

<u>4-ch RAIDO by SATA Host-IP Demo Instruction</u> Rev1.6 22-Aug-23

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4-ch RAID0 by SATA Host-IP Demo Instruction

Rev1.6 22-Aug-23

This document describes the instruction to run 4-ch RAID0 by using SATA Host-IP on FPGA development board and AB09-FMCRAID board. The demo is designed to write/verify data with four SATA-III devices. User can control test operation through Serial console.

1 Environment Setup

To run SATA Host RAID0 demo on FPGA development board, please prepare following hardware.

- 1) Supported FPGA Development board: KC705/VC707/ZC706/VC709/KCU105/ZCU102/ Zynq Mini-ITX
- 2) PC with Xilinx programmer software (Vivado) and Serial console software
- 3) AB09-FMCRAID board
- 4) Power supply for SATA device to connect to power connector on FMCRAID board
- 5) Four SATA-III devices connecting at CN0-CN3 of FMCRAID board
- 6) Xilinx Power adapter for Xilinx board or ATX Power for Mini-ITX board
- 7) micro USB cable for programming FPGA between FPGA Development board and PC
- 8) mini/micro USB cable for Serial console connecting between FPGA board and PC



Figure 1-1 SATA Host RAID0 Demo Environment Setup on KC705













Figure 1-7 SATA Host RAID0 Demo Environment Setup on ZCU102



2 Demo setup

- 1) Power off system.
- 2) Set up board option.
 - a) For ZC706 board only,
 - i. Set SW11="00000" to configure PS from JTAG, as shown in Figure 2-1.
 - ii. Set SW4="01" to connect JTAG with USB-to-JTAG interface, as shown in Figure 2-2.



Figure 2-1 SW11 setting to configure PS from JTAG on ZC706 board



Figure 2-2 SW4 setting to use USB-to-JTAG on ZC706 board

- b) For Zynq Mini-ITX board only,
 - i. Set SW7="00000" to configure PS from JTAG, as shown in Figure 2-3.
 - ii. As shown in Figure 2-4, install a jumper on JP1 pins 1-2 to enable JTAG chain, install the power module onto the board via J8, J9, J10 connectors, and connect ATX power cable to FPGA board via P2 connector.



Figure 2-3 SW7 setting to configure PS from JTAG on Zynq Mini-ITX





Figure 2-4 The power module installed onto the board

c) For ZCU102 only, set SW6="0000" (SW = ON) to configure PS from JTAG, as shown in Figure 2-5.



Figure 2-5 SW6 setting to configure PS from JTAG on ZCU102

- 3) Connect AB09-FMCRAID board to FMC-HPC, FMC1-HPC, or FMC-HPC0 connector on FPGA development board.
- 4) Connect four SATA-III devices to CN0-CN3 on FMCRAID board.
- 5) Connect power to power connector on FMCRAID board.





Figure 2-6 AB09-FMCRAID connection

- 6) Connect micro USB cable from Xilinx development board to PC for JTAG programming
- 7) Connect mini/micro USB cable from Xilinx board to PC for Serial console.



Mini USB for Serial console Figure 2-7 USB cable connection



- 8) Power on FPGA development board and power supply for SATA device.
- 9) Open Serial console such as TeraTerm, HyperTerminal and set Buad rate=115,200 Data=8 bit Non-Parity Stop=1.
- 10) Download configuration file and CPU firmware to FPGA

a) For ZC706/Zynq Mini-ITX board, open Vivado TCL shell, change current directory to ready_for_download. Next, run xxx_ HSATARaid0x4.bat as shown in Figure 2-8. For example, type zc706_HSATARaid0x4.bat, zcu102_HSATARaid0x4.bat, MiniITX_7z045(or 7z100)_HSATARaid0x4.bat.



b) For KC705/VC707/VC709/KCU105 board, use Vivado tool to program bit file, as shown in Figure 2-9.

