Tektronix[®]

DDR5 Memory Interface Electrical Verification and Debug

Opt. DDR5SYS - System Level Transmitter Tests Datasheet



The DDR (Dual Data Rate) is a dominant and fast-growing memory technology. It offers high data transfer rates required for virtually computing applications, from consumer products to the most powerful servers. The high speed of these signals requires high-performance measurement tools. The Tektronix TekExpress DDR Tx is an automated test application used to validate and debug the DDR5 designs of the DUT as per the JEDEC specifications. The solution enables you to achieve new levels of productivity, efficiency, and measurement reliability.

Key features

- Supports 52 measurements of DDR5 System Transmitter Tests as per DDR5 JEDEC specification:
 - 21 Clock measurements
 - 09 Write Burst measurements
 - 01 Write Data Eye measurement
 - 13 Read Burst measurements
 - 08 Command and Address measurements
- User-Defined Acquisition (UDA) mode for Clock, Write Clock, CA, CS, Data Strobe, and data for both Write and Read traffic (or bursts).

UDA: The TekExpress DDR Tx 'DDR5' Transmitter Solution puts control back where it should be, with the user. User defined acquisition mode allows you to run DDR5 JEDEC compliance measurements by customizing scope settings like sample rate, record length, bandwidth, and more

 De-embedding support for Clock, Command Address, Data Strobe, and data for both Write and Read traffic (or bursts)

- Number of UIs support for Clock and Read/Write data measurements
- Deploys DDR DFE standalone application, that can be launched from TekScope > Analyze > DDR DFE
- Support DFE for Write Data Eye measurements
- Multi-Run feature is applicable for all tests
- Save worst case waveform in known/TekExpress sessions
- Retain Vertical Scale support duringacquisition
- · User-friendly measurement configurations
- Test report to reflect all the statistics of the measurement
- · User can select the source and the channel in the acquisition panel
- Multiple Burst Detection Method supported Read and Write, Write Only, Read Only, and Visual Search
- Diamond shape mask and margin analysis for Write Data Eye measurement

Applications

Tektronix provides the most comprehensive solution to serve the needs of the engineers designing DDR silicon for server, computer, graphics systems, mobile, embedded systems, and for those who are validating the physical-layer compliance of DDR Memory Compliance Test Specification.

The Tektronix option DDR5SYS (TekExpress DDR Tx) includes compliance and debug solution for the following:

- DRAM components
- Data Buffer/RCD components
- System boards
- · Embedded systems
- Servers and Client/Desktop

The Tektronix option DDR5SYS is compatible with the following Tektronix oscilloscope models:

- DPO71604SX, DPO72304SX, DPO73304SX
- Non-ATI channels of DPS75004SX, DPS75904SX, DPS77004SX
- MSO72304DX, MSO72504DX, MSO73304DX, DPO72304DX, DPO72504DX, DPO73304DX

The above-mentioned Tektronix oscilloscopes are designed to meet the challenges of the next generation memory standards and provide the industry's leading vertical noise performance with the highest number of effective bits (ENOB) and flattest frequency response for oscilloscopes in their class.

DDR5 system level tests

The Tektronix TekExpress DDR Tx solution reduces the effort and accelerates the compliance testing for DDR systems and devices with several unique and innovative capabilities.

The TekExpress DDR Tx application provides a simple, step-by-step, and easy-to-use interface to speed up the testing process. User can select the memory technology of interest in Device, Data Rate, Burst Detection Method, select the probing configuration used for Clock, and strobe in the Setup DUT panel, in the next step perform the test selection as per measurement group (Clock, Command Address, Data Strobe, and Data for both Read and Write traffic (or bursts)) and individual measurements within the group provide different methods of Burst detection.

V TekExpress DDR Tx - (U	Intitled) Option	15 T C C C
Setup Status Results Reports (Configuration (Configuration) (C	Acquire live waveforms User Defined Acquisiton Use pre-recorded waveform files Duri b UUT001	Pouse
Ready.		

Figure 1: TekExpress DDR Tx – application launch screen

Acquisitions

The TekExpress DDR Tx application comes with a unique feature to select or deselect the signal. Once the signal is selected in the acquisition panel, the user can select the signal source connected to the oscilloscope.

	Signal	Source		Signal	Source
~	DQ	CH2	~	Clock	CH3
~	DQS	CH1		Add.Cmd	

Figure 2: Acquisition panel - signal source selection

De-embed filters

Easily de-embed the interposer and the probe effects by applying suitable de-embed filters within the DDR5 standard.

