



# *CDM-IP*

## *Quick-Start Guide*

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For IP Enabled Satellite Modems

Part Number CD/CDMIPQSG.IOM

Rev. 0

May 15, 2003





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Registered Company.



## CUSTOMER SUPPORT

Contact Comtech EF Data Customer Support for:

- ▶ Product support or training
- ▶ Information on upgrading or returning a product

A Customer Support representative may be reached at:

Comtech EF Data  
Attention: Customer Support Department  
2114 West 7th Street  
Tempe, Arizona 85281 USA

(480) 333-2200 (Main Comtech EF Data Number)

(480) 333-4357 (Customer Support Desk)

(480) 333-2161 FAX

or, E-Mail can be sent to the Customer Support Department at:

[cdmipsupport@comtechefdata.com](mailto:cdmipsupport@comtechefdata.com)

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2. Request a Return Material Authorization (RMA) number from the Comtech EF Data Customer Support Department.
3. Be prepared to supply the Customer Support representative with the model number, serial number, and a description of the problem.
4. To ensure that the product is not damaged during shipping, pack the product in its original shipping carton/packaging.
5. Ship the product back to Comtech EF Data. (Shipping charges should be prepaid.)

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## ABOUT THIS MANUAL

This manual provides installation and operation information for the Comtech EF Data CDM-IP Enabled Modems. This is a technical document intended for earth station engineers, technicians, and operators responsible for the operation and maintenance of the CDM-IP Enabled Modems.

## CONVENTIONS AND REFERENCES

### CAUTIONS AND WARNINGS



Indicates information critical for proper equipment function.



Indicates a hazardous situation that, if not avoided, may result in minor or moderate injury. CAUTION may also be used to indicate other unsafe practices or risks of property damage.



Indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.

## METRIC CONVERSION

Metric conversion information is located on the inside back cover of this manual. This information is provided to assist the operator in cross-referencing English to Metric conversions.

## RECOMMENDED STANDARD DESIGNATIONS

Recommended Standard (RS) Designations have been superseded by the new designation of the Electronic Industries Association (EIA). References to the old designations are shown only when depicting actual text displayed on the screen of the unit (RS-232, RS-485, etc.). All other references in the manual will be shown with the EIA designations (EIA-232, EIA-485, etc.) only.

## TRADEMARKS

All product names mentioned in this manual may be trademarks or registered trademarks of their respective companies and are hereby acknowledged.

## REPORTING COMMENTS OR SUGGESTIONS CONCERNING THIS MANUAL

Comments and suggestions regarding the content and design of this manual will be appreciated. To submit comments, please contact the Comtech EF Data Customer Support Department.

## EMC COMPLIANCE

This is a Class A product. In a domestic environment, it may cause radio interference that requires the user to take adequate protection measures.

## EN55022 COMPLIANCE

This equipment meets the radio disturbance characteristic specifications for information technology equipment as defined in EN55022.

## EN50082-1 COMPLIANCE

This equipment meets the electromagnetic compatibility/generic immunity standard as defined in EN50082-1.

## FEDERAL COMMUNICATIONS COMMISSION (FCC)

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. If not installed and used in accordance with the instruction manual, it may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference; in which case, users are required to correct the interference at their own expense.

**Note:** To ensure compliance, properly shielded cables for DATA I/O shall be used. More specifically, these cables shall be shielded from end to end, ensuring a continuous shield.

## SAFETY COMPLIANCE

### EN 60950

Applicable testing is routinely performed as a condition of manufacturing on all units to ensure compliance with safety requirements of EN60950.

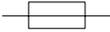
This equipment meets the Safety of Information Technology Equipment specification as defined in EN60950.

### LOW VOLTAGE DIRECTIVE (LVD)

The following information is applicable for the European Low Voltage Directive (EN60950):

<HAR>	Type of power cord required for use in the European Community.
	CAUTION: Double-pole/Neutral Fusing. ACHTUNG: Zweipolige bzw. Neutralleiter-Sicherung.

International Symbols:

Symbol	Definition
	Alternating Current.
	Fuse.

Symbol	Definition
	Protective Earth.
	Chassis Ground.

