HEIDENHAIN

Technical Manual
TNC 122

April 97

This Technical Manual for the HEIDENHAIN TNC 122 straight cut control applies for the NC software version 246 117 08 and is subject to change without notice.

Foreword

The HEIDENHAIN TNC 122 is a compact, three-axis straight cut control for machine tools with central drive. It has been developed as the successor model for the TNC 121, to which it is compatible for installation. The TNC 122 has an expanded range of functions.

This Technical Manual is intended for all machine tool builders and machine tool distributors, and for retrofitting companies who wish to replaced an installed TNC 121 with a TNC 122. It provides the information required for mounting, electrical connection and commissioning the control.

For information on the new and improved operating features, please refer to the User's Manual.

Contents

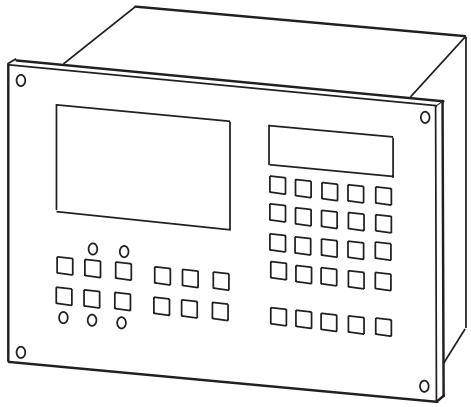
1 Specifications

Type of control	Straight cut control for 3 axes and paraxial positioning
Program memory	Memory for up to 500 NC blocks, 20 NC programs
Design	Compact control for panel mounting 7-segment LED for actual position display LED dot matrix 5 x 7 for preset display
Tool memory	One tool for length and radius compensation
Modes of operation	Manual operation Positioning with manual data input Program run single block Program run automatic Programming and editing
Program input	Manually through TNC keyboard Through RS-232-C/ V.24
Display step	1 µm or 5 µm (0.000 05 in., 0.000 2 in.)
Programmable function	Nominal position in absolute or incremental dimensions Subprograms, program section repeats Tool radius compensation R+/R- Bolt-hole circle, hole circle segment, linear hole pattern Feed rate / rapid traverse M functions
Languages	Dutch, English, French, German, Spanish
Max. traverse	± 9999.999 mm
Max. traversing speed	30 000 mm/min
Position encoders	Incremental HEIDENHAIN position encoders, optionally with distance-coded reference marks 16 μA_{PP} /40 μA_{PP} selectable Grating Periods: 4, 10, 20, 40, 100, 200 µm
PLC cycle time	24 ms
Control inputs	3 position encoder inputs (sinusoidal inputs) 15 PLC inputs +1 PLC input for a control-is-ready acknowledgment
Control outputs	One analog output (for central drive) 15 PLC outputs + 1 PLC input for control-is-ready signal
Data interface	RS-232-C/ V.24, up to 38 400 baud

Power supply	Primary-clocked power supply 100 V to 240 V
Power consumption	19 W
Ambient requirements	Operation : 0° to +45° C Storage : –30° to +70° C Relative humidity, mean annual: < 75%, for max. 30 days per annum, naturally distributed: < 95%
Weight	Approx. 3 kg

2 Hardware

Id. Nr. 284 083 xx



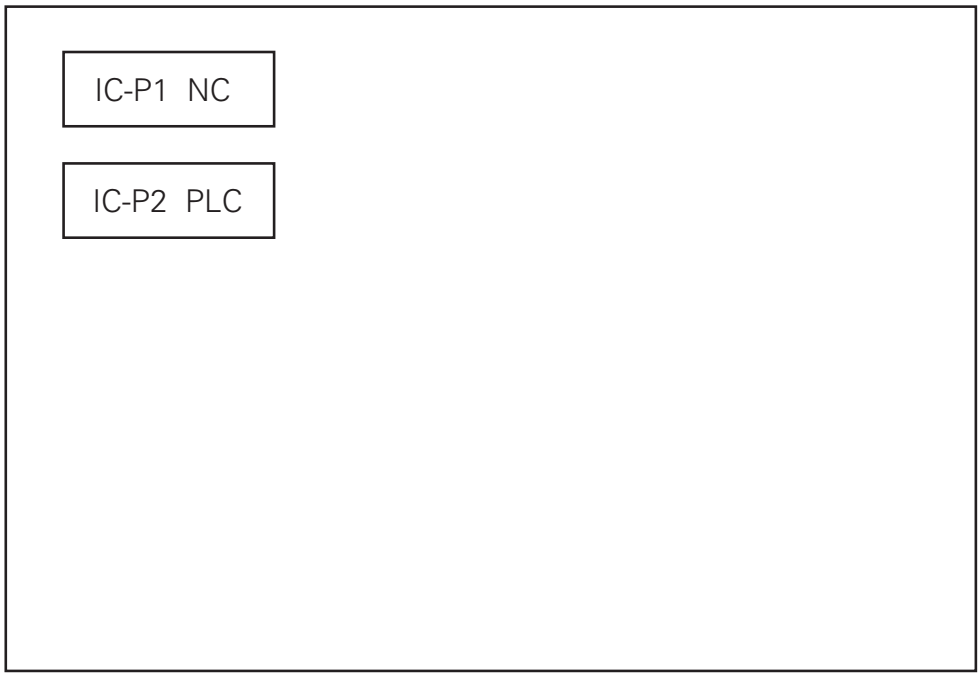
3 Software

Software versions

The NC software 246 117 07, together with the PLC software 277 938 13 of the TNC 122 replaces the following software versions of the TNC 121:

Software Version of TNC 121
205 438
205 443
205 444
205 446
205 455
205 456 unipolar standard
205 457 bipolar standard
205 430

4 EPROM Sockets



The PLC EPROM is a 2 MB or 4 MB chip.

Danger of electrical shock!
Unplug the power cord before opening the housing.

Danger to internal components!
When handling components that can be damaged by electrostatic discharge (ESD), observe the safety recommendations in DIN EN 100 015. Use only antistatic packaging material. Be sure that the work station and the technician are properly grounded during installation.

5 Power Supply

The voltage must comply with specifications:

Component	Power supply	Voltage range	Max. power consumption	Power consumption
NC	Primary clocked power supply	100 – 240 V (–15% to +10%) 48 – 62 Hz	—	Approx. 19 W
PLC	24 V (with basis insulation according to EN 50 178)	Lower limit 20.4 V⎓ Upper limit 31 V ⎓ [1]	Max. 10 mA per input Max. 100 mA per output	

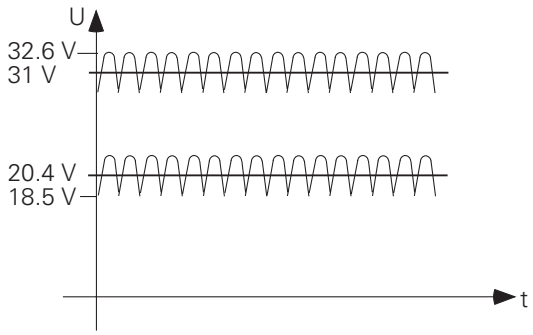
[1] Voltage surges up to 36 V ⎓ for t < 100 ms are permissible.
All small contactors and relays must have a quenching diode.

PLC power supply

The PLC (PLC inputs and outputs) of the TNC 122 is powered from the 24 V machine control voltage supply.

Danger to internal components!
Connect inductive loads only with a quenching diode parallel to the inductance.

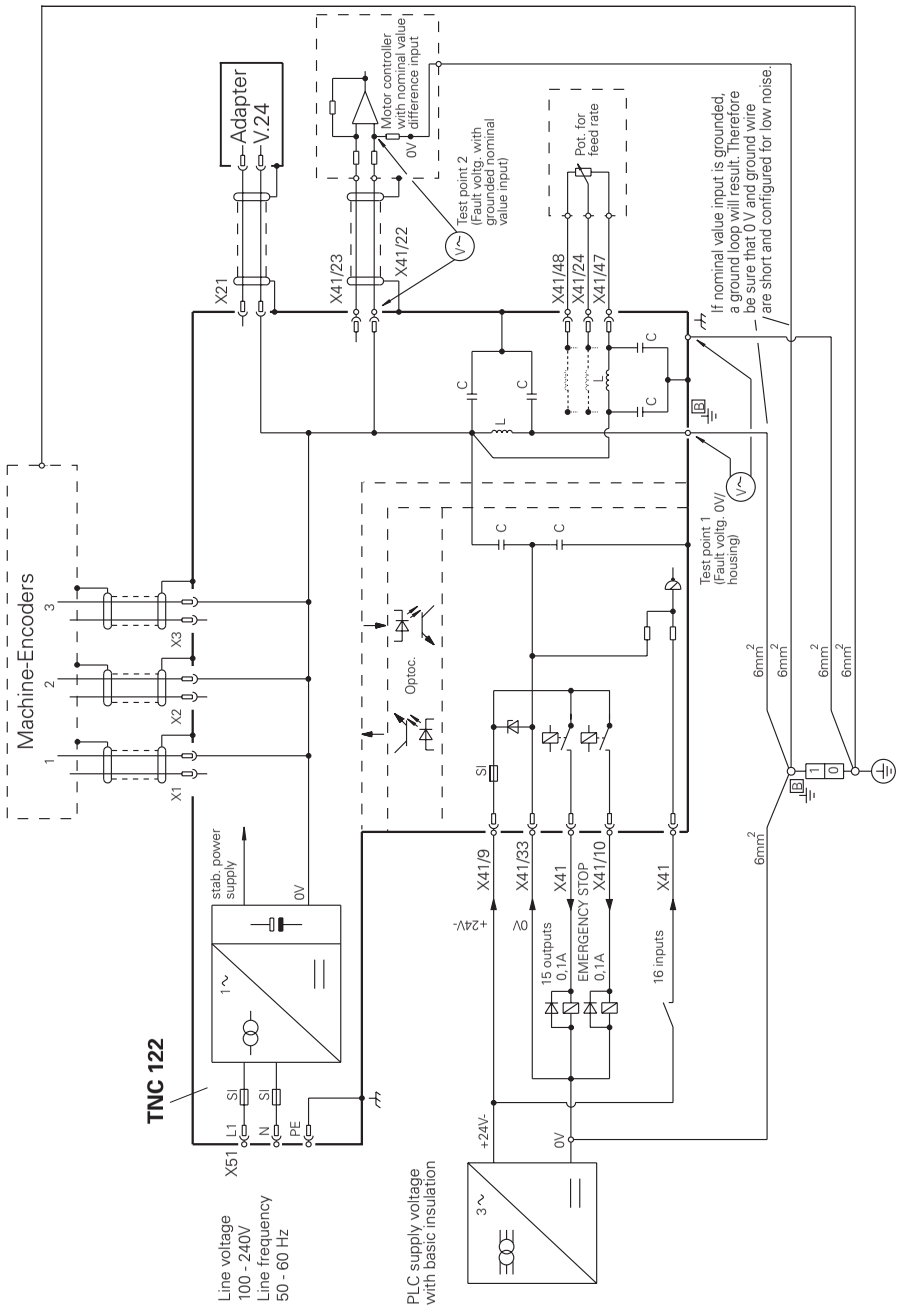
Superposed AC components as they arise from a three-phase bridge rectifier without smoothing (see DIN 40110/1075, Section 1.2) must not exceed 5%. This results at the upper limit in the absolute value 33.4 V and at the lower limit the absolute value of 18.5 V.



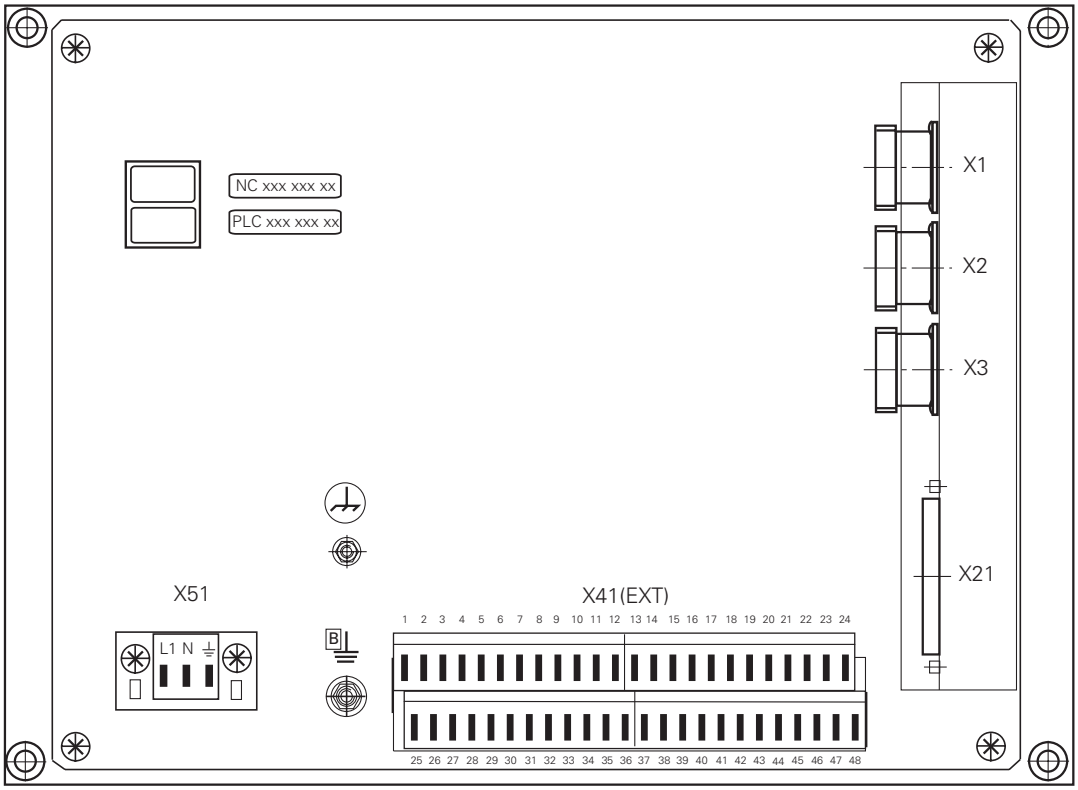
To increase the noise immunity, connect the ground terminal on the rear panel to the central ground point of the machine.
(Minimum cross-section: 6 mm^2)

The 0 V line of the PLC power supply must be grounded with an earth lead (∅ ≥ 6 mm^2) to the main frame ground of the machine.

6 Grounding Diagram



7 Connections



X1 = Encoder 1
X2 = Encoder 2
X3 = Encoder 3

X21 = RS-232-C/V.24 data interface

X41 = PLC inputs/PLC outputs/analog output/feed rate override/24 V PLC
X51 = Power supply

B = Signal ground

Danger to internal components!
Do not engage or disengage any connections while the unit is under power.

Interfaces X1, X2, X3, X21 comply with the recommendations in EN 50 178 for separation from line power.

The outputs at connection X41 are metallically isolated from the device electronics by means of optocouplers.

