SIEMENS

SINUMERIK System 3

Electronic Gearbox

Difference Description relating to Startup Instructions Part 2

Electronic Gearbox

SINUMERIK System 3, Part 2

Difference Description relating to Startup Instructions

Basic Model 4

Edition: 08.85

SINUMERIK® Documentation

Key to editions

The editions listed below have appered prior to this present edition.

The "revisions" column contains a list of the sections which have been revised, in each case with reference to this present edition.

Diskette number: 194/195/B10K

Edition	Order number	Revisions
08.85	E80210-T114-X-A-7600	New edition

Nomenclature

This description applies to the electronic gearbox (ELG), a supplementary component of the SINUMERIK System 3 G A4, which can be used to couple several axes together with extreme precision.

This description supplements the SINUMERIK System 3 Startup Instructions, Part 2 (for basic model 4).

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13. Startup Check List for ELG

Machine data for
electronic gearbox

% TEA1

N100 =..... (Feedrate override 1 %)
N101 =..... (" 2 %)
N102 =..... (" 4 %)
N103 =..... (" 6 %)
N104 =..... (" 8 %)
N105 =..... (" 10 %)
N106 =..... (" 20 %)
N107 =..... (" 40 %)
N108 =..... (" 60 %)
N109 =..... (" 70 %)
N110 =..... (" 80 %)
N111 =..... (" 90 %)
N112 =..... (" 100 %)
N113 =..... (" 110 %)
N114 =..... (" 120 %)
N155 =..... (Scan time increase)
N156 =..... (SEVO controller delay)
N166 =..... (Gearbox ON tolerance)
N167 =..... (Threshold for adaptive pilot control)
N168 =..... (Evaluation factor for following error compens.)
N169 =..... (Monitoring limit for following error)
N170 =..... (Semi-automatic centering speed)
N171 =..... (Software status)

N2000 =..... (Setpoint output (--) channel assignment)
N2001 =.....
N2002 =.....
N2003 =.....
N2040 =..... (Exact stop tolerance range, coarse)
N2041 =.....
N2042 =.....
N2043 =.....
N2120 =..... (Clamping tolerance)
N2121 =.....
N2122 =.....
N2123 =.....
N2160 =..... (Tolerance range zero mark monitoring)
N2161 =.....
N2162 =.....
N2163 =.....

N2200 =..... (Backlash compensation)
N2201 =.....
N2202 =.....
N2203 =.....
N2400 =..... (Reference point value)
N2401 =.....
N2402 =.....
N2403 =.....
N2440 =..... (Zero offset)
N2441 =.....
N2442 =.....
N2443 =.....
N2520 =..... (Circular gain factor)
N2521 =.....
N2522 =.....
N2523 =.....
N2560 =..... (Part actual value factor)
N2561 =.....
N2562 =.....
N2563 =.....
N2600 =..... (Mult. gain)
N2601 =.....
N2602 =.....
N2603 =.....
N2640 =..... (Drive error threshold)
N2641 =.....
N2642 =.....
N2643 =.....
N2680 =..... (Max. speed setpoint)
N2681 =.....
N2682 =.....
N2683 =.....
N2720 =..... (Drift compensation)
N2721 =.....
N2722 =.....
N2723 =.....
N2760 =..... (Acceleration)
N2761 =.....
N2762 =.....
N2763 =.....
N2800 =..... (Max. speed)
N2801 =.....
N2802 =.....
N2803 =.....
N2840 =..... (Shutdown speed)
N2841 =.....
N2842 =.....
N2843 =.....
N2880 =..... (Jogging speed)
N2881 =.....
N2882 =.....
N2883 =.....

N2920 =..... (Rapid jog)
N2921 =.....
N2922 =.....
N2923 =.....
N2960 =..... (Reference point approach speed)
N2961 =.....
N2962 =.....
N2963 =.....
N3000 =..... (Incremental feedrate)
N3001 =.....
N3002 =.....
N3003 =.....
N3120 =..... (Pilot control factor)
N3121 =.....
N3122 =.....
N3123 =.....
N3160 =..... (Vector compensation +)
N3161 =.....
N3162 =.....
N3163 =.....
N3200 =..... (Vector compensation -)
N3201 =.....
N3202 =.....
N3203 =.....
N3280 =..... (Compensation value)
N3281 =.....
N3282 =.....
N3283 =.....
N3320 =..... (Tolerance range for contour monitoring)
N3321 =.....
N3322 =.....
N3323 =.....
N3360 =..... (Contour threshold speed)
N3361 =.....
N3362 =.....
N3363 =.....
N3960 =..... (Main axis increments)
N3961 =..... (Secondary axis increments)
N3962 =.....
N3963 =.....

ELG machine data bits

BIT	7	6	5	4	3	2	1	0
N5000	0	0	0	0	0	0	0	0
N5001	0	0	0	0	0	0	0	0
N5002	0				0			
N5003	0	0	0	0	0	0	0	0
N5004		0	0	0	0	0	0	0
N5016	0	0	0	0	0			
N5020	0				0			
N5021	0				0			
N5022	0				0			
N5023	0	0	0	0	0			
N5600			0				0	0
N5601			0				0	0
N5602			0				0	0
N5603			0				0	0
N5640								
N5641								
N5642								
N5643								

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14.1 ELG Machine Data

General values

MD No.	Designation	Machine data standard values	Maximum input value	Reference system	Input unit
100	Feedrate override 2nd position	1	130	---	%
101	-//- 3rd position	2	130	---	%
102	-//- 4th position	4	130	---	%
103	-//- 5th position	6	130	---	%
104	-//- 6th position	8	130	---	%
105	-//- 7th position	10	130	---	%
106	-//- 8th position	20	130	---	%
107	-//- 9th position	40	130	---	%
108	-//- 10th position	60	130	---	%
109	-//- 11th position	70	130	---	%
110	-//- 12th position	80	130	---	%
111	-//- 13th position	90	130	---	%
112	-//- 14th position	100	130	---	%
113	-//- 15th position	110	130	---	%
114	-//- 16th position	120	130	---	%
115				---	
116				---	
117				---	
118				---	
119				---	
120				---	
121				---	
122				---	
123				---	
124				---	

ELECTRONIC GEARBOX MACHINE DATA

GENERAL VALUES

MD No.	Designation	Machine data standard values	Maximum input value	Reference system	Input unit
150				---8)	
151				---	
152				---	
153				---	
154				---	
155	Increase in scanning time	0	4	---	0.5 ms
156	Position controller delay	500	1000	---	ms
157					
158					
159					
160					
161					
162					
163					
164					
165					
166	Gearbox ON tolerance	100	10000	MS	units
167	Thresh.value f.adapt.pilot control	10	100	MS	units
168	Following error compens.factor	500	1000	----	0.1 %
169	Tol.range of following error monitoring	20	10000	MS	units
170	Speed for semi-autom.centering	1000	30000	MS	1/1000 rev/min
171	Current softw.status No.	----	----	----	--------
172					
173					
174					

E L E C T R O N I C G E A R B O X M A C H I N E D A T A

A X I S - S P E C I F I C V A L U E S (max. 4 axes)

MD No. 7)	D e s i g n a t i o n	Machine data standard values	Maximum input value	Reference 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*	Coarse exact stop tol.range	100	32000	MS	units
208*					
212*	Clamping tolerance	100	32000	MS	units
216*	Tol.range zero mark monitoring	0	0	MS	units
220*	Backlash compensation	0	+/- 255	MS	units
224*					
228*					
232*					
236*					
240*	Ref.point coordinates	0	+/- 99999999	MS	units
244*	Zero offset	0	+/- 9999	MS	units
248*					
252*	Circular gain factor	1666	10000	MS	0.01 s**-1
256*	Part 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 setpoint	8192	16000	---	VELO 4)
272*	Drift compensation	0	500	---	VELO 4)
276*	Acceleration	50	2000	IS	1000 units/s**2
280*	Max. speed	10000	24000	IS	1000 units/min
284*	Ref.point shutdown speed	300	15000	IS	1000 units/min
288*	Jogging speed	2000	15000	IS	1000 units/min
292*	Rapid jog	10000	15000	IS	1000 units/min
296*	Ref.point approach speed	10000	15000	IS	1000 units/min

E L E C T R O N I C G E A R B O X M A C H I N E D A T A

A X I S - S P E C I F I C V A L U E S (max. 4 axes)

MD No. 7)	D e s i g n a t i o n	Machine data standard values	Maximum input value	Reference system	Input unit
300*	Incremental feedrate	500	15000	IS 8)	1000 units/min
304*					
308*					
312*	Pilot control factor	10000	16000	---	
316*	Vector distance addr. + with leadscrew pitch error compens.	0	6249	---	MD number
320*	Vector distance addr. - with leadscrew pitch error compens.	0	6249	---	MD number
324*	Distance betw.2 leadscrew pitch error compens.points	0	32000	MS	units
328*	Compens.value for leadscrew pitch error compensation	0	100	MS	units
332*	Tol.range for contour monitoring	1000	32000	MS	units
336*	Thresh.speed f.contour monitoring	0	24000	MS	1000 units/min
340*					
344*					
348*					
352*					
356*					
360*					
364*					
368*					
372*					
376*					
380*					
384*					
388*					
392*					
396*	No.of enc.pulses p.axis rev.	18000	2 000 000	----	

ELECTRONIC GEARBOX MACHINE DATA BITS

GENERAL BITS

MD No.	7	6	5	4	3	2	1	0
5000								
5001								
5002		Unit of input system 9)				Unit of measuring system 9)		
5003								
5004	Mach.data input							
5005								
: :								
5016						Direc.-dep. leadscr.pitch error comp.	Leadscrrew pitch error comp.active	Pilot control active
5017								
5018								
5019								
5020		Number of main 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 setpoint output for alarm message (hardware signal) 1)		
5023							Opt.	Following error comp. active	Tool-rel. revolut. feedrate
5024								

1) 0000 = No axis
0001 = 1st axis | 0011 = 3rd axis
0010 = 2nd axis | 0100 = 4th axis

2) 0000 = No NC
0001 = NC 1 |
0010 = NC 2 |

E L E C T R O N I C G E A R B O X M A C H I N E D A T A B I T S

A X I S - S P E C I F I C B I T S (max. 4 axes)

MD No. 7)	7	6	5	4	3	2	1	0
560*	Modulo 360° act.value displ.				Radius axis	Whole degrees		Measuring circ. monit.deactiv.
564*	Axis exists	Part actual value factor active	Rotary axis	Part actual value /2	Part actual value *2	Actual val. sign change	Setpoint sign change	Ref. point in minus direction
568*								
572*								
576*								

C O M P E N S A T I O N F L A G S f o r LEADSCREW PITCH ERROR COMPENSATION

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

- = 0
+ = 1
no = 0
yes = 1

Key to machine data

1) unit = 2 * MS unit
   e.g. MS = 1/2 µm
   --- unit = 1 µm

   The measuring system unit (MS) of the drive axis is determined by the number of encoder pulses per axis revolution (machine datum MD 396*), providing the part actual value is evaluated as 1 (MD 564* bit 4 and bit 5 = 0, MD 256* = 0).

   The measuring system unit of the drive axis (rotary axis) is then calculated using the formula below:

$$MS = \frac{360}{4 * I * Kue} \quad \text{(degrees)}$$

   where I = No. of pulses/encoder revolution
   Kue = Transmission ratio between encoder and axis speed
   so that I * Kue = MD 396*

   The following equation applies to the drive axis:

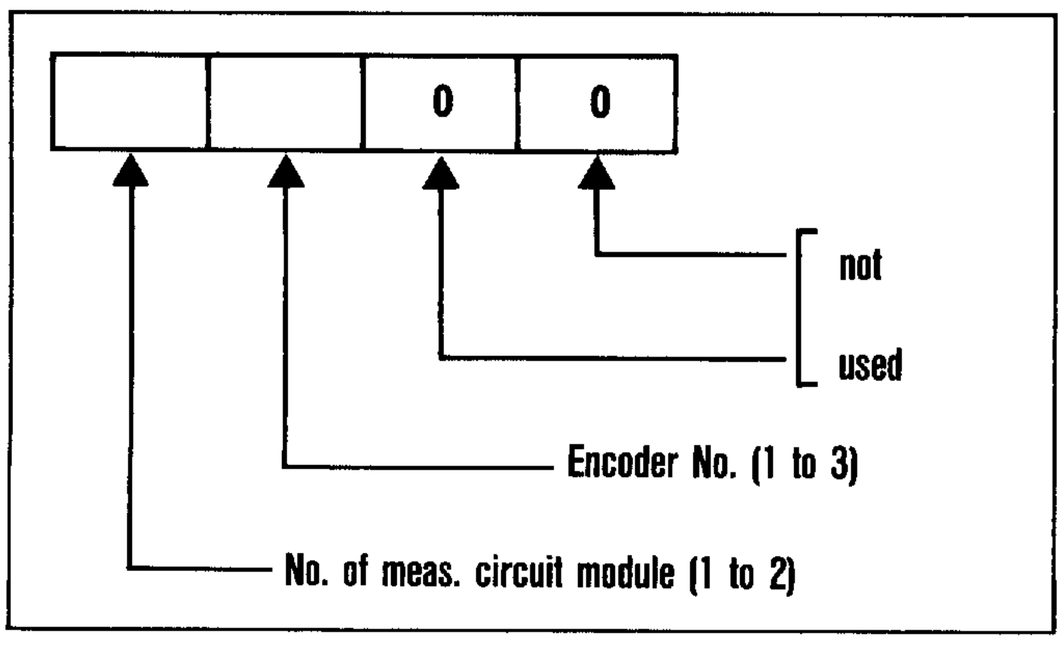
$$1 \text{ unit} = \frac{180}{\text{MD } 396*} \quad \text{(degrees)}$$

2) +/- 1 VELO = +/- 10V / DAU No.of bits

   where 12 bits = 2048
   14 bits = 2048 * 4
   16 bits = 2048 * 16

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

4) Machine datum No. 2000:



5) A machine datum is assigned to each axis in the axis-specific machine data. The "*" in the MD No. characterizes the number of the axis; "*" = Axis No. -1

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

6) MS = Units of the measuring system
   IS = Units of the input system

7) Note on machine datum 5002:

Position control resolution

Bit2	Bit1	Bit0		
0	0	0	0.5×10^{-2} mm	a)
0	0	1	0.5×10^{-3} inches	a)
0	1	0	0.5×10^{-3} mm	
0	1	1	0.5×10^{-4} inches	a)
1	0	0	0.5×10^{-4} mm	a)
1	0	1	0.5×10^{-5} inches	a)
1	1	0	2×10^{-4} mm	a)
1	1	1	2×10^{-5} inches	a)

Input resolution

Bit6	Bit5	Bit4		
0	0	0	10^{-2} mm	a)
0	0	1	10^{-3} inches	a)
0	1	0	10^{-3} mm	
0	1	1	10^{-4} inches	a)
1	0	0	10^{-4} mm	a)
1	0	1	10^{-5} inches	a)

a) Combination not yet released

14.2 ELG Service Data

MD No.	D e s i g n a t i o n			Ref. system	Output unit
8000	Drive axis following error			MS	0.5 units 3)
8001	Drive axis speed setpoint			---	VELO 4)
8002	Adaptive pilot control factor			---	----
8003				---	
8004				---	
8005				---	
8006				---	
8007				---	
8008				---	
8009				---	
8010				---	

14.3 ELG Setting Data

Matching of peripheral equipment to universal interface

SE No.	7	6	5	4	3	2	1	0
5000								
: : :								
5010			Equipment coding - data input					
5011	Stop bits		Transfer format - data input Parity type	Parity bit		Baud rate		
5012			Equipment coding - data output					
5013	Stop bits		Transfer format - data output Parity type	Parity bit		Baud rate		
5014			Xon Start character (e.g. DC1 = 11H)					
5015			Xoff 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-transfer character	Evaluate readiness f.operation	Output without trailer	
: : :								
5026			Code for "End of transfer" (e.g. ETX = 03H)					

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	PT 80 page tele-
	5012	0000 0000	00H	printer 20 mA
	5013	1100 0010	C2H	V.24, 300 baud
RTS LINE	5010		-	Siemens
	5011		-	PT88 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/punch
	5012	0000 0000	00H	
	5013	1100 0100	C4H	V.24, 1200 baud
RTS LINE	5010		-	Facit punch
	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
	5011		-	3/8 reader
	5012		-	
	5013		-	V.24, 9600 baud
RD/PF	5010	0000 0011	03H	Siemens
	5011	1100 0110	C6H	computer-aided part
	5012	1100 0011	03H	programmer 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	programmer
	5012	0000 0000	00H	PG 675
	5013	1100 0100	C4H	V.24, 1200 baud
				Interface
				Printer

14.4 ELG Alarm List

POWER ON ALARMS

Alarm No.	Designation	Locking of ELG-BB2
1	Battery alarm, power supply unit	X
2	Overtemperature	
3	PC stop	X
4	System of units invalid	
:		
8	Incorrect axis or spindle assignment	
:		
16	V.24 parity error	
17	V.24 overflow error	
18	V.24 stop signal error	
19	V.24 external equipment not ready	
:		
22	V.24 time monitoring	
23	V.24 character parity error	
24	V.24 irrelevant EIA character	
:		
28	V.24 ring memory overflow	
29	V.24 block too long (max. 254 characters)	
:		
32	V.24 data format error	
33		
34	V.24 interface operator error	
35	V.24 Siemens reader error	
:		
:		

ELG alarm list

RESET ALARMS

Alarm No.	Designation	Locking of ELG-BB2
100*		
104*	DAU limiting tripped	
108*	Gear factor overflow	X
112*	Down-time monitoring	
116*	Contour monitoring	
120*		
124*		
128*		
132*	Hardware control loop	X
136*	Axis contamination	
140*		
144*		
148*		
152*		
156*	Speed setpoint too high	
160*	Drift too high	
164*		
168*	Controller enable for traversing axis refused	
172*		
176*		
180*		
184*	Stop after reference cam	
188*		
192*		
196*		

ELG alarm list

RESET ALARMS

Alarm No.	Designation	Locking of ELC-BB2
2000	EMERGENCY STOP	X
:		
2035	Program speed too high	
:		
:		
:		
:		
2200	ELG - Power on error	
2201	ELG - Compensation not possible	
2202	ELG - Error in computing part setpoint	
2203	ELG - Error in computing ELG constants	
2204		
2205	ELG - Part setpoint too high	
2206	ELG - Part setpoint close to tolerance limit	
2207	ELG - Gearbox function not permissible	
:		
2214	ELG - Operation of V.24 interface not permitted	
2215	ELG - Max. following error monitoring value exceeded	
:		
3000		
:		
3016	Error in PC-ELG data channel	
3017		
3018	Data not available (PC-ELG data channel)	
3019		

14.5 Summary of Interface Signals

14.5.1 PC Input Signals from ELG

Group	Byte addr.* NC1	NC2	NC3	NC4	7	6	5	4	3	2	1	0
Ready signals	E64	E74	E84	E94			NC-(ELG) 882	NC-(ELG) 881	V.24 executing			
	E65	E75	E85	E95			NC-(ELG) Alarm					
Gearbox-specific signals	E66	E76	E86	E96	Coupling on	Gearbox constant computed		Rapid traverse	Tooth space reached			
	E67	E77	E87	E97								
Axis-specific signals	E68	E78	E88	E98	Exact position reached ④	③	②	Actual value stored	Exact position reached ①			
	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								
											Ref. point reached	Traverse instruction

① = 1st axis
② = 2nd axis
③ = 3rd axis
④ = 4th axis

* The ELG can occupy the location of NC2 or NC3 in the switching RAM (defined with appropriate code on the CPU of the ELG 6FX1125-8AC)

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14.5.2 PC Output Signals to ELG

Group	Byte addr.*				Bit number							
	NC1	NC2	NC3	NC4	7	6	5	4	3	2	1	0
Ready signals	A64	A74	A84	A94	*Emergency stop	Oper. panel disabled					Reset	Data Start
Feedrate override	A65	A75	A85	A95								
Gearbox-specific signals	A66	A76	A86	A96	Overall feedrate enable							
Ready signals	A67	A77	A87	A97	Compute gearbox constant	Gearbox OFF	Gearbox ON	Single indexing	Semi-autom. centring	Actual value stored	Following error monitor active	
Axis-specific signals	A68	A78	A88	A98	Data Stop							
	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								
						Follow-up operation	Axis disable	*Delay (ref. point)	Feedrate enable	Controller enable		

① = 1st axis
② = 2nd axis
③ = 3rd axis
④ = 4th axis

* The ELG can occupy the location of NC2 or NC3 in the switching RAM

SP03538.0 EN.

