86100CU-400 PLL and Jitter Spectrum Measurement Application

(for use with Agilent 86100C Digital Communications Analyzers)

User's Guide

Agilent Technologies

Notices

Manual Part Number

86100-90110

Edition

August 2008
Printed in USA

Agilent Technologies, Inc.
Digital Test Division
1400 Fountaingrove Parkway
Santa Rosa, CA 95403, USA

Trademark Acknowledgements

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, Agilent 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. Agilent shall not be liable for errors or for incidental or consequential damages in connection with the furnishing, use, or performance of this document or of any information contained herein. Should Agilent 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 shall control.

Restricted Rights Legend

If software is for use in the performance of a U.S. Government prime contract or subcontract, Software is delivered and licensed as "Commercial computer software" as defined in DFAR 252.227-7014 (June 1995), or as a "commercial item" as defined in FAR 2.101(a) or as "Restricted computer software" as defined in FAR 52.227-19 (June 1987) or any equivalent agency regulation or contract clause. Use, duplication or disclosure of Software is subject to Agilent Technologies' standard commercial license terms, and non-DOD Departments and Agencies of the U.S. Government will receive no greater than Restricted Rights as defined in FAR 52.227-19(c)(1-2) (June 1987). U.S. Government users will receive no greater than Limited Rights as defined in FAR 52.227-14 (June 1987) or DFAR 252.227-7015 (b)(2) (November 1995), as applicable in any technical data.

Safety Notices

CAUTION

Caution denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in damage to or destruction of the product. Do not proceed beyond a caution sign until the indicated conditions are fully understood and met.

WARNING

Warning denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning sign until the indicated conditions are fully understood and met.

Contents

1

Installing the Application

Introduction

The *86100CU-400 PLL and Jitter Spectrum Measurement Application* is a collection of Microsoft® Excel workbook applications that perform Jitter Transfer Measurements (phase locked loop measurements), jitter spectrum, and jitter phase-noise measurements. These workbook applications run on a PC and control an 86100C digital communications analyzer and data, clock, and jitter sources via a GPIB or LAN connection as shown in Figure 1-1. The following workbook files are provided:

86100CU-400 PLL and Jitter Spectrum Measurement Application . . . . 86100C_400_A.01.00.xls
PCI Express (generation 1) PCIexpressG1.JTF.xls
PCI Express (generation 2) PCIexpressG2.JTF.xls

The workbook applications can be installed on the 86100C, but it is recommended that you use an external display. There are two versions of the *86100CU-400 PLL and Jitter Spectrum Measurement Application*. One versions works with Microsoft Excel 2003 with SP3 and the other version works with Excel 2007 with SP1 or later. Be sure to download the correct version.

NOTE

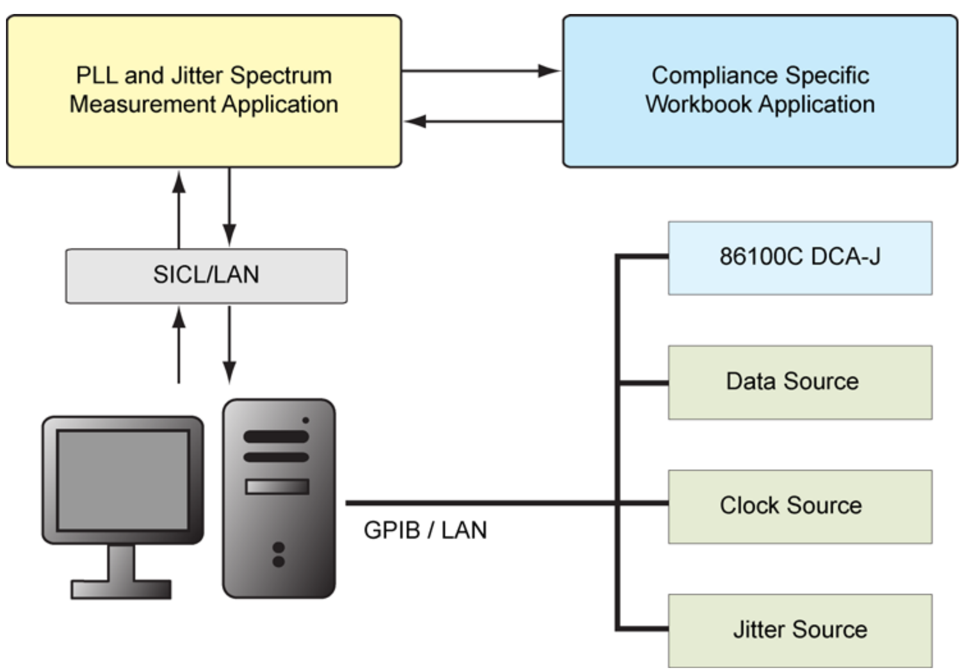


Figure 1-1. Required Workbooks, PC, and Test Equipment

Compliance-Specific Workbooks

Compliance-specific workbook applications make it easy to perform measurements that are targeted for a specific measurement standard as they automatically

- configure the *86100CU-400 PLL and Jitter Spectrum Measurement Application* workbook,
- collect the returned data,
- and present the measurement results.

As shown in Figure 1-1, compliance-specific workbooks do not communicate directly with the instruments. Because they configure many of the settings for you, you do not have configure the main workbook. When using the *86100CU-400 PLL and Jitter Spectrum Measurement Application* workbook to perform Jitter Transfer Measurements, jitter spectrum, and jitter phase-noise measurements, you'll need to configure the individual settings as described in this chapter.

The compliance-specific workbooks are not locked, so you can modify them to meet your measurement needs. Before modifying these workbook, it is recommended that you be experienced the techniques required. Always make a backup copy before modifying any workbook. Agilent does not provide any support for modifying these workbooks.

Data Rate Range

The signal must be within the data rate range supported by the clock recovery module:

86108A . . . . .50 Mb/s to 7.1 Gb/s
83496B standard . . . . .50 Mb/s to 7.1 Gb/s
83496B Option 200. . . . . 50 Mb/s to 13.5 Gb/s
83496B Option 201 . . . . .7.1 Gb/s to 13.5 Gb/s

Communication Bus

You can use one or more of the following methods to connect the test equipment to the PC:

- GPIB using an Agilent 82350B GPIB interface PCI card
- GPIB using an Agilent 82357A or 82357B USB-to-GPIB converter
- LAN using an E5810A LAN/GPIB gateway
- National Instruments based GPIB or LAN connections

NOTE

The instructions in this user's guide assume that you are familiar with using the 86100C and can lock the trigger on the signal. If not, refer to the 86100C online help. It is also assumed that you know how to use Microsoft Excel.

NOTE

For a technical review of the importance of these measurements as well as insights into the root causes of jitter, refer to Agilent Product Note 86100C-2 "Solving Jitter Problems Through Jitter Spectrum and Phase Noise Analysis".

NOTE

The *86100CU-400 PLL and Jitter Spectrum Measurement Application* will not work with 86100A, 86100B, or 83496A products. An 83496A can be upgraded to an 83496A-UAB which is compatible. Contact your local Agilent representative for details.

NOTE

If the *86100CU-400 PLL and Jitter Spectrum Measurement Application* stops responding during operation, press the Escape key.

Required Equipment

Test Equipment

Table 1-1 lists the compatible equipment that you can use in your test setups. As shown, instruments like the N4903B can be used as the source for both the data, clock, and jitter. Be sure to select an instrument that meets your measurement needs. For example, a jitter source is only required for Jitter Transfer Measurements (JTF). Also, ifferent jitter sources offer varying ranges of jitter.

Table 1-1. Compatible Test Equipment

	86108A	83496B	83496A (Opt UAB)	N4903B J-BERT High-Performance Serial BERT	N5182A MXG RF Vector Signal Generator	81150A Pulse Function Arbitrary Noise Generator	E8267D PSG with IQ option	33250A Function / Arbitrary Waveform Generator
Jitter Receiver (Clock Recovery Module)	•	•	•					
Data Source				•	•	•		
Clock Source				•	•	•	•	
Jitter Source [a]				•	•	•	•	•

a. Required for the JTF measurement.

Computer

Available hard drive space . . . 100 Mb
RAM . . . 500 Mb
Processor . . . ≥ 1 GHz
Operating system . . . Windows® 2000, XP, or Vista
One of the following hardware interfaces:
- 82357A/B GPIB-to-USB converter, or
- 82350B GPIB PCI card, or
- E5810A LAN/GPIB gateway

Agilent IO Libraries Suite (Revision 15.0 or later)

Microsoft Excel

Excel 2003 with Service Pack 3 (SP3) or Excel 2007 with Service Pack 1 (SP1)

SICL/LAN Support

GPIB and LAN instrument control is supported by the Agilent IO Libraries Suite which is shipped on a disc with the instrument. This software includes the Agilent Connection Expert, which facilitates the sending of remote commands to the instrument by using a GPIB or LAN device address. If you can not establish a LAN connection on the 86100C, install the Agilent IO Libraries LAN patch. This patch is located on the 86100C at C:\InfiniiumInstaller\AgtInstIoLanPatch.msi. An IP address can be substituted instead of using domain names.

SICL/LAN support requires that two programs be unblocked by the instrument’s firewall. If you upgraded the instrument firmware versions A.07.00 and below to revision A.08.00 and above, you might be prompted by a firewall application to block the Agilent Remote I/O Port Mapper Utility and the Agilent Remote I/O Server. If you decide to allow the features to be blocked, then remote control of the DCA over SICL/LAN will not be possible. We recommend that you select Unblock on these features. However, if you block these features, you can always reconfigure the firewall at a later time to allow SICL/LAN.

Some firewall applications might block an echo request (ping) from the Agilent Connection Expert version 15.0 and above. If a ping is blocked the "Instrument I/O on this PC" auto-detect function will not find the 86100C DCA even though it has been added and tested correctly under the Change Properties dialog box. To resolve this on the Microsoft Windows Firewall, refer to “Step 3. Setup the Communications Bus” on page 1-7.

For more information on communicating with the instrument using the Agilent's IO Libraries Suite, refer to the book *IO Libraries Suite Connectivity Guide with Getting Started*.

Installation

Use the following steps to install the applications, connect the instrument bus, and configure your measurements. For a listing of software and hardware requirements, refer to “Required Equipment” on page 1-4.

Step 1. Obtain the Application

1 Visit the Agilent’s download web page at:

   www.agilent.com/find/jtf

2 Click **Download**. Select the application version that is compatible with the version of Excel that you are using.

3 Complete the registration form and click **Submit**.

Step 2. Upgrade 86100C software

1 Confirm that the 86100C software revision is A.08.00 or above. On the 86100C, click **Help** > **About 86100C**. The version is listed in the dialog box. If the software revision is *below* A.08.00, perform the following steps.

2 Copy the software upgrade file to a USB Flash Drive, external USB CD-RW drive, LAN folder, or other device so that the file will be available to copy to the 86100C.

3 On the 86100C **File** menu, click **Exit** and then click **Yes** to exit the 86100C application.

4 On the Windows **Start** menu, click **My Computer**.

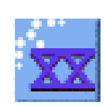
5 Select the D: drive and create a new folder. Give the new folder a meaningful name. For example, Software Upgrade.

6 Copy the upgrade file (.exe file extension) from an external memory device to your new folder.

7 Select the upgrade file to begin the installation. Click **Next** twice for the installation wizard to automatically uninstall the current version and install the newer version.

8 If you are prompted by a firewall application to block the Agilent Remote I/O Port Mapper Utility and the Agilent Remote I/O Server, select Unblock as shown in Figure 1-2 on page 1-7. See the introduction to this section for more information.

9 On the Windows desktop, double click the program icon to start the 86100C.



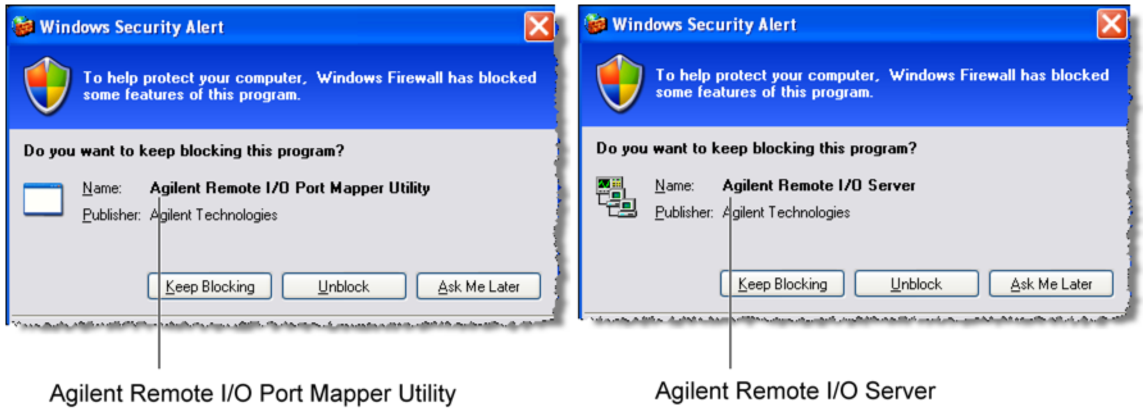


Figure 1-2. Example Windows Firewall Security Alerts

Step 3. Setup the Communications Bus

If you use a USB to GPIB converter

1. Install the drivers that come with the USB to GPIB converter.
2. Install the manufacturer's provided VISA libraries.
3. Connect the USB-to-GPIB converter to the computer.
4. Connect the GPIB cable from the converter to the instruments.

If you use a GPIB card

1. Install the GPIB card and load the supplied driver.
2. Install the manufacturer's provided VISA libraries.
3. Connect the GPIB cable between the GPIB port on the control computer and the GPIB port on the 86100C.

If you use a LAN connection
If you are controlling the 86100C over SICL/LAN with the Agilent Connection Expert, this procedure describes configuring the Windows Firewall. Settings using a different firewall will be similar.

1. On the 86100C, click **Help** > **About 86100C** and confirm that software revision A.08.00 or above is installed.
2. Minimize the 86100C application to view the Windows desktop.
3. On the **Start** menu, click **Control Panel**.
4. If Category View is set, click **Switch to Classic View**.
5. Open **Windows Firewall**.
6. On the Exceptions tab, clear or select to unblock (allow) the **Agilent Remote I/O Port Mapper Utility** and the **Agilent Remote I/O Server**. These programs allow control of the 86100C DCA over SICL/LAN. If these utilities are not listed, click **Add Program** in the dialog box and add them using the following paths:

Agilent Remote I/O Port Mapper Utility found at C:\Program Files\Agilent\IO Libraries Suite\bin\portmap.exe

Agilent Remote I/O Server found at C:\Program Files\Agilent\IO Libraries Suite\bin\siclland.exe

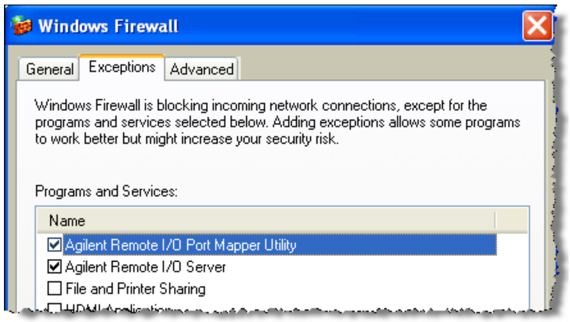


Figure 1-3. 86100C SICL/LAN Programs

7 On the Windows Firewall, click the **Advanced** tab.

8 Click **ICMP** to open the ICMP Settings dialog box.

9 Clear or select **Allow incoming echo request**. Selecting this feature allows the Agilent Connection Expert's (version 15.0 and above) **Instrument I/O on this PC** to automatically find the 86100C DCA.

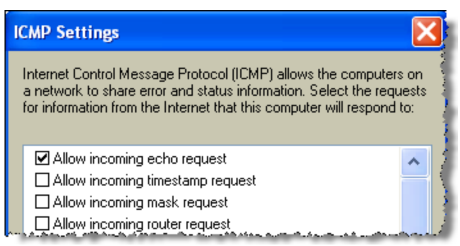


Figure 1-4. Allow Incoming Echo Request

Step 4. Configure Agilent IO Libraries Suite

1 Install the Agilent IO Libraries Suite on the PC.

2 On the PC, open the Agilent Connection Expert and locate the 86100C instrument device address.

3 If communication is via the LAN, for the 86100C connection, note the TCPIPx value and enter it in the spreadsheet's **IO Port** field for the DCA Setup. For example, enter TCPIP0.

4 In the Agilent Connection Expert, locate the Hostname for the 86100C connection. Enter this string into the spreadsheet's **Address** field for the DCA Setup.

After configuring the Agilent Connection Expert with the above steps, sending commands to the instrument changes the instrument from local mode into remote mode, which is similar to GPIB control. If, however, the device address inst0 is used instead of gpib0,7 the instrument will not change from local to the remote mode and some dialog boxes may be presented during the SICL/LAN session that require front-panel operation.

Step 5. Install Applications on the PC

- Place all of the downloaded application files in a separate folder on the PC. All files must be located in the same folder.

Step 6. Setup the Application

1. Start Microsoft Excel.
2. Click **Tools** > **Add-Ins**.
3. Select **Analysis ToolPak** and **Analysis ToolPak - VBA**.
4. Click **File** > **Open** and open the Jitter Transfer and Spectrum workbook, 86100C_400_A.01.00.xls
5. To configure and learn about the Jitter Transfer and Spectrum workbook, Chapter 2, “Configuring the Workbook”.

