SERIES P8721-000-P

Single Axis Position Controller

- PID-analog output (+/- 10 V) and 2 or 3 switched speed positioning
- 200 address line program memory
- manual operation
- single set operation
- auxiliary functions

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1. Short Description

Whilst the P8721-000-P with option Analog-output is specifically designed to provide closed loop (proportional, integral, differential) analog control of 4 quadrant drives, it also serves the purpose of operating as a 2 or 3 speed controller, as the P8721-000-R.

When used as a closed loop controller, it is essential that:
A 4 quadrant drive – usually a high dynamic servo drive, is used.
The drive is capable of accepting a +/- reference signal for direction, without a dead-band.
The encoder is torsional rigidly coupled to motor.
The mechanics of the machine are backlash-free.

Whilst it is possible to use lower specification drives and mechanics, it may then not always be possible to achieve the performance and accuracy which is commonly expected of a closed loop system.

When using a simple inverter driven AC motor, it is essential to use the drive in F/V or FCC mode, rather than the full Flux Vector (which tends to fight the position controller at low speeds).

Physically, the P8721-000-P connections are compatible with the "old" 87P/P8721PID 2 or 3 switched speed controller. It may also be more attractive when coupled to a PLC, when relays are not required. It is necessary to use this model, when Auxiliary Functions are required.

As a 2 or 3 speed positioning system, it has the following features: -

- Absolute and incremental positioning modes
- Operation in 200 lines program mode
- Single set operation
- Manual operation, slow and fast mode
- Batch counter with completed output
- Auxiliary outputs
- Pulse multiplicator
- Datum/reference setting routines
- Tool offset compensation in incremental mode
- Incremental error compensation
- Backlash/Spindle compensation
- Tolerance window blanking
- Encoder monitoring
- max. input frequency 20 kHz

The unit is suitable for operation with any type of 2 or 3 speed bi-directional drive or any variable speed drive with 1, 2 or 4 quadrant of control.

The performance and accuracy obtained is dependent on the type of drive chosen.

The outputs for stepped speed drives are transistors. These outputs can be configured in a number of ways to suit all types of control circuits. Actual position is monitored by an incremental Encoder. The power supply unit is external. If relays are required, an external relay card can be provided. The controller can be used to position machinery to any desired absolute position. Alternatively, the controller can be used to feed material through a process.
As an analog closed loop controller, it has the additional features of :-

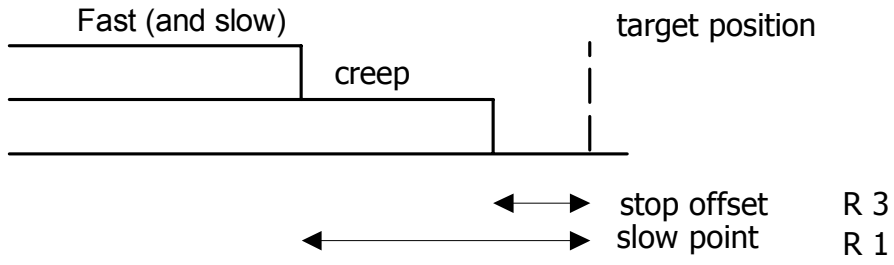
- PID- analog output +/- 10 V
- Top speed setting
- Acceleration/Deceleration rate settings
- PID term optimisation
- Go to Datum routines

2. Functions

The P8721-000-P can be configured for switched speed or regulated PID-analog output.

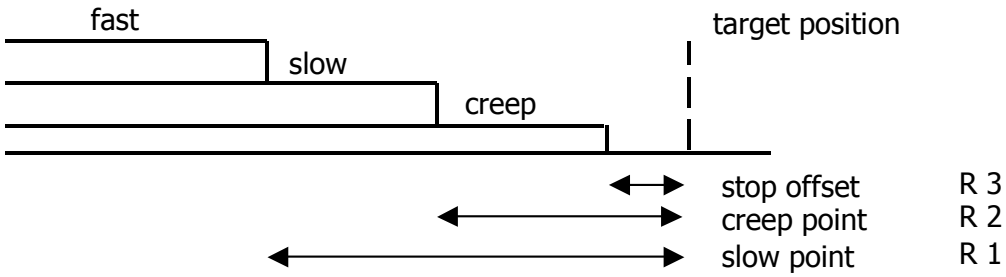
2.1 Two speed operation (switched)

NB: R1 = R2 > R3 The value in Register 1 must be the same value as R2



2.2 Three speed operation (switched)

NB: R1 > R2 > R3 The value in Register 1 must be larger than R2



Notice: The stop offset is only effective when **R8 = 1xxxxx**.

2.3 Option PID-analog +/- 10 V output (regulated)

(see pages 32/33 for full description)

The setting is effected using Registers R50 to R66

2.4 Setting Datum/Reference

Datum can be set in a variety of ways. The method is selected in Register R8/3

R8 = xx0xxx Datum to R7
Closing input St 3 / 4 transfers the value set in R7 into Actual Value Display

R8 = xx1xxx Setting to Preset
Closing input St 3 / 4 transfers the Demand display value into Actual Value Display

R8 = xx2xxx Automatic reference + (positive direction)

R8 = xx3xxx Automatic reference – (negative direction)

R8 = xx4xxx Datum with keypad alone
The value of R7 is transferred to Actual Display by accessing R7, typing in value and then pressing E.

2.4.1 Operation of Go to Datum

After switch on of unit, initiating "Start" or "Datum" will cause the axis to move in the direction set in R8/3. The output "going to datum" St5/7 is on.

When the Axis activates the respective end limit switch, it will stop for a time as set in R10. It will then move slowly in the opposite direction. When it comes off the limit switch, the Encoder marker input St1/8 is enabled. When the next marker pulse is detected, the Axis stops and value of R7 is loaded into actual value display. The going to datum output is now turned off.

The speeds for going to Datum are set as follows:;

1. Analog control
   First phase (from start to hitting end limit)
   Speed set in R67 (rpm)
   Second phase (from reversal to marker pulse)
   Speed set in R68 (rpm)
2. Switched speed control
   First phase (from start to hitting end limit)
   Speed set in R69
   For Creep speed **R69 = xxxxx0**
   For Slow speed **R69 = xxxxx1**
   For Fast speed **R69 = xxxxx2**
   Second phase (from reversal to marker pulse)
   Speed is always equal to Creep speed

2.6 Encoder monitoring

If after positioning is activated, no Encoder pulses are received after a time set in R19 (0.1 to 9.9 sec), positioning will be aborted and fault 01 will be displayed. Setting R19 to 0.0 sec, disables this feature.

2.7 Batch counter

Register **R18/6** sets the method of counting whether adding or subtracting

R18 = xxxxx0 No Quantity counter
R18 = xxxxx1 Automatic subtracting
R18 = xxxxx2 Automatic adding
R18 = xxxxx3 Manual subtracting
R18 = xxxxx4 Manual adding
R18 = xxxxx5 Automatic add/subtract
R18 = xxxxx6 Manual add/subtract
R18 = xxxxx7 Automatic subtracting, STOP when "zero"
R18 = xxxxx8 Manual subtracting, STOP when "zero"

With adding function, the counter starts from zero. When the set quantity is reached, the quantity complete output will be pulsed. With subtracting function, counting from pre-set to zero takes place. When zero is reached, the quantity complete output will be pulsed.
With add/subtract function, subtracting will take place if a pre-set value is entered. On reaching zero, adding will ensue. The quantity complete output will still be pulsed at zero count.

2.8 Program counter

The program counter will be active when **R46** > 0.
R 47 will be incremented after a complete program-operation. If **R47** >= **R46**, a message „Count" is shown in the actual-value-window (after program-operation) and the counting value (**R47**) is shown in the Target-value-window.
Simultaneously with this message the output **ST5Pin8** will be activated. If **R48** = 0 the output works "static". If **R48** > 0 the output will be reset after selected pulse-time in **R48.** The message (display and output **ST5Pin8**) will be cleared after pressing any key (also when time in **R48** not ran off). In **R47,** the counter value can be deleted respective set to a new value**.**
Parameter:

R46 PCC-Limit	- releases when reached	(Access always possible)
R47 PCC-Counter	- value	(Access always possible)
R48 PCC-Timer	- for output-signal	(Access protected by **R98**)

2.8.1 Auxiliary Functions

When operating in program mode, an auxiliary function can be selected on each address line. The setting is 0 – 9. The outputs appear on St5/18 to 21, binary coded. The output is set when the appropriate address line is selected and start given. It will remain active on until the new line is selected and start activated. When "Program End" is reached, all Auxiliary outputs are reset.

