C O M M U N I C A T I O N S

E1 Fiber Optic Converter
with Service Channel Interface

LE-820M/1E1 Plus
LE-1300S/1E1 Plus

User's Manual

Rev. 2.0

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About This Guide

This manual provides all the information required to install, configure, and use LE-820M/1E1 Plus and LE-1300S/1E1 Plus E1 to fiber optic converters. The above two models are identical in their functionality with the only difference being in their optical interface. While the LE-820M/1E1 Plus has multimode optical interface operating at 820 nm wavelength, the LE-13001E1 Plus has single mode fiber optic interface operating at 1300 nm wavelength. For the sake of simplicity the naming convention “E1 Plus” will be used to cover both models throughout this guide. The manual is intended for use by personnel familiar with telecommunication networks; consequently it assumes basic knowledge of telecom networks and ITU-T G.703 concepts.

Overview of the User’s Manual

Introduction – provides general information about the E1 Plus.
Installation – helps to understand and install the E1 Plus.
Configuration – explains all available settings on the E1 Plus and what options exist for configuration and use.
Specifications – lists the equipment’s specifications.
Port pinouts – provides pinout data for the equipment’s ports.
Glossary – provides the meaning for some networking terms used in this manual

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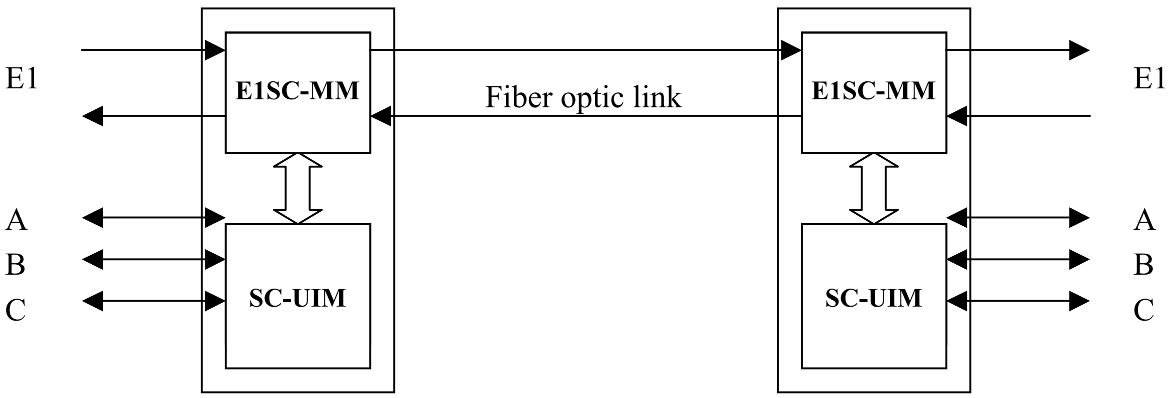
1. Introduction

1.1 General Description

The E1 Plus fiber optic converter (LE-820M/1E1 Plus and LE-1300S/1E1 Plus) products from LaserBit Communications offer cost effective and highly reliable solution for connecting equipment with ITU-T G.703 (E1) interface to optical networks. The converters give fully transparent connection both for structured or unstructured signals at E1 (2.048 Mbps) level. The devices are designed to be extremely flexible yet easy to use. The copper line interface is configurable both for balanced (UTP) and unbalanced (COAX) connection. Copper and fiber loop back modes provide useful help in troubleshooting. The loop back modes also can be turned on and monitored remotely. Color LED indicators provide extended status and alarm reporting. The selectable line coding and AIS handling gives further flexibility when integrating the equipment into an existing system. The E1 Plus models are equipped with Service Channel feature, which transmits one voice channel, one RS-232 channel and 2 x 24 low speed signal bits on top of the data stream. This solution makes the equipment ideal for applications where alarm and status monitoring or remote management of other equipment is required. Besides the AC Power Supply, the devices can be ordered with 48 VDC PSU for Telco applications.

1.2 Theory of operation

The basic function of the E1 Plus converter is to transmit and receive E1 signal over fiber optic networks. In addition to that, the equipment is capable of transmitting auxiliary service data on top of the standard E1 data stream. The two functions are realized by two independent functional units inside the device as it is shown on Figure 1 below.



A – RS-232 serial, duplex, up to 38.400 kbps
B – Analogue voice channel, 16 kbps ADPCM
C – Low speed alarm and control signals, 2 x 24

The E1SC-UIM (User Interface Module) gathers the RS-232 asynchronous serial data, the analogue voice channel and the alarm and control signals together and converts them into a synchronous 64 kb/s digital data stream using unique framing and error correction protocol. This data is then passed to the E1SC-MM (Media converter and Multiplexer) module, which multiplexes the service channels and the incoming E1 data onto a 2.5 Mb/s digital stream then converts it to optical signals. At the opposite side the optical signals are converted back to electrical, de-multiplexed and the data is passed to the corresponding interfaces, that is E1 to the line interface and service channels to the SC-UIM module. The SC-UIM module decodes the 64 kb/s digital data and converts it back to RS-232 serial, analogue voice and low speed signaling.

More detailed information about the functional blocks inside the individual modules can be seen on Figure 2. (E1SC-MM) and Figure 3. (SC-UIM) E1SC-MM (Media converter and Multiplexer).

