SPA-ZC 100/SPA-ZC 102
LON®/SPA Gateway

Programming Manual

(Empty)

Contents:

1. Features

- LONWORKS®, connection module for devices including SPA-bus interface.
- Polling of measurements, indications and events from the SPA-bus slave modules to the local data base.
- Spontaneous sending of changed measurements, indications and events to LonWorks devices.
- Transparent transfer of settings and other parameter data messages in SPA-bus format.
- Configuration/programming via LonWorks interface.
- SPA-bus interface using 9-pin D-connector with RS-485, RS-232 or TTL-level signalling, max. communication rate of 19200 bits/s.
- LonWorks interface using glass or plastic fibre cables, with max. communication rate of 1.25 Mbits/s.[1]

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2. Introduction

2.1. Description of contents

This manual describes the operation principle and the programming of configurable parameters of SPA-ZC 100 and SPA-ZC 102. Later on, both devices are referred as LON/SPA -gateways or simply LSGs. The mechanical and electrical installation of the LON/SPA-gateway modules are described in SPA-ZC 100 Installation manual (1MRS750741-MUM) and SPA-ZC 102 Installation manual (1MRS750742-MUM).

The document is divided in five main sections: the introduction part, description of operation, the configuration part, trouble shooting part and appendixes.

2.2. Typical applications of LON/SPA gateway

The SPA-bus device to which this module is connected can be any protective relay, control module or alarm annunciator which has an interface for the SPA-bus (RS-485, RS-232 or logic/TTL interface). The selection of the SPA interface type is done by the DIP-switches located between the D9-connector and fibre optics connectors. The operating voltage for SPA-ZC 100 is taken from device it is connected to. The SPA-ZC 102 is equipped with internal power supply.

2.2.1. Substation control system with single "master" device

LON/SPA-gateway is connected with fiber optic cables to RER 111, which is called LON star-coupler in this text. Via LON star-coupler the gateways are connected to the substation level Remote Control Gateway. Instead of the remote control gateway the star-coupler may be connected to some other LonWorks "master" device like MicroScada, SCS MMC computer or gateway to station bus.

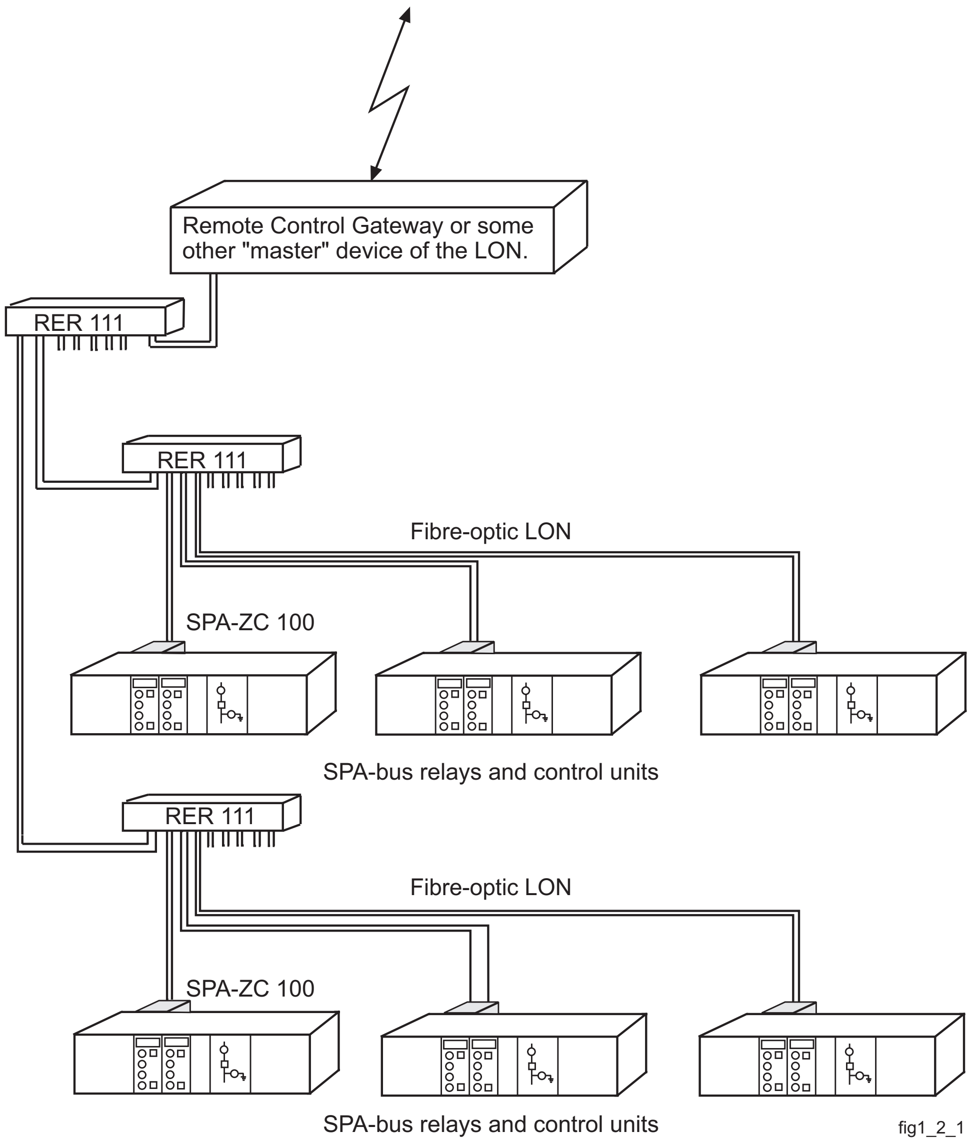

Fig. 2.2.1.-1 Structure of a substation protection and control system with LonWorks and LON/SPA-gateways. Remote Control Gateway directly connected to LonWorks in single master configuration.

2.2.2. Substation control system with two "master" devices

LON/SPA-gateway is connected with fibre optic cables to a LON star-coupler. Via LON star-coupler the gateways are connected to the substation level Remote Control Gateway and SCS MMC computer. Instead of the remote control gateway and SCS MMC computer there can be also some other "master" devices of LonWorks.

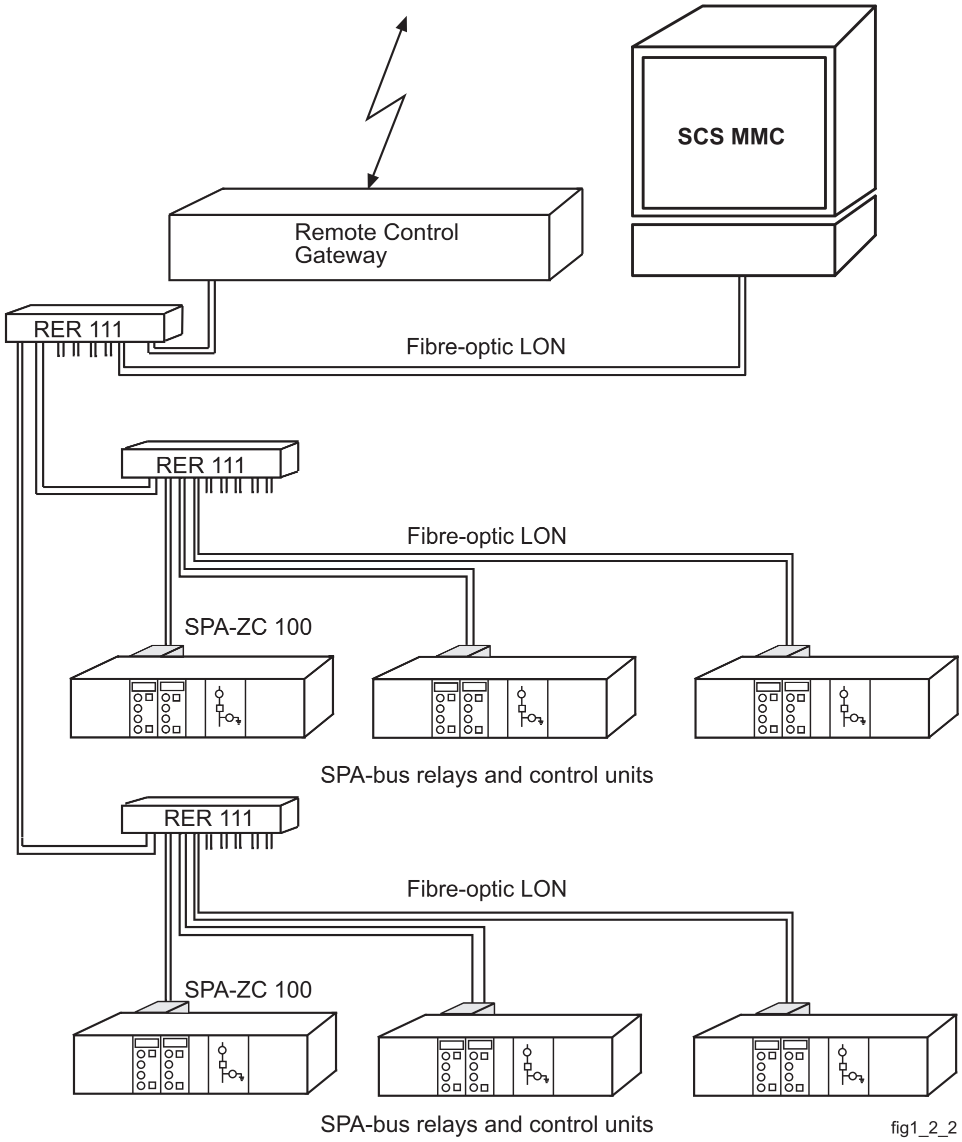

Fig. 2.2.2.-1 Structure of a substation protection and control system with LonWorks and LON/SPA -gateways. SCS MMC and Remote Control Gateway connected to LonWorks in double master configuration.

2.2.3. Use of LON/SPA-gateway with small SPA-bus devices

SPA-ZC 102 is a LON/SPA-gateway which contains power supply. It has same functionality as SPA-ZC 100, but it can also be used with fibre optics converters on SPA-bus connectors.

