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FERMILAB-Conf-95/110

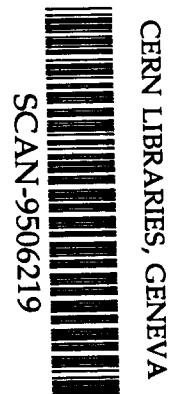
**FOCEX—A Fiber-Optic Cable EXtender for a
High Speed Parallel RS485 Data Cable**

J.T. Meadows, J.T. Anderson, P.S. Cooper, J. Engelfried, J.W. Franzen and B.G. Forster

*Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510*

F. Levinson, J. Rawls and S. Haber

*Finisar Corporation
Menlo Park, California 94025*



SW 9587

May 1995

Presented at the *Real Time 95 Conference*, East Lansing, Michigan, May 22-26, 1995

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FOCEX - a Fiber-Optic Extender for a High Speed Parallel RS485 Data Cable

J.T. Meadows, J.T. Anderson, J.W. Franzen, B.G. Forster
 Fermilab Computing Division, On-Line Systems Dept., Data Acquisition Hardware Group
 P. S. Cooper, J. Engelfried
 Fermilab Physics Section
 PO Box 500, Batavia, Illinois 60510

F. Levinson, J. Rawls, S. Haber
 Finisar Corporation, 3515 Edison Way, Menlo Park, California 94025

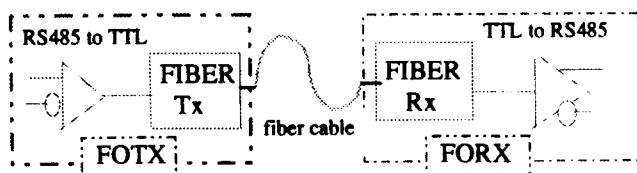
Abstract

There seems to be an echo in the Data Movers Community.

"For longer-distant, high speed data links, optical fibre becomes more cost-effective than copper or other hard wire cable systems." The previous statement is quotable from many oral and written sources.

Fermilab¹ supplied to Finisar Corp. of Menlo Park, CA., a set of specifications for card functions, sizes and interconnector pin assignments. Finisar designed and assembled a set of fiber optical P.C. cards using 100 megabyte/sec commercial optoelectronics and a serialization and deserialization HOT-ROD chipset designed by GAZELLE Microcircuits, Inc. (A Tri-Quint Semiconductors company).

The cooperative effort between Fermilab and Finisar has allowed Fermilab to create a reliable 50 Megabytes/sec (40 bit parallel RS485 DART² data bus) cable to cable extender using a virtually invisible Fiber Channel point-to-point(FC-0) fiber optical single-simplex system. The system is easily capable of sustaining a 50 megabytes/sec of data, control and status line throughput at distances of 1625 feet (500 meters) using standard multi-mode fiber.



¹ Fermilab is operated by Universities Research Association Inc. under Contract No. DE-AC02-76CHO3000 with the United States Department of Energy.

² DART - Fermilab Data Acquisition Real Time. Is a Computer Division high speed transport bus using a 40 bit parallel IEEE EIA-RS485 Differential TTL cable clocked at 10MHZ (max speed of RS485@approx. 25 meters) =50 megabytes per second(32 data bits and 8 control and/or status bits.)

I. INTRODUCTION

High energy physics detectors now produce more unweighted data, at faster rates than ever before. The time has come when the front end circuits that produce the data can no longer discriminate what is good and what is important. The assembly of raw data events is being done in local smart crates using the power of the local or on-board computer only to gather and send the data out of the detection areas by high speed data moving interfaces. The farther distances and the required higher speeds now demand that more reliable data link drivers be built to transport the data out to distribution or mass storage systems for later analysis.

The construction, assembly and installation of 11 complete Fiber Cable Extender sets(FOCEXs), which included 1-one return status set, was requested by Fermilab experiment E781 (SELEX: Segmented Large-x Baryon Spectrometer Experiment). The eleventh FOCEX set is being used to return status's and/or flow control bits to the originating sources from the multiple remote receiving destinations.

