

High-Speed Ethernet to Single/Dual DS3/E3 Network Extender V5.2

July 9th, 2008



Operating Information

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International Electrotechnical Commission (IEC) Statement

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Chapter 1: Description and Requirements

The E3Switch converters described herein are used in pairs to connect two Ethernet LANs via either one or two E3 or T3/DS3 links at up to 88Mbit/s actual user data rate per direction. The LAN interface is RJ45 100/1000BaseTX copper or SFP 1000BaseX fiber-optic. The telecom link must be point-to-point and may support either framed or unframed data. The two converters must have an E3 or T3/DS3 link between them. Reverse topology to bridge an E3 or T3/DS3 data-stream over an intermediate IP or Ethernet LAN is not possible.

The converters must be used in pairs. Single-ended operation is not possible – i.e., connecting Ethernet to a DS3/E3 PPP/HDLC backbone or remote router is not supported.

For ease of installation, the converter does not require a configuration setup and will typically work immediately upon connection of LAN and telecom cables.

The hot-swappable converter card draws a minimal amount of power and may be purchased in a variety of chassis. Single units ship in high-reliability fan-free chassis and are available in a 100-240VAC or a $\pm 7-50$ Volt DC models. NEBS-III, redundant-power chassis are available in 6-slot/1U and 20-slot/3U versions.

Both HTTP and SNMP management of the converters is possible either in-band through the LAN or telecom ports or out-of-band through either LAN port if the software option to enable the second LAN-SFP port has been purchased. Firmware shipped prior to June, 2007 does not support management.

Remote firmware upgrade to a converter is possible through either the LAN or DS3/E3 connection (for converters containing firmware shipped after February, 2007).

If the dual DS3/E3 option or password upgrade has been purchased, then LAN data is forwarded at twice the single-DS3/E3 data rate across the link. The converter will monitor the telecom connection status and automatically switch to an available link should a single DS3/E3 link fail. Firmware shipped after April 2008 has the ability to maintain strict packet order at the receiving end of dual DS3/E3 links if desired and automatically choose the lowest-latency DS3/E3 path during transmission.

The converter will buffer data, and implements flow-control and quality-of-service mechanisms to eliminate data loss. This model will NOT perform MAC address filtering to forward only required packets across the telecom-speed link.

The converters at each end of the telecom link are identical and each generates its own DS3/E3 transmit clock. There is no master/slave relationship. If spare units are being purchased, only one rather than two is required.

The converter will pass all error-free packets unaltered which do not exceed 1650 bytes in length (or 9600 bytes with jumbo-frame upgrade). This included stacked-VLAN, q-in-q frames and all modern router protocols.

The converter has been designed with attention paid to maximum throughput, minimum latency and minimal packet loss. As such, it often significantly outperforms similar switches on the market – under some conditions operating twice as fast. The converter is often both a cost effective and bandwidth efficient alternative to routers or their associated telecom cards, which, in addition to being expensive, usually introduce HDLC bandwidth loss and associated inefficiencies of 10% or more.

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

Chapter 2: Quick Set-up

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

Attach an Ethernet UTP5 cable from your LAN equipment to the RJ-45 LAN port #2. The converter can perform automatic cross-over vs. straight-through cable adaptation. The LAN 2 light should will change from orange to green if a properly negotiated link has been established. **The network equipment attached to the LAN port of the converter should be set for autonegotiation mode in order to allow the converter 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 interoperability section of this document for more information