A Vivado 2015.4.1	Hardware Manager - unconne	ected	
File Flow Tools Window Help	 No hardware target is open. 	Open target	
	Hardware	ស Auto Connect	
VIVADO. Productivity. Multiplied.	🔍 🎞 章 📓 🔍 🕨 ≽	Recent Targets	
1. Click Open Hardware Manager	2. Ope	n target -> Auto Connect	
Tasks	· •	Open New Target	
	Hardware Mager - local	host/xilinx_tcf/Digilent/210203336077A	
	 There are trug cores 	s. Program device Refresh device 5 Click Program device	
Manage IP Open Hardware Manager Xilinx Td Store	Hardware	S. Olick Program device ↔ FPGA model	
	🔍 🛣 🖨 🛃 💵 💌		
Program Device	Name	Status	
	□- Iocalhost (1)	Connected	
Select a bitstream programming file and download it to your hardware device. You can optionally select a debug probes file that corresponds to	☐ Ø xilinx_tcf/Digilent/	/210203336077A (1) Open 3. Select FPGA device	
the debug cores contained in the bitstream programming file.	- 🚰 XADC (System	m Monitor) to program bit file	
Bitstream file: Dr/Temp/HSATARaid0y4 KC705 hit			
	Hardware Device Properties	_ 🗆 🖻 ×	
Enable end of startup check	xc7k325t_0		
Program Cancel	Name: xc7k325t	t_0	
6. Click Program button to	Part: xc7k325t	t	
start FPGA programming	ID code: 3365109	4. Click "" to select Programming file	
	Status: Program	(HSATARaid0x4_xxx.bit)	
	Programming file: /Temp/H	ISATARaid0x4_KC705.bit	
	Probes file:		
Figure 2-0 F	Programmed by \	/ivado	



11)Check LED status on Xilinx development board. The description of LED is follows.

Table 1 LED Definition									
GPIO LED	ON	OFF							
0/D4	Normal operation	System is in reset condition							
1/R/D5	System is busy	Idle status							
2/C/D6	Error detect	Normal operation							
3/L/D7	Data verification fail	Normal operation							



Figure 2-10 4-bit LED Status for user output

12)After programming completely, LED[0] and LED[1] are ON for initializing RAID0 system. LED[1] is OFF when RAID0 completes initialization process. Now system is ready to receive command from user. After that, main menu is displayed as shown in Figure 2-12.



Figure 2-11 LED status after program configuration file and RAID0 initialization complete



📒 COM5 - Tera Term VT	
<u>File Edit Setup Control Window H</u>	elp
++++ Start SATA RAID0x4 Test d	esign [Ver = 1.2] ++++
Waiting device ready Wait SA	ATA Linkup
SATA Gen3 Device Detect SATAS	Speed = Gen3
Main menu [Ver = 1.2] [0] : Identify Device [1] : Write SSD [2] : Read SSD [3] : Security Erase	Main menu to select operating command
	· · ·

Figure 2-12 Main menu after program configuration file and RAID0 initialization complete

13) If some SATA devices cannot be detected, error message (CH[X] Not Detect) will be displayed as shown in Figure 2-13. Please check SATA device in error channel.



Figure 2-13 Error message when some devices cannot be detected



3 Test Menu

3.1 Identify Device

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

- 1) SSD model number
- 2) Security feature set is supported or not supported. If some devices are not supported, user must not use menu 3 for the test.
- 3) Normal Erase Mode Time: The estimation time to complete security erase command, returned from SATA device. Minimum valid value is 2 minutes. This information will be displayed when SATA device supports Security feature set.
- 4) RAID capacity: Capacity which is output value from RAID0 block. The value is calculated by (4 x SATA CH#0 capacity).



Figure 3-1 Result from Identify Device menu



3.2 Write SSD

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

1) Start LBA: Input start address of RAID0 in sector unit. The input can be decimal unit or add "0x" as a prefix "0x" for hexadecimal unit.

2) Sector Count: Input total transfer size in sector unit. The input can be decimal unit or add "0x" as a prefix for 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.

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.

💻 c	ом5 -	Tera Ter	m VT				
<u>F</u> ile	<u>E</u> dit	<u>S</u> etup	C <u>o</u> ntrol	<u>W</u> indow	<u>H</u> elp		
+++ Hn Enter Select 1.90 3.99 6.06 28.9 30.9 30.9 33.0	rite dat Start L Sector ed Patt 7 GB 22 GB 34 GB 34 GB 399 GB 399 GB 376 GB	a selecte BA : 0 - Count : 1 ern (0)Ir	ed +++ Ox773CCABF L - Ox773CCI nc32 [1]Dec3 ent transfe	=> 0 ACD => 0x400 32 (2) ATT_U r size	0000] Inpu 133H11_1	ut from user [4]LFSR=> <mark>4</mark>	
Total Ha [0] : [1] : [2] : [3] :	= 34[GB ain Henu Identif Hrite S Read SS Securit	8], Time 1 [Ver = 1 1 Device SD SD 1 D 1 Erase	= 16[s] , ` 1.3]	Transfer spe	ed = 2068	[HB/s]] Outpu	ut performar