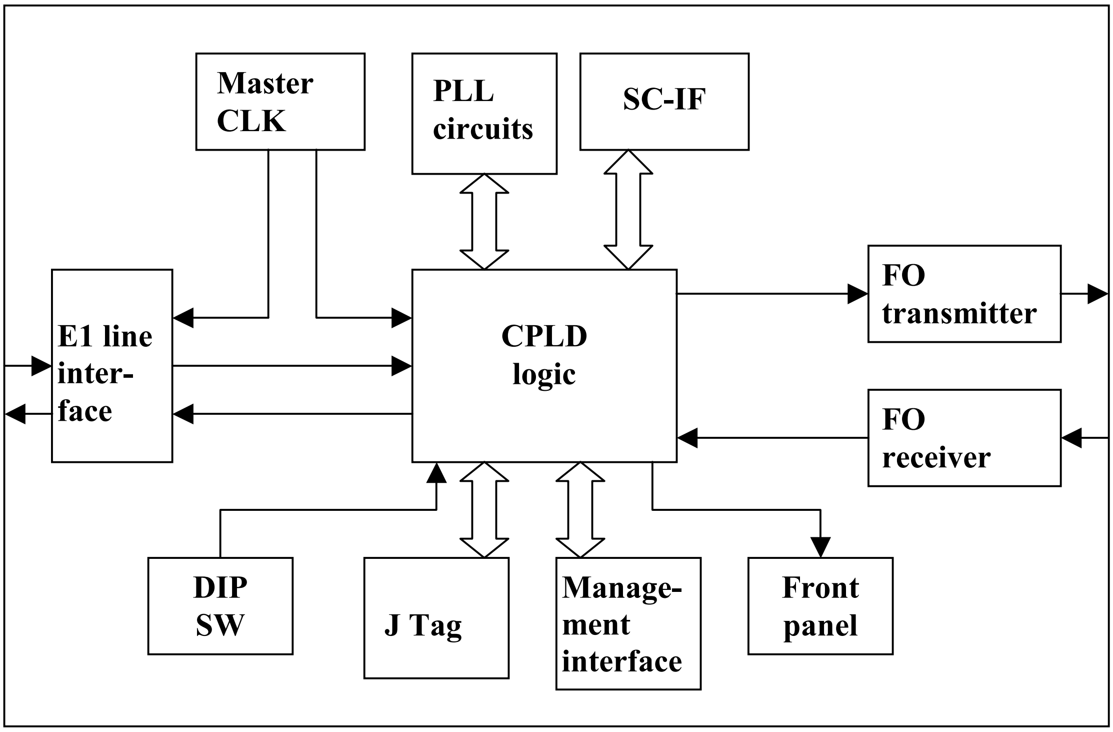


Figure 2. E1SC-MM Function Blocks

E1 line interface

The E1 line interface provides physical connection to the E1 network via balanced 120 Ohm UTP or unbalanced 75 Ohm coaxial ports. It provides data and clock recovery, AMI/HDB3 encoding and decoding, AIS and BPV detection.

CPLD logic

The CPLD (Complex Programmable Logic Device) is the heart of the E1 Plus unit. The two major functions of this block is to multiplex/demultiplex the E1 data and the service channel data and to perform the encoding and decoding of the optical serial data.

PLL (Phase Locked Loop) circuits

Three independent PLL’s are used by the CPLD logic for the encoding and decoding of the optical serial data.

FO transmitter/receiver

The fiber optics transmitter and receiver convert the electrical signals to optical and the optical to electrical respectively.

Master Clock

The Master Clock is used as a reference clock source when the device looses the sync on the E1 side. By doing so the service and management communication between the two E1 Plus units is not affected by the sync loss.

SC-IF

The Service Channel Interface is the interconnection between E1SC-MM (Media converter and Multiplexer) and the E1SC-UIM (User Interface Module). It carries synchronous duplex 64 kbps data, which contains the RS-232 asynchronous serial data, the analogue voice channel and the alarm and control signals.

DIP SW

The configuration switch block contains 8 micro switches used to select line coding, E1 line loop back and fiber loop back.

J Tag

The J Tag is the test interface of the CPLD logic, through which the functionality of the electronics can be checked. The same interface is used to download the new operating code to re-program the CPLD.

Management Interface

The management interface provides information about the local and remote frame sync loss and can be used to set the device to dual loop back mode.

Front Panel

The Front Panel gives information about the actual status of the equipment including power, optical and E1 line status.

Operation

The E1 line interface receives the G.703 data, recovers the clock from the signal, decodes the data and detects AIS or BPV errors. The recovered clock and data then passed to the CPLD logic. This programmable electronics receives the E1 data and clock and the service channel data, multiplexes them into a 2.5 Mbps synchronous data stream. This data stream is then encoded for optical transmission and passed to the FO transmitter, which converts the electrical signals to optical. In the opposite direction the optical signal is received by the FO receiver, converted to electrical and transmitted to the CPLD block. The CPLD decodes the data stream, demultiplexes it and sends the E1 data and the recovered clock to the E1 line interface. The service channel data is passed to the service channel module. The E1 line interface module encodes the data received from the CPLD block using AMI or HDB3 coding and transmits the E1 signal out to the G.703 port.

E1SC-UIM (User Interface Module)

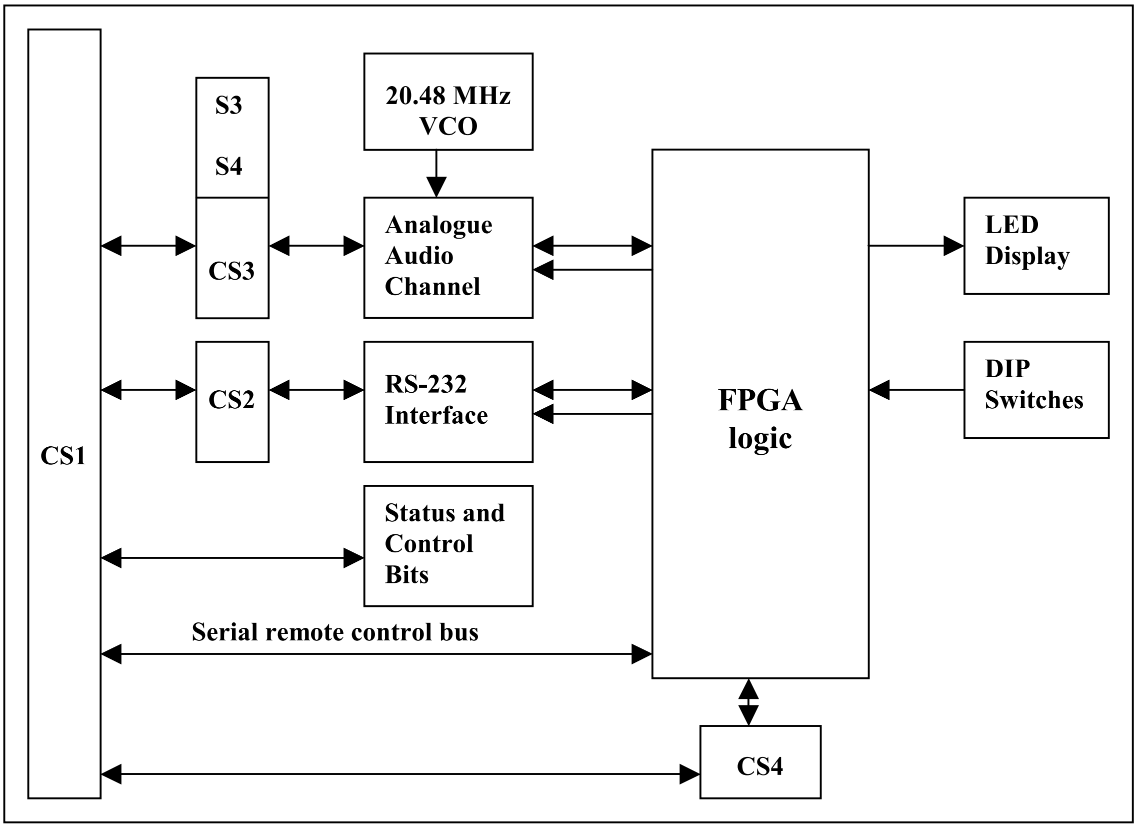


Figure 3. E1SC-UIM Function Blocks

CS1 System connector

All signals of the SC-UIM are available on this 96 pin connector. Two DB-37 connectors are used to make these signals accessible on the rear side of the unit.