Electrostatic Discharge Information

Electrostatic discharge (ESD) can damage or destroy electronic components. All work on electronic assemblies should be performed at a static-safe work station. The following figure shows an example of a static-safe work station using two types of ESD protection:

- Conductive table-mat and wrist-strap combination.
- Conductive floor-mat and heel-strap combination.

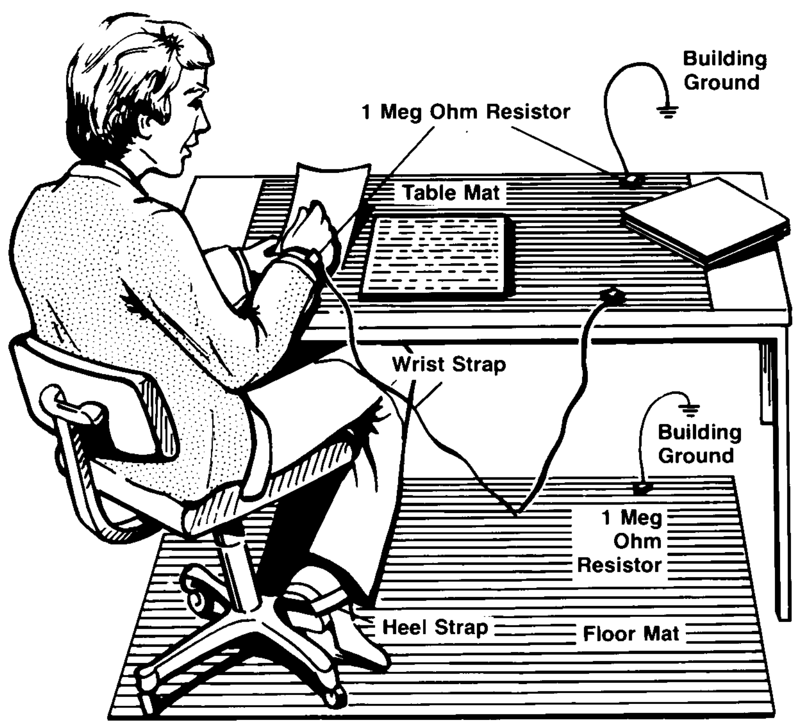


Figure 1-5. Static-safe Work Station

Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone. To ensure user safety, the static-safe accessories must provide at least 1 MΩ of isolation from ground. Purchase acceptable ESD accessories from your local supplier.

WARNING

These techniques for a static-safe work station should not be used when working on circuitry with a voltage potential greater than 500 volts.

2

Configuring the Workbook

Introduction

Open the *86100CU-400 PLL and Jitter Spectrum Measurement Application* workbook (86100C_400_A.01.00.xls). Notice that the Setup worksheet is displayed as shown in Figure 2-1. This chapter shows you how to configure this worksheet for instrument communications and measurements. Because running a compliance-specific workbook, overwrites the configuration settings in this workbook to known standards, always click **Save Setups** to save your entries.

Refer to “To Configure the Workbook Application” on page 2-3 for a step-by-step procedure on configuring the communication settings. To learn about configuring the measurement settings, refer to “Reference of Setup Entries” on page 2-5. For most measurement needs, you can use the default values until you learn more about the individual settings and measurements. To learn how to make measurements, refer to Chapter 3, “Making Measurements”.

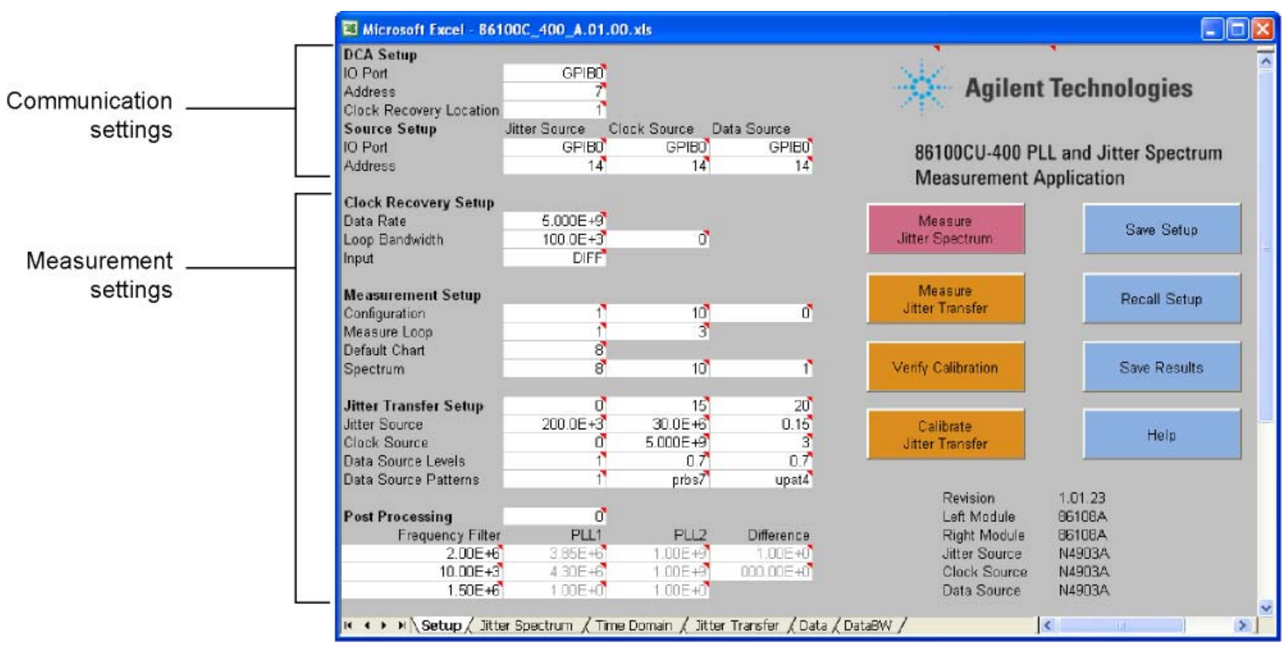
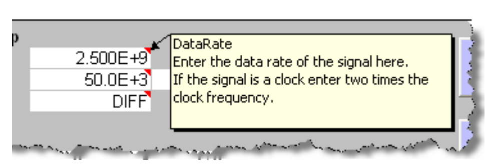


Figure 2-1. Workbook’s Setup Worksheet

A red triangle in the corner of an entry field indicates the presence of a comment. Comments provide information on the purpose of the field. Place the cursor over the cell to enable the comment; do not click the mouse.



To Configure the Workbook Application

Use the following steps to quickly setup the workbook application for measurements. For more detailed information on all of the entries in the Setup tab, refer to "Reference of Setup Entries" on page 2-5. After completing this procedure, refer to "To Make a Jitter Spectrum and Phase Noise Measurement" on page 3-5 to learn how to perfom a measurement.

1 Open the workbook, and click the Setup worksheet tab.

2 In the **DCA Setup** area, locate the **IO Port** field.

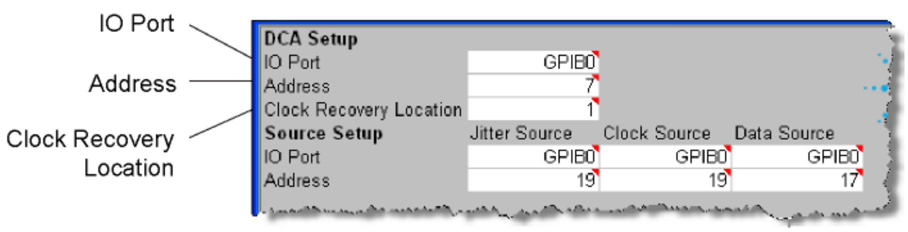


Figure 2-2. DCA Setup Area

3 If you are using GPIB, enter the GPIB port number. For example, enter GPIB0. If using a LAN, enter the 86100C host name. For example, TCPIP0.

4 In the **Address** field, enter the GPIB address of the 86100C if you are using GPIB. For example, enter 7. If using a LAN, enter the 86100C host name. For example, TCPIP0::10.0.0.5::gpib0,7::INSTR.

5 In the **Clock Recovery Location** field, enter the location of the clock recovery module in the 86100C mainframe. For 83496B modules, enter 1 if the module is in the left slot and enter 3 if the module is in the right slot. For 86108A modules, enter 1.

6 In the **Source Setup** area, locate the **IO Port** field. The Source Setup area includes entries for the Jitter Source, Clock Source, and Data Source.

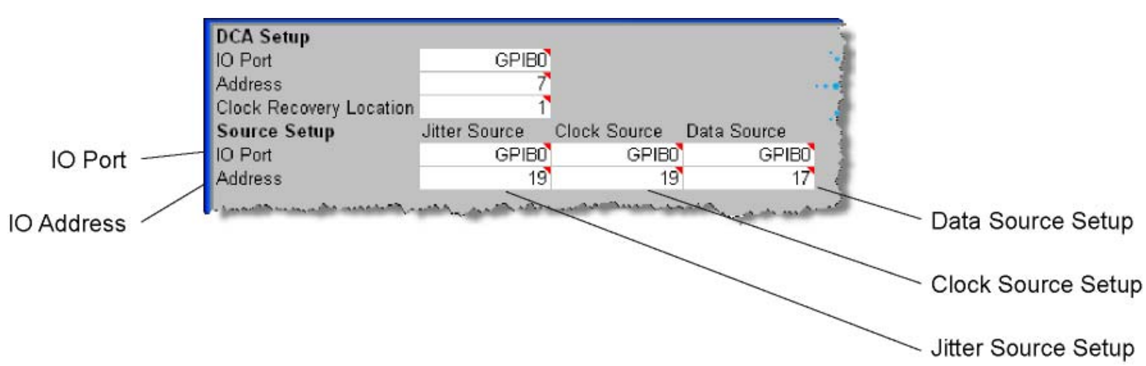


Figure 2-3. Source Setup Area

7 For each instrument type field, enter the GPIB port number or LAN host name.

8 In the **Address** fields for each instrument type, enter the GPIB address or LAN host name. Depending on the test equipment that you use, these fields may represent the same instrument.

9 In the **Clock Recovery Setup** area, locate the **Data Rate** field, enter the signal's data rate. For example, 10.000E+9 for 10 Gb/s. If the signal is a clock, enter two times the clock frequency.

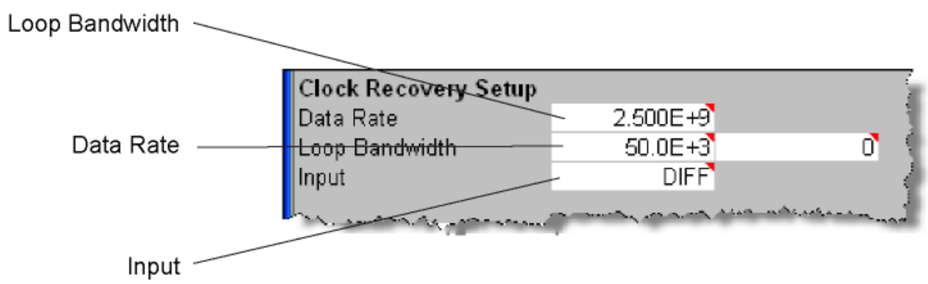


Figure 2-4. Clock Recovery Setup Area

10 In the **Loop Bandwidth** field, enter the desired loop bandwidth setting for the clock recovery module. For example, 8.0E+6 (8.0 MHz). For best sensitivity use the lowest loop bandwidth setting that maintains lock with your signal.

11 In the **Input** field, enter one of the following strings to specify the input signal type at the clock recovery input.

Signal Type	Entry String
Data input:	ELEC
$\overline{\text{Data}}$ input:	EINV
Differential input:	DIFF
Optical input (if supported):	OPT

Reference of Setup Entries

This section describes each setup entry field. When using the application, move the cursor over the red triangle on each field to view a ToolTip.

DCA and Source Setup

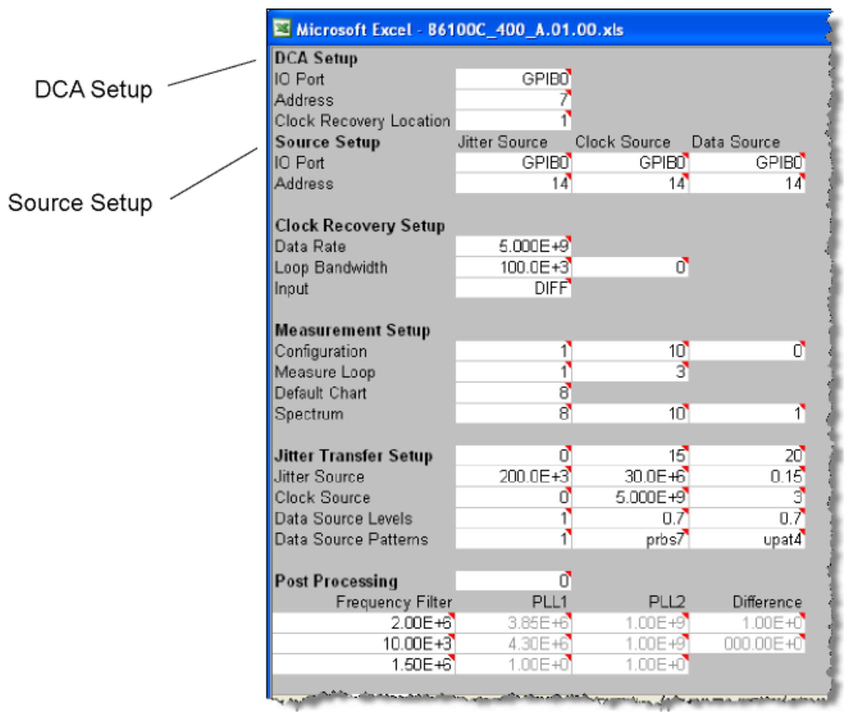


Figure 2-5. GPIB Setup Area

DCASystem

IO Port. If using GPIB, enter GPIBx where x is the address of the port where the 86100C is located. For example, enter GPIB0. If using a LAN, enter the TCPIPx where x. For example, TCPIP0.

Address. If using GPIB, enter the GPIB address of the 86100C. For example, enter 7. If using a LAN, enter the 86100C host name.

Clock Recovery Location. Enter an 86100C module slot designation if two clock recovery modules are used. If only on clock recovery module is installed, the application can automatically locate the module. When using two clock recovery modules, enter 1 if the module that you want to use is installed in the left slot and enter 3 if the module is located in the right slot.

Source Setup

Enter the **IO Port** and **Address** for the Jitter, Clock, and Data Source instruments. For the **IO Port**, when using GPIB, enter GPIBx where x is the address of the port where the 86100C is located. For example, enter GPIB0. If using a LAN, enter the TCPIPx where x. For example, TCPIP0.

For the **Address**, when using GPIB, enter the GPIB address of the 86100C. For example, enter 7. If using a LAN, enter the 86100C host name.

Clock Recovery Setup

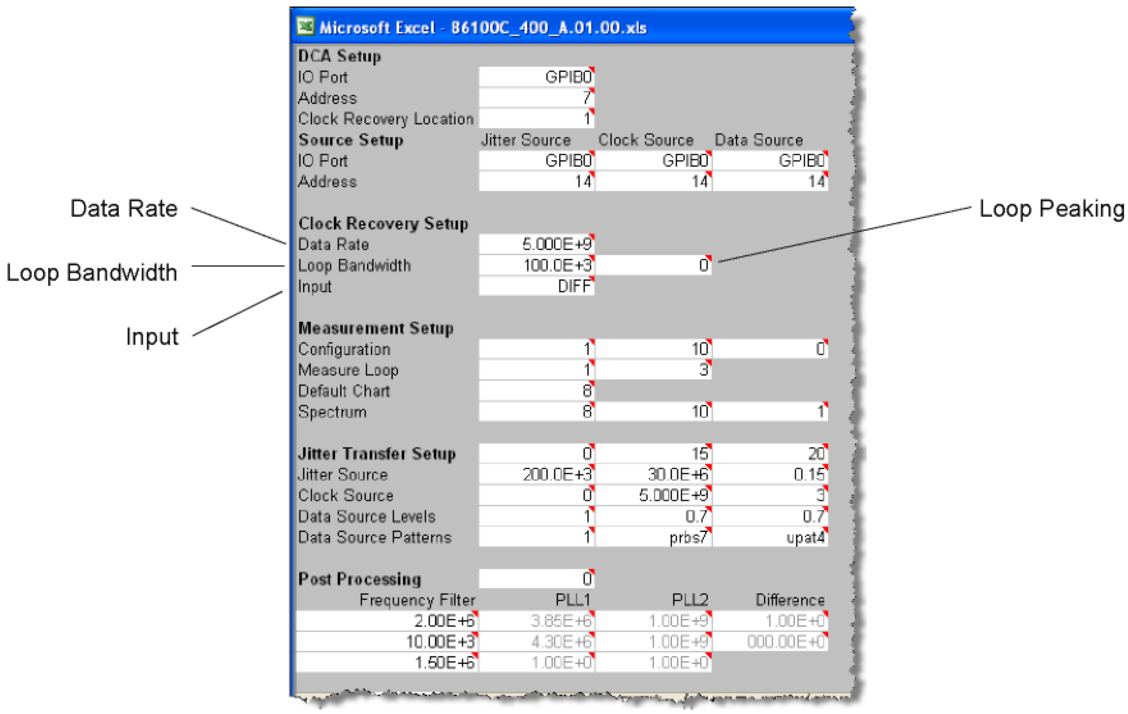


Figure 2-6. Clock Recovery Setup Area

Data Rate

Enter the signal's data rate. For example, 10.000E+9 for 10 Gb/s. When measuring a clock, the clock-recovery modules regard the clock as a data signal. A clock signal with a 101010 data pattern is perceived to have a rate that is double the clock rate. So, for clock signals, always enter a data rate that is twice the clock rate. For example, for a typical 100 MHz PCI Express reference clock, enter 200 Mb/s. As a result, the measurable range of clock frequencies is half the range of measurable data rates. For example, when using an 83496B Option 200 (data rate range of 50 Mb/s to 13.5 Gb/s), the effective clock rate range that can be tested is 25 MHz to 6.75 GHz.

