

USER MANUAL



HDU-409 Lists 1, 2, and 3 Doubler
Product Catalog: HDU-409-L1,
HDU-409-L2, HDU-409-L3
CLEI: T1R6AE0C, T1R6AEDC,
T1R6X50E



Revision History of This Manual

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Issue	Release Date	Revisions Made
01	April 29, 1998	Initial release of 150-409-100-01.
02	June 24, 1998	Modified front panel and cover. Changed deployment rules. (150-409-100-02)
03	July 14, 1998	Corrected CLEI Code. (150-409-100-03)
04	December 18, 1998	Corrected CLEI Code; new LED indication for margins. (150-409-100-04)
05	December 13, 1999	Added PG-Flex Fault applications and expanded the thermal deployment rules. (150-409-100-05)
01	April 30, 2003	Rebranded PairGain document 150-409-100-05 to new catalog number and updated to include List 3.

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April 30, 2003

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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**.

The following types of messages, identified by icons, may be included in text:



Notes provide information about special circumstances.



General cautions indicate the possibility of personal injury, product failure, or equipment damage if instructions are ignored or not completely followed.



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



An electrical shock caution indicates the presence of a dangerous level of electrical power and the potential for serious personal injury or equipment damage.



A laser caution indicates the potential for permanent eye damage or blindness due to direct exposure to laser beams.

For a list of abbreviations used in this document, refer to “Appendix E - Glossary” on page 34.

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 “Appendix D - Product Support” on page 32. If you must store the equipment for a prolonged period, store the equipment in its original container.

TABLE OF CONTENTS

Overview	1
Features	2
Product Description	3
Applications	6
PG-Flex Deployment	7
Generic Information	9
Doubler Enclosure Capacities with Full Solar Load.....	9
Alternative Doubler Enclosure Capacities.....	16
Mixing HiGain Doublers	18
Micro Doubler Capacity Deployment Rules.....	18
Installation	20
Loopback Operation in HiGain Systems	22
Appendix A - Functional Description	25
Appendix B - Specifications	27
Appendix C - Ground Faults	29
Ground Fault Detection.....	29
HiGain Fault Isolation.....	30
PG-Flex Fault Isolation.....	31
Appendix D - Product Support	32
Appendix E - Glossary	34
Certification and Warranty	Inside Back Cover

LIST OF FIGURES

- 1. HDU-409 Front Panel 3
- 2. Typical HDU Installation with PG-Flex 7
- 3. Two Doubler HDU Installation with PG-Flex 8
- 4. AT&T 819 Enclosure, Slot Locations 1 through 14 17
- 5. Installing the HDU-409 in an Enclosure 20
- 6. HiGain Loopbacks..... 24
- 7. Doubler Block Diagram 25

LIST OF TABLES

- 1. Front Panel Components and Labels 4
- 2. Front Panel Status Indicator LED 5
- 3. HDU-409 Circuit Ranges..... 6
- 4. HDU-409 Indoor Enclosure Capacities 11
- 5. Capacities with Full Solar Load, 239 T1 Repeaters 12
- 6. Capacities with Full Solar Load, LD-1 Repeaters 15
- 7. SPLB Generic Command Set 23
- 8. HDSL Signal Cable Loss 26
- 9. Fault Isolation Guide 30
- 10. Fault Isolation Guide for PG-Flex 31

OVERVIEW

The ADC® HiGain® HDU-409 Lists 1, 2, and 3 are low-power doubler units that extend the range of a HiGain repeaterless T1 transmission system. The doubler units are installed between any doubler-compatible HiGain Line Unit (HLU) and a HiGain Doubler Unit (HDU) or HiGain Remote Unit (HRU). Each doubler allows 1.544 Mbps transmission over an additional Carrier Serving Area (CSA) range.

Each CSA with one doubler encompasses approximately 24,000 feet (7.3 km) using 24 American Wire Gauge (AWG) or 18,000 feet (5.5 km) using 26 AWG loops. Two doublers can triple the CSA range up to 36,000 feet (11 km) using 24 AWG or up to 27,000 feet (8.2 km) using 26 AWG loops. Three doublers extend the 24 AWG range up to 48,000 feet (14.6 km) and four doublers (with a locally-powered HRU) extend the range up to 60,000 feet (18.3 km). The HDU-409 Lists 1, 2, and 3 are identical except that:

- The List 1 is only compatible with the HiGain product line.
- Lists 2 and 3 are compatible with HiGain and PG-Flex® product lines.

Refer to “PG-Flex Deployment” on page 7 for more information regarding the PG-Flex doubler applications.

FEATURES

- The unit occupies one standard 239 T1 mechanics slot.
- Powered by any doubler-compatible HiGain or PG-Flex (List 2 or List 3 only) Central Office (CO) line unit.
- Front-panel status display Light Emitting Diode (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.
- Can be used in four-span line-powered circuits (three doublers and one remote) or five-span locally-powered circuits (four doublers and one remote).
- Compatible with PG-Flex List 3x line units in configurations with up to three spans.
- Complies with the applicable requirements of Network Equipment Building System (NEBS) Generic Equipment requirements of GR 1089 CORE and GR 63 CORE compliance.
- Minimal wander and jitter.

PRODUCT DESCRIPTION

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. Figure 1 on page 3 shows the front panel of the HDU-409 and Table 1 on page 4 describes the doubler unit components and labels.

