

# HCTL-IP RAID0x8 DDR Demo Instruction

## Rev1.0 22-Aug-23

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## HCTL-IP RAID0x8 DDR Demo Instruction

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This document describes the instruction to run 8-ch RAID0 with DDR by using SATA HCTL-IP. To run the demo, FPGA development board and AB09-FMCRAID board are applied. The demo is designed to write/verify data with eight SATA-III devices. User controls test operation through Serial console.

#### 1 Environment Setup

To run the demo on FPGA development board, please prepare following environment.

- 1) FPGA Development board: KCU105
- 2) PC with Xilinx programmer software (Vivado) and Serial console software such as HyperTerminal
- 3) AB09-FMCRAID board, provided by Design Gateway
- 4) Power supply connecting to power connector on FMCRAID board to be SATA device power
- 5) Eight SATA-III devices connecting at CN0-CN7 of FMCRAID board
- 6) Xilinx Power adapter for Xilinx board
- 7) Two micro USB cables for programming FPGA and Serial console connecting between FPGA Development board and PC



Figure 1-1 HCTL-IP RAID0x8 DDR demo setup on KCU105



### 2 Demo setup

- 1) Power off system.
- 2) Connect AB09-FMCRAID board to FMC-HPC connector on FPGA development board.
- 3) Connect eight SATA-III devices to CN0-CN7 on FMCRAID board.
- 4) Connect power to power connector on FMCRAID board.



5) Connect two micro USB cables from Xilinx development board to PC for JTAG programming and Serial console.





- 6) Power on FPGA development board and power supply for SATA device.
- 7) Open Serial console such as TeraTerm, HyperTerminal and set Buad rate=115,200 Data=8 bit Non-Parity Stop=1.
- 8) Use Vivado tool to download configuration file which includes CPU firmware, as shown in Figure 2-3.

rigaro z o.										
Vivado 2017.4	HARDWARE MANAGER - unconnecte	d								
Eile Flow Iools Window Help	1 No hardware target is open. Open	en target								
	Hardware	Auto Connect								
Quick Start Create Project > Open Project >	HARDWARE M AGER - localho	Open New Target st/xilinx_tcf/Digiler Program device Refresh device								
Open Example Project >	Hardware	? _ D Ľ X								
	Q ≍ ≑ Ø ►	» 🔳 💠								
Tasks	Name	Status								
1. Click Open Hardware Manager	V localhost (1)	Connected 3. Select FPGA device								
Manage IP >	✓	03089568 Open to program bit file								
Xilinx Tcl Store >	v @ xcku040_0 (1)	Not programm								
Program Device	download it to your hardware device. Yo	m Monitor)								
can optionally select a debug probes file that corresponds to the debug cores contained in the bitstream programming file. 5. Click "…" to select Programming file (HSATARaid8Ddr_KCU105.bit)										
Bitstream file: D:/Temp/HSATAF	Raid8Ddr_KCU105.bit 🛞									
Debug probes file:										
✓ Enable end of startup check										
?	Program         Cancel									
	6. Click Program button start FPGA programmir	to								
Figure 2-3	Programmed by Viv	vado								

9) Check LED status on Xilinx development board. The description of LED is shown in Table 2-1.

GPIO LED	ON	OFF
0	Normal operation	System is in reset condition
1	System is busy	Idle status
2	Error detect	Normal operation
3	Data verification fail	Normal operation



Figure 2-4 4-bit LED Status for user output



10)After programming completely, LED[0] and LED[1] are ON during RAID0 initialization process. Then, LED[1] changes to OFF to show that RAID0 completes initialization process and system is ready to receive command from user. After that, main menu is displayed as shown in Figure 2-6.



Figure 2-5 LED status after program configuration file and RAID0 initialization complete



Figure 2-6 Main menu after programming configuration file and RAID0 initialization complete

11) If some SATA devices are not detected, "CH[0-7] Not Detect" will be displayed as shown in Figure 2-7. CH[0]-[7] is referred to SATA channel which has found the error. Please check SATA device in error channel.



