DDR Analysis

Online Help

077-0231-01

Tektronix

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www.tektronix.com

077-0231-01

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DDR Analysis Online Help Part Number, 076-0178-01

Contacting Tektronix

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For product information, sales, service, and technical support:

- In North America, call 1-800-833-9200.
- Worldwide, visit www.tektronix.com to find contacts in your area.

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General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

While using this product, you may need to access other parts of a larger system. Read the safety sections of the other component manuals for warnings and cautions related to operating the system.

To Avoid Fire or Personal Injury

Use Proper Power Cord. Use only the power cord specified for this product and certified for the country of use.

Connect and Disconnect Properly. Do not connect or disconnect probes or test leads while they are connected to a voltage source.

Connect and Disconnect Properly. Connect the probe output to the measurement instrument before connecting the probe to the circuit under test. Connect the probe reference lead to the circuit under test before connecting the probe input. Disconnect the probe input and the probe reference lead from the circuit under test before disconnecting the probe from the measurement instrument.

Observe All Terminal Ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

Do Not Operate With Suspected Failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Avoid Exposed Circuitry. Do not touch exposed connections and components when power is present.

Terms in this Manual

These terms may appear in this manual:

WARNING. *Warning statements identify conditions or practices that could result in injury or loss of life.*

CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Welcome

DDR (Dual Data Rate) is a dominant and a fast growing memory technology. It offers the high data transfer rates needed for virtually all computing applications, from consumer products to the most powerful servers. The high speeds of these signals require high performance measurement tools.

The DDRA application includes compliance measurements as part of our DDR Analysis solution. The DDR Analysis solution enables you to achieve new levels of productivity, efficiency, and measurement reliability. It requires the Jitter and Eye Diagram Analysis tool (Opt. DJA) and the Advanced Search and Mark capability (Opt. ASM).

Some of the DDRA features are:

- Provides debug, analysis, and compliance into one solution for multiple DDR standards such as DDR (see page 1), DDR2 (see page 1), DDR3 (see page 2), LPDDR (see page 2) and GDDR3 (see page 2)
- Enables analysis of compliance measurements either through the DDRA or DPOJET application for all bursts in an acquisition
- Differentiates data reads from writes, or analyzes signal integrity on the clock or on a data (DQ) line during Read or Write cycles, or measures Data to Strobe setup and hold during Write cycles
- Includes limit files to test measurement pass/fail status per standard, speed grades and speed bins. Supports non-standard speed grades
- Provides both single-ended and differential measurements on Data, Strobe, Clock, Address and Command signals
- Includes comprehensive measurement statistics
- Includes sophisticated graphical analysis tools such as Histograms, Time Trends, Spectrums, Bathtub Plots, and Real-Time Eye® diagrams with superimposition of the strobe eye with the data eye
- Produces consolidated HTML reports automatically with pass/fail information, statistical measurement results, setup information and plots
- Automatically applies signal slew rate derating of measurement limits for Address/Command and data signals
- Dynamically normalizes limits for clock measurements such as tERR based on the measured tCK(avg)

DDR

DDR is the DRAM (Dynamic Random Access Memory) technology responsible for increasing data transfer rates to meet high-speed requirements and data capacity of computer systems.

DDR2

DDR2 is the Double Data Rate 2 SDRAM and is widely available in products with data rates up to 1066MT/s.

DDR3

DDR3 DRAM memory is widely available in products and extends data rates to 1600 MT/s and faster rates to come.

Low Power DDR

LPDDR (Low Power DDR) is an emerging technology for mobile phones and portable computing devices, driven by the need for faster operation with long battery life.

Graphic DDR3

GDDR3 (Graphic DDR) offers faster access and is used in graphics-intensive applications such as video cards and gaming systems.

Related Documentation

Tektronix manuals are available at: www.tektronix.com/manuals and www.tektronix.com/software. Use the following table to determine the document that you need:

Table 1: List of reference documents

For information on	Refer to
■ Operating the Oscilloscope	Oscilloscope user manual. Oscilloscope user online help.
■ Software warranty ■ List of available applications ■ Compatible oscilloscopes ■ Relevant software and firmware version numbers ■ Applying a new option key label ■ Installing an application ■ Enabling an application ■ Downloading updates from the Tektronix Web site	*Optional Applications Software on Windows-Based Oscilloscopes Installation Manual*, which is provided on the Optional Applications Software on Windows-Based Oscilloscopes DVD, in the Documents directory.

Conventions

Online Help uses the following conventions:

- When steps require a sequence of selections using the application interface, the “>” delimiter marks each transition between a menu and an option. For example, **Analyze > DDR Analysis.**
- The terms “DDR application” and “application” refer to DDRA.
- The term “DPOJET application or “DPOJET” refers to Jitter and Eye Diagram Analysis Tool.
- The term “oscilloscope” refers to any product on which this application runs.
- The term “DUT” is an abbreviation for Device Under Test.
- The term “select” is a generic term that applies to the methods of choosing an option: with a mouse or with the touch screen.
- User interface screen graphics are taken from a DPO7000 series oscilloscope.

You can find a PDF (portable document format) file for this document in the Documents directory on the *Optional Applications Software on Windows-Based Oscilloscopes DVD*. The DVD booklet contains information on installing the application from the DVD and on how to apply a new label. You can also find the PDF and the Online Help at **Start > Programs >TekApplications > DDRA**.

Table 2: Icon descriptions

Icon	Meaning
	This icon identifies important information.
	This icon identifies conditions or practices that could result in loss of data.
	This icon identifies additional information that will help you use the application more efficiently.

Technical Support

Tektronix welcomes your comments about products and services. Contact Tektronix through mail, telephone, or the Web site. Click Contacting Tektronix for more information. Tektronix also welcomes your feedback. Click Customer feedback for suggestions for providing feedback to Tektronix.

Customer Feedback

Tektronix values your feedback on our products. To help us serve you better, please send us your suggestions, ideas, or other comments you may have regarding the application or oscilloscope.

Direct your feedback via e-mail to

techsupport@tektronix.com

Or FAX at (503) 627-5695, and include the following information:

General Information

- Oscilloscope model number (for example: DPO7000 or DSA/DPO70000/B series) and hardware options, if any.
- Software version number.
- Probes used.

Application-specific Information

- Description of the problem such that technical support can duplicate the problem.
- If possible, save the oscilloscope and application setup files as `.set` and associated `.xml` files.
- If possible, save the waveform on which you are performing the measurement as a `.wfm` file.

Once you have gathered this information, you can contact technical support by phone or through e-mail. In the subject field, please indicate "DDRA Problem" and attach the `.set`, `.xml` and `.wfm` files to your e-mail. If there is any query related to the actual measurement results, then you can generate a `.mht` report and send it. If you need to send very large files, technical support can assist you to transfer the files via ftp (file transfer protocol).

The following items are important, but optional:

- Your name
- Your company
- Your mailing address
- Your phone number
- Your FAX number

Enter your suggestion. Please be as specific as possible.

Please indicate if you would like to be contacted by Tektronix regarding your suggestion or comments.

Product Description

DDR Analysis is a standard specific solution tool for Tektronix Performance Digital Oscilloscopes (DPO7000 and DSA/DPO70000/B series). DDR Analysis requires Jitter and Eye Diagram Analysis Tool (Opt.DJA) and the advanced Search and Mark capability (Opt. ASM).

The features of DDRA are:

- Provides debug, analysis, and compliance in one solution for multiple DDR standards such as DDR (see page 1), DDR2 (see page 1), DDR3 (see page 2), LPDDR (see page 2), and GDDR3 (see page 2)
- Supports multiple standards such as DDR, DDR2, DDR3, LPDDR and GDDR3
- Identifies Read and/or Write operations automatically
- Custom data rates and input levels to tailor DDRA Read and/or Write burst identification
- Provides both single-ended and differential measurements on Data, Strobe, Clock, Address and Command signals
- Analyze compliance measurements either through DDRA or Jitter and Eye Diagram Analysis Tool
- Limit files to test measurement pass/fail status
- Automatically applies signal slew rate derating of measurement limits for Address/Command and data signals
- Dynamically normalizes limits for clock measurements such as tERR based on the measured tCK(avg)

DDRA Prerequisites

To use the DDRA application, you need to have Opt. ASM (Advanced Search and Mark Tool) and DPOJET Advanced (Opt. DJA) enabled.

Requirements and Restrictions

Microsoft .NET Framework version 3.0 or higher, and MATLAB Component Runtime 7.5 are required to operate DDRA on your oscilloscope. These are included in the distribution and automatically installed with DDRA, if not already present.

Supported Probes

The application supports the following probes:

- TAP2500
- TAP1500
- TCP0030
- P6158
- P6101B
- P6246
- P6247 (DPO7254 only)
- P6248 (DPO7254 only)
- P6249
- P6150
- P6158
- P7240
- P7260
- P7330
- P7340A
- P7350
- P7360A
- P7380A
- P7313A
- P7513
- P7500 Series TriMode

Installing the Application

Refer to the *Optional Applications Software on Windows-Based Oscilloscopes Installation Manual* for the following information:

- Software warranty.
- List of available applications, compatible oscilloscopes, and relevant software and firmware version numbers.
- Applying a new option installation key label.
- Installing an application.

- Enabling an application.
- Downloading updates from the Tektronix Web site.

You can find a PDF (portable document format) file for this document in the Documents directory on the *Optional Applications Software on Windows-Based Oscilloscopes DVD*. The DVD booklet contains information on how to install the application from the DVD and on how to apply a new option installation key label.

About DDRA

Click **Help** > **About DDRA** to view application details such as the software released version number, application name and copyright.

Starting the Application

On the oscilloscope menu bar, click **Analyze** > **DDR Analysis** to open the application.

Menu Controls

Table 3: Application Menu Controls descriptions

Item	Description
Tab	Shortcut to a menu in the menu bar or a category of menu options; most tabs are short cuts.
Area	Visual frame with a set of related options.
Option button	Button that defines a particular command or task.
Field	Box that you can use to type in text, or to enter a value with the Keypad or a Multipurpose knob.
Check Boxes	Use to select configuration options or clear preferences.
Browse	Displays a window where you can look through a list of directories and files.
Command button	Button that initiates an immediate action such as Run command button  in the control panel.
Virtual Keypad icon 	Click to use on-screen keypad to enter alphanumeric values.
MP knob references (a or b)  	Identifiers that show which Multi Purpose Knob (MPK) may be used as an alternate means to control a parameter; turn the knob on the oscilloscope front panel to adjust the corresponding parameter. Also, the value can be entered directly on the MPK display component.

Virtual Keypad

Select the  icon and use the virtual keypad to enter alphanumeric values, such as reference voltage levels.

Tips on the DDRA User Interface

Here are some tips to help you with the application user interface:

- Use the Single button  to obtain a set of measurements from a single new waveform acquisition. Pushing the button again before processing has completed will interrupt the processing cycle.
- Use the Run button  to continuously acquire and accumulate measurements. If prior measurements have been acquired and have not been cleared, the new measurement are added to the existing set. Push the button again to interrupt the current acquisition.
- Use the Recalc button  to perform measurements on the waveform currently displayed on the oscilloscope without performing a new acquisition. This is useful if you wish to modify a configuration parameter and re-run the measurements on the current waveform.
- Use the Clear button  to clear all existing measurement results. Note that adding or deleting a measurement, or changing a configuration parameter of an existing measurement, will also cause measurements to be cleared. This is to prevent the accumulation of measurement statistics or sets of statistics that are not coherent.

Application Directories

The installation directory for DDRA executables is `C:\Program Files\TekApplications\DDRA` and the installation directory for user files is `C:\TekApplications\DDRA`. During installation, the application sets up a limits folder in the user directory. This folder contains limit files for various DDR standards and speed grades.

File Name Extensions

Table 4: File name extensions

File Extension	Description
`.csv`	An ascii file containing Comma Separated Values. This file format may be read by any ascii text editor (such as Notepad) or may be imported into spreadsheets such as Excel.
`.xml`	An ascii file containing measurement setup information, limits or other data in Extensible Markup Language.
`.set`	A binary file containing oscilloscope setup information in a proprietary format.
`.mht`	An HTML archive file, compatible with common Windows applications; contains the full report, including text and graphics.
`.wfm`	A binary file containing an oscilloscope waveform record in a recallable, proprietary format.

Returning to the Application

When you access oscilloscope functions, the DDRA control windows may be replaced by the oscilloscope control windows or by the oscilloscope graticule. You can access oscilloscope functions in the following ways:

- From the menu bar on the oscilloscope, choose **Analyze > DDR Analysis**.
- Alternatively, you can switch between recently used control panels using the forward or backward arrows  on the right corner of the control panel.

Control Panel

The Control Panel appears on the right of the application window. Using this panel, you can start or stop the sequence of processes for the application and the oscilloscope to acquire information from the waveform. The controls are Clear, Recalc, Single, and Run. The following table describes each of these controls:

Item	Description
Clear	Clears the current result display and resets any statistical results and autoset ref levels. For any input sources that have reference level autoset enabled, clears the current ref levels so that they will be recalculated during the next acquisition.
Recalc	Runs the selected measurements on the currently displayed waveform(s), without first performing a new acquisition.
Single	Initiates a single new acquisition and runs the selected measurements.
Run	Initiates new acquisitions and runs the selected measurements repeatedly until Stop is clicked. For any non-live sources (Reference waveforms or Math waveforms not dependent on a live channel), only a single processing cycle will occur.
Show Plots	Displays the plot summary window when clicked. This button appears in the control panel only when one or more plots have been defined.
Advanced Setup DPOJET 	Transitions to the Jitter and Eye Diagram Analysis application when clicked, importing all currently defined DDRA measurements. This button appears in the control panel when you open the DDR analysis application. This is useful if you wish to add additional measurements not defined in DDRA, or wish to change measurement configurations to intentionally deviate from those recommended by DDRA.

Saving a Setup

The DDRA application state is automatically saved along with the oscilloscope state. To save the oscilloscope settings and the application state, follow these steps:

1. Click **File** > **Save As** > **Setup**.
2. In the file browser, select the directory to save the setup file.
3. Select or enter a file name. The application appends `*_DDRA.xml` and `*_DPOJET.xml` to store the DDR setup, and *.set to store the oscilloscope settings.
4. Click **Save**.

NOTE. *After the oscilloscope application is started, DDRA needs to be launched at least once before any saved DDRA configuration can be recalled.*

Recalling a Saved Setup

To recall a previously saved set of application and oscilloscope settings, do the following steps:

1. Click **File > Recall..**.
2. Click **Setup** in the left column if it is not already selected.
3. Select the directory in the file browser from which you wish to recall the setup file.
4. Select a .set file and click **Recall**.

NOTE. *Only .set files can be selected for recall; any corresponding *_DDRA.xml and *_DPOJET.xml file in the same directory will be recalled as well, if DDRA has been launched at least once since the oscilloscope application was started. If DDRA has not been launched at least once, the oscilloscope settings will be recalled but the DDRA configuration will be ignored.*

Recalling the Default Setup

To recall the default application and oscilloscope settings, click **File > Recall Default Setup**.

NOTE. *Recalling default setup sets the DDRA application to DDR3 generation and data rate, None.*

Limits

A limits file allows you to configure the limits used to determine Pass or Fail status for tests. Each limits file includes a list of one or more measurements, and the ranges of acceptable values for any or all statistics for each measurement that include combinations of all measurements and statistical characteristics, and an appropriate range of values for each combination.

The application provides preconfigured limits files for many combinations of standards and speed grades. You can create one by specifying limits for any of the result parameters such as Mean, Std Dev, Max, Min, peak-to-peak, population, MaxPosDelta and MinPosDelta. For each of these result parameters, you can specify the Upper Limit Equality (ULE), Lower Limit Equality (LLE), or Both. The measurement names in the limits file must be entered as mentioned in About DDR Analysis.

To include Pass/Fail status in the result statistics, you can create a custom limits file in the following format using an XML editor or any other editor. If the file is created in any other editor such as Notepad, it should be saved in Unicode format.

The following is a sample of the limit file for DDR2 generation, the data rate being 667 MHz

```
<?xml version="1.0" encoding="utf-16" ?>
<Main>
<Measurement>
<NAME>DDR Hold-Diff</NAME>
<STATS>
<STATS_NAME>Min</STATS_NAME>
<LIMIT>BOTH</LIMIT>
<ULE>175e-12</ULE>
<LLE>0</LLE>
</STATS>
</Measurement>
<Measurement>
<NAME>tDH-Diff(base)</NAME>
<STATS>
<STATS_NAME>Min</STATS_NAME>
<LIMIT>BOTH</LIMIT>
<ULE>175e-12</ULE>
<LLE>0</LLE>
</STATS>
</Measurement>
</Main>
```

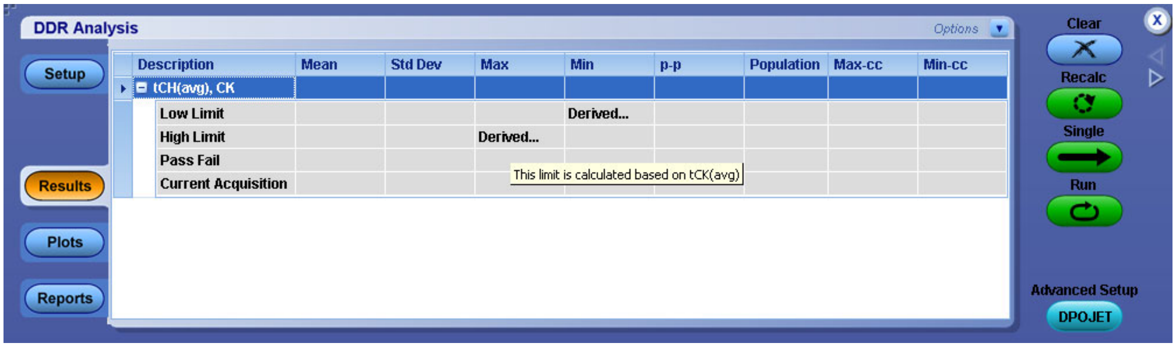
You can find limit files for various data rates of different DDR standards and speed bins at `C:/TekApplications/DDRA/Limits`.

Dynamic Limits

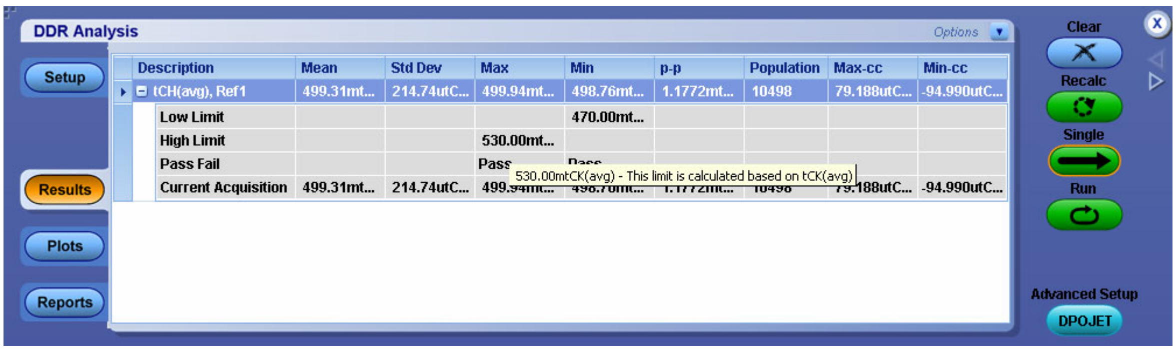
The application supports both static (predefined using limits file) and dynamic limits. Dynamic limits are available only for DDRA clock measurements. They are calculated using the result of other measurement(s).