2.9 Fault monitoring

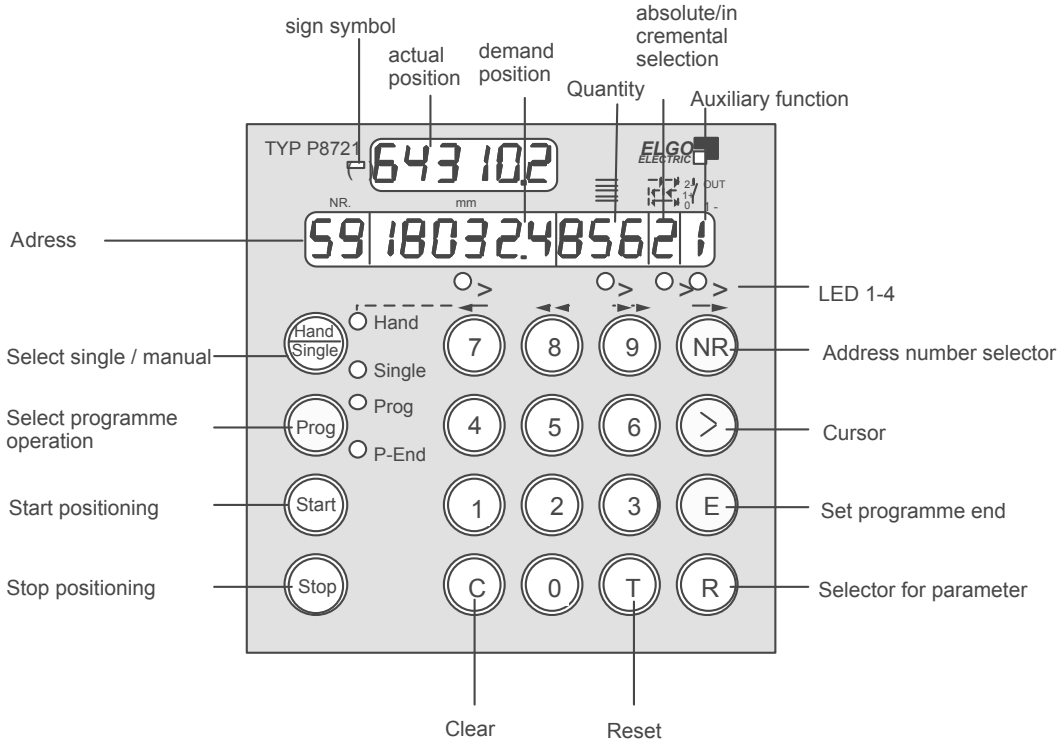
When a fault occurs, it's number flashes in Actual Value Display

Fault number
01 = Encoder
02 = End Limit minimum
03 = End Limit maximum
04 = Actual position < min software limit (R13) Hand
Target position < min software limit (R13) Single
05 = Actual position > max software limit (R14) Hand
Target position > max software limit (R14) Single
***07** = External stop activated or wire break
08 = Number of Program lines greater than 99

The fault message is cleared by pressing any button.
"07" also flashes if Stop on front panel is activated in middle of any move.

***Notice for 07:** The external stop input must be linked before system can operate. Therefore, if external n/c pushbutton is not fitted, then insert a permanent wire link.

3. Front Panel

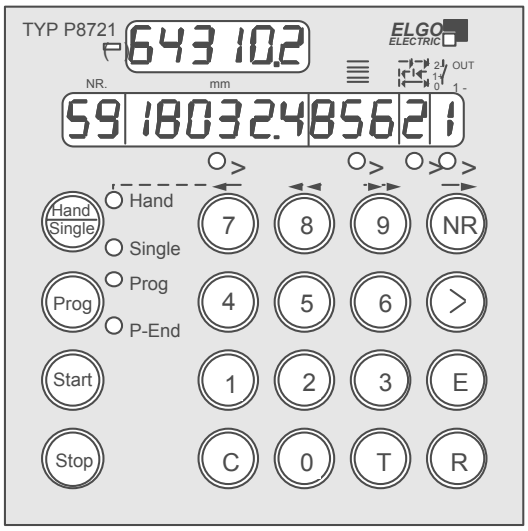


3.1 Functions of Display

Address Window	: Shows address line of Program (or Register Nr)
Actual Position	: Shows the Actual Position of the axis
Demand Position	: Here you can enter the required position (or Register value)
Quantity Window	: Shows how many pieces are left to be cut (or have been cut) or how many incremental moves yet to be completed.
Abs/Incr Window	: Defines Target window 0 = Absolute dimension 1 = Incremental + positive direction 2 = Incremental - negative direction 3 = Incremental from zero 4 = Incremental from zero – tool offset

3.2 Functions of LED's

LED "Hand"	: Illuminates after selecting "Single" mode by "Hand/Single" button
LED "Single"	: Illuminates after selecting "Hand" mode by "Hand/Single" button
LED "Prog"	: Illuminates when "Program" mode is selected.
LED "P-End"	: Illuminates when program operation is complete (program end)
LED 1 - 4	: Indicate which input window is selected. Windows can be changed by button **>**



3.3 Function of the Keypad

Hand/Single

1. Alternate pressing will select "Single".
A Demand position can be entered. Using Cursor > Button enables quantity to also be set.
2. Alternate pressing will select "Hand".
The Buttons 7/8/9/NR can be used for manual positioning at fast and creep speeds in both directions.

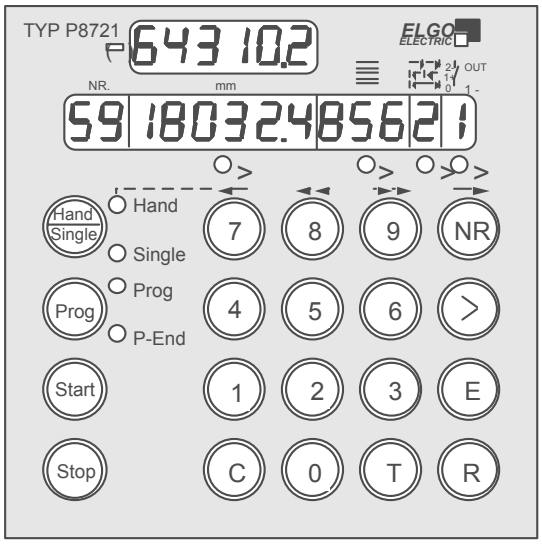
Prog Selects Program mode.
Execute the desired program by pressing "Start".
(or Press R, to access Registers)

Start Starts positioning action
The Start Button is inhibited when programming or setting of Registers is selected – also in Hand mode.

Stop Motion is stopped.

NR This Button is only active in Program mode. It has the following functions.

1. Start the programming action. Thereafter, only the Cursor Button > needs pressing
2. Checks existing program. Pressing "NR" repeatedly scrolls through the program.
3. Selects the required address in Table mode (see section 4.3).



> The Cursor Button selects the Target windows sequentially.
On completion of a line, the next press of ">" will select the next Address line.
LEDs 1 – 4 indicate the selected Window.

E This Button will :

- Set the end of program and reset the controller into operation mode.
  This Button should be pressed only when the last window is selected (LED3)
- Stop the entered Register values.
- End Register setting at any point.

R Selector for entry of Register values. Only active when "Prog" selected.

T Reset Button : Resets all Target windows to zero in Program mode.

C Clears selected Target window value.

0 – 9 Numerical keys for data entry.

4. Controller in Operation

Switch on conditions: On switch on, the controller assumes the same conditions as at time of switch off. The Actual position is memorised.

In "Hand" and "Prog", the Target windows are set to zero.
In "Single" the Demand value is made to equal Actual value.

When automatic datum routine feature is selected,R8/3 = 2 or 3 the controller will not operate, until the datum routine has been carried out.

4.1 Single set operation

In addition to Program operation, a Single dimension can be set.
In Single operation, only an Absolute dimension and quantity can be entered. The Windows "Abs/Incr" and "Aux" are inactive.

Press Hand/Single	Till LED "Single" is illuminated alone.
Use Keys 0 – 9	To enter desired position.
Press >	LED under Quantity Window illuminates.
Use Keys 0 – 9	To enter desired quantity.
Press >	LED under Target window illuminates.
Press Start	The Axis moves to required position.

Enter new Position and Quantity and start as required.

4.2 Program Operation (R8/4 = 0)

4.2.1 Selection of a Program Block

The P8721 has a Program memory of 200 Address lines. These can be divided into several Blocks of **equal** quantity of lines (see Register R41). Each Block can store a different Program, which can be selected for operation, at will. If for example, 8 Blocks of 25 Lines is set, selecting a Block higher than 8, will result in Block 8 being selected.

To select the required Block for operation.