Figure 2-7 Error message when some devices are not detected



### 3 Test Menu

#### 3.1 Identify Device

Select '0' to send Identify device command to RAID0. When operation is completed, all information is displayed on the console, i.e.

- 1) SSD model number
- 2) Security feature set is supported or not. If some devices are not supported, user must not run menu 3 to test Security erase command.
- 3) Normal Erase Mode Time: This is estimation time to complete Security erase command. Minimum valid value is 2 minutes. This information is displayed when the device supports Security feature set.
- 4) SSD capacity which is output value from RAID0 block. The value is equal to eight times of SATA CH#0 capacity.



Figure 3-1 Result from Identify Device menu



#### 3.2 Write Device

Select '1' to send Write command to RAID0. Five inputs are required for this menu.

- 1) Start LBA: Input start address of RAID0 in sector unit. The input is decimal unit when input only digit number. User can add "0x" to be prefix when input is hexadecimal unit.
- 2) Sector Count: Input total transfer size in sector unit. The input is decimal unit when input only digit number. User can add "0x" to be prefix when input is hexadecimal unit.
- 3) Test pattern: Select test pattern of test data for writing to RAID0. Five types can be selected, i.e. 32-bit increment, 32-bit decrement, all 0, all 1, and 32-bit LFSR counter.
- 4) Numerator ratio (NMT): Input numerator of transfer rate ratio. Valid value is 1 to 15.
- 5) Denominator ratio (DMT): Input denominator of transfer rate ratio. Valid value is NMT input to 15.

Transfer rate ratio = (NMT/DMT) x 6400 MB (200 MHz x 256-bit)

For example, when input NUM = 5 and DMT = 8, Transfer rate ratio =  $5/8 \times 6400 = 4000$  MB/s. This rate is applied for Write Device menu in this document.

🔟 COM19 - Tera Term VT 📃 💼 🔳	×
File Edit Setup Control Window KanjiCode Help	
+++ Write Device selected +++ Enter Start LBA : 0 - 0x3B9DE957F => 0 Enter Sector Count : 1 - 0x3B9DE9580 => 0x8000000 Input from user Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 4	*
Sustain rate = (NMT/DMT)x6400 MB Enter Numerator ratio (NMT) : 1 - 15 => 5 Enter Denominator ratio (DMT) : 5 - 15 => 8 Sustain rate = 4000MB/s Sustain rate value 4.000 GB 8.000 GB 12.000 GB	
$\begin{bmatrix} 60.000 & GB \\ 64.000 & GB \\ 68.000 & GB \end{bmatrix}$ Output performance $\begin{bmatrix} Total = 68[GB] & Time = 12[s] & Transfer sneed = 4000[MB/s] \end{bmatrix}$	
Main menu [Ver = 1.0] [0] : Identify Device [1] : Write Device [2] : Read Device	
[3] : Security Erase	•

Figure 3-2 Input and result of Write Device menu

As shown in Figure 3-2, if all inputs are valid, the operation will be started. During writing data, current transfer size is displayed to the console to show that system still be alive. Finally, test performance, total size, and total time usage are displayed on the console as test result.