Loop Bandwidth

Enter the desired loop bandwidth setting for the clock recovery module. For example, 8.0E+6. For best sensitivity when making jitter spectrum or PLL/jitter transfer measurements, use the lowest loop bandwidth setting that maintains lock with your signal.

Loop Peaking

Selects PPL loop 1 through 4 for peaking. The availability of the following settings depends upon the loop bandwidth setting.

Selected Loop Peaking	Entry Value
Automatic (default):	0
Loop 1:	1
Loop 2:	2
Loop 3:	3
Loop 4:	4

Input

Enter one of the following strings to specify the input signal type at the clock recovery input.

Signal Type	Entry Value
Data input:	ELEC
$\overline{\text{Data}}$ input:	EINV
Differential input (default):	DIFF
Optical input (if supported):	OPT

Measurement Setup

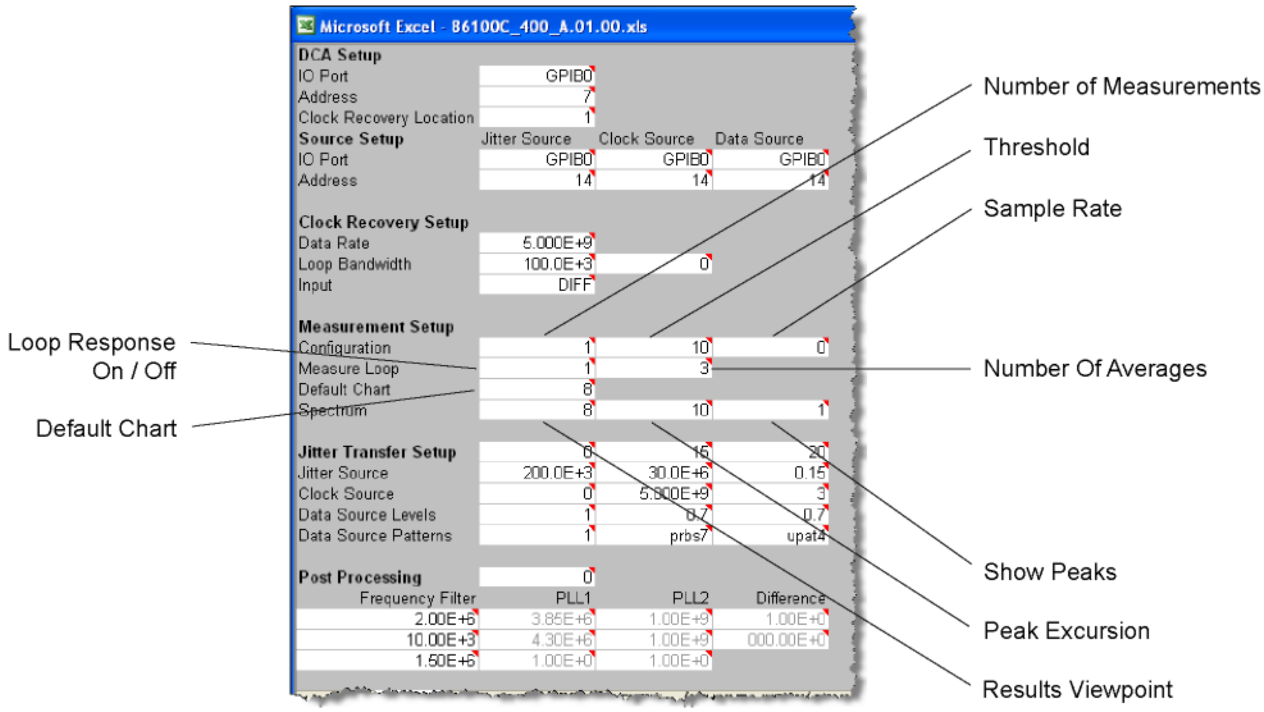


Figure 2-7. Measurement Setup Area

Configuration

Number of Measurements. Sets the maximum number of jitter spectrum measurements the system makes before processing and displaying the averaged result for all acquisitions. This is similar to setting the averaging factor for general oscilloscope waveform acquisition. The default setting is 1. The maximum value is 32767.

Threshold. Sets the measurement threshold value. For for single measurements, enter zero (0). This allows control of when data is saved and displayed. This parameter is based on the magnitude of the phase error at the output of the 83496B phase detector. When the magnitude of the error signal exceeds threshold value multiplied by the standard deviation of the error signal, the system will stop acquiring data and display the results. Thus the threshold value can stop acquisition prior to when the **Number of Measurements** setting has been achieved. If the threshold value is never observed, the measurement will stop when the **Number of Measurements** has been met. When set to 0, each phase measurement will be recorded. For information on using this feature to capture a phase transient or glitch, refer to “Capturing Transients” on page 3-20.

Sample Rate. Selects the sample rate of the internal acquisition system. Selecting 40 Ms/s enables measurement of the highest frequency jitter spectrum and phase noise possible (3 kHz to 20 MHz offset). Selecting 4 Ms/s enables measuring as close to the carrier as possible (300 Hz to 2 MHz offset).

Sample Rate Selection	Field Value
83496B	
40 Ms/s (default)	0
4 Ms/s	64
86108A	
52.5 Ms/s (default)	0
6.6 Ms/s	64

Measure Loop

Loop Response On/Off. Controls whether or not the loop response of the clock recovery module, having been locked to the signal being evaluated, is measured. When selected on (default setting), the loop response is measured allowing the system to provide accurate results via loop-response compensation and to display the dataBW worksheet as described in "dataBW Worksheet" on page 3-18. Enter 0 if you're making multiple measurements on a specific signal such that relocking is not required; earlier loop response measurements will be valid and the loop response need not be re-measured. If the data rate changes or the pattern of a data signal changes, the loop response should be remeasured.

Measurement of the Loop Response	Field Value
Off	0
On (default)	1

CAUTION

Avoid turning the Loop Response On/Off setting to off. This feature is intended for experienced, knowledgeable users only and could result in inaccurate measurements.

Number of Averages. Sets the number of measurements that are taken in the characterization of the loop bandwidth of the clock-recovery module and is generally not altered by the user. Note that this does not control how many measurements are acquired on the test signal (achieved with the **Number of Measurements** parameter) and is only used as part of the test system characterization.

Default Chart

Specifies which of three charts is displayed the result data. You can always display the remaining two charts by clicking on the appropriate Worksheet tab.

Selection	Field Value
Time Chart	5
Histogram Chart	6
Jitter Spectrum Chart (default)	8

Spectrum

Results Viewpoint. You can select to display results from different points-of-view including the signal at the input to the clock recovery module (setting 15), the signal observed after passing through the PLL post processing function (setting 12), or the phase error observed at the output of the clock-recovery module's phase detector (setting 3). For more information on the setting 12, refer to "Post Processing" on page 2-14.

Selection	Field Value
Phase Error	3
Input Spectrum (default)	8
Post Processed (Post processing must be turned on)	12

Peak Excursion. Peak excursion is the ratio of the signal amplitude to the local noise floor. The default value for this setting is 10. The peak-excursion value sets the minimum ratio of the signal-to-noise floor to receive a marker. When the value is large, only very prominent spectral lines will be marked.

Show Peak Markers. This entry allows you to display or hide peak markers on the Jitter Spectrum Chart. Enter 1 (the default setting) to show markers on the peaks. Enter 0 to hide the markers. Use the **Peak Excursion** setting to define the level needed to identify a peak.

When periodic jitter is present, the jitter spectrum and phase noise charts may contain spectral lines, which can become cluttered by the presense of markers. Use the **Peak Excursion** and **Show Peak Markers** to reduce marker clutter on the chart. The show peaks enables or disables the placement of markers.

With **Show Peak Markers** on, you can determine the actual energy for these periodic tones. Simply place the computer's cursor over a marker to display the signal level. In the jitter spectrum chart, spectral tones are displayed in seconds-versus-frequency. The marker will read out the jitter magnitude in seconds rms. The marker function will display the signal's center-of-mass, which may be composed of multiple trace points. In the phase noise display, energy is displayed as the signal power normalized to a 1 Hz bandwidth relative to the carrier power. While this is useful for a noise spectrum, it can be problematic for spectral tones. Trace markers are designed to show the total signal power of the tone relative to the carrier, without being normalized to a 1 Hz bandwidth. This is similar to how periodic modulation is displayed on a spectrum analyzer. Thus the peak markers will be located at the x-axis position of the tone, but will be placed several dB higher than the trace peak position. The marker readout is thus a dBc value rather than a dBc/Hz value.

- To setup averaging in the frequency domain, refer to “Averaging the Measurement in the Frequency Domain” on page 3-22.
- To capture transients, refer to “Capturing Transients” on page 3-20.

Jitter Transfer Setup

After the measurement is run, the Jitter Transfer and dataJTF worksheets are displayed.

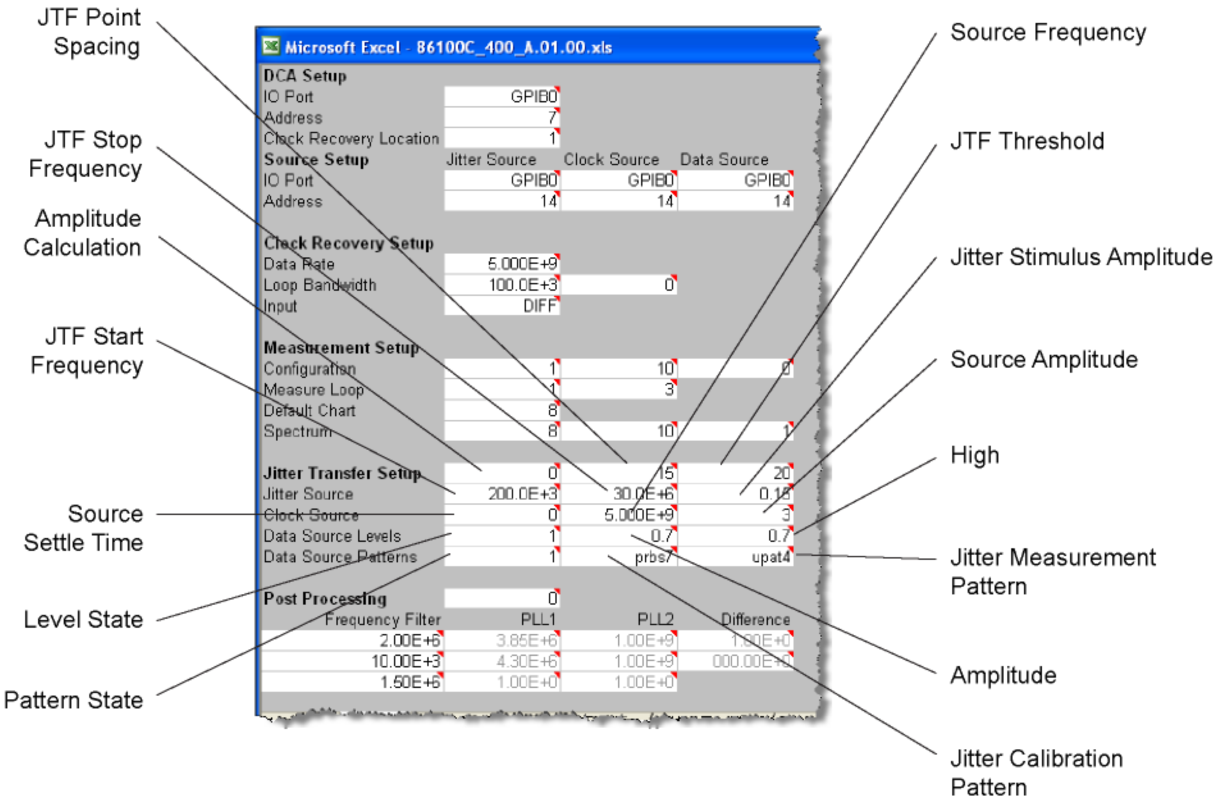


Figure 2-8. Jitter Transfer Setup Area

Amplitude Calculation. This field determines how the amplitude values are calculated. Custom frequency-amplitude pairs are used by some measurements, such as SONET/SDH jitter transfer measurements.

Calculated Amplitude List Type	Field Value
Constant amplitude level (default)	0
Custom frequency-amplitude pairs	1

JTF Point Spacing. Sets the number of points-per-decade used in the jitter transfer measurement. The default value is 15.

JTF Threshold. This threshold value is the ratio of the measured jitter during jitter transfer to the measured jitter spectrum at the jitter transfer frequency. By using the measured jitter spectrum information, the measurement skips points where incorrect results may occur due to periodic jitter inherent to the device under test. The default ratio is 20.

Jitter Source

JTF Start Frequency. Enter the start frequency for the jitter transfer measurement.

JTF Stop Frequency. Enter the stop frequency for the jitter transfer measurement.

NOTE

Be sure to enter a start or stop frequency that is within the range of the jitter source. Entering frequencies beyond the range of the jitter source results in innacurate measurements.

Jitter Stimulus Amplitude. Enter the amplitude of the jitter transfer stimulus. For the N4903A (J-BERT), this sets the peak-to-peak jitter in UI (unit intervals). For the 33250, it sets the level in peak-to-peak volts.

Clock Source

Source Settle Time. Enter the wait time in seconds for source to settle before the measurement is made. This allows the device-under-test to acquire lock.

Source Frequency. Enter the desired clock source frequency in Hz.

Source Amplitude. When using a separate clock source, enter the desired clock source amplitude in dBm.

Data Source Levels

Level State. Enter 1 to control the amplitude and level of highs of the data source. This is the default setting. Enter 0 to prevent selecting of levels in the data source.

Amplitude. Sets the amplitude of the data source.

High. Sets the high level of the data source.

Data Source Patterns

Pattern State. Enter 1 to control the patterns of the data source. This is the default setting. Enter 0 to prevent the selection of patterns in the data source.

Jitter Calibration Pattern. Enter the name of the pattern in the data source instrument that will be used during the calibration of the jitter transfer measurement.

Jitter Measurement Pattern. Enter the name of the pattern in the data source instrument that will be used during the measurement.

Post Processing

The Post Processing fields controls algorithms that are applied to the measurement results which can emmulate system behavior. The **Low-Pass Filter Cutoff**, **Frequency 1**, and **Frequency 2** entries shown in Figure 2-10 always effect the measurement results regardless of the state of the post-processing on and off setting. These setting effect jitter spectrum and phase noise measurements. When post-processing is turned off, notice that the remaining fields are turned gray.

Post processing also allows you to pass the measured spectrum into a software model. The measured jitter is filtered to determine the relevence of the spectral content at the system level. The processing employs a virtual network composed of two PLL's and a transport delay that is user definable. This configuration accomodates filter functions from a clock recovery all the way to a complex two-path filter function as specified in PCIexpress. For example, you could model the the post processing that is used for PCI Express reference clock. This is accomplished through use of a virtual network that implements the PCI-Express difference function. This function is designed to assess the impact of the jitter of a signal as it would be seen by a receiver. You define the network using two third-order PLLs, a transport delay, and a high-pass filter. Since the PCI-Express system uses a distributed clock, there will be a delay term altering the phase of the receiver clock relative to the phase of the clock used at the transmitter. Also, the PPL bandwidths of the transmitter and the receiver will not be identical. When post processing is used, Histogram measurement result worksheet is displayed. Refer to "Histogram Worksheet" on page 3-16.

