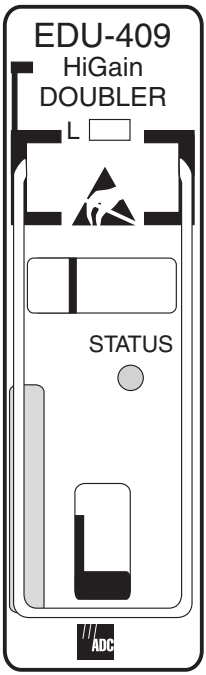
HiGain

USER MANUAL



EDU-409 List 1 Doubler Unit
Product Catalog: 150-409-115-05

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Revision History of This Manual

To order copies of this document, use document catalog number 150-409-115-05.

Issue	Release Date	Revisions Made
01	August 14, 1998	Initial release
02	August 24, 1998	Modify Tables 1 and 2
03	March 26, 1999	Update Technical Specifications
04	January 26, 2000	Change practice title
05	March 1, 2002	ADC rebranding of document; no technical changes

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January 26, 2000

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USING THIS MANUAL

The following conventions are used in this manual:

- `Monospace type` indicates screen text.
- Keys you press are indicated by small icons such as Y or ENTER. Key combinations to be pressed simultaneously are indicated with a plus sign as follows: CTRL + ESC.
- Items you select are in **bold**.

Three types of messages, identified by icons, appear in text.

Notes contain information about special circumstances.

Cautions indicate the possibility of personal injury or equipment damage.

The Electrostatic Discharge (ESD) symbol indicates that a device or assembly is susceptible to damage from electrostatic discharge.

For a list of abbreviations used in this document, refer to "Glossary" on page 25.

UNPACK AND INSPECT YOUR SHIPMENT

Upon receipt of the equipment:

- Unpack each container and inspect the contents for signs of damage. If the equipment has been damaged in transit, immediately report the extent of damage to the transportation company and to ADC DSL Systems, Inc. Order replacement equipment, if necessary.
- Check the packing list to ensure complete and accurate shipment of each listed item. If the shipment is short or irregular, contact ADC DSL Systems, Inc. as described in "Product Support" on page 23. If you must store the equipment for a prolonged period, store the equipment in its original container.

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OVERVIEW

The HiGain® EDU-409 List 1 List 1 is a low-power doubler unit that extends the range of a HiGain repeaterless G.703 transmission system. The doubler units are installed between any doubler-compatible HiGain E1 Line Unit (ELU) and HiGain E1 Doubler (EDU) or HiGain E1 Remote Unit (ERU). They allow 2.048 Mbps transmission over twice the normal High Capacity Digital Service (HCDS) range.

Adding a doubler can double the HCDS range to approximately 7.32 km (24,000 feet) of 0.51-mm wire or 5.49 km (18,000 feet) of 0.4-mm wire loops. Two doublers can triple the HCDS range to 10.97 km (36,000 feet) of 0.51-mm wire or to 8.22 km (27,000 feet) of 0.4-mm wire loops. Three doublers extend the 0.51-mm wire range to 14.6 km (48,000 feet).

FEATURES

The EDU-409 List 1 includes:

- Occupation of one standard 239 T1 mechanics slot
- Power by any doubler-compatible HiGain line unit
- Front-panel status display LED
- Lightning and power-cross protection on both sides of the High bit-rate Digital Subscriber Line (HDSL) interface
- Extremely low power dissipation
- Extremely low latency
- Compatibility with a 4-span line-powered circuit
- Minimal wander and jitter

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APPLICATIONS

HiGain doublers operate with any number of T1, Plain Old Telephone Service (POTS), Digital Data Service (DDS), or other HiGain systems sharing the same cable binder group.

The EDU-409 List 1 has a range of up to 35 dB loss at 260 kHz on each of the four HDSL loops. A list of HDSL signal cable losses for various cable gauges at 260 kHz and 135 Ω is provided in Table 1. The table is applicable to HDSL cable pairs running between the ELU and the EDU-409 List 1 and between the EDU-409 List 1 and another EDU or ERU.

