

Clock Jitter Measurement

Clock Jitter measurement

- Overview
- Executing Clock Jitter Measurement
- SSA-J Enhancement

Overview

- Overview of clock jitter measurement
- Relation between phase deviation (spurious) and jitter
- Clock jitter measurement with the E5052B

Other topics about Clock Jitter Measurement

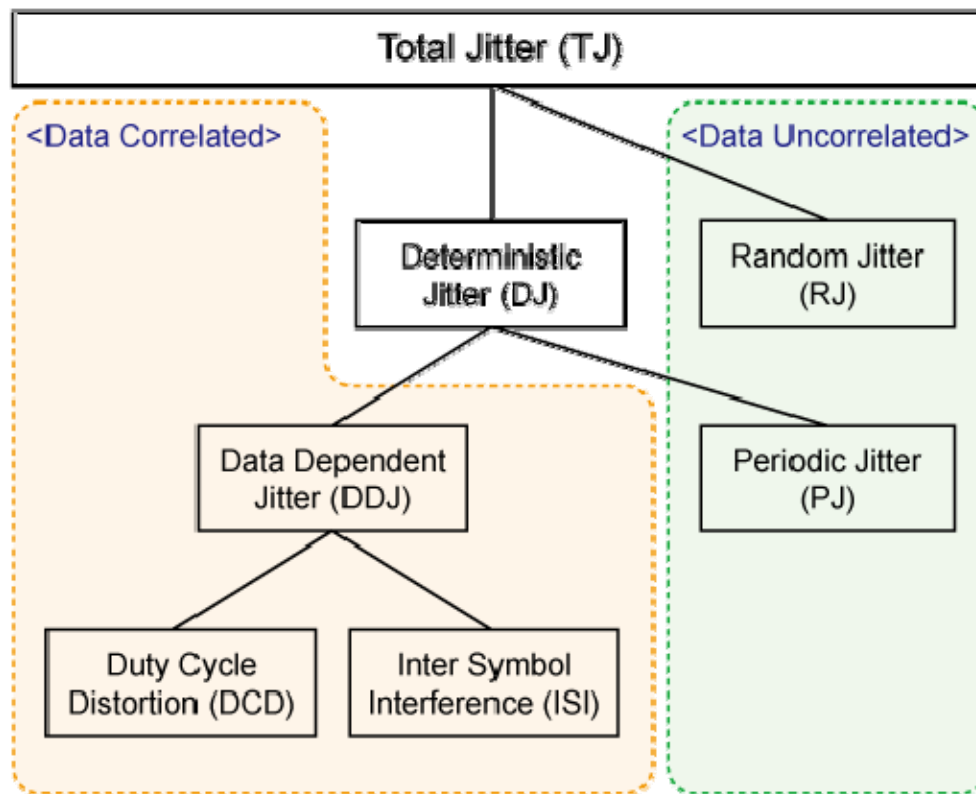
The E5052B provides application software that lets you perform very-low-level clock jitter measurement. To use this function, you need to separately purchase the E5001A SSA-J Precision Clock Jitter Analysis Software option. For more information, contact your local Agilent customer center listed at the end of this manual or your distributor.

Overview of clock jitter measurement

The periods (reference times) of clock sources actually vary depending on a number of factors such as noise. This variation is called jitter, which is generally evaluated using a statistical measurement method. Jitter analysis is an important measurement for applications that handle high-frequency signals.

There are two types of jitter: one dependent on data (Data Correlated or Data Dependent) and one independent of data (Data Uncorrelated or Data Independent). Each type of jitter has various components (jitter components, figure below).

Jitter Components



ssa0028

The E5052B can measure only data-uncorrelated jitter components. Such data-uncorrelated jitters are described below.

