

# Keysight N9051A Pulse Measurement Software

Software Version 2.2

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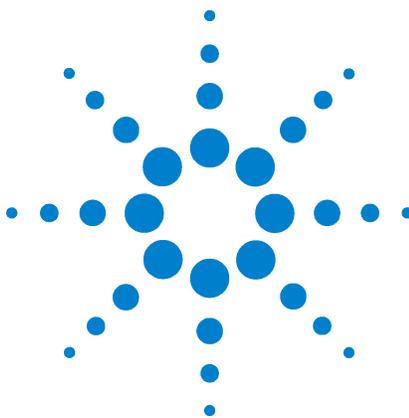
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# 1 Introducing the Agilent N9051A Pulse Measurement Software

**This manual is a reference to all functions in N9051A. Refer to the N9051A Getting Started Guide for installation procedure and start-up tutorials.**

The Agilent N9051A Pulse Measurement Software provides easy-to-use time-oriented measurements of Pulsed RF or Microwave signals in spectrum analyzers and oscilloscopes. It automatically finds pulse edges in time, and then measures parameters such as rise time, fall time, pulse width, PRI (interval), PRF, duty cycle, peak-to-average ratio and much more. Algorithms determine pulse characteristics according to methods from IEEE standard 181. Parameters are listed in a table for each pulse, up to 1000 pulses.

It also includes time display with zoom, units' conversion, trace math, and markers. Graphs for PDF, CDF, and CCDF are also available.

The vertical axis is calibrated in dBm, Watts, or Volts. Unlike solutions based on diode detectors and oscilloscopes, the amplitude values are trustworthy to within ~1–2 dB.

With additional options, the N9051A can also measure frequency and phase vs. time, provide parameters like chirp width, and provide extended statistics, trends, and histograms.

It is designed to support the Agilent PSA and X-Series Signal Analyzers (to 50 GHz and 160 MHz bandwidth). This is accomplished by using the Agilent 89600 VSA software for the “front end”. This brings flexibility and supportability for other front end hardware as it becomes available.

It can be installed inside any X-Series Signal Analyzer and appears in the “MODE” menu where you can access it as needed. In this environment, operation of the Pulse Measurement Software is identical to using it in a stand-alone PC.

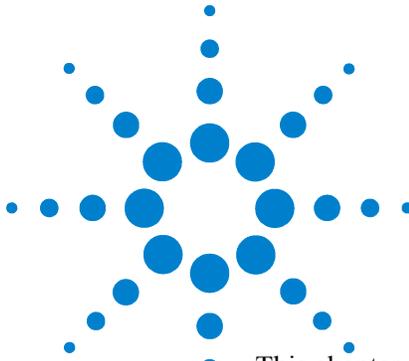
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**NOTE**

English (United States) is the only Windows regional and language option supported.

---

# 1 Introducing the Agilent N9051A Pulse Measurement Software



## 2 Menu Features

- This chapter provides descriptions and examples of parameter settings for each function available in the Pulse Measurement Software, as well as understanding how to use the graphical trace displays.

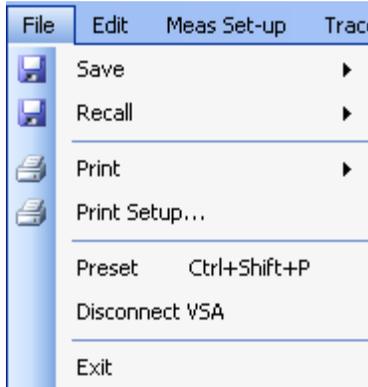
The Menu Bar at the top of the application looks like this:



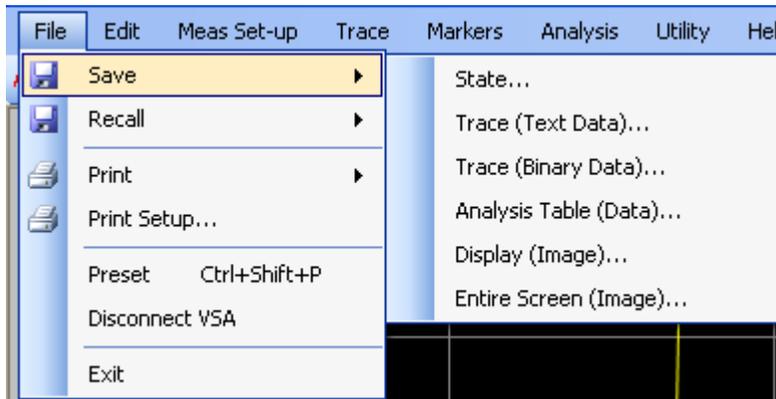
Each pull-down menu is described below.

## File

Opens the pull-down menu that enables you to handle files, preset the application, disconnect from VSA, or Exit.



## Save



### State

Enables you to save your measurement setup. Saving a State means you will be saving these parameters of the measurement:

Setup of the RF parameters, such as Center Frequency, Range, Reference level, and time record length.

Selected Analysis, and Analysis parameters.

**Trace (Text Data)**

Saves the selected trace in a ASCII text comma-separated values (CSV) file. This file can be examined with a text-based editor, and/or easily imported into a spreadsheet program (such as Excel) using the appropriate filter. The data is stored in pairs: a point-number index, and trace value (vertical axis) in volts.

**Trace (Binary Data)**

Saves the selected trace in a binary file for later recall back into the display. This file format is not supported as a means of importing or exporting data in/out of this software.

**Analysis Table (Data)...**

Saves the analysis data as a .CSV file for import into a spreadsheet. The data consists of a 2-dimensional table, where each row represents a distinct pulse, and each column a parameter for that pulse. For details on analysis features, see [“Analysis” on page 29](#).

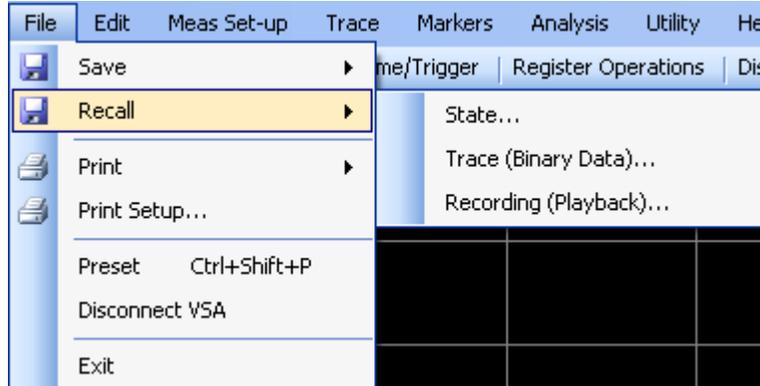
**Display (Image)...**

Saves the trace display as an image. The image includes the graticule, marginal annotation (e.g. scale factor or time), and all traces that are currently on. Markers also appear; however, their associated numerical values do not. If both displays are on, then select the desired one (make it “active”) by clicking within the graticule area. Several formats are available such as bmp, jpg, gif, and png.

**Entire Screen (Image)...**

Saves the entire screen (the entire application window) as an image. The formats available are bmp, jpg, gif, tif, and png.

### Recall



This selection enables you to recall three file types:

- 1.State
- 2.Trace (Binary Data)...
- 3.Recording (Playback)...

#### **State**

Recalls a previously saved state, which allows the user to duplicate a previous measurement setup.

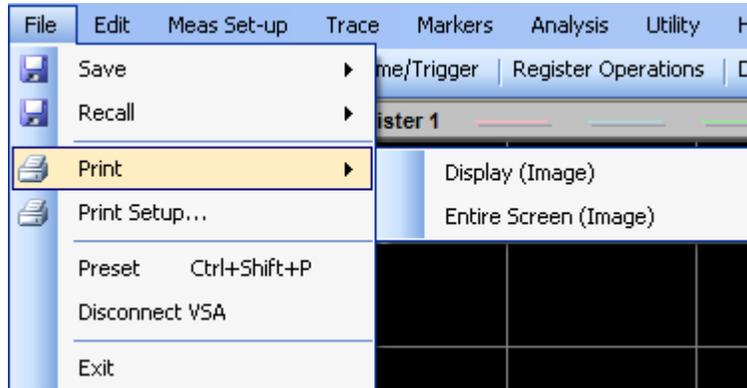
#### **Trace (Binary Data)...**

Recalls previous saved trace data back into the display.

#### **Recording (Playback)...**

Recalls a VSA “capture” recording. VSA recordings are an alternative to “live” data from hardware, and can be used to demonstrate the features of the software, or to analyze a file that was “captured” by a colleague. You cannot create VSA recordings in the Pulse Measurement Software, but you can play back files that have been recorded with the licensed Agilent 89600 VSA. You can also play back “synthesized” SDF recordings generated with other tools, such as MATLAB. For more information, refer to 89600 VSA documentation (which can be accessed from the Agilent 89600 help directory in the Program Files directory tree) and search for topics “SDF” or “recording”.

## Print



### Display (Image)

Prints the active trace display as an image.

### Entire Screen (Image)

Prints the Entire screen as an image

## Print Setup

Brings up the Windows Print Setup dialog, which allows you to select a printer and setup parameters.

## Preset

Resets the Pulse Measurement Software to startup configuration.

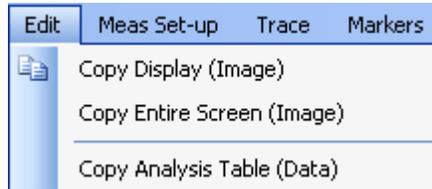
## Disconnect VSA

Disconnects the Pulse Measurement Software from the VSA measurement resource. This relinquishes control of the hardware so that another application can access it. If running in an X-Series Analyzer, this allows the user to switch to another mode (such as Spectrum) in the host analyzer without quitting the Pulse Measurement Software. To reconnect, click on the Run toolbar button.

## Exit

Exits the Pulse Measurement Software, and shuts down any VSA components in use. Also releases control of measurement hardware. Any data that was not previously saved will be lost.

## Edit



### Copy Display (Image)

Saves the active trace display to the clipboard, where it can then be pasted into another application.

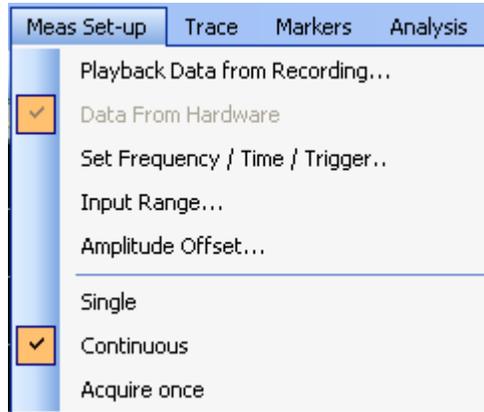
### Copy Entire Screen (Image)

Saves the entire screen to the clipboard, where it can then be pasted into another application.

### Copy Analysis Table (Data)

Saves the Analysis Table data to the clipboard, where it can then be pasted into another application.

## Meas Set-up



### Playback Data from Recording

Opens a file selection dialog for selecting a VSA recording file (such as an SDF file). The VSA will now use this recording as input rather than hardware.

### Data From Hardware

When checked, indicates that data is being taken from the VSA, and not from a recording provided by Pulse software. If you are taking data from a recording, and wish to return to hardware acquisition, check this item.

---

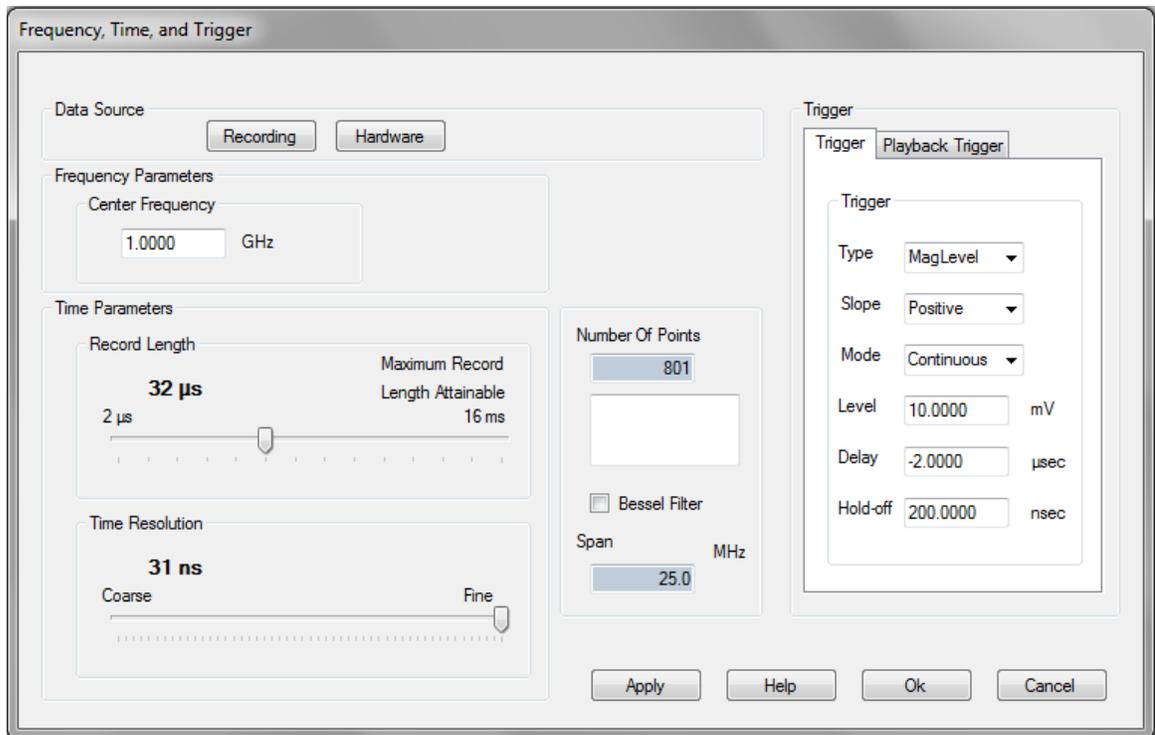
#### NOTE

If the Pulse Measurement Software cannot find and control hardware, it may substitute a recording of its own. In this case, the message “Hardware Not Found – Using Simulated Data” will be displayed. If you have measurement hardware to use, but can’t establish a connection to it, refer to “Instrument Control” in the “Troubleshooting” chapter.

---

## Set Frequency / Time / Trigger

Opens the main acquisition setup dialog. This dialog contains selections for Center Frequency, Time display length, and data density (number of points). It also contains controls for trigger setup, both for "live" data as well as recorded data. There is also a convenient section to easily switch between Hardware and recorded data. Record length and time resolution are set by sliders.



## Data Source Group

This group is a convenient means to select "Live" or "Recorded" data.

VSA recordings are an alternative to "live" data from hardware, and can be used to demonstrate the features of the software, or to analyze a file that was "captured" by a colleague. You cannot create VSA recordings in the Pulse Measurement Software, but you can play back files that have been recorded with the Agilent 89600 VSA. You can also play back "synthesized" SDF recordings generated with other tools, such as MATLAB. For more information, refer to 89600 VSA documentation (which can be accessed from the Agilent 89600 help directory in the Program Files directory tree) and search for topics "SDF" or "recording".

## Frequency Parameters Group

### Center Frequency

Sets the center frequency of the Pulse Measurement Software to the desired frequency. When you click on the text box, a small dialog appears in which to enter the digits and multiplier (MHz, for example).

### Bessel Filter checkbox

This checkbox is only available when the data is being acquired from hardware. When checked, a Bessel "window" filter is applied to the incoming data to reduce ringing effects when the rise time of the pulse approaches the measurement bandwidth of the hardware. Selecting this filter has the apparent effect of reducing the span by a factor of approximately two.

## Time Parameters Group

This group is dominated by a set of slider controls which are used to control the time Record Length and the Time Resolution, plus some auxiliary displays.

The Record Length control sets the length of time that is captured and processed. In the default case, this value is approximately the full (un-zoomed) time interval on the trace displays, from left to right edges. The interval begins with a trigger event (unless Trigger Type is Free Run), offset by the Trigger Delay. If you need to see a long time interval, to capture a pulse with a long repetition interval, or to see many consecutive pulses, then increase the value of Record Length.

The Time Resolution control determines the sampling interval, in time, i.e., the time interval between adjacent samples of the waveform. If you need to resolve fast changes in the waveform (e.g. a fast rise time), then move the Time Resolution control toward the "fine" end to increase the number of samples per unit time.