CS2

DB-9 connector for RS-232 connection, situated on the front side of the equipment.

CS3

RJ-11 connector for telephone handset connection, placed on the front side of the equipment.

CS4

The CS4 multiplexed digital data connector is a ten-pin interface provides interconnection between E1SC-MM (Media converter and Multiplexer) and the E1SC-UIM (User Interface Module). It carries synchronous duplex 64 kbps data, which contains the RS-232 asynchronous serial data, the analogue voice channel and the alarm and control signals.

S3

Analogue voice channel momentary push button. Pushing the button will cause the buzzer of the remote unit to buzz until the button is released. This button is used to warn the remote side to switch its S4 switch to "hook-on" position after a conversation is finished.

S4

Analogue voice channel hook switch, used to initiate a voice call. The normal position of the switch is "hook-on". If it is switched to "hook-off" position, the buzzer of the remote device start buzzing while the green status LED starts blinking at both sides. After changing the position of the switch at the remote side to "hook-off" the buzzer will stop and both LED's change to steady green. The voice communication channel is now open. The channel can be close by turning any of the to S4 switches to "hook-on" position.

FPGA logic

The FPGA (Field Programmable Gate Array) is the central controlling and processing unit of the service channel module. It gathers the RS-232 asynchronous serial data, the analogue voice channel and the alarm and control signals together and converts them into a synchronous 64 kb/s digital data stream using unique framing and error correction protocol. After turning the equipment ON the FPGA downloads its operating code, which takes approximately 100 ms. Afterwards it initializes the voice channel and the RS-232 circuits based on the DIP switch configuration. The FPGA uses clock signals from the E1SC-MM module to start the multiplexed digital channel, the receive and the transmit clock is independent from each other. As soon as the circuits are synchronized, the E1SC-UIM is ready to work.

Analogue Audio Channel

An ADPCM codec is used to convert the analogue voice signals into a 16 kbps digital data and vice versa.

RS-232 Interface

The asynchronous serial interface is controlled by an UART chip. The parameters of the communication are set by DIP switches and can be changed remotely too.

Status and Control Bits

The 2x24 bits low speed signaling can be used to monitor or control remote equipments, alarm systems, etc. The signals are sampled and refreshed in every 8 ms. The RX and TX sides are independent, both can be set up for either serial or parallel operation. The not used inputs and outputs can be left un-terminated. The inputs can be connected to TTL/HCMOS compatible source and are protected from static electricity and voltage overload. The outputs can be connected to relays or TTL/HCMOS compatible devices and maximum load should not exceed 30 V or 40 mA.

DIP Switches

The configuration switches of the E1SC-UIM are used to set up the operational parameters of the RS-232 interface, the status and controlling signal channels and the 64 kbps digital channel.

LED Display

There are three LED indicators showing the actual state of the service channel unit including initialization, loop back and voice channel status.

2. Installation

The step-by-step procedure of installing the E1 Plus converter is explained in the followings.

Configuration

Before connecting the E1 Plus device to the E1 and optical network, the operating parameters for the desired configuration should be set up. These parameters should match with the connected E1 equipment and network parameters and can be set up by DIP switches and jumpers. The jumpers and part of the DIP switches are situated inside the unit and will become accessible only after removing the cover of the unit. Please see the Configuration section of this manual for more details.

E1 Line Connection

After making sure that the settings of the equipment are appropriate for the current configuration, the E1 line can be connected to the selected interface. If you use the unbalanced interface, please pay attention to the TX/RX directions. When the balanced interface is used, compare the pinout specification of the E1 Plus unit and the E1 equipment to be connected and use a proper cable for the interconnection.

Fiber Connection

Verify that the connectors of the equipment and the optical network are compatible. Connect the TX side of the opposite unit to the RX port and the RX side of the remote device to the TX port of the local equipment.

Power connection

The E1 converter can be ordered with three different power supply options, 230 VAC, 110 VAC and 48VDC. Check your unit before connecting it to the power source. Incorrect power connection can cause permanent damage to the equipment. After all the cable connections are arranged, turn the power switch to ON position. The Power LED on the front side of the unit should be on, and if the cable connections were made properly and the connected equipments are operational the RX and TX status LED’s should light both on the E1 and copper side.

3. Configuration

Before connecting the E1 Plus device to the G.703 network it should be configured to work properly with the local E1 equipment. All E1 Plus units are pre-configured in the factory with the following settings:

G.703 interface

Line interface: Unbalanced, 75 Ohm BNC connection
Line coding: HDB3

Service channel

RS-232 interface: 9600, 8, 1, NP
Voice port: Panasonic handset

3.1 Location of connectors and indicators

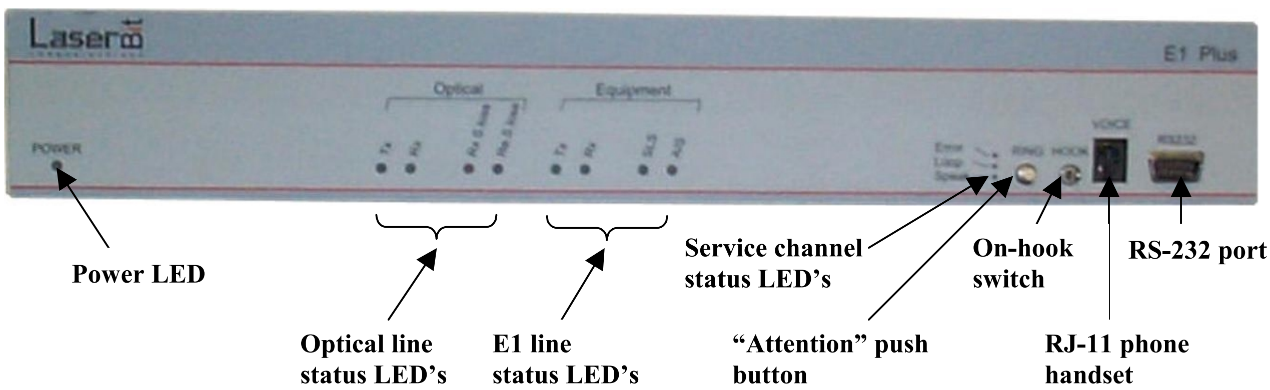


Figure 4. E1 Plus unit front panel

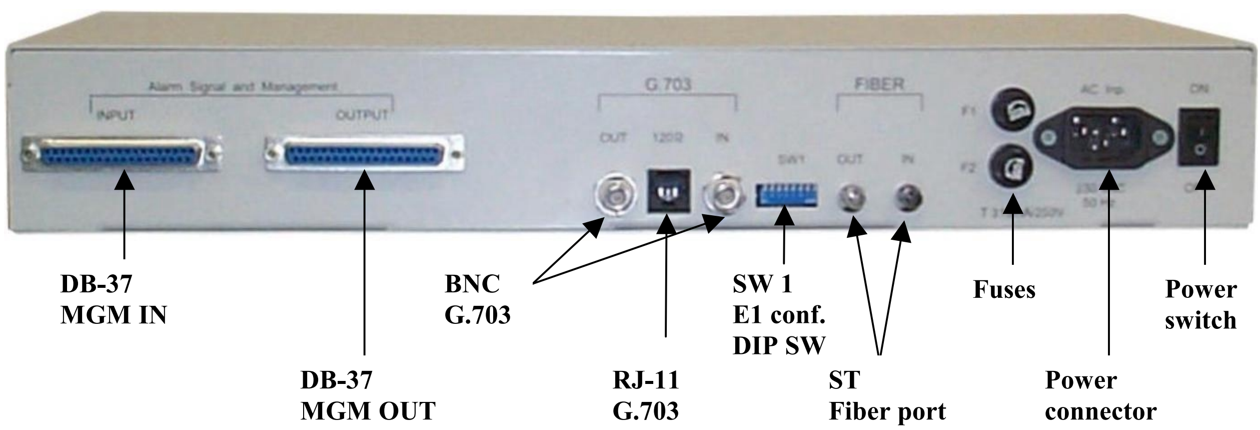
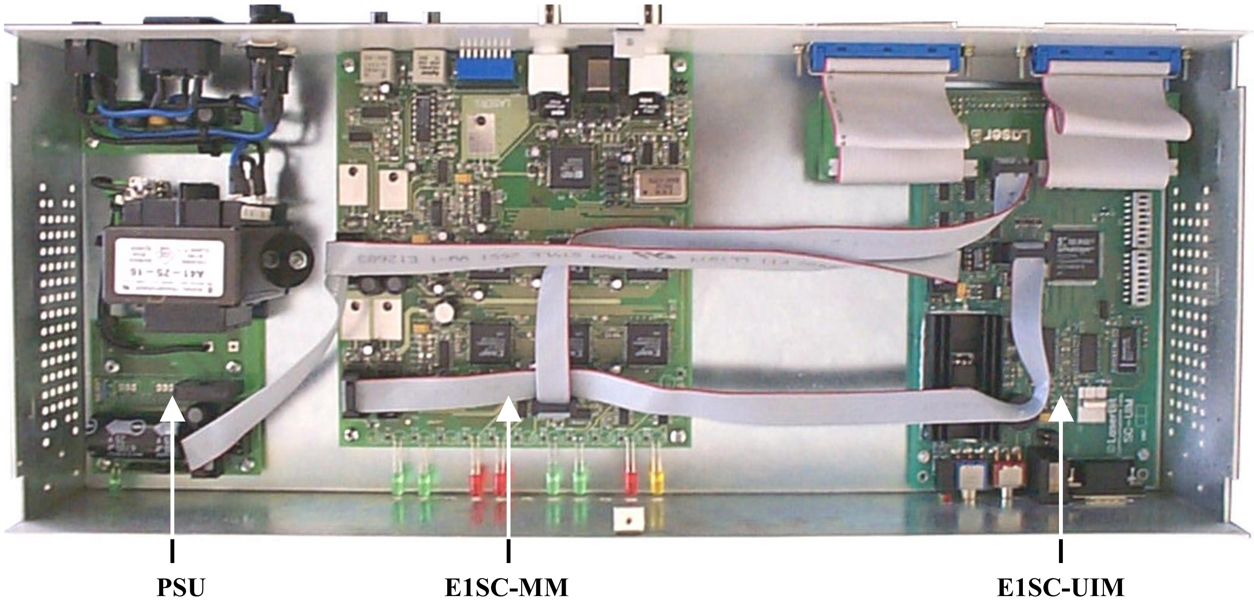
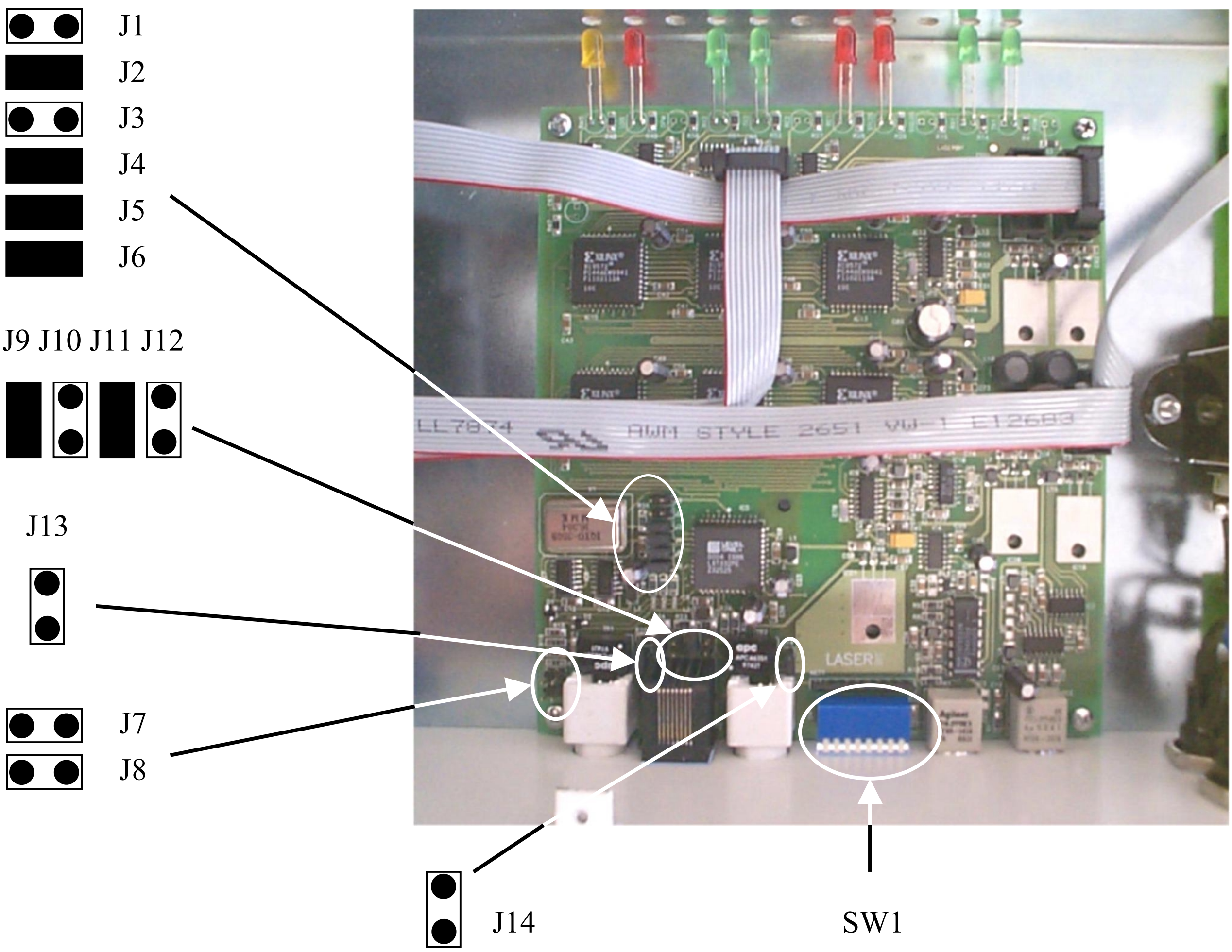


