

B&R SYSTEM 2000

Logic Scanner LS251

User's Manual

Version: **1.0 (March 1998)**
Model No.: **MASYS2LS-E**

We reserve the right to change the contents of this manual without warning. The information contained herein is believed to be accurate as of the date of publication, however, Bernecker and Rainer Industrie-Elektronik Ges.m.b.H. makes no warranty, expressed or implied, with regards to the products or the documentation contained within this book. Bernecker and Rainer Industrie-Elektronik Ges.m.b.H. shall not be liable in the event of incidental or consequential damages in connection with or arising from the furnishing, performance or use of these products.

1. General Information

2. Logic Scanner LS251

3. Expansion Card LS071

Index



CONTENTS

Chapter 1	7	8. PC Resources	28
General Information	7	8.1 PCI Bus	28
1 Manual Contents	9	8.2 Plug & Play	28
2 General Information	10	8.3 Interrupt	29
3 Remote I/O Bus	11	8.4 Memory	29
3.1 Remote Master	11	9 Installation in the PC	29
3.2 Remote Slave	11	9.1 Protection against Electrostatic Dis-	29
3.3 Connection	11	charge	29
3.4 Expansion	12	9.2 Installation of the LS251	30
4 CAN Field Bus	13		
4.1 Features of the CAN Bus	13		
4.2 Bus Length and Cable Type	13		
4.3 Connection	15		
Chapter 2	19	Chapter 3	31
Logic Scanner LS251	19	Expansion Card LS071	31
1 Technical Data	21	1 Technical Data	33
2 Overview of the Components	22	2 Overview of the Components	34
3 Description of the Components	23	3 Description of the Components	35
3.1 RS485, Remote I/O Bus	23	3.1 RS232 Interface	35
3.2 CAN Field Bus	23	3.2 CAN Field Bus	35
3.3 CAN Node Number Dials	24	3.3 CAN Node Number Dial	35
3.4 Buffer Battery	24	4 Installation in the PC	36
3.4.1 Battery Data	24		
3.4.2 Data/Real Time Buffering	24		
3.4.3 Battery Change	25		
4 Memory	26		
5 Online Connection	26		
6 Operating System	26		
7 Visualization	27	Index	37
7.1 DOS Visualization	27	Relevant Conversions	40
7.2 Windows® Visualization	28		



CHAPTER 1

GENERAL INFORMATION

1 Manual Contents

Chapter 1 - General Information

Description of the contents of this manual and an overview of the functions of the Logic Scanner LS251, the Expansion Card LS071, the remote I/O buses and the CAN field buses

Chapter 2 - Logic Scanner LS251

Technical data and the components of the Logic Scanner LS251 are explained in chapter 2.

Chapter 3 - Expansion Card LS071

Technical data and the components of the Expansion Card LS071 are explained in chapter 3.

Index

Index of key words with page numbers for finding relevant information quickly

Relevant Conversions

Tables for metric to imperial conversions.

2 General Information

More and more open and closed loop processes use HW neutral standard PCs for visualization. Process data is collected in a central controller and uses either a point to point or network connection to transfer data.

When using the Logic Scanner LS251, the controller no longer has to handle data collection. The Logic Scanner comes in the form of a PCI bus card that can be used in every PC equipped with a PCI bus slot. The LS251 is equipped with an integrated, high performance PCC CPU. This CPU processes the complete controller program. A remote CPU is therefore not required on the PCC rack.

The connections to the field inputs and outputs can be made using a CAN field bus or a remote I/O bus. The master function is taken over by the LS251.

The control program can be processed completely independent of the performance demands for visualization using the high performance processor on the logic scanner. The B&R PCC operating system guarantees stable, real time and deterministic multitasking, that is not influenced by the operating status of the visualization software or the PC operating system.

If a software reset is triggered with [Ctrl] + [Alt] + [Del], or the PC system comes to a stand still, this does not effect the logic scanner.

Programming is completely compatible with the B&R 2003, B&R 2005 and B&R 2010 systems. Existing programs can be used directly.

Integrating the CPU and the CAN and remote I/O field bus connections on a slot card achieves the highest performance when accessing the inputs and outputs. Short cycle times up to 1 msec are possible.

Visualization via the PC bus provides fast access to the process data. There is no pause during screen regeneration.

The LS071 expansion card expands the interface possibilities by providing an extra RS232 and a CAN interface. The module is connected to the LS251 with flat ribbon cable.

3 Remote I/O Bus

An I/O module is coupled to the remote master through the use of a remote I/O bus. The coupling can be achieved up to a maximum distance of 1200 m without installing a repeater. A maximum of 31 slaves can be coupled to a remote master without using a repeater.

