UG-1040
6NIA1 Network Interface Adapter

August 2007
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# Revisions

<table>
<thead>
<tr>
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<th>Date</th>
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<tbody>
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1 General Description

The 6NIA1 Network Interface Adapter provides high speed Ethernet connections to QEI’s 6CPP6 Central Processor Panel and 6ACP5 Alternating Current Panel. The 6NIA interfaces to the 6CPP6 via connectors P1 and P2 on the 6CPP6. For the 6ACP5, the panel mount version is used with an RS-232 cable connecting the 6NIA to the 6ACP5 for communications.

The board is provided with (2) Ethernet ports: the first port (Port 1) supports either 10BaseT or 10Base AUI and the second port (Port 2) is 100BaseTX or 100FX (standard option). These ports are compliant with IEEE 802.3 (10Base ports) and 802.3u (100 Base ports) Ethernet standards. All the communications and interface functions on the 6NIA are handled by a dedicated microprocessor to prevent any processor loading on the 6CPP6/6ACP5 and retain their high speed data and communications management capability.

In addition to the Ethernet ports, the 6NIA is equipped with two serial ports utilizing RS232 interface. One of these ports is intended to provide a serial data link utilizing one of several available data link protocols. The commonly used PPP (point to point protocol) is provided as standard but others are available on optional basis. The second port is used for special diagnostic purposes, while standard network diagnostics, monitoring and trouble analysis is performed via the 6CPP6 or 6ACP5 utilizing their test panel facilities.

The standard network protocol stack provided with the 6NIA is IP with either TCP (Transmission Control Protocol) or UDP (User Datagram Protocol) that are user selectable and configurable. The IP stack is fully compliant with BSD and offers a full complement of network services. These functions are utilized extensively for remote diagnostics and platform configuration of 6CPP6 and the 6ACP5. The WEB Server can be utilized to provide easy access to information by browsers. For special applications, the seven-layer ISO OSI protocol stack is also available. For those applications that require OSI upper (application) layers the 6NIA utilizes RFC1006 for encapsulation into TCP.

Any byte-oriented protocol installed on the 6CPP6 or 6ACP5 can operate as application over TCP/IP or UDP/IP. The 6NIA provides a virtual path, via a “Connection”, between each selected component (client IED or server) on the 6CPP6/6ACP5 and the corresponding field device. The use of TCP or UDP offers either a connection oriented or a connectionless service depending on the user’s choice.

The 6NIA also supports UCA 2.0 (IEC 61850), in both client and server modes, including GOOSE. As standard application, UCA is provided over TCP/IP utilizing RFC1006 and Ethernet or PPP as a link. UCA is also available with the standard seven-layer OSI stack. More information on the configuration of UCA 2.0 (client and server) can be found in the ConfigWiz® User’s Guide Addenda (UM-2012, UCA 2.0 Server and UCA 2.0 Client) and QEI’s documentation on its UCA Client Configurator program.

The 6NIA1 also supports many robust security features. These security features include:

- Password protection of any network port using strong 128-bit MD5 encryption.
• Full Data Encryption on any network port, using Secure Sockets (SSL) or IPSec with a full complement of strong encryption algorithms (available algorithms may be subject to export and other restrictions or requirements).

• Secure Authentication, with Server- and Client-side certificates, using an internal Certificate Authority, an external one or a combination of the two, to combine maximum reliability with simplest maintenance.

• Encrypted Routing, Gateway, Bridging and Firewall capabilities, allowing you to protect and control access to substation devices, even those which provide no encryption or access control of their own.

• A configurable Web Server, to view both scaled and raw data (analog, status and accumulator points) from a remote location. Configurable items include annunciation colors, alarm thresholds values, point names and scale factors for analog and accumulator points.

• Complete customization flexibility to add security features without impacting interoperability with legacy systems. Add as much or as little protection as you need on each individual port.

• Integrated Security Management System to provide simple and comprehensive management of passwords and certificates.

• The following services are also optionally supported. Contact QEI for more information:
  - NFS and SMB (file sharing capabilities)
  - FTP, SFTP, TFTP (file transfer capabilities)
  - NTP (Network time synchronization)
  - IPv6 (Next Generation IP Protocol)
  - DHCP, DNS, BOOTP, SNMP (Network Configuration and Management)

  These security features are optionally available. Configuration of these features is accomplished via QEI’s ConfigWiz®. See the List of Related Documentation in Section 13 of this manual for more information.

The MAC or Ethernet address for each port is preprogrammed at the factory. A label on the solder side of the 6NIA under each port shows the assigned Ethernet address.

Several LEDs are included to monitor different operations, such as speed, collision, link, transmit and receive.
2 Hardware Specification

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microprocessor</td>
<td>Motorola PowerPC MPC855T</td>
</tr>
<tr>
<td></td>
<td>32-bit data and address bus</td>
</tr>
<tr>
<td>FLASH Memory</td>
<td>4 MB. Used for board parameters, OS, application and other necessary data.</td>
</tr>
<tr>
<td>SDRAM</td>
<td>16 MB, standard; expandable up to 32 MB</td>
</tr>
<tr>
<td>Dual Port RAM</td>
<td>1 kB, for 6CPP6 interface</td>
</tr>
</tbody>
</table>

2.1 Communication Ports

Port 1 10BaseT (J2)
- Interface: Ethernet IEEE 802.3 compliant
- Protocols: IP (TCP, UDP), OSI
- Bit Rate: Up to 10MBS
- Connector: RJ45, 568A straight pinned

Port 1 10Base-AUI (P1)
- Interface: Ethernet IEEE 802.3 compliant
- Protocols: IP (TCP, UDP), OSI
- Bit Rate: Up to 10MBS
- Connector: DB-15 Female