8 Pin Layout

X1, X2, X3
Encoder input

Flange socket with
9-pin female insert

Pin number	Assignment
1	I_1+
2	I_1–
5	I_2+
6	I_2–
7	I_0+
8	I_0–
3	+ 5 V
4	0 V
9	Internal shield
Housing	External shield

X21 Data interface
RS-232-C/V.24

D-sub connector with
25-pin female insert

Pin number	Assignment
1	Housing
2	RXD
3	TXD
4	CTS
5	RTS
6	DTR
7	GND signal ground
8 – 19	Do not use
20	DSR
21 – 25	Do not use

X51 Power connector

Terminal board, 3-pole

Pin number	Assignment
L1	Live (230 V, F2.5 A fuse)
N	Neutral
⏚	Protective ground

Power consumption: typically 10 W

X41

PLC inputs

PLC outputs

Feed rate override

PLC power supply

Terminal board,
48 contacts

TNC 122 Contact	Connection-assignment	TNC 121 Contact
1	I8 High=M26/ Low=M27	
2	I9 High=M24/ Low=M25	
3	I10 High=M22/ Low=M23 or M09	
4	I11 High=M20/ Low=M21 or M05	
5	I12 M08 coolant ON/ M09 OFF	
6	I13 M04 left spindle ON/ M05 OFF	
7	I14 M03 right spindle ON/ M05 OFF	
8	I15 acknowledgment M function	
9	+24 V PLC	
10	Control-is-ready output	
11	O13 M04 left spindle ON/ M05 OFF or High=M18/ Low M19	
12	O11 High=M20/ Low=M21 or M05	
13	O9 High=M24/ Low=M25	
14	O7 High=M28/ Low=M29	
15	O5 Output for negative traverse direction (for one-quadrant drives) Erosion (205430) M02,M30 switches the output = 0	13
16	O4 Output for rapid traverse (erosion 205430 M02,M30 Stop-erosion output=0)	11
17	O3 Output for Z axis enable	18
18	O2 Output for Y axis enable	20
19	O1 Output for X axis enable	22
20	O0 Output for Manual operating mode	16
21	not assigned	
22	0 V Analog voltage	8
23	+/– 10 V Analog voltage (depending on MP 70)	9
24	Feed rate override (wiper)	4
25	I0 Input NC start	1
26	I1 Input NC stop	2
27	I2 Input rapid traverse key (Erosion 205430 erosion ended, acknowledge with M36)	7
28	I3 Input for control-is-ready acknowledgment	
29	I4 not assigned	
30	I5 not assigned	
31	I6 High=M23/ Low=M33	
32	I7 High=M28/ Low=M29	
33	0 V PLC	6

X41

continued

TNC 122 Contact	Connection-assignment	TNC 121 Contact
34	O14 M04 right spindle ON/ M05 OFF or High=M16/ Low=M17	
35	O12 M08 coolant ON/ M09 OFF	
36	O10 High=M22/ Low=M23 or M09	
37	O8 High= M26/ Low=M27	
38	O6 High=M32/ Low= M33	
39	24 V for neg. traverse direction output	12
40	24 V for rapid traverse output	10
41	24 V for Z axis enable output	17
42	24 V for Y axis enable output	19
43	24 V for X axis enable output	21
44	24 V for "manual" / "not manual" output	15
45	"Not manual" output (inverted O0)	14
46	not assigned	
47	Feed rate override 0 V	3
48	Feed rate override 15 V	5

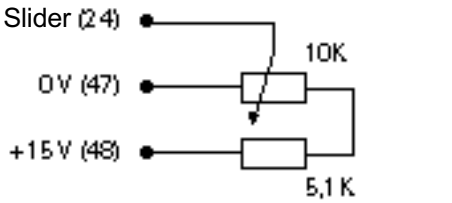
The assignments are in accordance with the PLC Standard Program Id. Nr. 277 938 13!

The 24 Vdc power supply is monitored for reverse polarity and overvoltage. Reverse polarity blows a fuse (F 2.0 A). Overvoltage above 47 V destroys the damping diode and blows the fuse. Maximum current load is 300 mA.

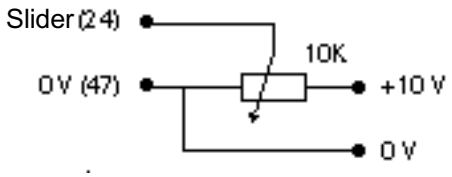
PLC outputs: Inductive loads are permitted only with anti-surge diode!

Change of the I/O assignment only if Program 205 430 is active:
With the M functions M02 an M30 the output is switched to zero. Through the M function M36 the output O5 is switched to 1 and is used to start the erosion process. Through input I2 the function M36 is acknowledged and indicates that erosion has ended. In this case the feed-rate potentiometer is without function.

Installation of the Potentiometer:



Internal-source voltage for pot



External-source voltage for pot

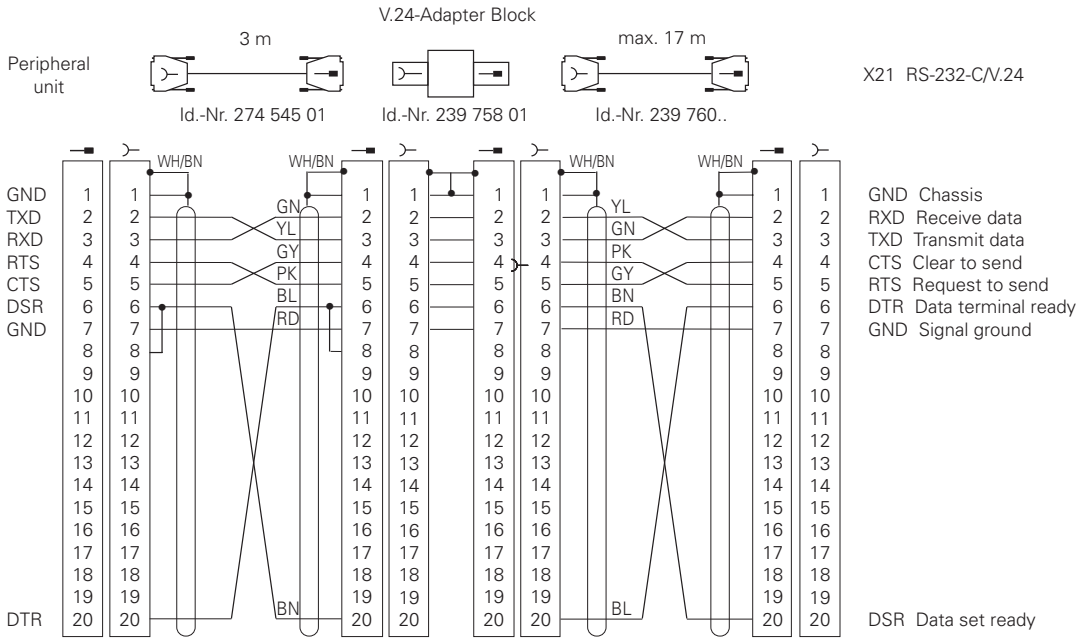
X21 Data Interface

The TNC 122 is equipped with an RS-232-C/V.24 data interface for operation in FE or EXT mode (see the User's Manual). Programs and a list of the machine parameters can be output though this interface. An RS-232-C adapter must be provided for a peripheral unit, such as a PC, FE 401, or printer, to be connected to the control panel. The following drawing illustrates how to connect the adapter block to X21.

HEIDENHAIN guarantees that, if properly connected, the RS-232-C/V.24 serial interface will reliably transmit data between the TNC and a peripheral unit up to a distance of 20 meters.

HEIDENHAIN provides a standard cable 3 meters in length (Id.-Nr. 274 545 01) for connecting peripheral units.

The data format in FE and EXT mode is fixed at 7 data bits, 2 stop bits and even parity. The FE mode operates with ACK/NAK handshake, the EXT mode with DC1/DC3 handshake and RTS/CTS. The data transfer rates are 9600 baud in FE mode and 2400 baud in EXT.



The interface complies with the recommendations in EN 50 178 for separation from line power.

9 Machine Integration

9.1 Encoders

You can continue to use the same incremental position feedback encoders on the TNC 122, as you used on the TNC 121.

Signal period

The signal period of the linear encoder is entered in machine parameter MP330.x (in µm). On linear encoders with sinusoidal output signals, the signal period is the same as the grating period:

Signal period (~) = Grating period

The standard linear encoders from HEIDENHAIN have a grating period of 20 µm. Older encoders have a grating period of 40 µm.
If linear position feedback is carried out with a rotary encoder on the ballscrew, then to calculate the signal period you must consider not only the line count of the encoder (see the technical data for the encoder) but also the pitch of the ballscrew:

$$\text{Signal period (~)} = \frac{\text{Screw pitch [mm]} \cdot 1000\ [\mu\text{m/mm}]}{\text{Line count}}$$

MP330 Signal period
Input values: 4, 10, 20, 40, 100, 200 [µm]

MP330.0 Axis 1
MP330.1 Axis 2
MP330.2 Axis 3

Machine parameter MP7320 can set the encoder amplitude so that older encoder models (on machines with TNC 121) can be adapted to the TNC 122.

MP7320 Switchover of encoder input amplitude
Input values: 0 to 7

Bit 0	Axis	X	+0 = 16 µA
			+1 = 40 µA
Bit 1	Axis	Y	+0 = 16 µA
			+2 = 40 µA
Bit 2	Axis	Z	+0 = 16 µA
			+4 = 40 µA

Traverse direction

Machine parameters MP210 and MP1040 define the axis traverse direction. The traverse directions for the axes on numerically controlled machine tools are specified in DIN.

MP210 defines the counting direction of the encoder signals. The counting direction depends on the mounting configuration of the encoders.

MP210 Counting direction of encoder signals
Input values: 0 to 7

Bit 0	Axis X	+0 = positive
		+1 = negative
Bit 1	Axis Y	+0 = positive
		+2 = negative
Bit 2	Axis Z	+0 = positive
		+4 = negative

MP1040 defines the polarity of the nominal voltage for positive direction of traverse.

MP1040 Polarity of the nominal voltage with positive direction of traverse
Input values: 0 to 7 (must be "0" if MP70 is on "1" or "2")

Bit 0	Axis X	+0 = positive
		+1 = negative
Bit 1	Axis Y	+0 = positive
		+2 = negative
Bit 2	Axis Z	+0 = positive
		+4 = negative

Assignment of encoder inputs

The individual axes can be assigned to the encoder inputs X1 to X3 with machine parameter MP110.

MP110 Assignment of axes to encoder inputs
Input values: 0 to 2
0 = encoder input X1
1 = encoder input X2
2 = encoder input X3

MP110.0	Axis 1
MP110.1	Axis 2
MP110.2	Axis 3

9.2 Traverse Ranges

The traverse ranges are set with machine parameters. The traverse ranges are defined by software limit switches. The input values for the software limit switches are based on the scale datum.

If the machine moves to a software limit switch, the following error message appears:

LIMIT SWITCH <axis>...

and the corresponding marker is set (M2624 to M2629).

MP 910 Positive traverse direction
Entry range: –9999.999 to +9999.999 [mm]

MP910.0 Software limit switch axis X+
MP910.1 Software limit switch axis Y+
MP910.2 Software limit switch axis Z+

MP 920 Negative traverse direction
Entry range: –9999.999 to +9999.999 [mm]

MP920.0 Software limit switch axis X–
MP920.1 Software limit switch axis Y–
MP920.2 Software limit switch axis Z–

		Set	Reset
M2624	Limit switch axis X+	NC	NC
M2625	Limit switch axis X–	NC	NC
M2626	Limit switch axis Y+	NC	NC
M2627	Limit switch axis Y–	NC	NC
M2628	Limit switch axis Z+	NC	NC
M2629	Limit switch axis Z–	NC	NC

9.3 Reference Marks

For workpiece machining, the datum setting procedure assigns a unique position value (coordinate) to each axis position. Since the actual position values are generated incrementally by the encoder, this relationship between axis positions and position values must be restored each time the power is interrupted.

HEIDENHAIN linear encoders are provided with one or more reference marks. When a reference mark is traversed, a signal is generated that identifies that position as a reference point. After a power interruption, crossing over the reference marks will restore the relationship between axis slide positions and position values that was last established through the datum setting procedure. Crossing over the reference marks also restores all machine-based references.

Since it is inconvenient to move the axes over large traverses to restore the reference point, HEIDENHAIN recommends position encoders with distance-coded reference marks. On these encoders the absolute position value is available after crossing two reference marks.

9.3.1 Traversing the Reference Marks

The reference marks of the axes should be traversed after the control is switched on. Machines with the TNC 121 are usually equipped with scales that have a reference mark at each end. To prevent the software limit switch ranges from being shifted, always traverse the reference mark upon which the software limit switches are based.

If referencing is not desired, it can be deactivated with machine parameter MP1340.x or by pressing the NO ENT key.

To traverse the reference marks, press the machine axis direction buttons. The sequence of axes is determined by the user.

When the reference marks are crossed over,

- the software limit switches are activated
- the datum point last set is restored

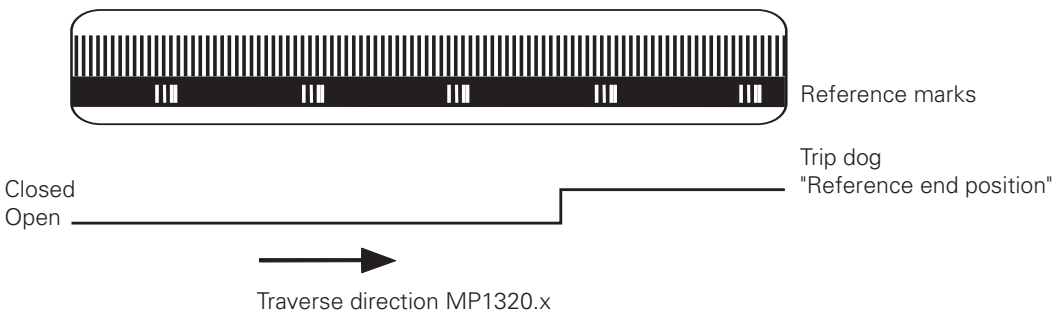
If the position encoders have distance-coded reference marks, the machine datum is based on the scale reference point (on linear encoders the scale reference point is the first reference mark after the start of the measuring length; on angle encoders the scale reference point is marked).

Manual execution (standard process)
The reference mark is traversed with the axis-direction keys.

