FL-net (OPCN-2)
Network Interface Module
Model: R3-NFL1

Users Manual

M·SYSTEM CO.,LTD.

CONTENTS

BEFORE GETTING STARTED...

Thank you for choosing M-System R3 Series Remote I/O, model R3-NFL1 FL-net (OPCN-2) Interface Module.

This manual describes necessary points of caution when you use this product, including function descriptions, installation, wiring procedure and hardware setup. Please read this manual carefully to ensure this product's safe use before getting started.

A series of documents is provided for this product as listed below, each providing helpful instructions and suggestions for maximum use of the R3-NFL1. They are available in the CD package that came with your product.

Title	Reference No.	Contents
R3-NFL1 FL-net (OPCN-2) Interface Module Users Manual	EM-8426-B	This document. Describes the hardware functions and setup.
R3-NFLBLD FL-net Configuration Builder Software Users Manual	EM-8426-C	Describes the software functions and operations.

 CAUTION !

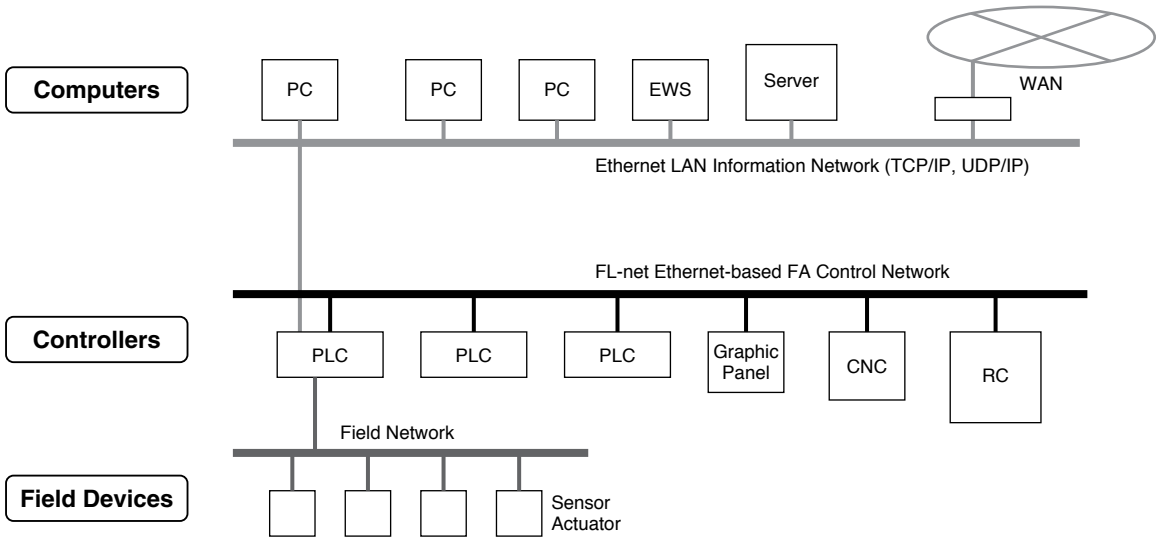
If you intend to use the R3-NFL1 in the following environments or conditions, redundant and/or failsafe system designs should be used to ensure the proper degree of reliability and safety.

- Environments or conditions which are not defined in this manual
- Nuclear power control devices, railway control devices, aircraft control devices, transportation vehicles, fuel control equipment, medical equipment, recreational equipment, safety equipment, and other critical equipment for which safety must be secured according to relevant laws.
- Those devices which inherently require extremely high level of safety and reliability.

1. FL-net (OPCN-2) OVERVIEW

1.1 FL-net (OPCN-2) PROTOCOL

FL-net enables personal computers and FA controllers, such as programmable controllers (PLCs) or computerized numeric controllers (CNCs), by different manufacturers to be interconnected, controlled and monitored, as shown in the following illustration.



FL-net (OPCN-2), which has been established in the JIS (Japan Industrial Standards) and the JEM (Japan Electrical Manufacturers) standards, is adopted by most PLC manufacturers. Detailed information such as the certified products list, FL-net specifications and implementation guides is available at the Open PLC Network (OPCN) in the Japan Electrical Manufacturers Association (JEMA) web site: http://jema-net.or.jp/Japanese/hyojun/opcn-e/top-opcn.htm.

The OPCN standardized the OPCN-1, applied to the device level in the above illustration, and the OPCN-2, applied to the controller level. The FL-net was originally developed by the Manufacturing Science and Technology Center (MSTC) and then standardized as the controller level network, OPCN-2, thus referred to as FL-net in this manual.

1.2 FL-net FEATURES

• Open Standards for Multiple Vendors

FL-net enables personal computers and FA controllers, such as programmable controllers (PLCs) or computerized numeric controllers (CNCs), by different manufacturers to be interconnected, controlled and monitored.

<table>
<tr><td>Application Layer</td><td colspan="2">User Application Interface</td></tr>
<tr><td rowspan="3">FA Link Protocol Layer</td><td rowspan="2">Cyclic Transmission</td><td>Message Service</td></tr>
<tr><td>Message Transmission</td></tr>
<tr><td colspan="2">Token Management</td></tr>
<tr><td>Transport Layer</td><td colspan="2">UDP</td></tr>
<tr><td>Network Layer</td><td colspan="2">IP</td></tr>
<tr><td>Data Link Layer</td><td colspan="2" rowspan="2">Ethernet
(IEEE 802.3 standard)</td></tr>
<tr><td>Physical Layer</td></tr>
</table>

• Conforms to Widely Used Standards

The use of Ethernet with the standard UDP/IP achieves efficient communications including the following benefits:

Low cost
Configuration employing widely used communication devices reduces the overall cost.

Compatible with existing network devices
Transceivers, network hubs, cables, LAN cards for personal computers, and other network devices widely used for Ethernet can be used.

Future upgrading in speed
Baud rates are expected to improve in the future, increased to 10 Mbps, 100 Mbps, or up to 1 Gbps.

Optical communications
Fiber optics media converters which are also commonly used for Ethernet, when inserted in strategic sections of the network, not only enable a long-distance transmission, but also improve noise resistance of the system and protect it against lightning surges when installed outdoor.

• Supports Needed Functions Among FA Controllers

The FL-net specifications, originally developed based on users' requirements, support the following features:

Large-scale network
Up to 254 devices (nodes) can be connected on the network.

Two data transmission modes
The FL-net supports the cyclic transmission mode in which each node continuously shares all data in the common memory, and the message transmission mode in which specific data is sent only when requested between relevant nodes.

Large-capacity Common Memory
The common memory is provided with a large capacity of 8k bits and 8K words.

High-speed response
High-speed response time of 50 milliseconds per 32 nodes (for 2k bits and 2k words) is achieved.

High reliability by the masterless configuration
The absence of a master in the FL-net network enables nodes to be added or removed readily without affecting any other nodes. This allows any device on the network to be freely turned on or off, and facilitates its maintenance.

1.3 FL-net FAQ

Q1 What is Ethernet?

A. Ethernet is a specification which defines the cable types used in a Local Area Network (LAN). Data on the Ethernet can be transferred among computers at a communication speed of 10 Mbps to 100 Mbps. Currently, the Ethernet most used for office applications is that of 100-Mbps twisted pair cable (UTP). Ethernet can support various types of software protocol provided by multiple vendors.

Q2 What is FL-net?

A. FL-net is a network that connects FA controllers, such as PLCs (PLC) or numerical control devices (CNC) and performs high-speed exchange of control data among these controllers. The cables and other components are the same as those used in Ethernet systems.

Q3 What is the difference between FL-net and Ethernet?

A. The Ethernet connects host computers/personal computers to controllers in order to give production instructions, to monitor and control various production data (information network).

In addition, the FL-net is used to connect between the controllers and exchange the data in the high speed (control network).

When one controller module must be equipped for both the host Ethernet and the local FL-net control, use extreme care not to misconnect the cables.

Q4 How do you use an FL-net module?

A. An FL-net module is mounted to a FA controller such as PLC or CNC, and configured with a node number (station number) and a link allocation setting for the common memory (link register) just like these devices are. The cyclic transmission among the controllers is enabled without needing a special PLC communication program.

Moreover, no special communication program is required for reading and rewriting data or communication parameters from/to the PLC. It should be noted that each controller will need a program if the data is handled using message transmission among the controllers.

Q5 What is protocol? Specifically, what protocol does FL-net support?

A. Protocol consists of the rules necessary for communication between devices. The FL-net supports the UDP/IP protocol on the physical layer and uses a dedicated protocol called FA Link Protocol on the upper layer.

Q6 Can a general-purpose PC be connected to the FL-net?

A. An FL-net module mounted to FA controllers is an intelligent module that has processors on the boards. Ethernet modules mounted to PCs are referred to as dumb boards, which means that they are not 'intelligent'. Although it depends on the PC's performance and how it is used, using the intelligent type FL-net board is recommended.

Q7 What is topology?

A. Network topology indicates the wiring configuration of a network. Star (tree), bus and ring configurations are typical ones. It is probably easier to think of these as logical arrangements rather than the physical layout of the cables.

The 10BASE-T/100BASE-TX used on the FL-net uses the star topology. The 10BASE5 uses the bus topology.

Q8 What is the relationship between the type of network cable and the cable length and number of modules that can be connected?

A. The following are some of the standards, characteristics and limitations of most commonly used Ethernet cable.

Note: Values shown in ( ) indicate that a repeater is used.

10BASE-T/100BASE-TX

Twisted pair cable (STP/UTP). The maximum transmission distance per segment is 100 meters (500 meters). The maximum number of modules per segment is 254.

10BASE5

Thick coaxial cable (yellow cable). The maximum transmission distance per segment is 500 meters (2500 meters). The maximum number of modules per segment is 100 (254).

10BASE-FL

Fiber optics cable. The maximum transmission distance per segment is 2000 meters. The maximum number of modules per segment is 254.

2. FL-net GENERAL PRECAUTIONS

The following are restrictions and precautions unique to the FL-net.

1) Other Ethernet data shall not be handled on the FL-net communication cables.
2) Do not connect the FL-net to a router.
3) An Ethernet switch has no effect even if used on the FL-net.
4) The real-time characteristics of the FL-net communication will be dramatically reduced if infrared or other types of wireless media are used.
5) The performance of a personal computer, if used on the FL-net, its operating system and application software may dramatically change the real-time characteristics of the FL-net communication.
6) Use the preset IP address.

