DS3/E3 over Ethernet Pseudowire Gateway V5.4

November 11th, 2010

Operating Information

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International Electrotechnical Commission (IEC) Statement

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Chapter 1: Description and Requirements

The E3Switch TDM-over-PSN pseudowire gateways described herein are used in pairs to extend a full or fractional E3 or T3/DS3 TDM circuit over an intermediate Ethernet Layer-2 packet switched network (PSN). The TDM circuit may be channelized or unchannelized and may contain framed or raw/encrypted data. The gateway will regenerate the outgoing TDM clock and alarm conditions being received at the remote end.

The LAN interface is RJ45 100/1000BaseTX copper or SFP 1000BaseX fiber optic. The two gateways must have a LAN between them. Reverse topology, to bridge two LANs over an intermediate E3 or T3/DS3 circuit, is not possible with this product; for that, please see our LAN Extender product line.

The gateways must be used in pairs. Single-ended operation for connection to a third-party TDMoPSN gateway is not supported.

For ease of installation, the gateway requires minimal configuration, and, for full-rate E3/T3, will typically work immediately upon connection of LAN and TDM cables.

The hot-swappable gateway card may be purchased in standalone or multi-card chassis and draws a minimal 6 watts of power. Standalone, single units ship in high-reliability, fan-free 1U chassis with rackmount brackets and are available in a 100-240VAC or a ±35-75 volt DC models. NEBS-III, redundant-power multicard chassis are available in 6-slot/1U and 20-slot/3U versions.

Both HTTP and SNMP management of the gateways is possible either in or out-of-band through either the copper or SFP LAN port. An SFP transceiver is required to use the SFP LAN port.

Remote firmware upgrade to a gateway is possible through the LAN port, but may require a 15-second outage during gateway reboot.

While the hardware for two TDM circuit connections is present on the unit, only one, bidirectional circuit is currently supported.

The gateway will buffer data from the LAN to remove jitter, and implements quality-of-service mechanisms to eliminate data loss. Packets received out-of-sequence will be properly reordered when possible. The depth of the jitter buffer may be configured to achieve minimum latency. The number of bytes per packet is configurable to allow balancing of bandwidth vs latency according to user's desire.

The gateway supports VLAN tagging, Type of Service (ToS) and DiffServ configuration.

A gateway's configuration must be manually set via the LAN port. The gateways do not currently auto-negotiate parameters of the pseudowire connection.

The gateway has been designed with attention paid to minimum latency and minimal packet loss – containing resequencing functionality that may not be present in other products. The gateway is often a cost-effective and simpler alternative to a router. Even when connected to a LAN port on a router, eliminating a router TDM card can free up expensive, limited, router backplane bandwidth .

The gateway is plug-and-play and can often be installed in several minutes. Network topologies and configuration settings of equipment connected to the gateway can be complex, however, so additional time should be allocated to achieve a properly functioning system.

Chapter 2: Quick Set-up

Attach the gateway to a power source. The front panel lights should illuminate. Green is normal; orange indicates an error.

Attach an Ethernet UTP5 cable from your LAN equipment to the RJ-45 LAN Port 2. The gateway can perform automatic cross-over vs straight-through cable adaptation. The LAN 2 light will change from orange to green if a properly negotiated link has been established. **The network equipment attached to the LAN port of the gateway should be set for autonegotiation mode in order to allow the gateway to negotiate a 100Mbit full-duplex connection.** Disabling autonegotiation or using old LAN equipment may result in the attached LAN equipment configuring to half-duplex mode, resulting in CRC errors and packet loss. Refer to the interoperability section of this document for more information

Attach two 75-ohm coaxial cables from the Port 2 BNC connectors of the gateway to the input and output connectors of your E3 or DS3 link. Once the gateway is receiving a valid TDM signal, the DS3/E3 Port LED will change from orange to alternating orange/green. The DS3/E3 Port LED will change to constant green when a full, unerrored pseudowire connection has been established between the two gateways with no TDM alarms at either end.

Further HTTP management of the gateway via LAN is required in the following situations:
- if using fractional rather than full-speed E3/T3
- if using unframed E3/T3
- if more than two E3Switch gateways exist on the LAN.
- to configure for minimal latency or maximum jitter tolerance
- to change the default administrator password. This is suggested, as configuration cannot be modified after 5 minutes of any power cycle if the default password has not been changed.

There is no further required configuration for the gateway.

