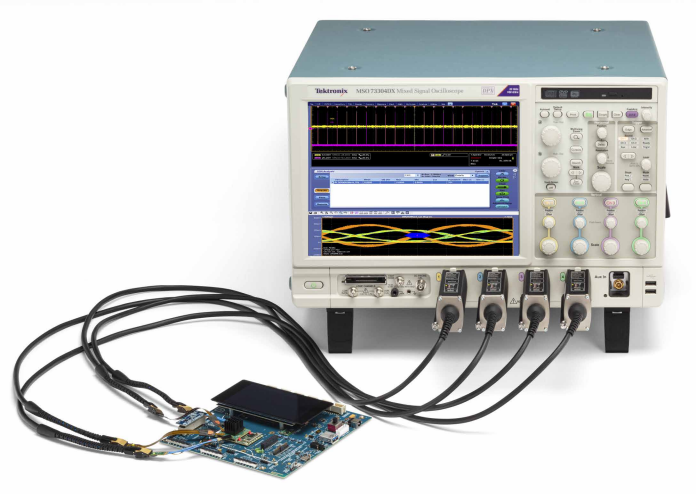
LPDDR5-5X Memory Interface Electrical Verification and Debug

Opt. LPDDR5SYS - 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 LPDDR5-5X 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 158 measurements of LPDDR5-5X System Transmitter Tests as per LPDDR5 JEDEC specification:
  - 33 Clock measurements
  - 11 Write Clock measurements
  - 58 Write Data measurements
  - 1 Write Data tDQ2DQ measurement
  - 30 Read Data measurements
  - 13 CA Rx Specification measurements
  - 12 CS Rx Specification 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 for LPDDR5-5X Transmitter Solution puts control back where it should be, with the user. User defined acquisition mode allows you to run LPDDR5-5X JEDEC compliance measurements by customizing scope settings like sample rate, record length, bandwidth, and more
- De-embedding support for Clock, Write Clock, CA, CS, Data Strobe, and data for both Write and Read traffic (or bursts)
- Number of UIs support for Clock, Write Clock and Read/Write data measurements
- Multi-Run feature is applicable for all tests
- Save worst case waveform in known/TekExpress sessions
- Retain Vertical Scale settings supported during acquisition
- 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
- Hexagon shape mask and margin analysis for Write Data, CA, CS Eye measurement
- Custom Data Rate support upto 15000MT/s
- Single Ended mode support

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 LPDDR5SYS (TekExpress DDR Tx) includes compliance and debug solution for the following:

- DRAM components
- System boards
- Embedded systems
- Mobile
- Automotive
- Internet of things (IoT)

The Tektronix option LPDDR5SYS is compatible with the following Tektronix oscilloscope models:

- MSO71604DX, MSO72004DX, MSO72304DX, MSO72504DX, and MSO73304DX.
- DPO71604DX, DPO72004DX, DPO72304DX, DPO72504DX, and DPO73304DX.
- DPO71604SX, DPO72004SX, DPO72304SX, DPO72504SX, and DPO73304SX.

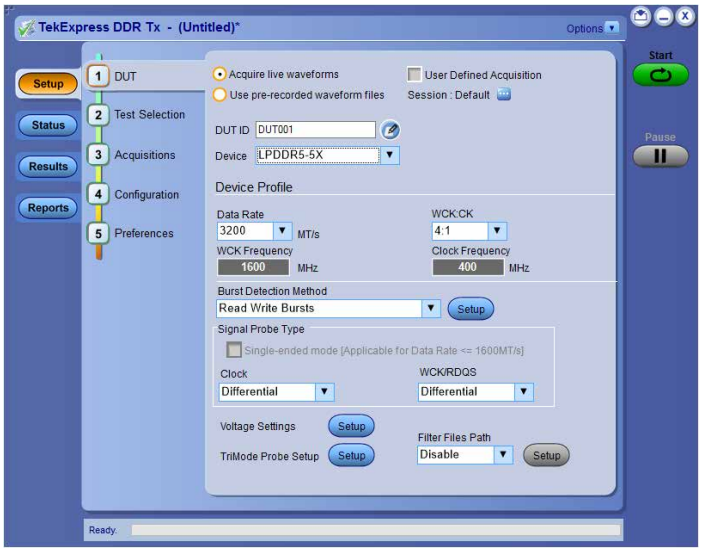
- Non-ATI channels of DPO75002SX, DPO75902SX, DPO7702SX, DPS75004SX, DPS75904SX, and DPS77004SX.

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.

