E0312-A

Instruction Manual

PROFIBUS-DP SI-Units

EX120-SPR1

EX121-SPR1

SMC Pneumatik GmbH
Boschring 13 - 15
D-63329 Egelsbach
Germany
Tel.: +49-(0)6103-4020
FAX: +49-(0)6103-402139

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1. Introduction

1.1 Basic Features

PROFIBUS, as defined under EN 50170, or DIN 19245, Parts 1 and 2, is an open-architecture, manufacturer-independent bus, and thus allows employing any PROFIBUS-compatible PLC or add-on PC controller board as PROFIBUS-master. A variety of generic sensors and actuators are commercially available.

PROFIBUS is a multiple-master fieldbus based on token passing that may be operated as a master-slave fieldbus in cases where exclusively simple types of bus members are involved. Employing a single master is recommended whenever operation with multiple masters is not absolutely essential. PROFIBUS employs a deterministic accessing procedure, is capable of operating in real time, and employs relatively sophisticated hardware that supports a wide variety of parameter sets.

*The EX120-SPR1 and EX121-SPR1 SI-Units described here support the generic **PROFIBUS-DP**-protocol defined under EN 50170, but do not support the PROFIBUS-FMS-protocol, the PROFIBUS-PA protocol, or any of the following company-proprietary protocols:*

SINEC® L2-DP
SINEC® L2-FMS
SINEC® L2-TF
SINEC® L2-cyclic periphery

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The PROFIBUS DP (Decentral Periphery) Protocol

The PROFIBUS-DP protocol is a subclass of the PROFIBUS-FMS (Fieldbus Message Specification) protocol, i.e., employs short block lengths, is optimized for high transmission rates, is suitable for interfacing peripheral I/O-devices and sensors/actuators to a PLC or a PC, simplifies network setup and installation, and is usually employed at the lowest sensor/actuator) to intermediate (cell) levels of network architectures.

As many as 32 passive or active devices, or 122 devices equipped with three or fewer signal amplifiers (repeaters), may be interconnected to the bus. Various transmission rates (bit rates expressed in baud, i.e., bits/second) may be employed, but the maximum bit rate that may be employed will be determined by total bus length. SI-units automatically detect the bit rate in use, which may range from 9.6 kbaud to 1.5 Mbaud. Shielded, twisted-pair cabling conforming to the PROFIBUS-standard, EN 50170, is employed as the transmission medium.

PROFIBUS-DP conforms to the RS-485-standard. Signal amplitudes are 1.5 V to 5 V on 54 Ω.

1.2 Models EX120-SPR1 and EX121-SPR1 SI-Units

Models EX120-SPR1 and EX121-SPR1 SI-units allow control of SI solenoid-valve banks via a PROFIBUS-DP bus. Both models incorporate the same electronics. The only differences between them are the type of housing employed, the inscriptions on their housing covers, and the pin assignments of the 18-pin connectors employed for interfacing them to valve banks. Model EX121-SPR1 SI-units are designed for mounting on DIN-rails and are interfaced to valves by means of a ribbon cable. Model EX120-SPR1 SI-units interface directly to Series **VQ1000/2000** miniature solenoid valves, while Model EX121-SPR1 SI-units interface directly to Series **SY3000/5000** solenoid valves.

Their internal electronics are accommodated on three circuit boards, a power-supply board, a bus-interface board, and a valve-interface board.

Each SI-unit is capable of controlling as many as 16 single-acting solenoid valves or 8 double-acting solenoid valves, or equivalent combinations thereof. SI-units transmit signals to valves, but accept no signals transmitted by valves.

SI solenoid-valve banks are supplied with all internal connections factory prewired; i.e., users need only connect up the signal and voltage-supply lines interfacing valve banks to SI-units. SI-unit device addresses may be either manually assigned using the pair of rotary selector switches on their front panels or automatically assigned by software via the bus. Which of these two modes for assigning their device addresses is currently enabled is determined by the setting of the sliding selector switch immediately adjacent to the 18-pin connector on their valve-controller boards.

Since SI-units automatically adjust to the transmission rate (i.e., the bit rate, expressed in baud) in use on the PROFIBUS-DP bus, which supports various transmission rates ranging from 9.6 kbaud to 1.5 Mbaud, they incorporate no external controls for setting transmission rate. The neutral status, i.e., the status where all valve outputs are set to zero provided that no errors have been detected on the bus, may be programmed from the user interface.

This status corresponds to PROFIBUS-FMS Object Index 41, except that the default status, i.e., the status assumed by valve outputs when a transmission error is detected, is predefined as zero for all valve batteries, and is not freely programmable by users. PROFIBUS-DP employs no predefined indices, as in the case of PROFIBUS-FMS.

2. System Layout

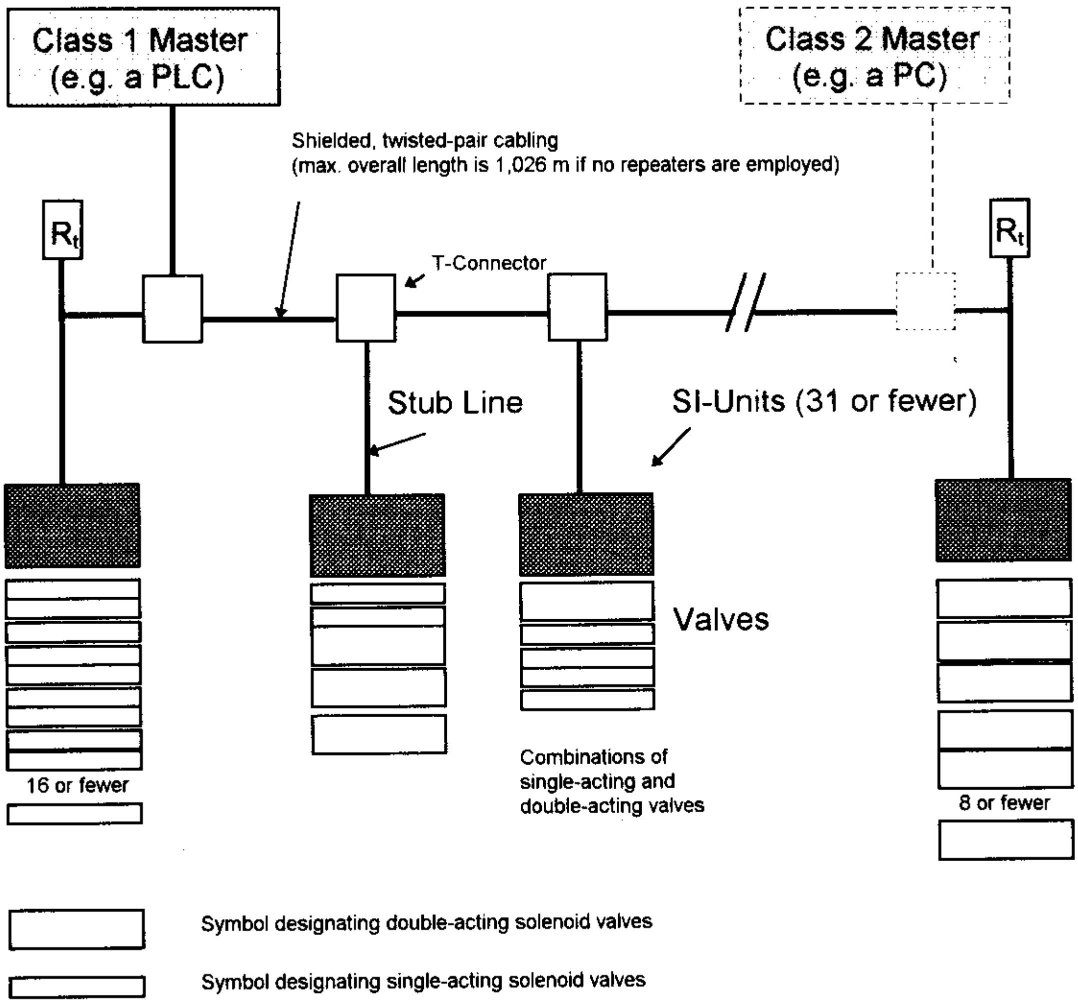
2.1 Block Schematics

Two types of master are employed in conjunction with the PROFIBUS-DP bus:

Class 1 masters:	Communicate with slaves and with control-signal networks.
Class 2 masters:	Employed for setup and checkout purposes only.

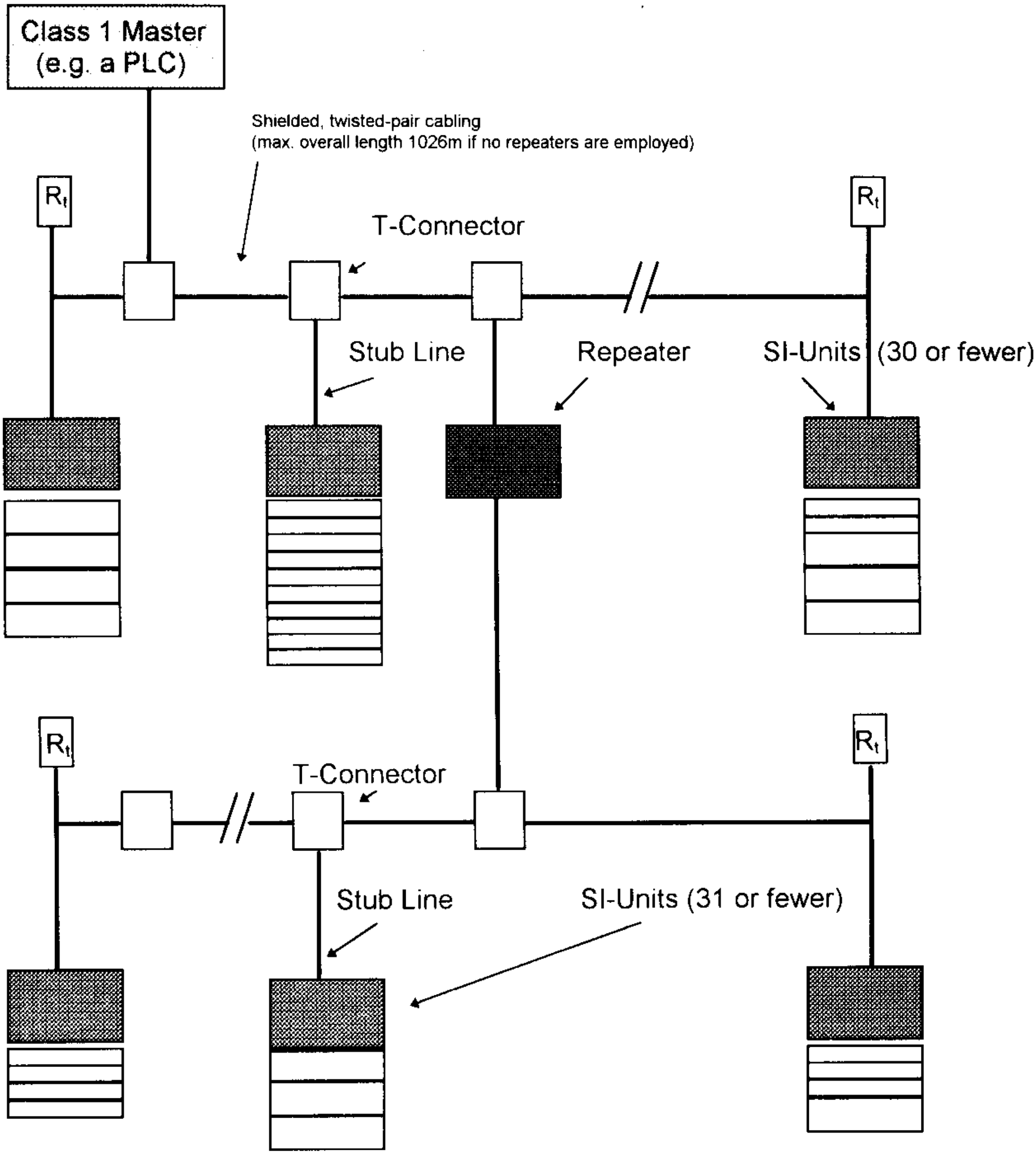
Several Class 1 and Class 2 masters may be simultaneously interfaced to the bus. Class 2 masters are employed in setting up and checking out relatively lengthy networks. Intercommunication among Class 1 masters is not supported. Bus cycle times increase as more masters are added. In order to simplify and accelerate bus setup, it is recommended that networks be designed around a single master, i.e., that buses be operated in monomaster mode.