The concept of dynamic limits is explained taking an example of a measurement, tCH(avg):

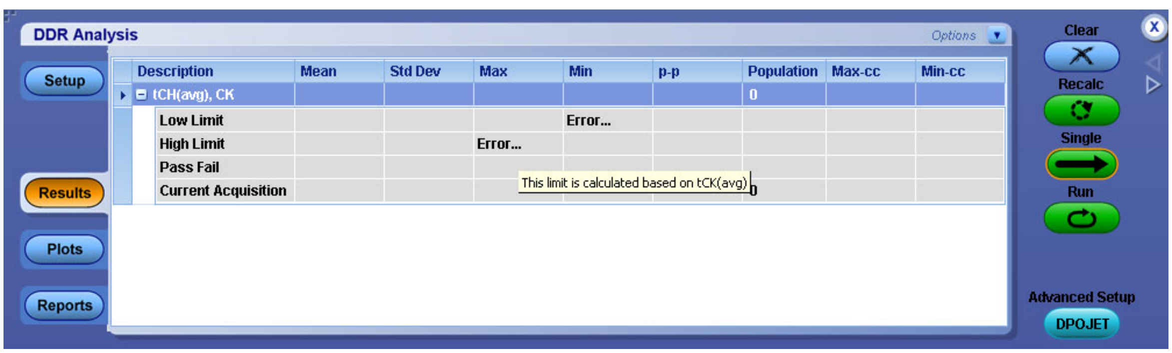
- If the dynamic limits of a measurement depend on the result of other measurement(s) that has not yet been calculated, the limit text field in the results panel shows “Derived...”. A tool tip displays the message “This limit is calculated based on measurement tCK(avg)”.



- On clicking Run/Single, the results are shown in the following figure:



- If there is an error in calculating dynamic limits, the limit text field displays “Error...” as shown. A tool tip displays the message “This limit is calculated based on measurement tCK(avg)”.



References

- Dynamic Limits for LPDDR Measurements
- Dynamic Limits for DDR Measurements
- Dynamic Limits for DDR2 Measurements
- Dynamic Limits for DDR3 Measurements

DDR Standards and their Measurements

The following table lists the measurements displayed for each DDR standard:

NOTE. *For more details on the measurements, refer to the Algorithms section.*

Measurements	DDR	DDR2	DDR3	LP-DDR ‡	GDDR3 †
Write Bursts					
Data Eye Width	✓	✓	✓	✓	✓
Slew Rate-Hold-Fall(DQ)		✓	✓		
Slew Rate-Hold-Rise(DQ)		✓	✓		
Slew Rate-Hold-SE-Fall(DQS)		✓			
Slew Rate-Hold-SE-Rise(DQS)		✓			
Slew Rate-Setup-Fall(DQ)		✓	✓		
Slew Rate-Setup-Rise(DQ)		✓	✓		
Slew Rate-Setup-SE-Fall(DQS)		✓			
Slew Rate-Setup-SE-Rise(DQS)		✓			
tDH-Diff(base)		✓	✓	✓	
tDH-Diff(derated)		✓			
tDH-SE(base)	✓	✓	✓	✓	
tDH-SE(derated)		✓			
tDQSH		✓	✓	✓	
tDQSL		✓	✓	✓	
tDS-SE(base)	✓	✓	✓	✓	
tDS-SE(derated)		✓			
tDS-Diff(base)		✓	✓	✓	
tDS-Diff(derated)		✓			

Measurements	DDR	DDR2	DDR3	LP-DDR ‡	GDDR3 †
tDIPW-SE	✓	✓	✓	✓	
tDSS-Diff	✓	✓	✓	✓	
tDSS-SE	✓	✓	✓	✓	
tDQSS-Diff	✓	✓	✓	✓	
tDQSS-SE	✓	✓	✓	✓	
tDSH-Diff	✓	✓	✓	✓	
tDSH-SE	✓	✓	✓	✓	
Read Bursts					
Data Eye Width	✓	✓	✓	✓	✓
tDQSCK-Diff	✓	✓	✓	✓	
tDQSCK-SE		✓			
tDQSQ-Diff		✓	✓		
tDQSQ-SE	✓	✓		✓	
tAC-Diff	✓	✓		✓	
tQH	✓	✓	✓	✓	
Slew Rate(Diff)					
Input Slew-Diff-Fall(DQS)		✓			
Input Slew-Diff-Rise(DQS)		✓			
Input Slew-Diff-Rise(CK)		✓			
Input Slew-Diff-Fall(CK)		✓			
SRQdiff-Rise(DQS)			✓		
SRQdiff-Fall(DQS)			✓		
SRQdiff-Rise(CK)			✓		
SRQdiff-Fall(CK)			✓		
Clock(Diff)					
tCH(abs)		✓	✓		
tCH(avg)		✓	✓		
tCK(abs)		✓	✓		
tCK(avg)		✓	✓		
tCL(abs)		✓	✓		
tCL(avg)		✓	✓		

Measurements	DDR	DDR2	DDR3	LP-DDR ‡	GDDR3 †
tERR (Includes measurements from tERR2 to 49per)			✓		
tERR(11–50per)		✓			
tERR(2per)		✓			
tERR(3per)		✓			
tERR(4per)		✓			
tERR(5per)		✓			
tERR(6–10per)		✓			
tJIT(cc)		✓	✓		
tJIT(duty)		✓	✓		
tJIT(per)		✓	✓		
tHP		✓			
VID(ac)	✓	✓		✓	
Clock(Single Ended)					
Vix(ac)CK	✓	✓		✓	
Vox(ac)CK		✓			
AC-Over-shoot(CK)	✓	✓	✓	✓	
AC-Over-shoot(CK#)	✓	✓	✓	✓	
AC-Under-shoot(CK)	✓	✓	✓	✓	
AC-Under-shoot(CK#)	✓	✓	✓	✓	
DQS(Single Ended)					
Vix(ac)DQS	✓	✓		✓	
Vox(ac)DQS		✓			
AC-Over-shoot(DQS)	✓	✓	✓	✓	
AC-Over-shoot(DQS#)	✓	✓	✓	✓	
AC-Under-shoot(DQS)	✓	✓	✓	✓	
AC-Under-shoot(DQS#)	✓	✓	✓	✓	
Address/Command					
tIS(base)	✓	✓	✓	✓	
tIH(base)	✓	✓	✓	✓	

Measurements	DDR	DDR2	DDR3	LP-DDR ‡	GDDR3 †
tIS(derated)		✓	✓		
tIH(derated)		✓	✓		
tIPW-High	✓	✓	✓	✓	
tIPW-Low	✓	✓	✓	✓	
AC-Overshoot	✓	✓	✓	✓	
AC-Undershoot	✓	✓	✓	✓	

‡ The clock measurements displayed for LPDDR and DDR standards are tCH, tCK, tHP,, and tCL.

† The application displays a hint on selecting GDDR3 as the standard: "GDDR3 not completely supported. Some features may not function".

Derating

Signal slew rate derating is required to verify the setup and hold timing requirements on address/command and data signals. The base setup and hold limits are defined using input signals that have a 1.0 V/ns slew rate. To determine final pass/fail status, the limits must be adjusted based on the actual slew rates of the target signals, according to derating tables appearing in the DDR2 and DDR3 specifications.

DDR2 derated measurements for data signals are as follows:

- tDS-SE(derated)
- tDH-SE(derated)
- tDS-Diff(derated)
- tDH-Diff(derated)

DDR3 derated measurements are as follows:

- tDS-Diff(derated)
- tDH-Diff(derated)

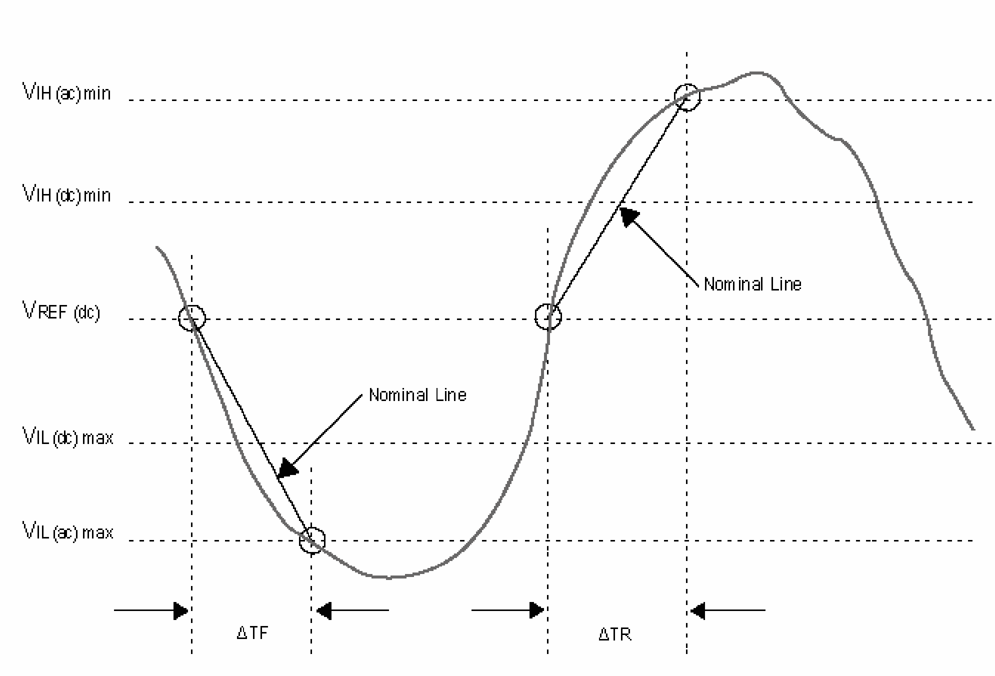
The DDR2/DDR3 Address/Command derated measurements are as follows:

- tIH(derated)
- tIS(derated)

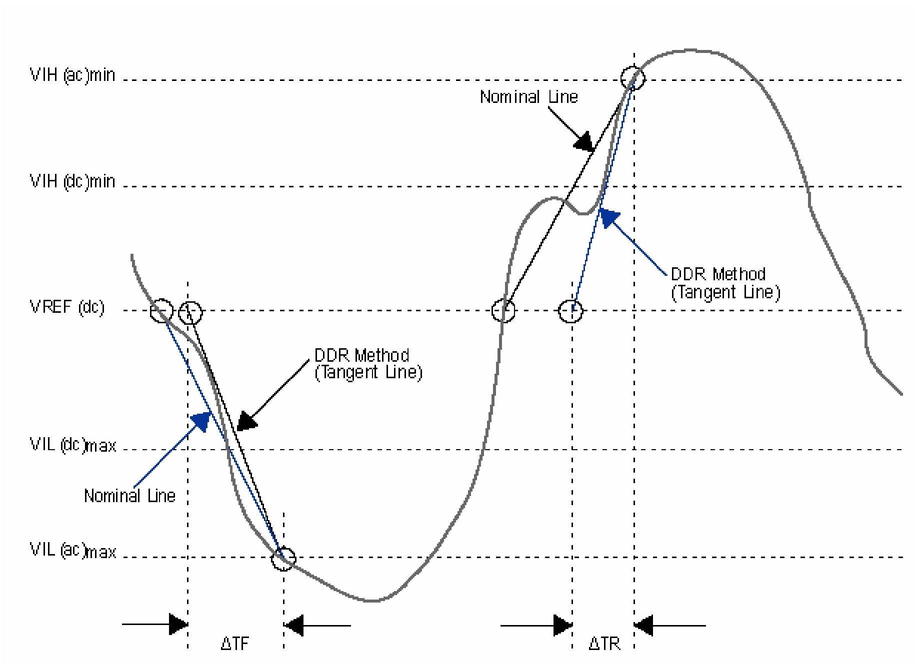
The derated value (Δ) is calculated as per the JEDEC standard using either the DDR Method or Nominal Method, depending on the user configuration.

Derating is explained taking an example of Setup(tIS) measurement. The same concept is applicable for other derated measurements.

When the nominal method is set, Setup(tIS) nominal slew rate for a rising signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IH(ac)min}$. Setup (tIS) nominal slew rate for a falling signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IL(ac)}$max.



If the DDR Method is set, the application takes the maximum slope. This method is applicable if the actual signal is earlier than the nominal slew rate line.



According to the specified reference levels, rise slew rate is always positive whereas fall slew rate is negative. A single slew rate value is obtained by averaging the absolute values of rise and fall slew rate. Using this value and a similarly-derived slew rate for the clock signal, the total setup time (tIS) is calculated by adding ΔtIS to the tIS(base)limit from the following table:

Table 5: Address/Command Setup and Hold Values

Units(ps)	DDR3–800	DDR3–1066	DDR3–1333	DDR3–1600
tIS(base)	200	125	65	45
tIH(base)	275	200	140	120

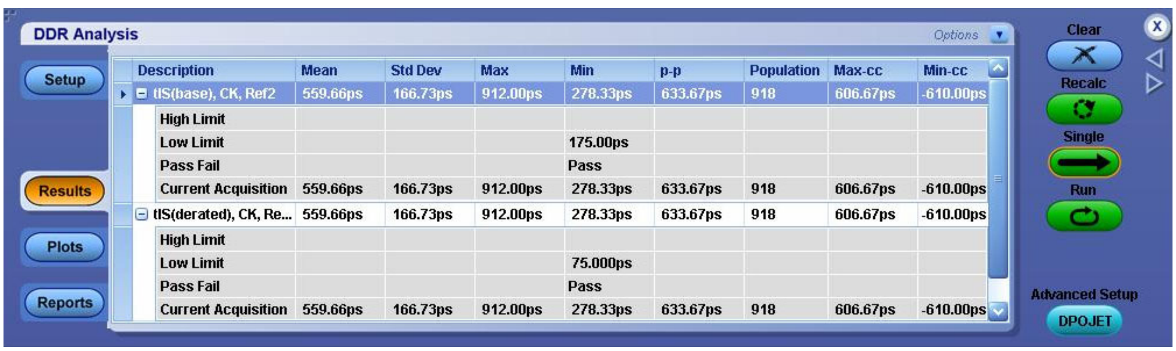
ΔtIS is determined using the derating table (AC 175 (see page 35)), where the Y-axis represents the Address/Command slew rate and the X-axis, the clock differential value. By indexing the Address/Command value and Clock differential value, ΔtIS value is obtained from AC175 table.

The calculated slew rate is approximated to the derating table specified value (Example: 0.4 V/ns ≈ 1.0V/ns). For values greater than 4.0 V/ns, the table returns the base limit value.

For example: For a Clock differential value= 1.0 V/ns, Address/Command Slew Rate =1.0 V/ns, and AC 175 Threshold selected in Step 5 (see page 33), the resulting derated values are:

$tIS_{deratedlimit}$= $tIS(base)_{limit}$+ΔtIS.
$tIS_{deratedlimit}$= 200+ 40= 240

The result statistics of the both tIS(base) and tIS(derated) are the same as shown in the following figure. In case of derating, the limit values get changed depending on the signal slew rate.



Reference

- DDR3 Measurement Sources
- DDR2 Measurement Sources

About DDR Analysis

The DDR Analysis window allows you to select various standards, set up and run a pre-configured measurement either through the DDRA or the DPOJET application.

Select **Analyze > DDR Analysis** to open the DDRA application.

The setup panel in the DDR Analysis application includes the following steps:

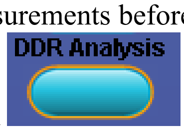
- Generate Rate and Levels
- Measurements
- Sources
- Burst Detection
- Thresholds and Scalings

NOTE. *You can use the Next/Prev buttons or click directly on the step numbers to traverse through the steps in the DDR Analysis. The steps for which configuration is complete are denoted* .

The setup panel displays hints to help you understand the configuration options wherever applicable.

You can run a set of measurement in either of the two ways:

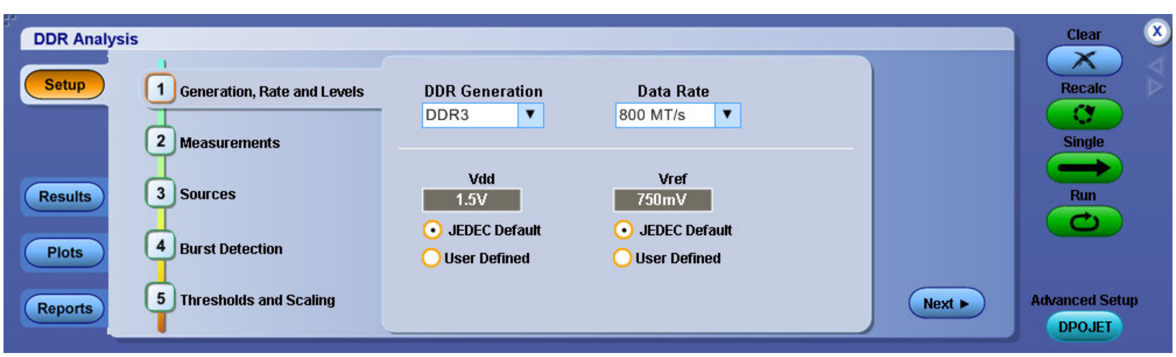
- Click **Run** to start the acquisition sequence using the selected settings and to view the results in the DDRA window. This is the normal way to generate results.
- Click 

to move to the DPOJET application, where you can add or modify measurements before sequencing. For more details, refer to the DPOJET Online Help. You need to click 

in the DPOJET application to return to the DDRA window. Alternatively, you can reselect **Analyze >DDR Analysis** from the menu bar.

Step1: Generation, Rate and Levels

Select the DDR generation, data rate and the voltage levels (if required). There are different speed bins for each standard data rate for specific DDR generations.



1. Select the DDR Generation from the drop-down list.
2. Select the Data Rate from the drop-down list. On selecting Custom, an edit box allows you to enter the value using the virtual keypad. Limit files are not defined for custom data rates for Pass/Fail status and as a result the application displays a hint at the bottom of the screen "Please provide a limits file under Jitter and Eye > Limits". Note that selecting non-standard data rates in ASM (under Search > DDR Read or DDR Write), changes the data rate to "None" in DDRA.
3. Set the voltage levels:
   - If you select JEDEC Defaults, the application uses the nominal voltage levels according to the JEDEC specification.
   - If you select User Defined, enter the Vdd (see page 23) or Vref (see page 23) voltage values using the virtual keypad.

Vdd

Is the supply voltage for each DDR standard. Vdd is based on DDR generation.

Vref

Is the reference voltage for each DDR standard. Vref is calculated using Vdd, which in turn is based on DDR generation. In most cases, Vref=0.5Vdd.

The following table lists the minimum and maximum values of Vdd and Vref in the **User Defined** mode for all DDR generations:

DDR Generations	Vdd			Vref		
	Default	Min	Max	Default	Min	Max
DDR ‡	2.5 V	1.5 V	3.6 V	1.25 V	750 mV	1.8 V
DDR2	1.8 V	1.08 V	2.52 V	900 mV	540 mV	1.26 V
DDR3	1.5 V	900 mV	2.1 V	750 mV	450 mV	1.05 V
LPDDR	1.8 V	1.08 V	2.52 V	900 mV	540 mV	1.26 V
GDDR3	1.8 V	1.08 V	2.52 V	900 mV	540 mV	1.26 V

‡ DDR 400 MT/s has Vdd value set to 2.6 V.

NOTE. *If you select Manual Threshold Settings in Step 5 and then subsequently choose user-defined Vdd or Vref voltages in Step 1 , the following message is displayed "You have selected manual control of measurement thresholds in Step 5. Please verify that they are appropriate for these settings". This is because the Vref voltage is normally used to determine the proper high, mid, and low thresholds. If these thresholds are under manual control, there is no point in manually setting Vref.*

Vdd and Vref

The configured values of Vdd and Vref are used to calculate $V_{IH(ac)}$min, $V_{IH(dc)}$min, $V_{IL(dc)}$max and $V_{IL(ac)}$max, which are applied on the input signal. These levels are further used for calculating Setup and Hold measurements.

For DDR2, the relationship between Vdd and Vref is as shown in the following tables:

Table 6: Input DC logic Level

Symbol	Parameter	Min	Max	Units
$V_{IH(dc)}$	DC input logic high	Vref+0.125	–	V
$V_{IL(dc)}$	DC input logic low	–0.3	Vref–0.125	V

Table 7: Input AC logic Level

Symbol	Parameter	DDR2–400, DDR2–533		DDR2–667,DDR2–800		Units
		Min	Max	Min	Max	
$V_{IH(ac)}$	AC input logic high	Vref+0.250	–	Vref+0.200	–	V
$V_{IL(ac)}$	AC input logic low	–	Vref–0.250	–	Vref+0.200	V

NOTE. *Similar reference voltage levels are defined for DDR3 standard.*

Speed Bins

For each DDR standard, the DDRA application automatically applies limits appropriate for the standard data rates without speed bins. Limit values are different for different speed bins. If you want to test according to a speed bin, you must manually configure the limit values from within DPOJET by manually overriding the limit file before running the measurements.

For more details, refer to the topic "**Limits**" of the DPOJET help.