14.5.3 Machine Control Panel Signals from PC to ELG

Marker #	Bit number 7	6	5	4	3	2	1	0
Mn.	Mode switch D 8	C 7	B 6	A 5	Feedrate/rapid traverse override switch D 4	C 3	B 2	A 1
Mn + 1	16	15	14	13	12	11	10	9
Mn + 2	Rapid traverse override act. 25	Rapid traverse overr. 24	Direction keys + 23	- 22	Axis selector switch, code B 21	A 20	19	18

SP03539.0 EN

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

14.5.4 Table for ELG-PC Data Transfer

S I N U M E R I K S Y S T E M 3 E L G E L G - P C D A T A T R A N S F E R

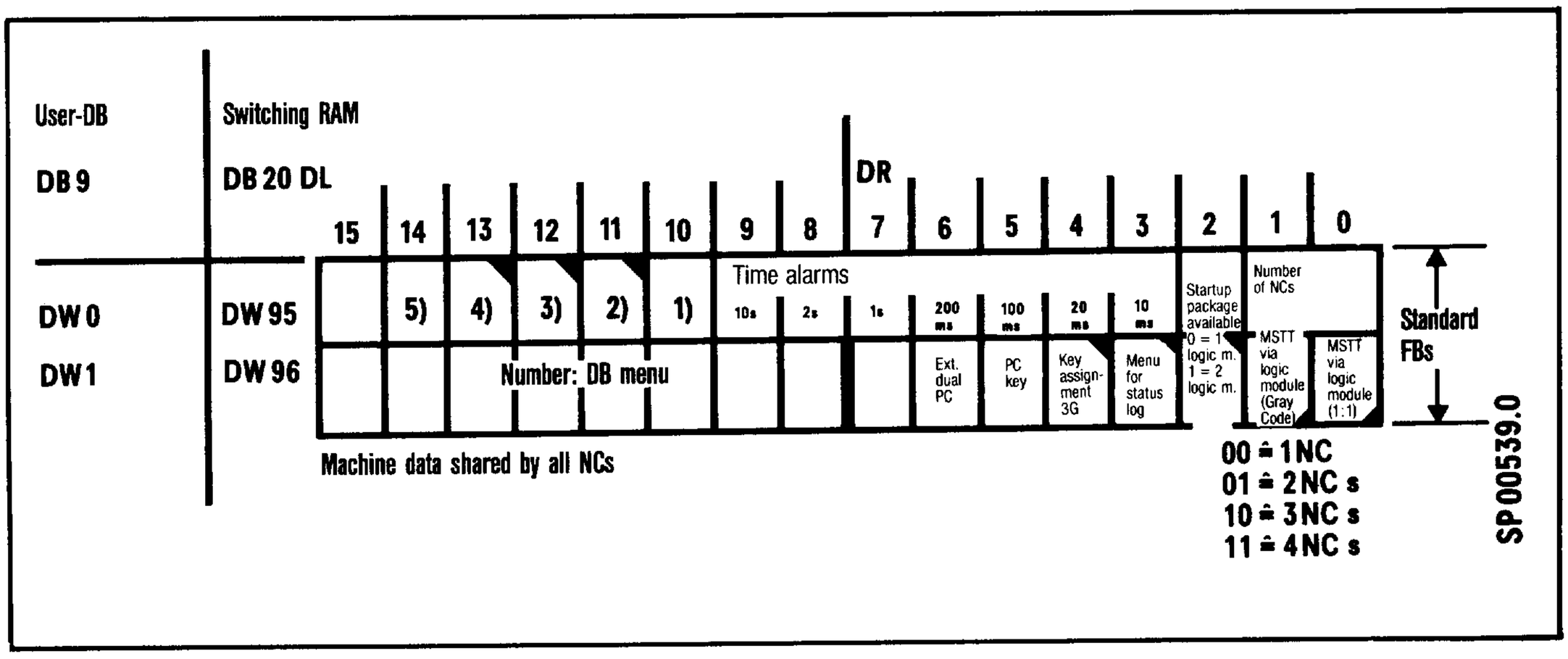
FUNCTION	ADDRESS AREA	CODING 543210	WRITE	READ	RELATIVE ADDRESS 1ST	RELATIVE ADDRESS 2ND	VALUE + -MSB LSB	NOTES
R-PARAMETERS	0 - 99	001001(09)	X	X	00-99	00	+/-99999.999	*
MACHINE DATA	0 - 4999	001010(10)	X	X	00-99	00-49	+/-999999999	$
MACHINE DATA BITS	5000 - 6999	011100(28)	X	X	00-99	50-69	00000001	$ # &
ACT.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	

* = For range of values see list of ELG part parameters
$ = "Write" with "COUPLING ON" not permissible
\# = Not transferrable with FB22 functional module of the PC basic program
& = Byte-by-byte transfer
. = Position of decimal point variable
: = The decimal point is fixed in the 3rd or 4th position depending on the input system

14.6 ELG Part Parameters

SINUMERIK SYSTEM 3 ELG ASSIGNMENT LIST OF ELG PART PARAMETERS					
Symbol (ELG displ.	PART PARAMETERS Meaning	R-PARAMETER NUMBER	UNIT OF MEASUREMENT	RANGE OF VALUES	SIGN
Z0	Number of threads of cutter or number of teeth of pinion-shaped cutter (negative sign for upcut milling)	R 20	1	0 - 999	+/-
Z2	Number of workpiece teeth	R 21	1	1 - 999	+
TOLER	Max. following error for following error monitoring	R 40	MS unit (depen- resol.)	0 - 10000	+ ing on
TANG (Udv)	Differential component for tangential motion	R 60	Degrees/ mm or degrees/ 0.1 inches	0-999.99999	+/-
AXIAL (Udz)	Differential component for axial motion	R 61	Degrees/ mm or degrees/ 0.1 inches	0-999.99999	+/-

14.7 PC Machine Data



User DB * DB9				Switching RAM DBn	DL								DR							
NC1	NC2	NC3	NC4		15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DW2	DW36	DW70	DW104	DW98										Store M-signal	MSTT fr. marker (opt. 2)	MSTT fr. E-map (opt. 1)		MSTT via perhiph.	Standard S-transfer	M.-Dec.
DW3	DW37	DW71	DW105	DW98																NC as ELG
DW4	DW38	DW72	DW106	DW99																
DW5	DW39	DW73	DW107	DW100																
DW6	DW40	DW74	DW108	DW101																
.	.	.	.	.																
.	.	.	.	.																
.	.	.	.	.																
DW13	DW47	DW81	DW115	DW108																
DW14	DW48	DW82	DW116	DW109																
DW15	DW49	DW83	DW117	DW110																
DW16	DW50	DW84	DW118	DW111																
DW17	DW51	DW85	DW119	DW112																
DW18	DW52	DW86	DW120	DW113																
DW19	DW53	DW87	DW121	DW114																
DW20	DW54	DW88	DW122	DW115																
DW21	DW55	DW89	DW123	DW116																
DW22	DW56	DW90	DW124	DW117																
DW23	DW57	DW91	DW125	DW118																
DW24	DW58	DW92	DW126	DW119																
DW25	DW59	DW93	DW127	DW120																
DW26	DW60	DW94	DW128	DW121																
.	.	.	.	.																
.	.	.	.	.																
.	.	.	.	.																
DW35	DW69	DW103	DW137	DW130																

Standard FB s

User

Standard FB s

User

n = DB 20 for NC 1; DB 24 for NC 3
DB 22 for NC 2; DB 26 for NC 4

* The ELG can occupy the NC area of NC2 or NC3 (defined by means of appropriate coding on the CPU of the ELG)

SP 00540.0

15. Prerequisites

15.1 Possible System Configurations

(in preparation)

15.2 Identification of the Software System in the EPROM 27256:

The system software for the electronic gearbox, software status 02, is contained in 2 EPROM chips.

The first of these two EPROMs contains a leader (header) in which a code number and the cross totals are stored. The code number is made up as follows:

570 801 9 00 1 02

- 02 — Software status
- 1 — Number of EPROM module in the system
- 00 — Counter (language code)
- 9 — Code for software package
- 801 — Number of software system (electronic gearbox)
- 570 — Product group for SINUMERIK

The code number and the cross totals are used to check:

- whether the system software is valid,

- whether the actual cross totals coincide with the stored cross totals.

In the event of discrepancies both EPROMs should be replaced.

List of EPROM cross-totals

No.	EPROM No.	Function	Cross-total (hex.)
IC 57	570 801 0007-02	Basic system	00 3B 56 57
IC 58	570 801 0008-02	Basic system	00 3C 47 ØA

16. Validity Check, Cancellation of Memory Areas, Input/Output of Machine Data and Setting Data

16.1 Validity Check

As soon as the ELG-CPU enters the cycle, the red LED on the front of the CPU 6FX1125-8AC goes out.

A lit LED indicates a fault.

Remedy:

- Implement cancel functions
- Check jumpering on the ELG assemblies and the NC switch group
- Check coding switch X2 for NC No. on the ELG-CPU

No measuring circuit modules need be connected for the validity check (pre-requisite: cancel 8 implemented).

Notes on the ELG-PC delivery software:

A PC-EPROM module with special test software is supplied to permit a validity check to be performed on the ELG.

This test software can be used to transfer the ELG part parameters from the NC to the ELG in the form of R-parameters. Two switches are provided on the machine control panel for this purpose; they must be connected to EB48 to EB50.

"Skip" switch	ELG display selected (0 --► 1)
"Dry" switch	Part parameters transferred from NC to ELG.

The ELG display can be cancelled by pressing either the "Mode" key or the "Skip" switch (1 --► 0).

The NC reset key is also effective for the ELG.

Procedure: (after implementing cancel functions 7 to 9)

1) Enter part parameters in the NC (R-parameters)

R01	-999	--►	Z0
R02	123	--►	Z2
R03	99999	--►	Toler
R04	+123.45678	--►	Axial
R05	-876.54321	--►	Tang

Note:
The "External data transfer" option must be set at the NC to permit the R-parameters to be transferred from the NC to the ELG.

2) Select the ELG display with the "Skip" key.

3) Transfer the part parameters to the ELG by pressing the "Dry" switch (0 - 1 signal).

4) Check that the transfer is error-free by selecting the ELG display and checking the part parameters.

5) Modify the part parameters by means of a manual input in the MDI mode with the ELG display selected.

Note:
The "Dry" switch must be set to "0".

6) Repeat the transfer as necessary by pressing the "Dry" switch (0 --► 1 signal).

16.2 Cancel Functions for ELG

Cancellation of memory areas

The cancel operations must be performed under the following circumstances:

- Initial startup
- Replacement of 03500 power supply
- Replacement of system software on ELG-CPU
- Cancellation of certain memory areas

Caution:
Cancel operations are only possible in conjunction with the ELG if the ON switch on the FBG 03830 is set to "1" (irrespective of whether the ELG is defined as NC 2, 3 or 4 in the switching space).

A cancel operation is effected by pressing the cancel key together with the corresponding numeric key. This action restarts the controller via a hardware reset, e.g. reset key on 03500 of the PC line with ELG or by switching on again. The keys must be held down for approximately 10 to 15 seconds until the memory areas have been cancelled.

Note:
If the PC is in the stop status, it is not possible to start the ELG (nor therefore to cancel the memory areas).

The following areas can be cancelled:

Cancel machine data with Cancel 8 — 9
Cancel setting data with Cancel 9 — 8
Cancel R-parameters with Cancel 7 — 7

+ Power on reset (or mains on)

16.3 Input Functions for ELG

Loading standard setting data for universal interface

This function can be used to preset the universal interface of the ELG for a standard device when activating the controller. Setting data which is permanently stored in the EPROM of the controller is loaded in the setting data memory.

The ON switch on the FBG 03830 must be set to "1".

Operation:

9 + + Power on reset (or mains ON)

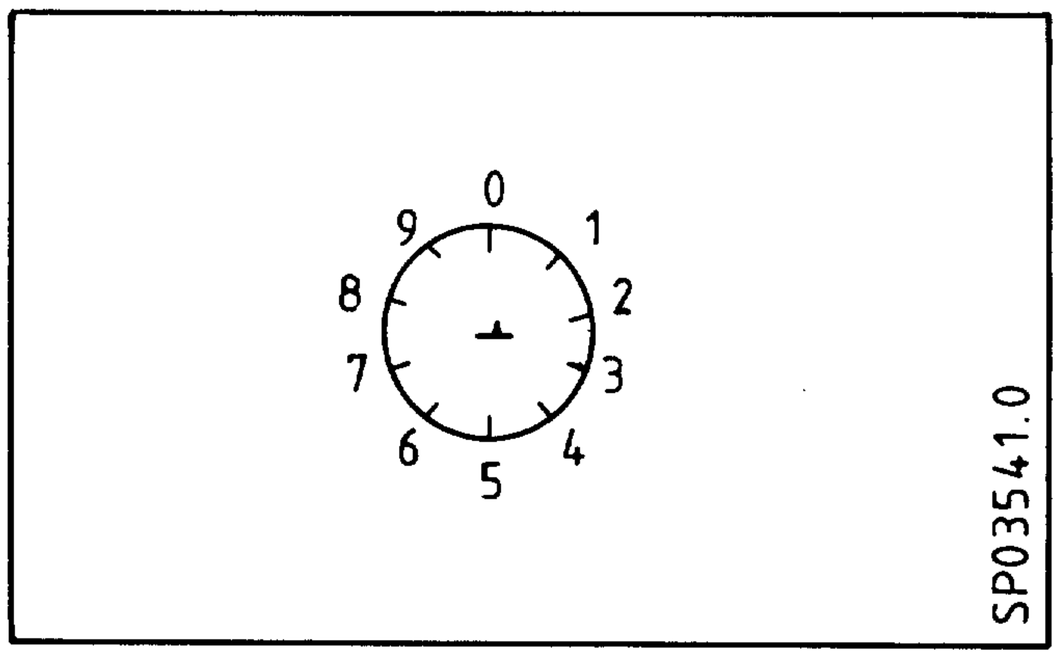
The keys (INPUT 9) must be held down together for approximately 5 to 10 seconds.

ELG standard setting data bits for universal interface:

Setting data			Unit
No.	Binary code	Hex.code	
5010	0000 0000	00H	Siemens
5011	1100 0010	C2H	PT80
5012	0000 0000	00H	Page teleprinter
5013	1100 0010	C2H	
5014	0000 0000	00H	V.24/20 mA
5015	0000 0000	00H	300 baud
5016	0000 0000	00H	

16.4 ON switch

- ON switch S1



S1:
Standard setting 0

The cancel operations are only possible in conjunction with the ELG if the switch is set to "1" (irrespective of the NC area occupied by the ELG in the switching space).

Note:
In the variant with dual PC in the 2-row logic frame only the ON switch S1 of the NC switch group in the PC1 row (next to the ELG unit) is valid.

16.5 Input of Machine and Setting Data via Input/Output Devices

Sequence of operations for data input

Select the data input mode (DATA INPUT).

The data input is started by means of the "DATA START" command (interface signal).

The data type is recognized automatically on reading in.

The following code must be entered:

- Machine data: ←%TEA1
- Setting data: %SEA

During reading in the wait message "V.24 RUNNING!" appears in line 15; this message disappears again on termination of the transfer. No data input is possible whilst the gearbox coupling is switched on.

Alarm 22 appears in conjunction with closed-loop data transfers if data is not transmitted by the peripheral device within 60 s.

The transfer is aborted if the operating mode is changed or following the "DATA STOP" command (interface signal). Otherwise the transfer is terminated on reading in of the "end-of-transfer" character (M02).

Sequence of operations for data output

Select the data output mode (DATA OUTPUT).

The data output is started by means of the "DATA START" command (interface signal).
Machine data is output first of all. Setting data can be output when all machine data has been transferred by entering "DATA START" again, providing the operating mode has not been changed beforehand.

During reading out the wait message "V.24 RUNNING" appears in line 15; the message disappears again on termination of the transfer. No data output is possible whilst the gearbox coupling is switched on.

Alarm 22 appears in conjunction with closed-loop data transfers if the ELG cannot transmit data to the peripheral device within 60 s.

The transfer is aborted if the operating mode is changed or following the "DATA STOP" command (interface signal).

16.6 Tape Format

Machine data:	Setting data:
%TEA1	%SEA
N... = ...LF	N... = ...LF
N... = ...LF	N... = ...LF
.	.
.	.
.	.
M02 LF	M02 LF

16.7 Handling of the startup package

If the startup package of the functional module package 6 is available for the PC, the following functions can be implemented with the aid of the NC operator's panel:

1) Input/output of machine data bits

2) Input/output of machine data words

3) Input/output of setting data bits

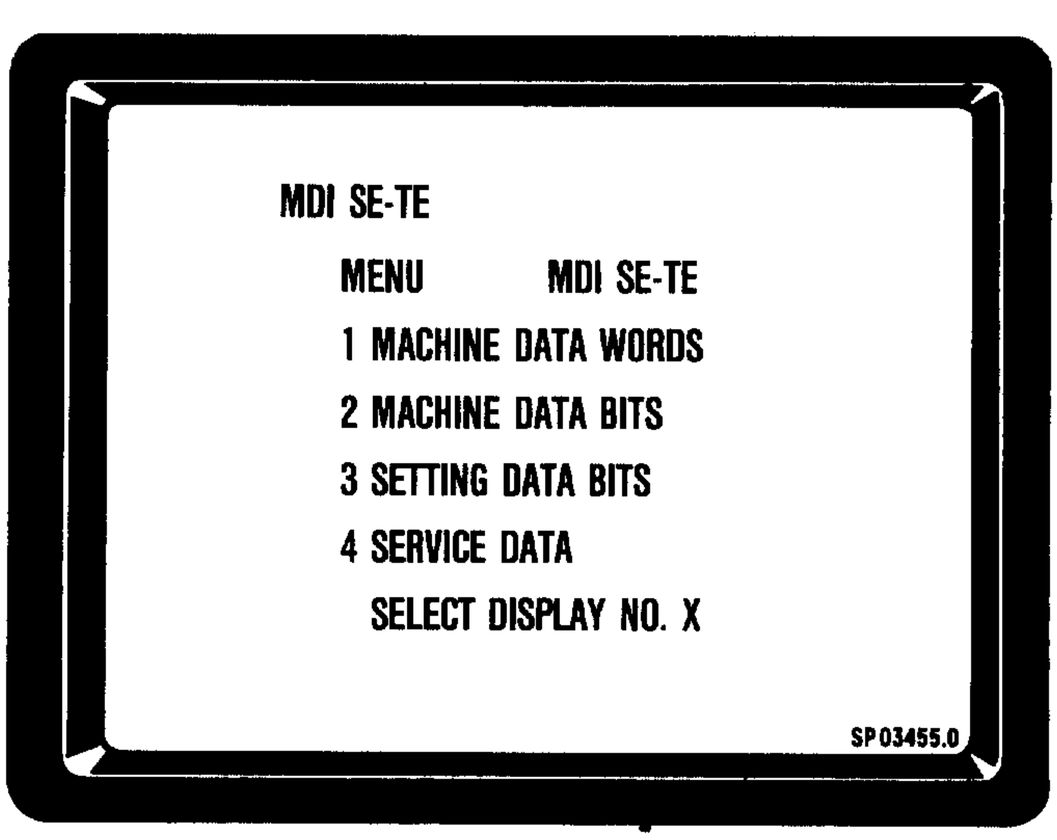
4) Display of service data

A menu display is provided for selecting the various displays.