Chapter 3: Front Panel

Front Panel Indicators
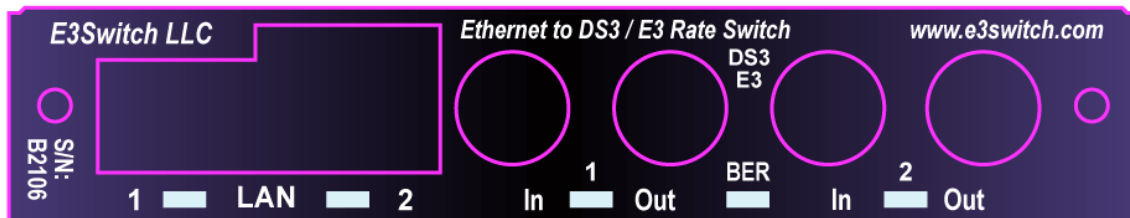
All Indicators:	Green indicates normal operation.
	Orange indicates an error condition.
	Black indicates a disabled port.

DS3/E3 1/2:   Green if the unit has a bidirectional TDM circuit established with no alarm conditions.
Orange indicates an alarm or loss of the incoming TDM connection.
Flashes orange/green if incoming circuit is OK but an outgoing alarm condition is being transmitted.

BER: Green if OK.
Orange flash for each BPV bit error.
Orange steady for absence of DS3/E3 receive signal, loss of frame lock onto receive bit-stream, drive-level fault on transmit cable, or excessive receive bit errors.

LAN1/2:   Green when a properly negotiated 100/1000BaseTX Full-Duplex or SFP LAN connection exists.
Flashes black each time a packet is received on this port.
Orange indicates no valid connection.

Chapter 4: Remote Management HTTP and SNMP

Gateways contain both an HTTP management interface, which may be accessed via a web browser, and an SNMPv2c agent.

Unit's IP/MAC Address

The source Ethernet MAC address of E3Switch gateways is 00:50:C2:6F:xx:xx. The gateway's current IP and MAC addresses are always both shown at the HTTP management screen.

The gateway's management interface can be initially contacted at either its automatic link-local IP address e3switch.local as described below or at its initial numeric IP address described below. Note that after initial setup, an operator may have changed the contact IP address to a new value and the initial addresses below may not work. Prior to operator reconfiguration the unit will respond to HTTP, SNMP and ping requests to its initial IP address.

For initial communication with the gateway, it may be necessary to set the network address of the host port communicating with the gateway to 169.254.xxx.xxx with subnet mask 255.255.0.0. Security protocols advise routers not to forward packets with these link-local IP addresses, so a direct connection is advised. Once initial contact has been established with the HTTP management interface of the gateway, the gateway's IP address can be set to a new, static value if desired.

If a unit's operator-configured IP address is lost or forgotten, it can be recovered as described later in this chapter.

Other than the e3switch.local addresses described below, all IP addresses used within the gateway's management interface must be in xxx.xxx.xxx.xxx numeric format rather than a human-readable DNS-resolvable hostname.

Automatic Link-Local IP Address

E3Switch products are shipped with an initial IP address that conforms to recent zero-configuration link-local standards. This allows multiple E3Switch gateways on the same IP network to initialize with unique IP addresses without conflict and allows simple ping/HTTP/SNMP access to the gateways using hostnames e3switch.local or e3switch-2.local,... provided that, free, ZeroConf mDNS software has been installed on the machine attempting to communicate with the gateway. **Do not prefix www.** prior to e3switch.local. www.e3switch.local will not work.

If powered-up on a connected LAN, the gateways negotiate between themselves to determine which gateway is assigned name e3switch.local and which receives e3switch-2.local and so on. Since the assigned name will not necessarily be fixed to a particular gateway after power cycles, the system manager will probably want to use/set the gateway's numeric IP address sometime during or after initial installation.

Web descriptions are available for ZeroConf mDNS and Link-local IPV4LL ip addresses. Free ZeroConf software such as Bonjour for Windows or Avahi is available for Windows/Linux/Unix machines.

Initial Numeric IP Address

The gateway can also be contacted at its initial default IP numeric address which always takes the form 169.254.aa.bbb. Units typically have the initial IP address listed on top of the chassis or can be initially contacted at the IP address above where aa.bbb matches the serial number listed on the front label.

The gateway's current IP and MAC addresses are both shown at the HTTP management screen.

Unknown IP Address Recovery

The following methods may be used to determine a gateway's IP address if lost or forgotten. Note that once determined, management communication with the unit may only be possible from a host configured to the same IP subnet address if the unit's default router address is invalid.

To manually discover a unit's IP address, unplug all LAN and BNC cables from the gateway and power cycle the unit. 30 seconds after powerup, the gateway will begin blinking out its IP address on the leftmost LED. Each digit is counted up as an orange blink with a pause between digits and a short blink for a 0. A decimal in the IP address is indicated with a green blink. For example, <orange><orange><pause><short-orange><pause><green>... would be an IP address that begins "20."

