $\pm$ reference frequency oscillator error (ppm) for measurement gate >1 ms
Resolution	Hz to 2 decimal places, ppm to 2 decimal places

<b>Symbol Clock Frequency Tolerance</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.4.7.3) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.9.5)
Definition	Frequency error relative to 250 kHz symbol clock as per 19.4.7.3 / 17.2.9.5. Measurement averaged over a fully coded OFDM packet with minimum payload length of 16 symbols (64 $\mu$ s)
Data Output Format	Hz and ppm
Range	$\pm 40$ ppm
Resolution	Hz to 2 decimal places, ppm to 2 decimal places
Analysis Length	16 to 500 symbols (default 55 symbols)
<b>Transmitter Center Frequency Leakage</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.4.7) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.9.6.1)
Definition	Measurement of the leakage of the center carrier
Data Output Format	dB
Resolution	dB to 2 decimal places
<b>Transmitter Spectral Flatness</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.4.7) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.9.6.2)
Definition	Graphical display of RF sub-carrier power level Display includes limit lines (as per 17.2.9.6.2) Overall Pass/ Fail status indicated For measurement failure, a numeric measurement result of the failing sub-carrier(s) is reported
Unit of Measurement	dBr
<b>Transmitter Modulation Accuracy</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.7.2.7) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.9.6.3)
Definition	Peak and Average EVM. Measurement averaged over a fully coded OFDM packet with minimum payload length of 16 symbols (64 $\mu$ s)
Measurement Accuracy	(54 Mbps, +18 dBm to -45 dBm)
802.11g	<2% residual RMS EVM
802.11a	<2.3% residual RMS EVM (typical < 2%)
Modulation Setting	Data rates 6, 9, 12, 18, 24, 36, 48 or 54 Mbps
Data Output Format	Peak and Average EVM pilots only, dB or percentage Peak and Average EVM on each sub carrier (frequency domain), % vs sub-carrier -26 to +26 EVM vs Symbol (time domain), % vs symbol number, 1 to specified analysis length
<b>Measurement Configuration</b>	
Analysis Length	16 to 500 symbols (default 40 symbols)

OFDM Pilot Tracking	User selection of Phase tracking only or Phase and Amplitude tracking (default Phase tracking only)
Channel Estimation	User selection of Long Training Sequence or Full Packet (default Long Training Sequence)
<b>Receiver Minimum Input Sensitivity</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.5.1) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.10.1)
Definition	Packet Error Rate (PER) at defined power level
Power Range	See Reference Radio Transmitter section
Mode	Network: MT8860C forms a connection with the DUT. Unicast and Broadcast Packets supported  Direct: MT8860C transmits defined number of packets
Data Packet Structure	Adheres to relevant 802.11 specifications for MAC header formatting, scrambling, encoding, interleaving and calculation of the appropriate CRC/FCS checksum
Number of Transmitted packets	1 to 10,000 (default 500)
Payload Length	60 to 1,500 bytes (default 1,024 bytes)
Payload	All 0's, 0101, Counting, PN7, 1010, Random (Payload data is scrambled over the air)
Data Rates	6, 9, 12, 18, 24, 36, 48 or 54 Mbps
<b>Network Mode Settings</b>	
Inter-packet Interval	0 to 65535 ms
Inter-packet Resolution	1 ms
DUT TX Power Level	-30 to +30 dBm  This is the expected power level of the ACK packet transmitted by the DUT in response to a correctly received Unicast packet. This value is used by the MT8860C to calculate the amount of return path attenuation required to prevent MT8860C reference radio receiver saturation.
<b>Direct Mode Settings</b>	
Inter-packet Spacing	0 to 200 slots (default 5 slots)
Inter-packet Resolution	9 $\mu$ s
DUT MAC Address Range	00-00-00-00-00-00 to FF-FF-FF-FF-FF-FF
<b>Receiver Adjacent Channel Rejection</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.5.2) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.10.2)
Definition	Adjacent Channel measurements made with external modulated signal source (e.g. MG3700A) using Interferer input port
<b>Receiver Maximum Input Level</b>	IEEE Std 802.11g-2003 / IEEE Std 802.11-2007 (19.5.3) IEEE Std 802.11a-1999 / IEEE Std 802.11-2007 (17.3.10.4)
Definition	Receiver PER specification as for 19.5.1 (above)

<b>Additional TX Measurements</b>	
CCDF	CCDF defined as percentage of samples against dB, where percentage of samples is normalized to the average power in the gate, and dB is defined as the relative value of samples greater than the average
Measurement Scales	Y-axis, Log scale, fixed values of 100, 10, 1, 0.1, 0.01% X-axis, dB scale, fixed values of 0 to 12dB
Occupied Bandwidth (OBW)	Measures the frequency range within which the specified percentage power is contained
Occupied Bandwidth Percentage	1 to 99%
Power Spectral Density (PSD)	As per ETSI EN 300-328 (4.3.2 / 5.7.3). The maximum power measured in a 1 MHz bandwidth within the occupied bandwidth of the signal
<b>Additional RX Measurements</b>	
Frame Reception Rate (FRR)	As defined in the CTIA / Wi-Fi Alliance CWG RF Test Plan $\text{FRR (\%)} = (\text{ACKs received from DUT} / \text{data packets transmitted by MT8860C}) \times 100$ Specification as for 19.5.1 (above)
<b>802.11n Measurements</b>	
	The following applies to the 11n High Throughput (HT) modes that use OFDM modulation  (For non-HT modes, please refer to the 802.11b, 802.11g, 802.11a measurement sections above)
<b>Transmit Power Levels</b>	
	IEEE Std 802.11n-2009 (20.3.21.3)
Definition	Average, peak and crest factor power measurements on HT OFDM modulated signals on the supported channels
Damage Level	> +27 dBm
Dynamic Range	20 MHz channel b/w: +18 dBm to -50 dBm average power (+27 dBm peak)
	40 MHz channel b/w: +16 dBm to -50 dBm average power (+27 dBm peak)
Accuracy (#1)	± 0.6 dB (+18 dBm to -30 dBm) ± 1.0 dB (-30 dBm to -50 dBm)
Resolution	dBm to 2 decimal places
Capture Width	10 μs to 5.95 ms
Time Resolution	0.1 μs marker resolution with 10 μs time window
<b>Transmit Spectrum Mask</b>	
Definition	Display of Spectrum measurement derived from gate 1 or 2
Gate Width	From gate 1 or 2, 50μs to 5.95ms

Frequency Span	20 MHz channel b/w:	70 MHz ( $f_c \pm 35$ MHz)
	40 MHz channel b/w:	130 MHz ( $f_c \pm 65$ MHz)
Flatness over Frequency Span	$\pm 1$ dB	
Linearity	$\pm 0.8$ dB (50 dB dynamic range CW measurements)	
Resolution	dBr to 1 decimal place	
Range (modulated carrier power)	20 MHz channel b/w:	+18 dBm to -40 dBm
	40 MHz channel b/w:	+16 dBm to -40 dBm
Dynamic Range	20 MHz channel b/w:	(For signals with 8 dB crest factor and Dither Mode set to ON) $\pm 11$ MHz from $f_c$ ; 30 dB (typical 46 dB) $\pm 20$ MHz from $f_c$ ; 40 dB (typical 48 dB) $\pm 30$ MHz from $f_c$ ; 43 dB (typical 50 dB)
	40 MHz channel b/w:	(For signals with 10 dB crest factor and Dither Mode set to ON) $\pm 60$ MHz from $f_c$ ; 43 dB (typical 48 dB)
Receiver Resolution Bandwidth	Equivalent to 100 kHz Gaussian	
Noise Floor (for all supported channels)	2.4 GHz frequency band:	(With Input Level Range 3L selected) -110 dBm
	5 GHz frequency band:	(With Input Level Range 3L selected) -105 dBm

Spurious Specification (for all supported channels)	2.4 GHz frequency band: (With Dither Mode ON)	20 MHz channel b/w:	< -45 dBc
		40 MHz channel b/w:	± (25 MHz to 40 MHz); < -30 dBc ± (40 MHz to 50 MHz); < -40 dBc ± (50 MHz to 60 MHz); < -45 dBc ± (60 MHz to 65 MHz); < -48 dBc
	5 GHz frequency band: (With Dither Mode ON)	20 MHz channel b/w:	< -43 dBc
		40 MHz channel b/w:	± (25 MHz to 40 MHz); < -30 dBc ± (40 MHz to 50 MHz); < -40 dBc ± (50 MHz to 60 MHz); < -45 dBc ± (60 MHz to 65 MHz); < -48 dBc
<b>Measurement Configuration</b>			
Dither Mode	OFF - Default mode ON - Additional Signal processing removes spurs from the spectral measurement		
<b>Transmit Center Frequency Tolerance</b>	IEEE Std 802.11n-2009 (20.3.21.4)		
Definition	Average Frequency of the HT OFDM carrier signal		
Data Output Format	Hz and ppm		
Accuracy	±1 kHz ± reference frequency oscillator error (ppm) for measurement gate >1 ms		
Resolution	Hz to 2 decimal places, ppm to 2 decimal places		
<b>Symbol Clock Frequency Tolerance</b>	IEEE Std 802.11n-2009 (20.3.21.6)		
Definition	Frequency error relative to 250 kHz symbol clock as per 20.3.21.6. Measurement averaged over a fully coded HT OFDM packet with minimum payload length of 16 symbols (64 μs)		
Data Output Format	Hz and ppm		
Range	±40 ppm		
Resolution	Hz to 2 decimal places, ppm to 2 decimal places		
Analysis Length	16 to 500 symbols (default 55 symbols)		

<b>Transmitter Center Frequency Leakage</b>	IEEE Std 802.11n-2009 (20.3.21.7.2)		
Definition	Measurement of the leakage of the center carrier		
Data Output Format	dB		
Resolution	dB to 2 decimal places		
<b>Transmitter Spectral Flatness</b>	IEEE Std 802.11n-2009 (20.3.21.2)		
Definition	<p>Graphical display of RF sub-carrier power level</p> <p>Display includes limit lines (as per 20.3.21.2)</p> <p>Overall Pass/ Fail status indicated</p> <p>For measurement failure, a numeric measurement result of the failing sub-carrier(s) is reported</p>		
Unit of Measurement	dBr		
<b>Transmitter Modulation Accuracy</b>	IEEE Std 802.11n-2009 (20.3.21.7.3 / 20.3.21.7.4)		
Definition	Peak and Average EVM. Measurement averaged over a fully coded HT OFDM packet with minimum payload length of 16 symbols (64 $\mu$ s)		
Measurement Accuracy	2.4 GHz frequency band:	20 MHz channel b/w:	(72.2 Mbps, +18 dBm to -45 dBm) <2% residual RMS EVM
		40 MHz channel b/w:	(150 Mbps, +16 dBm to -45 dBm) <2% residual RMS EVM
	5 GHz frequency band:	20 MHz channel b/w:	(72.2 Mbps, +18 dBm to -45 dBm) <2.3% residual RMS EVM (typical < 2%)
		40 MHz channel b/w:	(150 Mbps, +16 dBm to -45 dBm) <2.3% residual RMS EVM (typical < 2%)

Modulation Settings	PPDU Format:	HT-Mixed Mode, HT-Greenfield	
	PPDU Type:	20 MHz, 40 MHz, 40 MHz Upper, 40 MHz Lower, 40 MHz Duplicate	
	Modulation & Coding Scheme:	MCS Index 0 to 7 and MCS 32 (Duplicate)	
	Guard Interval:	HT-Mixed Mode:	Long (800ns), Short (400 ns)
HT-Greenfield:		Long (800 ns) only	
Data Output Format	Peak and Average EVM pilots only, dB or percentage Peak and Average EVM on each sub carrier (frequency domain), % vs sub-carrier -26 to +26 EVM vs Symbol (time domain), % vs symbol number, 1 to specified analysis length		
<b>Measurement Configuration</b>			
Analysis Length	16 to 500 symbols (default 40 symbols)		
OFDM Pilot Tracking	User selection of Phase tracking only or Phase and Amplitude tracking (default Phase tracking only)		
Channel Estimation	User selection of Long Training Sequence or Full Packet (default Long Training Sequence)		
<b>Receiver Minimum Input Sensitivity</b>	IEEE Std 802.11n-2009 (20.3.22.1)		
Definition	Packet Error Rate (PER) at defined power level		
Power Range	-20 dBm to -100 dBm at MT8860C test port		
Mode	Direct: MT8860C transmits defined number of packets		
Data Packet Structure	Complies with 802.11 specifications for MAC header formatting, scrambling, encoding, interleaving and calculation of the appropriate CRC/FCS checksum		
Number of Transmitted Packets	1 to 10,000 (default 500)		
Payload Length	50 to 1772 bytes		
Data Rates	20 MHz channel b/w:	6.5, 7.2, 13, 14.4, 19.5, 21.7, 26, 28.9, 39, 43.3, 52, 57.8, 58.5, 65, 72.2 Mbps	
	40 MHz channel b/w:	6, 6.7, 13.5, 15, 27, 30, 40.5, 54, 60, 81, 90, 108, 120, 121.5, 135, 150 Mbps	
<b>Direct Mode Settings</b>			
Inter-packet Spacing	10 to 1000 $\mu$ s		
DUT MAC Address range	Valid Unicast MAC address only. Broadcast and Multicast MAC addresses not supported.		

<b>Receiver Adjacent Channel Rejection</b>	IEEE Std 802.11n-2009 (20.3.22.2)
<b>Receiver Non-adjacent Channel Rejection</b>	IEEE Std 802.11n-2009 (20.3.22.3)
Definition	Adjacent Channel measurements made with external modulation signal source (e.g., MG3700A) using external interferer port
<b>Receiver Maximum Input Level</b>	IEEE Std 802.11n-2009 (20.3.22.4)
Definition	Receiver PER specification as for 20.3.22.1 (above)
<b>Additional TX Measurements</b>	
CCDF	CCDF defined as percentage of samples against dB, where percentage of samples is normalized to the average power in the gate, and dB is defined as the relative value of samples greater than the average
Measurement Scales	Y-axis, Log scale, fixed values of 100, 10, 1, 0.1, 0.01% X-axis, dB scale, fixed values of 0 to 12dB
Occupied Bandwidth (OBW)	Measures the frequency range within which the specified percentage power is contained
Occupied Bandwidth Percentage	1 to 99%
Power Spectral Density (PSD)	As per ETSI EN 300-328 (4.3.2 / 5.7.3). The maximum power measured in a 1 MHz bandwidth within the occupied bandwidth of the signal
<b>TX Measurement Controls</b>	
Averaging	1 to 1,000 (default 1)
Triggers	4 trigger sources are available; Free Run, RF, Video and External In Network Mode operation, the RF trigger (rising edge) must be selected
Free Run	Continuous unsynchronised
RF Edge	RF triggering on rising or falling edge, detected at RF input User set level
RF Edge Dynamic Range	+18 dBm to -40 dBm average power with Input Level Range set to AUTO
Video	Video triggering on rising or falling edge, detected at IF
Video Trigger Dynamic Range	(+18 dBm to -50 dBm average power with Input Level Range set to AUTO) Triggers at -10 dB below average power level (DSSS data rates) Triggers at -20 dB below average power level (OFDM data rates)
External	TTL input, BNC on Rear Panel

Measurement Gates	Two gates for Power, Spectrum, Frequency and CCDF measurements. Gate positions set directly by remote command	
Settable Gate Range	10 $\mu$ s to 5.95 ms	
TX Analysis auto-configure function	Using this function, the following parameters are automatically configured by the MT8860C; Input Level Range Pre-trigger Capture Width Trigger settings Measurement Gate settings	
<b>Reference Radio Transmitter (802.11b, 802.11g, 802.11a only)</b>	Network and Direct Modes	
Supported Channels	802.11b / 802.11g (DSSS)	Channels 1 to 14 (2412 – 2484 MHz)
	802.11g (OFDM)	Channels 1 to 13 (2412 – 2472 MHz)
	802.11a	Channels 36, 40, 44, 48 (5150 – 5250 MHz) Channels 52, 56, 60, 64 (5250 – 5350 MHz) Channels 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140 (5470 – 5725 MHz) Channels 149, 153, 157, 161, 165 (5725 – 5825 MHz)
Output Power (for supported channels)	802.11b / 802.11g	-3 to -100 dBm (settable to 0 dBm but performance unwarranted)
	802.11a	-8 to -100 dBm (settable to 0 dBm but performance unwarranted)
Power Accuracy (for supported channels, CW, 18 to 28° C)	802.11 b / 802.11g	$\pm$ 1.0 dB (-3 dBm to -90 dBm) $\pm$ 2.0 dB typical (<-90 dBm to -100 dBm)
	802.11a	$\pm$ 1.0 dB (-8 dBm to -90 dBm) $\pm$ 2.0 dB typical (<-90 dBm to -100 dBm)
Settable resolution	0.1 dB	
Output Impedance	50 $\Omega$ < 2:1 VSWR	
Frequency Accuracy	$\pm$ 20 ppm	

