

# Keysight

## N9051B Pulse Measurement Software

Notice: This document contains references to Agilent. Please note that Agilent's Test and Measurement business has become Keysight Technologies. For more information, go to [www.keysight.com](http://www.keysight.com).

# Notices

© Keysight Technologies, Inc.  
2006-2014

© HEYS Professional Services, Inc.

2014© Raymond Technical Services,  
LLC 2014

No part of this manual may be reproduced in any form or by any means (including electronic storage and retrieval or translation into a foreign language) without prior agreement and written consent from Keysight Technologies, Inc. as governed by United States and international copyright laws.

## Manual Part Number

N9051-90018

## Edition

October 2014

Published in USA

Keysight Technologies  
1400 Fountaingrove Pkwy.  
Santa Rosa, CA 95403 USA

## Trademarks

n/a

## Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED "AS IS," AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT WILL CONTROL.

## Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

## Restricted Rights Legend

U.S. Government Restricted Rights. Software and technical data rights granted to the federal government include only those rights customarily provided to end user customers. Keysight provides this customary commercial license in Software and technical

data pursuant to FAR 12.211 (Technical Data) and 12.212 (Computer Software) and, for the Department of Defense, DFARS 252.227-7015 (Technical Data - Commercial Items) and DFARS 227.7202-3 (Rights in Commercial Computer Software or Computer Software Documentation).

# Safety Notices

## CAUTION

A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

---

## WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

---

# Third Party Open Source Licenses

## SourceGrid

"MIT License"

Copyright (c) 2009 Davide Icardi

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

## Math.NET Numerics

"MIT License"

Copyright (c) 2002-2014 Math.NET

Permission is hereby granted, free of charge, to any person obtaining a copy of this software and associated documentation files (the "Software"), to deal in the Software without restriction, including without limitation the rights to use, copy, modify, merge, publish, distribute, sublicense, and/or sell copies of the Software, and to permit persons to whom the Software is furnished to do so, subject to the following conditions:

The above copyright notice and this permission notice shall be included in all copies or substantial portions of the Software.

THE SOFTWARE IS PROVIDED "AS IS", WITHOUT WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND NONINFRINGEMENT. IN NO EVENT SHALL THE AUTHORS OR COPYRIGHT HOLDERS BE LIABLE FOR ANY CLAIM, DAMAGES OR OTHER LIABILITY, WHETHER IN AN ACTION OF CONTRACT, TORT OR OTHERWISE, ARISING FROM, OUT OF OR IN CONNECTION WITH THE SOFTWARE OR THE USE OR OTHER DEALINGS IN THE SOFTWARE.

## Commercial Software Component License

Gigasoft ProEssentials (graphing/charting)

"All prices (for Developer licenses) include royalty free distribution of our components with your compiled EXE applications that run locally on a client's system."



# Table of Contents

## 1 Introducing the Keysight N9051B Pulse Measurement Software

## 2 Menu Features

Data Entry	11
Menu Bar	12
File	12
Save	12
State	13
Trace (Text Data)	13
Trace (Binary Data)	13
Analysis Table (All Data)...	14
Analysis Table (Selected Data)...	14
Upper Display (Image)...	15
Entire Screen (Image)...	15
Recall	15
State	15
Trace (Binary Data)...	15
Read SDF File	16
Print	17
Display (Image)	17
Entire Screen (Image)	18
Print Setup	18
Preset	18
Exit	18
Edit	19
Copy Display (Image)	19
Copy Entire Screen (Image)	19
Copy Analysis Table (Data)	19
Meas Set-up	20

Input Range	20
Amplitude Offset	21
Set Frequency / Time / Trigger	22
Measurement	22
Trigger	23
Single	24
Continuous	24
Trace	25
Display Options	25
Set Scale	28
Markers	29
All Markers Off	29
Delta Markers Off	29
Analysis	30
Analysis Selection Tab	30
Base Analysis (Magn vs Time)	31
Analysis Thresholds Tab	32
Variable Analysis Thresholds	33
Ignore Dropouts Tab	33
Utility	35
Pulse License Status	35
Set Colors	35
Align Expired Items	35
Align Everything	36
Help	37
Contents	37
About	37
Show Tool Tips	37
Main Toolbar	38
Preset	38
Stop	38
Run	38

Input Range	38	
Set Freq/Time/Trigger	38	
Display Options	38	
Base Analysis (Magn vs Time)	38	
Set Scale	39	
Phase and Frequency	39	
Extended Analysis	39	
Graphical Trace Displays	40	
Display Annotation	40	
Vertical (Y) axis scale	40	
Horizontal (X) axis scale	41	
Clock display	41	
Mouse Control Functions on Trace/Graticule	42	
Left-Click Functions (Zoom)	42	
Right-Click Functions	42	
Markers	45	
Marker Selection and Placement	45	
Setting a Delta Marker	46	
All Markers Off	46	
Delta Markers Off	46	
Right-Clicking a Marker Button	46	
Tabular Results Window	47	
Instrument State Tab	47	
Pulse Measurement Tab	47	
Statistics	48	
Status Bar	48	
Program Status	48	
Calibration Status	48	
Deep Capture Progress	49	
Input Overload Status	49	
Deep Capture Progress Bar	49	
Phase and Frequency (Option 3FP)	50	

Phase Display, Scaling, Markers	50
Frequency Display, Scaling, Markers	51
Phase and Frequency Analysis Results Display	51
Phase and Frequency Dialog	51
Extended Analysis (Option 4FP)	53
User Interface	53
Parameter Selection	54
Table Data	60
“Halt On Value” Trigger Filter	61
Deep Capture (Option 5FP)	62
Display	62

### 3 Performance Characteristics

#### Appendix A Appendix

Application Architecture	67
Pulse Measurement Software Approach	69
Introduction	69
Pulse Assumptions	69
Top and Base	69
User-Adjustable Analysis Thresholds	70
Pulse “Corner” (A and B) Points	72
Pulse Analysis Algorithms	72
Amplitude - Pulse (for each pulse)	72
Amplitude - Record (for entire Time Record acquisition)	73
Time (for each pulse)	73
Phase and Frequency Functions	74
Statistics Tab	75
Phase and Frequency (Option -3FP)	78
Extended Analysis (Option -4FP)	79



# 1 Introducing the Keysight N9051B Pulse Measurement Software

**This manual is a reference to all functions in N9051B. Refer to the N9051B Getting Started Guide for installation procedure and start-up tutorials.**

The Keysight N9051B Pulse Measurement Software provides easy-to-use time-oriented measurements of Pulsed RF or Microwave signals in signal analyzers. 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 1050 pulses.

It also includes time display with zoom, units' conversion, and markers.

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 N9051B can also measure frequency and phase vs. time, provide parameters like chirp width, and provide extended statistics, trends, and histograms.

Pulse can be installed inside any X-Series Signal Analyzer and appears in the "MODE" menu where you can access it as needed.

## NOTE

When using a UXA with the Pulse Software, instead of starting the Pulse Software via the "Mode" menu, you start it via the Windows Start menu.

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

---



## 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:

### Data Entry

Several measurement parameters require manual data entry (e.g. Record Length, Center Frequency, etc.). This is done by clicking on a textbox and entering the appropriate data.



Clicking on the textbox causes the unit scale factor to be transferred from the unit designator to inside of the textbox. In this example the 'm' for milliseconds is transferred from the label (ms) to the inside of the textbox, where it can be edited along with the numeric data.

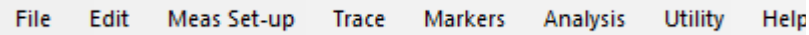


Double-clicking on the textbox causes the unit scale factor to be left out of the highlighted characters; thus numeric key entries will not over-write the unit prefix, allowing you to more easily re-use the existing prefix. The new data value is processed once the textbox loses focus. This happens whenever another control (button, textbox, checkbox, radio button) is clicked on or the Enter key is pressed.

Various common unit prefixes are recognized (f, p, n,  $\mu$  or u, m, K, M, G, T) for scale factors. Either mu ( $\mu$ ) or 'u' are recognized for micro. The inputs are context-sensitive and case-insensitive, so that typing either 'M' or 'm' for Center Frequency will be translated into megahertz while typing 'M' or 'm' for Record Length will be translated into milliseconds.

## Menu Bar

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, print, preset the application, or Exit.

### NOTE

The default location for file storage is “X:\ProgramData\Agilent\Keysight N9051B Pulse Measurement Software”, where 'X' is the system drive (usually C:).

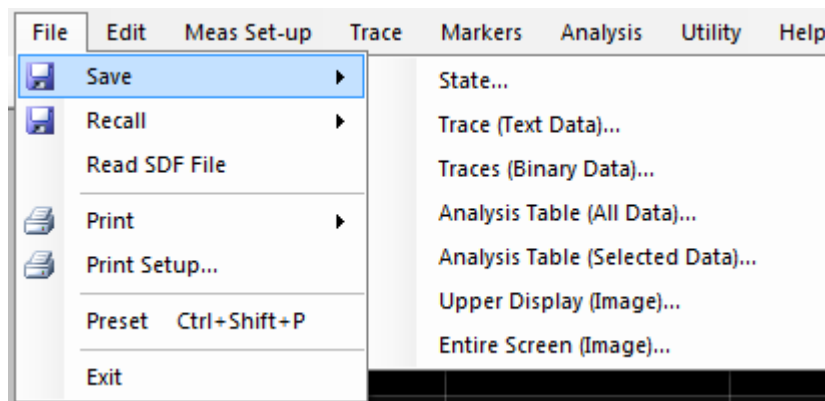
---

This directory is hidden in Windows 7 as the default condition. It can be made visible by doing the following -

1. Select Start button/Click Control Panel/Appearance and Personalization
2. Click Folder Options
3. Click View tab
4. Click Show hidden files, folder, and drives

## Save

Save data/image to the hard drive.



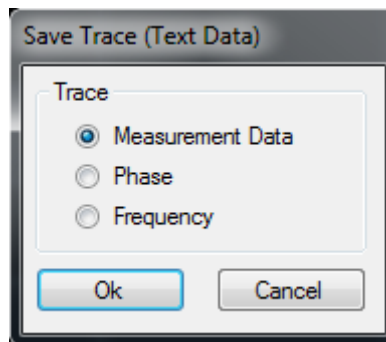
## State

Enables you to save your measurement setup. Pulse prompts for a filename in which to save the state. Saving the State means you will be saving these parameters of the measurement:

1. RF parameters, such as Center Frequency, Range, Reference level, and time record length.
2. Triggering parameters.
3. Selected Analysis, and Analysis parameters.
4. Display scaling.

## 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 imported into a spreadsheet program (such as Excel). Pulse prompts for a filename in which to save the data. The data are stored in pairs: a point-number index, and trace value (vertical axis) in volts for Measurement Data, degrees for Phase, and Hz for Frequency. After selecting Trace (Text Data) from the File menu the following dialog comes up to allow selection of Measurement Data, Phase, or Frequency.



## Trace (Binary Data)

Saves the selected trace in a binary file for later recall back into the display. Pulse prompts for a filename in which to save the data.

This binary file can be read using the following C# routine:

```
using System.IO;

const int size = 1000000;
float[] magnitude = new float[ size ] ;
float[] I          = new float[ size ] ;
float[] Q          = new float[ size ] ;
```

```

string filename = @"C:\trace.tra";
using( BinaryReader br = new BinaryReader(
    File.Open( filename, FileMode.Open ) ) )
{
    int NumberOfPoints    = br.ReadInt32();
    int NumberOfPulses    = br.ReadInt32();
    double Bandwidth      = br.ReadDouble(); // Hz
    double RecordLength   = br.ReadDouble(); // sec
    double SampleRate     = br.ReadDouble(); // samp/s
    double AmplitudeOffset = br.ReadDouble(); // dB
    double CenterFrequency = br.ReadDouble(); // Hz
    double SampeInterval  = br.ReadDouble(); // sec
    double StartTime     = br.ReadDouble(); // sec
    double StopTime      = br.ReadDouble(); // sec

    for( int k = 0; k < NumberOfPoints; k++ )
    {
        magnitude[ k ] = br.ReadSingle(); // volt
        I[ k ]         = br.ReadSingle(); // volt
        Q[ k ]         = br.ReadSingle(); // volt
    }
}

```

### Analysis Table (All Data)...

Saves the analysis data as a .CSV file for import into a spreadsheet. Pulse prompts for a filename in which to save the data. 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 30](#).

### Analysis Table (Selected Data)...

Saves the analysis table, similar to [“Analysis Table \(All Data\)...”](#), but only for the parameters (columns) selected by the user under the Analysis menu.

### Upper Display (Image)...

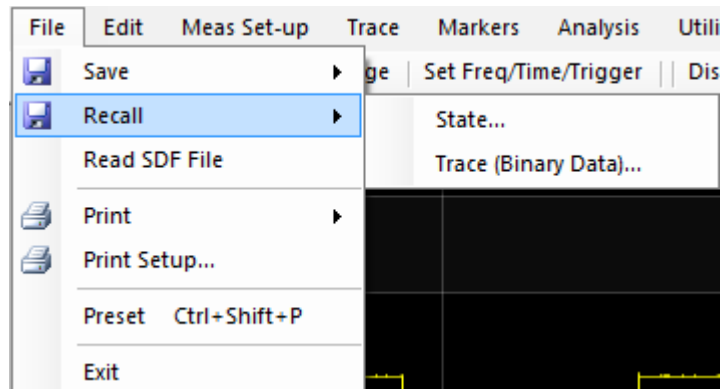
Saves the trace display as an image. Pulse prompts for a filename in which to save the data. The image includes the graticule, marginal annotation (e.g. scale factor or time), and all traces that are currently on. Markers also appear; however, their associated numerical values do not. Several formats are available such as bmp, jpg, gif, and png.

