Gigabit Serial Links
Using Fibre Channel Technology

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The FCX System

Fibre Channel Systems is launching a new product line that utilizes Fibre Channel link technology for inter-processor, processor-to-peripheral, and peripheral-to-peripheral communications. The FCX System is an inexpensive, high-performance data acquisition system specifically designed to be scalable and flexible. The FCX system is independent of processor architecture so any general purpose or DSP processor may be supported with modular I/O components and special purpose interface modules. The FCX System is ideal for real-time data acquisition, digital signal processing, image processing, and instrumentation applications.

Communication System

Fibre Channel, a scalable, high-performance interconnect standard, provides very fast transfer of large volumes of data between devices over relatively long distances. The Fibre Channel standard (ANSI X3.320-1994) addresses the need for an inexpensive, high-performance data transfer mechanism between processors and peripherals for the workstation and PC markets. The technology is supported by a growing Fibre Channel Association which includes Sun Microsystems, IBM, Hewlett-Packard, Seagate, and many others. Fibre Channel products are available today and Dataquest has projected the Fibre Channel market will exceed $1 billion by 1998, making it one of the fastest growing interconnect standards to date.

The Fibre Channel

Fibre Channel is a connection technology. A range of different topologies—point-to-point, rings, multidrop busses, and crosspoint switches—can be realized depending on the needs of a particular system. Fibre Channel makes use of unique addresses to connect devices over distances of up to 10 kilometers per link. Links are duplex—data is transported in both directions simultaneously—and they are designed to transport data at the highest possible speed with the least delay, performing simple error detection or correction in hardware.

Fiber Channel has several classes of service to support different applications and architectures. Circuit switched connections are direct point-to-point links with guaranteed bandwidth. Packet (frame) switched service supports communication without a dedicated connection that provides guaranteed delivery and receipt confirmation. Connectionless service (datagram) is a one-to-many circuit that speeds transmission time without confirmation of receipt.

A Fibre Channel switch—called a fabric—is an active, intelligent interconnection scheme used to connect devices. A fabric creates and maintains a connection of any class so all a device has to do is manage a simple point-to-point connection between itself and the fabric. The Fibre Channel arbitrated loop (FC-AL) topology offers a low cost, efficient way to connect multiple ports in a peer-to-peer loop without hubs or switches. Each device on the loop shares the link bandwidth but the port is much simpler and can be controlled by a state machine. Several companies now use this topology for data warehouse systems.

Physically, a link consists at least two devices each having at least one N_port (“node” port) connected by a pair of fibers or copper wires. N_ports may be connected to a fabric through F-ports (“fabric” ports) to form a switched network. Fibre Channel supports communication rates of 133, 266, 531, 1063 Mbits/s with data payload rates of 12.5, 25, 50, and 100 MBytes/s respectively.

Fibre Channel data is encoded and decoded using the IBM-patented 8b/10b encode/decode

method. This scheme encodes both data and clock signals onto a single pair of wires using balanced bit patters to simplify transmission. The receiver recovers the clock from the transmitted data signal. This method requires fewer wires, is more reliable, and provides greater transmission distance than data/strobe type encoding. The 8b/10b encoding also allows the use of industry standard, low cost optical gigabit link modules (GLM), copper gigabit link modules, and optical link cards (OLC). Different link modules are used depending on system requirements for transmission distance, cost, and noise immunity. Copper GLM units allow connections over shorter distances using shielded twisted pair wire or coaxial cable. Longer transmission distances and better noise immunity are achieved using low cost, short wavelength (780nm) optical GLMs. These modules are connected using 50µ or 62.5µ multi-mode optical fiber. Long wavelength GLMs are used for distances up to 10 km or more with single mode optical fiber. Connection methods can be mixed within a system or fabric.

Fibre Channel Physical and Signaling Layers

The Fibre Channel structure is defined as five functional layers called FC-0 through FC-4. The lower three layers are concerned primarily with the hardware interface while the upper two are associated with the mapping of current standards onto the Fibre Channel physical link. The three physical levels, FC-0, FC-1, and FC-2 are called collectively FC-PH and are defined as follows:

- FC-0 covers the physical characteristics of the interface and media, including cables, connectors, drivers, LEDs, lasers, transmitters, and receivers.

- FC-1 defines the 8b/10b encoding/decoding and transmission protocol used to integrate data with the clock information for serial transmission.