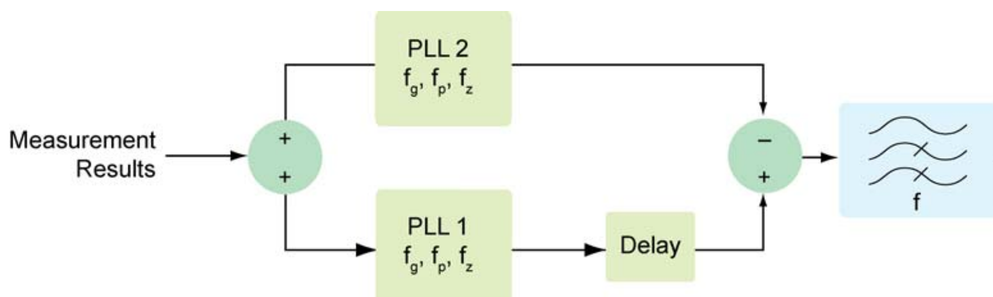


Figure 2-9. Post Processing Block Diagram

You enable the post-processing software model by setting the **On / Off Setting** to 1 (on). When enabled, the software model is applied to the following measurements:

- Jitter spectrum
- Phase Noise spectrum
- Jitter versus time
- Frequency versus time
- Jitter histogram (note that the jitter histogram is only available when post processing is enabled)

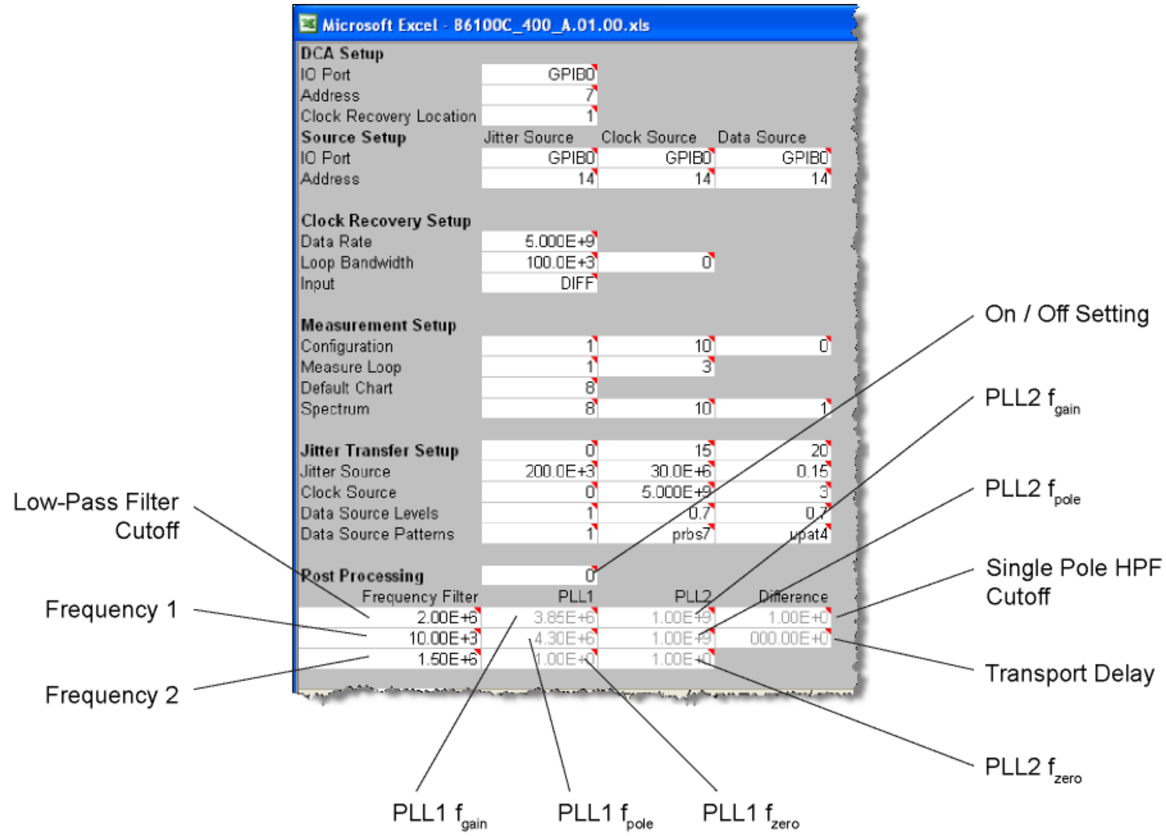


Figure 2-10. Post Processing Setup Area

Post Processing On/Off

Turns post processing on or off. Enter 1 to enable post processing. Enter 0 to disable post processing.

Low-Pass Filter Cutoff

Low-pass filter cutoff frequency for jitter-versus-time chart. Refer to “Time Domain Worksheet” on page 3-13.

Frequency 1 and 2

These entries establish the frequencies for jitter integration. Frequency 1 is the low end limit and its default value is 10 kHz. Frequency 2 is the high end limit and its default value is 1.5 MHz. This frequency band is applied to jitter spectrum and phase noise measurements even when post processing is turned off. The allowable range of the frequency values is from 300 Hz to 2 MHz (when the sample rate is 40 MS/s) or 3 kHz to 20 MHz (when the sample rate is set to 40 MS/s.

Random jitter is determined through integration of the jitter spectrum, with the spectral tones removed, over three different bandwidths. The first is from the first filter frequency to the maximum frequency of the measurement (either 2 MHz or 20 MHz, depending on the sample rate setting). The second bandwidth is from second filter frequency to the maximum frequency. The third bandwidth is the frequency range between the two filter settings.

PLL1/2 f_{gain}, f_{pole}, and f_{zero}

These entries describe two third-order PLL models each with a gain term (f_{gain}) which is the frequency at which the PLL has unity gain), a pole frequency (f_{pole}), and a zero frequency (f_{zero}). All values should be entered in Hertz.

The PLLs can be defined as second order rather than third order. To create a second order PLL, the pole frequency (f_{pole}) for each PLL can be set to a large value, such as 1 GHz). To determine the gain and zero frequency entries from natural frequency and damping factor, the following equations are used:

$$\textit{gain frequency} = \textit{natural frequency} \times \textit{damping factor} \times 2$$

$$\textit{zero frequency} = \frac{\textit{natural frequency}}{2 \times \textit{damping factor}}$$

Single Pole HPF Cutoff and Transport Delay

The difference function is defined by a high-pass filter frequency (Hz) and a time difference accounting for the transport delay between the two PLLs in seconds. As shown in Figure 2-9, the transport delay is added to PLL1.

Default Settings

DCA Setup

IO Port . . . GPIB0
Address . . . 7
Clock Recovery Location . . . 3

Source Setup

Jitter Source
- IO Port. . . GPIB0
- Address. . . 14

Clock Source
- IO Port. . . GPIB0
- Address. . . 14

Data Source
- IO Port. . . GPIB0
- Address. . . 14

Clock Recovery Setup

Data Rate (bits/second). . . 5.000E+9
Loop Bandwidth (Hertz) . . . 100.0E+3
Loop Peaking . . . 0 (automatic selection)
Input. . . DIFF (differential input)

Measurement Setup

Configuration
- Number of Measurements . . . 1
- Threshold . . . 10
- Sample Rate . . . 0 (40 Ms/s rate for 83496B or 52.5 Ms/s for 86108A)

Measure Loop
- Loop Response On/Off . . . 1 (on)
- Number of Averages . . . 3

Default Chart . . . 8 (jitter spectrum chart)

Spectrum
- Results Viewpoint . . . 8 (input spectrum)
- Peak Excursion . . . 10
- Show Peak Markers . . . 1 (show)

Jitter Transfer Setup

Amplitude Calculation . . . 0
Point Spacing. . . 15
Threshold . . . 20

Jitter Source
- Start Frequency (Hertz). . . 200.0E+3
- Stop Frequency (Hertz) . . . 30.0E+6
- Jitter Stimulus Amplitude (UI or Vp-p). . . 0.15

Clock Source
- Source Settle Time (seconds). . . 0.2
- Frequency (Hertz) . . . 5.000E+9
- Amplitude (dBm). . . 3

Data Source Levels
- Level State . . . 1 (set)
- Amplitude (mV). . . 0.7
- High Level (mV). . . 0.7

Data Source Patterns
- State . . . . . 1 (on)
- Pattern for Calibration prbs7
- Pattern for Measurement upat2

Post Processing

Post Processing On/Off . . . . . 0 (off)
Low-Pass Filter Cutoff . . . . . 2 MHz
Frequency 1 . . . . . 10 kHz
Frequency 2 . . . . . 1.5 MHz
PLL1 f_{gain} . . . . . 3.85 MHz
PLL1 f_{pole} . . . . . 4.30 MHz
PLL1 f_{zero} . . . . . 1.00 Hz
PLL2 f_{gain} . . . . . 1.00 GHz
PLL2 f_{pole} . . . . . 1.00 GHz
PLL2 f_{zero} . . . . . 1.00 Hz
Single Pole HPF Cutoff . . . . . 1.00 Hz
Transport Delay 0s

3

Making Measurements

Introduction

This chapter shows you how to make measurements using the workbook. After the measurements are made, you can view the measurement tables and charts in the worksheets as described in "Viewing the Measurement Results" on page 3-10. When the spreadsheet performs a measurement, the 86100C is in remote mode and will not respond to front-panel control unless you press the 86100C's front-panel LOCAL key.

NOTE The instructions in this book assume that you know how to use the 86100C and can lock the trigger on the signal. If not, refer to the 86100C online help.

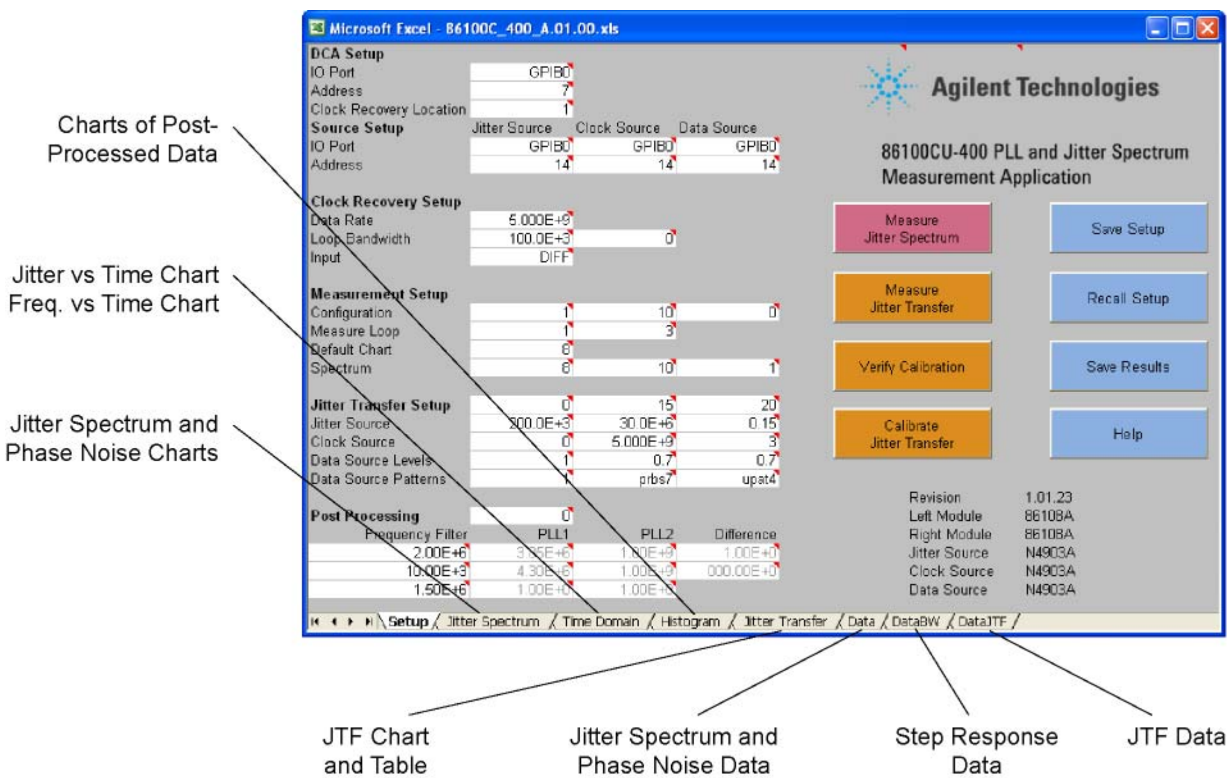
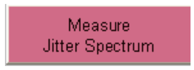


Figure 3-1. Measurement Result Worksheets

Jitter Spectrum Measurement

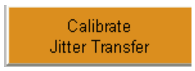


Click to initiate a jitter spectrum and phase noise measurement on your device-under-test. Refer to “To Make a Jitter Spectrum and Phase Noise Measurement” on page 3-5.

Jitter Transfer Measurement

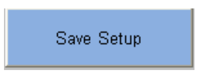
Click to measure the Jitter Transfer Function (JTF) using your device-under-test. A calibration should be performed using the Calibrate Jitter Transfer button before making the measurement. Refer to “To Make a Jitter Transfer Function Measurement” on page 3-7.

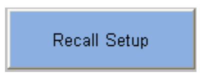
Click to view the calibration data for a JTF measurement. This is used to confirm that the calibration data is valid.



Use this feature to calibrate a JTF measurement. Connect the source directly to the 86100C without the DUT and then click this button. After the calibration, connect the device-under-test in the test setup and then click Measure Jitter Transfer.

Setup and Results

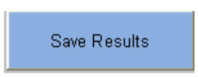




Click to save and recall all of your configuration settings to a spreadsheet file. The settings file is saved in the following default sub-folder:

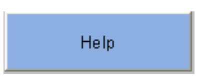
...*workbook folder*\Measurement Setups

You can always return the workbook application to its original configuration settings by recalling the default.xls file.



Click to save your measurement results as a separate smaller workbook that includes the charts but does not include the supporting spreadsheet information. If you need to save the data as well, click **File** > **Save As** to save the entire workbook. The settings file is saved in the following default sub-folder:

...*workbook folder*\Measurement Results



Click to view the user’s guide (this book) in PDF format.

Clock Recovery Inputs

Consider the following when connecting the DUT’s output signal to the appropriate clock recovery input on the 86100C:

- For single ended electrical signals, connect the signal to the DATA+, DATA– inputs on the 83496B module or the CDR+, or CDR– inputs on the 86108A module.
- For differential electrical signals, connect both DATA+ and DATA– inputs on the 83496B. Or, the CDR+ and CDR– inputs on the 86108A.
- For single-mode optical signals (1250 nm to 1620 nm), use 9/125 µm input fiber. Optical signals require an 83496B.
- For multimode optical signals (780 nm to 1330 nm), use 62.5/125 µm input fiber. Optical signals require an 83496B.

Clock Signals

When measuring a clock, the clock-recovery modules regard the clock as a data signal. A clock signal with a 101010 data pattern is perceived to have a rate that is double the clock rate. So, for clock signals, always enter a data rate that is twice the clock rate. For example, for a typical 100 MHz PCI Express reference clock, enter 200 Mb/s. As a result, the measurable range of clock frequencies is half the range of measurable data rates. For example, when using an 83496B Option 200 (data rate range of 50 Mb/s to 13.5 Gb/s), the effective clock rate range that can be tested is 25 MHz to 6.75 GHz.

Inability to Lock

Loop Bandwidth. When setting the loop bandwidth, enter the minimum value, since the narrowest loop bandwidth setting results in the lowest noise. If you enter 1 kHz the 86100C automatically selects the narrowest loop bandwidth setting available at the data rate you have chosen. If the 86100C fails to lock to the input signal, increase the loop bandwidth setting. If lock still fails, enter the maximum loop bandwidth setting for the data rate . Enter 10 MHz and the 86100C automatically selects the widest loop bandwidth setting available at the data rate. If lock is established, reduce the loop bandwidth until lock occurs at the narrowest loop bandwidth setting possible. If lock still fails, the problem is likely independent of the loop bandwidth.

Injected Step Function. The spreadsheet application injects a step function into the loop in order to characterize its own loop dynamics. It is possible that in some circumstances injecting that small step can cause the loop to fall out of lock. If that happens, increasing the loop bandwidth by 10% should correct the problem.

To Make a Jitter Spectrum and Phase Noise Measurement

The default frequency band for the measurement is between 10 kHz and 1.5 MHz. To change this range, refer to “Frequency 1 and 2” on page 2-15. view the Setup worksheet and enter new Frequency 1 and Frequency 2 values . Post processing does not need to be enabled as these values are always used when measuring jitter spectrum and phase noise.

1 Connect the device-under-test (DUT) to the 86100C as shown in Figure 3-2. A source is not used. Connect the DUT’s output signal to the appropriate on the 86100C clock recovery input as described “Clock Recovery Inputs” on page 3-3.

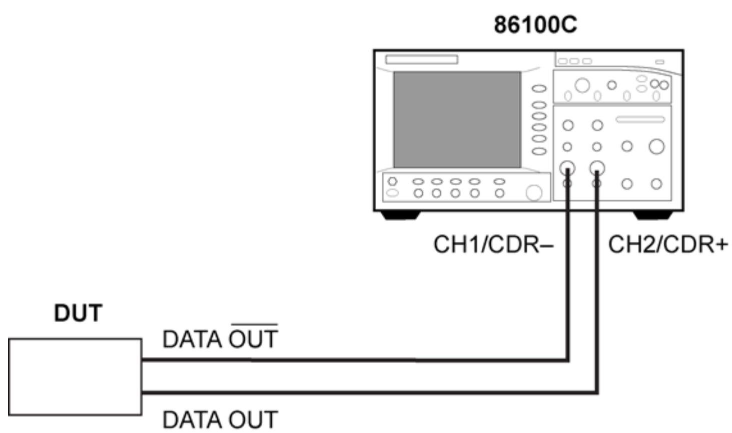


Figure 3-2. Example of Test Equipment Setup with a Differential Electrical Signal

2 Lock the clock recovery of the 86100C on the signal from the DUT using one of two methods:

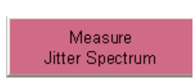
- Lock the clock recovery manually from the 86100C’s front panel.
- Lock the clock recovery from within the workbook. These settings override any manual settings made from the 86100C front panel. In the workbook, view the Setup worksheet and locate the Clock Recovery Setup entry fields: Data Rate, Loop Bandwidth, Input, and Loop Peaking (86108A) fields. The workbook application performs a lock sequence on the test signal when you initiate a measurement. To locally control the 86100C again, you must press the 86100C front-panel LOCAL key.