Types of Jitters

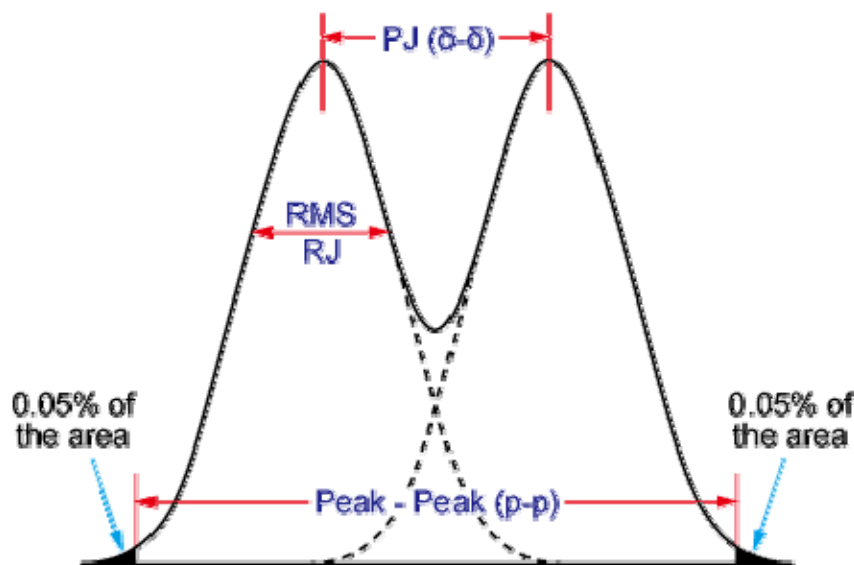
Jitter	Description
Random jitter (RJ)	Jitter that occurs randomly. Generally, it is expressed as a Gaussian distribution of probability density function (PDF) with an average value (m) and a standard deviation (s). Its peak-to-peak (p-p) value has no limit. As measurement time becomes longer, the p-p value measured during the time becomes larger.
Periodic jitter (PJ)	Jitter that occurs over entire periods independent of data patterns. Its peak-to-peak (p-p) value has a limit. Even when measurement time is elongated, the p-p value converges to a finite value.

The dual Dirac model is used to obtain periodic jitter (PJ). The standard deviation of a random jitter (RJ) distribution is obtained from the RMS value of actually measured random jitter. The dual Dirac model consists of two identical Gaussian defined with the RMS value of the random jitter.

The distance between the two Gaussian is adjusted so that the probability density function (PDF) of the model matches the measured jitter histogram. The model for analysis is identified under the condition that the peak-to-peak (p-p) distance representing 99.9% of the area of the model's PDF matches the width that contains 99.9% of the area of the measured histogram (**dual Dirac Model**).

PJ ($\delta - \delta$), which is a parameter indicating the actual effect of the periodic jitter component, is defined by the distance between the average values of the two Gaussian. The effective value of periodic jitter independent of its waveform is calculated by rms sum analysis using the standard deviation of the random jitter. This is obtained from the random jitter/periodic jitter histogram giving the RMS value of the periodic jitter.

dual Dirac Model



ssa0028

Relation between phase deviation (spurious) and jitter

Equation 7-1 shows the relation between jitter (J) expressed in seconds (s) or unit intervals (UI) and phase deviation (spurious) expressed in radians $\Delta\phi$, where the frequency of the clock signal is expressed as $f_c[\text{Hz}]$.

Equation 7-1

$$J[s] = \frac{1}{2\pi f_c} \Delta\phi[rad] \quad J[UI] \equiv \frac{J[s]}{\frac{1}{f_c}} = f_c \bullet J[s] = \frac{1}{2\pi} \Delta\phi[rad]$$

The following equation gives the relation between phase deviation $\Delta\phi$ and single-side-band (SSB) phase-noise spectrum, $L\phi(f)$ [dBc/Hz]. A and B in the equation indicate the frequency range specified with the band marker.

Equation 7-2

$$\Delta\phi = \sqrt{2 \times 10^{\frac{IPN}{10}}} \quad [rad]$$

Equation 7-3

$$IPN = 10 \times LOG \left[\int_A^B 10^{\frac{L\phi(f)}{10}} df \right] \quad [dBc]$$

IPN (Integrated Phase Noise)	Relative value of phase-noise power integrated over a range between frequencies A and B
------------------------------	---

The following equation gives the residual *FM* component (RFM) within a range of frequencies A and B.

Equation 7-4

$$RFM = \sqrt{2 \times \int_A^B f^2 \times 10^{\frac{L\phi(f)}{10}} df} \quad [Hz_{rms}]$$

Clock jitter measurement with the E5052B

The E5052B uses Phase-Noise measurement and Transient measurement for clock jitter measurement. The user window is used to display the jitter trend and histogram.

NOTE

To use this function, you need to purchase the E5001A SSA-J Precision Clock Jitter Analysis Software. For more information, contact your local Agilent customer center listed at the end of this manual or your distributor.