Figure 5. E1 Plus unit rear panel

3.2 E1 Plus unit internal module arrangement

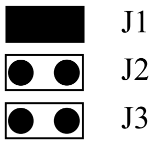


3.3 Configuration Jumpers – E1SC-MM

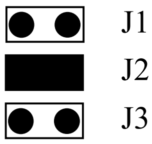


Jitter attenuator settings (J1, J2, J3)

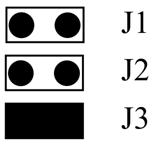
Jitter attenuator disabled



The jitter attenuation circuit is placed in the receiver paths of copper side*



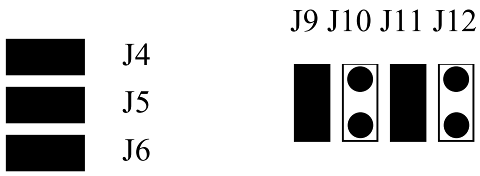
The jitter attenuation circuit is placed in the transmit paths of copper side



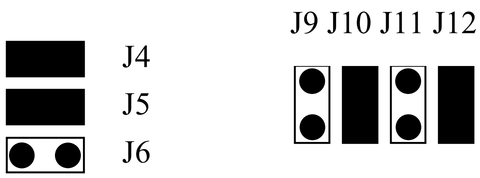
These three jumpers must not be installed together in the same time, only one of them.

E1 line settings (J4, J5, J6, J9, J10, J11, J12)

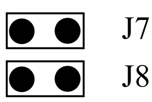
75 Ohm balanced operation*



120 Ohm unbalanced operation

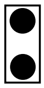


Line equalization (J7, J8)



Factory setting, do not change.

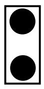
TX Logic GND



J13 Signal output is not connected to the logic ground*

J13 Signal output is connected to the logic ground. Use this setting if it is required by the network operator.

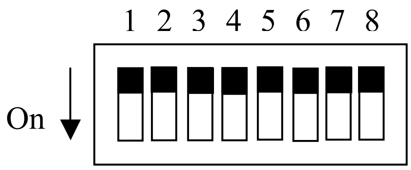
RX Logic GND



J14 Signal input is not connected to the logic ground*

J14 Signal output is connected to the logic ground. Use this setting if it is required by the network operator.

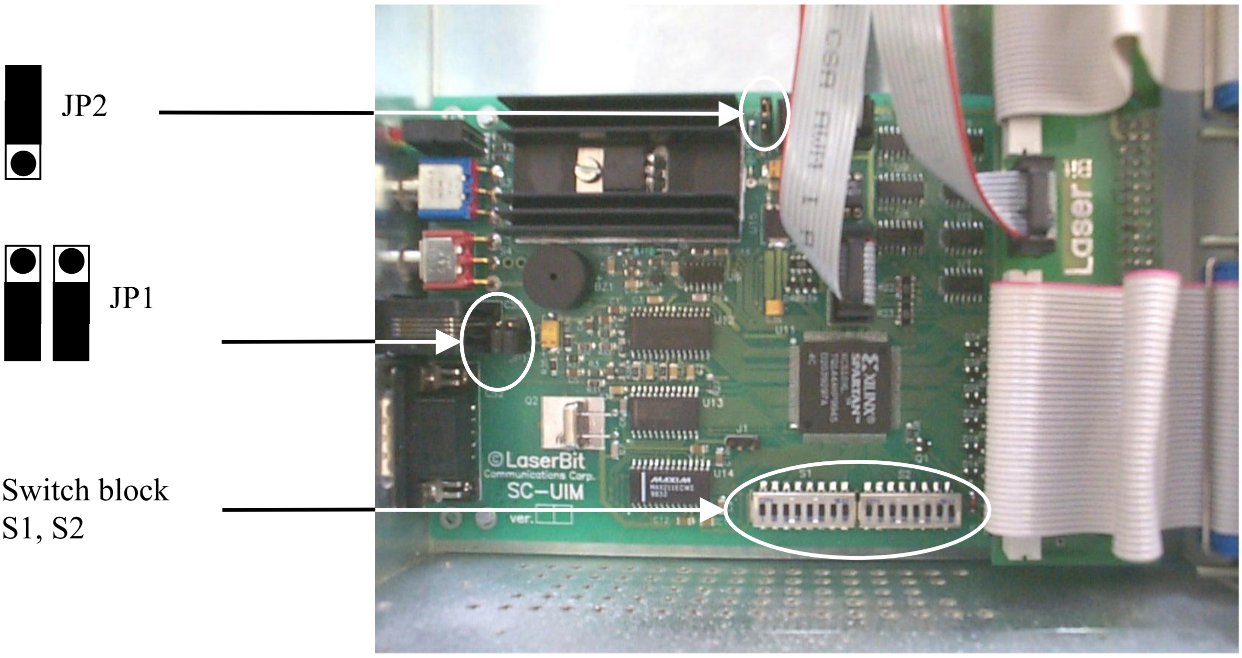
DIP Switch settings (SW1)



Switch No.	ON	OFF
1	AMI	HDB3*
2	E1 line loop back	Normal Operation*
3	Optical loop back	Normal Operation*
4-8	N/A	N/A

Asterisk (*) denotes factory setting.

3.4 Configuration Jumpers – E1SC-UIM

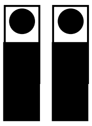


Power source selector (JP2)

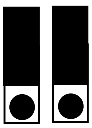
JP2 Locally stabilized voltage (+5V)*

JP2 Incoming voltage (+5V)