LPDDR5-5X 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.

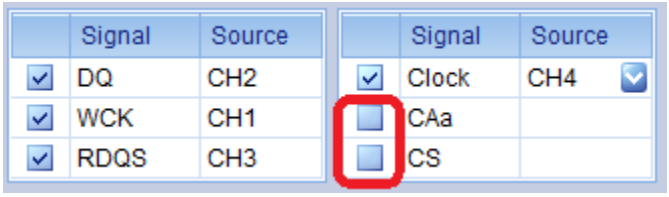
The TekExpress DDR Tx application provides a simple, step-by-step, and easy-to-use interface to speed up the testing process. User can select the memory technology of interest in Device, Data Rate, Burst Detection Method, select the probing configuration used for Clock, and strobe in the Setup DUT panel. Perform the test selection in the next step as per the 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.



TekExpress DDR Tx – application launch screen for LPDDR5-5X

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.



Acquisition panel – signal source selection for LPDDR5-5X

De-embed filters

Easily de-embed the interposer and the probe effects by applying suitable de-embed filters within the LPDDR5-5X standard.

De-embed filters for LPDDR5-5X

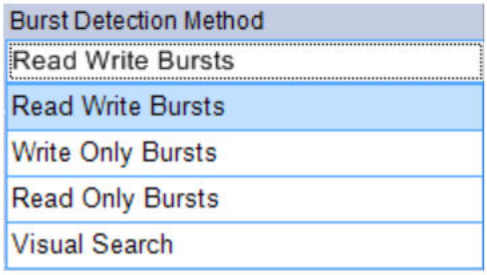
Comprehensive measurements

The option LPDDR5SYS adds a long list of JEDEC specific measurements for LPDDR5-5X memory standards. The TekExpress DDR Tx application covers Electrical measurements, Timing measurements, and Eye Diagram measurements as per the JEDEC standards.

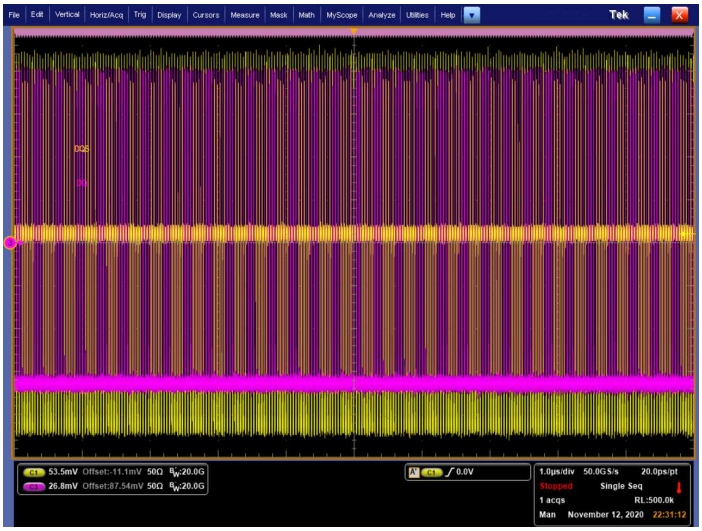
Automated Read and Write Burst detection

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

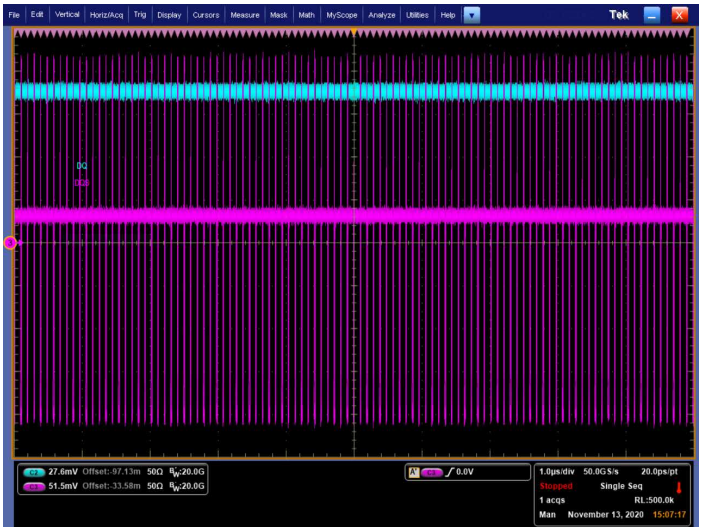
- Read Write Bursts – when the DUT traffic is configured to send both Read and Write bursts then this method is used for burst detection.
- Write Only – when the DUT traffic is configured to send all Write Bursts then this method is used for burst detection.
- Read Only – when the DUT traffic is configured 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