Number of Points is an auxiliary display showing the total number of sample points – approximately the Record Length divided by the Time Resolution. (The user does not have direct control over Number Of Points. Its value is a function of the two sliders.) Increasing the Record Length, or decreasing the Time Resolution interval, will increase the Number of Points. As the Number of Points increases, the overall measurement cycle time will slow down; this is because a large amount of data must be transferred and processed. The maximum Number of Points is ~409,000; if you hit this limit, then you must either (a) reduce the Record Length, in order to make the Time Resolution more fine; or (b) make the Time Resolution more coarse, in order to further increase the Record Length.

Span indicates the frequency bandwidth that is equivalent to the Time Resolution setting. If you are familiar with the "bandwidth" of your signal, this indicator may help you adjust the Time Resolution control. The Span is also the width of the frequency-domain Spectrum display (see "[Display Options](#)" on page 24). For additional details on how these controls function, please refer to "[Instrument Control Parameters](#)" on page 65.

## Trigger Group

Trigger settings give you control over the conditions which cause the start of data acquisition. This is useful for “stabilizing” a repetitive waveform, so that successive acquisitions (in Continuous mode) start at the same time relative to the waveform shape. Trigger settings are also important for catching an intermittent or single-shot event.

There are two tabs in the trigger group, one for controlling hardware, and the other for use with recordings. The functions for each are essentially the same. Consult your instrument specifications for a description of instrument trigger capabilities.

### Type

The selections available for the trigger type vary depending on the instrument hardware used, and whether using hardware or recording. The default for hardware is Free Run, and for recording is Level.

The Free Run type is especially useful if you are unsure the Pulse software is controlling the hardware, or whether the signal is present and has pulses on it, or what the amplitude excursions of the signal are. By using Free Run, you can at least see the waveform, and start to characterize it.

### Slope

Selects rising or falling edge for trigger.

### Mode

Sets the state of the measurement acquisition to either Continuous or Single.

---

**NOTE**

The triggering conditions must be met before an actual acquisition takes place.

---

- **Continuous**

Sets the state of the measurement software to be initiated on a continuous (repeated) basis. This setting is the same as the Continuous check-box under Meas Set-up.

- **Single**

Sets the state of the measurement software to take a single measurement acquisition at a time. This setting is the same as the Single check-box under Meas Set-up. If in single mode, selecting Acquire Once from the drop-down Meas Set-up menu or selecting Run from the Main Toolbar initiates only a single cycle of acquisition and analysis. Then the system waits for the next instruction.

### Level

Sets the threshold level for the trigger.

---

**NOTE** The units for Trigger Level are always in Volts, even if the Display Units are set to dBm or Watts. You may find it useful to briefly examine the waveform in Volts (see “[Display Options](#)” on page 24), with Trigger Type as **Free Run**, to help you set the right Trigger Level.

---

### Delay

Sets the delay from the time the trigger condition is met until the acquisition record starts.

---

**NOTE** This value can be negative for "pre-trigger" viewing, so that a short interval of time before the Trigger Level is crossed may be seen.

---

### Hold-off

Sets the time interval required from the time of a trigger until the trigger is re-armed. This may help “stabilize” a waveform that contains a burst or train of pulses.

---

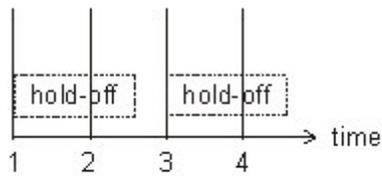
**NOTE** For Infiniium Series oscilloscopes, the threshold off value needs to be non-zero. Refer to the oscilloscope documentation.

---

### For Input = Hardware

Trigger Hold-off is the “Conventional” definition and specifies the length of time after a trigger before the next trigger can occur. This allows you to configure the analyzer to ignore trigger signals for a specified period of time. The first trigger signal initiates a hold-off; the next trigger signal after the hold-off starts the measurement and a new hold-off. This feature is often used in conjunction with IF Mag trigger to trigger a measurement at the start of a pulse or burst. To insure no false triggers, set the hold-off longer than the pulse to be measured.

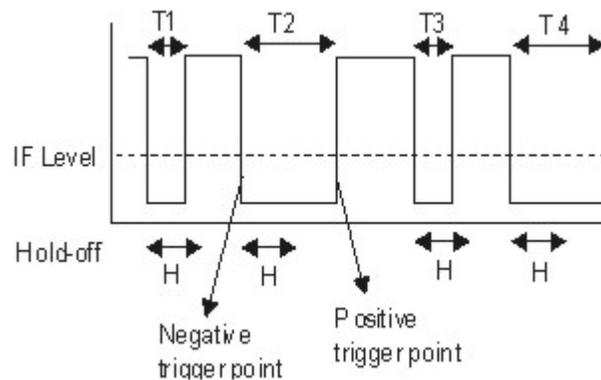
In this illustration, the first trigger starts the trigger hold-off. The second trigger is ignored as it occurs during the hold-off. The third trigger starts the next measurement (and a new hold-off).



1. first trigger -- starts hold-off
2. second trigger -- ignored
3. third trigger -- measurement start
4. fourth trigger -- ignored

**For Input = Recording**

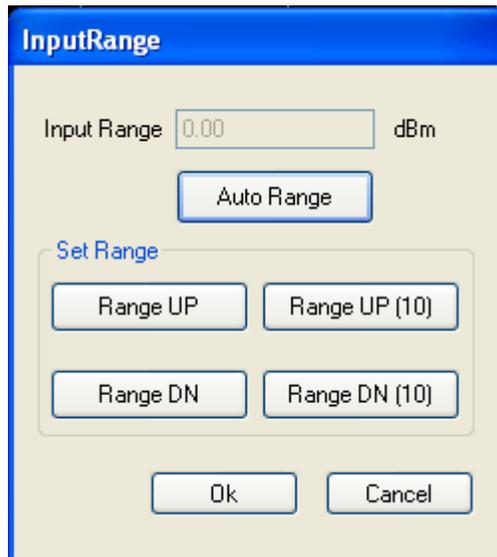
Trigger Hold-off is the "Below Level" definition. Trigger Hold-off specifies an amount of time that the analyzer's input signal must be a stable low value (below the trigger level) before the next trigger can occur.



- Time T1 is less than the hold-off time (H). The analyzer does not recognize the signal as being low and there is no trigger.
- Time T2 is longer than the hold-off time (H). After the hold-off time, the analyzer triggers at the negative trigger point for a negative slope and the positive trigger point for a positive slope.
- When the trigger input signal goes low again, the hold-off starts. Time T3 is less than the hold-off time (H). The analyzer does not recognize the signal as being low and there is no trigger.
- Time T4 is longer than hold-off time (H), so the analyzer will trigger on the next negative or positive trigger point depending on the specified slope.

## Input Range

Opens a dialog for setting the input amplitude range of the instrument hardware. This adjusts the attenuation and/or gain of the signal path leading to the ADC. (This should NOT be confused with display full scale.)



The range of the VSA must be set properly to avoid overloading the mixers and/or ADC in the signal measurement path, while maximizing the dynamic range of the measurement. It affects both the sensitivity of the analyzer as well as the maximum signal without overload.

The range is adjusted by selecting **Range UP** or **Range DN**. It can be adjusted in approximately 1 dB or 10 dB steps. For convenience, there is also an **Auto Range** function, which automatically sets the range to the optimum value. Set the range so that the overload indicator is off.

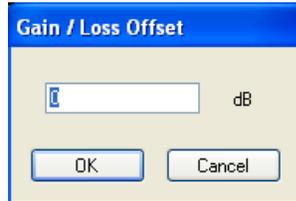
---

**NOTE** A repeatable, triggered signal must be present to ensure proper function of **Auto Range**.

---

## Amplitude Offset

Opens a dialog for setting an amplitude offset. This is useful for compensating for cable losses, attenuators, or even amplifiers so that the display reads the actual signal level at the desired test point. Entering a positive value will increase the displayed result (for example: compensate for a loss). Entering a negative value will decrease the displayed result (for example: compensate for external gain).



### Single

Stops continuous measurement acquisition. If in single mode, selecting **Acquire Once** in the Meas Set-up drop-down menu or selecting **Run** from the “[Main Toolbar](#)” on page 37 initiates a single cycle of acquisition and analysis. The system waits for further instruction. Note that the triggering conditions must be met before an actual acquisition takes place. These conditions are either that the trigger is set “on” or you are not in “free run”.

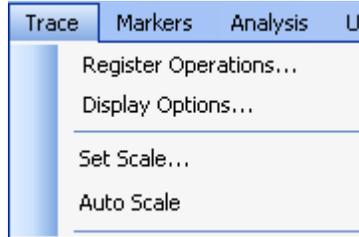
### Continuous

Causes measurements to be initiated on a continuous (repeated) basis. Note that the triggering conditions must be met before an actual acquisition takes place! These conditions are either that the trigger is set “on” or you are not in “free run”.

### Acquire Once

Causes a single acquisition cycle to be initiated, after which the acquisition stops. Normally used while in Single mode. If in Continuous mode, clicking Acquire Once puts the software into Single mode. Note that the triggering conditions must be met before an actual acquisition takes place!

## Trace



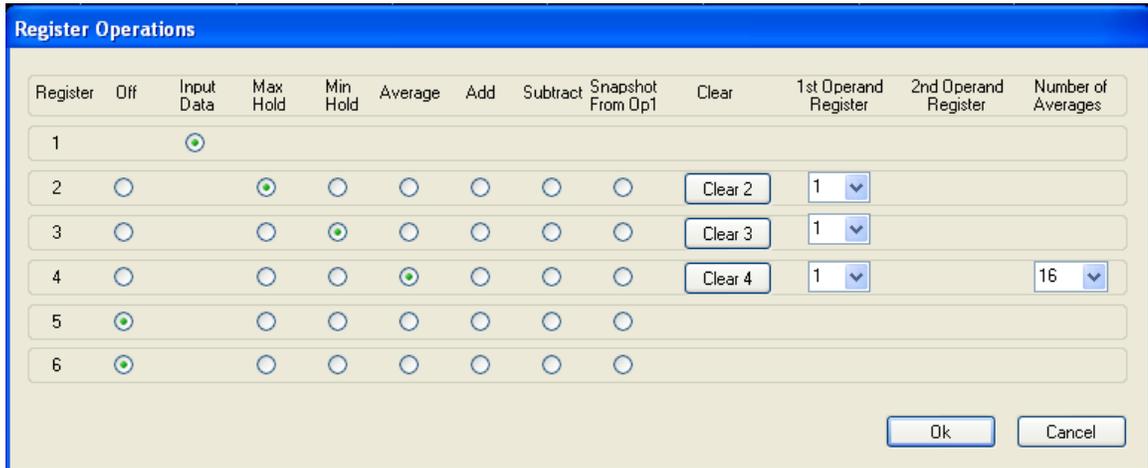
### Register Operations

Register Operations define the source of the data in a register. There are 6 “registers” in the Pulse Measurement Software to permit trace-based storage and manipulation. The registers and Pulse architecture are described in the Appendix. Register 1 is always used for “raw” data – meaning the latest fresh data acquired, with no processing, whether from measurement hardware or from playback of files (see [“Playback Data from Recording” on page 15](#)). Registers 2 through 6 can be used for a variety of trace functions:

- Max Hold – stores the maximum value for each time-point (horizontally) across successive acquisitions.
- Min Hold – stores the minimum value for each time-point (horizontally) across successive acquisitions.
- Average – stores the running average across successive acquisitions; you can set the average factor.
- Add -- stores the result of adding two selected registers together.
- Subtracts – stores the result of subtracting two selected registers from each other.
- Snapshot from Op1 – stores the current instant value. To repeat snapshot, return to register operations.

Most operations require you to select the source of the operands. Any operations that are continuously cumulative also have a “reset”.

Registers are “off” (empty or null) until one of the above operations is selected. However, the register must also be displayed for it to be visible; see [“Display Options” on page 24](#).



The figure above shows Register 2 set to capture the maximum values from Register 1. The Max Hold radio button has been selected. In addition, the 1st Operand Register has been set to 1 to indicate that Register 1 is the source for the Max Hold operation. Register 2 can be cleared by clicking the Clear 2 button. This will reset the system so that a new set of readings is used to calculate the data (Max Hold in this case).

Note that Min Hold, Average, and Snapshot From Op1 behave in a similar manner to Max Hold in that an operation is performed on data from the register listed in 1st Operand Register. Selecting Average makes a drop down box in the Number of Averages column visible.

Functions Add and Subtract take two operands (1st Operand Register and 2nd Operand Register) which refer to the register numbers used for the operation. Although not shown in the figure, Register 4 could be set to the sum (Add) of Registers 3 and 4 by setting the Add button in row 5 along with setting the 1st Operand Register to 3 and the 2nd Operand Register to 4.

Trace math operations are performed with every measurement update.

## Display Options

The display is controlled with the **Display Dialog**. There are two windows available in the **Graph Area**; an upper window and a lower window. The upper window is always visible. The lower window is turned on if any **lower window** display items are selected.

The Display Options menu is used to control:

- the registers (or other data source) that are visible, and in which display. (See “Register Operations” on page 23.)
- which of the two available displays (Upper, Lower, or both) are enabled.
- the units for the vertical axis.

By default, only Register 1 is selected in the Upper display (and Lower display is off). Register 1 can not be turned off, or removed from the upper display.

To use Registers 2 through 6, you must first define the Operation in the Register Operation menu that loads the register, and then also define where to view it in Display Options. A maximum of 3 registers can be selected for either display. If you try to turn on a fourth register, it will be ignored.

---

**NOTE**

You can perform Register Operations “in the background” (not continuously displayed), and display the register only when you want to.

---

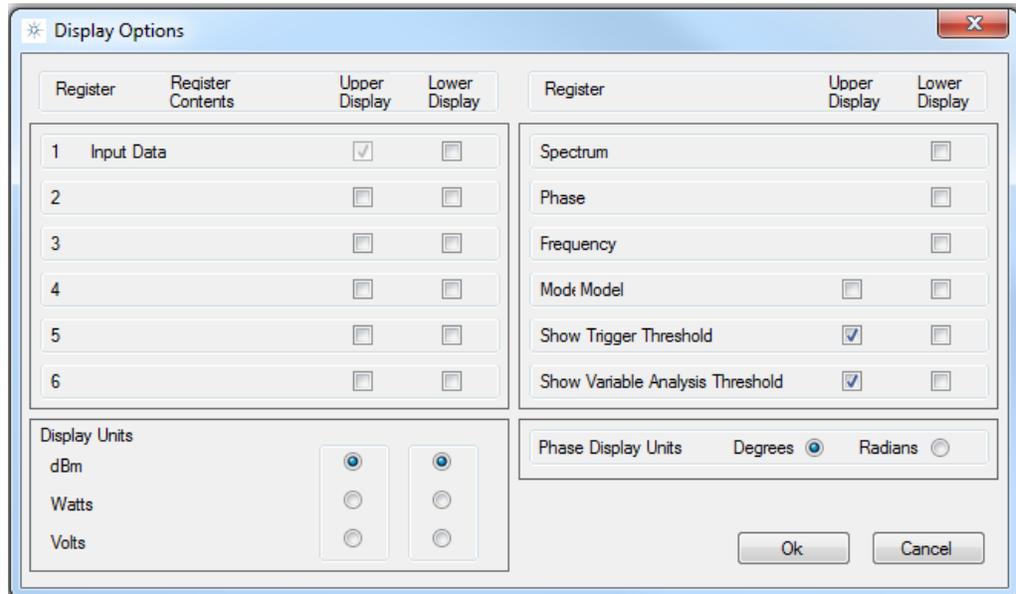
In addition to Registers 1 through 6, there are four other sources of data to display:

- Spectrum is the power spectrum calculated from the measured data. It can only be displayed in Lower Display, and then converts the display’s horizontal axis to be in units of frequency (instead of time). The frequency span of the spectrum’s horizontal axis is determined by the “span” calculated from the Time settings in the Frequency, Time, & Trigger dialogue (under Meas Set-Up), and can not be adjusted independently. The data source for Spectrum is always Register 1 (Input Data). Mixing spectrum with time-based traces or registers in the same display is not available.
- Phase is the unwrapped phase of the input signal ( $\arctan(Q / I)$ ). Phase display is only available in the lower window. When phase is selected it is the only display allowed in the lower window. Phase can be displayed in either degrees or radians.
- Frequency display is only available in the lower window. When frequency is selected it is the only display allowed in the lower window.
- Model is the straight-line “ideal” pulse that best fits the measured data. The general pulse shape is trapezoidal: horizontal “base” (across the noise floor), sloped sides (rise & fall), and a flat or sloping top. The data source is the register selected for analysis in the Analysis Selection Dialog. For details on analysis algorithms, please refer to the Appendix “[Pulse Measurement Software Approach](#)” on page 67.