16.7.1 Startup Menu

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

Menu for startup displays



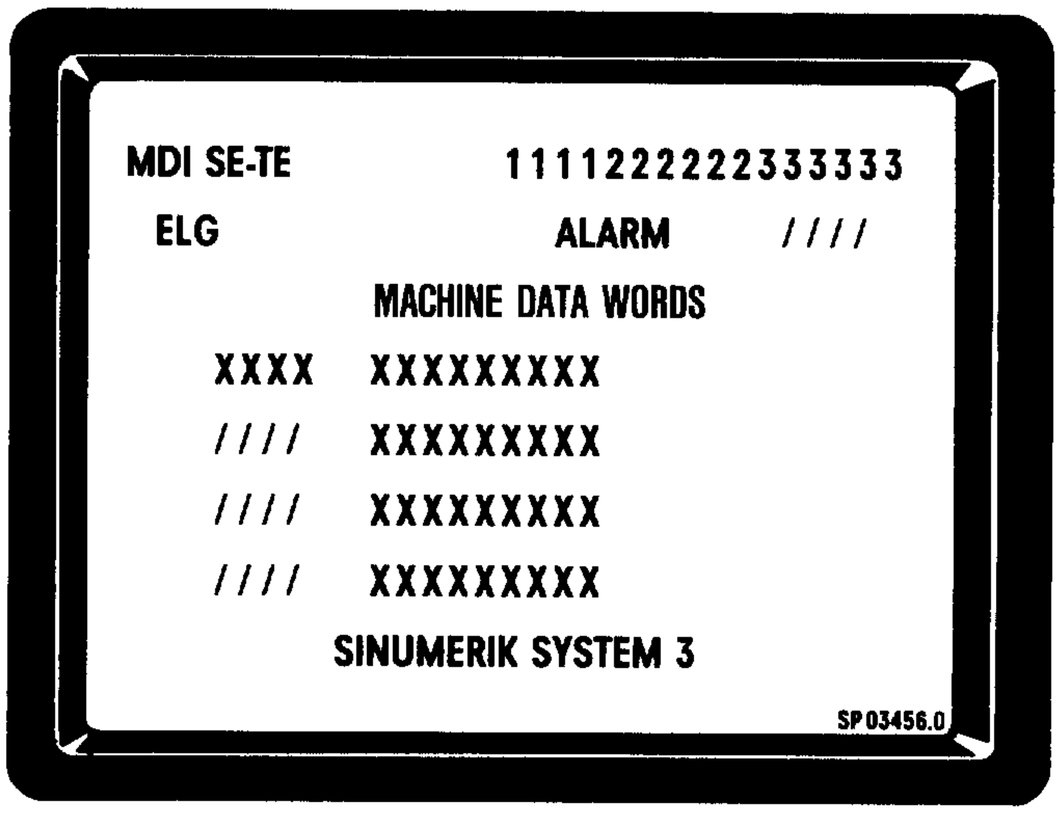
After selection of the startup menu, the required startup display can be selected by pressing the numeric keys 1...4 on the keyboard:

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 after the last selection appear when the display is selected.
Cancellation of the startup displays by means of:

- Input of digits 1 to 4
- Mode ≠ MDI-SETE
- PC key or MODE key
- Selection of a different NC interface

16.7.2 Startup Display for Machine Data Words



Selection of display by entering 1 for SELECT DISPLAY NO. in the menu.

Cancellation of display by actuating the PC key. The following then appears:

MDI-SETE mode: ELG menu
Other modes: ELG basic display

Machine data is updated after inputting a machine data number or after advancing with the paging key, after an input and after selecting a display (last displayed range).

If an invalid machine data number is preset, the next permissible number is displayed by the PC. The cursor must be set to the MD number before entering the new address. The valid machine data is listed in the ELG startup instructions.

The paging keys can be used to page up or down to the next machine data numbers.

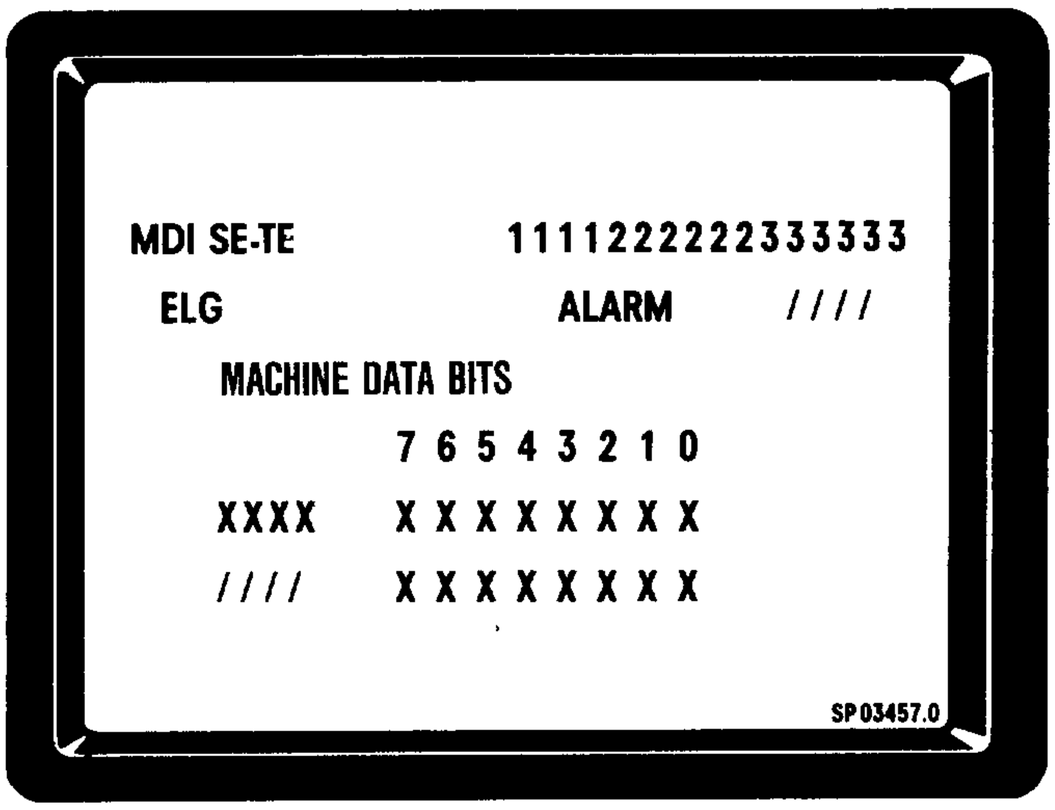
The next 4 machine data words are displayed by actuating the [↓/⇩] key.

The preceding machine data is displayed by actuating the [↑] key.

The cursor can be positioned within the input fields with the [→] and [←] keys.

Inputs are made with the input key. No machine data can be entered when the coupling is ON.

16.7.3 Startup Display for Machine Data Bits



Selection of display by entering 2 for SELECT DISPLAY NO. in the menu.

Cancellation of display by actuating the PC key. The following then appears:

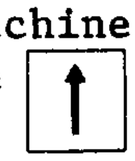
MDI-SETE mode: Menu
Other modes: Basic display

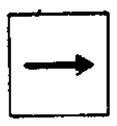
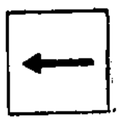
The machine data bits are updated after input of a machine data number or after advancing with the paging key, after an input and after selecting a display (last displayed range).

A desired machine datum can be preset by inputting a new address. If this number is in an invalid range, the next permissible number is displayed by the PC. The cursor must be set to the MD number before entering the new address.

The paging keys can be used to page up or down to the next machine data numbers.

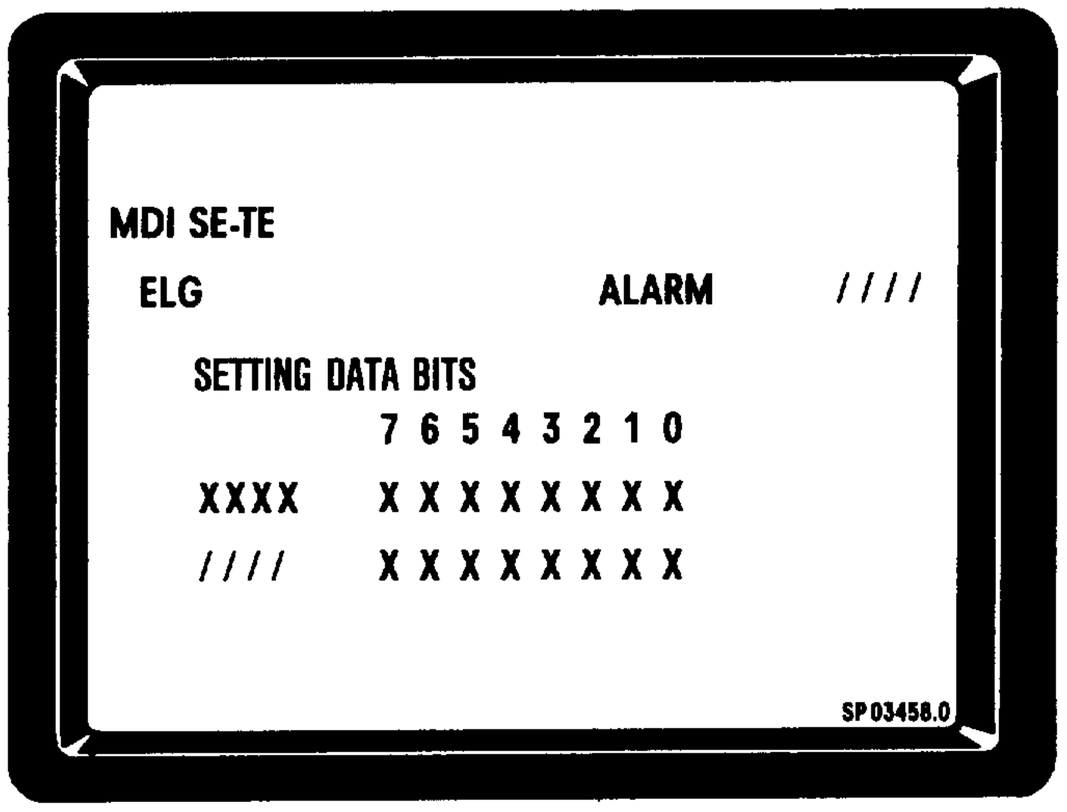
The next 2 machine data bits are displayed by actuating the  key.

The preceding machine data is displayed by actuating the  key.

The cursor can be positioned within the input fields with the  and  keys.

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

16.7.4 Startup Display for Setting Data Bits



Selection of display by entering 3 for SELECT DISPLAY NO. in the menu.

Cancellation of display by actuating the PC key. The following then appears:

MDI-SETE mode: Menu
Other modes: Basic display

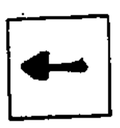
The setting data is updated after input of a setting data number or after advancing with the paging key, after an input and after selecting a display (last displayed range).

Possible setting data bits: 5000 - 5023.

The paging keys can be used to page up or down to the next setting data numbers.

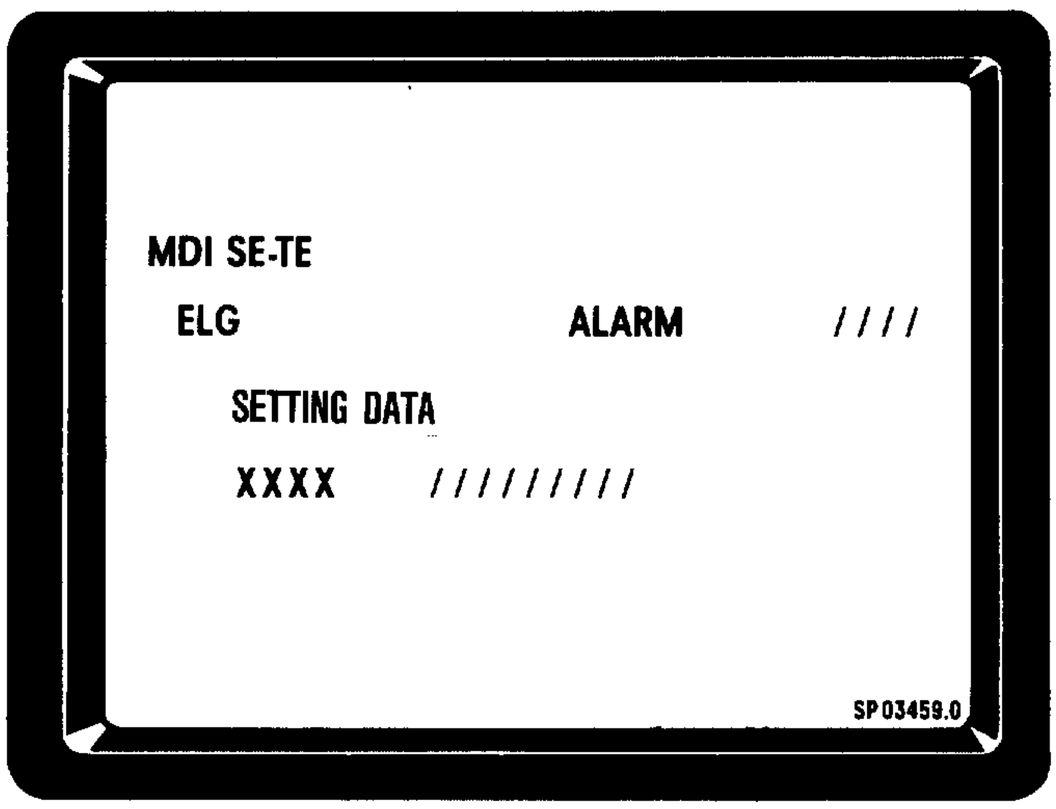
The next 2 setting data bit addresses are displayed by actuating the  key.

The preceding machine data is displayed by actuating the  key.

The cursor can be positioned within the input fields with the  and  keys.

The setting data bits are entered individually in accordance with the cursor position. They are transferred by means of the input key.
No setting data bits can be input when the coupling is ON.

16.7.5 Startup Display for Service Data



Selection of display by entering 4 for SELECT DISPLAY NO. in the menu.

Cancellation of display by actuating the PC key. The following then appears:

MDI-SETE mode: Menu
Other modes: Basic display

*Possible service data Nos. 8000 - 8003

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

* Advancing with the paging key

(↓/⇩ or ↑)

17. Manual Startup of the Drive Axis

17.0 General

Startup of the SINUMERIK 3GA4 must be terminated prior to startup of the "electronic gearbox". The machine data specified is valid only for the drive axis unless otherwise specified.

17.1 Machine Data

No standard machine data can be preset (by means of input functions) for the ELG.

The machine data can either be specified via the operator's panel of the NC (if the startup package is available) or via the universal interface on the ELG CPU.

17.2 Direction of Control of the Drive Axis

An incorrectly set direction of control will result in uncontrolled axis movement at maximum speed. The position direction of control and the speed direction of control should therefore always be checked before closing the control loop.

Procedure:

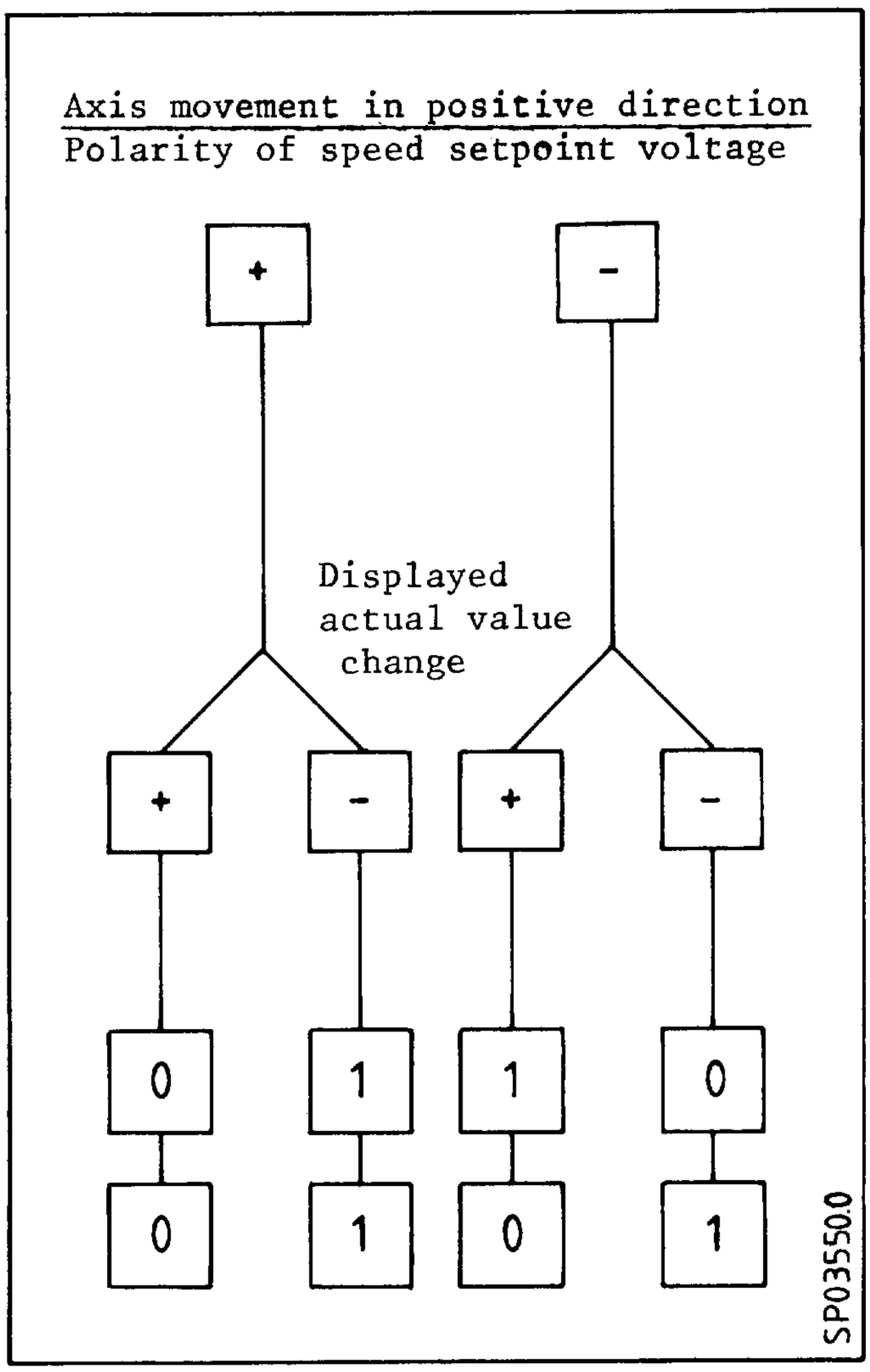
The information below must be available:
Traversing direction of the drive axis (information from the customer or as per ISO).

