User Manual

RFM3000 Series
RF Power Meter

bkprecision.com

Safety Summary

The following safety precautions apply to both operating and maintenance personnel and must be followed during all phases of operation, service, and repair of this instrument.

WARNING

Before applying power to this instrument:

- Read and understand the safety and operational information in this manual.
- Apply all the listed safety precautions.
- Verify that the voltage selector at the line power cord input is set to the correct line voltage. Operating the instrument at an incorrect line voltage will void the warranty.
- Make all connections to the instrument before applying power.
- Do not operate the instrument in ways not specified by this manual or by B&K Precision.

Failure to comply with these precautions or with warnings elsewhere in this manual violates the safety standards of design, manufacture, and intended use of the instrument. B&K Precision assumes no liability for a customer's failure to comply with these requirements.

Category rating

The IEC 61010 standard defines safety category ratings that specify the amount of electrical energy available and the voltage impulses that may occur on electrical conductors associated with these category ratings. The category rating is a Roman numeral of I, II, III, or IV. This rating is also accompanied by a maximum voltage of the circuit to be tested, which defines the voltage impulses expected and required insulation clearances. These categories are:

Category I (CAT I): Measurement instruments whose measurement inputs are not intended to be connected to the mains supply. The voltages in the environment are typically derived from a limited-energy transformer or a battery.

Category II (CAT II): Measurement instruments whose measurement inputs are meant to be connected to the mains supply at a standard wall outlet or similar sources. Example measurement environments are portable tools and household appliances.

Category III (CAT III): Measurement instruments whose measurement inputs are meant to be connected to the mains installation of a building. Examples are measurements inside a building's circuit breaker panel or the wiring of permanently-installed motors.

Category IV (CAT IV): Measurement instruments whose measurement inputs are meant to be connected to the primary power entering a building or other outdoor wiring.

WARNING

Do not use this instrument in an electrical environment with a higher category rating than what is specified in this manual for this instrument.

WARNING

You must ensure that each accessory you use with this instrument has a category rating equal to or higher than the instrument's category rating to maintain the instrument's category rating. Failure to do so will lower the category rating of the measuring system.

Electrical Power

This instrument is intended to be powered from a CATEGORY II mains power environment. The mains power should be 115 V RMS or 230 V RMS. Use only the power cord supplied with the instrument and ensure it is appropriate for your country of use.

Ground the Instrument

⚠WARNING

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical safety ground. This instrument is grounded through the ground conductor of the supplied, three-conductor AC line power cable. The power cable must be plugged into an approved three-conductor electrical outlet. The power jack and mating plug of the power cable meet IEC safety standards.

⚠WARNING

Do not alter or defeat the ground connection. Without the safety ground connection, all accessible conductive parts (including control knobs) may provide an electric shock. Failure to use a properly-grounded approved outlet and the recommended three-conductor AC line power cable may result in injury or death.

⚠WARNING

Unless otherwise stated, a ground connection on the instrument's front or rear panel is for a reference of potential only and is not to be used as a safety ground. Do not operate in an explosive or flammable atmosphere.

⚠WARNING

Do not operate the instrument in the presence of flammable gases or vapors, fumes, or finely-divided particulates.

⚠WARNING

The instrument is designed to be used in office-type indoor environments. Do not operate the instrument

- In the presence of noxious, corrosive, or flammable fumes, gases, vapors, chemicals, or finely-divided particulates.
- In relative humidity conditions outside the instrument's specifications.
- In environments where there is a danger of any liquid being spilled on the instrument or where any liquid can condense on the instrument.
- In air temperatures exceeding the specified operating temperatures.
- In atmospheric pressures outside the specified altitude limits or where the surrounding gas is not air.
- In environments with restricted cooling air flow, even if the air temperatures are within specifications.
- In direct sunlight.

This instrument is intended to be used in an indoor pollution degree 2 environment. The operating temperature range is 0°C to 40°C and 20% to 80% relative humidity, with no condensation allowed. Measurements made by this instrument may be outside specifications if the instrument is used in non-office-type environments. Such environments may include rapid temperature or humidity changes, sunlight, vibration and/or mechanical shocks, acoustic noise, electrical noise, strong electric fields, or strong magnetic fields.

Do not operate instrument if damaged

WARNING

If the instrument is damaged, appears to be damaged, or if any liquid, chemical, or other material gets on or inside the instrument, remove the instrument's power cord, remove the instrument from service, label it as not to be operated, and return the instrument to B&K Precision for repair. Notify B&K Precision of the nature of any contamination of the instrument.

Clean the instrument only as instructed

WARNING

Do not clean the instrument, its switches, or its terminals with contact cleaners, abrasives, lubricants, solvents, acids/bases, or other such chemicals. Clean the instrument only with a clean dry lint-free cloth or as instructed in this manual. Not for critical applications

WARNING

This instrument is not authorized for use in contact with the human body or for use as a component in a life-support device or system.

Do not touch live circuits

WARNING

Instrument covers must not be removed by operating personnel. Component replacement and internal adjustments must be made by qualified service-trained maintenance personnel who are aware of the hazards involved when the instrument's covers and shields are removed. Under certain conditions, even with the power cord removed, dangerous voltages may exist when the covers are removed. To avoid injuries, always disconnect the power cord from the instrument, disconnect all other connections (for example, test leads, computer interface cables, etc.), discharge all circuits, and verify there are no hazardous voltages present on any conductors by measurements with a properly-operating voltage-sensing device before touching any internal parts. Verify the voltage-sensing device is working properly before and after making the measurements by testing with known-operating voltage sources and test for both DC and AC voltages. Do not attempt any service or adjustment unless another person capable of rendering first aid and resuscitation is present.
Do not insert any object into an instrument's ventilation openings or other openings.

WARNING

Hazardous voltages may be present in unexpected locations in circuitry being tested when a fault condition in the circuit exists.

WARNING

Fuse replacement must be done by qualified service-trained maintenance personnel who are aware of the instrument's fuse requirements and safe replacement procedures. Disconnect the instrument from the power line before replacing fuses. Replace fuses only with new fuses of the fuse types, voltage ratings, and current ratings specified in this manual or on the back of the instrument. Failure to do so may damage the instrument, lead to a safety hazard, or cause a fire. Failure to use the specified fuses will void the warranty.

Servicing

WARNING

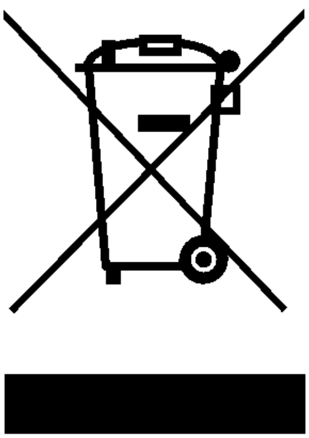
Do not substitute parts that are not approved by B&K Precision or modify this instrument. Return the instrument to B&K Precision for service and repair to ensure that safety and performance features are maintained.

For continued safe use of the instrument

- Do not place heavy objects on the instrument.
- Do not obstruct cooling air flow to the instrument.
- Do not place a hot soldering iron on the instrument.
- Do not pull the instrument with the power cord, connected probe, or connected test lead.
- Do not move the instrument when a probe is connected to a circuit being tested.

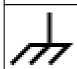
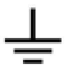
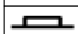
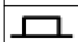
Compliance Statements

Disposal of Old Electrical & Electronic Equipment (Applicable in the European Union and other European countries with separate collection systems)



This product is subject to Directive 2002/96/EC of the European Parliament and the Council of the European Union on waste electrical and electronic equipment (WEEE), and in jurisdictions adopting that Directive, is marked as being put on the market after August 13, 2005, and should not be disposed of as unsorted municipal waste. Please utilize your local WEEE collection facilities in the disposition of this product and otherwise observe all applicable requirements.

Safety Symbols

Symbol	Description
DANGER	indicates a hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	indicates a hazardous situation which, if not avoided, could result in death or serious injury
CAUTION	indicates a hazardous situation which, if not avoided, will result in minor or moderate injury
	Refer to the text near the symbol.
	Electric Shock hazard
~	Alternating current (AC)
	Chassis ground
	Earth ground
	This is the In position of the power switch when instrument is ON.
	This is the Out position of the power switch when instrument is OFF.
NOTICE	is used to address practices not related to physical injury.

Contents

General Information

This instruction manual provides you with the information you need to install, operate, and maintain the RFM3000 RF Power Meter. Section 1 is an introduction to the manual and the instrument.

1.1 Organization

The manual is organized into five sections and two Appendices, as follows:

Section 1 **General Information** presents summary descriptions of the instrument and its principal features, accessories, and options.

Section 2 **Installation** provides instructions for unpacking the instrument, setting it up for operation, connecting power and signal cables, and initial power-up.

Section 3 **Getting Started** describes the controls and indicators and the initialization of operating parameters. Several practice exercises are provided to familiarize yourself with essential setup and control procedures.

Section 4 **Operation** describes the display menus and procedures for operating the instrument locally from the front panel.

Section 5 **Application Notes** provides supplementary information about RFM3000 and sensor operation, advanced features, pulse measurement information, and measurement accuracy.

1.2 Description

The RFM3000 provides design engineers and technicians the utility of traditional benchtop instruments, the flexibility and performance of modern USB RF power sensors, and the simplicity of a multi-touch display built with advanced technology.

As a benchtop meter, the RFM3000 provides a standalone solution for capturing, displaying, and analyzing peak and average RF power in both the time and statistical domains through an intuitive, touch screen display.

The RFM3000 RF Power Meter utilizes up to four RFP Series Sensors with industry-leading performance and capabilities either independently or for synchronized multi-channel measurements of CW, modulated, and pulsed signals.

Providing the ultimate flexibility, the RFM3000 sensors can be disconnected and independently used as standalone instruments.

1.3 Features

- Compatible with B&K Precision's RFP3000 Series USB RF Power Sensors
- Capture/display/analyze peak and average power
- Independent or synchronous multi-channel measurements (up to 4 channels)
- Trigger synchronization
- Supports SCPI-1999.0
- Sensor verification test source
- Display 16 common power measurements
- Ethernet:10/100/1000 BaseT; HiSLIP
- HDMI output for mirror display
- Sensors can be used as standalone instruments

1.4 Front Panel

Refer to table 1.1 for a description of each of the illustrated items. The function and operation of all controls, indicators, and connectors are the same on the standard and optional models.

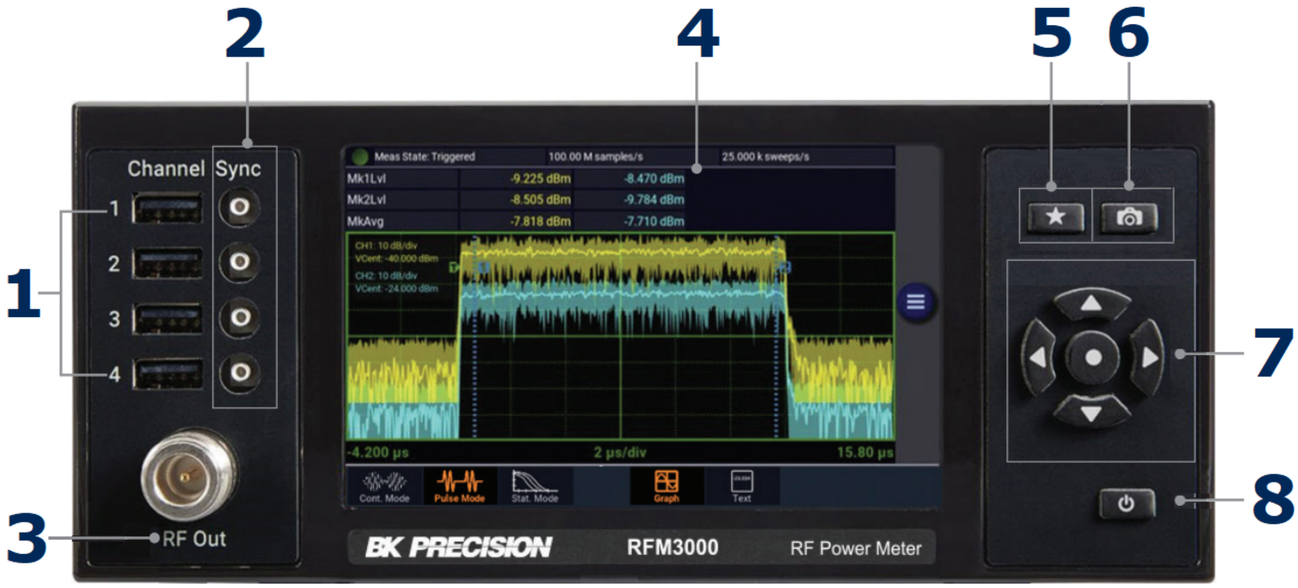


Figure 1.1 Front Panel

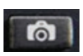
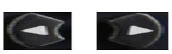
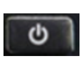
Item		Description
1	USB Host	Four sensor inputs are located on the front and rear panels of the instrument. These are standard USB 2.0 Type A receptacles designed to accept only RFP3000 Series Sensors or standard USB keyboards, mice, and flash drives.
2	Sync Ports	Four sensor trigger inputs are located on the front and rear panels of the instrument. These are standard SMB receptacles designed to accept only BK Precision power sensor trigger cables. ⚠CAUTION **Do not attempt to connect anything other than RFP3000 sensors and trigger cables!**
3	RF Output	The output of the built-in 50 MHz programmable test source is available from a Type-N connector located on the front, or optionally on the rear panel of the instrument. This test source is used to verify basic performance of sensors used with the RFM3000.
4	Display Screen	Color touch screen display for the measurement and trigger channels, screen menus, status messages, text reports, and help screens.
5		Favorites key. (This function is not fully implemented at this time). Enables the user to setup a customized menu to allow grouping frequently used menu items into one convenient menu.
6		Store image key saves a screen image of the meter to local storage. The images can be copied to an external USB storage device.
7		Used to assist navigating between items on the display and in the menus. Unless the user is in digit editing numeric entry mode.
		Used for incrementing or decrementing numeric parameters, or scrolling through multi-line or multi-page displays.
		Selects an on-screen item or menu and completes a numeric or picklist entry
8		Toggles the instrument between "on" (fully powered) and "standby" (off, except for certain low-power internal circuits) modes. Entering standby mode will perform a save of the current instrument state before shutdown. Pressing and holding the On/Standby key for several seconds will force standby mode if the instrument has become non-responsive. In this case, no context save is performed

Table 1.1 Front Panel

1.5 Rear Panel

Refer to table 1.2 for a description of each of the illustrated items. The function and operation of all controls, indicators, and connectors are the same on the standard and optional models.