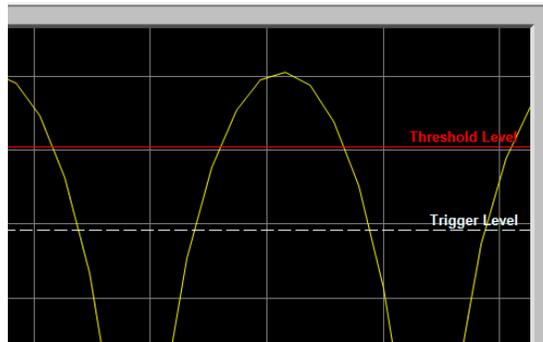
The Trigger and Variable Analysis Threshold levels can be displayed on the screen by checking the appropriate check boxes.

Display Units perform amplitude conversion, changing the meaning and scale of the vertical axis. The fundamental measurement units are volts. Watts are calculated based on  $V^2/(R)$ , where R assumes a 50-Ohm impedance. dBm are calculated based on  $10 \log P$ , where P is power relative to one milli-watt. Aside from choosing units that are familiar or convenient to you, remember also that linear displays (volts or watts) show detail in large signals (pulse-on period), while logarithmic displays (dBm) will “expand” low signals (pulse-off or noise).

## 2 Menu Features

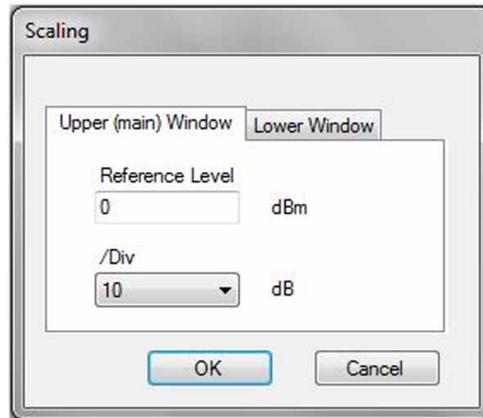


The Trigger and Variable Analysis Threshold levels are displayed in the example below.



## Set Scale

Opens a dialog for setting the scaling in the trace display windows. The units seen in this dialog match the units selected under Display Options dialog. The “Reference Level” refers to the top graticule line in the display, as is customary in a spectrum analyzer.



## Auto Scale

Auto scales the trace(s) when clicked.

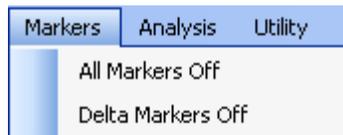
## Markers

---

**IMPORTANT** The majority of marker functions are controlled via the mouse, using the marker window and displays. See [“Markers” on page 45](#). Only a small number of related functions are located here under Markers in the main menu.

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For a more detailed description of Markers, see [“Markers” on page 45](#).



### All Markers Off

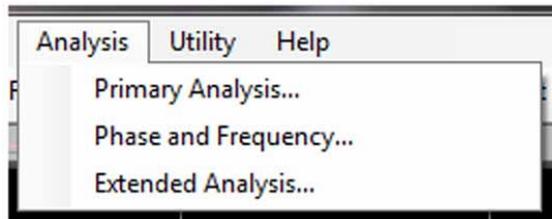
Turns all markers off.

### Delta Markers Off

Turns delta markers off.

## Analysis

“Analysis” refers to the algorithms in the Pulse Measurement Software used to automatically find RF pulses, locate features along each pulse cycle, and characterize those features.




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### NOTE

Phase and Frequency and Extended Analysis are available only if the software license to enable these optional features is installed. For Phase and Frequency see [page 49](#). For Extended Analysis see [page 52](#).

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### Primary Analysis

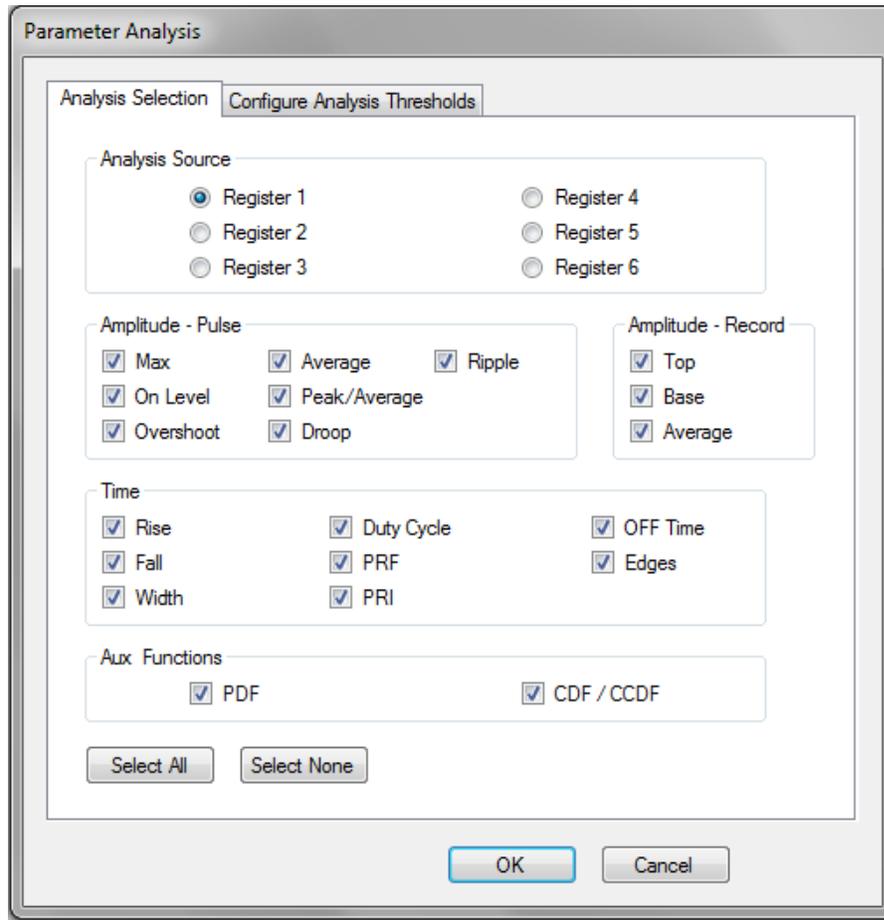
The Primary Analysis selection opens a dialog that controls the calculation and display of analysis data.

### Analysis Selection Tab

The Pulse Measurement Software automatically find pulses in the waveform, locate features in those pulses, and then characterize the features. This dialog allows the user to:

- Select the source of the waveform to analyze; you may analyze any of the six data registers (default is register 1, which is the current data from the VSA);
- Turn on or off the individual analysis features (these are grouped into amplitude- and time-related parameters);
- Enable graphical summaries of power statistics: PDF (Power Distribution Function); CDF (Cumulative Distribution Function); CCDF (Complementary CDF).

The results are generally displayed in the bottom section of the application display, under one of the tabs. Click on the appropriate tab to display the results.



Most of the measurement results are evident from their names. A few that deserve extra comments:

- “Amplitude – Pulse” refers to parameters for an individual pulse. “Amplitude – Record” refers to parameters for the entire measurement record.
- “Top” refers to the statistically most prevalent amplitude level (straight line) when the pulses are “on”.
- “Base” is the statistically most prevalent amplitude level when the pulses are “off”.
- “Edges” displays the instant in *absolute* time when an edge occurs. For contrast: "Rise" and "Fall" describe the duration of transition from off state to on state.

For details on analysis algorithms, please refer to the [“Pulse Measurement Software Approach”](#) on page 67.

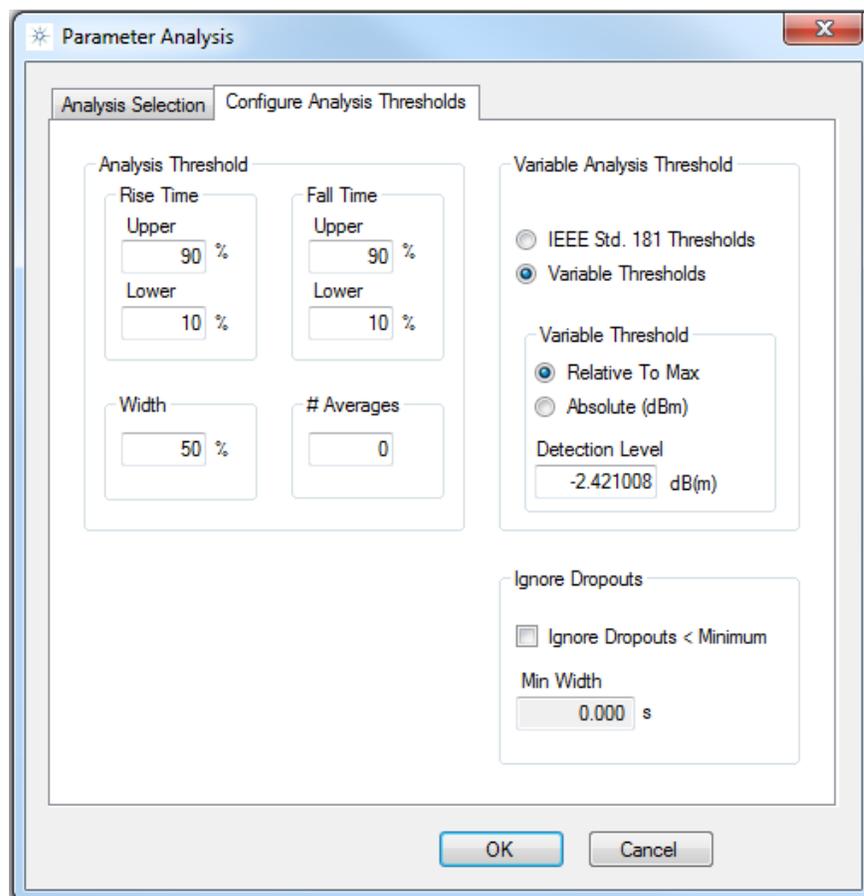
## Configure Analysis Thresholds Tab

The Configure Analysis Thresholds tab controls the thresholds used to characterize the pulse parameters chosen in the Analysis Selection tab.

The Analysis Threshold entries set the thresholds for rise/fall/width calculations, expressed as a percent of voltage difference between the “base” (pulse-off condition, typically noise floor) and “top” (pulse-on condition). Refer to [“Pulse Measurement Software Approach” on page 67](#) for details.

### NOTE

The level threshold calculations are based in linear units (volts), even if the display is currently in dBm or Watts.



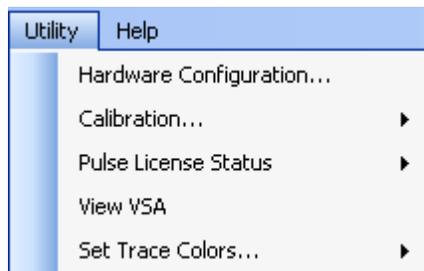
The Variable Analysis Threshold area controls the pulse detection method. There are two choices:

- **IEEE Std. 181 Thresholds** - Uses the “bi-modal histogram method”, applied to the entire acquisition. This method is traditional, standards-based, and similar to the algorithm used in the HP 8990 and 8991 Peak Power Meters. However, it functions best when all pulses in an acquisition have the same pulse-on amplitude.

- **Variable Thresholds** - Uses a modified 2-step algorithm, suitable for cases where the pulses in an acquisition have widely varying pulse-on amplitudes. First, pulses are “detected” used a Detection Level which is either (a) Relative to Max; or (b) Absolute. Relative to Max means a level X dB below the maximum amplitude found during an entire acquisition. Absolute means an X dBm absolute value. If enabled under Display Options, the level will be drawn as a line over the trace. The Detection Level is used to detect each pulse, and isolate it by breaking the acquisition into sub-segments containing only one pulse. Each sub-segment is enlarged by 10 sample points on either side of the Detection Level crossing, to include samples that represent the pulse-off level. The Time Resolution setting (under Frequency, Time, and Trigger) must be set such that these samples mostly fall into the pulse-off period (to establish the “base” level). Second, each pulse is analyzed individually within its own sub-segment. The “top” and “base” calculations, plus the Upper/Lower/Width thresholds, are still based on IEEE 181, but only within the sub-segment, and so for each pulse individually.

The Ignore Drop-Outs area modifies the pulse analysis algorithms to ignore brief intra-pulse drops in amplitude. These are typically a side-effect of intra-pulse modulation (Barker phase shift, FSK or frequency-stepping, etc.), where the magnitude of the pulse briefly falls. If these drop-outs are deep enough to cross a threshold, the pulse analysis logic may determine that the current pulse has ended (and start looking for a new pulse). If you check the box “Ignore Drop-Outs < Minimum”, then the algorithms will “wait” the Min-Width time before assuming the pulse has ended. If the pulse-on amplitude returns before this time, the pulse is considered to be continuing (same pulse). Obviously, this entry should be less than the smallest expected pulse-off interval between pulses.

## Utility



### Hardware configuration

Opens a dialog for selecting the instrument hardware that the Pulse software will use (through the VSA's control). For most users, there are a few situations where this dialog can help establish a connection to an instrument. (First, ensure there is a valid hardware connection using "Agilent Connection Expert".)

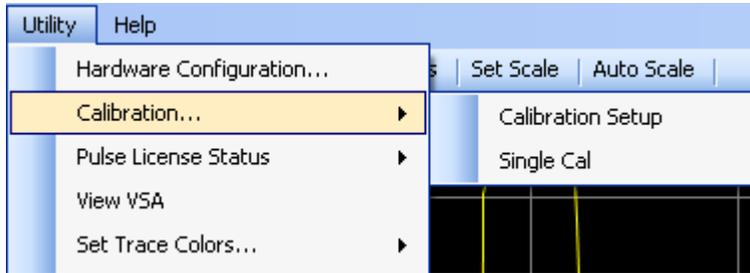
If you see the error message "Hardware not found, using simulated data"... this means the system is playing back a file instead of using hardware. Try un-checking the "Simulate Hardware" checkbox within the Hardware Configuration dialog. Check that the "ADC1" table lists the instrument you want to use, and it has a check mark against it. If this table lists multiple instruments, un-check any other instruments from the list. Then click "OK" and wait a moment for the software to initialize the hardware.

If this step fails, please see the "Troubleshooting" chapter for "Instrument Control" problems.

If making Phase or Frequency measurements, the **Frequency/Reference/Timebase** of the signal source (transmitter) and the analyzer probably need to be locked to each other. Depending on the situation, you may lock the source to the analyzer's 10 MHz Ref Output, or lock the analyzer EXT Ref In to a suitable source output. In the latter case, use the Hardware Configuration menu, then select the hardware being used, click **Configure**, and set **Lock Reference** to **True**. This commands the analyzer to lock its reference to an external input.

Other features in this dialog are intended for advanced users. Please see the Agilent 89601 VSA documentation for detailed information on hardware configuration.

## Calibration



### Calibration Setup

Opens the VSA Calibration dialog. Please see the 89601 documentation for information on VSA calibration.

### Single Cal

Performs an immediate calibration of the VSA input system.

## Pulse License Status

Opens the Pulse license dialog.

## View VSA

Opens the VSA display window so that the user can see the 89601 VSA software "behind the scenes". This selection is only available if the user has a valid paid-for license to operate the full Agilent 89601 VSA software, which is distinct from the license to operate Agilent N9051A Pulse Measurement Software.

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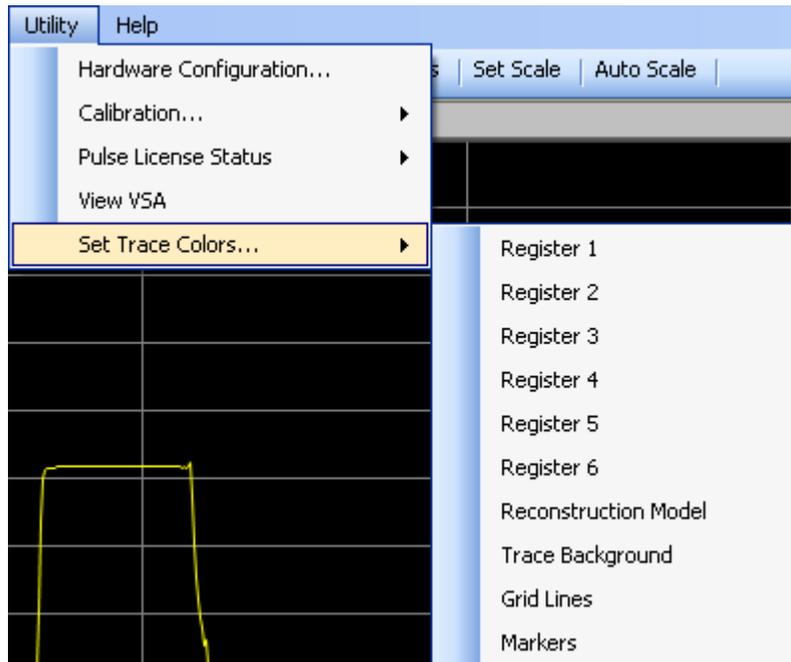
**CAUTION**

Use this feature *ONLY* for the purpose of *observing* measurements in the VSA. Do not *change* any measurement settings in VSA. Changing settings in the VSA while the Pulse Measurement Software is running can disrupt the program and cause the Pulse Measurement Software to *be terminated!* Use this feature with *extreme* caution!

