Lenze
Antriebstechnik

Operating instructions

Manual for positioning system SX-1 and programming terminal PT-1

1. Contents

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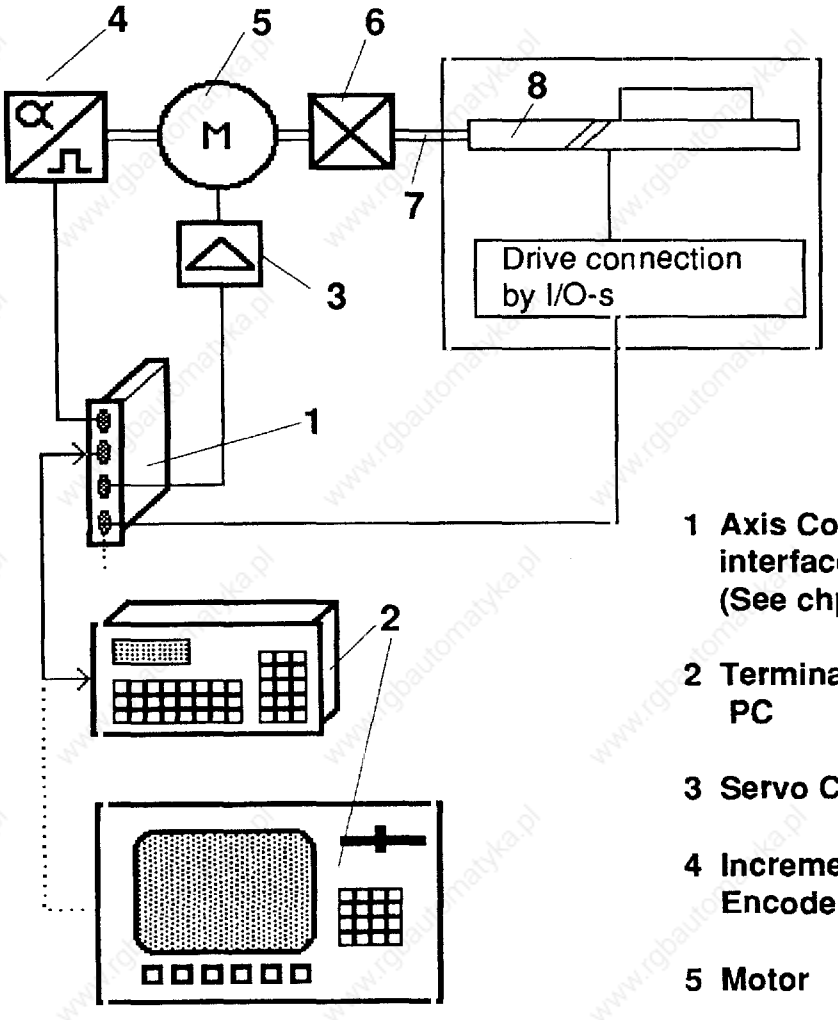
3. General Information

3.0 Introduction

The SX-1 Positioning System allows the precise positioning of workpiece, tool or material, with optimum control of speed and acceleration. Multi-axis systems may be configured using a personal computer, by interconnecting SX-1 units using the I/O facilities built in. Alternatively, axes may be co-ordinated by using a Programmable Logic Controller (PLC).



1 Axis Controller SX-1, with interface connectors X1-X4 (See chpt. 3.1.1)

2 Terminal PT-1, PC

3 Servo Controller

4 Incremental or Absolute Encoder

5 Motor

6 Gearbox or Coupling

7 Drive Shaft

8 Workpiece, Tool or Material

3.1 Positioning System SX-1

3.1.1 Layout of the SX-1

1 **Mounting holes**
2 **Metal case**
3 **Ventilation louvres**
4 **Status :** single character display of mode and error codes

5 **Reset:** resets the controller

6 **Ax.Nr:** defines axis number. Updated by Power On or Reset

7 **LED Green:** b.s.: Bus select
LED Red: w.d.: Watch Dog (error) Illuminated upon internal faults

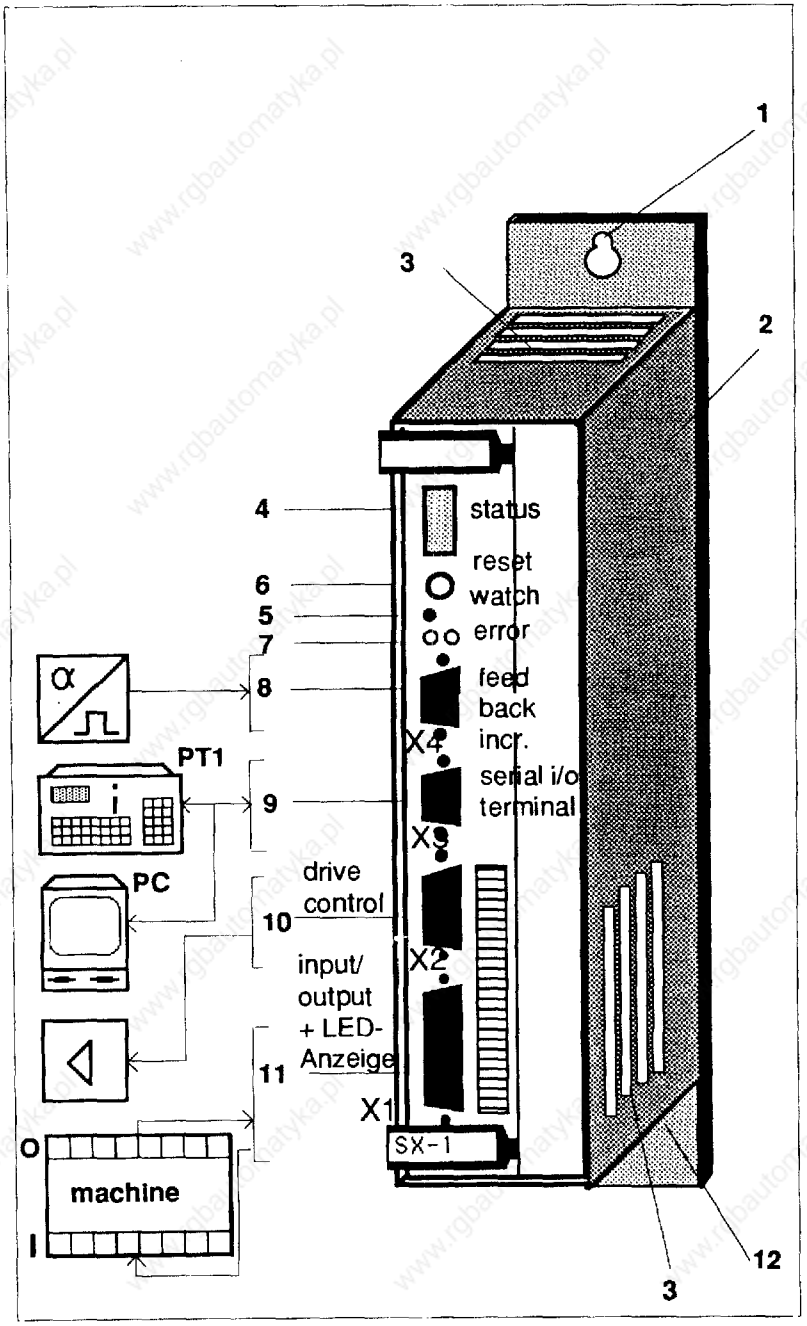
8 **Feedback/inc Feedback/abs** Measuring System Connector X4 for Incremental or Absolute/Serial Encoder

9 **Serial I/O terminal:** Serial (Data) Connector X3 for Programming Terminal/Controller or for Host Computer or PLC

10 **Drive Control:** Controller Connector X2 for Servo Reference signal and end-of-travel and reference switches

11 **Input/Output:** Parallel Interface Connector X1 for...

12 **Main Power Supply Connection (underneath)**



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3.1.2 Technical Data for the SX-1

Weight	3,5 kg
Environmental Temperature	
- Operating	0 ° ... 45° (Up to 55 °C with forced ventilation)
- Storage	-20 ° ... +70 °C
Humidity	10 ... 90 % relative humidity, non-condensing
Supply	AC 110/220 V, +10 %, -15 %; 50/60 Hz
Power Consumption	30 VA
Protection	IP 20
Processor	Motorola 6809
Program Storage	EEPROM 8 kByte
Largest Single Program	2000 Byte

Interface Connections

Parallel Interface X1	Inputs and Outputs using external 24 V DC supply
Inputs (E)	12 inputs with opto-isolation; 5 ms time constant; 5 inputs are user-programmable 4 inputs used to select operating mode (encoded). Software Version 4.XX 8 inputs used to select operating mode (non-encoded). Software Version 5.XX Input current: 5 mA per input
Outputs (A)	11 outputs in total 9 opto-isolated; short circuit protected; maximum load 100 mA 8 of which are user-programmable, 1 dedicated to "Drive in Position"
Controller Interface X2	±10 V into 10 kΩ minimum with 13 bit D/A convertor Resolution 2.5 mV approx; 2 relay contact outputs for "Fault" and "Drive Enable" I max 100 mA 4 opto-isolated inputs with 1 ms time constant for "Enable NC System" and "Cancel Fault". End-of-Travel Limit Switches + and - (or Right and Left) Reference (Home) Position Switch
Option:	Analog Override - 0 to 10 V corresponds to a Speed Override of 0-125 %

Serial Interface X3	RS 422 link for Program Input and parameter entry from PT-1 or for DNC up to 64 SX-1 may be operated on this bus
Measuring System Interface X4	Incremental Encoder Interface with complementary inputs Supply provided 5 V at 200 mA maximum. Maximum frequency 200 kHz. Alternatively: Absolute Encoder Interface with SSI protocol, with supply of 18 V at 400 mA maximum

Options

EA-4	16 Inputs Tin 3 ms I in ≤ 5 mA 16 Outputs 8 Outputs 100 mA max. 8 Outputs 1 A 50 % Duty Cycle Addressing: up to 6 EA-4 cards per SX-1Position Controller An external supply is required for Inputs and Outputs 24 V d.c. (20-33 V) Output Current Inom = 5 A

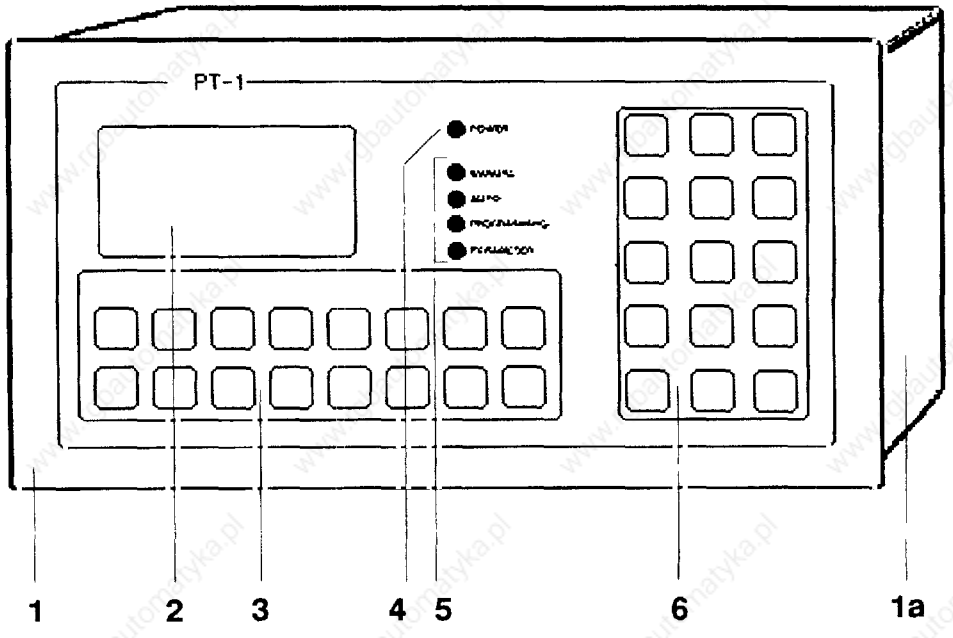
3.2 User Terminal PT-1

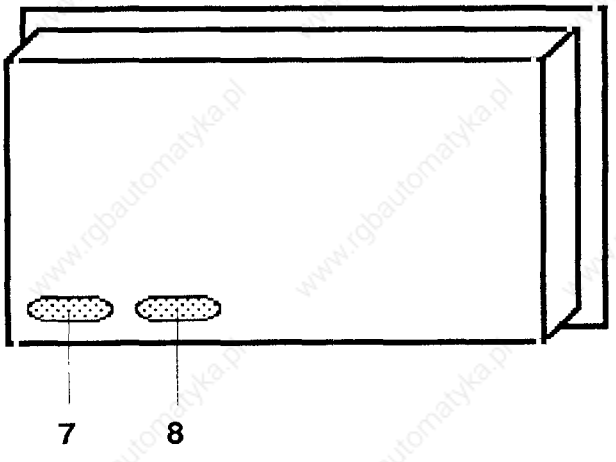
The terminal has several functions:

- **Parameter Mode:** entering, changing and displaying Parameters describing drive and machine dynamics
- **Program Mode:** entering, changing and de-bugging the program for motion and logic control of the sequence
- **Jog Mode:** moving the axis in the "manual-remote" mode (continuous, incremental and programmed distance jogging)
- **Homing:** starting the "homing" sequence in "manual-remote" mode
- **Auto Mode:** operating in the automatic mode, i. e. to start and stop a selected program
  There are two Automatic Modes:
  E.S. = Single Step. One instruction at a time e. g. for test purposes
  F.S. = Consecutive . Continuous operation of the program e. g. from start to end
  While the program is running, the PT-1 displays the current axis number, Actual Position, "Following Error", and current Program Number.
- **Test Mode:** enables movement of the drives without position feedback
- **Control Mode:** set outputs, read inputs for start-up and test functions

The PT-1 Terminal is normally supplied with power from the SX-1 connection. However, it may be operated "offline" from a 24 V DC supply (see Chapter 5.3.3)

3.2.1 Layout of the PT-1





Rear View (Reduced Scale)

1 Membrane front panel

1a Metal case

2 LCD Display - 4 Lines and 16 Columns

3 Function Keyboard. Most keys have two functions.

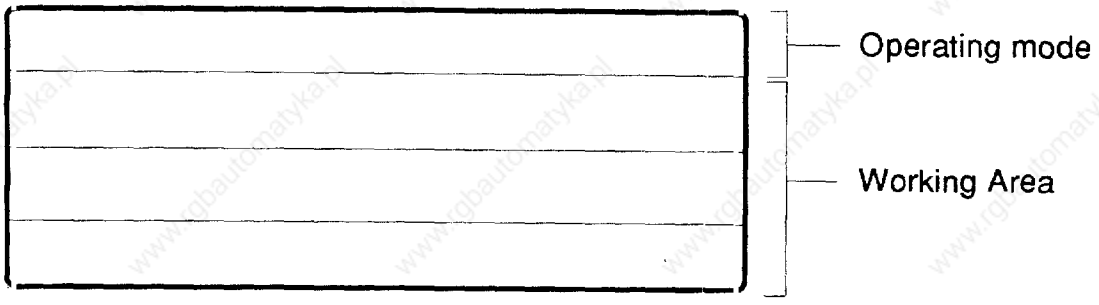
4 LED "Power On". Ready for operation

5 LED Mode display:
MANUAL
AUTOMATIC
PROGRAM
PARAMETER

6 Numeric Keyboard, with additional special keys

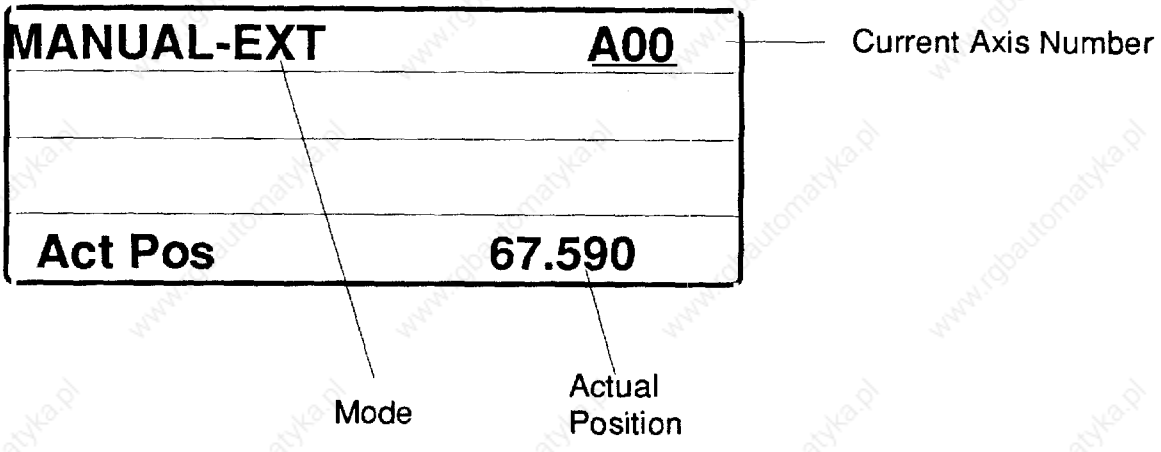
7 Connector for the serial link to the SX-1 Controller

3.2.2 Display



The display is of 4 Lines by 16 Columns:
Line 1: Operating mode
Lines 2-4: Working Area, i. e. Input of Program Instructions, Parameter Data, Variable values, Actual Position display, etc.

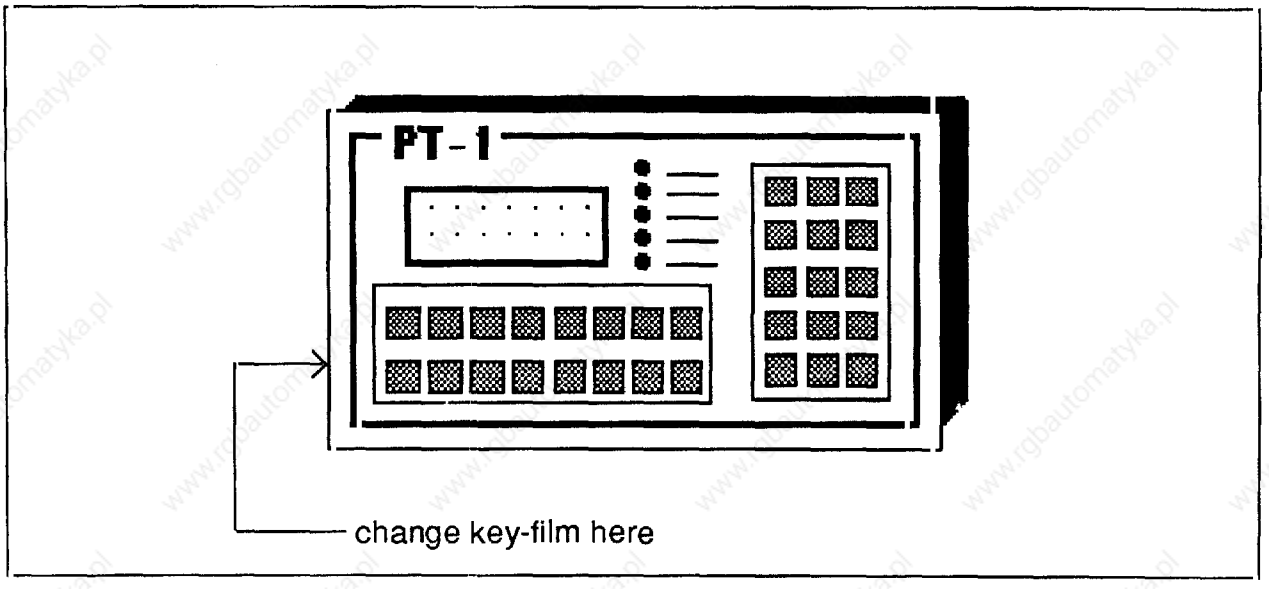
Example of Display



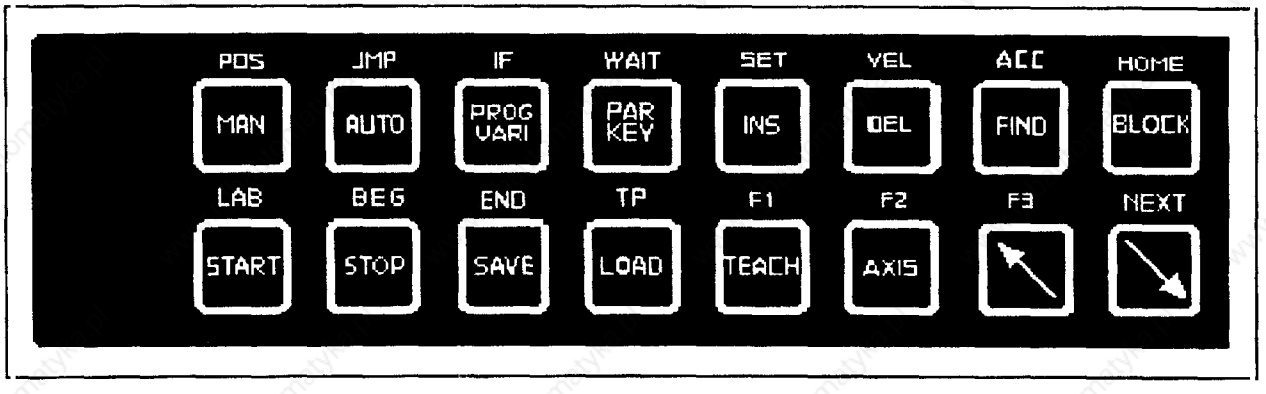
3.2.3 Keyboard

The PT-1 has a Membrane Keyboard with two areas: a Function keyboard and a Numeric keyboard with additional special keys.

The Function Keyboard
The keyboard legend can be changed by inserting an "Underlay" in the slot a the left of the keyboard.



Operator´s Keyboard for Programming and Parameter Entry



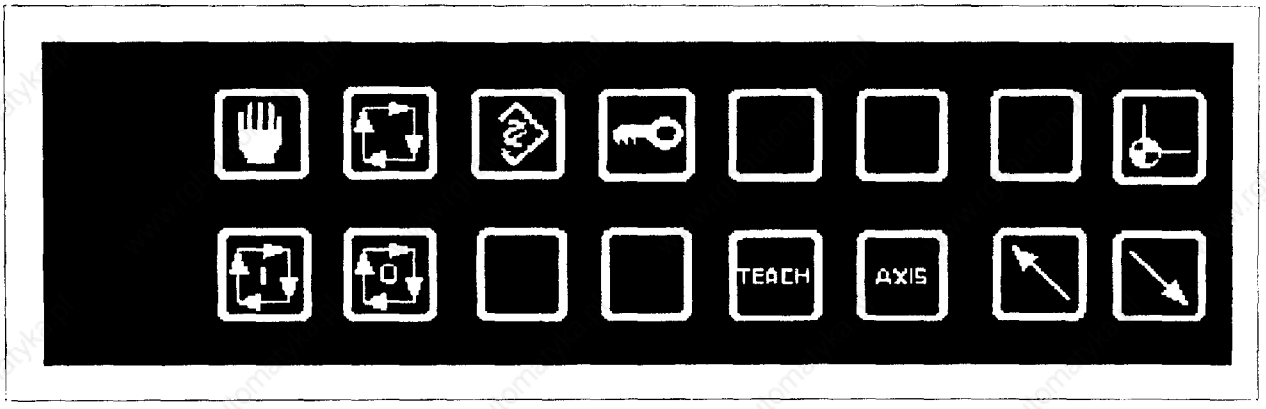
Most of the keys have two functions, which are selected according to the operating mode selected. The legend above the keys relates to Program Mode.

Code	Mnemonic	Meaning
POS	Position	Absolute or Relative positioning
JMP	Jump	Jump to a label
IF	If	Conditional instruction
WAIT	Wait	Wait for time or condition
SET	Set	Set output, flag, counter or variable
VEL	Velocity	Select speed
ACC	Acceleration	Select acceleration
DEC	Deceleration	Select deceleration
HOME	Home	Initiate selected Homing sequence
LAB	Label	Jump destination label
BEG	Begin	Start of Program or Sub-Routine
END	End	End of Program or Sub-Routine
TP	Text	Define text for display during program
NEXT	Next	Select the next instruction within a group
MAN	Manual	Manual mode
AUTO	Automatic	Automatic mode
PROG	Program	Select Programming mode
VAR	Variable	Select Variable entry mode
PAR	Parameter	Select Parameter mode
KEY	Key	Enter the key number
CODE	Mnemonic	Meaning
INS	Insert	Insert an instruction line
DEL	Delete	Delete an instruction line
FIND	Find	Find a Parameter number or Instruction number
BLOCK	Block	Select a Block of instructions
START	Start	Start program execution
STOP	Stop	Stop program execution
SAVE	Save	Save program or parameters from PT-1 to SX-1
LOAD	Load	Load program or parameters from SX-1 to PT-1
TEACH	Teach	The release of the changeable desired positions and the transfer in the program Display change-over from actual positions to following error
AXIS	Axis	Current Axis Number
	Arrow keys	1) The relaying on following or preceding program line/parameter line 2) Manual operation of axis to the left or to the right

The Numeric and Special Keyboard

Code	Meaning
0 ... 9	Numeric keys. In some modes these have special meanings
+/-	Plus/Minus (or direction)
CE	"Clear Entry" or "Correct Error": if pressed before ENTER, the entry is discarded
MODE	Prepares for data/text entry, or moves the cursor
ENTER	The instruction or data is entered into memory

The User Keyboard "Underlay"



Symbol	Meaning		
	Manual Mode	Select	Remote
	Automatic Mode	Select	
	Variable Data Entry		
	Key Code Number		
	Reference (Home)	Manual-Remote	
	Start	Auto-Remote	
	Stop		

3.2.4 Technical Data for the PT-1

Weight	1 kg
Environmental Temperature	
- Operating	0 ° - +45 °C
- Storage	-20 ° - +70 °C
Humidity	10 - 90 % relative humidity, non-condensing
Supply	AC/DC 16 V/360 mA - 36 V/100 mA (from SX-1)
Protection	Front Panel IP 65 Case IP 20
Processor	Motorola 6809
Memory	8 kByte Battery (Nickel-Cadmium) maintained RAM for Program and Parameter storage
Display	4 Lines by 16 Columns LCD Alpha-Numeric Display 5 LEDs for display of mode
Keyboard	15 keys for Numeric and special functions 16 keys for operating mode selection and programming
Interface	RS 485 (422) for connection of up to 64 SX-1

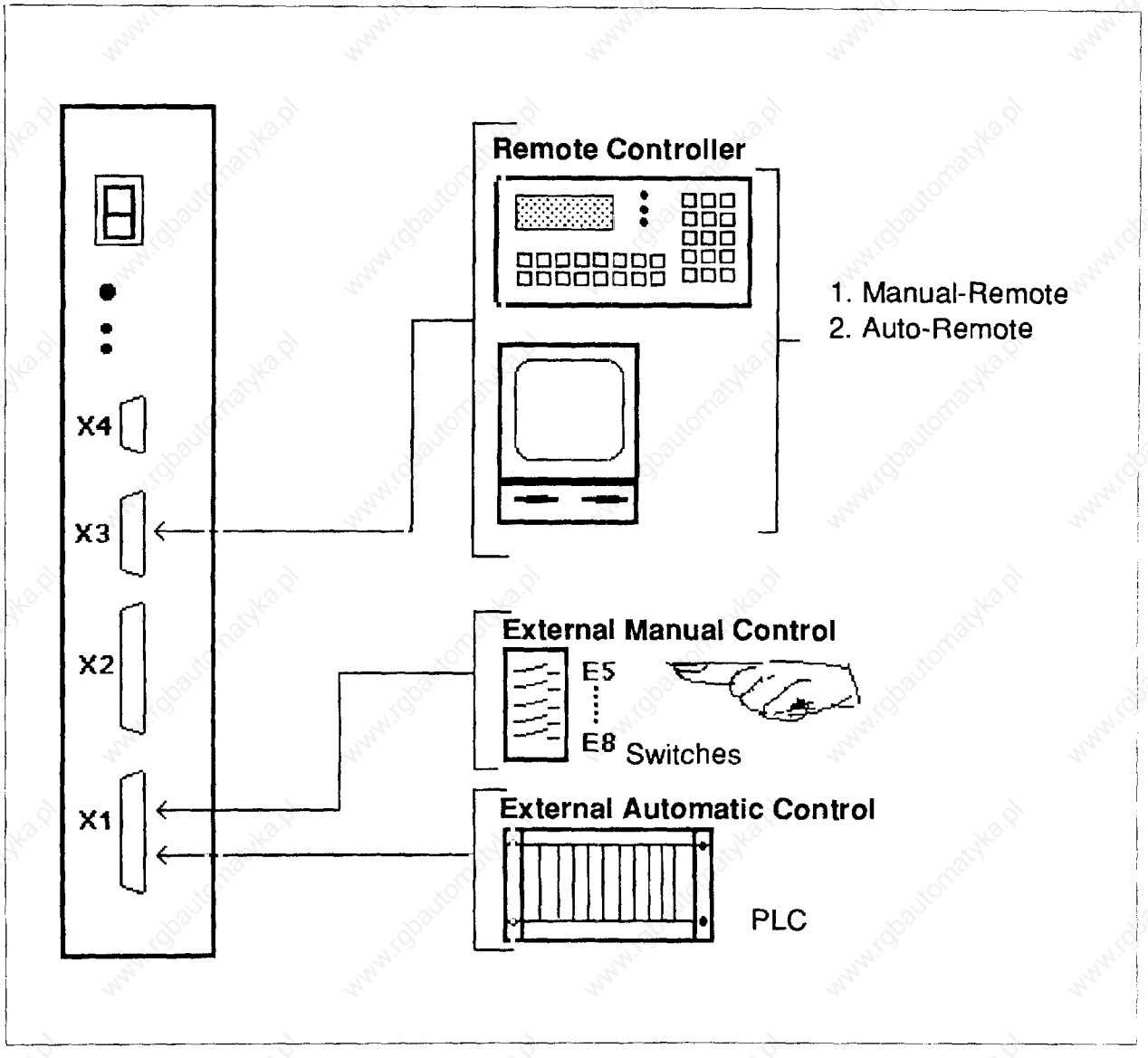
4. SX-1 Operating Modes - Over View

(For detailed information, refer to Chapter 6 "General Operation")

The SX-1 has different operating modes for starting the axis control, verifying programming, and diagnosing and correcting errors.

There are three ways of operating the SX-1:

- Remote Controller (e. g. from PT-1 or PC)
- Manual-External (e. g. from switches)
- Manual-Automatic (e. g. from PLC)



4.1 Remote Control

In the Remote modes, the control signals are provided via the Serial Interface Connector X3. You may use either the PT-1 Terminal, or a Host Computer (either an Industrial Computer or a PC). There are extra instructions for DNC operation.

There are two modes of Remote Operation: **"Manual-Remote"** and **"Auto-Remote"**

4.1.1 Manual-Remote (see chpt. 4.4, page 4/3)

In this mode, manual control is possible with the following facilities:
- Jog in both directions at two speeds (defined by Parameters 7 and 8)
- Jog for preset distances (Incremental)
- Jog to a programmed position or distance
- Home

4.1.2 Auto-Remote

In this mode, program operation and axis movement is controlled by Start and Stop commands from the PT-1 or other computer.
You can:
- Select the program number
- Run the program in Single-Step mode (V 4.XX Software only) (Step)
- Run the program in Consecutive (sequential) mode from beginning to end (Auto)

For futher information see Chapter 8.6

4.1.3 Test Mode

In this mode, the Controller operates without the closed Position Loop.
The Manual and Automatic functions are still available (see Chapter 6.1.1)

Warning: There is no position and servo monitoring in this mode, and control is not therefore guaranteed.

4.2 Manual-External

In this mode it is possible, without the PT-1, to jog the axis in both directions at two speeds, (V 4.0 only) and to Home (Reference), using external switches. The control signals are provided via the Parallel Interface Connector X1.

4.3 Automatic-External

In this mode, program execution is started and stopped by Inputs (X1), e. g. from a supervisory controller or PLC. The program is selected by Parameter P0 "PRG.NR"

For further information and selecting these modes, see Chapter 6.2.

4.4 Manual-Remote Operation

The following menues select Manual-Remote operation

Mode selection switches	V 4.X				V 5.X						
	E5	E6	E7	E8	E5	E6	E7	E8	E9	E10	E11
	1	0	1	1	1	0	0	1	0	0	0

"REMOTE"

MAN

Menu: Manual-Remote

LED "MANUAL" illuminated

Manual-Remote	A00
> <__ __>	
Incremental Mode	
Distance Mode	

MODE

Menu selection:
Move the cursor to the required selection on the menu

> <__ __> (Jog Mode)
Incremental Mode
Distance Mode

ENTER

Enter the selected mode:

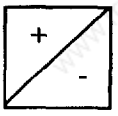
Jog Mode
Incremental Mode
Distance Mode

Exit from the menu using the MAN key

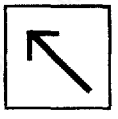
Operating in the selected menu

Continuous Jog

Manual-Remote	A00
< _ _ S _ _ >	
ACTUAL POS	± xxxxx.xxx



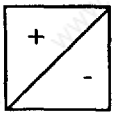
Two Speeds:
Slow: S Fast: F
Toggle SPEED with +/- on Numeric keypad



Jog in two directions
(Function keyboard)

Incremental Jog

Manual-Remote		+ A00
1 = 0,001		2 = 0,01
3 = 0,1	4 = 1	5 = 10
ACTUAL POS		+ xxxxx.xxx



Toggle DIRECTION with +/- on Numeric keypad
Select the distance with the appropriate number, e. g. 2 = 0.01 units per movement

Distance Mode

Manual-Remote	A00
PR	+ xxxxx.xxx
ACTUAL POS	+ xxxxx.xxx

MODE

Choose Absolute or Incremental mode

ENTER

PT-1 expects you to enter:
direction of movement
length of movement
terminate with ENTER key

START

Commence movement

MAN **Display:**

Manual-Remote	A00
> <__ __>	
Incremental Mode	
Distance Mode	

Note: To quit the Distance Mode, it is sometimes necessary to press ENTER to terminate number entry.

