

World Class Design | World Class Function | 30 Years Expertise in Industrial Motor Control

DC MOTOR DRIVE

3600XRi

4Q



SPRINT ELECTRIC

Please read this information before installing or using the product.

Install, use and maintain this product following the procedures provided.

The manual(s) cannot provide all details, variations and contingencies required for your installation, operation and maintenance of this product or the apparatus with this product installed. For further help or information, refer to your local Supplier sales office.

Application area

The equipment described is intended for industrial (non-consumer) motor speed control.

Intended users

To safely enable the user to obtain maximum benefit from the equipment:

- Ensure this information is available to all persons required to install, configure or service the described equipment or any other associated operation.
- Always store the manual in a conveniently accessible area for quick reference.
- Make it available for the next user/owner of the product.

This product is of the restricted sales distribution class according to IEC 61800-3 and has a "professional equipment" designation as defined in EN 61000-3-2.

Safety

Ensure all users and operators understand the included WARNINGS, CAUTIONS and NOTES, which alert the user to safety issues. COMPLY WITH WARNINGS AND CAUTIONS AT ALL TIMES. Each of these carries a special meaning and should be read carefully:



WARNING!
A WARNING is given when non-compliance with the warning may result in personal injury and/or equipment damage.



CAUTION!
A CAUTION is given when non-compliance with the caution may result in permanent equipment damage.

NOTE A note provides specific information to make important instructions clear.

Symbols

 Attention	 Electrostatic Discharge (ESD)	 Electric Shock Hazard
See the instructions for use. Specific warnings not found on the label.	This equipment contains ESD sensitive parts. Observe static control precautions when handling, installing and servicing this product.	Disconnect the mains supply before working on the unit. Do not touch presets, switches and jumpers! Always use the correct insulated adjustment tools.



WARNING!

Only qualified personnel must install, operate and maintain this equipment.

A qualified person is someone technically competent and familiar with all safety information, established safety practices, installation, operation, maintenance and the hazards involved with this equipment and any associated machinery.

Hazards

This equipment can endanger life through rotating machinery and high voltages.



WARNING!

PERSONAL INJURY AND/OR ELECTRICAL SHOCK HAZARD

- Always isolate all power supplies from the equipment before starting any work.
- Never perform high voltage resistance checks on the wiring without first disconnecting the product from the circuit under test.
- Use guarding and additional safety systems to prevent injury and electric shock.
- Metal parts may reach 90°C during operation.



CAUTION!

EQUIPMENT DAMAGE HAZARD

- We thoroughly test our products. However, before installation and start-up, inspect all equipment for transit damage, loose parts, packing materials, etc.
- Installation must observe the required environmental conditions for safe and reliable operation.
- In a domestic environment, this product may cause radio interference, requiring adequate measures to be taken. Obtain the permission of the supply authority before connecting to the low voltage supply.

General risks

Installation

- Ensure mechanically secure fixings are in use as recommended.
- Ensure cooling airflow around the product is as recommended.
- Ensure cables/wire terminations are as recommended and are torqued correctly.
- Ensure the product rating is correct - do not exceed the rating.

Application risk

Electromechanical safety is the responsibility of the user. The integration of this product into other apparatus or systems is not the manufacturer's or distributor of the product's responsibility. It is the user's responsibility to ensure the compliance of the installation with any regulations in force.

Health and safety at work

Electrical devices can constitute a safety hazard. Thorough personnel training is an aid to SAFETY and productivity. SAFETY awareness not only reduces the risk of accidents and injuries in your plant but also has a direct impact on improving product quality and costs. If you have any doubts about the SAFETY of your system or process, consult an expert immediately. Do not proceed without doing so. If in doubt, refer to the Supplier.

Weight

Consideration should be given to the weight of our heavier products when handling.

Risk assessment

Under fault conditions or conditions not intended: the motor speed may be incorrect; the motor speed may be excessive; the direction of rotation may be incorrect; the motor may be energised.

In all situations, the user should provide sufficient guarding and/or additional redundant monitoring and safety systems to prevent risk of injury.

NOTE: During a power loss event, the product will commence a sequenced shut-down procedure. Therefore, the system designer must provide suitable protection for this case.

Maintenance

Only qualified personnel should maintain and effect repair using only the recommended spares, alternatively return the equipment to the factory for repair. The use of unapproved parts may create a hazard and risk of injury.



WARNING!

PERSONAL INJURY AND/OR EQUIPMENT DAMAGE HAZARD

When replacing a product, all user-defined parameters that define the product's operation must be installed correctly before returning to use. Failure to do so may create a hazard and risk of injury.

The packaging is inflammable and incorrect disposal may lead to the generation of lethal toxic fumes.

Repairs

Repair reports can only be given if the user makes sufficient and accurate defect reporting. Remember that the product without the required precautions can represent an electrical hazard and risk of injury, and that rotating machinery is a mechanical hazard.

Protective insulation

Isolated product



WARNING!

The drive and motor must be connected to an appropriate safety earth. Failure to do so presents an electrical shock hazard. Exposed metal work in this equipment is protected by basic insulation and bonding to a safety earth.

This product is classified as a component and must be used in a suitable enclosure.

1. This is achieved through basic insulation and protective earth grounding, or double-insulation to provide SELV Control Circuits.
2. This protection allows a safe connection to other low voltage equipment.
3. **Earth bonding is the responsibility of the installer.**

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1 Introduction

The 3600XRI DC Drive is an isolated, 4 Quadrant speed controller for brushed shunt wound or permanent magnet DC motors. This Class 1 product has basic insulation and protective earth. Its control signals are isolated from the mains AC supply, and their connection to other isolated instruments is permitted.

Electrically isolated control circuits allow interfacing to external sources.

It has both speed and current control modes and can motor or regenerate in both forward or reverse directions of rotation. The drive incorporates a fully controlled thyristor bridge with a current loop to protect the drive and motor.

**This component is hazardous. Please obtain expert help if you are not qualified to install this equipment. Make safety a priority.
Read about the general risks and warnings at the front of this manual.**



This apparatus complies with the protection requirements of the relevant EU Directives.

- All models are of open chassis construction only for use in a suitable enclosure with a fused supply. For suitable fuses refer to "10 Specifications" on page 26.
- The unit uses closed-loop control of both armature current and feedback voltage for precise control of motor torque and speed.
- A stall timer protects the motor and drive and automatically removes power after 30 seconds if the required speed is not achievable. During this period, the unit can provide up to 150% of the preset maximum current for up to 30 seconds allowing for high, short-term torques during acceleration etc.
- Electrically isolated control circuits allow interfacing to external sources.
- Independent control of either the current or speed loops by external inputs allows for torque or speed control applications with overspeed or overcurrent protection.
- Derive the speed demand signal from either a potentiometer, 0-10 V signal or 4-20 mA current loop. A bipolar speed demand is only possible with a voltage input.
- Speed feedback signal selection: ARMATURE VOLTAGE, or shaft-mounted TACHOMETER.
- On-board function switches select the SPEED and CURRENT ranges.
- Independent adjustment presets provide FORWARD UP RAMP, FORWARD DOWN RAMP, REVERSE UP RAMP, REVERSE DOWN RAMP.
- The positive and negative current limits are independently adjustable.
- Motor braking can be fast or ramped, and provision is made to adjust the motoring and braking torque independent of rotation direction. The unit returns braking energy to the supply.
- Control the shaft direction using linear voltage signals or pushbuttons.
- The unit can directly connect to a PLC logic controller.
- The unit has a comprehensive range of extra inputs and outputs.

2 Mechanical dimensions

Mount the unit using the two centre fixing slots, and allow satisfactory cooling air to flow over the fins (vertically, with 50 mm end space). The unit must have a substantial earth connection. Connect the earth (cross-sectional area at least 6 mm²) to the heatsink earth screw provided. Use a star washer to obtain optimum earth continuity.

