STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
TRENTON, NEW JERSEY 08625

METRIC SPECIFICATIONS FOR SINGLE MODE FIBER OPTIC MULTIPLEXER

N.J. Specification No. EBM-SMF-MUX Effective Date: July 1, 2001

New Jersey Department of Transportation Specifications for a medium range communication system designed to operate on single mode fiber optic cable.

The purpose of these specifications is to describe minimum acceptable design and operating requirements for this equipment.

GENERAL - I

1-1 General Requirements

The data transmission system shall be designed for medium speed communication over single mode fiber-optic cable via a nodal network. The distribution multiplexer shall be designed to support low speed communication needs such as RS232 data ports, PBX style voice communications, 3002/DS-0 audio circuits, T1/DS-1, discrete Digital I/O, etc. In addition, the equipment shall be capable of passing its total capacity to a higher level fiber optic multiplexer over a high speed interface.

1-2 Single Mode Fiber and Optical Budgets

The Distribution multiplexer system shall operate with complete self-healing capability with no more than four single mode fibers on any link. The equipment shall be capable of operating at 1 310 and/or 1 550 nanometer wavelength(s) and shall be configured to operate at 1 310 nanometers. The transmission equipment shall have an optical budget of at least 26 decibels between nodes.

1-3 Environment

All transmission equipment shall operate in the temperature range of -20 °C to +60 °C and a relative humidity of 5 to 95 percent non-condensing. The equipment must be designed to operate inside a NEMA 3R outdoor enclosure. The manufacturer must supply certification by an independent technical laboratory confirming that the equipment complies with these environmental specifications.

1-4 Testing

The equipment is subject to testing as described in Section IV of this specification.

1-5 Electrical Power

All equipment defined in this specification shall operate on standard 120 volts AC electrical service. The equipment shall operate over a voltage range of 105 to 125 volts AC at 60 hertz. An external power supply, suitable for mounting in a 483 millimeter rack, can be utilized to convert from AC line voltage to the voltage levels required by each component. The power supply system shall contain a premium surge suppression system which shall protect the equipment from all reasonable variances. Minimum specifications for surge suppression are:

A.	UL 1449 Suppression Voltage:	600 volts
B.	Maximum Single Surge Current:	16 kiloamps Withstand
C.	Surge Energy Capability:	500 joules
D.	Surge Life Cycles	
	3 kiloamps, 8/20 microseconds:	>1500 Operations
	10 kiloamps, 8/20 microseconds:	>200 Operations
E.	Response Time:	Instantaneous, Continuously Conducting

However, superior surge suppression capability shall be supplied, if the manufacturer's standard literature requires it.

1-6 Components

The following components are included in this specification:

A. Distribution Multiplexer

B. Central Channel Bank

The special provisions and/or contract drawings shall specify the exact quantities of additional interface cards, over the minimum specified in this document. Each distribution multiplexer shall be supplied with at least twenty-five percent additional data ports over those specifically identified in the contract documents.

All necessary interconnection cables and other components necessary to provide a fully operational system shall be provided incidentally with the associated component.

DISTRIBUTION MULTIPLEXER - II

2-1 Multiplexer Speed

The distribution multiplexer shall operate at a minimum speed of 20 megabits per second.

2-2 Bit Error Rate

The BER of the distribution multiplexer shall not exceed 10 to the -8 between any two nodes of the system.

2-3 483 millimeter Rack Mountable

Each Distribution Multiplexer assembly component shall be configured for mounting in a standard 483 millimeter electronics rack. All necessary mounting hardware shall be supplied for each component. The complete distribution assembly shall not require more than 914 millimeters of rack space.

2-4 Battery Backup

Sufficient rechargeable battery backup shall be supplied to power the multiplexer equipment for at least two hours, in the absence of line voltage. The battery backup system shall fully recharge within twelve hours.

2-5 Redundant Fiber/Self-Healing Ring

The Distribution multiplexer system shall be capable of operating in a Self-Healing architecture. Redundant fiber loops shall be accomplished via "collapsed ring" or true alternate routed fiber-optic paths. Self-healing refers to the ability of the multiplexer network to maintain operation upon loss of a single fiber automatically. In addition, the malfunction or power failure of a single node (except the master node), shall not bring down any of the other nodes of the network.

2-6 Mechanical Dimension and Weight

The complete distribution multiplexer and support equipment shall not require more than 914 millimeters of 483 millimeter rack space. The total weight of the assembly shall not exceed 34 kilograms.

2-7 Fiber Optic Connectors

The distribution multiplexer shall utilize FC/PC or ST single mode fiber connectors. Two transmit and two receiver connectors shall be mounted on the main shelf's face plate. Indicator alarms shall be present to indicate the loss of either data ring.