Modulation Accuracy (for supported channels, unless stated)	802.11b / 802.11g (DSSS)	<10% RMS EVM; 11 Mbps, <-20 dBm (channels 1 to 13)
	802.11g (OFDM)	<5.6% RMS EVM; 54 Mbps, <-20 dBm (nominal < 4%)  Nominally <5.6% RMS EVM, 54 Mbps, <-3 to -20 dBm
	802.11a	<5.6% RMS EVM; 54 Mbps, <-20 dBm
<b>Reference Radio Receiver (802.11b, 802.11g, 802.11a only)</b>	Network Mode only	
Supported Channels	See Reference Radio Transmitter Section (above)	
Maximum Safe Input	+27 dBm Peak Power	
Damage Level	+32 dBm peak power (excluding range 3, +18 dBm)	
Input VSWR (for supported channels)	802.11b	Nominally <1.5:1
	802.11g	
	802.11a	Nominally <1.6:1
Minimum Receive Sensitivity (for < 1% PER)	802.11b / 802.11g	-50 dBm (1 Mbps)
		-45 dBm (11 Mbps)
		-50 dBm (6 Mbps)
-30 dBm (54 Mbps)		
	802.11a	-50 dBm (6 Mbps)
		-27 dBm (54 Mbps)
<b>Signal Generator Mode (802.11b, 802.11g, 802.11a only)</b>	In this mode, MT8860C can be configured to transmit a continuous RF signal at the Test Port  NOTE: Transmitter measurements are not supported. For receiver testing, chipset vendor control software is required to directly configure the device under test (DUT) and read the receiver packet count register	
Transmit Modes	CW (single carrier)  Continuous Framed (dynamic duty cycle)  Continuous Modulated (100% duty cycle)  Carrier Suppression (100% duty cycle, 0101 payload, scrambler disabled)	
Supported Channels	See Reference Radio Transmitter Section (above)	
Data Rates and Modulation	Applicable when the transmit mode is set to Continuous Framed or Continuous Modulated	

802.11b / 802.11g (DSSS)	1 Mbps 11-chip Barker DBPSK 2 Mbps 11-chip Barker DQPSK 5.5 Mbps CCK DQPSK 11 Mbps CCK DQPSK	
802.11g (OFDM) 802.11a	6, 9, 12, 18, 24, 36, 48, 54 Mbps OFDM (BPSK, QPSK, 16-QAM, 64-QAM)	
Data Packet Structure (Continuous Framed and Continuous Modulated)	Adheres to relevant 802.11 specifications for MAC header formatting, scrambling, encoding, interleaving and calculation of the appropriate CRC/FCS checksum	
Payload Length	60 to 1,500 bytes (default 1,024 bytes)	
Payload	All 0's, 0101, Counting, PN7, 1010, Random (Payload data is scrambled over the air)	
Inter-packet Spacing (Continuous Framed)	0 to 200 slots (default 5 slots)	
Inter-packet Resolution	802.11b / 802.11g (DSSS)	20 $\mu$ s
	802.11g (OFDM) 802.11a	9 $\mu$ s
DUT MAC Address range	00-00-00-00-00-00 to FF-FF-FF-FF-FF-FF	
Output Power (for supported channels)	See Reference Radio Transmitter Section (above)	
Power Accuracy (for supported channels, CW, 18 to 28° C)	See Reference Radio Transmitter Section (above)	
Settable resolution	See Reference Radio Transmitter Section (above)	
Output Impedance	See Reference Radio Transmitter Section (above)	
Frequency Accuracy	See Reference Radio Transmitter Section (above)	
Modulation Accuracy (for supported channels, unless stated)	See Reference Radio Transmitter Section (above)	
<b>General</b>		
<b>Path Loss Table</b>	Compensation for cable and system loss can be specified for each supported channel. Independent values can be specified for the TX and RX paths. When the path loss table is enabled, the TX and RX path loss values for the selected channel are applied to both the measurement results and MT8860C transmitted power level.	
<b>Reference Frequency Oscillator</b>	10 MHz TCXO fitted as standard	
Frequency	10 MHz	

Aging	<±1 ppm / year, <±2.5 ppm /10 years	
Drift (Temperature Coefficient)	<±0.5 ppm, 0 to +45°C	
<b>Inputs &amp; Outputs</b>		
<b>Front Panel Inputs &amp; Outputs</b>		
Test Port In / Out (for supported channels)	Provides connection to DUT, N-type (f), 50Ω nominal	
	Maximum Input Power:	+27 dBm Peak (Input Level Ranges 1, 1L, 2 2L) +18 dBm Peak (Input Level Ranges 3, 3L)
	VSWR:	Nominally <1.5:1 (2.4 GHz frequency band) Nominally <1.6:1 (5 GHz frequency band)
Interferer Input (for supported channels)	Provides input for external signal source (e.g. MG3700A), N-type (f)	
	Maximum Input Power:	+ 27 dBm
	VSWR:	Nominally <1.5:1 (2.4 GHz frequency band) Nominally <1.6:1 (5 GHz frequency band)
	Loss to Test Port In/Out: (using supplied test data)	Nominally 22 dB ± 1 dB (2.4 GHz frequency band) Nominally 24 dB ± 1 dB (5 GHz frequency band)
WLAN Reference Input	Allows an external reference radio to be used for DUT receiver measurements using only the leveling loop and attenuator of MT8860C. In this mode, no measurements are supported by MT8860C. For correct leveling operation, the external radio must transmit a signal with the following characteristics;	
	Packet duration:	>110 μs
	Input Level Range:	+12 dBm to +18 dBm average power
	Maximum Input Power:	+ 27 dBm
<b>Rear Panel Inputs &amp; Outputs</b>		
GPIO	All MT8860C parameters (except the supply switch) are remotely programmable. The GPIO is designed in accordance with IEEE 488.2	

Ethernet RJ45	Allows MT8860C to be remotely programmed by a LAN-connected computer. The following LAN interface protocols and related [port numbers] are supported; VXI-11 using VISA Sockets LAN [5025] TELNET [5024] File Transfer Protocol (FTP) [23]
10 MHz out	As Reference Frequency Oscillator specification, TTL
10 MHz in	TTL
Digital Inputs	BNC, TTL
Input 1	BNC, TTL input for the external trigger source
Input 2	BNC, TTL input TX signal for External Reference radio. The TX signal must be the same length as the transmission from the external WLAN radio
<b>Digital Outputs</b>	
Output 1	BNC, TTL compatible The user can select between one of the following; 1. The TX trigger signal from the internal reference radio 2. The trigger signal from the MT8860C when the signal trigger is set to RF 3. The trigger signal from the MT8860C when the signal trigger is set to Video (default setting)
Output 2	BNC, TTL compatible The user can select between one of the following; 1. The TX trigger signal from the internal reference radio (default setting) 2. The trigger signal from the MT8860C when the signal trigger is set to RF 3. The trigger signal from the MT8860C when the signal trigger is set to Video
<b>Power Requirements</b>	
AC Supply	85 to 264V
Frequency	47 to 63 Hz
Power	100 VA
<b>Dimensions and Weight</b>	
Dimensions (D x W x L)	180 mm x 320 mm x 350 mm
Weight	<10 kg
<b>Rated Range of Use</b>	

Operating Temperature Range	+5°C to +40°C	
Operating Humidity	<75% non condensing	
<b>Conditions of Storage</b>		
Temperature	-20°C to +70°C	
Safety	Conforms with the product safety standard BS EN 61010-1 (Equivalent to IEC 61010-1) for class 1 portable equipment, for use in a Pollution Degree 2 environment. The instrument is designed to be operated from an Installation Category 2 supply	
Electromagnetic Compatibility (EMC)	Conforms to the protection requirements of EN61326; RF emission and immunity class A	
<b>MN8861A</b>		
Supported Channels 802.11n HT 2.4 GHz (20 MHz channel bandwidth)	Channels 1- 13 (2412 - 2472 MHz)	
Supported Channels 802.11n HT 5 GHz (20 MHz channel bandwidth)	Channels 36, 40, 44, 48 (5150 - 5250 MHz) Channels 52, 56, 60, 64 (5250 - 5350 MHz) Channels 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140 (5470 - 5725 MHz) Channels 149, 153, 157, 161, 165 (5725 - 5825 MHz)	
Supported Channels 802.11n HT 2.4 GHz (40 MHz channel bandwidth)	Secondary = +1	Secondary = -1
	Primary = 1 - 9	Primary = 9 - 13
Supported Channels 802.11n HT 5 GHz (40 MHz channel bandwidth)	Secondary = +1	Secondary = -1
	Primary = 36, 44, 52, 60, 100, 108, 116, 124, 132, 149, 157	Primary = 40, 48, 56, 64, 104, 112, 120, 128, 136, 153, 161
PPDU HT Format	HT-Mixed Mode	
PPDU Types	20 MHz, 40 MHz, 40 MHz Duplicate	
Modulation and coding scheme	MCS index 0 - 7 and MCS 32 (Duplicate)	
Guard interval	Long (800 ns), Short (400 ns)	
Data Rates (20 MHz channel b/w)	6.5, 7.2, 13, 14.4, 19.5, 21.7, 26, 28.9, 39, 43.3, 52, 57.8, 58.5, 65, 72.2 Mbps	
Data Rates (40 MHz channel b/w)	6, 6.7, 13.5, 15, 27, 30, 40.5, 54, 60, 81, 90, 108, 120, 121.5, 135, 150 Mbps	
Modulation	OFDM (BPSK, QPSK, 16-QAM, 64 QAM)	
Packet spacing	10 -1000 µs	
Number of packets	1 - 10000	
Output Power 2.4 GHz (supported channels) MT8860C output	-20 dBm to -100 dBm (settable to -3 dBm, unwarranted)	

Output Power 5 GHz (supported channels) MT8860C output	-20 dBm to -100 dBm (settable to -8 dBm, unwarranted)
Power accuracy (supported channels)	±1.0 dB (-20 to -90 dBm, CW 18 to 28°C) 2.4 GHz
	±1.0 dB (-20 to -90 dBm, CW 18 to 28°C) 5 GHz
	±2.0 dB typical (<-90 dBm to -100 dBm, CW 18 to 28°C)
Settable resolution	0.1 dB
Radio specification	Complies with IEEE Std 802.11n-2009 radio specification for transmit spectral mask, modulation accuracy, and spectral flatness.
<b>MN8861A Supplementary Specification</b>	
<b>Connectors</b>	
Test Port	N (m)
Digital interface Tx On line	BNC TTL output connectors to Digital In 2 on MT8860C Active High for the length of the packet
Control interface	USB
<b>General</b>	
Power supply (supplied)	85 to 264 V AC
Frequency	47 to 63 Hz
Power	<20 VA
<b>Size and Weight</b>	
Dimensions	85 mm (h) x 115 mm (w) x 72 mm (d)
Weight	<0.6 kg
Operating temperature range	+5°C to +40°C
Operating humidity	<75% non-condensing
Safety	Complies to BS EN 61010-1 (equivalent to IEC 61010-1)
EMC	Conforms to the protection requirements of EEC Council Directive 89/336/EEC
<b>Order Information</b>	
<b>Part number</b>	
MT8860C	WLAN Test Set with 802.11b/g measurements

Supplied Accessories	<p>Power cable</p> <p>Ethernet cable</p> <p>Cat 5E cross-over patch cable</p> <p>N-type termination plug (6GHz, 50Ω) fitted to the WLAN Reference Input</p> <p>MT8860C WLAN Test Set Operation manual (printed copy)</p> <p>MT8860C WLAN Test Set Remote programming manual (printed copy)</p> <p>Product CD containing;</p> <ul style="list-style-type: none"> <li>• LANLook software</li> <li>• Source code for LANLook</li> <li>• CombiTest + MT8860x Plug-in Production Test software</li> <li>• Ethernet Communicator software</li> <li>• Source code for Ethernet Communicator</li> <li>• National Instruments VISA Run-Time engine</li> <li>• CombiTest MT8860x Plug-in Operation Manual (pdf)</li> <li>• MT8860C WLAN Test Set Operation manual (pdf)</li> <li>• MT8860C WLAN Test Set Remote programming manual (pdf)</li> </ul>
<b>Options and accessories</b>	
MT8860C-001 (Option 1)	Rack mount kit (CANNOT be ordered with option 2)
MT8860C-002 (Option 2)	Front panel handles (CANNOT be ordered with option 1)
MT8860C-014 (Option 14)	802.11a transmitter and receiver measurements
MT8860C-114 (Option 114)	Retrofit 802.11a transmitter and receiver measurements
MT8860C-017 (Option 17)	802.11n transmitter and receiver measurements (Requires MN8861A Receiver Accessory for 802.11n receiver measurement support, sold separately)
MN8861A	Receiver Accessory for MT8860C
MT8860C-117 (Option 117)	Retrofit, 802.11n transmitter and receiver measurements (Requires MN8861A Receiver Accessory for 802.11n receiver measurement support, sold separately)
MT8860C-098 (Option 98)	Standard calibration to ISO 17025 and ANSI/NCSLI Z540-1 (Certificate of calibration only)
MT8860C-099 (Option 99)	Premium calibration to ISO 17025 and ANSI/NCSLI Z540-1 (Certificate of calibration with test report and uncertainty data included)
2000-1613-R	Bluetooth / dual band WLAN antenna and adapter
2000-1548-R	N-type termination plug (6 GHz, 50 Ω)
2100-2	GPIB cable, 2m
2000-1371-R	Ethernet cable

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3-806-152	Cat 5E cross-over patch cable
B0329G	Protective cover (CANNOT be ordered with option 1 or option 2)
13000-00258	MT8860C WLAN Test Set Operation Manual
13000-00259	MT8860C WLAN Test Set Remote Programming Manual

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(#1): The instrument is calibrated with CW signals. A modulation correction factor is applied for all measurements on DSSS and OFDM packets.



# Appendix B — Supported Channels and Data Rates

The tables below show the supported channels and data rates for each of the IEEE standards.