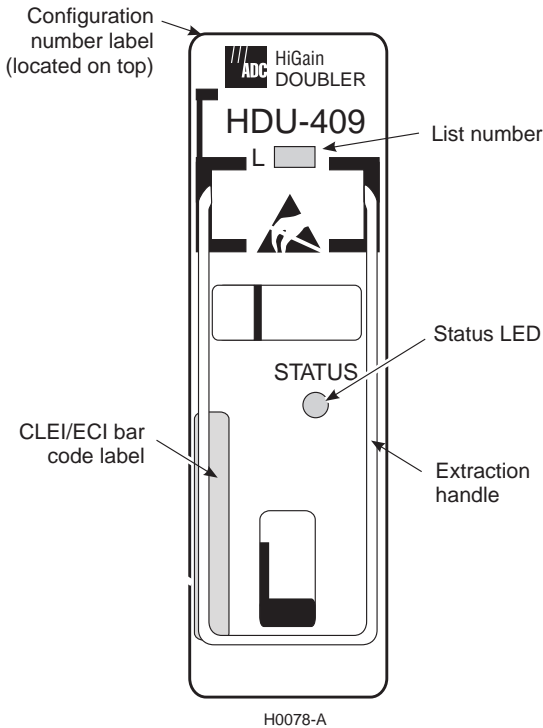


Figure 1. HDU-409 Front Panel

Table 1. Front Panel Components and Labels

Name	Function
Status LED	Indicates operational status of doubler (see Table 2 on page 5).
CLEI/ECI Bar Code Label	Contains human-readable Common Language Equipment Identifier (CLEI) code number and Equipment Catalog Item (ECI) bar code number.
Configuration number	<p>For some products the configuration number may contain either a five- or six-digit warranty configuration number or a stand-alone two- or three-digit configuration number as follows:</p> <ul style="list-style-type: none"> Digit 1 - Last digit of shipment year. Digits 2 and 3 - Shipment month. Digits 4, 5, and 6 - Configuration number. <p>The configuration number identifies the version of the product. New configuration numbers usually accompany changes in the last two characters of the CLEI code.</p> <p>The configuration number can also be found on a small bar label that also contains the Julian date code. The configuration number appears as either a stand-alone CFG xx number or as a 15-character number comprised of the part number and a 3-character extension. For example, the number 150-2404-15-x03 is comprised of the part number and an x03 configuration number. This gummed label may be attached to the PC board or to the front panel.</p>

The front panel of the HDU-409 contains a tri-color LED. The LED color and activity provides information on system functionality. Table 4 provides a list of all alarm indications in priority order.

Table 2. Front Panel Status Indicator LED

LED	Description
Flashing Red about once per second	Indicates an HDSL Cyclic Redundancy Check (CRC) error has occurred between the HDU-409 and the upstream module.
Flashing Red rapidly	Indicates an HDSL CRC error has occurred between the HDU-409 and the downstream module.
Flashing Yellow about once per second	Indicates a Network Doubler Unit (NDU) loopback is in effect in the HDU-409 towards the network. This tests the integrity of the upstream span.
Flashing Yellow rapidly	Indicates a Customer Doubler Unit (CDU) loopback is in effect in the HDU-409 towards the customer. This tests the integrity of the downstream span.
Flashing Green about once per second	Indicates synchronization is being attempted between the HDU-409 and the upstream (network) module.
Flashing Green rapidly	Indicates synchronization is being attempted between the HDU-409 and the downstream (customer) module.
Steady Yellow	Indicates the HDSL margin is less than the margin threshold provisioned for the circuit.
Steady Green	Indicates HDSL frame synchronization has been achieved between the HDU-409 and both the upstream and downstream modules.

APPLICATIONS

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

The HDU-409 can be used in two- to five-span circuits, depending on the models of the HLU and HRU being used with the doubler units and the power option chosen for the HRU. The number of doublers is equal to one less than the number of spans as shown in Figure 6 on page 24.

Table 3 lists the maximum number of HDU-409 doubler units that can be deployed according to which HLU and HRUs are used.



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.

Table 3. HDU-409 Circuit Ranges

HLU Model	Maximum Number of HDU-409 Doublers Per Circuit ^(a)			
	Line-Powered Remote		Locally-Powered Remote	
	I-CPE ON	I-CPE OFF	I-CPE ON	I-CPE OFF
HLU-388 List 2x, HLU-319 List 2x, HLU-231 List 3D, HLU-231 List 6D, HLU-232 List 1D HLU-231 List 7x, HLU-431 List 1D	1	2	2	2
HLU-231 List 8D, HLU-319 List 5D, HLU-388 List 5D HLU-231 List 8/List 8E, HLU-319 List 5/List 5E, HLU-388 List 5/List 5E	2	3 ^(b)	2	4 ^(c)

(a) HRU-411 applications with Current-Customer Premises Equipment (I-CPE) ON are limited to single HDU-409 doubler circuits. The HRU-412 is limited to applications with one and two doublers only.

(b) Requires HRU-402 or HRU-411.

(c) Requires HRU-402 List 1 or List 3.

PG-FLEX DEPLOYMENT

Figure 2 shows a typical HDU-409 List 2 or List 3 installation for the PG-Flex subscriber carrier system. For each doubler installed between the PG-Flex Central Office Terminal (COT) and Remote Terminal (RT), two auxiliary power pairs are required between the COT and RT. A maximum of two doublers may be installed in a PG-Flex system.