The following table lists the speed bins available for which pre-configured limit files are provided:

DDR Generation	Speed bins
DDR-400	400A, 400B and 400C
DDR2	
DDR2-667	800C and 800D
DDR2-800	800C, 800D and 800E
DDR3	
DDR3-800	800D and 800E
DDR3-1066	1066E, 1066F and 1066G

DDR Generation	Speed bins
DDR3-1333	1333F *, 1333G, 1333H and 1333J *
DDR3-1600	1600G †, 1600H, 1600J and 1600K †

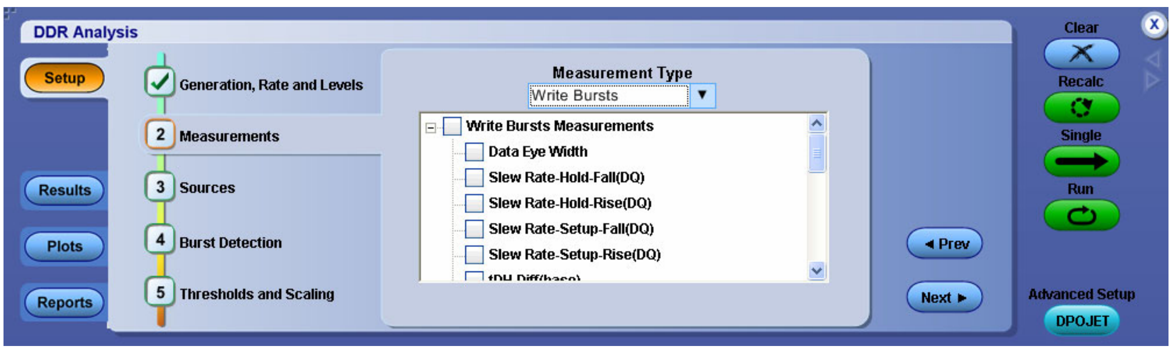
* 1333F and 1333J are optional

† 1600G and 1600K are optional

NOTE. *You can find limit files for various speed bins at* `C:\TekApplications\DDRA\Limits`*. You need to manually select these limit files by clicking **Analyze** > **Jitter and Eye Analysis** > **Preferences** > **Limits**.*

Step2: Measurements

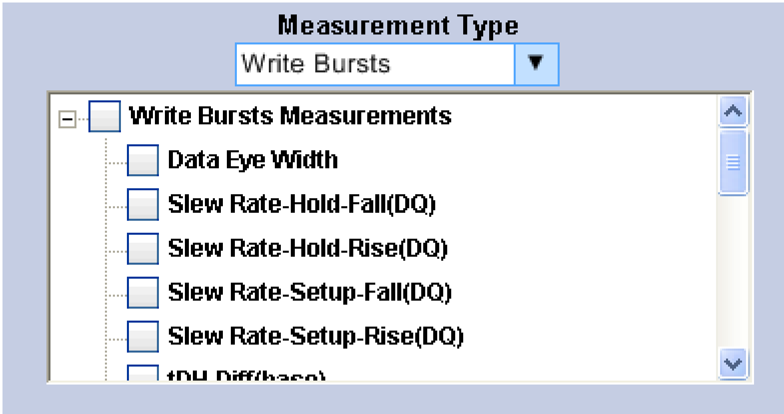
Measurement availability depends on the selected DDR standard. Select the **Measurement Type** (Read Bursts, Write Bursts, Slew Rate(Diff), Clock(Diff), Clock(Single Ended), DQS(Single Ended), or Address/Command) from the drop-down list. A message prompts you to select one or more measurement before moving to the next step.



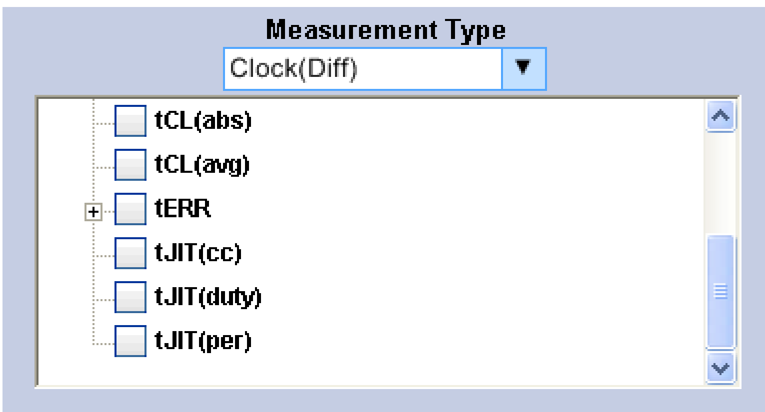
Tree Structure Flow

The measurement tree structure flow is as follows:

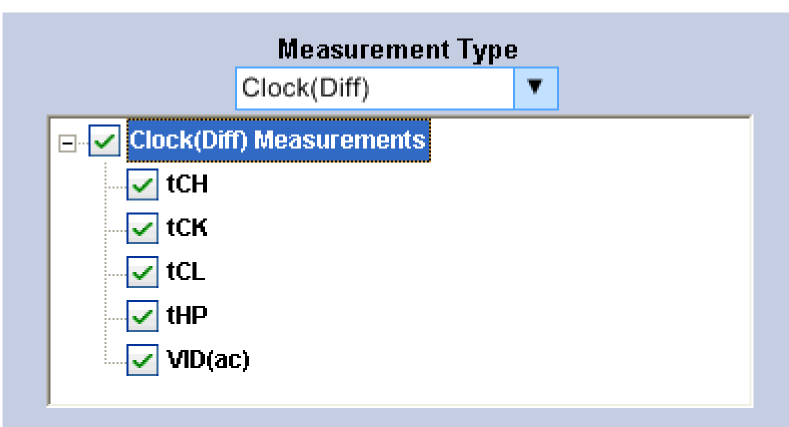
- The tree structure displays only the measurements appropriate for the selected measurement type.



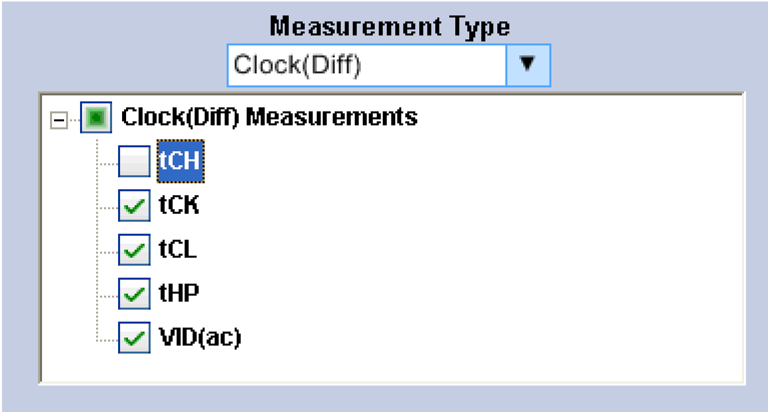
- For the DDR3 generation, the Clock(Diff) measurement type displays both parent and nested elements (such as tERR) as shown:



- Click to expand and show the elements within the parent element.
- Click to collapse and hide the elements within the parent element.
- Selecting the parent check box, selects all the children elements. Selecting all the children elements, selects the parent element.



- Clearing the parent check box clears all the children elements.
- When the children include both checked and unchecked elements, the parent element becomes highlighted as shown:



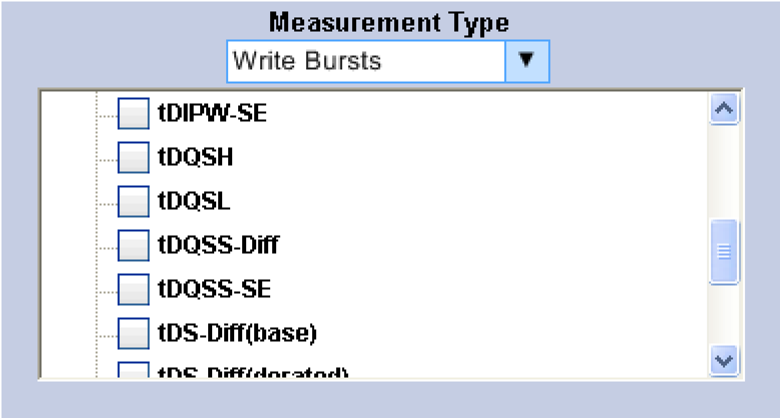
NOTE. *If you move to the next step without selecting any measurements, the application displays the message "Please select measurements in Step2".*

Measurement Selection Based on Signal Type

The application adds the suffix SE (Single-ended) or Diff (Differential) for relevant measurements depending on the signal type.

- If your signal type is differential, the measurements with suffix **Diff** should be selected and those with SE should be deselected. The signal should be probed with a differential probe. If only one leg of a differential signal is probed (using a single-ended probe), the automatically-configured reference levels will not be correct. This can be resolved by using a Math waveform as the source, and defining the Math so that the single-ended signal is centered around 0 V. This will not be a proper JEDEC-compliant measurement but it will allow the measurements and/or eye diagram to function.
- If your signal type is single-ended, the measurements with suffix **SE** should be selected and those with Diff should be deselected. Some measurements on differential signals demand that the two legs of the differential signal be separately probed with single-ended probes. These measurements are placed in measurement types that segregate them from measurements made with a differential probe.

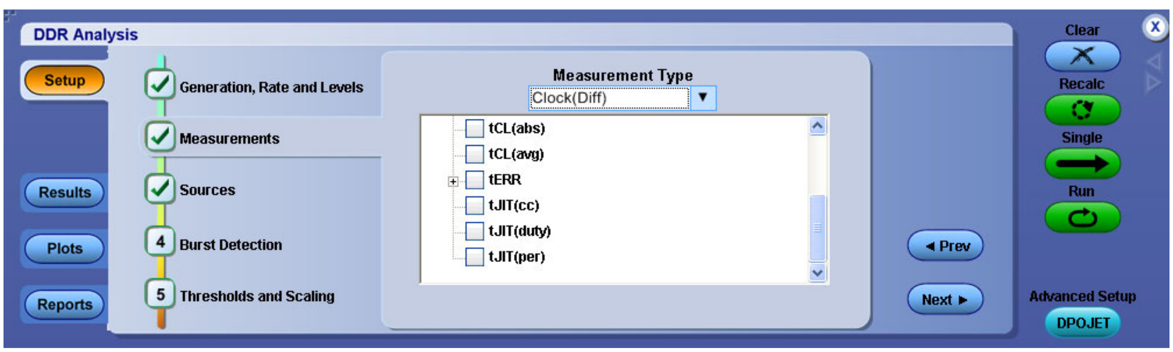
For example: For DDR3 800 MT/s, Write burst selection shows both SE and Diff measurements as shown in the following figure. You need to select appropriate measurements based on the signal type to obtain valid results. For measurements with suffix Diff, DQ is SE and DQS is Diff whereas for measurements with suffix SE, both DQ and DQS are SE. Measurements such as Data Eye Width, tDQSH and tDQSL can be used for both Diff and SE measurements.



NOTE. *The application displays a hint "Cannot select Diff and SE measurements at the same time" when measurements with suffix SE and Diff are selected together under Write Bursts of DDR2/DDR3 generation.*

Timing error (tERR) measurements

Timing error measurements for the DDR3 generation such as tERR(2per), tERR(3per) until tERR(50per) are grouped together and included as a nested element (tERR) under the parent element, Clock(Diff)measurements. Selecting tERR selects all the timing error measurements.



Reference

- Hints

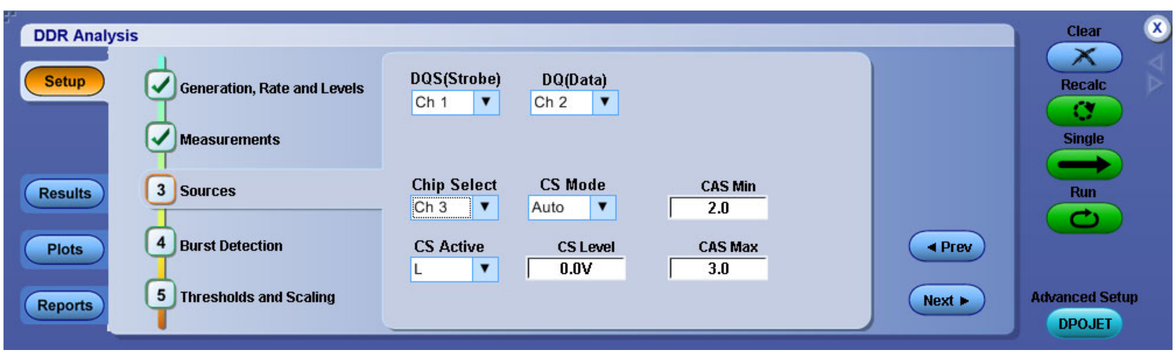
Step3: Sources

On the sources step, identify all measurement sources that are required for your set of selected measurements. The sources are mutually exclusive. The application displays only the sources applicable for the selected measurement(s). A maximum of four sources are available at a time. Example: Selecting all SE measurements shows four sources such as DQS#, DQS(Strobe), Clock, and Clock#.

NOTE. *If the same channels are used for DQ/DQS/Clock sources (Example: DQ=Ch1, DQS=Ch1), the application displays a hint "Cannot use the same waveform for different sources". If Live and Ref channels are used together (Example: Ch1 for DQS and Ref2 for DQ), the application displays a hint "Cannot use Live and Ref waveforms together".*

1. For each required signal, select the appropriate source.
2. If you wish to filter the data bursts based on a chip select signal, select the Chip Select source (see page 30) using the Chip Select drop down. Set numeric values for CAS Min/CAS Max (see page 30), and CS Level (see page 30) using the virtual keypad. Select CS Active (see page 30) and CS Mode (see page 30) as shown in the following figure. Chip Select source is available only for Read and Write bursts measurements.

NOTE. *If a Chip Select source is selected, CS-DQS(Strobe) is used for signal separation otherwise DQS(Strobe)-DQ(Data) is used. You need to configure DQ source to enable Search and Mark.*



Chip Select Source

Chip select source is used as a logic input to select read or write bursts corresponding to the chip select signal. When a chip-select signal source other than none is specified, reads or writes will only be shown when the chip-select source is active.

CAS Min/CAS Max

These values determine the CAS (Column Address Strobe) range for the memory being tested and specify the time-delay (in clock cycles) from the chip-select signal to the read or write bursts. The configured CAS range allows the user to offset the region where the chip-select logic source is measured for activity.

CS Level

CS Level specifies the logic-level above or below which the chip-select level is considered active and is applicable when CS Mode is set to Manual.

CS Active

Selects whether the chip-select source logic is considered active high or active low.

CS Mode

CS Mode consists of two modes– Auto and Manual. CS Auto mode calculates the level automatically for you (as half the peak-to-peak voltage), while manual mode allows you to specify a CS level. In cases where an entire acquisition could occur with no transitions on the chip-select line, you need to select manual mode to set the correct logic level.

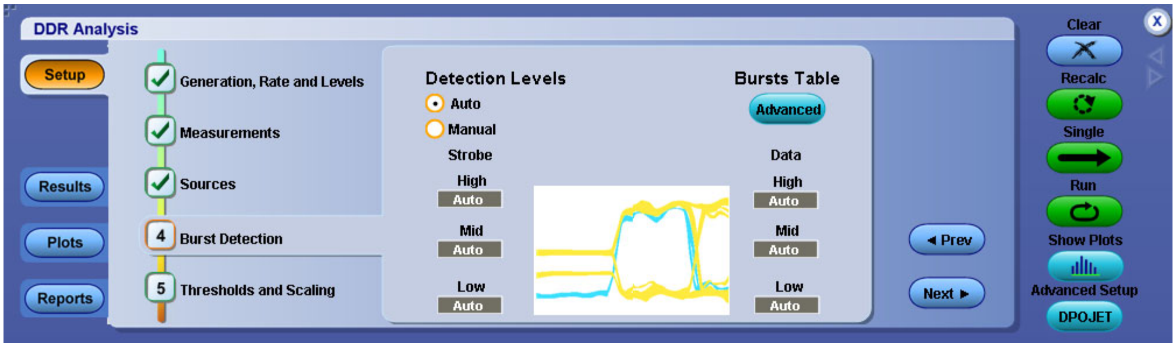
Reference

- Hints
- LPDDR Measurement Sources
- DDR Measurement Sources
- DDR2 Measurement Sources
- DDR3 Measurement Sources

Step4: Burst Detection

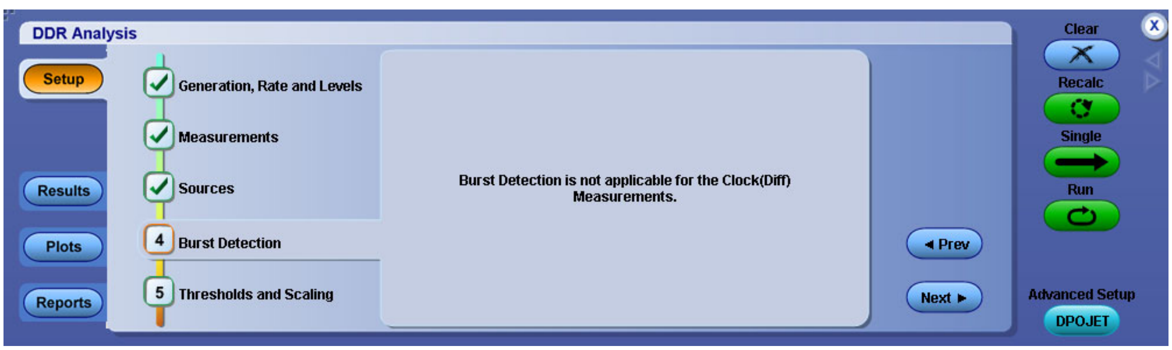
The burst detection panel controls how data bursts are identified within a waveform that includes tri-state levels. For appropriately-probed signals with good signal fidelity, no adjustment to the default values should be required. For signals with poor fidelity or unusual properties, burst detection can be improved by switching to Manual control and adjusting the detection levels.

NOTE. *The High/Mid/Low levels used for burst detection have no relationship to the reference levels used for measurement points. The measurement thresholds are defined in* *Step 5 (see page 33).*



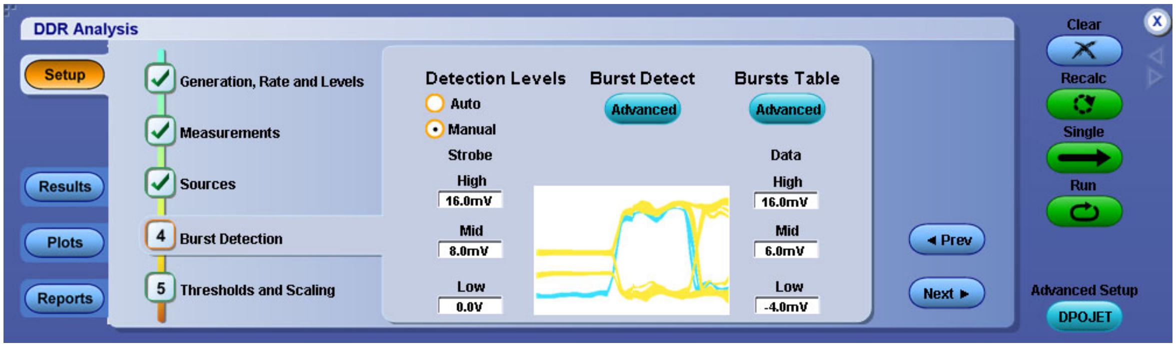
Set the burst detection levels to view the results in the Mark table. For more details on how to view results, refer to the "Search - Results: Mark Table Control Window" in your oscilloscope online help.