Example a) A network that uses no signal amplifiers (repeaters)



R_t: Terminating resistors (120-150 Ω) required for RS-485 serial transmission

Example b) A network equipped with signal amplifiers (repeaters)



Note: A Class 1master may also be inserted into the secondary PROFIBUS-DP loop. Throughout this manual, „master" will i nvariably imply a Class 1 Master, unless otherwise stated.

Double-acting valves are designated by double-height rectangles. The valve configurations schematized here are for illustation purposes only, and may be varied. The sole restrictions on valve configurations arise from the fact that each SI-unit is equipped with 16 putput drivers, and is thus capable of controlling as many as 16 single-acting solenoid valves, or 8 double-acting solenoid valves, or equivalent combinations thereof, such as 8 single-acting and 4 double-acting valves.

SI-units incorporate no terminating resistors (R_t). Terminating resistors must thus be installed on each end of PROFIBUS-DP-bus networks. These may be either 120-Ω to 150-Ω resistors attached to each end of network cabling or mating 9-pin sub-D-connectors incorporating terminating resistors plugged into the 9-pin sub-D-connectors on the initial and final SI-units. (For example, the firm of Weidmüller plans to introduce a line of 9-pin sub-D-connectors incorporating sets of terminating resistors and selector switches for selecting the terminating resistance to be employed. No external terminating resistors will be needed if such connectors are employed.)

Stub lines should be kept as short as possible, particularly if high transmission rates are to be employed. The PROFIBUS-DP-standard allows employing as many as 3 repeaters per line, i.e., one repeater between each string of 31 slaves. The maximum number of SI-units that may be employed on each bus line is decremented by one for each repeater added. For example, if a single repeater is employed on a line, the maximum number of SI-units that may be employed on that line will be reduced to 30, and if the maximum of three repeaters are employed on a line, no more than 28 SI-units may be employed on that line.

2.2 Compatible PLC's and PC's

SI solenoid-valve banks (SI-units plus their interfaced solenoid valves) may be controlled by any PLC or add-on PC-board compatible with the PROFIBUS-DP-standard.

Banks of PROFIBUS solenoid valves may be controlled by any PLC or add-on PC-board compatible with the PROFIBUS-DP standard.

a) Compatible PLC's:

Manufacturer	Model(s)	Bus Components
Siemens	SIMATIC®-S5-115U SIMATIC®-S5-135U SIMATIC®-S5-155U SIMATIC®-S5-95U SIMATIC®-S7-Series	IM308-B /IM308-C communications processors SINEC COM ET200 system software
Other manufacturers	All compatible models	

b) Compatible add-on PC-boards:

Manufacturer	Model(s)	Application
Siemens	CP5411	PC communications processor
Hilscher	CIF30 DPM/DPS	DP-master/slave
Other manufacturers	All compatible boards	

The PLC-models listed above represent but a small selection of the large number of commercially available compatible units. Software drivers that allow controlling valve operation without need for add-on PC-boards (masters) are also commercially available from several manufacturers.

2.3 Interfaceable Solenoid Valves

Interfaceable to Model EX120-SPR1 SI-units are Series **VQ1000/2000** miniature solenoid way valves. Interfaceable to Model EX121-SPR1 SI-units, i.e., units designed for mounting on DIN-rails, are Series **SY3000/5000** solenoid valves. Both series of valves are available as SI solenoid-valve batteries complete with SI-units.

Ordering information (Part Nos.) for valves of those series interfaceable to PROFIBUS-DP SI-units:

EX120 SI-units:	**VV5Q$1-$$$$SN-$**
EX121 SI-units:	**SS5Y$-45S1ND-$$$-C$$**
EX122 SI-units:	**SS5Y$-45SND-$$$-C$$**

Note: EX122 SI-units are supplied in the same housings as EX121 SI-units, i.e., housings designed for mounting on DIN-rails, but that allow directly interfacing valve batteries to SI-units without employing a ribbon cable. SI-units equipped with this type of housing are designated Model EX122-SPR1.

Refer to SMC product catalogs E135-A and E138-A for further information on valves of these series.

3. Technical Data

3.1 General Data

Operating temperature	0 to + 50°C
Storage temperature	- 20°C to + 85°C
Relative humidity	≤ 90 %, noncondensing
Protection Class	IP 20 (as defined under DIN 40050/IEC 144)

3.2 Data Related to the PROFIBUS-DP-Standard (EN 50170)

Control mode for solenoid valves interfaced to SI-units	Valve operation is controlled by SI-units, which are designed to act as passive members (slaves) of the PROFIBUS-DP-bus.
Total number of bus members accommodated without need for incorporating repeaters	32 (masters/slaves)
Total number of repeaters accommodated	3
Total number of bus members accommodated with use of 3 repeaters	126 (masters/slaves) Employing a single-master bus configuration is recommended.
Transfer rates (bit rates) and maximum cable lengths employable without need for incorporating repeaters (The transmission rate in use is automatically detected by SI-units)	Varies with overall bus length and the type of cabling employed (Type A or Type B)

Bit Rate [kbaud]	Type A Cabling [m]	Type B Cabling [m]
1,500	200	unacceptable
500	400	200
187.5	1,000	600
93.75	1,200	1,200
19.2	1,200	1,200
9.6	1,200	1,200

Hamming interval	4 bits
Types of cabling employed	Type A, as defined under PROFIBUS-DP-standard EN 50170 Type B[1], as defined under PROFIBUS-standard DIN 19245, Part 1
Cabling parameters - Surge impedance [Ω] - Capacitance per unit length [pF/m] - Loop impedance [Ω/km][4] - Conductor diameter [mm] - Conductor cross-sectional area [mm^2]	Type A: 135 to 165 (3 MHz - 20 MHz); < 30; < 100; > 0.64; > 0.34 Type B[1]: 100 to 130 (> 100 kHz); < 60; < 160; > 0.53; > 0.22
Transmission medium (cabling)	Shielded, twisted-pair cabling, having a surge impedance of 100 Ω to 130 Ω. a capacitance per unit length of roughly 60 pF/m, and conductors with cross-sectional areas of 0.22 mm^2 or greater (24 AWG[2])
Bus architecture	Linear, terminated at both ends by terminating resistors. Conforms to RS-485. Stub lines (stubs) to members should be < 0.3 m long and have no stub lines of their own.
Interconnections to SI-units Supply-voltage connector Bus connector	 5-pin connector, per DIN 45322 9-pin sub-D connector
Rated standoff voltages:	50 V_{rms} continuous duty 500 V_{rms} peak

1. Type B cabling should no longer be employed if its use can be avoided.

2. The loop resistance, i.e., the total resistance of both supply and return lines, of cabling employed for transmitting supply voltages to valves should not exceed 9 Ω. This loop resistance will depend upon the type of cabling employed, its total length, and the cross-sectional areas of its conductors. At least 24 V - 10 %, i.e., 21.6 V, should be available at the far ends of the cabling employed. For a total of 16 valves in the loop, the total dissipated power will be 16 x 2.1 W = 33.6 W. Dividing this by the worst-case supply voltage, 21.6 V, we obtain a current draw of 33.6 W/21.6 V = 1.6 A, which is also a worst-case value. The worst-case loop resistance is thus 21.6 V/1.6 A = 14 Ω. Applying a safety factor of 1.5 to this value, we obtain 14 Ω/1.5 = approximately 9 Ω as the maximum loop resistance, i.e., the maximum round-trip resistance of voltage-supply lines.

3. "AWG" stands for "American Wire Gauge," a measure of wire diameter.

4. Experience indicates that stub lines longer than those specified under the EIA RS-485-standard may be employed, particularly at low transmission rates, provided that the total capacitance of all stub lines of the bus, which is, of course, frequency dependent, does not exceed the following values:

   0.6 nF at 500 kbaud,
   1.0 nF at 187.5 kbaud,
   3.0 nF at 93.75 kbaud, or
   15 nF at 19.2 kbaud or 9.6 kbaud,

   where the total length of all stub lines of the bus should be included in the total length of bus cabling, since stub lines add to the total length of the bus.

A wide variety of PROFIBUS-DP products are commercially available from various manufacturers. The following table lists but a few examples for one particular manufacturer only:

Manufacturer	Product Function/Application
Weidmüller	Digital and analog input modules Digital and analog output modules PT100 input modules Many other certified PROFIBUS-DP products are commercially available.