3 On the 86100C, manually verify the quality of the input signal. Poorly defined waveforms may prevent the ability to measure the signal.

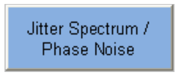
4 Open the workbook, if not already opened.

5 On the Setup worksheet, configure the Measurement Setup fields. Refer to “Measurement Setup” on page 2-9.

6 In the workbook, click the **Measure Jitter Spectrum**button.



7 Open the Jitter Spectrum worksheet and click **Jitter Spectrum / Phase Noise** to view the jitter spectrum and phase noise charts.



8 Open the Time Domain worksheet to view charts showing Jitter-vs-Time and Frequency-vs-Time.

To Make a Jitter Transfer Function Measurement

1 Connect the source instrument directly to the 86100C. Do not connect the DUT at this time. Figure 3-3 shows the connection if you are using an N4903A. If you using separate jitter and data sources, connect the equipment as shown in the example of Figure 3-4. Connect the source's output signal to the appropriate on the 86100C clock recovery input as described in "Clock Recovery Inputs" on page 3-3.

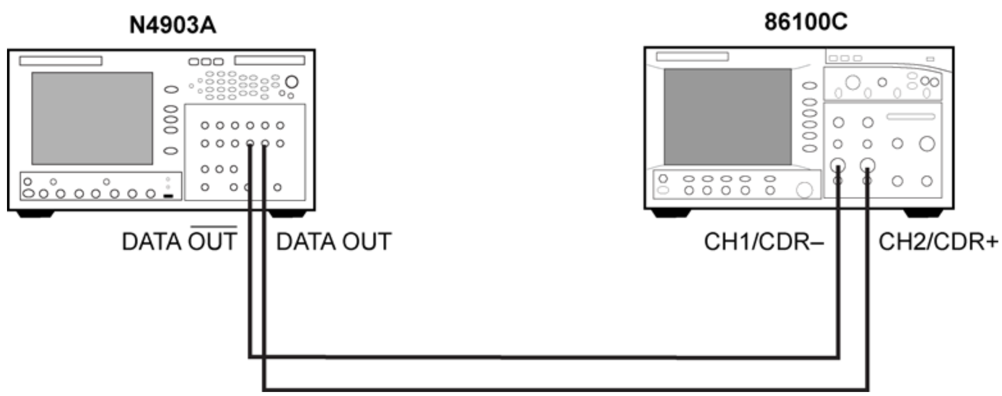


Figure 3-3. N4903A Connected to the 86100C

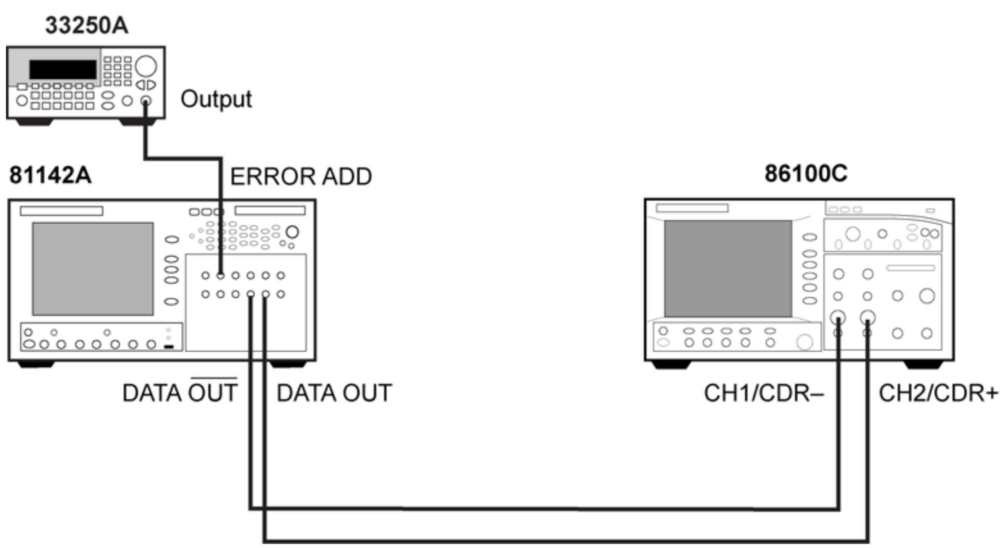


Figure 3-4. Alternate Setup Using Separate Data and Jitter Sources

2 Lock the clock recovery of the 86100C on the signal using one of two methods:

- Lock the clock recovery manually from the 86100C's front panel.
- Lock the clock recovery from within the workbook. These settings override any manual settings made from the 86100C front panel. In the workbook, view the Setup worksheet

and locate the Clock Recovery Setup entry fields: Data Rate, Loop Bandwidth, Input, and Loop Peaking (86108A) fields. The workbook application performs a lock sequence on the test signal when you initiate a measurement or calibration. To locally control the 86100C again, you must press the 86100C front-panel LOCAL key.

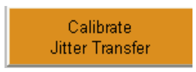
3 On the 86100C, manually verify the quality of the input signal. Poorly defined waveforms may prevent the ability to measure the signal.

4 Open the workbook, if not already opened.

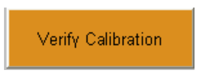
5 On the Setup worksheet, configure the Measurement Setup fields. Refer to “Measurement Setup” on page 2-9.

6 On the Setup worksheet, configure the Jitter Transfer Setup fields. Refer to “Jitter Transfer Setup” on page 2-12.

7 In the workbook, click the **Calibrate Jitter Transfer** button.



8 When the calibration is finished, click **Verify Calibration**. Open the DataJTF worksheet, and confirm that the calibration data is linear indicating that it is valid.



9 Open the Setup worksheet.

10 Connect the DUT in the test setup.

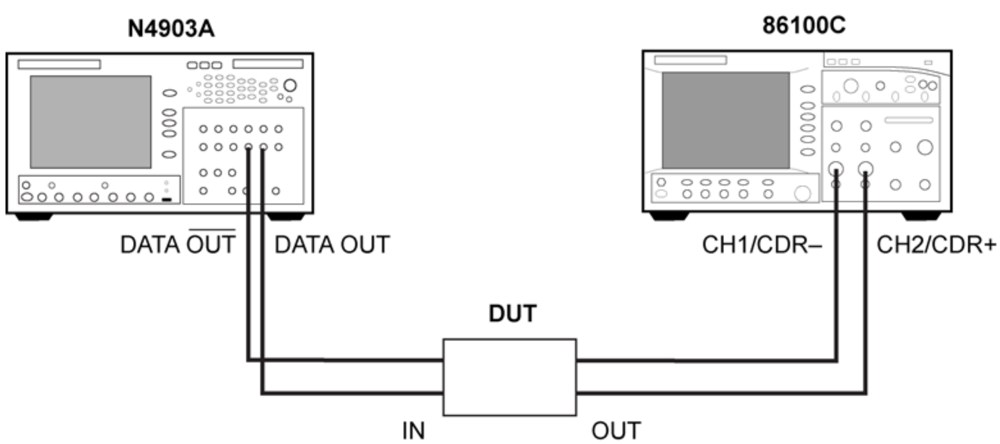
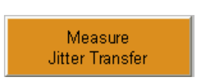


Figure 3-5. Example Equipment Setup with the DUT Connected

11 In the workbook, click **Measure Jitter Transfer**.

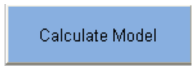


12 Open the Jitter Transfer worksheet to view the measurement results.

NOTE The Jitter Transfer and dataJTF worksheets are not displayed until a JTM measurement is made.

13 Click the **Calculate Model** button. A third-order type-2 PPL model is calculated from the data and displayed in the chart as shown in Figure 3-6 on page 3-9. Notice that the model’s

f_{zero}, f_{gain}, and f_{pole} values are also listed on the chart.



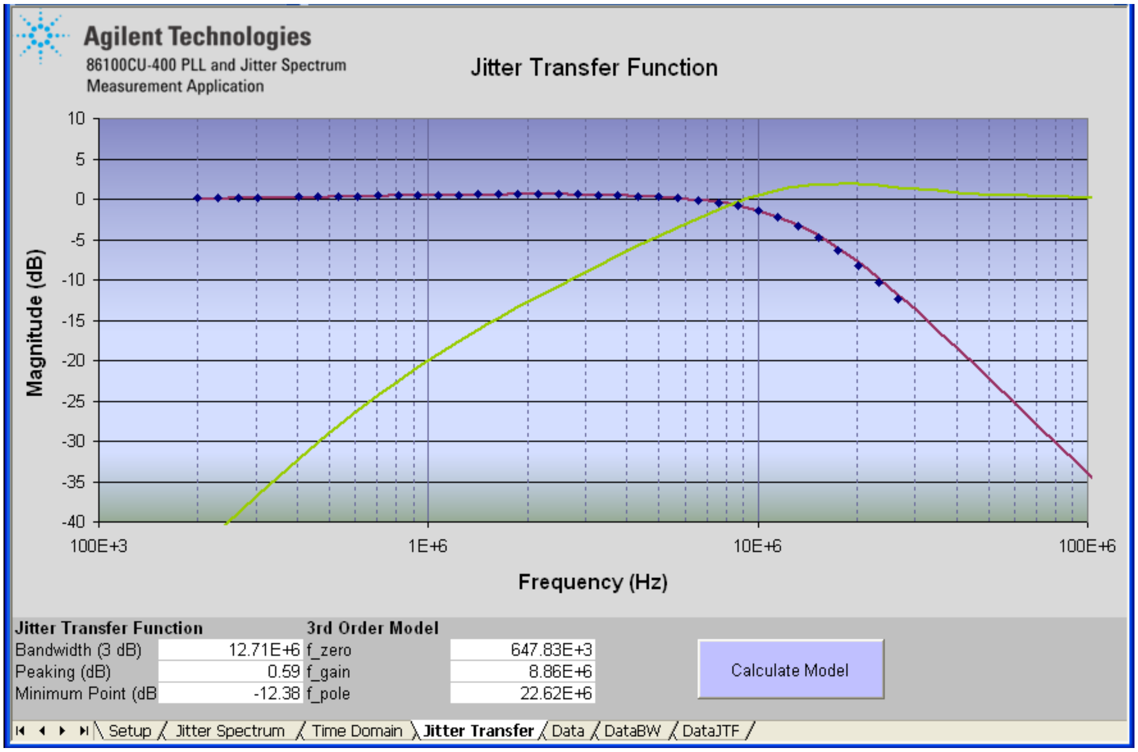


Figure 3-6. JTF Measurement Results

Viewing the Measurement Results

This section describes the worksheets that display the measurement results. Most of the worksheets are always available. However, the following worksheets are displayed based on worksheet settings:

- The Jitter Transfer worksheet is not displayed until a JTM measurement is made as explained in "To Make a Jitter Transfer Function Measurement" on page 3-7.
- The Histogram worksheet is not displayed unless post-processing is activated as explained in "Post Processing" on page 2-14.
- dataBW worksheet is not displayed unless the **Loop Response On/Off** field is switched on as described in "Loop Response On/Off" on page 2-10.

Jitter Spectrum Worksheet

The Jitter Spectrum worksheet displays charts of the input signal's jitter spectrum and phase noise. The jitter spectrum chart shows jitter (in seconds$_{rms}$) versus jitter frequency. The jitter phase noise chart shows jitter power (dBc/Hz) relative to the total signal power (normalized to a 1 Hz bandwidth) versus jitter frequency. Click the displayed Jitter Spectrum / Phase Noise button to switch between viewing the two charts. To configure which chart is shown in the initial view, refer to "Default Chart" on page 2-10.

NOTE If the button is not displayed, click on any spreadsheet cell.

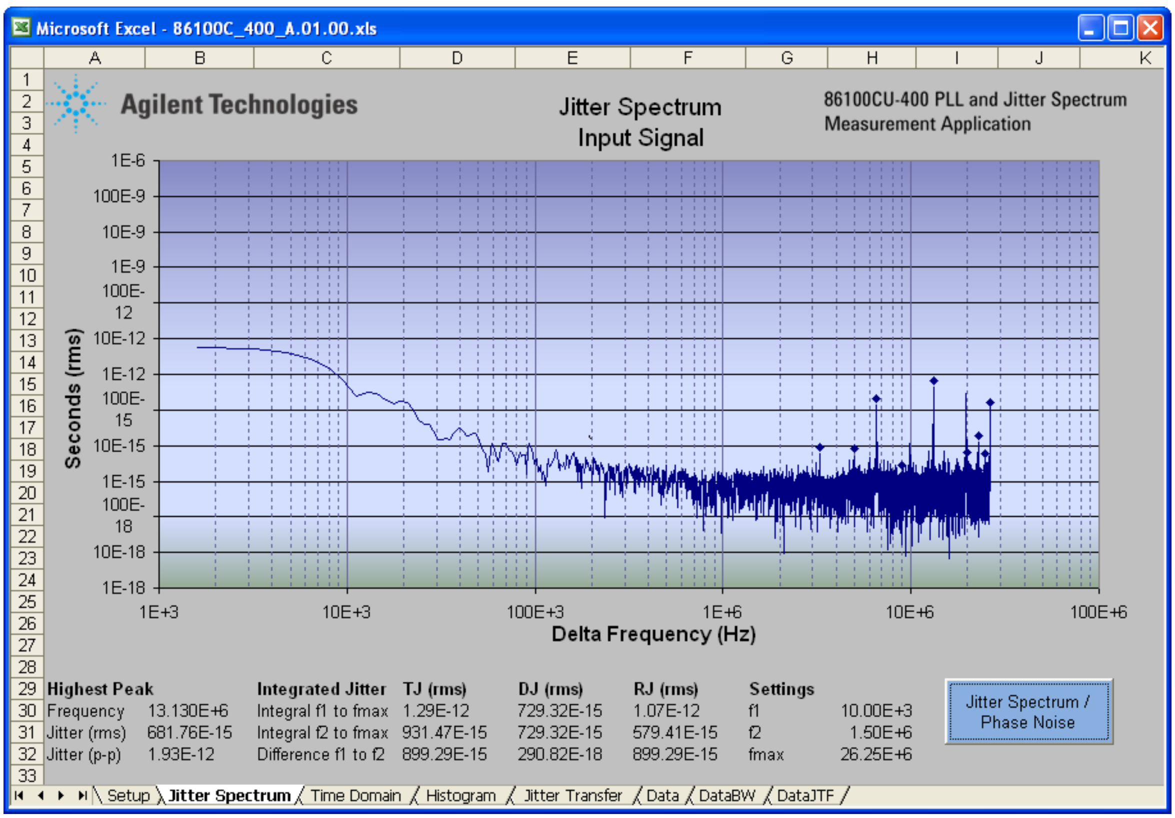


Figure 3-7. Example of the Jitter Spectrum Worksheet

Periodic jitter is displayed as discrete spectral lines. However, there can be spurious spectral lines that are artifacts of the measurement process. At this point in time, the jitter spectrum and phase noise measurement is not synchronized with the data pattern so it is possible that some pattern effects can be seen in the measurement results. When evaluating a data signal composed of an even-length repeating pattern it is possible for a small spike to be present if the difference between the pattern repetition rate (data rate/ pattern length) and a harmonic of the sample rate (4 Mb/s or 40 Mb/s) falls within the frequency measurement window. For odd length repeating patterns two small spikes can occur, one where the difference between the pattern repetition rate and a harmonic of the sample rate falls within the frequency measurement window and another at half that frequency. For example, with the following measurement configuration,

Data Rate: . . . . 9.953 Gb/s
Sample Rate: . . . . 40 MHz
Frequency Measurement Window: . . . . 3 kHz to 20 MHz
Pattern Length: . . . . 127 Bits (odd)
Pattern Repetition Rate: . . . . 78.4 MHz [1]
Pattern Repetition/2: . . . . 39.2 MHz

the following measurement spurs are possible:

Between 80 MHz – 78.4 MHz: . . . . 1.6 MHz
Between 40 MHz – 39.2 MHz: . . . . 800 kHz

Deterministic jitter is determined over similar ranges. It is determined by taking the rms sum of all the spectral peaks of the jitter spectrum. Note that the user has control over the definition of what is determined to be a spectral peak, which can influence this result.

Total jitter is determined by performing an rms integration of the complete spectrum over the integration limits defined by the user.

Random jitter is determined through integration of the jitter spectrum, with the spectral tones removed, over three different bandwidths. The first is from the first filter frequency to the maximum frequency of the measurement (either 2 or 20 MHz, depending on the sample rate setting). The second bandwidth is from second filter frequency to the maximum frequency. The third bandwidth is the frequency range between the two filter settings.

1.78.4 MHz approximately equals 99.953 Gb/s divided by 127 bits.

Time Domain Worksheet

This worksheet displays two charts: Jitter-vs-Time and Frequency-vs-Time.

