SAC HOST PORT COMMUNICATIONS

MicroComm DXI

Omron Host Protocol

Table of Contents

1. Intent & Scope

This document describes the interface to a PLC (Programmable Logic Controller) or HMI (Human-Machine Interface) host via an Omron network (which uses the FINS command system). The DXI emulates a CV-series PC (though it does not implement all features of the CV-series PC, just a subset).

Please note that low level communication details of the underlying protocol are beyond the scope of this document. This document is mainly concerned with the communication between the DXI and a PLC-based or HMI-based Host. Further references to a PLC-based Host apply equally to an HMI-based host.

2. References

“FINS Commands Reference Manual”, copyright 1993 by Omron (M11W227E11299.pdf). Only commands for CV-series PCs are supported.

“MicroComm DXI - Host Port Command/Status Messages”, copyright Harding Instruments Co. Ltd. This describes the actual messages that are used by the DXI. This can be found on the Harding Instruments Co. Ltd. website at www.harding.ca (http://www.harding.ca/uploads/pdf/IM-MES-DXI-R14_5.pdf).

3. Overview

The MicroComm DXI quickly and reliably exchanges command and status messages with external computer systems, which are referred to as “host computers”. This can be done with a variety of protocols, which are selected by the user in the configuration of the DXI system.

Omron network drivers allow the MicroComm DXI (hereafter referred to as DXI) to act like an independent PLC on an Ethernet network. The DXI is configured as the PC/CPU on the Omron network. The DXI can read and write registers on the real PLC, and the real PLC can read and write virtual registers on the DXI system. Since the DXI system looks like a PLC on the network, even though it is not a real PLC, it is sometimes referred to as a “pseudo-PLC”.

The DXI and the external PLC exchange command and status information by reading and writing blocks of registers. These command and status messages are generally associated directly with a particular master station in the DXI system; therefore, the DXI uses a separate set of register blocks for communications with each master station. This results in increased system performance by allowing multiple commands to be transmitted simultaneously to different master stations.

For each master station controlled by the host, the user must allocate two blocks of five registers[1] for that master to communicate with the PLC plus one (optional) register for “handshaking”. The first block of registers (always located on the DXI “pseudo-PLC”) is called the “input registers”. The PLC sends all commands for a particular DXI master station through its input registers. The PLC writes these registers and the DXI reads them.

The other block of registers, called the “output registers”, carry status messages from the DXI system to the PLC. Two different methods can be used to send status messages from the DXI system to the PLC. The DXI configuration determines which method is used. The handshake register (depending upon the mode of the output registers) is used to coordinate the output registers between the PLC and the DXI. There are two modes.

In the first method, called “peer to peer” mode, the DXI sends status messages to the PLC by writing directly to output registers contained within the PLC. The DXI generates a command to update the registers on the PLC and then waits for the PLCs response.

In the other method, called “polled” mode, the output registers are located on the DXI “pseudo-PLC” and the PLC or HMI must read them periodically (i.e., poll) to determine if there is a new message from the DXI system. **When polled mode is used, the DXI never writes commands the PLC**. Instead, the PLC reads status messages from virtual registers on the DXI pseudo-PLC. The DXI only sends responses, not commands.

To ensure that both the DXI and the PLC receive every message sent by the other, they must coordinate the message transfers. The handshake register and careful sequencing are used to ensure that the sending party does not overwrite any message before the receiving party reads it. The handshake register is located on the DXI pseudo-PLC (like the output registers in polled mode). The PLC writes to the handshake register to tell the DXI that the DXI can update the output registers.

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[1] Note, in this document the terms “input” and “output” are with respect to the DXI system.

The DXI also supports an optional "top of queue" update feature. If this feature is used, the DXI will maintain a block of queue registers that show the top N entries on the alarm queue for each master station. In peer-to-peer mode these registers are maintained on the PLC. In polled mode they are maintained on the DXI pseudo-PLC.

The register usage is described in greater detail later in this document (see the sections on communication between the PLC and the DXI).

