Quin Systems Limited

Programmable Transmission System

Q-Drive Installation Manual

Issue 9

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Relevant Directives

The product is designed to be incorporated into a system for the control of machinery, and needs external equipment to enable it to fulfil this function. It must not be relied upon to provide safety-critical features such as guarding or emergency stop functions. It must not be put into service until the machinery into which it has been incorporated has been declared in conformity with the Machinery Directive 89/392/EEC and/or its relevant amendments.

The installation instructions in this manual should be followed in constructing a system which meets requirements.

The product has been tested in typical configurations, and meets the EMC Directive 89/336/EEC and the Low Voltage Directive 73/23/EEC as amended by 93/68/EEC.

The product as normally supplied has low voltages accessible to touch, and must be mounted within a suitable cabinet to meet any required IP rating to BS EN 60529.

Contents

Figures and Tables

1. Introduction

This document is the Installation Manual for the Q-Drive series 200/400, members of the Quin Systems digital Programmable Transmission System (PTS) range.

The systems comprise hardware and software to control one or more servo motors. The hardware is highly modular, allowing systems to be easily expanded or upgraded. The software provides full control over all aspects of the system, but has a simple high-level user interface.

The Q-Drive series 200 and 400 units are intended for controlling 3-phase brushless a.c. servo motors equipped with a resolver or Hiperface sensor for position feedback, or asynchronous a.c. motors using resolver or encoder feedback. They are fully digital systems, offering high performance torque, speed and position control. Digital control allows comprehensive diagnostics, motor and drive parameter tuning, and data or fault logging.

The Q-Drive is available in several versions, each of which is available in several current and voltage ratings. The standalone Q-Drive is a normal digital drive, used with a separate position control system such as the MiniPTS 3. The Q-Drive 1+1 is fitted with a Quin PTS position controller supporting one servo axis and one additional encoder input, and allowing simple synchronization between them. The Q-Drive Map can also perform complex motions and synchronization, and supports position synchronization between units using SynchroLink. The Q-Drive SERVOnet is designed for use in a distributed system, supervised by a Quin Machine Controller.

PLEASE READ THIS MANUAL BEFORE INSTALLATION.

It is very important that the guidelines for installation are observed, otherwise damage to the system or to the machine may occur. Quin Systems Limited accept no liability for damage or costs arising from incorrect or inadequate installation of the systems, or from incorrect programming of the system for the required application. Digital control systems are not simple, but can be used successfully to control industrial machinery and provide great improvements in reliability, performance and flexibility.

This issue of the manual covers the following drive firmware versions:

Standalone drives (analogue input)	2007 or later
Intelligent drives (digital control using PTS)	2207 or later
Hiperface standalone drives	3003 or later
Hiperface intelligent drives	3203 or later

These versions of the intelligent drives correspond to PTS firmware V1.9.1 or later.

2. Unpacking and Inspection

Inspect the packaging for external signs of damage, if possible before signing the delivery receipt, as this may indicate that it has been mishandled in transit. When unpacking the system, keep all the packaging materials if possible. If it is necessary to ship the system to another site, or to return it for service, the original packing can be re-used.

Inspect the system carefully when it is unpacked. Check for any loose parts, any circuit boards loose in their card guides, cables not connected, or any bending of the case or chassis.

If any defect or damage is suspected, do not connect power to the system. Notify the carrier immediately, and contact your sales office or the Quin Systems Service Department:

Quin Systems Limited
Service Department
Oaklands Business Centre
Oaklands Park
Wokingham
Berkshire RG41 2FD
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Telephone	+44 (0)118 977 1077
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	support@quin.co.uk
Web site	http://www.quin.co.uk/index.html

3. System Specifications

This section gives the overall specifications of the system, including mechanical details and environmental requirements.

3.1 Features

The Q-Drive series 200 and 400 systems are fully digital high performance motor drives. They are designed to control 3 phase brushless a.c. servo motors, equipped with a resolver or Hiperface sensor for position feedback, or asynchronous a.c. motors using encoder or resolver feedback. Suitable motors have the following characteristics.

Brushless a.c. servo motor:

> Rotor constructed with permanent magnets, arranged in 1, 2, 3, 4, 5 or 6 pole pairs, without commutator. Electronic commutation uses shaft position feedback from a single speed resolver or a Hiperface sensor. Stator constructed with 3 windings, star or delta connected.

Asynchronous a.c. motor

> Squirrel cage induction motor with 1, 2, 3, 4, 5 or 6 pole pairs, without commutator. A resolver or encoder is used for speed feedback.

Motors fitted with Hall effect sensors and/or tachogenerators are not suitable.

Each drive is a single axis unit including a dynamic braking module, for connection to a 3 phase power supply. It is possible to connect multiple drives to a common d.c. bus voltage. Series 200 drives use a 230V 3 phase supply, usually via a transformer. Series 400 drives connect directly to a 400V 3 phase supply. An internal filter is fitted to reduce noise on the mains supply.

The power driver offers galvanic isolation between the control and power electronics. It uses an IGBT output stage. It has a digital PWM current loop controller providing very low motor ripple currents and high efficiency.

The digital controller allows simple software upgrades, and is fully programmable. Standalone units are configured via an RS232 or RS485 serial link. Units fitted with a position controller use an internal high speed serial link to pass information between the drive controller and the position controller. The position controller module has RS232 and RS485 serial ports, and a SERVOnet link for real-time networking and synchronization, based on CANbus.

The drive controller has an energy management system which controls the cooling fan. Temperature monitoring in the drive and a thermostat switch in the motor are standard. The system executes multiple control loops, with both torque (current) and speed control loops fully programmable. The current outputs to the motor are sinusoidal, providing smooth torque and excellent performance at low speeds.

Note that asynchronous motor control is an option available on the standard drive hardware, and Appendix B lists the changes to the drive parameters when this option is used. The Hiperface feedback sensor option requires different hardware, and must be specified when ordering. Appendix C lists the changes to the drive parameters and interfaces for this option.

3.2 Mechanical specification

The table below gives the overall dimensions and maximum weights for the Q-Drive series 200/400 units. There are two case sizes depending on the voltage and power rating of the unit. They are normally rear mounted on a panel, but can be mounted recessed through a panel, with the rear part of the unit behind the mounting panel to allow better cooling.

Dimensions	Small	Large	
Height	300	422	mm
Width	74	122	mm
Depth	210	300	mm
Weight	3.2	10.5	kg

Sufficient additional clearance must be left in front of the unit for the resolver, serial port and other connectors on the front panel, and below the unit for the motor and power connections. The system must be mounted vertically with at least 50mm clearance above and below the unit and 10mm each side to allow cooling air to circulate. All units are fitted with a cooling fan.

3.3 Environmental specification

Temperature:	storage	0 to 70°C
	operating	0 to 45°C
Relative humidity:	20 to 80% non-condensing	

The system is normally supplied in a case or chassis with ventilation holes top and bottom, and therefore is not protected against dust, particles, or liquids. If necessary, the unit can be supplied in a suitable sealed cabinet. Please contact your sales office or Quin Systems directly for further details.

3.4 Power supply specification

The Q-Drive series 200 systems are designed for a 230V 3 phase power supply. The Q-Drive series 400 systems are designed for a 400V 3 phase supply. The frequency range for all units is 45-65Hz. An additional 6.7V d.c. supply may be connected to maintain power to the drive controller even when the mains power is removed. This allows the system to keep track of the motor position when the drive is powered down. Units fitted with a Quin position controller also require 24V d.c. for the digital inputs and outputs.

The 3 phase supply needs to have external EMC filters fitted for all drives rated at more than 10A, and where more than two smaller drives share the same cabinet or supply feed. An external filter is also required when the d.c. bus terminals are fitted, for applications where braking energy is shared between drives.

3.5 Electrical specification

This table summarizes the electrical specifications of the Q-Drive units.

Description	Units	Series 200	Series 400
Supply voltage	V a.c.	3×230 +10% –20%	3×400 +10% –20%
Supply frequency	Hz	45 to 65	
Operating temperature	°C	0 to 45	
Storage temperature	°C	0 to 70	
PWM chopper frequency	kHz	7.5	
Analogue input range (differential)	V	±10	
Analogue input voltage (+ve input)	V	±20	
Analogue input voltage (–ve input)	V	±10	
Analogue input impedance	Ω	8k	
Speed control range		1/32768	
Speed loop bandwidth	Hz	max. 150	
Current loop bandwidth	Hz	max. 2000	
Max. output voltage to motor	V	3×220	3×390
Output frequency to motor	Hz	0 to 500	
Incremental encoder simulation	pulses/rev	0 to 2048	
Max. resolver speed	rpm	8000	
Link encoder signal levels		RS-485	
Link encoder max. count rate	counts/s	2.4×10^6	
Brake module ON switching threshold	V	385	670
Brake module OFF switching threshold	V	380	660
Overvoltage trip ON threshold	V	410	710
Overvoltage trip OFF threshold	V	400	700
Undervoltage trip OFF threshold	V	230	295
Undervoltage trip ON threshold	V	220	380
Resolver characteristics (see Appendix C for Hiperface sensor)	Speed one (1 sine/cosine period per turn)		
	Ratio 0.5		
	Reference frequency 5kHz to 10kHz		

Table 1: Electrical specification

The following table lists the different models in the Q-Drive range, with their current and power ratings.

Drive type		Rated rms current (A)	Rated peak current (A)	Max. rms current (A)	Max peak current (A)	Rated power (kW)	Max. power (kW)
Small	205	5	7	10	14	2	4
	210	10	14	20	28	4	8
	218	18	25	36	50	7	14
	403	3.5	5	7	10	2.5	5
	405	5	7	10	14	3.5	7
	409	9	13	18	25	6	12
Large	420	20	28	40	56	13.5	27
	430	30	42	60	84	20	40

Table 2: Model ratings

This table shows the braking power ratings for the Q-Drive units.

Drive type		Braking resistor value (Ω)	Peak braking power (W)	Max. continuous braking power (W)	Max. surge energy (J)
Small	205	39	3800	150	1800
	210	39	3800	150	1800
	218	39	3800	150	1800
	403	56	8000	250	2600
	405	56	8000	250	2600
	409	56	8000	250	2600
Large	420	11	41000	1000	21000
	430	8	56000	1000	24000

Table 3: Braking power ratings

The surge energy rating is the maximum permitted dynamic brake application from cold. To a first approximation, heat is then removed from the braking resistor at the rate given by the continuous braking power value; thus a time interval of about 20s must be allowed between successive full-energy stops to allow the braking resistor to cool.

The braking energy may be shared between several of the small drives by linking their d.c. bus terminals (link all + together, and all – together), up to a total current rating of 60A. The set of drives must synchronise their brake modules' switching by linking the small "BR" terminals, and they must always be connected to the same 3-phase supply, not switched separately by individual contactors or isolators. Note that this feature is not available on models fitted with an internal EMC filter.

The electrical characteristics of the Q-Drive position controller module are listed here. The position controller is fitted in the Q-Drive 1+1, Map and SERVOnet systems.

External power supplies :

Encoder supply		+5V
Digital i/o supply		+24V
Logic standby supply		+6.7V (7.0V max. off load, 6.0V min. on load, 650mA)

Encoder input :

Frequency (count rate) 600 kHz maximum (2.4×10^6 counts per second)
Track A input leads track B input for positive direction

Analogue output :

Output range	0–5V
Resolution	12 bits
Output impedance	<100Ω

Digital inputs :

Voltage rating		+24V nominal
Input current	typical:	10–20 mA
	maximum:	50 mA
Threshold voltage		10–16V
Reverse voltage		+50V maximum
Isolation voltage		250V a.c. peak or d.c.

Digital outputs :

Saturation voltage (output on)	1.9V maximum (at full load current)
Breakdown voltage (output off)	300V minimum
Reverse breakdown voltage	50V minimum
Load current	100 mA maximum
Isolation voltage	250V a.c. peak or d.c.

3.6 Relevant directives

The product is designed to be incorporated into a system for the control of machinery, and needs external equipment to enable it to fulfil this function. It must not be relied upon to provide safety-critical features such as guarding or emergency stop functions. It must not be put into service until the machinery into which it has been incorporated has been declared in conformity with the Machinery Directive 89/392/EEC and/or its relevant amendments.

The installation instructions in this manual should be followed in constructing a system which meets requirements.

The product has been tested in typical configurations, and meets the EMC Directive 89/336/EEC and the Low Voltage Directive 73/23/EEC as amended by 93/68/EEC.

The product as normally supplied has low voltages accessible to touch, and must be mounted within a suitable cabinet to meet any required IP rating to BS EN 60529.

4. Mounting Details

The Q-Drive systems have mounting holes on the rear metal plate, for fixing to the electrical panel inside a cabinet. The units are fixed with three M5 bolts through holes at the top and bottom of the unit. The fixing centres for these bolts are shown in the diagram below. Note that the top fixing holes are keyhole shaped to allow the unit to be slotted over the heads of the mounting bolts. The diagram below shows the fixing centres and dimensions for both the small and large drive units.

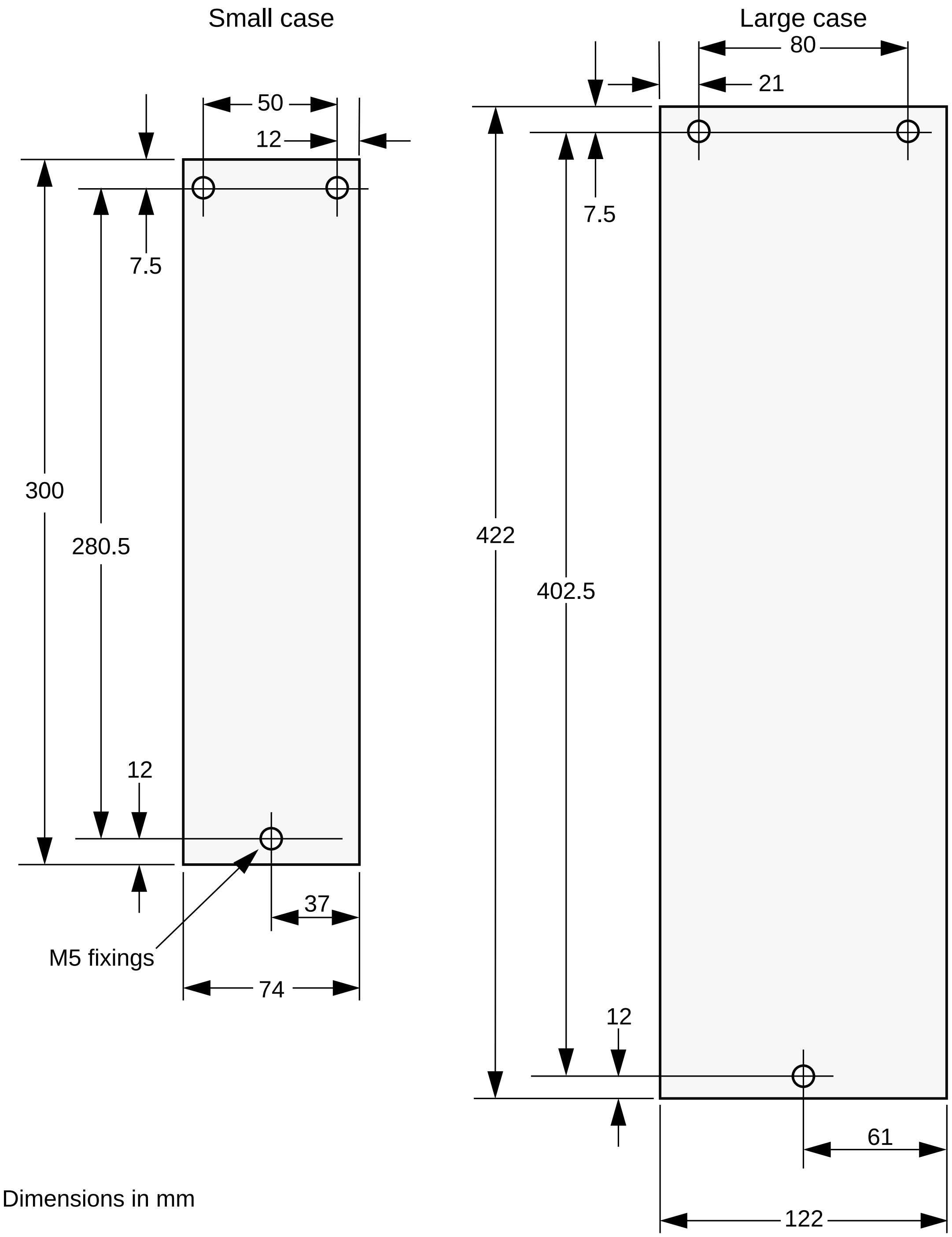


Figure 1. Fixing centres for the Q-Drive.

The small Q-Drive systems can be installed through a cutout in the mounting plate, in such a way that the braking resistor protrudes behind the plate. This can sometimes be an advantage because of the improved ventilation and cooling available behind the mounting plate rather than in front. The sketch below shows the revised fixing centres and the panel cutout for this mounting arrangement. The unit protrudes 70mm behind the mounting plate and 140mm in front when installed in this way. Suitable mounting brackets are supplied with the unit.

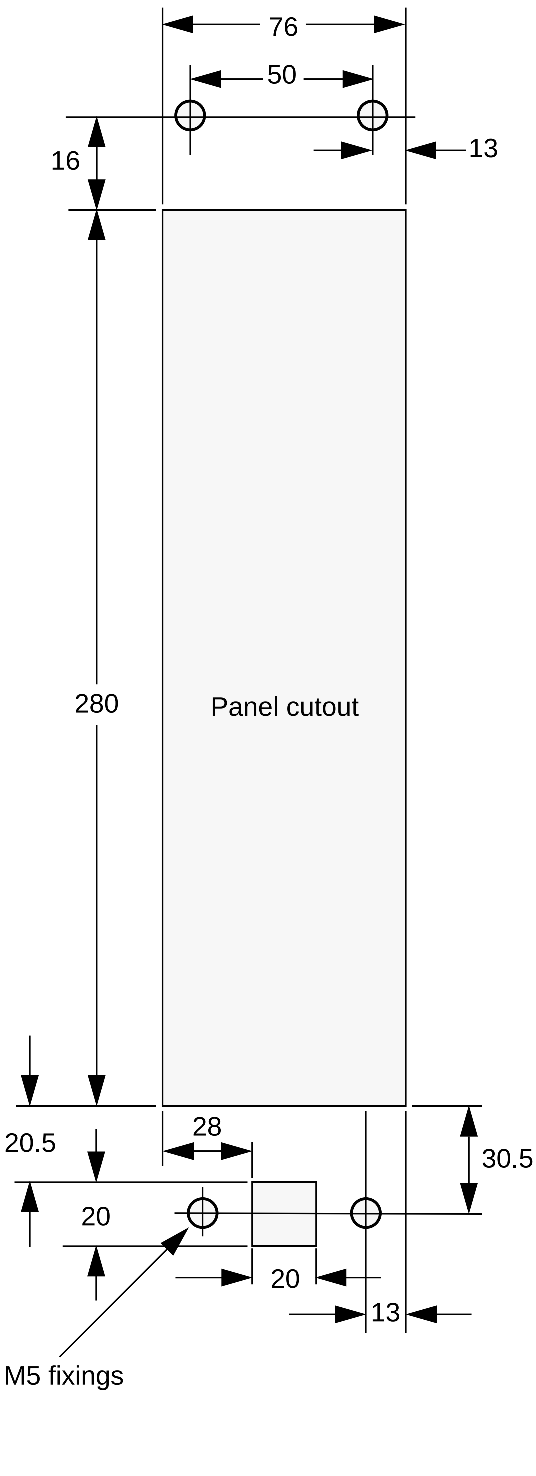


Figure 2. Installing a small Q-Drive through a mounting plate.

5. Connections

The Q-Drive systems have several connectors. All models have the following connectors fitted to the drive digital control board.

- 9 way D plug for RS-232 serial port, used for initial drive configuration.
- 9 way D socket for resolver or Hiperface sensor input.
- 15 way D socket for link encoder or encoder simulation output.
- 25 way D socket for analogue input, 6.7V backup power supply, and drive enable inputs.
- Screw terminals for 3 phase mains supply input.
- Two-part screw terminal connector for 3 phase motor power and optional brake.

Models fitted with the Hiperface sensor feedback option have an additional 2 pin power connector for the sensor power supply input.

Standalone Q-Drive models also have a 6 way IDC header, used for an RS-485 serial link, and a hexadecimal rotary switch used to set the node address.

Models fitted with the Quin PTS position controller also have the following connectors.

- 9 way D plug and socket P1 and S1 for SERVOnet high speed network, based on CANbus.
- 9 way D socket S2 for RS-232 programming terminal port.
- 9 way D socket S3 for RS-485 port, used for Operator's Panel or low speed plc communications link such as Modbus or Data Highway.
- 10 way and 8 way two-part screw terminal connectors T1 and T2 for isolated 24V digital inputs and outputs.