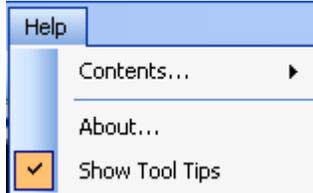
---

## Set Trace Colors

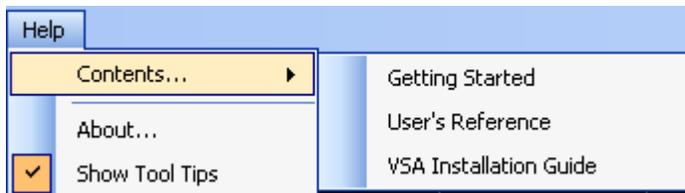
Use this menu to set custom colors for the traces and other graphical features. Each selection will bring up the Windows color selection dialog.



## Help



### Contents



Opens the appropriate Help file with a PDF viewer.

The *Getting Started Guide* includes:

- procedures for installation, including system configuration and establishing hardware control
- licensing, including redemption of Certificates of Entitlement
- a measurement section to quickly familiarize first-time users with the operation of Pulse Measurement Software.

The *User's Reference* contains detailed information on each feature and display in the Pulse Measurement Software. Other sections include:

- error messages and troubleshooting
- an appendix of reference information

The VSA Installation Guide provides detailed information on how the Agilent 89601 is used to establish a connection to the instrument to be controlled.

### About

About lists the version number, date created, copyright information, and other pertinent information describing the software.

### Show Tool Tips

When checked (default), hovering the mouse over selected areas of the screen shows a short description of that feature. Un-checking this item disables Tool Tips.

## Main Toolbar



The toolbar is directly below the main menu. The row of buttons provides the Run/Stop controls, plus a number of convenient one-click buttons to access some of the more commonly-used dialogs and functions.

### Abort!

Performs an immediate measurement abort to the VSA to stop an acquisition in progress.

### Run

Starts the measurement cycle.

---

**NOTE** The trigger conditions must be met for an acquisition to occur.

---

This button will also re-connect the VSA session if it had been previously disconnected.

### Stop

Stops the measurement cycle.

### Set Freq/Time/Trigger

This button is a quick way to open the main acquisition setup dialog described in [“Set Frequency / Time / Trigger” on page 16](#).

### Register Operations

This button is a quick way to open the register operations dialog described in [“Register Operations” on page 23](#).

### Display Options

This button is a quick way to open the display options dialog described in [“Display Options” on page 24](#).

### **Select Analysis**

This button is a quick way to open the display options dialog described in [“Analysis Selection Tab” on page 29](#)

### **Set Scale**

This button is a quick way to open the set scale dialog. See [“Set Scale” on page 27](#) for more information.

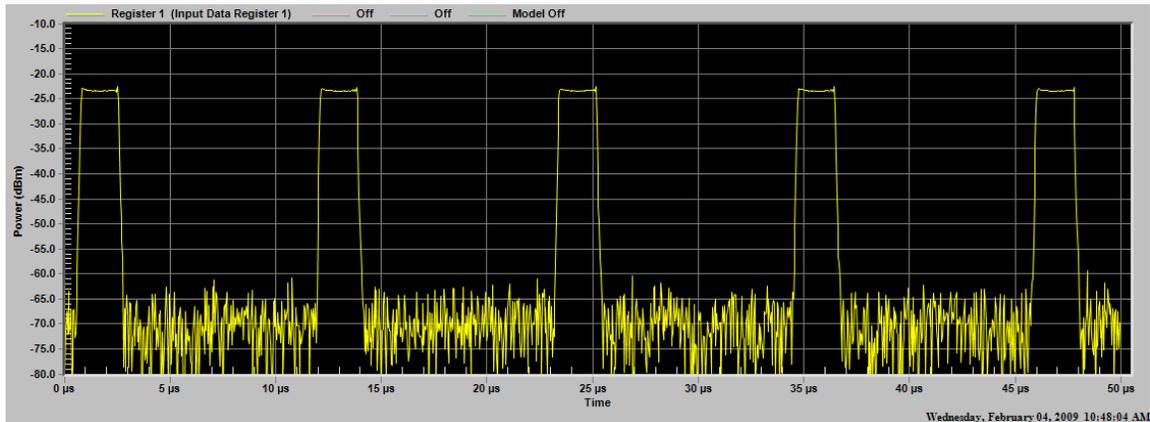
### **Auto Scale**

Auto scales the trace(s) when clicked. See [“Auto Scale” on page 27](#) for details.

### **Phase and Frequency**

Opens the Phase and Frequency dialog (grayed out if the Phase and Frequency license is invalid).

## Graphical Trace Displays



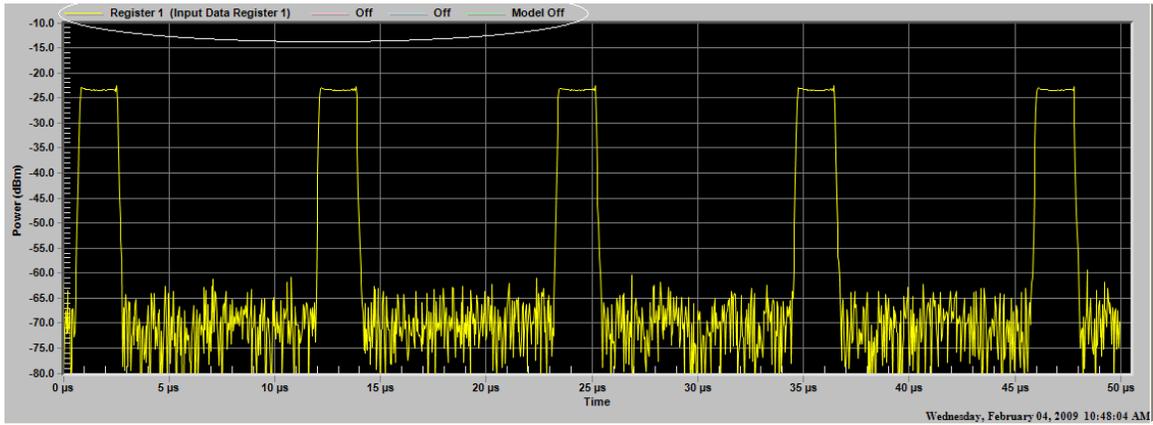
Trace displays are X-Y Cartesian graphs, normally used to plot the input signal versus time. Only one display is shown by default; however, you can enable a second display with the Display Options menu. The horizontal axis is time by default; however, a spectrum display is available via the Display Options menu.

The display(s) are resizable simply by “grabbing” the separator bar(s) between above/below them with the mouse and moving them.

Be aware that the display resolution of the trace is limited by the resolution of physical display device itself. The number of measurement points (up to 409,000) can be much greater than the number of display pixels (perhaps 2000). Therefore, the software can not always display all the information and detail that is captured and measured. Be assured that the “analysis” functions of the Pulse Measurement software use the full-resolution of the data acquired; the software will find, count, and measure pulses even if they cannot be seen. If you need to verify graphically that a pulse is present, use the “zoom” feature (“drag” a box with the mouse) to take a closer look with greater time resolution.

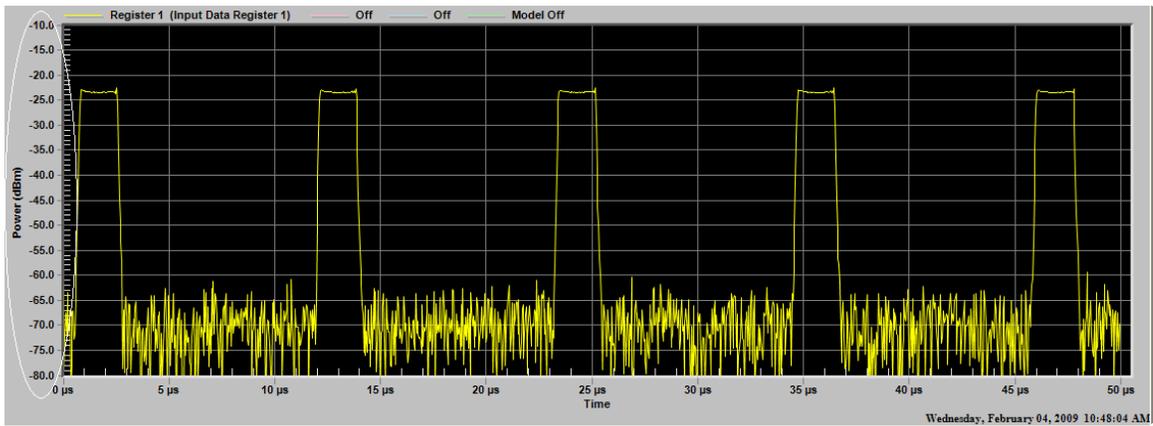
## Display Annotation

### Graph Title and trace color



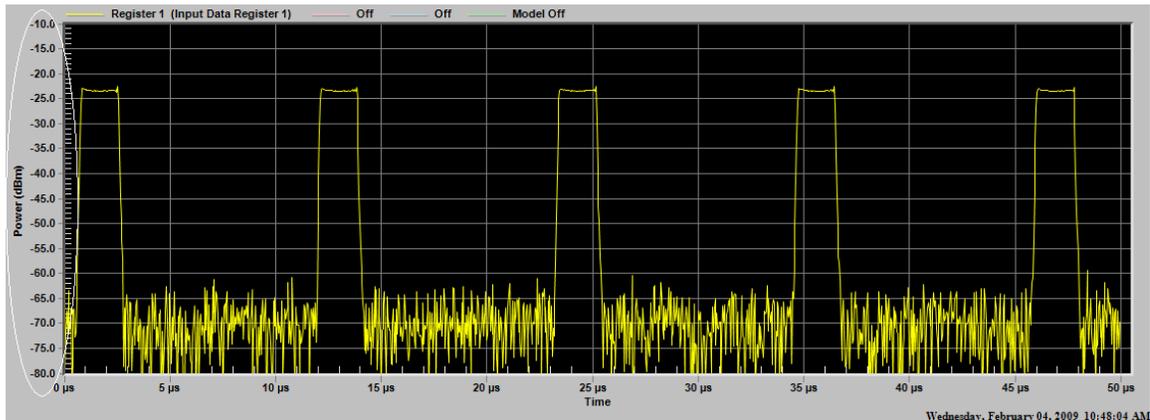
Shows the trace definition and color.

### Vertical (Y) axis scale



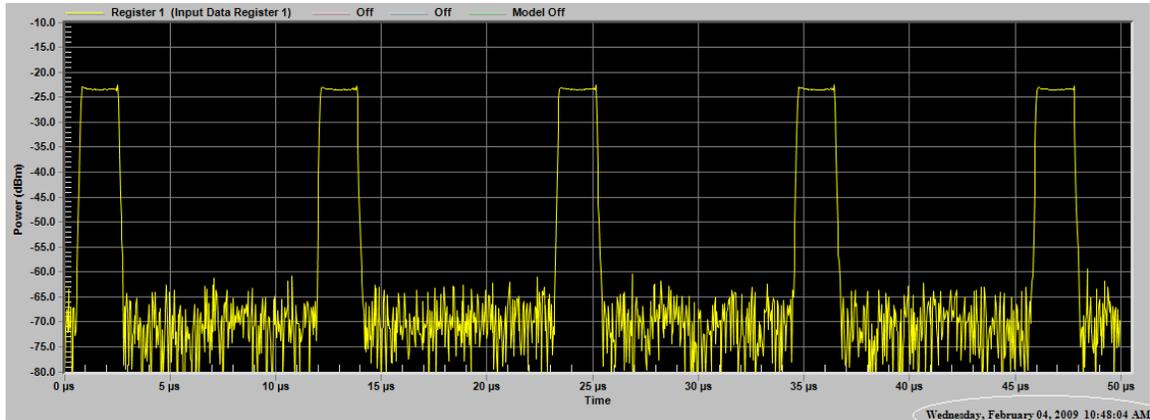
Shows the vertical scaling and units.

## Horizontal (X) axis scale



Shows the horizontal scaling and units (time or frequency).

## Clock display



Displays the current system time.

## Control Functions

There are several functions that can be performed on the trace display by various mouse maneuvers. The left mouse button is used for selecting items and for zooming. The right mouse button brings up a context menu. The contents of the context menu are dependent upon the mouse cursor location. If the mouse cursor is over a graph window (either upper or lower), then the right mouse context menu contains the following: Set Scale, Increase Y Axis 50%, Autoscale, Set

## 2 Menu Features

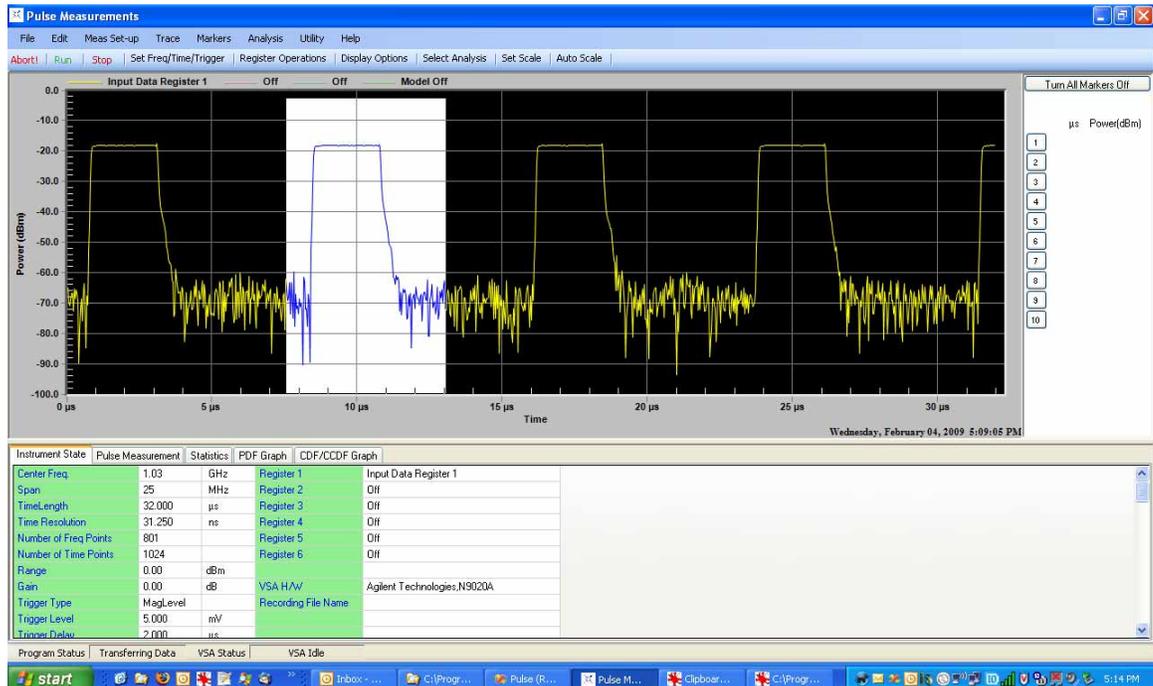
Freq/Time/Trigger, Register, Display, Analysis, All Markers Off, and Delta Markers Off. If the mouse cursor is over the data window in bottom pane the only menu item available is Analysis.

### Select Active Display (by Single Click)

A single click of the mouse will set the specific window as “Active”. This applies when both trace windows are shown and determines which window succeeding commands are directed to. Examples include saving or printing the active window image or data.

### Zoom (by Dragging the Mouse)

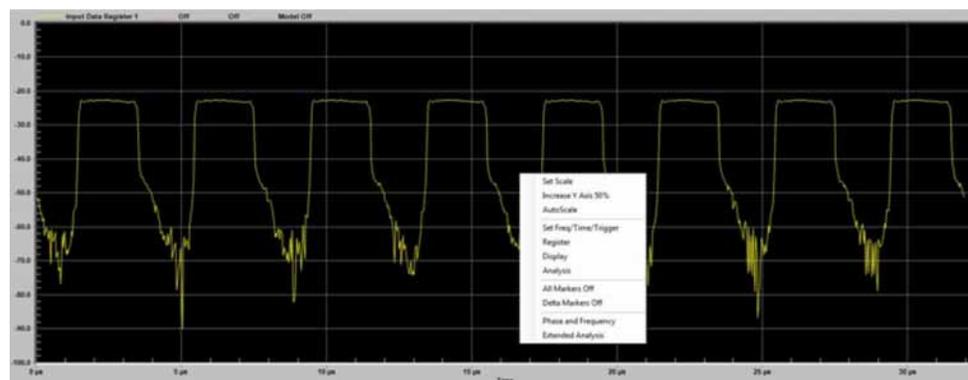
Dragging the mouse over a desired portion of the trace with the left mouse button pressed executes the “Zoom” function, which expands and scales the selected portion of the trace to fill the entire graph window.