Port 2 10/100BaseTX (J3)
- Interface: Ethernet IEEE 802.3u compliant
- Protocols: IP (TCP, UDP), OSI
- Bit Rate: Up to 100 MBS
- Connector: RJ45, 568A straight pinned

Port 2 100BaseFX (U8, optional)
- Interface: Ethernet IEEE 802.3u compliant
- Protocols: IP (TCP, UDP), OSI
- Bit Rate: Up to 100 MBS
- Connector: ST, multimode or SC, Single Mode (See Ordering Information)
### Auxiliary Port RS-232 (P3, AUX-SMC1)

<table>
<thead>
<tr>
<th>Protocol</th>
<th>PPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>RS-232, asynchronous, hardware handshaking supported</td>
</tr>
<tr>
<td>Bit Rate</td>
<td>150 to 38,400 bps</td>
</tr>
<tr>
<td>Connector</td>
<td>6pin Molex</td>
</tr>
</tbody>
</table>

### Test Panel Port RS-232 (P2, TPANEL-SMC2)

<table>
<thead>
<tr>
<th>Protocol</th>
<th>ASCII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td>RS-232, asynchronous, no hardware handshaking</td>
</tr>
<tr>
<td>Bit Rate</td>
<td>115000 baud</td>
</tr>
<tr>
<td>Connector</td>
<td>5pin Molex</td>
</tr>
</tbody>
</table>

### Power Input, J4

| Voltage | 12Vdc nominal, range 10.5 to 14.4 volts |
| Current | 6CPP6: 320 mA  
Standalone: 300 mA |
| Connector | 2pin MOLEX |

### Environment

| Temperature | 0 to +70°C |
| Humidity | 5 to 95% @ +70°C, non-condensing |

### Physical Dimensions

| 8.5” x 5.5” x 0.75” |

### Weight

| 0.4 lbs. |
3 Installation

If the 6NIA1 is provided as part of a new RTU or with a 6CPP6, the 6CPP6 and 6NIA will already be configured to function. However, in cases where the 6NIA1 is provided as an upgrade to an existing 6CPP6, there are a few steps that must be taken to ensure correct operation.

1. The 6NIA1 plugs into the 6CPP6 at connectors P1 and P2. These connectors are keyed, so there is only one way to insert the 6NIA1 into the 6CPP6. For a reference, see Figure 3.1 below.

![Figure 3.1 6NIA1 Position](image-url)
2. Connect 12VDC power from the 6CPP6 to the 6NIA1. The cable is:
   - 12VDC Power Cable – P/N 30 - 057922 - 018

This cable plugs into the 6CPP6 J12 and the 6NIA J4. It is keyed so that the polarity is automatically correct. Figure 3.2 shows this power cable in bold. The 6NIA will not operate without this cable. If your 6NIA upgrade kit did not come with this power cable, contact QEI.

Figure 3.2 12VDC Power Cable Connections between 6NIA1 and 6CPP6
3. Remove the Real Time IC. On the 6CPP6 board, remove the IC located at IC position U105. The 6NIA1 has a Real Time IC, making this one redundant. See Figure 3.3 for location of U105, which is in bold. Failure to remove this IC will cause improper operation.

![Figure 3.3 Real Time IC Position (U105) on 6CPP6](image)

4. The 6NIA upgrade kit should also come with a 6CPP6 Program Link disk, that has on it a new link file to NIA Loader to the 6CPP6. The link will have a part number with the following format:

   Part Number: 80-002XXX-001, Rev ‘ ‘

   File Name: lnk2xxxR.s19 (where ‘R’ is the rev letter of the file)

All 6CPP6 Program Link files that support 6NIA operation have a ‘2’ in the fifth place from the left. If the 6CPP6 intended to operate with a 6NIA1 has a link with a ‘1’ in the fifth place, the 6NIA1 and 6CPP6 will not operate properly.

The 6CPP6 can be queried for its current link by using the ‘ver’ command in the 6CPP6 Test Panel. Use the Flashload command in ConfigWiz® to download the new link file.
4 Jumper Settings

Some hardware and firmware options are selected by individual pluggable jumpers. Individual pluggable jumpers are designated JP10, JP11, JP15, JP16, JP17 and JP18. Their functions are defined in the table below.

<table>
<thead>
<tr>
<th>JUMPER REF DESIGNATION</th>
<th>FUNCTION</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>JP10 (1-2)</td>
<td>RS-232 Reset from P3</td>
<td>IN – enabled, reset enabled from RS-232 port, required when operating in standalone mode with 6ACP5. *OUT – disabled, reset from 6CPP6, required in adapter mode when plugged into 6CPP6.</td>
</tr>
<tr>
<td>JP10 (3-4)</td>
<td>Watchdog Timer</td>
<td>IN – enabled *OUT – disabled (Reset Performed by 6CPP6 or 6ACP5)</td>
</tr>
<tr>
<td>JP11</td>
<td>External Reset</td>
<td>*IN – enabled OUT – disabled</td>
</tr>
<tr>
<td>JP15 &amp; JP16</td>
<td>Port 2 Speed (set for both JP15 &amp; JP16)</td>
<td>1-2 – Twisted Pair (auto-negotiate) 2-3 – Fiber Mode (100Base FX only)</td>
</tr>
<tr>
<td>JP17</td>
<td>Port 1 Port Determination</td>
<td>*IN – Automatically determine network port OUT – Manually force physical port</td>
</tr>
<tr>
<td>JP18</td>
<td>Port 1 Enable (if JP17 is installed, remove JP18)</td>
<td>IN – AUI port enable *OUT – TP port enable, or auto port select (JP17 IN)</td>
</tr>
</tbody>
</table>

* default jumper position
5 LED Indicators

LED's are physically placed according to function. For example, the Port 1 LEDs are located next the RJ45 (J2) connector for Port 1, the Port 2 LEDs are located next to the Fiber Optic connector (U8, if equipped) and the Power LED's are located near the power connector, J4. The table below describes the LED's and their functions.