Selecting another Menu:

MAN AUTO PROG VARI PAR KEY

corresponding to the inscription next to the LED´s.

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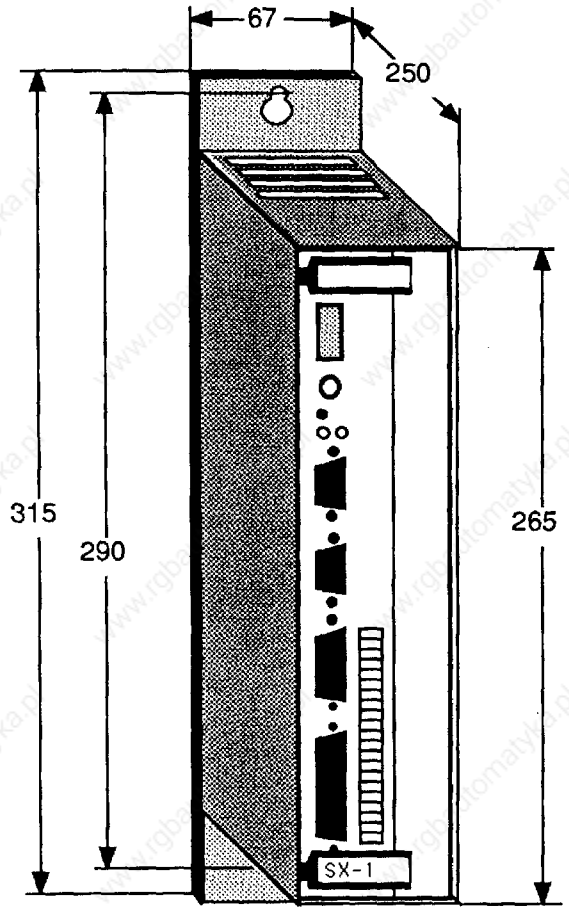
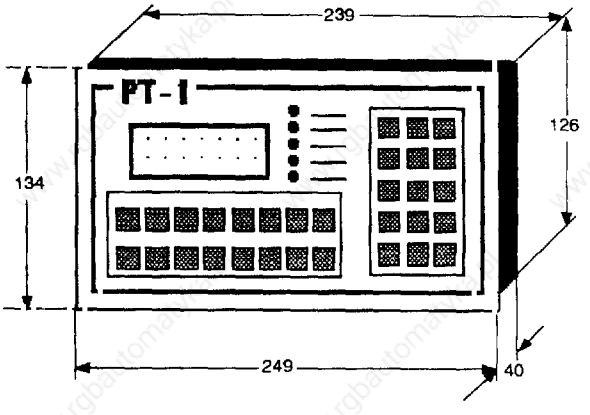
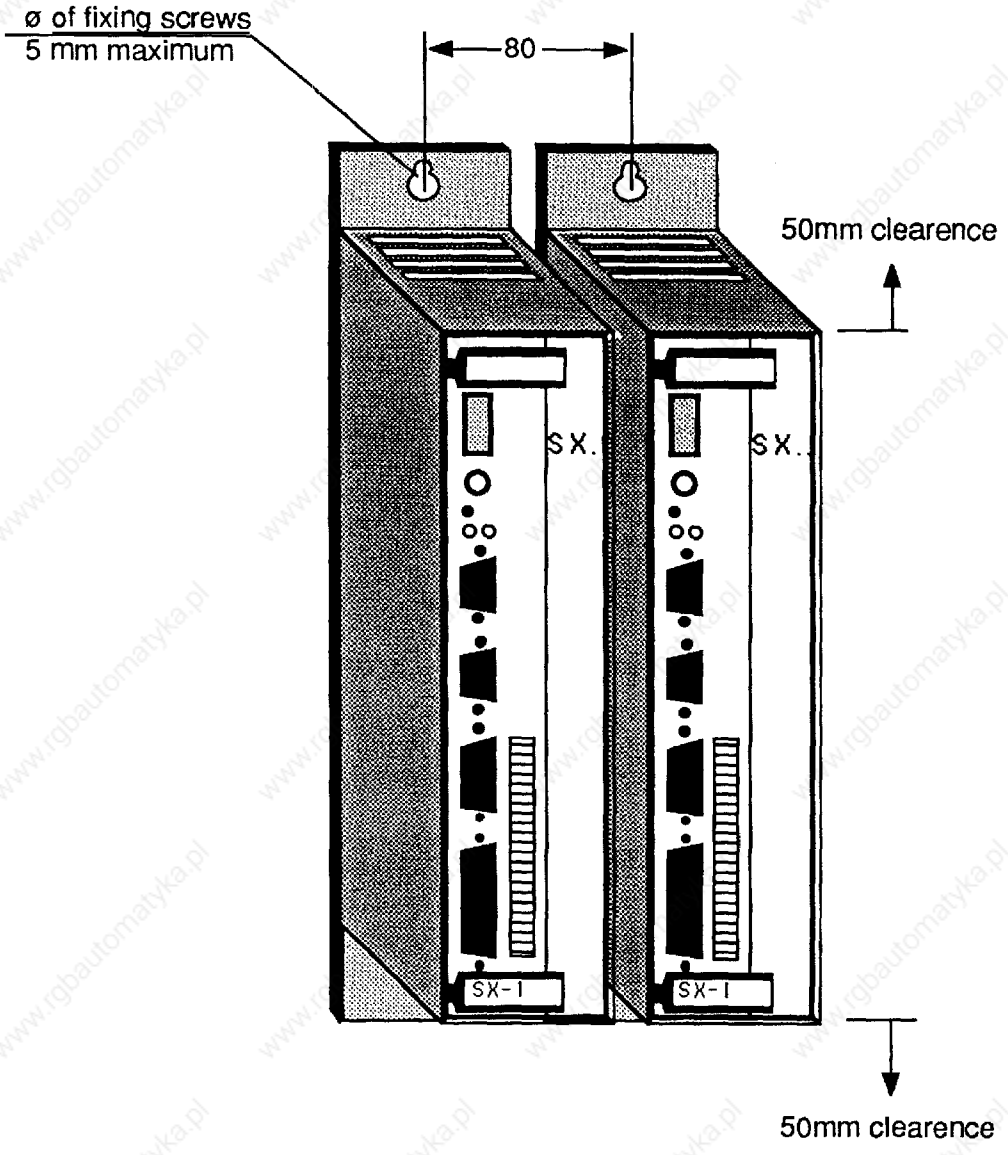
5. Installation
5.1 Dimensions, Mounting, and Ventilation





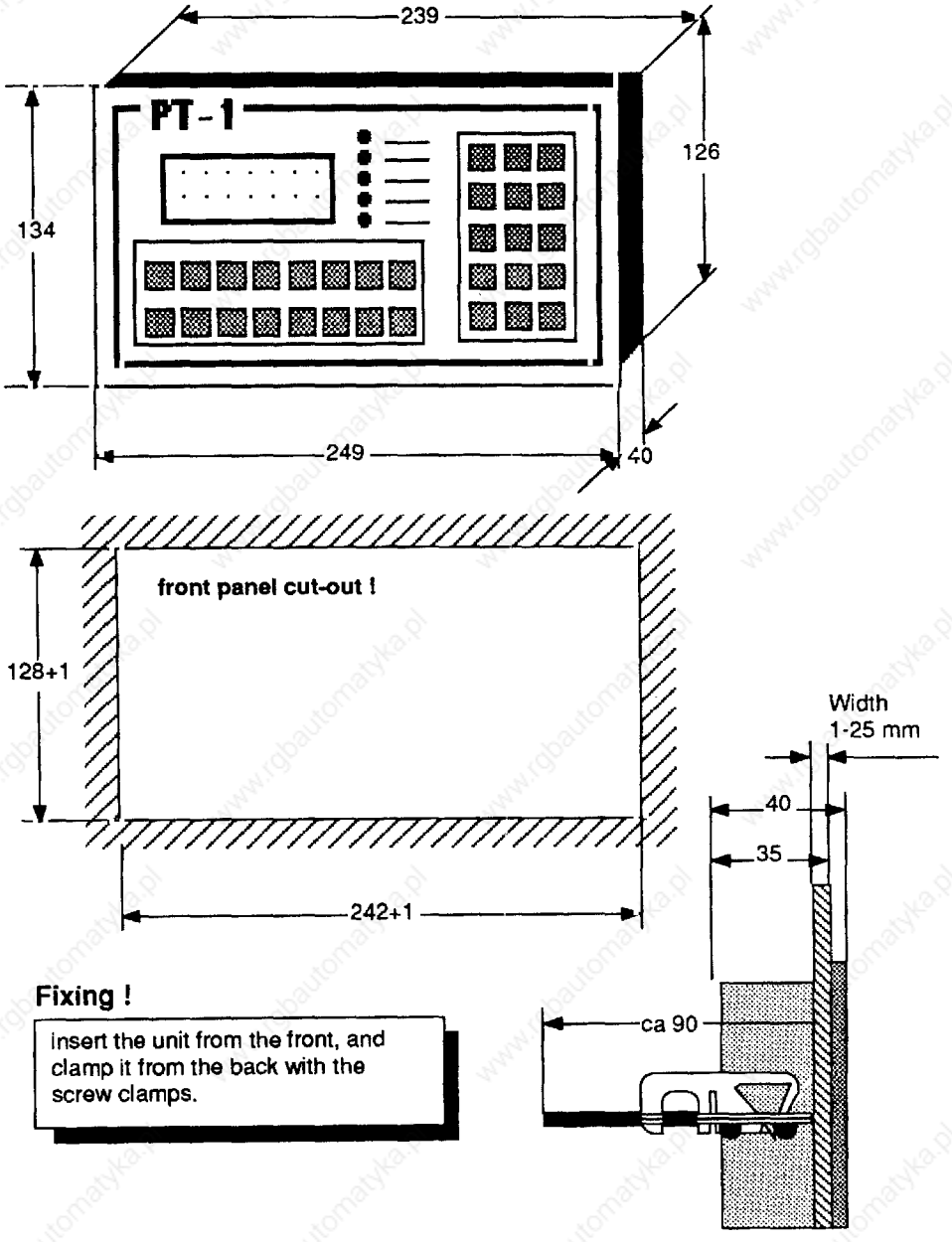
Attention!

When installing, ensure that the upper and lower ventilation louvres are not obstructed. A 50 mm clearance is required at the top and the bottom. Avoid penetration of dirt and dust.



Attention!

Avoud obstructing the upper and lower ventilation gratings. At the top and at the bottom there should be a minimum spacing of 50 mm. Between two control units SX-... there should be a minimum spacing of 10 mm /corresponding to a distance of 80 mm between the mounting screws.
Avoid penetration of dirt.



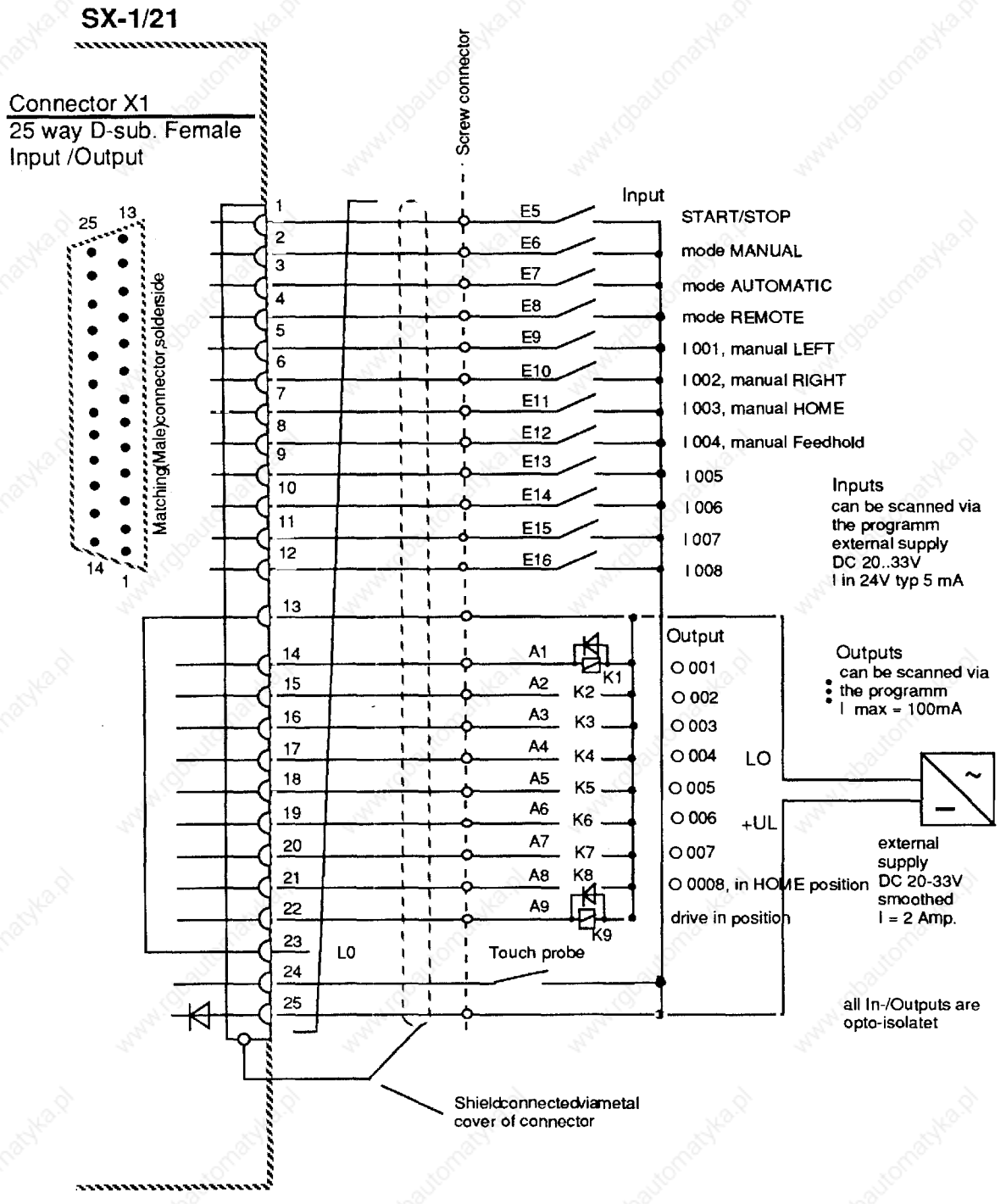
5.2 Power Supply Voltage

SX-1: The external supply is connected at the bottom of the board (AX-1) or the case (SX-1)

PT-1: The supply is normally derived from the SX-1 Axis Controller

5.3 Interface Connections

5.3.1 Parallel Connector X1 (Inputs/Outputs) V5.XX Functions for Software Version V5.XX



Setting the modes of operation
Softwareversion 5.XX

Parallel Connector X1

25 way D-Sub

Functions for Software Version 5.XX

pin 1	Input E5	Control and Function		
pin 2	Input E6			
pin 3	Input E7			
pin 4	Input E8			
pin 5	Input E9			
pin 6	Input E10			
pin 7	Input E11	Control	I 001	I 001 - I 004 are available for program operation when Auto-Remote is selected.
pin 8	Input E12		I 002	
			I 003	
			I 004	
pin 9	Input E13	I 005 - I 008 are free inputs, available for user-program use at all times.	I 005	
pin 10	Input E14		I 006	
pin 11	Input E15		I 007	
pin 12	Input E16		I 08	
pin 13	L 0 external			
pin 14	Output A1	Available for user-program use at all times.	O 001	
pin 15	Output A2		O 002	
pin 16	Output A3		O 003	
pin 17	Output A4		O 004	
pin 18	Output A5		O 005	
pin 19	Output A6		O 006	
pin 20	Output A7		O 007	
pin 21	Output A8		O 008	
pin 22	Drive in position (active low)			
pin 23	Not used			
pin 24	Touch probe Input			
pin 25	External DC Supply			

Explanation of Connections:

- Use inputs E05 - E12 (pins 1-8) to select mode and function (see Chapter 6.2) Inputs E09 to E12 may be used as I 001 - I 004 in the application program.

- Inputs E13 - E16 (pins 9-12) are used as I 005 to I 008 in the application program.

- Outputs A1 - A8 (pins 14-21) are used as O 001 to O 008 in the application program.

- Output O 008 can be selected to indicate "Reference Warning". For this function, set DIP Switch S3 Section 2 = off.

- Output O 007 can be set so that it is always activated if the difference between the Required and Actual position is within the in-position window.

- Pin 22 "$\overline{\text{Drive in Position}}$" (active low)
  This output is high when a position command is executed and the in-position window is not yet reached. It is still active when positioning is stopped by E05 or Analog Override = 0 V.

- Pin 23: Not used

- Pin 24: Touch Probe (TP) Input

- Pin 13 and pin 25: External power supply for isolated Inputs and Outputs (13 is 0 V; 25 is +24 V)

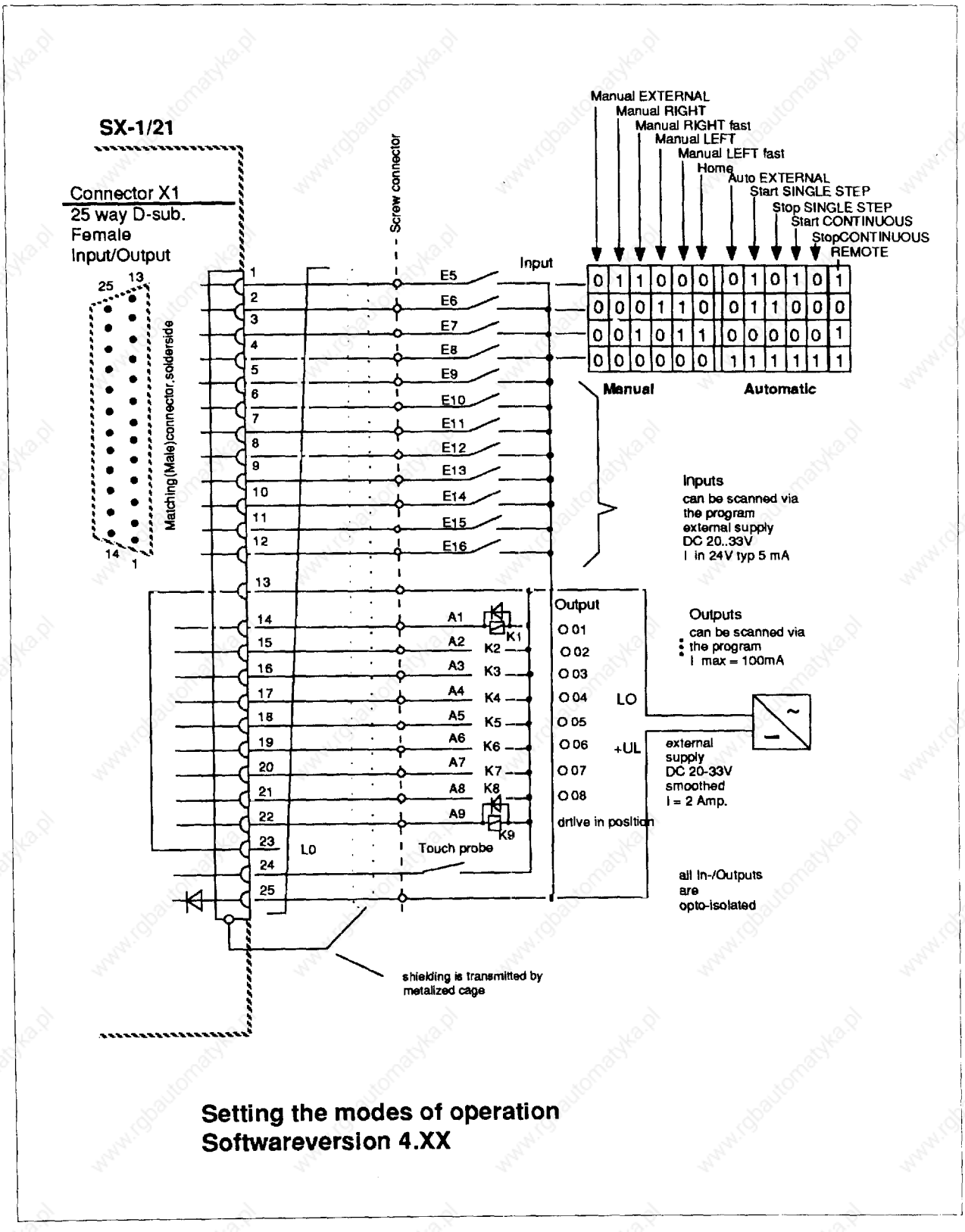
Additional Functions:
The outputs O 007 and O 008 can be used for system functions:

O 007 can be used for **"Drive in Position":** activated whenever the drive is within the position window.
Selected by DIP-Switch S3 Section 6 = off.

O 008 can be used for **"Reference Warning":** activated when the drive is "home".
When set, it can only be reset by faults E04, E05 and E07.
Selected by DIP-Switch S4 Section 2 = off.

WARNING!
When using these functions, the outputs O 007 and O 008 may not be used in the application program.

5.3.1 Parallel Connector X1 (Inputs/Outputs) V4.XX



Setting the modes of operation
Softwareversion 4.XX

Parallel Connector X1

25 way D-Sub

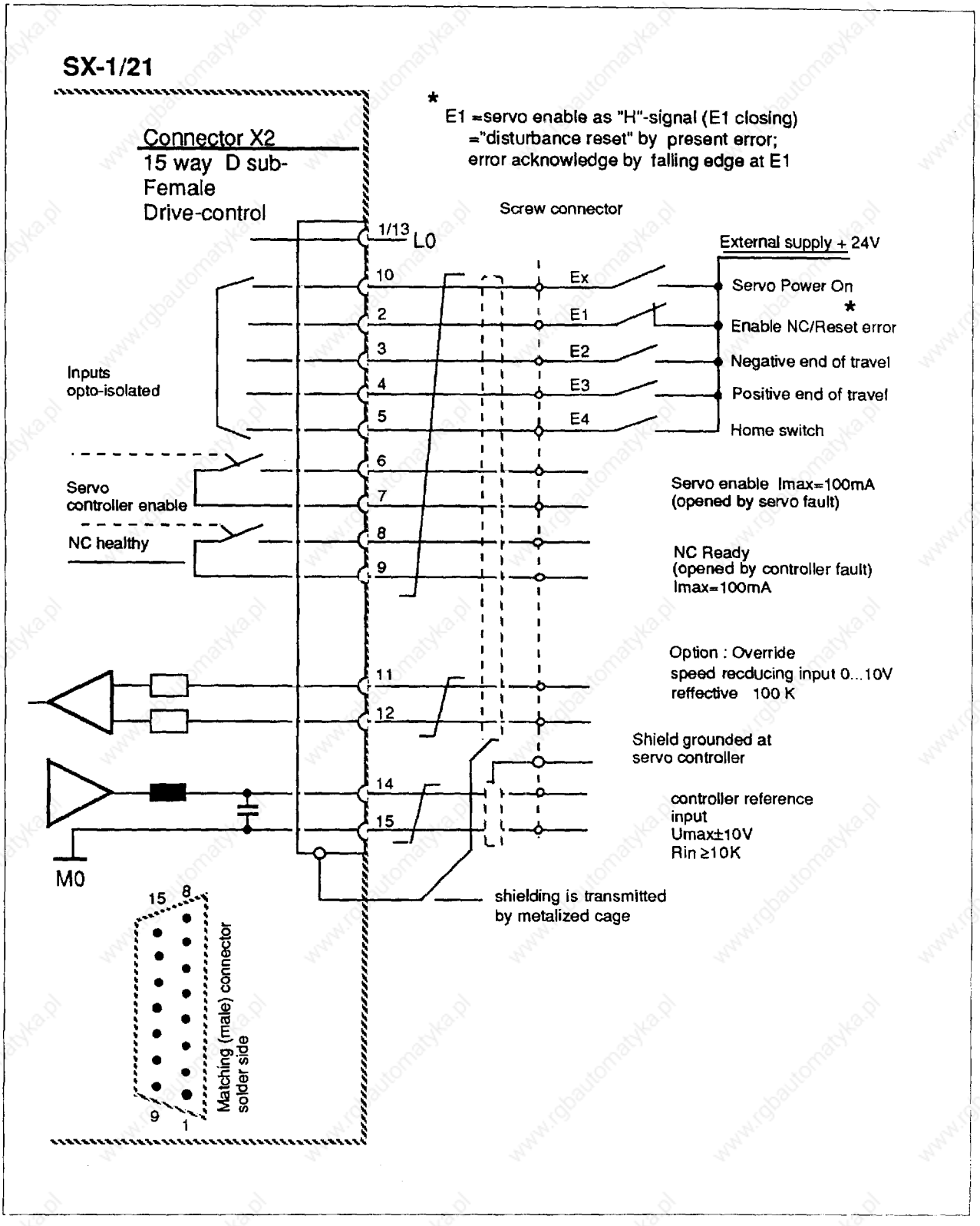
Functions for Software Version 4.XX

pin 1	Input E5	Control and Function	
pin 2	Input E6		
pin 3	Input E7		
pin 4	Input E8		
pin 5	Input E9	Available for user-program	I 001
pin 6	Input E10		I 002
pin 7	Input E11		I 003
pin 8	Input E12		I 004
pin 9	Input E13		I 005
pin 10	Input E14		I 006
pin 11	Input E15		I 007
pin 12	Input E16		I 008
pin 13	L 0 external		
pin 14	Output A1	Available for user-program	O 001
pin 15	Output A2		O 002
pin 16	Output A3		O 003
pin 17	Output A4		O 004
pin 18	Output A5		O 005
pin 19	Output A6		O 006
pin 20	Output A7		O 007
pin 21	Output A8		O 008
pin 22	Drive in position		
pin 23	not used		
pin 24	Touch probe Input		
pin 25	External supply		

Explanation of Connections:

- Use inputs E05 - E08 (pins 1-4) to select mode and function (see Chapter 6.2)
- Inputs E09 - E16 (pins 5-12) are used as I 001 to I 008 in the application program.
- Outputs A01 - A08 (pins 14-21) are used as O 001 to O 008 in the application program.

5.3.2 Drive Control Connector X2



Drive Control Connector X2

15 way D-sub

pin 1	0 V external supply (internally connected to pin 13)
pin 2	Enable NC (E1) and Error Reset
pin 3	End Switch - (E2): negative limit
pin 4	End Switch + (E3): positive limit
pin 5	Reference Switch (E4)
pin 6	Servo Enable Contact 1
pin 7	Servo Enable Contact 2
pin 8	Controller Ready Contact 1
pin 9	Controller Ready Contact 2
pin 10	Input "Servo Power On"*
pin 11	Analog Input 1
pin 12	Analog Input 2
pin 13	Not used
pin 14	Drive Reference +/-10 Volt
pin 15	Drive Reference signal ground

* Series 21 only

Explanation of Connections:

- Pin 2: **Control Enable and Fault Reset**
  The NC expects this input to be active (high). If not, the drive will not be enabled: Error E 03 reported. Error is cancelled by a positive edge on pin 2. Program execution is aborted when this contact is opened. The position loop is opened.

- Pin 3 - 4: **End of Travel Limit Switches**
  The software limit switches normally prevent driving on to these safety limit switches in error. In Manual modes, you can drive off the switch on the opposite direction. In Auto modes, the program is aborted and an error message displayed.

- Pin 5: **Reference (Home) Switch**
  The point of origin for distance measurement is approximately defined by this switch. Used with a zero position marker from the Encoder, the precise Zero Position can then be defined.

- Pin 6-7: **Servo Enable Contact**
  This contact can be opened or closed to enable the servo. It is operated by the SX-1 when there is an Enable input (pin 2) and a positive result for internal checks. If there is a fault concerning the operation of the position loop (enable fault, Encoder error), then this output is cancelled.

- Pin 8-9: **Ready/Disturbance Contact**
  This contact is closed when no fault (e. g. error EXX) is present.

• Pin 10: **Servo Power On**
When the input is active, the Controller is enabled and the Reference signal is activated at zero until movement takes place. When the input is not active, the control automatically terminates the movement.

