To: T10 Technical Committee
From: Rob Elliott, HP (elliott@hp.com)
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Subject: 07-119r0 SAS-2 Far-end loopback phy test function

Revision history
Revision 0 (9 March 2007) First revision

Related documents
sas2r08 - Serial Attached SCSI - 2 (SAS-2) revision 8
02-218r0 SAS Remove far-end retimed loopback (Jim Coomes, Seagate) - accepted into sas-r00b
Serial ATA 2.6 (from the Serial ATA International Organization)

Overview
Many phy designs implement far-end loopback phy test modes, where the phy retransmits everything it receives. As with test patterns, there should be a common mechanism for entering these test modes.

The Serial ATA specification defines two far-end loopback modes and defines enabling them via the BIST Activate FIS:

  a) far-end retimed: required
  b) far-end analog: optional

SAS-1 original included far-end retimed loopback, but it was removed. Many SAS phy designs do implement this feature, however, with vendor-specific mechanisms.

SAS-2 should define standardize controls using the Protocol-Specific diagnostic page and the SMP PHY TEST function.

Suggested changes to SAS-2

4.10 Phy test functions

The optional Protocol-Specific diagnostic page for SAS (see 10.2.9.1) provide methods for an application client to enable and disable a phy test function (e.g., transmission of the CJTPAT) for a selected phy in a SAS target device with an SSP target port. The optional SMP PHY TEST FUNCTION function (see 10.4.3.25) provides similar methods for expander devices and SAS target devices with SMP target ports.

The application client sends a SEND DIAGNOSTIC command with the Protocol-Specific diagnostic page or an SMP PHY TEST FUNCTION function specifying the phy in the SAS target device that is to perform the phy test function and the phy test function to be performed. If the phy test function requires a specific phy test pattern and/or phy test pattern physical link rate, then it also specifies the phy test pattern and phy test pattern physical link rate.

The SEND DIAGNOSTIC command may be sent through any SSP target port to any logical unit in the SAS target device that contains the phy that is to perform the phy test function.

For the SEND DIAGNOSTIC command, the phy shall begin the specified phy test function after the SSP target port receives an ACK for the RESPONSE frame transmitted in response to the SEND DIAGNOSTIC command that requested the phy test function. For the SMP PHY TEST FUNCTION function, the phy shall begin the specified phy test function after the SMP target port transmits the SMP response frame.

Once a SAS phy has begun performing a phy test function, it shall ignore its receiver. To stop a SAS phy from performing a phy test function, an application client sends a SEND DIAGNOSTIC command or an SMP PHY TEST FUNCTION function to a SAS phy in the SAS target device that is not performing a phy test function requesting a phy test function of 00h (i.e., STOP). If no such phy is available, the phy test function only stops on power loss.

In the far-end analog phy test mode, the phy shall retransmit the analog signal that it receives (e.g., after an equalizer but before the clock recovery circuitry).

In the far-end retimed phy test mode, the phy shall retransmit the signal that it receives, after performing clock recovery and synchronizing the received signal to its transmit clock. The phy shall maintain dword synchronization. The phy may delete deletable primitives that it receives, and shall transmit a deletable primitive whenever it underflows (i.e., whenever the transmitter is ready to transmit a dword but the receiver has not provided another dword to transmit). The phy may transmit dwords with a different disparity that it receives them.

While in a far-end loopback phy test mode, the phy shall operate its OOB signal detector to detect COMINIT.

The phy shall remain in a far-end loopback phy test mode until:

   a) the phy test function is stopped via another phy;
   b) the phy receives a COMINIT;
   c) power off; or
   d) if it is in the far-end retimed phy test mode, the phy loses dword synchronization.