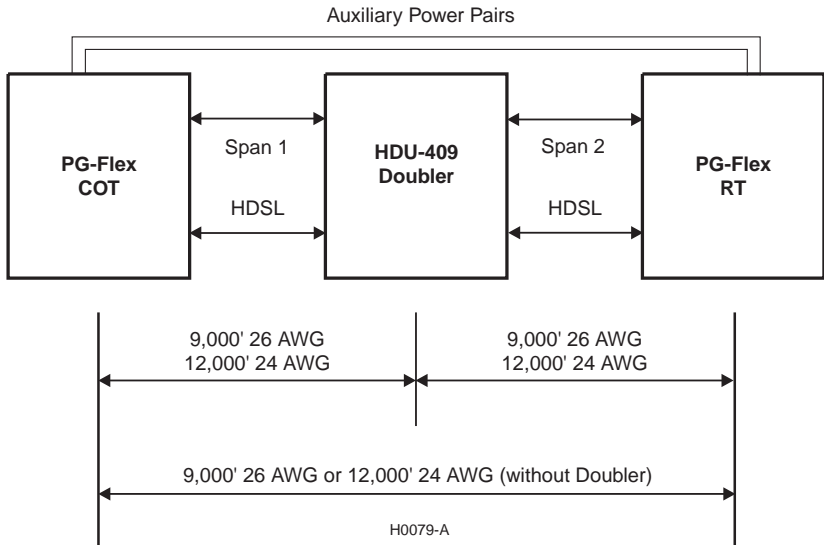


Figure 2. Typical HDU Installation with PG-Flex

With two doublers, four sets of auxiliary power pairs must be installed between COT and the RT. These auxiliary power pairs must be the same wire gauge (or larger) as the pairs used for HDSL and power.

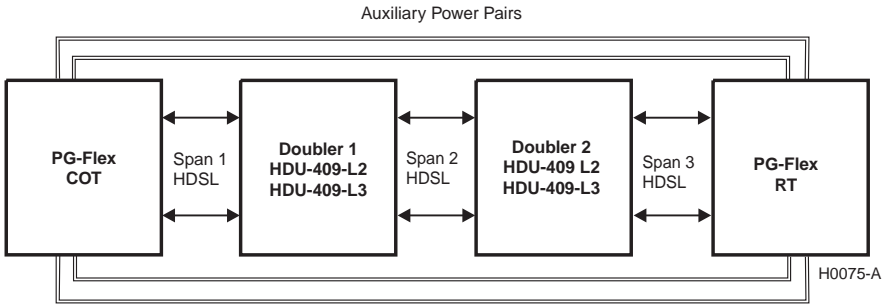


Figure 3. Two Doubler HDU Installation with PG-Flex



PG-Flex systems do not support doubler loopbacks.

The PG-Flex system can operate with a number of other systems, sharing the same cable binder group, such as:

- T1 (1.544 Mbps capability)
- POTS
- DDS
- Other PG-Flex systems

With doublers, PG-Flex CO line units produce $\pm 125V$ to $\pm 130V$ on the HDSL and auxiliary power pairs. At least $\pm 75V$ is required at the RT for ringer voltage and POTS loop current to meet specification.

Refer to the PG-Flex COT shelf, RT enclosure, and line unit practices for additional information on PG-Flex powering and auxiliary power pair requirements (see “Documentation” on page iii).

GENERIC INFORMATION

This section provides generic information for both the HiGain and PG-Flex applications.

DOUBLER ENCLOSURE CAPACITIES WITH FULL SOLAR LOAD

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 and the second at 70 dB and so on. This allows 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, try to make all spans the same electrical length (same 196 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 This rule minimizes power consumption and dissipation from the HLU providing doubler power. It requires the spans closer to the HLU to be as short as possible and the spans farther from the HLU to be as long as possible. This choice minimizes the I^2R loss in the cable pairs and reduces the thermal stress on the HLU.



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

The HDU-409 can be housed in a variety of outdoor enclosures manufactured by ADC and a variety of 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 are listed in Table 4, Table 5, and Table 6 starting on page 11. The capacities listed in Table 5 and Table 6 are based on a maximum outside temperature of +115°F (+46.1°C). Consult ADC for the latest deployment rules when using the enclosures at ambient temperatures above 115 °F or when using enclosures not listed.



These requirements comply with Bellcore standards, which require HDSL equipment placed in outdoor cabinets to operate in an outside ambient temperature 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.

The capacities listed for the indoor enclosures in Table 4 on page 11 assume no solar load. The capacities listed for the outdoor enclosures in Table 5 and Table 6 on page 15 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 sides of the doubler. The top of one unit can be adjacent to the bottom of another, but should be avoided.



Rule 1 does not apply to the HRE-819, the Keptel RF 819, and all enclosures listed in Table 5 on page 12 with Universal Card Cage enclosures. These products have the required slot separations built into their design.