Table 1. *HDSL Signal Cable Loss*

Cable Gauge	Loss @ 260 kHz (dB/km)[(a)]	Ω per km
0.4 mm/26 AWG	13.94	272
0.51 mm/24 AWG	10.47	171
0.61 mm/22 AWG	8.14	105
0.91 mm/19 AWG	5.74	52

(a) Add 3 dB for each bridged tap and 1 dB for each cable gauge change.

The EDU-409 List 1 can be used in two-span to four-span circuits, depending on the models of the ELU and ERU being used with the doubler units and the power option chosen for the ERU. The number of doublers is equal to one less than the number of Spans (as shown in Figure 3 on page 10).

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Table 2 lists the maximum number of EDU-409 List 1 doubler units that can be deployed as a function of the ELU and ERU that are used with it.

Table 2. *EDU-409 List 1 Circuit Ranges*

ELU Model	Maximum Number of EDU-409 List 1 Doublers Per Circuit	
	Line Powered Remote	Local Powered Remote[a]
ELU-319 List 5D ELU-319 List 6D	1	2
ELU-319 List 5E ELU-319 List 6E	3[b]	2

(a) Requires ERU-412 List 1D and List 2D. ERU-412 List 1E and 2E do not support local power.
(b) Requires ERU-412 List 1E and 2E

Each span can take up to 30 seconds to acquire HDSL synchronization. The total time to acquire end-to-end synchronization increases with the number of spans.

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The physical location of the doublers is driven by the following three deployment rules:

1 Place the enclosures at the electrical limits, 35 dB, of each span. This places the first doubler at the 35 dB location, the second at 70 dB, and so on, allowing the maximum circuit range to be realized.

Caution must be observed when pushing doubler spans to their 35 dB maximum range. Refer to ADC's Technical Advisory #TA-015 on HiGain operating ranges and general deployment guidelines.

2 If Rule 1 is not applicable, then try to make all spans the same electrical length (same 260 kHz loss). This minimizes the maximum span loss and assures maximum operating margin, resulting in optimal transmission performance on the HDSL cable pairs. If specific application constraints preclude using Rule 2, or if two different circuit layout choices have the same maximum span loss, then use Rule 3.

3 If Rules 1 and 2 are not applicable, make the spans closer to the ELU as short as possible while making the spans farther from the ELU as long as possible. This choice minimizes the I^2R loss in the cable pairs, and reduces the thermal stress on the ELU. Following this rule minimizes the power consumption and dissipation of the ELU that provides the doubler power.

Only those ERUs that have a local powering option can be used in local ERU-powered applications.

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PRODUCT DESCRIPTION

The EDU-409 List 1 List 1 includes:

- An open-framed cover
- A front panel featuring:
  - Status display
  - Configuration number

COVER

The open-framed cover reduces thermal stress and improves reliability allowing air to freely circulate over all components. The open cover also permits the doubler to be easily distinguished from the 239 T1 repeater.

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FRONT PANEL

Figure 1 shows the front panel of the EDU-409 List 1, and Table 3 describes the doubler unit components.

