

# POSITIONServo



S929

## Model 940 USERS MANUAL

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## Safety Information

All safety information given in these Operating Instruction have the same layout:



**Signal Word!** (Characteristics the severity of the danger)

Note (describes the danger and informs on how to proceed)

Icon		Signal Words	
	Warning of hazardous electrical voltage	<b>DANGER!</b>	Warns of <b>impending danger</b> . Consequences if disregarded: Death or severe injuries.
	Warning of a general danger	<b>WARNING!</b>	Warns of <b>potential, very hazardous situations</b> . Consequences if disregarded: Death or severe injuries.
	Warning of damage to equipment	<b>STOP!</b>	Warns of <b>potential damage to material and equipment</b> . Consequences if disregarded: Damage to the controller/drive or its environment.
	Information	<b>Note</b>	Designates a general, useful note. If you observe it, handling the controller/drive system is made easier.

# 1 General Information

The PositionServo line of advanced general purpose servo drives utilizes the latest technology in power semiconductors and packaging. The PositionServo uses Field Oriented control to enable high quality motion.

The PositionServo Model 940 is available in four mains (input power) configurations:

1. **400/480V** (nominal) three phase input. An external input mains (line) filter is available. These drives have the suffix "T4N". Actual voltage can range from 320 - 528 VAC.
2. **120/240V** (nominal) Single Phase input with integrated input mains (line) filter, Actual input voltage can range from 80VAC to 264VAC. The maximum output voltage is approximately equal to the input voltage. These drives have the suffix "S2F".
3. **120V or 240V** (nominal) Single or Three Phase input. Actual input voltage can range from 80VAC to 264VAC. The maximum output voltage is approximately equal to the input voltage. An external input mains (line) filter is available. These drives have the suffix "Y2N".
4. **120V or 240V** (nominal) single phase input. When wired for  **Doubler mode** (L1-N), the input is for 120V nominal only and can range from 45VAC to 132 VAC and the maximum output voltage is double the input voltage. When wired to terminals L1-L2/N, the input can range from 80 VAC to 264 VAC and the maximum output voltage is equal to the input voltage. These drives have the suffix "S1N".

The PositionServo 940 will accept feedback from an incremental encoder (that includes Hall channel information) or from a resolver. It accepts commands from a variety of sources, including analog voltage, RS485 interface (PPP and Modbus RTU), Ethernet interface, CANopen interface, digital pulse train, and master encoder reference. The control will operate in current (torque), velocity, or position (step and direction / master encoder) modes.

The 940 utilizes a software package called MotionView. MotionView provides a window into the drive allowing the user to check and set parameter. It has a real-time oscilloscope tool, for analyses and optimum tuning, as well as a User Program. This User Program can be utilized to command motion and handle the drives I/O. The MotionView programming language is designed to be very user friendly and easy to implement.

The EPM (Electronic Programming Module) stores all drive setup and tuning information. This module can be removed from the drive and reinstalled into another PositionServo 940, making field replacement of the PositionServo 940 extremely easy.

The PositionServo 940 controls supports Point-to-Point (PPP) and Modbus RTU over RS485, Ethernet TCP/IP and CANopen (DS301, DS402) communication protocols.

The PositionServo 940 supports incremental quadrature encoder or resolver feedback devices. A second encoder can also be supported during position and velocity modes.

## 1.1 About these Operating Instructions

- These Operating Instructions are provided to assist the user in connecting and commissioning the Model 940 servo drive. Important safety instructions are contained in this document which must be observed carefully.
- All persons working on and with the controller must have the Operating Instructions available and must observe the information and notes relevant for their work.
- The Operating Instructions must always be in a complete and perfectly readable state.

## 1.2 Scope of Supply

Scope of Supply	Important
<ul style="list-style-type: none"> <li>• 1 Model 940 Servo type E94P...</li> <li>• 1 Users Manual (English)</li> <li>• 1 MotionView CD ROM including               <ul style="list-style-type: none"> <li>- configuration software</li> <li>- documentation (Adobe Acrobat)</li> </ul> </li> </ul>	<p>After reception of the delivery, check immediately whether the scope of supply matches the accompanying papers. Lenze does not accept any liability for deficiencies claimed subsequently.</p> <p><b>Claim</b></p> <ul style="list-style-type: none"> <li>• visible transport damage immediately to the forwarder</li> <li>• visible deficiencies / incompleteness immediately to your Lenze representative.</li> </ul>

## 1.3 Legal regulations

Identification	Nameplate	CE Identification	Manufacturer
	Lenze controllers are unambiguously designated by the contents of the nameplate	In compliance with the EC Low-Voltage Directive	AC Technology Corp. member of the Lenze Group 630 Douglas Street Uxbridge, MA 01569 USA
<b>Application as directed</b>	<p><b>E94P... servo controller</b></p> <ul style="list-style-type: none"> <li>• must only be operated under the conditions prescribed in these Instructions.</li> <li>• are components               <ul style="list-style-type: none"> <li>- for closed loop control of variable speed and torque applications with PM synchronous motors</li> <li>- for installation in a machine.</li> <li>- for assembly with other components to form a machine.</li> </ul> </li> <li>• are electric units for the installation into control cabinets or similar enclosed operating housing.</li> <li>• comply with the requirements of the Low-Voltage Directive.</li> <li>• are not machines for the purpose of the Machinery Directive.</li> <li>• are not to be used as domestic appliances, but only for industrial purposes.</li> </ul> <p><b>Drive systems with E94P... servo inverters</b></p> <ul style="list-style-type: none"> <li>• comply with the EMC Directive if they are installed according to the guidelines of CE-typical drive systems.</li> <li>• can be used               <ul style="list-style-type: none"> <li>- for operation on public and non-public mains</li> <li>- for operation in industrial premises and residential areas.</li> </ul> </li> <li>• The user is responsible for the compliance of his application with the EC directives.</li> </ul> <p><b>Any other use shall be deemed as inappropriate!</b></p>		
<b>Liability</b>	<ul style="list-style-type: none"> <li>• The information, data, and notes in these instructions met the state of the art at the time of publication. Claims on modifications referring to controllers which have already been supplied cannot be derived from the information, illustrations, and descriptions.</li> <li>• The specifications, processes and circuitry described in these instructions are for guidance only and must be adapted to your own specific application. Lenze does not take responsibility for the suitability of the process and circuit proposals.</li> <li>• The specifications in these Instructions describe the product features without guaranteeing them.</li> <li>• Lenze does not accept any liability for damage and operating interference caused by:               <ul style="list-style-type: none"> <li>- Disregarding the operating instructions</li> <li>- Unauthorized modifications to the controller</li> <li>- Operating errors</li> <li>- Improper working on and with the controller</li> </ul> </li> </ul>		
<b>Warranty</b>	<ul style="list-style-type: none"> <li>• Warranty conditions: see Sales and Delivery Conditions of Lenze Drive Systems GmbH.</li> <li>• Warranty claims must be made to Lenze immediately after detecting the deficiency or fault.</li> <li>• The warranty is void in all cases where liability claims cannot be made.</li> </ul>		
<b>Disposal</b>	<b>Material</b>	<b>Recycle</b>	<b>Dispose</b>
	Metal	•	-
	Plastic	•	-
	Assembled PCB's	-	•

## 2 Specifications

### 2.1 Electrical Characteristics

Single-Phase Models					
Type	Mains Voltage <sup>(1)</sup>	1~ Mains Current (doubler)	1~ Mains Current (Std.)	Rated Output Current <sup>(4)</sup>	Peak Output Current <sup>(5)</sup>
E94P020S1N	120V <sup>(2)</sup> or 240V <sup>(3)</sup>	9.7	5.0	2.0	6
E94P040S1N		16.8	8.6	4.0	12
E94P020S2F	120 / 240V <sup>(3)</sup> (80 V -0%...264 V +0%)	--	5.0	2.0	6
E94P040S2F		--	8.6	4.0	12
E94P080S2F		--	15.0	8.0	24
E94P100S2F		--	18.8	10.0	30

Single/Three-Phase Models					
Type	Mains Voltage <sup>(1)</sup>	1~ Mains Current	3~ Mains Current	Rated Output Current <sup>(4)</sup>	Peak Output Current <sup>(5)</sup>
E94P020Y2N	120 / 240V <sup>(3)</sup> 1~ or 3~ (80 V -0%...264 V +0%)	5.0	3.0	2.0	6
E94P040Y2N		8.6	5.0	4.0	12
E94P080Y2N		15.0	8.7	8.0	24
E94P100Y2N		18.8	10.9	10.0	30
E94P120Y2N		24.0	13.9	12.0	36
E94P020T4N	400 / 480V 3~ (320 V -0%...528 V +0%)	--	2.7	2.0	6
E94P040T4N		--	5.5	4.0	12
E94P050T4N		--	6.9	5.0	15
E94P060T4N		--	7.9	6.0	18

<sup>(1)</sup> Mains voltage for operation on 50/60 Hz AC supplies (48 Hz -0% ... 62Hz +0%).

<sup>(2)</sup> Connection of 120VAC (45 V ... 132 V) to input power terminals L1 and N on these models doubles the voltage on motor output terminals U-V-W for use with 230VAC motors.

<sup>(3)</sup> Connection of 240VAC or 120VAC to input power terminals L1 and L2 on these models delivers an equal voltage as maximum to motor output terminals U-V-W allowing operation with either 120VAC or 230VAC motors.

<sup>(4)</sup> Drive rated at 8kHz Carrier Frequency. Derate Continuous current by 17% at 16kHz.

<sup>(5)</sup> Peak RMS current allowed for up to 2 seconds. Peak current rated at 8kHz. Derate by 17% at 16kHz.

#### Applies to all models:

Acceleration Time Range (Zero to Max Speed)	0.1 ... 5x10 <sup>6</sup> RPM/sec
Deceleration Time Range (Max Speed to Zero)	0.1 ... 5x10 <sup>6</sup> RPM/sec
Speed Regulation (typical)	± 1 RPM
Input Impedance (AIN+ to COM and AIN+ to AIN-)	47k Ω
Power Device Carrier Frequency (sinusoidal commutation)	8,16 kHz
Encoder power supply (max)	+5 VDC @ 300 mA
Maximum encoder feedback frequency	2.1 MHz (per channel)

## 2.2 Environment

Vibration	2 g (10 - 2000 Hz)
Ambient Operating Temperature Range	0 to 40°C
Ambient Storage Temperature Range	-10 to 70°C
Temperature Drift	0.1% per °C rise
Humidity	5 - 90% non-condensing
Altitude	1500 m/5000 ft [derate by 1% per 300m (1000 ft) above 1500m (5000 ft)]

## 2.3 Operating Modes

### Torque

Reference	± 10 VDC 16-bit; scalable
Torque Range	100:1
Current-Loop Bandwidth	Up to 3 kHz

### Velocity

Reference	± 10 VDC or 0...10 VDC; scalable
Regulation	± 1 RPM
Velocity-Loop Bandwidth	Up to 400 Hz
Speed Range	5000:1 with 5000 ppr encoder

### Position

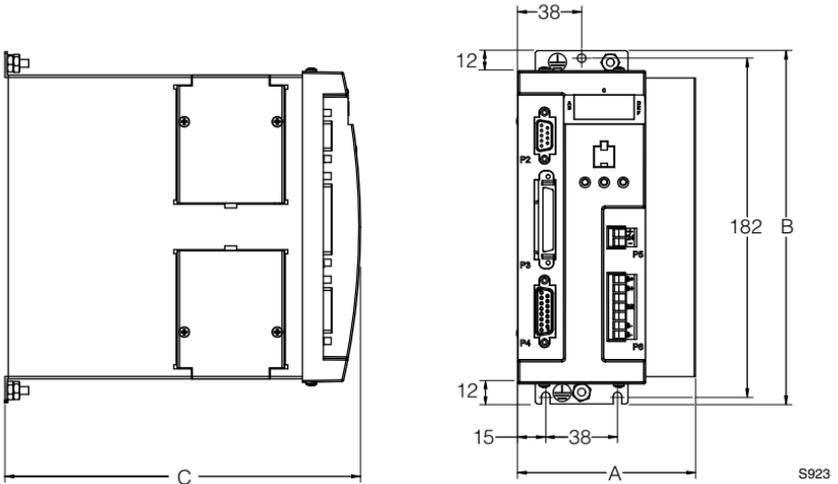
Reference	0...2 MHz Step and Direction or 2 channels quadrature input; scalable
Minimum Pulse Width	500 nanoseconds
Loop Bandwidth	Up to 200 Hz
Accuracy	±1 encoder count

## 2.4 Connections and I/O

RS232 serial interface	Standard 9-pin D-shell (DCE) (P2)
Encoder Feedback (primary)	Standard 15-pin D-shell (P4)
Encoder Feedback (secondary)	Option module with standard 9-pin D-shell (P12)
Resolver feedback	Option module with standard 9-pin D-shell (P11)
Encoder buffered repeat	In 50-pin SCSI controller connector (P3)
Mains Power	4-pin removable terminal block (P1)
Motor Power	6-pin pin removable terminal block (P7)
Regen and Bus Power	5-pin removable terminal block (P6)
"Keep Alive" 24VDC Power	2-pin removable terminal block (P5)
Digital Inputs	12 programmable, 1 dedicated (5-24V) (P3)
Digital Outputs	4 programmable, 1 dedicated (5-24V @ 100mA) (P3)
Analog Input	1 differential; ±10 VDC (16-bit). (P3)
Analog Output	1 single ended; ±10 VDC (10-bit). (P3)
I/O Controller	Standard 50-pin SCSI. (P3)
Windows® Software:	MotionView (Windows 98, NT, 2000, XP)

# 3 Dimensions

## 3.1 Model 940 Dimensions



Type	A (mm)	B (mm)	C (mm)	Weight (kg)
E94P020S1N	67	190	190	1.1
E94P040S1N	69	190	190	1.2
E94P020S2F	67	190	235	1.3
E94P040S2F	69	190	235	1.5
E94P080S2F	88	190	235	1.9
E94P100S2F	103	190	235	2.2
E94P020Y2N	67	190	190	1.3
E94P040Y2N	69	190	190	1.5
E94P080Y2N	95	190	190	1.9
E94P100Y2N	115	190	190	2.2
E94P120Y2N	67	190	235	1.5
E94P020T4N	69	190	190	1.5
E94P040T4N	95	190	190	1.9
E94P050T4N	115	190	190	2.2
E94P060T4N	67	190	235	1.4



## 4 Installation

Perform the minimum system connection. Please refer to section 8.1 for minimum connection requirements. Observe the rules and warnings below carefully:

---



### DANGER!

Hazard of electrical shock! Circuit potentials are up to 480 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Disconnect incoming power and wait 60 seconds before servicing drive. Capacitors retain charge after power is removed.

---



### STOP!

- The PositionServo 940 must be mounted vertically for safe operation and enough cooling air circulation.
  - Printed circuit board components are sensitive to electrostatic fields. Avoid contact with the printed circuit board directly. Hold the PositionServo 940 by its case only.
  - Protect the drive from dirt, filings, airborne particles, moisture, and accidental contact. Provide sufficient room for access to the terminal block.
  - Mount the drive away from any and all heat sources. Operate within the specified ambient operating temperature range. Additional cooling with an external fan may be recommended in certain applications.
  - Avoid excessive vibration to prevent intermittent connections
  - DO NOT connect incoming (mains) power to the output motor terminals (U, V, W)! Severe damage to the drive will result.
  - Do not disconnect any of the motor leads from the PositionServo 940 drive unless (mains) power is removed. Opening any one motor lead may cause failure.
  - Control Terminals provide basic isolation (insulation per EN61800-5-1). Protection against contact can only be ensured by additional measures, e.g., supplemental insulation.
- 



### WARNING!

For compliance with EN61800-5-1, the following warning applies.