NOTE. *Burst Detection is based on the measurement type and is applicable only for Write Bursts, Read Bursts, and DQS(Single Ended) measurement types.*

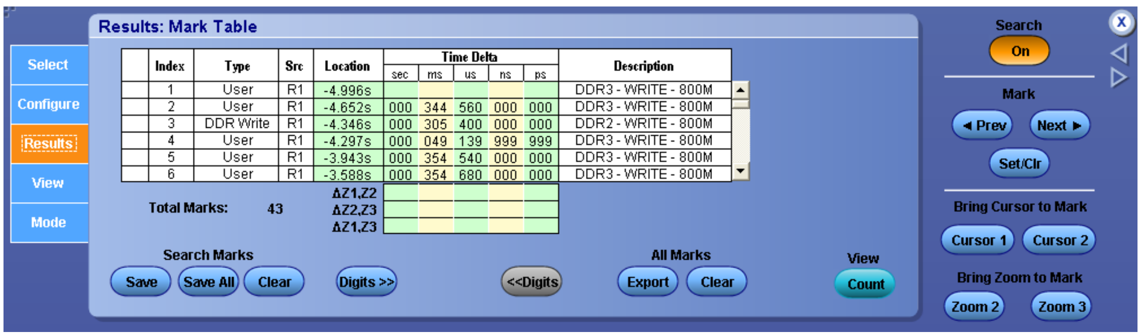


1. Select the type of burst detection level for the search.

- If you select Auto, the application calculates these levels for you . It is recommended unless you find that manual levels are necessary for reliable detection.
- If you select Manual, enter both the Strobe and Data reference levels for the signal (High, Mid, and Low). As you adjust the detection levels, observe the search-and-mark sprites that appear above the waveform. These sprites are dynamically updated as you adjust the levels, helping you to identify levels that properly delimit the selected burst type. Click Advanced under Burst Detect to set the Edge Detection Hysteresis value, and the Termination Logic Margin in the Advanced Burst Detection window.



2. Click **Advanced** to view the search results in the **Results:Mark table**.



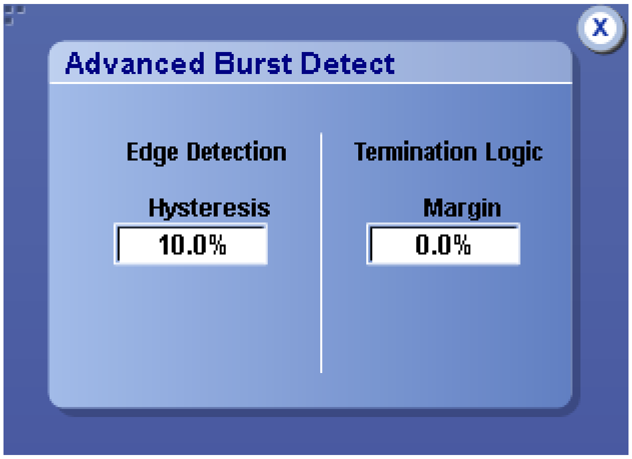
NOTE. *Use the forward and backward arrows at the right corner of the control panel to switch between DDRA and Results:Mark table window.*

Reference

- Hints

Advanced Burst Detection

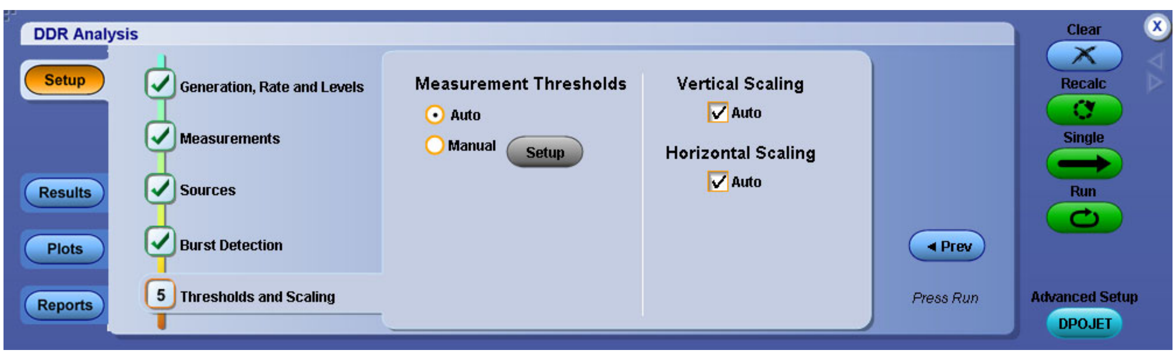
The following advanced burst detection settings need not be changed in most cases:



- **Edge Detection Hysteresis:** This control configures the internal edge finder's hysteresis band which is used to detect read or write bursts. In the event of noisy inputs, it can be increased to correct marks which may be larger than appropriate.
- **Termination Logic Margin:** This control can be increased to help in terminating marks on back-to-back writes in cases where otherwise a continuous strobe would cause a write-mark to merge two back-to-back writes.

Step5: Thresholds and Scaling

The left half of this panel controls selection of critical voltage thresholds used by the measurement algorithms. The right half determines whether scaling is automatically adjusted each time you sequence.



Measurement Thresholds

Select either Auto or Manual as the Measurement Threshold type.

- If you select Auto, the application calculates these levels for you based on the DDR generation and speed grade. It is recommended that you use this option.
- If you select Manual, set the measurements levels by clicking the **Setup** button.

For more details, refer to the topic “Ref Levels” of the DPOJET help.

***NOTE.** For every measurement selected in DDRA, appropriate reference levels are set in the DPOJET application. You can change these levels, if needed, from the DPOJET application.*

Vertical Scaling

Selecting Auto performs autoset on the oscilloscope vertical settings only.

For more details, refer to the topic “Source Autoset” of the DPOJET help.

Horizontal Scaling

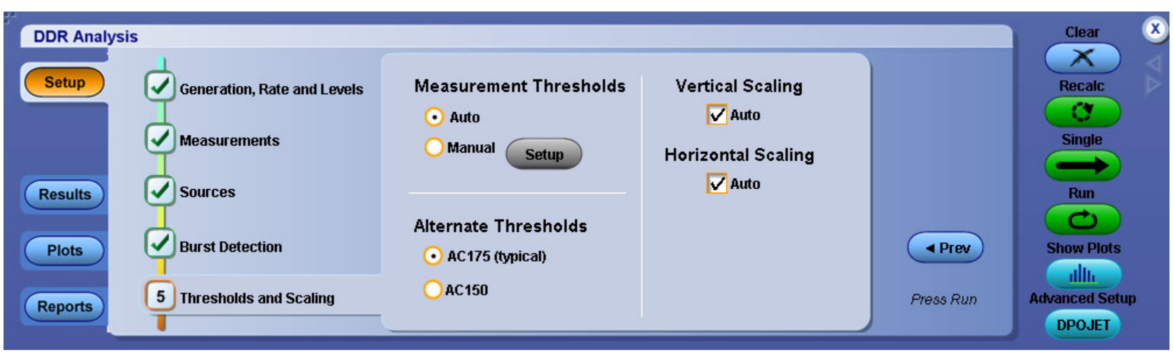
Selecting Auto performs autoset on the oscilloscope horizontal settings only.

For more details, refer to the topic “Source Autoset” of the DPOJET help.

***NOTE.** If both Vertical and Horizontal are checked, the application performs autoset on both vertical and horizontal oscilloscope settings when Single/Run is selected.*

Alternate Thresholds

Alternate Thresholds only apply to the DDR3 Address and Command measurement type. It allows you to select derating values(Δ) from the derating tables– AC 175 (see page 35) and AC 150. The default is AC 175.



AC 175 . The AC 175 Threshold derating table is as follows:

Table 8: Derating Values for DDR3 800/1066/1333/1600 MT/s tIS/tIH

ΔtIS, ΔtIH derating in ps AC/DC based
AC 175 Threshold(VIH(ac))= VREF(dc)+175 mV, VIL(ac)=VREF(dc)–175 mV
CK , CK# Differential Slew Rate

		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADDR Slew rate (v/ns)	2.0	88	50	88	50	88	50	96	58	104	66	112	74	120	84	128	100
	1.5	59	34	59	34	59	34	67	42	75	50	83	58	91	68	99	84
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	–2	–4	–2	–4	–2	–4	6	4	14	12	22	20	30	30	38	46
	0.8	–6	–10	–6	–10	–6	–10	2	–2	10	6	18	14	26	24	34	40
	0.7	–11	–16	–11	–16	–11	–16	–3	–8	5	0	13	8	21	18	29	34
	0.6	–17	–26	–17	–26	–17	–26	–9	–18	–1	–10	7	–2	15	8	23	24
	0.5	–35	–40	–35	–40	–35	–40	–27	–32	–19	–24	–11	–16	–2	–6	5	10
	0.4	–62	–60	–62	–60	–62	–60	–54	–52	–46	–44	–38	–36	–30	–26	–22	–10

AC 150 . The AC 150 Threshold derating table is as follows:

Table 9: Derating Values for DDR3 800/1066/1333/1600 MT/s tIS/tIH

ΔtIS, ΔtIH derating in ps AC/DC based
AC 150 Threshold(VIH(ac))= VREF(dc)+150 mV, VIL(ac)=VREF(dc)–150 mV
CK , CK# Differential Slew Rate

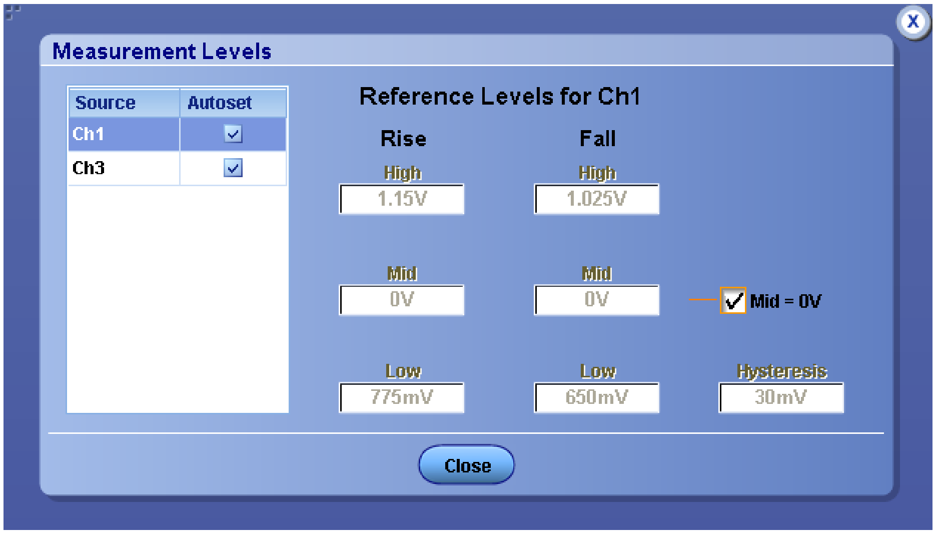
		4.0 V/ns		3.0 V/ns		2.0 V/ns		1.8 V/ns		1.6 V/ns		1.4 V/ns		1.2 V/ns		1.0 V/ns	
		ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH	ΔtIS	ΔtIH
CMD/ADDR Slew rate (v/ns)	2.0	75	50	75	50	75	50	83	58	91	66	99	74	107	84	115	100
	1.5	50	34	50	34	50	34	58	42	66	50	74	58	82	68	90	84
	1.0	0	0	0	0	0	0	8	8	16	16	24	24	32	34	40	50
	0.9	0	–4	0	–4	0	–4	8	4	16	12	24	20	32	30	40	46
	0.8	0	–10	0	–10	0	–10	8	–2	16	6	24	14	32	24	40	40
	0.7	0	–16	0	–16	0	–16	8	–8	16	0	24	8	32	18	40	34
	0.6	–1	–26	–1	–26	–1	–26	7	–18	15	–10	23	–2	31	8	39	24
	0.5	–10	–40	–10	–40	–10	–40	–2	–32	6	–24	14	–16	22	–6	30	10
	0.4	–25	–60	–25	–60	–25	–60	–17	–52	–9	–44	–1	–36	7	–26	15	–10

Reference

- Hints

Measurement Levels

By definition, edges occur when a waveform crosses specified reference voltage levels. Reference voltage levels must be set so that the application can identify state transitions on a waveform. By default, the application automatically chooses reference voltage levels when necessary.



The DDRA application uses three basic reference levels: High, Mid and Low. In addition, a hysteresis value defines a voltage band that prevents a noisy waveform from producing spurious edges. The reference levels and hysteresis are independently set for each source waveform, and are specified separately for rising versus falling transitions.

Item	Description
Measurement Reference Levels Setup (one level per source)	
Rise High	Sets the high threshold level for the rising edge of the source.
Rise Mid	Sets the middle threshold level for the rising edge of the source.
Rise Low	Sets the low threshold level for the rising edge of the source.
Fall High	Sets the high threshold level for the falling edge of the source.
Fall Mid	Sets the middle threshold level for the falling edge of the source.
Fall Low	Sets the low threshold level for the falling edge of the source.
Hysteresis	Sets the threshold margin to the reference level which the voltage must cross to be recognized as changing; the margin is the relative reference level plus or minus half the hysteresis; use to filter out spurious events.

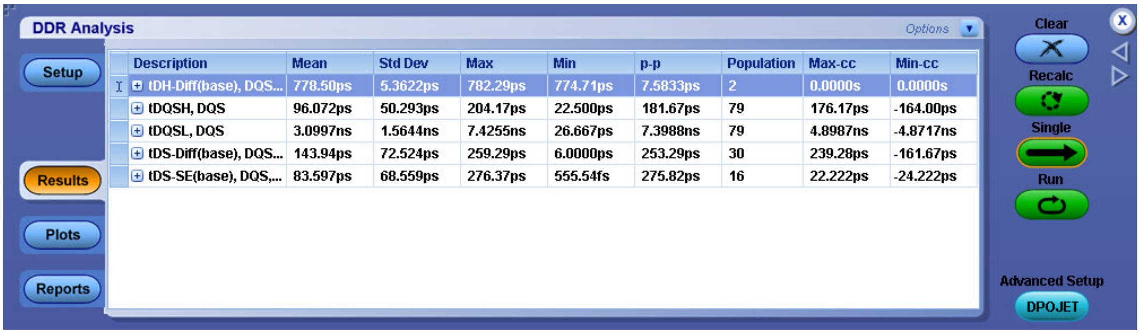
Hints

The DDRA application displays the following hints at different steps:

Hint	Step	Description
Select a standard data rate in DDRA	1	Displayed when data rate is None. When you select a non standard data rate in ASM, the data rate is set to None in DDRA.
GDDR3 not completely supported. Some features may not function.	1	Displayed on selecting GDDR3 standard, which does not have standard data rates. Only Data Eye Width measurement is available for both Read and Write bursts.
Please provide a Limits file under Jitter and Eye > Limits	1	Displayed for custom data rates for which limits are not defined. You need to manually configure the limits.
You have selected manual control of measurement thresholds in Step 5. Please verify that they are appropriate for these settings.	1	Displayed when Vdd or Vref values are set to User Defined in Step 1 after thresholds are set to Manual in Step 5.
Cannot use Live and Ref waveforms together.	2 or 3	Displayed on selecting both Live and Ref waveforms as source for DQ and DQS. Example: Data Eye Width measurement with sources as Ch1 for DQ and Ref1 for DQS.
Cannot use the same waveform for different sources.	2 or 3	Displayed on selecting the same source for DQ and DQS. Example: Data Eye Width using Ch3 for both DQ and DQS.
Cannot select Diff and SE measurements at the same time.	2	Displayed on selecting measurements with suffix SE and Diff. Example: DDR2, Write bursts, tDH-Diff and tDH-SE measurements.
Use unique sources that are either Live or Ref.	2 or 3	Displayed on selecting measurements which require DQ, DQS and Clock sources. Example: DDR3, 800MT/s, select all Read burst measurements.

Results as Statistics

Result statistics for most of the measurements show **Population** in terms of UI or transitions. According to the JEDEC specification, the analysis for most of the clock measurements is done for a 200-cycle moving window. However, for clock measurements such as tCL(avg) and tCH(avg), the population is shown as tCK(avg) units. For some measurements such as Data Eye Width, exactly one measurement occurs per acquisition. For such measurements, the population increases by one for each acquisition independent of the number of UI in the acquisition.



Reference

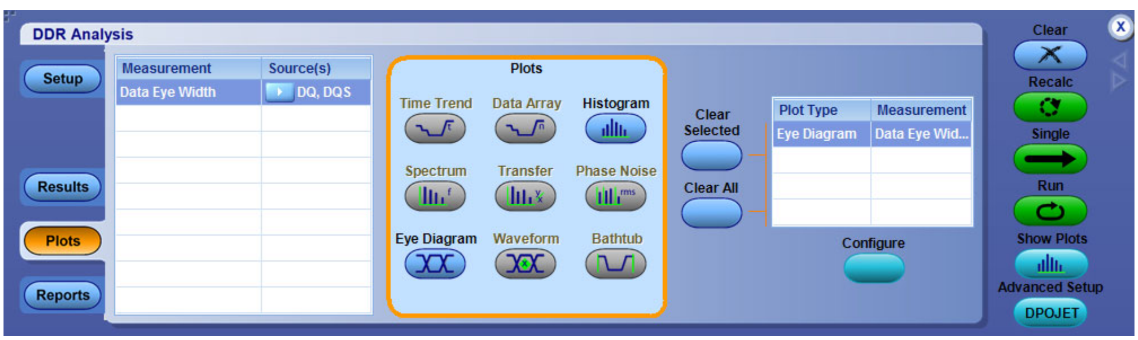
- Dynamic Limits

For more details, refer to the topic "Viewing Statistical Results" of the DPOJET help.

Plots

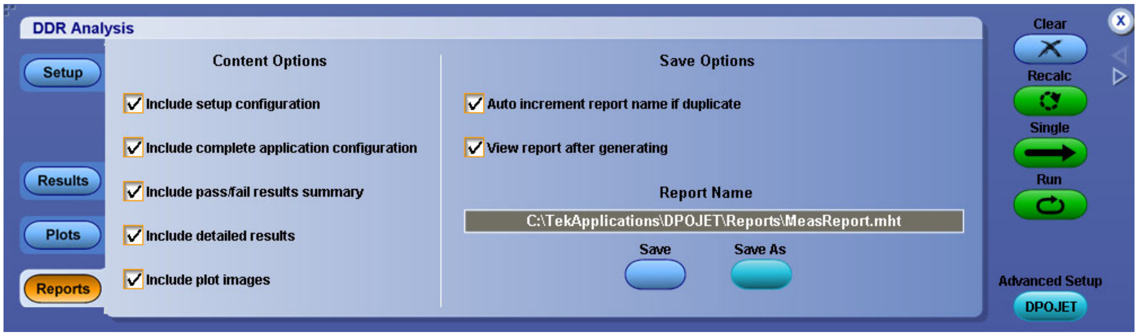
The only measurement for which a plot is automatically configured is Data Eye Width, which is available for both Read and Write bursts. However, plots may be added for other measurements through the plot panel. The plot selection and configuration methods are identical to those used for DPOJET. For more details, refer to the DPOJET help.

For acquisitions containing more than one read or write burst, time trend plots connect together all measurements within each burst with a continuous line, but do not draw lines between bursts. If a vertical cursor is placed where it does not intersect a line, the cursor annotation will read "NaN" (Not a Number).



For more details, refer to the topic "About Configuring Plots" of the DPOJET help.

Reports



For more details, refer to the topic “About Reports” of the DPOJET help.

Switching between the DDRA and DPOJET Applications

For advanced analysis, click 

to switch to the DPOJET application. Likewise, click 

in the DPOJET application to revert to the DDRA application.

The transition behaves as follows:

- The application name in the title bar switches between **DDR Analysis** and **Jitter and Eye Diagram Analysis Tool**.
- Measurement name remains unchanged while traversing from DDRA to DPOJET.
- Within DPOJET, more measurements may be added to those automatically configured in DDRA. These measurements must be configured manually.
- Once in DPOJET, measurements automatically configured by DDRA may be reconfigured. (The measurements will generally no longer be JEDEC-compliant in this case.)
- Upon returning to DDRA, new or non-standard measurements will be retained.
- Measurement sequencing, results analysis and report generation can be done from either application.
- Any change in generation and measurement type in the DDRA deselects all the currently selected measurements.
- Switching back from DPOJET to DDRA, always resets focus to the Setup panel.

- DPOJET or DDRA application is always accessible from the oscilloscope menu bar, as an alternative to the quick navigation buttons.
- If DPOJET application is opened from the oscilloscope menu (Analyze > Jitter and Eye Diagram Analysis), the shortcut button to DDR Analysis is not shown. This shortcut only appears if DPOJET is entered from the DDRA interface.

Introduction to the Tutorial

This tutorial teaches how to set up the application, take measurements, and view results as plots or statistics.

Before you begin the tutorial, perform the following tasks:

- Set up the oscilloscope.
- Start the application.
- Recall the tutorial waveform.