### Entire Screen (Image)...

Saves the entire screen (the entire application window) as an image. Pulse prompts for a filename in which to save the data. The formats available are bmp, jpg, gif, tif, and png.

## Recall

Recall data from the hard drive.



This selection enables you to recall two file types:

- State
- Trace (Binary Data)...

### State

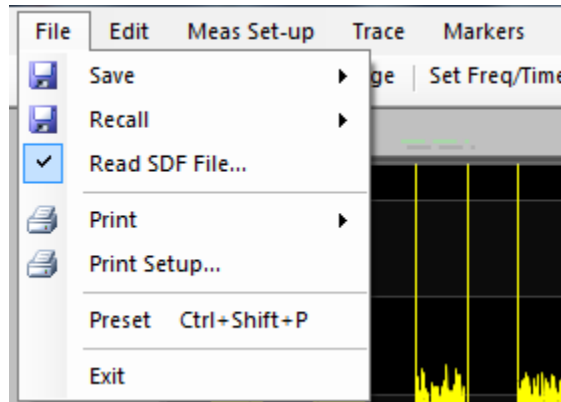
Recalls a previously saved state, which allows the user to duplicate a previous measurement setup. Pulse prompts for a filename containing the data.

### Trace (Binary Data)...

Recalls previous saved trace data back into the display. Pulse prompts for a filename containing the data.

## Read SDF File

Opens the Read SDF Data File dialog shown below. This feature is convenient for retrieving readings taken on another machine.



The Open File button brings up a file selection menu (choose which SDF file to read). The file parameters are listed in the upper right corner of the dialog box. Record Size the length of the total SDF file in seconds.

Start Time and Duration control the amount of data to be read from the file. Stop Time is Start Time plus Duration. It is computed, and as such is read only. Stop Time and Duration can never be greater than Record Size.

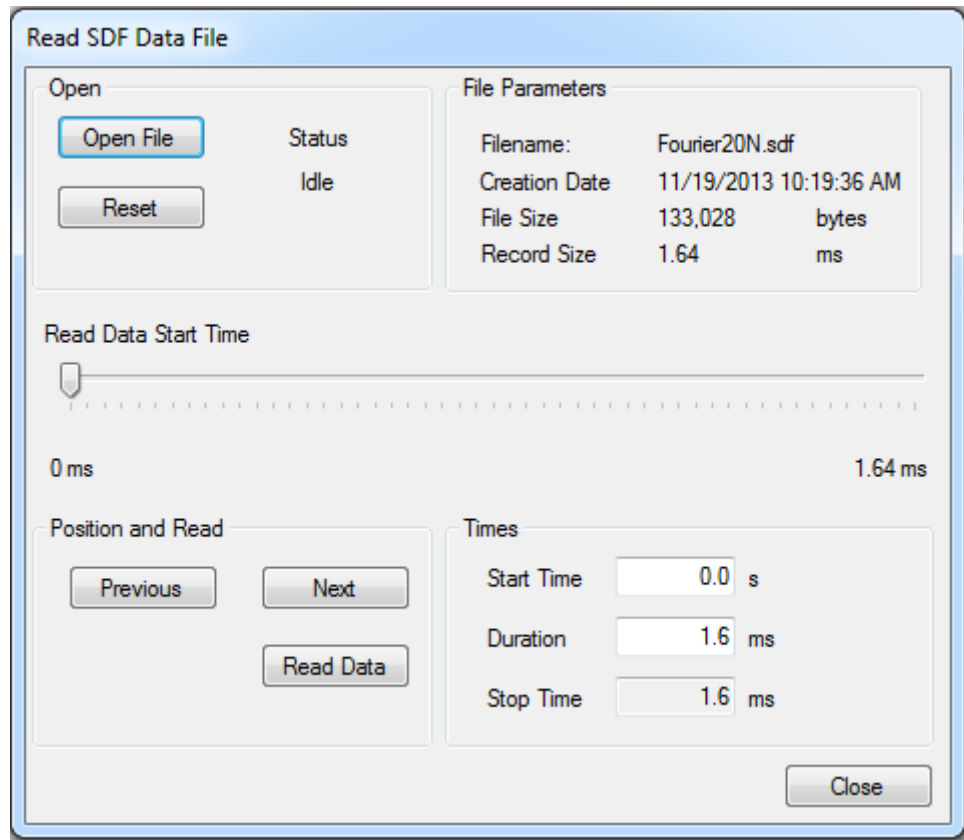
The Start Time can be set by 1) typing the start time into the Start Time textbox, 2) moving the slider to the desired start time, or 3) clicking on the Previous or Next buttons. The Previous and Next buttons reduce/advance the start time by an amount equal to Duration.

Data are read into Pulse when the Read Data button is clicked.



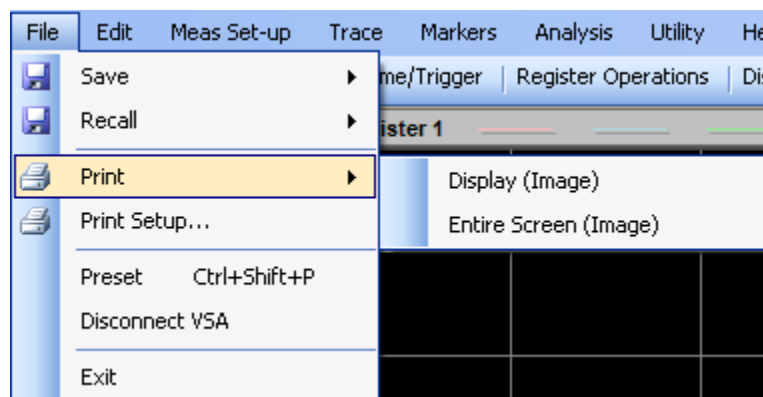
Menu Features  
File

The Reset button is used to put the SDF file read routines in a working configuration. This may be necessary after reading a defective/corrupted SDF file.



Print

Sends images/data to the printer.



Display (Image)

Prints the active trace display as an image.

Menu Features  
File

### Entire Screen (Image)

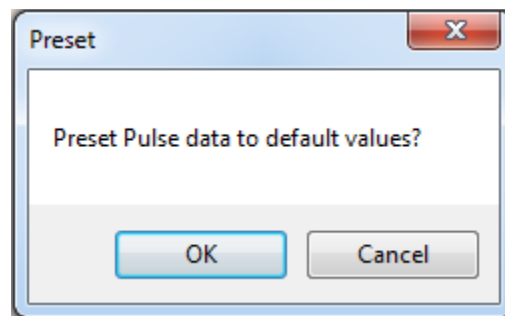
Prints the Entire screen as an image

### 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. Clicking on the Preset button brings up the following menu which allows canceling the preset operation.

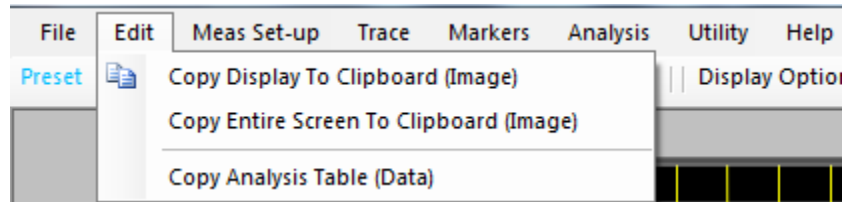


### Exit

Exits the Pulse Measurement Software. Also releases control of measurement hardware. Any data that was not previously saved will be lost.

## Edit

Facilitates copying displays and data to the clipboard.



### Copy Display (Image)

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

### Copy Entire Screen (Image)

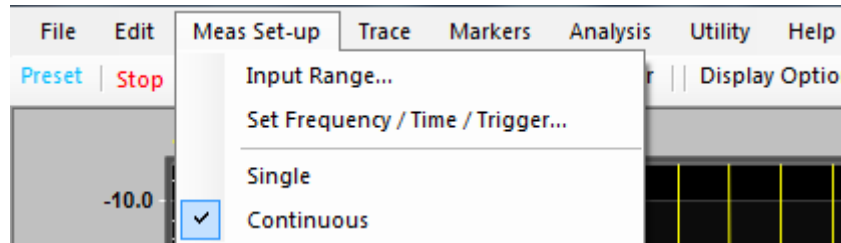
Saves the entire screen to the clipboard, where it can then be pasted into another application.

### Copy Analysis Table (Data)

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

## Meas Set-up

Controls the xSA attenuator, provides offset to account for external gain/attenuation, sets measurement parameters, and sets the operating mode (single measurement, continuous measurements).

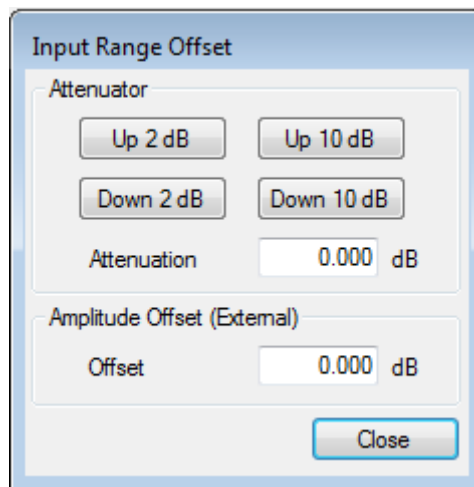


## Input Range

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

The attenuation is adjusted by selecting Up 2 dB, Down 2 dB, Up 10 dB, or Down 10 dB. It can be adjusted in 2 dB or 10 dB steps. Set the attenuation so that the overload indicator on the instrument is off.

Changes or entries made to the Attenuator control do not actually take effect in the hardware until this dialog box is closed.



## Amplitude Offset

Opens a dialog for setting an amplitude offset. This is useful for compensating for cable losses, attenuators, or gain (amplifier) so that the display reflects 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).

## Set Frequency / Time / Trigger

Brings up the following dialog which controls the measurement and triggering parameters.

**Frequency, Time, and Trigger**

Measurement	Trigger	Parameters	Mode	Slope
Center Freq: 30.0000 MHz	Type: <input type="radio"/> Free Run, <input checked="" type="radio"/> Video, <input type="radio"/> External 1, <input type="radio"/> External 2, <input type="radio"/> RF Burst, <input type="radio"/> Line	Level: -45.00 dBm	<input checked="" type="radio"/> Continuous, <input type="radio"/> Single	<input checked="" type="radio"/> Positive, <input type="radio"/> Negative
Record Leng: 5.00 ms		Delay: -2.00 μs		
Sample Interval: 20.00 ns		Holdoff: 200.00 ns		
# Points: 250.00 K				
Bandwidth: 40.00 MHz				

Close

### Measurement

**Center Freq** is the RF or microwave frequency to which the analyzer is tuned. Normally this is the "RF carrier" frequency of the pulsed signal.

**Record Leng** is the time duration of the acquisition, and normally the duration of the X-axis (time-axis) of the trace display.

**Sample Interval** is the time in-between samples, and in-between trace points. It represents the minimum time resolution of the measurement. Certain pulse analysis algorithms depend on acquiring enough points, relative to the actual features of a pulse, to function correctly; for example, its width. See Appendix A for details. The Sample Interval is coupled to Bandwidth; see further comments on this below.

**# Points** is the total number of samples in an acquisition. It is computed from  $(\text{Record Leng})/(\text{Sample Interval})$ . This display is a read-only display; it cannot be directly changed by user, but rather indirectly by changing Record Leng or Sample Interval.

**Band width** is the frequency range within which the analyzer can "see" the RF signal, where Center Freq is the middle of this range. It is computed from Sample Interval, and is normally (with some exceptions) equal to  $1/((1.25 * (\text{Sample Interval}))$ ). This display is a read-only display; it cannot be directly changed by user, but rather indirectly by changing Sample Interval. If the input signal is "chirped" (linear FM modulation) or "hopped" over a set of frequencies, then Bandwidth must be wide enough to include the range of frequencies occupied by the signal. In addition, the edges of the pulse (rising,

falling) include spectral content wider than the RF carrier itself. Thus, the user will need to make the Sample Interval short enough (the Bandwidth wide enough) to accurately represent the pulse edges without distortion.

## Trigger

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.

### Type

The Free Run type is especially useful if you are unsure of the amplitude excursions of the signal. By using Free Run, you can at least see the waveform, and start to characterize it.

Type of triggering can be Free Run, Video, External, RF Burst, and Line.

### Parameters

Parameters are Trigger Level, Trigger Delay, and Trigger Holdoff.

### Level

Sets the threshold level for the trigger.

**NOTE** Level control determines the level needed to trigger an acquisition; there are other controls, under Analysis, that can be used to set the amplitude used by the analysis algorithms to recognize a pulse.

---

### 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.

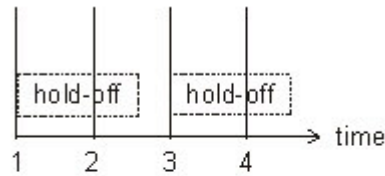
---

### 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.

Trigger Hold-off is 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. 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

### 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

Measurements initiated on a continuous (repeated) basis. This setting is the same as the Continuous check-box under Meas Set-up.

#### – Single

Sets Pulse to take a single measurement when the Run button on the Main Toolbar is pressed. This setting is the same as the Single check-box under Meas Set-up.

### Slope

Selects rising or falling edge for trigger.

### Single

Sets the mode to single measurement. A new measurement is made each time the Run button on the Main Taskbar is clicked on. This is the same mode control shown in the Frequency, Time, and Trigger dialog.

