



User Guide

Low voltage DC operation in Elevator Applications

Unidrive M700

Frame sizes 3 to 10

Issue: 1

Original Instructions

For the purposes of compliance with the EU Machinery Directive 2006/42/EC

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 User Guide 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 User Guide, without notice.

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This User Guide provides information for installing and operating the drive in Low voltage DC mode. The information is in logical order for designing, configuration set up and operation. Chapter 1 *Safety information* contains general safety information it is essential that the warnings are observed and the information considered when designing and working with a system.

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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 User Guide.

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 voltage and current and carries a high level of stored electrical energy 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 User Guide carefully.

The STOP and Safe Torque Off (STO) function on the drive provides a highly secure method for preventing the motor from being driven when the Safe Torque Off (STO), Drive enable signal is absent. The Safe Torque Off (STO) input does not offer electrical safety. Before any work is performed on the installation the AC supply and Low voltage DC supply have to be isolated by an approved electrical isolation device for at least 10 minutes to allow the drives internal capacitors to fully discharge.

With the sole exception of the Safe Torque Off (STO) 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 Safe Torque Off (STO) function 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 Access

Drive access must be restricted to authorized personnel only. Safety regulations which apply at the place of use must be complied with.

1.5 Compliance with regulations

The installer is responsible for complying with all relevant regulations, such as national wiring regulations, accidental 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 ground (PE) connections.

The Elevator drive User Guide 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:

- 2006/42/EC: Safety of machinery.
- 2014/30/EU: Electromagnetic Compatibility (EMC) Directive

1.6 Motor

Low speed operation may cause the motor to overheat where 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.

Synchronous, permanent magnet servo motors can alone generate electrical power if they are rotated this can result in the drive becoming energised through the motor terminal connections even when the supply to the drive is disconnected.

The motor must be isolated from the drive before gaining access to any potential live parts.

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 of the controlled system. Measures must be taken to prevent unwanted changes due to error or tampering.

1.8 Electrical installation

1.8.1 Electrical shock risk

The voltages present in the following locations can cause severe electric shock which may be lethal;

- AC supply cables and connections
- DC supply cables and connections
- Braking resistor cables and connections
- Output motor cables and connections
- Many internal parts of the drive, and external options

Before any work is performed on the installation the AC supply and Low voltage DC supply have to be isolated by an approved electrical isolation device for at least 10 minutes to avoid the risk of severe electric shock which may be lethal.

Unless otherwise indicated, control terminals are single insulated and must not be touched.

1.8.2 Stored charge

The drive contains capacitors that remain charged to a potentially lethal voltage after the AC supply, or Low voltage DC supply has been disconnected. If the drive has been energised, the supply must be isolated for at least ten minutes before work may continue.

2 Introduction

Before reading this document it is assumed that the user is familiar with the drives documentation. This User Guide details configuration and operation of the drive with a Low voltage DC supply in an Elevator system.

2.1 Modes of operation

There are three basic configurations of operation supported on the drive for either the AC supply or the Low voltage DC supply as detailed following.

1: AC supply

Standard operation with the AC supply + optional external user 24 Vdc for Control PCB backup and supplementing the drives internal 24 Vdc supply

2: Low voltage DC through selection of Low under voltage threshold

Backup operation with a Low voltage DC supply selecting the Low under voltage threshold, or as required in some low power applications, continuous operation from a Low voltage DC supply. Control over the transition between the AC supply and Low voltage DC supply must be managed externally within the system for correct and safe operation. An external user 24 Vdc is required for operation.

3: Low voltage DC using on-board control the to manage seem-less control

Backup operation with a Low voltage DC supply, using the additional control on-board the drive which can manage the external contactor control for correct seem-less transition from the AC supply to Low voltage DC supply (the drive must be disabled to transition from Low voltage DC mode to AC mode for drive frame sizes 3 to 6, this allows the internal soft start circuit to manage the inrush). An external user 24 Vdc is required for operation.

NOTE:

It is important to consider pre charging of the drive when applying either the AC or the Low voltage DC power supplies, and during transitioning between power supplies.

Operating modes

Mode	Pr 06.072 User Supply Select (external user 24 Vdc supply)	Pr 06.068 Low Voltage DC Mode Enable	Pr 06.067 Low Under Voltage Threshold Select	Operation
AC supply mode	On (1)	Off (0)	Off (0)	AC supply mode, uses standard under voltage threshold, optional external user 24 Vdc supply for backup of Control PCB and, or supplement drives internal 24 Vdc supply
Low voltage DC mode	Off (0)	Off (0)	On (1)	Operation with Low voltage DC mode selecting Low under voltage threshold, external user 24 Vdc supply required for Control PCB (frame 3 and larger), Power Stage (frame 6 and larger), heatsink fans (frame 9 and larger)
AC supply mode transition to Low voltage DC supply mode with external contactor control	Off (0)	On (1)	Off (0)	AC supply mode with standard under voltage threshold and seem-less transition to Low voltage DC mode with Low under voltage threshold (drive must be disabled to transition from Low voltage DC mode to AC mode for frame sizes 3 to 6), external user 24 Vdc supply required for Control PCB (frame 3 and larger), Power Stage (frame 6 and larger), heatsink fans (frame 9 and larger)

2.2 Power supplies

For Low voltage DC operation an external DC supply is required which could be in the form of a UPS or external batteries. The length of time that the drives and system will be able to operate and run the motor will be dependent upon the Elevator system supply requirements along with the battery capacity.

- For Low voltage DC operation drive frame sizes 3 and larger require an external user 24 Vdc supply connected to the Control PCB to power the drive control stage.
- For drive frame sizes 6 and larger the external user 24 Vdc supply is required for the Power Stage dependent upon the final DC Bus voltage level. If the DC Bus is below the AC supply loss level (*refer to section 5.3*) this is required.
- For drive frame sizes 9 and larger the external user 24 Vdc supply is also required for the heatsink cooling fans dependent upon the final DC Bus voltage level. If the DC Bus is below the AC supply loss level (*refer to section 5.3*) this is required.

Vac supply ratings

Drive model	AC supply voltage range
200 Vac	200 to 240 \pm 10 %
400 Vac	380 to 480 \pm 10 %
575 Vac	500 to 575 \pm 10 %
690 Vac	500 to 690 \pm 10 %

For standard AC operation the supply must be within the allowable operating range specified for the given drive model as detailed in the *Drive User Guide*. It is possible that for 200 V products installed in low power systems that these could be supplied from either a three phase or single phase supply.

DC supply range

DC supply voltage operating range (Vdc)			
Drive model	Min	Max	Over voltage
200 Vac	24	339	415
400 Vac	24	679	830
575 Vac	24	813	990
690 Vac	24	976	1190

The allowable DC voltage for Low voltage DC operation is as detailed above. Where the Low voltage DC supply is in the form of a battery / UPS the length of time that the drive and system will be able to operate and run the motor will be dependent upon the Elevator system supply requirements along with the battery capacity.

External user 24 Vdc supply specification

External user 24 Vdc supply requirements		
Nominal operating		24.0 Vdc
Minimum operating	(Frame 6) (Frame 3 to 5 & 7 to 10)	18.6 Vdc 19.2 Vdc
Maximum operating	(Frame 3 to 6) (Frame 7 to 10)	28.0 Vdc 30.0 Vdc (IEC), 26.0 Vdc (UL)
Minimum start-up voltage	(Frame 6) (Frame 3 to 5 & 7 to 10)	18.4 Vdc 21.6 Vdc
Maximum power	(Frame 3 to 6) (Frame 7 to 10)	40 W 60 W
Recommended fuse	(Frame 3 to 5) (Frame 6 to 10)	3A, 50 Vdc 4A, 50 Vdc

For drive frame sizes 3 and larger an external user 24 Vdc supply is required to power the drive Control PCB of the drive during Low voltage DC operation. The 24 Vdc supply will maintain power on the Control PCB when the AC supply is no longer present during operation in Low voltage DC mode, or, also whilst the system is in energy saving, sleep mode.

The external user 24 Vdc supply is also required for drive frame sizes 6 and larger for the Power Stage dependent upon the final DC Bus voltage level. If the DC Bus is below the AC supply loss level this is required.

For drive frame sizes 9 and larger the external user 24 Vdc supply is also required for the heatsink cooling fans dependent upon the final DC Bus voltage level. If the DC Bus is below than the AC supply loss level this is required.