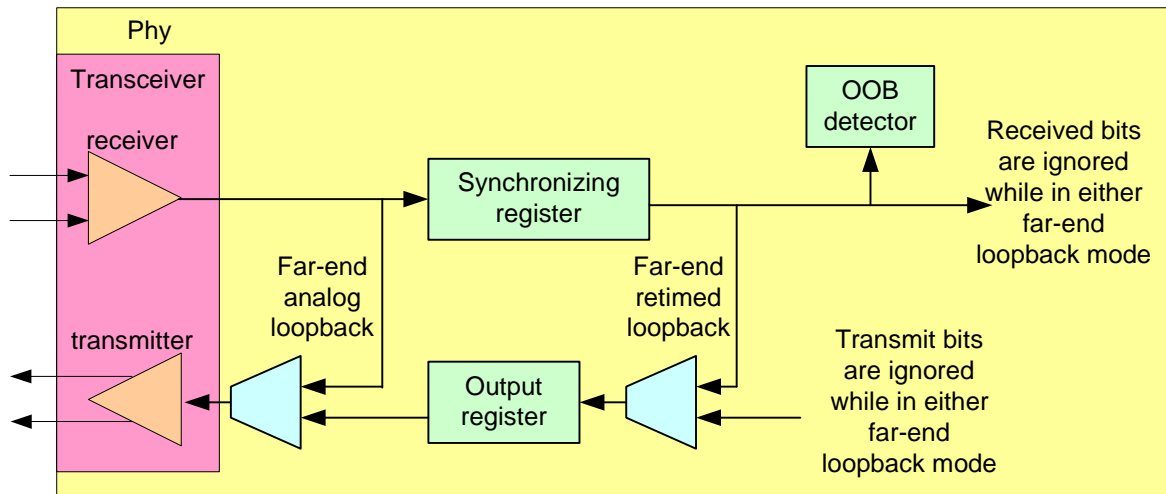Figure 1 shows the far-end analog and far-end retimed loopback phy test modes.

Figure 1 — Far-end analog and far-end retimed loopback phy test modes

10.2.9 SCSI diagnostic parameters

10.2.9.1 Protocol-Specific diagnostic page

The Protocol-Specific diagnostic page for SAS provides a method for an application client to enable and disable phy test functions (see 4.10) for selected phys. The diagnostic page format is specified in SPC-4.

The Protocol-Specific diagnostic page is transmitted using the SEND DIAGNOSTIC command. If the device server receives a RECEIVE DIAGNOSTIC RESULTS command with the PAGE CODE field set to 3Fh, it shall terminate the command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and

the additional sense code set to INVALID FIELD IN PARAMETER LIST. Table 1 defines the Protocol-Specific diagnostic page for SAS.

Table 1 — Protocol-Specific diagnostic page for SAS

Byte\Bit	7	6	5	4	3	2	1	0
0	PAGE CODE (3Fh)							
1	Reserved				PROTOCOL IDENTIFIER (6h)			
2	(MSB)							
3	PAGE LENGTH (001Ch)							(LSB)
4	PHY IDENTIFIER							
5	PHY TEST FUNCTION							
6	PHY TEST PATTERN							
7	Reserved				PHY TEST PATTERN PHYSICAL LINK RATE			
8	Reserved							
10								
11	PHY TEST PATTERN DWORDS CONTROL							
12	PHY TEST PATTERN DWORDS							
19								
20	Reserved							
31								

The PAGE CODE field shall be set to 3Fh.

The PROTOCOL IDENTIFIER field shall be set to 6h indicating this is a SAS SSP specific diagnostic page.