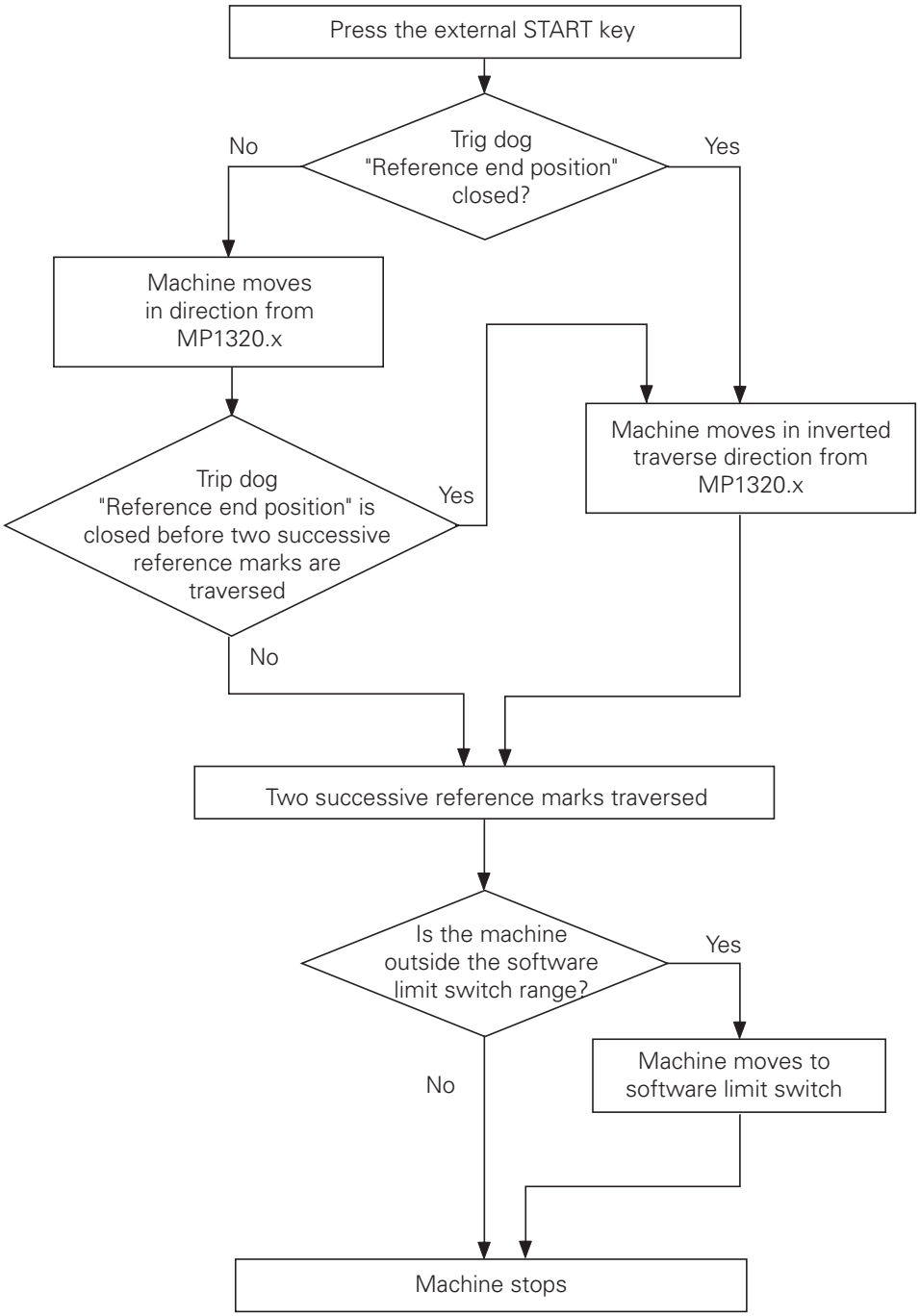
Automatic execution (not in TNC 122)
The direction of traverse and the speed when crossing over the reference marks is defined with machine parameters (MP1320.x, MP1330.x). The sequence of functions when crossing over the reference marks can be defined separately for each axis with MP1350.x.

A trip dog for the reference end position is necessary to prevent the traverse range from being exceeded when the reference marks are crossed over. Install the trip dog at the end of the traverse range. The trigger signal line from the trip dog is connected to a vacant PLC input. In the PLC program, this PLC input is combined with the markers for "Reference end position" (M2556 to M2558)

Encoders with distance-coded reference marks
Machine parameter MP1350.x=0

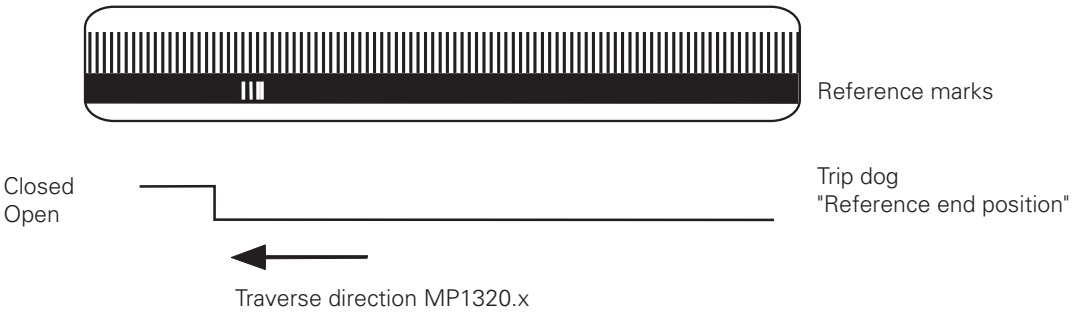


Sequence for "Automatic reference mark traverse" (pressing the machine START key).
MP1350.x = **0**

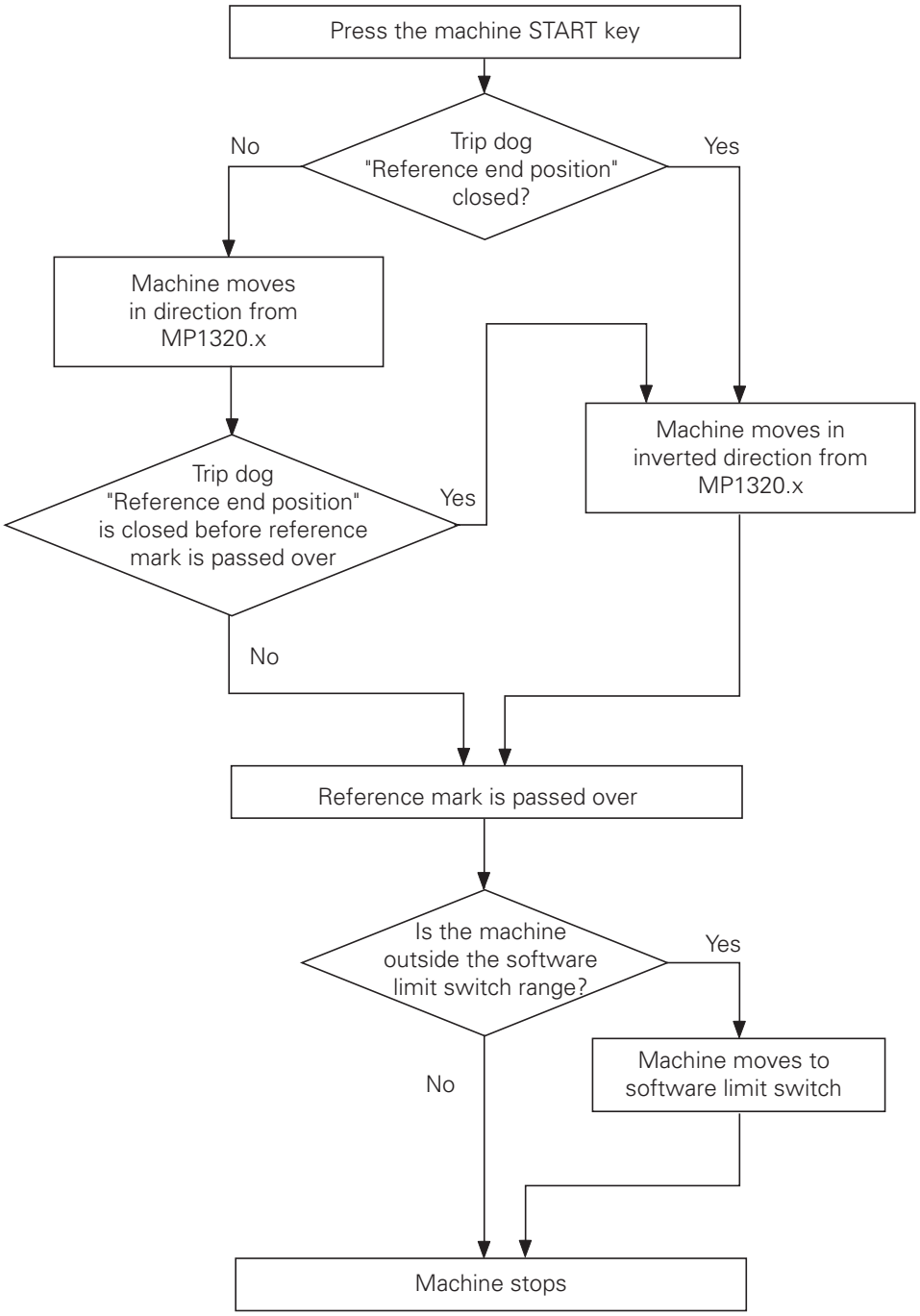


Encoders with one reference mark

Machine parameter MP1350.x = 1



Sequence for "Automatic reference mark traverse" (pressing the machine START key).
MP1350.x = **1**



MP1320 Traverse direction for crossing over the reference marks with EXT start
Input values: 0 to 7

Bit 0	Axis X	+0 = positive
		+1 = negative
Bit 1	Axis Y	+0 = positive
		+2 = negative
Bit 2	Axis Z	+0 = positive
		+4 = negative

MP1330 Feed rate for crossing over the reference marks
Entry range: 80 to 30 000[mm/min]

MP1330.0	Axis X
MP1330.1	Axis Y
MP1330.2	Axis Z

MP1340 Sequence when crossing over the reference marks
Input values: 0 = no reference mark evaluation
1 = 1st axis
2 = 2nd axis
3 = 3rd axis

MP1340.0	Axis X
MP1340.1	Axis Y
MP1340.2	Axis Z

MP1350 Sequence for crossing over reference marks
Input values: 0 = encoder with distance-coded reference marks
1 = encoder with one reference mark

MP1350.0	Axis X
MP1550.1	Axis Y
MP1350.2	Axis Z

		Set	Reset
M2556	Reference end position for axis X	PLC	PLC
M2557	Reference end position for axis Y	PLC	PLC
M2558	Reference end position for axis Z	PLC	PLC

9.4 Position Feedback Control of the NC Axes

The TNC 122 operates according to the principle of closed-loop control with servo lag. Servo lag means that there is always a difference (trailing error) between the nominal position commanded by the NC and the actual position of the axes. Closed-loop control would not be possible without this difference.

The k_v factor (position loop gain) must be matched to the machine (see also "Characteristic kink"). If a very high k_v factor is chosen the servo lag will be very small, but this may cause oscillations in the machine axis. If the k_v factor is too small, the new position will be reached too slowly.

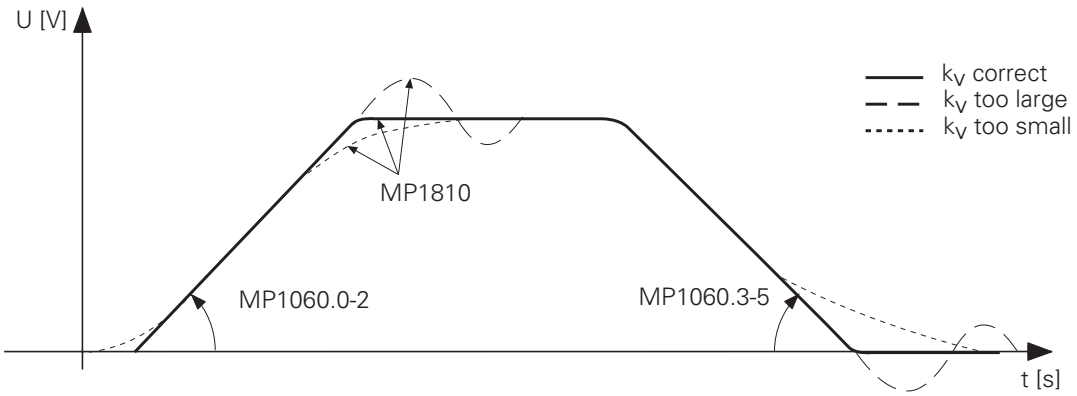
The maximum feed rate (not the rapid traverse) is defined in machine parameter MP1010.0–2. It represents the feed rate at an analog voltage of 11 V at the servo input.

The acceleration can be entered in machine parameter MP1060.x. It determines the ramp gradient of the rising edge (MP1060.0–2) and the approach to the position (MP1060.3–5).

To improve the positioning behavior, machine parameter MP1051.x can be used to define a bottom voltage below which the control will not go.

When the axis is in position (the positioning window has been reached) the "axis in position" marker is set. The PLC program must then disable the position controller for the axes to come to a stop.

The optimum k_v factor must be determined empirically. The following diagram illustrates traversing behavior at different k_v factors:



The k_v factor (MP1810) is generally determined by the maximum feed rate of the machine (MP1010) and the servo lag according to the following formula:

$$k_v = \frac{Ve}{s_a}$$

k_v = position loop gain $[\frac{m/min}{mm}]$

v_e = maximum feed rate $[\frac{m}{min}]$

s_a = servo lag [mm]

or

$$s_a = \frac{Ve}{k_v}$$

Rapid traverse control
For operation at rapid traverse, both programmed and manually actuated, MP80 determines the analog supply voltage for the motor controllers. The machine's circuit diagram will indicate whether the controller input should be supplied by external analog voltage or the analog voltage of the control, and whether amplified tachometer signals are used.

Programming of rapid traverse: Select the axis, enter the value, press and hold the machine rapid traverse button, confirm by pressing the "ENT" key.

External analog voltage for rapid traverse at the controller input (MP80 =**1**):
If MP80 = 1, the controller will be switched to external analog voltage supply when the machine axes are moving at rapid traverse. The control loop remains closed although the control is not monitoring it. The control does not begin monitoring the loop until the axis comes within a certain distance to the target position. This distance is defined in MP4210 and is transmitted to the PLC. To resume feedback control, the PLC resets the "rapid traverse" output (X41, pin 16).

In order to ensure that servo lag monitoring does not respond during rapid traverse, the control operates internally with a rapid traverse from MP1010.3-5 and a "servo lag" is internally adjusted such that it remains within the permissible range of servo lag monitoring (floating nominal value). The servo lag internal adjustment is defined with machine parameter MP1850 such that no oscillations result. The rapid traverse in MP1010.3-5 must correspond with the actual rapid traverse.

The correct setting for the internal adjustment can be checked in a special display (activated with MP7322) showing the actual feed rate, the analog voltage of the control and the internal nominal servo lag as a percentage of the actual servo lag.
If the display sways between 80% and 120% this results in oscillations within the control. These oscillations can be prevented by properly setting MP1850. The setting in MP1010.x is correct if the display remains stable at approx. 100%. The behavior of the floating nominal value can also be measured at the analog output with an oscilloscope.

Analog voltage of the control for rapid traverse at the servo input of (MP80 = **2**):
If the feedback input is supplied from the control during rapid traverse and the tachometer voltage must be switched, then enter the value 2 in MP80. In MP1010.3-5 enter the same rapid traverse rate as the machine had with the TNC 121.