Input - Servo Power ON

The input at X2 pin 10 is used for instant interruption of the program and movement.
When **open:**

- The Reference is zeroed instantly (Actual = Required Position)
- Servo Enable and Ready Outputs are opened
- Error E06 (power loss) is reported
- The following error monitor is cancelled

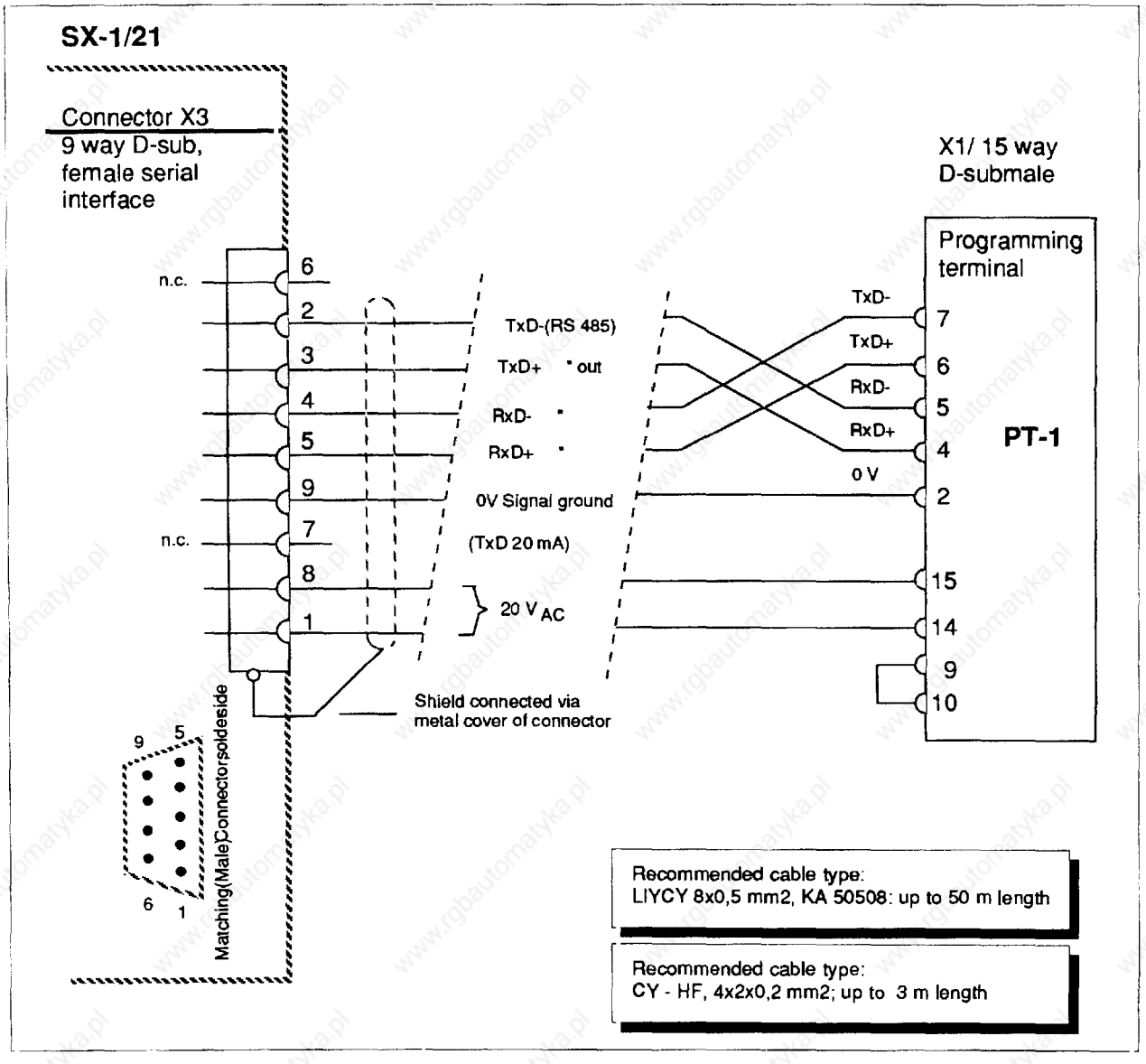
When **closed:**

- E06 is cancelled
- Servo Enable and Ready Outputs are restored
- An interrupted program is restarted with a positive edge on E5
- An interrupted automatic movement is completed
- An interrupted manual movement must be restarted with the key

5.3.3 Serial Interface X3 (PT-1 Connection)

9 pin D-sub, Female

pin 1	Power Supply to PT-1
pin 2	TXD - (RS 485, RS 422)
pin 3	TXD + (RS 485, RS 422)
pin 4	RXD - (RS 485, RS 422)
pin 5	RXD + (RS 485, RS 422)
pin 6	Not used
pin 7	Not used
pin 8	Power Supply to PT-1
pin 9	Signal Ground (RS 485, RS 422)

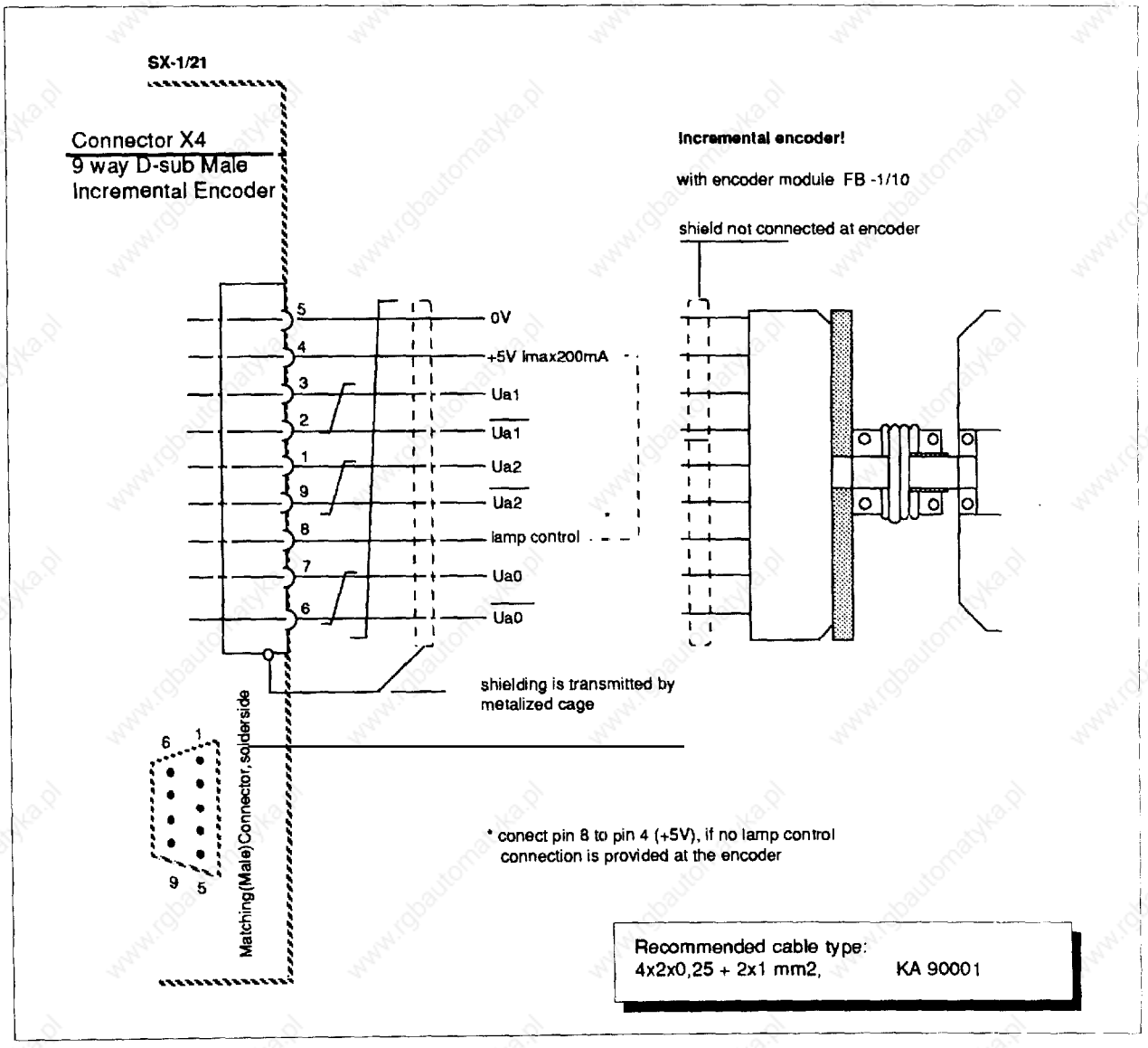


5.3.4 Incremental Encoder Connection X4

9 pin D-Sub, Male (Encoder Module FB-1)

pin 1	$\overline{UA2}$
pin 2	$\overline{UA1}$
pin 3	UA1
pin 4	+5 V supply
pin 5	0 V supply
pin 6	$\overline{UA0}$
pin 7	UA0
pin 8	Lamp Control *
pin 9	$\overline{UA2}$

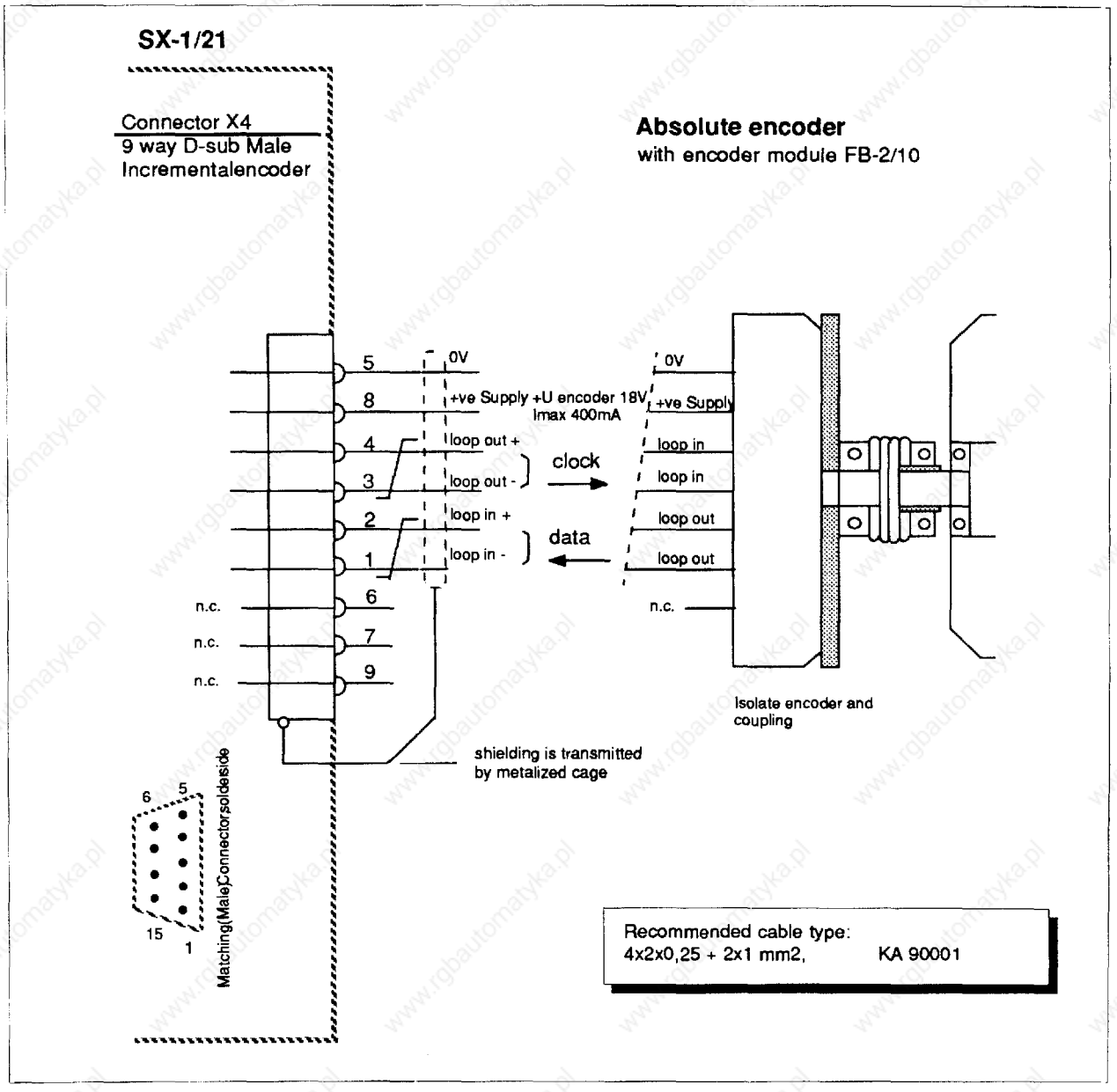
* Connect pin 8 to pin 4 if no "Lamp Control" connection is provided at the encoder.



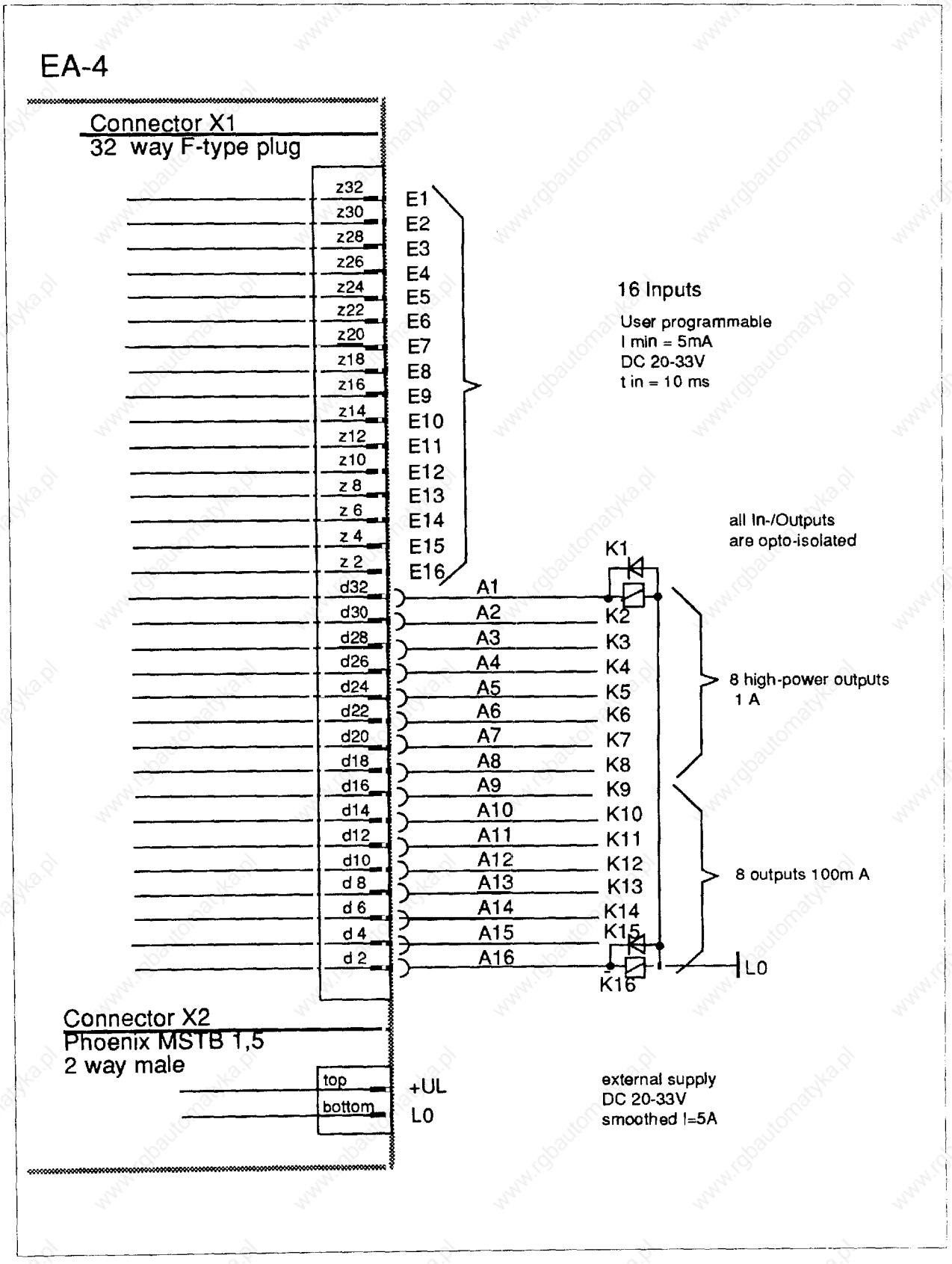
5.3.4 Absolute Encoder Connection X4

9 pin D-sub, Male (Encoder Module FB-2)

pin 1	loop in -
pin 2	loop in +
pin 3	loop out -
pin 4	loop out +
pin 5	0 V Supply
pin 6	not used
pin 7	not used
pin 8	+ U Supply
pin 9	not used

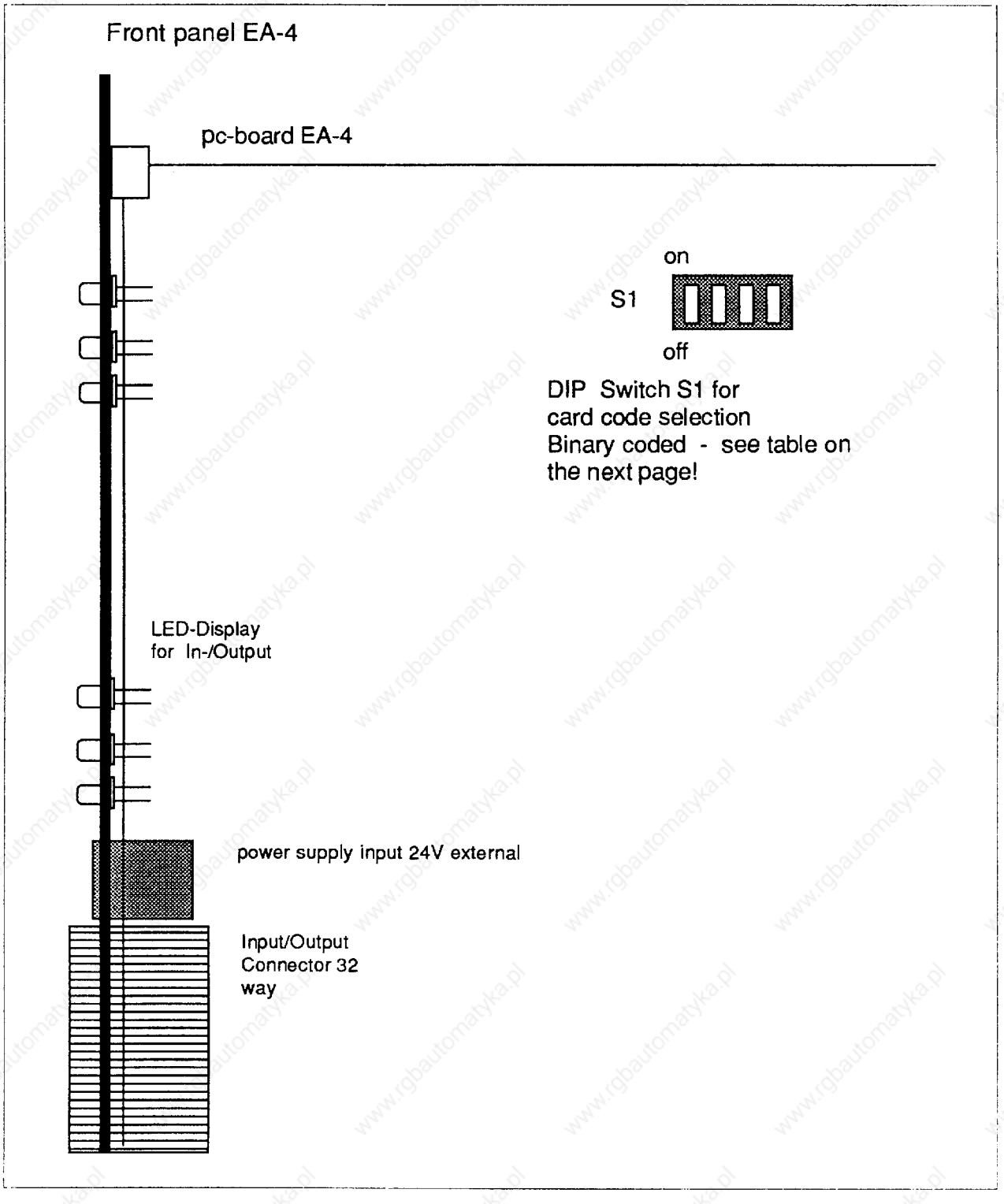


Parallel Interface
5.3.4/1 Option: I/O Expansion EA-4



Option: I/O Expansion EA-4

DIP Switch for I/O Card Coding



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Description of EA-4

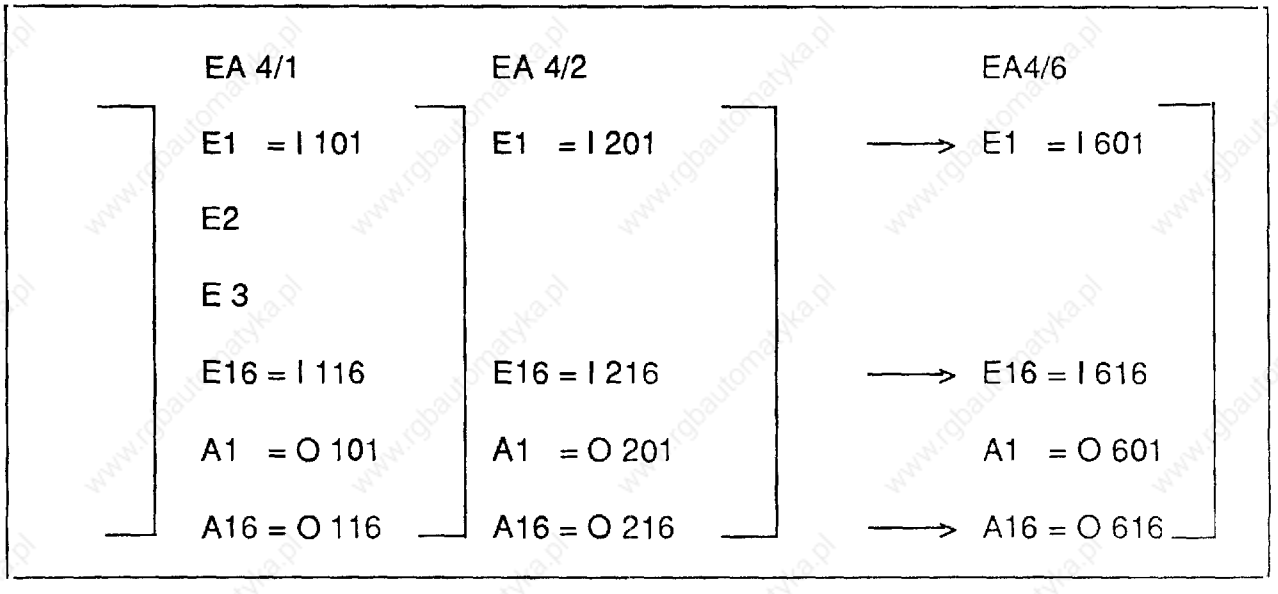
Up to 6 EA-4 cards (maximum of 96 Inputs; 96 Outputs) can be used in an application program using the ECL programming language with one Position Controller. The EA-4 cards used are addressed according to the settings of DIP switch S1.

SW 4	3	2	1	EA-4 Number
on	on	on	on	1
on	on	on	off	2
on	on	off	on	3
on	on	off	off	4
on	off	on	on	5
on	off	on	off	6

In the application program the inputs and outputs are divided into module groups and addressed as follows:

Group 0 are SX-1 I/O (I 001 - I 008, O 001 - O008)

Group 1 are first EA-4 I/O (I 101 - I 116, O 101 - O 116)
Group 2 are second EA-4 I/O (I 201 - I 216, O 201 - O 216) etc.



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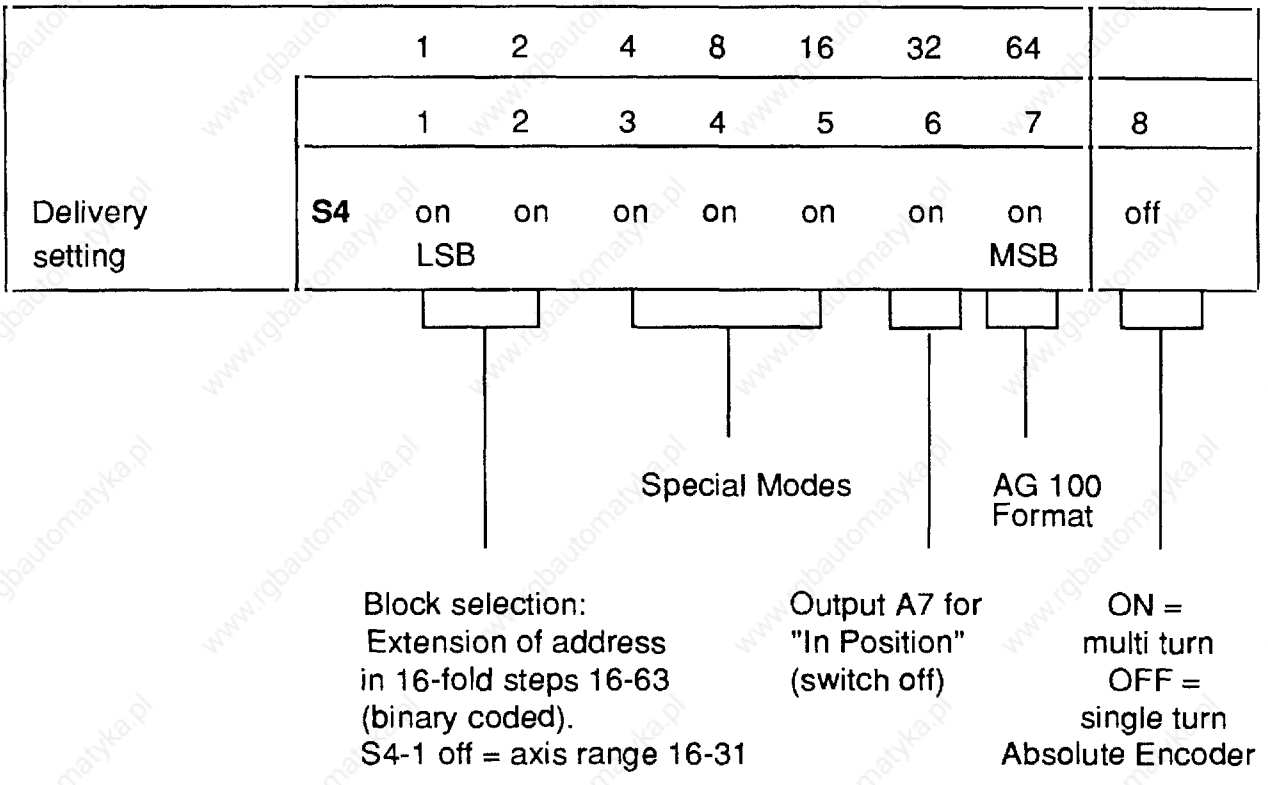
5.3.5 SX-1 Internal Adjustments

The SX-1 may be adapted for various operating conditions by internal coding switches and jumpers (links). For the location of the switches and jumpers on the card, see the diagram at the end of this section (page 5/22).

On Front Panel:

• Switch S2: Axis Number Selection for Normal Operation (Standard). The switch is below the Status Display LED: with it, you can select numbers in the range 0 - 15. The axis Address is internal and is valid for the serial link X3.
S3 Section 4 = ON

On the Motherboard:



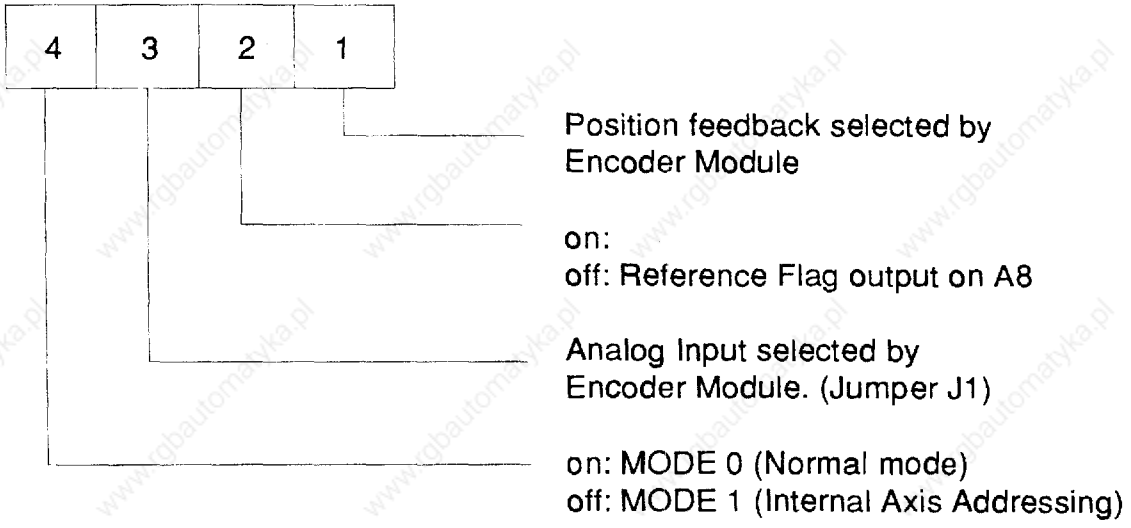
Special Modes for Internal Addressing:

When interpolating, only addresses 0 - 3 are permitted, but since several interpolation groups may be connected to a serial communications link, the following options are provided:

S3 section 4 = OFF
The Interpolation address is selected on the Front Panel (address 0-3), and the Serial Communications Link address with S4 sections 1-5 (address 0-31).

• Switch S3 Configuration

Selection of principal modes and hardware configuration.



Delivery state					
	4	3	2	1	
S3	on	X	on	X	

• Jumpers for selecting the Baudrate:

Jumper		
	J 2	19200 bd
	J 3	9600 bd
	J 4	4800 bd
	J 5	2400 bd
	J 6	1200 bd

Delivery state: J3 installed.

• Selection of multiplication for the Incremental Encoder

At the Encoder module, the pulse count may be multiplied by one, two or four. This is selected by J1, J2 and J3 on the Encoder module.

	J1	J2	J3
*4	open	Jumper	open
*2	open	open	Jumper
*1	open	Jumper	Jumper
Delivery state:	open	Jumper	open

Drive Enable and NC Ready

The outputs for Drive Enable and NC Ready may be set for active high and active low. This may be altered on the SX-1 card by Jumpers J9, J10 and J11, J12.

• Selection for Drive Enable

	J10	J9
Drive Enable active "L"	Jumper	open
Drive Enable active "H"	open	Jumper
Delivery state active "high"	open	Jumper

• Selection for NC Ready

	J12	J11
NC Ready active "L"	Jumper	open
NC Ready active "H"	open	Jumper
Delivery state active "high"	open	Jumper

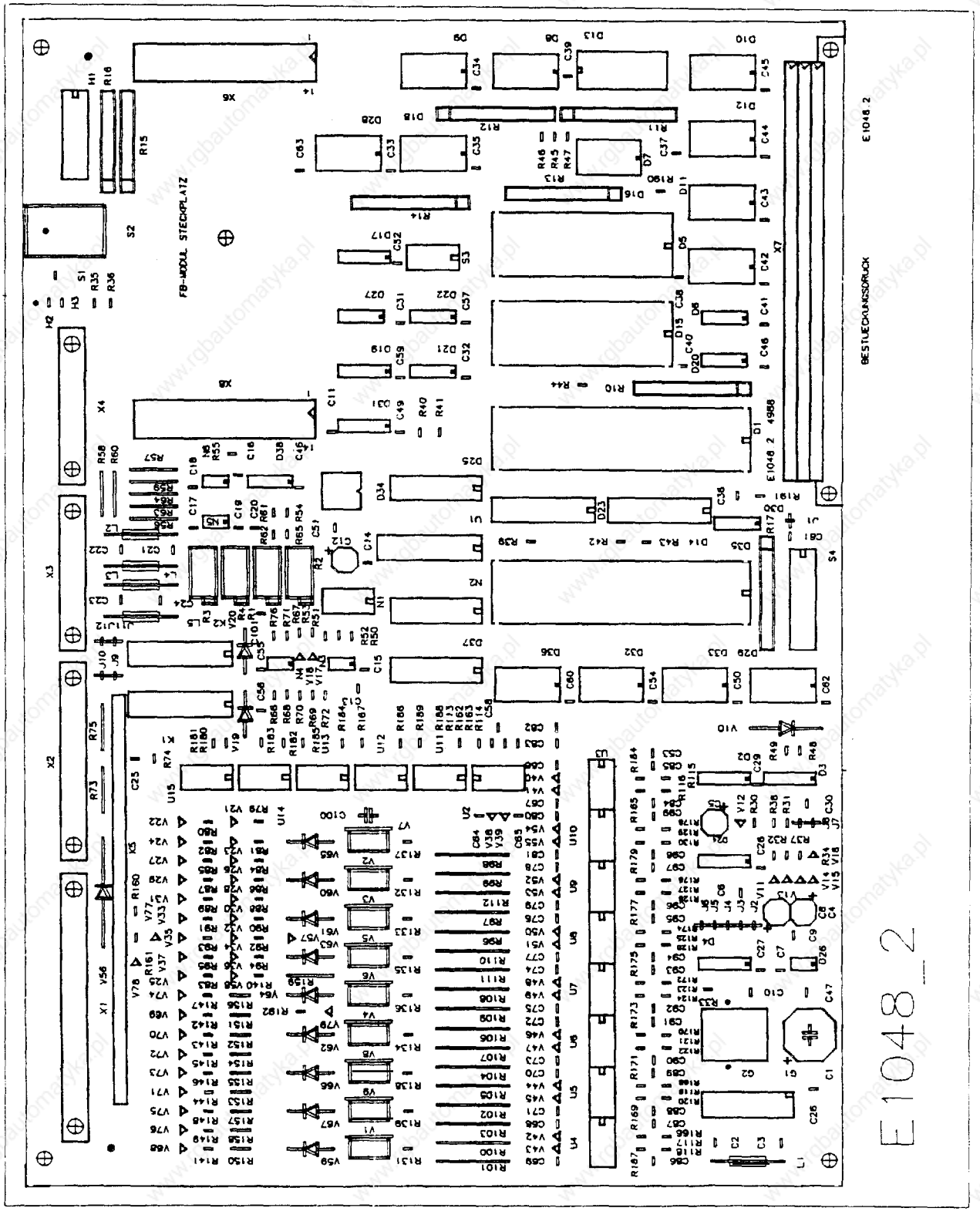
Selection of other Jumpers

Warning!

The following jumpers must not be disturbed. Their setting is given only to allow checking and correction of unintentional change. If they are changed, then normally the controller will not function.

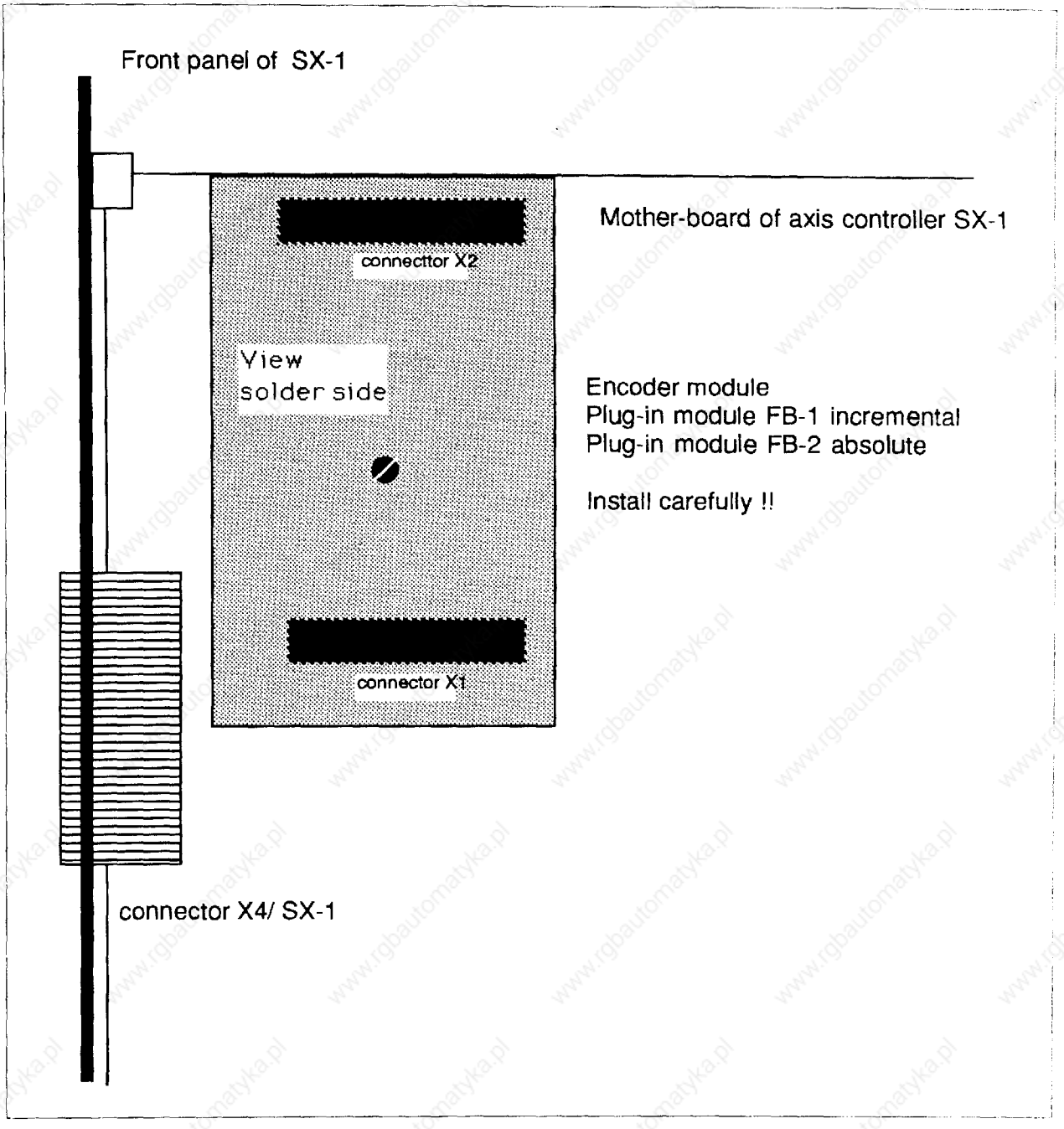
J1	External System Clock	Jumper - standard (open - from Slave axis)
J8	Watchdog	Jumper
J7	External Reset	open

· Axis Controller Module SX-1/21



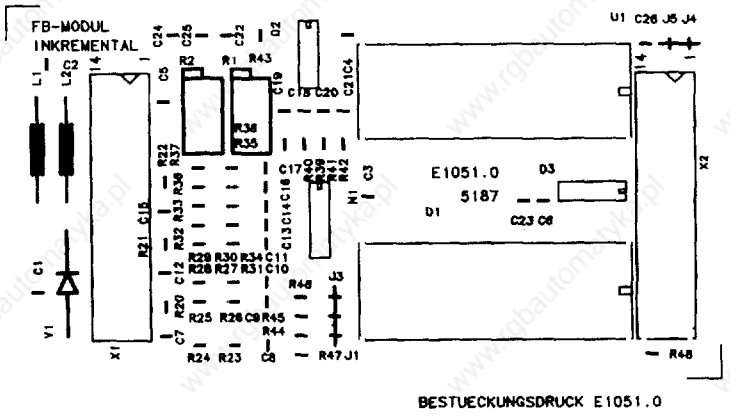
• Axis Controller Module SX-1/21

Installation



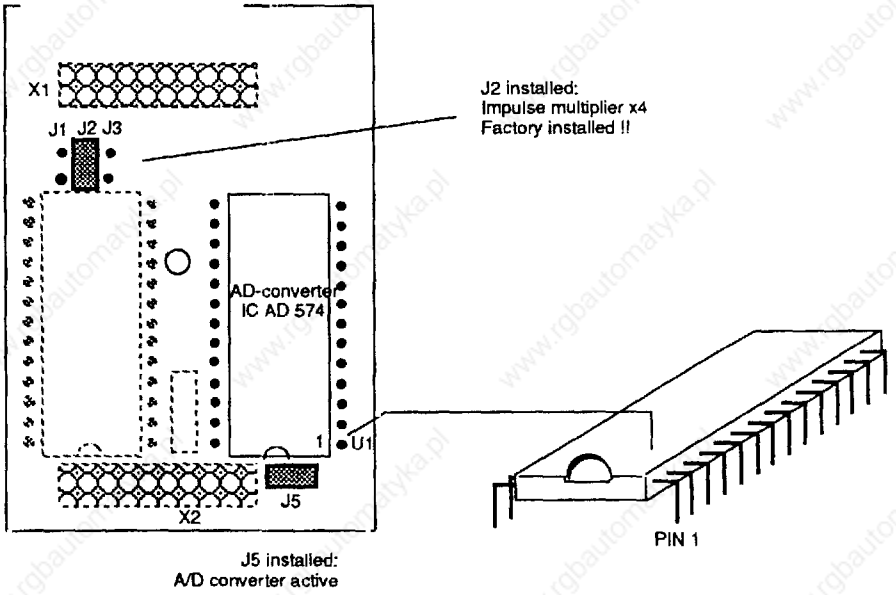
• Encoder Module FB-1 (Incremental)

Component Layout



Encoder module FB1/FB2

FB-1, incremental
feedback module



Warning !