2-8 High Speed Interface

The distribution multiplexer shall optionally include a high speed interface system which shall operate at a minimum speed of DS-1 and exhibit the following characteristics:

A. Line Code = B3ZS

B. Connector = BNC
C. Distance from Source = 135 meters maximum

D. Impedance = 75 ohms ± 5%

Via this interface, a distribution multiplexer shall be able to pass the entire data stream for the whole network. The capacity must be at least double that required for the

configuration defined in the contract documents. If necessary, this capacity can be satisfied with more than one interface, provided that all incidental components are supplied to accomplish this. The intent is to be able to pass the information from one distribution network over a SONET multiplexer system for distribution at a central channel bank, as described in Section III.

The special provisions or contract documents shall specify which distribution nodes will require this interface.

2-9 Required Interface Cards

A. RS232/RS422 Ports

Each distribution node shall be able to support at least thirty (30) individual RS232 ports. These ports shall be configurable for 1 200, 2 400, 4 800, 9 600, and 19 200 baud rates. The multiplexer system shall fully support Carrier Detect, DTR, DSR, RTS, and CTS signaling in that the system will be utilized to drive 202 and Hayes Compatible modems which require these control signals. As a minimum, each distribution multiplexer shall be equipped with at least five (5) RS232 ports. These ports shall be user configurable for RS422 service.

Each RS232 port shall be configurable for point to point or multi-drop operation. Multi-drop operation allows one central port to communicate with one or more slave ports on the loop. The master port may be located on the Channel Bank system.

The RS232 ports shall be terminated on DB-9 terminals configured for DTE operation. This termination may be via a secondary panel with internal cabling leading to the multiplexer cards. An adapter with free hanging connectors is not acceptable. If an external panel is utilized, each port and internal cable shall be clearly labeled. All electrical connections on the external rack must be insulated and covered to prevent accidental contact with any other component.

B. Field Telephone Circuit

Each distribution multiplexer shall be supplied with at least one telephone interface. Via this interface, a user shall be able to plug in a standard telephone terminated with a modular jack. Via PBX circuitry, the user shall be able to call any other port on the distribution loop or at the Central Channel Bank. If a central channel bank interface is required, the user shall be able to transfer out to an outside line terminated at the Central Channel Bank.

C. DS-0 Audio Circuitry

Each distribution multiplexer shall have the option of being equipped with a 2-wire or 4-wire audio circuit. Frequency response of this circuit shall be 200 to 3 400 hertz or greater. This circuit shall meet or exceed 3002 standards.

D. DS-1/T-1 Circuitry

Each distribution multiplexer shall have the ability to support one T-1 or equivalent circuit. This card shall be supplied as required by the contract documents.

E. Ethernet Interface Bridge

Each distribution multiplexer shall have the ability to support one ethernet interface card. This card would allow a PC at the distribution node to be connected to an ethernet network at the central channel bank. The card shall be supplied as required by the contract documents.

F. Contract Closures/Monitors

Each distribution multiplexer shall be equipped with the ability to drive eight external relays and to read eight external ground true inputs.

2-10 Diagnostic Cards

Each distribution multiplexer shall be equipped with a diagnostic card which shall indicate the operating status of the node on the network. The function of this card may be included on another component in the multiplexer chassis.

2-11 Configuration and Diagnostic Software

The configuration of the distribution node shall be maintained in non-volatile memory or dip switches and shall be secure for power failures exceeding one month in duration. In addition, a software program, executable from a PC, shall be provided to graphically illustrate and upload the network configuration. Via an RS232 connection to the master node, a PC software program shall be provided which can be utilized to monitor the entire network. Via this program, the operator shall be able to identify any faults which are displayed or are obtainable from the diagnostic card of any distribution multiplexer.

2-12 Synchronization

The distribution multiplexer shall be able to synchronize to any of the following sources via user configuration at any node:

A. External DS1

B. Free-running (Internal Clock)

C. Loop Derived from Incoming Signal from another Distribution Multiplexer.

2-13 Size of Distribution Loop

Each distribution node loop shall be able to support at least fifty distribution nodes in a single loop.

CENTRAL CHANNEL BANK - III

The central channel bank shall be designed to operate at a central site. Via the high speed interface described in Subsection 2-8, any circuit on the central channel bank shall be configurable to connect to any of the distribution nodes of the slave networks. The channel bank shall support all of the interfaces listed in Subsection 2-9.

3-1 Compatibility of Low Speed Data Modules

The central channel bank shall utilize the same plug-in low speed data modules as those utilized in the distribution multiplexer.