4. Message Register Blocks

All command and status messages in the five-register blocks start with a code word followed by a maximum of 4 parameter words. All codes and parameters are two bytes (16-bits) in size; as a result, the code and parameters are limited to the range 0–65535. The value 0 is used as a null function code to indicate that there is no valid message in the register block. The input and output register blocks have the function code word in the first (lowest numbered) register. The first parameter is in the second register, the second is in the third register, etc. The register mapping is as follows:

Code	→	Base Register
Param #1	→	Base Register + 1
Param #2	→	Base Register + 2
Param #3	→	Base Register + 3
Param #4	→	Base Register + 4

The DXI processes the command message in the input registers when the code register is written. Similarly, it may update the output registers with a new status message when the code register is read and the command is executed. Wherever possible, block register transfers should be used for better performance. A block transfer means that all 5 registers should be read with a single FINS command, not a separate FINS command to read each of the 5 registers.

5. Command messages from PLC to DXI

The PLC sends command messages to the DXI by writing to the input registers. Because Omron FINS commands support block register updates, this is the preferred method of updating the DXI input registers. Single register transfers are possible with FINS commands but they are not recommended for DXI communication.

When the PLC is writing to the DXI input registers using block transfers there is no need for handshaking since the DXI will queue each received message for processing, and there is no possibility of overwriting the previous register contents.

However, when single register transfers are used, the PLC must ensure that the parameter values are written before the code register since the DXI will process the message when the code register is written. If the code register is not written last, the DXI processes the command using the new command code and the parameters from the previous message. In many cases this could result in errors; in others it could simply result in unexpected call connections and other strange behavior. **Furthermore, if the code register is not written to, the**

DXI will not process the command. Therefore, even if PLC is sending the same command with different parameters, it must re-write the code register. If it does not, the command will not be processed and will appear to be "lost".

6. Status messages from DXI to PLC

As stated earlier, there are two modes for the DXI to send messages to the PLC: peer-to-peer and polled. The peer-to-peer mode is the preferred communication mode (if the PLC can implement it). This is because peer-to-peer mode has fewer delays and can achieve faster response times (i.e., from the time that something happens, like a call request, until the PLC receives a message).

6.1 Peer-to-Peer Mode

In this mode, the DXI will write messages to the output registers located on the PLC using a block register transfer to update all 5 registers at the same time.

In peer-to-peer mode the DXI will write a message to the output registers and then wait for the PLC to read those registers before writing another message. Since the output registers are on the PLC in peer-to-peer mode, the DXI cannot tell when the PLC has read them. Therefore the PLC must write to the handshake register to acknowledge that it has read the current message from the output registers and that it is ready for the DXI to write the next message. The PLC can write any value into the handshake register; it is the write operation that is important, not the value written.

If a message is not acknowledged by writing the handshake register, the DXI system will not send further status messages to this master until a timeout period has expired. This will significantly slow the apparent response time of the system. This timeout is set to 13 seconds in the DXI (this is not configurable by the user).

Note that the handshake register is volatile. This means that the PLC cannot rely on reading back the value written. The value returned when reading the handshake register indicates whether or not the DXI has placed a new message into the output registers. On startup the PLC should initialize the output registers to 0, so it can reliably detect the first message. The PLC software should look for a non-zero value in the code register to detect a new message (0 is not a valid message). When it is done processing the command it should clear the registers, i.e., change the code register to 0 (the others do not have to be cleared). Then it should write to the handshake register to indicate that the PLC is ready for a new message. The PLC then goes back to checking for non-zero code registers.

6.2 Polled Mode

If the DXI configuration is set up to use polled mode, the PLC must poll the DXI output registers for each master to determine if new status information is available. If new status information is available, it must transfer the output register block to local registers within the PLC for processing.

In polled mode the DXI will update the output registers (located on the DXI), putting a non-zero value in the handshake register to send a message. The DXI does not send another message until the PLC has read the output code register. The PLC should always read all of a master's output registers with a single FINS commands. Single register transfers (i.e., reading each output register with a separate command) can cause problems due to the fact that reading the output registers causes the registers to change. Ergo, they should not be used by the PLC.