The front panel layouts and connection details for both the standalone units and the intelligent systems fitted with position controllers are shown on the following pages.

5.1 Standalone Q-Drive

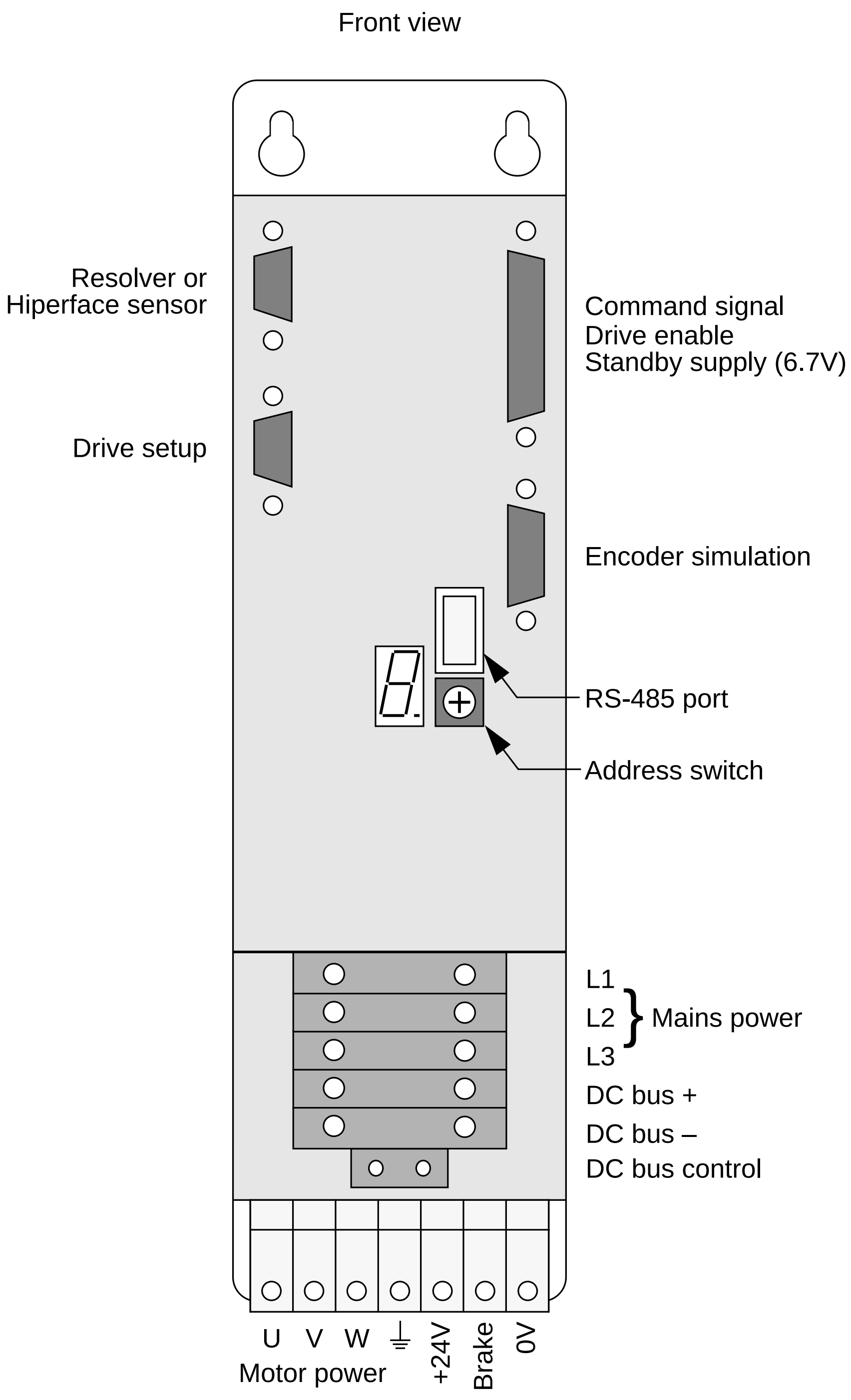


Figure 3. Standalone Q-Drive front panel layout

The resolver is connected via a 9 way D type socket. The pin connections to this are shown below. A typical cable with twisted pair and screen connections is shown in figure 6 on page 26. The connections for using a drive with a Hiperface sensor are given in Appendix C.

Pin no.	Signal	Pin no.	Signal
1	SCREEN	6	THERMOSTAT2
2	THERMOSTAT1	7	SIN2V5
3	SIN	8	COS2V5
4	COS	9	REFB
5	REF		

Table 4: Resolver connections

The connections to the motor itself are shown in the following table. The unit uses a two-part screw terminal connector for the motor and brake connections. Note that units without the optional brake signals use a 4 way connector, while those with the brake signals use a 7 way connector.

Pin no.	Signal	Description
1	U	Motor power (3-phase)
2	V	Motor power (3-phase)
3	W	Motor power (3-phase)
4	SCREEN	Motor cable screen or shield
5	+24V	+24V d.c. brake supply (optional, 30V max.)
6	BRAKE	Brake relay signal (optional, 2.5A max. load)
7	0V	0V brake supply (optional)

Table 5: Motor and brake connections

The drive setup and configuration serial port uses a 9 way D type plug. This is used for configuring the drive at the factory, and can be used to set drive parameters if the drive is not using the RS-485 interface. The pin connections to this are shown below.

Pin no.	Signal	Pin no.	Signal
1		6	
2	RXD	7	
3	TXD	8	
4	RTS	9	
5	GND		

Table 6: Drive setup connections

The RS-485 programming serial port uses a 6 way header plug, suitable for IDC ribbon cable connectors. It supports multi-drop operation with several drives connected to the same serial link. The drive may be configured to use this port to set parameters instead of the RS-232 serial port. The pin connections to this are shown below.

Pin no.	Signal	Pin no.	Signal
1	TXD	2	/TXD
3	RXD	4	/RXD
5	GND	6	GND

Table 7: RS-485 programming port connections

The connections to the 25 way D type socket are shown below. This includes the command signal and drive enable signals, and the standby supply for the encoder simulation output signals if required.

Pin no.	Signal	Description
1	GND	General purpose ground for digital inputs, outputs, and 0V reference for command signal input.
2	COMMAND V+	Non-inverted analogue input.
3	COMMAND V–	Inverted analogue input.
5	GND	
7	/EXTLIMI	Current limit input - limits drive current to programmed value, or switches between speed and current loop control modes. *
8	RDY1	Drive ready relay contact (24V 0.4A).
10	RDY2	Drive ready relay contact (24V 0.4A).
11	GND	
12	/ENABLE	Drive enable. Link to GND to enable drive. *
13	GND	
14	GND 24V	0V for optoisolated enable input.
15	ENABLE 24V	+24V optoisolated enable input.
19	/ENDSW1	Positive limit switch input. *
20	/ENDSW2	Negative limit switch input. *
23	V6OK	Reserved. Do not connect.
24	V6PWR	External 6.7V standby supply input. Maintains digital drive controller and encoder simulation if required.
25	V6GND	External power supply ground.
* Signals marked are active low, with internal 4K7 pull-up resistors to +5V. Switch these to GND with a volt-free contact to operate.		

Table 8: Command signal and drive enable connections

The connections to the 15 way D type socket are shown below. On a standalone unit, this provides the encoder simulation output signals generated by the drive controller from the resolver feedback signals.

Pin no.	Signal	Description
1	GND	Internal ground
2	GND	
3		
4		
5		
6	/Z	Encoder simulation Z marker output (inverted)
7	Z	Encoder simulation Z marker output (true)
8	/B	Encoder simulation track B output (inverted)
9	B	Encoder simulation track B output (true)
10	/A	Encoder simulation track A output (inverted)
11	A	Encoder simulation track A output (true)
12	GND	
13		
14		
15		

Table 9: Encoder simulation connections

When encoder speed feedback is used with an asynchronous a.c. motor, the encoder input connections are as shown in Table 14: this lists the complete connections for the link encoder input.

The controller used with a Hiperface sensor has different signals on this connector, shown in Appendix C.

5.2 Q-Drive with position controller

Three versions of the Q-Drive fitted with a Quin PTS position controller are available. The Q-Drive 1+1 supports one servo axis and one additional encoder input, and allows simple synchronization between them. The Q-Drive Map can also perform complex motions and synchronization, and supports position synchronization between units using SynchroLink. The Q-Drive SERVOnet is designed for use in a distributed system, supervised by a Quin Machine Controller. These systems have the same hardware and connections, but are configured with different software options. The connections to the digital drive controller are similar to those used on the standalone drives, but with some differences. They do not have the RS-485 programming port or the address switch. In addition, there are extra connections to the position controller itself.

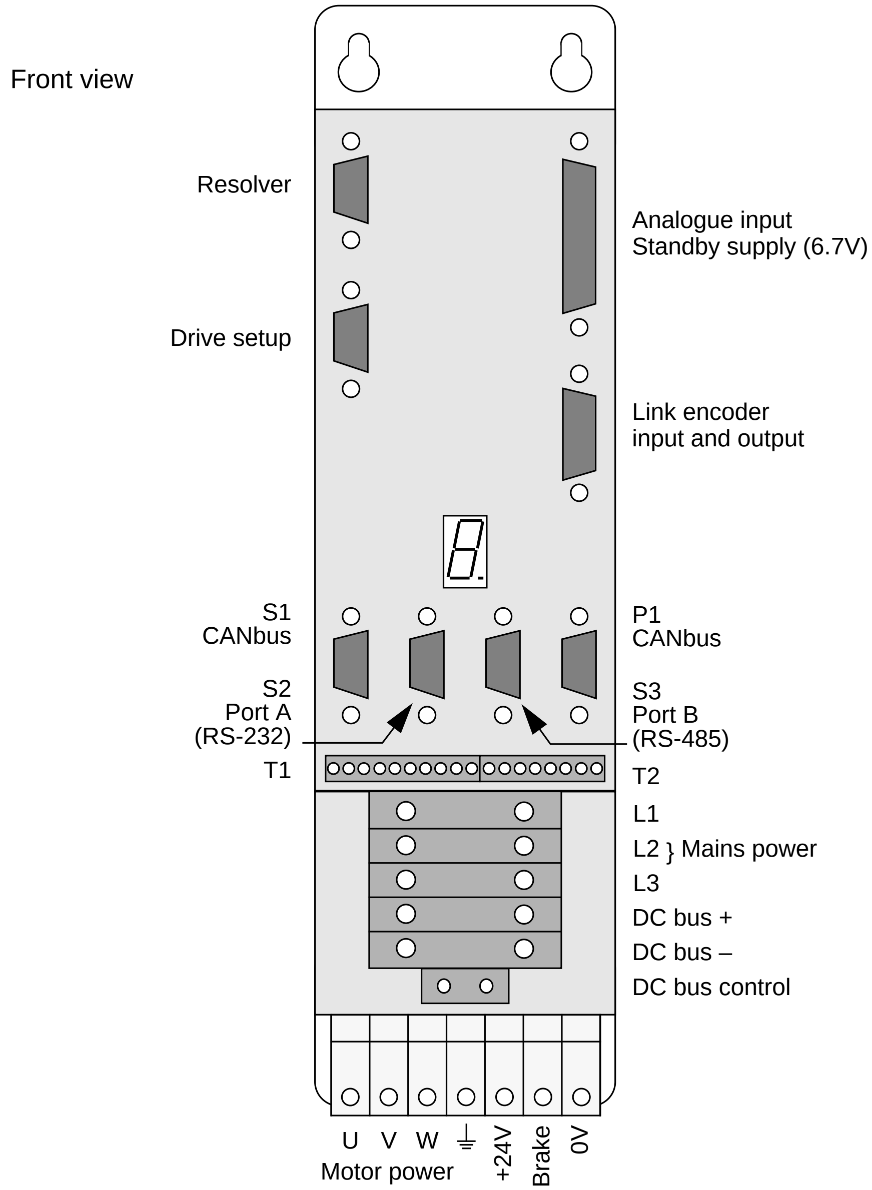


Figure 4. Q-Drive front panel layout with position controller

The resolver is connected via a 9 way D type socket. The pin connections to this are shown below. A typical cable with twisted pair and screen connections is shown in figure 6 on page 26. Appendix C gives the connections for a Hiperface sensor.

Pin no.	Signal	Pin no.	Signal
1	SCREEN	6	THERMOSTAT2
2	THERMOSTAT1	7	SIN2V5
3	SIN	8	COS2V5
4	COS	9	REFB
5	REF		

Table 10: Resolver connections

The connections to the motor itself are shown in the following table. The unit uses a two-part screw terminal connector for the motor and brake connections. Note that units without the optional brake signals use a 4 way connector, while those with the brake signals use a 7 way connector.

Pin no.	Signal	Description
1	U	Motor power (3-phase)
2	V	Motor power (3-phase)
3	W	Motor power (3-phase)
4	SCREEN	Motor cable screen or shield
5	+24V	+24V brake supply (optional, 30V max.)
6	BRAKE	Brake relay signal (optional, 2.5A max. load)
7	0V	0V brake supply (optional)

Table 11: Motor and brake connections

The drive may use a 9 way D type plug for initial factory configuration or firmware upgrades. The pin connections to this are shown below.

Pin no.	Signal	Pin no.	Signal
1		6	
2	RXD	7	
3	TXD	8	
4	RTS	9	
5	GND		

Table 12: Drive setup connections

The connections to the 25 way D type socket are shown below. This includes the analogue input and standby supply for a system fitted with a position controller. More details are given in Table 8: this lists the signals as used on a standalone drive.

Pin no.	Signal	Pin no.	Signal
1	GND	14	Do not connect
2	ANALOGUE IN+	15	Do not connect
3	ANALOGUE IN–	16	
4		17	
5	GND	18	
6		19	/ENDSW1
7	/EXTLIMI	20	/ENDSW2
8	RDY1	21	
9		22	
10	RDY2	23	Do not connect
11	GND	24	V6PWR
12	Do not connect	25	V6GND
13	GND		

Table 13: Analogue input and standby supply connections

The connections to the 15 way D type socket are shown below. On a system fitted with a position controller, an external encoder may be connected as a master position axis, except where this input is used for asynchronous motor speed feedback. These encoder signals are buffered and available as link encoder output signals. Appendix C gives connections for the Hiperface version.

Pin no.	Signal	Description
1	GND	Internal ground
2	GND	
3	AI	Encoder input track A (true)
4	/AI	Encoder input track A (inverted)
5	BI	Encoder input track B (true)
6	/Z	Link encoder output Z marker (inverted)
7	Z	Link encoder output Z marker (true)
8	/B	Link encoder output track B (inverted)
9	B	Link encoder output track B (true)
10	/A	Link encoder output track A (inverted)
11	A	Link encoder output track A (true)
12	GND	
13	/BI	Encoder input track B (inverted)
14	ZI	Encoder input Z marker (true)
15	/ZI	Encoder input Z marker (inverted)

Table 14: Link encoder connections

The RS-232 serial port on the position controller uses a 9 way D type socket. The pin connections to this are shown below.

S2 pin no.	Signal	S2 pin no.	Signal	
			RS-232	RS-485
1		6		
2	/TXD	7	RTS	TXD
3	/RXD	8	CTS	RXD
4		9		
5	GND			

Table 15: Serial port A connections

The RS-485 serial port for the Operator's Panel or Modbus interface uses a 9 way D type socket. The pin connections to this are shown below.

S3 pin no.	Signal		S3 pin no.	Signal
	RS-485	RS-232		
1	High termination		6	+Vbias
2	TXD	RTS	7	/TXD
3	RXD	CTS	8	/RXD
4	Low termination		9	AUXOUT
5	GND	GND		(0–5V analogue)

Table 16: Serial port B connections

The SERVOnet high speed network ports use both a 9 way D type plug and a socket. This allows units to be daisy chained together easily with standard cables, while allowing any unit to be bypassed by linking the two cables together. The pin connections to these are shown below. Note that this complies with the CAN in Automation (CiA) draft standard DS102 Version 2.0, CAN Physical Layer for Industrial Applications, but with additional signals used for error detection.

Pin no.	Signal	Pin no.	Signal
1	LINK1	6	CAN_0V
2	CAN_L	7	CAN_H
3	CAN_GND	8	CAN_ERR
4	LINK4	9	CAN_V+ (7–13V)
5	CAN_SHLD (screen)		

Table 17: SERVOnet (CANbus) connections

Two-part screw terminal blocks T1 and T2 are used for the 24V isolated digital input and output signals. The connections to T1 and T2 are as follows:

Signal	Screw terminal number
Input 1	T1.1
Input 2	T1.2
Input 3	T1.3
Input 4	T1.4
Input 5	T1.5
Input 6	T1.6
Input 7	T1.7
Input 8	T1.8
0V I/O	T1.9
24V I/O	T1.10
Output 1	T2.1
Output 2	T2.2
Output 3	T2.3
Output 4	T2.4
Output 5	T2.5
Output 6	T2.6
Output 7	T2.7
Output 8	T2.8

Table 18: Input/output connections : T1 and T2

Inputs 1 to 4 can be programmed for a fast response, and are used for referencing or position snapshot functions.

5.3 Typical installation

This section shows some typical installation diagrams for the standalone Q-Drives and the position control versions.

The following diagram shows the connections for the mains power supply, motor and resolver, illustrated with the standalone Q-Drive. This power wiring is the same for all Q-Drive systems, including the position control models.

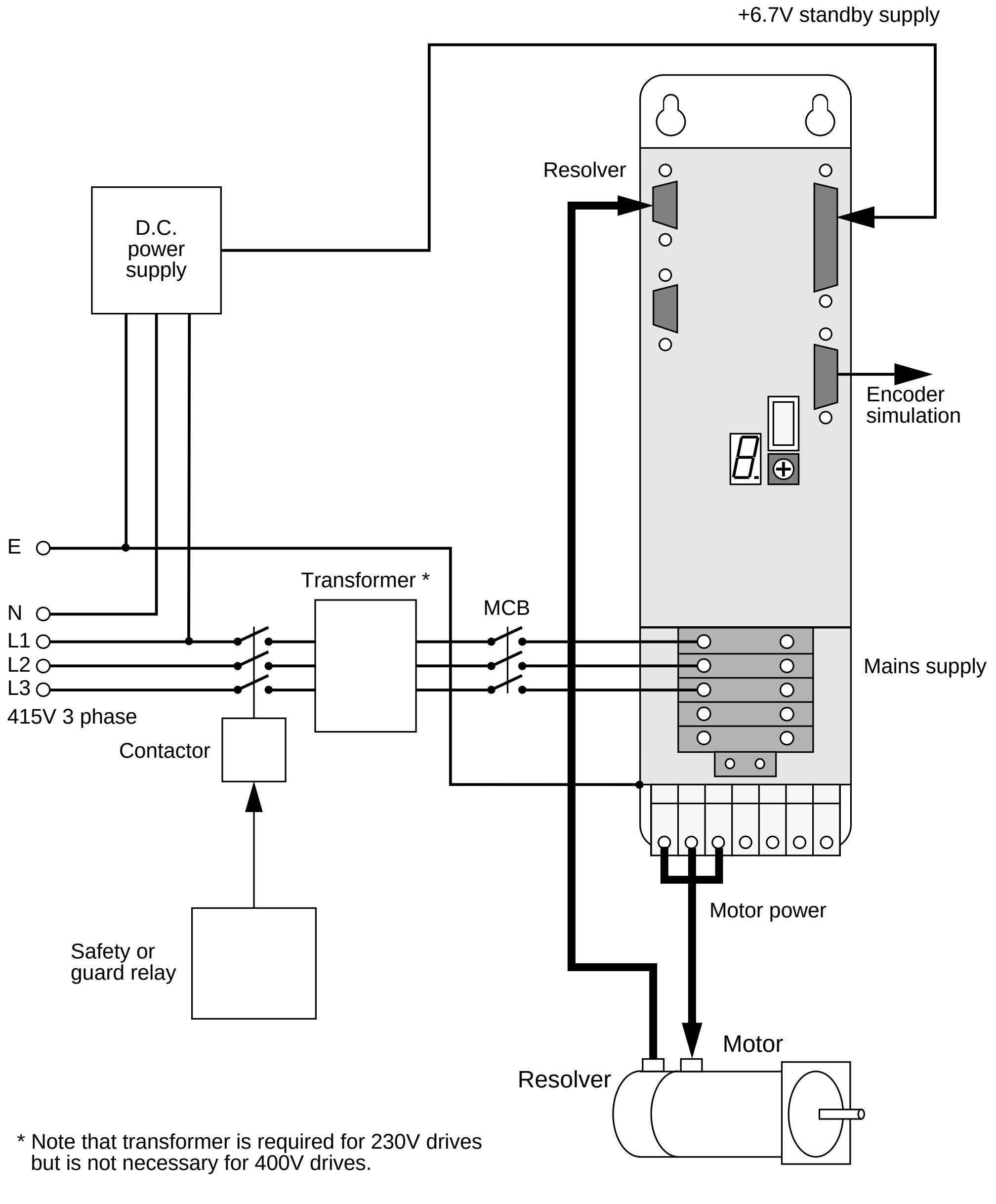


Figure 5. Q-Drive power connections

An external mains filter is necessary for the 15A or larger drives, and may be necessary for smaller models in particular instances.

