48V Application Note

Unidrive SP

Universal Variable Speed AC Drive for induction and servo motors

Issue: 1

General Information

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation or adjustment of the optional operating parameters of the equipment or from mismatching the variable speed drive with the motor.

The contents of this document are believed to be correct at the time of printing. In the interests of a commitment to a policy of continuous development and improvement, the manufacturer reserves the right to change the specification of the product or its performance, or the contents of the document, without notice.

Drive software version

This product is supplied with the latest version of software. If this product is to be used in a new or existing system with other drives, there may be some differences between their software and the software in this product. These differences may cause this product to function differently. This may also apply to drives returned from a Control Techniques Service Centre.

If there is any doubt, contact a Control Techniques Drive Centre.

Environmental statement

Control Techniques is committed to minimising the environmental impacts of its manufacturing operations and of its products throughout their life cycle. To this end, we operate an Environmental Management System (EMS) which is certified to the International Standard ISO 14001. Further information on the EMS, our Environmental Policy and other relevant information is available on request, or can be found at www.greendrives.com.

The electronic variable-speed drives manufactured by Control Techniques have the potential to save energy and (through increased machine/process efficiency) reduce raw material consumption and scrap throughout their long working lifetime. In typical applications, these positive environmental effects far outweigh the negative impacts of product manufacture and end-of-life disposal.

Nevertheless, when the products eventually reach the end of their useful life, they can very easily be dismantled into their major component parts for efficient recycling. Many parts snap together and can be separated without the use of tools, while other parts are secured with conventional screws. Virtually all parts of the product are suitable for recycling.

Product packaging is of good quality and can be re-used. Large products are packed in wooden crates, while smaller products come in strong cardboard cartons which themselves have a high recycled fibre content. If not re-used, these containers can be recycled. Polyethylene, used on the protective film and bags for wrapping product, can be recycled in the same way. Control Techniques' packaging strategy favours easily-recyclable materials of low environmental impact, and regular reviews identify opportunities for improvement.

When preparing to recycle or dispose of any product or packaging, please observe local legislation and best practice.

Contents

1 Safety Information

1.1 Warnings, Cautions and Notes

A Warning contains information which is essential for avoiding a safety hazard.

A Caution contains information which is necessary for avoiding a risk of damage to the product or other equipment.

NOTE

A Note contains information which helps to ensure correct operation of the product.

1.2 Electrical safety - general warning

The voltages used in the drive can cause severe electrical shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to the drive.

Specific warnings are given at the relevant places in this document.

1.3 System design and safety of personnel

The drive is intended as a component for professional incorporation into complete equipment or a system. If installed incorrectly, the drive may present a safety hazard.

The drive uses high voltages and currents, carries a high level of stored electrical energy, and is used to control equipment which can cause injury.

Close attention is required to the electrical installation and the system design to avoid hazards either in normal operation or in the event of equipment malfunction. System design, installation, commissioning and maintenance must be carried out by personnel who have the necessary training and experience. They must read this safety information and this document carefully.

The STOP and SECURE DISABLE functions of the drive do not isolate dangerous voltages from the output of the drive or from any external option unit. The supply must be disconnected by an approved electrical isolation device before gaining access to the electrical connections.

With the sole exception of the SECURE DISABLE function, none of the drive functions must be used to ensure safety of personnel, i.e. they must not be used for safety-related functions.

Careful consideration must be given to the functions of the drive which might result in a hazard, either through their intended behaviour or through incorrect operation due to a fault. In any application where a malfunction of the drive or its control system could lead to or allow damage, loss or injury, a risk analysis must be carried out, and where necessary, further measures taken to reduce the risk - for example, an over-speed protection device in case of failure of the speed control, or a fail-safe mechanical brake in case of loss of motor braking.

The SECURE DISABLE function has been approved[1] as meeting the requirements of EN954-1 category 3 for the prevention of unexpected starting of the drive. It may be used in a safety-related application. **The system designer is responsible for ensuring that the complete system is safe and designed correctly according to the relevant safety standards.**

1.4 Environmental limits

Instructions in this document regarding transport, storage, installation and use of the drive must be complied with, including the specified environmental limits. Drives must not be subjected to excessive physical force.

1.5 Compliance with regulations

The installer is responsible for complying with all relevant regulations, such as national wiring regulations, accident prevention regulations and electromagnetic compatibility (EMC) regulations. Particular attention must be given to the cross-sectional areas of conductors, the selection of fuses or other protection, and protective earth (ground) connections.

This document contains instruction for achieving compliance with specific EMC standards.

Within the European Union, all machinery in which this product is used must comply with the following directives:

98/37/EC: Safety of machinery.
89/336/EEC: Electromagnetic Compatibility.

1.6 Motor

Ensure the motor is installed in accordance with the manufacturer's recommendations. Ensure the motor shaft is not exposed.

Standard squirrel cage induction motors are designed for single speed operation. If it is intended to use the capability of the drive to run a motor at speeds above its designed maximum, it is strongly recommended that the manufacturer is consulted first.

Low speeds may cause the motor to overheat because the cooling fan becomes less effective. The motor should be fitted with a protection thermistor. If necessary, an electric forced vent fan should be used.

The values of the motor parameters set in the drive affect the protection of the motor. The default values in the drive should not be relied upon.

It is essential that the correct value is entered in parameter **0.46** motor rated current. This affects the thermal protection of the motor.

1.7 Adjusting parameters

Some parameters have a profound effect on the operation of the drive. They must not be altered without careful consideration of the impact on the controlled system. Measures must be taken to prevent unwanted changes due to error or tampering.

[1]For sizes 2 and 3, independent approval pending.

2 Introduction

The Unidrive SP is normally operated from a 3-phase AC supply (200V, 400V etc.) or a DC supply of the equivalent rectified voltage. This provides power for all control circuits via the SMPS (Switch Mode Power Supply), and power for the motor via the inverter.

An external 24Vdc power supply may be used to power just the control circuits when the high voltage AC supply is not present. This allows for example the encoder position to be maintained or the setting up of parameters.

It is also possible to operate the Unidrive SP from two low voltage DC supplies, 24V to supply the control electronics as above and 48V to supply the power electronics. This low voltage DC supply operation is intended to allow for motor operation in an emergency back-up situation following failure of the AC supply, for example in elevators, or to limit motor speed of servo motors during commissioning of equipment, for example a robot cell.

2.1 48Vdc operation

In low voltage operation two DC supplies must be provided as follows:

24Vdc This supply must be connected to the +24V external input on the green control terminal block.

48Vdc This supply must be connected to:
1) The 48V terminal. This powers up the SMPS, generating the additional voltage rails that the drive requires in order to run the motor.
2) The high current DC bus terminals. This provides the power for the motor.