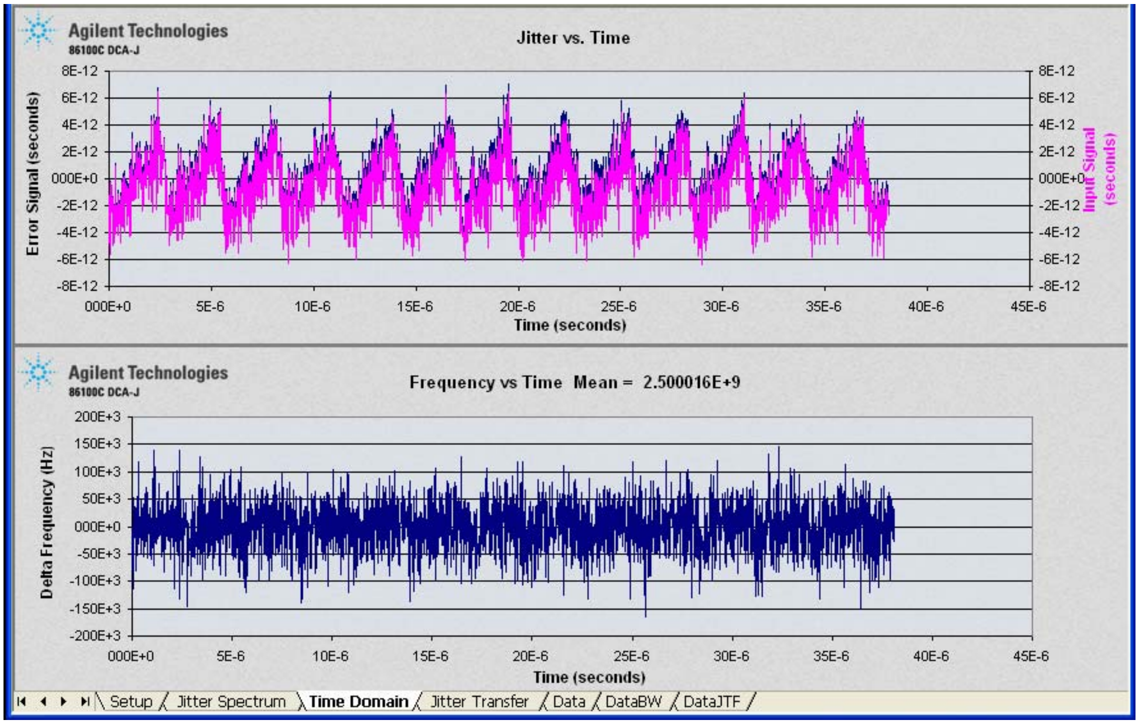


Figure 3-8. Example Time Domain Worksheet

Jitter vs Time Chart

On the chart, the pink trace is the phase modulation seen at the input of the clock-recovery module's phase detector. This plot indicate how the clock-recovery module can track jitter and remove it from a general waveform analysis. Thus the pink input phase error is a measure of the total jitter observed by the clock-recovery module. Since phase is the integral of frequency, if triangle shaped SSC frequency modulation were present, this display would be a parabolic shaped phase deviation. Viewing the input phase in the jitter domain provides an important troubleshooting capability. If phase transients occur, for example when a PLL loses synchronization or exceeds its allowable phase range, the phase glitch can be observed directly in the pink input phase trace.

The blue phase error trace is an indication of the actual signal that the measurement system is observing and the residual jitter not tracked by the clock-recovery module. It is simply an indicator of how hard the clock-recovery module's phase lock loop is working to track the incoming signal. If the input phase and the phase error were similar, it would indicate that the clock-recovery module's phase lock loop is not tracking the input signal. Note that the axes for the input phase error are orders of magnitude larger than the vertical axis for the phase error.

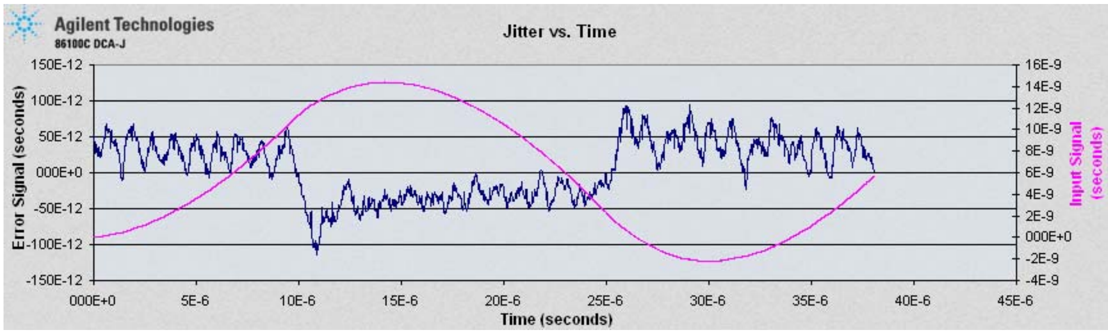


Figure 3-9. Chart Showing Signal with SSC

Frequency vs Time Chart The Frequency vs Time chart is generated by differentiating the measured phase. Since frequency is the derivative of phase and differentiation can sometimes generate artificial noise, you can apply the post-processing low-pass filter to smooth out this effect. Refer to “Single Pole HPF Cutoff and Transport Delay” on page 2-16. The jitter spectrum can be processed to determine random, deterministic, and total jitter. You can define the range of the spectrum to be processed using two filter settings as explained in “Frequency 1 and 2” on page 2-15.

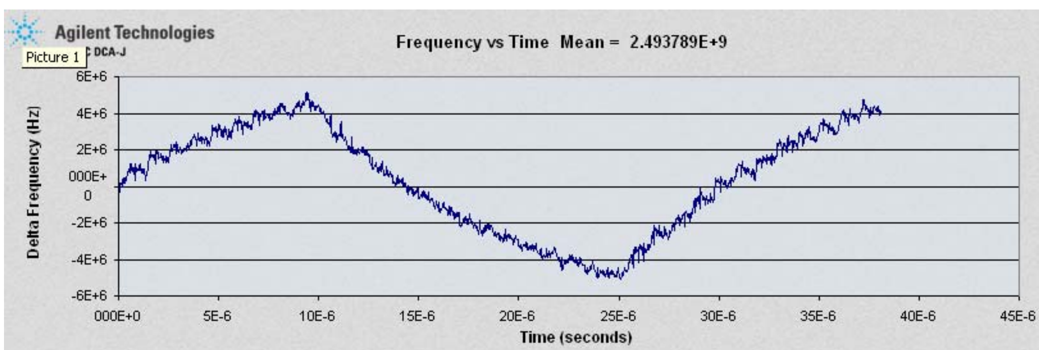


Figure 3-10. Chart Showing Signal with SSC

Jitter Transfer Worksheet

The Jitter Transfer worksheet displays a chart of the jitter transfer function. This worksheet is not displayed until a JTF measurement is made. When the **Calculate Model** button is clicked, a third-order type-2 PPL model is calculated from the data and displayed in the chart as shown in Figure 3-11. Notice that the model's f_{zero}, f_{gain}, and f_{pole} values are also listed on the chart.

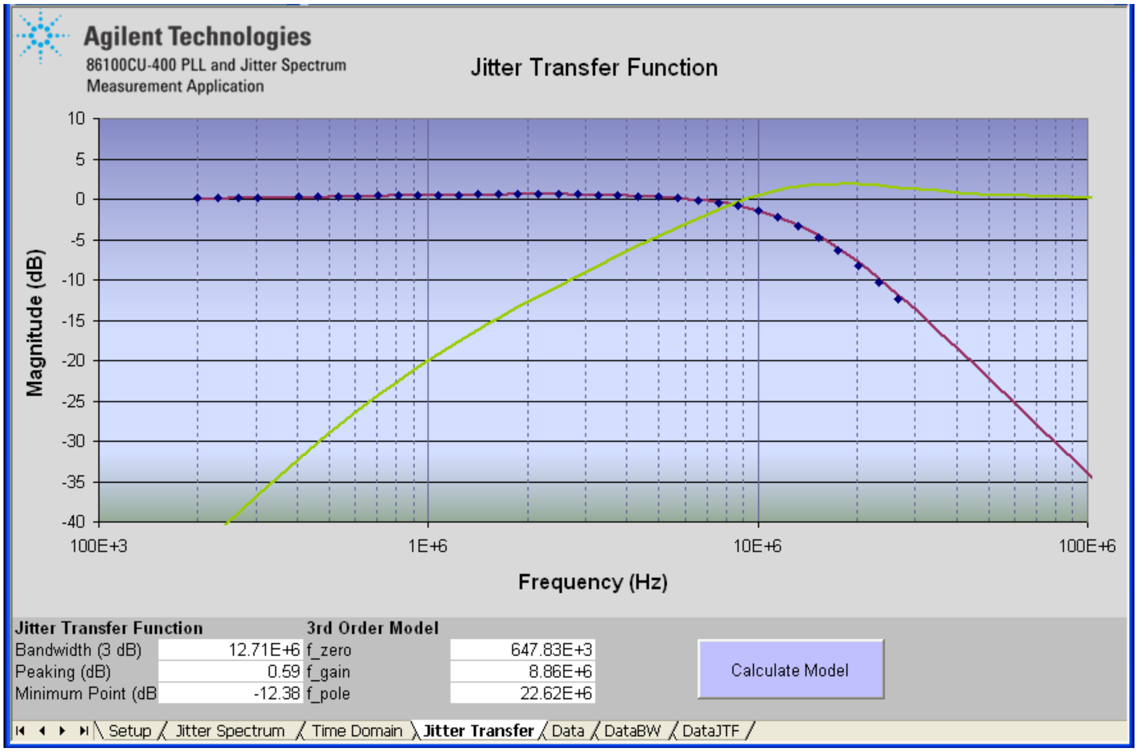


Figure 3-11. Example of the Jitter Transfer Worksheet

Histogram Worksheet

This worksheet displays the test signal as it would be observed having gone through post processing. It is only available when post-processing is turned on. Refer to “Post Processing” on page 2-14. Post processing allows the measured signal to be passed through two virtual PLLs with a fixed transport delay between them. The loop bandwidths of the virtual PLL’s can clean up the jitter, but the clean up is affected by any time delay the signal experiences traveling from one PLL to the other. There are two charts in this worksheet. The Processed Signal Jitter chart shows the observed jitter, measured in seconds, as a function of time. The Processed Signal Jitter Histogram chart shows the probability density, which is how often the signal reaches a given jitter magnitude. The pink traces of the histograms represent the cumulative distribution functions for each half of the histogram.

Figure 3-12. Example of the Histogram Worksheet

data Worksheet

This worksheet displays phase-error data from the clock-recovery module's PLL phase detector output.

	A	B	C	D	E	F	G	H	I	J
1	7/18/2008 16:27	Jitter Spectrum / Phase Noise Application						3.17E+04	2.00E+06	3.85E
2	52500000	Revision	1.01.20					1.40E+07	10000	4.30E
3	209	001,100,200,						1.74E+04	1500000	1.00E
4	0.7351		3.37	1.90E-08					2.13E-01	
5	5.00E+04	Frequency vs Time Mean =								1.9E
6	2.50E+09	2.500016E+9		1.60E+03		2.50E-12	-70.7931815			9E
7	-11000	86108A	-7.87301E-15	1.00E+03			5.55E+08			
8	DIFF	2281	27327.62012	32768		8		24586		
9	9	9	3.37			1		3.56	Post Processing	
10	24576	Time	time error	frequency	spectrum	spectrum avera	phase noise	input phase	frequency	PLL1
11	27480	0	-1.20E-12	0	5.162E-13			-1.20E-12	0.00E+00	
12	27684	1.90E-08	-2.81E-12	1602.173	9.079E-13	9.0792E-13	-71.97404	-2.81E-12	-4.50E+04	
13	28040	3.81E-08	-5.61E-12	3204.346	7.13E-13	7.1301E-13	-74.0730878	-5.62E-12	-1.14E+05	
14	27464	5.71E-08	-1.07E-12	4806.519	1.605E-13	1.60499E-13	-87.0255333	-1.11E-12	3.64E+04	
15	27356	7.62E-08	-2.23E-13	6408.691	9.703E-14	9.70348E-14	-91.3964482	-2.62E-13	5.22E+04	
16	27496	9.52E-08	-1.33E-12	8010.864	9.537E-14	9.5369E-14	-91.5468517	-1.37E-12	1.03E+04	
17	27524	1.14E-07	-1.55E-12	9613.037	2.576E-13	2.57639E-13	-82.9147507	-1.59E-12	1.80E+03	
18	27616	1.33E-07	-2.27E-12	11215.21	2.373E-13	2.37335E-13	-83.6277594	-2.32E-12	-1.90E+04	
19	27384	1.52E-07	-4.44E-13	12817.38	1.052E-13	1.05213E-13	-90.6935998	-5.03E-13	3.58E+04	
20	27864	1.71E-07	-4.22E-12	14419.56	2.534E-14	2.53387E-14	-103.059307	-4.28E-12	-7.74E+04	
21	27948	1.90E-07	-4.88E-12	16021.73	1.942E-14	1.9421E-14	-105.369554	-4.96E-12	-7.98E+04	
22	27508	2.10E-07	-1.42E-12	17623.9	1.216E-14	1.21642E-14	-109.433316	-1.51E-12	3.34E+04	
23	27644	2.29E-07	-2.49E-12	19226.07	1.24E-14	1.2404E-14	-109.263733	-2.59E-12	-3.79E+03	
24	27856	2.48E-07	-4.16E-12	20828.25	2.397E-14	2.39746E-14	-103.539983	-4.27E-12	-4.99E+04	
25	27912	2.67E-07	-4.60E-12	22430.42	2.25E-14	2.24971E-14	-104.092451	-4.72E-12	-5.20E+04	
26	27752	2.86E-07	-3.34E-12	24032.59	1.409E-14	1.40864E-14	-108.159008	-3.48E-12	-6.21E+03	

Setup / Jitter Spectrum / Time Domain / Jitter Transfer / **Data** / DataBW / DataJTF

Figure 3-13. Example of the data Worksheet

Data on this worksheet confirms that the loop response has been measured; there is no information relative to the signal being measured. Each measurement is based on a 40 Ms/s or 4 Ms/s time record of 12288 points. Results are displayed as a function of time or transformed to be displayed in the (jitter) frequency domain. Because the loop response is known, it is possible to remove its response as well as view the signal from the perspective of the input to the clock recovery module or the output of the internal phase detector.

dataBW Worksheet

This worksheet displays the measurement data of the loop response of the clock recovery module while it is locked to the signal being measured. The chart shows the response to internally generated step. The dataBW worksheet is not displayed unless the Loop Response On/Off field is switched on as described in "Loop Response On/Off" on page 2-10.

The following chart is also displayed on the worksheet. It shows the response of the clock recovery module to an internally generated step (within the loop). The application uses this response to back out the effects of the clock recovery module on the measured results.

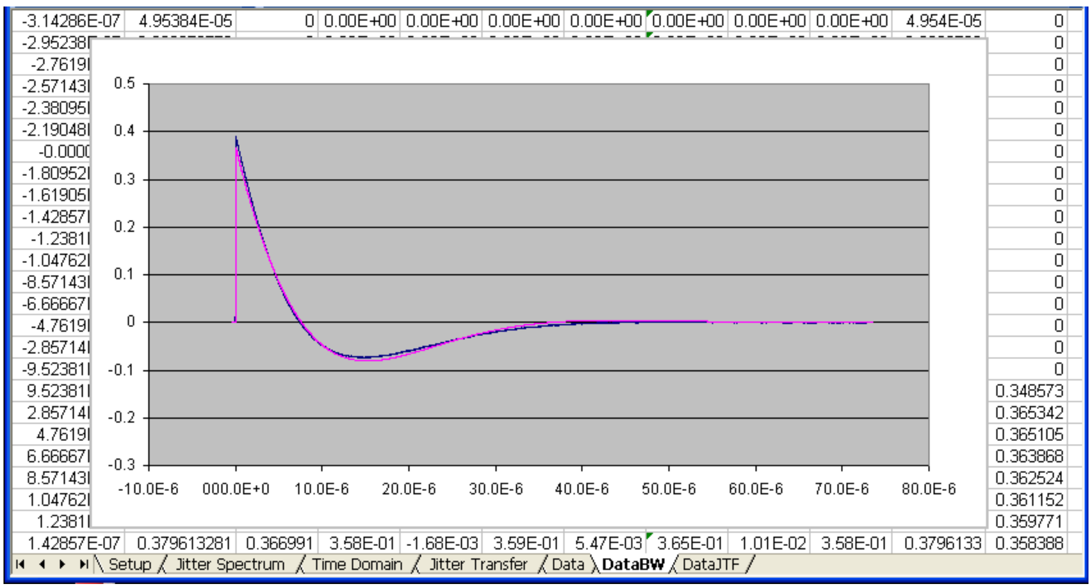


Figure 3-14. Example of the dataBW Worksheet

dataJTF Worksheet

The dataJTF worksheet is not displayed until a JTM measurement is made.