3.1 Remote Master

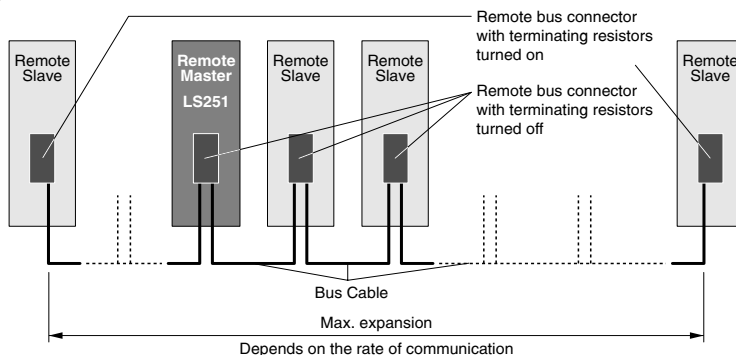
The remote master used is the LS251 logic scanner LS251.

3.2 Remote Slave

The remote slave used can be a B&R SYSTEM 2003 (e.g. EX477), 2005 (e.g. PS476) or 2010 (EX200).

3.3 Connection

3.3.1 Cable Connections



3.3.2 Bus Cable

Standard: DIN 19245 Part 3

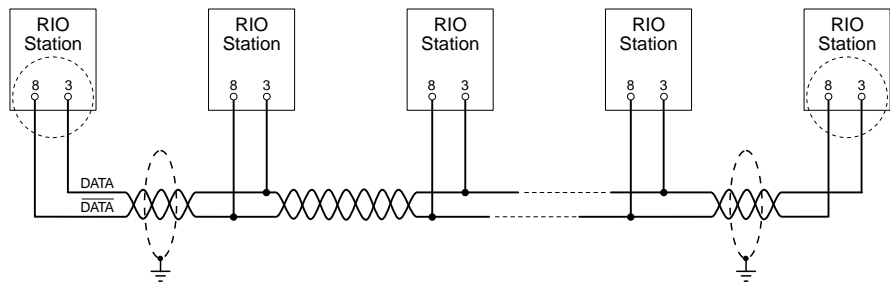
The connection between the remote master and the slave modules is achieved by using twisted pair cable that must conform to the following specifications:

Wave Impedance	135 - 165 Ω (3 - 20 MHz)
Capacitance per unit length	< 30 pF / m
Loop Resistance	< 110 Ω / km
Wire Diameter	> 0.64 mm
Core Cross Section	> 0.34 mm ²

Both ends of the system must be provided with terminating resistors.

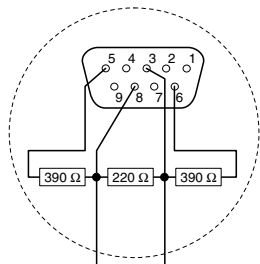
3.3.3 Connection Bus
Cable - Station

The two bus cable wires are connected to the individual stations in the following order:



3.3.4 Terminal
Resistors

The remote I/O bus is provided with terminating resistors at both ends:



The remote bus connector 0G1000.00-090 can be obtained from B&R and features integrated terminal resistors. The terminal resistors can be turned on or off.

3.4 Expansion

The maximum expansion of a remote system depends on the rate of communication:

Expansion [m]	Transfer Rate [kBit/sec]
1200	100
1000	181
400	500
200	1000
100	2000

4 CAN Field Bus

4.1 Features of the CAN Bus

- Low costs
- High noise immunity through differential signals
- Bus structure
- Open system
- Fast data transfer for small data packets (up to 8 Bytes)
- Error detection by means of CRC (Cyclic Redundancy Check) and frame check -> Hamming Distance 6
- Predictable transfer times for high priority messages (real time behavior)
- Easy use

4.2 Bus Length and Cable Type

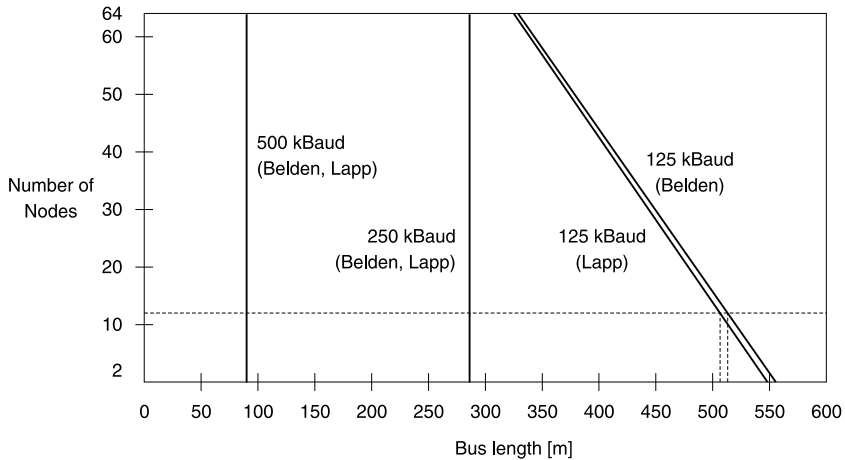
The type of cable used depends largely on the bus length and the number of nodes. The bus length is determined by the transfer rate. The following bus lengths are permitted with a maximum oscillator tolerance of 0.121 %.