Figure 3-2 Input and result of Write SSD menu



← 64-bit header of each sector →

	48	bit l	BA	Add	ress	= 0	0>	00,00		32	-bit	LFSF	R pat	ttern				48-	bit L	BA /	Addr	ess	= 1										
Offset	0	4	2	3	4	5	6	7	8	9	A	В	C	D	E	F] .	0	4	2	3	4	5	6	7	8	9	Α	В	С	D	Е	F
0000000000	0	00	00	00	00	00	00	00	01	00	00	00	02	00	00	00		01	00	00	00	00	00	00	00	02	00	00	00	04	00	00	00
000000010	04	00	00	00	09	00	00	00	12	00	00	00	24	00	00	00		09	00	00	00	12	00	00	00	24	00	00	00	49	00	00	00
000000020	49	00	00	00	92	00	00	00	24	01	00	00	49	02	00	00		92	00	00	00	24	01	00	00	49	02	00	00	92	04	00	00
000000030	92	04	00	00	24	09	00	00	49	12	00	00	92	24	00	00		24	09	00	00	49	12	00	00	92	24	00	00	24	49	00	00
000000040	24	49	00	00	49	92	00	00	92	24	01	00	24	49	02	00		49	92	00	00	92	24	01	00	24	49	02	00	49	92	04	00
000000050	49	92	04	00	92	24	09	00	24	49	12	00	49	92	24	00		92	24	09	00	24	49	12	00	49	92	24	00	93	24	49	00
48-bit LBA Address = 4 Disk#0 Disk#1																																	
000000130	20	F 1	C6	74	41	C.3	вD	FQ	83	86	1B	ΠЗ	06	ΠD	37	26		41	сз	вD	FQ	83	86	1B	ΠЗ	06	пъ	37	26	00	1 &	6F	40
0000000180	00	12	6F	40	18	34	DC	98	30	68	BS	31	60	ΠΩ	70	63		18	34	DC	98	30	68	BS	31	60	DΩ	70	63	CO	20	F1	76 76
0000000100	CO	AU	F1	00	81	41	C3	an	03	83	86	1B	07	06	οn.	37		81	41	C3	an	03	83	86	1B	07	06	nn.	37	OF	00	14	6F
0000000100	OF	nc	1A	6E	1F	18	34	DC	3F	30	68	B8	7F	60	DO	70		1F	18	34	DC	3F	30	68	BB	7F	60	חת	70	FF	CO	ΔN	E1
00000001E0	FF	CO	An	E1	FF	81	41	C3	FE	03	83	86	FD	07	06	nD		FF	81	41	C3	FE	03	83	86	FD	07	06	ΠD	FA	0F	nc	1A
00000001F0	FA	OF	OC	1A	F 4	1F	18	34	E9	ЗF	30	68	D3	7F	60	DO		F4	1F	18	34	E9	ЗF	30	68	D3	7F	60	DO	A7	FF	CO	AO
0000000200	04	00	00	00	00	00	00	00	09	00	00	00	12	00	00	00	-	05	00	00	00	00	00	00	00	OA	00	00	00	14	00	00	00
0000000210	24	00	00	00	49	00	00	00	92	00	00	00	24	01	00	00		29	00	00	00	52	00	00	00	A4	00	00	00	49	01	00	00
1	48-	bit L	BA	Addr	ess	= 2												48-	bit L	BA	Addı	ess	= 3										
Offeet	l n	4	2	3	4	5	6	7	8	q	۵	в	c	р	F	F		n	4	2	3	4	5	6	7	8	q	Δ	в	c	п	F	F
000000000	2	00	00	00	00	nn	00	00	04	00	00	00	ng	00	00	00	1	a 3	00	00	00	00	nn	nn	nn	07	00	00	00	OF	00	00	00
000000000000000000000000000000000000000	12	00	00	00	24	00	00	00	49	00	00	00	92	00	00	00		1F	00	00	00	ЗF	00	00	00	7F	00	00	00	FF	00	00	00
0000000020	24	01	00	00	49	02	00	00	92	04	00	00	24	09	00	00		FF	01	00	00	FF	03	00	00	FF	07	00	00	FF	OF	00	00
0000000030	49	12	00	00	92	24	00	00	24	49	00	00	49	92	00	00		FF	1F	00	00	FF	ЗF	00	00	FF	7F	00	00	FF	FF	00	00
0000000040	92	24	01	00	24	49	02	00	49	92	04	00	92	24	09	00		FF	FF	01	00	FF	FF	03	00	FF	FF	07	00	FF	FF	OF	00
0000000050	24	49	12	00	49	92	24	00	93	24	49	00	27	49	92	00		FF	FF	1F	00	FF	FF	ЗF	00	FE	FF	7F	00	FD	FF	FF	00
							Dis	sk#2																	Di	sk#3	3						
														. .				6.2	2.4	_ 0	417	<i>a</i> 4	40	7.1	00		0.1	40	20	10	22	05	70
00000001A0	83	86	18	D3	06	DD	37	A6	UC	1A	6E	4C	18	34	DC	98		24	A4 46	02	46	10	40	14	90	09	10	42	39	21	23	00 50	20
0000000180	30	68	88	31	60	DU	70	63	CU	AU	E1	C6	81	41	C3	8D		42	40	DA A 4	E0	40 0E	00	14	λ 1	90	10	29	94 40	17	12	32 22	20
0000000100	03	83	86	18	07	06	UD	37	UF	UC CO	1A	6E	1F	18	34	DC		42 25	24	A4 46	00	55	10	40	14		09	10	42 20	17	21	23	03 52
0000000100	3F	30	68	88	71	6U	DU	70	FF	CU	AU	El	FF	81	41	03		21' FF	42	40	۵ <i>۵</i>	51	40	C4	48	FO	90	10	29 Q1	11	17	12	22
00000001E0	FE	03	83 20	00 60	rD D2	07	06	UU DO	ra N7	UF	00	1A	14 45	1F	18	34 41		F7	72 2F	24	46	CE	55 5F	48	80	90	BF	90	18	32	17 7F	21	23
00000001F0	E9	51	30	68	00	71	60	00	A7	11	00	AU	4Ľ	11	81	41		07	21	00	10	00	00	10	00	OF	00	00	10	15	00	00	00
0000000200	06	00	00	00	00	00	00	00	00	00	00	00	13	00	00	00		3F	00	00	00	7F	00	00	00	FF	00	00	00	FF	01	00	00
0000000210	32	00	00	00	04	00	00	00	09	00	00	00	92	01	00	00					00	12		00	00		00		00		91	00	00
	Ē	in	Iro	· 7.	.2	L v	om	nlc	ΔTα	ot	do	to	in	CO	ntn	r#(1/#1	1 ^	∖f ∕	ı dı	ovi	2	e h	w 1	FC	SD.	na	tto	rn				

