BREA Technologies, Inc.
14902 Mesita Drive
Houston, TX 77083-3209
P: (281) 530-3063
F: (281) 988-0358
BillG@breatech.com

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To: T10 Technical Committee
From: Bill Galloway
Subj: SAS Spare Primitives

SAS needs to define spare primitives that will be decoded by the receiver to allow for future expansion. Each of these spare primitives needs a defined action for SAS 1 devices.

Update the tables with following primitives:

Primitive	Use	From			To			Type
		I	E	T	I	E	T	
~~AIP (RESERVED)~~ AIP (RESERVED WAITING ON PARTIAL)	SAS				I	E	T	Single
AIP (RESERVED 0)	SAS				I	E	T	Single
AIP (RESERVED 1)	SAS				I	E	T	Single
AIP (RESERVED 2)	SAS				I	E	T	Single
~~CHANGE~~ BROADCAST (CHANGE)	SAS	I	E		I	E	T	Redundant
~~CHANGE (RESERVED 0)~~ BROADCAST (RESERVED CHANGE)	SAS				I	E	T	Redundant
~~CHANGE (RESERVED 1)~~ BROADCAST (RESERVED 0)	SAS				I	E	T	Redundant
~~CHANGE (RESERVED 2)~~ BROADCAST (RESERVED 1)	SAS				I	E	T	Redundant
~~ENABLE_SPINUP~~ NOTIFY(ENABLE_SPINUP)	All	I	E		I		T	Single
NOTIFY(RESERVED 0)	SAS				I	E	T	Single
NOTIFY(RESERVED 1)	SAS				I	E	T	Single
NOTIFY(RESERVED 2)	SAS				I	E	T	Single
OPEN_REJECT(BAD DESTINATION)	SAS		E		I	~~E~~	T	Single
OPEN_REJECT(CONNECTION RATE NOT SUPPORTED)	SAS	I	E	T	I	~~E~~	T	Single
OPEN_REJECT(PROTOCOL NOT SUPPORTED)	SAS	I		T	I	~~E~~	T	Single
OPEN_REJECT(STP RESOURCES BUSY)	SAS		E		I			Single
OPEN_REJECT(WRONG DESTINATION)	SAS	I		T	I	~~E~~	T	Single
OPEN_REJECT(RESERVED ABANDON 0)	SAS				I		T	Single
OPEN_REJECT(RESERVED ABANDON 1)	SAS				I		T	Single
OPEN_REJECT(RESERVED ABANDON 2)	SAS				I		T	Single
OPEN_REJECT(RESERVED ABANDON 3)	SAS				I		T	Single
OPEN_REJECT(NO DESTINATION)	SAS		E		I	~~E~~	T	Single
OPEN_REJECT(PATHWAY BLOCKED)	SAS		E		I		T	Single
OPEN_REJECT(RETRY)	SAS	I		T	I	~~E~~	T	Single
OPEN_REJECT(RESERVED CONTINUE 0)	SAS				I		T	Single
OPEN_REJECT(RESERVED CONTINUE 1)	SAS				I		T	Single
OPEN_REJECT(RESERVED INITIAIALIZE 0)	SAS				I		T	Single
OPEN_REJECT(RESERVED INITIAIALIZE 1)	SAS				I		T	Single
OPEN_REJECT(RESERVED STOP 0)	SAS				I		T	Single
OPEN_REJECT(RESERVED STOP 1)	SAS				I		T	Single

Primitive	Use	From			To			Type
		I	E	T	I	E	T	
RRDY (RESERVED 0)	SSP				I		T	Single
RRDY (RESERVED 1)	SSP				I		T	Single
~~DONE (RESERVED)~~ DONE (RESERVED TIMEOUT)	SSP				I		T	Single
DONE (RESERVED 0)	SSP				I		T	Single
DONE (RESERVED 1)	SSP				I		T	Single
DONE (RESERVED 2)	SSP				I		T	Single