Setting Up the Oscilloscope

The steps to set up the oscilloscope are:

- Click **File > Recall Default Setup** in the oscilloscope menu bar to recall the default settings.
- Press the individual CH1, CH2, CH3, and CH4 buttons as needed to add or remove active waveforms from the display.

Starting the Application

Click **Analyze > DDR Analysis** to open the application.

Waveform Files

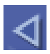
The DDRA application provides the following waveforms at `C:\TekApplications\DDRA\Waveforms`:

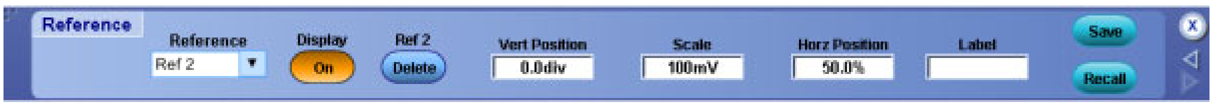
- DDR2_800_DQS_Write.wfm
- DDR2_800_DQ_Write.wfm
- DDR2_800_CLK.wfm

NOTE. *These waveforms have to be used only for Write bursts and CLK.*

Recalling a Waveform File

To recall a waveform file, follow these steps:

1. Click **File > Recall** in the oscilloscope menu bar to display the Recall dialog box.
2. Click Waveform icon in the left of the Recall dialog box.
3. Select Ref1, Ref2, Ref3, or Ref4 as the Destination option.
4. Browse to select the waveform. Use the keypad to edit the waveform file name.
5. Click **Recall**. The oscilloscope recalls and activates the Reference Waveform control window.
6. Click **On** to display the waveform.
7. Click  to return to the application. Alternatively, DDRA can also be accessed from **Analyze > DDR Analysis**.



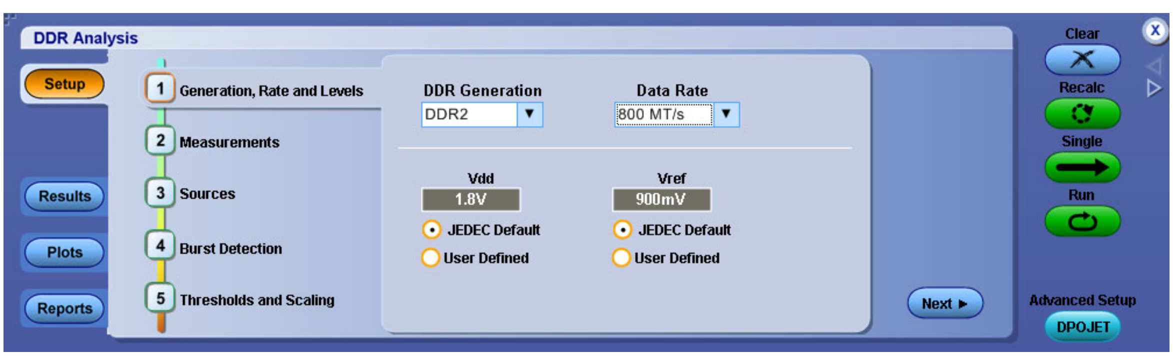
Taking a Measurement

In this tutorial, we are taking the following example:

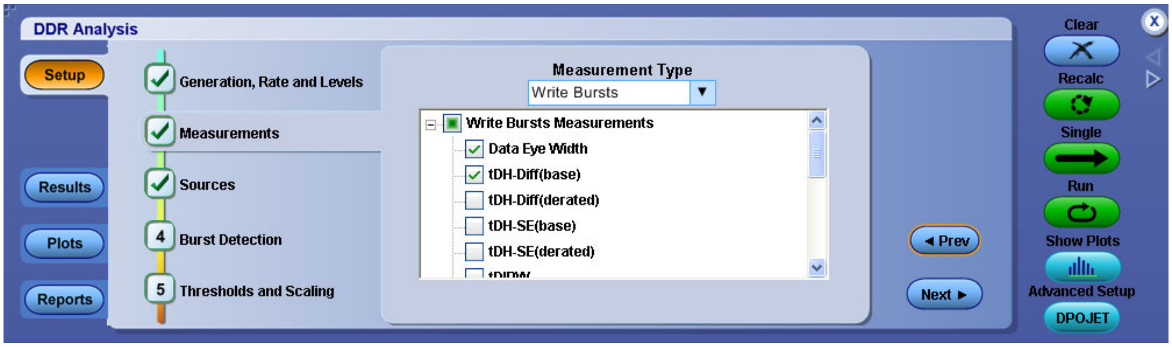
DDR2 800MT/s, Write bursts - Differential measurements

Waveforms Used: DDR2_800_DQS_Write.wfm and DDR2_800_DQ_Write.wfm

1. To set the application to default values, click **File > Recall Default Setup**. This is not necessary if you have just started the application.
2. To view the DDRA application, select **Analyze > DDR Analysis**.
3. At Step 1, select the DDR2 standard and the data rate as 800 MT/s. The default voltage settings are retained as shown:



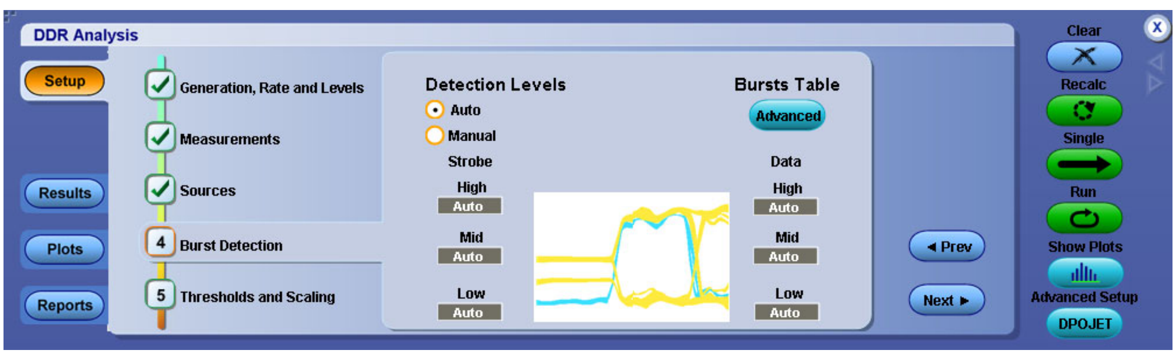
4. At Step 2, select all the measurements except tDS-SE(base) and tDH-SE(base) under Write bursts as shown. This is because the reference waveform is differentially probed.



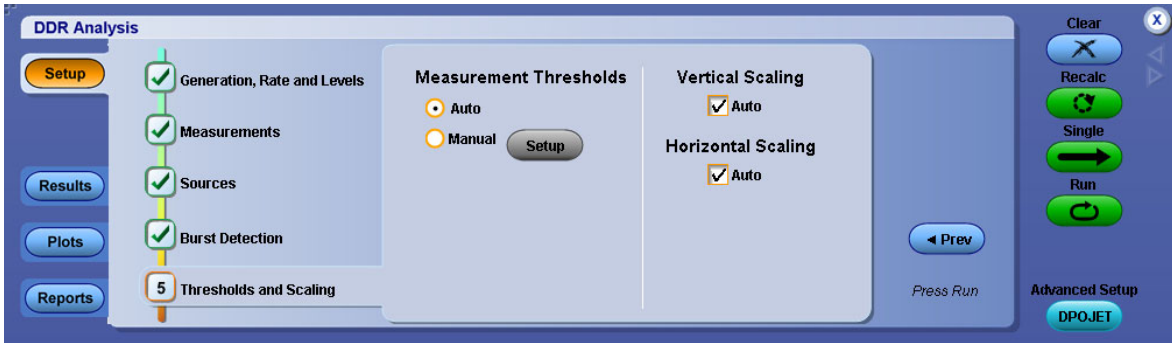
5. At Step 3, select the sources. In this example, DQS is recalled as Ref1 and DQ as Ref2 as shown. Since none of the selected measurements requires the clock, the clock source selection will be ignored.

NOTE. *Alternatively, you could simply click Single from step 3 since no more configuration changes will be made.*

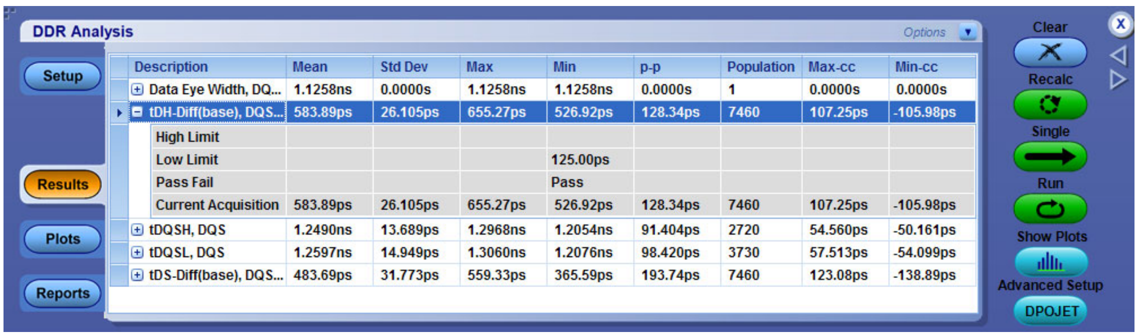
6. At Step 4, retain the default settings as shown:



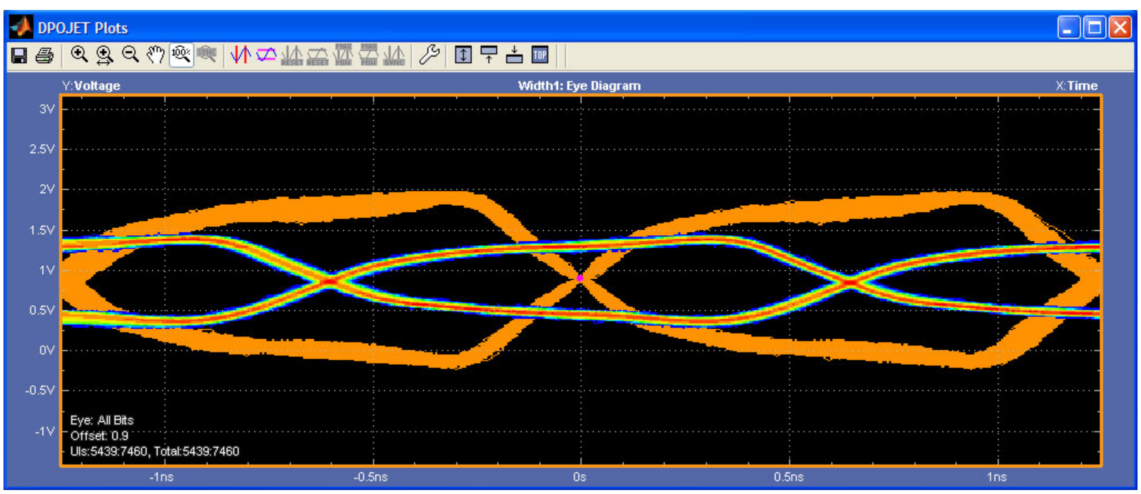
7. At Step 5, retain the default settings as shown:



8. Click **Single** to run the application. When complete, the result statistics with limits are shown in the results tab.



The eye diagram plot is displayed as shown:



About Parameters

This section describes the DDRA application parameters and includes the menu default settings. Refer to the user manual of your oscilloscope for operating details of other controls, such as front-panel buttons.

The parameter tables list the selections or range of values available for each option, the incremental unit of numeric values, and the default selection or value.

Step1: Generation, Rate and Levels Parameters

Step1 includes the following parameters:

Table 10: Generation, Rate and Levels Parameters

Option	Parameters	Default setting
DDR Generation	DDR, DDR2, DDR3, LPDDR and GDDR3	DDR3
Data Rate †	**DDR:** 200 MT/s, 266 MT/s, 333 MT/s, 400 MT/s, Custom and None **DDR2:** 400 MT/s, 533 MT/s, 667 MT/s, 800 MT/s, 1066 MT/s, Custom and None **DDR3:** 800 MT/s, 1066 MT/s, 1333 MT/s, 1066 MT/s, Custom and None **LPDDR:** 200 MT/s, 266 MT/s, Custom and None **GDDR3:** 500 MT/s, 600 MT/s, 700 MT/s, 800 MT/s, 900 MT/s, 1000 MT/s, 1200 MT/s, Custom and None	200 MT/s for LPDDR and DDR 400 MT/s for DDR2 None for DDR3 500 MT/s for GDDR3
Vdd	JEDEC Default, User Defined	JEDEC Default
Vref	JEDEC Default, User Defined	JEDEC Default

† Data rate varies for different DDR standards.

Step2: Measurements Parameters

Step2 includes the following parameters under Measurement Type:

- Read Bursts
- Write Bursts
- Slew Rate(Diff)
- Clock(Diff)

- Clock(Single Ended)
- DQS(Single Ended)
- Address/Command

Step3: Sources Parameters

Step3 includes the following parameters:

Table 11: Source Parameters

Option	Parameters	Default setting
DQS(Strobe)	Ch1-Ch4, Ref1-Ref4, Math1-Math4	Ch1
DQS#(Strobe)	Ch1-Ch4, Ref1-Ref4, Math1-Math4	Ch3
DQ(Data)	Ch1-Ch4, Ref1-Ref4, Math1-Math4	Ch2
Addr/Cmd	Ch1-Ch4, Ref1-Ref4, Math1-Math4	Ch4
Clock	Ch1-Ch4, Ref1-Ref4, Math1-Math4	Ch3
Clock#	Ch1-Ch4, Ref1-Ref4, Math1-Math4	Ch4
Chip Select	None, Ch1-Ch4, Ref1-Ref4, Math1-Math4	None
CS Mode *	Auto, Manual	Auto
CAS Min *	0–1k	2.0
CS Active *	High, Low	Low
CS Level *	Left, Right	0.0
CAS Max *	0–1k	3.0

* **Available only when Chip select source is selected.**

Step4: Burst Detection Parameters

Step4 has the following parameters:

Table 12: Burst Detection Parameters

Option	Parameters	Default setting
Detection Levels	Auto, Manual	Auto
Advanced Burst Detection †		
Edge Hysteresis	0–50%	10%
Termination Logic Margin	0–100%	0%

† **Available only for Manual Burst detection.**

Step5: Thresholds and Scaling Parameters

Step5 has the following parameters:

Table 13: Thresholds and Scaling Parameters

Option	Parameters	Default setting
Thresholds	Auto, Manual	Auto
Vertical Scaling	Set, Clear	Clear
Horizontal Scaling	Set, Clear	Clear
Alternate Thresholds *	AC 175, AC 150	AC175
Measurement Levels		
Rise High	–20 V to 20 V	1 V
Rise Mid	–20 V to 20 V	0 V
Rise Low	–20 V to 20 V	–1 V
Fall High	–20 V to 20 V	1 V
Fall Mid	–20 V to 20 V	0 V
Fall Low	–20 V to 20 V	–1 V
Hysteresis	0 to 10 V	30 mV

* Available only for Address and Command Measurement type.

LPDDR Measurement Sources

The sources required for analysis are DQS (Strobe), DQS# (Strobe), DQ (Data) , Clock, Clock #, and Addr/Cmd. DQ and DQS can be either Single-Ended (SE) or Differential (Diff). Read and Write bursts have CS as an optional source.

The following table lists the sources required for each LPDDR measurement:

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
Write Bursts			
Data Eye Width	Eye Width	DQS and DQ	None
tDH-SE	DDR Hold-SE	DQ and DQS-Diff	None
tDIPW-SE	High Time	DQ	DQS †
tDQSH	Pos Width	DQS-Diff and DQ-SE	None
tDQSL	Neg Width	DQS-Diff and DQ	None
tDQSS-Diff	Skew	DQS-Diff and Clock	DQ †
tDQSS-SE	Skew	DQS-Diff and Clock	DQ †
tDSH-Diff	Hold	DQS-Diff and Clock	DQ †
tDSH-SE	Hold	DQS-Diff and Clock	DQ †
tDSS-Diff	Setup	DQS-Diff and Clock	DQ †
tDSS-SE	Setup	DQS-Diff and Clock	DQ †
tDS-SE	Setup	DQS-SE and DQ	None
Read Bursts			
Data Eye Width	Eye Width	DQS and DQ	None
tAC-Diff	DDR Setup-Diff	DQ and Clock	DQS †
tDQSCK-Diff	Skew	DQS and Clock	DQ †
tDQSQ-SE	Setup	DQS-SE and DQ	None
tQH	Hold	DQS-Diff and DQ	None
Clock(Diff)			
tCH	Pos Width	Clock	None
tCK	Period	Clock	None
tCL	Neg Width	Clock	None
tHP	Period	Clock	None
VID(ac)	High–Low	Clock	None
Clock(Single Ended)			
AC-Overshoot(CK#)	Overshoot	Clock#	None
AC-Overshoot(CK)	Overshoot	Clock	None
AC-Undershoot(CK#)	Undershoot	Clock#	None
AC-Undershoot(CK)	Undershoot	Clock	None

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
Vix(ac)CK	V-Diff-Xovr	Clock and Clock#	None
DQS(Single Ended)			
AC-Overshoot(DQS#)	Overshoot	DQS#, DQ and DQS-SE	None
AC-Overshoot(DQS)	Overshoot	DQS-SE and DQ	None
AC-Undershoot(DQS#)	Undershoot	DQS#, DQ and DQS-SE	None
AC-Undershoot(DQS)	Undershoot	DQS-SE and DQ	None
Vix(ac)DQS	V-Diff-Xovr	DQS#, DQ and DQS-SE	None
Address/Command			
AC-Overshoot	Overshoot	Addr/Cmd	None
AC-Undershoot	Undershoot	Addr/Cmd	None
tIH(base)	DDR Hold–SE	Clock and Addr/Cmd	None
tIPW-High	High Time	Addr/Cmd	None
tIPW-Low	Low Time	Addr/Cmd	None
tIS(base)	DDR Setup–SE	Clock and Addr/Cmd	None

† Required so that the Search-and-Mark feature can properly identify bursts

DDR Measurement Sources

The sources required for analysis are DQS(Strobe), DQ(Data), DQS# (Strobe), Clock, Clock#, and Addr/Cmd. DQ and DQS can be either Single-Ended (SE) or Differential (Diff). Chip Select is available, as appropriate, as an optional qualifier.

The following table lists the sources required for each DDR measurement:

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
Write Bursts			
Data Eye Width	Eye Width	DQS and DQ	None
tDH-SE	DDR Hold-SE	DQS-SE and DQ	None
tDIPW-SE	High Time	DQ	DQS *
tDQSS-Diff	Skew	DQS-Diff and Clock	DQ *
tDQSS-SE	Skew	DQS-Diff and Clock	DQ *
tDSH-Diff	Hold	DQS-Diff and Clock	DQ *
tDSH-SE	Hold	DQS-Diff and Clock	DQ *
tDSS-Diff	Setup	DQS-Diff and Clock	DQ *
tDSS-SE	Setup	DQS-Diff and Clock	DQ *
tDS-SE	Setup	DQS-SE and DQ	None
Read Bursts			
Data Eye Width	Eye Width	DQS and DQ	None

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
tAC-Diff	DDR Setup-Diff	DQ and Clock	DQS *
tDQSCK-Diff	Skew	DQS and Clock	DQ *
tDQSQ-SE	Setup	DQS-SE and DQ	None
tQH	Hold	DQS-Diff and DQ	None
Clock(Diff)			
tCH	Pos Width	Clock	None
tCK	Period	Clock	None
tCL	Neg Width	Clock	None
tHP	Period	Clock	None
VID(ac)	High–Low	Clock	None
Clock(Single Ended)			
AC-Overshoot(CK#)	Overshoot	Clock#	None
AC-Overshoot(CK)	Overshoot	Clock	None
AC-Undershoot(CK#)	Undershoot	Clock#	None
AC-Undershoot(CK)	Undershoot	Clock	None
Vix(ac)CK	V–Diff–Xovr	Clock and Clock#	None
DQS(Single Ended)			
AC-Overshoot(DQS#)	Overshoot	DQS#, DQS-SE and DQ	None
AC-Overshoot(DQS)	Overshoot	DQS-SE and DQ	None
AC-Undershoot(DQS#)	Undershoot	DQS#, DQS-SE and DQ	None
AC-Undershoot(DQS)	Undershoot	DQS-SE and DQ	None
Vix(ac)DQS	V–Diff–Xovr	DQS-SE and DQS#	None
Address/Command Measurements			
AC-Overshoot	Overshoot	Addr/Cmd	None
AC-Undershoot	Undershoot	Addr/Cmd	None
tIH(base)	DDR Hold–SE	Clock and Addr/Cmd	None
tIPW-High	High Time	Addr/Cmd	None
tIPW-Low	Low Time	Addr/Cmd	None
tIS(base)	DDR Setup–SE	Clock and Addr/Cmd	None

* Required so that the Search-and-Mark feature can properly identify bursts

DDR2 Measurement Sources

The sources required for analysis are DQS(Strobe), DQ(Data), DQS# (Strobe), Clock, Clock#, Chip Select, and Addr/Cmd. DQ and DQS can be either Single-Ended (SE) or Differential (Diff). Read and Write bursts have CS as an optional source.