Power Stage external user 24 Vdc supply, drive frame sizes 6 and larger, Low voltage DC mode

External user 24 Vdc supply		
Drive model	DC Bus (Vdc)	
200 Vac	Vdc < 205	Connect external user 24 Vdc supply to Power Stage
400 Vac	Vdc < 410	
575 Vac	Vdc < 540	
690 Vac	Vdc < 540	

2.3 External components

The drive in Low voltage DC mode uses external contactors for selection of the power supply, these power supplies being the AC supply, Low voltage DC supply, UPS supply and External user 24 Vdc supply.

The external contactors are also required to support the drives seem-less external contactor control for safe operation from the AC supply to the Low voltage DC supply, refer to System 3 and System 4 in section 6.5 for further details and Pr **06.068**, Pr **06.069** and Pr **06.070**. During operation in Low voltage DC mode contactor feedback is required to support the transition between the AC supply and the Low voltage DC supply by the drive. Alternatively the transition between the AC supply and the Low voltage DC supply can be managed by the Elevator controller.

NOTE:

It is important to consider pre charging of the drive when applying either the AC or the Low voltage DC power supplies, and during transitioning between power supplies.

2.3.1 Drive frame sizes 3 to 6

The external contactor control on the drive is setup to control the AC supply contactor for operation with frame sizes 3 to 6, managing the transition from the AC supply to the Low voltage DC supply. The inrush from the AC supply and the Low voltage DC supply is managed on the power stage of the drive with an internal inrush circuit.

During the transition from the Low voltage DC supply back to the AC supply the drives internal soft start circuit relay must be in circuit (*drive in Under Voltage state*) drive disabled, to manage the inrush current for when the AC supply is reapplied.

For operation with a UPS the external contactor control is managed by the Elevator controller to connect and disconnect both the AC supply and the UPS supply with both of these being synchronized. The inrush from the AC supply and the UPS supply are managed on the drive with an internal inrush circuit.

2.3.2 Drive frame sizes 7 and larger

The external contactor control on the drive is setup to control a DC supply contactor for operation with drive frame sizes 7 and larger, managing the transition from the AC supply to the Low voltage DC supply. The inrush from the AC supply is managed through the drives half controlled rectifier, the inrush from a Low voltage DC supply connected directly to the drives DC Bus must be managed with an external soft start circuit.

During the transition from the Low voltage DC supply back to the AC supply the drives half controlled rectifier will manage the inrush current when the AC supply is reapplied. The external soft start circuit is required to manage the inrush current for when the Low voltage DC supply is applied.

For operation with a UPS the external contactors are managed by the Elevator controller to connect and disconnect both the AC supply and UPS supply, both of these being synchronized. The AC supply and UPS supply inrush current is managed through the drives half controlled rectifier.

2.3.3 Contactor control

The contactor control for the transition from the AC supply to Low voltage DC supply can be managed locally by the drive when operating in Low voltage DC mode using the on-board control to manage seem-less control Pr **06.068** - *Low Voltage DC Mode Enable* = On (1).

Alternatively when operating in Low voltage DC mode the transition from the AC supply to the Low voltage DC supply can be managed externally by the Elevator controller. In the instance the Elevator controller is managing the transition using Pr **06.067** - *Low Under Voltage Threshold* = On (1). The transition from the AC supply to Low voltage DC supply must consider, and manage the inrush current when connecting power supplies, for drive frame sizes 7 and larger using an external soft start circuit. Pr **06.067** - *Low Under Voltage Threshold* can also be managed by the Elevator controller selecting based upon the active power supply.

NOTE:

It is important to consider pre charging of the drive when applying either the AC or the Low voltage DC power supply, and during transitioning between power supplies.

2.4 Low voltage DC operation

Low voltage DC operation is available on all drives, and can typically be used to support the following modes of operation in Elevator systems.

2.4.1 Low voltage DC mode for Rescue operation

Low voltage DC mode is used to provide rescue operation for the Elevator system where the AC supply is no longer available. This operation requires the Low voltage DC supply or UPS to deliver power to the drive, Elevator controller and motor along with motor contactors, brakes, auxiliary components, which could include door controller and car lighting etc. The Low voltage DC supply for rescue operation is rated to supply the complete Elevator system, and deliver the required operating power to the motor. The Low voltage DC supply could come from either

- a) DC battery supply system connected directly to the drives DC Bus
- b) UPS system connected via the drives AC rectifier input stage

Low voltage DC supply

- Pre charging of the drive when first applying the AC supply for drive frame sizes 3 to 6 will be using the drives internal soft start circuit.
 - Transitioning from the AC supply to the Low voltage DC supply where the DC Bus is already charged does not require any soft start to be active
 - During a transitioning from the Low voltage DC supply to the AC supply the drive must be in the *Under Voltage state* where the soft start circuit is active to limit the AC inrush current.
 - Connecting the Low voltage DC supply where the DC Bus is discharged will use the drives internal soft start circuit.
- Pre charging of the drive when first applying the AC supply for drive frame sizes 7 and larger will be using the drives half controlled rectifier.
 - Transitioning from the AC supply to the Low voltage DC supply where the DC Bus is already charged does not require any pre-charging
 - During a transitioning from the Low voltage DC supply to the AC supply the drives half controlled rectifier will limit the AC inrush current.
 - Pre charging for the Low voltage DC supply where the DC Bus is discharged requires an external soft start circuit.

UPS supply

- Pre charging of the drive when first applying the AC supply for drive frame sizes 3 to 6 will be using the drives internal soft start circuit.
 - Transitioning from the AC supply to the UPS supply where the DC Bus is already charged does not require any soft start to be active

- During a transitioning from the UPS supply to the AC supply the drive must be in the *Under Voltage state* where the soft start circuit is active to limit the AC inrush current.
- Connecting the UPS supply where the DC Bus is discharged will use the drives internal soft start circuit.
- Pre charging of the drive when first applying the AC supply for drive frame sizes 7 and larger will be using the drives half controlled rectifier.
 - Transitioning from the AC supply to the UPS supply where the DC Bus is already charged does not require any pre-charging
 - During a transitioning from the UPS supply to the AC supply the drives half controlled rectifier will limit the AC inrush current.
 - Pre charging for the UPS supply where the DC Bus is discharged will use the drives half controlled rectifier.

2.4.2 Low voltage DC mode continuous operation

Low voltage DC mode is used for normal operation of the Elevator system. The Low voltage DC supply delivers full power to the drive, Elevator controller and Motor along with motor contactors, brakes, auxiliary components which could include door controller and car lighting etc. The Low voltage DC supply for continuous operation is rated to supply the complete system, and deliver full power to the motor. The Low voltage DC supply could come from either

- c) DC battery supply system connected directly to the drives DC Bus
- d) UPS system connected via the drives AC rectifier input stage

Low voltage DC supply

- Pre charging of the drive when first applying the Low voltage DC supply for drive frame sizes 3 to 6 will be using the drives internal soft start circuit.
- The drives internal soft start circuit is active when the drive is in the *Under Voltage state*
- Pre charging of the drive when first applying the Low voltage DC supply for drive frame sizes 7 and larger requires an external soft start circuit.
- The external soft start circuit should be designed around the external Low voltage DC supply

UPS supply

- Pre charging of the drive when first applying the UPS supply for drive frame sizes 3 to 6 will be using the drives internal soft start circuit.
- The drives internal soft start circuit for the UPS supply is active once the drive is in the *Under Voltage state*
- Pre charging of the drive when first applying the UPS supply for drive frame sizes 7 and larger will be using the drives half controlled rectifier.
- The drives half controlled rectifier is active once the UPS supply is applied.