A/D converter IC AD 574 must be installed with pin 1 of IC in pin 1 of the socket (see drawing)

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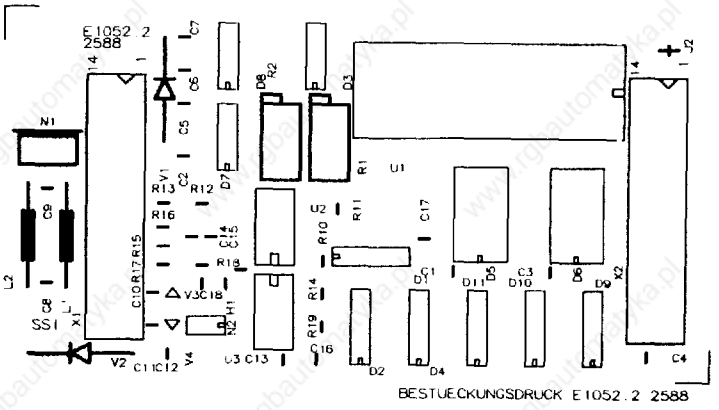
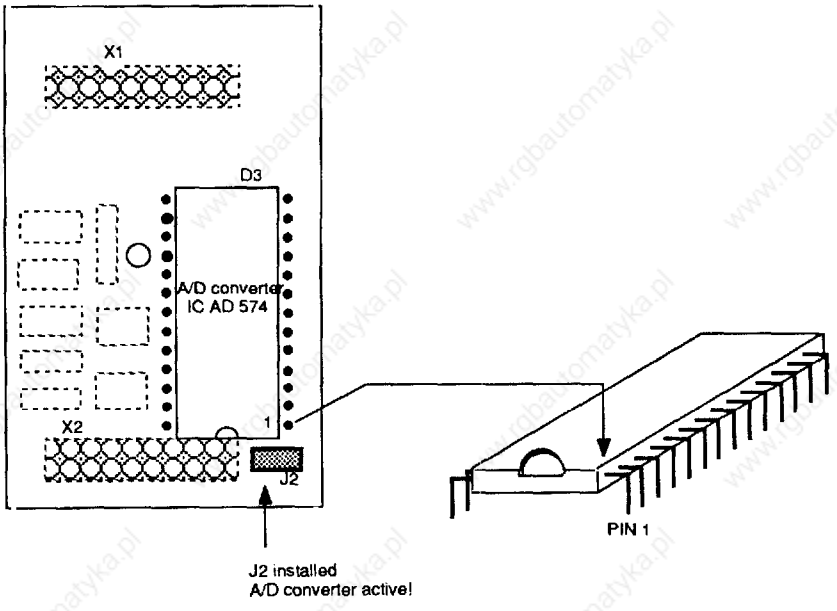
· Encoder Module FB-2 (Absolute)

Component Layout



Plug-in module for FB2

FB-2, absolute
feedback module



Warning !

A/D converter IC AD 574 must be installed with pin 1 of IC on pin 1 of the socket (see drawing)

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5.4 Protective Measures and Interference (Noise) Avoidance

All Inputs and Outputs of the SX-1 (excepting the Analog Input and Output) are isolated from the internal bus. For added security, you must take the following precautions:

5.4.1 Encoder Cable

The cable should be in shielded and twisted pairs for each channel, and of sufficient cross section to avoid voltage drops. Maximum length is 50 m.
The encoder should ideally be installed electrically isolated from the machine, so that the shields can be connected to both the SX-1 and the Encoder case. With non-isolated Encoder mounting, connect the shields only at the SX-1 end.
Use only the cables recommended by the supplier.

5.4.2 Inputs and Outputs

A common shield should be provided for all inputs and outputs, the shield being grounded at one end only.

5.4.3 Analog Output (Reference Signal) and Analog Input (Override)

These should be connected by shielded cable to the drive control.

5.4.4 Main Power Supply

AC 110/220 Volt +10 % -15 %; 50/60 Hz; max. 30 VA.
Supplies with heavy interference must be externally filtered, for example using an isolating transformer and/or voltage stabilizer.

5.4.5 External 24 V DC Supply

This supply has no special requirements such as stabilization: however, it should incorporate a suitable filter capacitor. The voltage must not drop below 20 V or rise above 33 V. High frequency noise should be avoided.

5.4.6 General Rules

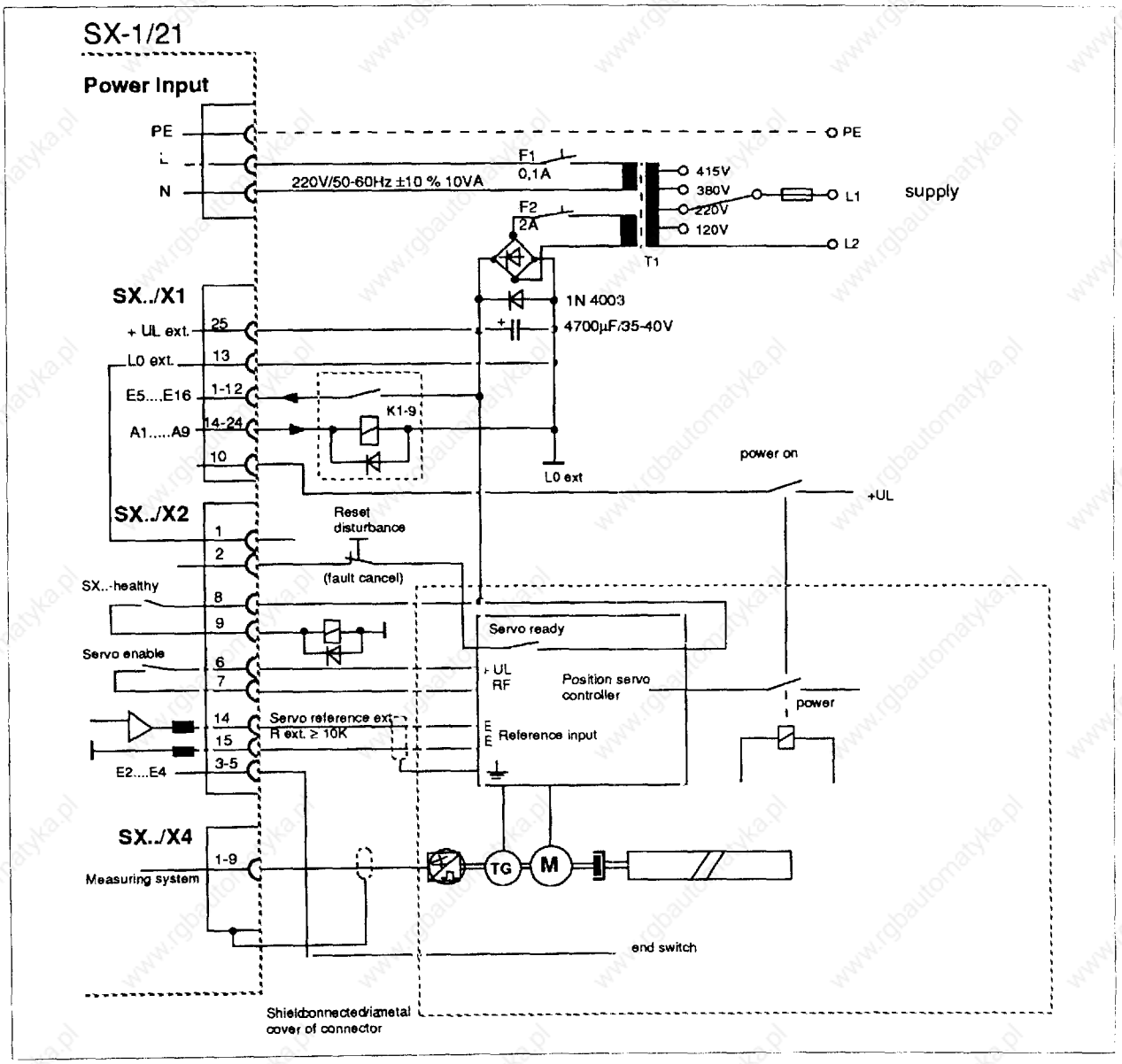
Inductive loads, such as the coils of relays, contactors and solenoid valves, should be suppressed using fast-recovery diodes or RC filters.

Pay attention to slowly-opening contacts in thermostat valves.

5.5 Interconnection of SX-1 and Servodrive (Suggested)

Before interconnecting the SX-1 and the Servodrive, you must consider the following items:

- The servo drive should be selected to suit the load.
- The Emergency Stop circuit should be checked for correct operation.
- The a.c. supply to the SX-1 should be of the correct voltage and frequency, and within tolerance.
- The d.c. supply for the Inputs and Outputs should be of the correct voltage, polarity and within tolerance.



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6. Startup Procedure
6.1 Startup Structure

After completion of the mounting and interconnection of the SX-1 with the servo controller, and carefully checking out the connections, the SX-1 may be put into operation. The startup procedure is in three parts:

1. Setting Parameters
The SX-1 control is adjusted to suit the servo drive, axis position control units, and the position feedback, by means of Parameters. These include maximum speed, distance units, acceleration, positioning accuracy, etc (See Chapter 7).

2. Programming
By the program, it is possible to determine the logic conditions, the timing and the motion control of the application that the SX-1 is required to control (See Chapter 8).

Parameter Setting means: to adjust the mode of movement according to physical conditions.

Programming means: to adjust the time and distance of movement, and perhaps also to adjust the mode of movement.

The separation of Parameter setting and Programming offers great system flexibility. For example, the Parameters may be set by the machine builder, whilst the Program is set by its user. Also, the SX-1 can save several user programs at one time, e.g. to allow the handling of different parts or operations.

The entry of Parameters and Programs is performed with the PT-1 terminal. This is therefore connected via the interface connector X3 of the SX-1 (See Chapter 3.1.1). It is also possible to operate the PT-1 off-line, since it has an internal non-volatile program memory.

Alternatively to using the PT-1, you can use the EPAS software for IBM or Siemens PG-675/685.

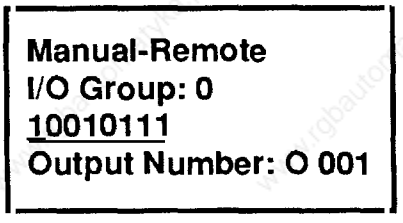
3. Debugging
After successfully entering Parameters and Programs, it may be necessary to find and remove faults or "bugs". The LCD display of the PT-1, or the 7-segment-display of the SX-1, are very helpful for diagnosis (See Chapter10). The PT-1 fault display is only operative in Manual or Automatic modes (i. e. not in Parameter or Programming modes).

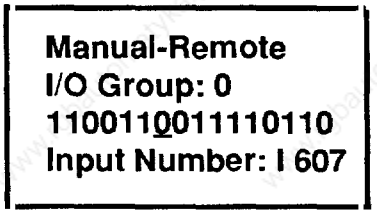
6.1.1 Diagnostic Methods

The **ACTUAL POSITION** and the **FOLLOWING ERROR** can be displayed on the PT-1. In the "Automatic Continuous" mode use the TEACH key to select.

Input/Output Test mode:
(Only for Software Version 5.XX)

In the remote control mode (e. g. from PT-1), it is possible to test the input conditions, and to set the outputs, provided that the "key" code number has been given. This function is obtained from the **INS/SET** key on the PT-1.
On the PT-1 display, the number of the I/O group will appear on the second line.
In the third line, the logic state of the Input or Output groups are shown with "0" or "1".
In the last line of the display you can see the I/O at the cursor position.





In the left-hand display, the SX-1 outputs O 001 to O 008 are shown. The cursor is on the first position - O 001. The Inputs to the SX-1 are shown in the sequence I 1, I 2, I 3, I 4, I 5, I 6, I 7, I 8, E 1, E 2, E 3, E 4, E 5, E 6, E 7, E 8.
In the right-hand display, the inputs I 601 to I 616 of an I/O Extension card with Group number 6 (= 6. EA-4) are shown. The cursor is on the 7th position - I 607.

Selecting Inputs and Outputs:
After selecting the test function, you may shift between Inputs and Outputs. Enter and leave this function as required with the **INS/SET** key.
The **Mode** key selects the I/O Group.
The **"arrow" keys** select Inputs or Outputs. The cursor position is indicated by the flashing "underline", with the related I/O number shown in the fourth line.
In the Manual-Remote mode, the outputs may be set (press the **"1"** key) and reset (press the **"0"** key).

NOTE:
When leaving this mode, all Outputs are reset to zero (off).

6.1.2 Test Mode Operation

The test mode is provided for use during commissioning and for servicing and trouble-shooting. The operating mode is pre-selected by Parameter P24 = 0, but this is not operable until after the control is reset.

NOTE:
After the test session, then P24 must be set to a non-zero value.

In the servo test mode, the direct speed (velocity) reference signal is given to the servo.

All modes can be used.

All ECL program instructions may be used, with the exception of Touch Probe and "Actual Position" instructions.

NOTE:
There is no monitoring of the Actual Position and Software Limits in this mode.

The internal Commanded Position is indicated as the Actual Position.

NOTE!
The Position Loop is not active in the Test mode.
A servo-controlled stop cannot be guaranteed in this mode (switch the brake).

6.2 Modes of Operation - Software Version 5.XX

Operating Mode selection and Function with Software Version 5.XX

1. External Remote

Control is from the PT-1 or EPAS, using the serial communication link. The Manual, Home, Automatic and Continuous modes are available.

This mode is selected by input E8. SX-1 displays "d" on the 7-segment display. Input E5 starts and stops the movement of the axis: E5 = High continues the program, and E5 = Low interrupts the program.

IMPORTANT:
With Remote control, there is no supervision of the communications link: security functions must be performed with inputs E1 and E5.

2. Manual External

In this mode, the drive may be moved continuously in either direction. The speed is preset using Parameter P 08 "Manual-Slow". This mode is selected by input E6. SX-1 displays "H". Movement in negative direction is selected by E 09 = high (axis report "-") and in positive direction by E 10 = high (axis report "-|").

Homing is initiated by E 11 (axis report "r"). When the reference switch, input E 4, is active high, axis report "π" is shown, and when the reference pulse is received, axis report zero "0" is shown.
To enable all functions, input E 05 must be active (high).

3. Automatic External

In this mode, it is possible to initiate automatic operation of a sequence using the I/O controls. The Number of the program is preselected by Parameter P0.
This mode is selected by E 7. SX-1 displays "A".
The program is started and interrupted by input E 5.

In the automatic mode, the inputs E 9, E 10 and E 11 are available as I 001, I 002 and I 003 for the application program.

Mode Selection Inputs

Software V 5.XX

Mode	E5	E6	E7	E8	E9	E10	E11	E12
Manual	1	1	0	0	0	0	0	
Jog negative direction	1	1	0	0	1	0	0	
Jog positive direction	1	1	0	0	0	1	0	
Home (Reference)	1	1	0	0	0	0	1	
Go to Zero	1	1	0	0	0	0	0	1
Automatic (Stop)	0	0	1	0	0	0	0	
Automatic (Start)	1	0	1	0	0	0	0	
Remote	1	0	0	1	0	0	0	

If more than one operation mode is selected at one time, an error E12 (Mode Double-Selected) is shown on SX-1.
Input E5 is read dynamically for Start function, and statically for the supervisory function. All movement are interrupted by opening E5 and resumed by closing E5.
A change of mode is not valid until E5 is active.

6.2 Modes of Operation - Software Version 4.XX

(For a general description of operation, see Chpt. 4)
You must state that Software Version 4.XX is required when ordering.

Operating Modes

1. **Remote:**
   Selection of Manual-Remote or Automatic-Remote from the PT-1 terminal.
2. **External:**
   Selection of Manual-External or Automatic-External Mode via inputs E5 to E8.

Selecting Operating Mode

Select Automatic and Remote modes in the order **E8, E7, E6, E5;** and you must select manual modes in the order **E5, E6, E7, E8,** otherwise there will be malfunction!
To de-select a mode, use the reverse order.
The following chart shows the state of input signals E5-E8 and the modes selected:

Mode	E 5	E 6	E 7	E 8	Display of SX-1
Manual External	0	0	0	0	
Jog Right	↑ 1	0	0	0	—
Jog Right, Fast	↑ 1	0	1	0	— H
Jog Left	0	↑ 1	0	0	⊣
Jog Left, Fast	0	↑ 1	1	0	⊣
Home	0	0	1[b]	0	**r n O**
Automatic External	0	0	0	1	
Start Single Step (0 —> 1)	↑ 1[a]	1	0	1	
Stop Single Step	0	1	0	1	**A**
Start Continuous	↑ 1[a]	0	0	1	
Stop Continuous	0	0	0	1	
Remote Control	1[c]	0	1	1	**d**

a) Input E5 is read dynamically for the "start" function, and statically for the supervisory function.
b) Homing is initiated by the 0-1 edge at E7, and E7 is monitored statically during the homing cycle.
c) Input E5 is monitored statically as the supervisory function.

Notes - Remote Mode

Program execution is monitored using input E5:
program execution is interrupted if this contact is opened; movement is stopped at maximum deceleration. When E5 is re-activated, the remaining distance is first travelled, and then program execution is continued.

Notes - Manual External - Software V 4..00

In this mode, you may move the axis in either direction and to the Home position (with inputs E5-E8). For each direction there is one input: E5 controls movement to the right, and E6 to the left. With the additional input E7, you may obtain the Fast speed.

NOTE:
To finish Fast movements, open E7 first, or you will start a "Home" sequence.

Notes - Automatic External - Software 4.00

Automatic -Single Step - SS

The signal on E5 is read dynamically and statically, i. e. the instruction is initiated on the rising edge.

Automatic - Continuous - FS

The program is started when the input E5 is activated, and stopped when the signal is removed. Positioning movements are stopped at 100 % deceleration. When the input is re-activated, firstly the remainder of the positioning instruction is executed using program data, and then the remaining instructions are carried out.
Selection of manual mode causes the program to be re-started from the beginning when re-starting in the automatic mode.

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7. Parameters

7.1 Parameters and their meaning

7.1.1 The Parameters at a glance

Axis Parameter

Number of Parameter	Name of Parameter	Meaning
P 0	Pgm	Program Number
P 1	Resol	Resolution 1.000 to 9999.999 Increments/Unit
P 2	IPR	Increments per Revolution 1...10,000
P 3	Vo/Vm	Analog Voltage to Speed Ratio
P 4	Tscan	Scanning rate 3 to 30 ms
P 5	Max V	Maximum speed 0.1 to 6,000.0 Units /s
P 6	Max A	Max. acceleration 1 to 60,000 Units/s^2
P 7	MAN S	Manual slow jog speed ≤ max. V
P 8	MAN F	Manual fast jog speed ≤ max. V
P 9	Lim -	Software Limit negative 0...-99999.999 Units
P 10	Lim +	Software Limit positive 0...+99999.999 Units
P 11	Offset	Zero offset 0...±99999.999 Units
P 12	Ssign	Sign of Analog Servo Output
P 13	Esign	Sign of Position Feedback
P 14	Tool +	Backlash correction, positive 0...99999.999 u.
P 15	Tool -	Backlash correction, negative 0...99999.999 u.

Servo Parameters

Number of Parameter	Name of Parameter	Meaning
P 16	KV0	KV0, range 0.1 to 25.0 KV
P 17	KV1	KV1, range ≤ KV0
P 18	KV2	KV2, range ≤ KV1
P 19	KP1	KP1, switch point output for KV1, 0.1 to 9.9 V
P 20	KP2	KP2, switch point output for KV2, ≥ KP1
P 21	Schl F	Following Error Tolerance 12.5 % / 25 % / 50 % / 100 % / 200 % / 500 %
P 22	Pos F	In-Position Window 1 to 30,000 increments
P 23	I-Fkt	Integration Factor
P 24	Mode	Mode of Operation: Normal ≠ 0, Test = 0

For details of Parameter Limits, see Chapter 7.4

Control Parameters

Number of Par.	Name of Par.	Meaning
P 25	Hom M	Homing Mode 0 ... 5
P 26	Hom V	Homing Velocity: 0.1 to 6000.0 units per sec.
P 27	Hom N	Homing necessary for position control YES/NO?
P 28	Ramp	Acceleration Characteristic LIN/SIN²
P 29	Endl	Relative or Absolute positioning REL/ABS
P 30	END-M	Limit Switch mode - (0 = closing; 1 = opening)
P 31	Vsend	Variable Transmission Mode
P 32	Umdre	Units per revolution for direct positioning)
		*) sin² stands for quadratic velocity change

Declaration of variables

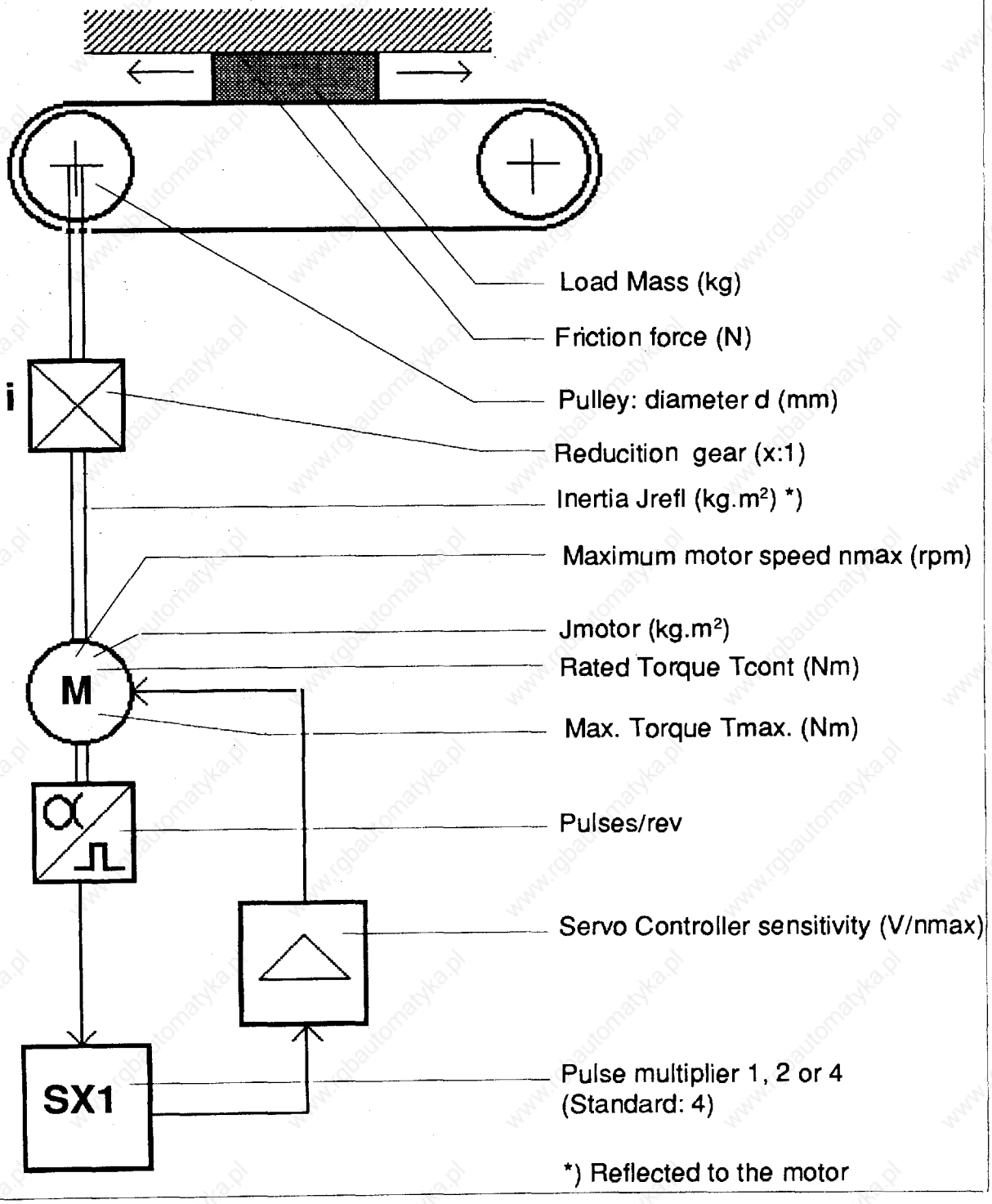
Number of Parameters	Name of Parameters	Meaning
P 33	N-VØØ	Name of Variable VØØ (up to c characters)
P 34	F-VØØ	Format of Variable VØØ (xxx; xxxx; xxxx.x; xxxxx.xxx)
P 35	L-VØØ	Lower limit of Variable VØØ (depends on format)
P 36	H-VØØ	Upper limit of Variable VØØ (depends on format)
.		
.		
.		
P 89	N-V14	Name of Variable V14 (up to 6 characters)
P 90	F-V14	Format of Variable V14 (xxx; xxxx; xxxx.x; xxxxx.xxx)
P 91	L-V14	Lower limit of Variable V14 (depends on format)
P 92	H-V14	Upper limit of Variable V14 (depends on format)

Formats Used:

xxx	for VEL %, ACC %, DEC %
xxxxx	for WAIT ms, counters
xxxx.x	for VEL Units/s
xxxxx.xxx	for position data

7.1.2 Meaning of Parameters

To assist understanding of the following descriptions, we show here a simple example of a servo axis using a toothed (timing) belt drive.



PØ: Program Number (Pgm #)

The program selected for Automatic-external operation.

P1: Resolution [Increments per Unit]

Units for P1: Increments per Length Measuring Unit (mm, inch, degrees, radians etc.).
Range of values: 1.0000 ... 9999.9999

For Incremental Encoder:

$$P1 = \frac{(I/rev) \cdot iv \cdot i}{Vk}$$

For Absolute Encoder:

$$P1 = \frac{(I/rev) \cdot i}{Vk}$$

I/rev. = Pulses per revolution
iv = Pulse multiplier in SX-1 (1, 2 or 4; Standard: 4)
i = Reducer ratio
Vk = Feed constant (Units/Revolution at gearbox output) Resol./Turn = Resolution/ Revolution for multi- or single turn absolute encoder.

P2: Increments per Revolution [Inc/Rev]

For Incremental Encoder:
The incremental encoder is used for homing. When searching for the Home position, a zero (marker) pulse is expected within one revolution, calculated from the number of encoder pulses. If the zero pulse is not found within the number of pulses corresponding to one revolution, there is an Error reported.

Units: Quantity
Range : 1 ... 10.000

$$P\,2 = (I/rev) \cdot Iv$$

I/rev = Pulses per revolution
iv = Pulse multiplier in SX-1 (1, 2 or 4; Standard: 4)

For Absolute Encoder: Given by the Resolution per revolution

Selection of the data transfer channel is performed with switch S2 on the printed circuit board (See Chapter 5.3.5).

P3: Analog Voltage to Speed Ratio (Vo/Vm) [ratio]

The value entered is the ratio of the speed used to the nominal speed multiplied by the reference voltage for nominal speed.

$$P3 = \frac{N_{used}}{N_{rated}} \cdot Vin$$

Units: Ratio
Range: 0.1 to 9.9
Nrated = maximum motor speed
Nused = maximum speed used
Vin = reference for maximum speed

P4: Scanning rate (T)

The scanning rate should not be changed by the user: it is only used for tests.
The smaller the time, the better the control quality. Standard values are 3 ms for Incremental Encoder, and 5 ms for Absolute Encoder. With control over the loop from external Override or Interpolation, P4 must always be set to 5 ms.

P5: Maximum speed (max. V) [Units/s]

Units for P5: Length Units (mm, inch, degrees, etc) per second.
Range: 0.1 ... 6000.0

$$P5 = \frac{Vk \cdot nmax}{i \cdot 60} \equiv Vmax$$

Vk = Feed constant (Units/Revolution at gearbox output)
n max = maximum speed of motor and controller combination
i = Reducer ratio

P6: Maximum Acceleration (max A) [Units/s²]

Units for P6: Distance Units (mm, inch, degrees, etc) per second²
Range: 0.1 ... 60,000

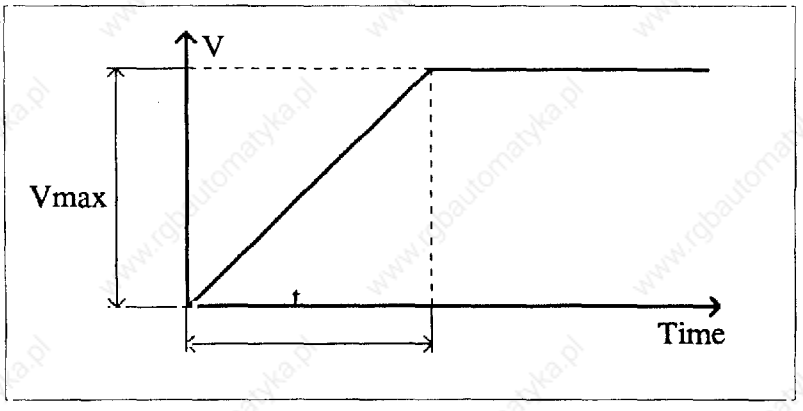
The maximum acceleration may be calculated as follows:

1.

$$P6 = \frac{Vmax}{t}$$

Vmax = maximum velocity of the drive
t = acceleration time

The values for Vmax and the acceleration time may be read from the velocity diagram for the application.



2.

$$P6 = \frac{Mdbes}{J_{Motor} + J_{Load}} \cdot \frac{Vk}{2\pi \cdot i}$$

Mdbes = Permissible accelerating torque (Nm)
J_{Motor} = Moment of Inertia of the motor (kgm^2)
J_{Load} = Moment of Inertia of the load (kgm^2)
If there is a gear reduction, the load moment of inertia should be reflected to the motor shaft by dividing it by the square of the gear ratio.
Vk = Feed constant; Feed per Revolution
i = Gear Reduction Ratio

Note:
The permissible accelerating torque should be determined according to the Duty Cycle of the motor.

P7: Manual slow jog speed (MAN S) [Units/s]

Units for P7: Distance Units per second.
Upper limit: Vmax (see P5)

This value determines the slow Jog speed in the manual modes.

P8: Manual fast jog speed (MAN F) [Units/s]

Units for P8: Distance Units per second.
Upper limit: Vmax (see P5)

This value determines the Fast Jog speed in manual modes.