**Note:** For additional symbols, refer to “Cautions” listed earlier in this preface.

## WARRANTY POLICY

This Comtech EF Data product is warranted against defects in material and workmanship for a period of two years from the date of shipment. During the warranty period, Comtech EF Data will, at its option, repair or replace products that prove to be defective.

For equipment under warranty, the customer is responsible for freight to Comtech EF Data and all related custom, taxes, tariffs, insurance, etc. Comtech EF Data is responsible for the freight charges **only** for return of the equipment from the factory to the customer. Comtech EF Data will return the equipment by the same method (i.e., Air, Express, Surface) as the equipment was sent to Comtech EF Data.

## LIMITATIONS OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper installation or maintenance, abuse, unauthorized modification, or operation outside of environmental specifications for the product, or, for damages that occur due to improper repackaging of equipment for return to Comtech EF Data.

*No other warranty is expressed or implied. Comtech EF Data specifically disclaims the implied warranties of merchantability and fitness for particular purpose.*

## EXCLUSIVE REMEDIES

The remedies provided herein are the buyer's sole and exclusive remedies. Comtech EF Data shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or any other legal theory.

## DISCLAIMER

Comtech EF Data has reviewed this manual thoroughly in order that it will be an easy-to-use guide to your equipment. All statements, technical information, and recommendations in this manual and in any guides or related documents are believed reliable, but the accuracy and completeness thereof are not guaranteed or warranted, and they are not intended to be, nor should they be understood to be, representations or warranties concerning the products described. Further, Comtech EF Data reserves the right to make changes in the specifications of the products described in this manual at any time without notice and without obligation to notify any person of such changes.

If you have any questions regarding the equipment or the information in this manual, please contact the Comtech EF Data Customer Support Department

# Chapter 1. Getting Started

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## 1.1 INTRODUCTION

This quick start guide will allow a user to configure a pair of CDM-IP 550 or CDM-IP 300L (referred to as CDM-IP in rest of the document) from beginning (i.e. starting from factory default settings) and be able to pass traffic within minutes. It is assumed that the user is familiar with the configuration of the base satellite modem.

### 1.1.1 EQUIPMENT LIST

Following equipment is required:

Item	Equipment	Quantity	Comments
1	CDM-IP Modem	2	Can be CDM-IP 550 or CDM-IP 300L <b>Note:</b> CDM-IP 550 can be used with a CDM-IP 300L, but customer will need to provide equipment to convert 70 MHz IF to L-band for a duplex connection.
2	10/100 BaseT Ethernet Hub	2	Provided by customer <b>Note:</b> Only 10BaseT operation is supported in EasyConnect™ mode. RJ-45 crossover Ethernet cables can be substituted to directly connect PC to CDM-IP modem without the use of a hub.
3	PC with NIC and a terminal emulation program	2	Provided by customer
4	Console cable (DB-9 to RJ-11)	1	Supplied by Comtech EF Data
5	Ethernet cables (CAT 5)	4	Provided by customer
6	IF cables	2	Provided by customer (To interconnect TX-RX between both CDM-IP modems.)

## 1.1.2 EQUIPMENT SETUP

Step	Description
------	-------------

- |   |   |
|---|---|
| 1 | Connect each CDM-IP to the PC via the Ethernet Hub.   |
| 2 | Connect the TX IF on CDM-IP 1 to RX IF of CDM-IP 2 and vice-versa.  |
| 3 | Connect the DB-9 end of the console cable to the COM1 or COM2 port of the PC and the RJ-11 end to the console port at the back of CDM-IP 1. |
| 4 | Connect CDM-IP 1 and CDM-IP 2 to suitable power supply and turn them ON.  |

## 1.1.3 TRANSMIT AND RECEIVE IF CONFIGURATION

Step	Description
------	-------------

- |   |  |
|---|--|
| 1 | Configure the transmit and receive IF parameters on CDM-IP 1 and CDM-IP 2 via the front panel.<br><br><b>Note:</b> The IF parameters can also be set via console menu, Telnet, web interface and SNMP - but for this exercise, it is recommended that the front panel be used. |
| 2 | Set the <b>TxPower</b> to minimum level.   |
| 3 | Before proceeding to next step, make sure that each CDM-IP is appropriately carrier-locked to the other CDM-IP.  |