If the PLC is using block register transfers it can poll for new messages by reading the entire output register block periodically. Each time that the output code register is read indicates to the DXI that it can update the output registers. If there is no message, then the output code register (the first in the block of registers) will be zero. If there is a command, then the output code register will be non-zero. The PLC must detect and process each message before polling for another new message to prevent messages from being lost.

The handshake register is not needed in polled mode. However, it can be used to increase the performance of the communications link. This is done by assigning all the master station's handshake registers to sequential register addresses, and using a single block read of all the handshake registers (to check for new messages on any of the master stations). Any non-zero handshake registers are masters that have messages pending. For each master station with a new message, the PLC will need to do another block read of the output registers to read the new message.

7. Queue Register Blocks

The DXI can maintain a block of queue registers that show the top N entries on the alarm queue for each master station. This feature is optional and will only be activated if the queue registers are configured for a particular master station.

Each entry in this queue requires 2 registers, the first (lowest addressed) register in each pair holds an alarm type code, and the next holds the ID number of the device that generated the alarm. The length of the queue is set in the DXI master’s configuration. Since each queue entry requires 2 registers, the number of elements in the queue will be half the configured queue length.

The alarm codes are documented in the MicroComm DXI host port command and status message specification. An alarm code value of zero is used to indicate no alarm is present and, therefore, to ignore the device number.

In peer-to-peer mode the queue registers are maintained on the PLC. The DXI can update these registers at any time, so it is important that they are used for display purposes only and that they are redisplayed periodically to reflect any changes the DXI may make to the registers.

In polled mode the queue registers are maintained on the DXI pseudo-PLC. The PLC must poll the queue registers periodically and then use its local copy to update its queue display. The PLC can read these registers at any time.

8. Future Version Compatibility

All the command and status function codes are defined in the MicroComm DXI Host port command/status message specifications. However, the MicroComm DXI system may be enhanced by adding new command codes at any point in the future. Therefore, it is important that the PLC not write any command codes not defined in the function code specification. A command code that is ignored by the DXI today may do something completely unexpected in a future version of the DXI software.

Similarly, the PLC must accept and ignore any status message sent by the DXI that it does not understand. When a message is ignored it must still be acknowledged so that the DXI can continue sending other status messages. Each type of message can be enabled/disabled in the DXI host port configuration.

9. Establishing a Connection

Because the Omron protocol uses UDP/IP for connections, the DXI and PLC must know each other's IP address and their port number. The configuration of the Omron host (from the DXI menus) is described later in this document. UDP/IP (User Datagram Protocol/Internet Protocol) is a standard Internet protocol. Its main feature is that communication between two computers (in our case the PLC and the DXI) does not require a permanent 'connection' (i.e., connection in the Internet sense, a physical connection is obviously required).

In TCP/IP, the PLC would have to establish a connection with the DXI. The DXI could then to determine the IP address of the PLC from this connection. However, in UDP/IP there is no connection established. All commands are 'broadcast' on the Ethernet link and then the appropriate PLC or DXI will process these commands. Therefore, the DXI must know the IP address of the PLC and the PLC must know the address of the DXI to be able to 'broadcast' the message.[2]

In peer-to-peer mode the PLC should write to the handshake register to start a session. This tells the DXI that the PLC is ready for it to write to the output registers.

In polled mode the PLC should read the handshake register first if there is one. This will let the PLC know if the DXI has a message ready for it to read from the output registers. If handshake registers are not used then the output registers should be read first.

The DXI only supports a subset of the FINS commands. The current implementation supports the following FINS commands from the PLC (i.e., which the DXI can recognize and decode). The only command that the DXI sends to the PLC is the "Memory Area Write". A description of the command format can be found in the FINS command reference. These all return the appropriate FINS responses.