## 802.11b

**Table B-1.** 802.11b Channels

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442	14	2484

**Table B-2.** 802.11b Supported Data Rates

Supported Data Rates (Mbps)
1, 2, 5.5, 11

## 802.11g

**Table B-3.** 802.11g Channels

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442		

**Table B-4.** 802.11g Supported Data Rates

Supported Data Rates (Mbps)
1, 2, 5.5, 11
6, 9, 12, 18, 24, 36, 48, 54

**802.11a**

**Table B-5.** 802.11a Channels

Channel	Frequency (MHz)	Channel	Frequency (MHz)
36	5180	116	5580
40	5200	120	5600
44	5220	124	5620
48	5240	128	5640
52	5260	132	5660
56	5280	136	5680
60	5300	140	5700
64	5320	149	5745
100	5500	153	5765
104	5520	157	5785
108	5540	161	5805
112	5560	165	5825

**Table B-6.** 802.11a Supported Data Rates

Supported Data Rates (Mbps)
6, 9, 12, 18, 24, 36, 48, 54

**802.11n (2.4 GHz Band, 20 MHz)**

**Table B-7.** 802.11n Channels (2.4 GHz Band, 20 MHz Channel Bandwidth)

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	2412	8	2447
2	2417	9	2452
3	2422	10	2457
4	2427	11	2462
5	2432	12	2467
6	2437	13	2472
7	2442		

**Table B-8.** 802.11n Supported Data Rates (2.4 GHz Band, 20 MHz Channel Bandwidth)

Non High-Throughput (Non-HT) PPDU Format	High-Throughput (HT) PPDU Format		
	MCS	Data Rate	
		800 ns Guard Interval	400 ns Guard Interval
1, 2, 5, 5, 11	0	6.5	7.2
6, 9, 12, 18, 24, 36, 48, 54	1	13.0	14.4
	2	19.5	21.7
	3	26.0	28.9
	4	39.0	43.3
	5	52.0	57.8
	6	58.5	65.0
	7	65.0	72.2

**802.11n (2.4 GHz Band, 40 MHz)**

**Table B-9.** 802.11n Channels (2.4 GHz Band, 40 MHz / 40U / 40L / 40D Channel Bandwidth)

Channel	Frequency (MHz)	Channel	Frequency (MHz)
1, +1	2422	7, +1	2452
2, +1	2427	8, -1	2437
3, +1	2432	8, +1	2457
4, +1	2437	9, -1	2442
5, -1	2422	9, +1	2462
5, +1	2442	10, -1	2447
6, -1	2427	11, -1	2452
6, +1	2447	12, -1	2457
7, -1	2432	13, -1	2462

**Table B-10.** 802.11n Supported Data Rates (2.4 GHz Band, 40 MHz / 40U / 40L / 40D Channel Bandwidth)

Non High-Throughput (Non-HT) PPDU Format	High-Throughput (HT) PPDU Format		
	MCS	Data Rate	
		800 ns Guard Interval	400 ns Guard Interval
1, 2, 5.5, 11	0	13.5	15.0
6, 9, 12, 18, 24, 36, 48, 54	1	27.0	30.0
	2	40.5	45.0
	3	54.0	60.0
	4	81.0	90.0
	5	108.0	120.0
	6	121.5	135.0
	7	135.0	150.0
	32	6.0	6.7

**802.11n (5.0 GHz Band, 20 MHz)**

**Table B-11.** 802.11n Channels (5.0 GHz Band, 20 MHz Channel Bandwidth)

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
36	5180	100	5500	132	5660
40	5200	104	5520	136	5680
44	5220	108	5540	140	5700
48	5240	112	5560	149	5745
52	5260	116	5580	153	5765
56	5280	120	5600	157	5785
60	5300	124	5620	161	5805
64	5320	128	5640	165	5825

**Table B-12.** 802.11n Supported Data Rates (5.0 GHz Band, 20 MHz Channel Bandwidth)

Non High-Throughput (Non-HT) PPDU Format	High-Throughput (HT) PPDU Format		
	MCS	Data Rate	
		800 ns Guard Interval	400 ns Guard Interval
1, 2, 5.5, 11	0	6.5	7.2
6, 9, 12, 18, 24, 36, 48, 54	1	13.0	14.4
	2	19.5	21.7
	3	26.0	28.9
	4	39.0	43.3
	5	52.0	57.8
	6	58.5	65.0
	7	65.0	72.2

## 802.11n (5.0 GHz Band, 40 MHz)

**Table B-13.** 802.11n Channels (5.0 GHz Band, 40 MHz / 40U / 40L / 40D Channel Bandwidth)

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
36, +1	5190	100, +1	5510	132, +1	5670
40, -1	5190	104, -1	5510	136, -1	5670
44, +1	5230	108, +1	5550	149, +1	5755
48, -1	5230	112, -1	5550	153, -1	5755
52, +1	5270	116, +1	5590	157, +1	5795
56, -1	5270	120, -1	5590	161, -1	5795
60, +1	5310	124, +1	5630		
64, -1	5310	128, -1	5630		

**Table B-14.** 802.11n Supported Data Rates (5.0 GHz Band, 40 MHz / 40U / 40L / 40D Channel Bandwidth)

Non High-Throughput (Non-HT) PPDU Format	High-Throughput (HT) PPDU Format		
	MCS	Data Rate	
		800 ns Guard Interval	400 ns Guard Interval
1, 2, 5.5, 11	0	13.5	15.0
6, 9, 12, 18, 24, 36, 48, 54	1	27.0	30.0
	2	40.5	45.0
	3	54.0	60.0
	4	81.0	90.0
	5	108.0	120.0
	6	121.5	135.0
	7	135.0	150.0
	32	6.0	6.7

# Appendix C — 802.11n Spectrum Masks and Carriers

The 8011.n spectrum masks and associated carrier allocations are shown in the figures below.

## 20 MHz Non-HT

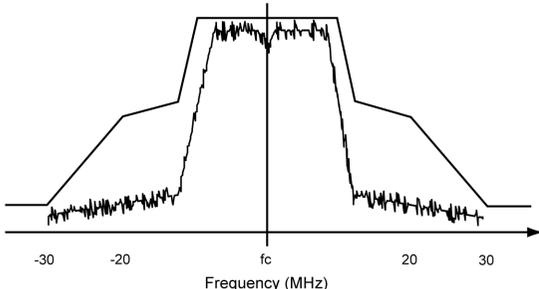


Figure C-1. 20 MHz Non-HT Spectrum Mask

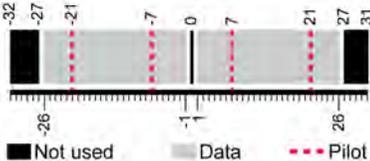


Figure C-2. 20 MHz Non-HT Sub-Carrier Allocation

20 MHz HT

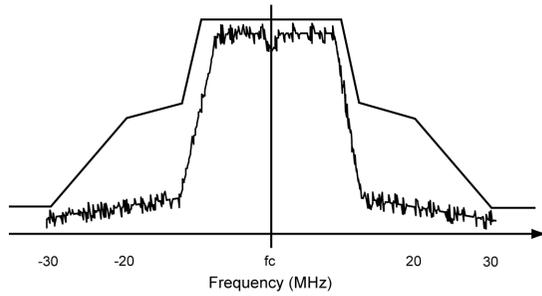


Figure C-3. 20 MHz HT Spectrum Mask

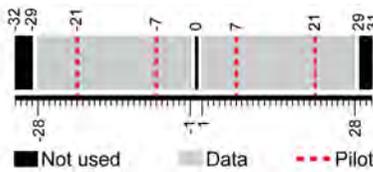


Figure C-4. 20 MHz HT Sub-Carrier Allocation

40 MHz Non-HT (Upper)

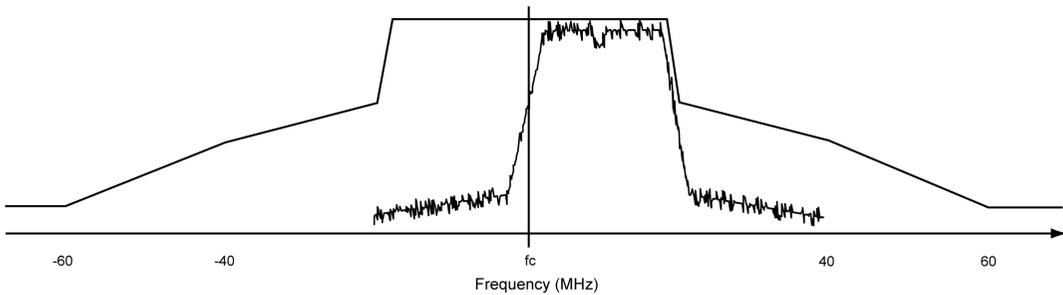


Figure C-5. 40 MHz Non-HT (Upper) Spectrum Mask

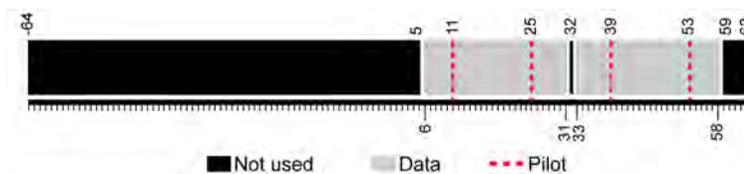


Figure C-6. 40 MHz Non-HT (Upper) Sub-Carrier Allocation

### 40 MHz Non-HT (Lower)

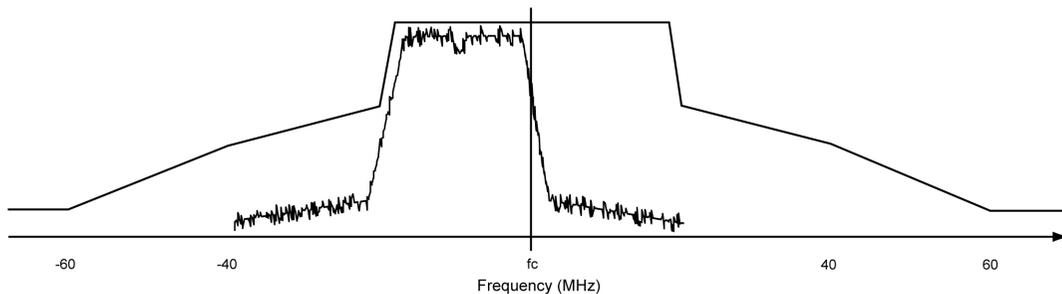


Figure C-7. 40 MHz Non-HT (Lower) Spectrum Mask

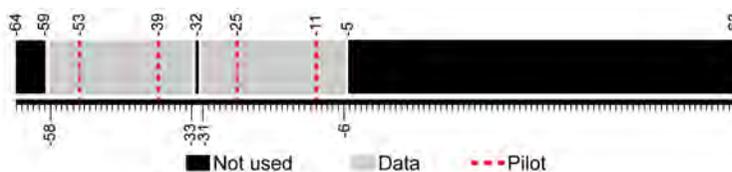


Figure C-8. 40 MHz Non-HT (Lower) Sub-Carrier Allocation

### 40 MHz HT (Upper)

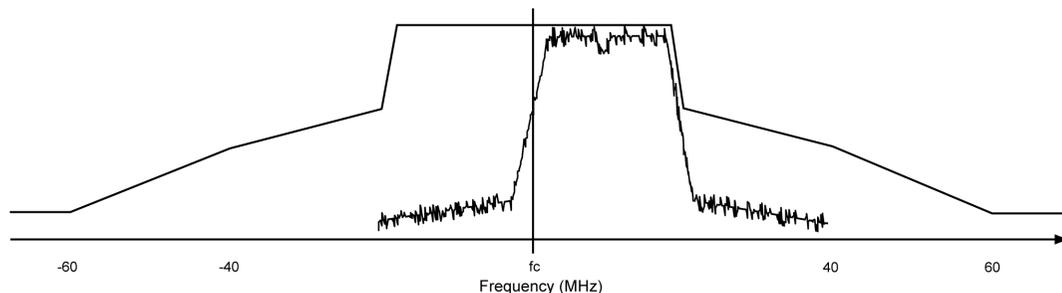


Figure C-9. 40 MHz HT (Upper) Spectrum Mask

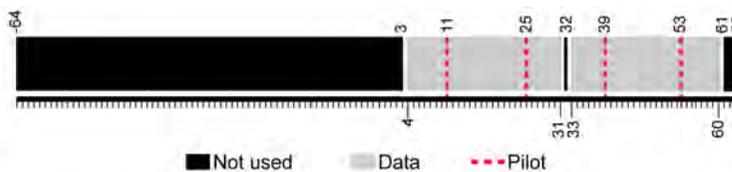


Figure C-10. 40 MHz HT (Upper) Sub-Carrier Allocation

40 MHz HT (Lower)

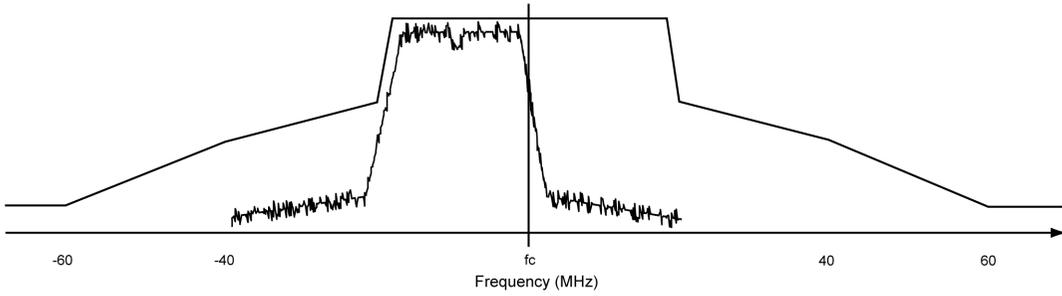


Figure C-11. 40 MHz HT (Lower) Spectrum Mask

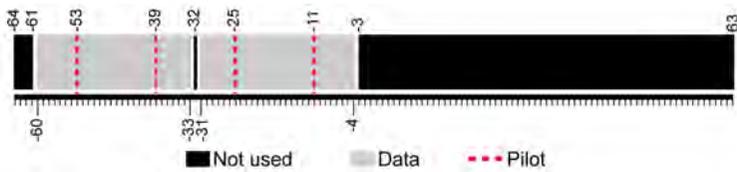


Figure C-12. 40 MHz HT (Lower) Sub-Carrier Allocation

40 MHz HT

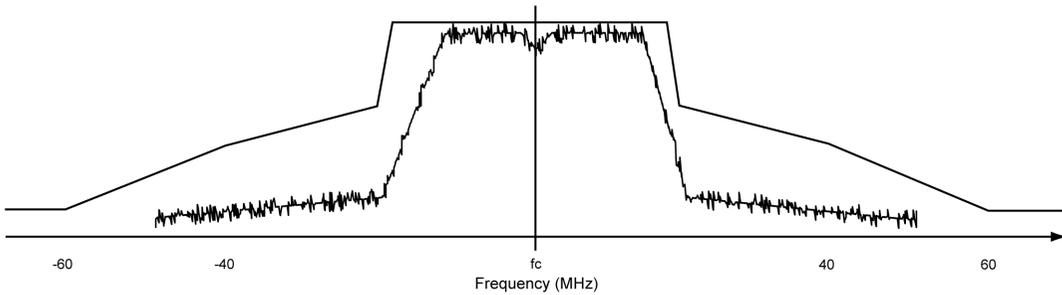


Figure C-13. 40 MHz HT Spectrum Mask

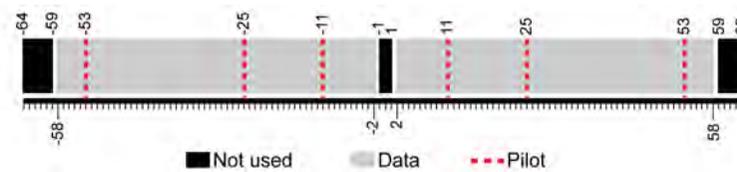


Figure C-14. 40 MHz HT Sub-Carrier Allocation

40 MHz HT (Duplicate)

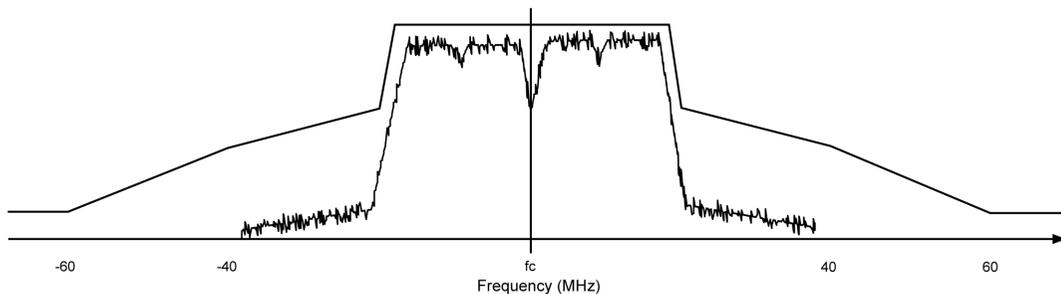


Figure C-15. 40 MHz HT (Duplicate) Spectrum Mask

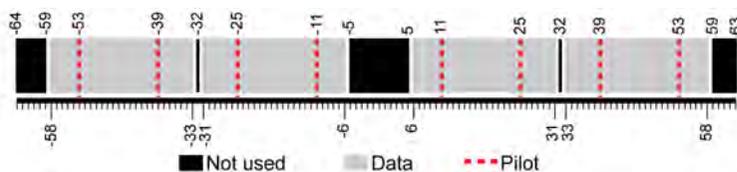


Figure C-16. 40 MHz HT (Duplicate) Sub-Carrier Allocation

40 MHz Non-HT (Duplicate)

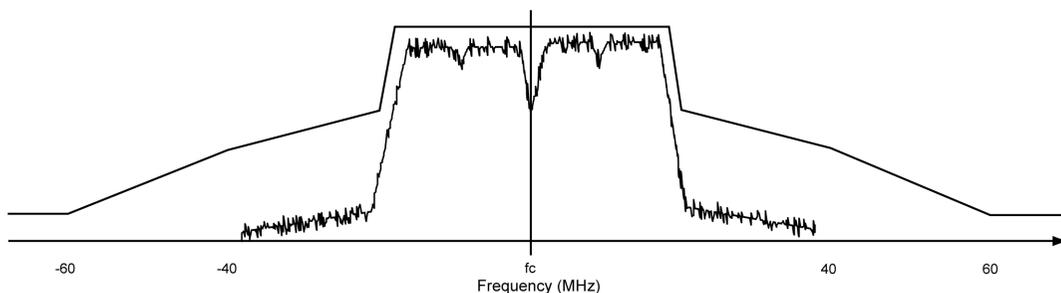


Figure C-17. 40 MHz Non-HT (Duplicate) Spectrum Mask

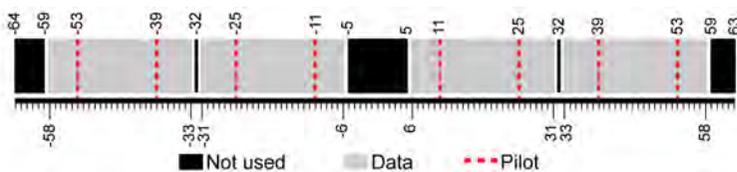


Figure C-18. 40 MHz Non-HT (Duplicate) Sub-Carrier Allocation



# Appendix D — Terminology Glossary

**Table D-1.** Terminology Glossary

<b>Acronym</b>	<b>Meaning</b>
ACK	Acknowledgment
AP	Access Point
BSS	Basic Service Set
BSSID	Basic Service Set Identification
CCK	Complementary Code Keying
DBPSK	Differential Binary Phase Shift Keying
DES	Data Encryption Standard
DQPSK	Differential Quadrature Phase Shift Keying
DSSS	Direct-Sequencing Spread-Spectrum
DUT	Device Under Test
EVM	Error Vector Magnitude
FER	Frame Error Ratio
FRR	Frame Reception Rate
GPIB	General Purpose Interface Bus
HT	High Throughput
IEEE	Institute of Electrical and Electronic Engineers
ISM	Industrial Scientific and Medical
ISO	International Standards Organization
LAN	Local Area Network
MAC	Medium Access Control
MCS	Modulation and coding scheme
OFDM	Orthogonal Frequency Division Multiplexing
PER	Packet Error Rate
PPDU	Phy Protocol Data Unit
RF	Radio Frequency
RSSI	Received Signal Strength Indication
RX	Receive
SSID	Service Set Identifier
STA	Station
TX	Transmit
USB	Universal Serial Bus
WLAN, W-LAN	Wireless Local Area Network
WM	Wireless Medium



# Appendix E — Technical Support

Whilst every effort has been made to ensure the quality and reliability of this product, there may be times when operation difficulties are experienced and technical support is required.