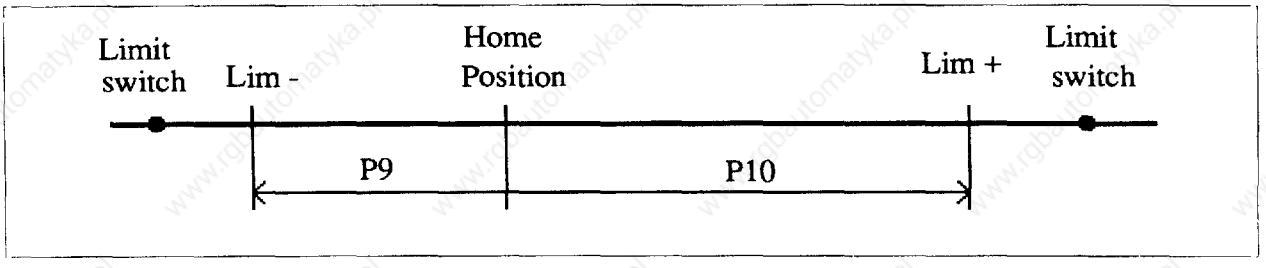
P 9: Software Limit of movement left (Lim -)
P10: Software Limit of movement right (Lim +)

Units for P9 and P10: Distance Units (mm, inch, degrees)
Range: P9 0 ... - 99999.999 (Lim -)
P10 0 ...+ 99999.999 (Lim+)

These limits of movement are "software limit switches", which should be placed before the "hardware limit switches". In automatic mode, a movement is not started if calculation shows that the end point is beyond these limits. In the manual modes, you can jog up to these limits.

The left limit is given as a negative number, and the right limit as a positive number. When the values ±99999.999 are entered, there are no limits. Thus you are able to program limits relevant to the direction of movement, for example:

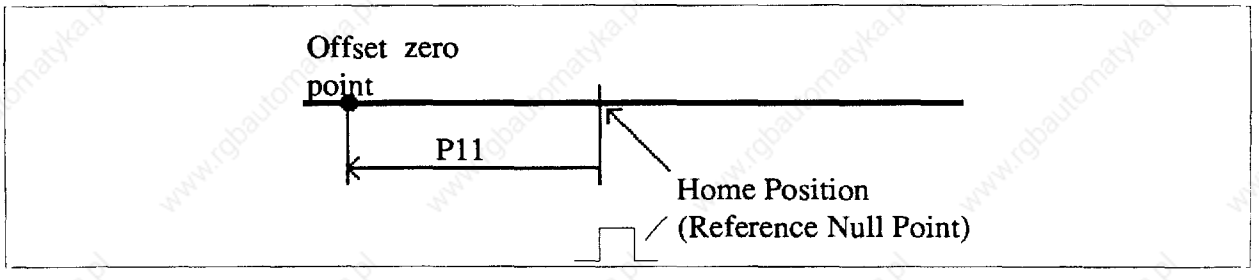
Lim - -0.1 mm
Lim + +0



P11: Zero Offset (Home Position Offset) (Offset)

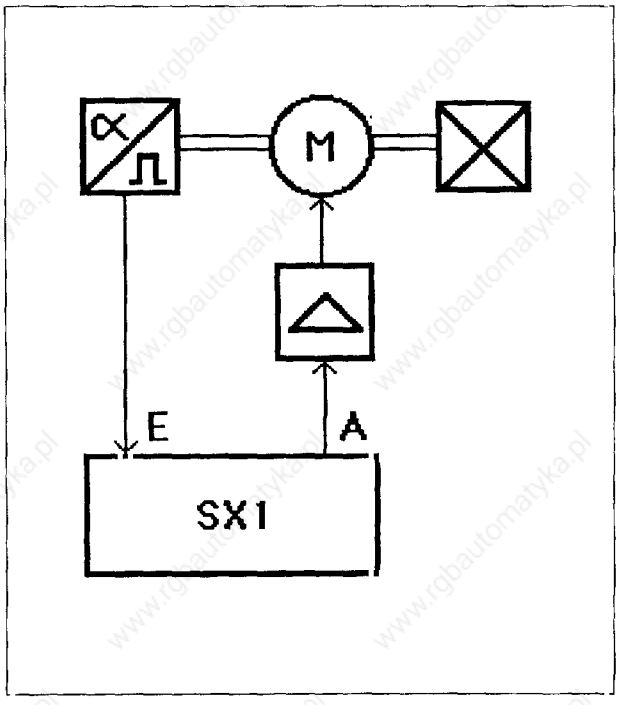
Units for P11: Distance Units

This is used to shift the zero point with respect to the Home position for programmed movements. The software limit switches P9 and P10 always refer to the true zero (Home) position.



P12: Sign of Analog Servo Output (S SIGN)
P13: Sign of Position Feedback (E SIGN)

Possible values: "Normal", "Inverse"



The direction parameters S SIGN and E SIGN are used to invert the sign of the Servo output and the Encoder Feedback (for forward or reverse motion). Two forms of reversal are possible:

NOTE!

1. You may use the software direction sign in order to correct polarity if one connection (Analog output or Encoder feedback) is incorrect. This would result in positive feedback, i. e. when the motor is started, it goes in the wrong direction and a "Following Error too big" message occurs (E 05).

2. If BOTH signs S SIGN and E SIGN are reversed, the direction of movement is reversed.

NOTE:
Always check the End Of Travel switch wiring for correct operation when changing these parameters.

P14: Backlash Correction Positive direction (Tool +)
P15: Backlash Correction Negative direction (Tool -)

Units: Distance Units
Range of Values: P14: Ø ... +99999.999
P15: Ø ... -99999.999

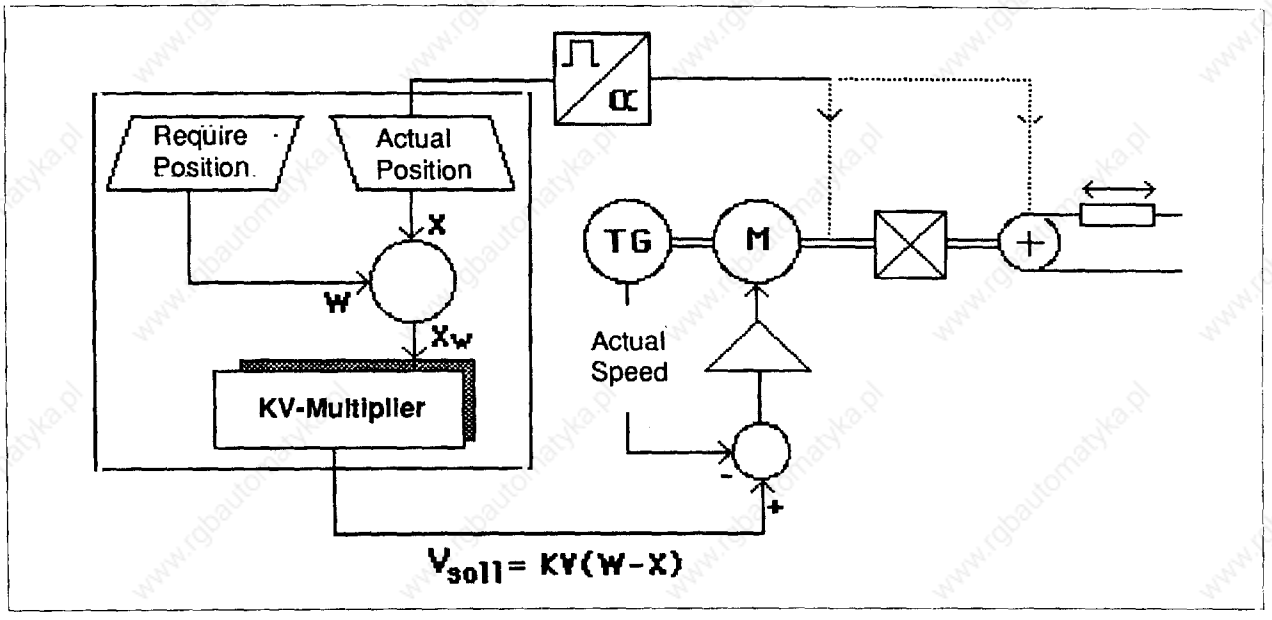
With these parameters you may correct for tool offset or lost motion (backlash) during positioning. With absolute positioning in the positive direction, you move towards the destination less the amount of P14, and in the negative direction less the amount in P15.

P16, P17, P18: KV Factors (KV0, KV1, KV2)

These gain factors, with the switchpoint parameters P19 and P20, adjust the position loop gain to suit the machine.
P16 = KV0
P17 = KV1
P18 = KV2
Delivery Setting for P16, P17 and P18: 1

For an explanation, see the next page.

Coupling of the Load to the Servo System

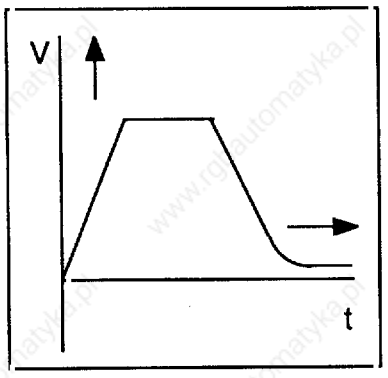


The numerical control SX-1 produces a control signal that is dependent upon the difference between the Required Position W and the Actual Position X. This signal causes a movement in such a direction as to reduce that difference. Thus the difference between Required and Actual position (W - X = XW) becomes zero when (W - X) = 0, and the servo stops.

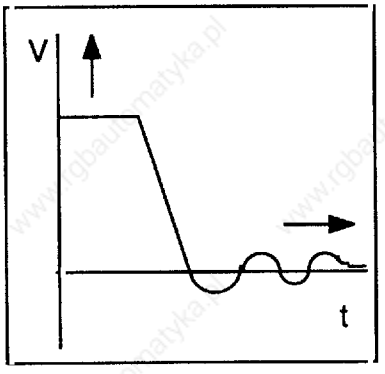
This voltage produced by the numerical control is determined by the KV factor (= voltage produced per increment of position error) and is very important in determining drive stiffness, stability and accuracy.

$$KV = \frac{V}{XW}$$

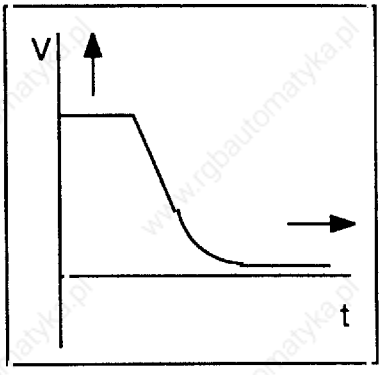
V = Velocity in m/min
XW = Position Error in mm



Ideal KV0 adjustment



KV0 too large: Gradually reduce to the ideal value



KV0 too small: Gradually increase to the ideal value

NOTE

If it is impossible to achieve ideal response, please check the drive configuration and couplings.

P19, P20: Switch point output (KP1, KP2)

The SX-1 provides facility for 3 position loop gains, set by the parameters. This allows optimum use of the full acceleration capability of the drive up to torque limits, and at the same time prevents over-driving the control should an excessive acceleration parameter be entered.

The Gain Break Points are the voltages at which the corresponding gain factors change.

KP1: Gain Break point to KV1
KP2: Gain Break point to KV2.

P19: KP1 typical value 15 % of Vmax
P20: KP2 typical value 40 % of Vmax

KV-factor and Gain Break points in general

The aim of each positioning movement is:
1. To have as small a difference between the Required and Actual positions as possible, i. e. to reach final position as quickly as possible.

2. To reach the required position with high accuracy.

You can achieve both aims by using a high value of KV.
Consider:

$$Vref = KV \cdot (W - X)$$

Vref = Velocity demanded
KV = Position Loop Gain
W = Required Position
X = Actual Position
W - X = Difference Required/Actual Position = Following Error

The SX-1 numerical control produces an analog voltage output which is the product of the following error and the KV factor. This output is used to produce movement of the servo drive in such a way as to reduce the following error to zero.

$$Vref = KV \cdot ds$$

ds = Following Error

NOTE:
1. The higher the KV factor, the smaller the following error required to produce a given speed of the drive (drive responds quickly).
2. When even a small change in the actual position occurs, e. g. due to a disturbing force, then a large change in analog output is produced to resist the disturbance.

The upper limit of the KV value is determined by the drive dynamics, and the natural frequency of the load. If the KV value is too large, then the drive becomes unstable.

A starting-point for determining KV is to assume constant accelerating torque T_{max} and resultant acceleration.

$$a\ (t) = constant$$

a = angular acceleration

Speed then increases linearly with time:

$$w\ (t) = a \cdot t$$

w = angular speed

During acceleration, the distance increases quadratically with time:

$$s\ (t) = 1/2 \cdot a \cdot t^2$$

For the Gain Factor we have:

$$KV = \frac{Vref}{ds} \qquad \frac{m/min}{mm}$$

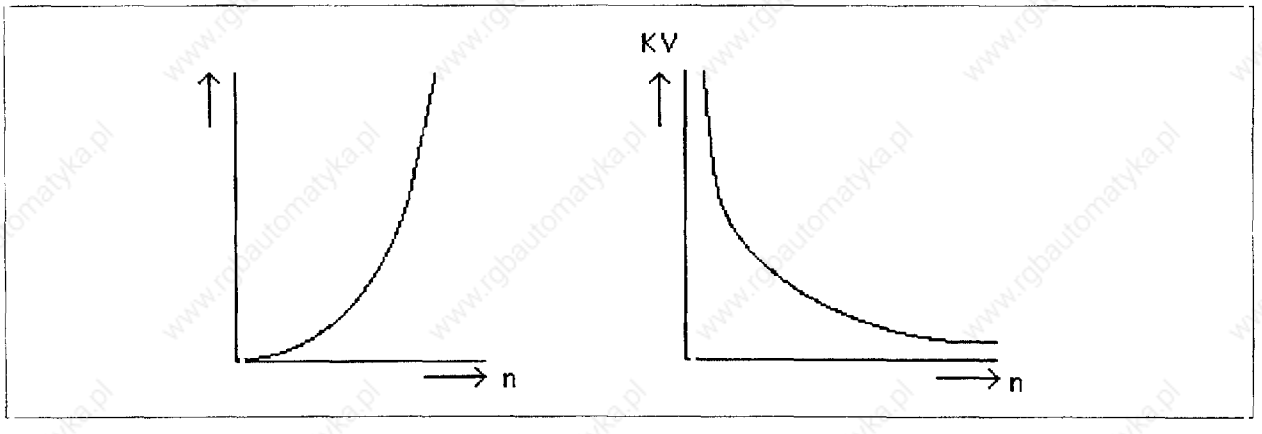
And because of the units used, we have:

$$KV = \frac{2a}{Vref} \cdot 16.6\,\frac{1}{s}$$

For rotary movements, the angular velocity is proportional to r. p. m., i. e.:

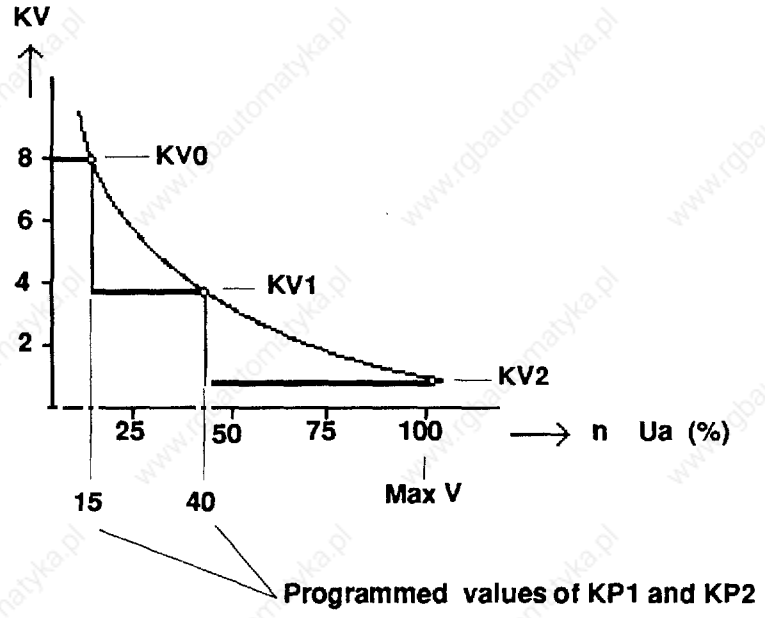
$$KV \sim 1/n$$

In diagrammatic form:



For a drive system with constant acceleration at all speeds, optimally KV would vary in inverse proportion to speed. However, this algorithm would take much time to calculate, and the accuracy, stability and stiffness would not be greatly improved over the SX-1 algorithm, which selects one of three different KV values, according to speed.

R. p. m. = Velocity = Reference Voltage Vref: thus voltage can be used to define the Gain Break points for the KV factors.



The Gain Break point voltages are the values where the corresponding KV values change.

NOTE:

The KV values and Break Point voltages are normally set by experienced servo engineers at the machine supplier, and should NOT be changed by the user without good reason.

P21: Following Error Tolerance (E Lim)

Units: %

Values: 12.5, 25, 50, 100, 200, 500
The Following Error is the difference between the required and actual position. The Tolerance or Limit is the permitted deviation from the theoretical value as a percentage.

$$100\ \% = \frac{(Vmax)}{KV2 \cdot 16.667} = \frac{P5}{P18} \cdot 16.667$$

If it is required that the control continue operation despite small torque variations such as variable friction, sudden load changes, etc, but at the time to react to driving into an obstacle, then increase the Following Error Tolerance. On the other hand, to achieve sensitive response to changes in Following Error, reduce the tolerance.

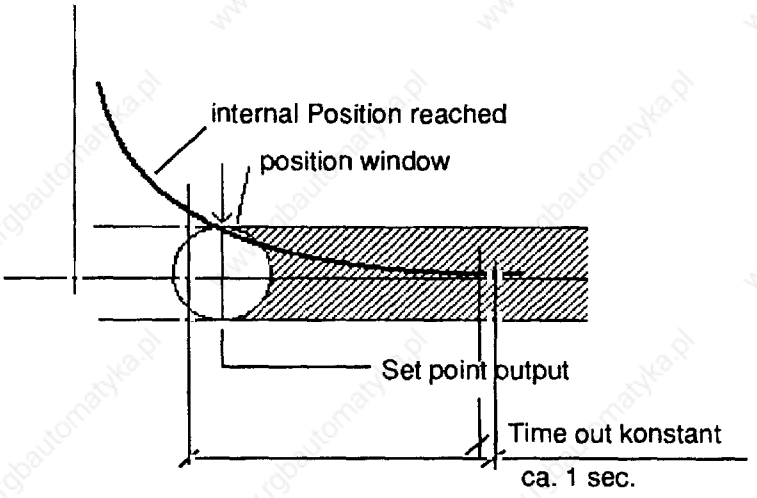
The **standard value** is **12.5 %** for normal servo drives.
In some cases a higher value must be used, for example to allow for acceleration transients.

Following Error Display: In Manual and Automatic modes, the PT-1 displays the actual position. Use the TEACH key to toggle the display of the Following Error, which is shown in Distance Units.

P22: In-Position Window (Pos W), with Time-out Supervision

Units: Increments
Range of Values: 1 to 30 000
Standard Value: 100

When the Required (calculated) position reaches its final value, the axis may some time to reach, or may never quite reach , the theoretical value, due to control limitations: instead it is assumed to achieve an acceptable tolerance. The "Position Window" defines the band of positions which are accepted as sufficiently accurate. When this window is reached, the commanded movement is assumed to be completed, and the next instruction is commenced, even though final position may not yet quite be reached. This allows faster operation of the program.



Time-out supervision

If final positioning time exceeds 1 second, error E 16 is displayed. Positioning time-out is reported if the position window is not reached within the Time-out period.

HINTS: Check KV-values
Check drive operation
Is position window too small?

Time-out is commenced when the internal commanded position is reached.

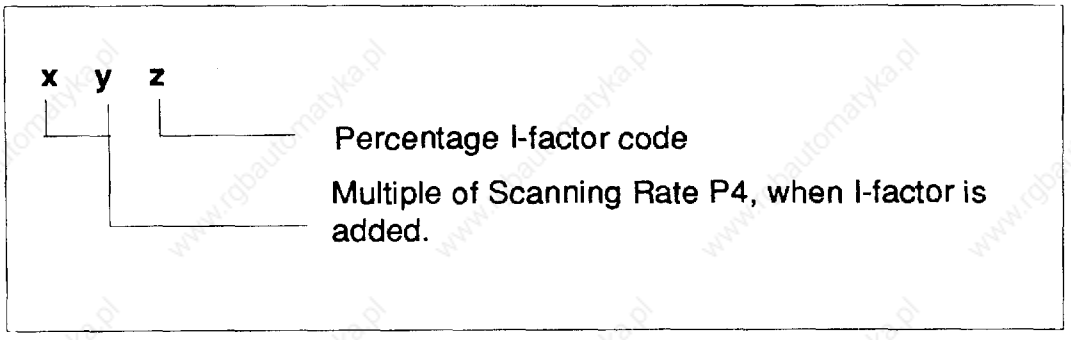
P23: Integration Factor (I-Fct.)

Unit: % and Correction Interval (defined by code number)

The position controller is of the Proportional type: it is possible to introduce an Integral term by defining this code number.

Standard value: 0

The code number has three digits:



Values:
xy = 1 to 25
z = 0 to 7 meaning:

0 =	0	% factor
1 =	100	% factor
2 =	50	% factor
3 =	25	% factor
4 =	12.5	% factor
5 =	6.25	% factor
6 =	3.125	% factor
7 =	1.6	% factor

Example: Code 034 means:
Every third scanning time, add an Integration factor of 12.5 %. The highest code number is 257.

This parameter is normally zero.

The I-factor is calculated only at standstill: it is not used during positioning.
The I-factor is dependent upon movement.
The I-factor is limited to 20 % of maximum Vref.

P24: Mode of Operation

Normal mode of operation: P24 non-zero.

Test mode is selected when P24 = 0.

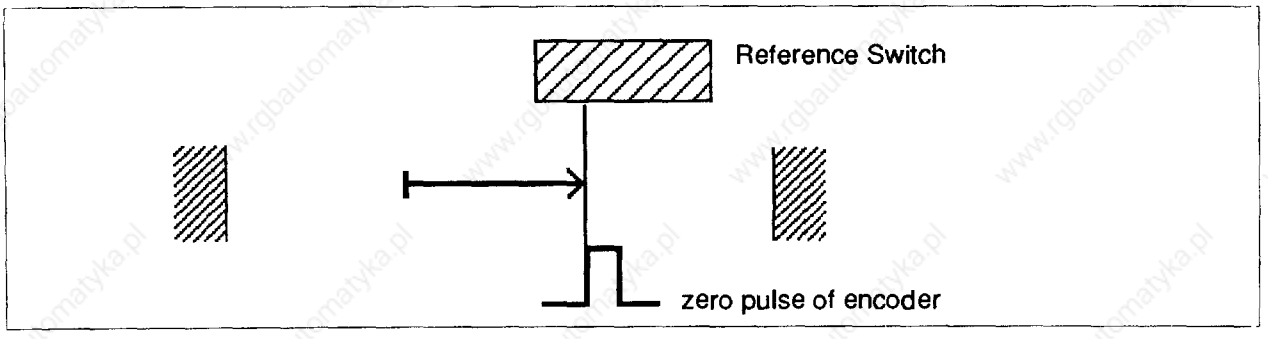
Attention!
This mode is only used for installation and commissioning. See Chapter 6.1.2.

P25: Homing Mode (Hom M)

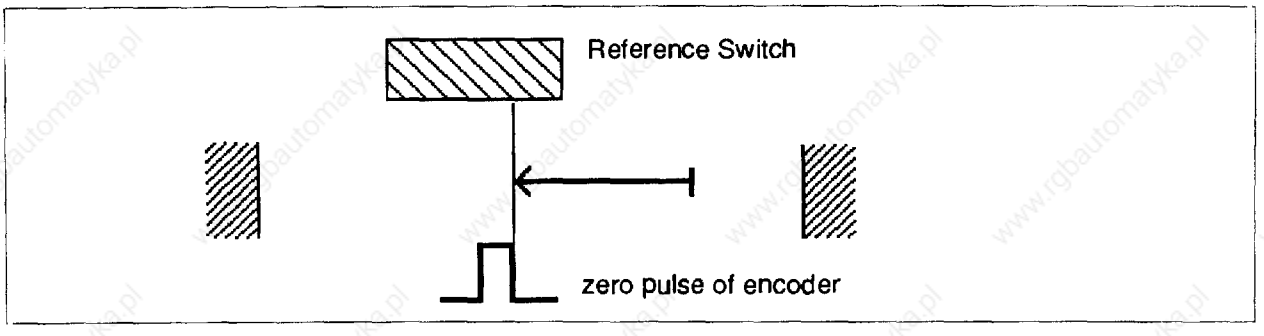
Versions: 0 ... 5

If you are using an incremental position feedback system, it is normally necessary to initialize the distance measuring system after switch-on, if absolute positioning is required. This is done by "Homing" or "Referencing":
Six methods are available:

Version 0:
Drive in positive direction to Reference Switch: then go to zero (marker) pulse of the encoder.

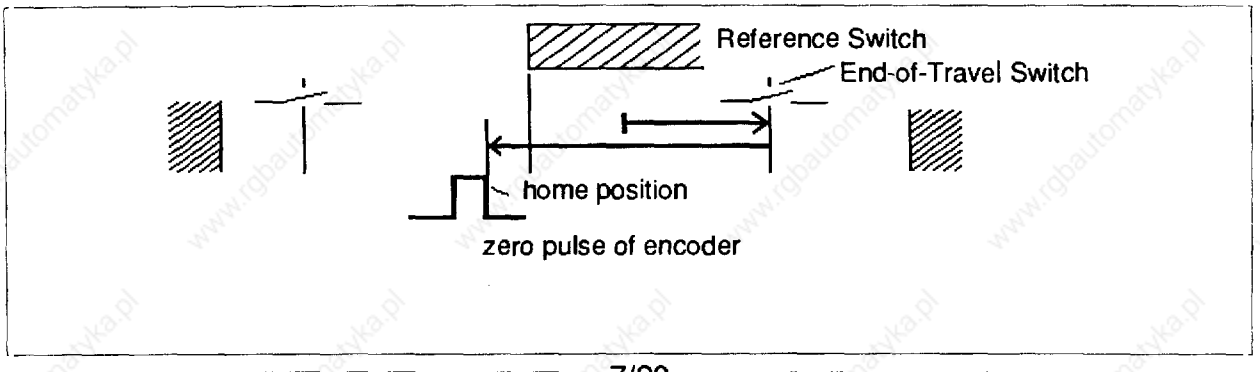


Version 1:
Drive in negative direction to Reference Switch: then go to zero marker pulse of the encoder.

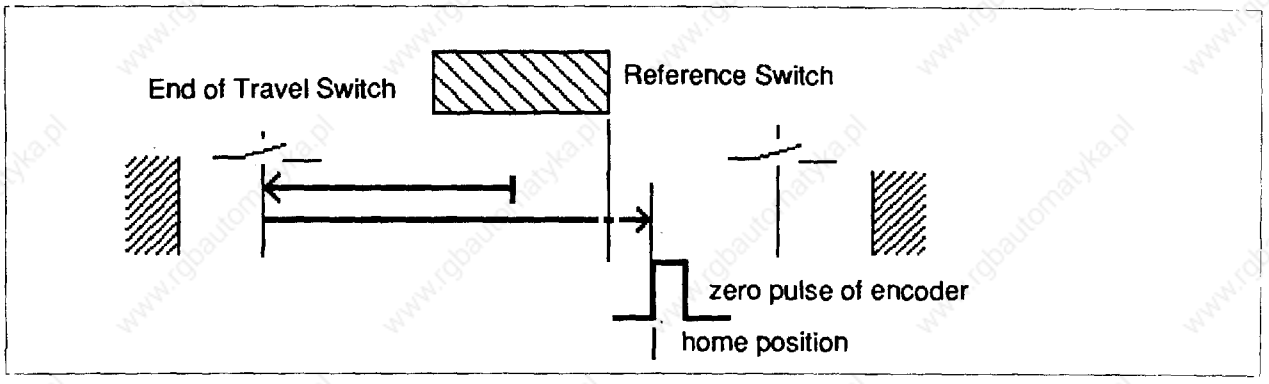


Version 2:

Drive in positive direction to End-of-Travel Switch: then reverse towards Reference Switch. The home position is the first zero pulse after leaving the Reference Switch.

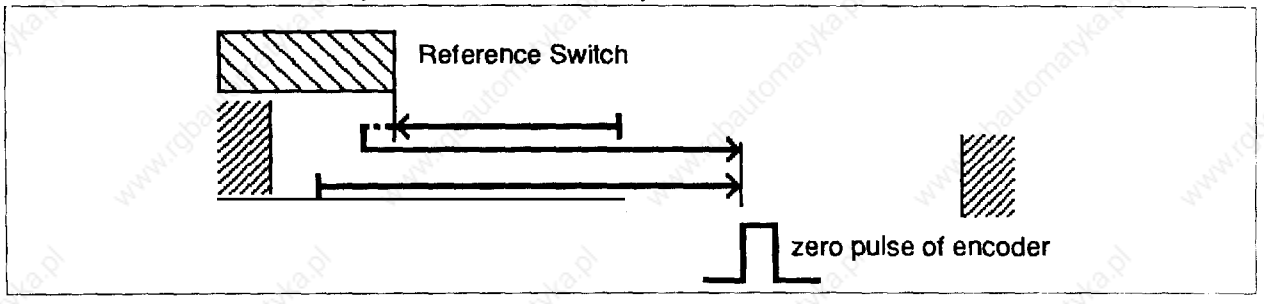


Version 3:
As Version 2, but with reversed directions.

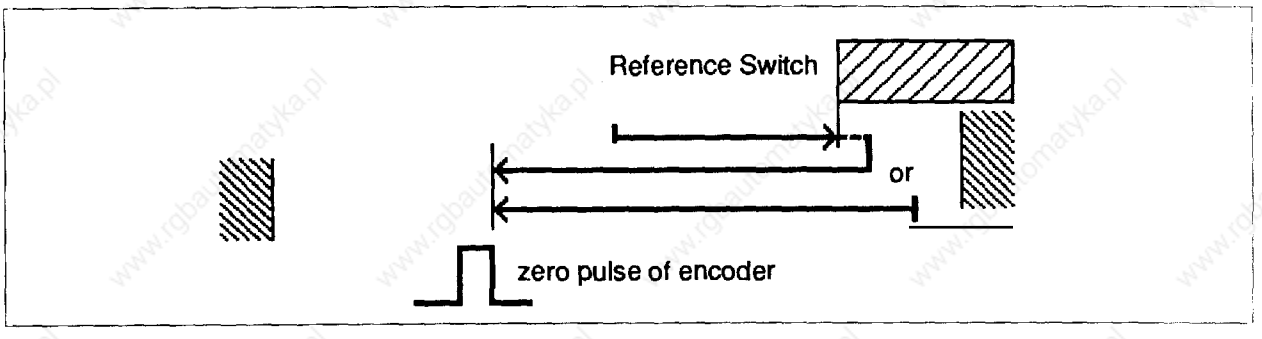


Version 4:

Here, the Reference Switch is closed up to the Negative Limit Switch. If this signal is active, the drive goes in the positive direction to the falling edge, and then finds the first zero pulse thereafter. If the signal is not active, the drive goes in the negative direction to the Reference Switch, then positive to the zero pulse.



Version 5:
As Version 4, but with reversed directions.



P26: Homing Velocity (Hom V)

Units: Distance Units per second
Range of values: 0.1 ... 6000.0

Parameter P26 defines the homing velocity.

P27: Homing Necessary? (Hom N)

Possible: Yes or No

This Parameter is used to select whether or not the start of automatic program operation is dependent on first having Homed.

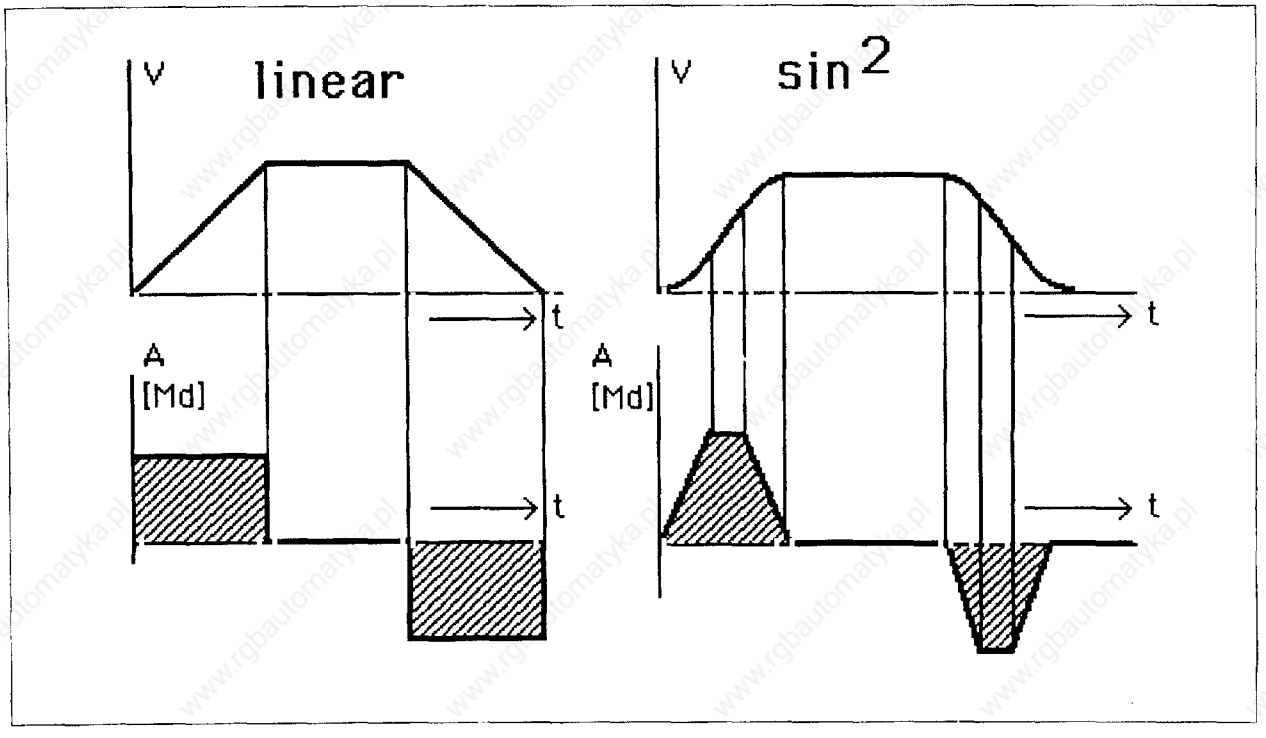
No (homing not necessary): program starts in any event.