2.2 Change-over of supplies

It is unlikely that a drive will always be operated in low voltage mode. In general a drive will have a high voltage AC supply for normal operation and just use the low voltage supply in special circumstances. When changing over supplies the following points must be observed:

- Operation from nominal voltage AC and low voltage DC supplies at the same time is not possible.
- Seamless change-over from one supply to another is not possible.
- The inverter must be disabled during change over of supplies.
- There must be a minimum time when the drive is disabled and no high current supply is connected.
- The 24V supply may be permanently connected.

3   Supply requirements

3.1   24V Supply

The requirements of the user 24V input of the drive are as follows:

Maximum continuous operating voltage:	30.0V
Minimum continuous operating voltage:	19.2V
Nominal operating voltage:	24.0V
Minimum start up voltage:	21.6V
Maximum power supply requirement at 24V:	53W

Minimum and maximum voltage values include ripple and noise. Ripple and noise levels must not exceed 5%.

3.2   48V Supply

The requirements of the 48V supply to the drive are as follows:

Maximum short-term surge voltage:	72V
Maximum continuous operating voltage:	60V
Nominal continuous operating voltage:	48V
Minimum continuous operating voltage:	36V
Minimum start up voltage:	40V
Current rating:	2 x drive rated output current (Heavy Duty rating)

Minimum and maximum voltage values include ripple and noise. Ripple and noise levels must not exceed 5%.

One common 48V supply MUST be used to supply the +48V terminal and the +DC (high current) terminal of the drive. Separate supplies CANNOT be used.

NOTE

If the 48V supply is from a battery and the voltage drops below 36V a UV trip will occur. A UV trip automatically resets if the DC bus is back within specification, which means it is possible for the drive cycle in and out of the trip state if the drop in voltage only occurs under load.

I.e. The drive is in the 'rdy' condition and the DC bus is within specification. The drive is given the run command, which enables the output causing current to flow. The DC bus drops and a UV trip is seen, the drive output is thus disabled. The DC bus then rises back the previous level and the UV trip resets. If the run command is still present the drive output is enabled, which causes current to flow etc.

One of the following should be implemented to prevent this loop from occurring :

1. SM applications module not used: A threshold from menu 12 should be used to monitor the DC bus and trip the drive should it drop below normal operating levels with a charged battery.
2. SM applications module used: A software trap should be added to prevent this loop from occurring.

3.3   Grounding arrangement

The 48Vdc supply may be connected to ground or left floating. The instructions below ensure user safety for both cases in the event of a contactor sticking which results in high voltage appearing at the 48V negative terminal at the drive.

3.3.1   Systems with an isolated 48V supply.

The 48V supply can be floating with respect to ground although it may have a high impedance ground to drain leakage currents. In the event of a fault where AC and DC supplies are connected at the same time a high current will then not flow to ground.

In this case:

- The 48V terminals at the drive and battery **must** be protected from user contact.
- The 48V supply must be able to withstand mains potential with respect to ground and be suitable for use in an industrial environment (category 2 supply).
- Cables rated for the voltage of the rectified 3-phase AC supply must be used to connect the drive to the 48V supply.

> ⚠ **WARNING**   In the event of a fault, the 48V terminal of the drive and the 48V supply source (including any wiring in-between) could be at a potentially lethal voltage!

3.3.2   Systems with a grounded 48V supply.

The ground connection for the 48V supply must be a high current connection with an I^2t rating greater than the fuses F2a & F2b.

> ⚠ **WARNING**   If the I^2t of the ground connection is not greater than that of the fuses used, then the 48V terminal and associated wiring could be at a potentially lethal voltage in the event of a fault.

This is so that in the event of a fault where AC and DC supplies are connected at the same time a high current will flow to ground and blow the fuses in the 48Vdc path.

- The wiring from the drive to fuses F2a, F2b & F2c must be protected to a voltage rating equal to or exceeding the rectified 3-phase AC supply voltage.
- The wiring from the fuse to the 48V supply must be rated correctly for the supply.

4   Important considerations

> ⚠️ **WARNING**
>
> Failure to adhere to any of the following may result in damage to equipment or injury to personnel:

- The 3-phase AC and 48Vdc supplies must never be connected at the same time. This will cause a large fault current to flow.

- The DC bus must be forcibly discharged to 48V or less when changing from one supply to another to ensure that the pre-charge circuits operate correctly. If the load motor is a permanent magnet type, steps must be taken to ensure that it is stationary or rotating slowly enough that the emf induced in the windings is less than 25V rms.

- The +48V terminal and +DC bus terminal must always be connected when running from the 48V supply. DC bus voltage feedback is provided via this connection.

- The +48V and +DC bus terminals must have separate supply fuses, each correctly rated for the drive size in question. Both connections must come from the same 48V power supply.

- The drive must be disabled if the softstart bypass contactor is not closed when operating from the 48V supply.when neither supply is connected. This is to prevent damage to the discharge resistor.

- If the system is expected to absorb power from the load through the motor, further considerations must be made to the 48V supply & brake resistor circuit. See Chapter 9 *48V operation speed limitation* on page 17 for further details.

- Software should not be used to interlock the supplies, discharge resistor and drive enable. A software failure could result in hardware damage. Software may however be used for time delays and selection logic.

- The 48V supply arrangement must adhere to one of the methods detailed in Chapter 6 *48V power circuit* on page 6.

- For 48V operation under AC supply loss conditions, all relays and contactors must be driven from a maintained supply.

- All thermal overload devices used must be connected to the supply selection interlocks, removing AC and DC supplies in the event of a device tripping.

5 24V control module supply

The 24V control module supply should be connected as shown in .