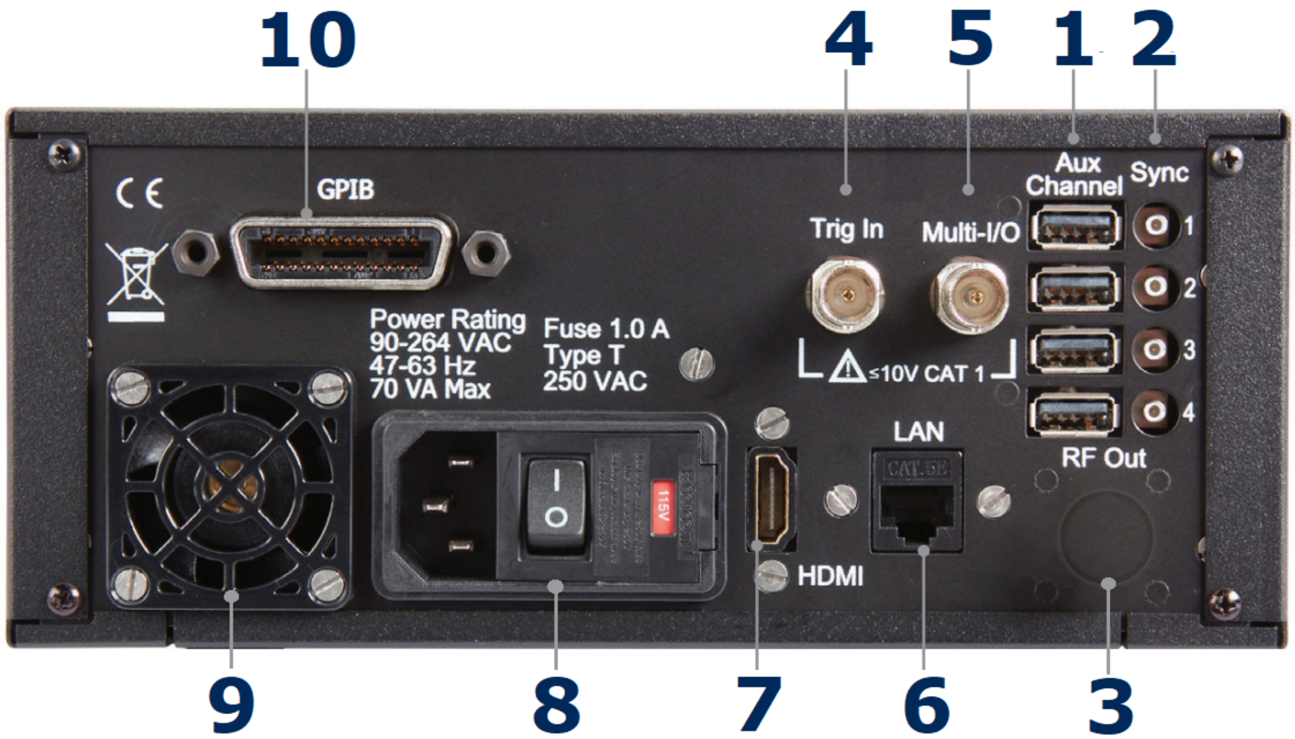


Figure 1.2 Rear Panel

Item		Description
1	USB Host	Four sensor inputs are located on the front and rear panels of the instrument. These are standard USB 2.0 Type A receptacles designed to accept only RFP3000 Series Sensors or standard USB keyboards, mice, and flash drives.
2	Sync Ports	Four sensor trigger inputs are located on the front and rear panels of the instrument. These are standard SMB receptacles designed to accept only BK Precision power sensor trigger cables. **CAUTION** **Do not attempt to connect anything other than RFP3000 sensors and trigger cables!**
3	RF Output	The output of the built-in 50 MHz programmable test source is available from a Type-N connector located on the front, or optionally on the rear panel of the instrument. This test source is used to verify basic performance of sensors used with the RFM3000.
4	Trig In	BNC input for connecting an external trigger signal to the power meter. Voltage range is ±5 volts, but the input impedance is 1 Megohm to allow use of common 10x oscilloscope probe for a ±50 volt input range.
5	Multi-I/O	BNC input/output for flexible use. May serve as a status or alarm output, signal level monitor, or settable voltage source
6	LAN Ethernet	LAN connector for remote control and firmware updates. Allows DHCP or fixed (IP / Subnet) setting mode. LAN parameters can be configured through the menu.
7	HDMI	HDMI receptacle for connecting an external monitor to mirror front panel display. The image resolution will be 800 x 480 and will be stretched to fit the external full display size.
8	AC Line Input	A multi-function power input module is used to house the AC line input, main power switch, and safety fuse. The module accepts a standard AC line cord, included with the power meter. The power switch is used to shut off main instrument power. The safety fuse may also be accessed once the line cord is removed. The instrument's power supply accepts 90 to 264 VAC, so no line voltage selection switch is necessary. **CAUTION** **Replace fuse only with specified type and rating: 1.0A-T (time delay type), 250 VAC.**
9	HDMI	Cooling air intake.
10	GPIB	24-pin GPIB (IEEE-488) connector for connecting the power meter to the remote control General Purpose Instrument Bus. GPIB parameters can be configured through the menu.

Table 1.2 Rear Panel

1.6 Touch Screen Display

The RFM3000 can be controlled through the touch screen display and by use of the front panel buttons. Table **1.3** describes the different areas of the display layout of the RFM3000. Figure **1.3** shows the Graph Display mode of the instrument using the Pulse Measure mode with a menu exposed. Figure **1.4** shows the same measure mode with the menus hidden. The Text Display mode of the instrument provides a table view of measured parameters. Parameters depend on the Measure mode selected. See Section Menu Referencefor more information on the display format.

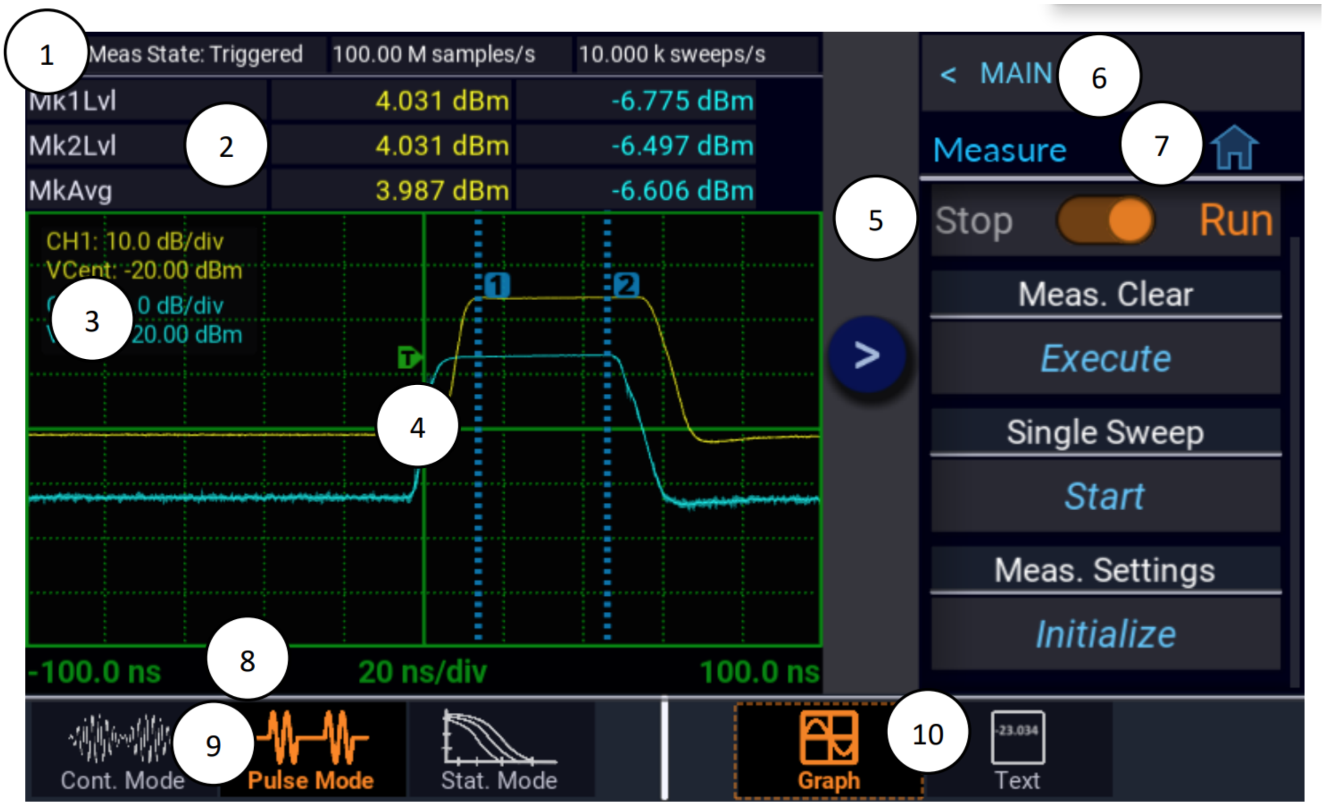


Figure 1.3 Display

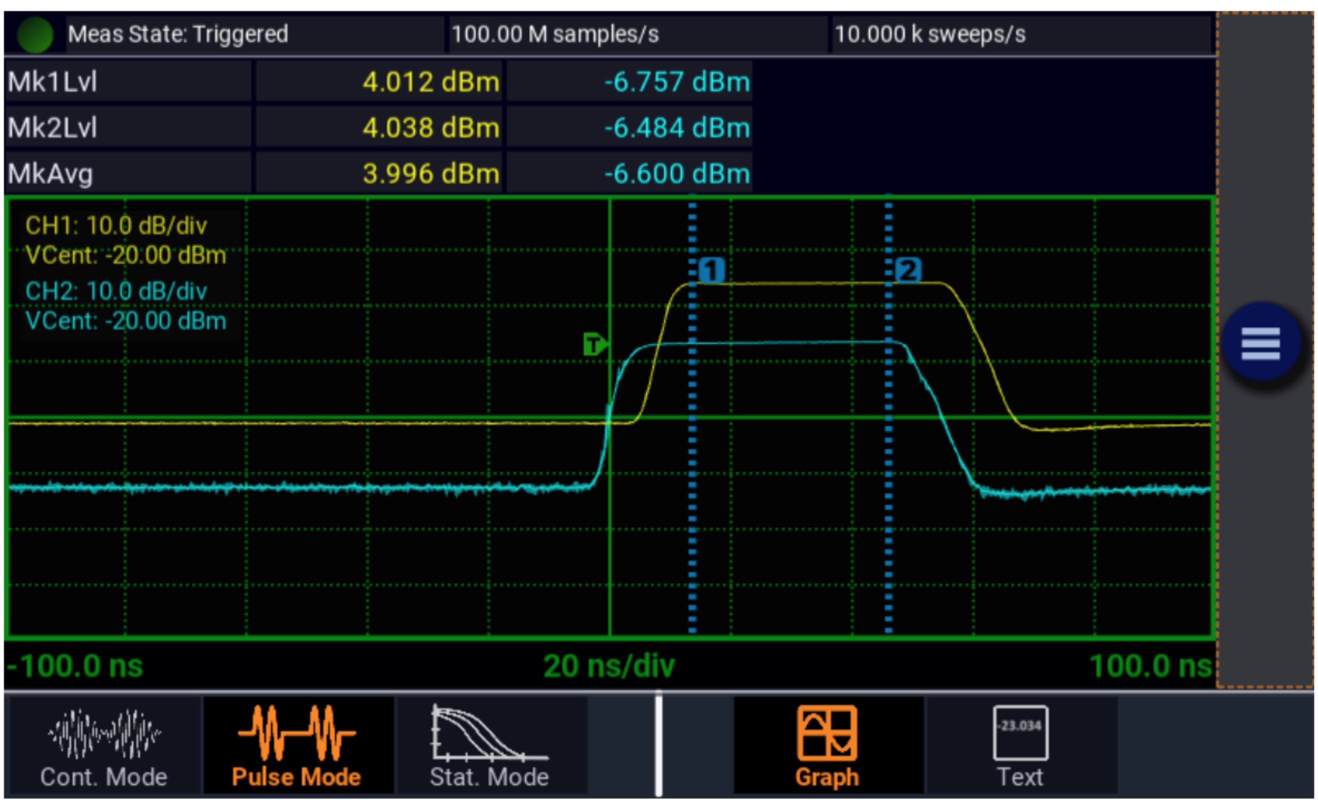


Figure 1.4 Display Hidden Menu

Item		Description
1	Status Bar	Indicates the measurement acquisition status of the unit. In Pulse mode, the sample rate and number of sweeps per second are also shown. In Statistical mode, it indicates the gating setting in use, run time, and number of points.
2	Parameters	Displays a table of measurements for each channel that is enabled on the meter. In Pulse and Continuous mode, measurements indicated are for power levels at each marker and the average power between the markers. For Statistical mode, the measurements are Average power, Maximum power, and Peak-to-Average Ratio or Crest Factor.
3	Channel Status	This area indicates which channels are ON and their individual scale and vertical center. NOTICE **The base RFM3000 model only permits two sensors to be active at any one time. With the RFM300-4CH option, four sensors can be active at any one time.**
4	Main Display	This area will show a plot when in Graph Display mode or a table of parameters when in Text Display mode for the measurement mode selected.
5	Menu Bar	Select to show and to hide the on-screen menus.
6	Menu Parth	Used to navigate the menu structure. Shows the menu that will be displayed when selected.
7	Current Menu/Home	Displays the name of the current menu and provides a home shortcut to the top-level Main menu. When in the Main or top level menu, this field is not available.
8	Horizontal Scale	For Pulse and Continuous mode, indicates the time per division for the waveform display. In Statistical mode, the horizontal scale for the CCDF graph is in dBr (dB relative).
9	Measure Mode	Indicates and allows selection of the current Measurement mode. Modes available are Continuous, Pulse, and Statistical.
10	Display Mode	Indicates and allows selection of the current Display mode in use. Modes available are Graph and Text. NOTICE **The Graph Display mode for Continuous Measure mode will be a flat trace. It is best to use Text Display mode for continuous signal measurements.**

Table 1.3 Display

Installation

This section contains unpacking and repacking instructions, power requirements, connection descriptions, and preliminary checkout procedures.

2.1 Contents

Please inspect the instrument mechanically and electrically upon receiving it. Unpack all items from the shipping carton, and check for any obvious signs of physical damage that may have occurred during transportation. Report any damage to the shipping agent immediately. Save the original packing carton for possible future reshipment. Every power supply is shipped with the following contents:

- RFM3000 RF Power Meter
- Line Cord
- Information Card (describes where to download the latest manual, software, utilities)

2.2 Input Power & Fuse Requirements

The RFM3000 is equipped with a switching power supply that provides automatic operation from a line voltage input within: The supply has a universal AC input that accepts line voltage input within:

Voltage: 100 - 240 VAC (+/- 10 %)
Frequency: 43 to 63 Hz
Input Power: 70 VA MAX.

CAUTION

Before connecting the instrument to the power source, make certain that a 1.0-ampere time delay fuse (type T) is installed in the fuse holder on the rear panel.

Before removing the instrument cover for any reason, position the input module power switch to off (0 = OFF; 1 = ON) and disconnect the power cord.

Connect the power cord supplied with the instrument to the power receptacle on the rear panel. See figure ??

WARNING

The included AC power cord is safety certified for this instrument operating in rated range. To change a cable or add an extension cable, be sure that it can meet the required power ratings for this instrument. Any misuse with wrong or unsafe cables will void the warranty.

2.3 Connections

Sensor(s) Compatible sensors can be connected to any of the USB ports on the front or rear panel. The base RFM3000 model only permits two sensors to be active at any one time. With the RFM3000-4CH model, four sensors can be active at any one time. Sensors become active when plugged into a USB port or immediately if already plugged in when the RFM3000 powers up.

Note:

The base RFM3000 model only permits two sensors to be active at any one time.
With the RFM3000-4CH option, four sensors can be active at any one time.

Trigger Most triggered applications can use the RF signal applied to the sensors for triggering. For measurements requiring external triggering, connect the external trigger signal to the **Trig In** BNC connector on the rear panel and connect a Sync cable from the Sync connector on the meter to the **Multi I/O** port on the sensor.

Note:

The Sync cable must be connected to the Sync port corresponding to the USB port for the sensor Channel in use.

Remote If the instrument is to be operated remotely using the GPIB (IEEE-488) bus, connect the instrument to the bus using the rear panel GPIB connector and appropriate cable. For Ethernet control, connect to the rear panel LAN connector. In most cases, it will be necessary to configure the interface using the System > I/O > Config menu.

2.4 Preliminary Check

The preliminary check verifies that the instrument is operational and has the correct software installed. It should be performed before the instrument is placed into service.

To perform the preliminary check, proceed as follows:

1. Press the lower half (marked "O") of the power switch in the center of the power module on the rear panel.
2. Connect the AC (mains) power cord to a suitable AC power source; 90 to 264 VAC, 47 to 63 Hz.
   – The power supply will automatically adjust to voltages within this range.
3. Press the upper half (marked "—") of the power switch in the center of the power module on the rear panel, it will enter standby mode.
4. Press the ON/STBY key on the front panel to turn the instrument on. The cooling fan and display backlight should turn on.
5. A bootup screen should appear that shows the boot status. After a self-check, the instrument will execute the application program. There will be some temporary dialogs indicating application initialization and channel updating. After several moments, a screen similar to figure 2.1 should be displayed.

