SIEMENS

SINUMERIK System 3

Electronic Gearbox

Operating Instruction

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Operating Instructions

Issue: 06.85

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The sections with changes – related to this issue in each case – are listed in the column "Modifications".

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1. Introduction

1.1 General

Coupling of several axes in one machine tool is necessary in various technologies, e.g. in producing gears on a hobbing machine.
Until now, this has usually been effected using a mechanical gearing. This costly mechanical system which is susceptible to wear can be replaced by an electronic gearbox.

The electronic gearing (abbreviation ELG) links an axis of rotation (drive axis, C-axis) with extremely accurate electronics to a spindle or axis of rotation. Two further linear axes can also be coupled to the drive axis for an electronic differential.

The ELG is integrated in the PC card row of SINUMERIK System 3, basic model 4, by the SIMATIC S5 - PC130W-B interface control system.

Communication with peripheral equipment (e.g. NC) is exclusively via the PC.

With the aid of functional modules (SINUMERIK System 3GA4, Package 6) especially developed for the electronic gearing, all necessary information is transferred from the NC or from the operator to the ELG via the PC. In this way, technological data of the ELG (e.g. input parameters, machine data) can also be modified via the operator's panel of the NC.

Furthermore, information from the ELG can be displayed on the VDU of the NC with the aid of PC display programs (Package 1).

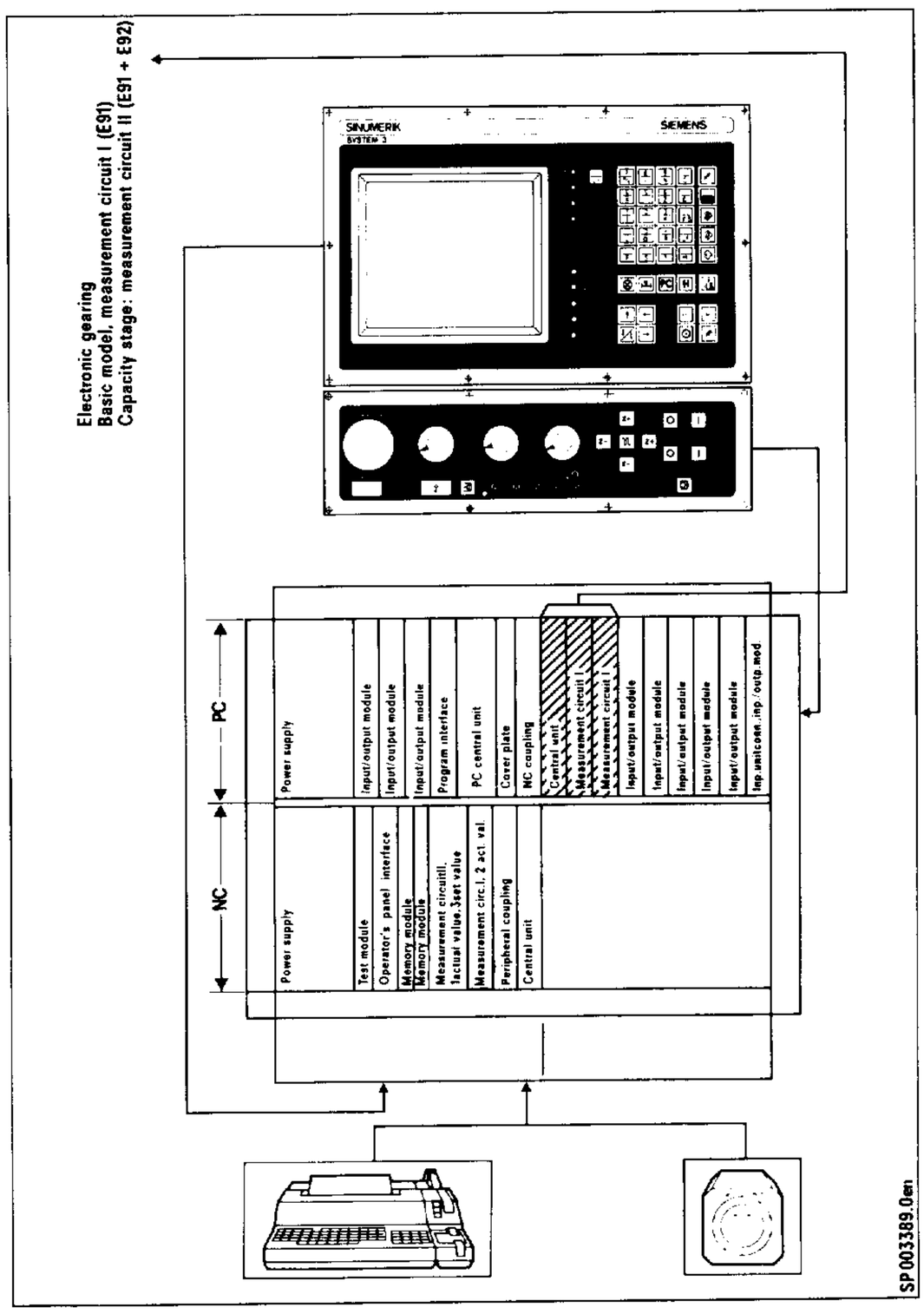
These Operating Instructions presuppose that the SINUMERIK System 3GA4, Package 6 functional modules are utilized.

1.2 Hardware

The electronic gear**box** is accommodated in the PC card row of the logic rack of System 3. It comprises a CPU module and either one or two measurement circuit modules depending on the application. The NC-PC-ELG connection is set up via the coupling modules.

The electrical connections between the various modules of the electronic gearing and to the coupling module are implemented via a small, additional bus board in front of the rear wall of the subrack.

Fig. 1 shows the structure of a SINUMERIK 3M controller with electronic gearing



1.3 Features of the ELG

- Highly accurate electronic linking of two axes of rotation with freely programmable transmission ratio 1:999 to 999:1

- Additional electronic differential with up to two linear axes

- Workpiece processing with the indexing method

- Minimal synchronization error

- Fast compensation of load-dependent changes in speed

- Monitoring of following error

- Position controller with incremental position measuring

- Data input/output via universal interface

- Concentricity compensation (in preparation)

- Backlash compensation

- Transmission of actual value for feed related to workpiece revolution (in preparation)

2. Principle of operation of the electronic gearbox

2.1 Functional description

The possibility exists with the ELG to couple an axis of rotation (drive axis, C-axis) with highly accurate electronics to a second axis of rotation or spindle (B-axis). In addition, the drive axis can be linked to two further linear axes (Y-axis, Z-axis) for an electronic differential.

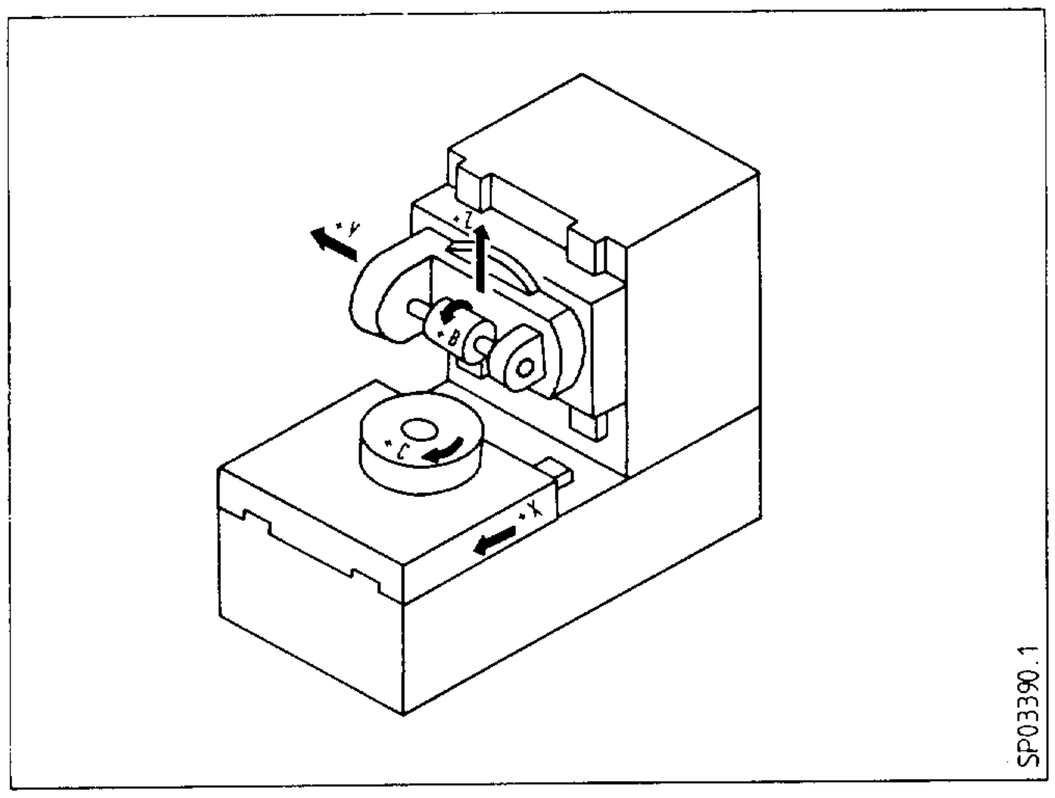
Using the example of a hobbing machine, the operation of the electronic gearing is explained below.

Fig. 2 shows the schematic diagram of a hobbing machine.

Axes:

X = Radial axis
Y = Tangential axis
Z = Axial axis
B = Hob axis of rotation 1)
C = Workpiece axis of rotation (drive axis)

1) Corresponds, for example, to the spindle in System 3



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Control of axes X, Y, Z and B (spindle) is with the aid of the NC (3M GA4). Tool B is a worm gear shaped as a cutter and must be at an exact defined speed ratio to the workpiece (C-axis).

The cutter is traversed in Z-direction over the entire thickness of the workpiece to give the teeth their complete shape. A superimposed additional rotation derived from the Z-motion is produced in the C-axis in the case of helical-toothed workpieces.

The cutter is traversed while processing the Y-direction in order to achieve uniform wear of the tool. This also causes an additional motion in the C-axis.

The depth of the teeth is determined by the X-axis. Fig. 3 shows the structure of the electronic gearing. The C-axis (drive axis) is controlled by the ELG.

In addition, the pulses of the shaft encoder of cutter axis of rotation (B), axial (Z) and tangential axis (Y) are supplied to the actual value acquisition unit ① of the ELG. These axes must be switched to follow-up operation for the ELG, as the ELG software merely requires their current actual value.

In conjunction with the input data Z_o (number of threads on cutter), Z_2 (number of teeth on workpiece) and ud_z, ud_y (dimension for helic angle or tangential motion), the program calculates cyclically the nominal angle of rotation of the tool table ($\varphi_{2\,set}$) ②.

This nominal angle of rotation is compared with the actual angle of rotation ($\varphi_{2\,act}$) of the tool table processed in the actual value acquisition unit ③. The difference (so-called following error) is processed in a position controller ④ and output via a D/A converter to the subordinate speed controller for the drive axis.

The transmission behaviour of the position controller is influenced by the precontrol unit such that the following error during machining adopts a minimum value, in order to obtain a high degree of coupling rigidity.

If the actual value of the tool table and the set value differ by more than 1 workpiece-dependent value, a fault

is determined and an alarm message (hardware signal) is output ⑤. This signal can be utilized to disengage the cutter from the workpiece; e.g. the workpiece traverses clear in the +X direction via appropriate mechanical elements.

In order to achieve feed related to workpiece revolution without additional shaft encoder (with 1024 pulses per axis revolution), the pulses from the shaft encoder in the ELG are standardized and transmitted to the switching RAM module of the NC ⑥.

The NC (prerequisite: basic model 4B) can make use of this standardized actual value when programming feed related to workpiece revolution.

The electronic gearing is supplied with all necessary data from the PC via the coupling module. Machine and setting data can also be transferred with a universal interface (V.24 and 20 mA line current interface).

2.2 Linkage equations for the electronic gearbox

The nature of linking the drive axis with the guide axis and with the two differential axes is described below, using the example of hobbing.

2.2.1 Hobbing spur teeth by means of axial cutter feed

In hobbing, the hob and the workpiece must be at a defined speed ratio to one another.

The pick-up for rotary motion of the cutter spindle (B) determines the angle of rotation of the workpiece table (C) via the electronic gearing in accordance with the formula below:

$$\varphi_{2\,set} = \varphi_{o\,act} \cdot \frac{z_o}{z_2}$$

$\varphi_{2\,set}$ = Set value for angle of of the workpiece table (drive axis)

$\varphi_{o\,act}$ = Actual angle of rotation of the guide axis (cutter)

z_o = Number of threads of cutter

z_2 = Number of teeth of workpiece

z_o and z_2 are specified as R parameters, e.g. via the NC and/or the PC; the quotient is formed internally.

The above equation assumes that workpiece and tool axis (cutter) have the same activation system for the measuring system. Nevertheless, different activation of the measuring systems is taken into consideration in the internal calculation of transmission constants.

2.2.2 Hobbing helical teeth by means of axial cutter feed

When helical teeth are cut with a hob which remains in a fixed position, and the Z-axis is moved (axial motion), the C-axis also moves. The angle of rotation of the C-axis is a function of the displacement of the Z axis and the angle of the teeth.

When the hob is running and the teeth are helical, a direction-dependent angle of rotation derived from the hob angle of rotation and a direction-dependent angle of rotation derived from the Z-motion are superimposed on the workpiece.

$$\varphi_{2\,set} = \varphi_{o\,act} \frac{z_o}{z_2} + sz \cdot \frac{ud_z}{z_2}$$

s_z = Displacement of Z-axis

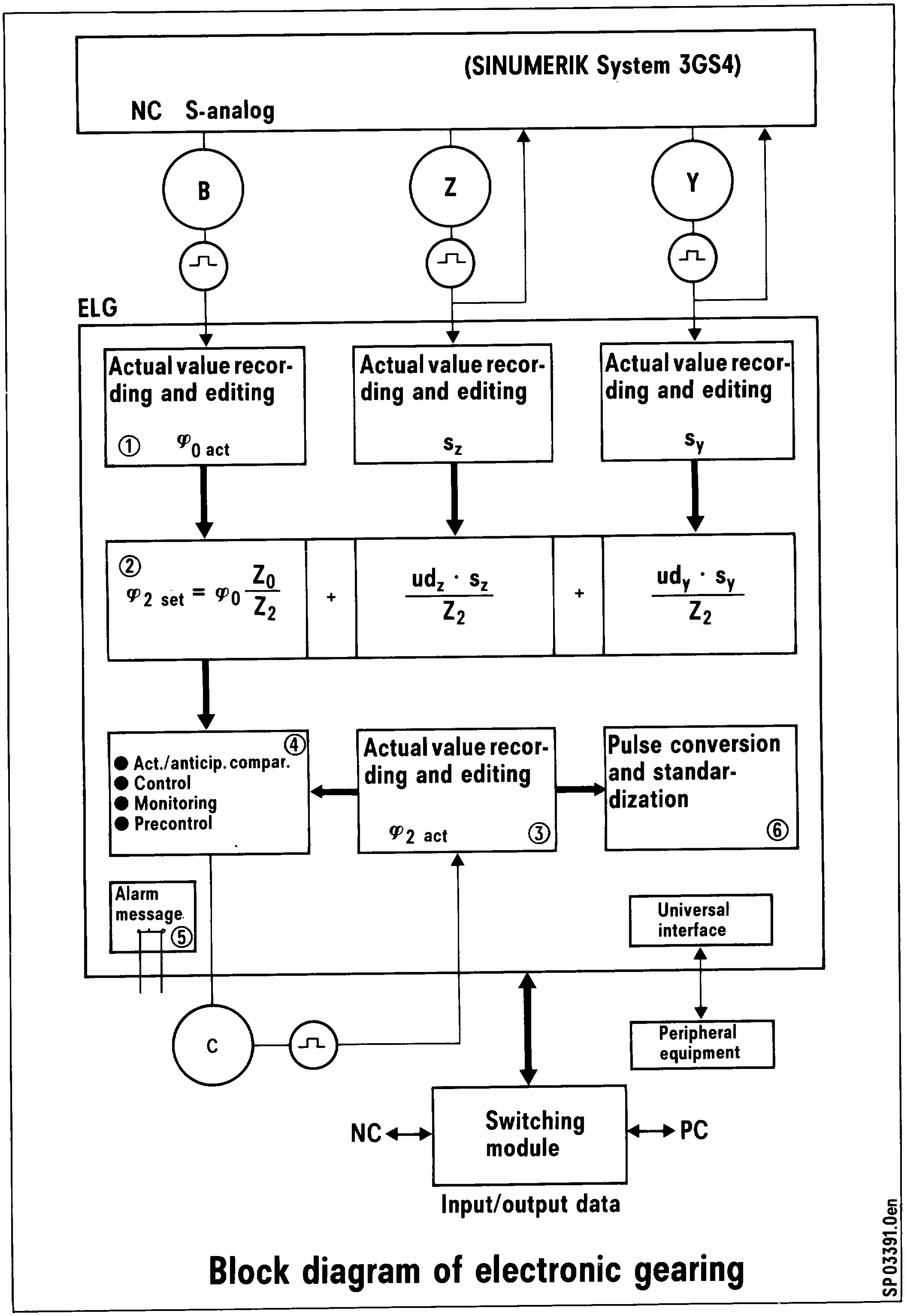
ud_z = Differential component for axial motion
It is a signed constant and a function of the lead angle of the teeth β_o and the module.

The following is true for ud_z:

$$ud_z = \frac{\sin \beta_o}{m_N \cdot \pi} \cdot 360 \left[\frac{°}{mm}\right]$$

See Section 13 for further symbols.

Fig 3: Structure of the electronic gearbox



Block diagram of electronic gearing

2.2.3 Hobbing helical teeth by means of diagonal cutter feed

When helical teeth are hobbed by means of diagonal cutter feed, the workpiece must be subjected to an additional turn made up of two components. The first component serves to generate the tooth angle, and the second to compensate for the tangential motion of the hob. This second component is independent of the spiral angle of the workpiece.

$$\varphi_{2_{set}} = \varphi_{o_{act}} \cdot \frac{z_o}{z_2} + s_z \cdot \frac{ud_z}{z_2} + s_y \cdot \frac{ud_y}{z_2}$$

s_y = Displacement of the Y-axis

ud_y = Differential portion for tangential motion
It is a signed constant for the additional turn required by the workpiece, which is a function of the spiral angle of the cutter γ_o and the module.

The following is true for ud_y:

$$ud_y = \frac{\cos \gamma_o}{m_N \cdot \pi} \cdot 360 \quad \left[\frac{°}{mm}\right]$$

See Section 13 for further symbols.

ud_y and ud_z are specified as the R-parameters, e.g. via the NC and/or the PC.

3. Data traffic NC-PC-ELG

Communications of the electronic gearing with the NC or with the operator (operator's panel) are effected exclusively via the PC.

The coupling between ELG and PC or NC and PC is implemented via a joint switching RAM module.

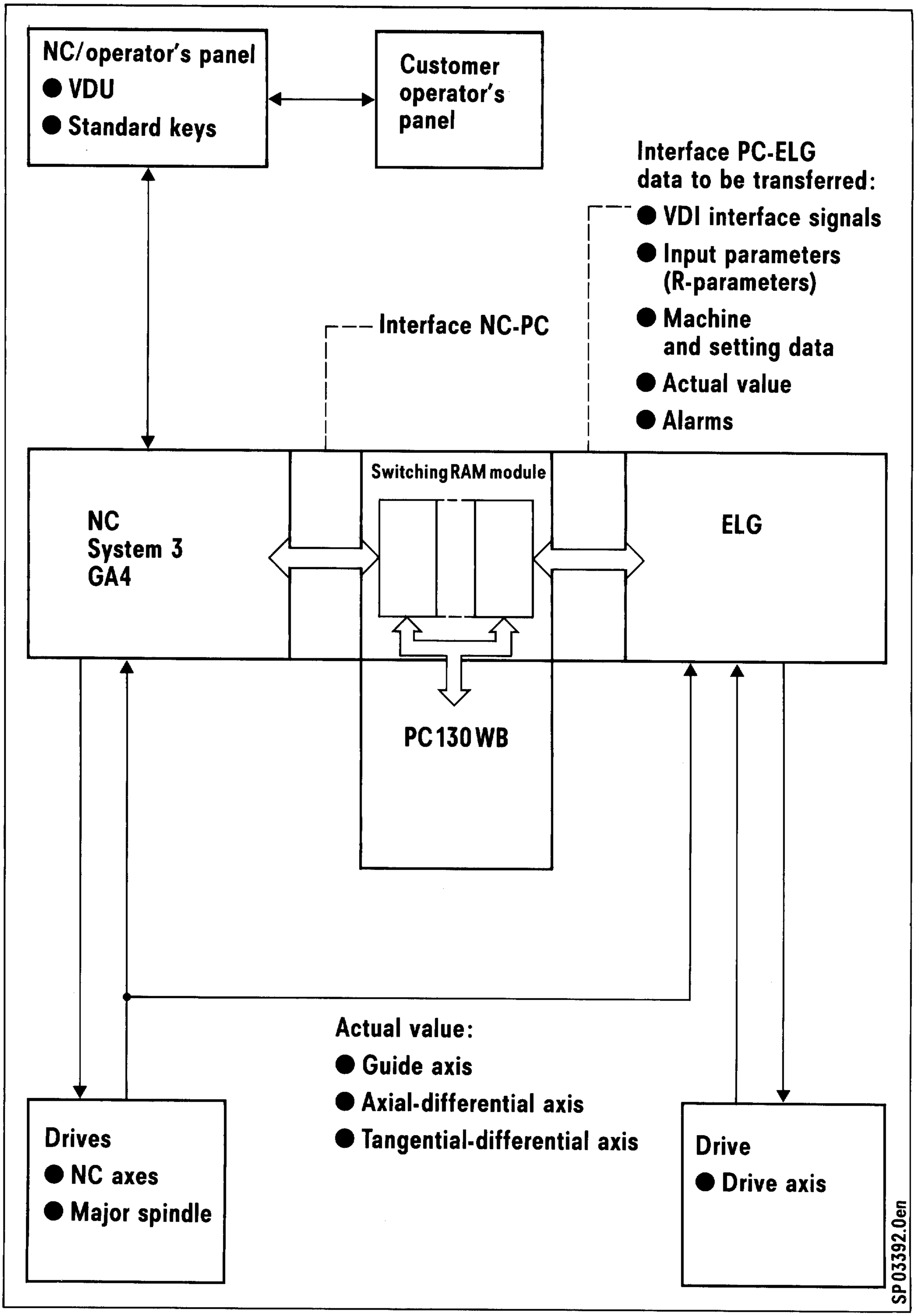
Data transfer between NC-PC-ELG is organized by the functional module package 6 (SINUMERIK System 3 GA4).