Figure 5-1
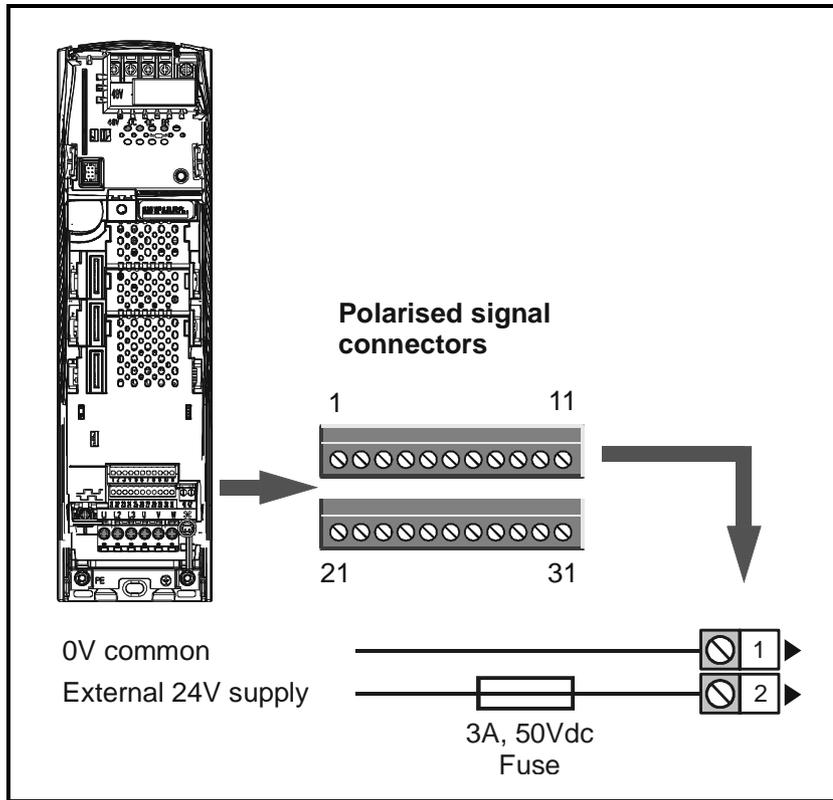
6   48V power circuit

The power circuit arrangement can vary depending on the nature of load on the motor and the source of the 48V supply. There are three power circuit configurations available for the following three system conditions:

• A system where the drive does not absorb any energy from the load (no regen energy).
• A system where the drive can absorb a low level of energy from the load and the energy can be returned to the 48V supply (e.g. in the case of a battery).