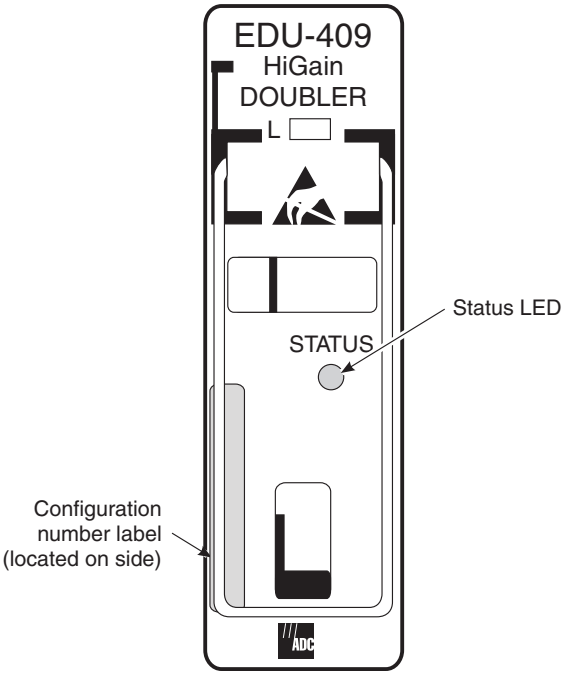

Figure 1. *EDU-409 List 1 Front Panel*

Table 3. *Front Panel Components and Labels*

Name	Function
Status LED	Indicates operational status of doubler. See Table 4 on page 9.
Configuration number	Contains either a five-digit or six-digit warranty configuration number or a standalone two or three-digit configuration number as follows: Digit 1 = Last digit of shipment year Digits 2 and 3 = Shipment month Digits 4 and 5 = Configuration number The configuration number can also be found on a small bar label that also contains the Julian date code and part number. This gummed label may be attached to the PC board or to the front panel.

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INSTALLATION

This section describes the compatibility and installation for the EDU-409 List 1.

COMPATIBILITY

The EDU-409 List 1 is compatible with the following ADC outdoor enclosures:

- HRE-500, single-slot unit
- HRE-458, 10-slot unit
- HRE-819, 12-slot unit

INSTALLING THE EDU-409 LIST 1

To install the EDU-409 List 1 in an enclosure, perform the following steps and refer to the enclosure installation manual for information about cabling, proper connections, grounding, and line and local power.

This product incorporates static sensitive components. Proper electrostatic discharge procedures must be followed.

To install the doubler unit, slide the doubler unit into the card guides for the desired slot (see Figure 2 on page 8). Then push the unit into the enclosure until it is seated in the card-edge connector. The unit should snap into place, indicating that it is properly seated.

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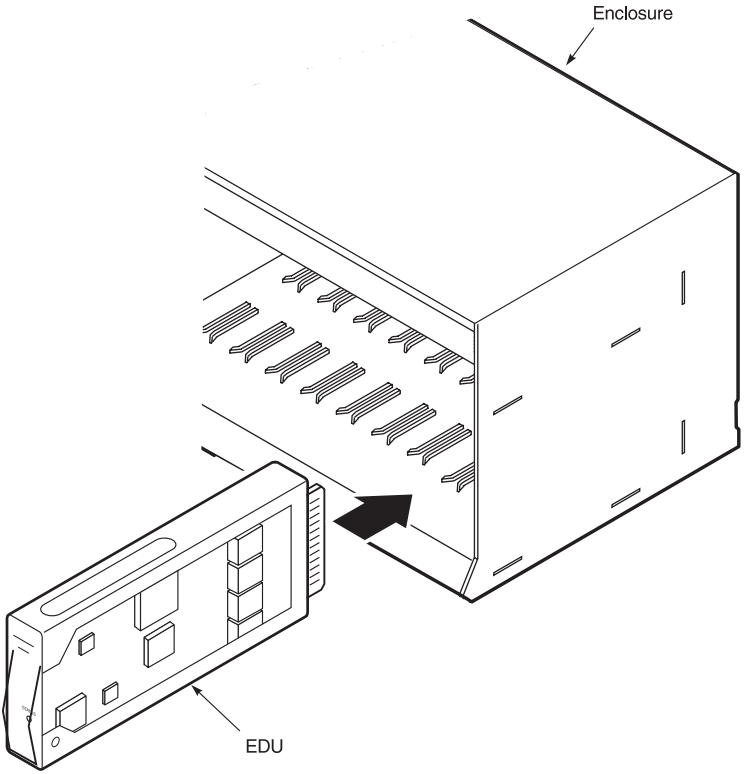

Figure 2. *Installing the EDU-409 List 1 in a Remote Enclosure*

Some enclosures may require you to adjust the retaining bar located on the front of the enclosure to secure the unit. Refer to the appropriate ADC user manual for the enclosure.

Once the EDU-409 List 1 is installed in the enclosure, the front panel Status LED flashes green if power is applied from an upstream line unit. When the loops on both sides of the EDU synchronize, the LED constantly glows solid green. Refer to the section titled "Alarms" on page 9 for more details on LED operation.