Suitable fixing bolts:

4/8/16/32 A unit: M5 x 35 mm

36 A unit: M5 x 50 mm

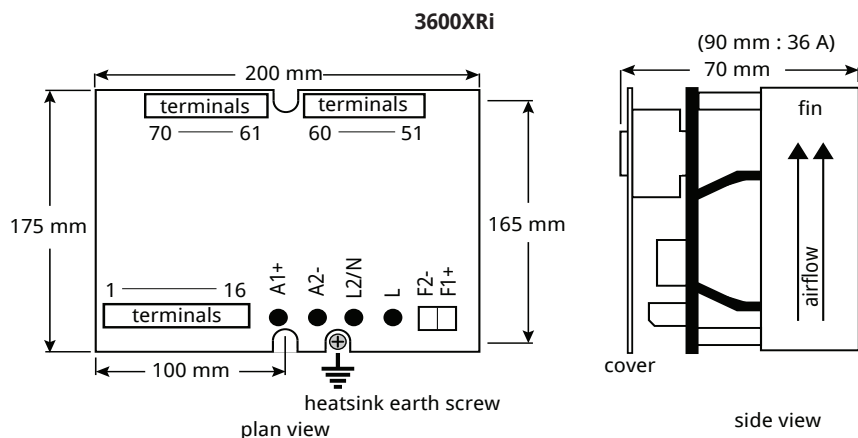


Figure 1 Mechanical dimensions

3 Guide for systems used in the EU

Special consideration must be given to installations in member states of the European Union regarding noise suppression and immunity. According to IEC 1800-3 (EN61800-3), the drive units are classified as complex components only for professional assemblers, with no CE marking for EMC.

The drive manufacturer is responsible for the provision of installation guidelines. The resulting EMC behaviour is the responsibility of the manufacturer of the system or installation. The units are subject to the LOW VOLTAGE DIRECTIVE 73/23/EEC and are CE marked accordingly.



Following the procedures outlined below will normally be required for the drive system to comply with the European regulations, some systems may require different measures. Installers must have a level of technical competence to correctly install. Although the drive unit itself is not subject to the EMC directive, considerable development work has been undertaken to ensure that the noise emissions and immunity are optimised.

- * EN61800-3 specifies two alternative operating environments. These are the Domestic (1st environment) and Industrial (2nd environment). There are no limits specified for conducted or radiated emissions in the industrial environment, hence it is usual for the AC supply filter to be omitted in Industrial systems.

Definition of an industrial environment: all establishments, other than those directly connected to a low-voltage power supply network that supplies buildings used for domestic purposes.

4 Multiple drives

The arrangement shown below is for multiple drives with one filter, showing the star point earthing method.

The filter should be rated for the worst case total armature current load. The drive units are designed to function normally on unfiltered AC supplies shared with other thyristor DC drives. (Not AC drives).

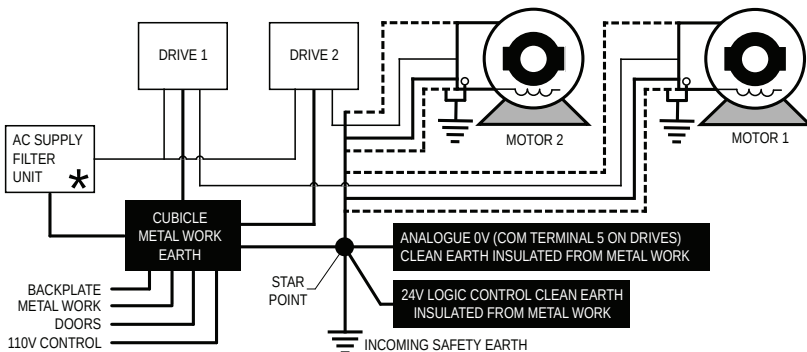


Figure 2 Star point connections for multiple drives

5 Requirements for EMC compliance

- Keep parallel runs of power and control cables at least 0.3 metres apart. Cross-overs must be at right angles.
- Keep sensitive components at least 0.3 metres from the drive and power supply cables.
- The AC connections from the filter to the drive must be less than 0.3 metres or, if longer, correctly screened.
- Do not run filtered and unfiltered AC supply cables together.
- Control signals must be filtered or suppressed, e.g. control relay coils and current carrying contacts. The drive module has built-in filters on signal outputs.
- The AC supply filter must have a good earth connection to the enclosure back plane. Take care with painted metal to ensure good conductivity.
- The AC input filter has earth leakage currents. Earth RCD devices may need to be set at 5% of rated current.
- The metal enclosure will be RF ground. The AC filter, drive earth and motor cable screen should connect directly to the metal cabinet for best performance.
- Linear control signal cables must be screened, with the screen earthed at the drive end only. Minimise the length of screen stripped back and connect it to an analogue earth point.
- (1) The motor cable must be screened or armoured with 360 degree screen terminations to earth at each end. The cable must have an internal earth cable and the screen must extend into the enclosure and motor terminal box to form a Faraday cage without gaps.
- (2) The internal earth cable must be earthed at each end. The incoming earth must be effective at RF.
WARNING! The earth safety must always take precedence.



WARNING!
ELECTRIC SHOCK HAZARD

AC supply filters must not be used on supplies that are unbalanced or float with respect to earth.

The drive and AC filter must only be used with a permanent earth connection. No plugs/sockets are allowed in the AC supply.

The AC supply filter contains high voltage capacitors and should not be touched for a period of at least 20 seconds after the removal of the AC supply.

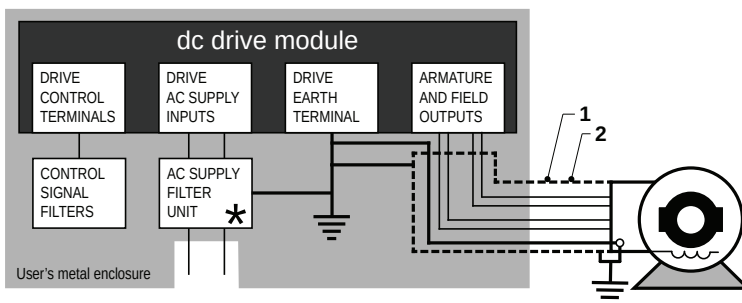


Figure 3 Connections for EMC compliance

6 Installation



WARNING!

ELECTRIC SHOCK HAZARD

Disconnect the mains supply before working on the unit. **DO NOT TOUCH PRESETS, SWITCHES AND JUMPERS!** Always use the correct insulated adjustment tools.

6.1 Motor installation

- Foot-mounted motors must be level and secure.
- Ensure accurate alignment of the motor shaft and couplings.
- Do not hammer pulleys or couplings onto the motor shaft.
- Protect the motor from ingress of foreign matter during installation.

Earthing: Connect the motor to the system enclosure earth.

6.2 Drive installation

Requirements during installation and operation:

- Avoid vibration.
- Protect the drive from pollutants.
- Ambient operating temperature must be within -10°C and +40°C.

POWER CABLING: Use correctly rated cable: minimum 600 Vac, 2 x armature current, enclosed in metal conduit or trunking, or screened. The screen must be earthed at the motor and drive - refer to "5 Requirements for EMC compliance" on page 4.

FUSING: The drives **MUST BE FUSED EXTERNALLY** with semiconductor fuses. The fuses must be semiconductor types with a maximum amps squared seconds rating according to the Rating table, page 28). The fuse current rating must be at least 1.75 times the armature current. The voltage rating must be suitable for the AC supply. Failure to use the correct semiconductor fuse ratings will invalidate

any warranty. Special consideration must be given to installations in member states of the EU. Refer to "5 Requirements for EMC compliance" on page 4.

CONTROL SIGNALS: Avoid running signal cables close to power cables. Earth the screens at the drive end only.

SUPPRESSION: The drives have excellent noise immunity. However, installations involving electrical welding or RF induction heating may require further filters on the line and armature terminals. Contactor coils and sparking contacts may also require suppression. A 100 Ω resistor in series with a 0.1 μF capacitor is usually adequate in these situations.

MECHANICAL: Optimise heatsink airflow. Avoid vibration and ambient temperature outside -10 to +45°C. Protect the drive from pollutants.

MOTOR: Ensure the motor is correctly wired and that the motor and load are free and safe to rotate. The motor must ideally have a minimum armature time constant of approximately 10 ms ($T = L/R$). For motors with lower time constants e.g. servo-motors, use an armature choke in series with the motor (refer to the motor supplier for choke data). Failure to do this may cause damage.

6.3 Typical applications

SPRINT ELECTRIC LTD. does not accept any liability whatsoever for the installation, fitness for purpose or application of its products. It is the users responsibility to ensure that the unit is correctly used and installed.