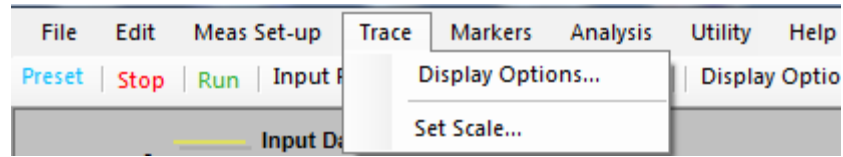
### Continuous

Sets the mode to continuous. This is the same mode control shown in the Frequency, Time, and Trigger dialog.



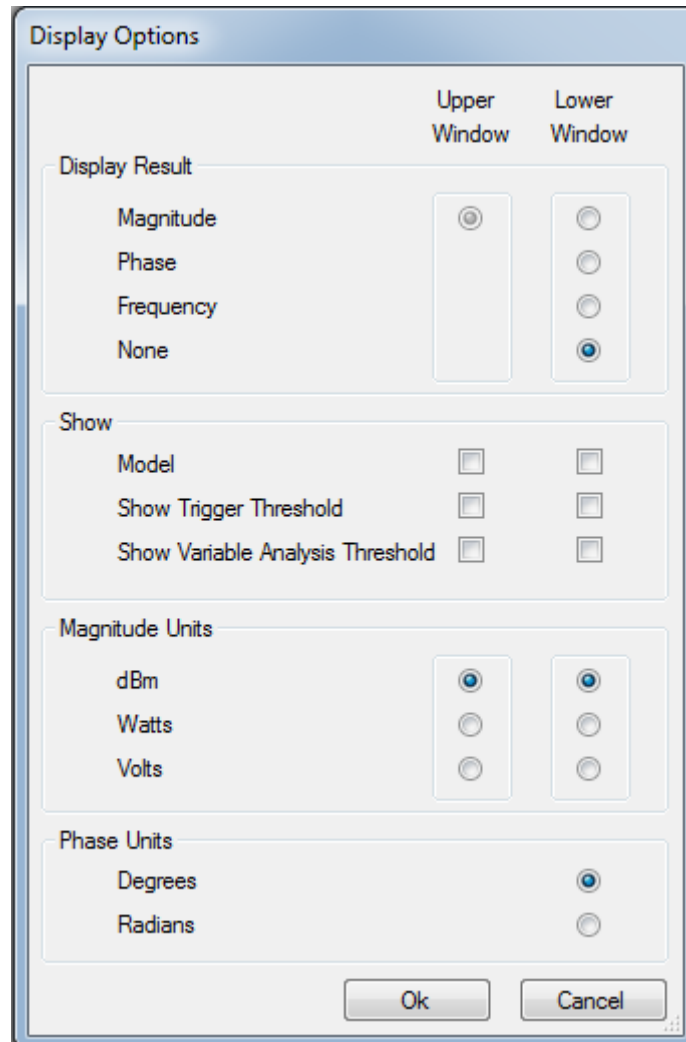
## Trace

Sets the display options and graphical scaling.



## Display Options

Opens the Display Options dialog. The Display Result and Show boxes control what is shown on the screen. There are two windows available in the Graph Area; Upper Window and Lower Window. The Upper Window is always visible. Selecting a radio button other than None from the Lower Window column causes the Lower Window to be visible. Selecting None causes the Lower Window to close.

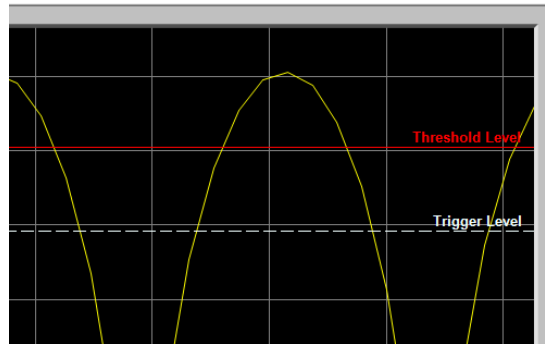


The items shown in the Show box are only active for Magnitude display.

Model displays an idealized model that corresponds to a best fit (least squares) of the data.

Show Trigger Threshold displays the trigger level as a dashed white line on the Upper/Lower Window. The trigger level can be adjusted by dragging the trigger line up or down using the mouse (click on line and hold left mouse button down while dragging).

Show Variable Analysis Threshold shows the Variable Analysis Threshold level as a solid red line. This is only active when Variable Analysis Thresholds are selected (instead of IEEE181 thresholds). The Variable Analysis Threshold can be adjusted by dragging the threshold line up or down using the mouse (click on line and hold left mouse button down while dragging).



Magnitude Units are selected separately for the Upper Window and Lower Window.

Phase Units only apply to phase measurements.

The Display Options menu is used to control:

- which of the two available windows (Upper, Lower, or both) are enabled.
- the units for the vertical axis.
- 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. For details on analysis algorithms, please refer to the Appendix **“Pulse Measurement Software Approach” on page 69.**

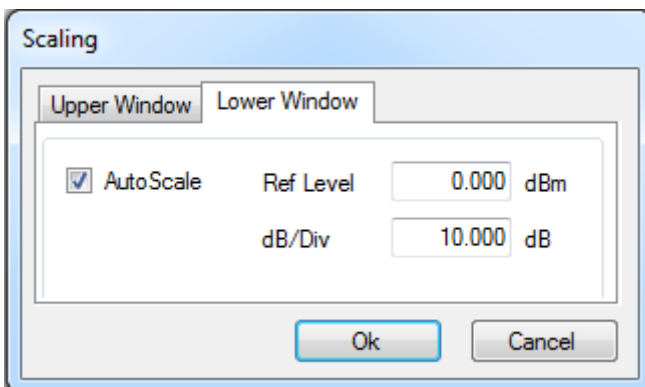
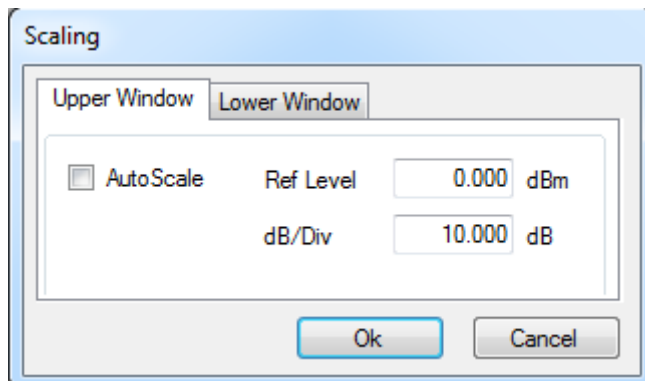
The Trigger and Variable Analysis Threshold levels can be displayed on the screen by checking the appropriate check boxes.

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).

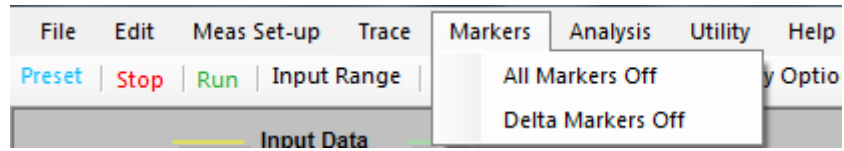
## Set Scale

The Set Scale dialog controls the scaling of the graphical displays. The "Reference Level" refers to the top graticule line in the Window, as is customary in a signal analyzer. The per division amount (x/Div) controls the range of the vertical axis. The units are set using the Display Options dialog. Reference Level and per/Div are adjusted separately for each type of unit.

When AutoScale is checked, then the scale factors are automatically computed and updated with each acquisition. The Ref Level and dB/Div values are ignored when AutoScale is checked. AutoScale uses the largest possible "even" value for dB/Div that permits the max and min values of the trace to be displayed; therefore, if the Record Length of the acquisition is short compared to the pulse width or PRI, it is possible that only the pulse-on or pulse-off state will be acquired, and so AutoScale will not necessarily encompass the pulse-on to pulse-off range.



## Markers



### IMPORTANT

The majority of marker functions are controlled via the mouse, using the marker window and displays. See [“Markers” on page 45](#). Only the delete functions are accessible from the Markers tab in the main menu.

---

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

### All Markers Off

Turns all markers off.

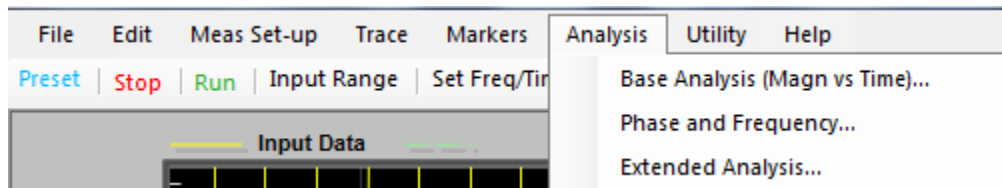
### Delta Markers Off

Turns delta markers off. This converts any Delta markers to regular markers.

## 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.

The Analysis menu controls the analysis and tabular data displays. The tabular displays are shown in the lower section of the display under the tabs "Pulse Measurement" and "Statistics".



**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 50](#). For Extended Analysis see [page 53](#).

---

### Analysis Selection Tab

Pulse automatically finds pulses in the waveform, locates features in those pulses, and then characterizes the features. This dialog allows the user to turn on or off the individual analysis features (these are grouped into amplitude- and time-related parameters);

The results are displayed in the bottom section of the application display. Click on the appropriate tab to display the results.

Most of the measurement results are evident from their names. A few deserve clarification:

- "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 69](#).

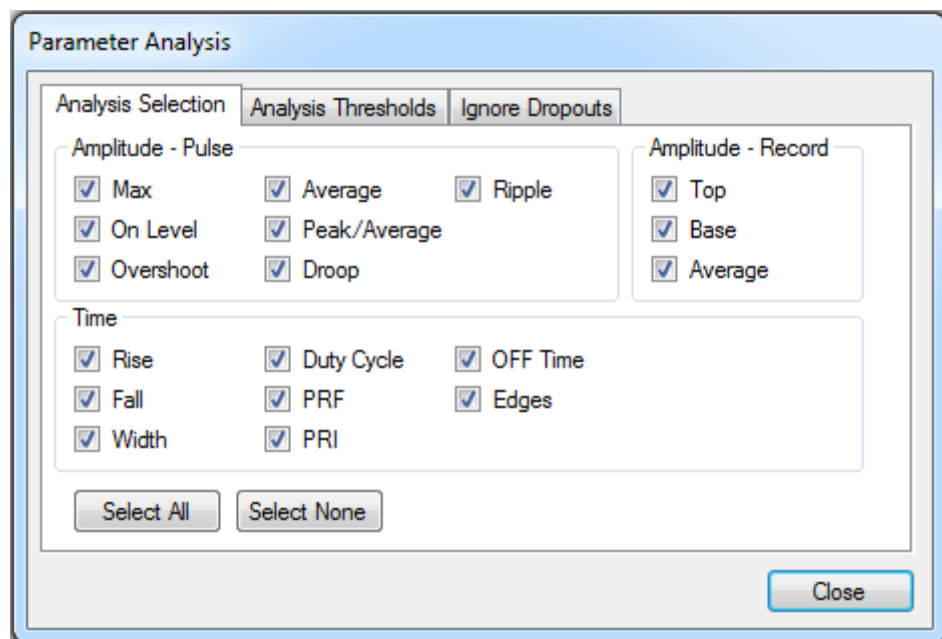
Most of the measurement results are evident from their names. A few that deserve extra comments:

- “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 69](#).

### Base Analysis (Magn vs Time)

The Base Analysis (Magn vs Time) dialog consists of three sections (tabs): Analysis Selection, Analysis Thresholds, and Ignore Dropouts. The Analysis Selection tab controls which parameters are displayed. Parameters, such as rise time and PRF are displayed in columns. Checking the associated checkbox causes the parameter to be displayed in the tabular data displays.



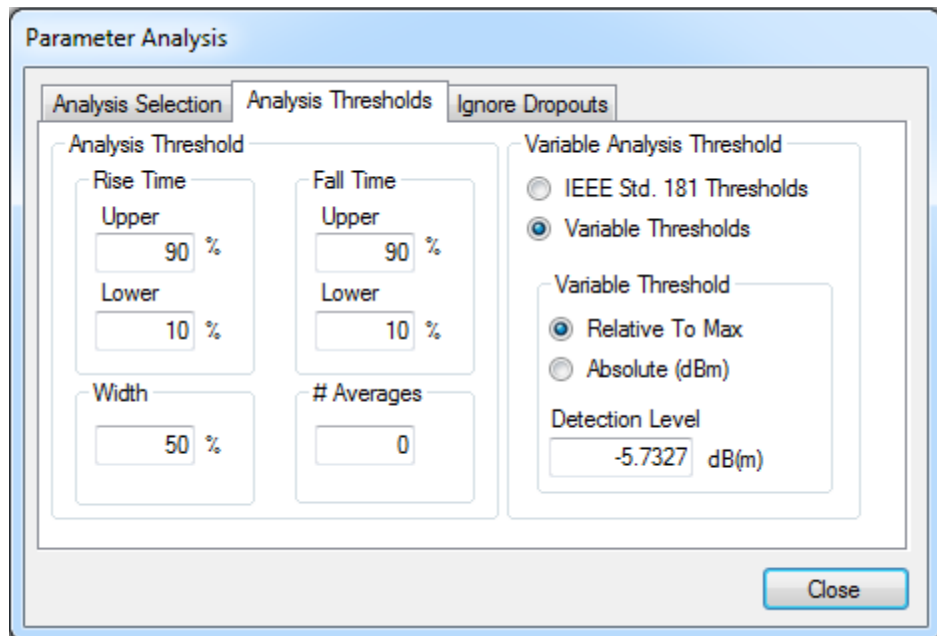
## Analysis Thresholds Tab

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 69](#) for details.