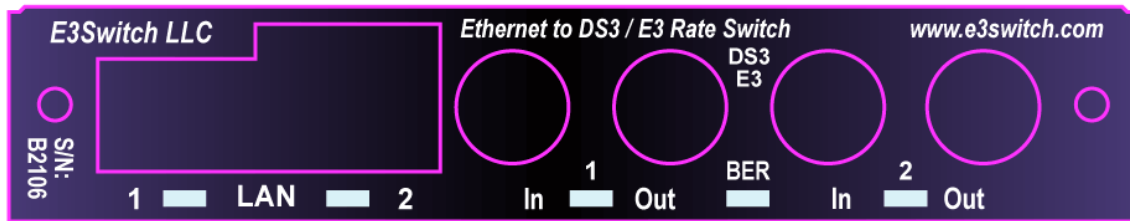
Attach two 75-ohm coaxial cables from either Port 1 or 2 BNC connectors of the converter to the input and output connectors of your E3 or DS3 link. Once each converter is receiving a valid signal from the remote partner, the DS3/E3 Port LED will change from orange to green This indicates that the converter has achieved proper sync lock with the remote converter. A green indicator will only be seen if a remote E3Switch converter is connected.

Refer to the management chapter of this manual if HTTP or SNMP operating statistics are desired or to change the default administrator password.

There is no further configuration or setup required for the converter.

Chapter 3: Front Panel

Front Panel Indicators



- All Indicators: Green indicates normal operation.
Any orange indicates an error condition.
Black indicates a disabled port.
- DS3/E3 1/2: Green if the unit has synchronized to a valid carrier signal pattern from the remote unit and data can be transferred on the link.
Flashes black each time a packet is received on this port.
Orange indicates no valid connection or loss of receive sync with remote unit.
Flashes orange/green if incoming signal is OK but remote unit is not receiving a valid sync from local unit.
Flashes orange/black if link is OK but waiting in a configured return-to-service delay period.
- 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.
Note: In a dual DS3/E3 unit, the BER will reflect the status of an operational link if one fails.
- LAN1/2: Green when a properly negotiated 100/1000BaseTX Full-Duplex or SFP LAN connection exists.
Flashes off each time a packet is received on this port.
Orange indicates no valid connection.
Flashes orange/black if in a configured "down if telecom down" mode.

Chapter 4: Remote Management HTTP and SNMP

Converters shipped or upgraded with firmware after March, 2007 contain an HTTP web management interface. Converters shipped or upgraded with firmware after June, 2007 contain an SNMPv2c agent.

Unit's IP/MAC Address

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

If the unit contains a management interface as described [above](#), it 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 converter, it may be necessary to set the network address of the host port communicating with the converter to 169.254.xxx.xxx with subnet mask 255.255.0.0. For security, routers are advised 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 web management interface of the converter, the converter'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 converter'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 converters are shipped with an initial IP address that conforms to recent zero-configuration link-local standards. This allows multiple E3Switch converters on the same IP network to initialize with unique IP addresses without conflict and allows simple ping/HTTP/SNMP access to the converters using hostnames `e3switch.local` or `e3switch-2.local`,... provided that the free [ZeroConf](#) mDNS software has been installed on the machine attempting to communicate with the converter.

The converters negotiate between themselves to determine which converter 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 converter after power cycles, the system manager will probably want to use/set the converter'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 converter can also be contacted at its initial default IP numeric address which always take the form 169.254.aa.bbb. Units shipped after October 20th, 2007 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. For units shipped prior to November, 2007, serial numbers listed on the front label translate to IP addresses as follows:

- .51.bbb => .51.bbb
- .15.bbb => .49.bbb
- IP3.bbb => 51.bbb
- B2hh6 => .50.bbb where bbb is the base10 decimal version of the base16 hexadecimal number hh.

The converter's current IP and MAC addresses are both shown at the web-management screen.

Unknown IP Address Recovery

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

For firmware dated July 9th, 2008 or later, unplug all LAN and BNC cables from the converter and power cycle the unit. 30 seconds after powerup, the converter 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 earlier firmware or those with access to packet sniffers, upon powerup, the converter 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 converters 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

Note: In order to log in with Internet Explorer 7+ or if difficulty occurs when logging in with known-valid credentials, firmware prior to October 18th, 2007 must be upgraded to ameliorate a new feature present in IE7 authentication messages. This is also the case with some versions of Opera. Contact the factory for an upgrade or attempt login with FireFox, Mozilla, or a browser earlier than IE7+ for immediate resolution.