<table>
<thead>
<tr>
<th>LED</th>
<th>FUNCTION</th>
<th>INDICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Port 1 Link</td>
<td>Monitors link integrity, off when no link exists.</td>
</tr>
<tr>
<td>D2</td>
<td>Port 1 Rx</td>
<td>Receive indicator</td>
</tr>
<tr>
<td>D15</td>
<td>Port 1 Tx</td>
<td>Transmit indicator</td>
</tr>
<tr>
<td>D3</td>
<td>Port 1 Collision</td>
<td>Collision indicator</td>
</tr>
<tr>
<td>D8</td>
<td>Port 2 Speed</td>
<td>ON indicates 100Mbps</td>
</tr>
<tr>
<td>D6</td>
<td>Port 2 Link</td>
<td>Monitors link integrity, off when no link exists.</td>
</tr>
<tr>
<td>D4</td>
<td>Port 2 Rx</td>
<td>Receive indicator</td>
</tr>
<tr>
<td>D5</td>
<td>Port 2 Tx</td>
<td>Transmit indicator</td>
</tr>
<tr>
<td>D7</td>
<td>Port 2 Collision</td>
<td>Collision indicator</td>
</tr>
<tr>
<td>D9</td>
<td>Heartbeat</td>
<td>Monitors board status, 1 blink/second indicates OK.</td>
</tr>
<tr>
<td>D10</td>
<td>Spare</td>
<td>Spare</td>
</tr>
<tr>
<td>D11</td>
<td>3.3V</td>
<td>3.3V indicator</td>
</tr>
<tr>
<td>D12</td>
<td>5V</td>
<td>5V indicator</td>
</tr>
<tr>
<td>D13</td>
<td>12V</td>
<td>12V indicator</td>
</tr>
</tbody>
</table>
6  Functional Description

The 6NIA1 Network Interface Adapter consists of three major functional sections: the main processor and memory section, the communications section, and the power section.

The following paragraphs give a brief description of the operation of each of these three sections.

6.1  The Main Processor and Memory Section

The main processor and memory section control the entire operation of the 6NIA and consists of the following blocks:

- The Processor
- FLASH memory
- RAM memory
- Real-time Clock

6.1.1  The Processor Block

The Processor block consists of the microprocessor, Motorola MPC855T PowerPC with 32-bit data bus and the 32-bit address bus, the clock generator, watchdog timers.

Under program control, the microprocessor services all the I/O and communications functions.

6.1.2  FLASH Memory

FLASH memory consists of a 4 MB block and is used to store board parameters, the operating system and the application code.

6.1.3  RAM Memory

RAM memory consists of a 16 MB block and can be expanded up to 32 MB. RAM is the temporary storage area where program variables and intermediate process variables are stored.
6.2 Communication Interface Section

The 6NIA1 contains circuitry for two Ethernet communications ports and two serial communication ports. The following are descriptions of the communications ports usage in a typical SCADA system including, their physical interfaces and options available to them.

6.2.1 Ports 1 – 10BaseT / AUI

Port 1 on the 6NIA1 is comprised of a 10BaseT connection (J2) and a 10Base AUI port (P1). Either connection can be used at any one time, but not both at the same time. The 6NIA has circuitry that can automatically determine which connection is made, or a jumper setting can be made to force the physical connection selection via JP17 and JP18.

The 10BaseT connection is an RJ45 jack, which supports the 568A straight wiring standard. See Figure 5.2 for pinout information. The AUI port at P1 is a female DB15 connector (pinout in Figure 5.3) with hardware lock, which supports all standard media access units (MAU) devices, including 10BaseFL units.

<table>
<thead>
<tr>
<th>PIN #</th>
<th>SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TPOP (Twisted Pair Out, positive)</td>
</tr>
<tr>
<td>2</td>
<td>TPON (Twisted Pair Out, negative)</td>
</tr>
<tr>
<td>3</td>
<td>TPIP (Twisted Pair In, positive)</td>
</tr>
<tr>
<td>4</td>
<td>NC</td>
</tr>
<tr>
<td>5</td>
<td>NC</td>
</tr>
<tr>
<td>6</td>
<td>TPIN (Twisted Pair In, negative)</td>
</tr>
<tr>
<td>7</td>
<td>NC</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
</tr>
</tbody>
</table>

Figure 5.2 10BaseT (J2) Pinout

<table>
<thead>
<tr>
<th>PIN #</th>
<th>SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NC</td>
</tr>
<tr>
<td>2</td>
<td>CIP (AUI Collision In, positive)</td>
</tr>
<tr>
<td>3</td>
<td>DOP (AUI Data Out, positive)</td>
</tr>
<tr>
<td>4</td>
<td>NC</td>
</tr>
<tr>
<td>5</td>
<td>DIP (AUI Data In, positive)</td>
</tr>
<tr>
<td>6</td>
<td>NC</td>
</tr>
<tr>
<td>7</td>
<td>NC</td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
</tr>
<tr>
<td>9</td>
<td>CIN (AUI Collision In, negative)</td>
</tr>
<tr>
<td>10</td>
<td>DON (AUI Data Out, negative)</td>
</tr>
<tr>
<td>11</td>
<td>NC</td>
</tr>
<tr>
<td>12</td>
<td>DIN (AUI Data In, negative)</td>
</tr>
</tbody>
</table>

Figure 5.3 10Base AUI (P1) Pinout

Both connections support the IEEE 802.3, which includes the following functions and features:
• Preamble generation and stripping
• Destination address checking
• CRC generation and checking
• Automatically pads short frames on transmit
• Framing error (dribbling bits) handling

and the following collision support:
• Collision enforcing (jamming)
• Truncated binary exponential backoff algorithm for random wait
• Two non-aggressive backoff modes
• Automatic frame retransmission (until attempt limit reached)
• Automatic discard of incoming collided frames
• Delay retransmission of new frames for specific interframe gap