Figure 3-3 Example Test data in sector#0/#1 of 4 devices by LFSR pattern

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 LFSR pattern (as shown in Figure 3-3), 32-bit increment pattern.

Stripe size in 4-ch RAID0 demo is 1 sector (512-byte). So, LBA address in the header of 1st sector in Disk#0, Disk#1, Disk#2, and Disk#2 are equal to 0, 1, 2 and 3 sequentially. The address in the header of the next sector for Disk#0 is 4.



Figure 3-4 – Figure 3-6 show error message when user input is invalid. "Invalid input" message is displayed on the console. Then, it returns to main menu to receive new command.

🚇 COM3 - Tera Term VT	x
<u>File Edit Setup Control Window H</u> elp	
+++ Write data selected +++ Enter Start LBR : 0 - 0x773CCABF => 0x80000000 Out-of-range LBA address Invalid input Error message Main menu [Ver = 1.0] [0] : Identify Device [1] : Write SSD [2] : Read SSD	•

Figure 3-4 Invalid Start LBA input



Figure 3-5 Invalid Sector count input

💻 COM5 - Tera Term VT	
<u>File Edit Setup Control W</u> indow <u>H</u> elp	
+++ Write data selected +++ Enter Start LBA : 0 - 0x773CCABF => 0 Enter Sector Count : 1 - 0x773CCACD => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 Invalid input Main menu [Ver = 1.3] [0] : Identify Device [1] : Write SSD [2] : Read SSD [3] : Security Erase	[4]LFSR=>5 Out-of-range pattern

Figure 3-6 Invalid Test pattern input



3.3 Read SSD

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

1) Start LBA: Input start address of RAID0 in sector unit. The input can be decimal unit or add "0x" as a prefix for hexadecimal unit.