Primitive	1st	2nd	3rd	4th
~~AIP (RESERVED)~~ AIP (RESERVED WAITING ON PARTIAL)	K28.5	D27.4	D01.4	D07.3
AIP (RESERVED 0)	K28.5	D27.4	D31.4	D16.7
AIP (RESERVED 1)	K28.5	D27.4	D16.7	D30.0
AIP (RESERVED 2)	K28.5	D27.4	D29.7	D01.4
~~CHANGE~~ BROADCAST (CHANGE)	K28.5	D02.0	D31.4	D30.0
~~CHANGE (RESERVED 0)~~ BROADCAST (RESERVED CHANGE)	K28.5	D02.0	D04.7	D01.4
~~CHANGE (RESERVED 1)~~ BROADCAST (RESERVED 0)	K28.5	D02.0	D16.7	D31.4
~~CHANGE (RESERVED 2)~~ BROADCAST (RESERVED 1)	K28.5	D02.0	D29.7	D16.7
~~ENABLE_SPINUP~~ NOTIFY(ENABLE_SPINUP)	K28.5	D31.3	D31.3	D31.3
NOTIFY(RESERVED 0)	K28.5	D31.3	D07.0	D01.3
NOTIFY(RESERVED 1)	K28.5	D31.3	D01.3	D07.0
NOTIFY(RESERVED 2)	K28.5	D31.3	D27.3	D10.2
OPEN_REJECT(BAD DESTINATION)	K28.5	D31.4	D31.4	D31.4
OPEN_REJECT(CONNECTION RATE NOT SUPPORTED)	K28.5	D31.4	D04.7	D29.7
OPEN_REJECT(PROTOCOL NOT SUPPORTED)	K28.5	D31.4	D29.7	D07.3
OPEN_REJECT(STP RESOURCES BUSY)	K28.5	D31.4	D27.4	D01.4
OPEN_REJECT(WRONG DESTINATION)	K28.5	D31.4	D16.7	D24.0
OPEN_REJECT(RESERVED ABANDON 0)	K28.5	D31.4	D02.0	D27.4
OPEN_REJECT(RESERVED ABANDON 1)	K28.5	D31.4	D30.0	D16.7
OPEN_REJECT(RESERVED ABANDON 2)	K28.5	D31.4	D07.3	D02.0
OPEN_REJECT(RESERVED ABANDON 3)	K28.5	D31.4	D01.4	D30.0
OPEN_REJECT(NO DESTINATION)	K28.5	D29.7	D29.7	D29.7
OPEN_REJECT(PATHWAY BLOCKED)	K28.5	D29.7	D16.7	D04.7
OPEN_REJECT(RETRY)	K28.5	D29.7	D27.4	D24.0
OPEN_REJECT(RESERVED CONTINUE 0)	K28.5	D29.7	D02.0	D30.0
OPEN_REJECT(RESERVED CONTINUE 1)	K28.5	D29.7	D24.0	D01.4
OPEN_REJECT(RESERVED INITIAIALIZE 0)	K28.5	D29.7	D30.0	D31.4
OPEN_REJECT(RESERVED INITIAIALIZE 1)	K28.5	D29.7	D07.3	D16.7
OPEN_REJECT(RESERVED STOP 0)	K28.5	D29.7	D31.4	D07.3
OPEN_REJECT(RESERVED STOP 1)	K28.5	D29.7	D04.7	D27.4

Primitive	1st	2nd	3rd	4th
RRDY (RESERVED 0)	K28.5	D01.4	D02.0	D31.4
RRDY (RESERVED 1)	K28.5	D01.4	D30.0	D02.0
~~DONE (RESERVED)~~ DONE (RESERVED TIMEOUT)	K28.5	D30.0	D27.4	D29.7
DONE (RESERVED 0)	K28.5	D30.0	D31.4	D24.0
DONE (RESERVED 1)	K28.5	D30.0	D16.7	D01.4
DONE (RESERVED 2)	K28.5	D30.0	D29.7	D31.4

Update the following text:

7.1.4 Primitives not specific to type of connections

7.1.4.1 AIP (Arbitration in progress)

AIP is sent by an expander device after a connection request to indicate that the connection request is being processed and indicate the status of the connection request.

The versions of AIP representing different statuses are defined in table 49.

Table 49 — AIP primitives

Primitive	Description
AIP (NORMAL)	Expander device has just accepted the connection request.
AIP (WAITING ON CONNECTION)	Expander device has determined the routing for the connection request, but the destination phys are all busy with active connections.
AIP (WAITING ON DEVICE)	Expander device has determined the routing for the connection request and forwarded it to the output physical link.
AIP (WAITING ON PARTIAL)	Expander device has determined the routing for the connection request, but the destination phys are all busy with other connection requests that have also received AIP (WAITING ON PARTIAL).
AIP (RESERVED WAITING ON PARTIAL)	Processed the same as AIP (WAITING ON PARTIAL).
AIP (RESERVED 0)	Processed the same as AIP (NORMAL).
AIP (RESERVED 1)	Processed the same as AIP (NORMAL).
AIP (RESERVED 2)	Processed the same as AIP (NORMAL).