		0	X)
De-Embed	l Filter File Path		
Clock			
CLK	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx		
CLK+	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx		
CLK-	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx		
Data - Read			
DQ	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx	×	
DQS	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx	X	
Data - Write			
DQ	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx	X	
DQS	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx	×	
DQS+	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx		
DQS-	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx		
CA/CS			
ADDR CMD	C:\Program Files\Tektronix\TekExpress\TekExpress DDR Tx		
		Close	

Figure 3: De-embed filters

Comprehensive measurements

The option DDR5SYS adds a long list of JEDEC specific measurements for DDR5 memory standards. The TekExpress DDR Tx application covers Electrical measurements, Timing measurements, and Eye Diagram measurements as per the JEDEC standards.

Automated Read and Write Burst detection

The TekExpress DDR Tx provides different ways to detect the burst cycles that are used to perform measurements:

- Read Write Bursts when the DUT traffic is configured to send both Read and Write bursts then this method is used for burst detection.
- Write Only when the DUT traffic is configured to send all Write Bursts then this method is used for burst detection.
- Read Only when the DUT traffic is configured to send all Read Bursts then this method is used for burst detection.
- Visual Search defining Visual Trigger areas to identify and gate area of interest for measurements

Burst Detection Metho	bd
Read Write Bursts	
Read Write Bursts	
Write Only Bursts	
Read Only Bursts	
Visual Search	

Figure 4: Burst detection

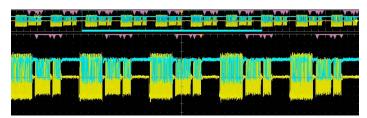


Figure 5: Automated Read and Write Burst detection - for Write Bursts

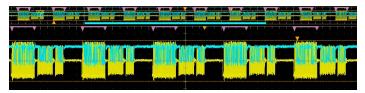


Figure 6: Automated Read and Write Burst detection - for Read Bursts

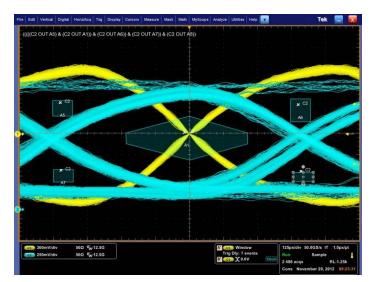


Figure 7: Visual trigger

Test selection

The TekExpress DDR Tx test selection panel allows the user to select the various measurements supported by the application.

- Supports 52 measurements of DDR5 System Transmitter Tests as per DDR5 JEDEC specification:
 - 21 Clock measurements
 - 09 Write Burst measurements
 - 01 Write Data Eye measurement
 - 13 Read Burst measurements
 - 08 Command and Address measurements

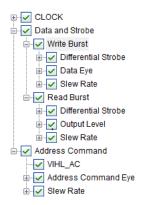


Figure 8: Test selection panel - tree view of measurements

Configurations

Ease of use measurement configuration to configure measurements by group instead of running through all the 50+ measurements.

Test Selection	Global Settings	Measurements		
Acquisitions	Clock Clock_Slew_R WR_Differentia	al_Strobe		
4 Configuration	···· WR_Data_Eye ···· WR_Slew_Rate			
5 Preferences	···· RD_Differentia ···· RD_Output_Le ···· RD_Slew_Ration ···· Address_Comm ···· Address_Comm	evel and		

DDR DFE standalone plugin

The DDR5 application supports data rates from 3200 MT/s to 6400 MT/s. This increase in the data rate is realized without the need for differential signaling at the DQ pins i.e. the DQ bus is single-ended – same as DDR3/4. However, due to the many impedance mismatched points that exist along with the memory subsystem, ISI due to reflections are expected to increase. At data rates >= 4800 MT/s, the data eye at the DRAM ball is expected to be closed. A 4-tap DFE is implemented in the DDR5 DRAM Rx to help equalize the DQ signals and open the data eyes after the data is latched by the receiver.

The TekExpress DDR Tx application provides DDR DFE as a standalone software application in Tektronix's performance scopes. It is used to perform 4 tap DFE operation on the DDR5 write burst signals coming from the DDR5 DUTs.

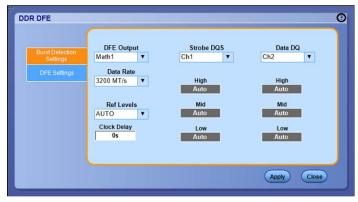


Figure 9: DDR DFE standalone plugin

Results and reporting with waveform

The measurement configurations and JEDEC pass/fail limits are automatically applied for the selected measurements based on the memory specification and the selected speed grade. The results report includes DDR measurements statistical data, measurement plots, and the screenshot of the waveforms with the cursors. Hyperlinks within the report allows you to navigate between the sections.