NOTE:

During operation in Low voltage DC mode where the Low under voltage threshold is selected there is no power down parameter save carried out, any parameter save must be carried out prior to power down parameter **mm.xxx** = 1001

NOTE:

If the external 24Vdc is permanently connected to the drive and powering the control stage there will be no power down save carried out, any parameter save must be carried out prior to power down parameter **mm.xxx** = 1001

3 Low Voltage DC Operation

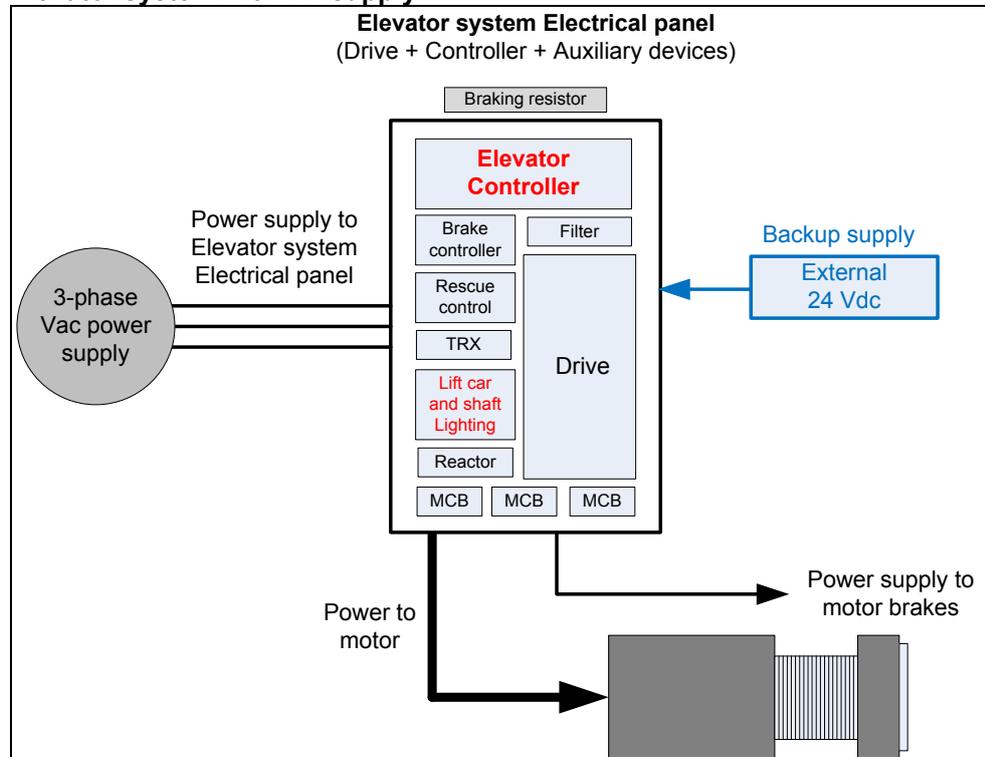
Following is an example of a drive system electrical panel with an AC supply for normal operation. The AC supply in this system could be for example a 200 V, or 400 V supply and is used to supply all components within the electrical panel including the drive and Elevator controller, Motor contactors and brake along with Elevator car and associated controls such as door controller, lighting etc... In some lower power Elevator systems the AC supply could be a single phase AC supply for systems such as Home Elevators.

In the following example the external user 24 Vdc supply is connected to the drive to provide back up for the Control PCB and to supplement the drives internal 24 Vdc supply.

Pr 06.072 - User Supply Select (external user 24 Vdc supply)	On (1)
Pr 06.068 - Low Voltage DC Supply Mode Enable	Off (0)
Pr 06.067 - Low Under Voltage Threshold Select	Off (0)

For operation with the AC supply the minimum *Standard Under Voltage Threshold* (Pr **06.065**) is 175 Vdc (200 V drive) 330 Vdc (400 V drive) and 435 Vdc (575, 690 V drive)

Elevator system with AC supply



Under normal operation the maximum voltage transient that can be re-applied without controlling the charging current (*soft start circuit inactive*) is, Peak Rectified AC voltage – Pr **06.065** *Standard Under Voltage Threshold* = Max Voltage Transient

This situation could occur for example during a supply brownout.

- Minimum Under voltage threshold for a 400 V drive is 330 Vdc
- Maximum allowed supply voltage for a 400 V drive is 480 + 10 %
- Peak of the maximum allowed supply voltage = $480 \times 1.1 \times \sqrt{2} = 747$ Vdc
- Difference between under voltage threshold and the peak supply voltage = $747 - 330 = 417$ Vdc.
- Therefore, when Pr **06.068** - *Low Voltage DC Supply Mode Enable* = Off (0) for a 400 V drive, the peak supply voltage must never exceed Pr **06.066** - *Low Under Voltage Threshold* + 417 Vdc
- On a 400 V supply Pr **06.066** - *Low Under Voltage Threshold* can be reduced to = $(400 \times 1.1 \times \sqrt{2}) - 417 = 205$ Vdc without having to add an external contactor.

AC supply ratings

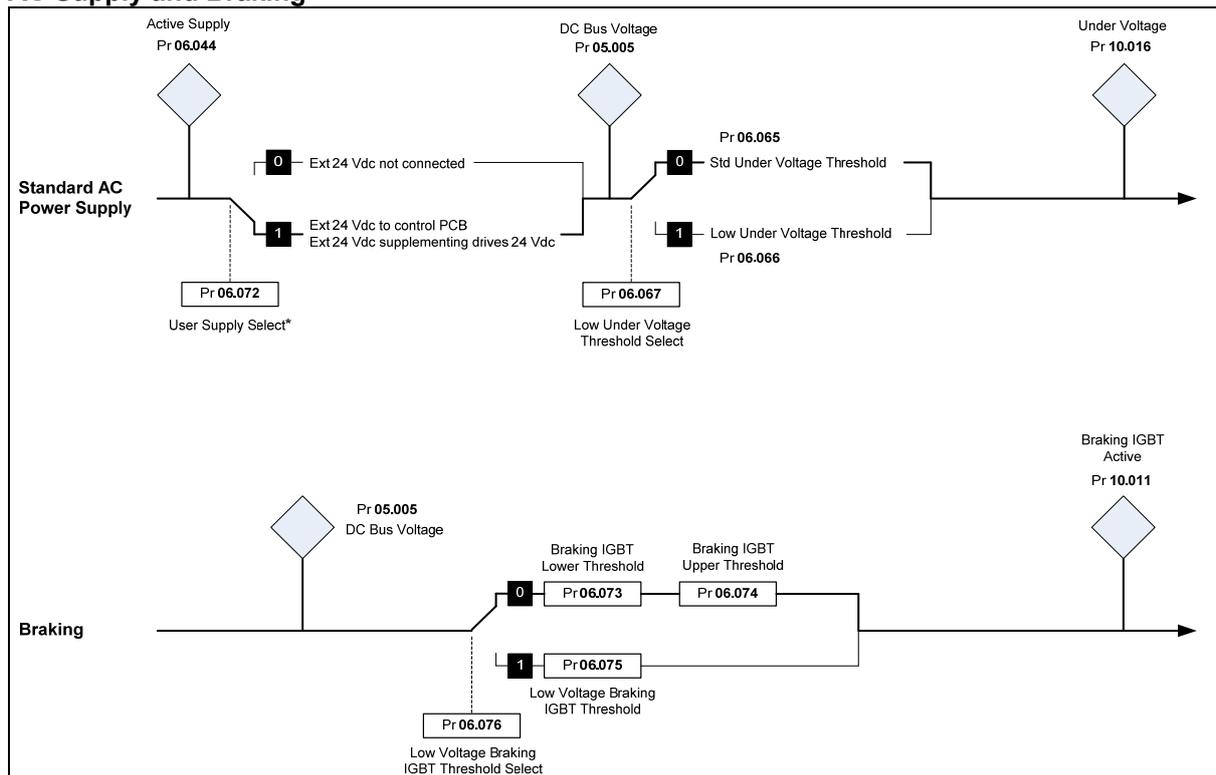
Drive model	AC supply voltage rating	Pr 06.065 – Standard Under Voltage Threshold	Supply loss level
200 Vac	200 to 240 \pm 10 %	175	205
400 Vac	380 to 480 \pm 10 %	330	410
575 Vac	500 to 575 \pm 10 %	435	540
690 Vac	500 to 690 \pm 10 %	435	540

The AC supply in the example above will be rated to deliver full power to the complete Elevator system.

Where Pr **06.067** - *Low Under Voltage Threshold Select* = Off (0) the under voltage threshold is defined by Pr **06.065** - *Standard Under Voltage Threshold*. If Pr **06.067** - *Low Under Voltage Threshold Select* = On (1) then the under voltage threshold is defined by Pr **06.066** - *Low Under Voltage Threshold*.