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

Table 4. HDU-409 Indoor Enclosure Capacities

Vendor	Description	Model No.	HDU-409 Doubler Capacity	239 T1 Repeater Capacity
CHARLES	Indoor wall mount	CiAC2300	7	7
		CiAC2002	2	2
SPC	Indoor rack/wall mount	4400-09	18	18

Table 5. Capacities with Full Solar Load, 239 T1 Repeaters

Vendor	Description	Model No.	HDU-409 Doublor Capacity	239 T1 Repeater Capacity	Recommended Slot Assignment for Maximum Capacity
AT&T	Outdoor dual chamber pole/wall mount	819	14	25	1, 3, 5, 7, 8, 10, 12, 14, 15, 17, 19, 21, 23, 25 (See Figure 4)
	Outdoor 841 cabinet	27A, B, C or D shelf	13 per shelf/ 52 total	25 per shelf/ 100 total	All odd slots
	Outdoor cabinet	809	6	12	(a)
ALCATEL (Available from Charles Ind.)	Outdoor canister, pole/wall mount	621204	6	12	(a)
		621205	11	25	All even or odd slots from 1 to 12, plus 14,17, 19, 22 and 25
		621206	19	50	All even or odd slots from 1 to 12, plus 14,17, 19, 22, 25, 28, 31, 34, 35, 38, 41, 44, 48
CHARLES	Outdoor canister, pole/wall mount	CIAC4306	3	6	(a)
		CIAC3300	2	3	1, 3
		CIAC5312	5	12	(a)
		CIAC5325	7	25	1, 3, 5, 7, 9, 11, 13, 15, 17, 22 24
		CIAC5350	9	50	All odd slots from 1-33
		CIAC6321	2	2	All slots
SIERRA SUNRISE	Outdoor canister, pole/wall mount	3011	3	6	(a)
		3021	3	5	1, 3, 5

Table 5. Capacities with Full Solar Load, 239 T1 Repeaters (Continued)

Vendor	Description	Model No.	HDU-409 Doubler Capacity	239 T1 Repeater Capacity	Recommended Slot Assignment for Maximum Capacity	
ABACON	Outdoor dual chamber pole/wall mount	HDSL 16	14	16	All slots but 1 and 16	
SPC	Outdoor canister, pole/wall mount	7130-08FP	4	8	1, 3, 6, 8 or 2, 4, 5, 7	
		7130-12FP	6	12	(a)	
		7130-25FP	10	25	All odd slots from 1-19	
	Outdoor canister, pole/wall mount with universal card cage	7130-0656P-TA 7130-0656P-TB2	6	6	All slots	
		7130-V856P-TQA 7130-V856P-TQB 7130-08P-UNIV-HORZ-TQB2	8	8		
		7030-12P-UNIV-VERT-TQA 7030-12P-UNIV-HORZ-TQA 7030-12P-UNIV-VERT-TQB2 7030-12P-UNIV-HORZ-TQB2	12	12		
		7130-1656-QA	12	16		Slots 1-12

Table 5. Capacities with Full Solar Load, 239 T1 Repeaters (Continued)

Vendor	Description	Model No.	HDU-409 Doubler Capacity	239 T1 Repeater Capacity	Recommended Slot Assignment for Maximum Capacity
SPC	Dual dome outdoor canister wall mount with universal card cage	7030-24P-UNIV- HORZ-TQA	24	24	All slots
		7030-24P-UNIV- HORZ-TQB2			
		7030-32P-UNIV- HORZ-TQA	24	32	
ADC	Outdoor canister, pole/wall mount with universal card cage	HRE-458	10	10	All slots
		HRE-504	4	4	
		HRE-506	6	6	
		HRE-500	1	1	
		HRE-602	2	2	
	Outdoor dual chamber, pole/wall mount	HRE-819	12	12	
	Dual dome outdoor canister wall mount with universal card cage	HRE-524	24	24	

Table 5. Capacities with Full Solar Load, 239 T1 Repeaters (Continued)

Vendor	Description	Model No.	HDU-409 Doubler Capacity	239 T1 Repeater Capacity	Recommended Slot Assignment for Maximum Capacity
KEPTEL	Outdoor single chamber	RF 809	6	12	(a)
	Outdoor dual chamber	RF 819	12	12	All slots
	Outdoor single chamber	RF 820	8	8	

(a) All even or all odd-numbered slots.

Table 6. Capacities with Full Solar Load, LD-1 Repeaters

Vendor	Description	Model No.	HDU-409 Doubler Capacity	LD-1 Repeater Capacity	Recommended Slot Assignment for maximum Capacity
NORTEL	LD1 Outdoor canister, pole/wall mount	QCD14 (A & B)	4	6	2 per row, non-adjacent, staggered (non-overlapping)
		QCD15 (A & B) QCD10 A	6	12	
		QCD7 A QCD16 (A & B) QCD8 (A & B)	10	25	
		QCD9 (A & B) QCD17 (A & B)	20	50	



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

ALTERNATIVE DOUBLER ENCLOSURE CAPACITIES

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 or LD1 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 or LD1 repeaters (or fractions thereof) installed.



Rule one on page 11, in the section titled, “Doubler Enclosure Capacities with Full Solar Load” on page 9, does not apply if the adjacent slot is occupied by a T1 or LD1 repeater; however, slots adjacent to doublers should be left vacant if possible.

The AT&T 819 enclosure has two, individual isolated chambers as shown in Figure 4. 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.