7.1.4.4 ~~CHANGE~~ BROADCAST

BROADCASTs are used to notify all devices in a SAS domain of an event.

When an expander port receives a BROADCAST it shall transmit the same BROADCAST on at least one phy in all other expander ports. BROADCAST shall only be sent outside of connections.

An expander device is not required to queue multiple identical BROADCAST indications for the same expander port. If a second identical BROADCAST indication is requested before the first indication has been transmitted, the second indication may be dropped.

~~CHANGE~~ BROADCAST (CHANGE) is sent by an expander device to notify initiator ports and other expander devices that a configuration change has occurred. ~~CHANGE shall only be sent outside of connections.~~

~~CHANGE (RESERVED 0), CHANGE (RESERVED 1), and CHANGE (RESERVED 2) are reserved, and shall be broadcast by expander devices the same as CHANGE.~~

See 7.11 for details on domain changes. See 10.3.1.2 for details on counting ~~CHANGEs~~ BROADCAST (CHANGE) in an expander device.

BROADCAST (RESERVED CHANGE) shall be processed the same as BROADCAST (CHANGE). BROADCAST (RESERVED 0) and BROADCAST (RESERVED 1) shall be ignored by initiators and targets.

Global change: CHANGE to BROADCAST (CHANGE)

7.1.4.6 ~~ENABLE_SPINUP~~ NOTIFY

NOTIFY may be sent in place of an ALIGN. It may or may not affect the ALIGN sequencing (i.e.., rotation through ALIGN(0), ALIGN(1), ALIGN(2), or ALIGN(3)). NOTIFY shall not be transmitted until at least three ALIGNs have been transmitted since the previous NOTIFY. Otherwise, the selection of when and how often to transmit NOTIFY is outside the scope of this standard.

NOTIFY shall not be forwarded through expander devices.

NOTIFY (ENABLE_SPINUP) is transmitted by an initiator port or expander port and is used to specify to an SSP target device that it may temporarily consume additional power (e.g. while spinning-up rotating media) while transitioning into the active or idle power condition state. The length of time the SSP target device consumes additional power and the amount of additional power is vendor-specific. NOTIFY (ENABLE_SPINUP) shall interact with the device's power condition state transitions, controlled by the Power Conditions mode page (see SPC-3) and/or the START STOP UNIT command (see SBC-2 and RBC), as described in TBD.

Initiator devices and expander devices shall transmit NOTIFY (ENABLE_SPINUP)s while attached to SSP target devices (i.e., devices that report SSP target support in their IDENTIFY address frames). They shall transmit one NOTIFY (ENABLE_SPINUP) after power on when the enclosure is ready for initial target device spin-up. After the initial NOTIFY (ENABLE_SPINUP), they shall transmit NOTIFY (ENABLE_SPINUP) periodically.

~~ENABLE_SPINUP shall be sent in place of an ALIGN. It may or may not affect the ALIGN sequencing (i.e.., rotation through ALIGN(0), ALIGN(1), ALIGN(2), or ALIGN(3)). ENABLE_SPINUP shall not be transmitted until at least three ALIGNs have been transmitted since the previous ENABLE_SPINUP. Otherwise, the selection of when and how often to transmit ENABLE_SPINUP is outside the scope of this standard.~~

NOTE 14 The initiator device or expander device uses NOTIFY (ENABLE_SPINUP) to avoid exceeding enclosure power supply capabilities during spin-up of multiple target devices. It may choose to rotate transmitting NOTIFY (ENABLE_SPINUP) across all of its ports, distributing it to N ports at a time if the enclosure power supply is capable of powering N target devices spinning up at a time. An expander device may allow this timing to be configured by a NVROM programming with enclosure-specific sequencing patterns, or may employ more complex, dynamic interaction with the enclosure power supply.

NOTE 15 NOTIFY (ENABLE_SPINUP) should be transmitted as frequently as possible to avoid incurring application layer timeouts.

~~ENABLE_SPINUP shall not be forwarded through expander devices.~~

I_T nexus loss, logical unit reset, and hard reset shall not cause a target device to spin-up automatically on receipt of NOTIFY (ENABLE_SPINUP).