The ELG can thus be controlled by the NC. Input parameters, ELG operating modes and instructions are transmitted by a NC in the form of R-parameters or auxiliary functions to the PC. After linkage in the user program, the appropriate interface signals of the ELG are then set by the PC.

The Fig. 4 below
shows data traffic NC-PC-ELG

Fig. 4:

Summary of data traffic NC-PC-ELG



The parameters required for all gearing functions are calculated internally from the following input parameters:

Z_o - Number of threads of hob during hobbing or number of teeth of shaper cutter during shaping

Z_2 - Number of teeth of workpiece

u_{dz} - Axial differential component

u_{dy} - Tangential differential component

and the following machine data:

N_{00} - Number of pulses per hob/ shaper cutter revolution

N_{02} - Number of pulses per workpiece table revolution (drive axis)

The calculation is initiated by an interface signal "Calculate gearing constants", which can be set from the NC via an M-function.

The PC should ensure an input disable for the NC during the calculation. The calculation is acknowledged by the ELG with the "Gearing constant calculated" interface signal. The PC must then withdraw the "Input disable".

The gearing constants can only be re-calculated when the coupling is disengaged.
The gearing function is not interrupted by changes on the operating mode switch, nor by RESET.

The coupling between drive axis and hob/shaper cutter as well as the differential axes is de-activated by means of the "Gearing OFF" interface signal. The "Coupling ON" signal is cancelled.

The drive axis can be traversed in this status in the JOG or INC mode by means of separate direction keys.

4.2 Semi-automatic centring (HAE)

When "Coupling ON" is present, the drive axis (C-axis) can be traversed in both directions in addition to the actual motion, in order to permit centring of the cutter for workpieces which have already been machined. The "Semi-automatic centring" interface signal is supplied when the coupling is activated for this purpose. The cutter approaches the workpiece in JOG or INC mode. The C-axis is then displaced in INC mode by means of the direction keys until there is contact between one flank of the workpiece and a flank of the cutter. When contact is made, the actual value is stored by means of the "Transfer actual value" interface signal. The electronic gearing acknowledges this procedure by means of the "Actual value transferred" interface signal. This must be followed by a traverse in the opposite direction, likewise until the flanks make contact. When the next actual value has been transferred, the C-axis automatically derives half the distance between the two actual value transfer points. The cutter is then exactly in the centre of the tooth gap. This status is acknowledged by means of the "Tooth gap reached" interface signal. The "Semi-automatic centring" operating mode can be cancelled by the PC with the "Tooth gap reached" signal.

The entire procedure is in part positive-controlled internally. When the second actual value is transferred, there is an automatic traverse to the centre of the tooth gap. The procedure can, however, be interrupted at any time by cancelling the "Semi-automatic centring" interface signal.

When utilizing the functional module package 6, the instructions necessary for semi-automatic centring can be selected by the NC by way of auxiliary functions.

The "Semi-automatic centring" ELG operating mode is cancelled with ELG-RESET by the functional modules in package 6.

4. ELG operating modes

The operating modes of the ELG are described below. The operating modes of the ELG are selected and cancelled by means of interface signals between the PC and the electronic gearing; these signals can be set by the NC (System 3 GA4) via M-functions. The required data are transmitted to the ELG in R-parameter format, actuated by an M-function.

The user is able to select the M-functions and the R-parameter numbers with the aid of functional modules in the PC.

Note on the machine control panel signals of the ELG:

Functional module package 6 automatically presets only the axis selector switch with the code of the drive axis. The user program must supply the other machine control panel signals for the ELG.
When called, this program also supplies the functional modules with the appropriate parameters.

4.1 Gearing ON / Gearing OFF

The function of the gearing is activated by an interface signal "Gearing ON", which in turn is triggered by an M-function. The drive axis then follows all motions of the cutter in accordance with the transmission ratio or all motions of the tangential (Y) axis and/or axial (Z) axis, if the differential components ud_y and ud_z are not equal to zero.

A "Coupling ON" interface signal is present, providing the gearing function is activated; no other operating mode is permitted (exception: Semi-automatic centring). The "Coupling ON" message is displayed on the VDU of the NC when the ELG basic pattern is selected.

"Gearing ON" should only be selected when the guide axes are at a standstill, in order to avoid excessive sudden changes in the set value of the drive axis, which might result in errors.

The link between drive axis and cutter and the differential axes is formed in accordance with the formula below:

$$\varphi_{2set} = \varphi_{o\,act.} \cdot \frac{z_o}{z_2} + s_z \cdot \frac{ud_z}{z_2} + s_y \cdot \frac{ud_y}{z_2}$$

(See Section 13 for symbols)

The ud_z and ud_y values can either be entered directly or calculated in the NC by means of an R-parameter calculation.

The differential components for the drive axis are obtained from the formulae for:

- Axial motion:

$$ud_z = \frac{\sin \beta_o}{m_N \cdot \pi} \cdot 360 \left[\frac{^\circ}{mm}\right]$$

- Tangential motion:

$$ud_y = \frac{\cos \gamma_o}{m_N \cdot \pi} \cdot 360 \left[\frac{^\circ}{mm}\right]$$

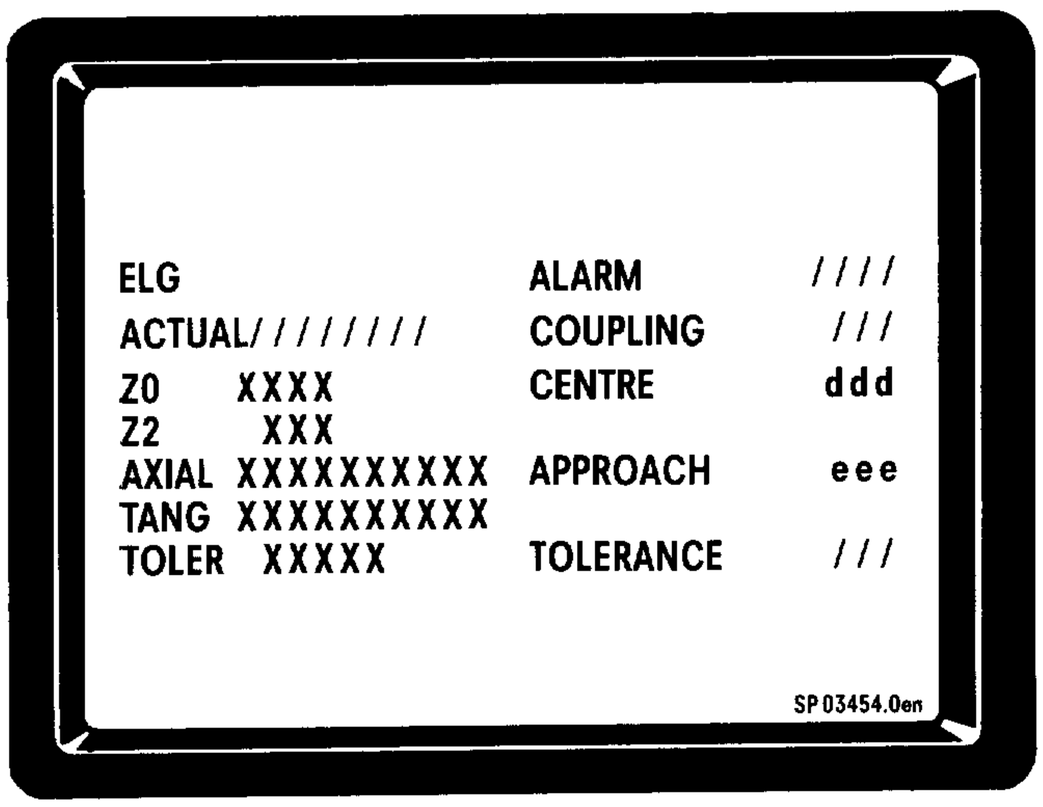
(See Section 13 for symbols)

Before the gearing function is engaged, the gearing constants must have been calculated once.

If the interface signal "Single pitch" is present when the coupling is switched on, the motions of the cutter are <u>not</u> taken into consideration by the drive axis.

When the ELG basic pattern is selected, the following pattern appears for semi-automatic centring:

ELG basic pattern in the "Semi-automatic centring" operating mode (HAE)



The following information only appears in the ELG basic pattern if the "Semi-automatic centring" operating mode is selected (see also Section 8).

CENTRING ddd ON — with gearing coupling switched on COUPLING ON

OFF — with gearing coupling switched off COUPLING OFF

APPROACH eee

- — Initial status when selecting semi-automatic centring (basic position)
- *- — After first transfer of actual value (with "Transfer actual value" interface signal; previously motion in "-" direction of traverse
- or -* — After first transfer actual value; previously motion in "+" direction of traverse
- *-* — After second transfer of actual value and during traverse of drive axis to centre of tooth gap
- *!* — After the drive axis has reached the centre of the tooth gap (acknowledgement with "Tooth gap reached" interface signal).

After the "Semi-automatic centring" operating mode is cancelled, this HAE auxiliary information is deleted in the ELG basic pattern.

4.3 Single pitch (EZT)

If the "Single pitch" interface signal is present (triggered by an M-function in the NC), the drive axis can be traversed by the NC by one tooth pitch at a time in either the positive or negative direction, either by means of the direction key or by means of M-functions; the pitch is calculated from N_{02}/Z_2. The values Z_0, ud_z and ud_y may be zero.

An appropriate differential component must be entered in order to create helical teeth in the "Single pitch mode".

The single pitch mode is not possible unless the gearing is OFF.
In order to make helical teeth, the machine must therefore always be switched between "Single pitch" and "Gearing ON/OFF".

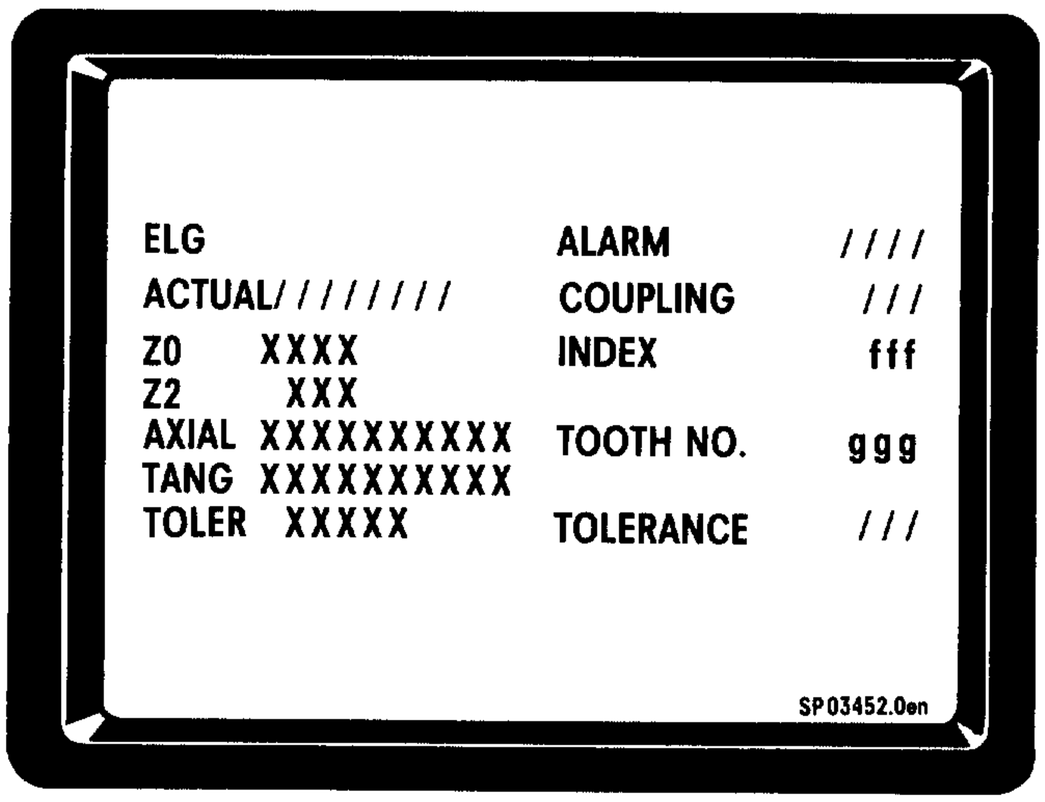
An example of an NC program for single pitch with helical teeth is explained in the Annex (Section 13).

If the "Single pitch" gearing function is present when switching on, the drive axis only follows the motions of the differential axes, but the motions of the cutter are not taken into consideration.

Single pitch can again be cancelled with the aid of an M-function.

Before selecting "Single pitch", the gearing parameters must have been calculated once (see Section 4.1).

The following pattern is displayed in the ELG basic pattern during SINGLE PITCH:



The following information appears in the ELG basic pattern only when the SINGLE PITCH mode is selected.
Condition: "Single pitch" = "i"
interface signal)

INDEX fff ON with gearing coupling switched off
COUPLING OFF

OFF with gearing coupling switch on
COUPLING ON
Note: If semi-automatic centring has also been selected, the auxiliary information is displayed by semi-automatic centring.

TOOTH NO. ggg 1 Number of the currently machined tooth gap. When single pitch is selected, the counter is set at the starting value 1. The counter counts to max. Z2.
Z2

When single pitch is cancelled ("Single pitch" = "0" interface signal), this auxiliary information is deleted in the ELG basic pattern (see also Section 8).

5. Input parameters

The values below are processed as input parameters by the electronic gearing:

Symbol (ELG basic pattern)	Input parameters Meaning	R-parameter number ELG/PC	Dimension	Value range	Sign
Z0	Number of threads of cutter or number of teeth of the shaper cutter (negative sign for up milling)	R 20	1	0-999	+/–
Z2	Number of workpiece teeth	R 21	1	2-999	+
TOLER	Maximum following error for monitoring	R 40	Measuring system unit (depending on resolution)	0-10 000	+
TANG (Udy)	Differential component for tangential motion	R 60	Degrees/ mm or degrees/ 0.1 inch	0-999.99999	+/–
AXIAL (Udz)	Differential component for axial motion	R 61	Degrees/ mm or degrees/ 0.1 inch	0-999.99999	+/–

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These values are transferred by the NC via the PC to the electronic gearing by means of an R-parameter transfer.

This is initiated by means of a freely selectable M-function.

In addition, the input parameters can also be entered manually by way of the operator's panel of the NC. To do this, the ELG basic pattern must be selected. Data is entered with the input key, depending on the cursor position.

The cursor can be positioned at the individual input parameters with the

[→] or [←] keys.

Manual entry of input parameters is only possible when the mode selector switch is in the MDI-PP position.

A subroutine in the NC permits computation of ud_z and ud_y from the standard module, the lead angle of the cutter and the tooth helix angle of the workpiece.

6. Monitoring following error of the drive axis

In addition to the standard NC monitoring functions (measurement circuit monitoring, etc.), it is also possible to monitor the following error with the aid of workpiece-dependent limit values.

If the difference between the set value and actual value of the drive axis exceeds this limit value, a contact is opened and alarm message 2215 output. A hardware signal is thus present which, for example, could cause the cutter to disengage from the workpiece.

The contact corresponds to the "Controller enable" signal of an unassigned set output where the axis No. must be defined with machine datum MD 5022. The workpiece-dependent limit value can be input as R-parameter (R40), and can also be changed in the course of "COUPLING ON".

A minimum monitoring value (e.g. caused by the machine) can be preset with machine datum MD 169. The following error is compared with the larger of the two values (MD 169 or R40).

Monitoring of the following error can be initiated or cancelled with the "Following error monitoring active" interface signal. It is only active with "COUPLING ON".

The contact is ...

... closed, if

following error < max. limit value

... open, if

following error > max. limit value
and
"Following error monitoring
active" = "1"

The contact is reclosed after an alarm message when the coupling is switched off (= normal position).
The alarm (2215) can be cancelled with RESET.

The ELG basic pattern displays whether following error monitoring is activated or not (TOLERANCE ON or OFF). The limit value (TOLER) is also displayed. This limit value can also be changed manually by way of the operator's panel of the NC; to do this, the mode selector switch must be in the MDI-PP position.

Note:

If the workpiece-dependent limit value (R40) transferred from the PC to the ELG is smaller than the machine data value MD 169, the ELG does not take over this new limit value.

The following error continues to be monitored at the last valid limit value.

7. Setting-up modes

The machine control panel signals (e.g. mode switch) of the ELG must be supplied in the user program. The functional module package 6 automatically presets merely the signals of the axis selector switch with the code of the drive axis.

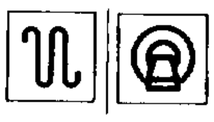
When the coupling is disengaged, the following modes are possible for the drive axis (C-axis):

7.1 Conventional (JOG)

JOG mode on selector switch

The drive axis can be traversed using separate direction keys.
The feed rate is defined by way of the machine datum and can be changed with the feed compensation switch.

A rapid traverse override key can be actuated for rapid traverse.



If the rapid traverse mode is engaged and the toggle switch is at "Rapid traverse compensation", this rapid traverse compensation switch is active between 0 and 100 %.

Irrespective of this switch, the 0 % position of the feed compensation switch leads to mandatory feed and rapid traverse stop.

The actual value of the drive axis is displayed in the ELG basic pattern.

7.2 Incremental feed (INC)

The incremental feed mode can, for example, be utilized for traversing away from the contour or for exact setting.

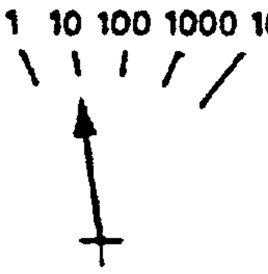
The auxiliary motion of the drive axis necessary for semi-automatic centring, when the gearing function is engaged, is only possible when the mode switch is at the INC position.

Defined positioning by hand is possible.

The feedrate is set by way of machine datum, depending on the feed compensation switch.

Operation

Presetting of the incremental feed by way of mode selector switch



The drive axis is traversed using separate direction keys.
The incremental feed sequence is run in latching mode.

The displacement traversed (Δs) is dependent on the resolution of the measuring system (measuring system unit) of the drive axis (Section 11).

The following applies:

$$\Delta S = \text{Increments} * (2 * \text{measuring system unit})$$

Example:

Measuring system unit = 0.0005°
Mode switch at → 1000

$\Delta S = 1000 * 2 \times 0.0005° = 1°$

In contrast,
where measuring system unit = 0.005°:

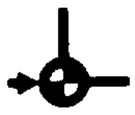
$\Delta S = 10°$

Allowance is made for the measuring system unit when displaying the actual value of the drive axis.

7.3 Reference point approach (REF)

It is necessary to use the reference point approach method with the drive axis (axis of rotation) if concentricity compensation (spindle lead error compensation) is used for the drive axis.

This creates a relationship between measuring system and machine enabling the control system, and thus the measuring system and the machine, to re-synchronize at any time, even when voltage has been disconnected.



Reference point approach mode on selector switch

After pressing the appropriate direction key, the cutter traverses to the reference point (direction in latching mode).

The approach direction selected is checked by the control system before starting (false direction: operation not accepted, no motion is initiated).

When traversing to the reference point, "REF. AXIS TRAVERSING!" is displayed as information in the message line.

Feed stop is active, as are feed/rapid traverse compensation switch when "Rapid traverse compensation active" switch is active.

The reference point approach rate is set by way of machine datum at startup.

When the reference point is reached, the actual value storage unit is set at the value input as reference point coordinates per machine datum.
The actual value display only agrees with the preset machine data value if the resolution of the measuring system corresponds to 0.5×10^{-3}° (i.e. machine datum MD 396* for drive axis = 180 000).
After the reference point is reached, "REF. PT. REACHED" is displayed in the message line.

8. ELG-specific PC display patterns

Information of the ELG can be displayed on the VDU of the NC with the aid of functional module package 6 specially developed for the electronic gearing and the PC display programs (functional module package 1).