## Right-click Functions

Right-clicking the mouse brings up a context menu with several useful choices.



**Zoom All the Way Out** Reduces magnification of the trace, reverting to the original full scale. (You must have already zoomed in to see this option on the menu.)

---

**NOTE**

This option is only available when you have zoomed in on a signal.

---

**Increase Y-axis 50%** Scales the vertical axis by 50%, to allow viewing of data that may have been inadvertently driven off screen or to accommodate changes in the pulse amplitude. Note that the normal Set Scale and Auto Scale functions are not available while in zoomed mode.

**Set Frequency / Time / Trigger** This context menu item brings up the Main Setup Dialog. See [“Set Frequency / Time / Trigger” on page 16](#) for more information.

**Register** This context menu item brings up the Register Operations dialog. See [“Register Operations” on page 23](#) for further details.

**Display** This context menu item brings up the Display Operations dialog. See [“Display Options” on page 24](#) for further details.

**Analysis** This context menu item brings up the Select Analysis dialog. See [“Analysis Selection Tab” on page 29](#) for further details.

**All Markers Off** Turns all the markers in the window off.

**Delta Markers Off** Turns off the Delta Marker function, but leaves all markers on in “normal” mode.

**Phase and Frequency** Opens the Phase and Frequency dialog (grayed out if the Phase and Frequency license is invalid).

## Markers



The marker window provides a means to select and place markers. It also presents a table of the selected markers and their values.

### Marker Selection and Placement

To place a marker, first select the marker you wish to place by clicking on the numbered button. When you move the mouse over to the trace window, a set of cross hairs will appear. Move the mouse to the desired location (actually, only the X axis portion is used). When in the desired location, click the mouse to activate the marker. If you wish to move the marker, or it is not exactly in the desired location, simply repeat this process.

To place a marker more accurately in time (or frequency), it may be useful to temporarily “zoom” in on a portion of the trace, place the marker where you want it, then un-zoom again. (Of course, this assumes that the trace is stable from acquisitions to acquisition (using triggers), or frozen (using Stop).)

When the maker is placed, it is indicated by a white diamond with its number adjacent to it. Also, its values will be shown in the table to the right of the button, and the button will turn a golden color to indicate it is on.

### Setting a Delta Marker

Setting a Delta marker is similar to a normal marker. Simply *double-click* the button instead. This will turn on the Delta marker function, and the placed marker will become the reference. The reference button will turn red to indicate that it is the reference, and the other active buttons will turn blue. The values in the marker table for the reference are absolute, and the other values display the difference between that particular maker and the reference.

### All Markers Off

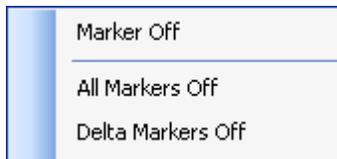
A button at the top of the marker window will simultaneously turn off all markers in that window.

### Delta Markers Off

If the Delta Markers are on, a second button becomes visible, which when clicked turns off the Delta Marker function and all markers in that window revert to “normal” markers.

### Right-Clicking a Marker Button

Right-clicking a marker button will bring up a context menu with the following selections.



**Marker Off** Turns the selected marker off.

**All Markers Off** Turns *all* markers off.

**Delta Markers Off** Turns Delta Marker mode off. All markers revert to “normal” markers.

**Viewing Markers on different traces** To view the markers on another trace in the window, click on the trace identifier for that trace, located in the upper left corner of the display area. (This also shows the trace color for the desired trace.)

## Tabular Results Window

| Instrument State      | Pulse Measurement | Statistics | PDF Graph           | CDF/CCDF Graph              |
|-----------------------|-------------------|------------|---------------------|-----------------------------|
| Center Freq.          | 1.03165           | GHz        | Register 1          | Input Data Register 1       |
| Span                  | 20.063694...      | MHz        | Register 2          | Off                         |
| TimeLength            | 50.000            | μs         | Register 3          | Off                         |
| Time Resolution       | 38.938            | ns         | Register 4          | Off                         |
| Number of Freq Points | 3201              |            | Register 5          | Off                         |
| Number of Time Points | 4096              |            | Register 6          | Off                         |
| Range                 | 0.00              | dBm        |                     |                             |
| Gain                  | 0.00              | dB         | VSA H/W             | Agilent Technologies.N9020A |
| Trigger Type          | MagLevel          |            | Recording File Name |                             |
| Trigger Level         | 10.000            | mV         |                     |                             |
| Trigger Delay         | 2.000             | μs         |                     |                             |
| Trigger Holdoff       | 200.000           | ns         |                     |                             |

The Tabular Results window is the main source for analysis results. There are several tabs, each with specific information.

### Instrument State Tab

Presents tabular information on the setup of the Pulse Measurement Software. It includes information on RF settings such as center (tune) frequency, input parameters, triggering, and the VSA front end hardware. It also shows display register contents, and if using pre-recorded signals, the name of the recording file.

### Pulse Measurement Tab

Presents the selected measurements. Each column represents the selected measurement(s), and each row represents the specific pulse. Note that some fields may be blank because results could not be computed. For example, PRI would not be calculated after the last complete pulse.

Refer to the Appendix, “[Pulse Measurement Software Approach](#)” on page 67 for specific details on the computational algorithms used for Pulse Measurement Software.

### Statistics

Presents statistics on the pulse measurements, both for the current acquisition as well as the cumulative total. There is a reset (in red) to reset the cumulative statistics. For more information, see “[Statistics Tab](#)” on page 72.

### PDF Graph

Presents a probability density function (PDF) plot of the data.

### **CDF/CCDF Graph**

Presents cumulative probability density function (CDF) and complementary cumulative probability density function (CCDF) plots of the data.

### **Program Status**

Shows the current status of the program and of the VSA. There is also a message area for important measurement warnings, such as input overload, and for certain other events. Refer to the “Troubleshooting” section of the *Getting Started Guide* for a complete description of messages, what they mean, and possible actions to be taken.

## Phase and Frequency

---

**NOTE** The Phase and Frequency features are optional, and available only if the corresponding license (-3FP) is purchased and installed.

---

The Phase and Frequency option allows the user to graphically display phase and frequency data in a manner similar to what is currently used to display pulse data. The option adds the following capabilities to Pulse. These parameters are calculated for each pulse –

1. Pulse-to-Pulse change in phase relative to the first pulse.
2. Mean phase.
3. Phase trend over the pulse.
4. Bandwidth.
5. Start frequency (relative to tuned center frequency).
6. Stop frequency (relative to tuned center frequency).
7. Frequency trend over the pulse.
8. Frequency deviation from linear fit to frequency over the pulse.

---

**IMPORTANT** Valid measurements of phase (most cases) or frequency (some cases) require that the **Frequency/Timebase/Reference** of the analyzer is locked to that of the signal source or transmitter, or visa versa. Typically, the 10 MHz Ref Out is always available **from** the analyzer. To lock the analyzer with a reference supplied **to** it, select the **Utility** menu in the N9051A software, then **Hardware Configuration**, highlight the hardware, click **Configure**, and set **Lock Reference** to **True**.

---

### Phase Display, Scaling, Markers

Phase is displayed in the lower window only. Phase is displayed by itself in the window because it is not specified in the same units as the other data quantities. Logic in Pulse ensures that phase is not displayed with any other quantities. Phase is displayed as an unwrapped quantity. Scaling, autoscaling, and marker functions work for phase like they do for other data.

### Frequency Display, Scaling, Markers

Frequency is displayed in the lower window only. Frequency is displayed by itself in the window because it is not specified in the same units as the other data quantities. Logic in Pulse ensures that frequency is not displayed with any other quantities. Scaling, autoscaling, and marker functions work for frequency like they do for other data.

## Phase and Frequency Analysis Results Display

Phase and Frequency analysis results are displayed in the Analysis Table along with the other pulse analysis data. A sample is shown below. The data are intermixed with other analysis results. Note that the last entry in the table (number 6 in this case) may be blank (shown as dashes) if the pulse is incomplete.

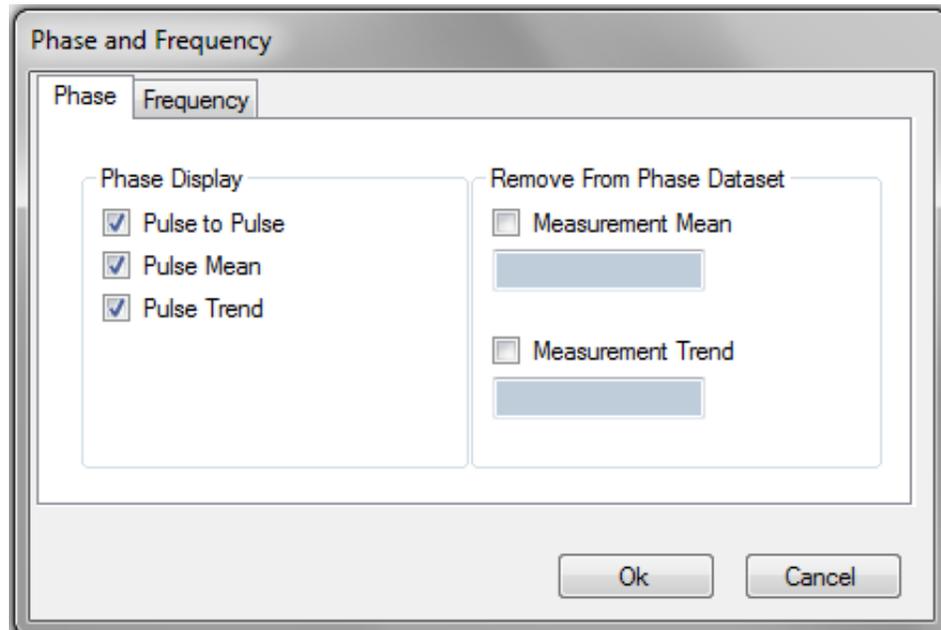
| Instrument State | Pulse Measurement |        | Statistics      | PDF Graph | CDF/CCDF Graph |       |        |          |       |
|------------------|-------------------|--------|-----------------|-----------|----------------|-------|--------|----------|-------|
|                  | Phase             | Phase  | Phase           | Band-     | Start          | Stop  | Freq   | Freq     | Freq  |
|                  | Pls-Pls           | Mean   | Trend           | width     | Freq           | Freq  | Mean   | Trend    | Dev   |
| Pulse            | (mdeg)            | (Kdeg) | (deg/ $\mu$ ... | (MHz)     | (MHz)          | (MHz) | (KHz)  | (MHz/... | (KHz) |
| 1                | 0.00              | -1.33  | -610.46         | 26.63     | -12.18         | 14.45 | 253.74 | 19.90    | 42.01 |
| 2                | 37.16             | -1.35  | -612.34         | 26.68     | -12.08         | 14.60 | 368.85 | 19.91    | 41.10 |
| 3                | -3.45             | -1.37  | -614.62         | 26.68     | -11.97         | 14.72 | 477.54 | 19.91    | 40.60 |
| 4                | 51.35             | -1.39  | -616.55         | 26.68     | -11.86         | 14.82 | 592.86 | 19.92    | 42.31 |
| 5                | 14.92             | -1.40  | -618.59         | 26.63     | -11.75         | 14.88 | 693.32 | 19.90    | 41.04 |
| 6                | ...               | ...    | ...             | ...       | 0.00           | ...   | ...    | ...      | ...   |

## Phase and Frequency Dialog

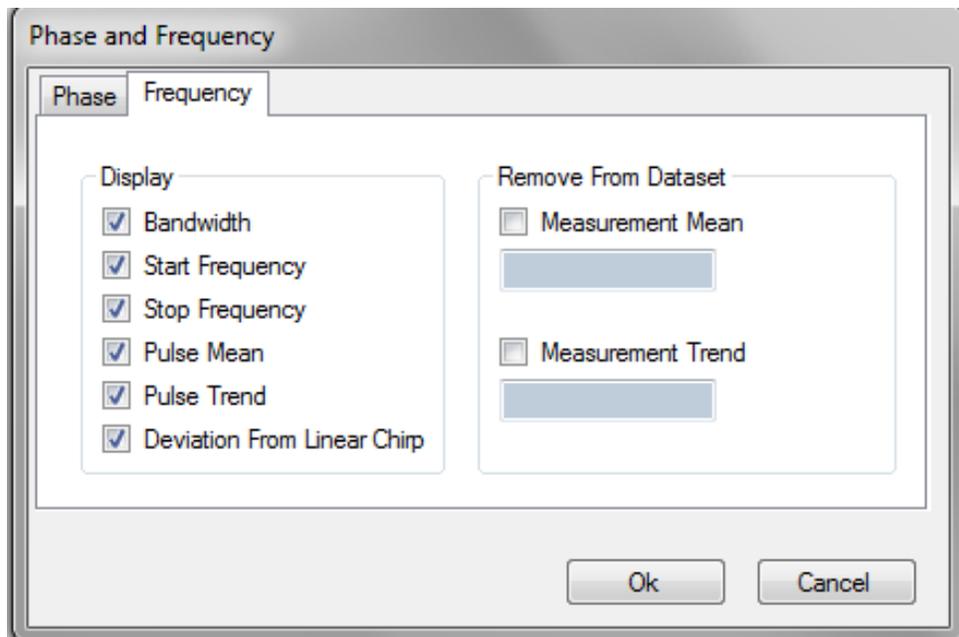
The Phase and Frequency dialogs are shown in the following figures. Functions are selected at a top level by clicking on the appropriate tab. The Phase dialog is selected by clicking on the Phase tab.

Checking a checkbox on the left hand side of the dialog causes the corresponding data element to be displayed in the Analysis Results Table. Checking a checkbox on the right hand side of the dialog causes the mean and/or trend to be removed from the data plotted on the graph. Checking the right hand checkboxes has no effect on the data displayed in the Analysis Results Table. If a right hand checkbox is checked, then the associated parameter is displayed in the corresponding text box below the checkbox.

The Pulse-to-Pulse calculation lists the phase difference between a pulse and the reference pulse. The first pulse is the reference pulse.



The Frequency tab is shown below. Checking a checkbox on the left hand side of the dialog causes the corresponding data element to be displayed in the Analysis Results Table. Checking a checkbox on the right hand side of the dialog causes the mean and/or trend to be removed from the data plotted on the graph. Checking the right hand checkboxes has no effect on the data displayed in the Analysis Results Table. If a right hand checkbox is checked, then the associated parameter is displayed in the corresponding text box below the checkbox.



## Extended Analysis

---

**NOTE** The Extended Analysis features are optional, and available only if the corresponding license (-4FP) is purchased and installed.

---

The Extended Analysis option adds the capability to combine analysis results from the main Pulse measurement window and compute and display statistical and analytical properties of the data. The calculated results from each measurement are stored in an extended data buffer. The following capabilities are added to Pulse:

1. Compute mean, max, min, standard deviation, median, mode, RMS, trend, second order fit of the selected data parameter (e.g. rise time, PRI).
2. Filter measurements based upon a user-defined threshold level. Pulse can be set to stop acquiring data when an outlier occurs and presents the outlier data to the user.
3. Plot of individual data values, versus time.
4. Plot a histogram of data values.
5. Plot of residuals after removing mean and trend.

The maximum number of pulses that can be processed is 200,000.

The Extended Analysis option provides an in-depth analysis of a single parameter. The analysis data from each acquisition cycle of the baseline Pulse software is copied to a large buffer (Extended Analysis Data Buffer, EADB). The extended analysis computations are performed on the data in the EADB.

The Extended Analysis option permits the user to assess offsets, trends, and second order shifts in the data. The data can be viewed with the offsets and/or trends and/or second order components removed.

---

**NOTE** The EADB is not continuous or “gap-free”. Pulses which occur between measurement acquisition cycles are lost, and not displayed.