   The network address must be grouped for all devices (192.168.250).

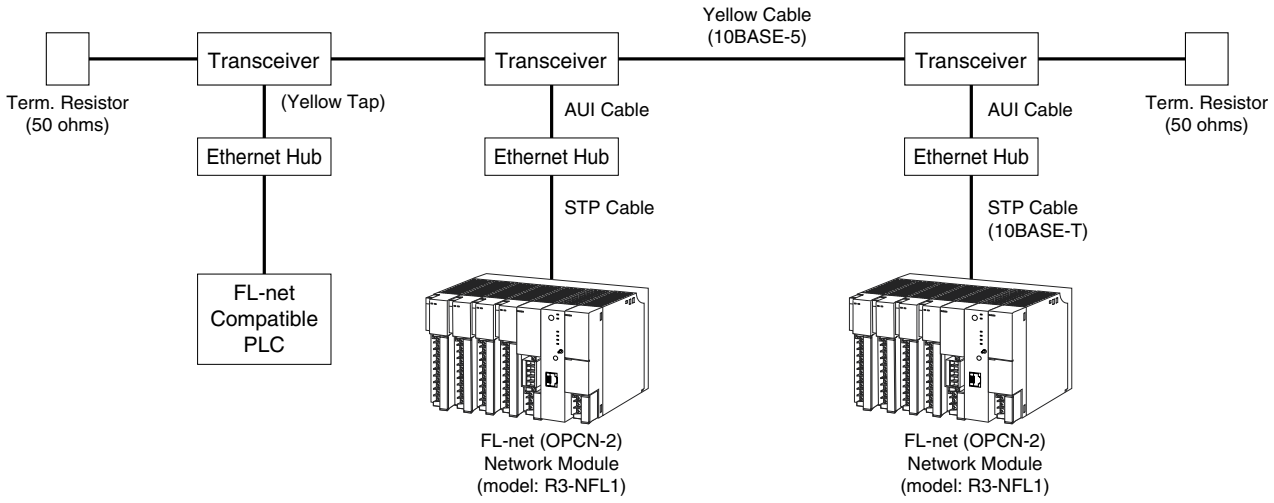
   The node numbers should be assigned among the recommended range (1 to 249).

   Duplicate node numbers are not checked during the initial setting but alerted only when communication has been started. Be careful not to set an identical node number to multiple devices.
7) Always provide a proper ground. Be sure to use a heavy gauge wire for grounding.
8) Keep away the FL-net from electrical noise sources. Avoid routing the FL-net cables alongside power cables.
9) The real time characteristics of the FL-net communication may be reduced depending upon data volumes and other factors when the cyclic and message transmissions are performed simultaneously.
10) There is no need of assigning consecutive addresses without break when mapping the common memory area used for the cyclic transmission for each node.
11) When the transceiver is equipped with an SQE switch, follow instructions in the supplier's manual for correct setting.
12) The fixed time communication characteristics of the overall system depends upon the processing performance of the devices connected to it. The communication processing speed of all will be automatically adjusted to match that of the slowest one (allowable minimum frame interval). This means an addition of one module to the network may dramatically reduce the real-time performance of the overall system that has been previously achieved.
13) The message transmission header is composed in the big-endian format, while the data is in the little-endian format. Except the system parameters, data section of a Profile Read message, is in the big-engian format. (Big-endian refers to a multi-byte data architecture in which the most significant bit (MSB) is stored at the lowest address and thus dispatched first.)
14) Do not mix devices of different protocol versions or modes on single network. The current updated Version 2.0 is not compatible with the older Version 1.0.

3. FL-net INTERFACE MODULE

3.1 SYSTEM CONFIGURATION

The R3 Series Remote I/O device can accept various types of I/O modules mounted on a backplane (the Base). It is connected to the FL-net via the R3-NFL1 Network Module.

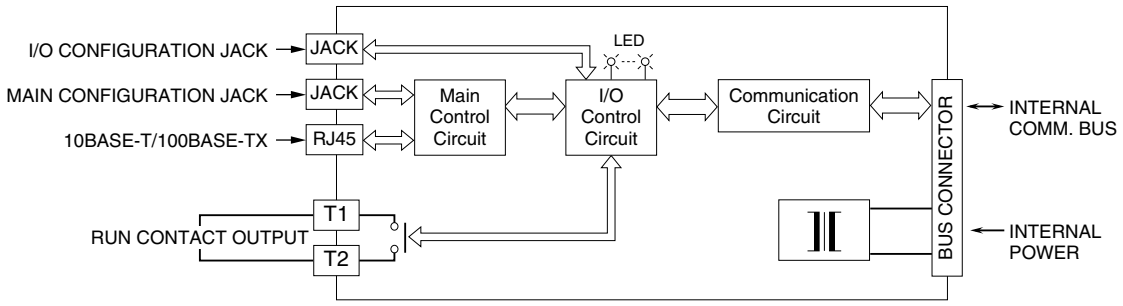


A small system can be configured only with Ethernet hubs. Multiple hubs can be interconnected via twisted-pair cables to expand it, and fiber optics media converters are used to connect to those in remote locations. Choose appropriate types of hubs which can be connected via 10BASE5 or 10BASE2 cables if they are to be used with the FL-net.

3.1.1 GENERAL SPECIFICATIONS

Model	R3-NFL1
Internal current consumption	130mA
Operating temperature	-10 to +55°C (14 to 131°F)
Operating/storage humidity	30 to 90% RH (non-condensing)
Atmosphere	No corrosive gas or heavy dust
Insulation resistance	≥100MΩ with 500V DC (Ethernet to internal bus or internal power to RUN output)
Dielectric strength	1500V AC @1 minute (Ethernet to internal bus or internal power to RUN output)
Module dimensions	W27.5 x H139 x D109 mm (1.08” x 5.47” x 4.29”)
Weight	200 g (7.1 oz)
Protocol	FL-net (OPCN-2), Version 2.00 (incompatible with Version 1.00)
Baud rate	10 Mbps and 100 Mbps
Physical layer standard	Conforms to IEEE 802.3 (CSMA/CD)
Transmission media	10BASE-T: STP cable, category 5 100BASE-TX: STP cable, category 5e or higher
Maximum segment length	100 meters
Maximum number of nodes	254
Maximum cyclic data size	8k bits + 8k words / system (1 word = 16 bits) 4k bits + 256 words / node
Maximum message data size	1024 bytes per transmission cycle
Token cycle time	50 milliseconds (2k bits + 2k words / node, 32 nodes in total)

3.1.2 FUNCTIONAL BLOCK DIAGRAM



3.1.3 SUPPORTING TOOL: FL-net CONFIGURATION BUILDER

The FL-net Configuration Builder, model R3-NFLBLD, is a PC software program to set up the FL-net related parameters and allot the common memory area of the R3-NFL1.

- The configuration setup is downloaded to the R3-NFL1 via Ethernet.
- The configuration stored in the R3-NFL1 can be uploaded and stored in a file.
- The management tables stored in the R3-NFL1 can be called up on the screen.

For detailed information, refer to the R3-NFLBLD Users Manual (EM-8426-C).

3.1.4 COMMON MEMORY ALLOCATION

The R3-NFL1 supports the common memory as shown in the tables below.

Transmitting to FL-net

	Maximum effective size	Contents
Area 1	256 words (4k bits)	Updated values of specifically assigned I/O modules (in the bit / word units)
Area 2	256 words	Identical to the above, but in the word units only

Receiving from FL-net

	Maximum size	Contents
Area 1	512 words (8k bits)	Values supplied to specifically assigned output modules (in the bit / word units)
Area 2	8192 words	

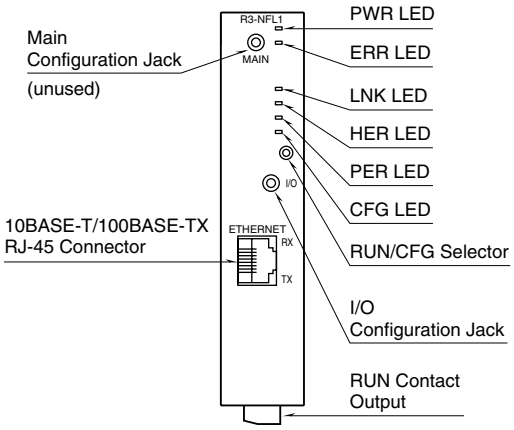
The common memory is assigned to specific I/O modules in the R3-NFLBLD program.

The I/O data format depends upon the I/O module type.

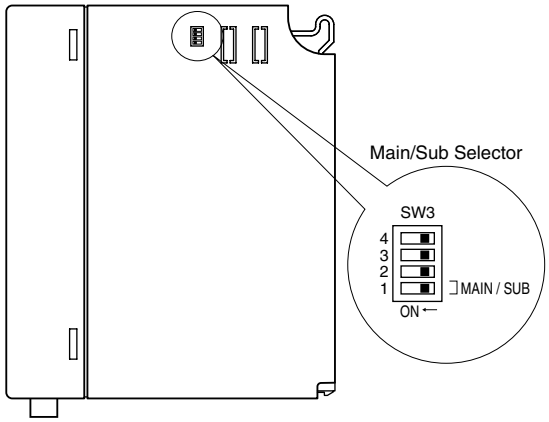
- Temperature input (thermocouple and RTD): 16-bit binary data. With °C temperature unit, raw data is multiplied by 10. For example, 25.5°C is converted into 255. With °F unit, the integer section of raw data is directly transferred. For example, 135.4°F is converted into 135. Minus temperature is converted into negative values, represented in 2's complements.
- Analog (voltage/current) I/O: 16-bit binary data. Basically, 0 to 100% of the selected range is converted into 0 to 10000 (binary) or 0000 to 2710 (hexadecimal). -15 to 0% is represented in 2's complements.
- Discrete I/O: Channel 1 data is assigned to the LSB, Channel 2 to the second LSB, and so on in the ascending order. '1' is given to the relevant bit when the contact is closed (on). Data exceeding 16 channels is assigned to the following words in the same manner. Discrete signals can be assigned to any bit / word of the common memory, point by point.