The PAGE LENGTH field shall be set to the number of bytes in the diagnostic page after the PAGE LENGTH field (i.e., 001Ch)

The PHY IDENTIFIER field specifies the phy identifier (see 4.2.7) of the phy that is to perform or to stop performing a phy test function (i.e., the selected phy). If the PHY IDENTIFIER field specifies a phy that does not exist, then the device server shall terminate the SEND DIAGNOSTIC command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

The PHY TEST FUNCTION field specifies the phy test function to be performed and is defined in table 2. If the PHY TEST FUNCTION field specifies a phy test function that is not supported, then the device server shall terminate the SEND DIAGNOSTIC command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

Table 2 — PHY TEST FUNCTION **field**

Code	Name	Description
00h	STOP	If the selected phy is performing a phy test function, then the selected phy shall stop performing the phy test function and originate a link reset sequence. If the selected phy is not performing a phy test function, then this function has no effect on the selected phy. [a]
01h	TRANSMIT_PATTERN	If the selected phy is not performing a phy test function, the selected phy shall be set to transmit the phy test pattern specified by the PHY TEST PATTERN field at the physical link rate specified by the PHY TEST PATTERN PHYSICAL LINK RATE field and set to ignore its receiver. If the selected phy receives data while transmitting the pattern, then the selected phy shall ignore the received data. If the selected phy is performing a phy test function, the device server shall terminate the SEND DIAGNOSTIC command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to PHY TEST FUNCTION IN PROGRESS. [a]
02h	FAR_END_RETIMED_LOOPBACK	If the selected phy is not performing a phy test function, the selected phy shall be set to the far-end retimed loopback mode (see 4.10). If the selected phy is performing a phy test function, the device server shall terminate the SEND DIAGNOSTIC command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to PHY TEST FUNCTION IN PROGRESS. [a]
03h	FAR_END_ANALOG_LOOPBACK	If the selected phy is not performing a phy test function, the selected phy shall be set to the far-end analog loopback mode (see 4.10). If the selected phy is performing a phy test function, the device server shall terminate the SEND DIAGNOSTIC command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to PHY TEST FUNCTION IN PROGRESS. [a]
~~02h~~04h - EFh	Reserved	
F0h - FFh	Vendor specific	
[a] If there is no SSP target port available to receive a SEND DIAGNOSTIC command to stop a phy from performing a phy test function, then a power on may be required to cause the phy to stop performing the function and originate a phy reset sequence.		

If the PHY TEST FUNCTION field is set to TRANSMIT_PATTERN (i.e., 01h), then the PHY TEST PATTERN field specifies the phy test pattern to be transmitted as defined by table 212. If the PHY TEST PATTERN field specifies a phy test pattern that is not supported by the specified SAS phy, then the device server shall terminate the SEND DIAGNOSTIC command with CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and the additional sense code set to INVALID FIELD IN PARAMETER LIST.

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10.4.3.25 PHY TEST FUNCTION function

The PHY TEST FUNCTION function requests actions by the specified phy. This SMP function may be implemented by any management device server. In zoning expander devices, if zoning is enabled then this function shall only be processed from SMP initiator ports that have access to zone group 2 or the zone group of the specified phy (see 4.9.3.2).

Table 3 defines the request format.

Table 3 — PHY TEST FUNCTION request

Byte\Bit	7	6	5	4	3	2	1	0
0	SMP FRAME TYPE (40h)							
1	FUNCTION (92h)							
2	Reserved							
3	REQUEST LENGTH (09h)							
4	(MSB)			EXPECTED EXPANDER CHANGE COUNT				
5								(LSB)
6				Reserved				
8								
9	PHY IDENTIFIER							
10	PHY TEST FUNCTION							
11	PHY TEST PATTERN							
12				Reserved				
14								
15	Reserved				PHY TEST PATTERN PHYSICAL LINK RATE			
16				Reserved				
18								
19	PHY TEST PATTERN DWORDS CONTROL							
20				PHY TEST PATTERN DWORDS				
27								
28				Reserved				
39								
40	(MSB)			CRC				
43								(LSB)

The SMP FRAME TYPE field shall be set to 40h.

The FUNCTION field shall be set to 92h.

The REQUEST LENGTH field shall be set to 09h. For compatibility with previous versions of this standard, a REQUEST LENGTH field set to 00h specifies that there are 9 dwords before the CRC field.