MP1010 Feed rate at 10 V analog voltage
Input: 80 to 30 000 [mm/min]

MP1010.0 Axis X
MP1010.1 Axis Y
MP1010.2 Axis Z

Rapid traverse for amplified tachometer signals or external rapid traverse voltage
Input range: 80 to 30 000 [mm/min]

MP1010.3 Axis X
MP1010.4 Axis Y
MP1010.5 Axis Z

MP1050 Analog voltage for rapid traverse
Input range: 4.5 to 11.0 [V]

MP1050.0 Axis X
MP1050.1 Axis Y
MP1050.2 Axis Z

MP1051 Lower limit of analog voltage
Input range: 0 to 35 [transformer increment]
(1 transformer increment = 2.93 mV)

MP1051.0 Axis X
MP1052.1 Axis Y
MP1053.2 Axis Z

MP70 Bipolar or unipolar analog voltage
Input: 0 or 2

0 = bipolar
1 = unipolar, traversing the position outputs 0 volt
2 = unipolar, traversing the position inverts the voltage

MP80 Supply voltage for position controller during rapid traverse
Input range: 0 to 2

0 = Reserved
1 = Controller input supplied with external voltage (MP1850)
2 = Controller input supplied with analog voltage from the control

MP1060 Acceleration during position approach
Input range: 0.001 to 3.0 [m/s^2]

MP1060.0 Axis X
MP1060.1 Axis Y
MP1060.2 Axis Z

Deceleration during position approach
Input range: 0.001 to 3.0 [m/s^2]

MP1060.3 Axis X
MP1060.4 Axis Y
MP1060.5 Axis Z

MP1810 k_v factor
Input range: 0.10 to 10.00 $[\frac{m/min}{mm}]$

MP1810.0 Axis 1
MP1810.1 Axis 2
MP1810.2 Axis 3

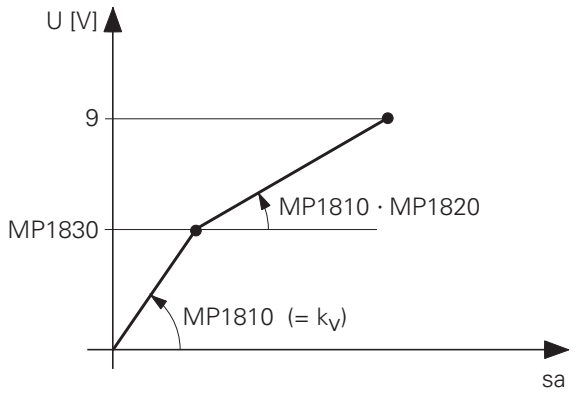
MP1850 Proportion for internal adjustment of servo lag (if MP80 = 1)
Input range: 0 to 65535

Characteristic kink

To enable correct processing of the internal nominal value on machines that have a high rapid traverse speed, the k_V factor must be adjusted to this speed range.
In such cases a characteristic kink can be entered, providing the following advantages:

- a normal k_V factor for the machining feed rate
- a separate k_V factor for rapid traverse

The position of this characteristic kink is defined in machine parameter MP1830. In the upper range the k_V factor is multiplied by the factor in MP1820.



The kink point must lie above the range of machining feed rates. Under these conditions the lag can be calculated as follows:

$$s_a = \frac{Ve}{k_v} \cdot \left[\frac{MP1830\ [\%]}{100\ [\%]} + \frac{100\ [\%] - MP1830\ [\%]}{MP1820 \cdot 100\ [\%]} \right]$$

MP1820 Multiplication factor for the k_V factor
Input range: 0.001 to 9.000

MP1820.0 Axis X
MP1820.1 Axis Y
MP1820.2 Axis Z

MP1830 Characteristic kink
Input range: 0.000 to 100.000 [%]

MP1830.0 Axis X
MP1830.1 Axis Y
MP1830.2 Axis Z

Offset compensation

An offset error can be compensated. An offset error exists if the axis drifts when the controller input is supplied with 0V analog voltage. If the axis does drift, an offset voltage must be output to prevent the drifting. To define the analog offset voltage, press MOD and enter the code number 75 368 to call the "AV OFFSET" dialog prompt. The optimum input value (a multiple of 2.93 mV = 1 transformer step) must be determined empirically. Before this, the bottom voltage must be set to zero with MP1051. For bipolar drives, enter the proper algebraic sign for the voltage.

Feed rate enable

It is only possible to move the axes if the feed rate enable is present in marker M2451 and complementary marker M2467. If the feed rate enable is removed, the analog voltage output is 0 V and the axes stop moving immediately.

		Set	Reset
M2451	Feed rate enable	PLC	PLC
M2467	Complementary feed rate enable	PLC	PLC

Axes in position

When the axes have reached the defined positioning window (MP1030.x), the "Axis in position" markers are set by the NC. This is also done when the control voltage is switched on.

The markers will only be reset by the NC if the axes leave the positioning window when being traversed. This also applies when the reference marks are crossed over.

		Set	Reset
M2008	Axis X in position	NC	NC
M2009	Axis Y in position	NC	NC
M2010	Axis Z in position	NC	NC

Open the control loop

In order to lock or disengage an axis, the control loop must be opened by the PLC. As soon as the "Axis in position" markers (M2008 to M2010) are reset, the control loop must be closed again so that the axis can be moved. Before the control loop is closed, an actual and nominal value transfer must be performed.

		Set	Reset
M2544	Open control loop axis X	PLC	PLC
M2545	Open control loop axis Y	PLC	PLC
M2546	Open control loop axis Z	PLC	PLC

Actual/nominal value transfer

If markers M2552 to M2554 are set, the momentary actual position value is taken as the nominal position value.

		Set	Reset
M2552	Actual/nominal value transfer axis X	PLC	PLC
M2553	Actual/nominal value transfer axis Y	PLC	PLC
M2554	Actual/nominal value transfer axis Z	PLC	PLC

9.5 Monitoring Functions

The NC monitors the axis positions and the dynamic behavior of the machine. If the fixed values in the machine parameters are exceeded, an error message is displayed and the machine is stopped. Position, standstill and movement are monitored.

Position monitoring

Machine parameters MP1720.x determine the range for the continuous position monitoring of the machine (servo lag monitoring). Monitoring goes into effect as soon as the axes are under control of the position control loop. If the limits in MP1720 are exceeded, the following blinking error message appears:

POS. ERROR A <axis>

The control must be switched off to correct this error. Realistic input values are approximately 1 to 1.4 times the servo lag at rapid traverse.

MP1720 Position monitoring
Input range: 0.001 to 200.000 [mm]

Movement monitoring

At short intervals (several control cycles) the path actually traversed is compared with the nominal path as calculated by the NC. If the path traversed during this interval deviates from the calculated path, the following blinking error message will appear:

POS. ERROR C <axis>

Movement monitoring is not active below the voltage entered in machine parameter MP1140.

If 12 [V] is entered in this machine parameter, no movement monitoring will be in effect. It is not possible to safely operate the machine without movement monitoring.

MP1140 Movement monitoring
Input range: 0.03 to 12.00 [V]

Standstill monitoring

This monitoring goes into effect when the axes have reached the positioning window. The range within which the axes may move is defined in MP1110. As soon as the position deviation is larger than the value in MP1110, the following blinking error message is displayed:

POS.ERROR D <axis>

The message will also appear during approach to a target position if an overshoot is larger than the value entered in MP1110, or if the axis moves in the opposite direction at the beginning of a positioning move.

MP1110 Standstill monitoring
Entry range: 0.001 to 30.000 [mm]

Positioning window

The positioning window defines the range within which the control considers a position to have been reached. When the position has been reached, the control starts the execution of the next block. The size of the positioning window is defined in MP1030.x.

When the axes reach the positioning window, markers M2008 to M2010 are set.

MP1030 Positioning window
Entry range: 0.001 to 2.000 [mm]

MP1030.0 Axis X
MP1030.1 Axis Y
MP1030.2 Axis Z

Encoder monitoring

Monitoring of the encoder signals must be activated with MP31.
If the signal amplitude is faulty the following error messages can appear:

ENCODER <axis> DEFECT	If the signal amplitude is no longer being evaluated
AMPL <axis> TOO SMALL	If the signal amplitude is too small
OVERLOAD <axis>	If the signal amplitude is too large

MP31 Monitoring of the amplitude of the encoder signals
Input values: 0 to 7

Bit 0	Axis X	+0 = no monitoring +1 = monitoring active
Bit 1	Axis Y	+0 = no monitoring +2 = monitoring active
Bit 2	Axis Z	+0 = no monitoring +4 = monitoring active

9.6 Display and Operation

The position display can be set with MP7322 to show:
- the actual position referenced to the currently set datum
- the actual position referenced to the scale reference point
- the current trailing error
- the actual feed rates and the nominal voltage and % value for servo lag

MP7322 Position display
Input values: 0 to 3

0 = Actual position referenced to the currently set datum
1 = Current servo lag
2 = Position referenced to scale reference point
3 = Actual feed rates, nominal voltage, % value for trailing error

The display step for the axis positions can be selected with MP7290.

MP7290 Display step
Input values: 0 or 1

0 = 1 µm
1 = 5 µm

Machine parameter MP7285 can be used to define whether the position of the tool tip or the face of the spindle (zero tool) is displayed as the actual value.

MP7285 Take tool length into account in position display
Input values: 0 or 1

0 = position of tool tip is displayed
1 = position of zero tool is displayed

The TNC 122 can switched to different dialog languages with machine parameter MP7230.

MP7230 Dialog language
Input values: 0 to 7

0 = German
1 = English
2 = French
3 = Dutch
4 = Spanish
5 to 7 = *reserved*

Machine parameters can select whether the RAM and the EPROM are to be tested when the control is switched on. When commissioning it is recommended that the memory test be deactivated. The message "Memory test" is displayed during the memory test.

MP7690 Memory test at switch-on
Input values: 0 to 3

0 = EPROM and RAM test at switch-on
1 = EPROM test at switch-on
2 = RAM test at switch-on
3 = No memory test at switch-on

The TNC 122 can also be used when no machine is connected to it. MP7210 sets the modes it can then be used in.

MP7210 Programming station
Input values: 0 to 2

0 = Control
1 = Programming station, PLC active
2 = Programming station, PLC not active

9.7 EMERGENCY STOP Circuit

The control has one PLC input (X41/28) and one PLC output (X41/10) with the designation "Control is ready" for the EMERGENCY STOP routine.

If a malfunction is recognized in the control, the TNC switches the control-is-ready output off, a blinking error message appears on the screen, the PLC program is halted and the outputs are reset. This error message cannot be cleared. When the error has been corrected it is necessary to run through the switch-on routine again.

If the control-is-ready input is switched off by an event outside the control, the following error message will appear:

EMERGENCY STOP

The NC then sets markers M2190 and M2191. This error message cannot be cleared until the control voltage is switched on again.

When an EMERGENCY STOP occurs all outputs are reset.
The control evaluates an external EMERGENCY STOP like an external and internal stop. If the EMERGENCY STOP button is pressed while an axis is moving, the axis is brought to a stop. I

If the EMERGENCY STOP causes the servo amplifier to block, the output nominal values can exceed the position monitoring defined by machine parameters. In such a case the following error message will be displayed:

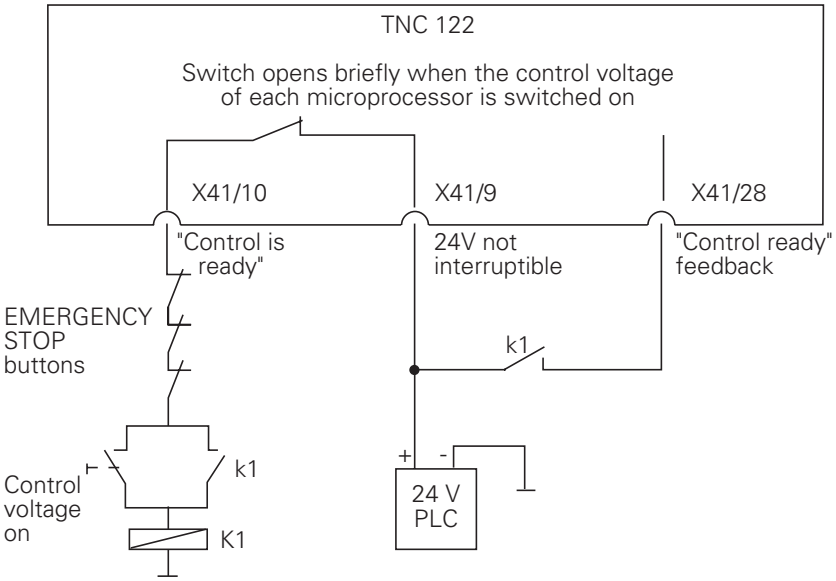
POS. ERROR <axis>

		Set	Reset
M2190	Non-blinking error message displayed	NC	NC
M2191	EMERGENCY STOP displayed	NC	NC

9.7.1 EMERGENCY STOP Connection Diagram

In case of a malfunction, the control-is-ready output should switch the 24 V supply voltage off. Because this function is so critical, the TNC 122 checks this output each time the power supply is switched on.

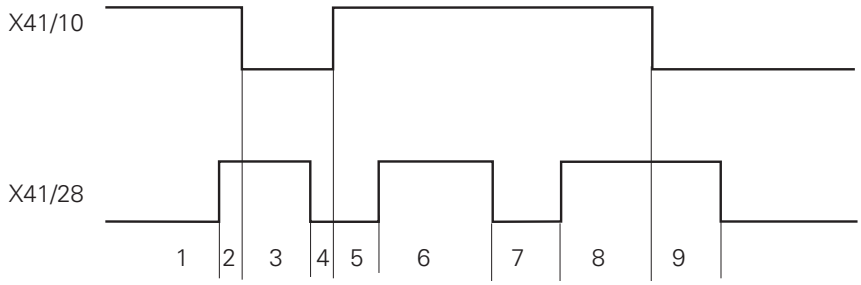
HEIDENHAIN recommends the following wiring:



If the control is not to be part of the EMERGENCY STOP circuit, output X41/10 must be short-circuited with input X41/28.

9.7.2 EMERGENCY STOP Flowchart

The external electronics must fulfill the prescribed basic requirements. In particular, the acknowledgment for "control is ready" must be received within 200 ms.



		Display
1	Waiting for control voltage.	NO CONTROL VOLTG
2	Recognition of the control voltage at X41/28 and reset control-is-ready output at X41/10.	
3	Maximum time until control-is-ready signal at X41/28 must go to 0 (t < 200 ms). If time limit is exceeded, error message:	EMERG STOP DEFEC
4	Recognition of acknowledgment, output X41/10 set.	
5	Waiting for control voltage.	NO CONTROL VOLTG
6	Normal control operation. Output and control-is-ready acknowledgment are set.	
7	Control voltage switched off by external event.	EMERGENCY STOP
8	When the control voltage is switched on again the error message can be cleared; then return to normal operation.	
9	If an error is detected, the control switches off the control-is-ready output (X41/10).	Blinking error message

10 Exchanging the Control

The control should be exchanged only on machines that are recommended by HEIDENHAIN. If you wish to retrofit other machines, contact your HEIDENHAIN service representative.

The PLC EPROM contains the appropriate machine parameters and the PLC program for the following software types of the TNC 121. These are activated with a code number (see below).