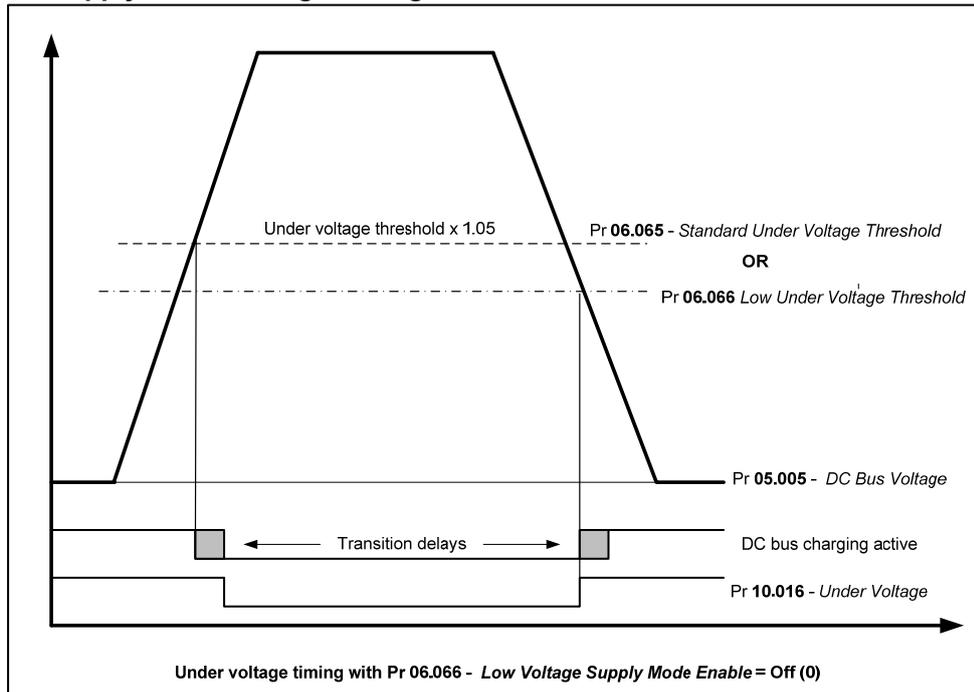
During operation with the AC supply, backup operation for the Control PCB is possible with an external user 24 Vdc supply. This 24 Vdc supply can also be used to supplement the drives own internal 24 Vdc supply. In this case setting Pr **06.072** - *User Supply Select* (external user 24 Vdc supply) = On (1) will generate a drive trip if the external user 24 Vdc supply is lost, where Pr **06.072** - *User Supply Select* (external user 24 Vdc supply) = Off (0) no drive trip is generated on loss of the 24 Vdc supply.

AC Supply and Braking



* In the above figure Pr **06.072** - *User Supply Select* = On (1) in this example the external user 24 Vdc supply is connected and is being used to back-up the Control PCB, and supplement the drives internal 24 Vdc supply.

AC Supply Under Voltage Timing



NOTE:

Power down save is carried out when the DC Bus voltage passes Pr **06.065** - *Standard Under Voltage Threshold* in either direction.

NOTE:

If the external 24Vdc is permanently connected to the drive and powering the control stage there will be no power down save carried out, any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

3.1 Low Voltage DC Mode

Any drive can be configured for Low voltage DC operation however there are differences in the electrical connections and operating voltage range depending on the drive frame size. When set up for Low voltage DC operation the drive can deliver rated torque to the motor, up to the speed which can be supported from the Low Voltage DC supply.

Low voltage DC operation is primarily intended for rescue operation following failure of the AC supply. It is also possible to use Low voltage DC mode for continuous operation of the drive in low power low applications such as Home Elevators.

Where the Low voltage DC supply is in the form of a battery / UPS the length of time that the drive and system will be able to operate and run the motor will be dependent upon the Elevator system supply requirements along with the battery capacity.

Low voltage DC operation can be used whilst operating in any of the following modes:

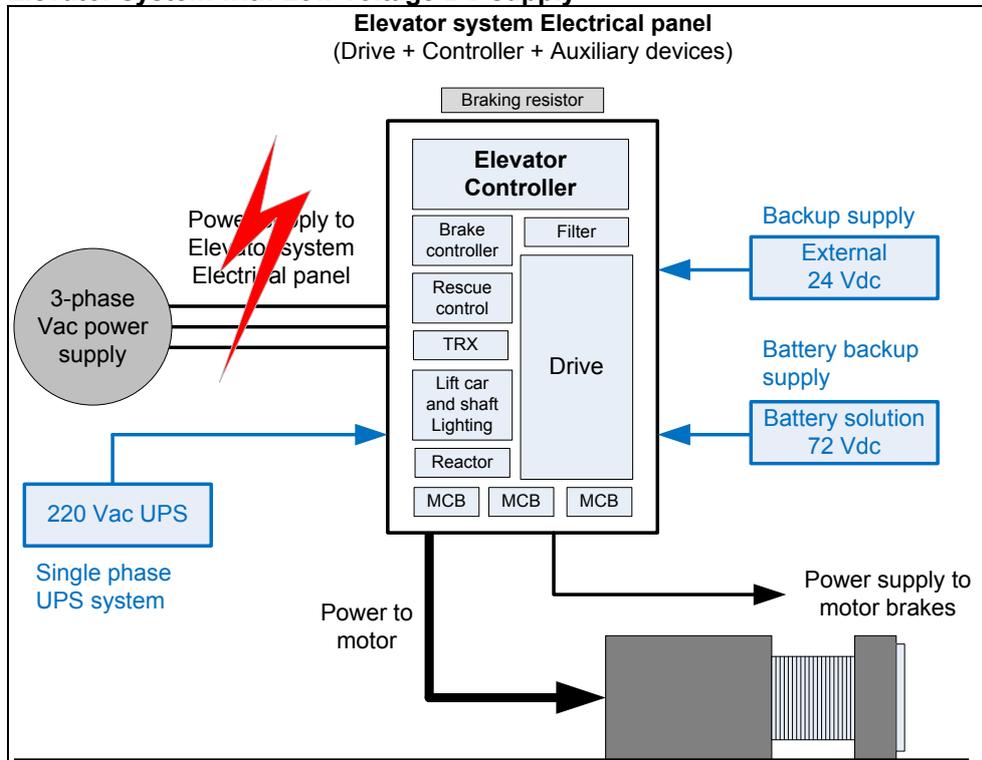
- Open loop mode (Fixed boost and Open loop vector modes) with an asynchronous motor
- RFC-A closed loop vector with an asynchronous motor
- RFC-S closed loop servo with an synchronous PM servo motor

3.2 Low under voltage threshold select

In this mode of operation the user defines Pr **06.066** - *Low Under Voltage Threshold* based upon the Low voltage DC supply and selects this through setting Pr **06.067** - *Low Under Voltage Threshold Select* = On (1). All contactor sequencing required to switch from the AC supply to the Low voltage DC supply, must be managed external to the drive within the system ensuring that the inrush current is managed correctly. An external user 24 Vdc supply is required.

Pr 06.072 - User Supply Select (external user 24 Vdc supply)	Off (0)
Pr 06.068 - Low Voltage DC Supply Mode Enable	Off (0)
Pr 06.067 - Low Under Voltage Threshold Select	On (1)

Elevator system with Low voltage DC supply



The figure above shows Low voltage DC mode where the supply to the electrical panel and drive is from either the single phase UPS system or the Battery backup supply and the additional external user 24 Vdc supply is being supplied to the drive. During operation in Low Voltage DC Mode the external user 24 Vdc supply should also be connected to (1) the drives Control PCB (2) the Power Stage (drive frame sizes 6 and larger) and (3) the Heatsink cooling fans (drive frame sizes 9 and larger).