Press Prog	Selects Program mode
Press R	The Nr (Address) Window flashes.
Key in 40	40 appears in Nr Window (flashing).
Press >	The previously selected Program Block is displayed in Target window.
Press C	Clears value to zero.
Key in (say) 3	3 appears in Target window.
Press E	Program Block 3 is called up and sequence is ended. controller returns to Operation mode.

Now the Block can be used with the existing program, or a new program can be entered.

4.2.2 Enter a program

The required Program Block is selected in accordance with section 4.2.1.

Press Prog	Selects Program mode
Press Nr	"01" appears in Nr Window.
	→ LED illuminates under **Target window**.
Press C	Clears existing value.
Use Keys 0 – 9	To enter new dimension.
Press >	LED illuminates under **Quantity Window**.
Press C	Clears existing value.
Use Keys 0 – 9	To enter required quantity.
Press >	LED illuminates under **Abs/Incr** Window
Press C	Clears existing value.
Press : 0	Absolute Position
	Incremental move in positive direction
	→ Incremental move in negative direction
Press >	LED illuminates under **Auxiliary window**
Press C	Clears existing value
Use Keys 0 – 9	to enter required function (i.e. 10 max)

One line of program is now complete. The Operator can now end programming or continue to next Address line.
To end programming - **Press E**
To move to next line - **Press >**

4.3 Table operation mode (R8/4 =1)

If R8/4 is set to 1, then the Controller operates in 99 selectable address Table mode. Programming is exactly the same as in 4.2.2.

4.3.1 Operation in Table mode

An address line of the stored program can be called up and positioning effected to that setting.

Press Prog	Selects Program mode
Press T	Resets Controller.
Press Nr	The Nr Window flashes "0".
Key in (say) 58	"58" flashes in Nr Window.
Press >	The programmed values of address 58 are displayed.
Press Start	The Axis executes the demanded settings.

4.4 Manual operation

Press T Resets target windows to zero
Use the Button **"Hand/Single"** to select "Hand". LED **"Hand"** illuminates.

Buttons **7/8/9/NR** can be used to move the axis forward and backwards at high and low speeds (whilst the button is depressed). The remaining buttons are inhibited in manual mode.

The Buttons have the following functions :

Button **7** Slow Reverse

Button **8** Fast Reverse

Button **9** Fast Forwards

Button **NR** Slow Forwards

If a 3 speed drive is used, the Fast and Creep speeds are used. Physical direction of movement can be reversed by setting of Register R64.
When operating in switched speed mode (i.e. without Analog output) the outputs Fast/Slow/Creep/Reverse are set according to the button pressed.
When closed loop analog control is used, the respective speeds are set in R60-63 in rpm. The proportional analog output voltage is given when the button is pressed.

5. Register Input

5.1 Unlocking Registers by Security Code

The values of Registers R1 to R97 can be changed after the Security Code 250565 has been entered into Register R98. (Note that Register R40/R6/R7 are accessible without the need for the security-code). Accessing Registers can only take place when the Controller is in Program Mode. In Register input mode, the decimal point is extinguished. All Registers are entered in the target position window.

Use Button **E** to : a) Store Register values b) End editing

Press Prog	Controller is set to Program mode. LED "Prog" illuminates.
Press R	The Nr Window flashes
Press C	Clears display to zero.
Key in "98"	Value 98 appears in Nr Window with "8" flashing.
Press >	The Target window shows "000000" without decimal point.
Press C	Clears display to zero.
Key in "250565"	Display shows 250565 (The Security Code).
Press E	The Controller is now set to data entry mode. All Windows are set to zero. Decimal point is reinstated.

5.2 Setting and Changing Register Values

Example: The Slowdown Point of 20.0 mm needs to be entered.
Assuming that Registers have been unlocked as above :

Press R	The Nr Window flashes.
Press C	Clears display to zero.
Press 1	1 (flashing) is displayed in Nr Window i.e. Register 01.
Press >	The existing value of R01 is displayed in Target window decimal point is extinguished.
Press C	Clears old value to zero.
Key in "200"	Window shows 200 (i.e. 20.0 mm).
Press E	The new value is memorised. All Windows are reset to zero and decimal point is reinstated.

Any Register from 1 to 97 can be selected and changed in the above manner. If sequential Registers are to be set, Press > twice instead of E and continue editing Register by Register. Press E on completion.

It is possible to run the Controller with Registers unlocked, e.g. having set the Stop offset Register R03, you may now execute a "Single" move and then go back to edit R03.

5.3 Locking of Registers

Once all the values have been set, it is necessary to relock the Registers to avoid accidental changes. There are two methods to do so.

a) Use Security Code

Press R	
Key in 98	
Press >	000000 is displayed
Press C	Locks Registers
Press E	

b) Switch off Controller.

6. Register List (Registers signed as * can be changed without security code)

No.	Function	Range	Default setting	Customers setting
R 1	Slow speed distance	0.1 mm	200	
R 2	Creep speed distance	0.1 mm	100	
R 3	Stop offset	0.1 mm	0	
R 4	Backlash compensation	0.1 mm	50	
R 5	Retract distance	0.1 mm	500	
R 6 *	Tool Width	0.1 mm	0	
R 7	Datum/reference value	0.1 m	1000	
R 8	System Register 1	See page 18	100000	
R 9	Position reached pulse	0.1 s	10	
R 10	Backlash dwell time	0.1 s	10	
R 11	Quantity reached pulse	0.1 s	10	
R 12	Tolerance window	0.1 mm	0	
R 13	Min software limit	0.1 mm	0	
R 14	Max software limit	0.1 mm	500000	
R 15	Software limit selection	See page 23	0	
R 17	Display brightness	0-15	10	
R 18	System Register 2	See page 24	0	
R 19	Encoder pulse monitor time	0.1 s	0	
R 20	Decimal point	See page 25	0	
R 21	Slow speed distance (backwards only)	0,1 mm	200	
R 22	Creep speed distance (backwards only)	0,1 mm	100	
R 23	Stop offset (backwards only)	0,1 mm	0	
R 24	Forced loop range window	0.1 mm	0	
R 25	Fixed Position	0.1 mm	1000	
R 28	System Register 3	See page 26	0	
R 29	Time delay for Drive inhibit	0,1 sec	10	
R 30	Program end pulse	0,1 sec	10	
R 31	Closed loop inhibit time in Hand	0,1 sec	10	
R 33	Controller switch on condition	0,1 sec	0	
R 34	Start time delay time	0,1 sec	0	
R 40*	Program Block selection	See page 12	0	
R 41	Number of lines in Prog Block	1-99	20	
R 46	Program counter Limit	1-99	0	
R 47	Program cycle counter	0 - 9999	0	
R 48	Pulse time for program counter output	0.1 sec	0	
R 50	Speed	UPM 1-10000	2000	
R 51	Acceleration/Deceleration	revs/sec2	30	
R 52	P term	1-3000	20	
R 53	I term	1-1000	1	
R 54	D term	1-1000	1	
R 55	I limit	1-1000	1	
R 56	Encoder edge multiplier	1,2,4	4	
R 57	Encoder pulses per rev	1-10000	250	
R 58	Stop-ramp selection	1-3	213222	
R 60	Speed back hand slow	Rpm	100	
R 61	Speed back hand fast	Rpm	1000	
R 62	Speed forward hand fast	Rpm	1000	
R 63	Speed forward hand slow	Rpm	100	
R 64	Direction of manual buttons	0.1	0	
R 65	Speed to fixed position	Rpm	500	
R 66	Acceleration for fixed position	revs/sec2	5	
R 67	Speed datum sequence phase 1	Rpm	100	
R 68	Speed datum sequence phase 2	Rpm	10	
R 69	Speed datum sequence with relays phase 1	0,1,2	0	
R 88	System Register 4	See page 30	0	
R 90	Button enable in service mode	0,1,2	0	
R 94	Inch / factor multiplier	0.0… 9.99999	100000	
R 96	Pulse scaling factor 0.00001… 9.99999	0.0… 9.99999	100000	
R 97	Inch / mm selection	0, 1, 2, 3	0	
R 98	Security code	250565	-	
R 99	Service, see chapter 14.	- -	-	

Logical sequence values such as these must always be present, regardless whether 3 speed, 2 speed or 1 speed drive is used.
R1 > R2 > R3 for 3 speed drive **R1 = R2 > R3** for 2 speed or 1 speed drive.

7. Description of Registers

R1 - Slow speed distance
Distance to demand position at which the controller switches from high speed to slow speed. The output high speed will be switched off.

R2 - Creep speed distance
Distance to demand position at which the controller switches from slow to creep speed

R3 - Stop offset distance
The over run distance can be programmed to compensate for distance from the switch-off point of the motor to standstill. For exact positioning, the over run distance should be very small (0.0 to 0.5 mm). Therefore the mechanical friction should be steady and the creep speed should be very slow.