It also has the following features:
• Maximum 10MPS bit rate
• Optional full-duplex support
• Back-to-back frame reception
• Detection of receive frames too long
• Multibuffer data structure
• Supports 48-bit addressing in three modes
• External context-addressable memory
• Heartbeat indicator
• Transmission network management and diagnostics
• Receiver network management and diagnostics
• Error counters
• Internal and external loop back mode

NOTE: The Ethernet or MAC addresses are pre-programmed at the factory. A label is affixed to the solder side of the board with the address for the port. If that label is missing, contact QEI Customer Service to obtain the address.
### 6.2.2 Port 2 – 100Base TX/FX

Port 2 on the 6NIA1 is comprised of a 10/100BaseTX connection (J3) and an optionally equipped 100Base FX port (U8). Either connection can be used at any one time, but not both at the same time. A jumper setting must be made to force the physical connection selection on the fiber optic channel via JP15 and JP16.

The 10/100BaseTX connection is an RJ45 jack, which supports the 568A wiring standard. See Figure 5.4 for pinout information. The fiber optic port at U8 is a multimode transceiver with ST connectors, or a single mode transceiver with SC Connectors.

<table>
<thead>
<tr>
<th>PIN #</th>
<th>SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TPOP (Twisted Pair Out, positive)</td>
</tr>
<tr>
<td>2</td>
<td>TPON (Twisted Pair Out, negative)</td>
</tr>
<tr>
<td>3</td>
<td>TPIP (Twisted Pair In, positive)</td>
</tr>
<tr>
<td>4</td>
<td>CMRO (Twisted Pair Out CM Rejection)</td>
</tr>
<tr>
<td>5</td>
<td>CMRO (Twisted Pair Out CM Rejection)</td>
</tr>
<tr>
<td>6</td>
<td>TPIN (Twisted Pair In, negative)</td>
</tr>
<tr>
<td>7</td>
<td>CMRI (Twisted Pair In CM Rejection)</td>
</tr>
<tr>
<td>8</td>
<td>CMRI (Twisted Pair In CM Rejection)</td>
</tr>
</tbody>
</table>

Figure 5.4 10/100Base TX (J3) Wiring

This port also supports auto-negotiation on the 10/100Base TX port. The port is IEEE 802.3u compliant, which includes the following:

- Support for three different physical interfaces: 100 Mobs 802.3 MII, 10Mbps 802.3 MII and 10 Mbps 7 wire interface
- Large on-chip transmit and receive FIFO buffers to support varying bus latencies
- Retransmission from transmit FIFO buffer for runts and collisions
- Automatic internal flushing of the receive FIFO buffer after a collision
- External buffer description tables of user-definable size
- Address recognition for broadcast, single station address, promiscuous mode, multicasting hashing
- Full MII support
- Interrupts supported per frame or per buffer
- Automatic interrupt vector generation for receive and transmit events
- Ethernet channel uses DMA burst transactions to transfer data to and from external circuitry.

**NOTE:** The Ethernet or MAC addresses are pre-programmed at the factory. A label is affixed to the solder side of the board with the address for the port. If that label is missing, contact QEI Customer Service to obtain the address.
6.2.3 Auxiliary Serial Port (AUX-SMC1)

This RS-232 port (P3) is designed to be an interface to IED’s requiring a network interface communication link or to replace the 6CPP6 interface for devices that the 6NIA cannot plug into, like the 6ACP5. A special cable is provided for this purpose.

The port uses standard RS-232 levels and supports asynchronous communications and hardware handshaking. The pinout for this port is given below. The connector is an inline 6pin Molex straight connector.

<table>
<thead>
<tr>
<th>PIN #</th>
<th>SIGNAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RX</td>
</tr>
<tr>
<td>2</td>
<td>TX</td>
</tr>
<tr>
<td>3</td>
<td>RTS</td>
</tr>
<tr>
<td>4</td>
<td>CTS</td>
</tr>
<tr>
<td>5</td>
<td>COM</td>
</tr>
<tr>
<td>6</td>
<td>RESET</td>
</tr>
</tbody>
</table>

6.2.4 Test Panel Serial Port

The Test Panel serial port (P2) is an asynchronous port to provide diagnostic status and commands to exercise the 6NIA.

NOTE
This port is not intended for customer use. Only QEI personnel can access this port.

6.3 Power Section

The 6NIA operates from a single 12 VDC power input. The following voltages are internally generated from this 12 VDC supply:

- +3.3 VDC for internal use is generated by a voltage regulator.
- +5 VDC for internal use.

In standalone mode, the 6NIA has a +5V regulator installed at U33.
7 Typical Applications

The 6NIA1 was designed to provide the transition from today’s RTU’s to tomorrow’s fully automated, Ethernet capable substations. Therefore, as your substation communication needs grow, the 6NIA can be ‘daughtered’ to your 6CPP6-based RTU to add local substation Ethernet to handle IED communications or a SCADA Web Server to view real time substation data from anywhere.

7.1 Substation LAN to Legacy SCADA/EMS Master

A 6CPP6-based RTU with a 6NIA1 daughter board can collect data from networked substation devices and disseminate it to the legacy master in its required format. This configuration allows you to upgrade your substations with the latest IED’s without having to upgrade your legacy Master Station. In addition, the 6CPP6 based RTU will also support the Legacy RTU at the same time.

The figure below is a typical example of the addition of a Substation LAN to a Legacy RTU/Master Station system.
7.2 SCADA Web Server

While the 6CPP6-based RTU with 6NIA1 is collecting data from field devices and servicing Master Station data requests, it can also support a web page. The web page can be used as local or remote HMI to view real-time substation data, while all of the other functions are being processed. This feature is very useful when problems occur to ascertain causes and start troubleshooting. See figure below.
8 6NIA Supported Network Diagnostics

8.1 General Information

The NETDIAG command allows the user to run a number of network diagnostic commands from the test-panel. The commands are described individually, in the logical order you would want to run them.