Health and Safety at Work

Devices constitute a safety hazard. It is the responsibility of the user to ensure compliance with any Acts or By-Laws in force. **ONLY skilled persons should install this equipment.**

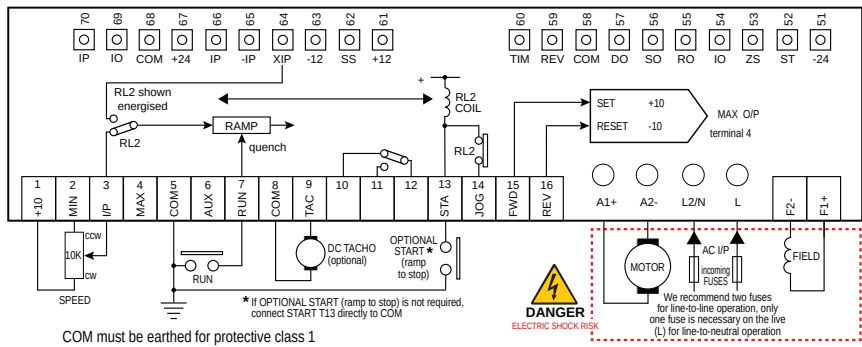


WARNING! PERSONAL INJURY AND/OR EQUIPMENT DAMAGE HAZARD

To ensure safe operation of the unit, always apply the ac supply before closing the run contact to prevent spurious firing due to erratic mains contactor operation. Do not remove the ac supply while the armature current is flowing - quench the drive first using the run contact.

We recommend an initial start using the Basic Connection.

BASIC CONNECTION. FORWARD SPEED CONTROL BY POTENTIOMETER



ALTERNATIVE FORWARD SPEED CONTROL BY CENTRE ZERO POTENTIOMETER

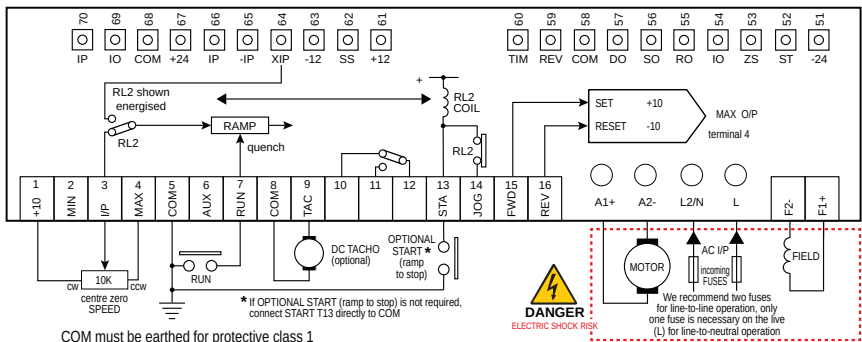


Figure 4 Basic connection

7 Commissioning

7.1 Initial settings - without power

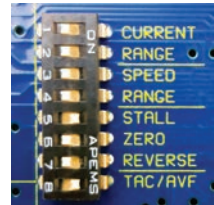
The suggested Comissioning strategy is to start in the safest possible mode of operation and progressively exercise each element of the system until full functionality has been achieved. For this reason, all drive units are shipped to run using the:

- highest supply voltage option at nominal speed
- ARMATURE VOLTAGE feedback mode
- lowest speed range
- lowest current range

To avoid damage, ensure the supply selection jumper on the drive matches the incoming ac supply - refer to "Figure 6 User adjustments" on page 10.

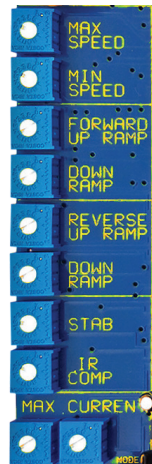
1. Set the following switches:

- Select the current range using switches S1 and S2 - set to the minimum motor rating that includes the motor rating current. Refer to "Figure 6 User adjustments" on page 10.
- Set switches S3 and S4 to OFF to select feedback full scale at 100%, 50 V.
- Set switches S5, S6 and S7 to provide the desired relay function - Refer to "Figure 6 User adjustments" on page 10.
- Set switch S8 to ON to select Armature Voltage, and the Tacho input to T9 must be disconnected.



2. For an initial start, adjust the following presets:

MAX SPEED	Fully anti-clockwise
MIN SPEED	Fully anti-clockwise
FORWARD UP RAMP	Fully anti-clockwise
FORWARD DOWN RAMP	Fully anti-clockwise
REVERSE UP RAMP	Fully anti-clockwise
REVERSE DOWN RAMP	Fully anti-clockwise
STABILITY	Mid-way
IR COMP	Fully anti-clockwise
MAX CURRENT	Set the MAX CURRENT from your motor rating plate - clockwise rotation of the potentiometer gives 0-100% current limit. For example, 50% rotation provides a 50% current limit for the selected current range set by switches S1 and S2.

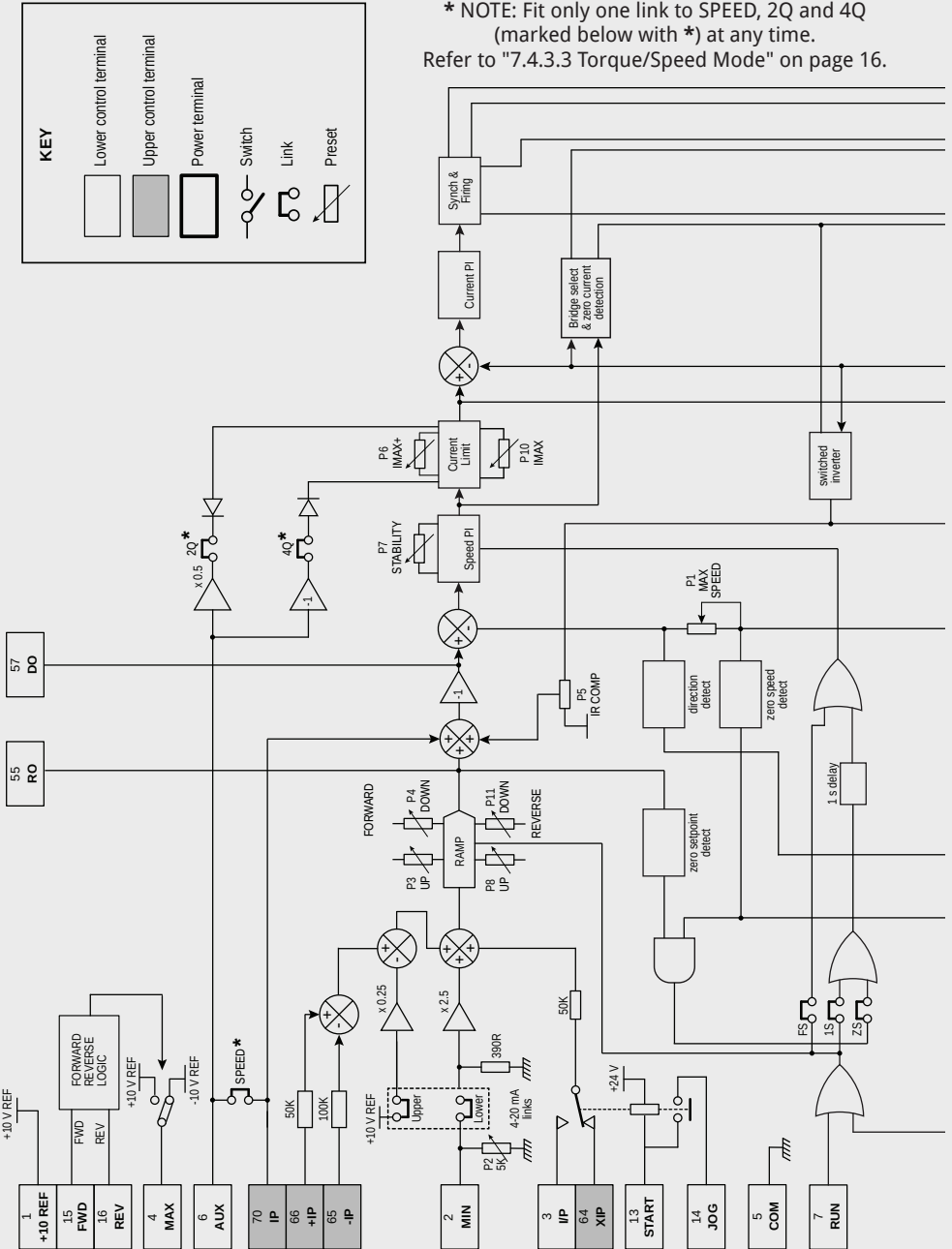


3. Links - ensure that:

- The link for the MAX CURRENT potentiometer mode is in the POS I/ NEG I position.
- The 4Q TORQUE/2Q TORQUE/SPEED link is in the SPEED position.
- 1S and ZS QUENCH links are fitted.



