
LAN BRIDGE 150

LAN Bridge 150 Technical Manual

Order No. EK-LB150-TM-001

The *LAN Bridge 150 Technical Manual* is a reference document that provides technical information on the LAN Bridge 150 network bridge. This document also provides an overview, operational information, block-diagram level functional descriptions, and maintenance information on the LAN Bridge 150.

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digital™

EK–LB150–TM–001
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Preface

This manual is organized as follows:

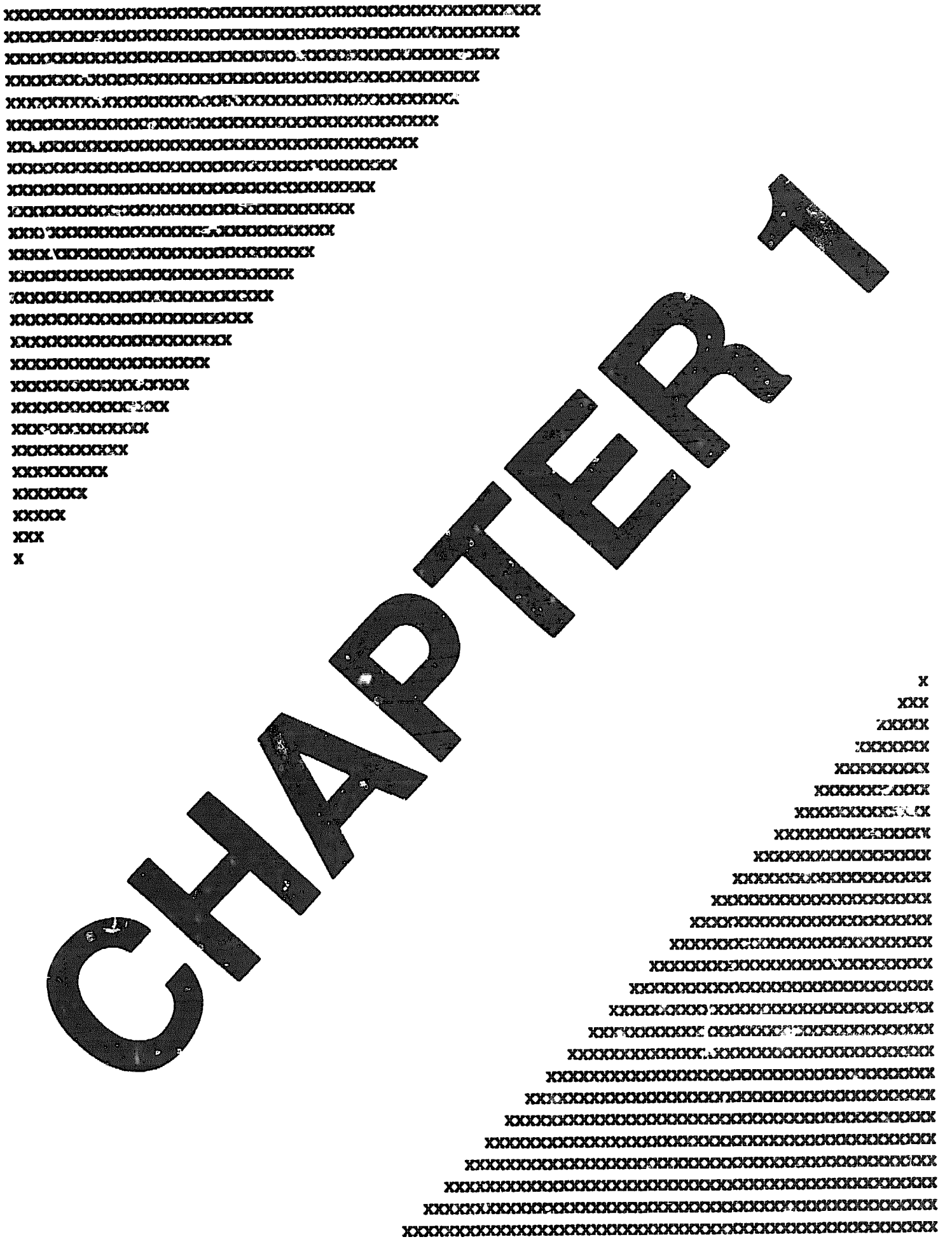
Chapter 1	Provides a overview of the LAN Bridge 150. Configuration considerations and LAN Bridge 150 specifications are also included.
Chapter 2	Discusses LAN Bridge 150 operating states and data structures. Also describes various features included in the LAN Bridge 150 unit, such as loop detection and message filtering.
Chapter 3	Provides block-level functional descriptions of the LAN Bridge 150 hardware circuits.
Chapter 4	Describes the maintenance procedures for the LAN Bridge 150.

RELATED DOCUMENTS

Additional information about the LAN Bridge 150 can be found in the following documents:

- *Communications Options Minireference Manual, Vol. 4* (Order No. EK-CMIV4-RM)
- *DECconnect System General Description* (Order No. EK-DECSY-GD)
- *DECconnect System Planning and Configuration Guide* (Order No. EK-DECSY-CG)
- *DNA Ethernet Node Product Architectural Specification* (Order No. AA-X440A-TK)
- *DNA Maintenance Operations Functional Specification* (Order No. AA-X436A-TK)
- *DECnet Router Installation/Operations Manual* (Order No. AA-X019-TK)

- *DECnet Digital Network Architecture Phase IV: Routing Layer Functional Specification* (Order No. AA-X435A-TK)
- *Ethernet Communications Server DECnet Router Software Installation Guide* (Order No. AA-X019B-TK)
- *Ethernet Transceiver Tester User's Guide* (Order No. EK-ETHTT-UG)
- *Field Maintenance Print Set* (Order No. MP01785-01)
- *Guide to Networking on VAX/VMS* (Order No. AA-Y512A-TE)
- *LAN Bridge 150 Installation* Guide (Order No. EK-LB150-IN)
- *LAN Traffic Monitor Installation Guide* (Order No. AA-JP15A-TE)
- *LAN Traffic Monitor User's Guide* (Order No. AA-JP16A-TE)
- *LAN Traffic Monitor Identification Card* (Order No. EK-LANTM-IC)
- *Remote Bridge Management Software Use* (Order No. AA-FY93C-TE)
- *Attenuator Installation and Configuration Reference Card* (Order No. EK-DEFOE-RC)
- *Bridge and Extended LAN Reference* (Order No. EK-DEBAM-HR)


CHAPTER 1

1

Introduction

1.1 Introduction to the LAN Bridge 150 Unit

The LAN Bridge 150 hardware unit, also referred to as the bridge, is a specialized local area network (LAN) station that connects multiple Ethernet networks to form a single extended local area network. You can use the bridge with baseband networks, broadband networks, or a combination of both. The stations connected within the extended LAN communicate with one another as if they were all on the same LAN. The connected LANs can be either Ethernet or IEEE 802.3 specification LANs or a combination of both.

1.1.1 Product Versions and Designations

There are two versions of the LAN Bridge 150 unit: the local bridge and the remote bridge. Table 1–1 describes the two versions. Both versions are shown in Figure 1–1.

Figure 1–1: Local and Remote LAN Bridge 150 Units

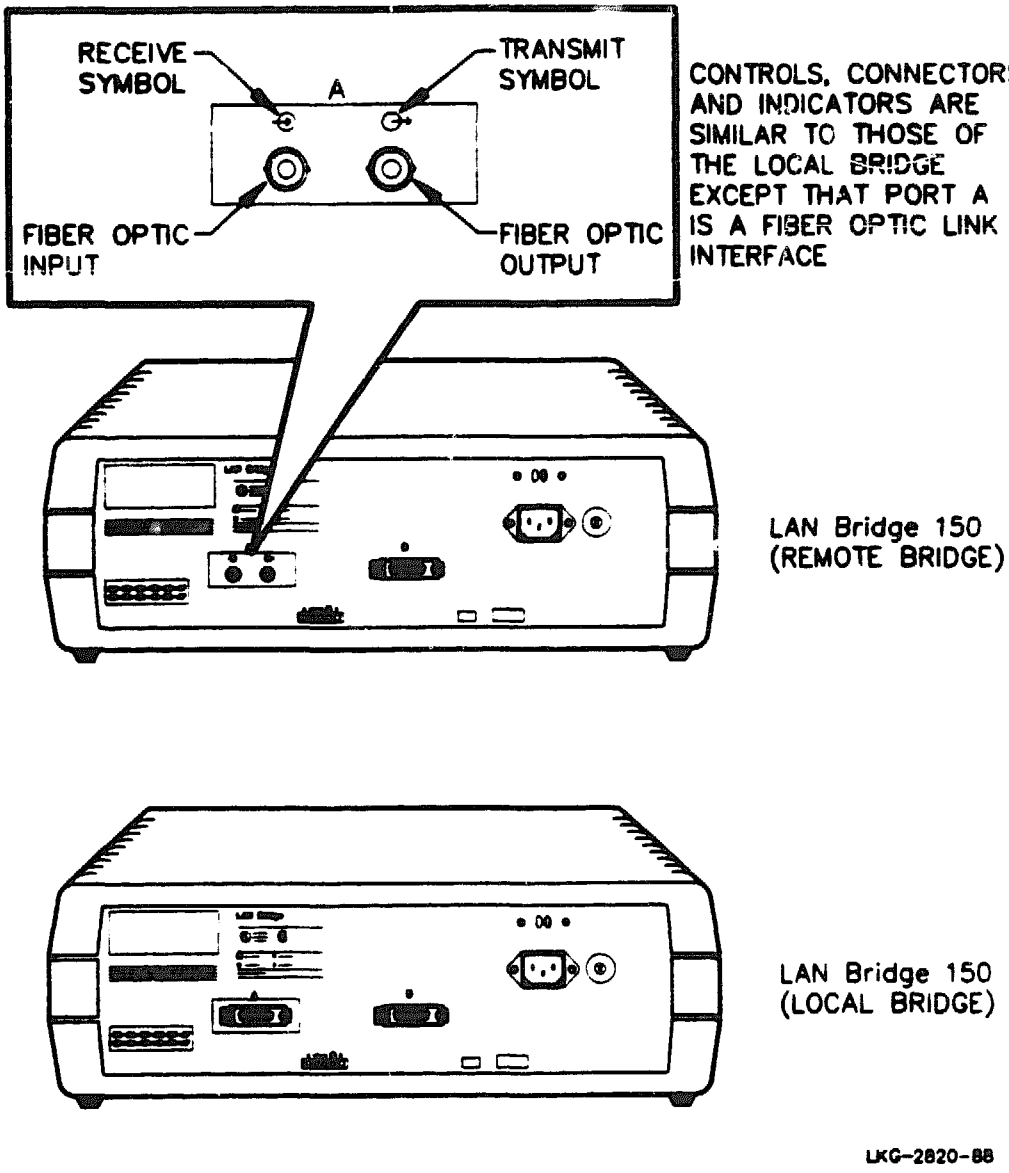


Table 1–1: Versions of the LAN Bridge 150

Version	Description
Local Bridge	Connects LANs separated by 100 m (328 ft) or less. The distance from the bridge to either LAN cannot exceed the maximum allowable transceiver cable length of 50 m (164 ft).
Remote Bridge	Connects LANs separated by more than 100 m (328 ft) or where fiber-optic cable capabilities are needed. A fiber-optic cable is used to connect two remote bridges or to connect a remote bridge and a remote repeater. A fiber-optic cable can be up to 3000 m (9842 ft) in length when connecting two remote bridges or up to 1500 m (4921 ft) when connecting a remote bridge and a remote repeater.

There are four model designations of the LAN Bridge 150 unit, as shown in Table 1–2. Note that the only difference between U.S. and European versions is the product labeling and the voltage selection switch setting.

Table 1–2: LAN Bridge 150 Product Designations

Model	Version	Power Requirements	Product Labeling
DEBET-AC	Local, AUI to AUI	120 Vac Nominal	U.S.
DEBET-AD	Local, AUI to AUI	240 Vac Nominal	Non-U.S.
DEBET-RP	Remote, AUI to 3 km fiber	120 Vac Nominal	U.S.
DEBET-RQ	Remote, AUI to 3 km fiber	240 Vac Nominal	Non-U.S.

The introduction of Ethernet and IEEE 802.3 LANs has reduced the cost and increased the capability of networking. This improvement has resulted in an increased demand for networking. To accommodate the increased demand, larger and denser networks are being created. However, as networks approach the design limitations of single-LAN technology, their performance may be degraded by the limitations.

The LAN Bridge 150 unit minimizes many single-LAN limitations by creating a high-speed, logical link between two LANs. Networks that are joined by bridges are called extended LANs. Note that each individual LAN can be of maximal configuration in terms of length, number of stations, and other specifications.

The LANs that make up this extended network can be either IEEE 802.3 or Ethernet baseband or broadband. The LAN Bridge 150 unit provides this logical extension without creating a bottleneck in the network.

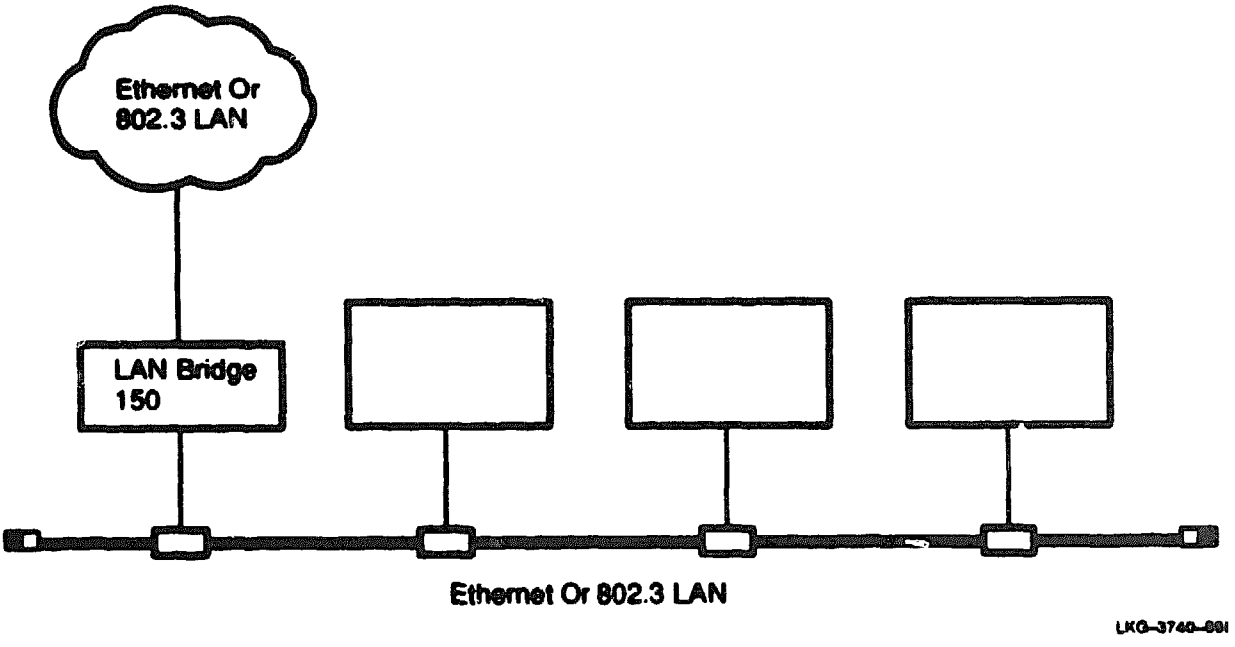
The LAN Bridge 150 unit dynamically learns the locations and station addresses of nodes for each of the networks that are connected to the bridge. This learning capability enables the LAN Bridge 150 unit to forward packets selectively, based on their destination addresses. In this way, the bridge can create an extended LAN that has the following advantages:

- More stations—Each LAN can still support its maximum number of stations including the bridge. However, the bridge is transparent to the stations; so the two LANs appear as one larger, extended LAN to all users.
- Larger network—Each LAN can still support the maximum length for a LAN, but the extended LAN can be much longer.
- Reduced traffic—The bridge forwards only nonlocal traffic. Thus, if a large LAN is broken into several smaller LANs, the traffic on any one of these smaller LANs may be greatly reduced.

1.1.2 Extended Networks

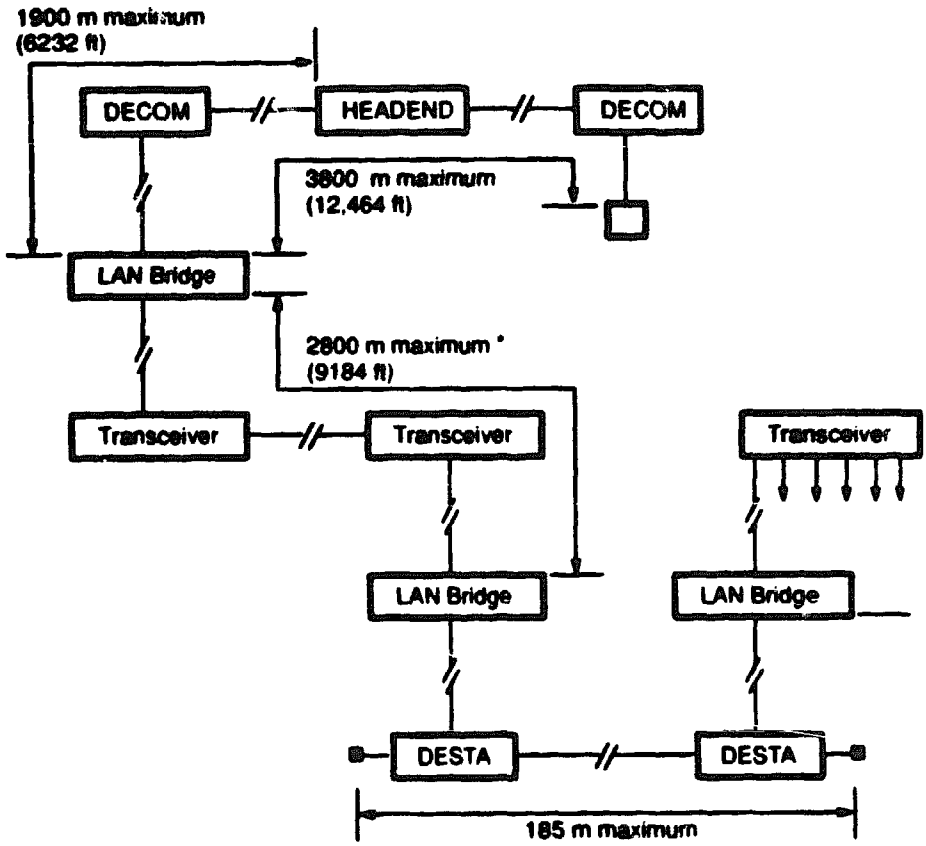
Figure 1–2 shows an example of an extended network that uses a LAN Bridge 150 unit. If these two networks were joined with a repeater instead of a bridge, all packets that originate on one of the networks would also appear on the other network. The LAN Bridge 150 unit filters packets so that only those packets destined for a station on the opposite network are forwarded. Packets destined for stations on the same network are filtered. This does not mean that all repeaters should or can be replaced by bridges. The two devices are functionally different, and a careful evaluation of the network requirements is needed to determine which device is more appropriate in a given situation.

Figure 1–2: LAN Extended by Means of a LAN Bridge 150 Unit



The Ethernet-type and/or IEEE 802.3-type networks that a bridge can connect can be two maximum-length broadband, two baseband (each with the maximum number of stations), or one of each. The LAN Bridge 150 unit can connect the two Ethernet-type LANs so that they appear as a single extended LAN. This allows a logical extension of an Ethernet LAN beyond the normal limitations of 2800 meters (9184 feet) for baseband or 3800 meters (12,464 feet) for broadband Ethernet (see Figure 1–3). Broadband and baseband Ethernet networks are each limited to 1024 stations; however, LAN Bridge 150 units can overcome this limitation by joining two or more LANs together, thereby creating an extended LAN.

Figure 1–3: Several LANs Connected With LAN Bridge 150 Units



* The 2800-meter (9184-foot) maximum distance between any two nodes is the sum of two 50-meter (164-foot) transceiver cables, three 500-meter (1640-foot) coaxial cable segments, four 50-meter (164-foot) transceiver cables connected to repeaters, and 1000 meters (3280-foot) of point-to-point lir -

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1.1.3 Transparent Operation

Bridge operation is transparent to other stations on the LAN, and no special software is required on any station unless the LAN Bridge 150 unit is configured to operate as a LAN Traffic Monitor (more information on the LTM feature is provided in the following sections). Remote Bridge Management Software (RBMS) version 2.0 is available for VMS hosts. RBMS allows you to observe and control any LAN Bridge 150 unit in the network.

1.1.4 LAN Bridge 150 to Network Connections

The LAN Bridge 150 unit connects to the network through a transceiver cable and one of the following devices:

- H4000 Ethernet transceiver (baseband)
- H4005 Ethernet transceiver (baseband)
- DELNI local network interconnect
- DECOM broadband modem
- DESTA Ethernet/IEEE 802.3 transceiver

The LAN Bridge 150 unit can be either a local bridge or a remote bridge. The local bridge is connected to two LANs through transceiver cables. The remote bridge is connected to one LAN through a transceiver cable and to either another remote bridge or a remote repeater over a fiber-optic link. Remote bridges can be used when the distance between LANs is more than 100 meters (328 feet) or where adverse environmental conditions exist.

The LAN Bridge 150 unit operates at the Data Link layer of the International Standards Organization (ISO) model and, therefore, is transparent to protocols above this layer. There are no jumper or switch settings required to make the bridge compatible with either 802.3-type or Ethernet-type LANs.

1.2 LAN Bridge 150 Functional Description

The LAN Bridge 150 unit provides a logical link between two LANs and extends the range of the LAN. The LAN Bridge 150 unit actually minimizes many of the limitations of conventional LAN systems and provides the following advantages:

- The LAN Bridge 150 unit selectively forwards or filters (disregards) packets based on the destination address contained in each packet.

  A dynamic address-learning capability enables the LAN Bridge 150 unit to acquire a working knowledge of the network configuration. By storing source addresses from received packets, the bridge learns which port (A or B of the bridge) is associated with each active station on the extended network.

  Once the LAN Bridge 150 unit has built a database of station locations, the bridge selectively forwards packets based on the destination address. This minimizes network congestion by keeping local traffic local and allows literally thousands of stations to be connected to the extended network.

- The LAN Bridge 150 unit functions at the Data Link layer and is protocol independent. This allows non-Digital Ethernet LANs to be included in the extended LANs. Typical protocols include DECnet, Xerox Network System (XNS), Transmission Control Protocol Internet Protocol (TCP/IP), Local Area Transport (LAT), or any protocols based on Ethernet or on IEEE 802.3 standards.

- The LAN Bridge 150 unit has an automatic backup feature that is based on its ability to learn the locations of other bridges in the extended network. When bridges are configured in a loop, one of the bridges automatically enters a BACKUP state. Thus the data link loop is broken and the BACKUP LAN Bridge 150 unit serves as a warm standby. This enhances network availability.

- The LAN Bridge 150 is IEEE 802.1 compliant and LAN Bridge 100 compatible (works with all previous Digital bridge products). A software switch allows you to select (lock in) 802.1 compatibility mode or select an autoconfigure compatibility mode (automatic mode) between 802.1 and LAN Bridge 100. The automatic mode allows bridges with either LAN Bridge 100 spanning tree or IEEE 802.1 spanning tree modes to work together in one configuration.

- The LAN Traffic Monitor (LTM) function is optional software available for use with LAN Bridge 150 units. This optional feature allows the LAN Bridge 150 unit to be used as a base from which to gather traffic data in the form of counters, and periodically forward them to a VMS operating system for compilation and analysis. More information on this optional feature is provided in Section 1.3.1.

- Optional Remote Bridge Management Software (RBMS) allows network operators to monitor and control individual bridges in the extended network. By using RBMS to change bridge parameters or to load a forwarding database over the network, operators can control the extended network better.

- Supports 802.2 test and exchange identification (XID) functions

1.3 LAN Bridge 150 General Description

All the controls, status LEDs, and connectors are located on the I/O panel of the LAN Bridge 150 unit. The I/O panel of a local bridge is shown in Figure 1–4, and the I/O panel of a remote bridge is shown in Figure 1–5. Table 1–3 through Table 1–6 describe the controls, status LEDs, and connectors available on local and remote bridges.

Figure 1–4: Local LAN Bridge 150 Controls, Status LEDs, and Connectors

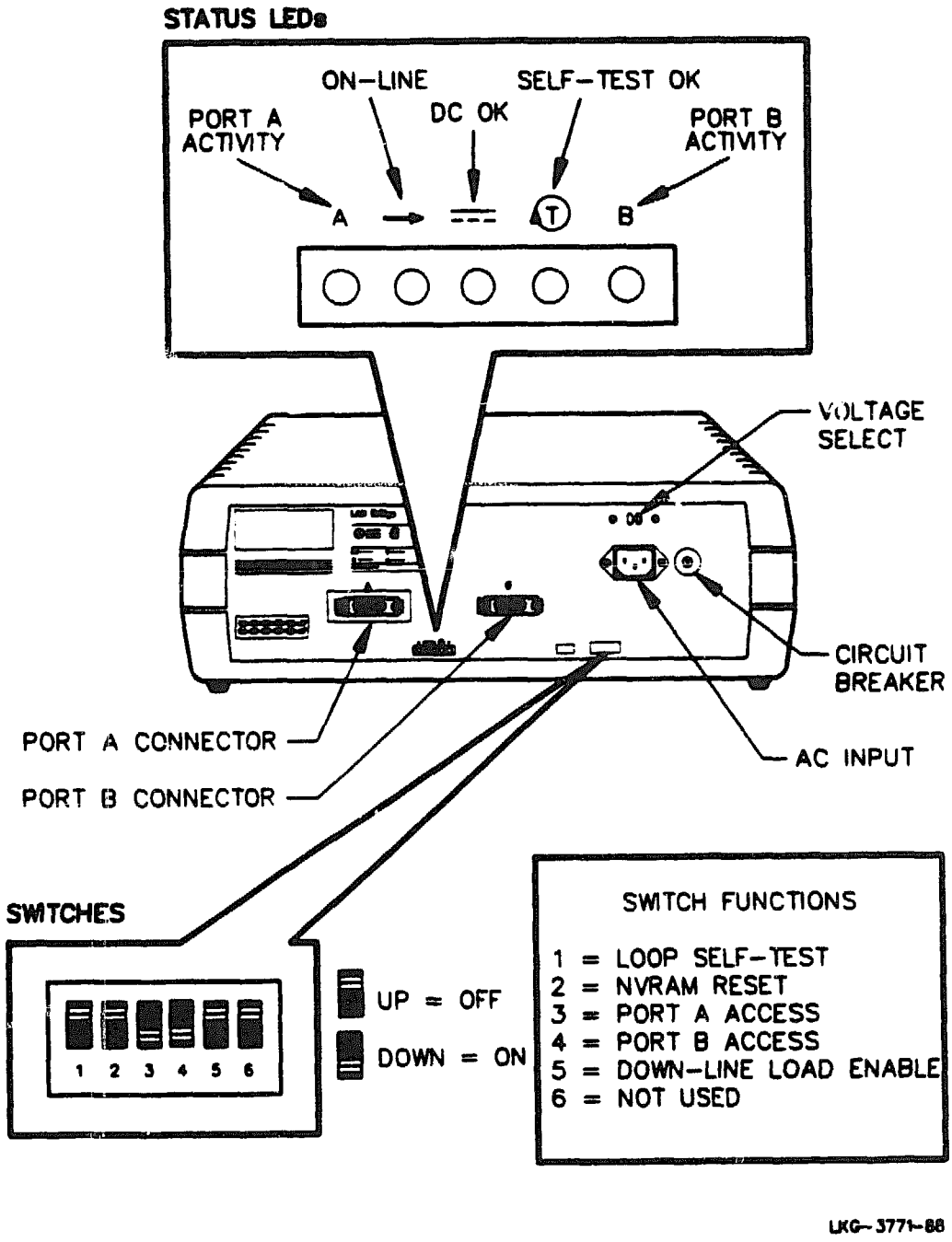


Figure 1–5: Remote LAN Bridge 150 Controls, Status LEDs, and Connectors

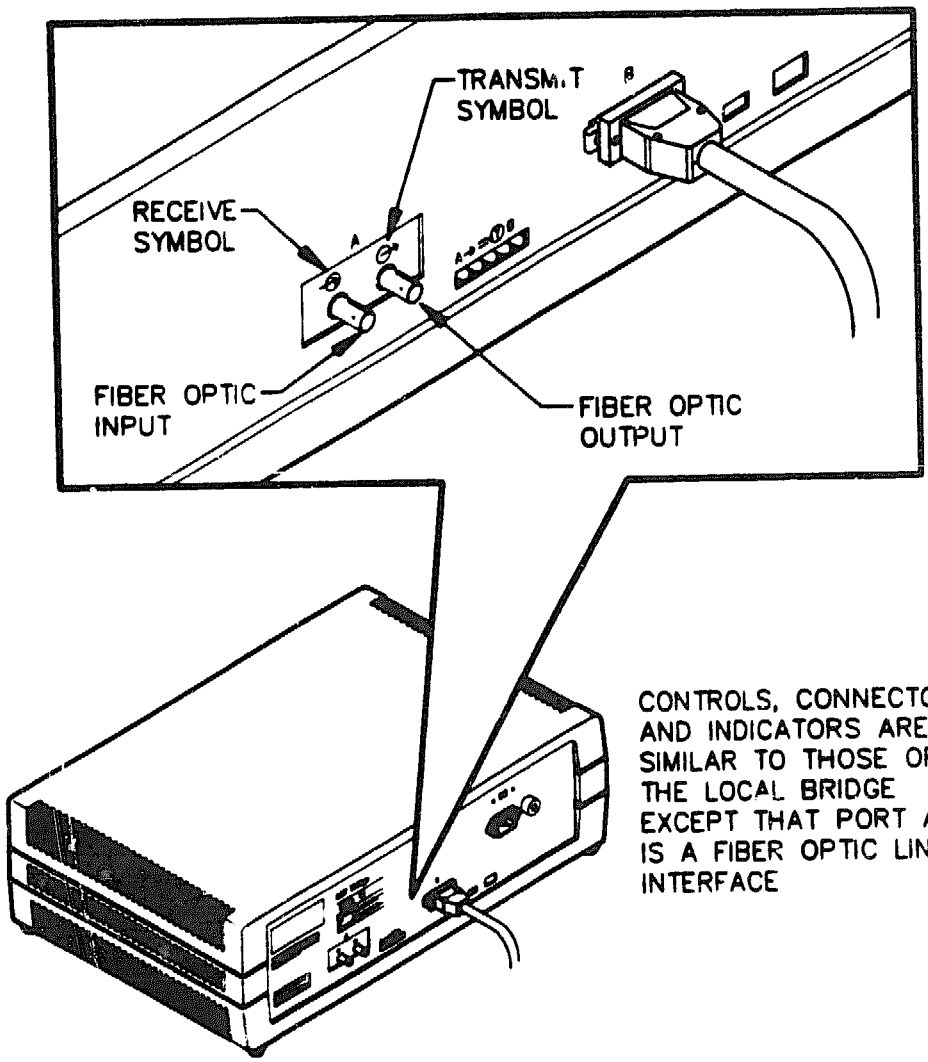


Table 1–3: LAN Bridge 150 Controls

Control	Description
Voltage Select Switch	Used to set the bridge input voltage to the range required for operation in your country. This switch was factory set for the correct power source for your country. Do not change this switch setting unless you are sure that it is incorrect (see your electrician if you are not sure).
Circuit Breaker	Provides overcurrent protection for the bridge. If an overcurrent condition causes the circuit breaker to trip, the white center portion of the circuit breaker pops out as a visual indication, and the ac power is cut off from the bridge. The circuit breaker can be reset by pressing in the white center portion.
Bridge Switches	These six switches control the LAN Bridge 150 functions. Each switch is described in Table 1–4.

Table 1–4: LAN Bridge 150 Switch Functions

Switch Number	Name	ON (Down)	OFF (Up)
1	Loop Self-Test[1]	The bridge loops self-test continuously after power up. Loopback terminators must be installed. This switch position is for manufacturing and field service use only.	Bridge runs self-test once powered up or reset.
2	NVRAM Reset[1]	NVRAM resets to factory default settings when the bridge is powered up. NVRAM Reset removes all bridge management configuration changes.	Prevents NVRAM from resetting to factory default settings when the bridge is powered up. This setting should be used to prevent the loss of parameters stored by RBMS during a power failure.

[1]Switch settings can be changed for port access while the bridge is operating. However, the switch settings for Loop Self-Test, NVRAM Reset, and Down-Line Load Enable are read-only during power up. Changing these switches while the bridge is operating has no effect on bridge operation. To change these switches, unplug the unit, change the setting, then plug the unit back in.

Table 1–4 (Cont.): LAN Bridge 150 Switch Functions

Switch Number	Name	ON (Down)	OFF (Up)
3	Port A Access[2]	Stations on the LAN connected to Port A that have bridge management capabilities are allowed to read and write (modify) bridge management parameters.	Stations on the LAN connected to Port A that have bridge management capabilities can read but cannot write bridge management parameters.
4	Port B Access[2]	Stations on the LAN connected to Port B that have bridge management capabilities are allowed to read and write (modify) bridge management parameters.	Stations on the LAN connected to Port B that have bridge management capabilities are allowed to read but cannot write bridge management parameters.
5	Down-Line Load Enable[1]	Configures unit to operate as a LAN Traffic Monitor. Enables unit to down-line load the LTM Listener software image from load host.	Configures unit to operate as a bridge.
6	Not Used	–	–

[1]Switch settings can be changed for port access while the bridge is operating. However, the switch settings for Loop Self-Test, NVRAM Reset, and Down-Line Load Enable are read-only during power up. Changing these switches while the bridge is operating has no effect on bridge operation. To change these switches, unplug the unit, change the setting, then plug the unit back in.

[2]Port A and Port B access switches can prevent bridge management software from changing any of the bridge's internal parameters. If security is a concern at the site, set the bridge's parameters with RBMS and then disable one or both ports by putting one or both switches in the up position. Bridge management software can still read the bridge's counters and other parameters. Placing either switch in the down position enables bridge management software write-access from stations on the LAN connected to that port of the bridge. Normally, both switches are placed in the down position to enable bridge management software write-access from stations on either LAN.

Table 1–5: LAN Bridge 150 Status LEDs

Name	ON Steady	OFF	Blinking
Port A Activity	A message is being received or transmitted on Port A.	No message traffic on Port A.	Short messages are being received or transmitted on Port A or the bridge is checking for loops (sending Hello messages) about once a second.
On-Line	Unit is configured as a bridge, is fully operational, and is forwarding messages.	When configured as a bridge, the unit is in the INITIALIZE, PREFORWARDING, BACKUP, or BROKEN state. When configured as an LTM Listener, the request for down-line load of the LTM Listener software image from a load host has failed.	The load host successfully down-line loaded the LTM Listener software image.
DC OK	Internal power supply is functioning properly.	Internal power supply is not functioning properly.	N/A
Self-Test OK	Passed self-test.	Running self-test.	NVRAM failed and requires replacement. This failure does not affect normal operation. *
Port B Activity	A message is being received or transmitted on Port B.	No message traffic on Port B.	Short messages are being received or transmitted on Port B or the bridge is checking for loops (sending Hello messages) about once a second.

*NVRAM stores network pointers, parameters, and addresses set by RBMS so that they are not lost in the event of a power failure. If the Self-Test OK LED is blinking, you can bypass the fault by setting the NVRAM Reset switch (switch 2 on the I/O panel) to the down (on) position, and then turning the bridge power off and on. (See Chapter 4 for more information on troubleshooting.) Note that NVRAM reset causes the bridge to use default parameters.

Table 1–6: LAN Bridge 150 Connectors

Connector	Description
ac Input	This connector accepts ac input voltages of 120 or 240 Vac, depending on the setting of the voltage selection switch (refer to Table 1–3).
Port A	For local bridges, this 15-pin, female, D-type connector accepts a transceiver cable. A slide latch is provided for locking the transceiver cable in place. The pins have the following definitions: 1. Chassis ground 2. Collision presence + 3. Transmit + 4. Ground 5. Receive + 6. +12 volt return 7. No connection 8. Ground 9. Collision presence – 10. Transmit – 11. Ground 12. Receive – 13. +12 volts 14. Ground 15. Ground For remote bridges, Port A has two fiber-optic connectors. The left-hand connector (marked ⊖) is for receiving optical data. The right-hand connector (marked ⊖) is for transmitting optical data.
Port B	For local and remote bridges, this 15-pin, female, D-type connector accepts a transceiver cable. A slide latch is provided for locking the transceiver cable in place. The pins have the same definitions as for Port A.

1.3.1 LAN Traffic Monitor (LTM) Option

The LTM is an Ethernet/IEEE 802.3 LAN monitor that uses the LAN Bridge 150 unit as a hardware base. Both versions of the LAN Bridge 150 unit (local or remote) support the LTM option. When the LAN Bridge 150 unit is configured to operate as a LAN Traffic Monitor, bridge operations are suspended until the unit is reconfigured for bridge operation. The LAN Bridge 150 hardware unit processes 48-bit Ethernet addresses, and the LTM software calculates the statistics. The statistics are periodically reported to a host system that performs additional data reduction, such as averaging and peak traffic analysis. LTM has two components:

- The LTM Listener—a LAN Bridge 150 hardware unit that is down-line loaded with LTM monitoring software.
- The LTM User Interface (UI)—remote application software that is installed on any DECnet VMS operating system with an Ethernet controller and associated driver.

For more information about the LTM, refer to the *LAN Traffic Monitor User's Guide*.

1.3.2 LAN Traffic Monitor Software

The basic software required for installing and operating the LTM follows:

- LAN Traffic Monitor distribution software—installed on each LTM load host.
- DECnet Phase IV software, running on VMS Version 4.4— installed on each LTM load host.

The distribution software must be installed on a load host that runs DECnet Phase IV software and that is connected to the same extended LAN as the LTM Listener. Digital recommends installing the LTM Listener software on a load host that is on the same LAN as the LTM Listener. Doing so avoids the possibility of segmenting the load host from the LTM Listener due to a bridge failure. The distribution software includes an LTM Listener software image file that is down-line loaded to the LTM Listener. All software must be installed and verified before operating the LTM.

1.3.3 Remote Bridge Management Software (RBMS)

RBMS is an optional product available for VMS hosts. RBMS significantly enhances the network's operation by allowing you to observe and control bridges in the network. RBMS allows you to:

- Understand and modify your network topology by displaying and modifying the bridge forwarding database.
- Evaluate network performance by displaying bridge counters, status, and characteristics.
- Troubleshoot network problems by understanding your network topology, disabling selected bridges to segment your network, and signaling selected bridges to run their built-in self-test diagnostics.
- Save your configuration data in the bridge's nonvolatile RAM (NVRAM) so that it is not lost during a power failure. Changes are saved by bridge hardware.

NOTE

Before beginning problem solving, show and record bridge parameters. This will help recover any specific parameters lost during problem solving (an NVRAM reset will discard all parameters). To do this, type the following commands at the RBMS prompt:

```
RBMS>  USE LAN BRIDGE X
(X = enter bridge name or bridge hardware address)

RBMS>  SHOW SPANNING CHARACTERISTICS TO X.Span
       (X = bridge_name or address)

RBMS>  SHOW MANAGEMENT ADDRESSES TO X.Address
       (X = bridge_name or address)
```

- Remotely switch the LAN Bridge 150 unit between automatic mode and IEEE 802.1 mode.
- Password protection.
- Remotely determine whether the LAN Bridge 150 unit is operating as an LTM Listener or a bridge.

For more information on RBMS, refer to the *Remote Bridge Management Software Use*.

1.4 Configuration Considerations

This section describes some configuration considerations that apply to implementing extended LANs with LAN Bridge 150 units. Refer to the *DECconnect System Planning and Configuration Guide* for additional information on LAN configuration.

LANs connected by bridges appear as one extended LAN as far as data traffic is concerned.

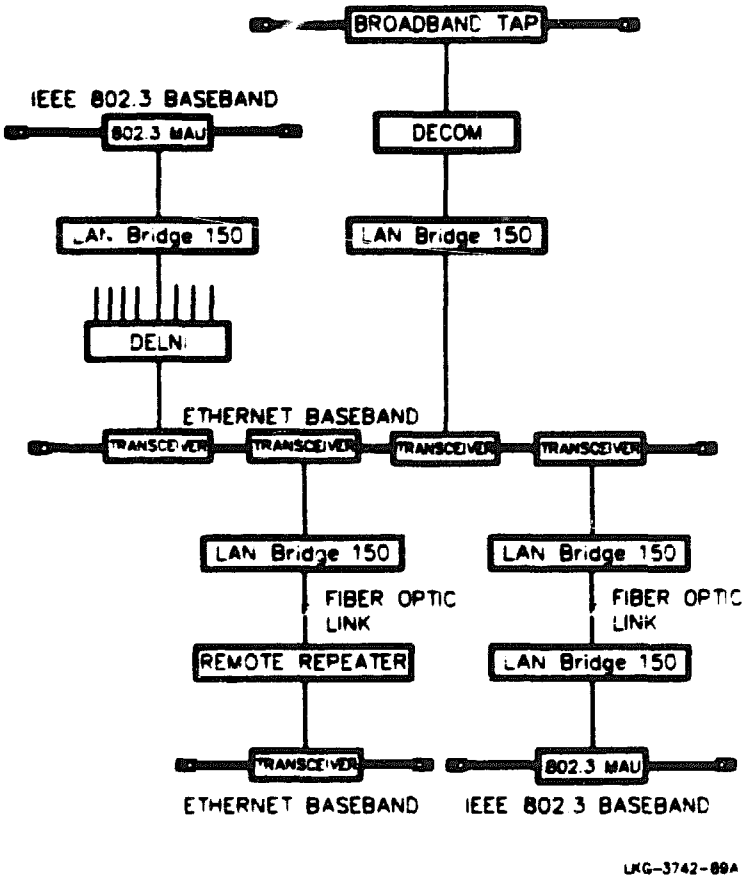
Individual LANs that are connected by bridges can each be configured for up to the normal maximum for length, number of stations, and other specifications. For example, each Ethernet baseband LAN can be up to 2800 meters (9186 feet) and have 1024 stations.