When test execution is complete, the application automatically opens the Results panel and displays the summary of test results.

Overall Test Result 💊 Pass				Preferences
Test Name	Measurement D.	Pass/Fall	Value	Margin
tCK_Duty_UI_Error	tCK Duty UI Error	Pass	5.8129mUl	0.0442 UI
tCK_1UI_RJ_NoBUJ tCK_1UI_RJ_NoBUJ	tCK 1ULRJ NoBUJ	🎯 Pass	2.4126mUI	0.0276 UI

Figure 10: Measurement results

Tek	tro	nix					ess DDR ⁻ er Test Repo						
Setup Informati	ice :												
DUT ID				01			Scope Model			1.0907	33045X		
Date/Tirm			2019	11-04 11:56:57			Scope Serial N	umber		PQ10	00204		
Device Type			DDRS				SPC, Factory C	alibration		PASS.	PASS		
TekExpress Ver	rsion			work:4.14.0.5			Scope F/W Ver				11 Build 42		
App Version				Dx:10.0.4.15			DPOJET Versio			10.0.			
DUT Signal			Cong				Clock Signal P			Differ			
Overall Executiv			0.01.4				DC/S Signal Pro	phing		Diffe			
Overall Test Re			Pass				Data Kate			3200.	0 MT/s		
DUT COMMENT		General Com	ment - DDR Tx										
							1.0						
	Inor						Pass Pass						
Test Name Som ICK_Duty_UL_E ICK_TUL_RI_NO	itor Gui												
	itor Gui	Test Result	Margin	Low Limit	High Limit	Sed Dev		Max	Min	P-P	Population	Mas-CC	Min-CC
ICK, Duty, UI, E ICK, TUL, RJ, Not ICK, Duty, UI, En Measurement Details ICK, Duty, UI, En St.	nor Measured Value	Test Result Pass	Margin 0.0442 UI	Los Limit N.A	High Limit 6.0500 til	Sed Dev 0.0003 UI	Pass	Max 5.6129mtR	Min 5.8129m/Ji	P-P 0.0000 UI	Population	Max-CC 0.0003 UI	10000
TCK_Duty_UL_EI TCK_TUL_RJ_Nol TCK_Duty_UL_EI Measurement	Neasured Value	100000000000000000000000000000000000000	Cast of the	1287250000	1007 No. 100	100000	Pass	10.22	0.000	2.2	Population 1	0.0000 UI	9.0000 UI
CK, Duty, UL, E CK, TUL, RJ, Nor CK, Duty, UL, E Measurement Details CT, Duty, UL En 25	Neasured Value	100000000000000000000000000000000000000	Cast of the	1287250000	1007 No. 100	100000	Pass	10.22	0.000	2.2	Population	0.0000 UI	10000000
ICK, Duty, UL, B ICK, TUL, BJ, Nol ICK, Duty, UL, B1 Measurement Datails ICK, Duty, UL En ICK, Duty, UL En ICK COMMENTS	nor Bul Measured Value 3.6129m68	100000000000000000000000000000000000000	Cast of the	1287250000	1007 No. 100	100000	Pass	10.22	0.000	2.2	Population 1	0.0000 UI	9.0000 UI
CK, Duty, UL, E CK, TUL, RJ, Nor CK, Duty, UL, E Measurement Details CT, Duty, UL En 25	nor Bul Measured Value 3.6129m68	100000000000000000000000000000000000000	Cast of the	1287250000	1007 No. 100	100000	Pass	10.22	0.000	2.2	Population 1 Population	0.0000 UI	9.0000 U

Figure 11: Measurement report

Verification versus debug

The TekExpress DDR Tx application provides a comprehensive set of JEDEC timing and electrical measurements for the DDR5 standard. Also, it provides access to the DPOJET advanced Jitter and Timing analysis engine that allows flexibility to reconfigure the existing measurements or to perform new measurements that are not defined by the JEDEC specification using new user-specified test limits. Additionally, it features logging, filters, histograms, and time trends that are available in DPOJET. The user can also switch between debug mode and the compliance mode.

Oscilloscope triggering and waveform identification

The Tektronix Pinpoint[®] trigger system provides the most comprehensive high-performance trigger system in the industry. The Pinpoint trigger system encompasses threshold and timing related triggers, Dual A and B Event Triggering, Logic Qualification, Window Triggering, and Reset Triggering.