DC supply range

DC supply voltage operating range (Vdc)				Pr 06.066 – Low Under Voltage Threshold	Pr 06.065 – Standard Under Voltage Threshold
Drive model	Min	Max	Over Voltage		
200 Vac	24	339	415	24 ⇒ 175	175
400 Vac	24	679	830	24 ⇒ 330	330
575 Vac	24	813	990	24 ⇒ 435	435
690 Vac	24	976	1190	24 ⇒ 435	435

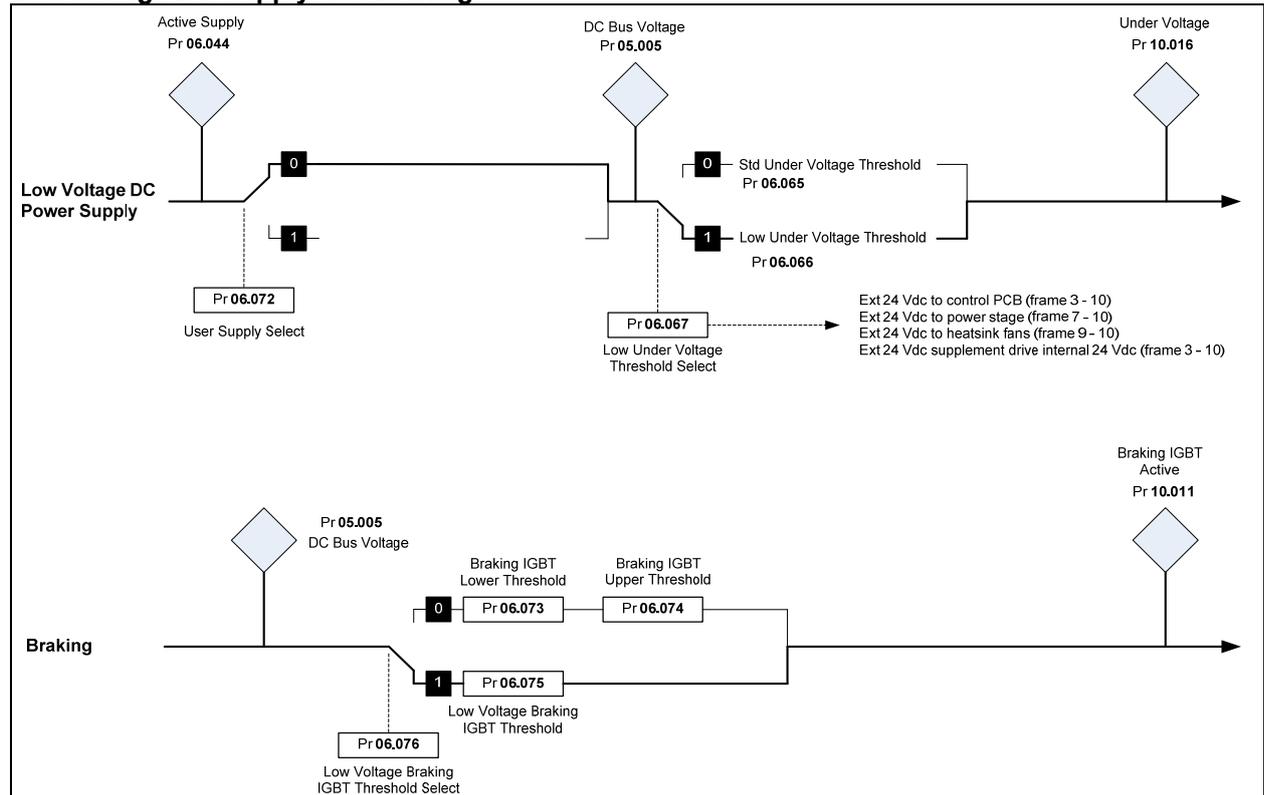
If Pr 06.067 - Low Under Voltage Threshold Select = Off (0) then the under voltage threshold is defined by Pr 06.065 - Standard Under Voltage Threshold and is typically associated to operation with the AC supply. If Pr 06.067 - Low Under Voltage Threshold Select = On (1) then the under voltage threshold is defined by Pr 06.066 - Low Under Voltage Threshold which is set-up for the Low voltage DC supply. The minimum Pr 06.066 - Low Under Voltage Threshold for Low Voltage DC Mode is 24 Vdc.

Under normal operation the maximum voltage transient that can be re-applied without controlling the charging current (*soft start circuit inactive*) is, Peak Rectified AC voltage - Pr 06.065 - Standard Under Voltage Threshold = Max Voltage Transient.

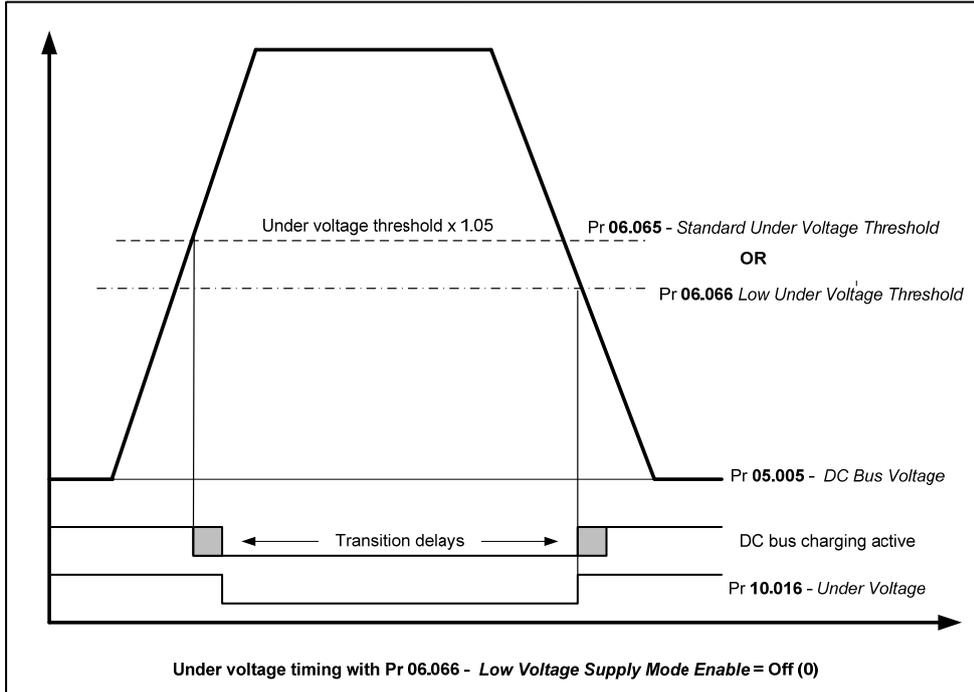
This situation could occur for example during a power supply brownout.

- Minimum Under voltage threshold for a 400 V drive is 330 Vdc
- Maximum allowed supply voltage for a 400 V drive is 480 + 10 %
- Peak of the maximum allowed supply voltage = $480 \times 1.1 \times \sqrt{2} = 747$ Vdc
- Difference between under voltage threshold and the peak supply voltage = $747 - 330 = 417$ Vdc.
- Therefore, when Pr **06.068** - *Low Voltage DC Supply Mode Enable* = Off (0) for a 400 V drive, the peak supply voltage must never exceed Pr **06.066** - *Low Under Voltage Threshold* + 417 Vdc
- On a 400 V supply Pr **06.066** - *Low Under Voltage Threshold* can be reduced to = $(400 \times 1.1 \times \sqrt{2}) - 417 = 205$ Vdc without having to add an external contactor.

Low Voltage DC Supply and Braking



Low Voltage DC Supply Under Voltage Timing



NOTE:

For drive frame sizes 7 and larger when operating with a single phase UPS the power supply should be connected to L1 and L2. Input L3 should be connected directly to L2 to avoid a supply loss fault, and to allow the half controlled rectifier to start up and limit the inrush current for operation with the single phase UPS.

NOTE:

During operation in Low voltage DC mode where the Low under voltage threshold is selected there is no power down parameter save carried out, any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

NOTE:

If the external 24 Vdc is permanently connected to the drive and powering the control stage there will be no power down save carried out, any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

3.3 AC Supply Mode with seem-less transition to Low voltage DC Mode + Contactor Control

In this mode of operation the user defines Pr **06.065** - *Standard Under Voltage Threshold* and Pr **06.066** - *Low Under Voltage Threshold* based upon the Low voltage DC supply. Pr **06.066** - *Low Under Voltage Threshold* = On (1) which manages the selection and sequencing of the AC supply to the Low voltage DC supply through the internal contactor control. An external charging circuit may be required for drive frame sizes 7 and larger. An external user 24 Vdc supply is required.