## 1.1.4 SERIAL CONSOLE PORT COMMAND LINE INTERFACE (CLI) CONFIGURATION

Step	Description
------	-------------

- |   |  |
|---|--|
| 1 | Launch the terminal emulation program - such as HyperTerminal on Microsoft Windows.  |
| 2 | Select the appropriate COM port (to which the DB-9 end of the console cable is connected) and configure it for: <ul style="list-style-type: none"><li>▶ 38,400 bps</li><li>▶ 8 data bits</li><li>▶ no parity</li><li>▶ 1 stop bit</li><li>▶ no hardware flow control</li></ul> |
| 3 | Press return and to bring up the Main menu.  |

## 1.1.5 MAIN MENU

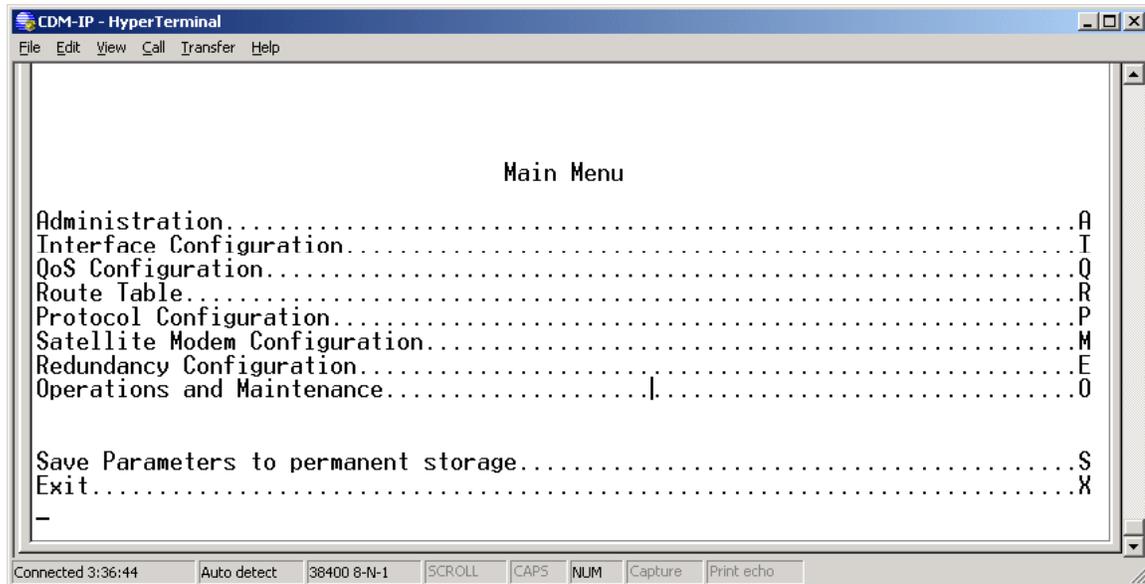


Figure 1. Main Menu

To use the Command Line Interface (CLI), select the appropriate sub-menu or the entry by pressing the character indicated at the right. Enter **x** to return to the previous menu.

**Note:** Any CDM-IP configuration changes need to be saved to permanent storage by selecting [**S**] from any menu screen and then typing [**y**] to save.

## 1.1.6 RESTORING FACTORY DEFAULT CONFIGURATION

The following sections in this guide assume that the CDM-IP is still in factory default configuration for IP. If that's not the case, the factory default configuration can be restored from the menu:

### Step Description

- 1 From the **Main Menu**, select **Operations and Maintenance** sub-menu [**O**].
- 2 From the **Operations and Maintenance** menu, select **Database Operations** sub-menu [**D**].
- 3 From the **Database Operations** menu, select **Restore Factory Default** option [**R**].
- 4 Confirm when prompted by typing '**yes**' when the following prompt is displayed;

```
Are you sure you want to restore factory default settings?  
WARNING: Chosing Yes will restore factory defaults and then  
reboot..
```

This will erase any user configuration and restore the CDM-IP to factory default configuration. Proceed to Section 1.2 to perform the EasyConnect™ Mode configuration or to Section 1.3 to perform the Router Mode configuration.