This can be accomplished by using RS-485 to fibre optics converter SPA-ZC 21 as interface module to the fibre optic SPA-bus (figure 2.4). SPA-ZC 102 have to be configured to give power to SPA-ZC 21. The SPA-bus devices connected to one gateway may together include max. 8 SPA-bus slave units. This kind of arrangement is useful with small SPA-bus devices like single function relays or small control and measuring units.

In this application it must be noted that one gateway can handle max. 16 analog inputs, 16 digital inputs (16 x 16 bits) and 16 digital outputs.

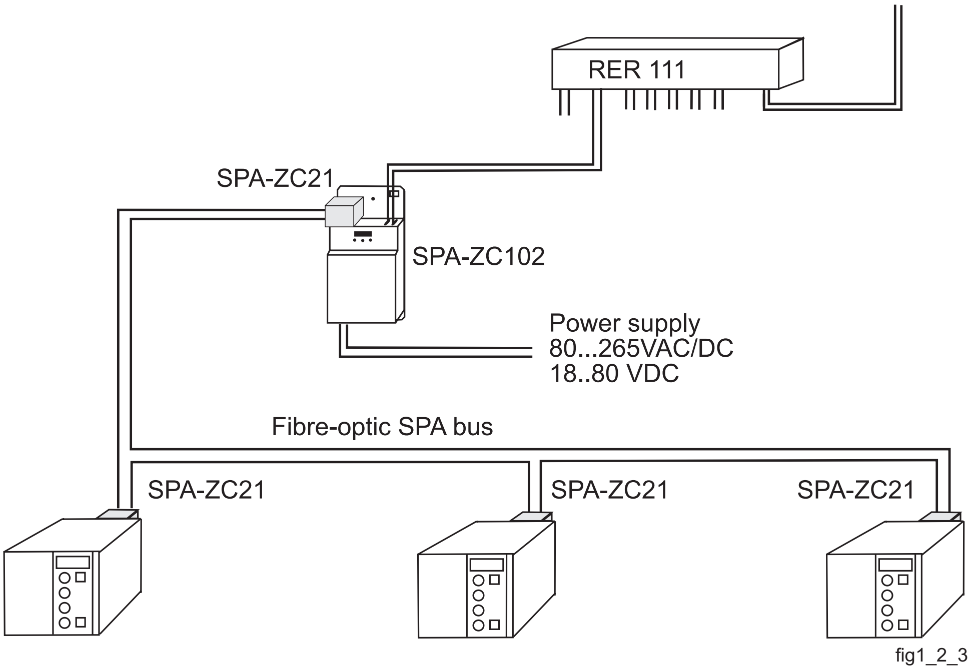

Fig. 2.2.3.-1 System structure with the fibre optic SPA-bus loop.

3. Description of operation

3.1. General operation model

The main functions of the LON/SPA-gateway are illustrated in figure 3.1. In principle the gateway is like any other SPA-bus master unit including all the necessary SPA-bus master functions. The main difference to the real SPA-bus master unit is the limited size of the data base and event buffer, and the limited maximum number of SPA-bus slave units.

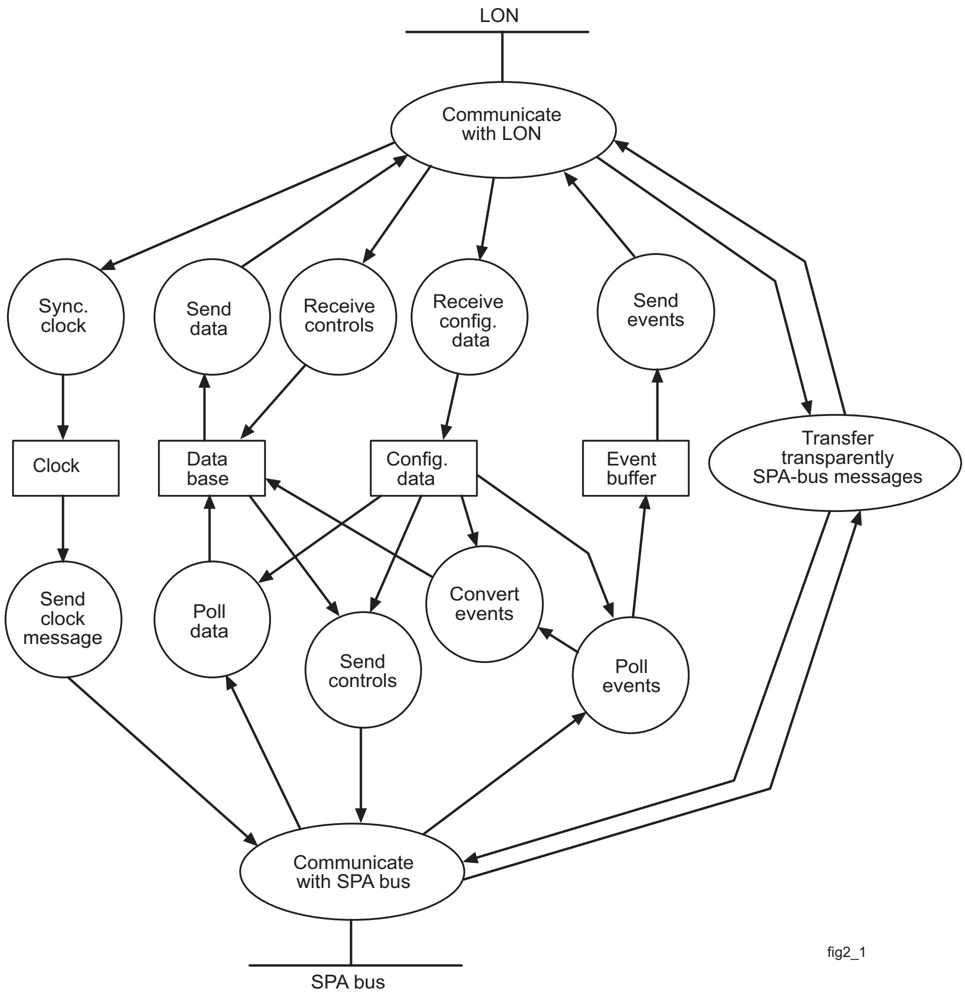

Fig. 3.1.-1 Functions of the LON/SPA-gateway.

The LON/SPA-gateway polls digital and analog data according to definitions made in DA AI and DA DI configuration data. The events polled from SPA-device(s) are temporarily stored in buffer, capable of storing 50 events. The ratio of data polls to event polls is adjustable and is stored in configuration data. Polled data values are sent to LONWORKS by using the network variables. Polled events can be sent using either a network variable of SNVT_alarm format or an explicit message. Control data received by network variables are sent to SPA according to DA DO definitions. The LSG receives time synchronisation messages from LONWORKS and updates internal realtime clock. Internal clock is used to complete the time stamps of the events polled from SPA-device. The LSG broadcasts time synchronisation messages to SPA-devices by using the WT and WD type messages. The configuration commands are sent to LSG using the message code 0x43 and configuration is stored in EEPROM of Neuron chip. Direct SPA requests are received by explicit message from LONWORKS and are transferred as they are

3.2. Configuration and communication data structures

3.2.1. Overview of data structures

The database of the LON/SPA-gateway includes:

- 52 network variables:
  - 16 output network variables for analog input (AI) objects in 32-bit fixed point format or floating point format
  - 16 output network variables for digital input (DI) objects in 16-bit binary format
  - 16 input network variables for digital output (DO) objects in 16-bit binary format
  - 1 clock warning message input
  - 1 clock message input
  - 1 gateway status output for communication statistics
  - 1 event data output for sending the buffered event data
- Address table with 4 entries for the addresses of peer devices on LONWORKS
- 48 data definitions for the objects
  - 16 data definitions for the polled analog input objects (DA AI)
  - 16 data definitions for the polled digital input objects (DA DI)
  - 16 data definitions for the digital output objects (DA DO)
- Definitions for the SPA-bus communication parameters, event sending method (SP)
- Unit list definition for the SPA units under event and data polling (UN)

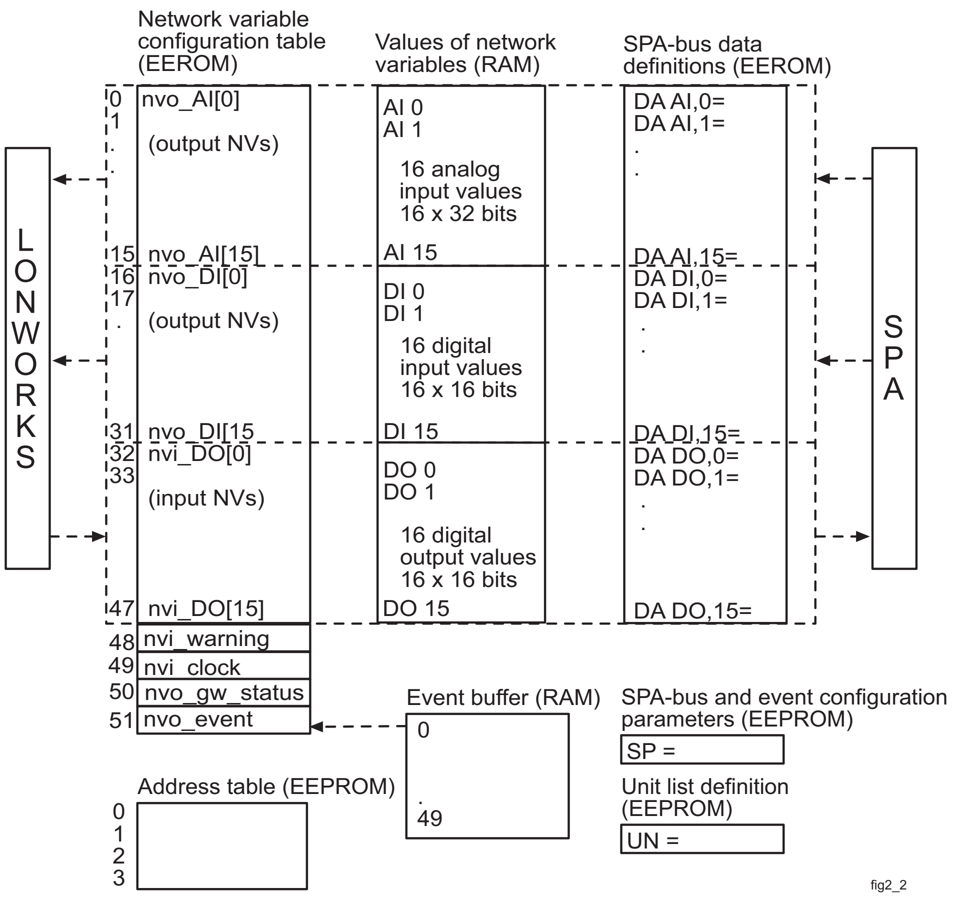

Fig. 3.2.-1 Overview of data structures in the LON/SPA-gateway.