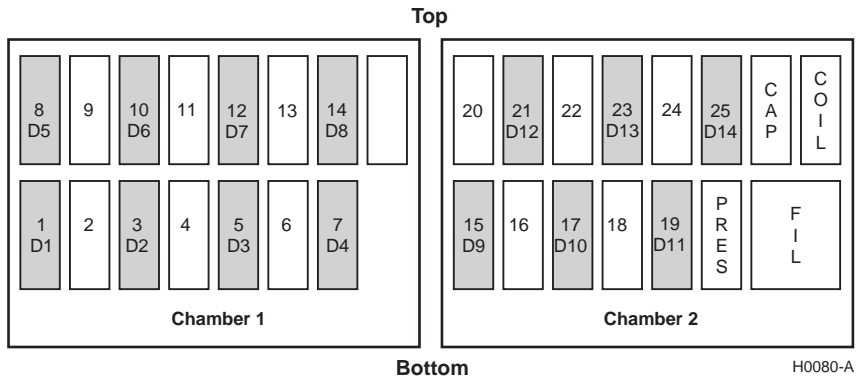


Figure 4. AT&T 819 Enclosure, Slot Locations 1 through 14

The AT&T 819 can house up to 14 HDU-409 doublers in the slots designated as D1 through D14 as shown in Figure 4.



Because the length of the HDU-409 extends beyond the depth that older AT&T 819 T1 repeater apparatus covers can accommodate, the cover must be replaced by a deeper cover.

MIXING HIGAIN DOUBLERS

The HiGain HDU-439 mini doubler can also be installed along with the HDU-409 micro doubler in the same enclosure. Assign a thermal weight of 1.5 HDU-409 for every HDU-439 and round down to the nearest whole number. This results in one of the following thermal relationships:

$$\mathbf{a)} \ 1.5 \text{ (HDU-409)} = 1 \text{ (HDU-439)}$$

$$\mathbf{b)} \ 1 \text{ (HDU-409)} = 2/3 \text{ (HDU-439)}$$

For example, if an AT&T 819 case has only 10 HDU-409 doublers leaving room for four more HDU-409 doublers, the number of HDU-439 doublers that can be allotted to these 4 slots is determined by using **(b)** as follows:

$$4 \text{ (HDU-409)} = (4) (2/3) \text{ (HDU-439)}$$

$$4 \text{ (HDU-409)} = 2.66 \text{ (HDU-439)} = 2 \text{ (HDU-439)}$$

Similarly the number of HDU-439 doublers that can be allotted to 6 empty HDU-409 slots is:

$$6 \text{ (HDU-409)} = (6) (2/3) \text{ (HDU-439)} = 3 \text{ (HDU-439)}$$



When assigning slot locations, make sure there is an empty slot between any two adjacent doublers (HDU-409 and HDU-439).

MICRO DOUBLER CAPACITY DEPLOYMENT RULES

The deployment rules for micro doubler capacity are summarized below:

- 1 Use Table 4 on page 11 for indoor enclosures.
- 2 Use Table 5 and Table 6 on page 15 for outdoor enclosures with full solar load for ambient temperatures up to 115°F maximum.
- 3 The capacities shown in Table 5 can be increased to all odd or even slots (where applicable) for non-solar load (shaded or manhole applications). The non-adjacency constraint still applies for these increased capacity applications. The capacity of the ABACON HDSL 16 enclosure can be increased to 16 for non-solar load applications.

- 4** For non-solar applications in an environment up to 95°F maximum, the capacity for an SPC, 32-slot 7030-32P enclosure can be increased to all 32 slots.
- 5** Decrease capacities in Table 5 and Table 6 on page 15 by five percent (round up to the nearest whole number) for every 5°F (2.8°C) increase, or fraction thereof, in ambient temperatures above 115°F (46°C). Always assign the empty slots to the highest (uppermost) positions.
- 6** Increase the capacities by five percent (round down to the nearest whole number) for every full +5°F (2.8°C) reduction in ambient temperature, below 115°F (46°C). The non-adjacency constraint still applies for these increased capacity applications.
- 7** Decrease any outdoor capacity by one for every four T1 or LD1 repeaters, or fraction thereof, that are installed with the doublers.
- 8** For all outdoor applications, decrease the capacity by one for every two adjacent doublers that are not separated by at least one empty slot.

INSTALLATION

To install the HDU-409 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 (see “Documentation” on page iii).



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

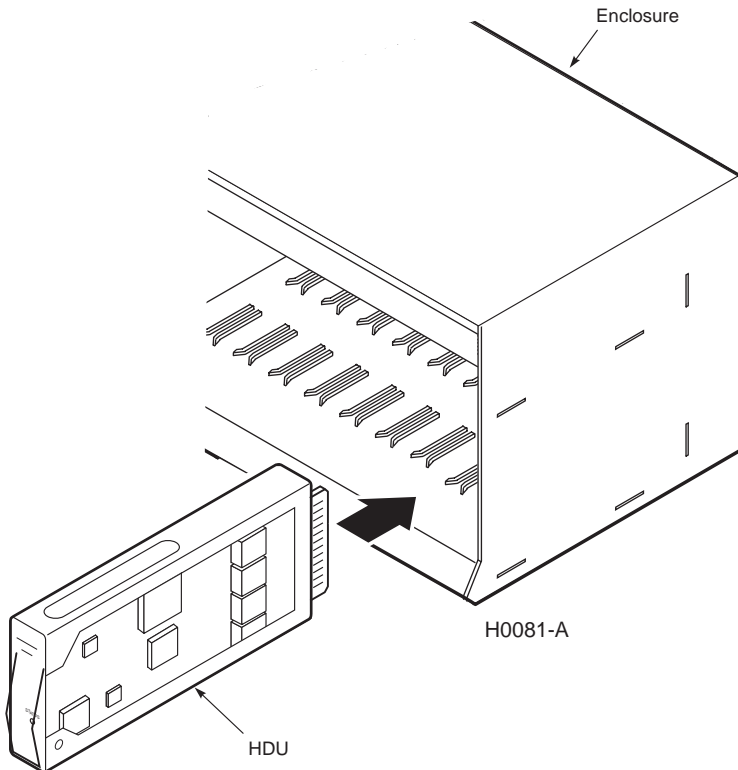


Figure 5. *Installing the HDU-409 in an Enclosure*

- 1** To install the doubler unit, slide the doubler unit into the card guides for the desired slot (see Figure 5 on page 20).
- 2** Next, push the unit into the enclosure until it is seated in the card-edge connector. The unit snaps into place, indicating that it is properly seated.