## 1.2 EASYCONNECT™ POINT-TO-POINT SYSTEM CONFIGURATION

The steps in this guide will lead to following configuration:

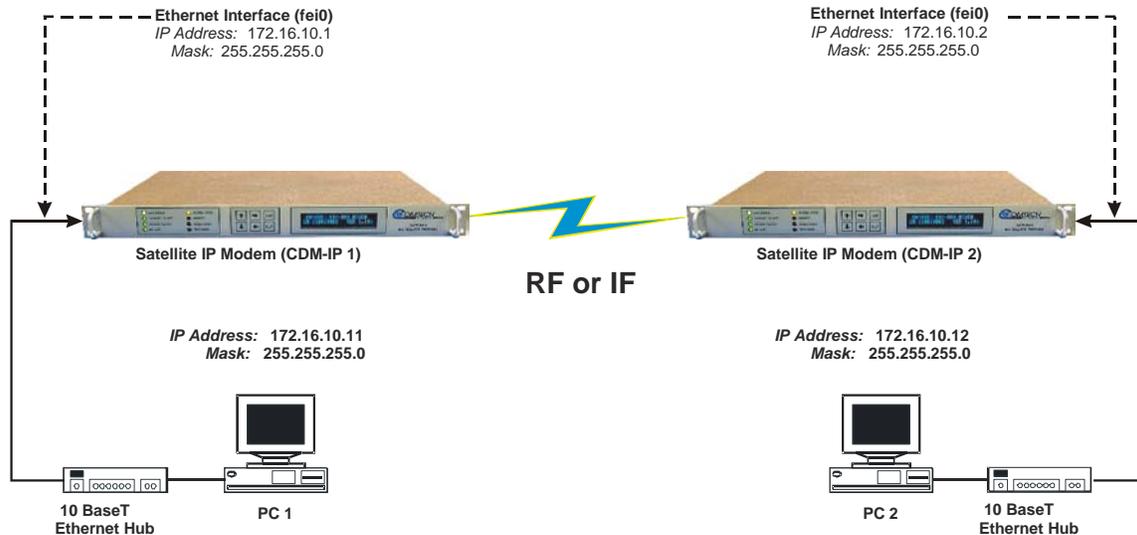


Figure 2. EasyConnect™ Point-to-Point System Configuration

### 1.2.1 PC CONFIGURATION

Step	Description
1	Set the IP address on PC 1 to <b>172.16.10.11</b> , mask to <b>255.255.255.0</b> .
2	Set the IP address on PC 2 to <b>172.16.10.12</b> , mask to <b>255.255.255.0</b> .
3	Reboot the PCs (if required).



### 1.2.2 CDM-IP CONFIGURATION

After restoring the factory default settings, the CDM-IP will be in EasyConnect™ Mode, which will automatically put the CDM-IP in 10BaseT Half Duplex. Select **Interface Configuration\Ethernet Interface(feio)** to verify the Speed Mode is 10 baseT Half Duplex. If desired 10BaseT Full Duplex can be selected, but the CDM-IP will not allow Auto Speed Mode or 100 BaseT when in EasyConnect™.

The CDM-IP will also be in Point-to Point HDLC Addressing Mode. HDLC addresses are used to identify remote satellite interfaces when there are more than two CDM-IP modems sending and receiving traffic. In Point-to-Point Mode, there is no need to define any HDLC addresses since all of the traffic will be to and from a single remote CDM-IP.

### 1.2.3 SETTING IP ADDRESS(ES)

- | Step | Description  |
|------|--|
| 1    | From the <b>Main Menu</b> select <b>Interface Configuration</b> sub-menu [I].                      |
| 2    | From the <b>Interface Configuration Menu</b> select <b>Ethernet Interface (fei0)</b> sub-menu [E]. |
| 3    | Set <b>IP Address</b> [I].<br><b>CDM-IP 1 to 172.16.10.1</b><br><b>CDM-IP 2 to 172.16.10.2</b>     |
| 4    | Set <b>Subnet Prefix Length</b> [M] to <b>24</b>   |

The other parameters can be left to their factory default settings.