• A system where the drive may absorb significant levels of energy from the load, and dissipate it into brake resistors.

The arrangements for all three configurations are provided on the following pages. Component descriptions (including fusing information) are provided in Chapter 8 *Components list* .

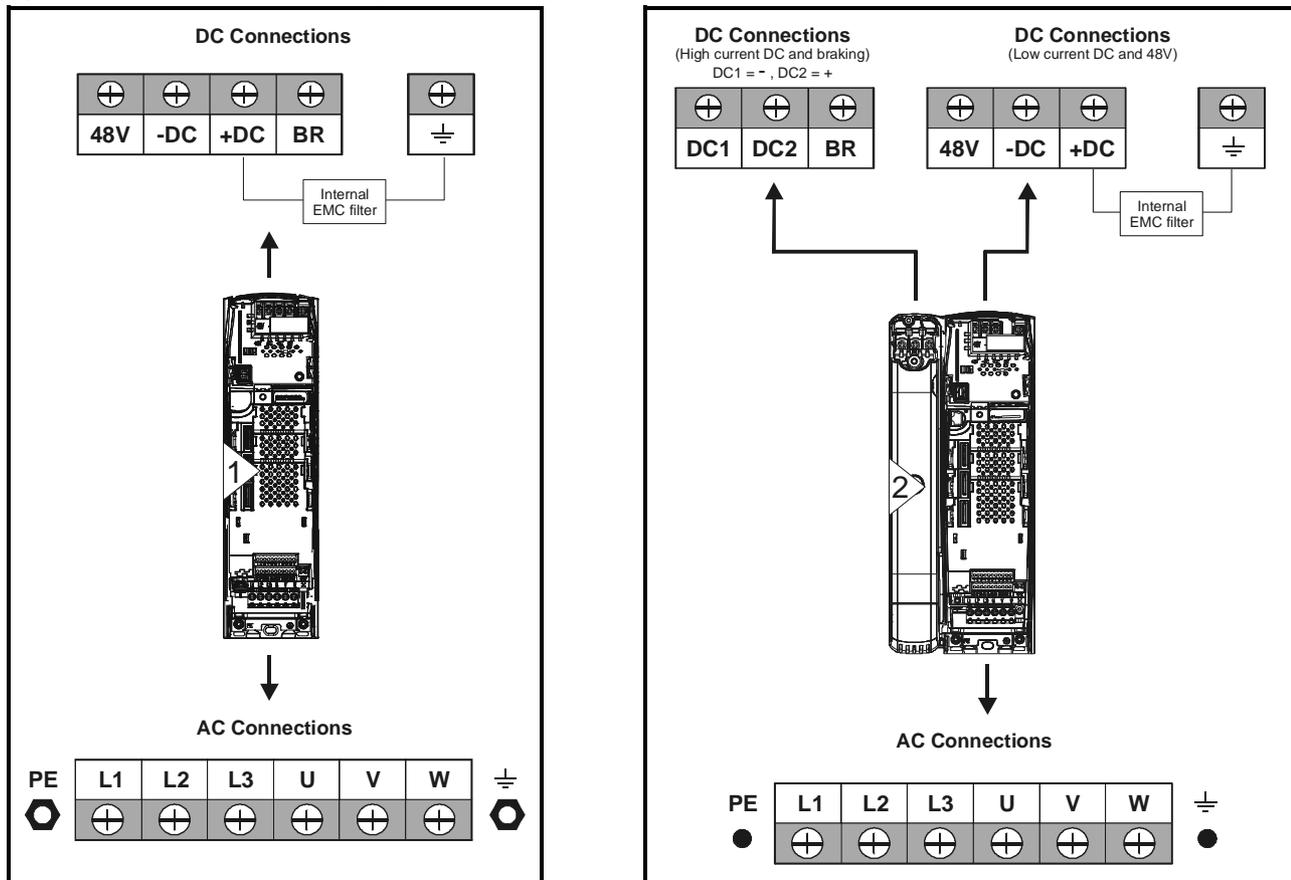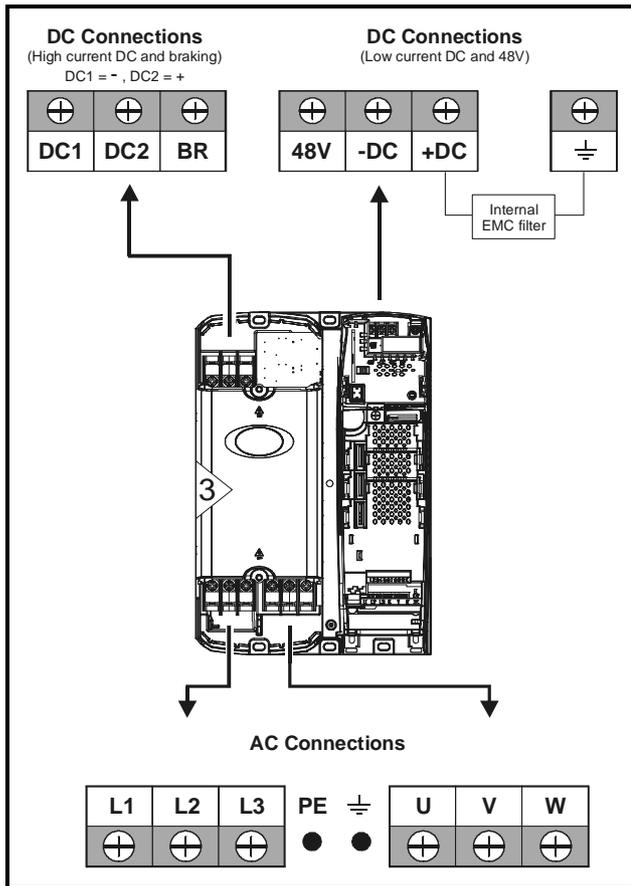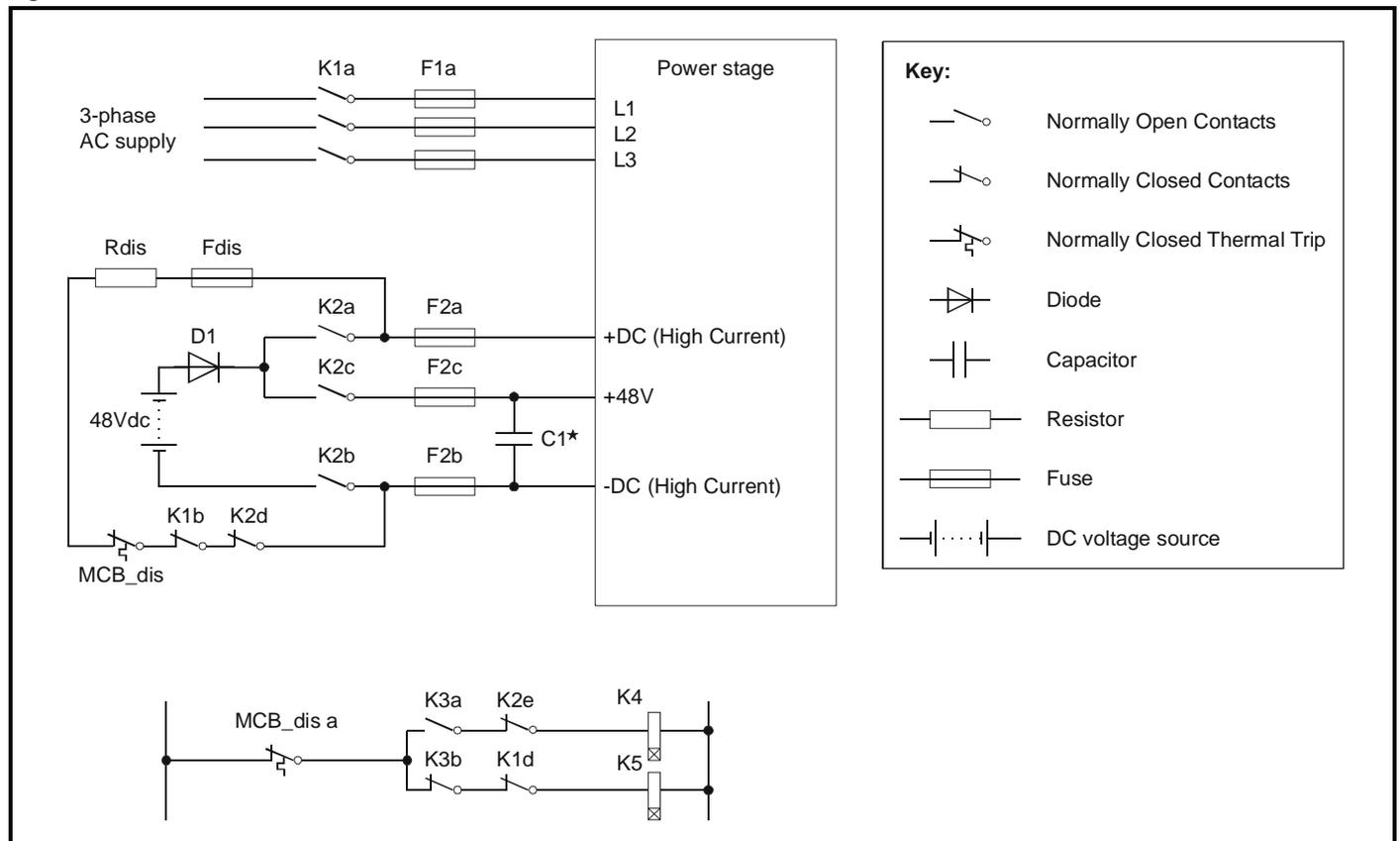**Figure 6-1   Unidrive SP size 1 and 2 power connections**