3.3 Data Related to SI-Units

Supply voltage:	24 VDC nominal Tolerance range: 21 VDC to 27 VDC Separate voltage supplies for electronics and loads (valves) Common reference voltage
Maximum current draw by electronics:	70 mA, for no external load at nominal voltage
Max. current draw by loads (valves)	1.4 A
Outputs: - Total number of channels - Rated power output per channel - Output voltage - Polarity - Fusing	 16 2.1 W + 24 VDC ± 10 % Negative terminal is common One 800 mAF TR3 fuse on each pair of 8 channels
Minimum actuation delay for slaves	0.1 ms
Diagnostic facilities: - Bus-error indicator - Diagnostic-error indicator - Ready-status indicator (indicates that the + 5 VDC supply for the electronics is present)	 Red LED labeled "BF" Red LED labeled "DIA" Green LED labeled "RUN"

3.4 Electromagnetic Compatibility (EMC)

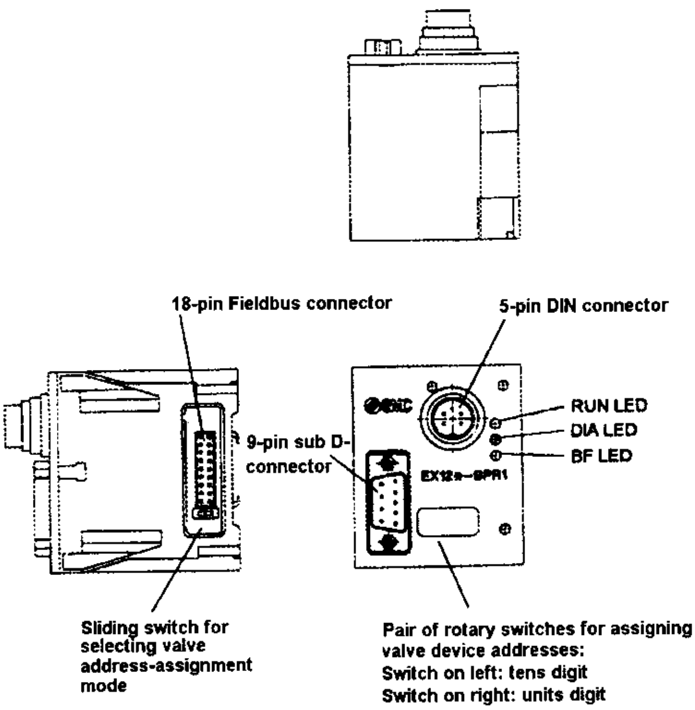
Broadcast interference (cf. the note below)	EN 500081-2, from 1993 EN 55011, Class A, Group 1	
Noise immunity	EN 50082-2, from 1995	
Housing	EN 61000-4-2 -ESD, 4 kV for direct contact -8 kV for air gap EN 61000-4-8, 30 V/m, 50 Hz RF-field ENV 50140, 10 V/m, 80 MHz - 1,000 MHz RF-field ENV 50204, 10 V/m, 900 MHz RF-field	Class B Class A Class A Class A
Bus interface	EN 61000-4-4, 2 kV bursts ENV 51041, 10 V, 150 kHz - 80 MHz RF/conducted	Class A Class A
Supply line (DC)	EN 61000-4-4, 2 kV bursts ENV 51041, 10 V, 150 kHz - 80 MHz RF/conducted	Class A Class A

Class A: Normal operation maintained for interference falling within the prescribed limits.
Class B: Unit operation temporarily affected only, or malfunctioning, but such from which the unit is able to recover without external intervention.

Note: When this manual was written, both EX120-SPR1 and EX121-SPR1 SI-units had been tested and certified for compliance with broadcast-interference standards EN 50081-2 and EN 55011, i.e., for compliance with those standards applicable to industrial use. These units are not intended for private or commercial use, and should not be used in residential or commercial areas until such time as they have been tested and certified under EN 50081-1.

4. Description of the Models EX120-SPR1 and EX121-SPR1 SI-Units

4.1 External Connectors and Controls



Further information on these external connectors and controls will be presented below.

5-pin DIN-connector:

The 5-pin female DIN-connector on SI-units (a female connector conforming to DIN 45322, e.g., a Lumberg Model SGR 50/6) accepts mating male connectors on cabling carrying the supply voltages for the SI-unit's electronics and for its interfaced valves (loads).[1]

The pin assignments for this connector are as follows:

Pin 1	+ 24 VDC + 10 %	Supply voltage for valves (loads)
Pin 2	0 V	Signal ground for SI-unit electronics
Pin 1	GND	Case ground (protective ground)
Pin 4	+ 24 VDC + 10 %	Supply voltage for SI-unit electronics
Pin 5	0 V	Signal ground for control signals to valves (loads)

1) If these voltages come from separate power supplies, the supply voltage for the SI-unit must be on and have reached its nominal value before switching on the supply voltage for its interfaced valves, and both of these voltages must be on and have reached their nominal values before switching on the supply voltage to the bus master.

SMC

9-pin sub-D-connector

The 9-pin sub-D-connector interconnects the PROFIBUS-DP fieldbus to the SI-unit. The pin assignments for this connector are as follows:

Pin 1	Shield	Through ground / protective ground
Pin 2	GND24	N/C (reserved for 24-VDC supply ground line)
Pin 3	RxD / TxD-P	Receive data (in) / transmit data (out)
Pin 4	RTS	"Ready to Send" signal
Pin 5	DGND	Digital ground (digital-signal ground)
Pin 6	VP	+ 5 VDC supply for terminating resistors
Pin 7	P24	N/C (reserved for 24-VDC supply line)
Pin 8	RxD / TxD-N	Receive-data (out) / transmit-data (in) Also termed "Data Line A."
Pin 9	CNTR-N	N/C (reserved for repeater-control / directional-control signals)

Notes:

1. Those signals transmitted by the four pins set in boldface type (Pins 3, 5, 6, and 8) must be present, i.e., represent mandatory signals, since they are essential to data communications on the bus, and must conform to EN 51070, the PROFIBUS-DP-standard. Since the PROFIBUS-DP-standard stipulates employment of a 9-pin sub-D-connector, no other pins remain available, and pin assignments must be as stated above.
2. VP (Pin 6), the + 5 VDC supply for terminating resistors, must be made available to SI-units and must be referenced to DGND (Pin 5), the digital-signal ground. According to EN 51070, the PROFIBUS-DP-standard, the power supply providing the + 5 VDC to terminating resistors must be capable of handling a current draw of at least 10 mA. Terminating resistors may be either externally connected or incorporated into 9-pin sub-D-connectors. A terminating resistor must be connected to each end of each length of PROFIBUS-DP-bus cabling; i.e., two terminating resistors will be required if no repeaters are employed, four terminating resistors will be required if a single repeater is employed, etc.
3. Since all data lines are interconnected by the bus connector, failures of members of the bus will not interrupt communications with the other members of the bus.
4. Since transmission rates on the bus are limited to 1.5 Mbaud, no inductances other than those arising from the real (Ohmic) parts of the impedances of terminating resistors will be required, since all members of the bus represent purely capacitive loads.

4.2 Status Indicators (Status LED's)

SI-units are equipped with three front-panel LED's, labeled **"RUN"** (a green LED), **"DIA"** (a red LED), and **"BF"** (a red LED) that indicate SI-unit status, as follows:

LED	**LED-Status** (SI-unit configured)	**SI-Unit Status**
"RUN" (green)	ON	The + 24 VDC supply to the SI-unit is present.
	OFF	The + 24 VDC supply to the SI-unit is absent (due to, e.g., a blown fuse).
"DIA" (red)	ON	A failure in the SI-unit's valve-controller circuitry has been detected.
	OFF	The SI-unit's valve controller is operating normally.
"BF" (red)	ON	A failure has been detected on the bus. A bus communications cycle could not be concluded within the monitoring period set by control parameters.
	OFF	The bus is operating normally.

The status indications listed in the table above are for the case where the SI-unit involved has been configured. The following LED-status should be observed for a few seconds (this time delay is setup-dependent) after the supply voltage has been switched on:

RUN	ON
DIA	OFF
BF	ON

Once the SI-unit has been configured, this should change to:

RUN	ON
DIA	OFF
BF	OFF

If the red "BF"-LED remains on, then configuration is incomplete or has been incorrectly performed. If the green "RUN"-LED fails to illuminate when the + 24-VDC supply is switched on, then either the power supply is defective or one or both of the SI-unit's two microfuses is blown.

4.3 Diagnostic Data Provided by the Fieldbus Interface

On startup, the EX12$ PROFIBUS-DP interface transmits a diagnostic message consisting of 7 bytes (numbered Byte 0 through Byte 6), each consisting of 8 bits (numbered Bit 0 through Bit 7), containing the following items of data to the master:

Byte(s)	Bit(s)	Diagnostic Data
0	0 through 7	Message header
1	0 through 3	Collective status report for Valves 0 through 7 (valves protected by Microfuse 1)
	4 through 7	Collective status report for Valves 8 through 15 (valves protected by Microfuse 2)
2 through 6 (not used)	N/A	N/A

Note: Of the three types of user-definable diagnostics defined under PROFIBUS-DP-standard EN 51070, status reporting for interfaced devices is the only type supported. Device-address and data-channel diagnostics are not supported. Defining a diagnostic message of the form "+ 24 VDC supply absent or fuse(s) blown" is recommended.

4.4 Microfuses

Each SI-unit is equipped with **a pair of** identical microfuses situated on its valve-controller board, i.e., the circuit board with the 18-pin ribbon-cable connector for interfacing the SI-unit to valves. Each of these microfuses is assigned to 8 of the total of 16 output drivers.

The green "RUN"-LED will be extinguished if a fuse blows.

Use only the correct replacement fuses: Wickmann TR3 0.8 A Microfuse
Part No.: 19303K 800MA

Note:

Switch off the + 24-VDC power supply and disconnect the cable connecting the supply to the SI-unit, i.e., unplug the 5-pin DIN-connector, before undertaking a fuse replacement.

5. SI-Unit Setup Procedures

5.1 Assigning SI-Unit Device Addresses

SI-units may be either manually assigned device addresses using the pair of rotary selector switches on their front panels, or automatically assigned device addresses by software via the bus.

The setting of the sliding selector switch on their valve-controller board, which is situated immediately adjacent to the 18-pin ribbon-cable connector and is accessible by opening their housings, determines whether their device addresses must be manually assigned using the pair of front-panel rotary selector switches or will be automatically assigned by software via the bus.

Note:

Each SI-unit must be assigned a unique device address. Device addresses 00, 01, and, in some cases, also 02, are reserved for other purposes in some types of applications, and thus should never be assigned to SI-units.

To assign a device address to an SI-unit proceed as follows:

Set the sliding selector switch to "+": The SI-unit's device address must then be manually assigned using the pair of rotary selector switches on its front panel. **Valid device addresses will be 02 - 99 or 03 - 99 (decimal)**

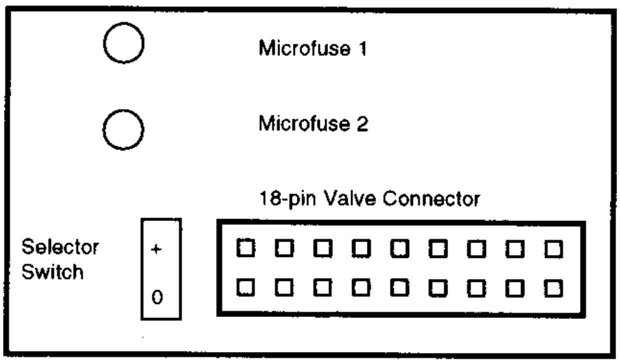
Set the sliding selector switch to "0": The SI-unit's device address will then be automatically assigned by software via the fieldbus. **Valid device addresses will be 02 - 99 or 03 - 99 (decimal)**

The factory-preset defaults are follows:

Sliding selector switch:	0	i.e., a device address will be automatically assigned by software via the fieldbus.
Device address:	03	i.e., the left-hand rotary selector switch is set to 0 and the right-hand rotary selector switch is set to 3.

Note:

- **Device addresses altered using the front-panel rotary selector switches on SI-units will not be recognized and their new device addresses stored in their internal EEPROM's until the voltage supply to their electronics has been switched off and switched on again.**
- **Device addresses altered by software, i.e., altered via the fieldbus, become effective immediately and will be immediately stored in the internal EEPROM's of the SI-units involved.**



To manually assign a device address, set this sliding selector switch "+," and then assign a device address using the pair of front-panel rotary selector switches. Use the left-hand switch to set the tens digit to an integer ranging from 0 through 9, and the right-hand switch to set the units digit to an integer ranging from 0 through 9. The pointer on these switches indicates the integer selected.