Polarity of the speed voltage setpoint at the controller at which the axis moves in the positive direction (information from the customer or test with battery box).

Position direction of control test:
Move the drive axis mechanically in the positive direction.
Observe the direction in which the actual value changes on the current actual value display.

Set the machine data bits for changing the sign of the speed setpoint MD 564* bit 1 and sign change for part actual value MD 564* bit 2.

Example:



When setting the position direction of control of the drive axis, the procedure which must be followed is that for the SINUMERIK System 3. The most important point to observe is that the position direction of control is correct and that the axis does not effect any uncontrolled traversing motions. The setting need only be made for the drive axis. The customer should check prior to making sample workpieces that the drive axis moves in the correct direction when the cutter direction of rotation is set. The coupling must of course be switched on for this purpose.

Matching is possible via MD 564* (depending on the drive axis number entered in MD 5020). Both bit 1 and bit 2 must be inverted in order to obtain the correct position direction of control. If the "+" and "-" direction keys for manual operation are then the wrong way round, this can be altered in the PC program (call FB 180).

Setting the differential components:

The customer must likewise check that the differential components (axial and tangential) are added or subtracted in accordance with the sign entered.
The direction can be modified in MD 564* bit 2.

* For the axial and tangential axes

17.3 Closing the Speed Control Loop

Switch off the controller, then connect the setpoint connector and cancel any other interlocks for this axis (fuses, controller disable). Keep other axes locked. Switch on controller.

Note: Press emergency stop button if feed axis starts uncontrolled traverse.

Possible causes of uncontrolled traversing:

a) Incorrect polarity of position control loop or speed control loop:
Incorrect machine data bits.
Symptom: axis traverses at maximum speed.

b) Position control loop not closed:
Symptom: Axis traverses at constant low speed.
Cause: The instrument (position encoder) is not following the axis motion.

A short-circuit to ground, an interrupt or a line short-circuit will cause the measuring circuit monitor to be tripped.

c) Setpoint not received by speed controller:
Symptom: Axis traverses at a constant low speed (drift).

d) Control loop fault:
Symptom: Oscillation and extreme reciprocation of the axis.
Causes:
Speed feedback interrupted
Incorrect polarity of speed feedback
Incorrect optimization
Circular gain factor too high

17.4 Jogging Mode

The setpoint cable of the drive axis is connected and the direction of control is correct. The position control loop is closed and the gain settings are correct.

The alarms below may prevent axis movement (not applicable when the coupling is switched on):

Axis	Alarm	
	2000	Emergency stop
	2088	Error in drive unit - speed controller not ready (servo not ready)
1 2 3 4	1680 1681 1682 1683	Controller enable of a traversing axis refused
1 2 3 4	1560 1561 1562 1563	Speed setpoint too high Tripped via machine datum 264*
1 2 3 4	1120 1121 1122 1123	Clamping error Axis not in position Tripped via machine datum 212*
1 1 3 4	1160 1161 1162 1163	Contour monitoring Tripped via machine datum 332* and 336*
1 2 3 4	1320 1321 1322 1323	Control loop hardw.fault Measuring circuit signal monitor tripped for axes
1 2 3 4	1360 1361 1362 1363	Measuring circuit fault, contamination
1 2 3 4	1600 1601 1602 1603	Drift too high

The following signals are required in addition for jogging mode (no alarms tripped):

- Feed enables X, Y, Z, 4.
- No axis locks.
- Controller enables X, Y, Z, 4.
- Overall feed enable.

→ Interface test, Section 8 → Not when coupling switched on

If there is no feed enable and no controller enable, no "Feed hold" message is output to the operator's panel of the NC.

17.5 Drift Compensation

No automatic drift compensation can be carried out with the ELG. Drift compensation is only possible by modifying MD 272*. The following error of the ELG is output in DB n DW 48, 49.
The value is represented in hexadecimal format (i.e. it must be converted to decimal format). The displayed value must be divided by 2 and entered in MD 272*.

* corresponds to the drive axis number.

17.6 Tests for all Manual Functions:

Limit switch (if provided)
Incremental dimension
Approach to reference point

18. Drive Optimization, Monitoring of Drive Axis, Final Operations

18.1 Speed Calibration and Definition of the Maximum Setpoint for the Drive Axis

The maximum drive axis speed desired by the customer MD 280* must be assigned to a tacho voltage.

It should be remembered that approximately 10 % is required as a control standby. The natural limits are set by the measuring circuit module (10 V) or the controller of the drive.

Example 1)

Maximum permissible input voltage of the drive controller: -10 V.
The value 8192 ≙ setpoint output up to 10 V is entered under MD 280*.

The maximum speed of the drive axis must however be reached at 9 V (10 % control standby).

Speed compensation

This setting should be performed at a low speed and a low speed setpoint.
Measuring point:
Speed setpoint at the controller of the drive with a defined (e.g. jogging) speed set by the ELG. Setting performed at the potentiometer, speed compensated at the controller.

Example 2)

The controller of the drive must be limited to a speed setpoint which is less than 10 V.

The value 4096 (for example) is entered under MD 280* (up to 5 V setpoint).

The maximum axis speed must be reached at 4 V.

The speed setpoint output voltage can be limited by the NC by means of MD 280*.

* Dependent on the axis number set for the C-axis

Conversion: 10 V corresponds to roughly 8192 units (VELO).

The limit entered under MD 280* must not be reached during operation.

18.2 Multiplication Factor for the Drive Axis

The multiplication factor must be calculated on the basis of machine-specific data and entered in MD 260*.

The following data is required for the calculation:

- Setpoint voltage at the drive at maximum speed (Umax [V])
- Number of increments per revolution of the drive axis (MD 396*)
- Maximum speed of drive axis (MD 288*)

The following formulae are required for calculating the mult. gain:

$$1\ MS = \frac{360}{4 \times I \times Kue} \quad \text{(degrees)} \qquad (1)$$

MS = Measuring system unit

This is determined by:

I = No. of pulses/encoder revolution
Kue = Transmission ratio between encoder and axis speeds

Prerequisite:
The actual value evaluated for the drive axis must be 1
(MD 256* = 0, MD 564*, bits 4 and 5 = 0)

The following applies:

IxKue=MD 396* No. of increments per axis revolution (1a)

1 unit = 2 M (2)

$$1\ unit = \frac{2 \times 360}{4 \times I \times Kue} \quad \text{(degrees)} \qquad (2a)$$

$$1 \text{ unit} = \frac{180}{\text{MD } 396^*} \quad \text{(degrees)} \qquad (2b)$$

$$V = 180 \times 10^3 \times \frac{\text{MD } 280^*}{\text{MD } 396^*} \quad \left(\frac{\text{degrees}}{\text{min}}\right) \qquad (3)$$

V Axis speed $\left(\frac{\text{degrees}}{\text{min}}\right)$

MD 280* Maximum axis speed (1000 units/min)

MD 396* No. of increments per axis revolution

Conversion to revolutions/min:

$$V = \frac{180 \times 10^3}{360} \times \frac{\text{MD } 280^*}{\text{MD } 396^*} \qquad (3a)$$

$$V = 500 \times \frac{\text{MD } 280^*}{\text{MD } 396^*} \quad (\text{min}^{-1}) \qquad (3b)$$

The revolutions/min values are normally preset. The machine data values can be calculated by adjusting the formula (1000 units/min).

$$\text{MD} = \frac{V_x \times \text{MD } 396^*}{500} \quad \left(\frac{1000 \text{ units}}{\text{min}}\right) \qquad (4)$$

where:

MD_x Machine datum to be calculated, e.g.
MD 280*, MD 284*, MD 288*, MD 292*
MD 296*, MD 300*, MD 336*

V_x Speed in min^{-1} for max. speed, jogging speed, rapid jogging, etc.

Finally the mult. gain is calculated in accordance with the following formula:

Mult. gain =

$$\frac{3 \times 10^7}{V \quad (1000_{max} \text{ units/min})} \times \frac{\text{Umax (V)}}{10 \text{ V}} \qquad (5)$$

V_{max} Result of MD 280*

U_{max} Setpoint voltage at maximum axis speed.

When the calculated value is entered, it is necessary to check that the following error also coincides with the desired circular gain factor (see also chapters on following error and circular gain factor).

Mult. gain table - input values:

Vmax MD 280* 1000 units/min	Umax 4V	5V	8V	9V
24000			1000	1125
23000			1043	1174
22000			1091	1227
21000			1143	1285
20000		750	1200	1350
19000			1263	1421
18000			1333	1500
17000			1412	1588
16000		937	1500	1687
15000		1000	1600	1800
14000		1071	1714	1929
13000		1154	1846	2077
12000		1250	2000	2250
11000		1364	2182	2455
10000		1500	2400	2700
9000		1667	2667	3000
8000		1875	3000	3375
7000		2143	3429	3857
6000		2500	4000	4500
5000		3000	4800	5400
4000		3750	6000	6750
3000		5000	8000	9000
2000		7500	12000	13500
1000	12000	15000	24000	27000
800	15000	18750	30000	32000
750	16000	20000	32000	
600	20000	25000		
500	24000	30000		
400	30000	32000		

18.3 Speed Gain (Circular Gain Factor) for Drive Axis

Definition:

$$\text{Circular gain} = \frac{\text{Speed}}{\text{Following error}} \quad \frac{\text{m/min}}{\text{mm}}$$

Unit of circular gain as per VDI standard

General

The maximum permissible circular gain is dependent on:

The design or speed of the drives (rise time, acceleration and braking capacity), machine quality.

Experience with series-manufactured machines will have revealed values in practice which in 80 % of all cases are between 1 and 1.5 m/min/mm. In these cases the value obtained in practice will be set, and a check will be performed for overshoots or instability.

In the case of hob cutters the value of the circular gain factor may be significantly higher (approximately 2 to 4). This is however dependent to a large extent on the design features of the individual machines of various manufacturers (e.g. on the type of drives used, on whether a single or multiple-thread worm gear is used, on the index gear, on the transmission ratios, etc.).

Important: Proper speed control optimization is a prerequisite of a correct circular gain setting.

It is not advisable to set the circular gain factor in the "Jog" mode of the electronic gearbox, since the jogging speeds are usually considerably lower than the normal machining speeds.

On the other hand the actual circular gain factor should coincide with the circular gain factor entered in MD 252*. This check should be performed in the "Jog" mode of operation.

These values coincide when the displayed following error is the same as the theoretically calculated value.

The data below is required to calculate the expected following error:

- Speed travelled (jog) in MD 288* (Note: the value in the MD is only valid for 100 % F-override)

Circular gain set in MD 252*

$$\Delta s = \frac{V_{jog}}{CG} = \frac{\text{MD 288*}}{\text{MD 252*}/1666} \text{ units}$$

Example:
Jogging feedrate MD 2883 = 2000 (1000 units/min)

Circular gain factor MD 2523 = 1666 ($0.01\ S^{-1}$)
(C-axis = 4th axis)

$$\Delta s = \frac{2000}{1666/1666} = 2000 \text{ units (1unit=2MS)}$$

$\Delta s = 2000 \times 2$ MS = 4000 MS

The actual following error for the drive axis can be read out either under MD 8000 (if startup package provided) or in DBn DW48/49 (n = 22 when ELG ≙ NC2).

The value displayed has the unit MS (= 0.5 units).
The following must apply: $\Delta s = \Delta s_{display}$

Any deviations must be compensated either by altering the mult. gain (MD 260*) or by altering the speed compensation at the speed controller.

Prerequisites for setting the circular gain factor:

- Optimization of the speed controller must be terminated.
- Drift compensation must have been effected.

Subsequent modification of MD 252* (circular gain factor):

Once the following error check has been performed, no further checks are necessary when MD 252* is modified, providing the mult. gain or the speed controller have not been altered.

If the pilot controller is active, the ELG requires a few minutes to compensate the following error again.

18.4 Acceleration

The acceleration entered under MD 276* with the unit

$$b \quad (10^{-2} \quad \frac{m}{sec}2)$$

is only active in the following modes of operation:

- Manual (jog, rapid jog)
- Incremental feed
- Approach to reference point
- Single indexing

The acceleration is not active when the coupling is switched on.

Acceleration with coupling switched on:

The acceleration of the drive axis is entirely dependent on the acceleration of the main axes. The most important role is played by the spindle (cutter) of the NC.

The spindle must be delayed by means of the NC machine data such that the drive of the drive axis does not approach the current limit.

The setting must be performed for the least favourable operating conditions.

Unfavourable operating conditions are as follows:

- High cutter speed
- High number of cutter threads (Z0)
- Low number of teeth (Z2)
- Large workpiece diameter

The manufacturer should be consulted for more detailed information.

18.5 Shutdown Speed MD 284*

A speed which permits a reliable approach should be selected for approaching the reference point and for a shutdown at high speed.

18.6 Following Error Compensation

When the coupling is switched on, the following error can be compensated in one of two ways:

a) Adaptive pilot control
b) Following error compensation

These two methods of compensation can be used either singly or jointly.

The relevant machine data is as follows:

Pilot control: MD 167, MD 5016 bit 0, MD 312*
Following error compensation : MD 168, MD 5023 bit 1

If both compensation methods are used, the importance of each method is determined by MD 168.

Examples:

MD 168 = 500 (0.1 %)
means
50 % pilot control
50 % following error compensation

MD 168 = 600 (0.1 %)
means
40 % pilot control
60 % following error compensation

An optimum setting of the mult. gain is essential for correct functioning of the following error compensation (option 6).

Setting the adaptive pilot control:

The pilot control is only matched if:

- the "pilot control" option, MD 5016 bit 0, is selected
- the coupling is switched on
- the following error is greater than the tolerance set under MD 167.

Procedure for setting the adaptive pilot control

- Drift compensation must be performed.

- Only the pilot control, and not the following error compensation, is activated.

- Enter the value 1 in MD 167; MD 312* ≠ 0.

- With the coupling switched on the axis is moved at the highest possible speed (> 50 % of the maximum speed). (The part parameters should be set as necessary by the machine manufacturer.)

- Observe the following error in DBn DW 48/49 or MD 8000. The following error must become smaller. This matching may take some time (several minutes).

- At a constant spindle speed the following error should be only a few increments (the fewer the better). If the following error fluctuates around 0, this is a result of dynamic processes in the machine (e.g. spindle speed not constant, encoder not mounted flush on the spindle or drive axis). This fluctuating following error cannot be compensated.

  In the case of machines whose control action varies substantially - primarily as a result of the drive - MD 167 should be set after matching to a value between 10 and 40 increments.

18.7 Final Operations

Making sample workpieces:

Following startup of the electronic gearbox the customer should make sample workpieces. This is the only method of determining whether or not the optimum machine data has been set.

The value of the circular gain factor and the type of following error compensation used are dependent on the results.

Making a machine data strip:

On termination of startup a machine data strip must be made and printed out. It should then be inserted in the system logbook together the startup log.

The remaining final operations are the same as for the SINUMERIK 3GA4.

19. Description of the ELG Machine Data

19.1 General

The machine data is used to match the controller to the machine tool. It must be determined and optimized carefully by the startup personnel if concrete settings have not already been specified by the machine manufacturer or the end user.

It is entered in the RAM of the CPU 6FX1125-8AC. This memory is protected by the battery of the power supply unit against loss of data when the ELG is switched off.

A large proportion of the machine data is activated immediately on input (new input), whilst other machine data is not activated until the POWER ON routine is executed. It is therefore advisable to switch the ELG off then on again after modifying the machine data.

The machine data can be entered via the V.24 interface. It is also possible to modify the machine data (input and display) via the operator's panel of the NC when using the PC functional module package 6 (startup package).

The machine data of the ELG is sub-divided into the following groups:

MD 100 - 1999: General MD values
MD 2000 - 3963: Axis-specific MD values
MD 5000 - 5023: General MD bits
MD 5600 - 5643: Axis-specific MD bits
MD 6000 - 6249: Compensation bits for leadscrew pitch error compensation

The symbol * in conjunction with the axis-specific MD bits represents the axis designation:

* = 0 - 1st axis
* = 1 - 2nd axis
* = 2 - 3rd axis
* = 3 - 4th axis

The meaning of the MD bits always applies to the set state of the bit, i.e. MD bit = "1". If the bit is not set, the statement must be negated.

The following applies in conjunction with the axis-specific machine data (MD values and MD bits):

- Only the axis-specific machine data which affects the axis assignment and the actual value should be defined where appropriate for the main axis, the axial differential axis and the tangential differential axis.

  This data is as follows:

  MD values: MD 200* Axis assignment
  MD 256* Part actual value factor
  MD 396* No. of encoder pulses per axis revolution

  MD bits: MD 560*,
  Bit 0: Deactivation of measuring circuit monitor
  MD 564*,
  Bit 2: Sign change Actual value
  MD 564*,
  Bit 3: Part actual value *2
  MD 564*,
  Bit 4: Part actual value :2
  MD 564*,
  Bit 6: Part actual value factor active
  MD 564*,
  Bit 7: Axis exists

- All axis-specific machine data must be defined on the other hand for the drive axis. If the coupling is switched on, some machine data is not active, e.g. contour monitoring (MD 332*, MD 336*).

19.2 General MD values

MD No.	Meaning	Standard value
	Feedrate override	
100	" - Switch position 2	1
101	" - Switch position 3	2
102	" - Switch position 4	4
103	" - Switch position 5	6
104	" - Switch position 6	8
105	" - Switch position 7	10
106	" - Switch position 8	20
107	" - Switch position 9	40
108	" - Switch position 10	60
109	" - Switch position 11	70
110	" - Switch position 12	80
111	" - Switch position 13	90
112	" - Switch position 14	100
113	" - Switch position 15	110
114	" - Switch position 16	120

Sign	Input limits		Graduation	Units
+	0	130	1	%

A feedrate override switch with up to 16 settings can be used.

The percentage values for the 15 settings of the feedrate override switch can be set individually with this machine data. This permits, for example, finer settings within a selectable range.

It is possible to enter any percentage values in 1 % steps starting at 0 %. The 1st setting (extreme left-hand setting) must however be 0 %; the upper limit is 130%.

MD No.	Meaning			
155	Increase in scan time			
Sign	Input limits		Gradua-tion	Units
+	0	4	1	0.5 ms

The standard, permanently set scan time for the position controller is 2 ms. It can be incremented in 0.5 ms steps by the input value, e.g. an input value 3 will yield a new scan time of 3 1/2 ms.

If several main components are used (e.g. cutter + axial differential + tangential differential) and various available options added (following error compensation, pilot control, following error monitoring, spindle measured value transfer), the default basic scan time will no longer be adequate. In this case the scan time must be increased in MD 169. It can be increased in accordance with the table below:

No.	ELG functions	Input in MD 169		
		1 main component	2 main components	3 main components
1	Only traversing of drive axis with coupling ON	none	none	1
2	Traverse + following error compensation	none	1	2
3	Traverse + following error compensation + following error monitoring	none	1	2
4	Traverse + compensation + following error monitoring + actual value transfer	none	1	2
5	Traverse + pilot control	none	1	2
6	Traverse + pilot control + following error monitoring	none	1	2
7	Traverse + following error monitoring + actual value transfer	none	1	2
8	Traverse + pilot control + following error compensation	none	2	2
9	Traverse + pilot control + following error compensation + following error monitoring	none	2	2
10	Traverse + pilot control + following error compensation + following error monitoring + actual value transfer	none	2	2

Meanings:

* 1 main component:
B-axis (cutter) or
Y-axis (tangential differential) or
Z-axis (axial differential)

* 2 main components:
B-axis and Y-axis or
B-axis and Z-axis or
Y-axis and Z-axis

* 3 main components:
B-axis and Y-axis and Z-axis

* Options:
Following error compensation
Pilot control
Following error monitoring
Spindle measured value transfer

General values

MD No.	Meaning			
156	Pos.controller		shutdown delay	
Sign	Input limits		Gradua-tion	Units
+	0	1000	1	ms

The output of the position controller (speed setpoint) is set to 0 V when the delay time has been set.