At this point the basic configuration is over and you should be able to:

- From **PC1**
  - Ping 172.16.10.1 (**CDM-IP 1**)
  - Ping 172.16.10.2 (**CDM-IP 2**)
  - Ping 172.16.10.12 (**PC 2**)
- From **PC2**
  - Ping 172.16.10.2 (**CDM-IP 2**)
  - Ping 172.16.10.1 (**CDM-IP 1**)
  - Ping 172.16.10.11 (**PC 1**)



Do not enable IF Loopback (or link the TX to RX by a BNC cable or satellite link) on a CDM-IP modem operating in EasyConnect™ when connected to a LAN. In this configuration, EasyConnect™ will resend all layer 2 broadcast packets and cause a “broadcast storm” on the LAN. To perform a loop test to verify the modem or satellite link, do one of the following:

**(CDM-IP 550 Only)** Reconfigure the CDM-IP 550 to CDM 550 Emulation Mode by selecting Configuration/Interface and then selecting EIA-422/530, V.35, or EIA-232.

Set the CDM-IP modem to Router Mode.

## 1.3 ROUTER MODE POINT-TO-POINT SYSTEM CONFIGURATION

The steps in this guide will lead to following configuration:

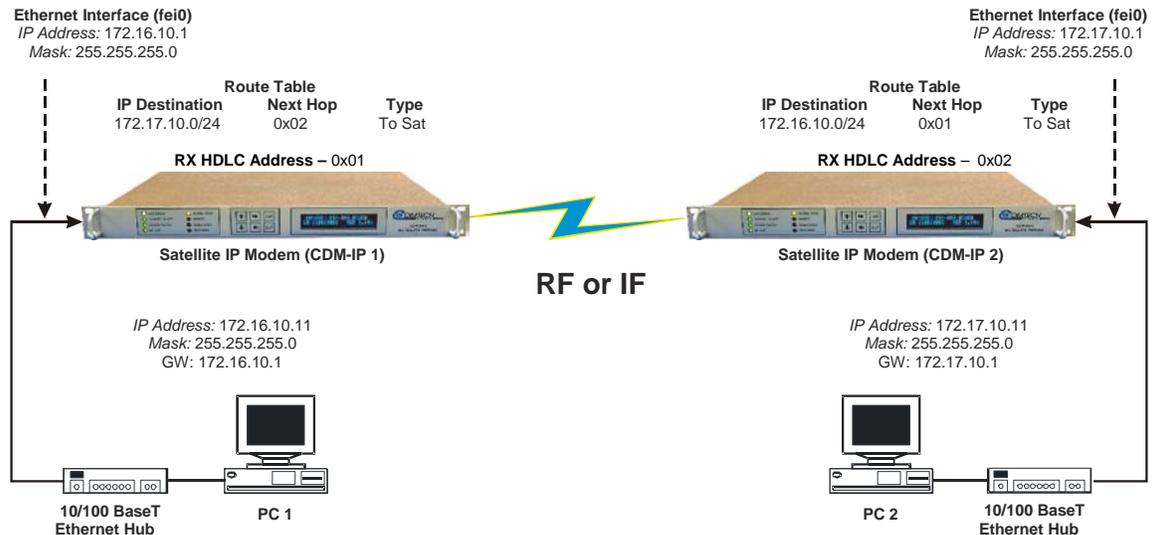


Figure 3. Router Mode Point-to-Point System Configuration

### 1.3.1 PC CONFIGURATION

Step	Description
1	Set the IP address on <b>PC 1</b> to <b>172.16.10.11</b> , mask to <b>255.255.255.0</b> . Set PC Gateway to <b>172.16.10.1</b>
2	Set the IP address on <b>PC 2</b> to <b>172.17.10.11</b> , mask to <b>255.255.255.0</b> . Set PC Gateway to <b>172.17.10.1</b>
	Reboot the PCs (if required).