Note: The transparent plastic covers will have to be removed from the rotary selector switches before they may be reset.

5.2 Transmission Rate (Bit Rate)

Since SI-units automatically detect the transmission rate (bit rate, expressed in baud) in use on the PROFIBUS-DP, there are no provisions for manually selecting a transmission rate.

SI-units support all transmission rates specified under the PROFIBUS-DP-standard, up to, and including, the maximum rate of 1.5 Mbits/s (1.5 Mbaud) = 1,500 kbits/s (1,500 kbaud).

The transmission rates specified under the PROFIBUS-DP-standard are:
9.6, 19.2, 93.75, 187.5, 500, and 1,500 kbits/s (kbaud).

The maximum tolerated length of a PROFIBUS-DP bus is inversely proportional to the transmission rate employed (cf. Section 3, hereof, entitled "Technical Data").

6. Installation

Switch off all system supply voltages before undertaking any installation work or connecting or disconnecting any cables.

Observe VDE or local regulations applicable to multiplexed transmission systems, e.g., VDE 0113, Part 1, and European Standard EN 60204, Part 1, at all times when installing PROFIBUS-DP devices.

SI-units are equipped with three connectors:

- an external voltage supply connector (a 5-pin female DIN-connector)
- a bus connector (a 9-pin male sub-D-connector)
- a valve connector (an 18-pin ribbon-cable connector).

Connect the mating cables to all three of these connectors before switching on the supply voltage or activating any interfaced units. Solenoid-valve batteries are supplied with all necessary internal connections for both single-acting and/or double-acting solenoid valves prewired.

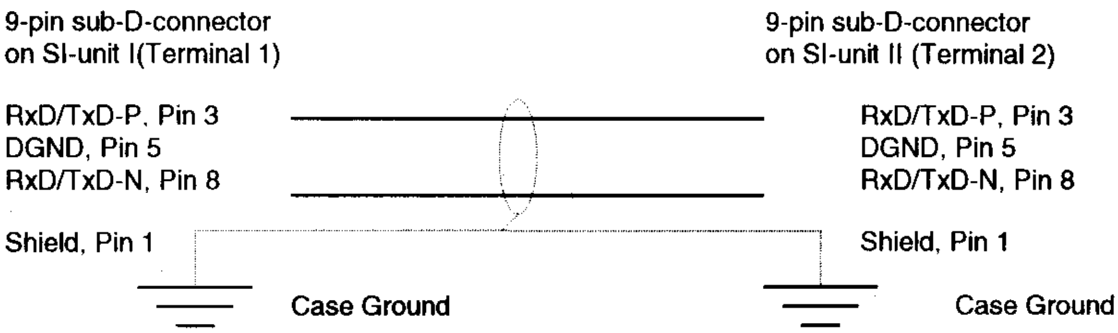
6.1 Connecting Up the Bus

Connect up the members of the bus as shown in the block schematic of Section 2.1, hereof. Observe the instructions issued by the manufacturers of the PLC or the add-on PC-board employed, as well as the regulations of EN 50170, or of DIN 19245, Parts 1 and 2, at all times. The following further points should also be observed when connecting up the bus:

1. Switch off all supply voltages before connecting or disconnecting any cabling.
2. All SI-units and the bus cable should be situated at least 200 m distant from any sources of interference, such as inverters, and any high-voltage power lines.
3. Use exclusively Type A cabling, as specified under Section 3, "Technical Data."
4. Equip all terminal SI-units, i.e., those at the ends of bus lines, with terminating resistors.

Example:

Minimal interconnections of bus members, with cable shielding grounded at both ends:



Do not cross the two signal lines connected to Pins 3 and 8. The voltage drops across the respective DGND-terminals of the various bus members should never exceed ± 7 V, which could happen if a PROFIBUS-DP network includes devices located in other buildings.

This voltage drop will have to be reduced if it exceeds ± 7 V. This may be accomplished by interconnecting members' DGND-terminals using, e.g., special sub-D-connectors incorporating a common ground line on Pin 5.

6.2 Bus Cabling

Shielded, twisted-pair, cabling complying with EN 50170 should be employed for connecting up the bus. Using twisted pairs improves electromagnetic compatibility (EMC).

The shielding on the cabling employed should be generously dimensioned, and grounded by low-resistance, low-inductance, contacts. Although grounding only one end of its shielding will preclude low-frequency ground loops, it will not reduce the effects of airborne magnetic RF-interference, i.e., will not improve EMC at frequencies above 1 MHz. Using twisted pairs also reduces the effects of airborne magnetic RF-interference, but has no effect on electrical RF-interference. Grounding cable shielding at both ends will also reduce the effects of magnetic RF-interference and preclude ground loops, but also has no effect on electrical RF-interference.

No general recommendations may be made here. Cabling will have to be configured to suit the conditions of the particular industrial environment involved.

Here are a few examples of suitable choices of bus cabling:

1. Cabling complying with EN 50170 **Type A cabling**
2. Cabling complying with DIN 19245 **Type B cabling**

A typical example of Type A cabling:	Siemens SINEC® R L2 Bus Cable Part No.: 6XV 1830-0A H10
Typical examples Type B cabling:	Belden RS 485 9841 "Low-Capacitance Cable" Sumitomo RS 485 9841 Cable

Each end of bus cabling must be terminated by a resistor in order to preclude interfering reflections at the free ends and to provide a defined no-load reference voltage on the bus line. Type A cabling has a high surge impedance. Cabling is regarded as properly terminated when the resistance of the terminating resistors employed equals its surge impedance.

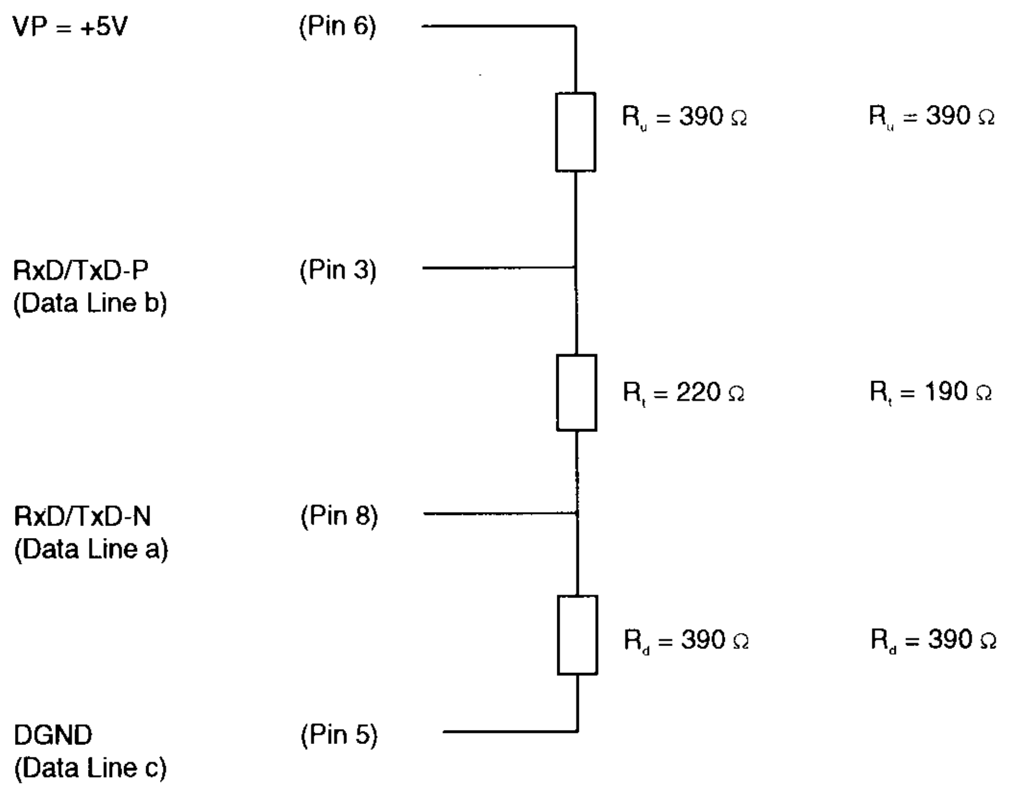
Note: **When designing extensions of existing bus networks, plan on using exclusively Type A cabling in order to keep transmission losses low. Use of Type B cabling should be avoided wherever possible.**

Type A cabling should be employed instead of Type B cabling (cf. Section 3, hereof, entitled "Technical Data") wherever feasible. If employment of Type B cabling, which is limited to transmission rates of 500 kbaud and less, cannot be avoided, employ the cable terminations described below.

6.3 Cable Terminations

Assuming that the minimum number of interconnections (i.e., interconnections providing the mandatory signals only) between bus members is to be employed, the following resistances should be employed for terminating the free ends of bus cabling (the pin numbers of sub-D bus connectors are stated, enclosed in parentheses, for reference). Although the interconnecting lines involved are also commonly designated "Data Line a," Data Line b," and "Data Line c," these designations are unrelated to the designations "Type A cabling" and "Type B cabling."

Mandatory Signal: Pin-No: Type A Cabling Type B Cabling
(9-pin sub-D-connector)



6.4 Connections to Valves

SI solenoid-valve batteries are supplied fully internally prewired, and the only connections remaining to be made are the voltage-supply line (the line equipped with a 5-pin DIN-connector) and the bus line (the line with a 9-pin sub-D-connector) interfacing them to SI-units.

SI-units are equipped with a total of 16 outputs (output drivers labeled AT1 through AT 16). The assignments of these outputs to valve-actuating solenoids are as listed below.

Cables with 18-pin ribbon-cable connectors interface valve batteries to SI-units. In the case of Model EX121-SPR1 SI-units, a hard-wired flat-ribbon cable provides the necessary interfacing. The first 16 of the total of 18 pins (or conductors) are uniquely allocated to the 16 output drivers of SI-units, while the remaining 2 pins (Pins 17 and 18) provide a common ground. Pin 1 is marked, e.g., by an arrow, for identification. The numbering of the remaining pins is as shown in the illustration below:

Pin No.:	1	3	5	7	9	11	13	15	17	
	0	0	0	0	0	0	0	0	X	X = 0 V or ground
	0	0	0	0	0	0	0	0	X	
	2	4	6	8	10	12	14	16	18	

Each pin identified by a "0" is assigned to one of the 16 output drivers, AT1 through AT16, i.e., Bit 0 through Bit 15 of control words.

Pin No.	1	3	5	7	9	11	13	15	17
Driver Output	AT2	AT4	AT6	AT8	AT10	AT12	AT14	AT16	AT18

Pin No.	2	4	6	8	10	12	14	16	18
Driver Output	AT1	AT3	AT5	AT7	AT9	AT11	AT13	AT15	AT17

The single-acting valve closest to the SI-unit is actuated by output driver AT1. The double-acting valve closest to the SI-unit is actuated by output drivers AT1 and AT2.

A total of 16 output drivers, or 16 control bits, are available for use. These may be distributed over a maximum of 16 single-acting valves, each of which requires 1 bit for actuation, or 8 double-acting valves, each of which requires 2 bits for actuation. More than 8 double-acting valves, for example, 10 double-acting valves, cannot be controlled by a single SI-unit, since this would require transmitting 10 x 2 bits = 20 bits, which exceeds the maximum number of bits, 16 bits, available for controlling valves.