Target devices with multiple target ports shall accept NOTIFY (ENABLE_SPINUP)s from all target ports (e.g., NOTIFY (ENABLE_SPINUP) received on target port A serves as a wakeup for a START STOP UNIT command received through target port B).

NOTIFY (RESERVED 0), NOTIFY (RESERVED 1), and NOTIFY (RESERVED 2) shall be ignored by all devices.

Global change: ENABLE_SPINUP to NOTIFY (ENABLE_SPINUP).

7.1.4.11 OPEN_REJECT

OPEN_REJECT indicates that a connection request has been rejected and indicates the reason for the rejection. The response to some OPEN_REJECTs is to abandon the connection request and the response to other OPEN_REJECTs is to retry the connection request.

~~The versions of OPEN_REJECT representing different abandon reasons are defined in table xx.~~

All of the OPEN_REJECT reasons in table xx shall result in the originating device abandoning the connection request. All of the OPEN_REJECT reasons in table yy may result in the originating device retrying the connection request.

Table xx — OPEN_REJECT abandon primitives

Originator	Primitive	Description
Expander device	OPEN_REJECT(BAD DESTINATION)	The destination SAS address equals the source SAS address or the expander device determines the connection request needs to be routed to the same port as the port through which the connection request arrived.
Expander device	OPEN_REJECT(CONNECTION RATE NOT SUPPORTED)	Requested connection rate is not supported on some physical link between the source device and destination device.
Destination device	OPEN_REJECT(PROTOCOL NOT SUPPORTED)	Destination device exists but does not support the requested initiator/target role and/or protocol.
Expander device	OPEN_REJECT(STP RESOURCES BUSY)	Destination device exists but there are too many STP initiators trying to access the SATA device.
Destination device	OPEN_REJECT(WRONG DESTINATION)	The destination SAS address does not match the end device.
	OPEN_REJECT(RESERVED ABANDON 0)	Process the same as OPEN_REJECT (WRONG DESTINATION)
	OPEN_REJECT(RESERVED ABANDON 1)	Process the same as OPEN_REJECT (WRONG DESTINATION)
	OPEN_REJECT(RESERVED ABANDON 2)	Process the same as OPEN_REJECT (WRONG DESTINATION)
	OPEN_REJECT(RESERVED ABANDON 3)	Process the same as OPEN_REJECT (WRONG DESTINATION)

Table yy — OPEN_REJECT retry primitives

Originator	Primitive	Description
Expander device	OPEN_REJECT(NO DESTINATION)[c]	No such destination device.
Expander device	OPEN_REJECT(PATHWAY BLOCKED)[b]	An expander device determined the pathway was blocked by higher priority connection requests.
Destination device	OPEN_REJECT(RETRY)[a]	Destination device exists but is not able to accept connections~~; try again~~.
	OPEN_REJECT(RESERVED INITIAIALIZE 0)[c]	Process the same as OPEN_REJECT(NO DESTINATION).
	OPEN_REJECT(RESERVED INITIAIALIZE 1)[c]	Process the same as OPEN_REJECT(NO DESTINATION).
	OPEN_REJECT(RESERVED CONTINUE 0)[b]	Process the same as OPEN_REJECT(PATHWAY BLOCKED).
	OPEN_REJECT(RESERVED CONTINUE 1)[b]	Process the same as OPEN_REJECT(PATHWAY BLOCKED).
	OPEN_REJECT(RESERVED STOP 0)[a]	Process the same as OPEN_REJECT(RETRY).
	OPEN_REJECT(RESERVED STOP 1)[a]	Process the same as OPEN_REJECT(RETRY).

[a] If the I_T nexus loss timer is already running, it is stopped

[b] If the I_T nexus loss timer is already running, it continues running. Abandon connection request rather than retry if the I_T nexus loss timer expires.

[c] If the I_T nexus loss timer is already running, it continues running; if it is not already running, it is initialized and started. Abandon connection request rather than retry if the I_T nexus loss timer expires.

When a destination device detects more than one reason to transmit an OPEN_REJECT, the device shall transmit only one OPEN_REJECT primitive and shall select that primitive using the following priority:

1) OPEN_REJECT (WRONG DESTINATION) (highest priority selection);
2) OPEN_REJECT (PROTOCOL NOT SUPPORTED); or
3) OPEN_REJECT (RETRY) (lowest priority selection).