Extended LANs may consist of combinations of any of the following LANs joined by bridges:

- Ethernet baseband
- Ethernet broadband
- IEEE 802.3 baseband (10base5)
- ThinWire Ethernet (10base2)

Within these configurations, bridges can be connected to the network through transceivers. Alternatively, remote bridges may be connected directly to other remote bridges or remote repeaters. Also, a bridge may be connected to a DELNI interconnect that may or may not be connected to a remote network. Figure 1–6 shows some of the possible configurations involving bridges.

Figure 1–6: LAN Bridge 150 Configurations



1.4.1 Performance Considerations

A packet may have to travel through a number of bridges before reaching its destination. Note that increasing the number of bridges in the data path causes corresponding increases in the data path delay. This delay could have a negative impact on network performance, especially with time-critical protocols or with interactive tasks such as character echoing for users on terminal servers. A general rule for networks with typical traffic loading is that performance may start to degrade if a packet must travel through more than seven bridges to get from its source station to its destination station.

1.4.2 Loop Considerations

When the LAN Bridge 150 unit is turned on, it executes an internal self-test. This test takes about 15 seconds. The bridge then spends about 30 seconds learning station addresses and communicating with other bridges in the network to determine whether there are any loops (multiple paths between two or more LANs).

When bridges in an extended LAN form a loop, a loop detection process (described in Chapter 2) determines that one or more of the looped bridges enters the BACKUP state, so that only one path exists between any two LANs.

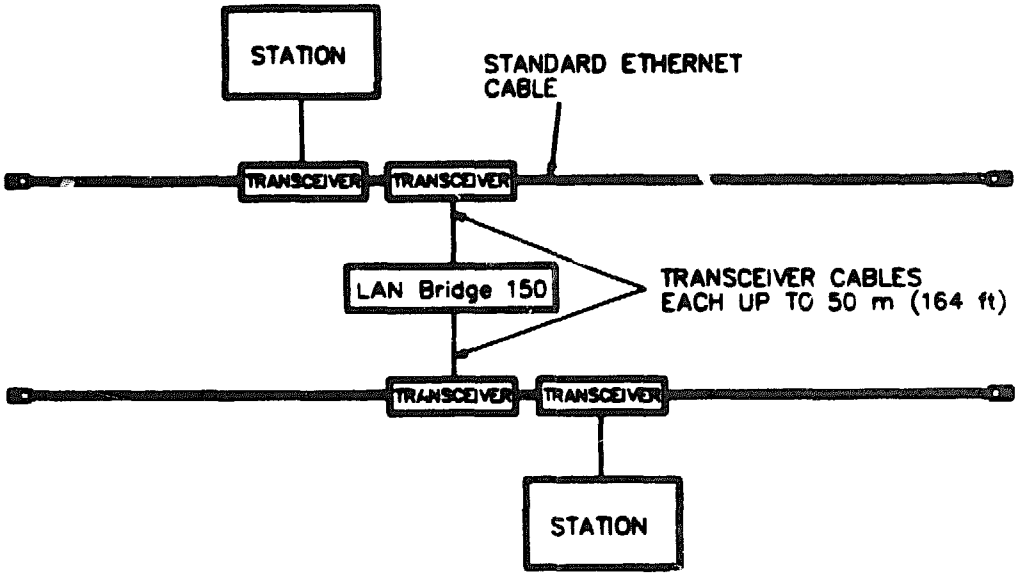
If an on-line bridge fails, a backup bridge takes over and begins forwarding packets With RBMS software, bridges can be selectively placed in the BACKUP state. In this way the most direct path with the fewest number of bridges can be provided for the heaviest network traffic.

If the bridge is in a loop with a repeater, the bridge enters the BACKUP state. The bridge continues to check the loop through the repeater about once a second. If the repeater fails, the bridge automatically takes over and begins forwarding packets.

1.4.3 Local LAN Bridge 150 Considerations

The local LAN Bridge 150 unit (DEBET-AC or DEBET-AD) connects two LANs that are separated by less than 150 meters (492 feet). This distance is made up of the combined length of two transceiver cables, each 50 meters (164 feet). Figure 1–7 shows a typical extended LAN configuration using a local LAN Bridge 150 unit.

Figure 1–7: Typical Extended LAN with a Local LAN Bridge 150 Unit



1.4.4 Remote LAN Bridge 150 Considerations

Two remote LAN Bridge 150 units (DEBET-RP/-RQ) connect two LANs that are separated by up to 3000 meters (9840 feet). The length of the fiber-optic link joining the two remote bridges can be up to 3000 meters (9840 feet).

The fiber-optic link has all of the characteristics of a LAN except that it has no stations and its length cannot exceed 3000 meters (9840 feet). As such, the fiber-optic link must be included in the path cost of the extended LAN (more information on path cost computation is provided in Chapter 2). The extended LAN example shown in Figure 1–8 is drawn to show that the fiber-optic link between the remote bridges is equivalent to a LAN.

Figure 1–8: Example Showing a Fiber-Optic Link as a LAN

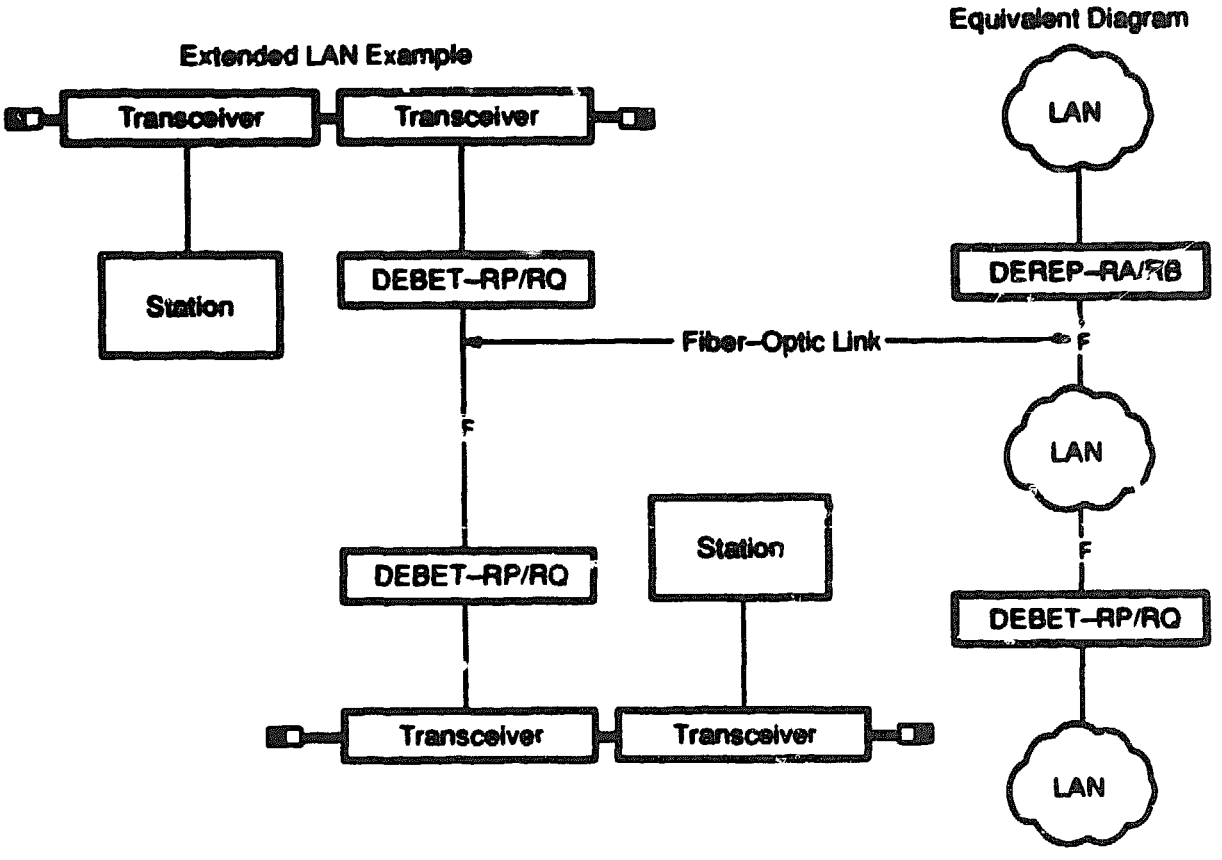
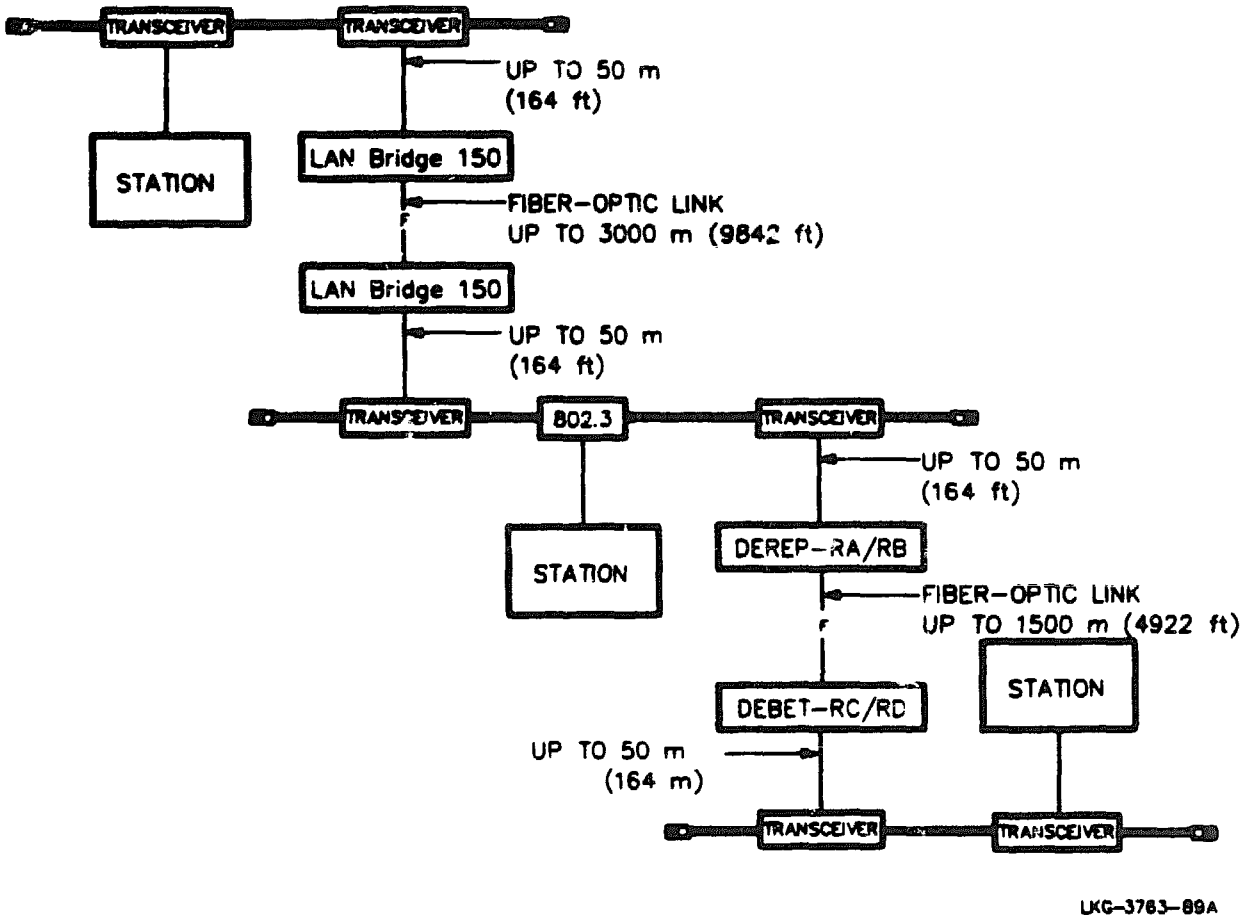


Figure 1–9 shows some of the possible extended LAN configurations using remote bridges.

Figure 1–9: Extended LANs Using Remote Bridges



1.4.4.1 Fiber-Optic Cable Between LAN Bridge 150 Units

In a bridge-to-bridge configuration, the dual-cable fiber-optic link that connects the bridges does not affect the cable configuration guidelines of either of the LANs connected to the bridges. The end-to-end light loss of the cable must not exceed 12 dB for the 62.5/125 cable (For the 50/125 cable, you must factor in a 4 dB launch loss that permits the 8 dB loss). The type of optical fiber used affects the length of the cable. An initial 12 dB loss budget is based on using 62.5/125 optical fiber with a bandwidth of 160 MHz x km measured at 850 nm.

NOTE

When you have a fiber-optic cable link, a failure cannot be detected in the cable (link broken), and a bridge pair

backing up the fiber-optic link will not take over since it does not detect the failure. Failure will be detected only by loss of connectivity.

CAUTION

Exceeding the loss limit may cause the bridge configuration to fail.

To achieve long distances, particularly those more than 1000 meters (3280 feet), installation of the fiber-optic cable must be carefully planned. The type and quality of the cable's optical fiber, the cable repair strategy, and the cable's total end-to-end light loss are of great importance to successful bridge installation.

The end-to-end cable light loss depends on the quality of the fiber, the number and quality of splices required for installation, and the number and quality of the connectors used.

The cable repair strategy affects the budget in that cable repair typically consists of replacing a section of cable. This requires two splices. The repaired link must remain under the end-to-end light loss budget. If the initial installation uses the entire loss budget, a repair would not be possible. Therefore, plan for a minimum of two splices (about 0.5 dB for each splice).

For longer cable runs or for installations requiring more splices, request a lower-loss fiber-optic cable from your cable vendor.

1.4.4.2 LAN Bridge 150 to Repeater Considerations

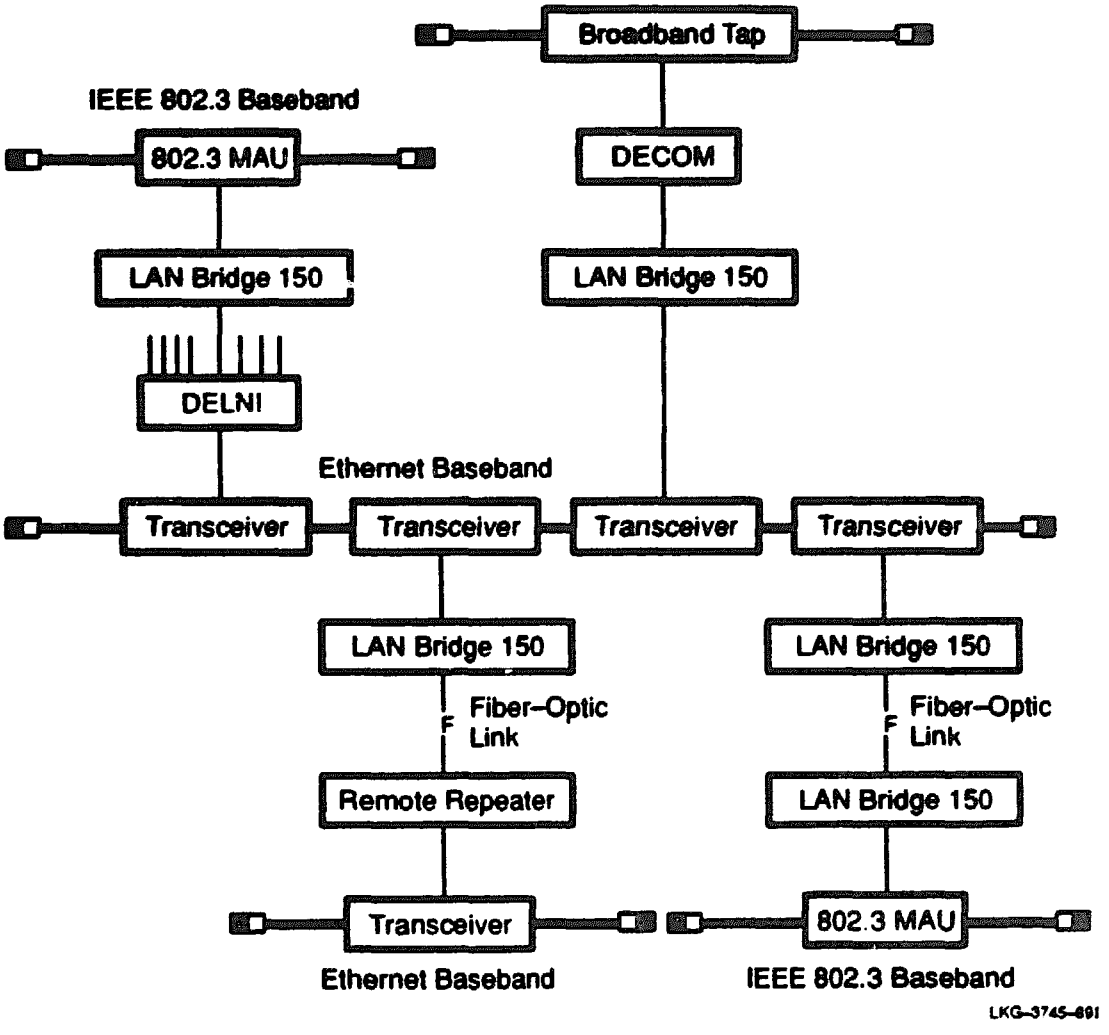
When a remote bridge is connected to a remote repeater, the fiber-optic cable can be up to 1500 meters (4921 feet). When a remote bridge is connected to a remote repeater, the length of the fiber-optic cable is considered part of the length of that LAN (see Figure 1–10). Therefore, the distance between the bridge and the farthest end station on the LAN cannot exceed 2800 meters (9184 feet).

The 2800-meter (9184-foot) distance between any two stations on a typical Ethernet LAN is made up of the following:

- Two 50-meter (164-foot) transceiver cables (connecting the farthest end stations)
- Three 500-meter (1640 foot) coaxial cable segments
- Four 50-meter (164 foot) transceiver cables (connected to repeaters)

- 1000 meters (3280 feet) of point-to-point fiber-optic link

Figure 1–10: Remote Bridge to Repeater Configuration



1.5 LAN Traffic Monitor Configurations

The following sections describe several ways for configuring the LAN Bridge 150 hardware unit as an LTM Listener unit. For more information about the LTM, refer to the *LAN Traffic Monitor User's Guide*.

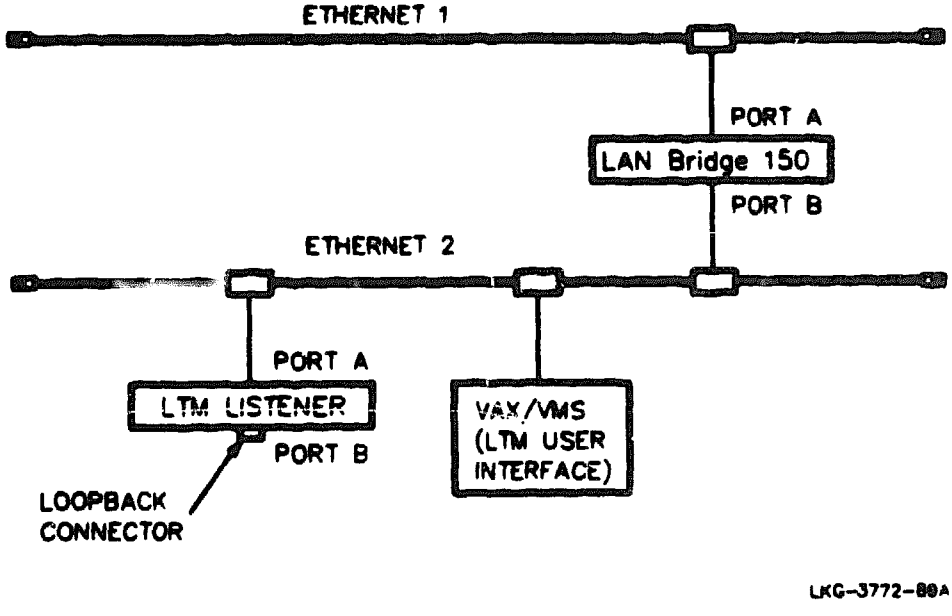
1.5.1 Single Port Configuration with Loopback Connector Installed

As shown in Figure 1–11, the LTM Listener always monitors Ethernet 2 and sends statistics to the user interface on Ethernet 2. The LTM Listener can send statistics to a user interface on Ethernet 1 also, as long as the LAN Bridge 150 unit connects the two Ethernets. Note that Port B has a loopback connector installed and is not in operation.

CAUTION

The LAN Bridge 150 unit fails self-test if an unused port is left disconnected unless the unused port is the fiber-optic port used with the remote version (DEBET-RP/RQ). An Ethernet loopback connector (shipped with the unit) must be connected to the unused transceiver port. Do NOT install a fiber-optic loopback connector to an unused fiber-optic port. A fiber-optic loopback causes the bridge to fail the power-up self-test.

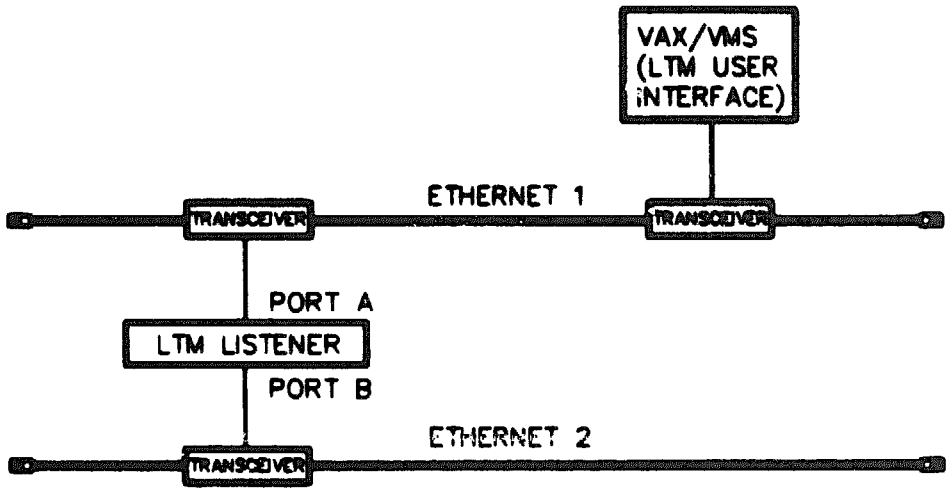
Figure 1–11: LTM Single Port Configuration



1.5.2 Dual Port Connections Between Two Ethernets

As shown in Figure 1–12, the LTM Listener is connected to two completely separate Ethernets. In this case, the LAN Traffic Monitor can monitor either Ethernet 1 or 2 but must report to the LTM user interface on Ethernet 1.

Figure 1–12: LTM Connected to Two Separate Ethernets



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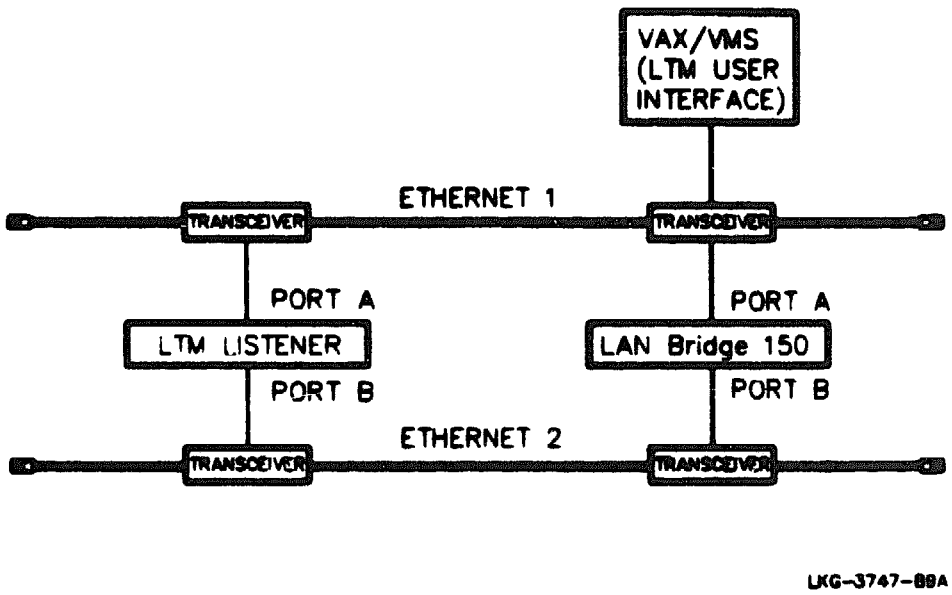
1.5.3 Dual Port Connections With Bridged Ethernets

The configuration shown in Figure 1–13 describes two Ethernet LANs bridged together, forming a single extended LAN. The LTM Listener can monitor either Ethernet 1 or 2 and can report to either port.

Figure 1–13: LTM on Two Connected Ethernets



NOTE

Digital recommends that you configure the LTM Listener to report on the port that has the least number of intervening bridges between it and the LTM user interface host(s). Doing so minimizes the impact of a possible bridge failure.

1.6 Bridge/Router Considerations

This section discusses some considerations for configuring extended LANs that include LAN Bridge 150 units and routers.

NOTE

The information in this section applies specifically to equipment manufactured by Digital Equipment Corporation. However, all routers and bridges designed for layered architecture networks adhere to similar operating principles and may have similar parameters that should be considered when implementing networks with bridges and routers.

The configuration shown in Figure 1–14 involves a LAN Bridge 150 unit that is installed in parallel with a router. This configuration creates many problems and therefore is not recommended (see Section 1.6.1). The configuration shown in Figure 1–15 is a general case in which two local area networks are connected by a LAN Bridge 150 unit. This configuration does not have associated problems, provided that routing parameters are set properly in all routers.

The information contained in this section assumes that you are familiar with the concept of routing and how routers operate on LANs. For more information on the subject of routing, refer to the following documents:

- *DECnet Digital Network Architecture Phase IV: Routing Layer Functional Specification* (Order No. AA-X435A-TK)
- *Guide to Networking on VAX/VMS* (Order No. AA-Y512A-TE)
- *Ethernet Communications Server DECnet Router Software Installation Guide* (Order No. AA-X019B-TK)

The LAN Bridge 150 unit operates at the Data Link layer and is transparent to higher protocol layers in the Digital Network Architecture (DNA) model (such as Routing, End Communication, Session, and so on).

Since the LAN Bridge 150 unit connects two local area networks to form an extended LAN, higher protocol layers effectively see a single LAN. For the Routing layer, the creation of an extended LAN means either the addition of nodes (stations) and/or routers to the existing network or the actual merging of two distinct networks.

NOTE

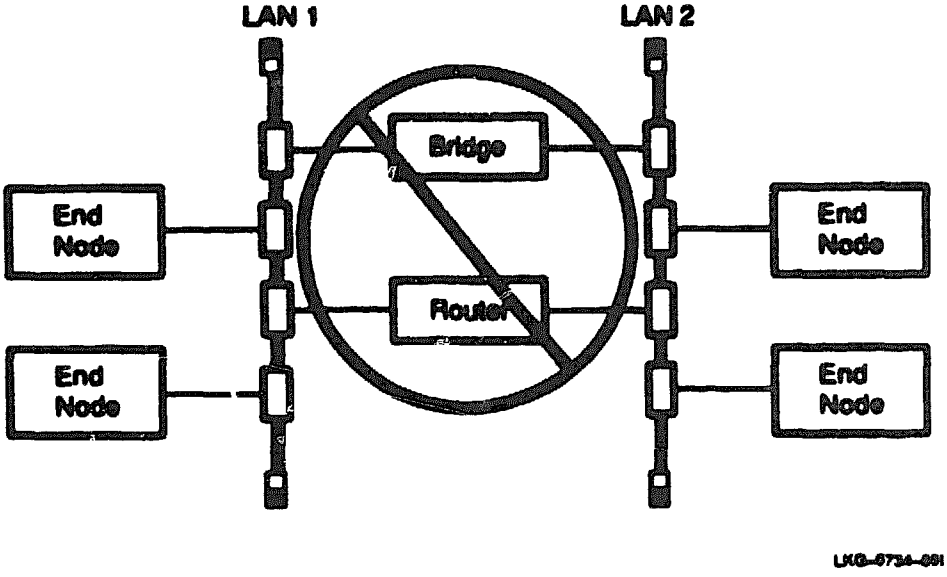
An Ethernet repeater and LAN Bridge 150 unit are similar since both devices provide a channel through which data can pass (a repeater connects segments together to form a LAN, while a bridge connects LANs together to form an extended LAN). In addition, both devices are transparent to the higher protocol layers in the DNA model. Thus both devices introduce similar symptoms if implemented incorrectly.

1.6.1 LAN Bridge 150 Unit in Parallel With a Router

The configuration in which a LAN Bridge 150 unit is installed in parallel with a router (see Figure 1–14) does not enhance network performance. Since the LAN Bridge 150 unit can handle all of the traffic on both LANs, there is no need to have a router in parallel with the bridge to "assist" it.

In fact, in this configuration, both router ports are connected to the same extended LAN. This causes problems for the router since the router may receive two copies of the packet. Consequently, if the router is a designated router, it will hear its own Hello message on the other link. In response, the router defers to the "echo" Hello message and ceases to be the designated router for the LAN. This has a major impact on the network because end nodes on the LAN will not be able to communicate with nodes that are not on the LAN.

Figure 1–14: Bridge in Parallel With a Router



There are additional problems associated with having routers receive multiple copies of packets on a LAN. Adhering to the following guideline eliminates potential problems:

- A router should never have two ports connected to the same LAN or extended LAN. That is, a router should never be in parallel with a bridge or a repeater.

For more information regarding routers and bridges, refer to the *Bridge and Extended LAN Reference* manual.

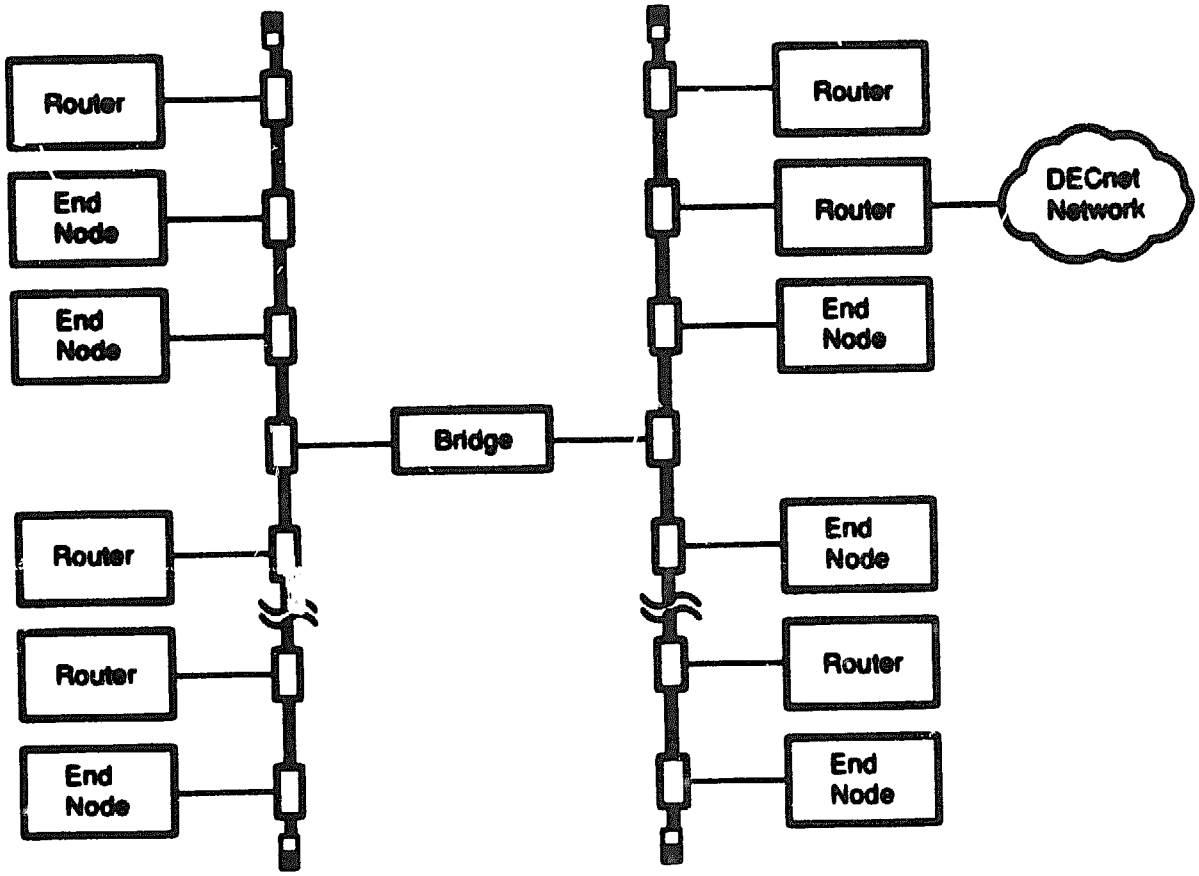
1.6.2 Modifying Router Parameters for Extended LANs

This section identifies router parameters that must be set to reflect the Extended LAN. The parameters may need to be modified when two LANs are joined with a LAN Bridge 150 unit (see Figure 1–15).

Each of the two LANs shown in Figure 1–15 has many nodes, some of which are broadcast routers (levels 1 and 2), while other nodes are broadcast nonrouters (end nodes). (For a brief description of Level 1 and Level 2 routing, see Section 1.6.3.) When the bridge is installed, the network grows larger. Consequently, the following parameters may have to be modified in all routers in the extended LAN:

- MAXIMUM BROADCAST NONROUTERS
- MAXIMUM BROADCAST ROUTERS

Figure 1–15: An Extended LAN With Routers



The MAXIMUM BROADCAST NONROUTERS parameter specifies the maximum number of Ethernet nonrouting nodes (end nodes) that the router database can contain at any one time. This parameter can range from 0 to 1022 and has a typical default value of 64.

The MAXIMUM BROADCAST NONROUTERS parameter must be greater than or equal to the actual number of nonrouting nodes on the LAN. The larger this number is, the greater the memory overhead for the router. However, if this number is less than the number of active end nodes, some end nodes will be unreachable because of limits on the size of the router's database.

NOTE

When nodes on a LAN are configured into multiple DECnet areas, this parameter is set on a per-area basis. For more information about areas, see Section 1.6.3. Also refer to the *Ethernet Communications Server DECnet Router Software Installation Guide*.

If the MAXIMUM BROADCAST NONROUTERS parameter is set too low, it is difficult to diagnose on networks with many nodes (both routing nodes and end nodes). One of the symptoms of this parameter being set too low is partial partitioning of the network. Under this condition, some nodes may lose their ability to initiate conversations with other nodes even though they are on the same LAN.

Therefore, whenever network changes are made, the network manager should take steps to verify (and, if necessary, modify) this parameter in all routers so that it is either equal to or greater than the number of nonrouting nodes in the extended LAN.

The MAXIMUM BROADCAST ROUTERS parameter specifies the maximum number of Ethernet routing nodes that the router database can contain at any one time (this applies to routing nodes on the same Ethernet). Routing nodes include Level 1 and Level 2 routers (see Section 1.6.3). In a multiple area network, this parameter must include all the Level 1 routers in a particular area plus all the Level 2 routers in the entire network. This parameter can range from 0 to 32 and has a typical default value of 10.

The larger the value for this parameter, the greater the memory overhead for the router. Also, the more routers there are on the Ethernet, the greater is the control traffic associated with the temporary looping property of the routing algorithm.

If this parameter value is too small, some routers will be unreachable because of limits on the size of the router's database. That is, when the MAXIMUM BROADCAST ROUTERS parameter is exceeded, routers with the lowest priority are dropped from the router's database.

Therefore, whenever network changes are made, the network manager should take steps to verify (and, if necessary, modify) this parameter so that it is either equal to or greater than the number of Level 1 routers in the DECnet area plus the number of Level 2 routers in the extended LAN.

1.6.3 Setting Up Multiple Areas

When the total number of routers and/or nonrouters on the extended LAN approach the maximum values, the network manager can set up multiple areas on the Ethernet.

In general, each area is a group of nodes. Nodes are grouped together in areas for purposes of hierarchical routing. Hierarchical routing involves the addition of a second level of routing to the network. Routing within an area is referred to as Level 1 routing; routing between areas is called Level 2 routing. When creating multiple areas on the Ethernet, the number of routers and nonrouters are considered separately for each area.

For more information on configuring multiple area LANs with routers, refer to *DECnet Digital Network Architecture Phase IV: Routing Layer Functional Specification*.

1.7 Specifications

Specifications for the LAN Bridge 150 are divided into the following categories:

- Physical dimensions
- Cable specifications
- Environmental specifications
- Electrical specifications

Table 1–7: Physical Dimensions

Dimension	With Enclosure	Without Enclosure*
Height	16.2 cm (6.4 in)	13.3 cm (5.3 in)
Width	49.4 cm (19.4 in)	43.6 cm (17.2 in)
Depth	31.3 cm (12.3 in)	29.8 cm (11.7 in)
Weight	6.7 kg (15 lb)	4.5 kg (10 lb)

*The plastic enclosure is easily removed, and brackets are provided to allow mounting of the unit on a wall or in a cabinet. An optional kit (part number H039) is available for mounting the bridge on a wall or partition without removing the plastic enclosure.

Table 1–8: Cable Specifications

Item	Value
ac power cord length	U.S. 1.83 m (6 ft) Others 2.5 m (8.2 ft)
Transceiver cable length	BNE4 12 m (39 ft) maximum, BNE3 50 m (164 ft) maximum
Fiber-optic cable	62.5/125
Minimum bandwidth	160 MHz measured at a wavelength of 850 nm; 500 MHz at a wavelength of 1300 nm
Fiber-optic connectors	Stainless steel, Amphenol type 906, SMA style, or equivalent
Maximum attenuation	Less than 1.5 dB

1.8 Operating Environment Specifications

The LAN Bridge 150 is designed to operate in a nonair-conditioned environment or in an exposed area of an industrial site. However, 50° C (122° F) is the maximum ambient temperature that must not be exceeded at the air intake of the bridge. This applies even when the LAN Bridge 150 is mounted in a cabinet. The bridge is not intended to operate in an air plenum.

Table 1–9: Operating Environment Specifications

Item	Value
Temperature	5° C to 50° C (41° F to 122° F)
Maximum rate of change	20° C/hr (36° F/hr)
Relative humidity	10% to 95% (noncondensing)
Wet-bulb temperature	32° C (90° F) maximum
Dew point	2° C (36° F) minimum
Altitude	Sea level to 2.4 km (8000 ft)
Air flow	37.5 CFM. Note that about 10 to 15 cm (4 to 6 in) of space must be provided on both ends of the unit for adequate air flow

Table 1–10: Shipping Environment Specifications

Item	Value
Temperature	-40° C to 66° C (-40° F to 151° F)
Relative humidity	0% to 95% (noncondensing)
Altitude	Sea level to 9.1 km (30,000 ft)

1.9 Power Specifications

The LAN Bridge 150 unit features a self-contained power supply, power cord options for all major Digital markets, and adequate power to drive two external transceivers.

Table 1–11: Power Specifications

Item	Value
Voltage (Domestic)	88 Vac to 132 Vac (nominal 120 Vac)
Voltage (International)	176 Vac to 264 Vac (nominal 240 Vac)
Current at 120 volts	1.1 amps
Current at 240 volts	.7 amps
Frequency	47 Hz to 63 Hz
Power Consumption	168 watts
Heat Dissipation	574 BTU/hr

1.10 Fiber Cable Budgets

The following tables provide fiber cable loss budget information.

Table 1–12: DEBET-RP/-RQ to DEBET-RP/-RQ (bridge-to-bridge) Fiber Links

Fiber Type	Wavelength	Power Budget (dB)	Distance (km)*	Minimum Attenuation (dB)
50/125	850	8	2.0	n/a
62.5/125	850	12	3.0	1
85/125	850	13	–	3
100/140	850	14	–	4

*Power budget, fiber quality, number of splices/connections, and installation quality are factors used in determining achievable distances

Table 1–13: DEBET-RP/-RQ to DEREP-RP/-RQ (bridge-to-repeater) Fiber Links

Fiber Type	Wavelength	Power Budget (dB)	Distance (km)*	Minimum Attenuation (dB)
50/125	850	8	1.5	n/a
62.5/125	850	12	1.5	1
85/125	850	13	1.5	3
100/140	850	14	1.5	4

*Power budget, fiber quality, number of splices/connections, and installation quality are factors used in determining achievable distances

CHAPTER 2

2

Operation

2.1 Introduction

This chapter describes the operational states and processes control operation of the LAN Bridge 150 unit. This chapter also describes the initialization block and descriptor ring data structures.