## E-1 Contacting Support

For immediate assistance contact your local Anritsu sales engineer or field application engineer. A list of all regional offices can be found on our internet site at the following location: <http://www.anritsu.com/contact.asp>.

## E-2 Reporting Problems

Technical support can also be obtained by sending an e-mail to our technical support team at [wlan.support@anritsu.com](mailto:wlan.support@anritsu.com). Please include the details below.

- MT8860C serial number
- LANLook version (if used)
- Description of the problem
- List of error messages displayed
- Description of procedure to replicate the problem
- Details of efforts already made to correct the problem

Every effort will be made to ensure that a response is provided within three working days.

## E-3 Anritsu Service Centers

A list of all Anritsu service centers is provided on our internet site at the following location: <http://www.anritsu.com/contact.asp>.

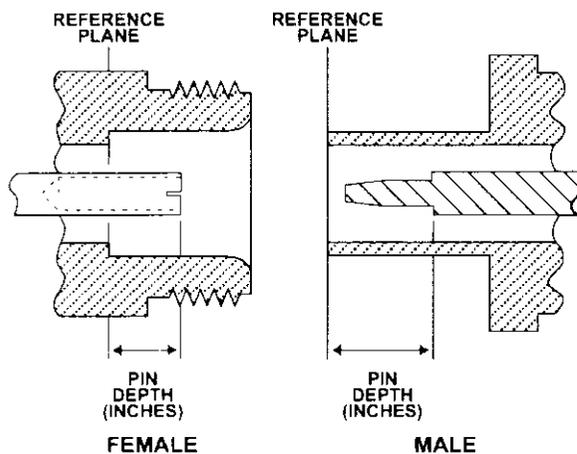


# Appendix F — Connector Care and Handling

Follow the precautions listed below when handling or connecting cables. Complying with these precautions will guarantee longer component life and less equipment down time due to connector or device failure.

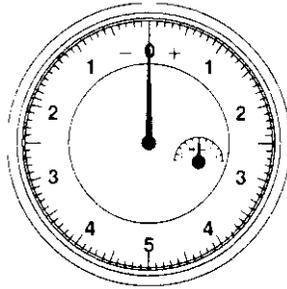
## F-1 Pin Depth Mating Connectors

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).



**Figure F-1.** N Connector Pin Depth Definition

The center 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 center 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 equivalent can be used for this purpose.



**Figure F-2.** Pin Depth Gauge

If the measured connector is out of tolerance in the "+" region, the center 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 center 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	01-163	207 -0.000	207 +0.000
N - Female		+0.030	-0.030
WSMA - Male	01-162	-0.000	Same as pin depth
WSMA - Female		-0.010	
3.5 mm - Female			

## F-2 Torquing Connectors

Over torquing connectors is destructive; it may damage the connector center 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.*

## F-3 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.

## F-4 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.

**Note**

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 center.

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 center pin of the connector
- If installed, do not disturb the Teflon washer on the center 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 center pin has not been bent or damaged.



# Appendix G — PC Regional Settings

The LANLook software is designed to operate on Windows XP or Windows Vista (32-bit) in an English, Japanese, or Chinese language environment. Performance cannot be guaranteed when installed on any other system.

Operation difficulties may be experienced if LANLook is operated on a PC running in a language environment, such as Swedish and German, where a comma is used as the decimal symbol (e.g., 3,6), instead of a point (e.g., 3.6).

Follow the appropriate procedure below to change the decimal symbol to a point (.).

## G-1 Windows XP

1. Open the [Control Panel] from the Windows [Start] menu.
2. Open [Regional and Language Options].
3. Click the [Customize...] button.
4. Select the point (.) setting from the "Decimal Symbol" drop-down field.

## G-2 Windows Vista

1. Open the [Control Panel] from the Windows [Start] menu.
2. Open [Regional and Language Options].
3. Click the [Formats] tab.
4. Click [Customize this format...].
5. Click the [Numbers] tab.
6. Select the point (.) setting from the "Decimal symbol" drop-down field.



# Appendix H — Network Mode Considerations

## H-1 Windows Firewall Settings for Tx Testing

When configured for Data Analysis mode, the MT8860C transmits ICMP (Internet Control Message Protocol) “echo request” data packets to the DUT. This packet type contains a control message that instructs the DUT to re-transmit the data received. Under certain circumstances however, the security settings on the PC may prevent the DUT from receiving the "echo request" packets and, as no "echo reply" packets are returned, measurement analysis cannot be performed at the MT8860C.

To prevent this from happening, the PC security settings should be modified accordingly. Different levels of protection can be maintained whilst still ensuring that the "echo request" packets are received by the DUT.

Four security setting procedures are available. One of these procedures, as detailed over the following pages, should be performed by the user to ensure that packet loop-back is unhindered.

- Disable the Windows Firewall
- Enable TCP port 445
- Allow echo request packets for all connections
- Allow echo request packets for only the DUT connection

<b>Note</b> Users should follow only one of the procedures in this appendix.
--

## H-2 Disabling the Windows Firewall

Turning off the Windows firewall completely is the easiest procedure to perform but disables all protection.

1. Select [Windows Firewall] from the Windows [Control Panel]. The [Windows Firewall] dialog displays.
2. Click the [General] tab, select “Off (not recommended)” and click [OK] to close.

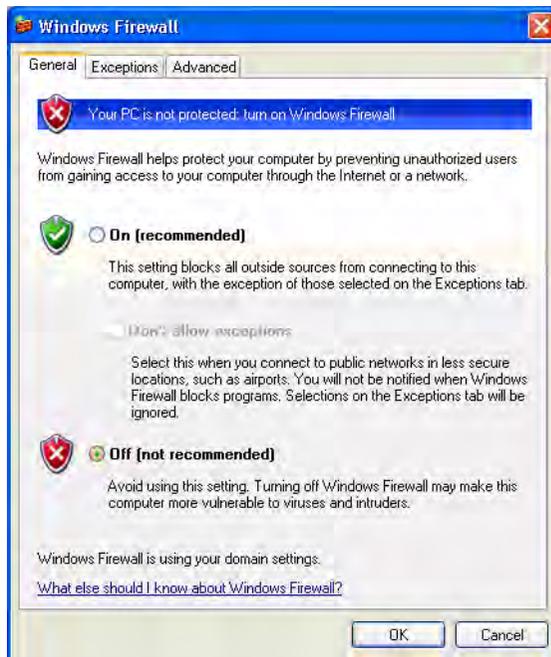
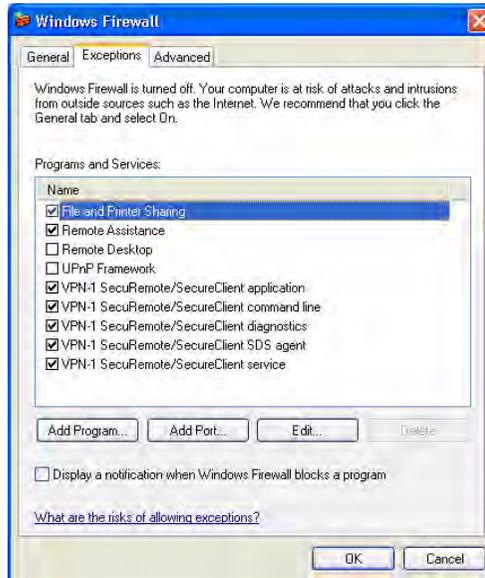


Figure H-1. [Windows Firewall] Dialog

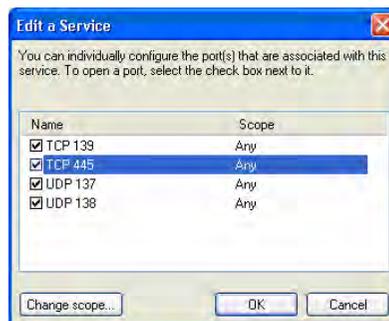
## H-3 Enabling TCP Port 445

1. Select [Windows Firewall] from the Windows [Control Panel]. The [Windows Firewall] dialog displays.
2. Click the [General] tab and clear the “Don’t allow exceptions” check box.
3. Click the [Exceptions] tab, highlight “File and Printer Sharing” and click [Edit].



**Figure H-2.** Windows Firewall Exception Settings

4. Select “TCP 445” and click [OK] to close.



**Figure H-3.** [Edit a Service] Dialog

## H-4 Echo Request Packets

1. Select [Windows Firewall] from the Windows [Control Panel]. The [Windows Firewall] dialog displays.
2. Click the [General] tab and clear the “Don’t allow exceptions” check box.
3. Click the [Advanced] tab, and then click the ICMP [Settings...].

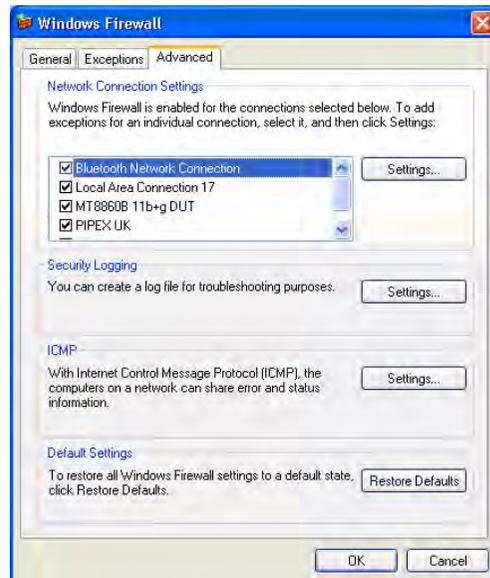


Figure H-4. Windows Firewall Advanced Settings

4. Select “Allow incoming echo request” and click [OK] to close.

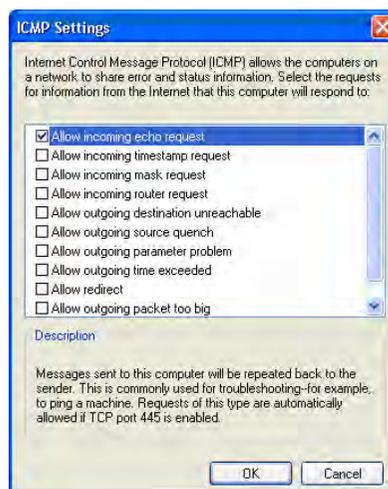
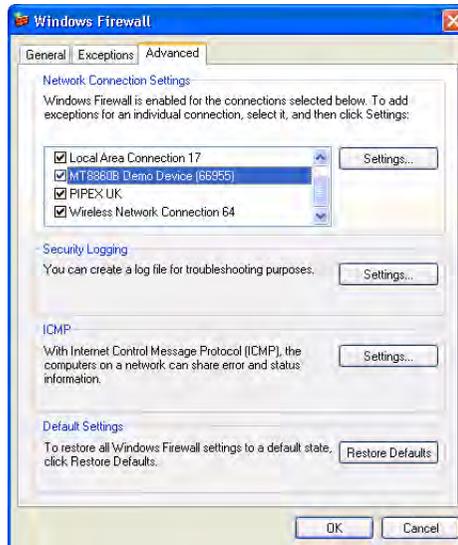


Figure H-5. [ICMP Settings] Dialog

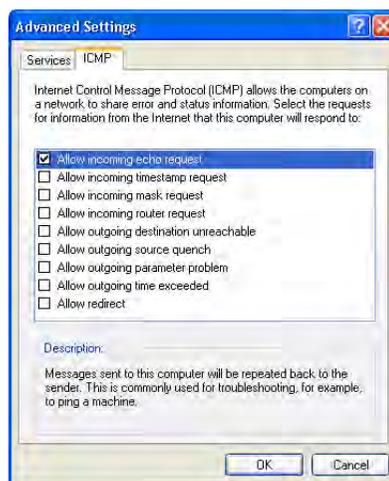
## H-5 Echo Request Packets for DUT Only

1. Select [Windows Firewall] from the Windows [Control Panel]. The [Windows Firewall] dialog displays.
2. Click the [General] tab and clear the “Don’t allow exceptions” check box.
3. Click the [Advanced] tab, scroll the network connection settings, highlight “MT8860C Demo Device (66955)” and click [Settings...].



**Figure H-6.** Exception Settings

4. Select the [ICMP] tab, select “Allow incoming echo request” and click [OK] to close.



**Figure H-7.** [Advanced Settings] Dialog

## H-6 Devices with Power-Save Mode Enabled

In order to preserve energy and extend battery life, a WLAN station (STA) can be configured to periodically enter a power-save mode whereby the transmitter and receiver of the STA are turned off. Testing the RF performance of an STA that is repeatedly entering power-save mode is not very practical and for that reason the CWG RF test plan states that when evaluating the RF performance of Wi-Fi mobile converged devices, power-save mode should be disabled.

Although the MT8860C does not detect the power-save state of a STA, a method is provided in the firmware that may enable the MT8860C to perform repeatable RF measurements on STA devices that have power-save mode enabled. Using information bits contained in both the beacon management frames and data frames transmitted by the MT8860C, the method tries to ensure that an STA is "awake" before a Tx or Rx measurement is performed and remains "awake" for the entire measurement duration. Configuration of the information bits is achieved using the remote command MEASCFG 1,DRVCFG. Details on the command format, can be found in the MT8860C Remote Programming Manual (13000-00259).

<b>Note</b>	Although this method was successful for a number of STA devices tested, other devices still entered a power-save mode.
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# Appendix I — Remote Operation Using LAN

LAN communication is supported by the MT8860C via the Ethernet connector on the rear panel of the instrument. It is functionally equivalent to the GPIB connector. The Ethernet connector enables the MT8860C to be remotely programmed by a LAN-connected computer. The distance between the computer (or network connection device) and the MT8860C is limited to 100 meters (10BaseT and 100BaseT).

The MT8860C supports the following LAN interface protocols and related [port numbers]:

- VXI-11 using VISA
- Sockets LAN [5025]
- TELNET [5024]
- File Transfer Protocol (FTP) [23]

VXI-11 and sockets LAN are used for general programming. A VISA installation on the controller is required for remote control over LAN when using VXI-11 protocol. TELNET is used for interactive, single command at a time instrument control. FTP is for file transfer and is only used to upgrade the instrument firmware.

<b>Note</b>	Only one session can be open at any given time. A message indicating that a connection is not possible will be reported if an attempt is made to open another session.
-------------	--

Detailed information about each LAN protocol is provided later in this appendix.

## I-1 MT8860C Addressing

The MT8860C can be addressed in the following ways, depending upon:

- How the network is configured (DHCP enabled/disabled)
- How the MT8860C is configured (SYSCFG LAN,MODE MANUAL/AUTO)
  1. If the MT8860C is configured to use an AUTO IP address, but there is no DHCP server available, the MT8860C will default to the IP address 192.168.168.2
  2. If the MT8860C is configured to use an AUTO IP address and there is a DHCP server available, the IP address will be assigned automatically. If the DHCP server uses dynamic DNS to link the <hostname> with the assigned IP address, the MT8860C <hostname> may be used in place of the IP address.