This product can cause a d.c. current in the protective earthing conductor. Where a residual current-operated protective (RCD) or monitoring (RCM) device is used for protection in case of direct or indirect contact, only an RCD or RCM of Type B is allowed on the supply side of this product.

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## UL INSTALLATION INFORMATION

- Suitable for use on a circuit capable of delivering not more than 200,000 rms symmetrical amperes, at the maximum voltage rating marked on the drive.
  - Use Class 1 wiring with minimum of 75°C copper wire only.
  - Shall be installed in a pollution degree 2 macro-environment.
- 

## 4.1 Wiring



### DANGER!

Hazard of electrical shock! Circuit potentials are up to 480 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Disconnect incoming power and wait 60 seconds before servicing the drive. Capacitors retain charge after power is removed.

---



### WARNING!

Leakage current may exceed 3.5mA AC. Minimum size of the protective earth conductor shall comply with local safety regulations for high leakage current equipment.

---



### STOP!

Under no circumstances should power and control wiring be bundled together. Induced voltage can cause unpredictable behavior in any electronic device, including motor controls.

---

Refer to section 5.1.1 for Power wiring specifications.

## 4.2 Shielding and grounding

### 4.2.1 General guidelines

Lenze recommends the use of single-point grounding (SPG) for panel-mounted controls. Serial grounding (a “daisy chain”) is not recommended. The SPG for all enclosures must be tied to earth ground at the same point. The system ground and equipment grounds for all panel-mounted enclosures must be individually connected to the SPG for that panel using 14 AWG (2.5 mm<sup>2</sup>) or larger wire.

In order to minimize EMI, the chassis must be grounded to the mounting. Use 14 AWG (2.5 mm<sup>2</sup>) or larger wire to join the enclosure to earth ground. A lock washer must be installed between the enclosure and ground terminal. To ensure maximum contact between the terminal and enclosure, remove paint in a minimum radius of 0.25 in (6 mm) around the screw hole of the enclosure.

Lenze recommends the use of the special PositionServo 940 drive cables provided by Lenze. If you specify cables other than those provided by Lenze, please make certain all cables are shielded and properly grounded.

It may be necessary to earth ground the shielded cable. Ground the shield at both the drive end and at the motor end.

If the PositionServo 940 drive continues to pick up noise after grounding the shield, it may be necessary to add an AC line filtering device and/or an output filter (between drive and servo motor).

## EMC

Compliance with EN 61800-3/A11

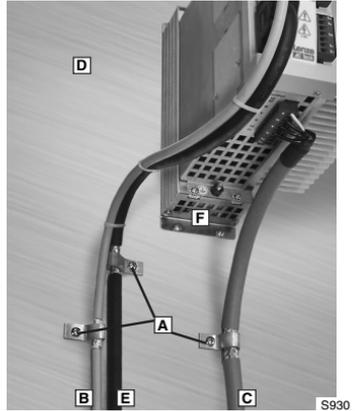
This is a product of the restricted sales distribution class according to IEC 61800-3. In a domestic environment this product may cause radio interference in which the user may be required to take adequate measures

### Noise emission

Drive Models ending in the suffix "2F" are in compliance with class A limits according to EN 55011 if installed in a control cabinet and the motor cable length does not exceed 10m. Models ending in "N" will require an appropriate line filter.

- A** Screen clamps
- B** Control cable
- C** Low-capacitance motor cable  
(core/core < 75 pF/m, core/screen < 150 pF/m)
- D** Earth grounded conductive mounting plate
- E** Encoder Feedback Cable
- F** Footprint or Sidemount Filter (optional)

### Installation according to EMC Requirements



## 4.2.2 EMI Protection

Electromagnetic interference (EMI) is an important concern for users of digital servo control systems. EMI will cause control systems to behave in unexpected and sometimes dangerous ways. Therefore, reducing EMI is of primary concern not only for servo control manufacturers such as Lenze, but the user as well. Proper shielding, grounding and installation practices are critical to EMI reduction.

## 4.2.3 Enclosure

The panel in which the PositionServo 940 is mounted must be made of metal, and must be grounded using the SPG method outlined in section 4.2.1.

Proper wire routing inside the panel is critical; power and logic leads must be routed in different avenues inside the panel.

You must ensure that the panel contains sufficient clearance around the drive. Refer to Section 3.2 suggested cooling air clearance.

## 4.3 Line filtering

In addition to EMI/RFI safeguards inherent in the PositionServo 940 design, external filtering may be required. High frequency energy can be coupled between the circuits via radiation or conduction. The AC power wiring is one of the most important paths for both types of coupling mechanisms. In order to comply with IEC61800-3, an appropriate filter must be installed within 20cm of the drive power inputs.

Line filters should be placed inside the shielded panel. Connect the filter to the incoming power lines immediately after the safety mains and before any critical control components. Wire the AC line filter as close as possible to the PositionServo 940 drive.



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**Note**

The ground connection from the filter must be wired to solid earth ground, not machine ground.

---

If the end-user is using a CE-approved motor, the AC filter combined with the recommended motor and encoder cables, is all that is necessary to meet the EMC directives listed herein. The end user must use the compatible filter to comply with CE specifications. The OEM may choose to provide alternative filtering that encompasses the PositionServo 940 drive and other electronics within the same panel. The OEM has this liberty because CE requirements are for the total system.

## 4.4 Heat sinking

The PositionServo 940 drive contains sufficient heat sinking within the specified ambient operating temperature in their basic configuration. There is no need for additional heat sinking. However, you must ensure that there is sufficient clearance for proper air circulation. As a minimum, you must allow an air gap of 25 mm above and below the drive.

## 4.5 Line (Mains) fusing

External line fuses must be installed on all PositionServo drives. Connect the external line fuse in series with the AC line voltage input. Use fast-acting fuses rated for 250 VAC or 600 VAC (depending on model), and approximately 200% of the maximum RMS phase current.

# 5 PositionServo 940 Connections

The standard PositionServo 940 drive contains seven connectors: four quick-connect terminal blocks, one SCSI connector and two subminiature type “D” connectors. These connectors provide communications from a PLC or host controller, power to the drive, and feedback from the motor. Prefabricated cable assemblies may be purchased from Lenze to facilitate wiring the drive, motor and host computer. Contact your Lenze Sales Representative for assistance.

As this manual makes reference to specific pins on specific connectors, we will use the convention PX.Y where X is the connector number and Y is the pin number.

## 5.1 External Connectors

### 5.1.1 P1 & P7 - Input Power and Output Power Connections

P1 is a 3 or 4-pin quick-connect terminal block used for input (mains) power. P7 is a 6-pin quick-connect terminal block used for output power to the motor. P7 also has a thermistor (PTC) input for motor over-temperature protection. The tables below identify connector pin assignments.

**DANGER!**

Hazard of electrical shock! Circuit potentials are up to 480 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Disconnect incoming power and wait 60 seconds before servicing drive. Capacitors retain charge after power is removed.

**STOP!**

DO NOT connect incoming power to the output motor terminals (U, V, W)! Severe damage to the PositionServo will result.

All conductors must be enclosed in one shield and jacket around them. The shield on the drive end of the motor power cable should be terminated to the conductive machine panel using screen clamps as shown in section 4.2. The other end should be properly terminated at the motor shield. Feedback cable shields should be terminated in a like manner. Lenze recommends Lenze cables for both the motor power and feedback. These are available with appropriate connectors and in various lengths. Contact your Lenze representative for assistance.

**Wire Size**

Current (Arms)	Terminal Torque (lb-in)	Wire Size
$I \leq 8$	4.5	16 AWG (1.5mm <sup>2</sup> ) or 14 AWG (2.5mm <sup>2</sup> )
$8 < I \leq 12$	4.5	14 AWG (2.5mm <sup>2</sup> ) or 12 AWG (4.0mm <sup>2</sup> )
$12 < I \leq 15$	4.5	12 AWG (4.0mm <sup>2</sup> )
$15 < I \leq 20$	5.0 - 7.0	10 AWG (6.0mm <sup>2</sup> )
$20 < I \leq 24$	11.0 - 15.0	10 AWG (6.0mm <sup>2</sup> )

**P1 PIN ASSIGNMENTS (INPUT POWER)**

Pin	Standard Models		Doubler Models	
	Name	Function	Name	Function
1	PE	Protective Earth (Ground)	PE	Protective Earth (Ground)
2	L1	AC Power in	N	AC Power Neutral (120V Doubler only)
3	L2	AC Power in	L1	AC Power in
4	L3	AC Power in (3- models only)	L2/N	AC Power in (non-doubler operation)

**P7 PIN ASSIGNMENTS (OUTPUT POWER)**

Pin	Terminal	Function
1	T1	Thermistor (PTC) Input
2	T2	Thermistor (PTC) Input
3	U	Motor Power Out
4	V	Motor Power Out
5	W	Motor Power Out
6	PE	Protective Earth (Chassis Ground)

## 5.1.2 P2 - Serial Communications Port

P2 is a 9-pin D-sub connector that is used to communicate with a host computer via standard RS-232 interface using a proprietary Point-to-Point Protocol (PPP). This port is present on all Model 94 and 940 drives. All levels must be RS-232C compliant.

### P2 PIN ASSIGNMENTS (COMMUNICATIONS)

Pin	Name	Function
1	RESERVED	
2	TX	RS-232 (transmit)
3	RX	RS-232 (receive)
4	RESERVED	
5	GND	Common
6	RESERVED	
7	RESERVED	
8	RESERVED	
9	RESERVED	



#### STOP!

Do not make any connection to Reserved pins!



#### Note

If you purchase serial cables from a third party, you must use a pass-through cable, not Null-Modem (not crossover)

## 5.1.3 P3 - Controller Interface

P3 is a 50-pin SCSI connector for interfacing to the front-end of the controllers. It is strongly recommended that you use OEM cables to aid in satisfying CE requirements. Contact your Lenze representative for assistance.

### P3 PIN ASSIGNMENTS (CONTROLLER INTERFACE)

Pin	Name	Function
1	MA+	Master Encoder A+ / Step+ input <sup>(2)</sup>
2	MA-	Master Encoder A- / Step- input <sup>(2)</sup>
3	MB+	Master Encoder B+ / Direction+ input <sup>(2)</sup>
4	MB-	Master Encoder B- / Direction- input <sup>(2)</sup>
5	GND	Drive Logic Common
6	5+	+5V output
7	BA+	Buffered Encoder Output: Channel A+ <sup>(1)</sup>
8	BA-	Buffered Encoder Output: Channel A- <sup>(1)</sup>
9	BB+	Buffered Encoder Output: Channel B+ <sup>(1)</sup>
10	BB-	Buffered Encoder Output: Channel B- <sup>(1)</sup>
11	BZ+	Buffered Encoder Output: Channel Z+ <sup>(1)</sup>
12	BZ-	Buffered Encoder Output: Channel Z- <sup>(1)</sup>
13-19		Empty
20	AIN2+	Positive (+) of Analog signal input
21	AIN2-	Negative (-) of Analog signal input
22	ACOM	Analog common
23	AO	Analog output

24	AIN1+	Positive (+) of Analog signal input
25	AIN1 -	Negative (-) of Analog signal input
26	IN_A_COM	Digital input group ACOM terminal <sup>(3)</sup>
27	IN_A1	Digital input A1
28	IN_A2	Digital input A2
29	IN_A3	Digital input A3 <sup>(3)</sup>
30	IN_A4	Digital input A4
31	IN_B_COM	Digital input group BCOM terminal
32	IN_B1	Digital input B1
33	IN_B2	Digital input B2
34	IN_B3	Digital input B3
35	IN_B4	Digital input B4
36	IN_C_COM	Digital input group CCOM terminal
37	IN_C1	Digital input C1
38	IN_C2	Digital input C2
39	IN_C3	Digital input C3
40	IN_C4	Digital input C4
41	RDY+	Ready output Collector
42	RDY-	Ready output Emitter
43	OUT1-C	Programmable output #1 Collector
44	OUT1-E	Programmable output #1 Emitter
45	OUT2-C	Programmable output #2 Collector
46	OUT2-E	Programmable output #2 Emitter
47	OUT3-C	Programmable output #3 Collector
48	OUT3-E	Programmable output #3 Emitter
49	OUT4-C	Programmable output #4 Collector
50	OUT4-E	Programmable output #4 Emitter

<sup>(1)</sup> See Note 1, Section 5.1.7 - Connector and Wiring Notes

<sup>(2)</sup> See Note 2, Section 5.1.7 - Connector and Wiring Notes

<sup>(3)</sup> See Note 3, Section 5.1.7 - Connector and Wiring Notes

## 5.1.4 P4 - Motor Feedback / second loop encoder input

P4 is a 15-pin DB connector that contains connections for Hall Effect sensors and incremental encoder feedback. Refer to the P4 pin assignments table for the connector pin assignments. Encoder inputs on P4 have 26LS32 or compatible differential receivers for increased noise immunity. Inputs have all necessary filtering and line balancing components so no external noise suppression networks are needed.

All conductors must be enclosed in one shield and jacket around them. Lenze recommends that each and every pair (for example, EA+ and EA-) be twisted. In order to satisfy CE requirements, use of an OEM cable is recommended. Contact your Lenze representative for assistance.

The PositionServo 940 buffers encoder feedback from P4 to P3. Encoder Feedback channel A on P4, for example, is Buffered Encoder Output channel A on P3. The Hall sensors from the motor must be wired to the 15-pin connector (P4).



## STOP!

Use only +5 VDC encoders. Do not connect any other type of encoder to the PositionServo 940 reference voltage terminals. When using a front-end controller, it is critical that the +5 VDC supply on the front-end controller NOT be connected to the PositionServo 940's +5 VDC supply, as this will result in damage to the PositionServo 940.



## Note

- The PositionServo 940 encoder inputs are designed to accept differentially driven hall signals. Single-ended or open-collector type hall signals are also acceptable by connecting "HA+", "HB+", "HC+" and leaving "HA-, HB-, HC-" inputs unconnected. You do not need to supply pull-up resistors for open-collector hall sensors. The necessary pull-up circuits are already provided.
- Encoder connections (A, B, and Z) must be full differential. PositionServo doesn't support single-ended or open-collector type outputs from the encoder.
- An encoder resolution of 2000 PPR (pre-quadrature) or higher is recommended.

## Using P4 as second encoder input for dual-loop operation.

P4 can be used as a second loop encoder input in situations where the motor is equipped with a resolver as the primary feedback. If such a motor is used, the drive must have a resolver feedback option module installed. A second encoder can then be connected to the A and B lines of the P4 connector for dual loop operation. See "Dual loop feedback operation" for details (Section 8.4).

## P4 PIN ASSIGNMENTS (ENCODER)

Pin	Name	Function
1	EA+	Encoder Channel A+ Input <sup>(1)</sup>
2	EA-	Encoder Channel A- Input <sup>(1)</sup>
3	EB+	Encoder Channel B+ Input <sup>(1)</sup>
4	EB-	Encoder Channel B- Input <sup>(1)</sup>
5	EZ+	Encoder Channel Z+ Input <sup>(1)</sup>
6	EZ-	Encoder Channel Z- Input <sup>(1)</sup>
7	GND	Drive Logic Common/Encoder Ground
8	SHLD	Shield
9	PWR	Encoder supply (+5VDC)
10	HA-	Hall Sensor A- Input
11	HA+	Hall Sensor A+ Input
12	HB+	Hall Sensor B+ Input
13	HC+	Hall Sensor C+ Input
14	HB-	Hall Sensor B- Input
15	HC-	Hall Sensor C- Input

<sup>(1)</sup> See Note 1, Section 5.1.7 - Connector and Wiring Notes

### 5.1.5 P5 - 24 VDC Back-up Power Input

P5 is a 2-pin quick-connect terminal block that can be used with an external 24 VDC (500mA) power supply to provide “Keep Alive” capability: during a power loss, the logic and communications will remain active. Applied voltage must be greater than 20VDC.