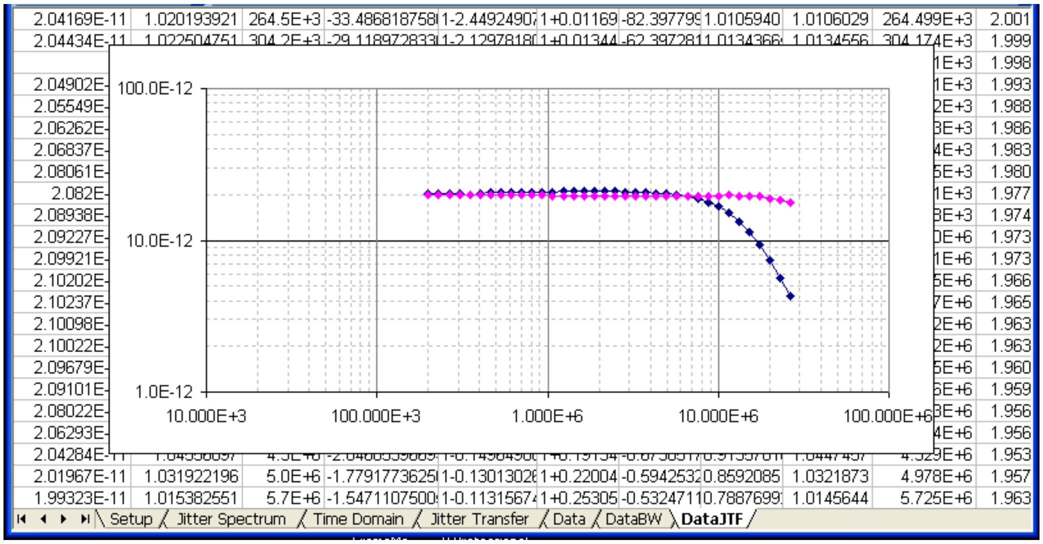


Figure 3-15. Example of the dataJTF Worksheet

Capturing Transients

A well-behaved signal may occasionally have a significant phase-error component. For example, this can occur whenever the phase detector in a clock multiplier circuit phase wraps (phase exceeds ± π). This section describes how to evaluate the signal over a long period of time and record the measurement only when the large phase error occurs.

You will need to adjust the Threshold and Number of Measurement settings that are shown in Figure 3-16. The Loop Response On / Off setting can be used to reduce the test time. A high Threshold setting when combined with a large Number of Measurements setting results in a long test time.

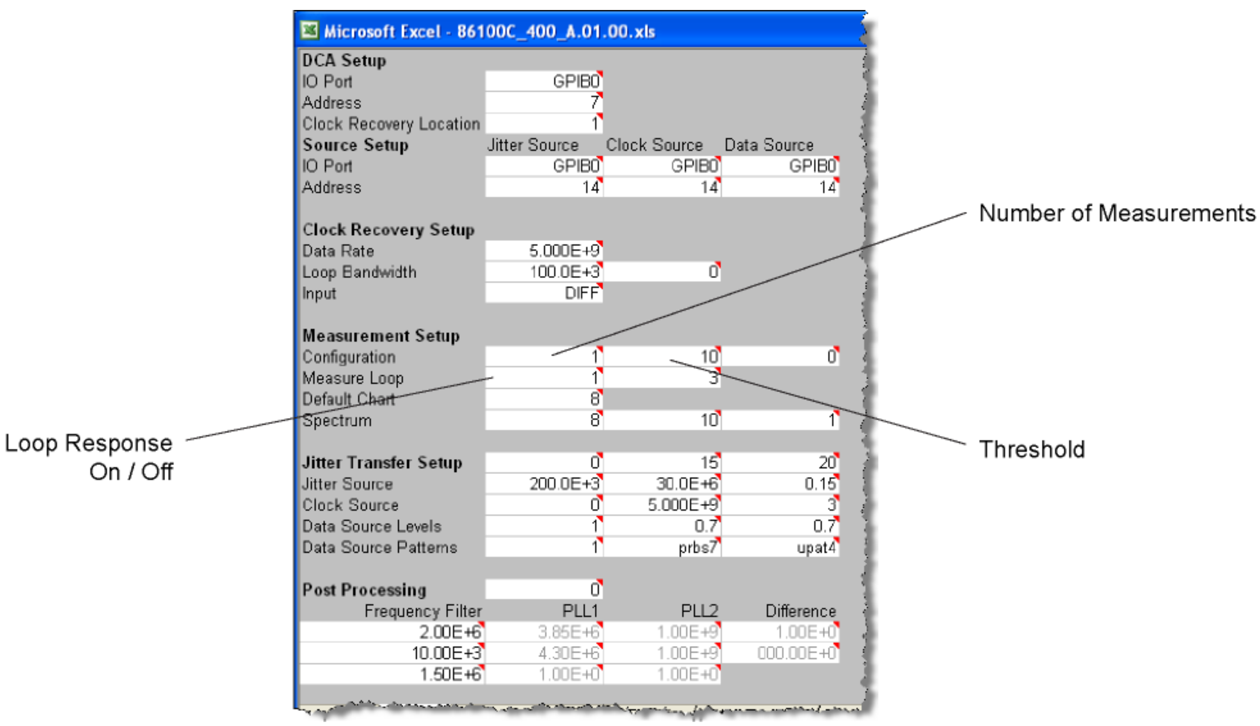


Figure 3-16. Entry Fields Used for Measuring Transients

Threshold

The Threshold setting is the setting at which data is saved and recorded as expressed by the following equation:

$$\text{threshold setting} = \frac{\text{transient peak phase-error}}{\sigma}$$

where σ is the overall standard deviation of the phase error.

For example, a Threshold of 2, stops the measurement (captures the transient) when the phase error is double the overall standard deviation. If the threshold is never met, the measurement stops when the maximum Number of Measurements is reached. If this happens, decrease the threshold. If the system trips on signals other than the event that is being sought, increase the threshold.

If the threshold is reached, the phase error chart shows the result of only the last measurement (where the threshold was reached), while the phase noise and jitter spectrum charts are averaged over all the measurements taken.

Number of Measurements

The Number of Measurements setting determines the maximum number of measurements performed if a transient is not located as defined by the Threshold setting. Measurements continue until either of the following events occur:

- a phase error meets the Threshold or
- the maximum number of measurements is reached.

Loop Response On / Off

If you're an experienced user, you can decrease measurement time by turning this setting off (enter 0). The default setting is on which causes the loop response to be measured and allows the system to provide accurate results via loop-response compensation. For situations where a large number of measurements is made, you can prevent the measurement algorithm from taking the time to remeasure the loop response for every measurement.

1. Configure all of your measurement settings so that you are ready to capture a transient.
2. Set the Number of Measurement setting to 1 (on).
3. Set the Loop Response On/Off to 1 (on).
4. Make a measurement.

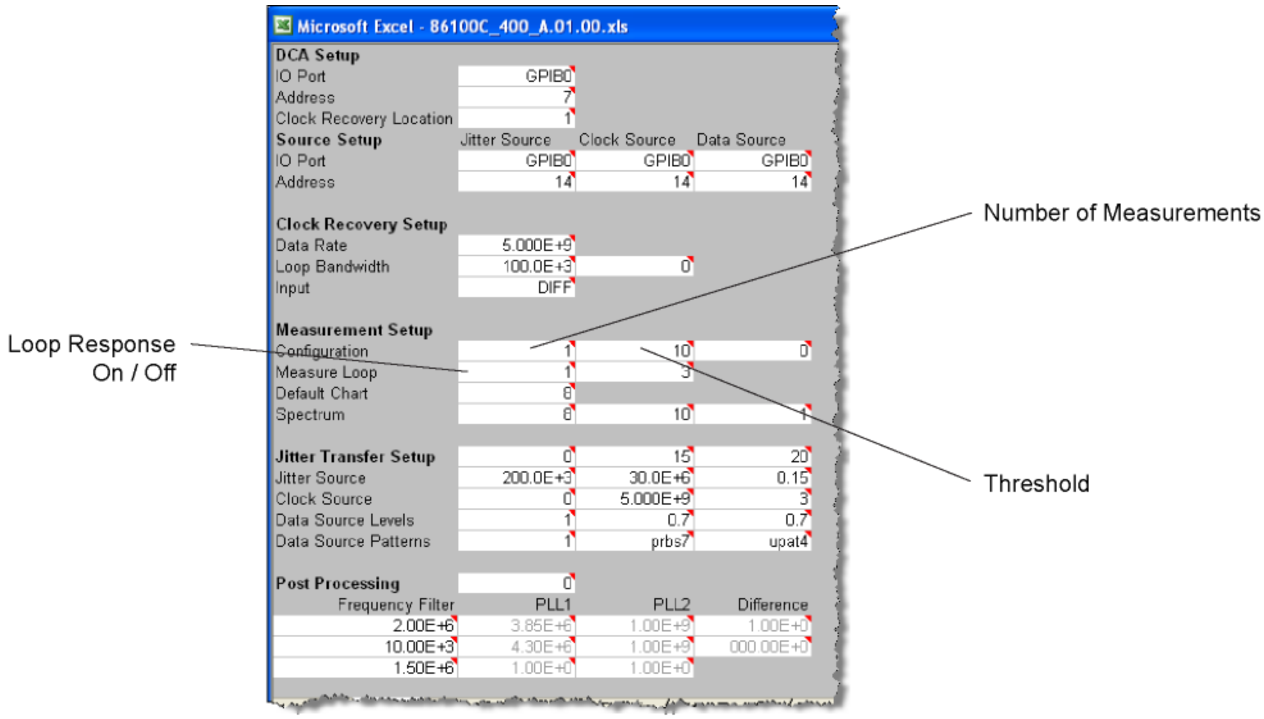
   Do not make any changes to data rate or the data pattern. The clock recovery module has been locked to the signal being evaluated and a standard jitter spectrum and phase noise measurement has been made. The workbook has evaluated and recorded the loop response and further measurements of the loop are not required.
5. Increase the Number of Measurement setting to the desired value.
6. Set the Loop Response On/Off to 0 (off).
7. Make your measurement to search for a transient.
8. Return the Loop Response On/Off setting to 1 (on).

CAUTION

Be sure to return the Loop Response On/Off setting to 1 (on) or the accuracy of future measurements may be compromised.

Averaging the Measurement in the Frequency Domain

To minimize noise in the frequency response plots, configure the measurement to average in the frequency domain (the phase error in the time domain will not be averaged). Configure the following parameters in the Setup worksheet.



Loop Response On/Off

Enter a 1 to specify that the loop response is measured.This parameter determines if the clock recovery module's loop response (as locked to the signal being evaluated) will be measured.

Number of Measurements

Set the parameter to the number of averages desired.

Threshold

Threshold sets the phase error threshold to trigger the saving data process and records a jitter spectrum or phase noise measurement. Set to a large number, for example 100, this state is likely never reached, allowing the desired number of averages to be completed before the data is recorded and processed.

Measuring Signals Below 50 Mb/s

Because the minimum data rate supported by the 83496B and 86108A modules is 50 Mb/s, the minimum data rate supported by the application is 50 Mb/s (or a 25 MHz clock). However, depending on your data pattern, you may be able to lock the clock recovery module to a slower data or clock rate.

For example, a 1011001 pattern at 25 Mb/s looks just like a 11001111000011 pattern at 50 Mb/s. A clock signal is just a special case where the pattern is a repeating 101010. If you have a signal you need to evaluate that is below the minimum 50 Mb/s rate, try locking the clock recovery module by configuring the module as to a signal that is 2, 3 or 4 times faster than the actual data rate. The clock recovery circuit then considers each bit in the pattern to be 2, 3, or 4 consecutive identical bits. Provided the clock recovery module can lock to the signal, the jitter spectrum and phase noise measurement results will not be affected by this approach.

Verifying System Operation

As long as the 83496B is capable of locking onto the signal being tested, the workbook application should provide good measurement results. The workbook application performs best with narrow loop bandwidth settings for the clock-recovery module. However, complicated signals may require the module to be set to a wider loop bandwidth to achieve lock. Use the lowest loop bandwidth for which a lock condition can be achieved.

Verification of operation can be achieved by measuring a high quality signal generator that is producing a simple clock or sinusoid. Use of a high quality generator should yield a signal with low jitter spectrum noise (and low phase noise) providing an indication of the system's ability to observe low-jitter signals. Some examples of signal generators that might be used include the Agilent 8257D or 8267D. Any generator capable of producing a clock-like signal at GHz frequencies will work. Although signals with reduced spectral purity result in higher jitter noise results, the basic system operation can still be confirmed. The ability to also produce a specific level of periodic jitter at a specific frequency will also help verify system operation.

In the following example, a 2.5 GHz clock signal from an Agilent 8267D is measured. The Signal Studio software application is used to generate 0.1 UI of periodic jitter at 1.2 MHz.

The following is the workbook configuration:

Data rate: . . . . 5×10^{9} (double the frequency when measuring a clock)
Loop BW: 100000
Input: . . . . ELEC (single-ended clock-recover input)

The 8267D has extremely low phase noise, thus the jitter spectrum is quite low, under 1 fs above 300 kHz. The periodic jitter is seen as several tones, with the dominant tone at 1.2 MHz. There are also tones at 2.4 MHz and 3.6 MHz. These represent harmonic distortion components of the desired 1.2 MHz periodic jitter.

Notice that the harmonic distortion components are several orders of magnitude smaller than the main tone (the y-axis is logarithmic). The very low phase noise of the source allows the distortion tones to be observed. More common digital communications signals often have jitter noise that would completely obscure these tones. In addition to the 1.2 MHz series of tones, there are also tones at approximately 950, 1900, and 2850 kHz. These tones originate from the switching power supply in the 83496B. Again, the ultra low jitter of the 8267D source allows these spurious tones to be observed.

The magnitude of the 1.2 MHz tone can be confirmed by going to the Results worksheet as shown in Figure 3-17 on page 3-25.

3	Left Module	86108A		
4	Right Module	86108A		
5	Data Rate	5.E+09		
6	Loop Bandwidth	1.E+05		
7	Transition Density	0.9953		
8	Input	ELEC		
9				
10	Frequency Filter	PLL1	PLL2	Difference
11	2.00E+06	4.65E+06	9.40E+06	1.00E+00
12	1.00E+04	1.00E+09	1.00E+09	1.20E-08
13	1.50E+06	3.99E+06	8.06E+06	
14				
15				
16	Integrated Jitter	TJ (rms)	DJ (rms)	RJ (rms)
17	Integral f1 to fmax	7.49E-12	7.49E-12	5.08E-14
18	Integral f2 to fmax	4.05E-14	3.06E-14	2.65E-14
19	Difference f1 to f2	7.49E-12	7.49E-12	4.33E-14
20				
21	Highest Peak			
22	Frequency	1.20E+06		
23	Jitter (rms)	7.49E-12		
24	Jitter (p-p)	2.12E-11		

Figure 3-17. Results Worksheet

The jitter frequency is measured at 1,200,011 Hz vs. an expected value of 1,200,000 Hz. The magnitude of the jitter is 7.49 ps rms and 21.2 ps peak-peak. The system was set to produce 0.1 UI pp of sinusoidal jitter. At 5 Gb/s, 1 UI is 200 ps. Thus the 21 ps value is within 5% of the expected 20 ps pp value.

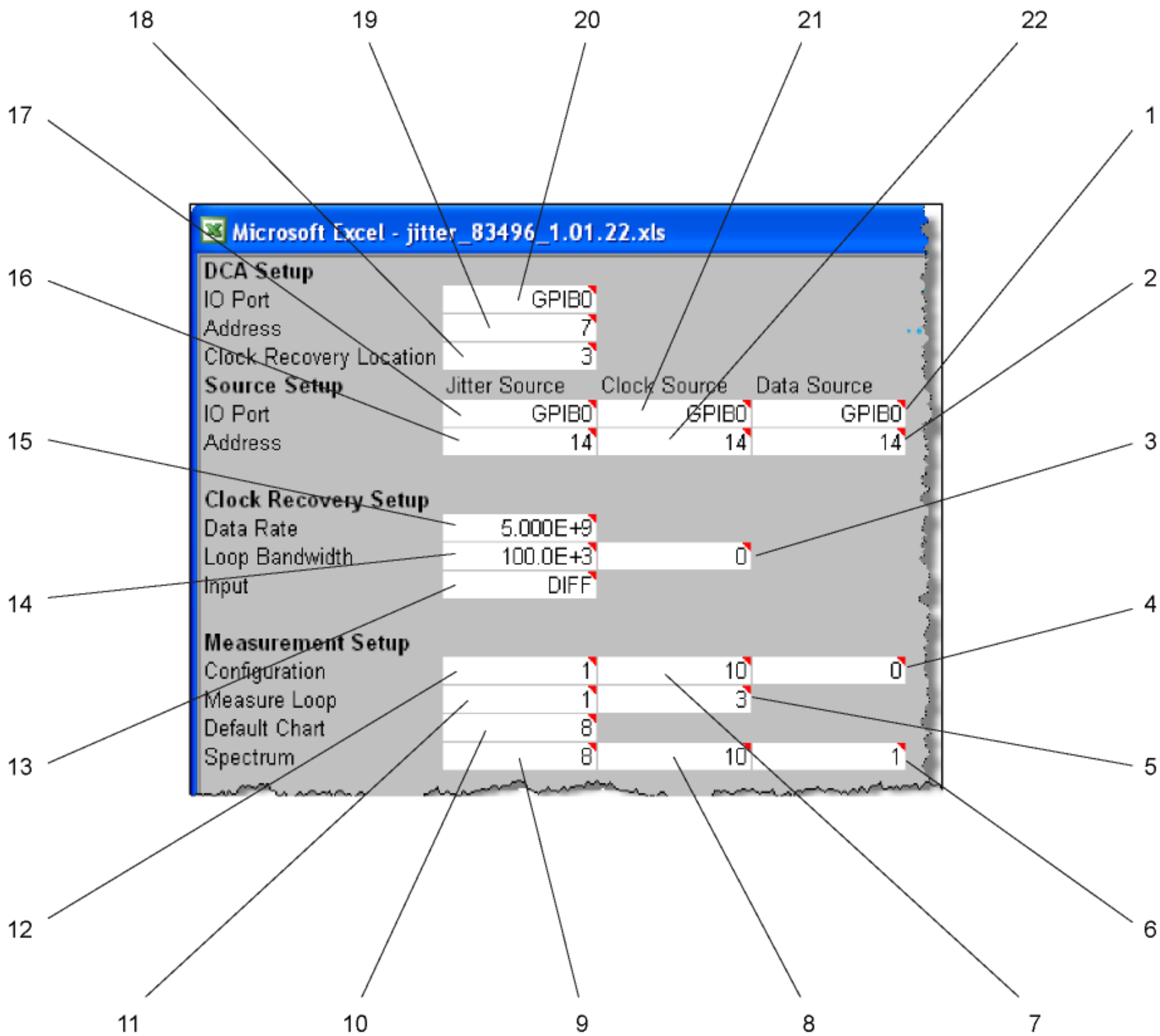
The best way to gauge the magnitude of the random jitter, represented by the noise floor of the jitter spectrum, is to integrate it over a specific bandwidth. The maximum frequency range of the application is 20 MHz. The integration limits are defined as part of the post processing system and shown as Filter 1 and Filter 2 in the results page (and are used to set the integration limits whether or not the signal is processed through the virtual PLL's). In this setup the F1 filter value is 10 kHz, F2 is 1.5 MHz. The integrated jitter from 10 kHz to 20 MHz is 50.8 fs, from 1.5 MHz to 20 MHz is 26 fs, and from 10 kHz to 1.5 MHz is 43 fs. This is all noted in the results table above.