The <hostname> is fixed for each MT8860C and has the format 'Axxxxxxx', where xxxxxxx represents the last 7 digits of the instrument serial number. A label located on the rear panel of the instrument provides serial number details. Use the examples shown in the table below to determine the <hostname> of the instrument.

**Table I-1.** Hostname Determination

Serial number	Hostname
6K00002643	A0002643
000839002	A0839002

**Note** If the DHCP server does not use dynamic DNS, the <hostname> cannot be used to communicate with the MT8860C over the LAN.

- If the MT8860C is configured to use a MANUAL IP address, the IP address can be configured manually using the SYSCFG LAN,ADDR command (default setting is 192.168.168.2).

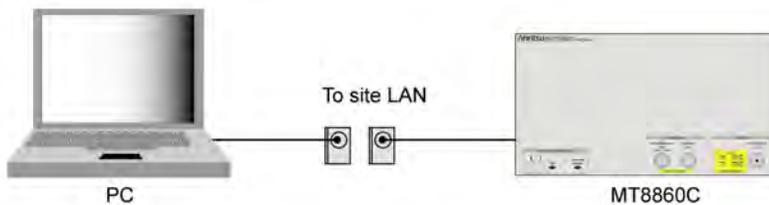
Refer to the SYSCFG LAN commands in the MT8860C Remote Programming manual (13000-00259F.pdf) for further information on IP addressing.

## I-2 Setting up the LAN Interface

For LAN operation, the MT8860C must be connected to the LAN and an IP address assigned to the MT8860C either manually or by using DHCP server.

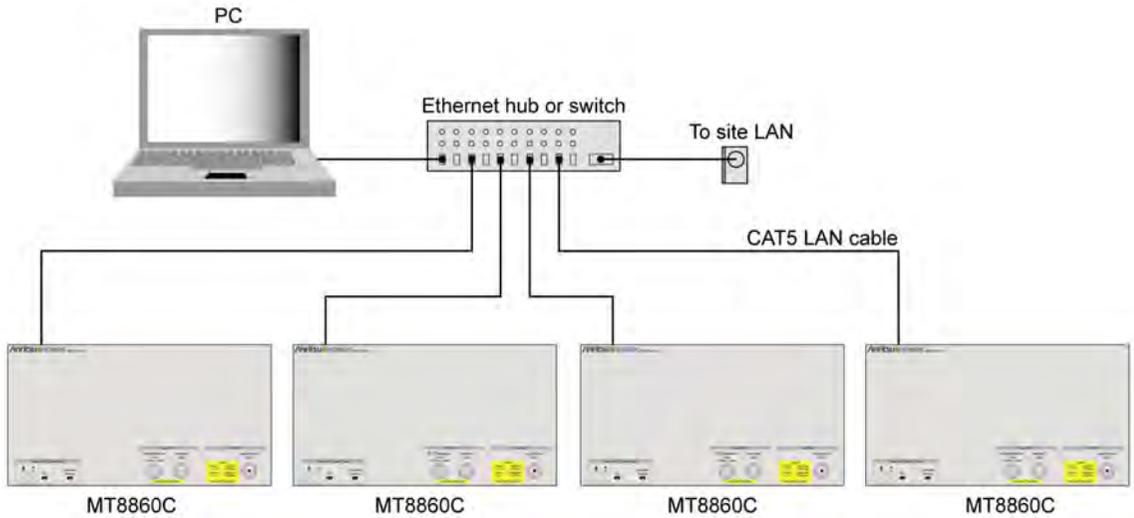
Typically, there are four ways in which the MT8860C can be connected to a LAN.

Method 1: Direct connection to a “Corporate” (Enterprise) network.



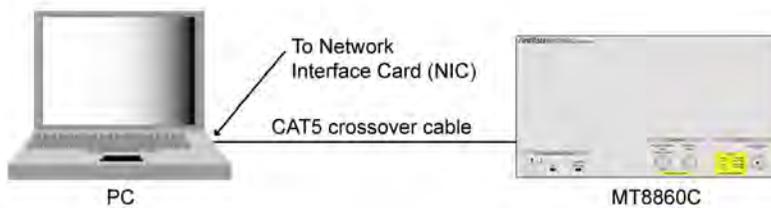
**Figure I-1.** Direct Connection to Corporate Network

Method 2: Ethernet switch / hub connection to a “corporate” (Enterprise) network.



**Figure I-2.** Ethernet Switch Connection to Corporate Network

Method 3: Direct connection to a private LAN.

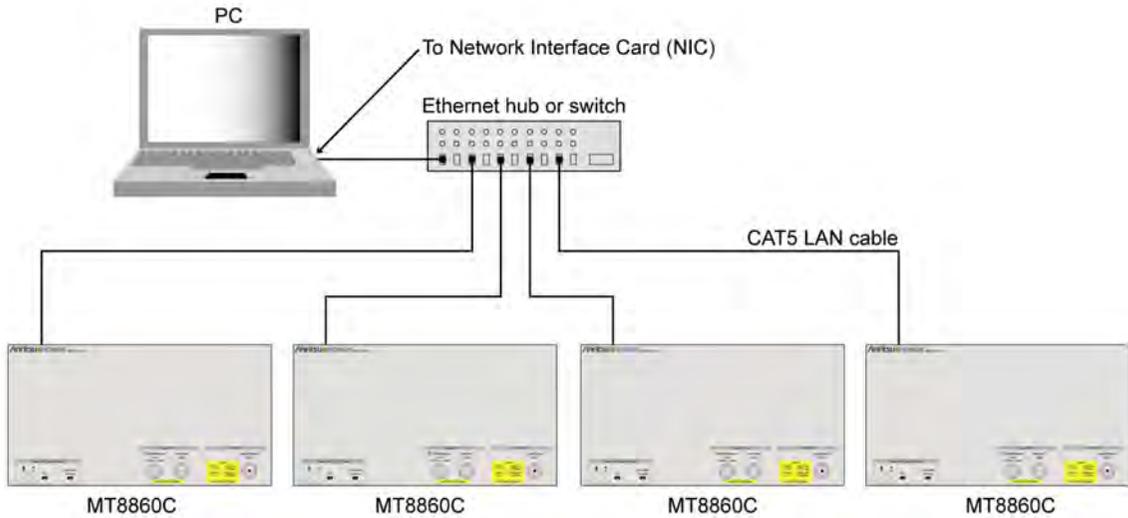


**Figure I-3.** Direct Connection to a Private LAN

The interface hardware does not support auto MDIX ('Auto-cross'). Consequently, when connecting the MT8860C directly to a PC, a CAT5 crossover cable must be used. It is also recommended that DHCP is disabled on both the MT8860C and PC.

Method 4: Ethernet switch / hub connection to a private LAN.

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**Figure I-4.** Ethernet Switch Connection to Private LAN

For all methods described above, the follows steps should be taken when connecting the MT8860C to the LAN.

1. Power OFF the MT880C.
2. Connect the MT8860C as illustrated.
3. For methods 2 and 4, apply power to the Ethernet Hub or switch.
4. Power ON the MT8860C.

## I-3 LAN Interface Protocols

### VXI-11

The MT8860C supports the LAN interface protocol described in the VXI-11 standard. VXI-11 is an instrument control protocol based on Open Network Computing/Remote Procedure Call (ONC/RPC) interfaces running over TCP/IP. It is intended to provide GBIB capabilities such as SRQ (Service Request), status byte reading, and DCAS (Device Clear State) over a LAN interface. This protocol is a good choice when migrating from GPIB to LAN. It is recommended that the VXI-11 protocol be used for instrument communication over the LAN interface.

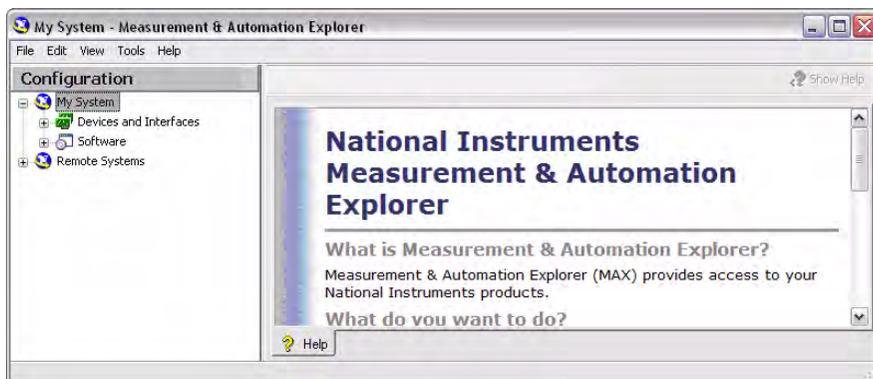
**Note**

A VISA installation on the controller is required when using VXI-11 protocol for remote control over LAN. VISA is a standard that provides input and output functions for configuring, programming and troubleshooting instrumentation systems comprising GPIB, VXI, PXI, Serial, Ethernet, and/or USB interfaces. The standard was originally defined by the VXIplug&play System Alliance but is now officially maintained by the IVI Foundation (<http://www.ivifoundation.org>). With the exception of some interface specific configuration functions, test programs can be written that are completely independent of the interface used.

NI-VISA Run-Time Engine is provided on the MT8860C Product CD. NI-VISA is National Instruments implementation of the VISA I/O standard and includes software libraries, interactive utilities and configuration programs. Please visit the National Instruments Drivers and Updates page at <http://www.ni.com/support/> for technical support for the NI-VISA Run-Time Engine, including the availability of upgrades. Technical support from National Instruments for the NI-VISA Run-Time Engine is subject to its then current support policy.

The example below demonstrates how a VXI-11/ VISA session can be opened using National Instruments 'Measurements & Automation Explorer' program.

1. On the PC, access the Windows programs directory and select [National Instruments] > [Measurement & Automation].



**Figure I-5.** [Measurement & Automation Explorer]

2. Right-click [Devices and Interfaces] and select [Create New...] from the pop-up menu.

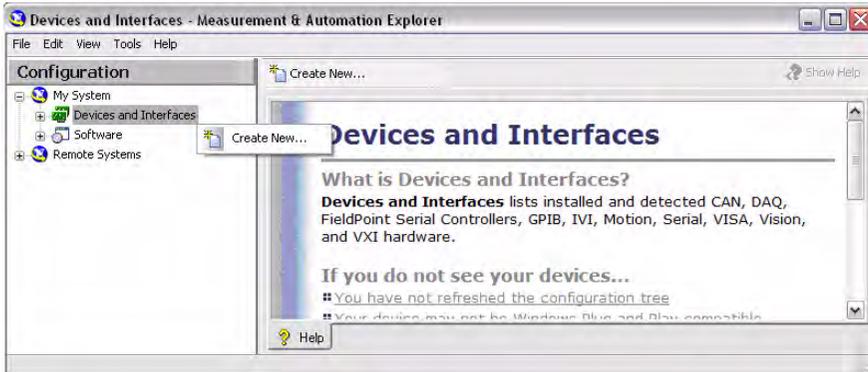


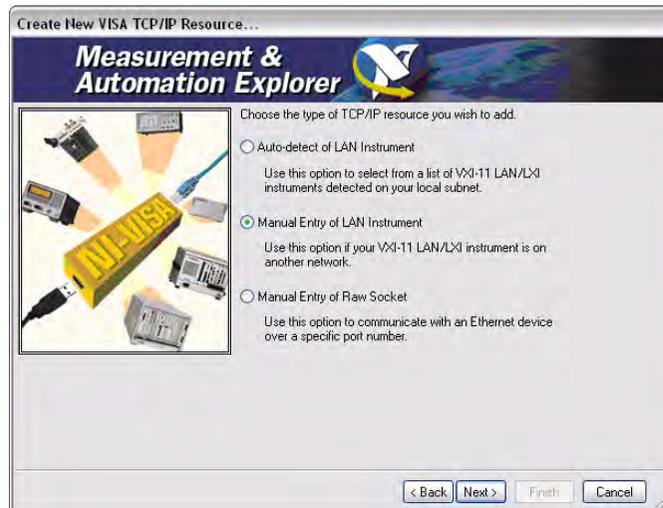
Figure I-6. Create New

3. From the [Create New...] screen, select [VISA TCP/IP Resource], and then click [Next>].



Figure I-7. VISA TCP/IP Resource

- From the [Create New TCP/IP Resource...] screen, select “Manual Entry of LAN Instrument”, and click [Next>].



**Figure I-8.** [Create New VISA TCP/IP Resource]

- Enter the hostname or IP address, and click [Validate].



**Figure I-9.** Enter Hostname

6. A message indicates whether a session can be established with the MT8860C.



Figure I-10. Success



Figure I-11. Error

7. Click [OK] to close the message. From the [Create New TCP/IP Resource...] screen click [Next>]. An Alias name for the instrument can be specified. This is not the computer name. It is the name used for instrument identification within the program and displayed in the menu as an option in case of an Ethernet link.



Figure I-12. Specify Alias

8. Click [Next>].



Figure I-13. Create Devices

9. Click [Finish]. The instrument is now registered and can be addressed via the resource string or alias name.

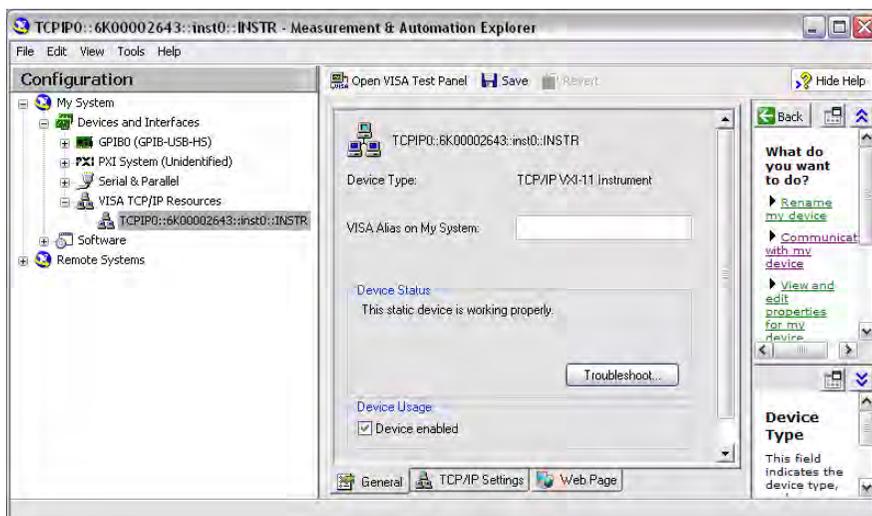


Figure I-14. [General] Tab

Clicking the [TCP/IP Settings] tab displays the following screen.

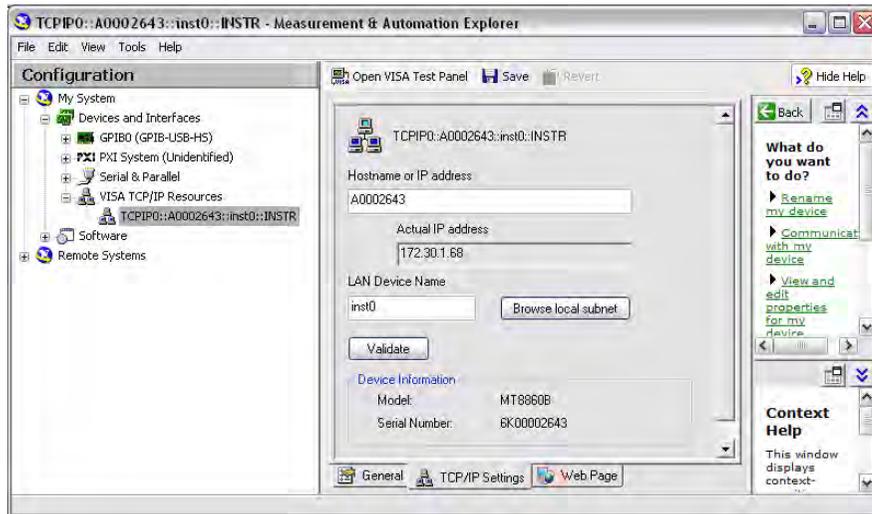


Figure I-15. [TCP/IP Settings] Tab

Clicking the [Web Page] tab displays the following screen.

