

SATA-IP Introduction (Intel)

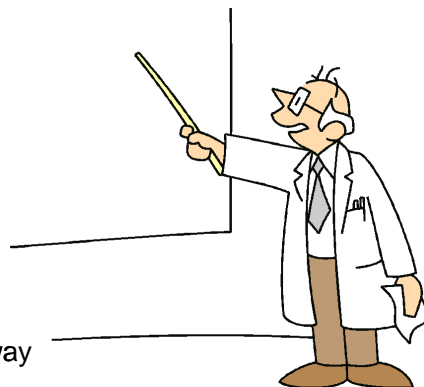
Support Arria10 SX



Magician of the Storage!

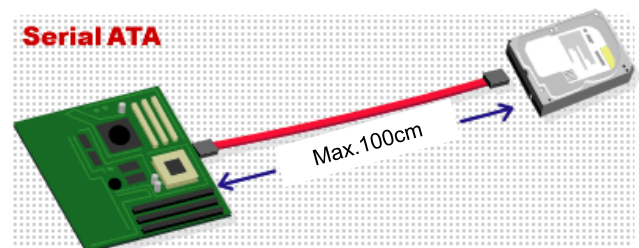
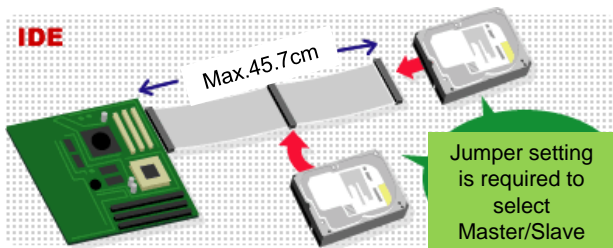
Agenda

- **SATA Overview**
 - Summary, Features and Trend
 - Merit and Solution
- **SATA-IP Introduction**
 - Summary
 - Application



What is SATA?

- **Standard storage interface of HDD/SSD**
 - SATA1.0 released in year 2000, the latest standard is SATA3.0.
- **Improved from IDE (Parallel-ATA)**
 - Cable (from 80 line 46cm to flat narrow cable 1m)
 - High-speed (PATA: Max.133MB/s -> SATA: Max.600MByte/s)
 - Jumper setting is not required anymore.



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Features of SATA device

- **Popular**
 - Compatibility. Easy to replace.
 - Commodity. Easy to buy.
- **Low price**
 - 2.5"SSD 480GB is 50USD
 - 3.5"HDD 4TB is 80USD



KingSpec SSD 480GB Internal Solid State Drive for PC, Laptop Sata3 2.5" 7mm Hard Disk for Computer P4-480
by KingSpec
★★★★★ 1 customer review
Price: \$50.45
Color: 480GB



WL 4TB 7200RPM 64MB Cache SATA 6.0Gb/s 3.5" Hard Drive (For RAID, NAS, DVR, Desktop PC) w/1 Year Warranty
by Generic
★★★★★ 71 customer reviews | 6 answered questions
Price: \$79.88
= Capacity: 4TB
= Rotation Speed: 7200RPM
= 64MB Buffer Size
= Interface: 3.5" SATA 6.0Gb/s
= Warranty: 1 Year Warranty from Retailer

(06-Jan-2019 Amazon.com)

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Trend of SATA device

- SATA storage is switching to SSD from HDD.
- SSD has advantage compared with HDD in toughness & silence.
- HDD has advantage compared with SSD in capacity and price.

	HDD	SSD
Life Expectancy	☆☆☆	☆☆☆☆☆
Operating Temperature	☆☆☆	☆☆☆☆☆
Storage Temperature	☆☆☆☆	☆☆☆☆☆
Operating Shock	☆	☆☆☆☆☆
Operating Vibration	☆	☆☆☆☆☆
Humidity	☆☆☆☆	☆☆☆☆☆
Altitude	☆☆☆	☆☆☆☆☆
Acoustic Noise	☆☆☆	☆☆☆☆☆
Raw Media Error Rate	☆☆☆	☆☆☆☆☆
Apps Data Error Rate	☆☆☆☆	☆☆☆☆☆
Performance-Sequential	☆☆☆☆	☆☆☆☆☆
Performance-Random	☆☆	☆☆☆☆☆
Power Idle	☆☆☆	☆☆☆☆☆
Power Read/Write	☆☆	☆☆☆☆☆
Capacity	☆☆☆☆☆	☆☆☆☆☆
Cost/IOPS	☆☆☆	☆☆☆
Cost/MBps	☆☆☆☆	☆☆☆
Cost/GB	☆☆☆☆☆	☆☆☆

Merit of SATA adoption

- **Huge non-volatile storage**
 - GigaByte/TeraByte capacity.
- **High-speed and Low cost**
 - Several Megabyte per second Read/Write speed
 - Mass produced goods
- **Compatibility**
 - Easy and quick to repair and recover, just replace.
 - Your product lineup will be various with different capacity storages



512GB	SSD-N512S/PM3P	¥94,815(税込) / ¥90,300(税抜)
256GB	SSD-N256S/PM3P	¥50,085(税込) / ¥47,700(税抜)
128GB	SSD-N128S/PM3P	¥25,620(税込) / ¥24,400(税抜)



Just change storage capacity to arrange various products from high-end model to low cost model.