Figure 6-2   Unidrive SP size 3 power connections

6.1 No regen energy circuit configuration

This configuration is suitable for systems where the 48V power supply cannot absorb any energy from the load through the drive.

Figure 6-3

* C1 is only required with Unidrive SP size 1.

6.1.1 Preventing over-voltage trips from occurring without the use of a brake resistor

If the load is transferring energy back to the drive through the motor, the DC bus voltage will rise. If the 48V supply is unable to absorb this energy, the DC bus voltage will continue to rise until the drive trips out on over-voltage (OU). The drive over-voltage level is 72Vdc.

There are two ways of preventing this from happening:

1. Lower the setting of the regen current limit (Pr **4.06**). This limits how much energy the drive will absorb from the load.

> ⚠️ **WARNING**
>
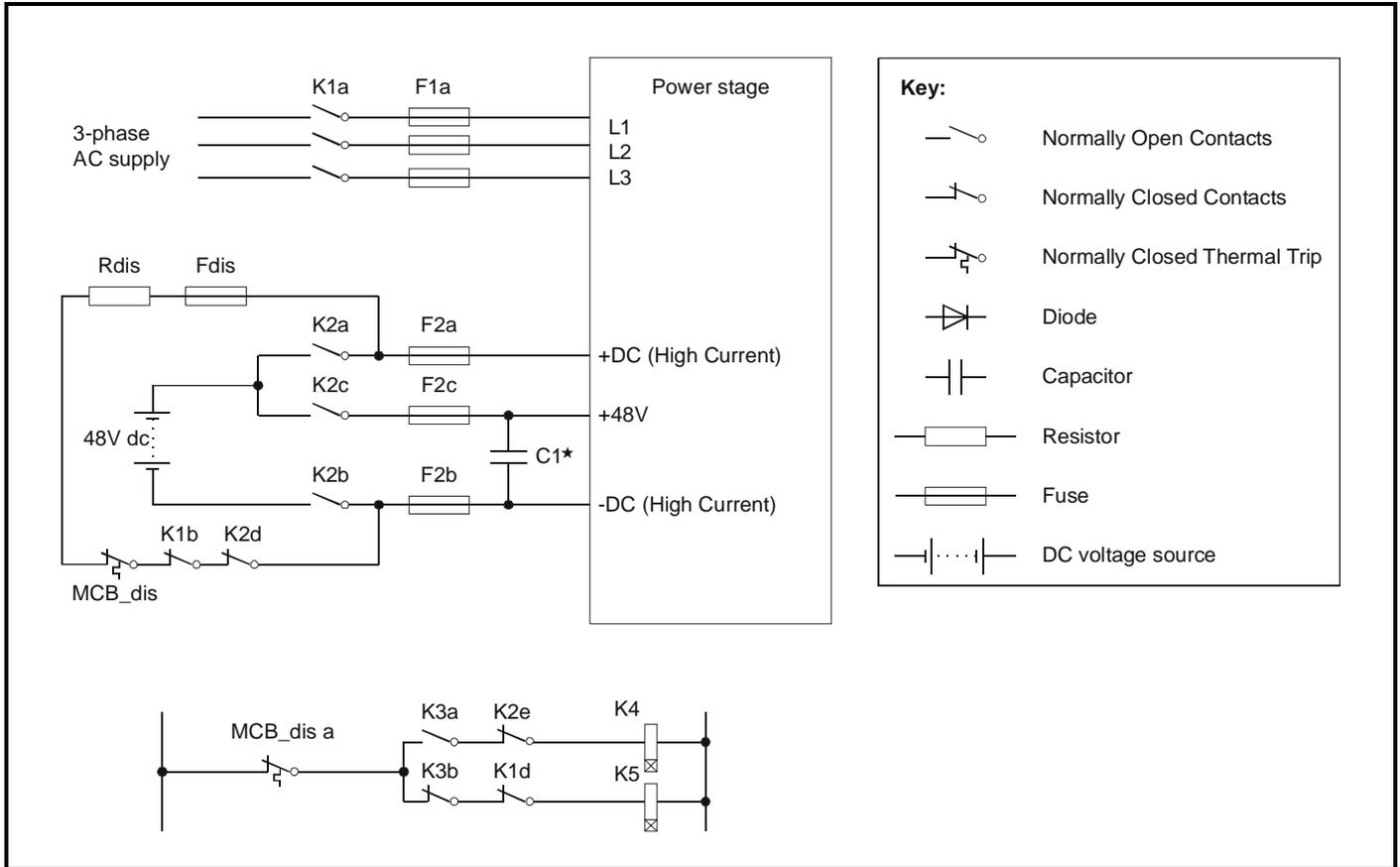> Reducing the regen current limit can result in the drive losing control of the load under overhauling load conditions.

2. Ensure that the drive is operating in one of the *Standard ramp* modes (Pr **2.04**) and lower the setting of the *Standard ramp voltage* (Pr **2.08**) to 65. The changing of the *Standard ramp voltage* can be automated by the use of the variable select function, (menu 12) and the programmable logic function, (menu 9).

6.2   Low level regen energy circuit configuration

This configuration is suitable for systems where the 48V power supply can absorb energy from the load through the drive, such as a battery. If a high level of energy is transferred from the load to the drive, it may be necessary to fit braking resistors. If this is the case, refer to section 6.3.

Figure 6-4

* C1 is only required with Unidrive SP size 1

6.3 Significant regen energy circuit configuration (braking resistor required)

This configuration is suitable for systems where the drive may be expected to absorb energy from the load at drive rated current (including overload current if applicable), and dissipate this energy into a brake resistor. However, further consideration is required when using a brake resistor in 48V mode:

As the DC bus voltage varies the motor power available varies in proportion to the voltage but the power that may be dissipated in a brake resistor varies with the square of the voltage. To enable the maximum brake power to match that from the motor in 48V mode, the brake resistor value must be reduced in proportion to the voltage. The arrangement shown in Figure 6-5 automatically connects the appropriate brake resistor depending on the supply voltage. Note that the brake resistor thermal overload devices are also connected to the supply selection interlocks. If either resistor overheats, then the 48V and AC supplies are both tripped off. See section 8.5 *Minimum brake resistor value* on page 16.

Figure 6-5

* C1 is only required with Unidrive SP size 1

NOTE

The total brake resistance used in 48V mode is the parallel configuration of R_norm and R_48V.

7   48V power circuit control logic and sequencing

Control logic is required to interlock and sequence the contactors set out in Chapter 6 *48V power circuit* to ensure correct operation. This can be accomplished using relays and timers or an SM-Applications option module.

Figure 7-1 shows the basic logic that is required. The logic provides the following functions:

- change-over delay
- prevention of both supplies being connected to the drive at the same time
- the discharge contactor is closed when neither supply is connected
- automatic change over of the supply if the AC supply fails, or change-over by switch selection
- the drive is disabled when neither supply is connected