3.2 COMPONENT IDENTIFICATION

■ **FRONT VIEW**



■ **SIDE VIEW**

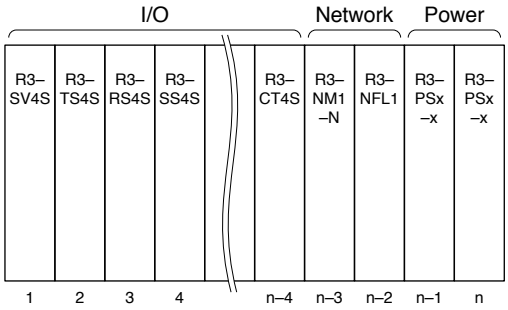


Main configuration jack		Unused
10BASE-T/100BASE-TX RJ-45 connector		Connected to Ethernet twisted-pair cable
Indicator LED	PWR	Green light turns on when the CPU and the internal bus function normally.
	ERR	Red light turns on in an abnormality of the system.
	LNK	Red light turns on while the R3-NFL1 is participating FL-net (normal communication)
	HER	Red light turns on in an abnormality of the R3-NFL1 module (e.g. I/O modules assigned with the common memory are not mounted, or hardware abnormality such as the burnout).
	PER	Red light blinks on with the parameter setting error.
	CFG	Red light blinks in 0.2 second intervals at the startup; blinks in 2 second intervals while the builder software is used; blinks in 1 second intervals while the module starts up in the safe boot mode.
	TX	Green light turns on while transmitting.
	RX	Amber light turns on while receiving.
RUN/CFG selector		Toggle switch; RUN or CFG (Configuration) With the switch set to CFG, the module stops the internal data scanning, and is ready to download the configuration setting from the PC via Ethernet. The output operation also stops when the exiting node output clear setting is set to 'Switch to the subsystem's control.' When the power supply is turned on with the switch set to CFG, the module starts up in the safe boot mode if it is switched to the RUN position while the CFG LED blinks three times (3 seconds). The temporary node number, 254, is assigned to the module in this mode, so that the system can safely starts even when the real node number is unknown. This safety function is independent and valid even when the firmware is in a critical failure.
I/O configuration jack		Connected to a dedicated cable used to configure I/O modules using the R3CON PC Configurator Software.
RUN contact terminal block		Relay turns on when the CPU and the internal bus function normally.
Main/Sub selector		When two network modules are mounted on single base, one must be 'Main' (OFF) network and the other must be 'Sub' (ON) network. For single communication, the network module must always be set to 'Main' (OFF).

4. MOUNTING FL-net INTERFACE MODULE

Module Position

The R3-NFL1 module is mounted with other modules on the base. Basically, mount the I/O modules from the left end (I/O 1) to the right direction, followed by the network module(s) and the power supply module(s).

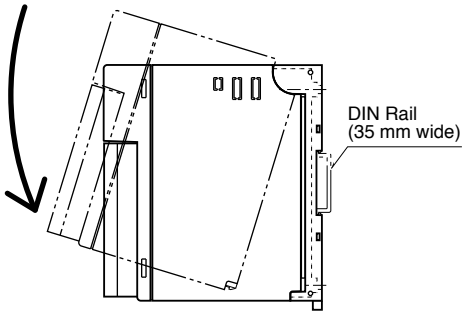


The builder software identifies each I/O module by its I/O address, normally its slot (position) number assigned from the left (I/O 1) to the right (I/O n) on the R3-BSx base. The positions may be freely arranged with the R3-BSWx base which is provided with address setting switches for each slot.

How to Mount the Module

Align the positioning guide at the upper bottom of the module to the top of the base and push it down until it clicks against the base connector.

When removing the module, pull it up in holding the adaptor at the lower bottom the module.



Hardware Switch Setting

Set the Main/Sub selector and the RUN/CFG selector at the front referring to Section 3.2.

I/O Modules

The DIP switches on the side of I/O modules must be properly configured before joining the FL-net. Refer to the data sheet of each module.

Unused channels (unconnected terminals) must be also properly handled, because it may alert as a hardware error and turn HER LED on. Follow instructions given in the instruction manual of respective I/O modules or specify such channels on the R3CON software.

5. USAGE GUIDE

5.1 ABOUT FL-net

5.1.1 GENERAL DESCRIPTIONS

Concept

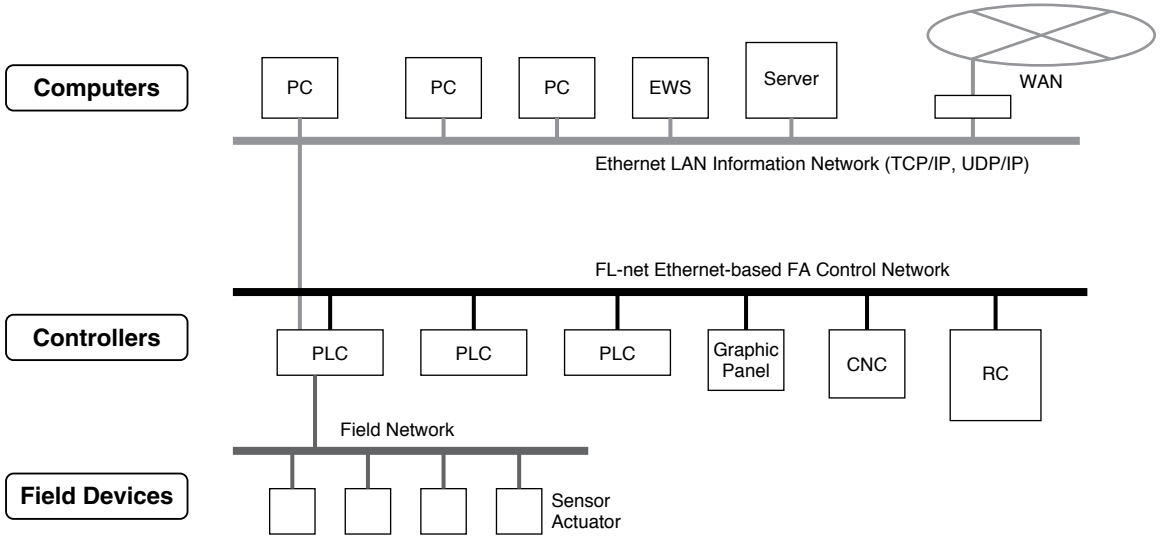
FL-net is an FA control network using Ethernet. It supports the cyclic data transmission and the message data transmission.

FL-net systems have the following features.

- Ethernet is used for the physical and data link layers to communicate between controllers.
- Most commonly used UDP/IP protocol is used for basic data exchanges.
- While benefited by the above basic architecture, the FL-net ensures a certain data transfer cycle time by managing and controlling data access between each node on the network (collision control).

FL-net is designed to provide realtime communications between controllers in manufacturing systems, such as programmable controllers (PLCs), robot controllers (RCs), and computerized numeric controllers (CNCs).

The following illustration shows the positioning of the FL-net.



Protocol Layer Configuration

The FL-net is composed of six protocol layers.

Application Layer		User Application Interface
FA Link Protocol Layer		Cyclic Transmission / Message Service
		Cyclic Transmission / Message Transmission
		Token Management
Transport Layer		UDP
Network Layer		IP
Data Link Layer		Ethernet (IEEE 802.3 standard)
Physical Layer		Ethernet (IEEE 802.3 standard)

FA Link Protocol Layer

The FA link protocol layer of the FL-net is characterized by the following:

1) Transmission control using masterless token system avoids collision.
2) Refresh cycle time can be regulated since the system circulates a token in a fixed time.
3) The token is transmitted together with a cyclic data.
4) The node with the smallest node number among those who participate the network at the startup time shall dispatch the token.
5) If no token is transmitted for a specified time period, the next node in the token circulation ring shall dispatch a new token.
6) The masterless token system characterized by the above will keep the network from stopping in case of failure of certain nodes.
7) The protocol provides information management tables to refer operating status of other nodes such as online/offline status, hardware alarm status.

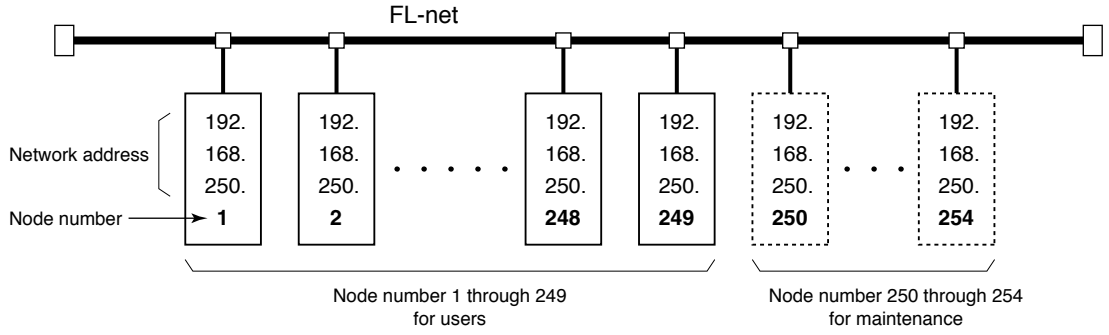
IP Address

The default FL-net IP address is 192.168.250.N (N: Node number between 1 and 254). Do not assign duplicate node numbers. It is recommended to use Class C address, with the host address in the lower byte matching the FL-net protocol node number.

5.1.2 NODE NUMBER

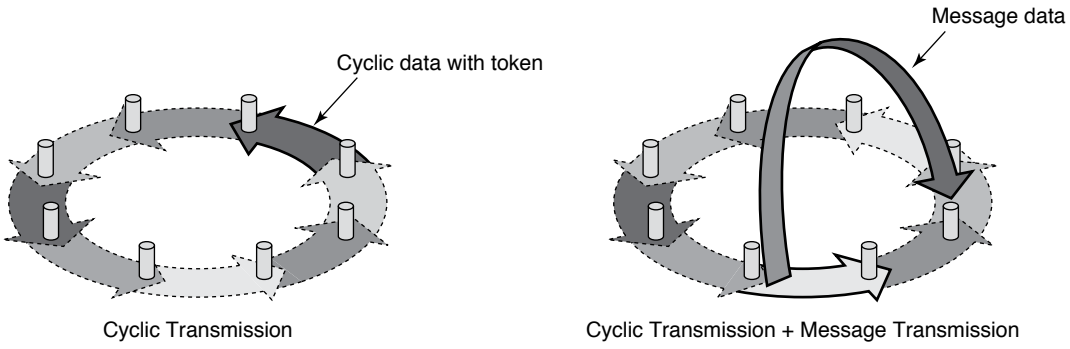
Up to 254 nodes can be connected to the FL-net network. Each node is assigned with a node number from 1 to 254.