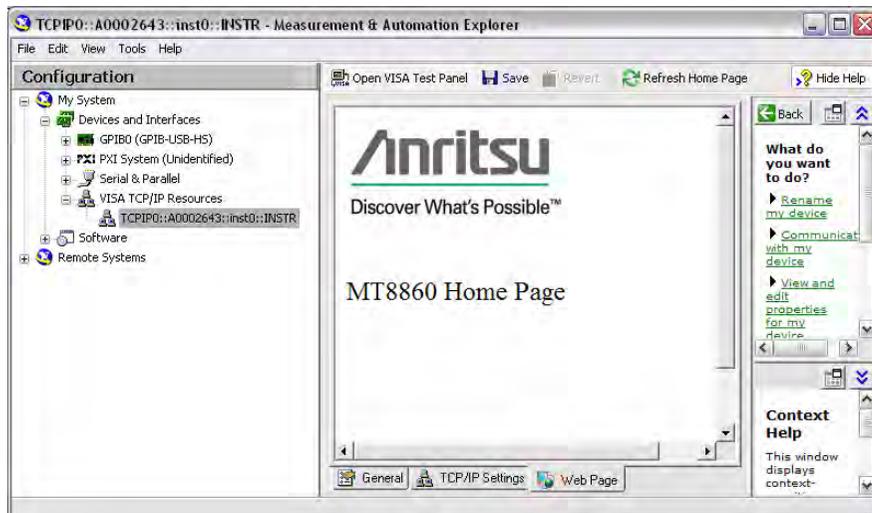


Figure I-16. [Web Page] Tab

10. To open a VISA session, click “Open VISA Test Panel”.

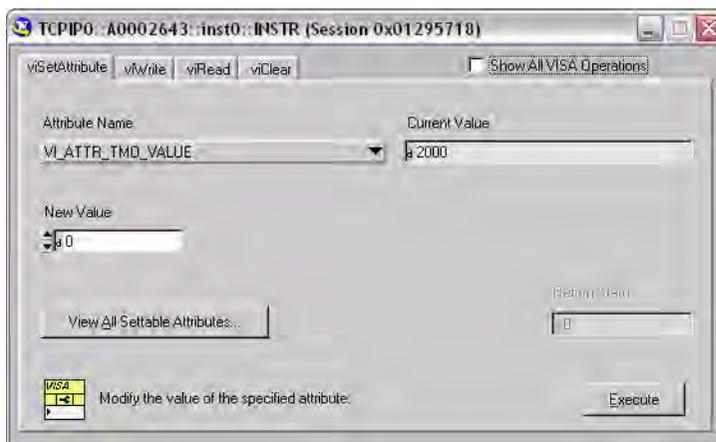


Figure I-17. VISA Test Panel

11. Commands can be sent to the instrument by selecting the viWrite. Enter the required command(s) in the Buffer window and click [Execute] to send the command(s) to the instrument.

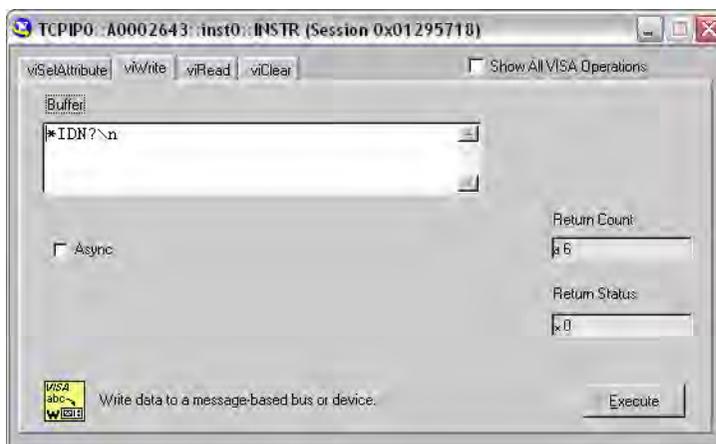


Figure I-18. ViWrite Tab

12. Message response strings can be read back from the instrument by selecting the [viRead] tab. Click [Execute] to perform a read operation.

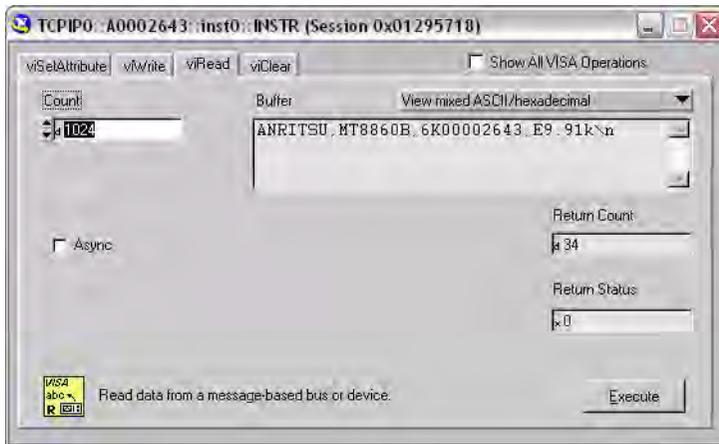


Figure I-19. ViRead Tab

13. Close the VISA session, by selecting 'Close' from the drop-down menu.

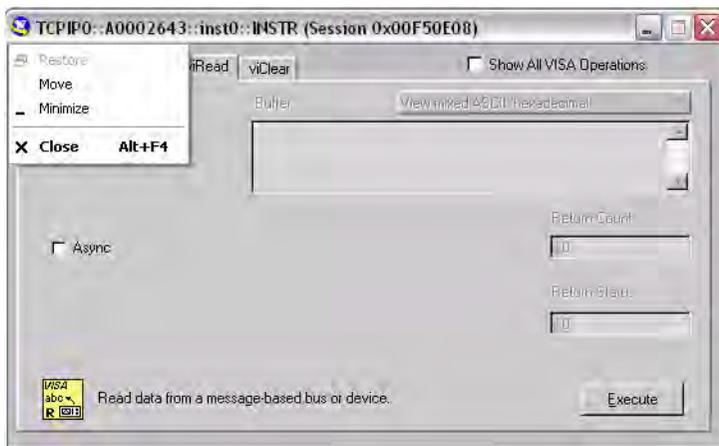


Figure I-20. Close Session

## Sockets LAN [5025]

Socket LAN is a method used to communicate with the MT8860C over the LAN interface using the Transmission Control Protocol/Internet Protocol (TCP/IP). A socket is a fundamental technology used for computer networking and allows applications to communicate using standard mechanisms built into network hardware and operating systems. The method accesses a port on the MT8860C from which bi-directional communication with a network computer can be established.

Socket LAN can be described as an internet address that combines Internet Protocol (IP) with a device port number and represents a single connection between two pieces of software. The socket can be accessed using code libraries packaged with the computer operating system. MT8860C implements a socket Applications Programming Interface (API) that is compatible with Berkeley sockets, for UNIX systems, and Winsock for Microsoft systems. MT8860C is also compatible with other standard sockets APIs. MT8860C can be controlled using commands that are output to a socket connection established in your program.

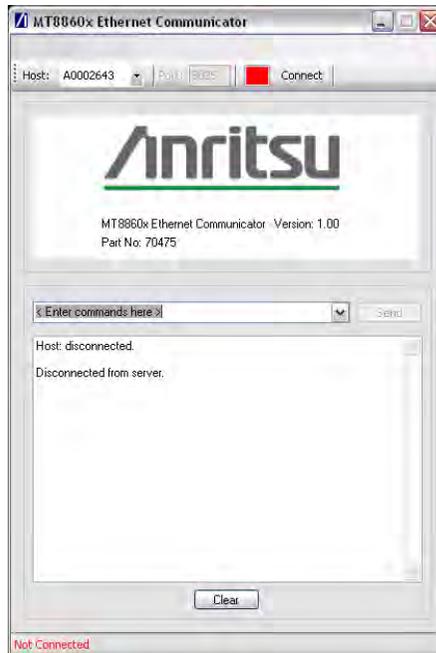
An example of a Socket LAN application 'MT8860x Ethernet Communicator' is included on the MT8860C Product CD. Both source code and executable are provided.

1. Install the 'MT8860x Ethernet Communicator' application from the Product CD.
2. On the PC, access the Windows programs directory and select [Anritsu] > [MT8860x Ethernet Communicator].



**Figure I-21.** Ethernet Communicator

3. Enter the <hostname or IP Address> into the “Host” edit box and click [Connect]. If another session (FTP, Telnet, VXI or Socket LAN) is in progress the application will display the following response from the server.



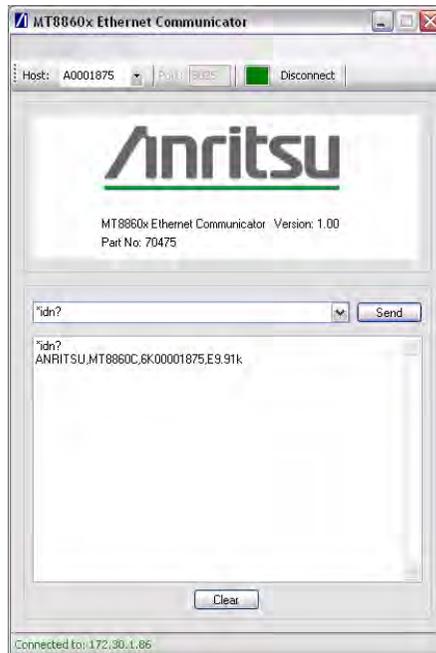
**Figure I-22.** Disconnected from Server

4. On a successful connection, the [Disconnect] button is shown and the connected LED flashes green. The status bar will show the IP Address of the connected unit.



**Figure I-23.** Connected

5. Remote programming commands can be sent to the instrument by typing the command into the drop-down box and clicking the Send button. Transmitted commands are retained within the drop-down entry field.



**Figure I-24.** Remote Commands

6. Multiple commands may be entered separated by a semi-colon (;).

---



**Figure I-25.** Multiple Commands

7. Click [Disconnect] to close the Socket LAN session.

---



**Figure I-26.** Disconnected from Server

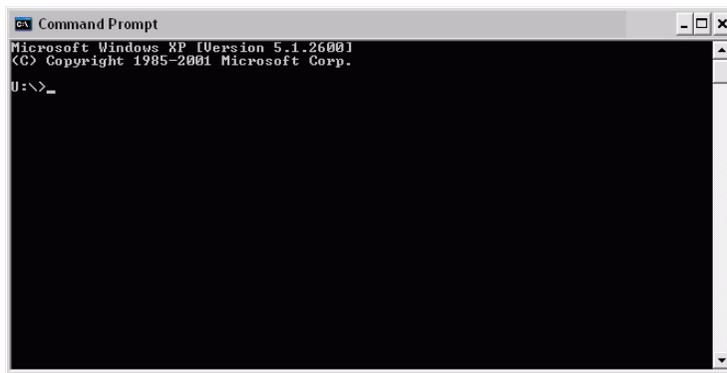
---

## TELNET [5024]

Telnet provides a means of communicating with MT8860C over the LAN. The Telnet client run on a LAN connected computer, creates a login session on the MT8860C. A connection, established between computer and MT8860C opens a Telnet window with a command line prompt. Using the Telnet protocol to send commands to the MT8860C is similar to communicating with the MT8860C over GPIB. A connection is established with MT8860C and information is then sent to or received from the instrument using GPIB commands. Communication is interactive: one command at a time.

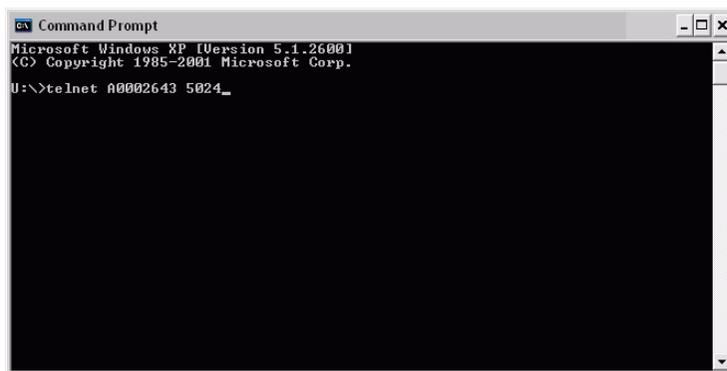
TELNET can be used from the command prompt window as follows:

1. On the PC, access the Windows programs directory and select [Accessories] > [Command Prompt].



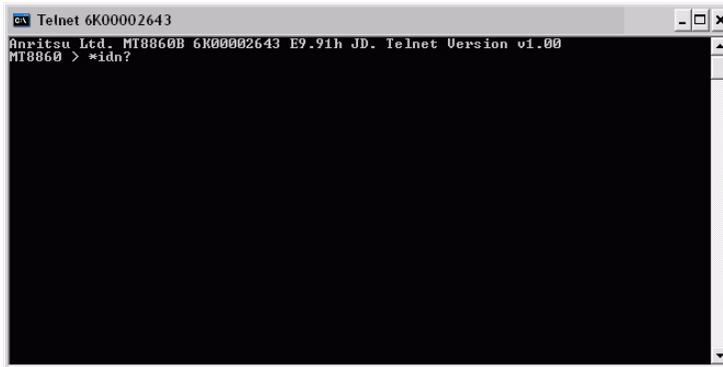
**Figure I-27.** Command Prompt

2. At the command prompt, type `telnet <hostname or ip address> 5024`.



**Figure I-28.** Host Name or IP Address

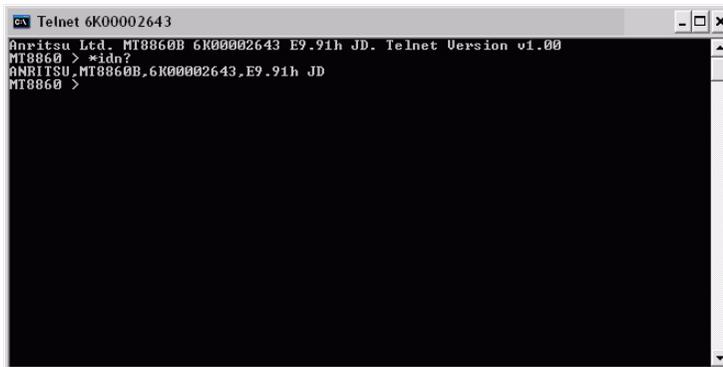
3. At the MT8860 > prompt, enter GPIB commands (e.g. \*idn?).



```
Telnet 6K0002643
Anritsu Ltd. MT8860B 6K0002643 E9.91h JD. Telnet Version v1.00
MT8860 > *idn?
```

Figure I-29. GPIB String

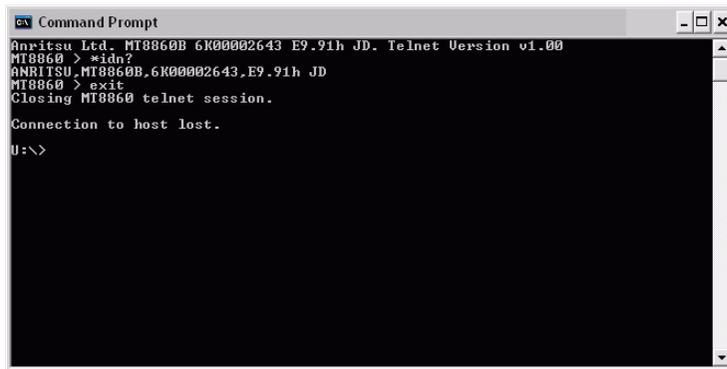
4. The response string is returned.



```
Telnet 6K0002643
Anritsu Ltd. MT8860B 6K0002643 E9.91h JD. Telnet Version v1.00
MT8860 > *idn?
ANRITSU,MT8860B,6K0002643,E9.91h JD
MT8860 >
```

Figure I-30. Response String

5. Type `exit` at the `MT8860 >` prompt to end the Telnet session.



```
Command Prompt
Anritsu Ltd. MT8860B 6K00002643 E9.91h JD. Telnet Version v1.00
MT8860 > *idn?
ANRITSU,MT8860B,6K00002643,E9.91h JD
MT8860 > exit
Closing MT8860 telnet session.
Connection to host lost.
U:\>
```

**Figure I-31.** Exit to End Session

## File Transfer Protocol FTP [23]

FTP is provided for instrument firmware upgrade. Two methods are recommended:

- Directory browser
- FTP client, e.g., FileZilla

These utilities allow files to be copied to the MT8860C bootload folder using Windows style cut-and-paste and/or drag-and-drop operations.

### Note

Microsoft provides an FTP client that can be run from a Command Prompt window. However, due to the different file formats used by MT8860C, the use of this is not advised for the firmware upgrade operation. If you wish to use this method please contact wlan.support@anritsu.com for further details.