Expansion [m]	Transfer Rate [kBit/sec]
7306 ¹⁾	10
3613 ¹⁾	20
1397 ¹⁾	50
658	100
510	125
215	250
67	500

¹⁾ To the CiA (CAN in Automation) the maximum bus length is 1000 m.

B&R default values for different cable types are defined by the number of nodes and the bus length:

Cable 1	Belden YR 29832, 4.15 nsec/m
Cable 2	Lapp cable 2170204, 4.15 nsec/m



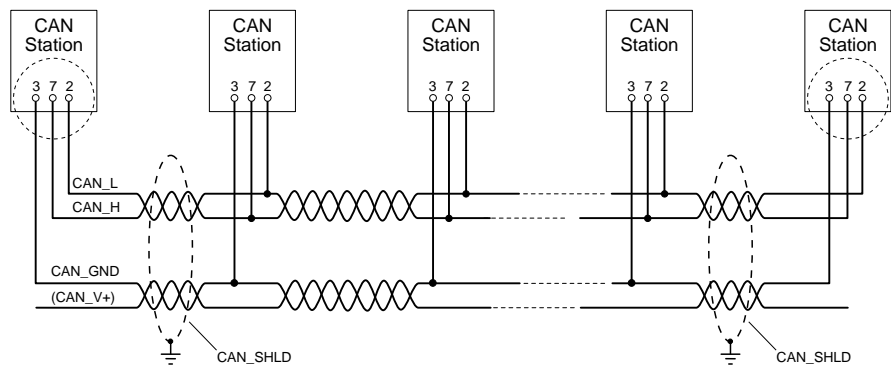
Example for 12 nodes:

Manufacturer	Baudrate	Bus length	Baudrate	Bus length	Baudrate	Bus length
Belden	500 kBaud	90 m	250 kBaud	286 m	125 kBaud	513 m
Lapp	500 kBaud	90 m	250 kBaud	286 m	125 kBaud	506 m

4.3 Connection

4.3.1 Connection Bus Cable - Station

It is essential to use a four wire twisted pair cable for the bus cable.



4.3.2 CAN Signal according to CiA/ CAL

CAN Signal	Description
CAN_GND	CAN Ground
CAN_L	CAN Low
(CAN_SHLD)	Shield
CAN_H	CAN High
(CAN_V+)	CAN Supply 8 - 15 V, optional

All CAN interfaces from B&R are supplied internally, therefore CAN_V+ does not have to be connected in CAN networks which do not contain devices from other manufacturers.

4.3.3 Branch Line

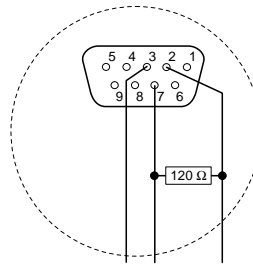
Branch lines should be avoided if possible. However, it is possible to connect nodes to the bus with a branch line as long as the distance is less than 30 cm.

4.3.4 Termination Resistance

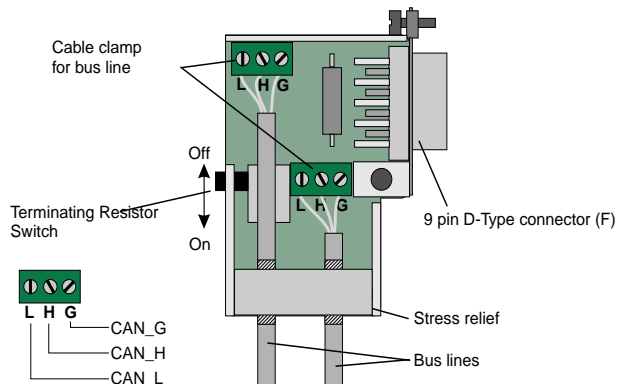
CAN networks are cabled using a bus structure, where both ends of the bus are equipped with termination resistors.

9 Pin D-Type Connector (m)

For modules using a CAN interface, terminating resistor pins are assigned in the 9 pin D-Type (M) connector as shown in the following diagram.

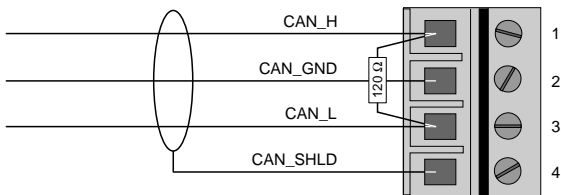


The terminating resistors are already integrated in CAN bus connectors 7AC911.9 provided by B&R. They can be turned on or off.