2.2 Operational States

The LAN Bridge 150 unit has six operational states that control its functions. (An operating state transition diagram is shown in Figure 2–1). The LAN operational states for the bridge are:

- SELF-TEST
- BROKEN
- INITIALIZATION
- PREFORWARDING
- FORWARDING
- BACKUP

Figure 2–1: Operating State Transition

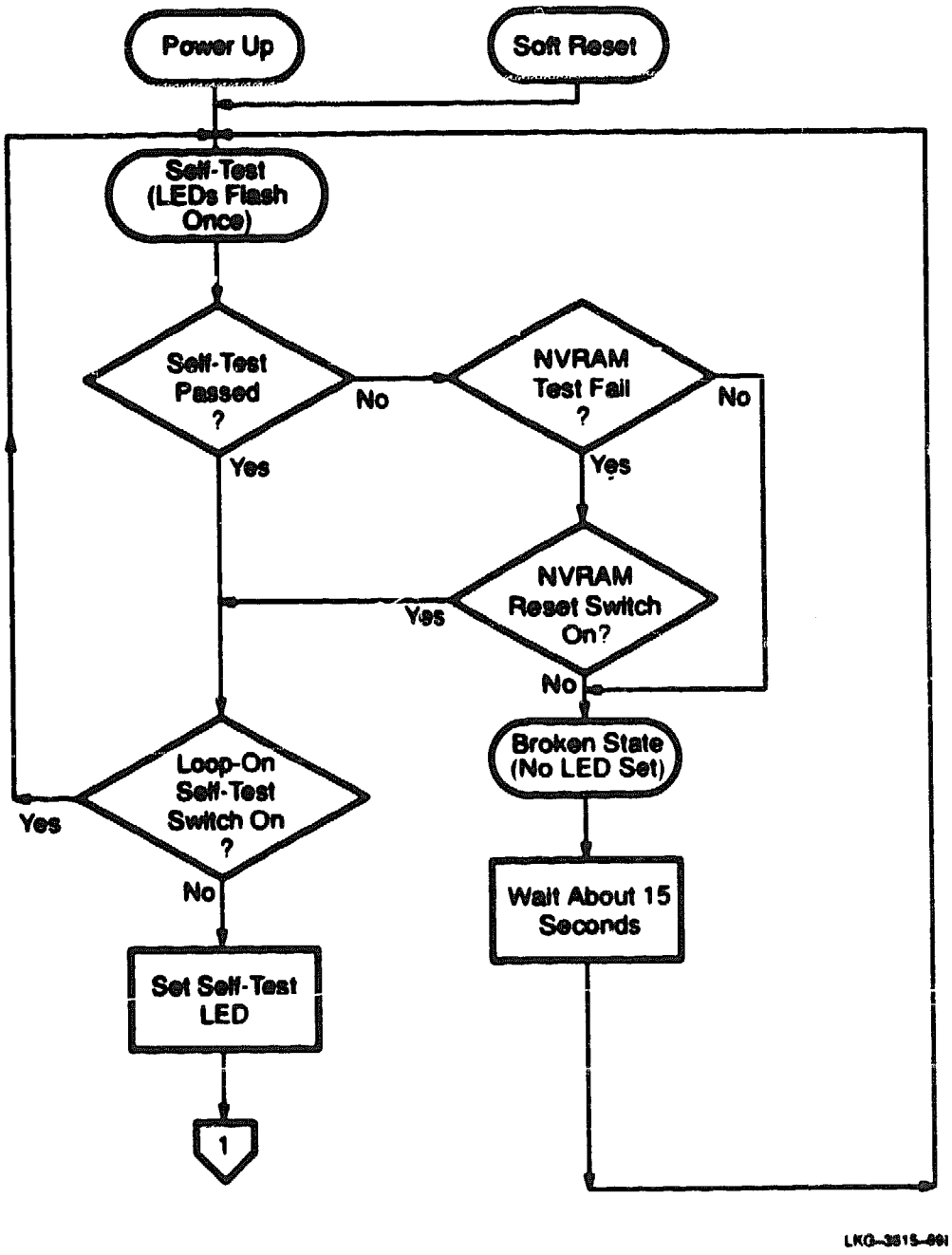


Figure 2–1 Cont'd on next page

Figure 2–1(Cont.): Operating State Transition

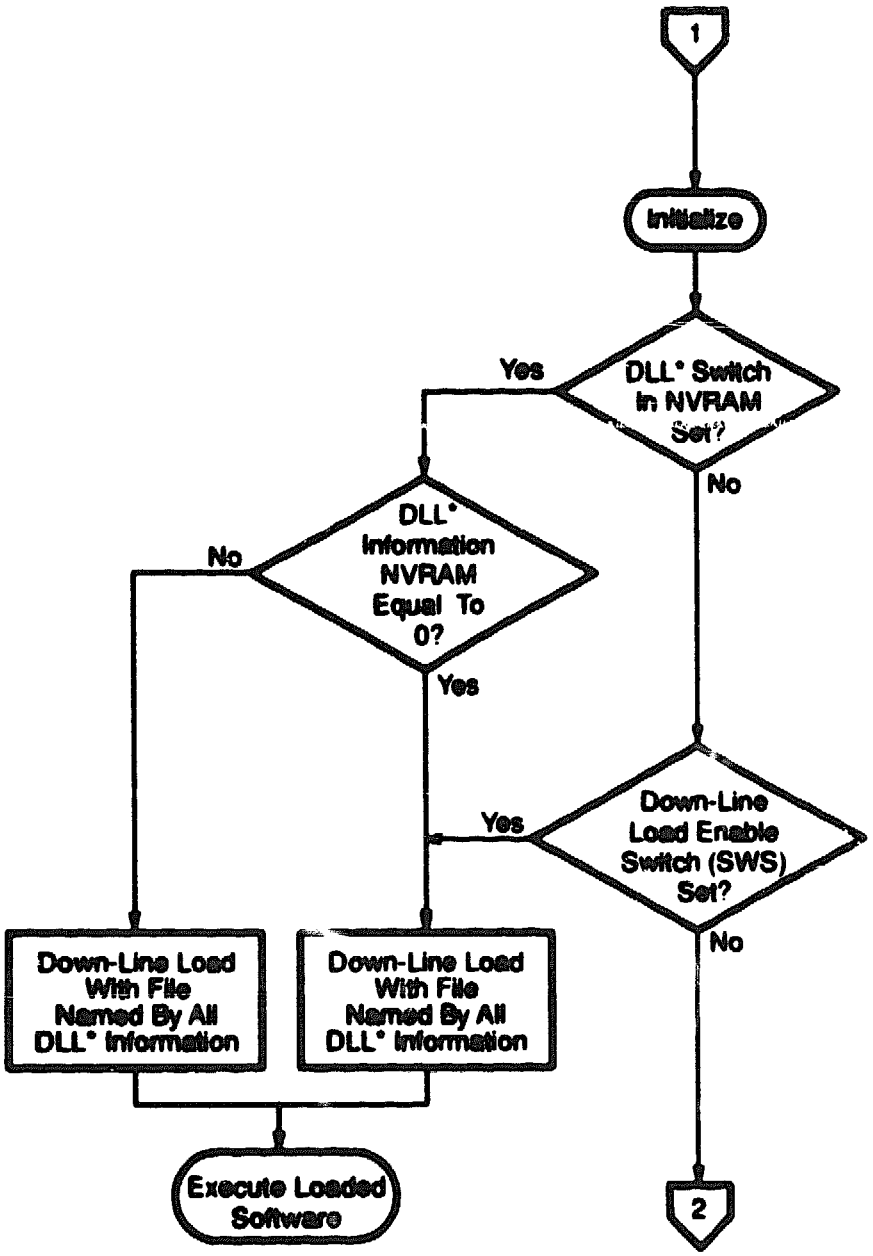
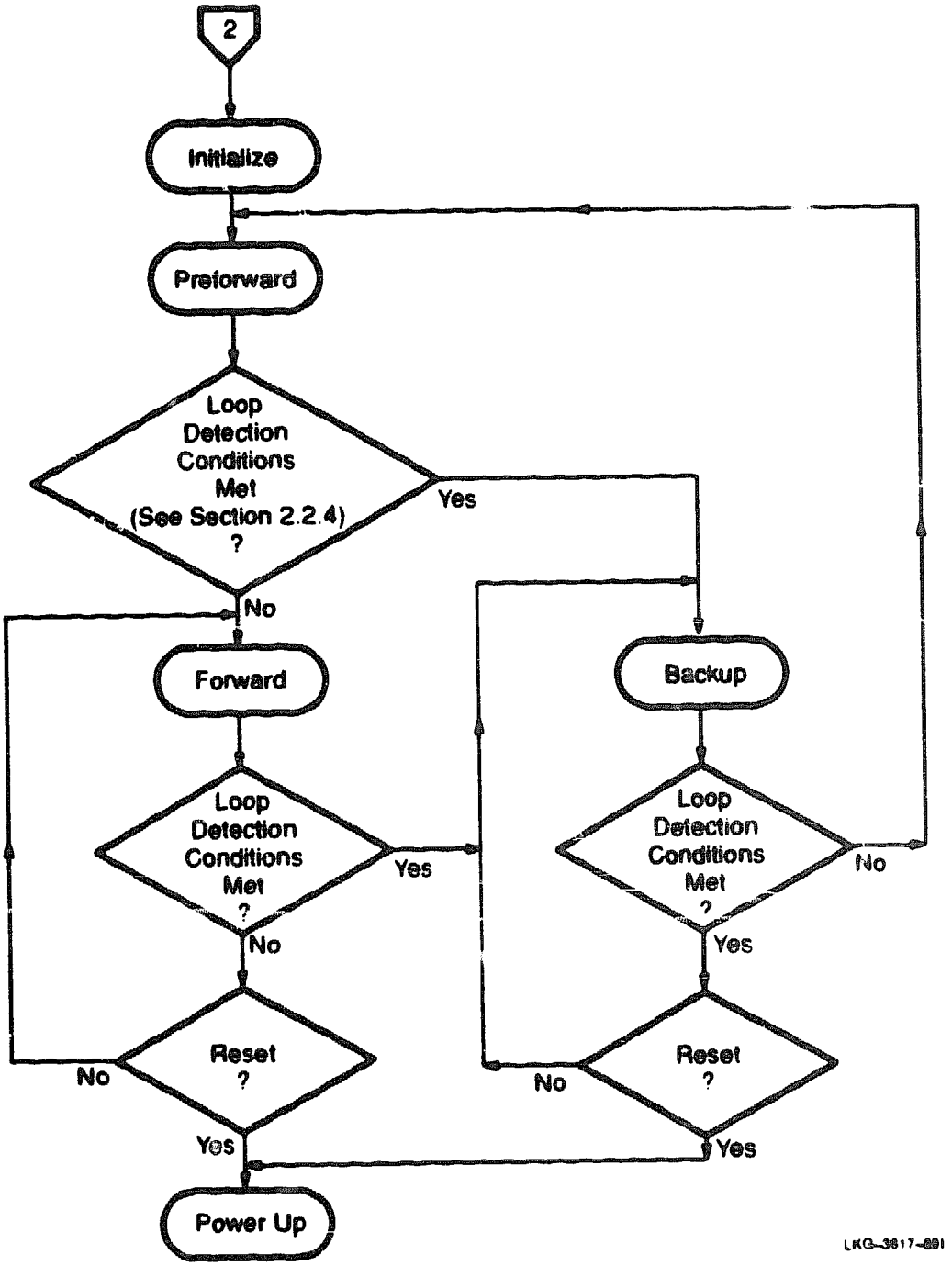


Figure 2–1 Cont'd on next page

Figure 2–1(Cont.): Operating State Transition



2.2.1 Self-Test State

The SELF-TEST state is entered on power up, on a soft reset command received from bridge management software or from the BROKEN state.

The SELF-TEST state sets the LAN Bridge 150 unit to a known condition and tests the hardware and firmware by performing read/write operations to various hardware locations.

The SELF-TEST state loops (repeats) if the Loop Self-Test switch (located on the LAN Bridge 150 connector panel) is set to the on position. A description of the self-test procedure is provided in Section 2.9.

If the self-test fails (except for nonvolatile RAM [NVRAM] failures), the LAN Bridge 150 unit enters the BROKEN state.

If NVRAM fails and the NVRAM Reset switch (located on the I/O panel) is enabled, the LAN Bridge 150 unit enters the INITIALIZATION state using default parameters. If NVRAM fails and the NVRAM Reset switch is disabled, the LAN Bridge 150 unit enters the BROKEN state.

If the self-test passes, the LAN Bridge 150 unit enters the INITIALIZATION state.

2.2.2 Broken State

The BROKEN state is entered if errors occur in self-test. In the BROKEN state, the LAN Bridge 150 unit reenters the SELF-TEST state every 15 seconds until the unit is powered off.

2.2.3 Initialization State

The INITIALIZATION state is entered on completion of the self-test.

2.2.3.1 Bridge Initialization

The microprocessor uses the INITIALIZATION state to perform the following operations:

- Initialize various system counters and registers.
- Allocate necessary buffer space in packet memory.

- Write the initialization blocks and the descriptor rings into packet memory (see Section 2.3).
- Write the LAN Bridge 150 unit's physical address into the Ethernet address table and into the LANCEs.
- Write the pointers to the initialization block into the LANCE control and status registers.
- Determine whether the bridge down-line loads as part of the INITIALIZATION state.
- Write the initialization and start bits into the LANCE control and status registers.

If the bridge determines that a down-line load will not occur, the INITIALIZATION state exits to the PREFORWARDING state after the initialization and start bits are written into the LANCE control and status registers.

2.2.3.2 Down-Line Loading

The LAN Bridge 150 unit may perform a down-line load (DLL) as part of the INITIALIZATION state.

The DLL feature is controlled using a hardware "down-line load enable" switch and two software parameters: DLL-switch and DLL-info. The hardware switch must be manually set or cleared. Software parameter values for DLL-switch and DLL-info are entered using RBMS.

An algorithm examines the hardware switch and software parameters to determine whether the bridge down-line loads. If the bridge is configured to DLL, the algorithm specifies which file to load. A block diagram of the algorithm is contained in Figure 2–1.

Maintenance Operation Protocol (MOP) messages control the DLL operation. Once the down-line load operation begins, the bridge attempts to complete the operation until the load is successful or the bridge power is turned off.

When the down-line load is complete, the INITIALIZATION state exits to the state determined by the loaded software.

2.2.4 Preforwarding State

The PREFORWARDING state is entered after the initialize and start bits are written into the LANCE control and status registers. This state may also be entered from the BACKUP state when the LAN Bridge 150 unit becomes the root bridge in the extended LAN or a designated bridge on a LAN (see Section 2.5).

The LAN Bridge 150 unit uses the PREFORWARDING state to:

- Learn the location of active stations on the network.
- Perform loop detection functions to determine whether it is the root bridge in the extended LAN or a designated bridge on a LAN (see Section 2.5).

The operations performed in the PREFORWARDING and FORWARDING states (see Section 2.2.5) are identical except that packets are not forwarded during the PREFORWARDING state. This prevents the formation of transient loops.

The duration (forwarding delay) of the PREFORWARDING state has a default value of 30 seconds. The forwarding delay can be changed using RBMS (see *Remote Bridge Management Software Use*).

The PREFORWARDING state exits to the BACKUP state if the LAN Bridge 150 unit determines that the following loop detection conditions (see Section 2.5) are met:

- The LAN Bridge 150 unit is not a root bridge.
- The bridge is not a designated bridge on a LAN.

If the loop detection conditions are not met, the PREFORWARDING state exits to the FORWARDING state.

2.2.5 Forwarding State

The FORWARDING state is entered from the PREFORWARDING state when loop detection conditions are not met (refer to Sections 2.2.4 and 2.5).

The FORWARDING state is similar to the PREFORWARDING state except that packets may be forwarded. In this state, the LAN Bridge 150 unit performs address filtering functions. The LANCE chips receive and store packets in memory. The packets are discarded or processed depending on a determination made by the microprocessor and table lookup subsystem.

Other tasks carried out in the FORWARDING state include address table maintenance and loop detection functions. Bridge management functions such as RBMS and maintenance functions that use MOP can also be performed.

The FORWARDING state exits to the SELF-TEST state if a reset operation is performed.

The FORWARDING state exits to the BACKUP state if loop detection conditions are met (refer to Section 2.5).

2.2.6 Backup State

The BACKUP state is entered when loop detection conditions are met (see Section 2.5). RBMS commands may be used to force the LAN Bridge 150 unit into the BACKUP state by "disabling" a link in the bridge.

During the BACKUP state, the LAN Bridge 150 unit "listens" to network traffic. If the LAN Bridge 150 unit determines that loop detection conditions are not met, it enters the PREFORWARDING state.

2.3 Packet Memory Data Structures

The LANCE initialization blocks and the descriptor rings are the data structures that manage packet memory.

The LANCE chips use these structures to locate available buffer space for storing incoming packets and for finding packets that are to be transmitted.

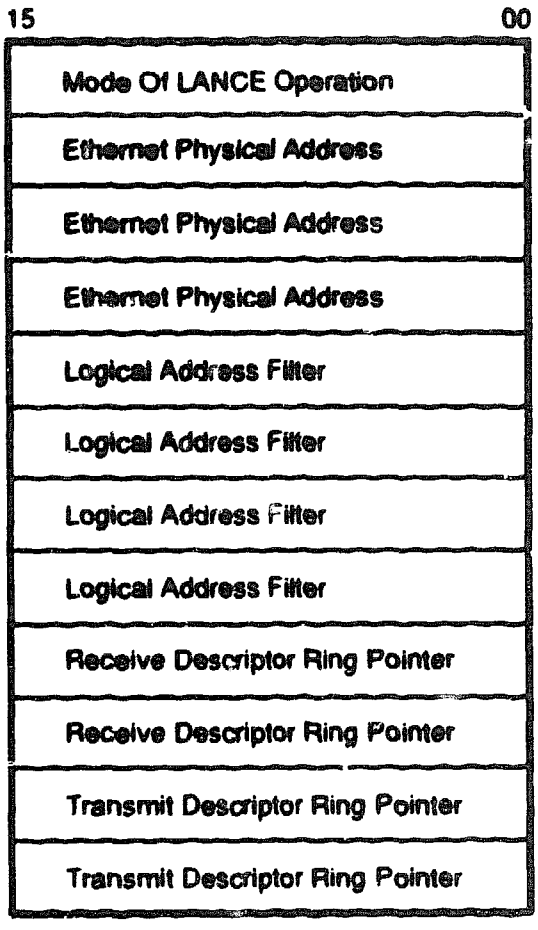
The microprocessor writes the initialization blocks and descriptor rings into packet memory during the initialization state. The microprocessor uses the descriptor rings to find packets in memory and to identify packets that are ready for transmission by a LANCE.

2.3.1 Initialization Blocks

The microprocessor writes two initialization blocks into packet memory to initialize the two LANCE chips. Each block uses 12 words of contiguous memory.

Each LANCE uses its own initialization block to configure its operating parameters. The fields in an initialization block are identified in Figure 2–2.

Figure 2–2: LANCE Initialization Block Field Functions



The functions of each field in the initialization block are defined as follows:

- Mode of LANCE operation—Promiscuous mode is selected, signifying that all addresses are received.
- Ethernet physical address—This field contains the 48-bit Ethernet address assigned to the LAN Bridge 150 unit. The LANCE uses this address to detect packets (such as RBMS or MOP commands) addressed to the LAN Bridge 150 unit. This address is also transmitted by the LAN Bridge 150 unit in loop detection (Hello) messages.
- Logical address filter—The 64-bit filter helps to detect multicast addresses. This filter is not used by the LAN Bridge 150 unit since the LANCE operates in promiscuous mode and receives all packets.

- Receive descriptor ring pointer—This field points to the base (lowest) address of the receive descriptor ring. Another part of this field defines the number of entries in the receive descriptor ring (1, 2, 4, 16, 32, 64, or 128 entries).

- Transmit descriptor ring pointer—This field points to the base (lowest) address of the transmit descriptor ring. Another part of this field defines the number of entries in the transmit descriptor ring (1, 2, 4, 16, 32, 64, or 128 entries).

2.3.2 Descriptor Rings

Four descriptor rings (one transmit and one receive ring for each LANCE) are written into packet memory by the processor during the INITIALIZATION state.

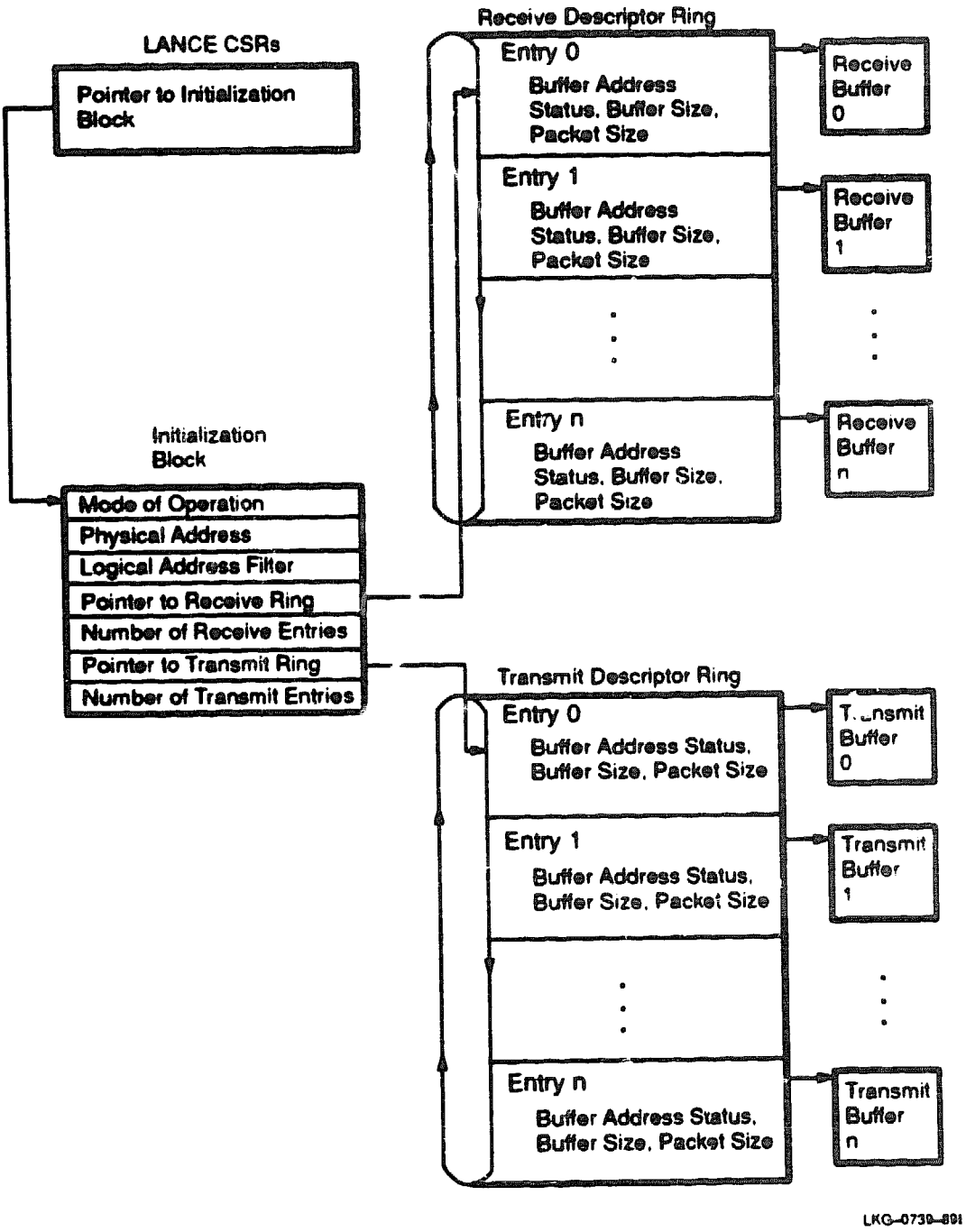
A descriptor ring is a circular queue of tasks that the LANCE and processor use to locate buffer space or packets in packet memory. Figure 2–3 illustrates the concept of descriptor rings.

Each descriptor ring is made up of entries that define the location and status of buffer space in packet memory. Each entry is four words in length. Thus each entry starts on a quadword boundary in the descriptor ring address space. The number of entries in a descriptor ring is defined in the ring pointer of the initialization block.

Receive descriptor rings are used by the LANCE chips to find available buffer space for writing incoming packets. The processor uses the receive descriptor rings to find the destination and source addresses in packets the LANCE chips receive (the destination and source addresses are contained in the first 12 bytes of a packet).

Transmit descriptor rings are written to by the processor to identify packets awaiting transmission. The LANCE reads the transmit descriptor rings to find packets awaiting transmission.

Figure 2–3: Descriptor Ring Structures



2.3.2.1 Receive Descriptor Ring Entry

Each receive descriptor ring entry is made up of four words that define the location and status of buffer space in packet memory. Figures 2–4 through 2–7 show the fields that make up each word in the receive descriptor ring entry. Tables 2–1 through 2–4 describe the bit functions of each word in the receive descriptor ring entry.

Figure 2–4: Bit Format of Word 0 in the Receive Descriptor Ring Entry

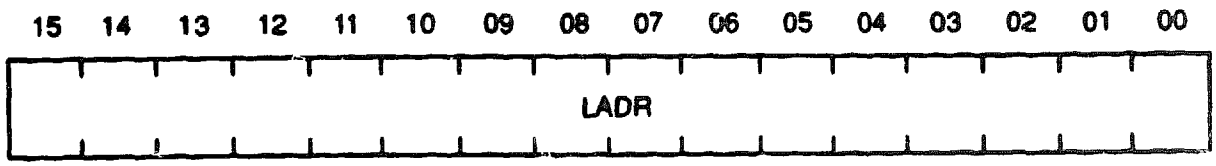


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Table 2–1: Bit Descriptions of Word 0 in the Receive Descriptor Ring Entry

Bit(s)	Name	Description
<15:00>	LADR	Low address. The low-order 16 bits of the address of the transmit data buffer corresponding to this receive descriptor ring entry.

Figure 2–5: Bit Format of Word 1 in the Receive Descriptor Ring Entry

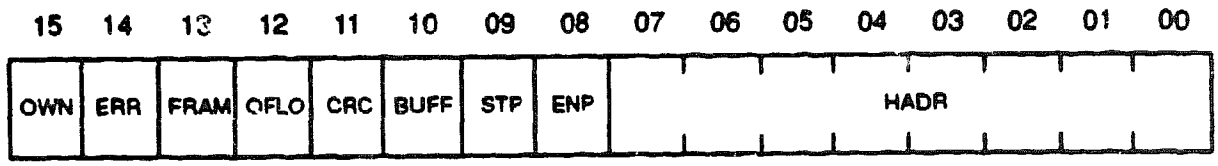

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Table 2–2: Bit Descriptions of Word 1 in the Receive Descriptor Ring Entry

Bit(s)	Name	Description
<15>	OWN	Ownership bit. When set, indicates that the LANCE owns or has use of the receive descriptor ring entry and the corresponding receive data buffer. The LANCE clears the OWN bit to give the entry to the microprocessor. The microprocessor sets the bit to give the entry back to the LANCE.
<14>	ERR	Error summary. Indicates that one or more of the following error bits is set: FRAM, OFLO, CRC, or BUFF.
<13>	FRAM	Framing error. Indicates that the received packet has both a CRC error and that the number of bits in the packet is not a whole multiple of 8.
<12>	OFLO	Overflow. Indicates that the LANCE has lost part or all of the packet because the internal data silo overflowed before the LANCE could write the packet into packet memory
<11>	CRC	CRC error. Indicates that the packet has a CRC error.
<10>	BUFF	Buffer error. Indicates that the LANCE filled the receive data buffer and was unable to chain to another receive data buffer to store the remainder of the packet. Either there was not enother receive buffer available or the LANCE was unable to read the receive descriptor ring entry quickly enough to find the new buffer before the LANCE internal data silo overflowed. Data buffers must be at least 64 bytes long to allow the LANCE time to find the next data buffer for buffer chaining.
<09>	STP	Start of packet. Indicates that this receive data buffer starts a new packet.
<08>	ENP	End of packet. Indicates that this receive data buffer ends a packet.
<07:00>	HADR	High address. The high-order 8 bits of the address of the receive data buffer corresponding to this receive descriptor ring entry.

Figure 2–6: Bit Format of Word 2 in the Receive Descriptor Ring Entry

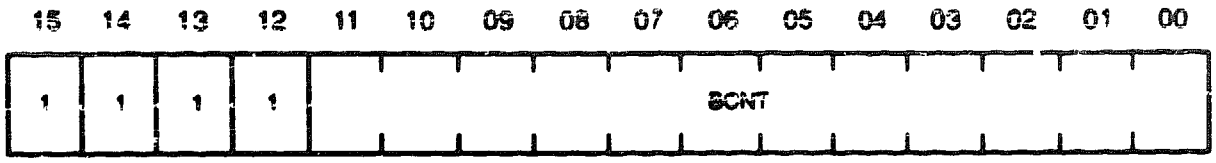

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Table 2–3: Bit Descriptions of Word 2 in the Receive Descriptor Ring Entry

Bit(s)	Name	Description
<15:12>	1	Must be ones (1s)
<11:00>	BCNT	Buffer byte count. The length of the data buffer corresponding to this entry in the receive descriptor ring expressed as a twos (2s) compliment number

Figure 2–7: Bit Format of Word 3 in the Receive Descriptor Ring Entry

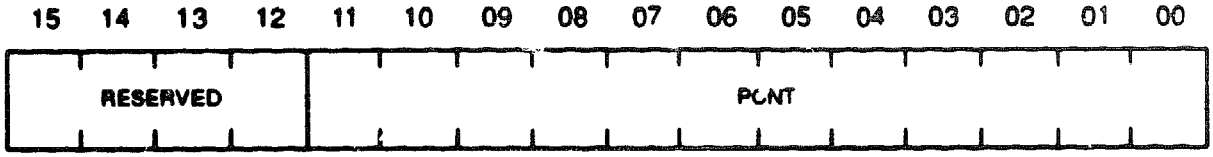

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Table 2–4: Bit Descriptions of Word 3 in the Receive Descriptor Ring Entry

Bit(s)	Name	Description
<15:12>	RESERVED	Not used.
<11:00>	PCNT	Packet byte count. The number of bytes in the received packet.

2.3.2.2 Transmit Descriptor Ring Entry

Each transmit descriptor ring entry is made up of four words that define the location and status of packets stored in packet memory. Figures 2–8 through 2–11 show the fields that make up each word in the transmit descriptor ring entry. Tables 2–5 through 2–8 describe the bit functions of each word in the transmit descriptor ring entry.

Figure 2–8: Bit Format of Word 0 in the Transmit Descriptor Ring Entry

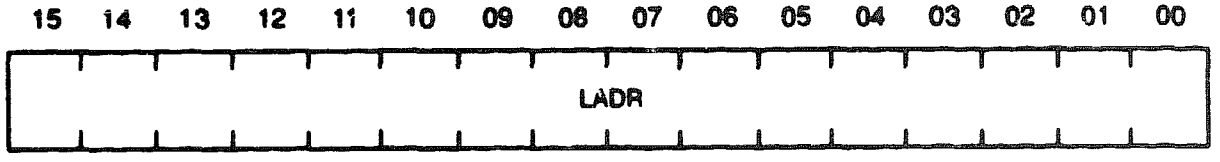

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Table 2–5: Bit Descriptions of Word 0 in the Transmit Descriptor Ring Entry

Bit(s)	Name	Description
<15:00>	LADR	Low address. The low-order 16 bits of the address of the transmit data buffer corresponding to this transmit descriptor ring entry

Figure 2–9: Bit Format of Word 1 in the Transmit Descriptor Ring Entry

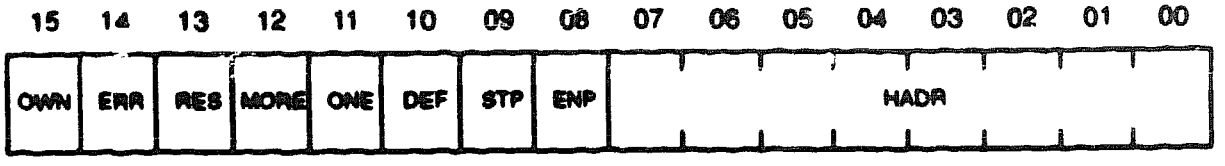

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Table 2–6: Bit Descriptions of Word 1 in the Transmit Descriptor Ring Entry

Bit(s)	Name	Description
<15>	OWN	Ownership bit. When set, indicates that the LANCE owns or has use of the receive descriptor ring entry and the corresponding transmit data buffer. The microprocessor sets the OWN bit to tell the LANCE to transmit the contents of the data buffer as a packet. The LANCE clears the bit to give the entry back to the microprocessor.
<14>	ERR	Error summary. Indicates that one or more of the following error bits is set in the transmit descriptor ring entry word 3: UFLO, LCOL, LCAR, or RTRY.
<13>	RES	Not used.
<12>	MORE	More. Indicates that more than one retry was needed to transmit the packet.
<11>	ONE	One. Indicates that exactly one retry was needed to transmit the packet.
<10>	DEF	Deferred. Indicates that the LANCE had to defer or wait for a pause in the message traffic on the network before transmitting the packet.
<09>	STP	Start of packet. Indicates that this is the first buffer to be used by the LANCE for this packet. It is used for data chaining buffers.
<08>	ENP	End of packet. Indicates that this is the last buffer to be used by the LANCE for this packet. It is used for data chaining buffers.
<07:00>	HADR	High address. The high-order 8 bits of the address of the transmit data buffer corresponding to this transmit descriptor ring entry.

Figure 2–10: Bit Format of Word 2 in the Transmit Descriptor Ring Entry

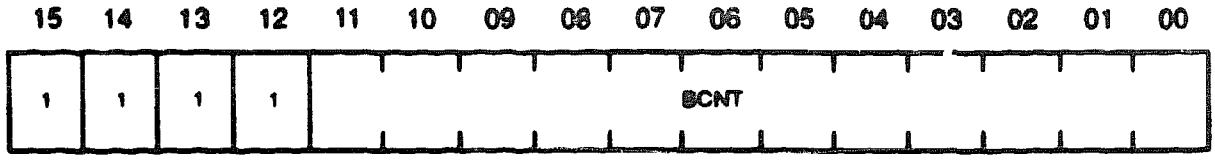

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Table 2–7: Bit Descriptions of Word 2 in the Transmit Descriptor Ring Entry

Bit(s)	Name	Description
<15:12>	1	Must be ones (1s).
<11:00>	BCNT	Buffer byte count. The length of the data buffer corresponding to this entry in the transmit descriptor ring expressed as a twos (2s) compliment number.

Figure 2–11: Bit Format of Word 3 in the Transmit Descriptor Ring Entry

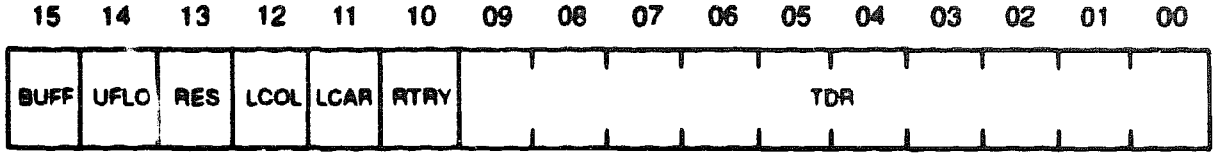

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Table 2–8: Bit Descriptions of Word 3 in the Transmit Descriptor Ring Entry

Bit(s)	Name	Description
<15>	BUFF	Buffer error. Indicates that the LANCE did not find the end of the packet (ENP) bit in the current buffer and did not own the next buffer.
<14>	UFLO	Underflow error. Indicates that the LANCE has truncated the packet because it was unable to read data words from memory quickly enough.
<13>	RES	Not used.
<12>	LCOL	Late collision. Indicates that a collision occurred after the LANCE transmitted the first 64 bytes of the packet. All nodes should have detected activity on the network by this time. This suggests that the collision detect circuitry of some other node on the network has failed. The LANCE does not retry on late collisions.
<11>	LCAR	Loss of carrier. Indicates that the carrier-presence input to the LANCE went false during transmission of this packet. The LANCE does not retry upon loss of carrier.
<10>	RTRY	Retry error. Indicates that the LANCE failed to transmit the packet in 16 attempts because of repeated collisions on the network.
<09:00>	TDR	Time domain reflectometry. An internal counter that counts system clocks (10 MHz) from the start of a transmission to the occurrence of a collision. This value is useful in determining the approximate distance to a fault in the network cable. The TDR value is valid only if RTRY is set.

2.4 Learning and Forwarding

The main function of the LAN Bridge 150 unit is filtering network traffic. This minimizes network traffic by keeping local traffic local.

The LAN Bridge 150 unit "listens" to network traffic and acquires a working knowledge of which stations are associated with which LAN (LANs are identified as being connected to Port A or Port B of the bridge). This knowledge is acquired by reading the source addresses of incoming packets and noting the port through which the packet entered. Thus each station address that is heard from becomes associated with a port of the bridge.

The LAN Bridge 150 unit stores the information in a station address table that holds the station address (48 bits) and the status of each station (16 bits). The status is written by the firmware and defines the port associated with an address, the age of the address, and so on.

When subsequent packets are received that are intended for a known (previously stored) address, the bridge can determine whether the packet should be forwarded or ignored. The bridge also updates any existing status for the station that sent the packet. If the sending station was previously unknown, the bridge adds the new address and its status to the table.

Figure 2–12 illustrates the table lookup (TLU) process. The Troll feature (see Section 2.4.5) shown in the figure can be set by RBMS. This feature controls access to certain stations on the network.

Figure 2–12: Table Lookup Process

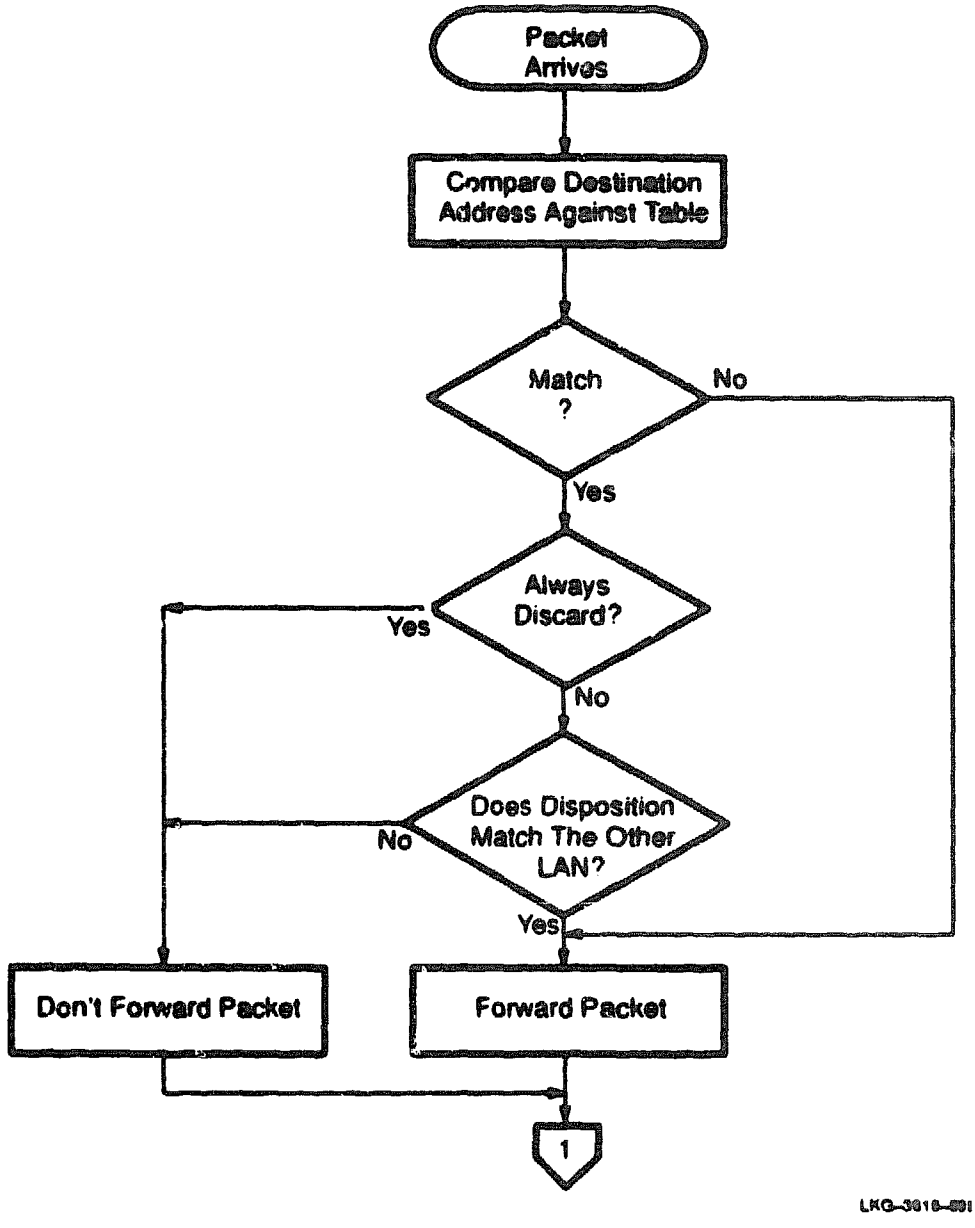
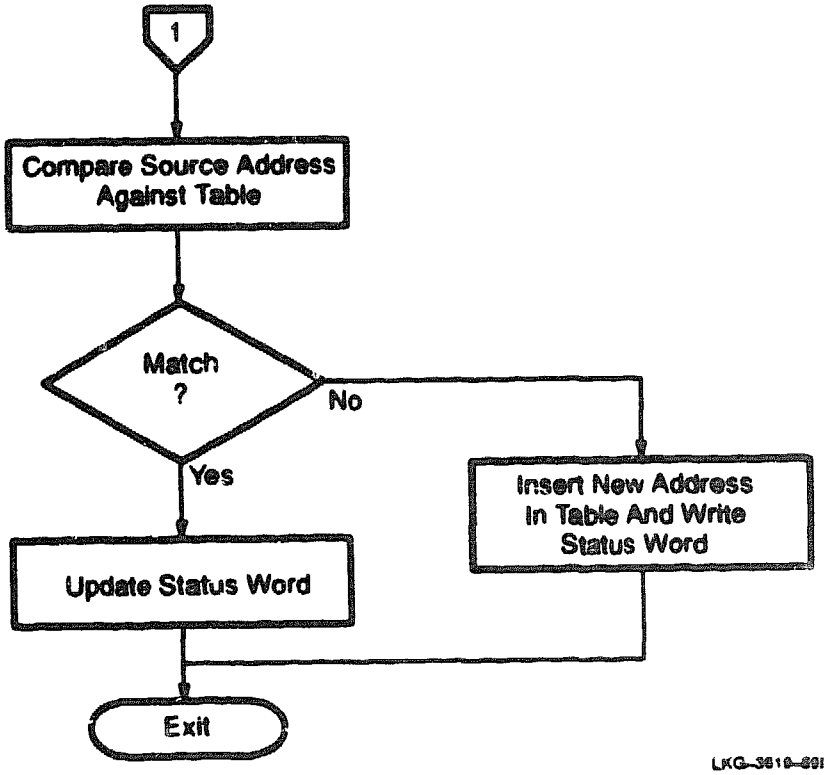


Figure 2–12 Cont'd on next page

Figure 2–12(Cont.): Table Lookup Process



2.4.1 Table Initialization

When the LAN Bridge 150 unit first becomes active, the network address table is empty. Because the table is empty, the processor has no means of accessing status information to perform packet filtering. The bridge must construct a list of active stations on the network. To do this, the bridge processor places the bridge in the PREFORWARDING state to monitor all traffic on the two LANs to which it is connected.

In the PREFORWARDING state, source addresses are extracted from the packets received from the LANs, but the packets are not forwarded. These source addresses and a status word for each station address are inserted in ascending order into the network address table.

The bridge exits the PREFORWARDING state after the preforwarding delay time of 30 seconds. The preforwarding delay time can be changed by use of RBMS.

2.4.2 Address Table Entries

Address table entries are used to keep track of the status of known network stations. A station becomes known when the LAN Bridge 150 unit receives a packet from the station.

An address table entry has the fields shown in Figure 2–13.

Figure 2–13: Address Table Entry

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The status is a 16-bit word stored in address table RAM. The status functions include:

- Identifying the port associated with the station address.
- Logging the age of the last packet received.

- Noting any special status that can be set by RBMS, such as a nonaging or limited access address and so on.