The links are designed to handle the rather isolated and long distant problems existing between the output data cable buses of the event building front end data acquisition hardware and the data stream destinations(a set of PORTAKAMPS located approximately 110 meters(425 feet) away. The cable data source acquisition hardware is located in a below ground pit area very near where high levels of electromagnet, magnetic, RF and capacitive signal noise effects can be introduced to the data bus equipment and cables.

The FOCEX module sets allow the experiment's needed RS485 data cabling lengths/per stream to be no greater than 20-25 feet. The shortness of the cable and the use of the NIM crates and the NIM FARADAY shielded design form factor for shielding and powering the fiber extender units lowers the susceptibility to stray induced noises.

The General DART Hardware System INCLUDING THE FOCEX SYSTEM

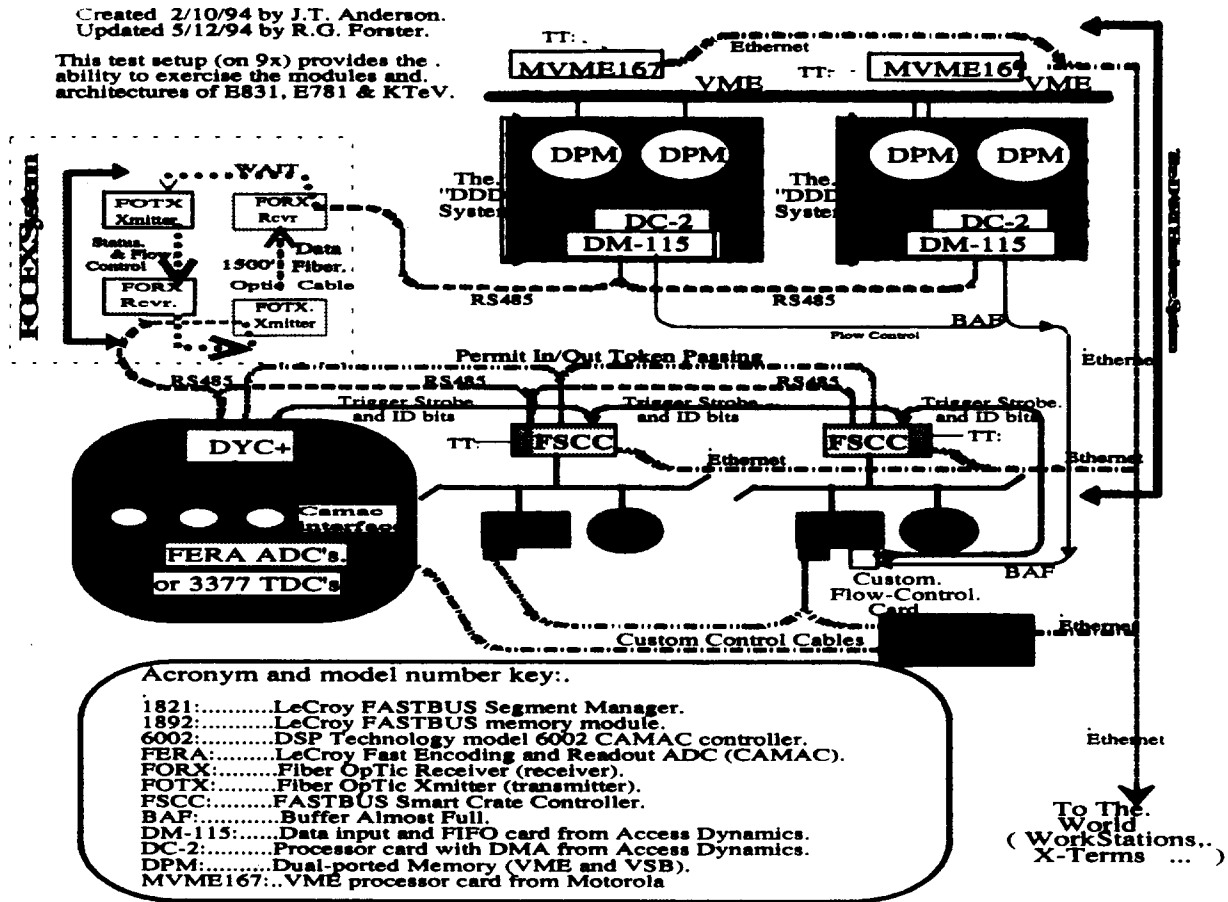


Figure 1: Fibre Optic Cable EXtender in the data stream flow

II. SYSTEM COMPONENTS

There are 8 subsystems contained in the FOCEX system.

- The RS485 DART² DATA (parallel to TTL) converter and fiber transmitter control card DAH009. Called the FOTX motherboard.
- The fiber receiver (TTL to RS485) DART² DATA bus driver control card DAH010. Called the FORX motherboard.
- The FTC-1000 and FRC-1000 Finisar fiber link transmitter and receiver daughter cards which are mounted on their respective motherboards. The rear DIN connectors pin outs are VME standards J2/P2 compatible and can be aligned to plug into the VME J2/P2 connectors of a U6 or U9 VME crate.

- A 40 bit parallel, 100 megabit/sec to 1 Gbit/sec. TTL compatible input/output, point to point data communication chipset.
HOTROD Tx(GA9011-8x encoder/ serializer)
HOTROD Rx(GA9012-8x deserializer/ decoder)

• A single set of FOTX and FORX modules configured to return selected control and/or flow control signals from several of the downstream destination devices to their respective upstream sources.

The FOTX transmit module consist of a Finisar FTC-1000 card and a FERMILAB RS485 to TTL fiber transmitter interface control card(DAH009).