Note: **The least-significant bit, D0, of control words, which consist of 16 bits designated D0 through D15, is allocated to output driver AT1, i.e., to the output driver for the valve closest to the SI-unit. Similarly, the most significant bit, D15, of control words is allocated to output driver AT16.**

Here are a few examples of pin allocations for the bus connector (the 18-pin connector):

a) Actuation of a total of 16 single-acting valves, designated Valves 1 through 16, which requires 1 x 16 bits = 16 bits.

b) Actuation of a total of 8 double-acting valves, designated Valves 1 through 8, which requires 2 x 8 bits = 16 bits.

c) Actuation of a combination of 8 single-acting valves plus 4 double-acting valves, designated Valves 1 through 12, which requires (8 x 1 bit) + (4 x 2 bits) = 8 bits + 8 bits = 16 bits.

d) Actuation of a combination of 1 single-acting valve plus 1 double-acting valve, designated Valves 1 and 2, which requires (1 x 1 bit) + (1 x 2 bits) = 1 bit + 2 bits = 3 bits.

Pin No.	1	3	5	7	9	11	13	15	17
Driver Output	2	4	6	8	10	12	14	16	0 V, or ground for the + 24 VD C supply
a)	Valve 2	Valve 4	Valve 6	Valve 8	Valve 10	Valve 12	Valve 14	Valve 16	
b)	Valve 1b	Valve 2b	Valve 3b	Valve 4b	Valve 5b	Valve 6b	Valve 7b	Valve 8b	
c)	Valve 2	Valve 4	Valve 6	Valve 8	Valve 9b	Valve 10b	Valve 11b	Valve 12b	
d)	Valve 2a								

Pin No.	2	4	6	8	10	12	14	16	18
Driver Output	1	3	5	7	9	11	13	15	0 V, or ground for the + 24 VDC supply
a)	Valve 1	Valve 3	Valve 5	Valve 7	Valve 9	Valve 11	Valve 13	Valve 15	
b)	Valve 1a	Valve 2a	Valve 3a	Valve 4a	Valve 5a	Valve 6a	Valve 7a	Valve 8a	
c)	Valve 1	Valve 2b	Valve 5	Valve 7	Valve 9a	Valve 10a	Valve 11a	Valve 12a	
d)	Valve 1								

Pin allocations for all other possible combinations of valves may be readily derived from these examples. The above examples of valve combinations yield the following pin and driver allocations:

Tabular listing of pin and driver allocations for the above examples:

SI-Unit Output Driver (AT)	Pin No. of 18-Pin Ribbon-Cable Connector	Example (a)	Example (b)	Example (c)	Example (d)
AT1	2	Valve 1	Valve 1a	Valve 1	Valve 1
AT2	1	Valve 2	Valve 1b	Valve 2	Valve 2a
AT3	4	Valve 3	Valve 2a	Valve 3	Valve 2b
AT4	3	Valve 4	Valve 2b	Valve 4	Output drivers AT4 through AT16 are not used.
AT5	6	Valve 5	Valve 3a	Valve 5	
AT6	5	Valve 6	Valve 3b	Valve 6	
AT7	8	Valve 7	Valve 4a	Valve 7	
AT8	7	Valve 8	Valve 4b	Valve 8	
AT9	10	Valve 9	Valve 5a	Valve 9a	
AT10	9	Valve 10	Valve 5b	Valve 9b	
AT11	12	Valve 11	Valve 6a	Valve 10a	
AT12	11	Valve 12	Valve 6b	Valve 10b	
AT13	14	Valve 13	Valve 7a	Valve 11a	
AT14	13	Valve 14	Valve 7b	Valve 11b	
AT15	16	Valve 15	Valve 8a	Valve 12a	
AT16	15	Valve 16	Valve 8b	Valve 12b	
	17	0 V / ground			
	18	0 V / ground			

7. Programming Notes

7.1 The Data-Security Level (Level 2)

Level 2 of the ISO/OSI reference model PROFIBUS-DP defines the telegram formats, data-security mechanisms, and reserved services available. Unlike PROFIBUS-FMS, PROFIBUS-DP has only the following two services available:

SRD Send and request data with acknowledge.
Data is transmitted and receipt acknowledged within a single transfer cycle.

SDN Send data with no acknowledge.
Telegrams are transmitted to a selected group of slaves, but the slaves do not acknowledge their receipt.

Under the SRD-service, masters transmit data to slaves (inapplicable in the case of SI-units) and receive acknowledgments of receipt from slaves, all within a specified time period. Since SI-units are incapable of receiving data, they respond by transmitting the standardized abbreviated acknowledgment **"E5 (hex)."**

Active members (masters) and passive members (slaves) may be added or deleted from the bus at any time. Active members are able to detect any new active members added. Once a master has received a new active member's parameter set, it will begin communicating with that member's slaves.

<u>Parameter sets consist of:</u>

parametric configuration data,
lists of address assignments for interfaced slaves, and bus parameters.

Following a reset or restoration of the supply voltage following an disruption, the master will attempt to establish contact with each and every slave assigned to it, following the order in which slaves are addressed, starting with the slave with the lowest address and proceeding in increments to the slave with the highest address, is prescribed.

If more than one master is employed, the master holding the token (a specially formatted signal) will attempt to conclude a communications cycle with each and every slave assigned to it within the specified token-retention period.

The token-retention period needed here will be automatically determined by software, and will be chosen such that a master should be able to exchange data with each and every slave assigned to it once during the token-retention period, applying a safety factor of 1.25 or more, as indicated by previous experience, in order to allow for potential needs for retransmitting telegrams.

Bus cycles are characterized by their "target rotation time," the maximum length of time a master will wait for return of the token, which is longer than the "real rotation time," the length of time elapsed until the token is actually returned.

The total length of telegrams, including their headers, is 255 bytes. With the lone exception of Data_Exchange telegrams, which have 9-byte headers, since they lack source and destination bytes, DSAP and SSAP, respectively, all telegrams have 11-byte headers.

In the interest of maintaining data security, slaves may be written to only by that master that transmitted their parameter set and configured them.

Masters must maintain the following telegram sequencing when initializing slaves:

1. Request the slave to transmit diagnostic information.
2. (Optionally, assign the slave a new address, a procedure reserved for Class 2 masters.)
3. Transmit a parameter set to the slave.
4. Configure the slave.
5. Request the slave to transmit diagnostic information prior to exchanging data with the slave in order to provide that the initialization has been properly concluded.
6. Exchange data with the slave.
7. (Revert to global-control mode.)

<u>Note:</u> **Masters may request diagnostic data from any slave, including slaves other than those assigned to them. However, they should not request diagnostic data at regular intervals, since that might overload the system.**

Refer to EN 51070, the PROFIBUS-DP-standard, for further information on these matters.

7.2 Interfacing to PROFIBUS-DP Masters

7.2.1 Device Profiles for Generic PROFIBUS-DP Masters

PROFIBUS-DP-networks require an optionally available **DPF** (Device-Profile File)/**Type File** diskette containing the specific items of data needed for configuring slaves interfaced to SI-units. This data will allow configuring slaves assigned to a master from the master, provided that due account is taken of the instructions contained in the descriptive materials supplied with the particular PROFIBUS-DP-master employed. Each DPF is certified for use with a specific PROFIBUS-DP-device, and should not be altered by users.

Type files in the typdat4x-directory are for use with Version 4.X and later versions of COMET 200© software and IM308-B© modules. Type files in the typdat5x-directory are for use with Version 1.0 and later versions of Windows COM software, IM308-C© modules, and Version 2.x STEP7© software packages.

The slave data involved are for slave IC's bearing the designation LSPM2© ("Lean Siemens PROFIBUS-DP Multiplexer) employed in SI-units, which so far as users are concerned, behaves like a RAM-chip.

Masters address slaves' LSPM2©-chips via Level 2 of the 7-level model. PROFIBUS-DP-networks employ nonstandard user interfaces rather than the standardized Level 7 interface. These user interfaces are more convenient to use, but provide similar functions.

Whenever slaves' LSPM2©-chips receive a valid telegram they automatically generate a response telegram, as specified under EN 50170. SI-units' LSPM2© bus-protocol chips are capable of automatically detecting the transmission rate in use. No port settings will be altered during transmission-rate-detection procedures, which will be initiated following a reset and whenever watchdog timers time out. LSPM2©-chips conduct transmission-rate-detection procedures starting at the highest transmission rate, 1.5 Mbaud, and work their way down through the set of available transmission rates in sequence until telegrams are correctly received.

The data provided on DPF-diskettes will be explained below for the case where Models EX120-SPR1 and EX121-SPR1 SI-units are employed and the addresses of their slaves are assigned by software via the fieldbus (designation: "EX120/121-SPR1(SW)"). The statements made below will also apply if slaves' addresses are hardware preset, or assigned by the rotary selector switches on SI-units (designation: "EX120/121-SPR1(HW)"). Each line of program code is followed by a brief explanation, enclosed in parentheses.

```
;Device-Profile File for SMC valve batteries equipped with 16 outputs
;Filename: SMC_1400.DPF
;Version:      1.0
;Author:       Kohlmeier
;Date:         02.09.96
;
Vendor_Name = "SMC Pneumatik GmbH"
Model_Name = "EX120/121-SPR1(SW)"
Revision = 1
;
Ident_Number = 0x1400
;       (656 decimal = 290 hexadecimal, assigned by the PNO)
Protocol_Ident = 0
;       (Specifies that the protocol applies to DP-devices only.)
Station_Type = 0
;       (Specifies that compact stations are involved.)
FMS_supp = 0
;       (Specifies that PROFIBUS-FMS protocols will not be supported.)
```

Hardware_Release = "1"!   Software_Release = "1"

;

9.6_supp = 1

; (Specifies that a transmission rate of 9.6 kbaud will be supported.)

19.2_supp = 1

; (Specifies that a transmission rate of 19.2 kbaud will be supported.)

93.75_supp = 1

; (Specifies that a transmission rate of 93.75 kbaud will be supported.)

187.5_supp = 1

; (Specifies that a transmission rate of 187.5 kbaud will be supported.)

500_supp = 1

; (Specifies that a transmission rate of 500 kbaud will be supported.)

1.5M_supp = 1

; (Specifies that a transmission rate of 1.5 Mbaud will be supported.)

;

;

MaxTsdr_9.6 = 60

; (Sets a maximum response time, T_{sdr}, for slaves of 60 T_{bit} = 60/9,600 bits/s = 6.25 ms.)

MaxTsdr_19.2 = 60

; (Sets a maximum response time, T_{sdr}, for slaves of 60 T_{bit} = 60/19,200 bits/s = 3.12 ms.)

MaxTsdr_93.75 = 60

; (Sets a maximum response time, T_{sdr}, for slaves of 60 T_{bit} = 60/93,750 bits/s = 640 µs.)

MaxTsdr_187.5 = 60

; (Sets a maximum response time, T_{sdr}, for slaves of 60 T_{bit} = 60/187,500 bits/s = 320 µs.)