The address is the unique 48-bit station address of the originating station.

2.4.3 Binary Search

Under the heaviest network traffic conditions, the bridge must be able to filter or forward a continuous stream of minimum-size (64 bytes) incoming packets. Thus it is essential that the TLU subsystem quickly find entries in the active station list or determine that an entry is not present. The active station list is an ordered list (ascending numerical order) of 48-bit station addresses corresponding to active stations on the network.

A rapid search is accomplished using a binary decision tree search method. Figure 2–14 shows a binary decision tree for 16 stations.

The binary search is started at the middle entry of the table. A comparison is made between the address received and the middle entry and a "greater than," "less than," or "equal to" determination is made. This determination results in the following actions:

- If the received address is greater than the accessed entry of the table, the search continues at the center of the upper half of the tree. In Figure 2–14, the search would continue at address 12.
- If the received address is less than the accessed entry of the table, the search continues at the center of the lower half of the tree. In Figure 2–14, the search would continue at address 4.
- If the received address is equal to the accessed entry of the table, the search ends.

If the search continues, another "greater than," "less than," or "equal to" determination is made on the remaining part of the tree. This process continues until the address is found or is determined to be missing from the table.

When the search ends, the results are made available to the search results register. The results include a pointer to the last location probed, and bits that indicate whether the received address was less than, greater than, or equal to the address in the last location probed.

The binary search algorithm requires a maximum of 13 probes in a table containing 8000 entries. The example in Figure 2–14 requires a maximum of four probes. To optimize the LAN Bridge 150 processor performance, the results of a search are sought only after enough time has elapsed to guarantee that the required number of probes has been performed.

Figure 2–14: Binary Decision Tree

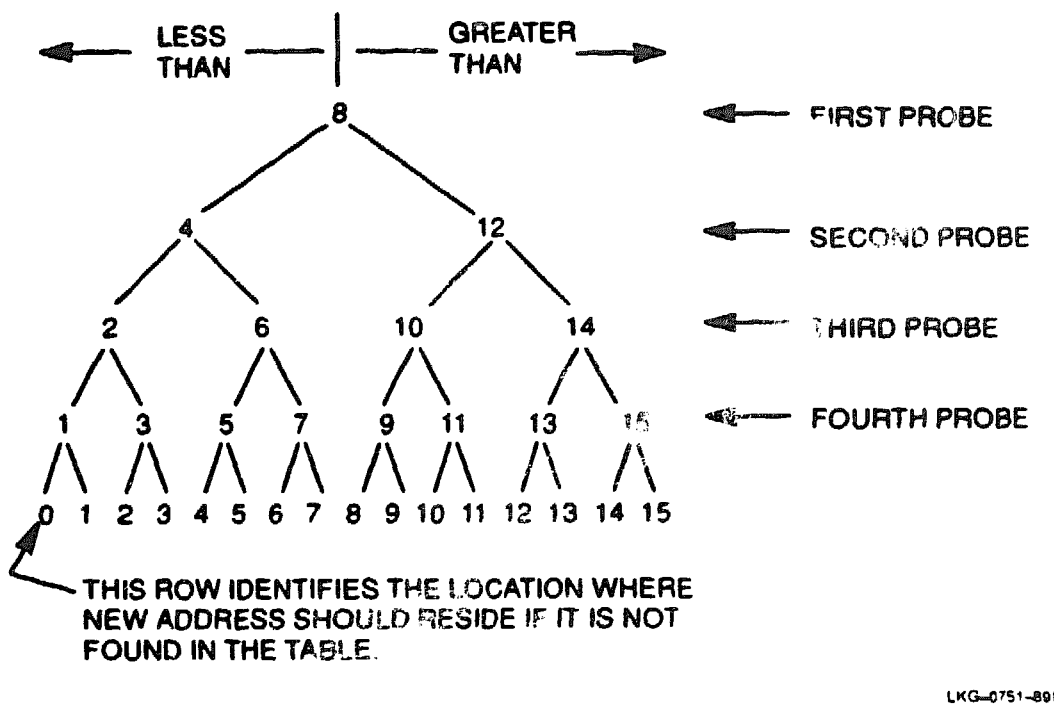
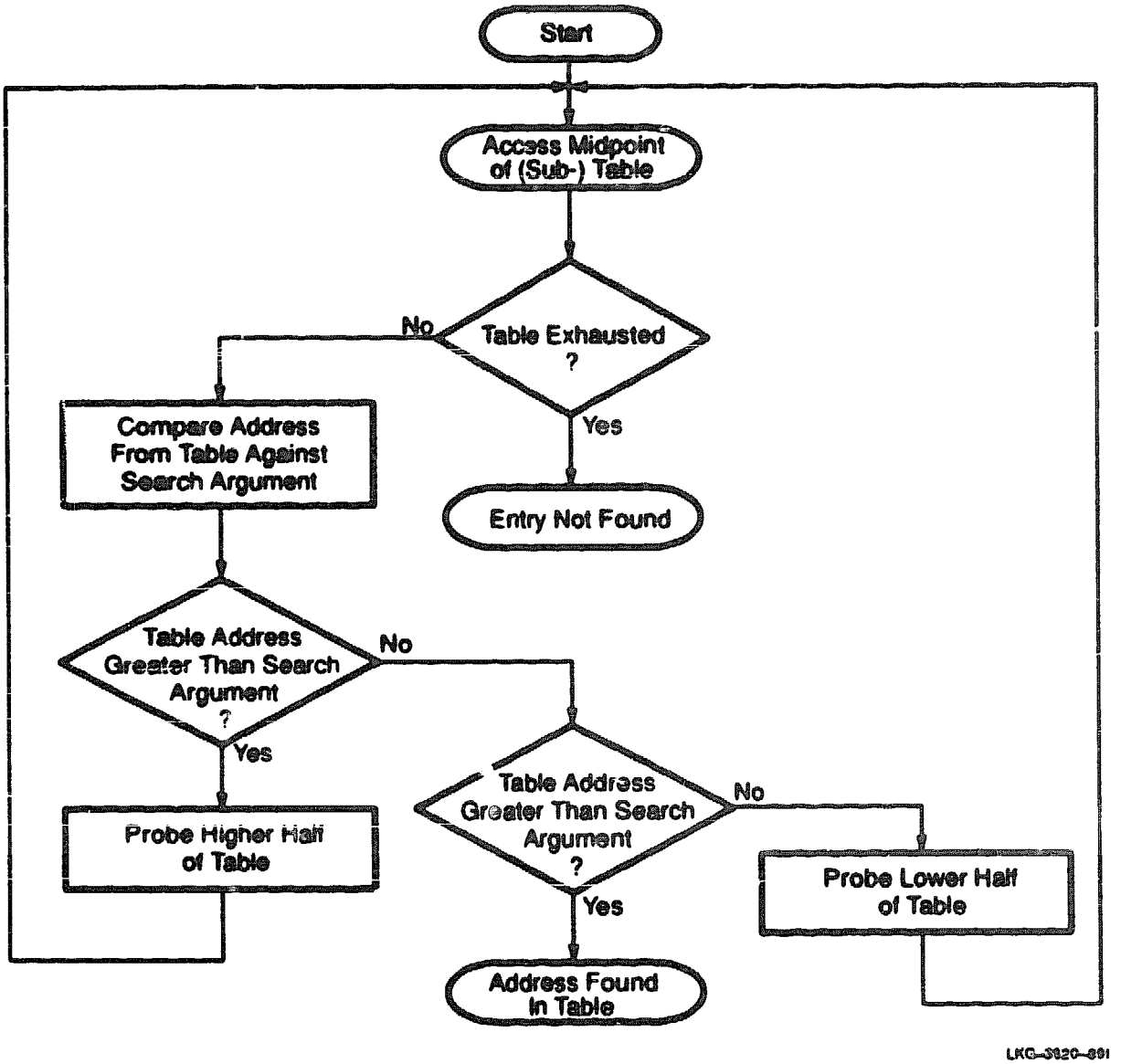


Figure 2–15 illustrates the decisions that control the binary search process.

Figure 2–15: Binary Search Process



2.4.4 Forwarding

When the LAN Bridge 150 unit has found an incoming packet's destination address to be stored in the active station list of the address table, it checks the corresponding status word to determine whether the packet should be forwarded or ignored.

When the bridge has not found the destination address from an incoming packet to be stored in the active station list of the address table, the bridge forwards the packet by default.

NOTE

If certain conditions are set by use of RBMS, the LAN Bridge 150 unit places additional constraints on the decision of whether to filter or forward packets. Some of these conditions are discussed in Section 3.4.5.

2.4.5 Writing the Ethernet Address Table

An optional software package, Remote Bridge Management Software (RBMS), can be used to specify additional conditions for the bridge's decision on whether to filter or forward packets. Users of RBMS can write into the active station list to regionalize multicast packets or limit the access of certain stations on opposite sides of the bridge.

More detailed information on implementing the following features is provided in *Remote Bridge Management Software Use*.

Regionalization

A number of protocols use multicast packets for initializing, locating other stations, and so on. It is easy to confine such protocols to a particular region of the network by instructing the bridge not to pass such multicast packets. This is done by entering the multicast addresses into the Ethernet address table of the bridge. In this way, the bridge recognizes the addresses as being on the same side of the bridge as the originating station and does not forward them.

Limiting Access

It may be desirable from a network management standpoint to limit the ability of some stations on one side of the bridge to send packets to certain station on the opposite side of the bridge. This is referred to as the Troll feature, which can be activated by RBMS.

The appropriate bridge management protocol packet instructs the bridge to flag none, some, or all of the addresses in the active station list as controlled addresses. This causes the bridge firmware to drop packets originating from one side of the bridge destined for these controlled addresses on the opposite side. In other words, the bridge never forwards a packet to what is considered to be a controlled address.

2.4.6 Special Cases

The LAN Bridge 150 unit handles the following special cases.

2.4.6.1 Stale Packets

A packet that is to be forwarded becomes stale if the bridge is not able to forward the packet within two seconds because of outbound congestion. This stale packet time is measured from the reception of the last byte of the CRC off the inbound local area network (LAN) to the start of transmission of the destination address on the outbound LAN. The LAN Bridge 150 unit recovers from a stale packet condition by causing an unsuccessful transmission of the packet.

2.4.6.2 Swapped Sides

If a station is moved from one side of the bridge to the other, its presence on the new port supersedes its presence on the old port (the status word is updated).

2.4.6.3 Address Aging

The relative age of station addresses in the Ethernet address table is determined by the amount of time elapsed since the station was last heard from.

If two minutes have elapsed since the station was last heard from, the bridge considers the station to have ceased to exist on that side of the bridge. Any data in the status word indicating that the station exists on that side of the bridge is ignored.

If that station later transmits from its previous side of the bridge, its address is relearned.

NOTE

Two minutes is the normal amount of time allowed for aging. However, for two minutes following a topology change, only 30 seconds of aging are allowed. Topology changes can change the location (port) associated with an address and cause partitioning of the extended LAN.

Shortened aging time minimizes partitioning by clearing the address table of entries whose locations were affected by the topology change.

2.4.7 Ethernet Address Table Maintenance

When the LAN Bridge 150 unit finds the source address from an incoming packet to be in the active station list of the Ethernet address table, it updates the corresponding status word. Updating the status word includes resetting the aging timer, noting the port associated with the address and so on.

When the source address from an incoming packet is not stored in the active station list, the bridge must insert the new address (and status) into its place in the ordered table.

New addresses and their search status (last location probed and the equal to or greater than bits) are first stored in the new address entry portion of the address table.

As a background operation (see Section 2.6), the new address entries are presorted in the new entry portion of the table. Then each address is inserted into the active station list.

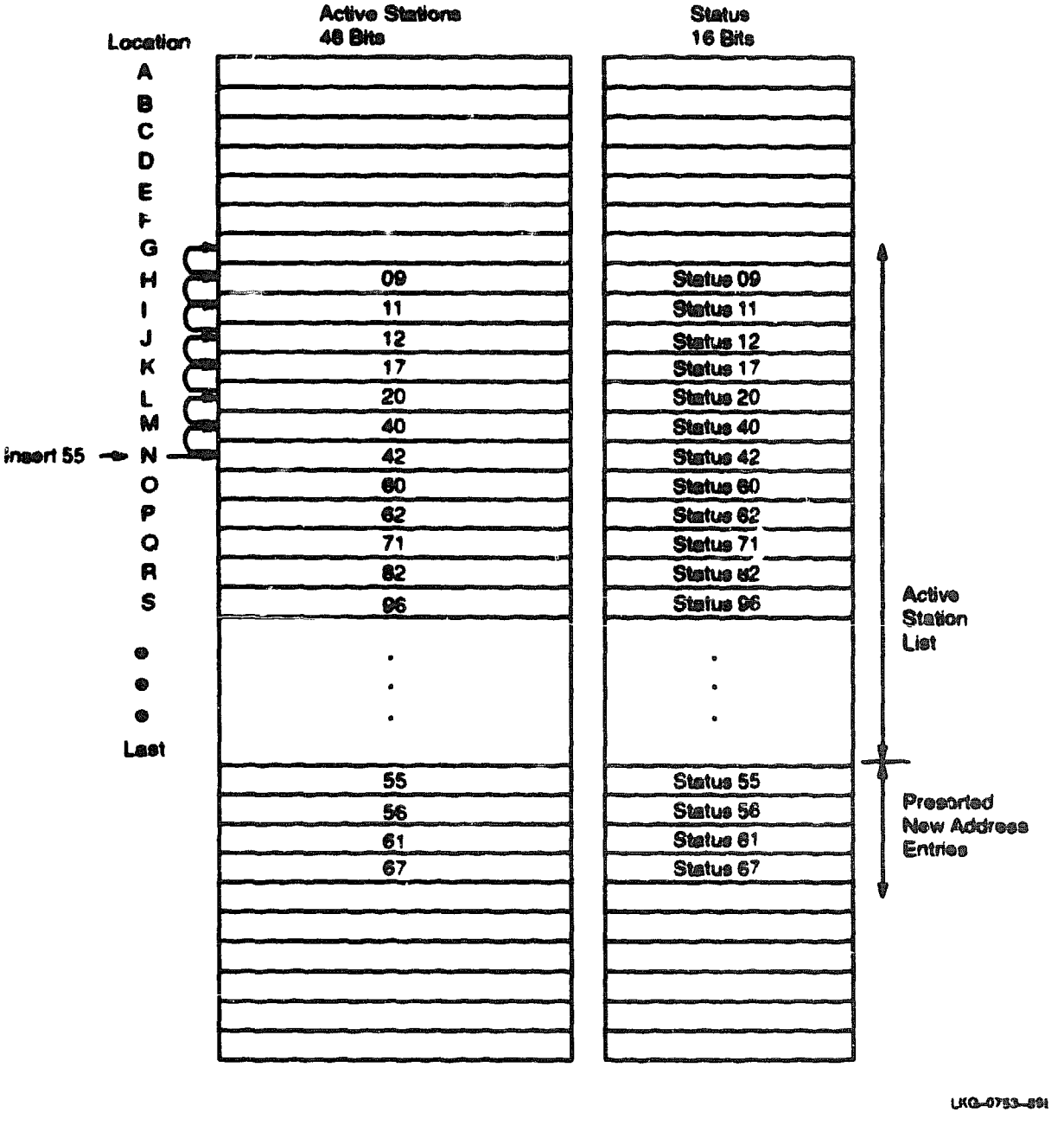
2.4.7.1 Inserting New Addresses

When a new source address is inserted into the active station list, it must be inserted in its proper location in the ordered table. Often, this requires numerous existing entries to be shifted up so that the proper location is "vacated" to accommodate the new address.

As an example, Figure 2–16 shows addresses that must be moved to accommodate the new address 55. Address 55 must be inserted into location N to maintain the ordered nature of the table.

Since the new address 55 must be inserted into location N in the active station list, seven addresses must be transferred up one location at a time until location N is vacated.

Figure 2–16: Inserting a New Address into the Ordered Table



2.4.7.2 Single-Entry Compare

When several new addresses have accumulated in the new address entry portion of the address table, they are presorted using a single-entry comparison before they are inserted into the active station list. Presorting new entries quickens the process of insertion into the active station list.

Under normal conditions, a binary search is initiated using the middle location in the active station list. A binary search continues until the address is found or the table is exhausted.

A special location (0000) in the address table is used to initiate single-entry comparisons. When location 0000 is probed by the microprocessor, a single comparison is made and no further locations are probed.

Once the new entries are presorted, the microprocessor then uses 64-bit moves (see Section 2.4.7.3) to insert each address into its location in the active station list.

2.4.7.3 64-Bit Move

Shifting any address in the address table involves moving 48 bits of address and the corresponding 16 bits of status, a total of 64 bits. Since the microprocessor can manipulate only 16 bits of data at a time, each address shift would require four address-to-address transfers.

To accelerate the task of table maintenance, a special address range is mapped so that when the microprocessor addresses the special address range, all 64 bits (the address and status) are moved at once. The low-order 48 bits that make up the Ethernet address are read from RAM, temporarily stored in the comparator PALs and then written into the new location in RAM. The high-order 16 bits that make up the status word are written from the status RAM, temporarily stored in the microprocessor status register, and then written into the new location in the status RAM.

2.5 Loop Detection

LAN configurations cannot include any loops (redundant paths) because packets transmitted onto the LAN will circulate around any loop indefinitely.

All LAN Bridge 150 units have a loop detection feature. This is an automatic process that logically configures a loop-free extended network. This process, performed by a spanning tree computation algorithm, provides the following features to enhance extended network performance:

- **Loop detection—If LAN Bridge 150 units are accidentally configured in a loop, the process will compute a loop-free portion of the topology. This prevents packets from circulating around the extended network indefinitely.**

- **Backup—LAN Bridge 150 units can be deliberately configured in a loop in such a way that one LAN Bridge 150 unit in the loop can serve as the backup for any one of the other LAN Bridge 150 units in the loop.**

- **The process is self-maintaining—The process is a continuous one that responds dynamically to changes in network topology. Changes may be caused by a malfunctioning LAN Bridge 150 unit or by using Remote Bridge Management Software to change parameters in the spanning tree computation algorithm. When changes are sensed, the algorithm recomputes the new network topology and again becomes stable and self-maintaining.**

- **The process is deterministic—A fixed set of rules controls the process so that when variables are changed, the results can be predicted.**

- **The process requires low network overhead—The messages that control the spanning tree are transmitted by participating LAN Bridge 150 units at 1-second intervals, thus using a very small percentage of the available network bandwidth. For example, if the interval between Hello messages is 1 second (the default), the overhead caused by Hello messages in a stable configuration is 64 bytes per second (0.005% on the network).**

NOTE

Hello messages are 60 bytes in length. The Hello multicast address is (HEX) 09-00-2B-01-00-01, and the type field is 80-38. This message is for use in Digital's LAN Bridge 100 spanning tree message. The LAN Bridge 150 also uses IEEE 802.1 Part D MAC Bridge Standard. For more information on hello messages, refer to the IEEE 802.1 Part D MAC Bridge Standard.

2.5.1 The Spanning Tree Principle

Although the LAN Bridge 150 units in an extended network can be physically placed in an arbitrary fashion, the logical network that the LAN Bridge 150 units automatically create is always a *spanning tree*. The spanning tree has the following basic properties:

- **There are no loops; that is, there is only one path between any two LAN Bridge 150 units.**

- All LANs are connected.

The process by which the LAN Bridge 150 units construct the logical spanning tree from an arbitrary physical configuration is called the spanning tree computation process.

2.5.2 The Spanning Tree Computation Process

The spanning tree computation process consists of the following steps:

1. The extended network elects a single root bridge.
2. The extended network elects a designated bridge on each of its LANs. The designated bridge is the LAN Bridge 150 unit with the lowest path cost to the root bridge. A path cost is the sum of all the line-cost parameter values in any given path of lines. RBMS may be used to modify line cost parameter values (see Section 2.7).
3. All LAN Bridge 150 units except designated bridges turn off all lines, except for the single line that is the lowest path cost to the root bridge. Designated bridges turn off all lines except for the single line that is the lowest path cost to the root bridge and any lines attached to LANs for which they are the designated bridge.

2.5.2.1 Types of Spanning Tree Modes

The spanning tree computation process developed by Digital Equipment Corporation was first implemented in Digital's LAN Bridge 100 product. This spanning tree algorithm was offered to the IEEE and is now part of the IEEE 802.1 Part D MAC Bridge Standard.

Although the two algorithms are identical and produce exactly the same spanning tree topologies, the 802.1 standard uses several different parameters to implement the algorithm. For example, the multicast address used for bridge Hello messages in the LAN Bridge 100 spanning tree mode is different than the multicast address used for Hello messages in the IEEE 802.1 spanning tree mode. As a result, bridges that operate in one of these two spanning tree modes cannot understand Hello messages from bridges that operate in the other spanning tree mode.

To illustrate the problems involved in having two types of bridges in the same network, assume that a LAN Bridge 100 is connected in a loop with a bridge using IEEE 802.1 spanning tree mode. Since the two bridges cannot understand each other's Hello messages, the first one to receive a Hello message from the other will simply ignore the message and pass it on. The sender of that Hello

message, detecting its own Hello message on both of its ports, will place itself in the BACKUP state.

In this situation, the spanning tree algorithm is no longer deterministic. A user cannot predict (or control) which of the two bridges will be the forwarding bridge and which will be the backup bridge.

Another problem can arise if both bridges come up at the same time. This causes both bridges to cycle continuously between the BACKUP state and the FORWARDING state.

2.5.2.2 Migration Bridges

To help solve this problem, Digital manufactures the LAN Bridge 150 and LAN Bridge 200 models. These bridges can dynamically adapt to either the LAN Bridge 100 spanning tree mode or the IEEE 802.1 spanning tree mode, depending on what the network configuration requires. An auto-select software switch controlled by the bridge management lets you either enable this auto-select feature or allows locking the bridge in the IEEE 802.1 spanning tree mode. Bridges with this auto-select feature are sometimes called *migration* bridges.

When a migration bridge is installed, it defaults to the IEEE 802.1 spanning tree mode. If it detects any bridges operating in the LAN Bridge 100 spanning tree mode, it automatically switches to that mode and discards any Hello messages received from an IEEE 802.1 spanning tree bridge. This subdivides the network into two parts: one part that uses the LAN Bridge 100 spanning tree mode on one side of the bridge and another part that uses the IEEE 802.1 spanning tree mode on the other side of the bridge. Each of these two parts operates in its own spanning tree mode and, more importantly, results in a spanning tree topology that is deterministic. If the migration bridge stops hearing the LAN Bridge 100 spanning tree mode messages, it automatically reverts back to the IEEE 802.1 spanning tree mode.

2.5.3 Spanning Tree Example

When LAN Bridge 150 units are first activated (either by being powered on or by being reset using a bridge management command), each LAN Bridge 150 unit assumes that it is the root bridge of the spanning tree. Each LAN Bridge 150 unit sends out Hello messages on all its LANs declaring itself to be the root bridge of the extended network. These Hello messages are multicast to all other bridges that are directly connected to the same LANs. For example, in Figure 2–17, bridge B10's Hello message is received by bridges B3, B4, B9, B11, and B14.

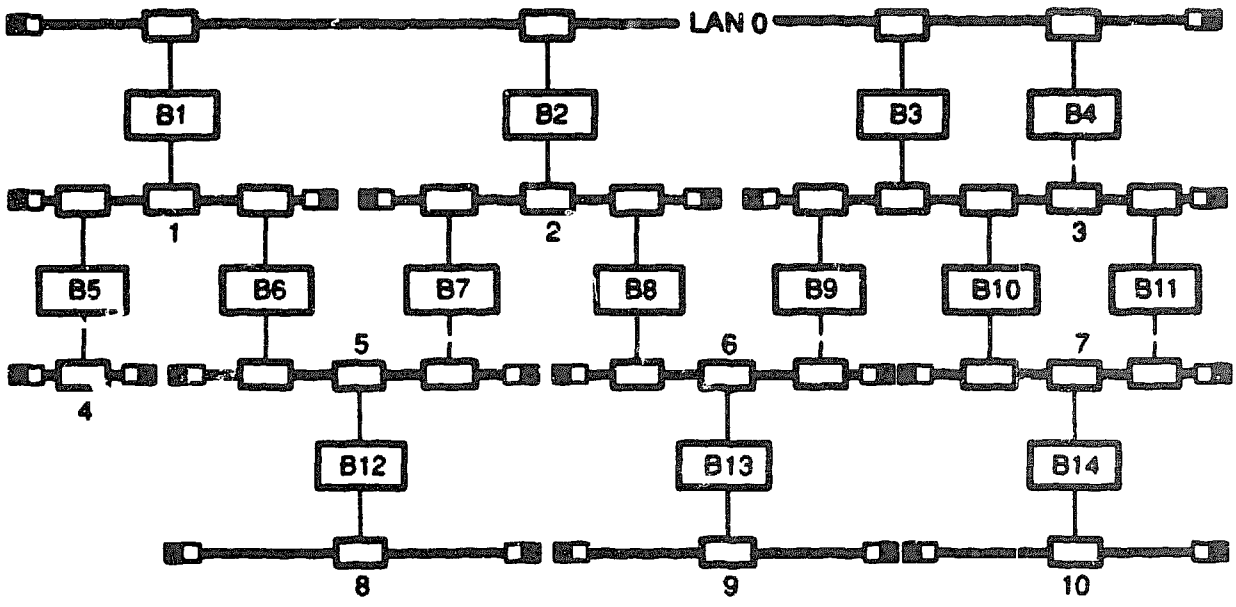
Because the LAN Bridge 150 unit is declaring itself the root bridge, it also declares itself the designated bridge on all its LANs.

As LAN Bridge 150 units receive Hello messages from other LAN Bridge 150 units, each bridge compares the root bridge and designated bridge information in the received Hello messages to its own information. When performing the comparison, the bridge compares the new root bridge, root path cost, and designated bridge to the current root bridge, root path cost, and designated bridge. The root bridge and designated bridge fields are simply the network address of the root bridge and designated bridge with a root priority prefix. This root priority prefix can be set by bridge management and defaults to a fixed value that is equal for all bridges. If a bridge finds that a Hello message contains better root information (lower values), it ceases to declare itself as the root, stores the new root information just received, and begins to send out the new information.

In a stable environment (all bridges and lines remain active), this process eventually leads to a single root bridge being elected as well as a single designated bridge per LAN. If no further events occur, the network will remain configured in the original spanning tree created by the spanning tree computation algorithm. Note that given the same bridges, the same set of conditions, and the same set of parameters, the spanning tree computation algorithm will always derive the same configuration.

Figure 2–17 shows the end result of the algorithm for a 14-bridge extended network. In this network, the bridges have the addresses B1 through B14. All root priority fields are assumed to be the default (128). If address B1 is assumed to be arithmetically less than address B2, then B1 will become the root bridge. Figure 2–17 also shows the lines that are put into the BACKUP state. In this state the bridges continue to receive Hello messages over these lines; however, the lines are not used for forwarding. This BACKUP state is what allows the bridges to form a loop-free tree from an arbitrary physical connection and yet have the flexibility to reconfigure themselves if a line goes down. Figure 2–17 also shows the designated bridges that result from the algorithm: bridges B2, B3, B5, B6, B8, B10, B12, B13, and B14.

Figure 2–17: Result of the Spanning Tree Computation Algorithm



- Broken lines indicate lines that are in the BACKUP state.
- Bridge B1 is the root bridge.
- Bridges B2, B3, B5, B6, B8, B10, B12, B13, B14 are the designated bridges.

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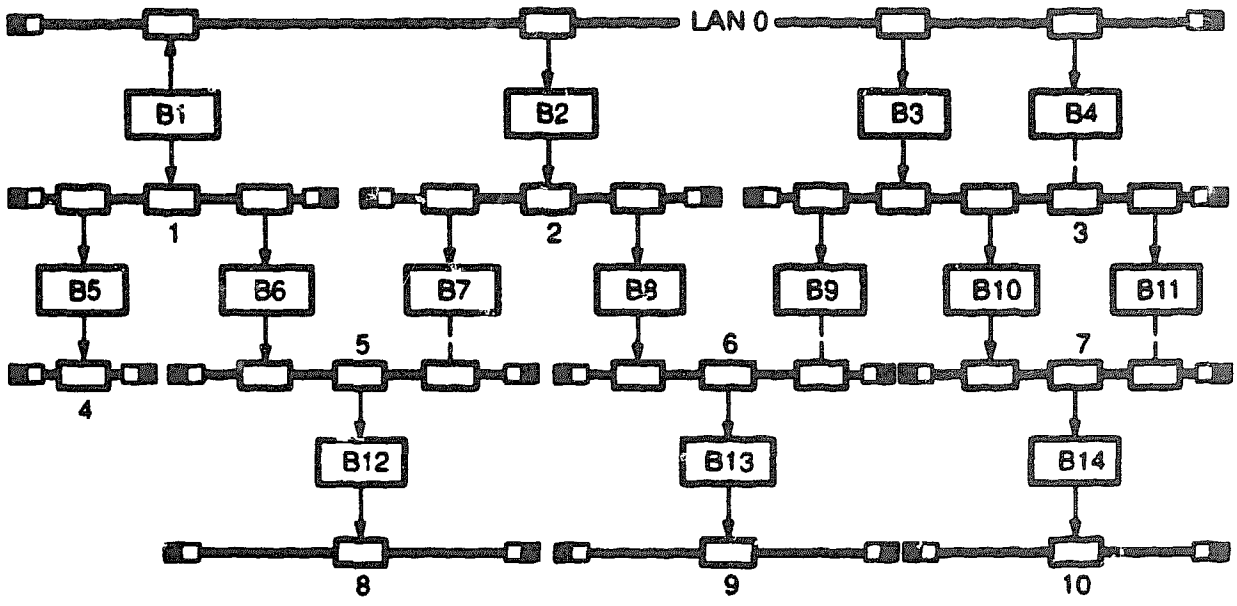
When a stable spanning tree configuration has been established and a bridge determines that it is not the root bridge, it stops sending out Hello messages. Instead, it sends out a Hello message only when it receives a Hello message from the designated bridge on the line to the root bridge. Other than topology change notification messages, bridges do not send a Hello message on the line over which they received the Hello message (the line to the designated bridge).

Therefore, in a stable network, each LAN has only one bridge (the designated bridge) that sends out Hello messages. Figure 2–18 shows the Hello message propagation in the stable network shown in Figure 2–17.

Figure 2–18: Hello Message Propagation



- ↑ and ↓ indicate direction of Hello message propagation.
- Broken lines indicate lines that are in the BACKUP state.
- Bridge B1 is the root bridge.
- Bridges B2, B3, B5, B6, B8, B10, B12, B13, B14 are the designated bridges.

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2.5.4 Spanning Tree Parameters

Certain parameters used in the spanning tree computation algorithm can be set using bridge management commands, and almost all parameters and variables involved in the algorithm can be read using management commands. This capability allows network managers to monitor and influence decisions made by individual bridges. For information on using this capability, refer to *Remote Bridge Management Software Use*.

2.5.5 Examples of the Spanning Tree Algorithm

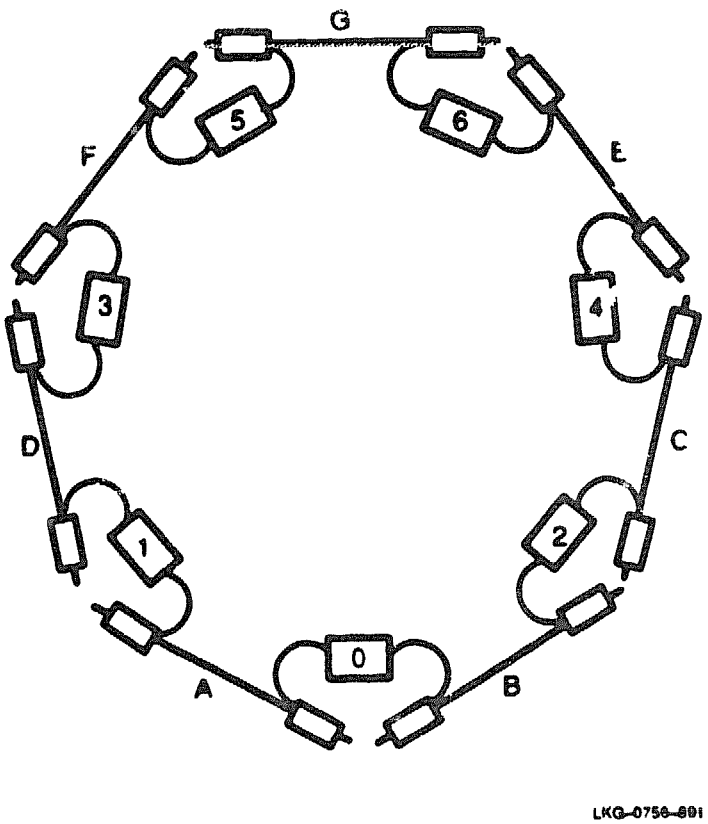
Figure 2–19 represents a possible physical network in which seven networks are tied together with bridges to form a large extended LAN. This particular configuration may not be practical, but it serves to explain the function of the loop detection process. When the bridges in the network of Figure 2–19 are powered up, the following events occur as part of the spanning tree algorithm.

1. All bridges send out Hello messages that contain the bridge ID.
2. Since Bridge 0 has the lowest ID, it is recognized as the root of the spanning tree.
3. The root bridge establishes itself as the designated bridge on each of the LANs it connects.
4. Each of the other bridges determines its distance from the root bridge in terms of the number of bridges between it and the root bridge.
5. The algorithm elects a designated bridge on each LAN. The designated bridge is the one with the lowest path cost to the root bridge.

Designated Bridge	LAN
1	D
2	C
3	F
4	E
5	G

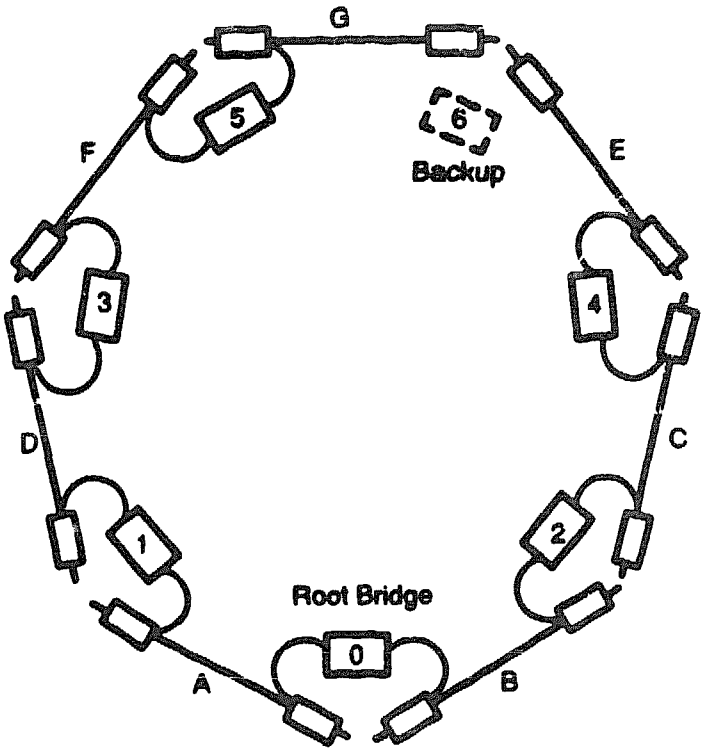
6. In the case of LAN G, the distance to the root bridge is the same through Bridge 5 or Bridge 6. Bridge 5 becomes the designated bridge because its ID is lower than that of Bridge 6. Bridge 6 goes into the BACKUP state because it is neither a root bridge nor a designated bridge.

Figure 2–19: Hypothetical Extended LAN Using Bridges



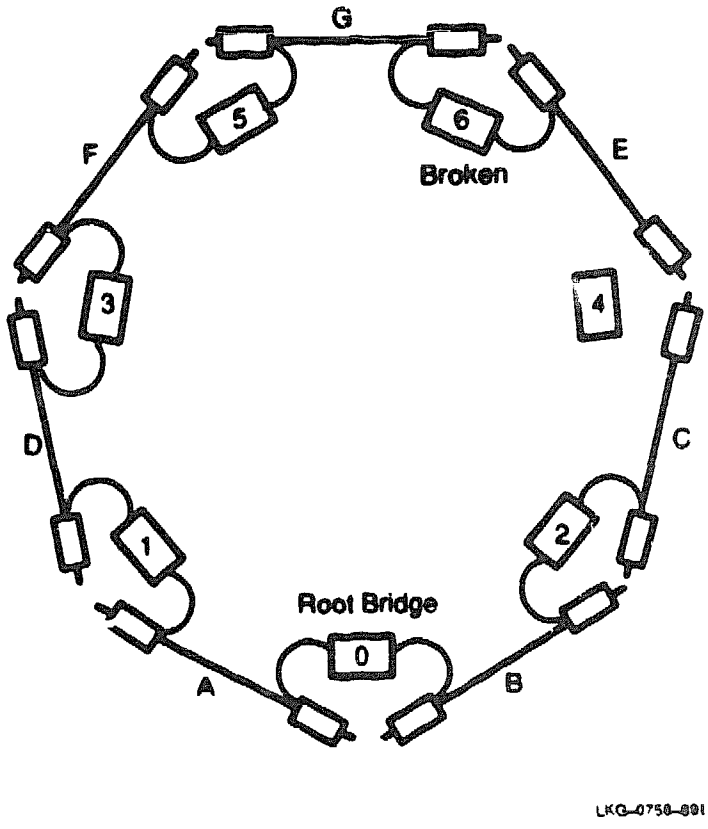
The logical network formed as a result of the learning algorithm is shown in Figure 2–20.

Figure 2–20: Logical Extended LAN Formed by Learning Algorithm



If a bridge goes from FORWARDING state to a BROKEN state, the spanning tree algorithm reconfigures the network topology. For example, if Bridge 4 malfunctions, Bridge 6 goes to the FORWARDING state and becomes the designated bridge for LAN E. Bridge 0 is still the root bridge. The new logical network topology is shown in Figure 2–21.

Figure 2–21: Reconfigured Logical Extended Network

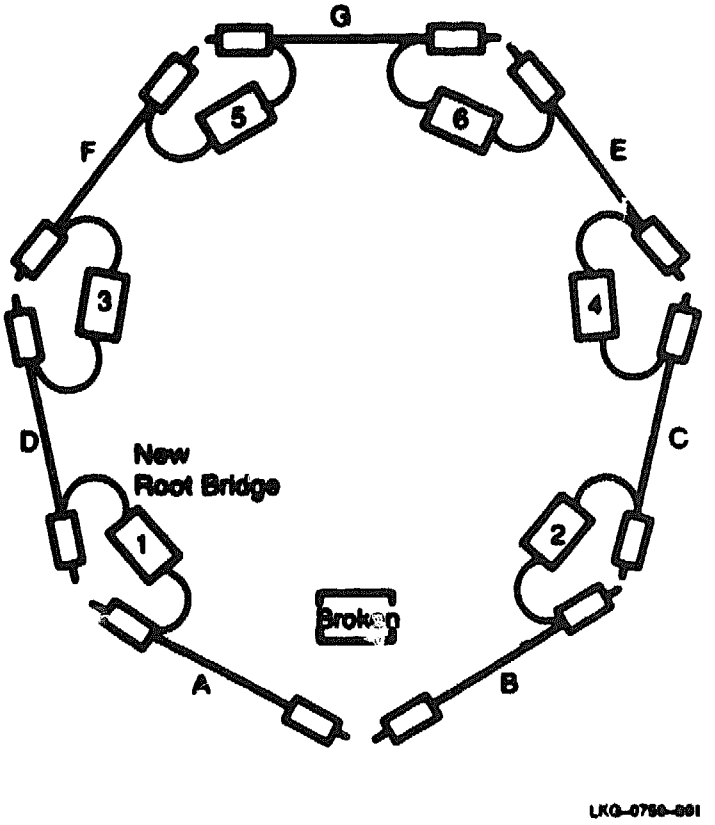


If the root bridge of Figure 2–21 malfunctions:

- Bridge 1 becomes both the root bridge and designated bridge for LANs A and D.
- Bridge 6 goes into the FORWARDING state and becomes the designated bridge for LAN E.
- Bridge 4 becomes the designated bridge for LAN C.
- Bridge 2 becomes the designated bridge for LAN B.

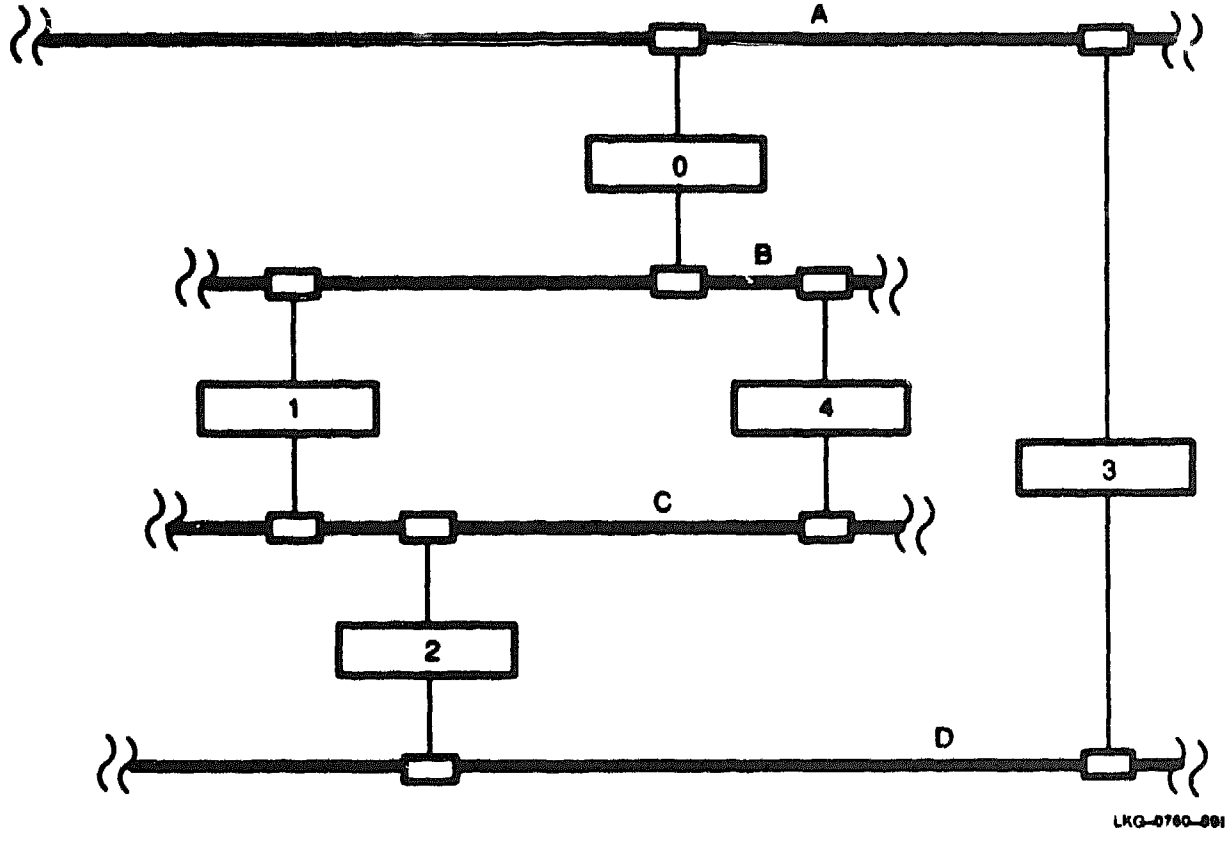
The new logical network topology is shown in Figure 2–22.