Solution for embedded system

- **1: Use Existing SATA chip (ASSP)**
 - Merit: Device cost
 - Demerit: Limitation of MOQ, support and fixed function
- **2: Use FPGA+SATA-IP core**
 - Merit: Flexibility, support special usage such as RAID, MOQ etc..
 - Demerit: Device cost (In case of SATA function only)

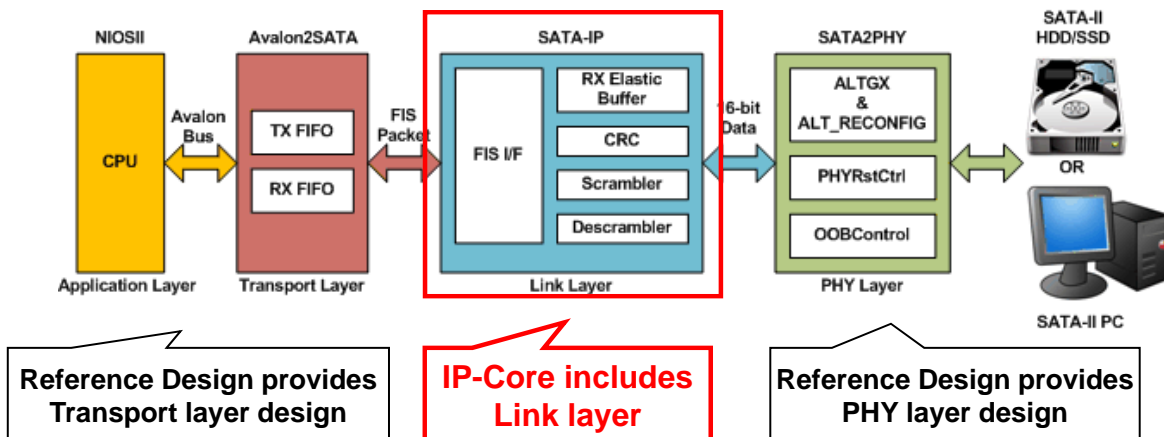
Conclusion:

If the system is simple function and the availability is acceptable, ASSP may be better for you.

For other case, FPGA + SATA-IP core is best solution for you!!

What is SATA-IP?

- Implement SATA channel by transceiver resource.
- IP-Core includes Link layer (and some part of Transport layer).
- Reference Design available for PHY layer and Transport layer.



Product Lineup

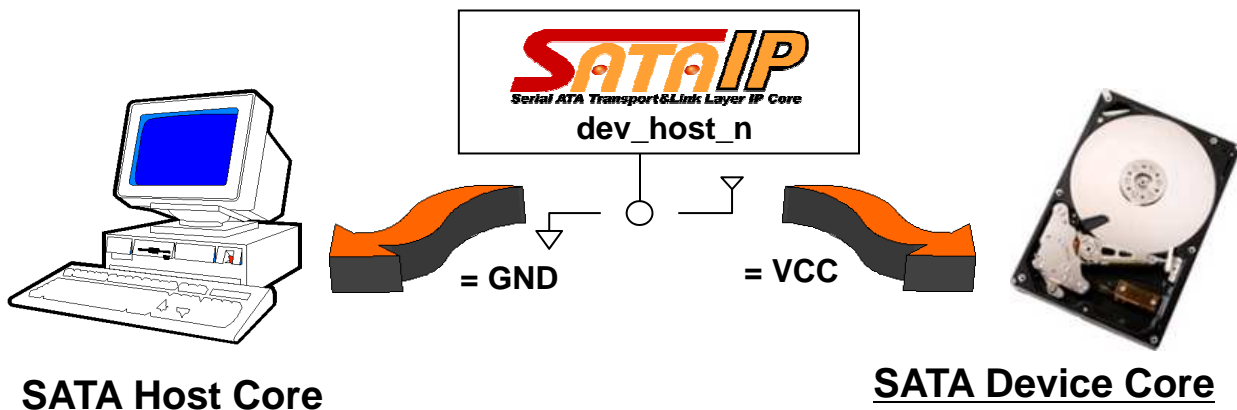
Prod. No.	Device	Speed	Available reference design
SATA-IP-A10SX	Arria10 SX	SATA-III	Host
SATA-IP-A10GX	Arria10 GX	SATA-III	Host
SATA-IP-A5GX	ArriaV GX	SATA-III	4chRAID, Host, HostIP, exFAT
SATA-IP-A5ST	ArriaV ST	SATA-III	Host, Linux(AHCI)
SATA-IP-S5GX	StratixV GX	SATA-III	4chRAID, Host
SATA-IP-S4GX	StratixIV GX	SATA-III	4chRAID, Host, HostIP, Duplicator
SATA-IP-C5SX	CycloneV SX	SATA-II	Host, Linux(AHCI)

Stratix/Arria family supports
SATA3.0 (6Gbps)

Many reference design available
(Can check operation for evaluation)

Supports both of Host and Device

- Single IP-Core supports both of Host (PC side) and Device (Disk side).
 - Select between Host function and Device function by dev_host_n signal input.



