METHODS AND APPARATUS FOR INTERCONNECTING SAS DEVICES USING EITHER ELECTRICAL OR OPTICAL TRANSCEIVERS

BACKGROUND

1. Field of the Invention

The invention relates generally to serial attached SCSI (SAS) device interconnections and more specifically relates to methods and apparatus for using either electrical or optical transceivers for such SAS device interconnections.

2. Discussion of Related Art

SAS standards include a detailed specification of the electrical interconnect utilized between two SAS devices. Electrical signaling standards are defined for a variety of transmission rates between devices including, at present, up to 6 GB per second data signaling. Further enhancements to SAS specifications envision 12 GB or higher speed in the relatively near future.

In the SAS signaling standards, out of band (OOB) signals are low-speed signal patterns that do not appear in normal data streams. OOB signals consist of a defined amount of idle time followed by a defined amount of burst time, the idle-burst pair repeated a specified number of times, and ending with a period of idle time. In accordance with the SAS (and serial advanced technology attachment-SATA) standards, in the idle period of the SAS OOB signal the electrical interconnection physical link carries a D.C. idle level—i.e., a differential 0V signal where the positive and negative differential signal paths are both driven toward ground potential. During the burst time of the SAS OOB signal the differential electrical physical link carries signal transitions represented as differential voltages driven on the positive and negative signal paths between the transceiver transmission transceiver and the receiving transceiver—thus presenting a level of energy to be received by the other side.

A variety of OOB signals are differentiated based on the duration of the idle time between the various burst times and other timing aspects of the idle and burst signaling periods. SAS and SATA specifications include a variety of such OOB signals including, for example, COMSAS, COMINIT, COMRESET, and, COMWAKE.

Despite the use of differential electrical signaling in accordance with the SAS specifications, as the transmission rates increase, cable length for the electrical signaling is limited. For example, at relatively high SAS transmission speeds electrical signaling cables may be limited to no more than a few meters of total length to avoid degradation of the signal quality.

Fiber-optic signaling capabilities are known to provide both high speed transmission and noise immunity over significant lengths of optical transmission media. However, in view of the requirements in the SAS standard for OOB signaling, it has been problematic to effectively utilize fiber-optic signaling for interconnection of SAS devices. In particular, current SFP (small form-factor pluggable) optical transceivers (including widely utilized quad small form-factor pluggable-QSFP) are incapable of utilizing present SAS standards for electrical OOB signaling. In particular, there is no optical midpoint or "D.C. idle" signal available in such SFP optical transceiver modules. In other words there is no equivalent signaling capability in SFP optical transceivers to represent an OOB idle time.

Some prior solutions have attempted to provide OOB signaling for SAS interconnect utilizing optical transceiver modules by encoding an idle time as the period of time that an optical laser is turned off (i.e., an optical laser off duration represents some analogous idle time duration in accordance with the SAS specifications). This prior technique presents other problems—the turn-on/turn-off time of high speed, low cost, SFP optical modules is several orders of magnitude slower than the timing requirements for OOB signaling in accordance with the SAS and SATA specifications. Further, problems arise in the receiving transceiver sensing loss of optical signal. The receiving transceiver sensing of a loss of optical signaling (RXloss) may impose further significant delays and distortion in the timing such that the desired OOB transmission may be corrupted.

Thus it is an ongoing challenge to provide simple, cost-effective, high-speed optical signaling between SAS/SATA devices that permit full compliance with the SAS/SATA standard including the OOB signaling capabilities.

SUMMARY

The present invention solves the above and other problems, thereby advancing the state of the useful arts, by providing methods, apparatus, and systems for utilizing digital encoding of SAS OOB signals to enable use of optical communication media for coupling SAS/SATA devices. Features and aspects hereof permit devices to optionally use either standard SAS/SATA electrical signaling over electrical communication media or digitally encoded SAS OOB signaling to permit use of either electrical or optical communication media.

Features and aspects hereof include apparatus associated with a serial attached SCSI (SAS) device for coupling with another SAS device using an optical physical communication medium or using an electrical physical communication medium. The apparatus includes PHY control circuits coupled with a physical communication interface and adapted to control data exchanges on the physical communication medium. The apparatus also includes digital out of band (OOB) decoder logic coupled with the PHY control circuits. The digital OOB decoder logic is adapted to detect receipt of a digitally encoded signal corresponding to a SAS OOB signal. The digitally encoded signal is received from said another SAS device through the PHY control logic. The apparatus also includes digital OOB encoder logic coupled with the PHY control circuits. The digital OOB encoder logic is adapted to generate a digitally encoded signal corresponding to a SAS OOB signal. The digital OOB encoder is further adapted to apply the digitally encoded signal to the PHY control circuits for transmission to the other SAS device.

Other features and aspects hereof include a method operable in a serial attached SCSI (SAS) device. The method includes receiving over a communication medium a digitally encoded signal from another SAS device and decoding the received digitally encoded signal to generate a signal representing a SAS out of band (OOB) signal. The method then processes the generated signal as though the SAS OOB signal had been received.

Still other features and aspects hereof include a method operable in a serial attached SCSI (SAS) device. The method includes generating a SAS OOB signal within the SAS device to be forwarded to another SAS device and encoding the SAS OOB signal as a digitally encoded signal. The method then transmits the digitally encoded signal over a communication medium to said another SAS device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an exemplary SAS device enhanced in accordance with features and aspects hereof to