The following table lists the sources required for each DDR2 measurement:

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
Write Bursts			
Data Eye Width	Eye Width	DQS and DQ	None
Slew Rate-Setup-Rise(DQ)	Rise Slew Rate	DQ	DQS †
Slew Rate-Setup-SE-Rise(DQS)	Rise Slew Rate	DQS-SE	DQ †
Slew Rate-Setup-Fall(DQ)	Fall Slew Rate	DQ	DQS †
Slew Rate-Setup-SE-Fall(DQS)	Fall Slew Rate	DQS-SE	DQ †
Slew Rate-Hold-Rise(DQ)	Rise Slew Rate	DQ	DQS †
Slew Rate-Hold-SE-Rise(DQS)	Rise Slew Rate	DQS-SE	DQ †
Slew Rate-Hold-Fall(DQ)	Fall Slew Rate	DQ	DQS †
Slew Rate-Hold-SE-Fall(DQS)	Fall Slew Rate	DQS-SE	DQ †
tDH-Diff(base)	DDR Hold–Diff	DQS-Diff and DQ	None
tDH-Diff(derated)	DDR Hold–Diff	DQS-Diff and DQ	None
tDH-SE(base)	DDR Hold–SE	DQS-SE and DQS#	None
tDH-SE(derated)	DDR Hold–SE	DQS-SE and DQS#	None
tDIPW-SE	High Time	DQ	DQS †
tDQSH	Pos Width	DQS-Diff and DQ	None
tDQSL	Neg Width	DQS-Diff and DQ	None
tDQSS-Diff	Skew	DQS-Diff and Clock	DQ †
tDQSS-SE	Skew	DQS-Diff and Clock	DQ †
tDSH-Diff	Hold	DQS-Diff and Clock	DQ †
tDSH-SE	Hold	DQS-Diff and Clock	DQ †
tDSS-Diff	Setup	DQS-Diff and Clock	DQ †
tDSS-SE	Setup	DQS-Diff and Clock	DQ †
tDS-Diff(base)	Setup	DQS-Diff and DQ	None
tDS-Diff(derated)	Setup	DQS-Diff and DQ	None
Read Bursts			
Data Eye Width	Eye Width	DQS and DQ	None

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
tAC-Diff	DDR Setup-Diff	DQ and Clock	DQS †
tDQSCK-Diff	Skew	DQS and Clock	DQ †
tDQSCK-SE	Skew	DQS and Clock	None
tDQSQ-Diff	DDR Setup-Diff	DQS and DQ	None
tDQSQ-SE	Setup	DQ and DQS-SE	None
tQH	Hold	DQS-Diff and DQ	None
Slew Rate(Diff)			
InputSlew-Diff-Fall(CK)	Fall Slew Rate	Clock	None
InputSlew-Diff-Fall(DQS)	Rise Slew Rate	DQS-Diff	None
InputSlew-Diff-Rise(CK)	Rise Slew Rate	Clock	None
InputSlew-Diff-Rise(DQS)	Fall Slew Rate	DQS-Diff	None
Clock(Diff)			
tCH(abs)	Pos Width	Clock	None
tCH(avg)	DDR tCH(avg)	Clock	None
tCK(abs)	Period	Clock	None
tCK(avg)	DDR tCK(avg)	Clock	None
tCL(abs)	Neg Width	Clock	None
tCL(avg)	DDR tCL(avg)	Clock	None
tERR(11–50per)	DDR tERR(m–n)	Clock	None
tERR(2per)	DDR tERR(n)	Clock	None
tERR(3per)	DDR tERR(n)	Clock	None
tERR(4per)	DDR tERR(n)	Clock	None
tERR(5per)	DDR tERR(n)	Clock	None
tERR(6–10per)	DDR tERR(m–n)	Clock	None
tHP	Period	Clock	None
tJIT(cc)	CC–Period	Clock	None
tJIT(duty)	DDR tJIT(duty)	Clock	None
tJIT(per)	DDR tJIT(per)	Clock	None
VID(ac)	High–Low	Clock	None
Clock(Single Ended)			
AC-Overshoot(CK#)	Overshoot	Clock#	None
AC-Overshoot(CK)	Overshoot	Clock	None
AC-Undershoot(CK#)	Undershoot	Clock#	None
AC-Undershoot(CK)	Undershoot	Clock	None
Vix(ac)CK	V–Diff–Xovr	Clock and Clock#	None
Vox(ac)CK	V–Diff–Xovr	Clock and Clock#	None
DQS(Single Ended)			
AC-Overshoot(DQS#)	Overshoot	DQS#, DQS-SE and DQ	None

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
AC-Overshoot(DQS)	Overshoot	DQ and DQS-SE	None
AC-Undershoot(DQS#)	Undershoot	DQS#, DQS-SEand DQ	None
AC-Undershoot(DQS)	Undershoot	DQS-SE and DQ	None
Vix(ac)DQS	V–Diff–Xovr	DQS-SE and DQS#	None
Vox(ac)DQS	V–Diff–Xovr	DQS-SE and DQS#	None
Address/Command Measurements			
AC-Overshoot	Overshoot	Addr/Cmd	None
AC-Undershoot	Undershoot	Addr/Cmd	None
tIH(base)	DDR Hold–SE	Clock and Addr/Cmd	None
tIH(derated)	DDR Hold–SE	Clock and Addr/Cmd	None
tIPW-High	High Time	Clock and Addr/Cmd	None
tIPW-Low	Low Time	Clock and Addr/Cmd	None
tIS(base)	DDR Setup–SE	Clock and Addr/Cmd	None
tIS(derated)	DDR Setup–SE	Clock and Addr/Cmd	None

† Required so that the Search-and-Mark feature can properly identify bursts

DDR3 Measurement Sources

The sources required for analysis are DQS(Strobe), DQ(Data), DQS# (Strobe), Clock, Clock#, and Addr/Cmd. DQ and DQS can be either Single-Ended (SE) or Differential (Diff). Chip Select is available, as appropriate, as an optional qualifier.

The following table lists the sources required for each DDR3 measurement:

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
Write Bursts			
Data Eye Width	Eye Width	DQS and DQ	None
Slew Rate-Setup-Rise(DQ)	Rise Slew Rate	DQ	DQS ‡
Slew Rate-Setup-Fall(DQ)	Fall Slew Rate	DQ	DQS ‡
Slew Rate-Hold-Rise(DQ)	Rise Slew Rate	DQ	DQS ‡
Slew Rate-Hold-Fall(DQ)	Fall Slew Rate	DQ	DQS ‡
tDH-Diff(base)	DDR Hold-Diff	DQS-Diff and DQ-SE	None
tDH-Diff(derated)	DDR Hold-Diff	DQ and DQS-Diff	None
tDIPW-SE	High Time	DQ	DQS
tDQSH	Pos Width	DQS-Diff and DQ	None
tDQSL	Neg Width	DQS-Diff and DQ	None
tDQSS-Diff	Skew	DQS-Diff and Clock	DQ ‡
tDQSS-SE	Skew	DQS-Diff and Clock	DQ ‡

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
tDSH-Diff	Hold	DQS-Diff and Clock	DQ ‡
tDSH-SE	Hold	DQS-Diff and Clock	DQ ‡
tDSS-Diff	Setup	DQS-Diff and Clock	DQ ‡
tDSS-SE	Setup	DQS-Diff and Clock	DQ ‡
tDS-Diff(base)	DDR Setup–Diff	DQS-Diff and DQ	None
tDS-Diff(derated)	DDR Setup–Diff	DQ and DQS-Diff	None
Read Bursts			
Data Eye Width	Eye Width	DQS and DQ	None
tDQSCK-Diff	Skew	DQS and Clock	DQ ‡
tDQSQ-Diff	Setup	DQS and DQ	None
tQH	Hold	DQ and DQS-Diff	None
Slew Rate(Diff)			
SRQdiff-Fall(CK)	Fall Slew Rate	Clock	None
SRQdiff-Fall(DQS)	Fall Slew Rate	DQS-Diff	DQ ‡
SRQdiff-Rise(CK)	Rise Slew Rate	Clock	None
SRQdiff-Rise(DQS)	Rise Slew Rate	DQS-Diff	DQ
Clock(Diff)			
tCH(abs)	Pos Width	Clock	None
tCH(avg)	DDR tCH(avg)	Clock	None
tCK(abs)	Period	Clock	None
tCK(avg)	DDR tCK(avg)	Clock	None
tCL(abs)	Neg Width	Clock	None
tCL(avg)	DDR tCL(avg)	Clock	None
tERR	DDR tERR	Clock	None
tJIT(cc)	CC–Period	Clock	None
tJIT(duty)	DDR tJIT(duty)	Clock	None
tJIT(per)	DDR tJIT(per)	Clock	None
Clock(Single Ended)			
AC-Overshoot(CK#)	Overshoot	Clock#	None
AC-Overshoot(CK)	Overshoot	Clock	None
AC-Undershoot(CK#)	Undershoot	Clock#	None
AC-Undershoot(CK)	Undershoot	Clock	None
DQS(Single Ended)			
AC-Overshoot(DQS#)	Overshoot	DQ, DQS-SE, Clock and DQS#	None
AC-Overshoot(DQS)	Overshoot	DQS-SE and DQ	None
AC-Undershoot(DQS#)	Undershoot	DQS#, DQ and DQS-SE	None
AC-Undershoot(DQS)	Undershoot	DQS-SE and DQ	None

DDR measurements	DPOJET base measurement	Performed on	Additional required sources
Address/Command Measurements			
AC-Overshoot	Overshoot	Addr/Cmd	None
AC-Undershoot	Undershoot	Addr/Cmd	None
tIH(base)	DDR Hold–SE	Clock and Addr/Cmd	None
tIH(derated)	DDR Hold–SE	Clock and Addr/Cmd	None
tIPW-High	High Time	Addr/Cmd	None
tIPW-Low	Low Time	Addr/Cmd	None
tIS(base)	DDR Setup–SE	Clock and Addr/Cmd	None
tIS(derated)	DDR Setup–SE	Clock and Addr/Cmd	None

‡ Required so that the Search-and-Mark feature can properly identify bursts

Measurement Range Limits

The following tables lists the measurement range limits of DDR measurements for different standards and data rate:

NOTE. *Measurement Range Limits are provided for each measurement under the General configure tab of the DPOJET application. These range limits are always ON (OFF is disabled) for two source measurements such as Skew, Setup, Hold and others. The range limits are used by the algorithms to associate valid edge of first source to the valid edge of the second source.*

Generation	Data rate	UI=1/CK speed	Measurement range			
			Read bursts		Write bursts	
			Max=+ UI/2	Min=-UI/2	Max= UI	Min=0
LPDDR	200 MT/s	5 ns	2.5 ns	– 2.5 ns	5 ns	0
	266 MT/s	3.759 ns	1.880 ns	–1.880 ns	3.760 ns	0
DDR	200 MT/s	5 ns	2.5 ns	– 2.5 ns	5 ns	0
	266 MT/s	3.759 ns	1.880 ns	–1.880 ns	3.76 ns	0
	333 MT/s	3.003 ns	1.5 ns	–1.5 ns	3 ns	0
	400 MT/s	2.5 ns	1.25 ns	–1.25 ns	2.5 ns	0
DDR2	400 MT/s	2.5 ns	1.25 ns	–1.25 ns	2.5 ns	0
	533 MT/s	1.876 ns	0.938 ns	–0.938 ns	1.88 ns	0
	667 MT/s	1.5 ns	0.7496 ns	–0.7496 ns	1.5 ns	0
	800 MT/s	1.25 ns	0.625 ns	–0.625 ns	1.25 ns	0
	1066 MT/s	0.938 ns	0.469 ns	—0.469ns	0.938 ns	0
DDR3	800 MT/s	1.25 ns	0.625 ns	–0.625 ns	1.25 ns	0

Generation	Data rate	UI=1/CK speed		Measurement range		
	1066 MT/s	0.938 ns	0.469 ns	—0.469 ns	0.938 ns	0
	1333 MT/s	0.75 ns	0.375 ns	–0.375 ns	0.75 ns	0
	1600 MT/s	0.625 ns	0.3125 ns	–0.3125 ns	0.625 ns	0

The following measurements have different range limits as shown:

Measurement range	Read bursts	Write bursts	Addr/Cmd
0 to 1 UI		tDS-SE(base)	
		tDS-SE(derated)	
		tDS-Diff(base)	
		tDS-Diff(derated)	
		tDH-SE(base)	
		tDH-SE(derated)	
		tDH-Diff(base)	
		tDH-Diff(derated)	
0 to 2UI		tDSH-Diff	tIH(base)
		tDSH-SE	tIH(derated)
		tDSS-Diff	tIS(base)
		tDSS-SE	tIS(derated))
0.5 to 1.5 UI		tQH	
–1UI to +1UI	tDQSCK-Diff	tDQSS-Diff	
	tDQSCK-SE	tDQSS-SE	

Dynamic Limits for LPDDR Measurements

The following table lists the dynamic limits for LPDDR measurements, which are common for all LPPDR data rates. For more details, refer to the LPDDR JEDEC standard specification mentioned in the application *readme.txt*.

NOTE. *Dynamic limits are the same for all LPDDR data rates.*

Table 14: Dynamic Limits for LPDDR

	Dynamic limits		
Measurement	**Min**	**Max**	**Units**
tCH	0.45	0.55	tCK
tCL	0.45	0.55	tCK
Vix(ac)CK	0.4 * Vdd	0.6 * Vdd	–

Table 14: Dynamic Limits for LPDDR (cont.)

Measurement	Dynamic limits		
	Min	Max	Units
Vix(ac)DQS	0.4 * Vdd	0.6 * Vdd	–
Vid(ac)	0.6 * Vdd	*Vdd+0.6	–

Dynamic Limits for DDR Measurements

The following table lists the dynamic limits for DDR measurements, which are common for all DDR data rates. For more details, refer to the DDR JEDEC standard specification mentioned in the application *readme.txt*.

NOTE. *Dynamic limits are the same for all DDR data rates.*

Table 15: Dynamic Limits for DDR

Measurement	Dynamic limits		
	Min	Max	Units
tCH	0.45	0.55	tCK
tCL	0.45	0.55	tCK
Vix(ac)CK	0.5*Vdd–0.2	0.5*Vdd+0.2	–
Vix(ac)DQS	0.5*Vdd–0.2	0.5*Vdd+0.2	–
Vid(ac)	0.7	Vdd+0.6	–

Dynamic Limits for DDR2 Measurements

The following table lists the dynamic limits for DDR2 measurements. For more details, refer to the DDR2 JEDEC standard specification mentioned in the application *readme.txt*.

NOTE. *Dynamic limits are the same for all DDR2 data rates except for those data rates specifically mentioned in the table.*

Table 16: Dynamic Limits for DDR2

Measurement	Data rate (MT/s)	Dynamic limits		
		Min	Max	Units
tCH(avg)	667, 800	0.48	0.52	tCK(avg)
tCL(avg)	667, 800	0.48	0.52	tCK(avg)

Table 16: Dynamic Limits for DDR2 (cont.)

Measurement	Data rate (MT/s)	Dynamic limits		
		Min	Max	Units
tCH(abs)		0.45	0.55	–
tCL(abs)		0.45	0.55	–
tIPW		0.6	NA	–
Vix(ac)CK		0.5*Vdd–0.175	0.5*Vdd+0.175	–
Vix(ac)DQS		0.5*Vdd–0.175	0.5*Vdd+0.175	–
Vox(ac)CK		0.5 * Vdd–0.125	0.5 x Vdd+0.125	–
Vox(ac)DQS		0.5 x Vdd–0.125	0.5 x Vdd+ 0.125	–
Vid(ac)		0.5	Vdd	–

Dynamic Limits for DDR3 Measurements

The following table lists the dynamic limits for DDR3 measurements. For more details, refer to the DDR3 JEDEC standard specification mentioned in the application *readme.txt*.

NOTE. *Dynamic limits are the same for all DDR3 data rates.*

Table 17: Dynamic Limits for DDR3

Measurement	Dynamic limits		
	Min	Max	Units
tCH(avg)	0.47 * tCK(avg)	0.53 * tCK(avg)	tCK(avg)
tCL(avg)	0.47 * tCK(avg)	0.53 * tCK(avg)	tCK(avg)
tCH(abs)	0.43 * tCK(avg)	NA	tCK(avg)
tCL(abs)	0.43 * tCK(avg)	NA	tCK(avg)
†tERR(13–50)	(1 + 0.68ln(n)) * tJIT(per)min	(1 + 0.68ln(n)) * tJIT(per)max	–

† Includes measurements from tERR13per to tERR50per

Error Codes and Warnings

Code	Description
E102	File does not exist.
E103	DPOJET is not able to open the help file. In order to use the help file, please reinstall DPOJET.
E104	Mask Hits measurement requires an Eye diagram plot but no more plots can be assigned. Please remove a plot before adding a Mask Hits measurement.

Code	Description
E105	The maximum number of plots you can select is 4.
E106	No Spectrum plot data is available.
E202	The upper range must be greater than the lower range.
E400	A measurement failed to complete successfully.
W410	Number of edges are not sufficient for a measurement.
E411	In at least one zone, there are too few edges to complete a measurement.
E424	No edges or UI of the required type were found in the waveform. If this is not a clock signal, check the Vref threshold and record length.
E425	No transitions of the selected Bit Type were found in the waveform.
E500	The record lengths of the source waveforms differ. Please configure for sources with equivalent record lengths.
E1001	Vertical Autoset Failed: Signal on Source x has extreme offset.
E1002	Vertical Autoset Failed: Amplitude of Source x is too small.
E1003	Vertical Autoset Failed: Amplitude or DC offset of Source x is too high.
E1004	Vertical Autoset Failed: No signal on Source x.
E1005	Vertical Autoset Failed: Signal on Source x exceeds top of scale.
E1006	Vertical Autoset Failed: Signal on Source x exceeds bottom of scale.
E1007	Vertical Autoset Failed: Signal on Source x is clipped on top.
E1008	Vertical Autoset Failed: Signal on Source x is clipped on bottom.
E1009	Vertical Autoset Failed: Measurement error (ISDB error code = 6) on Source x.
E1010	Vertical Autoset Failed: Measurement error (ISDB error code = 7) on Source x.
W1011	A change to Source x vertical settings caused overload disconnect. Original settings are restored and Source x is reconnected. Ignore oscilloscope message.
E1012	Vertical Autoset Failed: None of the selected measurements use live sources (Ch1-Ch4). Horizontal autoset works for live sources only.
E1013	Vertical Autoset Failed: Invalid signal on Source x.
E1020	Horizontal Autoset Failed: None of the selected measurements use live sources (Ch1-Ch4). Horizontal autoset works for live sources only.
E1021	Horizontal Autoset Failed: On Source x, cannot determine resolution of rising/falling edges.
E1022	Horizontal Autoset Failed: Horizontal resolution is at the maximum.
E1035	Oscilloscope has gone into invalid state. Please restart the system.
E1040	Autoset Failed: None of the live sources (Ch1-Ch4) selected.
W1051	Ref Level Autoset: Waveform for the source x is clipped.
W1053	Ref Level Autoset: Source amplitude is extremely low.
E1054	Ref Level Autoset: Error in setting reference levels.
E1055	Ref Level Autoset Failed: No waveform to measure.
E1056	Ref Level Autoset: Unstable Histogram for waveform on source x.
E1057	Ref Level Autoset: No selected source.
E1058	Ref Level Autoset Failed: Invalid signal on source x.