When an expander device detects more than one reason to transmit an OPEN_REJECT, the expander shall transmit only one OPEN_REJECT primitive and shall select that primitive using the following priority:

1) OPEN_REJECT (BAD DESTINATION) (highest priority selection);
2) OPEN_REJECT (NO DESTINATION); or
2) OPEN_REJECT (CONNECTION RATE NOT SUPPORTED); or
2) OPEN_REJECT (STP RESOURCES BUSY); or
3) OPEN_REJECT (PATHWAY BLOCKED) (lowest priority selection).

See 7.12 for details on connection requests.

7.1.5.3 DONE

DONE is used to start closing an SSP connection and indicate a reason for doing so. This primitive may be originated by an SSP initiator port or an SSP target port. DONE is not used to close an SMP or STP connection.

The versions of DONE representing different reasons are defined in table 51. The SSP state machine describes when these are used (see 7.16.7).

Table 51 — DONE primitives

Primitive	Description
DONE (ACK/NAK TIMEOUT)	Timed out waiting for an ACK or NAK. The ACK/NAK count does not match the frame count. Transmitter is going to transmit BREAK in 1 ms unless DONE is received prior to that.
DONE (CLOSE CONNECTION)	Finished transmitting all frames.
DONE (CREDIT TIMEOUT)	Timed out waiting for an RRDY.
DONE (RESERVED TIMEOUT)	Processed the same as DONE (ACK/NAK TIMEOUT).
DONE (RESERVED 0)	Processed the same as DONE (CLOSE CONNECTION).
DONE (RESERVED 1)	Processed the same as DONE (CLOSE CONNECTION).
DONE (RESERVED 2)	Processed the same as DONE (CLOSE CONNECTION).

7.1.5.5 NAK (Negative acknowledgement)

NAK indicates the negative acknowledgement of an SSP frame and the reason for doing so.

The versions of NAK representing different reasons are defined in table 52.

Table 52 — NAK primitives

Primitive	Description
NAK (CRC ERROR)	The frame was ~~not~~ discarded and has a bad CRC.
NAK (RESERVED 0)	Processed the same as NAK (CRC ERROR).
NAK (RESERVED 1)	Processed the same as NAK (CRC ERROR).
NAK (RESERVED 2)	Processed the same as NAK (CRC ERROR).

See 7.16.3 for details on SSP frame transmission.

7.1.5.6 RRDY (Receiver ready)

RRDY is used to increase SSP frame credit.

The versions of RRDY representing different reasons are defined in table xx.

Table xx — RRDY primitives

Primitive	Description
RRDY	Increase frame credit by one.
RRDY (RESERVED 0)	Processed the same as RRDY.
RRDY (RESERVED 0)	Processed the same as RRDY.

See 7.16.4 for details on SSP flow control.

7.11 Domain changes

SAS initiator ports scan the domain during a discover process (see 4.6.11.5) to search for initiator devices, expander devices and target devices after power on or receiving a BROADCAST (CHANGE) primitive sequence.

~~The CHANGE primitive sequence shall only be sent outside of a connection.~~ The expander device shall transmit BROADCAST (CHANGE) from at least one phy in each expander port other than the expander port that is the cause for transmitting BROADCAST (CHANGE).

Expander devices shall transmit BROADCAST (CHANGE) for the following reasons:

a) after an expander phy has lost bit synchronization;
b) after the link reset sequence completes; and
c) after the expander device receives BROADCAST (CHANGE).

CHANGE shall only be sent outside of connections, after the identificatino sequence completes. BROADCAST (CHANGE) may be sent by initiator ports to force expander devices to exchange SAS addresses, but should not be sent by target ports.

~~An expander device is not required to queue multiple CHANGE indications for the same expander port. If a second CHANGE indication is requested before the first indication has been transmitted, the second indication may be dropped.~~

An initiator port that detects BROADCAST (CHANGE) shall follow the initiator device specific rules (see 7.8.2) to discover the topology.

A fanout expander device that detects BROADCAST (CHANGE) shall follow the fanout device specific rules (see 7.8.3) to discover the topology.

An edge expander device that detects BROADCAST (CHANGE) shall follow the edge device specific rules (see 7.8.4).

7.12.3.1.2 Arbitration status

Arbitration status shall be conveyed between expander devices and by expander devices to SAS endpoints using ~~four types of~~ different AIP primitives. This status is used to monitor the progress of connection attempts and to facilitate pathway recovery as part of deadlock avoidance.