7.2 Block diagram



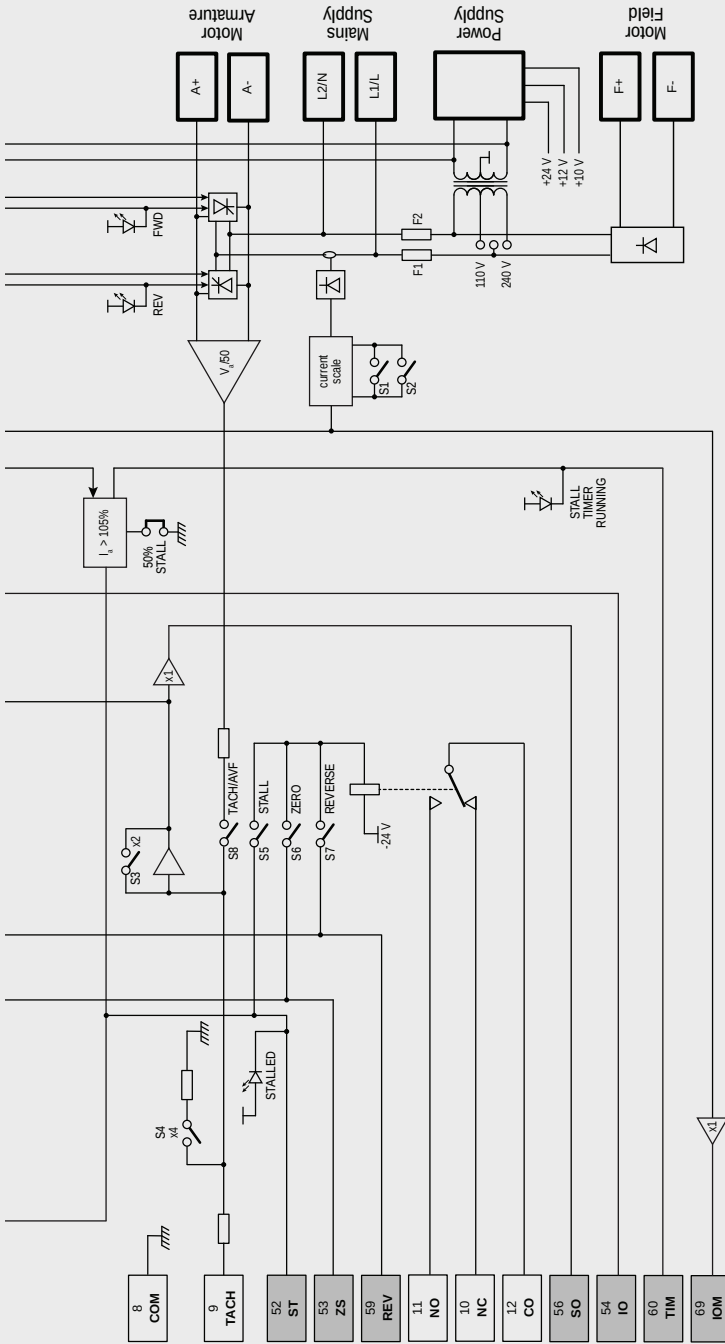
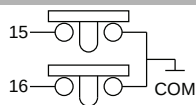
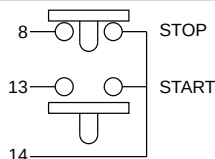


Figure 5 Block diagram

7.3 Terminal descriptions

7.3.1 Control terminals

1 +10	+10 V precision reference. 10 mA maximum. Short-circuit proof.
2 MIN	Minimum (ACW) end of setpoint potentiometer, or 4-20 / 0-20 mA current loop input.
3 I/P	+/-10 V input for speed setpoint.
4 MAX	Maximum (CW) end of setpoint pot in bi-directional systems. Set by FWD/REV inputs to +10 V or -10 V (defaults to -10 V if T15 and T16 are unused).
5 COM	COMMON (4-20 mA / 0-20 mA return). Internally connected to T8, T58 and T68.
6 AUX	Auxiliary input. Function set by links – refer to "7.4.3.3 Torque/Speed Mode" on page 16.
7 RUN	Connect to COMMON to run. Function set by links – refer to "7.4.3.5 Quench Mode" on page 17. It is good practice to connect a normally open auxiliary contact of the drive's supply contactor in series with this input. (WARNING: Run is an electronic inhibit function. The field remains energised and all power terminals remain "live". RUN must not be relied upon during hazardous operations).
8 COM	Common - internally connected to T5, T58 and T68.
9 TACH	DC Tacho input 25-400 V - negative for forward rotation with positive setpoint.
10 N/C	
11 N/O	Relay contact rating 1 A, 125 Vac. Configurable function – refer to "7.4.2.3 S5 / S6 / S7 : STALL / ZERO/ REVERSE" on page 15.
12 C/O	
8 COM	N/C STOP pushbutton.
13	N/O START pushbutton.
14	START latch line (JOG).
15	N/C FORWARD pushbutton.
16	N/C REVERSE pushbutton.



7.3.2 Ancillary terminals

51 -24	-24 V relay supply. 25 mA. NOT SHORT-CIRCUIT PROOF
52 ST	Stall relay driver output. Maximum 25 mA. External relay is de-energised when stall timer trips if connected as in "Figure 7 Relay circuits" on page 13.
53 ZS	Zero speed relay driver output. Maximum 25 mA. External relay is de-energised at zero speed if connected as in "Figure 7 Relay circuits" on page 13.
54 IO	Scaled current output. ± 5 V for $\pm 100\%$. 1 k Ω output impedance.
55 RO	Speed setpoint ramp output. ± 10 V for $\pm 100\%$. 1 k Ω output impedance.
56 SO	Speed output. Full-scale reading determined by max speed preset setting. Variable between ± 4 V for $\pm 100\%$ to ± 9 V for $\pm 100\%$. 1 k Ω output impedance. Typically 7.5 V full-scale.
57 DO	Inverted total speed demand output. +10 V for -100%; -10 V for +100%. 1 k Ω output impedance.
58 COM	COMMON. Internally connected to T5, T8 and T68.
59 REV	Relay driver. Maximum 25 mA. External relay is de-energised when the speed reverses or at zero speed if connected as in "Figure 7 Relay circuits" on page 13.
60 TIM	Relay driver. Maximum 25 mA. External relay is de-energised when the stall timer is operating (current demand > 105%) if connected as in "Figure 7 Relay circuits" on page 13.
61 +12	+12 V output. 10 mA maximum.
62 SS	Stop/Start input. Close to -12 V to force a stall condition. Close to +12 V to release stall condition.
63 -12	-12 V output. 10 mA maximum.
64 XIP	Input to speed setpoint ramp circuit when START relay RL2 is de-energised (T3 is disconnected). ± 10 V for $\pm 100\%$.
65 -IP	Auxiliary inverting speed input. 0V to -10 V for 0V to +100% speed; 0V to +10 V for 0 to -100% speed.
66 +IP	Auxiliary non-inverting speed input. ± 10 V for $\pm 100\%$.
67 +24	+24 V output. 25 mA maximum. NOT SHORT-CIRCUIT PROOF
68 COM	Drive Common. Internally connected to T5, T8 and T58.
69 IOM	Metering output, 0 to 5 Vdc representing 0 to 100% scaled armature current. Refer to "7.4.2.1 S1 / S2 : CURRENT RANGE" on page 14.
70 IP	Auxiliary input to speed demand scaled ± 10 V for $\pm 100\%$. Do not use if TORQUE/SPEED link is in the SPEED position as the auxiliary input function is already being used by the AUX (T6) auxiliary terminal.

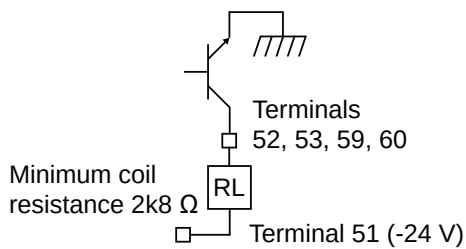


Figure 7 Relay circuits

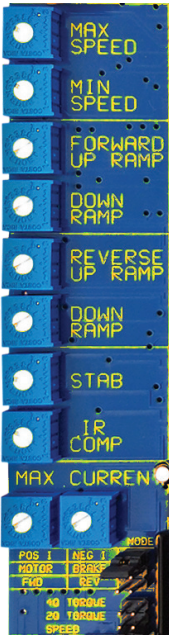
7.3.3 Power terminals

A1+	Motor armature connection (positive).
A2-	Motor armature connection (negative).
L2/N	Line ac return; either neutral or L2.
L	Line ac supply input.
F2-	Motor field connection (negative).
F1+	Motor field connection (positive).