Node	Applications
1 to 249	Used for standard FL-net devices
250 to 254	Used for FL-net maintenance purposes
255	Reserved for internal system use; Not available to users.
0	Reserved for internal system use; Not available to users.



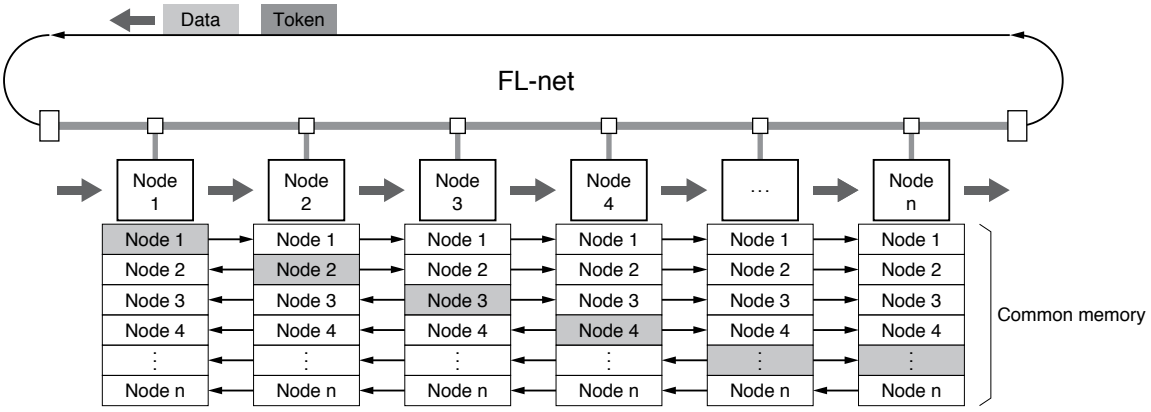
5.1.3 TRANSMISSION DATA TYPE

The FL-net protocol supports two types of data communication.



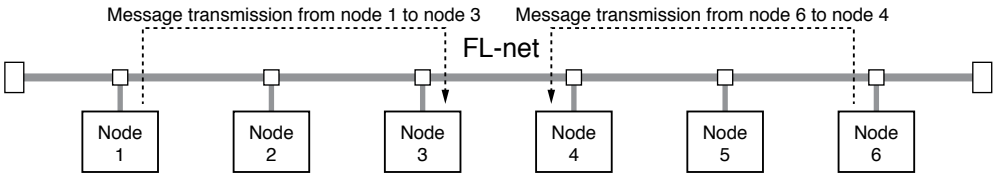
Cyclic Transmission

Cyclic transmission means a function that supports cyclic data exchange between the nodes. All nodes share data simultaneously in the common memory.



Message Transmission

Message transmission means a function that supports non-cyclic data exchange between the nodes. Specific data is sent from one node to another only when requested.

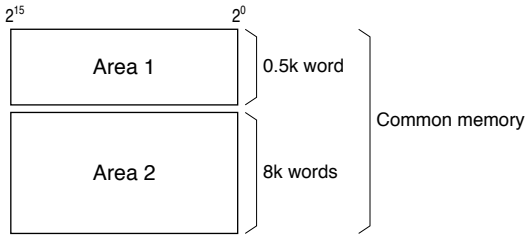


5.1.4 TRANSMISSION DATA VOLUME

Cyclic Transmission

Common memory size = 8k bits (0.5k word) + 8k words = 8.5k words.

The maximum available data volume per node = 8.5k words (1 word = 2 bytes)



Message Transmission

The maximum data length of one message frame = 1024 bytes (excluding the header)

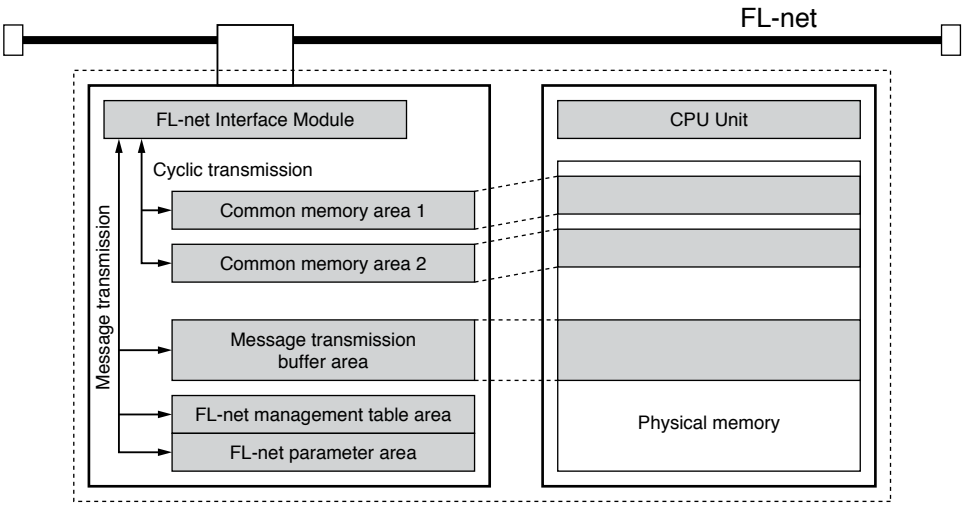
5.1.5 DATA REFRESH CYCLE TIME

With cyclic transmissions, the common memory is refreshed on a regular cycle time. Message transmissions are controlled so that the common memory refresh time does not exceed the allowable refresh cycle time.

Each node constantly monitors message frames that travel through the network from the time it receives own token until it does the next own token. When no message frame travels through the network for the entire cycle time, 120% of the cycle time is fixed as the maximum allowable refresh cycle time.

The allowable refresh cycle time is thus determined actively according to the number of joining nodes in the network.

5.1.6 DATA AREA AND MEMORY



5.1.7 COMMUNICATIONS MANAGEMENT TABLES

The own node management table, the participating node management table and the network management table are available to monitor the status of nodes.

Users do not have to be aware of the contents of these tables since there is no user programming used for the R3-NFL1.

For detailed information, please refer to Appendix C.

5.1.8 CYCLIC TRANSMISSION

Cyclic Transmission Function

Cyclic transmission means a function that supports cyclic data exchange between nodes.

- The cyclic transmission implements common memory interface.
- Each node sends its whole data while it holds the token.
- Nodes having no cyclic data are acceptable.

Only one token exists in the network at any given time. If there is more than two, the one with the smallest destination node number prevails, and the others are discarded.

A frame including a token (token frame) is provided with a destination node number and a sender node number. Each node in turn becomes the token holding node when its node number matches with the destination node number in the received token frame.

The token rotation order is determined in the ascending order of node numbers registered in the participating node management table. The node with the largest node number releases a token to the one with the smallest node number.

Common Memory

- The common memory interface provides nodes participating the cyclic transmission with a virtual memory area on the network.
- Each node on the FL-net has a specific transmission area in the common memory that does not overlap with others. A transmitting area of one node must be a receiving area for all other nodes. Having no transmitting area but only receiving areas is also allowed.

  The transmitting area size for each node can be allotted freely within the maximum area range within the common memory.
- Each node broadcasts its own data in a fixed cycle time. The other nodes receive and store it in its relevant memory area. The contents of each memory area are identical, thus it can be called the 'common' memory.

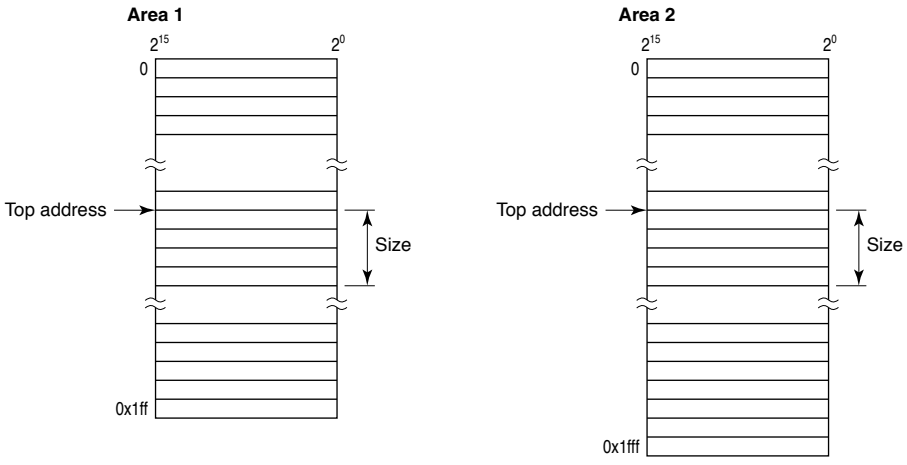
  The application used by a node gets access to transmitting data of other nodes by specifying its address on its own memory.
- The common memory will not update itself with receiving data until all frames from one node are successfully received, thus concurrence of multi-frame data in the node units is guaranteed.

Area 1 and Area 2 Data

A node shall be assigned with two transmitting data areas, area 1 and area 2, in the common memory.

A transmitting area is defined with the top address and the size.

Access to the areas is made by word address. The area 1 consists of 0.5k word (8k bits) and the area 2 consists of 8k words.