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

**NOTE**

The level threshold calculations (10%, 50%, 90%) are based in linear units (volts), even if the display is currently in dBm or Watts.





## Variable Analysis Thresholds

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.
- 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 (start/stop), to include samples that represent the pulse's off level.

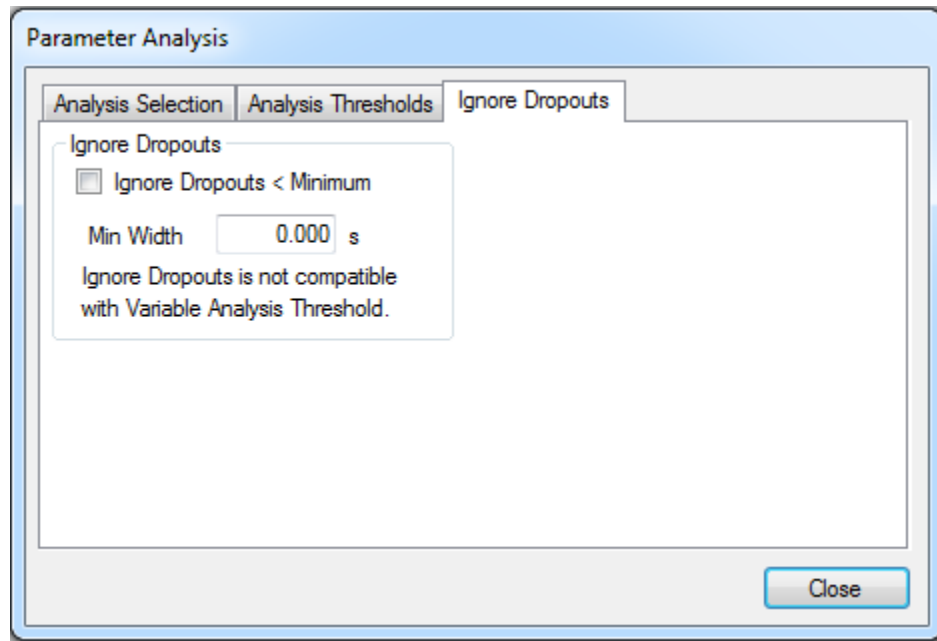
The Time Resolution setting (under Frequency, Time, and Trigger) must be set such that these samples mostly fall into the pulse-off period (to establish the "base" level). Second, each pulse is analyzed individually within its own sub-segment (area where the pulse is on). The "top" and "base" calculations, plus the Upper/Lower/Width thresholds are the same as for IEEE 181, but are applied to each pulse individually.

## Ignore Dropouts Tab

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).

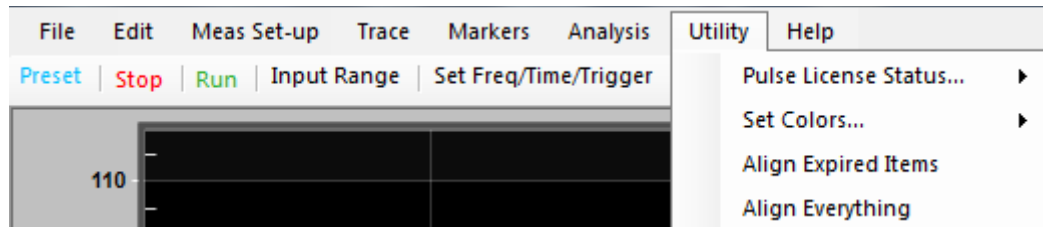
Checking the "Ignore Drop-Outs < Minimum" box causes the pulse detection algorithm to wait until the Min-Width time before assuming the pulse has ended. If the pulse-on amplitude rises above the 10% threshold before this time, then the pulse is considered to be continuing (same pulse). This entry should be less than the smallest expected off time between pulses.

Menu Features  
Analysis



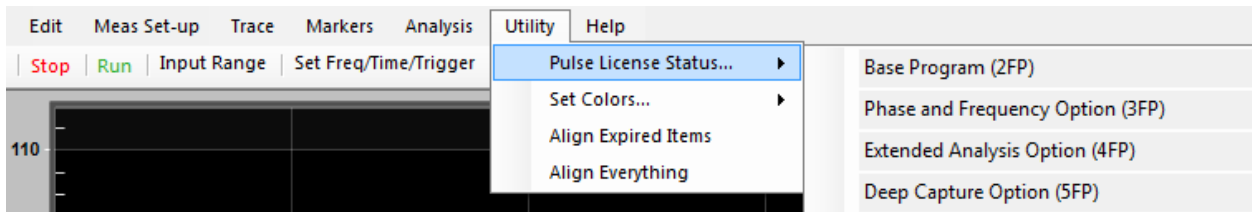
## Utility

The Utility menu contains Pulse license status, and controls setting of colors and calibration/alignment.



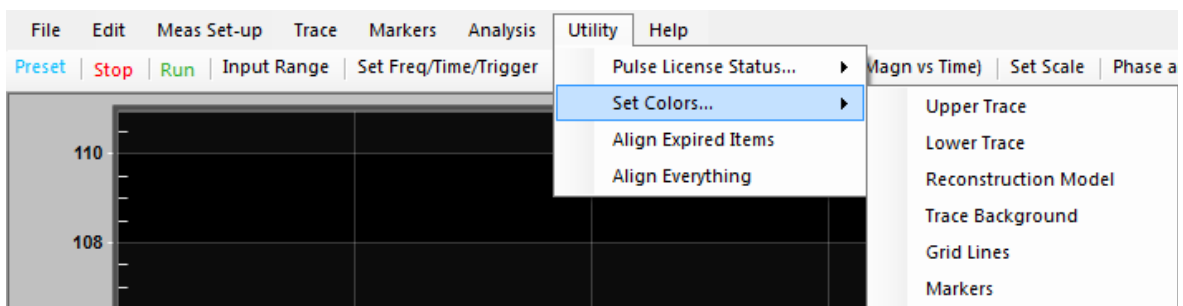
### Pulse License Status

Lists the installed licenses.



### Set Colors

Sets the colors for the upper trace, lower trace, model, background, grid lines, and markers. Each selection will bring up the Windows color selection dialog.



### Align Expired Items

Performs an alignment of only the items whose calibration has expired.

Menu Features  
Utility

## Align Everything

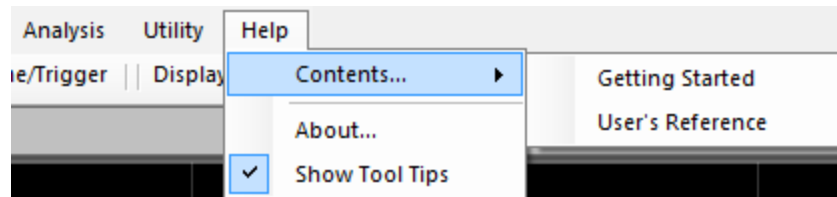
Performs an alignment of everything.

**NOTE**

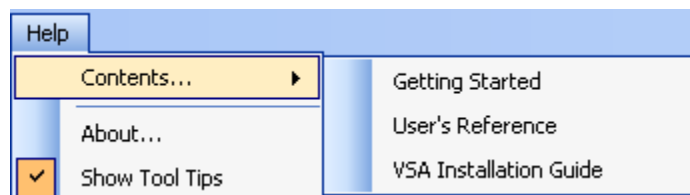
The xSA cannot be used for making measurements during the alignment process

---

## Help



## Contents



Opens the appropriate Help file.

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

## About

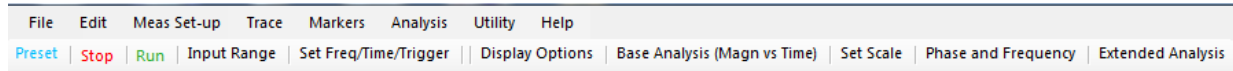
About lists the version number, date created, copyright information, and other pertinent information describing the software.

## 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.



### Preset

Configures Pulse in a default condition. Same function as File/Preset.

### Stop

Stops the measurement cycle.

### Run

Starts the measurement cycle.

---

**NOTE**

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

---

### Input Range

This button is a quick way to open the input range dialog described in **“Input Range” on page 20**. Same function as Meas-Setup/Input Range.

### 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 22**. Same function as Meas-Setup/Set Frequency/Time/Trigger.

### Display Options

This button is a quick way to open the display options dialog described in **“Display Options” on page 25**. Same function as Trace/Display Options.

### Base Analysis (Magn vs Time)

This button is a quick way to open the display options dialog described in **“Base Analysis (Magn vs Time)” on page 31**. Same function as Analysis/Base Analysis (Magn vs Time).

## Set Scale

This button is a quick way to open the set scale dialog. See **“Set Scale” on page 28** for more information. Same function as Trace/Set Scale.

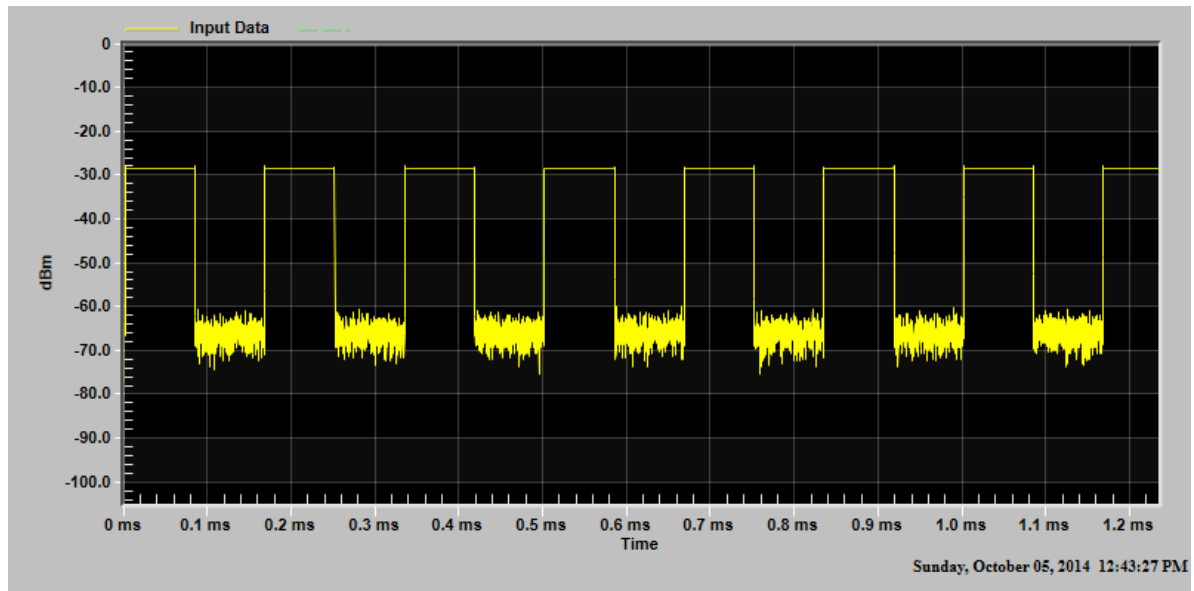
## Phase and Frequency

Opens the Phase and Frequency dialog (not visible, if the Phase and Frequency license is invalid).

## Extended Analysis

Opens the Extended Analysis dialog (not visible if the -4FP license is invalid). Same function as Analysis/Extended Analysis/.

## 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.

The display(s) are re-sizable 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 50M) can be much greater than the number of display pixels on the horizontal axis (20K). Therefore, the software can not always display all the information and detail that is captured and measured. The "analysis" functions use the full resolution of the data acquired; the software will find, count, and measure pulses even if they cannot be seen. Zooming can be used to verify graphically that a pulse is present.

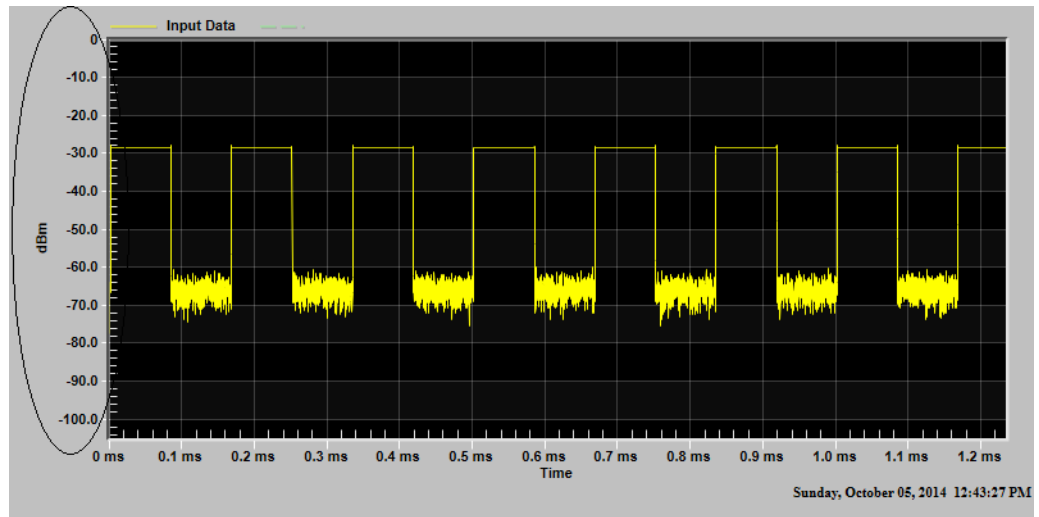
### Display Annotation

#### Vertical (Y) axis scale

Display units and scaling are shown in the left-hand axis.

