

TECHNICAL DESCRIPTION

OF

10G WDM

SUBMARINE LINE TERMINAL EQUIPMENT

FOR UNREPEATERED SYSTEM

(FLASHWAVE S850)

FUJITSU LIMITED

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1. General

This document describes about the functionality and performance information of the Fujitsu's FLASHWAVE S850, Submarine Line Terminal Equipment for 10Gb/s unrepeated WDM system (10G WDM-SLTE).

The world of telecommunications is rapidly evolving in response to customer demands for increased bandwidth, flexible service provision and guaranteed network performance, therefore, Fujitsu continually leads the way in the development and evolution of advanced optical solutions. Fujitsu's comprehensive portfolio of 10G WDM-SLTE and submersible cable provides solutions for today's and future's undersea networks.

Fujitsu's 10G WDM-SLTE, FLASHWAVE S850, has been designed with outstanding technology and meets ITU-T and ETSI recommendations. The FLASHWAVE S850 includes dispersion compensation technology, multiplexers, demultiplexers, and integrated optical post-and pre-amplifiers which are based on Erbium-doped fiber amplifiers (EDFAs) technology. In addition, it also offers better optical transmission performance with Forward Error Correction (FEC) coding features.

In order to meet customer demand on increasing bandwidth, the FLASHWAVE S850 allows seamless in-service upgrading capability. Three (3) types of the FLASHWAVE S850 are listed in the following table. It provides a wide range of traffic capacities up to 32λ per fiber pair with 10Gb/s system. Figure 1 shows the overview of FLASHWAVE S850 within a terminal station.

Table 1 FLASHWAVE S850 Line-up

Type	Number of WDM	FEC Type	Typical Rack Layout
FLASHWAVE S850-8UR	8	3rd-Generation Ultra-FEC (Iterated BCH coding)	Figure 5
FLASHWAVE S850-16UR	16		
FLASHWAVE S850-32UR	32		