The effects of this delay time are as follows:

1. When the position is approached (digital zero), the clamping tolerance MD 212* is not activated until this time has expired. The time selected should be sufficiently long to permit the larger following error to be eliminated (alarm 112*). If the coupling is switched on, the idle position of the drive axis (clamping tolerance) is not monitored.

2. Delay time before output of the controller disable signal following an EMERGENCY STOP and other faults causing the axes to be stopped immediately.

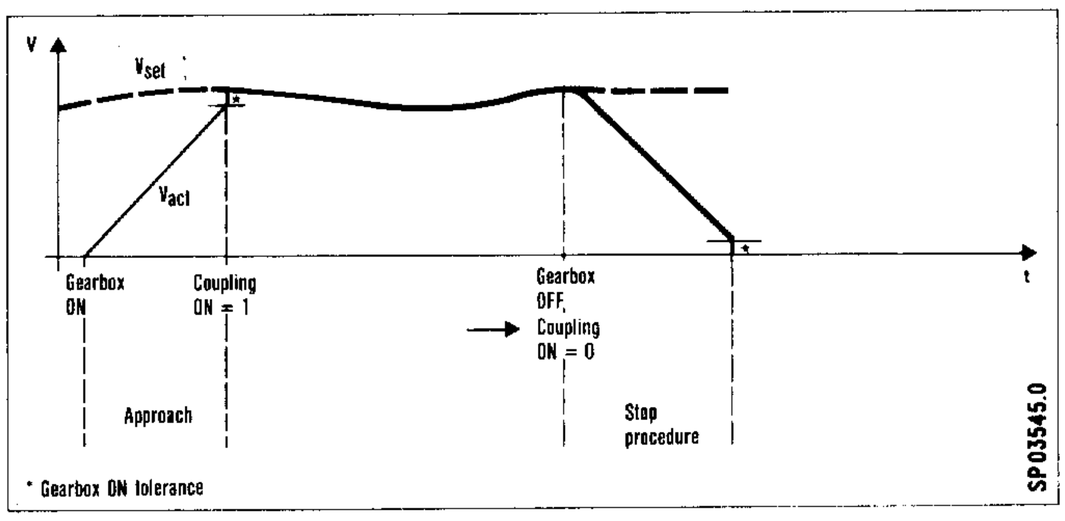
3. Delay time prior to output of the controller disable signal, if the controller enable of a traversing axis is cancelled by the interface unit. If the coupling is switched on, the controller enable signal is not evaluated by the ELG.

General values

MD No.	Meaning			
166	Gearbox ON tolerance			
Sign	Input limits		Gradua-tion	Units
+	0	10 000	1	units

The gearbox function should only be activated when the main axes are stopped. If the gearbox function is connected, for example, when a main axis is rotating, there will be a constant acceleration when approaching the drive axis until the deviation between the speed setpoint and the actual speed is less than the gearbox ON tolerance (MD 166).

The remaining differential speed is then output instantaneously in a scanning interval. The approach of the drive axis is thereby terminated, and the "coupling ON" = 1 interface signal is supplied as an acknowledgement.



The "coupling ON" interface signal is reset immediately (0-signal) on deactivation of the gearbox function. The drive axis is braked at a constant rate until the actual speed is less than the gearbox ON tolerance. A speed = 0 is then set instantaneously.

General values

MD No.	Meaning			
167	Threshold for adaptive pilot control			
Sign	Input limits		Gradua-tion	Units
+	0	100	1	units

Only active when the pilot control function is activated (MD 5016, bit 0 and MD 312* + 0 for drive axis).

It is possible to feed forward an auxiliary variable (pilot control speed) in addition to the position control, in order to keep the following error of the drive axis (difference between the set position and the actual position) as low as possible. This pilot control speed is formed by multiplying the position command variable by a particular factor. This factor must be determined precisely, in order to compensate the following error. It will be determined constantly and automatically when the coupling is switched on, providing adaptive control has been activated (MD 167 ≠ 0).

The adaptive control sensitivity can be set by means of the threshold value (MD 167). This defines the following error as of which the pilot control factor is to be matched.

Threshold value = 1: maximum sensitivity
Threshold value = 0: adaptive control deactivated

A value between 5 and 20 is recommended.

General values

MD No.	Meaning			
168	Following error compensation factor			
Sign	Input limits		Gradua-tion	Units
+	0	1000	1	0.1 %

0 = no compensation

Only active when the following error compensation function is activated (MD 5023, bit 1).

The setpoint for the drive axis is calculated using the formula below:

$$\varphi_{2_{set}} = \frac{Z_o}{Z_2} \times \varphi_{o_{act}} \pm \frac{U_{dz}}{Z_2} \times S_z \pm \frac{U_{dy}}{Z_2} \times S_y$$

The P-position controller means that the following error is .

$$\Delta\varphi = \frac{n_2}{k_v}$$ where n_2 ... Drive axis speed
k_v ... P-gain of position controller

The position of the drive axis would thus be falsified by this speed-related value $\Delta\varphi$.

An electronic gearbox with a high coupling rigidity means however that $\Delta\varphi$ must be compensated.

The following error of the drive axis can be minimized as follows:

- Feeding forward a speed-related speed allowance (pilot control)

- Modification of the part setpoint of the drive axis ahead of the position controller (following error compensation)

If both methods are activated, the proportion of following error compensation can be determined by entering the following error compensation factor (value = 1000).

The circular gain factor entered in MD 252* must coincide exactly with the actual circular gain at the machine, in order for the following error to be compensated exactly.

General values

MD No.	Meaning			
169	Tolerance range for following error monitoring			
Sign	Input limits		Graduation	Units
+	0	16 000	1	units

If the coupling is switched on, the difference between the set position and the actual position of the drive axis (following error) can be compared with a limit value.

The limit value may be specified either as an R-parameter (R40) or as a machine datum (MD 169). The value used for the comparison with the following error is always the higher value.

If the following error of the drive axis exceeds the limit value, the "controller enable" relay signal of a specified set-point channel (MD 5022) is opened (providing the "following error monitor active" interface signal = 1). Alarm 2015 is output in addition.

General values

MD No.	Meaning			
170	Speed for semi-automatic centering			
Sign	Input limits		Graduation	Units
+	0	30 000	1	$\frac{1}{1000}$ U/min

If the coupling is switched on, an additional rotary motion can be superimposed on the drive axis in addition to the slave motion of the spindle and the differential axes. This can be effected by actuating the + or - direction keys, providing the "semi-automatic centering" interface signal = 1 and the operating mode switch is set to the incremental feed position (INC). This superimposed additional motion is then effected at the speed entered in MD 170. The speed can be varied by means of the feedrate override switch.

MD No.	Meaning			
171	Current software status number			
Sign	Input limits		Graduation	Units

The number of the software status of the electronic gearbox can be read out under MD 171.

19.3 Axis-Specific Values

Up to 40 axes can be made available, in order to keep the system software as universal as possible. With the ELG however, only the first 4 axes can be activated and implemented by the hardware.

The meaning of the machine data changes in steps of 40 MD numbers, e.g.:

MD 2840	Reference point shutdown speed for the 1st axis
2841	Reference point shutdown speed for the 2nd axis
2842	Reference point shutdown speed for the 3rd axis
2843	Reference point shutdown speed for the 4th axis
2880	Jogging speed for the 1st axis
.	etc.
.	
.	

The last position of the MD No. is represented by the symbol * for the sake of simplicity. The real digit as described above should be used in place of this symbol * for displaying and entering the machine data.

Axis-specific values

MD No.	Meaning			
200*	Axis assignment			
Sign	Input	limits	Gradua-tion	Units
+	0000	2300	BCD	-

Not yet significant

MD 200* | | | 0 | 0 |

Measuring circuit No.(corresp.to encoder no. 1, 2 or 3)

Measuring circuit module No. (1 or 2)

The assignment of measuring circuit channels (encoder number of measuring circuit module 1 or 2) to axes is defined here.

Example: Axis assignment for a hob cutter:

MD No.	Axis No.	Meas. circuit module No.	Meas. circuit No.	Axis assignment (MT)	Axis designation
2000	1	1	1	11000	Axial differential axis
2001	2	1	2	12000	Tangential differential axis
2002	3	1	3	13000	Main axis (cutter)
2003	4	2	1	21000	Drive axis

This assignment can however be modified for test purposes.

Example: Measuring circuit channels for first and third axes interchanged

Normal assignment:
MD 2000 -> 1100 1st axis
2001 -> 1200 2nd axis
2002 -> 1300 3rd axis

Assignment after interchange:
MD 2000 -> 1300 3rd axis
2001 -> 1200 2nd axis
2002 -> 1100 1st axis

Note: If the axis assignment is modified, the actual value cables and the setpoint signals of the axes must be interchanged accordingly. No other machine data need be interchanged.

Note: The input value 0000 is only permissible if the corresponding axis has been declared unavailable (MD 564*, bit 7, = 0).

Axis-specific values

MD No.	Meaning			
204*	Coarse exact stop tolerance range			
Sign	Input limits		Gradua-tion	Units
+	0	32.000	1	units

The coarse exact stop tolerance range is active for the following modes of operation:

- Manual
- Incremental feed
- Single indexing

The position is said to be reached when the axis arrives at the set position ± the set exact stop tolerance range (approach to the position).

Effects of monitoring:
If the set position is not reached within this range, no further traversing instructions are executed.

Remedy: Check following error and drift, and enter the following error in MD 372* "0" (drift compensation) when the axes have stopped by means of manual input of the drift value.

When the coupling is ON, the coarse exact stop tolerance range is <u>not</u> effective!

Axis-specific values

MD No.	Meaning			
212*	Clamping tolerance			
Sign	Input limits		Gradua-tion	Units
+	0	32.000	1	units

The controller monitors the idle position (position held) in the following modes of operation:

- Manual
- Incremental feed
- Single indexing

If the clamping tolerance is exceeded after the delay for position monitoring MD 156, alarm 112* will appear.

The following cases may occur:

a) If the controller enable signal of an axis is reset by the interface controller, the axis can no longer be held in position by the controller. The interface controller must hold the axis in position itself by means of clamping. The clamped axis may be forced out of position by mechanical influences.

b) The axis may be forced out of position by major mechanical forces or drive errors.

The clamping tolerance entered must be <u>greater than the coarse exact stop tolerance range.</u>

If the coupling is ON, the position of the drive axis is <u>not</u> monitored with the clamping tolerance range.

Axis-specific values

MD No.	Meaning			
216	Tolerance range for zero mark monitoring			
Sign	Input limits		Graduation	Units
+	0	0	1	units

The count of the part actual value counter is checked every 4000 units travel. The nature of the system is such that slight fluctuations will occur; on average these cancel each other out. Fluctuations greater than those permitted by the tolerance range might however lead to inaccuracies. (Monitoring can however only be activated with the measuring circuit modules 6FX1121-4BA...)

Axis-specific values

MD No.	Meaning			
220*	Backlash compensation			
Sign	Input limits		Graduation	Units
±	0	255	1	units

In the case of axes with indirect measuring systems a mechanical backlash will result in an error in the travel. When the direction of movement is reversed, the table will either be moved too far or not far enough by the backlash value depending on the design.

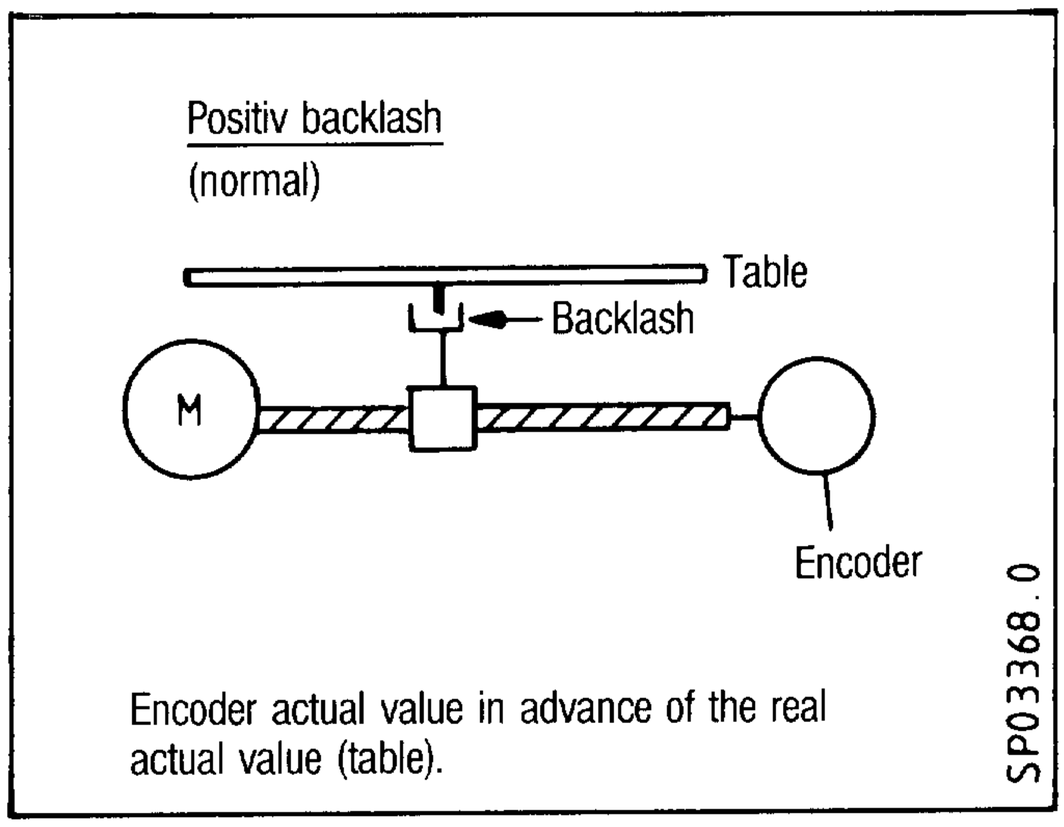


Table does not move far enough

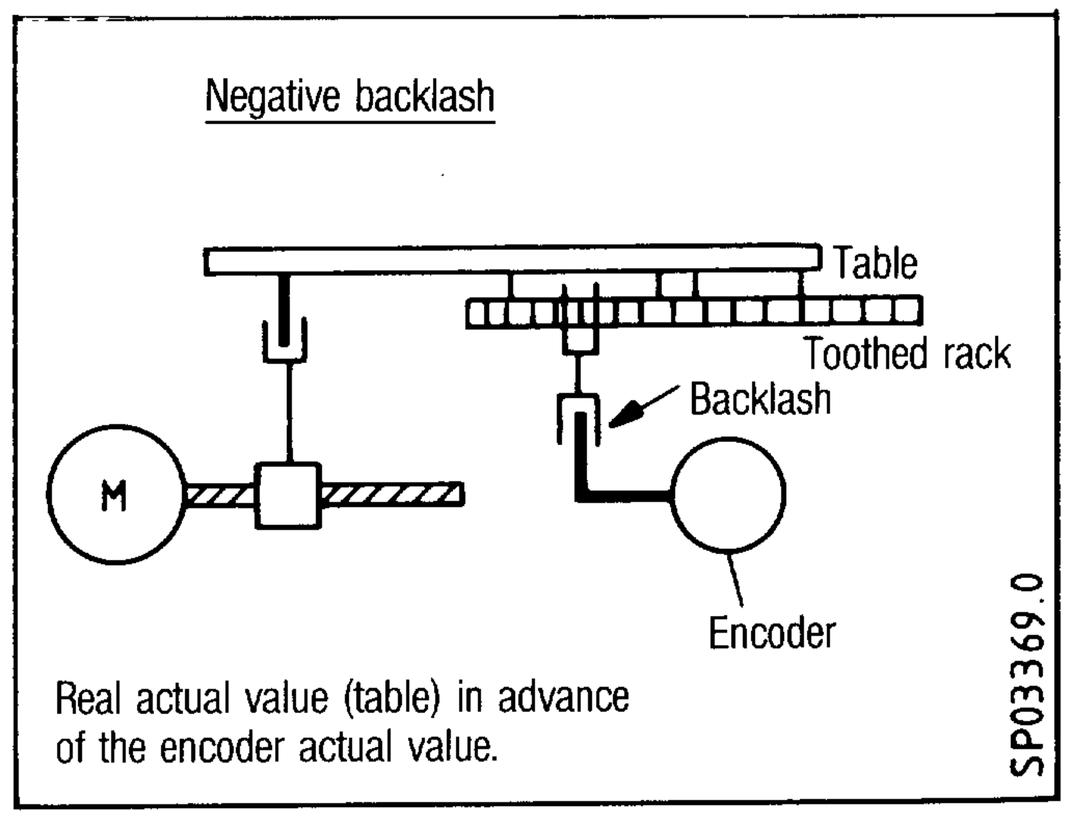


Table moves too far

With a positive backlash the compensation value (backlash value) entered will be positive; with a negative backlash it will be negative.

Axis-specific values

MD No.	Meaning			
240*	Reference point coordinates			
Sign	Input limits		Gradua-tion	Units
±	0	99 999.999	1	units

The difference between the absolute machine zero and the fixed reference point is entered for the relevant axis.

When the reference point is reached, the actual value memory is set to this value.

The actual value displayed for the drive axis will only coincide with the specified machine data value if the resolution of the measuring system is 0.5 x 10^{-3}° (i.e. MD 396* = 180 000).

Axis-specific values

MD No.	Meaning			
244*	Zero offset			
Sign	Input limits		Gradua-tion	Units
±	0	9999	2	units

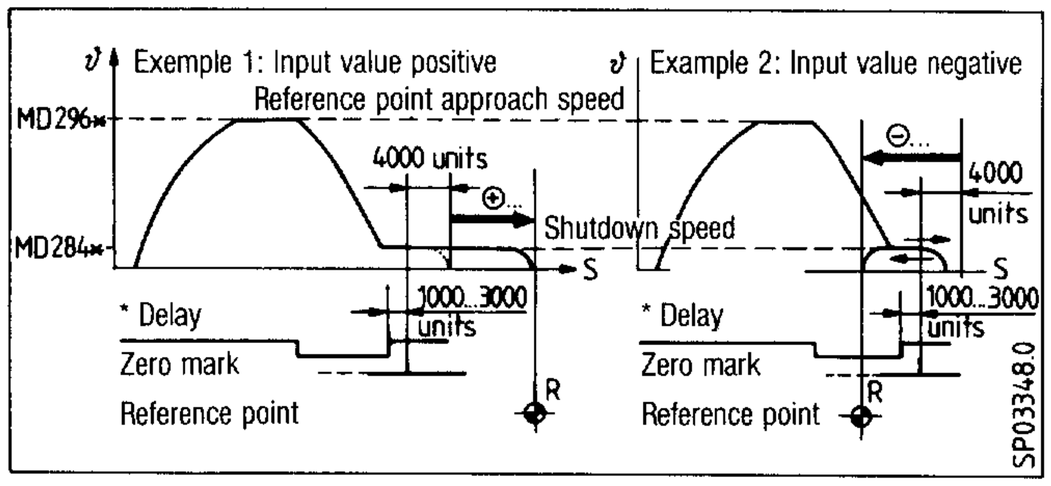
The reference points of the measuring system can be shifted by means of the zero offset. This permits the reference point to be shifted electrically up to ± 32.000 units instead of mechanical shifting or rotation of the instrument (and thus also of the *delay cam).