The FORX receiver module consist of a Finisar FRC-1000 card and a FERMILAB fiber receiver TTL to RS485 interface control card(DAH010).

² DART - See footnote #2

III. SERIALIZATION

The FOTX asynchronously receives 40 bits of parallel RS485 input cable data and control signals at up to a 10MHZ(50mbytes/sec) rate, included in the 40 bits is an appropriate data strobe level. The latched data and control lines are encrypted (FDDI 4bit/5bit encryption formula) and serially sent over the fiber cable to the remotely located FORX receiver unit.

The FORX deserializes the encrypted 50bit word packet and latches the decoded(FDDI 5b/4b) word into a 41 bit 4kword deep storage FIFO(one bit/wd is a parity/error flag bit.). The data is flushed out of the receiver's FIFO buffer into the interface control card's output driver latches where a detected and appropriately timed data strobe pulse is regenerated. Due to design, the FORX module is limited to a sustained 52.50 megabytes flush rate. The slightly faster FORX clock rate assures that the Tx and Rx controllers will not over or underrun each other.

IV. CONTROL LINES

Control line 'transitional changes of state' recognition are designed into the FORX and FOTX PAL programs. A fiber word is transmitted for each control line transitional change of state detected. The DART RS485 Control lines can change states but must do so at an appropriate time outside of the data window time period. There are NO accompanying FORX 'DART data cable strobes' generated for any received 'change of state' of any control line. Reactions to the control line state changes are left up to the destination devices.

V. SYSTEM RELIABILITY

The GAZELLE HOT ROD chipsets used on the FTC-1000 and the FRC-1000 modules have been tested for long term stability by Finisar Corp.. The fiber link and control circuits were designed around the ASYNCHRONOUS capability

feature of the HOT ROD chipset design. The use of the ASYNCHRONOUS data transfer mode eliminates the need for any synchronous controls signals and allows the input strobe rate to be run at any rate slower than 90 Megabytes/second(17-18MHZ).