Handset MIC polarity



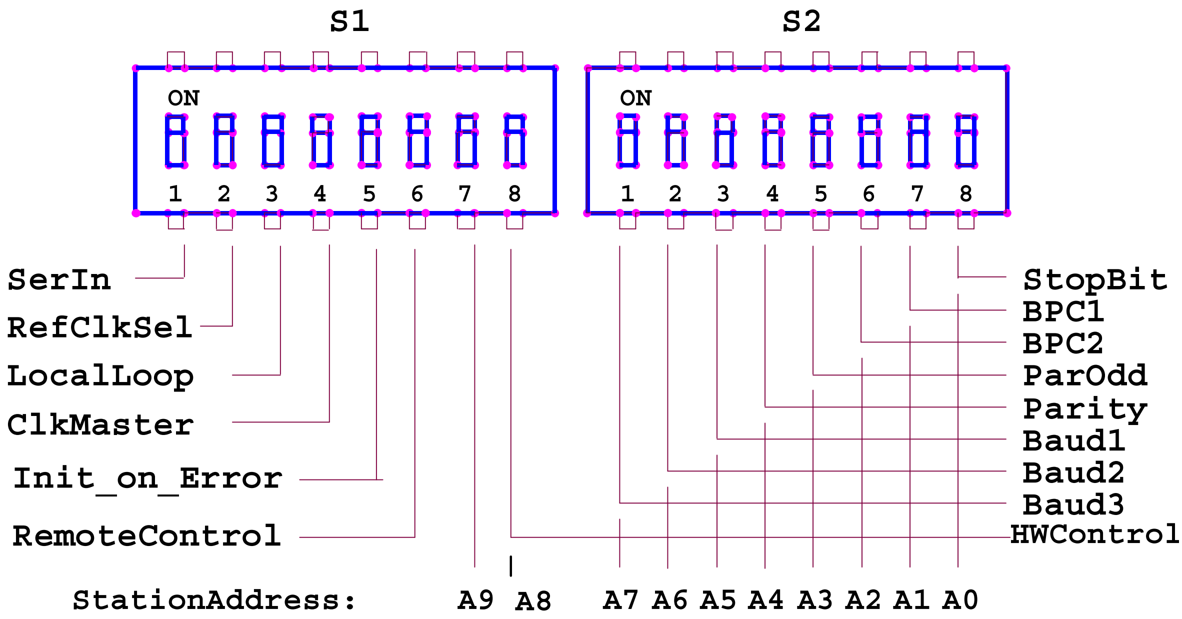
JP1 Panasonic type handset*



JP1 Siemens type handset

3.5 Service channel configuration settings (S1, S2)

Factory setting : 0 0 0 0 0 0 0 0   1 0 1 0 0 1 1 0



SerIn: Method of handling the inbound 24 bit low speed signaling data
OFF – 24 signaling bits are taken from the parallel input*
ON – 24 signaling bits are taken from the serial input

RefClkSel: Reference Closk Source selection for the ADPCM PLL
OFF – data channel receive clock (RXC)*
ON – data channel transmit clock (TXC)

LocalLoop: Local Loop Mode selection
OFF – Normal mode*
ON – Test mode

ClkMaster: Receive and Transmit clock source
OFF – Normal Mode (incoming RXC and TXC)*
ON – Test Mode (internal RXC and TXC)

Init_on_Error: behavior of the signaling bits on ERROR condition
OFF – all bits keep their previous state*
ON – all bits become inactive

RemoteControl: RS-232 configuration mode
OFF – configuration through S1,S2 switches*
ON – configuration through the internal control bus (future extension)

Multifunction Switches (S1[7-8], S2[1-8])

If RemoteControl=OFF

S1[7] – N/A

S1[8] - S2[1-8] – RS-232 configuration switches

If RemoteControl=ON

S1[7-8] - S2[1-8] – Station address for remote management

S1[7] – A9 … S2[8] – A0

HWControl: RTS/CTS flow control

OFF – Flow control disabled*

ON – Flow control enabled

Baud1, Baud2, Baud3: RS-232 baud rate

0 0 0 300 Baud
0 0 1 600 Baud
0 1 0 1200 Baud
0 1 1 2400 Baud
1 0 0 4800 Baud
1 0 1 9600 Baud*
1 1 0 19200 Baud
1 1 1 38400 Baud

Parity: parity handling on the RS-232 line

OFF – Parity checking and parity bit generation is disabled*

ON – Parity checking and parity bit generation is enabled

ParOdd: Parity selection

OFF – Odd Parity*

ON – Even Parity

BCP1, BCP2: Character length

0 0 5 bits / character
0 1 6 bits / character
1 0 7 bits / character
1 1 8 bits / character*

StopBit: Number of stop bits

OFF – 1 stop bit (in case of 5 bits/character 1,5 stop bit)*

ON – 2 stop bits

4. Technical specifications

E1 Line

Interface:	G.703
Nominal bit rate:	2048 kbit/s
Bit rate tolerance:	± 50 ppm
Line code:	AMI/HDB3
Connector:	BNC 75 Ohm/RJ-45 120 Ohm

Optical

820 nm multimode	
TX Power:	-15 dBm (min)
RX Sensitivity:	-31 dBm
Connector:	ST multimode
1300 nm single mode:	
TX Power:	-18 dBm (min)
RX Sensitivity:	-31 dBm
Connector:	ST single mode

Common Digital data stream

Type of traffic flow:	serial, synchronous, duplex
Speed:	64 kbit/s
Interface:	TTL compatible

Analogue voice channel

Frequency range:	200 – 3400 Hz
Codec:	ADPCM 16 kbit/s
Characteristic:	A-law
Relevant standard:	ITU-T G.726
Connector:	RJ-11

RS-232 serial channel

Type of traffic flow:	serial, asynchronous, duplex
Speed:	300/600/1200/2400/9600/19200/38400 bit/s
Speed tolerance:	± 4 %
Number of data bits:	5/6/7/8
Number of start bits:	1
Number of stop bits:	1/1.5/2
Parity:	Odd/Even/No parity
Flow control:	HW (RTS/CTS)/No flow control
Interface:	DTE
Connector:	DB-9, male

Status and control signals (2x24 bits)

Type of traffic flow:	serial, synchronous, duplex / parallel
Number of data bits:	24
Serial data clock:	8 kHz
Sampling period:	8 ms
Parallel data input:	TTL compatible
Parallel data output:	Open collector, 30 V / 40 mA

System

Power:	110 VAC / 230 VAC / -48 VDC
Dimensions (WxDxH):	435 x 206 x 65 mm (1.5 U)
Operating temperature:	0 – 50 ^{0}C
Storage temperature:	-20 – 50 ^{0}C
Humidity:	0 – 95 % non condensed

5. Port Pinouts

Serial RS-232 (DB-9 male)

Pin	Signal	Function
1	DCD	Data Carrier Detected
2	RXD	Received Data
3	TXD	Transmitted Data
4	DTR	Data Terminal Ready
5	GND	Signal Ground
6	DSR	Data Set Ready
7	RTS	Request To Send
8	CTS	Clear To Send
9	RI	Ring Indicator

Handset (RJ-11)

Pin	Signal	Function
1	T_d	Handset MIC
2	R_a	Handset receiver
3	R_b	Handset receiver
4	T_c	Handset MIC

E1 (RJ-45)

Pin	Signal	Function
1	RX (A)	Data Receive A
2	RX (B)	Data Receive B
3	GND	Ground
4	TX (A)	Data Transmit A
5	TX (B)	Data Transmit B
6	GND	Ground
7	N/A	-
8	N/A	-

Alarm Signal and Management INPUT (DB-37)