The EXPECTED EXPANDER CHANGE COUNT field is defined in the SMP CONFIGURE GENERAL request (see 10.4.3.15).

The PHY IDENTIFIER field specifies the phy (see 4.2.7) to which the SMP PHY TEST PATTERN request applies.

If the PHY IDENTIFIER field specifies the phy which is being used for the SMP connection, the management device server shall not perform the requested operation and shall return a function result of SMP FUNCTION FAILED in the response frame.

The PHY TEST FUNCTION field specifies the phy test function to be performed, and is defined in table 4. If the PHY TEST FUNCTION field specifies a phy test function that is not supported by the phy, the management device server shall return a function result of UNKNOWN PHY TEST FUNCTION in the response frame.

Table 4 — PHY TEST FUNCTION **field**

Code	Name	Description
00h	STOP	If the selected phy is performing a phy test function, then the selected phy shall stop performing the phy test function and originate a link reset sequence. If the selected phy is not performing a phy test function, then this function has no effect on the selected phy.
01h	TRANSMIT_ PATTERN	If the selected phy is not performing a phy test function, the selected phy shall be set to transmit the phy test pattern specified by the PHY TEST PATTERN field at the physical link rate specified by the PHY TEST PATTERN PHYSICAL LINK RATE field and set to ignore its receiver. If the selected phy receives data while transmitting the pattern, then the selected phy shall ignore the received data. If the selected phy is performing a phy test function, the management device server shall return a function result of PHY TEST FUNCTION IN PROGRESS in the response frame.
02h	FAR_END_ RETIMED_ LOOPBACK	If the selected phy is not performing a phy test function, the selected phy shall be set to the far-end retimed loopback mode (see 4.10). If the selected phy is performing a phy test function, the device server shall return a function result of PHY TEST FUNCTION IN PROGRESS in the response frame.
03h	FAR_END_ ANALOG_ LOOPBACK	If the selected phy is not performing a phy test function, the selected phy shall be set to the far-end analog loopback mode (see 4.10). If the selected phy is performing a phy test function, the device server shall return a function result of PHY TEST FUNCTION IN PROGRESS in the response frame.
02h04h - EFh	Reserved	
F0h - FFh	Vendor specific	

If the PHY TEST FUNCTION field is set to 01h, the PHY TEST PATTERN field specifies the phy test pattern to be performed, and is the same as that defined in table 212 for the Protocol-Specific diagnostic page (see 10.2.9.1). The phy test pattern shall be sent at the physical link rate specified by the PHY TEST PATTERN PHYSICAL LINK RATE field.

The PHY TEST PATTERN PHYSICAL LINK RATE field specifies the physical link rate at which the phy test function, if any, shall be performed. Table 5 defines the values for this field.

Table 5 — PHY TEST PATTERN PHYSICAL LINK RATE **field**

Code	Description
0h - 7h	Reserved
8h	1,5 Gbps
9h	3 Gbps
Ah	6 Gbps
Bh - Fh	Reserved for future physical link rates

The PHY TEST PATTERN DWORDS CONTROL field and the PHY TEST PATTERN DWORDS field are as defined in table 212 for the Protocol-Specific diagnostic page (see 10.2.9.1).

The CRC field is defined in 10.4.3.1.

Table 6 defines the response format.

Table 6 — PHY TEST FUNCTION response

Byte\Bit	7	6	5	4	3	2	1	0
0	SMP FRAME TYPE (41h)							
1	FUNCTION (92h)							
2	FUNCTION RESULT							
3	RESPONSE LENGTH (00h)							
4	(MSB)							
7	CRC							(LSB)

The SMP FRAME TYPE field shall be set to 41h.

The FUNCTION field shall be set to 92h.

The FUNCTION RESULT field is defined in 10.4.3.2.

The RESPONSE LENGTH field shall be set to 00h.

The CRC field is defined in 10.4.3.2.