Figure 7-1   Control logic diagram
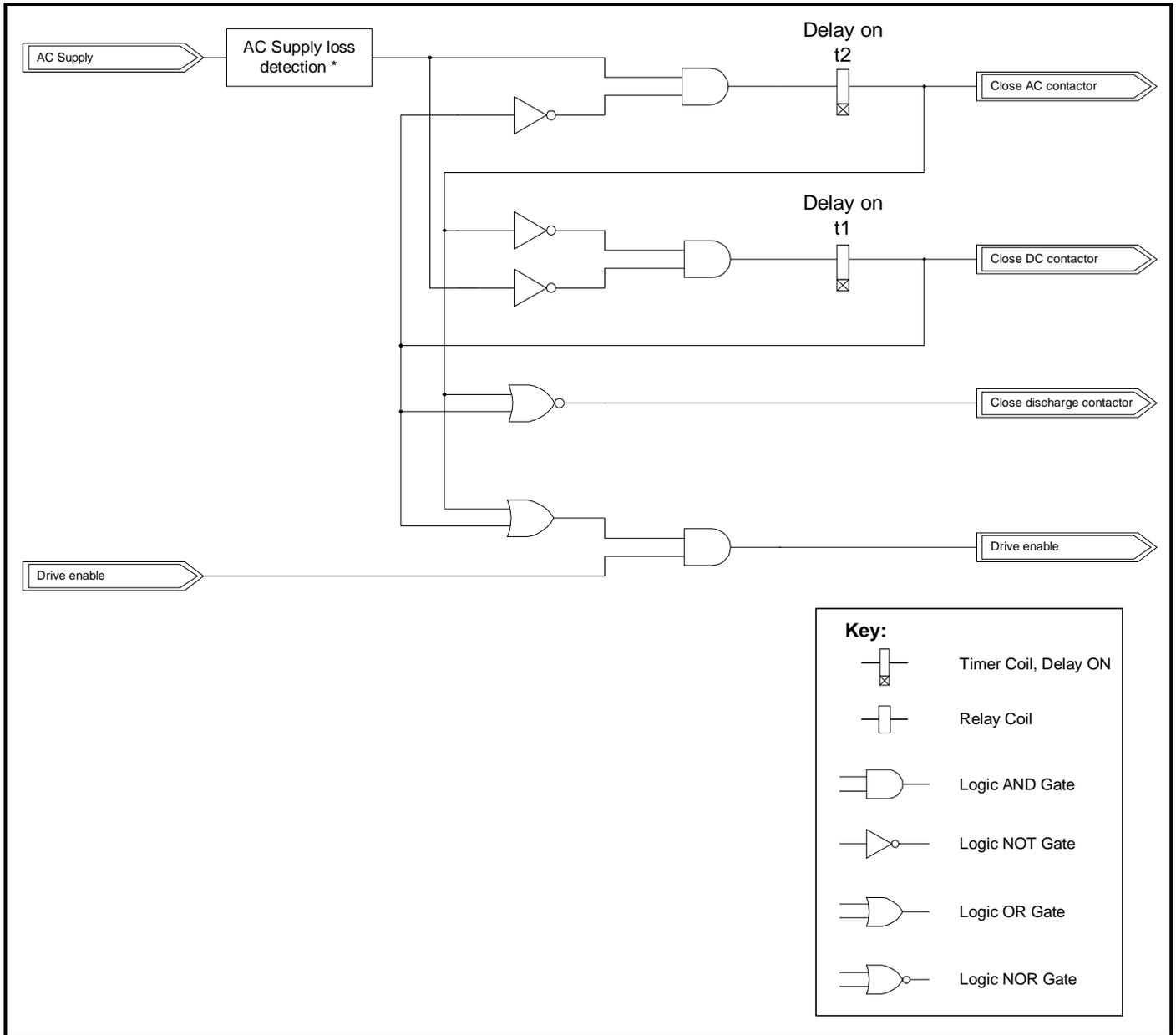
*Supply loss detection signal shown, this could also be the output of a supply selector switch (48Vdc or nominal AC supply).

Figure 7-2 shows the sequencing of the signals which must be accomplished with this logic.

Figure 7-2 Control logic and sequencing
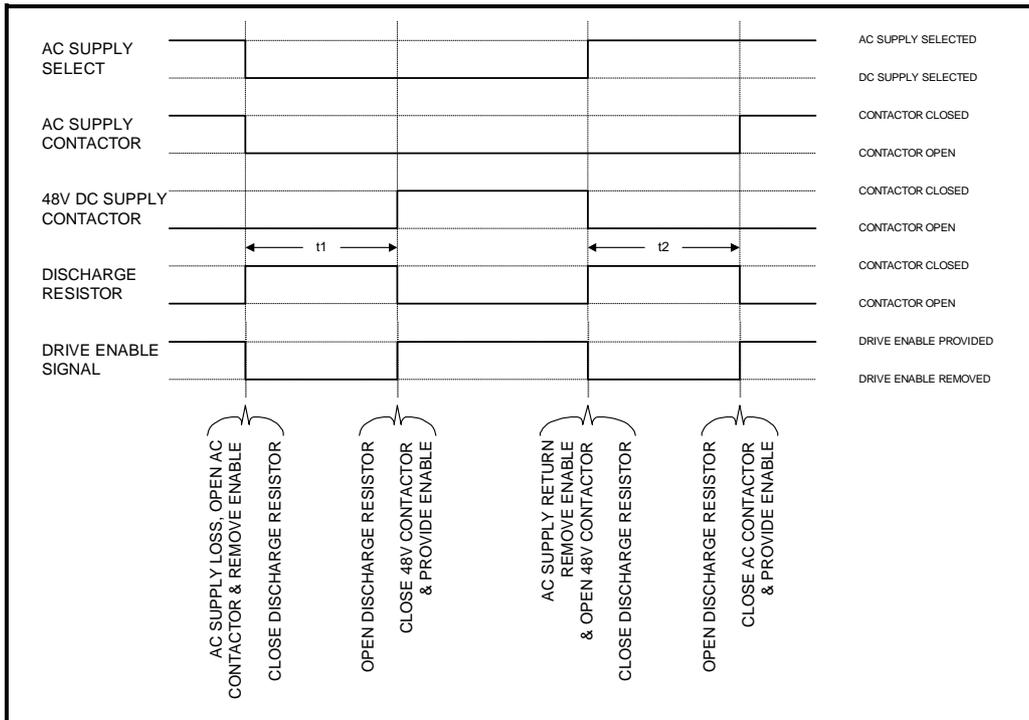
7.1   Control implementation using relays

The required control functions can be implemented using relays as shown in Figure 7-3.

Figure 7-3   Control relays for all frame sizes
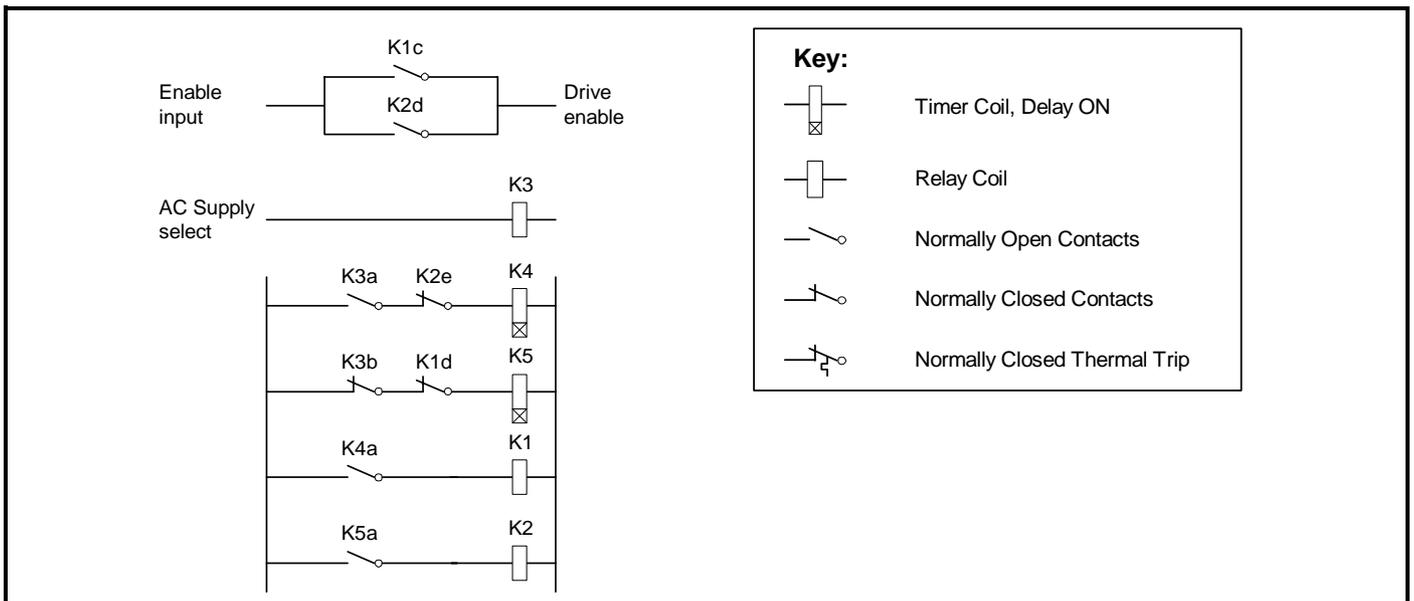
## 7.2 Control implementation using the SM-Applications option