The clock jitter measurement provides the following capabilities:

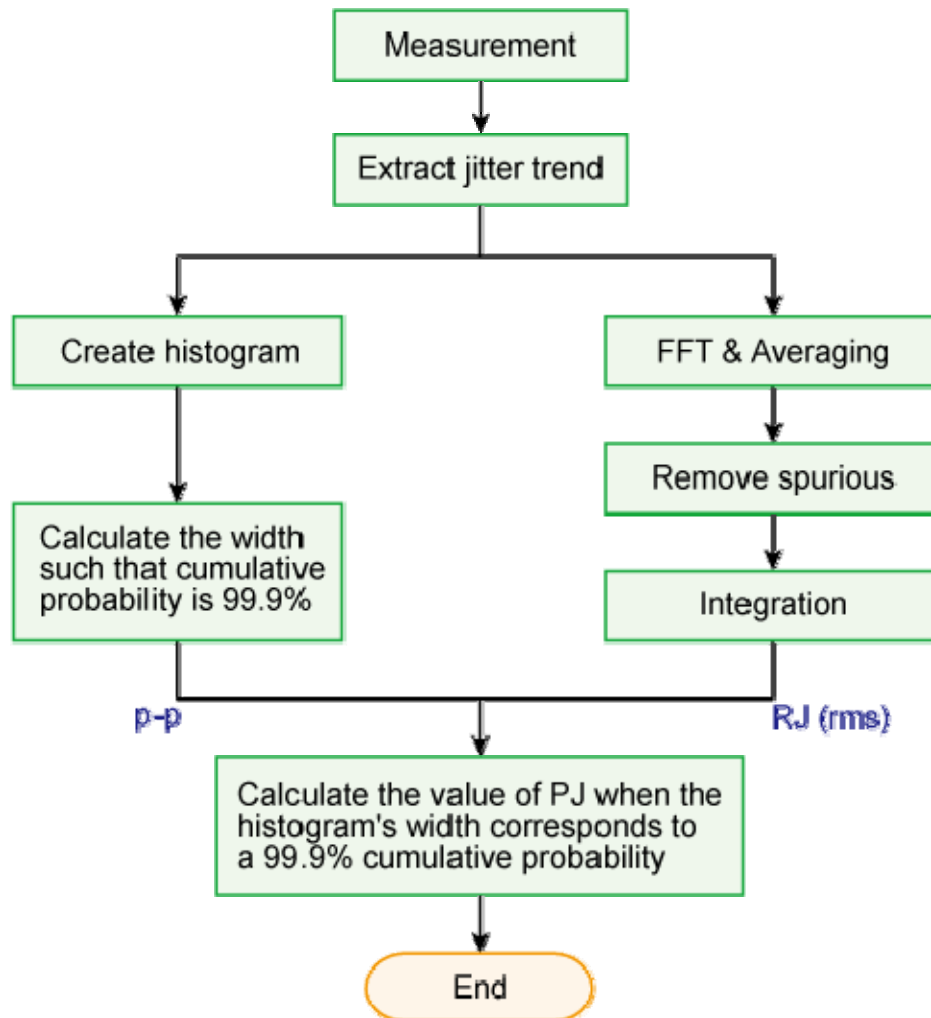
- Displaying the jitter trend and total jitter value
- Displaying the jitter probability distribution (histogram)
- Displaying the periodic jitter (PJ) value and random jitter (RJ) value

The clock jitter measurement of the E5052B provides three analysis functions that you can select from the screen.

Analysis function	Description
Random jitter analysis (RJ)	Displays the clock frequency and the RMS value of the random jitter in phase-noise measurement.
<i>Frequency</i> analysis for periodic jitter (PJ Frequency)	In phase-noise measurement, displays the clock frequency and the RMS value of the periodic jitter with the spurious power value display enabled.
Decomposition analysis for periodic jitter (PJ Decomposition)	Displays the jitter trend and histogram for jitter value analysis. The target frequency for transient measurement can be linked.

The following figure shows the decomposition analysis for periodic jitter.

Flow of decomposition analysis for periodic jitter



ssa0030

NOTE

If Auto trend Correction is ON, Jitter trend is removed.

Executing Clock Jitter Measurement

- Starting the VBA program
- Ending the VBA program
- Random jitter analysis
- Frequency analysis for periodic jitter

- Decomposition analysis for periodic jitter
- Installing the program
- Error messages

Starting the VBA program

Follow these steps to start up the program.

1. Press **Macro Setup**.
2. Press **Application**.
3. Press **Jitter**.

The following screen appears.

Initial screen for jitter analysis



ssa0158

Ending the VBA program

It is required to push the button 9 in Screen for random jitter analysis to end the program.

NOTE

After ending the program with this step, only the current window is active and other windows are inactive.

It is required to preset when you need to activate another windows.