It is however inadvisable to set a shift which is greater than the travel between two zero marks, since this can be achieved by adjusting the control cam correctly.

The zero offset path is traversed at the shutdown speed (MD 284*), which should already be reached at the control cam.

If the reference point is not shifted, it will be 4000 units behind the first zero mark after release of the control cam.

Notes on a positive direction of approach to the reference point:



With a positive input the axis moves the distance entered in the positive direction beyond the normal reference point (4000 units after the zero mark).

With a negative input the axis crosses the zero mark, then moves to the value formed from the difference between 4000 units and the input value. If the zero offset is greater than -4000 units, the axis, and thus also the direction of movement, will be reversed.

Axis-specific values

MD No.	Meaning			
252*	Circular gain factor			
Sign	Input limits		Gradua-tion	Units
+	0	10 000	1	0.01 s^{-1}

When entering the circular gain factor, it should be remembered that the gain factor of the complete position control loop is dependent on other controlled system parameters. Strictly speaking a distinction must therefore be made between a "desired circular gain factor" (above MD) and an "actual circular gain factor" (at the machine). These circular gain factors will only be identical if all parameters of the control loop are correctly adjusted in relation to one another. These parameters are as follows:

- Mult. gain (MD 260*)
- Speed compensation at the speed controller
- Tachogenerator at the drive

Circular gain factor conversions:

$$KV\ (0.01\ s^{-1}) = 1666\ KV\ (\frac{1000\ units/min}{units})$$

Circular gain check

The circular gain factor for the drive axis entered in MD 252* can be checked during traversing via the following error display.

Prerequisites:

- Optimized speed controller
- Drift compensation when axes stopped

Definition:

$$KV = \frac{Speed\ V}{Following\ error\ s}\quad (\frac{m/min}{mm}) \qquad (1)$$

The circular gain factor calculated using the conversion formula below is entered under MD 252*:

$$KV\ (0.01\ s^{-1}) = \frac{10^5}{60} \times KV\ (\frac{m/min}{mm}) \qquad (2)$$

$$KV\ (0.01\ s^{-1}) = 1666 \times KV\ (\frac{m/min}{mm}) \qquad (3)$$

The number 1666 is therefore entered for the circular gain factor 1.

or $KV\ (0.01\ s^{-1}) =$

$$= 1666^{\times}\ KV\ (\frac{1000\ units/min}{units}) \qquad (4)$$

Procedure:

The actual circular gain factor at the machine should coincide with the desired circular gain factor entered in MD 252*.

It is checked by traversing the drive axis in the JOG mode of operation with the feedrate override switch set to 100 %. This condition is fulfilled if the actual following error (MD 8000) coincides with the theoretically calculated value.

When the drive axis is traversed in the JOG mode of operation and the feedrate override switch is set to 100 %, the speed is MD 288*.

The formula for the theoretically calculated following error ΔS, taking the input unit of the controller into account, is therefore as follows:

KV = Circular gain

$$\Delta s = \frac{V_{jog}}{KV} = \frac{MD\ 288*}{\frac{MD\ 252*}{1666}}\ (units) \qquad (5)$$

Example:

Jog feedrate MD 2883 = 2000 $(1000\frac{units}{min})$

Circular gain factor
MD 2523 = 1666 (0.015^{-1})

where * = 3, i.e. 4th axis = drive axis

$$\Delta s = \frac{2000}{\frac{1666}{1666}} = 2000\ units$$

The actual following error for the drive axis can be read out as the service value under MD 8000 (or under the address DBn, DW48/49 in the switching RAM, n = 22 when ELG = NC2).

The value of the following error MD 8000 corresponds to 0.5 units.

The following is thus valid for the actual following error Δs':

$$\Delta s' = \frac{MD\ 8000}{2}\ (units) \qquad (6)$$

The actual circular gain factor Δs' and the desired circular gain factor coincide if the following applies:

$$\Delta s = \Delta s'$$

In the event of deviations, the differences must be compensated at the mult. gain (MD 260*) or at the speed controller.

Conversion of the following error in degrees:

$$1\ unit = \frac{180}{MD\ 396*}\ (degrees) \qquad (7)$$

$$\Delta s' = 90 \times \frac{MD\ 8000}{MD\ 396*}\ (degrees) \qquad (8)$$

Condition:
The actual value evaluated for the drive axis must be 1.
(MD 256* = 0, MD 564*, bits 4 and 5 = 0)

This condition must always be fulfilled for both the drive axis and the main axis.

Example:

MD 8000 = 4000
MD 3963 = 18000, where * = 3:
Drive axis = 4th axis

$$\Delta s' = 90 \times \frac{4000}{18000} \text{ degrees} = 20 \text{ degrees}$$

Conversion of speed in $\frac{\text{degrees}}{\text{min}}$:

Jog feedrate MD 288* (1000 $\frac{\text{units}}{\text{min}}$)

results with equation 7.

$$V = 180^{x} \; 10^{3} \times \frac{\text{MD 288*}}{\text{MD 396*}} \; (\frac{\text{degrees}}{\text{min}}) \quad (9)$$

Example:

MD 2883 = 2000 (1000 $\frac{\text{units}}{\text{min}}$)
MD 3963 = 18 000

where * = 3, i.e. drive axis = 4th axis

$$V = 180^{x} \; 10^{3} \times \frac{2000}{18000} \; \frac{\text{degrees}}{\text{min}} =$$

$$= 20000 \; \frac{\text{degrees}}{\text{min}}$$

or

$$V = 55.55 \; \frac{1}{\text{min}}$$

Speed:

$$V = 500^{x} \; \frac{\text{MD 288*}}{\text{MD 396*}} \; (\frac{1}{\text{min}}) \quad (10)$$

Axis-specific values

MD No.	Meaning			
256*	Part actual value factor			
Sign	Input limits		Gradua-tion	Units
+	1	16	1	0.5units

The part actual values received from the measuring system (measuring circuit) are multiplied by the part actual value factor before being further processed by the controller, and may be evaluated differently as a result.

Part actual value factor	Value of a 0.5 µm instrument pulse
0 (2)	0.5 µm
1	0.25 µm
3	0.75 µm
4	1.0 µm
5	1.25 µm
6	1.5 µm
7	1.75 µm
8	2.0 µm

The part actual value factor can be overridden by multiplying or dividing by two (via MD 564* bits 3 and 5).

Example:

MD 564* bit 4 = 1 (part actual value/2)
MD 256* = 5 (part actual value factor)

together with an instrument/machine assignment of 0.5 µm/pulse results in a final evaluation of 1.25 µm: 2 = 0.625 µm per instrument pulse.

Note:

The number of encoder pulses (prior to internal quadrupling) per axis revolution must be entered as a machine datum (MD 396*) for the drive axis and the main axis (both are rotary axes).

It is thus not necessary to match the actual value for these two axes as a result of multiplication factors (MD 256*; MD 564*, bit 3) or division factors (MD 564*, bit 4). These evaluation factors are also ignored when calculating the transmission ratio.

The evaluated part actual value must therefore always be 1 for the drive and main axes, i.e.:

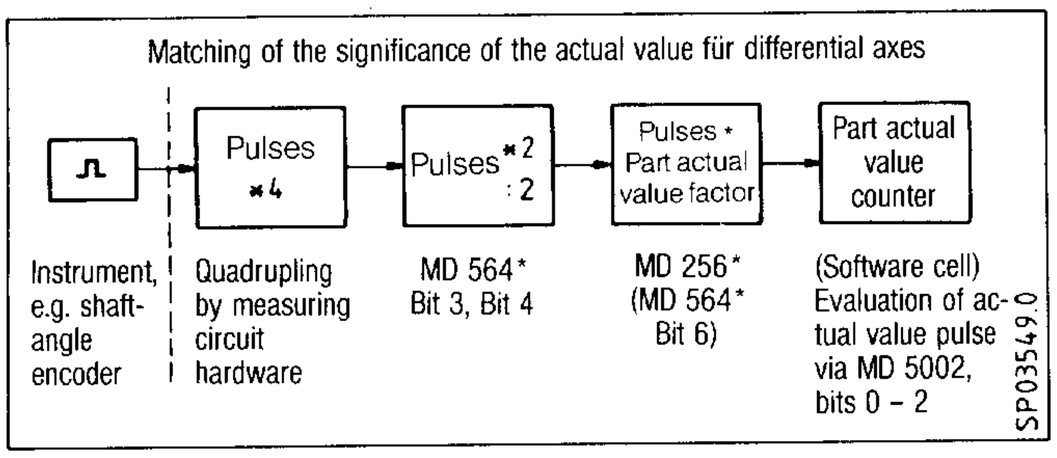
MD 256i = 0
MD 564i, bit 3 = 0
MD 564i, bit 4 = 0

i = Axis index for drive and main axes

In the case of the two differential axes (axial, tangential) on the other hand the significance of the actual value

must coincide with the position controller resolution defined in MD 5002, bits 0...3. It can be matched with the aid of the part actual value factors.

It should be noted that the part actual value factor (MD 256*) does not become active until MD 564*, bit 6 is set.



Axis-specific values

MD No.	Meaning			
260*	Mult. gain			
Sign	Input limits		Gradua-tion	Units
+	0	32.000	1	$\frac{3 \cdot 10^7}{V_{max}(\frac{1000units}{min})}$

The mult. gain factor is used to match the controlled system to the circular gain factor set with MD 252*. The mult. gain is purely a multiplication factor for the circular gain entered, and should be used for digital speed matching, since it permits extremely fine adjustments.

The value must be entered as follows:

$$MULT.GAIN_{Input} = \frac{3 \times 10^7}{V_{max}(\frac{1000units}{min})} \times \frac{U_{max(V)}}{}$$

V_{max} = Maximum axis speed, e.g. as entered under machine datum MD 280*

U_{max} = Speed setpoint voltage for V_{max} (speed compensation)

When the mult. gain has been correctly entered or matched, it should be possible to set a circular gain factor which corresponds exactly to the entered value for the relevant axis.

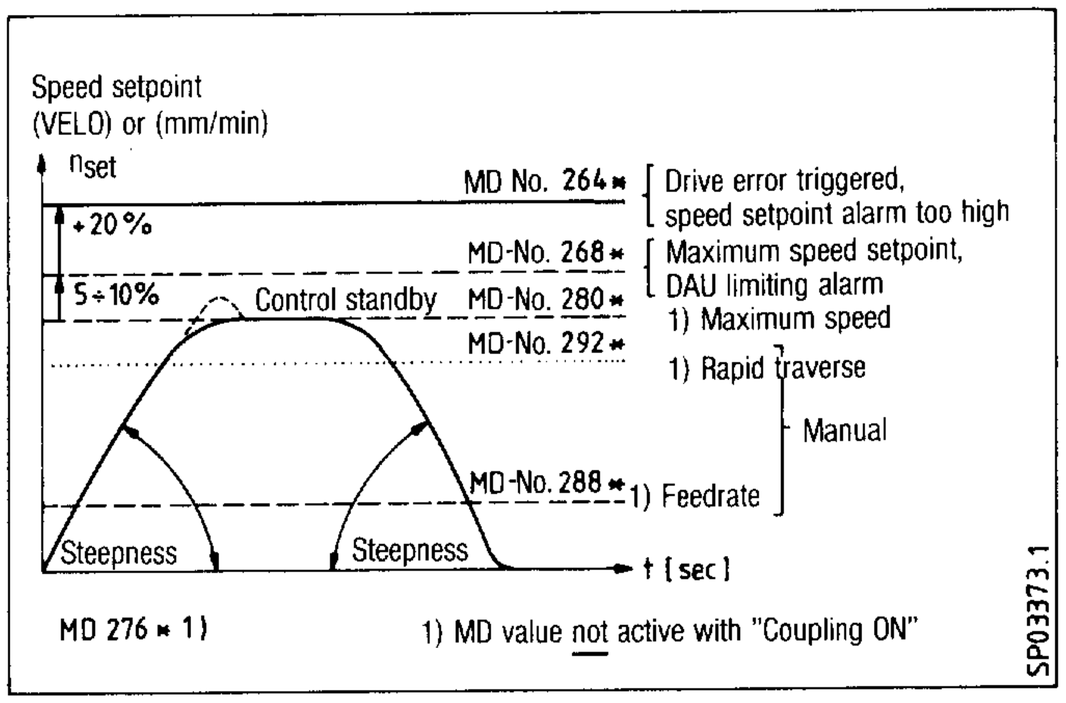
Axis-specific values

MD No.	Meaning			
264*	Threshold for drive errors			
Sign	Input limits		Gradua-tion	Units
+	0	16.000	1	VELO

Alarm 156* (speed setpoint too high) is output if the speed setpoint specified is too high (measuring circuit and drive error). The value entered must be greater than the maximum definition value for the maximum speed setpoint entered under MD 268*.

This monitoring facility is also active when the coupling is switched on.

Standard value: approx. 20 % higher than MD 268*



Axis-specific values

MD No.	Meaning			
268*	Maximum speed setpoint			
Sign	Input limits		Gradua-tion	Units
+	0	16.000	1	VELO

This input is used to define the maximum voltage to be output as the speed setpoint. It is based on any setpoint limitations in the speed controller

(normally 10 V). If the limit value is exceeded, alarm 104* is output (DAU limitation).

Caution:

The maximum speed must however be really reached, i.e. the speed should be compensated such that reading and setting accuracies of speed fluctuations which occur during operation do not cause the maximum speed setpoint to be reached accidentally (e.g. maximum speed = 9 ./. 9.5 V).

This monitoring facility is also active when the coupling is switched on.

Standard value: approx. 5 - 10 % higher than the speed setpoint for the maximum axis speed.

Axis-specific values

MD No.	Meaning			
272*	Drift compensation			
Sign	Input limits		Gradua-tion	Units
±	0	500	1	VELO

The temperature drift of analog electronic components (primarily in the motor drive unit) causes the axes to drift away from the set position until the counter setpoint corresponds to the temperature drift on account of the following error which results.

Analog drift values can be eliminated via the software by setting the following error to "0" when the axes have stopped by means of manual input of the drift value.

The following error for the drive axis can be read out as a service value (MD 8000).

With compensation values greater than 500 VELO the position deviation can no longer be termed drift; instead it constitutes a fault and alarm 160* is output.

Axis-specific values

MD No.	Meaning			
276*	Acceleration			
Sign	Input limits		Gradua-tion	Units
+	0	2000	1	1000 units/s^2

The acceleration entered is active with the following modes of operation:

- Manual
- Incremental feed
- Approach to reference point
- Single indexing

The drive axis is accelerated and braked at the rate entered.

If the coupling is switched on, this acceleration value is not active for the drive axis. It is dependent entirely on the acceleration of the main axes. It should be noted that the drive of the drive axis does not reach the current limit.

Axis-specific values

MD No.	Meaning			
280*	Maximum speed			
Sign	Input limits		Gradua-tion	Units
+	0	24.000	1	1000 units/min

The speed is monitored with MD 280* with the following modes of operation:

- Manual
- Incremental feed
- Approach to reference point
- Single indexing

Alarm 2035 is output if the limits are exceeded.

The entered value represents the speed limit up to which the axis can accelerate (rapid traverse limiting).

If the coupling is on, the speed of the drive axis may exceed this limit value; there will then be no limiting to this MD value.
(See description of MD 264*)

Axis-specific values

MD No.	Meaning			
284*	Reference point shutdown speed			
Sign	Input limits		Gradua-tion	Units
+	0	15.000	1	1000 units/min

The shutdown speed takes effect when approaching the reference point as soon as the reducing cam is reached, i.e. as soon as the *delay signal is active (see MD 244*). Only the first setting (0 %) of the feedrate override switch is taken into account.

Standard value:
Recommended upper limit 1 m/min; the ideal values are between 200 and 500 mm/min depending on the circular gain factor.

Axis-specific values

MD No.	Meaning			
288*	Jog feedrate			
Sign	Input limits		Gradua-tion	Units
+	0	15.000	1	1000 units/min

The value entered is valid for traversing in JOG mode with the feedrate override switch set to 100 %.

Axis-specific values

MD No.	Meaning			
292*	Rapid jog			
Sign	Input limits		Gradua-tion	Units
+	0	24.000	1	1000 units/min

The value entered is valid for traversing in JOG mode with the rapid traverse override key pressed and the rapid traverse override switch set to 100 %.

Axis-specific values

MD No.	Meaning			
296*	Reference point approach speed			
Sign	Input limits		Gradua-tion	Units
+	0	15.000	1	1000 units/min

If the direction key pointing towards the reference point (selectable with MD 564*) is pressed in the "Approach to reference point" mode of operation, the axis will accelerate to the reference point approach speed (exception: if the axis is already at the delay cam, see also MD 244*).

Axis-specific values

MD No.	Meaning			
300*	Incremental feedrate			
Sign	Input limits		Gradua-tion	Units
+	0	15.000	1	1000 units/min

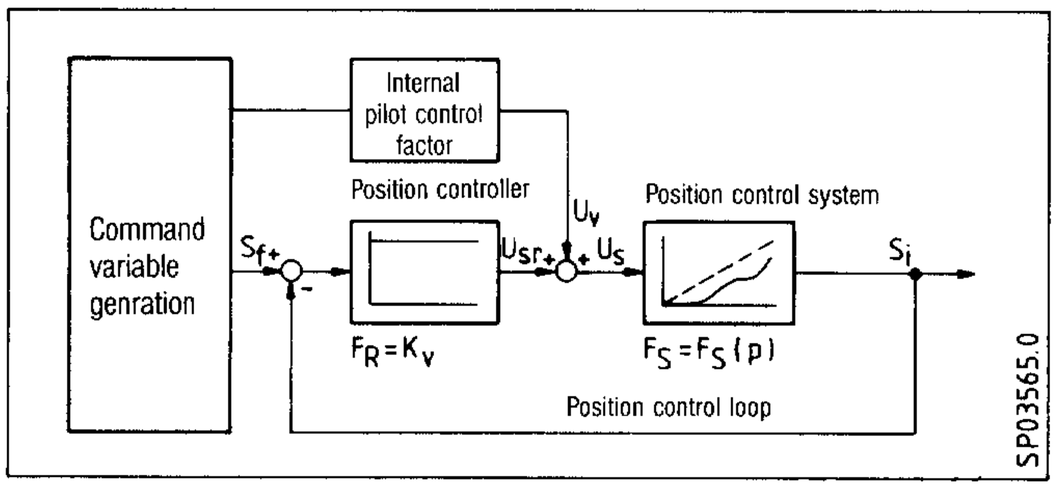
The speed entered is only active if the incremental feed mode of operation (INC) is set.

Axis-specific values

MD No.	Meaning			
312*	Pilot control factor			
Sign	Input limits		Gradua-tion	Units
+	0	16.000	1	

The following error can be substantially reduced with the aid of the pilot controller whilst retaining a constant circular gain (circular gain factor). It is only active when the gearbox coupling is switched on.

The speed setpoint signal U_s for the pilot controller is made up of a closed-loop component (U_{sr}), comprising the following error, and an open-loop component (U_v), comprising the position setpoint.



If the adaptive control system is switched off (see MD 167), the pilot control component can only be influenced by means of machine datum MD 312*.

If the adaptive control system is switched on, the controller-internal factor for pilot control is determined constantly and automatically, which means that with steady-state movements the following error can be more or less eliminated. The pilot control factor for the drive axis (MD 312*) must likewise not be zero.

If the adaptive pilot control system is used, it should be remembered on initial startup that the drive axis must be traversed for an extended period of time (approximately 5 minutes) at a constant speed with the coupling switched on, in order to permit the internal factor to be set. This is also the case when modifying the machine data relating to the measuring circuit (e.g. circular gain factor, mult. gain, etc.).