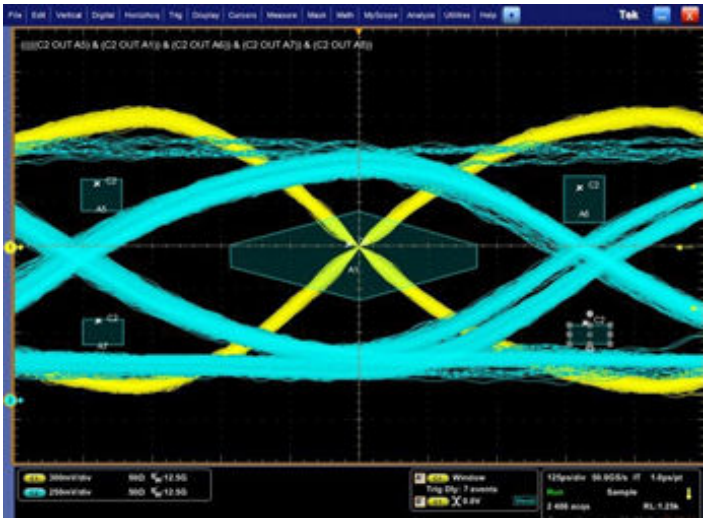
Burst detection



Automated Write Burst detection – for Write Bursts



Automated Read Burst detection – for Read Bursts



Visual trigger

Test selection

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

- Supports 158 measurements of LPDDR5-5X System Transmitter Tests as per LPDDR5 JEDEC specification:
  - 33 Clock measurements.
  - 11 Write Clock measurements.
  - 58 Write Data measurements.
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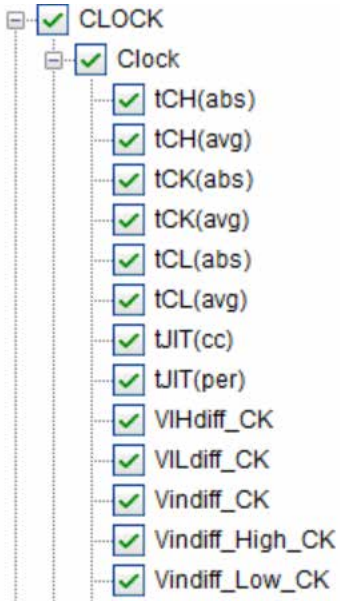
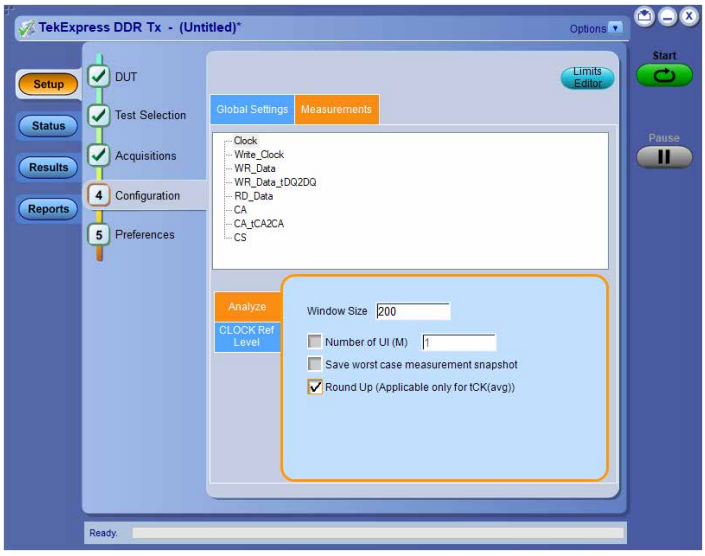