### Directory Browser

1. On the PC, open [My Computer] or [My Documents].



Figure I-32. [My Computer]

2. Type ftp://admin:anritsu@<hostname or IP address> in the address bar.

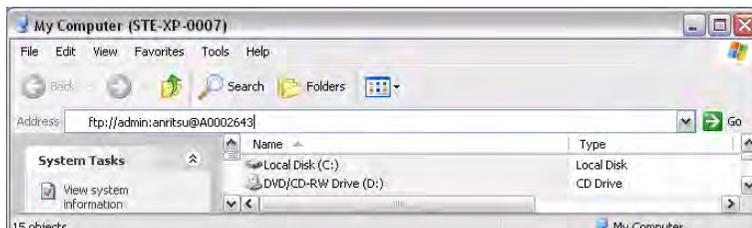
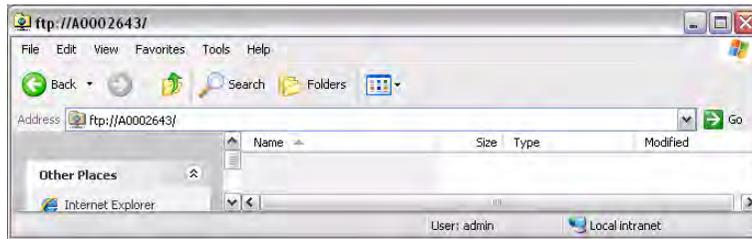


Figure I-33. Hostname or IP Address

3. The MT8860C bootload folder is now accessible.



**Figure I-34.** Bootload Folder

4. Files can now be copied from / to the MT8860C bootload folder.
5. Exit the window to close the session.

### FileZilla Client

The FileZilla Client is a free, Open Source FTP client for Windows. It supports FTR, SFTP, and FTPS (FTP over SSL/TLS). FileZilla can be downloaded from the following location:

<http://filezilla-project.org/download.php?type=client>

1. Run the file filezilla.exe.



**Figure I-35.** [FileZilla]

2. Enter the following details:
  - Host: <hostname or IP address>
  - Username: admin

- Password: anritsu

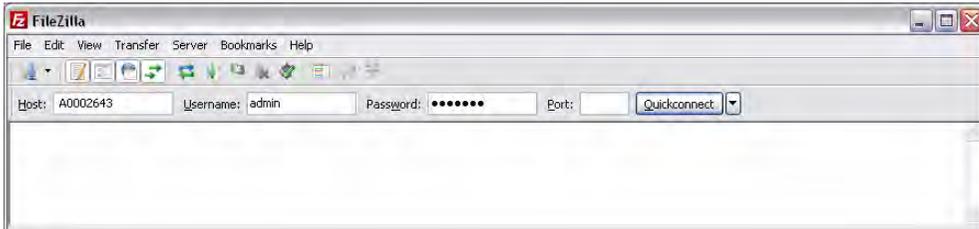


Figure I-36. Enter Host, Username, and Password

3. Click [Quickconnect].

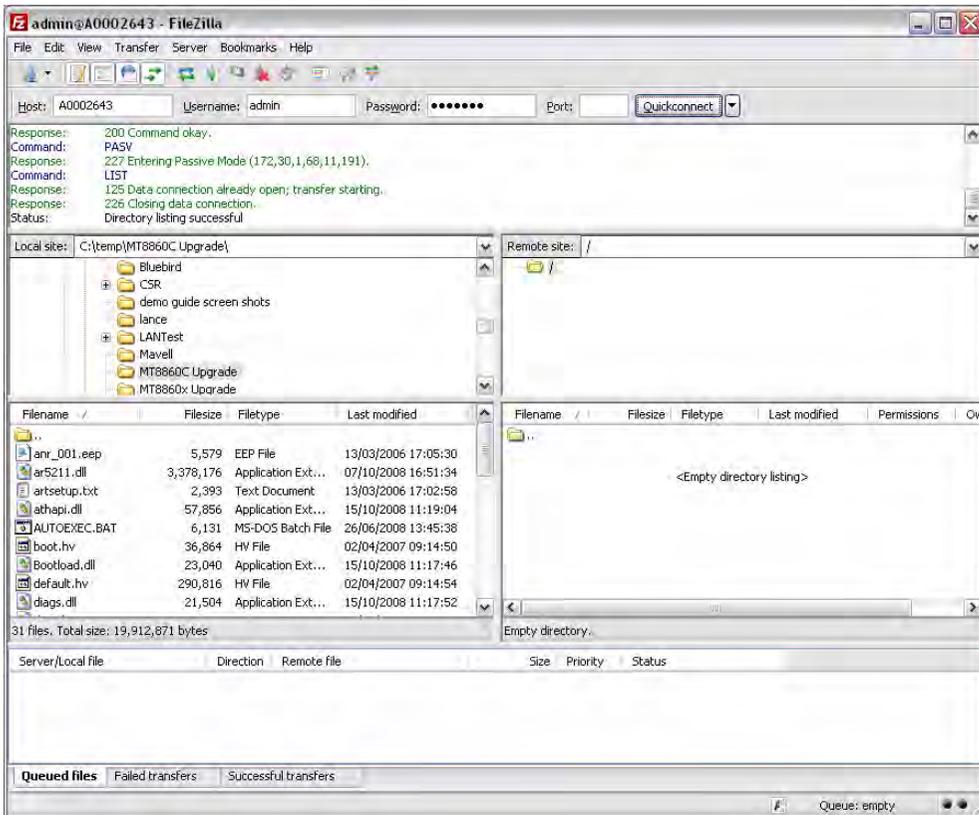


Figure I-37. Quickconnect

4. Files can now be copied from / to the MT8860C bootload folder using a simple drag-and-drop operation.

5. Exit FileZilla to close the FTP session.

**Note**

Filezilla does not close the FTP session. This should not be a problem as the application is used only for downloading new firmware files to the MT8860C. A power-cycle operation must be performed on the MT8860C before the new firmware becomes effective.

Instructions on how to perform a firmware upgrade using the LAN interface are provided in Chapter 15 of this manual.

## I-4 Fault Finding

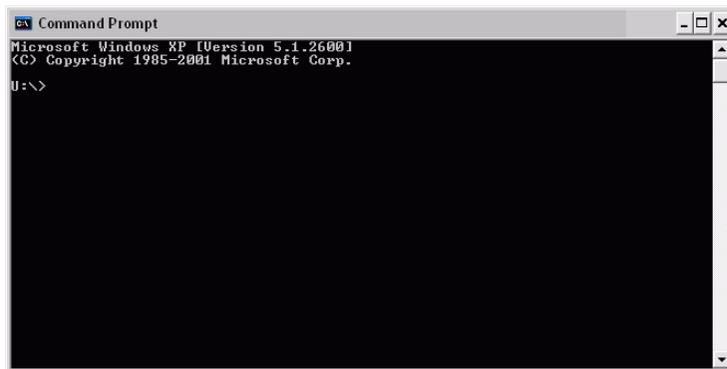
Follow the steps below if experiencing problems with the LAN connection on the MT8860C.

- Verify that the rear panel LAN connector green LED is flashing.
- Check the LAN configuration, making sure that the correct cable type has been used.
- Check connectivity using Ping.

Ping is a computer network tool that can be used to test whether a particular host is reachable across an IP network. It is named after the sound that a sonar makes and is inspired by the principle of echo-location.

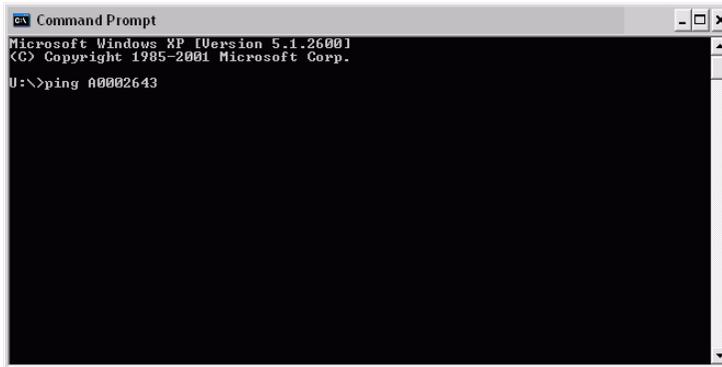
Ping works by sending ICMP “echo request” packets to the target host and listening for ICMP “echo response” replies. Ping measures the round-trip time, records any packet loss and prints a summary of the echo response packets received.

1. On the PC, access the Windows programs directory and select [Accessories] > [Command Prompt].



**Figure I-38.** [Command Prompt]

2. At the command prompt, type ping <hostname or IP address>.



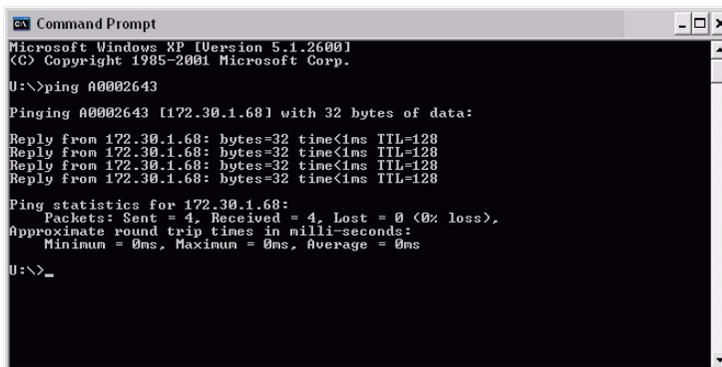
```

Command Prompt
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.
U:\>ping 00002643

```

**Figure I-39.** Enter Hostname or IP Address

3. If the MT8860C is connected, it responds as shown below.



```

Command Prompt
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.
U:\>ping 00002643
Pinging 00002643 [172.30.1.68] with 32 bytes of data:
Reply from 172.30.1.68: bytes=32 time<1ms TTL=128
Ping statistics for 172.30.1.68:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms
U:\>_

```

**Figure I-40.** Response from MT8860C

4. At the command prompt, type exit to close the MS-DOS command window.

### Obtaining the LAN IP Address of the MT8860C

If the LAN DHCP mode of the MT8860C has been set to MANUAL (static) and the IP address modified from the default setting (192.168.168.2), a LAN connection to the instrument shall not be possible unless the IP address value is known.

If the IP address is not known, it can be found by:

- Using a GPIB remote interface
- Using a PC monitor keyboard and mouse
- Using a USB memory device

**Method 1: Using a GPIB Remote Interface**

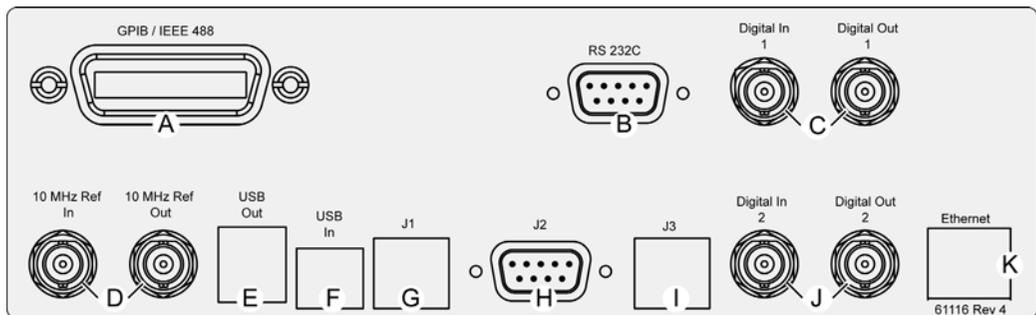
1. Establish a GPIB connection as detailed in chapter 5.
2. Click [System Utilities] tab > [Diagnostics] tab.
3. The current LAN configuration can be determined by:
  1. In the “Send String:” field enter the remote command: SYSCFG? LAN.
  2. Click [Query].
  3. A response string containing the LAN configuration displays.
4. The LAN configuration can be modified using the remote commands: SYSCFG LAN,MODE and SYSCFG LAN,ADDR. Refer to the MT8860C Remote Programming manual for further details.

**Note**

LAN configuration changes become effective only after the MT8860C has been power-cycled.

**Method 2: Using a PC Monitor, Mouse and Keyboard**

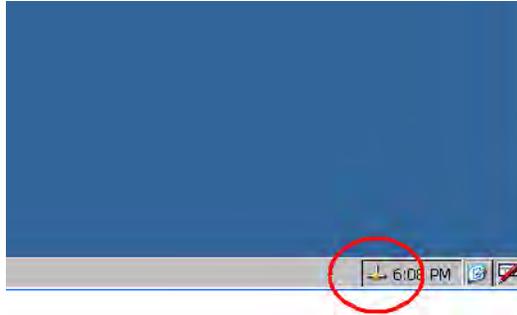
1. Power-down (turn off) the MT8860C.
2. Connect a PC monitor to connector ‘H’ located on the rear panel of MT8860C.
3. Connect a keyboard to the PS2 connector (‘G’) located on the rear panel of MT8860C
4. Connect a mouse to the PS2 connector (‘I’) located on the rear panel of MT8860C.



**Figure I-41.** MT8860C Rear Panel Connectors

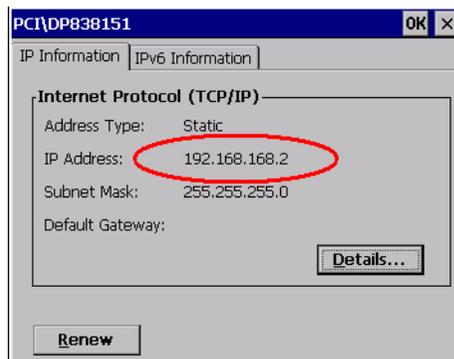
5. Power-on the MT8860C.

6. When the MT8860C has finished booting up (indicated by 'On' LED turned fully on, and the 'Controller Activity' LED turned off), the following desktop displays on the PC monitor.



**Figure I-42.** System Tray

7. Double-click the network icon (circled) in the system tray (lower right of the screen). The following window displays, showing the current IP configuration.



**Figure I-43.** IP Address Window

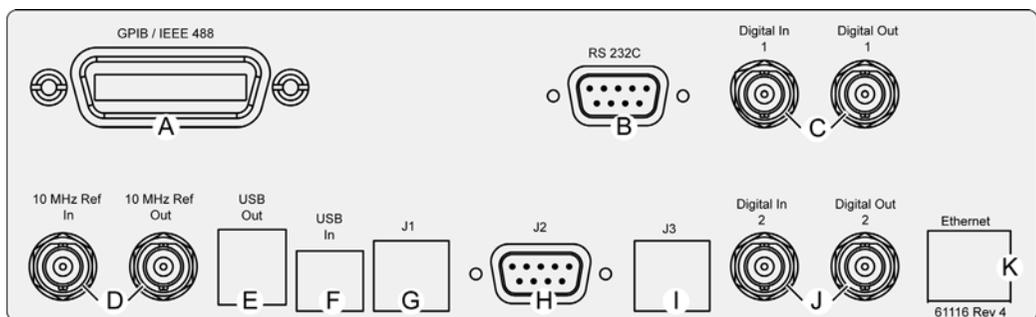
8. Use these IP settings to make an Ethernet connection to the unit.
9. Details on how to modify the LAN configuration are provided below. Refer to "Changing the MT8860C LAN Configuration" for details.

### Method 3 –Using a USB Memory Device

This method will set the MT8860C LAN configuration to the following default values:

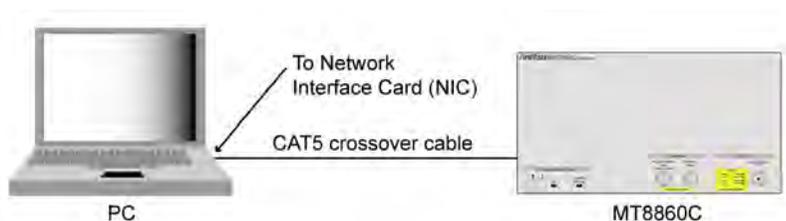
IP address: 192.168.168.2  
Subnet Mask: 255.255.255.0

1. Power-down (turn off) the MT8860C.
2. Remove any device connected to the USB out connector (“E” in the figure below), or the PS2 connectors (“G” and “I” in the figure below).
3. Insert a USB memory device into one of the USB Out connectors (“E”) located on the rear panel of the MT8860C.



**Figure I-44.** MT8860C Rear Panel Connectors

4. Power-on the MT8860.
5. When the MT8860C has finished booting up (indicated by ‘On’ LED turned fully on, and the ‘Controller Activity’ LED turned off), the MT8860C IP configuration is set to the default values shown above.
6. Remove the USB memory device.
7. Using a CAT5 crossover cable, connect MT8860C to a PC.



**Figure I-45.** CAT5 Crossover Connection

8. Details on how to modify the LAN configuration are provided below. Refer to “Changing the MT8860C LAN Configuration” below.