#### P5 PIN ASSIGNMENTS (BACK-UP POWER)

Pin	Name	Function
1	+24 VDC	Positive 24 VDC Input
4	Return	24V power supply return



#### WARNING!

Hazard of unintended operation! The “Keep Alive” circuit will restart the motor upon restoration of mains power when the enable input remains asserted. If this action is not desired, then the enable input must be removed prior to re-application of input power.

### 5.1.6 P6 - Braking Resistor and DC Bus

P6 is a 5-pin quick-connect terminal block that can be used with an external braking resistor (the PositionServo 940 has the regen circuitry built-in). The Brake Resistor connects between the Positive DC Bus (either P6.1 or 2) and P6.3.

#### P6 TERMINAL ASSIGNMENTS (BRAKE RESISTOR AND DC BUS)

Pin	Terminal	Function
1	B+	Positive DC Bus / Brake Resistor
2	B+	
3	BR	Brake Resistor
4	B-	Negative DC Bus
5	B-	

### 5.1.7 Connectors and Wiring Notes

#### Note 1 - Encoder Inputs

Each of the encoder output pins on P3 is a buffered pass-through of the corresponding input signal on P4. This can be either from a motor mounted (primary feedback) encoder or from an auxiliary encoder when a resolver is the primary feedback device on the motor.

Via software, these pins can be re-programmed to be a buffered pass through of the signals from a feedback option card. This can be either the second encoder option module (E94ZAENC1) or an encoder emulation of the resolver connected to the resolver option module (E94ZARSV1, E94ZARSV2 or E94ZARSV3).

#### Note 2 - Encoder Outputs

An external pulse train signal (“step”) supplied by an external device, such as a PLC or stepper indexer, can control the speed and position. of the servomotor. The speed of the motor is controlled by the frequency of the “step” signal, while the number of pulses that are supplied to the PositionServo 940 determines the position of the servomotor. “DIR” input controls direction of the motion.

### Note 3 - Digital Input

The ENABLE pin (IN\_A3, P3.29) must be wired through a switch or an output on a front-end controller to digital input common (IN\_ACOM, P3.26). If a controller is present, it should supervise the PositionServo 940's enable function. The ENABLE circuit will accept 5-24V control voltage.

## 5.1.8 P11 - Resolver interface module (Option Module)

PositionServo drives can operate motors equipped with resolvers. Resolver connections are made to a 9 pin D-shell female connector (P11) on the resolver option module E94ZARSV2 (scalable) or E94ZARSV3 (standard). When the motor profile is loaded from the motor database or from a custom motor file, the drive will select the primary feedback source based on the motor data entry.

When using a Lenze motor with resolver feedback and a Lenze resolver cable, the pins are already configured for operation. If a non-Lenze motor is used, the resolver connections are made as follows:

### P11 PIN ASSIGNMENTS (Resolver Feedback)

Pin	Name	Function
1	Ref +	Resolver reference connection
2	Ref -	
3	N/C	No Connection
4	Cos+	Resolver Cosine connections
5	Cos-	
6	Sin+	Resolver Sine connections
7	Sin-	
8	PTC+	Thermal sensor
9	PTC-	



### STOP!

Use only 10 V (peak to peak) or less resolvers. Use of higher voltage resolvers may result in feedback failure and damage to the resolver option module.

### 5.1.9 P12 - Second encoder interface module (Option Bay 2)

PositionServo drives can support a second incremental encoder interface for dual-loop systems. Depending on the motor's primary feedback type (encoder or resolver) a second encoder can be connected as follows:

- If the primary motor feedback is an encoder (connected to P4), the second encoder interfaces through the encoder option module (E94ZAENC1) at P12 on Option Bay 2.
- If the motor primary feedback is a resolver connected to the resolver option module (E94ZARSV1) at P11 on Option Bay 2, the second encoder connects to the P4 connector on the drive. In this case, the hall inputs on P4 are not used.

The 2nd Encoder Option Module includes a 9 pin D-shell male connector. When using a Lenze motor with encoder feedback and a Lenze encoder cable, the pins are already configured for operation. If a non-Lenze motor is used, the encoder connections are made as follows:

#### P12 PIN ASSIGNMENTS (Second Encoder Feedback)

Pin	Name	Function
1	E2B+	Second Encoder Channel B+ Input
2	E2A-	Second Encoder Channel A- Input
3	E2A+	Second Encoder Channel A+ Input
4	+5v	Supply voltage for Second Encoder
5	COM	Supply common
6	E2Z-	Second Encoder Channel Z- Input
7	E2Z+	Second Encoder Channel Z+ Input
8	N/C	No Connection
9	E2B-	Second Encoder Channel B- Input

The second encoder needs to be enabled using MotionView software. See section "Dual-loop feedback" (Section 8.4) for details.



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#### STOP!

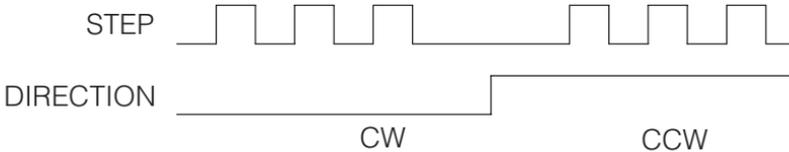
Use only +5 VDC encoders. Do not connect any other type of encoder to the option module otherwise damage to drive's circuitry may result.

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## 5.2 Digital I/O details

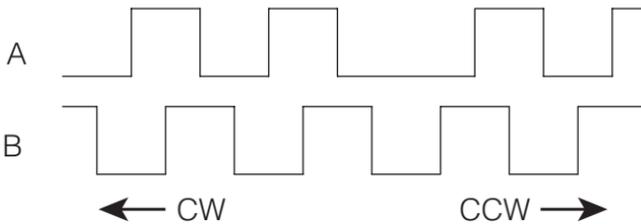
### 5.2.1 Step & Direction / Master Encoder Inputs (P3, pins 1-4)

You can connect a master encoder with quadrature outputs or a step and direction pair of signals to control position in step / direction operating mode (stepper motor emulation). These inputs are optically isolated from the rest of the drive circuits and from each other. Both inputs can operate from any voltage source in the range of 5 to 24 VDC and do not require additional series resistors for normal operation.



Timing characteristics for Step And Direction signals

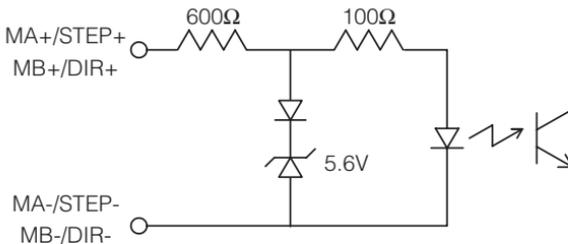
S904



Timing characteristics for Master Encoder signals

S905

Input type/ output compatibility	Insulated, compatible with Single-ended or differential outputs (5-24 VDC)
Max frequency (per input)	2 MHz
Min pulse width (negative or positive)	500nS
Input impedance	700 $\Omega$ (approx)



Master encoder/step and direction input circuit

S906

Differential signal inputs are preferred when using Step and Direction. Single ended inputs can be used but are not recommended. Sinking or sourcing outputs may also be connected to these inputs. The function of these inputs "Master Encoder" or "Step and Direction" is software selectable. Use MotionView set up program to choose desirable function.

## 5.2.2 Digital outputs

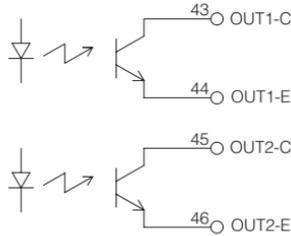
There are a total of five digital outputs (“OUT1” - “OUT4” and “RDY”) available on the PositionServo 940 drive. These outputs are accessible from the P3 connector. Outputs are open collector type that are fully isolated from the rest of the drive circuits. See the following figure for the electrical diagram. These outputs can be either used via the drives internal User Program or they can be configured as Special Purpose outputs. When used as Special Purpose, each output (OUT1-OUT4) can be assigned to one of the following functions:

- Not assigned
- Zero speed
- In-speed window
- Current limit
- Run-time fault
- Ready
- Brake (motor brake release)

Please note that if you assign an output as a Special Purpose Output then that output can not be utilized by the User Program. The “RDY” Output has a fixed function, “ENABLE”, which will become active when the drive is enabled and the output power transistors becomes energized.

### Digital outputs electrical characteristics

Circuit type	Isolated Open Collector
Digital outputs load capability	100mA
Digital outputs Collector-Emitter max voltage	30V



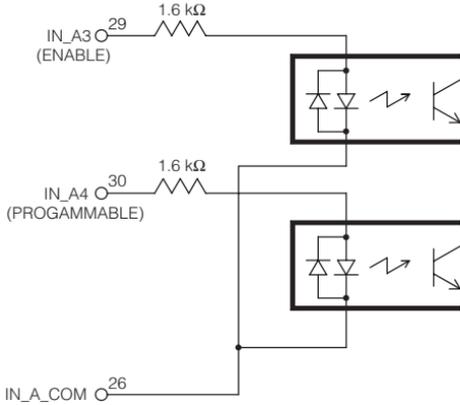
S907

**Digital outputs circuit**

### 5.2.3 Digital inputs

#### IN\_Ax, IN\_Bx, IN\_Cx (P3.26-30, P3.31-35, P3.36-40).

The PositionServo 940 Drive has 12 optically isolated inputs. These inputs are compatible with a 5 -24V voltage source. No additional series resistors are needed for circuit operation. The 12 inputs are segmented into three groups of 4, Inputs A1 - A4, Inputs B1 - B4, and Inputs C1 - C4. Each group, (A, B and C) have their own corresponding shared COM terminal, (ACOM, BCOM and CCOM). All inputs have separate software adjustable de-bounce time. Some of the inputs can be set up as Special Purpose Inputs. For example inputs A1 and A2 can be configured as limit inputs, input A3 can be set up as an Enable input and input C4 can be used as a registration input. Reference the 940 Programming Manual for more detail.



S908

**Digital inputs circuit.**

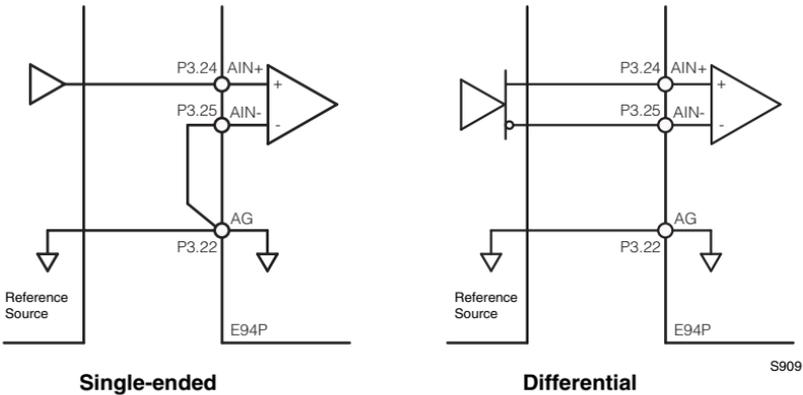
## 5.3 Analog I/O details

### 5.3.1 Analog reference input

#### AIN+, AIN1- (P3.24 and P3.25)

The analog reference input can accept up to a  $\pm 10V$  analog signal across AIN1+ and AIN2-. The maximum limit with respect to analog common (ACOM) on each input is  $\pm 18VDC$ . The analog signal will be converted to a digital value with 16 bit resolution (15 bit plus sign). This input is used to control speed or torque of the motor in velocity or torque mode. The total reference voltage as seen by the drive is the voltage difference between AIN1+ and AIN1-. If used in single-ended mode, one of the inputs must be connected to a voltage source while the other one must be connected to Analog Common (ACOM). If used in differential mode, the voltage source is connected across AIN+ and AIN- and the driving circuit common (if any) needs to be connected to the drive Analog Common (ACOM) terminal.

Reference as seen by drive:  $V_{ref} = (AIN1+) - (AIN1-)$  and  $-10V \leq V_{ref} \leq +10V$



Single-ended

Differential

#### AIN2+, AIN2- (P3.20 and P3.21)

The analog reference input can accept up to a  $\pm 10V$  analog signal across AIN2+ and AIN2-. The maximum limit with respect to analog common (ACOM) on each input is  $\pm 18VDC$ . The analog signal will be converted to a digital value with 10 bit resolution (9 bit plus sign). This input is available to the User's program. This input does not have a predefined function. Scaling of this input is identical to AIN1.

### 5.3.2 Analog output

#### AO (P3.23)

The analog output is a single-ended signal (with reference to Analog Common (ACOM)) which can represent the following Motor data:

- Not Assigned
- RMS Phase Current
- Peak Phase Current
- Motor Velocity
- Phase U Current
- Phase V Current
- Phase W Current
- Iq current
- Id current

MotionView Setup program can be used to select the signal source for the analog output as well as its scaling.

If the output function is set to "Not Assigned" then the output can be controlled directly from user's program. See the 940 Programming Manual for details on programming.

## 5.4 Communication interfaces

### 5.4.1 RS232 interface (standard)

Programming and diagnostics of the 940 drive is done over the standard RS232 communication port. The baud rate for this port can be configured to one of 7 different settings, ranging from 2400 to 115200. Drives are addressable with up to 32 addresses from 0-31. Communication speed and address are set from the drive's front panel display.

### 5.4.2 RS485 interface (option module)

PositionServo 940 drives can be equipped with an RS485 communication interface option module (E94ZARS41) which is optically isolated from the rest of the drive's circuitry. This option module can be used for two functions: drive programming and diagnostics using MotionView from a PC (with RS485 port) or as a Modbus RTU slave. The 940 family of drives support 7 different baud rates, ranging from 2400 to 115200. Drives are addressable with up to 32 addresses from 0-31. The factory setting for the baud rate is 38,400 with a node address of "1". The drives address must be set from the front panel display of the drive. When used with MotionView software, the communication speed is also set from the front panel display. Please note that baud rate and address are applied to both RS232 and RS485 interfaces in this case. If used for Modbus RTU communications, the Modbus baud rate is set as a parameter within MotionView.

#### PIN ASSIGNMENTS (RS485 interface)

Pin	Name	Function
1	ICOM	Isolated Common
2	TXB	Transmit B
3	TXA	Transmit A

### 5.4.3 Using RS232 and RS485 interfaces simultaneously

When establishing communication between MotionView and a 940 drive, a communication method must be selected. The connection choice can be either "UPP over RS485/RS232" or "Ethernet". The "UPP over RS485/RS232" selection establishes a RS232 connection between MotionView and the first drive on the network. Multiple drives can then be added to the network via RS485. Each drive on the network will have a different Node Address. When setting up communications the node address of the target drive must be set. MotionView will then send out a communications packet to the first drive on the network, via the RS232 connection. If the node address set in this packet doesn't match the node address of the drive, the drive will resend the packet, via RS485, to the next drive on the network. This process will continue until the target drive is reached. The following message, "Device with address # not present in the network" will appear if the target node could not be found.