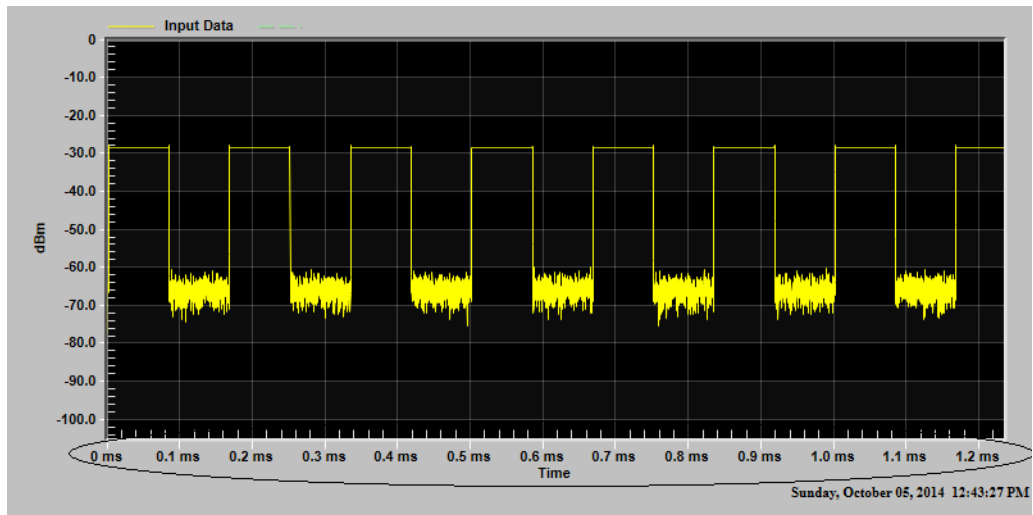


Menu Features  
Graphical Trace Displays



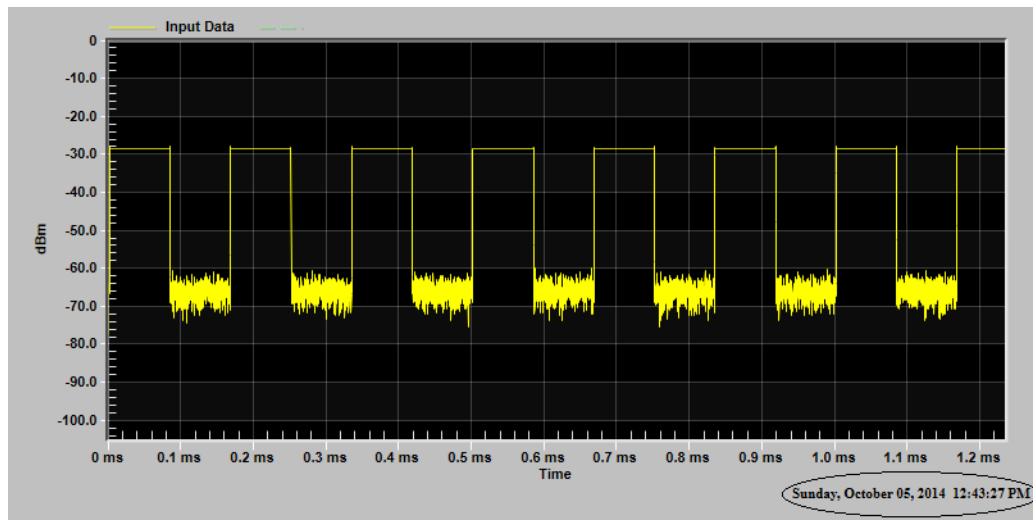
### Horizontal (X) axis scale

Scaling and units (time, phase, or frequency) are shown in the horizontal axis.



### Clock display

The current time and date are shown in the clock annotation.



## Mouse Control Functions on Trace/Graticule

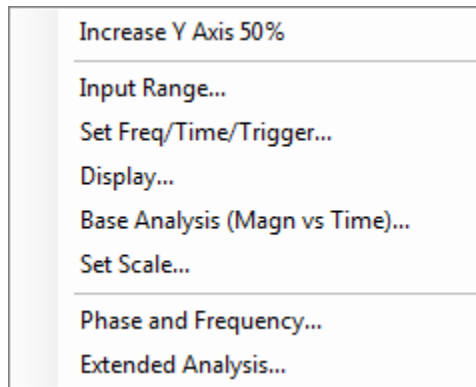
There are several functions that can be performed on the trace display by various mouse maneuvers.

### Left-Click Functions (Zoom)

Zooming is done by visualizing a rectangle to "zoom" in on and positioning the mouse over a corner of the rectangle (e.g. upper left corner) and pressing the left mouse button. Keeping the left mouse button pressed, the mouse is used to place the mouse pointer over the opposite corner of the rectangle (e.g. lower right corner) and the left mouse button is released. This expands and scales the selected portion of the trace to fill the entire Upper/Lower window.

### Right-Click Functions

Pressing 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: Increase Y Axis 50%, Input Range, Set Freq/Time/Trigger, Display, Base Analysis (Magn vs Time), Set Scale, Phase and Frequency, Extended Analysis. If the mouse cursor is over the data window in bottom pane the only menu item available is Analysis.



**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 Set Scale and Auto Scale functions are not operational while in zoomed mode.

**Input Range** - Brings up Input Range dialog.

**Set Frequency / Time / Trigger** - Brings up the Frequency/Time/Trigger Dialog. See **“Set Frequency / Time / Trigger” on page 22** for more information.

**Display** - Brings up the Display Operations dialog. See **“Display Options” on page 25** for further details.

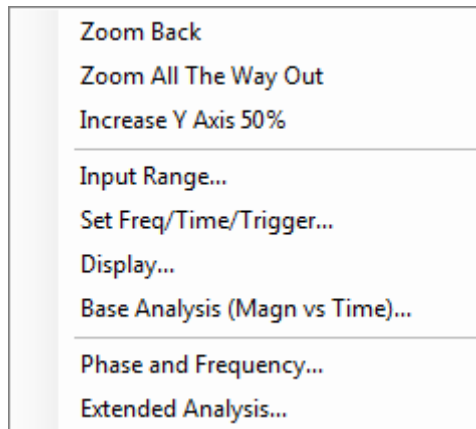
**Base Analysis (Magn vs Time)** - Brings up the Base Analysis (Magn vs Time) dialog. See **“Analysis Selection Tab” on page 30** for further details.

**Phase and Frequency** - Opens the Phase and Frequency dialog (grayed out if the -3FP license is missing).

**Extended Analysis** - Opens the Extended Analysis dialog (grayed out if the -4FP license is missing).

### Right-Click Function with Zoom

Right-clicking the mouse brings up a context menu with two additional choices. If you zoom in on the trace, then two additional selections are available in the right -click menu. (i.e., **Zoom Back** and **Zoom All the Way Out**).



**Zoom Back** - Reverts to previous zoom. When a zoom is performed, zoom parameters are pushed onto a stack. Zoom Back pops the last one off of the top of the stack, allowing close examination of multiple areas without zooming all the way out in between zooming operations.

**Zoom All the Way Out** - Returns to unzoomed mode. (You must have already zoomed in to see this option on the menu.)

**NOTE**

The Set Freq/Time/Trigger context menu item is greyed out while reading SDF files.

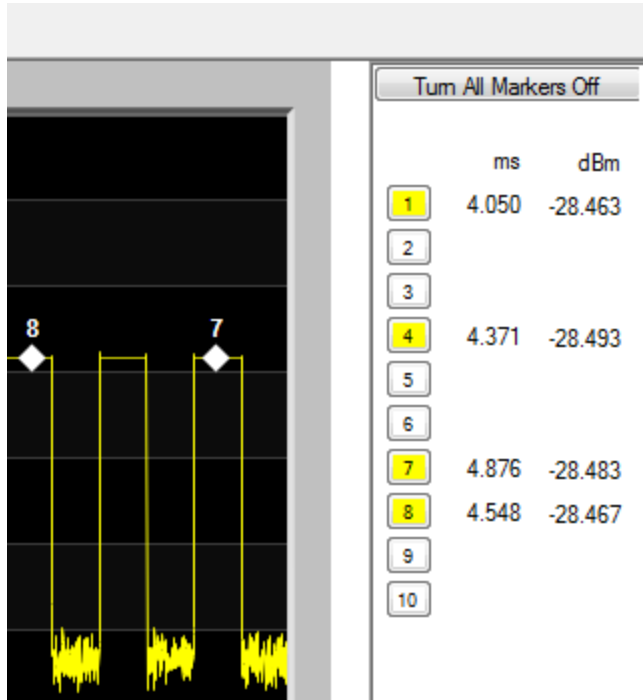
---

## Markers

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

Markers display the time and magnitude/phase/frequency associated with a point in the Upper/Lower Window.

Markers are placed on the trace. Only the X coordinate is selectable.



### Marker Selection and Placement

To place a marker, first select the marker you wish to place by clicking on the numbered button on the right side of the screen. Move the mouse to the desired location (only the X axis portion is selectable). When at 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 along the X axis it may be useful to temporarily "zoom" in on a portion of the trace, place the marker where you want it, then ZoomBack. (Of course, this assumes that the trace is stable from acquisitions to acquisition (using triggers), or frozen (using Stop).)

When the marker is placed, it is indicated by a white diamond with its associated 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. Double-click the button instead of a single click. 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 to indicate that they are delta markers. The values in the marker table for the reference are absolute. The other values display the difference between that particular marker and the reference marker.

## All Markers Off

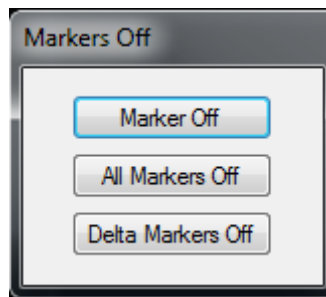
Turn off all markers in the window.

## Delta Markers Off

Turn all markers into normal markers, rather than delta 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.

## Tabular Results Window

The Tabular Results window is the primary display of 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 summaries of information from other dialogs such as center (tune) frequency, input parameters, and triggering.

Instrument State	Pulse Measurement	Statistics		
Center Frequency	30.000	MHz	Risetime Lower Percent	10%
Record Length	500.000	μs	Risetime Upper Percent	90%
Time Resolution	21.000	ns	Falltime Lower Percent	10%
Number of Data Points	23.810	Kpoints	Falltime Upper Percent	90%
Trigger Type	Video		Width Threshold	50%
Trigger Level	-49.000	dBm	Input Range Offset	0 dB
Trigger Delay	-2.100	μs	Amplitude Offset	0 dB
Trigger Holdoff	200.000	ns		

### Pulse Measurement Tab

Presents the selected measurements. Each column represents the selected measurement(s), and each row lists data for a 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 because calculating PRI requires the rising edge of the next pulse. If the next pulse (or part of it) were available, then it would be the last pulse.

Instrument State	Pulse Measurement		Statistics						
	Rising Edge	Falling Edge	Max	Average	Average	Droop	Droop	Droop	Over-
Pulse	(μs)	(μs)	(dBm)	On Level	Pulse	Mag	(%)	/Time	shoot
	(μs)	(μs)	(dBm)	(dBm)	(dBm)	(dBm)	(%)	(dBm/μs)	(dBm)
1	2.0994	85.4688	-27.59	-28.57	-31.58	0.00	0.0	0.00	-46.93
2	168.7634	252.1383	-28.28	-28.58	-31.59	-100.54	0.0	-138.97	-57.61
3	335.4324	418.7802	-27.74	-28.57	0.00	-94.39	0.1	-132.81	-48.46
4	---	---	---	0.00	0.00	---	---	---	---

Refer to the Appendix, **“Pulse Measurement Software Approach”** on [page 69](#) for specific details on the computational algorithms used for Pulse Measurement Software.

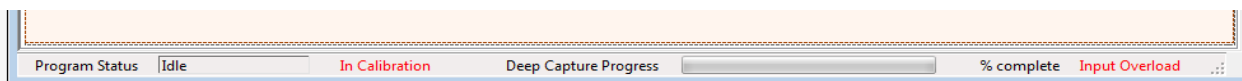
### Statistics

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 75**.

Instrument State	Pulse Measurement	Statistics	Max	Avera...	Avera...	Droop	Droop	Droop	Over-
				On Le...	Pulse	Mag		/Time	shoot
			(dBm)	(dBm)	(dBm)	(dBm)	(%)	(dBm/...	(dBm)
<b>Current Record</b>									
	Parameter Maximum	---	-27.59	-28.57	-31.58	-94.39	0.1	-132.81	-46.93
	Parameter Minimum	---	-28.28	0.00	0.00	0.00	0.0	0.00	-57.61
	Parameter Average	---	-30.36	-31.07	-37.61	-106.24	0.0	-144.66	-52.40
	Pulses	4							
<b>Cumulative</b>									
	Parameter Maximum	---	-27.54	73.00	-31.55	-32.33	65.0	-19.69	-43.03
	Parameter Minimum	---	0.00	0.00	0.00	0.00	-0.2	0.00	0.00
	Parameter Average	---	-30.31	-31.06	-37.70	-96.16	0.0	-88.99	-51.90
	Current Record	3252							
	<b>Reset Cumulative</b>								

### Status Bar

Program Status shows the current status of Pulse. It consists of a program status box, a calibration annunciator, deep capture progress, and input overload annunciator.



### Program Status

Idle

Armed = Waiting for trigger.

Processing = Calculating.

Reading = Transferring data from instrument.

Reading File = Reading data file.

### Calibration Status

Calibration Needed = Some part of the instrument needs to be aligned to remain with specification.

Aligning = Instrument is calibrating.