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ALARMS

The front panel of the EDU-409 List 1 contains a tri-color LED. The LED color and activity provides information on system functionality (see Table 4).

Table 4. *Front Panel Status Indicator*

LED	Description
Flashing Green once per second	Indicates synchronization is being attempted between the EDU-409 List 1 and the upstream (network) module.
Flashing Green more than once per second	Indicates synchronization is being attempted between the EDU-409 List 1 and the downstream (customer) module.
Steady Green	Indicates HDSL frame synchronization has been achieved between the EDU-409 List 1 and both the upstream and downstream modules.
Flashing Red once per second	Indicates an HDSL Cyclic Redundancy Check (CRC) error has occurred between the EDU-409 List 1 and the upstream module. See "Technical Specifications" on page 21.
Flashing Red more than once per second	Indicates an HDSL CRC error has occurred between the EDU-409 List 1 and the downstream module. See "Technical Specifications" on page 21.
Flashing Yellow once per second	Indicates an NDU (Network Doubler Unit) loopback is in effect in the EDU-409 List 1 towards the network. This tests the integrity of the upstream span.
Flashing Yellow more than once per second	Indicates a CDU (EDU-409 List 1 to customer) loopback is in effect in the EDU-409 List 1 towards the customer. This tests the integrity of the downstream span.

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LOOPBACK OPERATION

When equipped with the EDU-409 List 1, a HiGain system can execute a number of loopback commands. The loopbacks can be initiated from the ELU craft port or from the ELU front-panel buttons.

For more information about doubler loopback commands, refer to the appropriate ELU practices (see"Product Support" on page 23).

All NDU loopbacks are towards the network. All CDU loopbacks are towards the customer. Figure 3 is a diagram of a HiGain loopback system.

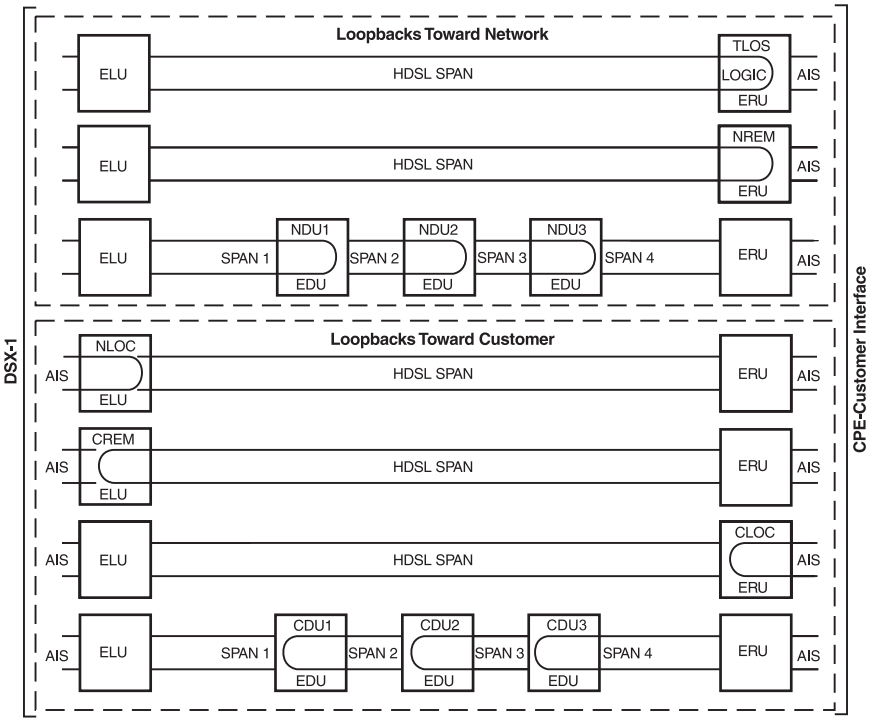

Figure 3. *HiGain Loopbacks*

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FUNCTIONAL DESCRIPTION

HiGain uses the ADC Two-Binary, One-Quaternary (2B1Q) HDSL transceiver system to establish two full-duplex 1040 kbps data channels between the ELU and the ERU units. Each EDU-409 List 1 increases the maximum range by approximately 3.66 km (12,000 feet) of 0.51-mm wire or 2.74 km (9,000 feet) of 0.4-mm wire per doubler.