The functional modules in package 6 are divided into two individual packages:

a) Basic package:

This package contains functional modules

- for the linkage and configuration of ELG control signals
- for transferring the input parameters between NC or operator's panel and PC and ELG
- for controlling the ELG basic pattern

b) Startup package:

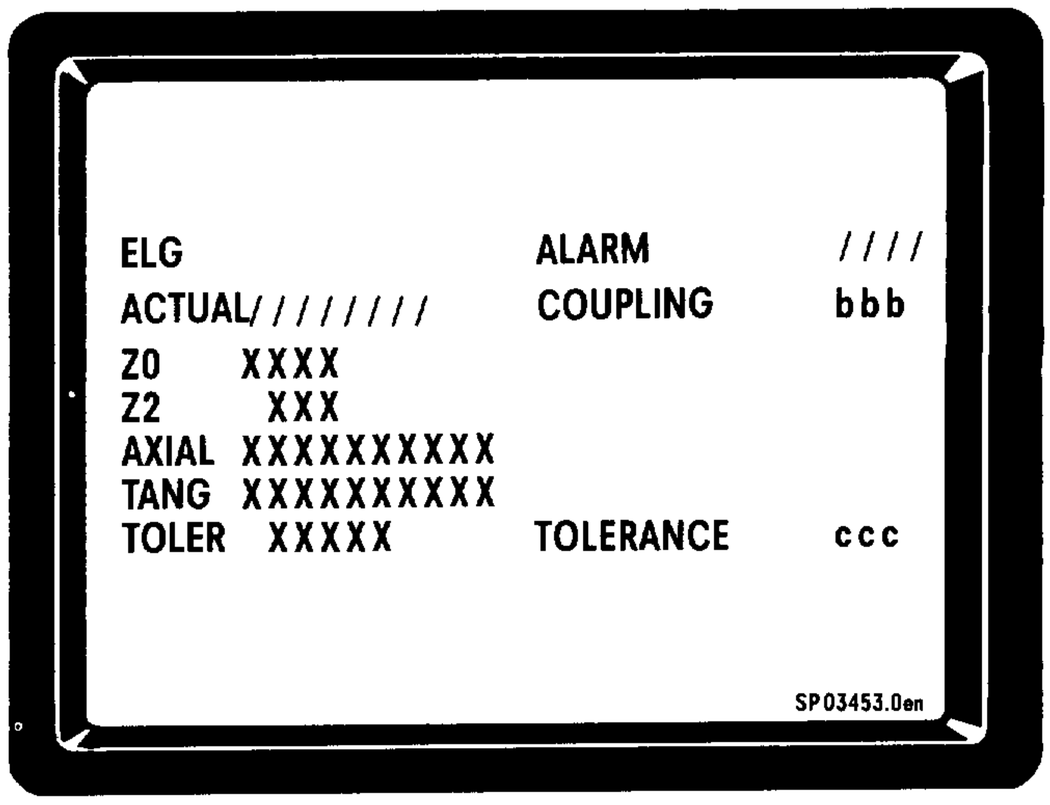
This package contains additional functional modules facilitating startup of the ELG.

It enables input and display of
- Machine data
- Setting data
- Service data (only display)

on the VDU of the NC operator's panel.

8.1 ELG basic pattern without submode

The user must define himself the mode of selecting the ELG basic pattern in his PC program by switching the two binary inputs in the "Control ELG basic pattern" functional module accordingly.



The following are displayed in the ELG basic pattern:

ACTUAL — Actual value of drive axis (constantly updated). If no axis number has been input in machine datum 5020, actual value is displayed at 0.

ALARM — The ALARM text and one alarm number in each case are superimposed if an ELG alarm is present ("ELG-Alarm" = 1 interface signal).
If various ELG alarms occur simultaneously, the alarm numbers appear in the display one after the other for a period of 5 seconds each.

Input parameters:
(See Section 5)

ZO — Number of threads of the cutter or number of teeth of the shaper cutter

Z2 — Number of teeth of workpiece

AXIAL — Differential component for axial motion

TANG — Differential component for tangential motion

TOLER — Max. following error for monitoring

ELG function messages:

COUPLING

bbb ... ON — when gearing coupling is switched on ("Coupling ON" = "1" interface signal)

OFF — when gearing coupling is switched off ("Coupling ON" = "0" interface signal)

TOLERANCE

ccc ... ON when following error monitoring unit is active

OFF when following error monitoring unit in-active

Furthermore, additional information is displayed depending on the single pitch or semi-automatic centring modes (for more detailed description, see Section 4).

The following NC information is also displayed:

- NC mode (Line 1)
- NC alarm display in clear text (Line 14)
- NC status messages (Line 16)

Various ELG operating statuses cause messages to appear on the VDU of the NC in the information line (Line 15).

8.2 Startup patterns

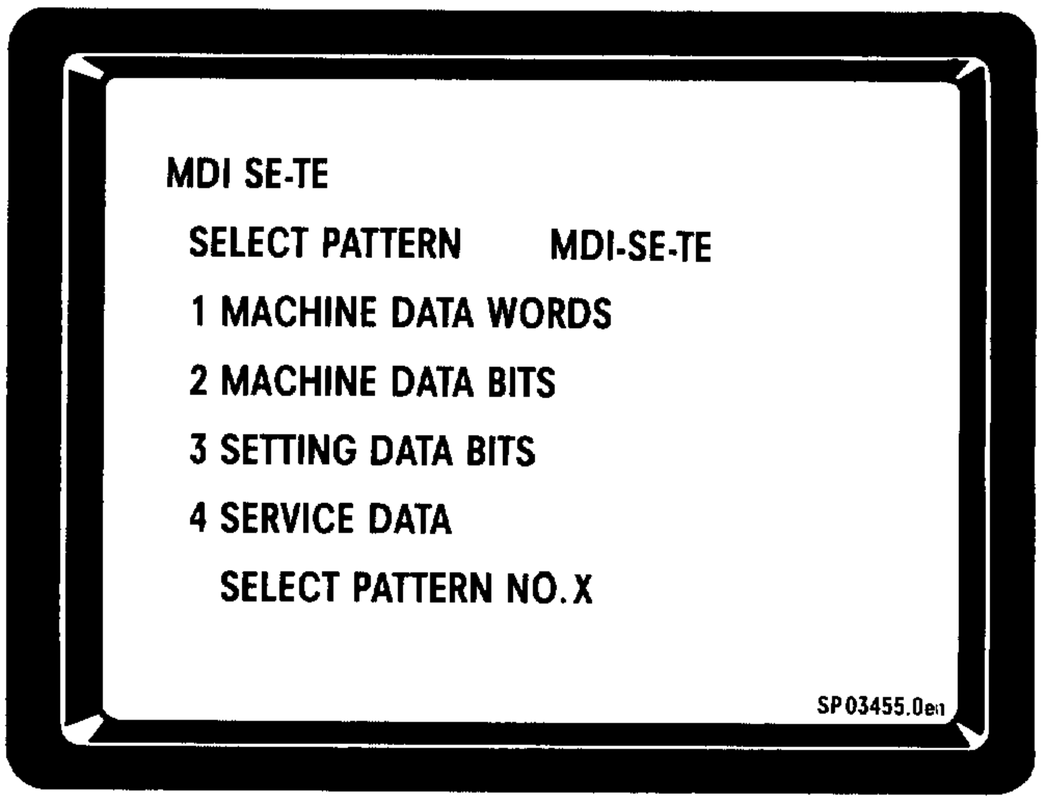
The following ELG-specific patterns are only displayed on the VDU of the NC when the startup package (package 6) is used.

8.2.1 Startup select pattern

Select:

If the basic pattern for the ELG is present on the VDU of the NC, the following startup select pattern is displayed when the mode switch is in the MDI-SETE position:

Select pattern for startup patterns



After selection of the startup select pattern, the required startup pattern can be selected by pressing the figure keys 1...4 on the keyboard:

1 = Machine data of the ELG (words)
2 = Machine data of the ELG (bits)
3 = Setting data of the ELG (bits)
4 = Service data of the ELG

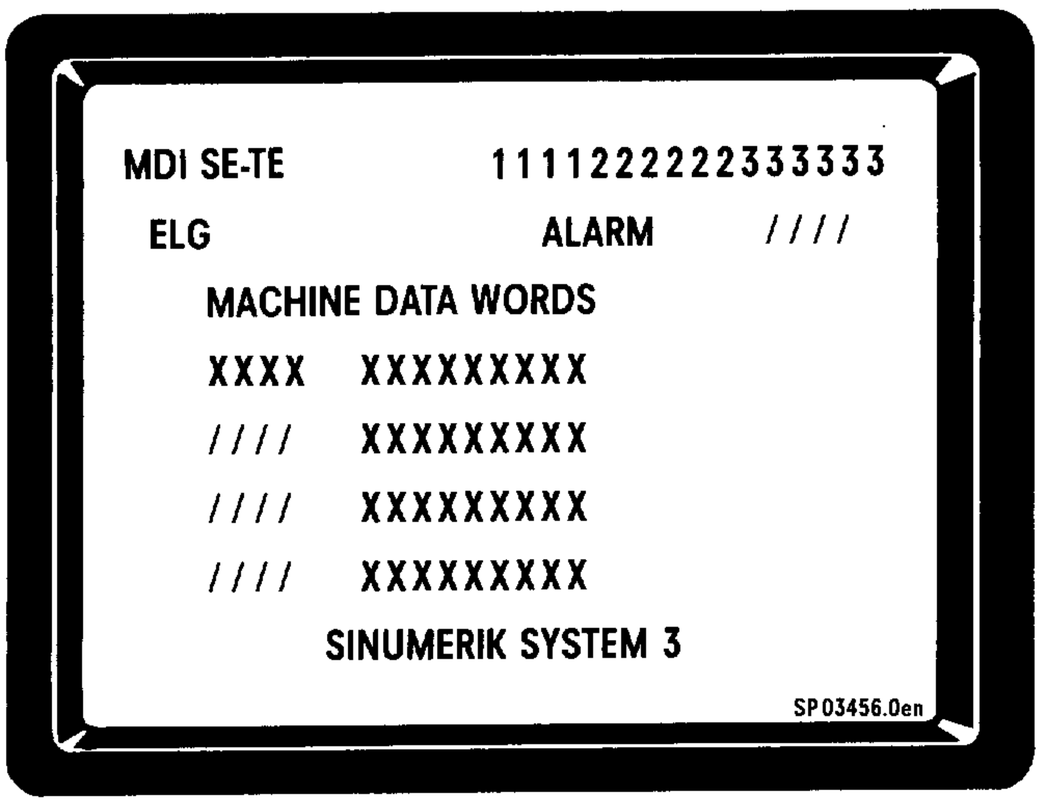
The values displayed at last selection appear when selecting the pattern.

Cancel:

Cancellation of the startup patterns is by:

- Input of figures 1 to 4
- PC key
  (if mode ≠ MDI-SETE)
- Selection of a different NC interface
- Mode key 

8.2.2 Startup pattern for machine data words



Selection of pattern by inputting 1 in SELECTION PATTERN NO. of the select pattern.

Cancellation of pattern by actuating the PC key. The following then appear for

- MDI-SETE mode: ELG select pattern
- other mode: ELG basic pattern

Machine data are updated after inputting a machine data number or after advancing with the paging key, after inputting and when selecting a pattern (last displayed range).

If an invalid machine data number is preselected, ALARM 3018 is signalled.

The valid machine data are listed in the ELG startup instructions.

If the cursor is in the input field for the machine data number, the paging keys can be used to page up or down to the next machine data bits.

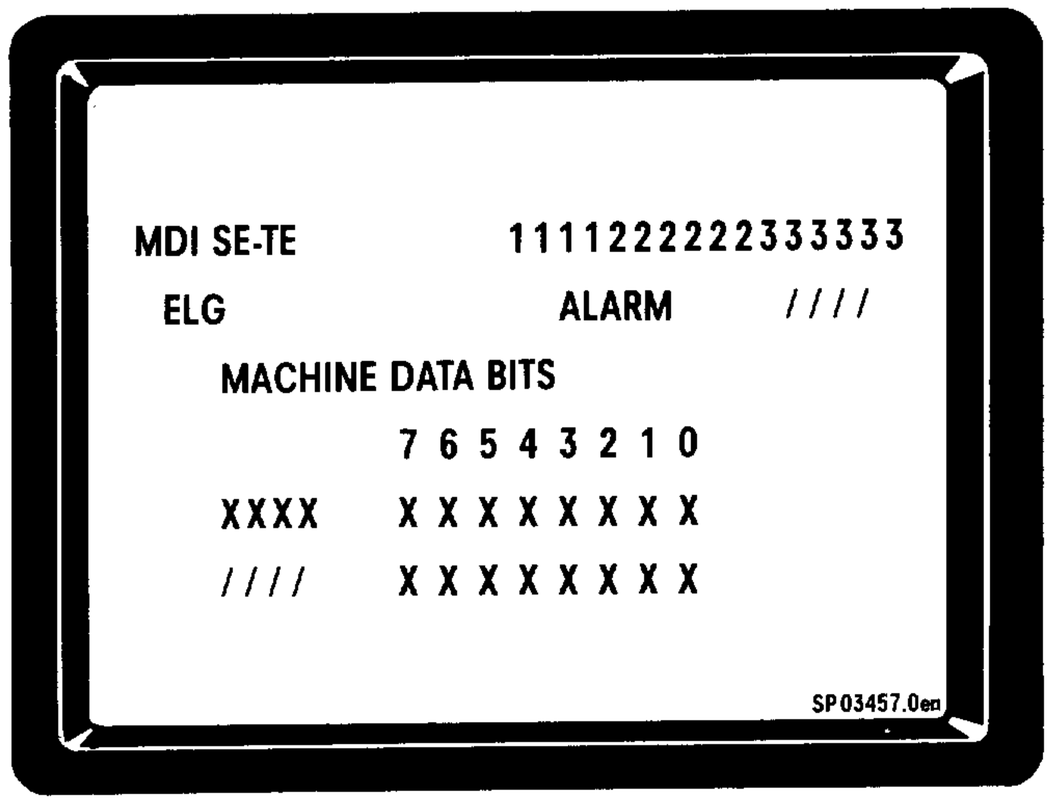
The next 4 machine data words are displayed by actuating key.

The previous machine data are displayed by actuating key.

The cursor can be positioned inside the input fields with keys or .

Entry is by way of the input key . No machine data can be entered when the coupling is ON.

8.2.3 Startup pattern for machine data bits



Selection of pattern by inputting 2 in SELECT PATTERN NO. of the select pattern

Cancellation of pattern by actuation of the PC key. The following then appears in

- MDI-SETE mode: Select pattern
- other mode: Basic pattern

The machine data bits are updated after input of a machine data number or after advancing with the paging key, after an input and when selecting a pattern (last displayed range).

Presetting to the required machine datum is achieved by inputting a new address. If this number lies in the invalid range, ALARM 3018 is signalled.

If the cursor is in the input field for the machine data number, the paging keys can be used to page up or down to the next machine data numbers.

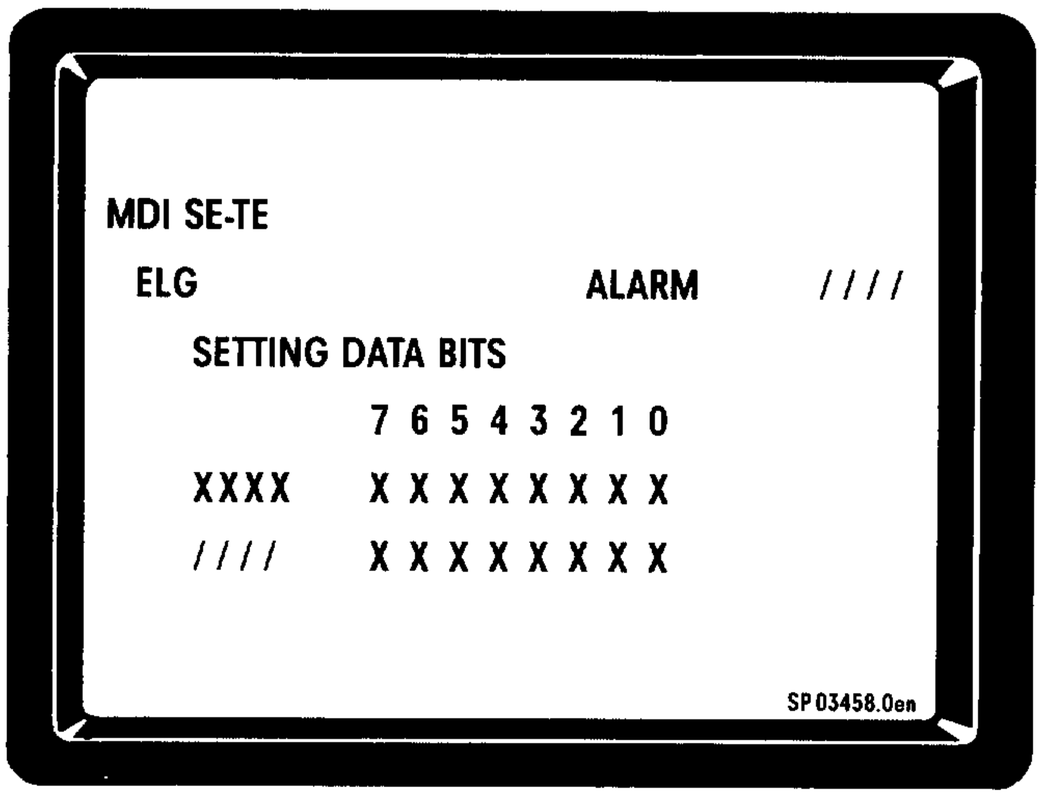
The next 2 machine data bits are displayed by actuating key [↓/⇩] .

The previous machine data are displayed by actuating key [↑] .

The cursor can be positioned inside the input fields with keys [→] or [←] .

The machine data bits are input individually with the input key, depending on the cursor position. The byte in which the appropriate bit has been changed is transferred to the ELG and subsequently read out. No machine data bits can be entered when the coupling is ON.

8.2.4 Startup pattern for setting data bits



Selection of pattern by inputting 3 in SELECT PATTERN NO. of the select pattern.

Cancellation of pattern by actuation of the PC key. The following then appears for

- MDI-SETE mode: Select pattern
- Other mode: Basic pattern

The setting data are updated after input of a setting data number or after advancing with the paging key, after an input and when selecting a pattern (last displayed range).

Possible setting data bits: 5000 - 5023

If the cursor is in the input field for the setting data number, the paging keys can be used to page up or down to the next 2 setting data numbers.

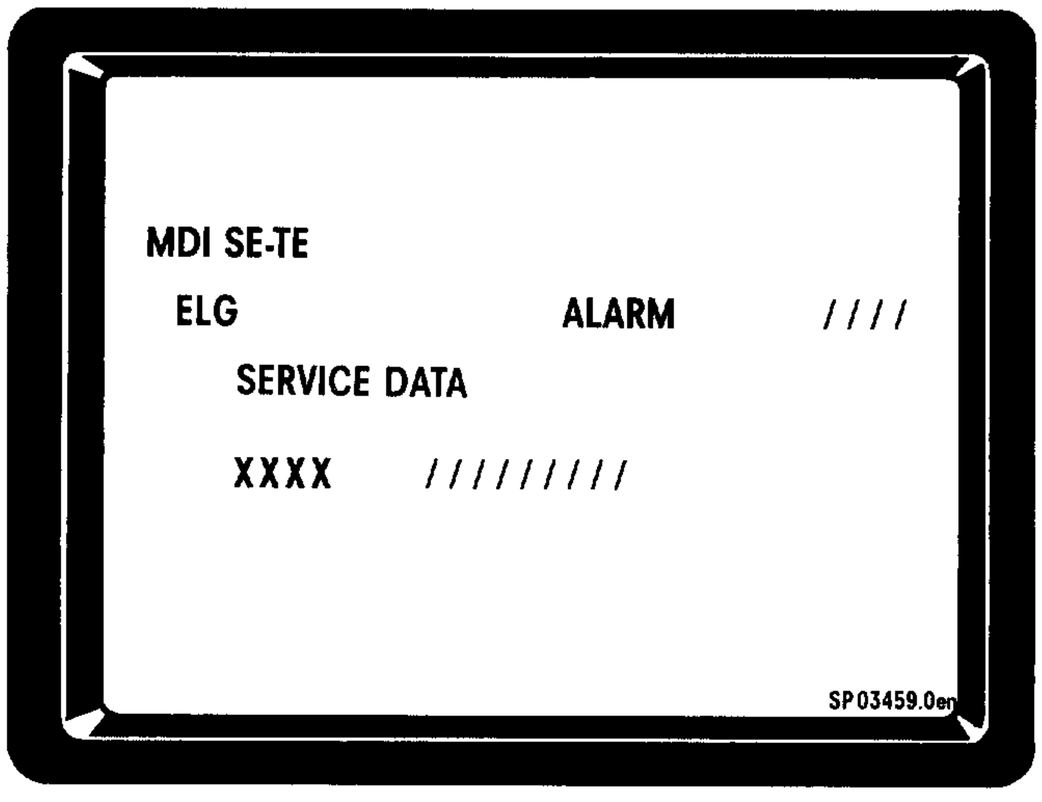
The next 2 setting data addresses are displayed by actuating key [↓/⇩] .

The previous machine data are displayed by actuating key [↑] .

The cursor can be positioned inside the input fields with keys [→] or [←] .

The setting data bits are entered individually, depending on the cursor position.
Transfer is by way of input key [⇨] .
No setting data bits can be input when the coupling is activated.

8.2.5 Startup pattern for service data



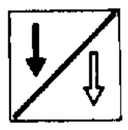
Selection of pattern after inputting figure 4 in SELECT PATTERN NO. of the select pattern.

Cancellation of pattern by actuation of the PC key. The following then appears for

- MDI-SETE mode: Select pattern
- Other mode: Basic pattern

* Possible service data no. 8000 - 8002 (see Section 11.2)

The value selected (service data no.) is constantly updated.

* Advance with the paging key ( or )

9. Data input/output with universal interface

The ELG has a serial interface which can either be operated as V.24 interface or as 20 mA line current interface. It is connected to the CPU card module (6FX1125-8AC), pin X111 of the ELG.

Machine and setting data can be transferred to the ELG with the aid of this universal interface.

The interface must be first set to the peripheral equipment using setting data 5010 to 5016. The interface data can be set separately for data input and output.

The universal interface can be preset on startup to the Siemens PT80 page teleprinter, using input 9. The specification of the ELG universal interface is contained in Section 10.

9.1 Data input operation

Selection of the data input mode (DATA INPUT): 

Data input is started (DATA START key is defined by the user) using the "DATA START" instruction (interface signal).

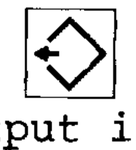
The type of data is automatically recognized during loading.

The "V.24 RUNNING!" wait message appears in line 15 during loading; this is extinguished after completion of transfer. Data input is not possible while gearing coupling is activated.

In the case of uncontrolled data transfer, Alarm 22 appears if data are not transmitted by the peripheral equipment within 60 s.