	<del>( (</del>	6 <mark>4-</mark> bi	t he	ader	of e	ach s	sect	or—)																										
	48-	bit L	BA	Add	ress	= 0	0x	00,00		32	e-bit	Incre	emer	nt pa	itteri	1	_		48	bit L	BA /	Addı	ess	= 1										
Offset	0	_ <b>†</b>	2	3	4	5	6	7	8	- 9	A	В	4	D	E	F			0	1	2	3	4	- 5	6	7	8	9	Α	В	С	D	E	F
0000000000	00	00	00	00	00	00	00	00	02	00	00	00	03	00	00	00			01	00	00	00	00	00	00	00	82	00	00	00	83	00	00	00
0000000010	04	00	00	00	05	00	00	00	06	00	00	00	07	00	00	00			84	00	00	00	85	00	00	00	86	00	00	00	87	00	00	00
0000000020	08	00	00	00	09	00	00	00	ΟA	00	00	00	OB	00	00	00			88	00	00	00	89	00	00	00	8A	00	00	00	8B	00	00	00
0000000030	0C	00	00	00	OD	00	00	00	0E	00	00	00	OF	00	00	00			8C	00	00	00	8D	00	00	00	8E	00	00	00	8F	00	00	00
0000000040	10	00	00	00	11	00	00	00	12	00	00	00	13	00	00	00			90	00	00	00	91	00	00	00	92	00	00	00	93	00	00	00
0000000050	14	00	00	00	15	00	00	00	16	00	00	00	17	00	00	00			94	00	00	00	95	00	00	00	96	00	00	00	97	00	00	00
	48	-bit L	BA	Add	ress	= 8		De	/#0																	De	ev#1							
00000001A0	68	00	<b>0</b> 0	00	69	00	00	00	6A	00	00	00	6B	00	00	00			E8	00	00	00	E9	00	00	00	ΕA	00	00	00	EΒ	00	00	00
00000001B0	6C	00	00	00	6D	00	00	00	6E	00	00	00	6F	00	00	00			EC	00	00	00	ED	00	00	00	EE	00	00	00	EF	00	00	00
00000001C0	70	00	00	00	71	00	00	00	72	00	00	00	73	00	00	00			FO	00	00	00	F1	00	00	00	F2	00	00	00	FЗ	00	00	00
00000001D0	74	00	00	00	75	00	00	00	76	00	00	00	77	00	00	00			F4	00	00	00	F5	00	00	00	F6	00	00	00	F7	00	00	00
00000001E0	78	00	00	00	79	00	00	00	7A	00	00	00	7B	00	00	00			F8	00	00	00	F9	00	00	00	FA	00	00	00	FΒ	00	00	00
00000001F0	7C	00	00	00	7D	00	00	00	7E	00	00	00	7F	00	00	00			FC	00	00	00	FD	00	00	00	FE	00	00	00	FF	00	00	00
0000000200	08	00	00	00	00	00	00	00	02	04	00	00	03	04	00	00			09	00	00	00	00	00	00	00	82	04	00	00	83	04	00	00
0000000210	04	04	00	00	05	04	00	00	06	04	00	00	07	04	00	00			84	04	00	00	85	04	00	00	86	04	00	00	87	04	00	00
	40																							_										
	48-		BA	Addi	ress	= 6											_		48	-bit L	BA	Add	ress	= 7										
Offset	0	1	2	3	4	5	6	7	8	- 9	A	В	С	D	E	F			0	<u> </u>	2	3	4	- 5	6	7	8	- 9	A	В	C	D	E	F
0000000000	06	00	00	00	00	00	00	00	02	03	00	00	03	03	00	00			07	00	00	00	00	00	00	00	82	03	00	00	83	03	00	00
0000000010	04	03	00	00	05	03	00	00	06	03	00	00	07	03	00	00			84	03	00	00	85	03	00	00	86	03	00	00	87	03	00	00
0000000020	08	03	00	00	09	03	00	00	ΟA	03	00	00	OB	03	00	00			88	03	00	00	89	03	00	00	8A	03	00	00	8B	03	00	00
0000000030	OC	03	00	00	OD	03	00	00	ΟE	03	00	00	OF	03	00	00			8C	03	00	00	8D	03	00	00	8E	03	00	00	8F	03	00	00
0000000040	10	03	00	00	11	03	00	00	12	03	00	00	13	03	00	00			90	03	00	00	91	03	00	00	92	03	00	00	93	03	00	00
0000000050	14	03	00	00	15	03	00	00	16	03	00	00	17	03	00	00			94	03	00	00	95	03	00	00	96	03	00	00	97	03	00	00
	Dev#6																	De	ev#7															
00000001A0	68	03	00	00	69	03	00	00	6A	03	00	00	6B	03	00	00			E8	03	00	00	E9	03	00	00	EA	03	00	00	EB	03	00	00
00000001B0	6C	03	00	00	6D	03	00	00	6E	03	00	00	6F	03	00	00			EC	03	00	00	ED	03	00	00	EE	03	00	00	EF	03	00	00
00000001C0	70	03	00	00	71	03	00	00	72	03	00	00	73	03	00	00			FO	03	00	00	F1	03	00	00	F2	03	00	00	FЗ	03	00	00
00000001D0	74	03	00	00	75	03	00	00	76	03	00	00	77	03	00	00			F4	03	00	00	F5	03	00	00	F6	03	00	00	F7	03	00	00
00000001E0	78	03	00	00	79	03	00	00	7A	03	00	00	7B	03	00	00			F8	03	00	00	F9	03	00	00	FA	03	00	00	FB	03	00	00
00000001F0	7C	03	00	00	7D	03	00	00	7E	03	00	00	7F	03	00	00			FC	03	00	00	FD	03	00	00	FE	03	00	00	FF	03	00	00
0000000200	0E	00	00	00	00	00	00	00	02	07	00	00	03	07	00	00			OF	00	00	00	00	00	00	00	82	07	00	00	83	07	00	00
0000000210	04	07	00	00	05	07	00	00	06	07	00	00	07	07	00	00			84	07	00	00	85	07	00	00	86	07	00	00	87	07	00	00
Fig	ure	э З·	-3	Ex	an	npl	e T	Tes	t da	ata	ı in	S	ect	ora	#0/	/#1	of	D	ev	#0/	/#1	/#	6/#	<b>‡</b> 7	by	ind	crei	me	nt	ра	tte	ern		