3.3. SPA interface

3.3.1. SPA communication definitions

SPA-bus interface implements the master side of the SPA-bus protocol. Following parameters of SPA interface are configurable: Baudrate (19.2 and 9,6 kbit/s), parity, receive timeout delay and number of retransmissions. Fixed communication parameters are: 7 data bits and 1 stop bit. The SPA-bus interface parameters are defined in SP-command. By default SP-command definitions are:

event mode =1 (events in SNVT_alarm format)
baudrate = 9600
data bits = 7
parity = even
stop bits = 1
receive_timeout = 100ms
number of retransmissions = 2
poll ratio = 8
analog events = disabled
single master mode.

See chapter 4.4.3 “SP-command” for details.

3.3.2. Unit list definition

The SPA-bus slave units connected to the gateway are defined in unit list. The unit list definition is used for event and data polling so it have to be made before any data object definition. The maximum number of slave units is 8. All slave units in polling sequence have to have consecutive slave numbers. Definition in the unit list includes slave number of first SPA-unit (1...999), the number of slave units and slave type (0...15). The slave numbers have to be in a increasing consecutive order starting from the first SPA-unit number. Unit list definitions are made in UN-command. By default UN has no definition. See chapter 3.4.4 “UN-command” for details.

3.3.3. Data definitions

The SPA-bus data definitions together with the unit list definition controls the acquisition of data and events from the SPA-bus devices. Each data definition includes the SPA-bus data address (unit, channel and data numbers) and some attributes used in storing data to the data base. The definitions are configured using the programming commands described in chapter 3.4 "Programming the SPA-bus interface and data definitions".

3.3.4. Clock synchronisation

The clock of the gateway is synchronised with clock synchronisation messages broadcasted by LONWORKS "master" device. The gateway synchronises the clocks of the SPA-bus modules by sending the broadcast message.

Both WT and WD type clock synch messages are sent to the SPA-bus using the broadcast address number 900.

Second clock message (WT-message) is sent in 1 second intervals. Once a minute (every 60 seconds) a full date and time message (WD-message) is sent instead of WT-message.

The LON/SPA-gateway sends clock messages to SPA-bus when configuration valid stamp is set (CV =WK).

3.4. LONWORKS interface

The analog input (AI), digital input (DI), digital output (DO) and event data values are transferred using network variables of LonTalk® protocol.

In general a message containing an AI or DI network variable is sent to LONWORKS, when change in AI or DI value is detected. By default the event network variable update is sent whenever there is at least one event in the event buffer. Alternatively events can be sent by using the explicit message format.

3.4.1. nvo_AI variables:

Analog input data is cyclically polled from the SPA-bus. An nvo_AI network variable is updated and a network variable update message is sent to LONWORKS if the new polled value differs from the previous value more than the limit given by the dead band. If use of analog events is enabled, then the AI data is additionally sent to LONWORKS using an event message of type "analog event".

3.4.2. nvo_DI variables:

Digital input data is either cyclically polled or updated by events received from the SPA-bus. If the DI values changes its state the nvo_DI network variable is updated and a network variable update message is sent to LONWORKS. If the DI variable was updated from SPA-bus event, then its value is additionally sent to LONWORKS using an event message of type "digital event".

All DI object can be updated by cyclical poll, only objects DI[0]...DI[6] can be updated from events.

If nvo_DI[15] is defined and it is bound as priority network variable (see chapter 3.5) then it will be a high priority DI, which is polled with every other SPA-bus poll message. In this case also nvo_DI[14], nvo_DI[13],... can be used as high priority DIs.

3.4.3. nvi_DO variables:

By updating the nvi_DO network variables the digital outputs of the SPA-bus devices connected to the LON/SPA-gateway can be controlled. The DO variables can be updated by any device connected to LONWORKS including another LON/SPA-gateway.

If nvi_DO network variable is bound as priority network variable (read chapter 3.5) and its definition creates only one SPA-bus message then it will be a high priority DO. The SPA-bus W-message generated from the update of a high priority DO will bypass all other SPA-bus messages when sent to the SPA-bus.

3.4.4. Event network variable

Events can be sent from LON/SPA-gateway by using update of event network variable or by using explicit message sending. This is set in mode-field of SP-command. Also the choice between one or two masters node(s) (data acquisition units on LONWORKS) is made in SP-command. If only one master is receiving, any of the address table entries can be used. If two master units are used, the addresses of two masters have to be declared in address table entries 0 and 1. However the configuration of event network variable have to be set to use address table entry 0.

3.4.5. Network variable configuration

The network variable configuration table entries are written, when the data base network variables are bound to network variables in other nodes of LONWORKS as described in chapter 3.5. The configuration data of each network variable includes e.g. the 14-bit network variable selector and information of the receiver of the AI and DI variables. The network variable selector is used as "object address" defining the logical address of the data on LONWORKS.

When the LON/SPA-gateway is configured to send events to two master units, the event network variable have to be configured to use the address table entry 0. As previously stated, the event data is actually sent to masters defined in address table entries 0 and 1.

3.4.6. Handling of errors in network variable transfer

If the sending of an AI or DI network variable update message to LONWORKS fails after making the defined number of retries, then the sending is retried again after a few seconds.

The sending of network variable messages is retried only if acknowledged message service is used. If network variables are sent using broadcast then unacknowledged repeated service is recommended to overcome temporary failures.

3.5. Event handling

Events are cyclically polled from the SPA-bus slaves (SPA-bus events) or internally generated in the LON/SPA-gateway (digital events or analog events). New events are sent to the "master" node(s) of the LONWORKS. If two masters are used, the addresses of the master nodes are defined by address table entries 0 and 1. (Read chapter 3.5).

3.5.1. Event buffer

The size of the event buffer is 50 events.

One event in the event buffer contains:

- event type (SPA-bus event, analog event, digital event)
- object address (0...65535, nv selector or SPA address)
- event data (32 bit floating point analog value or 16 bit mask and 16 bit digital data value)
- time stamp (year...0.1 millisecond)

3.5.2. Special events

In addition to event codes received from the SPA-bus slave units, the LON/SPA-gateway can generate the events in special situations. The following event codes are used:

- E53 = no connection to slave
- E54 = connection with slave re-established
- E51 = overflow in gateway’s event buffer

When special events are sent using nvo_event (nv index 51) the slave index reported in location field is calculated as follows:

LSG_slave_index = 512 + node + (subnet-1)*128

where: node = node number of LON/SPA-gateway (1...127)

subnet = subnet number of LON/SPA-gateway (1...4)

The range from subnet 1, node 1 to subnet 4 node 102 are reported as slave_index range from 513 to 998. All other valid combinations are reported as maximum slave_index 999.

Note: Event E51 can also be generated from the slave unit, when event buffer of slave unit overflows.

3.5.3. Handling of errors in event transfer

If the sending of an event to LONWORKS fails after making the defined number of retries, then the sending is retried again after a few seconds. If double master configuration is defined each master connection is supervised separately.

If a SPA-bus slave does not respond to an event poll, it will be suspended from the continuous event poll and polled next time after a certain timeout period. If a slave has "dropped out" from the event poll also the polling of cyclically polled AI or DI objects will be suspended and polled again after the timeout.

3.6. General about LonTalk protocol

LonTalk protocol supports two types of application layer objects: network variables and explicit messages.

3.6.1. Network variables

LonTalk protocol employs a data oriented application protocol. In this approach, application data items such as temperatures, pressures, states, text strings and other data items are exchanged between nodes in standard engineering and other predefined units. The command functions are then encapsulated within the application programs of the receiver nodes rather than being sent over the network. In this way, the same engineering value can be sent to multiple nodes which each has a different application for that data item.

The data items in LonTalk application protocol are called network variables. Network variable can be any single data item or data structure with the maximum length of 31 bytes.

Network variables are addressed on application level using network variable selectors. The selector is a 14-bit number in the range 0...12287.

3.6.2. Explicit messages

Explicit messages containing up to 229 bytes of data can also be sent over the network. Different types of explicit messages are classified using an 8-bit message code.

A special range of message codes is reserved for foreign frame transmission. Up to 229 bytes of data may be embedded in a message packet and transmitted like any other message. LonTalk protocol applies no special processing to foreign frames - they are treated as a simple array of bytes. The application program may interpret the data in any way it wishes.

Used message codes:

Message type	Message codes
Application Messages	0x00...0x3E
Application Responses	0x00...0x3E
Response if node is off-line	0x3F
Foreign Messages	0x40...0x4E
Foreign Responses	0x40...0x4E
Response if node is off-line	0x4F
Network Diagnostic Messages	0x50...0x53
Network Diagnostic Responses	0x00...0x3E
Network Management Messages	0x61...0x7F
Network Management Responses	0x00...0x3E

Layer 2...6 services

LonTalk protocol offers four basic types of message transport services:

- acknowledged service
- request/response service
- unacknowledged repeated service
- unacknowledged service

3.6.3. Network addressing

In LonTalk protocol the message address is composed of three components:

- domain (not used by LON/SPA-gateway)
- subnet (1...255)
- node (1...127)

The subnet/node may be replaced by one byte group address (0...255). Node number may be replaced by 6 byte Neuron® ID. Messages may be broadcasted into a single subnet or to all subnets of a domain.

3.6.4. General message format

The data part of a network variable message contains 2 bytes for 2-bit control information and 14-bit network variable selector and the data itself.

1	X	network variable
selector (14 bits)		
data 1...31 bytes		

X = 0, variable update message or response to a poll
X = 1, variable poll message

Fig. 3.6.4.-1 General format of the data part of network variable messages.