Transmission is interrupted if the mode is changed or using the "DATA STOP" instruction (interface signal). Otherwise, transmission is stopped by inputting the "End of transmission" character (M02 or M30 and/or ETX).

9.2 Data output operation

Selection of data output mode (DATA OUTPUT). 

Data output is started (DATA START key should be defined by the user) using the "DATA START" instruction (interface signal).
Machine data are output first.
Setting data can be output after completion of machine data transmission by repeating the "DATA START" instruction, provided the mode has not been changed beforehand.

The "V.24 RUNNING!" wait message appears in line 15 during readout; this is extinguished after completion of transfer. Data output is not possible while the gearing coupling is activated.

In the case of uncontrolled data transmission, Alarm 22 appears if the ELG cannot send data to the peripheral equipment within 60 s.

Transmission is interrupted by changing the mode or by using "DATA STOP" instruction (interface signal).

9.3 Paper tape code

The data on the paper tape are coded according to fixed rules, i.e. one combination of punched holes corresponds to one specific character.

Input of machine and setting data is only possible with paper tape code DIN 66025 (ISO). The control system recognizes the correct code by reading the first %.

The input data are checked for single errors:

- Character parity
  In the ISO code, each character must have an even number of bits (logic "1") (corresponds in the paper tape: number of punched holes per character).

- Block parity
  The number of characters in a block (including LF) must be even. The block parity check can either be initiated or cancelled via the setting datum.

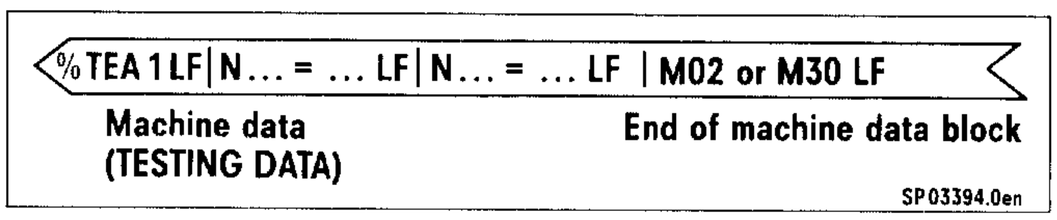
The leading end is used to distinguish various paper tapes. All characters are permitted in the leading end except for % because this is used for automatic recognition.

The leading end is ignored by the control system and not stored.

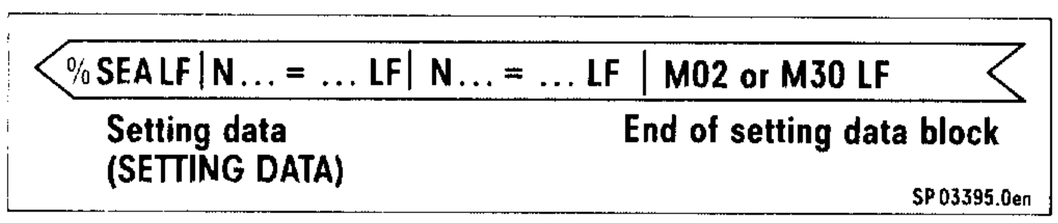
9.4 Paper tape format

The paper tapes must have the following formats:

Machine data: Identification code %TEA1



Setting data: Identification code %SEA



The valid identification numbers (N...) can be found in the lists of machine data and setting data.

10. Planning instructions Universal interface

10.1 V.24 interface

10.1.1 General

The V.24 interface contains V.24 receiver and V.24 transmitter, both in accordance with DIN 66020.
DIN 66020 defines the interface between data terminal equipment DTE and data communication equipment DCE. It is based on recommendations V.24 and V.28 of the CCITT, which in turn are derived from the American EIA Standard RS 232.

The interface also complies with VDI Guideline 2880, which provides specifications for task and data traffic of store-programmable control equipment.

The interface signals used represent a subset of all V.24 or RS 232 standard signals, and thus correspond in their electrical characteristics to these signals.

10.1.2 V.24 interface lines

The ELG is understood as data terminal equipment DTE with respect to the standard.

The SINUMERIK System 3 in contrast is understood as data communication equipment DCE.

ELG	- DTE
Transmission path	- DCE
Peripheral equipment	- DTE
SINUMERIK System 3	- DCE

Ground wires

E1: 101 - Protective Ground

E2: 102 - Signal Ground
This wire is the joint return for all interface lines (with the exception of E1).

Data lines

D1: 103 - Transmitted Data / TxD
Data are transmitted from the DTE to the DCE on this line. Rest condition in logic "One".

D2: 103 - Received Data / RxD
Data are transmitted from the DCE to the DTE on this line. Rest condition in logic "One".

Control lines

S1.2: 102/2 - Data Terminal Ready/DTR
The DTE signals readiness for data transmission to the DCE.

S2: 105 - Request to Send /RTS
The DTE controls the sending section of the DCE data channel.

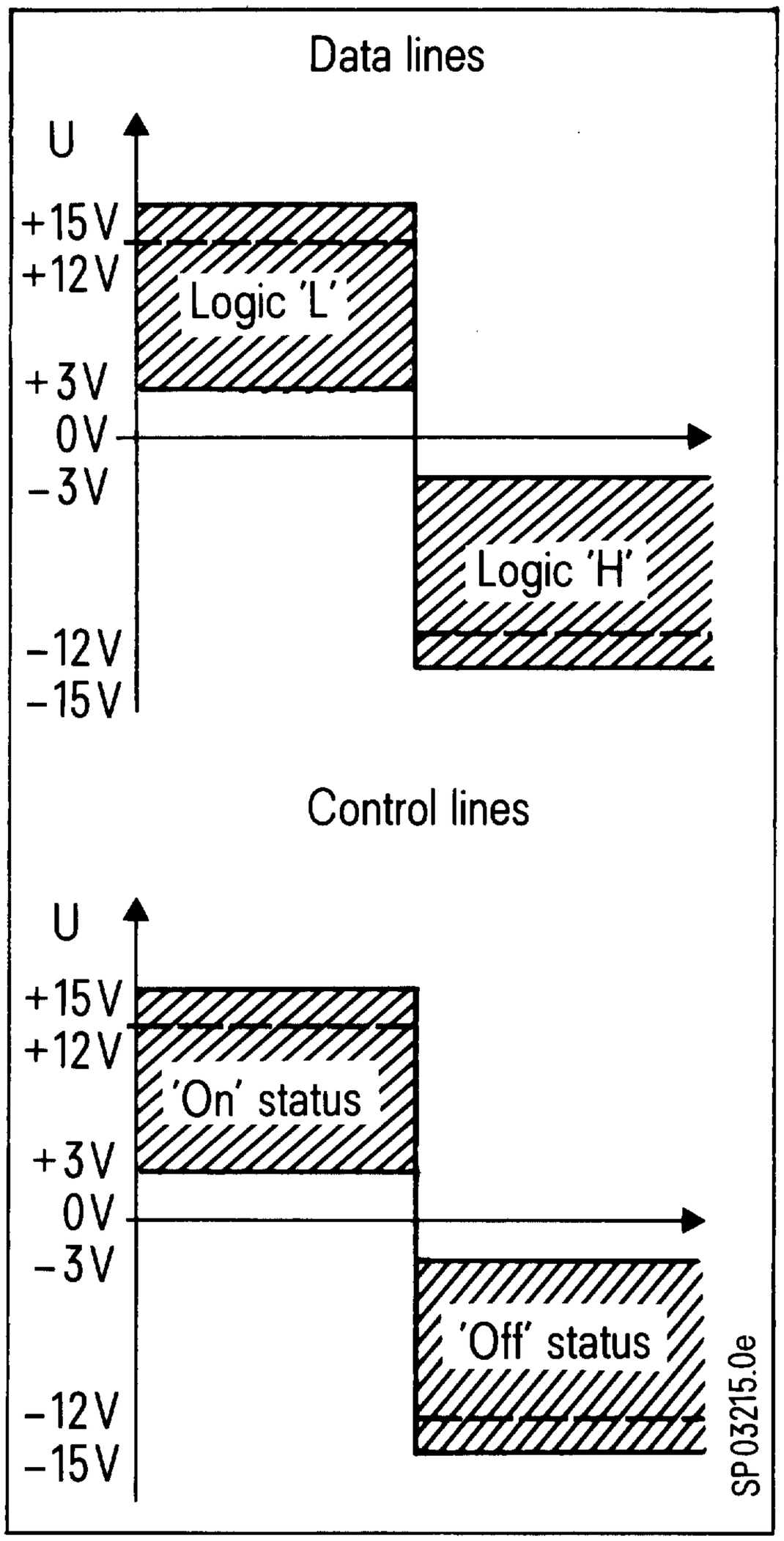
Status lines

M1: 107 - Data Set Ready /DSR
The DCE signals to the DTE whether it is at transmission status.

M2: 106 - Clear to Send /CTS
The DCE signals to the DTE whether it is ready to transmit data signals via the data channel.

E1/2, D1/2, S1.2, S2, M1/2 = DIN 66020
101 to 108.2 = CCITT (V.24)

10.1.3 Allocation of polarity and level of the V.24 interface signals



Level of the ELG interface ± 12 V.

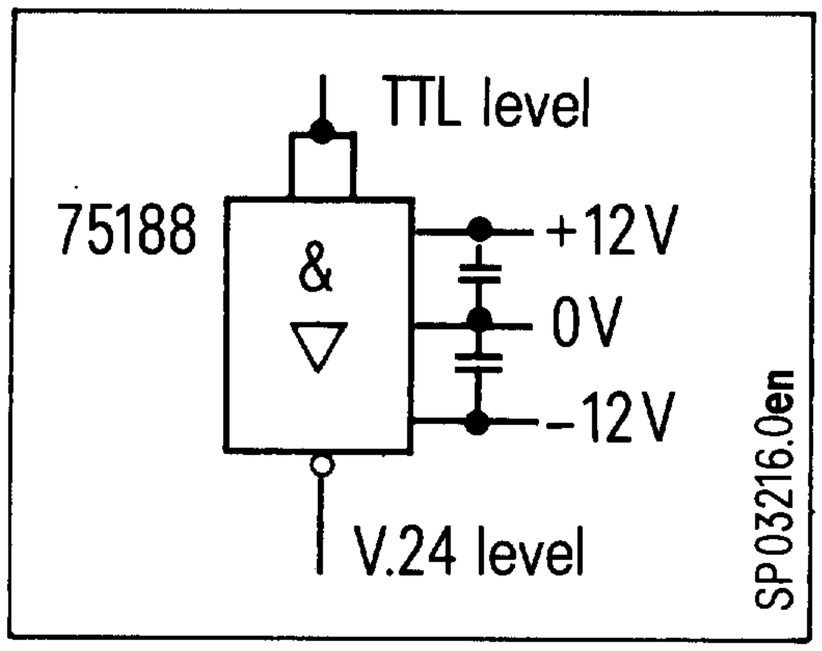
All signal levels refer to Signal Ground E2 (102).

The signal status is undefined in the transient area (+3 to -3 V).
(Range of hysteresis of receiver circuits 75189 A)

10.1.4 V.24 driver and receiver

10.1.4.1 V.24 driver

The V.24 output signals * TxD, RTS and DTR are generated in the V.24 driver module 75188 from the TTL-signals of the USART 8251A.

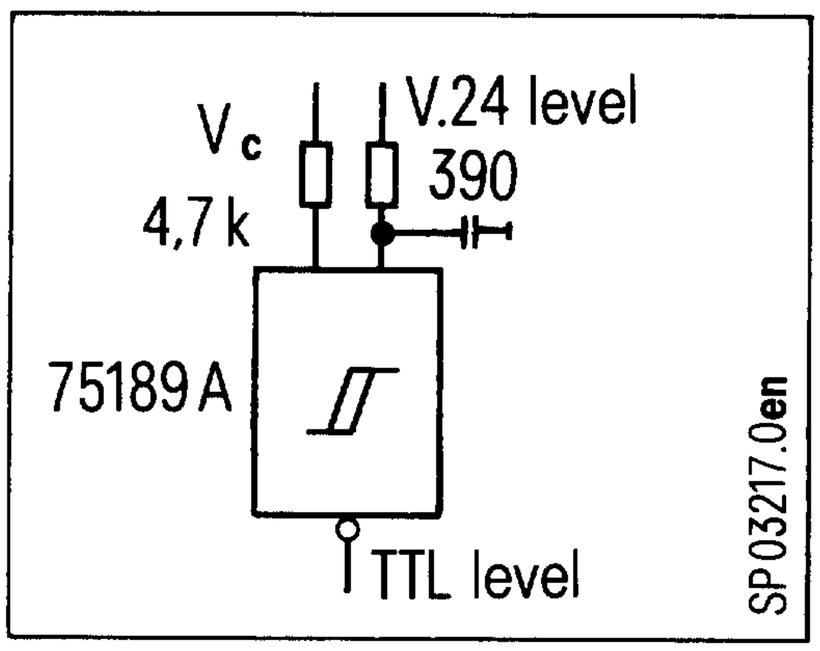


Circuit 75188 data

Max. supply voltage	V_{CC} ± 15 V
Max. output current (limited)	I_O 10 mA
Operating voltage and V.24 level	V_{CC} ± 12 V

10.1.4.2 V.24 receiver

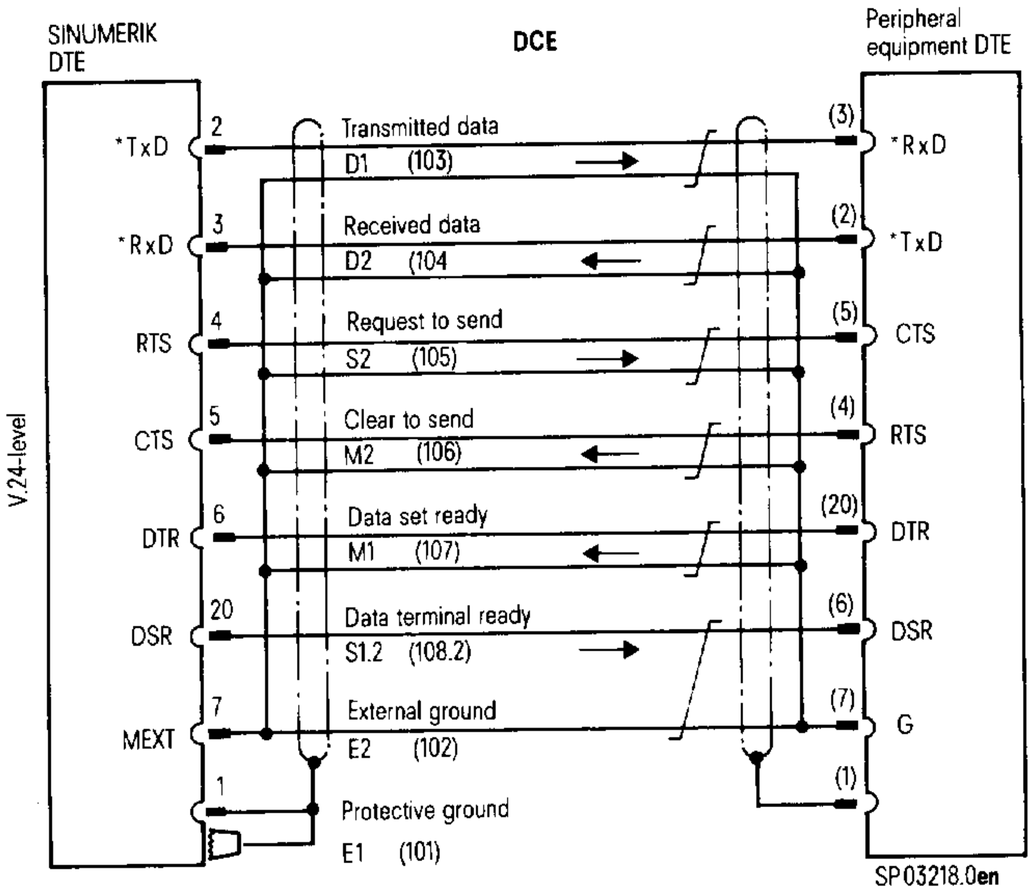
The V.24 input signal * RxD, CTS and DSR are passed to receiver circuits 75189 after filtering via a RC lowpass filter.



Circuit 75189A data

Max. input voltage	V_{CC} ± 30 V
Equivalent input resistance	390 Ohm

10.1.5 Coupling of interface to peripheral equipment in V.24



The names of signals and the arrows indicating direction of action refer to the ELG as DTE.

Which of the control and status lines present are used, depends on the peripheral equipment. In the simplest case, lines E2 and D1 are sufficient for a receiver (printer, puncher) and lines E2 and D2 for a transmitter (reader)
The specification for the peripheral equipment applies for its electrical connection.

A unit conforming to the RS 232C Standard is assumed in representing the interface coupling.

The interface is designed according to VDI Guideline 2880 and the ELG wired as DTE. If a peripheral unit also wired as DTE is connected, the appropriate lines must be cross-connected in the connecting cable (transmitter with receiver).

Part of the interface contains both the V.24 signals and the signals for 20 mA line current operation.
A V.24 transmitter and a 20 mA transmitter may not be connected simultaneously to the ELG interface.

As pins 10, 12, 13, 14, 16, 19, 21, 24 on the ELG side are always assigned to the 20 mA interface, it is imperative to assure that they are not connected to peripheral equipment in V.24 operation.

The decision as to whether V.24 or 20 mA mode of operation is applied depends not on rerunning of jumpers but on the assignment of pins in the plug-in cable connector.

10.1.6 Length of transmission path

The max. cable length in V.24 transmission is 30 m.

10.2 20 mA line current interface

10.2.1 General

The 20 mA interface is designed in accordance with VDI Guideline 2880 as full duplex interface with two pairs of lines. It can be operated on the ELG side actively or passively by the available power sources by appropriate connections in the plug-in cable connector. In general usage, this interface is also referred to as TTY interface.

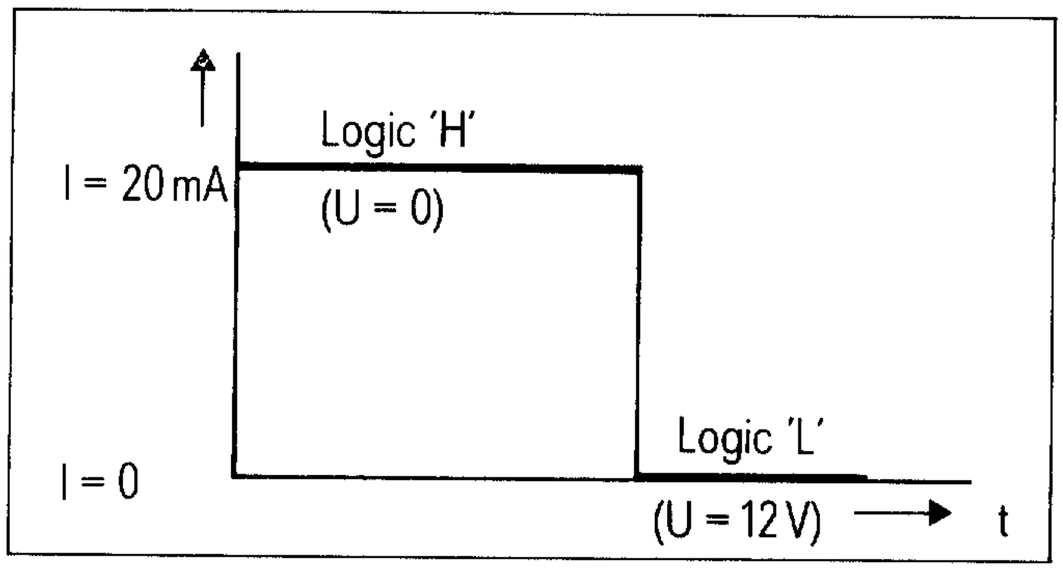
The information below (not signal level) for V.24 interface corresponds to that of the 20 mA interface:

Signal	V.24	20 mA +	20 mA -
Transm. data	D1	TTY2	TTY1
Received data	D2	TTY4	TTY3

The signal designations refer to the ELG as DTE.

10.2.2 20 mA signal level

In contrast to the V.24 interface, information is communicated in the case of 20 mA interface not by voltage level but by impressed current.



SP03219.0en

Logic "0": I = 0
Logic "1": I = 20 mA

Level 1-signal 20 mA ± 30 %
(max. no-load voltage 30V)

0-signal 0 mA ... 2 mA

Voltage for line current source at ELG: U = 12 V

10.2.3 Coupling of interface to peripheral equipment at 20 mA

The 20 mA interface is designed as full duplex interface with two pairs of lines.
It can be operated on the ELG side either as active or passive interface.