0101	Memory Area Read
0102	Memory Area Write
0103	Memory Area Fill
0104	Multiple Memory Area Read
0701	Clock Read
0702	Clock Write

The DXI only supports the DM Area (type 82) of Omron memory. The Omron PLC is divided into many different types of memory. All other memory areas are invalid and cause the DXI to return an error to the PLC.

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[2] Note that the term 'broadcast' in this instance means that the command is sent out regardless of whether anyone is listening or not. The address is set in the configuration.

When a FINS command is sent from the DXI to the PLC, the DXI starts a 6-second timer. If this timer expires before the command's response is received by the DXI, then the DXI resends the command. The DXI tries (a maximum of) 2 times before giving up. It will then go onto the next command (if there is one) to be sent after this timeout. This cannot be changed in the configuration.

A maximum of 20 commands can be queued up on the DXI. If more than 20 commands are queued up then the newest commands will be ignored and not sent to the host computer. As soon as a response is received the next command in the queue is processed (sent if in peer-to-peer or ready to be read if in polled mode). The command buffer size cannot be changed in the configuration. It is important that the PLC process commands quickly to prevent commands from being lost by exceeding this limit.

The DXI cannot decode FINS command/response 'broadcast' addresses (i.e., with an address of 0xFF) on the network. These are ignored and, therefore, no response sent.

10. Synchronizing the PLC and DXI

If the PLC connects to the DXI after the DXI has been running for some time, the PLC's status information will not be in sync with the DXI's status information. For example, the DXI may have call requests queued on master stations or calls in progress. Therefore, to obtain this information, PLC should send a status request command station (see STAT command in the host port command/status specification) for each master. This special DXI command causes the DXI to send all the messages the PLC will need to synchronize its status with the DXI. The messages that are sent are exactly the same as if the call requests had just been queued, or the calls had just been made; therefore, that no additional command processing, other than that required for normal operation, need to be done.

11. Error Conditions

If the PLC sends an invalid register read or write command to the DXI (i.e., if it tries to access a register that is not defined in the DXI configuration), or attempts to write to a read only register, the DXI will ignore the command and respond with an error. These errors are logged by the DXI.

If the PLC issues command messages with invalid or disabled command codes, the DXI will ignore them. See above for a list of the supported command codes.

12. Configuration

12.1 IP Address

The host port IP address is determined by the IP address of the SAC computer that is acting as the pseudo-PLC. This IP address is, typically, set when the system software is installed on the SAC computer. The host address can be changed by amending the /etc/hosts file on the SAC computer (from the system menu)[3].

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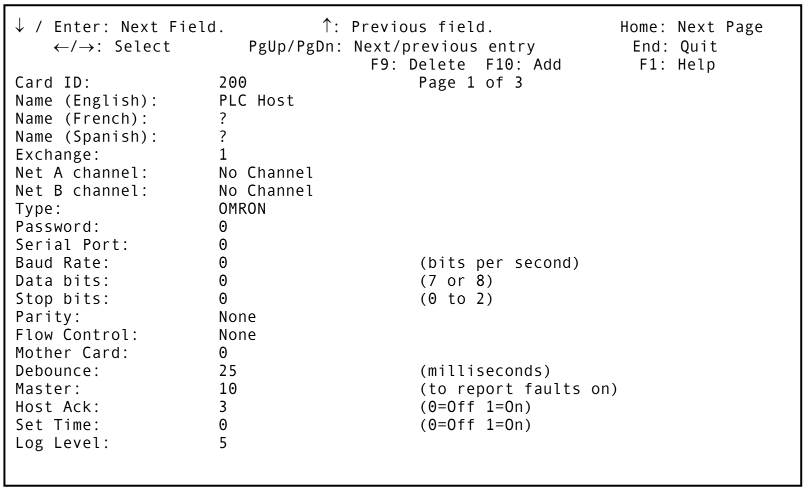
[3] Normally this is done during setup but the user can do it afterwards. Check the DXI documentation for instructions on changing the DXI's IP address.

12.2 Host Port

When configuring a card as a host port using the Omron driver, the following fields must be defined in the card database of the hardware configuration.