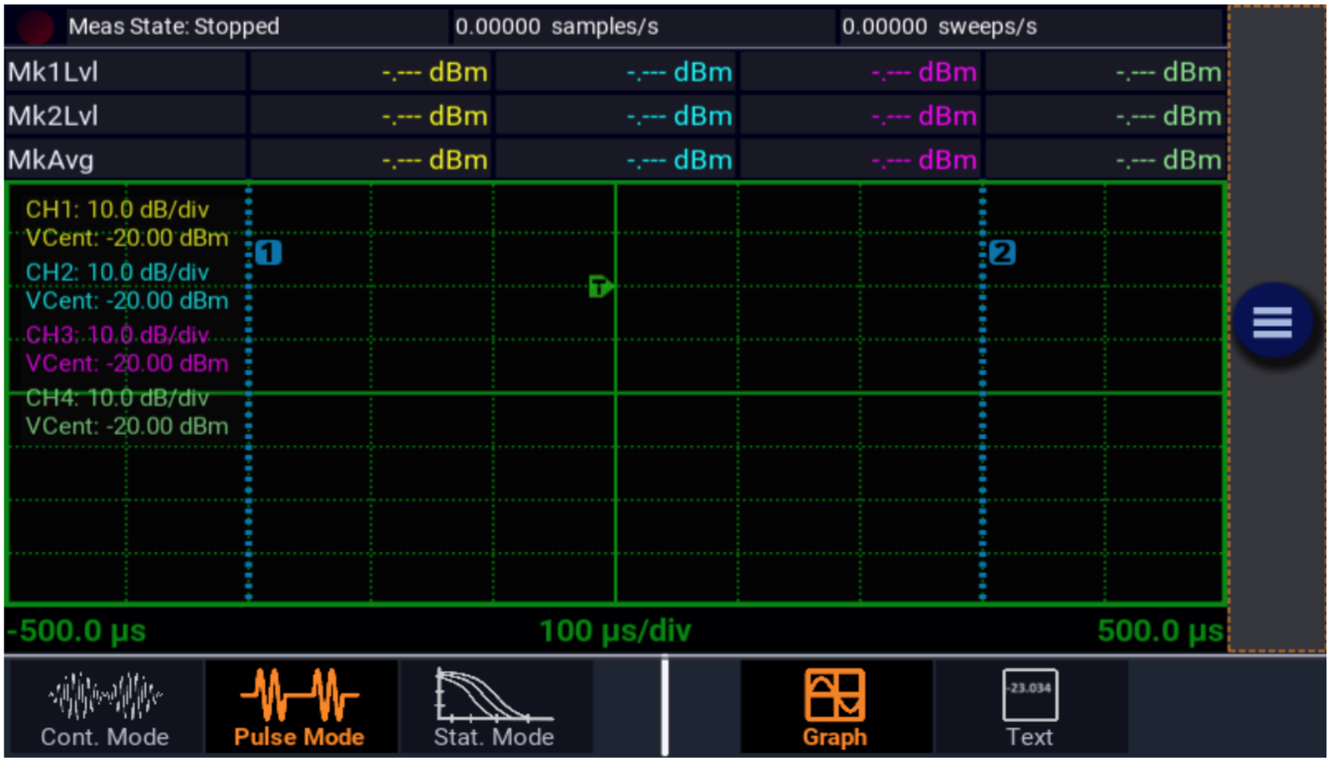


Figure 2.1 Power-On Display

6. On the front panel, press the select key to bring up the on-screen menu. From the Main menu, use the touch screen or the navigation keys on the front panel to browse to System > Reports > Configuration and select Show. A display similar to figure 2.2 will appear.

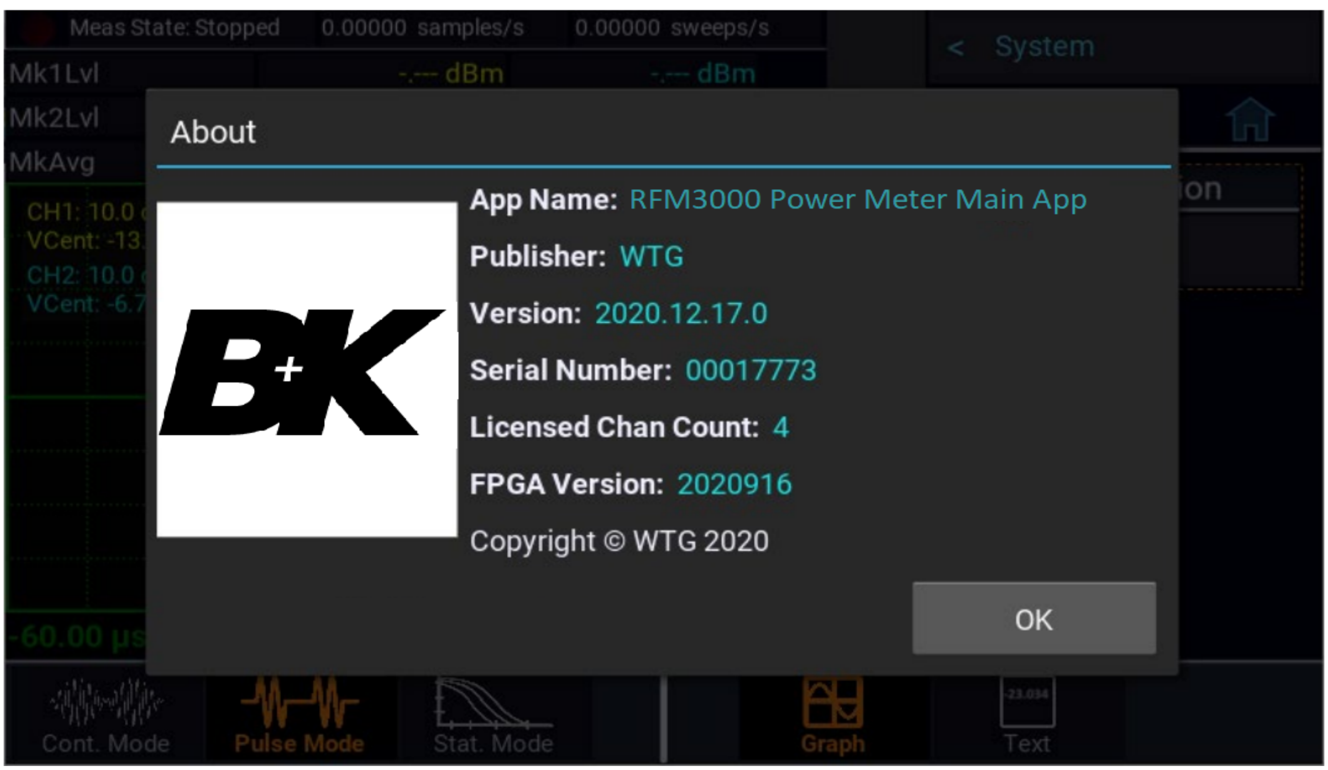


Figure 2.2 Configuration Report Display

Getting Started

This chapter will introduce the user to the RFM3000 RF Power Meter. The chapter will identify display organization, list the configuration of the instrument after initializing, and provide practice exercises for front panel operation. For additional information, see Section 4 **Operation**.

3.1 Initialization

The steps below initialize the RFM3000 and prepare it for normal operations. Step 3 should only be performed when you wish to set the meter operations to a known state. This is typically done when you first power on the instrument or at the start of a new test.

1. If the main power is off, press the power switch located on the rear panel. See figure **1.2**.
2. Press the key to turn on the RFM3000.
3. After a self-check, the instrument will execute the application program.
   - There will be some momentary dialogs indicating application initialization and channel updating.
   - After the last dialog the main screen will be on the display.

CAUTION

When selecting a sensor for an exercise or a measurement, be sure you know the power range of the sensor. Operation beyond the specified upper power limit may result in a permanent change of characteristics or burnout.

4. Connect the sensor USB cable to the Channel 1 input on the front or rear of the instrument.
   - When the sensor is connected or disconnected, the instrument will momentarily show a channel update dialog.

Note:

Connecting the Sync cable from the Multi I/O port on the sensor to the corresponding Sync port on the instrument for the sensor in use is necessary if using an external trigger or when performing measurements across multiple channels

5. Use the nagivation keys to navigate the menus.
   - The touch screen can be used to navigate the menus.
6. From the **Main** menu, select the **Measure** menu, and navigate to the **Meas. Settings** option.
7. Select **Initialize**.
   - This will load the default operating parameters listed in table **3.1**.
   - This table only shows the parameters that are affected by initialization.

Parameter	Default
Measure Mode Select	Graph
Parameters Related to the Measure Menu Measurement	
Measurement	Run
Parameters Related to the Display Menu	
View	Graph
Parameters Related to the Channel > Channel # > Menus	
Channel1	On
Channel2	On
Channel3	On(4 CH option)
Channel4	On(4 CH option)
Vertical Scale	10 dB/Div
Vertical Center	-20.00 dBm
Averaging	8
Units	dBm
Video BW	HIGH
Peak Hold	OFF
dB Offset	0 dB
Parameters Related to the Time Menu	
Timebase	100 uS/div
Position	5.0 divisions
Trigger Delay	0.0 uS
Parameters Related to the Trigger Menu	
Holdoff	0 uS
Trigger Mode	AUTOPKPK
Trigger Slope	Positive
Trigger Source	CH1
Parameters Related to the Markers Menu	
Marker 1	-300 uS
Marker 2	300 uS
Parameters Related to the Pulse Def. > CH# Pulse Def > Menus	
Distal	90%
Mesial	50%
Proximal	10%
Pulse Units Watts	
Start Gate	5.00%
End Gate	95%
Parameters Related to the Stat Mode Menu	
Cursor Mode	Power

Table 3.1 Default

3.2 Taking Measurements

To perform accurate measurements, the following is a minimum list of things you should know about the signal that you wish to measure.

Signal Frequency

The center frequency of the carrier must be known to allow sensor frequency response compensation.

Modulation Bandwidth

If the signal is modulated, know the type of modulation and its bandwidth. Note that power sensors respond only to the amplitude modulation component of the modulation, and constant envelope modulation types such as FM can be considered a CW carrier for power measurement purposes.

3.2.1 Continuous Mode

Continuous mode is best for measuring repetitive signals. Since this mode performs a continuous measurement, it does not differentiate between the times a pulsed or periodic signal is off, and the times it is on. If you wish to make measurements that are synchronous with a period of a waveform, consider using Pulse mode instead.

Continuous mode is best for the following types of measurement:

- Moderate signal level (above -40 dBm for Peak sensors and -60 dBm for CW sensors).
- Signal that is CW or continuously modulated with a modulation bandwidth that is less than the VBW of the sensor in use.
- Signal modulation may be periodic, but only non-synchronous measurements are needed (overall average and peak power).
- Noise-like digitally modulated signals such as CDMA and OFDM when only average measurements are needed.

The measured result is the average power of the signal. Since the graphic display would basically just show a straight line, measurements in Continuous mode are best viewed using the Text Display mode. Figure 3.1 shows a two-channel measurement displaying an average, minimum, and maximum power in Continuous mode.

Figure 3.1 Average

3.2.2 Pulse Mode

For periodic or pulsed signals, it is often necessary to analyze the power for a portion of the waveform, or a certain region of a pulse or pulse burst. For these applications, the RFM3000 Series has a triggered **Pulse** mode.

The trigger signal can be either internal, triggered from a rising or falling edge on the measured signal; or external, triggered from a rear-panel BNC input. The trigger level and polarity are both programmable, as is the trigger delay time and trigger holdoff time. Displays of both pre- and posttrigger data are available, and an auto-trigger mode can be used to keep the trace running when no trigger edges are detected.

An auto peak-to-peak trigger level setting can be chosen to automatically set the trigger level based on the currently applied signal. The timebase can be set from 5 ns/div to 50 ms/div. The RFM3000's graphical display has 10 horizontal and 8 vertical divisions. Vertical units can be set in dBm, Watts, and dB Volts. Setting vertical resolution does not affect the sensitivity of the instrument and is provided for ease of viewing.

Programmable markers can be moved to any portion of the trace that is visible on the screen. They can be used to mark regions of interest for detailed power analysis. The instrument can display power at each marker, as well as average, minimum, and maximum power in the region between the two markers. This is very useful for examining the power during a TDMA or GSM burst when only the modulated portion in the center region of a timeslot is of interest.

By adjusting trigger delay and other parameters, it is possible to measure the power of specific timeslots within the burst. Trigger holdoff allows burst synchronization even if there is more than one edge in the burst that may satisfy the trigger level. Set the holdoff time to slightly shorter than the burst's repetition interval to guarantee that triggering occurs at the same point in the burst each sweep. Figure 3.2shows marker measurements for pulses on CH1 and CH2.

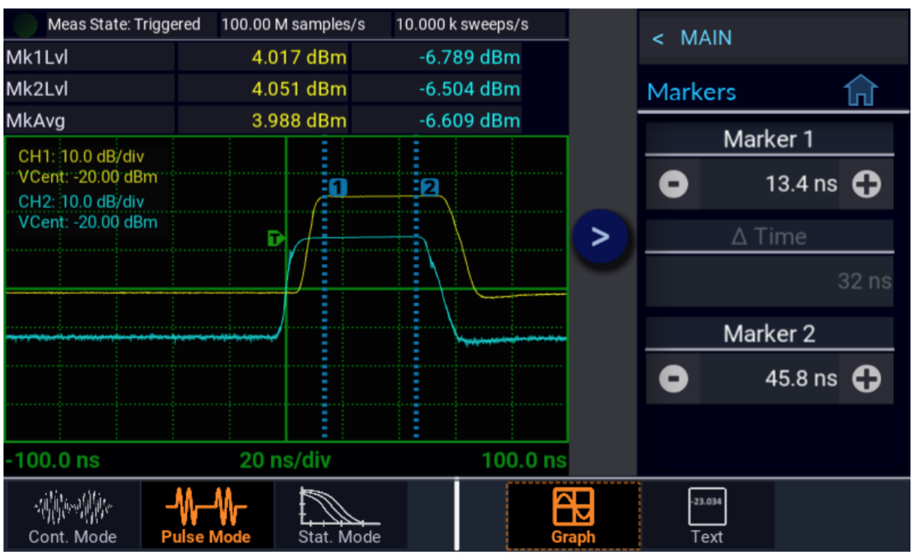


Figure 3.2 Marker Measurements

Pulse mode is only available when using RFP Series power sensors and is the best choice for most pulse modulated and periodic signals. Pulse mode requires a repeating signal edge that can be used as a trigger, or an external trigger pulse that is synchronized with the modulation cycle.

Pulse mode performs measurements that are synchronous with the trigger (that is the measurements are timed or gated) so that the same portion of the waveform is measured on each successive modulation cycle. Multiple modulation cycles may be averaged together, and measurement intervals may span both before and after the trigger.

Pulse mode is best for the following types of measurements:

- Moderate signal level (above about -40 dBm except when modulation is off).
- The signal is periodic.
- A time snapshot of a single event is needed (minimum single-shot time is 200 nanoseconds).
- Typical modulation and signal types: LTE, 5G, RADAR, SatCom, TCAS, Bluetooth, Wireless LAN.

3.2.3 Statistical Mode

Certain modulated signals are completely random and provide no event that can serve as a trigger for measurements. CDMA or OFDM are common examples. The RFM3000's **Statistical** mode was designed to provide measurements for these types of signals.

Statistical mode is only available when using peak power sensor. It is the best choice for analyzing signals with a high crest factor, that are noise-like with random or infrequent peaks, or are modulated in a random, non-periodic fashion. Statistical mode yields information about the probability of occurrence of various power levels without regard for when those power levels occurred.