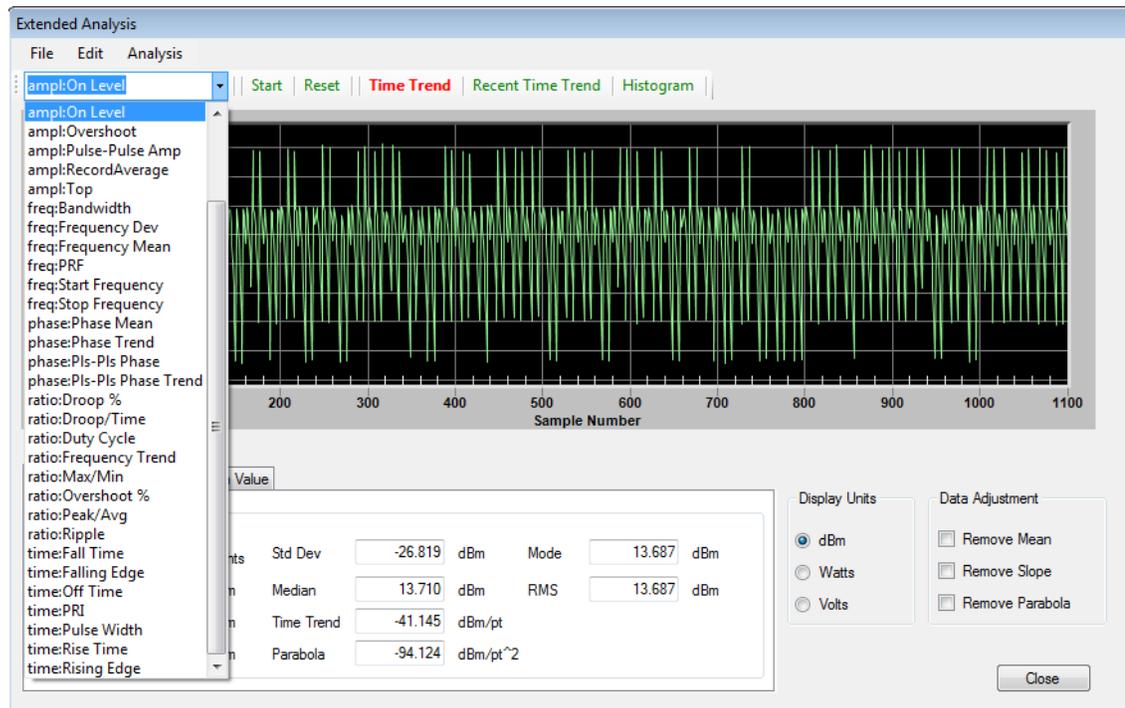
---

## User Interface

Extended Analysis features are controlled and viewed in a completely separate display window. The window is fixed in size, but may be repositioned in the display, or minimized; it can also be hidden under another window.

### Parameter Selection

The Extended Analysis User Interface is shown below. The user selects a parameter to analyze. This is done by selecting the parameter from the drop down box.



### Selectable Parameters

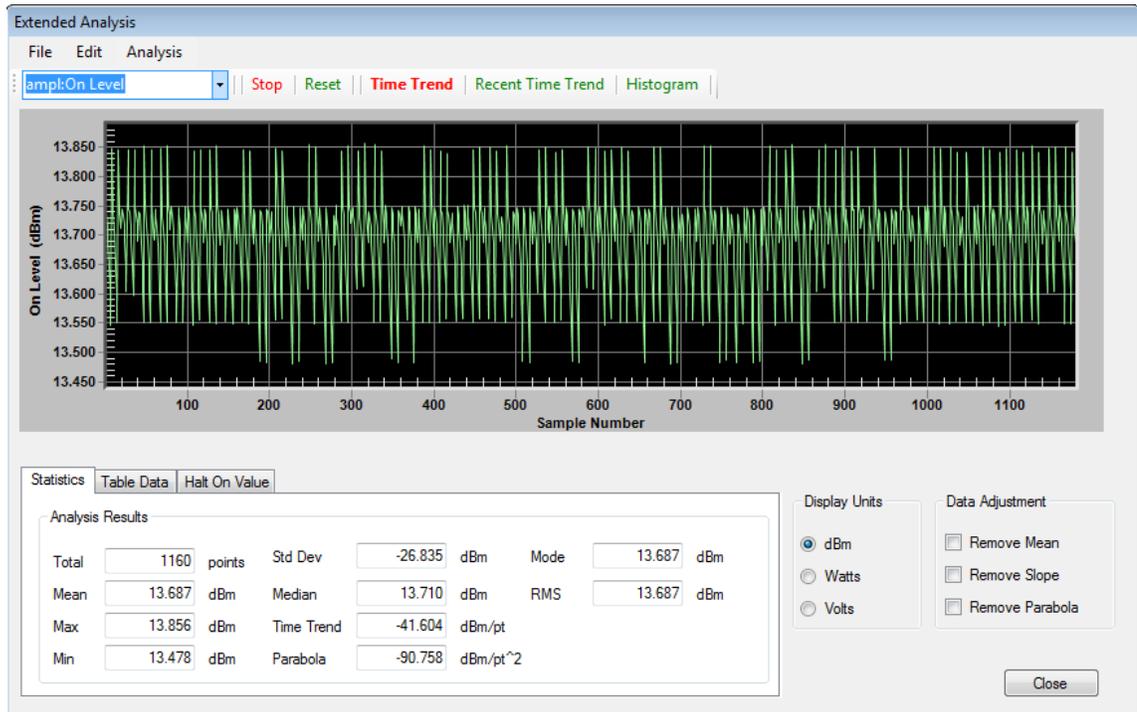
| PARAMETER         | DESCRIPTION  |
|-------------------|--|
| time:Rising Edge  | pulse rising edge  |
| time:Falling Edge | pulse falling edge   |
| ampl:Max          | maximum pulse amplitude                                      |
| ampl:Min          | minimum pulse amplitude                                      |
| ampl:On Level     | average amplitude of pulse at on level (nominally above 90%) |
| ampl:Average      | average amplitude of pulse                                   |
| ampl:Droop        | magnitude of droop from pulse rising edge to falling edge    |
| ratio:Droop %     | ratio of ampl:Droop to pulse on level                        |
| ratio:Droop/Time  | ampl:Droop per time  |
| ampl:Overshoot    | pulse overshoot  |
| ratio:Overshoot % | ratio of ampl:Overshoot to pulse on level                    |
| ratio:Ripple      | maximum ripple amplitude                                     |

**Selectable Parameters**

| <b>PARAMETER</b>          | <b>DESCRIPTION</b>   |
|---------------------------|--|
| ampl:Top                  | measurement top level (all pulses)   |
| ampl:Base                 | measurement base level (all pulses)  |
| ampl:RecordAverage        | measurement average amplitude  |
| time:Rise Time            | pulse rise time (nominally 10%-90%)  |
| time:Fall Time            | pulse fall time (nominally 90%-10%)  |
| time:Pulse Width          | pulse width (nominally rising edge 50% to falling edge 50%)                  |
| time:Off Time             | pulse falling edge (nominally 50%) to next pulse rising edge (nominally 50%) |
| time:PRI                  | pulse repetition interval  |
| freq:PRF                  | pulse repetition frequency   |
| ratio:Peak/Avg            | ratio of pulse peak to average amplitude                                     |
| ratio:Max/Min             | ratio of pulse maximum to pulse minimum value                                |
| ratio:Duty Cycle          | ratio of pulse on time (nominally at 50% level) to pulse period              |
| phase:Pls-Pls Phase       | pulse phase relative to first pulse  |
| phase:Pls-Pls Phase Trend | phase trend over entire record   |
| phase:Phase Mean          | average phase over entire record   |
| phase:Phase Trend         | phase trend over single pulse  |
| freq:Start Frequency      | chirp start frequency  |
| freq:Stop Frequency       | chirp stop frequency   |
| freq:Bandwidth            | chirp bandwidth (stop frequency – start frequency)                           |
| freq:Frequency Mean       | average frequency over pulse   |
| ratio:Frequency Trend     | frequency trend over pulse   |
| freq:Frequency Dev        | maximum deviation from a linear frequency over pulse                         |

The Start button in the toolbar is selected to begin acquiring data into the EADB. The Start button is relabeled Stop and changed to red while acquiring data. The selected parameter from the EADB can be displayed in one of three ways, selected by the corresponding button, and indicated in red. The Stop button is selected to halt data collection. Selecting Start again will resume data collection. The reset button clears all data from the EADB.

**Time History** The Time Trend view shows the selected parameter sequentially as accumulated, starting with the 0th Sample Number (pulse) on left, to most recently added samples on the right. The population grows with each acquisition (up to 200,000), and some points may disappear due to display pixel limitations.

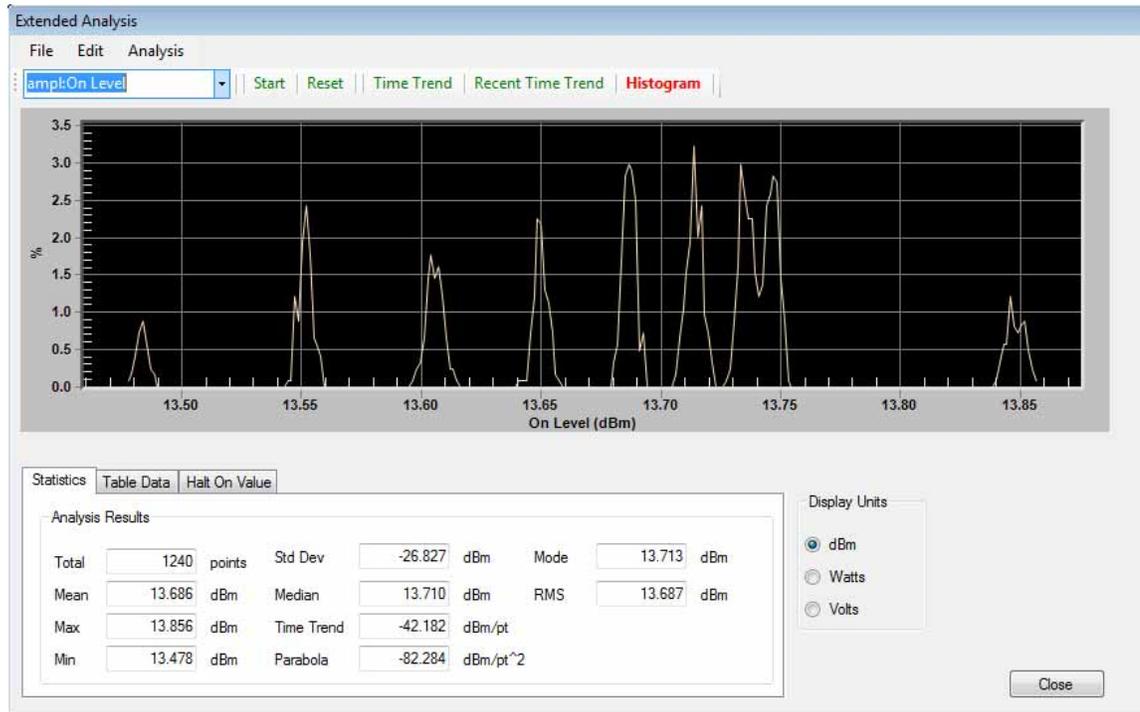


## 2 Menu Features

The Recent Time Trend displays the most recent 150 data points. This view ensures that no data points are invisible, due to limits of display resolution (pixels).



**Histogram** The Histogram view shows the frequency of occurrence (%) on vertical axis versus the parameter value (dBm, msec, etc.) on horizontal axis. The scaling of both axis and the size of the histogram “bins” are automatically set by the program, and are not available to be set by the user.



**Statistics** Analysis results are displayed in the lower section of the dialog. These include total number of data points, mean, maximum, minimum, standard deviation, median, time trend (linear fit to data), parabola (second order fit to data), mode, and RMS value.

Data can be viewed in dBm, watts, or volts by selecting the appropriate radio button.

The data adjustment checkboxes (Remove Mean, Remove Slope, Remove Parabola) subtract the mean, trend, and parabola values from the graphical display. They have no impact on the Analysis Results tabular data.

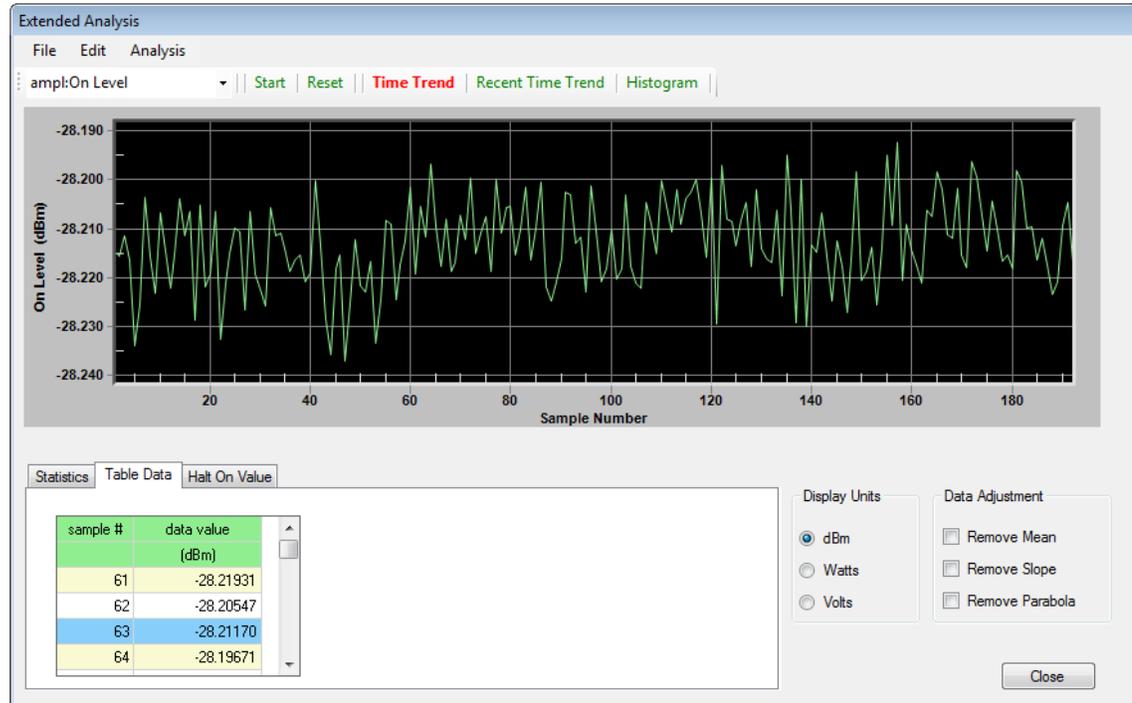
## 2 Menu Features

If a new parameter is selected, Pulse will recall the parameter data from the EADB and compute and display the new data. This is shown below. All of the analysis parameters are stored in the EADB, so selecting a new parameter brings up the previously recorded data. For example, it is not necessary to acquire new measurements when switching from maximum amplitude to PRF.



## Table Data

If the user selects a data point on the graph with the mouse while in Time History mode, the selected data point and several immediately surrounding data points will be displayed on the data table in the Table Data tab. The selected data point is shown with a blue background.



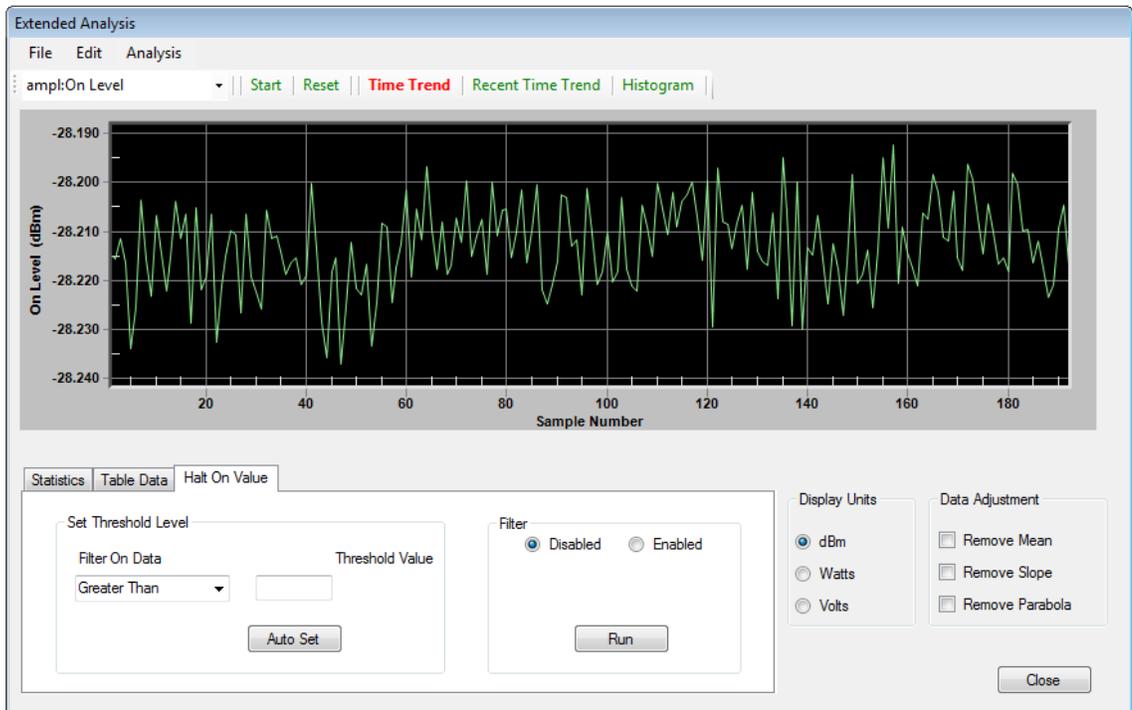
### “Halt On Value” Trigger Filter

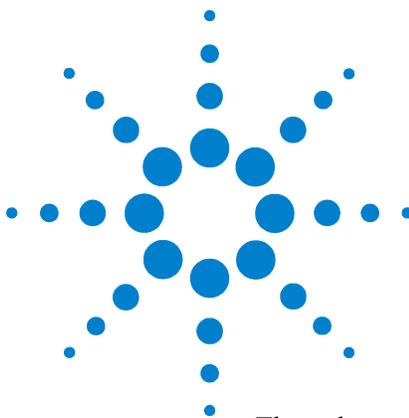
The Extended Analysis option provides the capability to halt data collection if a parameter exceeds a certain level. The concept is useful for detecting outlying data. For example, to detect a runt pulse, the user could collect data from a number of pulses (say 100 pulses) in the Extended Analysis dialog. The Halt On Value tab is selected and the threshold level is set.