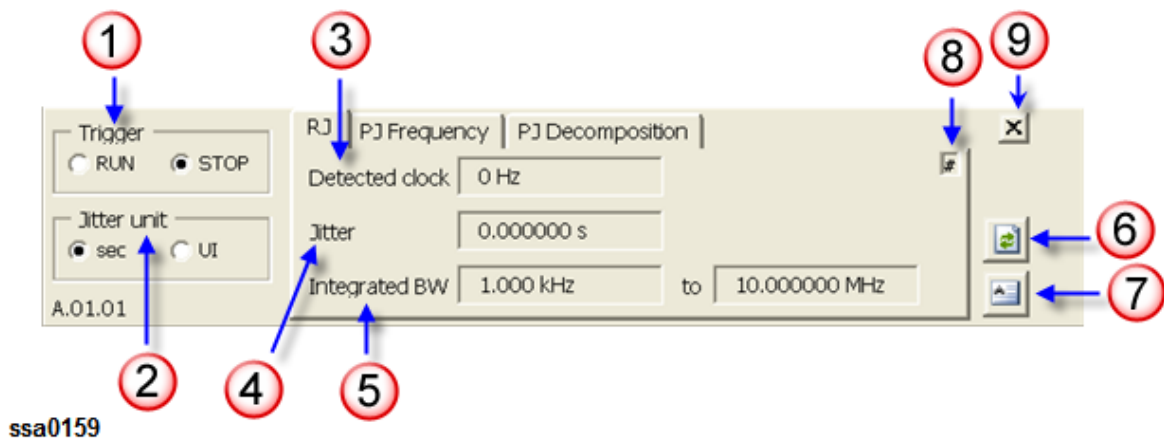
Random jitter analysis

Overview

This analysis displays the clock frequency and the rms value of random jitter in phase-noise measurement. You can use the band marker on the screen to specify an analysis range. In this case, the analysis range is also displayed.

Setting procedure

Screen for random jitter analysis



1. Select **RJ** from the analysis function selection tabs (default)
2. When you want to specify an analysis range, it is required to change the value of the integrated BW using either of the following two methods:
 - i. VBA interface: When you change the value using the VBA interface, the setting of Trigger should be "Stop" (1 in Screen for random jitter analysis)
 - ii. Band Marker Function: When you change the value using the Band marker function, it is not required to fix the setting of trigger. It is available to set, Run or Stop (1 in Screen for random jitter analysis). For more information on band marker function, refer to Searching for Positions that Match Specified Criteria
 - iii. Select a jitter display unit (2 in Screen for random jitter analysis).

Button	Function
sec	Displays data in the unit of second.
UI	Displays data in the unit of unit interval.

4. Select the **RUN** button (1 in Screen for random jitter analysis).
5. The measurement starts, and the clock frequency (3 in Screen for random jitter analysis) and the random jitter rms value (4 in Screen for random jitter analysis) are displayed.
6. Click the **STOP** button (1 in Screen for random jitter analysis) to finish the measurement.

NOTE

From Firmware ver **A.03.10**, the maximum and minimum frequency (5 in Screen for random jitter analysis) can be set using VBA. This setting does not change even by changing tabs (i.e. From Frequency tab to Decomposition tab or vica-versa), but once exiting SSA-J, it is initialized.

Example of screen for random jitter analysis

Saving analysis result

You can save the analysis result to a file by following the steps below.

1. Click the tab of the analysis result that you want to save. At this time, analysis is carried out once.
2. Use the Save/Recall function to save the analysis result. For details, refer to File Saving and Loading Instrument Status Settings.

Recalling analysis result

You can recall the analysis result from a file by following the steps below.

1. Use the Save/Recall function. For details, refer to File Saving and Loading Instrument Status Settings
2. Press the **Refresh** button (6 in Screen for random jitter analysis).

Saving analysis result to a file

You can save the result of random jitter analysis to a text file by pressing the **Export** button (7 in Screen for random jitter analysis) .

Pressing the Export button opens the analysis result file in the Notepad application. Pressing this button during measurement writes the analysis result displayed at that time.

Notes on measurement

If you select another analysis function tab (PJ Frequency/PJ Decomposition) during measurement, the current measurement is aborted. In this case, the # sign (8 in Screen for random jitter analysis) is displayed for the analysis result to indicate a possible mismatch of displayed information between the E5052B and VBA.

Note that the # sign is not displayed if the E5052B's displayed information is changed without using the VBA.

Frequency analysis for periodic jitter

Overview

This analysis displays the clock frequency and the RMS value of the periodic jitter when the spurious power value display is enabled in phase-noise measurement. You can use the band marker on the screen to specify an analysis range.

Setting procedure

Screen for periodic jitter frequency analysis



1. Select **PJ Frequency** from the analysis function selection tabs.
2. When you want to specify an analysis range, use the band marker on the phase-noise measurement screen.
3. Select a spurious sorting method displayed on the phase-noise measurement screen (3 in Screen for periodic jitter frequency analysis).