Approved IP-Core by Intel

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DSN Member Profile: DesignGateway Co., Ltd.

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FPGA Design Solutions Network

Overview

Design Gateway Co., Ltd. is the expert of FPGA logic design and development. We provide total solution with IP cores. We have rich experience more than 25years in FPGA field. We can response your request flexibly. Design Gateway Co., Ltd. specializes in IP cores for high performance and low resources usage solutions in data storage, networking and interface fields on FPGA such as NVMe, SATA, USB3.0, TCP/IP and UDP/IP. Providing various kind of reference design, ready for real board evaluation and experience technology background for supporting customer.

Available Design Services

Request Contact

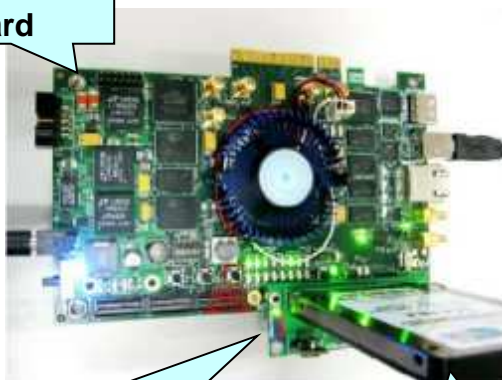
Design Services	Device Family	Country Supported
Embedded Design: ARM Drivers, ARM Applications, ARM Middleware, Nios II, arm-os Hardware Design: Turnkey (Board , Specification Development, System-Level Board design, FPGA, High Speed Transceiver, Timing Closure Altera -Design Services IP Integration	Arria V SoC, Cyclone IV, Stratix V, Arria 10 SoC, Stratix IV, Cyclone V, Cyclone V SoC, Arria V, Arria 10	APAC: Thailand Japan

DesignGateway is DSN partner of Intel

Free SOF-file for Evaluation

- Write/Read access to SATA device from Intel board.
- Measure real SATA drive performance.

Intel FPGA board



AB11-HSMCSATA adapter from DesignGateway

SSD/HDD

```

Altera Nios II EDS 10.1sp1 [gcc4]
Enter Sector Count : 1 - 0x1dcf321a : 0x1000000
Write Pattern? : 1011nc32 11Dec32 121A11_0 131A11_1 : 1
Prepare Data... Data Ready
.....
Speed = 279 MB/s

Main Menu
0. SATA Reset
1. IDENTIFY DEVICE
2. Write COMMAND
3. Read COMMAND
4. Dump Data
3
Enter Start LBA : 0 - 0x1dcf32af : 0
Enter Sector Count : 1 - 0x1dcf32b0 : 0x1000000
.....
Speed = 480 MB/s

Main Menu
0. SATA Reset
1. IDENTIFY DEVICE
2. Write COMMAND
    
```

Execute command via Nios2-terminal

Evaluation Environment (StratixIV GX version)