Code	Description
E1059	Ref Level Autoset Error: Source x is not defined.
E2001	The maximum number of measurements has been reached.
E2002	All the refs are used as sources by the measurements. Export to Ref is not possible.
E2003	Ref 'x' is already used as a measurement source.
E2004	Ref 'x' is already used as a destination for other measurement.
E2005	No measurement(s) are selected. Export to Ref is not possible.
E2006	No results available to export to ref.
E2007	There are no time trend results for the selected measurement(s).
E2008	No ref destination is selected. Results will not be exported to ref.
E3001	Could not open or create a log file. Please ensure that you have read/write permission to access log folders and files.
E3002	The specified path is invalid (for example: The specified path is not mapped to a drive).
E3003	The specified path, file name or both exceed the system defined length. For Example: On Windows-based platforms, the path name must be less than 248 characters and file names less than 260 characters.
E3004	The specified path directory is read-only or is not empty.
E3005	Please ensure that the file is currently not in use by other process and/or has not exceeded the file size limit.
E3006	Invalid filename: Check whether the file name contains a colon (:) in the middle of the string.
E3007	Select at least one measurement from the table before you save.
E3008	There are currently no results to save. Please run a measurement.
E3009	Current statistics is successfully saved at C:\TekApplications\DPOJET\Log\Statistics.
E3010	Access to file/directory denied. Please ensure that the file/directory has read/write permissions.
E3011	Mask Hits Measurements will not be selected as this feature is not available for Mask Hits measurement.
E3012	Folder does not exist.
E4000	Not enough data points. Unable to render plot(s).
E4001	Internal measurement error. Please remove a measurement and try again.
E4002	Not enough data points for spectrum computation.
E4003	Due to high memory usage, only a portion of the waveform could be processed. Please reduce your record length or the number of measurements.
E4004	An error occurred in the edge extraction process.
E4005	Qualifier: The record length and sample interval must match across the waveforms.
E4006	A maximum of 4096 qualifier zones is supported. The entire waveform will not be processed and hence partial measurement results are available.
E4007	Logic Qualifier enabled and no qualifier zones found.
W4008	The configured Ref voltage for Overshoot must be greater than or equal to the mid autoset ref levels.

Code	Description
W4009	The configured Ref voltage for Undershoot must be lesser than or equal to the mid autoset ref levels.
E9004	Derating will not be applied to the limits as Slew Rate measurements failed.
W9005	Derating value calculated using single Slew Rate measurement value.
W9006	Derating value cannot be computed since the calculated Slew Rate is not present in the derating table †.
E9007	Derating Error *.

* Slew Rate measurements used to calculate the derated value failed to Run as there are no sufficient edges on the Rise and Fall slopes of the waveform.

Base measurement limits are not defined as per the specification.

† Signal Slew Rate value is outside the derating table (Ex: If DDR2-800 MT/s tDS derating with a differential probe has a DQS differential slew rate of 0.65 V/ns, this warning message is displayed as the derating table definition starts from 0.8 V/ns).

Derating value is "not supported" (TBD) in the specification (Ex: If the DQS differential slew rate is 2.0 V/ns and the DQ slew rate is 0.7 V/ns, then the value is "-"(TBD).

Derating will not be applied for the above cases and the base limit will be displayed in the results table.

About Algorithms

The DDRA application can take measurements by selecting either Clock, Strobe, Data or Chip Select as sources. The number of waveforms used by the application depends on the type of measurement being taken.

Oscilloscope Setup Guidelines

For all measurements, use the following guidelines to set up the oscilloscope:

- The signal is any channel, reference, or math waveform.
- The vertical scale for the waveform must be set so that the waveform does not exceed the vertical range of the oscilloscope.
- The sample rate must be set to capture sufficient waveform detail and avoid aliasing.
- Longer record lengths increase measurement accuracy but the oscilloscope takes longer to measure each waveform.

Search and Mark Algorithms

DDR search algorithms look for patterns in data (DQ) to determine start and end of bursts. All searches use histogram analysis around edges found in the waveform, where edges are determined using the supplied min/max/mid levels. These levels and the speed grade are configurable in the DDRA application's first and fifth steps.

DDR search operates by scanning through both DQ and DQS and measuring peak to peak voltage and mid-levels. The mid-level detected on DQS is then used with a 10% hysteresis band to extract the edges from the DQS signal. These edges are stored and are then used for bit rate estimation.

All DDR searches use waveform shape expectations to determine start or stop of a Read and Write burst. The application will scan for first the start of any burst, followed by that burst's termination condition. Once a start condition has been found, only the termination condition will be searched for until the end-of-record.

Data Eye Width

Data Eye Width is common for both Read and Write bursts. The type of burst is determined by the ASM settings. If a waveform contains multiple bursts of the same kind, the Data Eye Width is calculated and respective Eye Diagram rendered for all bursts within one acquisition. It uses the DPOJET measurement, Eye width with eye diagram plot enabled. Set DQ to Data signal and DQS to explicit clock edge.

If an explicit clock is used the DQS eye will be superimposed onto the Data Eye diagram. The superimposed eye can be turned off from Eye diagram plot configuration panel. For Write bursts, the DQS eye is offset from the Data eye (crossing in the center), whereas eye diagrams overlap for Read bursts. The position of eye diagrams can be controlled using the Ref Clock alignment property on the Eye diagram plot configuration panel. The left and center options indicate where the DQS crossing shall be located so that Data Eye will maintain its normal position. Left is suitable for Read bursts and center for Write bursts. Use Auto to automatically determine the offset property.

For more details, refer to the topic “Eye Width” of the DPOJET help.

tDH-Diff(base)

tDH-Diff(base) is defined as the input hold time between Data (DQ) and Differential Strobe (DQS) signal. It is the elapsed time taken from the mid-level of the DQS signal to the specific level (VIH(dc) and VIL(dc), where VIH(dc) is on a falling slope of DQ signal and VIL(ac) is on a rising slope of the DQ signal). This measurement requires you to set up correct reference levels for DQS and DQ signals for different speeds. The DDRA application will set up these levels automatically when “JEDEC Default” mode is selected. When “User Defined” mode is selected, then these reference levels are calculated based on your input for Vref and Vdd.

tDH-Diff(base) uses the DPOJET measurement, DDR-Hold-Diff.

For more details, refer to the topic “DDR-Hold-Diff” of the DPOJET help.

tDH-Diff(derated)

Derating limits are calculated by adding the tDH(base) limit and ΔtDH(derating) value. ΔtDH for a rising signal is defined as the slew rate between the last crossing of $V_{IL(dc)}$max and the first crossing of $V_{REF(dc)}$, and for a falling signal is defined as the slew rate between the last crossing of $V_{IH(dc)}$ min and the first crossing of $V_{REF(dc)}$.

tDH-Diff(derated) uses the DPOJET measurement, DDR-Hold-Diff, to calculate the base value.

For more details, refer to the topic “DDR-Hold-Diff” of the DPOJET help.

tDS-Diff(derated)

Derating limits are calculated by adding the tDS(base) limit and ΔtDS(derating) value.. ΔtDS for a rising signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IH(ac)}$min, and for a falling signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IL(ac)}$max and the first crossing of $V_{IL(ac)}$max.

tDS-Diff(derated) uses the DPOJET measurement, DDR-Setup-Diff, to calculate the base value.

For more details, refer to the topic “DDR-Setup-Diff” of the DPOJET help.

tDH-SE(base)

tDH-SE(base) is defined as the input hold time between DQ and single-ended DQS signal.

tDH-SE(base) uses the DPOJET measurement, DDR-Hold-SE.

For more details, refer to the topic “DDR-Hold-SE” of the DPOJET help.

Slew Rate-Hold-Fall(DQ)

Slew Rate-Hold-Fall(DQ) measures the slew rate on the DQ-SE signal between the falling edge from V_{REF} to $V_{IL(ac)}$max. This measurement is available for both DDR2 and DDR3 generation.

Slew Rate-Hold-Fall(DQ) uses the DPOJET measurement, Fall Slew Rate.

For more details, refer to the topic “Fall Slew Rate” of the DPOJET help.

Slew Rate-Hold-SE-Fall(DQS)

Slew Rate-Hold-SE-Fall(DQS) measures the slew rate on the DQS-SE signal between the falling edge from V_{REF} to $V_{IL(ac)}$max.

Slew Rate-Hold-SE-Fall(DQS) uses the DPOJET measurement, Fall Slew Rate.

For more details, refer to the topic “Fall Slew Rate” of the DPOJET help.

Slew Rate-Hold-Rise(DQ)

Slew Rate-Hold-Rise(DQ) measures the slew rate on the DQ-SE signal between the rising edge from V_{REF} to $V_{IH(ac)}$min. This measurement is available for both DDR2 and DDR3 generation.

Slew Rate-Hold-Rise(DQ) uses the DPOJET measurement, Rise Slew Rate.

For more details, refer to the topic “Rise Slew Rate” of the DPOJET help.

Slew Rate-Hold-SE-Rise(DQS)

Slew Rate-Hold-SE-Rise(DQS) measures the slew rate on the DQS-SE signal between the rising edge from V_{REF} to $V_{IH(ac)}$min.

Slew Rate-Hold-SE-Rise(DQS) uses the DPOJET measurement, Rise Slew Rate.

For more details, refer to the topic “Rise Slew Rate” of the DPOJET help.

Slew Rate-Setup-Fall(DQ)

Slew Rate-Setup-Fall(DQ) measures the slew rate on the DQ-SE signal between the falling edge from V_{REF} to $V_{IL(ac)}$max. This measurement is available for both DDR2 and DDR3 generation.

Slew Rate-Setup-Fall(DQ) uses the DPOJET measurement, Fall Slew Rate.

For more details, refer to the topic “Fall Slew Rate” of the DPOJET help.

Slew Rate-Setup-SE-Fall(DQS)

Slew Rate-Setup-SE-Fall(DQS) measures the slew rate on the DQS-SE signal between the falling edge from V_{REF} to $V_{IL(ac)}$max.

Slew Rate-Setup-SE-Fall(DQS) uses the DPOJET measurement, Fall Slew Rate.

For more details, refer to the topic “Fall Slew Rate” of the DPOJET help.

Slew Rate-Setup-Rise(DQ)

Slew Rate-Setup-Rise(DQ) measures the slew rate on the DQ-SE signal between the rising edge from V_{REF} to $V_{IH(ac)}$min. This measurement is available for both DDR2 and DDR3 generation.

Slew Rate-Setup-Rise(DQ) uses the DPOJET measurement, Rise Slew Rate.

For more details, refer to the topic “Rise Slew Rate” of the DPOJET help.

Slew Rate-Setup-SE-Rise(DQS)

Slew Rate-Setup-SE-Rise(DQS) measures the slew rate on the DQS-SE signal between the rising edge from V_{REF} to $V_{IH(ac)}$min.

Slew Rate-Setup-SE-Rise(DQS) uses the DPOJET measurement, Rise Slew Rate.

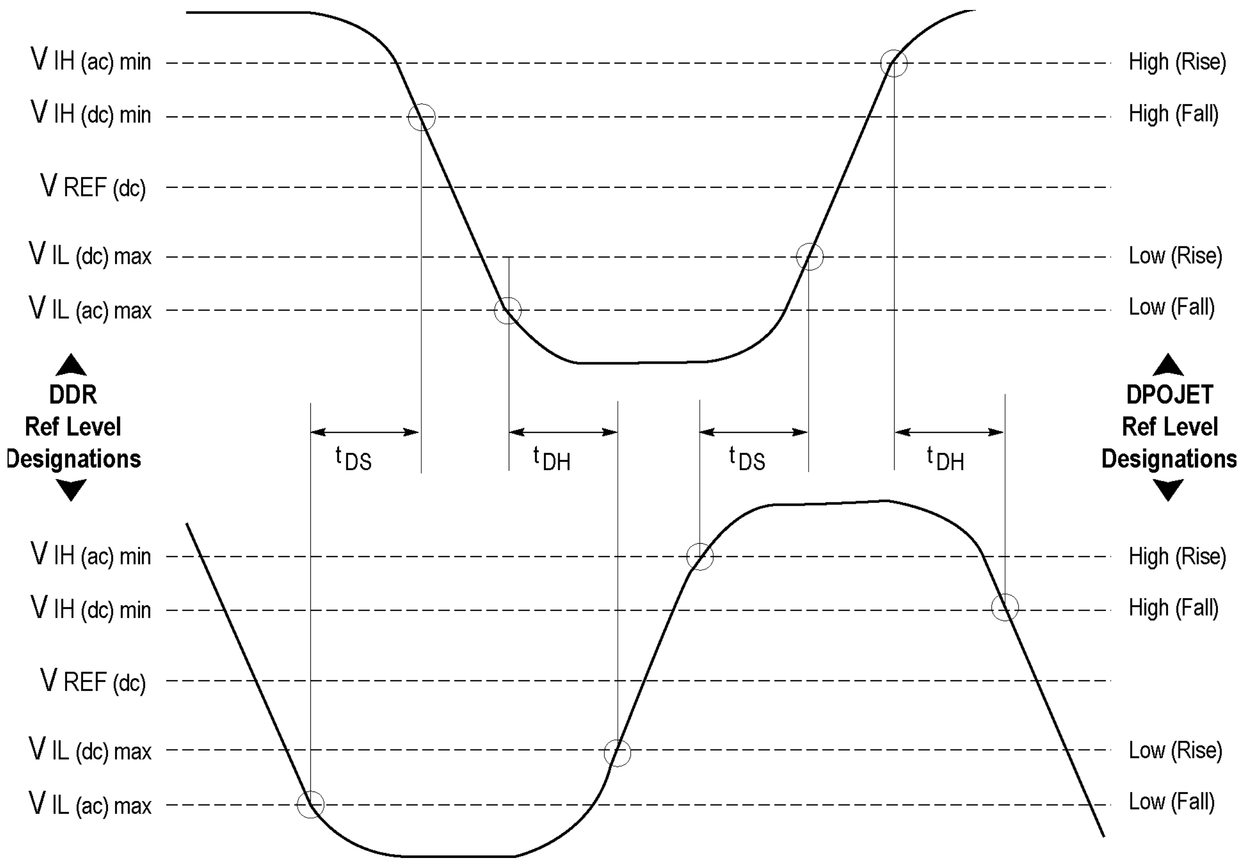
For more details, refer to the topic “Rise Slew Rate” of the DPOJET help.

tDS-Diff(base)

tDS-Diff(base) is defined as the input setup time between DQ and differential DQS signal. It is the elapsed time taken from the mid-level of the DQS signal to the specific level (VIH(ac) and VIL(ac), where VIH(ac) is on a falling slope of DQ signal and VIL(ac) is on a rising slope of the DQ signal).

tDS-Diff(base) uses the DPOJET measurement, DDR Setup-Diff.

For more details, refer to the topic “DDR-Setup-Diff” of the DPOJET help.



The configured values of Vdd and Vref are used to calculate $V_{IH(ac)}$min $V_{IH(dc)}$min, $V_{IL(dc)}$max and $V_{IL(ac)}$max, which are applied on the input signal. These levels are further used for calculating Setup and Hold measurements.

The relationship between Vdd and Vref for DDR2 standard is as shown in the following tables. For other DDR standards, please refer to their JEDEC specifications.

Table 18: Input DC logic Level

Symbol	Parameter	Min	Max	Units
$V_{IH(dc)}$	DC input logic high	Vref+0.125	–	V
$V_{IL(dc)}$	DC input logic low	–0.3	Vref–0.125	V

Table 19: Input AC logic Level

		DDR2–400, DDR2–533		DDR2–667,DDR2–800		Units
Symbol	Parameter	Min	Max	Min	Max	
$V_{IH(ac)}$	AC input logic high	Vref+0.250	x	Vref+0.200	–	V
$V_{IL(ac)}$	AC input logic low	–	Vref–0.250	–	Vref+0.200	V

tDS-SE(base)

tDS-SE(base) is the input setup time between DQ and single-ended DQS signal. It is the elapsed time between VIH(dc)min of DQS and VIL(ac) max of DQ.

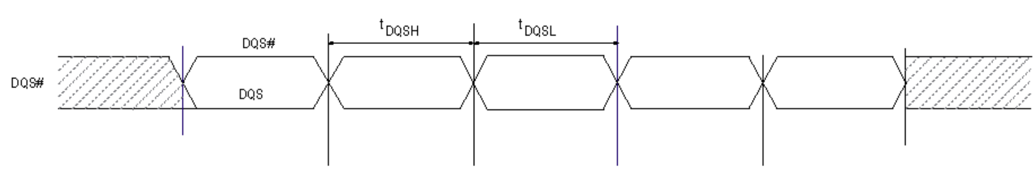
tDS-SE(base) uses the DPOJET measurement, DDR-Setup-SE.

For more details, refer to the topic “DDR-Setup-SE” of the DPOJET help.

tDQSH

tDQSH is the high pulse width on the DQS(Strobe) input. Amount of time the waveform remains above the mid reference voltage level.

tDQSH uses the DPOJET measurement, Pos Width.

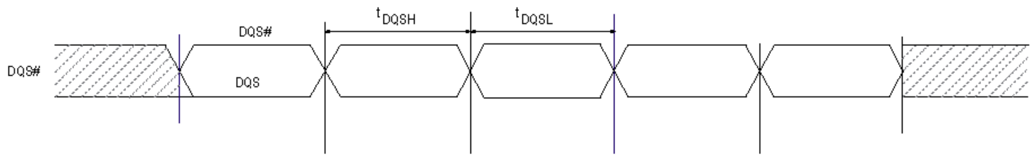


For more details, refer to the topic “Positive and Negative Width” of the DPOJET help.

tDQSL

tDQSL is the low pulse width on the DQS(Strobe) input. Amount of time the waveform remains below the mid reference voltage level.

tDQSL uses the DPOJET measurement, Neg Width.



For more details, refer to the topic “Positive and Negative Width” of the DPOJET help.

tDIPW-SE

tDIPW-SE is defined as the input pulse width on the DQ signal.

tDIPW-SE uses the DPOJET measurement, High Time.

For more details, refer to the topic “High Time” of the DPOJET help.

tDSS-Diff

tDSS-Diff is defined as the elapsed setup time from the DQS falling edge to the clock rising edge.

tDSS-Diff uses the DPOJET measurement, Skew.

For more details, refer to the topic “Skew” of the DPOJET help.

tDSS-SE

tDSS-SE is defined as the elapsed setup time from the DQS falling edge to the clock rising edge.

tDSS-SE uses the DPOJET measurement, Skew.

For more details, refer to the topic “Skew” of the DPOJET help.

tDSH-Diff

tDSH-Diff is defined as the elapsed hold time from the DQS falling edge to the clock rising edge.

tDSH-Diff uses the DPOJET measurement, Hold.

For more details, refer to the topic “Hold” of the DPOJET help.

tDSH-SE

tDSH-SE is defined as the elapsed hold time from the DQS falling edge to the clock rising edge.

tDSH-SE uses the DPOJET measurement, Hold.

For more details, refer to the topic “Hold” of the DPOJET help.

tDQSS-Diff

tDQSS-Diff is defined as the elapsed time from the DQS rising edge to the clock rising edge.

tDQSS-Diff uses the DPOJET measurement, Setup.

For more details, refer to the topic “Setup” of the DPOJET help.

tDQSS-SE

tDQSS-SE is defined as the elapsed time from the DQS rising edge to the clock rising edge.

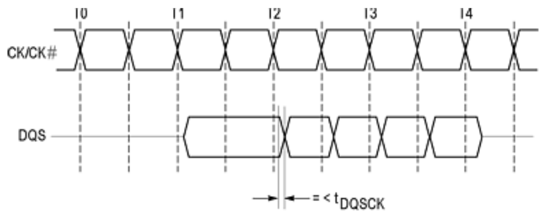
tDQSS-SE uses the DPOJET measurement, Setup.

For more details, refer to the topic “Setup” of the DPOJET help.

tDQSCK-Diff

tDQSCK-Diff is the DQS output access time from CK or CK#.

tDQSCK-Diff uses the DPOJET measurement, Skew.



The application calculates this measurement using the following equation:

$$Skew = T_n - T_{DQS(n)}$$

for mid level

Where:

T_n specifies the clock edges.

$T_{DQS(n)}$ specifies the DQS edges.