Button	Function
Jitter	Sorts jitters in ascending order.
Frequency	Sorts frequencies in ascending order.

4. Select a display unit (2 in Screen for periodic jitter frequency analysis).

Button	Function
sec	Displays data in the unit of second.
UI	Displays data in the unit of unit interval.

5. Select the **RUN** button (1 in Screen for periodic jitter frequency analysis).
6. The measurement starts, and the lists of clock frequencies (4 in Screen for periodic jitter frequency analysis) and periodic jitter rms values (5 in Screen for periodic jitter frequency analysis) are displayed.
7. Select the point you want to analyze from the list (5 in Screen for periodic jitter frequency analysis). When you select a point, the marker moves to the analysis point on the phase-noise measurement screen.
8. Click the **STOP** button to finish the measurement (1 in Screen for periodic jitter frequency analysis).

NOTE

From Firmware ver **A.03.10**, all the frequencies of Frequency-Jitter list measured through PJ Frequency tab are displayed. Previously, only single frequency (displayed as blue) selected in the PJ Frequency tab was displayed.

Example screen of periodic jitter frequency analysis**Saving analysis result**

You can save the analysis result to a file by following the steps below.

1. Click the tab of the analysis result that you want to save. At this time analysis is carried out once.
2. Use the Save/Recall function to save the analysis result. For details, refer to File Saving and Loading Instrument Status Settings.

Recalling analysis result

You can recall the analysis result from a file by following the steps below.

1. Use the Save/Recall function. For details, refer to File Saving and Loading Instrument Status Settings.
2. Press the **Refresh** button (6 in Screen for random jitter analysis).

Saving analysis result to a file

You can save the analysis result of random jitter analysis to a text file by pressing the **Export** button (7 in Screen for periodic jitter frequency analysis).

Pressing the Export button opens the analysis result file in the Notepad application. Pressing the Export button during measurement writes the analysis result displayed at that time.

Note on measurement interruption

If you select another analysis function tab (RJ/PJ Decomposition) during measurement, the current measurement is aborted. In this case, the # sign (8 in Screen for random jitter analysis) is displayed for the analysis result to indicate a possible mismatch of displayed information between the E5052B and VBA.

Note that the # sign is not displayed if the E5052B's displayed information is changed without using the VBA.

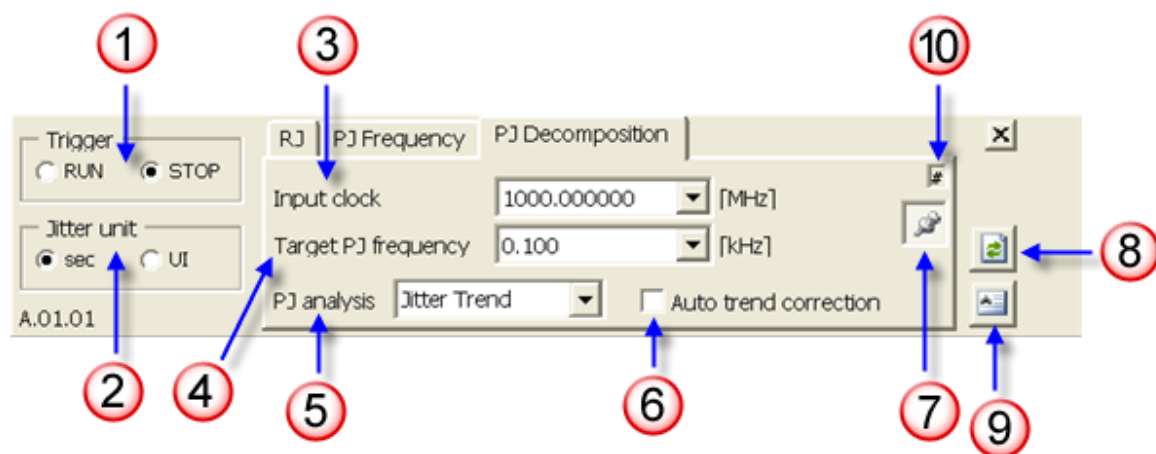
Decomposition analysis for periodic jitter

Overview

This analysis displays the jitter trend and histogram for jitter value analysis. The target frequency for transient measurement is linked.

Setting procedure

Screen for periodic jitter decomposition analysis



ssa0163

1. Select **PJ Decomposition** from the analysis function selection tabs.

2. Specify a clock frequency (MHz) for the periodic jitter frequency analysis (3 in Screen for periodic jitter decomposition analysis). Frequencies added here are saved in the list.
3. *Enter* the period jitter frequency you want to analyze (4 in Screen for periodic jitter decomposition analysis). Frequencies entered here are saved in the list of jitter values (5 in Screen for periodic jitter frequency analysis).
4. Select an analysis function (5 in Screen for periodic jitter decomposition analysis).