4 Pin Terminal Block

For modules using a CAN interface, terminating resistor pins are arranged in the 4 pin terminal block as shown in the following diagram.



A 4 pin terminal block and a 120 Ω terminating resistor are included with the delivery of the modules.

CHAPTER 2

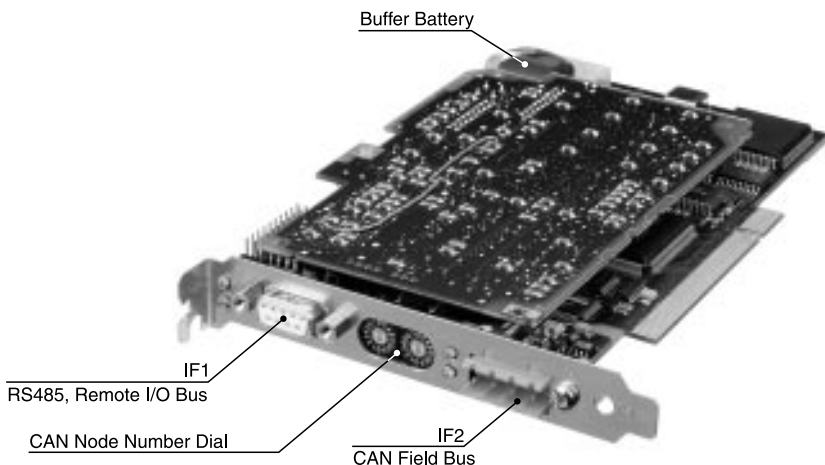
LOGIC SCANNER LS251

1 Technical Data

Module ID	LS251
General Information	
Model Number	5LS251.60-1
Type	Standard PCI Half Size Card, Plug & Play
Output Power without LS071 with LS071	max. 7.75 W max. 8.5 W
Operating Temperature	0 - 55 °C
Humidity	0 - 95 % (not condensing)
Controller	
Processor Architecture	32 Bit
Typical Command Cycle Time	0.13 µsec
Data and Program code Cache	2 x 256 Byte
Standard Memory Construction Operating Memory System RAM User RAM System PROM User PROM	2 MByte DRAM 174 KByte SRAM 850 KByte SRAM 512 KByte FlashPROM 512 KByte FlashPROM
Real Time Resolution	Non-volatile 1 sec
Data Buffering Buffer Battery Battery Monitoring Buffer Life	Lithium battery 3 V / 950 mAh Yes min. 4 years
Standard Communication Interface	
User Interface 1 Connection Type Electrical Isolation Baudrate 100 kBit/sec 181 kBit/sec 500 kBit/sec 1000 kBit/sec 2000 kBit/sec	RS485 interface (for remote I/O) 9 Pin D Type connector (F) Yes Expansion Distance max. 1200 m max. 1000 m max. 400 m max. 200 m max. 100 m
User Interface 2 Connection Type Electrical Isolation Max. Baudrate	CAN interface 4 Pin connector block Yes 500 kBit/sec (see chapter 1 "General Information", section "CAN Field Bus")

Module ID	LS251
Controller	
Remote I/O bus	
Access Procedure	Master/Slave principle
Number of Slaves	max. 31 (without repeater)
Intelligent Slaves with CPU possible ?	Yes
Protocol Handling	through own processor
Transfer Time	897 µsec for 64 digital I/O and 16 analog I/O
Topology	physical bus
Coupling to Bus	direct
Transfer Method	twisted pair cable
Terminating Resistance	external
CAN Field Bus	
Multi master capable	Yes
Number of stations	max. 64 (without repeater)
Controller	Controller 82527
Priority	through object identifier
Protocol	from CiA/CAL
Transfer method	4 wire twisted pair cable
Terminating resistance	optional external cable
Interface Expansion	with expansion card LS071 in neighboring slot 1 x CAN 1 x RS232

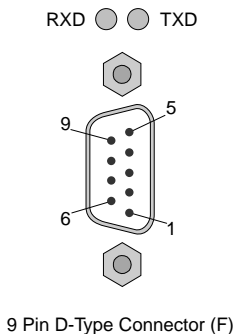
2 Overview of the Components



3 Description of the Components

3.1 RS485, Remote I/O Bus

The cabling of remote I/O networks is explained in chapter 1 "General Information" section "Remote I/O Bus".



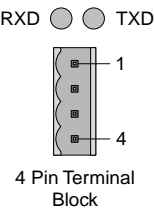
Pin	RS485 Interface, 9 Pin D Type Connector (F)	
1	Shield	Shield connection (casing)
2	-	Reserved
3	DATA	Data
4	CNTRL	Transmit Enable (control wire)
5	GND	Isolated Supply
6	+5 V / 50 mA	Isolated supply (e.g. for Bus connection)
7	-	Reserved
8	DATA\	Data\
9	CNTRL\	Transmit enable\

3.2 CAN Field Bus

A 4 pin terminal block and a 120 Ω bus terminating resistor are included with every delivery.