## 5.4.4 MODBUS RTU support

As a default, the RS232 and RS485 interfaces are configured to support MotionView program operations. In addition, the RS485 interface can be configured to support the MODBUS RTU slave protocol. The interface can be configured through the MotionView program. When configured for MODBUS operation, the baud rate for RS485 is set by the parameter "Modbus baud rate" in MotionView, while the RS232 baud rate is set on the drive's front panel. Thus RS485 and RS232 can have different speeds at the same time if RS485 is configured for MODBUS operation. Please note that if RS485 is configured for MODBUS operation, the command repeat function (see 5.4.3) is unavailable even if baud rates are set the same for both interfaces.

The Modbus RTU slave interface protocol definitions can be found in the MotionView help menu under "Product Manuals".

## 5.5 Motor Selection

The PositionServo 940 drive is compatible with many 3-phase AC synchronous servo motors. MotionView is equipped with a motor database which contains over 600 motors for use with the 940 drive. If the desired motor is in the database, no data to set it up is needed. Just select the motor and click "OK". However, if your motor is not in the database, it can still be used, but some electrical and mechanical data will need to be provided to create a custom motor profile. The auto-phasing feature of the 940 allows the user to correctly determine the relationship between phase voltage and hall sensor signals, eliminating the need to use a multi-channel oscilloscope.

### 5.5.1 Motor connection.

Motor phase U, V, W (or R, S, T) are connected to terminal P7. It is very important that motor cable shield is connected to Earth ground terminal (PE) or the drive's case.

The motor feedback cable must be connected to encoder terminal P4 if the motor is equipped with an incremental encoder. If the motor is equipped with a resolver it needs to be connected to terminal P11 on the resolver option module.

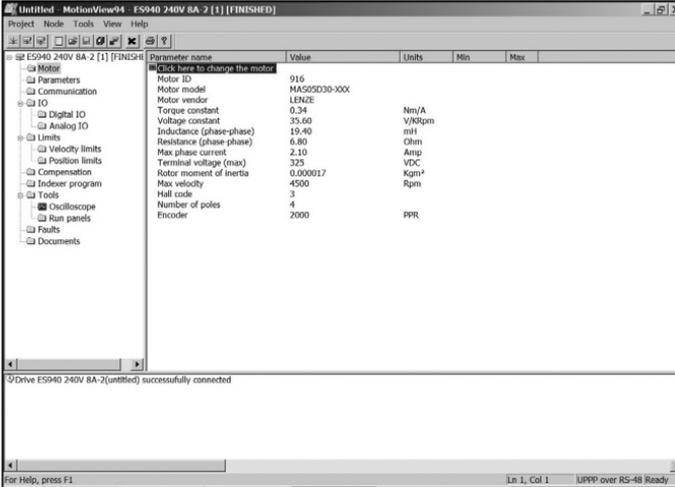
### 5.5.2 Motor over-temperature protection

If using a motor equipped with an encoder and PTC thermal sensor, the encoder feedback cable will have flying leads exiting the P4 connector to be wired to the P7.1 (T1) and P7.2 (T2) terminals. If using a motor equipped with a Resolver and a PTC sensor, the connector on the Resolver Option Module (P11) provides this connection.

Use parameter "Motor PTC cut-off resistance" (see section 6.3.12) to set the resistance which corresponds to maximum motor allowed temperature. The parameter "Motor temperature sensor" must also be set to ENABLE. If the motor doesn't have a PTC sensor, set this parameter to DISABLE. This input will also work with N.C. thermal switches which have only two states; Open or Closed. In this case "Motor PTC cut-off resistance" parameter can be set to the default value.

## 5.5.3 Motor set-up

Once you are connected to the PositionServo 940 via MotionView a “Parameter Tree” will appear in the “Parameter Tree Window”. The various parameters of the drive are shown here as folders and files. If the “Motor” folder is selected, all motor parameters can be viewed in the “Parameter View Window”. To view selected motor parameters or to select a new motor click the section marked “CLICK HERE TO CHANGE”.



### MotionView's “Motor Group” folder and its contents

S911



#### Note

If the drive is ENABLED, a new motor cannot be set. You can only set a new motor when the drive is DISABLED.

#### To View selected motor parameters or to make a new motor selection:

- Click “Click here to change the motor” from the Parameter View Window (see figure above). If you are just viewing motor parameters click Cancel on Motor Parameters dialog when done to dismiss the dialog box.
- Select motor Vendor from the right list box and desired motor from the left list box.
- If you will be using a “custom” motor (not listed in our motor database) go to “Using a custom motor” topic in the next section.
- Finally, click the OK button to dismiss the dialog and return to MotionView's main program.

## 5.6 Using a custom motor

You can load a custom motor from a file or you can create a new custom motor.

- To create a custom motor click “CREATE CUSTOM” and follow the instructions in the next section “Creating custom motor parameters”.
- To load a custom motor click “OPEN CUSTOM” button then select the motor file and click the “OPEN” button to select or click the “CANCEL” button to return to the previous dialog box.
- Click OK to load the motor data and return to the main MotionView menu or Cancel to abandon changes. When clicking OK for a custom motor, a dialog box will appear asking if you want to execute “Autophasing” (see section 5.6.2).

### 5.6.1 Creating custom motor parameters



#### STOP!

Use extreme caution when entering custom parameters! Incorrect settings may cause damage to the drive or motor! If you are unsure of the settings, refer to the materials that were distributed with your motor, or contact the motor manufacturer for assistance.

1. Enter custom motor data in the Motor Parameters dialog fields. Complete all sections of dialog: Electrical, Mechanical, Feedback. See Section 6.8.3 for explanation of motor parameters and how to enter them.



#### Note

If unsure of the motor halls order and encoder channels A and B relationship, leave “B leads A for CW”, “Halls order” and “inverted” fields as they are. You can execute autophasing (see section 5.6.2) to set them correctly.

2. Enter motor model and vendor in the top edit boxes. Motor ID cannot be entered, this is set to 0 for custom motors.
3. Click “Save File” button and enter filename without extension. Default extension .cmt will be given when you click OK on file dialog box.



#### Note

Saving the file is necessary even if the autophasing feature will be used and some of the final parameters are not known. After autophasing is completed the corrected motor file can be updated before loading it to memory.

4. Click OK to exit from the Motor Parameters dialog.
5. MotionView will ask if you want to autophase your custom motor. If you answer “No”, the motor data will be loaded immediately to the drive’s memory. If you answer “Yes”, the motor dialog will be dismissed and the drive will start the autophasing sequence. Refer to section 5.6.2 for autophasing information.
6. If you answered “Yes” for autophasing, you will be returned to the same motor selection dialog box after autophasing is complete. For motors with incremental encoders, the fields “B leads A for CW”, “Halls order” and “inverted” will be assigned correct values. For motors with resolvers, the fields “Offset in degree” and “CW for positive” will be assigned correct values.
7. Click “Save File” to save the custom motor file and then click “OK” to exit the dialog box and load the data to the drive.

## 5.6.2 Autophasing

The Autophasing feature determines important motor parameters when using a motor that is not in MotionView's database. For motors equipped with incremental encoders, Autophasing will determine the Hall order sequence, Hall sensor polarity and encoder channel relationship (B leads A or A leads B for CW rotation). For motors equipped with resolvers, Autophasing will determine resolver angle offset and angle increment direction ("CW for positive").

### To perform autophasing:

1. Complete the steps in the previous section "Setting custom motor parameters". If the motor file you are trying to autophase already exists, simply load it as described under "Using a custom motor" at the beginning of this section.
2. Make sure that the motor's shaft is not connected to any mechanical load and can freely rotate.



### STOP!

Autophasing will energize the motor and will rotate the shaft. Make sure that the motor's shaft is not connected to any mechanical load and can freely and safely rotate.

3. **Make sure that the drive is not enabled.**
4. It is not necessary to edit the field "Hall order" and check boxes "inverted" and "B leads A for CW" as these values are ignored for autophasing.
5. Click OK to dismiss motor selection dialog. MotionView responds with the question "Do you want to perform autophasing?"
6. Click OK. A safety reminder dialog appears. Verify that it is safe to run the motor then click "Proceed" and wait until autophasing is completed.



### Note

If there was a problem with the motor connection, hall sensor connection or resolver connection, MotionView will respond with an error message. Common problems are with power, shield and ground terminations or an improper cable is being used. Correct the wiring problem(s) and repeat steps 1 - 6.

If the error message repeats, exchange motor phases U and V (R and S) and repeat. If problems persist, contact the factory.

7. If autophasing is completed with no error then MotionView will return to the motor dialog box. For motors with incremental encoders, the parameter field "Hall order" and the check boxes "inverted", "B leads A for CW" will be filled in with correct values. For resolver equipped motors, fields "Offset" and "CW for positive" will be correctly set.
8. Click "Save File" to save the completed motor file (you can use the same filename as you use to save initial data in step 1) and click OK to load the motor data to the drive.

## 5.6.3 Custom Motor Data Entry

A Custom Motor file is created by entering motor data into the "Motor Parameters" dialog box. This box is divided up into the following three sections, or frames:

- Electrical constants
- Mechanical constants
- Feedback

When creating a custom motor you must supply all parameters listed in these sections. All entries are mandatory except the motor inertia ( $J_m$ ) parameter. A value of 0 may be entered for the motor inertia if the actual value is unknown.

### 5.6.3.1 Electrical constants

#### Motor Torque Constant (Kt).

Enter the value and select proper units from the drop-down list.



---

**Note**

Round the calculated result to 3 significant places.

---

#### Motor Voltage Constant (Ke).

The program expects Ke to be entered as a phase-to-phase Peak voltage. If you have Ke as an RMS value, multiply this value by 1.414 for the correct Ke Peak value.

#### Phase-to-phase winding Resistance (R) in Ohms ( ).

This is also listed as the terminal resistance (Rt). The phase-to-phase winding Resistance (R) will typically be between 0.05 and 200 Ohms.

#### Phase-to-phase winding Inductance (L).

This must be set in millihenries (mH). The phase-to-phase winding Inductance (L) will typically be between 0.1 and 200.0 mH.



---

**Note**

If the units for the phase-to-phase winding Inductance (L) are given in micro-henries ( $\mu\text{H}$ ), then divide by 1000 to get mH.

---

#### Nominal phase current (RMS Amps)

Nominal continuous phase current rating ( $I_n$ ) in Amps RMS. Do not use the peak current rating.



---

**Note**

Sometimes the phase current rating will not be given. The equation below may be used to obtain the nominal continuous phase-to-phase winding current from other variables.

---

 **$I_n = \text{Continuous Stall Torque} / \text{Motor Torque Constant (Kt)}$** 

---

The same force x distance units must be used in the numerator and denominator in the equation above. If torque (T) is expressed in units of pound-inches (lb-in) then, Kt must be expressed in pound-inches per Amp (lb-in/A). Likewise, if T is expressed in units of Newton-meters (N-m), then units for Kt must be expressed in Newton-meters per Amp (N-m/A).

**Example:**

Suppose that the nominal continuous phase to phase winding current ( $I_n$ ) is not given. Instead, we look up and obtain the following:

Continuous stall torque T = 3.0 lb-in

Motor torque constant Kt = 0.69 lb-in/A

Dividing, we obtain:

$$I_n = 3.0 \text{ lb-in} / 0.69 \text{ lb-in/A} = 4.35 \text{ (A)}$$

Our entry for ( $I_n$ ) would be 4.35.

Note that the torque (lb-in) units cancelled in the equation above leaving only Amps (A). We would have to use another conversion factor if the numerator and denominator had different force x distance units.

## Nominal Bus Voltage (Vbus)

The Nominal Bus Voltage can be calculated by multiplying the Nominal AC mains voltage supplied by 1.41. When using a model with the suffix "S1N" where the mains are wired to the "Doubler" connection, the Nominal Bus Voltage will be doubled.

### Example:

If the mains voltage is 230VAC,  $V_{bus} = 230 \times 1.41 = 325V$

This value is the initial voltage for the drive and the correct voltage will be calculated dynamically depending on the drive's incoming voltage value.

## Rotor Moment of Inertia (Jm)

From motor manufacturer or nameplate.



---

### Note

Round the calculated result to 3 significant places.

---

## Maximum Motor Speed in RPM

This is also listed as "Speed @ Vt" (motor speed at the terminal voltage rating). The maximum motor speed will typically be a round even value between 1000 and 6000 RPM.

## Number of Poles

This is a positive integer number that represents the number of motor poles, normally 2, 4, 6 or 8.

### 5.6.3.2 For motors equipped with incremental encoders only:

#### Encoder Line Count

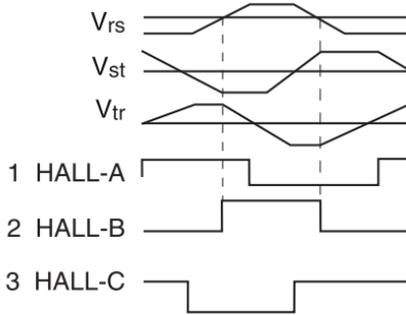
The Encoders for servomotors normally have Line Counts of 1000, 1024, 2000, 2048, 4000, or 4096. The Encoder Line Count must be a positive integer and must be pre-quadature.

#### Index pulse offset. Enter 0 (zero)

Index marker pulse position. This field is reserved for backward compatibility. All PositionServo drives determine actual marker pulse position automatically.

## Halls Order

Each hall signal is in phase with one of the three phase-phase voltages from the motor windings. Hall order number defines which hall sensor matches which phase-phase voltage. Motor phases are usually called R-S-T or U-V-W or A-B-C. Phase-Phase voltages are called  $V_{rs}$ ,  $V_{st}$ ,  $V_{tr}$ . Halls are usually called HALL-A, HALL-B, HALL-C or just Halls 1, 2, 3. A motor's phase diagram is supplied by motor vendor and usually can be found in the motor data sheet or by making a request to the motor manufacturer. A sample phase diagram is shown below.



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### The Halls Order is obtained as follows:

1. By looking at the " $V_{rs}$ " Output Voltage, determine which Hall Voltage is lined up with (or in phase with) this voltage. We can determine which Hall Voltage is in phase with the  $V_{rs}$  Output Voltage by drawing vertical lines at those points where it crosses the horizontal line (zero). The dashed lines at the zero crossings (above) indicate that Hall B output is lined up with (and in phase with) the  $V_{rs}$  Output Voltage.
2. Look at the " $V_{st}$ " Output Voltage. Determine which Hall Voltage is in phase with this Voltage. As can be seen, Hall C output is in phase with the  $V_{st}$  Output Voltage.
3. Look at the " $V_{tr}$ " Output Voltage. Determine which Hall Voltage is in phase with this Voltage. As can be seen, Hall A output is in phase with the  $V_{tr}$  Output Voltage.



#### Note

If hall sensors are in phase with the corresponding phase voltage but are inverted 180 degrees (hall sensor waveform edge aligns with the phase-phase voltage waveform but the positive hall sensor cycle matches the negative phase-phase waveform or visa-versa), you must check the "Inverted" check box.

4. The phases that correspond to the Vrs Vst Vtr voltages are Hall B then Hall C then Hall A or Halls number 2 then 3 then 1. Referring to the following table, we find that 2-3-1 sequence is Halls Order number 3. We would enter 3 for the Halls Order field in motor dialog.

#### HALL ORDER NUMBERS FOR DIFFERENT HALL SEQUENCES

Halls Order	Hall Sequence
0	1-2-3
1	1-3-2
2	2-1-3
3	2-3-1
4	3-1-2
5	3-2-1



#### Note

Each Hall Voltage will be in phase with one and only one Output Voltage.