0	message code (<80H)
data 0...229 bytes	

Fig. 3.6.4.-2 General format of the data part of anexplicit message.

3.7. Use of LonTalk protocol in LON/SPA-gateway

Data in the data base is transferred using network variables or explicit messages (events). Programming commands, events and SPA-bus messages or other foreign messages are transferred using LONWORKS's explicit messages.

All the explicit application messages are sent using acknowledged service. The service type (ack, unackd, unackd repeated) to be used with network variables can be configured to the network variable configuration tables in the normal way. Request/response service is not used with application data.

All the network management functions of LonTalk protocol are supported (implemented by Echelon®'s Neuron chip firmware).

The default communication rate of LONWORKS is 1.25 Mbits/s.

The number of application layer and network layer message buffers is 11 for incoming messages and 11 for outgoing messages. For outgoing priority messages there are 7 buffers. The size of the incoming message buffers is 66 bytes and of outgoing message buffers 82. The number of simultaneous transactions is 12 (ENSURE THIS). The gateway node can belong to only one domain. The size of the message buffers can be changed while node is in reset state. If buffer size is incremented, the number of the buffers must be decreased so that the total count of bytes in buffers is not increased.

The size of the address table is reduced to 4 entries. This means that the LON/SPA-gateway is able to send network variables or events using max. 4 different destinations' addresses. The destination address can be a single node/subnet or a group or a broadcast address.

3.7.1. LON/SPA-gateway network variables

Index dec	Index hex	Variable	Network direction	Explanation
0	0H	nvo_AI[0]	nv output	Analog input 0
1	1H	nvo_AI[1]	nv output	Analog input 1
2	2H	nvo_AI[2]	nv output	Analog input 2
3	3H	nvo_AI[3]	nv output	Analog input 3
4	4H	nvo_AI[4]	nv output	Analog input 4
5	5H	nvo_AI[5]	nv output	Analog input 5
6	6H	nvo_AI[6]	nv output	Analog input 6
7	7H	nvo_AI[7]	nv output	Analog input 7
8	8H	nvo_AI[8]	nv output	Analog input 8
9	9H	nvo_AI[9]	nv output	Analog input 9
10	AH	nvo_AI[10]	nv output	Analog input 10
11	BH	nvo_AI[11]	nv output	Analog input 11
12	CH	nvo_AI[12]	nv output	Analog input 12
13	DH	nvo_AI[13]	nv output	Analog input 13
14	EH	nvo_AI[14]	nv output	Analog input 14
15	FH	nvo_AI[15]	nv output	Analog input 15
16	10H	nvo_DI[0]	nv output	Digital input 0
17	11H	nvo_DI[1]	nv output	Digital input 1
18	12H	nvo_DI[2]	nv output	Digital input 2

19	13H	nvo_DI[3]	nv output	Digital input 3
20	14H	nvo_DI[4]	nv output	Digital input 4
21	15H	nvo_DI[5]	nv output	Digital input 5
22	16H	nvo_DI[6]	nv output	Digital input 6
23	17H	nvo_DI[7]	nv output	Digital input 7
24	18H	nvo_DI[8]	nv output	Digital input 8
25	19H	nvo_DI[9]	nv output	Digital input 9
26	1AH	nvo_DI[10]	nv output	Digital input 10
27	1BH	nvo_DI[11]	nv output	Digital input 11
28	1CH	nvo_DI[12]	nv output	Digital input 12
29	1DH	nvo_DI[13]	nv output	Digital input 13
30	1EH	nvo_DI[14]	nv output	Digital input 14
31	1FH	nvo_DI[15]	nv output	Digital input 15
32	20H	nvi_DO[0]	nv input	Digital output 0
33	21H	nvi_DO[1]	nv input	Digital output 1
34	22H	nvi_DO[2]	nv input	Digital output 2
35	23H	nvi_DO[3]	nv input	Digital output 3
36	24H	nvi_DO[4]	nv input	Digital output 4
37	25H	nvi_DO[5]	nv input	Digital output 5
38	26H	nvi_DO[6]	nv input	Digital output 6
39	27H	nvi_DO[7]	nv input	Digital output 7
40	28H	nvi_DO[8]	nv input	Digital output 8
41	29H	nvi_DO[9]	nv input	Digital output 9
42	2AH	nvi_DO[10]	nv input	Digital output 10
43	2BH	nvi_DO[11]	nv input	Digital output 11
44	2CH	nvi_DO[12]	nv input	Digital output 12
45	2DH	nvi_DO[13]	nv input	Digital output 13
46	2EH	nvi_DO[14]	nv input	Digital output 14
47	2FH	nvi_DO[15]	nv input	Digital output 15
48	30H	nvi_warning	nv input	Time synch warning message
49	31H	nvi_clock	nv input	Time synchronization message
50	32H	nvo_gw_status	nv output	Gateway diagnostic status
51	33H	nvo_event	nv output	Event NV of SNVT_alarm type

3.7.2. Structures of application messages

The data part of a network variable message contains 2 byte control information (2 control bits and 14-bit network variable selector) and 1..31 data bytes.

Control bit b7 is always "1" in network variable messages. Control bit b6 is "1" in network variable update messages and "0" in network variable poll messages.

Note:All the multi byte structures are sent msb-byte first and lsb-byte as last byte (in Motorola fashion).

nvo_AI, nvo_DI or nvi_DO network variable messages

Analog input:

1	1	selector msb	Analog input values are sent using fixed point integer values with scaling factor 1000.
selector lsb			(E.g. value 1.05 is sent as 1050)
AI data 4 bytes			Alternatively analog values are sent as 32 bit floating point values. (IEEE 754 single precision format)

Digital input:

1	1	selector msb	If data is in decimal format, values are sent using fixed point integer values with scaling factor 100.
selector lsb			(E.g. value 1.05 is sent as 105)
DI data 2 bytes			If data is in integer format, values are sent without scaling.

Digital output (BIN, HEX, DEC, INT):

1	0	selector msb	If data is in decimal format (DEC), values are sent using fixed point value with scaling factor 100.
selector lsb			(E.g. value 1.05 is sent as 105)
DO data 2 bytes			If data is in integer format (INT), values are sent without scaling.

Digital output (BWR):

1	0	selector msb		iiii = bit number (0...15)
selector lsb				
i i i i		x x x x		xxxx xxxx xxx = not used
x x x x		x x x	d	d = bit value (0 or 1)

3.7.3. Clock synchronization messages

The real-time clock of the LON/SPA-gateway may be synchronised by broadcasting network variables nv_warning and nv_clock to the network one after another. The delay between nv_warning and nv_clock may not exceed 100 milliseconds. The delays under approx. 30 ms cause significant amount of clock messages to be missed.

Warning message:

1	0	selector lsb	Default value for the selector is 2FFEH
selector lsb			
delay			Delay between sending the warning message and the time synch message

Time synch message:

	1	0	selector lsb	default value for the selector is 2FFFH
	selector lsb			
1	year			year in binary format
2				
3	month			month in binary format
4	day			day in binary format
5	hour			hour in binary format
6	minute			minute in binary format
7	second			second in binary format
8	milliseconds and 100 microseconds			milliseconds and hundreds of microseconds as 16-bit binary number
9				

Fig. 3.7.3.-1 The contents of the clock synchronisation messages.

3.7.4. Gateway diagnostic status

Network variable nv_gw_status may be fetched e.g. using the network management command `Network Variable Fetch`.

1 2	transmitted msg	number of transmitted SPA-bus messages
3 4	received msg	number of received replies
5 6	failed msg	number of failed messages (no correct reply received)
7 8	common msg	number of broadcast messages
9 10	retransmitted msg	number of retransmissions
11 12	received timeouts	number of received timeouts (no reply received)
13 14	parity errors	number of replies with parity error
15 16	checksum errors	number of replies with checksum error
17 18	received nacks	number of replies of type N:#:
19 20	AI error bits	bit array indicating AI not responding to polls
21 22	DI error bits	bit array indicating DI not responding to polls
23 24	DO error bits	bit array indicating DO not responding to updates
25	unit list	bit array of slave units not responding to event polls
26 27	LON snd cnt	number of packets sent on LON (nv updates or explicit messages)
28 29	LON rcv cnt	number of packets received from LON
30	LON snd fail	number of failed transmissions (no ack)
31	LON alloc fail	number of failed buffer allocation for messages to transmit

Note: When one of SPA-bus counters exceeds it's maximum value all SPA-bus counters will be reset.

3.8. Event messages

An event message from the LON/SPA-gateway contains one event. Events are sent by network variable update of nvo_event (index 51, 32H) or as explicit messages. Event format is selected by the event mode option in SP-command.

3.8.1. Network variable event type

The structure type of event network variable is SNVT_alarm according to LonMark interoperability guideline. One update message from LON/SPA -gateway contains one event. The structure and contents of a SNVT_alarm update message is shown in next table. The all four types of events are included in the content description part.

1 2 3 4 5 6	Location string	Contents: SPAnnn, where nnn is interpreted as: (Analog) SPA events: nnn = number of the SPA slave in ASCII format Digital or analog event: nnn = 512 + own node number + (own subnet number -1)*128.
7 8	Object ID	(Analog) SPA events: channel number. Digital/analog event: index of corresponding network variable + 1
9	Alarm type	(Analog) SPA events: event code + 128 Digital/analog event: 129 (E1)
10	Priority level	Alarm priority: 0 (0=lowest level)
11 12	Index to SNVT	SPA event: 0 Analog SPA event: 202 Digital event: 83 Analog event: 252
13 14 15 16	Value	SPA event: no value Analog SPA event: 32 bit analog fixed point value, scale 1000. Digital event: 16 msb indicates changed bits in the data part and 16 lsb is new value of the DI-object Analog event: 32 bit analog fixed point value, scale 1000.
17 18	Year	Year 0 ... 3000 (0 = year not specified)
19	Month	0 ... 12 (0=not specified)
20	Day	0 ... 31 (0=not specified)
21	Hour	0 ... 23
22	Minute	0 ... 59
23	Second	0 ... 59
24 25	Millisecond	0 ... 999
26 27 28 29	Alarm limit	Alarm limit: 0

Fig. 3.8.1.-1 The contents of nvo_event network variable.