The following table shows recommended cable sizes for the Q-Drive units.

Drive type		Supply cable size (mm^2)	Motor cable size (mm^2)
Small	205	1.5	1.5
	210	1.5	1.5
	218	2.5	2.5
	403	1.5	1.5
	405	1.5	1.5
	409	1.5	1.5
Large	420	2.5	2.5
	430	4	4

Table 19: Cable sizes

The recommended maximum cable length between the motor and the drive is 15m.

The following diagram gives details of the resolver cable connections, showing the normal use of twisted pairs and the screen connections.

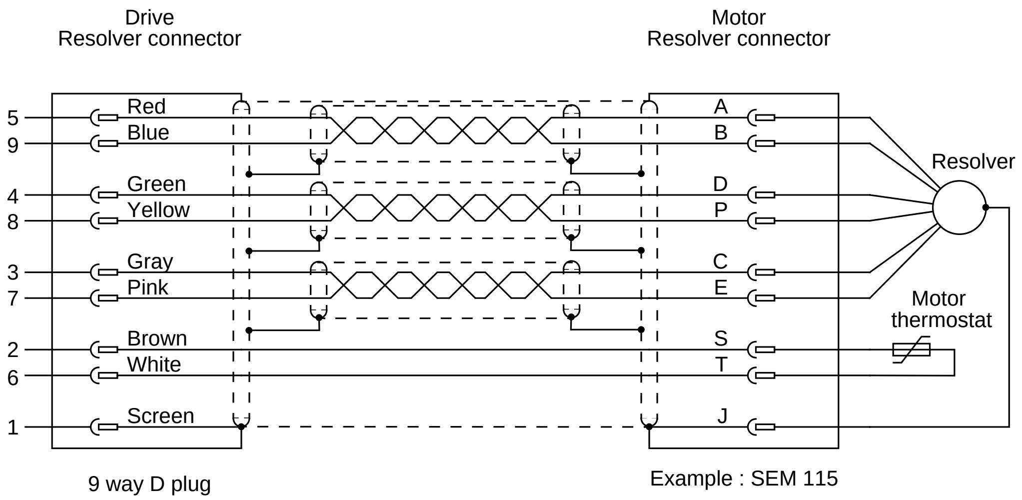


Figure 6. Typical resolver cable connections.

The connections for a Hiperface sensor are listed in Appendix C.

The analogue output and drive enable signals between a separate position control system such as the Quin MiniPTS3 and a standalone Q-Drive are shown in the next diagram. The diagram shows the terminal and connector pin numbers. Note that three different methods of connecting the drive enable signal are shown, with drives 1 and 3 connecting to optocoupled enable inputs and drive 2 connecting to an enable input with an internal pull-up resistor.

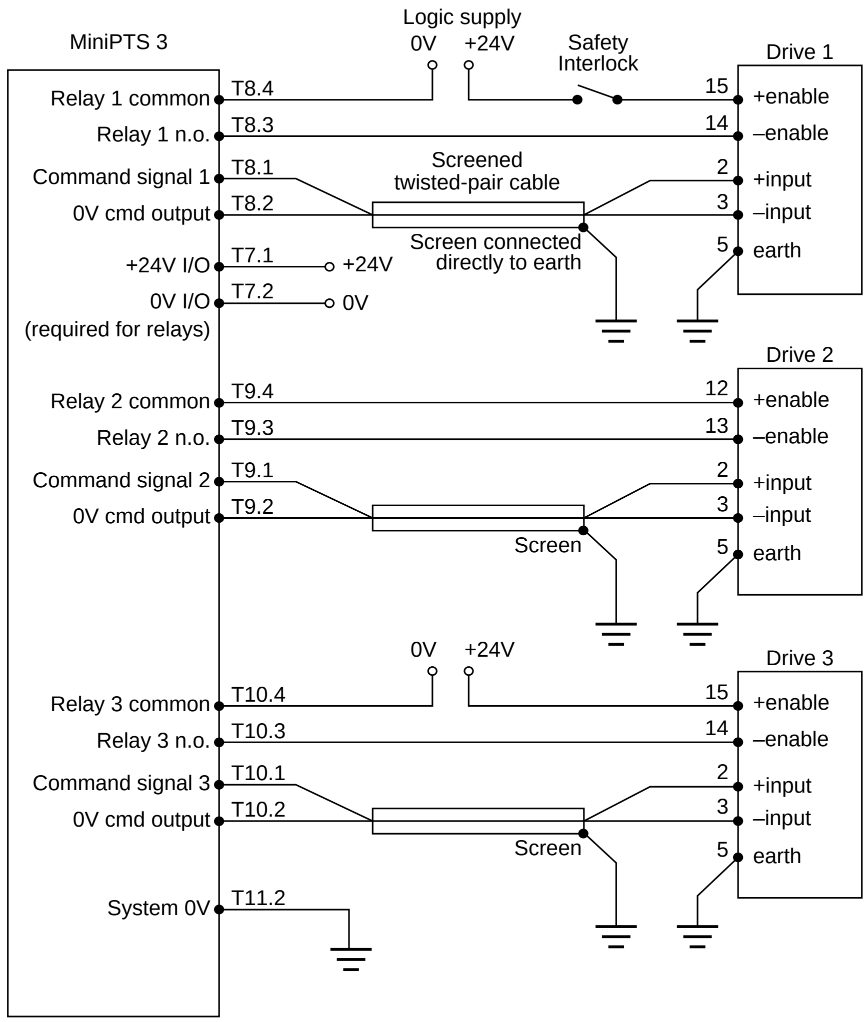


Figure 7. Drive command connections to a standalone Q-Drive.

In some applications, it may be useful to connect a 100nF capacitor across each command signal (for example, between T8.1 and T8.2 in the diagram above) to reduce cross-coupling of switching noise between drives.

The following diagram shows the additional connections used with the Q-Drive 1+1 or Map versions.

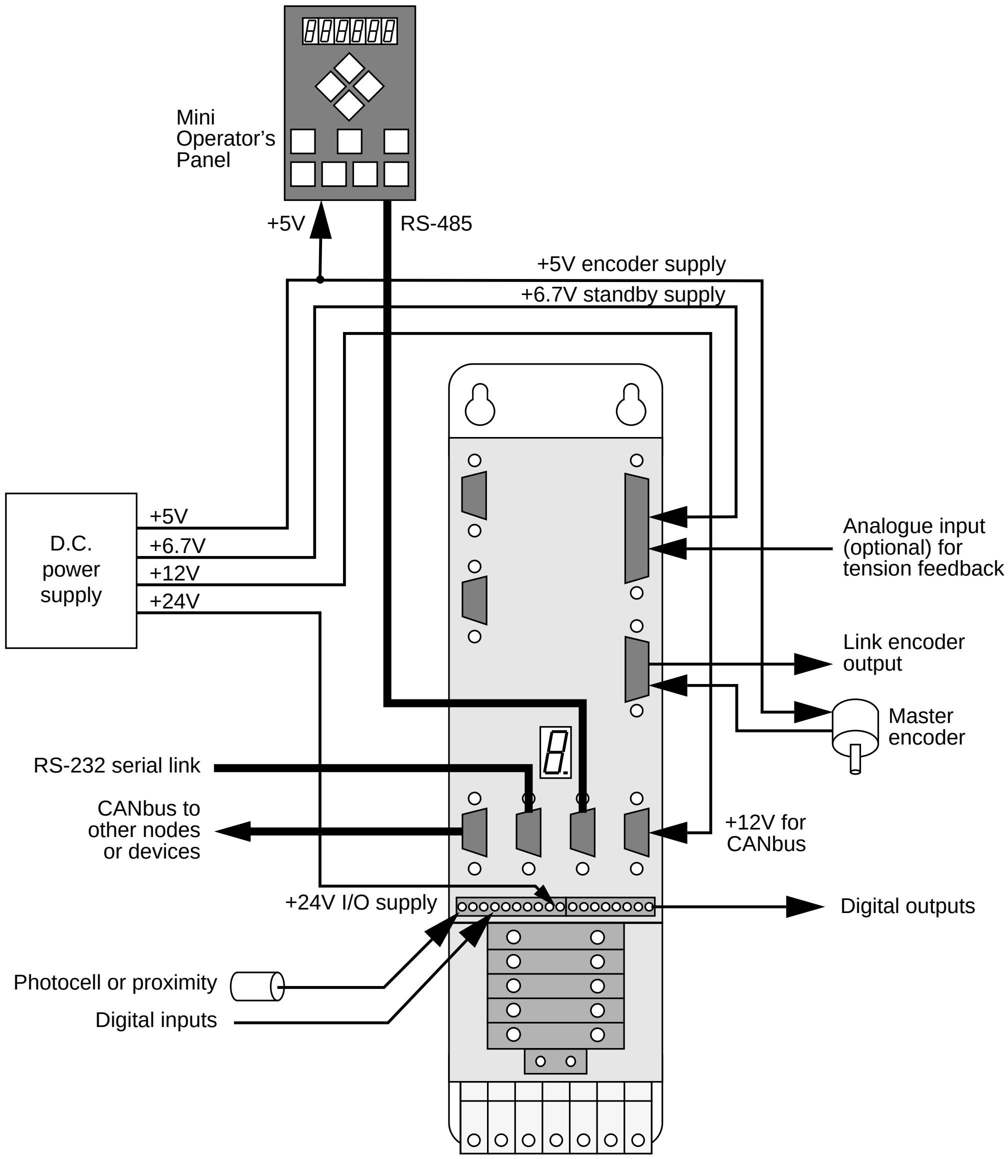


Figure 8. Q-Drive 1+1 or Map connections

The connections required for a typical Q-Drive SERVOnet installation are shown in the following diagram.

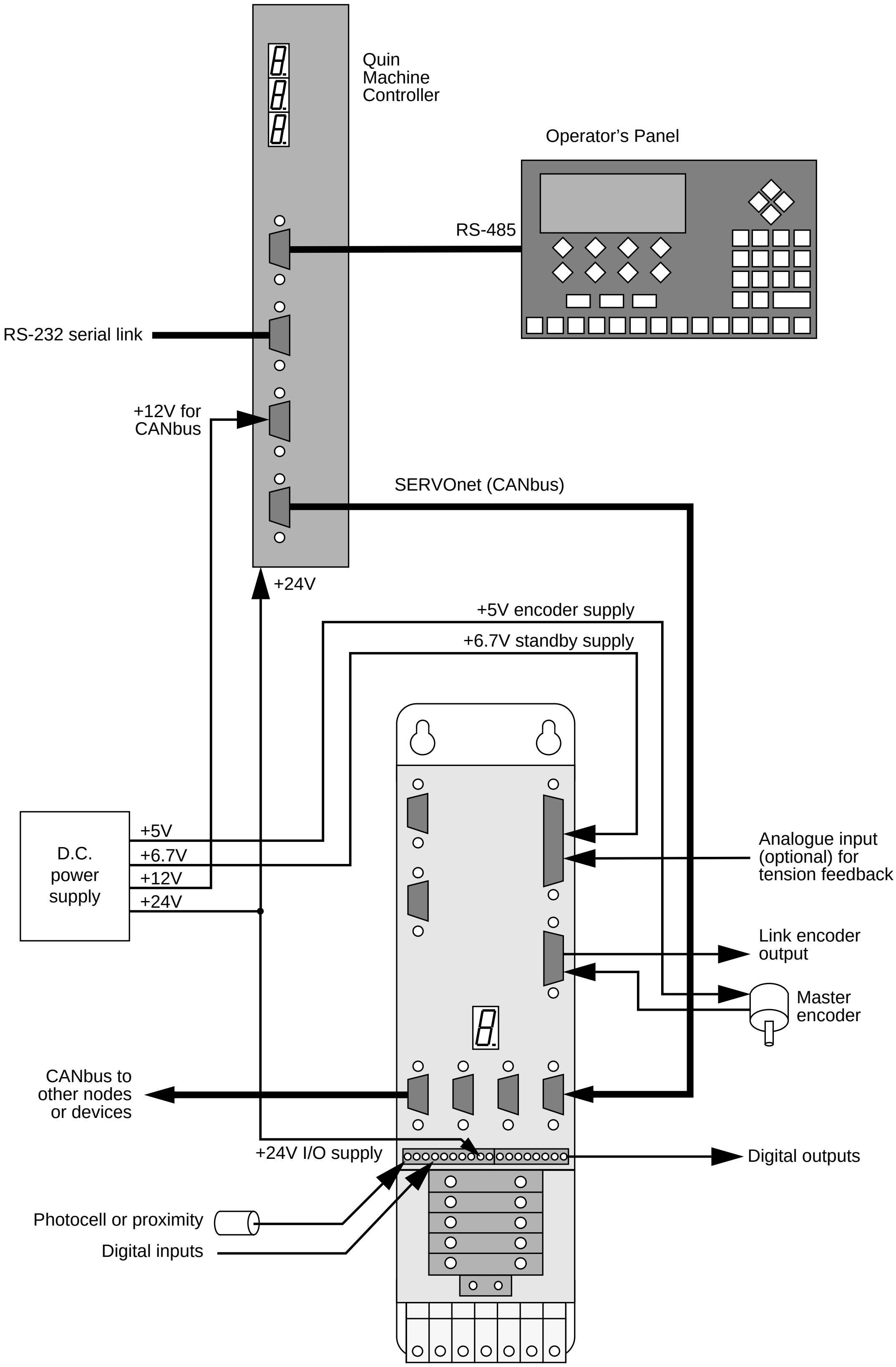


Figure 9. Q-Drive SERVOnet connections

This diagram shows typical circuits for the digital input and output lines on the Quin PTS position controller module fitted in the Q-Drive, with the indicator LEDs on the front panel connector board shown as well.

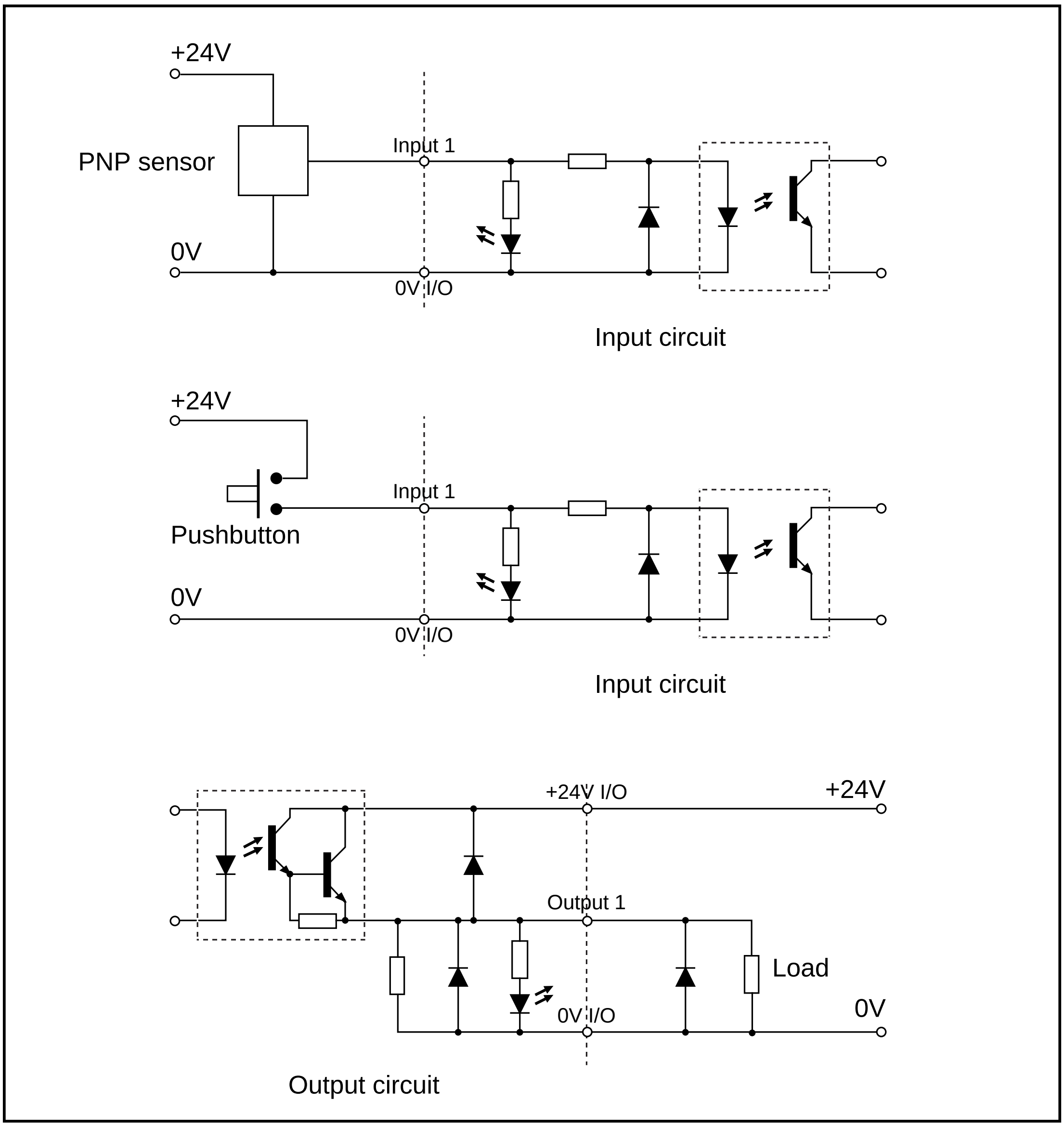


Figure 10. Input and output circuits

6. Setting Up a Q-Drive

6.1 Introduction

The Q-Drive series 200/400 systems are fully digital, and as such they offer comprehensive diagnostics, motor and drive parameter tuning, and data or fault logging via the built-in software within the drive.

To set up a drive, use the program QDRIVE.EXE on a PC or compatible machine. The program runs under the Windows 95 or NT 4 operating systems (or later). QDRIVE.EXE may be installed from the supplied floppy disks by executing the SETUP.EXE program as usual. The program uses a serial port on the PC to communicate with the drive, and allows a wide range of operations to be performed.

On a drive fitted with a Quin PTS position controller, the PC should be connected to serial port A on the controller module, the second socket from the left at the bottom of the unit. On a standalone drive, the PC should be connected to the drive RS-232 serial port or the RS-485 serial port, whichever is enabled by the setting of the hexadecimal rotary address switch. If the switch is set to zero, then the RS-232 port is selected. If it is set to any other value, then the RS-485 port is selected, and the drive uses the switch value as its node address for multidrop operation.

6.2 Using the Q-Drive Setup program

It is beyond the scope of this manual to describe fully the operation of a typical Windows program, and it will be assumed that most readers are familiar with the normal operation of the mouse, menus, dialogue boxes, etc.

The program has a number of functions available. These are selected by one of the pull-down menu options, or by clicking on the buttons below the menu. The main functions are listed here and are detailed in the following sections.

- Loading drive parameters from PC, saving drive parameters to PC and storing all parameters in drive permanent memory.
- Viewing drive status, alarms and snapshots of drive operation.
- Reading and setting drive parameters.
- Motor stimulus generator for use when tuning a drive.
- Oscilloscope function for tracing real-time data such as speed or current.

Each option brings up a window containing text fields, up/down buttons, or other pushbuttons. The operation of the program is reasonably simple, and includes tooltips; move the mouse over an item and a brief description of the item appears.

Some general points of note are:

- When configuring a drive through a PTS position controller there should be no active PTS program. It is best to issue the RS command from the PTS Terminal before using the Q-Drive setup program. The setup program uses the PTS commands AO, CH, MO, OM, PC, QP, QQ, SY, WT, and the variable $QP.

- When configuring a standalone Q-Drive without a PTS controller fitted, it is necessary to enable and disable the motor by shorting the motor enable connections. Any suitable switch (preferably a momentary pushbutton type) may be used. The setup software uses digital setpoint commands via the serial port to set the motor speed, so the analogue setpoint input should be held at 0V.

- Always have an external method of shutting off the drive if a fault occurs. Do not rely solely on the PC software.

- Drive settings are uploaded to the PC for viewing when a particular screen display is selected. If the PC is then connected to a different drive, or the drive settings are modified by some other method, the setup program does not automatically detect the change and update the displayed values. To refresh the display with the current values in the drive, change the selected display page or scan for drives again.

6.3 Configuring drive communications

When QDRIVE.EXE is started it automatically scans the PC for available serial ports, and then scans for Q-Drives if an appropriate serial port is found. If a drive is correctly connected to the PC before QDRIVE.EXE is started then it is detected and selected automatically. If it is necessary to use a different serial port from the current selection use the “Scan for drive(s)” button to scan the newly selected serial port for connected Q-Drives. If more than one drive is connected to the serial port, as with a SERVOnet system, then select the appropriate drive and press space or enter. Once a drive is selected the Q-Drive setup software can be used.