Test data of each sector has different 64-bit header which consists of 48-bit LBA address and 16-bit all 0 value. 48-bit LBA address is unique value for each sector. After that, the test pattern is filled following user selection such as 32-bit increment pattern (as shown in Figure 3-3).

Stripe size in 8-ch RAID0 demo with DDR is 1 sector (512-byte). So, LBA address in the header of 1<sup>st</sup> sector in Disk#0 - Disk#7 are equal to 0 - 7 sequentially. The address in the header of the next sector for Disk#0 is 8.



Figure 3-4 – Figure 3-8 show error message when user input is invalid. "Invalid input" is displayed on the console and then returns to main menu to receive new command.

COM19 - Tera Term VT
File Edit Setup Control Window KanjiCode Help
Out-of-range LBA address
+++ Write Device selected +++
Out-of-range LBA address
Fenter Start LBA : Ø - Øx3B9DE957F => Øx40000000
Invalid input Error message
--- Main menu [Uer = 1.0] --[Ø] : Identify Device
[1] : Write Device
[2] : Read Device
[3] : Security Erase

Figure 3-4 Invalid Start LBA input



Figure 3-5 Invalid Sector count input



Figure 3-6 Invalid Test pattern input









Figure 3-8 Invalid Denominator ratio input



Figure 3-9 shows error message when buffer is overflow. If transfer rate ratio setting to NMT and DMT parameter is too high, the buffer in the system will be overflow. In the example, 4800 MB/s (600 MB/s for one device) is set which is higher than 8 SATA devices performance, "ERROR: Buffer Overflow" is displayed on the console.

After that, the system waits for 10 seconds which is timeout value of SATA HCTL-IP to check the error situation on the IP. "No RAID0 Error" is shown when there is no error from RAID0.

When error is found, the operation of previous command in each SATA device does not finish in good sequence. It is recommended to power-off/on all SATA devices and press "RESET" button to restart the system. For the next trial after buffer overflow, please set the lower transfer rate to run the test.