Software of the TNC 121	PLC software no. TNC 122	NC software no. TNC 122	Code no.
205 438	277 939 14	246 117 08	1
205 443			2
205 329			2
205 444			3
205 446			4
205 455			5
205 456			6
205 457			7
205 430			8

The TNC 122 with standard PLC program can also replace a TNC 121 with SE 121 (see machine parameters MP4xxx for more information on this.)

Proceed as follows to replace the TNC 121 by the TNC 122:

Before removing the TNC 121

- Check the software number to see whether the PLC and NC software number of the TNC 122 can perform the functions of the TNC 121 (see the above table). If there is any doubt, contact your HEIDENHAIN service representative.
- Determine the following parameters and functions of the machine with the TNC 121 still installed:
  What is the maximum feed rate? What is the analog voltage at the maximum feed rate?
  Is the analog voltage for the rapid traverse supplied by the control or by an external source (shown on wiring diagram)?
  Are the drives bipolar or unipolar?
  Axis lock yes/no?
  Reference mark traverse desired yes/no?
- Determine the pin layout of the terminal board using the circuit diagram and mark the wires for the connection to X41 of the TNC 122.

Removing the TNC 121

- Disconnect the power supply, disconnect the cable from the terminal board, remove the encoder connector.
- Remove the mounting screws, remove the housing.

- Insert sponge rubber gasket, slide unit into position, tighten screws.
  Insert encoder connectors, wire connector X41 according to the documented layout of the TNC 121 (see connector layout X41).
  Connect power supply.
- Differences compared to TNC 121:
  Connect signal ground to the central ground point of the machine.
  Include control-is-ready output (X41/10) and control-is-ready input (X41/28) in the emergency stop circuit (see Section 9.7).

Commissioning the TNC 122:

- Switch on the control.
- Activate the appropriate PLC program and machine parameters with the code number as follows:

  – Press the MOD key
  – Enter code number 77 80 83
  – Press the ENT key
  – Press the MOD key
  – Enter the appropriate code number from the above list
  – Press the ENT key

  Depending on the model of machine and its mechanical condition it may be necessary to re-optimize the machine parameters that affect the control loop. especially parameters MP1010, MP1030, MP1050, MP1051, MP1060, MP1810 and MP1850. This requires checking the analog output and the tachometer voltage with an oscilloscope.
- If desired, set the software limit switch ranges to conform to maximum permissible traverse.
  Note: The software limit switches are always referenced to a fixed reference mark! Ensure that the same reference mark is always used for referencing.

Test all functions.

11 Machine Parameters

11.1 Entering and Changing Machine Parameters

A list of machine parameters is accessible through the MOD function **Code number** in the manual operation mode. To call the complete list of machine parameters, enter the code number 95148. A subset of MOD functions is more readily available through the MOD function **User parameters.** The machine parameters included in the user parameters are indicated in the following list with *). It is possible to change these parameters.

The values of the machine parameters can be changed as follows:
- Select the list of machine parameters.
- Use the arrow key to select the desired machine parameter.
- Enter the new value.
- Confirm your entry by pressing ENT.

To leave the list of machine parameters, press DEL.

11.2 Machine Parameter List

Machine Parameter	Function and input	Input value
MP 31	Monitoring of encoder signal amplitude Input values: 0 to 7 Bit 0 Axis X +0 inactive +1 active Bit 1 Axis Y +0 inactive +2 active Bit 2 Axis Z +0 inactive +4 active	
MP 40	Displayed axes Input values: 0 to 7 Bit 0 Axis X +0 not displayed +1 displayed Bit 1 Axis Y +0 not displayed +2 displayed Bit 2 Axis Z +0 not displayed +4 displayed	
MP70	Analog output bipolar or unipolar Input values: 0 or 2 0 = bipolar 1 = unipolar (ensure that MP1040 = 0!) traversing the end position outputs 0 V 2 = unipolar, traversing the end position inverts the nominal-value voltage	
MP80	Analog voltage source for rapid traverse from the control or from external source Input values: 0 to 2 0 = *reserved* 1 = analog voltage from external source 2 = analog voltage from control (Position control loop closed)	
MP110.0-2	Assignment of encoder inputs to the machine axes Input values: 0 to 2 0 = encoder input X1 1 = encoder input X2 2 = encoder input X3	
MP210	Counting direction of encoder signals Input values: 0 to 7 Bit 0 Axis X +0 = positive +1 = negative Bit 1 Axis Y +0 = positive +2 = negative Bit 2 Axis Z +0 = positive +4 = negative	
MP330.0-2	Grating period Input values: 4, 10, 20, 40, 100, 200 [µm]	

Machine Parameter	Function and input	Input value
MP910.0-2	Software limit switch max. value Input range: –9 999.99 to +9 999.99 [mm]	
MP920.0-2	Software limit switch min. value Input range: –9 999.99 to +9 999.99 [mm]	
MP1010.0-5	Rapid traverse for normal and amplified tachometer signals Input range: 80 to 30 000 [mm/min] MP1010.0-2 normal rapid traverse for X, Y, Z MP1010.3-5 increased rapid trav. for X, Y, Z	
MP1030.0-2	Positioning window Input values: 0.005 to 2.000 [mm]	
MP1040	Polarity of nominal value voltage for positive traversing direction Input values: 0 to 7 Bit 0 Axis X +0 = positive +1 = negative Bit 1 Axis Y +0 = positive +2 = negative Bit 2 Axis Z +0 = positive +4 = negative	If MP70 = 1, then MP1040 must equal 0.
MP1050.0-2	Analog voltage for rapid traverse Input values: 4.5 to 11 [V]	10 V
MP1051.0-2	Lower limit of analog voltage Input values: 0 to 35 [factor 2.93 mV]	
MP1060.0-5	Acceleration Input values: 0.001 to 3.000 [m/s^2] 1060.0 to 1060.2: accelerate 1060.3 to 1060.5: decelerate	
MP1110	Standstill monitoring Input values: 0.001 to 30.000 [mm]	
MP1140	Motion monitoring Input values: 0.03 to 10 [V]	
MP1320	Traverse direction when crossing over the reference marks Input values: 0 to 7 Bit 0 Axis X: + 0 = positive + 1 = negative Bit 1 Axis Y: + 0 = positive + 2 = negative Bit 2 Axis Z: + 0 = positive + 4 = negative	

Machine Parameter	Function and input	Input value
MP1330.0-2	Feed rate for crossing over the reference marks Input values: 80 to 30 000 [mm/min]	
MP1340.0-2	Sequence of axes for crossing over the reference marks Input values: 0 to 3 0 = no reference mark evaluation 1 = Axis X 2 = Axis Y 3 = Axis Z	
MP1350.0-2	Type of referencing Input values: 0 or 1 0 = encoder with distance-coded reference marks 1 = encoder with one reference mark	
MP1720	Position monitoring with servo lag (EMERGENCY OFF) Input values: 0 to 200 [mm]	
MP1810.0-2	k_v factor for operation with servo lag Input values: 0.1 to 10 [1/min]	
MP1820	Multiplication factor for the k_v factor Input values: 0.001 to 9	
MP1830	Characteristic kink for the k_v factor Input values: 0 to 100 [%]	
MP1850	Factor for internal servo-lag adjustment with external rapid traverse voltage Input values: 0 to 65535	Only if MP80 = 1

Machine Parameter	Function and input	Input value
MP4110	Time for timers T0 to T15 Input values: 0 to 65 535 [24 ms]	
MP4110.0		Waiting time controller enable X
MP4110.1		Waiting time unclamp X start
MP4110.2		Waiting time clamp X stop
MP4110.3		Waiting time controller enable Y
MP4110.4		Waiting time unclamp Y start
MP4110.5		Waiting time clamp Y stop
MP4110.6		Waiting time controller enable Z
MP4110.7		Waiting time unclamp Z start
MP4110.8		Waiting time clamp Z stop
MP4110.9		SE pulse formation / duration
MP4110.10		Waiting time O5 traverse direction, delay erosion start M36
MP4110.11		Delay time for rapid traverse output O4 (night erosion switch-off)
MP4110.12 MP4110.13 MP4110.14 MP4110.15		
MP4120.0 to MP4120.7	Preset value for counters C0 to C7 Input values: 0 to 65 535	
MP4210	Setting a number in the PLC word range D768 to D804 Input values: –9 999.999 to +9 999.999 [mm]	
MP4210.0		X switch-off point for rapid trav.
MP4210.1		Y switch-off point for rapid trav.
MP4210.2		Z switch-off point for rapid trav.
MP4210.3	Position control loop to XYZ potentiometer=0, NC stop, lag<0.5	Only with MP 4310.4 and .5 =1
MP4210.4	Number of D/A converter steps per PLC cycle with control by PLC	Input approx. 0.4
MP4210.5	Multiplication factor for the feed rate potentiometer Potentiometer value * MP4210.5= NC % block	Input approx. 0.1 to 1.2 External pot. 100%: factor 0.66 External pot. 150%: factor 1.0
MP4210.6		
MP4210.7	Selection of code no. for software level for position control loop via PLC	Input 1 to 8 (for software level of TNC 121, see Chapter 10)
MP4210.8 MP4210.9		

Machine Parameter	Function and input	Input value
MP4220	Setting a number in the PLC word range W960 to W968 Input values: 0 to 65535	
MP4220.0		1 = bipolar without SE functions 2 = unipolar without SE functions 5 = bipolar with SE functions 6 = unipolar with SE functions 12 = erosion with SE functions
MP4220.1		0 = Static M output +1 = M03/M05 impulse or M16/M17 impulse +2 = M04/M05 impulse or M18/M19 impulse +4 = M08/M09 impulse +8 = M20/M21 impulse +16 = M22/M23 impulse +32 = M24/M25 impulse +64 = M26/M27 impulse +128 = M28/M29 impulse +256 = M32/M33 impulse
MP4220.2		0 = M acknowledgment to I15 +1 = M03 automatic +2 = M04 automatic +4 = M8/M9 automatic +8 = M16/M17 automatic +16 = M18/M19 automatic +32 = M20/M21 automatic +64 = M22/M23 automatic +128 = M24/M25 automatic +256 = M26/M27 automatic +512 = M28/M29 automatic +1024 = M32/M33 automatic +2048 = M00/M02/M05/M30 automatic
MP4220.3	If potentiometer closed, NC stop feed rate potentiometer minimum	Minimum potentiometer feed rate 0%
MP4220.4	If potentiometer closed, NC stop feed rate potentiometer maximum	Active minimum potentiometer feed rate 0%

A change to the machine parameters MP4220.x only becomes active after a power interruption.

Machine Parameter	Function and input	Input value
MP4310	Setting a number in the PLC marker range M2192 to M2211 Input values: 0 or 1	
MP4310.0		X trav. direction 0=neg., 1=pos.
MP4310.1		Y trav. direction 0=neg., 1=pos.
MP4310.2		Z trav. direction 0=neg., 1=pos.
MP4310.3		Actual and nominal value transfer in automated operational mode 0 = no, 1=yes
MP4310.4		1 = open position control loop when override closed or NC stop
MP4310.5	Only effective if MP 4310.4 is active	1 = no controller enable when override closed or NC stop
MP4310.6		1 = rapid traverse output O4 set in automated operating mode
MP4310.7		1 = M05 output via O11 (M20/M21) and reset via M03, M04, M13, M14; M09 output via O10 (M22/M23) and reset via M08, M13, M14
MP4310.8		0 = EMERGENCY STOP cancels the SE outputs 1 = EMERGENCY STOP does not cancel the SE outputs
MP4310.9		Position control loop 0 = NC control 1 = PLC control
MP4310.10		0 = M functions active in MDI 1 = M functions not active in MDI
MP4310.11		1= switch off PLC position control loop monitoring
MP4310.12		1= rapid traverse information (MP block) is not switched when the advance switch point is reached
MP4310.13 MP4310.14 MP4310.15 MP4310.16 MP4310.17 MP4310.18 MP4310.19		

A change to the machine parameters MP4310.x only becomes active after a power interruption.

Machine Parameter	Function and input	Input value
MP7210 *)	Programming station or machine control Input values: 0 to 2 0 = control 1 = programming station, PLC active 2 = programming station, PLC not active	
MP7230 *)	Dialog language Input: 0 to 7 0 = German 1 = English 2 = French 3 = Dutch 4 = Spanish 5 = reserved 6 = reserved 7 = reserved	
MP7285 *)	Tool length is included in the position display value for the tool axis Input values: 0 or 1 0 = tool length is included 1 = tool length is not included	
MP7290 *)	Display step 1 µm or 5 µm Input values: 0 or 1 0 = 1µm 1 = 5 µm	
MP7320	Encoder signal amplitude Input values: 0 to 7 0 = 16µA encoders +1 = 40µA encoders on X-axis +2 = 40µA encoders on Y-axis +4 = 40µA encoders on Z-axis	
MP7322 *)	Position display mode Input values: 0 to 3 0 = display actual position 1 = display servo lag 2 = display reference position 3 = display actual feed rate and nominal value voltage	
MP7680 *)	Memory function for axis direction buttons Input values: 0 or 1 0 = not stored 1 = stored	
MP7690	Memory test during switch-on or after reset Input values: 0 to 3 +0 = memory test during switch-on +1 = no RAM test during switch-on +2 = no EPROM test during switch-on	

12 PLC Description

The TNC 122 features an integrated PLC for 15 inputs and 15 outputs. PLC programs for specific machine models (see Chapter 10) have been prepared and stored by HEIDENHAIN in the EPROM.

If in rare cases the PLC program must be altered or rewritten, we recommend using the **PLC.EXE programming software**, version 2.2 from HEIDENHAIN. This program can also generate the binary code for the PLC EPROM (see the User's Manual for PLC.EXE).
The PLC program assigns fixed functions to the inputs and outputs at the X41 terminal block (see Chapter 8 "Pin Layout."

In the TNC 122 the PLC program is run directly from the EPROM; there is no RAM memory for this task.
For servicing purposes the logical status of the markers, inputs, outputs, timers and counters can be transmitted through the RS-232-C/V.24 port to a computer. Transmission is activated by entering the code number 807 667 in the TNC 122.
Under menu item "File/TNC 12x Monitor" the program PLC.EXE provides a function (PLCMONI.EXE) for immediately displaying the logical status of operands, provided that the code number was entered.

- Use the rightward cursor key on the TNC to scroll through the markers.
- Use the "R+/-" key on the TNC to scroll back through the markers.
- Press the NO ENT key to leave the display.

12.1 PLC EPROM

The PLC EPROM is a 2-MB or 4 MB chip with 16-bit data organization. It is programmed in Motorola format, which means that the most significant byte of a word is located at the first (lowest) address.

Addresses:

$00000 ...	$0000 ...
$00400 $00402 $00403	PLC Program start address Chip identifier (1 word) PLC program length
$00405	$0000
$00406 ... $0041C $0041E	10th MP list ... 2nd MP list 1st MP list
$00420	$0000
$007E0	PLC Program in binary format and up to 10 machine parameter tables
$1C000	20 PLC error messages in 7 languages 20 dialogs in 7 languages (30 characters each)
$1FF00	PLC software number
$1FFFC	Checksum
$1FFFE	One's complement checksum

The error messages and dialogs are filed in the individual languages in the sequence and syntax ('...',0). Each dialog can have up to 16 characters (see also the User's Manual for PLC.EXE).