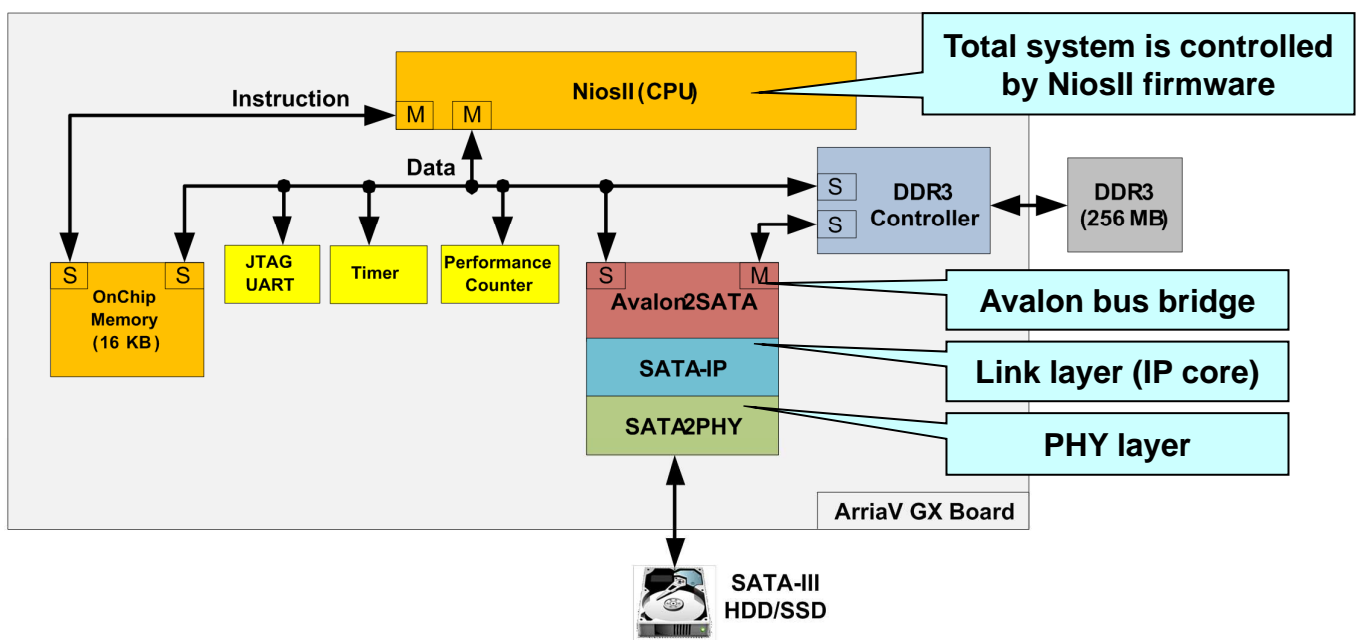
Reference Design (Summary)

- QuartusII project attached to the deliverables
- Full source code (VHDL) except IP core
- Can save user system development duration
 - Confirm real board operation by original reference design.
 - Then modify a little to approach final user product.
 - Check real operation in each modification step.



No risk to back to rebuild, able to develop for short term!

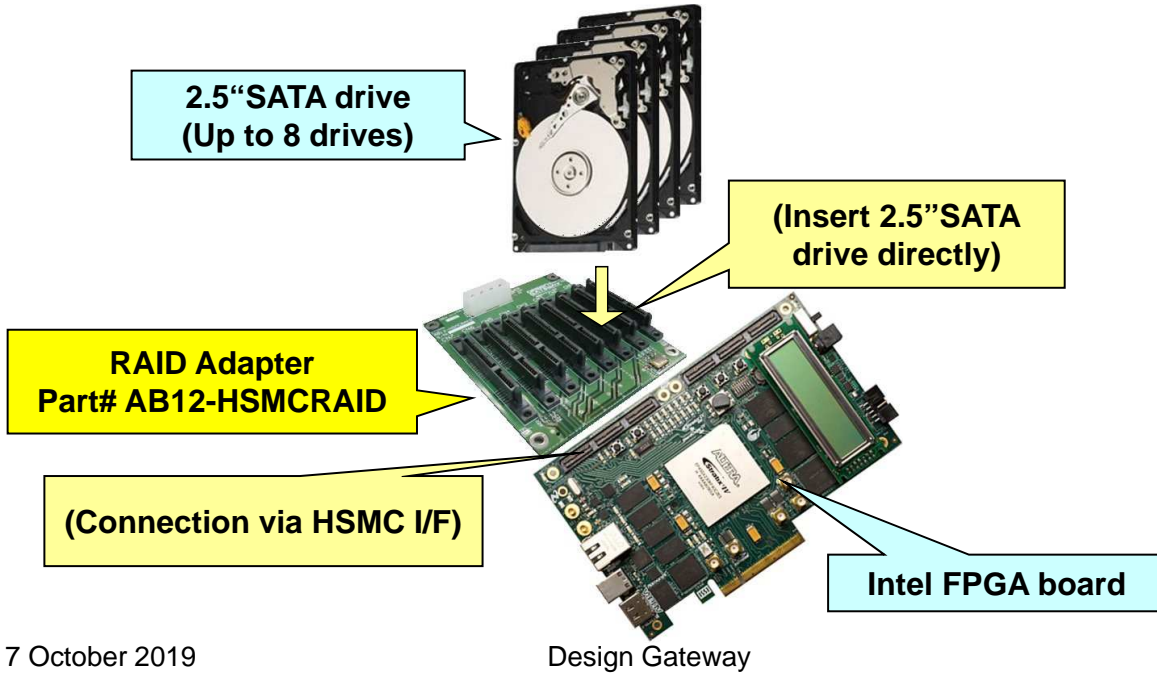
Reference Design (Structure)