Figure 2–22: Reconfigured Logical LAN With a New Root Bridge



Another example of an extended network is shown in Figure 2–23. Notice that bridges are connected in such a way that two physical loops exist. The loop detection function of the bridge helps to configure the network logically so that no loops exist.

Figure 2–23: Extended LAN Showing Physical Loops

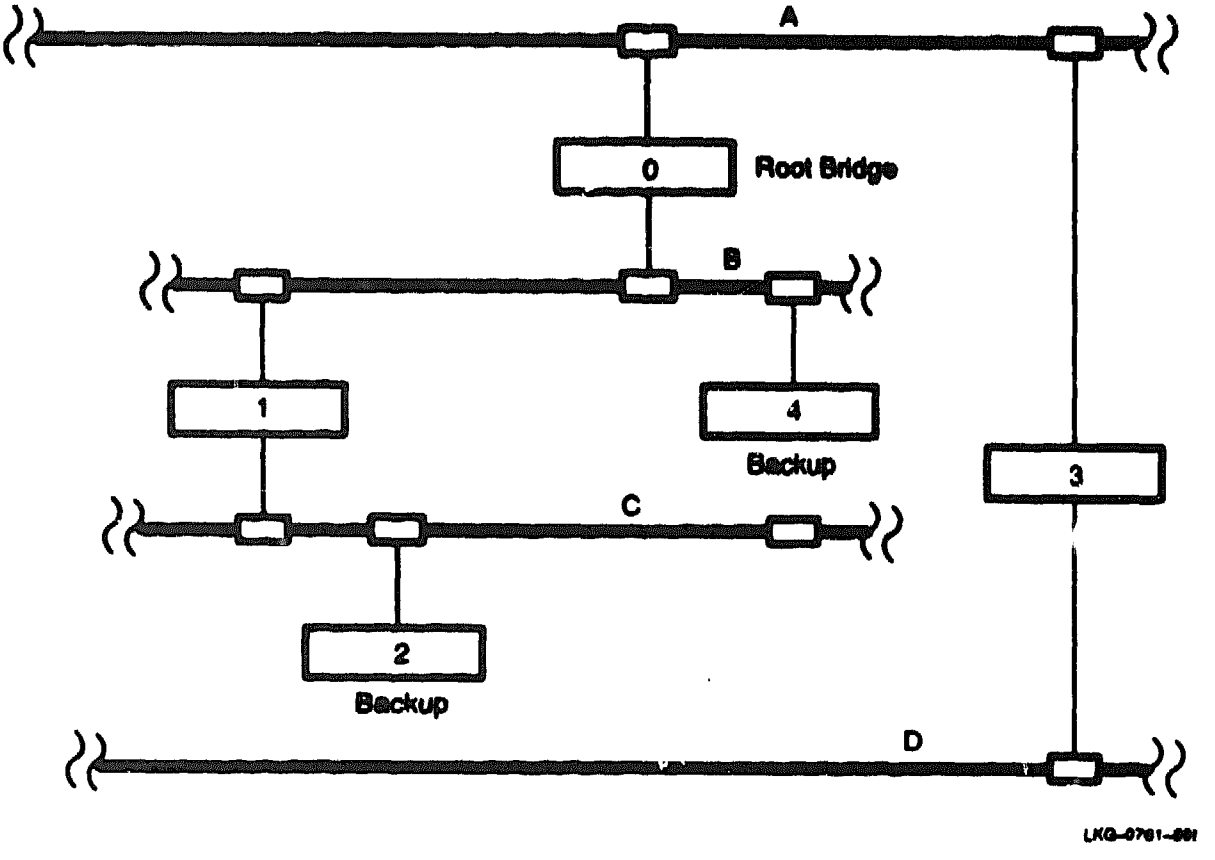


After the network is configured by the spanning tree algorithm:

- Bridge 0 is established as the root bridge of the spanning tree and is the designated bridge for LANs A and B.
- Bridge 1 is established as the designated bridge for LAN C.
- Bridge 3 is established as the designated bridge for LAN D.
- Bridges 2 and 4 enter the BACKUP state.

The logical configuration is shown in Figure 2–24.

Figure 2–24: Logical Extended LAN With Backup Bridges

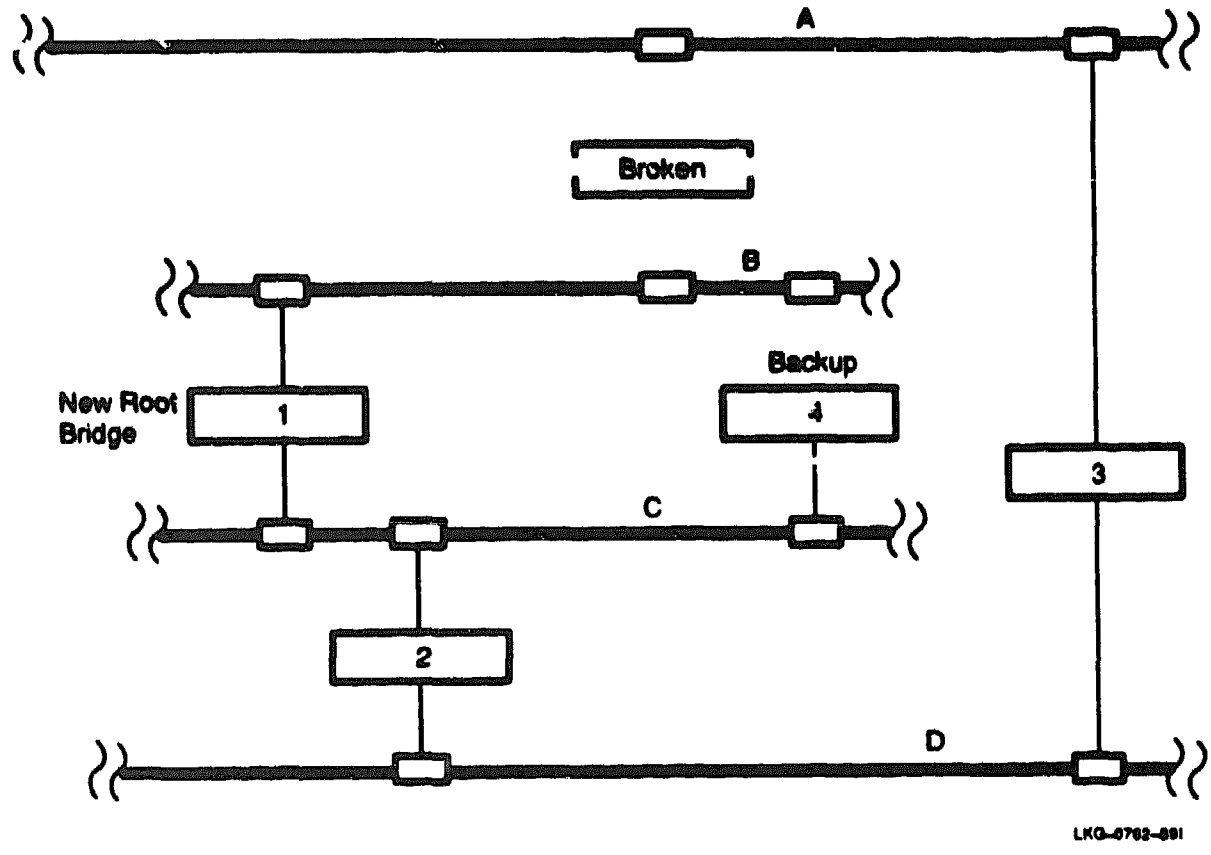


In the network of Figure 2–24:

- If Bridge 1 malfunctions, Bridge 4 becomes operational and the designated bridge for LAN C.
- If Bridge 3 malfunctions, Bridge 2 becomes the designated bridge for LAN D.
- If Bridge 0 (the root bridge) malfunctions, Bridge 1 becomes the new root bridge and designated bridge for LANs B and C, Bridge 2 becomes operational and the designated bridge for LAN D, and Bridge 3 becomes the designated bridge for LAN A.

The new logical network topology formed as a result of the root bridge malfunction is shown in Figure 2–25.

Figure 2–25: Logical Network Topology for New Root Bridge



2.6 Foreground and Background Operations

The main function of the LAN Bridge 150 unit is filtering and forwarding packets. To operate efficiently under the heaviest network traffic conditions, the LAN Bridge 150 unit must be able to filter or forward a packet every 32 ms.

During normal operation, the LAN Bridge 150 unit performs a variety of operations that includes:

- Performing loop detection functions.
- Receiving packets and writing them into packet memory.
- Using the descriptor rings to allocate buffer space and to find packets in packet memory.
- Transmitting packets from packet memory.
- Performing a binary search of the addresses in the Ethernet address table.
- Presorting new address entries.
- Storing new address entries in the Ethernet address table.
- Responding to bridge management instructions.
- Performing MOP operations.
- Performing Test and XID operations

Though all of the operations listed here support the main function of the LAN Bridge 150 unit, some operations may be less critical thus their execution may be delayed until an operation of higher priority is completed.

To prioritize the various operations, those in the critical path of filtering or forwarding packets are considered foreground operations. Less critical operations are considered background operations.

2.6.1 Foreground Operations

Foreground operations must occur so that the LAN Bridge 150 unit can filter or forward packets. The LAN Bridge 150 unit must:

- Receive packets from a LAN.
- Scan and write the receive descriptor ring.
- Write the packets into packet memory.
- Compare the destination address to the Ethernet address table.
- Decide whether to forward or filter the packets.
- Scan and write the transmit descriptor ring.
- Transmit (forward) the packets to the other LAN.

- Compare the source address to the Ethernet address table.
- Perform loop detection functions.

Most of the foreground operations are in the critical path of filtering or forwarding packets and are called critical path operations.

Loop detection functions, though not in the critical path, have the highest priority and are performed as foreground operations. Loops in an extended network cause unnecessary packet traffic that can degrade performance of critical path operations. This condition can ultimately prevent background operations from executing, since background operations are deferred until foreground operations are completed.

Loop detection functions maintain LAN Bridge 150 unit performance levels by detecting and eliminating loops. This optimizes usage of the critical path by minimizing unnecessary traffic, thus allowing time for execution of background operations.

2.6.2 Background Operations

Background operations support the main function of the LAN Bridge 150 unit but are not in the critical path of filtering or forwarding packets. Table 2–9 identifies major background operations in order of their priority.

Table 2–9: Background Operations

Operation	Description
Address Table Maintenance	Typical operations include: – Updating the address table status word – Presorting new address entries – Storing new addresses in the address table
Bridge Management Operations	Responding to bridge management instructions
Maintenance Operation Protocol Functions (MOP)	Responding to requests for system identification, loop data messages, or counter messages
Timer Functions	Resetting various timers
Counter Maintenance Functions	Maintaining pointers to various queues, such as the transmit and receive descriptor rings
Control of State Changes	Dictated by timers and counters that are controlled in the background

2.7 Remote Software and Bridge Access

Remote software (such as Remote Bridge Management Software and LAN Traffic Monitor software) use the network to communicate with the bridge. Bridge switches 3, 4, and 5 control communications between the bridge and the node running remote software. Table 2–10 describes the switch positions that control bridge access.

Password protection is supported by RBMS version 2.0 and the LAN Bridge 150 to provide further bridge protection.

Table 2–10: Bridge Access Switches

Switch Number	Name	ON (Down)	OFF (Up)
3	Port A Access	Stations on the LAN connected to Port A that have bridge management capabilities are allowed to read and write (modify) bridge management parameters. If a load host resides on Port A, the switch must be ON for down-line loading software.	Stations on the LAN connected to Port A that have bridge management capabilities can read but cannot write bridge management parameters.
4	Port B Access	Stations on the LAN connected to Port B that have bridge management capabilities are allowed to read and write (modify) bridge management parameters. If a load host resides on Port B, the switch must be ON for down-line loading software.	Stations on the LAN connected to Port B that have bridge management capabilities can read but cannot write bridge management parameters.
5	Down-Line Load Enable	Configures unit to operate as a LAN Traffic Monitor. Enables the unit to down-line load software (such as LTM Listener software) from a load host. When the switch is ON, the bridge does not forward packets. Applicable Port A access or Port B access switch must be ON so that the load host can write to bridge memory.	Configures unit to operate as a bridge. Disables the down-line function. RBMS Can override the switch causing the bridge to operate as a LAN Traffic Monitor.

2.8 Maintenance Operation Protocol (MOP)

The LAN Bridge 150 unit implements network interconnect (NI) maintenance protocols as specified in the *Digital Network Architecture Maintenance Operations Functional Specification* (Order No. AA-X436A-TK). The operational description and message formats of these protocols are specified in that document. The minimum functional requirements for an NI port are outlined in the *Digital Network Architecture Ethernet Node Product Architecture Specification* (Order No. AA-X440A-TK).

The bridge supports the following minimum set of maintenance functions:

- Request identification and system identification packets
- Loop data and loop data packets
- Request counters and counters messages

These maintenance functions are further defined in Table 2–11.

Table 2–11: MOP Request and Response Messages

Request Message	Response Message
Request Identification—A message from network management requesting a system identification message from the LAN Bridge 150.	System Identification—A response from the bridge containing – MOP version number – Console state – Hardware address – Functions – Device
Loop data—A message from the network management instructing the LAN Bridge 150 to loop data.	Looped data—A message from the LAN Bridge 150 in response to a loop message. Loop messages are forwarded in the direction indicated by the Ethernet address table.

2.9 Self-Test

The self-test is resident in the LAN Bridge 150 firmware and is started on power up or soft reset. The self-test program is designed to:

- Test 95% of all stuck-at (SA1 or SA0) faults.
- Provide a maximum amount of fault isolation to the failing functional block.

The self-test is run in one of two switch-selectable modes:

- Normal
- Loop-on-self-test

In normal mode, the self-test starts from the power-up vector and begins testing at the lowest level with the CPU and ends testing at the more functional network tests. If no errors are found, self-test illuminates the Self-test OK status LED and jumps to the LAN Bridge 150 firmware. If an error is found, a code corresponding to the failing test is written to NVRAM, and the Self-test OK status LED remains off. The LAN Bridge 150 unit enters the BROKEN state, waits 15 seconds, and then reenters the SELF-TEST state. If an error is again detected, the error is handled in the same manner as before. The error code previously stored in NVRAM is overwritten with the most recent error code.

When the loop-on-self-test switch is turned on, the self-test operates the same as it does in normal mode except that it repeats the entire self-test until either an error is detected or the LAN Bridge 150 unit is powered off. The NVRAM write test is disabled after the first pass to avoid exhausting its write capability. The Self-test OK status LED is turned on at the end of the first pass and remains on unless an error is found. If an error is found, the Self-test OK status LED is turned off, and a code corresponding to the failing test is written to the NVRAM and the manufacturing register. The self-test then loops on the failing test and generates a trigger pulse (once each pass) at one of the external pins. This trigger pulse is an aid to troubleshooting the LAN Bridge 150 module.

The self-test contains three main modules:

1. Basic tests
2. LANCE tests
3. Table Lookup (TLU) tests

2.9.1 Basic Tests

Basic tests are run from ROM and include testing of:

- Program ROM
- Program RAM
- NVRAM
- Ethernet address ROM

- Ethernet address RAM
- Timer check
- Packet memory
- Packet memory refresh

Sections 2.9.1.1 through 2.9.1.9 provide a description of each of these basic tests.

2.9.1.1 Program ROM Test

This test does the following:

- Performs a CRC32 calculation on the program ROM excluding the last longword location in the ROM.
- Compares the results of the calculated CRC with the CRC character stored in the last word location of the ROM.

2.9.1.2 Program RAM Test

Program RAM is tested for all stuck-at (SA1 or SA0) faults and coupling faults using a modified version of the Nair, Thatte, and Abraham's testing procedure (refer to *Functional Testing of Semiconductor Random Access Memories—Computing Surveys,* Vol 15, No. 3, September 1983).

2.9.1.3 NVRAM Checksum Test

This test performs a checksum calculation on the NVRAM and compares the calculated checksum with the value stored in the NVRAM. The checksum is calculated using the 16-bit ones complement binary arithmetic, shifting before adding.

2.9.1.4 NVRAM Write Test

This test verifies that the NVRAM can be written to. The NVRAM write test is disabled after the first pass of the self-test in manufacturing mode.

2.9.1.5 Ethernet Address ROM Checksum Test

This test performs a checksum calculation on the Ethernet address ROM and compares the result of the calculation to the checksum value previously stored in the ROM. The checksum is calculated using the 16-bit ones complement binary arithmetic, shifting before adding.

2.9.1.6 Ethernet Address RAM Test

The Ethernet address RAM is tested for stuck-at faults (SA1 or SA0) and coupling faults using a modified version of the Nair, Thatte, and Abraham's testing procedure.

2.9.1.7 Timer Test

The timer test does the following:

- Starts the software clock and checks that the interrupt occurs at the correct vector and the correct IPL.
- Checks that the interrupt can be acknowledged or reset by reading address location 4000.
- Checks that the interrupt occurs at the correct interval (498 milliseconds).

2.9.1.8 Packet Memory Test

Packet memory is tested for stuck-at faults (SA1 or SA0) and coupling faults using a modified version of the Nair, Thatte, and Abraham's testing procedure.

2.9.1.9 Packet Memory Refresh Test

This test verifies that packet memory refresh is working. A data pattern is written into the RAM; the test waits 1 second, then reads the location to verify that the pattern read agrees with the pattern written. This is repeated until all bits are checked for SA1 and SA0 faults.

2.9.2 LANCE Tests

There are three categories of LANCE tests:

- Reset
- Internal loop
- External loop

2.9.2.1 LANCE Reset Test

This test verifies that LANCE chips can be reset to a known state. Bits in both LANCE chips are set to a predetermined state. LANCE A is reset and LANCE B is checked to verify that the bits are still set, then LANCE A is checked to verify that it is cleared. Next, bits in LANCE A are again set to the predetermined state. This time, LANCE B is reset and LANCE A is checked to verify that the bits are still set. Finally, LANCE B is checked to verify that it is cleared.

2.9.2.2 Internal Loop Tests

The internal loop tests include:

- Transmit CRC Logic Test
- Receiver CRC Logic Test
- Receive Bad CRC Test
- Collision Test
- Multicast Address Test
- Reject Physical Address Test
- Byte Swap and Broadcast Address Test

Transmit CRC Logic Test

This test clears the disable transmit CRC (DTCR) bit in the mode register to enable CRC generation on the packet transmission. The test then transmits a packet and compares the received CRC character with a precalculated value.

Receive CRC Logic Test

This test sets the disable transmit CRC (DTCR) bit in the mode register to disable CRC generation on packet transmission. The test then transmits a packet with a precalculated CRC character and verifies that the packet was received correctly with no CRC errors.

Receive Bad CRC Test

This test sets the disable transmit CRC (DTCR) bit in the mode register to disable CRC generation on packet transmission. The test then transmits a packet with a bad CRC character appended and verifies that the receiver flags a CRC error.

Collision Test

In this test, a packet is transmitted in internal loop mode with the mode register collision bit set. The test then verifies that the LANCE detects an error and retries the transmission 16 times. After the sixteenth retry failure, a retry error is indicated.

Multicast Address Test

This test checks the ability of the LANCE to accept or reject a packet with the multicast bit set in the destination address of the transmitted packet.

The test uses the following procedure:

1. Transmit a packet with an address that the logical address filter should accept.
2. Verify that the packet is transmitted and received correctly.
3. Transmit a packet with an address that the logical address filter should reject.
4. Verify that the packet is transmitted but not received.

Reject Physical Address

This test transmits a packet with the destination address not equal to the LANCE address. The test then verifies that the packet is transmitted correctly but is not accepted by the LANCE receiver. The test also checks the transmit status and looks for unexpected interrupts.

Byte Swap and Broadcast Address Check

The LANCE has the BYTE SWAP bit set in CSR3 and the destination address of the packet is a broadcast address. When an internal loop packet is transmitted, the receiver unit should accept the packet. Transmit and receive status is checked along with the data.

2.9.2.3 External Loop Tests

These tests are used to determine the port-to-port loop configuration. A flag is set to enable the network port to network port testing if there is a valid configuration available. In port-to-port testing, packet sizes vary from 64 to 1500 bytes. There are two external loop tests:

- External loop test
- Port-to-port loop test

External Loop Test

This test takes the following steps to determine what network loopback configuration is connected to the LAN Bridge 150 unit:

1. An external loop packet is sent on Port A.
2. If the packet is not received, the self-test considers it a hard error and halts.
3. If the packet is received back on Port A, the self-test determines that there must be transceivers connected to both ports.
4. An external loop packet is sent on Port B.
5. Status and data are checked at both ports.
6. If the external loop packet transmitted on Port A is received on Port B, the self-test determines that there must be a port-to-port loop configuration.
7. If the external loop packet transmitted on Port B is received on Port A, the self-test sets a flag to indicate that a port-to-port configuration exists.
8. If any of the status/data checks or transmit/receptions fail, the self-test indicates the hard error and halts.

Port-to-Port Loop Test

The port-to-port test requires that both ports are connected together through a manufacturing loopback cable. The test also requires that the port-to-port flag be set.

NOTE

This test will fail unless the loop-on-self-test switch located in the LAN Bridge 150 I/O panel is set to the Enable position.

The port-to-port loop test creates a maximum amount of activity on the LAN Bridge 150 hardware by starting operations with the binary search hardware and timer hardware at the same time as it does port-to-port looping through the manufacturing loopback cable. The size of the packets transmitted varies from 64 bytes to 1518 bytes. Both transmit and receive data chaining is tested.

2.9.3 Table Lookup (TLU) Tests

The TLU tests test the following:

- Status RAM
- Basic binary search
- Binary search engine

2.9.3.1 Status RAM Test

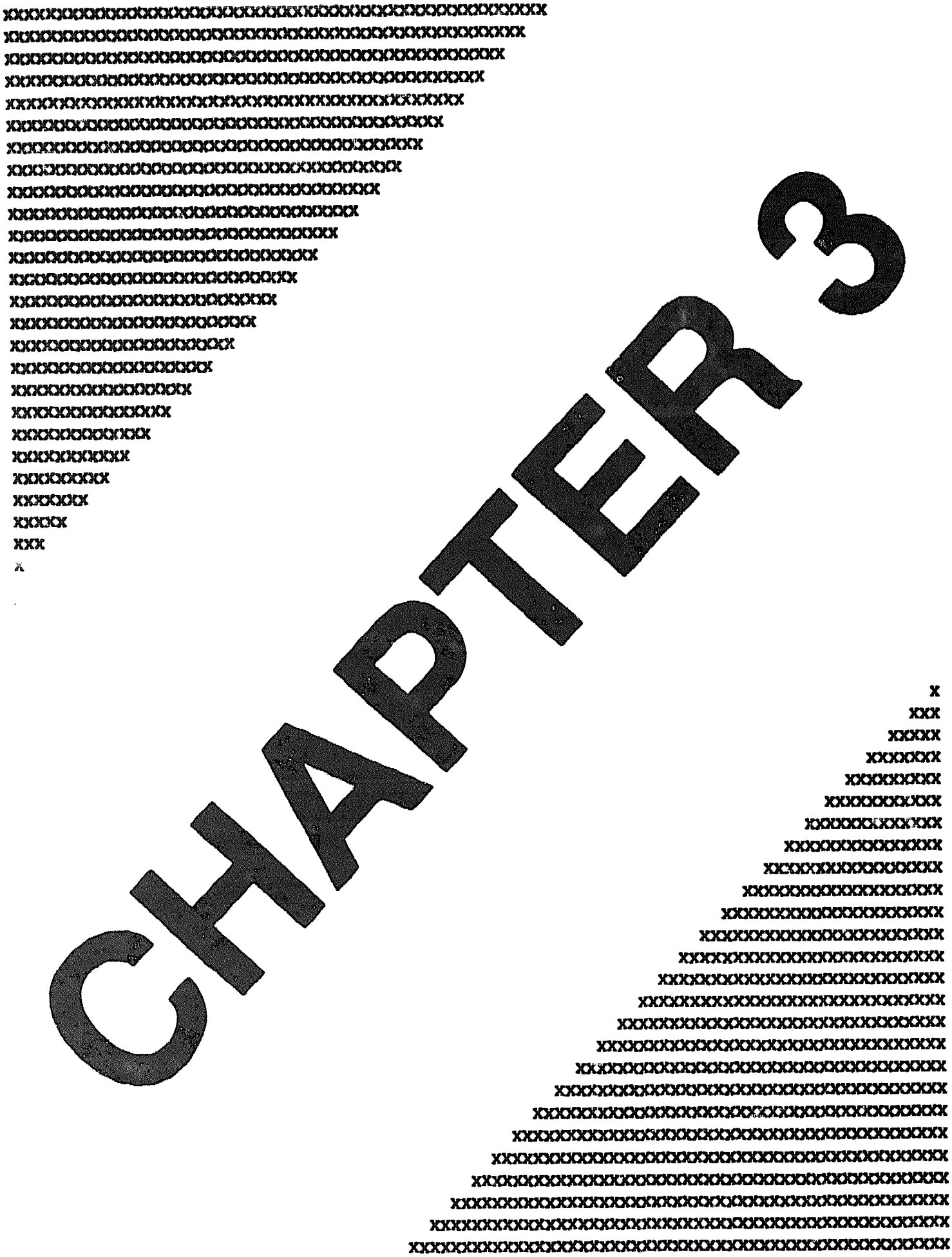
Status RAM is tested for stuck-at faults (SA1 or SA0) and coupling faults using a modified version of the Nair, Thatte, and Abraham's testing procedure.

2.9.3.2 Basic Binary Search Test

This test verifies that the search registers can be read from and written into by the processor. The test also verifies that data from the search registers can be written into the Ethernet address table RAM in 64-bit increments by writing to addresses FC000-FFFFF (this tests the 64-bit move function).

2.9.3.3 Binary Search Engine Test

This test verifies that the binary search engine can search the network address RAM for entries scattered throughout its address range. A check is made to ensure that a binary search is actually done during the search for stored network addresses.


CHAPTER 3

3

Technical Description

3.1 Introduction

This chapter contains a technical description of the hardware and hardware subsystems that make up the LAN Bridge 150 unit. The discussion takes a top-down approach, beginning with the system level description of the LAN Bridge 150 and ending with discussions at the circuit level.

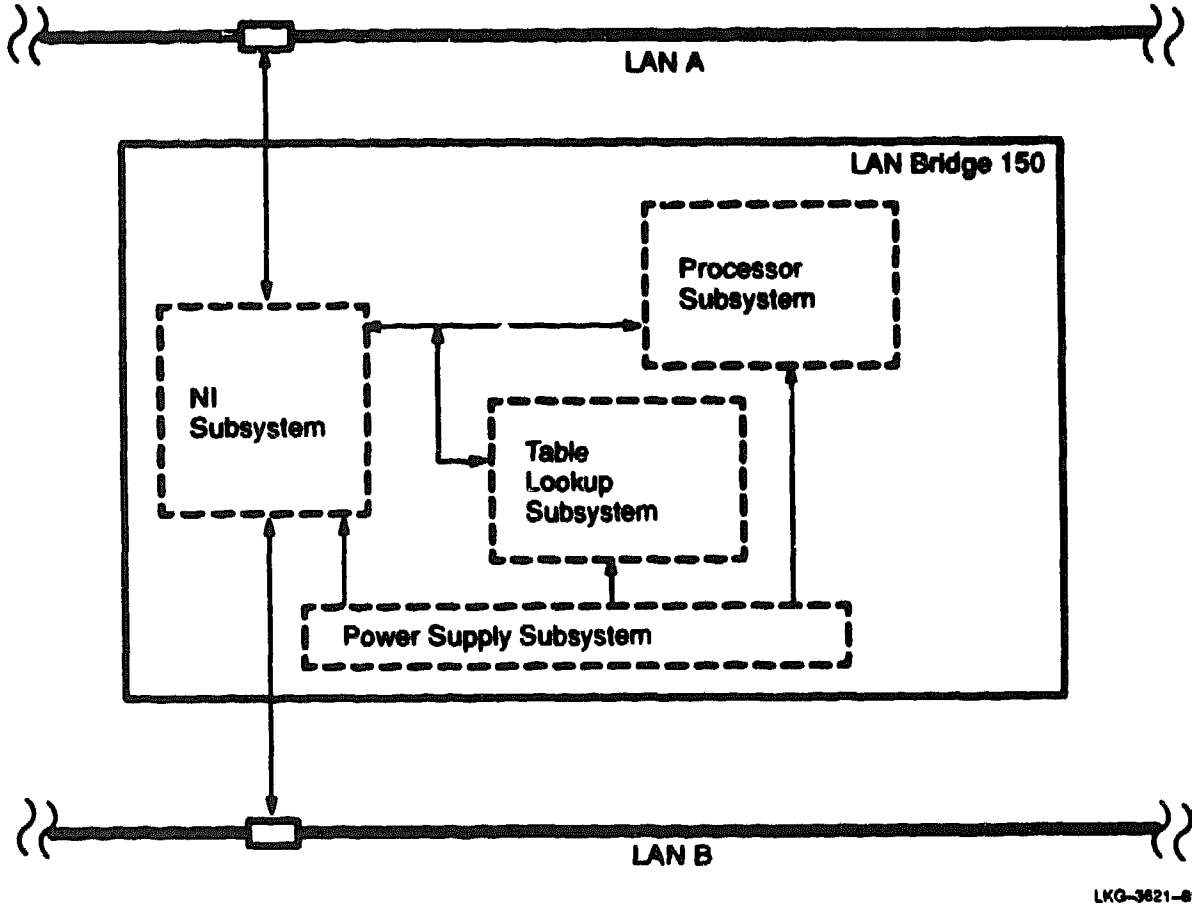
3.2 Hardware Overview

The LAN Bridge 150 unit is made up of four subsystems, as shown in Figure 3–1. Each subsystem provides the following functions:

- The network interconnect (NI) subsystem receives packets from the LAN on one side of the LAN Bridge 150 unit and stores them in memory. The NI may forward the packets to the LAN on the other side depending on a determination made by the LAN Bridge 150 unit firmware.
- The table lookup (TLU) subsystem performs searches of 48-bit Ethernet addresses stored in an 8K-by-48-bit address table. The results of the search are used by the LAN Bridge 150 firmware to determine whether a packet should be forwarded to the LAN on the other side of the LAN Bridge 150 unit.
- The processor subsystem keeps track of packets stored in packet memory and determines whether those packets will be filtered or forwarded. The processor maintains the Ethernet address table in the TLU. The processor also responds to loop detection messages, Maintenance Operation Protocol (MOP) functions, and bridge management or Remote Bridge Management Software (RBMS).

- The power supply subsystem provides all of the voltages required to support the NI, TLU, and processor subsystems as well as the transceivers connected to Port A and Port B.

Figure 3–1: LAN Bridge 150 Subsystems

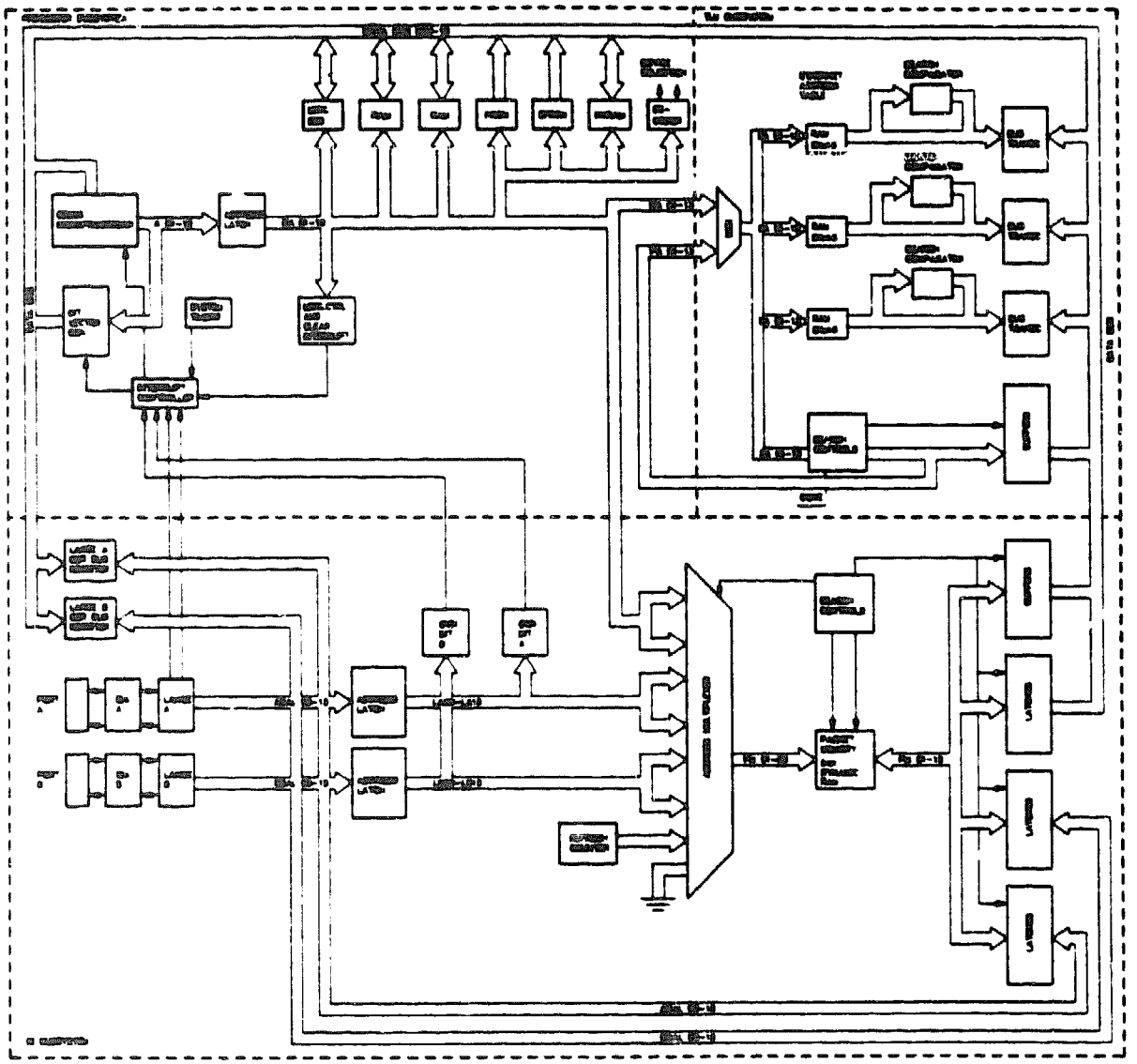


3.2.1 Overview of LAN Bridge 150 Functional Blocks

The LAN Bridge 150 subsystems interact through a system of bus structures and control lines. The block diagram in Figure 3–2 shows relationships among the major circuits of the LAN Bridge 150 unit.

The design incorporates a system of bus switches (latches) that isolate memory structures in each of the subsystems. This important design element enhances the operating speed of the LAN Bridge 150 unit by allowing concurrent operation of the NI, TLU, and processor subsystems.

Figure 3–2: LAN Bridge 150 Functional Block Diagram



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3.2.2 The Data Path

This section provides a general discussion of one typical LAN Bridge 150 operation, illustrating how the hardware is used to forward packets. Each of the circuits mentioned in the discussion is shown in Figure 3–2.

As an example of LAN Bridge 150 operation, assume that a minimum size packet is present at Port A. The LAN Bridge 150 unit performs the following steps:

1. The serial interface adapter (SIA) receives the packet from Port A transceiver and sends it to the Local Area Network Controller for Ethernet (LANCE).

   The LANCE stores the packet in packet memory and clears an OWN bit in the LANCE A receive descriptor ring. This causes the OWN interrupt generator to send an OWN interrupt to the processor.

2. The processor responds to the OWN interrupt by reading the LANCE A receive descriptor ring that points to the buffer containing the packet. The processor then reads the 48-bit destination address (located in the first 6 bytes of the packet) and copies it into the TLU.

3. The TLU performs a binary search, which compares the destination address against addresses already stored (in ascending numerical order) in the address table. The processor uses the results of the search to determine whether the packet must be forwarded and one of the following occurs:

   - If no match is found (that is, if the destination address does not equal a known source address), the processor, by default, forwards the packet to the LAN at Port B. Go to Step 4.

   - If a match is found (that is, if the destination address equals a known source address), the processor checks the corresponding 16-bit status word in the processor RAM to determine the location (Port A or Port B) of the station.

     If the destination is on Side A, the processor disregards the packet. Go to Step 5.

     If the destination is on Side B, the processor determines, by default, that the packet is to be forwarded to the LAN at Port B.

4. The LAN Bridge 150 unit transmits the packet to Port B as follows:

   - The processor writes the data from the LANCE A receive descriptor ring into the LANCE B transmit descriptor ring, resets the OWN bit

in the descriptor ring, and sets the transmit demand bit in LANCE B CSR.

- When transmit conditions at Port B are met, LANCE B reads the packet from packet memory and transmits it to the LAN at Port B using the SIA.

5. The LAN Bridge 150 unit compares the source address of the incoming packet to addresses stored in the Ethernet address table. This keeps the address table and status word up to date.

3.3 Processor Subsystem

The processor subsystem is responsible for overall operation of the LAN Bridge 150 unit. The processor allocates buffers to the LANCE network controllers, initiates binary searches, and maintains the address table of the TLU.

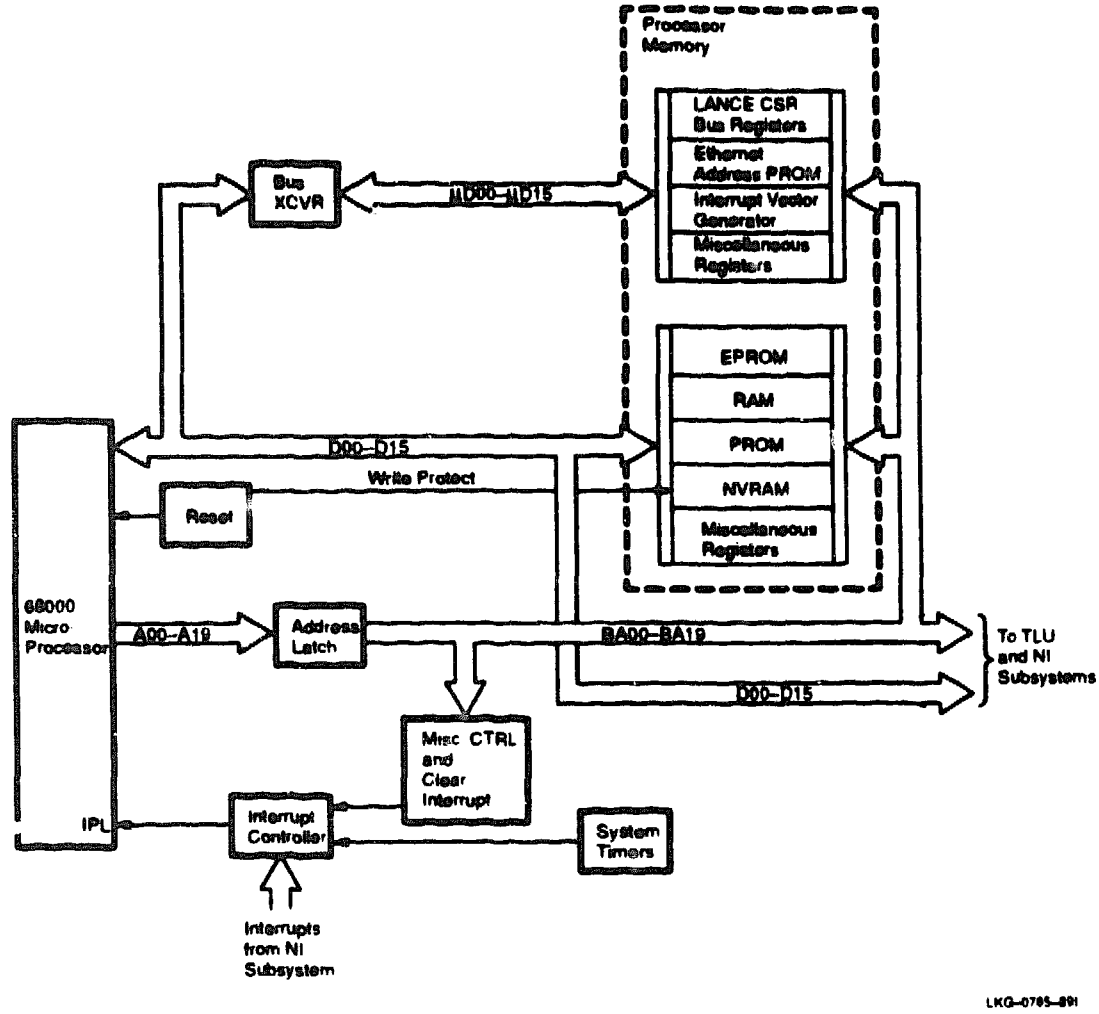
3.3.1 Processor Circuit Descriptions

The processor consists of the following circuitry (see Figure 3–3):

- Motorola 68000 microprocessor
- Interrupt controller
- Processor memory
- System timers
- Reset circuitry

To minimize capacitive loading of the processor data bus (D00-D15), a secondary data bus (UD00-UD15) is incorporated into the architecture (see Figure 3–3). The secondary data bus is joined to the primary data bus by a pair of octal bus transceivers. The secondary data bus is enabled by the address decoding circuitry.