#### B leads A for CW.

This is the encoder phase relationship for CW/CCW shaft rotation. When you obtain the diagram for your motor phasing similar to shown above, it's assumed by the software that the motor shaft rotates CW when looking at the mounting face of the motor. For that rotation Encoder phase A must lead phase B. If it does leave check box unchecked. Otherwise (if B leads A ) check B leads A for CW box.



#### Note

Lenze convention references the shaft direction of rotation from the front (shaft end) of the motor. Some manufacturers' timing diagrams are CW when viewed from the "rear" of the motor.

#### 5.6.3.3 For resolver equipped motors only:

If parameter "Resolver" is checked, following parameters appear on the form:

##### Offset in degree (electrical )

This parameter represents offset between resolver's "0 degree" and motor's windings "0 degree".

##### CW for positive

This parameter sets the direction for positive angle increment.

"Offset in degree" and "CW for positive" will be set during Auto-Phasing of the motor.

## 6 Programmable Features and Parameters

All PositionServo 940 series drives are configured through one of the interfaces: RS232, RS485 or Ethernet. The drives have many programmable and configurable features and parameters. These features and parameters are accessible via a universal software called MotionView. Please refer to the MotionView Manual for details on how to make a connection to the drive and change parameter values.

This chapter covers programmable features and parameters specific to the PositionServo Model 940 drive in the order they appear in the Parameter Tree of MotionView. Programmable parameters are divided into groups. Each group holds one or more user's adjustable parameters.

All 940 series drives can execute a User Program in parallel with motion. Motion can be specified by variety of sources and in three different modes:

- Torque
- Velocity
- Position

In Torque and Velocity mode Reference can be taken from Analog Input AIN1 or from the User Program by setting a particular variable (digital reference). See Programmer's Manual for details on programming. In Position mode, the reference could be taken from MA/MB master encoder/step and directions inputs (available in terminal P3) or from trajectory generator. Access to the trajectory generator is provided through the User Program's motion statements, MOVE<sub>x</sub> and MDV. See Programmer's Manual for details on programming.

Whether the reference comes from an external device, (AIN1 or MA/MB ) or from the drives internal variables (digital reference and trajectory generator) will depend on the parameter settings. Refer to "Parameters" group in MotionView.

### 6.1 Parameters storage and EPM operation

#### 6.1.1 Parameter's storage

All settable parameters are stored in the drive's internal non-volatile memory. Parameters are saved automatically when they are changed. In addition, parameters are copied to the EPM memory module located on the drive's front panel. In the unlikely event of drive failure, the EPM can be removed and inserted into the replacement drive, thus making an exact copy of the drive being replaced. This shortens down time by eliminating the configuration procedure. The EPM can also be used for replication of the drive's settings.

#### 6.1.2 EPM operation

When the drive is powered up it first checks for a white EPM in the EPM Port. If the EPM Port is empty, no further operation is possible until a white EPM is installed into the EPM Port. The drive will display "E<sub>P</sub>-" until an EPM is inserted.

If a different color EPM is inserted the drive may appear to function however, some operations will not be correct and the drive may hang. The White EPM is the only acceptable EPM for the PositionServo 940 drive. If a white EPM is detected, the drive compares data in the EPM to that in its internal memory. In order for the drive to operate, the contents of the drive's memory and EPM must be the same. Press the enter button to load the EPM, this will take a moment.



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#### STOP!

If the EPM contains any data from an inverter drive, that data will be overwritten during this procedure.

---

### 6.1.3 EPM fault

If the EPM fails during operation or the EPM is removed from the EPM Port the drive will generate a fault and will be disabled (if enabled). The fault is logged to the drives memory. Further operation is not possible until the EPM is replaced (inserted) and the drive's power is cycled. The fault log on the display shows "F\_EP" fault.

## 6.2 Motor Group

The motor group shows the data for the currently selected motor. Refer to Section 5.5 for details on how to select another motor from the motor database or to configure a custom motor.

## 6.3 Parameters Group

### 6.3.1 Drive operating modes

The PositionServo has 3 operating mode selections: Torque, Velocity, and Position.

**For Torque and Velocity modes** the drive will accept an analog input voltage on the AIN+ and AIN- pins of P3 (see section 5.3.1). This voltage is used to provide a torque or speed reference.

**For Position mode** the drive will accept step and direction logic signals or a quadrature pulse train on pins P3.11-14.

#### 6.3.1.1 Velocity mode

In velocity mode, the servo controller regulates motor shaft speed (velocity) proportional to the analog input voltage at input AIN1, if parameter "Reference" is set to "External". Otherwise the reference is taken from the drive's internal variable. (See Programmer's manual for details).

For analog reference, Target speed (set speed) is calculated using the following formula:

$$\text{Set Velocity (RPM)} = \text{Vinput (Volt)} \times \text{Vscale (RPM/Volt)}$$

where:

- Vinput is the voltage at analog input (AIN+ and AIN-)
- Vscale is the velocity scale factor (input sensitivity) set by the Analog input (Velocity scale) parameter (section 6.3.6).

$$\text{Set Velocity (RPM)} = \text{Vinput (Volt)} \times \text{Vscale (RPM/Volt)}$$

#### 6.3.1.2 Torque mode

In torque mode, the servo control provides a current output proportional to the analog input signal at input AIN1, if parameter "Reference" is set to "External". Otherwise the reference is taken from the drive's internal variable. (See Programmer's manual for details).

For analog reference "Set Current", (current the drive will try to provide), is calculated using the following formula:

$$\text{Set Current(A)} = \text{Vinput(Volt)} \times \text{Iscale (A/Volt)}$$

where:

- Vinput is the voltage at analog input
- Vscale is the current scale factor (input sensitivity) set by the Analog input (Current Scale) parameter (section 6.5.2).

### 6.3.1.3 Position mode

In this mode the drive reference is a pulse-train applied to P3.1-4 terminals, if the parameter "Reference" is set to "External". Otherwise the reference is taken from the drive's internal variable. (See Programmer's manual for details).

P3.1-4 inputs can be configured for two types of signals: step and direction and Master encoder quadrature signal. Refer to section 5.2.1 for details on these inputs connections. Refer to section 8.3 for details about positioning and gearing.

When the Reference is set to Internal, the drives reference position, (theoretical or Target position), is generated by trajectory generator. Access to the trajectory generator is provided by motion statements, MOVEx and MDV, from the User Program. See Programmer's manual for details

### 6.3.2 Drive PWM frequency

This parameter sets the PWM carrier frequency. Frequency can be changed only when the drive is disabled. Maximum overload current is 300% of the drive rated current when the carrier is set to 8kHz, it is limited to 250% at 16kHz.

### 6.3.3 Current Limit

The CURRENT LIMIT setting determines the nominal current, in amps RMS per phase.

### 6.3.4 8 kHz Peak current limit and 16 kHz Peak current limit

Peak current sets the motor RMS phase current that is allowed for up to 2 seconds. After this two second limit, the current limit will be reduced to the value set in the Current Limit parameter. When the motor current drops below nominal current for two seconds, the drive will automatically re-enable the peak current level. This technique allows for high peak torque on demanding fast moves and fast start/stop operations with high regulation bandwidth. The control will use only the Peak current limit parameter for the carrier frequency selected.

### 6.3.5 Analog input scale (Current scale)

This parameter sets the analog input sensitivity for current reference used when the drive operates in Torque mode. Units for this parameter are A/Volt. To calculate this value use the following formula:

$$I_{scale} = I_{max} / V_{in\ max}$$

$I_{max}$             maximum desired output current (motor phase current RMS)  
 $V_{in\ max}$         max voltage fed to analog input at  $I_{max}$

**Example:**         $I_{max} = 5A$  (phase RMS)  
                       $V_{in\ max} = 10V$   
                       $I_{scale} = I_{max} / V_{in\ max} = 5A / 10V = 0.5 A / Volt$  (value to enter)

### 6.3.6 Analog input scale (Velocity scale)

This parameter sets the analog input sensitivity for the velocity reference used when the drive operates in Velocity mode. Units for this parameter are RPM/Volt. To calculate this value use the following formula:

$$V_{scale} = VELOCITY_{max} / V_{in\ max}$$

$VELOCITY_{max}$     maximum desired velocity in RPM  
 $V_{in\ max}$             max voltage fed to analog input at  $Velocity_{max}$

**Example:**         $VELOCITY_{max} = 2000$  RPM  
                       $V_{in\ max} = 10V$   
                       $V_{scale} = VELOCITY_{max} / V_{in\ max}$   
                               $= 2000 / 10V$   
                               $= 200 RPM / Volt$  (value to enter)

### **6.3.7 ACCEL/DECEL Limits (Velocity mode only)**

The ACCEL setting determines the time the motor takes to ramp to a higher speed. The DECEL setting determines the time the motor takes to ramp to a lower speed. If the ENABLE ACCEL\DECEL LIMITS is set to DISABLE, the drive will automatically accelerate and decelerate at maximum acceleration limited only by the current limit established by the PEAK CURRENT LIMIT and CURRENT LIMIT settings.

### **6.3.8 Reference**

The REFERENCE setting selects the reference signal being used by the drive. This reference signal can be either External or Internal. An External Reference can be one of three types, a Analog Input signal, a Step and Direction Input or a Input from a external Master Encoder. The Analog Input reference is used when the drive is either in Torque or Velocity mode. The Master Encoder and Step and Direction reference is used when the drive is in Position Mode. An Internal Reference is used when the motion being generated is derived from drive's internal variable(s), or User Program, (See programmer's manual).

### **6.3.9 Step input type (position mode only)**

This parameter sets the type of input for position reference the drive expects to see. Signal type can be step and direction (S/D) type or quadrature pulse-train (Master Encoder / Electronic Gearing). Refer to section 5.2.1 for details on these inputs.

### **6.3.10 Fault Reset Option**

The FAULT RESET OPTION selects the type of action required to reset the drive after a FAULT signal has been generated by the drive. ON DISABLE clears the fault when the drive is disabled. This is useful if you have a single drive and motor connected in a single drive system. The ON ENABLE option clears the fault when the drive is re-enabled. Choose ON ENABLE if you have a complex servo system with multiple drives connected to an external controller. This makes troubleshooting easier since the fault will not be reset until the drive is re-enabled. Thus, a technician can more easily determine which component of a complex servo system has caused the fault.

### **6.3.11 Motor temperature sensor**

This parameter enables / disables motor over-temperature detection. It must be disabled if the motor PTC sensor is not wired to either P7.1-2 or to the resolver option module (P11).

### **6.3.12 Motor PTC cut-off resistance**

This parameter sets the cut-off resistance of the PTC which defines when the motor reaches the maximum allowable temperature. See section 5.5.2 for details how to connect motor's PTC.

### **6.3.13 Second encoder**

Disables or enables second encoder. Effectively selects single-loop or double-loop configuration in position mode. The second encoder connects to the Encoder Option Module (E94ZAENC1) connector P12, Refer to section 8.4 for details on dual loop operation.

### 6.3.14 Regen duty cycle

This parameter sets the maximum duty cycle for the brake (regen) resistor. This parameter can be used to prevent brake resistor overload. Use the following formula to set the correct value for this parameter.

$$D = P * R / (U_{max})^2 * 100\%$$

where:

D (%)	regen duty cycle
U <sub>max</sub> (V)	bus voltage at regen conditions. U <sub>max</sub> =390V for 230VAC drives and 770V for 400/480VAC drives
R (ohm)	regen resistor value
P (W)	regen resistor rated power



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#### Note

If calculation of D is greater than 100% set it to 100% value. If calculation of D is less than 10% then resistor power rating is too low. Refer to section 5.1.6 for details on braking resistor selection.

---

### 6.3.15 Encoder repeat source

This parameter sets the feedback source signal for the buffered encoder repeat outputs (P3.1-6). The source can be the drive's encoder input (P4) or an optional feedback module (resolver, second encoder etc.)

### 6.3.16 System to master ratio

This parameter is used to set the scale between the reference pulse train (when operating in position mode) and the system feedback device. In a single loop configuration, the system feedback device is the motor encoder or resolver. In a dual-loop system the system encoder is the second encoder. See sections 8.3 and 8.4 for details.

### 6.3.17 Second to prime encoder ratio

This parameter sets the ratio between the secondary encoder and the primary feedback device when the drive is configured to operate in dual-loop mode. When the primary feedback device is a resolver, the pulse count is fixed at 65,536. The resolutions of encoders are "post quadrature" (PPR x 4). See section 8.4



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#### Note

Post quadrature pulse count is four times the pulses-per-revolution (PPR) of the encoder.

---

### 6.3.18 Autoboot

When set to "Enabled" the drive will start to execute the user's program immediately after cold boot (reset). Otherwise the user program has to be started from MotionView or from the Host interface.

### 6.3.19 Group ID

See Programmer's manual for details. This parameter is only needed for operations over Ethernet network.

### 6.3.20 Enable switch function

If set to "Run", input IN\_A3 (P3.29) acts as an "Enable" input when the user program is not executing. If the user program is executing, the function will always be "Inhibit" regardless of the setting. This parameter is needed so the drive can be Enabled/ Disabled without running a user's program.

### 6.3.21 User Units

This parameter sets up the relationship between User Units and motor revolutions. From here you can determine how many User Units there is in one motor revolution. This parameter allows the user to scale motion moves to represent a desired unit of measure, (inches, meters, in/sec, meters/sec, etc).

For example:

A linear actuator allows a displacement of 2.5" with every revolution of the motor's shaft.

User Units = Revolutions / Unit

User Units = 1 Revolutions / 2.5 Inches

User Units = 1 / 2.5 Revolutions / inch

User Units = 0.4 Revolutions / inch

## 6.4 Communication

### 6.4.1 IP Setup

This action button opens dialog for TCP/IP related parameters setup.

### 6.4.2 RS-485 configuration

This parameter sets how the optional RS485 interface will function. The RS485 interface can be configured for normal operation (programming and diagnostics using MotionView software) or as a Modbus RTU slave. See section 5.4 for details on communication interfaces.

### 6.4.3 Modbus baud rate

This parameter sets the baud rate for RS485 interface in Modbus RTU mode. When the drive is operating in normal mode the baud rate is set to the same setting as the RS232 interface.

### 6.4.4 Modbus reply delay

This parameter sets the time delay between the drives reply to the Modbus RTU master. This delay is needed for some types of Modbus masters to function correctly.

## 6.5 Analog I/O Group

### 6.5.1 Analog output

The PositionServo 940 has one analog output with 10-bit resolution on P3.23. The signal is scaled to  $\pm 10V$ . The analog output can be assigned to following functions:

- Not Assigned
- Phase current RMS
- Phase current Peak
- Motor Velocity
- Phase U current
- Phase V current
- Phase W current
- Iq current (Torque component)
- Id current (Direct component)

## 6.5.2 Analog output current scale (Volt/amperes)

Applies scaling to all functions representing CURRENT values.

## 6.5.3 Analog output velocity scale (mV/RPM)

Applies scaling to all functions representing VELOCITY values.

(Note: that mV/RPM scaling units are numerically equivalent to volts/kRPM)

## 6.5.4 Analog input dead band

Allows the setting of a voltage window (in mV) at the reference input AIN1+ and AIN1- (P3.24 and 25) such that any voltage within that window will be treated as zero volts. This is useful if the analog input voltage drifts resulting in motor rotation when commanded to zero.

## 6.5.5 Analog input offset parameter

Allows you to adjust the offset voltage at AIN1+ and AIN1- (P3.24 and P3.25). This function is equivalent to the balance trim potentiometer found in analog drives. Lenze recommends that this adjustment be made automatically using the "Adjust analog voltage offset" button while the external analog reference signal commands zero speed.