When the system is verified with a signal other than the one described above, the results will obviously be different. Results will depend on the quality of the source and the precision to which periodic jitter can be produced. As noisier sources are used, the integrated jitter spectrum will be larger. However, the example given should provide some levels that can be expected for specific conditions as well as an indication of the lower regions of what can be observed.

Active-X Support

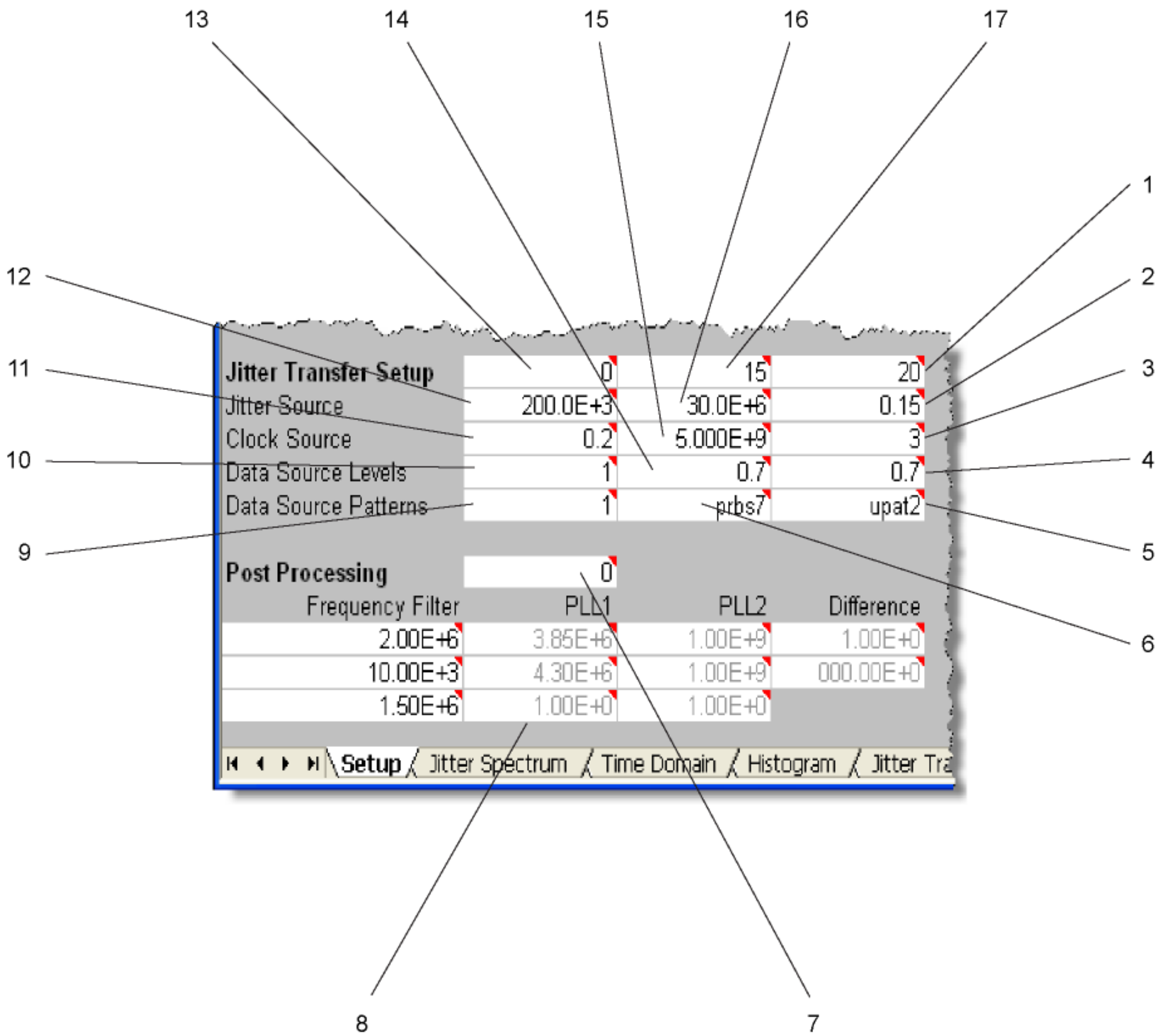
You can use Active-X to control the PLL and Jitter Spectrum Measurement Application workbook. The supplied standard-specific workbooks use Active-X to control the PLL and Jitter Spectrum Measurement Application workbook and can be studied to learn the techniques involved.

You can reference the fields in the Setup worksheet by a field name rather than its row and column specifier. Figure 3-18 and Figure 3-19 identify each field and its associated name. For Post Processing, one name (representing a 4 x 3 array) is used to specify all the values of the Frequency Filter, PLL1, PLL2, and Difference entries. See item 8 in Figure 3-19.



Item	Field Name	Item	Field Name	Item	Field Name
1	DatGen_IOport	**9**	sChart	**16**	SigGen_addr
2	DatGen_addr	**10**	chart	**17**	SigGen_IOport
3	CR_Loop	**11**	meas_loop	**18**	Crloc
4	sRate	**12**	max_meas	**19**	GPIB_addr
5	loop_ave	**13**	CR_input	**20**	DCA_IOport
6	show_peaks	**14**	CR_LBW	**21**	ClGen_IOport
7	threshold	**15**	DataRate	**22**	CkGen_addr
8	peak_exc				

Figure 3-18. Field Names for Active-X Control (1 of 2)



Item	Field Name	Item	Field Name	Item	Field Name
1	JTFthreshold	**7**	post_process	**13**	JTF_list
2	JTF_amp	**8**	OJFT	**14**	DatGenAmpl
3	JTF_clock_amp	**9**	DatGenPatState	**15**	JTF_clock
4	DatGenHigh	**10**	DatGenLevState	**16**	JTF_stop
5	DatGenPatMeas	**11**	JTF_settle	**17**	JTFpointspace
6	DatGenPatCal	**12**	JTF_start		

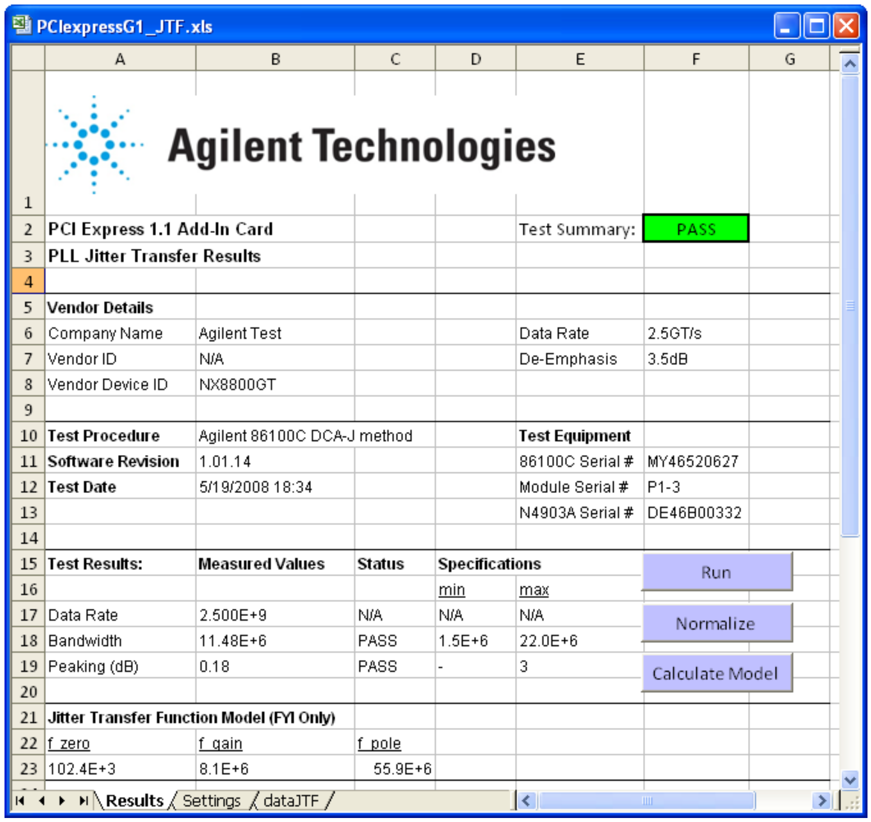
Figure 3-19. Field Names for Active-X Control (2 of 2)

4

Standard-Specific Workbooks

Introduction

PCI Express 1.1 Add-In Card

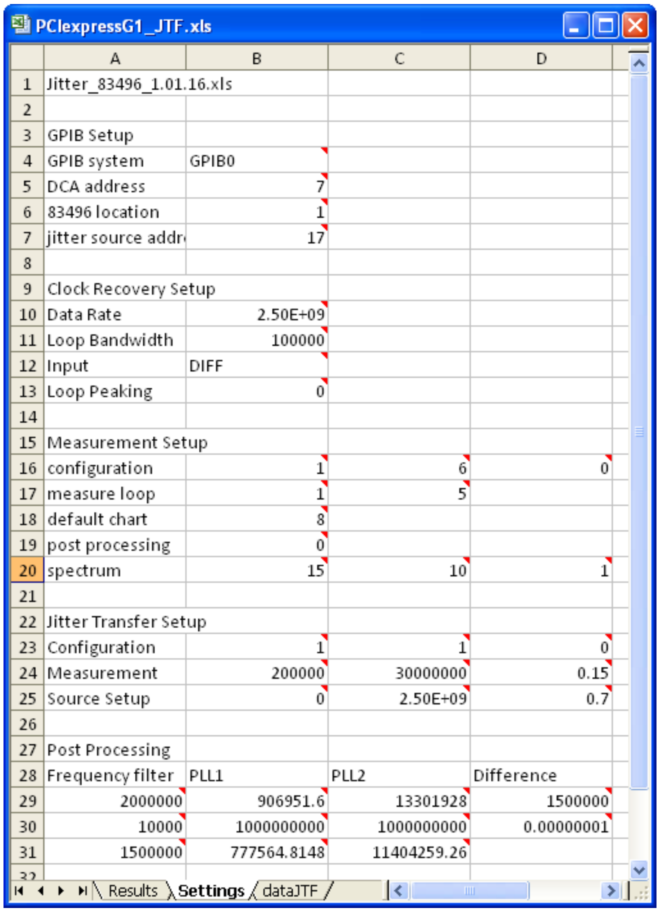

PClexpressG1_JTF.xls

Agilent Technologies

	A	B	C	D	E	F	G
2	PCI Express 1.1 Add-In Card				Test Summary:	PASS	
3	PLL Jitter Transfer Results						
4							
5	Vendor Details						
6	Company Name	Agilent Test			Data Rate	2.5GT/s	
7	Vendor ID	N/A			De-Emphasis	3.5dB	
8	Vendor Device ID	NX8800GT					
9							
10	Test Procedure	Agilent 86100C DCA-J method			Test Equipment		
11	Software Revision	1.01.14			86100C Serial #	MY46520627	
12	Test Date	5/19/2008 18:34			Module Serial #	P1-3	
13					N4903A Serial #	DE46B00332	
14							
15	Test Results:	Measured Values	Status	Specifications		Run	
16				min	max		
17	Data Rate	2.500E+9	N/A	N/A	N/A	Normalize	
18	Bandwidth	11.48E+6	PASS	1.5E+6	22.0E+6		
19	Peaking (dB)	0.18	PASS	-	3	Calculate Model	
20							
21	Jitter Transfer Function Model (FYI Only)						
22	f_zero	f_gain	f_pole				
23	102.4E+3	8.1E+6	55.9E+6				

Results / Settings / dataJTF

Figure 4-1.



PCIexpressG1_JTF.xls

	A	B	C	D
1	Jitter_83496_1.01.16.xls			
2				
3	GPIB Setup			
4	GPIB system	GPIB0		
5	DCA address	7		
6	83496 location	1		
7	jitter source addr	17		
8				
9	Clock Recovery Setup			
10	Data Rate	2.50E+09		
11	Loop Bandwidth	100000		
12	Input	DIFF		
13	Loop Peaking	0		
14				
15	Measurement Setup			
16	configuration	1	6	0
17	measure loop	1	5	
18	default chart	8		
19	post processing	0		
20	spectrum	15	10	1
21				
22	Jitter Transfer Setup			
23	Configuration	1	1	0
24	Measurement	200000	30000000	0.15
25	Source Setup	0	2.50E+09	0.7
26				
27	Post Processing			
28	Frequency filter	PLL1	PLL2	Difference
29	2000000	906951.6	13301928	1500000
30	10000	1000000000	1000000000	0.00000001
31	1500000	777564.8148	11404259.26	

Results | Settings | dataJTF

Figure 4-2.

5

Solving Problems

Introduction

This chapter provides solutions to problems that you may experience while trying to configure the application and perform measurements.

If the application can not control the 86100C

- Confirm that you are using an 86100C with an 86108A or 83496B or 83496AUB module. The application does not work with an 86100A, 86100B, or 83496A.
- Confirm that the 86100C software revision is A.08.00 or above. If needed, upgrade the software revision as described in "Step 2. Upgrade 86100C software" on page 1-6.
- A firewall is blocking communication via LAN on the 86100C. Refer to "Step 3. Setup the Communications Bus" on page 1-7.

If the 86100C can not lock triggering on the signal

The clock recovery module's loop bandwidth setting may be set too low. This can be set by manually controlling the instrument or through the workbook's Setup worksheet.

- Set the loop bandwidth to 1 kHz which forces the 86100C to automatically select the narrowest loop bandwidth setting for the selected data rate. If the 86100C fails to lock to the input signal, increase the loop bandwidth setting.
- Set the loop bandwidth to 10 MHz which forces the 86100C to automatically select the widest loop bandwidth setting available at the data rate. If lock is established, reduce the loop bandwidth until lock occurs at the narrowest loop bandwidth setting possible.

If a clock signal can not be measured

When measuring a clock, the 86100C regards the clock as a data signal. A clock signal with a 101010 data pattern is perceived to have a rate that is double the clock rate. As a result, the measurable range of clock frequencies is half the range of measurable data rates. For example, when using an 83496B Option 200 (data rate range of 50 Mb/s to 13.5 Gb/s), the effective clock rate range that can be tested is 25 MHz to 6.75 GHz.

- In the workbook, set the data rate to double the rate of the clock.

If an error message occurs in Excel

- Select the required Excel add-ins. Refer to “Step 6. Setup the Application” on page 1-9.

If the application stops running

- Excel's AutoRecovery feature may have been enabled. Enabling AutoRecover interupts the application during its measurement to save recovery files. In Excel, click **Tools** > **Options**. Click on the **Save** tab and select **Disable AutoRecover**. This setting turn off this feature for the active workbook.
- Confirm that the start or stop frequency that is entered in the Jitter Transfer Setup area of the Setup worksheet is within the range of the jitter source. Entering frequencies beyond the range of the jitter source results in incomplete measurements.
- Press the Escape key.

If post-processing does not work

- Enable post processing. Refer to “Post Processing On/Off” on page 2-15.

If measurement noise level is too high

- Reduce the clock recovery module's loop bandwidth setting.

If the dataBW worksheet is not visible

- Enable the loop response as described in "Loop Response On/Off" on page 2-10.

If the Histogram worksheet is not visible

- Enable the post processing as described in "Post Processing On/Off" on page 2-15.

Index