Pr 06.072 - <i>User Supply Select</i> (external user 24 Vdc supply)	Off (0)
Pr 06.068 - <i>Low Voltage DC Supply Mode Enable</i>	On (1)
Pr 06.067 - <i>Low Under Voltage Threshold Select</i>	Off (0)

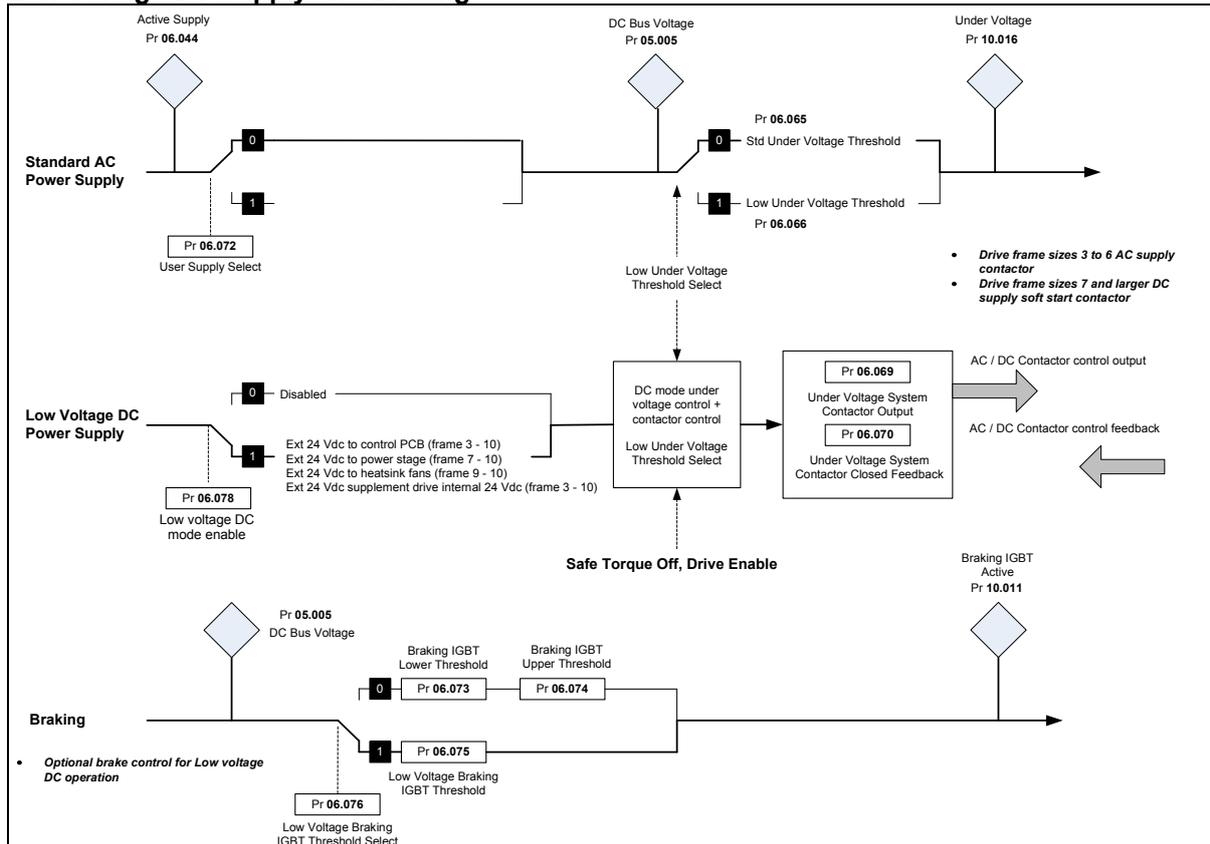
This mode of Low voltage DC operation uses the additional drive on-board under voltage monitoring and contactor control which will manage the external contactor control for correct seem-less transition from the AC supply to Low voltage DC supply ensuring correct safe operation. The drive must be disabled to transition back from the Low voltage DC supply to the AC supply. This ensures the internal soft start circuit is active and manages the inrush current for drive frame sizes 3 to 6, for drive frame sizes 7 larger and external soft start circuit may be required.

Any drive can be configured for Low voltage DC operation however there are differences in the electrical connections and operating voltage range depending on the drive frame size. When set up for Low voltage DC operation the drive can deliver rated torque to the motor up to the speed which can be supported from the Low voltage DC supply.

Low voltage DC operation can be used whilst operating in any of the following modes:

- Open loop mode (Fixed boost and Open loop vector modes) with an asynchronous motor
- RFC-A closed loop vector with an asynchronous motor
- RFC-S closed loop servo with an synchronous PM servo motor

Low Voltage DC Supply and Braking



NOTE:

Power down save is carried out when the DC Bus voltage passes Pr **06.065** - *Standard Under Voltage Threshold* in either direction during operation with the AC supply.

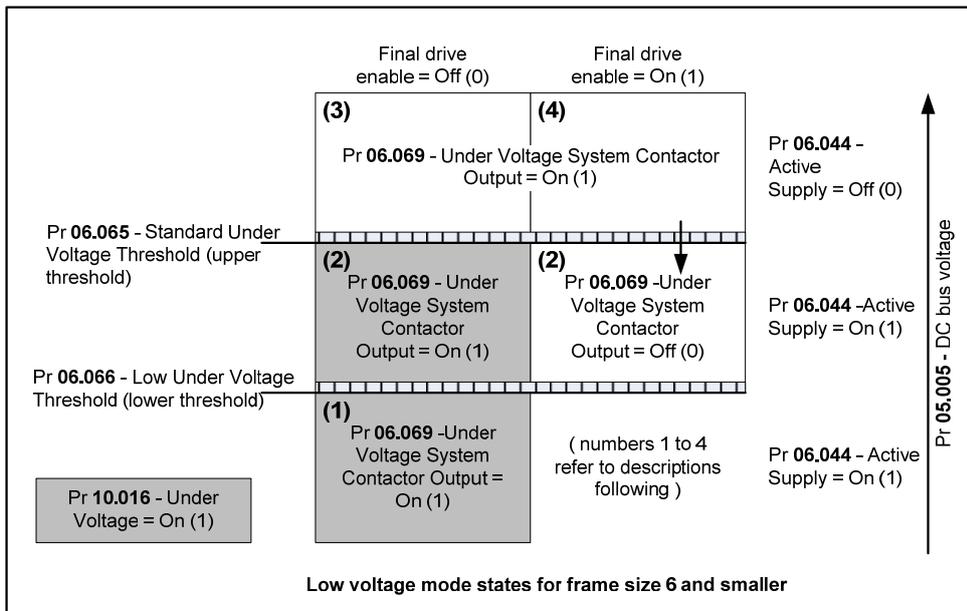
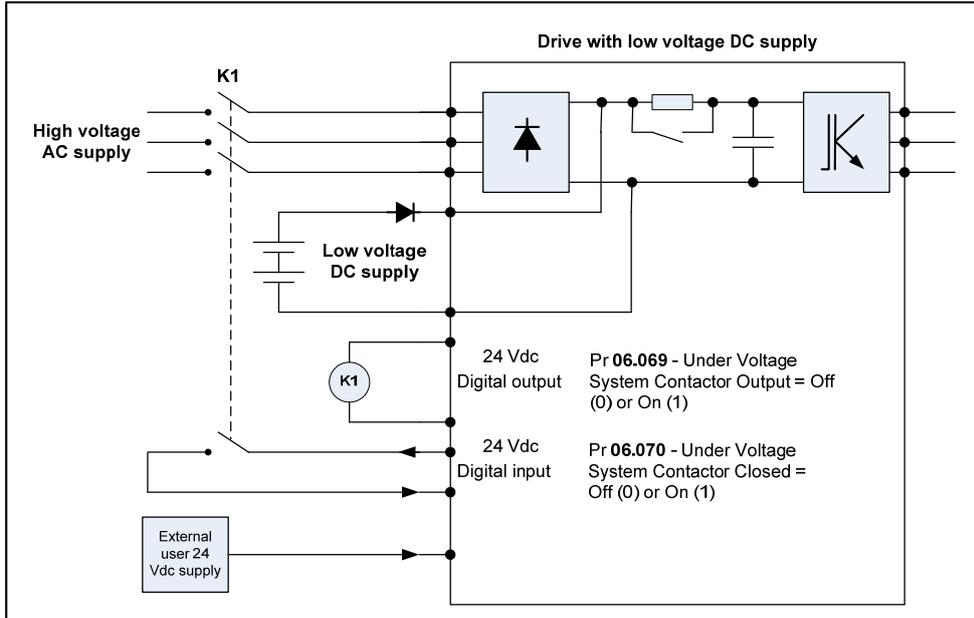
NOTE:

During operation in Low voltage DC mode where the Low under voltage threshold is selected there is no power down parameter save carried out, any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

NOTE:

If the external 24Vdc is permanently connected to the drive and powering the control stage there will be no power down save carried out, any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