Data Concurrence

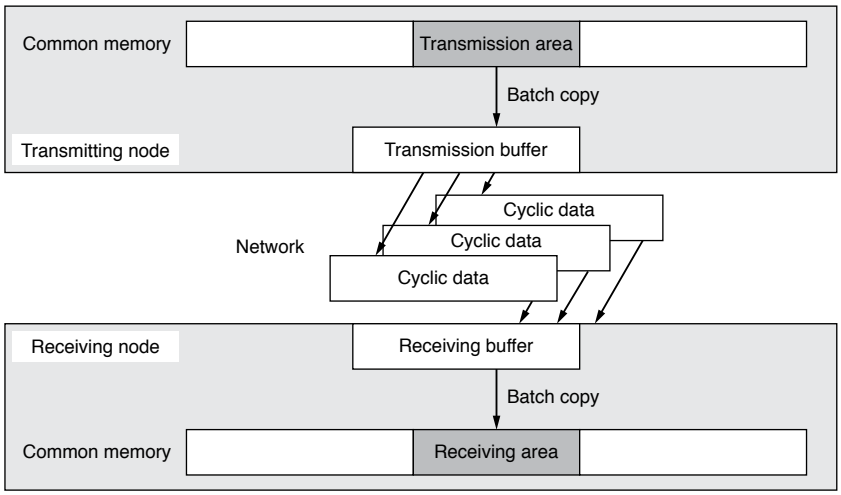
Multiple frames may be used if the transmitting data size of one node exceeds the transmission size of one frame. The following procedure is taken to guarantee the concurrence of data in the node units.

Transmitting timing

Upon receiving a transmitting request from the upper layer, the cyclic data from the local node is copied into the buffer, prepared for transmission, and then transmitted in order. If the size of the data held in the transmitting node is greater than the maximum capacity that can be sent in one frame (1024 bytes), the data in the buffer is divided into multiple frames before transmitting.

Refresh timing when receiving data

As soon as the receiving node has received all the cyclic data from one node, the relevant area in the common memory is refreshed in synchronization with the upper layer. When a node receives cyclic data in multiple frames, the area is refreshed as soon as all the frames from the sender node have been received. If the received frames are incomplete, all the data that was transmitted from the node is discarded.



5.1.9 MESSAGE TRANSMISSION

Message Transmission Function

Message transmission means a function that supports non-cyclic data exchange between nodes.

- When a node receives a token, it sends up to one (message) frame before transmitting its own cyclic frames.
- Data volume that can be transmitted in a frame is equal to or less than 1024 bytes (except the header).
- Algorithm is provided so as not to exceed the allowable maximum refresh cycle time for cyclic transmission.
- Both 'peer-to-peer' transmission to a specific destination node and 'broadcast' transmission to all nodes are provided.
- Delivery acknowledgement function is provided to confirm successful data delivery to the destination node in the peer-to-peer message transmission.

Supported Messages

The R3-NFL1 supports the FL-net defined functions listed in the following table. Only the server function is supported.

Server function allows the module to build a response frame to a request message.

Client function allows the module to transmit a request message and to receive its response frame.

Message Type	Server	Client
Byte block read	No	No
Byte block write	No	No
Word block read	Yes	No
Word block write	Yes	No
Network parameter read	Yes	No
Network parameter write	No	No
Start / Stop command	Yes	No
Profile read	Yes	No
Log data read	Yes	No
Log data clear	Yes	No
Message echo back	Yes	No
Transparent mode	No	No
Vendor specific	No	No

Transaction Code

The header of each message contains a request transaction code or a response transaction code that determines the type of message frame.

Transaction code (decimal)	Application
65005	Word block read frame (request)
65006	Word block write frame (request)
65007	Network parameter read frame (request)
65009	Stop command frame (request)
65010	Start command frame (request)
65011	Profile read frame (request)
65013	Log data read frame (request)
65014	Log data clear frame (request)
65015	Message echo back frame (request)
65205	Word block read frame (response)
65206	Word block write frame (response)
65207	Network parameter read frame (response)
65209	Stop command frame (response)
65210	Start command frame (response)
65211	Profile read frame (response)
65213	Log data read frame (response)
65214	Log data clear frame (response)
65215	Message echo back frame (response)

Word Block Read

This function reads messages in the word units (16 bits per address) from the virtual address space (32-bit address space) of a specific node in the network.

A request message contains the target node number, the word block offset address (virtual address) and the word block size, and a response message is returned accordingly.

It is used only when necessary to communicate with the I/O modules, in order to reduce the overall load to the data traffic using the cyclic transmission.

32-bit virtual address configuration

1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0
A				B												C								D							

	Bit	Contents
A	31 to 28	I/O module type 0 : Di 1 : Ai 2 : Do 3 : Ao
B	27 to 16	Di/Do data size Specify the bit count (1...64) for Di/Do data if the entire virtual address space is not to be used. '0' means the whole words defined by the virtual address space is assigned.
C	16 to 8	Slot (module) number 1...16 (max. value depends upon the hardware module type) or 0. '0' can be specified only for the Di's module status* information.
D	7 to 0	Channel number 1...64 (max. value depends upon the hardware module type)

*Module Status is a word composed of bits indicating each I/O module's status (mounted or not), provided also for the cyclic transmission. Read only. Refer to the R3-NFLBLD Users Manual (EM-8426-C) for more information.

Virtual address size

Specify the 16-bit word data size for each type of signals:

Di/Do : 1 to 4 words
Ai : 1 to 16 words
Ao : 1 to 8 words

The Di/Do data can be assigned bit by bit as explained in the above table, within a single node station.

Data

Each channel of Di/Do data is assigned to single bits, a binary value of which the digit of the relevant channel is shifted to the LSB. When the data volume exceeds 16 bits, a following word is used. Channel numbers may not be a value multiplied by 16, but any value is possible.

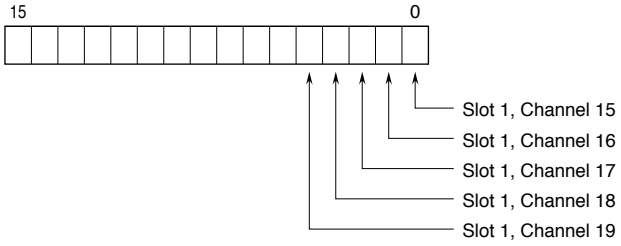
The data is continuously scanned and updated in the internal memory, and is returned without loss of time upon request. If the updated data is not available due to e.g. an I/O module failure, an error message is returned.

[Example]

Request message Word block offset address : 0x0005010F
A : 0 = Di
B : 005 = 5 bits of data is requested.
C : 01 = Slot number 1
D : 0F = Channel 15

Response message
4-byte size of data is usually defined for Di/Do data, however, only 5 bits is specifically requested in 'B' section of the request message. The response message is composed accordingly as shown below.

A response message is composed in the word unit. A whole word is sent but it contains only 5 bits of data in it.



Response message result

When a response message is normally returned, the M_RLT (response message result) at the header of the response shows '0'.

When a response message is abnormal, the M_RLT shows '1' and the data section contains the following 16-bit codes.

-1 : Invalid parameter
-2 : No response due to the module Not mounted or failed

Word Block Write

This function writes messages in the word units (16 bits per address) to the virtual address space (32-bit address space) of a specific node in the network. The configuration of the virtual address space is identical to that used for Word Block Read function.

Network Parameter Read

This function reads from the network the network parameters related to a specified node. The response for this request is composed as follows:

Word offset	Parameter
+0	Node identification (equipment name)
+5	Vendor identification
+10	Product model identification
+15	Area 1 top address in common memory
+16	Area 1 data size in common memory
+17	Area 2 top address in common memory
+18	Area 2 data size in common memory
+19	Token watchdog time
+20	Allowable minimum frame interval
+21	FA link status Upper layer operation signal error Common memory data validity notification Common memory (top address/size) setting completion Address overlapping detection
+22	Protocol version
+23	Upper layer status
+24	Allowable refresh cycle time / RCT setting time
+25	Refresh cycle measurement time (current)
+26	Refresh cycle measurement time (maximum)
+27	Refresh cycle measurement time (minimum)

Start / Stop Command

This function starts / stops operations of the remote device connected to the FL-net. Start / Stop means the following conditions of the R3-NFL1.

Stop

- The R3-NFL1 stops the internal bus scanning for the I/O modules.
- The last output data is held at the network module and is not sent to output modules.
- The last scanned input data is transmitted cyclically. Used for maintenance of the internal data.

Start

- The R3-NFL1 starts the internal bus scanning for the I/O modules.

Profile Read

This function reads from the network the device profile data related to a specified node. The R3-NFL1 provides the following information in the response message.

Profile	ID		Data		
	Length	Character	Type	Length	Character
Device profile common specifications version	6	COMVER	Integer	1	1
System parameter identifier	2	ID	PrintableString	7	SYSPARA
System parameter revision number	3	REV	Integer	1	1
System parameter revision date	7	REVDATE	Integer	2	2005
			Integer	1	1
			Integer	1	1
Device category	10	DVCATEGORY	PrintableString	3	SP-RIO
Vendor identification	6	VENDOR	PrintableString	8	M-SYSTEM
Product model identification	7	DVMODE	PrintableString	7	R3-NFL1

Log Data Read

This function reads from the network the log data related to a specified node. The following log data is provided for the R3-NFL1.

Log category	Log item	Implemented (Y) or Not (N)
Transmission / reception	Total number of transmissions at socket unit	Y
	Total number of transmission errors at socket unit	Y
	Number of Ethernet transmission errors	N
	Total number of receptions	Y
	Total number of reception errors	Y
	Number of Ethernet reception errors	N
Frame types	Number of tokens transmitted	Y
	Number of cyclic frames transmitted	Y
	Number of peer-to-peer messages transmitted	Y
	Number of broadcast messages transmitted	Y
	Number of tokens received	Y
	Number of cyclic frames received	Y
	Number of peer-to-peer messages received	Y
	Number of broadcast messages received	Y
Cyclic transmission	Number of cyclic reception errors	Y
	Number of cyclic address size errors	Y
	Number of cyclic CBN errors	Y
	Number of cyclic TBN errors	Y
	Number of cyclic BSIZE errors	Y
Message transmission	Number of message retransmissions	Y
	Number of message over-retransmissios	Y
	Number of message reception errors	Y
	Number of message version-of-sequence number errors	Y
	Number of message sequence number retransmissions recognized	Y
ACK-related	Number of ACK errors	Y
	Number of ACK version-of-sequence number errors	Y
	Number of ACK sequence number errors	Y
	Number of ACK node number errors	Y
	Number of ACK TCD errors	Y
Token-related	Number of token multiplications recognized	Y
	Number of tokens discarded	Y
	Number of tokens re-issued	Y
	Number of token holding timeouts	Y
	Number of token monitoring timeouts	Y
Status 1	Total service time	Y
	Number of frame waiting states	Y
	Number of participations	Y
	Number of self-exits	Y
	Number of exits by skipping	Y
	Number of exits of other nodes recognized	Y
Status 2	List of participation recognized nodes	N

Log Data Clear

This function clears from the network the log data related to a specified node.