## Deep Capture Progress

(see below)

## Input Overload Status

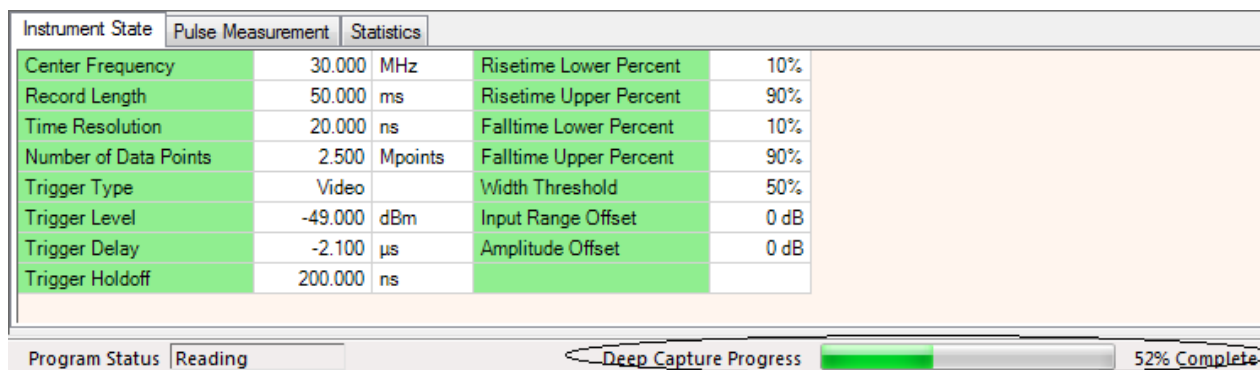
Illuminated when instrument input is overloaded.

## Deep Capture Progress Bar

The Deep Capture Progress Bar and numeric readout show the current progress of the deep capture reading operation. The progress bar/numeric readout are visible whenever the number of data points exceeds the size of the deep capture transfer buffer (50K points).

### NOTE

A data transfer from the instrument to Pulse cannot be interrupted. Data transfer happens after the measurement has been made on the instrument and data are being transferred to Pulse. The size of the transfer has been limited to 50K points to maintain responsiveness. The progress bar/numeric readout shows the progress of the data transfer operation.



## Phase and Frequency (Option 3FP)

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

If making Phase or Frequency measurements, the Frequency/Reference/Timebase of the signal source (transmitter) and the analyzer should be locked to each other.

---

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.

---

### 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, auto-scaling, 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, auto-scaling, 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 7 in this case) will be partially blank (shown as dashes) because the pulse is incomplete by definition (some calculations require portions of the next pulse as part of the calculation).

Instrument State	Pulse Measurement			Statistics											
	Rising Edge	Falling Edge	Average On Level	PRI	PRF	Phase Pls-Pls	Phase Mean	Phase Trend	Start Freq	Stop Freq	Band-width	Freq Mean	Chirp Slope	Freq Dev	
Pulse	( $\mu$ s)	( $\mu$ s)	(dBm)	( $\mu$ s)	(KHz)	(deg)	(deg)	(deg/ $\mu$ s)	(Hz)	(Hz)	(Hz)	(Hz)	(Hz/ $\mu$ s)	(KHz)	
1	1.9852	42.0477	-20.23	80.000	12.50	0.00	158.16	0.00	-134.002	-129.180	4.822	-131.591	0.120	25.065	
2	81.9851	122.0480	-20.24	80.000	12.50	-3.17	154.97	0.00	-160.298	-138.068	22.230	-149.183	0.555	25.120	
3	161.9850	202.0484	-20.23	80.001	12.50	-6.42	151.78	0.00	-172.416	-122.025	50.391	-147.220	1.257	24.688	
4	241.9853	282.0480	-20.23	79.999	12.50	-9.63	148.52	0.00	-160.089	-115.350	44.738	-137.720	1.116	23.447	
5	321.9851	362.0485	-20.23	80.000	12.50	-12.85	145.29	0.00	-129.658	-164.094	34.436	-146.876	-0.859	26.732	
6	401.9851	442.0481	-20.24	80.000	12.50	-16.04	142.08	0.00	-138.020	-101.816	36.203	-119.918	0.903	26.227	
7	481.9853	---	-20.24	---	---	---	---	---	---	---	---	---	---	---	

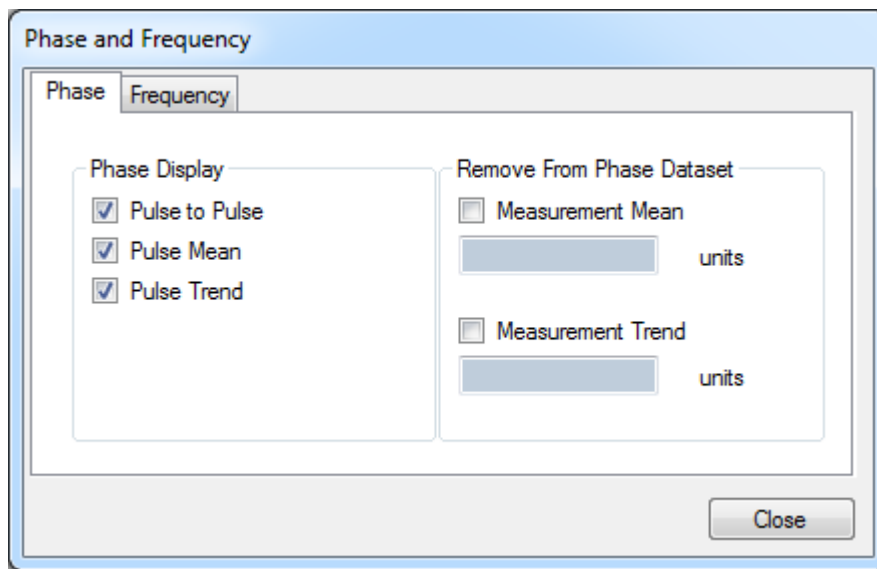
## Phase and Frequency Dialog

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.

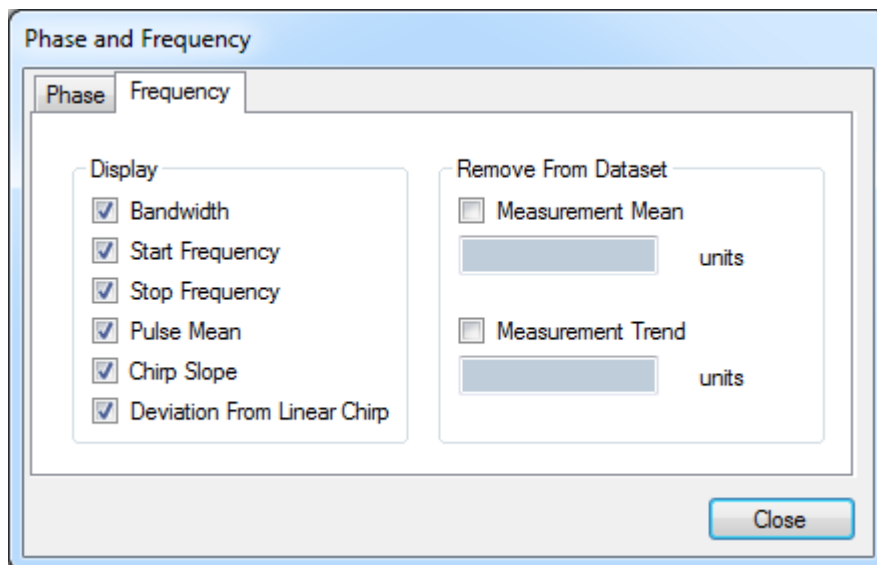
Checking a checkbox on the left hand side of the dialog causes the corresponding data element to be displayed in the Analysis Results Table. Checking a checkbox on the right hand side of the dialog causes the mean and/or trend to be removed from the data plotted on the graph. Checking the right hand 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.

Menu Features  
Phase and Frequency (Option 3FP)



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 (Option 4FP)

**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 not captured, and consequently not included.

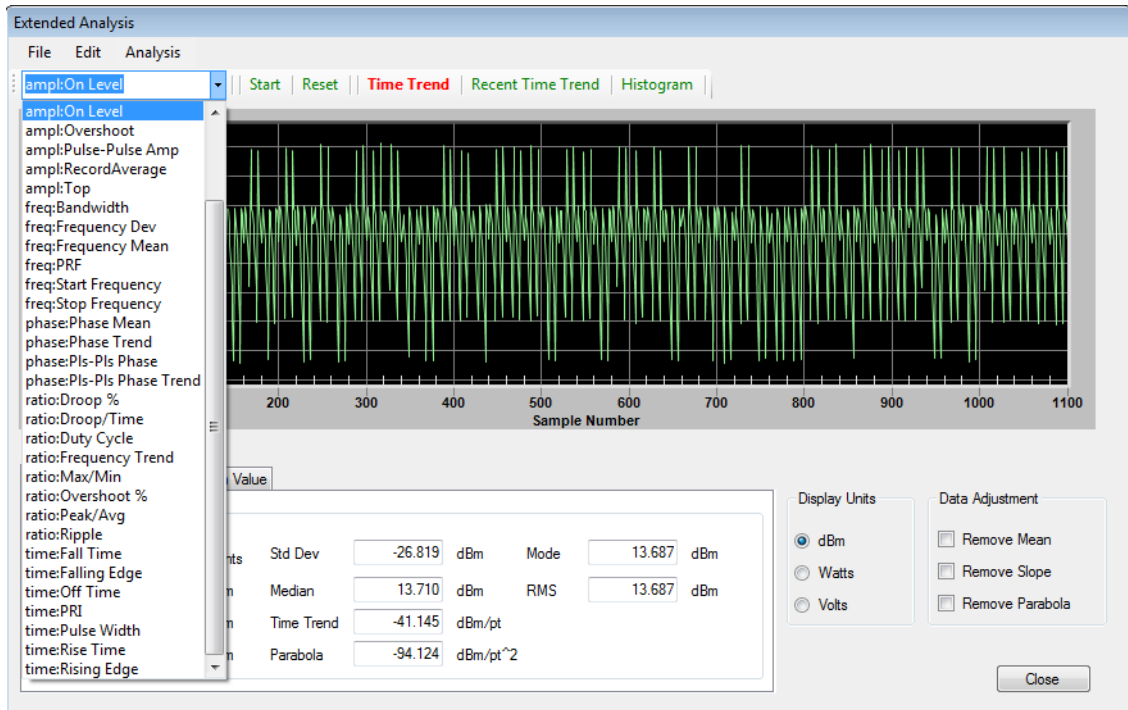
---

## 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.



**Table 2-1** 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:Drop	magnitude of droop from pulse rising edge to falling edge
ratio:Drop %	ratio of ampl:Drop to pulse on level
ratio:Drop/Time	ampl:Drop per time
ampl:Overshoot	pulse overshoot
ratio:Overshoot %	ratio of ampl:Overshoot to pulse on level
ratio:Ripple	maximum ripple amplitude

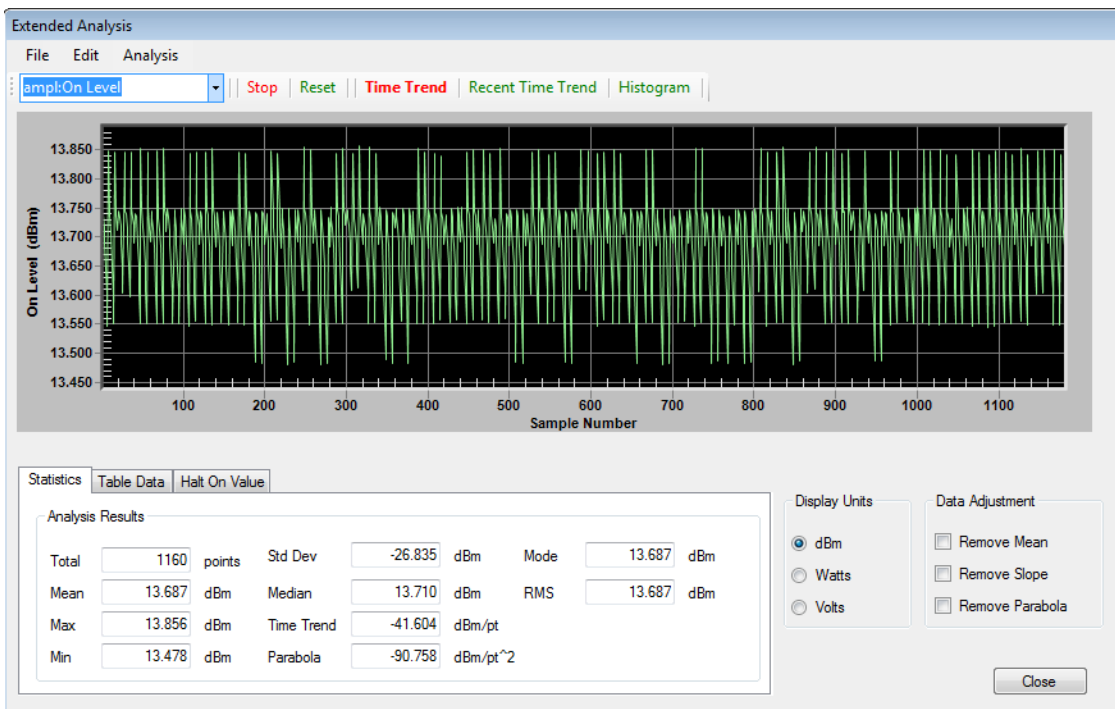
**Table 2-1** Selectable Parameters

<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.