The web management statistics are initially accessible without a password. The web settings are initially accessible within the first several minutes after powerup with username *admin* and no password. If the unit hasn't had its default password changed, after several minutes the settings 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 powerup. If the web-management password is lost or forgotten, it may be reset by accessing the web-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 web-management interface.

Security

Please also refer to the password section above.

Web Interface Security

Access to the web-management interface statistics and settings can be selectively limited to users knowing the web-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 web 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 converter implements SNMPv2c, which is inherently an insecure protocol, however the converter 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 converter 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 web-management interface to meet the user's needs, and most SNMP variables can also be set through the web-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 Web Management

The converter contains a comprehensive, user-friendly web 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 web interface in a more user-friendly manner.

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

SNMP

The converter 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 converter 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 web-management interface and is implemented as a configuration file having a `snmpd.conf` structure. `snmpd.conf` is described by 3rd-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 converter 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 converter. As mentioned earlier, access to certain of the trees or variables is initially disabled for security reasons, but can be set as the user wishes through the VACM settings. The converter can typically return 1000 MIB variables per second in bulk requests and support SNMP packet sizes up to 5000 bytes.

Chapter 5: Operating Modes and Configuration

Telecom

There are only three necessary configuration settings for telecom ports:

- E3 vs DS3
- cable length (for long DS3 runs only)
- M13 vs. C-Bit (for DS3 only).

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.

Packet Flow

Packet Order and Channel Bonding/Aggregation

On single-telecom converters, LAN packets delivery order is guaranteed with the exception that high-priority 802.1p CoS packets may be transmitted before lower priority packets. The remainder of this section applies to dual-telecom units only.

Dual DS3/E3 converters have three settings available for DS3/E3 utilization:

- Failover
- Load-Balancing
- Bonded (in firmware beginning March 2008)

Failover mode utilizes only one DS3/E3 channel and transmits only sync signals on the other DS3/E3 channel unless the first fails. This setting is generally not useful, as the other two settings will also revert to a single operational channel if either fails.

The next two modes determine packet order preservation. While traveling across dual telecom links, packet ordering can be lost as short packets arrive on one path before longer packets on the other or if telecom path lengths differ. As an aside, to reduce latency, E3Switch converters dynamically compute telecom path delays and attempt to use the shorter path first.

“Bonded” mode guarantees packet delivery order is preserved, although high-CoS traffic will bypass low-Cos traffic. In “load-balancing” configuration, or for firmware shipped before March 2008, packet order is generally maintained but not guaranteed.

The optimum settings for bandwidth, latency performance or data integrity is often determined only by trying each setting in the field. “Bonded” is preferred from a data-integrity and interoperability standpoint;

however, “load-balancing” mode will generally deliver packets to their final destination faster, especially for very high traffic loads of consistently small packets (<128 bytes).

Link aggregation (bonding) of the telecom channels allows packets to be delivered to the remote converter's LAN port in the same order in which they were presented to the local converter's incoming LAN port. The E3Switch converters do this in a highly-efficient manner which allows full bandwidth of both telecom channels to be utilized. 802.3ad link aggregation is not used and is a less efficient protocol which would segregate specific “conversations” to specific telecom links, leaving the bandwidth of the second path unavailable for utilization by a particular “conversation”.

Maintaining strict packet order can sometimes be detrimental. The TCP protocol already has some ability to assemble incoming packets in their correct order. In such a case, waiting to deliver packet number three until packet two has arrived at the converter simply introduces additional latency. If a packet is lost, this latency can grow larger until the loss is recognized. E3Switch converters have the ability to immediately recognize packet loss if successive packets are received from the same telecom channel, and in the worst case will not delay longer than 10ms waiting for a missing packet. Maximum packet-per-second forwarding rates can also be impacted if the bonding mode is required to re-order packets which are consistently < 128 bytes in length.

Maintaining packet order is most useful for non-TCP traffic such as financial UDP data where some expectation may exist for the data to arrive in the correct order.

Port to Port Packet Flow

Packets typically pass between LAN and telecom ports and are typically not filtered by MAC address.