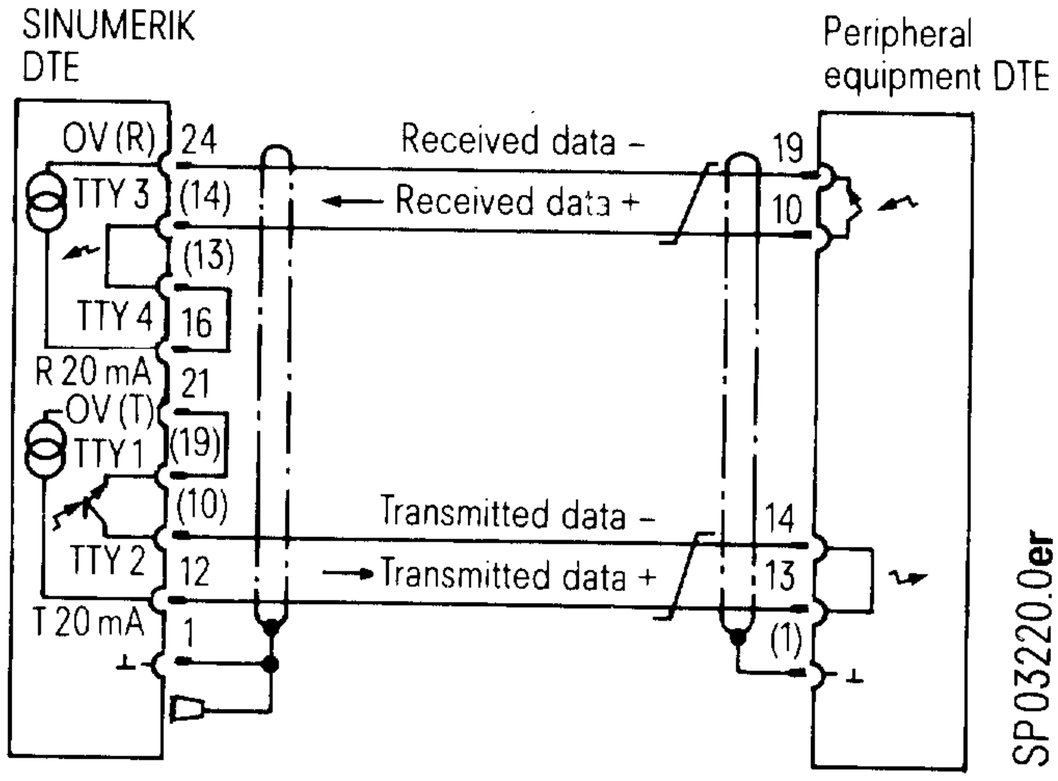
- Active interface:
  ELG supplies the 20 mA line current

- Passive interface:
  Peripheral equipment supplies the 20 mA line current

The "active" or "passive" definition is made on the ELG side by appropriate wiring in the plug-in cable connector and not by way of rerunning of jumpers on the module.

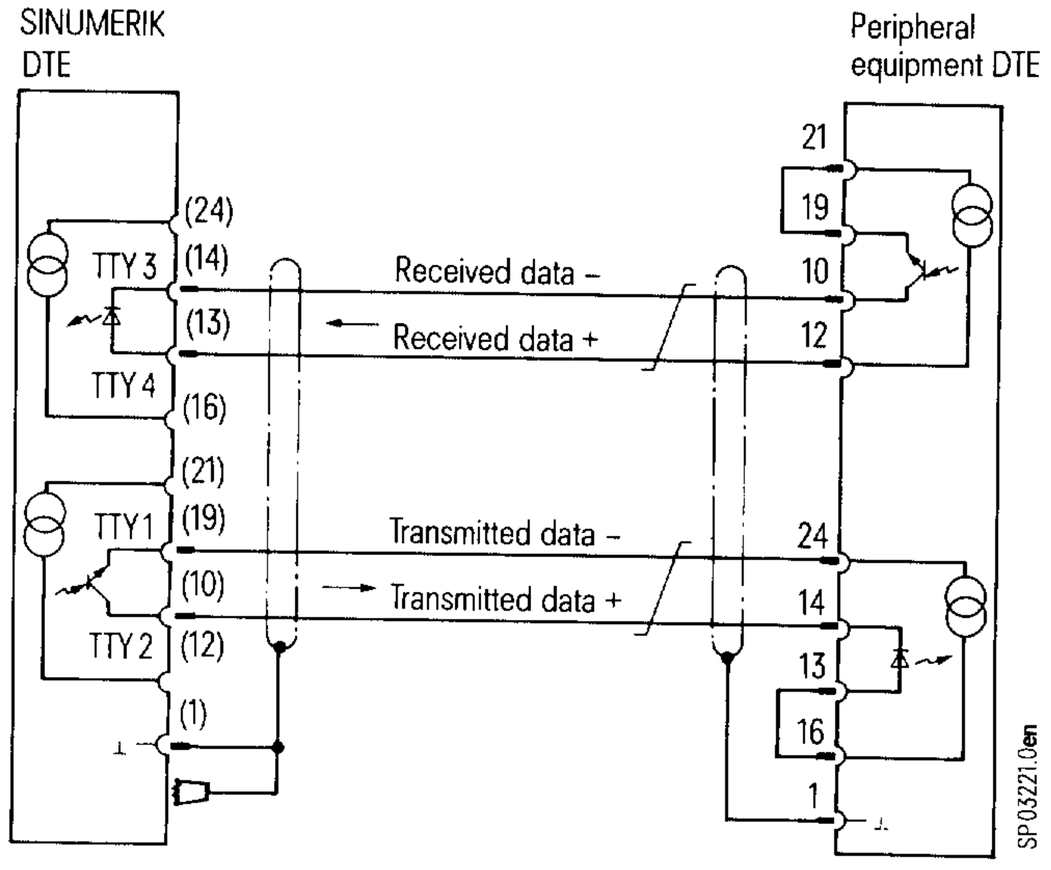
The line current should always be subjected to closed loop control (approx. 20 mA).
See also note in Section 10.1.5.

10.2.3.1 Full duplex interface active on ELG side



SP03220.0er

10.2.3.2 Full duplex interface passive on ELG side



SP03221.0en

The names of signals and the arrows indicating direction of action refer to the ELG as DTE.

The specification for the peripheral equipment applies for its electrical connection.

A peripheral unit in accordance with VDI 2880 specification is assumed in representing the interface coupling.

10.2.4 Length of transmission path

The max. cable path for the 20 mA line current interface is 1 km.

10.3 Summary of interfaces

10.3.1 Connection of interfaces

Connection is to the CPU card module 6FX1125-8A of the ELG.

First interface connection pin X111

V.24 interface and 20 mA 25-pin plug, D subminiature, jack, plug-in location 1 below.
Housing of plug-in cable connector:
Slide locking model

Second interface pin X121

Not populated!

Note: The following differences exist between the ELG interface and that of the NC (System 3):

ELG	NC (System 3)
Signal assignment as DTE	Signal assignment as DCE
Female plug-in connector	Male plug-in connector

A different transmission cable is thus necessary in contrast to the SINUMERIK System 3 for the ELG, or an adapter cable must be interconnected.

10.3.2 Connector pin assignment of the V.24/20 mA universal interface

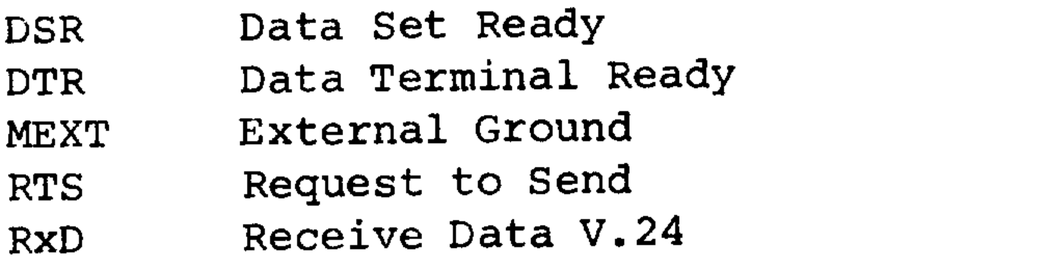
D subminiature, 25-pin, female plug-in connector on the SINUMERIK.

Pin	SINUMERIK signal name	Interface allocation	Name of signal according to DIN 66020, VDI 2880 (Reference to ELG as DTE)	
1	⊥		Protective ground	E1 (101)
2	*TxD	V.24	Transmitted data	D1 (103)
3	*RxD	V.24	Received data	D2 (104)
4	RTS	V.24	Ready to send	S2 (105)
5	CTS	V.24	Clear to send	M2 (106)
6	DSR	V.24	Data set ready	M1 (107)
7	MEXT	V.24	External ground	E2 (102)
8				
9				
10	TTY2	20 mA	Transmitted data +	
11				
12	T 20 mA	20 mA	Transmit line current source	
13	TTY4	20 mA	Received data +	
14	TTY3	20 mA	Received data –	
15				
16	R 20 mA	20 mA	Receive line current source	
17				
18				
19	TTY1	20 mA	Transmitted data –	
20	DTR	V.24	Data terminal ready	
21	OV (T)	20 mA	Power return line	
22				
23				
24	OV (R)	20 mA	Power return line	
25				

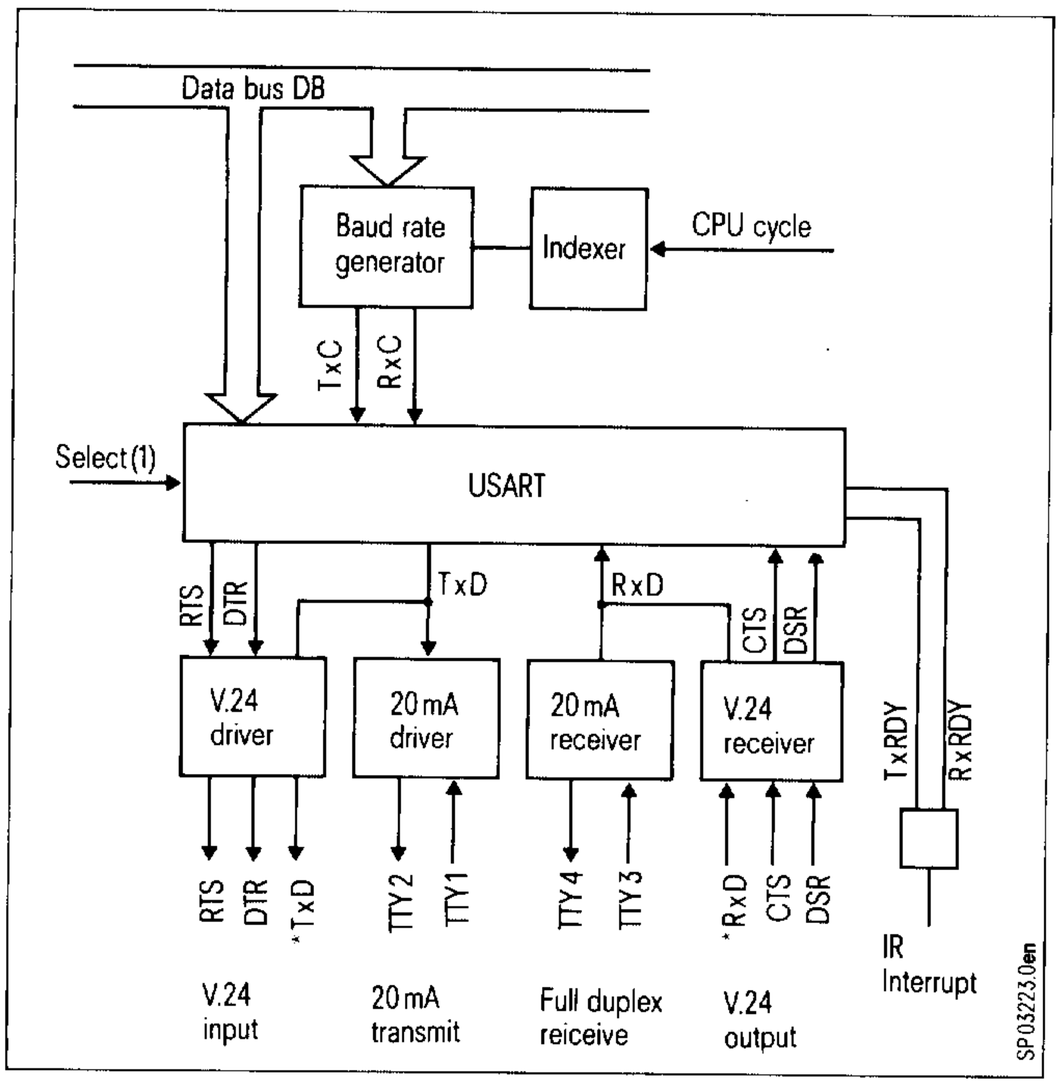
10.3.3 Explanation of signal names

CTS	Clear to Send
DSR	Data Set Ready
DTR	Data Terminal Ready
MEXT	External Ground
RTS	Request to Send
RxD	Receive Data V.24
R20mA	Receive Source 20 mA
TxD	Transmit Data V.24
TTY1	Teletype (-20mA) Transmit Data
TTY2	Teletype (+20mA) Transmit Data
TTY3	Teletype (-20mA) Receive Data
TTY4	Teletype (+20mA) Receive Data
T20mA	Transmit Source 20 mA
OV(R)	OV - Receive 20 mA
OV(T)	OV - Transmit 20 mA

10.3.4 Structure of a serially transmitted character



10.3.5 Block diagram of the V.24/20 mA universal interface



10.4 Interface adapter circuit to perhipheral equipment

10.4.1 General

Depending on the type of data transfer, a distinction is made between peripheral equipment into:

- Power-controlled units
  - o Control operation by way of DSR, DTR, CTS, RTS control lines

- Uncontrolled units
  - o Asynchronous transfer without control modulation

- Character controlled units
  - o Control operation by way of control characters on the data transmission lines

On the ELG side, setting to peripheral units per interface and data direction is by way of setting data (see Selection Table). Activation of the control lines is exclusively by means of their electrical connection.

10.4.2 Setting data

Setting Data No.	Function Bit 7	6	5	4	3	2	1	0
5010	Device coding - data input -							
5011	Transfer format - data input - Stop bits	Type of parity	Parity bit		Baud rate			
5012	Device coding - data output -							
5013	Transfer format - data output - Stop bits	Type of parity	Parity bit		Baud rate			
5014	Xon - Character (e.g. DC1 = 11H)							
5015	Xoff - Character (e.g. DC3 = 93H)							
5016	Special bits: Output without 1st Xon charac.	End of block CR LF	Output in EIA code	Stop at character end of transfer	Interpret data terminal readiness	Output without trailer		
5026	Code for "End of transfer" (e.g. ETX = 03H)							

When starting up, the interface can be aligned on the Siemens PT 80 page teleprinter (general-purpose printer) by INPUT 9 (simultaneous actuation of keys 9 and ⇨ with Mains On; start-up switch of limiter 6FX1122-1AA in position 1).
The setting data are preset as follows:

Setting datum No.	Binary code	Hex code	Unit
5010	0000 0000	00H	Siemens
5011	1100 0010	C2H	PT 80 page teleprinter 20 mA / V.24
5012	0000 0000	00H	300 baud
5013	1100 0010	C2H	
5014	0000 0000	00H	
5015	0000 0000	00H	
5016	0000 0000	00H	
5026	0000 0000	00H	

10.4.2.1 Description of setting data

Specific data per interface

Byte 1, 3 Equipment coding

00 H = Power-controlled units (Standard data traffic)
01 H = Xon/Xoff-character-controlled units

02 H = Siemens System 3/8 reader
03 H = Siemens PD/PF programming place

Unit setting data are listed in the selection table in Section 10.7.1

Byte 2, 4 Transfer format

- Bit 3 ... 0 baud rate

0000 = 110 baud
0001 = 150 baud
0010 = 300 baud
0011 = 600 baud
0100 = 1200 baud
0101 = 2400 baud
0110 = 4800 baud
0111 = 9600 baud

- Bit 4 Parity bit

0 = without parity
1 = with parity

Determination whether an additional generated 9th bit is to be transferred as parity bit after the 8 data bits.

- Bit 5 Type of parity

0 = even
1 = odd

Determination whether the additional generated parity bit is to extend the 8 bit data information to even or odd.

If bit 4 is set at 0, bit 5 has no significance.

- Bit 7 and 6 Number of stop bits

00 = 1 Stop bit
01 = 1 Stop bit
10 = 1 1/2 Stop bits
11 = 2 Stop bits

Byte 5 Xon character

Definition of the Xon character in character-controlled operation.

Byte 6 Xoff character

Definition of the Xoff character in character-controlled operation.

Byte 7 Special bits

- Bit 1 Output without trailer

0 = Data output with trailer (as paper tape)
1 = Data output without trailer (in memory)

- Bit 2 Interpret DSR readiness

0 = "DSR" line (pin 6) is not interpreted
1 = "DSR" line (pin 6) is interpreted

- Bit 3 Stop at "End of transfer" character

0 = Stop readin at MO2/M30
1 = Stop readin at "End of transfer" character

Allows readin of machine and setting data as block.

- Bit 4 Output in EIA code

0 = Output in ISO code
1 = Output in EIA code

Bit 4 should always be "0"!

- Bit 5 End of block CR LF

0 = Completion of block, output with LF CR CR
1 = Completion of block, output with CR LF

- Bit 7 Output without first Xon character

0 = Start of output after request via Xon character
1 = Start of output without request

When character-controlled equipment is linked, Data Start is used to start data output without waiting

for the Xon character from the external device. Subsequent starting and stopping by way of the Xon and Xoff characters.

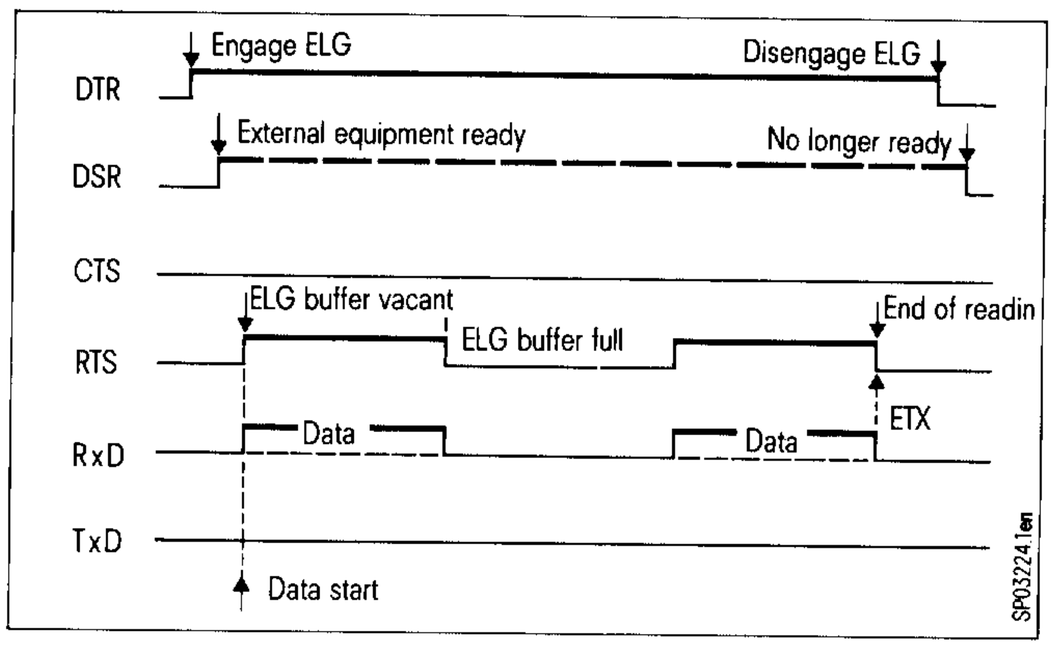
Byte 10 Code for "End of transfer"

Definition of the character for end of transfer in ISO code (e.g. ETX = 03H) or in EIA code.

10.5 Description of the course of signals in data transmission

10.5.1 Course of signals in line controlled equipment

10.5.1.1 Data input (Peripheral equipment to the ELG)



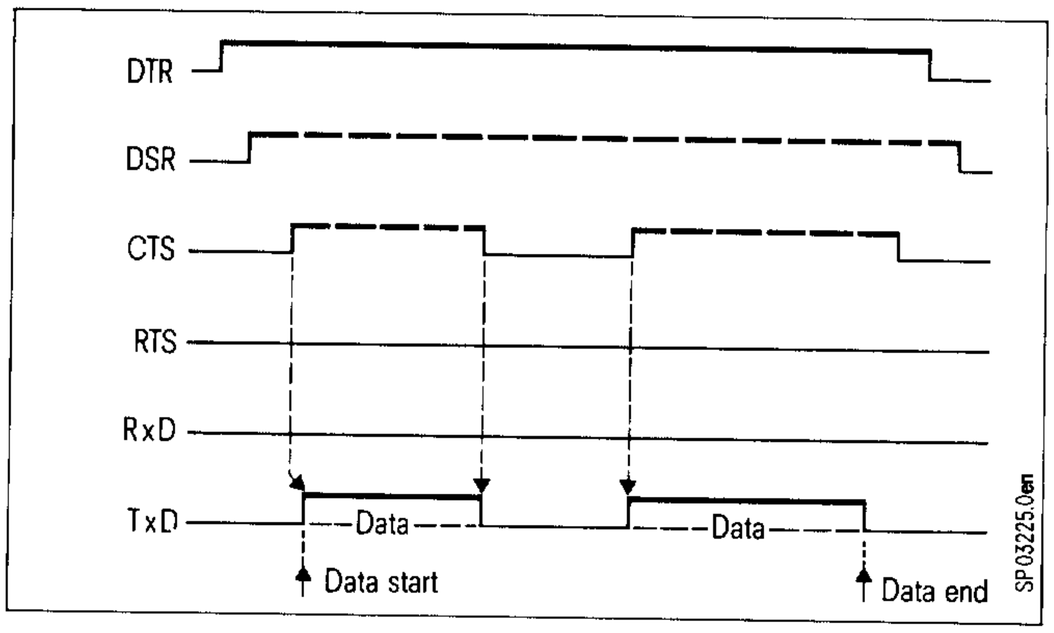
When the ELG is engaged, DTR becomes High = "1". The DSR line must be connected if the external unit readiness is to be interpreted.

Data readin is started with "Data Start" and controlled with "RTS". RTS becomes "1" with Data Start and the external unit can transmit data.

If the ELG cannot keep pace with recording data, it stops transfer by cancelling RTS. When the ELG buffer is again vacant, RTS again becomes "1" and transfer is again enabled.

When the ELG reads the "End of transfer" character (M02 or M30 and/or ETX), it stops transfer by cancelling RTS.