A block diagram of the EDU-409 List 1 with pinouts is shown in Figure 4. The doubler unit power supply uses the HDSL simplified line voltage to produce +5 Vdc and +3 Vdc required by the EDU-409 List 1 electronics. The power feed is passed on to the HDSL output pair, to power a second doubler or a remote unit.

The maximum power dissipation of the doubler unit is 3 W.

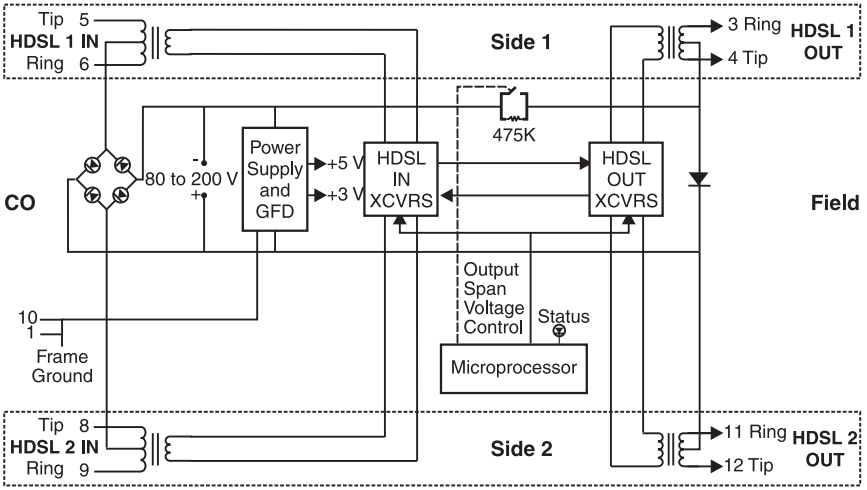

Figure 4. *Doubler Block Diagram*

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DOUBLER ENCLOSURE CAPACITIES WITH FULL SOLAR LOAD

The EDU-409 List 1 can be housed in a variety of outdoor enclosures manufactured by ADC and other vendors. The number of doublers used in any of the enclosures depends on the maximum outside ambient temperature. The doubler capacities for several of these standard enclosures is listed in Table 5 on page 13 and Table 6 on page 14. The capacities listed in Table 6 (for both indoor and outdoor enclosures) are based on a maximum outside temperature of +46.1 °C (+115 °F). Consult ADC for the latest deployment rules when using the enclosures at ambient temperatures above +46.1 °C.

These requirements comply with Bellcore standards, which require HDSL equipment place in outdoor cabinets to operate in a temperature, outside the housing, of -40 °F (-40 °C) with no solar load and +115 °F (+46.1 °C) with a maximum solar load and maximum power dissipation.

Full solar load is equal to maximum sunlight exposure as defined in Bellcore's Technical Advisory TR-TSY-000057.

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The capacities listed for the indoor enclosures in Table 5 assume no solar load. The capacities listed for the outdoor enclosures in Table 6 assume a full solar load as described above. The "Recommended Slot Assignment for Maximum Capacity" column assigns slots according to the following thermal stress reduction rules:

1 Always leave at least one empty slot between adjacent doublers. The adjacency rule only applies to the left- and right-hand sides of the doubler. The top of one unit can be adjacent to the bottom of another, though the latter configuration should be avoided if possible.

Rule 1 does not apply to the HRE-458 and HRE-819 enclosures since these products have the required slot separations already built into their design.

2 Allow as much room as possible between doublers on all four sides.

Slot assignments that do not follow the recommended configurations in Table 5 and Table 6 are permissible as long as the above two rules are applied. Otherwise, damage may occur to doubler units.