German '.....',0
English '.....',0
French '.....',0

12.2 PLC Commands

12.2.1 Load and store commands

LOAD (L)

Logic execution with the LOAD command

Operands: M, I, O, T, C
The addressed operand is copied into the Logic Accumulator. An L command is always used at the start of a logic chain to enable subsequent gating commands.

Word execution with the LOAD command

Operands: B, W, D, K
The addressed operand (B, W, D) or a Constant (K) is copied or loaded into the Word Accumulator. The sign is added if necessary. In contrast to logic execution, an L command must always be used at the start of a word gating chain. It is not possible to use a gating command.

LOAD NOT (LN)

Logic execution with the LOAD NOT command

Operands: M, I, O, T, C
The complement of the addressed operand is loaded into the Logic Accumulator. A load command is always used at the start of a logic chain to enable subsequent gating commands.

Word execution with the LOAD NOT command

Operands: B, W, D, K
The content of the addressed operands (B, W, D) or a Constant (K) is loaded into the Word Accumulator as a complement. The sign is added if necessary. In contrast to logic execution, a load command must always be used at the start of a word gating chain. It is not possible to use a gating command.

LOAD TWO'S COMPLEMENT (L–)

Operands: B, W, D, K
The contents of the addressed operand (B, W, D) or a Constant (K) is loaded into the Word Accumulator as a two's complement. The sign is added if necessary. The two's complement allows negative numbers to be stored, i.e. if a number is loaded with L–, it appears in the Accumulator with the opposite sign. This command can only be used with Word execution.

LOAD BYTE (LB)

Operands: M, I, O, T, C
The LB command copies 8 Markers, Inputs, Outputs, Timers or Counters with ascending numbering into the Word Accumulator. Each operand occupies 1 bit in the Accumulator. The designated operand address occupies the LSB in the Accumulator, the designated address + 1 the LSB + 1 and so on. In this way, the last affected operand occupies the MSB. The sign is added if necessary.

LOAD WORD (LW)

Operands: M, I, O, T, C
The LW command copies 16 Markers, Inputs, Outputs, Timers or Counters with ascending numbering into the Word Accumulator. Each operand occupies 1 bit in the Accumulator. The designated operand address occupies the LSB in the Accumulator, the designated address + 1 the LSB + 1 and so on. In this way, the last affected operand occupies the MSB The sign is added if necessary.

LOAD DOUBLEWORD (LD)

Operands: M, I, O, T, C
The LD command copies 32 Markers, Inputs, Outputs, Timers or Counters with ascending numbering into the Word Accumulator. Each operand occupies 1 bit in the Accumulator. The designated operand address occupies the LSB in the Accumulator, the designated address + 1 the LSB + 1 and so on. In this way, the last affected operand occupies the MSB.

ASSIGN (=)

Logic execution with the ASSIGN command

Operands: M, I, O, T, C
In conjunction with a Logic Operand (M, I, O, T, C), ASSIGN copies the contents of the Logic Accumulator into the addressed operand. ASSIGN is only used at the end of a logic chain to ensure that a gating result is available. The command can be used several times in succession.

Word execution with the ASSIGN command

Operands: B, W, D
ASSIGN in conjunction with a Word Operand (B, W, D) copies the contents of the Word Accumulator into the addressed operand. In contrast to bit execution, ASSIGN can also be used within a word logic chain. The command can be used several times in succession.

ASSIGN BYTE (B=)

Operands: M, I, O, T, C
ASSIGN BYTE copies 8 bits from the Word Accumulator to Markers, Inputs, Outputs, Timers or Counters with ascending numbering. Each bit corresponds to one operand. The LSB in the Accumulator is copied to the designated operand address, the LSB + 1 to the designated address + 1 and so on. The last affected operand is occupied by the MSB.

ASSIGN WORD (W=)

Operands: M, I, O, T, C
ASSIGN WORD copies 16 bits from the Word Accumulator to Markers, Inputs, Outputs, Timers or Counters with ascending numbering. Each bit corresponds to one operand. The LSB in the Accumulator is copied to the designated operand address, the LSB + 1 to the designated address + 1 and so on. The last affected operand is occupied by the MSB.

ASSIGN DOUBLEWORD (D=)

Operands: M, I, O, T, C
ASSIGN DOUBLEWORD copies 32 bits from the Word Accumulator to Markers, Inputs, Outputs, Timers or Counters with ascending numbering. Each bit corresponds to one operand. The LSB in the Accumulator is copied to the designated operand address, the LSB + 1 to the designated address + 1 and so on. The last affected operand is occupied by the MSB.

ASSIGN NOT (=N)

Logic execution
Operands: M, I, O, T, C
In conjunction with a logic operand (M, I, O, T, C), ASSIGN NOT copies the complement of the contents of the Logic Accumulator into the addressed operand. See ASSIGN (=) for the sequence of operations.

Word execution
Operands: B, W, D
In conjunction with a word operand (B, W, D), ASSIGN NOT copies the complement of the contents of the Word Accumulator into the addressed operand.

ASSIGN TWO'S COMPLEMENT (=-)

Operands: B, W, D
ASSIGN TWO'S COMPLEMENT copies the TWO'S COMPLEMENT of the contents of the Word Accumulator into the addressed operand.

12.2.2 Set commands

SET (S)

Operands: M, I, O, T, C
The function of this command depends on the contents of the Logic Accumulator. If the Logic Accumulator = 1, the addressed operand is set to 1; otherwise the operand remains unchanged. An S command is used at the end of a logic chain so that the gating result influences the operand. The command can be used several times in succession.

RESET (R)

Operands: M, I, O, T, C
The function of this command depends on the contents of the Logic Accumulator. If the Logic Accumulator = 1, the addressed operand is set to 0; otherwise the operand remains unchanged. An R command is used at the end of a logic chain so that the gating result influences the operand. The command can be used several times in succession.

SET NOT (SN)

Operands: M, I, O, T, C
The function of this command depends on the contents of the Logic Accumulator. If the Logic Accumulator = 0, then the addressed operand is set to 1; otherwise the operand remains unchanged. An SN command is used at the end of a logic chain so that the gating result influences the operand. The command can be used several times in succession.

RESET NOT (RN)

Operands: M, I, O, T, C
The function of this command depends on the contents of the Logic Accumulator. If the Logic Accumulator = 0, then the addressed operand is set to 0; otherwise the operand remains unchanged. An RN command is used at the end of a logic chain so that the gating result influences the operand. The command can be used several times in succession

12.2.3 Logical Connective Operations

AND (A)

Logic execution with the AND command

Operands: M, I, O, T, C

This command functions in different ways depending on its position in the program:

a) At the start of a logic chain the command functions as an L command. That is, the logic state of the operand is loaded into the Logic Accumulator.

b) Within a logic chain the contents of the Logic Accumulator and the logic state of the operand (M, I, O, T, C) are gated with AND. The result of the operation is stored in the Logic Accumulator.

Word execution with the AND Command

Operands: B, W, D, K

The contents of the Word Accumulator and the contents of the operand (B, W, D, K) are gated with AND. In accordance with the different sizes of operand (B = 8 bits; W = 16 bits; D = K = 32 bits), 8, 16 or 32 bits will be influenced in the Accumulator.

Thus: Bit 0 of the Accumulator is gated with bit 0 of the operand
Bit 1 of the Accumulator is gated with bit 1 of the operand, and so on.

AND NOT (AN)

Logic execution with the AND NOT command

Operands: M, I, O, T, C

This command functions in different ways depending on its position in the program:

a) At the start of a logic chain the command functions as an LN command. That is, the complement of the operand is loaded into the Logic Accumulator.

b) Within a logic chain, the contents of the Logic Accumulator and the logic state of the operand (M, I, O, T, C) are gated with AND NOT. The result of the operation is stored in the Logic Accumulator.

Word execution with the AND NOT command

Operands: B, W, D, K

The contents of the Word Accumulator and the contents of the operand (B, W, D, K) are gated with AND NOT. In accordance with the different sizes of operand (B = 8 bits; W = 16 bits; D = K = 32 bits), 8, 16 or 32 bits will be influenced in the Accumulator.

Thus: Bit 0 of the Accumulator is gated with bit 0 of the operand
Bit 1 of the Accumulator is gated with bit 1 of the operand, and so on.

The result of the operation is stored in the Word Accumulator.

OR (O)

Logic execution with the OR command

Operands: M, I, O, T, C

This command functions in different ways depending on its position in the program:

a) At the start of a logic chain the command functions as an L command. That is. the logic state of the operand is loaded into the Logic Accumulator.

b) Within a logic chain, the contents of the Logic Accumulator and the logic state of the operand (M, I, O, T, C) are gated with OR. The result of the operation is stored in the Logic Accumulator.

Word execution with the OR command

Operands: B, W, D, K

The contents of the Word Accumulator and the contents of the operand (B, W, D, K) are gated with OR. In accordance with the different sizes of operand (B = 8 bits; W = 16 bits; D = K = 32 bits), 8, 16 or 32 bits will be influenced in the Accumulator.

Thus: Bit 0 of the Accumulator is gated with bit 0 of the operand
Bit 1 of the Accumulator is gated with bit 1 of the operand, and so on.

The result of the operation is stored in the Word Accumulator.

OR NOT (ON)

Logic execution with the OR NOT command

Operands: M, I, O, T, C

This command functions in different ways depending on its position in the program:

a) At the start of a logic chain this command functions as an LN command. That is, the complement of the operand is loaded into the Logic Accumulator.

b) Within a logic chain, the contents of the Logic Accumulator and the logic state of the operand (M, I, O, T, C) are gated with OR NOT. The result of the operation is stored in the Logic Accumulator.

Word execution with the OR NOT command

Operands: B, W, D, K

The contents of the Word Accumulator and the contents of the operand (B, W, D, K) are gated with OR NOT. In accordance with the different sizes of operand (B = 8 bits; W = 16 bits; D = K = 32 bits), 8, 16 or 32 bits will be influenced in the Accumulator.

Thus: Bit 0 of the Accumulator is gated with bit 0 of the operand
Bit 1 of the Accumulator is gated with bit 1 of the operand, and so on.

The result of the operation is stored in the Word Accumulator.

EXCLUSIVE OR (XO)

Logic execution with the EXCLUSIVE OR command

Operands: M, I, O, T, C

This command functions in different ways depending on its position in the program:

a) At the start of a logic chain the command functions as an L command. That is, the logic state of the operand is loaded into the Logic Accumulator.

b) Within a logic chain the contents of the Logic Accumulator and the logic state of the operand (M, I, O, T, C) are gated with EXCLUSIVE OR. The result of the operation is stored in the Logic Accumulator.

Word execution with the EXCLUSIVE OR command

Operands: B, W, D, K

The contents of the Word Accumulator and the contents of the operand (B, W, D, K) are gated with EXCLUSIVE OR. In accordance with the different sizes of operand (B = 8 bits; W = 16 bits; D = K = 32 bits), 8, 16 or 32 bits will be influenced in the Accumulator.

Thus: Bit 0 of the Accumulator is gated with bit 0 of the operand
Bit 1 of the Accumulator is gated with bit 1 of the operand, and so on.

The result of the operation is stored in the Word Accumulator.

EXCLUSIVE OR NOT (XON)

Logic execution with the EXCLUSIVE OR NOT command

Operands: M, I, O, T, C

This command functions in different ways depending on its position in the program:

a) At the start of a logic chain this command functions as a LN command. That is, the complement of the operand is loaded into the Logic Accumulator.
b) Within a logic chain the contents of the Logic Accumulator and the logic state of the operand (M, I, O, T, C) are gated with EXCLUSIVE OR NOT. The result of the operation is stored in the Logic Accumulator.

Word execution with the EXCLUSIVE OR NOT command

Operands: B, W, D, K

The contents of the Word Accumulator and the contents of the operand (B, W, D, K) are gated with EXCLUSIVE OR NOT. In accordance with the different sizes of operand (B = 8 bits; W = 16 bits; D = K = 32 bits), 8, 16 or 32 bits will be influenced in the Accumulator.

Thus: Bit 0 of the Accumulator is gated with bit 0 of the operand
Bit 1 of the Accumulator is gated with bit 1 of the operand, and so on.

The result of the operation is stored in the Word Accumulator.

12.2.4 Arithmetic Commands

ADDITION (+)

Operands: B, W, D, K

With arithmetic functions the operand is first expanded to the size of the Accumulator (32 bits). Then the contents of the operand are added to the Word Accumulator. The result of the operation is stored in the Word Accumulator and can be processed further.

SUBTRACTION (–)

Operands: B, W, D, K

With arithmetic functions the operand is first expanded to the size of the Accumulator (32 bits). Then the contents of the operand are subtracted from the contents of the Word Accumulator. The result of the operation is stored in the Word Accumulator and can be processed further.

MULTIPLICATION (x)

Operands: B, W, D, K
With arithmetic functions the operand is first expanded to the size of the Accumulator (32 bits). Then the contents of the operand are multiplied with the contents of the Word Accumulator. The result of the operation is stored in the Word Accumulator and can be processed further. If the result of multiplication causes an overflow, Marker M3168 is set; otherwise it is reset.

DIVISION (/)

Operands: B, W, D, K
With arithmetic functions the operand is first expanded to the size of the Accumulator (32 bits). Then the contents of the Word Accumulator are divided by the contents of the operand. The result of the operation is stored in the Word Accumulator and can be processed further. If division by 0 is attempted, the Marker M3169 is set; otherwise it is reset.

REMAINDER (MOD)

Operands: B, W, D, K
With arithmetic functions the operand is firstly expanded to the size of the Accumulator (32 bits). Then the REMAINDER is determined by dividing the contents of the Word Accumulator by the contents of the operand. The REMAINDER is stored in the Word Accumulator and can be processed further. If the MOD command is not correctly executed then the Marker M3170 is set; otherwise it is reset.

INCREMENT (INC, INCW)

INCREMENT operand (INC)

Operands: B, W, D
The content of the addressed operand is increased by one.

INCREMENT Word Accumulator (INCW)

The content of the Word Accumulator is increased by one.

DECREMENT (DEC, DECW)

DECREMENT operand (DEC)

Operands: B, W, D
The content of the addressed operand is decreased by one.

DECREMENT Word Accumulator (DECW)

The content of the Word Accumulator is decreased by one.

12.2.5 Comparisons

EQUAL TO (==)

Operands: B, W, D, K
With this command a direct transfer from Word to Logic processing occurs. The content of the Word Accumulator is compared with the content of the addressed operand. If the Word Accumulator is equal to the operand, the condition is true and the Logic Accumulator is set to 1. If they are not equal, the Logic Accumulator is set to 0. The comparison takes place over the number of bits corresponding to the operand, i.e. B = 8 bits, W = 16 bits and D = K = 32 bits.