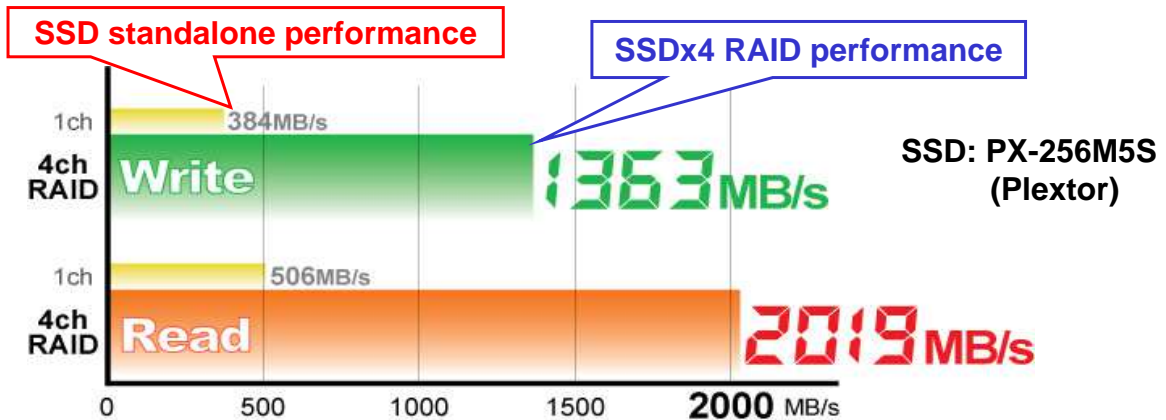
Block diagram of SATA-IP reference design

Development tool for RAID system

- HSMC extension board with 8 SATA connectors.
- Direct connect to 2.5 inch SSD or HDD.



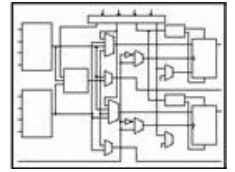
RAID System Performance



- 1.4GB/s for Write speed (RAID efficiency = 89%)
 - Enough speed for Super high resolution video recording
- 2GB/s for Read speed (RAID efficiency = 99.8%)
 - SSD drive count minimized for video playback system

SATA-IP Optional Product

- **HCTL-IP Core**
 - Pure hard-wired host controller core
 - Automatic read/write execution without CPU
 - Best performance because firmware overhead not exist
- **AHCI-IP Core**
 - SATA access possible from LinuxOS
 - Support ARM Core for SoC family
- **FAT32-IP/exFAT-IP**
 - Provide FAT32/exFAT access feature by hardwired logic
 - Can record data as 'file' -> PC can access to data via file

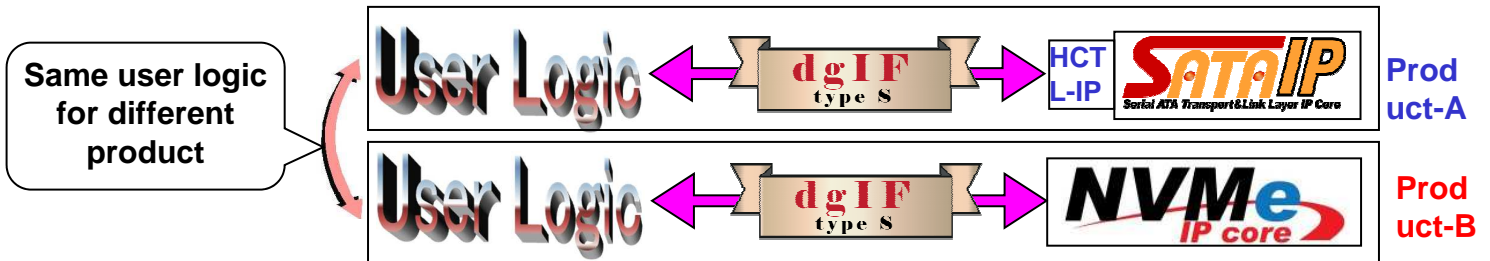


HCTL-IP Core (Optional Product)

- **Controller IP core designed by pure hard-wired logic**
 - Full automatic SATA-IP control instead of CPU and its firmware
 - Can build storage system without CPU
 - Can save CPU time completely in SoC application system
- **Minimize overhead by high speed state machine**
 - Theoretically the best performance (especially for write)
 - Write improvement example: CPU control=**465MB/s** -> Host-IP=**525MB/s**
 - Provides reference design for both 1ch and 4ch-RAID0 on Intel board

HCTL-IP Core (Cont'd)

- **Common interface among all Storage IP-Core (dgIF typeS)**
 - Same user interface among other IP-Core (NVMe-IP) product
 - Can keep same user logic for different storage between SATA and NVMe



- **Simple user interface for easy use**
 - Set R/W type, address, sector count parameter and issue request pulse
 - Very popular data interface by general FIFO