Message Echo Back

This function requests a specific node to return exactly the received message. It is used to run the FL-net module's internode testing.

5.2 SETTING UP FL-net

Refer to the R3-NFLBLD Users Manual (EM-8426-C).

6. TROUBLESHOOTING

6.1 WHAT TO CHECK FIRST

Confirm the following checkpoints first whenever the FL-net interface module does not seem to operate properly.

1) Are all hardware modules firmly mounted on the base?
2) Have all hardware switches for the R3-NFL1 module been correctly set?
3) Has the IP address for the R3-NFL1 module been correctly set?
4) Has the common memory area been correctly set?
5) Is there any looseness or other abnormalities at the connectors (terminals) on the module?
6) Are the communication cables properly connected?
7) Is the terminal resistance for the 10BASE5 cable connected?
8) Is the ground for the 10BASE5 cable connected?
9) Is a cross cable not being used for 10BASE-T cable?
10) Does the cable meet Category 5 specifications?
11) Is the power supplied to the Ethernet hub and the repeater (if any)?
12) Is the link light on the Ethernet hub turned on?

6.2 CONFIRMING ETHERNET IP ADDRESS

IP address of the FL-net interface module and its connecting status can be confirmed using a general purpose Windows PC. The following procedure using 'Ping' function is applied to Windows 7.

1) Go to Start > All Programs > Accessories > Command prompt.
2) Enter 'Ping' command and run the basic communications test between the FL-net interface module and the PC. Compose the command as follows: Ping [IP address] or Ping [Host name].

[Example] `Ping [192.168.250.13]`

When the device with the target IP address is correctly set and connected to the network, the following response message is returned.

```
Pinging 192.168.250.13 with 32 bytes of data:

Reply from 192.168.250.13:bytes=32 time<10ms TTL=128
Reply from 192.168.250.13:bytes=32 time<10ms TTL=128
Reply from 192.168.250.13:bytes=32 time<10ms TTL=128
Reply from 192.168.250.13:bytes=32 time<10ms TTL=128

Ping statistics for 192.168.250.13:
Reply from 192.168.250.13:bytes=32 time<10ms TTL=128
Packets: Sent=4, Received=4, Lost=0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum=0ms, Maximum=0ms, Average=0ms
C:\>
```

When the device with the target IP address is Not connected (NG), the following response message (timeout) is returned.

```
Pinging 192.168.250.13 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 192.168.250.13:
Packets: Sent=4, Received=0, Lost=4 (100% loss),
Approximate round trip times in milli-seconds:
Minimum=0ms, Maximum=0ms, Average=0ms
C:\>
```

APPENDIX A. ETHERNET OVERVIEW

A-1. GENERAL DIFFERENCES BETWEEN ETHERNET AND FL-net

1) FL-net is a network designed for FA environments and is not completely compatible with general-purpose Ethernet devices. Some devices are not suitable due to noise resistance and environment resistance requirements.
2) Only FL-net-compatible controllers and control devices can be connected to the FL-net to meet the demands of control applications requiring responsiveness in realtime communications.
3) FL-net employs cyclic communications using the broadcasting function supported by UDP/IP protocol based on the 10BASE5 and 10BASE-T standards.

   The following restrictions currently apply.

   • Most currently compatible devices use 10-Mbps Ethernet LAN.

   • Connection to other general-purpose Ethernet systems is not supported.

   • TCP/IP communications are not supported.

   • Ethernet switches cannot be used effectively (no benefit).

   • Routers and similar devices should not be used.

APPENDIX B. NETWORK SYSTEM DEFINITION

B-1. COMMUNICATION PROTOCOL STANDARD

Protocol consists of the rules necessary for communication between devices. The FL-net communication protocol conforms to the following standards:

FL-net communication protocol	Standards
FL-net	FA link protocol specification (JEM 1479 FA Control Network [FL-net (OPCN-2) protocol specifications])
UDP	RFC 768
IP, ICMP, etc.	RFC 791, 792, 919, 922, 950
ARP etc.	RFC 826, 894
Ethernet	IEEE 802.3

B-2. COMMUNICATION PROTOCOL LAYER CONFIGURATION

Communications protocol is modelled in a layer structure. Communication processing is expressed and standardized using these layers,

FL-net consists of six protocol layers as shown in the following diagram.

<table>
<tr><td>Application Layer</td><td></td><td colspan="2">User Application Interface</td></tr>
<tr><td rowspan="3">FA Link Protocol Layer</td><td rowspan="3"></td><td rowspan="2">Cyclic Transmission</td><td>Message Service</td></tr>
<tr><td>Message Transmission</td></tr>
<tr><td colspan="2">Token Management</td></tr>
<tr><td>Transport Layer</td><td></td><td colspan="2">UDP</td></tr>
<tr><td>Network Layer</td><td></td><td colspan="2">IP</td></tr>
<tr><td>Data Link Layer</td><td rowspan="2"></td><td colspan="2" rowspan="2">Ethernet
(IEEE 802.3 standard)</td></tr>
<tr><td>Physical Layer</td></tr>
</table>

B-3. PHYSICAL LAYER

With a baud rate of 10 Mbps, five transmission methods are available in the Ethernet's physical layer: 10BASE5, 10BASE2, 10BASE-T, 10BASE-F, and 10BROAD-36 (although not commonly used).

There is also 100-Mbps Ethernet.

The FL-net uses 10BASE5 (recommended), 10BASE2 and 10BASE-T among these methods.

B-4. IP ADDRESS

An IP address (INET address) is used to identify a specific communications device from many others connected to the Ethernet. A unique IP address must be assigned to each device.

An IP address is comprised of a network address indicating the network to which the device is connected, and a host address of the individual device. It is classified into three classes, depending on the network size: Class A, B, and C (Class D and Class E are also used for other specific purposes).

	Top octet value	Network address	Host address
Class A	0 to 127	xxx.xxx.xxx.xxx	xxx.xxx.xxx.xxx
Class B	128 to 191	xxx.xxx.xxx.xxx	xxx.xxx.xxx.xxx
Class C	192 to 223	xxx.xxx.xxx.xxx	xxx.xxx.xxx.xxx

Note: xxx. indicates the corresponding address sections.

The IP addresses for communications devices connected to the same network will all have the same network address; each device will have a unique host address. The default FL-net IP address is 192.168.250.N (N: Node number between 1 and 254). It is recommended to use Class C address, with the host address in the lower byte matching the FL-net protocol node number.

B-5. SUBNET MASK

The FL-net subnet mask is fixed at 255.255.255.0, matching Class C original network address and host address. There is no need for the users to change this setting.

B-6. TCP/IP, UDP/IP TRANSMISSION PROTOCOL

TCP, UDP and IP are major protocols used in Ethernet. IP protocol is positioned in the network layer which controls the flow of communication data.

TCP and UDP protocols are positioned in the transport layer. While both use IP at the network layer, the provided services are significantly different. TCP provides a reliable delivery service so that the upper layer will not need to be aware of the breaks in data. UDP, however, functions by simply transferring data clusters from IP (datagrams) to the upper layer without modification, and without confirming whether the data has reached the destination. It leaves the confirmation of reception and the retransmission processing to the top layer. UDP does not have the reliability of TCP, but can deliver communications services with small overhead.

FL-net uses UDP because TCP's elaborate data confirmation and retransmitting procedures are redundant in the FL-net system. High-speed data exchange is enabled by replacing these procedures with those for controlling the right to transmit using tokens and performing multiple frame division/reconstruction in the upper FL-net protocol layer.

B-7. PORT NUMBER

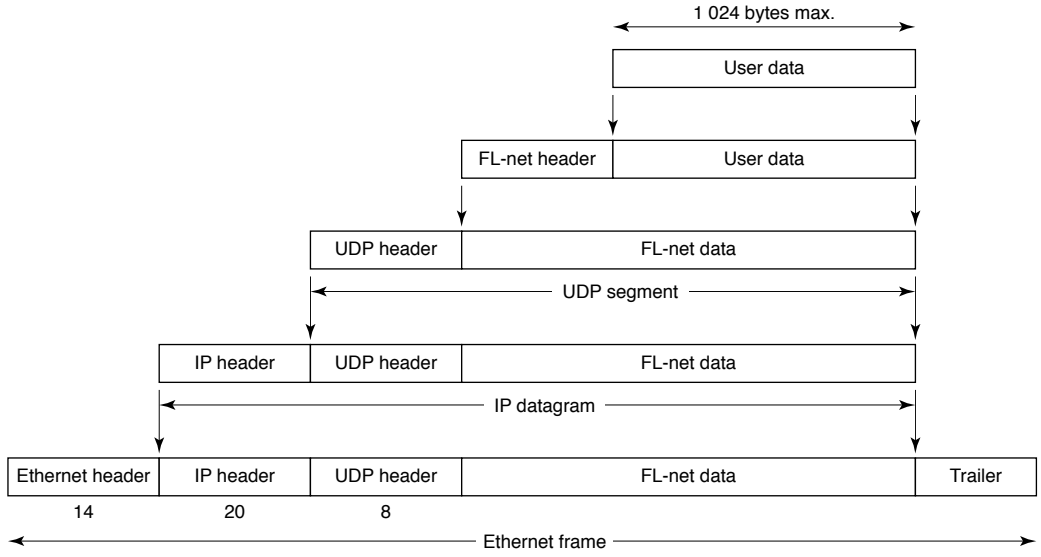
The following port numbers are assigned in advance to enable services in the FL-net protocol layer located above the transport layer. FL-net users, however, do not need to set these port numbers in parameters or elsewhere.