Figure 3–3: Processor Subsystem



3.3.2 The Microprocessor

The heart of the processor subsystem is the microprocessor. The microprocessor used in the LAN Bridge 150 unit is the Motorola 68000, a single-chip device with address and data on separate buses. The 68000 has built-in mechanisms for handling incoming interrupt information and for controlling bus arbitration. The 68000 also provides status information that allows decoding of the current bus operation.

The 68000 microprocessor has a 32-bit internal architecture and a 16-bit external data path. The address bus is 23 bits wide with separate control lines for accessing the upper and lower bits either as separate bytes or together as words. The processor is driven by a 10-MHz (100-ns) system clock that results in a processor cycle time of 400 ns without WAIT states.

3.3.3 Interrupt Controller

The interrupt controller (see Figure 3–4) monitors the interrupt priority level (IPL) lines. The controller responds to the interrupt request if the priority of the request is higher than the priority of the processor. If two or more interrupt requests are presented to the interrupt controller at the same time, the highest level is passed on to the processor and the other levels remain pending.

The microprocessor acknowledges the interrupt by placing the interrupt level on address lines A1 through A3. When the interrupt vector generator is enabled by the function code lines (FC0-FC2), it reads the address lines A1 through A3 and places a corresponding interrupt vector onto the data bus. Table 3–1 identifies each interrupt, its priority, and its vector.

Figure 3–4: Hardware Interrupt Configuration

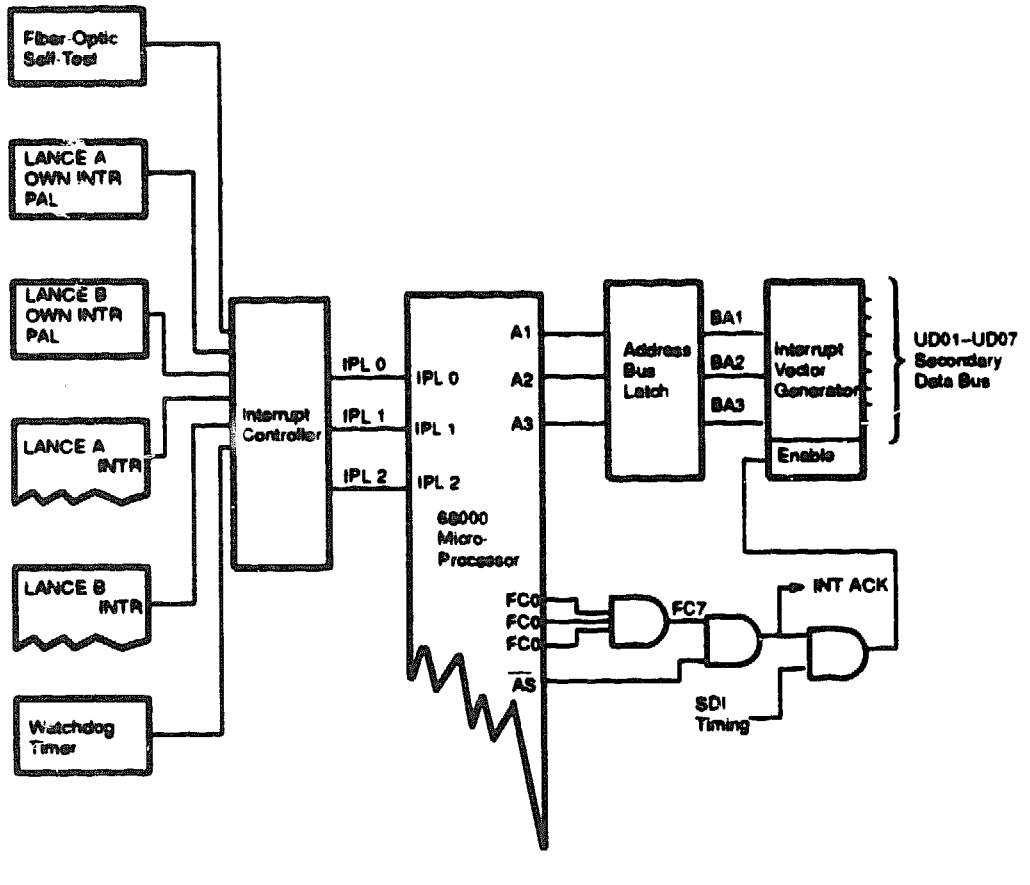


Table 3–1: Hardware Interrupts

Interrupt Level	Vector Address	Interrupt
6	46	Watchdog timer
5	45	LANCE B interrupt. Generated when CSR0 status flag is set for LANCE B
4	44	LANCE A interrupt. Generated when CSR0 status flag is set for LANCE A
3	43	OWN bit interrupt B. Generated when OWN bit (set by LANCE B) is detected
2	42	OWN bit interrupt A. Generated when OWN bit (set by LANCE A) is detected
1	41	Fiber optic self-test. Generated during self-test if a fiber-optic module is installed. This causes self-test to verify operation of the fiber-optic circuitry

3.3.4 Processor Memory

The processor memory contains the following components:

- PROM (stores the program code)
- RAM (holds a copy of the program code)
- RAM (holds the address table status)
- PROM (holds the physical address of the LAN Bridge 150 unit)
- NVRAM (records diagnostic and bridge management parameters)
- Miscellaneous control registers

3.3.4.1 PROM

The PROM (programmable, read-only memory) section of processor memory stores 32K words and contains all LAN Bridge 150 firmware, including self-test.

3.3.4.2 Program RAM

Program RAM contains 8K words and is made up of two 8K-by-8-bit static RAM devices. The program RAM contains a copy of the LAN Bridge 150 program code and data structures. The program executes from program RAM after the LAN Bridge 150 unit has powered up and self-test has passed.

3.3.4.3 Address Table Status RAM

The address table status RAM contains 8K words and is made up of two 8K-by-8-bit static RAM devices. The address table status RAM contains status words that correspond to each entry in the Ethernet address table of the TLU. The status includes information such as the following:

- The port (Port A or Port B) on which the address resides
- The age of the address
- Whether the address is used by the LAN Bridge 150 unit for special purposes
- Whether the address is learned through normal LAN Bridge 150 operation or is fixed (written into memory by bridge management so that it cannot age)

3.3.4.4 Physical Address PROM

The physical address PROM is a 32-bit-by-8-bit PROM device. This PROM contains the unique 48-bit (6 bytes) station address of the LAN Bridge 150 unit and a 2-byte checksum of the address (Port A).

The physical address is used for bridge management functions, Maintenance Operation Protocol (MOP) functions, and for loop detection purposes.

Port B Address

The LAN Bridge 150 has a second Ethernet address located at Port B. The bridge can be accessed through either port. The Port B address is derived from the Port A address by adding Hex 40 to the third byte from the right or 3rd low-order byte. For example, if Port A has the address **08-00-2B-02-B3-AF**, adding Hex 40 to "02" of the Port A address gives Port B an address of **08-00-2B-42-B3-AF**. If "02" were "12" in the Port A address, then the Port B address would be **08-00-2B-52-B3-AF**.

3.3.4.5 NVRAM

Nonvolatile RAM (NVRAM) contains 2K bytes and is a single 2K-by-8-bit memory device. NVRAM stores diagnostic information and LAN Bridge 150 parameters during a power-down period.

NVRAM is write-protected by the reset circuitry during all power-up and power-down cycles.

3.3.4.6 Miscellaneous Control Registers

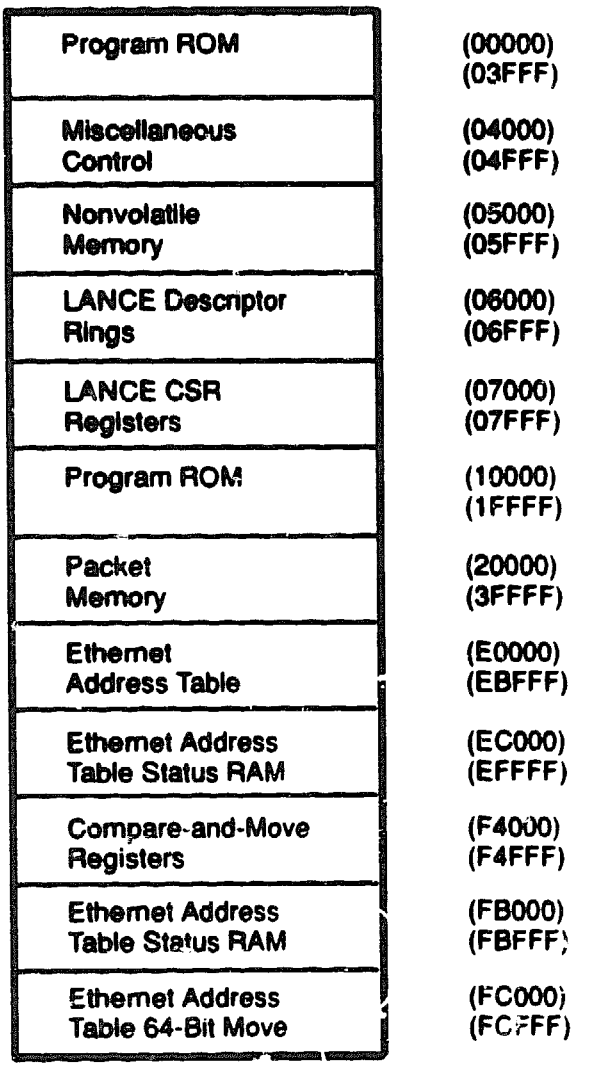
The miscellaneous control registers monitor and control operation of the LAN Bridge 150 unit. The registers and their functions are as follows:

- Miscellaneous control registers enable interrupts and loopback functions. A memory map control bit causes RAM address space to be remapped after power up is completed (see Section 3.3.5.6).
- A self-test error latch holds error status if errors occur during self-test.
- A programming selection buffer holds LAN Bridge 150 configuration information such as switch settings or whether a fiber-optic module is present. The processor uses this buffer to set program functions.

3.3.5 Processor Memory Map

The LAN Bridge 150 unit has approximately 1 megabyte of address space. When the LAN Bridge 150 unit is powered on, the program executes from program ROM. Program RAM is hidden and is not accessible. The memory map shown in Figure 3–5 illustrates the mapping used for powering up the LAN Bridge 150 unit.

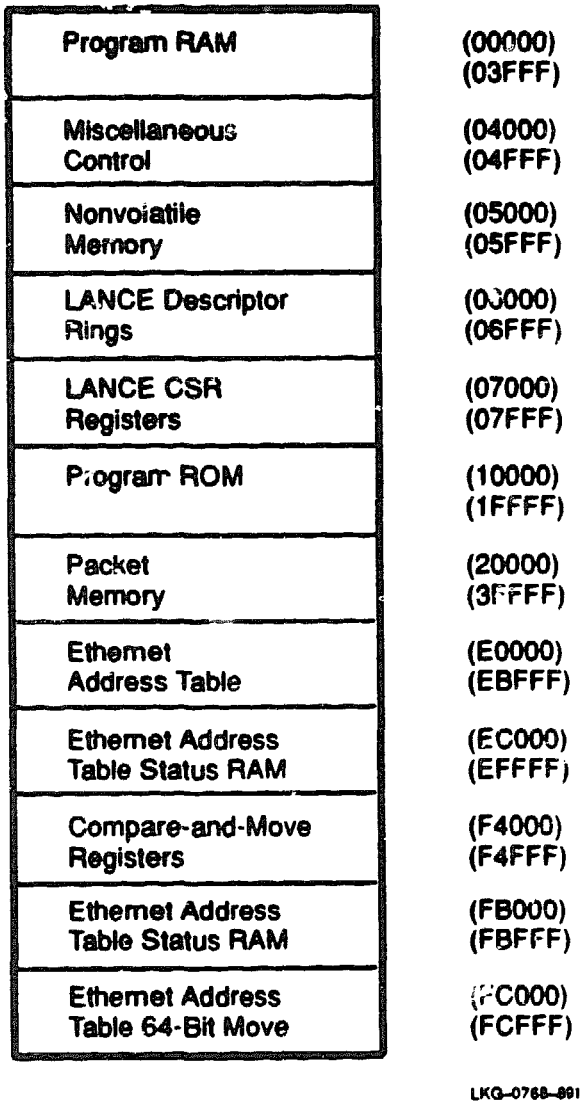
Figure 3–5: Address Mapping Used During Power Up



After the bridge completes self-test, the address space for program RAM is remapped to the range of 00000-03FFF and the program firmware is copied from ROM into program RAM. Thereafter, the program executes from program RAM. Executing the program from RAM provides more flexibility by allowing the use of soft interrupt vectors.

The memory map shown in Figure 3–6 illustrates the mapping used for operation of the LAN Bridge 150 unit after power up and self-test have completed.

Figure 3–6: Address Mapping Used for Normal LAN Bridge 150 Operation



3.3.5.1 Program ROM

Program ROM contains the firmware that is used to control the operation of the LAN Bridge 150 unit.

During power up, program ROM is mapped into the ranges of 00000-03FFF and 10000-1FFFF. After power up and self-test are complete, RAM is mapped into the range of 00000-03FFF and the firmware (except for self-test) is copied into RAM. Subsequent program execution is from RAM.

3.3.5.2 Miscellaneous Control

The miscellaneous control region (04000-04FFF) contains various registers used to monitor and control operation of the LAN Bridge 150 unit (see Section 3.3.4.6).

3.3.5.3 Nonvolatile Memory

Nonvolatile memory (NVRAM) resides in memory address space 05000-05FFF. NVRAM stores bridge management parameters when the LAN Bridge 150 unit is powered off. If power up self-test fails, NVRAM stores a diagnostic error code.

3.3.5.4 LANCE Descriptor Rings

The LANCE A and LANCE B transmit and receive descriptor rings reside in address space 06000-06FFF. To clear the OWN interrupt, the OWN bit in the descriptor rings are cleared using the range of 06000-06FFF.

The LANCE descriptor rings are used to allocate and find buffer space in packet memory.

Note that the descriptor rings also reside within the packet memory address space and range from 26000 through 26FFF. This is the range used by the LANCE processors to access the descriptor rings.

3.3.5.5 LANCE CSR Registers

The LANCE A and LANCE B CSR registers (a total of eight registers) are used to monitor and control the operation of the LANCE processors. The registers are mapped into the range of 07000-07FFF.

3.3.5.6 Program RAM

Program RAM is used for program execution after the LAN Bridge 150 unit powers up and self-test is complete.

During power up of the LAN Bridge 150 unit, program RAM is hidden and is not accessible. After power up and self-test are complete, RAM is remapped into the range of 00000-03FFF and the firmware (except for self-test) is copied into RAM. The interrupt vector address space is included in RAM after RAM is remapped.

3.3.5.7 Packet Memory

Packet memory (20000-3FFFF) is used to store packets while the LAN Bridge 150 unit is determining whether to forward or filter the packets. The LANCE A and LANCE B descriptor rings and the initialization blocks also reside in packet memory.

3.3.5.8 Ethernet Address Table

The Ethernet address table (EC000-EBFFF) is 8K by 48 bits and contains 48-bit Ethernet station addresses. A station address (and a corresponding status word) is stored when a packet is received from that station.

3.3.5.9 Ethernet Address Table Status RAM

The Ethernet address table status RAM is 8K by 16 bits and contains 16-bit status words that correspond to each station address stored in the Ethernet address table (see Section 3.3.4.3).

The Ethernet address table status RAM is mapped into two regions of address space: EC000-EFFFF and FB000-FBFFF. Both regions contain the same data.

3.3.5.10 Compare-and-Move Registers

Three 16-bit compare-and-move registers (F4000-F4FFF) are used to store search arguments (48-bit Ethernet addresses), while magnitude comparisons are performed by the TLU. These registers are also used in the read/write operation associated with a 64-bit move.

Each register and address is identified as follows:

F4*xx*0 Search register with address bits <47-32>
F4*xx*2 Search register with address bits <31-16>
F4*xx*4 Search register with address bits <15-00>
F4*xx*6 Results register

Writing to address F4*xx*4 triggers the binary search of the Ethernet address table. The binary search starts at a midpoint in the address table defined by address lines BA13-BA03. If the address lines BA13-BA03 are all zeros, then a single entry comparison is performed using location 0 in the Ethernet address table.

Writing to address F4*xx*6 also triggers a binary search of the Ethernet address table. In this case, the TLU searches the address table using the same search argument that was used for the previous search.

3.3.5.11 Ethernet Address Table 64-Bit Move

Address space FC000-FCFFF accesses the Ethernet address table and the Ethernet address table status RAM. The memory configuration addressed in this range is 8K by 64 bits (64 bits include a 48-bit Ethernet address and a 16-bit status word). This capability is necessary for performing a 64-bit move (see Chapter 2 for more information on 64-bit moves).

3.3.6 System Timers

The system timer is driven by the 10-MHz system clock from the Network Interconnect (NI) subsystem and provides the following functions:

- Clock interrupt to the processor
- Hardware watchdog timer
- Clock to the refresh counter

The clock interrupt to the processor occurs about every 0.5 seconds and drives a real-time clock. This clock is used to keep track of how long each network address has remained unused in the address table. If a station has been inactive for 2 minutes, the LAN Bridge 150 unit considers the corresponding address to be invalid.

The watchdog timer is used as a hardware check on the firmware. It is the responsibility of the firmware to reset the watchdog timer once every 15 seconds. If the timer is not reset, it will expire and cause a system reset. If the firmware is operating properly, this situation will not occur.

The clock to the refresh counter occurs every 12.5 μs and is used to increment the refresh counter.

3.3.7 Reset Circuitry

The reset circuitry is responsible for the following functions:

- Resetting the hardware on power up
- Resetting the hardware upon a watchdog timer reset
- Write-protecting the NVRAM during power-up, power-down, and reset sequences

The reset circuitry monitors VCC (+5 volts) to sense when power is stable. During power up, the reset circuitry holds the LAN Bridge 150 unit in reset mode and keeps the NVRAM write-protected until all state-saving devices are stable.

3.4 Network Interconnect Subsystem

The network interconnect (NI) subsystem provides the interface between the other LAN Bridge 150 subsystems and the physical channel of the extended LAN by performing the following functions:

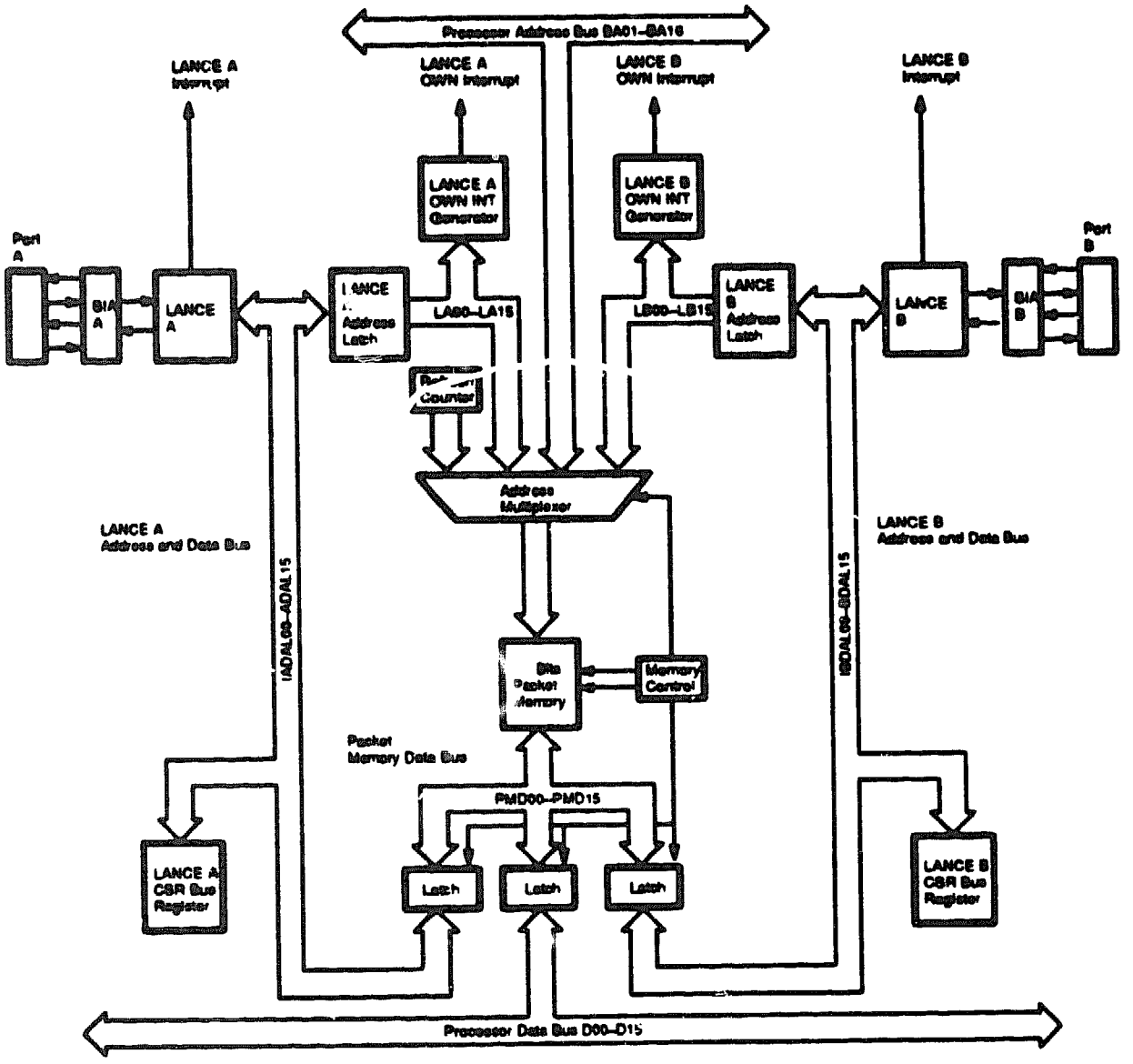
- Receiving and decapsulating packets from the LAN connected to Port A or Port B of the LAN Bridge 150 unit.
- Writing packets into packet memory in locations determined by the processor.
- Writing packet status information into the receive descriptor rings.
- Reading the transmit descriptor rings to determine the location(s) of any packet that is ready for transmission.
- Reading packets from packet memory and encapsulating packets for transmission to the LAN connected to Side A or Side B.
- Transmitting encapsulated packets to the specified LAN according to the Ethernet channel access method.

3.4.1 NI Subsystem Circuits

The NI subsystem is made up of two physical channel interface circuits (NI ports), a LANCE CSR control circuit, and a packet memory. Figure 3–7 is a block diagram of the NI subsystem.

The NI subsystem bus structures and packet memory are isolated from processor and TLU bus structures and memory. This allows concurrent operation of the NI, processor, and TLU and helps minimize the time required to perform LAN Bridge 150 functions. In addition, the LANCE processor and microprocessor buses have independent access to packet memory. This allows maximum utilization of the memory cycle time and guarantees minimal delay for access.

Figure 3–7: NI Subsystem



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3.4.2 NI Ports

The NI subsystem has two ports. Each interface circuit connects to one of the two LANs joined by the LAN Bridge 150 unit. Each NI port consists of one SIA chip and one LANCE chip. This discussion describes one NI port; the other NI port is identical.

NOTE

In a remote LAN Bridge 150 unit, a fiber-optic module is included in Port A. The fiber-optic interface is described in Section 3.4.2.5.

3.4.2.1 SIA Chip

The SIA chip is a 24-pin device that interfaces the LANCE chip to the network transceiver. The SIA chip performs the following functions:

- Detection of data presence on the network
- Conversion of collision-presence signals to TTL levels
- Manchester decoding of data
- Manchester encoding of data
- Interfacing of differential signal line pairs and TTL levels

The SIA chip requires a 20-MHz crystal for its internal oscillator. The oscillator generates the clock for the Manchester-encoded data stream. The 20-MHz is halved to provide the 10-MHz transmit clock and receive clock. The LANCE uses the transmit clock to set the data rate. The LANCE uses the receive clock to gate sampling of the receive data line.

3.4.2.2 LANCE Chip

The LANCE is a 48-pin, very-large-scale-integration (VLSI) device designed to provide data-link services over a CSMA/CD local area network. The LANCE chip performs the following functions:

- Direct memory access to packet memory
- Buffer management by using descriptor rings in packet memory
- Runt packet filtering
- CRC generation and checking

- Transmission backoff and retry

The LANCE operates in promiscuous mode. This mode causes the LANCE to accept all packets regardless of their destination address. The LANCE is monitored and controlled by control and status registers (CSRs), which are physically separate from the LANCE. CSR control is described in more detail in the following section.

The LAN Bridge 150 unit does not use the LANCE's ability to generate CRC. However, the bridge does preserve incoming CRC sequences for use on outgoing packets. Note that the probability of externally undetectable errors originating within the LAN Bridge is no greater than 1 in 109.

A table called the initialization block that is stored in system memory is loaded into packet memory upon initialization. The initialization block is used by the LANCE to do the following:

- Determine the size and location of the descriptor rings in packet memory
- Set operating parameters for the LANCE (such as promiscuous mode)

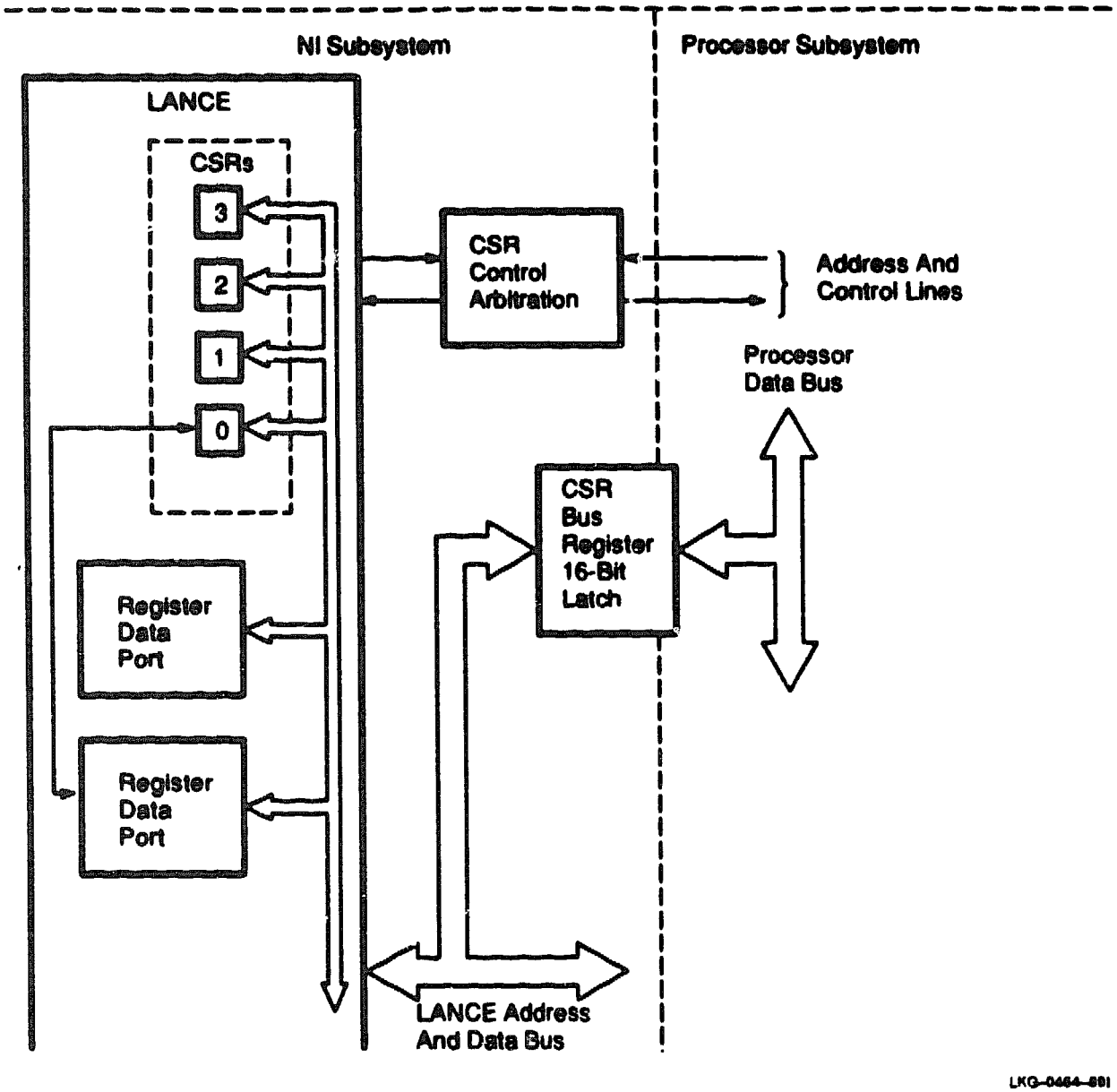
LANCE Control and Status Registers

There are four control and status registers (CSRs) within each LANCE that are programmed by the processor. The CSRs are accessed through a register address port (RAP) and a register data port (RDP) as shown in Figure 3–8. Data is read from or written into a CSR in a two-step operation.

1. The CSR is addressed by writing the register address into the RAP of the LANCE.
2. Data that is read from or written into the RDP is also read from or written into the CSR that is selected by the RAP.

During the final stage of LAN Bridge 150 initialization, the microprocessor sets the RAP to CSR0. Once the RAP is set, it remains set until rewritten and it is not rewritten once the LANCE starts operation. With the RAP set to CSR0, each time the RDP is accessed, CSR0 is accessed.

Figure 3–8: CSR Control



3.4.2.3 LANCE CSR Bus Registers

The CSR bus registers are bidirectional latches that interface the processor data bus to the LANCE address/data bus (see Figure 3–8). The latches isolate the two buses to allow concurrent operation of the NI and processor subsystems. They also minimize processor WAIT states since the processor does not have to wait for the LANCE address/data bus to read the LANCE CSR registers.

3.4.2.4 LANCE CSR Control Circuit

The LANCE CSR control circuit (see Figure 3–8) manages the transfer of data between the LANCE internal CSRs and the CSR bus registers.

After the LANCE is initialized, the RAP is set to CSR0 (see Section 3.4.2.3). CSR0 remains selected as long as the LANCE continues to operate.

When the processor wants to read from CSR0, it actually reads from the CSR bus register, which is part of the processor's memory map. Reading from the bus register triggers the CSR control to initiate a read from the RDP into the bus register. Therefore, each time the bus register is read, the data in the bus register is updated. This guarantees that the processor does not have to wait for the LANCE bus, but it also means that the data obtained from the bus register is old and must be treated as such. The processor must read the bus register twice to get fresh data. However, the processor will incur WAIT states if it attempts back-to-back accesses of the CSR while the LANCE is performing a DMA operation.

When the processor wants to write to CSR0, it writes to the CSR bus register. The CSR control arbitrates for the LANCE bus and writes the data into CSR0 as soon as the LANCE bus is available. The maximum delay incurred is 4.8 μs.

3.4.2.5 Fiber-Optic Module

The fiber-optic module is included only in remote LAN Bridge 150 units and performs functions similar to those of a transceiver.

The fiber-optic module converts emitter-coupled logic (ECL) levels from the SIA to optical signals for transmission through a fiber-optic cable. Conversely, optical signals received from the fiber-optic cable are converted to ECL levels for use by the SIA circuitry.

3.4.3 LANCE Address Latch

There are two LANCE address latches, one for each LANCE (refer back to Figure 3–7). This section describes the address latch for one LANCE. An identical circuit exists for the other LANCE.

The LANCE address latch multiplexes the LANCE address/data bus to provide a separate address bus and data bus for packet memory access.

The LANCE latches a packet memory address into the latch by asserting the address latch enable (ALE) signal to the latch and writing the address onto the LANCE address/data bus. The latched address is then placed onto the LANCE address bus where it is used by the address multiplexer to access packet memory.

When the ALE signal is deasserted, the LANCE address/data bus becomes available for data functions.

3.4.4 OWN Interrupt Generator

There are two OWN interrupt generators, one for each LANCE (refer back to Figure 3–7). This section describes the OWN interrupt generator for one LANCE. An identical circuit exists for the other LANCE.

The OWN interrupt generator is a programmed array logic (PAL) device that generates an interrupt when it detects that an OWN bit has been set in the LANCE receive descriptor ring. The interrupt is sent to the interrupt controller in the processor subsystem.

In packet memory, every fourth address in the range of receive descriptor ring addresses contains an OWN bit. When the OWN interrupt generator detects these specific addresses on the LANCE address bus, it looks at bit <15> of the LANCE address/data bus (bit <15> carries the OWN bit). If the PAL detects that an OWN bit is cleared, it generates an interrupt signal. This signals the processor that a packet memory buffer is ready for processing by the processor and TLU subsystems. see Chapter 2 for more information on the OWN bit function.

3.4.5 Packet Memory

Packet memory (refer back to Figure 3–7) stores packets during the forward/filtration process. In addition, this memory contains the descriptor rings (transmit and receive descriptor rings) and the initialization blocks for each LANCE.

The packet memory architecture allows access by either of the LANCEs, by the processor, or by the refresh address counter.

The cycle times of the devices that access packet memory are inherently slower than the memory cycle access time, which is about 300 ns. To minimize memory circuit WAIT states, data bus latches hold the data retrieved from packet memory until it can be read by the requesting device. This improves memory performance by allowing the memory to begin its next cycle immediately without waiting for slower devices.

Packet memory is made up of the following circuits:

- Address multiplexer
- Memory control circuit
- Dynamic RAM (DRAM)
- Data latches

3.4.5.1 Address Multiplexer

The address multiplexer (refer back to Figure 3–7) determines which device (LANCE A, LANCE B, the processor, or the DRAM refresh counter) addresses packet memory. Steering inputs to the multiplexer come from the memory control circuits (see Section 3.4.5.2).

When a 16-bit address is present at the input to the multiplexer, the steering inputs apply the high-order (row) address and then the low-order (column) address onto the DRAM address bus.

3.4.5.2 Memory Control Circuit

The memory control circuit (refer back to Figure 3–7) coordinates memory activity and arbitrates the priority of the LANCE, processor, and refresh counter. Table 3–2 identifies the priorities assigned to the four devices. Figure 3–9 is a block diagram of the memory control circuit. The memory control circuits perform the following functions:

- The synchronization circuit synchronizes the control signals of memory accessing devices with the memory control circuit.
- The arbitration circuit selects which device (processor, LANCE A, LANCE B, or refresh counter) addresses packet memory.

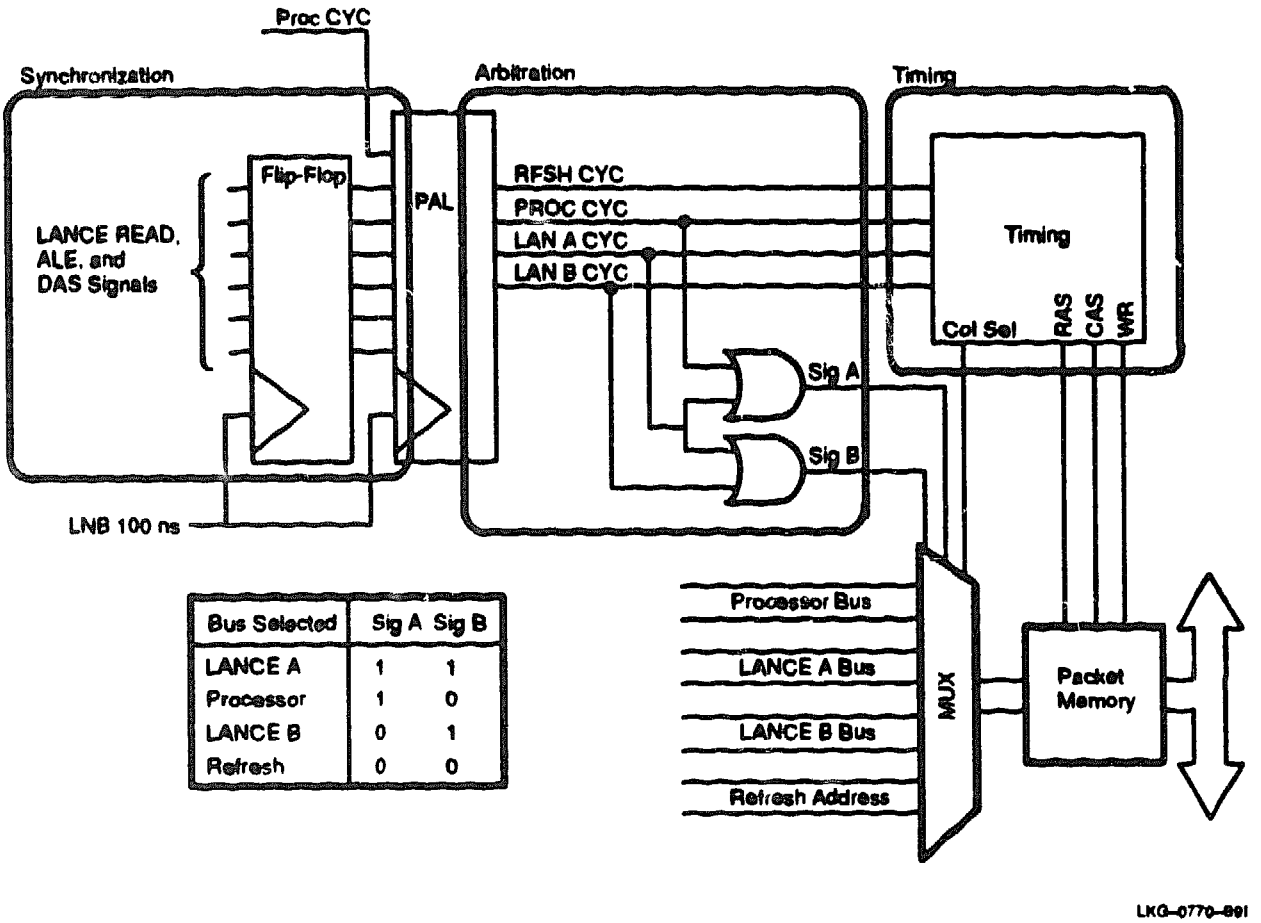
- The timing circuit ensures that row and column address strobes and the write signal are properly gated to the DRAM.

Table 3–2: Device Priorities

Priority	Device
1	Refresh
2	Processor
3	LANCE A*
4	LANCE B*

*LANCE A and LANCE B alternate priority

Figure 3–9: Memory Control Circuit



Bus Selected	Sig A	Sig B
LANCE A	1	1
Processor	1	0
LANCE B	0	1
Refresh	0	0

3.4.5.3 Dynamic Packet Memory

The dynamic packet memory stores packets while the processor and TLU perform the forward filtration process. The memory also contains the LANCE descriptor rings and the LANCE initialization blocks. Refer to Chapter 2 for a description of the initialization blocks and descriptor rings.

DRAM memory is made up of 16 64K-by-1-bit devices (each device is an array of 128 rows by 512 columns).

The DRAM address bus is 16 bits wide but is multiplexed into 8-bit row addresses and 8-bit column addresses. Row address strobe (RAS) and column address strobe (CAS) signals select which row and column are read from

memory. RAS, CAS, and WRT (write-enable) signals are driven by the memory control circuit (see Section 3.4.5.2).

The DRAM data bus is 16 bits wide. When CAS strobes the DRAM, the data is either read from or written to the data bus depending on the state of WRT.

Each DRAM row must be refreshed at least once every 2 ms. Since each DRAM contains 128 rows, one row must be refreshed every 15 μs (128 x 15 μs = 1.920 ms). To allow for any delays, the refresh counter addresses a row in memory every 12.5 μs (see Section 3.4.5.4).

3.4.5.4 Refresh Counter

The refresh counter increments and accesses a row address in packet memory every 12.5 μs.

The refresh counter is made up of a dual 4-bit binary counter that is configured as an 8-bit binary counter. The incoming 12.5-μs clock that increments the counter comes from the system timer (see Section 3.3.6).

3.4.5.5 Data Bus Latches

Packet memory data bus latches (refer back to Figure 3–7) are controlled by the memory control circuit (see Section 3.4.5.2). The latches interface the packet memory data bus (PMD 00-15) to the following bus structures:

- ADAL 00-15 (LANCE A address/data bus)
- BDAL 00-15 (LANCE B address/data bus)
- D00-15 (processor data bus)

The data latches and buffers perform two functions:

- They isolate the memory data bus from external data buses to allow concurrent operation of the NI and other subsystems.
- They hold data retrieved from memory until the data can be read by the requesting device. This improves memory performance by allowing the memory to begin its next cycle without waiting for slower devices.

3.5 Table Lookup Subsystem

Each time a LANCE writes a new packet into packet memory, the processor reads the destination address of the packet and sends the address to the table lookup (TLU) subsystem.

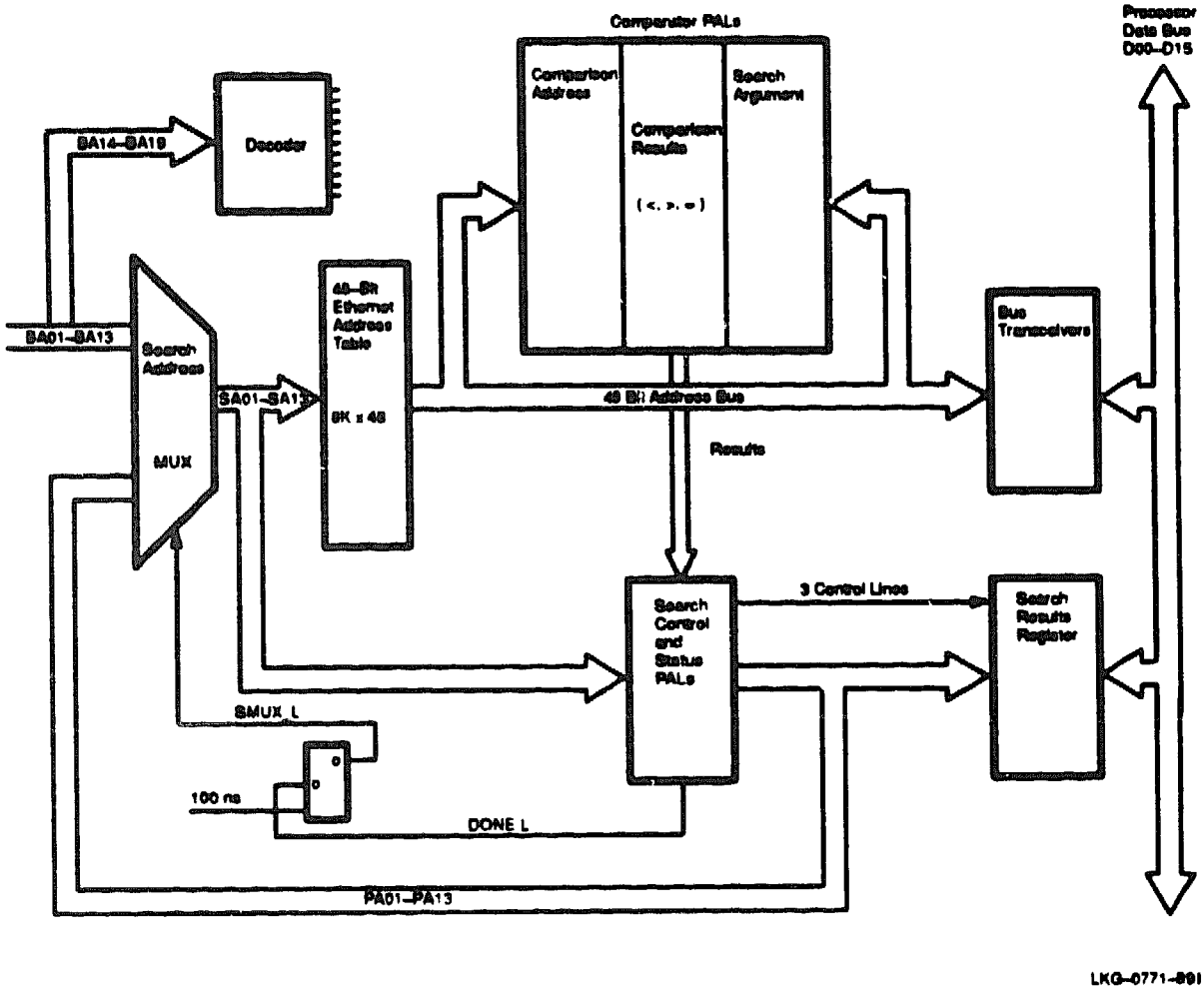
The TLU compares the destination addresses from incoming packets to addresses stored in memory. The results of each comparison are made available to the processor, which determines whether the packet should be forwarded or ignored.