Packets arriving at one telecom port will not be passed out the other, so it is not possible to use one dual-channel converter in a 3-unit topology at the junction of a Y or V; use two converters at such a junction with a LAN switch or router to properly control traffic flow to the branches of such a topology.

LAN-to-LAN

LAN-to-LAN packet flow can be enabled, if desired, in units where the second SFP/LAN port has been enabled. LAN-to-LAN unidirectional flow for monitoring may also be configured if desired.

LAN-to-LAN flow can result in dropped packets if the destination LAN port bandwidth is too low. An example would be 2x 44Mbit/s traffic from a dual-DS3 and > 12Mbit/s traffic from the other LAN port exceeding 100Mbit/s of a 100Base-TX LAN port which was receiving both DS3 and LAN-to-LAN traffic. The unit will attempt to preserve incoming DS3/E3 packets while dropping LAN-to-LAN packets in such an instance.

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.

Forwarding

Certain packets are not forwarded. Management unicast packets destined for the local unit are not forwarded. Dual-LAN units can be configured for management-only LAN ports which will drop incoming unicast packets not destined for an E3Switch MAC address. Spanning-tree packets are passed transparently between LAN and DS3/E3 ports, but not necessarily between LAN and LAN ports.

Loopback

Packet flow from DS3 ports to LAN can be configured to automatically disable in certain situations in which the converter is receiving loopback data. This prevents attached LAN equipment from becoming confused or disabling ports when it receives packets with MAC addresses that it has sent. The automatic loopback traffic disable will only occur if the local converter has requested the remote to loopback. This

occurs when an SNMP request sets the local converter dsx3SendCode variable to dsx3SendLineCode, which requests the remote converter to loopback DS3 data received. DS3 loopback initiated by the carrier or any source other than described above cannot be recognized as loopback data and the setting described will be irrelevant.

LAN Port Settings

The hardware for two LAN ports exist on all converters shipped; however, entry-level models ship with only the RJ-45 100Base-TX mode enabled. See upgrades section of this manual to enable these additional features if required:.

- GbE, GigE 1000Base-T for the RJ-45 LAN port2.
- Jumbo frames (9600 bytes).
- SFP LAN port1 which can accept optical or copper (100/1000) SFP transceivers.
- If SFP port has been enabled, either LAN port can be configured as a dedicated out-of-band management port if desired.

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

The autonegotiation mode of the converter must match the autonegotiation mode of attached LAN equipment. If autonegotiation is enabled on the converter it must be enabled on the attached equipment. If disabled on the converter, 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 converters require full duplex to operate.

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 converter 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 converter's autonegotiation advertisement of strictly full-duplex capability.

SFP Second LAN Port

The SFP LAN Port 1 hardware exists on all converters shipped and may be enabled as purchased or enabled by purchasing an upgrade password. This upgrade enables 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 has been enabled, then either LAN port may be to pass all packets to DS3/E3 or to selectively pass only management or 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 data-only packets, the unit will drop incoming management packets destined for an E3Switch MAC address. This provides a moderate level of security. These packets and management broadcast/multicast packets may not be forwarded to the second LAN if LAN-to-LAN traffic is configured.

If a LAN port is configured for management-only packets, the unit will not forward, to the DS3/E3, unicast packets destined for non-E3Switch MAC addresses. Broad and multicast packets will be forwarded. LAN-to-LAN forwarding may occur if so configured.

VLAN

The converter passes all VLAN information, unaltered, between ports. VLAN configuration settings apply only to communication with the converter'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. These settings only apply to packets to and from the converter's management entity.

VoIP / Video or High-CoS Priority Frames

Receive queue space is reserved in the converter to allow frames with high 802.1p class-of-service (CoS) priority settings to bypass existing frames waiting to be transmitted to the DS3/E3. This allows voice, video and other high-priority traffic to experience low-latency transmission. Firmware shipped since July 2008 allows the "high" CoS level to be configured. Most VoIP traffic is tagged at CoS 5 or 6, so level 5 is typically a good setting for the high-CoS value. Prior firmware has the high-CoS level set at ≥ 6 . On such units, CoS can often be set/confirmed at 6 on the source VoIP equipment.