MaxTsdr_500 = 100

; (Sets a maximum response time, T_{sdr}, for slaves of 100 T_{bit} = 100/500,000 bits/s = 200 µs.)

MaxTsdr_1.5M_supp = 150

; (Sets a maximum response time, T_{sdr}, for slaves of 150 T_{bit} = 150/1,500,000 bits/s = 100 µs.)

;

Redundancy = 0

; (Specifies that redundant behavior will not be supported.)

Repeater_Ctrl_Sig = 2

; (Specifies that TTL-levels are to be employed for RTS-signals to repeaters (Pin 4).)

24V_Pins = 0

; (Specifies no + 24 VDC/max. 100 A supply voltage across Pins 7 and 2 of bus connector.)

Freeze_Mode_supp = 0

; (Specifies that the optional "FREEZE Mode" service will not be supported.)

Sync_Mode_supp = 1

; (Specifies that the optional "SYNC Mode" service will be supported.)

Auto_Baud_supp = 1

; (Specifies that automatic detection of transmission rate will be supported.)

Set_Slave_Add_supp = 1

; (Specifies that the option of altering slave addresses following a power-up will be supported.)

User_Prm_Data_len = 5

; (Specifies that parameter telegrams to LSPM2©-chips require 5 bytes of user parameters.)

User_Prm_Data = 0x00,0x00,0x00,0x00,0x00

; (Specifies that 5 bytes of user parameters must be transmitted in data format 5 x 0x00, since

; LSPM2©-chips are not software-programmable.)

Min_Slave_Interval = 1

; (Sets the minimum time interval between transmissions to slaves to 100 µs.)

Modular_Station = 0

; (Specifies that the slave involved is nonmodular, which must be specified, since

; LSPM2©-chips do not support I/O-configurations that differ from module to module.)

Module = "Compact DP-device 16A" 0x21,0x00

; (Specifies that the slave involved has 16-bit outputs and 0-bit inputs.)

EndModule

Note: Fail-safe modes are not supported. Error checking is at the byte-level only, and cannot be extended to pairs of bytes.

7.2.2. Configuring Siemens PROFIBUS-DP Masters (e.g., Siemens Model IM308-B©) at the MS-DOS-Level

The DPF-diskettes supplied with SI-units include a Type File with filename **SM1400td.200**, which is needed for assigning device addresses from software, i.e., via the bus, plus another with filename **SM1401td.200**, which is needed for hardware assignment of device addresses, i.e., assigning device addresses using the pair of rotary selector switches on SI-units. These files should be copied to the directory holding the **COMET 200 for MS-DOS** configuration software. Valve banks may then be called up for configuration by specifying the type (Model No.) of SI-unit to which they are interfaced and whether they are to be configured from software or by hardware, i.e., by entering **"SMC EX120 SW," "SMC EX121 SW," "SMC EX120 HW,"** or **"SMC EX121 HW."** A configuration menu having the format shown below will then appear onscreen. Enter the identification codes (ID) **033,** identifying board slot **0**, and **00**, identifying board slot **1**.

Configuration menu display-page format:

Executable file currently running: C:**EX120BET.200** SIMATIC S5 / COM ET 200

CONFIGURATION

Station Number: 12 Area: P Station Model: **SMC EX120/121 SW**
Station Designation: Slave 12 SMC EX 120/121
Next Unused Address: DE: 0 DA: 0 AE: 0 AA: 0

Configuration: Range Address E: A:
(Shift F6: Displays the DP-slave parameter telegram)

0.	**1.**	2.	3.	4.	5.	6.	7.
033	**000**						
8.	9.	10.	11.	12.	13.	14.	15.
16.	17.	18.	19.	20.	21.	22.	23.
24.	25.	26.	27.	28.	29.	30.	31.

F1	F2	F3	F4	F5	F6	F7	F8
ADD STATION	DISABLE STATION	DELETE STATION	NEW STATION	ASSIGN ADDRESS	TRANS-FER	HELP	EXIT

Note: ET200 software supports as many as 31 identification codes (ID).
ID 0:033 implies that 2-byte outputs are enabled.
ID 1:000 stands for "complete module."

Note: Do not interchange the above entries for ID's 0 and 1.

In order to run device-profile files under **COM ET200 for MS-DOS**, they must be in the same directory, e.g., **C:\COMET200**, holding the **COM ET200 for MS-DOS** configuration software. Cf. also informative material supplied by Siemens on Version 4.0 and later versions of its **COM ET 200 for MS-DOS** configuration software.

The remainder of installation procedures are as described in the instruction manual for the DP-master employed, e.g., the "Installation and Testing Manual for the Siemens ET200 Decentral Periphery System" if a Siemens ET200 unit is employed.

Device-profile files for use with Version 4.0 and later versions of COM ET for MS-DOS:

Part No.:	SMC EX120/121
Filename:	**SMC1400td.200**
Station Model:	SMC EX120/121 SW (software assignment device addresses via the bus)
ID-Code:	05120 (= 1400 hexadecimal)

Part No.:	SMC EX120/121
Filename:	**SMC1401td.200**
Station Model:	SMC EX120/121 HW (hardware assigned device addresses via rotary switches)
ID-Code:	05121 (= 1401 hexadecimal)

7.2.3 Configuring Siemens PROFIBUS-DP Masters (e.g., Siemens Model IM308-C©) at the Windows Level

The DPF-diskettes supplied with SI-units include a Type File with filename **SM1400AX.200**, which is needed for assigning device addresses from software, i.e., via the bus, plus another with filename **SM1401AX.200**, which is needed for hardware assignment of device addresses, i.e., assigning device addresses using the pair of rotary selector switches on SI-units. These files should be copied to the **TYPDAT5X**-directory holding the **COMET 200 for Windows** configuration software. Valve banks may then be called up for configuration by specifying the type (Model No.) of SI-unit to which they are interfaced and whether they are to be configured from software or by hardware, i.e., by entering **"SMC EX120 SW," "SMC EX121 SW," "SMC EX120 HW,"** or **"SMC EX121 HW."**

A slave configuration menu headed "Slave Parameters," where the following entries should be made, will then appear:

Family:	I/O
Station Model:	SMC EX120/121

Also enable response monitoring, set Error Mode to QVZ, set the Station Number desired, and enable SYNC-mode.

ID-codes will have already been entered into the "Configuration" menu. The only thing left to do here is define the output-channel addresses to be employed, as follows:

ID-Code:	0	16DA
	1	0000

Next, open the "ID-Code" window and select the following options:

Channel Type:	Outputs
Length:	2
Format:	Byte
Associated ID:	33

The **"COM ET200 for Windows"** user interface, combined with a Siemens IM308-C© master module interfaced to a Siemens Simatic S5 or S7 programmable logic controller, provide convenient means for designing and setting up PROFIBUS-DP-networks (Siemens' older IM308-B© model cannot be employed here).

Device-profile files for use with Versions 2.0 and later versions of COM ET200 for Windows and S7:

The associated data are identical to those listed above for the MS-DOS versions, except that the filenames involved differ, and are as follows:

SM1400AX.200 for software assignment of device addresses
SM1401AX.200 for hardware assignment of device addresses

In order to run device-profile files under **COM ET200 for Windows** when configuring bus networks controlled by Siemens S5 IM308-C© PLC's, the files must be in the **TYPDAT5X**-subdirectory of the directory holding the **COM ET200 for Windows** configuration software, e.g., **C:\COMWIN20\TYPDAT5X**. For Version 2.0 and later versions of the software for the Siemens S7© PLC, the subdirectory involved will be **STEP7_V2\S7DATA\TYPDATEI**, and device-profile files should be copied to that directory. Versions 1.x of the software for the Siemens S7© PLC and software for the Siemens CP 3432-5 DP© communications processor bearing the legend "NCM©" use device-profile files taken from the DPF-DP-directory.

Cf. also the manuals for Version 5.0 and later versions of the Siemens COM ET200 for Windows software and for STEP7©. Diagnostics, including diagnostics for particular types of slaves, are also covered in the manuals for the various versions of Siemens COM ET200 for Windows software and STEP7© software packages.

Parameter sets will not be transferred; i.e., the default settings, 00 00 00 00 00, of the DP-slave parameter-set telegram **should not be altered**.

Note: Here is a summary of the various versions of the Siemens COM ET200© software:
Versions 1.x, 2.x, 3..x, and 4.x are for use with MS-DOS applications
Versions 5.x and 6.x are for use with Windows applications

The Models EX120-SPR1 and EX121-SPR1 SI-units operate with Siemens IM308-C© and later, i.e., suffix-C and later versions, master modules and **Versions 4.x, 5.x, and 6.x** of the COM ET200 configuration software.

7.3 PROFIBUS-DP Service-Access Points

Open-architecture fieldbuses, such as PROFIBUS, are referenced to a standard, the so-called "ISO/OSI Reference Model," which has 7 defined levels, ranging from Level 1, the hardware level, to Level 7, the applications level. Compliance with this standard provides for open communications on the bus.

All data interchanges are transmitted via service-access points (SAP's) listed in the headers of PROFIBUS telegrams, as is also the case for PROFIBUS-FMS, which also has a user level (Level 7) that has been fully specified under the ISO/OSI Reference Model.

In the case of PROFIBUS-DP, Level 7 has deliberately been left out in order to simplify matters. The DP-protocol should be regarded as a standardized Level 2 application. A user interface replaces the otherwise unused Level 7

Although SAP's 54 through 62 and the default SAP have been reserved for PROFIBUS-DP, textual descriptions correlated to software modules written in the programming language, e.g., C++, employed that serve the same purpose are employed instead of numbered SAP's.

The following PROFIBUS-DP services are supported:

Default Data Interchanges	(Write_Read Data)
Master-Master Communications	(M-M_Communications)
Assigning Station Addresses	(Set_Slave_Add)
Reading Outputs	(Rd_Outp)
Transmitting Control Commands to DP-Slaves	(Global_Control)
Reading Configuration Data	(Get_Cfg)
Reading Diagnostic Data	(Slave_Diagnosis)
Transmitting Parametric Data	(Set_Prm)
Checking Configuration Data	(Chk_Cfg)

As many as 244 bytes of net data, plus another 11 bytes for their headers, may be transmitted by a telegram. Although, at least in principle, as many as 127 members, numbered 0 through 126, may be interfaced to the bus, in practice, many commercially available masters do not fully support this capability. For example, Siemens IM308-C© masters support device addresses 03 through 124 only.

SMC

<u>Note:</u> **Address 126 is reserved for installation purposes only, and should never be used for interchanging data. This exclusion applies to all masters, regardless of their type or manufacturer.**

Station addresses and identification codes are stored in a serial EEPROM incorporated into SI-units for this purpose.

7.4 Bus Cycle Times

7.4.1 Relevant Bus Timing Factors

The following discussion reviews those bus timing factors of relevance to PROFIBUS-DP, from the time masters call up data from slaves, through to their reception of responses from slaves.