7.4 Preset, switches and links

7.4.1 Presets

Preset	Description
MAX SPEED	Sets maximum speed for 100% demand.
MIN SPEED	Sets minimum speed for application. Note: Minimum speed function only operates if the speed demand is from a 10k potentiometer connected between terminals 1 and 2 with its wiper connected to terminal 3. When operating with a 4 – 20 mA or 0 - 20 mA reference, the MIN SPEED preset is used to adjust the burden resistance.
FORWARD UP RAMP	Forward acceleration.
FORWARD DOWN RAMP	Forward deceleration.
REVERSE UP RAMP	Reverse acceleration.
REVERSE DOWN RAMP	Reverse deceleration.
STAB	Stability.
IR _{COMP}	IR compensation.
MAX CURRENT	2x current limit presets. Refer to "8.2 Maximum Current Mode" on page 21.

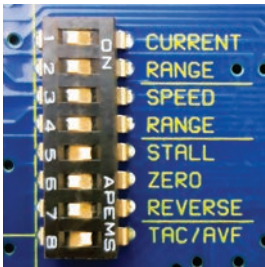


7.4.2 Switches

7.4.2.1 S1 / S2 : CURRENT RANGE

These two switches set the maximum current as a percentage of the rated current of the unit. The MAX CURRENT presets can then adjust the maximum current between this current and zero.

S1	S2	% of rated
OFF	OFF	25%
ON	OFF	50%
OFF	ON	75%
ON	ON	100%



7.4.2.2 S3 / S4 : SPEED RANGE

These two switches set the range of the speed feedback voltage for Armature and DC Tacho. Adjustment within the range is through the MAX Speed preset.

S3	S4	Speed Feedback Voltage
OFF	OFF	25 - 50 V
ON	OFF	50 - 100 V
OFF	ON	100 - 200 V
ON	ON	200 - 400 V

7.4.2.3 S5 / S6 / S7 : STALL / ZERO/ REVERSE

These three switches control the function of the relay on terminals 10 - 12.

S5	S6	S7	Energised relay state
ON	OFF	OFF	Motor NOT stalled
OFF	ON	OFF	Motor speed > $\pm 1\%$
OFF	OFF	ON	Motor speed > +5% (forward)

As an example, with S6 ON and S5 and S7 OFF, when the motor speed is greater than $\pm 1\%$, the relay is energised, terminals 11 and 12 are shorted, and terminals 10 and 12 are open. When the speed is less than $\pm 1\%$, the relay is de-energised and the opposite is true: terminals 10 and 12 are short and terminals 11 and 12 are open.

If more than one of S5 – S7 is ON then the relay operation is the ANDing of the switch states. For example, if switches S5 and S6 are ON, the relay is only de-energised if the motor is stalled AND the speed is less than $\pm 1\%$. In effect, this indicates a failure for the motor to start.

7.4.2.4 S8 : TAC/AVF

When S8 is ON, speed feedback is taken from the armature voltage. There must be no connection to terminal T9.

When S8 is OFF, speed feedback is from the TACH terminal T9.

7.4.3 Links

7.4.3.1 Supply Voltage Selector

A link is provided to configure the unit for either HIGH or LOW voltage operation. The actual operating voltage then depends on the drive model:

	HIGH	LOW
LL	415 V	240 V
LN	240 V	110 V
LV60	60 V	30 V
LV48	48 V	24 V



7.4.3.2 Maximum Current Mode

There are three link positions which determine the function of the MAX CURRENT presets (P6 and P10).

POS I/NEG I:

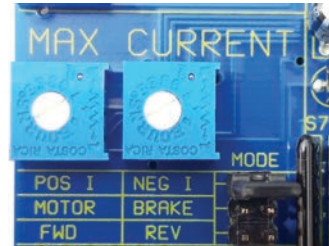
When the link is in this position, P6 sets the positive current limit and P10 sets the negative current limit irrespective of the direction of rotation of the motor. This is the default position.

MOTOR/BRAKE:

With the link in this position, P6 sets the current limit when motoring and P10 sets the current when generating irrespective of the direction of motor rotation and the polarity of current.

FWD/REV:

With the link in this position, P6 sets the current limit in the forward direction and P10 sets it for the reverse direction irrespective of the polarity of current or whether motoring or regenerating.



7.4.3.3 Torque/Speed Mode

There are three positions for this link which determine the function of the AUX analogue input on T6.

4Q TORQUE:

When the link is in this position, the voltage on T6 sets the maximum positive and negative currents (0 to +5 V for 0 to 100% of positive or negative current limits).

2Q TORQUE:

With the link in this position, the voltage on T6 sets the maximum positive current (+10 V = +100% of positive current limit). The maximum negative current is only limited by the setting of the negative current preset.

SPEED:

With the link in this position, the voltage on terminal 6 is an auxiliary input to the speed loop demand summing amplifier that bypasses the ramp. Positive for forward rotation.

Refer to "8.1 Torque Control Mode" on page 20.



7.4.3.4 4/20 mA and 0/20 mA Modes

There are two links which can be used to configure the unit for current loop operation with T2 the input and T5 the return.

If just the lower link is fitted 0 - 20 mA operation is selected. With both links fitted 4 - 20 mA operation is possible but only if the MIN SPEED preset is adjusted such that there is a 250 Ω resistance between T2 and T5.



7.4.3.5 Quench Mode

There are three link positions that determine the behaviour of the quench circuit. The factory setting is for the FS and ZS links to be fitted.

Note that opening the RUN input always resets the setpoint ramp output to zero. The other effects of opening the RUN input depend on the position of the links below.

FS:

With only this link fitted, the drive is quenched immediately by a stall condition or the removal of the RUN signal on T7.



1S:

With only this link fitted, the drive is quenched after one second by a stall condition or the removal of the RUN signal on T7.

ZS:

With only this link fitted, the speed ramp is reset by a stall condition or removal of the RUN signal on T7, and the drive is quenched one second after zero speed is reached. The drive will also be quenched if the motor shaft is at "standstill", that is, the setpoint and speed feedback are both less than $\pm 1\%$.



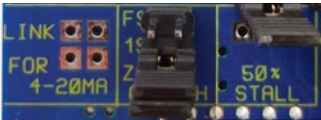
CAUTION!

We recommend that the FS or the 1S link is fitted at all times.

If no links are fitted, a stall condition or the removal of RUN from T7 will reset the speed ramp but the drive will not be quenched. Also, if only the ZS link is fitted and the motor cannot reach zero speed, neither a stall condition nor removal of RUN will quench the drive.

7.4.3.6 Stall Timer

Refer to "8.4 Stall Timer" on page 23 for details.



7.4.4 LEDs

There are four LEDs in the top left-hand corner of the drive board indicating the direction of armature current flow and the status of the stall timer.



		STALL	TIMER
+	-	These LEDs indicate the status of the stall timer.	
The LED that is illuminated indicates the direction of armature current flow.		• If both are off, the stall timer is not in operation.	
		• If just the TIMER LED is illuminated then the stall timer is in operation but hasn't tripped.	
		• If both the TIMER and STALL LEDs are illuminated then the timer has tripped and the drive has been quenched (provided that an appropriate quench mode has been selected – refer to "7.4.3.5 Quench Mode" on page 17).	

7.5 Pre-operation motor check list

With no power applied, complete the following check list:

- Check for the correct insulation between all motor windings and earth (disconnect all drive cables before testing).
- Check inside the motor connection box for foreign objects, damaged terminals etc.
- Check that motor brushes are in good condition, correctly seated and free to move in brush boxes. Check for the correct action of brush springs.
- Check that motor vents are free of any obstruction or protective covers.

7.6 Field and setpoint check

1. **With no power applied, remove the RUN line connection at Terminal 7 and disconnect leads A+ and A-. Make the leads safe.**
2. **Apply mains power to the unit** and check that the correct field voltage appears between terminals F+ and F-.
If the field voltage is too high, reduce it by connecting in half-wave configuration with the field connected between terminals L and F2-.
3. With no connections to FWD and REV (T15 and T16), check that the voltage at MAX (T4) is -10 V.
4. Check that the clockwise rotation of the speed setpoint potentiometer increases the voltage on IP (T3) to a maximum of +10 V. Now reset the potentiometer to minimum by turning fully counter-clockwise.
5. **Remove the power supply and reconnect the Armature Leads.**

7.7 Operating the drive



WARNING! **PERSONAL INJURY AND/OR EQUIPMENT DAMAGE HAZARD**

Do not exceed the drive and motor armature voltage and current ratings.