The program options allow questions and messages to be suppressed (for experienced users only), and to choose whether to store the program configuration (window positions, ’scope colours and trace selections, etc.) for next time it is used.

Press the “Next” button to see useful information on what to do next.

6.4 Drive status

The “Drive Status” button brings up information on the drive and snapshots of what the drive is doing. The drive information includes serial number, current limits and firmware version numbers. Make a note of this information when contacting Quin Systems for technical support. The drive status display contains snapshots of the motor position and speed, drive current output, and drive temperature. Moving the motor by hand (with the drive disabled) rotates the motor position indicator if the drive is correctly configured.

The drive status and alarm registers are displayed by pressing the appropriate button. Each bit in these registers is shown with a description of the present state. For a standalone Q-Drive with no PTS position controller fitted, you can reset the drive from the alarm register display.

6.5 Motor configuration

Seven parameters give the basic drive configuration for any given motor. They are listed on the screen shown when the “Motor Configuration” button is pressed. See section 10.2, on page 50 for information on each parameter listed on this screen.

The drive uses a resolver for position feedback from the motor. The resolver shift angle must be set correctly for the drive to work properly. Pressing the “Set Resolver Shift Angle” button will produce a dialogue box that can perform an automatic detection of the correct resolver shift angle.

NOTE: an incorrectly configured resolver shift angle can cause the motor to spin very fast out of control. This may damage any attached machinery. Carefully test this parameter before mounting the motor on any machine. Please note the following points:

- Ensure that you can stop the drive independently of the PC.
- The maximum drive current is automatically reduced to just less than one third of its rated value during the shift angle detection to protect the drive electrics.
- For a Q-Drive 1+1, Q-Drive MAP and Q-Drive SERVOnet, the PTS command string “`SE400/SA90000/SV3000/PC/MR500/MR-500/MO`” is used to test the drive with a short move. The test procedure relies on several other PTS parameters in order to work properly, including CW, KP, KI and KV. The default values for these (after an RS) are normally satisfactory [though KP of 100 rather than 256 is better for certain drive/motor combinations]; any changes from the default values may cause problems.
- For a standalone Q-Drive it is necessary to enable and disable the drive manually, as indicated by the setup software. A momentary pushbutton switch is ideal for this as the motor enable can be removed by just releasing the switch.
- Incorrect wiring can cause the automatic detection of the shift angle to fail.

During the shift angle detection procedure, the motor may move suddenly, and at high speed. This happens when the safe range of the shift angle is being detected.

6.6 Motor options

The “Motor Options” button displays a screen giving the options that determine how the drive will control the motor, and what the motor is restricted from doing. See section 10.3, on page 52 for information on these parameters.

6.7 Encoder configuration

The drive has an encoder interface which can either connect to an external encoder or output simulated encoder signals from the resolver position data. The settings for this are given in this window; see section 10.4, on page 53 for more information.

6.8 ’Scope

Once the above steps have been completed the motor/drive interface should be correctly configured. The ’scope allows a stimulus to be applied to the motor and the response to be recorded. The current and velocity control loops within the drive can then be adjusted to produce the desired performance. It is a good idea to perform the final tuning of the motor when attached to the machine if possible, so that the inertia load of the machine is present.

When the ’scope is selected, a toolbar appears containing buttons representing the main functions; start/stop, configuration, tuning and drive status. Each function of the ’scope uses a dialogue box to configure or display the settings, as detailed below. The colours and line widths of the ’scope display are configurable from the ’scope menu.

The motor stimulus dialogue box provides a simple signal generator to make the motor move. The motor can be stimulated in current or velocity control, and various repeating step changes in current or speed can be programmed. Sensible speeds and time intervals should be chosen for the motor/machinery in use.

The current loop and speed loop control gains dialogue boxes present the PID control gains used in the drive. Pressing space or enter on any parameter in these dialogue boxes updates the value in the drive, so tuning can be performed interactively.

The ’scope records two traces of information from the drive. The drive parameter and scale for each of these traces can be selected, along with the ’scope trigger and timebase. Parameter 67 (instant current) and parameter 68 (instant speed) provide useful feedback of what the drive is doing, and using parameter 99 (internal digital setpoint) as trace 1 allows you to accurately measure the demand input and actual response of the drive, with clean triggering on demand current or speed changes.

Once the motor stimulus has been configured and the ’scope is displaying the drive response, the performance may be tuned by adjusting the PID gains in the drive. Each drive is shipped from Quin Systems with PID gains suitable for a motor as used for testing, but this does not take into account any specific motor, nor the external load to be attached to the motor shaft. For more information on tuning see section 10.7, on page 58.

Important information on ’scope vertical scales
The ’scope collects all the data in the drive before displaying the graph on the PC screen. The drive performs the scaling of the data as per the trace scales requested from the PC. With the default setting, when a trace contains values too big for the selected scale the drive *wraps* the data before sending it to the PC (rather than clipping it). This has the advantage that you can monitor the ripple on a high value steady state signal by using a small scale, and the disadvantage that the data reported by the PC has incorrect scale information. It is also possible to set up the drive such that it clips or saturates data values that are too large at the current selected scale factor.

For example. The motor is rotating at a constant speed of 1000 RPM. The ’scope is configured to trace parameter 68 (instant speed) at a scale of 118.5 RPM/div. The collected data will show a straight line at approximately 51 RPM with any steady state ripple immediately visible. Therefore steady state tuning can be investigated but the PC is reporting incorrect scale information.
[to calculate this: 1000 RPM / (118.5 RPM/div * 4 div) gives remainder 51 RPM]

When using the ’scope always bear in mind what you expected to see and that the data might be wrapped if your trace scale is smaller than the data values.

6.9 All parameters

The “All Parameters” window allows the user to view or change any drive parameter. The important drive parameters are described later in Chapter 10., while a full list of the drive parameters and a brief description of their functions is given in Appendix A. Note that some parameters are read only and cannot be changed.

BEWARE! - Most drive parameters should only be changed with care, by engineers who have experience of these systems. It is possible to cause severe damage to a machine by modifying these parameter values incorrectly.

The window displays values in decimal and (for some parameters) scaled units. Values may be entered in any format by typing a new value in the appropriate box, or by clicking on the up/down buttons. Pressing the space or enter key sends the new value to the drive. Parameters that consist of binary flags can be changed using a dialogue box which lists each binary flag with an indication of its present setting.

7. Safety - Using Guards and Limits

All machines should include comprehensive safety features. This is essential both for normal safety considerations, and to comply with Health and Safety requirements. It can also prevent any unwanted interference with the machine while it is running.

All moving machinery must be guarded so that it cannot be reached by anybody while in motion. The guards should be fitted with guard switches or sensors, connected so as to immediately cut power from the motors when any guard is opened. On some machines, it may be useful to lock the guards closed by means of a solenoid to prevent them from being opened while the machine is running. This allows the machine to detect any attempt to open a guard and shut down the machine cleanly before unlocking the guard and allowing it to open.

Motors which have constraints or limits on their range of motion should be fitted with hard wired limit switches. These should cut power from the motors if any motor goes outside its limits of travel. The machine must also have one or more locking emergency stop pushbutton switches, accessible from several positions around the machine. Anyone operating or working on the machine must be able to instantly stop the machine at any time by hitting an emergency stop switch.

Guards, emergency stop and limit switches may be connected into the PTS motor control systems, by using the digital input lines. However, the programmable input functions on the PTS unit should only be used in addition to the conventional hard wired guard and limit switches, not to replace them. The digital inputs can be used to trigger a smooth shutdown sequence, or to generate a limit switch error and shut down immediately. The control system can then remove power from the motors and drives if required, under software control, by using a digital output line to switch the motor supply contactors. **In all installations the limit switches and guard switches MUST remove all electrical power from the motors and drives, independently of any action of the control system.** If power is removed from the control system, then again all power must be removed from the motors. This is easily done by connecting the onboard relay on each axis controller into the drive enable function, or into the control circuit for the motor and drive main contactors. Note that this does not apply to the Q-Drive 1+1, Map or SERVOnet systems with a Quin PTS position controller fitted, as the drive enable function is controlled by an internal signal from the controller module.

Note that in most cases, it is not necessary to remove power from the control system, only from all the high power equipment. If power to the control system and encoders can be maintained even when the motors and drives are shut down, then the system does not lose any position information. This can allow the machine to start up again much more quickly than if the control system is powered off as well, since the machine does not need to execute a complete initialization before it can be restarted.

For more information on programming the Q-Drive for limit switch inputs and user defined functions, please refer to the descriptions of the DL and DI commands in the Input/Output Configuration section of the Q-Drive Reference Manual.

8. Encoders

8.1 Introduction

The Q-Drive uses a resolver or Hiperface sensor on the back of the servo motor to provide position feedback to the drive. Standalone drives derive a simulated quadrature encoder signal from the position feedback signals, which is used by an external position control system. A separate encoder may be used instead if higher resolution is required. Units that include a position controller read this position information directly via a digital link to the drive controller. These units have the option to connect an external incremental quadrature encoder as a second master axis, as used in following applications. They do not support directly any other type of encoder, although the intelligent units can read position information from absolute encoders across the CANbus interface.

8.2 What is an encoder ?

An encoder used in a position or speed control system is simply a device to measure the position of some moving part of the machine. Often it is used to measure the shaft position of a motor, but it may equally well be used to read the position of, for example, a linear slide driven by a leadscrew mechanism. In all cases, the encoder measures position (or speed) and converts it to some electrical signal. In the discussions below, rotary encoders are described, but most of the information applies equally well to linear encoders.

8.3 Types of encoders

Encoders come in various types. All of them have the same basic design. They have a device to measure positions or angles, and one or more detectors which give signals when the measuring device is moved. In optical encoders, the measuring device is a glass or plastic disc with a graticule or diffraction grating pattern on it. Filament lamps or light emitting diodes (LEDs) shine light through the disc, passing through the pattern and into light sensitive detectors such as phototransistors. When the disc is moved, the motion of the grating causes the light falling on the photodetectors to vary. The resulting electrical signals from the photodetectors are amplified to produce a usable output signal, either TTL, open collector or line driver. Some of the basic encoder types are described below.

8.3.1 Single phase encoders

These have a single photodetector and a single track on the optical grating. They provide a pulse output which indicates the motion of the shaft and the distance travelled, but does not distinguish the direction of motion. They are used in speed controllers for some unidirectional motor systems. Very coarse single phase encoders are available, consisting of a disc with a number of slots cut into the rim, say ten or twenty slots, and a slotted optical switch or magnetic sensor. These can be used for coarse control or measurement of speed in some systems.

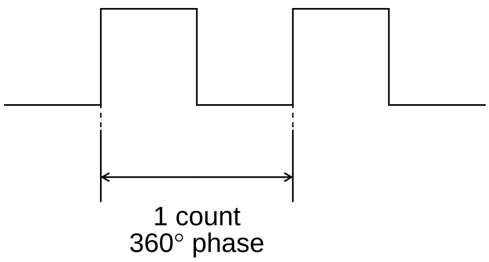


Figure 11. Single phase encoder signal.

8.3.2 Incremental or quadrature encoders

These have two photodetectors, but usually still only one track on the encoder disc. The two pulse signals are usually denoted by the names A and B. To use an incremental encoder to measure position, it is simply necessary to count the pulse cycles on the A and B tracks produced when the shaft is moved. By distinguishing the positive and negative directions, and counting either up or down appropriately, the count value represents the signed distance from the starting position to the current position.

In order to determine the direction of rotation of the shaft, the two detectors are aligned such that the signals from the one track on the disc appear phase shifted on one detector relative to the other by nominally 90°, a quarter of a cycle. When two signals have this 90° phase relationship, they are described as being in quadrature. This phase shift between the two signals allows the direction of motion to be distinguished, as well as the distance travelled. In one direction the track A signal will lead the track B signal, while in the opposite direction they are reversed, and the track B signal will lead the track A signal. This allows incremental encoders to be used for position feedback in servo motor control systems. In addition, it is possible to detect every transition on each signal track, to increase the available resolution of the encoder by a factor of four.

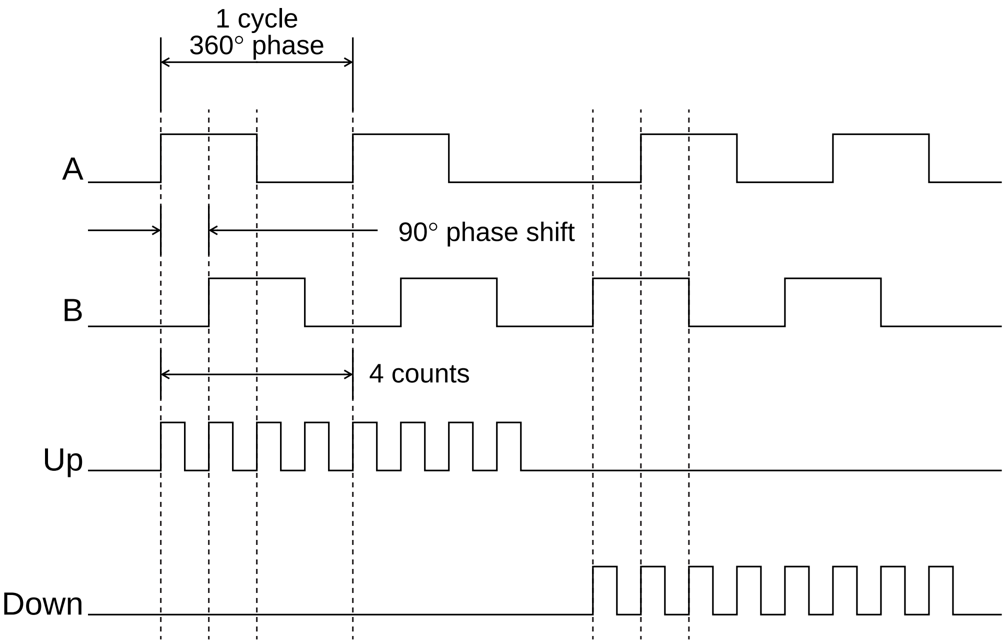


Figure 12. Incremental encoder signals and multiplication.

The major drawback of incremental encoders is that when a system is first turned on, there is no information about the current motor position. The encoder indicates only how far and in what direction the motor moves from this starting position. To provide a datum point, many incremental encoders have an extra track on their optical disc and a third photodetector. This third track, known as the marker or reference track, gives only one pulse per complete revolution of the encoder shaft. It is used to define an absolute zero position for the shaft, by moving until the marker signal is detected and setting the position counters to zero at that point. The marker signal is typically only one half or one quarter of an encoder cycle, and so provides an accurate datum position.

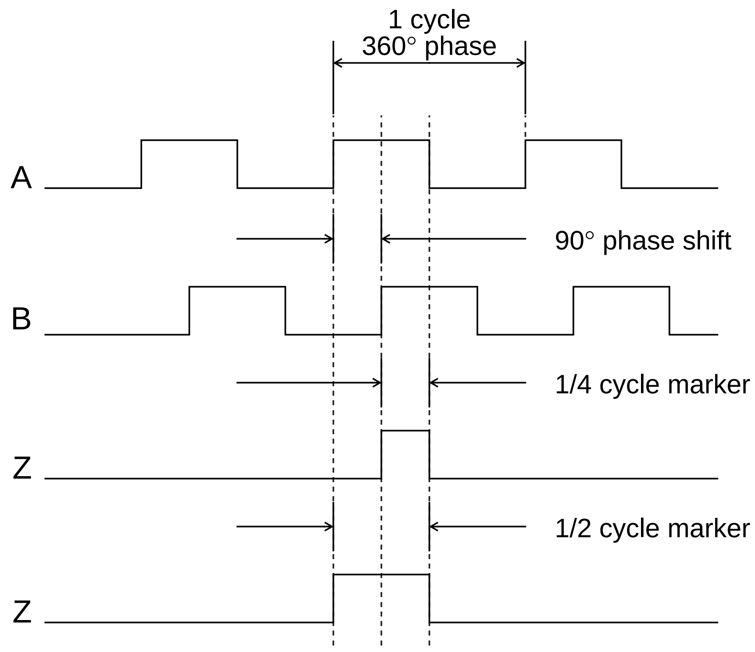


Figure 13. Incremental encoder marker signals.

Incremental encoders are readily available from 100 to 2500 counts per turn, and hardware multiplication of the encoder signals increases this by four times to 10,000 counts per turn. There are also now available incremental encoders using semiconductor lasers and interferometric techniques that give 81,000 counts per turn as standard, and up to 16 times this with hardware interpolation (1,296,000 counts per turn).

8.3.3 Absolute encoders

Absolute encoders have several tracks on the optical disc, and several photodetectors. The transitions between dark and light portions of the tracks on the encoder disc are arranged such that the parallel data available from the photodetectors represents the absolute position of the shaft. Absolute encoders are available from 8 bits to 14 bits wide, or even more, and with either binary, BCD or Gray code outputs. Gray code is often used to avoid possible problems when sampling the data while it is changing. With Gray code, only one bit of the data changes at any one encoder line transition, so that even if the data output changes while it is sampled, the error can only be ±1 bit.

Absolute encoders overcome the problem with incremental encoders of finding the zero position when the system is first started, since the absolute position value is always available. However, they are much more expensive than incremental encoders, they have to be physically larger to get the increased number of tracks onto the disc, and they require as many wires in the connecting cable as they have data bits. They also have the limitation that the position values are defined for only one revolution of the shaft, and then they cycle through the same values again. In contrast, incremental encoders with their counters may be used over any range of position values, limited only by the size of the counters used. In addition, absolute encoders of greater than 12 bits resolution (4096 counts per turn) are less commonly available and very expensive.

8.3.4 Hybrid encoders

Hybrid encoders are a combination of incremental and absolute encoders, in an attempt to work around the drawbacks of the two types. They have both incremental and absolute data signals, but usually only at low to medium resolution. They use a low resolution absolute encoder disc of, say, 8 bits precision, in conjunction with a higher resolution incremental encoder track. This gives some absolute position information at all times, and the incremental track allows finer position control than just the absolute data.

8.3.5 CANopen encoders

The Q-Drive has provision for using CANopen compatible absolute encoders. These are single or multiturn absolute encoders with a CANbus interface, having a software protocol that conforms to the CANopen encoder profile. They have typically 12 bits of position data per turn (4096 counts), and often have up to 12 bits of turns count data (4096 turns) available as well. The data from the encoder is returned in a CANopen message, when requested by the axis card or in response to a regular clock tick message. This avoids the cabling problems of parallel absolute encoders, while giving absolute position information at all times.

8.4 Encoder installation

Optical encoders with their glass or plastic disc are precision devices, and are relatively fragile. It is important that the encoder is mounted correctly so as to avoid any damage or excessive wear that could reduce its working life. The following points should be considered when installing an encoder.

- The encoder shaft should not be subject to any end or side thrust, and there should be no misalignment of the shaft. All of these will cause excessive wear of the encoder bearings, and will give rise to additional friction in the system. The encoder shaft should be connected by means of a suitable flexible coupling. These are available specifically for use with shaft encoders, designed for minimum backlash. The data sheet for any particular encoder includes the maximum permissible limits for the shaft loading.

- If possible, do not mount the encoder in an exposed protruding position, where it may be easily damaged.

- When using an encoder with a standard housing, avoid contact with oil or water as this may damage the internal electronics. Where the application requires a higher degree of environmental protection for the encoder, use one with an IP sealing rating or heavy duty housing.

- If the encoder is driven by a pulley which itself is chain or belt driven, the pulley should be mounted in its own bearings, and a coupling used to connect the encoder to the pulley. This is to avoid excessive side loads on the encoder shaft due to the sideways forces acting on the pulley.

- Do not pull the encoder cable. Make sure that the cable can not be caught up in any moving parts of the machine.

- Keep the encoder cable length as short as possible. If the cable is too long, it will be more susceptible to electrical noise. It is also necessary to ensure that the encoder supply voltage is still correct at the encoder end of the cable, as a long cable can produce a significant drop in the supply voltage. Check the resistance of the cable, and the supply current requirements of the encoder. If necessary, adjust the local power supply to compensate for the losses, but be careful not to exceed the supply voltage rating of the encoder or it will be damaged. Alternatively, either use several wires in the cable for the supply connections, or use a remote sense connection so that the power supply can regulate for the correct voltage at the far end of the cable.

9. Motors

9.1 Types of motor

There are many different types of electric motor, including d.c. servo motors, a.c. motors, and brushless servo motors. Each type has quite different performance characteristics, and is suitable for different applications.

Normal brushed d.c. servo motors are widely used. They develop full torque over a wide speed range, and are easily controlled. However, the torque does fall off at speeds near the maximum speed limit for the motor, and they have only a limited intermittent overdrive capability. The maximum torque available at a given speed is limited by the commutation of the motor brushes. The brushes are also subject to wear, and must be inspected and replaced at regular intervals. The diagram below shows a typical torque-speed plot for a d.c. servo motor.