Button	Function
Jitter Trend	Displays the jitter trend and analyzes the total jitter.
Histogram	Displays the histogram and analyzes the total jitter.
PJ Separation	Displays the histogram and Gaussian and analyzes the total jitter and periodic jitter.

5. Turns on/off the jitter trend auto correction function (6 in Screen for periodic jitter decomposition analysis).

The average of the narrow band measurement frequencies used in transient measurement is set to the phase reference frequency offset value.

To turn on this function, select the **Auto Trend Correction** checkbox.

6. Select a display unit (2 in Screen for periodic jitter decomposition analysis).

Button	Function
sec	Displays data in the unit of second.
UI	Displays data in the unit of unit interval.

7. Select the **RUN** button (1 in Screen for periodic jitter decomposition analysis).

NOTE

The previous analysis result is cleared.

8. Measurement starts, and the analysis result is displayed.

Button	Function
Jitter Trend	<ul style="list-style-type: none">• Total jitter (p-p)• Total jitter (rms)• Clock
Histogram	<ul style="list-style-type: none">• Total jitter (p-p)• Total jitter (rms)• Sampling count• Clock
PJ Separation	<ul style="list-style-type: none">• Total jitter (p-p)• Total jitter (rms)• Periodic jitter (d -d)• Sampling count• Clock

NOTE

If fitting fails, ? (question mark) is added at the end of the analysis result.

9. Click the **STOP** button to finish the measurement (1 in Screen for periodic jitter decomposition analysis).

Example screen for periodic jitter decomposition analysis

Adjusting the position where the analysis result is displayed

You can display the result of periodic jitter decomposition analysis at your desired position. Clicking the **Adjust Position** button (7 in Screen for periodic jitter decomposition analysis) will bring up another window on which you can adjust the display position as shown in the figure below.

Saving analysis result

You can save the analysis result to a file. Follow the steps below.

1. Click the tab of the analysis result that you want to save. At this time analysis is carried out once.

2. Use the Save/Recall function to save the analysis result. For details, refer to File Saving and Loading Instrument Status Settings.

Recalling analysis result

You can recall the analysis result from a file by following the steps below.

1. Use the Save/Recall function. For details, refer to File Saving and Loading Instrument Status Settings.
2. Press the **Refresh** button (6 in Screen for random jitter analysis).

Saving analysis result to a file

You can save the result of random jitter analysis to a text file by pressing the **Export** button (7 in Screen for periodic jitter decomposition analysis).

Pressing the Export button opens the analysis result file in the Notepad application. Pressing the Export button during measurement writes the analysis result displayed at that time.

Note on measurement interruption

If you select another analysis function tab (RJ/PJ Frequency) during measurement, the current measurement is aborted. In this case, the # sign (10 in Screen for random jitter analysis) is displayed for the analysis result to indicate a possible mismatch of displayed information between the E5052B and VBA.

Note that the # sign is not displayed if the E5052B's displayed information is changed without using the VBA.

Installing the program

To install the program, you need to separately purchase the E5001A SSA-J option. After you purchase this, a license certificate is issued from Agilent Technologies.

Follow the instructions on the license certificate to access the Agilent Technologies license server and receive your license key code.

NOTE

License key codes are managed based on the serial number of the E5052B. The license for a certain E5052B cannot be transferred to any other E5052B.

There are two types of E5001A licenses: permanent license and limited-time license, which have different methods for entering the license code. For more information, see Example of entering a permanent license key code or Example of entering a limited-time license key code.

Follow these steps to enable this function after receiving your license key code.

Setting procedure

1. Press **System**.
2. Press the **Service Menu** button.
3. Press the **Install Option License** button.
4. Press the **Jitter** button.
5. The screen below appears for entering the license key code (SIGN=xxxxxx). After entering it, press the **Enter** key. After installation, the **Jitter** button is enabled (on).

NOTE

You can enter the license key code with the keyboard.

License key code entry screen

License Code for Jitter																	X
a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
s	t	u	v	w	x	y	z	1	2	3	4	5	6	7	8	9	0
'	-	=	[]	\	;	'	,	.	/		BS	Shift	Enter			

ssa0141

6. After entering the license code, the restart confirmation dialog box appears. Press **Yes** to restart the firmware.

Example of entering a permanent license key code

For the following sample permanent license, enter "128E234EE8B0."

```
FEATURE SSA-J Agilent 1.000 permanent uncounted \  
HOSTID=VDH=E5052A_JP1KL00066 SIGN=128E234EE8B0
```

Example of entering a limited-time license key code

For the following sample limited-time license, enter "1-apr-2006, 1-may-2006, 1269EA605D7C."

```
FEATURE SSA-J Agilent 1.000 1-may-2006 uncounted \  
HOSTID=VDH=E5052A_JP1KL00066 START=1-apr-2006 \  
SIGN=1269EA605D7C
```

Confirming installation of E5001A

You can confirm that the E5001 is installed by checking the following items.