For those with access to packet sniffers, upon power-up, the gateway will broadcast several gratuitous ARP packets on its network ports which can be examined with a sniffer or packet monitoring software to determine a unit's IP address. The source Ethernet MAC address of such packets and E3Switch gateways is 00:50:C2:6F:xx:xx. Tcpdump or Wireshark are two readily available software packages to examine network packets.

Additionally, examination of the MAC address table of an attached LAN switch or router may provide the IP address if the E3Switch MAC address prefix (00:50:C2:6F:xx:xx) can be located.

Management Passwords

The HTTP management statistics page is initially accessible without a password. The HTTP settings page is initially modifiable within the first several minutes after powerup with username *admin* and no password. If the unit has not had its default password changed, after several minutes the settings page will be locked for security reasons. It is desirable to change the default password of the unit. For security reasons, changing the default password of the unit must be done within the first several minutes of any powerup. If the HTTP management password is lost or forgotten, it may be reset by accessing the HTTP management settings within the first minute after powerup and with no BNC cables attached to the unit.

SNMP statistics may initially be accessed using the read-only community name *public*. Write-community names and variable access authorization may be set through the HTTP management interface.

Security

Please also refer to the password section above.

HTTP Interface Security

Access to the HTTP management interface statistics and settings pages can be selectively limited to users knowing the HTTP management password, which is transmitted securely on the network using MD5 encoding. New values of management settings, or modifications of the administrator password are not encrypted and are visible to users monitoring network packets, as is statistical data requested by an MD5 authorized user or any information visible on a HTTP page.

When logging out from any secure webpage, the browser window should always be closed! Browsers typically continue to send administrator credentials continuously even after apparent logout.

SNMP Security

The gateway implements SNMPv2c, which is inherently an insecure protocol; however, the gateway enhances security by implementing view-based access management (VACM), which can restrict read or write access to specific management settings and statistics. When shipped, the gateway allows read access to "safe" SNMP statistics and prohibits read and write access to statistics and settings which could allow determination of network topology or interfere with normal link traffic. The VACM configuration can be updated through the HTTP management interface to meet the user's needs, and most SNMP variables can also be set through the HTTP management interface in a more secure manner than SNMP allows.

– SNMP VACM Security Warning –
As shipped, the default "safe_ro_view" is secure but not private.
View based access model VACM for SNMPv2c provides good restriction
of access to only specified statistics but no data privacy and
minimal user authentication. When a specific variable is enabled
for reading or writing, from a security perspective it should
be considered either public for reading or public for writing.
Alternatively, most configuration parameters can be set through
the HTTP password-protected interface which is secure.
Viewing snmpd.conf exposes it and community names to visibility by
3rd party network sniffers. All SNMPv2c data on the network
is visible. All community names can be "guessed" and, when used,
become visible to sniffers. Source IP addresses of requests
can be forged. Enabling a write community should be considered
insecure with respect to the specific view variables enabled.
Variables in the groups: interface, ds3, dot3 & mau, control the
link datapath; allowing write access allows disabling the link.
Specific variables disabled for all write users are secure.
Specific statistics disabled for all read users are invisible
and secure.

HTTP Management

The gateway contains a comprehensive, user-friendly HTTP management interface which allows a manager to monitor bit-error-rates on the DS3/E3 link, lost packets, and user-friendly status messages at a single, color-coded HTTP screen. A screenshot is available at www.e3switch.com. Most settings that can be modified via SNMP can also be set through the HTTP interface in a more user-friendly manner.

Refer to the configuration section of this document for guidance on specific settings.

Event Log File

A timestamped log of operating status and events may be accessed at the HTTP management administration page.

Resetting

Two options for resetting the gateway may be accomplished at the HTTP management administration page. A management software reset will reset counters, statistics, MIB variables, and management software of the gateway without interrupting data flow across the link. A hardware reset will temporarily interrupt link data flow as if the gateway had experienced a power cycle. For new functionality to take effect, a hardware reset is required after upgrading firmware but need not be initiated immediately. A software reset is not appropriate after upgrading firmware, as only the management CPU would be reset while the packet transfer CPU would be operating with the older, incompatible version of firmware.

SNMP

The gateway contains an SNMP agent which can respond to version 1 and version 2c requests for network statistics from remote SNMP clients. The agent can also generate notifications of important network events such as when network ports go up/down or experience high error rates. These trap notifications can be sent to multiple hosts if desired, and using free or commercial software, the receiving hosts can log the notifications or even generate email or pager messages for network managers.

SNMPv2c is inherently an insecure protocol, so the gateway implements VACM to restrict access to "safe" statistics and settings. Please refer to the security discussion section of this document.

SNMP configuration of various parameters such as community names and trap destinations is accessed through the HTTP management interface and is implemented as a configuration file having an snmpd.conf structure. Snmpd.conf is described by third parties in publicly available documents.