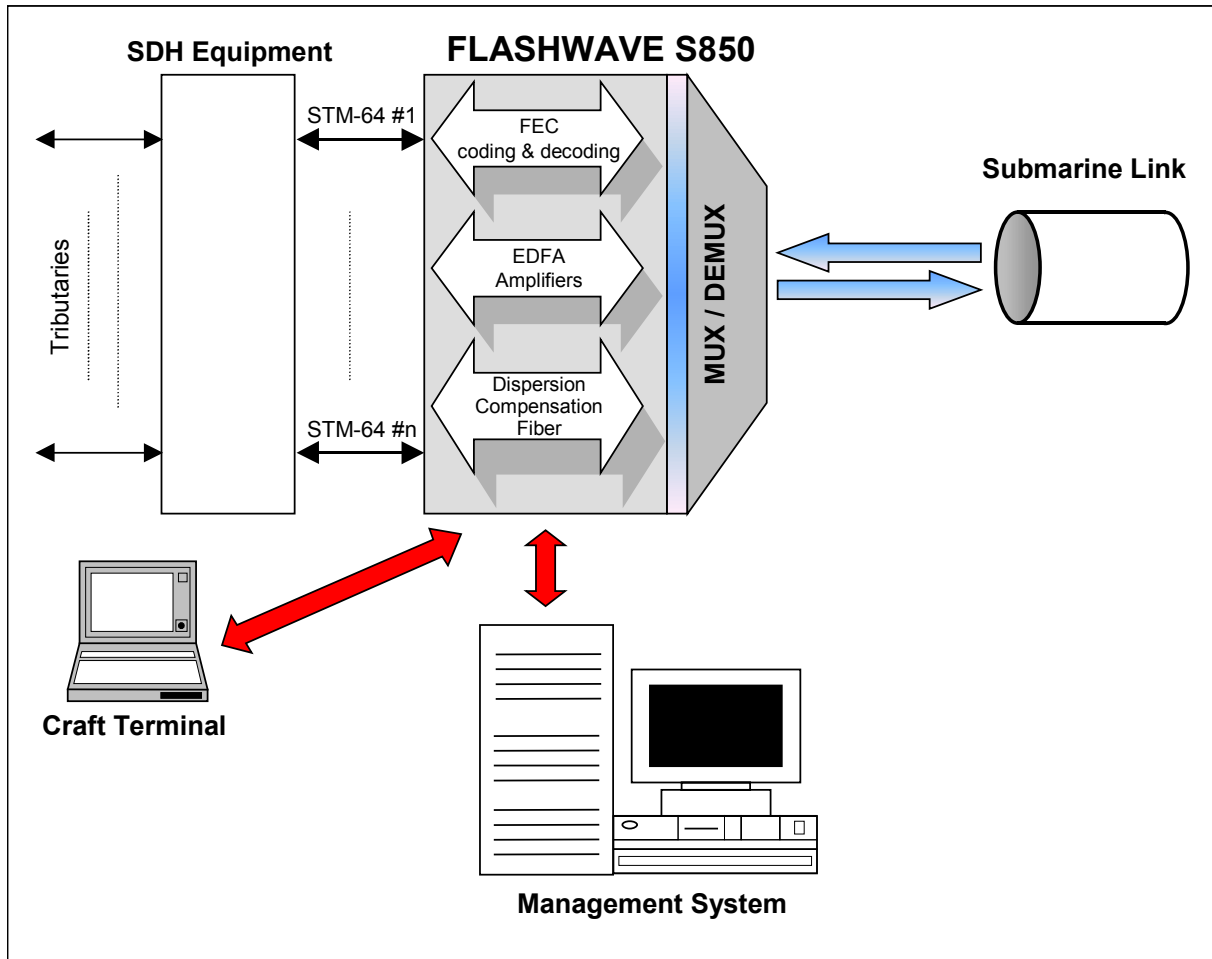


Figure 1 FLASHWAVE S850 Overview at Terminal Station

2. Functional Description

In general, FLASHWAVE S850 provides the following principal functions:

- It provides STM-64 optical interfaces, namely S-64.2a, S64.2b, L64.2c and I64.1, which are compliant to ITU-T Recommendation G.691 for tributary interface between submarine link and terrestrial network.
- It also provides the flexible tributary interface, as an option. STM-16 tributary interface is available instead of STM-64 tributary interface using 4 x STM-16 Muxponder.
- It performs WDM multiplex and demultiplex functions. The incoming STM-64 signals will be multiplex into WDM optical line signal at transmitting side. At receiving side, incoming aggregate line signal will be demultiplex into STM-64 signals.
- It offers flexible and upgradable WDM bandwidth capacities based on operator's demand with in-service upgrading facilities.
- It offers a better error performance than ITU-T G.826 and additional benefit of virtually eliminating the error floor phenomenon with Forward Error Correction (FEC) feature.
- It is equipped with pre-amplifier and post-amplifier, which are based on the Erbium-doped fiber amplifier (EDFA) technology realizing long distance unrepeated transmission.
- It provides a better optical transmission performance by compensating for positive or negative chromatic dispersion with Dispersion Compensation Fiber.
- It provides auxiliary communication channels accesses, such as engineering order wire and data communication channel for operation & maintenance purposes.
- It provides audible & visible alarm indication for any malfunctions or abnormal conditions on the equipment. Furthermore, it also provides all maintenance information, such as alarms, status changes and performance data, to Management System.
- It confirms to the operational safety with EN 60825 and IEC 825 (class 1, 2, 3A or 3B).

2.1 Transmission Function

FLASHWAVE S850 provides bi-directional interface between terrestrial and submarine networks. It multiplexes the incoming STM-64 signals to optical WDM line signal for submarine transmission network. At receive end, it de-multiplexes the received optical WDM line signal to individual STM-64 signals for terrestrial network. Figures 2 and 3 show the functionality block diagram of FLASHWAVE S850.

2.1.1 Transmitting

In transmit side, each transmit tributary (TRIB) receives individual incoming STM-64 signal from terrestrial network. The incoming STM-64 signals are converted from optical to electrical signal, and the electrical signals proceed to FEC encoding process. With overhead information added in the FEC process, the signal bit rate is increased by 7% and becomes 10.7 Gb/s. The electrical signals are converted back to optical signals of which wavelength are compliant with WDM wavelength (ITU-T G.692). Then, the signals are amplified by EDFA to appropriate level before pass to WDM section (MUX).

The WDM section multiplexes up to 32 wavelength signals into WDM aggregate line signal. The dispersion compensation fiber is provided to compensate for the chromatic dispersion accumulated along the transmission line. The optical post-amplifier (EDFA) provides adequate output power for long distance unrepeatereed transmission.