Table 5. *Indoor Enclosure Capacities*

Vendor	Description	Model #	EDU-409 List 1 Doubler Capacity	239 T1 Repeater Capacity
CHARLES	Indoor wall mount	CiAC2300	7	7
		CiAC2002	2	2
SPC	Indoor rack and wall mount	4400-09	18	18

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Table 6. *Outdoor Enclosure Capacities with Full Solar Load*

Vendor	Description	Model No.	EDU-409 List 1 Doubler Capacity	239 T1 Repeater Capacity	Recommended Slot Assignment for Maximum Capacity
AT&T	Outdoor Dual chamber pole/wall mount	819	12	25	1, 3, 5, 9, 11, 13, 15, 17, 19, 21, 23, 25 (See Figure 5 on page 17)
AT&T	Outdoor 841 cabinet	27A, B, C or D shelf	11 per shelf/44 total	25 per shelf/100 total	1, 3, 6, 8, 10, 11, 12, 16, 18, 20, 23, 25
AT&T	Outdoor cabinet	809	6	12	All even or all odd-numbered slots.
ALCATEL	Outdoor canister, pole/wall mount	621204	5	12	1, 3, 5, 8, 10
		621205	7	25	2, 5, 9, 12, 14, 17, 24
		621206	9	50	2, 5, 9, 12, 14, 17, 24, 31, 47
CHARLES	Outdoor canister, pole/wall mount	CiAC4306	3	6	All even or all odd-numbered slots.
		CiAC3300	2	3	1, 3
		CiAC5312	5	12	All even or all odd-numbered slots.
		CiAC5325	7	25	1, 3, 9, 11, 13, 17, 22
		CiAC5350	9	50	1, 5, 9, 14, 16, 23, 32, 41, 49
SIERRA	Outdoor canister, pole/wall mount	3011	3	6	All even or all odd-numbered slots.
SUNRISE		3021	3	5	1, 3, 5
SPC	Outdoor canister, pole/wall mount	7130-08FP	3	8	1, 3, 6
		7130-12FP	5	12	1, 3, 5, 7, 11
		7130-25FP	7	25	2, 4, 8, 11, 14, 16, 25
ADC	Outdoor canister, pole/wall mount	HRE-458	8	10	1, 2, 4, 5, 7, 8, 9, 10

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Table 6. *Outdoor Enclosure Capacities with Full Solar Load (Cont.)*

Vendor	Description	Model No.	EDU-409 List 1 Doubler Capacity	239 T1 Repeater Capacity	Recommended Slot Assignment for Maximum Capacity
ADC	Outdoor dual chamber, pole/wall mount	HRE-819	12	12	All slots

Some of the Table 6 capacities are conservative estimates. Ongoing tests at ADC may result in increasing some of these estimates.

Thermal constraints must be observed to ensure reliable service for worst-case conditions.

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ALTERNATIVE DOUBLER ENCLOSURE CAPACITIES

The number of doublers can be increased by two for applications where the enclosures are underground or not exposed to direct sunlight. However, any increase in capacity is still subject to rule 1 on page 4.

The doubler capacity numbers listed for each outdoor enclosure must be reduced by one for every additional +5 °F (+2.8 °C) rise, or any fraction thereof, in outside ambient temperatures above +115 °F (+46.1 °C).

The capacities can be increased by one for every additional +5 °F (+2.8 °C) reduction in outside ambient temperatures above +115 °F (+46.1 °C).

Reduce the doubler capacity by one for every two doublers that do not have an empty slot between them. If the application allows seven doublers, but two are directly adjacent to each other, then the total capacity must be reduced to six.

Standard T1 repeaters can be installed in the same enclosure with doubler units. If this method is used, the maximum number of doublers that can occupy the same case with the standard repeaters must be reduced by one for every four T1 repeaters (or fractions thereof) installed. T1 repeaters located with doublers in outdoor enclosures should be placed in slots that are not adjacent to the doublers.

Rule 1 in the section titled "Doubler Enclosure Capacities with Full Solar Load" on page 12 does not apply if the adjacent slot is occupied by a T1 repeater.

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The AT&T 819 enclosure has two, individual isolated chambers as shown in Figure 5. Slots 1 through 14 are in one chamber. The other chamber contains slots 15 through 25 along with the Pressure (PRES), Filter (FIL), Capacitor (CAP), and COIL slots.