10.5.1.2 Data output (ELG to peripheral equipment)



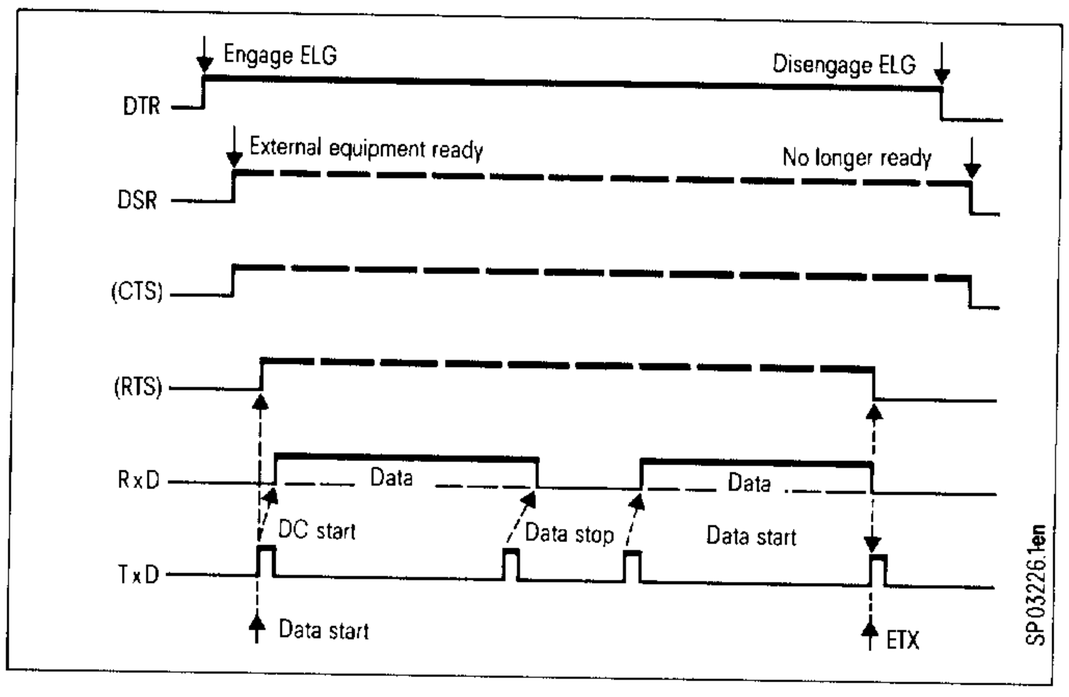
When the ELG is engaged, DTR becomes "1". The DSR line must be connected if external unit readiness is to be interpreted.

The CTS line must be connected if the external unit is to control data transfer.

Data readout is started with Data Start when CTS has become "1" (if connected). If the external unit cannot keep pace with data recording, it stops transfer by cancelling CTS. When its buffer again becomes vacant, CTS is again changed to "1" and transfer restarted. The ELG ends data transfer after outputting end of program or ETX and a trailer.

10.5.2 Course of signals in character-controlled equipment

10.5.2.1 Data input (Peripheral equipment to the ELG)



When the ELG is engaged, the DTR of all interfaces becomes "1". The DSR line must be connected if external unit readiness is to be interpreted.

The ELG changes the RTS signal to "1" with "Data Start"; RTS is not cancelled until end of transfer or in the event of an error.

The ELG enables data readin by transmitting the "Xon" character (setting byte no. 5). The external unit then sends data to the ELG. If the ELG cannot keep pace with recording data, it stops transfer by transmitting the "Xoff" character (setting byte no. 6).

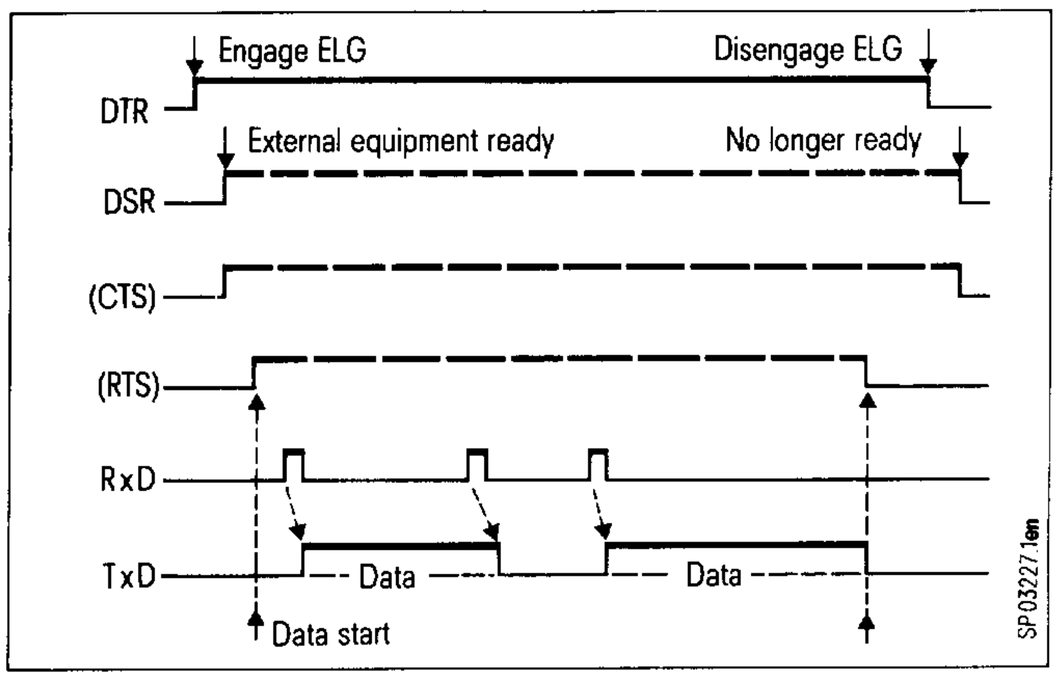
As the external unit generally cannot stop accurately at one character, the ELG is able to record a number of further characters. When the ELG is again ready to record, data transfer is again enabled by "Xon".

When the ELG reads the "End of transfer" character (M02 or M30 and/or ETX), it transmits the "Xoff" character and changes RTS to "0".

If the CTS line is connected, this must have already become "1" at Data Start and may not become "0" until the end of data transfer.

The RTS and CTS lines do not normally need to be connected to the external unit in character-controlled operation.

10.5.2.2 Data output (ELG to peripheral equipment)



When the ELG is engaged, the DTR of all interfaces becomes "1". The DSR line must be connected if external unit readiness is to be interpreted.

The ELG changes the RTS signal to "1" with "Data Start"; RTS is not cancelled until end of transfer or in the event of an error.

The ELG starts data readout after receiving the "Xon" signal. When bit 7 of setting datum 7 (output without first Xon character) is set, the ELG starts data readout with Data Start.

If the external unit cannot keep pace with recording data, it stops transfer by transmitting the "Xoff" control character. The ELG can then transmit 2 further characters before transfer is stopped. When the external unit is again ready to record, it restarts transfer by transmitting the Xon control character.

The ELG ends data transfer after outputting end of program or ETX (and a trailer) by cancelling RTS.

If the CTS line is connected, this must have already become "1" at Data Start and may not become "0" until the end of data transfer.

The RTS and CTS lines do not normally need to be connected to the external unit in character-controlled operation.

10.6 Connection of peripheral equipment in practice

The connecting examples for specific units treated below are based on their state of development at the point in time at which this documentation was printed. They can therefore not be bindingly applied to further developed units and represent only a recommendation.

10.6.1 Equipment setting data
(Selection Table)

Display Type of equipment	No.	Setting datum	Unit
	5010	Equipment coding - Input -	
	5011	Transfer format - Input -	
	5012	Equipment coding - Output -	
	5013	Transfer format - Output -	
	5014	DC start character	
	5015	DC stop character	

	No.	Binary code	HEX code	
RTS LINE	5010	0000 0000	00H	Siemens
	5011	1100 0010	C2H	PT80 page teleprinter
	5012	0000 0000	00H	20 mA
	5013	1100 0010	C2H	V.24, 300 baud
RTS LINE	5010		-	Siemens
	5011		-	PT80 printer
	5012	0000 0000	00H	
	5013	1100 0111	C7H	V.24, 9600 baud
RTS LINE	5010	0000 0000	00H	SINUMERIK
	5011	1100 0111	C7H	810 reader
	5012		-	
	5013		-	V.24, 9600 baud
RTS LINE	5010	0000 0000	00H	Sanyo Cassette
	5011	1100 0100	C4H	M25020-ZE601
	5012	0000 0000	00H	
	5013	1100 0100	C4H	V.24, 1200 baud
RTS LINE	5010	0000 0000	00H	Teletype, ASR33
	5011	1100 0000	C0H	Full duplex
	5012	0000 0000	00H	
	5013	1100 0000	C0H	20 mA, 110 baud
RTS LINE	5010	0000 0000	00H	Facit 4040
	5011	1100 0100	C4H	Reader/puncher
	5012	0000 0000	00H	
	5013	1100 0100	C4H	V.24, 1200 baud
RTS LINE	5010		-	Facit puncher
	5011		-	4070/MI77
	5012	0000 0000	00H	
	5013	1100 0011	C3H	V.24, 600 baud

Display Type of equipment	No.	Setting datum	Unit
	5010	Equipment coding - Input -	
	5011	Transfer format - Input -	
	5012	Equipment coding - Output -	
	5013	Transfer format - Output -	
	5014	DC start character	
	5015	DC stop character	

	No.	Binary code	HEX code	
RTS LINE	5010	0000 0000	00H	Facit reader
	5011	1100 0010	C4H	4030
	5012		-	
	5013		-	V.24, 1200 baud
Xon/Xoff	5010	0000 0001	01H	Portable reader
	5011	1100 0110	C6H	
	5012		-	V.24, 4800 baud
	5013		-	
	5014	0001 0001	11H	
	5015	1001 0011	93H	
PTR	5010	0000 0010	02H	Siemens System 3/8
	5011		-	reader
	5012		-	
	5013		-	V.24, 9600 baud
RD/PF	5010	0000 0011	03H	Siemens
	5011	1100 0110	C6H	programming place
	5012	1100 0011	03H	PD...PG
	5013	1100 0110	C6H	V.24, 480 baud
	5014	0001 0001	11H	(in preparation)
	5015	1001 0011	93H	
RTS LINE	5010	0000 0000	00H	Siemens PC
	5011	1100 0100	C4H	PG 675
	5012	0000 0000	00H	programming unit
	5013	1100 0100	C4H	V.24, 1200 baud
				Interface
				Printer

10.6.2 Equipment connection data

10.6.2.1 Siemens PT80 page teleprinter

Equipment data

Transfer rate 300 baud

Character format 1 Start bit
8 Data bits
2 Stop bits

Order No. for PT80 according to SINUMERIK specification:

V.24 model: L22751-A80-D442
(Interface card module STT104)

20 mA model: L22751-A80-D441
(Interface card module SST104 + LAT101)
Additional cable for terminal connection:
6FC9340-4KA

No reader operation controlled by the ELG (Start/Stop) is possible in the unit with 20 mA interface.

10.6.2.2 Siemens PT88 printer

Equipment data

Interface adapter SAP-S1 (V.24)

Setting of mode switch

Switch S1

1	2	3	4	5	6
ON	ON	ON	OFF	OFF	OFF

Transfer rate 9600 baud

Switch S2

1	2	3	4	5	6
ON	OFF	OFF	ON	OFF	ON

BUSY line switched to line 108.2 (DTR)

10.6.2.3 SINUMERIK reader (810)

Equipment data

Transfer rate 9600 baud

Character format 1 Start bit
8 Data bits
2 Stop bits

Settings

Pin 27 P02:
Jumper at position 2 and 5

Pin 27 S02:
Position 1, 2, 3, 4 open

Switch block A:

1	2	3	4	5	6	7	8
ON	ON	-	OFF	OFF	OFF	OFF	OFF

Switch block B:

1	2	3	4	5	6	7	8
ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF

10.6.2.4 Sanyo cassette M2502U with interface ZE601 (V.24)

Equipment data

Transfer rate 1200 baud

Character formats 1 Start bit
8 Data bits
1 Stop bit

Special operating conditions of the Sanyo cassette

- No controlled operation (Start/Stop) by ELG possible.
  (To do this, the RTS signal of the ELG would have to be logic "H" during reading and writing; this does not conform with the standard.
  RTS is "H" while reading,
  "L" while writing).

- Tape cannot stop accurately at one character.
  (This can possibly cause USART alarm messages from the ELG; particularly in the case of "Program start with LF").

10.6.2.5 Teletype ASR3320/3WE
Full duplex operation

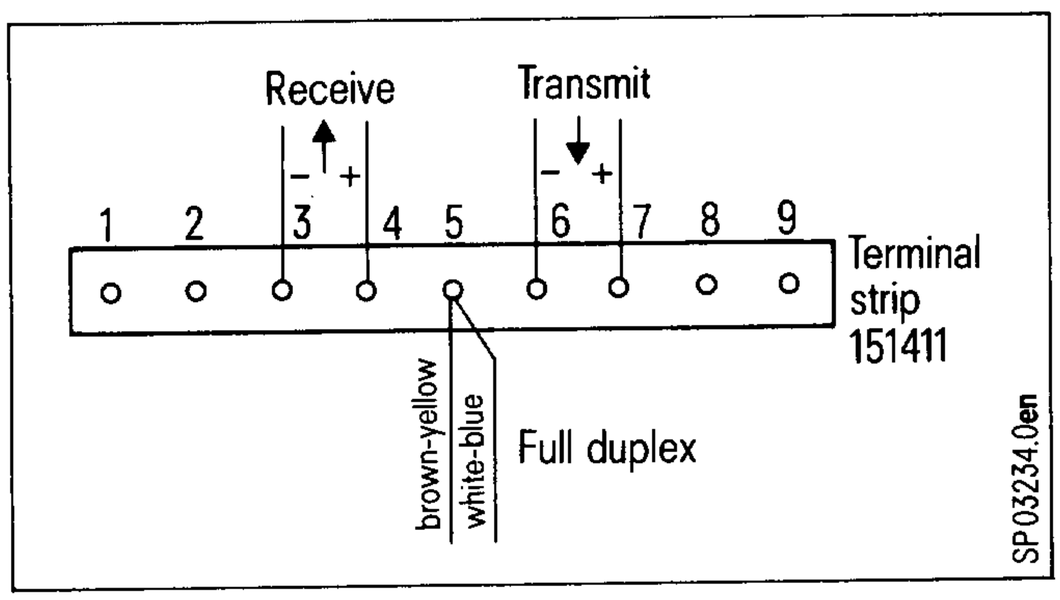
Equipment data

Interface	20 mA full duplex
Transfer rate	110 baud
Character format	1 Start bit 8 Data bits 2 Stop bits

Connection data

The teletype interface receives data via current loop TTY1/TTY2 and transmits data via current loop TTY3/TTY4.

Terminal strip in Teletype



10.6.2.6 Facit puncher/reader
- Comb. 4040, 4042 -
with PI81 interface

Equipment data

Interface	V.24
Transfer rate	1200 baud
Character format	1 Start bit 8 Data bits 2 Stop bits

Settings of switches to the PI81 interface

1 = Switch position ON
0 = Switch position OFF

Switch 1 (S1)

1.1	1.2	1.3	1.4	1.5	1.6	1.7
0	0	1	1	1	0	0

Switch S2 (S2)

2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9
0	0	0	0	0	1	0	0	0

Switch 3 (S3)

3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9
0	0	0	0	0	1	0	0	0

Switch 4 (S4)

4.1	4.2	4.3	4.4	4.5	4.6
1	1	0	0	0	0

Controlled operation via RTS, CTS

10.6.2.7 Facit puncher 4070
with MI77 interface

Equipment data

Interface	V.24
Transfer rate	600 baud
Character format	1 Start bit 8 Data bits 2 Stop bits

Setting of switches on the MI77 interface

Switch preselect of right-hand mode: serial

Switch S1
S1-1 to S1-8 OFF

Switch S2

S2-1	2	3	4	5	6	7	8
OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF

Switch S3
Position V.24/$\overline{\text{TTY}}$

Switch S4
Position 6: 600 baud

10.6.2.8 Facit reader 4030

Equipment data

Interface	V.24
Transfer rate	1200 baud
Character format	1 Start bit 8 Data bits 2 Stop bits

Settings on the interface module

Jumper	Function	Jumper designation
A	V.24 or line current	W1
E	Protect.ground on chassis	W2
G	V.24	W3
O	1200 baud	W4
U	All baud rates except 110 baud	W6

All other jumpers open

10.6.2.9 Portable reader

Equipment data

Interface V.24

Character-controlled operation via Xon/Xoff

Transfer rate 4800 baud

Character format 1 Start bit
8 Data bits
2 Stop bits

Special operating conditions

- The paper tape character on which the reader is currently located is not read during start.
- The reader cannot stop accurately at one specific character. To read in machine and setting data consecutively, it is necessary to insert between end of program (M30*) and start of subsequent program an intermediate leader on the paper tape of at least 3 feed holes.
- No % may be contained in the commentary (...).

10.6.2.10 Siemens system 3/8 reader

Special device,
Equipment coding 02H

Equipment data

Interface V.24

Character-controlled operation via Xon/Xoff

Transfer rate 9600 baud

Character format 1 Start bit
8 Data bits
1 Parity bit (even parity)
2 Stop bits

Read rate

Forward at
250 (300) lines/s at 50 (60) Hz
Backwards at
500 (600) lines/s at 50 (60) Hz
by means of manual start on the reader

10.6.2.11 Siemens PC PG 675 programming unit, interface printer

Equipment data

Interface V.24

Transfer rate 1200 baud

Character format 1 Start bit
8 Data bits
2 Stop bits

Machine and setting data can be transferred from the PG675 to the ELG and/or from the ELG to the PG675 with the aid of the CP/M-86 operating system and a special TRANS-PGIN transfer program.

10.6.3 Equipment cable diagrams

The appropriate cable connection diagrams for the peripheral equipment described in Section 10.6.2 are presented in the "SINUMERIK System 3 Electric Gearing" interface description.

11. Alarm messages

11.1 Display of ELG alarms

The ALARM text and the appropriate Alarm Number are only displayed in the case of the ELG-specific display patterns in Line 3 of the VDU of the NC if an ELG alarm is present ("ELG-ALARM" interface signal = 1). If several ELG alarms have occurred simultaneously, the alarm numbers appear in the display one after the other for a period of 5 seconds each. The alarms can be cancelled either with RESET or with POWER ON RESET (Mains OFF, Mains ON). Reset is only active if the gearing function is disengaged.

Supply of the ELG-RESET signal should be effective in the user program (e.g. Reset key of the NC operator's panel).

11.2 Description of ELG alarms

LIST OF ALARMS: POWER-ON ALARMS

Alarm No.	Description
1	BATTERY ALARM MAINS UNIT
Inquiry:	- with power on - cyclical
Effect:	with engaged and disengaged gearing coupling: - Release of set value relay (set value 0) - Cancelling of ELG-READY 2 (BB2)
Significance:	Battery voltage fallen so that buffering (e.g. of machine data memory) no longer assured.
Remedy:	Replace battery next to mains unit under voltage
2	OVERHEAT
Inquiry:	Cyclical
Effect:	Cancelling of ELG-BB1
Significance:	The initial temperature (ϑ) of the fan is larger than/equal to 55°C (perm. temperature range 0°C ... 55°C)
Remedy:	Check temperature in built-in cabinet

LIST OF ALARMS: POWER-ON ALARMS

Alarm No.	Description
3	PC STOP
Inquiry:	- cyclical
Effect:	With engaged and disengaged gearing coupling: - Release of set value relay (set value 0) - Cancelling of ELG-BB2 - Controller enable is cancelled in MD156 after time has elapsed (controller enable relays are released) - VDI input signals are not interpreted by ELG
Significance:	Cyclical and alarm-controlled operation of PC is interrupted. Traversing with the machine is not possible.
Remedy:	Read out cause of interruption (USTACK) with programming unit.
4	SYSTEM OF UNITS INVALID
Inquiry:	- With power on - Change according to MD
Effect:	Conversion factor is assumed to be 1
Significance:	An invalid combination has been selected in MD5002 for the measuring system unit (position control adjustment) and the unit of the input system.
Remedy:	Correct MDBIT 5002

Alarm No.	Description
8	FALSE ALLOCATION OF AXIS or SPINDLE
Inquiry:	Change according to MD
Effect:	- Release of set value relay, i.e. set value 0 affected axis
Significance:	Value larger than 2300 input in MD200* (1300 = first measurement circuit, third actual value pin)
Remedy:	Correct value in MD200*
16	V.24 PARITY ERROR
Effect:	V.24 transfer interrupted
Significance:	The alarm can only be triggered if the "with parity bit" SDBIT is set. The started character (8 data and 1 parity) has false parity. The alarm does not concern V.24 character parity error in ISO or EIA paper tape (Alarm 23)
Remedy:	- Check SDBIT 5011, 5013 - Check external equipment

LIST OF ALARMS: POWER-ON ALARMS

Alarm No.	Description
17	V.24 OVERFLOW ERROR
Effect:	- V.24 transfer interrupted
Significance:	The external equipment has transmitted a new character although the ELG has not yet processed the previous character.
Remedy:	- Check SDBIT 5011, 5013 - Check external equipment
18	V.24 STOP SIGNAL ERROR
Effect:	V.24 transfer interrupted
Significance:	- Number of stop bits is false - False baud rate
Remedy:	- Check SDBIT 5011, 5013 - Check external equipment
19	EXTERNAL EQUIPMENT NOT READY V24
Effect:	No files are ready
Significance:	The DSR signal from external equipment has low level.
Remedy:	- Start external equipment - Do not employ DSR

LIST OF ALARMS: POWER-ON ALARMS

Alarm No.	Description
22	V.24 TIME MONITORING
Significance:	- The ELG cannot output any character for 60 s * External equipment blocks CTS (clear to send) signal longer than 60 s * External equipment transmits no DC1 within 60 s when using control signals (DC1-DC4) - The ELG has received no character for 60 s
Remedy:	- Check and switch on external equipment - Check and plug in cables
23	V.24 CHARACTER PARITY ERROR
Effect:	V.24 transfer interrupted
Significance:	(Depending on the definition of the "%" or "EOR" program start, the ELG automatically sets the code in ISO or EIA and thus character parity immediately after the above character has appeared.) A character was discovered not to have the set parity when checking the following characters.
Remedy:	Check paper tape. The machine and setting data can only be transferred in ISO code.