Master callup -->	**Tsyn** -->	Header (11 bytes) + useful data (244 bytes or less) transmitted to the slave -->
Slave response -->	**Tsdr** -->	Header (11 bytes) + useful data (244 bytes or less) transmitted to the master -->
	Tid1	

The reference level (idle status) of the transmission line is binary 1. PROFIBUS-DP data interchanges employ so-called "NRZ" (nonreturn to zero) code; i.e., no transitions from binary 0 to binary 1, or from binary 1 to binary 0, occur while a bit is being transmitted. PROFIBUS-DP characters consist of 11 bits, 1 start bit, 8 data bits, 1 (even) parity bit, and 1 stop bit. The line will revert to its idle status, binary 1, whenever no transmissions are in progress. Transmission of a start bit causes line status to drop to binary 0. Allowance for an idle period of duration Tsyn or longer before transmitting telegrams is essential in order to allow time for the line to return to its idle status.

Tsyn: Tsyn, the synchronization period, is that time period within which each member must receive at least one idle-status signal before it will accept the initial bit of a callup. This time period varies with the bus-protocol chip employed, which in this case is a Siemens LSPM2©.

Tsdr: Tsdr is the time required for a slave to respond, which under the PROFIBUS-DP-standard is defined in terms of a range extending from Tsdrmin to Tsdrmax, where Tsdrmax is the time by which each and every DP-slave should have responded. As can be seen from the values of Tsdr listed below, which are taken from the device-profile file (MaxTsdr), Tsdr = Tsdrmax in all cases, as required by the standard.

Transmission Rate [kbaud]	9.6	19.2	93.75	187.5	500	1500
Tsdr = Tsdrmax, expressed in bit intervals: (T_{bit} = 1/transmission rate	60	60	60	60	100	150
Tsdr [µs]	6250	3125	640	320	120	40

Tid1: After receiving the final character of a message, the master must wait for a time period Tid1 before transmitting the next message. This time period must be at least equal to Tsyn plus a safety factor that becomes increasingly important at high transmission rates.

The general rule applicable here is: Tid1 ≥ 33 Tsyn

This restriction is not checked by the CPU, and compliance is thus the responsibility of users.

7.4.2 Bus Cycle Times

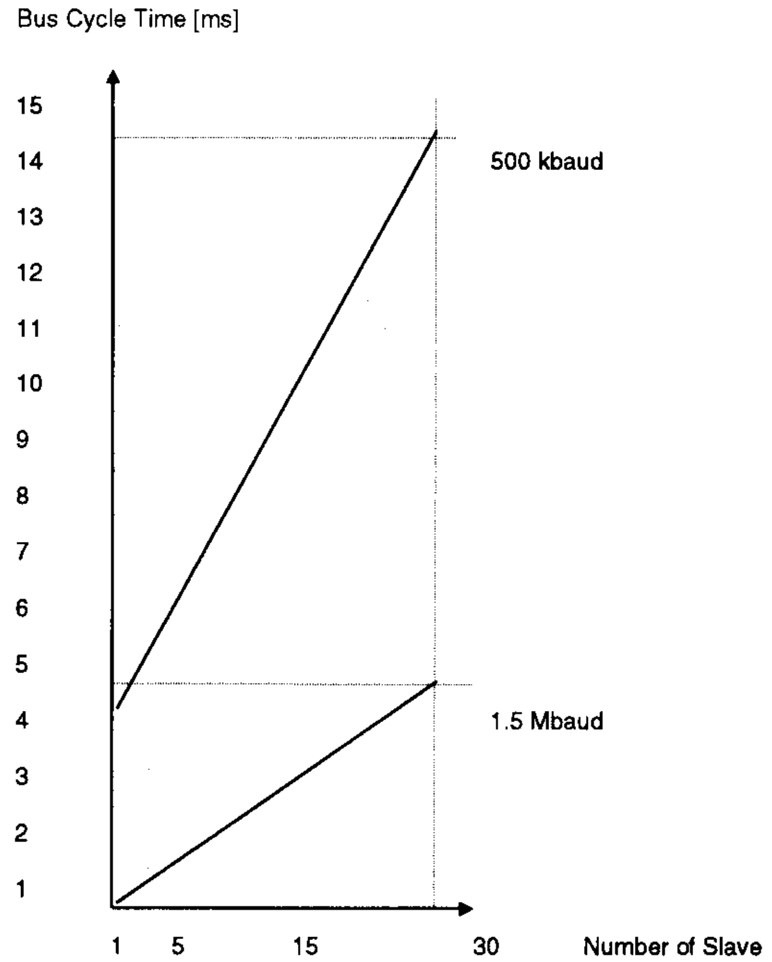
As can be seen from the listing of the device-profile file (FMS_supp = 0), these SI-units do not allow combining PROFIBUS-FMS with PROFIBUS-DP, and the more rapid bus response times of the DP-specification will thus apply.

Definition of bus cycle time: The time interval required for a DP-master to service all slaves of a bus network, i.e., the time interval required for the master to write to their outputs. This same interval will be required for the master to read the inputs of all slaves. However, the latter does not apply in this case, since the SI-units described here have no inputs (they have 16-bit outputs only).

A short bus cycle time is essential to maintaining short total response times, assuming that the refresh cycles of slaves remain fairly short. Each PROFIBUS-slave will be assigned the same priority.

Bus cycle time is inversely proportional to the transmission rate in use. The plot below illustrates the interrelationships among bus cycle time, the total number of slaves in use, and transmission rate.

This example presumes that the PROFIBUS-DP-network involved has been configured from a single master and 30 slaves, and that each of the 30 slaves has 16 channels or takes up 16 bits (i.e., that each slave takes up 2 bytes).



In general, in addition to the SI-units described here, certified devices from other manufacturers complying with EN 51070 may also be incorporated into PROFIBUS-DP-networks. It is thus essential that any other types of slaves present be taken into account when computing bus cycle times. To simplify matters, we will classify slaves into three groups based on the numbers and types of digital inputs/outputs with which they are equipped.

mDO	Slaves equipped with m output channels or m-bit digital outputs
nDI	Slaves equipped with n input channels or n-bit digital inputs
nDImDO	Slaves equipped with n inputs channels and m output channels (hybrid modules)

When employed as PROFIBUS-DP-slaves, Models EX120-SPR1 and EX121-SPR1 SI-units fall under Group mDO, where m = 16, since they are equipped with 16-bit outputs. The basis for computing bus cycle times is DIN 19245, Part 3. It will be presumed that the PROFIBUS-DP-network is fully operational, that delay times are minimal, and that an overhead constant of 476 applies.

The general formula for computing PROFIBUS-DP bus cycle (BC) times, T_{BC}, is as follows:

$$T_{BC} = T_{bit} * [476 + S_I * (213+d_I*11) + S_O * (158+d_O*11) + S_{IO} * (246+d_{IO} * 11)]$$

- T_{bit}: The bit time, the reciprocal of the transmission rate
- 476: Overhead constant
- $S_I * (213+d_I*11)$: Share due to pure input modules (nDI)
- $S_O * (158+d_O*11)$: Share due to pure output-modules (mDO)
- $S_{IO} * (246+d_{IO} * 11)$: Share due to hybrid I/O-modules (nDImDO)

Notes:
1. In practice, allowances must be made for diagnostic telegrams and telegram resends due to electromagnetic interference. A **safety factor of 1.25 or greater** should thus be applied when computing monitored timing factors, e.g., $T_{I,...} = 1.5\ T_{I}$.
2. For multimaster networks, the respective bus cycle times of all masters employed should be added. The times required for interchanging token telegrams may usually be safely neglected.

This equation applies to monomaster networks only. The overhead factor applies to each bus cycle. The factor of 11 is due to the fact that transmitting UART-characters converts 1 byte into 11 bits.

Definitions of the symbols and terminology employed:

T_{BC} **Bus cycle time**
The total time required to complete a bus communications cycle. If several masters are present, their respective bus cycle times should be added to form the grand total, where the times required for interchanging token telegrams may be neglected.

T_{bit} **Bit time = 1/transmission rate**
The time required to transmit a single bit, which is the reciprocal of the transmission rate, expressed in bits/s (baud), in use.
Example: For a transmission rate of 500 baud, the bit time, T_{bit}, is 1/500,000 = 2 µs.

S_I **The total number of pure input modules (nDI) present, S_I = n**
di **The number of bytes input to each input module**

S_o **The total number of output modules (mDO) present, $S_o = m$**

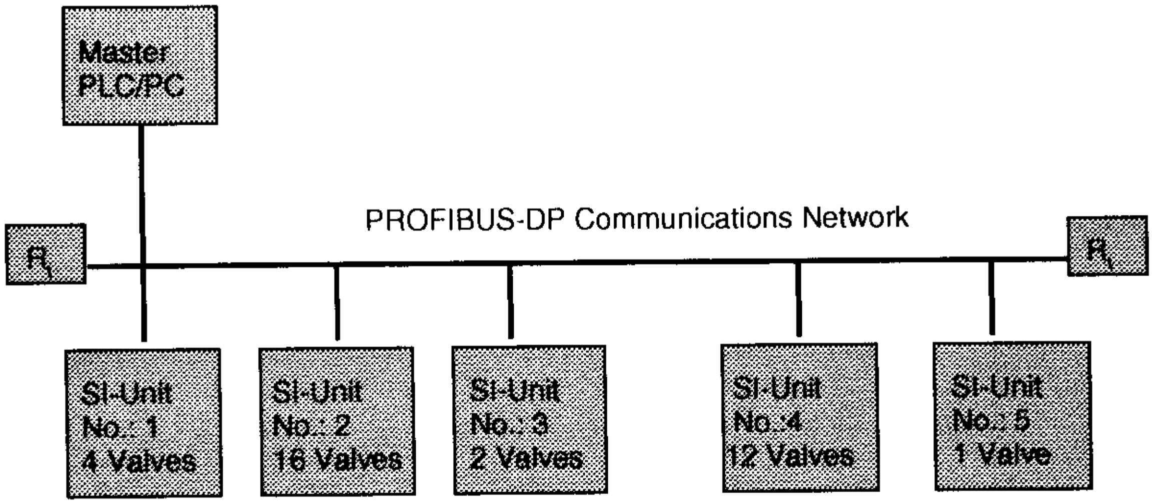
d_o **The number of bytes output by each output module**
(Models EX120-SPR1 and EX121-SPR1 SI-units are output modules with $d_o = 2$)

S_{IO} **The total number of hybrid modules, i.e., modules having both inputs and outputs (nDImDO) present**

d_{IO} **The number of bytes input to/output by hybrid modules**

Example a:

Given a PROFIBUS-DP-network incorporating a single master (a PLC or add-on PC-board) plus 5 of the EX120/121-SPR1 SI-units described here, but no other slaves, running at 1.5 Mbaud, compute its bus cycle time, applying a safety factor of 1.5.



Solution:

First compute the network's bit time, T_{bit}: Tbit = 1/1,500,000 bits/s = 667 ns

Since exclusively SI-units are present, and all are pure output modules taking up 2 bytes each, we have:

$$S_I = 0,\ S_{IO} = 0,\ d_o = 2,$$

and, setting $S_o = 5$, the formula above reduces to:

$$T_{BC} = T_{bit}\,[476 + S_0\,(158 + 11d_0)] = 667\text{ ns}\,[476 + 5\,(158 + 22)] = 0.9\text{ ms.}$$

Applying the safety factor of 1.5, we then have for the total bus cycle time, $T_{BCtotal}$:

$T_{BCtotal}$ = 1.5 (0.9 ms) = approximately 1.4 ms.