2) Sector Count: Input total transfer size in sector unit. The input can be decimal unit or add "0x" as a prefix for hexadecimal unit.

3) Test pattern: Select test pattern to verify data from RAID0. Test pattern must be matched with the test pattern which is used during write test. Five types can be selected, i.e. 32-bit increment, 32-bit decrement, all 0, all 1, and 32-bit LFSR counter.

Similar to write test 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.



Figure 3-7 Input and result of Read SSD menu



Figure 3-8 and Figure 3-9 show the error message when data verification is failed. "Verify fail" message 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.

"RESET" button must be pressed to restart the system when user cancels the operation.

🗵 COM5 - Tera Term VT	• 💌
<u>F</u> ile <u>E</u> dit <u>S</u> etup C <u>o</u> ntrol <u>W</u> indow <u>H</u> elp	
+++ Read data selected +++ Enter Start LBA : O - Ox773CCABF => O Enter Sector Count : 1 - Ox773CCACO => Ox4000000 Selected Pattern [O]Inc32 [1]Dec32 [2]All_O [3]All_1 [4]LFSR=> O	
Verify fail 1st Error at Byte Addr = 0x00000000 Expect Data = 0x00000003_00000002_00000000_00000000 Read Data = 0x00000002_00000001_00000000_00000000 Press any key to cancel operation 2.220 GB 4.446 GB 6.671 GB 	Verify fail withou cancel operation
28.925 GB 31.152 GB 33.377 GB Total = 34[GB] , Тіме = 15[s] , Transfer speed = 2225[MB/s]	
Main menu [Ver = 1.3] [O] : Identify Device [1] : Hrite SSD [2] : Read SSD [3] : Security Erase	÷

Figure 3-8 Data verification is failed but wait until read complete

💆 COM5 - Tera Term VT	- • •
<u>F</u> ile <u>E</u> dit <u>S</u> etup C <u>o</u> ntrol <u>W</u> indow <u>H</u> elp	
+++ Read data selected +++ Enter Start LBA : 0 - 0x773CCABF => 0 Enter Sector Count : 1 - 0x773CCACO => 0x4000000 Selected Pattern [0]Inc32 [1]Dec32 [2]All_0 [3]All_1 [4]LF	\$R=> 0
Verify fail 1st Error at Byte Addr = 0x00000000 Expect Data = 0x00000003_00000002_00000000_0000 Read Data = 0x00000002_00000001_0000000_0000 Press any key to cancel operation Operation is cancelled Please reset system before start new test	0000 Verify fail with 0000 cancel operation
Main menu [Ver = 1.3] [0] : Identify Device [1] : Hrite SSD [2] : Read SSD [3] : Security Erase	-





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 estimation of operation time to run security erase is also displayed in Identify device menu.

After selecting the menu, warning message is displayed on the console. User input '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 alive. Finally, total time usage is displayed as shown in Figure 3-10.

Figure 3-11 shows the example when user inputs other keys to cancel the command.

COM5 - Tera Term VT	
<u>File Edit Setup Control Window Help</u>	
+++ Secumity Emage selected +++	^
Security Erase will erase all contents on SSD It may use long time for this operation Press 'y' to confirm : -> 'y' to continue operation	,
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 Security Erase complete Time = 19[s]	
Main menu [Ver = 1.2] [0] : Identify Device [1] : Write SSD [2] : Read SSD [3] : Security Erase	

Figure 3-10 Result from Security Erase command

🚇 COM5 - Tera Term VT	X
<u>File Edit Setup Control Window H</u> elp	
+++ Security Frase selected +++	~
Security Erase will erase all contents on SSD It may use long time for this operation Press 'y' to confirm : Cancel operation Main menu [Ver = 1.2] [0] : Identify Device [1] : Write SSD [2] : Read SSD [3] : Security Erase	ut

Figure 3-11 Cancel Security Erase command



4 Revision History

Revision	Date	Description
1.0	24-Nov-14	Initial version release
1.1	3-Apr-15	Add ZC706 support
1.2	7-Sep-16	Add CPU and support KCU105 board
1.3	29-Sep-16	Add Zynq Mini-ITX support
1.4	9-Nov-16	Add Security erase command and support VC709
1.5	2-Aug-17	Add LFSR pattern
1.6	15-Jan-18	Add ZCU102 support