The TLU, with assistance from the processor subsystem, also maintains the Ethernet address table. Table maintenance functions include comparing source addresses from incoming packets to addresses stored in memory. The results of each comparison are made available to the processor, which determines whether the address should be stored in the address table or ignored.

3.5.1 Overview of the TLU

The functional blocks of the TLU are shown in Figure 3–10. This illustration can guide you through the overview of TLU operation.

Figure 3–10: Table Lookup Subsystem



1. The processor initiates the TLU binary search process in the following way:

   - The processor writes the search argument (the new 48-bit Ethernet address) from the data bus into the search compare registers of the comparator PALs. The processor uses three write cycles to write the three address words into the search compare registers. The words are written in sequence of the low, middle, and high word of the address.

   - The search control and status PAL detects when the final (highest) byte is written into the search compare registers by the processor. After a delay of about 50 ns, the search control and status PAL deasserts the DONE signal. The deasserted DONE signal does two things:

After 50 ns, it steers the multiplexer to select subsequent addresses from the search control and status PALs.

After 100 ns, it prevents the processor from addressing any registers in the TLU.

Before the DONE signal is deasserted (during the 50-ns delay), the processor addresses the location in the Ethernet address table, where the binary search begins. This address is used to start the binary search. Addresses for subsequent probes of the address table are provided by the search control and status PALs.

2. Once the processor has written the first address to be probed in the Ethernet address table, the search control and status PALs in the TLU assume control of the binary search process.

NOTE

Ethernet addresses are stored in order of magnitude in the address table, higher locations having the higher addresses. This ordering is necessary for the binary search process to function. see Chapter 2 for a detailed description of the binary search process.

- The comparator PALs perform bit-by-bit comparisons of the latched search argument against addresses probed in the address table.

- The search control and status PALs use the results of each comparison (> [greater than], < [less than], or = [equal to]) to determine the next step in the search process.

  "Greater than" causes a search to be performed at a higher location in the address table.

  "Less than" causes a search to be performed at a lower location in the address table.

  "Equal to" indicates a match. A match terminates the search.

- The binary search ends either when a match is found or when the bottom address of the binary tree (an odd address) is probed and no match has been found.

  The search control and status PALs assert DONE. This enables the decoder to allow the processor to read the search results register. This register indicates whether a match was found and contains the location of the last address searched.

3. After the search, the search control and status PALs report the results of the search by setting "equal to" or "greater than" bits in the search results register. The address of the last location probed is included in the register data. These results dictate what the processor does with the location address.

   - If the "equal to" bit is set, it means that a match was found.

     If a destination address was compared, the processor checks a corresponding 16-bit status word in RAM to determine the location (bridge Port A or Port B) of the Ethernet address and whether the packet should be forwarded or ignored. The status word location in RAM corresponds to the Ethernet address location in the address table.

     If a source address was compared, the processor updates the status word in RAM.

   - If the "greater than" bit is set, it means the search argument was greater than the address in the last location probed. This also indicates that no match was found.

     If a destination address was compared, the processor forwards the packet since it cannot determine the location (Port A or Port B) of the station with that address.

     If a source address was compared, the processor adds the new address and status word to the Ethernet address table as a background task.

   - If neither the "greater than" nor the "equal to" bit is set, it means the search argument was less than the address in the last location probed. This also indicates that no match was found.

     If a destination address was compared, the processor forwards the packet, since it cannot determine the location (Port A or B) of the station with that address.

     If a source address was compared, the processor adds the new address and status word to the Ethernet address table as a background task.

3.5.2 Circuit Descriptions

The TLU contains the following circuits:

- Search address multiplexer
- 48-bit address comparator circuitry, which includes:

- Ethernet address table memory
- Bus transceivers
- Ethernet search address comparator PALs
- Binary search control and status PALs
- Search results register

3.5.3 Search Address Multiplexer

The search address multiplexer (refer back to Figure 3–10) selects the processor bus (BA01-BA13) or the search control bus (PA01-PA13) to address the Ethernet address table memory.

Four quad 2:1 multiplexers make up the multiplexer circuit. The single steering input to the multiplexer is a signal called SMUXL. This signal is derived from the DONE signal when DONE is deasserted by the search control and status PALs. SMUXL is gated to the multiplexer by the 100-ns clock signal.

3.5.4 48-Bit Address Comparator

The 48-bit address comparator performs bit-by-bit comparisons of the 48 bits that make up an Ethernet address. The PALs contain the compare and move registers (see Section 3.3.5.10) that are used for 64-bit moves (see Chapter 2).

3.5.4.1 Functional Description

The 48-bit comparator is made up of three 16-bit comparators. Figure 3–11 shows the structure of a 48-bit comparator. This illustration shows the circuits that compare the low 16 bits, the middle 16 bits, and the high 16 bits of the 48-bit Ethernet address.

The address table memory is 8K by 48 bits. Thus one location in memory accesses the entire 48-bit Ethernet address.

Figure 3–11: 48-Bit Comparator

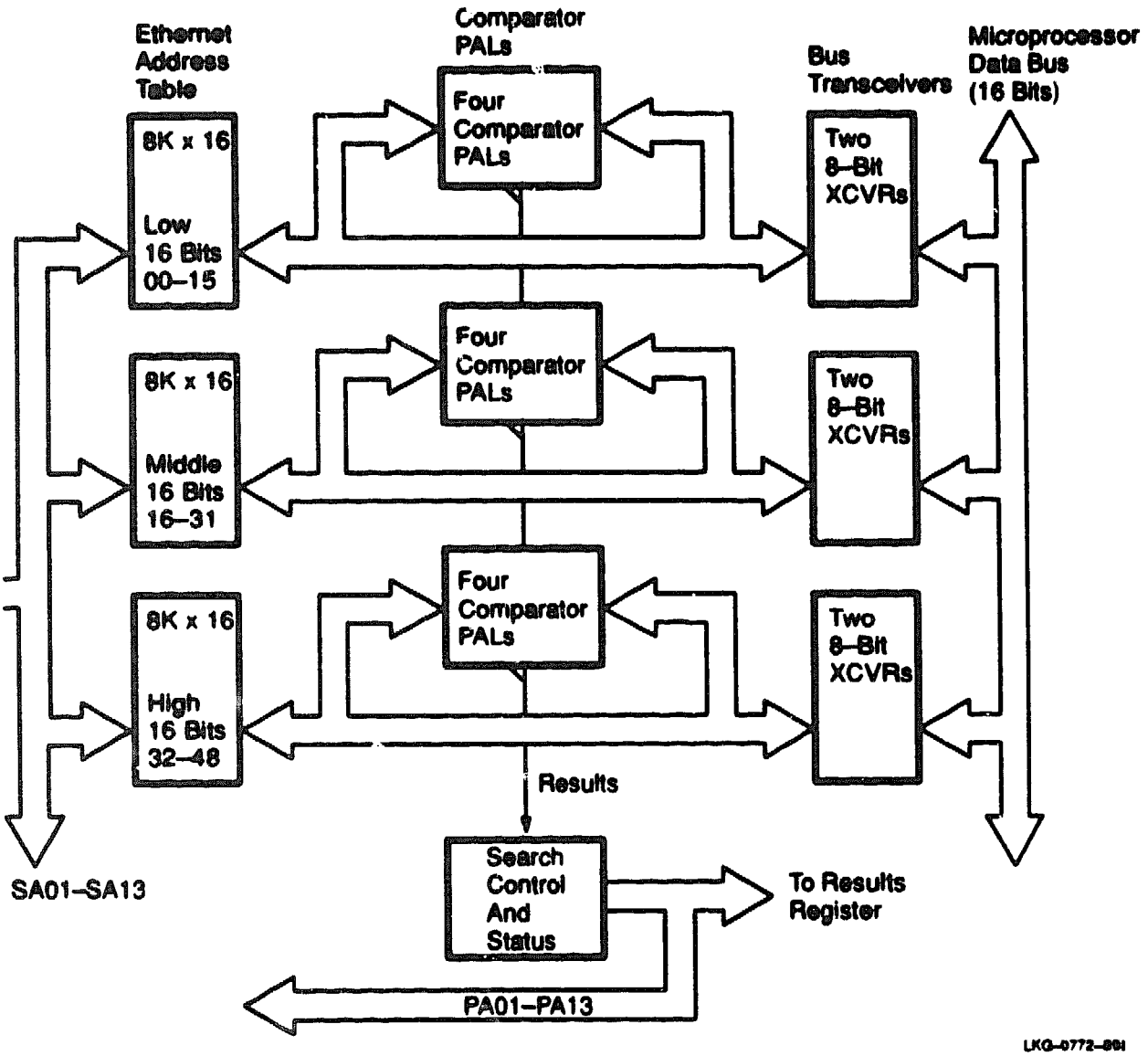
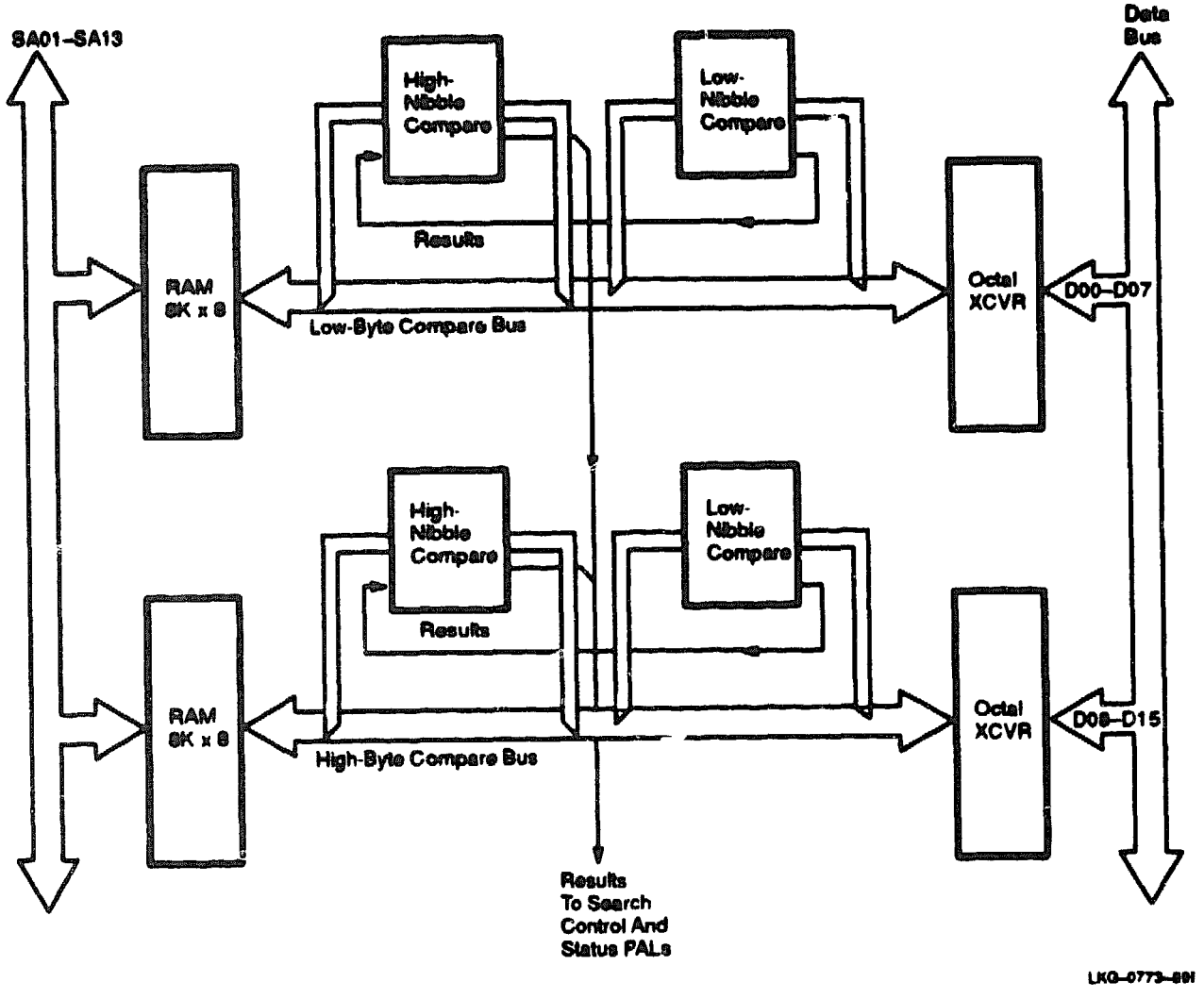


Figure 3–12 shows the structure of . 16-bit comparator. This illustration shows the circuits that perform a bit-by-bit comparison of the four nibbles that make up a 16-bit portion of the 48-bit address.

The results of each byte comparison are sent to the search control PALs, which determine the next step.

Figure 3–12: 16-Bit Comparator



3.5.4.2 Address Comparator Circuit Descriptions

The address comparator is made up of the following circuits:

- Ethernet address table memory
- Bus transceivers

- Ethernet search address comparator PALs
- Binary search control and status PALs
- Search status register

3.5.4.3 Ethernet Address Table Memory

The Ethernet address table memory stores (in ascending numerical order) Ethernet addresses. The addresses can be either or both of the following:

1. Addresses of stations from which the LAN Bridge 150 unit has received packets
2. Addresses that have been down-line loaded by Remote Bridge Management Software (RBMS)

The memory is mapped as 8K by 48 bits and is made up of 6 8K-by-8-bit RAM devices. The devices are addressable by the processor or by the search control PALs.

Data (48-bit addresses) can be read out of address table memory for the following purposes:

- The comparator PALs use addresses for performing address comparisons.
- The comparator PALs temporarily store addresses during table maintenance operations.
- Memory data may be used by RBMS or for Maintenance Operation Protocol (MOP) purposes.

3.5.4.4 Bus Transceivers

The bus transceivers are bidirectional and allow data to be transferred between the data bus (D00-D15) and the internal compare bus.

In normal LAN Bridge 150 operation, Ethernet addresses are transferred from the data bus to the compare bus. The addresses are latched into the comparator PALs for comparison against addresses stored in the Ethernet address table.

Bidirectional transfer capabilities allow bridge management to read addresses from the Ethernet address table.

The transfer direction is controlled by the processor BWRT control line and the SXC0, SXC1, and SXC2 control lines from the decoder.

3.5.4.5 Ethernet Search Address Comparators

The comparator PALs perform bit-by-bit comparisons between data received through the processor's data bus and data accessed from the Ethernet address table.

When the bus transceivers place the 48-bit Ethernet address onto the compare bus, each PAL latches one nibble (4 bits) of the address. As the search control and status PALs probe the address table, each comparator PAL compares its latched nibble against a corresponding nibble accessed from the address table. A "greater than," "less than," or "equal to" result is sent to the search control and status PALs.

The comparator PALs are also used during a 64-bit move for temporarily storing bits that make up the Ethernet address (see Chapter 2 for more information on 64-bit moves).

3.5.4.6 Search Control and Status PALs

The search control and status PALs have two functions. They control the binary search process once it is initiated by the processor and they write the search status to the search results register.

When the search control PALs detect that the final (highest) byte of the 48-bit Ethernet address is latched into the comparator PALs, they read the address that is on the search address bus (SA01-SA13). This address, which is used for the first probe of the Ethernet address table, is also used by the search control PALs to calculate successive addresses to be probed during the binary search of the address table.

The search control and status PALs deassert the DONE signal. This has two effects.

- It inhibits the decoder from allowing the processor to address any of the TLU hardware.
- It steers the multiplexer to select search addresses from the search control and status PALs.

The PALs continue the binary search process by monitoring the results ("greater than" or "equal to") from the address comparator PALs. Depending on the results, the PAL determines the next step in the search process as follows:

- When the results are "greater than," the PAL equation calculates the next address to be probed. The calculated address is placed onto the address bus.
- When the results are "less than" (actually, not "greater than" and not "equal to"), the PAL equation calculates the next address to be probed. The calculated address is placed onto the address bus.
- When the results are "equal to," the PALs terminate the search and reassert the DONE signal. The reasserted DONE signal enables the decoder to allow the processor to read the search results register. It also steers the multiplexer to select the search address from the processor.

3.5.4.7 Search Results Register

The search results register contains the address and status of the last location probed by the search control and status PALs. The register data is latched in the search control and status PALs and is addressed through a buffer on the processor data bus.

The 16 bits of register data are written onto the PAL address lines (PA00-PA13) and PAL control lines. The register is addressable by the processor only when the binary search is not in progress (the DONE signal is deasserted). The definitons of the 16 bits are listed in <REFERENCE>(cst3).

Table 3–3: Search Results Register Bit Descriptions

Bit	Definition
<15>	Equal To (EQ) bit. Asserted when a search results in a found entry.
<14>	Not used.
<13:01>	Search address bits corresponding to the last address probed by the search PAls. When accompanied by the EQ bit being set, the address indicates where the entry is located. When EQ is not set, the address indicates where the entry should reside.
<00>	Greater Than (GT) bit. Asserted when a search does not result in a found entry and the last comparison found the search argument to be greater in magnitude than the table entry.

3.6 Power Supply

The power supply subsystem is a switching type, regulated ac-to-dc converter that uses a transformer in a half-wave transformer-coupled mode.

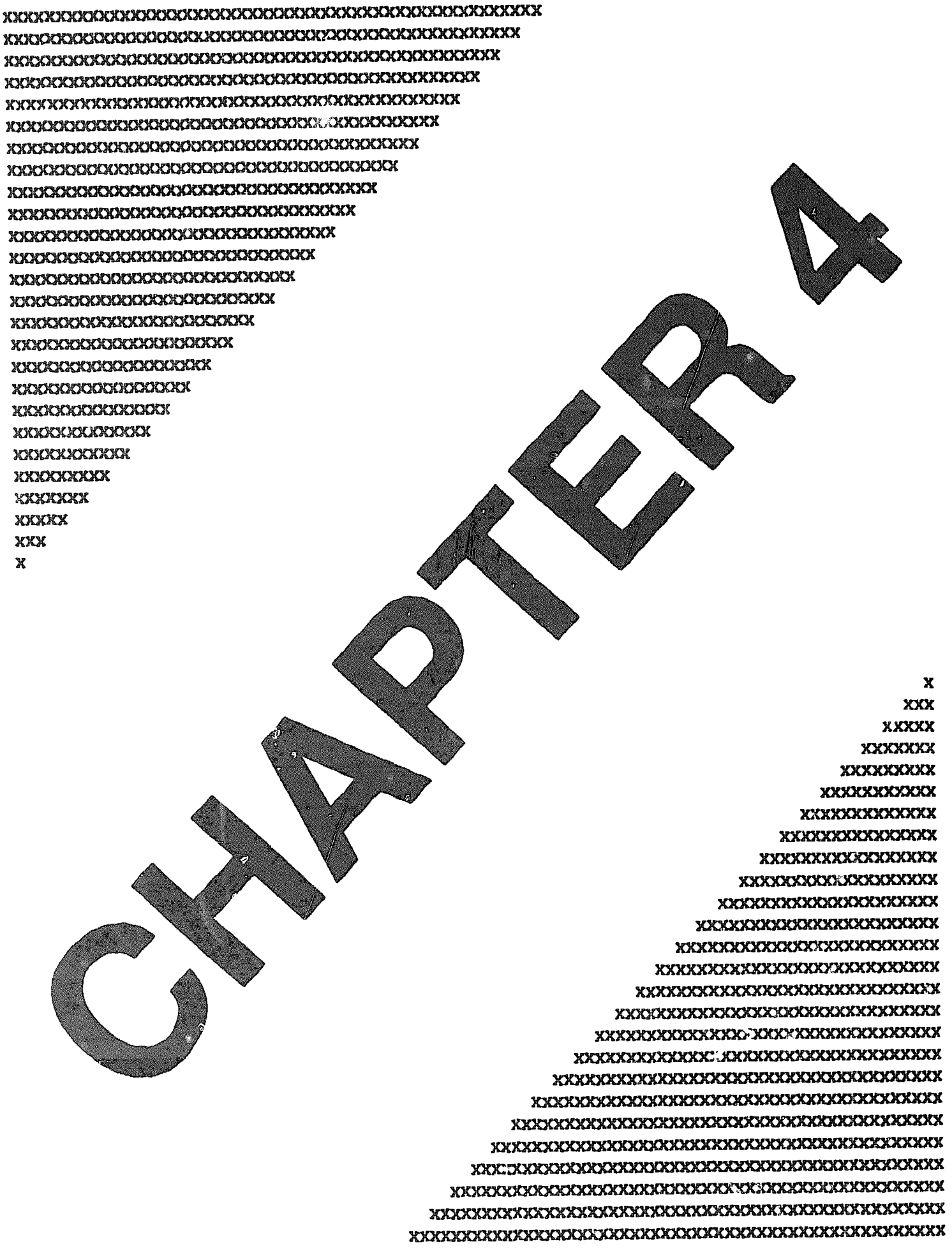
Power regulation is achieved by modulating the pulse width of the inverter's primary current conduction time. An increase in the input power decreases the pulse width of the inverter's primary current conduction time to lower the output voltage. Conversely, a decrease in the input power increases the pulse width of the inverter's primary current conduction time to raise the output voltage.

The voltage input range is switch selectable and can be either of the following:

- 88 Vac to 132 Vac (115 Vac nominal)
- 176 Vac to 264 Vac (230 Vac nominal)

The power supply provides the following regulated output voltages that are used by the LAN Bridge 150 circuitry:

Revision F09 and above
+5 volts at 20 amps
+12 volts at 2.5 amps
-12 volts at 2.0 amps
Ground


CHAPTER 4

4

Maintenance

4.1 Scope

This chapter provides information on maintaining the LAN Bridge 150 unit, including:

- Maintenance philosophy
- Preventive maintenance
- Corrective maintenance
- LAN Bridge 150 unit disassembly

4.2 Maintenance Philosophy

The maintenance philosophy for the LAN Bridge 150 unit is option swap. In other words, maintenance is concerned with determining whether a LAN Bridge 150 unit is faulty, and replacing the LAN Bridge 150 unit when necessary.

Maintenance of the LAN Bridge 150 unit consists of corrective procedures only. Instructions for replacing faulty LAN Bridge 150 units are provided as part of these procedures.

4.2.1 Required Equipment

For testing and replacing LAN Bridge 150 field replaceable units (FRUs), equipment is categorized as either required or optional. The required equipment is supplied with the bridge at installation time and consists of:

- Two 15-pin AUI loopback connectors (P/N 12-22196-01) for testing DEBET-AC/AD.
- *LAN Bridge 150 Installation* guide for verification of unit operation after performing replacement procedures.

Not supplied but also required when performing testing or replacement procedures on the LAN Bridge 150:

- One fiber-optic loopback connector (P/N 29-25037-01) and one attenuating spacer (P/N 12-30068-01).
- #2 Phillips-head screwdriver—for opening the unit and removing FRUs.
- Small 3/16-inch nut driver—for removing the power supply ground-wire nut.
- 3/16-inch torque wrench—for replacing the power supply ground-wire nut.

NOTE

The torque wrench can be used to remove the ground-wire nut as a substitute for the nut driver.

4.2.2 Optional Equipment

The H4080 test connector may be helpful in performing some corrective maintenance procedures. Note that this test device is not supplied with the carrier detect (CD) kit.

The H4080 test connector is a transceiver that is connected to a short length of coaxial cable. This test connector can replace an on-line transceiver for off-line self-testing of the LAN Bridge 150 unit.

NOTE

The H4000-TA (or H4000-TB) Ethernet transceiver testers cannot be used to test the data path through a LAN Bridge 150 unit because all H4000-Tx testers have the same Ethernet address. This prevents the LAN Bridge 150 unit from forwarding the test packets. However, testers may be used to test the links that normally connect to the ports of the bridge.

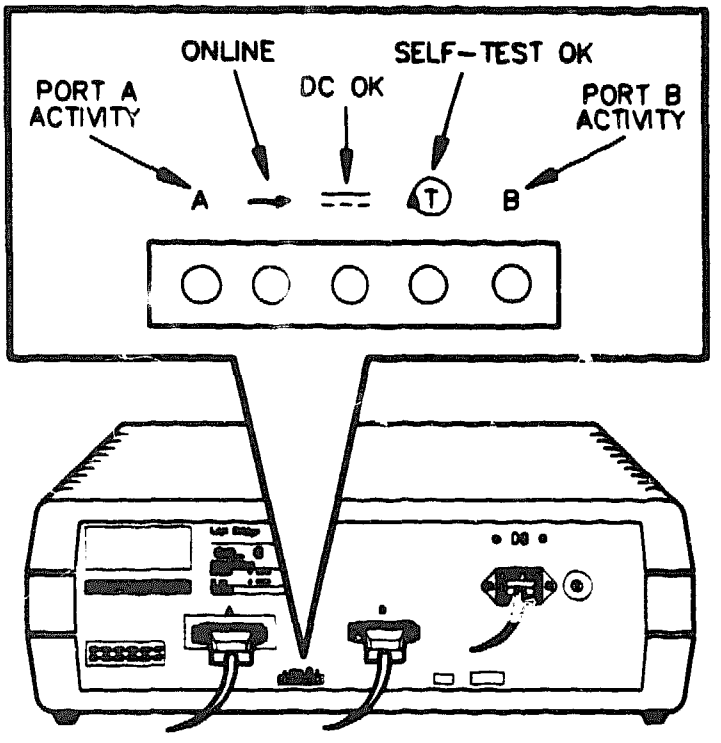
4.3 Preventive Maintenance

There are no preventive maintenance (PM) procedures for the LAN Bridge 150 unit. However, the LAN Bridge 150 self-test should be run when network PM is performed. To run self-test, perform the following steps:

1. Start the self-test either by interrupting power or by remote bridge management intervention.

2. Observe the status LEDs shown in Figure 4–1. The Self-test OK status LED should light within 10 seconds after self-test is started. If loop-detection conditions are not met, the On-line status LED should light within 20 seconds after the Self-test OK status LED lights. If a failure is noted, refer to Figure 4–2.

Figure 4–1: LAN Bridge 150 Status LEDs



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4.4 Corrective Maintenance

Perform corrective maintenance when there are indications that a LAN Bridge 150 unit or a bridge FRU is faulty. This involves verifying and replacing the faulty LAN Bridge 150 unit or a bridge FRU. Do this by analyzing the results of the self-test and isolating the LAN Bridge 150 unit from the network by using loopback connectors.

4.4.1 Troubleshooting Tips

The following tips on troubleshooting a LAN Bridge 150 unit are illustrated in the troubleshooting flowchart (Figure 4–2):

- Understand the symptoms of the problem before starting to troubleshoot. This helps prevent misinterpretation of the symptoms.
- Look for obvious problems first. For example:

  For loose cable connections, make sure:

  - Transceiver cables are locked in place with the slide latches.
  - Fiber-optic cables are not misthreaded and are screwed firmly together.
  - Transmit and receive cables are not interchanged.

  Power cord not plugged in.

  Incorrect power or no power at the electrical outlet.

  Bridge switches set incorrectly (refer back to Chapter 1).

  Circuit breaker tripped (located on the bridge's I/O panel).

  Note whether fan is running; if not, power problems may exist.

  Operator error.

- If the self-test fails, it automatically executes again after 15 seconds. It is not necessary to cycle bridge power.
- Test communication through the bridge by attempting to communicate to a node on the other side of the bridge. VMS systems use the SET HOST command to establish a logical link.
- Consider possible environmental problems, such as power fluctuations, high ambient temperature, interference from other equipment, and so on.
- When down-line load is enabled using the hardware switch or RBMS, ensure that a load host is established for down-line loading the appropriate LAN Traffic Monitor software. For software installation details, refer to the *LAN Traffic Monitor Installation Guide*.

4.4.2 Fault Diagnosis

Use the troubleshooting flowchart shown in Figure 4–2 to isolate problems and identify a faulty LAN Bridge 150 unit, associated transceivers, transceiver cables, or fiber-optic cables.

It is possible that a fault exists in the transceiver or other equipment electrically close to the LAN Bridge 150 unit. In some cases, this type of fault initially appears to be in the LAN Bridge 150 unit. However, careful execution of the troubleshooting procedures in this section will either isolate the fault to the LAN Bridge 150 unit or point to other possible sources of the malfunction.

When the troubleshooting flowchart leads to a malfunction in a transceiver or remote repeater, use the appropriate documents and tools to troubleshoot these devices. These include:

- *H4000 Transceiver Technical Manual* (Order No. EK-H4000-TM)
- *H4005 Transceiver Technical Manual* (Order No. EK-H4005-TM)
- *Ethernet Repeater Technical Manual* (Order No. EK-DEREP-TM)

NOTES

1. After troubleshooting the LAN Bridge 150 unit, be sure to reconnect all cables and to reset any switches to their correct positions.

2. When NVRAM failure occurs, the fault can be bypassed and the bridge can continue to operate. However, replace the bridge as soon as possible.

   - Even when NVRAM fails, RBMS parameters can be set over the network if Switch 2 is placed in the down position. However, the bridge reply to RBMS commands indicates partial success in setting parameters, since any set parameters will be lost in the event of subsequent hard or soft resets (including power-down periods). The parameters must be set each time a reset occurs. As long as this condition exists, the Self-test OK status LED blinks to indicate that NVRAM has failed.

     Before beginning troubleshooting, show and record bridge parameters. This helps recover any specific parameters lost during troubleshooting (NVRAM reset will discard all parameters). To do this, type the following commands at the RBMS prompt:

     ```
     RBMS>  USE LAN BRIDGE X
     (X = enter bridge name or bridge hardware address)

     RBMS>  SHOW SPANNING CHARACTERISTICS TO X.Span
            (X = bridge_name or address)

     RBMS>  SHOW MANAGEMENT ADDRESSES TO X.Address
            (X = bridge_name or address)
     ```

   - Default parameters are used if Switch 2 is placed in the down position. The Self-test OK status LED is steadily lit to indicate a successful self-test.

Figure 4–2: Troubleshooting Flowchart

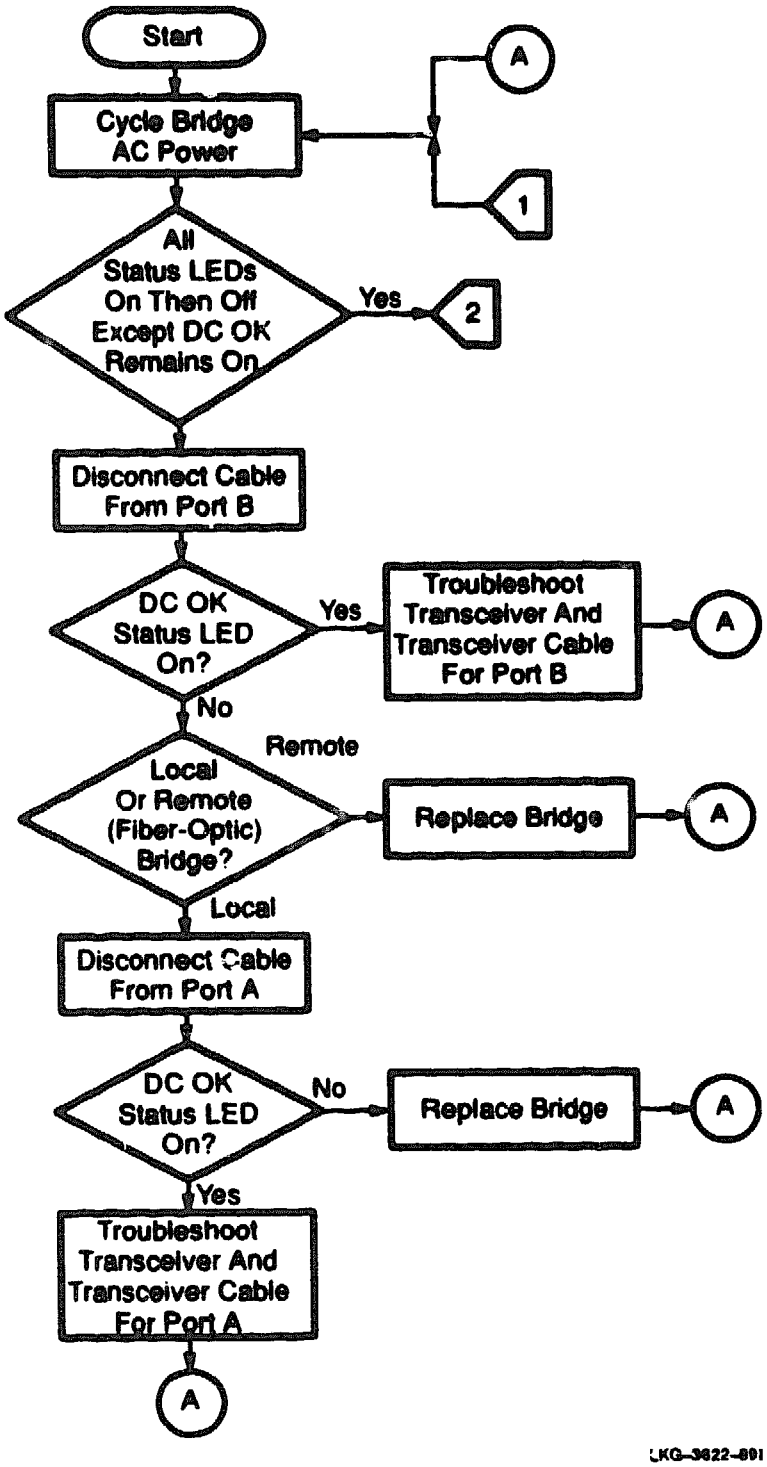

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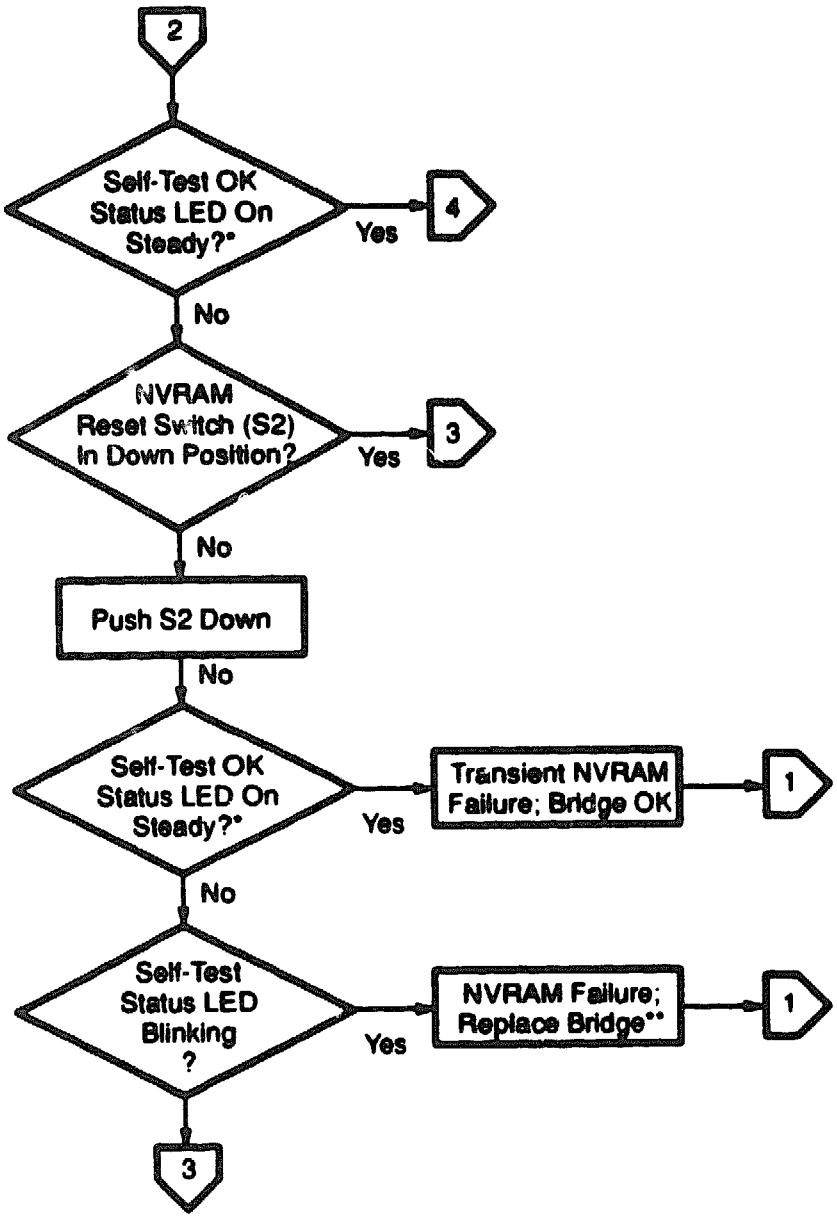
Figure 4–2(Cont.): Troubleshooting Flowchart



* In 15 seconds
**See Section 4.4.2. Item 2 under "Notes"

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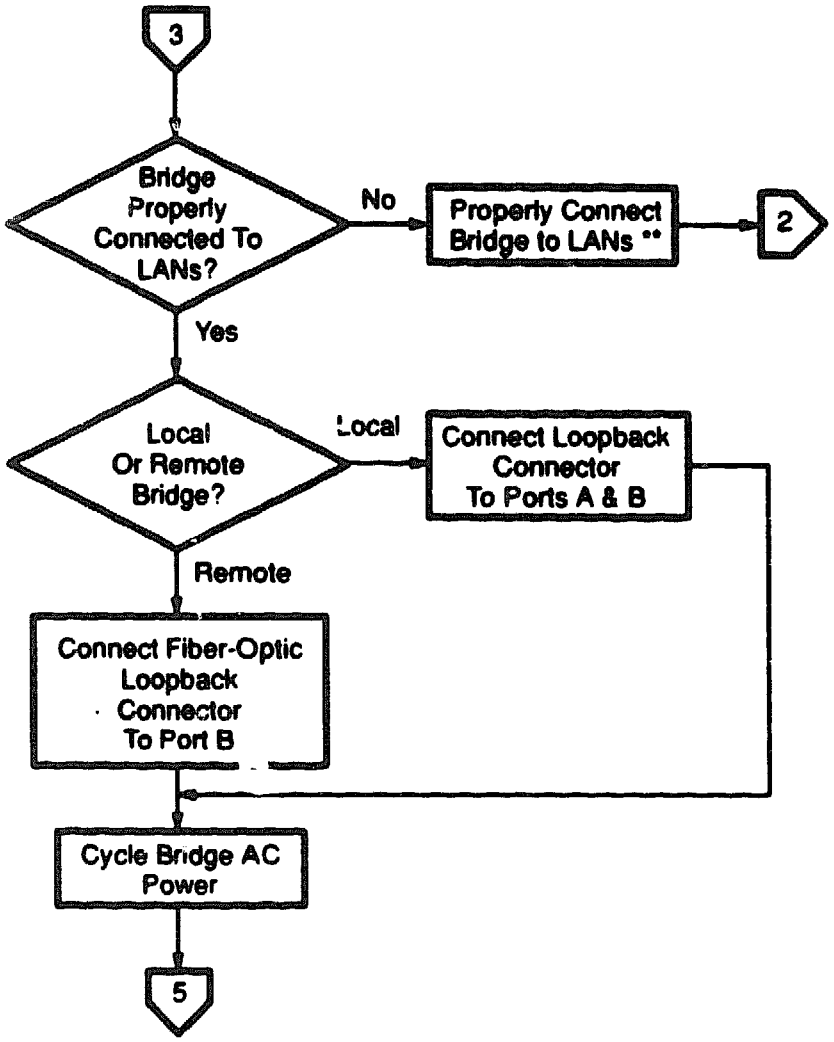
Figure 4–2(Cont.): Troubleshooting Flowchart



* After 15 seconds
**Refer to Troubleshooting Tips (Section 4.4.1).