Notes:
1. The numbers of valves interfaced to SI-units have no effect on bus cycle time, since all valves interfaced to given SI-units will be simultaneously addressed.
2. Bus cycle time increases as the total number of members present increases.
3. SI-units closer to the master will be addressed before those that are farther away from the master.

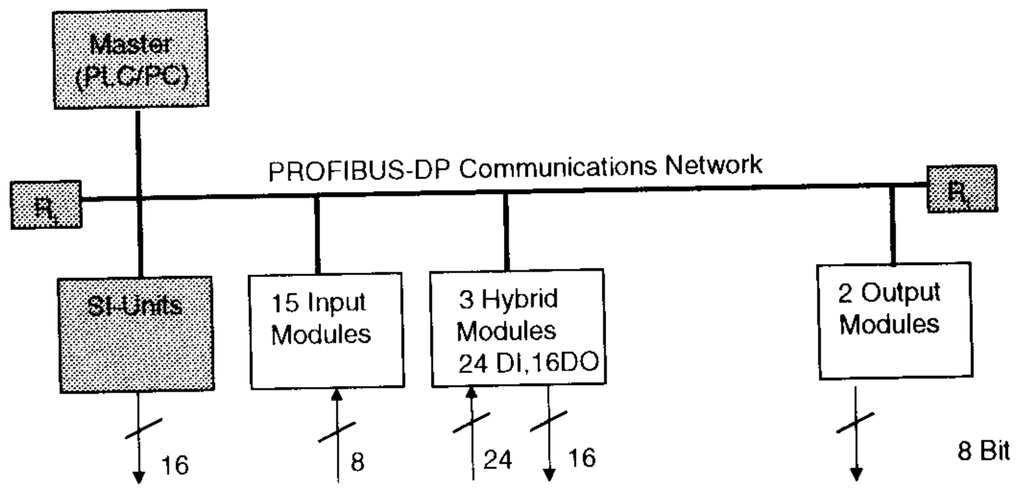
Example b:

Given a monomaster PROFIBUS-DP-network configuration with the following slaves:

- 4 Model EX120/121-SPR1 SI-units interfaced to varying numbers of valves
- 15 input modules equipped with 8-bit inputs
- 3 hybrid modules equipped with 24-bit inputs and 16-bit outputs
- 2 other output modules equipped with 8-bit outputs

The transmission rate in use is 187.5 baud, and the network requires use of a safety factor of 1.3. Compute its total bus cycle time, $T_{BCtotal}$, and its total bus cycle time for a transmission rate of 1.5 Mbaud.

Block schematic of the network of Example b:



Valves
(As many as 16 single-acting valves, or
8 double-acting valves, or equivalent
combinations there of may be interfaced
to each SI-Unit.

Solution:

The bus cycle time, T_{BC}, is given by:

T_{BC} = bit time (overhead constant + total cycle time for the input modules + total cycle time for the SI-units + total cycle time for the other output modules + total cycle time for the hybrid modules)

Notes:

1. The formula for bus cycle time appearing on the preceding page must be extended by an additional term in order to account for the share of bus cycle time taken up by pure output modules, since the output modules of this example employ differing word lengths (d = 2 bytes and d = 1 byte).

2. Members of PROFIBUS-DP-networks are able to control their inputs/outputs byte-by-byte only. For example, d = 2 for 12-bit pure output modules, d = 3 for 18-bit output modules, etc., d =1 for 4-bit pure input modules, d = 4 for 25-bit pure input modules, etc.

The bit time here is: T_{bit} = 1/187,500 bits /s = 5.3 µs.
Setting: S_i = 15, d_i = 1
S_{01} = 4, d_{01} = 2 (for the Model EX120/121-SPR1 SI-units)
S_{02} = 2, d_{02} = 1 (for the other output modules)
S_{IO} = 3, d_{IO} = 3 + 2 = 5,

we obtain:

T_{BC} = 5.3 µs [476 + 15 (213 + 11) + 4 (158 + 22) + 2 (158 + 11) = 3 (246 + 55)]
= 5.3 µs (476 + 3360 + 720 + 338 + 903)
= 5.3 µs (5797)
= 30.7 ms,

and: $T_{BCtotal}$ = 1.5 (30.7 ms) = approximately 40 ms.

Example c:

The response times of the solenoid valves employed are obtained by adding their actuation lags (ON/OFF-actuation delay times) to the total bus cycle time, $T_{BCtotal}$.

What is the response time, T_R, for a VQ1200 solenoid valve that has an actuation lag of 10 ms, as stated in Product Catalog D315-A, when incorporated into a monomaster PROFIBUS-DP-network in which exclusively SI-units having a total bus cycle time, $T_{BCtotal}$, of 15 ms are employed as slaves?

Solution: T_R = $T_{BCtotal}$ + valve actuation delay
= 10 ms + 15 ms = 25 ms.

7.4.3 Network Response Times

The response times of PROFIBUS-DP-networks are largely dependent upon the following factors:

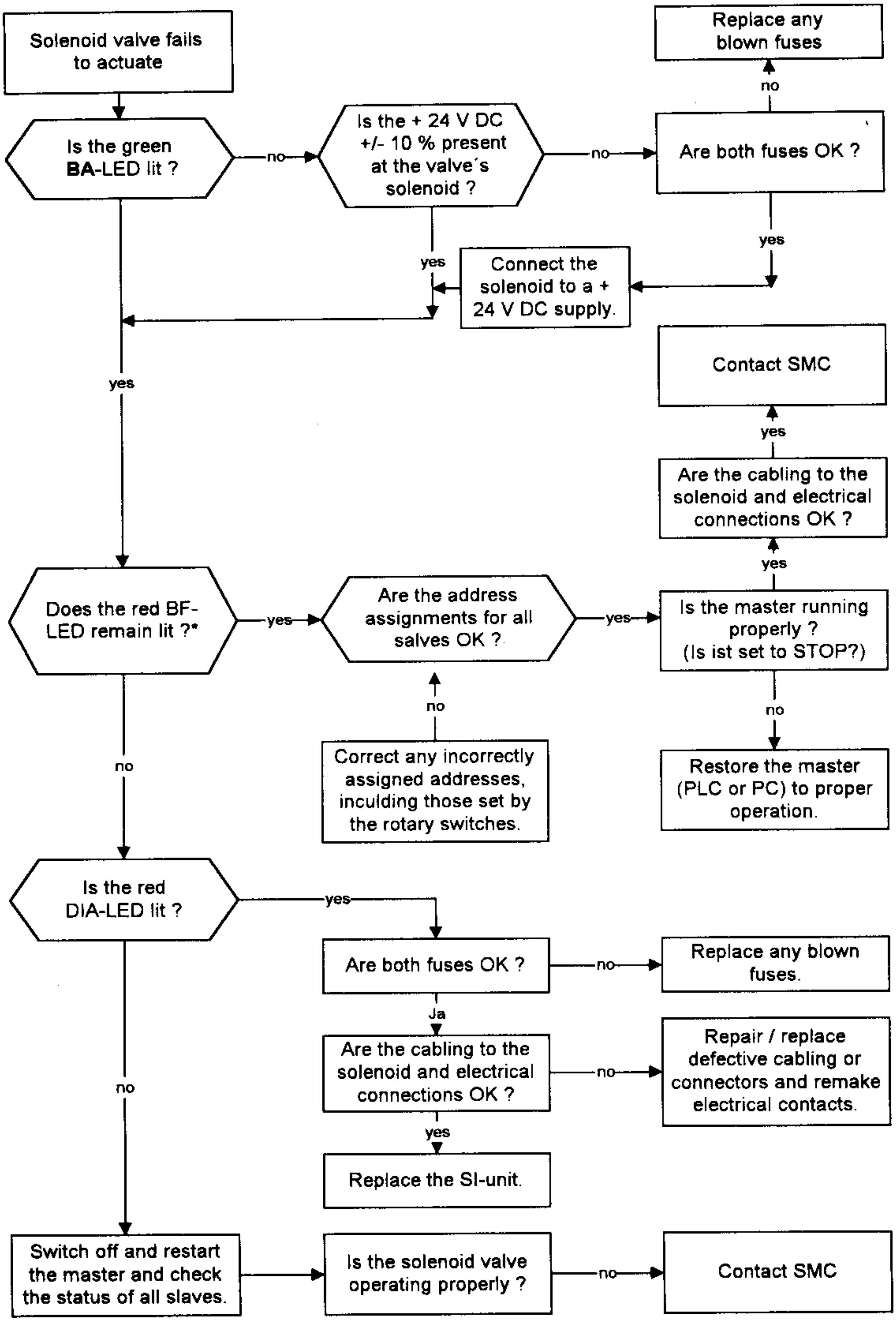
Tsdr	(Cf. Section 7.4.1 hereof.)
Transmission rate	bit rate, the number of bits transmitted per second
Min_Slave_Interval	
The agreed net block length	

Min_Slave_Interval

Min_Slave_Interval is the time interval between two consecutive polling cycles, i.e., communications cycles during which slaves may exchange data with the master. In the case of the SI-units equipped with LSPM2©-chips described here, this time interval is **0.1 ms**. Specifying a Min_Slave_Interval allows employing uniform bus timing, which is essential in real-time applications, since slave response times are predefined. The disadvantage is that the slowest member of a bus network can hold up traffic on the entire bus.

8. Troubleshooting

Overleaf is a flow chart that should aid troubleshooting failures or malfunctions of the actuating solenoids of SI-valve banks. This flow chart is based on the relatively primitive diagnostics provided by the four status LED's on SI-units. In the event that these prove inadequate for localizing the cause(s) of the failure(s) or malfunction(s) involved, try the more extensive diagnostics provided by the master employed (cf. its instruction manual and the manuals for the software for the PLC or PC employed).



Nach dem Einschalten kann es während der Hochlaufphase (Standard-Einstellung: 20 Sekunden) vorkommen, daß die SI-Einheit als Slave zu spät vom Master (z.B. IM308B,C) erkannt wird, obwohl alle 3 LEDs auf der SI-Einheit keinen Fehler anzeigen (d. h. nur grüne LED ist an). In diesem Fall genügt ein Neustart des Masters. Die Versorgungspannung für die Slaves sollte grundsätzlich vor der des Masters einschwingen.

9. Acronyms Employed

Acronym	Designation
PROFIBUS	Process Fieldbus
DP	Decentral Periphery
DPF	Device-Profile File
DSAP	Destination Service Access Point
FMS	Fieldbus Message Specification
ISO	International Organization for Standardization
LSPM2©	Lean Siemens Profibus Multiplexer (a slave-protocol chip used for DP)
NRZ	Nonreturn to Zero
OSI	Open Systems Interconnection
PLC	Programmable Logic Controller
PNO	Profibus Nutzerorganization e.V. (German Profibus User Organization)
SAP	Service Access Point
SDN	Send Data With No Acknowledge
SINEC®L2	Registered trademark for the PROFIBUS used by Siemens
SRD	Send and Request Data With No Acknowledge
SSAP	Source Service Access Point
STEP®	Registered trademark for a PLC-programming language devised by Siemens