## 6.5.6 Adjust analog voltage offset

This control button is useful to allow the drive to automatically adjust the analog input voltage offset. To use it, command the external reference source input at AIN1+ and AIN1- (P3.24 and 25) to zero volts and then click this button. Any offset voltage at the analog input will be adjusted out and the adjustment value will be stored in the "Analog input offset" parameter.

## 6.6 Digital I/O

The 940 has four digital outputs. These outputs can be either assigned to one of the following functions, or be used by the drives internal User Program

- **Not Assigned** No special function assigned. Output can be used by the User Program.
- **Zero Speed** Output activated when drive is at zero speed, refer to "Velocity Limits Group" (Section 6.7) for settings.
- **In Speed Window** Output activated when drive is in set speed window, refer to "Velocity Limits Group" (Section 6.7) for settings.
- **Current Limit** Output activated when drive detects current limit.
- **Run Time Fault** A fault has occurred. Refer to Section 7.3 for details on faults.
- **Ready** Drive is enabled.
- **Brake** Command for the holding brake option (E94ZAHBK2) for control of a motor mounted brake. This output is active 10ms after the drive is enabled and deactivates 10ms before the drive is disabled.
- **In position** Position mode only. See 940 Programming Manual for details

### 6.6.1 Digital input de-bounce time

Sets de-bounce time for the digital inputs to compensate for bouncing of the switch or relay contacts. This is the time during an input transition that the signal must be stable before it is recognized by the drive.

## 6.6.2 Hard limit switch action

Digital inputs IN\_A1-IN\_A2 can be used as limit switches if their function is set to "Fault" or "Stop and Fault". Activation of this input while the drive is enabled will cause the drive to Disable and go to a Fault state. The "Stop and Fault" action is available only in Position mode when the "Reference" parameter is set to "Internal" i.e. when the source for the motion is the Trajectory generator. See Programmer's Manual for details on "Stop and Fault" behavior.

## 6.7 Velocity Limits Group

These parameters are active in Velocity Mode Only.

### 6.7.1 Zero Speed

Specifies the upper threshold for motor zero speed in RPM. When the motor shaft speed is at or below the specified value the zero speed condition is set to true in the internal controller logic. The zero speed condition can also trigger a programmable digital output, if selected.

### 6.7.2 Speed Window

Specifies the speed window width used with the "In speed window" output.

### 6.7.3 At Speed

Specifies the speed window center used with the "In speed window" output.

These last two parameters specify speed limits. If motor shaft speed is within these limits then the condition AT SPEED is set to TRUE in the internal controller logic. The AT SPEED condition can also trigger a programmable digital output, if selected.

For example if "AT SPEED" is set for 1000 RPM, and the "SPEED WINDOW" is set for 100, then "AT SPEED" will be true when the motor velocity is between 950 -1050 RPM.

## 6.8 Position limits

### 6.8.1 Position Error

Specifies the maximum allowable position error in the primary (motor mounted) feedback device before enabling the "Max error time" clock (described next). When using an encoder, the position error is in post-quadrature encoder counts. When using a resolver, position error is measured at a fixed resolution of 65,536 counts per motor revolution.

### 6.8.2 Max Error Time

Specifies maximum allowable time (in mS) during which a position error can exceed the value set for the "Position error" parameter before a Position Error Excess fault is generated.

### 6.8.3 Second Encoder Position Error

Specifies the maximum allowable error of the second encoder in post quadrature encoder counts before enabling the "Second encoder max error time" clock (described next).

### 6.8.4 Second Encoder Max Error Time

Specifies maximum allowable time (in mS) during which the second encoder's position error can exceed the value set for the "Second encoder position error" parameter before a Position Error Excess fault is generated.

## 6.9 Compensation group

### 6.9.1 Velocity P-gain (Proportional)

Proportional gain adjusts the system's overall response to a velocity error. The velocity error is the difference between the commanded velocity of a motor shaft and the actual shaft velocity as measured by the primary feedback device. By adjusting the proportional gain, the bandwidth of the drive is more closely matched to the bandwidth of the control signal, ensuring more precise response of the servo loop to the input signal.

### 6.9.2 Velocity I-gain (Integral)

The output of the velocity integral gain compensator is proportional to the accumulative error over cycle time, with I-gain controlling how fast the error accumulates. Integral gain also increases the overall loop gain at the lower frequencies, minimizing total error. Thus, its greatest effect is on a system running at low speed, or in a steady state without rapid or frequent changes in velocity.



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**Note**

The following four position gain settings are only active if the drive is operating in Position mode. They have no effect in Velocity or Torque modes.

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### 6.9.3 Position P-gain (Proportional)

Position P-gain adjusts the system's overall response to position error. Position error is the difference between the commanded position of the motor shaft and the actual shaft position. By adjusting the proportional gain, the bandwidth of the drive is more closely matched to the bandwidth of the control signal, ensuring more precise response of the servo loop to the input signal.

### 6.9.4 Position I-gain (Integral)

The output of the Position I-gain compensator is proportional to accumulative error over cycle time, with I-gain controlling how fast the error accumulates. Integral gain also increases overall loop gain at the lower frequencies, minimizing total error. Thus, its greatest effect is on a system running at low speed, or in a steady state without rapid or frequent changes in position.

### 6.9.5 Position D-gain (Differential)

The output of the Position D-gain compensator is proportional to the difference between the current position error and the position error measured in the previous servo cycle. D-gain decreases the bandwidth and increases the overall system stability. It is responsible for removing oscillations caused by load inertia and acts similar to a shock-absorber in a car.

### 6.9.6 Position I-limit

The Position I-limit will clamp the Position I-gain compensator to prevent excessive torque overshooting caused by an over accumulation of the I-gain. It is defined in terms of percent of maximum drive velocity. This is especially helpful when position error is integrated over a long period of time.

## 6.9.7 Second encoder I-gain (Integral)

This parameter sets second encoder position I-gain when the drive is in a dual-loop configuration.

## 6.9.8 Gain scaling window

Sets the total velocity loop gain multiplier ( $2^n$ ) where  $n$  is the velocity regulation window. If, during motor tuning, the velocity gains become too small or too large, this parameter is used to adjust loop sensitivity. If the velocity gains are too small, decrease the total loop gain value, by decreasing this parameter. If gains are at their maximum setting and you need to increase them even more, use a larger value for this parameter.

## 6.10 Tools Group

### 6.10.1 Oscilloscope tool

The oscilloscope tool gives real time representation of different signals inside the PositionServo 940 drive and is helpful when debugging and tuning drives. Operation of the oscilloscope tool is described in more detail in the MotionView Software User's Manual. The following are the signals that can be observed with the oscilloscope tool:

<b>Phase Current (RMS):</b>	Motor phase current
<b>Phase Current (Peak):</b>	Motor peak current
<b>Iq Current:</b>	Measures the motor Iq (torque producing) current
<b>Motor Velocity:</b>	Actual motor speed in RPM
<b>Commanded Velocity:</b>	Desired motor speed in RPM (velocity mode only)
<b>Velocity Error:</b>	Difference in RPM between actual and commanded motor speed
<b>Position Error:</b>	Difference between actual and commanded position (Step & Direction mode only)
<b>Bus voltage:</b>	DC bus voltage
<b>Analog input:</b>	Voltage at drive's analog input
<b>Absolute position:</b>	Absolute position (actual position)
<b>Target position:</b>	Requested position

### 6.10.2 Run Panels

#### Check Phasing

This button activates the Autophasing feature as described in section 5.6.2. However, in this panel only the motor phasing is checked, the motor data is not modified.

## 6.11 Faults Group

Faults Group loads the fault history from the drive. The 8 most recent faults are displayed with the newer faults replacing the older faults in a first-in, first-out manner. In all cases fault # 0 is the most recent fault. To clear the faults history from the drive's memory click on the "Reset Fault history" button. Each fault has its code and explanation of the fault. See section 7.3 for details on faults.

# 7 Display and Diagnostics

## 7.1 Diagnostic display

The PositionServo 940 drives are equipped with a diagnostic LED display and 3 push buttons to select displayed information and to edit a limited set of parameter values.

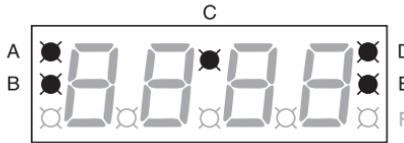
Parameters can be scrolled by using the "UP" and "DOWN" (▲▼) buttons. To view a value, press "Enter" (↵). To return back to scroll mode press "Enter" again.

After pressing the "Enter" button on editable parameters, the yellow LED "C" (see figure in the next section) will blink indicating that parameter value can be changed. Use "UP" and "DOWN" buttons to change the value. Press "Enter" to store new setting and return back to scroll mode.

Display	Description
StRt	current drive status - (↵) to view: rUn - drive running dI5 - drive disabled F_XX - drive fault. Where XX is the fault code (section 7.3.2)
Hx.xx	Hardware revision (e.g. H2.00)
Fx.xx	Firmware revision (e.g. F2.06)
bAud	RS232/RS485(normal mode) baud rate - (↵) to set ▲▼ selects from 2400 to 115200 baudrates
Adr	Drive's address - (↵) to set ▲▼ sets 0 - 31 drive's address
FLt5	Stored fault's history - (↵) to view ▲▼ scroll through stored faults F0XX to F7XX, where XX is the fault code (section 7.3.2)
Ht	Heatsink temperature - (↵) to view Shows heatsink temperature in °C if greater than 40°C. Otherwise shows "LO" (low).
EnC	Encoder activity - (↵) to view Shows primary encoder counts for encoder diagnostics activity
HALL	Displays motor's hall sensor states - (↵) to view Shows motor hall states in form XXX, where X is 1 or 0 - sensor logic states.
bU5	Displays drive DC bus voltage - (↵) to view Shows DC bus voltage value
CUrr	Displays motor's phase current (RMS) Shows current value if drive is enabled, otherwise shows "dI5"

## 7.2 Diagnostic LEDs

The PositionServo 940 has five diagnostic LEDs mounted on the periphery of the front panel display as shown in the drawing below. These LEDs are designed to help monitor system status and activity as well as troubleshoot any faults.



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LED	Function	Description
A	Enable	Orange LED indicates that the drive is ENABLED (running).
B	Regen	Yellow LED indicates the drive is in regeneration mode.
C	Data Entry	Yellow LED will flash when changing.
D	Comm Fault	Red LED illuminates upon a communication fault. (available in CANbus only)
E	Comm Activity	Green LED flashes to indicate communication activity.

## 7.3 Faults

### 7.3.1 FAULT CODES

Below are fault codes mostly caused by hardware operations. Additional fault codes are listed in Programmer's manual.

Fault Code	Fault	Description
F_0U	Over voltage	Drive bus voltage reached the maximum level, typically due to motor regeneration
F_Fb	Feedback error	Resolver signal lost or at least one motor hall sensor is inoperable or not connected.
F_0C	Over current	Drive exceeded peak current limit. Software un-capable to regulate current within 15% for more then 20mS. Usually results in wrong motor data or poor tuning.
F_0t	Over temperature	Drive heatsink temperature has been reached maximum rating.
F_EF	External fault input activated	Digital input was programmed as external fault input and has been activated.
F_0S	Over speed	Motor reached velocity above its specified limit
F_PE	Excess position error	Position error exceeded maximum value.
F_bd	Bad motor data	Motor profile data invalid or no motor is selected
F_09	Motor over temperature	Optional motor temperature sensor (PTC) indicates that the motor windings have reached maximum temperature
F_10	Subprocessor failure	Error in data exchange between processors. Usually happens when EMI level is high resulting from poor shielding and grounding.
F_14	Undervoltage	Happens bus voltage level drops below 50% of nominal bus voltage while drive is operating. Attempt to enable drive with low bus voltage also result in this fault.
F_15	Hardware overload protection	Happens if phase current at any time becomes higher than 400% of total drive's current capability for more then 5uS.
F_33	Negative Limit Switch	Negative limit switch is activated
F_34	Positive Limit Switch	Positive limit switch is activated
F_36	Drive Disabled by User at Enable Input	Drive disabled while operating or attempt to enable drive without deactivating "Inhibit input". "Inhibit" input has reverse polarity.

There are additional error codes related to the programming of the 940. Please reference the programmer's manual for more information.

### 7.3.2 Fault Event

When drive encounters any fault, the following events occur:

- Drive is disabled
- Internal status is set to "Fault"
- Fault number is logged in the drive's internal memory for later interrogation
- Digital output(s), if configured for "Run Time Fault", are asserted
- Digital output(s), if configured for READY, are de asserted
- If the display is in the default status mode, the LEDs display F\_XX where XX is current fault code.
- "Enable" LED turns OFF

### 7.3.3 Fault Reset

Fault reset is accomplished by disabling or re-enabling the drive depending on the setting of the "Reset option" parameter (section 6.3.10).

## 8 Operation

This section offers guidance on configuring the PositionServo drive for operations in torque, velocity or position modes without requiring a user program. To use advanced programming features of PositionServo please perform all steps below and then refer to the "Programmer's Manual" for details on how to write motion programs.

### 8.1 Minimum Connections

For the most basic operation, connect the PositionServo 94 to mains (line) power at terminal P1, the servomotor power at P7 and the motor feedback as appropriate.



#### DANGER!

Hazard of electrical shock! Circuit potentials are up to 480 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Disconnect incoming power and wait at least 60 seconds before servicing drive. Capacitors retain charge after power is removed.

Below is a list of the minimum necessary connections:

- Connect a serial cable between PositionServo's P2 and your PC serial port using a straight-through 9 pin RS232 cable (available as EWLC003BA1NA).
- Connect mains power to terminal P1. Mains power must be as defined on the drive's data label (see section 2.1).
- If the motor is equipped with an encoder, connect the encoder cable to the PositionServo feedback connector P4.  
If the motor is equipped with a resolver, install the "Resolver option module" (E94ZARSV1) in the lower option bay and connect the resolver cable to P11.
- Connect motor windings U, V, W (sometimes called R, S, T) to terminal P7 according to Section 5.1.1. Make sure that motor cable shield is connected as described in section 4.2.
- Provide an Enable switch according to Section 8.5.
- Perform drive configuration as described in the next section.



#### Note

You must configure the drive before it can be operated. Proceed to Section 8.2.

### 8.2 Configuration of the PositionServo

Regardless of the mode in which you wish to operate, you must first configure the PositionServo 940 for your particular motor, mode of operation, and additional features if used.

Drive configuration consists of following steps:

- Motor Selection
- Mode of operation selection
- **Reference source selection (Very Important)**
- Drive parameters (i.e. current limit, acceleration / deceleration) setup
- Operational limits (velocity or position limits) setup
- Input / Output (I/O) setup
- Velocity / position compensator (gains) setup
- Optionally store drive settings in a PC file and exit the MotionView program.

## To configure drive:

1. Ensure that the control is properly installed and mounted. Refer to Section 4 for installation instructions.
2. Perform wiring to the motor and external equipment suitable for desired operating mode and your system requirements.
3. Connect the serial port P2 on the drive to your PC serial port.
4. Make sure that the drive is disabled.
5. Apply power to the drive and wait until "d ,5" shows on the display. For anything other than this, refer to the chart below before proceeding.