3.3.1 Drive frame sizes 3 to 6 operation



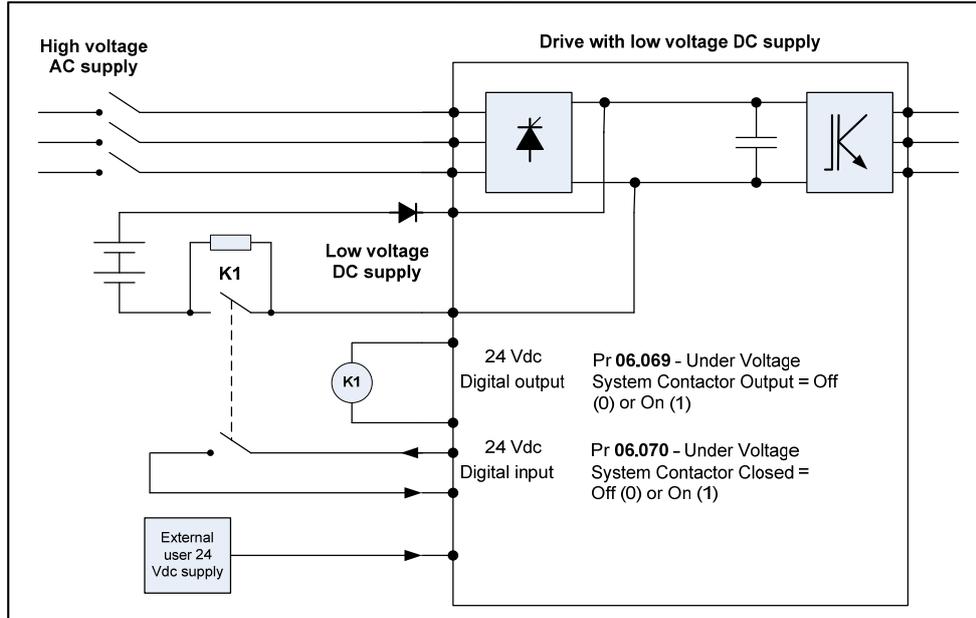
The various items that make up final drive enable can be seen in Pr 06.010 - Enable Conditions.

Looking at the different operating states for Low voltage DC operation as shown above for drive frame sizes 6 and smaller:

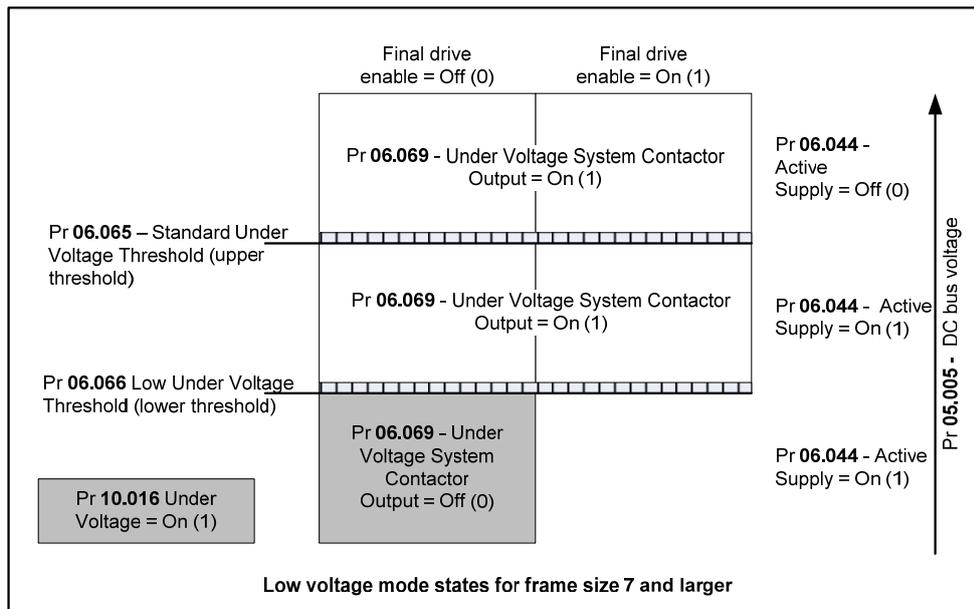
1. If Pr 05.005 - DC Bus Voltage is below the Pr 06.066 - Low Under Voltage Threshold the drive is in the Under Voltage state and the internal charge system is active to limit the charging current either from the Low voltage DC supply or the AC supply. The AC contactor as shown above will be closed and it is possible for the AC supply to charge the DC Bus of the drive.
2. If Pr 05.005 - DC Bus Voltage is above the Pr 06.066 - Low Under Voltage Threshold, but below Pr 06.065 - Standard Under Voltage Threshold, there are two possible states depending on whether the drive is enabled or not.
 - a. If the drive is not enabled then the drive will remain in the Under Voltage state, the internal charge system is active and the AC contactor will remain closed, so the DC Bus can be charged by the AC supply.

- b. If the drive is enabled then the internal charge system is inactive so that the drive can run from the Low voltage DC supply. In this case the AC contactor will be opened so that it is not possible for the AC supply to charge the DC Bus.
- 3. If Pr 05.005 - DC Bus Voltage is above Pr 06.065 - Standard Under Voltage Threshold then Pr 10.016 - Under Voltage active will be Off (0) and the AC contactor will be closed so the drive can run from the AC supply.
- 4. If the Pr 05.005 - DC Bus Voltage subsequently falls below Pr 06.065 - Standard Under Voltage Threshold and the drive is enabled, the drive can continue to run, but Pr 06.070 Under Voltage System Contactor Closed is set to Off (0) to open the AC supply contactor. The DC Bus voltage will now drop until it reaches the Low voltage DC supply level. This gives a smooth changeover from the AC supply to the Low voltage DC supply without stopping the motor.

3.3.2 Drive frame sizes 7 and larger operation



The charge system for the AC supply is provided by the half controlled thyristor input bridge within the drive.



NOTE:

For drive frame sizes 7 and larger the external contactor which is used to support the soft start charging system for Low voltage DC mode is located in the DC supply connections.

Initial charging from the *Under Voltage state* is limited by the inrush resistor and then as the DC Bus exceeds Pr **06.066** - *Low Under Voltage Threshold* the external DC contactor will be closed using the output from Pr **06.069** - *Under Voltage System Contact Output*. If the AC supply is reconnected the half controlled rectifier will limit the additional charging current.

The charge system for the AC supply is provided by the half controlled thyristor input bridge within the drive. The system operates in a similar way to standard mode (i.e. Low voltage DC mode not enabled) with the following differences.

1. The thyristor charge system always uses a threshold voltage related to Pr **06.065** - *Standard Under Voltage Threshold*.
2. Pr **06.069** - *Under Voltage System Contact Output* is set to On (1) when the DC Bus voltage is above Pr **06.066** - *Low Under Voltage Threshold*.
3. Pr **10.016** - *Under Voltage* active cannot be Off (0) if Pr **06.070** *Under Voltage System Contactor Closed* = Off (0).

3.3.3 Elevator controller

The transition from AC Supply mode to the Low Voltage DC mode could also be managed externally by the Elevator controller in which case the Elevator controller would also activate a digital input to the drive to enable and disable Low voltage DC mode.

3.4 External user 24 Vdc supply for Low voltage DC mode

During Low voltage DC operation an external user 24 Vdc supply is required to power the Control PCB (drive frame sizes 3 and larger), Power Stage (drive frame sizes 6 and larger) and heatsink cooling fans (drive frame sizes 9 and larger).

External user 24 Vdc supply specification

Nominal operating		24.0 Vdc
Minimum operating	(Frame 6) (Frame 3 to 5 & 7 to 10)	18.6 Vdc 19.2 Vdc
Maximum operating	(Frame 3 to 6) (Frame 7 to 10)	28.0 Vdc 30.0 Vdc (IEC), 26.0 Vdc (UL)
Minimum start-up voltage	(Frame 6) (Frame 3 to 5 & 7 to 10)	18.4 Vdc 21.6 Vdc
Maximum power	(Frame 3 to 6) (Frame 7 to 10)	40 W 60 W
Recommended fuse	(Frame 3 to 5) (Frame 6 to 10)	3A, 50 Vdc 4A, 50 Vdc

- For drive frame sizes 3 and larger an external user 24 Vdc supply is required to power the drive Control PCB. The 24 Vdc supply will maintain power on the Control PCB when the power supply is no longer present and during operation in Low voltage DC mode, or, whilst the drive system is in energy saving, sleep mode.
- For drive frame sizes 6 and larger the external user 24 Vdc supply is also required for the Power Stage dependent upon the final DC Bus voltage level. If the DC Bus is below the AC supply loss level this 24 Vdc supply is required.
- For drive frame sizes 9 and larger the external user 24 Vdc supply is also required for the heatsink cooling fans dependent upon the final DC Bus voltage level. If the DC Bus is below the AC supply loss level this 24Vdc supply is required.