During commissioning, first set R12 to zero (to eliminate Tolerance window blanking), then set the value of R03 to 0.0 and execute a number of moves in both directions. Note the average overrun distance and then set R03 to that value. Then set R12 to suit.

Notice: Stop offset is only functional when R8/1 = 1

R4 - **Backlash overrun**
To correct for screw or pinion backlash, the Demand position should be approached from one direction only. In positive direction therefore, the Demand position will be overrun by the value of R4 and driven back at creep speed after a time delay of R10, to the Demand position.

R5 - Retract distance
There are different modes available in the P8721, selectable by Register R18/2.
If R18/2 = 0 Retract Position = Actual + R5
If R18/2 = 1 Retract Position = Value of R5
Whilst the input St3/8 is held on, the slide will move to the "Retract" position. On release of input, slide will return to the original position. (Value 0)
When input St3/8 is activated, the slide moves to position as set in R5 but will not return to original position on release of input. (Value 1)

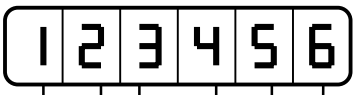
R6 - Tool offset compensation
This Register can be accessed without Security Code. When moving in incremental, it is often the case that the subsequent function is a cut that removes part of the material. Thus to cut the correct pre-set lengths, it is necessary to move the demanded distance plus the "Tool Offset". This feature is active in incremental mode only.

R7 - Datum/Reference
This Register can be accessed without Security Code.
The Datum value is stored in this Register. The value is used in different ways, in accordance with setting of P8/3. Input St3/8 initiates loading.

R8 - System Register 1

This Register sets the basic operating functions of the unit.

Target window



Spindle compensation
0 = no spindle compensation
1 = negative spindle compensation
2 = positive spindle compensation
3 = negative spindle compensation with forced loop (R24)
4 = positive spindle compensation with forced loop (R24)
5 = negative spindle compensation with backlash
6 = positive spindle compensation with backlash

Relay output configuration
0 = 3 speed operation
1 = Forwards + Backwards
2 = 2 speed Run + Reverse
3 = 2 speed separate output operation
4 = Fast only in reverse
5 = 3 speed Binary coded
6 = 3 speed operation forwards + backwards

Program Memory
0 = Program line operation mode
1 = Table operation mode

Datum/reference
0 = Datum to R7 with external pulse by key-switch
1 = Datum to the target value window with external key-switch
2 = Reference run +
3 = Reference run –
4 = Datum to R7 by key-board only

Display windows (program mode only)*
0 = All windows in use
1 = Target alone
2 = Target + Batch counter
3 = Target + Batch counter + Abs/Incr.

Type of positioning
0 = Analog positioning
1 = Fast/slow/stop mode

*** Display selection for single mode see R28/6**

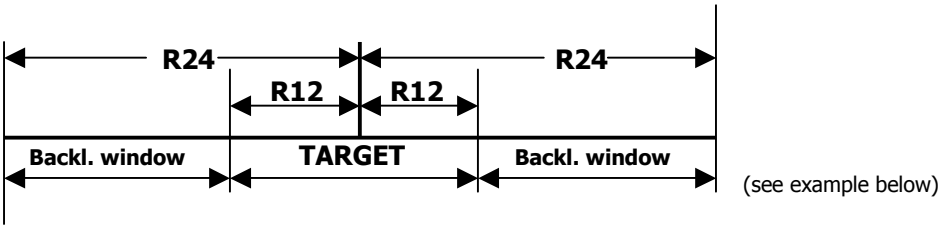
7.1 Backlash positioning

Adjustable in register **R8/6**

R8 = XXXXX5	**Backlash with negative spindle compensation**
R8 = XXXXX6	**Backlash with positive spindle compensation**

If the **actual value** after positioning is inside the range of the backlash window, with next START a new positioning (if necessary with forced loop) will be proceeded to the old target position.

S**ingle mode** = START to the target value
Program mode = No address line stepping, START to the present target value



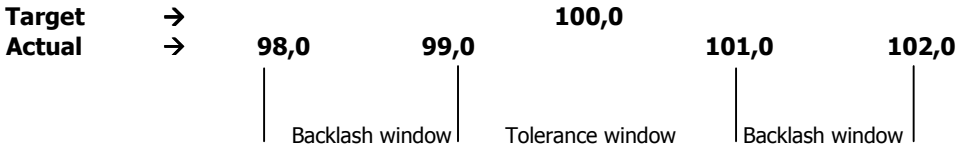
(see example below)

Backlash window:
Target **= 100,0**
Tolerance window **R12** **= 1,0**
Loop window **R24** **= 2,0**

Example:
The window range for the backlash positioning **= 98,0... 99,0** and **101,0... 102,0**

- If the actual value is in the range of this values, a backlash positioning will be proceeded
- If the actual value is in the range of the tolerance window 99,0 - 101,0, thus in the single mode no START is activated. In the program line mode, it will be stepped to the next address line and positioned to new target.
- Outside of the tolerance and backlash windows, it will be positioned to the target value (Single mode). In the program line mode, it will be stepped to the next address line and positioned to new target.

Example of the window ranges, with above settings:



7.2 Output configurations

These depend on setting of Register R8/5

Value 0 **3 speed operation (Elgo standard default)**
3 speeds selected by relays 1,2 & 3
output 4 sets direction reverse

OUTPUT ST5/	1	2	3	4
Creep forwards	X			
Slow forwards	X	X		
Fast forwards	X	X	X	
Creep reverse	X			X
Slow reverse	X	X		X
Fast reverse	X	X	X	X

R1 = Run, R2 = Slow & R3 = Fast combined with Run.
If used with 2 speed, R2 or R3 = Fast.
Can also be used with single speed.

Value 1 **2 speed operation**
Independent outputs forward and reverse
Independent outputs fast and slow

OUTPUT ST5/	1	2	3	4
Creep forwards	X	X		
Slow forwards				
Fast forwards	X		X	
Creep reverse		X		X
Slow reverse				
Fast reverse			X	X

R1 = Run forwards, R4 = Run reverse, R2 = Creep, R3 = Fast

Value 2 **2 speed operation**
Speed set by Relays 2 & 3
Direction set by Relay 4

OUTPUT ST5/	1	2	3	4
Creep forwards	X	X		
Slow forwards				
Fast forwards	X		X	
Creep reverse	X	X		X
Slow reverse				
Fast reverse	X		X	X

R1 = Positioning (drive inhibit or brake)
R2 = Creep, R3 = Fast (both independent)

Value 3 **2 speed operation**
Independent outputs for direction and speed

OUTPUT ST5/	1	2	3	4
Creep forwards	X			
Slow forwards				
Fast forwards		X		
Creep reverse			X	
Slow reverse				
Fast reverse				X

Value 4 **3 speed operation**
Forwards – 3 Outputs set speeds
Reverse – always fast
Output 4 = reverse

OUTPUT ST5/	1	2	3	4
Creep forwards	X			
Slow forwards	X	X		
Fast forwards	X	X	X	
Creep reverse	X	X	X	X
Slow reverse	X	X	X	X
Fast reverse	X	X	X	X

Value 5 **3 speed operation**
Binary coded Outputs 2 & 3 for speed
Output 1 = Forwards, Output 4 = Reverse

OUTPUT ST5/	1	2	3	4
Creep forwards	X	X		
Slow forwards	X		X	
Fast forwards	X	X	X	
Creep reverse		X		X
Slow reverse			X	X
Fast reverse		X	X	X

Value 6 **3 speed operation**
Output 1 = Run forwards, Output 4 = Run reverse

OUTPUT ST5/	1	2	3	4
Creep forwards	X			
Slow forwards	X	X		
Fast forwards	X	X	X	
Creep reverse				X
Slow reverse		X		X
Fast reverse		X	X	X

R9 - Time position reached
At the end of each move, the controller gives an output, to signal "in position". The length of this pulse is set in R9. Setting 0.0 gives a maintained output.
This output St5/14 is active when Actual position = Demand position +/- Tolerance window R12

R10 - Backlash dwell time
When the machine stops at the end of the over run, it is usually desirable to have a short delay. The time is set in this Register.

R11 - Pulse output "quantity complete"
When the batch counter goes from 1 to 0, a pulse output is given. The length of this pulse is set in R11.

R12 - Tolerance window
It is possible to enter a value in Register R12 that represents an acceptable tolerance e.g. 0.1 mm. When the Actual Position is within the Tolerance window, the Actual position displayed is made equal to the Demand position. The actual error is not lost, as the controller knows the true position.