The resistor must be attached between pins 1 and 3.

The cabling of a CAN field bus is explained in chapter 1 "General Information" section "Can Field Bus".



Connector	CAN Field Bus, 4 Pin Terminal block	
1	CAN_H	CAN High
2	CAN_GND	CAN Ground
3	CAN_L	CAN Low
4	CAN_SHLD	Shield

3.4.3 Changing the Battery

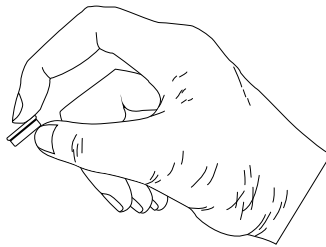
The product design allows the battery to be changed when the PC is turned off (Logic Scanner LS251 is at zero volts) and also when the PC is turned on. Changing the battery under operating voltage is, however, not allowed in many countries.



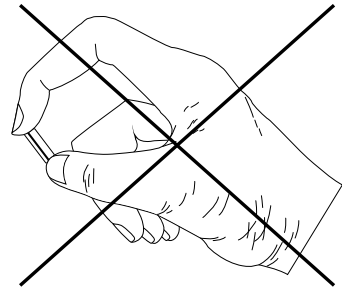
Data stored in the RAM will be lost if the battery is changed while the PC is switched off!

- 1) Touch the mounting rail or ground connection (not the power supply!) in order to discharge any static charge from your body.
- 2) Remove the battery from the holder by pulling the removal strip (don't use uninsulated tools-> risk of short circuit). The battery should not be held by its edges. **Insulated** tweezers may be used for removing the battery.

Right:



Wrong:



- 3) New batteries are to be inserted with proper polarity. The **removal strip ①** should be pulled straight, and the battery inserted with the "+" side facing down ②. The removal strip **must** be left protruding from the upper side of the battery so that it can be changed in the future.

①



②



- 4) Now push the excess part of the removal strip under the battery so that it does not hang loose.



Lithium batteries are considered hazardous waste and should be disposed of accordingly!

4 Memory

The LS251 is equipped with 512 KByte User FlashPROM and 850 KByte User RAM. System modules are provided with 256 KByte FlashPROM. If the FlashPROM memory for the user program is not sufficient for the user program, it can be transferred to the LS251 from the hard disk using the DL tools.

The complete SRAM can be addressed via the PCI Bus.

5 Online Connection

The online connection is made via the PCI bus and the SRAM of the LS251.

A suitable driver is included with PG2000 version >V 2.35. Otherwise, the online connection must be made using the RS232 interface on the LS071 expansion circuit board.

The LS251 can be programmed via CAN like every other B&R CPU. Programming through a CAN network is possible when PG2000 is coupled to a processor using CAN interface. This processor routes to the LS251 via CAN.

6 Operating System

The Logic Scanner LS251 comes with a pre-installed operating system. The operating system can be updated using the PCI bus and the programming system PG2000 >V 2.35.

If the Expansion Card LS071 is being used, upgrades can be made using the RS232 interface together with the older versions of PG2000.

Upgrading the operating system must be carried out in the following way:

- 1) Turn off the power supply to the PC
- 2) Switch both node number dials on the LS251 to position 0
- 3) Turn the power back on
- 4) Establish online connection with the PC
- 5) PG2000 start (no connection will be show in the message window)
- 6) Choose menu point "SYSTEM" - "SERVICE" - "PCCSW UPDATE" (starting with PG-Version 2.30)
- 7) The window **System Download** will be opened
- 8) Set desired baudrate and connection in this window
- 9) Press **"OK"** to start system download



User Flash will be deleted!

Download progress is shown in the status bar.

- 10) When download is 100 % complete, the node number dials must be switched to a position other than 00 and FF
- 11) Turn PC off/on

It is possible that connection to LS251 is not created immediately during operating system download, in which case a red message window may appear.

It is then necessary to repeat the download.

7 Visualization

7.1 DOS Visualization

With DOS visualization, the LS251 Logic Scanner can be accessed through the PCI bus with a NET2000 driver. The NET2000 driver must be programmed separately on the LS251 in the System FlashPROM or in the User FlashPROM.

A NET2000 PCI driver must also be loaded on the visualization device. B&R can provide NET2000 DDK (Driver Development Kit) to create the driver.

Visualization can be coupled to the expansion card using the CAN interface or the RS232 interface. This module can be used with all standard PCC drivers.

7.2 Windows® Visualization

32 Bit operating systems such as Windows® 95 or Windows NT™ offer the possibility to couple the visualization using the new B&R process imaging PVI (Process Visualization Interface). Using the PVI, every visualization device is able to read/write data (internal variables, inputs/outputs or extra modules) from the LS251.