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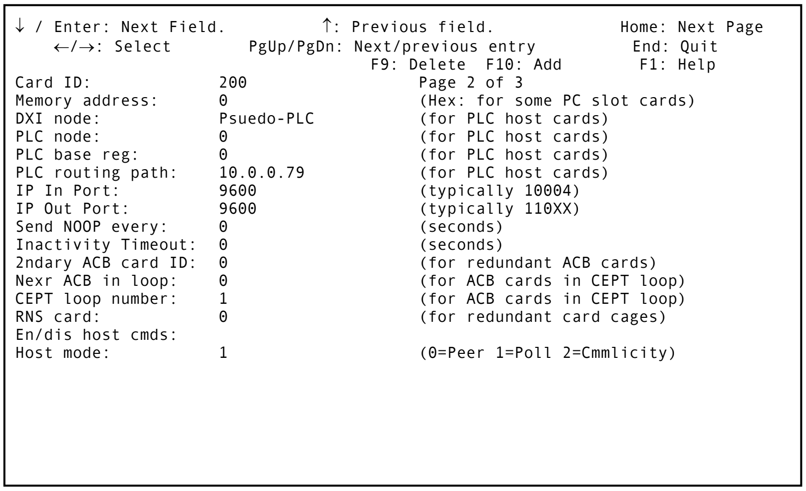
↓ / Enter: Next Field.         ↑: Previous field.           Home: Next Page
    ←/→: Select       PgUp/PgDn: Next/previous entry         End: Quit
                                   F9: Delete  F10: Add       F1: Help
Card ID:             200                  Page 1 of 3
Name (English):      PLC Host
Name (French):       ?
Name (Spanish):      ?
Exchange:            1
Net A channel:       No Channel
Net B channel:       No Channel
Type:                OMRON
Password:            0
Serial Port:         0
Baud Rate:           0                    (bits per second)
Data bits:           0                    (7 or 8)
Stop bits:           0                    (0 to 2)
Parity:              None
Flow Control:        None
Mother Card:         0
Debounce:            25                   (milliseconds)
Master:              10                   (to report faults on)
Host Ack:            3                    (0=Off 1=On)
Set Time:            0                    (0=Off 1=On)
Log Level:           5
```

The “Card ID” field is a unique identifier for this card. It will be used to direct messages from master stations to this card (see the master’s “External host” setting).

The “Exchange” field must contain the exchange ID of the SAC computer that the PLC will be connected to. This is the SAC exchange number, not the QNX node number.

The “Type” field must be set to “OMRON”.

The “Host Acknowledge” field selects the way that the DXI acknowledges host port commands. When this field is “0” the DXI will only respond to host port commands that fail for some reason (i.e. busy stations, invalid Ids, etc.) with a negative acknowledgement. When this field is “1” the DXI will acknowledge all commands from the PLC with either a positive or negative acknowledgement. When this field is “2” the DXI will acknowledge all commands as above, and it will also send all status messages resulting from commands from other sources in the form of positive acknowledgements. When this field is “3” the DXI will acknowledge all commands, and send all status messages resulting from commands without the positive acknowledgement prefix. See DONE, FAIL, and BUSY in the host port command/status message specifications for additional information on the acknowledgment messages.