The Advanced Search and Mark feature in the Tektronix MSO/ DPO5000, DPO7000, and MSO/DPO70000 Series oscilloscopes find unique events in the waveforms. It scans acquired waveform data for multiple occurrences of an event and marks each occurrence.

The Search and Mark feature has a close relationship with the Pinpoint trigger system since they both can be used to discriminate signal characteristics. Search and Mark includes signal-shape discrimination features of the Pinpoint trigger system and extends them across live channels, stored data, and math waveforms.

The Visual Trigger makes the identification of the desired waveform events quick and easy by scanning all the acquired analog waveforms and comparing them with the geometric shapes on the display. By discarding the acquired waveforms which do not meet the graphical definition, Visual Triggering extends the oscilloscope's trigger capabilities beyond the traditional hardware trigger system.

Supported oscilloscopes

DPO71604SX, DPO72304SX, DPO73304SX, DPS75004SX, DPS75904SX, DPS77004SX, MSO72304DX, MSO72504DX, MSO73304DX, DPO72304DX, DPO72504DX, and DPO73304DX

Recommended probes

Active probes	Description
P7720	20 GHz TriMode probe with TekFlex connector technology
P7716	16 GHz TriMode probe with TekFlex connector technology
Probe tips	Description
P77STFLXA/P77STCABL	Active, Solder-in Tip with TekFlex connector technology, probe tips to probe directly on the motherboard/vias or interposers with 0 Ω resistor.
P77STFLXB/P77STLRCB	Active, Solder-in Tip with TekFlex connector technology, probe tips to probe on the SI Interposer with 100 Ω resistor (Nexus XH Series Interposer).
SI Interposer	EdgeProbe TM , Direct Attach, and Socketed Interposer are available from Nexus. Order directly from Nexus. Request the s-par files for all individual signals on the interposer instead of getting a generic nominal s-par model.
	Refer the Nexus's page for more information: http://www.nexustechnology.com/products/memory-interposers/ ddr5-main-memory-interposers/.

Ordering information

To order a new DPO/MSO70000 Series:

Nomenclature	Description
SX, DX >= 16G	·
DPO-UP DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO71604SX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72304SX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO73304SX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPS75004SX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPS75904SX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPS77004SX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72304DX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72504DX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO73304DX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
MSO72304DX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
MSO72504DX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
MSO73304DX DDR5SYS	License: DDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)

To order floating licenses on existing DPO/MSO70000 Series:

Product Nomenclature	Description	Mapped Options	Required Options
DPOFL-DDR5SYS	License; DDR5 System-level Tx TekExpress Compliance/ Debug Automation Software; Floating	DDR5SYS	SDLA64, DJA, and VET
DPOFT-DDR5SYS	License; DDR5 System-level Tx TekExpress Compliance/ Debug Automation Software; Floating Trial	DDR5SYS	SDLA64, DJA, and VET



Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

ASEAN / Australasia (65) 6356 3900 Belgium 00800 2255 4835* Central East Europe and the Baltics +41 52 675 3777 Finland +41 52 675 3777 Hong Kong 400 820 5835 Japan 81 (3) 6714 3086 Middle East, Asia, and North Africa +41 52 675 3777 People's Republic of China 400 820 5835 Republic of Korea +822 6917 5084, 822 6917 5080 Spain 00800 2255 4835* Taiwan 886 (2) 2656 6688 Austria 00800 2255 4835* Brazii +55 (11) 3759 7627 Central Europe & Greece +41 52 675 3777 France 00800 2255 4835* India 000 800 650 1835 Luxembourg +41 52 675 3777 The Netherlands 00800 2255 4835* Poland +41 52 675 3777 Russia & CIS +7 (495) 6647564 Sweden 00800 2255 4835* United Kingdom & Ireland 00800 2255 4835* Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777 Canada 1 800 833 9200 Denmark +45 80 88 1401 Germany 00800 2255 4835* Italy 00800 2255 4835* Mexico, Central/South America & Caribbean 52 (55) 56 04 50 90 Norway 800 16098 Portugal 80 08 12370 South Africa +41 52 675 3777 Switzerland 00800 2255 4835* USA 1 800 833 9200

* European toll-free number. If not accessible, call: +41 52 675 3777

For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit www.tek.com. Copyright © Tektronix, Inc. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specification and price change privileges reserved. TEKTRONIX and TEK are registered trademarks of Tektronix, Inc. All other trade names referenced are the service marks, trademarks, or registered trademarks of their respective companies.

> 7 Feb 2021 61W-61695-1 www.tek.com