Using a second processor simplifies some of the external circuits that are required as some of the logic and timing can be implemented in software, for example as DPL code. To use this option for automatic change-over of supplies under mains loss conditions, the control circuits must be fed from a maintained supply so that when AC power fails the control circuits stay live.

This circuit below uses the control board and second processor to control the power contactors K1 & K2. Nominal AC/48Vdc supply selection relay K3 (not shown) provides a supply status signal to the processor. The software then provides time delays and some interlocks. Note that hardware interlocks are used for supply switching and drive enable. Software should not be used for the interlocks as a software fault could result in hardware damage.

Figure 7-4   Control relays with SM-Applications option module
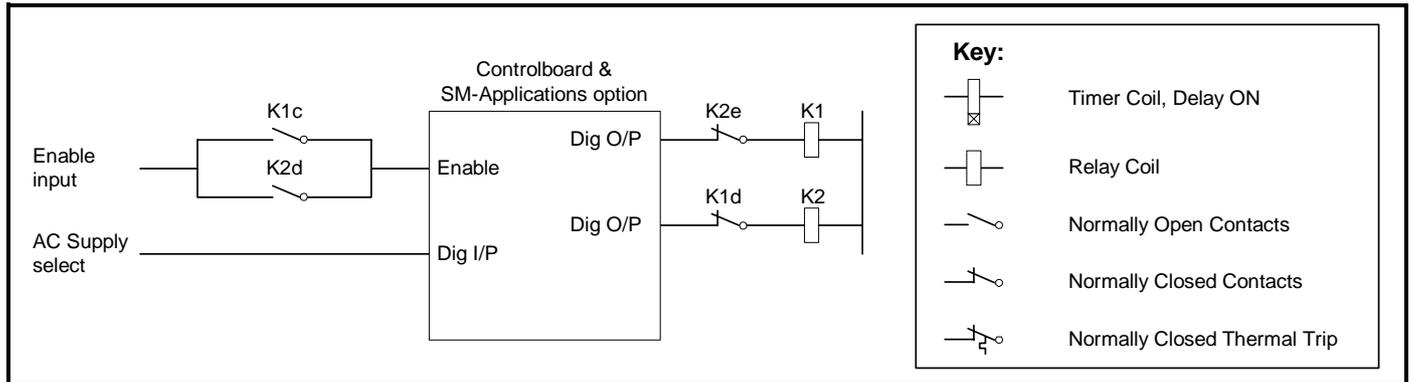
Figure 7-5   Sequencing for the SM-Applications option module
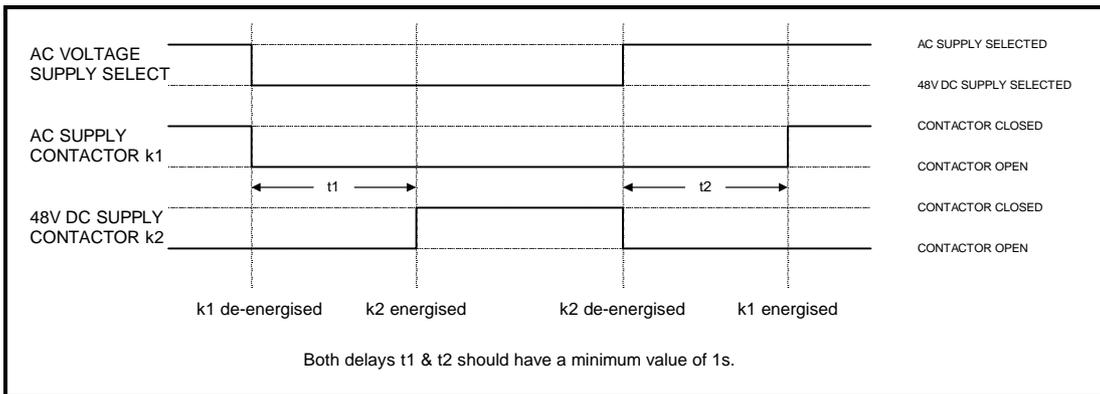
The SM-Applications program should be based on the above sequencing, controlling two of the drive's digital outputs depending on the state of the AC supply select digital input.

8 Components list

8.1 Fusing information

European fuse specifications

Table 8-1 Recommended fuse voltage rating

Fuse	Fuse voltage rating
F1a	The fuse voltage rating must be suitable for the drive supply voltage and of type: gG HRC industrial fuses to IEC60269 (BS88)
F2a, F2b, F2c, Fdis	The fuse voltage rating must be suitable for the rectified drive AC supply voltage, e.g. ≥400Vdc for a SPx20x and ≥750Vdc for a SPx40x

Table 8-2 Recommended fuse current rating

Fuse	F1a (A)	F2a & F2b (A)	F2c (A)	Fdis (A)	MCB_dis
SP1201	10	10	1	2	4133-0117
SP1202	12	15			
SP1203	20	15			
SP1204	20	25			
SP2201	20	30			
SP2202	25	35			
SP2203	32	50			
SP3201	50	70		6	4133-0217
SP3202	63	90			
SP1401	6	5		4	4133-0117
SP1402	6	6			
SP1403	2	10			
SP1404	12	15			
SP1405	12	20			
SP1406	16	20			
SP2401	20	30			
SP2402	25	35			
SP2403	32	50			
SP3401	40	70		12	4133-0217
SP3402	50	80			
SP3403	63	100			