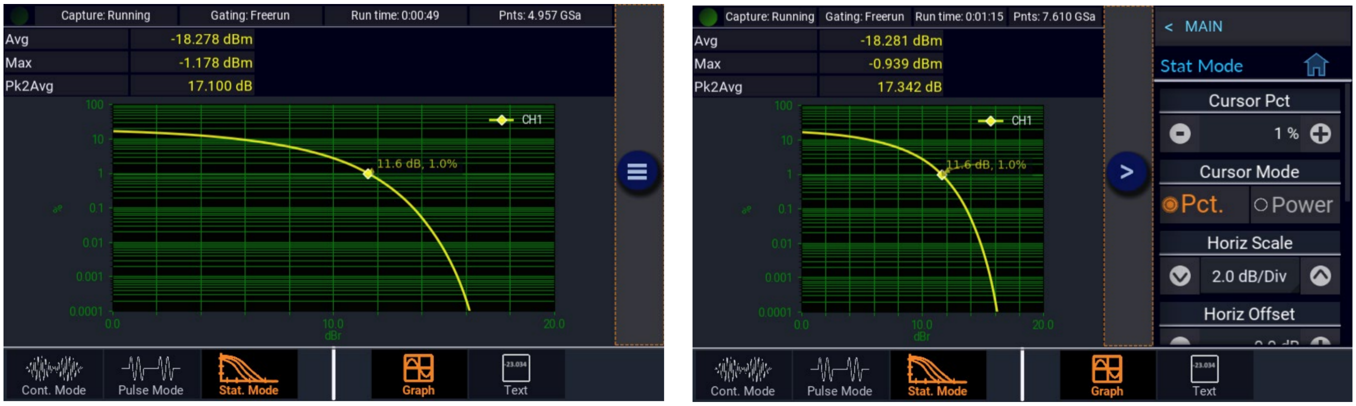
In Statistical mode the instrument continuously samples the input signal and processes all of the samples to build power histograms. Many digitally modulated spread-spectrum formats use bandwidth coding techniques or many individual modulated carriers to distribute a source's digital information over a wide bandwidth, and temporally spread the data for improved robustness against interference. When these techniques are used, it is difficult to predict when peak signal levels will occur. Analysis of millions of data points gathered during a sustained measurement of several seconds or more can yield the statistical probabilities of each signal level with a high degree of confidence.

Statistical mode is best forthe following types of measurements:

- Moderate signal level (above about -40 dBm except when modulation is off).
- Noise-like digitally modulated signals such as CDMA (and all its extensions) or OFDM when probability information is helpful in analyzing the signal.
- Any signal with random, infrequent peaks, when you need to know the peak-to-average ratio or Crest Factor and just how infrequent those peaks are.

Complementary Cumulative Distribution Function (CCDF)

The statistical analysis of the current sample population is displayed using a normalized Complementary Cumulative Distribution Function (CCDF) presentation shown in figure ??. The CCDF is the probability of occurrence of a range of peak-to-average power ratios on a log-log scale. CCDF is non-increasing in y-axis and the maximum power sample lies at 0%. A cursor allows measurement of power or percentage at a user-defined point on the CCDF. As with all other graphical displays, the trace can be easily scaled and zoomed. The statistical data may be presented as a table in Text Display mode.
The CCDF is a useful tool for analyzing communication signals that have a Gaussian-like distribution (CDMA, OFDM) where signal compression can be observed at rarely occurring peaks. It is most often presented graphically using a log-log format where the x-axis represents the relative offset in dB from the average power level and the log-scaled y-axis is the percent probability that power will exceed the x-axis value.



CCDF CCDF with Cursor Menu

Figure 3.3 CCDF

In a non-statistical peak power measurement, the peak-to-average ratio is the parameter that describes the headroom required in linear amplifiers to prevent clipping or compressing the modulated carrier. The meaning of this ratio is easy to visualize in the case of simple modulation in which there is close correspondence between the modulating waveform and the carrier envelope. When this correspondence is not present, the peak-to-average ratio alone does not provide adequate information.

It is necessary to know what fraction of time the power is above (or below) particular levels. For example, some digital modulation schemes produce narrow and relatively infrequent power peaks that can be compressed with minimal effect. The peak-to-average ratio alone would not reveal anything about the fractional time occurrence of the peaks, but the CCDF clearly shows this information. In Figure 3-8, assume a full length run of one hour plus has been made and the CCDF is analyzed. At 0% is the maximum peak power that occurred during the entire run. At 1% is the power level that was exceeded only 1% of the time during the entire run.

Note that this analysis does not depend upon any particular test signal, or upon synchronization with the modulating signal. The analysis can be done using actual communication system signals. Normal operation is not disturbed by the need to inject special test signals. This type of analysis is particularly suited to the situation in which the bit error rate (BER) or some other error rate measure is correlated with the percentage of time that the signal is corrupted. If known short intervals of clipping are tolerable, the CCDF can be used to determine optimum transmitter power output. The CCDF is also used to evaluate various modulation schemes to determine the demands that will be made on linear amplifiers and transmitters and the sensitivity to non-linear behavior.

Operation

This section presents the control menus and procedures for operating the RFM3000 in the manual mode. All the display menus that control the instrument are illustrated and accompanied by instructions for using each menu item.

4.1 Control Menus

The menus that control the RFM3000 RF are accessed from the top-level MAIN menu. Display the MAIN menu by selecting the icon on the display. The Menus and parameters may be selected by using the navigation keys or the touch screen.

Some menus have mode-dependent properties. Typically, one or more menu boxes in a submenu may change as the measurement mode is changed from Continuous to Pulse to Statistical. Section **Menu Reference** these menus are indicated for mode dependency.

Menus with more selections than what fits on the display can be scrolled with the touch screen or front panel buttons.

4.2 Parameter Date Entry and Selection

The RFM3000's parameters can be changed in various ways depending on the type of parameter being addressed.

4.2.1 Numerical Data Entry & Drop Down Menus

Numerical data can be incremented/decremented by selecting the "+" and "–" icons with the front panel keys or by touching them. Selecting the numeric setting brings up an on-screen numeric keypad as shown in figure **4.1**.

Some parameters use a drop down menu to select a setting. The Trigger source setting in figure **4.1** is an example of a drop down menu. Use the arrow up and down icons to cycle through the settings or select the value to view all available option in the drop down menu.

Numeric Keypad

Trig Source Drop Down Menu

Figure 4.1 Numerical Data Entry & Drop Down Menus

4.3 Menu Reference

4.3.1 Main Menu

To open the **Main** menu press the icon.

The Main Menu shown in figure 4.2 is the top most menu level from which all other menus originate.

Measure >

Display >

Stat. Mode >

Channel >

Time >

Trigger >

Markers >

Pulse Def. >

Favorites >

System >

When navigating any submenu the icon will appear to the right of the submenu name.

Press the icon to return to the main menu.

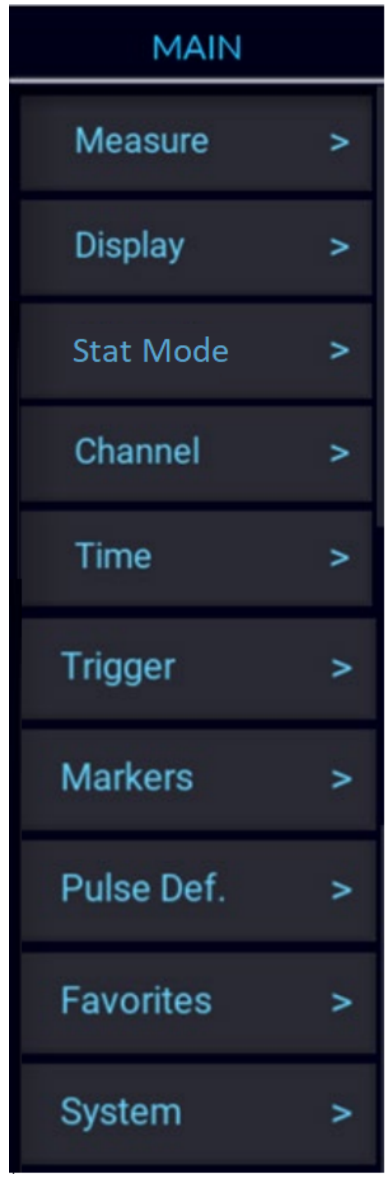


Figure 4.2 Main Menu

4.3.2 Measure >

To enter the **Measure** menu:

Press the ≡ icon then select the **Measure** menu.

The available setting vary depending on the mode selected. See figure **4.3** to view the available settings in each menu.

Measurement

Toogle the state of the data acquisition mode for taking measurements. If Measurement is set to Run, the RFM3000 immediately begins taking measurements (Continuous and Statistical modes), or arms its trigger and takes a measurement each time a trigger occurs (Pulse Mode). If set to Stop, the measurement will begin (or be armed) if Start is selected under the Single Sweep setting (Pulse Mode Only), and will stop once the measurement criteria (averaging) has been satisfied.

Meas. Clear/Stat Capture

Selecting Execute clears display traces, data buffers, and clears averaging filters to empty. In Statistical Measure mode, the menu item is replaced with Stat Capture and selecting Reset clears the acquired sample population.

Single Sweep

Only available in Pulse mode. Select to start a single measurement cycle in Pulse mode when Measurement is set to Stop. Enough trace sweeps must be triggered to satisfy the channel averaging setting.

Meas. Settings

This will load the default operating parameters listed in table **3.1**. Only the settings shown in the table are affected and all others remain in their current state.

Cont. Mode Measure Menu | Pulse Mode Measure Menu | Stat. Mode Measure Menu

Figure 4.3 Measure Menus

4.3.3 Display >

To enter the **Display** menu press the icon then select the **Display** menu.

View

Toogle between Text and Graph view. Text view displays a table of measurements for the current measurement mode. In Continuous mode, selecting Text displays the enabled channel power as shown in figure 3.1. Selecting Graph displays the trace graphical view.

Figure 4.4 Display Menu

Envelope

Enables/disables the Envelope display mode. In Pulse and Modulated modes, the Envelope display is used to highlight the range of signal excursions. When Envelope display mode is On, the trace is drawn as a wide line. The line is filled in between the minimum and maximum power readings. A series of vertical pixels, representing the range of signal excursions or "envelope" of the signal will be illuminated for each horizontal trace pixel. Envelope display is only available for Peak Power sensors.

Key Beep

Enable/disable the audible key beep.

4.3.4 Stat. Mode >

To enter the **Stat. Mode** menu press the icon then select the **Stat. Mode** menu.

Cursor Pct./Cur Pow Ref

Sets the CCDF cursor to the desired probability. When Cursor mode is set to Power, the menu item changes to Cur Pow Ref and sets the desired power

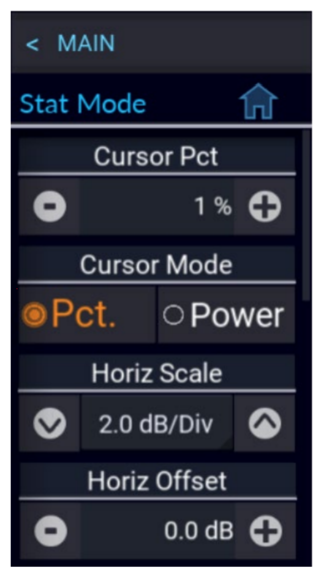


Figure 4.5 Stat. Mode

Cursor Mode

Select the independent variable for the CCDF cursor. If Percent is selected, probability at the cursor's intersection with the CCDF curve will be measured. If Power is selected, relative power at the cursor's intersection with the CCDF curve will be measured.

Horiz Scale

Select the horizontal scale for the statistical graphic display.

Horiz Offset

Select the horizontal offset for statistical graphic display.

Stat. Gating

Select **Freerun** or **Markers** gating for statistical acquisition. If **Freerun** is selected, all the samples are acquired without regard of sweep acquisition. If **Markers** are selected, then only samples within the time marker interval on the Pulse mode triggered sweep will be included in the statistical sample population.

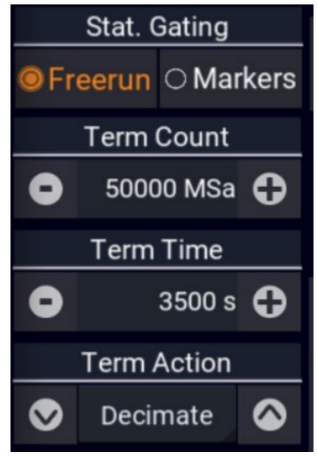


Figure 4.6 Stat. Mode

Term Count

Sets the terminal sample count for the CCDF acquisition.

Term Time

Sets the terminal running time for the CCDF acquisition.

Term Action

Select the action to take when either the terminal count is reached or terminal time has elapsed. Selecting Decimate will divide all sample bins by 2 and continue. The total sample count will be halved each time a decimation occurs. Selecting Restart clears the statistical sample population and starts a new one. Selecting **Stop** will stop accumulating samples and hold the result.

4.3.5 Channel >

To enter the **Channel** menu press the icon then select the **Channel** menu.

Channel

Select the channels settings menu to be configured.

Note:

The base RFM3000 model only permits two sensors to be active at any one time. With the RFM-4CH option, four sensors can be active at any one time.

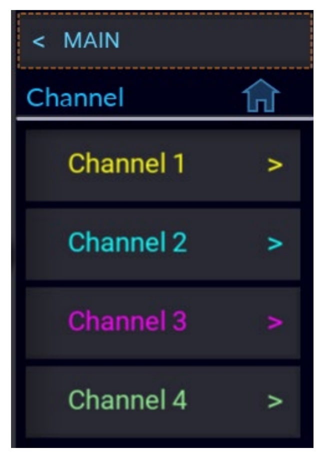


Figure 4.7 Channels

4.3.6 Channel Settings

To enter the **Channel** menu press the icon then select the **Channel** > **Channel #** menu.

Chan Enabled

Toggle the display of the trace and measurements for the selected channel. The channel may still be used as a trigger source when set to Off.

Vert Scale

Set the power or voltage vertical axis level for the trace display based on the untis as shown in table **4.8**

Units	Scale
dBm	0.1, 0.2, 0.5 1, 2, 5, 10, 20, 50 dB/div
Watts	1 pW to 500 MW/div in a 1-2-5 progression
Volts	1 μV to 100 kV/ div in a 1-2-5 progression

Table 4.1 Vertical Scale Range

Figure 4.8
Channel Setttings

Vert Center

Set the power or voltage, horizontal centerline, level of the graph for the specified channel in the selected channel untis.

Averaging

Only available in **Pulse** and **Statistical** modes. Set the number of traces averaged together to form the measurement result on the selected channel. Averaging can be used to reduce display noise on both the visible trace, marker, and automatic pulse measurements.

Trace averaging is a continuous process in which the measurement points from each sweep are weighted (multiplied) by an appropriate factor and averaged into the existing trace data points.

The most recent data will always have the greatest effect on the trace waveform, and older measurements will be decayed at a rate determined by the averaging setting and trigger rate. This averaging technique is often referred to as "exponential" averaging because averaging imposes a first-order Infinite Impulse Response (IIR) exponential filter with a time constant of "n" where n is the Average (number of averages) setting.

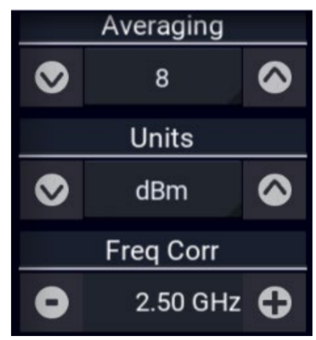


Figure 4.9
Channel Setttings

Note:

For timebase settings of 200 ns/div and faster, the RFP3000 Series sensors acquire samples using a technique called equivalent time or random interleaved sampling (RIS). In this mode, not every pixel on the trace gets updated on each sweep, and the total number of sweeps needed to satisfy the average setting will be increased by the sample interleave ratio of that particular timebase. At all times the average trace is the average of all samples for each pixel, and the min/max are the lowest and highest of that same block of samples for each pixel.

Units

Select the channel units. The trace may be shown in units of dBm, Watts, or Volts. The Units selection determines the range of the scale values and also affects displayed text and measurement values.

Freq. Corr

Sets the measurement frequency for the RF signal that is applied to the sensor for the current measurement. The appropriate frequency calibration factor from the sensor's calibration table will be interpolated and applied automatically. Application of this calibration factor compensates for the effect of variations in the flatness of the sensor's frequency response.

Note:

The power sensor has no way to determine the carrier frequency of the applied signal, so the user must always enter the frequency.

Filter State

Available in Continuous mode only. Sets the current value of the integration filter. The filter can be set to Off, On, or Auto.

Off, provides no filtering, and can be used at high signal levels when absolute minimum settling time is required.