### 1.3.2 SETTING CDM-IP MODEMS TO ROUTER MODE OPERATION

Perform the following steps on **CDM-IP 1**

Step	Description
1	From the <b>Main Menu</b> , select <b>Administration [A]</b> sub-menu.
2	From the <b>Administration</b> menu, select <b>CDM-IP Working Mode [C]</b> .
3	Confirm when prompted by typing 'y' when the following prompt is displayed; <b>Changing Modem working mode requires system Reboot.</b> <b>Do you want to continue(Y/N)[Enter :No]</b>
	Select <b>[1]</b> for <b>Router Mode</b> .
4	Allow CDM-IP to reboot. After reboot, select <b>Interface Configuration [I]</b> from the <b>Main Menu</b> .

- 5 From the **Interface Configuration** menu, select **Satellite/HDLC Interface (hdl0)** [H].
- 6 From the **Satellite/HDLC Interface (hdl0)** menu, select **HDLC Addr Mode [M]**.
- 7 Confirm when prompted by typing 'y' when the following prompt is displayed;

```
Changing HDLC address mode causes system Reboot.  
Do you want to continue(Y/N)[Enter :No]
```

Select [1] for **Small Network Mode**.

- 8 Allow CDM-IP to reboot. After reboot, select **Interface Configuration [I]** from the **Main Menu**.
- 9 From the **Interface Configuration** menu, select **Receive HDLC Channel Addresses [H]**.
- 10 From the **Receive HDLC Channel Addresses** menu, select [1] for **HDLC Addr 1**. The following prompt will be displayed;

```
Please enter a value for the HDLC Addr 1  
Press ESC to abort  
HDLC address [SMALL NETWORK] in hex <0x1 - 0xFE, enter = 0001>:
```

Enter [2] to set **HDLC Addr 1** to **0x01**.

**Note:** **HDLC Addr 1** will display as **0x0001**, although only the last 2 digits are used in **Small Network Mode**, allowing up to 254 separate HDLC addresses.

- 11 Repeat **Steps 1 - 9** on **CDM-IP 2**. Also, repeat **Step 10**, but set **HDLC Addr 1** to **0x02**.

Both CDM-IP modems are now in Router/Small Network Mode, which will mean that the CDM-IP modems will be on independent IP subnets and will require adding static routes to pass traffic between them. **Section 1.3.4, Route Table**, explains this procedure.

### 1.3.3 SETTING IP ADDRESS(ES)

Step	Description
------	-------------

- |   |   |
|---|---|
| 1 | From the <b>Main Menu</b> select <b>Interface Configuration</b> sub-menu [I].                                 |
| 2 | From the <b>Interface Configuration Menu</b> select <b>Ethernet Interface (fei0)</b> sub-menu [E].            |
| 3 | Set <b>IP Address [I]</b> .<br><b>CDM-IP 1</b> to <b>172.16.10.1</b><br><b>CDM-IP 2</b> to <b>172.17.10.1</b> |
| 4 | Set <b>Subnet Prefix Length [M]</b> to <b>24</b>  |

### 1.3.4 ROUTE TABLE

Perform the following steps on **CDM-IP 1**

**Step Description**

- 1 From **Main Menu**, select **Route Table [R]** sub-menu.
- 2 Enter **1** to configure the first route
- 3 Enter a suitable name
- 4 Set **IP Address** to **172.17.10.0**
- 5 Set **Number of Subnet Bits** to **24**
- 6 For **Interface to which route is destined to** <E-Ethernet S-Satellite Enter : S> select **S**
- 6 For **HDLC address [SMALL NETWORK]** in hex <0x1 - 0xFE, enter = 0000>: select **2**
- 7 CDM-IP 1 Route Table should display the following:

Route Name	Dest IP/SNet Bits	Next Hop	MultiCast	State
Route001..[test	172.17.10.0/24	0x2	N/A	toSat]

Perform the following steps on **CDM-IP 2**

**Step Description**

- 8 From **Main Menu**, select **Route Table [R]** sub-menu.
- 9 Enter **1** to configure the first route
- 10 Enter a suitable name
- 11 Set **IP Address** to **172.16.10.0**
- 12 Set **Number of Subnet Bits** to **24**
- 13 For **Interface to which route is destined to** <E-Ethernet S-Satellite Enter : S> select **S**
- 14 For **HDLC address [SMALL NETWORK]** in hex <0x1 - 0xFE, enter = 0000>: select **1**
- 15 CDM-IP 2 Route Table should display the following:

Route Name	Dest IP/SNet Bits	Next Hop	MultiCast	State
Route001..[test	172.16.10.0/24	0x1	N/A	toSat]

At this point the basic configuration is over and you should be able to:

- ▶ Ping PC 1 from PC 2 and vice versa
- ▶ Ping **CDM-IP 2** from PC 1 and vice versa
- ▶ Pass any other data between the 2 PCs

**5 From PC1**

Ping 172.16.10.1 (**CDM-IP 1**)

Ping 172.17.10.2 (**CDM-IP 2**)

Ping 172.17.10.11 (**PC 2**)

**6 From PC2**

Ping 172.17.10.1 (**CDM-IP 2**)

Ping 172.16.10.1 (**CDM-IP 1**)

Ping 172.16.10.11 (**PC 1**)

## 1.4 TROUBLESHOOTING IP MODULE

The CDM-IP comes with a variety of diagnostic tools to aid in identifying the traffic path going into and out of the CDM-IP modem. This troubleshooting section shows how to use some of these tools and also identifies several common problems encountered when first setting up 2 CDM-IP modems. If following these troubleshooting steps fails to resolve the problem, contact a Customer Support representative at:

Comtech EF Data  
Attention: Customer Support Department  
2114 West 7th Street  
Tempe, Arizona 85281 USA

(480) 333-2200 (Main Comtech EF Data Number)

(480) 333-4357 (Customer Support Desk)

(480) 333-2161 FAX

or, E-Mail can be sent to the Customer Support Department at:

[cdmipsupport@comtechefdata.com](mailto:cdmipsupport@comtechefdata.com)

### 1.4.1 EASYCONNECT™ MODE TROUBLESHOOTING

Use the following troubleshooting steps if unable to successfully send traffic in EasyConnect™.

EasyConnect™ Mode Troubleshooting		
<u>Step</u>	<u>Problem</u>	<u>Action</u>
1	No Ping response from the locally connected PC to the	a) Verify correct IP address/subnet on PC and CDM-IP.

CDM-IP Ethernet port. ICMP response is 'Request timed out'.

- b) Verify Ethernet connection – cables, hub, etc. PC, hub, and CDM-IP should have Ethernet activity LED lit.

**Note:** A PC must be connected to the CDM-IP using a hub, switch or a RJ45 crossover cable. When the CDM-IP Ethernet port senses an Ethernet connection, the CLI will display;

```
phymon_callback(): enet link  
change! link=1
```

If the connection is broken, the CLI will display;

```
phymon_callback(): enet link  
change! link=0
```

- 2 No Ping response from the locally connected PC to the remote CDM-IP or remote PC. ICMP response is 'Request timed out'.

- a) Verify both CDM-IP's are in EasyConnect™/Point-to-Point Modes.
- b) Verify IF link between modems for proper settings and carrier quality (RX signal level, Eb/No, etc). It is possible that there is a spectrum inversion, particularly if you are using the CDM-IP with RF converter equipment. If this is the case, the signal level & Eb/No may be OK, but no data will be received. To correct this invert the TX and RX Spectrum on one of the CDM-IP's.
- c) Send a constant ping from the PC 1 'ping 172.16.10.2 -t' to PC 2. In the CDM-IP 1, go to Operations and Maintenance/Diagnostics. Enable 'Dump Packets transmitted to Satellite Interface'. Verify that the Pings are being transmitted by observing 1 packet on CLI every second. If not displayed, reverify PC 1 and CDM-IP 1 settings. Disable 'Dump Packets transmitted to Satellite Interface' by entering 'T'.
- d) Continue sending constant ping from the PC 1 to PC 2. In the CDM-IP 2, go to Operations Maintenance/Diagnostics. Enable 'Dump Packets received from Satellite Interface'. Verify that the Pings are being received by observing 1 packet on CLI every second. If not displayed, reverify PC 2 and CDM-IP 2 settings. Disable 'Dump Packets received from Satellite Interface' by entering 'R'.