💶 COM19 - Tera Term VT File Edit Setup Control Window KanjiCode Help . +++ Write Device selected +++ Enter Start LBA :  $0 - 0 \times 3B9DE957F => 0$ Enter Sector Count :  $1 - 0 \times 3B9DE9580 => 0 \times 8000000$ Selected Pattern [0]Inc32 [1]Dec32 [2]All\_0 [3]All\_1 [4]LFSR=> 4 Sustain rate = (NMT/DMT)x6400 MB Enter Numerator ratio (NMT) : 1 - 15 => 6 Enter Denominator ratio (DMT) : 6 - 15 => 8 Sustain rate = 4800MB/s -> Speed is over specification for 8-SATA devices 4.800 GB (600 MB/s for 1 device) 14.400 GB ERROR: Buffer OverFlow -> Error message from buffer overflow Please wait 10 sec for monitoring SATA status No RAIDO Error -> Check that overflow error is not caused from RAID0 error Operation is cancelled Please reset system before start new test - Main menu [Ver = 1.0] ---[0] : Identify Device [1] : Write Device [2] : Read Device [3] : Security Erase

Figure 3-9 Example of buffer overflow



#### 3.3 Read Device

Select '2' to send Read command to RAID0. Six inputs are required for this menu.

- 1) Start LBA: Input start address of RAID0 in sector unit. The input is decimal unit when input only digit number. User can add "0x" to be prefix when input is hexadecimal unit.
- 2) Sector Count: Input total transfer size in sector unit. The input is decimal unit when input only digit number. User can add "0x" to be prefix when input is hexadecimal unit.
- 3) Test pattern: Select test pattern to verify data from RAID0. Test pattern must be matched with the test pattern using in Write Device menu. Five types can be selected, i.e. 32-bit increment, 32-bit decrement, all 0, all 1, and 32-bit LFSR counter.
- 4) Numerator ratio (NMT): Input numerator of transfer rate ratio. Valid value is 1 to 15.
- 5) Denominator ratio (DMT): Input denominator of transfer rate ratio. Valid value is NMT input to 15.

Transfer rate ratio = (NMT/DMT) x 6400 MB (200 MHz x 256-bit)

For example, when input NUM = 2 and DMT = 3, Transfer rate ratio =  $2/3 \times 6400 = 4266.67$  MB/s. This rate is applied for Read Device menu in this document.

6) Ddr Read Threshold: The minimum data size is stored in DDR before starting to read data from DDR to verify at sustain rate. Unit size is Mbyte and valid from 1 – 2047. In Read command, DDR is read in sustain rate, so the read logic needs to wait write data stored in DDR much enough before starting reading.



Figure 3-10 Input and result of Read Device menu

Similar to Write Device menu, if all inputs are valid, test system will read data from RAID0. Test performance, total size, and total time usage are displayed after end of transfer. "Invalid input" will be displayed if some inputs are out-of-range.



🚾 COM19 - Tera Term VT File Edit Setup Control Window KanjiCode Help ٠ +++ Read Device selected +++ Enter Start LBA : 0 - 0x3 Enter Start LBA : 0 - 0x3B9DE957F => 0 Enter Sector Count : 1 - 0x3B9DE9580 => 0x8000000 Selected Pattern [0]Inc32 [1]Dec32 [2]A11\_0 [3]A11\_1 [4]LFSR=> 0 Wrong pattern Sustain rate = (NMT/DMT)x6400 MB Enter Numerator ratio (NMT) : 1 - 15 => 2 Enter Denominator ratio (DMT) : 2 - 15 => 3 Sustain rate = 4266MB/s Enter Ddr Read Threshold : 1 - 2047 MB=> 1 Verify fail message Verify fail 1st Error at Byte Addr = 0x00000000 Expect Data[255:128] = 0x00000007 Expect Data[127:0] = 0x0000003 Read Data[255:128] = 0x0007FFFF Read Data[127:0] = 0x0001FFFF Press any key to cancel operation 4.257 GB 8.524 GB 12.791 GB = 0x00000007\_0000006\_00000005\_00000004
 = 0x00000003\_00000002\_00000000\_00000000
 = 0x0007FFFF\_FFF80004\_0003FFFF\_FFFC0002 = 0x0001FFFF\_FFFE0001\_00000000\_0000000 Verify fail without cancel operation 55.457 GB 59.724 GB 63.991 GB 68.257 GB Total = 68[GB] , Time = 16[s] , Transfer speed = 4266[MB/s] --- Main menu [Ver = 1.0] ---[0] : Identify Device [1] : Write\_Device **Output performance** [2] : Read Device [3] : Security Erase ÷