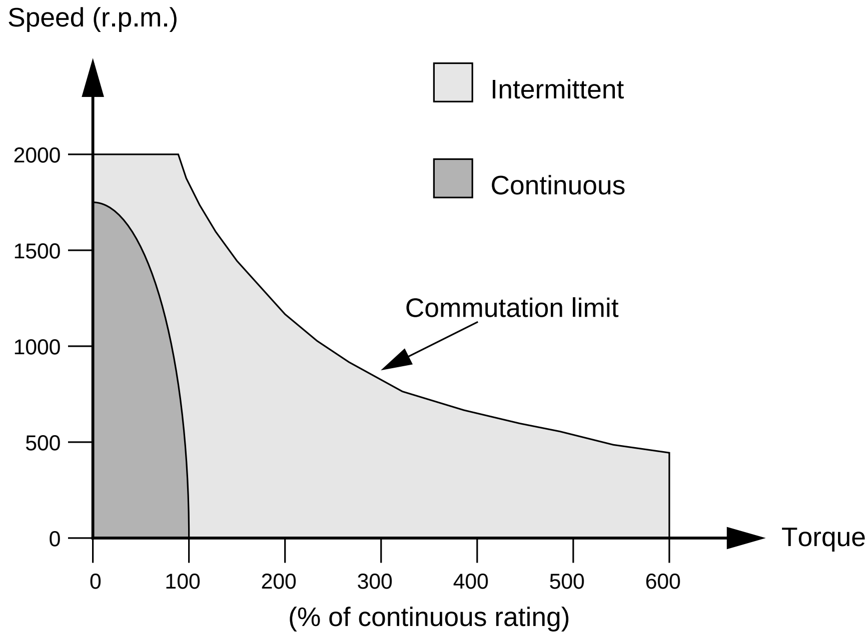


Figure 14. Torque-speed curve for a d.c. motor.

In contrast, a.c. motors are normally used with inverter drives in applications where the motor speed is constant or nearly so. They are designed for continuous near-synchronous operation, but they can be used with the Q-Drive for low cost applications, when assisted by speed feedback from a resolver or encoder. They have poor low speed torque, and do not particularly have any intermittent high torque capability. However, since they do not require brushes, they have lower maintenance requirements than brushed d.c. motors. The diagram below shows a typical torque-speed curve for an a.c. motor.

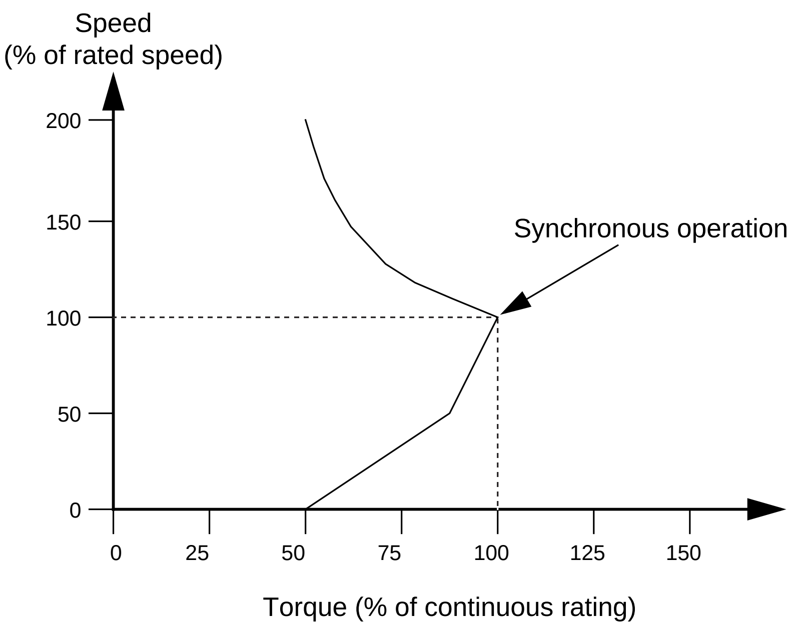


Figure 15. Torque-speed curve for an a.c. motor.

Brushless motors combine the best features of both d.c. and a.c. motors. They have high torque at all speeds, in some cases right up to the maximum speed of the motor. They have no brushes, giving improved reliability and lower maintenance than a brushed d.c. motor, and they do not suffer from the commutation limiting effects at high speeds and torques. They have a very high intermittent overdrive capability, up to as much as ten times the continuous rating for short periods. This is very useful in applications such as indexing, where the motor starts and stops very rapidly, but is not running continuously. They dissipate excess heat very quickly, because the motor windings are in the static outer case of the motor, not on the armature. This means they can run continuously at high power levels without overheating internally. All these factors combine to make brushless motors ideally suited for use in servo control systems. The diagram below shows a typical torque-speed curve for a brushless motor.

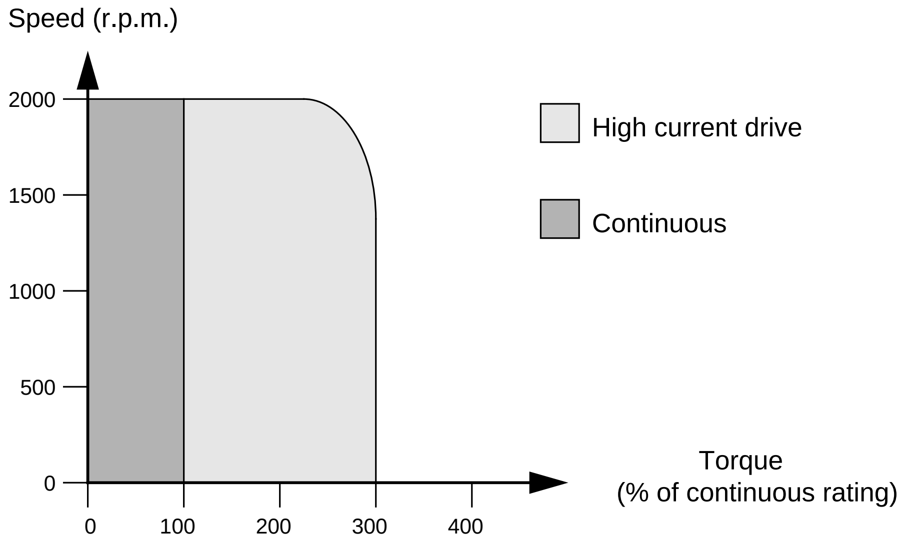


Figure 16. Torque-speed curve for a brushless motor.

Note that the Q-Drive systems are designed specifically for use with this type of a.c. brushless servo motor.

9.2 Choosing a motor

The choice of motor for a particular application depends on several factors. Some of these are given below.

- Maximum torque required.
- Continuous torque required (r.m.s.).
- Maximum motor shaft speed.
- Maximum acceleration rate.

The torque is the turning effort required from the motor in order to accelerate the mechanical load or system at the desired rate. It is usually measured in Newton metres (Nm), gramme centimetres (gcm), pound feet (lb ft) or ounce inches (oz in). In order to calculate the torque required from the motor, it is necessary to find out the following information about the mechanical system.

- The reflected total inertia of the system or load, at the motor shaft.
- The reflected total friction of the load.
- The internal motor inertia and friction.
- The maximum acceleration rate of the motor.
- Any gear or pulley ratios in the mechanical system.

For example, consider a motor driving a load via a belt and pulleys. The total torque required from the motor is given by :

$$T = \left(\left(\frac{D_1}{D_2}\right)^2 I_L + I_M\right)\frac{d^2\theta}{dt^2} + \frac{D_1}{D_2}F_L + F_M$$

where T = total motor torque required
D_1 = diameter of motor pulley
D_2 = diameter of load pulley
I_L = inertia of load
I_M = inertia of motor
$\frac{d^2\theta}{dt^2}$ = acceleration at motor shaft
F_L = friction torque of load
F_M = friction of motor.

In most cases, the inertia and friction can be assumed constant, unless the system has a changing load. In this case the maximum possible load should be used in the calculations. The required velocity profile of the motor should be sketched out by plotting motor velocity against time. The slope of this gives the motor acceleration, and thus the maximum required acceleration can be found from the steepest slope on the graph. This acceleration value can then be substituted in the torque equation for a given motor to see if the motor is powerful enough to do the job.

This can be repeated along the velocity-time plot for all accelerations to give a graph of torque against time. This can be used to find the average or r.m.s. continuous torque required by the system. Servo motors are often specified with both a continuous and a peak torque rating, and they should be chosen such that the torque requirement of the machine is well within the capacity of the motor. Care must also be taken to ensure that the maximum speed of the motor is not exceeded.

Note that if too large a motor is selected, the motor inertia is higher than for a smaller motor. This affects the maximum acceleration that the motor produces. It is not always the largest or most powerful motor that accelerates the load at the quickest rate. Also note that maximum power transfer from the motor into the load is obtained if the motor inertia and load inertia are similar.

The ideal motor should have as high a torque to inertia ratio as possible. Pancake or printed armature motors are often used because they have low rotor inertias. This is also another advantage of brushless motors, in that they have low rotor inertias. This is because the rotor often does not have any electrical windings but consists simply of a permanent magnet on a shaft.

9.3 Mounting the motor

The motor must be mounted rigidly to the structure of the machine or to a solid floor. If it is not mounted securely, it may vibrate or oscillate when the motor is powered up and the position or velocity control loops closed. The motor exerts as much torque on its mountings as it does on the load. If the mountings are flexible, they may form a resonant system, with the motor supplying plenty of power to sustain severe oscillations.

9.4 Connecting the motor to the load

The motor shaft must be connected securely to the load. This may be by means of a drive shaft, a toothed belt and pulleys, or by a gearbox. In all cases the coupling between the motor and the load must be as stiff as possible, and must have minimum backlash. At the same time, care must be taken to avoid adding any unnecessary friction into the system, as this reduces the performance of the servo system.

A common problem when connecting the motor to its load is backlash. This is usually found in gearboxes, where the input gear is allowed to move by a small amount between the teeth of the output gear, while the output gear is stationary. A similar effect is seen if the motor mountings are loose or sloppy, or if the coupling between motor and load is too flexible. The effect of backlash is not just a loss of position accuracy, but may in extreme cases result in a highly unstable system. All possible precautions must be taken to minimise or eliminate backlash in the system.

10. Drive Setup

This chapter describes some of the more important drive parameters. The order in which they are described reflects the groups of parameters displayed by the Q-Drive Setup program.

When using a Q-Drive 1+1, Q-Drive MAP or Q-Drive SERVOnet it is possible to read and set drive parameters using the QQ and QP commands respectively, through a program such as PTS Toolkit. The command QP250/1 instructs the drive to save all parameters in its non-volatile memory.

10.1 Drive Status

All the parameters used for this window of the Q-Drive Setup program come from the read only parameters, numbers 64 to 99. These parameters provide information about the drive, both its configuration and rating, and snapshots of motor position, speed, current, drive temperature and the analogue input signal.

Some other drive parameters are used for drive status and control. These are listed here.

Parameter 51 - seven segment display value
This parameter is used by the Quin position controller to show the usual PTS status display values on the seven segment LED display. When set to zero, the drive shows its normal status display values.

Parameter 250 - save parameters
Set this parameter to 1 to save all drive parameters to flash memory, on units fitted with a Quin PTS position controller. Please note that it is not advisable to use this to save drive parameters in PTS command sequences or strings.

Note that the normal SP command only saves PTS parameters, and does not save drive parameters.

Parameter 252 - clear alarms
Set this parameter to 1 to clear drive alarms, on units fitted with a Quin PTS position controller. Note that normally the PC command will clear drive alarms automatically before enabling the drive.

10.2 Motor Configuration

These parameters depend on the particular details of the motor to be used with the drive. The required information may be obtained from the motor rating plate, or from the manufacturer's data sheet.

Parameter 0 - number of motor pole pairs and options
This parameter contains the number of pole pairs of the motor. It may be between 1 and 6 pairs. A flag of value 16 is added to this to enable the use of an asynchronous a.c. motor, plus 256 if using encoder feedback, or 512 if using a Hiperface sensor.

Motor options			
Bit	Decimal	Description	
0	1	No. of pairs of motor poles	Range 1 to 6
1	2		
2	4		
3	8		
4	16	Motor type	0: Brushless 1: Asynchronous
5	32		
6	64		
7	128		
8	256	Feedback type	0: Resolver 1: Encoder 2: Hiperface
9	512		
10	1024		
11	2048		

Table 20: Motor options (address 0)

Parameter 1 - resolver or sensor shift angle
The resolver shift angle is required by the drive to calculate the actual position of the rotor for electrical signal generation. It corresponds to the mounting angle between the top dead centre positions of the resolver or Hiperface sensor and the motor itself. If the feedback device and the motor windings are correctly aligned, then this value is zero. Q-Drive Setup provides an automatic detection function to determine the correct shift angle for any given motor.

WARNING ! Incorrect setting of the shift angle can leave the motor and drive in a state where the drive is supplying a large current through one phase continuously. The drive power output devices are then in a high power dissipation region, and can be damaged if operated in this way for any significant time. It is recommended that the maximum motor current (parameter 3) is limited to a value no greater than 10000, less than 1/3 of its maximum value, until the correct shift angle has been determined.

Parameter 2 - thermostat switch type

This specifies whether the motor thermostat switch is normally open or normally closed. Set it to zero for normally open or one for normally closed. The unit recognises a closed switch with less than 1kΩ between the contacts, and an open switch with greater than 10kΩ between the contacts.

Parameter 3 - maximum motor current

This value ranges between 0 and 32767, and sets what fraction of the maximum drive current is allowed by the motor. If the maximum allowed motor current is equal to the maximum drive current, set this value to 32767. If the maximum allowed motor current is half the maximum drive current, set this value to about 16383. Q-Drive Setup presents this figure in Amps.

Parameter 4 - nominal motor current

This value ranges between 0 and 16383, and sets what fraction of the nominal drive current is allowed by the motor. If the nominal allowed motor current is equal to the nominal drive current, set this value to 16383. If the nominal allowed motor current is half the nominal drive current, set this value to about 8191. Q-Drive Setup presents this figure in amps. Any change to this value takes effect only after saving parameters in the drive.

Parameter 5 - motor I^2t limit

This value sets the maximum limit on the motor I^2t measured by the drive, expressed as the time in ms for the drive to trip at a current equal to twice the nominal current set by parameter 4. Any change to this value takes effect only after saving parameters in the drive.

Parameter 23 - maximum speed for 10V input

The maximum motor speed is normally printed on the motor rating plate. This drive parameter value should be set to the motor maximum speed in r.p.m. divided by 0.925. For the standalone drives with the analogue setpoint input, this sets the full speed range, i.e. the maximum input setpoint of 10V corresponds to this speed. If a negative value is entered, then the sense of the setpoint input is reversed.

The motor overspeed alarm is activated if the motor speed exceeds 1.25 times this maximum speed value.

10.3 Motor Options

These parameters complete the configuration of the drive for a particular motor by specifying how the motor should be controlled, and what restrictions are to be applied.

Parameter 24 - end switch configuration
This parameter sets the drive up for use with either normally open or normally closed contacts on the end switch inputs. End switch 1 inhibits motion in the positive direction, while end switch 2 inhibits motion in the negative direction. Set this parameter as follows:

Parameter 24	Set to 0	Set to 1
Bit 0 - end switch 1	Normally open (active low)	Normally closed (active high)
Bit 1 - end switch 2	Normally open (active low)	Normally closed (active high)

Table 21: Parameter 24 - end switch configuration

Parameter 25 - direction inhibit
This parameter sets up the system to drive the motor in one direction only. Setting bit 0 to 1 inhibits movement in the positive direction, while setting bit 1 to 1 inhibits movement in the negative direction.

Parameter 25	Set to 0	Set to 1
Bit 0 - positive inhibit	No effect	Inhibit positive movement
Bit 1 - negative inhibit	No effect	Inhibit negative movement

Table 22: Parameter 25 - direction inhibit

Parameter 26 - speed or current loop control
This parameter sets up the drive to operate in either speed loop control or current loop control. Set this parameter to 0 for speed loop control, or to 1 for current loop control. In speed loop control, the setpoint value is interpreted as a speed demand, while in current loop control, the setpoint value is interpreted as a current demand.

Parameter 33 - alarm latch enable
This parameter allows certain alarm flags to be latched when they occur. Set bits in this parameter to enable the corresponding alarm latch, as in the following table.

Parameter 33	Set to 0	Set to 1
Bit 0 - alarm 7 (over or under voltage)	Disable alarm latch	Enable alarm latch
Bit 4 - alarm 2 (I^2t limit)		
Bit 6 - alarm b (overspeed)		

Table 23: Parameter 33 - alarm latch enable

10.4 Encoder configuration

The encoder parameters set up options for the encoder simulation output on standalone drives, and for the link encoder input on intelligent drives.

Parameter 14 - encoder input configuration (optional)
This value is used to set up hardware options for the link encoder input. These should not normally be changed by the user.

Bit 0 of this parameter selects the source of the encoder output signals. It also determines the source of the quadrature encoder pulses available to the second axis of the Quin PTS position controller.
Set it to 0 to output the simulated encoder signals derived from the resolver. This is the normal setting for standalone drives, where the encoder simulation signals are required for position feedback by the external control system.
Set it to 1 to output a buffered copy of the link encoder input signals. This is the normal setting for drives fitted with an internal Quin PTS position controller.

Bit 1 of this parameter programs the drive to reset its encoder input position counter when a marker pulse is detected. This function is not used in the Q-Drive systems, and bit 1 should be set to 0.

When using an asynchronous a.c. motor with encoder feedback, both bits 0 and 1 of this parameter should be set, giving a value of 3. When using a Hiperface sensor, this parameter is read only. The sensor types are listed in Appendix C.

Parameter 17 - encoder resolution
This sets the number of lines per turn of the simulated encoder output, derived from the resolver feedback signals. It may be set between 1 to 2048 lines (quadrature cycles) per turn, giving 4 to 8192 encoder counts. Note that for values greater than 1024, the signals are extrapolated from the 12 bit (4096 count) resolver signals.

Parameter 18 - encoder marker pulse width and gating
This sets the width of the marker pulse output to 1, 2, or 4 encoder counts, and whether the marker is gated with the /A or /B signal. Set this parameter as follows:

Parameter 18	Marker pulse width (counts)	Gated with:
0	1	/B
1	2	/B
2	4	/B
4	1	/A
5	2	/A
6	4	/A

Table 24: Parameter 18 - marker pulse width and gating

Parameter 19 - encoder marker pulse position
This sets an offset between the marker pulse position and the resolver zero position, of up to ±1/2 a turn, represented by a parameter value between ±32767. For example, to move the marker pulse 90° ahead of the resolver zero, set this parameter to 16384.

Parameter 54 - external encoder lines per turn
This sets the number of lines per turn for an external encoder, when used for speed feedback with an asynchronous a.c. motor.

10.5 Drive control loop

These parameters set up the drive current and speed control loops. Please refer to section 10.7, on page 58 for a brief description of how to tune the drive control loop.

Parameter 6 - current loop proportional gain
Range 1 to 32767.

Parameter 7 - current loop integral gain
Range 0 to 32767. Note that if this value is set to zero, the change to zero has no effect until drive parameters are saved.

Parameter 8 - current loop differential gain
Range 0 to 32767.

Parameter 9 - phase advance
This parameter applies a phase advance, proportional to speed, to the drive current control loop. It is specified as tenths of degrees (electrical) of phase advance per 1000 r.p.m. of motor speed. For example, a value of 12 gives a phase advance of 1.2° at a speed of 1000 r.p.m. It has a range of 0 to 10° per 1000 r.p.m.

Parameter 20 - speed loop proportional gain
Range 1 to 32767.

Parameter 21 - speed loop integral gain
Range 0 to 32767. Note that if this value is set to zero, the change to zero has no effect until drive parameters are saved.

Parameter 22 - speed loop differential gain
Range 0 to 32767.

Parameter 28 - analogue setpoint offset
When the analogue setpoint is enabled by parameter 27, then this parameter sets up an offset value applied to the analogue input signal. It has a range of ±255.

Asynchronous motor parameters
Some control parameters are changed when using an asynchronous a.c. motor, and there are also some extra parameters, described briefly here. For more details about using an asynchronous motor, see Appendix B.

Parameter 9 - slip factor
This parameter sets the motor slip factor. It can be set to a value between 0 and 4915, representing 0 to 15% slip. The slip factor normally ranges from 1 to 7%. Usually 4% is a good value.

Parameter 11 - cos ϕ
Cos ϕ is found from the motor manufacturer's data, and is usually a value between 0.8 and 0.9. It is entered as $32768 \times \sin \phi$, as this allows greater precision.

Parameter 55 - field weakening speed
If field weakening is required, this parameter sets the speed in r.p.m. at which field weakening begins. If field weakening is not used (parameter 55 is set to 0) then an overspeed alarm is set when the motor speed is more than 33% faster than the synchronous speed.