LIST OF ALARMS: POWER-ON ALARMS

Alarm No.	Description
24	IRRELEVANT EIA CHARACTER V.24
Effect:	V.24 transfer interrupted
Significance:	An EIA character with correct parity which is not defined in the EIA code has been read in.
Remedy:	Check paper tape. It is not possible to transfer machine data in EIA code ("=" character is not defined in EIA code)
28	V.24 RING MEMORY OVERFLOW
Effect:	V.24 transfer interrupted
Significance:	The transfer rate is so high that more characters are read in than the ELG can process.
Remedy:	- RTS signal has no effect on input unit (RTS causes STOP of input unit) - Transfer rate (baud rate) too high

Alarm No.	Description
29	BLOCK TOO LONG (MAX. 254 CHARACTERS) V.24
Effect:	V.24 transfer interrupted
Significance:	The block read in has more than 254 characters. All read-in characters are counted (e.g. blanks, CR, LF, ...).
Remedy:	Divide block into 2 or several blocks.
32	V.24 DATA FORMAT ERROR
Effect:	V.24 transfer interrupted
Significance:	The permissible number of decades after an address is incorrect.
Remedy:	Check the program to be read in
34	OPERATOR ERROR V.24 INTERFACE
Effect:	No data have been read in
Significance:	The V.24 transfer was started and the PC signals DATA Start again.
Remedy:	Start V.24 again.

LIST OF ALARMS: POWER-ON ALARMS

Alarm No.	Description
35	SIEMENS READER ERROR V.24
Inquiry:	Only when the setting data (SD) have been set for the Siemens reader.
Effect:	V.24 transfer interrupted
Significance:	The Siemens reader has issued a collective error message.
Remedy:	- Restart V.24 transfer - Replace Siemens reader in the event of continued error

LIST OF ALARMS: RESET ALARMS

Alarm No.	Description
104*	DAC-LIMITER has responded
Inquiry:	Cyclical when coupling ON or coupling OFF
Effect:	No direct effect. The error is included in the following error.
Significance:	The set value at the DAC has been input higher than in MD268* (max. DAC-set value). Further increase in the set value is not possible!
Remedy:	- Traverse at lower speed - Check actual values (pulse transmitter) - Check MD268* - Cancel alarm using Reset key with coupling OFF

Alarm No.	Description
108*	OVERFLOW IN GEAR FACTOR
Inquiry:	At every motion of axis with coupling ON or coupling OFF
Effect:	- Release of set value relay (set value 0) - Cancelling of ELG-BB2 - Controller enable is cancelled in MD156 after time has elapsed (controller enable relays are released) - Follow-up operation - Actual value of machine has been lost (false position)
Significance:	If a value larger than 2 is input in MD256* (partial actual value factor), the partial actual value must be multiplied by the control system. When the axis is traversed rapidly, the register has overflowed in the case of an error. The partial actual value for the drive axis and guide axis should always be 1 (partial actual value factor = 0).
Remedy:	Reduce maximum speed. The maximum speed is dependent on MD256* (high partial actual value factor means lower speed!)

Alarm No.	Description
112*	MONITORING OF STANDSTILL
Inquiry:	Standstill monitoring is not active with engaged coupling! - With JOG; INC, REF: - while braking - at standstill - in the case of jamming
Effect:	- Set value 0 - Controller enable is cancelled in MD156 after time has elapsed (controller enable relay is released) - Follow-up operation
Significance:	- The following error when positioning could not be reduced faster than the time input in MD156. - In the event of jamming, the limit set in MD212* was exceeded.
Causes:	- Mechanically jammed axis has been forced out of position - Error in drive unit (actuator), in tachometer, in motor, in mechanical system or ELG measurement circuit hardware
Remedy:	- MD212* (jamming tolerance) must be larger than MD204* (limit to accuracy) - MD156 must be large enough for the following error to be reduced within this time

Alarm No.	Description
116*	CONTOUR MONITORING
Inquiry:	Contour monitoring is not active with engaged coupling! - Applies for JOG;INC,REF: for every traverse motion, however not: - when accelerating - when braking - at speeds lower than MD336* (contour speed)
Effect:	- Set value 0 - Controller enable is cancelled in MD156 after time has elapsed (controller enable relay is released) - Follow-up operation
Significance:	- The MD 332* tolerance band was exceeded at a speed larger than MD336*. - In accelerating or braking, the axis has not reached the new speed within the time set by the contour traverse factor.
Remedy:	- Increase MD332* tolerance band - Check contour traverse factor - Check optimization of speed controller

Alarm No.	Description
132*	HARDWARE CONTROL LOOP
Inquiry:	Cyclical with coupling ON or coupling OFF
Effect:	- Release of set value relay (set value 0) - Cancelling of ELG-BB2 - Controller enable is cancelled in MD156 after time has elapsed (controller enable relay is released) - Follow-up operation (only with coupling disengaged)
Significance:	The differential measurement circuit signals - are not in the same phase - have a short to ground - are entirely lacking
Remedy:	- Check whether measurement circuit connector is plugged in - By plugging in the short-circuit connector for the measurement circuit, it is possible to check whether the measurement circuit module is O.K. - Check differential signals with CRO - Replace measuring pick-up - Alarm can only be cancelled with Power On Reset

LIST OF ALARMS: RESET ALARMS

Alarm No.	Description
136*	AXIS FOULING
Inquiry:	Cyclical
Effect:	None
Significance:	An error is signalled to the ELG by the measuring system in the case of systems with fouling signal.
Remedy:	Check measuring system

LIST OF ALARMS: RESET ALARMS

Alarm No.	Description
156*	SET SPEED VALUE TOO HIGH
Inquiry:	Cyclical with coupling ON or coupling OFF
Effect:	With coupling OFF: - Set value 0 - Controller enable is cancelled in MD156 after time has elapsed (controller enable relay is released) - Follow-up operation With coupling ON: - Only alarm message; error included in following error
Significance:	A higher set speed value was output internally than previously set in MD264*. - The motor could not meet specified set speed value.
Remedy:	- Check whether value in MD264* is larger than the value in MD268* - Check drive

Alarm No.	Description
160*	DRIFT TOO HIGH
Inquiry:	Cyclical
Effect:	- Only alarm message - No traverse motion is possible with coupling disengaged
Significance:	The drift to be automatically balanced by the CNC has exceeded approx. 500 mV.
Remedy:	- Effect drift adjustment in MD272* - Check whether drift has been correctly adjusted in drive unit
168*	CONTROLLER ENABLE FOR TRAVERSING AXIS REFUSED
Inquiry:	Alarm is only signalled with gearing coupling disengaged.
Effect:	- Set value 0 - Controller enable is cancelled in MD156 after time has elapsed (controller enable relay is released) - Follow-up operation
Significance:	The axis-specific controller enable was cancelled by the PC during traverse motion.
Remedy:	Check PC program

Alarm No.	Description
184*	STOP BEHIND REFERENCE CAMS
Inquiry:	Only in reference point approach
Effect:	- Set value 0 - Reference point not reached
Significance:	The axis has stopped during reference point approach between reference cam and zero mark of the measuring system.
Remedy:	Restart reference point approach
2000	EMERGENCY OFF
Inquiry:	Cyclical with coupling ON and coupling OFF
Effect:	- Set value 0 - Cancelling of ELG-BB2 - Controller enable is cancelled in MD156 after time has elapsed (controller enable relays are released) - Follow-up operation (only with coupling disengaged)
Significance:	The EMERGENCY OFF signal is output by the PC to the NC.
Remedy:	- Check with PC-STATUS - Check whether EMERGENCY OFF key has been actuated - Check PC program

Alarm No.	Description
2035	PROGRAM SPEED TOO HIGH
Inquiry:	Alarm is only checked when gearing function disengaged.
Significance:	The set speed, e.g. for JOG, is higher than the max. speeds of the axis (MD280*)
Remedy:	- Preset lower axis speed (MD288*, MD292*) - Check MD280* max. speed

Alarm No.	Description
2200	ELG - POWER ON ERROR
Inquiry:	Alarm message on request to compute gearing parameters
Effect:	Traversing of gearing axis not possible
Significance:	Computation of gearing constants was not possible previously, because - Contour traverse factor smaller than 200 - Number of pulses/revolutions of drive or guide axis larger than 2,000,000 - Speed set too high for semi-automatic centring - Sequence of axis declarations not correct (MD5020, MD5021)
Remedy:	- Cancel alarm message by Power-On Reset - Check whether machine data are present - Check input of machine data MD170, MD5020, MD200*, MD252*, MD396*

Alarm No.	Description
2201	ELG - COMPENSATION NOT POSSIBLE
Inquiry:	- Cyclical before computing leading error compensation - Only with gearing function engaged if "Following error compensation" function has been activated
Effect:	- Maximum permissible partial set value is output - Coupling has fault; if necessary, cause coupled axes to be disengaged
Significance:	Computed partial set value too high for following error compensation
Remedy:	- Cancel alarm message by resetting with coupling OFF - Check constants and parameters; where necessary, lower speed of guide axis

Alarm No.	Description
2202	ELG - ERROR IN COMPUTATION OF PARTIAL SET VALUE
Inquiry:	- Cyclical when determining partial set value components - Only with gearing function engaged
Effect:	- Maximum permissible partial set value is output as long as overflow is present in computation of partial set value - Coupling has fault; if necessary, cause coupled axes to be disengaged
Significance:	Overflow in determining partial set value component of gearing transmission and/or of axial differential and/or of tangential differential and/or of semi-automatic centring
Remedy:	- Cancel alarm message by Reset with coupling OFF - Check constants and parameters; where necessary, lower speed of appropriate guide axis

Alarm No.	Description
2203	ELG - ERROR IN COMPUTING ELG CONSTANTS
Inquiry:	By request, to compute gearing parameters
Effect:	Traversing of drive axis not possible
Significance:	Computation of gearing parameters is not possible, because: - Workpiece number of teeth Z2 = 0 - Pulses/revolution of drive axis = 0 AND number of threads ZO ≠ 0 - Computation of the transmission parameter produces too high a value - Computation of axial/tangential parameter produces too high a value
Remedy:	- Cancel alarm message by Reset with coupling OFF - Check machine data MD396* or parameters ZO, Z2, Ud_y, Ud_z

Alarm No.	Description
2205	ELG - PARTIAL SET VALUE TOO HIGH
Inquiry:	Cyclical with gearing On before computing following error compensation
Effect:	- Maximum permissible partial set value is output
Significance:	Computed partial set value has remained close to tolerance limit for a long period of time. As coupling cannot be maintained accurately, dis-engagement of the coupled axes should be initiated.
Remedy:	- Cancel alarm message by Reset with coupling OFF - Check constants and parameters; where necessary, lower speed of appropriate guide axis

Alarm No.	Description
2206	ELG - PARTIAL SET VALUE CLOSE TO TOLERANCE LIMIT
Inquiry:	Cyclical with gearing On before computing compensation
Effect:	- Partial set value continues to be output; drive axis is not stopped! - Coupling has fault
Significance:	This alarm is a preliminary alarm for alarm 2205. The partial set value is here already in the tolerance area.
Remedy:	- Cancel alarm message by Reset with coupling OFF - Check constants and parameters; where necessary, lower speed of appropriate guide axis

Alarm No.	Description
2207	ELG - GEARING FUNCTION NOT PERMISSIBLE
Inquiry:	Cyclical with gearing On or during approach
Effect:	- Partial set value = 0 is output - Traversing of drive axis not possible
Significance:	- Gearing On is requested for non-computed gearing parameters - Alarm message 2204 is present - Approach condition not fulfilled
Remedy:	- Cancel alarm message by Reset; where necessary, first set "GEARING OFF" - Check whether computation of gearing parameters already completed before "Gearing On" request - Check constants and parameters

Alarm No.	Description
2214	ELG - OPERATION OF V.24 INTERFACE NOT PERMITTED
Inquiry:	Cyclical with gearing On
Effect:	- No data transfer possible via V.24 interface
Significance:	"Data Start" key actuated while "Gearing On"
Remedy:	- Cancel alarm message by Reset with coupling Off - Restart data transfer via V.24 interface

Alarm No.	Description
2215	ELG - MAX. FOLLOWING ERROR MONITORING VALUE EXCEEDED
Inquiry:	With coupling On and only with "Following error monitoring" option activated
Effect:	"Controller enable" relay contact of a vacant set value output (preset in MD No. 5022, bit 0-3) is opened.
Significance:	The drive axis following error has exceeded the max. permissible following error (set by MD No. 169 or R-parameter 40 (TOLER)). This hardware signal can be used to initiate disengagement of coupled axes.
Remedy:	- Check drives - Check constants and parameters; where necessary, lower speed of appropriate guide axis - Cancel alarm message by Reset with coupling OFF - Where necessary, set max. perm. following error somewhat higher

Alarm No.	Description
3016	ERROR PC-ELG DATA CHANNEL
Inquiry:	Cyclical
Effect:	- Only alarm message; data transfer is not performed for this eventuality (however acknowledgement is given)
Significance:	For external data transfer between PC-NC, - the code is false - the value is too high - dimension identification is not permissible
Remedy:	Check PC program
3018	DATUM NOT PRESENT, PC-ELG DATA CHANNEL
Inquiry:	Cyclical
Effect:	- Only alarm message; data transfer is not performed for this eventuality (however acknowledgement is given)
Significance:	An address (e.g. machine data no.) not recognized by the control system is selected in external data transfer PC-ELG. Alarm occurs in the case of false addressing of - machine data - setting data
Remedy:	Check PC program

12. ELG data lists

12.1 List of machine data

General values

MD-Nr.	Designation	Machine data Standard values	Maximum input values	Referen. system	Input unit
100	Feed override 2nd Position	1	130	---	%
101	-//- 3rd Position	2	130	---	%
102	-//- 4th Position	4	130	---	%
103	-//- 5th Position	6	130	---	%
104	-//- 6th Postition	8	130	---	%
105	-//- 7th Position	10	130	---	%
106	-//- 8th Position	20	130	---	%
107	-//- 9th Postition	40	130	---	%
108	-//- 10th Position	60	130	---	%
109	-//- 11th Position	70	130	---	%
110	-//- 12th Position	80	130	---	%
111	-//- 13th Postition	90	130	---	%
112	-//- 14th Postition	100	130	---	%
113	-//- 15th Postition	110	130	---	%
114	-//- 16th Position	120	130	---	%
115				---	
116				---	
117				---	
118				---	
119				---	
120				---	
121				---	
122				---	
123				---	
124				---	

Machine data electronic gearbox

General values

MD-Nr.	Designation	Machine data	Maximum input value	Refer. system	Input unit
150				--- 8)	
151				---	
152				---	
153				---	
154				---	
155	Increase in scanning time	0	4	---	0.5 MS
156	Delay position-controller	500	1000	---	MS
157					
158					
159					
160					
161					
162					
163					
164					
165					
166	Gearing-On tolerance	100	10000	MS	units
167	Threshold value for adaptive precontrol	10	100	MS	units
168	Following error compensation factor	500	1000	----	0.1 %
169	Tolerance band following error monitoring	20	10000	MS	units
170	Speed semi-automatic centring	1000	30000	MS	1/1000 rpm
171	Current software status number	----	----	----	--------
172					
173					
174					

Machine data electronic gearbox

Axis-specific values (max. 4 axes)

MD-Nr.	Designation	Machine data Standard values	Maximum input value	Refer. system	Input unit
2000	Axis assignment 1st axis	1100 H	---	8)	6)
2001	Axis assignment 2nd axis	1200 H	---		
2002	Axis assignment 3rd axis	1300 H	---		
2003	Axis assignment 4th axis	2100 H	2300 H		
204*	Xoarse stop tolerance range	100	32000	MS	units
208*					
212*	Jamming tolerance	100	32000	MS	units
216*	Tolerance band zero mark monitoring	0	0	MS	units
220*	Backlash compensation	0	+/- 255	MS	units
224*					
228*					
232*					
236*					
240*	Reference point coordinates	0	+/- 99999999	MS	units
244*	Zero offset	0	+/- 9999	MS	units
248*					
252*	Contour approach factor	1666	10000	MS	0.01 s**-1
256*	Parial actual value factor	0	16	MS	0.5 units
260*	Mult gain	2400	32000	MS	CX 5)
264*	Threshold for drive errors	8192	16000	---	VELO 4)
268*	Max. speed set value	8192	16000	---	VELO 4)
272*	Drift compensation	0	500	---	VELO 4)
276*	Acceleration	50	2000	IS	10000 units/s**2
280*	Max. speed	10000	24000	IS	1000 units/min
284*	Reference point interrupt speed	300	15000	IS	1000 units/min
288*	Conventional speed	2000	15000	IS	1000 units/min
292*	Conventional rapid traverse	10000	15000	IS	1000 units/min
296*	Reference point approach rate	10000	15000	IS	1000 units/min

Machine data electronic gearbox

Axis-specific values (max. 4 axes)

MD-Nr. 7)	Designation	Machine data Stand. values	Maximum input value	Refer. system	Input unit
300*	Rate of incremental feed	500	15000	IS 8)	1000 units/min
304*					
308*					
312*	Precontrol factor	10000	16000	---	
316*	Cursor distance address, + in SSFK	0	6249	---	
320*	Cursor distance address, - in SSFK	0	6249	---	
324*	Distance between 2 SSFK points	0	32000	MS	units
328*	Compensation value for SSFK	0	100	MS	units
332*	Tolerance band contour monitor.	1000	32000	MS	units
336*	Threshold rate contour monitor.	0	24000	MS	1000units/min
340*	Number of Pick-up pulses per axis				
344*					
348*					
352*					
356*					
360*					
364*					
368*					
372*					
376*					
380*					
384*					
388*					
392*					
396*	Number of Pick-up pulses per axis revolution	180000	2 000 000	----	

Machine data bits electronic gearbox

General bits

	7	6	5	4	3	2	1	0
5000								
5001								
5002	Unit of input system 9)				Unit of measuring system 9)			
5003								
5004	Machine data are input							
5005								
:								
:								
5016					Direction-dependet SSFK	SSFK active	Precontrol active	
5017								
5018								
5019								
5020	Number of guide axis (B)			1)	Number of drive axis (C)			1)
5021	Number of tangential differential axis (Y)			1)	Number of axial differential axis (Z)			1)
5022	Number of NC for actual value transfer			2)	Axis number of set value output for alarm message (hardware signal)			1)
5023					Optical actu. value transf. active	Following error comp. active	Feed relat. to tool revolution	
5024								

1) 0000 = no axis
0001 = 1. axis | 0011 = 3. axis
0010 = 2. axis | 0100 = 4. axis

2) 0000 = no axis
0001 = NC 1
0010 = NC 2

Machine data bits electronic gearbox

Axis-specific bits (max. 4 axes)

	7	6	5	4	3	2	1	0
560*	Modulo 360° actual value display				Radius axis	Whole degrees		Deactivate MX monitor.
564*	Axis in existence	Partial act. value factor active	Axis of rotation	Partial actual value /2	Partial actual value *2	Change in sign for actual value	Change in sign for set value	Ref. point in minus direction
568*								
572*								
576*								

Machine data bits electronic gearbox

Compensation flags for SSFK

	7	6	5	4	3	2	1	0
6000	C point 4		C point 3		C point 2		C point 1	
	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no
6001	C point 8		C point 7		C point 6		C point 5	
	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no
6002	C point 12		C point 11		C point 10		C point 9	
	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no
-//-								
-//-								
-//-								
-//-								
-//-								
-//-								
-//-								
-//-								
-//-								
6248	C point 996		C point 995		C point 994		C point 993	
	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no
6249	C point 1000		C point 999		C point 998		C point 997	
	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no	+ / -	yes / no

- = 0

+ = 1

yes = 0

no = 1

Service data electronic gearbox

MD-Nr.	Designation			Ref. system	Output unit
8000	Drive axis following error			MS	0.5 units
8001	Drive axis speed set value			---	VELO 4)
8002	Adaptive precontrol factor			---	----
8003				---	
8004				---	
8005				---	
8006				---	
8007				---	
8008				---	
8009				---	
8010				---	

3) Unit = 2 * MS unit
   e.g. MS = 1/2 $\frac{\mu m}{}$
   ---> unit = 1 $\frac{\mu m}{}$

The measuring system unit (MS) for the drive axis is determined by the number of pick-up pulses per axis revolution (machine datum MD 396*), provided the partial actual value is 1 (MD 564*/bit 4 and bit 5 = 0, MD 256* = 0).