```
↓ / Enter: Next Field.         ↑: Previous field.           Home: Next Page
    ←/→: Select       PgUp/PgDn: Next/previous entry         End: Quit
                                   F9: Delete  F10: Add       F1: Help
Card ID:             200                  Page 2 of 3
Memory address:      0                    (Hex: for some PC slot cards)
DXI node:            Psuedo-PLC           (for PLC host cards)
PLC node:            0                    (for PLC host cards)
PLC base reg:        0                    (for PLC host cards)
PLC routing path:    10.0.0.79            (for PLC host cards)
IP In Port:          9600                 (typically 10004)
IP Out Port:         9600                 (typically 110XX)
Send NOOP every:     0                    (seconds)
Inactivity Timeout:  0                    (seconds)
2ndary ACB card ID:  0                    (for redundant ACB cards)
Nexr ACB in loop:    0                    (for ACB cards in CEPT loop)
CEPT loop number:    1                    (for ACB cards in CEPT loop)
RNS card:            0                    (for redundant card cages)
En/dis host cmds:
Host mode:           1                    (0=Peer 1=Poll 2=Cmmlicity)
```

The “PLC base reg” field is not used. It should be set to 0 in the configuration.

The “PLC routing path” field is the IP address of the PLC. This can be stored as an IP address (i.e., 10.0.0.79) or as a name (if the name is in the /etc/hosts file of the SAC).

The “IP In Port” field should contain the TCP port number that the DXI will monitor for commands from the PLC. This can be the same as the “IP Out Port” and typically defaults to 9600.

The “IP Out Port” field should contain the TCP port number that the PLC will monitor for commands from the DXI. This can be the same as the “IP In Port” and typically defaults to 9600.

Omron messages have a three byte network address associated with each FINS command: the network address, node number, and unit address. The network address of the DXI is stored in “DXI network” field of the card database. The node number is set in the “DXI node” field of the card database. The unit address is always 0[4]. The network address for the PLC is stored in “PLC network” field of the card database. The node number is set in the “PLC node” field of the card database. The unit address is set in the “PLC module” field of the card database. When a command is received by the DXI the destination address must match the DXI network address. The response will be sent with the destination and source switched (so the destination of the response is the command’s source and vice versa). DXI commands are addressed to the PLC address.

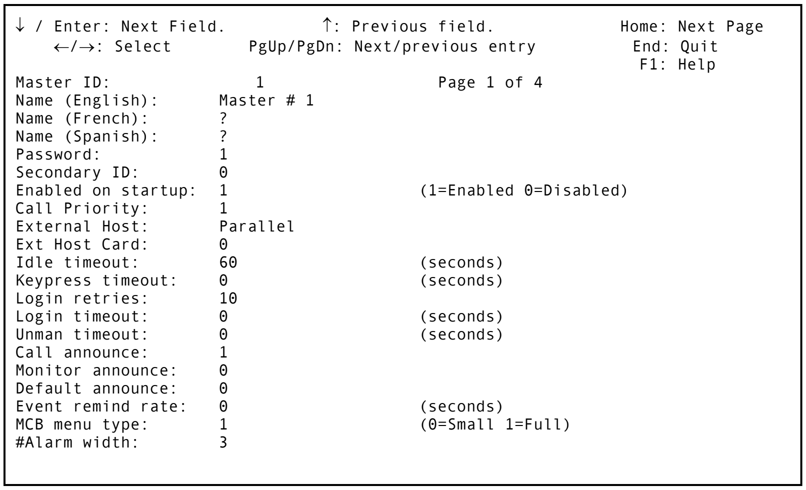
The “Host Mode” setting of 0 (Peer) causes the DXI to be in the “peer-to-peer” mode. A setting of 1 (Poll) will cause the DXI system to be in “polled mode”. See above for a description of these modes.

The “En/Dis host commands” field will bring up a list of the possible messages that the DXI can send to the PLC. Each of these messages can be enabled or disabled. When a message is disabled, the DXI will not send that message to, or accept that message from, the PLC.

12.3 Master

The following fields must be defined in the master’s software configuration.

The “External host” field is used to specify which host port is to be used for communication to and from this master station and how it will operate. It will be “None” when the master does not use a host port. It should be “Parallel” or “Exclusive” when the master has a host[5]. In parallel mode both the host port and the master display/keypad can actively control the master station at the same time (i.e. you can start a call with a host port command and end it by pressing a key on a DXI master station’s keyboard). In exclusive mode, the master’s screen (i.e., 4x20 LCD screen) is disabled until the user hits a key. If the user hits a key, then the master’s screen is enabled and the PLC and master keypad run in parallel mode. If the key press timeout expires (“Keypress TO”) without any keys being hit, the screen is disabled.