Drive display:	Meaning
EP	EPM missing. Refer to 6.1.2
EPP	EPM data Refer to 6.1.2
----	No valid firmware
----	Monitor mode

6. Using the drive's keypad and display, check that the baud rate is set to 38.4 (kbps).
7. Using the drive's keypad and display, check that the address is set to 1. Set if necessary.
8. Launch MotionView software on your computer.
9. From the MotionView menu, select <Project> <Connection setup>.
10. Select "UPPP over RS-485/RS-232", then select <Properties> and select the computer's serial port that the drive is connected to.
  - Select the Comm port that matches the serial port of the computer used for this connection
  - Set baud rate at 38400 and rest of the parameters at default.
11. Click <OK> twice to dismiss both dialog boxes.
12. From <Node> menu choose <Connect Drive>.
13. Click "Connect one" button, type "1" in the address box and press "OK" to dismiss dialog.
14. Drive connects and its icon appears in the left node tree of the MotionView's screen.



### Note

MotionView's "Connection setup" properties need only be configured the first time MotionView is operated or if the port connection is changed. Refer to MotionView User's Manual for details on how to make a connection to the drive.

15. Double-click on the drive's icon to expand parameter group's folders.
16. Select the motor to be used according to the Section 5.5.
17. Expand the folder "Parameters" and choose the operating mode for the drive. Refer to Section 6.3.1 for details on operating modes.
18. Click on the "Current limit" parameter (6.3.3) and enter current limit (in Amp RMS per phase) appropriate for the motor.
19. Click on the appropriate "Peak current limit" parameter (6.3.4) based on the "Drive PWM frequency" parameter (6.3.2) used and enter the peak current limit (in Amp RMS per phase) appropriate for your motor.
20. Set up additional parameters suitable for the operating mode selected in step 17.
21. After you configure the drive, proceed to the tuning procedure if operating in "Velocity", or "Position" mode. "Torque" mode doesn't require additional tuning or calibration.  
Refer to Section 8.6 for details on tuning.

## 8.3 Position mode operation (gearing)

In position mode the drive will follow the master reference signals at the P3. 1-4 inputs. The distance the motor shaft rotates per each master pulse is established by the ratio of the master signal pulses to motor encoder pulses (in single loop configuration). The ratio is set by "System to Master ratio" parameter (see section 6.3.16).

### Example 1.

**Problem:** Setup the drive to follow a master encoder output where 1 revolution of the master encoder results in 1 revolution of the motor

**Given:** Master encoder: 4000 pulses/revolution (post quadrature)  
Motor encoder: 8000 pulses/revolution (post quadrature)

**Solution:** Ratio of System (motor encoder) to Master Encoder is  $8000/4000 = 2/1$   
Set parameter "System to master ratio" to 2:1

### Example 2

**Problem:** Setup drive so motor can follow a master encoder wheel where 1 revolution of the master encoder results in 3 revolutions of the motor

**Given:** Motor encoder: 4000 pulses/revolution (post quadrature)  
Master encoder: 1000 pulses/revolution (post quadrature).  
Desired "gear ratio" is 3:1

**Solution:** Ratio is motor encoder PPR divided by master encoder PPR times the "gear ratio":  
 $(\text{Motor PPR}/\text{Master PPR}) \cdot (3/1) \Rightarrow (4000/1000) \cdot (3/1) \Rightarrow 12/1$   
Set parameter "System to master ratio" to 12:1

## 8.4 Dual-loop feedback

In dual-loop operation (position mode only) the relationship between the Master input and mechanical system movement requires that two parameters be set:

(1) "System to master ratio" sets the ratio between the second encoder pulses (system encoder) and the master input pulses.

(2) "Prime to second encoder ratio" sets the ratio between the second and primary (motor) encoder. If the motor is equipped with a resolver connected to the resolver option module, the primary encoder resolution of 65536 (post quadrature) must be used.

When operating in this mode the second encoder input is applied to integral portion of the position compensator. Therefore it is important that the Position I-gain and Position I-limit parameters are set to non 0 values. Always start from very small values of Position I-limit values.



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### Note

When operating with a resolver as the primary feedback, a second encoder can be connected to P4.

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## 8.5 Enabling the PositionServo

Regardless of the selected operating mode, the PositionServo must be enabled before it can operate. A voltage in the range of 5-24 VDC connected between P3.26 and 3.29 (input IN\_A3) is used to enable the drive. There is a difference in the behavior of input IN\_A3 depending on how the “Enable switch function” is set.

### When the “Enable switch function” is set to “RUN”:

IN\_A3 acts as positive logic ENABLE or negative logic INHIBIT input depending on:

If user program is not running: Activating IN\_A3 enables the drive

User program running: Activating IN\_A3 acts as negative logic

“Inhibit” and operates exactly as if parameter

“Enable switch function” set to “Inhibit” (see below)

### When the “Enable switch function” set to “Inhibit”:

IN\_A3 acts as negative logic INHIBIT input regardless of mode or program status.

Activating input IN\_A3 doesn't enable the drive. The drive can be enabled from the user's program or interface only when IN\_A3 is active. Attempt to enable drive by executing the program statement “ENABLE” or from interface will cause the drive to generate a fault #36. Regardless of the mode of operation, if the input is deactivated while the drive is enabled, the drive will be disabled and will generate a fault #36.



#### WARNING!

Enabling the servo drive allows the motor to operate depending on the reference command. The operator must ensure that the motor and machine are safe to operate prior to enabling the drive and that moving elements are appropriately guarded.

Failure to comply could result in damage to equipment and/or injury to personnel!

## 8.6 Tuning in velocity mode

In this mode, the settings for Position compensation will have no effect.

1. Make sure that power is applied to the drive and that the drive is connected to a PC running MotionView software
2. Make sure that the drive is disabled.
3. Select the “Parameters” folder from the node tree. Click on “Reference” parameter and change it to “Internal”. This will tell drive to use the internally generated reference.
4. Make sure that “Enable Accel/Decel limits” is set to “Disable”.
5. Select “Indexer program” ,click anywhere in programs pane then select menu “Indexer” -> “Import program from file” and choose the file named “TuneV”.

When program is loaded into the program pane click menu “Indexer” -> “Compile and send to drive”. Alternatively, you can press Shift+F6 on the keyboard or use toolbar button.

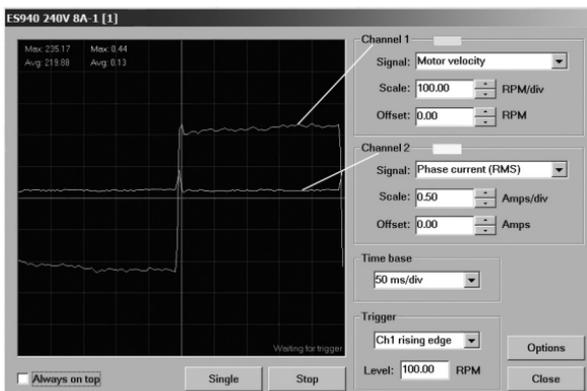
6. Select “Oscilloscope” tool from the node tree to engage the oscilloscope. Check checkbox “Always on top”, so MotionView main window doesn't cover the oscilloscope tool.

7. On the Scope tool select:
  - Channel 1: "Motor Velocity"
  - Scale: 100 Rpm/Volt
  - Channel 2: "Phase Current (RMS)"
  - Scale: Motor peak current parameter / 3
  - Timebase: 50mS
  - Trigger: Channel 1, Rising
  - Trigger level: 100 Rpm
 (Choose closest integer value: if  $10A/3=3.33(3)$  choose 3A)
8. Select "Compensation" from the Node tree. Set "Gain Setting" to "-2" if the motor is equipped with an encoder and to "-4" if the motor is equipped with a resolver.
9. Set the Velocity P-gain to 5000 and the Velocity I-gain to 20.
10. Apply voltage to IN\_A3 input and press F5 on the keyboard. Alternatively you can use menu "Indexer" -> "Run" or use button on the toolbar.
11. If the motor vibrates uncontrollably, disable the drive, rest P-Gain to 1000, and re-enable the drive.
12. Slowly increase the "Velocity P-gain" and observe the motor velocity waveform. Increasing the P-gain should increase the angle of the acceleration edge of the wave form. Continue increasing the P-gain to get the leading edge of the wave form as vertical as possible and stop once you start to get a slight overshoot. The current wave form should be spiking during the acceleration segment of the move. Continue to increase the P-gain until instability starts to appear in the waveform.



S949

Stop increasing the gain once you see oscillation appearing on either the current waveform or velocity waveform flat portion. Then lower the P-gain until the oscillation disappears



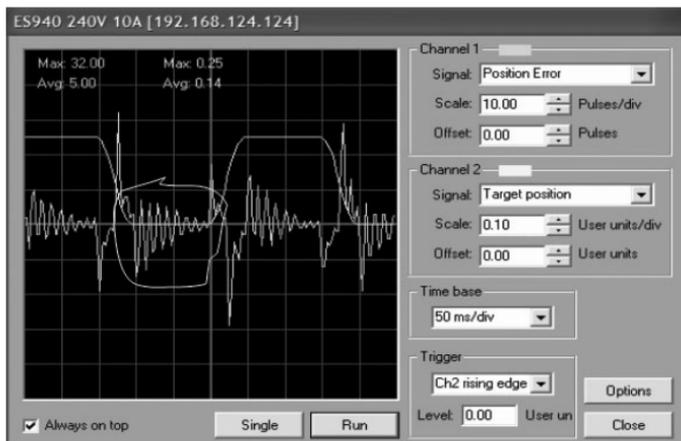
S951

13. Slowly increase the “Velocity I-gain” and watch for an overshoot on the motor velocity waveform. Stop increasing the setting when overshoot just starts to occur or is very narrow. The setting should be less than 5mS or less than 3-5%, if a steep acceleration/deceleration is desired in your servo system. If stiffness at low velocity or stall torque is desired then the “Velocity I-gain” can be increased allowing step overshoot up to approximately 15-30%.
14. Finally, check the motor Iq current. Set the oscilloscope Channel 1 source to Iq current. Observe the current waveform to insure that there is no significant oscillation.
15. Click “Indexer” -> “Stop” or alternatively Alt+F5 on the keyboard to stop the program. Remove voltage from IN\_A3 input.
16. Depending on the application you may want to set parameters “Reference” and “Enable switch function” to appropriate values. Refer to section 6 for details.

## 8.7 Tuning in position mode

In this mode the Velocity gains should be set first.

1. Perform velocity loop tuning as per section 8.6. Select I-Gain value for minimum overshoot.
2. Make sure that the drive is disabled.
3. Load program “TuneP.txt” found in User Data directory in current Motion View installation, compile and load it to the drive but don’t run it yet.
4. Select “Tools” then “Oscilloscope” tool from node tree.
5. On the Scope tool select:
  - Channel 1: “Position Error”
  - Scale: 100 pulses/div
  - Channel 2: “Target Position”
  - Scale: 0.1 Unit/div
  - Timebase: 50mS
  - Trigger: Channel 2, Rising
  - Trigger level: 0
6. Select “Compensation” from node tree. Set “Position P-gain” to 100 and “Position D-gain” to 0. Set “Position I-gain” to 0 and “Position I-limit” to 0.
7. Activate IN\_A3 and run the “TuneP.txt” program.
8. Slowly increase the P-gain while watching the Position Error waveform , (channel 1). While increasing P-gain you should observe the position error decrease. At some point you should start to experience high frequency oscillation noticeable on the Position Error waveform, (see picture below). Increase D-gain to suppress the oscillations.



S933

9. Continue to increase the P-gain until the position error stop decreasing. You will need to increase the D-gain again while increasing the P-gain to suppress the oscillations.
10. Stop the program.
11. The above method is suggested as a general guideline for position tuning. You will have to experiment with the gains to achieve the performance and stability needed for your individual application.
12. The general goal of tuning is to achieve the minimum acceptable position error while still maintaining stability. By increasing the P-gain you increase the response to position change and reduce the position error. At the same time a large P-gain can lead to instability, oscillation. By increasing the D-gain you improve the stability of the system. Generally, both P-gain and D-gain should be increased together.
13. While the program is stopped, edit the "TuneP" User Program and set the Accel and Decel variables to the maximum values your system can accept. Compile and load the program to the drive.
14. Set oscilloscope channel 1 to "Iq current". Set the scale to the appropriate value to see a full current pulse.
15. Observe that current, Iq, waveform. Check to make sure that there isn't any significant oscillation at the flat portion of the waveform. If so then decrease the P-gain to a level where the oscillation either disappears or is very small. (See pictures in section 9.2).
16. Trying to minimize the position error during the steady state of the move is where the I-gain comes into play. The same is true for holding the position accuracy. Increasing the I-gain will increase the drive's reaction time while the I-Limit will set the maximum influence that the I-Gain will have on to the loop. When adjusting the I-gain start with a very small value for both the I-gain and the I-Limit then increase the I-gain until stand-still reaction is compensated. Remember that large values of Position I-limit can cause large instability and unsettled oscillation of the mechanism.



#### Note

Remember that these are only initial settings for your system. Your application will likely require fine-tuning. To optimize settings you will need to experiment with combinations of all gains P, I and D and the I-limit.

# 9 Sample Motor Responses to Gain Settings

## 9.1 Motor response to gain settings (Velocity mode)

Initial settings:

The screenshot shows the MotionView94 interface for an ES940 240V 10A drive. The 'Parameters' window is open, displaying a list of motor parameters. The drive is currently in 'Velocity' mode. The status bar at the bottom indicates the drive is successfully connected and ready.

Parameter name	Value	Units	Min
Drive name	Velocity		
Drive mode	16 KHz		
Drive PWM frequency	16 KHz		
Current limit	6.0000	A	0.0000
8 KHz peak current limit	30.0000	A	0.0000
16 KHz peak current limit	10.0000	A	0.0000
Analog input (current scale)	0.2000	A/Volt	-3.0000
Analog input (velocity scale)	200.0000	RPM/Volt	-2000.0000
Enable Accel/Decel limits	Disable		
Accel limit	100.0000	RPM/Sec	0.1000
Decel limit	100.0000	RPM/Sec	0.1000
Internal	Internal		
Step input type	Master encoder		
Fault reset	on disable		
Motor temperature sensor	Disable		
Motor plc cutt-off resistance	2500	Ohm	2000
Second encoder	Disable		
Regen duty cycle	10	%	1
Encoder repeat source	Drive encoder I...		
Master to system ratio	1:7		-32767:1
Second to prime encoder ratio	5:6		-32767:1
Autoboot	Disabled		0
Group ID	12		
Enable switch function	Inhibit		
User units	1.0000	Revolutions/Unit	0.0000

Drive ES940 240V 10A(Lunt5led) successfully connected

For Help, press F1 | Ln 11, Col 8 | Ethernet UDP | Ready

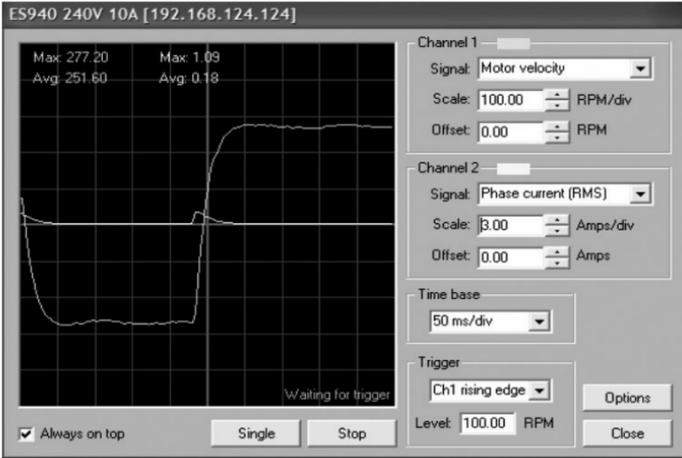
S934

### 9.1.1 P-gain

Velocity P-gain = 5000

Velocity I-gain= 20

Current didn't reach maximum possible value. (10A)



S935

Velocity P-gain = 32767 (max value).