**Note:** All pings transmitted will require a reply to be transmitted from the target host. Use the Diagnostics 'Dump Packets' tools to isolate where packets are lost in the CDM-IP duplex paths. Also, always disable "Dump Packets" before sending live traffic.

## 1.4.2 ROUTER MODE TROUBLESHOOTING

Use the following troubleshooting steps if unable to successfully send traffic in Router Mode.

Router Mode Troubleshooting		
<u>Step</u>	<u>Problem</u>	<u>Action</u>
1	No Ping response from the locally connected PC to the CDM-IP Ethernet port. ICMP response is 'Request timed out'.	<p>a) Verify correct IP address/subnet on PC and CDM-IP.</p> <p>b) Verify Ethernet connection – cables, hub, etc. PC, hub, and CDM-IP should have Ethernet activity LED lit.</p> <p><b>Note:</b> A PC must be connected to the CDM-IP using a hub, switch or a RJ45 crossover cable. When the CDM-IP Ethernet port senses an Ethernet connection, the CLI will display;</p> <pre>phymon_callback(): enet link change! link=1</pre> <p>If the connection is broken, the CLI will display;</p> <pre>phymon_callback(): enet link change! link=0</pre>
2	No Ping response from the locally connected PC to the remote CDM-IP or remote PC. ICMP response is 'Request timed out'.	<p>a) Verify both CDM-IP's are in Router/Small Network Modes.</p> <p>b) Verify PC's Gateways are set to local CDM-IP address.</p> <p>c) Verify IF link between modems for proper settings and carrier quality (RX signal level, Eb/No, etc). It is possible that there is a spectrum inversion, particularly if you are using the CDM-IP with RF converter equipment. If this is the case, the signal level &amp; Eb/No may be OK, but no data will be received. To correct this invert the TX and RX Spectrum on one of the CDM-IP's.</p>
3	No Ping response from PC 1 to PC 2 or vice versa. ICMP response is  ' Reply from 172.XXX.10.1 - Destination net unreachable'	<p>a) Verify CDM-IP Route Tables are correct</p>

## METRIC CONVERSIONS

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### Units of Length

Unit	Centimeter	Inch	Foot	Yard	Mile	Meter	Kilometer	Millimeter
1 centimeter	—	0.3937	0.03281	0.01094	$6.214 \times 10^{-6}$	0.01	—	—
1 inch	2.540	—	0.08333	0.2778	$1.578 \times 10^{-5}$	0.254	—	25.4
1 foot	30.480	12.0	—	0.3333	$1.893 \times 10^{-4}$	0.3048	—	—
1 yard	91.44	36.0	3.0	—	$5.679 \times 10^{-4}$	0.9144	—	—
1 meter	100.0	39.37	3.281	1.094	$6.214 \times 10^{-4}$	—	—	—
1 mile	$1.609 \times 10^5$	$6.336 \times 10^4$	$5.280 \times 10^3$	$1.760 \times 10^3$	—	$1.609 \times 10^3$	1.609	—
1 mm	—	0.03937	—	—	—	—	—	—
1 kilometer	—	—	—	—	0.621	—	—	—

### Temperature Conversions

Unit	° Fahrenheit	° Centigrade
32° Fahrenheit	—	0 (water freezes)
212° Fahrenheit	—	100 (water boils)
-459.6° Fahrenheit	—	273.1 (absolute 0)

Formulas
$C = (F - 32) * 0.555$
$F = (C * 1.8) + 32$

### Units of Weight

Unit	Gram	Ounce Avoirdupois	Ounce Troy	Pound Avoir.	Pound Troy	Kilogram
1 gram	—	0.03527	0.03215	0.002205	0.002679	0.001
1 oz. avoir.	28.35	—	0.9115	0.0625	0.07595	0.02835
1 oz. troy	31.10	1.097	—	0.06857	0.08333	0.03110
1 lb. avoir.	453.6	16.0	14.58	—	1.215	0.4536
1 lb. Troy	373.2	13.17	12.0	0.8229	—	0.3732
1 kilogram	$1.0 \times 10^3$	35.27	32.15	2.205	2.679	—



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