Statistics and settings accessible via SNMP are called MIB-variables and are organized in a hierarchical tree topology. The MIB variable trees implemented by the gateway include recent versions of the DS3/E3, interface, MAU, dot3, and many of the typical IP-network MIB trees. The full list of MIB trees available is listed by viewing the system.sysORTable of the gateway. As mentioned earlier, access to certain trees or variables is initially disabled for security reasons, but can be set as the user wishes through the VACM settings. The gateway can typically return 1000 MIB variables per second in bulk requests and support SNMP response message sizes up to 5000 bytes.

Upgrading Firmware

For activation of additional capabilities of the gateway, see the "Feature Activation" section. Feature upgrades do not necessarily require a firmware upgrade.

Firmware upgrades may be transferred to the gateway via the LAN port. A hardware reset, which will interrupt link data flow for several seconds, will be required at some point after the transfer in order to begin using the new firmware. Instructions for performing the TFTP transfer are included with all firmware shipments. The most common source of problems when performing upgrades is attempting a TFTP transfer in ASCII or text mode rather than binary or image mode.

Feature Activation/Upgrade

For activation of additional capabilities of the gateway after initial purchase, supply the factory with the serial number from the *front* of your gateway (also shown at the HTTP management page for recent firmware) and purchase an alphanumeric "factory upgrade key" which is entered at the HTTP management screen.

Chapter 5: Operating Modes and Configuration

Telecom

There are four, low-level configuration settings for TDM ports; though, typically, the default settings are appropriate:
- E3 vs DS3
- cable length (for long DS3 runs only)
- unframed or M13 vs C-Bit framing
- fractional or full-rate utilization

Use a "DS3" configuration setting for North America, Japan, and South Korea; otherwise, "E3" speed.

The cable length setting will transmit a slightly stronger signal on long DS3 coax runs. The M13/C-Bit setting sets the AIC bit in DS3 frames to either 0 or 1. This bit is typically ignored by the DS3 carrier; however DS3 carrier equipment set to autosense the incoming DS3 framing type will need this setting to be correct.

DS3 Circuit ID PMDL

DS3 Path Maintenance Data Link (PMDL) identification messages associated with C-Bit framed DS3 links may be received. Circuit ID messages convey human-readable, configurable, physical location information of the DS3 source equipment. PMDL Circuit ID messages facilitate confirmation of the data source when presented with a pair of unlabeled BNC cables.

Packet Flow

Packet Order

802.1p Class of Service (CoS), and DiffServ when appropriate, levels are configurable to ensure timely delivery of TDM packets through the LAN.

While traveling across packet switched networks, received packets may arrive out of sequence for a variety of reasons. E3Switch gateways will use sequence numbers, present in the packets, to restore original packet order.

Receive Jitter Buffer Depth and Latency

While traveling across packet switched networks, received packets may exhibit slight variations in traversal time. The function of the configured receive-buffer-depth is to absorb this jitter and ensure that there is always data available to present to the outgoing, constant-bit-rate, TDM circuit when an incoming LAN packet is delayed. Larger configured buffer depths result in greater latency, so it is desirable to determine the minimum required value for this setting. The amount of LAN packet jitter in the system can be determined at the HTTP web management status page by examining the "Min/Cur/Max Pkts Waiting" and "Jitter Buffer Underflow" counters. The "Jitter Buffer Depth" value should be adjusted at the HTTP web management settings page until no "Jitter Buffer Underflow" errors accumulate and the "Min Pkts Waiting" level is at least one. The typical latency incurred per, 1000-byte, LAN packet of jitter buffer depth in a full-rate TDM circuit is 0.2ms. Configuring a, rather deep, 5-packet buffer would introduce 1ms of delay into the system. For fractional TDM circuits with large TDM Frames per Packet settings described below, the latency introduced is the product of the "Jitter Buffer Depth" and the latency per LAN packet, which can become too large if care is not taken.

TDM Frames per Packet and Latency

For the following discussion, if the incoming TDM is unframed, the term "frame" simply refers to the number of TDM bits that would constitute a frame if framing were in effect.

Each LAN packet requires approximately 50-bytes of overhead for transmission. Accordingly, on limited bandwidth LANs, it is desirable to consolidate as many complete, TDM frames as possible into each LAN packet. At full T3 TDM speed, this results in two frames per packet and a latency of approximately 0.2ms. At full E3 speed, this results in seven frames per packet and a latency of approximately 0.3ms.