LESS THAN (<)

Operands: B, W, D, K
With this command, a direct transfer from Word to Logic processing occurs. The content of the Word Accumulator is compared with the content of the addressed operand. If the Word Accumulator is smaller than the operand, the condition is true and the Logic Accumulator is set to 1. If the Word Accumulator is greater than or equal to the operand, the Logic Accumulator is set to 0. The comparison takes place over the number of bits in the operand, i.e. B = 8 bits, W = 16 bits and D = K = 32 bits.

GREATER THAN (>)

Operands: B, W, D, K
With this command, a direct transfer from Word to Logic processing occurs. . The content of the Word Accumulator is compared with the content of the addressed operand. . If the Word Accumulator is greater than the operand, the condition is true and the Logic Accumulator is set to 1. If the Word Accumulator is less than or equal to the operand, the Logic Accumulator is set to 0. The comparison takes place over the number of bits in the operand, i.e. B = 8 bits, W = 16 bits and D = K = 32 bits.

LESS THAN OR EQUAL TO (<=)

Operands: B, W, D, K
With this command, a direct transfer from Word to Logic processing occurs. The content of the Word Accumulator is compared with the content of the addressed operand. If the Word Accumulator is less than or equal to the operand, the condition is true and the Logic Accumulator is set to 1. If the Word Accumulator is greater than the operand, the Logic Accumulator is set to 0. The comparison takes place over the number of bits in the operand i.e. B = 8 bits, W = 16 bits and D = K = 32 bits.

GREATER THAN OR EQUAL TO (>=)

Operands: B, W, D, K
With this command, a direct transfer from Word to Logic execution occurs. The content of the Word Accumulator is compared with the content of the addressed operand. If the Word Accumulator is greater than or equal to the operand, the condition is true and the Logic Accumulator is set to 1. If the Word Accumulator is smaller than the operand, the Logic Accumulator is set to 0. The comparison takes place over the number of bits corresponding to the operand, i.e. B = 8 bits, W = 16 bits and D = K = 32 bits.

UNEQUAL (<>)

Operands: B, W, D, K
With this command, a direct transfer from Word to Logic execution occurs. The content of the Word Accumulator is compared with the content of the addressed operand. If the Word Accumulator and the operand are not equal, the condition is true and the Logic Accumulator is set to 1. If the Word Accumulator is equal to the operand, the Logic Accumulator is set to 0. The comparison takes place over the number of bits corresponding to the operand, i.e. B = 8 bits, W = 16 bits and D = K = 32 bits.

12.2.6 Parenthetical Expressions

Parentheses with logical commands

The execution sequence in an instruction list can be altered by using parentheses. The open-parentheses command loads the contents of the Accumulator onto the Program Stack. If the Logic Accumulator is addressed in the last command before an open-parentheses instruction, the content of the Logic Accumulator is loaded into the Program Stack. By addressing the Word Accumulator, the content of the Word Accumulator will be distributed.

The close-parentheses instruction initiates the gating of the buffered value from the Program Stack with the Logic Accumulator and/or the Word Accumulator, depending on which Accumulator was addressed before the open-parentheses instruction. The result is then available in the corresponding Accumulator. The maximum nesting level is 16 parentheses.

AND [ ]	(A[ ])
AND NOT [ ]	(AN[ ])
OR [ ]	(O[ ])
OR NOT [ ]	(ON[ ])
EXCLUSIVE OR [ ]	(XO[ ])
EXCLUSIVE OR NOT [ ]	(XON[ ])

Parentheses with arithmetic commands

With arithmetic commands, only word execution is possible. The execution sequence in an instruction list may be altered by using parentheses. The open-parentheses command loads the content of the Word Accumulator onto the Program Stack. The Accumulator is then available for the calculation of intermediate results. The close-parentheses instruction initiates the gating of the buffered value from the Program Stack with the content of the Word Accumulator. The result is again loaded into the Accumulator. The maximum nesting level is 16 parentheses.

ADDITION [ ]	(+[ ])
SUBTRACTION [ ]	(–[ ])
MULTIPLICATION [ ]	(x[ ])
DIVISION [ ]	(/[ ])
REMAINDER [ ]	(MOD[ ])

Parentheses with comparison commands

The execution sequence in an instruction list can be altered by using parentheses. The open-parentheses command loads the contents of the Word Accumulator onto the Program Stack. The Accumulator is now available for the calculation of intermediate results.

The "close-parentheses" instruction initiates the gating of the buffered value from the Program Stack with the content of the complete Word Accumulator. The result is again loaded into the Accumulator. The maximum nesting depth is 16 parentheses.

A direct transition from Word to Logic execution takes place with comparison commands. If the comparison condition is true, the Logic Accumulator is set to 1. If the condition is not true, the Logic Accumulator is set to 0.

EQUAL TO [ ]	(==[ ])
LESS THAN [ ]	(<[ ])
GREATER THAN [ ]	(>[ ])
LESS THAN OR EQUAL TO [ ]	(<=[ ])
GREATER THAN OR EQUAL TO [ ]	(>=[ ])
UNEQUAL [ ]	(<>[ ])

12.2.7 Shift Commands

SHIFT LEFT (<<)

Operands: B, W, D, K
Since the sign bit (MSB) is included with this command, it is grouped in with arithmetic commands. For this reason and out of time considerations, this command should not be used for the isolation of bits. A SHIFT LEFT instruction causes the contents of the Word Accumulator to be multiplied by two. For this purpose the bits in the Accumulator are simply shifted one place to the left. The result must be within the range of –2 147 483 648 to +2 147 483 647, otherwise the Accumulator will contain an undefined value. The number of shift operations is determined by the operand; the right side of the Accumulator is filled with zeros.

SHIFT RIGHT (>>)

Operands: B, W, D, K
Since the sign bit (MSB) is included with this command, it is grouped in with arithmetic commands. For this reason and out of time considerations, this command should not be used for the isolation of bits. A SHIFT RIGHT instruction causes the contents of the Word Accumulator to be divided by two. For this purpose the bits in the Accumulator are simply shifted one place to the right. The number of shift operations is determined by the operand. The set bits, which are shifted beyond the Accumulator to the right, are lost; the Accumulator is filled from the left-hand side including the sign.

12.2.8 Bit Commands

BIT SET (BS)

Operands: B, W, D, K
With this command, each bit in the Accumulator can be accessed. The BS command sets the addressed bit to 1. The selection (addressing) of the corresponding bit is derived from the content of the specified Operand or a Constant. In the bit-numbering, bit 0 corresponds to the LSB and bit 31 corresponds to the MSB. For operand contents larger than 32, the operand value Modulo 32 is used — that is, the integer remainder from the division (operand value)/32.

BIT CLEAR (BC)

Operands: B, W, D, K
With this command, each bit in the Accumulator can be accessed. The BC command sets the addressed bit to 0. The selection (addressing) of the corresponding bit is derived from the content of the specified Operand or a Constant. In the bit-numbering, bit 0 corresponds to the LSB and bit 31 corresponds to the MSB. For operand contents larger than 32, the operand value Modulo 32 is used — that is, the integer remainder from the division (operand value)/32.

BIT TEST (BT)

Operands: B, W, D, K
With this command, the status of each bit in the Accumulator can be interrogated. With BT commands, a direct transition from Word to Logic execution takes place. The BIT TEST tests the status of a bit from the Word Accumulator and then acts correspondingly on the Logic Accumulator. If the tested bit is 1, the Logic Accumulator is set to 1; if it is 0, the Logic Accumulator is set to 0. The program continues in logic execution. The selection (addressing) of the corresponding bit is derived from the content of the specified Operand or a Constant. In the bit numbering, bit 0 corresponds to the LSB and bit 31 corresponds to the MSB. For operand contents larger than 32, the operand value Modulo 32 is used — that is, the integer remainder from the division (operand value)/32.

12.2.9 Stack Operations

Load Data onto the Data Stack (PS)

Logic Execution with the PS Command

Operands: M, I, O, T, C
With the PS command, data is buffered by loading the addressed operand onto the Data Stack. Since the Data Stack is 16-bit, a minimum width of one Word must be used when writing to it. During this the operand value is copied into bit 7 of the current address in the Data Stack. The free bits of the reserved memory are undefined or unused. If there is a stack overflow, an error message will be issued.

Word execution with the PS command

Operands: B, W, D, K

With the PS command data is buffered by copying the addressed memory area (B, W, D, K) into the current address of the Data Stack. With Word execution, two Words are reserved as standard on the Data Stack per PS command. The operand is extended in the Stack with sign justification corresponding to the MSB. If there is a stack overflow, an error message will be issued.

Load Logic Accumulator onto the Data Stack (PSL)

The Logic Accumulator can be buffered with the PSL command. For this purpose, the Logic Accumulator is loaded onto the Data Stack. Since the Data Stack is 16-bit, it must be written to with a minimum width of one Word. During this the content of the Logic Accumulator is copied into the current address of the Data Stack. The free bits of the reserved memory are undefined or unused. If there is a stack overflow, an error message will be issued.

Load Word Accumulator onto the Data Stack (PSW)

The content of the Word Accumulator can be buffered with the PSW command. For this purpose, the Word Accumulator is copied into the Data Stack. The content of the Word Accumulator (32 bits) reserves two Words on the Data Stack. If there is a stack overflow, an error message results.

Acquire data from the Data Stack (PL)

Logic execution with the PL command

Operands: M, I, O, T, C

The PL command complements the PS command. Data that have been saved with PUSH can be taken from the Data Stack again with PULL. With logic execution, bit 7 is copied from the current address of the Data Stack into the addressed operand with a PL command. If the Stack is empty, an error message will be issued.

Word execution with the PL command

Operands: B, W, D

The PL command complements the PS command. Data that have been saved with PUSH can be taken from the Data Stack again with PULL. With Word execution, two Words are copied from the current address of the Data Stack into the addressed memory area with a PL command. If the Stack is empty, an error message will be issued.

Acquire Logic Accumulator from the Data Stack (PLL)

The PLL command complements the PSL command. With a PLL instruction, bit 7 from the current address of the Data Stack is copied into the Logic Accumulator. If the stack is empty, an error message will be issued.

Acquire Word Accumulator from the Data Stack (PLW)

The PLW command complements the PSW command. With a PLW instruction, two Words are copied from the Data Stack into the Word Accumulator. If the stack is empty, an error message will be issued.

12.2.10 Jump Commands

Unconditional jump (JP)

Operands: jump address (LBL)
The JP command instructs the processor to continue the program at the specified jump address (Label). This command interrupts a logic sequence.

Jump if Logic Accumulator = 1 (JPT)

Operands: jump address (LBL)
The JPT command is a conditional jump command. If the Logic Accumulator is 1, the program is continued from the specified jump address (Label). If the Logic Accumulator is 0, the jump is not processed. This command interrupts a logic sequence.

Jump if Logic Accumulator = 0 (JPF)

Operands: jump address (LBL)
The JPF command is a conditional jump command. If the Logic Accumulator is 0, the program is continued from the specified jump address (Label). If the Logic Accumulator is 1, the jump is not processed. This command interrupts a logic sequence.

Call Module (CM)

Operands: jump address (LBL)
CM instructs the processor to leave the main program and process the Module designated by the jump address (LBL). Modules are independent subprograms and are terminated by the EM command. They can also be called at multiple points in the main program. This command interrupts a logic sequence.

Call Module if Logic Accumulator = 1 (CMT)

Operands: jump address (LBL)
The CMT command is a conditional module call. If the Logic Accumulator is 1, the Module with the specified jump address (Label) is processed. If the Logic Accumulator is 0, the main program continues without a module call. This command interrupts a logic sequence.

Call Module if Logic Accumulator = 0 (CMF)

Operands: jump address (LBL)
The CMF command is a conditional module call. If the Logic Accumulator is 0, the Module with the specified jump address (Label) is processed. If the Logic Accumulator is 1, the main program continues without a module call. This command interrupts a logic sequence.

End of Module, End of Program (EM)

Every program and/or every subprogram (Module) is terminated with an EM command. EM in a Module initiates the return jump to the Call Module (CM, CMT, CMF). The program is continued with the instruction following the Call Module. EM is handled as program end criterion; thus subsequent program instructions can only be reached using a jump address.

End of Module if Logic Accumulator = 1 (EMT)

The EMT command only initiates the return jump to the Call Module (CM, CMT, CMF) if the Logic Accumulator is 1.

End of Module if Logic Accumulator = 0 (EMF)

The EMF command only initiates the return jump to the Call Module (CM, CMT, CMF) if the Logic Accumulator is 0.

Jump Label (LBL)

Operands: ASCII name (with up to 32 characters)

The jump label defines a program position as an entry point for the CM and JP commands. Up to 1000 jump labels per file can be defined.

The ASCII name of the jump label can be up to 32 characters long, although only the first 16 characters are used to differentiate between jump labels.

12.3 Classes of Markers and Bytes

Marker	Application
M1000 to M1999	To be assigned as desired. Settings erased after power interruption (Reset).
M0 to M999	To be assigned as desired. Settings erased after power interruption (Reset).
M2000 to B3000	Reserved for NC-to-PLC interface.

Byte	Application
B0 to B127	To be assigned as desired. Settings erased after power interruption (Reset).
B128 to B255	To be assigned as desired. Settings erased after power interruption (Reset).
B256 to B1023	Reserved for NC-to-PLC interface.