Example: R12 = 0.2 Therefore tolerance window is +/- 0.2mm

	Display without Tolerance	Display with tolerance
Actual Display	199.8	200.0
Target Display	200.0	200.0

R13/R14 - Min/Max software limits

		Fault Message
Target < Limit R13	=	**04**
Target > Limit R14	=	**05**

Single set operation
Immediately after a start signal, the controller checks the software limits. If the Demand position is greater or smaller than the corresponding limit, the controller will stop and show the error message on the display. The backlash distance in R4 is considered at the check of the Max software limit, if the backlash is activated in R8/6.

Manual operation
The movement will stop when software limits are reached. If moving at high speed, the drive will drop to creep speed at a distance set in R1 from this limit. This prevents running into the ends of the machine. The end limit values are taken into account for minus the backlash value as set in R4, if R8/6 is selected.

R15 - Software Limit Selection

Software limits (R13 & R14) are active in accordance with the setting of R15/6

xxxxx0	Both software limits active
xxxxx1	Min software limit (R13) inhibited
xxxxx2	Max software limit (R14) inhibited
xxxxx3	Both software limits (R13 & R14) inhibited

External end limits St3/3 & 7 are active in accordance with R15/5

xxxx0x	Both limits active
xxxx1x	Min limit St3/3 inhibited
xxxx2x	Max limit St3/7 inhibited
xxxx3x	Both limits inhibited

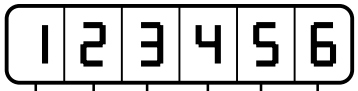
R17 - Display brightness
With the setting of this Parameter, the brightness of the displays can be altered.

0= dark, 15 = max brightness.

R18 - System Register 2

This Register also sets the functions of the controller.

Target window



batch counter
0 = no batch counter
1 = automatic subtracting
2 = automatic adding
3 = manual subtracting (external input St3/7)
4 = manual adding (external input St3/7)
5 = automatic add/sub (in Single only)
6 = manual add/sub for (in Single only)
7 = automatic subtracting, STOP when "zero"
8 = manual subtracting, STOP when "zero"

Option

positioning in program mode
0 = Absolute
1 = Incremental + positive direction
2 = Incremental – negative direction
3 = Incremental from zero
4 = Incremental from zero minus "tool offset value"

positioning in single
0 = Absolute
1 = Incremental + positive direction
2 = Incremental – negative direction
3 = Incremental from zero
4 = Incremental from zero minus "tool offset value"

retract mode
0 = retract to Actual + P5 setting value =- subtracts
1 = retract to P5 setting return on deactivation
2 = retract whilst input active return on deactivation
3 = retract to Actual + P5 without return
4 = retract to P5 without return
5 = retract whilst time in R10 in positive direction, no return
6 = retract to Actual – P5 in negative direction, return on deactivated
7 = retract whilst time in R10 in negative direction, return on deactivated
8 = retract to Actual – P5 in negative direction, no return.
9 = retract whilst time in R10 in negative direction, no return.

serial link
0 = none
1 = with RS232

R19 - Encoder monitoring
If after positioning is initiated, no Encoder pulses are sensed after a time set in R19, positioning will be aborted and Fault 01 will be displayed. Setting R19 to 0.0, disables Encoder pulse monitoring.

R20 - Decimal Point
The decimal point is placed in a fixed position and is optical only. It does not change the resolution of the system. The position depends on setting of R97.

With R97 = xxxxx0 = mm mode
R20 = xxxxx0 = 1/10
R20 = xxxxx1 = 1/1000
R20 = xxxxx2 = 1/100
R20 = xxxxx3 = without

With R97 = xxxxx1 = Inch mode 1/100

Decimal point is fixed at 1/100

With R97 = xxxxx2 = Inch mode 1/1000

Decimal point is fixed at 1/1000

With R97 = xxxxx3 = "Inch" factor freely =programmable in R94
R20 = xxxx0x = 1/10
R20 = xxxx1x = 1/1000
R20 = xxxx2x = 1/100
R20 = xxxx3x = without

R24 – Forced loop range window
If actual the position during a absolute positioning is inside the range of "Actual value -/+ **R24** value", at Start there a "forced loop operation" is executed.

Example for **a negative forced loop**:
R8/6 = **XXXXX3** = **forced loop –**
Loop window = **R24** = **1.0**
Actual value = **200.0**

With actual values of **200.1... 201.0** it will not be positioned directly back to the target value, but with a negative „forced loop.

R25 - Fixed Position (PID only)
Activating the input St3/19 will send the Axis to a prefixed position as set in R25.
The speed and acceleration of this move can be set independent of all others :-

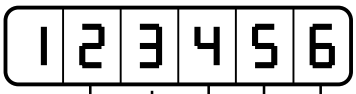
R65 = speed
R66 = acceleration/deceleration

R65 fixed position → unit of speed = **rpm**
R66 fixed position → unit of acceleration **r/s**

R28 - System Register 3

This Register also sets the functions of the controller.

Target window



Display windows in single mode*
0 = All windows in use
1 = Target alone
2 = Target + batch counter
3 = Target + batch counter + Abs/Incr

Front sided START/STOP button interlock
0 = both enabled
1 = STOP disabled
2 = START disabled
3 = both disabled

START interlock in the tolerance window
0 = Start in the tolerance window enabled
1 = Start input in the tolerance window disabled

External STOP logic
0 = Stop is "active low"
1 = Stop is "active high"

Separate slowdown parameter selection
0 = Slowdown in both direction set by R1, R2, R3
1 = Slowdown forward set by R1, R2, R3,
and reverse separately in R21, R22, R23

*** Display selection for program mode see R8/2**

R29 - Time Delay for Drive inhibit (Positioning)
On activating start, output St5/15 is activated.
On arriving in position, after a time delay of R29 this output deactivates.

R30 - Program End
On reaching the last line of the program, & completing the move and quantity batch, the program end output ST5/17 will pulse for the time set in this register.
If the register is set to zero then the output will latch until the next start input is given. The register is in seconds from 0.0 to 9.9 seconds.

R31 - Closed loop inhibit time
Releasing Manual Jog buttons or activating "Stop", will cause the Axis to stop instantly, without any ramp. Under closed loop control, positioning has to be inhibited and the error counter set to zero under such crash stop conditions.

Once standstill is achieved, the closed loop control can take over again, to hold the Axis in the instantaneous position reached. The time of closed loop inhibit is set in R31.

R33 - **Controller switch on mode**
The value set in R33 will determine the mode of operation that the controller assumes on power up

Value 0 - same as power off
Value 1 - single set mode
Value 2 – program mode
Value 3 – manual mode

R34 - **Start delay time**
On activating start, the controller calculate the parameters to arrive in position, after a time delay of this Parameter the controller start the analog output.

R40 - Program Block selection (see section 4.2.1)
This Register can be accessed without opening Security Code in R98.
The Program Block required for operation should be entered.

R41 - **Number of Lines in each Program Block**
Enter the number of lines required per Program Block (1 – 99). The number of Blocks will be calculated automatically.

Example :	Total number of Lines	= 200
	Number of Lines required per Block	= 25 (enter 25 into R41).
	Therefore number of Program blocks	= 8

An entry of lines bigger than 99 results in an error message "08".

Parameters for Analog (PID) Control (R50-R58):

R50 - Speed (input in rpm, referred to Encoder)

The maximum speed is set in this Register, in rpm. The speed is monitored by the Encoder speed (1 – 10000 rpm). Should there be gearing between motor and Encoder, this must be considered in the calculation to set R50.

Example :	Required motor speed in rpm	= 3000
	Gearing ratio i	= 10
	Therefore R50 = rpm/i	= 3000/10 = 300

Edge multiplier and Multiplication factor must not be considered in the calculation (see example in section 9)

R51 - Acceleration (Deceleration) (input in revs/sec2 referred to Encoder)

The acceleration is set in this Register in revolutions per second squared. (see example in section 9)

R52 - P Term (Proportional Amplification; setting 1 – 3000)

During operation, the difference between demand and actual positions will be multiplied by the value of this Register and result in an Analog output. The greater the proportional amplification, the more responsive (eventually also unstable) will be the system.

Hint : when using DC-servo drives, the value should not exceed 20.

R53 - I Term (Integral step, setting 1 – 1000)

During operation, the Analog control voltage will continue to increase step by step, until there is zero difference between demand and actual position. The maximum increase in voltage is limited by R55. The greater the I term, the slower is the response.

R54 - D Term (Differential voltage, setting 1 – 1000)

During operation, any small error in the output voltage will be compensated for by Increasing the voltage instantaneously, but without instability of the system. The value of the instantaneous voltage is set in this Register (max +/- 10v =1000).