Once the HDU-409 is installed in the enclosure, the front panel Status LED flashes green to indicate power is applied from an upstream line unit. When the loops on both sides of the HDU synchronize, the LED is steady green. Refer to Table 2 on page 5 for more details on LED operations.

LOOPBACK OPERATION IN HIGAIN SYSTEMS



Doubler loopbacks work only with HiGain systems. PG-Flex does not support doubler loopbacks.

When equipped with the HDU-409 a HiGain system can execute the types of loopbacks listed in Table 7.

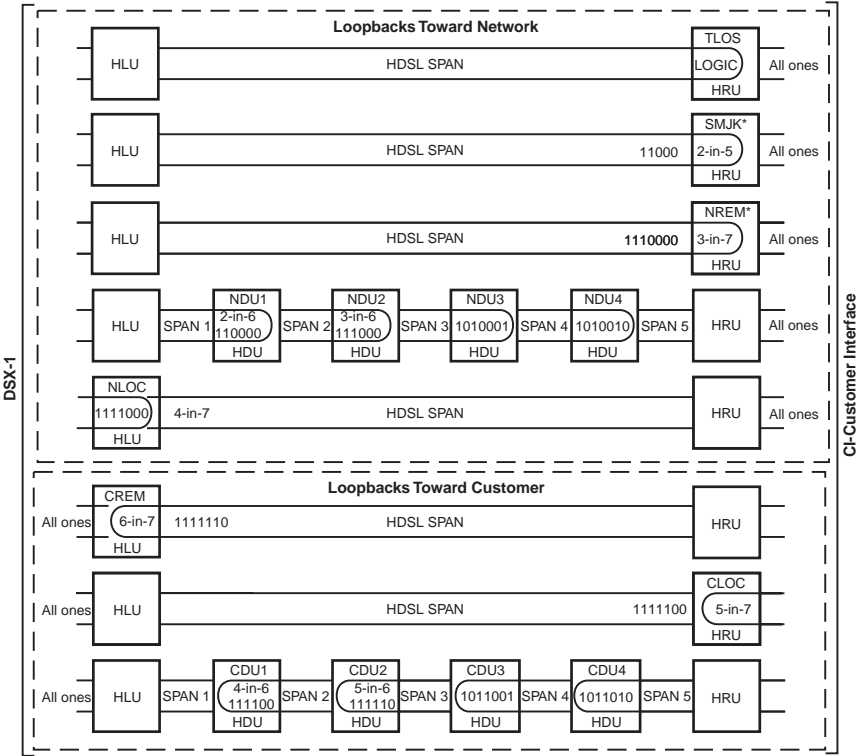
The loopbacks can be initiated from any of the following:

- The HLU craft port
- The HLU front-panel buttons
- A family of Special Loopback (SPLB) in-band commands initiated at the T1 input port at either the HLU or HRU
- The HRU craft port, if remote provisioning is enabled from the HLU

The SPLB generic command set for four-doubler loopbacks is listed in Table 7. The commands are specific combinations of either 6 or 7 bits that continuously repeat. All NDUx loopbacks are towards the network. All CDUx loopbacks are towards the customer. Figure 6 on page 24 is a diagram of the various HiGain loopbacks.

Table 7. *SPLB Generic Command Set*

Command Set	Loopback
NDU1	1 1 0 0 0 0 (2-in-6)
NDU2	1 1 1 0 0 0 (3-in-6)
NDU3	1 0 1 0 0 0 1
NDU4	1 0 1 0 0 1 0
CDU1	1 1 1 1 0 0 (4-in-6)
CDU2	1 1 1 1 1 0 (5-in-6)
CDU3	1 0 1 1 0 0 1
CDU4	1 0 1 1 0 1 0



* Set the SAIS option to ENA to send AIS (indicated by an all ones pattern) to the CI during SmartJack loopback, NREM, and TLOS. Use the 3-in-5 code to loop down.

H0082-A

Figure 6. HiGain Loopbacks

For more information about other doubler loopback commands, see the appropriate HLU user documentation.

APPENDIX A - FUNCTIONAL DESCRIPTION

HiGain uses the ADC Two-Binary, One-Quaternary (2B1Q) HDSL transceiver system to establish two full-duplex 784 kbps data channels between the HLU, HDU, and HRU units. Each HDU-409 increases the maximum range by approximately 12,000 feet (3.7 km) using 24 AWG or 9,000 feet (2.75 km) using 26 AWG per doubler. See Table 2 on page 3 for deployment rules.

A block diagram of the HDU-409 with pinouts is shown in Figure 7 on page 25. The doubler unit power supply uses the HDSL simplified line voltage to produce +5 Vdc and +3 Vdc required by the HDU-409 electronics. The power feed is passed on to the HDSL output pair to power a second doubler or a remote unit.