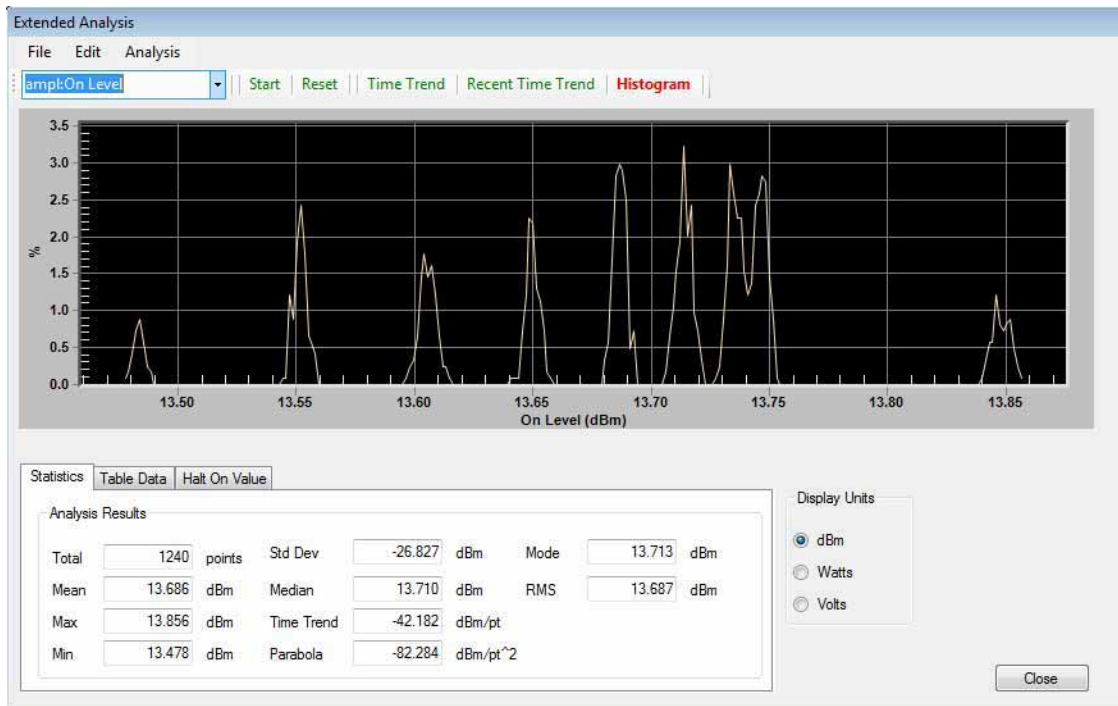
Menu Features  
Extended Analysis (Option 4FP)

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.

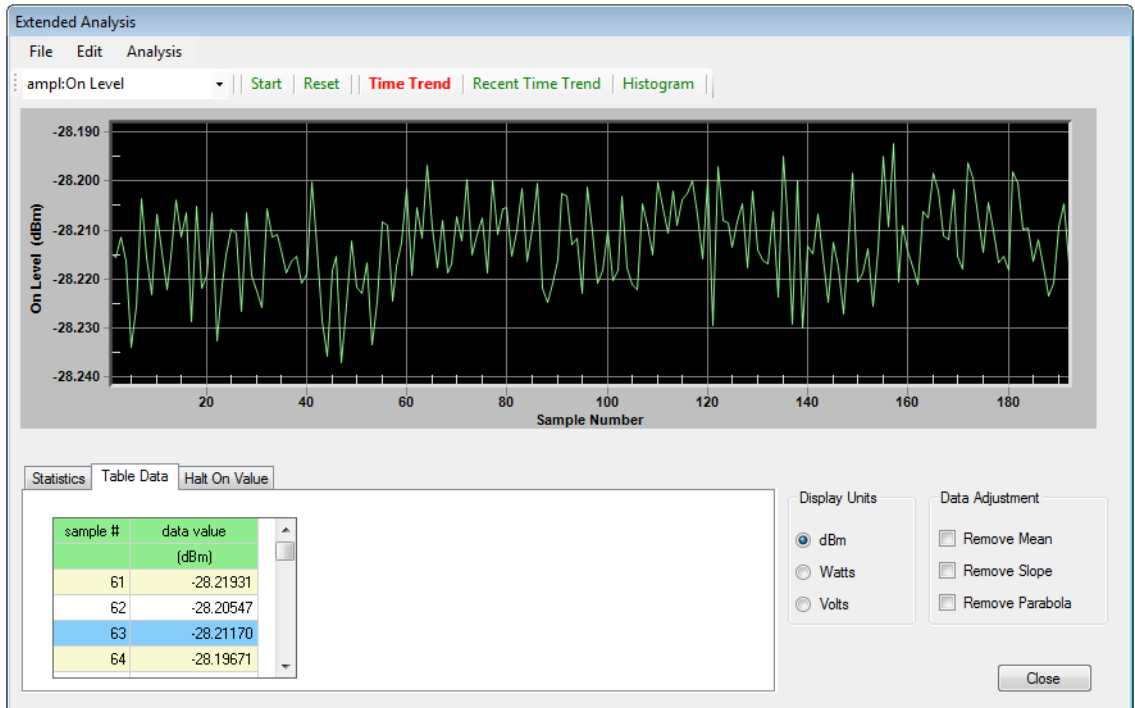
Menu Features  
Extended Analysis (Option 4FP)

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.



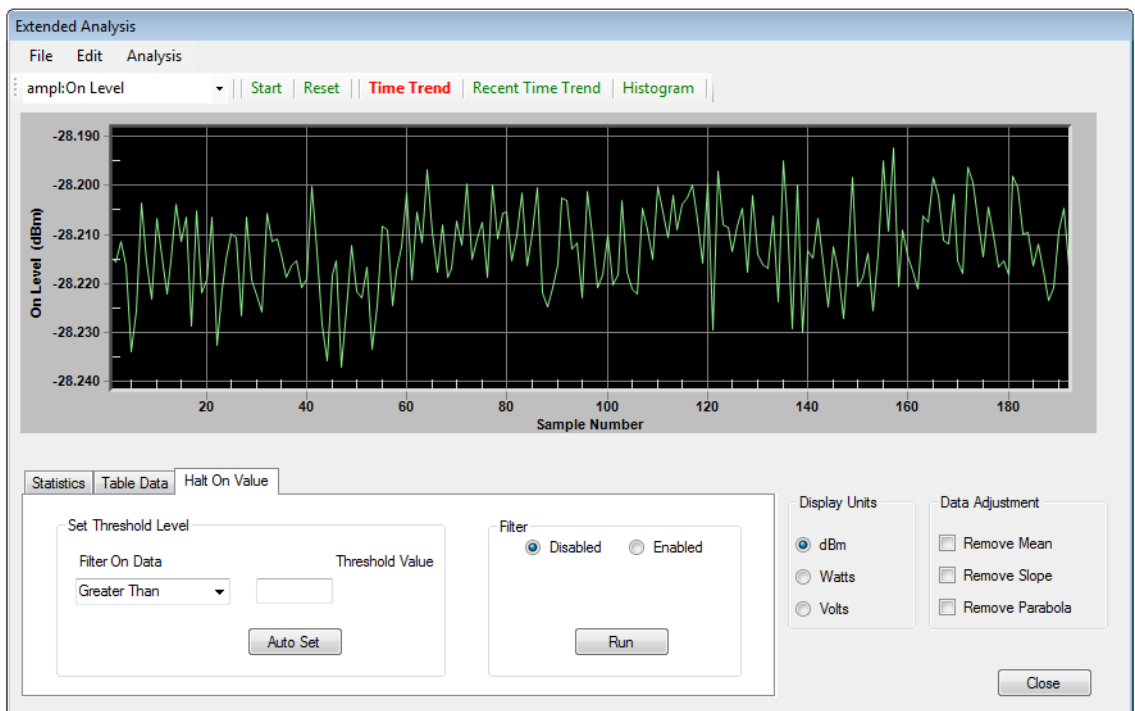
## “Halt On Value” Trigger Filter

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.



## Deep Capture (Option 5FP)

**NOTE** The Deep Capture features are optional, and available only if the corresponding license (-5FP) is purchased and installed.

The Deep Capture option increases the capacity of Pulse from 409K data points to 50M data points on instruments with the DP2 option and 4M data points without the DP2 option.

All UXA's (N9040B) and PXA's (N9030A) are capable of the full (50M data point capture) as are MXA's (N9020A) and EXA's (N9010A) with B40, B85, B1A, B1X, B1Y, or DP2 options. CXA's (N9000A) do not work with the DP2 option and as such the Deep Capture option is limited to 4M data points. MXA's and EXA's without B40, B85, B1A, B1X, B1Y, or DP2 options are also limited to 4M data points.

### Display

Deep Capture progress is shown in the Deep Capture Progress bar at the bottom of the screen. A numeric readout immediately to the right of the progress bar gives the numeric value of the progress bar. The progress bar shows the progress of the data transfer between instrument and Pulse.

A data transfer from the instrument to Pulse cannot be interrupted. Data transfer happens after the measurement has been made on the instrument and data are being transferred to Pulse. The size of the transfer has been limited to 50K points to maintain responsiveness.

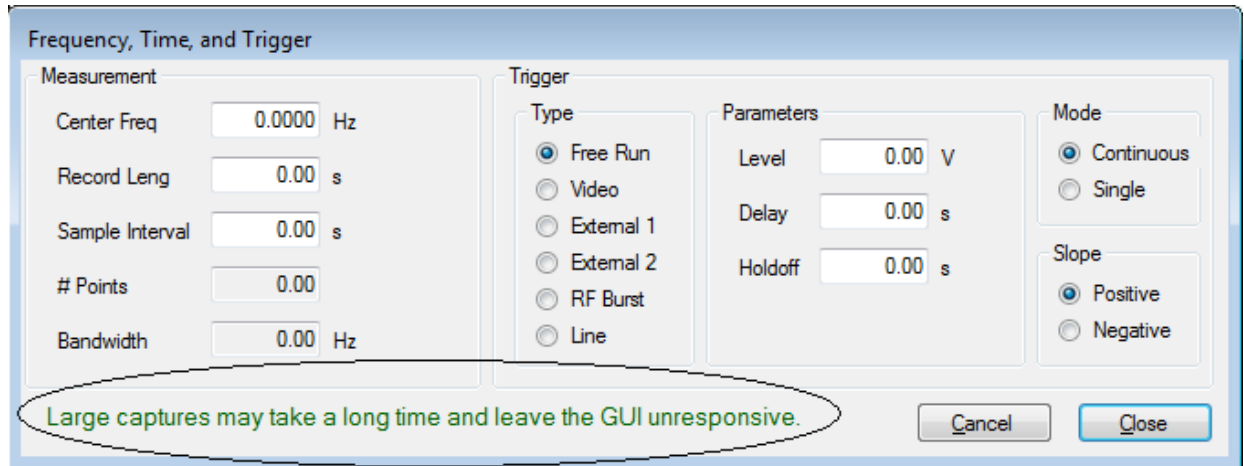
Instrument State	Pulse Measurement	Statistics		
Center Frequency	30.000	MHz	Risetime Lower Percent	10%
Record Length	50.000	ms	Risetime Upper Percent	90%
Time Resolution	20.000	ns	Falltime Lower Percent	10%
Number of Data Points	2.500	Mpoints	Falltime Upper Percent	90%
Trigger Type	Video		Width Threshold	50%
Trigger Level	-49.000	dBm	Input Range Offset	0 dB
Trigger Delay	-2.100	µs	Amplitude Offset	0 dB
Trigger Holdoff	200.000	ns		

Program Status	Reading	Deep Capture Progress	52% Complete
----------------	---------	-----------------------	--------------

**NOTE** On instruments without the DP2 option, data are transferred in a single operation. Whereas the DP2 instruments can be interrupted after 50K data points have been transferred, on the non-DP2 instruments Pulse must wait until the entire measurement data have been transferred. This can take a significant amount of time (e.g. 60 sec) and leave Pulse unresponsive in the interim. Pulse displays a warning message ("Large captures may take a long

time and leave the GUI unresponsive.") in the Frequency/Time/Trigger dialog when the user selects a record length resulting in more than 250K data points on a non-DP2 machine.



Menu Features  
Deep Capture (Option 5FP)



### 3 Performance Characteristics

The pulse measurement performance of the N9051B is based on the bandwidth of the instrument used. The table below shows the nominal instrument performance at the maximum bandwidth for various bandwidth options.

These figures are nominal limits of pulses that can be measured with reasonable accuracy. Actual limits may vary, depending on the shape of the pulses, the type of measurements being made, and other factors. (Estimates are based on 3x, 6x, and 12x the sample interval).