When fractional TDM is in effect, as little as 4-bytes per frame may be in use. In this case, transmitting only two frames per LAN packet would still result in a 0.2ms latency, while waiting for each TDM frame to arrive; however, only 8 bytes of each 64-byte minimum LAN packet, and thus 13% of the required LAN bandwidth, would be in use for actual TDM data. This efficiency level may be too low in limited-bandwidth applications such as satellite links. Increasing the number of frames per packets in this case will increase the efficiency of the transmission but at a cost of approximately 0.1ms latency per T3 frame or 0.05ms latency per E3 frame.

Latency in milliseconds is approximately equal to 1000 x [frames per LAN packet] x [bits per full TDM frame] / [full TDM bitrate] – where [bits per full TDM frame] is 4760 for T3 and 1536 for E3; full TDM bitrate is 44,736,000 for T3 and 33,368,000 for E3. To achieve 97% efficiency of a 10Mbit/s satellite link in a fractional E3 environment, 9.7Mbit/s of E3 data / 33.368Mbit full E3 rate x 1536 = 446 bits / 8 = 55 bytes per E3 frame in use, allowing about 26 frames per LAN packet. The latency incurred if this maximum efficiency packing were in use would be 1000 x 26 x 1536 / 33,368,000 = 1.2ms. This single-packet latency must now be multiplied by the typical or maximum jitter buffer depth described in the prior section of this document to estimate the entire latency of the system.

Port to Port Packet Flow

LAN-to-LAN

Full LAN-to-LAN packet flow can be enabled on a unit, if desired. This might be useful if it was desirable for incoming SFP management packets to exit the copper LAN Port 2 of the unit, along with the packets carrying TDM data, in order to reach and manage the remote gateway. LAN-to-LAN unidirectional flow for monitoring may also be configured if desired.

LAN-to-LAN should be used cautiously in combination with management or data-only LAN port settings. The blocking of a subset of traffic can result in network and spanning tree topologies which can be inappropriate or difficult to diagnose.

Loopback

C-Bit T3 TDM ports will respond to FEAC loopback requests. A TDM port can also be put into loopback via appropriate DS3-MIB SNMP commands.

LAN Port Settings

The hardware for two LAN ports exist on all gateways shipped; however, entry-level models ship with only 100Base-TX mode on LAN Port 2 enabled. See upgrades section of this manual to enable these additional features if required:.

- GbE, GigE 1000Base-T for the RJ-45 LAN Port 2
- jumbo frames (9600 bytes)

See the "Interoperability" section of this manual for information on packet lengths and detailed port connection/autonegotiation discussion.

The autonegotiation mode of the gateway must match the autonegotiation mode of attached LAN equipment. If autonegotiation is enabled on the gateway it must be enabled on the attached equipment. If disabled on the gateway, it must be disabled on the attached equipment. This requirement is necessary to fulfill 802.3 standards which mandate a fallback to half-duplex operation if an autonegotiation mismatch exists. The gateways require full duplex LAN connections to operate.

LAN Port Speed

1000Mbit/s LAN speeds are only available via the SFP port or if GbE LAN has been purchased.

100Mbit/s is generally preferred over 1000Mbit/s, which generates significantly more power-requirements, heat, and radiated noise even in the absence of packet flow. 1000Mbit/s may slightly reduce path latency, as an incoming LAN packet must be fully received before being forwarded to an outgoing port. The latency savings to receive or transmit a 1500-byte packet at 1000Mbit/s vs 100Mbit/s speed is 0.108 milliseconds (1500bytes/packet x 8bits/byte / (100Mbits/s) - 1500bytes/packet x 8bits/byte / (1000Mbits/s)).

Setting more than one LAN port to 1000Mbit/s is not recommended and may result in underflow/overflow errors in certain high packet load, memory-intensive cases.

Autonegotiation Problems

There are rare cases with older LAN equipment in which it may be necessary to disable autonegotiation. If CRC-errors or short packet errors are seen in the management statistics of the LAN port, the attached LAN equipment has probably configured itself to half-duplex mode and colliding packets are being lost. In such a case, autonegotiation should be disabled on both the gateway and the attached LAN equipment, with both forced to 100BaseTX full-duplex. Autonegotiation interoperability and standards were not well understood by the industry at the inception of 100BaseTX, resulting in some older LAN equipment not understanding the gateway's autonegotiation advertisement of strictly full-duplex capability.

SFP Second LAN Port

The SFP LAN Port 1 hardware exists on all gateways shipped and allows an SFP transceiver to enable out-of-band management, through either LAN port, or fiber-optic LAN connections of 10km or more. Refer to interoperability section of this document for compatible SFP transceivers.

Dedicated Management/Data LAN Ports

If the SFP Second LAN Port is in use, then either LAN port may be configured to pass TDM data packets or, selectively, to pass only management or only TDM data packets when such can be determined.

LAN-to-LAN forwarding should be used cautiously in combination with management or data-only LAN port settings. The blocking of a subset of traffic can result in network and spanning tree topologies which can be inappropriate or difficult to diagnose.