The edge locations are determined by the mid-reference voltage levels. This is a skew measurement between the rising edge of DQS and the rising edge of clock.

For more details, refer to the topic "Skew" of the DPOJET help.

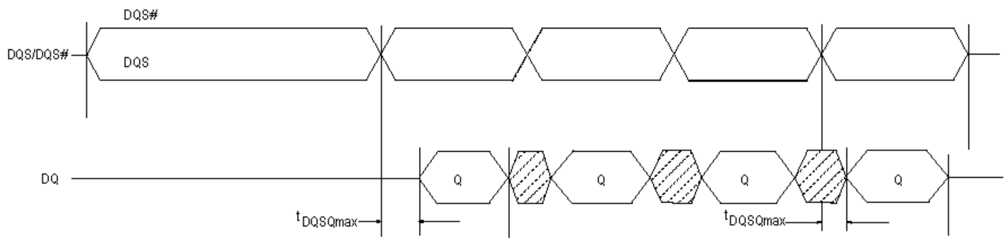
NOTE. *The JEDEC standard specifies that tDQSCK is the actual position of a rising strobe edge relative to CK, CK#. Hence, DQS should be in phase with CK. When DQS and CK are not in phase, there could be possibility of probe polarity interchange. You can overcome this by changing the edge direction to "Opposite as From" under edges configure tab for Skew measurements.*

For more details, refer to the topic "Configuring Edges for Skew Measurement" of the DPOJET help.

tDQSQ-Diff

tDQSQ-Diff is the DQS-DQ skew for DQS and associated DQ signals. Set JEDEC standard reference levels for DQ.

tDQSQ-Diff uses the DPOJET measurement, Setup.



For more details, refer to the topic “Setup” of the DPOJET help.

tDQSQ-SE

tDQSQ-SE is the skew measured between DQS and DQ single-ended signals.

tDQSQ-SE uses the DPOJET measurement, Setup.

For more details, refer to the topic “Setup” of the DPOJET help.

tAC-Diff

tAC-Diff is the DQ output access time from CK or CK#. Set DQ as the clock source and DQS as the differential source. Set appropriate reference levels for DQ.

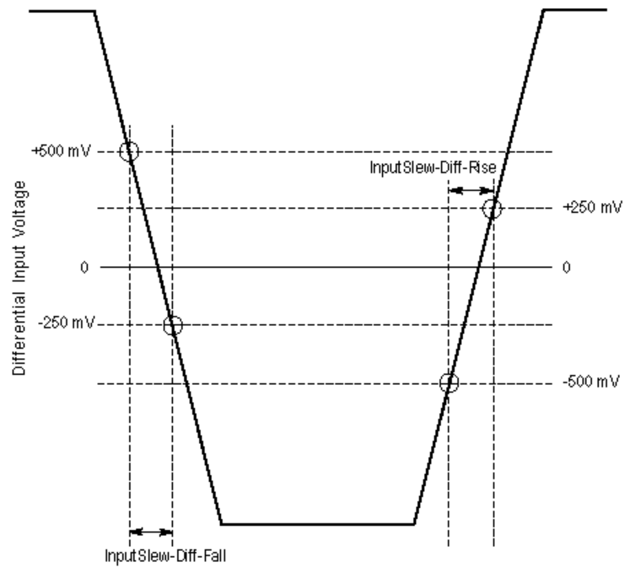
tAC-Diff uses the DPOJET measurement, DDR-Setup-Diff.

For more details, refer to the topic “DDR-Setup-Diff” of the DPOJET help.

Input Slew-Diff-Rise(DQS)

Input Slew-Diff-Rise(DQS) measures slew rate on differential DQS signals between the rising edges from low to high.

Input Slew-Diff-Rise(DQS) uses the DPOJET measurement, Rise Slew Rate.



NOTE. *The above figure is applicable for all DDR2 Slew Rate(Diff) measurements.*

For more details, refer to the topic “Rise Slew Rate” of the DPOJET help.

Input Slew-Diff-Fall(DQS)

Input Slew-Diff-Fall(DQS) measures slew rate on differential DQS signals between the falling edges from high to low.

Input Slew-Diff-Fall(DQS) uses the DPOJET measurement, Fall Slew Rate.

For more details, refer to the topic “Fall Slew Rate” of the DPOJET help.

Input Slew-Diff-Rise(CK)

Input Slew-Diff-Rise(CK) measures slew rate on differential CK signals between the rising edges from low to high. The clock differential voltage varies from 500 mV to –250 mV.

Input Slew-Diff-Rise(CK) uses the DPOJET measurement, Rise Slew Rate.

For more details, refer to the topic “Rise Slew Rate” of the DPOJET help.

Input Slew-Diff-Fall(CK)

Input Slew-Diff-Fall(CK) measures slew rate on differential CK signals between falling edges from clock high to low. The clock differential voltage varies from +500 mV to –250 mV.

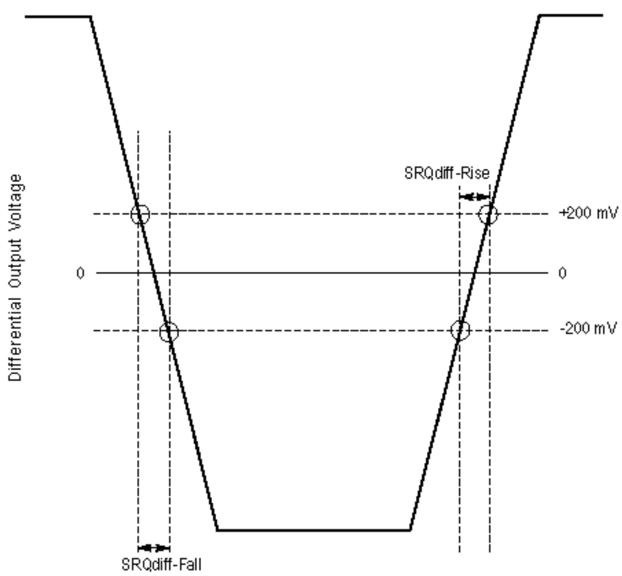
Input Slew-Diff-Fall(CK) uses the DPOJET measurement, Fall Slew Rate.

For more details, refer to the topic “Fall Slew Rate” of the DPOJET help.

SRQdiff-Rise(DQS)

SRQdiff-Rise(DQS) measures slew rate on differential DQS signals between the rising edges from low to high.

SRQdiff-Rise(DQS) uses the DPOJET measurement, Rise Slew Rate.



NOTE. *The above figure is applicable for all DDR3 Slew Rate(Diff) measurements.*

For more details, refer to the topic “Rise Slew Rate” of the DPOJET help.

SRQdiff-Fall(DQS)

SRQdiff-Fall(DQS) measures slew rate on differential DQS signals between the falling edges from high to low.

SRQdiff-Fall(DQS) uses the DPOJET measurement, Fall Slew Rate.

For more details, refer to the topic “Fall Slew Rate” of the DPOJET help.

SRQdiff-Rise(CK)

SRQdiff-Rise(CK) measures the slew rate on differential CK signals between the rsisng edges from low to high. As per the DDR3 specification, the clock differential value varies from +200 mV to –200 mV.

SRQdiff-Rise(CK) uses the DPOJET measurement, Rise Slew Rate.

For more details, refer to the topic “Rise Slew Rate” of the DPOJET help.

SRQdiff-Fall(CK)

SRQdiff-Fall(CK) measures the slew rate on differential CK signals between falling edges from high to low. As per the DDR3 specification, the clock differential value varies from +200 mV to –200 mV.

SRQdiff-Fall(CK) uses the DPOJET measurement, Fall Slew Rate.

For more details, refer to the topic “Fall Slew Rate” of the DPOJET help.

tCH(abs)

tCH(abs) is the high pulse width on the clock signal. It is the amount of time the waveform remains above the mid reference voltage level.

tCH(abs) uses the DPOJET measurement, Pos Width.

For more details, refer to the topic “Positive and Negative Width” of the DPOJET help.

tCH(avg)

tCH(avg) is the average width of the high-half cycle calculated across a sliding 200-cycle window of clock cycles.

tCH(avg) uses the DPOJET measurement, DDR tCH(avg).

The application calculates this measurement using the following equation:

$$tCH(avg)=\left(\sum_{j=1}^{N} tCH_j\right)/\left(N\times tCK(avg)\right)$$

Where:

N=200, which is configurable.

tCK(abs)

tCK(abs)is the absolute clock period. It is the elapsed time between consecutive rising crossings of the mid reference CK voltage level.

tCK(abs) uses the DPOJET measurement, Period.

For more details, refer to the topic “Period” of the DPOJET help.

tCK(avg)

tCK(avg) is calculated as the average clock period across a sliding 200-cycle window of low pulses.

tCK(avg) uses the DPOJET measurement, DDR tCK(avg).

The application calculates this measurement using the following equation:

$$tCK(avg) = \left(\sum_{j=1}^{200} tCK_j\right)/\ N$$

Where:

N=200, which is configurable.

Range: 200≤N≤1M

tCL(abs)

tCL(abs) is the low pulse width on the clock signal. It is the amount of time the waveform remains below the mid reference voltage level.

tCL(abs) uses the DPOJET measurement, Neg Width.

For more details, refer to the topic "Positive and Negative Width" of the DPOJET help.

tCL(avg)

tCL(avg) is defined as the average low pulse width calculated across 200-cycle window of consecutive low pulses.

tCL(avg) uses the DPOJET measurement, DDR tCL(avg).

The application calculates this measurement using the following equation:

$$tCL(avg) = \left(\sum_{j=1}^{N} tCL_j \right) / \left(N \times tCK(avg) \right)$$

Where:

N=200, which is configurable.

Range: 200≤N≤1M

tHP

tHP is the minimum of the absolute half period of the actual input clock. It is similar to DPOJET's Period measurement where the edge type is clock with edges selection set to both. Only the minimum result statistics will be compared with the limit values for PASS/FAIL status.

The application calculates this measurement using the following equation:

$$tHP = Min\left(tCH(abs), tCL(abs)\right)$$

Where:

tCH(abs) is the minimum of the actual instantaneous clock high time.

tCL(abs) is the minimum of the actual instantaneous clock low time.

tERR

tERR (Timing error) is the time difference between the sum of tCK transitions for a 200-cycle window to n times tCK(avg). The calculated value represents the accumulated error across many cycles (n). The number of cycles to be used is defined by n, which is configurable.

The application calculates this measurement using the following equation:

$$tERR(nper) = \left(\sum_{j=1}^{i+n-1} tCK_j \right) - n \times tCK(avg)$$

Where:

For tERR(nper):

n=2 for *tERR(2 per)*

n=3 for *tERR(3 per)*

n=4 for *tERR(4 per)*

n=5 for *tERR(5 per)*

n=6 for *tERR(6 per)*

.

.

.

.

n=49 for *tERR(49 per)*

For tERR(m-nper):

$6 \leq n \leq 10$ for *tERR(6–10 per)*

$11 \leq n \leq 50$ for *tERR(11–50 per)*

$13 \leq n \leq 50$ for *tERR(13–50 per)*

tJIT(cc)

tJIT(cc) is the difference in period measurements from one cycle to the next; that is, the first difference of the Period measurement.

tJIT(cc) uses the DPOJET measurement, CC–Period.

The application calculates this measurement using the following equation:

$$tJIT(cc) = Max\ of\ |tCK_{i+1} - tCK_i|$$

tJIT(duty)

tJIT(duty) is the largest elapsed time between the tCH from tCH(avg) or tCL from tCL(avg) for a 200-cycle window. This value represents the maximum of the accumulated value across a 200-cycle moving window.

tJIT(duty) uses the DPOJET measurement, DDR tJIT(duty).

The application calculates this measurement using the following equation:

$$tJIT(duty) = Min/max\ of\ \{tJIT(CH), tJIT(CL)\}$$

Where:

tJIT(CH) = {tCHi- tCH(avg)}

tJIT(CL) = {tCLi- tCL(avg)}

Where:

i=1 to 200

tJIT(per)

tJIT(per) is the largest elapsed time between the tCK from tCK(avg) for a 200-cycle window. This value represents the maximum of the accumulated value across a 200-cycle moving window.

tJIT(per) uses the DPOJET measurement, DDR tJIT(per).

The application calculates this measurement using the following equation:

$$tJIT(per) = Min/max\ of\ \{tCK_i - tCK(avg)\}$$

Where:

i=1 to 200

VID(ac)

VID(ac) is defined as the magnitude of the difference between the input voltage on CK and the input voltage on CK#.

VID(ac) uses the DPOJET measurement, High-Low.

For more details, refer to the topic “High Low” of the DPOJET help.

AC-Overshoot(CK)

AC-Overshoot(CK) is the positive-going amplitude, for each waveform event that exceeds the Vdd reference level on the CK signal.

AC-Overshoot(CK) uses the DPOJET measurement, Overshoot.

NOTE. *If the input waveform never exceeds Vdd, the measurement will return a population of 0 events.*

For more details, refer to the topic “Overshoot” of the DPOJET help.

AC-Overshoot(CK#)

AC-Overshoot(CK#) is the positive-going amplitude, for each waveform event that exceeds the Vdd reference level on the CK# signal.

AC-Overshoot(CK#) uses the DPOJET measurement, Overshoot.

NOTE. *If the input waveform never exceeds Vdd, the measurement will return a population of 0 events.*

For more details, refer to the topic “Overshoot” of the DPOJET help.

AC-Undershoot(CK)

AC-Undershoot(CK) is the negative-going amplitude (expressed as a positive number), for each waveform event that goes below the Vss reference level on the CK signal.

AC-Undershoot(CK) uses the DPOJET measurement, Undershoot.

NOTE. *If the input waveform never goes below Vss, the measurement will return a population of 0 events.*

For more details, refer to the topic “Undershoot” of the DPOJET help.

AC-Undershoot(CK#)

AC-Undershoot(CK#) is the negative-going amplitude (expressed as a positive number), for each waveform event that goes below the Vss reference level on the CK# signal.

AC-Undershoot(CK#) uses the DPOJET measurement, Undershoot.

NOTE. *If the input waveform never goes below Vss, the measurement will return a population of 0 events.*

For more details, refer to the topic “Undershoot” of the DPOJET help.

Vix(ac)CK

Vix(ac)CK is defined as the cross-point voltage for differential input signals measured across the clock signal.

Vix(ac)CK uses the DPOJET measurement, V–Diff–Xovr.

For more details, refer to the topic “V–Diff–Xovr” of the DPOJET help.

Vox(ac)CK

Vox(ac)CK is defined as the cross-point voltage for differential input signals measured across the clock signal.

Vox(ac)CK uses the DPOJET measurement, V–Diff–Xovr.

For more details, refer to the topic “V–Diff–Xovr” of the DPOJET help.

Vix(ac)DQS

Vix(ac)DQS is defined as the cross-point voltage for differential input signals measured across the DQS signal.

Vix(ac)DQS uses the DPOJET measurement, V–Diff–Xovr.

For more details, refer to the topic “V–Diff–Xovr” of the DPOJET help.

Vox(ac)DQS

Vox(ac)DQS is defined as the cross-point voltage for differential input signals measured across the DQS signal.

Vox(ac)DQS uses the DPOJET measurement, V–Diff–Xovr.

For more details, refer to the topic “V–Diff–Xovr” of the DPOJET help.

AC-Overshoot(DQS)

AC-Overshoot(DQS) is the positive-going amplitude, for each waveform event that exceeds the Vdd reference voltage level on the DQS signal.

AC-Overshoot(DQS) uses the DPOJET measurement, Overshoot.

NOTE. *If the input waveform never exceeds the specified reference level, the measurement will return a population of 0 events.*

For more details, refer to the topic “Overshoot” of the DPOJET help.

AC-Overshoot(DQS#)

AC-Overshoot(DQS#) is the positive-going amplitude, for each waveform event that exceeds the Vdd reference level on the DQS# signal.

AC-Overshoot(DQS#) uses the DPOJET measurement, Overshoot.

NOTE. *If the input waveform never exceeds the specified reference level, the measurement will return a population of 0 events.*

For more details, refer to the topic “Overshoot” of the DPOJET help.

AC-Undershoot(DQS)

AC-Undershoot(DQS) is the negative-going amplitude (expressed as a positive number), for each waveform event that goes below the Vss reference level on the DQS signal.

AC-Undershoot(DQS) uses the DPOJET measurement, Undershoot.

NOTE. *If the input waveform never goes below the specified reference level, the measurement will return a population of 0 events.*

For more details, refer to the topic "Undershoot" of the DPOJET help.

AC-Undershoot(DQS#)

AC-Undershoot(DQS#) is the negative-going amplitude (expressed as a positive number), for each waveform event that goes below the reference level on the DQS# signal.

AC-Undershoot(DQS#) uses the DPOJET measurement, Undershoot.

NOTE. *If the input waveform never goes below the specified reference level, the measurement will return a population of 0 events.*

For more details, refer to the topic "Undershoot" of the DPOJET help.

tIS(base)

tIS(base) is the input setup time measured on an address and command signal to the clock signal.

tIS(base) uses the DPOJET measurement, DDR Setup-Diff.

For more details, refer to the topic "DDR-Setup-Diff" of the DPOJET help.

tIH(base)

tIH(base) is the input hold time measured on an address and command signal to the clock signal.

tIH(base) uses the DPOJET measurement, DDR Hold-Diff.

For more details, refer to the topic "DDR Hold-Diff" of the DPOJET help.

tIS(derated)

Derating limits are calculated by adding the tIS(base) limit and ΔtIS(derating) value. ΔtIS for a rising signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{IH(ac)}$min, and for a falling signal is defined as the slew rate between the last crossing of $V_{REF(dc)}$ and the first crossing of $V_{il(ac)}$max.

tIS(derated) uses the DPOJET measurement, DDR Setup-Diff.

$tIS = tIS(base) + \Delta tIS$

For more details, refer to the topic "DDR-Setup-Diff" of the DPOJET help.

tIH(derated)

Derating limits are calculated by adding the tIH(base) limit and ΔtIH(derating) value. ΔtIH for a rising signal is defined as the slew rate between the last crossing of $V_{IL(dc)}$max and the first crossing of $V_{REF(dc)}$, and for a falling signal is defined as the slew rate between the last crossing of $V_{IH(dc)}$min and the first crossing of $V_{REF(dc)}$.

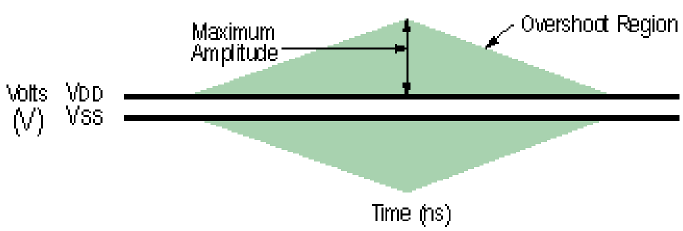
tIH(derated) uses the DPOJET measurement, DDR Hold-Diff.

For more details, refer to the topic "DDR-Hold-Diff" of the DPOJET help.

AC-Overshoot

AC-Overshoot is the maximum positive-going amplitude relative to Vdd, for each waveform event that exceeds the Vdd reference voltage level.

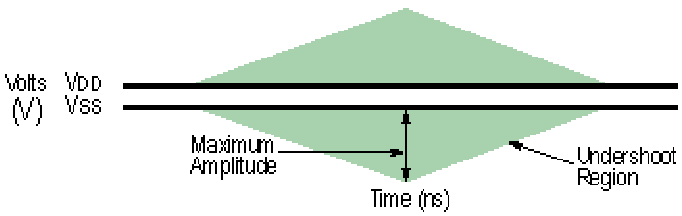
AC-Overshoot uses the DPOJET measurement, Overshoot.



AC-Undershoot

AC-Undershoot is the negative-going amplitude (expressed as a positive number) relative to Vss, for each waveform event that goes below the Vss reference voltage level.

AC-Undershoot uses the DPOJET measurement, Undershoot.



tIPW-High

tIPW-High is the high input pulse width measured on an address and command signal.

tIPW-High uses the DPOJET measurement, High Time.

For more details, refer to the topic “High Time” of the DPOJET help.

tIPW-Low

tIPW-Low is the low input pulse width measured on an address and command signal.

tIPW-Low uses the DPOJET measurement, Low Time.

For more details, refer to the topic “Low Time” of the DPOJET help.

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