Port Auto-Disable and Return-to-Service Delay

In addition to manually configuring a port as disabled, the converter 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 telecom links are down.

DS3/E3 Return to Service delay

The return-to-service delay prevents network topology thrashing if a telecom link is flapping up and down. If the telecom link is the only path to the remote network, the return-to-service delay should probably be set to 0. During the time that a telecom port is in a return-to-service delay, management packets will continue to flow across the telecom link in order to allow management of the remote converter.

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

LAN Auto-Disable

The LAN port can be configured to automatically disable itself when no telecom link 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 converter will also no longer be possible through a disabled LAN port.

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

Chapter 6: Interoperability

LAN

The LAN ports of the converter 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 converter will pass all unerrored packets which don't exceed 1650 bytes in packet length (9600 with jumbo frames enabled). This length allows q-in-q, 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 in order to automatically allow room for security protocol overheads.

If LAN equipment appears to disable a port connected to the converter, be aware that “sophisticated” routers and switches will often disable a LAN port if data being sent appears similar to data or MAC addresses being received, as is the case in telecom loopback.

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 converter 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 converter's autonegotiation advertisement of strictly full-duplex capability.

It is highly desirable to leave autonegotiation enabled so that changing attached LAN equipment doesn't 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, SFP copper or fiber-optic 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

Unless disabled in the settings or through autonegotiation, the converter sends pause command frames to attached LAN equipment when the converter's incoming LAN buffers become nearly full. The converter ignores pause command frames sent to it.

VoIP / Video or High-CoS Priority Frames

Receive queue space is reserved in the converter to allow frames with high 802.1p class-of-service (CoS) priority settings to bypass existing frames waiting to be transmitted to the DS3/E3. This allows voice, video and other high-priority traffic to experience low-latency transmission. Firmware shipped since July 2008 allows the “high” CoS level to be configured. Prior firmware has the high-CoS level set at ≥ 6 .

Telecom

The converter can transmit over a variety of E3 or T3/DS3 links (with appropriate media converters) 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 point-to-point telecom link must be unchannelized – i.e., not subdivided into T1 or E1 channels. The telecom link 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.

Be aware that during loopback testing, “sophisticated” routers and switches will often disable a LAN port if data being sent appears similar to data or MAC addresses being received. This can cause confusion.

Fiber/Copper Media Converters

Transition Networks DS3/E3 Coax to Fiber Media Converter, 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 loss of telecom signal lock in one direction at a rapid, consistent periodic rate, which is the difference in clock speeds of each telecom direction.

Routers and Switches:

Be aware that during loopback testing, “sophisticated” routers and switches will often disable a LAN port if data being sent appears similar to data or MAC addresses being received. This can cause confusion.

Chapter 7: Telecom Connections

Framing and Physical Link

The converter can transmit the LAN data over a variety of E3, T3/DS3 links (with the appropriate media converter) such as fiber optic, microwave radio, laser, copper, satellite, or a combination. The converter may be used with a standard (i.e., M13, M23, clear-channel, C-Bit or G.751) framed or unframed, E3 or T3/DS3 link with AMI and HDB3 or B3ZS encoding. The link must be unchannelized – i.e., not subdivided into T1/E1 channels. C-Bit framing is recommended for DS3 links.

Each converter internally generates the timing clock of its transmitted bit-stream, within E3 and T3/DS3 standards. The timing of the bit-stream being received by the converter will depend upon the bit rate transmitted by the remote converter. The telecom carrier equipment should be configured to accept bit-rate timing from its locally connected E3Switch converter.

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 lengthy 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 converter 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 converters can be used with the E3Switch converter 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 if SFP or GbE upgrade purchased).
- Full-duplex LAN connection.
- Data buffering.
- Upstream pause-frame flow-control messaging.