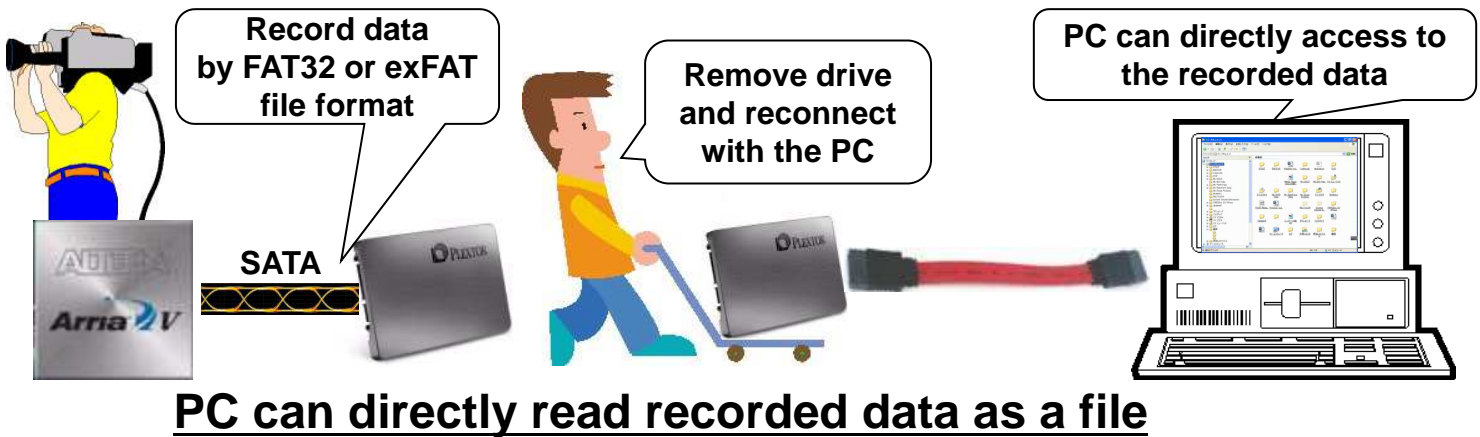
AHCI-IP Core (Optional Product)

- **Can access to SATA channel from Linux**
 - Reference design available for SoC device
 - Provide AHCI Linux driver C source code
- **Supports NCQ feature**
 - Queue re-order in multiple command
 - Minimum latency by using internal RAM for Queue table
 - Very high performance for random access
- **Multiple port count support by customization**
 - Standard product support 1 port
 - Port count can be increased by core customization



FAT32-IP/exFAT-IP Core (Optional Product)

- Supports data recording by FAT32/exFAT file format
 - In combination with both SATA-IP and HCTL-IP core
- PC can directly access to recorded data as a file
 - FPGA writes data to device, reconnect with PC, then PC can read data



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FAT32-IP/exFAT-IP (Cont'd 1)

- Feature description
 - Executes drive format and data write to file by pure hardwired logic.
 - IP core automatically generates file name.
 - User logic sends file data via FIFO interface.
- Limitation
 - Drive must be formatted by the IP core, not by the PC.
 - Files other than those generated by the IP core cannot be written to the drive.
 - File size is determined at format execution and cannot be changed.