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

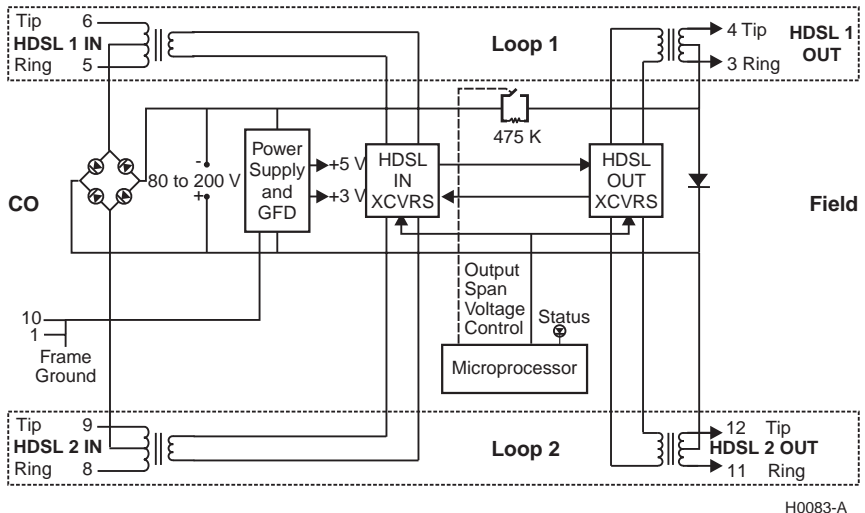


Figure 7. Doubler Block Diagram

Table 8 on page 26 provides a guide for the loss that occurs when using various cable gauges at 196 kHz and 135 Ω . It applies to the HDSL cable pairs between the COT and the HDU, and between the HDU and the RT.

To achieve optimum performance, make the electrical length (196 kHz loss) of all HDU spans as close to equal as possible. This results in the highest operating loop margins. If it is not possible to make all spans equal, choose span lengths that reduce the total power consumption of the CPT that powers the HDU. Do this by minimizing the length of Span 1 and Span 2. Use Table 8 on page 26 when you calculate the electrical length of each span.

The HDU-409 has a range of up to 35 dB loss at 196 kHz on each of the four HDSL loops. A list of HDSL signal cable losses for various cable gauges at 196 kHz and 135 Ω is provided in Table 8. The table is applicable to HDSL cable pairs running between the HLU and the HDU-409 and between the HDU-409 and another HDU or HRU.

Table 8. HDSL Signal Cable Loss

Cable Gauge	Ω per kFt (0.3048 km)	Loss @ 196 kHz (dB per kFt) ^(a)
26 AWG/0.4 mm	83.3	3.880
24 AWG/0.51 mm	51.9	2.841
22 AWG/0.61 mm	32.4	2.177
19 AWG/0.91 mm	16.1	1.535

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

APPENDIX B - SPECIFICATIONS

Appendix A lists the specifications for the HDU-409.

HDSL

Line Code	784 kbps, 2B1Q full duplex
Output	+13 dBm
Line Impedance	135 Ω
Resistive Signature Input/Output	5 Ω (typical)
Start-up Time (per span)	15 seconds (typical), 30 seconds (maximum)

Line Clock Rate Internal Stratum 4 clock

Power Dissipation 3.0W (nominal)

Maximum Provisioning Loss 35 dB @ 196 kHz, 135 Ω

Wander and Jitter Nominal - The absence of an HDSL framer from the HDU-409 reduces the Doubler Unit 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 μ s (maximum either direction)

Mounting Single 239 T1 Mechanics slot

Electrical Protection Secondary surge and power cross protection on all HDSL ports

Environmental

Operating Temperature	-40°F (-40°C) to +149°F (+65°C)
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	200 feet (61m) below sea level to 13,000 feet (4 km) above sea level

Dimensions

	HDU-409 (Single 239 T1 Mechanics)
Height	2.6 inch (6.6 cm)
Width	0.75 inch (1.9 cm)
Depth	6.5 inch (16.5 cm)
Weight	0.8 lbs (0.36 kg)

The HDU-409 Lists 1, 2, and 3 are compatible with the following ADC outdoor enclosures:

- HRE-500, single-slot unit
- HRE-458, 10-slot unit
- HRE-819, 12-slot unit
- HRE-504, four-slot unit
- HRE-506, six-slot unit
- HRE-602, two-slot unit
- HRE-524, 24-slot unit

APPENDIX C - GROUND FAULTS

GROUND FAULT DETECTION

The HDU-409 has Ground Fault Detection (GFD) circuits as described in R7-1, Section 7.2.1 of GR-1089 CORE, Issue 1, Revision 1, December, 1996.

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 HDU-409 and older doublers without a GFD circuit also support this new ground fault detecting feature, provided the doubler nearest the HLU is an HDU-409.



To operate properly, the ground fault circuit requires that the doubler enclosure ground plane be securely connected to earth ground. Failure to do so can cause false triggering of the GFD circuit.

HIGAIN FAULT ISOLATION

Solutions for common problems that may occur with the HDU-409 are listed in Table 9.