#### Nominal Instrument Performance for Each Device

Digitizer Option	Maximum Band width	Maximum Complex IQ Sample Rate	Minimum Instrument Rise Time (3x)	Minimum Detectable Pulse Width (6x)	Phase and Frequency Minimum Pulse Width (12x)
B10	10 MHz	12.5 MSa/s	240 ns	480 ns	960 ns
B25	25 MHz	31 MSa/s	100 ns	200 ns	400 ns
B40	40 MHz	50 MSa/s	60 ns	120 ns	240 ns
B85	85 MHz	106 MSa/s	28 ns	56 ns	112 ns
B1A	125 MHz	156 MSa/s	20 ns	40 ns	80 ns
B1X	160 MHz	200 MSa/s	15 ns	30 ns	60 ns
B2X	255 MHz	300 MSa/s	10 ns	20 ns	40 ns
B5X	510 MHz	600 MSa/s	5 ns	10 ns	20 ns

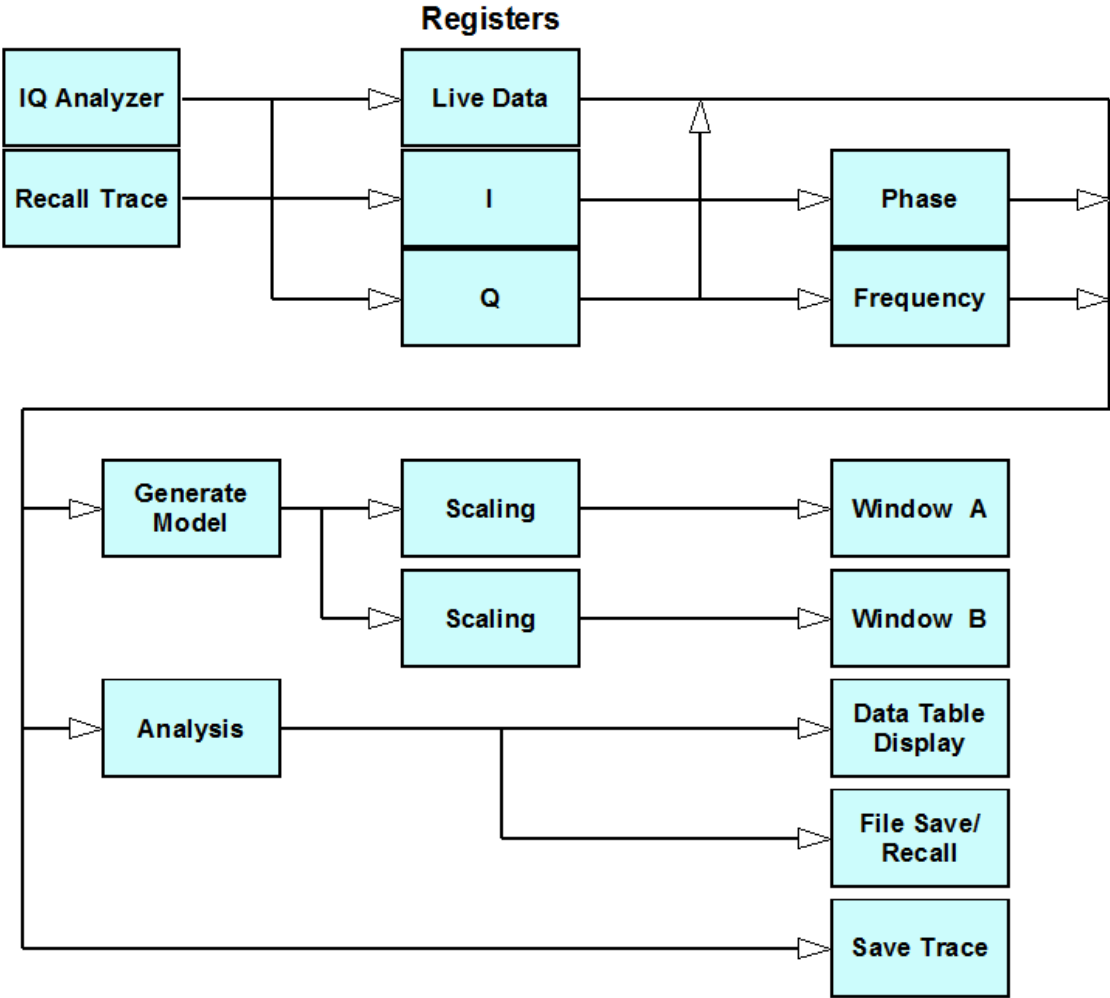
**Software Characteristics**

Maximum Markers	10 / Display
Record Length	100 s
Types of Triggers	Level Video External RF Burst Line
Waveform file types	.sdf
Maximum # of pulses	200,000
Maximum # of pulses displayed in table	1,049

# A: Appendix

## Application Architecture

The N9051B Pulse architecture is shown below.



Appendix  
Application Architecture

Data flows from either the instrument (via IQ Analyzer which is built into all xSA series instruments) or a data file (for saved data). Pulse converts I/Q data to magnitude, phase, and frequency data. This data are then used for analysis and to generate a model (of the pulses).

The magnitude/phase/frequency data along with the model are scaled and displayed.

The magnitude/phase/frequency data are analyzed and displayed in tabular form and/or saved to a file.

The magnitude/phase/frequency data can be saved for later recall.

# Pulse Measurement Software Approach

## Introduction

After acquiring a Time Record from the instrument, the N9051B 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.

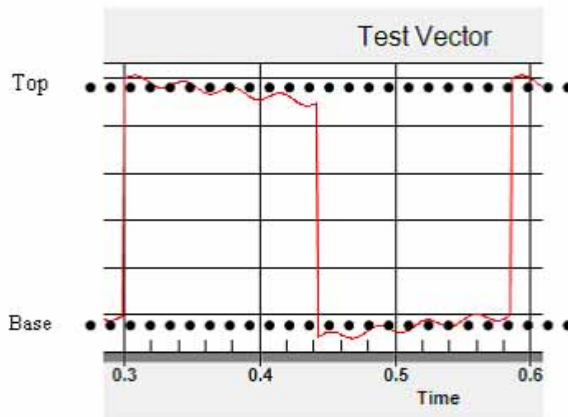
If there is a large amplitude "drop out" (dip) during the On interval, or a signal "spike" in the Off interval, the software may misrepresent these as separate pulse cycles.

The user can typically adjust **Record Length** to capture only a portion of a single pulse cycle, or capture many pulse cycles. The N9051B 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

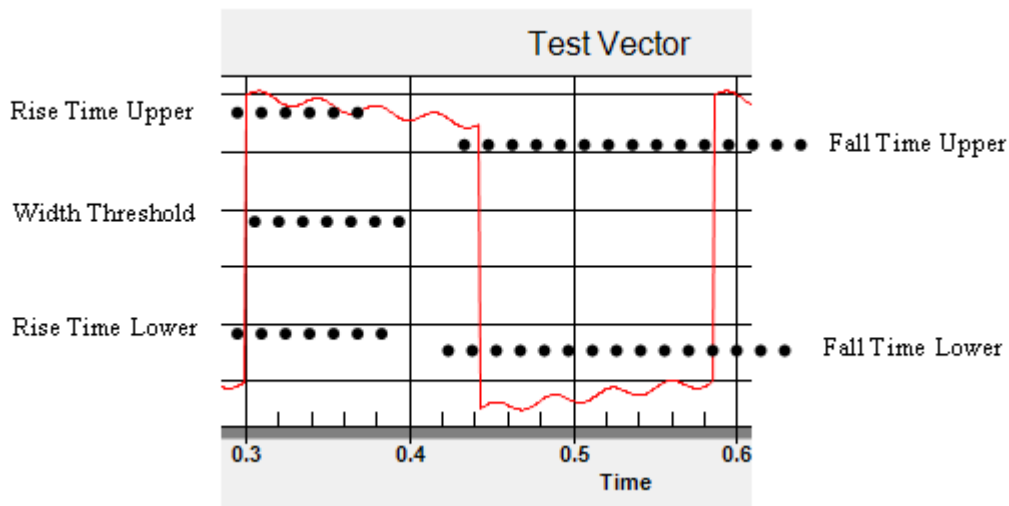
are not well separated, or where the majority of samples are scattered in a wide variety of amplitude values, will fail to yield well-defined “top” and “base” levels.



### 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.

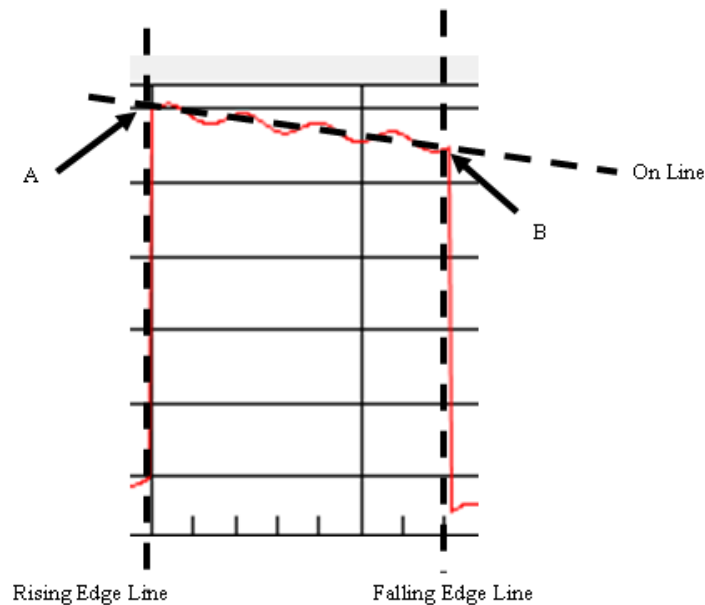
Fall Time Lower – threshold for transition between falling edge and Top. The default value is 10% of Range plus Base.

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 N9051B 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  $\mu\text{sec}$ .

**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).

### Phase and Frequency Functions

The following parameters are calculated over all of the data points in the top of each pulse (rising and falling edges are excluded).

Phase and frequency are calculated for all of the data points in the tops of all of the pulses. Smoothing is used to reduce some of the noise generated by the differentiation operation.

---

Phase and frequency are calculated for all of the data points in the tops of all of the pulses.

---

Smoothing is used to reduce some of the noise generated by the differentiation operation.

$$\begin{aligned} \text{wrapped\_phase} &= \text{atan}(Q / I) \\ \text{frequency} &= d(\text{phase}) / dt \end{aligned}$$

---

#### Pls-Pls Amplitude (dBm)

Amplitude difference between average amplitude of pulse and average amplitude of reference pulse.

$$\begin{aligned} \text{amplitude\_ref} &= \text{average amplitude of first pulse} \\ \text{pls\_pls\_amplitude} &= \text{average amplitude of pulse} - \text{amplitude\_ref} \end{aligned}$$

---

#### 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

$$\begin{aligned} \text{phase\_ref} &= \text{average phase of first pulse} \\ \text{pls\_pls\_phase} &= \text{average phase of pulse} - \text{phase\_ref} \end{aligned}$$

---

#### Phase Mean

Average from least squares fit of line between the 90% amplitude rising to 90% amplitude falling points.

---

#### Phase Trend

Phase Trend is the slope of the phase over the top of the pulse.

$$\text{phase\_trend} = (\text{ending\_phase} - \text{beginning\_phase}) / \text{pulse\_width}$$

---

#### Start Freq (Hz)

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

start\_frequency and stop\_frequency are calculated by fitting a line to the frequency data points along the top of the pulse.

start\_frequency is the intercept of the line and stop\_frequency is computed by adding start\_frequency to the product of the line slope and pulse\_width.

---

Stop Freq (Hz)

Frequency at same time-instant as Falling- Width point.  
(see Start Freq)

---

Bandwidth (Hz)

$\text{bandwidth} = \text{stop\_frequency} - \text{start\_frequency}$

---

Freq Mean (Hz)

$\text{frequency mean} = (\text{stop\_frequency} + \text{start\_frequency}) / 2$

---

Chirp Slope (Hz/s)

$\text{chirp\_slope} = (\text{stop\_frequency} - \text{start\_frequency}) / \text{pulse\_width}$

---

Freq Dev (Hz)

1. Fit a line between the start frequency and stop frequency.
2. Find the deviation from this line over the middle 50% of the top of the pulse (50% used to reduce end effects and noise).

$\text{deviation} = \text{actual frequency} - \text{frequency from line at same X value}$   
 $\text{frequency\_deviation} = \text{maximum deviation}$

---

## 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).

Appendix  
Pulse Measurement Software Approach

Instrument State	Pulse Measurement	Statistics							
			Max	Avera...	Avera...	Droop	Droop	Droop	Over-
				On Le...	Pulse	Mag		/Time	shoot
			(dBm)	(dBm)	(dBm)	(dBm)	(%)	(dBm/...	(dBm)
<b>Current Record</b>									
Parameter Maximum		---	-27.59	-28.57	-31.58	-94.39	0.1	-132.81	-46.93
Parameter Minimum		---	-28.28	0.00	0.00	0.00	0.0	0.00	-57.61
Parameter Average		---	-30.36	-31.07	-37.61	-106.24	0.0	-144.66	-52.40
Pulses		4							
<b>Cumulative</b>									
Parameter Maximum		---	-27.54	73.00	-31.55	-32.33	65.0	-19.69	-43.03
Parameter Minimum		---	0.00	0.00	0.00	0.00	-0.2	0.00	0.00
Parameter Average		---	-30.31	-31.06	-37.70	-96.16	0.0	-88.99	-51.90
Current Record		3252							
<b>Reset Cumulative</b>									

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.

Instrument State	Pulse Measurement	Statistics							
			Max	Avera...	Avera...	Droop	Droop	Droop	Over-
				On Le...	Pulse	Mag		/Time	shoot
			(dBm)	(dBm)	(dBm)	(dBm)	(%)	(dBm/...	(dBm)
<b>Current Record</b>									
Parameter Maximum		---	-27.59	-28.57	-31.58	-94.39	0.1	-132.81	-46.93
Parameter Minimum		---	-28.28	0.00	0.00	0.00	0.0	0.00	-57.61
Parameter Average		---	-30.36	-31.07	-37.61	-106.24	0.0	-144.66	-52.40
Pulses		4							
<b>Cumulative</b>									
Parameter Maximum		---	-27.54	73.00	-31.55	-32.33	65.0	-19.69	-43.03
Parameter Minimum		---	0.00	0.00	0.00	0.00	-0.2	0.00	0.00
Parameter Average		---	-30.31	-31.06	-37.70	-96.16	0.0	-88.99	-51.90
Current Record		3252							
<b>Reset Cumulative</b>									

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 N9051B 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 N9051B 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 (Sample Interval) 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.

## 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.