On, allows a user-specified integration time to be entered for use.

Auto, uses a variable amount of filtering, which is set automatically by the power meter based on the current signal level to a value that gives a good compromise between measurement noise and settling time at most levels.

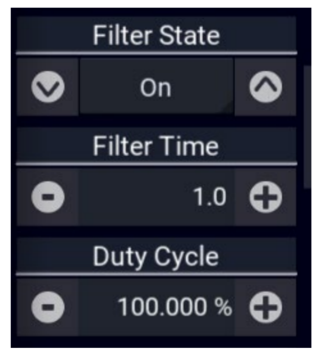


Figure 4.10
Channel Setttings

Filter Time

Available in Continuous mode only. Sets the length of the integration filter. The filter is a "sliding window" which averages samples taken within a time window whose duration is set by this field. All samples within the time window are equally weighted.

Duty Cycle

Available in Continuous mode only. Sets the duty cycle in percent for calculated CW pulse power measurements. Setting the duty cycle to 100% is equivalent to a CW measurement.

Video BW

Sets the sensor video bandwidth of the selected channel. HIGH is appropriate for most measurements. The actual bandwidth depends upon the sensor model.
LOW bandwidth offers additional noise reduction for CW or signals with very low modulation bandwidth. If LOW bandwidth is used on signals with fast modulation, measurement errors may result if the sensor cannot track the fast-changing envelope of the signal.

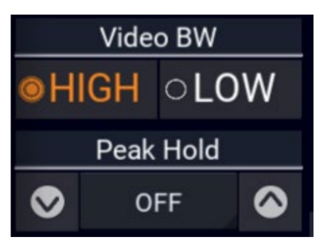


Figure 4.11
Channel Setttings

Peak Hold

Set the operating mode of the selected channel's peak hold function.

When set to OFF, peak values are not held.

When set to instantaneous (INST) instantaneous peak readings are held until reset by a new acquisition or cleared manually. This setting is used when it is desirable to hold the highest peak over a long measurement interval without any decay.

When set to average (AVG) peak readings are held for a short time, and then decayed towards the average power at a rate proportional to the Averaging setting. This is the best setting for most signals, because the peak will always represent the peak power of the current signal, and the resulting peak-to-average ratio will be correct shortly after any signal level changes.

dB Offset

Sets a measurement offset in dB for the selected channel. This is used to compensate for external couplers, attenuators, or amplifiers in the RF signal path ahead of the power sensor.

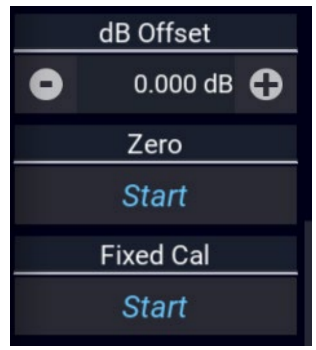


Figure 4.12
Channel Setttings

Zero

Performs a zero offset null adjustment. The sensor does not need to be connected to any calibrator for zeroing. This action removes the effect of small, residual power offsets, and should be performed prior to low-level measurements. The procedure is often performed in-system. There should be no RF signal applied to the sensor input prior to zeroing.

Fixed Cal

Performs a single point sensor gain calibration of the selected channel at 0 dBm and the current frequency setting. This requires a calibrated 0 dBm (1.00 mW) signal source at the current measurement frequency. This procedure calibrates the sensor's gain at a single point. At other levels, that gain setting is combined with stored linearity factors to compute the actual power.

CAUTION The built-in test source of the RFM3000 is not a sufficiently calibrated source for performing a fixed calibration. An external calibration source is required. Note that fixed calibration is NOT REQUIRED for USB power sensors.

4.3.7 Time >

To enter the **Time** menu press the ≡ icon then select the **Time** tab.

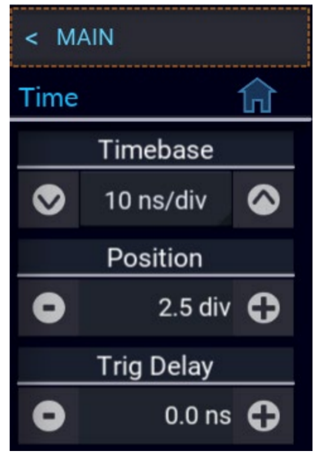


Figure 4.13
Time Setttings

Timebase

Controls the timebase, horizontal scale, of the Trace View. The Timebase pulldown menu permits selection of fixed timebase ranges from 5 ns/div to 50 ms/div (sensor series dependent) in a 1-2-5 progression.

Position

Sets the location of the trigger point on the acquired trace waveform. The Trig Delay setting is in addition to this setting, and will cause the trigger position to appear in a different location.

Trig Delay

The trigger delay time is set in seconds with respect to the trigger. Positive values means that the trace display shows a time interval after the trigger event. This positions the trigger event to the left of the trigger point on the display, and is useful for viewing events during a pulse, or some fixed delay time after the rising edge trigger. Negative trigger delay mean that the trace display shows a time interval before the trigger event, and is useful for looking at events preceding the trigger edge.

4.3.8 Trigger >

To enter the **Trigger** menu press the ≡ icon then select the **Trigger** tab.

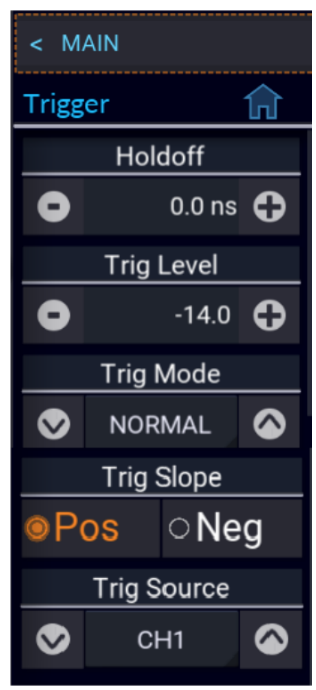


Figure 4.14
Trigger Setttings

Trigger Holdoff

Set the trigger holdoff time. Trigger holdoff is used to disable the trigger for a specified amount of time after each trigger event. The holdoff time starts immediately after each valid trigger edge and will not permit any new triggers until the time has expired. When the holdoff time is up, the trigger re-arms, and the next valid trigger event (edge) will cause a new sweep. This feature is used to help synchronize the power meter with burst waveforms such as a TDMA or GSM frame. The trigger holdoff resolution is 0.01 microseconds, and it should be set to a time that is longer than the burst duration but shorter than the frame repetition interval.

Trigger Level

Sets the threshold level for the trigger signal used in the Auto and Normal trigger modes. The trigger level can be entered numerically or changed by using arrow keys. The trigger level range has a range that is sensor model dependent (see the sensor specifications for your specific sensor model).

The trigger range is automatically adjusted to include the dB Offset parameter set for the source channel. For example, if the trigger level = 10 dBm and the dB Offset is changed from 0 to 20 dB, then the offset-adjusted trigger level will be displayed to the user as 30 dBm. Likewise, the maximum trigger level range will be extended to 40 dBm. The trigger level set point and setting range are both shifted upward by 20 dB.

Trigger Mode

Set the trigger mode for synchronizing data acquisition with pulsed signals.

Normal mode will cause a sweep to be triggered each time the power level crosses the preset trigger level in the direction specified by the trigger slope setting. If there are no edges that cross this level, no data acquisition will occur.

Auto mode operates in much the same way as Normal mode but will automatically generate a trace if no trigger edges are detected for a period of time (100 to 500 milliseconds, depending upon timebase). This will keep the trace updating even if the pulse edges stop.

The Auto PK-PK mode operates the same as Auto mode but will adjust the trigger level to halfway between the highest and lowest power or voltage levels detected. This aids in maintaining synchronization with a pulse signal of varying level.

The Freerun mode forces unsynchronized traces at a high rate to assist in locating the signal.

Trigger Source

Set the trigger source used for synchronizing data acquisition. The CH # settings use the signal from the associated sensor. Ext setting uses the signal applied to the rear panel TRIG IN connector.

The trigger source can be any of the resource channels (CH1, CH2, etc.), or the Ext(ernal) trigger input signal. The Ind(ependent) trigger setting allows each connected sensor to trigger independently from its own RF input.

The external trigger is attached to the Trig In BNC connector on the rear of the RFM3000 Power Meter and requires a TTL signal level, minimum pulse width of 10 ns, and maximum frequency of 50 MHz.

Note:

Connecting the Sync cable from the Multi I/O port on the sensor to the corresponding Sync port on the instrument for the sensor in use is necessary if using an external trigger or when performing measurements across multiple channels.

Trigger Slope

Set the trigger slope or polarity. When set to +, trigger events will be generated when a signal's rising edge crosses the trigger level threshold. When – is selected, trigger events are generated on the falling edge of the pulse.

Markers >

To enter the **Markers** menu press the icon then select the **Markers** > tab.

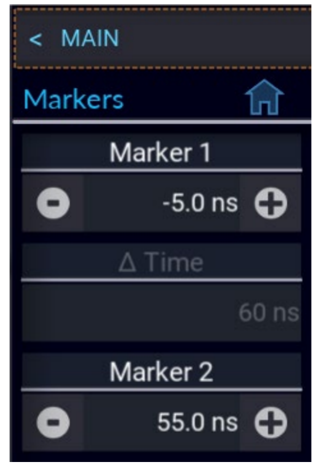


Figure 4.15
Marker Setttings

Marker

Set the time position of marker 1 or 2 relative to the trigger. Note that time markers must be positioned within the time limits of the trace window in the graph display. If a time outside of the display limits is entered, the marker will be placed at the first or last time position as appropriate.

ΔTime

Displays the result of Marker 2 - 1 in seconds. This item is read only.

4.3.9 Pulse Def. >

To enter the **Pulse Def** menu press the icon then select the **Pusle Def.** > tab.

Figure 4.16
Pulse Def Menu

CH # Pulse Def

Select the channel to be configured.

4.3.10 CH# Pulse Def

To enter the **CH# Pulse Def** menu press the icon then select the **CH# Pusle Def.** > tab of the channel to be configured.

Distal

Sets the pulse amplitude percentage that defines the end of a rising edge or beginning of a falling edge transition. Typically, this is 90% voltage or 81% power relative to the top level of the pulse. This setting is used when making automatic pulse risetime and falltime calculations.

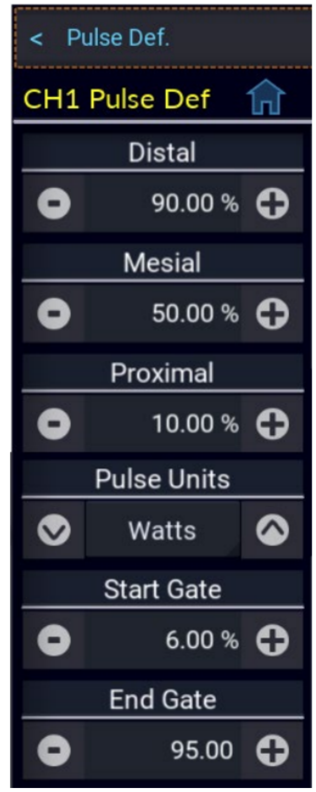


Figure 4.17
CH# Pulse Def Menu

Mesial

Sets the pulse amplitude percentage that defines the midpoint of a rising or falling edge transition. Typically, this is 50% voltage or 25% power relative to the top level of the pulse. This setting is used when making automatic pulse width and duty cycle calculations.

Proximal

Sets the pulse amplitude percentage that defines the beginning of a rising edge or end of a falling edge transition. Typically, this is 10% voltage or 1% power relative to the top level of the pulse. This setting is used when making automatic pulse risetime and falltime calculations.

Pulse Unites

Controls whether the distal, mesial, and proximal thresholds are computed as voltage or power percentages of the top/bottom amplitudes. If Volts is selected, the pulse transition thresholds are computed as voltage percentages. If Watts are selected, they are computed as power percentages.
units setting.

Many pulse measurements call for 10% to 90% voltage (which equates to 1% to 81% power) for risetime and falltime measurements, and measure pulse widths from the half-power (–3 dB, 50% power, or 71% voltage) points. The Pulse Units setting is independent of the channel's display

Start Gate

Sets the beginning of the pulse measurement region as a percentage of the pulse width. The **Start Gate** has a continuous range of 0.0% to 40.0% of the pulse width and may be entered numerically or varied using the up or down arrows.

End Gate

Sets the end of the pulse measurement region as a percentage of the pulse width. The End Gate has a continuous range of 60.0% to 100.0% of the pulse width and may be entered numerically or varied using the up or down arrows.
The Gate settings define the measurement interval for the following power related pulse measurements: Pulse Average, Pulse Peak, Pulse Minimum, and Pulse Droop/Tilt. Pulse timing measurements between mesial crossings such as width and period are not affected. The purpose of the Pulse Gate setting is to exclude edge transition effects from the pulse power measurements.

4.3.11 Favorites >

To enter the **Favorites** menu press the icon then select the **Favorites** > tab.
This function is not fully implemented at this time). Enables the user to setup a customized menu to allow grouping frequently used menu items into one convenient menu.

4.3.12 System >

To enter the **System** menu press the icon then select the **System** > tab.

The System menu displays the available system-level features and functionality.

Seonsr Data >

I/O Config >

Calibration >

Exit >

Reports >

Update Software

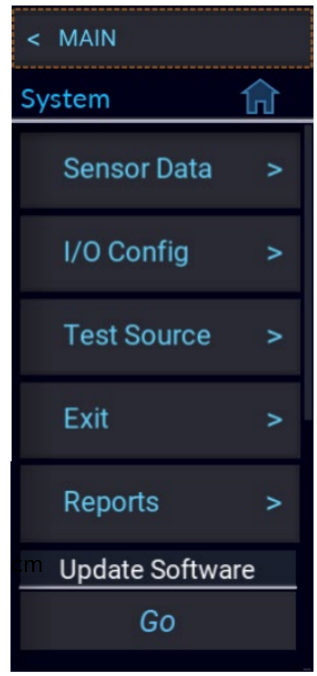


Figure 4.18 System Menu

Sensor Data >

To enter the **Sensor Data** menu press the icon then select the **System** > **Sensor Data** > tab.

Press **Show** to display information about the selected sensor in a pop-up log.
See figure **4.19**.

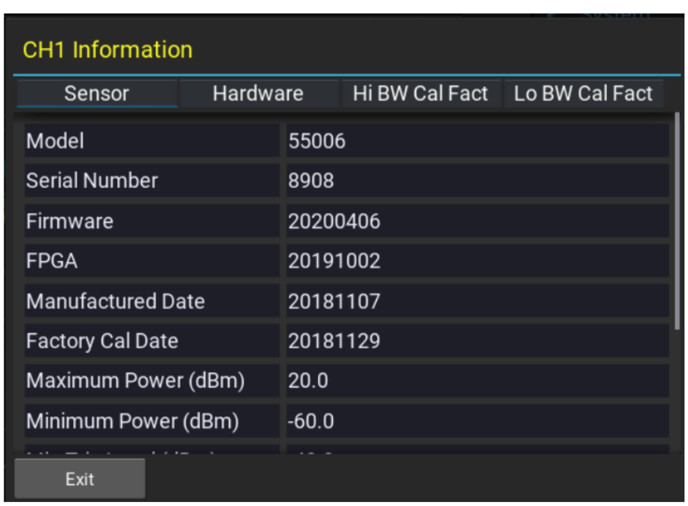


Figure 4.19 CH1 Information

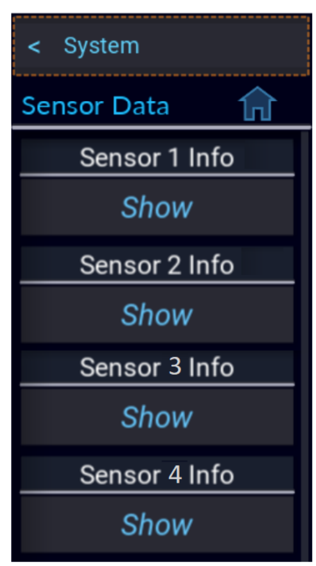


Figure 4.20 Sensor Data

I/O Config >

To enter the **I/O Config** menu press the icon then select the **System** > **I/O Config** > tab.