10.6 General configuration

These parameters set up various other configuration options and can be accessed from the “All Parameters” window of the Q-Drive Setup software.

Parameter 10 - EXTLIMI current limit
This value ranges between 0 (function OFF), 1 to 32767, and sets what fraction of the maximum drive current is allowed when the EXTLIMI logic input is true (active low). If the maximum allowed motor current is equal to the maximum drive current, set this value to 32767. If the required motor current limit value is half the maximum drive current, set this parameter to about 16383. Q-Drive Setup presents this figure in amps.

If this parameter is set to –1, then the EXTLIMI input is used to switch between current loop control and speed loop control mode, and parameter 26 is ignored. If the input is low (active) then current loop mode is selected, and if the input is high then speed loop mode is selected.

Parameter 12 - resolver sine/cosine adjustment factor
This parameter sets an adjustment factor to compensate for any assymmetry in the sine and cosine signals from the resolver. On a drive fitted with the Quin PTS position controller, values from 24576 to 32767 represent factors from 0.75 to 0.99, while values from –32768 to –24576 represent factors from 1.00 to 1.25. On a standalone drive the whole range from 0.75 to 1.25 is represented by values from 24576 to 40960. The Q-Drive Setup program qdrive.exe allows this value to be calculated automatically when the user double clicks in its value field in the drive parameters dialogue box. The motor must be moved through the maximum and minimum signal positions for the sine and cosine signals to allow the system to measure the signals and calculate the required adjustment factor.

Parameter 27 - digital or analogue setpoint
This parameter configures the drive to use either the analogue input signal or a digital parameter value as the speed or current setpoint. This is not normally set by the user. Standalone Q-Drive systems should have this set to 1 to enable the analogue input signal as the setpoint. Systems with an internal Quin PTS position controller use the digital setpoint via a serial link, and set this parameter to 0.

Parameter 30 - relay alarm/ready/enabled
This parameter sets up the drive relay to activate on either drive alarm, drive ready or drive enabled.

Parameter 30	Relay on	Relay off
0	Drive ready	Drive alarm
1	Drive alarm	Drive ready
2	Drive enabled	Drive disabled

Table 25: Drive status relay

Parameter 35 - motor brake delay
This parameter sets a brake delay time on the drive disable operation. When this is set to a non-zero value, disabling the drive operates as follows. The drive first releases the brake relay to engage the brake, and then waits for the set delay time before disabling the drive. There is no delay on enabling the drive.

The automatic brake operation, controlled by the drive enable signal, is disabled by setting this parameter to zero. It should not be used when the brake is controlled separately by the internal Quin PTS position controller.

Parameter 52 - motor turns counter value
This parameter contains the current value of the motor turns counter. It is automatically incremented and decremented by the drive as the motor rotates. It can be read at any time, or written to a particular value if required.

Parameter 53 - encoder input counter value
This parameter contains the current value of the encoder input position counter within the drive. It is automatically incremented and decremented by the drive in accordance with the encoder input signals. This is not the counter used by the Quin position controller.

10.7 Tuning the Drive Control loop

The Q-Drive contains two control loops which can be tuned to achieve the desired performance from the motor. If the Q-Drive is to be used in speed control mode both control loops are active, the speed loop supplying a demand to the current loop, otherwise only the current loop is active.

Tuning the drive should initially be performed with the motor dismounted from the machine. Once a reasonably tuned system has been reached then remount the motor and fine tune the control loops to adjust for the mechanics of the system.

Setting current loop gain parameters
Using the Q-Drive Setup software the current loop can be tuned graphically. Select the ’scope window and initially set:

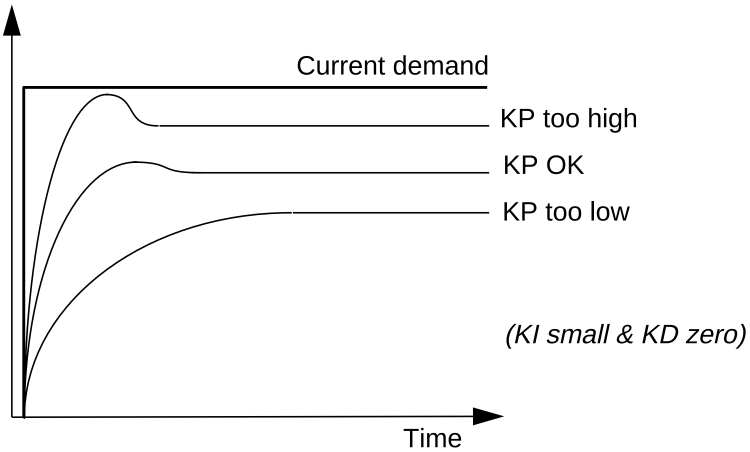
- KP current loop (parameter 6) to 20.
- KI current loop (parameter 7) to 5.
- KD current loop (parameter 8) to 0.
- Resolver shift angle (parameter 1) to +90° of correct setting. **Due to the resolver shift angle being set +90° from correct position the motor will not move during this tuning exercise.**

- The motor stimulus to produce a square wave current demand of quarter of the setting for max. rated current, and a time of tx=100ms, T=1000ms. The short time for the current pulse is important as this stops any damage to the drive electrics. NOTE: The setting of parameter 3 (max. current) may limit this.

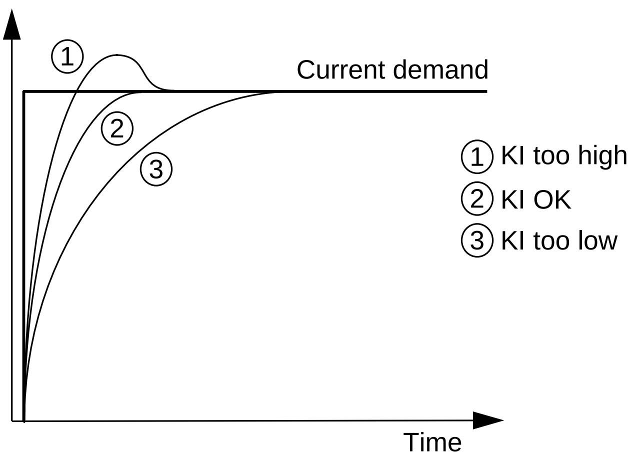
- The ’scope to monitor current comand (parameter 182) as trace 1 and instant current (parameter 67) as trace 2, using appropriate scales and trigger points.

Q-Drive Setup has a menu option on the ‘scope toolbar to do all this for you.

Tuning the current loop will involve increasing each of the control loop gains until a satisfactory motor/drive performance is reached. The aim of tuning the current loop is to produce a fast and smooth response with no overshoot (a critically damped first order response). First increase KP until the current loop control response is as follows (though the trace will have noise on the actual signal):



This value is normally about 100. Secondly increase KI until the current loop control response is as follows:



This value is typically around 20. For most applications KD should remain at zero. **Once this tuning has been performed reset the resolver shift angle to its original value**.

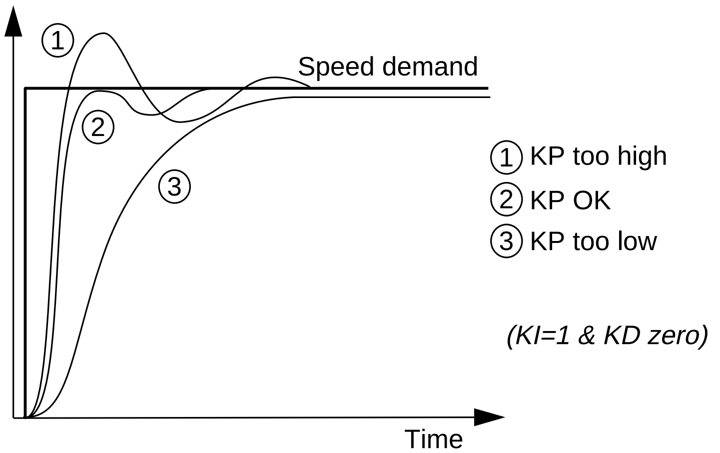
Setting speed loop gain parameters
Again the ’scope can be used to graphically tune the speed control loop of the Q-Drive. Initially set:

- KP speed loop (parameter 20) to 500
- KI speed loop (parameter 21) to 1
- KD speed loop (parameter 22) to 0
- Max. speed (parameter 23) to a value determined by the motor and the application.
- The motor stimulus to produce a square wave speed demand that reasonably exercises the motor.
- The ’scope to monitor digital setpoint (parameter 99) as trace 1 and instant speed (parameter 68) as trace 2, with appropriate vertical scales, trigger and timebase.

Q-Drive Setup has a menu option on the ‘scope toolbar to do all this for you.

The aim of tuning the speed loop is to achieve a fast and smooth response. It is not necessary for the demand speed and actual speed of the drive to be the same when in the steady state (when then actual speed has finished changing), This is because the PTS position control system automatically compensates for any steady state error.

First increase KP until the speed loop control response is as follows:



KP will typically be around 3000. Secondly set KI to a very small value (not 0). This is because the speed loop KI competes with the PTS position control loop and can produce unsatisfactory results when set to zero (no position holding at zero speed) or a large value (too much speed adjustment within the drive). The PTS position control loop will automatically compensate for any speed errors in the drive.

For most applications KD should remain at 0. Once this tuning has been performed use the ’scope to monitor the drive under normal operating conditions to check that all ranges of stimulus are catered for by your chosen gains.

11. Tuning the Position Control Loop

11.1 General

Tuning the position loop is the process of adjusting the various gain terms in the controller to get the best response from the motor and drive. The dynamic behaviour of the system depends on these gain constants, and on the mechanical characteristics of the system being controlled. The easiest way to choose suitable gain constants is by experiment, using the real motor and load. It is possible to calculate the required parameters, but this requires detailed knowledge of the motor and load transfer functions, which are not always available and are difficult to measure. In practice, with a software controlled system such as the Q-Drive it is very simple and much quicker just to experiment with gain settings. The Q-Drive allows the gain values for any motor to be changed at any time, even while the motor is moving, just by sending simple commands to the system via a standard computer terminal. In addition, there are several diagnostic aids on the system to provide information about the performance of the system.

11.2 Control algorithm

The motor control system operates by sampling the position of the motor at regular intervals, and calculating a motor demand signal according to some control algorithm. The algorithm used is of the following form.

$$V_{out} = KPe_i + KI\sum e_i + KD(e_i - e_{i-1}) - KV(p_i - p_{i-1}) + KF(d_i - d_{i-1})$$

where KP = proportional gain constant
KI = integral gain constant
KD = differential gain constant
KV = velocity feedback gain constant
KF = velocity feed-forward gain constant
e_i = position error (= demand position – measured position)
d_i = demand position
p_i = measured position

The actual scaling between position error and output voltage, for proportional gain only, is as follows:

$$V_{out} = \text{Error} \times \frac{KP}{256} \times \frac{10}{2048}\text{Volts}$$

where KP is the proportional gain term, and Error is the position error, measured in encoder counts. The other control terms have similar scalings.

11.3 Monitoring the performance

There are two main facilities provided in the Q-Drive to help to monitor the performance of the motors.

- Continuous display mode.
  The continuous display mode, accessed by the DM command, prints via the serial port a continuous display of the demand position, measured position, and position error on the current channel.

- Monitor function.
  An auxiliary analogue output may be programmed for use as a monitor output signal. The monitor output can be programmed to output a signal proportional to one of a wide range of measured values. This signal may be viewed on an oscilloscope or a chart recorder. This is particularly useful for seeing the effects of changes in the gain terms when used in conjunction with a storage oscilloscope, as the results can be seen immediately on the display trace. Note that on the Q-Drive, the auxiliary analogue output can give signals between 0V and +5V only, and has a limited frequency response.

- PTS Toolkit tuning display.
  The PTS Toolkit PC based front end software includes a simple tuning display. It allows the demand and measured speeds of any one axis to be plotted on the screen, together with the position error. It uses the serial port to upload the information from the PTS unit. It can operate in continuous mode with some limitations in sample rate, or in historical mode, where data is stored and buffered at the full system sample rate and every sample is uploaded to the PC.

These facilities are described fully in the Q-Drive Reference Manual.

11.4 A simple tuning procedure

Tuning a control system is never easy, especially if it is necessary to wring the last ounce of performance out of a motor. However, in most cases this simple outline procedure is a useful starting point for a fuller tuning exercise on a system.

NOTE : This procedure involves trying to set the system into oscillation in order to find an upper limit on the gain parameters. If this is likely to cause any problems or damage to the system, or it is impractical for any reason, then this procedure should not be followed.

- Firstly, the motor and drive must themselves be correctly set up. On most drive systems, the drive unit operates a velocity control loop to control the speed of the motor according to the speed demand signal it receives. This inner control loop should be set up according to the drive and motor manufacturer’s instructions. This should be done with the servo controller either disconnected or in the motor off state, so that it is not trying to control the position at the same time. Refer to section 10.5, on page 55, which describes the Q-Drive tuning parameters.

- Check that the control system is correctly connected to the drive and to the position encoder.

- Either :
  Connect an oscilloscope or chart recorder to the analogue monitor output, select the desired monitor function with the SF command, and set the monitor gain to some non-zero value with the KM command, say 400. For example, setting SF to 2 selects the measured velocity as the monitor function, so that the output voltage represents the measured change in motor position at each sample. Set up the auxiliary output channel number with the AO command.
  Or :
  Use the PTS Toolkit tuning display on a PC connected to the serial port to display the motor demand speed, measured speed and position error.

- Set the proportional gain to some low value, say 50, and set all other gain terms to zero. The default settings for the gain parameters are 256 for KP and KF, and zero for all other gain values. For a Q-Drive a more typical value for KP would be 100 to 180. Set the velocity and acceleration with the SV and SA commands to some suitable low values, depending on the resolution of the encoder.

- Enable the position control action with the PC command. If the motor immediately runs at high speed in one direction and then stops, giving a “motor position error” error message, then the sense of the encoder is reversed. Correct this by swapping one pair of encoder wires, or by setting the appropriate flag bit in the control word for the channel using the CW command. The following stages assume that the system is now correctly controlling the motor position.

- Try executing some simple move commands, such as MR1000. The motor should move as instructed. If at any time it starts to run at high speed in one direction and stops, as described above, then check the encoder connections again. If it moves as requested but starts to vibrate or oscillate, then the gain is already too high. Reduce it by halves until the vibration stops. The monitor output should show something approximating a trapezoidal or triangular velocity profile for the move.

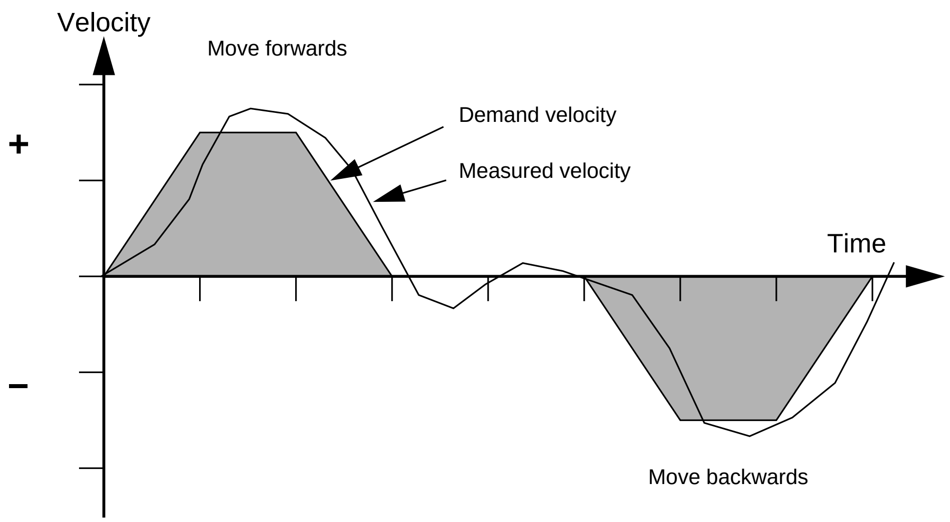


Figure 17. Motor performance for detuned system.

- When the motor is following some simple slow move commands correctly, the next stage is to try some fast moves. This is like giving the system a step function. Increase the speed and acceleration to larger values, and try some move commands again. Repeat this until the motor is making a very sudden motion.

- Set the system to repeatedly execute this sudden move, with a pause between each move to allow the system to settle. An example command string is :

```
MR1000/WT128/MR-1000/WT128/RP
```


This command string sets up a loop where the motor moves 1000 counts positive, pauses for half a second, moves back 1000 counts negative to its start position, and waits another half second. This repeats until stopped by using the AX abort execution or ER end repeat commands.

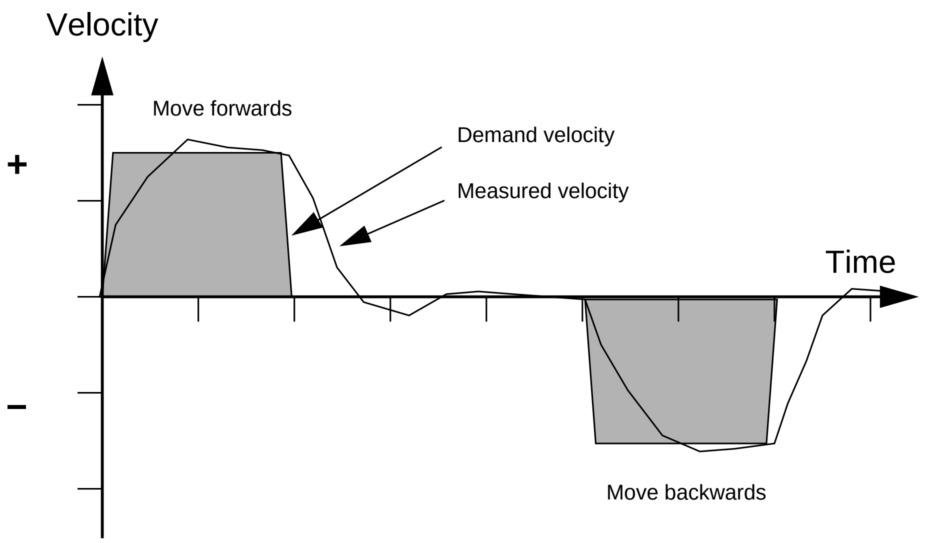


Figure 18. Motor performance for faster moves.

- While the system is executing this move command loop, slowly increase the proportional gain with the KP command until overshoot or ringing occurs at the end of each move. This is an indication that the system is beginning to become unstable. It should be possible to increase the gain to the point where the oscillation is sustained indefinitely, or decays away slowly. This is the highest usable value of KP without making the system completely unstable, although it is of no practical use because of the oscillations.

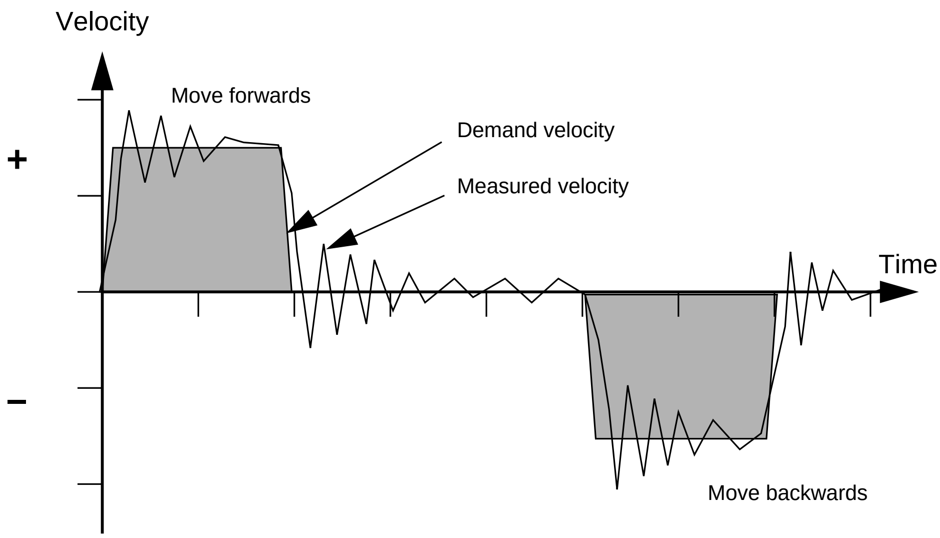


Figure 19. Motor performance with oscillation.

- Now increase the velocity feedback gain with the KV command. Velocity feedback adds damping into the system, and should begin to reduce the amplitude of the oscillations. This should be visible on the monitor signal. Continue to increase the value of KV until the oscillations stop, and there is little or no ringing at the end of each move. The KV term usually can be increased to a much larger value than the KP term. On many systems, it is possible to increase KV to the point where no oscillations or ringing occurs, and the time taken to reach the target position is a minimum. This is called critical damping.

  NOTE : On some very low inertia motors with small loads, the KV term may prove ineffective in damping the oscillations, and may make them worse. In this case, an additional external source of damping such as a tachogenerator must be fitted to the motor. This provides instant velocity feedback to the motor drive and is not subject to the sample time constraints of a digital system. Tachogenerators may of course be used with any systems, not just low inertia systems.