If a LAN port is configured for TDM data-only packets, the unit will drop incoming management packets destined for an E3Switch MAC address. This provides a moderate level of security. On a "data-only" LAN port, these management unicast packets and management broadcast/multicast packets may not be forwarded to the second LAN even if LAN-to-LAN traffic flow is configured.

VLAN

In some firmware versions it is possible to configure a VLAN ID for packets containing TDM data.

VLAN configuration settings shown at the HTTP management page may also be set for communication with the gateway's management entity.

As shipped, the unit will accept *management* packets with any VLAN tags and attempt to respond to the same. For more robust performance, specific VLAN tag settings can be configured.

Port Auto-Disable and Return-to-Service Delay

In addition to manually configuring a port as disabled, the gateway has the ability to delay a DS3/E3 port's return to service for a specified period of time after it has failed or disable a LAN port if both TDM circuits are down.

DS3/E3 Return to Service delay

The return-to-service delay prevents network topology thrashing if a TDM circuit is flapping up and down. Some TDM carriers will interrupt service for 50msec, once per day as a link test. A configurable, failure-time setting exists to prevent such tests from triggering a link-down, retun-to-service delay.

To exit the return-to-service delay, power-cycle the gateway or click the button which appears on the configuration HTTP screen of a gateway that is in configuration delay.

LAN Auto-Disable

The LAN port can be configured to automatically disable itself when no TDM circuit exists. This setting is useful for attached LAN equipment which requires the LAN port to go down in order to understand that the path to the remote network is no longer available. Use this setting cautiously, as management of the gateway will also no longer be possible through a disabled LAN port.

To exit the LAN-port-disabled condition, power-cycle the gateway, which will allow communication with the gateway for approximately one minute even if TDM ports are down.

Chapter 6: Interoperability

LAN

The LAN ports of the gateway support, at a minimum, all 100BaseTX Full-Duplex Ethernet connections up to maximum line lengths and are set to auto-MDI/MDIX to automatically detect/correct crossover vs straight LAN cable and autonegotiate for full-duplex and pause frame modes with the attached LAN equipment. Passwords may be purchased to upgrade to enhanced LAN port modes as described elsewhere in this manual.

The gateway will pass all unerrored packets which do not exceed 1650 bytes in packet length (9600 with jumbo frames enabled). This length allows QinQ, stacked VLAN, and extended packet-length router protocols to be passed without concern. The management agent accepts and responds with packets having MTU of 1350 bytes in order to automatically allow room for security protocol overheads.

Autonegotiation problems

There are rare cases with older LAN equipment in which it may be necessary to disable autonegotiation. If CRC-errors or short packet errors are seen in the management statistics of the LAN port, the attached LAN equipment has probably configured itself to half-duplex mode and colliding packets are being lost. In such a case, autonegotiation should be disabled on both the gateway and the attached LAN equipment with both forced to 100BaseTX full-duplex. Autonegotiation interoperability and standards were not well understood by the industry at the inception of 100BaseTX, resulting in some older LAN equipment not understanding the gateway's autonegotiation advertisement of strictly full-duplex capability.

It is highly desirable to leave autonegotiation enabled so that changing attached LAN equipment does not result in the new equipment defaulting to half-duplex if set to autonegotiate.

SFP LAN Port 1

This port is designed to be compatible with inexpensive, high-quality, copper or fiber-optic, SFP transceivers from Finisar, which allows LAN connections of 10km or more. Most other industry-standard SFP transceivers will work as well; however, fiber-optic features such as temperature and optical transmit/receive power and alarms will only be available if using Finisar transceivers. Non-Finisar copper, RJ45 SFP transceivers may only operate in 1000Base-T mode, while recommended transceivers from Finisar, and possibly Avago or 3Com will operate in 100Base-TX mode as well.

Pause Frames

The gateway generates no pause frames and ignores pause command frames sent to it.

Telecom

The gateway can transmit over a variety of E3 or T3/DS3 links (with appropriate media gateways) such as fiber optic, microwave radio, laser, copper, satellite, or a combination; however, the attachment interface is always via 75-ohm copper coaxial rather than optical. The TDM circuit may be either framed or unframed and supports both M13, M23, clear-channel, C-Bit, and G.751 framing. C-Bit framing is suggested for DS3 links.

Fiber/Copper Media Gateways

Transition Networks DS3/E3 Coax to Fiber Media Gateway, SCSCF3014-100 has been reported to lack the ability to properly maintain separate DS3/E3 transmit clock speeds in each direction and are not recommended. This problem typically manifests itself as frame slips or loss of TDM signal lock in one

direction at a rapid, consistent periodic rate, which is proportional to the difference in clock speeds of each TDM direction.