8.2 On-Board LED's

When diagnosing network problems, the first thing to do is to watch the LED's on the 6NIA card, for the appropriate interface. Each of the two 6NIA network connections has a set of LED's that indicate the status and operation of the hardware connection. It is important that you establish that the physical network hardware is properly connected before attempting the higher-level diagnostics. The LED indicators are:

- LINK - This LED is illuminated if the 6NIA is connected to an active Ethernet line. If this LED is not illuminated, check the network cabling, since it indicates the 6NIA is not connected properly to any other network device (i.e. a hub or router).

- RX - This LED illuminates whenever the 6NIA detects traffic on the net, regardless of the destination. This LED should flash periodically (or even continuously) when the 6NIA is connected to an active network. If the LINK light is on, but the RX light never illuminates, check the connections between the hub/router and the rest of the network. (This assumes that there is some traffic on the network as a whole!)

- TX - This LED illuminates whenever the 6NIA sends data over the Ethernet port. If the RX light flashes but the TX light does not, it indicates that either no one is talking to the 6NIA or the 6NIA network address parameters are not configured properly. (Remember, however, that the RX LED is lit whenever there is ANY traffic on the network, even if that traffic is intended for other devices on the net).

- COLL - This LED illuminates when there is a collision on the network. It should be lit rarely, if ever. Frequent collisions indicate either an overloaded network, or a network addressing problem (such as two devices with the same IP address on a single network).

- HS (Eth1 only) - This LED is illuminated if the port is running at 100 MBPS, and off if the interface is running at 10 MBPS. This speed is determined by the hardware that the 6NIA is connected to (usually the router/hub).
8.3 Diagnostic Command Summary

The network diagnostic commands are accessed by using the "NETDIAG" command from the test-panel. The NETDIAG command puts the test-panel in a special diagnostic mode; you can exit this mode by hitting <Escape>. While in this diagnostic mode, you will see a special command prompt, "6NIA>"

NOTES:

1. The Netdiag mode provides access to powerful network diagnostic commands. If misused, these commands can cause the 6CPP6 to restart, or can cause the network to become temporarily unavailable. However, they cannot be used to change configuration information permanently, so any problems caused accidentally can be fixed by re-starting the RTU.

2. While normal test-panel commands are case-insensitive, the network diagnostic commands ARE CASE-SENSITIVE, and must be entered in lower-case. Any options must be capitalized exactly as shown.

3. Proper and effective use of the network diagnostics assumes that the user has some familiarity with networking, network addressing and routing, and network protocols.

4. The network diagnostics are all patterned after standard UNIX or Linux commands. Detailed documentation on these commands can be easily found on the internet. However, note that not all of the standard options normally provided in a UNIX environment are available on the 6NIA.

Use the network diagnostics to systematically debug network problems. In general, the following utilities answer these questions:

<table>
<thead>
<tr>
<th>Diagnostic</th>
<th>Answers the Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>ifconfig</td>
<td>&quot;How are my ethernet/ppp devices configured?&quot;</td>
</tr>
<tr>
<td>ping</td>
<td>&quot;Can I talk to another computer on the network?&quot;</td>
</tr>
<tr>
<td>route</td>
<td>&quot;What network addresses can I access?&quot;</td>
</tr>
<tr>
<td>netstat</td>
<td>&quot;What network connections are present? What address(es) is the 6NIA listening to?&quot;</td>
</tr>
<tr>
<td>traceroute</td>
<td>&quot;What is the network path from me to another device?&quot;</td>
</tr>
<tr>
<td>tcpdump</td>
<td>&quot;Show me the network traffic in detail&quot;</td>
</tr>
</tbody>
</table>
8.4 Network Diagnostic Commands

8.4.1 ifconfig

ifconfig shows basic configuration information on the network devices. There are two versions of the command:

ifconfig

ifconfig <device>

The first version shows information on all ethernet devices that are up and running. The second version shows information on a specific device (and can be used to get information on a device which is NOT up and running). The possible devices are:

- eth0 - The 10baseT Ethernet Interface
- eth1 - The 10/100baseT Ethernet Interface
- ppp0 - The PPP interface
- lo - The loopback interface (used internally; this interface will be visible in many of the network commands; you should ignore it)

Here is sample output of running the two versions of ifconfig:

(bold -> typed by the user)

netdiag
Hit <esc> to return to Test Panel
6NIA> ifconfig

eth1   Link encap:Ethernet  HWaddr 00:00:00:D5:55:55
inet addr:192.168.0.100  Bcast:0.0.0.0  Mask:255.255.255.0
UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
RX packets:8924 errors:0 dropped:0 overruns:0 frame:0
TX packets:8900 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:100
RX bytes:579948 (566.3 kb)  TX bytes:516022 (503.9 kb)
Base address:0xe00

lo       Link encap:Local Loopback
inet addr:127.0.0.1  Mask:255.255.255.0
UP LOOPBACK RUNNING  MTU:16436  Metric:1
RX packets:25 errors:0 dropped:0 overruns:0 frame:0
TX packets:25 errors:0 dropped:0 overruns:0 carrier:0
collisions:0 txqueuelen:0
RX bytes:579948 (566.3 kb)  TX bytes:516022 (503.9 kb)

6NIA> ifconfig eth0

6NIA> ifconfig
eth0 Link encaps:Ethernet HWaddr 00:00:00:55:55:55
   BROADCAST MULTICAST MTU:1500 Metric:1
   RX packets:0 errors:0 dropped:0 overruns:0 frame:0
   TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
   collisions:0 txqueuelen:100
   RX bytes:0 (0.0 b) TX bytes:0 (0.0 b)
   Base address:0x3c00

Ifconfig prints out a lot of information about the interface and its history; in general, only a few items are of interest:

- **HWaddr** - This is the MAC address of the interface
- **inet addr** - This is the IP address assigned to the interface
- **Mask** - This is the netmask for the interface
- **UP and RUNNING** - These indicate that the interface is properly configured and operational.