Pin	Signal	Function	Electrical
1	GND	Signal ground	-
20	BI-0	Status and control input	TTL
2	BI-1	Status and control input	TTL
21	BI-2	Status and control input	TTL
3	BI-3	Status and control input	TTL
22	BI-4	Status and control input	TTL
4	BI-5	Status and control input	TTL
23	BI-6	Status and control input	TTL
5	BI-7	Status and control input	TTL
24	BI-8	Status and control input	TTL
6	BI-9	Status and control input	TTL
25	BI-10	Status and control input	TTL
7	BI-11	Status and control input	TTL
26	BI-12	Status and control input	TTL
8	BI-13	Status and control input	TTL
27	BI-14	Status and control input	TTL
9	BI-15	Status and control input	TTL
28	BI-16	Status and control input	TTL
10	BI-17	Status and control input	TTL
29	BI-18	Status and control input	TTL
11	BI-19	Status and control input	TTL
30	BI-20	Status and control input	TTL
12	BI-21	Status and control input	TTL
31	BI-22	Status and control input	TTL
13	BI-23	Status and control input	TTL
32	RPHGC	Phone ring contact common	Relay
14	RPHG0	Phone ring contact open	Relay
33	RPHG1	Phone ring contact closed	Relay
15	N/A	-	-
34	N/A	-	-
16	N/A	-	-
35	N/A	-	-
17	N/A	-	-
36	N/A	-	-
18	N/A	-	-
37	N/A	-	-
19	N/A	-	-

Alarm Signal and Management OUTPUT (DB-37)

Pin	Signal	Function	Electrical
1	GND	Signal ground	-
20	BO-0	Status and control input	Open Collector
2	BO-1	Status and control input	Open Collector
21	BO-2	Status and control input	Open Collector
3	BO-3	Status and control input	Open Collector
22	BO-4	Status and control input	Open Collector
4	BO-5	Status and control input	Open Collector
23	BO-6	Status and control input	Open Collector
5	BO-7	Status and control input	Open Collector
24	BO-8	Status and control input	Open Collector
6	BO-9	Status and control input	Open Collector
25	BO-10	Status and control input	Open Collector
7	BO-11	Status and control input	Open Collector
26	BO-12	Status and control input	Open Collector
8	BO-13	Status and control input	Open Collector
27	BO-14	Status and control input	Open Collector
9	BO-15	Status and control input	Open Collector
28	BO-16	Status and control input	Open Collector
10	BO-17	Status and control input	Open Collector
29	BO-18	Status and control input	Open Collector
11	BO-19	Status and control input	Open Collector
30	BO-20	Status and control input	Open Collector
12	BO-21	Status and control input	Open Collector
31	BO-22	Status and control input	Open Collector
13	BO-23	Status and control input	Open Collector
32	N/A	-	-
14	N/A	-	-
33	N/A	-	-
15	N/A	-	-
34	RES	Remote sync loss output	Open Collector
16	RXS	Local sync loss output	Open Collector
35	LOOP	Dual Loop input	Open Collector
17	GND	Signal ground	Open Collector
36	N/A	-	-
18	N/A	-	-
37	N/A	-	-
19	N/A	-	-

6. LED Description

All the status LED’s are located in the front panel of the E1 Plus unit. The indicators are arranged into four groups according to their function as detailed below.

Power

The power LED (green) lights when power supplied to the device that is the unit is connected to the appropriate power source and the power switch on the rear panel is switched on.

Optical

Tx – Transmit indicator (green); this LED lights up when the device is transmitting on its optical port.

RX – Receive indicator (green); this LED shows the presence of an optical signal on the RX side of the optical port.

Rx S. Loss – Receive Sync Loss (red); this LED lights when the unit has lost the sync of the incoming signal on the optical port.

Re S. Loss – Remote Sync Loss (red); this LED indicates that the remote unit is sending Sync Loss Frames, which means it has lost the sync on its optical side.

Equipment

Tx – Transmit indicator (green); this LED lights up when the device is transmitting on its E1 port. If the signals are reversed on the G.703 port e.g. the transmitter is connected to the opposite transmitter, the indicator is blinking. If the device detects a short circuit on the TX line the LED goes out.

Rx – Receive indicator (green); this LED lights up when the device is receiving valid data on its G.703 interface.

SLS – Signal loss (red); this LED indicates that there is no signal present on the RX side of the E1 port.

AIS – All ones (red); this LED is turned on when the equipment is receiving AIS signals on the E1 line interface.

Service channel

Error – Error indicator (red); if the ERROR LED is steadily ON, it means that the FPGA circuit could not download its operational code. Its blinking status indicates that other initialization error happened.

Loop – Loop back indicator (yellow); this LED lights up when the device is turned into loop back mode.

Speak – Voice channel status indicator (green); when this LED is turned ON the voice channel between the local and remote equipment is UP. When it blinks it indicates that call initiation from the remote site is in progress.

Appendix A

E1 background

The invention of the telephone in 1876 (A.G. Bell) has completely changed the world. Today it would be difficult for us to imagine our life without the telephone.
Even these days with the ever-growing number of computer networks and the booming Internet, voice communication still forms the major part of the total volume of the communication traffic.

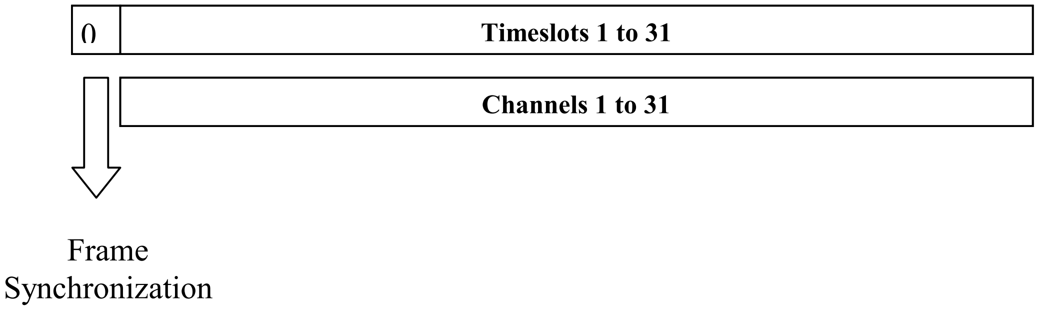
In the early days each telephone connection required a dedicated link all the way between two users. Shortly after the steadily growing number of subscribers led to the development of various methods and technologies, which enabled several telephone connections to be transmitted over a single cable. Most of the systems at that time used Frequency Division Multiplexing (FDM) technology. Here the idea was to modulate each telephone channel with a different carrier frequency to shift the signals into different frequency ranges.

With ever increasing demands for higher transmission rates with better quality and the advent of semiconductor circuits other techniques were developed. In the 1960s, digital systems started to appear. Here the telephone channels are separated by time using a new type of transmission method known as Pulse Code Modulation (PCM).