Table 9. Fault Isolation Guide

Problem	Solution
LED does not light	<ol style="list-style-type: none"> 1 Verify that the HLU is installed and operational in the CO. 2 Verify proper cabling between the doubler enclosure and the CO. 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 HLU cycles between self test and line power. If less than 100 Vdc is present, check the cabling or the HLU. Only the line units mentioned in the "Applications" section can be used to power doublers (see Table 3 on page 6). Other HLU 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.
HDU-409 loses power	The HLU at the CO is not present. Measure the resistance of the HDSL input loop. Resistance should be normal loop resistance plus the 25 Ω signature of the HLU.
HDSL line power only appears in very short bursts	A grounded pair is being detected by either the HLU or HDU-409 in Span 1. This causes the unit's GFD circuit to trigger which forces the HDSL line voltage off immediately after it cycles on. Remove the HLU and HDU-409 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 HDU-409 is not properly grounded.
HDU-409 shuts off after Span 1 comes up	A grounded pair is being detected by the HDU-409 in Span 2. Remove HDU-409 and check for ground fault in Span 2.

PG-FLEX FAULT ISOLATION

Solutions for common problems that may occur with the HDU-409 in PG-Flex applications are listed in Table 10.

Table 10. *Fault Isolation Guide for PG-Flex*

Problem	Solution
LED does not light	<ol style="list-style-type: none"> 1 Verify that the PG-Flex COLU is installed and operational in the CO. 2 Verify proper cabling between the doubler enclosure and the CO. 3 Measure 150 Vdc between pins 5 or 6 and/or 9 of the HDU. This voltage peaks every two minutes during the HDSL startup cycle. If less than 100 Vdc is present, check the cabling between the doubler enclosure and PG-Flex COT shelf. Refer to the COLU practice and verify the COLU is operating properly.
LED continues to flash green once a second	Synchronization is being attempted with the upstream unit.
HDU-409 loses power	<ol style="list-style-type: none"> 1 The COLU at the CO is not present or is not operating properly. 2 Check the cabling between the doubler housing and the PG-Flex COT shelf. Measure the resistance of the HDSL input loop. Resistance should be normal loop resistance plus the 25Ω signature of the COLU.
HDSL line power only appears in very short bursts	<p>With PG-Flex the GFD is in the COT line unit. Tip or ring ground faults between the COT and the doubler causes the power to turn on for a few seconds every two minutes. With the HDU-409 doubler, a ground fault after the doubler on Loop 2 has the same affect. On Loop 1, however, the DC power does not shut off because of a ground fault. When there is a ground fault on Loop 1, the doubler limits its output voltage to approximately -40V. Pair 2 maintains the normal 130V. This is enough voltage to power the doubler, but not the RT. Typically the HDSL Loop 1, after the doubler, will drop the resync periodically. Note that if the pairs are reversed, the polarity of the voltages are reversed.</p> <p>Remove the line units and doublers and check for cable faults.</p>
HDU-409 shuts off after Span 1 comes up	A grounded pair is being detected by the HDU-409 in Span 2. Remove HDU-409 and check for ground fault in Span 2.

APPENDIX D - PRODUCT SUPPORT

ADC Customer Service Group provides expert pre-sales and post-sales support and training for all its products.

Technical support is available 24 hours a day, 7 days a week by contacting the ADC Technical Assistance Center.

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- ADC Return Material Authorization (RMA) number and instructions must be obtained before returning products.

All telephone numbers with an 800 prefix are toll-free in the USA and Canada.

APPENDIX E - GLOSSARY

2B1Q	Two-Binary, One-Quaternary. Line coding used for HDSL.
AIS	Alarm Indicator Signal
AWG	American Wire Gauge. The standard used to describe wire size. The diameter of the wire increases as the gauge decreases. 26 gauge is 0.188 inches (4 mm) in diameter, 24 gauge is 0.241 inches (51 mm), and so on.
BBS	Bulletin Board System
Bridged Tap	A pair of wires connected in parallel across a single line to form a "T" configuration.
Cable Binder Group	A group of 25 pairs of wires.
CAP	Capacitor
CDU	HDU to Customer loopback
CO	Central Office
COLU	Central Office Line Unit
COT	Central Office Terminal
CRC	Cyclic Redundancy Check
CSA	Carrier Serving Area/Customer Service Area
DDS	Digital Data Service
FIL	Filter
GFD	Ground Fault Detection
HCDS	High Capacity Digital Service
HDSL	High-bit-rate Digital Subscriber Line
HDU	HiGain Doubler Unit
HLU	HiGain Line Unit

HRE	HiGain Remote Enclosure
HRU	HiGain Remote Unit
KBPS	Kilo (thousand) Bits Per Second
Loop	A length of twisted-pair copper wire connecting the local unit of an HDSL circuit to the remote unit.
MBPS	Mega (million) Bits Per Second
NDU	HDU to Network Loopback
NEBS	Network Equipment Building System
POTS	Plain Old Telephone Service
PRES	Pressure
RMA	Return Material Authorization
RT	Remote Terminal
SAIS	SmartJack AIS
SPLB	Special Loopback

CERTIFICATION AND WARRANTY

FCC CLASS A COMPLIANCE

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. 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, may 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.

LIMITED WARRANTY

Product warranty is determined by your service agreement. Contact your sales representative or Customer Service for details.

MODIFICATIONS

Any changes or modifications made to this device that are not expressly approved by ADC DSL Systems, Inc. voids the user's warranty.

All wiring external to the products should follow the provisions of the current edition of the National Electrical Code.

SAFETY STANDARDS COMPLIANCE

This equipment has been tested and verified to comply with the applicable sections of the following safety standards:

- GR 63-CORE - Network Equipment-Building System (NEBS) Requirements
- GR 1089-CORE - Electromagnetic Compatibility and Electrical Safety

For technical assistance, refer to "Appendix D - Product Support" on page 32.

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