3.8.2. Explicit message event type

An event message from LON/SPA-gateway may contain one event. Foreign message code 40H is used.

0	0	40H	Message code 40H.
1	event type (8 bits)		
2	object		
3	address (16bits)		
4	event data (32 bits)		
5			
6			
7			
8	year (msb)		
9	year (lsb)		
10	month		
11	day		
12	hour		
13	minute		
14	second		
15	ms and 100 µs (msb)		Bytes 15 and 16 contains a 16 bit number including milliseconds and hundreds of microseconds
16	ms and 100 µs (lsb)		

Fig. 3.8.2.-1 The contents of an event message.

LON/SPA-gateway uses the following event types:

Type code	Event type
0	SPA-bus event, event generated from SPA-bus events.
1	Analog event, event with 32 bit analog data value containing the contents of one AI of the LON/SPA-gateway.
2	Digital event, event with 16 bit data generated by converting event to DI data in the database.
7	SPA-bus analog event, event generated from SPA-bus analog event. Analog data in event data part.

3.8.3. SPA-bus events

The SPA-bus event identification of those SPA-bus events which are not converted to binary format is coded to "object address" as described in the following figure. The msb is equal to 1, to enable division of object address range to data addresses from 0 to 32767 (7FFFH) and event addresses from 32768 (8000H) to 65535.(FFFFH)

0	0	40H	Message code 40H
1	event type = 0/7		
2 3	1 i i i ccee	cccc eeee	
4 5 6 7	32-bit analog value scaled with 1000		
8 9	year (msb) year (lsb)		
10	month		
11	day		
12	hour		
13	minute		
14	second		
15 16	ms and 100 µs (msb) ms and 100 µs (lsb)		Bytes 15 and 16 contains a 16 bit number including milliseconds and hundreds of microseconds

Fig. 3.8.3.-1 The contents of a SPA event message.

Note: If the channel number is > 63, then bits `iii` are used to store the msb bits of the channel number. In this case the unit list contains only one unit or in other words the LON/SPA-gateway is connected to a SPA-bus device which contains only one SPA-bus slave unit.

Note: The master unit must have it own list of slave units connected via LONWORKS, because LON/SPA-gateway sends only the index to the unit list, not the slave number to the master unit.

3.8.4. Digital events

If event is converted to binary format and stored in a DI object, then object address will be the same as LonTalk network variable selector of the DI object. The selector is coded to the object address as described in the following figure.

0	0	40H	Message code 40H
1	event type = 2		
2 3	00ssss ss	ssssss ss	ssssssssssssss = network variable selector (14 bits)
4 5	16 bit mask		Mask indicating the changed bits in the data part
6 7	16 bit data		New value of the DI object
8 9	year (msb) year (lsb)		
10	month		
11	day		
12	hour		
13	minute		
14	second		
15 16	ms and 100 µs (msb) ms and 100 µs (lsb)		Bytes 15 and 16 contains a 16 bit number including milliseconds and hundreds of microseconds

Fig. 3.8.4.-1 The contents of a DI event message.

3.8.5. Analog events

If an AI value is sent as an event, then the object address will be the same as LonTalk network variable selector of the AI object. The selector is coded to the object address as described in the following figure.

0	0	40H	Message code 40H
1	event type = 1		
2 3	00ssss ss	ssssss ss	ssssssssssssss = network variable selector (14 bits)
4 5 6 7	32 bit analog value scaled with 1000		
8 9	year (msb) year (lsb)		
10	month		
11	day		
12	hour		
13	minute		
14	second		
15 16	ms and 100 µs (msb) ms and 100 µs (lsb)		Bytes 15 and 16 contains a 16 bit number including milliseconds and hundreds of microseconds

Fig. 3.8.5.-1 The contents of an AI event message.

3.9. Transparent SPA-bus messages

SPA-bus command messages (Read and Write messages) may be sent to the LON/SPA-gateway using explicit messages with message code 41H. After sending the given message to the SPA-bus and receiving reply message from the SPA-bus, the gateway sends the SPA-bus reply message to the sender of the SPA-bus command message using explicit message with message code 41H. Response messages from SPA-slaves can be up to 253 characters long. Messages longer than 253 characters are treated as failed. Long messages are split into parts containing up to 45 characters and are sent serately into LONWORKS. At the end of each part, excluding the last one, is a SPA continuation character “&” indicating that continuation follows.

0	41H	Message code 41H.
> or <		Message start character > in messages to gateway < in reply messages from gateway
ASCII character message following the rules of the SPA-bus protocol		
:		End of data part/header
C		Two checksum characters
0DH		Message end character, carriage return

Fig. 3.9.-1 The data part of a transparent SPA-bus message.

Note: The gateway send all data to the SPA-bus. It fetch the slave number from the data part of the message. If slave fails to respond the gateway send reply message with fetched number in slave number field. If gateway cannot fetch any number the slave number zero is returned. The reply must begin with "<" and end with <cr>.

3.10. LON/SPA-gateway configuration command messages

LON/SPA-gateway configuration commands may be sent to the gateway using explicit messages with message code 43H. After processing the given command, the gateway sends the command response to the sender of the configuration command using explicit message and message code 43H.

0	43H	Message code 43H.
Gateway configuration command/response composed of ASCII characters.		
0DH		Command/response end character, carriage return.

Fig. 3.10.-1 The data part of an configuration command and response messages.

4. Installation, configuration and programming

4.1. General

The mechanical and electrical installation of LON/SPA-gateway is described in SPA-ZC 100 Installation Manual or in SPA-ZC 102 Installation Manual. Before any actions described in following chapters, ensure the correct settings for SPA interface type, power supply and cable types of device from corresponding installation manual.

4.2. LONWORKS node installation (setting the node address)

When Neuron 3150 chips are shipped from the manufacturer they are assigned a unique, 6-byte identifier (Neuron ID). Each LONWORKS node has a service pin. Pressing the service pin causes Neuron chip to transmit a network management message "Service Pin Message" containing this Neuron ID. This information may then be used by a network management device to install the node (assign the node its logical node address).

Normally the node installation procedure goes as follows:

1. Start `Install Node` command of the device responsible of network management functions (usually the `master` node). This function will ask you to press the service pin on the node being installed.
2. Press the `Service Pin` of the module.
3. When the network manager node receives the `Service Pin Message`, it will set the address of the gateway node.

The node address is stored to the Neuron chip’s internal EEPROM memory (in the domain table) and usually also to the node list of the network manager node.

4.3. Programming the SPA-bus interface and data definitions

The configuration/programming of the gateway’s SPA-bus interface and data definitions is done by sending explicit messages including commands. The commands are composed of ASCII characters.

The available programming commands are the following:

- SP command
- UN command
- DA AI command
- DA DI command
- DA DO command
- CV command

SP command is used to setup the SPA-bus interface, UN command is used to program the unit list and DA commands are used to program the data definitions.

Before configuration data is written the so called "configuration validity stamp" in EEPROM memory must be reset. And after configuration is complete the validity stamp must be set to start the operation of the gateway. The validity stamp can be accessed by the CV command.

4.3.1. General command syntax

Command to and reply from a gateway when setting configuration:

Command: CC par,par=par,par

Reply: nn

CC = command name
par = parameters given with the command
nn = reply to command, two digit number in ASCII format
00 = command accepted
02 = command rejected
xx = other values indicate the position of a syntax or context error, e.g. no corresponding unit list definition

Command to and reply from gateway when reading configuration:

Command: CC par,par=

Reply: CC par,par=par,par

Reply to configuration reading is identical to the original configuration setting command.

Command to and reply from gateway when resetting configuration:

Command: CC parameter,parameter=0

Reply: nn

Note: The commands must be written with capitals and the separator characters (a space or a comma) cannot be replaced with another character. If the gateway does not recognize the command, it won't send a response.

4.3.2. CV command

CV command is used to set and reset the configuration validity stamp in the EEPROM memory.

Syntax: **CV =X**

Parameters: X = validity stamp (WK = valid stamp, 0 = reset stamp)

When the LON/SPA gateway starts up after power on, it checks whether the configuration validity stamp is equal to "WK" or not. If stamp is "WK", the gateway assumes that the configuration in the EEPROM is valid and starts communication with the SPA-bus. If stamp is not valid the operation starts only after the validity stamp is set to value "WK".

Before configuration data is written the configuration validity stamp in EEPROM memory must be reset. And after configuration is complete the validity stamp must be set to restart the operation of the gateway.

Example 1:

Set validity stamp.

Command: CV =WK

Reply: 00

Example 2:

Read validity stamp.

Command: CV =

Reply: CV =0

Example 3:

Reset validity stamp.

Command: CV =0

Reply: 00

Note: Rewriting a valid CV stamp can be used to reset/restart SPA-bus communications and statistics.

Note: Writing valid CV causes (re-)evaluation of priority bindings of DI:s (see chapter 3.5).

4.3.3. SP command

SP command is used to setup the SPA-bus configuration.

Syntax:

SP = mode,baur,par,timeout,retry,poll_ratio,analog_ev,two_masters

By default SP-command definitions are:

event mode = 1 (events in SNVT_alarm format)
baudrate = 9600
data bits = 7
parity = even
stop bits = 1
receive_timeout = 100ms
number of retransmissions = 2
poll ratio = 8
analog events = disabled
single master mode

Parameters:

mode = event mode. Format of transmitted event message (0 = explicit message format, 1 = SNVT_alarm format)

baudr = SPA-bus baudrate (19 200, 9 600 bits/s)

par = parity (E, O or N)

timeout = SPA-bus reply timeout (50, 100, 500 or 3 000 ms)

retry = number of retries in error situations (0...3)

poll_ratio = number of event polls per 8 data polls in one poll cycle (excluding priority data polls) (0, 1, 2, 3, 4, 6, 8, 12, 16, 24, 32, 48 or 64)

analog_ev = enable/disable use of analog events (A or 0 (=zero))

two_masters = single or double master configuration (S or D)

Example 1:

Define interface in explicit message mode, baudrate 9600, even parity, 50ms reply timeout, 2 retransmissions, 4 event polls per 8 data polls, no analog events, single master.

Command: SP =0,9600,E,50,2,4,0,S

Reply: 00

Example 2:

Read SPA-bus configuration.