Test selection panel – tree view of measurements

Configurations

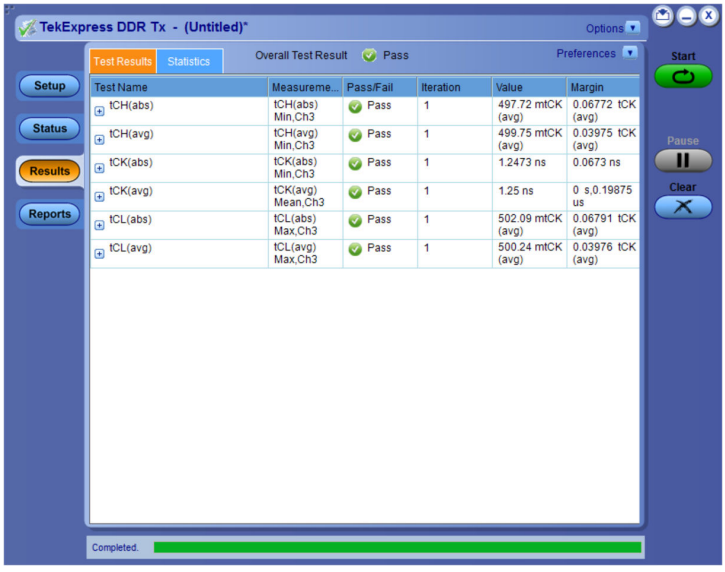
Ease of use measurement configuration to configure measurements by group instead of running through all the 50+ measurements.



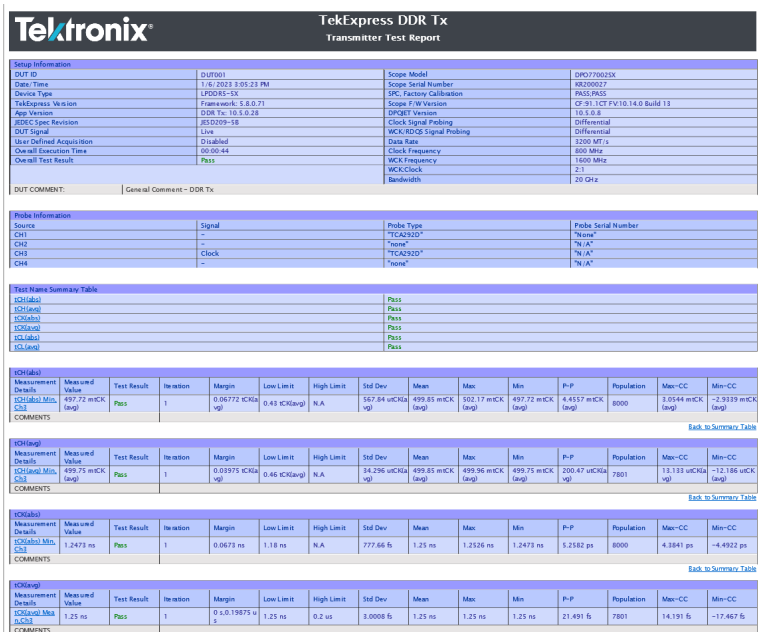
Results and reporting with waveform

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 of statistical data, measurement plots, and the screenshot of the waveforms with the cursors. Hyperlinks within the report allow 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.



Measurement results



TekExpress DDR Tx
Transmitter Test Report

Setup Information

DUT ID	DUT001	Scope Model	DPO77002SX
Date/Time	1/6/2023 3:05:23 PM	Scope Serial Number	KR200027
Device Type	LPDDR5-SX	SPC, Factory Calibration	PASS,PASS
TekExpress Version	Framework: 5.8.0.71	Scope F/W Version	CF:91.1CT FV:10.14.0 Build 13
App Version	DDR Tx: 10.5.0.28	DPOJET Version	10.5.0.8
JEDEC Spec Revision	JESD209-5B	Clock Signal Probing	Differential
DUT Signal	Live	WCK/RDQS Signal Probing	Differential
User Defined Acquisition	Disabled	Data Rate	3200 MT/s
Overall Execution Time	00:00:44	Clock Frequency	800 MHz
Overall Test Result	Pass	WCK Frequency	1600 MHz
		WCK:Clock	2:1
		Bandwidth	20 GHz

DUT COMMENT: | General Comment - DDR Tx

Probe Information

Source	Signal	Probe Type	Probe Serial Number
CH1	-	"TCA292D"	"None"
CH2	-	"none"	"N/A"
CH3	Clock	"TCA292D"	"N/A"
CH4	-	"none"	"N/A"

Test Name Summary Table

tCH(abs)	Pass
tCH(avg)	Pass
tCK(abs)	Pass
tCK(avg)	Pass
tCL(abs)	Pass
tCL(avg)	Pass

tCH(abs)

Measurement Details	Measured Value	Test Result	Iteration	Margin	Low Limit	High Limit	Std Dev	Mean	Max	Min	P-P	Population	Max-CC	Min-CC
tCH(abs) Min, Ch3	497.72 mtCK (avg)	Pass	1	0.06772 tCK(avg)	0.43 tCK(avg)	N.A	567.84 utCK(avg)	499.85 mtCK (avg)	502.17 mtCK (avg)	497.72 mtCK (avg)	4.4557 mtCK (avg)	8000	3.0544 mtCK (avg)	-2.9339 mtCK (avg)