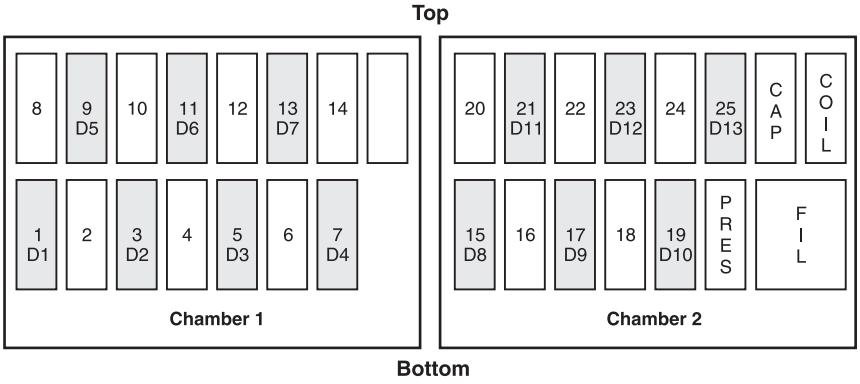

Figure 5. *AT&T 819 Enclosure*

The AT&T 819 can house up to 13 EDU-409 List 1 doublers in the slots designated as D1 through D13 as shown in Figure 5.

Because the length of the EDU-409 List 1 extends beyond the range that older AT&T 819 repeater apparatus covers can accommodate, the cover must be replaced by a deeper cover.

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MICRO DOUBLER CAPACITY DEPLOYMENT RULES

The deployment rules for micro doubler capacity are summarized below:

1 Use Table 5 on page 13 for indoor enclosures.

2 Use Table 6 on page 14 for outdoor enclosures with Full Solar Load for ambient temperatures up to 46.1 °C maximum.

3 The capacities shown in Table 6 can be increased by two for non-solar load (shaded or manhole applications).

4 Decrease capacities in Table 6 by one for every 2.7 °C increase, or fraction thereof, in ambient temperatures above 46.1 °C.

5 Increase the capacities by one for every full +2.7 °C reduction in ambient temperature below 46.1 °C.

6 Decrease any outdoor capacity by one for every four E1 repeaters, or fraction thereof, that are installed with the doublers.

7 For all outdoor applications, decrease the capacity by one for every two adjacent doublers that are not separated by at least one empty slot.

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GROUND FAULTS

GROUND FAULT DETECTION

The EDU-409 List 1 has ground fault detection (GFD) circuits. When used with HiGain line units, ground faults occurring at any point along any span are immediately detected. Ground fault conditions shut the HiGain circuit down. The line unit periodically tries to apply power to the first span to determine whether the fault condition is still present. As long as the condition exists, the power cycling and ground fault protection continues. To discontinue the ground fault protection, locate and repair the fault in the cable.

Circuits containing both the EDU-409 List 1 and older doublers without a GFD circuit also support this new ground fault detecting feature, provided the doubler nearest the ELU is an EDU-409 List 1.

The operation of the ground fault circuit requires that the doubler enclosure ground plane is properly connected to earth ground.

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GROUND FAULT ISOLATION

Solutions for common problems that may occur with the EDU-409 List 1 are listed in Table 7.