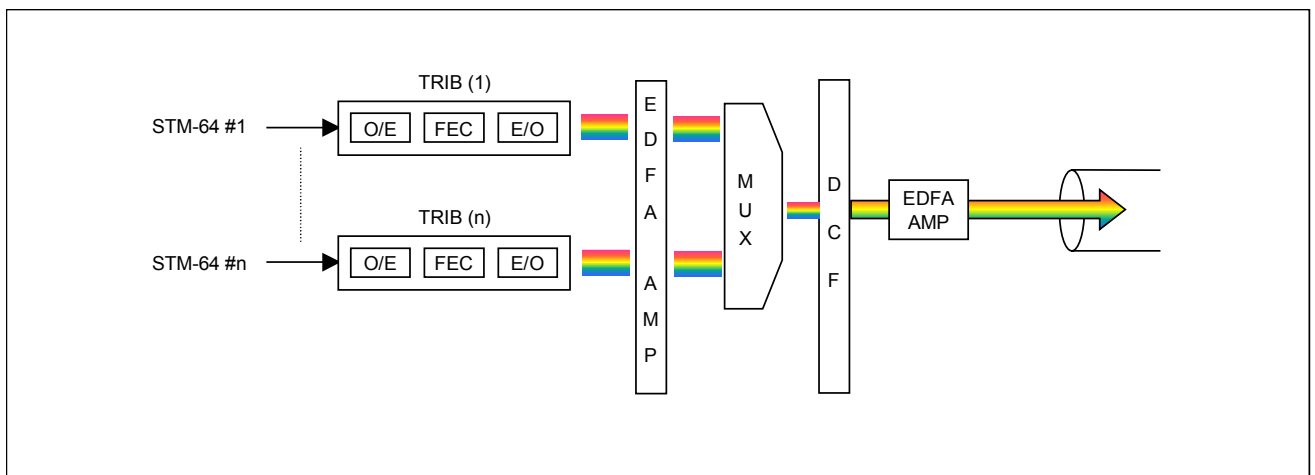


Figure 2 SLTE Functional Block Diagram (Transmit)

2.1.2 Receiving

In receive side, the WDM line signal is dispersion-compensated (DCF) and then demultiplexed to individual 10 Gb/s signals (DMUX). Optical power of each signal is amplified to appropriate level before proceed to tributary section (TRIB) where FEC decoding and signal conversion to STM-64 are made.

In order to achieve specific span length, the SLTE may employ Distributed Raman Amplification and/or In-line Remote Amplification technique. For that purposes, a powerful pump source is deployed at the receive side and large optical power is sent into the line fiber.

Distributed Raman Amplification

The pump power sent from the SLTE creates a broad distributed Raman gain along the line fiber. This amplification can increase the achievable span length.

Remote Optical Pumped Amplifier (ROPA)

An EDFA needs to be put in at a remote location in the line fiber for the In-line remote amplification technique. Then, the optical pump power sent from the SLTE energizes the remote EDFA and can increase the achievable span length.