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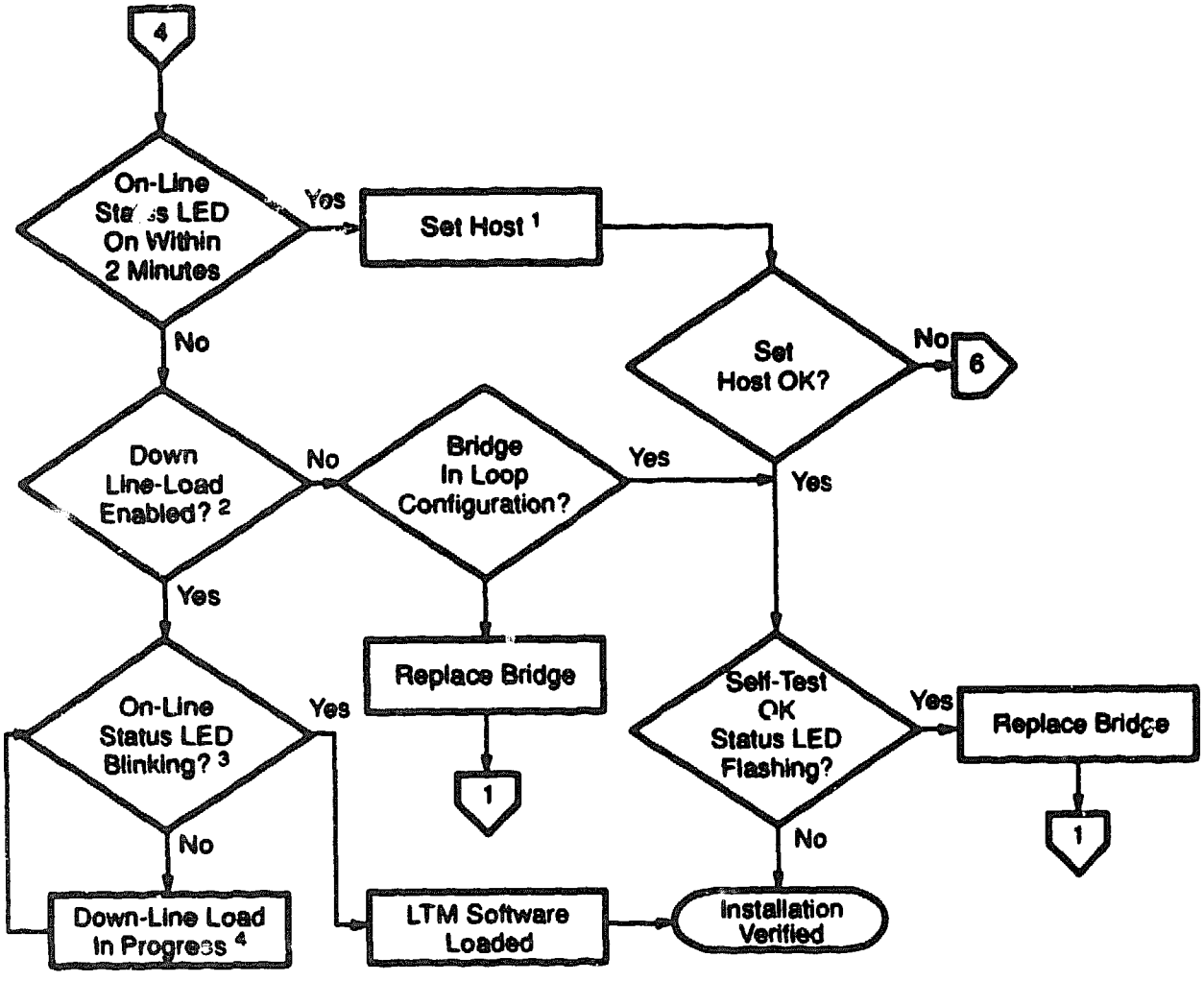
Figure 4–2(Cont.): Troubleshooting Flowchart



[1] From host on Port A to host on Port B

[2] Down-line switch may be enabled. See switch descriptions included in this manual.

[3] Flashing twice every 2 seconds indicates that the load host sucessfully down-line loaded the LTM Listener software image. Flashing once each second indicates that the load host has started the LTM Listener software.

[4] Check that the down-line load host has been set up. See *LAN Traffic Monitor Installation Guide* for details on setting up a load host.

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Figure 4–2(Cont.): Troubleshooting Flowchart

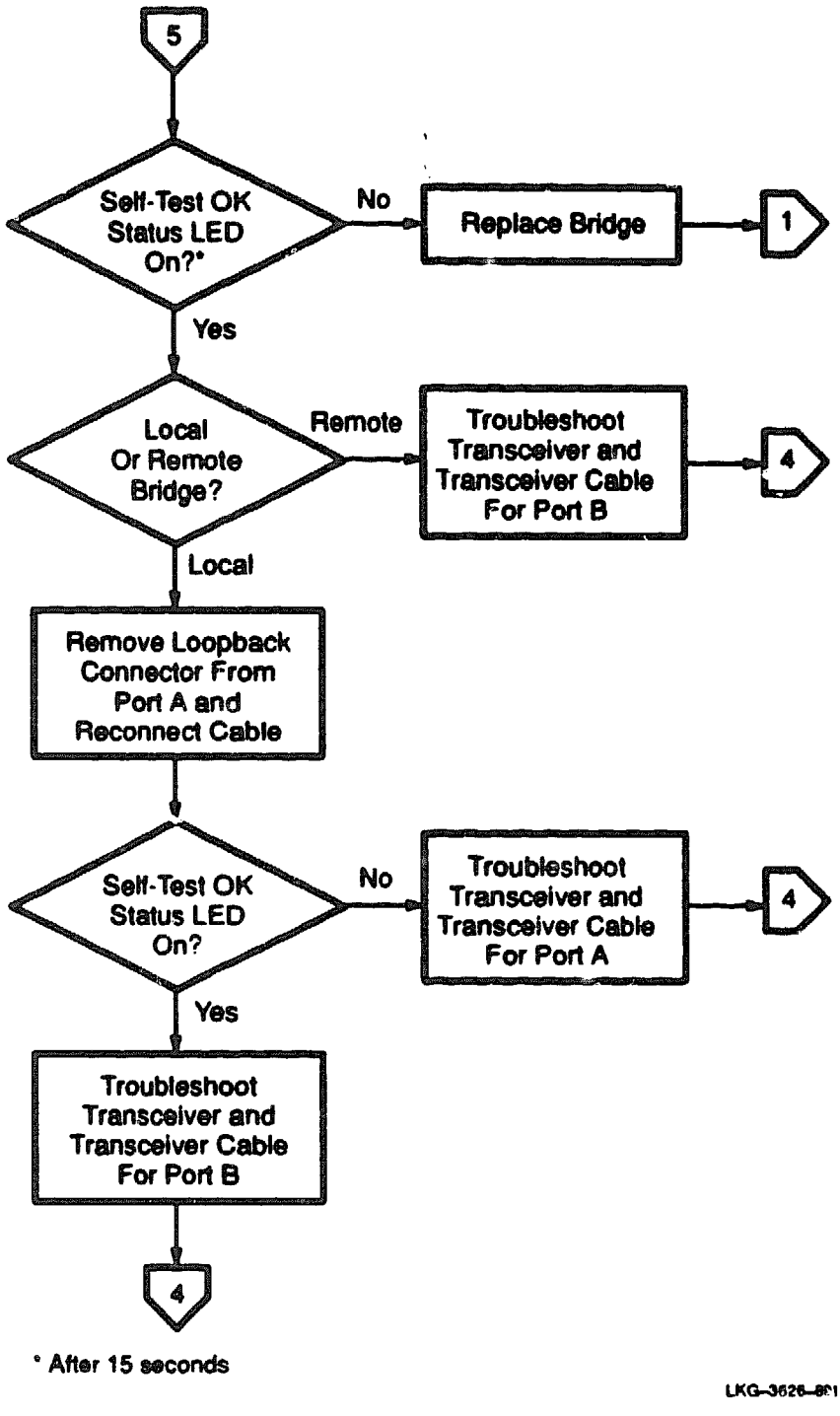

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Figure 4–2(Cont.): Troubleshooting Flowchart

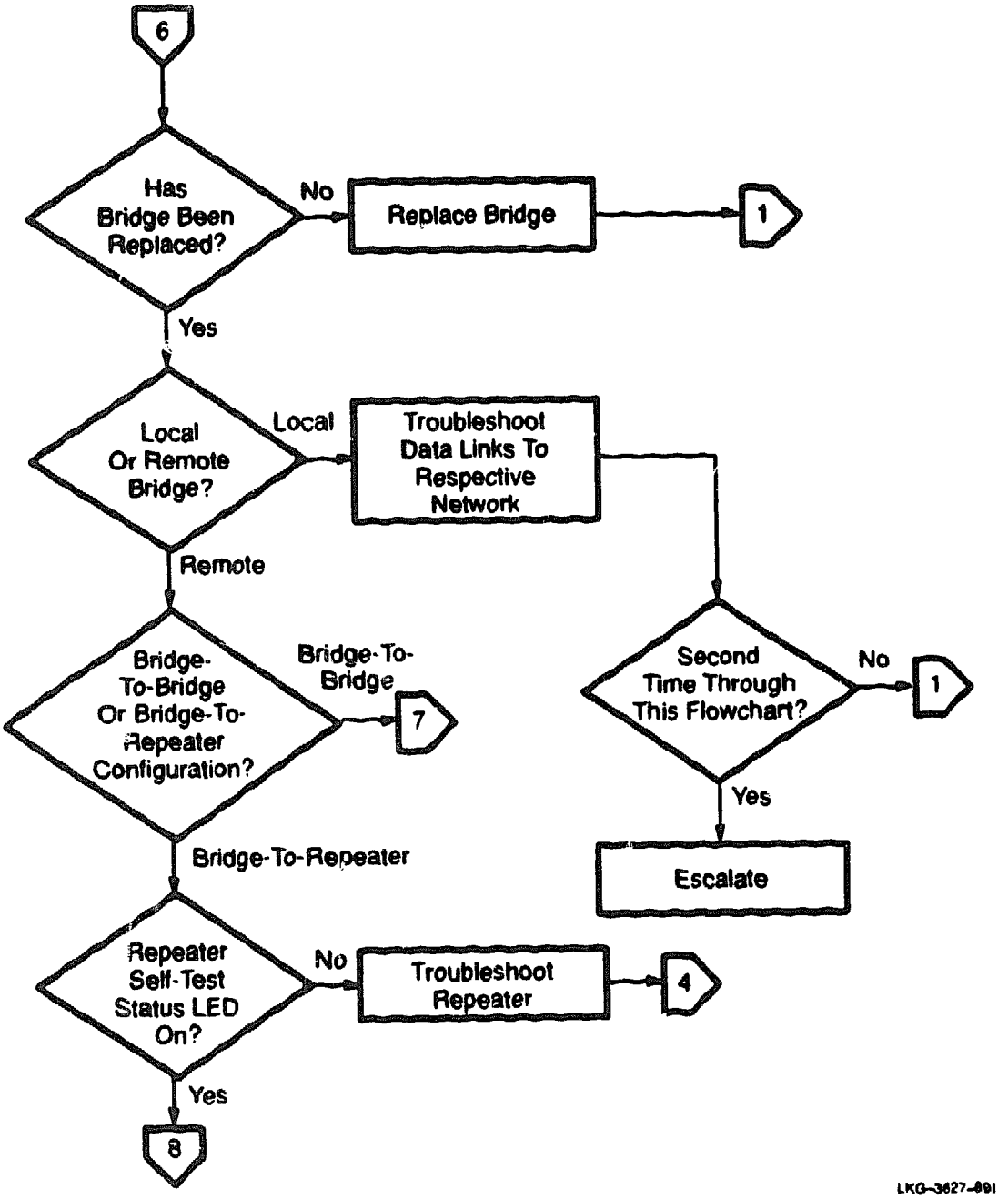

Figure 4–2 Cont'd on next page

Figure 4–2(Cont.): Troubleshooting Flowchart

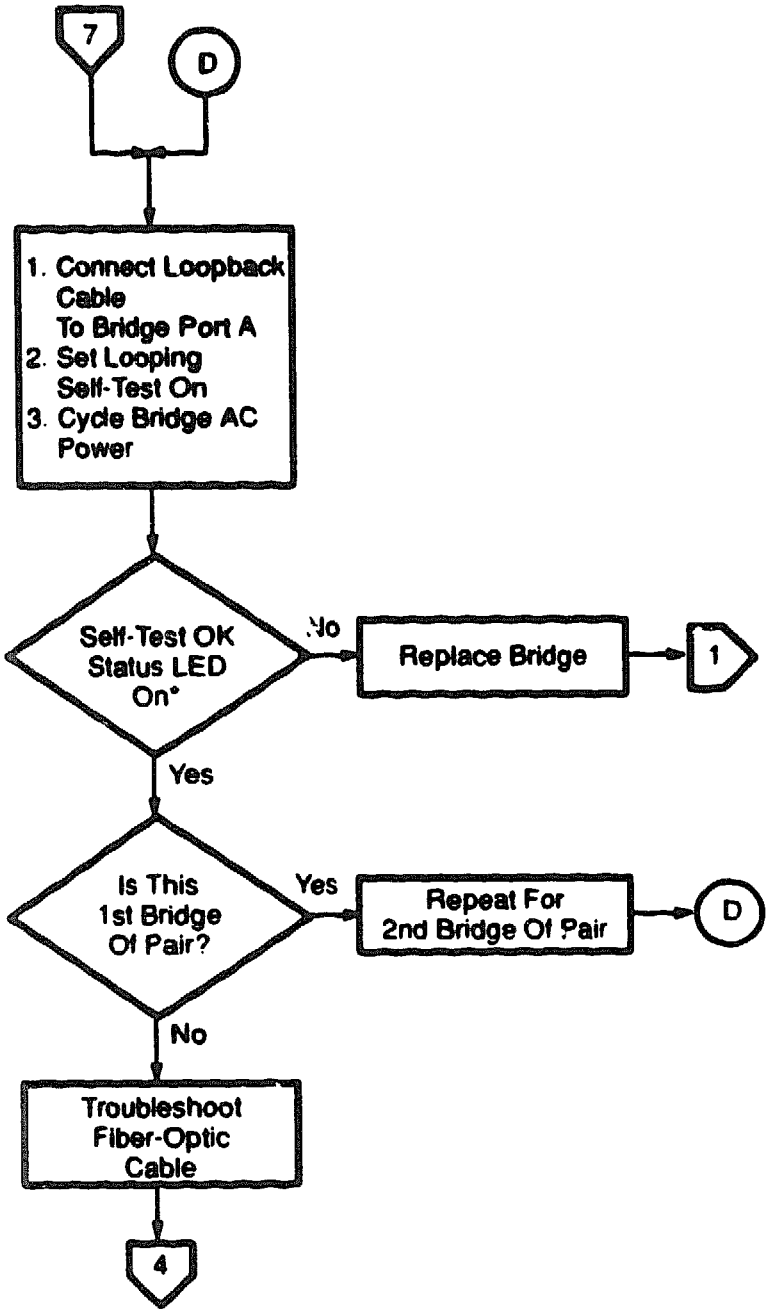

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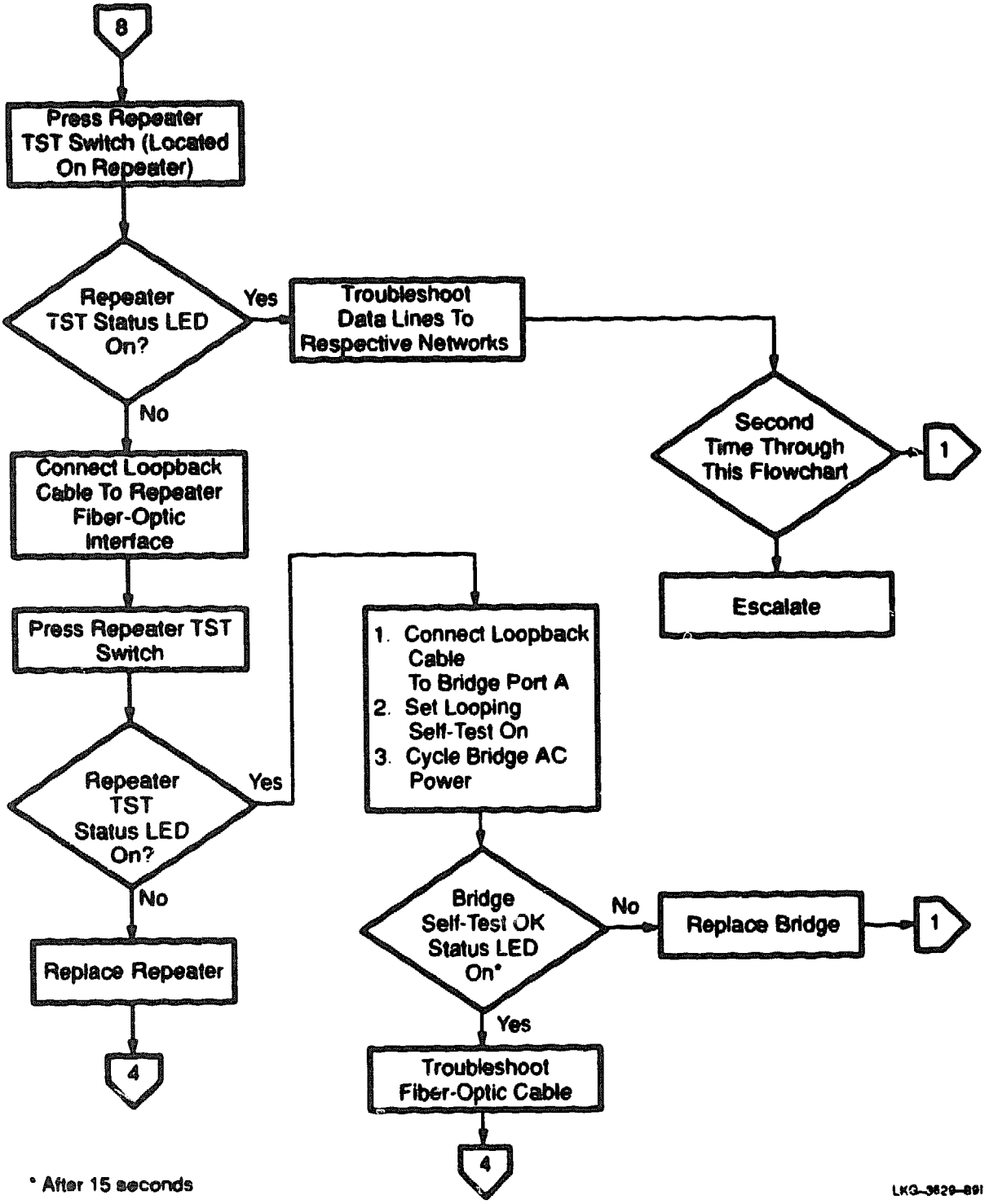
Figure 4–2(Cont.): Troubleshooting Flowchart



4.5 LAN Bridge 150 Replacement Procedures

Use the following procedures to replace a LAN Bridge 150 unit:

1. Unplug the power cord from the wall outlet and from the defective LAN Bridge 150 unit.
2. Disconnect the transceiver cables and/or the fiber-optic cable.
3. Test the replacement LAN Bridge 150 unit by installing loopback connectors and connecting power to the LAN Bridge 150 unit.
4. If the LAN Bridge 150 unit is rack-mounted or wall-mounted, go to Step 5. If the LAN Bridge 150 unit is a desk-top unit, replace it with another LAN Bridge 150 unit and go to Step 8.
5. Support the LAN Bridge 150 unit and remove the screws holding the mounting brackets to the rack or wall.
6. Remove the brackets from the LAN Bridge 150 unit.
7. Install a replacement LAN Bridge 150 unit in the rack or on the wall.
8. Connect the transceiver cables and/or fiber-optic cable to the replacement LAN Bridge 150 unit.

4.6 Bridge Disassembly

This section describes the disassembly procedure for the LAN Bridge 150 unit. Removal procedures for the following parts are provided:

- Plastic enclosure
- Chassis cover
- Power supply
- Fans
- Logic board

WARNING

To prevent electrical shock and damage to components, disconnect the power cord from the LAN Bridge 150 unit before opening the chassis.

The instructions in this section assume that:

- All external cables to the bridge have been removed. (Cables should be marked for proper replacement.)
- The LAN Bridge 150 unit has been removed from its rack or wall mounting.

CAUTION

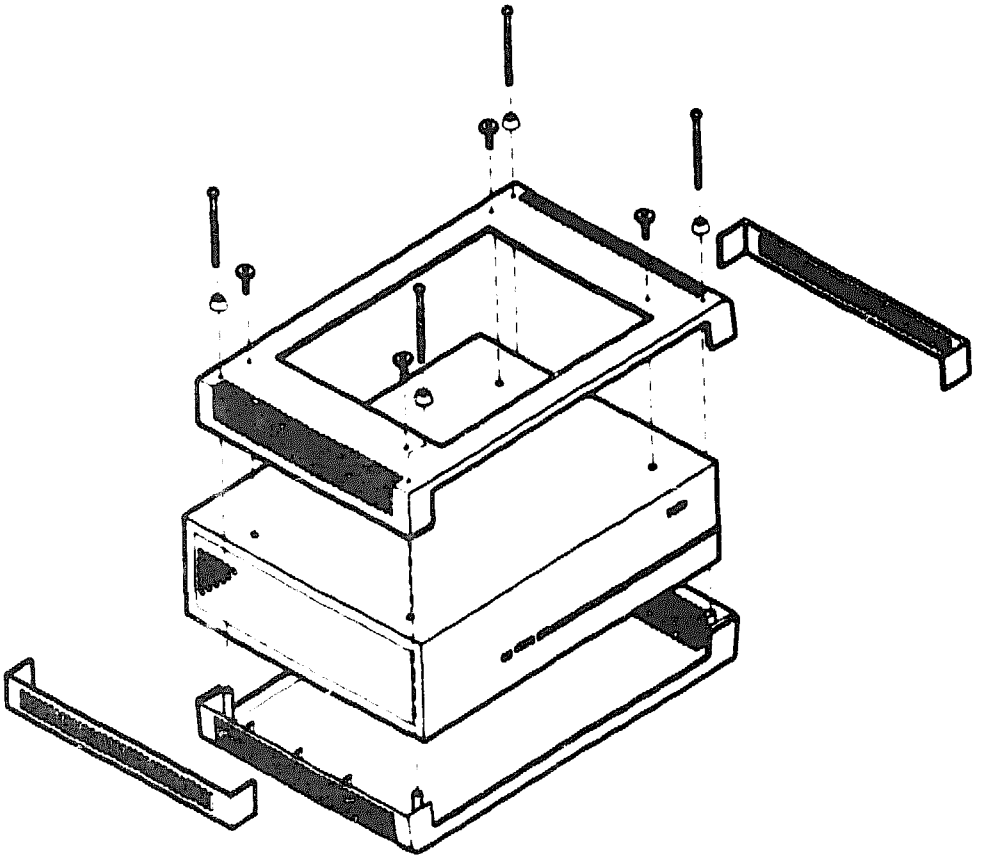
Modules in the bridge can be damaged by electrostatic discharges (ESD). Do not work inside the unit unless a static-control wrist strap is placed on your wrist and the wire from it is grounded to the metal chassis. A wrist strap, ground wire, and table pad are included in the Field Service Kit available from Digital (P/N 29-11762).

4.6.1 Plastic Enclosure Removal

To remove the plastic enclosure, follow these steps:

1. Remove the 4 screws (see Figure 4–3) that secure the rubber feet to the bottom of the plastic enclosure. These screws release the top plastic of the enclosure and the two side pieces.
2. Remove the 4 screws (see Figure 4–3) that hold the bottom of the enclosure to the chassis.

Figure 4–3: Removing the Plastic Enclosure



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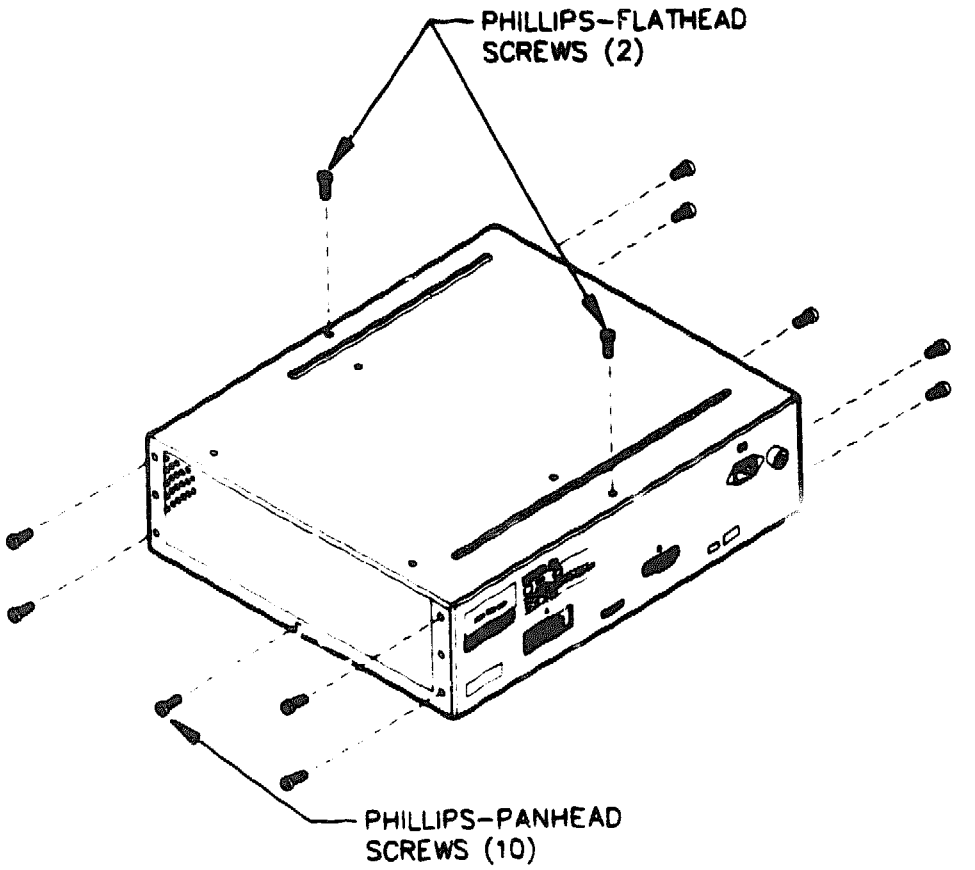
4.6.2 Opening the Chassis Cover

To open the metal chassis cover, make sure your ESD wrist strap is attached and perform the following:

1. Remove the plastic enclosure (refer back to Section 4.6.1).
2. Remove 14 chassis cover screws as follows (see Figure 4–4):
   - Remove 2 screws from the top of the chassis.

- Remove 12 screws, 6 from each end of the chassis.

Figure 4–4: Removing the Chassis Screws

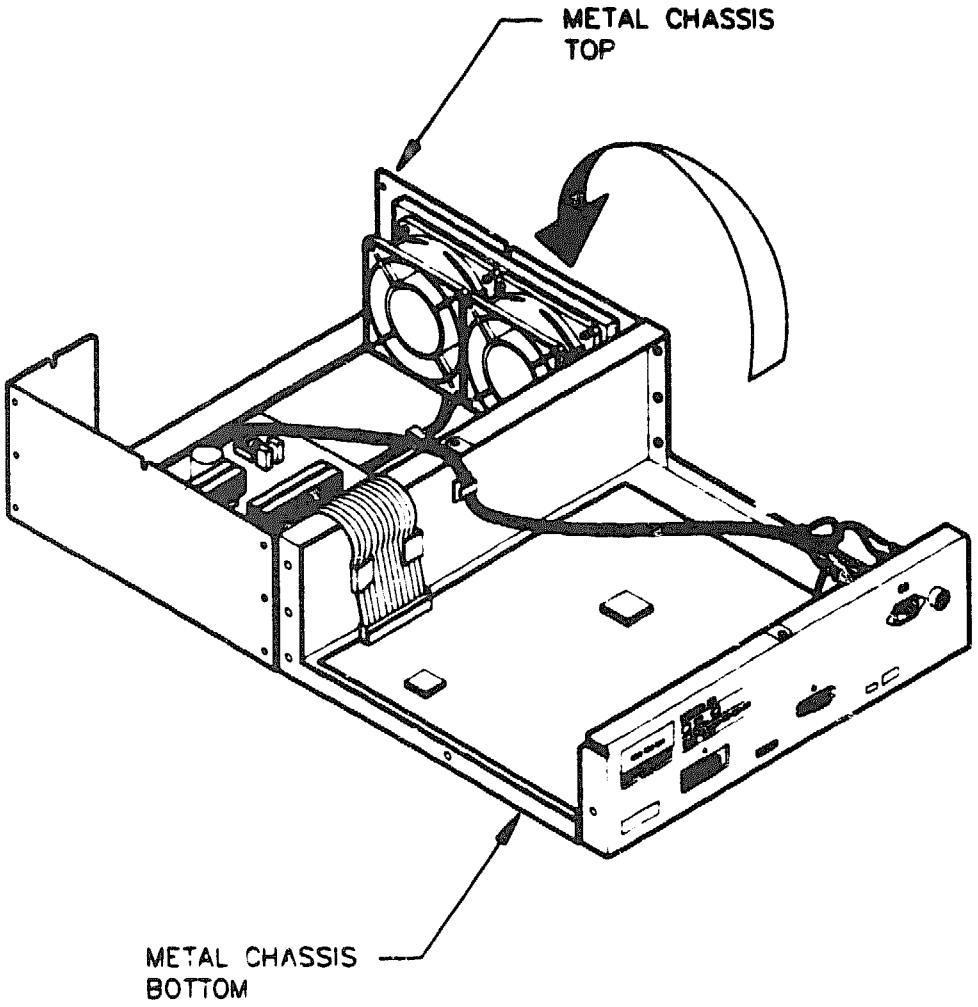


3. *Carefully* lift open the chassis cover and place it next to the bottom of the chassis (Figure 4–5).

NOTE

The dc power bus from the logic module to the power supply is still connected when opening the unit.

Figure 4–5: Opening the Chassis Cover

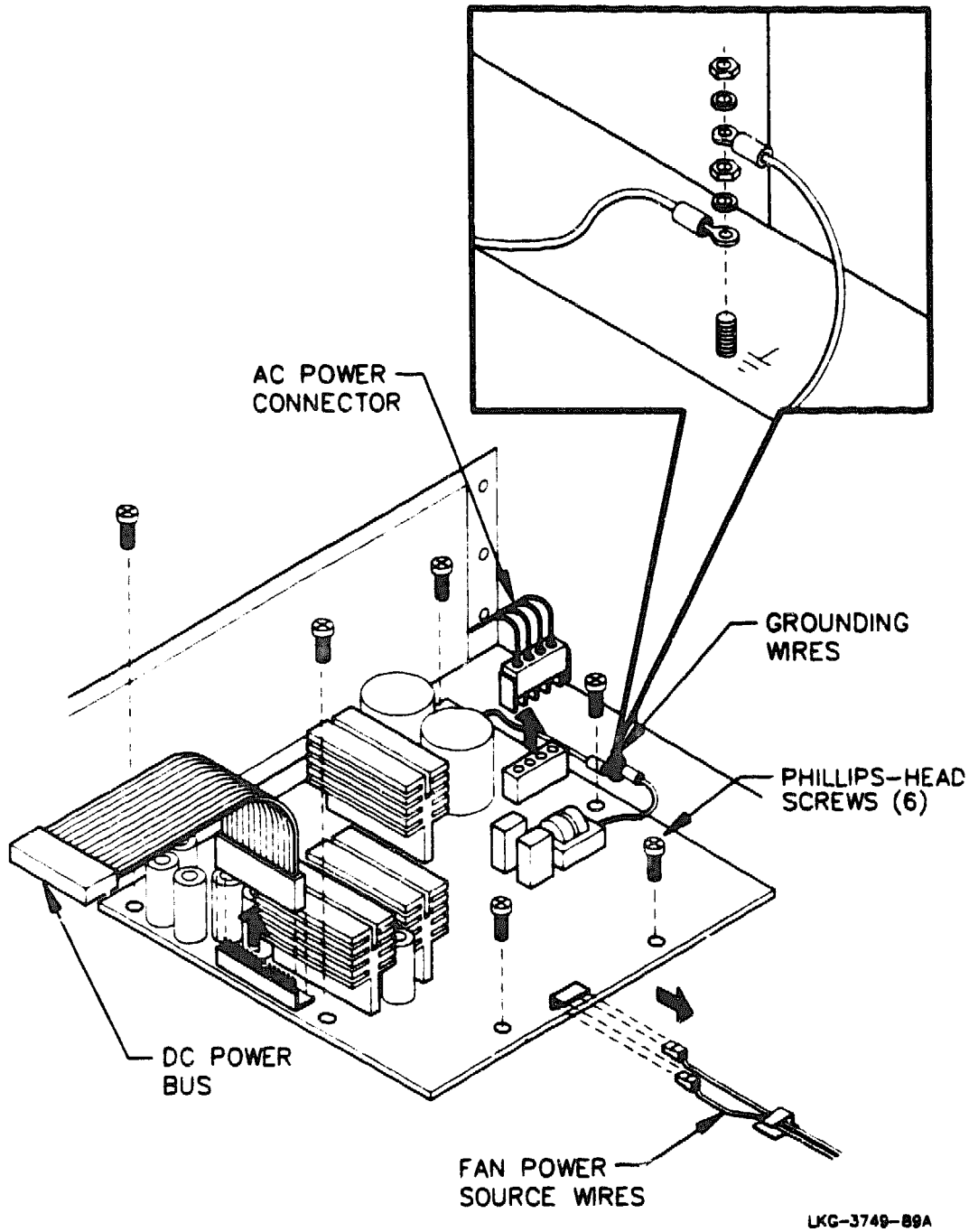


4.6.3 Removing the Power Supply Assembly

To remove the power supply assembly, make sure your ESD wrist strap is attached and follow these steps:

1. Remove the plastic enclosure (refer back to Section 4.6.1).
2. Open the chassis cover (refer back to Section 4.6.2).
3. Remove the fan power harness (2 connectors) from the power supply module (Figure 4–6).
4. Remove the power supply ground wire by removing the retainer nut (Figure 4–6).
5. Remove the 4-pin ac power harness connector (Figure 4–6).
6. Remove the 16-pin dc power bus connector (Figure 4–6).
7. Remove the 6 screws that secure the power supply assembly to the top chassis cover (Figure 4–6).
8. Carefully lift the power supply assembly out of the chassis.

Figure 4–6: Removing the Power Supply Assembly



4.6.4 Power Supply Assembly Replacement

To install the replacement power supply assembly, make sure your ESD wrist strap is attached and follow these steps:

1. Carefully set the replacement power supply on the chassis top in the proper position.
2. Reinstall the 6 screws that secure the power supply to the chassis.
3. Reconnect the 4-pin ac power connector.
4. Reconnect the 16-pin power connector.

NOTE

The 16-pin power bus connectors are keyed. Determine proper alignment before attempting reinstallation of the connectors.

5. Reconnect the grounding wires to the chassis. Using a torque wrench, tighten the ground nut to 27 inch/pounds ± 10%.
6. Reconnect the fan power harness.

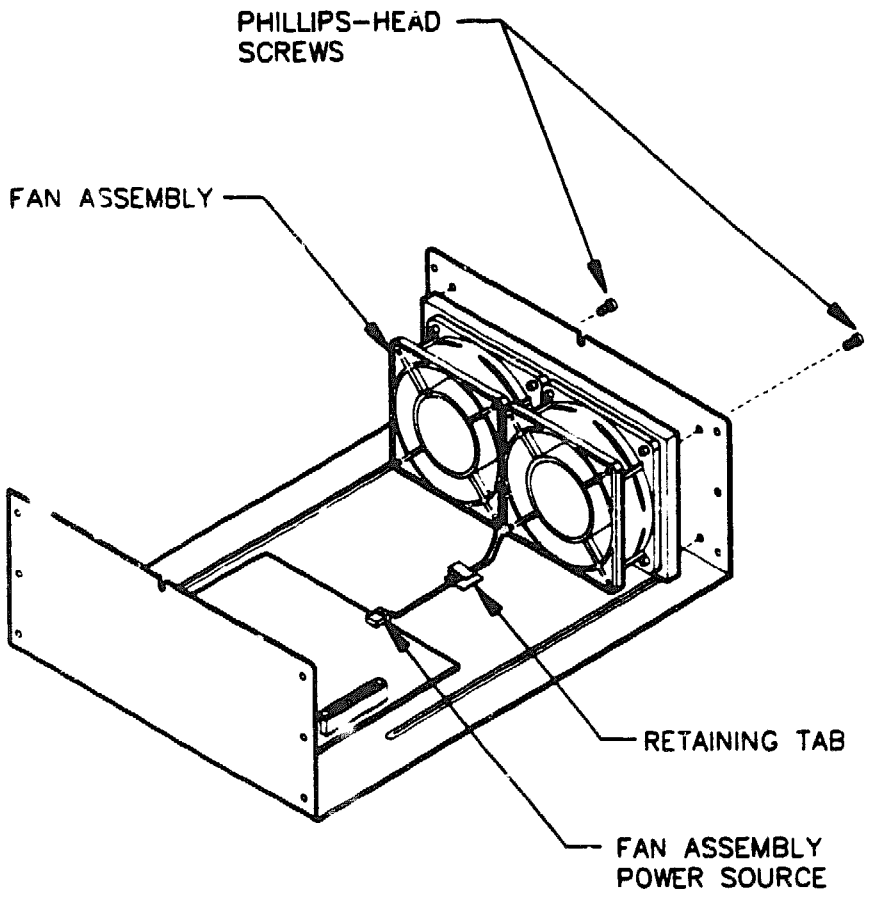
To reassemble the unit and verify proper operation, refer to section Section 4.7.

4.6.5 Removing the Fan Assembly

To remove the fan assembly, make sure your ESD wrist strap is attached and follow these steps:

1. Remove the plastic enclosure (refer back to Section 4.6.1).
2. Open the chassis cover (refer back to Section 4.6.2).
3. Remove the fan power harness connectors from the power supply (Figure 4–7).
4. Remove the 2 screws that hold the fan assembly in place (Figure 4–7).

Figure 4–7: Removing the Fan Assembly



4.6.6 Fan Assembly Replacement

To install the replacement fan assembly, make sure your ESD wrist strap is attached and follow these steps:

1. Place the replacement fan assembly on the chassis in the proper position and reinstall the two screws that secure it to the chassis.
2. Reinstall the fan power harness connectors to the power supply.

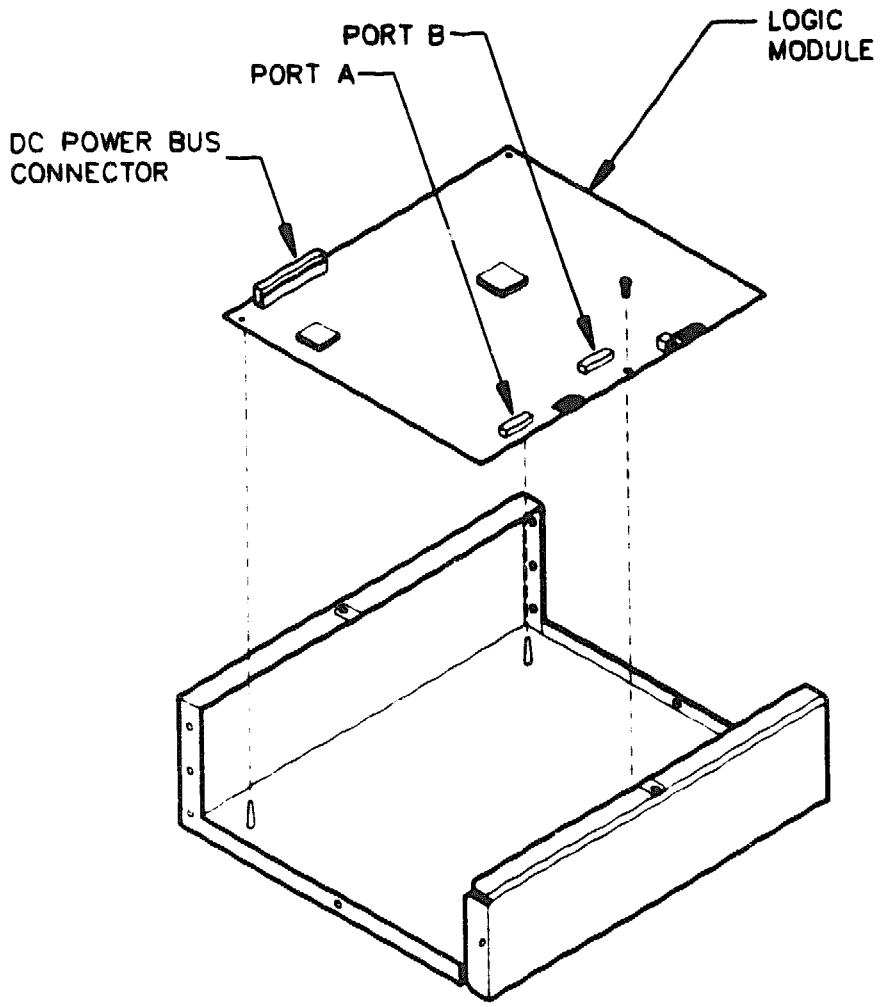
To reassemble the unit and verify proper operation, refer to Section 4.7.

4.6.7 Removing the Logic Module

To remove the logic module, make sure your ESD wrist strap is attached and follow these steps:

1. Remove the plastic enclosure (refer back to Section 4.6.1).
2. Open the chassis cover (refer back to Section 4.6.2).
3. Unplug the 2 interface connectors (Port A and Port B) shown in Figure 4–8.
4. Remove the dc power bus connector (Figure 4–8).
5. Remove the 1 retaining screw (Figure 4–8) that holds the logic module to the LAN Bridge 150 chassis.
6. While releasing the standoff clips that also hold the logic module in place (Figure 4–8), carefully lift the logic module out of the chassis.

Figure 4–8: Locations of Logic Module Retaining Hardware



4.6.8 Logic Module Replacement

To install the replacement logic module, make sure your ESD wrist strap is attached and follow these steps:

1. Carefully place the replacement logic module on the chassis bottom in the proper position. Secure the standoff clips.
2. Reinstall the 1 screw that secures the logic module to the chassis.
3. Reinstall the Port A, Port B, and dc power bus connectors.

To reassemble the unit and verify proper operation, refer to Section 4.7.

4.7 Reassembly and Reinstallation Procedures

To reassemble the unit, make sure your ESD wrist strap is attached and perform the following:

1. Lift the top of the chassis and turn it over, *carefully* placing it onto the bottom of the chassis.
2. Reinstall the 14 screws on the sides and top of the unit. Note that the 2 flathead screws go on the top of the chassis and should be reinstalled first to help with cover alignment (refer back to Figure 4–4 for screw locations).
3. To reinstall the unit:
   - If the unit is used on a desktop, reinstall the plastic enclosure by referring to Figure 4–3 as a guide. Note that the unit is upside down so that the rubber feet and screws can be reinstalled. Connect all cables and verify reinstallation of the unit by referring to the *LAN Bridge 150 Installation* guide, Chapter 4.

     NOTE

     The top and bottom of the enclosure have *arrows* imprinted on the inside to help with reassembly. The arrows indicate the front of the unit.

   - If the unit is used in a wall or rack mount, verify reinstallation by referring to the *LAN Bridge 150 Installation* guide, Chapter 4.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