The RFM3000 supports remote communication over LAN and GPIB (optional).

GPIB Address

Set and View the current GPIB address in use for instruments equipped with GPIB option.

To increae the GPIB address press the icon or the icon do decrease the address. Pressing the number box located between the increase and decrease icon will open the numeric keypad. The numeric keypad can be used to instantaneously change the GPIB address

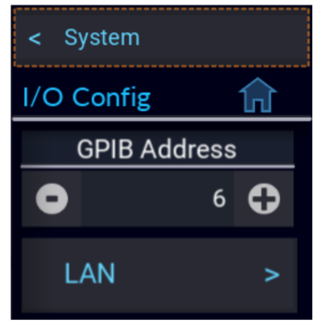


Figure 4.21 I/O Config

LAN

To enter the **I/O Config** menu press the icon then select the **System** > **I/O Config** > **LAN** > tab.

DHCP/AutoIP

Set the state of DHCP/AutoIP system for the Ethernet port.

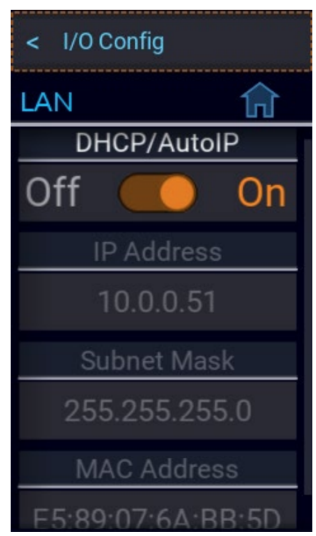


Figure 4.22 LAN

If DHCP/AutoIP is enabled (On), the instrument will attempt to obtain its IP Address and Subnet Mask, a DHCP (dynamic host configuration protocol) server on the network. If no DHCP server is found, the instrument will select its own IP Address and Subnet Mask values using the AutoIP protocol.

If DHCP/AutoIP is disabled (Off), the instrument will use the IP Address and Subnet Mask values that have been set by the user.

IP Address

Set the Internet Protocol (IP) address of the Ethernet adapter. If DHCP/AutoIP mode is enabled, this menu is read-only.

Subnet Mask

Set the subnet mask for the Ethernet adapter. If DHCP/AutoIP mode is enabled, this menu is read-only.

MAC Address

Displays the MAC address for the Ethernet adapter. This menu item is read-only.

Calibration >

To enter the **Calibrator** menu press the icon then select the **System** > **Calibrator** > tab.

Cal Output

Enable/disable the output of the built-in 0 dBm 50 MHz test source.

Note:

The built-in test source of the RFM3000 is not a sufficiently calibrated source for performing a fixed calibration. An external calibration source is required.

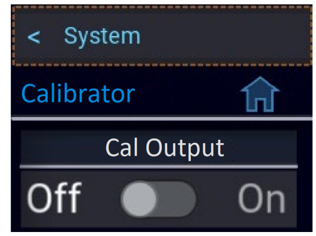


Figure 4.23 Calibrator

Exit >

To enter the **Exit** menu press the icon then select the **System** > **Exit** > tab.

Exit to Desktop

Exits the RFM3000 Power Meter Main application to access the OS Desktop.

Shut Down

Shuts down power to the PMX40 putting the meter in standby mode and is the same as pressing the ON/Standby button on the front panel.

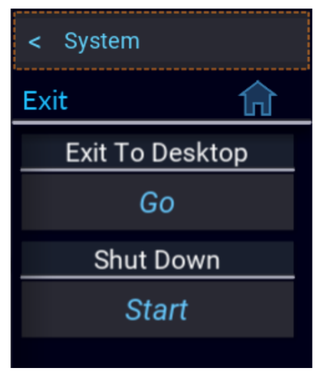


Figure 4.24 Exit

Reports >

To enter the **Reports** menu press the icon then select the **System** > **Reports** > tab.

Configuration

Select Show to display an About dialog with configuration information for the RFM3000 Power Meter like that shown in figure 2.2.

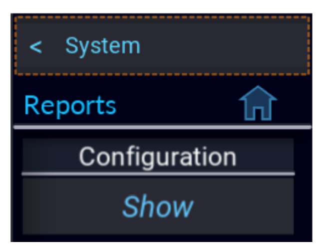


Figure 4.25 Reports

Update Software

To view the **Update Sofware** option press the  icon then select the **System** > tab.

Update Software

Select **Go** to search the connected USB drive for the *.tar software update file and update or re-install the version found. If no valid file is found, the dialog in figure **4.27** appears.

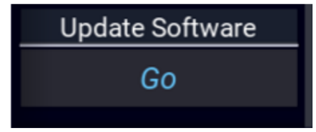


Figure 4.26
Update Software

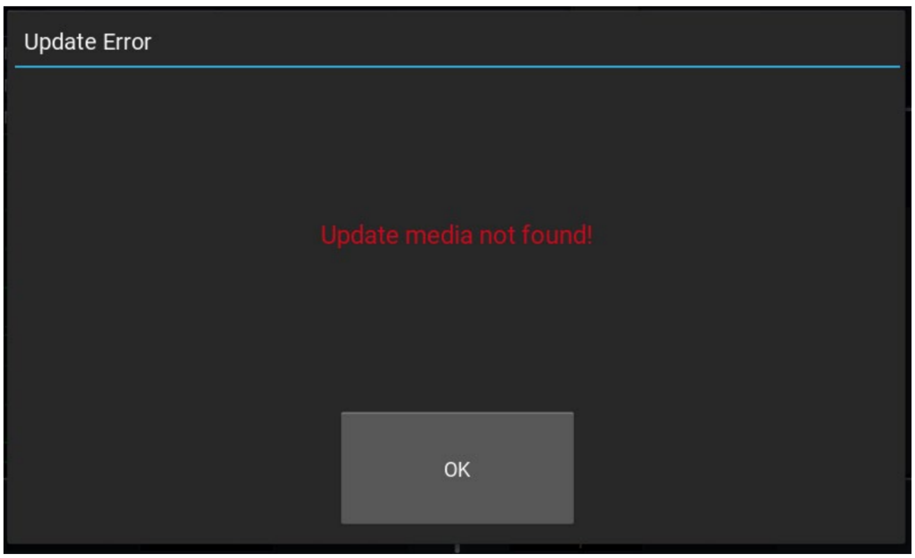


Figure 4.27 Update Error

Application Notes

This section provides supplementary material to enhance your knowledge of the RFM3000 operation, advanced features, and measurement accuracy. Topics covered in this section include pulse measurement fundamentals, automatic measurement principles, and an analysis of measurement accuracy.

5.1 Introduction to Pulse Measurements

5.1.1 Measurement Fundamentals

The following is a brief reaview of the power measurement fundamentals.

Unmodulated Carrier Power

The average power of an unmodulated carrier consisting of a continuous, constant amplitude sinewave signal is also termed continuous wave (CW) power. For a known value of load impedance R, and applied voltage V_{rms}, the average power is:

$$P = \frac{{V_{rms}}^2}{R} \quad watts$$

Power meters designed to measure CW power can use thermoelectric-based sensors which respond to the heating effect of the signal or diode detectors which respond to the voltage of the signal. With careful calibration accurate measurements can be obtained over a wide range of input power levels.

Modulated Carrier Power

The average power of a modulated carrier which has varying amplitude can be measured accurately by a CW type power meter with a thermoelectric detector, but the lack of sensitivity will limit the range. Diode detectors can be used at low power, square-law response levels. At higher power levels the diode responds in a more linear manner and significant error results.

Pulse Power

Pulse power refers to power measured during the on time of pulsed RF signals figure **5.1**. Traditionally, these signals have been measured in two steps: (1) thermoelectric sensors measure the average signal power, (2) the reading is then divided by the duty cycle to obtain pulse power, P_{pulse}:

$$P_{pulse} = \frac{Average \;\; Power}{Duty \;\; Cycle}$$

Where Duty Cycle:

$$Duty \;\; Cycle = \frac{Pulse \;\; Width}{Pulse \;\; Period}$$

Pulse power provides useful results when applied to rectangular pulses, but is inaccurate for pulse shapes that include distortions, such as overshoot or droop (Figure **5.2**).

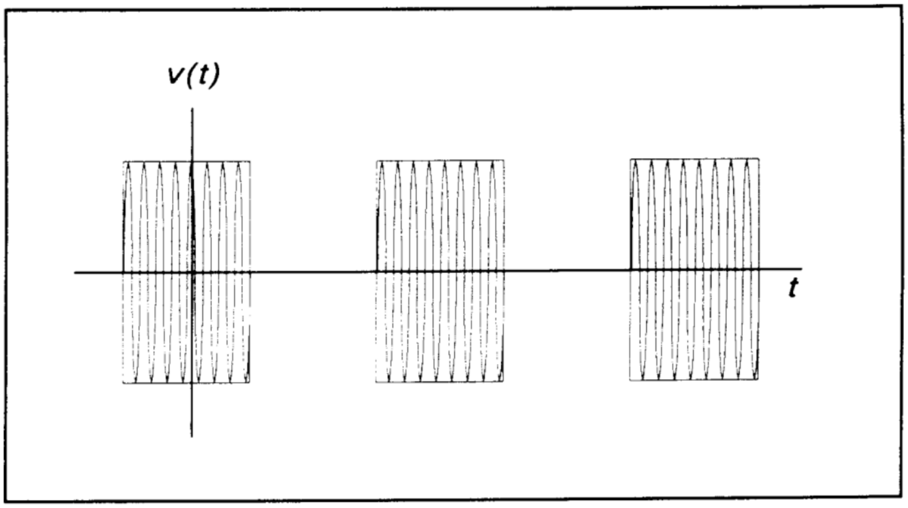


Figure 5.1 Pulsed RF Signal

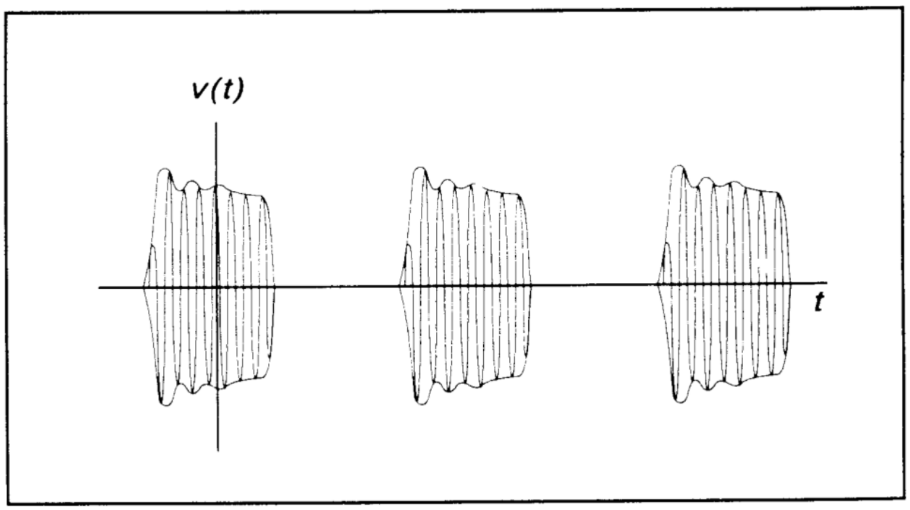


Figure 5.2 Distorted Pulsed Signal

Peak Power

The RFM3000 makes power measurements in a manner that overcomes the limitations of the pulse power method and provides both peak power and average power readings for all types of modulated carriers. The fast-responding diode sensors detect the RF signal to produce a wideband video signal, which is sampled with a narrow sampling gate. The video sample levels are accurately converted to power on an individual basis at up to a 100 MSa/sec rate. Since this power conversion is corrected based upon the sensor's linearity correction table, these samples can be averaged to yield average power without restriction to the diode square-law region.

If the signal is repetitive, the signal envelope can be reconstructed using an internal or external trigger. The envelope can be analyzed to obtain waveshape parameters including, pulse width, duty cycle, overshoot, rise time, fall time, and droop. In addition to time domain measurements and simple averaging, the RFM3000 has additional capabilities that allow it to perform statistical analysis on a complete set of continuously sampled data points.

Data can be viewed and characterized using a CCDF presentation format. These analysis tools provide invaluable information about peak power levels and their frequency of occurrence, and are especially useful for non-repetitive signals, such as those used in 5G and Wi-Fi applications.

5.1.2 Diode Detection

Wideband diode detectors are the dominant power sensing device used to measure pulsed RF signals. Several diode characteristics must be compensated to make meaningful measurements. These include the detector's nonlinear amplitude response, temperature sensitivity, and frequency response characteristic. Additional potential error sources include detector mismatch, signal harmonics, and noise.

Detector Response

The response of a single-diode detector to a sinusoidal input is given by the diode equation:

$$i = I_s(e^{av} - 1)$$

where:
$i = diodecurrent$
$v = netvoltageacrossthediode$
$I_s = saturationcurrent$
$\alpha = constant$

An ideal diode response curve is plotted in figure **5.3**

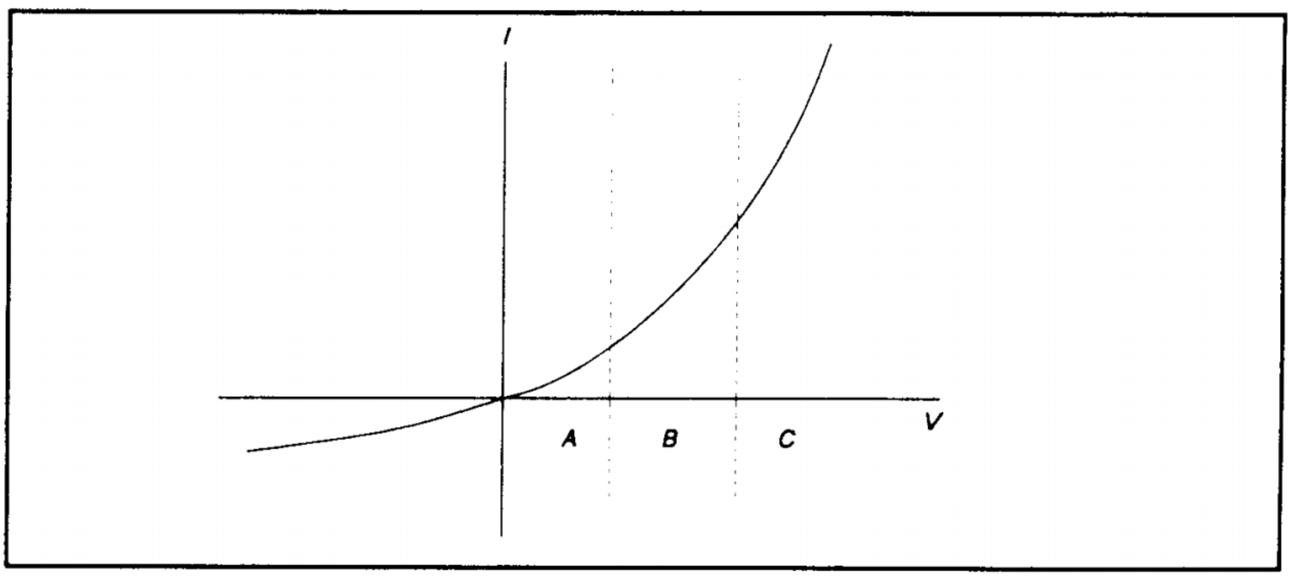


Figure 5.3 Ideal Diode Response

The curve indicates that for low microwave input levels (Region A), the single-diode detector output is proportional to the square of the input power. For high input signal levels (Region C), the output is linearly proportional to the input. In between these ranges (Region B), the detector response lies between square-law and linear.

For accurate power measurements over all three regions illustrated in figure **5.3**, the detector response is pre-calibrated over the entire range. The calibration data is stored in the instrument and recalled to adjust each sample of the pulse power measurement.

Temperature Effects

The sensitivity of microwave diode detectors (normally Low Barrier Schottky diodes) varies with temperature. However, ordinary circuit design procedures that compensate for temperature-induced errors adversely affect detector bandwidth. A more effective approach involves sensing the ambient temperature during calibration and recalibrating the sensor when the temperature drifts outside the calibrated range.