- Quality of service high-priority queuing.
- 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 converter should be set for autonegotiation mode in order to allow the converter 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 converter 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 converter's autonegotiation advertisement of strictly full-duplex capability.

It is highly desirable to leave autonegotiation enabled so that changing attached LAN equipment doesn't 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 Segmentation and Packet Switching

This converter does not perform MAC address filtering. This reduces system latency by removing two steps of filtering that have already been performed by attached routers or switches.

LAN Buffering, Loading and Flow Control

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

If the converter's packet memory begins to fill up, the converter applies flow control techniques to the machines connected to its LANs rather than simply dropping incoming packets. For connected 100/1000BaseTX LANs the converter uses 802.3x flow control. Flow control creates a much more efficient network by avoiding time-out requirements for packets that would otherwise be dropped during bursts of network traffic.

Unless disabled in the settings or during autonegotiation, the converter will transmit pause frames to attached LAN equipment when its buffer has reached approximately 60% capacity. The converter indicates to the attached equipment that it will not process received pause frames. It would be unlikely that such frames would be useful as the maximum data rate received from the converter is less than the DS3 rate.

If overflow errors appear on 1000Mbit port statistics at the converter, confirm that the pause packet counter is incrementing and that the attached LAN equipment can accept pause packets. If the overflow errors disappear when the LAN port speed is reduced to 100Mbit/s, it is possible that the attached LAN equipment is not receiving pause packets in time to interrupt large 1000Mbit traffic bursts. It may be necessary to operate at 100Mbit/s in this case, if packet loss during bursts is unacceptable.

LAN Packet Priority

LAN packets may optionally contain class of service (CoS) information (802.1p information), which may be used to specify packets that are time-critical. Queue space is reserved in the converter to allow frames

with a 802.1p CoS priority setting ≥ 6 (configurable in firmware beginning July 2008) to bypass existing frames waiting to be transmitted to the DS3/E3. This allows voice and other high-priority traffic to experience low-latency transmission.

LAN Packet Order

On single-telecom converters, LAN packets order is guaranteed with the exception that high-priority 802.1p CoS packets may be transmitted before lower priority packets. On dual-DS3/E3 converters, packet reassembly order is guaranteed (with bypass of high-CoS traffic) if configured in “bonded” mode (on firmware beginning March 2008). For “load-balance” configuration, or on firmware shipped before March 2008, packet order is generally maintained but not guaranteed. Refer to the configuration section of this document for further discussion.

TCP/IP and General Performance Tuning

In a TCP/IP environment, maximum performance across the E3, T3/DS3 link will be achieved by adjusting TCP/IP communication parameters of all LAN equipment attached to the converter including equipment attached indirectly via hubs, switches or bridges. It should be possible to achieve TCP/IP transfer rates within 5% of the theoretical maximum of 44Mbit/s for T3/DS3 or 34 Mbit/s for E3. The most important parameter to adjust for maximum performance is the TCP window size. A valuable TCP/IP performance testing tool called IPERF and many excellent links to how to set TCP parameters are available at: <http://dast.nlanr.net/Projects/Iperf/>

Dual-DS3/E3 converters will experience different throughput and latency if the “Port Bonding” parameter is configured as “Bonded” or “Load Balancing”. Refer to the operating modes and configuration section of this document for more information.

Chapter 9: DS3 Packets and Link Topology

Link Bit-Errors

The converters at each end of the link will maintain synchronization with each other even at very high DS3 bit-error rates. The converter will count and drop packets with FCS/CRC and length errors

Link Aggregation

Refer to the configuration section of this document for a thorough discussion.

Chapter 10: Troubleshooting

General

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

The Ethernet networks to which the converter interfaces 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 exists from improper network configurations*.

The next most frequent source of problems can arise from the E3, T3/DS3 *link configurations* or faults -- in other words, the microwave radio or fiber optic link or the interface and associated configuration settings between such equipment and the converter. It is important that the telecom link is operating in unchannelized mode.