COMMENTS

Back to Summary Table

tCH(avg)

Measurement Details	Measured Value	Test Result	Iteration	Margin	Low Limit	High Limit	Std Dev	Mean	Max	Min	P-P	Population	Max-CC	Min-CC
tCH(avg) Min, Ch3	499.75 mtCK (avg)	Pass	1	0.03975 tCK(avg)	0.46 tCK(avg)	N.A	34.296 utCK(avg)	499.85 mtCK (avg)	499.96 mtCK (avg)	499.75 mtCK (avg)	200.47 utCK(avg)	7801	13.133 utCK(avg)	-12.186 utCK (avg)

COMMENTS

Back to Summary Table

tCK(abs)

Measurement Details	Measured Value	Test Result	Iteration	Margin	Low Limit	High Limit	Std Dev	Mean	Max	Min	P-P	Population	Max-CC	Min-CC
tCK(abs) Min, Ch3	1.2473 ns	Pass	1	0.0673 ns	1.18 ns	N.A	777.66 fs	1.25 ns	1.2526 ns	1.2473 ns	5.2582 ps	8000	4.3841 ps	-4.4922 ps

COMMENTS

Back to Summary Table

tCK(avg)

Measurement Details	Measured Value	Test Result	Iteration	Margin	Low Limit	High Limit	Std Dev	Mean	Max	Min	P-P	Population	Max-CC	Min-CC
tCK(avg) Mea N,Ch3	1.25 ns	Pass	1	0 s,0.19875 us	1.25 ns	0.2 us	3.0008 fs	1.25 ns	1.25 ns	1.25 ns	21.491 fs	7801	14.191 fs	-17.467 fs

COMMENTS

Measurement report

Verification versus debug

The TekExpress DDR Tx application provides a comprehensive set of JEDEC timing and electrical measurements for the LPDDR5-5X 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.

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.

Specifications

Supported oscilloscopes

- MSO71604DX, MSO72004DX, MSO72304DX, MSO72504DX, and MSO73304DX.
- DPO71604DX, DPO72004DX, DPO72304DX, DPO72504DX, and DPO73304DX.
- DPO71604SX, DPO72004SX, DPO72304SX, DPO72504SX, and DPO73304SX.
- Non-ATI channels of DPO75002SX, DPO75902SX, DPO7702SX, DPS75004SX, DPS75904SX, and DPS77004SX.

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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).
P77STFLRA	Active, long reach solder-in tip with TekFlex connector technology
P77HTFLRA	Active, long reach high temperature solder-in tip with TekFlex connector technology
P77STFLRB	Active, long reach 55 Ω Solder-in tip with TekFlex Connector technology for DDR/LPDDR electrical Validation with interposers
P77HTFLRB	Active, long reach 55 Ω Solder in tip with TekFlex Connector technology for high-temperature DDR/LPDDR electrical Validation with interposers (up to 125 ºC)
SI Interposer	EdgeProbeTM, 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: *www.nexustechnology.com/products/memory-interposers/lpddr5-mobile-memory-interposers/*

Ordering information

To order a new DPO/MSO70000 Series

Nomenclature	Description
SX, DX >= 16G	
DPO-UP LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO71604DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO71604SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72004DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72004SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72304DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72304SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72504DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO73304SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO72504SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO73304DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO75002SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO75902SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPO7702SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
MSO72304DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
MSO71604DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
MSO72004DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
MSO72504DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
MSO73304DX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)

Table continued…

Nomenclature	Description
DPS75004SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPS75904SX LPDDR5SYS	License: LPDDR5 TekExpress Compliance/Debug Automation Memory Bus Electrical Validation and Analysis Software (require options SDLA64, DJA, and VET)
DPS77004SX LPDDR5SYS	License: LPDDR5 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-LPDDR5SYS	License; LPDDR5 System-level Tx TekExpress Compliance/ Debug Automation Software; Floating	LPDDR5SYS	SDLA64, DJA, and VET
DPOFT-LPDDR5SYS	License; LPDDR5 System-level Tx TekExpress Compliance/ Debug Automation Software; Floating Trial	LPDDR5SYS	SDLA64, DJA, and VET

Tektronix is ISO 14001:2015 and ISO 9001:2015 certified by DEKRA.

Product Area Assessed: The planning, design/development and manufacture of electronic Test and Measurement instruments.

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

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