R55 - I Limit (Integral Limit, setting 1- 1000)

The Integral voltage (R53) will only increase step by step up to a value as set in this Register to prevent the Integral term becoming too large, should it not be possible for some reason to reduce the error to zero.

Note: R55 must be set **>** than **R53 !**

R56 - Multi edge counter

1 = x 1 **2 = x 2** **4 = x 4**

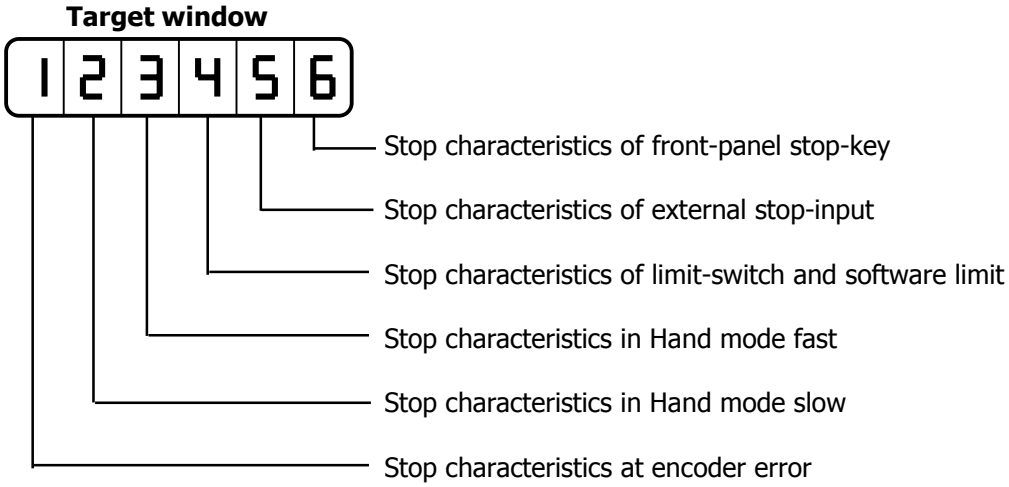
Entry of any other value will automatically select 1

R57 - Encoder resolution (max 10000 ppr)

The Encoder pulses per revolution are entered in this Register. This enables the calculation of speed to be effected.

R58 - Stop characteristics

This Register sets the stop characteristics of the controller in the different stop conditions.



Value 0 = Stop smoothly (Ramp of R51)
Value 1 = Stop abruptly
Value 2 = Stop turn motor off
Value 3 = Stop turn motor off, after timer in Register 31 closed loop control

Parameters for closed loop Analog control (R60-66)

R60 - Speed "Hand Slow Backwards"	Button 7	in rpm
R61 - Speed "Hand Fast Backwards"	Button 8	in rpm
R62 - Speed "Hand Fast Forwards"	Button 9	in rpm
R63 - Speed "Hand Slow Forwards"	Button NR	in rpm

R64 - Setting physical direction of Manual Buttons

R64 = xxxxx0 = Standard direction
R64 = xxxxx1 = Opposite direction

R65 - Speed to "Fixed Position" (in rpm)

The Axis will move to the Fixed Position at this speed, irrespective of other settings.

R66 - Acceleration (deceleration) for move to Fixed Position (in revs/sec2)

This is set irrespective of other values.

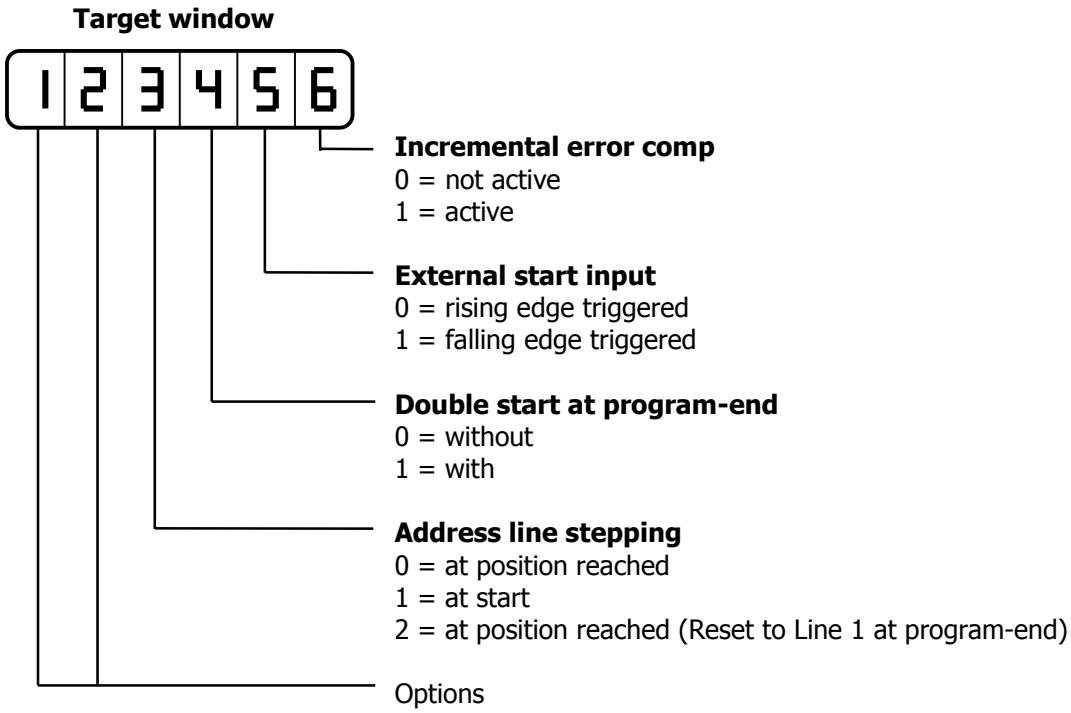
R67 - Speed of going to Datum – First phase (in rpm)

R68 - Speed of going to Datum – Second phase (in rpm)

R69 - Speed of going to Datum in First phase, in switched speed control mode

R88 - System Register 4

This Register sets further basic functions of the controller.



R90 - Service register
Only active when R98 is unlocked. Only for use during set-up of controller

R94 - **"Inch" Factor**
Any factor value can be entered here between 0.00001 and 9.99999 and selected by R97 = xxxxx3. When the display is switched between metric/inch", this factor will be used to change the display to secondary units.

R96 - **Encoder Pulse Multiplier**
A factor (0.00001 to 9.9999) can be entered in this Register. The incoming pulses will be multiplied by this factor, to manipulate the display to required dimensions. If no multiplication is required, this Register must be set to 1.00000.

R97 Inch/mm R97/6 =00000x

0 = mm operation
1 = inch operation. Resolution 1/100
2 = inch operation. Resolution 1/1000
3 = factor operation. As set in R94

Decimal point is set by R20/5

R98 - Security Code
Enter 250565 to unlock and change Parameters

R99 - Only for Service

R99 Service Register

When R99 is selected, the following functions can be called up:-

Security Register R98 must be opened and service Register R90 set.

R90 = 000001	Button 4	active
R90 = 000002	All buttons	active

NB: Select R90 before R99

Button 0 Displays state of inputs St3/1-8 in target window
Button 1 Displays state of inputs St3/14-21 in target window
Button 2 Displays state of outputs St5/1-8 in target window
Button 3 Displays state of outputs St5/14-21 in target window

The display is Binary coded decimal (B.C.D) i.e.
1= Input 1
2= Input 2
4= Input 3
8= Input 4 etc.
0000XX = pin 1-4 / pin 14-17
00XX00 = pin 5-8 / pin 18-21

Button 4 Displays SV and SN numbers of unit
Demand = SV number
Quantity = SN number
Button 5 Set outputs St5/1-8 with buttons
Button 6 Set outputs St5/14-21 with buttons

Use buttons 1-8 to set the respective output
(i.e. button 1 = output 1 resp. 14)

Button 7 I/O Test St3/1-8 >>>> St5/1-8
Button 8 I/O Test St3/14-21 >>>> St5/14-21

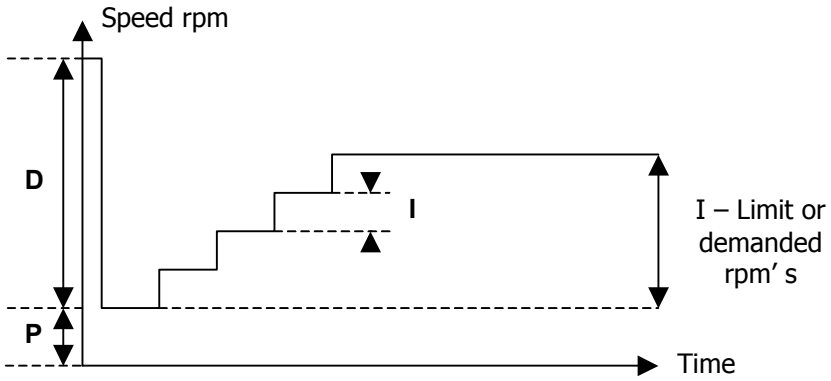
Activating an input will set the respective output
e.g. activating input 1 sets output 1 etc

Button 9 unused
Button NR Clear program memory
Button R Load Register defaults
Button T Clear Registers
Button Stop Test Displays
Button Start Display serial interface received information
Button E Exit Test Mode

8. Positioning with analog PID output

Analog range +/- 10 V

By using registers **R50**... **R66** the analog output will be adjusted



8.1. Offset adjustment of closed loop analog system

When the position controller is connected to the motor drive, it is possible to come "into position" with an error, due to an analog offset voltage.