This process can be made automatic by collecting calibration data over a wide temperature range and saving the data in a form that can be used by the power meter to correct readings for ambient temperature changes.

Frequency Response

The carrier frequency response of a diode detector is determined mostly by the diode junction capacitance and the device lead inductances.

The frequency response will vary from detector to detector and cannot be compensated readily. Power measurements must be corrected by constructing a frequency response calibration table for each detector.

Mismatch

Sensor impedance matching errors can contribute significantly to measurement uncertainty, depending on the mismatch between the device under test (DUT) and the sensor input. This error cannot be easily calibrated out, but can be minimized by employing an optimum matching circuit at the sensor input.

Signal Harmonics

Measurement errors resulting from harmonics of the carrier frequency are leveldependent and cannot be calibrated out. In the square-law region of the detector response (Region A, Figure 5-3), the signal and second harmonic combine on a root mean square basis. The effects of harmonics on measurement accuracy in this region are relatively insignificant. However, in the linear region (Region C, figure **5.3**), the detector responds to the vector sum of the signal and harmonics. Depending on the relative amplitude and phase relationships between the harmonics and the fundamental, measurement accuracy may be significantly degraded. Errors caused by even-order harmonics can be reduced by using balanced diode detectors for the power sensor. This design responds to the peak-to-peak amplitude of the signal, which remains constant for any phase relationship between fundamental and even-order harmonics. Unfortunately, for odd-order harmonics, the peak-to-peak signal amplitude is sensitive to phasing, and balanced detectors provide no harmonic error improvement. Measurement errors resulting from harmonics of the carrier frequency are leveldependent and cannot be calibrated out. In the square-law region of the detector response (Region A, figure **5.3**), the signal and second harmonic combine on a root mean square basis. The effects of harmonics on measurement accuracy in this region are relatively insignificant. However, in the linear region (Region C, figure **5.3**), the detector responds to the vector sum of the signal and harmonics. Depending on the relative amplitude and phase relationships between the harmonics and the fundamental, measurement accuracy may be significantly degraded. Errors caused by even-order harmonics can be reduced by using balanced diode detectors for the power sensor. This design responds to the peak-to-peak amplitude of the signal, which remains constant for any phase relationship between fundamental and even-order harmonics. Unfortunately, for odd-order harmonics, the peak-to-peak signal amplitude is sensitive to phasing, and balanced detectors provide no harmonic error improvement.

Noise

For low-level signals, detector noise contributes to measurement uncertainty and cannot be calibrated out. Balanced detector sensors improve the signal-to-noise ratio by 3 dB, because the signal is twice as large.

5.1.3 Pulse Definitions

IEEE Std 194™-1977 Standard Pulse Terms and Definitions “provides fundamental definitions for general use in time domain pulse technology.” Several key terms defined in the standard are reproduced in this subsection, which also defines the terms appearing in the RFM3000 text mode display of automatic measurement results.

5.1.4 Standard IEEE Pulse

The key terms defined by the IEEE standard are abstracted and summarized below. These terms are referenced to the standard pulse illustrated infigure **5.4**

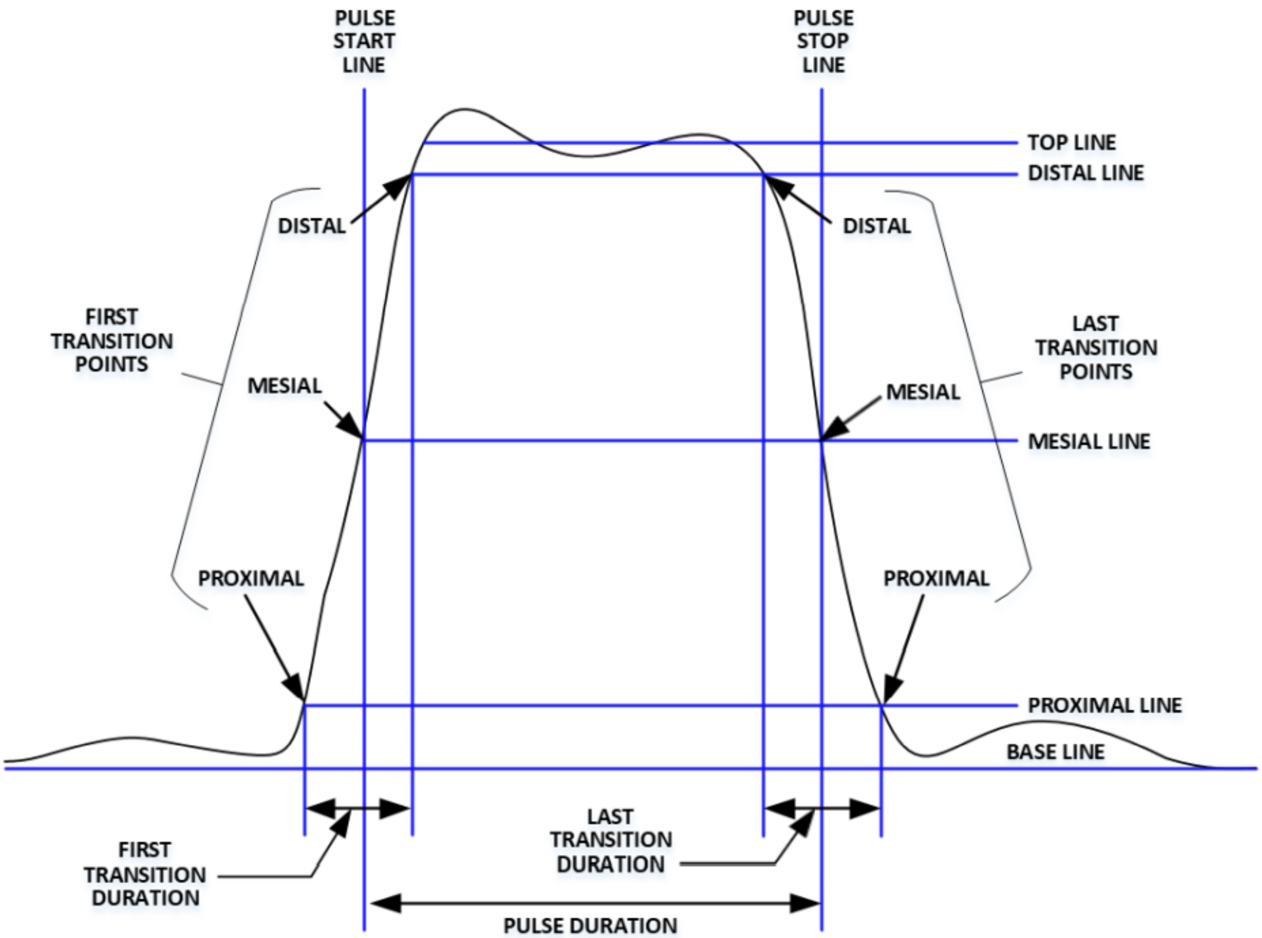


Figure 5.4 Stanard IEEE Pulse

Note:

IEEE Std 194™-1977 Standard Pulse Terms and Definitions has been superseded by IEEE Std 181™-2003. Many of the terms used below have been deprecated by the IEEE. However, these terms are widely used in the industry. For this reason, they are retained.

Term	Definition
Base Line	The two portions of a pulse waveform which represent the first nominal state from which a pulse departs and to which it ultimately returns.
Top Line	The portion of a pulse waveform which represents the second nominal state of a pulse.
First Transition	The major transition of a pulse waveform between the base line and the top line (commonly called the rising edge).
Last Transition	The major transition of a pulse waveform between the top of the pulse and the base line (commonly called the falling edge).
Proximal Line	A magnitude reference line located near the base of a pulse at a specified percentage (normally 10%) of pulse magnitude.
Distal Line	A magnitude reference line located near the top of a pulse at a specified percentage (normally 90%) of pulse magnitude.
Mesial Line	A magnitude reference line located in the middle of a pulse at a specified percentage (normally 50%) of pulse magnitude.

Table 5.1 Pule Terms

5.1.5 Automatic Measurements

The RFM3000 automatically analyzes the waveform data in the buffers and calculates key waveform parameters. The calculated values are displayed in text mode when you press the **TEXT/GRAPH** system key.

5.1.6 Automatic Measurement Criteria

Automatic measurements are made on repetitive signals that meet the following conditions:

- **Amplitude**
  - The difference between the top and bottom signal amplitudes must exceed 6 dB to calculate waveform timing parameters (pulse width, period, duty cycle). The top-to-bottom amplitude difference must exceed 13 dB to measure rise and fall time.
- **Timing**
  To measure pulse repetition frequency and duty cycle, there must be at least three signal transitions. The interval between the first and third transition must be at least 1/5 of a division (1/50 of the screen width). For best accuracy on rise and fall time measurements, the timebase should be set so the transition interval is at least one-half division on the display.

5.1.7 Automatic Measurement Terms

The following terms appear in the RFM3000 Text display in Pulse mode. The Text column lists the abbreviated forms that appear on the display screen.

Text	TERM	DEFINITION
Width	Pulse Width	The interval between the first and second signal crossings of the mesial line.
Rise	Risetime	The interval between the first signal crossing of the proximal line to the first signal crossing of the distal line.
Fall	Falltime	The interval between the last signal crossing of the distal line to the last signal crossing of the proximal line.
Period	Pulse Period	The interval between two successive pulses (reciprocal of the Pulse Repetition Frequency).
PRFreq	Pulse Repetition	The number of cycles of a repetitive signal that take place in one Frequency second.
Duty C	Duty Cycle	The ratio of the pulse on-time to off-time. Offtime Off-time The time a repetitive pulse is off (equal to the pulse period minus the pulse width).
Peak	Peak Power	The maximum power level of the captured waveform.
Pulse	Pulse Power	The average power level across the pulse width, defined by the intersection of the pulse rising and falling edges with the mesial line.
Avg	Average Power	The equivalent heating effect of a signal. IEEETop Top Amplitude The amplitude of the top line (see IEEE definitions). IEEEBot Bottom Amplitude The amplitude of the base line (see IEEE definitions). Skew Skew The time between the mesial level of a pulse on one channel and a pulse on a second channel.
EdgeDly	Edge Delay	The time between the left edge of the display and the first mesial transition level of either slope on the waveform.

Table 5.2 Automatic Measurement Terms

5.1.8 Automatic Measurement Sequence

The automatic measurement process analyzes the captured signal data in the following sequence:

1. Approximately 500 samples of the waveform (equivalent to one screen width) are scanned to determine the maximum and minimum sample amplitudes.
2. The difference between the maximum and minimum sample values is calculated and stored as the Signal Amplitude.
3. The Transition Threshold is computed as one-half the sum of the maximum and minimum sample amplitudes.
4. The processor locates each crossing of the Transition Threshold.
5. Starting at the left edge of the screen, the processor classifies each Transition threshold crossing according to whether it is positive-going (− +) or negative-going (+ −). Because the signal is repetitive, only three transitions are needed to classify the waveform, as follows:

Type	Sequence	Description
0	none	No crossings detected
1		Not used
2	+ −	One falling edge
3	− +	One rising edge
4	+ − +	One falling, followed by one rising edge
5	− + −	One rising, followed by one falling edge
6	+ − + −	Two falling edges
7	− + − +	Two rising edges

Table 5.3 Transition Threshold Crossing

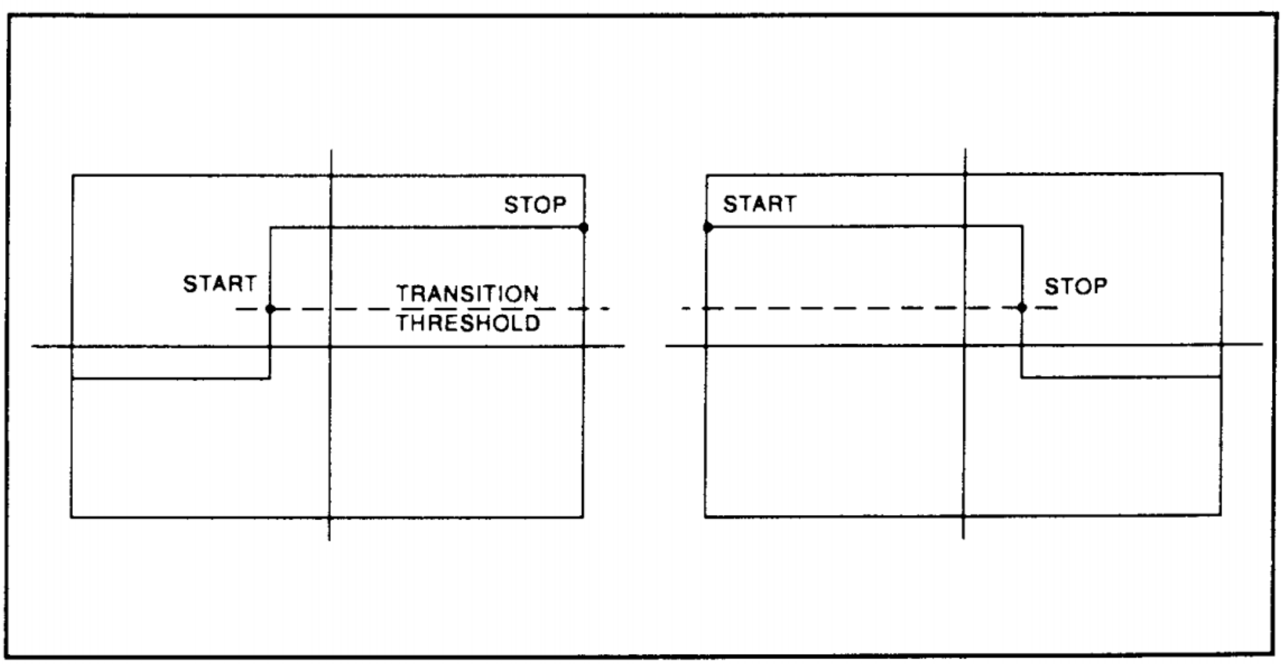


Figure 5.5 Step Waveforms

6. If the signal is Type 0, (No crossings detected) no measurements can be performed and the routine is terminated, pending the next reload of the data buffers.

7. The process locates the bottom amplitude (baseline) using the IEEE histogram method. A histogram is generated for all samples in the lowest 12.8 dB range of sample values. The range is subdivided into 64 power levels of 0.2 dB each. The histogram is scanned to locate the power level with the maximum number of crossings. This level is designated the baseline amplitude. If two or more power value have equal counts, the lowest is selected.

8. The process follows a similar procedure to locate the top amplitude (top line). The power range for the top histogram is 5 dB and the resolution is 0.02 dB, resulting in 250 levels. The level-crossing histogram is computed for a single pulse, using the samples which exceed the transition threshold. If only one transition exists in the buffer (Types 2 and 3), the process uses the samples that lie between the edge of the screen and the transition threshold (see figure **5.6**). For a level to be designated the top amplitude, the number of crossings of that level must be at least 1/16 the number of pixels in the pulse width; otherwise, the peak value is designated the top amplitude.