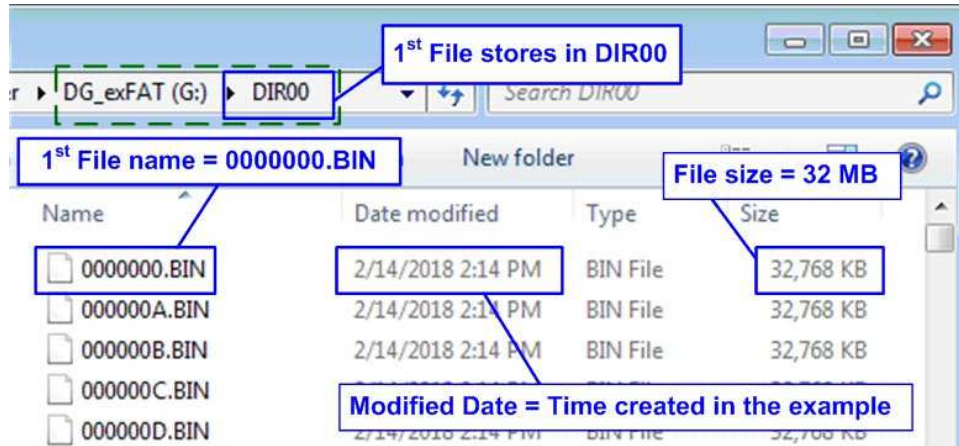
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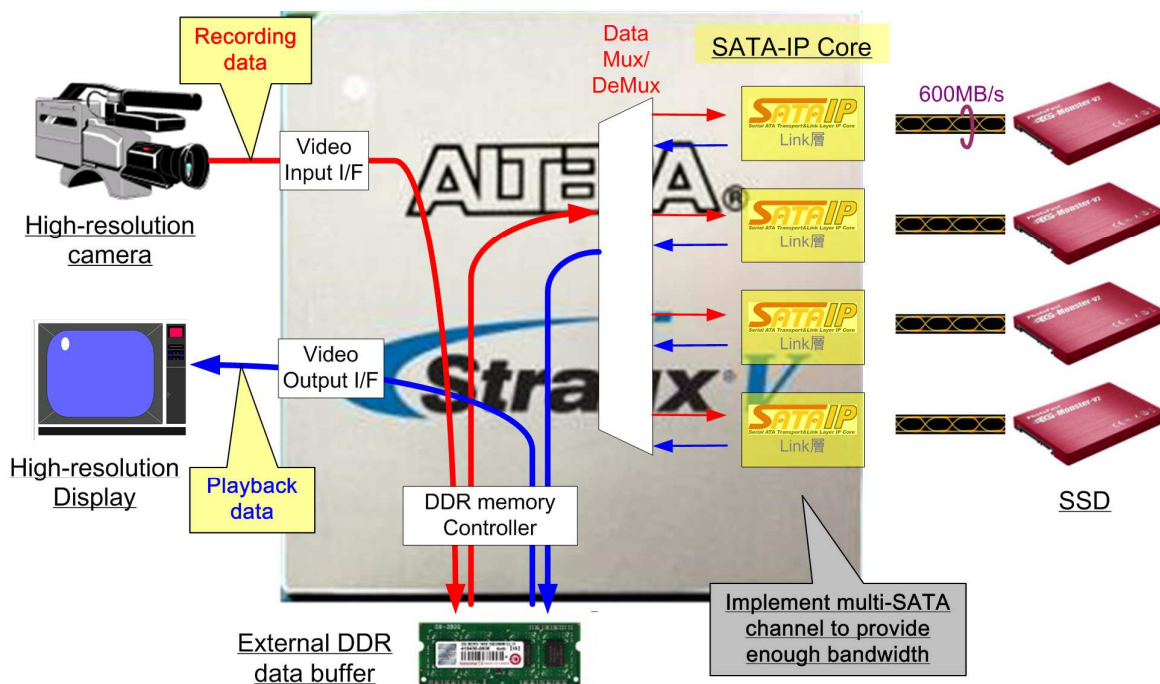
FAT32-IP/exFAT-IP (Cont'd 2)

- Reference design for real operation available
 - Executes test file generation via serial console.
 - User can confirm file read compatibility by drive re-plug to the PC.



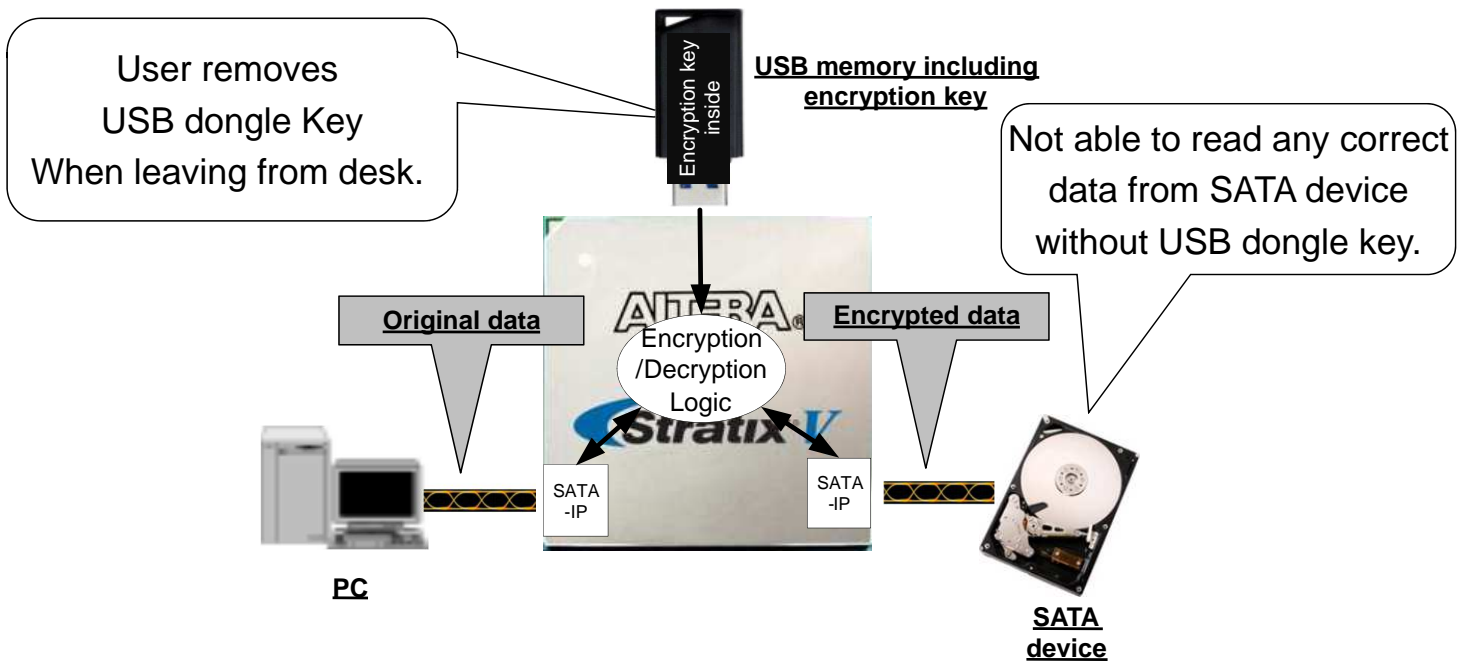
Generate test file, reconnect with PC, and can check file read compatibility