Command: SP =

Reply: SP =0,9600,E,50,2,4,0,S

Example 3:

Define events to be send in SNVT_alarm format, baudrate 9600, even parity, 50ms reply timeout, 2 retransmissions, 4 event polls per 8 data polls, no analog events, single master.

Command: SP =1,9600,E,50,2,4,0,S

Reply: 00

Note: Poll-ratio isn't exact it only defines how many events polls per 8 data polls gateway tries to send.

4.3.4. UN command

UN command is used to define the Unit list of the gateway.

Syntax:

UN =first_slave_number, slave_count, slave_type

Parameters:

first_slave_number =	slave number of the first unit list, 0...999
slave_count =	number of SPA slaves, 0...7 (0=remove slave)
slave_type =	SPA slave type:
	0 = SACO 16D
	1 = SACO 16A
	2 = protective relay
	3 = control unit
	4 = high voltage relay/extended data number (>255)

Semantics:

- Only one slave unit can be defined if slave type 4 is used.

Alternative command syntax:

UN entry_index=slave_number, slave_type

Parameters:

entry_index =	index of the unit list, 0...7

slave_number =	SPA slave number, 0...999 (0=remove slave)
slave_type =	SPA slave type:
	0 = SACO 16D
	1 = SACO 16A
	2 = protective relay
	3 = control unit
	4 = high voltage relay/extended data number (>255)

Semantics for alternative command:

- SPA slave numbers have to be in a sequential order.
- When configuring empty unit list, the smallest slave number have to be stored in entry number 0. Then next slave number have to be stored in entry number 1, and so on.
- Removing of the slave number definition always have to be applied to last used entry index.
- All the slaves are same type so if alternative command format is used the last given slave_type set the type for all slaves.

Example 1:

Remove all unit list definitions.

Command: UN =0,0,0

Reply: 00

Example 2:

Define units as control unit with slave numbers 100, 101, 102, 103 to the unit list entries 0 - 3.

Command: UN =100,4,3

Reply: 00

Example 3:

Add control unit with slave number 104 to unit list entry 4

Command: UN 4=104,3

Reply: 00

Example 4:

Read unit list entry 2

Command: UN 2=

Reply: UN 2=102,3

Example 5:

Reset unit list entry 4.

Command: UN 4=0,0

Reply: 00

Example 6:

Read unit list definitions

Command: UN =

Reply: UN =100,4,3

4.3.5. DA AI command

DA AI command is used to define an analog input object to the data base.

Syntax:

DA AI,i=s.cXd,dead band(,f)

Parameters:

i = index of analog input (0...15)
s = SPA slave number (1...999)
c = SPA channel number (0...255)
X = SPA data category (I, O, S or V)
d = SPA data number (1...255)
dead band = dead band as fixed point integer (0.01...655.35)
f = floating point value in use (F or empty)

Data defined by "s.cXd" is polled cyclically to update the data base object. If the data definition does not contain the channel number, data definition may not contain either the full stop after the slave number. In this case the definition is "sXd". Sent value can be analog fixed point value or analog floating point value with definition F.

An AI network variable in the data base is updated and value sent to LONWORKS if:

if (|polled value - value in data base| >= dead band)
then data base = polled value

Example 1:

Define an analog input 0 as input from slave 10 channel 2 input I1 with dead band value 0.1.

Command: DA AI,0=10.2I1,0.1

Reply: 00

Example 2:

Read definition of analog input 0.

Command: DA AI,0=

Reply: DA AI,0=10.2I1,0.1

Example 3:

Define an analog input 1 as input from slave 11 channel 1 input I1 with dead band value 0.5. Value will be sent as a floating point value.

Command: DA AI,0=10.2I1,0.5,F

Reply: 00

Example 4:

Reset definition of analog input 0.

Command: DA AI,0=0

Reply: 00

Note: If the dead_band value is set to smaller value than 0.01 then gateway interprets it as zero and in this case polled value is always sent to LONWORKS.

Note: If channel number is not used, a full stop may not be added after the slave number.

4.3.6. DA DI command

DA DI command is used to define a digital input object to the data base.

Syntax:

DA DI,i=s.c/cXd/d,format,s/d,bswitch[,E1/4,e1d,e2d,e3d,e4d]

Parameters:

i =	index of digital input (0...15)
s =	SPA slave number (1...999)
c/c =	SPA channel number 1 and 2 (0...255/c1...c1+15)
X =	SPA data category (I, O, S or V)
d/d =	SPA data number 1 and 2 (1...255/d1...d1+63)
format =	SPA data format (BIN, HEX , DEC or INT)
s/d =	single/double selection (S or D)
bswitch =	bit switch selection (1 for yes, 0 for no)
E1/4 =	SPA event 1 and 4 (E0...63/1...63)
e1d =	data for event 1 (00, 01, 10, 11, 0, or 1)
e2d =	data for event 2 (00, 01, 10, 11, 0, or 1)
e3d =	data for event 3 (00, 01, 10, 11, 0, or 1)
e4d =	data for event 4 (00, 01, 10, 11, 0, or 1)

If unit list definition is set to type 4 (UN =XXX,X,4), then the biggest data number can be 2047:

d/d = SPA data number 1 and 2 (1...2047/d1...d1+63)

If a definition does not include event definition (E1/4=E0), then object defined by "s.c/cXd/d" is cyclically polled from the SPA-bus. If the data definition does not contain the channel number, data definition may not contain either the full stop after the slave number. In this case the definition is "sXd".

If a definition includes event definition, then the object is updated from events. Data defined by "s.c/cXd/d" is read to initialize the object and to poll data in the background with low cycle rate. When an event updates a digital input object the event is also/not? sent to the master unit.

If a definition includes event definition but no valid data definition then object is updated only by events.

The "exd" fields, data for event "x", must be defined so that their values equal to the corresponding values read using definition "s.c/cXd/d" (see examples).

If data format is set to DEC, then digital input object is used as an analog input. Analog value 16-bit integer, scaled with 100.

If data format is set to INT, then digital input object is used as an integer input.

Double selection is allowed to for data BINary format.

If bit switch selection is set to "yes", then the order of the two data bits read by definition "s.c/cXd/d" are switched before storing to the data base. The bit switch selection must be set to "no" if the definition defines more than two bits. If definition defines only one data bit, bit_switch can be used to invert it. If input object is used as an analog input the bit switch selection "yes" cause the sending of the polled value to LONWORKS after every poll.

All DI object can be updated by cyclical poll, only objects DI[0]...DI[6] can be updated from events. If input object is used as an analog input, it cannot be updated from events.

If DI[15] is defined and it is bound as a priority network variable (read chapter 3.5) then it will be a high priority DI, which is polled with every other SPA-bus poll message. In this case also DI[14], DI[13],... can be used as high priority DIs. If more than one DI is defined as priority DI, still every other SPA-bus message is priority DI-poll.

Example 1:

Define digital input 0 as data from slave 33 channels 1/16 input I1. Data is cyclically polled to the data base.

Command: DA DI,0=33.1/16I1,BIN,S,O,E0

Reply: 00

Example 2:

Read definition of digital input 0.

Command: DA DI,0=

Reply: DA DI,0=33.1/16I1,BIN,S,O

Example 3:

Reset definition of digital input 0.

Command: DA DI,0=0

Reply: 00

Example 4:

Define digital input 0 as an analog input, slave number 5, data S1.

Command: DA DI,0=5S1,DEC,S,0,E0

Reply: 00

Example 5:

Define digital input 0 as an integer input, slave number 6, data S3.

Command: DA DI,0=6S3,INT,S,0,E0

Reply: 00

Example 6:

Define digital input 1 as status of object 1 in control unit SPTO 6D3, slave number 4. Update from events, initialization by reading channel 1 inputs 2 and 3.

Command: DA DI,1=4.1I2/3,BIN,D,0,E1/4,10,01,11,00

Reply: 00

The definition is done bearing in mind the following table:

state of object	event	I3 (open)	I2 (closed)
open	E1	1	0
closed	E2	0	1
undefined 11	E3	1	1
undefined 00	E4	0	0

Example 7:

Define digital input objects 1 to 4 as the digital inputs 1...16 from SACO 16D2 units in SACO 64D4 rack, slave numbers 10...13. Update by cyclical polling.

Commands: DA DI,1=10.1/16I1,BIN,S,0,E0

DA DI,2=11.1/16I1,BIN,S,0,E0

DA DI,3=12.1/16I1,BIN,S,0,E0

DA DI,4=13.1/16I1,BIN,S,0,E0

Example 8:

Define DI 1 as an event input updated from overcurrent relay's, slave number 10, channel 0 "trip event" E3 and "trip reset event" E4.

Command: DA DI,1=10.0E,BIN,S,0,E3/4,1,0,0,0

Reply: 00

Example 9:

Define DI 1 as a double point input from SPOC 110, slave number 70.

Command: DA DI,1=70.1/2I1,BIN,D,1,E1/4,10,01,11,00

Reply: 00

The following tablede should be considered in the definition:

state of object	event	2I1 (closed)	1I1 (open)
open	E1	0	1
closed	E2	1	0
undefined 11	E3	1	1
undefined 00	E4	0	0

Bit switch is used to change the bit order so that closed bit is lsb bit of the DI-object. The selection of event data match this bit order.

Note:If channel number is not used, a full stop may not be added after the slave number.

4.3.7. DA DO command

DA DO command is used to define a digital output object to the data base.

Syntax (command output):

DA DO,i=s.cX,format,c/g,open,close,exe,cancel

Syntax (general output):

DA DO,i=s.c/cXd/d,format,c/g

Parameters:

i = index of digital output (0...15)
s = SPA slave number (1...999)
c/c = SPA channel number 1 and 2 (0...255/c1...c1+15)
X = SPA data category (I, O, S, V)
d/d = SPA data number 1 and 2 (1...255/d1...d1+63)
format = SPA data format (BIN, BWR, HEX, DEC or INT)
<c/g> = command/general output selection (C or G)
<open> = data number for open message (1...255)
<close> = data number for close message (<open>...<open>+3)
<exe> = data number for execute message (<open>...<open>+3)
<cancel> = data number for cancel message (<open>...<open>+3)

If unit list definition is set to type 4 (UN =XXX,X,4), then the biggest data number can be 2047:

d/d = SPA data number 1 and 2 (1...2047/d1...d1+63)

When DO is a command output, then the four lsb bits of the 16-bit data received from LONWORKS is interpreted as follows:

Data value	Operation	
0001	select open/open	(send open message to SPA)
0010	select close/close	(send close message to SPA)
0100	execute	(send execute message to SPA)
1000	cancel	(send cancel message to SPA)

Command output can be only data type BIN.