P28: Acceleration Characteristic Linear or Sin² (Ramp)

This Parameter defines the mode of acceleration and deceleration. Sin²-type acceleration and braking gives a smoother response and reduces wear on mechanical parts, but at the expense of longer positioning times than with the Linear option.
The preset acceleration rate refers to change in velocity per unit time.

Lin = linear change in velocity with constant acceleration.

sin² = quadratic change in velocity with linear change in acceleration.



The defined mode of acceleration is used for all positioning.

Important notes regarding Sin² mode

1. If Sin² mode is selected, it is not possible to use position instructions with change-over of velocity, e. g. PA Vdd V.

2. Change of mode can be performed in a program using Flag F98
   (H = Sin², L = Lin)

3. Acceleration and Deceleration may not be separately defined.

4. DEC function is no longer operative.
   ACC defines the number of Scanning Periods for changing acceleration from zero to maximum.
   ACC = 1 means almost no delay in acceleration
   ACC = 100 means maximum delay in acceleration, i. e. 100 x 3 ms = 300 ms to reach maximum acceleration

5. Analog override is inoperative.

P29: Relative or Absolute positioning (Pos M)[Rel,Abs]

In principle, a linear axis is not endless: there is an "End-of-travel" limit. Rotary movements, however, can be "Endless" or "Relative".

When "Relative" is selected:
- Only Relative positioning (PR) instructions are accepted.
- Cumulative errors may occur due to "rounding-off" errors.

Note:

When using "endless" mode, chose an Integer value for resolution (P1). Zero point correction is not permitted (P11 = 0).

P30: Limit Switch Mode

Limit Switch contact mode can be selected:

0 = Inverse
1 = Normal

P31: Variable Transmission Mode

Unit: Quantity of SX-1 with PT-1.
Range: 0 ... 64

With the Variable Data menu, variable values may be changed, and when correct, sent to the SX-1 by pressing the ENTER key. If several axes are connected to the PT-1, then normally only the selected axis is supplied with data. If you wish to supply data in parallel to several SX-1 controls, then use Parameter P31.

For example:

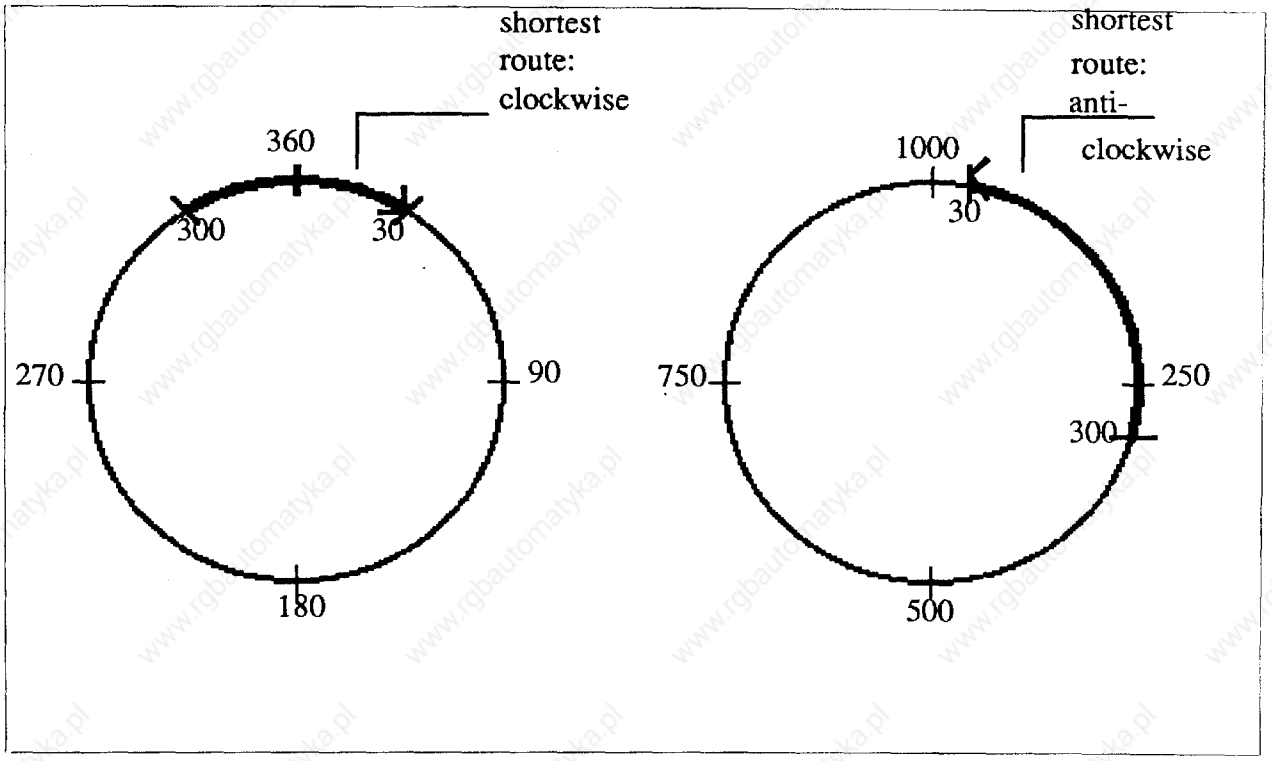
P31 = 1	Variable sent only to selected Axis.
P31 = 2	Variable sent to Axis No. 0 and No. 1

P32: Units per Revolution (U/rev)

Units (for P32): Units per Revolution
Range: 0.000 ... 99999.999

The number of "Units per Revolution" is used, together with the instruction "Position Absolute/Direct Positioning" (see Chapter 8) to reach required position by the shortest route.
For a given final position, the shortest distance (clockwise or anti-clockwise) will depend on the number of units per revolution.

Example:



Definition of variables

Some program instructions may be performed either with directly-specified values, or with indirectly-specified values by using variables (see Chapter 8).

Examples of programming with direct values:
PR 40.000
PA 6000.000

Examples of programming with indirect values, using variables:
PR V001
PA V002

V001 or V012 are values that are set later by the machine operator. The programmer has only to enter four constraints for each of these variables used:

Name; Format; Lower Limit; Upper Limit.

There are 255 variables in total: of these, V00 through V14 are defined using Parameters, and these must have consecutive parameter numbers, starting at V00,

i. e.	V00, V01, V02	permissible
	V00, V02, V04	not permissible

P33: Name of Variable ØØ (N-VØØ)

Up to 6 characters may be entered:
Example: Speed

Details of Entry: See Chapter 7.2

P34: Format of Variable ØØ (F-VØØ)

The MODE key selects the following formats:

xxx	for velocity, acceleration, deceleration (in %)
xxxxx	for counter values (increments) and delay periods (ms)
xxxx.x	for velocities in direct values, e. g. mm/s, m/min etc.
xxxxx.xxx	for distances, angles etc. in direct values

P35: Lower Limit of Variable ØØ (L-VØØ) (Low Limit: L-VØØ)

Input value format depends on P34.

P36: Upper Limit of Variable ØØ (H-VØØ) (High-Limit: H-VØØ)

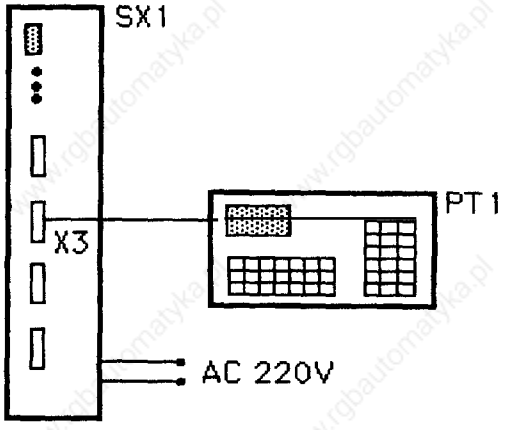
Input value format depends on P34.

This description is valid for all variables V00 to V14, using P37 to P40 for V01 etc.

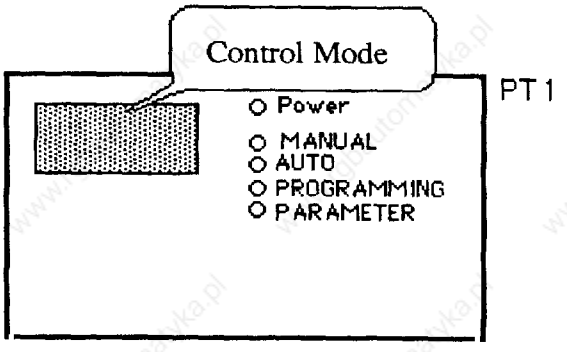
7.2 Parameter Entry and Variable Definition

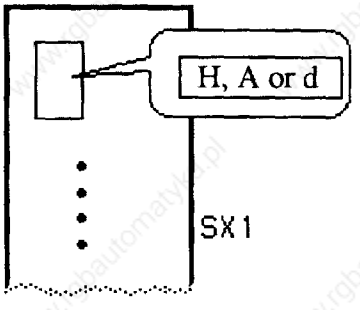
To enter Parameters, proceed as follows:

1. Connect the PT-1 terminal to the SX-1 via communications link X3 (PT-1 receives power from SX-1).



Now the PT-1 is, for example, in the "Auto-External" mode. This is indicated both in the LCD display, and by the LED (AUTO). The SX-1 LED should also show "A" for "Automatic-External" mode.





2. Press the PAR/KEY key:
   the PROGRAMMING and PARAMETER LED's should light together. The PT-1 expects the entry of a code number to permit entry of Parameters (see Chapter 12).

Key: — — — —

3. Input code numbers and press ENTER.
   PROGRAMMING LED goes out; PARAMETERS is illuminated.

P Ø TYP. Ø
H-14...
Pgm # Ø — —
Resol 5.5555

Line1 = Contents of working line
P0 = number of selected parameter:
Typ Ø = typical value of parameter Ø

Line 2 = Previous parameter name: (H-V14 variable) (see Chapter 7.3) - ignore for now

Line 3 = Working Line: name of parameter to be entered (= program number), and its present value (number blinks)

Line 4 = Next parameter name: resolution (P1).

4. Press the MODE key to enter or change a value.

MODE

Pgm # — —

Present value disappears: flashing dashes indicate the number of digits.

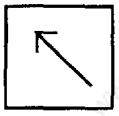
5. Enter the required Program number, e. g. 3, and press ENTER.

3 ENTER

Pgm # 3

The new value is shown in the display, which no longer flashes.

6. Select the next parameter with the arrow key.

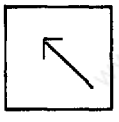
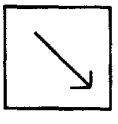


```
P1  INC/UNIT
Pgm #              3
Resol          5.5555
IPR \          4ØØØ
```

The contents of the LCD display scrolls up a line.
Line 1 = Contents of working line:
P1 = number of selected parameter
Incr/U = units for parameter to be entered
Line 2 = Previous parameter (here PØ).
Line 3 = Working line: name of parameter P1 (resolution), and its present value (5.555 increments/unit).
Line 4 = Next parameter name (P2).

7. Press MODE key (prepare to enter parameter).

8. Enter required value (resolution); terminate with ENTER key.
9. Continue to select the next parameter with arrow keys until all parameters are entered.

 or 

9a. OR: select the required parameter using the FIND key and terminate with the ENTER key.

10. Input of Variable Definitions:
a) Name of Variable:
On the display:

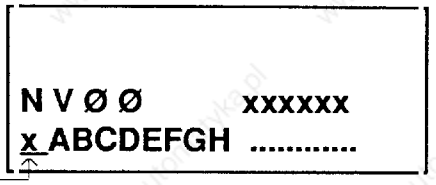
```
P33 Name
.....
N V Ø Ø          xxxxxx   ← blinks
```


```
N V Ø Ø          xxxxxx
x ABCDEFGH .....          ← Alphabet
↑
Cursor
blinks
```

In the bottom line, the character set is displayed in groups, selected by further use of the MODE key.

Use the arrow keys to move the cursor to the required character, and press ENTER to select. This character will then appear in the first position of the name.

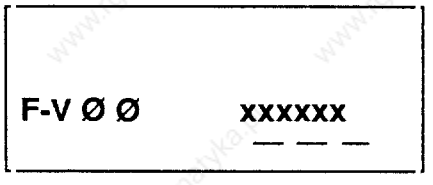
ENTER



The next five characters are selected and entered in the same way. After all six characters are entered, the name is displayed, and the previous and next parameters re-appear.

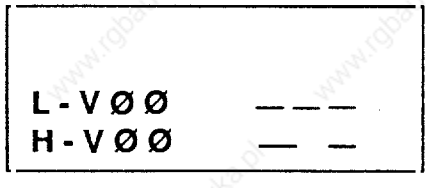
b) Selection of Format.
Firstly, use the arrow key to bring F-V00 into the working line.

By pressing the MODE key, the possible formats are displayed in turn. Select with the ENTER key.
(Note the assignment of formats - see P34 description).



c) Selection of Lower and Upper Limits.
Use the arrow keys to place L-V00 (and then H-V00) into the working line, and press MODE:

MODE



Enter the required value and terminate with the ENTER key. Then continue with all of the required variables. When no further variables are required, the name of the next variable must consist of the six "x" characters, i. e. xxxxxx.

Input of parameters is then finished.

The parameters are first stored in the memory of the PT-1. Pressing the SAVE key transmits them into the EEPROM memory of the SX-1 for preservation despite supply interruption. Do not forget to do this!

The values may be sent even when a program is running, but they are not then used until the program is stopped, because a short conversion routine must be performed. (The position control is switched off during this conversion, but the servo is still enabled, so a small amount of drift may occur).

Save with:

SAVE

```
SAVE -> Axis ØØ

 o.k.   =    <ENTER>
Axis?   =     <MODE>
```

PT-1 requests which Axis the parameters belong to?

- If the parameters belong to the Axis in the first line, press ENTER.

ENTER

```
SAVE -> Axis ØØ
Paramters
Sending
```

After the process is completed, the parameter display re-appears.

- If the parameters belong to a different Axis, press MODE

MODE

```
SAVE -> Axis  _ _

 o.k.   =    <ENTER>
Axis ?  =     <MODE>
```

Type in the Axis number and press ENTER.

The number in the first line disappears.

7.3 Changing Parameters

1. Firstly, you must select PARAMETER mode (see Chapter 7.2).

2. Load the parameters to be changed from the SX-1 into the PT-1 using the LOAD key. This copies the parameters from the SX-1 into the PT-1 memory.

3. Change and Edit the parameters as described in Chapter 7.2.

4. Remember to send the edited parameters back to the SX-1 using the SAVE key!

NOTE!

Whilst Saving, a certain time is required for programming the EEPROM.

1. The MODE key is used to commence the entry of values, and to select text character groups.

2. An incorrect entry may be cleared using the CE key provided that the ENTER key has not yet been pressed.

Valid Entry Check.

The PT-1 checks the entered values for validity, exceeding permitted range, etc, and reports when the conditions are not met when the ENTER key is pressed, e. g. in the first line ">" is displayed for "value too large" or "<" for "value too small". At the same time, the invalid entry is deleted. It is not possible to finish entry of that Parameter until an acceptable value is entered.

7.4 Parameter Limits

Limits of Ranges for SX-1

On entering Parameters, the allowable limits may be exceeded. In the first line of the PT-1 display, the following reports may appear:

>	limit exceeded
<	limit not reached
A:	gain factor KV out of range
G:	incremental velocity too high
S:	calculation of following error out of range

G	speed	$V_{max.} \cdot Resol \cdot T < 30\,000\,000$ $(P5 \cdot P1 \cdot P4)$
S	Following Error	$\frac{V_{max.} \cdot Resol}{KV\,2} < 445\,000 \cdot \frac{P\,5 \cdot P\,1}{P\,18}$
V	gain	$26{,}7 < \frac{V\,max. \cdot Resol}{V\,max.\,V \cdot KV0} < 1\,744\,830 \cdot \frac{(P5 \cdot P1}{P3 \cdot P16)}$

Note:

Whilst the reports A, G or S appear on the display, the diagnostic report "Data Not Sent"" also appears. The parameter data is unacceptable.

Attention:

Parameters which include "out of range" values may become "lost". An error message E27 "parameter values deleted" occurs, and default values are loaded.

Attention:

Operation with default values is not possible: if this occurs, check all Parameter data with respect to the limits, and re-enter as required.

Lenze

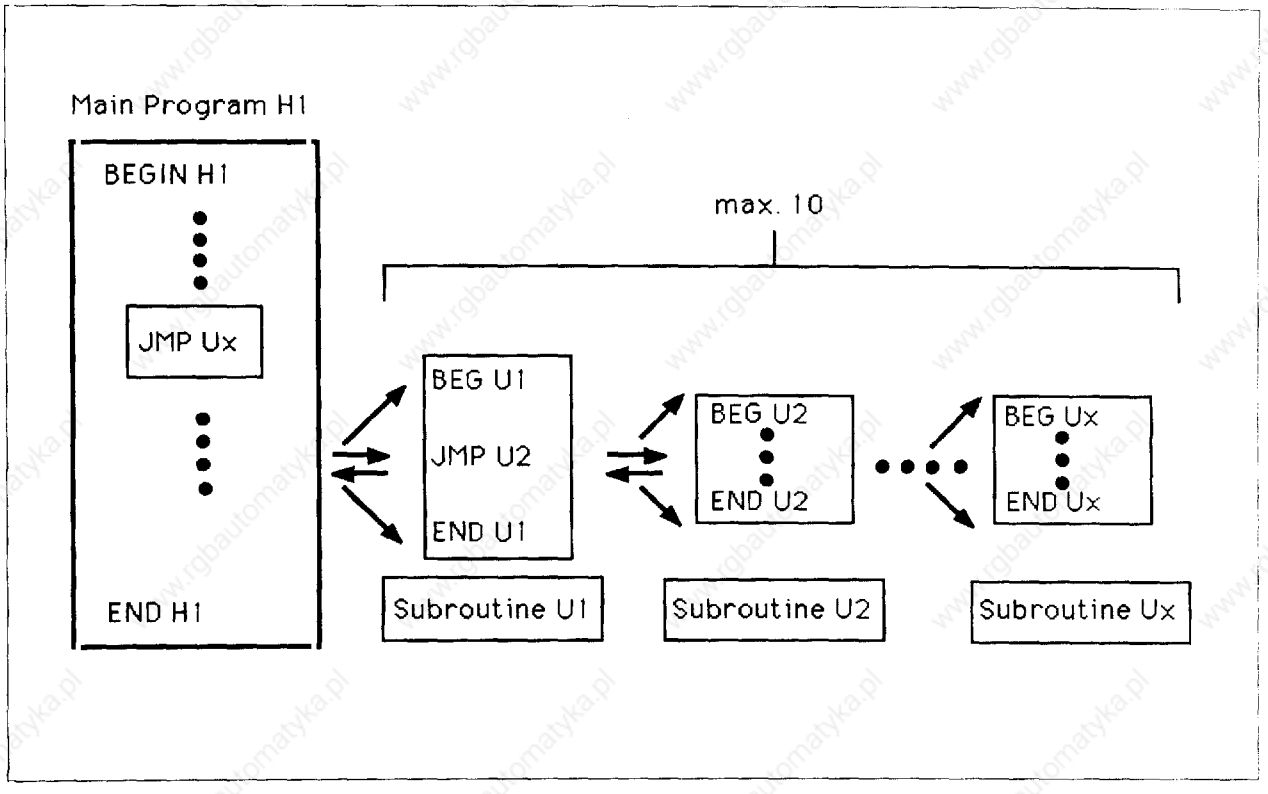
8. Programming

After the Parameters have been entered (see Chapter 7), you may commence programming.

The Program defines the logical and motion control functions to be performed by the SX-1. Furthermore, certain values fixed by the parameters (e. g. velocity, acceleration) may be modified by the Program for individual movements. Such values have priority over the values fixed by the parameters.

8.1 Program Structure

It is possible to make an easily-understood Program using only a few instructions from the ECL programming language. Main programs can be broken up into subroutines: the SX-1 can have up to 20 main Programs, each with up to 100 subroutines. It is possible to "nest" subroutines up to 10 deep. Subroutines are "called" using JMP (jump) instructions: when the END of a Subroutine is reached, the Program continues at the calling JMP instruction.



Example of a possible Program structure.

8.2 Program Instructions

8.2.1 Overview

A few program instructions are often sufficient to build a complex and understandable program. The following instruction groups are available:

- Organisation instructions (for structuring the program):
  - defining the begining and end of main programs and subroutines
  - conditional and unconditional jumps
  - branch conditions for building program loops

- Motion-related instructions:
  - relative and absolute positioning instructions
  - define velocity and acceleration/deceleration
  - homing

- Wait instructions

- Set instructions for outputs, counters and flags (including Boolean and Arithmetic).

8.2.2 Programming Instructions and their meaning

BEG Hnnnnnn, END Hnnnnnn

Meaning:
Beginning and End of Main program.
Input: BEG, ENTER, number, ENTER
Number of the Program H: nnnnnn = 1 ... 999 999

BEG Uww, END Uww

Meaning:
Beginning and End of Subroutine.
Input: BEG, MODE, ENTER, numbers, ENTER
Number of Subroutine U: ww = 0 ... 99

Label Lww

Meaning:
Jump destination Label.
A Label may be placed before any instruction: it becomes part of that instruction, and it may not exist alone.
It is "jumped" to by the JMP Lww instruction.
Number of Label L: ww = 0 ... 99

JMP Lww

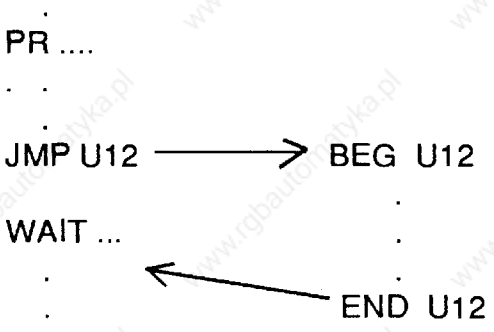
Meaning: Jump to Label Lww (destination).
Number of Label L: ww = 0 ... 99

When the program reaches this instruction, an unconditional jump to Label Lww will occur, and the program continues from that point.

JMP Uww

Meaning: Jump to Subroutine Uww
Number of Subroutines U: ww = 0 ... 99

When the program reaches this instruction, an unconditional jump to Subroutine Sww will occur, and the Subroutine is executed. When the end of the Subroutine is reached, the program is resumed at the instruction following the jump instruction. For example:



IF Ixxx = H Lww
IF Ixxx = L Lww

Meaning:
Jump to Label Lww (Address ww), if input I xx
- is either H = HIGH (=1)
- or L = LOW (=Ø)
Number of Inputs I: xxx = 1... 6.16
Number of Label L: ww = 0 ... 99

IF Ixxx = H Uww
IF Ixxx = L Uww

Meaning:
Jump to Subroutine Uww, if input I xxx
- is either H = HIGH (=1)
- or L = LOW (=Ø)
Number of Inputs I: xxx = 1... 6.16
Number of Subroutine U: ww = 0 ... 99

IF Fvv = H Lww
IF Fvv = L Lww

Meaning:
Jump to Label Lww (Address ww), if Flag Fvv
- is either H = HIGH (=1)
- or L = LOW (=Ø)

Number of Flag F: vv = 0 ... 99
Number of Label L: ww = 0 ... 99

A number of Flags are reserved as follows, and must not be used for other purposes:
F 99 = H ; Drive in motion
F 98 = H ; Linear Acceleration/Sin²
F 97 = H ; Axis Homed
F 96 = H ; Touch Probe signal not received
F 95 = H ; Touch Probe during Sin² accel/decel
F 94 = H ; External Override Active

IF Fvv = H Uww
IF Fvv = L Uww

Meaning:
Jump to Subroutine Uww, if Flag Fvv
- is either H = HIGH (=1)
- or L = LOW (=Ø)

Number of Flag F: vv = 0 ... 99
Number of Subroutine U: ww = 0 ... 99

IF Cvv = aaaa Lww
IF Cvv < aaaa Lww
IF Cvv > aaaa Lww

Meaning: Jump to Label Lww (Address ww), if the value of Counter Cvv is equal to (=), smaller than (<), or greater than (>) the value aaaa.
Number of Label L: ww = 0 ... 99
Number of Counter C: vv = 0 ... 99
Reference Value: aaaa = - 9999 to + 9999

IF Cvv = aaaa Uww
IF Cvv < aaaa Uww
IF Cvv > aaaa Uww

Meaning:
Jump to Subroutine Uww (adr. ww), if the value of Counter Cvv is equal to (=), less than (<) or greater than (>) the value aaaa.
Number of Subroutine U: ww = 0 ... 99
Number of Counter C: vv = 0 ... 99
Reference Value: aaaa = - 9999 to + 9999

IF > vvvvv.vvv Luu
IF < vvvvv.vvv Luu

Meaning:
Jump to Label Luu (Address uu), if the Position Value vvvvv.vvv is greater than (>) or less than (<) the Actual position.
Number of Label L: uu = 0 ... 99
Position Value: vvvvv.vvv = -99999.999 ... +99999.999.

NOTE:

PA
PA V
PA C

These instructions may not be used if Parameter P29 selects Relative (endless) positioning mode.

PA vvvvv.vvv

Meaning: Move to absolute position vvvvv.vvv.
Value: vvvvv.vvv = -99999.999 ... +99999.999

This position instruction refers to the home (zero) position of the machine.

NOTE:
If two absolute position instructions with the same value follow each other, the second instruction causes no further motion.

Example: PA 1000.000
PA 1000.000 ⟵ no effect

PR vvvvv.vvv

Meaning:
Move the distance vvvvv.vvv relative to the present position
Value: vvvvv.vvv = -99999.999 ... +99999.999

This position instruction relates motion to the present (actual) position of the machine, rather than to the home (zero) position.

NOTE:
If two relative position instructions with the same value follow each other, the second instruction causes a second movement of the same distance as the first.
Example: PR 1000.000
PR 1000.000

The machine moves the distance 1000.000 twice.

PA vvvvv.vvv Vend = ccc %
PR vvvvv.vvv Vend = ccc %

Meaning:
Position absolute (PA) or relative (PR) with motion continuation
Value: vvvvv.vvv = -99999.999 ... +99999.999

With this positioning mode, the terminal velocity is defined (Vend = ccc%). The succeeding movement is carried out at this velocity. The calculation time for this must be allowed for when defining scanning rate P4.

NOTE:

Never program a time delay with a WAIT instruction after this instruction!

Examples:

VEL 100 %	or	VEL 100 %
PR 1000.000 V10		PR 1000.000 V100
PR 1000.000		SET 0Ø8 = H
		PR 200.000

PA vvvvv.vvv C
PR vvvvv.vvv C

Meaning: Position absolute (PA) or relative (PR) with program continuation (C = Continue).
Value: vvvvv.vvv = -99999.999 ... +99999.999

When reaching this instruction, the program is continued immediately, without waiting for the completion of the positioning. Thus during a positioning movement, inputs or flags may be monitored and used for further control.

Example:
PA 100.000 C
L 02 IF F99 = L, L01
IF IØ1 = L, L02

During positioning to 100.000, Flag F99 and Input IØ1 are monitored. If Flag F99 is Low, jump to Label LØ1; if Input IØ1 is Low, jump to Label LØ2.

PA Vddd
PA Vddd Vend = Veee
PR Vddd
PR Vddd Vend = Veee
PA Vddd C
PR Vddd C

Meaning:
Positioning in a similar way (absolute (PA) or relative (PR) with motion continuation (V) or program continuation (C)), but with the distance vvvvv.vvv defined instead by a Variable Vdd: this may be specified later e. g. by the user.
Variable Definition: see Chapter 7.1.
Variable number V: ddd = 0 ... 255.
Variable number V: eee = 0 ... 255.

The contents of variable Vee is interpreted as velocity in Units/s.

STOP

Meaning: Stop the axis immediately

This instruction may only sensibly be used after a "Position and Continue Program"instruction (Continue, e. g. PA vvvvv.vvv C), because with normal positioning instructions, the program is stopped until the end position is reached (and therefore the STOP instruction would be too late).

HOME

Meaning:
Initiate the Homing cycle.

VEL ccc %
VEL Vddd %

Meaning:
Select Velocity (= VEL) directly (ccc) or by variable (Vddd) as a % of maximum value.
Value: ccc = 1 ... 100 %
Variable number V: ddd = 0 ... 255

VEL oooo.o U/s
VEL Vddd U/s

Meaning:
Select Velocity (=VEL) directly (ooooo) or by variable (Vddd) in Units per second.
Value ooooo: 0.1 to 6000.0
Variable number V: ddd = 0 ... 255

A much more precise definition of velocity is possible using "Units per second" than using percentage of maximum speed.

ACC ccc %
ACC Vddd %

Meaning:
Selection of Acceleration rates. Entered directly (ccc) or by Variable (Vddd) as a % of maximum.
Value: ccc = 1 ... 100 %
Variable number V: ddd = 0 ... 255

Note:
When using Sin^2 acceleration mode, this value defines the slew rate for changing velocity (see chapter 7.1.2 - P 28). Maximum acceleration can only be changed by using Parameter P6.
ACC = 1 is smallest slew time (max. acceleration)
ACC = 100 is largest slew time (min. acceleration)

DEC ccc %
DEC Vddd %

Meaning:
Selection of Deceleration rates. Entered directly (ccc) or by Variable (Vdd) as a % maximum.
Value: ccc = 1 ... 100 %
Variable number V: ddd = 0 ... 255

Note:
When using Sin^2 acceleration mode, this value is irrelevant, because acceleration and deceleration are the same.
Input instructions are ignored.

WAIT bbbb ms
WAIT Vddd ms
WAIT Iyyy = H
WAIT Izzz = L

Meaning:
Halt program execution for the time period specified, or until the input condition is met.

- WAIT bbbb ms: Wait bbbb ms; bbbb = 0 ... 9999;
- WAIT Vddd ms: Wait for the number of milliseconds defined by variable Vddd; ddd = 0 ... 255.
- WAIT Iyyy = H: Wait until Input Iyy is HIGH (H = 1); yy = 0.01 ... 6.16
- WAIT Izzz = L: Wait until Input Izz is LOW (L = Ø); zz = 0.01 ... 6.16

SET Oxxx = L
SET Oxxx = H
SET Fvv = L*)
SET Fvv = H*)

Meaning:
Set Output Oxxx (output) to Ø or 1 (L or H); set Flag Fvv to Ø or 1.
Number of Flag F: vv = 0 ... 99
Number of Output O: xxx = 0.01 ... 6.16
*) Flags F94 - F99 are functionally dedicated.

SET Cvv = yyyy
SET Cvv = Vddd

Meaning:
Preset Counter Cvv to value yyyy or to the value of Variable Vddd.
Number of Counter C: vv = 0 ... 99
Counter value : yyyy = -9999 to +9999
Variable number: ddd = 0 ... 255.

SET Cvv = C + aaaa
SET Cvv = C + Vddd

Meaning:
Add to the present value of Counter Cvv the value aaaa or the value of Variable Vddd.
Number of Counter C: vv = 0 ... 99
Value: aaaa = -9999 to +9999
Variable number V: ddd = 0 ... 255.

S Vddd = vvvvv.vvv

Meaning:
Preset Variable Vddd to value vvvvv.vvv.
Variable number V: ddd = 0 ... 255.
Value: vvvvv.vvv = -99999,999 to +99999,999

SET Vddd = V [Cvv]

Meaning:
Preset Variable Vddd to the value which is in the Variable [Cvv].
Example: If Counter C01 is at value 5, and ddd = 00, then the value of V05 is entered into V00.

Application: Enables a variable list (look-up table) to be defined at the start of a program or by host computer, to allow use of a relatively short program.

Counter number C: vv = 0 ... 99
Variable number V: ddd = 0 ... 255.

TXT: ttttttttttt

Meaning: The given text (up to 12 characters) is displayed on the PT-1. (Only in "Auto" mode).

Application: For Status and Diagnostic display on the PT-1,

Example: TXT: COMMENT

SET Oxxx = Iyyy • Fvv

Meaning:
Set Output Oxxx to the Boolean AND function of Input Iyyy and Flag Fvv.

Number of Output O: xxx = 0.01 ... 6.16
Number of Input I: yyy = 0.01 ... 6.16
Number of Flag F: vv = 0 ... 99

SET Oxxx = Iyyy + Fvv

Meaning:
Set Output Oxxx to the Boolean OR function of Input Iyyy and Flag Fvv.