- Stop the move command loop with the AX or ER command. If it is possible to run the machine at constant speed in one direction, then the KF feed-forward gain may be set up at this point as well. If not, it will have to be set up during more normal operation of the system. Set the speed to the desired operating speed of the motor. Turn on the continuous position display with the DM command, and start the motor at constant velocity with the VC command. The third column in the DM display shows the position error. Increase the value of KF and note that the position error values should decrease. KF may be increased until the position is approximately zero, at which point the feed-forward gain is compensating for the velocity lag present in the system with proportional gain only. The KF value may be increased further to the point where the motor position is ahead of the demand position, if required, without any problems.

This procedure, although it only describes setting up some of the gain terms, is sufficient in many cases to give acceptable performance from the motor system. However, an acceptable setup for any particular operation may not be ideal for a different operation, so it is useful to experiment with many different moves and profiles to find the best compromise. Clearly, the most important operation for the purpose of tuning the motors is the normal operation cycle of the machine. Note that by using the command sequence facilities on the system, it is quite feasible to change gain settings automatically, in response to an input signal or according to a set programme. This would be used, for example, on a robot arm, where the ideal setup depends on the load carried by the arm.

Tuning any control system is not a simple process, particularly a servo control system with a very fast response time. Most literature on control systems and tuning describes the application of controllers to large process plant, where the plant response time to a change is very long compared to the sample time of the controller. The situation is often quite different when dealing with high speed electric motors, which now can have mechanical time constants down to about 10 ms with no external load.

12. Testing the System

12.1 General

This section describes some simple test procedures for some parts of the PTS systems. These do not comprise a full system test, but may be useful to verify the basic operation of the system, the motor and the encoder.

All these tests require the use of a computer terminal or VDU with an RS-232 serial port. A simple portable terminal is sufficient for most tests. Some tests require additional test equipment, as given below.

12.2 Serial port

The system prints characters via the RS-232 serial port when it is powered up. These may be detected by using the terminal, or with a serial data analyser. The system normally prints a version and copyright message, followed by the '`>`' or '`:`' prompt character. An example for a Q-Drive 1+1 is shown here.

```
Q-Drive Version 1.9.1.1
Copyright 1998 Quin Systems Ltd

Motor1 found
Motor2 found

1:
Restoring parameters | Done
1:
```

If there is no response from the unit, or the messages are garbled, then check the connections between the terminal and the system, and also check that the serial data format on the terminal is set to eight data bits, one stop bit, no parity and 9600 baud. If there is still no response from the system on power-up, the serial data signals should be checked with a data analyser or an oscilloscope, to verify whether the system is actually sending any characters out.

Once the startup message is received, try sending characters to the system by typing them on the terminal keyboard. Each character should be echoed (printed on the terminal screen) as it is typed on the keyboard. Press the `Return` or `Enter` key. This sends the characters to the system as a command string. The system should respond, probably with an error message, followed by the command prompt character as before.

Once communications with the system are established via the serial port, it is possible to use the normal command set to test most other features of the system.

12.3 Encoder

Ensure that the shaft encoder is connected to the inputs of the Q-Drive, and that the motor power is switched off. Type "CH2" on the keyboard, and press Return, as the link encoder signals are normally routed to channel 2 of the Q-Drive position controller module. Type "DM" on the keyboard, and press Return. The system should start displaying data continuously, giving the demand position, measured position, and position error information.

The measured position data in the second column of data gives the current position, in encoder counts, of the encoder shaft. Turn the shaft by hand, and the displayed position data should change, showing that the system has measured the change in position of the shaft.

If the encoder position counts up and down by only one count, then one of the two phases of the encoder signals is not being detected. If the encoder position value does not change at all, then either both phase signals are missing, the encoder power supply is missing or off, or the light source in the encoder is faulty. If the position tends to count either up or down whichever direction the shaft is turned, then the track A and B signals are mixed up with their complementary signals, such that instead of the system receiving two signals in quadrature, it always receives two signals in opposite phase regardless of the shaft direction. These problems can be confirmed by monitoring the encoder signals with an oscilloscope.

If the encoder marker signal is used as the position reference signal, then this should also be checked. Type "DZ1/RM1" to enable referencing on the encoder marker pulse. Then type "WF/DF/RP". The system should respond with the 'W' prompt to indicate that it is waiting for the reference signal. Turn the encoder shaft so that it passes through the marker position, and the system should display the value of the reference position error, measured on the desired transition of the reference input signal. Continue to turn the encoder shaft to verify the operation of the reference input and marker signal as required. If the system does not display the value of the reference error, but stays in the waiting state with the 'W' prompt, then check that the marker input signal is present with an oscilloscope. If the encoder marker signal is not detected, there may be some problem with the encoder or the connections to it. Type "AX/WE" followed by Return when finished, to stop the wait command loop.

12.4 Digital signals

Equipment required :

Multimeter or DVM.
Connecting wire or pushbutton switch.
External power supply.

The digital signals may be checked using the multimeter in conjunction with the manual input and output commands. Set the external power supply to the voltage required by the digital inputs, usually +24V. Begin with all input and output lines disconnected from the external system. Type “`RI<Return>`” and check that all inputs are shown with a ‘0’. Connect the external power supply to each input line in turn, and use the RI command to verify the operation of each line.

Connect the external power supply to the +24V and 0V I/O connections. Connect the multimeter in turn to each output line, and using the SO set output and CO clear output commands, check the operation of the line. The SO command turns on the output optical isolator, pulling the output signal up to +24V, and the CO command turns the output isolator off.

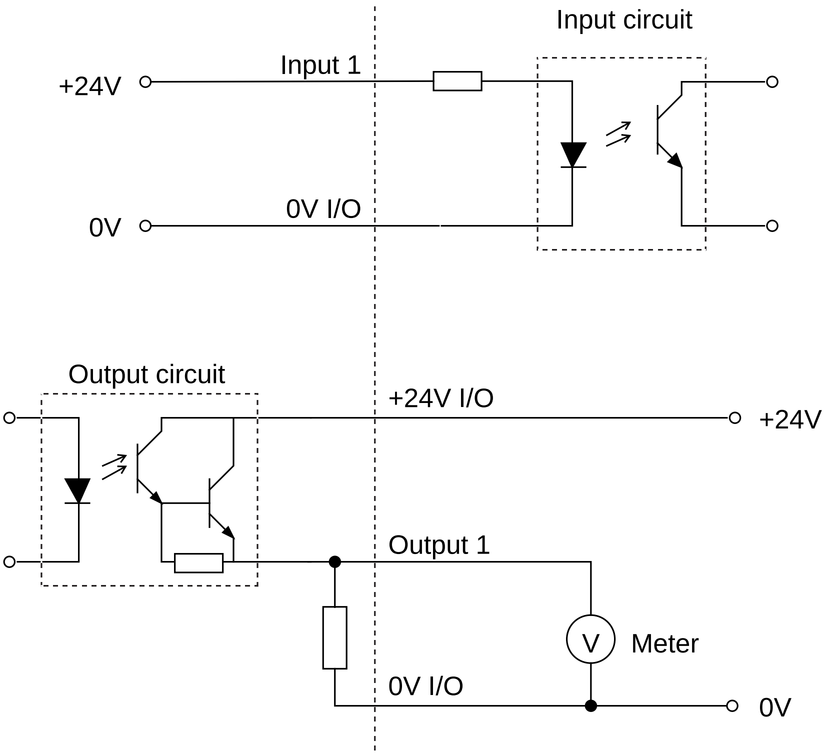


Figure 20. Testing the digital signals.

13. Board Configuration

This section gives details of the configuration options on the board used in the Q-Drive. described here for completeness, although the settings are not normally changed. The board is set up as described below when shipped.

The SRV1+1 board is used in the Q-Drive 1+1, Q-Drive MAP and Q-Drive SERVOnet systems.

The following table lists the fuses fitted in the Q-Drive series 200/400 models.

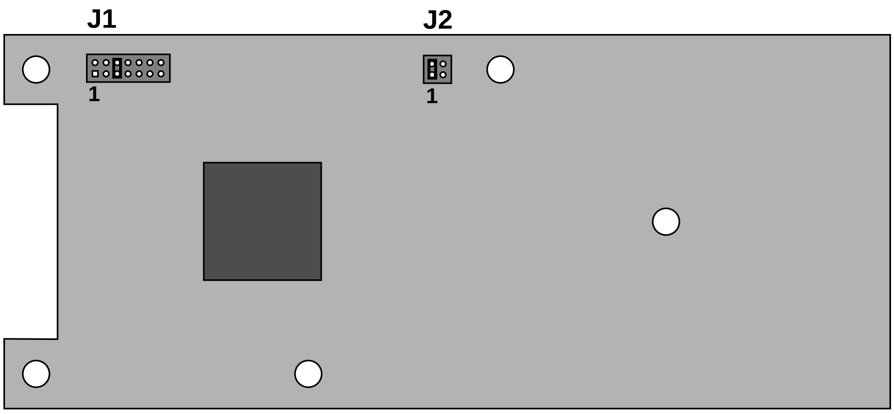
Drive type		DC bus (FBUS)	Braking module (FBR)	Internal power supply (FDEC)
Small	205	10A LF326 Littelfuse 6.3 × 32	3.15A Wickmann 19354 6.3 × 32 (Rbrake = 39Ω)	1A Wickmann 19181 5 × 20
	210	15A LF326 Littelfuse 6.3 × 32	3.15A Wickmann 19354 6.3 × 32 (Rbrake = 39Ω)	1A Wickmann 19181 5 × 20
	218	20A LF326 Littelfuse 6.3 × 32	3.15A Wickmann 19354 6.3 × 32 (Rbrake = 39Ω)	1A Wickmann 19181 5 × 20
	403	8A gG Ferraz 10.3 × 38	4A 500VFA Ferraz 6.3 × 32 (Rbrake = 56Ω)	1A Wickmann 19181 5 × 20
	405	8A gG Ferraz 10.3 × 38	4A 500VFA Ferraz 6.3 × 32 (Rbrake = 56Ω)	1A Wickmann 19181 5 × 20
	409	12A gG Ferraz 10.3 × 38	4A 500VFA Ferraz 6.3 × 32 (Rbrake = 56Ω)	1A Wickmann 19181 5 × 20
Large	420	50A URGA Ferraz 22 × 58	32A URGB Ferraz 14 × 51 (Rbrake = 8Ω)	1.6A Wickmann 19354 6.3 × 32
	430	50A URGA Ferraz 22 × 58	32A URGB Ferraz 14 × 51 (Rbrake = 8Ω)	1.6A Wickmann 19354 6.3 × 32

Table 26: Fuse types

NOTE : No fuse should be replaced until the reason for it blowing has been identified.

The jumper links on the SRV1+1 are described here.

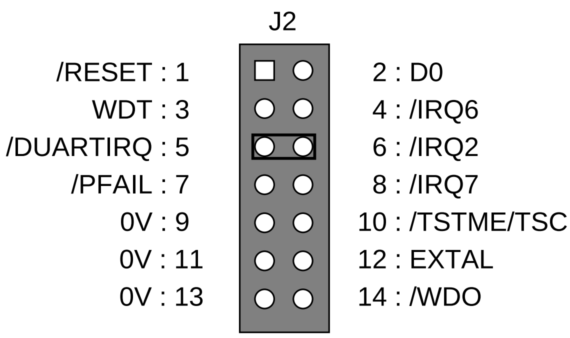
Top view



SRV1+1 module - component side

Figure 21. SRV1+1 board layout

J1: Reset and interrupt configuration
Jumper J1 is used to set up the power up reset options and interrupt signals for the MC68376 processor. It is normally factory set when supplied to suit the particular firmware fitted, but is described here for completeness.



The normal configuration is with /DUARTIRQ linked to /IRQ2 (pins 5–6).

J1 is located at the top right of the module, with pin 1 at the top left.

J2: Serial port A override
The serial ports on the SRV1+1 module are configured by the software for RS-232 or RS-485 as required, to reduce the number of jumpers that need to be configured by the customer for different applications. Jumper J2 allows the software configuration for port A to be overridden for testing. For normal operation under software control, link J2 pins 1 and 2. To force RS-232 operation, link pins 3 and 4.

A. Brushless Motor Parameters

This chapter gives a table of the Q-Drive series 200/400 parameters, when used with brushless a.c. servo motors. This is provided for reference only.

Entries in the note column have the following meaning :
O – Optional parameter that depends on the particular drive firmware.
S – Any change in this value takes effect only after drive parameters are saved.
Units fitted with a PTS position controller save drive parameters by executing the command `QP250/1`. Please note that it is not advisable to use this to save drive parameters in PTS command sequences or strings.

A second value in brackets in the limits/units column indicates that the standalone drives return different parameter values and ranges than the other Q-Drives.

Parameter	R/W	Note	Limits or Units	Description
0	R/W		1 to 6	Number of pairs of motor poles
1	R/W		±32767 (= ±180°)	Resolver shift angle
2	R/W	S	0 or 1	Motor thermostat n.o. or n.c. 0: thermostat n.o. 1: thermostat n.c.
3	R/W		0 to 32767	Maximum motor current
4	R/W	S	0 to 16383	Nominal motor current
5	R/W	S	0 to parameter 88	Maximum motor I^2t
6	R/W		1 to 32767	Current loop proportional gain
7	R/W		0 to 32767	Current loop integral gain (requires save if set to zero)
8	R/W		0 to 32767	Current loop differential gain
9	R/W		0 to 100 (1/10° per 1000rpm)	Phase advance with speed
10	R/W		-1 to 32767	EXTLIMI limit value +ve: current limit value (input on) -1: input off -> speed loop mode input on -> current loop mode
12	R/W		24576 to 32767 -32768 to -24576 (24576 to 40960)	Sine/cosine adjustment factor
14	R/W	S	0 to 3	Encoder configuration Bit 0: 0 -> output encoder simulation 1 -> output link encoder
17	R/W	S	1 to 2048	Encoder simulation pulses per turn

Table 27: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
18	R/W	S	0 to 2, 4 to 6	Encoder marker pulse width and gating 0 to 2: Z gated with /A signal 4 to 6: Z gated with /B signal
19	R/W		±32767 (= ±180°)	Encoder marker pulse offset (±1/2 turn)
20	R/W		1 to 32767	Speed loop proportional gain
21	R/W		0 to 32767	Speed loop integral gain (requires save if set to zero)
22	R/W		0 to 32767	Speed loop differential gain
23	R/W	S	±8191	Maximum speed for 10V input
24	R/W	S	0 to 3	End switches n.o. or n.c. Bit 0: 0 -> SW1 is n.o. 1 -> SW1 is n.c. Bit 1: 0 -> SW2 is n.o. 1 -> SW2 is n.c. Bit 15: SW1 resets speed loop integral gain
25	R/W	S	0 to 3	Inhibit direction Bit 0: inhibit positive direction Bit 1: inhibit negative direction
26	R/W		0 or 1	Speed or current loop control mode 0: speed loop mode 1: current loop mode
27	R/W		0 or 1	Digital or analogue setpoint 0: digital setpoint 1: analogue setpoint
28	R/W		±255	Analogue setpoint offset
29	R/W		0 to 32767 (rpm/s)	Command slope
30	R/W	S	0 to 2	Drive relay indicates: 0: ready 1: alarm 2: torque enable
32	R/W		0 to 32000	SSI communications watchdog period
33	R/W	S	0 to 255	Alarm latch enable Bit 0: alarm 7 (under or overvoltage) Bit 4: alarm 2 (I^2t limit exceeded) Bit 6: alarm b (overspeed)
34	R/W		0 to 256 counts	Encoder dead window
35	R/W	O	0 to 136 ms	Brake enable and delay time before drive is disabled
41–45	R/W			Scope setup parameters

Table 27: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
46	R/W		-1 or 0	Scope data saturation 0: saturation -1: no saturation (data wraps around)
50	R/W		±32767	Digital setpoint (speed or current)
51	R/W		0 to 255	LED display contents
52	R/W		±32767	Motor turns counter
60–63	R/W			Internal registers
64	R			Status register: see details later
65	R			Alarm register: see details later
66	R		°C	Heatsink temperature
67	R		$I = \text{value} \times \frac{2 \cdot \sqrt{2}}{32767} \times I_{max}$	Drive current
68	R		0.925 × r.p.m.	Motor speed
69	R		±32767 (0 to 65535)	Motor position within one turn
71	R		1 to 15	Axis address
72	R			Monitor version
73	R			Firmware version
74	R			FPGA version
82	R		°C	Fan switch on temperature
86	R		A r.m.s.	Maximum drive current I_{max}
87	R		A r.m.s.	Nominal drive current
88	R			Maximum drive I^2t
89	R			Power modules
90	R		V r.m.s.	Line voltage
91	R			Options
92	R			Hardware version
93	R		wwyy	Delivery date (week, year)
94	R			Customer
95	R			Serial number
96	R			Firmware options 0: brushless motors with resolver feedback only 1: also controls asynchronous motors with resolver or encoder feedback
97	R		$\text{value} = \frac{-10}{32767} V$	Analogue input value ±10V
98	R			

Table 27: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
99	R			Internal digital setpoint
100–179	R			Scope recorded data values
180	R			Resolver sine
181	R			Resolver cosine
182	R		$I = \text{value} \times \frac{2 \cdot \sqrt{2}}{32767} \times I_{max}$	Current setpoint
185	R			Phase U actual current
186	R			Phase V actual current
187	R			Phase W actual current
192	R			I^2t threshold
193	R			Instantaneous I^2t value

Table 27: Drive parameters

The following two tables list the detailed bit definitions for the drive status register and alarm register.

Status register			
Bit	Decimal	Description (when status bit is set to 1)	
0	1	Under or over voltage on DC bus	
1	2	Phase N over current or temperature	Power module faults
2	4	Phase U over current	
3	8	Phase V over current	
4	16	Phase W over current	
5	32		
6	64		
7	128		
8	256	Motor thermostat	
9	512	6V supply OK	
10	1024	End switch 1	
11	2048	End switch 2	
12	4096		
13	8192	EXTLIMI input	
14	16384		
15	32768	Drive disabled	

Table 28: Status register (address 64)

Alarm register			LED display (standalone drives only)
Bit	Decimal	Description	
0	1	Under or over voltage on DC bus	7
1	2	Power module fault	6
2	4		
3	8	Internal over temperature	4
4	16	I^2t limit exceeded	2
5	32	Resolver fault	5
6	64	Motor overspeed	b
7	128	Motor wiring error or fault	C
8	256	Motor thermostat	3
9	512		
10	1024		
11	2048		
12	4096		
13	8192	Software watchdog	9
14	16384	Firmware not OK	F
15	32768	Parameters not OK	E

Table 29: Alarm register (address 65)

The standalone drives may also display warning values on the LED display, without a corresponding flag in the alarm register.

2 I^2t limit (non-latched)

A Momentary overcurrent

B. Using an Asynchronous Motor

B.1 Setting up the Q-Drive

The Q-Drive can control asynchronous squirrel-cage motors as well as brushless servo motors. Set up the drive as follows:

- Check that the drive is programmed with firmware V2207 or later. Earlier versions do not support asynchronous motors. If necessary, update the drive firmware.

- Select the correct motor type, feedback type and number of pairs of motor poles by setting parameter 0.

- Set the correct values for maximum current, nominal current, slip factor and cos ϕ.
  The slip factor (parameter 9) can be set between 0 and 15% (standard range 1 to 7%). Usually 4% is a good value.
  Cos ϕ (parameter 11) is given by the motor manufacturer, and is usually a value between 0.8 and 0.9. It is set as $32768 \times \sin \phi$ to allow higher precision.

- Encoder feedback:
  If encoder feedback is used, the encoder must be powered externally. The encoder resolution is set in parameter 54, and parameter 14 is set set to 3.

- Field weakening:
  If field weakening is required, set parameter 55 to the speed in r.p.m. at which field weakening should begin. If field weakening is not used (parameter 55 is set to 0), then a motor overspeed alarm is set when the motor speed is more than 33% faster than the synchronous speed.

B.2 Drive parameters

This section gives a table of the Q-Drive series 200/400 parameters, when used with an asynchronous a.c. motor. This is provided for reference only.

Entries in the note column have the following meaning :
O – Optional parameter that depends on the particular drive firmware.
S – Any change in this value takes effect only after drive parameters are saved.
Units fitted with a PTS position controller save drive parameters by executing the command `QP250/1`. Please note that it is not advisable to use this to save drive parameters in PTS command sequences or strings.

A second value in brackets in the limits/units column indicates that the standalone drives return different parameter values and ranges than the other Q-Drives.