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 telecom. If long telecom 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 converter itself. This statement is not due to a narcissistic point of view, but rather to the simplicity of configuration features on the converter and the low-component count. A microwave radio link, for example, has wave-guides that can fill with water, antennas that can become misaligned, foreign objects that can block the path. From a failure point of view, the converter is a simpler device.

The converter'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 what they mean.

Performance

Performance issues are addressed in the previous chapter.

Interoperability

The interoperability section of this manual should be reviewed to ensure that appropriate equipment is connected to the converter. Connected LAN equipment should adhere to 802.3 standards, and connected telecom equipment should be in unchannelized mode – i.e., not broken into T1 or E1 channels.

Laboratory Testing

The converters may be tested back-to-back before introducing a complicated E3 or T3/DS3 link. To do so, the E3, T3/DS3 output port from one converter should be connected to the input port on the second through an appropriate 75-ohm cable. The input port on the first converter should be connected to the output port of the second in a similar manner.

Pinging

PING IS NOT RELIABLE. The protocol which Ping programs use does not guarantee delivery of the data packets. It is common for ping programs to contain bugs. Generally, however, 99% 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 programs 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 telecom link present, be sure to read the previous “Laboratory Testing” section first.

1. *The DS3/E3 light of the converter should be illuminated and green.* This indicates that a valid, framed carrier signal is being received from the remote converter. If orange, LAN data will not be received by

the local converter and the loss of data is occurring on the link between the converters. If flashing orange, the remote unit is not receiving a valid sync from the local unit. Check the TX path starting at the local unit. Ensure the link is set up in unchannelized mode (not subdivided into T1 or E1 channels). Either M13 or C-Bit framing is fine but the configuration page setting should match.

2. *Ensure a proper LAN cable is being used.* Straight-through or crossover cabling is acceptable. The LAN light of the converter 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.
3. The network equipment attached to the LAN port of the converter should be set for autonegotiation mode in order to allow the converter to negotiate a 100Mbit full-duplex connection. Forcing the either the converter'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 converter 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 converter's autonegotiation advertisement of strictly full-duplex capability.
4. If Ping is available, ping from the local machine to a machine on the same local LAN. Then ping to the machine or router, on the same local LAN, that is directly connected to the converter. Then ping to the machine or router, on the remote LAN, that is directly connected to the remote converter. Then ping to another machine on the remote LAN. During pinging, attempt to generate high traffic loading on the network.
5. Try different types of communication with the remote machine. Some examples might be a ping, a file transfer, a telnet connection if appropriate, a web page viewing if appropriate, a "find" remote computer if appropriate. If some work and some don't but those that do work consistently, there is possibly a network configuration issue.
6.
 - With LANs attached, verify, perhaps using pings, that data packets generated by a local machine cause the converter's light of the connected LAN port to blink. If not, determine if there's an intermediate router or piece of equipment that is not properly forwarding the data packets to the converter. Examine the Link/Activity light on the source machine and any intermediate machines to ensure they behave properly (usually flicker) as well.
 - If the local LAN light blinks with each packet, next verify that the packet traverses the link by monitoring the DS3 Port light at the remote converter. If the remote DS3 Port light doesn't blink, there is either a link malfunction or an interface configuration problem or failure between the converter and the link. Perhaps change 75-ohm cables. Ensure the link is delivering unchannelized AMI HDB3 or B3ZS data to the converter. Ensure this configuration is proper at BOTH ends of the link.
 - If the remote DS3 Port light blinks, attempt to locate the Link/Activity light on the destination machine. Ensure that it flickers. If not, the problem may be with an intermediate router or hub or converter intercepting the packet.
7. Perform the prior examinations but in the reverse direction – from the remote machine back to the local machine.
8. 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 Ethereal are readily available.

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The SHA2 Copyright

FIPS 180-2 SHA-224/256/384/512 implementation

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The BZIP2 License

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The atHTTPD License

E3Switch gratefully acknowledges Anthony Tonizzo (atonizzo@gmail.com) for his selfless contribution of athttpd to the eCos community.