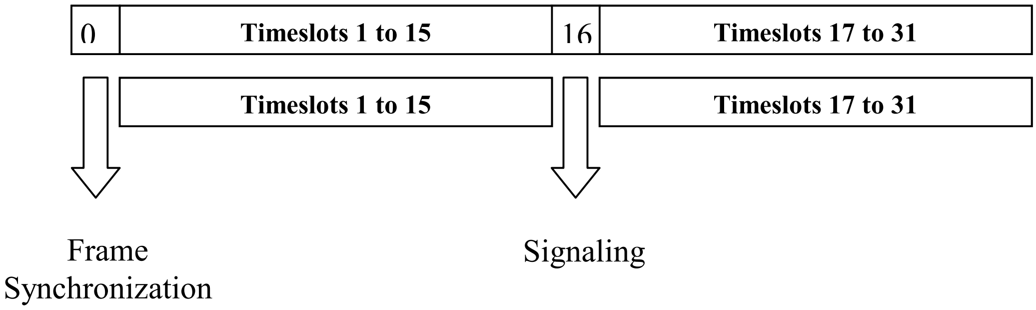
The analogue signal (speech) from the telephone is first converted to a Pulse Amplitude Modulated (PAM) signal using a process called sampling. Then using quantization and encoding this sampled analogue (PAM) signal is converted to a digital PCM signal. Based on the principle above the Plesiochronous Digital Hierarchy (PDM) has been developed.

Here the 300-3400 Hz band-limited analogue signal is sampled at 8000 Hz. Then the PAM signals are quantized using a 13-segment compression characteristic known as A-law (in T1 systems 15-segment μ-law characteristic is used). Finally the signal is encoded using an 8 bit code word format. This source coding produces 8-bit code words at a rate of 8 kHz, giving 64 kbps data rate. To improve the utilization of the transmission medium, the signals are transmitted by time division multiplexing, where the code-words are interleaved and contained in a PCM frame.

A primary frame consists of 32 code words called timeslots, which are numbered 0 to 31. A PCM31 frame comprises of 31 timeslots used for traffic and 1 timeslot used for synchronization.



In a PCM30 system the frame comprises of 30 timeslots used for traffic and 2 code words that are used for synchronization and signaling purposes.



PDH has two primary communication systems as its foundation. These are the T1 system based on 1544 kbps that is recommended by ANSI and the E1 system based on 2048 kbps that is recommended by ITU-T. The T1 system is used mainly in the USA, Canada and Japan. European and certain non-European countries use the E1 system.

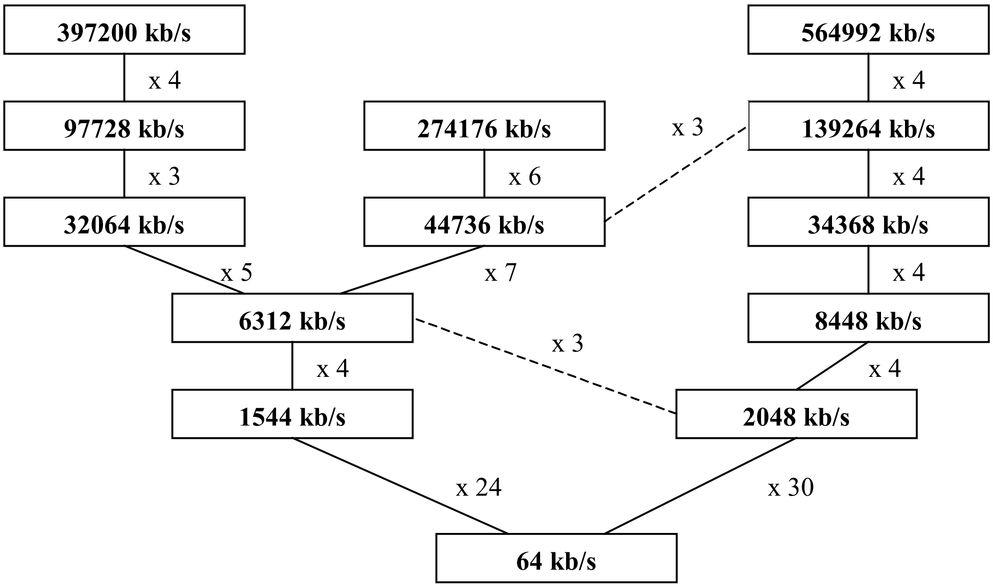
Appendix B

Characteristics of the PDH system.

	Characteristics	E1	T1
a	Sampling frequency	8000 Hz	8000 Hz
b	Number of samples per telephone signal	8000 per second	8000 per second
c	Length of PCM frame	1/b=1/8000/s=125 µs	1/b=1/8000/s=125 µs
d	Number of bits in each code word	8	8
e	Telephone channel bit rate	b x d=8000/s x 8 bit = 64 kbit/s	b x d=8000/s x 8 bit = 64 kbit/s
f	Encoding/decoding Number of segments in characteristic	A-law 13	µ-law 15
g	Number of timeslots per PCM frame	32	24
h	Number of bits per PCM frame	d x g = 8 x 32 = 256 bits	d x g + 1 = 8 x 24 + 1 = 193 bits
i	Length of an 8 bit timeslot	(c x d) / h (125 us x 8) / 256 approx. 3.9 µs	(c x d) / h (125 us x 8) / 193 approx. 5.2 µs
j	Bit rate of time-division multiplexed signal	b x h 8000/s x 256 bits 2048 kbit/s	b x h 8000/s x 193 bits 1544 kbit/s

Appendix C

Summary of PDH transmission rates.



Appendix D

GLOSSARY

A bit	remote (or distant) alarm indicator
AIS	Alarm Indication Signal
AMI	Alternate Mark Inversion
ATM	Asynchronous Transfer Mode
BER	Bit Error Ratio
CAS	Channel Associated Signaling
CRC-4	Cyclic Redundancy Check for 2048kbit/s Systems
E1	2048kbit/s PCM communication system mainly used in Europe
E&M	Exchange and Multiplex signaling
FAS	Frame Alignment Signaling
G.703	ITU-T Recommendation for Physical/Electrical Characteristic for Hierarchical Digital Interfaces
HDB3	High Density Bipolar code with a maximum of 3 zeros
ISDN	Integrated Services Digital Network
ITU-T	International Telecommunication Union Telecommunications Standardization Section
MFAS	Multiframe Alignment Signal
NFAS	Not Frame Alignment Signal
NMFAS	Not Multiframe Alignment Signal
PAM	Pulse Amplitude Modulation
PCM	Pulse Code Modulation
PCM30	30 channels with CAS signaling in timeslot 16
PCM30C	30 channels with CAS signaling in timeslot 16 and CRC error checking
PCM31	31 channels
PCM31C	31 channels with CRC error checking
PDH	Plesiosynchronous Digital Hierarchy
SDH	Synchronous Digital Hierarchy
S/Q	signal-to-quantizing noise
SONET	Synchronous Optical Network
T1	1544kbit/s PCM communication system mainly used USA, Canada and Japan
Y bit	distant multiframe alarm bit