1. Note the armature voltage rating given on the motor rating plate.
2. If the optional DC Tachogenerator is connected, ensure that the wire from it is disconnected and insulated.
3. **Apply mains power to the unit.** The ON lamp will light. Close the RUN contact (and, if fitted, close the optional START contact). **NOTE: If the optional START is not fitted, a permanent connection between START (T13) and COM (0 V) is required.**
4. Rotate the potentiometer to slowly increase the external setpoint from zero volts positive until the motor begins to rotate. Check the direction.
If the direction is wrong, **TURN OFF THE POWER WHEN THE MOTOR IS STATIONARY** and swap over the cables connected to the A1+ and A2- terminals. **Apply mains power to the unit.** The ON lamp will light. Close the RUN contact (and close the optional START contact if fitted).
5. Gradually increase the external setpoint until the potentiometer is fully clockwise (+10 V).
If the motor does not achieve rated output volts, stop the drive and adjust switches S3 and S4. For example, if the motor armature volts is 180 Vdc, set SW3 to OFF and SW4 to ON (refer to "Figure 6 User adjustments" on page 10).

6. Run the motor at maximum speed setpoint and adjust the **MAX SPEED** preset to achieve the armature voltage stated on the motor rating plate. Refer to the Warning above.
7. Rotate the potentiometer fully counter-clockwise and ramp the drive to zero.
8. If required, adjust the **MIN SPEED** preset.
9. Adjust the **FORWARD RAMP UP** and **FORWARD RAMP DOWN** potentiometers to suit your operation.
The "Alternative" Basic Connection ("Figure 4 Basic connection" on page 6) uses a single potentiometer to provide both Forward and Reverse operation. The mid-point of the potentiometer is zero volts; fully clockwise provides the maximum forward speed (+10 V); and fully counter-clockwise provides the maximum reverse speed (-10 V).
10. The drive is now fully functional in Armature Voltage Feedback. However, when the motor is loaded, you may observe speed droop. To compensate for this, increase the **IR** preset to maintain speed. Do not over-compensate or the motor will become unstable.

The drive is now fully commissioned in ARMATURE VOLTAGE feedback.

7.7.1 DC Tachogenerator Feedback



CAUTION! EQUIPMENT DAMAGE HAZARD

IR compensation must not be used with Tachogenerator feedback.
Ensure that the IR preset is fully counter-clockwise.

11. For systems using Tacho Feedback first measure the full speed tacho voltage while in AVF mode and determine the polarity - the wire to T9 must be negative when the speed demand into T3 is positive:
 1. Having measured the Tacho voltage at maximum speed, **TURN OFF THE POWER.**
 2. Set switch S8 to OFF to select TACHO operation.
 3. Set switches S3, S4 to select a speed range that encompasses the tacho voltage measured under AVF operation. For example, if the tachogenerator is 60 V/1000 rpm and the motor speed is 1500 rpm then the tacho voltage is 90 V, and this is within the voltage range 50-100 V provided by setting S3 to ON and S4 to OFF.
 4. Adjust the MAX SPEED preset to approximately match the full scale Tacho output, or mid-position.
 5. Re-connect T9, **TURN ON THE POWER**, run the drive and fine adjust MAX SPEED. Increase the MAX CURRENT preset to correspond to the motor armature current.
12. **STABILITY:** Adjust the STAB potentiometer to improve response. Clockwise rotation gives a faster response. (Excessive rotation in either direction may lead to instability, depending on load.)

The drive is now fully commissioned in TACHO feedback mode.

7.8 Bi-directional operation

Bidirectional operation can be achieved in several ways which provide a positive or negative speed setpoint on Terminal 3.

- A simple solution is a centre zero potentiometer connection between +10 (T1) and MAX (T4) - refer to the Alternative basic connection, "Figure 4 Basic connection" on page 6.
- Alternatively, wire a speed setting potentiometer to MAX (T4) and MIN (T2) to give a speed setpoint while MAX changes between +10 V and -10 V using FWD (T15) and REV (T16). Refer to "7.3 Terminal descriptions" on page 11.

8 Options

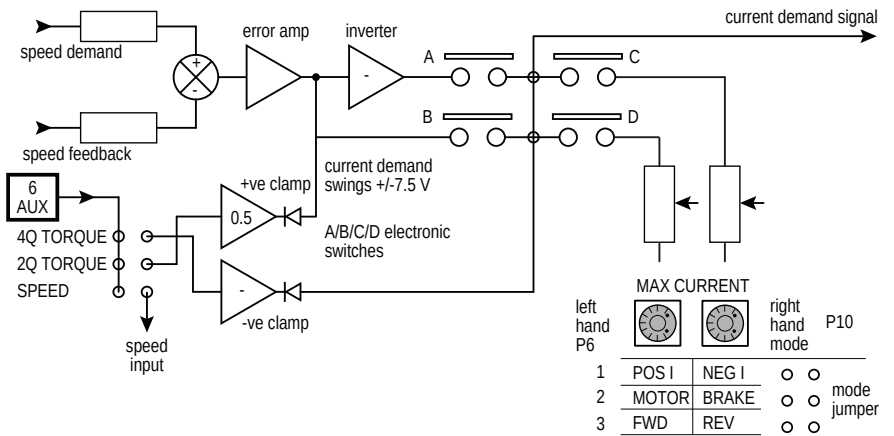
Consider the following changes to tune/improve the performance of the drive/system.

8.1 Torque Control Mode

The drive can control the torque (current) of the motor, instead of the speed (volts), by allowing an external input to clamp the current demand. NOTE: The speed loop then provides the current demand, and hence the speed loop must always be asking for more current than the clamp level. This technique gives automatic over-speed limiting.

Establish the correct operating limits by commissioning first in speed mode. Then implement torque control by moving the SPEED / 2Q / 4Q link from SPEED to the required TORQUE position (2Q or 4Q) and apply an appropriate torque control voltage to T6.

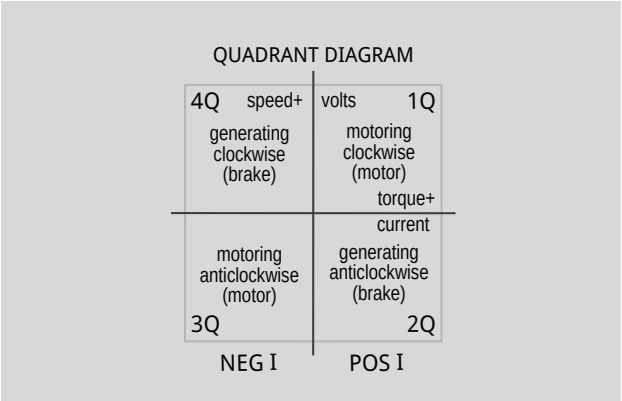
TORQUE/SPEED JUMPER: This is a 3-position jumper controlling the function of Terminal 6 (AUX). A schematic is shown below:



The 2Q TORQUE clamp operates in 1Q and 2Q on the positive current only.

The 4Q TORQUE clamp operates in all 4 quadrants on positive and negative currents.

The 4Q TORQUE mode can be used for load sharing by inputting the modulus current signal from SP69 on a master drive.



8.2 Maximum Current Mode

Refer to "7.4.3.2 Maximum Current Mode" on page 16 for details of the link settings.

The MAX CURRENT pots control the mode selected by the current MODE jumper. Refer to the quadrant diagram above to see the physical effect.

P6 POS I, quadrants 1 and 2 P10 NEG I, quadrants 3 and 4. This is the classic mode of operation. The disadvantage of this arrangement is that the current limit for braking in the forward direction becomes the same limit for motoring in the reverse direction.

P6 MOTOR, quadrants 1 and 3 P10 BRAKE, quadrants 2 and 4. This mode allows one preset to control the motoring current limit in both directions of rotation, and the other preset to control the braking current limit in both directions of rotation.

P6 FWD, quadrants 1 and 4 P10 REV, quadrants 2 and 3. This mode allows one preset to control the current limit for both motoring and braking in one direction of rotation, and the other preset to control the opposite direction.

8.3 Quench Mode

Refer to "7.4.3.5 Quench Mode" on page 17 for details of the link settings.