Chapter 12: Technical Specifications and Standards

General

E3Switch can often provide custom h/w and s/w solutions to meet requirements not shown below.

Indicators:	LAN Status/Rx; Telcom Status/Rx; Bit Error.
User Data Rate:	Single: DS3/T3: 43.4 Mbit/s ; E3: 33.2 Mbit/s . Dual DS3/T3: 86.8 Mbit/s ; E3: 66.4 Mbit/s
Aggregate Data Rate:	DS3/T3: 44.736 Mbit/s; E3: 34.368 Mbit/s.
Management:	SNMPv2c with VACM View-Based Access Control; HTTP comprehensive web interface; in-band through any port or out-of-band with second SFP LAN port option.
LAN:	100Base-TX to 1650 bytes (9600 byte and 1000Base-T options) – VLAN q-in-q – 1/2MByte buffers, SFP copper/optical available
VoIP/Video:	Dedicated VoIP queue for low-latency high-CoS 802.1p VoIP/video processing
Mechanical:	VAC: 4.75" wide 1U with 19"- rackmount brackets;VDC: 3.5" wide, DIN-railmount or rackshelf. 6-slot/1U and 20-slot/3U NEBS-III redundant power chassis available.
Electrical:	100-240VAC or ± 7 -50VDC. Redundant power chassis available.
Firmware Upgrades:	GbE/Jumbo-Frame ; Dual Telco Path with aggregation & failover; Optical/Copper SFP LAN

Network/Link

DS3/E3 Frame Format:	C-bit / M13 / M23 / G.751 – HDB3/B3ZS – Unchannelized (no T1/DS1/E1) or unframed.
DS3/E3 Waveshape Compliance:	ANSI T1.102-1993, Telcordia TR-NWT-000499 and GR-253-CORE, ITU-T G.703.
DS3/E3 Cabling:	DS3/T3: 300 meters; E3: 480 meters to radio/CSU; BNC – 75ohm one rx, one tx.
DS3/E3 Frame Lock:	250ms typical lock time. Lock maintained up to 10^{-2} BER typically.
LAN Layer-1:	100BaseTX full duplex – Autoneg/Auto-MDIX correction; 1000Base-X SFP and GbE options
LAN Layer-2:	802.3x flow-control; 802.1p CoS/priority for VoIP; 1650-byte packets (9600 for jumbo option); Transparent VLAN. Link aggregation for dual-channel option.
Packet Filtering:	No filtering. Broad/Multicasts forwarded to link; 500kByte buffering.
Packet Priority:	Seperate high-priority queue for 802.1p priority packets (i.e. VoIP/video).

Mechanical/Electrical

Dimensions (WxLxH):	VAC: 120mm x 215mm x 38mm (4.75" x 8.5" x 1.5") – ships with 19"rackmount brackets; VDC: 110mm x 100mm x 22mm (4.5" x 4.25" x 0.8") – DIN Rail or rack shelf mount. 6-slot/1U and 20-slot/3U NEBS-III redundant power chassis available.
Weight:	VAC: 1 kg / 2 lbs. – VDC: 0.5 kg / 1 lbs.
Power:	100-240VAC or ± 7 -50VDC – 3 Watts.
Power Connector:	VAC: IEC connector. VDC: Captive wire insertion
LAN Connectors:	RJ-45 with optional SFP port.
DS3/E3 Connectors:	Two 75-ohm BNC – one rx, one tx; Second optional T3/E3/DS3 channel.

Environmental

Operating Temperature:	0° C to 50° C (30° F to 122° F); Storage Temperature: -20° C to 70° C (-4° F to 158° F)
Operating Humidity:	10% to 90% -- Non-Condensing; Storage Humidity: 5% to 95% -- Non-Condensing

Regulations

RFI/EMI/RoHS:	FCC Part 15, Class A; EMC Directive (89/336/EEC) (CE Mark); EN55022, Class A; EN55082-1; AS/NZS 3548 (C-Tick Mark); ICES-003, Class A; VCCI, Class A; RoHS Compliant and others.
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