USA fuse specifications

Table 8-3 Recommended fuse voltage rating

Fuse	Fuse voltage rating
F1a	The fuse voltage rating must be suitable for the drive supply voltage and of type: Class CC fuses up to 30A, Class J above 30A
F2a, F2b, F2c, Fdis	The fuse voltage rating must be suitable for the rectified drive AC supply voltage, e.g. ≥400Vdc for a SPx20x and ≥750Vdc for a SPx40x

Table 8-4 Recommended fuse current rating

Fuse	F1a (A)	F2a & F2b (A)	F2c (A)	Fdis (A)	MCB_dis
SP1201	10	10			
SP1202	15	15			
SP1203	20	15			
SP1204	20	25		2	4133-0117
SP2201	20	30			
SP2202	25	35			
SP2203	30	50			
SP3201	45	70		6	4133-0217
SP3202	60	90			
SP1401	6	5	1		
SP1402	6	6			
SP1403	10	10			
SP1404	15	15			
SP1405	15	20			
SP1406	15	20		4	4133-0117
SP2401	20	30			
SP2402	25	35			
SP2403	30	50			
SP3401	40	70			
SP3402	45	80		12	4133-0217
SP3403	60	100			

8.2   Discharge resistor and protection

The discharge resistor is required to discharge the DC bus of the drive whilst changing from one supply to the other.

Drive	Rdis	MCB_dis
SP1201 to SP1204	150Ω (1270-3157)	4133-0117
SP2201 to SP2203		
SP3201 to SP3202	48 Ω (1270-2483)	4133-0217
SP1401 to SP1406	150Ω (1270-3157)	4133-0117
SP2401 to SP2403		
SP3401 to SP3402	48 Ω (1270-2483)	4133-0217

8.3   Blocking diode (D1)

The blocking diode D1, is used to prevent energy from being returned into the 48Vdc supply.

Diode type	Maximum working current (A)	Voltage rating (V)
Standard recovery	3 x drive output current rating	1,200

A suitable supplier for the above diode can be Semikron™ with the SNKxx12 stud diode. The diode must be mounted on a suitable heatsink. See manufacturer data for heatsink requirements of the device.

8.4 48V supply capacitor (C1)

Suitable capacitor type	Capacitor value (nF)	Voltage rating (V)
Metalised polyester	100	≥250

NOTE

This capacitor is only required with the Unidrive SP size 1. The capacitor should be connected directly to the drive terminals.

8.5 Minimum brake resistor value

As the DC bus voltage varies the motor power available varies in proportion to the voltage but the power that may be dissipated in a brake resistor varies with the square of the voltage. To enable the maximum brake power to match that from the motor in 48V mode, the brake resistor value must be reduced in proportion to the voltage. Please see below the minimum resistance values for operation with nominal AC supply and 48Vdc supply:

Model	Normal operation Minimum resistance R_norm	48V operation minimum resistance R_48V	Normal operation: 48V operation resistance ratio
SP1201 – SP1203	40 Ω	7 Ω	
SP1204	27 Ω	4.5 Ω	6:1
SP2201 – SP2203	15 Ω	2.5 Ω	
SP1401 – SP1404	75 Ω	13 Ω	
SP1405	53 Ω	9 Ω	12:1
SP2401 – SP2403	30 Ω	2.5 Ω	

NOTE

The total brake resistance used in 48V mode is the parallel configuration of R_norm and R_48V.

8.6 Contactor / Relay description

Contactor		Description
K1		Main AC supply contactor
	a	Normally open (NO) contacts supplying the drive with 3-phase AC when energised
	b	Normally closed (NC) contacts that bring in the discharge resistor when the AC supply is removed
	c	Normally open (NO) contacts providing the drive enable input
	d	Normally closed (NC) contacts for the DC supply interlock
K2		Main 48V DC supply contactor
	a	Normally open (NO) contacts supplying the drive with 48Vdc when energised
	b	Normally open (NO) contacts supplying the drive with 0V (48V supply) when energised
	c	Normally open (NO) contacts supplying the drive with 48Vdc to the SMPS when energised
	d	Normally closed (NC) contacts that bring in the discharge resistor when the DC supply is removed
	e	Normally closed (NC) contacts for the AC supply interlock
	f	Normally open (NO) contacts for the reduced resistance braking contactor
K3		AC/DC supply selection relay
	a	Normally open (NO) contacts providing the AC supply enable signal to K1
	2	Normally open (NO) contacts providing the DC supply enable signal to K2
K4		Timer delay on relay for AC supply (Minimum delay = 1s)
	a	Normally open (NO) contacts providing the AC supply enable signal to K1
K5		Timer delay on relay for DC supply (Minimum delay = 1s)
	a	Normally open (NO) contacts providing the DC supply enable signal to K2
MCB_dis		Thermal overload protection for discharge resistor
	a	Normally closed (NC) contacts which remove the supply should a resistor overload occur
MCB_norm		Thermal overload protection for high voltage braking resistor
	a	Normally closed (NC) contacts which remove the supply should a resistor overload occur
MCB_48V		Thermal overload protection for 48V braking resistor
	a	Normally closed (NC) contacts which remove the supply should a resistor overload occur

9 48V operation speed limitation

Whilst operating with the 48Vdc supply, the drive can provide rated torque to the motors at low speeds. The maximum speed that can be achieved whilst operating from this supply is dependant on the motor connected to the drive as described below.

9.1 Operation with an induction motor

The drive will effectively start to field weaken at the point that the output voltage requirement (based on the programmed V/F) reaches the maximum that the DC bus voltage of the drive can support (about 34V based on a DC bus of 48V). e.g. The drive would begin to field weaken the motor at around 4Hz for a 50Hz 400V motor.

The drive may continue to rotate the motor up to base speed. However, even with no external load (just a bare motor shaft) the motor could stall due to the reduced torque available whilst so far into field weakening.

> ⚠️ **WARNING**
> 48V operation CANNOT be used to limit the speed of an induction motor.

> ⚠️ **WARNING**
> The drive can only provide rated torque at low speeds as described above. It is very important to consider this when operating with an overhauling load such as lift applications, where even with correct braking resistor selection, the drive may not be able to maintain control of the load if the drive goes into field weakening.

9.2 Operation with a servo motor

The speed of the motor is limited based on the **ke** of the motor. e.g. with a 3,000rpm Unimotor (with a **ke** of 98.0V/krpm), a 48V DC bus would allow a motor speed of up to around 347rpm.

> ⚠️ **WARNING**
> The Unidrive SP in 48V operation may NOT be able to limit the speed of a servo motor with an overhauling load.

> ⚠️ **WARNING**
> If a permanent magnet motor is made to rotate at a high enough speed by an external torque, the DC bus of the drive and its associated wiring could rise above 48V.