Note that in the second example, we see no ‘inet’ addr, and the words UP and RUNNING are missing. This is because the particular 6NIA configuration file has device eth0 disabled. (in the Connection Component).

Most of the rest of the information printed is network communications statistics, which may help to indicate the general health of the network.

### 8.4.2 ping

The "ping" command is useful to see if it is possible to communicate with another device on the network. It is very useful to determine whether a) the other device is up and running, and b) the network routing information is correct for us to communicate with the other device.

There are two forms of the ping command:

- `ping <ip address>`
- `ping -c <count> <ip address>`

The first form of the "ping" command will make 10 attempts to contact the remote device; the second form allows you to specify any number of tries.

**NOTE:** If you specify a very large count and wish to abort the ping command, simply exit the diagnostic mode (using <ESC>). You must then re-enter the "netdiag" command to continue diagnostics.
When running "ping", you may see the following message:

    ping: sendto: Network is unreachable

This indicates one of two problems:

- The network interface on the 6NIA is not configured correctly  (hopefully you
determined this already using the "ifconfig" command).
- The network routing is incorrectly specified (i.e. there is no configured
pathway from the RTU to the desired target).

If you are already familiar with the "ping" command, you might be used to using a hostname;
i.e. "ping myhost.mynet.com" or "ping myhost". This form will NOT work on the 6NIA; for
reasons of security, reliability, and simplicity the RTU does NOT use DNS services.
Therefore you must provide an explicit IP address, rather than a host name for this command.

Here is a sample "ping" result:

6NIA> ping 192.168.0.70
PING 192.168.0.70 (192.168.0.70): 56 data bytes
64 bytes from 192.168.0.70: icmp_seq=0 ttl=255 time=4.4 ms
64 bytes from 192.168.0.70: icmp_seq=1 ttl=255 time=1.9 ms
64 bytes from 192.168.0.70: icmp_seq=2 ttl=255 time=1.8 ms
64 bytes from 192.168.0.70: icmp_seq=3 ttl=255 time=1.9 ms
64 bytes from 192.168.0.70: icmp_seq=4 ttl=255 time=1.9 ms
64 bytes from 192.168.0.70: icmp_seq=5 ttl=255 time=1.8 ms
64 bytes from 192.168.0.70: icmp_seq=6 ttl=255 time=1.9 ms
64 bytes from 192.168.0.70: icmp_seq=7 ttl=255 time=1.9 ms
64 bytes from 192.168.0.70: icmp_seq=8 ttl=255 time=1.9 ms
64 bytes from 192.168.0.70: icmp_seq=9 ttl=255 time=1.8 ms

--- 192.74.137.5 ping statistics ---
10 packets transmitted, 10 packets received, 0% packet loss
round-trip min/avg/max = 49.5/68.5/105.7 ms
6NIA>

This example shows a ping to a remote device (on the internet, as it so happens), with a
count of 10.

**NOTE:** For demonstration purposes, the RTU used in these examples was connected to the
internet via a gateway. This is obviously NOT typical of most RTU installations, and in fact it is
NOT recommended that you allow this type of access to occur unless your SCADA network is
protected via an extremely secure firewall.

### 8.4.3 route

route displays the routing information on the 6NIA. It shows the configured
local network address(es), as well as any additional fixed routes or gateways.
An example is:

6NIA> route-
 kernel IP routing table

<table>
<thead>
<tr>
<th>Destination</th>
<th>Gateway</th>
<th>Genmask</th>
<th>Flags</th>
<th>Metric</th>
<th>Ref</th>
<th>Use</th>
<th>Iface</th>
</tr>
</thead>
<tbody>
<tr>
<td>193.168.0.17</td>
<td>*</td>
<td>255.255.255.255</td>
<td>UH</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>eth1</td>
</tr>
<tr>
<td>192.168.0.0</td>
<td>*</td>
<td>255.255.255.0</td>
<td>U</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>eth1</td>
</tr>
<tr>
<td>default</td>
<td>192.168.0.1</td>
<td>0.0.0.0</td>
<td>UG</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>eth1</td>
</tr>
</tbody>
</table>

"route" displays the explicitly configured routes for the RTU. In this case, it shows that:

- The RTU has a point-to-point route to 193.168.0.17
- The RTU routes all packets with addresses "192.168.0.X" through the device "eth1" directly. (192.168.0.X is determined by the combination of the "destination" and the "Genmask" fields. Genmask is the netmask).
- All other addresses are accessed through the gateway at 192.168.0.1

8.4.4 netstat

The netstat command has two variations:

netstat
  OR
netstat -a

The first version shows all active TCP connections to the 6NIA. The second version also shows all ports that the RTU is listening to (i.e., addresses and ports to which a connection could be made). Here are some typical examples of the output of these commands:

6NIA> netstat
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp  2      0  192.168.0.100:10000     64.115.87.4:1523        ESTABLISHED
tcp  0      0   127.0.0.1:57224         127.0.0.1:1024          ESTABLISHED
tcp  8      0   127.0.0.1:1024          127.0.0.1:57224         ESTABLISHED
Active UNIX domain sockets (w/o servers)
Proto RefCnt Flags       Type       State         I-Node Path
6NIA> netstat -a
Active Internet connections (servers and established)
Proto Recv-Q Send-Q Local Address           Foreign Address         State
tcp  0      0   *:57222                 *:*                     LISTEN
tcp  0      0   *:102                   *:*                     LISTEN
tcp  0      0   *:57224                 *:*                     LISTEN
tcp  0      0   192.168.0.100:10000    *:*                     LISTEN
tcp  0      0   *:ftp                   *:*                     LISTEN
tcp  0      0   192.168.0.100:10000    64.115.87.4:1523        ESTABLISHED
tcp  0      0   127.0.0.1:57224         127.0.0.1:1024          ESTABLISHED
tcp  11     0   127.0.0.1:1024          127.0.0.1:57224         ESTABLISHED
Active UNIX domain sockets (servers and established)
Proto RefCnt Flags    Type    State    I-Node Path

A few notes about this command:

1. Any connection to the ip address 127.0.0.1 should be ignored. (In this case, these connections are used to implement the "netdiag" command itself).