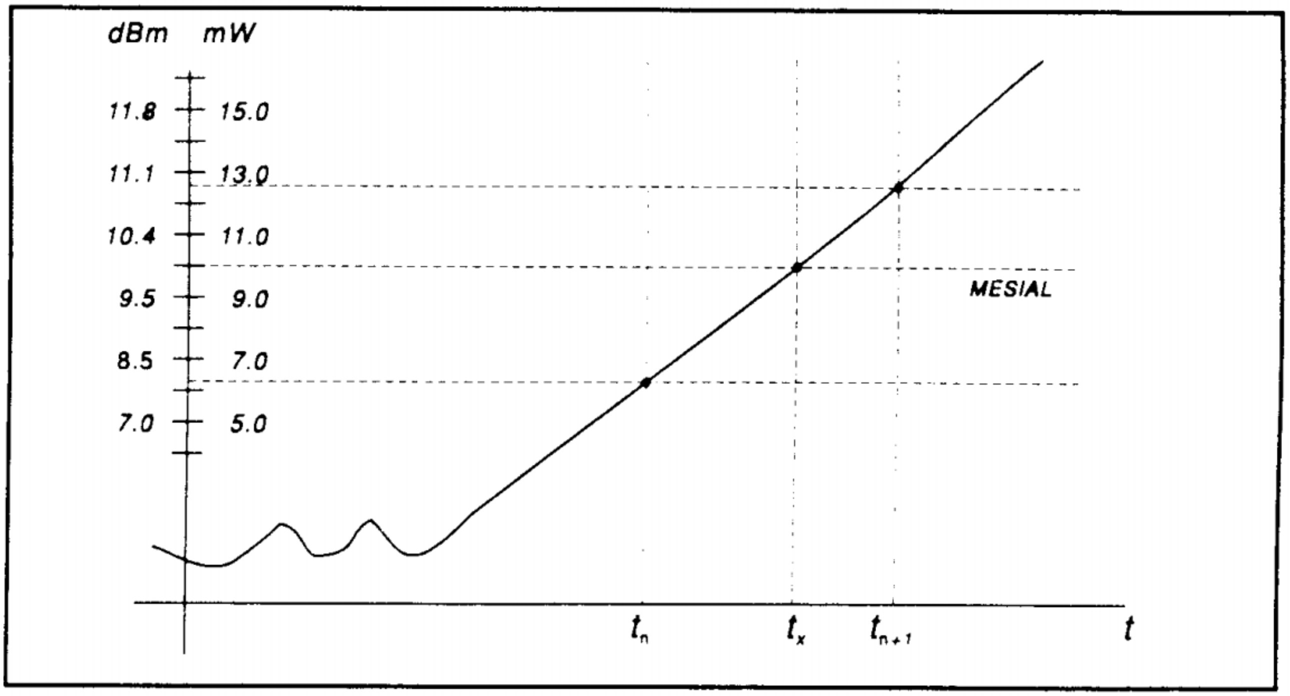


Figure 5.6 Time Interpolation

9. The process establishes the proximal, mesial, and distal levels as a percentage of the difference between top amplitude and bottom amplitude power. The percentage can be calculated on a power or voltage basis. The proximal, mesial, and distal threshold values are user settable from 1% to 99%, with the restriction that the proximal < mesial < distal. Normally, these values will be set to 10%, 50%, and 90%, respectively.

10. The process determines horizontal position, in pixels, at which the signal crosses the mesial value. This is done to a resolution of 0.1 pixel, or 1/5000 of the screen width. Ordinarily, the sample values do not fall precisely on the mesial line, and it is necessary to interpolate between the two nearest samples to determine where the mesial crossing occurred. This process is demonstrated in the example above (figure **5.6**):

Item	dBm	mW
Mesial value	10.0	10.0
Sample n	8.0	6.3
Sample n+1	11.0	12.6

Table 5.4 Interpolation Crossing

The interpolated crossing time, t_x, is calculated from:

$$t_x = t_n + \frac{P_{mes} - P_n}{P_{n+1} - P_n}$$

where P is in watts and n is the number of the sampling interval, referenced to the trigger event. For this example:

$$t_x = t_n + \frac{10.0 - 6.3}{12.6 - 6.3}$$

$$t_x = t_n + 0.6$$

11. The processor computes the rise and/or fall times of waveforms that meet the following conditions:

    - The waveform must have at least one usable edge (Types 2 through 7).
    - The signal peak must be at least 13 dB greater than the minimum sample value.

    The rise time is defined as the time between the proximal and distal crossings (− +).

    The fall time is defined as the time between the distal and proximal crossings (+ −).

    If no samples lie between the proximal and distal values for either edge (rise or fall), the risetime for that edge is set to 0 seconds.

12. The processor calculates the output values according to the following definitions:

a)	Pulse Width	Interval between mesial points
b)	Rise time	See Step 11
c)	Fall time	See Step 11
d)	Period Cycle	time between mesial points
e)	Pulse Repetition	Reciprocal of Period Frequency
f)	Duty Cycle Pulse	Pulse Width/Period
g)	Off-time	(Period) - (Pulse Width)
h)	Peak Power	Maximum sample value (See Step 1)
i)	Pulse Power	Average power in the pulse (between the mesial points)
j)	Overshoot	(Peak Power) - (Top Amplitude)
k)	Average Power	See Step 13
l)	Top Amplitude	See Step 8
m)	Bottom Amplitude	See Step 7
n)	Skew	See Step 14

5.1.9 Average Power Over an Interval

13. The average power of the signal over a time interval is computed by:

    a) summing the sample powers in the interval

    b) dividing the sum by the number of samples

    This process calculates Pulse Power, Average Power, and the average power between markers.

    Since each sample represents the power in a finite time interval, the endpoints are handled separately to avoid spreading the interval by one-half pixel at each end of the interval (see figure ??). For the interval in figure ??, the average power is given by:

$$P_{avg} = \frac{1}{2}(P_0 + P_n) + \frac{1}{n-1}\sum_{n=1}^{n-1} P_n$$

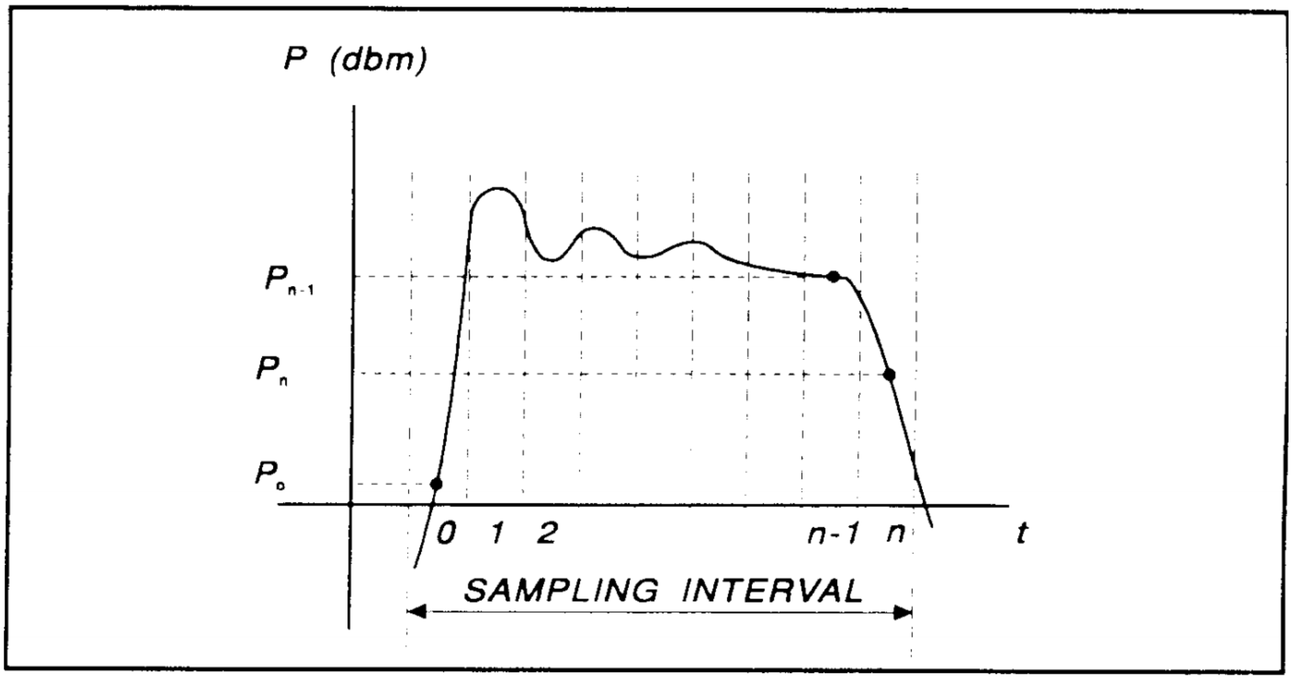


Figure 5.7 Sampling Interval

14. The processor calculates the delay between the two measurement channels. The time reference for each channel is established by the first signal crossing (starting from the left edge of the screen) which passes through the mesial level. The signal excursion must be at least 6 dB.

5.1.10 Statistical Mode Automatic Measurements

When operating in Statistical mode, the RFM3000 has a unique text format display that is available when the TEXT/GRAPH system key is pressed. A sample of the text display is shown in figure 5.8.

Figure 5.8 Statistical Mode Text Display

In the Statistical mode the following five automatic measurements are displayed in the RFM3000 Text display for both input channels and both trigger channels. The Text column lists the abbreviated forms that appear on the display screen. In the Statistical mode the following five automatic measurements are displayed in the PMX40 Text display for both input channels and both trigger channels. The Text column lists the abbreviated forms that appear on the display screen.

TEXT	TERM	DEFINITION
Avg	Average Power	The unweighted average of all linear power samples occurring since acquisition started.
Peak	Peak Power	The highest power sample occurring since acquisition was started.
Min	Minimum Power	The lowest power sample occurring since acquisition was started. In logarithmic units a reading below the clip level will display as down arrows.
Pk2Avg	Pk/Avg Ratio	The ratio (in dB) of the Peak Power to the Average Power.

Table 5.5 Statistical Automatic Measurements

The following six cursor measurements display the set position (independent variable) and measured value (dependent variables) where the movable cursor intersects the measurement trace.

The position or value measurement text for each dependent variable is displayed in the color of its channel. The independent variable is white.

Note that the intersection of the movable cursors and the CCDF traces can be moved outside the visible display area. This does not affect the measurements in any way.

TEXT	TERM	DEFINITION
Cursor Pwr	Cursor Powe	Cursor Mode - Power Ref
	Reference	The reference power level in dBr set by the user to define the measurement point on the normalized CCDF for probability in percent. Cursor Mode - Percent The measured power level in dBr of the normalized CCDF at the Probability in percent specified by the user.
Cursor Pct	Cursor Percentage	Cursor Mode - Power Ref The measured probability in percent of the normalized CCDF at the reference power level specified by the user. Cursor Mode - Percent The probability in percent set by the user to define the measurement point on the normalized CCDF for power level in dBr.
Total	Time	The total time in Hours:Minutes:Seconds that the data acquisition has been running.
	Points	The total number of data samples in MSa that has been acquired for each channel in the current run.

Table 5.6 Cursor Measurements

Note:

The total number of data samples is affected by the terminal settings. If Terminal Action is set to decimate, then the sample count will be halved each time the Terminal Count or Time is reached. This should have very little visible effect on the CCDF values, since the entire population is decimated uniformly. If Terminal Action is set to restart, then the sample count will be cleared to zero each time the Terminal Count or Time is reached.

5.2 Measurement Accuracy

The measurement accuracy of the RFM3000 is completely contingent upon the USB sensor with which it is being used. Please reference the sensor datasheet and/or associated uncertainty calculator for measurement uncertainties associated with a specific sensor.

Maintenance

This section presents procedures for maintaining the RFM3000.

6.1 Safety

The RFM3000 has been designed in accordance with international safety standards, general safety precautions must be observed during all phases of operation and maintenance. Failure to comply with the precautions listed in the Safety Summary located in the front of this manual could result in serious injury or death. Service and adjustments should be performed only by qualified service personnel.

6.2 Cleaning

Painted surfaces can be cleaned with a commercial spray-type window cleaner or a mild detergent and water solution.

Note:

⚠CAUTION When cleaning the instrument, do not allow cleaning fluid to enter the fan intake and exhaust vents. Avoid using chemical cleaning agents that can damage painted or plastic surfaces.

6.3 Inspection

If the RFM3000 malfunctions, perform a visual inspection of the instrument. Inspect for signs of damage caused by excessive shock, vibration, or overheating. Inspect for broken wires, loose electrical connections, or accumulations of dust or other foreign matter.

Correct any problems you discover, reboot the instrument, and observe the self-test results (see figure **6.1**). If the malfunction persists of the instrument fails the performance verification, contact BK Precision for service.

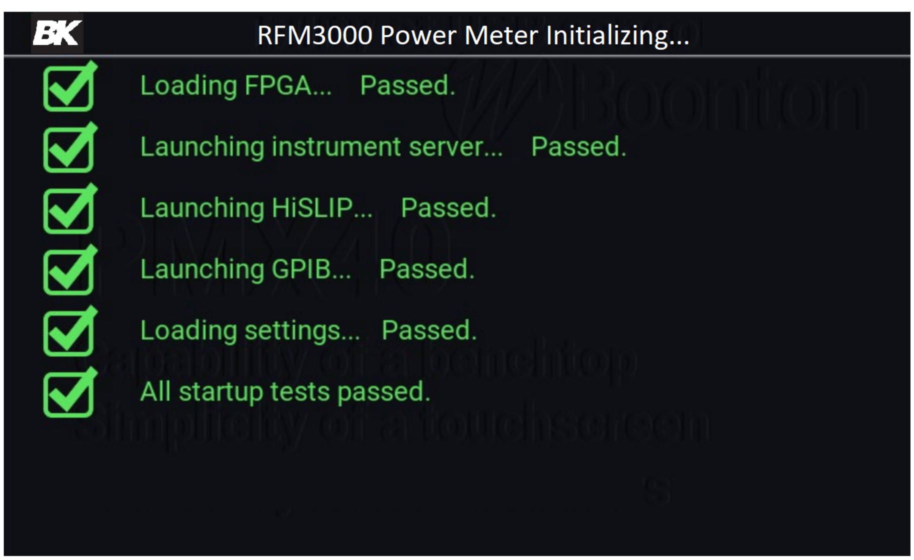


Figure 6.1 Self-Test Results

6.4 Lithium Battery

The RFM3000 contains one Lithium "coin cell" battery to provide for non-volatile storage of the instrument state. This is located on the Main Printed Circuit assembly. It should have a life of 5-10 years. When replacement is necessary, the battery must be disposed of in strict compliance with local environmental regulations.

6.5 Software Upgrade

Instrument operating software has been loaded into the Model RFM3000 at the factory, including the BK Precision Model RFM3000 Application Software. The Application Software will be updated from time to time to correct errors and add new features. Users can upgrade their software by downloading it from the BK Precision webpage, **bkprecision.com**. Copy the upgrade file(s) into the root directory on a USB drive, and plug the drive into one of the instrument's USB ports (front or rear). From the RFM3000 application, select the System menu, and select Go under Update Software.

Note:

CAUTION When loading new software into the Model RFM3000, some or all stored instrument configurations and preset operating selections may be lost. Contact BK Precision for information on which files may be affected.

Service Information

Warranty Service: Please go to the support and service section on our website at bkprecision.com to obtain an RMA #. Return the product in the original packaging with proof of purchase to the address below. Clearly state on the RMA the performance problem and return any leads, probes, connectors and accessories that you are using with the device.

Non-Warranty Service: Please go to the support and service section on our website at bkprecision.com to obtain an RMA #. Return the product in the original packaging to the address below. Clearly state on the RMA the performance problem and return any leads, probes, connectors and accessories that you are using with the device. Customers not on an open account must include payment in the form of a money order or credit card. For the most current repair charges please refer to the service and support section on our website.
Return all merchandise to B&K Precision Corp. with prepaid shipping. The flat-rate repair charge for Non-Warranty Service does not include return shipping. Return shipping to locations in North America is included for Warranty Service. For overnight shipments and non-North American shipping fees please contact B&K Precision Corp.

Include with the returned instrument your complete return shipping address, contact name, phone number and description of problem.

B&K Precision Corp.
22820 Savi Ranch Parkway
Yorba Linda, CA 92887
bkprecision.com
714-921-9095

LIMITED THREE-YEAR WARRANTY

B&K Precision Corp. warrants to the original purchaser that its products and the component parts thereof, will be free from defects in workmanship and materials for a period of **three years** from date of purchase.
B&K Precision Corp. will, without charge, repair or replace, at its option, defective product or component parts. Returned product must be accompanied by proof of the purchase date in the form of a sales receipt.
To help us better serve you, please complete the warranty registration for your new instrument via our website www.bk-precision.com
Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. The warranty is void if the serial number is altered, defaced or removed.
B&K Precision Corp. shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitations of incidental or consequential damages. So the above limitation or exclusion may not apply to you.
This warranty gives you specific rights and you may have other rights, which vary from state-to-state.

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Version: June 29, 2021