Figure 3-11 Data verification is failed but wait until read complete

🔟 COM19 - Tera Term VT	x
File Edit Setup Control Window KanjiCode Help	
+++ Read Device selected +++ Enter Start LBA : 0 - 0x3B9DE957F => 0 Enter Sector Count : 1 - 0x3B9DE9580 => 0x8000000 Selected Pattern [0]Inc32 [1]Dec32 [2]A11_0 [3]A11_1 [4]LFSR=> 0	*
Sustain rate = (NMI/DMI/Sb400 MB Enter Numerator ratio (NMT) : 1 - 15 => 2 Enter Denominator ratio (DMT) : 2 - 15 => 3 Sustain rate = 4266MB/s Enter Ddr Read Threshold : 1 - 2047 MB=> 1 Verify fail message	
Uerify fail         1st Error at Byte Addr       = 0x00000000         Expect Data[255:128]       = 0x0000007_00000006_00000005_00000004         Expect Data[127:0]       = 0x000003_00000002_0000000_00000000         Read Data[255:128]       = 0x0007FFFF_FF80004_0003FFFF_FFFC0002         Read Data[127:0]       = 0x0001FFFF_FFF0001_0000000_0000000000000	
Press any key to cancel operation 4.257 GB 8.524 GB Operation is cancelled Please reset system before start new test cancel operation	
Main menu [Ver = 1.0] [0] : Identify Device [1] : Write Device [2] : Read Device [3] : Security Erase	

Figure 3-12 Data verification is failed and press any key to cancel operation



Figure 3-11 and Figure 3-12 show the error message when data verification is failed. "Verify fail" is displayed with error address, expected data, and read data. User can press any key to cancel read operation or wait until all read process complete.

If read process is completed, output performance from read process will be displayed.

In case of cancel operation, the previous command does not complete in good sequence. It is recommended to power-off/on all SATA devices and press "RESET" button to restart system.



Figure 3-13 Example of buffer underflow

Figure 3-13 shows error message when buffer is underflow. If transfer rate ratio setting to NMT and DMT parameter is too high, the buffer in the system will be underflow. In the example, 4800 MB/s (600 MB/s for one device) is set which is higher than 8 SATA devices performance, "ERROR: Buffer Underflow" is displayed on the console.

After that, the system waits for 10 seconds which is timeout value of SATA HCTL-IP to check the error situation on the IP. "No RAID0 Error" is shown when there is no error from RAID0.

When system is error, the operation of previous command in each SATA device does not finish in good sequence. It is recommended to power-off/on all SATA devices and press "RESET" button to restart the system. For the next trial after buffer underflow, please set the lower transfer rate to run the test.



#### 3.4 Security Erase

Select '3' to send Security Erase command to RAID0. Please confirm that all SATA devices support Security Erase feature by using Identify device menu. The estimated time of security erase operation is also displayed in Identify device menu.

After selecting the menu, confirmation message is displayed on the console. User inputs 'y' or 'Y' to continue security erase operation or input other keys to cancel operation.

Number 0-9 is displayed on the console every second to show that system still run. After complete the operation, total time usage is displayed as shown in Figure 3-14.

Figure 3-15 shows the example when user inputs other keys to cancel the command.



Figure 3-14 Result from Security Erase command



Figure 3-15 Cancel Security Erase command



## 4 Revision History

Revision	Date	Description
1.0	8-Mar-18	Initial version release