The SYNCHRONOUS hand shaking feature would have been a hard feature to control and would have required some retrofitting to the various asynchronous DART data input sources.

Since the experiment's RS485 input rate is asynchronously applied at 10 MHZ the auto-insertion of fiber sychronization frames between data words frames is a constant stability feature and not a problem.

The separate FOTX and FORX interface modules removes the redundancy and under utilization of the returning fiber status circuits required for full twin-simplex configurations, saves money, reduces the need for extra and costly return fibers and components.

FLOW CONTROL RETURN CIRCUIT(WAIT,ETC.) utilizes the RAW MODE feature of the FOCEX modules(see section VII: A Second MODE).

By selecting a NIM module form factor for the interface chassis and the low current drain of the driver and receiver chips, a relatively cheap and readily available power source and crate system can be used. For heavily loaded NIM crates an ANCILLARY MOLEX power connector is located on the rear of the module. Both rear panel power connectors are fused and diode protected.

VI. THE SYSTEM IS RUNNING

As of this date the FOCEX system is running at E781 with 6 of the expected 10 streams having been tested at an average 20-30 megabytes/sec throughput with the data cable block burst speed of 50 megabytes/sec.

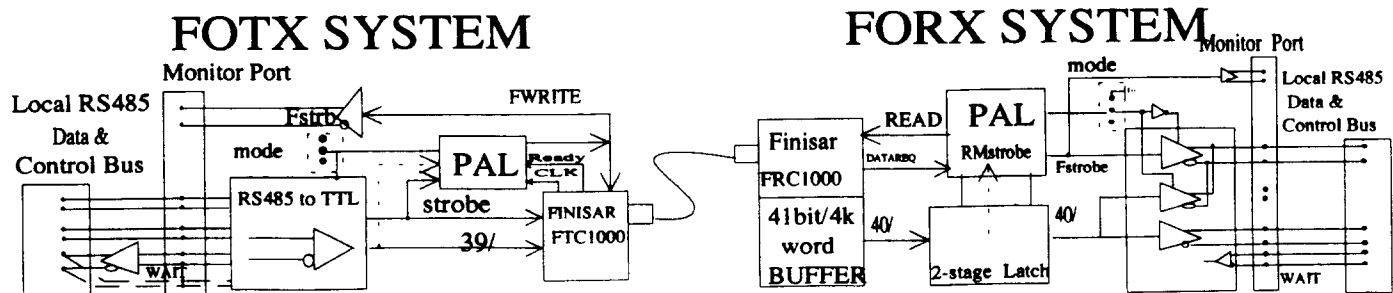


Figure #2: Block functional diagram of FOTX and FORX including Finisar FTC-1000 and FRC-1000.

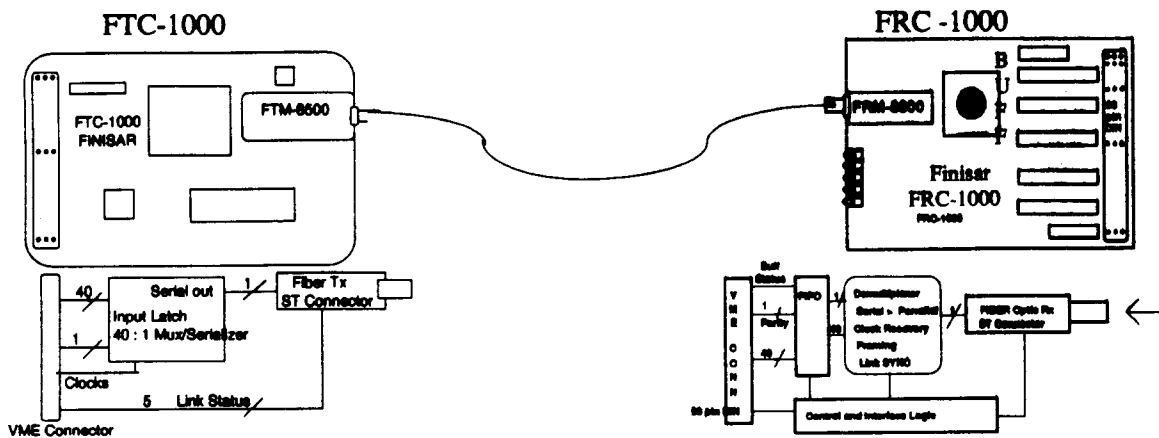


FIGURE #3: Block diagram of the FTC-1000 and the FRC-1000 daughter cards.