A driver is provided for the PVI that can serve the LS251 over a PCI bus. The driver will be available for delivery from the start of the second quarter of 1998. At present, a PVI can be coupled with a DLL interface (C, C++) or using a DDE interface (e.g. Visual Basic).

Coupling with applications using an OLE interface (Active X) is planned for subsequent expansions.

8. PC Resources

8.1 PCI Bus

The Logic Scanner LS251 is supplied as a PCI bus card. The PCI bus has the following advantages:

- Fast data transfer
- 33 MHz transfer frequency
- 32 Bit data bus size
- Plug & Play

8.2 Plug & Play

Plug & Play technology has made the operation of plug-in cards far easier.

The BIOS identifies the PCI module during the booting procedure and assigns it an address. If a module is added or taken away, the user does not have to make any setting changes.

8.3 Interrupt

The LS251 Logic Scanner reserves an interrupt. It is automatically assigned during the boot procedure by the Plug and Play technology.

8.4 Memory

Logic Scanner LS251 uses the following memory areas:

Memory Size	Memory Area
1 x 16 Byte	Memory area <1 MByte
1 x 4 KByte	Memory area <1 MByte
1 x 1 MByte	Extended Memory (>1 MByte)
1 x 2 MByte	Extended Memory (>1 MByte)

Memory is automatically assigned during the boot procedure.

9 Installation in the PC

9.1 Protection against Electrostatic Discharge

Static discharges can damage the electronics of the Logic Scanner LS251. Please pay attention to the following points to prevent accidental damage:

- Leave the LS251 Logic Scanner in the antistatic packing until you are ready to install it.
- Any static charge must be discharged before you touch the LS251. Before moving the LS251, touch a grounded metal surface e.g. the PC housing.
- Only hold the LS251 by its edges. Do not touch any connectors or components.
- Do not place the LS251 on any metal surfaces.
- Move the LS251 as little as possible to prevent new electrostatic charge from clothes, carpets or furniture.

9.2 Installation of the LS251

- 1) Before beginning installation you must first discharge any electro-static charge. Before installing the LS251, touch a grounded metal surface such as the PC housing.
- 2) Turn off the computer and all peripheral devices (monitor, printer etc.). Disconnect all connections to peripheral devices including the power supplies.
- 3) Take out the screws and remove the PC housing. This procedure is fully described in the computer manual.
- 4) Locate a free PCI bus expansion slot and remove the slot cover. Screws are necessary to fasten the LS251.
Keep the expansion slot cover safe so it can be replaced if the LS251 is removed. The cover must be in place for the cooling and spark protection of the system to function properly.
- 5) Hold the LS251 by the top edge and push it into the expansion slot.
- 6) Adjust the slots on the mounted side panels to line up with the screw holes on the side panels of the PC. Screw the LS251 in place with the screws removed from the expansion cover.
This step is important because it grounds the LS251.
- 7) Replace all the cables in the PC and stow them away so that they will not be damaged when removing the PC housing cover.
- 8) Replace the PC housing cover and screw it down securely.
- 9) Reconnect all power cables and connections to the periphery devices.

CHAPTER 3

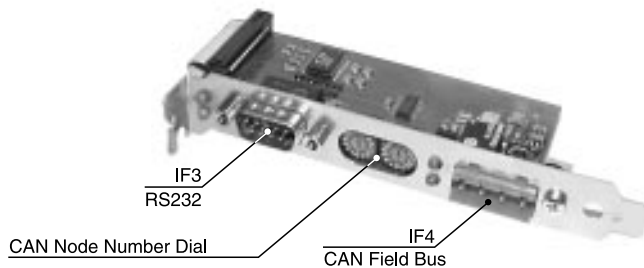
EXPANSION CARD LS071

1 Technical Data

Module ID	LS071
General Information	
Model Number	5LS071.9
Connection	Inserted in next slot to Logic Scanner LS251, has no contact to PCI or ISA slot
Supply	The LS071 is supplied from the LS251 through a flat ribbon cable
Power Output	Including LS251, max. 8.5 W
Operating Temperature	0 - 55 °C
Humidity	0 - 95 %
User Interface IF3	
Type	RS232
Controller	UART type ST16C650
FIFO	32 Bytes in send and receive directions
Connection	9 pin D-Type connector (M)
Electrical Isolation	NO
Input Filter	YES
Reverse Voltage Divider	YES
Maximum Range	15 m
Maximum Baudrate	115.2 kBaud
Handshake Controller	RTS, CTS
Network Capable	NO
Data Format	
Data Bits	5 to 8
Parity	YES / NO / even / odd
Stop Bits	1 / 2