The pilot control factor converted by the ELG can be read out as a service value in MD 8002. The significance of this value is different from that of the value entered in MD 312*.

The pilot control system is activated as follows:

a) By setting the general option flag for pilot control (MD 5016, bit 0).

and

b) By entering a pilot control factor (not 0) in MD 312* for the drive axis (Value = 0 in MD 312* means the pilot control will be switched off for this axis).

c) It is advisable in addition to activate the adaptive control system (MD 167).

Axis-specific values

MD No.	Meaning			
316*	Vector distance address for plus direction with lead-screw pitch error compensation			
Sign	Input limits		Gradua-tion	Units
+	6000	6249	1	MD num-bers

(Function in preparation)

Axis-specific values

MD No.	Meaning			
320*	Vector distance address for minus direction with lead-screw pitch error compensation			
Sign	Input limits		Gradua-tion	Units
+	6000	6249	1	MD num-bers

(Function in preparation)

Axis-specific values

MD No.	Meaning			
324*	Distance between two lead-screw pitch error compensation points			
Sign	Input limits		Gradua-tion	Units
+	0	32.000	1	units

(Function in preparation)

Axis-specific values

MD No.	Meaning			
328*	Compensation value with lead-screw pitch error compensation			
Sign	Input limits		Gradua-tion	Units
+	0	100	1	units

(Function in preparation)

Axis-specific values

MD No.	Meaning			
332*	Tolerance range for contour monitoring			
Sign	Input limits		Gradua-tion	Units
+	0	16.000	1	units

The contour monitor is active for the following modes of operation:

- Manual
- Incremental feed
- Approach to reference point
- Single indexing

On termination of an acceleration or deceleration process (i.e. on reaching a steady state) the following error will be proportional to the speed.

When traversing at a constant speed, there should therefore be no fluctuations in the following error, since this will result in deviations from the contour.

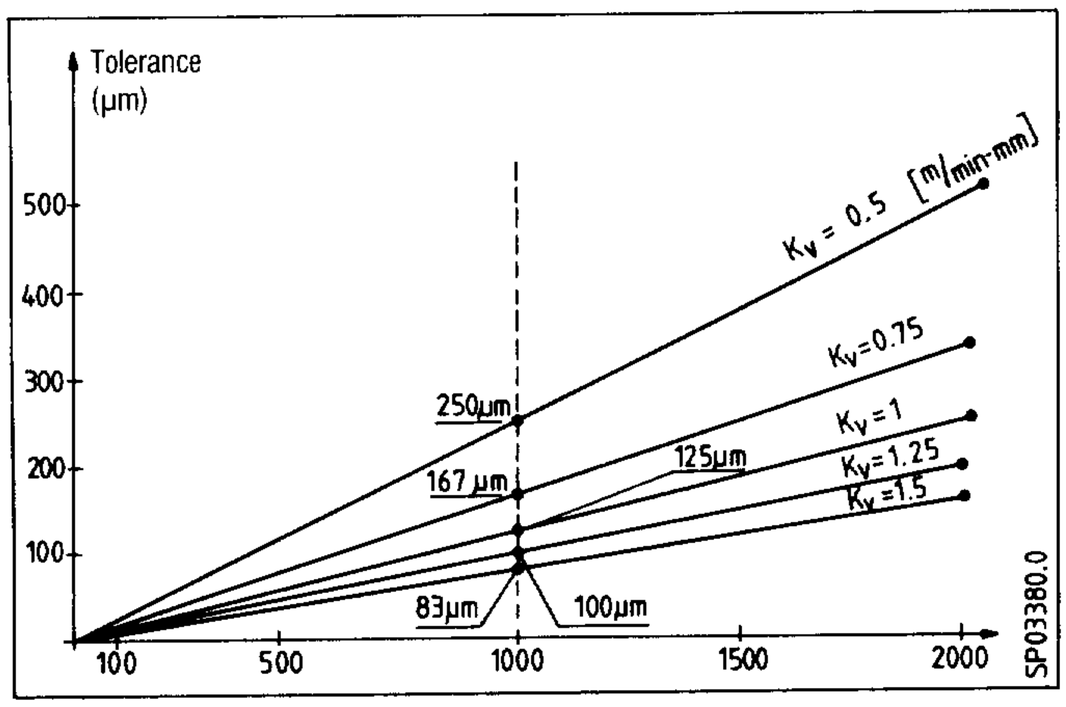
A tolerance range should be entered to prevent the contour monitor being triggered accidentally as a result of slight fluctuations in the speed stemming from control procedures during normal operation.

The diagram below shows the relationship between the input and tolerance values for contour monitoring at various circular gain factors.

If the gearbox coupling is switched on, the contour monitor with MD 332* is <u>not</u> active.

The following error of the drive axis can however be monitored with one limit value whilst the coupling is switched on (see MD 169).

Diagram of tolerance range for contour monitoring



Axis-specific values

MD No.	Meaning			
336*	Threshold speed for contour monitoring			
Sign	Input limits		Gradua-tion	Units
+	0	16.000	1	1000 units/min

(See also MD 332*)

The speed at which the contour monitor must be triggered is entered. The contour monitor will not be activated when the axis is stopped, even if 0 is entered. In this case the down-time monitor will intervene in the event of excessive axis movement.

Axis-specific values:

MD No.	Meaning			
396*	Number of encoder pulses per axis revolution			
Sign	Input limits		Gradua-tion	Units
+	2500	2 000 000	1	

The number of pulses of the shaft-angle encoder (number before quadrupling by the hardware in the measuring circuit) for one revolution of the relevant axis must be entered in MD 396* for the drive axis (MD 5020, bits 0...3) and the main axis (MD 5020, bits 4...7).

This machine datum can be used to calculate the resolution obtainable for the drive or main axis:

$$A = \frac{360}{4 \times \text{MD } 396^*} \text{ (degrees)} = 1 \text{ MS units}$$

where MD 396* = I x Kü

where A ... Resolution (degrees)

I ... Number of lines of the encoder on the drive axis

Kü... Transmission ratio between pulse encoder and drive axis

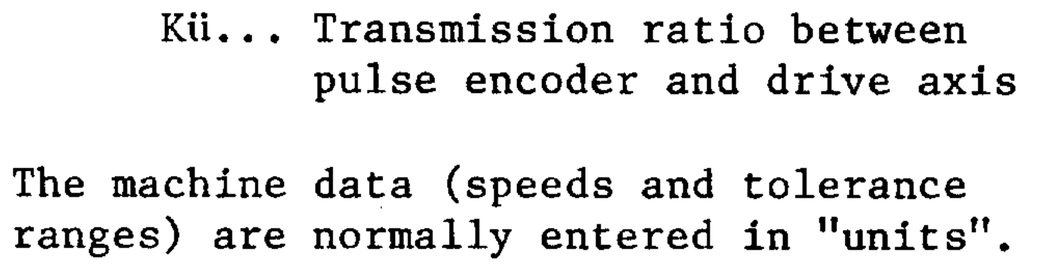
The machine data (speeds and tolerance ranges) are normally entered in "units".

The following is valid for the drive axis:

$$1 \text{ unit} = \frac{180}{\text{MD } 396^*} \text{ (degrees)} = 2 \text{ MS units}$$

This machine datum is insignificant with regard to the two differential axes; their position control resolution is defined in MD 5002.

19.4 General MD Bits



Bits, 4, 5, 6:

The unit of measurement of the input resolution and the position control resolution must be identical. If the coupling is ON, MD 5002, bits 4-7, has no significance.

BIT	6	5	4	UNIT OF MEASUREMENT
	0	0	0	10^{-2} mm
	0	0	1	10^{-3} inches
	0	1	0	10^{-3} mm *)
	0	1	1	10^{-4} inches
	1	0	0	10^{-4} mm
	1	0	1	10^{-5} inches
	1	1	0	Not permissible
	1	1	1	

*) Only this combination is currently available!

Bits 0, 1, 2:

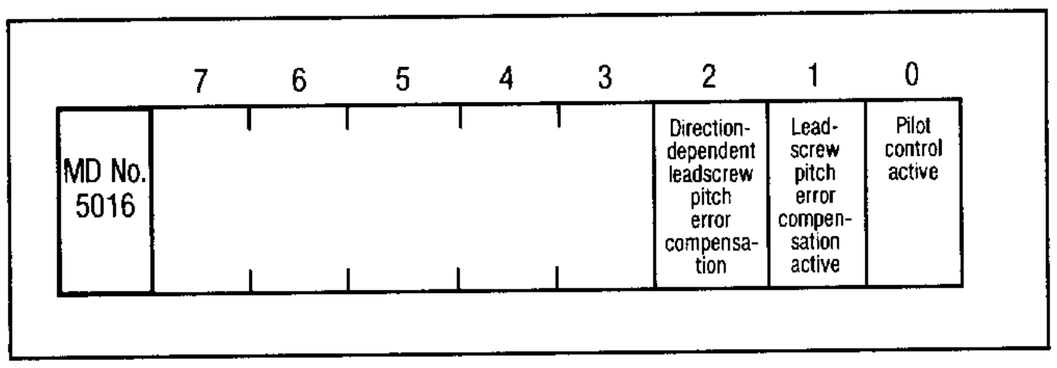
The position control resolution for the drive axis is defined exclusively with MD 396*.

The assignment of an increment of the part actual value of the two differential axes to a corresponding travel of the drive axis can be varied by means of the unit of measurement selected in MD 5002, bits 0...2. MD 5002, bits 0...2 thus defines the evaluation of the actual value of the axial and tangential differential axes. (See also description of MD 256*.)

Bit	2	1	0	Unit of Measurement
	0	0	0	$1/2 \cdot 10^{-2}$ mm
	0	0	1	$1/2 \cdot 10^{-3}$ inches
	0	1	0	$1/2 \cdot 10^{-3}$ mm *)
	0	1	1	$1/2 \cdot 10^{-4}$ inches
	1	0	0	$1/2 \cdot 10^{-4}$ mm
	1	0	1	$1/2 \cdot 10^{-5}$ inches
	1	1	0	$2 \cdot 10^{-4}$ mm
	1	1	1	$2 \cdot 10^{-5}$ inches

*) Only this combination is currently available!

General bits

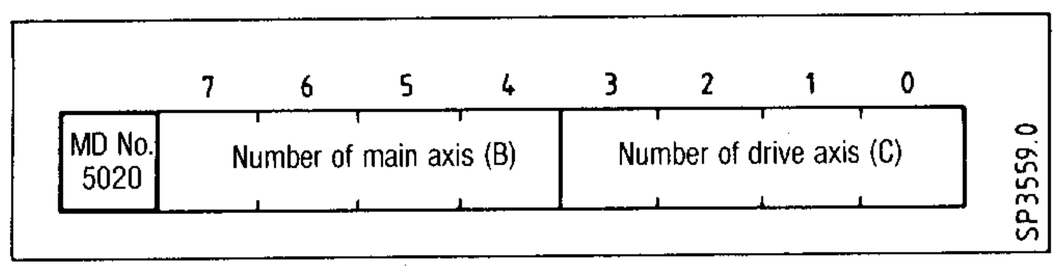


Bit 2: (in preparation)

Bit 1: Leadscrew pitch error compensation
(Function in preparation)

Bit 0: Bit = 1: pilot control system activated
(For description see MD 167 and MD 312*)

General bits



Bits 4-7:

Number of main axis (cutter)

If the coupling is switched on, the drive axis will follow the main axis in accordance with the transmission ratio.

The number of encoder pulses per axis revolution must be entered for this axis in MD 396*. The axis must be connected for follow-up operation (only actual value measured in the ELG).

The axis number must be lower than the drive axis number (MD 5020, bits 0...3).

Bits 0-3

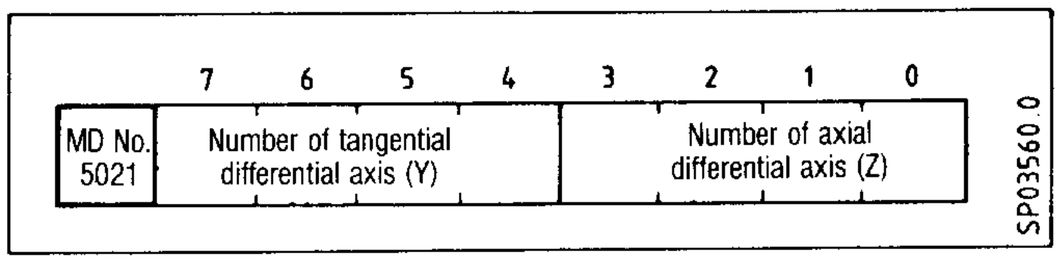
Number of drive axis

If the gearbox function is activated, this axis will follow all movements of the main axis (cutter) in accordance with the transmission ratio, or alternatively each movement of the tangential and axial axes in accordance with the differential components.

It is mandatory on account of the internal program structure for the drive axis to have a number higher than that of all other axes involved in the gearbox function (cutter, differential axis).

The number of encoder pulses per revolution of the drive axis must be entered in MD 396*.

General bits



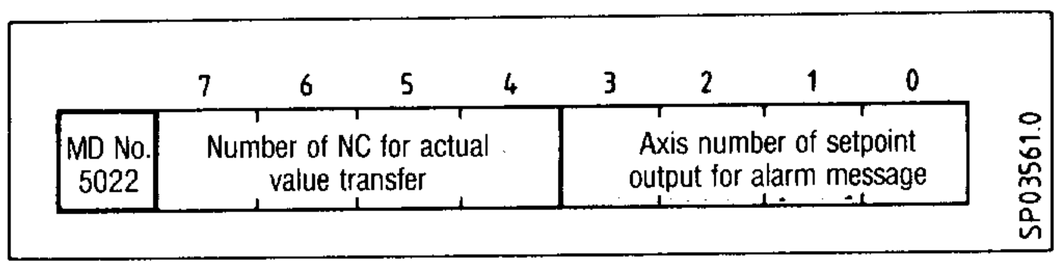
The drive axis follows all movements of the tangential (Y) axis or the axial (X) axis in accordance with the differential components Udy and Udx.

Both axes must be connected for follow-up operation (only actual value measured in the ELG).

The significance of the actual value is defined by means of machine datum MD 5002, bits 0...2. Matching to the position control resolution can be effected by means of MD 564*, bit 3 or 4, and with the part actual value factor (MD 256*).

The axis number must be lower than the number of the drive axis (MD 5020, bits 0...3).

General bits



Bits 4 - 7:

MD 5022, bits 4-7, is used to define the number of the NC area in the switching RAM to which the normalized actual value for the revolutional feedrate is transferred.

MD 5022				NC	Switching ram	
7	6	5	4		DB	DW
0	0	0	0	-	-	-
0	0	0	1	1	20	50
0	0	1	0	2	22	50

Bits 0 - 3:

Number of the axis whose relay contact (previously the controller enable signal in the setpoint cable) is opened if the coupling is ON and the following error monitor is activated, and the following error exceeds the limit value (see MD 169).

General bits

	7	6	5	4	3	2	1	0
MD No. 5023						Option: actual value transfer active	Following error compensation active	Tool-related revolutional feedrate

Bit 2:

The "Actual value transfer active" option permits the actual value of the drive axis (MD 5020, bits 0-3) or of the main axis (MD 5020, bits 4-7) to be normalized to 1024 pulses per axis revolution, and transferred cyclically to the switching RAM area of the NC (MD 5022, bits 4-7).

This normalized actual value is required to implement a workpiece or tool-related revolutional feedrate in the NC. It permits the second shaft-angle encoder previously necessary (1024 pulses) to be dispensed with.
The machine data bit N 427, bit 0 = 1, must be set in the NC for this purpose.
This function is only possible with the 4B basic version of the SINUMERIK System 3.

Bit 1:

Following error compensation activated (for description see MD 168)

Bit 0:

= 0: Actual value of the drive axis (MD 5020, bits 0-3)
Normalized to 1024 pulses per axis revolution.
= 1: Actual value of the main axis (MD 5020, bits 4-7)
Normalized to 1024 pulses per axis revolution.

19.5 Axis-specific MD Bits

	7	6	5	4	3	2	1	0
MD No. 560*	Modulo 360° actual value display				Radius axis	Whole degrees		Deactivation of measuring circuit monitor

Bit 7:

Only for rotary axes!
The actual value display changes from 359.999 to 0.

Bits 3, 2:

Only active for rotary axes!
Rounding (positioning) to whole or half degrees in the manual mode of operation in accordance with bit 2.

Bit = 1:

The alarms 132* are no longer activated.

Bit 0:

The hardware monitor can be deactivated separately for each axis.

Axis-specific bits

	7	6	5	4	3	2	1	0
MD No. 564*	Axis exists	Part actual value factor active	Rotary axis	Part actual value: 2	Part actual value x 2	Actual value sign change	Setpoint sign change	Reference point in minus direction

Bit 7:

If the bit is set, the position controller and the measuring circuit monitor will be activated (providing MD 560* = 0).

If this bit is set, a valid value must be set for the corresponding axis in MD 200* (axis assignment).

Note:

An axis can be declared not available if no axis with a higher number exists.

Example:

Axis number

① - Available	① - Available
② - Not available	② - Not available
③ - Available	③ - Not available
NOT POSSIBLE	POSSIBLE

Caution:
The bit does not activate the axis until after the POWER ON routine, although the axis address is displayed on the monitor immediately.

Bit 6:

Bit = 1 causes the part actual value factor (MD 256*) to be incorporated.

Bit 5:

Bit = 1 declares the relevant axis to be a rotary axis.

Bits 4, 3:

The part actual value can be influenced by the factor 2 for matching the position controller resolution to the instrument resolution. (This influencing is in addition to that in MD 256*).

Note:

The position controller resolution should only be matched to the instrument resolution with MD 396* (number of encoder pulses per axis revolution) for the drive axis (C) and the main axis (B).

Bit 2:

The sign of the instrument pulses can be reversed by converting the bit. (This is necessary if the axis runs away uncontrolledly due to an incorrect position direction of control.)

Bit 1:

Conversion of the bit causes a change in the polarity of the speed controller setpoint voltage. (This is necessary if the axis moves in the wrong mechanical direction.)

Bit 0:

Bit = 0 Approach to reference point started with + direction key.
Bit = 1 Start with -.