When DO is general output then all the data bits indicated by SPA channel and data numbers are sent to the SPA-bus either one by one (BIN format) or all at the same time (HEX format). The lsb bit (bit 0) of the received data is sent to the SPA data item corresponding to channel 1 and data number 1, and the msb bit (bit 15) to channel 2 data number 2.

In DEC format data is converted to ASCII characters and only one channel/data item can be defined in one digital output. In data format DEC data is transferred as 16-bit integer, scaled with 100.

In INT format data is converted to ASCII characters and only one channel/data item can be defined in one digital output. In data format INT data is transferred as 16-bit integer, without scaling.

In BWR format the first four bits of data determines to which of the bits the write directs and the last bit determines the new value.

If DO network variable is bound as a priority network variable (read chapter 3.5) and its definition creates only one SPA-bus message then it will be a high priority DO. The SPA-bus W-message generated from the update of a high priority DO will bypass all other SPA-bus messages when sent to the SPA-bus.

Example 1:

Define digital output 0 as general output controlling the output number 1 on channel 7 of slave number 10.

Command: DA DO,0=10.7O1,BIN,G

Reply: 00

Example 2:

Read definition of digital output 0.

Command: DA D0,0=

Reply: DA D0,0=10.7O1,BIN,G

Example 3:

Reset definition of digital output 0.

Command: DA D0,0=0

Reply: 00

Example 4:

Define digital output 1 as control output of object 1 in control unit SPTO 6D3, slave number 13.

Command: DA DO,1=13.1V,BIN,C,1,2,3,4

Reply: 00

Example 5:

Define digital output 2 as general output controlling the channel lamp of channel 7 in a SACO 16D1, slave number 10.

Command: DA DO,2=10.7I1,BIN,G

Reply: 00

Example 6:

Define digital output 3 as general output controlling all 16 output relays of SACO 16D1, slave number 11.

Command: DA DO,3=11.0V50,HEX,G

Reply: 00

Example 7:

Define digital output 4 as general output controlling analog output V40 of SPTO6D3, slave number 23.

Command: DA DO,4=23.0V40,DEC,G

Reply: 00

Example 8:

Define digital output 5 as general output controlling analog output V40 of SPTO6D3, slave number 24.

Command: DA DO,5=24.0V40,INT,G

Reply: 00

Example 9:

Define digital output 5 as general output controlling 16 channels in a SACO 1D1, slave number 10, in BWR format.

Command: DA DO,5=10.1/16I1,BWR,G

Reply: 00

Note: If channel number is not used, a full stop may not be added after the slave number.

4.4. Configuration of the network variables (binding)

During the configuration network variables of one LON/SPA-gateway are logically connected (bound) to the network variables in other nodes of LONWORKS (e.g. other LON/SPA-gateways or "master" units).

In the terminology of LonTalk protocol an output network variable is a variable which is sent to LONWORKS from a node and input network variable is a variable which is received by the node. In the case of the LON/SPA-gateway the DI and AI objects are "output" network variables and DO objects are "input" network variables.

When binding is done the output network variables of the LON/SPA-gateway are connected to the input network variables in some other nodes. Input network variables of the LON/SPA-gateway are bound to output network variables in other nodes.

The connections between network variables are done with the help of the network variable configuration table and address table. The network variable configuration table includes network variable selector values, which are used as system wide addresses of the network variables. The address table of a node contains addresses of all the other nodes to which the node is going to send messages. If messages are sent to group of nodes or if they are broadcasted to the network then address table also contains group address and broadcast address definitions.

4.4.1. High priority network variables

If a DI or a DO network variable is defined as a high priority network variable it's processing differs from the processing of a normal priority network variable. A high priority DI is polled in every other message sent on SPA-bus. The first high priority DI must be DI[15] and the next high priority DIs must have smaller indices in numerical order. If a DO is defined as a high priority DO an update message to it will bypass all other SPA-messages. The DI is defined as a high priority DO when it is bound as priority network variable and it's update generates only one SPA-message. The numbering rule is similar to high priority DI numbering rule.

High priority definition is made by binding two network variables together as priority network variables.

4.4.2. Network variable configuration table

The network variable configuration table contains a 3 byte entry for every network variable. The table can be updated and read using network management commands "Update Net Variable Config" (6BH) and "Query Net Variable Config" (68H). The device responsible for network management updates the network variable configuration table, when it makes the binding of the network variables.

An entry of the network variable configuration table contains the following information:

byte 1			byte 2	byte 3			
7	6	543210	76543210	7	6 5	4	32 10
p	d	selector msb	selector lsb	t	sety	a	addr ind

```
 |    |   |                |          |    |       |    |
 |    |   14 bit network variable     |    |       |    index to address table
 |    |   selector 0...2FFFH          |    |       |    0...14 = index
 |    |  (values 3000H...3FFFH        |    |       |    15 = not associated
 |    |   are used for unbound        |    |       |    with address table
 |    |   network variables)          |    |       |
 |    |                               |    |       |
 |    direction                       |    |       authentication
 |    0 = input network variable      |    |       0 = auth. not used
 |    1 = output network variable     |    |       1 = auth. used
 |                                    |    |
 priority                             |    service type
 0 = no priority                      |    0 = acknowledged
 1 = priority                         |    1 = unacknowledged/repeated
                                      |    2 = unacknowledged
                                      |
                                      turnaround
                                      0 = nv is not a turnaround nv
                                      1 = nv is a turnaround nv
```

When an output network variable is sent to LONWORKS the destination address is taken from the address table location defined by the 4-bit address table index.

4.4.3. Address table

The address table contains a 5 byte entry for each network address. The table can be updated and read using network management commands `Update Address` (66H), `Update Group Address Data` (69H) and `Query Address` (67H). The device responsible for network management updates the address table, when it makes the binding of the network variables.

Events sent as network variable update (mode = 1 on SP-command):

Any of the address table entries can be chosen to define the address of single master. If two masters are used, address table entries 0 and 1 have to be used. The addresses of the master devices are used to find destination address for the spontaneously sent event messages. When system is configured it must be taken care of that entry 0 is filled with proper value. The indexes can still be used by network variables sent to the defined "master" node.

Events sent as explicit message (mode = 0 on SP-command):

Address table entry 0 is reserved for the address of the "master" device. (If double master configuration is used then address table entry 1 is reserved for the address of the second master device). The addresses of the master devices are used to find destination address for spontaneously event messages.The default master address is node 126 on subnet 1. When the system is configured entry 0 must be filled with the proper value. The index 0 can also be used by the network variables sent to the "master" node.

The LON/SPA-gateway has 4 address table entries.

An entry of the address table contains the following information:

byte 1 76543210	**byte 2** 76543210		**byte 3** 76543210		**byte 4** 76543210		**bytes 5** 76543210
type	d	node	rptt	retr	rcvt	tx_t	subnet

```
|             |   |         |     |     |     |     |
|             |   node or   |     |     |     |     subnet or
|             |   group     |     |     |     |     group number
|             |   member    |     |     |     tx timer
|             domain table  |     |     |     timeout between retries
|             index 0 or 1| |     |     |     0 = 16ms, 1 = 24ms,
|                           |     |     |     2 = 32ms, 3 = 48ms,
|                           |     |     |     4 = 64ms, 5 = 96ms,
|                           |     |     |     6 = 128ms, 7 = 192ms
|                           |     |     rcv timer
address type                |     |     receive timeout for group messages
0 = not used,               |     |     0 = 128ms, 1 = 192ms,
    unbound or              |     |     2 = 256ms, 3 = 384ms
    turnaround              |     retry
                            |     maximum number of retries
1 = subnet node             |
3 = broadcast               rpt timer
   group address            time interval between messages
   = 80H+group size         sent with unackd repeated service
                            0 = 16ms, 1 = 24ms, 2 = 32ms, 3 =4 8ms
```

4.4.4. Domain table

The domain table contains the address of the node itself. The table can be updated and read using network management commands "Update Domain" (63H) and "Query Domain" (6AH). The device responsible for network management updates the address table, when it installs a node to the network.

Generally a LONWORKS node can belong to two domains. The LON/SPA-gateway can belong only to one domain, its domain table has only one entry.

An entry of the domain table contains 15 bytes:

bytes 1...6	**byte 7**	**byte 8**		**byte 9**	**bytes 10...15**
domain id	subnet	1	node	length	authentication key

```
|            |           |   |      |       |
|            |          bit  |      |       6-byte
|            |          not  |      |       authentication key
|            |          in   |      |       for authenticated
|            |          use  |      |       transactions.
|            |               |      |       Not used in LON/
|            |               |      |       SPA-gateway,
|            |               |      |       value =
|            |               |      |       FF,FF,FF,FF,FF,FF
|            |               |      Length of the domain id.
|            |               |      Not used in LON/SPA-gateway,
|            |               |      value = 0.
|            |               node number 1...127
|            subnet number 1...255
6-byte domain identification
Not used in LON/SPA-gateway,
value = FF,FF,FF,FF,FF,FF
```

4.5. LonTalk network management messages

The configuration of the network variables (binding) and other management of LONWORKS nodes is done using network management messages defined in LonTalk protocol. Usually these messages are sent by the device who is responsible for the network management, usually the "master" node of the system.

Here is a short summary of some of the network management messages.