- The return value of the *OPT? command (should be "SSA-J")
- Options displayed according to Checking the Product Information

- Options displayed at the startup of the E5052B

Error messages

If an error occurs during clock jitter measurement, a dialog box appears and the measurement stops. You may encounter the following messages.

Option SSA-J not Installed.
The E5001 (Option SSA-J) is not installed.
Unexpected error.
<p>This message may be displayed on the periodic jitter decomposition analysis screen.</p> <p>It indicates that the trend range of the current measurement is greatly different from those of previous measurements and thus analysis cannot be performed.</p>
Trigger error.
This message is displayed when the setting of the E5052B is changed during measurement and thus measurement cannot be triggered.
No AgtJitter data on SSA.
<p>This message may be displayed on the periodic jitter frequency analysis screen and the periodic jitter decomposition analysis screen.</p> <p>It indicates that no measurement data exists when you try to save/recall.</p>
File write error.
This message is displayed when writing to a file fails.

SSA-J Enhancement

NOTE

This information is relevant for SSA-J enhancement introduced in the E5052B Firmware revision A.03.10.

Data Save/Recall function

Previous to Firmware revision A.03.10, the SSA-J save/recall functionality used the E5052B save/recall function with using the trace data region for USER window. When the data was recalled, it required the User to press the SSA-J

renewal button after the recall. From ver A.03.10, this recall is automatic and User is not required to take any action.

NOTE

If save type value is not "State & Data" at saving time, SSA-J application Save/Recall doesn't operate.

NOTE

Even through recall, if the update button of SSA-J is not pressed, the recalled content is not reflected to SSA-J.

Command Addition for SSA-J Remote Control

From firmware revision A.03.10, two new commands SCPI.PROGRAM.COMMAND <command_string> and SCPI.PROGRAM.QUERY are added which can be used to control SSA-J remotely through a VBA program.

SCPI.PROGRAM.COMMAND <command_string> sends a OnCommand event to the VBA Application and the <command_string> is passed to the event handler as the parameter.

When this command is executed, the execution is followed with the description in OnCommand event handler written by VBA Application developer. Till the processing of this command continues, executing new command is not supported and generates an error (93, Program command error).

The following section explain the Event handler specifications for OnCommand:

OnCommand(ByVal CommandStr As String)

<command_string> passed in parameter for CommandStr :

PROGRAM:COMMAND

nError : if set other than 0, PROGRAM:COMMAND reports SCPI error.

:PROGRAM:QUERY? <query_string> sends a OnQuery event to the VBA Application and the <query_string> is passed to the event handler as the parameter. It can also be used to receive the return value for event handler as the query_response.

When this command is executed, the execution is followed with the description in OnQuery event handler written by VBA Application developer. Till the processing of this command continues, executing new command is not supported and generates an error (92, Program not running).

The following section explain the Event handler specifications for OnQuery:

OnQuery(ByVal QueryStr As String, RespStr As String)

<query_string> passed at the parameter for PROGram:QUERy?

This RespStr value is returned as the response of PROGram:QUERy?

nError : if set other than 0, PROGram:COMManD reports SCPI error.

Starting SSA-J

The E5052B executes the command sequence below when SSA-J application starts:

1. Saves settings for Save type (SCPI.MMEMory.STORe.STYPE) of Save/Recall function.
2. Sets the Save type value to **STaTe** (E5052B State Only).
3. Saves the current status.
4. Sets the Save type value to **DSTaTe** (E5052B State & Data)
5. Sets **Macro Setup** > **E5052 Event** > **ON**.

Refer to the command sequence below to start the SSA-J functionality remotely through VBA:

1. MMEMory:LOAD:PROGram "C:\Program Files\Agilent\E5052\vba\AgtJitter.vba".
2. PROGram:SElected:NAME "**E5052.Module1.main**".
3. PROGram:SElected:STaTe **RUN**.

Exiting SSA-J

The E5052B executes the command sequence below when SSA-J application exits:

1. Restores backup setting at boot for Save type (SCPI.MMEMory.STORe.STYPE) of Save/Recall function.
2. Recalls the state file to be saved at boot up.
3. Sets **Macro Setup** > **E5052 Event** > **OFF**.