12.4 Marker List

Marker	Function	Set	Reset
M0000 to M1499	To be assigned as desired	PLC	PLC
M1500	Rising edge I0 if M2497 set	NC	NC
M1501	Rising edge I1 if M2497 set	NC	NC
M1502	Rising edge I2 if M2497 set	NC	NC
M1503	Rising edge I3 if M2497 set	NC	NC
M1504	Rising edge I4 if M2497 set	NC	NC
M1505	Rising edge I5 if M2497 set	NC	NC
M1506	Rising edge I6 if M2497 set	NC	NC
M1507	Rising edge I7 if M2497 set	NC	NC
M1508	Rising edge I8 if M2497 set	NC	NC
M1509	Rising edge I9 if M2497 set	NC	NC
M1510	Rising edge I10 if M2497 set	NC	NC
M1511	Rising edge I11 if M2497 set	NC	NC
M1512	Rising edge I12 if M2497 set	NC	NC
M1513	Rising edge I13 if M2497 set	NC	NC
M1514	Rising edge I14 if M2497 set	NC	NC
M1515	Rising edge I15 if M2497 set	NC	NC
M1700	Falling edge I0 if M2497 set	NC	NC
M1701	Falling edge I1 if M2497 set	NC	NC
M1702	Falling edge I2 if M2497 set	NC	NC
M1703	Falling edge I3 if M2497 set	NC	NC
M1704	Falling edge I4 if M2497 set	NC	NC
M1705	Falling edge I5 if M2497 set	NC	NC
M1706	Falling edge I6 if M2497 set	NC	NC
M1707	Falling edge I7 if M2497 set	NC	NC
M1708	Falling edge I8 if M2497 set	NC	NC
M1709	Falling edge I9 if M2497 set	NC	NC
M1710	Falling edge I10 if M2497 set	NC	NC
M1711	Falling edge I11 if M2497 set	NC	NC
M1712	Falling edge I12 if M2497 set	NC	NC
M1713	Falling edge I13 if M2497 set	NC	NC
M1714	Falling edge I14 if M2497 set	NC	NC
M1715	Falling edge I15 if M2497 set	NC	NC
M2008	Axis X in position	NC	NC

Marker	Function	Set	Reset
M2009	Axis Y in position	NC	NC
M2010	Axis Z in position	NC	NC
M2045	Strobe signal M Code	NC	NC
M2050	Operating mode: Programming and Editing	NC	NC
M2051	Operating mode: Manual	NC	NC
M2054	Operating mode: Single block	NC	NC
M2055	Operating mode: Automatic	NC	NC
M2057	Operating mode: Cross over reference marks	NC	NC
M2072	M code bit 1	NC	NC
M2073	M code bit 2	NC	NC
M2074	M code bit 3	NC	NC
M2075	M code bit 4	NC	NC
M2076	M code bit 5	NC	NC
M2077	M code bit 6	NC	NC
M2078	M code bit 7	NC	NC
M2079	M code bit 8	NC	NC
M2160	Traversing direction (0 = positive, 1 = negative)	NC	NC
M2176	Code operating mode (lsb)	NC	NC
M2177	Code operating mode	NC	NC
M2178	Code operating mode	NC	NC
M2179	Code operating mode (msb)	NC	NC
M2180	1st PLC scan after power on	NC	NC
M2183	Program interruption (control-in-operation symbol is blinking)	NC	NC
M2184	Control in operation (control-in-operation symbol is on or blinking)	NC	NC
M2185	1st PLC scan after an interruption of the PLC program	NC	NC
M2190	Non-blinking error message is displayed	NC	NC
M2191	EMERGENCY STOP error message is displayed	NC	NC
M2192 to M2211	Can be set by MP4310.0 to MP 4310.19	NC	NC
M2448	NC start	PLC	PLC
M2449	Rapid traverse	PLC	PLC
M2450	Memory function for axis direction keys	PLC	PLC
M2451	Feed rate enable	PLC	PLC
M2456	Manual traverse X+	PLC	PLC
M2457	Manual traverse X–	PLC	PLC
M2458	Manual traverse Y+	PLC	PLC

Marker	Function	Set	Reset
M2459	Manual traverse Y-	PLC	PLC
M2460	Manual traverse Z+	PLC	PLC
M2461	Manual traverse Z-	PLC	PLC
M2464	Complement of NC-Start	PLC	PLC
M2465	Complement of rapid traverse	PLC	PLC
M2466	Complement of memory function for axis direction keys	PLC	PLC
M2467	Complement of feed rate enable	PLC	PLC
M2472	Complement of manual traverse X+	PLC	PLC
M2473	Complement of manual traverse X–	PLC	PLC
M2474	Complement of manual traverse Y+	PLC	PLC
M2475	Complement of manual traverse Y–	PLC	PLC
M2476	Complement of manual traverse Z+	PLC	PLC
M2477	Complement of manual traverse Z–	PLC	PLC
M2482	Acknowledgment of M code	PLC	PLC
M2488	NC stop (0 = stop)	PLC	PLC
M2497	Activate the edge evaluation for PLC inputs Rising edges: Markers M1500 to M1659 Falling edges: Markers M1700 to M1859	PLC	PLC
M2544	Open the control loop for axis X	PLC	PLC
M2545	Open the control loop for axis Y	PLC	PLC
M2546	Open the control loop for axis Z	PLC	PLC
M2552	Actual and nominal value transfer in axis X	PLC	PLC
M2553	Actual and nominal value transfer in axis Y	PLC	PLC
M2554	Actual and nominal value transfer in axis Z	PLC	PLC
M2556	Reference end position for axis X	PLC	PLC
M2557	Reference end position for axis Y	PLC	PLC
M2558	Reference end position for axis Z	PLC	PLC
M2624	Limit switch X+	NC	NC
M2625	Limit switch X–	NC	NC
M2626	Limit switch Y+	NC	NC
M2627	Limit switch Y–	NC	NC
M2628	Limit switch Z+	NC	NC
M2629	Limit switch Z–	NC	NC
M2924 to M2963	Error messages and dialogs	PLC	NC; PLC

Word addresses

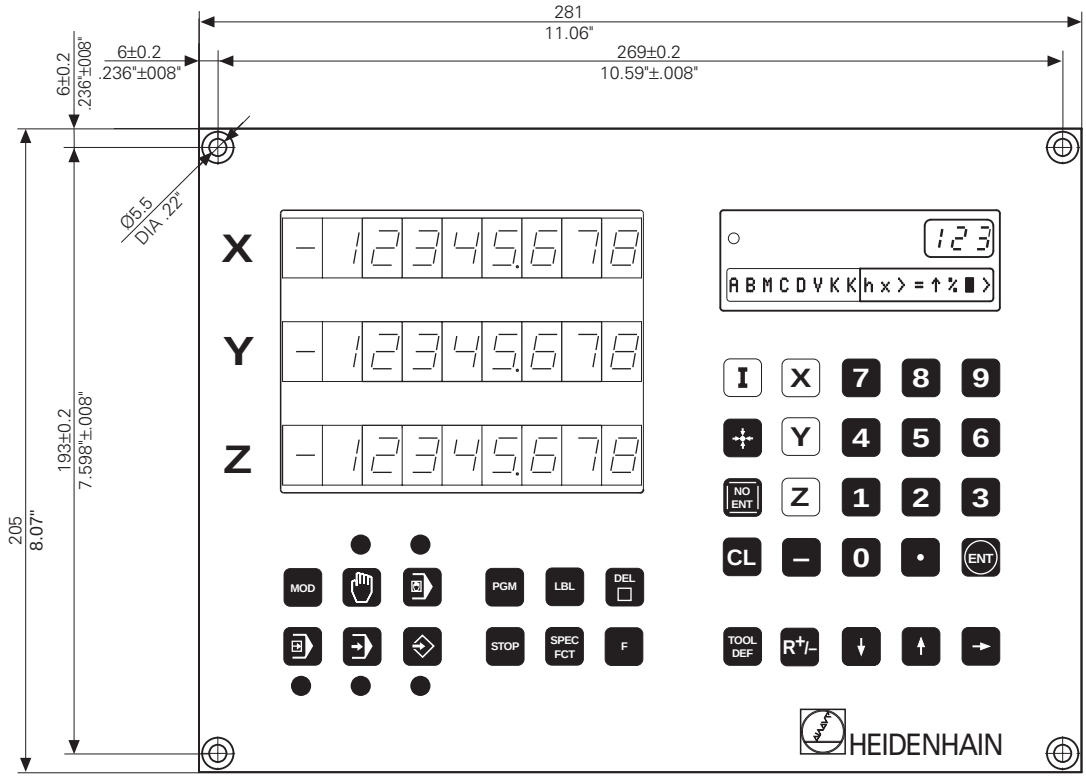
Word	Function
D288 to D296	Actual values in the X, Y and Z axes
D300 to D308	Nominal values in the X, Y and Z axes
D312 to D320	Reference values in the X, Y and Z axes
D324 to D332	Servo lag in the X, Y and Z axes
D360	Current feed rate in mm/min
D364	Maximum feed rate in mm/min
D768 to D804	Values from MP4210.0 to MP4210.9 (deceleration signal)
W969 to W968	Values from MP4310.0 to MP4310.4
W766	% factor for feed rate override

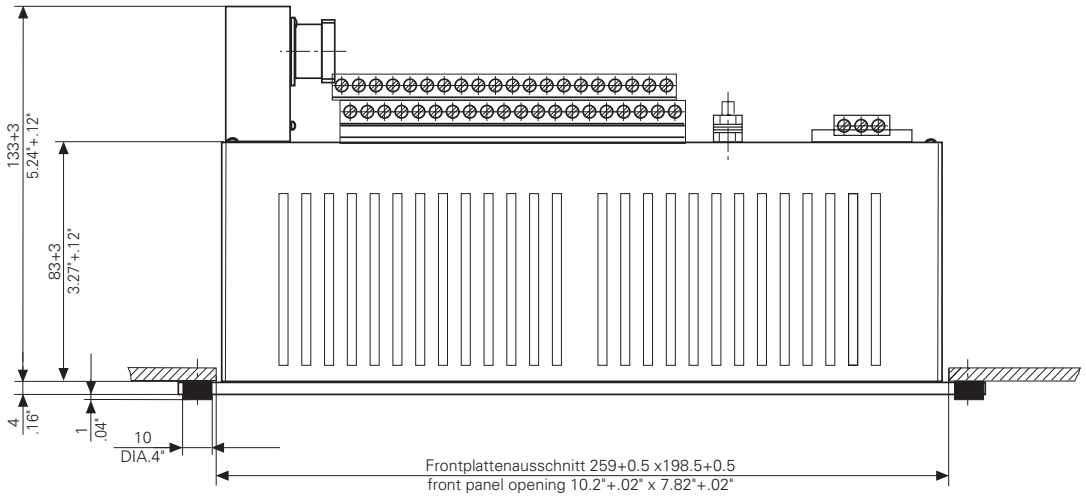
PROCESSOR CHECK X X ⇒
- 0 = Checksum NC-EPROM incorrect
- 1 = CRC sum MP incorrect
- 2 = CRC sum NC memory incorrect
- 4 = Cross feed between data bits in the RAM
- 5 = Checksum PLC-EPROM incorrect
- 6 = Stack overflow
- 7 = Timeout EEPROM
- A = Software error
- B = Incorrect interrupt
- C = Overflow time slice

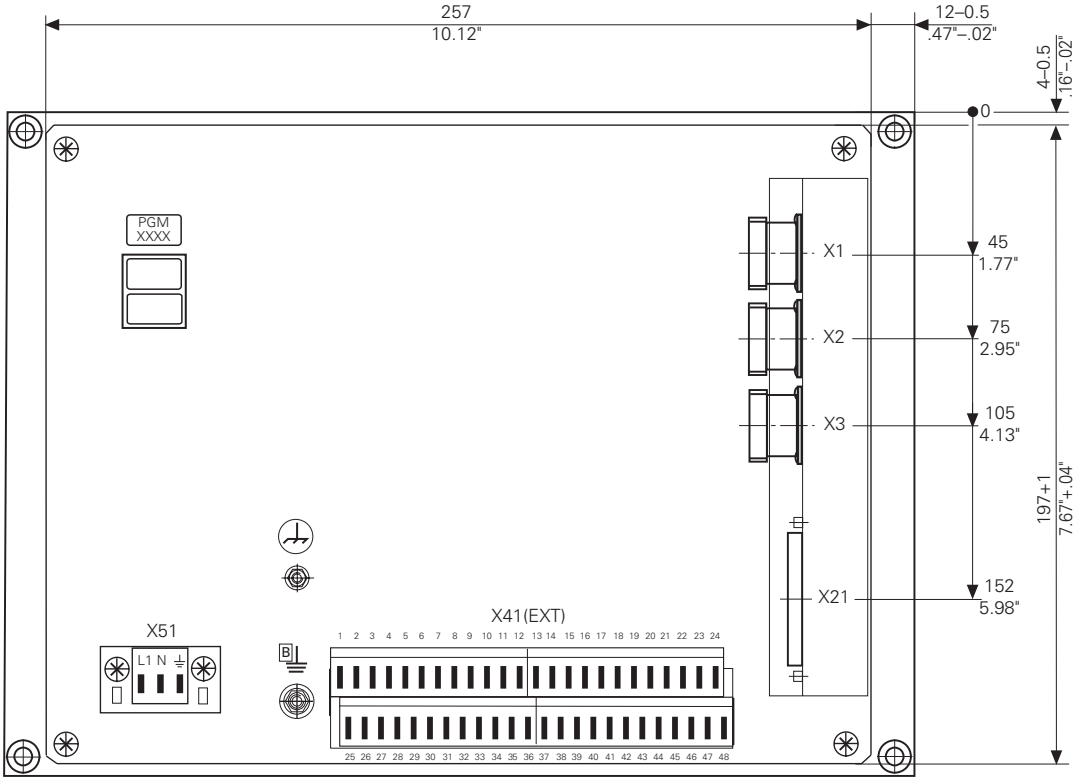
ENCODER <AXIS> DEFECT X X ⇒
- A = Signal amplitude too low
- B = Frequency exceeded

POS. ERROR X <AXIS> X ⇒
- A = Servo lag monitoring
- C = Movement monitoring
- D = Standstill monitoring

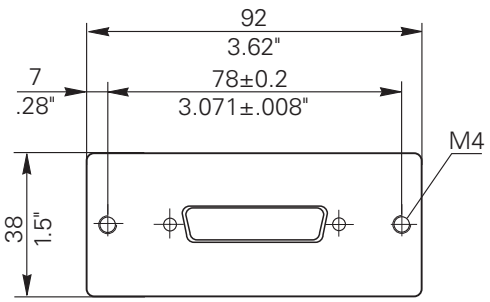
14 Dimensions

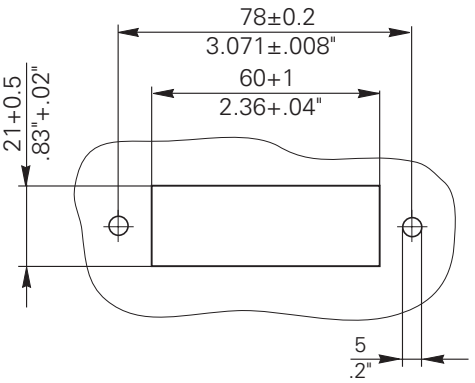


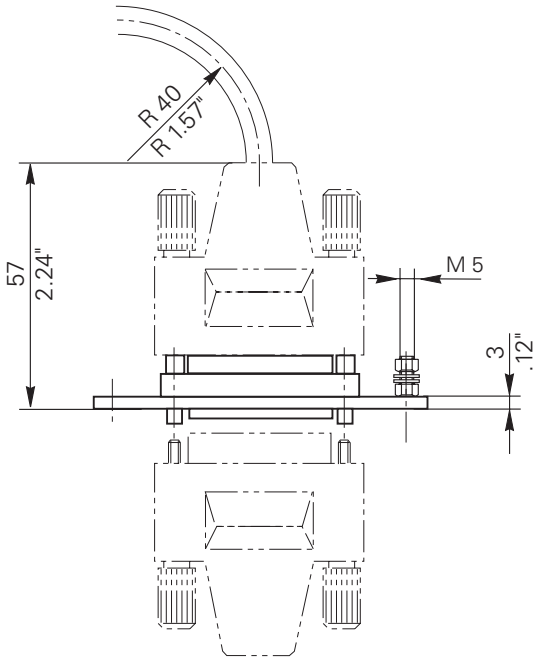



257
10.12"
12–0.5
.47"–.02"
4–0.5
.16"–.02"
0
PGM
XXXX
X1
X2
X3
X21
45
1.77"
75
2.95"
105
4.13"
152
5.98"
197+1
7.67"+.04"
X51
L1 N
X41(EXT)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

V.24–Adapter


92
3.62"
7
.28"
78±0.2
3.071±.008"
M4
38
1.5"


78±0.2
3.071±.008"
60+1
2.36+.04"
21+0.5
.83"+.02"
5
.2"


R 40
R 1.57"
57
2.24"
M 5
3
.12"

15 Subject Index