This error can be compensated for by adjusting the offset potentiometer of the drive (analog drives).

Typical procedure is as follows :

- Connect up Controller and Drive
- Set R57 (Encoder Resolution). The other Registers can be taken as default values.
- To achieve the greatest resolution in the display, set R96 (multiplication factor) to 100000 and R56 (edge multiplier) to 4. This is regardless what you will need for final operation of the system.
- Enter a dimension and execute a move.
  If the exact position cannot be reached, then the drive offset is not correctly set.
- Adjust the offset potentiometer in the drive until actual position equals the demand.
- Execute several more moves in both directions and adjust offset to the optimum.
- Check effect of offset in both directions. If correct positioning cannot be effected by the offset potentiometer, it is necessary to first make adjustments to Parameters R52-55.

8.2 Setting of Analog Parameters

Initial settings :

Enter Encoder Resolution in **R57** (max 10000 ppr)

Set Edge Multiplier in R56

Set the desired speed in **R50** (for program and single)
and **R60-63** (for Hand) – max 10000 rpm.

The product of Encoder Resolution and rpm should not exceed the maximum input frequency of the controller.

E.g. Resolution i = 1000 ppr
Max input freq. = 10000 Hz
Therefore rpm = f.max x 60 = 10000 Hz x 60 = 600 rpm
i = 1000

Set the acceleration revs/sec2 in **R51**

E.g. Velocity v = 3000 rpm
Time t = 5 sec
Accel. a = v = 3000 rpm / 60 = 10 revs/sec2
t = 5 sec

Set the Registers **R52, 53, 54, 55** to 1

Now position to a large demand value

Adjust the value of the P Term (**R52**) till the required top speed is achieved during the Move and the Axis positions without overshoot.

Should the demanded position not be quite reached, adjust the I Term (**R53**) until it can do so.

Notice: R55 (I Limit) must be at least as high a value as **R53**.

If the Axis overshoots, slightly reduce **R55**, but no lower than **R53**

If the system begins to oscillate (i.e. a too large a value of I term), then this can be eliminated by adding some small value of D Term (**R54**) to compensate.

9. Functions of the inputs (Connector St3)

St3/3+7 End limits

External limit switches can be connected Input logic is NPN i.e. input open = end limit activated St3/3 minimum end limit St3/7 maximum end limit

Fault monitoring :	End limit minimum active = 02 End limit maximum active = 03

Notice: If these are not connected to limit switches they need to be connected Normally closed (i.e. linked out).

St3/4 External start input

The input is edge triggered Logic : opening or closing can be selected by R88/5.

St3/5 Incremental backwards

The Axis will position in incremental, towards zero, with this input active.

St3/6 Incremental forwards

The Axis will position in incremental, towards maximum, with this input active.
The above two inputs have priority over the software selection in R18/3 and R18/4. In program mode. The input ST3/6 also needs to be closed.

St3/8 Datum setting

If 0 or 1 is set in R8/3, this input is active.

R8 = xx0xxx	Datum to R7
= xx1xxx	Datum to Demand selected

St3/14 External stop

Input logic is NPN i.e. Input open = stop active (no positioning possible)
Should a start signal be given, the Fault 07 will be displayed.
Input closed = Stop inactive (Positioning possible).
Stop input is also active in manual operation.

St3/16 Quantity adding/subtracting

Each pulse of this input will increment or decrement the counter.

St3/18 Retract

If **R18 =**	**x0xxxx**	move to position "Actual + R5"
	x1xxxx	move to position set in R5

St3/19 Fixed position

Activating this input starts the Axis to move to fixed position set in R25.
Speed and acceleration of this move can be set independently into R65 and R66.

10. Functions of the Outputs

St5/1-4 **Run Signals**
The functions are selectable. See page 20/21

St5/5 **Single Operation**
This output is set when Single is selected

St5/6 **Hand Operation**
This output is set when Hand is selected

St5/7 **Going to Datum**
If this feature is selected in R8/3, then on activating start, this output is set.
It resets when datum cycle is complete.

St5/14 **Position Reached**
Signals that position has been reached by pulsed or latched output.
If R9 is selected to zero, the output is latched i.e. "Axis in position". And is on until next move commences.
The output is set when Actual Position = Demand Position +/- Tolerance
Window R12. Should a value (0.1 to 9.9 sec) be set in R9, the output becomes
A pulse of that time when position is reached.

St5/15 **Positioning / Drive enable**
This output will switch on whilst any of the motion control outputs are on.
It will stay on until timer R29 has timed out after all of the motion control outputs

St5/16 **Quantity Reached**
Signals that the quantity has been reached by a pulse. The time is set in R11.
Quantity subtracting : when quantity = 0
Quantity adding : when required quantity is reached

St5/17 **Program End**
In program mode, this output pulses at the end of the program. The output time is set in R30.

St5/18-21 **Auxiliary Functions**
There are 10 Auxiliary functions (0-9). These outputs are binary coded.
The Operator sets the Auxiliary functions in decimal. The coded outputs are set, on the first start of each address line, and stay energised until the next address line is started.
St5/18 = 2(0)
St5/19 = 2(1)
St5/20 = 2(2)
St5/21 = 2(3)

11. Connections

St5 Output Signals (Push Pull)

1	Creep	These run signals are configurable in a number of ways see pages 19/20 (these signals are only for R8/5 = 0)
2	Slow	
3	Fast	
4	Reverse	
5	Single selected	
6	Hand selected	
7	Going to datum	
9	E	
10	E	
11	Common 0v potential for outputs	
14	Position reached/in position	
15	Drive enable/Positioning	
16	Quantity reached pulse	
17	Program end	
18	Auxiliary Function 2(0)	
19	Auxiliary Function 2(1)	
20	Auxiliary Function 2(2)	
21	Auxiliary Function 2(3)	
24	+24 VDC	

St7 RS232 serial interface (option)

1	RX
2	TX
3	0V

St8 Analog output

7	- / +10 VDC out
8	0 VDC - GND
9	Earth/ Screen PE

St1 Encoder inputs

1	0 V - GND
2	+ 24 VDC
3	A
4	B
5	Earth PE
6	A' (TTL only)
7	B' (TTL only)
8	Z
9	Z' (TTL only)

St3 Input Signals

Please note:
PNP (standard) inputs must be connected to + 24 V
NPN (optional) inputs must be connected to 0 V (GND)

1	-
2	-
3	Negative end switch
4	Start
5	Incremental backwards
6	Incremental forwards
3	Positive end switch
8	Datum
9	Earth
10	Earth
11	+24 VDC out (PNP common)
14	Stop
15	-
16	Quantity input
18	Retract
19	Go to Fixed Position (PID only)
20	-
21	-
23	0 V - GND (NPN common)

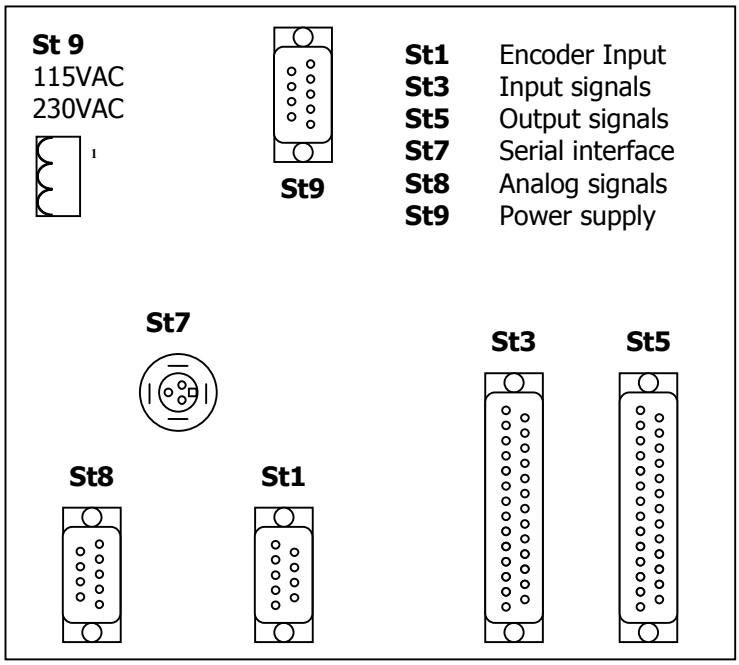
St9 Power supply (from NG13.0)