Chapter 7: Telecom Connections

Framing and Physical Link

The gateway can transmit the LAN data over a variety of E3, T3/DS3 links (with the appropriate media gateway) such as fiber optic, microwave radio, laser, copper, satellite, or a combination. The gateway may be used with a standard (i.e., M13, M23, clear-channel, C-Bit or G.751) framed or unframed, fractional or full-rate E3 or T3/DS3 link with AMI and HDB3 or B3ZS encoding. C-Bit framing is recommended for DS3 links. The gateway will report PMDL Circuit ID present on C-Bit links.

Each gateway regenerates the timing clock of the remote, received TDM bit-stream, within E3 and T3/DS3 standards. The receive and transmit clock rates are displayed at the unit's HTTP management page.

Telecom Cabling

For the E3 or T3/DS3 connection, two 75-ohm coaxial cables (one transmit and one receive) with BNC connectors are required at each end. It is important that 75-ohm cable be used and not 50-ohm cable. For long connections or in electrically noisy environments it may be important to use a high-quality 75-ohm cable which will have more consistent shielding and conduction. The maximum length of each cable shall be 440 meters for E3 or 300 meters for T3/DS3, but the acceptable cable lengths of equipment attached to the gateway must be met as well. For lengths over 135 meters, testing in field should be used to determine whether bit error rates are acceptable. Long cable lengths also require careful selection of cable type and attention to sources of external noise.

Third-party fiber to copper media gateways can be used with the E3Switch gateway to implement fiber-optic DS3/E3 links; however, refer to the interoperability section of this document for vendors to avoid.

Chapter 8: LAN Connections and Performance

LAN Ports

Each LAN port implements the following features to maximize LAN compatibility and link utilization and minimize packet loss:
- autosense/autoconfiguration/autonegotiation with the attached LAN.
- 100Mbit/sec data rates (1000Mbit/s via SFP or if GbE upgrade purchased).
- full-duplex LAN connection.
- data buffering.
- 1650-byte packet acceptance (1350 for mgmt and 9600 for jumbo).

These features and their ramifications are discussed below in more detail.

Autonegotiation

The network equipment attached to the LAN port of the gateway should be set for autonegotiation mode in order to allow the gateway to negotiate a 100Mbit full-duplex connection.

There are rare cases with older LAN equipment in which it may be necessary to disable autonegotiation. If CRC-errors or short packet errors are seen in the management statistics of the LAN port, the attached LAN equipment has probably configured itself to half-duplex mode and colliding packets are being lost. In such a case, autonegotiation should be disabled on both the gateway and the attached LAN equipment, with both forced to 100BaseTX full-duplex. Autonegotiation interoperability and standards were not well understood

by the industry at the inception of 100BaseTX, resulting in some older LAN equipment not understanding the gateway's autonegotiation advertisement of strictly full-duplex capability.

It is highly desirable to leave autonegotiation enabled so that changing attached LAN equipment does not result in the new equipment defaulting to half-duplex if set to autonegotiate. Autonegotiation must always be enabled for 1000Mbit/s links.

LAN Cabling

It is important to use the correct cabling for proper operation. Use UTP Category 5 network cable with RJ-45 connectors for the LAN ports, and do not exceed 100 meters (328 feet) in length. Either a straight-through or crossover cable may be used.

LAN Buffering, Loading and Flow Control

This gateway contains approximately 500kBytes of total packet buffer. Queue utilization can be monitored at the gateway's statistics HTTP page, and buffer overflow will appear as "Rx oflow" errors at the same HTTP page.

Chapter 9: TDM LAN Packet Format

General

A variety of different headers may be configured on the LAN packets that transport TDM data. The header format must be manually specified. The gateways do not currently negotiate with each other to determine packet format. **The header format must be identical for each pair of connected gateways.** Either SAToP or CESoTDM protocols may be selected depending upon whether full-rate or fractional TDM is desired.

Transport Layer

Depending upon the model purchased, LAN packets may be configured with simple MAC Layer 2 addressing or more sophisticated IP/UDP or MPLS headers.

Chapter 10: Troubleshooting

General

A great deal of diagnostic information is available by accessing the HTTP management interface of the gateway. Refer to the management section of this document for additional information.

The gateway's *front panel lights can provide useful information* but are often under-utilized. They are simple to read and can indicate where a data connection is being lost. It can be very helpful to learn their meaning and monitor flashes as a packet is received at each port.

Incoming Circuit ID is shown at the top of the gateway's HTTP management page for C-Bit DS3 links, facilitating confirmation of the remote data transmitter when presented with a pair of unlabeled BNC cables.

The Ethernet networks to which the gateway connects are complex and may contain thousands of devices, each of which requires proper configuration and performance. As such, network configuration and topology issues dominate when problems arise. When troubleshooting, solutions can be reached more rapidly by remembering that *the most frequent cause of problems arises from improper network configurations*.