- FC-2 defines the rules for signaling protocol, data framing, and control and exchange sequences. This layer also includes hardware parity checking and CRC generation and checking.

The FC-3 layer defines common interface services between the lower layers and the FC-4 layer. This layer includes protocols for data striping, group signaling, multicasts, and broadcasts. The FC-4 layer also called the ULP (upper layer protocol) defines a mapping for other communication standards onto the Fibre Channel physical layers. Some of the supported network and channel protocols are:

- Small Computer System Interface (SCSI)
- Intelligent Peripheral Interface Disk/Tape (IPI)
- High Performance Parallel Interface (HIPPI)
- Internet Protocol (IP)
- ATM Adaptation Layer (AAL5)
- Link Encapsulation (FC-LE)
- Single Byte Command Code (SBCCS)
- IEEE 802.2 (Ethernet)
- Vendor or user specific protocols

FC-3 and FC-4 are optional layers and a particular vendor could encapsulate specialized protocols (Reflective Memory, SCI, PCI, VME, C40, or ADSP21060) onto FC-4 to connect to existing hardware systems.

Fibre Channel Data Transport

The FC-2 layer defines several building blocks, called ordered sets, to aid the transport of FC-4 data across the link. Ordered sets indicate the start-of-frame, end-of-frame, idle condition, reset condition, connect sequence, disconnect sequence and so on. Data is transported over Fibre Channel in packets called “frames” which are generally composed of the following segments:

- start-of-frame (SOF) ordered set (4 Bytes)
- Frame Header (24 Bytes)
- Optional Extended Header (64 Bytes)
- Data payload (up to 2112 Bytes)
- CRC (4 Bytes)
- End-of-frame (EOF) ordered set (4 Bytes)

Frame format is not rigidly defined and may be modified by vendors or users.

Communication Model

In its simplest form, data transfer between modules requires only the SOF ordered set, data payload, CRC, and EOF ordered set. The payload

may be any size provided the receiver has sufficient buffer memory (frame store) to receive the frame. All classes of communication can be supported using this light weight protocol. However, an FC-2 frame header could be added to enable more sophisticated functions such as non sequential frame delivery, virtual channels between software processes running on each N_port, or to adhere to a standard FC-4 transport layer. The data transfer rate depends on the ratio of ordered sets and header to payload and rates over 100 MBytes per second can be achieved using standard frames.

Each FCX module will have one or more bidirectional Fibre Channel links and will support all classes of communication as well as public and private arbitrated loop topologies. A programmable DMA controller handles data transfer between the Fibre Channel physical layer and frame store.

Software Routines written in C will be supplied to support generic I/O operations. These routines will allow support for Fibre Channel communication across many host processors. The low level adaptor control and sequence code will execute from ROM. All standard communication classes will be supported:

- Class 1 (circuit switched) provides point-to-point connections with guaranteed link bandwidth and message acknowledgement. This class will be supported on direct N_port-to-N_port connections and through fabrics. This class provides synchronous protocols that allow both ports to synchronize on I/O completion.

- Class 2 (frame switched) provides communication between N_ports that do not have a dedicated connection. This mechanism increase flexibility at a reduced bandwidth. This class supports synchronous protocols as messages are acknowledged.

- Class 3 (connectionless) communication which allows the posting of datagrams to one or many ports. This mechanism provides non-blocking asynchronous communications with no message acknowledgment. Class 3 is especially useful for video, news, and multimedia servers.

- Class 4 (guaranteed fractional bandwidth) divides a connections into 256 subgroups which can be allocated to different clients. This class provides non-blocking continuous service and is ideal for most video applications.

- Class 5 (Isochronous) provides frame delivery based on a fixed time base. This service can be used to reconstruct time synchronized data or events.

Specialized variants of these services can be developed quickly and easily to support specific applications.

FCX System Fibre Channel Interface

FCX System components will provide FC-0, FC-1, and partial FC-2 support in hardware. The remaining functional layers will be implemented in software as needed to support user applications. This guarantees optimum performance for data acquisition and DSP applications while maintaining link interoperability insuring compatibility with other Fibre Channel vendors, switch fabrics, and commercially available peripherals.

System Compatibility

Interface modules are available to connect DSP Systems C40 products to the new FCX Fibre Channel system. More information about Fibre Channel technology is available from Fibre Channel Systems or the Fibre Channel Association. Please contact Fibre Channel Systems for details.

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