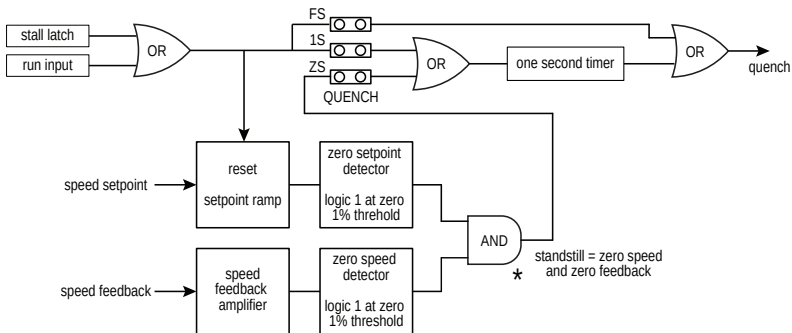


Figure 8 Drive quench circuit

NOTE: The AND gate (marked * in "Figure 8 Drive quench circuit" on page 21) will not release the ZS function at zero speed until the ramp circuit has an input. Remove the ZS link if the speed input is direct via T6. In this case, you MUST fit either FS or 1S if stall protection or quench via the RUN input is required.

NOTE: The purpose of the 1-second timer is to prevent zero speed (ZS) quenching from being a nuisance during shaft reversals, and to provide one second of regenerative braking when the setpoint ramp is reset by a stall or run command.

NOTE: The ZS function prevents the motor shaft from "creeping" at zero setpoint.

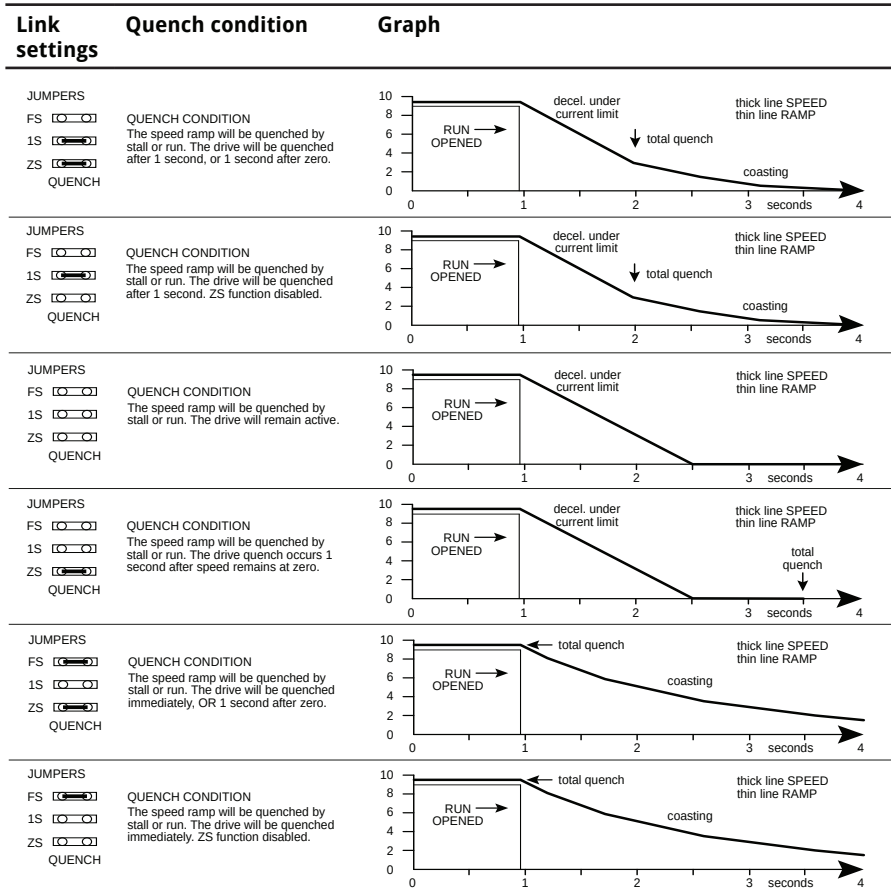
NOTE: When the RUN line operation must be rapid, but without regeneration, use the FS (fast) link.



WARNING! PERSONAL INJURY AND/OR EQUIPMENT DAMAGE HAZARD

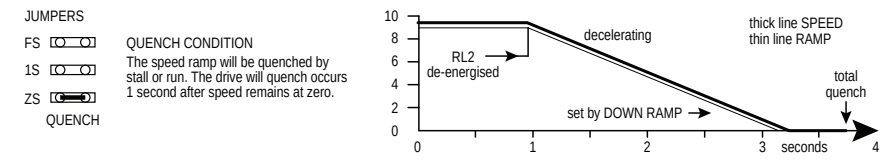
The field remains energised, and all power terminals remain "LIVE".
RUN must not be relied upon during hazardous operations.

The effect on the motor speed for each of the link positions can be seen in the graphs below. It is also possible to use links in more than one position. The factory setting is for the FS and ZS links to be fitted.



Quench behaviour is different when using the START/JOG controls on T13/T14 to stop the motor. Opening the STOP contact on T8 de-energises RL2, disconnecting the ramp circuit from T3, and connecting it instead to XIP on T64 causing the speed to ramp to zero at the set rate. The graph below shows the effect of operating the stop button with just the ZS link in place.

Note: Fitting the 1S or FS link does not affect this behaviour.



8.4 Stall Timer

NOTE: Selecting 2Q or 4Q torque mode inhibits stall, provided the torque limit applied to T6 does not exceed 105%.

The drive regulates the motor speed by adjusting the demand to the current control loop to control motor armature current and hence torque. If the torque required by the load exceeds that which the motor can produce, the motor will stall.

The drive's stall detection circuit monitors this condition. A motor current demand of less than 100% inhibits the timer, but when it exceeds 105% the timer ramps up at a rate proportional to the difference between the overload current demand and the 105% level. For a 150% overload, the time for the stall detection circuit to operate is approximately 30 seconds; for a 125% overload, it is around 60 seconds etc.

If the overload falls below 105% before the stall timer has tripped, the timer will ramp down. This characteristic of the stall circuit has the effect of limiting the average current to the motor.

In some applications, it may be required to provide protection at a lower average current but keep a high peak current (for example when the motor current rating is significantly lower than the drive current rating). In this case, the 50% STALL link feature reduces the threshold at which the timer starts ramping up to approximately 52.5%. A 150% overload is still possible, but the average is limited to 50%, giving a peak to average ratio of 3:1.

If a 50% threshold is too low, then a resistor can be fitted instead of the link:

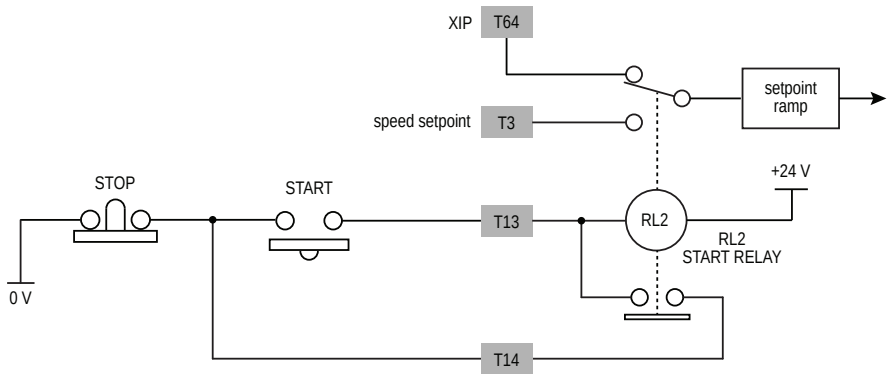
RESISTOR	THRESHOLD	OVERLOAD	RATIO	PEAK %
LINK	50%	150%	1 : 3	300%
100K	60%	150%	1 : 2.5	250%
220K	70%	150%	1 : 2.1	210%
470K	80%	150%	1 : 1.87	187%
1M	90%	150%	1 : 1.66	166%
OPEN	100%	150%	1 : 1.5	150%



WARNING!
PERSONAL INJURY AND/OR
EQUIPMENT DAMAGE HAZARD

RUN is in electronic inhibit function.
The field remains energised, and all power terminals remain "LIVE".
RUN must not be relied upon during hazardous operations.