The next most frequent source of problems generally arises from *faulty cabling or connectors* or incorrect cable type. Cabling must be UTP5 or better for LAN and 75-Ohm rather than 50-Ohm for TDM. If long TDM cable runs or an electrically noisy environment exists, high-quality coaxial cable will be required.

The least frequent cause of problems will be the hardware of the gateway itself. This statement is not due to a narcissistic point of view, but rather to the simplicity of configuration features on the gateway and the low-component count. A microwave radio link, for example, has waveguides that can fill with water, antennas that can become misaligned, foreign objects that can block the path. From a failure point of view, the gateway is a simpler device.

Performance

Performance issues are addressed in the prior chapters.

Interoperability

The interoperability section of this manual should be reviewed to ensure that appropriate equipment is connected to the gateway. Connected LAN equipment should adhere to 802.3 standards.

Pinging

Ping is not reliable. The protocol which ping programs use does not guarantee delivery of the data packets. **Ping programs from major software and hardware corporations are known to contain bugs, both in packet content and function**. Generally, however, nearly all of the ping packets on a test network that is not over-loaded should get through; if fewer are received, there is probably a problem.

The ping program is a useful, simple test for a TCP/IP Ethernet network. It is a program that sends a data packet from a source machine to a destination machine, which then returns a response packet. There is a plethora of information about ping and the free public-domain ping utilities available. Ping is often supplied as a standard operating system utility, and often the command "ping" followed by the destination machine's IP address or hostname is all that is required to be typed at the source machine's command line.

The default ping generates approximately one 64-byte packet per second. This is not a robust test. If convenient, locate a ping program or set command line parameters to generate perhaps 50 pings per second and try both small packets and large 1400-byte packets. Be aware that packets larger than 1400 bytes sometimes uncover bugs in the software of ping programs.

Step-by-Step Diagnosis

This section assumes that communication between two machines at opposite ends of the E3, T3/DS3 link (herein the link) is failing. If this is a test in the laboratory or without a TDM circuit present, be sure to read the previous "Laboratory Testing" section first.

1. If access to the HTTP management interface of the gateway is possible, many useful status messages will be displayed. Typically, any message highlighted in orange should be of concern. Error counters are of lesser concern if they are not incrementing, and some link errors would be normal as link cables are initially connected.

2. *The DS3/E3 **BER** light of the gateway should be illuminated and green*. This indicates that a valid, DS3/E3 waveshape is being received without bit errors and with proper framing. Refer to the front panel section of this document for other light colors.

    *The DS3/E3 **port** light of the gateway should be illuminated and green*. This indicates that a valid, framed carrier signal is being received from a remote E3Switch gateway. Refer to the front panel section of this document for other light colors.

    If flashing orange/black, the link is in a configured return-to-service delay mode as discussed elsewhere.

3. *Ensure a proper LAN cable is being used*. Straight-through or crossover cabling is acceptable. The LAN light of the gateway port to which any LAN is attached should be illuminated and green. If not, ensure that the attached equipment is set for autonegotiation and can accept 100BaseTX Full-Duplex links. Refer to front panel section of this document for other LAN light colors.

4. The network equipment attached to the LAN port of the gateway should be set for autonegotiation mode in order to allow the gateway to negotiate a 100Mbit full-duplex connection. Forcing either the gateway's or attached equipment's LAN port to 100Mbit full-duplex may not allow the proper autonegotiation and LAN connection to occur. There are rare cases with older LAN equipment in which it may be necessary to disable autonegotiation. **If CRC-errors or short packet errors are seen in the management statistics of the LAN port, the attached LAN equipment has probably configured itself to half-duplex mode and colliding packets are being lost**. In such a case, autonegotiation should be disabled on **both** the gateway and the attached LAN equipment with both forced to 100BaseTX full-duplex. Autonegotiation interoperability and standards were not well understood by the industry at the inception of 100BaseTX, resulting in some older LAN equipment not understanding the gateway's autonegotiation advertisement of strictly full-duplex capability.

5. Monitor lights during packet transmission:
    *   With LANs attached, verify, perhaps using pings, that data packets generated by a local machine cause the gateway's light of the connected LAN port to blink. If not, determine if there is an intermediate router or piece of equipment that is not properly forwarding the data packets to the gateway. Examine the Link/Activity light on the source machine and any intermediate machines to ensure they behave properly (usually flicker) as well.

6. Enlist the aid of a sniffer program to view at the source and destination machines exactly what data packets are being sent and received. Free public-domain programs such as Wireshark are readily available.

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Chapter 12: Technical Specifications and Standards

Please see separate specification datasheet.