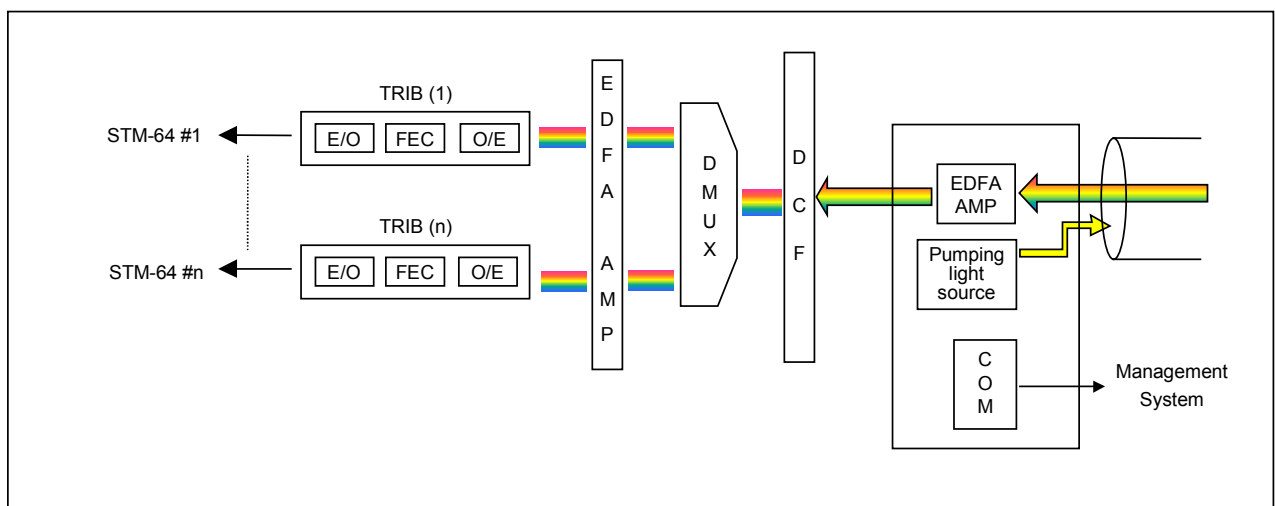


Figure 3 SLTE functional Block Diagram (Receive)

2.2 Maintenance System

The maintenance system of the SLTE is structured in a hierarchical approach. Figure 4 shows the block diagram of FLASHWAVE S850 maintenance system.

Management processor in a sub-rack collects alarm and status information of units installed within the sub-rack and transfers the information to RIC (Rack Indicator & Connector) shelf where maintenance information is processed and transferred to COMMON sub-rack or station alarm system. All maintenance information of the SLTE is collected into the Management System. The maintenance information can be monitored by Craft Terminal (CT) as well.