Parameter	R/W	Note	Limits or Units	Description
0	R/W			Motor type (see details later)
1	R/W		±32767 (= ±180°)	Resolver shift angle
2	R/W	S	0 or 1	Motor thermostat n.o. or n.c. 0: thermostat n.o. 1: thermostat n.c.
3	R/W		0 to 32767	Maximum motor current
4	R/W	S	0 to 16383	Nominal motor current
5	R/W	S	0 to parameter 88	Maximum motor I^2t
6	R/W		1 to 32767	Current loop proportional gain
7	R/W		0 to 32767	Current loop integral gain (requires save if set to zero)
8	R/W		0 to 32767	Current loop differential gain
9	R/W		0 to 4915 (0 to 15%)	Slip factor
10	R/W		-1 to 32767	EXTLIMI limit value +ve: current limit value (input on) -1: input off -> speed loop mode input on -> current loop mode
11	R/W		32768 × sin ϕ	Cos ϕ
12	R/W		24576 to 32767 -32768 to -24576 (24576 to 40960)	Sine/cosine adjustment factor
14	R/W	S	0 to 3	Encoder configuration Bit 0: 0 -> output encoder simulation 1 -> output link encoder Bit 1: 0 -> default 1 -> reset count on Z input Set to 3 for encoder feedback

Table 30: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
17	R/W	S	1 to 2048	Encoder simulation pulses per turn
18	R/W	S	0 to 2, 4 to 6	Encoder marker pulse width and gating 0 to 2: Z gated with /A signal 4 to 6: Z gated with /B signal
19	R/W		±32767 (= ±180°)	Encoder marker pulse offset (±1/2 turn)
20	R/W		1 to 32767	Speed loop proportional gain
21	R/W		0 to 32767	Speed loop integral gain (requires save if set to zero)
22	R/W		0 to 32767	Speed loop differential gain
23	R/W	S	±8191	Maximum speed for 10V input
24	R/W	S	0 to 3	End switches n.o. or n.c. Bit 0: 0 -> SW1 is n.o. 1 -> SW1 is n.c. Bit 1: 0 -> SW2 is n.o. 1 -> SW2 is n.c. Bit 15: SW1 resets speed loop integral gain
25	R/W	S	0 to 3	Inhibit direction Bit 0: inhibit positive direction Bit 1: inhibit negative direction
26	R/W		0 or 1	Speed or current loop control mode 0: speed loop mode 1: current loop mode
27	R/W		0 or 1	Digital or analogue setpoint 0: digital setpoint 1: analogue setpoint
28	R/W		±255	Analogue setpoint offset
29	R/W		0 to 32767 (rpm/s)	Command slope
30	R/W	S	0 to 2	Drive relay indicates: 0: ready 1: alarm 2: torque enable
32	R/W		0 to 32000	SSI communications watchdog period
33	R/W	S	0 to 255	Alarm latch enable Bit 0: alarm 7 (under or overvoltage) Bit 4: alarm 2 (I^2t limit exceeded) Bit 6: alarm b (overspeed)
34	R/W		0 to 256 counts	Encoder dead window
35	R/W	O	0 to 136 ms	Brake enable and delay time before drive is disabled
41–45	R/W			Scope setup parameters

Table 30: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
46	R/W		-1 or 0	Scope data saturation 0: saturation -1: no saturation (data wraps around)
50	R/W		±32767	Digital setpoint (speed or current)
51	R/W		0 to 255	LED display contents
52	R/W		±32767	Motor turns counter
53	R/W		±32767	Encoder input counter
54	R/W		lines/turn	Encoder resolution
55	R/W		r.p.m.	Field weakening speed
60–63	R/W			Internal registers
64	R			Status register: see details later
65	R			Alarm register: see details later
66	R		°C	Heatsink temperature
67	R		$I = \text{value} \times \frac{2 \cdot \sqrt{2}}{32767} \times I_{max}$	Drive current
68	R		0.925 × r.p.m.	Motor speed
69	R		±32767 (0 to 65535)	Motor position within one turn
71	R		1 to 15	Axis address
72	R			Monitor version
73	R			Firmware version
74	R			FPGA version
82	R		°C	Fan switch on temperature
86	R		A r.m.s.	Maximum drive current I_{max}
87	R		A r.m.s.	Nominal drive current
88	R			Maximum drive I^2t
89	R			Power modules
90	R		V r.m.s.	Line voltage
91	R			Options
92	R			Hardware version
93	R		wwyy	Delivery date (week, year)
94	R			Customer
95	R			Serial number

Table 30: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
96	R			Firmware options 0: brushless motors with resolver feedback only 1: also controls asynchronous motors with resolver or encoder feedback
97	R		$\text{value} = \frac{-10}{32767}\text{V}$	Analogue input value ±10V
98	R			
99	R			Internal digital setpoint
100–179	R			Scope recorded data values
180	R			Resolver sine
181	R			Resolver cosine
182	R		$I = \text{value} \times \frac{2 \cdot \sqrt{2}}{32767} \times I_{max}$	Current setpoint
185	R			Phase U actual current
186	R			Phase V actual current
187	R			Phase W actual current
192	R			I^2t threshold
193	R			Instantaneous I^2t value

Table 30: Drive parameters

This table shows the motor type options, set in parameter 0.

Motor options			
Bit	Decimal	Description	
0	1	No. of pairs of motor poles	Range 1 to 6
1	2		
2	4		
3	8		
4	16	Motor type	0: Brushless 1: Asynchronous
5	32		
6	64		
7	128		
8	256	Feedback type	0: Resolver 1: Encoder 2: Hiperface
9	512		
10	1024		
11	2048		

Table 31: Motor options (address 0)

The following two tables list the detailed bit definitions for the drive status register and alarm register.

Status register			
Bit	Decimal	Description (when status bit is set to 1)	
0	1	Under or over voltage on DC bus	
1	2	Phase N over current or temperature	Power module faults
2	4	Phase U over current	
3	8	Phase V over current	
4	16	Phase W over current	
5	32		
6	64		
7	128		
8	256	Motor thermostat	
9	512	6V supply OK	
10	1024	End switch 1	
11	2048	End switch 2	
12	4096		
13	8192	EXTLIMI input	
14	16384		
15	32768	Drive disabled	

Table 32: Status register (address 64)

Alarm register			LED display (standalone drives only)
Bit	Decimal	Description	
0	1	Under or over voltage on DC bus	7
1	2	Power module fault	6
2	4		
3	8	Internal over temperature	4
4	16	I^2t limit exceeded	2
5	32	Resolver fault	5
6	64	Motor overspeed	b
7	128	Motor wiring error or fault	C
8	256	Motor thermostat	3
9	512		
10	1024	Asynchronous motor overspeed	U
11	2048		
12	4096		
13	8192	Software watchdog	9
14	16384	Firmware not OK	F
15	32768	Parameters not OK	E

Table 33: Alarm register (address 65)

The standalone drives may also display warning values on the LED display, without a corresponding flag in the alarm register.

2	I^2t limit (non-latched)
A	Momentary overcurrent

C. Using a Hiperface Sensor

C.1 Introduction

Hiperface is an electrical interface for high performance position encoders introduced by Stegmann on their SinCos product line. The Hiperface signals include coarse and fine sine and cosine signal pairs, together with an RS-485 data channel. The coarse sine/cosine signals give shaft position within one turn, while the fine signals are used as incremental encoder signals, with or without interpolation.

The SinCos products provide 512 sine/cosine cycles per turn on the fine signals, and 1 cycle per turn on the coarse signals. In addition, the data channel provides absolute position data, either single or multi-turn (up to 4096 turns). They have an operating temperature range of -40°C to +125°C and a speed range up to 6000 r.p.m.

The SinCoder units are lower cost, keeping the same electrical interface but having no absolute position function. They provide 1024 sine/cosine cycles per turn on the fine signals. They have an operating temperature range of -30°C to +125°C and a speed range up to 6000 r.p.m.

Both types require a d.c. power supply in the range +7V to +12V, nominally +9V.

C.2 Connections

The Hiperface sensor is connected via the 9 way D type socket normally used for the resolver. The pin connections to this are shown below.

Pin no.	Signal	Pin no.	Signal
1	SCREEN	6	THERMOSTAT2
2	THERMOSTAT1	7	REFCOS
3	+COS	8	REFSIN
4	+SIN	9	DATA+
5	DATA-		

Table 34: Hiperface sensor connections

The power supply for the Hiperface sensor is connected to the additional two pin connector below the 15 way D type link encoder socket, as shown in the diagram on the following page. 0V is connected to pin 1, and the positive supply voltage to pin 2.

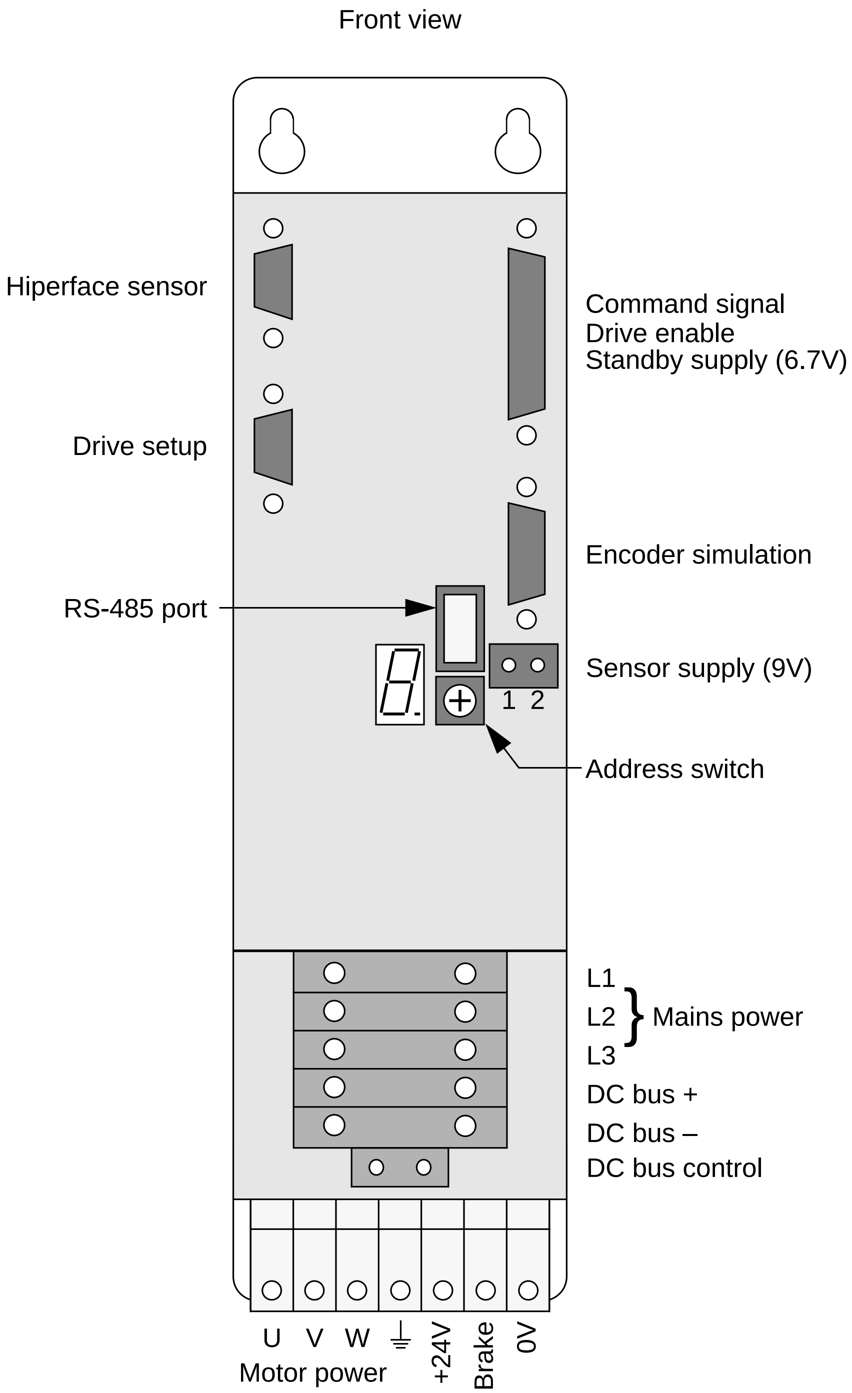


Figure 22. Q-Drive front panel layout with Hiperface

The connections to the 15 way D type socket for a standalone drive are shown below. Note that the standalone drive with a Hiperface sensor provides SSI or incremental encoder simulation output signals.

Pin no.	Signal	Description
1	GND	Internal ground
2		
3	CLK+	SSI clock input (true)
4	CLK-	SSI clock input (inverted)
5	DATA+	SSI data output (true)
6	/Z	Encoder simulation Z marker output (inverted)
7	Z	Encoder simulation Z marker output (true)
8	/B	Encoder simulation track B output (inverted)
9	B	Encoder simulation track B output (true)
10	/A	Encoder simulation track A output (inverted)
11	A	Encoder simulation track A output (true)
12		
13	DATA-	SSI data output (inverted)
14		
15		

Table 35: Encoder simulation connections

The connections to the 15 way D type socket for a drive fitted with a PTS position controller are shown below. This version of the drive retains the external encoder input option used by the PTS card in place of the SSI encoder simulation signals on the standalone drive. Note that the input encoder connections are not the same as on a normal unit with a resolver; the BI and /BI signals are on different pins.

Pin no.	Signal	Description
1	GND	Internal ground
2	BI	Encoder input track B (true)
3	AI	Encoder input track A (true)
4	/AI	Encoder input track A (inverted)
5		
6	/Z	Link encoder output Z marker (inverted)
7	Z	Link encoder output Z marker (true)
8	/B	Link encoder output track B (inverted)
9	B	Link encoder output track B (true)
10	/A	Link encoder output track A (inverted)
11	A	Link encoder output track A (true)
12	/BI	Encoder input track B (inverted)
13		
14	ZI	Encoder input Z marker (true)
15	/ZI	Encoder input Z marker (inverted)

Table 36: Link encoder connections

C.3 Drive parameters

This section gives a table of the Q-Drive series 200/400 parameters, when used with a Hiperface sensor for position feedback. This is provided for reference only.

Entries in the note column have the following meaning :
O – Optional parameter that depends on the particular drive firmware.
S – Any change in this value takes effect only after drive parameters are saved.
Units fitted with a PTS position controller save drive parameters by executing the command `QP250/1`. Please note that it is not advisable to use this to save drive parameters in PTS command sequences or strings.

A second value in brackets in the limits/units column indicates that the standalone drives return different parameter values and ranges than the other Q-Drives.

Parameter	R/W	Note	Limits or Units	Description
0	R/W			Motor type (see details later)
1	R/W		±32767 (= ±180°)	Resolver shift angle
2	R/W	S	0 or 1	Motor thermostat n.o. or n.c. 0: thermostat n.o. 1: thermostat n.c.
3	R/W		0 to 32767	Maximum motor current
4	R/W	S	0 to 16383	Nominal motor current
5	R/W	S	0 to parameter 88	Maximum motor I^2t
6	R/W		1 to 32767	Current loop proportional gain
7	R/W		0 to 32767	Current loop integral gain (requires save if set to zero)
8	R/W		0 to 32767	Current loop differential gain
9	R/W		0 to 100 (1/10° per 1000rpm)	Phase advance with speed
10	R/W		-1 to 32767	EXTLIMI limit value +ve: current limit value (input on) -1: input off -> speed loop mode input on -> current loop mode
12	R/W		24576 to 32767 -32768 to -24576 (24576 to 40960)	Sine/cosine adjustment factor
14	R			Sensor type 2: SinCos single-turn 7: SinCos multi-turn 18: SinCoder
17	R		1 to 2048	Encoder simulation pulses per turn

Table 37: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
18	R/W	S	0 to 2, 4 to 6	Encoder marker pulse width and gating 0 to 2: Z gated with /A signal 4 to 6: Z gated with /B signal
19	R/W		±32767 (= ±180°)	Encoder marker pulse offset (±1/2 turn)
20	R/W		1 to 32767	Speed loop proportional gain
21	R/W		0 to 32767	Speed loop integral gain (requires save if set to zero)
22	R/W		0 to 32767	Speed loop differential gain
23	R/W	S	±8191	Maximum speed for 10V input
24	R/W	S	0 to 3	End switches n.o. or n.c. Bit 0: 0 -> SW1 is n.o. 1 -> SW1 is n.c. Bit 1: 0 -> SW2 is n.o. 1 -> SW2 is n.c. Bit 15: SW1 resets speed loop integral gain
25	R/W	S	0 to 3	Inhibit direction Bit 0: inhibit positive direction Bit 1: inhibit negative direction
26	R/W		0 or 1	Speed or current loop control mode 0: speed loop mode 1: current loop mode
27	R/W		0 or 1	Digital or analogue setpoint 0: digital setpoint 1: analogue setpoint
28	R/W		±255	Analogue setpoint offset
29	R/W		0 to 32767 (rpm/s)	Command slope
30	R/W	S	0 to 2	Drive relay indicates: 0: ready 1: alarm 2: torque enable
32	R/W		0 to 32000	Communications watchdog period
33	R/W	S	0 to 255	Alarm latch enable Bit 0: alarm 7 (under or overvoltage) Bit 4: alarm 2 (I^2t limit exceeded) Bit 6: alarm b (overspeed)
34	R/W		0 to 256 counts	Encoder dead window
35	R/W	O	0 to 136 ms	Brake enable and delay time before drive is disabled
38	R/W			SSI encoder output number of bits (standalone drive only)

Table 37: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
39	R/W			SSI encoder output bits per turn (standalone drive only)
41–45	R/W			Scope setup parameters
46	R/W		-1 or 0	Scope data saturation 0: saturation -1: no saturation (data wraps around)
50	R/W		±32767	Digital setpoint (speed or current)
51	R/W		0 to 255	LED display contents
52	R/W		±32767	Motor turns counter
60–63	R/W			Internal registers
64	R			Status register: see details later
65	R			Alarm register: see details later
66	R		°C	Heatsink temperature
67	R		$I = \text{value} \times \frac{2 \cdot \sqrt{2}}{32767} \times I_{max}$	Drive current
68	R		0.925 × r.p.m.	Motor speed
69	R		±32767 (0 to 65535)	Motor position within one turn
71	R		1 to 15	Axis address
72	R			Monitor version
73	R			Firmware version
74	R			FPGA version
82	R		°C	Fan switch on temperature
86	R		A r.m.s.	Maximum drive current I_{max}
87	R		A r.m.s.	Nominal drive current
88	R			Maximum drive I^2t
89	R			Power modules
90	R		V r.m.s.	Line voltage
91	R			Options
92	R			Hardware version
93	R		wwyy	Delivery date (week, year)
94	R			Customer
95	R			Serial number
96	R		3000	Hiperface firmware option
97	R		$\text{value} = \frac{-10}{32767}\text{V}$	Analogue input value ±10V

Table 37: Drive parameters

Parameter	R/W	Note	Limits or Units	Description
98	R			
99	R			Internal digital setpoint
100–179	R	O		Scope recorded data values
180	R			Resolver sine
181	R			Resolver cosine
182	R		$I = \text{value} \times \frac{2 \cdot \sqrt{2}}{32767} \times I_{max}$	Current setpoint
185	R			Phase U actual current
186	R			Phase V actual current
187	R			Phase W actual current
192	R			I^2t threshold
193	R			Instantaneous I^2t value

Table 37: Drive parameters

The following table shows the motor type options, set in parameter 0.

Motor options			
Bit	Decimal	Description	
0	1	No. of pairs of motor poles	Range 1 to 6
1	2		
2	4		
3	8		
4	16	Motor type	0: Brushless 1: Asynchronous
5	32		
6	64		
7	128		
8	256	Feedback type	0: Resolver 1: Encoder 2: Hiperface
9	512		
10	1024		
11	2048		

Table 38: Motor options (address 0)

The following two tables list the detailed bit definitions for the drive status register and alarm register.

Status register			
Bit	Decimal	Description (when status bit is set to 1)	
0	1	Under or over voltage on DC bus	
1	2	Phase N over current or temperature	Power module faults
2	4	Phase U over current	
3	8	Phase V over current	
4	16	Phase W over current	
5	32		
6	64		
7	128		
8	256	Motor thermostat	
9	512	6V supply OK	
10	1024	End switch 1	
11	2048	End switch 2	
12	4096		
13	8192	EXTLIMI input	
14	16384		
15	32768	Drive disabled	

Table 39: Status register (address 64)

Alarm register			LED display (standalone drives only)
Bit	Decimal	Description	
0	1	Under or over voltage on DC bus	7
1	2	Power module fault	6
2	4		
3	8	Internal over temperature	4
4	16	I^2t limit exceeded	2
5	32	Resolver fault	5
6	64	Motor overspeed	b
7	128	Motor wiring error or fault	C
8	256	Motor thermostat	3
9	512		
10	1024		
11	2048		
12	4096		
13	8192	Software watchdog	9
14	16384	Firmware not OK	F
15	32768	Parameters not OK	E

Table 40: Alarm register (address 65)

The standalone drives may also display warning values on the LED display, without a corresponding flag in the alarm register.

2	I^2t limit (non-latched)
A	Momentary overcurrent

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