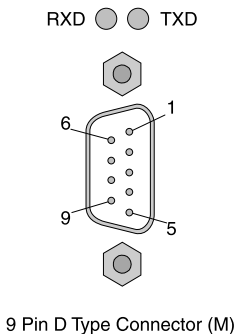
Module ID	LS071
User Interface IF4	
Type	CAN
Controller	Controller 82527
Connection	4 pin connection block
Multimaster Capable	YES
Number of Stations	max. 64
Priority	Through object identifier
Protocol	from CiA/CAL
Electrical Isolation IF4 - LS071 IF3 - IF4	YES YES
Transfer Medium	4 wire twisted pair cable
Maximum Range	1000 m
Maximum Baudrate	500 kBit/sec (see chapter 1 "General Information", section "CAN field bus")
Network Capable	YES
Bus Terminating Resistance	optional external cabling

2 Overview of the Components



3 Description of the Components

3.1 RS232 Interface

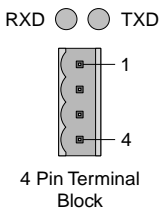


Pin	RS232 Interface, 9 pin D Type Connector (M)	
1	NC	
2	RXD	Receive Signal
3	TXD	Transmit Signal
4	NC	
5	GND	Ground
6	NC	
7	RTS	Request To Send
8	CTS	Clear To Send
9	NC	

3.2 CAN Field Bus

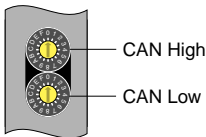
A 4 pin terminal block and a 120 Ω bus terminating resistor are included with every delivery. The resistor must be attached between pins 1 and 3.

The cabling of a CAN field bus is explained in chapter 1 "General Information" section "CAN Field Bus".



Connection	CAN Field Bus, 4 Pin Terminal Block	
1	CAN_H	CAN High
2	CAN_GND	CAN Ground
3	CAN_L	CAN Low
4	CAN_SHLD	Screen

3.3 CAN Node Number Dial



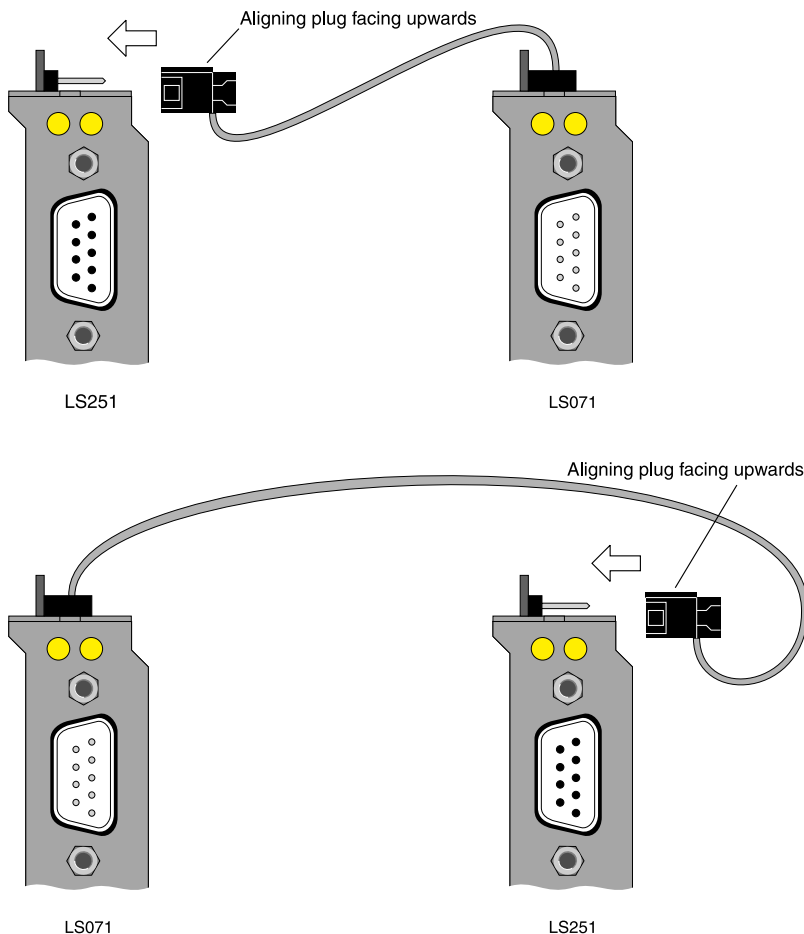
The Hex dials are used to set the CAN node number. The position of the dials can be evaluated by the application program. When a dial is turned during operation, a relevant warning message can be generated. The dial status can only be identified by the operating system during start-up.

4 Installation in the PC

The LS071 is installed in a free slot next to the LS251. Installation is the same as for the LS251. The procedure can be found in Chapter 2 "LS251 Logic Scanner " section "9 Installation in the PC".