Table 7. *Fault Isolation Guide*

Problem	Solution
LED does not light	**1** Verify that the ELU is installed and operational in the Central Office. **2** Verify proper cabling between the doubler enclosure and the Central Office. **3** Measure 100 to 200 Vdc between pins 5 or 6 and 8 or 9. This voltage peaks every 15 to 30 seconds as the ELU cycles between self test and line power. If less than 100 Vdc is present, check the cabling or the ELU. Only the line units mentioned in the Description and Features section can be used to power doublers. Other ELU models may not provide reliable operation and should not be used.
LED continues to flash green once a second	Synchronization is being attempted with the upstream unit.
EDU-409 List 1 loses power	The ELU at the Central Office is not present. Measure the resistance of the HDSL input loop. Resistance should be normal loop resistance plus the 25 Ω signature of the ELU.
HDSL line power only appears in very short bursts	A grounded pair is being detected by either the ELU or EDU-409 List 1 in Span 1. This causes the unit's ground fault detection (GFD) circuit to trigger, which forces the HDSL line voltage off immediately after it cycles on. Remove the ELU and EDU-409 List 1 and check for cable ground faults in Span 1. The doubler's GFD circuit can easily be checked by grounding any of the loop connectors to the doubler. This forces the circuit down immediately. If the circuit stays up, either the GFD circuit is defective or the EDU-409 List 1 is not properly grounded.
EDU-409 List 1 shuts off after Span 1 comes up	A grounded pair is being detected by the EDU-409 List 1 in Span 2. Remove EDU-409 List 1 and check for ground fault in Span 2.

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TECHNICAL SPECIFICATIONS

HDSL

Line Code	1040 kbps, 2B1Q full duplex
Output	+13 dBm
Line Impedance	135 Ω
Resistive Signature	Input/Output: 25 Ω (maximum)
	Line Output DC: 25 Ω (maximum)
Start-up Time (per span)	15 seconds (typical), 30 seconds (maximum)

Line Clock Rate

Internal Stratum 4 clock

Power Consumption

3.0 W (nominal), 3.2 W (maximum)

Maximum Provisioning Loss

35 dB @ 260 kHz, 135 Ω

Wander and Jitter

Nominal - The absence of an HDSL framer from the EDU-409 List 1 reduces the Doubler Unit's effect on a circuit's overall wander and jitter to second order insignificance when compared to the wander and jitter of other circuit modules.

Latency

80 microseconds (maximum either direction)

Mounting

Single 239 T1 Mechanics slot

Electrical Protection

Secondary surge and power cross protection on all HDSL ports

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Environmental

Operating Temperature	-40 °C (-40 °F) to +70 °C (+158 °F)
Operating Humidity (non-condensing)	5% to 95%
Operating Temperature in Outside Enclosures	Complies with Section 10.2.1.3 of TA-NWT-001210
Operating Elevation	60.96 m (200 feet) below sea level to 3.96 km (13,000 feet) above sea level

Dimensions

Height	6.6 cm (2.6 inch)
Width	1.9 cm (0.75 inch)
Depth	16.5 cm (6.5 inch)
Weight	1.76 kg (0.8 lbs)

Standards Compliance

EN-60950 Low Voltage

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ABBREVIATIONS

AIS	Alarm Indicator Signal
CAP	Capacitor
CDU	EDU to Customer loopback
CRC	Cyclic Redundancy Check
DDS	Digital Data Service
EDU	HiGain E1 Doubler Unit
ELU	HiGain E1 Line Unit
ERU	HiGain E1 Remote Unit
FIL	Filter
GFD	Ground Fault Detection
HCDS	High Capacity Digital Service
HDSL	High bit-rate Digital Subscriber Line
HRE	HiGain Remote Enclosure
KBPS	Kilo (thousand) Bits Per Second, sometimes written Kb/s
MBPS	Mega (million) Bits Per Second, sometimes written Mb/s
NDU	EDU to Network Loopback
POTS	Plain Old Telephone Service
PRES	Pressure
RMA	Return Material Authorization
SPLB	Special Loopback

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GLOSSARY

American Wire Gauge	The standard used to describe wire size. The diameter of the wire increases as the gauge decreases. 26 gauge is 4 mm (0.0157') in diameter, 24 gauge is 51 mm (0.0201'), and so on.
2B1Q	Two-Binary, One-Quaternary. Line coding used for HDSL.
Cable Binder Group	A group of 25 pairs of wires.
Bridged Tap	A pair of wires connected in parallel across a single line to form a “T” configuration.
Loop	A length of twisted-pair copper wire connecting the local unit of an HDSL circuit to the remote unit.

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This unit complies with the limits for CISPR-A for radiated emissions. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, can cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense. Refer to the installation section of the appropriate instruction manual for the unit you are installing to get information on cabling, correct connections and grounding

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