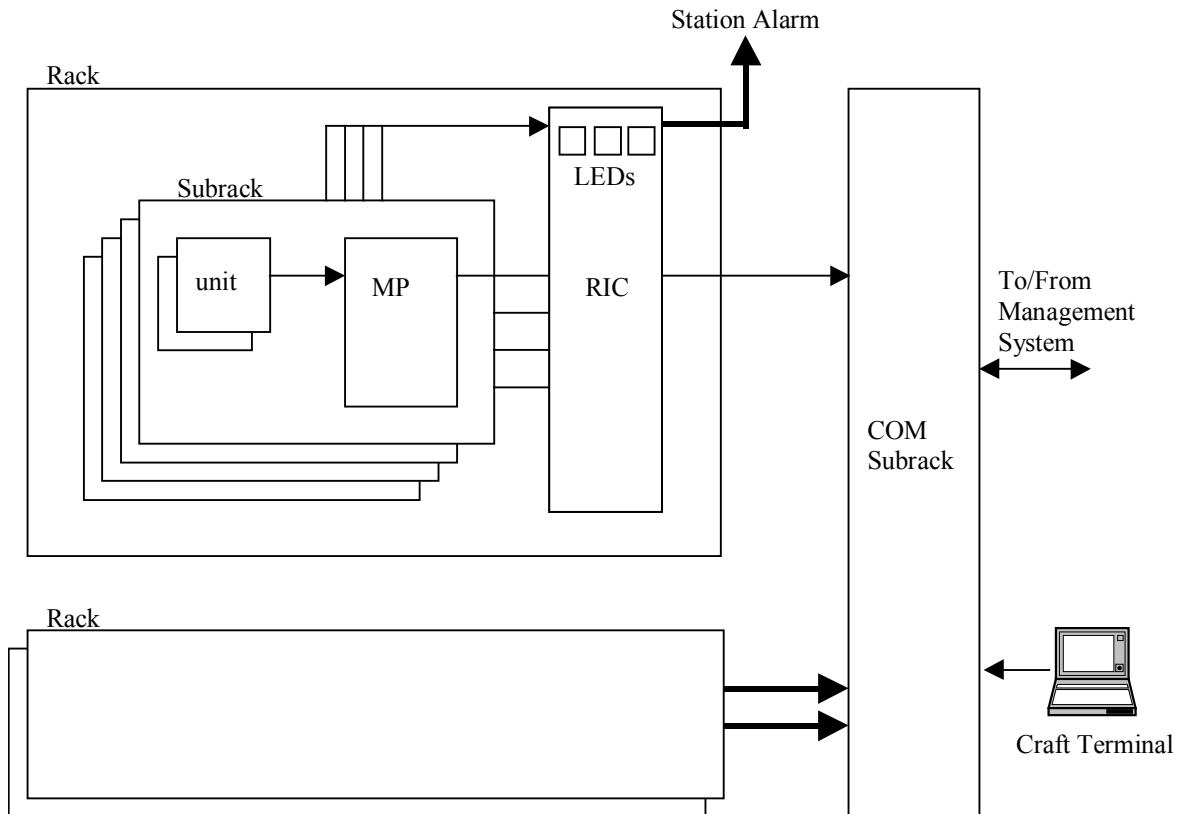


Figure 4 Maintenance System

2.3 AMS Function

If a failure on incoming STM-64 signal (OPT IN DOWN ALM) occurs at transmit-tributary function, an Alternate Maintenance Signal (AMS) will be inserted to replace the missing signal. The AMS pattern can be configured as STM-64 MS-AIS frame or 1100... pattern. At receive side, the failure is identified once the AMS is detected.

In the case of incoming WDM optical line signal missing, no signals will be sent towards the SDH equipment.

2.4 Erbium-Doped Fiber Amplifier (EDFA)

The EDFA is co-located within FLASHWAVE S850 as post-amplifier and pre-amplifier at transmit side and receive side, respectively. It is adopted to boost the power of lightwave signals for high capacity long-distance unrepeated transmission system.

2.5 Pre-emphasis Control

The FLASHWAVE S850 is equipped with Pre-emphasis Control function to equalize WDM signals level throughout the bandwidth. The optical output power of each wavelength is adjusted at specify level, which takes into account of EDFAs and line fiber characteristics. The Pre-emphasis Control is required after cable installation, cable repair or capacity-upgrading process.

2.6 Dispersion Compensation Fiber

The dispersion compensation fiber is included as a part of the FLASHWAVE S850. The DCF is used to pre- or post-compensate for chromatic dispersion accumulated along the line fiber, so that signal waveform distortion can be mitigated.

2.7 Engineering Service Channel

The FLASHWAVE S850 provides two types of order wire interface, namely audio interface and data channel interface. All of the order wire interfaces are provided at the COM sub-rack.

2.8 Dummy Light

The Dummy lights (DL) are required in order to obtain optimal SNR of wavelengths over the bandwidth, when channel counts are less than the final capacity. Continuous wave light source is used for DL.

3. Equipment Configuration

The FLASHWAVE S850 is designed based on European Telecommunication Standards Institute (ETSI) requirements and compliant to ETS 300 119 Series. The FLASHWAVE S850 provides standard architecture for equipment power distribution, air-cooling system, plug-in units and installation & cabling facilities. In addition, the FLASHWAVE S850 meets Electro-Magnetic Compatibility (EMC) requirements based on ETS 300 386-1.

In general, the FLASHWAVE S850 consists of 6 types of different rack, namely:

- TRIB Rack
- TMDRA Rack

The standard rack dimensions are 2200mm (H) × 300mm (D) × 600mm (W). The rack provides front access with back-to-back or against the wall installation. Figure 5 indicates the typical rack face layout of FLASHWAVE S850 series.

3.1 TRIB Rack

TRIB rack consists of three TRIB sub-racks.

The main features for this rack are to perform transmit-tributary function and receive-tributary function. For transmit-tributary function, the incoming STM-64 signal will be converted from 9.95328Gb/s (STM-64) to 10.7Gb/s line signal with Forward Error Correction (FEC) encoding function. In addition, Overhead (OH) processing and wavelength controlling will be performed as well. On the other hand, the receive tributary function will perform the FEC decoding process on the incoming WDM line signal before it is converted into STM-64 signal for terrestrial transmission network.

As an option, PSS sub-rack will be accommodated for 1+1 tributary unit protection.

3.2 TMDRA Rack

TMDRA rack consists of three different types of sub-rack, namely:

- COM sub-rack
- WDMA sub-rack
- DCF sub-rack

The COM sub-rack provides FLASHWAVE S850 management function, such as alarm collection, status provisioning and performance monitoring features. All maintenance information of the FLASHWAVE S850 is transferred to Management System through the COM sub-rack.

The WDMA sub-rack provides following functions;

- Combines individual channel signals into WDM aggregate line signal
- Optical amplification on the supplementary loss WDM aggregate signal due to pre-dispersion compensation.
- High power optical amplification to the line
- Pilot signal transmitting/receiving
- Distributed Raman Amplification and/or in-line Remote Amplification
- De-multiplexes the WDM aggregate line signal into individual channel signals
- Optical amplification on the supplementary loss WDM aggregate signal due to post-dispersion compensation.