Connection to the LS251 is made using a flat ribbon cable. The circuit board connector is inserted in the LS251 connector block. In order to guarantee proper polarity, the alignment plug of the circuit board connector must be facing upwards (see diagram).

Both PC slot covers must be pointing in the same direction and the cable must be routed flat over the circuit boards.



INDEX

B

Battery	24
Bus Cable	
CAN Field Bus	13
Remote I/O Bus	11

C

Cable	
CAN Field Bus	13
Remote I/O Bus	11
Cabling	
CAN Field Bus	15
Remote I/O Bus	11
CAN Field Bus	13, 23, 35
CAN Node Number Dial	24, 35
Components	
LS071	34
LS251	22

D

Diagnosis Mode	24
----------------------	----

E

Expansion Card. <i>See</i> LS071	
----------------------------------	--

I

Index, CAN Field Bus	16
Installation in the PC	
LS071	36
LS251	29
Interfaces	
CAN Field Bus	23, 35
RS232	35
RS485	23
Interrupt	28

L

Lithium Battery	24
Logic Scanner. <i>See</i> LS251	
LS071	33
CAN Field Bus	35
CAN Node Number Dial	35
Components	34
General Information	10
Installation in the PC	36
RS232 Interface	35
Technical Data	33
LS251	21
CAN Field	23
CAN Node Number Dial	24
Components	22
General Information	10
Installation in the PC	29
Interrupt	28
Memory	26, 29
On-line Connection	26
Operating System	26
PCI Bus	28
Plug & Play	28
Puffer Battery	24
Remote I/O Bus	23
RS485 Interface	23
Technical Data	21
Visualization	27

M

Memory	26, 29
--------------	--------

N

NET2000 DDK (Driver Development Kit)	27
NET2000 Driver	27

O

Online Connection	26
Operating System	26

P

PC Resources	
Interrupt	28
Memory	29
PCI Bus	28
Plug & Play	28
PCI Bus	28
Plug & Play	28
Process Imaging PVI	28
Process Visualization Interface	28
Puffer Battery	24
PVI	28

R

Remote I/O Bus	11, 23
RS232 Interface	35
RS485 Interface	23

T

Technical Data	
LS071	33
LS251	21
Terminating Resistor	
CAN Field Bus	16
Remote I/O Bus	12

V

Visualization	
DOS	27
Windows®	28

RELEVANT CONVERSIONS

METRIC AND IMPERIAL EQUIVALENTS

Some of the values in this manual and in other documentation that you may have contain values which are only given in metric. Follow the formulas and charts on this page to help with any conversion problems that you may have.

TEMPERATURE

Below are two formulas to help in the conversion from Fahrenheit to Centigrade and vice versa.

LINEAR MEASURE & WEIGHTS

All B&R documentation includes the product dimensions, weights, distances for cabling and cutout sizes in metric. Use the conversions below to calculate these measurements into the equivalent imperial units.

Fahrenheit °F	Metric °C
-40	-40
-20	-28.89
-10	-23.33
-5	-20.56
0	-17.78
5	-15.00
10	-12.22
15	-9.44
20	-6.67
25	-3.89
30	-1.11
35	1.67
40	4.44
45	7.22
50	10.00
55	12.78
60	15.56
65	18.33
70	21.11
75	23.89
80	26.67
85	29.44
90	32.22
95	35.00
100	37.78
105	40.56
110	43.33
115	46.11
120	48.89
125	51.67
130	54.44
135	57.22
140	60.00
145	62.78
150	65.56

Metric °C	Fahrenheit °F
-40	-40.00
-35	-31.00
-30	-22.00
-25	-13.00
-20	-4.00
-15	5.00
-10	14.00
-5	23.00
0	32.00
5	41.00
10	50.00
15	59.00
20	68.00
25	77.00
30	86.00
35	95.00
40	104.00
45	113.00
50	122.00
55	131.00
60	140.00
65	149.00
70	158.00
75	167.00
80	176.00
85	185.00
90	194.00

$$\begin{aligned} 5/9 \times (°F - 32) &= °C \\ (9/5 \times °C) + 32 &= °F \end{aligned}$$

English Units	Metric Units
1 inch	25.4 millimeters 2.54 centimeters
1 foot	30.48 centimeters 3.048 decimeters 0.3048 meter
1 yard	0.9144 meter
0.03937 inch	1 millimeter
0.3937 inch	1 centimeter
3.937 inches	1 decimeter
39.37 inches 3.2808 feet 1.0936 yards	1 meter
3280.8 feet 1093.6 yards 0.62137 mile	1 kilometer

English Units	Metric Units
1 pound	0.45359 kilogram
1 ounce	28.350 grams
1 short ton	907.18 kilograms 0.90718 metric tons
1 long ton	1016.0 kilograms 1.0160 metric tons