The threshold can be entered manually or by clicking on the Auto Set button. The Auto Set button sets the threshold level to the maximum (minimum) value of the readings plus (minus) four standard deviations. When the Enable radio button is checked Pulse will halt once a measurement occurs with a parameter outside of the threshold and the subject measurement will be displayed on the main screen. When Pulse halts on a measurement a red indicator showing “Measurement Halted” is displayed below the Enable button.

Measurement can be resumed either by clicking on the Run button in the Extended Analysis dialog or by clicking on the Run button on the main toolbar.

The Extended Analysis parameter must be set to the parameter to be used for filtering. In this case, the parameter should be set to `ampl:Top` to compute that average amplitude of the pulse. Note that these pulses must be collected in the Extended Analysis dialog. It is not enough to just collect pulses in Pulse.





## 3 Performance Characteristics

The pulse measurement performance of the N9051A is based on the instrument or measuring device used. The table below shows the nominal instrument performance for each device.

### Nominal Instrument Performance for Each Device

| Instrument Model                   | Maximum Carrier Frequency | Maximum Bandwidth | Maximum Sample Rate/Second | Minimum Instrument Rise Time | Minimum Detectable Pulse Width |
|------------------------------------|---------------------------|-------------------|----------------------------|------------------------------|--------------------------------|
| N9030A PXA with Option B1X         | 50 GHz                    | 140 MHz           | 400 MSa/sec                | 5 nsec                       | 25 nsec                        |
| N9030A PXA with Option B40         | 50 GHz                    | 40 MHz            | 200 MSa/sec                | 17.5 nsec                    | 88 nsec                        |
| N9030A PXA with Option B25         | 50 GHz                    | 25 MHz            | 100 MSa/sec                | 25 nsec                      | 150 nsec                       |
| N9030A PXA Signal Analyzer         | 50 GHz                    | 10 MHz            | 100 MSa/sec                | 100 nsec                     | 400 nsec                       |
| N9020A MXA with Option B40         | 26.5 GHz                  | 40 MHz            | 200 MSa/sec                | 17.5 nsec                    | 88 nsec                        |
| N9020A with Option B25*            | 26.5 GHz                  | 25 MHz            | 90 MSa/sec                 | 25 nsec                      | 150 nsec                       |
| N9020A MXA Signal Analyzer*        | 26.5 GHz                  | 10 MHz            | 30 MSa/sec                 | 100 nsec                     | 400 nsec                       |
| E444XA PSA with Option 122 and 123 | 50 GHz                    | 80 MHz            | 200 MSa/sec effective      | 10 nsec                      | 50 nsec                        |
| E444XA Series PSA                  | 50 GHz                    | 8 MHz             | 30 MSa/sec                 | 100 nsec                     | 500 nsec                       |

\* Data also applies to N9010A.

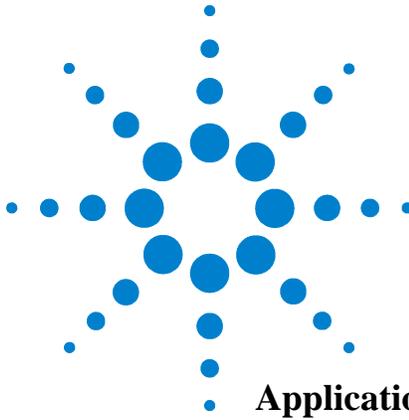
### 3 Performance Characteristics

#### Software Characteristics

|  |  |
|--|--|
| Maximum number of Traces   | 6 total  |
| Maximum Markers  | 10 / Display                                   |
| Frequency Points   | Variable: 51 to 409,601                        |
| Record Length *  | $T = 512,000 / (\text{Span} \times 1.28)$      |
| Types of Triggers<br>(available triggers are instrument dependent) | Level†<br>MagLevel<br>External<br>External TTL |
| Waveform file types  | .sdf   |
| Maximum # of pulses  | 1,050  |

\* The value displayed may not be realized based on certain sample rates.

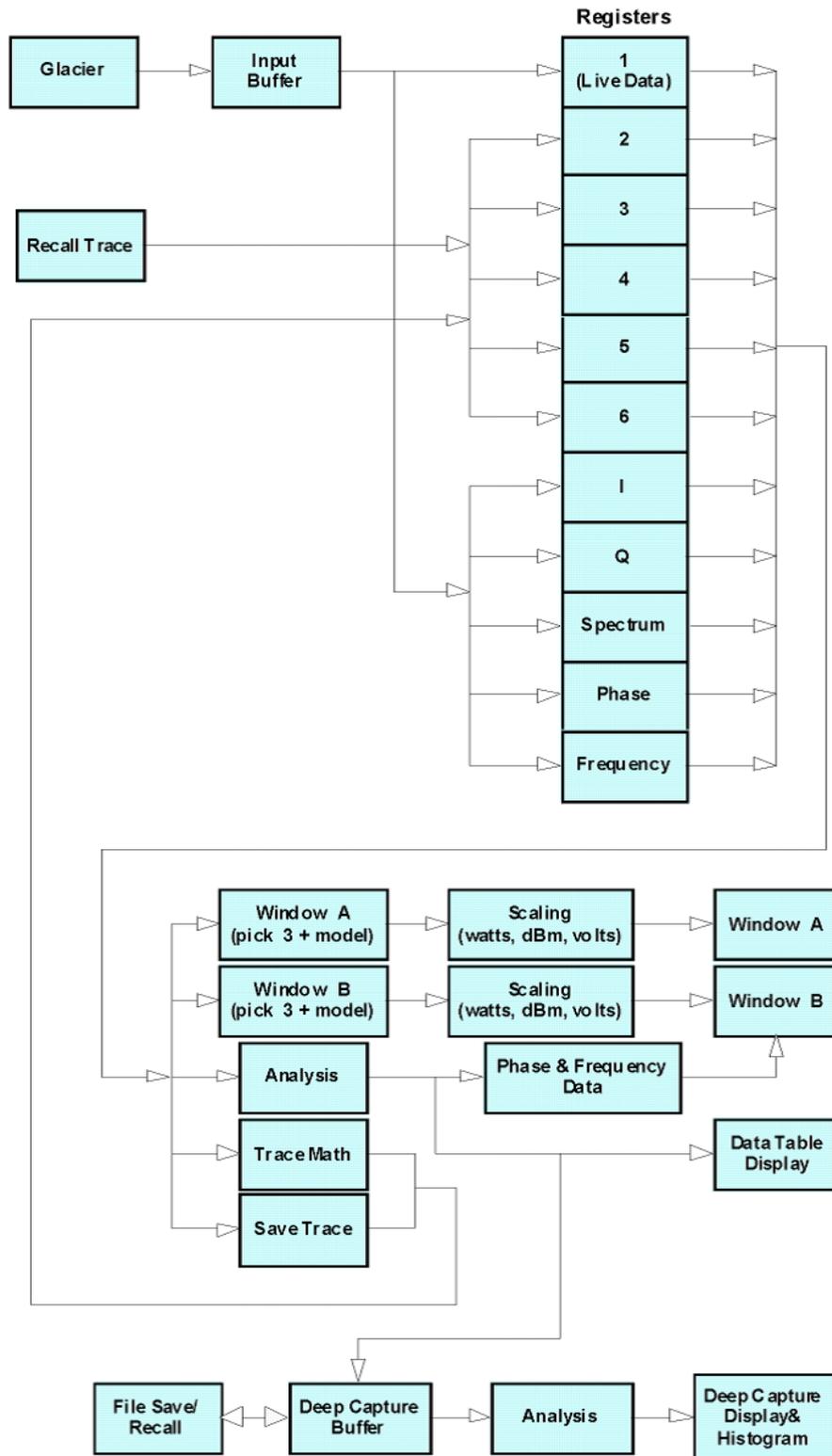
† Level (IF) for the 90000 series oscilloscope – 50% of full scale 0 to 5 GHz (4 Div = full scale)



## 4 Appendix

- **Application Architecture**

The N9051A Pulse architecture is shown below. The architecture revolves around a set of registers (numbered 1–6). Data from any of the registers can be directed to the display routines (Window A or B), used for analysis, be a source for trace math, or be saved to disk. Recalled trace data can be placed in registers 2–6.

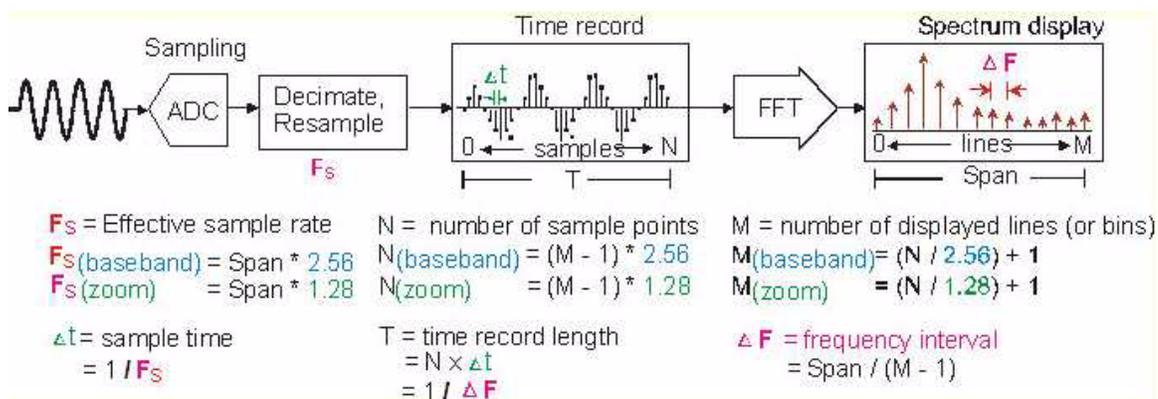


## Instrument Control Parameters

### Introduction

The N9051A Pulse Measurement Software normally controls an instrument to convert RF signals into the data arrays, for further processing. The Agilent 89600 VSA software is used as an intermediary “driver” layer, which allows control of many different instruments in a consistent way, and converts their data into consistent data arrays. The majority of instrument controls are found in the **Meas Set-Up** menus, particularly the **Set Frequency/Time/Trigger** dialog. The “time” parameters include **Time Resolution** (the “sample interval”, or time between samples) and the **Record Length** (the time duration of a single acquisition). These parameters must be set within the limitations of available memory (number of data points) and bandwidth (also called “span”) of the measuring instrument.

The following algorithms are based upon Agilent 89600 VSA documentation taken from the Tasks.chm file (89600) under Theory of Operation, Frequency and Time-Domain Interactions shown below. Note that N9051A usually uses the “zoom” mode (not baseband), and that most of its processing is on Time Records (not FFT Spectrum). These Time Records are complex (I and Q), and so contain both magnitude and phase information.



### Definitions

Based upon the VSA documentation, the following definitions will be used –

CF = center frequency

$F_s$  = effective sample rate

$K = 1.28 M$  = number of Frequency Points

$N$  = number of sample points = number of Time Points

$S$  = span (frequency)

$T$  = time record length

$t$  = sampling time (interval)

The factor K is used to add a buffer to measurements. It represents an acknowledgement of real-world phenomena such as finite cutoff regions for low pass filters. This factor has been in common usage in Agilent hardware.

### Relationships

$$F_s = K * S = 1 / t$$

Therefore,  $t = 1 / (K * S)$

$$N = (M - 1) * K$$

$$T = N * t = N / (K * S)$$

$S_{\text{machine}}$  = maximum span that the instrument is capable of

$$S_{\text{max}} (\text{max span}) = \text{lesser of } 2 * CF \text{ or } 2 * (S_{\text{machine}} - CF)$$

$$S_{\text{min}} = S_{\text{max}} / 10 \text{ for spectrum analyzers and } 50 \text{ MHz for oscilloscopes}$$

### Slider Actions

The sliders are defined to reflect a) time resolution, and b) time record length.

#### Time Resolution Slider

The sampling time ( $t_{\text{max}}$ ) is equal to  $1 / (K * \text{Span})$ . [ $t_{\text{max}} = 1 / (1.28 * S_{\text{min}})$ ,  $t_{\text{min}} = 1 / (1.28 * S_{\text{max}})$ ].

Setting the resolution slider also sets the value of span to  $S = 1 / (K * t) = 1 / (1.28 * t)$

#### Record Length Slider

Record Length (T) is equal to  $N * t$ .

The minimum record length ( $T_{\text{min}}$ ) =  $(M_{\text{min}}) / S_{\text{max}}$ .

The maximum record length ( $T_{\text{max}}$ ) =  $(M_{\text{max}}) / S_{\text{max}}$ .

Setting the record length slider also sets the value of number of frequency points (Number of Points listed in the dialog).

## Pulse Measurement Software Approach

### Introduction

After acquiring a Time Record, from the instrument and thru the VSA, the N9051A Pulse Measurement Software performs the rest of the analysis functions. The Software makes the following assumptions about the nature of RF pulses to be measured, and uses the algorithms and analysis approaches described below. Where possible, the methods used conform to IEEE Std 181 – 1977 “Standard on Transitions, Pulses, and Related Waveforms”. In addition, certain approaches are based on generally accepted procedures for the industry, and/or to maintain consistency with other measuring equipment.

### Pulse Assumptions

A typical pulse is assumed to have a format as follows:

The pulsed signal is concentrated into two clearly-separated states: On and Off.

The transitions from Off to On, or On to Off, are relatively short compared to the duration of On and Off intervals.

Each pulse “cycle” begins with a transition from Off to On; continues On for a period that is free of large amplitude variations; then transitions from On to Off; and continues Off for a period that is continuously without signal present. The minimum On period is specified for each instrument (depends on highest sample rate). The Off-to-On and On-to-Off transitions can be arbitrarily short, but the system’s ability to actually represent the signal or measure what this time is will be limited for each instrument.

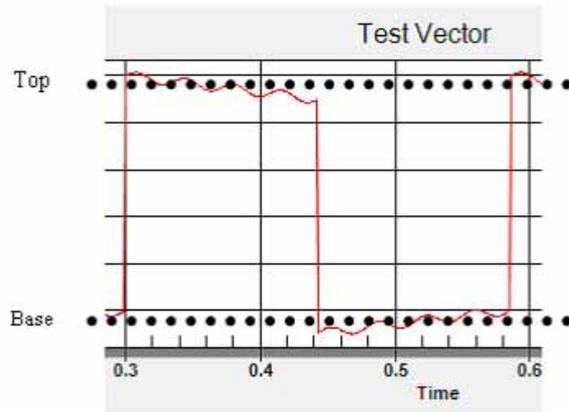
If there is a large amplitude “drop out” (dip) during the On interval, or a signal “spike” in the Off interval, the software may misrepresent these as separate pulse cycles.

The user can typically adjust **Record Length** to capture only a portion of a single pulse cycle, or capture many pulse cycles. The N9051A software will analyze as many parameters as possible, for as many pulses as possible, but an incomplete pulse cycle will be ignored.