The DCF sub-rack provides the accommodation of Dispersion Compensation Fiber.

TMDRA	TRIB
DCF	PSS
WDMA	TRIB (2) [CH5-8]
COM	TRIB (1) [CH1-4]

**Figure 5-1 Typical Layout of FLASHWAVE S850-8UR
 with 1+1 tributary unit protection**

TMDRA	TRIB	TRIB
DCF	PSS	
WDMA	TRIB (2) [CH5-8]	TRIB (4) [CH13-16]
COM	TRIB (1) [CH1-4]	TRIB (3) [CH9-12]

**Figure 5-2 Typical Layout of FLASHWAVE S850-16UR
 with 1+1 tributary unit protection**

4. Technical Data

4.1 Main Equipment Specification

Table 2 lists the main equipment specification of FLASHWAVE S850.

Table 2 FLASHWAVE S850 Equipment Specification

Item	Specification			
	FLASHWAVE S850 -8UR	FLASHWAVE S850 -16UR	FLASHWAVE S850 -32UR	
Number of WDM	8	16	32	
Rack Dimensions	ETSI Rack 2200(H) × 600(W) × 300(D) mm			
Tributary Interface	ITU-T S-64.2 / I-16			
Line	Bit rate	10.7 GHz		
	Code	NRZ		
Signal	Wavelength	1,555 nm region (C-band)		
Interface	Transmitter Power	< +21dBm/ch	< +18dBm/ch	< +15dBm/ch
	Receiver Sensitivity	< -30dBm/ch	< -28dBm/ch	< -27dBm/ch
FEC	Ultra-FEC (Iterated BCH coding)			
Environmental Conditions	Temperature	+5 to +40°C (operation)		
	Humidity	5 to 85 % RH		
	EMC/ESD	IEC 1000 series. IEC CISPR 22		
Power Supply	-40.5V to -57V (nominal -48V DC)			
Total Power Consumption* (approx.)	< 7.5kW	< 10 kW	< 15kW	
Rack Layout (typ.) *	Figure 5			
Monitoring Points	Electrical	DC power supply voltage		
	Optical	<ul style="list-style-type: none"> • Line output WDM signal • Line input WDM signal • Single wavelength output signal • Single wavelength input signal 		

Note* : Required rack and power consumption depend on the wavelength number, or system length.

4.2 System Alarm Capability

(1) Collective alarm

Each alarm from rack or sub-rack is classified into one of collective alarms listed in Table 3 below. The collective alarms are indicated at the LED on the front cover of the rack or the sub-rack. If an alarm is issued, then a corresponding collective alarm is generated.

Table 3 Collective Alarm

Type	Description
1. Major Alarm	Urgent alarm
2. Minor Alarm	Non-urgent alarm
3. Receiving Attention	Reminding the operator that rack or sub-rack is in alarming conditions and requesting acknowledgement by pushing "REC ATT" switch.

(2) Individual alarm

Individual alarms are indicated at the LED on the front cover of unit in alarming conditions. Craft Terminal can monitor the alarms as well.

(a) LED on the front cover

- FAIL LED
When this LED (red color) lights up, internal failure of the unit has occurred.
- LINE LED
When this LED (red color) lights up, incoming signal failure has occurred.
- PWR LED
When this LED (red color) lights up, failure of power units has occurred.

(b) Craft Terminal (CT)

The Craft Terminal is available to monitor the individual alarm in the equipment. Furthermore, CT provides following functions:

- 1) Monitoring of alarms, status and error performance
- 2) Categorization of alarms (Major or Minor)
- 3) Control of Pre-emphasis level
- 4) Indication of unit inventory
- 5) Management of operator's password

(3) Switch Operation

The following switches are provided on the front cover of sub-racks.

a) REC ATT

External alarms are suppressed by this switch, but corresponding indication on the alarm panel remains active and "REC ATT" alarm is activated.

b) LAMP TST

The LEDs on the equipment can be tested by pressing this switch for maintenance purpose.

c) BELL OFF

External "BELL" alarm is suppressed by this switch.

- d) CR
Reset switch to units in alarming conditions

- e) CPU RST
CPU reset switch

- f) PWR
Switch of power supply unit

4.3 Characteristics of Order Wire Interface

The following interfaces are provided through FEC overhead per each fiber pair:

Data Channel Interface

2.048 Mb/s	as per ITU-T G.703
Number of channels	2 / tributary