Number of Output O: xxx = 0.01 ... 6.16
Number of Input I: yyy = 0.01 ... 6.16
Number of Flag F: vv = 0 ... 99

SET Oxxx = Iyyy • Izzz

Meaning:
Set Output Oxxx to the Boolean AND function of Input Iyyy and Input Izzz.

Number of Output O: xxx = 0.01 ... 6.16
Number of Input I: yyy = 0.01 ... 6.16
Number of Input I: zzz = 0.01 ... 6.16

SET Oxxx = Iyyy + Izzz

Meaning:
Set Output Oxxx to the Boolean OR function of Input Iyyy and Input Izzz.

Number of Output O: xxx = 0.01 ... 6.16
Number of Input I: yyy = 0.01 ... 6.16
Number of Input I: zzz = 0.01 ... 6.16

SET Oxxx = Fvv • Fww

Meaning:
Set Output Oxxx to the Boolean AND function of Flag Fvv and Flag Fww.

Number of Output O: xxx = 0.01 ... 6.16
Number of Flag F: vv = 0 ... 99
Number of Flag F: ww = 0 ... 99

SET Oxxx = Fvv + Fww

Meaning:
Set Output Oxxx to the Boolean OR function of Flag Fvv and Flag Fww.

Number of Output O: xxx = 0.01 ...6.16
Number of Flag F: vv = 0 ... 99
Number of Flag F: ww = 0 ... 99

SET Fvv = Ixxx • Fww

Meaning:
Set Flag Fvv to the Boolean AND function of Input Ixxx and Flag Fww.

Number of Flag F: vv = 0 ... 99
Number of Input I: xxx = 0.01 ... 6.16
Number of Flag F: ww = 0 ... 99

SET Fvv = Ixxx + Fww

Meaning:
Set Flag Fvv to the Boolean OR function of Input Ixxx and Flag Fww.

Number of Flag F: vv = 0 ... 99
Number of Input I: xxx = 0.01 ... 6.16
Number of Flag F: ww = 0 ... 99

SET Fvv = Ixxx • Iyyy

Meaning:
Set Flag Fvv to the Boolean AND function of Input Ixxx and Input Iyyy.

Number of Flag F: vv = 0 ... 99
Number of Input I: xxx = 0.01 ... 6.16
Number of Input I: yyy = 0.01 ... 6.16

SET Fvv = Ixxx + Iyyy

Meaning:
Set Flag Fvv to the Boolean OR function of Input Ixxx and Input Iyyy.

Number of Flag F: vv = 0 ... 99
Number of Input I: xxx = 0.01 ... 6.16
Number of Input I: yyy = 0.01 ... 6.16

SET Fss = Fvv • Fww

Meaning:
Set Flag Fss to the Boolean AND function of Flag Fvv and Flag Fww.

Number of Flag F: ss = 0 ... 99
Number of Flag F: vv = 0 ... 99
Number of Flag F: ww = 0 ... 99

SET Fss = Fvv + Fww

Meaning:
Set Fag Fss to the Boolean OR function of Flag Fvv and Flag Fww.

Number of Flag F: ss = 0 ... 99
Number of Flag F: vv = 0 ... 99
Number of Flag F: ww = 0 ... 99

SET Vddd = Veee + Vfff

Meaning:
The result of the addition of Veee and Vfff is saved in Vddd.

Variable number V: eee = 0 ... 255
Variable number V: fff = 0... 255
Variable number V: ddd = 0 ... 255

SET Vddd = Veee - Vfff

Meaning:
The result of the subtraction of Vfff from Veee is saved in Vddd.

Variable number V: ddd = 0 ... 255
Variable number V: eee = 0 ... 255
Variable number V: fff = 0 ... 255

SET Vddd = Veee • Vfff

Meaning:
The result of the multiplication of Veee and Vfff is saved in Vddd.

Variable number V: ddd = 0 ... 255
Variable number V: eee = 0 ... 255
Variable number V: fff = 0 ... 255

SET Vddd = Veee : Vfff

Meaning:
The result of the division of Veee by Vfff is saved in Vddd.

Variable number V: ddd = 0 ... 255
Variable number V: eee = 0 ... 255
Variable number V: fff = 0 ... 255

SET Vddd = Veee

Meaning:
Variable Vddd is set equal to Veee.
Variable number V: dd d= 0 ... 255
Variable number V: eee = 0 ... 255

SKVddd = vvvvv.vvv

Meaning:
Add the value vvvvv.vvv to the present value of Vddd.

Variable number V: ddd = 0 ... 255
Value = vvvvv = -99999.999 ... +99999.999

IF Vddd > Veee Lvv

Meaning:
If Variable Vddd is greater than Variable Veee, then continue Program at Label Lvv.

Variable number V: ddd = 0 ... 255
Variable number V: eee = 0 ... 255
Number of Label L: vv = 0 ... 99

IF Vddd < Veee Lvv

IMeaning:
If Variable Vddd is smaller than Variable Veee, then continue Program at Label Lvv.

Variable number V: ddd = 0 ... 255
Variable number V: eee = 0 ... 255
Number of Label L: vv = 0 ... 99

IF Vddd = Veee Lvv

Meaning:
If Variable Vddd is equal to Variable Veee, then continue Program of Label Lvv

Variable number V: ddd = 0 ... 255
Variable number V: eee = 0 ... 255
Number of Label L: vv = 0 ... 99

IF > Vddd Lvv
IF < Vddd Lvv

Meaning:
Jump to Label Lvv if the position value in Vddd is > or < the Actual Position.

Variable number V: ddd = 0 ... 255
Number of Label L: vv = 0 ... 99

MOV Vddd → EEPROM

Meaning:
Variable Vddd is saved in EEPROM.
Variable number V: ddd = 0 ... 255

MOV EEPROM → RAM

Meaning:
All variables which are in RAM are over-written with values from EEPROM.

PA vvvvv.vvv DP

Meaning:
With a circular axis, or endless belt drive , the shortest route to an absolute position is used.
(DP = Direct Positioning).
Value: vvvvv.vvv = +99999.999 ... -99999.999

SET P = Vddd

Meaning:
The present position is set internally to the value of Vddd. The Reference and Actual position counters are set accordingly.

SET POS = ISTPOS

Meaning:
The present Actual position is used as the Reference position, and thereby the position controller is overridden.

SET Vddd = ISTPOS

Meaning:
The present Actual position is saved in Variable Vddd.

Variable number V: ddd = 0 ... 255

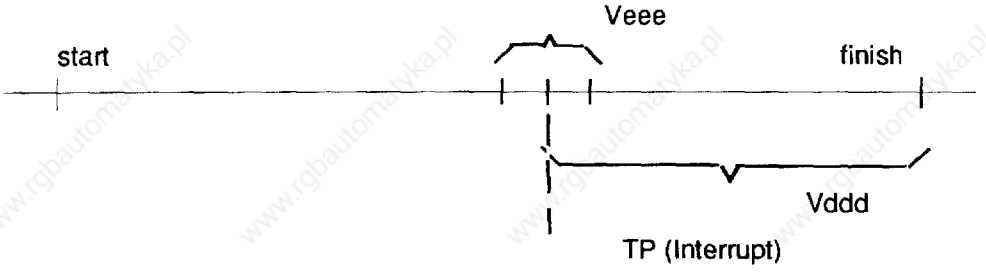
PTP +ppppp.ppp

Meaning:
During a positioning movement, an external signal (TP = Touch Probe) is anticipated. After the appearance of this signal, the distance +ppppp.ppp is covered.

NOTE:
If sin^2 acceleration is selected, the TP signal is accepted only when constant velocity is attained. If a TP input is received during acceleration or deceleration, then Flag F95 is set. The distance + ppppp.ppp that is still to be covered must be greater than the minimum stopping (braking) distance of the drive. A Position and Continue Program (....C) instruction should be used before this instruction.

Example:
```
PR  1000.000 C
PTP  100.000
IF F96 = H L10      Flag F96 indicates if TP signal is received.
```

PTP Vddd W = Veee



Meaning:
The PTP instruction is used to correct a previously started movement to an external input. When the TP (= Touch Probe) signal is received, the drive continues for the distance Vddd. The TP signal is accepted only in the "window" range Veee. If the TP signal is not received in the valid range , the Flag F96 is set: if a TP is accepted, F96 is reset.

PTP Vddd

Meaning:
The PTP Vddd instruction, in contrast with the PTP Vddd W = Veee instruction, specifies no "window" for the positioning distance. This means that after the start of positioning, the first TP signal is awaited. If the TP input is not received, the Flag F96 is set.

STP Vddd = ISTPOS

Meaning:
The Actual position is read into Variable Vddd during positioning: the moment this occurs is determined by the TP input.
Flags F95 and F96 are set as for other TP instructions.

SET SOLLP = Vddd

Meaning:
The Reference position is read from Variable Vddd. The aim position can be changed during a positioning movement. If the aim position is already passed, the axis reverses to it. Program execution continues after reaching the position aimed for.

SET Vddd = OVR

Meaning:
The analog value is read from the A/D converter into Variable Vddd. The analog value can lie in the range between 0 (-10V) and 4095 (+10V).

Condition:
The Analog Override option module must be inserted into the Feedback Module!

Description of the dedicated flags F94 to F99

F94

External Override Active
Status: H

F95

Touch Probe whilst Accelerating or Decelerating in $\sin^2$ mode.
Status: H

F96

Touch Probe not recognized.
Status: H

F97

Homed.
Status: H

F98

Acceleration mode:
Status: H = $\sin^2$
L = linear

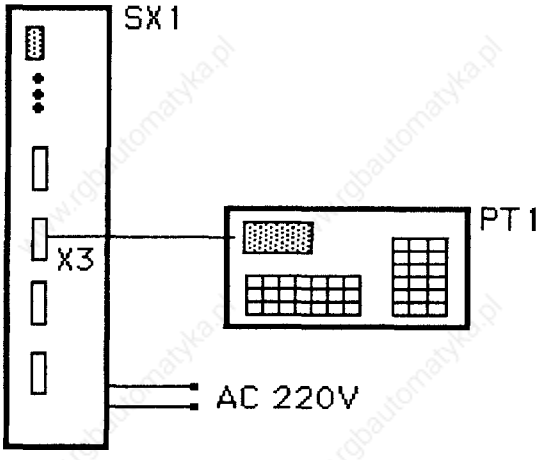
F99

Drive in motion
Status: H

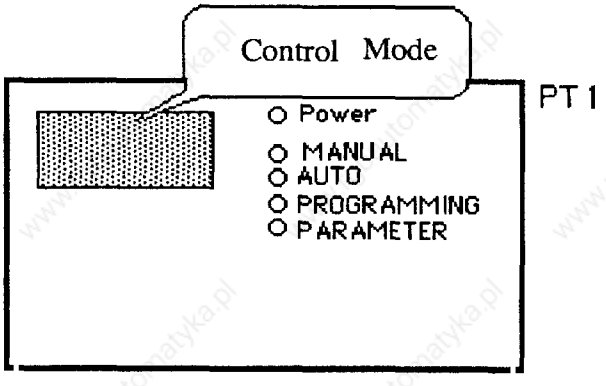
8.3 Program Entry

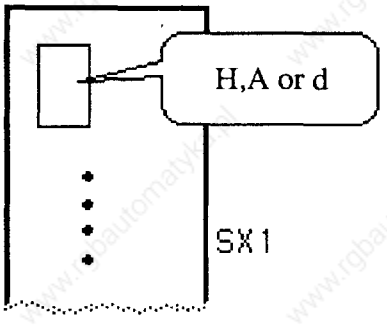
To Enter a Program, proceed as follows:

1. Connect the PT-1 to connector X3 of the SX-1 (the SX-1 supplies power to the PT-1).

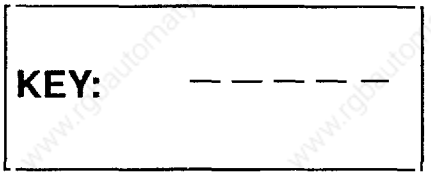


The PT-1 displays the operating mode pre-selected via Inputs on connector X1. This is displayed on the LCD display and corresponding LED on the PT-1, and on the 7-segment display of the SX-1.





2. Press PAR/KEY key.
   The PROGRAMMING and PARAMETER LED´s light together. The PT-1 awaits the entry of the Code number "key" to allow entry of the Program (see Chapter 11).



3. Type in the code number: finish with ENTER.

```
P Ø (TYP. Ø)
H-V14
Pgm #
Resol.
```

The PROGRAMMING LED is extinguished, and PARAMETER remains on.

5. Press the PROG key. The menu shown at the side appears. Position the cursor with the MODE key, according to whether you wish to Edit a Program, create a New Program, Erase a Program, or List the Programs. (For further details of these functions, see the end of this Chapter).

```
Edit        PGM <
New         PGM
Erase       PGM
List of     PGM´s
```

6. Here: Select "New PGM" in the second line using the MODE key, and press ENTER.

```
Program in PT-1 will be
erased
Pgm No =        — — —
```

7. The required Program number must now be chosen: e. g. type 6 and press ENTER.

```
Blk: Ø          M:  16

BEG    M     ØØØØØ6
END    M     ØØØØØ6
```

Line 1
Blk: = number of instructions in working line
M: 16 = amount of memory required
Line 2
empty
Line 3 and 4:
Beginning and End of Main Program M6.

7. Press INS (= Insert) key.

```
Blk:  Ø         M:  16
BEG   M       ØØØØØ6
>
END   M       ØØØØØ6
```

The cursor is inserted between the BEG and END instructions. The PT-1 is now ready for the entry of program instructions.

When entering the Program instructions, you should in general use the following sequence of keystrokes:

1. Press the required instruction key, e.g. WAIT	The instruction is displayed (e. g. from a group of similar instruction, in this case the "Wait" group), but without values.
2. Press the MODE key until the specific instruction in the group is displayed.	Here, for example, if the MODE key is pressed twice: WAIT I = L appears. The value following input I is empty.
3. Press ENTER.	At the place for value entry, the appropriate number of dashes _ _ _ _ appears (the last one blinking).
4. Enter the value with the numeric keypad, e.g. here type 2, and press ENTER.	The value is accepted, the display moves up one line, making room for the next instruction.

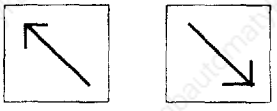
Note:

When you have selected the IF, POS and SET instruction groups, you may select the sub-groups using the NEXT and MODE keys.

IF	**IF I . . H Lvv (Uww)**	MODE	**IF I . . L Lvv (Uww)**
NEXT	**IF F . . H Lvv (Uww)**	MODE	**IF F . . L Lvv (Uww)**
NEXT	**IF C . . aaaa Lvv**	MODE	**IF C . . aaaa Uww**

There are six functions available for entering and editing programs:

LOAD	(Load a Program from the SX-1 to the PT-1)
SAVE	(Save a Program from the PT-1 to the SX-1)
	NOTE: After the **SAVE** function, the control must not be switched off immediately.
EDIT	(A Program in the PT1 may be edited)
NEW PGM	(Enter a new Program)
DELETE PGM	(Erase/Delete a Program)
LIST OF PGM´s	(The Directory of all Programs in the SX-1 is displayed)
	Scroll with the arrow-keys



LOAD

1. After selecting PAR, entering the code number, and switching to PROG, the main menu is displayed.

```
Edit        PGM  <
New         PGM
Erase       PGM
List of     PGM´s
```

2. LOAD

The message is displayed:

```
Program in PT 1
will be erased
Pgm No = ----------
```

3. Enter the required Program number, e. g. 4

```
Program in PT 1
will be erased
PGm No =      4
```

4. ENTER

The main menu is again displayed:

```
Edit        PGM  <
New         PGM
Erase       PGM
List of     PGM´s
```

5. ENTER

The first line of the selected program is displayed.

```
Blk:  27  M:   58

BEG   M ØØØØØ4
PA        22.4 V
```

6. FIND

Search for the required Instruction/ Block number
or

7. ↖ ↘

Scroll through the instruction numbers.

Completion of Program Entry

1. After the last instruction of a new or edited Program is entered, press ENTER once more.

```
Blk:  16  M:    53
PR +        22.3ØØ
PR +        17.2ØØ
WAIT          10 ms
```

2. ENTER

```
Pgm iO (Øs   ØL)
```

This message is displayed briefly (the Program is checked for syntax errors: if any are found, they are displayed in normal text), and then the main menu appears:

```
Edit        PGM
New         PGM
Erase       PGM
List of     PGM´s
```

SAVE

3. Now press the SAVE key:

SAVE

```
Save      to  Axis ØØ

o.k.      =   <ENTER>
Axis ?    =   < MODE >
```

Now the number of the axis to which the Program relates is requested. If the number at the top right is correct, press <ENTER>. If another axis is required, press the MODE key, enter the number, and press ENTER.

After a short time, the main menu re-appears.

EDIT

When the main menu is displayed, select the EDIT mode using the MODE key to move the cursor to EDIT.

Commence the function using the ENTER key. Now the Program displayed may be edited.

NEW PGM

If the main menu is displayed, select NEW PGM on the second line by using the MODE key to move the cursor to it.

Commence with ENTER:

ENTER

```
Program in PT-1
will be erased
Pgm No = ----------
```

After the entry of the new number and ending with ENTER, the present Program in the PT-1 is deleted, and the BEG(inning) and END instruction of the new Program appear.

ENTER

```
BLK : Ø  M:     16

BEG   M  ØØØØØ3
END   M  ØØØØØ3
```

See the beginning of this chapter for further details.

Erase PGM

If the main menu is displayed, select ERASE PGM on the third line by using the MODE key to move the cursor to it.

Commence with ENTER:

ENTER

```
Erase      PGM
PgmNo = -------
```

The Program to be deleted is requested. Enter the number and press ENTER.

ENTER

```
Edit       PGM
New        PGM
ERASE      PGM
List of    PGM's
```

The program is deleted and the main menu re-appears.

LIST OF PGM´s

If the main menu is displayed , select LIST OF PGM´s on the last line by using the MODE key to move the cursor to it.

Commence with ENTER:

ENTER

```
List of PGM´s
1 = PGM ØØØØØ1
2 = PGM ØØØØØ4
3 = PGM ØØØØ12
```

To display further Programs, use the arrow keys. When the last program is displayed, the fourth line remains empty.

Function Commands for Editing

Four Functions are available for handling instructions whilst programming:

DELETE (Delete an Instruction)
INSERT (Insert an Instruction)
TEACH (Insert one or more "taught" position movements)
LABEL (Jump address label)

DELETE

Pressing this key deletes the instruction at working line 3.

INSERT

When this key is used, the instruction in working line 3 is scrolled up, and a space is inserted after it, indicated with a ">" symbol.
The empty line is maintained after every instruction is entered, so that several instructions may be entered in succession. Press the enter key to leave this function.

TEACH

When this key is used, the instruction in working line 3 is scrolled up, and a positioning instruction PA is inserted after it. If the POS key is now pressed, the present Actual Position value is read, and a position instruction with the same value is inserted by pressing the ENTER key.

The TEACH-Function is then completed.

With the TEACH-Function, it is possible to drive to each position required in the Manual-External mode, and then enter these into the Program.

LABEL

Any instruction in the Program may be given a Label. This is necessary to define the destination address for a jump instruction.

The label number must be entered by pressing the LAB key BEFORE entry of an instruction in line 2. The label number is entered.

Every label L-instruction must be followed by the label number and then a program instruction, e. g.

```
L     13
VEL   90 %
```

8.4 Entry of Variable Data

It is always possible to enter or change data in those Variables which have been selected and named during Parameter entry. A code key number is not required.
The entry of Variable data is initiated as follows:

a) If a key code number has not yet been entered, press PROG/VAR key.

b) If a key code number has already been entered, either: Press PAR/KEY and ENTER (the key code validity is cancelled), or Press PROG/VAR twice (the key code validity is preserved).

1. PROG

   Briefly displayed in sequence:

Get
Installation data
Variables Loading

2. Then the first three Variables appear, with their values, if entered: otherwise values are Ø.

INPUT VAR	**VØØØ**	
Length	**ØØ**	= V000
Speed	**Ø**	= V001
Distance	**ØØØ**	= V002

3. For the entry of Variable data, line 2 is the working line. Use the arrow keys to place the required Variable there.

   ↖ ↘

e. g.

V002
Distance + Ø.ØØØ

4. Prepare for entry with the MODE key:

   MODE

V002
Distance + -.---

5. Enter the value with the numeric keypad.

V002
Distance + 8.12Ø

6. Enter with:

ENTER

Hint:

If an entry is invalid (too small or too large), then it is briefly displayed and the entry ignored.

The Variable data are only held in the buffer memory, and must be re-entered when the control is switched on again.

7. Save

SAVE

By using the SAVE key, the Variable data are loaded into EEPROM. When the control is switched on again, the Program uses the SAVED data.
Data entry may be performed whilst the Program is running.

8.5 Display and Editing Variable Values

After entering Variable values, they are immediately saved to the SX-1 (without pressing SAVE).

Variable values may also be changed whilst the Program is running:

a) by the user
b) from the Program itself. A display of the current values is possible by pressing the PROG/VAR key.
c) by parallel communications link data (option) with the aid of a PLC or from decade switches.

(See also Chapter 8.4)

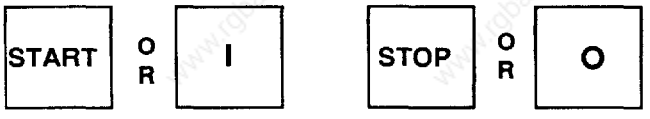
8.6 Selecting and Running a Program

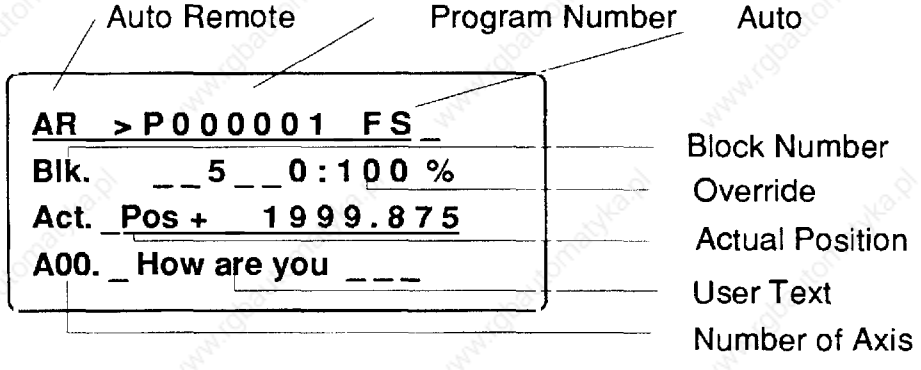
Automatic External

In this mode, the main Program whose number is given by Parameter PO is run. The use of the PT-1 is not necessary, but it may be connected for monitoring purposes (control of Actual position, display of Following Error, Text reports, etc.)
(For further details, see "Auto External" mode, Chapter 4.3)

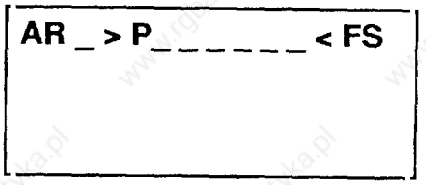
Automatic Remote Mode

In this mode, it is possible to use the PT-1 to select a Program from an archive of up to 20 Programs in the SX-1 controller, and to control it using the function keys.



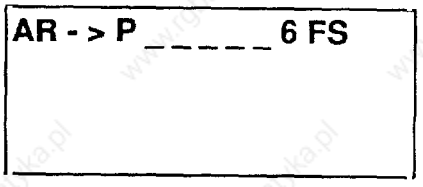


Program number selection and choice of Single Step (S-ST) or Continuous (Auto) running mode may only be performed when a Program is not running.



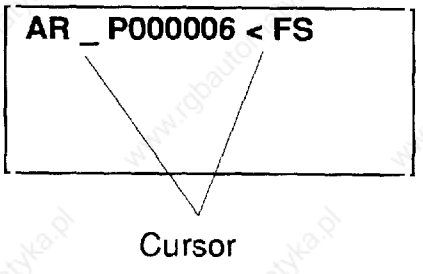
First choose a Program number.

Move the cursor to **P** using the **MODE** key, press **ENTER**, and the old Program number is deleted.



Enter a new Program number (e. g. 6) Save the number with the **ENTER** key. Now program number 6 may be started.

The change from "Auto" to "Step" mode can only be made after entering a key code number.



Move the cursor to "Auto" using the **MODE** key, and use the **ENTER** key to select:
"Auto" = Continuous Program operation
"Step" = Single Step Program operation

The **START** key is used to start each instruction in the "Step"mode.

(For further details, see also "Auto Remote" mode, Chapter 4.1.2)

8.7 Central Archiving of Programs and Parameters

Programs and Parameters may be archived using the data communications link. Software packages are available for the Siemens PG 675 and 685, and IBM AT and XT.

Please enquire for further information.

8.8 Axis Identification

When the SX-1 is Switched On or Reset, an Axis Identification number is displayed.

Example: Sequential display of

A = Axis ØØ
0
-
0

8.9 Software Identification

When the SX-1 is Switched On or Reset, a Software Identification number is displayed after the Axis Identification.

Example:

Software Identification e. g. Release 5.10
Pause
Axis Identification

9. Error Messages and Correction

Any error arising is displayed both on the 7-Segment display of the SX-1 and on the PT-1.

The SX-1 sequentially displays the error by a letter "E" followed by a 2-digit number.

The following errors are possible:

Error Code	Meaning	Possible Cause and Remedy
00	Internal fault	Press Reset key
01	End Switch approached Negative Limit	Return drive to working area
02	End Switch approached Positive Limit	Return drive to working area
03	Selected SX-1 missing	Check 24 Vdc External supply: Enable SX-1, Connector X2 pin 2, and on Connector X1 pins 13/25.
04	Position Feedback	Check power supply for encoder
05	Gain factor out of tolerance; motor not following the control command (incorrect rpm/volt)	Motor overloaded: check dimensioning, acceleration or velocity too high: reduce. Direction incorrect: reverse polarity (P12 or P13)
06	Servo Power failure	Connector X2 Pin 10: external power supply missing
07	Encoder watchdog	No encoder pulses present
08	Invalid Control command	Internal error
09	Left limit of travel is reached	Check Program; Home; Check -ve Software limit P9
10	Right limit of travel is reached	Check Program; Home; Check +ve Software limit P10

11	System set to Endless mode: does not allow Absolute positioning !	Change Program
12	Two operating modes selected!	Only in version 5.X
13	Ouput not present	Change Program
14	Mode selection incorrect	Check coding switch
15	Home position no found	Home
16	Excessive positioning time	Position window, KV value too small
17	Change of Acceleration mode not allowed	Check Program
18	Not used	
19	Instruction (present) not allowed, e. g. Override with $\sin^2$ mode	Check Program
20	Incorrect instruction	Internal error
21	Arithmetic overflow	Check input data
22	Stack Overflow	Check Program; memory capacity exceeded
23	Stack Underflow	Check Program
24	Program not present	Provide Program; check Parameter P0 - Program selection
25	Program memory full	
26	Not used	
27	Invalid Parameter data	Check Parameters with respect to data limits
28	Velocity too high	Check Parameters with respect to data limits
29	Excessive Following Error	Check Parameters with respect to data limits
30	Not used	

31	Acceleration max. too small	Check Parameters with respect to data limits
32	Acceleration max. too large	Check Parameters with respect to data limits
33	Marker (Zero) pulse missing when Homing	Check Parameter P2 (Encoder count)
34	Invalid command over comms. link	Only possible under DNC control
35	Home switch not found	Check switch
36	Position feedback detects no motion	Check encoder, encoder cables, and encoder coupling
37	Not used	

Error Codes 38 through 44 cover error which can only occur when coupled in interpolating mode.

38	Slave error whilst interpolating (on Master LED)	Read error code on Slave LED and correct
39	Master error whilst interpolating (on Slave LED)	Read error code on Master LED and correct
40	Instruction only for Master axis	Check Program
41	Instruction only for Slave axis	Check Program
42	Initialising of Master detects error	Internal error
43	Incorrect information whilst interpolating, in Slave	Internal error
44	Incorrect information whilst interpolating, in Master	Internal error
45	Parameters missing; Error when Saving Parameters or Programs	After initiating a SAVE-function, the SX-1 must remain switched on for sufficient time to ensure safe programming of the EEPROM

Correcting an Error

There are three types of error and error correction as follows:

a) Errors resulting from unusable Parameter data read upon switch-on. They can be corrected only by the entry of new or corrected Parameters.

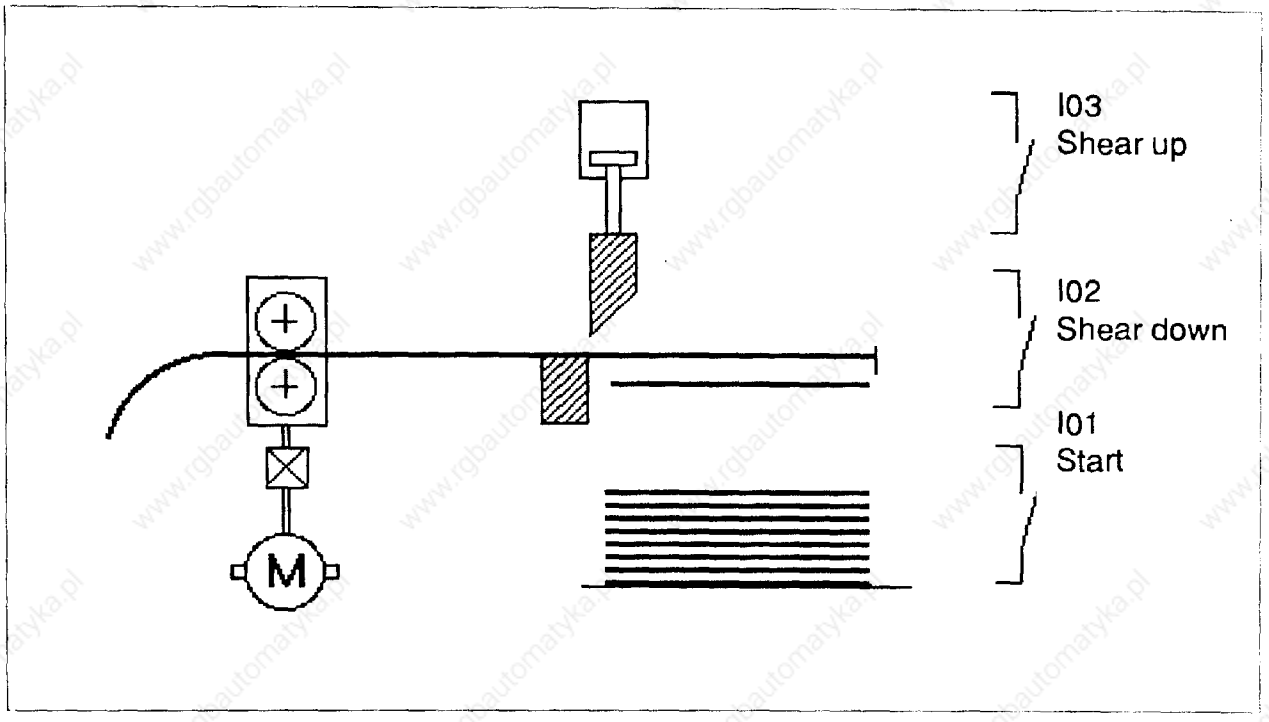
b) Errors arising when the SX-1 is executing a Program, or being manually operated. Program execution is stopped. The error may be cancelled by positive edge on Input E1 (Enable SX-1).

c) Serious errors which affect the functioning of the Position control (Errors E03, E04, E05). As well as reporting the error, the drive Enable is removed. Program execution is stopped. If the cause of the error is removed, and the error is cancelled as in b), the drive is enabled and the position loop restored.

All error outputs result in the opening of the "NC Healthy" output contact. The drive must thereby be stopped and secured, e. g. power removed and the brake applied (if fitted).

See also Chapter 6.

10. Application Examples
10.1 Cut-off line (Shear)



A d.c. motor feeds sheet metal from a coil through a pair of rollers to the Shear. The metal sheet must be cut off to the specified length.

Program

	BEG M000001	Start of main program 1
L00	WAIT I01 = H	Wait for Start signal
	VEL 100 %	Maximum Velocity
	ACC 100 %	Maximum Acceleration
	DEC 100 %	Maximum Deceleration
	PR 500.00	Feed 500,000 mm
	SET O01 = H	Shear down
	WAIT I 02 = H	Wait till Shear is down
	SET O01 = L	Shear up
	WAIT I03 = H	Wait till Shear is up
	JMP L00	Loop to Start instruction
	END M000001	End of main program 1

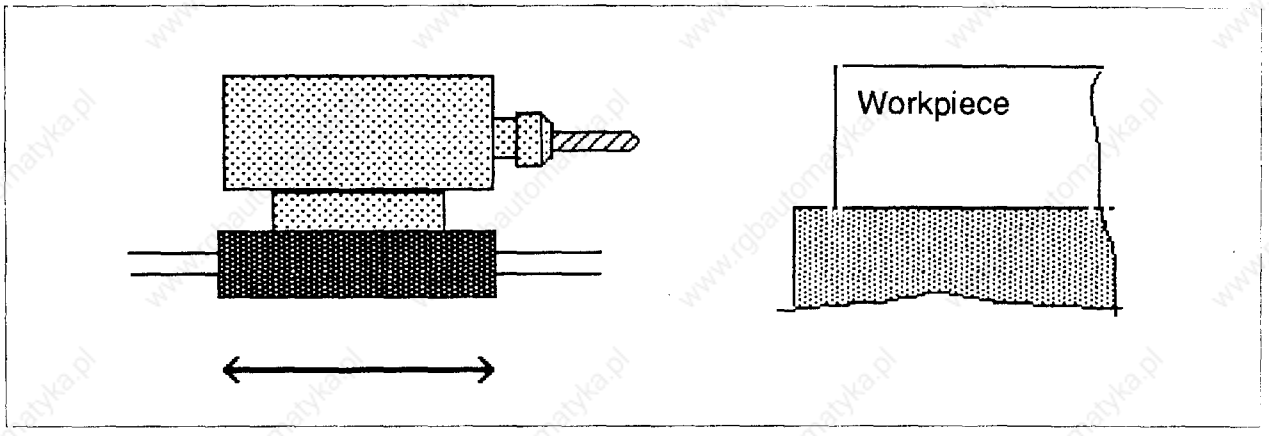
The example above shows how easily a program can be adapted to an application. However, it may be seen that to change the Cut-off length involves a change in the Program itself. For this reason, Variables are provided to allow access to data within the program, at operator level.