SATA-IP Application (1)



Advanced High-definition Video Recorder

SATA-IP Application (2)



Security Drive System

SATA-IP Application (3)

• Duplicator Application Reference Design

- Copy whole data from Master drive to multiple Slave drives
- Reference design for StratixIV GX board
- Design project available for formal SATA-IP customer

1-3 Blank SATA-IP Disk

Master SATA-IP Disk

CN3 CN2 CN1

CN1-3 for copy destination drive

CN0 for copy source drive

Complete 0123
Speed = 322 MB/s

Display copy result and performance

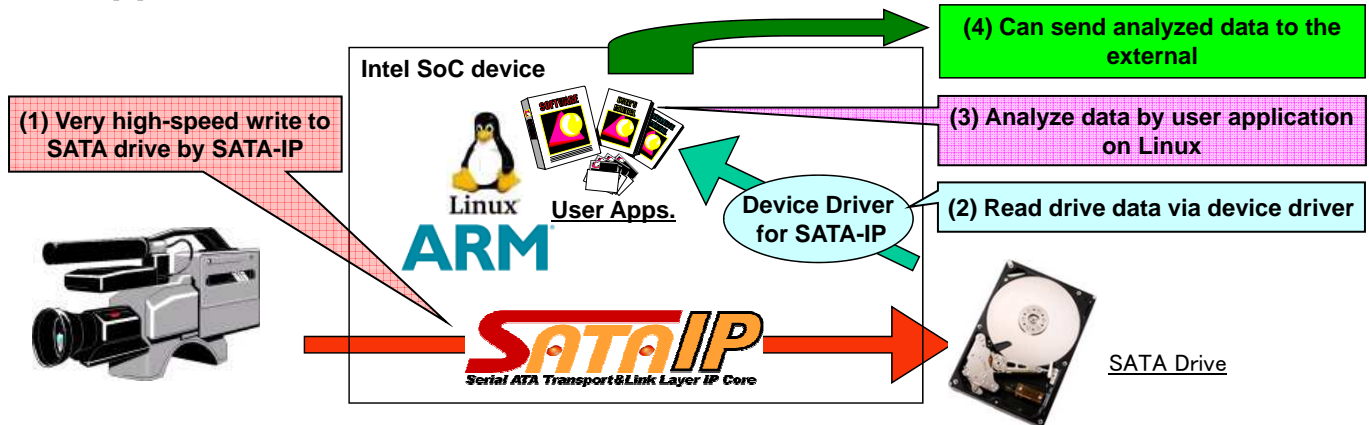
```

Altera Nios II EDS 10.1sp1 [gcc4]
+++ START DISK DUPLICATE +++
Disk Copy 98 %
Complete 0123
Speed = 324 [MB/s]
--- STORAGE DUPLICATOR MENU [Ver = 1.0] ---
[0]or[X] : RESET
[1]or[S] : START COPY
    
```

Display result by LCD/Nios2-terminal

SATA-IP Application (4)

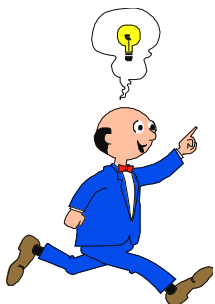
- Recording and Analysis system on Linux
 - Mount Linux and user analysis application on SoC device
 - Very high-speed data recording to SATA drive via SATA-IP core
 - Data read from SATA drive via device driver and analyze by user application



Recording and Analysis system on Linux (device driver and reference design available)

For more detail

- Detailed documents available on the web site.
 - http://www.dgway.com/SATA-IP_A_E.html
- Contact
 - Design Gateway Co., Ltd.
 - E-mail : sales@design-gateway.com
 - FAX : +66-2-261-2290



Revision History

Rev.	Date	History
1.0	04-Feb-09	English version initial release
1.3	31-Jul-12	Add introduction of summary of SATA Update explanation of RAID development tool (AB12-HSMCRAID board)
1.6E	27-Jul-16	Add Arria10SoC support
1.7E	03-Apr-17	Add common user interface (dgIF typeS) and its merit description for SATA Host-IP
1.8E	06-Jan-19	Add FAT32-IP/exFAT-IP for SATA-IP optional products
1.9E	04-Oct-19	Add Linux application example