3-2 Central Channel Bank Interface

Via a DS-1 or higher speed interface, the central channel bank shall be equipped with interface cards and connectors to allow it to connect to up to twenty (20) distribution node loops via a SONET multiplexer. If necessary, more than one discrete channel bank frame can be provided for this purpose. The exact number of ports and distribution node interfaces required for this order are included in the special provisions and contract plans. The interface shall have sufficient capacity to handle at least double the capacity required by the actual port assignments designated in the contract documents.

3-3 Diagnostics

The central channel bank shall meet the diagnostic capabilities described in Subsections 2-10 and 2-11.

3-4 483 millimeter Rack Mount Chassis

The central channel bank assembly shall be supplied completely installed in a standard seven foot 483 millimeter electronics rack. At least 20% of the rack space shall be left vacant. The rack shall be supplied complete with all necessary ventilation fans, power supplies, circuit breakers, fiber optic patch panels, and all incidental components recommended by the manufacturer's standard literature. Redundant power supplies shall be included in the rack to insure maximum equipment availability. Upon the loss of one supply, all the active components shall automatically switch to the second without any interruption in service. The rack shall be supplied with all door assemblies and/or blank panels, as required by the equipment configuration. At least three standard AC outlets, in addition to those required by the channel bank equipment, shall be included in the chassis. A complete shop drawing of the cabinet layout shall be provided for the approval of the Engineer prior to delivery of the equipment.

3-5 Battery Backup

Sufficient rechargeable battery backup shall be supplied in the rack, or internal to the equipment, to keep the communication equipment operational for a power failure of at least fifteen minutes in duration.

TESTING - IV

All equipment defined in this specification shall be subject to factory testing as subsequently described. The factory test shall demonstrate or provide confirmation that all of the equipment operates over the specified environmental range for each component. In addition, the operation of all mandatory and optional equipment, such as the RS232 Ports, DS-0, Field Telephone, Ethernet Interface, audio, etc., shall be demonstrated. A PC system shall be configured and utilized to run the diagnostic and configuration software. For each interface, the factory test procedure shall demonstrate that data can be transferred between two or more distribution nodes over the optical budget required in the specifications. In addition, the test shall demonstrate that the specified BER (Bit Error Rate) is obtainable.

The Supplier shall be responsible for submitting a test plan which has been designed to exercise and monitor the equipment for the purpose of determining compliance with the specifications.

TRAINING - V

Prior to the acceptance of the first unit of each type, training shall be provided for the Department's engineering, maintenance and operations staff, at a facility provided by the Department. The training shall include all material and manuals required for each participant. The training shall be as follows:

5-1 Maintenance Training

The training shall be provided for a minimum of 80 hours for at least five (5) personnel with an electronics background. The training shall include operation instructions, theory of operation, circuit description, field adjustments, preventive maintenance procedures, troubleshooting and repair of all components.

5-2 Engineering Training

The training shall be provided for a minimum of 40 hours for at least twenty (20) engineering and operations personnel. The training shall include a complete demonstration of the operation and capabilities of the equipment. This session should include a complete review of any field adjustments or calibration of the transmission equipment which may be necessary for optimum performance and should stress day-to-day operation and isolation of problems down to the unit level. For example, procedures should be discussed for identifying a faulty module in the field, as opposed to board level repairs covered in Section V-1. Particular attention shall be given to the operation of the diagnostic software packages to be provided including procedures for configuring the network and diagnosing faults.

INSTRUCTIONS AND GUARANTEES - VI

6-1 One set of complete schematics and operations/maintenance manuals of each component shall be supplied with each five assemblies furnished. Maintenance manuals shall include complete sub-component parts listing.

6-2 No changes or substitutions in these requirements will be acceptable unless authorized in writing. Inquiries regarding this specification shall be addressed to the Manager, Office of ITS Engineering, New Jersey Department of Transportation, P.O. Box 613, 1035 Parkway Avenue, Trenton, New Jersey 08625.

6-3 All components shall carry a two-year guarantee from the date of acceptance against any imperfections in workmanship or materials.

6-4 The manufacturer agrees to, upon the request of the Manager, Office of ITS Engineering to deliver to the Office, a sample of each assembly to be supplied in compliance with these specifications for inspection and test before acceptance. After completion of the test, the sample shall be returned.

6-5 The supplier shall furnish any and all equipment which they deem necessary for safe and reliable field and central operation of the communication equipment as part of the quoted price for the specified equipment.

6-6 All components furnished under this specification shall be current production equipment and of recent manufacture, identical models of which are in field operation in not less than five sites. Untried or prototype units shall not be considered for acceptance.

6-7 All major components shall be identified with a metal plate containing the serial number with a bar code identification.

6-8 Any repairs made by a manufacturer or representative shall be documented and returned with units when warranty repaired. This documentation shall include an explanation of the exact repairs made and identification of parts replaced by part number and circuit number. All warranty repairs shall be completed within thirty days of delivery of the equipment to the designated repair depot.