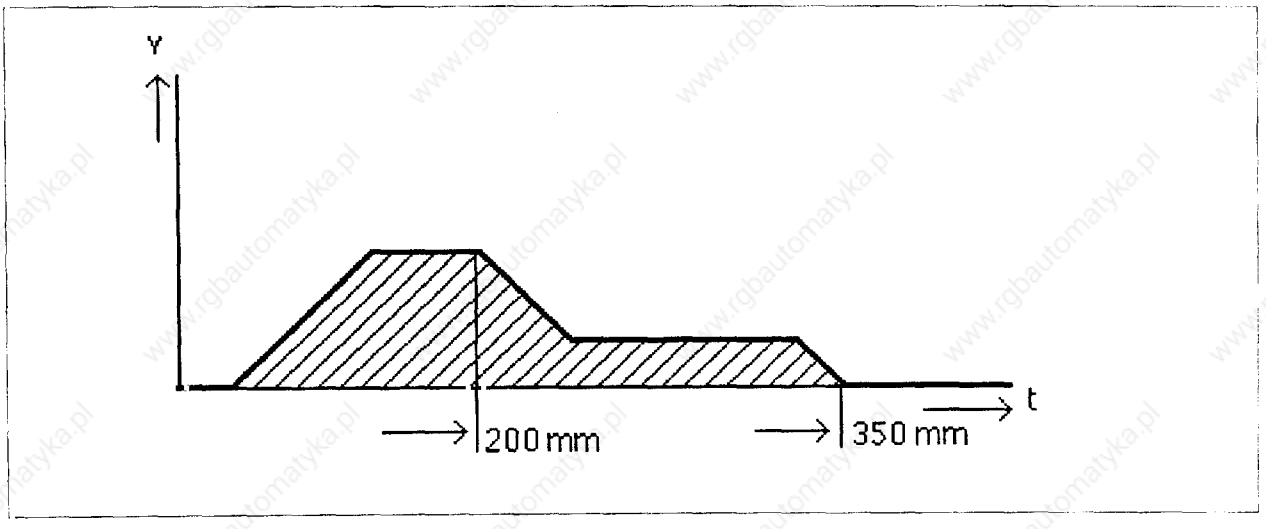
The program could be as following:

```
        BEG M000001
L00     WAIT I01 = H
        VEL % V00 ———————— The Velocity is defined by
        ACC 100 %          Variable V00.
        DEC 100 %
        PR V01 ———————————— The cut-off length is defined by
        SET O01 = H        Variable V01.
        WAIT I01 = H
        SET O01 = L
        WAIT I03 = H
        JMP L00
        END H000001
```

The machine operator thus has the ability to change the length of the sheets and the line speed with the aid of a simple "menu", similar in effect to a decade switch.

10.2 Transfer Unit





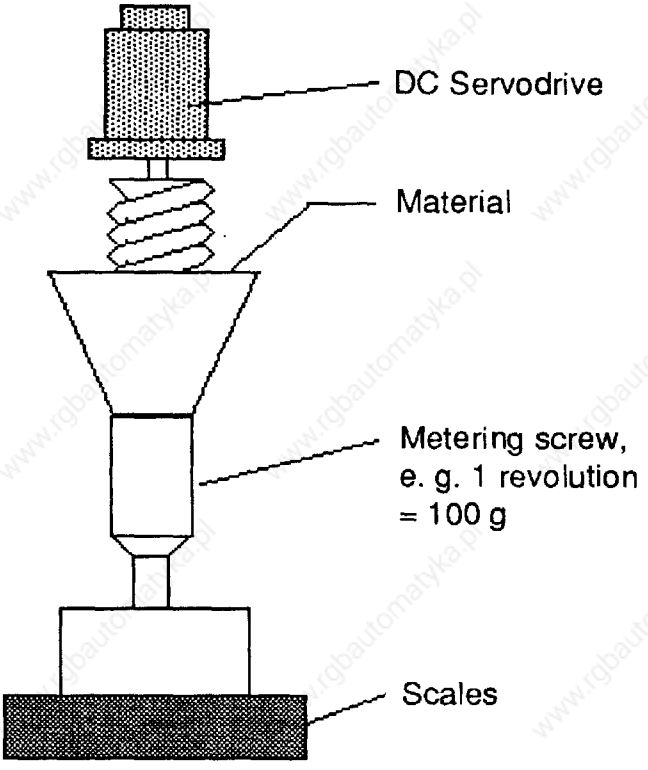
A hole is to be drilled in a workpiece. Therefore the unit must traverse close to the workpiece at high speed, then move at feed-speed for drilling. It must finally traverse back to the start position. During drilling, a check for drill breakage takes place: if this occurs, it must stop immediately and return to the start position.

Program

```
        BEG M000001     Start of main program  1
L00     WAIT I01 = L
        WAIT I01 = H    Wait for Start edge
        SET O02 = L     Reset "Ready" signal
        PA 200.000 V    Traverse to 200 mm/continue at 10 %
        PA 350.000 C    Feed to 350 mm and continue program
L02     IF F99 = L, L01 Check if drive has stopped
        IF I02 = L, L02 Check if drill has broken
        JMP S01         Jump to Subroutine for drill breakage
L01     WAIT 250 ms     Wait for cut to "clean up"
        VEL 100 %       Velocity 100 %
        PA 0.000        Return to Start  position
        SET O02 = H     "Ready" signal
        JMP L00         Loop to Start
        END M000001

        BEG S01         Start of Subroutine S01
        STOP            Stop drive
        SET O01 H       Report fault
        WAIT I 02 = L   Wait for acceptance of drill breakage
        SET O01 = L
        END S01
```

10.3 Bottling and Weighing Machine



The material is fed into its container using a metering screw. The amount of material is proportional to the movement of the screw, which is positioned with a Servomotor. To correct for density variations in the material, a sample is weighed every 100 fillings, and the amount is corrected for over- or under-weight.

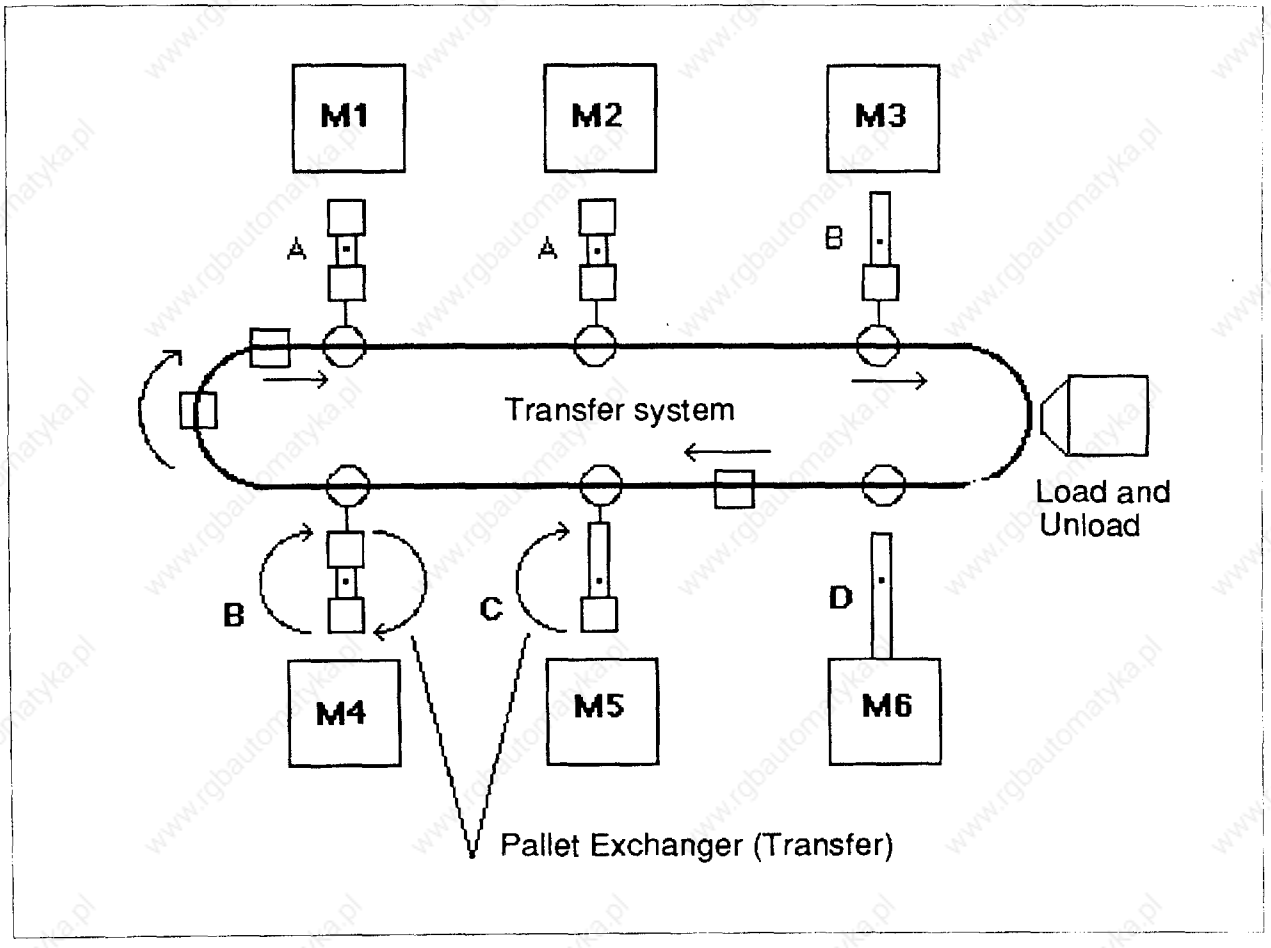
Program

```
        BEG M000004
        SET V00 = 1000.000      Set Variable V00 = 1000.000
L02     SET C00 = 0             Set Counter C00 = 0
L00     WAIT I01 = H            Wait for Start
        PR V00                  Meter 1000.000 g ± correction
        SET C00 = C + 1
        IF C00 > 100 L01        If counter > 100 then weigh sample
        JMP L00                 Return to Start
L01     SET O01 = H             Activate Scales
        WAIT 100 ms             Wait 100 ms
        IF I02 = H, S01         If Input I02 —> too little
        IF I03 = H, S02         If Input I03 —> too much
        SET O01 = L             Scales off
        JMP L02
        END M000004

        BEG S01
        SKV 00 = + 10.000       Set Variable V 00 + 10.000
        END S01

        BEG S02
        SKV 00 = - 10.000       Set Variable V  00 - 10.000
        END S02
```

10.4 Material Transfer



A transfer loop has several workstations, which operate on the workpieces. The required workstation for each workpiece is defined by 3 (binary-coded) inputs. The NC system should select the shortest direction to take to the workstation.

Program

```
        BEG M000001
L00     WAIT I04 = L            Wait for Start signal
        WAIT I04 = H
        JMP S01                 Read  input value and assign  to Counter C00

        IF C00 = 1  L01         Position 1
        IF C00 = 2  L02         Position 2
        IF C00 = 3  L03         Position 3
        IF C00 = 4  L04         Position 4
        IF C00 = 5  L05         Position 5
        IF C00 = 6  L06         Position 6
        IF C00 = 7  L00         Invalid Input

        PA 0.000 DP             Drive to Load/Unload position
        JMP S02                 Generate "Ready" signal
        JMP L00                 Return to Start

L01     PA 540.000 DP           Drive to Position 1
        JMP S02                 Generate "Ready" signal
        JMP L00

L02     PA 1020.000 DP          Drive to Position 2
        JMP S02                 Generate "Ready" signal
        JMP L00

L03
L04     Similar Positioning movements
L05

L06     PA 3400.000 DP          Drive to position 6
        JMP S02                 Generate "Ready" signal
        JMP L00
        END M000001

        BEG S01                 Subroutine for reading Binary-coded inputs
                                I01 through I03 to Counter C00
        SET  C00 = 0            Preset counter to 0
        IF I01 = L  L07
        SET  C00 = C + 1        Input I01 with weighting 1
L07     IF I02 = L  L08
        SET  C00 = C + 2        Input I02 with weighting 2
L08     IF I03 = L  L09
        SET  C00 = C + 4        Input I03 with weighting 4
L09     END S01
```

```
BEG S02          Generate "Read" signal
SET 001 = H      Impulse Output 001 for 500 ms
WAIT 500 ms
SET O01 = L
END S02
```

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11. User Key Codes

To enter a Program or Parameters, a code number must first be entered by selecting "Parameter" on the PT-1, whereupon "KEY" appears.

Depending on which Parameters you wish to edit or enter, you must use the appropriate key.

The following chart shows which code numbers are necessary to allow access to the Parameters.

Code:	**None**	**1000**	**2000**	**3333**
	Variable Data	Program P0 Pgm £ P7 MAN S P8 MAN F P9 Lim - P10 Lim+ P11 Ofset P14 Tool + P15 Tool - P26 Hom V	Program P1 Resol P2 IPR P3 Vo/Vm P4 Tscan P5 max V P6 max A P12 Ssign P13 Esign P21 ErLim P22 Pos W P25 Hom M P27 Hom N P28 Ramp P29 Pos M P30 End-M P31 Var-M P32 U/rev Variable- Definitions (P33 - P99)	Program P16 KV Ø P17 KV 1 P18 KV 2 P19 BP 1 P20 BP 2 P23 I-Fct P24 Test

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12. Instructions

(Version 5.10 January 1989)

Instruction	Meaning	Memory Used
BEG Hnnnnnn	Start of Main Program nnnnnn	5
BEG Uww	Start of Subroutine ww	2
END Hnnnnnn	End of Main Program nnnnnn	5
END Uww	End of Subroutine ww	2
HOME	Home sequence	1
VEL ccc %	Velocity preset to 1-100 %	2
VEL oooo.o U/s	Velocity preset in Units/second	3
VEL Vddd %	Velocity preset to % by Variable	2
VEL Vddd U/s	Velocity preset in U/s by Variable	2
ACC ccc %	Acceleration preset to 1-100 %	2
DEC ccc %	Deceleration preset to 1-100 %	2
ACC Vddd %	Acceleration in % by Variable	2
DEC Vddd %	Deceleration in % by Variable	2
JMP Lww	Jump to Label	6
JMP Uww	Jump to Subroutine	6
WAIT bbbb ms	Wait for bbbb milliseconds	3
WAIT Ixxx = H	Wait till Input xx is high	2
WAIT Ixxx = L	Wait till Input xx is low	2
WAIT Vddd ms	Wait for period by Variable in ms	2
TXT: ttttttttttt	Any 12 characters for display on PT-1	13
PA vvvvv.vvv	Position Absolute	5
PA vvvvv.vvv Vend	Position Absolute with Continue (Vend = ccc %)	5
PR vvvvv.vvv	Position Relative	5
PR vvvvv.vvv Vend	Position Relative with Continue (Vend = ccc %)	5
PA vvvvv.vvv C	Position Absolute and Continue Program	5
PR vvvvv.vvv C	Position Relative and Continue Program	5
STOP	Stop axis immediately	1
PA Vddd	Position Absolute by Variable	2
PA Vddd Vel = Veee	Position Absolute with Continue by Variable (Vee = [Units/s])	2
PR Vddd	Position Relative by Variable	2
PR Vddd Vel = Veee	Position Relative with Continue by Variable (Vee = [Units/s])	2

PA Vddd C	Position Absolute and Continue by Variable	2
PR Vddd C	Position Relative and Continue by Variable	2
LRvvvvv.vvv Mhh	Linear interpolation Relative of Master with Slave hh	6
LRvvvvv.vvvS	Linear interpolation Relative of Slave	5
LRvvvvv.vvvST Tvvvvv.vvv	Linear interpolation Relative of Slave with turning point (e. g. spooling)	9
LR Vddd MSThh	Linear interpolation Relative of Master with Slaves hh by Variable	6
LR Vddd Slave	Linear interpolation Relative of Slave by Variable	5
LR Vddd W = Veee	Linear interpolation Relative of Slaves with turning point (e. g. spooling) by Variable	9
PAvvvvv.vvv DP	Position Absolute by shortest route	5
PTP ppppp.ppp	Position to Interrupt by Constant	5
PTP Vddd W = Veee	Position to Interrupt by Variable	3
PTP Vddd	Position to Interrupt by Variable (no Window)	3
STP Vddd = ISTPOS	Set Variable = Actual Position by TP	2
SET P = Vddd	Set required position to Vdd value	2
SET Vddd = OVR	Set Variable to Override value	2
SET Oxxx = L	Set Output xxx Low	2
SET Oxxx = H	Set Output xxx High	2
SET Fww = L	Set Flag xx Low	2
SET Fww = H	Set Flag xx High	2
SET Cww = aaaa	Set Counter ww to aaaa	4
SET Cww = C + aaaa	Add aaaa to Counter ww	4
SET Oxxx = Iyyy*Fuu	Set Output xxx = Input yyy AND Flag uu	4
SET Oxxx = Iyyy + Fuu	Set Output xxx = Input yyy OR Flag uu	4
SET Oxxx = Iyyy*Izzz	Set Output xxx = Input yyy AND Input zzz	4
SET Oxxx = Iyyy + Izzz	Set Output xxx = Input yyy OR Input zzz	4
SET Oxxx = Fww*Fuu	Set Output xxx = Flag ww AND Flag uu	4
SET Oxxx = Fww + Fuu	Set Output xxx = Flag ww OR Flag uu	4

SET Fuu = Ixxx*Fww	Set Flag uu = Input xxx AND Flag ww	4
SET Fuu = Ixxx + Fww	Set Flag uu = Input xxx OR Flag ww	4
SET Fuu = Ixxx*Iyyy	Set Flag uu = Input xxx AND Input yyy	4
SET Fuu = Ixxx + Iyyy	Set Flag uu = Input xxx OR Input yyy	4
SET Fuu = Fss*Fww	Set Flag uu = Flag ss AND Flag ww	4
SET Fuu = Fss + Fww	Set Flag uu = Flag ss OR Flag ww	4
SET V [Cuu] = Vddd	Set Variable by Counter to Variable	
S Vddd = vvvvv.vvv	Set Variable	6
SET Vddd = V [Cuu]	Set Variable = Variable by Counter	3
SET Cuu = Vddd	Set Counter by Variable	3
SET Cuu = C + Vddd	Set Counter = Counter + Variable	3
SKVddd = vvvvv.vvv	Set Variable = Variable + Constant	6
SET Vddd = Veee + Vfff	Set Variable = Variable + Variable	4
SET Vddd = Veee - Vfff	Set Variable = Variable - Variable	4
SET Vddd = Veee * Vfff	Set Variable = Variable * Variable	4
SET Vddd = Veee : Vfff	Set Variable = Variable : Variable	4
SET Vddd = Veee	Set Variable = Variable	3
SET Vddd = ISTPOS	Set Variable = Actual Position	2
SET POS = ISTPOS	Set Required Position = Actual Position	1
SET P = Vddd	Set Position by Variable	5
MOV Vddd --> EEPROM	Copy Variable into EEPROM	2
MOV EEPROM -- > VAR	Copy all Variables from EEPROM to RAM	1
IF Ixxx = H Sww	If Input xxx = High go to Subroutine ww	7
IF Ixxx = L Sww	If Input xxx = Low go to Subroutine ww	7
IF Ixxx = H Lww	If Input xxx = High jump to Label ww	7
IF Ixxx = L Lww	If Input xxx = Low jump to Label ww	7
IF Fuu = H Sww	If Flag uu = High go to Subroutine ww	7
IF Fuu = L Sww	If Flag uu = Low go to Subroutine ww	7
IF Fuu = H Lww	If Flag uu = High jump to Label ww	7
IF Fuu = L Lww	If Flag uu = Low jump to Label ww	7
IF Cuu = aaaa Sww	If Counter uu = aaaa then go to Sww	7
IF Cuu < aaaa Sww	If Counter uu less than aaaa then Sww	7
IF Cuu > aaaa Sww	If Counter uu more than aaaa then Sww	7
IF Cuu = aaaa Lww	If Counter uu = aaaa then go to Lww	7
IF Cuu < aaaa Lww	If Counter uu less than aaaa then Lww	7
IF Cuu > aaaa Lww	If Counter uu more than aaaa then Lww	7

IF > vvvvv.vvv Luu	Jump to Label uu if Position > Actual Position	10
IF < vvvvv.vvv Luu	Jump to Label uu if Position < Actual Position	10
IF > Vddd Luu	Jump to Label uu if Position > Actual Position	7
IF < Vddd Luu	Jump to Label uu if Position < Actual Position	7
IF Vddd > Veee Luu	Jump to Label uu when Vddd > Veee	8
IF Vddd < Veee Luu	Jump to Label uu when Vddd < Veee	8
IF Vddd = Veee Luu	Jump to Label uu when Vddd = Veee	8

Explanations:

xxx	= Numbers between 0 01 and 0 08 (6 16)
yyy	= Numbers between 0 01 and 0 08 (6 16)
zzz	= Numbers between 0 01 and 0 08 (6 16)
ww	= Numbers between 0 and 99
uu	= Numbers between 0 and 99
ss	= Numbers between 0 and 99
ddd	= Numbers between 0 and 255
eee	= Numbers between 0 and 255
fff	= Numbers between 0 and 255
ggg	= Numbers between 1 and 125
hh	= Numbers 01, 02, 03, 12, 13 and 23
aaaa	= Numbers from -9999 to +9999
bbbb	= Numbers from 0 to +9999
oooo.o	= Numbers from 0.01 to 6000.0
ccc	= Numbers from 1 to 100
nnnnnn	= Numbers from 1 to 999999
vvvvv.vvv	= Numbers from -99999.999 to + 99999.999
ppppp.ppp	= Numbers from 0 to +99999.999
>	Greater than
<	Smaller than
=	Equal to
*	Logical "AND"
+	Logical "OR"
ttttttttttt	12 ASCII Characters

Calling and Operating the Menus

Summary

Menu	Manual control from PT-1	"Programming"
Calling a Menu	MAN	PROG VARI
Selecting part of Menu	MODE	MODE
Entering selected parts	ENTER	ENTER
Working with selected item	Details: See Chapter 4.4	Activation of basic commands
	Enter required data using PT-1, possibly with a preparatory ENTER	Activate commands with function key pad. Select instruction with these keys: MODE, NEXT ↘
		Enter required data from PT-1, possible with an ENTER to activate
		Details: Chap. 8.3, 8.4
Leaving the Menu	Possibly terminate number entry with "ENTER" key.	Press "ENTER" until Menu appears, then either: - choose another part of Menu - activate another Menu MODE
	Activate another Menu	

Menu	**Run and Control of Program "AUTO-REMOTE"**	**Parameter inspection and changing, Variable declaration "PARAMETER"**
Activate Menu	AUTO	PAR KEY
Enter Menu or part of Menu	ENTER Choose AUTO/Step MODE ENTER	Key number, and ENTER
Working in Menu	Start Program execution with START Interrupt with STOP Change Variables during Program execution with PROG VARI 2 x Scroll through with Prepare for entry with MODE Terminate entry with ENTER	Activate Parameter with FIND and complete entry of Parameter number with ENTER or scroll through with or Change Parameters with MODE PT-1 may request number entry which is completed with ENTER Declaration of Variables in similar manner Details: Chapter 7.2

Details: Chapter 8.5

Menu	**Run and Control of Program "AUTO-REMOTE"**	**Parameter inspection and changing "PARAMETER"**
	Complete data entry with "ENTER" key. Exit with [AUTO]	
Exit from Menu	You may stop programming with [STOP] Activate another Menu	You may complete data entry with "ENTER" key; Activate another Menu.

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ECL Command Structure

Key	Command	Memory Used
BEG STOP	BEG Hnnnnnn	5
	BEG Uww	2
END SAVE	END Hnnnnnn	5
	END Uww	2
HOME Block	HOME	1
VEL DEL	VEL ccc %	2
	VEL ooooo U/s	3
	VEL Vddd %	2
	VEL Vddd U/s	2
ACC FIND	ACC ccc %	2
	DEC ccc %	2
	ACC Vddd %	2
	DEC Vddd %	2
JMP AUTO	JMP Lww	6
	JMP Uww	6
WAIT PAR KEY	WAIT bbbb ms	3
	WAIT Ixxx = H	2
	WAIT Ixxx = L	2
	WAIT Vddd ms	2
TP LOAD	TXT ttttttttttt	13

Key	Command	Memory Used
POS MAN	PA vvvvv.vvv	5
	PA vvvvv.vvv VEND = ccc %	5
	PR vvvvv.vvv	5
	PR vvvvv.vvv VEND = ccc %	5
	PA vvvvv.vvv C	5
	PR vvvvv.vvv C	5
	STOP	1
	PA Vddd	2
	PA Vddd VEL = Veee	2
	PR Vddd	2
	PR Vddd VEL = Veee	2
	PA Vddd C	2
	PR Vddd C	2
	LR vvvvv.vvv Mhh	6
	LR vvvvv.vvv S	5
	LR vvvvv.vvv ST Tvvvvv.vvv	9
	LR Vddd Mhh	3
	LR Vddd SLAVE	2
	LR Vddd W = Veee	3
	PA Vddd DP	2
	PA vvvvv.vvv DP	5
	PTP ppppp.ppp	5
	S W Oxxx vvvvv.vvv	7
	PTP Vddd W = Veee	3
	PTP Vddd	2
	STP Vddd = ISTPOS	2
	SET SOLLP = Vddd	2
	SET Vddd = OVR	2
	SET Vddd -> SLAVE i	3
	SET Vddd <- SLAVE i	3

Key	Command	Memory Used
SET INS	SET Oxxx = L	2
	SET Oxxx = H	2
	SET Fww = L	2
	SET Fww = H	2
	SET Cww = aaaa	4
	SET Cww = C + aaaa	4
	SET Oxxx = Iyyy & Fuu	4
	SET Oxxx = Iyyy I Fuu	4
	SET Oxxx = Iyyy & Izzz	4
	SET Oxxx = Iyyy I Izzz	4
	SET Oxxx = Fww & Fuu	4
	SET Oxxx = Fww I Fuu	4
	SET Fuu = Ixxx & Fww	4
	SET Fuu = Ixxx I Fww	4
	SET Fuu = Ixxx & Iyyy	4
	SET Fuu = Ixxx I Iyyy	4
	SET Fuu = Fss & Fww	4
	SET Fuu = Fss I Fww	4
	SET V [Cuu] = Vddd	3
	S Vddd = gggggggg	6
	SET Vddd = V [Cuu]	3
	SET Cuu = Vddd	3
	SET Cuu = C + Vddd	3
	SK Vddd = gggggggg	6
	SET Vddd = Veee + Vfff	4
	SET Vddd = Veee - Vfff	4
	SET Vddd = Veee * Vfff	4
	SET Vddd = Veee : Vfff	4
	SET Vddd = Veee	3
	SET Vddd = ISTPOS	2

Key	Command	Memory Used
	SET SOLL = ISTPOS	1
	SET P = Vddd	5
	MOV Vddd -> EEPROM	2
	MOV EEPROM -> VAR	1
IF PROG VARI	IF Ixxx = H Uww	7
	IF Ixxx = L Uww	7
	IF Ixxx = H Lww	7
	IF Ixxx = L Lww	7
	IF Fuu = H Uww	7
	IF Fuu = L Uww	7
	IF Fuu = H Lww	7
	IF Fuu = L Lww	7
	IF Cuu = aaaa Uww	9
	IF Cuu < aaaa Uww	9
	IF Cuu > aaaa Uww	9
	IF Cuu = aaaa Lww	9
	IF Cuu < aaaa Lww	9
	IF Cuu > aaaa Lww	9
	IF > vvvvv.vvv Luu	10
	IF < vvvvv.vvv Luu	10
	IF > Vddd Luu	7
	IF < Vddd Luu	7
	IF Vddd > Veee Luu	8
	IF Vddd < Veee Luu	8
	IF Vddd = Veee Luu	8

Explanations to the ECL Commands:

xxx yyy zzz	Number between 001 and 008 (616)
ww uu ss	Number from 0 to 99
ddd eee fff	Number from 0 to 255
w i	Number from 0 to 7 Number from 1 to 7
hh	Number 01, 02, 03, 12, 13 and 23
aaaa	Number from -9999 to +9999
bbbb	Number from 0 to +9999
ooooo	Number from 1 to 6000.0
ccc	Number from 1 to 100
nnnnnn	Number from 1 to 99999
vvvvv.vvv	Number from -99999.999 to +99999.999
ppppp.ppp	Number from 0 to +99999.999
gggggggg	Number from -99999999 to +99999999
ttttttttttt	12 ASCII Signs
> < =	greater than less than equal to
+ - * :	plus minus multiplied witht divided by
& |	logical AND logical OR

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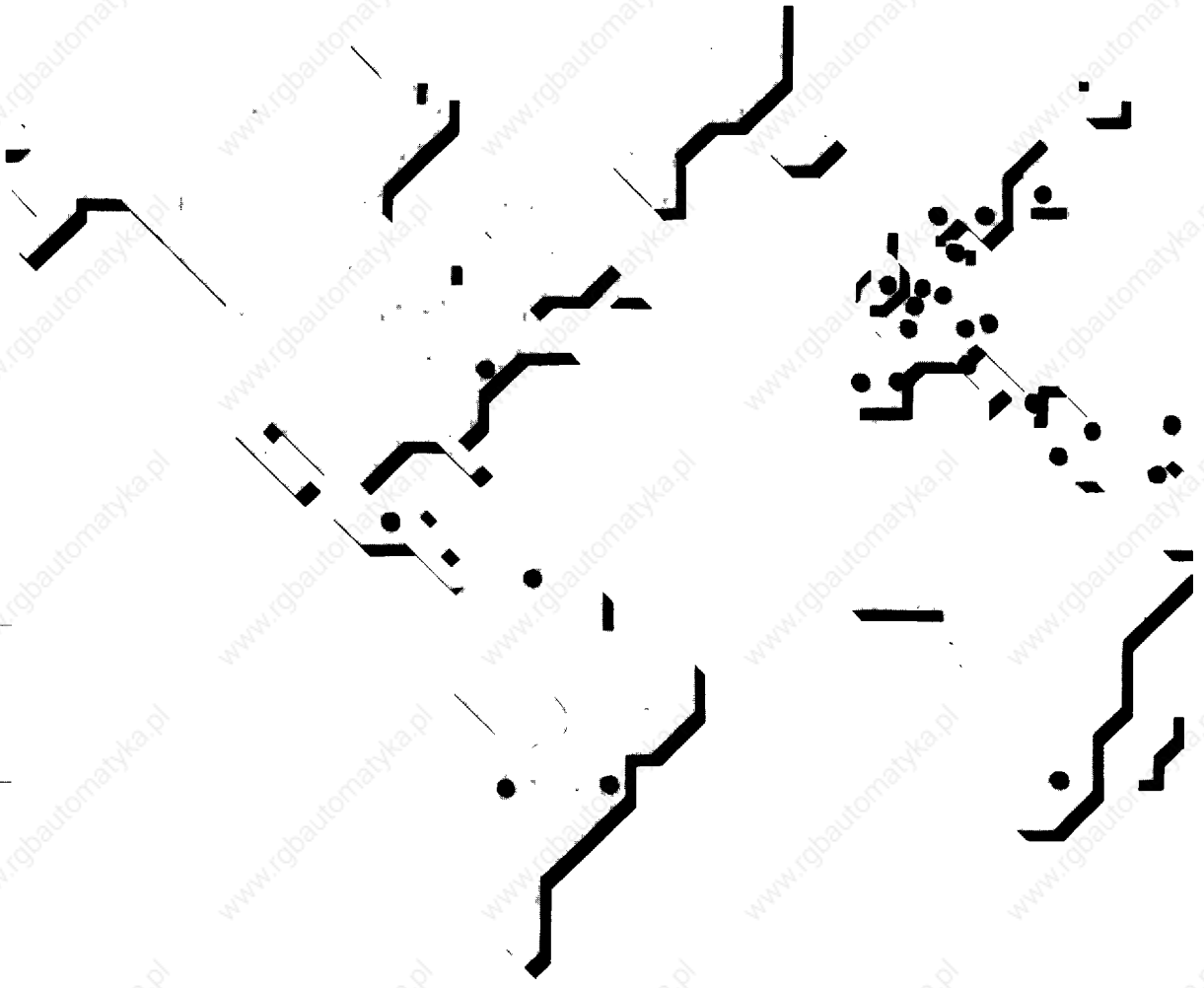
in aller Welt
worldwide



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