The measuring system unit for the drive axis (axis of rotation) can be calculated from the following formula:

$$MS = \frac{360}{4 * I * Kue} \ (°)$$

where I = Number of pulses/Pick-up revolution
Kue = Transmission ratio between pick-up and axis speed
so that I * Kue = MD 396*

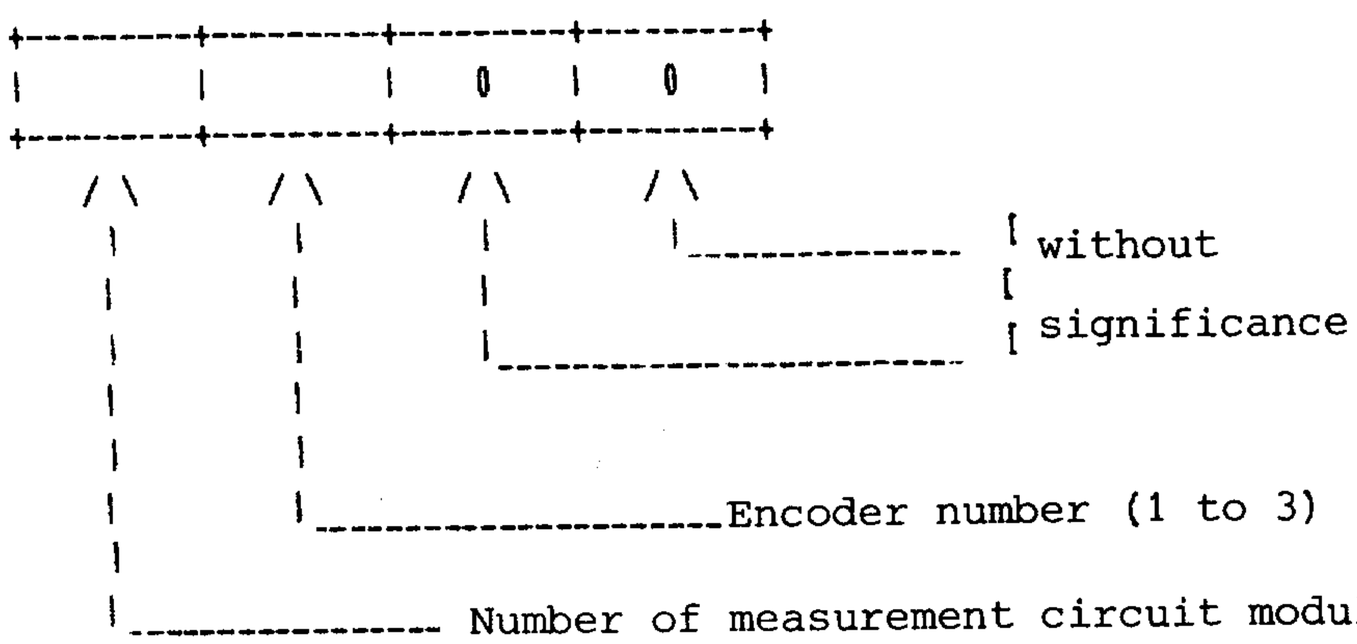
The following equation applies for the drive axis: 1 Unit = $\frac{180}{MD\ 396*}$ (°)

4) +/- 1 VELO = +/- 10 V / DAC number of bits

where the following apply: 12 bits = 2048
14 bits = 2048 * 4
16 bits = 2048 * 16

5) $$CX = \frac{3 * 10^{**}7}{Vmax\ (1000\ units/min)} * \frac{Umax\ (V)}{10\ (V)}$$

6) Re machine datum number 2000:



7) A machine datum is assigned to each axis in the axis-specific machine data. The "*" in the MD No. characterizes the No. of the axis, where: "*" = Axis No. - 1

i.e. in 1st axis ------> "*" = 0
2nd axis ------> "*" = 1
3rd axis ------> "*" = 2
4th axis ------> "*" = 3

8) MS = Units of the measuring system

   IS = Units of the input system

9) Note on machine datum 5002:

Position control sensitivity				Input sensitivity			
Bit2	Bit1	Bit0		Bit6	Bit5	Bit4	
0	0	0	0.5 * 10**-2 mm *)	0	0	0	10**-2 mm *)
0	0	1	0.5 * 10**-3 inch *)	0	0	1	10**-3 inch *)
0	1	0	0.5 * 10**-3 mm	0	1	0	10**-3 mm
0	1	1	0.5 * 10**-4 inch *)	0	1	1	10**-4 inch *)
1	0	0	0.5 * 10**-4 mm *)	1	0	0	10**-4 mm *)
1	0	1	0.5 * 10**-5 inch *)	1	0	1	10**-5 inch *)
1	1	0	2 * 10**-4 mm *)				
1	1	1	2 * 10**-5 inch *)				

*) Combination at present not released

12.2 Setting data bits electronic gearbox

Matching of peripheral equipment to
universal interface

SE-No.	7	6	5	4	3	2	1	0
5000								
:								
:								
5010	Equipment coding - data input							
5011	Transfer format - data input Stop bits		Type of parity	Parity bit		Baud rate		
5012	Equipment coding - data output							
5013	Transfer format - data output Stop bits		Type of parity	Parity bit		Baud rate		
5014	Xon Start character (e.g. DC1 = 11H)							
5015	Hoff Stop character (e.g. DC3 = 93H)							
5016	Special bits Start without Xon		End of block CR LF	Output in EIA code	Stop with end of trans. character	Interpret readiness	Output without trailer	
:								
:								
5026	Code for "End of transfer" (e.g. ETX = 03H)							

12.3 List of alarms, electronic gearbox

POWER ON ALARMS

Alarm No.	Designation	Locking of ELG-BB2
1	Battery alarm mains unit	X
2	Overheat	
3	PC stop	X
4	System of units invalid	
:		
8	False axis or spindle	
:		
16	V24 parity error	
17	V24 overflow error	
18	V24 Stop signal error	
19	External equipment not ready V24	
:		
22	V24 Time monitoring	
23	V24 Character parity error	
24	V24 Irrelevant EIA character	
:		
28	V24 Ring memory overflow	
29	Block too long (max. 254 characters) V24	
:		
32	V24 Data format error	
33		
34	Operator error V24 interface	
35	Siemens reader error V24	
:		
:		

RESET ALARMS

Alarm No.	Designation	Locking of ELG-BB2
100*		
104*	DAC-limiter has responded	
108*	Overflow for gear factor	X
112*	Standstill monitoring	
116*	Contour monitoring	
120*		
124*		
128*		
132*	Hardware control loop	X
136*	Axis fouling	
140*		
144*		
148*		
152*		
156*	Speed set value too high	
160*	Drift too high	
164*		
168*	Controller enable for traversing axis refused	
172*		
176*		
180*		
184*	Stop behind reference cam	
188*		
192*		
196*		

RESET ALARMS

Alarm No.	Designation	Locking of ELG-BB2
2000	EMERGENCY OFF	X
:		
2035	Program speed too high	
:		
:		
:		
:		
2200	ELG - Power On error	
2201	ELG - Compensation not possible	
2202	ELG - Error in computing partial set value	
2203	ELG - Error in computin ELG constants	
2204		
2205	ELG - Partial set value too high	
2206	ELG - Partial set valur close to tolerance limit	
2207	ELG - Gearing function not valid	
:		
2214	ELG - Operation of V24 interface not permitted	
2215	ELG - Max. following error monitoring value exceeded	
:		
3000		
:		
3016	Error PC-ELG data channel	
3017		
3018	Data not present (PC-ELG data channel)	
3019		

12.4 Summary of interface signals

12.4.1 PC input signals from ELG

Group	Byte address #				Bit Number							
	NC1	NC2	NC3	NC4	7	6	5	4	3	2	1	0
Ready signals	E64	E74	E84	E94			ELG READY 2 (4.11.1.2)	ELG READY1 (4.11.1.1)	V.24 running (4.11.1.2)			
	E65	E75	E85	E95			ELG alarm (4.11.1.4)					
Gearing-specific signals	E66	E76	E86	E96	Coupling ON (4.11.2.2)	Gearing constant computed (4.11.2.1)		Rapid traverse (4.11.1.5)	Tooth gap reached (4.11.2.4)			
	E67	E77	E87	E97								
Axis-specific signals	E68	E78	E88	E98	Position reached (4.11.3.3) ④ ③ ②			Actual value received (4.11.2.3)	Position reached (4.11.3.3)			
	E69	E79	E89	E99							①	①
	E70	E80	E90	E100							②	②
	E71	E81	E91	E101							③	③
	E72	E82	E92	E102							④	④
	E73	E83	E93	E103								
											Reference point reached (4.11.3.2)	Traverse instruc-tion (4.11.3.1)

① = First axis
② = Second axis
③ = Third axis
④ = Fourth axis

SP00541.0en

The ELG may be operated in place of NC2 or NC3 within the Dual port - RAM. (Allocation by Jumper-setting on the ELG CPU 6FX1125 - 8AC.)

12.4.2 PC output signals to ELG

Group	Byte adress NC1	NC2	NC3	NC4	Bit - number 7	6	5	4	3	2	1	0
Ready signals	A64	A74	A84	A94	*Emer-gency off (4.12.1.1)	Opera-tor's pan. disable (4.12.1.5)					Reset (4.12.1.2)	Data start (4.12.1.3)
	A65	A75	A85	A95								
Feed modula-tion	A66	A76	A86	A96	Overall feed enable (4.12.3.1)							
Gearing-specific signals	A67	A77	A87	A97	Compute gearing constant (4.12.2.1)	Gearing OFF (4.12.2.3)	Gearing ON (4.12.2.2)	Single ptich (4.12.2.6)	Semi-automatic centring (4.12.2.4)	Receive actual value (4.12.2.5)	Follow. er-ror moni-toring act. (4.12.2.7)	
Ready signals	A68	A78	A88	A98	Data stop (4.12.1.4)							
Axis-specific signals	A69	A79	A89	A99		①	①	①	①	①		
	A70	A80	A90	A100		②	②	②	②	②		
	A71	A81	A91	A101		③	③	③	③	③		
	A72	A82	A92	A102		④	④	④	④	④		
	A73	A83	A93	A103								
① = First axis ② = Second axis ③ = Third axis ④ = Fourth axis						Follow-up operation (4.12.4.5)	Axis disable (4.12.4.4)	*Decele--rat. (refe-rence pt.) (4.12.4.3)	Feed enable (4.12.4.2)	Controller enable (4.12.4.1)		

SP 00542.0en

12.4.3 Machine control panel signals from PC to ELG

Marker	Bit number 7	6	5	4	3	2	1	0
M n.	Mode switch 8	7	6	5	Feed/rapid traverse offset switch 4	3	2	1
M n+1.	16	15	14	13	12	11	10	9
M n+2.	Rapid traverse offset active 25	Rapid traverse override 24	Direction keys + 23	− 22	Axis selector switch Code A 21	B 20	19	18

n = 1 for NC1
23 for NC2
45 for NC3
67 for NC4

12.5 Table for data transfer ELG-PC

SINUMERIK SYSTEM 3 ELG — DATA TRANSFER ELG-PC

FUNCTION	ADDRESS RANGE	CODING 543210	WRITE	READ	RELATIVE ADDRESS 1.	2.	VALUE + −MSB LSB	NOTE
R-PARAMETERS	0 – 99	001001(09)	X	X	00 – 99	00	+/−99999.999	*
MACHINE DATA	0 – 4999	001010(10)	X	X	00 – 99	00 – 49	+/−999999999	$
MACHINE DATA BITS	5000 – 6999	011100(28)	X	X	00 – 99	50 – 69	00000001	$ # &
ACTUAL VALUE (AXES)	1 – 4	001100(12)		X	01 – 04	00	+/−99999;999	
ELG ALARMS	0 – 5999	011011(27)		X	01 – 99	00	----	#
SETTING DATA BITS	5000 – 5999	011101(29)	X	X	00 – 99	50 – 59	00000001	$ # &
SERVICE DATA	8000 – 8999	001010(10)		X	00 – 99	80 – 89	+/−999999999	

$ = »Write« with »coupling ON« not possible

\# = not transferrable with FB22 functional module of the basic program

& = Transfer by bytes

. = Position of the decimal point variable

; = Depending on the input system, the decimal point is at/from 3rd or 4th place

13. Annex

13.1 Symbols

$f_{2\,set}$	=	Workpiece axis set value (C-axis or drive axis)
$f_{2\,act}$	=	Workpiece axis actual value (C-axis or drive axis)
$f_{o\,set}$	=	Cutter set value (B-axis or lead axis)
$f_{o\,act}$	=	Cutter actual value (B-axis or lead axis)
s_z	=	Z-axis actual value (axial motion)
s_y	=	Y-axis actual value (tangential motion)
ud_z	=	Measure of tooth angle
ud_y	=	Measure of tangential compensation motion
Z_o	=	Number of threads of cutter
Z_2	=	Number of teeth of workpiece
δ_o	=	Tooth pitch angle
γ_o	=	Lead angle of cutter
m_N	=	Standard module
N_{00}	=	Number of pulses per cutter revolution (MD396*)
N_{02}	=	Number of pulses per drive axis revolution (MD396*)

13.2 Example of an NC program for single pitch with helical teeth

```
%100 (Single pitch with helical
     teeth)
N5 R20 0 R21 10 R12 8.18511
   R13 0 R14 0 R15 1
N10 G0 G90 X90 Z10 S500 M03 F.5 G95
N15 M52 G04 F.25
N16 M54
N20 G18 G41 D10 X40
N25 M50 G04 F.25
N30 G1 Z60
N35 G0 X80
N40 G40 X90 Z10
N45 M51 G04 F.25
N50 M56 G04 F.25
N55 R14 R15
N60 @03 - 20 R21 R14
N61 M55
N65 M30
```

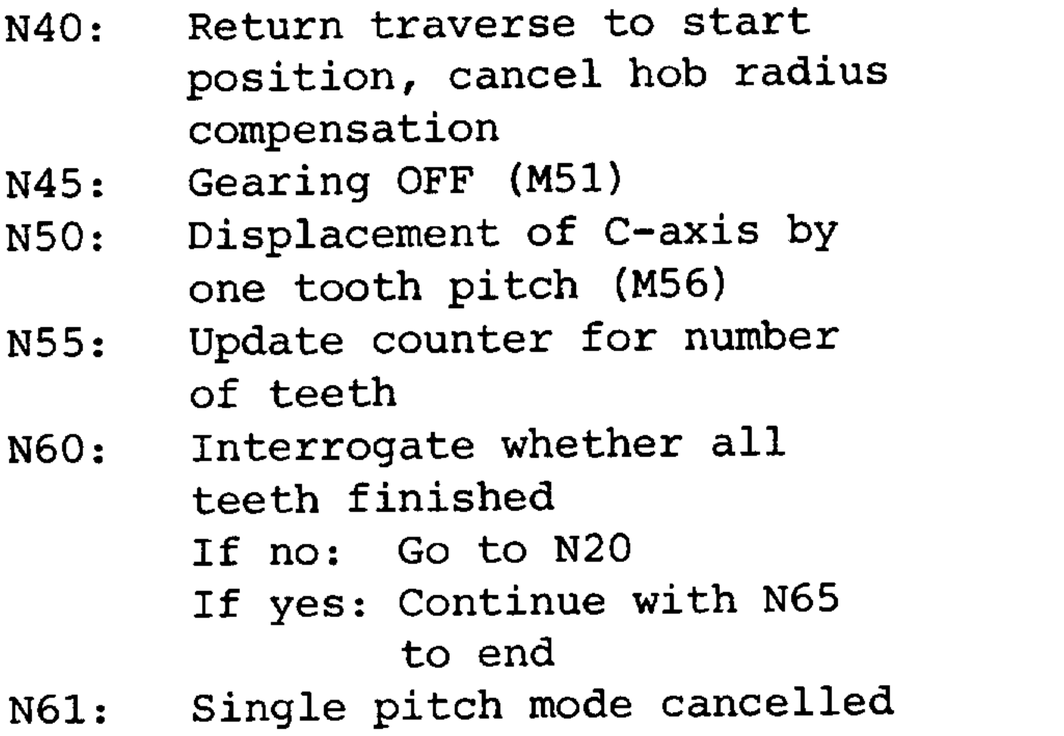
Key to program:

N5: R-parameter assignment
$R20 = Z_0$; $R21 = Z_2$;

$R12 = ud_z$; $R13 = ud_y$;

R14 = Counter for teeth;
R15 = Constant

N10: Approach start position
N15: Calculate gearing constants (M52)
N16: Single pitch mode selected (M54)
N20: Adjust to depth with hob radius compensation
N25: Gearing ON (M50)
N30: Cut a tooth gap with differential component
N35: Return traverse from workpiece
N40: Return traverse to start position, cancel hob radius compensation
N45: Gearing OFF (M51)
N50: Displacement of C-axis by one tooth pitch (M56)
N55: Update counter for number of teeth
N60: Interrogate whether all teeth finished
If no: Go to N20
If yes: Continue with N65 to end
N61: Single pitch mode cancelled (M55)
N65: End of program



13.3 Pick-up matching for various resolutions

Calculation of max. achievable resolution

The limit values for maximum speeds at given resolution are determined by the input frequency of the actual value recording system or the highest possible pick-up frequency.
The input frequency of the actual value recording system is 500 kHz per pick-up track for the measurement circuit modules currently used.

After introduction of a newly developed module (planned for 9/85), a maximum input frequency of 800 kHz per track will be possible.

The data refer to the input frequency before quadruple hardware interpretation.

The following formulae apply for the resolution:

$$A = \frac{360}{4 \cdot I \cdot k_{ü}} \quad (°) \qquad (1)$$

where $I \cdot k_{ü} = N_{02} = MD396^{*}$ (2)

or where $I = \frac{f_{max}}{n_{pick\text{-}up_{max}}}$ (3)

$$A = \frac{360 \cdot n_{max}}{4 \cdot f_{max} \cdot k_{ü}} \qquad (4)$$

where $k_{ü} = \frac{n_{pick\text{-}up}}{n_{axis}}$ (5)

Key to symbols:

A: Resolution of the measurement system in degrees (= measurement system unit)

I: Pulses per revolution of incremental shaft encoder (= number of lines)

f_{max}: Maximum permissible frequency of pick-up pulses, depending on limit frequency of pick-up or measurement circuit module)

$n_{pick\text{-}up_{max}}$: Max. permissible speed of incremental shaft encoder (sec^{-1})

$k_{ü}$: Transmission ratio of measurement gearing between incremental shaft encoder and axis

$n_{pick\text{-}up}$: Incremental shaft encoder speed

n_{axis}: Axis speed

N_{02}: Number of pulses per drive axis revolution

Example for selection of an incremental shaft encoder:

Required resolution for drive axis:

$$A = 0.0005\ °$$

Max. speed of axis:

$$n_{axis_{max}} = 150 \text{ rpm}$$

$$k_{ü} = 10$$

This gives the number of lines per axis revolution as follows:

$$N_{02} = I \cdot k_{ü} = \frac{360}{4} \cdot \frac{1}{A} = 90 \cdot 2000 = 180{,}000$$

$$I = \frac{N_{02}}{k_{ü}} = 18{,}000$$

$$n_{pick\text{-}up} = k_{ü} \cdot n_{axis} = 1500 \text{ rpm}$$

or

$$n_{pick\text{-}up} = 25 \text{ rps}$$

$$f_{max} = i \cdot n_{pick\text{-}up} = 18{,}000 \cdot 25 \text{ rps} = 450 \text{ kHz}$$

The scanning frequency of the incremental shaft encoder must thus be higher than 450 kHz.

e.g. Pick-up type: ROD 260
(Scanning frequency 1 MHz)
Number of lines 18,000

The matching of the incremental shaft encoder to an appropriate resolution is explained below for three types of pick-up.

a) Pick-up type: ROD 426 with scanning frequency max. 300 kHz (special model!); input frequency of measurement circuit module: 500 kHz

Resolution A [°]	Number of lines per revolution of hob or C-axis (Machine datum MD396*) $I \cdot k_{ü}$	Max. speed of hob or C-axis $n_{axis_{max}}$ [rpm]	Measurement gearing transmission ratio $n_{axis_{max}} : n_{pick\text{-}up} = 1/k_{ü}$	Number of pick-up lines (standard values) I
0.01	9,000	2000	1:5/1:2.5	1800/3600
0.005	18,000	1000	1:10/1:5	1800/3600
0.0025	36,000	500	1:20/1:10	1800/3600
0.002	45,000	400	1:12.5/1:9	3600/5000
0.001	90,000	200	1:25/1:18	3600/5000
0.0005	180,000	100	1:50/1:36	3600/5000
0.00025	360,000	50	1:100/1:72	3600/5000
0.0002	450,000	40	1:90	5000
0.0001	900,000	20	1:180	5000
0.00005	1,800,000	10	1:360	5000

b) Pick-up type: ROD 260 with scanning frequency 1 MHz for measurement circuit module input frequency of 500 kHz

Resolution A [°]	Number of lines per revolution of hob or C-axis (Machine datum MD396*) $I \cdot k_{ü}$	Max. speed of hob or C-axis $n_{axis_{max}}$ [rpm]	Measurement gearing transmission ratio $n_{axis_{max}} : n_{pick\text{-}up} = 1/k_{ü}$	Number of pick-up lines (standard values) I
0.01	9,000	3333.3(3000)	1:1	9,000
0.005	18,000	1666.7(1500)	1:1	18,000
0.0025	36,000	833.3(800)	1:2	18,000
0.002	45,000	666.7(650)	1:2.5	18,000
0.001	90,000	333.3(300)	1:5	18,000
0.0005	180,000	166.7(150)	1:10	18,000
0.00025	360,000	83.3(80)	1:20	18,000
0.0002	450,000	66.7(65)	1:25	18,000
0.0001	900,000	33.3(30)	1:50	18,000
0.00005	1,800,000	16.7(15)	1:100	18,000

c) Pick-up type: ROD 260 with scanning frequency 1 MHz for measurement circuit module input frequency of 800 kHz (Second development phase, approx. 9/85)

Resolution A [°]	Number of lines per revolution of hob or C-axis (Machine datum MD396*) $I \cdot k_{ü}$	Max. speed of hob or C-axis $n_{axis_{max}}$ [rpm]	Measurement gearing transmission ratio $n_{axis_{max}} : n_{pick\text{-}up} = 1/k_{ü}$	Number of pick-up lines (standard values) I
0.01	9,000	5333.3(500)	1:1	9,000
0.005	18,000	2666.7(2500)	1:1	18,000
0.0025	36,000	1333.3(1250)	1:2	18,000
0.002	45,000	1066.7(1000)	1:2.5	18,000
0.001	90.000	533.3(500)	1:5	18,000
0.0005	180,000	266.7(250)	1:10	18,000
0.00025	360,000	133.3(125)	1:20	18,000
0.0002	450,000	106.7(105)	1:25	18,000
0.0001	900,000	53.3(50)	1:50	18,000
0.00005	1,800,000	26.7(25)	1:100	18,000

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Bereich Steuerungs- und Automatisierungstechnik
Postfach 4848, D-8500 Nürnberg 1

Änderungen vorbehalten

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