Velocity I-gain=20

Gain Scaling = -2

The P-gain is set to its maximum value, per the (-2) in the Gain Scaling window. The current value is very close to the maximum but since the P-gain is maxed out we can't determine if we have achieved optimum settings.

Also notice that the oscilloscope Time Base is set to 10ms. This will allow us to view leading edge and current impulse response better. A real-time oscilloscope is essential when analyzing waveforms in depth and is a distinctive feature of the PositionServo drives.



S936

To increase the P-gain setting we need to set "Gain Scaling" one notch higher. This is done by changing the "Gain Scaling" setting from (-2) to (-1).

After changing the "Gain Scaling" setting, set the P-gain to 16000 (approximately the middle of the scale) and restart the drive. Then slowly increase the P-gain again. (Reference the next section).

Velocity P-gain = 20322

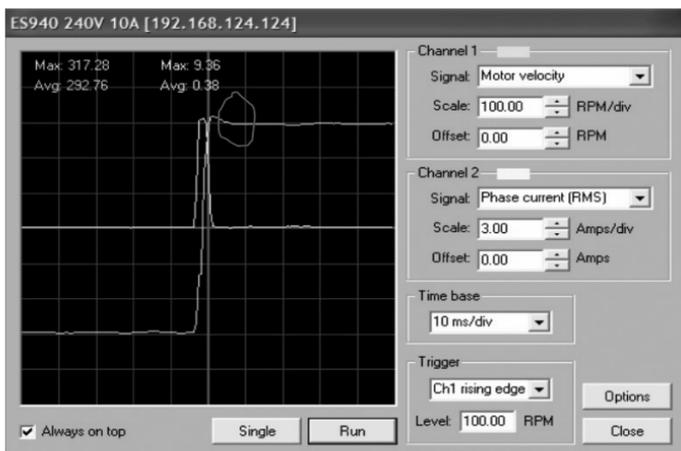
Velocity I-gain = 20

Gain Scaling = -1

We start to see a small overshoot at the leading edge of the Motor Velocity wave, but the current doesn't increase anymore. This is how fast the motor can reach the set velocity with current limit selected. Any further increase in gain will only increase the overshoot and will not improve the response.

P-gain should be decreased slightly, (approximately 10%), to remove the overshoot.

The Final value for the P-gain should be 18000



S937

## 9.1.2 I-gain

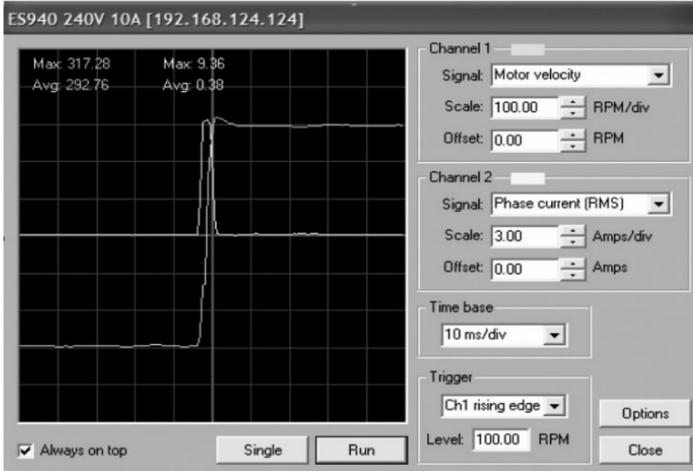
Velocity P-gain = 18000.

Velocity I-gain = 2396

Gain Scaling = -1

I-gain is increased to allow small velocity overshoot, (~10%), as a step response.

This setting is very application dependent. If in your application a high and more flat response is expected then leave this value so that the overshoot is no more than 10%. If your application requires stiffness at zero or near zero velocity and long term stability is desired you can increase I-Gain so that the overshoot reaches 30% (see next section).



S938

### Large I-Gain

#### I-Gain 7935. Overshoot 20%

The I-gain setting is very application dependent. If in your application requires a high and flat response then the I-gain should be set to give an overshoot of no more than 10%. If your application requires stiffness at zero or near zero velocity and have long term stability you can increase the I-Gain so that the overshoot reaches 30% (see below).



S939

### 9.1.3 Abnormal gains. Velocity mode

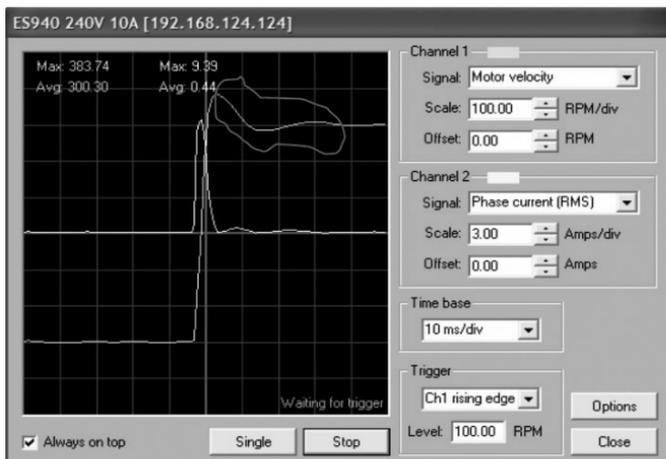
Velocity I-Gain is too high

Velocity P-gain = 18000.

Velocity I-gain = 12000

Gain Scaling = -1

Notice below that there is a large overshoot and a noticeable oscillation in the flat portion of the Motor Velocity waveform. The current waveform also has a small trace of instabilities at the flat portion of the waveform.



S940

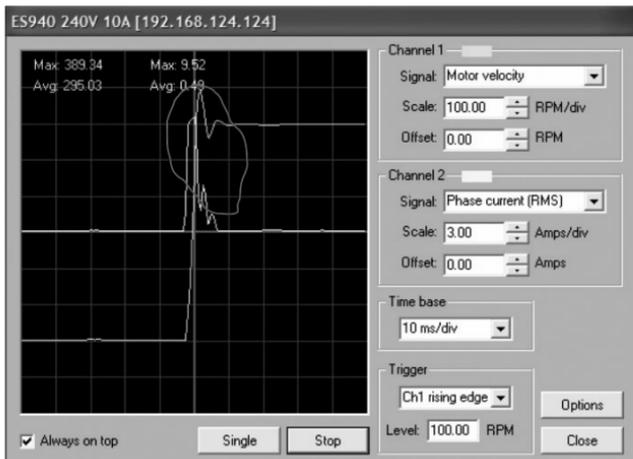
Velocity P-gain is too high

Velocity P-gain = 22720.

Velocity I-gain = 20

Gain Scaling = 0

Notice below that there is a large overshoot and a noticeable oscillation in flat portion of the Motor Velocity waveform. The current waveform also has some instability on trailing edge of the current impulse response.



S941

## 9.2 Motor response to gain settings (Position Mode)

### 9.2.1 P-gain selection

Position P-gain	=	2500
Position D-gain	=	0
Position I-gain	=	0
Position I-limit	=	0

**Problem:** Insufficient P-gain can cause large position error as motor changing position rapidly

**Treatment:** Increase P-gain.

**Side effects:** Increasing the P-gain might cause oscillations and might require an increase of the D-gain as well to overcome this problem.



S942

#### P-gain increase

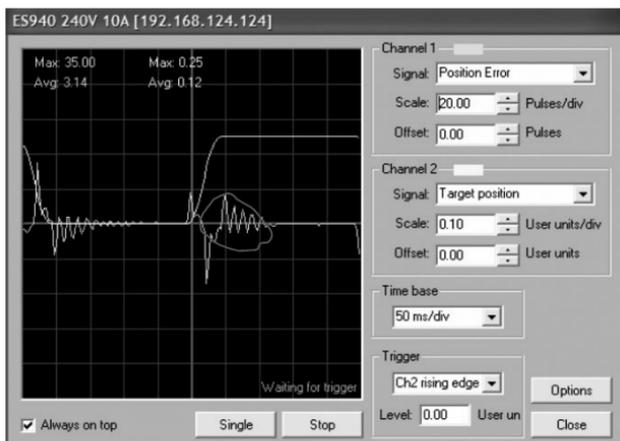
Position P-gain	=	8700
Position D-gain	=	0
Position I-gain	=	0
Position I-limit	=	0

**Positive effect:** Position error decreased

**Problem:** Noticeable oscillation (Channel 1). P-gain can't be set any higher due to increasing oscillation, (instability).

**Treatment:** Increase D-gain and then P-gain until position error stops decreasing

**Side effects:** Possible high noise produced by excess of D-gain. A compromise between the D-gain setting and an acceptable position error must be reached. This will be mainly controlled by value of P-gain.



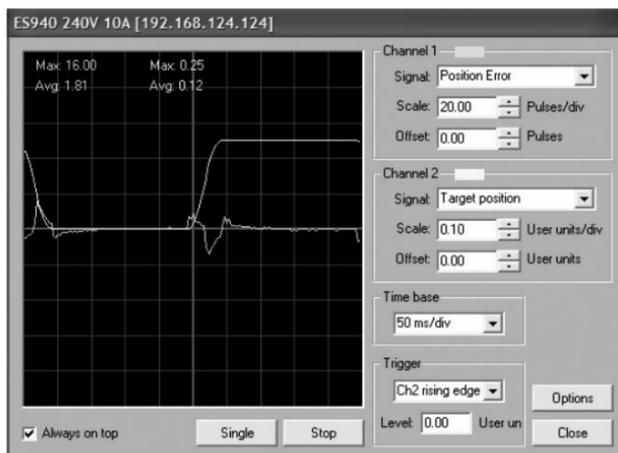
S943

## 9.2.2 Optimal P-gain / D-gain settings

Position P-gain	=	8700
Position D-gain	=	16000
Position I-gain	=	0
Position I-limit	=	0

**Positive effect:** Position error decreased. Oscillation eliminated by D-gain.

**Side effects:** Possible high noise produced by high P and D gains at 0 velocity. This problem arises since encoder has finite resolution. A compromise might have to be made by setting the P-gain and the D-gain lower to smooth out the operation at 0 velocity.

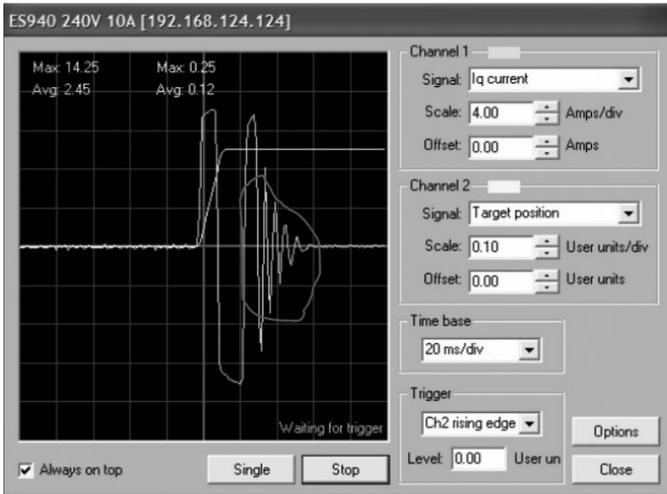


S944

### P and D gains setting check (problem).

Position P-gain	=	12673
Position D-gain	=	16000
Position I-gain	=	0
Position I-limit	=	0

**Problem:** Noticeable oscillation (Channel 1) on Iq current waveform.  
**Treatment:** Decrease the P-gain setting until oscillation disappears.

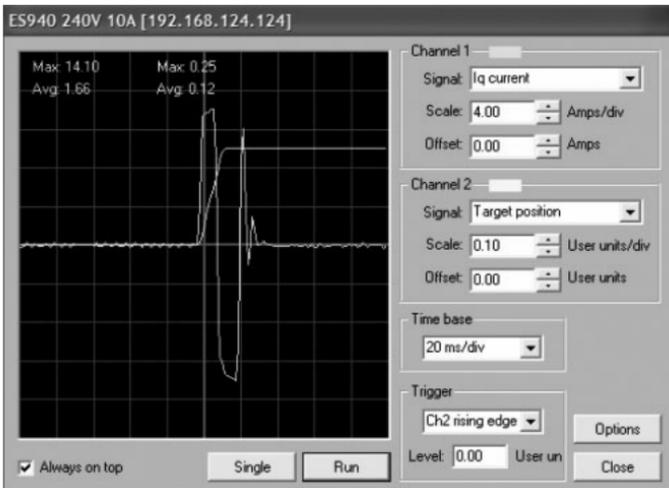


S945

### P and D gains setting check (corrected)

Position P-gain = 12673  
 Position D-gain = 16000  
 Position I-gain = 0  
 Position I-limit = 0

**Positive effect:** Oscillation stopped and stability is increased



S946

# 10 Troubleshooting



## DANGER!

Hazard of electrical shock! Circuit potentials are up to 480 VAC above earth ground. Avoid direct contact with the printed circuit board or with circuit elements to prevent the risk of serious injury or fatality. Disconnect incoming power and wait at least 60 seconds before servicing drive. Capacitors retain charge after power is removed.

### Before troubleshooting

Perform the following steps before starting any procedure in this section:

- Disconnect AC or DC voltage input from the PositionServo. Wait at least 60 seconds for the power to discharge.
- Check the PositionServo closely for damaged components.
- Check that no foreign material has become lodged on, or fallen into, the PositionServo.
- Verify that every connection is correct and in good condition.
- Verify that there are no short circuits or grounded connections.
- Check that the drive's rated phase current and RMS voltage are consistent with the motor ratings.

For additional assistance, contact your local PositionServo® authorized distributor.

<b>Problem</b>	External line fuse blows
<b>Possible Cause</b>	Line fuses are the wrong size Motor leads or incoming power leads are shorted to ground. <i>Nuisance tripping caused by EMI noise spikes caused by poor grounding and/or shielding.</i>
<b>Suggested Solution</b>	<ul style="list-style-type: none"> <li>• Check that line fuses are properly sized for the motor being used.</li> <li>• Check motor cable and incoming power for shorts.</li> <li>• Check that you follow recommendation for shielding and grounding listed in section "shielding and grounding" early in this manual.</li> </ul>

<b>Problem</b>	Ready LED is on but motor does not run.
<b>Suggested Solution</b>	<p><b>If in torque or velocity mode:</b> Reference voltage input signal is not applied. Reference signal is not connected to the PositionServo input properly; connections are open. In MotionView program check &lt;Parameters&gt; &lt;Reference&gt; set to &lt;External&gt;</p> <p><b>For Velocity mode only:</b> In MotionView check &lt;Parameters&gt; &lt;Compensation&gt;&lt;Velocity loop filter&gt; P-gain must be set to value more then 0 in order to run. Without load motor will run with P-gain set as low as 20 but under load might not. If P-gain is set to 0 motor will not run at all.</p> <p><b>In position mode with master encoder motion source (no program)</b> Reference voltage input signal source is not properly selected. In MotionView program check &lt;Parameters&gt; &lt;Reference&gt; set to &lt;External&gt;</p> <p><b>In position mode using indexing program</b> Variables ACCEL, DECEL, MAXV, UNITS are not set or set to 0. Before attempting the move set values of motion parameters ACCEL, DECEL, MAXV, UNITS</p>

<b>Problem</b>	In velocity mode, the motor runs away.
<b>Possible Cause</b>	<ul style="list-style-type: none"> <li>• Hall sensors or encoder mis-wired.</li> <li>• PositionServo not programmed for motor connected.</li> </ul>
<b>Suggested Solution</b>	<ul style="list-style-type: none"> <li>• Check Hall sensor and encoder connections.</li> <li>• Check that the proper motor is selected..</li> </ul>

# Notes



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