VII. EXTENDED SPECIFICATIONS OF THE INDIVIDUAL PARTS

FOTX(with Finisar card)

INPUT rate can be 90 Megabytes/sec of RS485 data Asynchronously applied and 100 Megabytes/sec of RS485 Synchronously applied.(40 bits of parallel RS485 lines)
 Single NIM module design form factor.
 Power + 6 Volts from a rear NIM connector or from a rear panel ancillary Molex connector.

A Second MODE

RAW MODE : Runs in a 40 bit Sample mode at a preprogrammed select rates.

FTC-1000/FTM-8500-8510 Fiber optic data link driver

40 bits TTL - 90 Megabytes Asynchronously
 100 Megabytes/sec Synchronously
 Can drive at a wavelength of 850 nanometers on 500 Meters of fiber wire using 62.5/125 or 50/125 multi-mode fiber with ST style connector.
 Power +5 Volts from 96 Pin DIN connector ROWb.

FORX(with Finisar RX card)

OUTPUT data rates is a 40 bit RS485, 50-52.5 Megabytes/sec flush rate as controlled by the FORX crystal and PAL selected.
 Single NIM module design form factor.
 Power +6 Volts from rear NIM connector or from a rear panel ancillary Molex connector.

A Second MODE

RAW MODE asserts a received 40 bit word onto RS485 data lines but does not assert a strobe pulse.
 A form of a strobe can be obtained from a set of the Port Monitor pins.

FRC-1000/FRM-8500-8510 Fiber optic data line receiver

40 bit TTL - 90 Megabytes Asynchronously and
 100 Megabytes/sec Synchronously.
 Can receive at a wavelength of 850 nanometers of fiber wire using 62.5/125 or 50/125 multi-mode fiber with ST style connector.
 Power +5 Volts from 96 Pin DIN connector ROWb.

ACKNOWLEDGMENT

We wish to thank Fermilab E781 (SELEX) both for demonstrating their confidence in us by posing their problem to us, and for accepting our solution.

REFERENCES

- [1] Fibre Channel, Physical and Signaling, Interface (FC-PH), Draft 4 May 1991
- [2] Finisar Users Manual for FTC-1000, FRC-1000 and FRM/FTM-8510 Specification Sheets.
- [3] Fiber Optics Handbook, Hewlett Packard, An introduction and reference guide to fiber optic technology and measurement techniques, October 1983
- [4] RT93 Conference Short Course, Datalinks of the future HIPPI, Fibre Channel, Sonet, ATM, etc., Don Tolmie, Los Alamos National Laboratory
- [5] EDN's Designers Guide to Electromagnetic Compatibility January 20, 1991
- [6] High-performance Parallel Interface: Mechanical, Electrical and Signaling Protocol Specification, (HIPPI-PH) X3T9. 3/88-023, Rev 8.1, 23 June 1991
- [7] Texas Instruments DATA BOOK, Transmission Circuits, Line Drivers, Receivers, Transceivers, Uarts sections: 2-9, 1993 issue.
- [8] Gazelle HOT ROD High-Speed Serial Link Guide and Specification Sheet, Microcircuits, Inc., a Tri-Quint Corporation company.
- [9] DART-Data acquisition for the next Generation Fermilab Fixed Target Experiments, G. Oleynik, et al, IEEE Transactions on Nuclear Science, Vol 41, No. 1