```
↓ / Enter: Next Field.         ↑: Previous field.           Home: Next Page
   ←/→: Select        PgUp/PgDn: Next/previous entry         End: Quit
                                                              F1: Help
Master ID:               1                Page 1 of 4
Name (English):      Master # 1
Name (French):       ?
Name (Spanish):      ?
Password:            1
Secondary ID:        0
Enabled on startup:  1                  (1=Enabled 0=Disabled)
Call Priority:       1
External Host:       Parallel
Ext Host Card:       0
Idle timeout:        60                 (seconds)
Keypress timeout:    0                  (seconds)
Login retries:       10
Login timeout:       0                  (seconds)
Unman timeout:       0                  (seconds)
Call announce:       1
Monitor announce:    0
Default announce:    0
Event remind rate:   0                  (seconds)
MCB menu type:       1                  (0=Small 1=Full)
#Alarm width:        3
```

The “Ext host card” field is used to specify which host port is to be used for communications to and from this master station. It is the card ID number of a DXI card configured as an Omron host.

The second page of the Master Station software configuration is shown on the next page.

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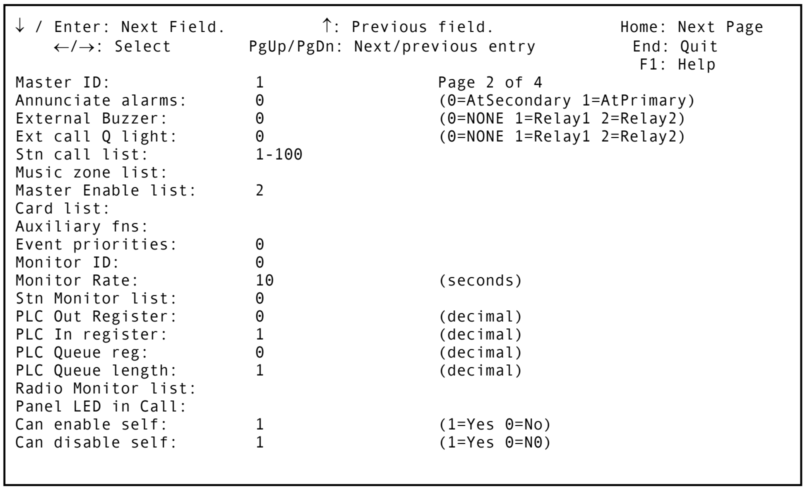
[4] Zero means that the address is from a PC’s CPU, not gateway/link unit. See the Omron command reference for more information.

[5] Parallel mode is the typical setting. Exclusive mode is rarely used and only affects masters that have DXI LCD keypad/displays.



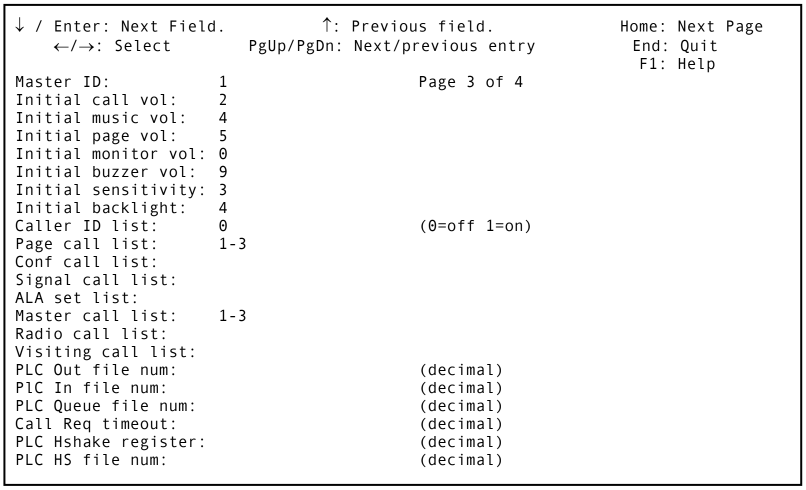
```
↓ / Enter: Next Field.          ↑: Previous field.             Home: Next Page
    ←/→: Select         PgUp/PgDn: Next/previous entry          End: Quit
                                                                 F1: Help
Master ID:               1                  Page 2 of 4
Annunciate alarms:       0                  (0=AtSecondary 1=AtPrimary)
External Buzzer:         0                  (0=NONE 1=Relay1 2=Relay2)
Ext call Q light:        0                  (0=NONE 1=Relay1 2=Relay2)
Stn call list:           1-100
Music zone list:
Master Enable list:      2
Card list:
Auxiliary fns:
Event priorities:        0
Monitor ID:              0
Monitor Rate:            10                 (seconds)
Stn Monitor list:        0
PLC Out Register:        0                  (decimal)
PLC In register:         1                  (decimal)
PLC Queue reg:           0                  (decimal)
PLC Queue length:        1                  (decimal)
Radio Monitor list:
Panel LED in Call:
Can enable self:         1                  (1=Yes 0=No)
Can disable self:        1                  (1=Yes 0=N0)
```

The “PLC Out register” field is used to specify the base address of a block of 5 output registers for the master station. This address will be either in the DXI pseudo-PLC or PLC (depending upon whether the card is in peer-to-peer or polled mode).

The “PLC In register” field is used to specify the base address of a block of 5 input registers for the master station. These registers are always in the PLC.

The “PLC Queue reg” field is used to specify the base address of a block of queue registers (“PLC Queue length” controls the number of registers in the block) for the master station.

The “PLC Queue length” field is used to specify the length of the queue register block for the master station. Each entry on the queue requires 2 registers so the actual length of the queue is 1/2 times this field’s value. This should be set to 0 to disable the PLC queue (the “PLC Queue reg” should also be 0 when the PLC queue is disabled).