1	24 VDC
2	0 VDC - GND
3	Earth

St9 Power supply 230/115 VAC (option)

1	**L1** - 230/115V AC 14VA
2	**N** - 230/115V AC
3	**PE** - Earth & Screens

11.1 Connector assignment (Rear)



12. Technical specifications

Power supply (must be indicated)	24 VDC (index 024) 115 VAC 50/60 Hz (index 115) 230 VAC 50/60 Hz (index 230)
Power consumption	14 VA
Consumption	24 VDC max. 110 mA 115 /230 VAC max. 100 mA
Encoder supply	24 VDC max. load 130 mA
Encoder circuit required	PNP (NPN option)
Input signals	PNP (NPN option), minimum pulse time 0.3 sec
Input current	max. 10 mA
Outputs	Potential free shutter relays max. switch able voltage DC- 30 V max. switch able voltage AC- 250 V
Memory	E²-PROM minimum 10 years service life
Connectors	Screw terminals, strain relieved
Display	Red low power LED 7 segment 10 mm high
Hardware	SMD micro controller with 128 K E-Prom
System accuracy	+/- 1 digit
Counting frequency	20 KHz, higher on request
Housing	Black, metal panel-housing 144 x 144 x 84 mm's plus 30 for connectors
Cut-out	138 x 138 mm
Ambient temperature	0… + 50 ° C

13. Installation/Wiring

Attention! *To ensure a perfect function of the controller P8721 the following installation guide-lines must be strictly observed and followed. Otherwise the guarantee expires and* ***ELGO Electric GmbH*** *takes no liability and guarantee for malfunctions or damages caused e.g. by incorrect installed wires or other external sources of error or interference, which are exactly explained below. Please read the instructions carefully before putting the controller into operation.*

To guarantee a perfect operation of the controller, the following (external) measures have to be taken additionally:

Place of installation:
Don't install the controller near to sources of interference generating strong inductive or capacitive interferences or strong electrostatic fields.
Install the external power supply directly beside the controller to avoid long low voltage wires.

Power supply:
Connect the external power supply to a phase of 230 VAC or 115 VAC, which is not used for engines.
If not possible use a galvanic separation over an additional transformer.

Wire installation:
Install all wires for low voltages and encoders always separately from power wires (230 VAC/400 VAC). Avoid to install these wires close to any contactor or contactor wires.

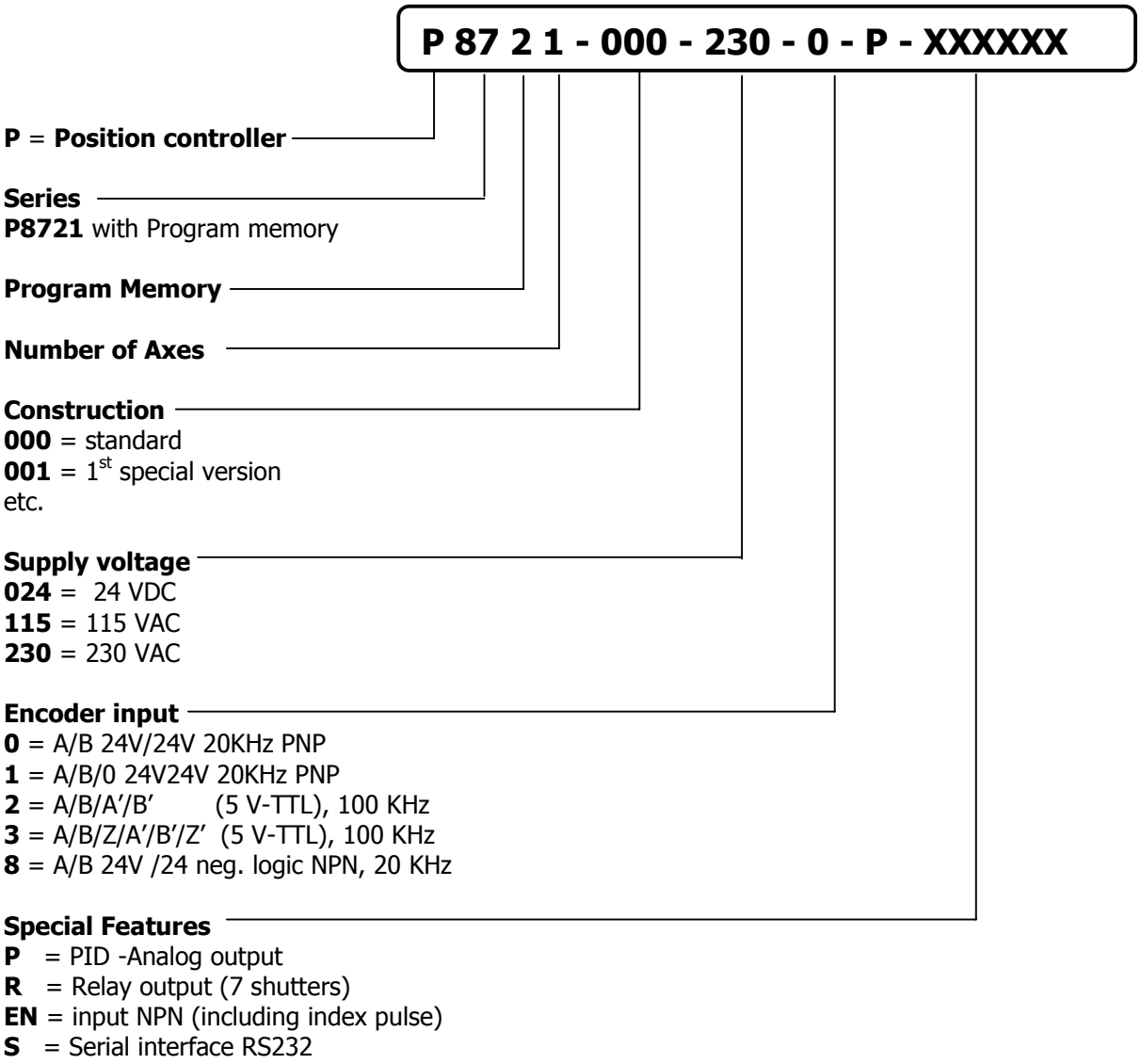
Shielding:
All external signal wires have to be installed shielded:
1. Rotary encoder wires and Analog input wires
2. Wires for all other input signals
3. Wires for all output signals
4. Wires from the power supply to the controller

All shields have to be connected centrally low ohm to **PE** (earth potential),connect only one-sided at the P8721-Controller.

IMPORTANT!
1. Don't connect the P8721-GND to **PE** (earth potential)
2. Don’t connect the shielding on both sides to **PE** (earth potential)
3. If the protective ground potential is heavily "contaminated" by interference voltages, try to connect the shielding to the GND potential instead of **PE** (earth potential)

Fault clearance:
If there occurs interferences in spite of applying all above mentioned measures proceed as follows:
1. Add RC elements over contactor reels of AC contactors (for example 0,1 µF/100 Ω).
2. Add recovery diodes over DC inductances
3. Add RC elements over each engine phase (in connector box of the engine)
4. Install a power filter before the external power supply

14. Type designation



15. Liability exclusion / Guarantee

We have checked the contents of this instruction manual carefully, to the best of our knowledge and belief for conformity with the described hardware and software. Nevertheless errors, mistakes or deviations can not be excluded, therefore we do not guarantee complete conformity. Necessary corrections will be included in the subsequent editions. We appreciate your ideas and improvement suggestions very much. Reprint, duplication and translation, even in extracts, are only allowed with a written authorization by the company ELGO Electric GmbH. We constantly strive for improving our products, therefore we keep all rights reserved for any technical modifications without any notice.

ELGO Electric does not assume any liability for possible errors or mistakes.

The guarantee period is one calendar year from the date of delivery and includes the delivered unit with all components. ELGO Electric GmbH will at its option replace or repair without charge defects at the unit or the included parts, verifiable caused by faulty manufacturing and/or material in spite of proper handling and compliance to the instruction manual.

Damages verifiably not caused by ELGO-Electric GmbH and due to improper handling are excluded from any guarantee e.g. by applying faulty voltage, diffusion of liquid into the interior of the engine, using force, scratching the surface, chemical influences etc.!

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Measure - Control - Position