Application	Port number
Token frame and cyclic frame	55000 (fixed)
Message frame	55001 (fixed)
Trigger frame and participation request frame	55002 (fixed)
Transmission	55003 (fixed)

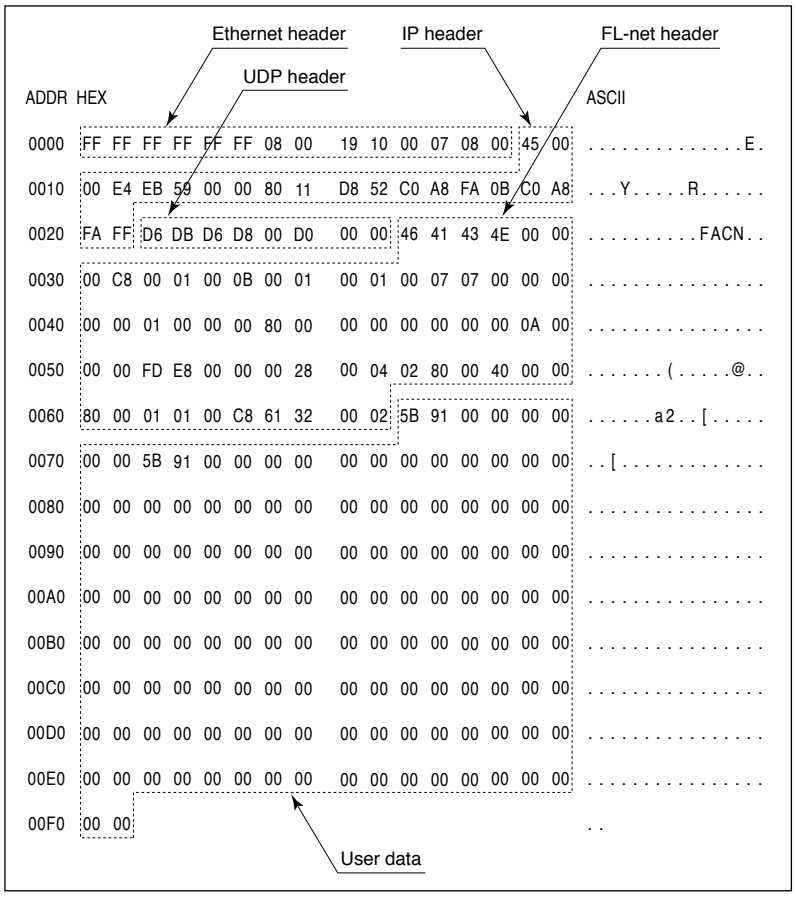
B-8. DATA FORMAT

Overview

The data transmitted and received on the FL-net is encapsulated in each communications protocol layer as shown below:

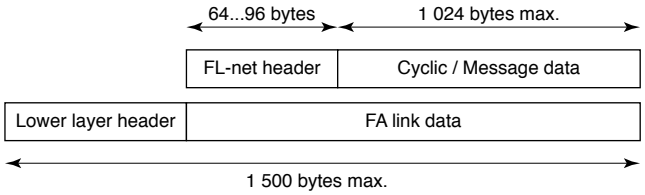


The following diagram shows an example of FL-net data for a single frame that can be observed on the communications line. 128 bytes of cyclic data is being transferred.



Header Format

The FL-net header, attached to the top of all data frames exchanged on the FL-net, consists of between 64 and 96 bytes.



B-9. Transaction Codes

The following services are supported by the message transmission.

- Byte block read
- Byte block write
- Word block read
- Word block write
- Network parameter read
- Network parameter write
- Stop command
- Start command
- Profile read
- Log data read
- Log data clear
- Message echo back
- Vendor specific message
- Transparent mode

The header of each message contains a request transaction code or a response transaction code that determines the type of message frame.

Transaction code	Application
0 to 9999	Reserved
10000 to 59999	Transparent mode message frame
60000 to 64999	Reserved
65000	Cyclic frame with token
65001	Cyclic frame without token
65002	Participation request frame
65003	Byte block read frame (request)
65004	Byte block write frame (request)
65005	Word block read frame (request)
65006	Word block write frame (request)
65007	Network parameter read frame (request)
65008	Network parameter write frame (request)
65009	Stop command frame (request)
65010	Start command frame (request)
65011	Profile read frame (request)
65012	Trigger frame
65013	Log data read frame (request)
65014	Log data clear frame (request)
65015	Message echo back frame (request)
65016	Vendor specific message frame (request)
65017 to 65202	Reserved for future expansion
65203	Byte block read frame (response)
65204	Byte block write frame (response)
65205	Word block read frame (response)
65206	Word block write frame (response)
65207	Network parameter read frame (response)
65208	Network parameter write frame (response)
65209	Stop command frame (response)
65210	Start command frame (response)
65211	Profile read frame (response)
65212	Reserved
65213	Log data read frame (response)
65214	Log data clear frame (response)
65215	Message echo back frame (response)
65216	Vendor specific message frame (response)
65217 to 65399	Reserved for future expansion
65400 to 65535	Reserved

APPENDIX C. NETWORK MANAGEMENT

C-1. MASTERLESS TRANSMISSION MANAGEMENT

Token

Basically, a node can transmit data while it holds a token.

In the following two cases, however, transmission is enabled without a token: (1) reissuing token due to a token monitoring timeout and (2) transmitting a participation request frame when the node has not joined in the network.

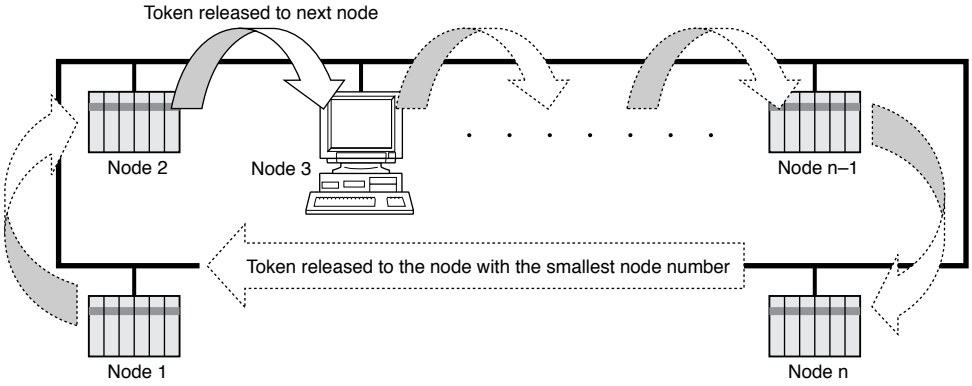
- A single token is circulated among all the nodes joining in the FL-net.
- The token holding node has the transmitting right until it releases the token to the next node.
- The token is monitored by the timer of each node. If no token is transmitted for a specified time period, the next node in the token circulation ring shall dispatch a new token.
- If there are two tokens in the network, they are unified into one.

Token Flow

Only one token exists in the network at any given time. If there is more than two, the one with the smallest destination node number prevails, and the others are discarded.

A frame including a token (token frame) is provided with a destination node number and a sender node number. Each node in turn becomes the token holding node when its node number matches with the destination node number in the received token frame.

The token rotation order is determined in the ascending order of node numbers registered in the participating node management table. The node with the largest node number releases a token to the one with the smallest node number.



Token and Frames

The following six types of cyclic data frames are available to be sent with a token.

1) When there is no cyclic data to be sent: Only a token frame is transmitted.
2) When there is only cyclic data: A token is transmitted together with cyclic frame.
3) When there is only cyclic data and this cyclic data is sent in divided form: Only the cyclic frames are transmitted and a token is attached to the last cyclic frame.
4) When there is only message data: The message frame is transmitted and then a token is transmitted.
5) When there are cyclic data and message data: The message frame is transmitted and then the cyclic frame is transmitted together with a token.
6) When there are cyclic data and message data and the cyclic data is sent in divided form: The message frame is transmitted and then only the cyclic frames are transmitted and a token is attached to the last frame.

Allowable Minimum Frame Interval

A frame interval means the time required for a node to transmit a frame after having received a token from another node. The allowable minimum frame interval is the least time that a node must wait until it can transmit a frame.

The FL-net maintains the same minimum allowable frame interval for the entire network. Whenever a node joins or is removed from the network, each node updates the minimum allowable frame interval by scanning the maximum value among the frame interval settings of all the nodes participating in the network.

C-2. IN-RING AND OUT-RING MANAGEMENT

Joining FL-net

When a node is started, it monitors the communications line until the joining token detection time elapses. If a token is not received during this time, the node assumes the network has just been started and it joins the network as a node in a new network. If a token is received, the node assumes that the network is active and the node joins the active network.

Network Startup Status

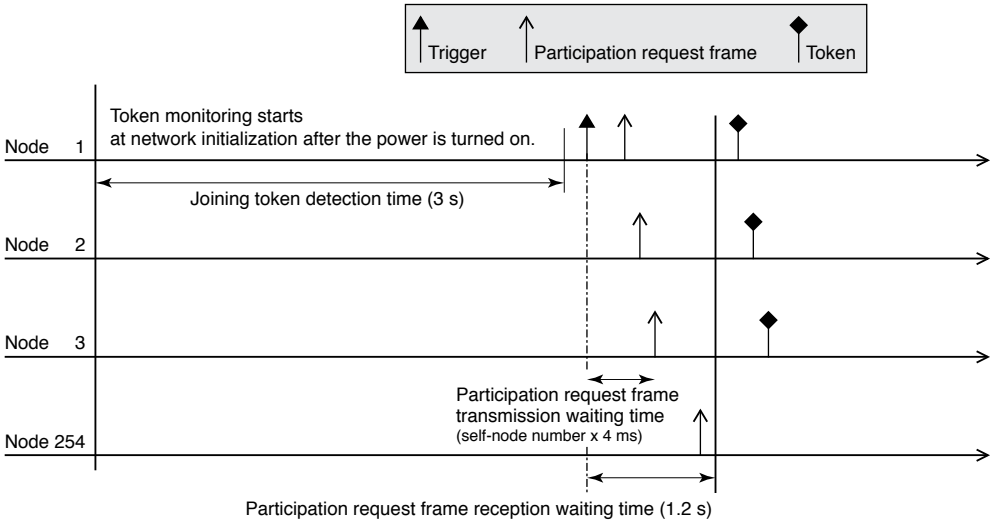
When no token is received during the joining token detection time, the node transmits a trigger frame after [the remainder of (node number / 8) x 4] milliseconds. If a trigger frame is received before the node transmits its trigger frame, the node shall transmit no trigger frame.