8.5 Optional START (ramp to stop)



- **Energising RL2** using the optional START push button connects the speed setpoint to the setpoint ramp.
- **De-energising RL2** by opening the STOP push button removes the speed setpoint on I/P (T3) causing the ramp output to reduce towards the value on XIP (T64). If the XIP is not used, the setpoint will reduce towards zero.

8.6 FORWARD/REVERSE truth table

Refer to "Figure 4 Basic connection" on page 6.

FORWARD (T15)	REVERSE (T16)	MAXIMUM OUTPUT (T4)
No connection	No connection	-10 V
CLOSED	CLOSED	-10 V
OPEN *	CLOSED	+10 V
CLOSED	OPEN *	-10 V

* Opening the FORWARD push button momentarily selects the +10 V output which is maintained after releasing the push button, until the REVERSE push button is opened momentarily which returns the output to -10 V. Releasing the REVERSE pushbutton does not affect the output.

9 Troubleshooting

PROBLEM	LIKELY CAUSES	REMEDY
Drive will not power-up, or no ON indication	Line fuses blown	POWER OFF! Check circuits and replace fuses with correct type (see Rating table, page 28)
	On-board F1, F2 fuses blown	Check field wiring
	Damaged transformer	Check supply select jumper
Line fuses blow on power-up	Short circuit load	Check load circuit
	Damaged unit	Replace unit
Fuses blow during running	Excessive armature voltage due to incorrect speed scaling	Reduce armature voltage Check speed scaling is correct
Motor accelerates out of control with small setpoint and tachometer feedback	Tacho polarity incorrect	Swap terminals 8 and 9
	Tacho coupling broken or slipping	Check integrity of coupling
	Tacho is faulty	Replace the tacho. In emergency, change to AVF (S8) and rescale voltage (S3 S4) - remove tacho connections from terminals
Motor runs too fast or too slow	Incorrect speed scaling (S3, S4 MAX SPEED)	Refer to "7.4.2.2 S3 / S4 : SPEED RANGE" on page 15
Stall lamp ON Refer to "7.4.4 LEDs" on page 17 for STALL and TIMER lamp operation	Insufficient torque	Check current settings (S1, S2 MAX CURRENT)
	Timer lamp shows that stall timer is integrating	Check the motor is correctly rated for the application
	No field, motor jammed	Check the circuits and motor
	No armature current	Check the armature circuit
	Demagnetised PM motor	Replace the motor
	Motor jammed	Free the motor
Motor will not turn (timer/stall lamps NOT lit)	No run circuit	Check run circuit T7 to T5
	No start circuit	Check start circuit T13, T14 to T5
	No setpoint	Check the external setpoint T3
Motor rotates in wrong direction	Transposed motor connections	Swap armature or field connections
Motor noise	Unstable drive	Rotate STAB anticlockwise
	Armature voltage rating of motor does not match AC supply	Use a more suitable motor and/or lower supply voltage
	Armature time constant too low	Insert a choke in series with the armature
Motor response has large overshoots	High inertia low friction loads	Rotate STAB anticlockwise Reduce ramp rates Current set too high
Motor response has speed-related instability	Loose tacho couplings	Improve tacho coupling
	Misaligned tacho	Re-align the tacho
	Eccentric load	Balance load Rotate STAB clockwise

10 Specifications

10.1 Technical specifications

Function	control action			dual loop proportional + integral				
	feedback method			tachometer/armature voltage switch select				
	0-100% regulation			0.1% typical (tacho); 2% typical (armature voltage)				
	maximum torque speed range			100:1 (tacho); 20:1 (armature voltage)				
	overload			150% continuous current for 30s				
Inputs	Analogue				Pushbutton functions			
	direct input				Forward			
	ramped input				Reverse			
	differential input (ramped)				Stop			
	4-20 mA input				Start			
	0-20 mA input				Jog			
	+/-10 V input							
Outputs	Signal outputs (all buffered)				Relay driver outputs (open collector, PNP)			
	speed output				stall timer tripped			
	current output +				stall timer ticking and tripped			
	current output +/-				zero speed			
	ramp output				shaft reverse			
	demand output							
Power rails	+/-24 V +/-25%			unregulated 25 mA				
	+/-12 V +/-5%			unregulated 10 mA maximum				
	+/-10 V +/-5%			regulated 10 mA maximum				
Supply ranges (45 Hz to 65 Hz auto-ranging)		24	30	48	60	110	240	415
	Max (V)	28	36	58	72	130	264	440
	Min (V)	22	27	44	54	100	200	360
	(Over full temperature range with outputs loaded)							
AC power up reset	minimum off-time before re-supply: 500 ms							
Field output	0.9 x ac supply; 2 A maximum (half-wave configuration 0.45 x ac supply - connect between L and F2-)							
Unit dissipation	Dw (Watts) = 3 x armature current (approximately)							
Environment	Altitude		3000 m maximum for full rating. Derate 1% / 100 m above 3000 m					
	Ambient		40 °C maximum for full rating. Derate 2.5% per °C above 40 °C					
	Humidity		85% RH at 40 °C, non-condensing					

Vibration	0.075 mm displacement 10 – 58 Hz 1g acceleration 58 – 150 Hz			
IP Rating	IP00			
Protection Supply fusing	Rating	Fuse	Fuseholder	Clearing I²t
	4 A	CH00608A	CP102071	35 A ² s
	8 A	CH00620A	CP102071	259 A ² s
	16 A	CH00730A	CP102053	265 A ² s
	32 A	CH00850A	CP102054	770 A ² s
	36 A	CH00850A	CP102054	770 A ² s
	The fuses must be semiconductor types as given above. Failure to use the correct semiconductor fuse ratings will invalidate any warranty. If the controller is connected line-to-line then a fuse is required in each ac line.			
Field fuses F1/F2 (2 A)				
Adjustable parameters	Maximum speed	25 V to 400 V speed feedback; switch selectable		
	Minimum speed	0 to 50% of Max Speed when used with an external with 10k pot		
	Forward ramps	1 to 30 s; linear ramp; independent up and down ramps		
	Reverse ramps	1 to 30 s; linear ramp; independent up and down ramps		
	Stability	Varies speed loop gain		
	IR _{COMP}	0 to 30% of armature voltage for 0 to 100% armature current		
	Max current	0 to 25%, 50%, 75% or 100%; separate max current presets for positive and negative; switch select; 3 operation modes		
Switched functions	S1, S2	Current range		
	S3, S4	Speed feedback range – 4 ranges of feedback voltage		
	S5, S6, S7	Relay function: stall / zero / reverse		
	S8	Speed feedback source: tachometer / armature volts		
Link functions	Speed / torque	Sets T6 operating mode; 3 modes		
	Current loop	Allows 4 – 20 mA or 0 – 20mA loop signal operation instead of ± 10 V		
	50% stall level	Allows peak to continuous ratios of 1.5 to 3		
	Current mode	Configuration of current limit operating mode; 3 modes		
	Quench	Sets mode of drive quench; 3 modes		
	Supply select	Dual supply voltage selector		
Lamps	Positive bridge	Stall timer ticking and tripped Stall timer tripped		
	Negative bridge			
Dimensions	Width 200 mm Depth 175 mm Height 70 mm (90 mm for 36 A unit)			
Fixings	4 / 8 / 16 / 32 A units	M5 x 35 mm bolts		
	36 A unit	M5 x 50 mm bolts		

10.2 Rating table

APPLICATION AREA: Industrial (non-consumer) "Motor speed control utilising DC Motors".

Each drive has the same features and terminals. Select the appropriate model depending on the motor current and the available supply voltage.

DRIVE TYPE 3600Xri	AC SUPPLY DUAL VOLTAGE	NOMINAL OUTPUT VOLTAGE	100% Amps dc output (A _{dc})	ISOLATION	MAXIMUM I ² t FOR FUSING
4/LN	240/110	180/90	4 A	isolated	510 A ² seconds
8/LN	240/110	180/90	8 A	isolated	510 A ² seconds
16/LN	240/110	180/90	16 A	isolated	510 A ² seconds
16/LL	415/240	320/180	16 A	isolated	510 A ² seconds
32/LL	415/240	320/180	32 A	isolated	5000 A ² seconds
36/LL	415/240	320/180	36 A	isolated	5000 A ² seconds

1. Low volt versions are available, operating on 60/30 Vac supplies giving 48/24 Vdc output and 48/24 Vac supplies giving 38/18 Vdc output.
2. Top terminals can be added on request.
3. All types are of open-chassis construction with rear heatsink.
4. Nominal output is based on a maximum Form Factor (ratio of RMS ac supply current to dc output) of 1.5.

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