Table 4.5.-1 LonTalk message summary

<table>
<tr><th>Message function</th><th>Code byte</th><th>Data bytes</th></tr>
<tr><td>Query Status</td><td>51</td><td>no data
Response message (15 bytes):
<xmit errors 2B>, <transaction timeouts 2B>,
<rcv_transaction full 2B>, <lost_msg 2B>,
<missed_msgs 2B>,
<reset cause>,<node state>,
<version number>, <error_log>,
<mode number></td></tr>
<tr><td>Clear Status</td><td>53</td><td>no data</td></tr>
<tr><td>Query Domain</td><td>6A</td><td><domain index>
Response message (15 bytes):
<6 byte domain id>,<subnet>,
<80H + node>,<domain id length>,
<6 byte authentication key></td></tr>
<tr><td>Update domain</td><td>63</td><td><domain index>
<6 byte domain id>,<subnet>,
<80H + node>,<domain id length>,
<6 byte authentication key></td></tr>
<tr><td>Query Address</td><td>67</td><td><address index>
Response message (5 bytes):
<addr type (or 80H+group size)>, 0=unbound, 1=subnet node, 3=broadcast,
<domain bit| node (or group member)>,
<rpt_timer|retry>,<rcv_timer|tx_timer>,
<subnet (or group number)></td></tr>
<tr><td>Update Address</td><td>66</td><td><address index>
Response message (5 bytes):
<addr type (or 80H+group size)>, 0=unbound, 1=subnet node, 3=broadcast,<domain bit| node (or group member)>,
<rpt_timer|retry>,<rcv_timer|tx_timer>,
<subnet (or group number)></td></tr>
<tr><td>Query NV Configuration</td><td>68</td><td><nv index>
Response message (3 bytes):
<p|d|sel msb>,<sel lsb>, <t|st|a|addr>
p = priority; 0 = normal, 1 = high
d = direction; 0 = input nv, 1 = output nv
sel_msb+sel_lsb = selector 14 bits
t = turnaround bit
st = service type; 00 = ackd,
01 = unackd rpt,
10 = unackd
a = authentication bit
addr = address table entry index</td></tr>
</table>

Table 4.5.-1 LonTalk message summary

Update NV Configuration	6B	<nv index> <p|d|sel msb>,<sel lsb>,<t|st|a|addr>
Read memory	6D	<mode>,<offset msb>,<offset lsb>,<count> mode = addressing mode; 0 = absolute 1 = read only relative (start of EEPROM, at address 0F000H) 2 = configuration relative (hardware and transceiver properties)
Write memory	6E	<mode>,<offset msb>,<offset lsb>,<count> <action>,<data bytes> action = action to be taken after write operation; 0=no action 1=both checksum recalculation 4=configuration checksum recalculation 8=only reset 9=both cs recalc. and reset C=config. cs recalc. and reset E.g. Write value 05 to configuration table offset 8: 6E 2,0,8,1,1,05
Update NV	<80H + sel msb>	<sel lsb>,<data bytes>
Poll NV	<C0H + sel msb>	<sel lsb>
Network Variable Fetch	73	<nv index> Response message: <nv index>,<data bytes>
Set Node Mode	6C	<mode>,<state> mode: 0 = offline 1 = online 2 = reset 3 = change state state: 2 = appl_uncnfg 3 = no_appl_uncnfg 4 = cnfg_online 6 = cnfg_offline State is given only, if mode = 3

5. Maintenance and service

5.1. Self diagnostic

5.1.1. SPA indicator

SPA indicator is lit whenever a LSG is sending a message to the SPA bus.

If the self-supervision of the LSG detects a fault in the SPA-bus communication, the SPA indicator remains lit.

5.1.2. LON indicator

The LON indicator has two functions: It operates as a Service LED indicating the status of the Neuron chip. It also indicates when an application of the LSG is sending messages to the LON network.

Normally, in the start-up situation, the LON indicator is lit once and then goes out.

Pressing of the service pin turns on the LON indicator.

The LON indicator is lit when a "Wink" message is received from the LON network.

The LON indicator is lit whenever the LSG application is sending a message to LON network. The LED is not lit when network management messages are sent or received.

Normally, the LON indicator is lit only when the LSG is sending data to the LON network.

5.2. Fault localization

The table below can be used to localise a fault and take corrective measures:

Problem	Fault type	Repair step
SPA and LON led not lit on start up. (Power supply trough the connection cable) SPA led is off. LON led is off.	Supply failing	Check if the SPA-bus device has power. Check that the LSG is properly connected to the device. Check the DIP-switch settings for SPA-bus interface type and supply voltage.
LSG gives no response to LONWORKS messages.	LONWORKS fault	Check the communication speed of devices sharing the same communication channel.
LON led is continuously blinking	LONWORKS fault	Check that the LSG is properly connected to the device. Check the fibre optic connections of LONWORKS. Check that the master address of the LSG is correct.
LSG works unreliably or that it gives different results to the same query.	LONWORKS fault	Ensure that the LONWORKS address of the LSG is unique in the communication network.

No response from SPA-device. SPA led is continuously on, and occasionally blinking.	SPA-bus fault	Check that the LSG is properly connected to the device. Check the operation of the SPA-bus device. Check the DIP-switch settings of the SPA-bus interface type. Check the configuration of the SPA-bus (SP-command): SPA-bus bit rate, parity, unit list definition. (See the chapter “Programming the SPA-bus interface and data definitions for details).

6. Appendix A

6.1. Default values of communication parameters of LON/SPA gateway

These values are set during manufacturing and they are stored in EEPROM of Neuron chip. Values may be read and written over the LONWORKS network using Read Memory and Write Memory network management messages with address mode = 2 (for more details see LONWORKS Technology Device Data chapter A6: The configuration structure).

Field of a structure	value	offset/ # of bits	Remarks
channel_id	0x0001	0x00 /16	
location	0	0x02 /6*8	set during installation
comm_clock	0	0x08 / 5	= input_clock/8
input_clock	5	/ 3	= 10 Mhz
comm_type	1	0x09 / 3	= Single ended
comm_pin_dir	0x0E	/ 5	= Dir.mode - single-end
preamble_length	6	0x0A / 8	= 240 µs
packet_cycle	4	0x0B / 8	= 4 ms
beta2_control	0	0x0C / 8	
xmit_interpacket	0	0x0D / 8	
recv_interpacket	0	0x0E / 8	
node_priority	0	0x0F / 8	= no priority slot allocated
channel_priorities	20	0x10 / 8	number of priority slots
collision_detect	1	0x11 / 1	= enabled
bit_sync_threshold	0	/ 2	= number of bits: 4
filter	0	/ 2	
hysteresis	0	/ 3	
cd_to_end_packet	0	0x12 / 6	
cd_tail	1	/ 1	
cd_preamble	1	/ 1	
non_group_timer	2	0x18 / 4	
nm_auth	0	/ 1	= no authentication
preemption_timeout	5	/ 3	= 10 sec

7. Appendix B

7.1. Configurations of LSGs for parallel operation of SPAU 341 C devices.

CONFIGURATION 1 used in devices SPA-ZC 100; 1MRS0090704-AB and 1MRS090704-DB.

LON network address: subnet 1, node 10

Data definitions:	Network variable configuration table:			
CV = 0	_ index			
SP = 1,9600,E,500,2,0,0,S	|	_ input/output		
UN = 10,1,2	|	|	_ selector	
	|	|	|	_ adress table
DA DI,1=10S13,DEC,S,1	11	40	01	41
DA DI,2=10I18,DEC,S,0	12	40	02	41
DA DI,3=10I5,DEC,S,0	13	40	03	41
DA DI,4=10V3,DEC,S,1	14	40	04	41
DA DO,1=10S18,DEC,G	21	00	05	4F
DA DO,2=10I14,DEC,G	22	00	06	4F
DA DO,3=10I16,DEC,G	23	00	07	4F
DA DO,4=10V4,DEC,G	24	00	08	4F
DA DO,5=10S19,DEC,G	25	00	09	4F
DA DO,6=10I15,DEC,G	26	00	0A	4F
DA DO,7=10I17,DEC,G	27	00	0B	4F
DA DO,8=10V5,DEC,G	28	00	0C	4F

Adress table:

01 83 01 11 31 01; group adress, three in group

CV = WK

CONFIGURATION 2 used in devices SPA-ZC 100; 1MRS0090704-AC and 1MRS090704-DC.

LONWORKS address: subnet 1, node 20

Data definitions:Network variable configuration table:

```
                                   CV =0   _ index
SP =1,9600,E,500,2,0,0,S    |      _ input/output
UN =20,1,2                  |      |      _ selector
                            |      |      |      _ adress table
DA DI,1=20S13,DEC,S,1       11     40     05     41
DA DI,2=20I18,DEC,S,0       12     40     06     41
DA DI,3=20I5,DEC,S,0        13     40     07     41
DA DI,4=20V3,DEC,S,1        14     40     08     41
DA DO,1=20S18,DEC,G         21     00     01     4F
DA DO,2=20I14,DEC,G         22     00     02     4F
DA DO,3=20I16,DEC,G         23     00     03     4F
DA DO,4=20V4,DEC,G          24     00     04     4F
DA DO,5=20S19,DEC,G         25     00     09     4F
DA DO,6=20I15,DEC,G         26     00     0A     4F
DA DO,7=20I17,DEC,G         27     00     0B     4F
DA DO,8=20V5,DEC,G          28     00     0C     4F
```

Adress table:

01 83 02 11 31 01; group adress, three in group

CV = WK

CONFIGURATION 3 used in devices SPA-ZC 100; 1MRS0090704-AD and 1MRS090704-DD.

LONWORKS address: subnet 1, node 30

Data definitions:Network variable configuration table:

```
CV =0                          _ index
SP =1,9600,E,500,2,0,0,S    |      _ input/output
UN 0=30,1,2                 |      |      _ selector
                            |      |      |      _ adress table
DA DI,1=30S13,DEC,S,1       11     40     09     41
DA DI,2=30I18,DEC,S,0       12     40     0A     41
DA DI,3=30I5,DEC,S,0        13     40     0B     41
DA DI,4=30V3,DEC,S,1        14     40     0C     41
DA DO,1=30S18,DEC,G         21     00     01     4F
DA DO,2=30I14,DEC,G         22     00     02     4F
DA DO,3=30I16,DEC,G         23     00     03     4F
DA DO,4=30V4,DEC,G          24     00     04     4F
```

DA DO,5=30S19,DEC,G	25	00	05	4F
DA DO,6=30I15,DEC,G	26	00	06	4F
DA DO,7=30I17,DEC,G	27	00	07	4F
DA DO,8=30V5,DEC,G	28	00	08	4F

Adress table:

01 83 03 11 31 01; group adress, three in group

CV =WK

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