When the participation request frame transmission waiting time (own-node number x 4 ms) is up after the first trigger frame has been received, each node transmits its participation request frame.

During the participation request frame reception waiting time (1200 ms) after the first trigger frame reception, duplicate node numbers and addresses are checked and the participating node management table is updated, thus each node shall wait for all nodes to transmit participation request frames.

If, by the participation request frame reception from other nodes, a node recognizes its address overlapped with another one's, it sets the top address and common memory size of areas 1 and 2 to '0' and does not transmit cyclic data. At the same time, it sets the address overlapping flag and resets the common memory data validity flag.

When the participation request frame reception waiting time is up, the node with the smallest node number transmits a token first according to the participating node management table. All nodes that have recognized overlapping addresses will not transmit/receive the token or the data.



Half Participation Status

When a token is received within the joining token detection time, the node recognizes that a link is already established and waits for transmission of a participation request frame until the token is circulated three times. In this period, duplicate node numbers and addresses are checked with the received frames and the participating node management table is updated.

If the node recognizes its address overlapped with another one's, it sets the top address and common memory size of areas 1 and 2 to '0' and does not transmit cyclic data. At the same time, it sets the address overlapping flag and resets the common memory data validity flag.

When no error is found in the node number, it will send out a participation request frame after the participation request frame transmission waiting time is up. The participation request frame is transmitted regardless of token holding.

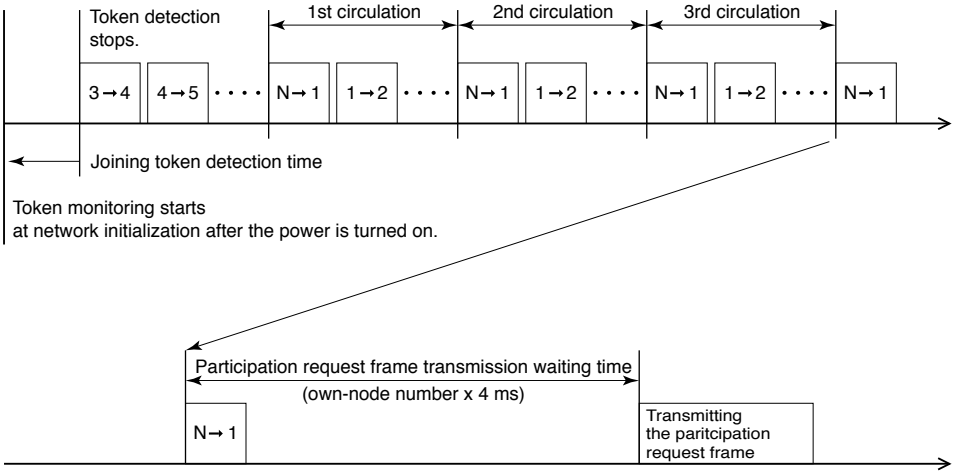
A node that has recognized a node number conflict does not transmit a participation request frame or join the network.

NOTES

Joining token detection time: This is the time to judge whether the network is in operation or not when a node is joining the network. If a token is detected within this time, the network is recognized as being in operation.

Circulation: A circulation starts when the node with the smallest node number receives a token.

Participation request frame transmission waiting time: A participation request frame is transmitted in [own-node number x 4] milliseconds after the first trigger frame reception in order not to overlap with newly joining nodes.



Exiting FL-net

Each node checks the node numbers of others whenever the token frame is received. If the token frame from a specific node is not received for three successive rounds, it is recognized as removed from the network (including a token-holding node that does not send the token after the token watchdog time has timed out). Its node information is deleted from the participating node management table.

C-3. NODE STATUS MANAGEMENT

Node status is managed using three types of management tables: Own node management table, Participating node management table, and Network management table.

Table name	Function
Own node management table	Used to manage the local node settings.
Participating node management table	Used to manage the information on the participating nodes.
Network management table	Used to manage the information common to the network.

C-4. OWN NODE MANAGEMENT TABLE

The own node management table manages the local node settings.

- Used for the participation request frame or the network parameter read request.
- Data is set from the FL-net upper layer at the startup of the node.
- The node number and the common memory area top address and data size can be set from the network.

Own Node Management Table		
Parameter	**Bytes**	**Contents (data range)**
Node number	1 byte	1 to 254
Area 1 top address in common memory	2 bytes	Word address (0 to 0x1ff)
Area 1 data size in common memory	2 bytes	Size (0 to 0x1ff)
Area 2 top address in common memory	2 bytes	Word address (0 to 0x1fff)
Area 2 data size in common memory	2 bytes	Size (0 to 0x1fff)
Upper layer status	2 bytes	RUN / STOP / ALARM / WARNING / NORMAL
Token watchdog time	1 byte	Unit: 1 ms (1 to 255)
Minimum allowable frame interval	1 byte	Unit: 100 µs (0 to 50)
Vendor identification	10 bytes	Vendor code
Product model identification	10 bytes	Product model number, device name
Node identification (equipment name)	10 bytes	User defined node name
Protocol version	1 byte	0x80 (fixed)
FA link status	1 byte	Participating or not participating, etc.
Own-node status	1 byte	Duplicate node number detection, etc.

C-5. PARTICIPATING NODE MANAGEMENT TABLE

Status of the nodes participating in the network is managed by the participating node management table maintained by each node. The table contains data that should be managed by each node participating in the network.

- Upon receiving a token frame at the startup, the node updates the participating node management table and the network management table.
- It updates the participating node management table every time it receives a token frame.
- It updates the participating node management table when it receives a participation request frame.
- If the token frame from a specific node is not received or in case of the token monitoring timeout for three successive rounds, the relevant node is deleted from the table.

Participating Node Management Table		
Parameter	**Bytes**	**Contents (data range)**
Node number	1 byte	1 to 254
Upper layer status	2 bytes	RUN / STOP / ALARM / WARNING / NORMAL
Area 1 top address in common memory	2 bytes	Word address (0 to 0x1ff)
Area 1 data size in common memory	2 bytes	Size (0 to 0x1ff)
Area 2 top address in common memory	2 bytes	Word address (0 to 0x1fff)
Area 2 data size in common memory	2 bytes	Size (0 to 0x1fff)
Allowable refresh cycle time	2 bytes	Unit: 1 ms (0 to 65535)
Token watchdog time	1 byte	Unit: 1 ms (1 to 255)
Minimum allowable frame interval	1 byte	Unit: 100 µs (0 to 50)
FA link status	1 byte	Participating or not participating, etc.

C-6. NETWORK MANAGEMENT TABLE

The network management table manages the information that is shared by all nodes in the network.

Network Management Table		
Parameter	**Bytes**	**Contents (data range)**
Token holding node number	1 byte	Node currently holding the token (1 to 254)
Minimum allowable frame interval	1 byte	Unit: 100 µs (0 to 50)
Allowable refresh cycle time	2 bytes	Unit: 1 ms (0 to 65535)
Refresh cycle measurement time (current)	2 bytes	Unit: 1 ms (0 to 65535)
Refresh cycle measurement time (maximum)	2 bytes	Unit: 1 ms (0 to 65535)
Refresh cycle measurement time (minimum)	2 bytes	Unit: 1 ms (0 to 65535)

C-7. MESSAGE SEQUENCE MANAGEMENT

The sequence number and version-of-sequence number in message transmissions are managed.

Transmitting Sequence Number Management Data		
Parameter	**Bytes**	**Contents (data range)**
Version-of-sequence number	4 bytes	Transmitting message transmission sequence version number
Sequence number (peer-to-peer)	4 bytes	0x1 to 0xffffffff
Sequence number (broadcasting)	4 bytes	0x1 to 0xffffffff

Receiving Sequence Number Management Data		
Parameter	**Bytes**	**Contents (data range)**
Version-of-sequence number	4 bytes	0x1 to 0xffffffff
Sequence number (peer-to-peer)	4 bytes	0x1 to 0xffffffff
Sequence number (broadcasting)	4 bytes	0x1 to 0xffffffff

M-SYSTEM WARRANTY

1. What is covered.

M-System Co., Ltd. ("M-System") warrants, only to the original purchaser of new M-System products purchased directly from M-System, or from M-System's authorized distributors or resellers, for its own use not for resale, that the M-System products shall be free from defects in materials and workmanship and shall conform to the specifications set forth in the product catalogue applicable to the M-System products for the Warranty Period (see Paragraph 5 below for the Warranty Period of each product).

THE ABOVE WARRANTY IS THE ONLY WARRANTY APPLICABLE TO THE M-SYSTEM PRODUCTS AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE.

2. What is not covered.

This warranty does not cover any M-System product which has been: (1) modified, altered or subjected to abuse, misuse, negligence or accident; (2) improperly installed or installed in conjunction with any equipment for which it was not designed; or (3) damaged or destroyed by disasters such as fire, flood, lightning or earthquake.

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3. Remedies.

If a defective product is returned to M-System in accordance with the procedures described below, M-System will, at its sole option and expense, either: (1) repair the defective product; (2) replace the defective product; or (3) refund the purchase price for the defective product paid by the purchaser. Except as otherwise provided by applicable state law, these remedies constitute the purchaser's sole and exclusive remedies and M-System's sole and exclusive obligation under this warranty.

4. Warranty Procedure.

If the purchaser discovers a failure of the M-System products to conform to the terms of this warranty within the Warranty Period, the purchaser must promptly (and, in any event not more than 30 days after the discovery of such failure) notify the relevant party as described below either by telephone or in writing at the below address to obtain an Authorized Return (AR) number and return the defective product to the relevant party. The designated AR number should be marked on the outside of the return package and on all correspondence related to the defective product. The purchaser shall return, at purchaser's expense, defective products only upon receiving an AR number. In order to avoid processing delays, the purchaser must include: copies of the original purchase order and sales invoice; the purchaser's name, address and phone number; the model and serial numbers of the returned product; and a detailed description of the alleged defect.

5. Warranty Period.

Signal Conditioner:	36 months from the date of purchase.
M-Rester:	12 months from the date of purchase.
Valve Actuator:	18 months from the date of shipment from M-System or 12 months from the date of its installation, whichever comes first.
Other Products:	36 months from the date of purchase.

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