### Top and Base

The first analysis operation is the calculation of Top and Base levels, using the bi-modal histogram method. Amplitude samples for the entire Time Record are collected into a histogram organized as frequency-of-occurrence versus magnitude. For pulses, the histogram should be bi-modal, with one “hump” representing the “On” state and the other “hump” representing “Off” state. (You can view these “humps” by enabling and viewing the PDF Graph.) The peaks of each hump – that is, the single most frequent amplitude level for each – becomes the “Top” and “Base” respectively. A waveform

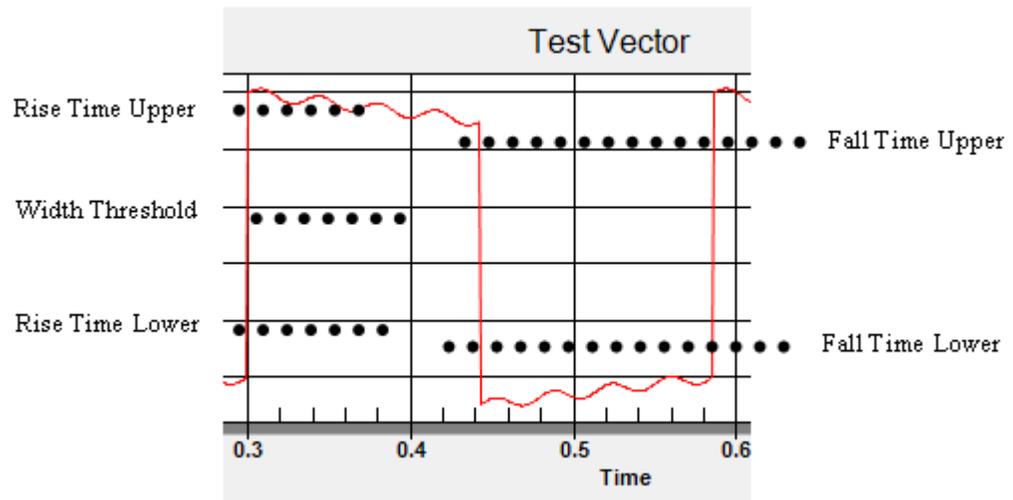
where these two levels are not well separated, or where the majority of samples are scattered in a wide variety of amplitude values, will fail to yield well-defined “top” and “base” levels.



### User-Adjustable Analysis Thresholds

The “shape” of each pulse is parameterized relative to amplitude threshold levels, as described below. These thresholds are scaled to Top and Base, as described above; the benefit is that the threshold levels adjust automatically to variations in the pulse-on amplitude and noise floor.

In the Analysis menu, under Primary Analysis, a tab contains controls where the user can view or modify the thresholds.

**NOTE**

The word “Range” below means the difference between Top and Base, a positive number. These values are in Volts; 50% of Top would correspond to 3 dB down.

Rise Time Lower – threshold for transition between Base and the rising edge of the pulse. The default value is 10% of Range plus Base.

Rise Time Upper – threshold for transition between rising edge and Top. The default value is 90% of Range plus Base.

Fall Time Upper – threshold for transition between rising edge and Top. The default value is 90% of Range plus Base.

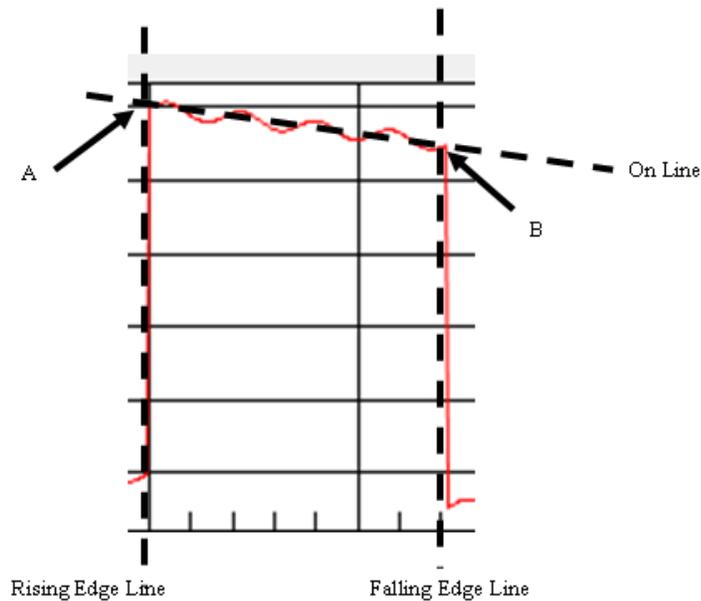
Fall Time Lower – threshold for transition between falling edge and Top. The default value is 10% of Range plus Base.

Width Threshold – threshold for pulse mid amplitude. The default value is 50% of Range plus Base. This is a single threshold for both rising and falling edges.

For *each* pulse, the N9051A software will compute the amplitude value and time value which best represents the six points where the data trace crosses these thresholds. These points are *interpolated* (straight line) *between* actual measured data samples, and do not need to coincide with them. These points can be referred to as Rising-Lower, Rising-Width, Rising-Upper, etc.

## Pulse “Corner” (A and B) Points

Two more points are found, which represent the “corners” of a trapezoid that approximates each pulse in the trace. Three lines are fit to the pulse data in order to perform the analysis (see figure below). First, a line is fit between the Rise Time Lower and Rise Time Upper points. Next, a line is fit between the Fall Time Upper and Fall Time Lower points. (Remember, these points are interpolated between measured samples.) Finally, a line (On Line) is fit to the pulse points occurring between the Rise Time Upper and Fall Time Upper thresholds using a least squares approach. Points A and B are the intersections between the three lines (see Figure below). The amplitude values and time values for points A and B are calculated, and do not coincide with measured samples.



## Pulse Analysis Algorithms

In the Analysis menu, under Primary Analysis, a tab displays all the parameters which can be measured, arranged in groups. These are listed below, with comments about the analysis method.

Rising Edge is the instant in absolute time that the pulse exceeds the Rise Time Lower threshold.

Falling Edge is the instant in absolute time that the pulse amplitude drops below the Fall Time Lower threshold.

### Amplitude - Pulse (for each pulse)

*Max* is the maximum amplitude of the pulse.

*On Level* is the average amplitude of the individual pulse during the interval when the pulse is on as compared to *Average* which is the average amplitude over the entire pulse cycle, including the off time until the next pulse begins.

*Overshoot* is the maximum of the absolute value of the difference between pulse amplitude *On Line*. *Overshoot* is not calculated unless there are at least ten data points associated with the pulse on portion.

*Overshoot %* is the overshoot computed in *K* divided by *Range* and expressed as a percentage.

*Average* is the average amplitude over an entire pulse cycle. Remember that a full cycle is the “on-period” plus the “off-period”, ending at the next rising edge.

*Peak/Avg* is the ratio of peak amplitude to average amplitude.

*Droop* is the reduction in amplitude from point A to point B. *Droop* is not calculated unless there are at least ten data points associated with the pulse on portion.

*Droop %* is the droop computed as above, divided by *Range* and expressed as a percentage.

*Droop/Time* is the droop computed in *H* divided by the pulse *On Time* in msec.

*Ripple %* is the maximum difference between the waveform and the *On Line* while in the on position divided by *Range* and expressed as a percentage.

#### **Amplitude - Record (for entire Time Record acquisition)**

*Top* is the level of *Top* over the entire measurement record.

*Base* is the level of *Base* over the entire measurement record.

*Average* (*Amplitude – Record*) is the average amplitude over the entire measurement record.

#### **Time (for each pulse)**

*Rise Time* is the time between the *Rise Time Lower threshold* and the *Rise Time Upper threshold*.

*Fall Time* is the time between the *Fall Time Upper threshold* and the *Fall Time Lower threshold*.

*Pulse Width* is the time between where the *Rising Edge Line* crosses the *Width Threshold* and where the *Falling Edge Line* crosses the *Width Threshold* (typically at the 50% level).

*Duty Cycle* is the pulse *Width* divided by *Width* plus *Off Time*, or pulse *Width* divided by the *PRI*.

*PRF* (*Pulse Repetition Frequency*) is the inverse of the *PRI*.

*PRI* (*Pulse Repetition Interval*) is the sum of the *Pulse Width* and the *Off Time*.

*Off Time* is the time between where the Rising Edge Line of the next pulse crosses the Width Threshold and the Falling Edge Line crosses the Width Threshold (typically at the 50% level).

**Aux Functions (graphs for *entire* Time Record acquisition)**

*PDF* is the Probability Distribution Function, displaying the frequency-of-occurrence as a function of each amplitude level between min (left) and max (right). This graph is available on a tab in the lower results area.

*CDF / CCDF* turns on the Cumulative Distribution Function and Complementary Cumulative Distribution Function graphs. These graphs accumulate (integrate) the PDF graph, from left to right, and compute its inverse. These graphs are available on a tab in the lower results area.

**Statistics Tab**

The Statistics tab presents data from the current stream of pulses. Each measurement is considered a new group of data. For example, if there are four pulses in a measurement, then the statistical parameters of the four pulses are calculated. The maximum of the four pulses is computed and listed as the maximum.

The parameters are calculated for each parameter. For example, if there are four pulses and the rise time parameter is active, then Max will be the maximum rise time for the four pulses. Similarly, Min is the minimum rise time for the four pulses:

- Max – maximum value for given parameter in pulse stream,
- Min – minimum value for given parameter in pulse stream,
- Mean – average of given parameter for all of the pulses,
- Pulses -- number of pulses included the statistical total; for “Current” this is the latest single acquisition, for “Cumulative” this is the combined pulses for multiple acquisitions.

The statistics are shown in a single tab (*Statistics* tab – see figure below).

| Instrument State      | Pulse Measurement | Statistics | PDF Graph | CDF/CCDF Graph |         |        |      |         |       |         |       |       |
|-----------------------|-------------------|------------|-----------|----------------|---------|--------|------|---------|-------|---------|-------|-------|
|                       |                   |            | Max       | Min            | Max     | Avg    | Peak | Droop   | Droop | Droop   | Over- | Over- |
|                       |                   |            |           |                | /Min    | /Avg   | /Avg | Mag     |       | /Time   | shoot | shoot |
|                       |                   |            | (dBm)     | (dBm)          |         | (dBm)  |      | (µV)    | (%)   | (µV/µs) | (mV)  | (%)   |
| <b>Current Record</b> |                   |            |           |                |         |        |      |         |       |         |       |       |
|                       | Parameter Minimum | ---        | -30.69    | -96.15         | 41.1    | -42.32 | 3.8  | -165.56 | -2.03 | -169.64 | 0.82  | 10.1  |
|                       | Parameter Average | ---        | -30.36    | -76.36         | 467.6   | -42.25 | 3.9  | -20.28  | -0.25 | -20.80  | 1.19  | 14.5  |
|                       | Pulses            | 12         |           |                |         |        |      |         |       |         |       |       |
| <b>Cumulative</b>     |                   |            |           |                |         |        |      |         |       |         |       |       |
|                       | Parameter Maximum | ---        | -29.60    | -48.28         | 34588.0 | -42.03 | 4.3  | 371.60  | 4.47  | 380.89  | 1.94  | 23.5  |
|                       | Parameter Minimum | ---        | -30.87    | -121.27        | 7.6     | -42.40 | 3.7  | -495.04 | -5.88 | -508.51 | 0.26  | 3.0   |

Statistics are divided into two groups: A) statistics for the current record, and B) statistics gathered since the last reset (or since turning on the analysis functions).

Before any of the data is captured, the data cells show three dashes ('---') to indicate that there is no data.

The statistics captured are *max*, *min*, and *average*. The only parameters shown are those chosen in the *Select Analysis* dialog. The data listed in the upper half pertain to the current record. The data in the lower half are aggregates across all readings since the last reset.

*Average* in the cumulative is calculated by taking the sum of all of the readings and dividing by the number of pulses. The number of pulses listed is the number of complete pulses. Any pulse without complete data (e.g. crossing 10% starting threshold or rising to at least 50% for the following pulse to compute PRI is considered incomplete and not included in the calculations).

The Reset button changes the state of all data cells to a null state ('---').

## Phase and Frequency (Option -3FP)

The measurement hardware controlled by N9051A is capable of capturing complex data; i.e. both magnitude and phase, represented by both I and Q data. Option -3FP enables new measurements in phase and frequency.

Phase and frequency measurements still rely on measurements of magnitude (amplitude) vs. time, whether displayed or not. For example, the algorithm that determines the time instants when the pulse-on period starts and stops is based on amplitude data.

Phase is calculated at each point by computing  $\text{atan}(Q/I)$ . The values are unwrapped to be continuous (no jumps around  $\pm\pi$ ). Phase is set to zero at the beginning of a pulse to keep phase numbers in a more readable range. The phase trace is “blanked” during the pulse-off interval, since no signal is present and the  $\text{atan}(Q/I)$  function is noisy and distracting.

Phase measurements usually require that the Center Frequency of the N9051A analyzer is exactly the same as the carrier frequency of the signal to be measured, and that these are not drifting relative to each other. Frequency offsets show up as continuous increasing/decreasing phase; phase noise or residual FM will degrade any phase measurements.

Frequency is calculated by differentiating phase. This is inherently a noisy process, so the results are smoothed across 7 adjacent points, using a difference table. (Refer to “Introduction to Numerical Analysis”, 2nd ed, F.B. Hildebrand, Dover, 1987, p. 111.) The algorithm and number of points are not user-modifiable.

For both phase and frequency, note that modifying the Time Resolution (or sample rate, linked to Span) in the Freq/Time/Trigger dialog will affect the noise in these calculations, as well as the time intervals associated with the frequency-smoothing algorithm above, and the degree to which edge-transients are included. The use of the Bessel filter will also have an impact.

Pls-Pls Phase – Phase of each pulse in an acquisition, relative to the first pulse in that acquisition. Phase is calculated as the average phase over the middle 75% of the interval between points A and B (see earlier diagram). This interval avoids corrupting the calculation with transients and ringing associated with the pulse edges. No parameter is calculated if there are fewer than five data points in the 75% interval.

Phase Mean – Average from least squares fit of line between the Width points.

Phase Trend – Slope from least squares fit of line between the Width points.

Start Frequency – Frequency at same time-instant as Rising-Width point.

Stop Frequency – Frequency at same time-instant as Falling- Width point.

Bandwidth – Absolute value of (Stop Frequency – Start Frequency).

Frequency Mean –  $(\text{Start Frequency} + \text{Stop Frequency}) / 2$ .

Chirp Slope –  $(\text{Stop Frequency} - \text{Start Frequency}) / (\text{Rising-Width-Time} - \text{Falling-Width-Time})$ .

Frequency Dev – Maximum absolute value of difference between actual frequency vs. time and line between Start and Stop Frequencies. Only the middle 50% of the data points between points A and B (see earlier diagram) are used in the calculation to avoid transient and noise issues.

## Extended Analysis (Option -4FP)

The Extended Analysis option computes general statistics for a particular analysis parameter (e.g. PRI, pulse width) accumulated from multiple successive acquisitions. After a measurement has been made and analyzed, the analysis results are appended to the Extended Analysis Data Buffer (EADB). The EADB contains all of the previous results (e.g. Width, PRI, Pulse-On Amplitude, ...). The user can switch parameters and bring up the data from the previous measurements for the new parameter. Note that the EADB is cleared whenever the Reset button is pressed.

The Extended Analysis option contains a display buffer. Data are transferred from the EADB to the display buffer and then displayed. When display settings such as display units (dBm, watts, volts) or data adjustment (remove mean, slope, parabola) are set, the changes are applied to the display buffer. The EADB is unaffected by display settings. The data adjustment settings compute the appropriate value (mean, slope, parabola/2nd order curve) and subtract the value from the display buffer.

The EADB can be displayed Time Trend, or as a Histogram. Only a single parameter can be displayed at a time. The horizontal and vertical scaling factors are automatically set, based on the range of data (not user controllable). In the case of Time Trend, the horizontal axis is labeled with "Sample Number"; each point is from an individual pulse (usually multiple pulses per Time Record acquisition), the "oldest" data is on left, "newest" data on right. The Samples (pulses) are evenly spaced in this view (regardless if PRI was changing). Also, these views are not truly contiguous or "gap-free"; there will typically be large segments of time, in-between Time Record acquisitions, that are "missing" in this view. In the case of Histogram, there are 250 bins horizontally (not user controllable). However, the user can "zoom" using a mouse-drag operation to draw a "box" around the portion of trace to expand. Use right-mouse-click anywhere on the graph to view other scaling and graphing controls available.

The *Halt On Value* feature allows stopping data capture when a parameter has a value outside of the specified range (e.g. find a runt pulse by monitoring *On Level* and setting the threshold below the typical levels). The *Auto Set* button sets the *Threshold Level* to the maximum (minimum)  $\pm 4.0$  standard deviations. This level should exclude 99.997% of the data and likely only trip on an errant condition.