2. Ignoring those connections, we see a single active connection, from IP address 64.115.87.4, connected to the RTU on port 10000 (This happens to be an EPort connection to a distant master-station).

3. In general you will not see any "UNIX domain sockets".

4. The "netstat -a" variation also shows a number of ports that the RTU is listening to. These are shown by the LISTEN state. Ports 57222 and 57224 are used internally; port 102 is an RFC1006 port (a UCA server, awaiting a connection) and port 10000 is the EPort connection (configured in the Eth Ports component; you can specify any port for an EPort connection). The RTU is also listening at the ftp port (which allows the configuration file to be uploaded via the ftp protocol).

You might also see the RTU listening on port 20000 (DNP-over-ethernet), on other ports explicitly configured for ethernet ports, or on port 8080 (if the 6CPP6 web-server is configured).

Note that entries that show up with a state of "LISTEN" are addresses at which you COULD connect to the RTU; entries that show up as ESTABLISHED are active sockets that ARE connected. (For example, in the above case, the EPort connection to the master-station (port 10000) has been made; the UCA connection (port 102) has not, and DNP-over-ethernet has NOT been configured (the RTU is not listening to port 20000).

8.4.5 traceroute

traceroute can be used on more advanced networks where a connection needs to be established through several "hops" through routers. Before running traceroute you should ALWAYS "ping" the remote host to ensure that there actually is a route established to the destination. Traceroute is only needed in advanced configurations; most frequently, the RTU will be configured on a single subnet (where traceroute is pretty much useless).

traceroute shows each "hop" needed to get from the rtu to the destination address. As an example, a traceroute to a device on the internet might look like:

6NIA> traceroute 192.74.137.5
traceroute to 192.74.137.5 (192.74.137.5), 30 hops max, 40 byte packets
  1 10.221.96.1 (10.221.96.1)  107.366 ms  165.337 ms  13.244 ms
  2 24.62.0.17 (24.62.0.17)  14.557 ms  13.494 ms  13.096 ms
This shows that it takes 18 "hops" for the packets to go from the RTU to the intended target.

8.4.6 tcpdump

tcpdump is a utility to show traffic on the network. It is a network "sniffer" that can help diagnose network and protocol problems. tcpdump is intended only for the very sophisticated user; it is useful only if you have a detailed understanding of network protocols at a very low level.

Because tcpdump provides the potential for "spying" on network traffic, access to this command is restricted. In order to use this command, you must have configured the 6CPP6 with a user named 'root' (without the quotes) and assigned a password for this user. Before issuing the tcpdump command, do the following:

1. enter the command “su”
2. when prompted, type in the root password.

If you fail to do this, the tcpdump command will respond with an error message. In any case; tcpdump will only run for 5 minutes at a time, severely limiting its potential as a network espionage tool while allowing its use for diagnosis of protocol problems.

You can disable this tool simply by not providing a 'root' user on the 6NIA, which is recommended for mature installations. For further information about the root user, see the <users?> Section in <the configwiz NIA /security addendum?>

To use tcpdump, you MUST provide it with a device, and can also specify a few additional arguments, as follows:

```
tcpdump -i <device> -l -x -c <count>
```

The arguments are:

- `i <device>` Specify eth0, eth1, or ppp0 - REQUIRED!
- `-l` (optional - improves readability of the output)
- `-x` (optional - Dumps out the raw packet contents)
- `-c <count>` (optional - dumps "count" packets, then exits).
NOTE: If you fail to specify a device, tcpdump will quickly hang the 6NIA, and subsequently restart the RTU. Always specify one of the three devices eth0, eth1, or ppp0; NEVER specify "-i lo" or run the command without specifying a device.

tcpdump has a number of options which may be useful to advanced users in certain situations. However, it is NOT intended for the novice user, and should be used carefully, particularly in high-traffic networks.

As with the "ping" utility, if a "-c <count>" argument is not specified, tcpdump will continue indefinitely; to stop it hit <ESC> or <control-C> (which will exit the network diagnostics and return to the 6CPP6 test-panel).

Here is the output of a typical tcpdump:

6NIA> tcpdump -i eth1 -l -x -c 8
Kernel filter, protocol ALL, datagram packet socket
tcpdump: listening on eth1
10:57:59.845005 < 64.115.87.4.1523 > 192.168.0.100.10000: P 855310730:855310738(8)
   ack 712851720 win 7208 (DF)
   4500 0030 c24a 4000 6f06 f0f9 4073 5704
c0a8 0064 05f3 2710 32fb 018a 2a7d 4108
   5018 1c28 6503 0000 ac00 0000 04ff 5808
10:57:59.966217 > 192.168.0.100.10000 > 64.115.87.4.1523: . 1:1(0) ack 8 win 6432 (DF)
   4500 0028 dec6 4000 4006 0366 c0a8 0064
   4073 5704 2710 05f3 2a7d 4108 32fb 0192
   5010 1920 711b 0000
10:58:00.208641 < 64.115.87.4.1523 > 192.168.0.100.10000: P 0:10(10) ack 1 win 7208 (DF)
   4500 0032 c34a 4000 6f06 eff7 4073 5704
c0a8 0064 05f3 2710 32fb 018a 2a7d 4108
   5018 1c28 6445 0000 ac00 0000 04ff 5808
   00bc
10:58:00.208641 > 192.168.0.100.10000 > 64.115.87.4.1523: . 1:1(0) ack 10 win 6432
<nop,nop, sack 1 {0:8} > (DF)
   4500 0034 dec7 4000 4006 0379 c0a8 0064
   4073 5704 2710 05f3 2a7d 4108 32fb 0194
   8010 1920 d1ef 0000 0101 050a 32fb 018a
   32fb 0192
10:58:00.935913 > 192.168.0.100.10000 > 64.115.87.4.1523: . 10:10(0) ack 12 win 7197 (DF)
   4500 0028 c44a 4000 6f06 edfb 4073 5704
c0a8 0064 05f3 2710 32fb 0194 2a7d 4113
   5010 1c1d 6e11 0000 0000 05b9 015a
   0800 a6
10:58:01.299549 < 64.115.87.4.1523 > 192.168.0.100.10000: . 10:10(0) ack 12 win 7197 (DF)
   4500 0028 c44a 4000 6f06 ef01 4073 5704
c0a8 0064 05f3 2710 32fb 0194 2a7d 4113
   5010 1c1d 6e11 0000 0000 05b9 015a
   0800 a6
10:58:01.723791 < 64.115.87.4.1523 > 192.168.0.100.10000: P 12:12(11) ack 10 win 6432 (DF)
   4500 0033 dec8 4000 4006 0379 c0a8 0064
   4073 5704 2710 05f3 2a7d 4108 32fb 0194
   5018 1920 13f2 0000 a800 0000 05b9 015a
   0800 a6
10:58:01.723791 > 192.168.0.100.10000 > 64.115.87.4.1523: . 12:12(0) ack 16 win 6432 (DF)
   4500 002e c54a 4000 6f06 edfb 4073 5704
c0a8 0064 05f3 2710 32fb 0194 2a7d 4113
   5018 1c1d bd03 0000 ac00 0000 04ff
10:58:01.723791 > 192.168.0.100.10000 > 64.115.87.4.1523: . 12:12(0) ack 16 win 6432 (DF)
   4500 0028 dec9 4000 4006 0383 c0a8 0064
4073 5704 2710 05f3 2a7d 4113 32fb 019a
5010 1920 7108 0000
9 Mechanical Outline
10 Interconnection Cables

Interconnecting cables can be purchased via standard distribution outlets. Cable specifications are listed below for each connection type, except the AUI interface.

10BaseT and 10/100BaseTX:
- CAT5e minimum, solid or stranded conductor
- TIA/568-A straight pinned (non-crossover)
- RJ45 connector

100BaseFX:

**Multimode:**
- ST Connector (bayonet locking system), composite minimum
- Multimode, 62.5 um core, 125 um cladding diameter

**Single Mode:**
- SC Connector
- Single Mode, 8 um core, 125 um cladding diameter

The cable required for the AUX-SMC1 serial port is QEI P/N 40-057758-001, has a 6pin Molex connector on the 6NIA end and a DB9 Female on the other for connection to a 6ACP5 or other RS-232 device.

11 Ordering Information

<table>
<thead>
<tr>
<th>Model</th>
<th>Assembly Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6NIA1-0</td>
<td>40-057653-000</td>
<td>6CPP6 Mounting, w/out Fiber Optic</td>
</tr>
<tr>
<td>6NIA1-1</td>
<td>40-057653-001</td>
<td>6CPP6 Mounting, with Fiber Optic, Multimode ST</td>
</tr>
<tr>
<td>6NIA1-2</td>
<td>40-057653-002</td>
<td>Panel Mounting, w/out Fiber Optic</td>
</tr>
<tr>
<td>6NIA1-3</td>
<td>40-057653-003</td>
<td>Panel Mounting, with Fiber Optic, Multimode ST</td>
</tr>
<tr>
<td>6NIA1-4</td>
<td>40-057653-004</td>
<td>6CPP6 Mounting, with Fiber Optic, Single Mode SC</td>
</tr>
<tr>
<td>6NIA1-5</td>
<td>40-057653-005</td>
<td>Panel Mounting, with Fiber Optic, Single Mode SC</td>
</tr>
</tbody>
</table>

**NOTE**
In cases where the 6NIA1 is mounted (plugged into) a 6CPP6, the 6CPP6 must be programmed with the correct Program Link. Consult QEI for 6CPP6 support for the 6NIA1 prior to use in an RTU.
### 12 Other Related Equipment/Programs

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Description</th>
<th>QEI Part #</th>
</tr>
</thead>
<tbody>
<tr>
<td>6CPP6</td>
<td>6CPP6 Central Processing Panel</td>
<td>40-057552-XXXX</td>
</tr>
<tr>
<td>6ACP5</td>
<td>6ACP5 AC Input Panel</td>
<td>40-057584-XXXX</td>
</tr>
<tr>
<td>ConfigWiz</td>
<td>ConfigWiz® Configuration Software</td>
<td>80-000063-001</td>
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</tbody>
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### 13 Other Related Documentation

<table>
<thead>
<tr>
<th>Doc No.</th>
<th>Document Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>UG-1024</td>
<td>6CPP6 Central Processing User’s Guide</td>
</tr>
<tr>
<td>UG-1029</td>
<td>6ACP5 AC Input Panel User’s Guide</td>
</tr>
<tr>
<td>TP-803</td>
<td>6CPP6 Test Panel Manual</td>
</tr>
<tr>
<td>TP-802</td>
<td>6ACP5 Test Panel Manual</td>
</tr>
<tr>
<td>UM-2012</td>
<td>ConfigWiz® User’s Guide</td>
</tr>
<tr>
<td>09-055007-001</td>
<td>6CPP6/6NIA1 Upgrade Guide and Instructions</td>
</tr>
</tbody>
</table>