To exit SSA-J application manually, click [x] right above button of the Jitter application window.

NOTE

When **AgtJitter.vba** is terminated with **Macro Break** key, the SSA-J application exits without performing the normal termination processing and is not a recommended process to exit from SSA-J application.

Use PROGram:COMMAnd "**CLOS**" to exit from SSA-J functionality remotely through VBA.

NOTE

When **AgtJitter.vba** is terminated with PROGram:SELEcted:STATe **STOP** Command remotely using VBA, the SSA-J application exits without performing the normal termination processing and is not a recommended process to exit from SSA-J application. A warning message in Echo window (If Echo State is ON) is displayed which can be turned ON/OFF using **Macro Setup > Echo Window Menu > Echo Window**.



ssa0172

SSA-J Remote Control (Control using VBA)

SSA-J remote control is executed through SCPI commands: SCPI.PROGram.COMMAnd and PROGram:QUERy?.

Following are the <command_string> that can be designated as the parameter of PROGram:COMMAnd.

- TRIG RUN : Trigger RUN
- TRIG STOP : Trigger STOP
- JUN SEC : jitter unit sec
- JUN UI : jitter unit UI
- UPD : Executes the renewal of the display.
- PAGE RJ : select RJ tab
- PAGE PJF : select PJ Frequency tab
- PAGE PJD : select PJ Decomposition tab
- IBWL <value> : Sets the Low side frequency of Integrated BW for RJ tab to <value>
- IBWH <value> : Sets the High side frequency of Integrated BW for RJ tab to <value>
- SORT JITT : Sort by Jitter

- SORT FREQ : Sort by Frequency
- ICL <value> : Sets the input clock frequency for PJ Decomposition tab to <value>.
- TPFR <value> : Sets the Target PJ frequency for PJ Decomposition tab to <value>
- PAN JTR : Jitter Trend
- PAN JHIS : Jitter Histogram
- PAN PJS : PJ Separation
- ATC ON|OFF : Auto trend correction setting for PJ Decomposition tab.
- CLOS : Exit SSA-J.

Following are the definition of <query_string> and <query_response> which can be designated as the parameter of PROGram:QUERy?

- TRIG (Response: RUN|STOP|WAIT) : WAIT is returned at the waiting status for the end of measurement. (The status from TRIG STOP is received to the actual end of measurement)
- JUN (Response: SEC|UI)
- PAGE (Response: RJ|PJF|PJD>
- RJDC (Response: <value>) : Queries the Detected clock value for RJ tab [Query only]
- RJIT (Response: <value>) : Queries the Jitter value for RJ tab [Query only]
- IBWL (Response: <value>)
- IBWH (Response: <value>)
- SORT (Response: JITT|FREQ)
- PFDC (Response: <value>) : Queries the Detected clock value for PJ frequency tab [Query only]
- JLIS : Queries the content of the list ordering frequency1, jitter1, frequency2, jitter2, ... displayed in jitter list [Query only]
- ICL (Response: <value>)
- TPFR (Response: <value>)
- PAN (Response: JTR|JHIS|PJS)
- ATC (Response: ON|OFF)
- PPTJ (Response: <value>) : Queries the PP TJ value of Result window for PJ Decomposition tab [Query only]

- RTJ (Response: <value>) : Queries the RMS TJ value of Result window for PJ Decomposition tab [Query only]
- NSAM (Response: <value>) : Queries the # Samples value of Result window for PJ Decomposition tab [Query only]
- RPJ (Response: <value>) : Queries the RMS PJ dd value of Result window for PJ Decomposition tab [Query only]
- PJDD (Response: <value>): Queries the RMS PJ dd value of Result window for PJ Decomposition tab [Query only]
- PDDC (Response: <value>): Query the Det. Clock value of Result window for PJ Decomposition tab. On screen display, it is displayed when Auto trend correction value is ON.
- ERR (Response: <string>): Returns the error occurred in the end of SSA-J command/query performance. [Query only]. After query, the content of the error is cleared. A SCPI error occurs with PROGram:COMManD, PROGram:QUERy?.

When (93, Program command error) occurs, the the command is enable to get the further information and any of the following values is returned:

- No error
- Invalid character
- Invalid separator
- Parameter not allowed
- Missing parameter
- Undefined header
- Invalid character in number
- Exponent too large
- Suffix not allowed
- Character data not allowed
- Execution error
- Data out of range
- Illegal parameter value

For example, when perform PROGram:COMManD "IBWL 1.0E30000", 93, Program command error is reported as SCPI error. After that, "Exponent too learge" is returned as the result of query if perform PROGram: QUERy? "ERR".