20. Overview of Assemblies and Standard Jumpering for ELG

20.1 ELG-CPU Assembly 6FX1125-8AC

- ELG-CPU with microprocessor 80186
- Connector X111 for universal interface (V.24/TTY)
- Connector X121 not used (2nd V.24 not equipped)
- 1 LED for CPU monitoring
- 2 plug-in locations for 2 EPROMs (Type 27256) with ELG system software
  Locations: I 57, I 58

Caution:

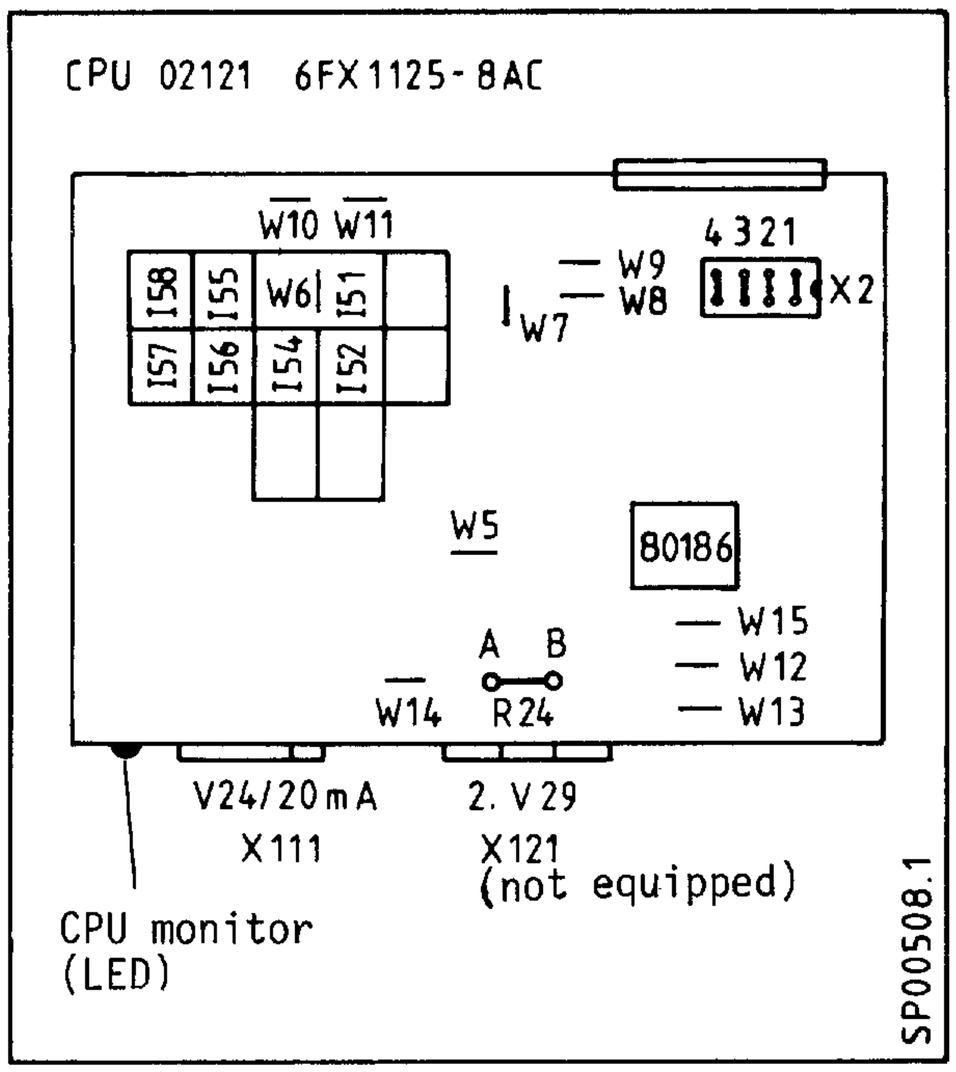
W 6 to
W 7 to
→ NOT PERMISSIBLE!

W 8 to
W 9 to
→ NOT PERMISSIBLE!

W10 to
W11 to
→ NOT PERMISSIBLE!

Fixed jumpers:

Bridge designation	Closed/open	Meaning
W 5	Closed	Open = 64K EPROM (I57, I58) Closed = 256 K EPROM (I57, I58)
W 6	Open	Closed = AB14 for EPROM (I50 - I56)
W 7	Closed	Closed = *DSAD for RAM (I50 - I56)
W 8	Closed	Closed = Supply Vcc for RAM (I51 - I56)
W 9	Open	Closed = Supply +5V for EPROM (I51 - I56)
W10	Open	Closed = AB15 for 256 K EPROM (I51 - I56)
W11	Closed	Closed = *WR for RAM or 64 K EPROM (I51 - I56)
W12	Open	Closed = INT 3 from BUS
W13	Closed	Closed = INT 3 to -5V
W14	Open	
W15	Closed	For test department (segregated on flow side)
B-A		Not used



Variable jumpers:
Switching RAM area of the ELG

The jumpering switch X2 on the ELG-CPU defines the NC area incorporated by the ELG in the switching RAM (03831).

ELG in switching space as	Switch X2	Remarks
NC1	X2 ON 1 2 3 4	ELG as NC1 for stand-alone version only X 2.4 set to ON X 2.3 set to ON
NC2	X2 ON 1 2 3 4	X 2.4 set to OFF X 2.3 set to ON
NC3	X2 ON 1 2 3 4	X 2.4 set to ON X 2.3 set to OFF
NC4	X2 ON 1 2 3 4	X 2.4 set to OFF X 2.3 set to OFF

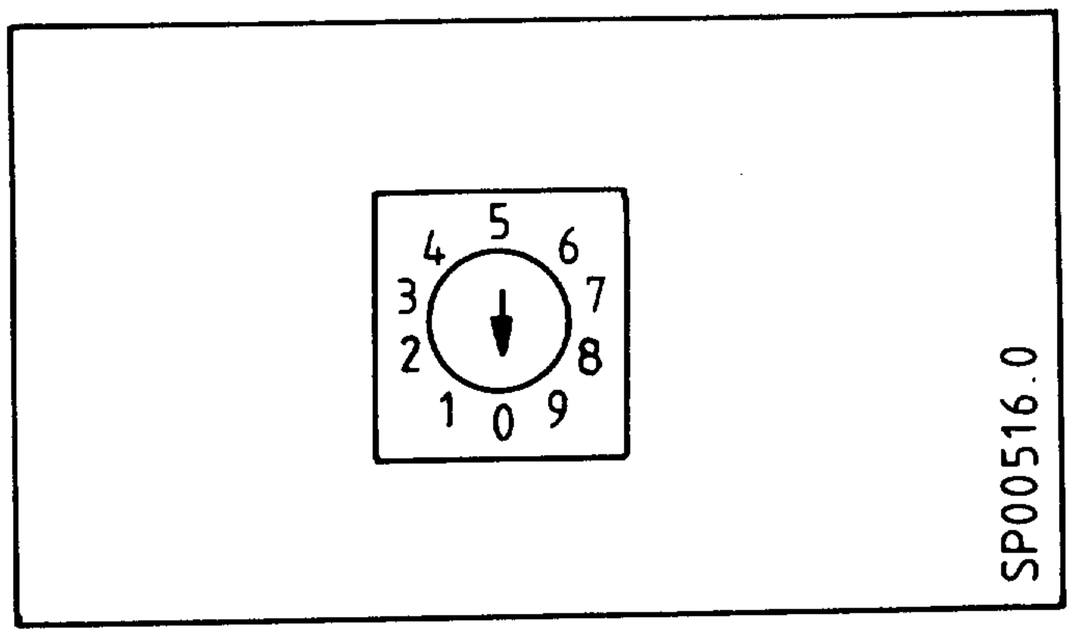
* Switches X 2.1 and X 2.2 are at present not used and should be set to OFF

20.2 ELG Measuring Circuit 6FX1126-8BB

- 3 actual value inputs
- 3 setpoint outputs
- 14 BIT DAU, 1 Velo $\frac{10\ V}{8192}$
- ULA module

Variable jumpers:
Measuring circuit functional modules:

The functional module jumpering switch S3 is used to define the number of the measuring circuit functional module:



S3 switch position	Jumpering for
0	1. Meas.circ. func. mod.
1	2. Meas.circ. func. mod.
2...9	Jumpering not possible

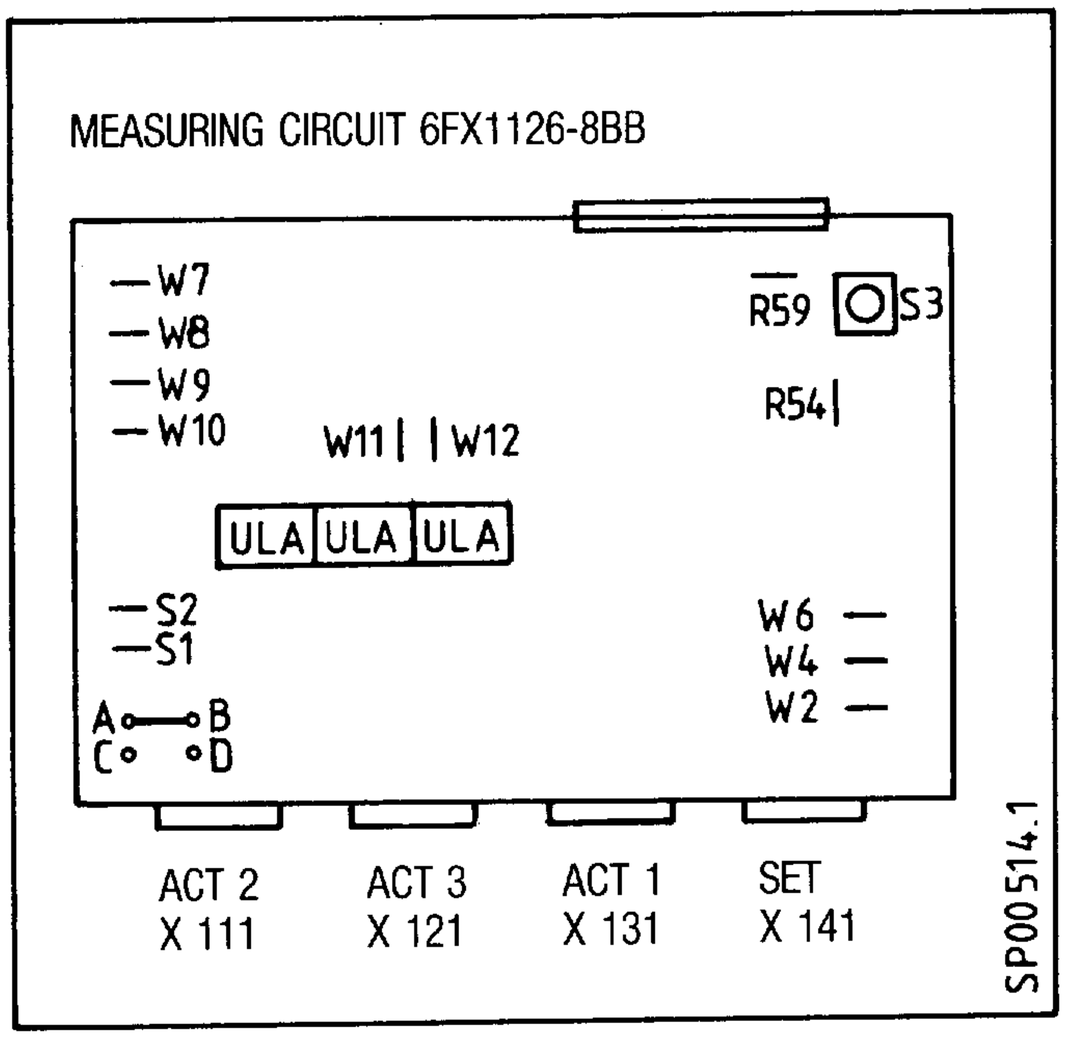
Note:
The signal assignment of the front connector (actual value and setpoint) of the ELG measuring circuit functional module is different from that of the measuring circuit functional module of the NC SINUMERIK System 3. Different actual value and setpoint cables are therefore required for the ELG.

The following signals are not present on the ELG measuring circuit functional module:

- NC-RDY relay output
- Servo-enable input

Fixed jumpers:

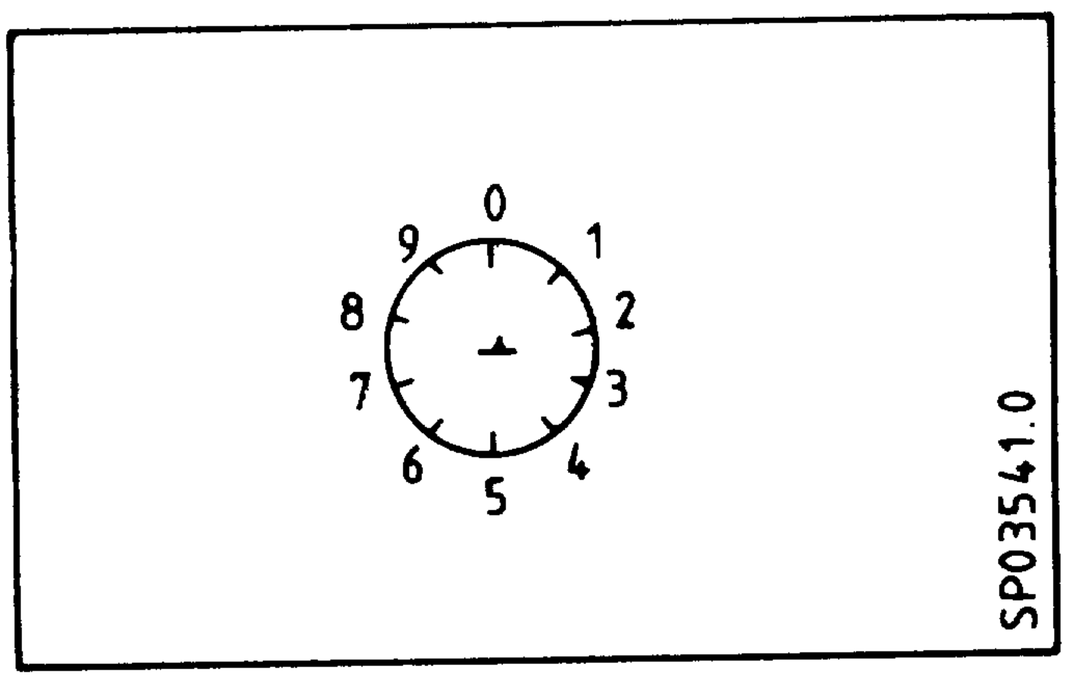
Bridge designation	Closed/ open	Meaning
W 2 W 4 W 6	Closed Closed Closed	Closed = Drive adjuster with differential input for speed setpoint (M_{SET})
W 7 W 8 W 9 W10	Closed Open Open Open	Segregated on flow side Wait 1 Wait 2 Wait 3 Wait 4
W11 W12	Closed Open	Closed = *DEN (low = active) Closed = DEN (high = active)
A-B C-D F-H E-G	Closed	Closed = Sensor input not active Not used if A-B = closed
S 1 S 2	Open Open	Identification code
R59 R54	Closed Closed	System clock forwarded



20.3 (1st) NC Switch Group (03831) 6FX1122-1AA...

- Functional module connected to PC section of PC1
- Coupling to PC1 via bus pc board
- Coupling to ELG via bus pc board
- Coupling to NC via PC switch group (03841) with cable via front connector (X832(83831)-X842(03841))
- Dual PC:
  Coupling to PC2 via PC switch group (03845) with cable via front connector (X833(03831)-X847(03845))
- Switching RAM for NC-ELG-PC data exchange
- On/off switch S1

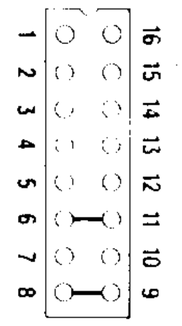
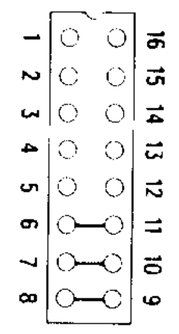
S1:



Normal setting 0

Cancel operations with the ELG are only possible with this switch set to 1 (irrespective of the NC area occupied by the ELG in the switching RAM).

Fixed jumpers:

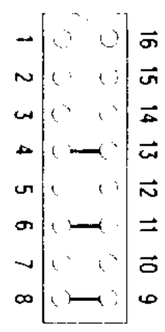
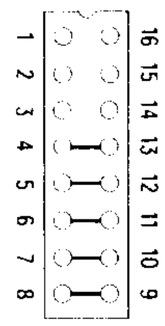
Type	Designation	Signal	Closed/open	Remarks
Jumper base P2 	1-16	ADR12	Open	NC address
	2-15	ADR13	Open	NC address
	3-14	ADR14	Open	NC address
	4-13	ADR15	Open	NC address
	5-12	ADR16	Open	NC address
	6-11	ADR17	Closed	NC address
	7-10	ADR18	Open	NC address
	8-9	ADR19	Closed	NC address
Jumper base P3 	1-16	-	Open	Test points
	2-15	-	Open	Test points
	3-14	-	Open	Test points
	4-13	ADR11	Open	PC address
	5-12	ADR12	Open	PC address
	6-11	ADR13	Closed	PC address
	7-10	ADR14	Closed	PC address
	8-9	ADR15	Closed	PC address
Single bridge	C-D	KCLK2M	Open	CLK 2MHz (PC)
Single bridge	E-F	0 V	Open	Board Select
Single bridge	G-H	KCLK5M	Open	CLK MHz (NC)
Single bridge	L-K	0 V	Open	2k/1k

- With the external dual PC these jumpers are valid for the NC switch group connected to the frame of PC1.

(2nd) NC switch group (03831)
6FX1122-1AA

- Functional module connected to PC section of PC2
- This 2nd NC switch group 03832 is only required for the external dual PC if the NC and the PC2 are connected in the same logic frame (NC with integrated PC).
- Caution:
  The jumpers are not the same as for the 1st NC switch group.
- Coupling to NC or PC2 via bus pc board
- On/off switch S1:
  Always set to 0

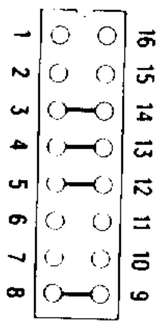
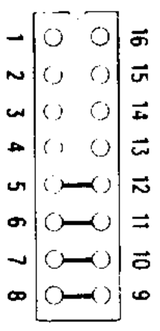
Fixed jumpers:

Type	Designation	Signal	Closed/open	Remarks
Jumper base P2 	1-16	ADR12	Open	NC address
	2-15	ADR13	Open	NC address
	3-14	ADR14	Open	NC address
	4-13	ADR15	Closed	NC address
	5-12	ADR16	Open	NC address
	6-11	ADR17	Closed	NC address
	7-10	ADR18	Open	NC address
	8-9	ADR19	Closed	NC address
Jumper base P3 	1-16	-	Open	Test points
	2-15	-	Open	Test points
	3-14	-	Open	Test points
	4-13	ADR11	Closed	PC address
	5-12	ADR12	Closed	PC address
	6-11	ADR13	Closed	PC address
	7-10	ADR14	Closed	PC address
	8-9	ADR15	Closed	PC address
Single bridge	C-D	KCLK2M	Open	CLK 2MHz (PC)
Single bridge	E-F	0 V	Open	Board Select
Single bridge	G-H	KCLK5M	Open	CLK MHz (NC)
Single bridge	L-K	0 V	Open	2k/1k

20.4 PC Switch Group (03845) 6FX1120-33A

- Functional module only required when using the external dual PC
- Functional module connected to PC section of PC2 (in accordance with system configuration)
- Used for data transfer between PC1 and PC2 (external dual PC)
- Coupling to PC1 via NC switch group 03831 with cable (6FC9340-7H..) via front connector (X847(03845)-X833 (03831))
- Coupling to PC2 via bus pc board

Fixed jumpers:

Type	Designation	Signal	Closed/open	Remarks
Jumper base X1 	1-16 2-15 3-14 4-13 5-12 6-11 7-10 8-9		Open Open Open Open Closed Closed Closed Closed	
Jumper base X2 	1-16 2-15 3-14 4-13 5-12 6-11 7-10 8-9		Open Open Closed Closed Closed Open Open Closed	
Single bridge Single bridge Single bridge	C-D E-F G-H		Open Open Open	

Notes on external dual PC with ELG:

1. Set the "ext. dual PC" PC machine datum to a 1-signal

   DB9 DR1, bit 6 = "1"

2. Set the "dual PC" NC machine datum to a 1-signal

   MD 452, bit 2 = "1"

Issued by Siemens AG
Logic and Process Control Systems Department
Postfach 4848, D-8500 Nürnberg 1

Siemens Aktiengesellschaft

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Order No. E80210-T114-X-A-7600
Printed in the Fed. Rep. of Germany
082 639 PA 2861.

progress in automation: Siemens