## Changing the MT8860C LAN configuration

Before the MT8860C LAN configuration can be modified, a LAN connection must be established between a PC and MT8860C. To enable this, the IP address of the PC must be in the same subnet as the address of the MT8860C, but not use the same IP address. For example, if the IP address of the MT8860C is 192.168.168.2, the IP address of the PC must be in the range of 192.168.168.1 to 192.168.168.254 (but not 192.168.168.2) for a successful connection. To change the IP setting of the PC:

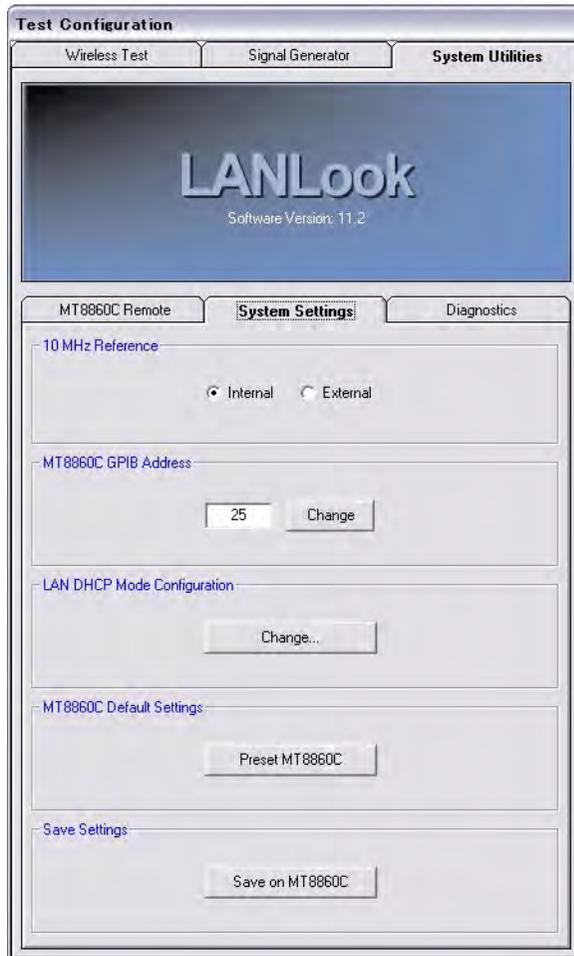
1. Access the Windows Control Panel.
2. Click the [Network and Internet Connection] icon, then select [Network Connections].
3. Right click the [Local Area Connection] icon and select [Properties].
4. Make sure the “Internet Protocol” (TCP/IP) check-box is selected.
5. Highlight “Internet Protocol (TCP/IP)”, then click [Properties].
6. Select “Use the following IP address” and enter an IP address in the range of 192.168.168.1 to 192.168.168.254 (but not 192.168.168.2). Make sure you do not choose an IP address that already exists on your network.
7. Tab to the “Subnet Mask” and enter the subnet mask indicated by MT8860C (e.g., 255.255.255.0)
8. Click [OK].
9. Having configured the PC, open the LANLook software application.
10. From the [MT8860C Remote] tab, set “Remote Interface” to “LAN”.

11. In the “Remote Connection - LAN” frame, enter the IP address of MT8860C and click [Connect]. LANLook should indicate that a remote connection has been established.



**Figure I-46.** MT8860C Remote Tab

12. Click [System Settings] tab.



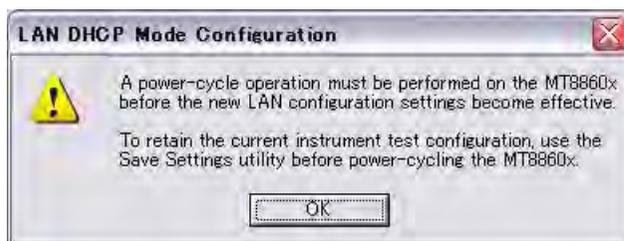
**Figure I-47.** System Settings Tab

- Click [Change...] in the “LAN DHCP Mode Configuration” frame to display the dialog below.



**Figure I-48.** LAN DHCP Mode Configuration

- Modify the LAN Configuration settings as required and click [OK]. LANLook displays the following Message.



**Figure I-49.** Power Cycle Warning

**Note** Make sure that a unique IP address is selected. An address conflict could result in unexpected and unwanted device behaviour on the network.

- Power-down (turn off) MT8860C and close LANLook.
- Reconfigure the IP settings of the PC so that they are compatible with the new IP configuration of MT8860C.
- Power-on the MT8860C.
- When the MT8860C has finished booting up (indicated by ‘On’ LED turned fully on, and the ‘Controller Activity’ LED turned off), open LANLook.
- In the “Remote Connection (LAN)” frame, enter the IP address of MT8860C and click [Connect]. LANLook should indicate that a remote connection has been established using the new IP configuration.



# Appendix J — Using LANLook with Agilent GPIB Controllers

This appendix explains how to use LANLook with Agilent GPIB hardware and software.

## J-1 Overview

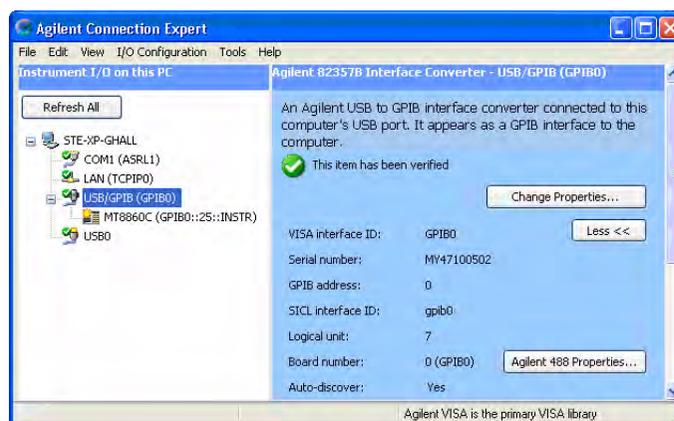
LANLook supports GPIB communication using the standardized VISA protocol and also the 488.2 protocol using the NI (National Instruments) gpib-32.dll functionality. VISA communication via LAN is also supported but is not detailed in this appendix. Consult the MT8860C Remote Programming Manual for details.

Using LANLook with an Agilent GPIB interface and VISA is straightforward because the VISA protocol implementation is standardized. The Agilent IO Library Suite software provides VISA software and also the IVI Foundation VISA-COM components, both of which are required by LANLook.

Communication using an Agilent GPIB interface and the 488.2 protocol is more complicated due to the lack of standardization. However, from version 14.1, the Agilent IO Library Suite can be configured to work with applications that were written for the NI 488.2 implementation. This is partly explained in the Agilent Application Note, "Tips on using Agilent GPIB Solutions in National Instrument's LabVIEW Environment", available on the Agilent website (Ref. 5990-3731EN).

The instructions in this appendix assume that the controller PC is installed with both the Agilent IO Library Suite (v14.1 or later) and an Agilent GPIB card or adapter. It is also assumed that no NI GPIB hardware or software is installed. It is possible to configure a system that has both Agilent and NI GPIB hardware and software installed, but that is beyond the scope of this appendix. Further information can be found in the Agilent and NI documentation.

Open the [Agilent Connection Expert] and select the GPIB interface or adapter to be used.



**Figure J-1.** Agilent Connection Expert

We are using an 82357B USB/GPIB Interface Converter, and can see that an MT8860C with a GPIB address of 25 is connected to it. The pane on the right shows the configuration settings. After changing the settings, both Agilent Configuration Expert and LANLook must be restarted.

For VISA communication with LANLook, set the VISA interface ID to "GPIB0". (Click the [Change Properties...] button.) The other settings do not affect VISA operation.

For 488.2 communication with LANLook, the following configuration must be set:

GPIB address: 0 (Click the [Change Properties...] button)

SICL interface ID: gpib0 (Click the [Change Properties...] button)

Board number: 0 (GPIB0) (Click the [Agilent 488 Properties...] button)

Open the [Agilent Connect Expert Options] dialog from the [Tools] menu. The "Enable Agilent GPIB cards for 488 programs" check box must be selected as shown below.



**Figure J-2.** Agilent Connection Expert Options

When LANLook is started, the [Remote Advanced Settings and Information] dialog displays as shown below.



**Figure J-3.** Remote Advanced Settings and Information

LANLook has identified the Agilent software components and has enabled the three remote interfaces, GPIB (488.2), GPIB (VISA), and LAN (VISA). Note that the LAN (VISA) interface functions only if a suitable network connection is available on the PC. Refer to the MT8860C Remote Programming Manual for details.

LANLook will now function with Agilent GPIB hardware and software.



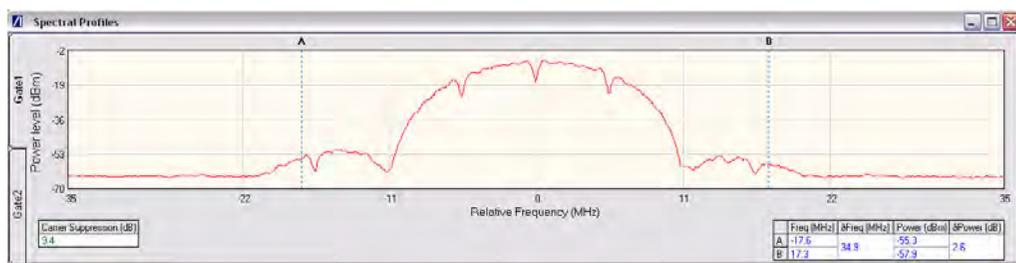
# Appendix K — Calculating RF Carrier Suppression

## K-1 Using IQ Offset Measurement

The IEEE Std 802.11b-1999 (18.4.7.7) specifies that the RF carrier suppression, measured at the channel center frequency, must be at least 15 dB below the peak SIN(x)/x power spectrum. The standard states that the measurement is to be performed while the DUT is configured to transmit a repetitive 01 data sequence with the scrambler disabled using DQPSK modulation. A 100 kHz resolution bandwidth is to be used by the measuring receiver.

The MT8860C performs the carrier suppression measurement by comparing the peak of the frequency response with the channel center frequency. The data pattern is not significant.

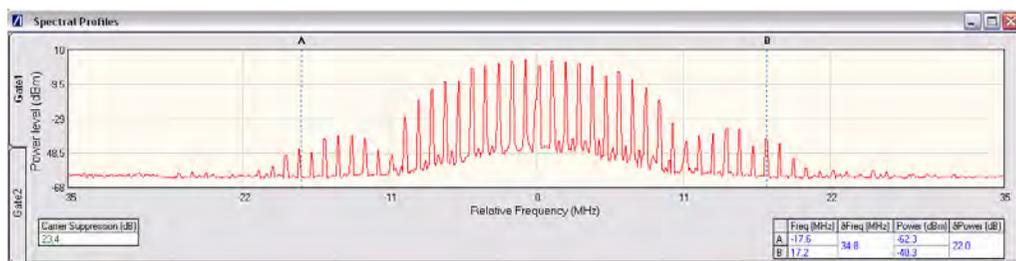
The spectral characteristic of a correctly formatted and scrambled 802.11b DSSS modulated signal are shown in the figure below.



**Figure K-1.** Spectral Characteristic of DSSS Modulated Signal - Scrambler Enabled

As can be seen, the carrier suppression result fails the 15 dB limit.

The RF carrier suppression, as defined in the standard, is a determination of peak ratios. An unscrambled 01 data sequence provides a spectrum with distinct peaks. An IQ offset leads to an additional peak at the center frequency as shown in the figure below.



**Figure K-2.** Spectral Characteristic of DSSS Modulated Signal - Scrambler Disabled

To perform the RF carrier suppression measurement as defined in the IEEE Standard, testing is limited to Direct Mode with the DUT configured using control software supplied by the chipset vendor.

As part of the EVM measurement process, the MT8860C includes an IQ offset measurement that returns the actual carrier feedthrough normalized to the mean power at the symbol timings. This measurement does not require a special test signal to be generated by the DUT and so can be performed in Network Mode. Using the IQ offset, an estimate of the RF Carrier Suppression can be made as follows.

The 802.11b standard employs Direct Sequence Spread Spectrum (DSSS) technology to enable coexistence on the Industrial, Science, and Medicine (ISM) band. This ensures that communications can continue in the presence of an interfering system, although throughput will be affected. DSSS uses a secondary modulation (faster than the information rate) to spread the frequency domain content over a larger band, creating a lower power spectral density. In DSSS, each data bit is modulated by a Pseudo Noise (PN) sequence that achieves the spectral spreading. For data rates of 1 & 2 Mbps, an 11-bit PN sequence is used. This is referred to as a "Barker Sequence". For data rate of 5.5 & 11 Mbps, CCK modulation is used that consists of an 8-bit sequence. This type of spreading technique results in "processing gain", the amount of which will depend upon the length of the PN sequence used.

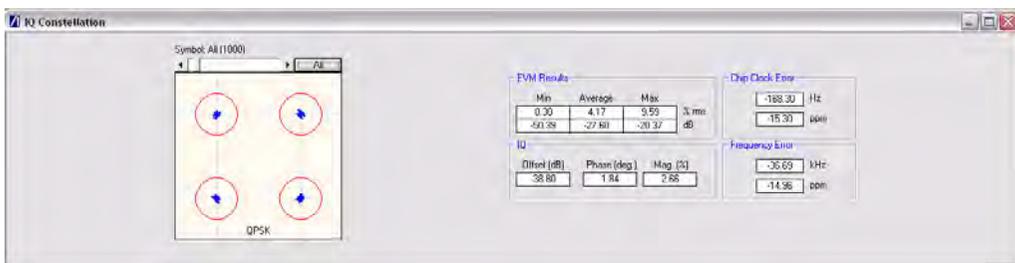
For 1 and 2 Mbps, the processing gain =  $10 \log_{10}(11) = 10.4$  dB.

For 5.5 and 11 Mbps, the processing gain =  $10 \log_{10}(8) = 9.03$  dB.

The IQ offset measurement determines the amount of carrier breakthrough (leakage) that exists. The measurement value is displayed as a ratio against the actual signal level. Given that the 802.11b specification states that the carrier suppression measurement is made relative to the peak of the SIN(x)/x frequency response, the amount of processing gain must be compensated for. Therefore, in the case of 1 and 2 Mbps;

Carrier suppression =  $-1 * (\text{IQ Offset} + 10.4)$

By using the equation above, the IQ offset measurement can be used to provide an estimate of the RF carrier suppression. If we take the example below, the measured IQ offset is -38.8 dB. Based on the equation above, the resultant carrier suppression is 27.6 dB.



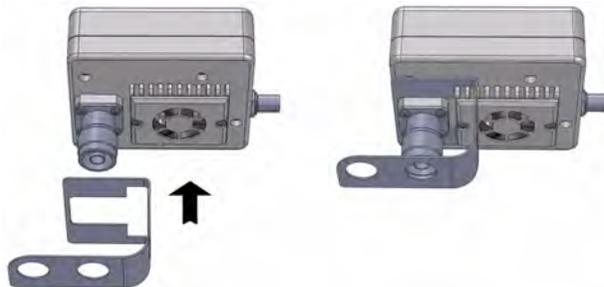
**Figure K-3.** EVM Results including IQ Offset Measurement

# Appendix L — MN8861A Stabilizing Bracket

## L-1 Fitting Procedure

A bracket is supplied to stabilize the MN8861A when used on an MT8860C in a test rack. The stabilizing bracket is not required when the MT8860C is used on a bench top. The procedure below explains how to attach the stabilizing bracket.

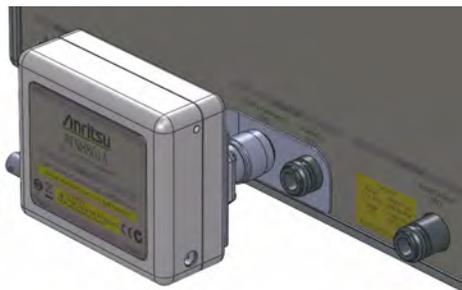
1. Turn the MN8861A round to view the rear side.



---

**Figure 1.** Rear of MN8861A with Stabilizing Bracket

2. Position the bracket over the connector and heat sink as shown in the figure above. Ensure that the bracket is positioned snugly against the fan guard.
3. Turn the MN8861A round to view the front side.
4. Slide the two holes in the stabilizing bracket over the “WLAN Reference” and “Interferer” input ports on the MT8860C as shown in the figure below.



---

**Figure 2.** MN8861A in Position on MT8860C using Stabilizing Bracket

5. Tighten the collar on the MN8861A connector to secure the unit in position.



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