```
↓ / Enter: Next Field.          ↑: Previous field.             Home: Next Page
    ←/→: Select         PgUp/PgDn: Next/previous entry          End: Quit
                                                                 F1: Help
Master ID:           1                    Page 3 of 4
Initial call vol:    2
Initial music vol:   4
Initial page vol:    5
Initial monitor vol: 0
Initial buzzer vol:  9
Initial sensitivity: 3
Initial backlight:   4
Caller ID list:      0                    (0=off 1=on)
Page call list:      1-3
Conf call list:
Signal call list:
ALA set list:
Master call list:    1-3
Radio call list:
Visiting call list:
PLC Out file num:                         (decimal)
PlC In file num:                          (decimal)
PLC Queue file num:                       (decimal)
Call Req timeout:                         (decimal)
PLC Hshake register:                      (decimal)
PLC HS file num:                          (decimal)
```

The third page of the Master Station software configuration is displayed on the right.

The “PLC Hshake register” field is used to specify the address of a master station’s handshake register in the DXI pseudo-PLC.

The “PLC Out file num”, “PLC In file num”, “PLC Queue file num”, and “PLC HS file num” fields are used to determine the type of FINS data. If set to 0 then they are assumed to be 82, which means two bytes per register in the “DM Area”[6]. If non-zero the entered values will be assumed to be valid memory areas. Currently, the DXI only supports type 82 (DM Area).

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[6] See the section on Memory Area Designations in the FINS command reference.

13. Redundant DXI SAC computers

When connecting to a SAC (System/Administration Computer) the host can test whether that SAC is active by sending an **ActS** command to any master on that SAC. If the SAC responds with **ActS 1**, then it is active. If it responds with **ActS 0**, it is inactive (i.e., running as the redundant SAC).

In a redundant SAC system, the host should send this **ActS** command to both SACs to determine which is active.

Once the host has determined which SAC is active, it should send all commands to the active computer only (except for the **NOOP** command, which can be sent to/from the inactive computer). All commands sent to an inactive computer will be **IGNORED** (except for **Actv**, which can be used to tell this SAC to become active).

The inactive SAC does not send any status response messages except for a periodic **NOOP** command, if enabled. The active SAC will send all of the status response messages for this exchange.