Failure to connect the external user 24 Vdc supply to the Control PCB on drive frame sizes 3 and larger will result in none of the above mentioned functions being available and [PSU 24V](#) will be displayed on the drives keypad. On drive frame sizes 6 and larger failure to connect the external user 24 Vdc supply to the Power Stage will result in "Waiting For Power Systems" being displayed on the drives keypad.

NOTE:

If the external 24Vdc is permanently connected to the drive and powering the control stage there will be no power down save carried out, any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

NOTE:

During operation in Low voltage DC mode where the Low under voltage threshold is selected there is no power down parameter save carried out, any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

NOTE:

The external user 24 Vdc supply to the Power Stage should be cycled ON and OFF with the power supply and Low voltage DC supply.

The external user 24 Vdc supply in addition can be used to commission the drive when the AC supply is not present, with the Control PCB and display operating correctly, or, can be used to supplement the drive's internal 24 Vdc supply when multiple SI option modules are used or there is heavy loading on the drives digital outputs and the current drawn by these is greater than the drives own internal 24 Vdc supply.

Once the required external user 24 Vdc supplies are connected to the drive it will remain in the "UV" *Under Voltage state* unless either the AC supply or Low voltage DC supply is present, therefore diagnostics may not be possible

3.5 Running the Motor

In order for the drive to obtain the correct motor parameter values, the auto tune should be carried out when operating from the AC supply and not during operation in Low Voltage DC mode. If it is not possible to complete the auto tune when operating from the AC supply the motor parameters should be obtained from the motor nameplate and entered into the drive manually. A static auto tune should be carried out for operation in RFC-S mode to derive the encoder phase offset value.

NOTE:

Power down save is carried out when the DC Bus voltage passes Pr **06.065** - *Standard Under Voltage Threshold* in either direction.

NOTE:

During operation in Low voltage DC mode where the Low under voltage threshold is selected there is no power down parameter save carried out, any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

NOTE:

If the external 24 Vdc is permanently connected to the drive and powering the control stage there will be no power down save carried out, , any parameter save must be carried out prior to power down with parameter **mm.xxx** = 1001

3.5.1 Maximum speed of motor

The maximum speed that can be achieved from the motor whilst operating in Low voltage DC mode is dependent upon the type of motor in the application, the Low voltage DC supply rating and power requirement from the complete system which the Low voltage DC supply is connected to. The Low voltage DC supply needs to be sufficiently rated in order to overcome the stator resistance of the motor, with the final voltage level from the Low voltage DC supply determining the maximum operating speed which can be achieved from the motor.

It is very important to consider that when operating with an overhauling load such as in an drive system, even with the correct braking resistor selection, the drive may not be able to maintain full control over the load due to the level of torque based on both the Low voltage DC supply, and when the drive goes into field weakening operation. The drive may rotate the motor up to rated speed, however even with minimal load the motor could stall due to the reduced torque available when operating in the field weakening region.

Where the Low voltage DC supply is in the form of a battery / UPS the length of time that the drive and system will be able to operate and run the motor will be dependent upon the drive systems power supply requirements along with the battery capacity.

3.5.2 Low voltage DC operation with Asynchronous induction motors

In order to generate torque with an asynchronous induction motor the drives AC output in Low voltage DC mode must be sufficient to overcome the stator resistance and magnetise the motor. The drive will also start to field weaken at the point at which the AC output voltage reaches its maximum level based upon the Low voltage DC supply connected to the drive and its final DC Bus voltage level.

Note reduced torque may be experienced during operation in Low voltage DC mode where the motor requires higher levels of voltage to fully magnetize the motor; the reasons for this are as follows

- The Low voltage DC supply has reached its maximum voltage supplying the drive.
- The drive has reached its maximum AC output voltage based on the Low voltage DC supply and final DC Bus voltage.

3.5.3 Low voltage DC operation with a Synchronous PM servo motors

During Low voltage DC operation the drive may NOT be able to limit the speed of a synchronous PM servo motor with a high overhauling load due to reduced motor torque resulting from the Low voltage DC supply rating.

The speed of the synchronous PM servo motor is limited based on the Ke (voltage constant) value as follows.

A drive with a Low voltage DC supply of 282 V, running a 255 rpm synchronous PM motor which has a Ke value of 1142 V/1000 rpm.

- Motor speed (rpm) per AC output volt **$255 \text{ rpm} / 1142 \text{ V} = 0.22 \text{ rpm/V}$**
- AC Output voltage from Low voltage DC supply **$282 \text{ V} / \sqrt{2} = 141.0 \text{ V}$**
- Final motor speed (rpm) at Low voltage DC supply **$0.22 \times 141 = 31.0 \text{ rpm}$**

The calculations above give an estimated value for motor speed based on the Low voltage DC supply and do not take into account motor volt drops etc.

If a synchronous PM servo motor on brake release rotates to a high speed due to the position of the Elevator car in the system and its loading, the DC Bus of the drive plus associated system wiring and fuse protection could rise above the rating of the Low voltage DC supply and its connections to the drive.

4 Parameter section

For Low voltage DC mode there are a number of parameters within the drive which support configuration of the drive, these include settings for the Low voltage DC supply, UPS and Brake control. The following section details the user parameters within the drive which are used for configuration of the Low voltage DC mode.

Parameter	Description	Notes
Pr 06.044	Active supply	Power supply status
Pr 06.072	User supply select	External user 24 Vdc supply
Pr 06.065	Standard under voltage threshold	
Pr 06.066	Low under voltage threshold	
Pr 06.067	Low under voltage threshold select	Low voltage DC operation using Low under voltage threshold select
Pr 06.068	Low voltage supply mode enable	Full Low voltage DC operation with internal under voltage threshold select and output contactor control
Pr 06.069	Under voltage system contactor output	
Pr 06.070	Under voltage system contactor closed	
Pr 06.071	Slow rectifier charge rate enable	Slow rectifier charge to preserve battery lifetime during power up
Pr 06.048	Phase loss input detection level	Disable input phase loss for operation with single phase UPS
Pr 06.073	Braking IGBT lower threshold	Brake control voltage setup and low voltage braking select.
Pr 06.074	Braking IGBT upper threshold	
Pr 06.075	Low voltage braking IGBT threshold	
Pr 06.076	Low voltage braking IGBT threshold select	

Parameter	Pr 06.044 Active Supply		
Short description	Indicates when the low voltage DC supply mode is enabled and the DC Bus voltage is below the Pr 06.065 - <i>Standard Under Voltage Threshold</i>		
Minimum	Off (0)	Maximum	On (1)
Default	n/a	Units	Off (0) or On (1)
Type	1 Bit Volatile	Update Rate	Background write
Display Format	Standard	Decimal Places	0
Coding	RO, ND, NC, PT		

If Pr 06.068 - *Low Voltage Supply Mode Enable* = Off (0) then Pr 06.044 - *Active Supply* = Off (0).
 If Pr 06.068 - *Low Voltage Supply Mode Enable* = On (1) then Pr 06.044 - *Active Supply* = Off (0) when the DC Bus voltage is above the Pr 06.065 - *Standard Under Voltage Threshold* otherwise Pr 06.044 - *Active Supply* = On (1).

In Regen mode Pr 06.044 - *Active Supply* is always = Off (0).

Parameter	Pr 06.072 User Supply Select		
Short description	Set = On (1) to select supply from external user 24 Vdc supply		
Minimum	Off (0)	Maximum	On (1)
Default	Off (0)	Units	Off (0) or On (1)
Type	1 Bit User Save	Update Rate	Background read
Display Format	Standard	Decimal Places	0
Coding	RW		

The power for the drive control system is either taken from the external user 24 Vdc supply or the AC supply (i.e. derived from the power circuit DC Bus). For drive frame sizes 7 and above a diode OR system is used to select the required power supply, therefore this is done automatically in hardware. Note the external user 24 Vdc supply connection is made to the Power Stage drive frame sizes 6 and larger and Control PCB with drive frame sizes 3 and larger.

If Pr 06.072 - *User Supply Select* = Off (0), Pr 06.068 - *Low Voltage Supply Mode Enable* = Off (0),

Pr **06.067** - *Low Under Voltage Threshold Select* = Off (0), the power supply used is determined as follows for drive frame sizes 3 to 6.

1. When the drive first powers up it attempts to use the AC supply or the external user 24 Vdc supply in turn until the drive fully powers up, beginning with the AC supply.
2. If the AC supply is active and Pr **05.005** - *DC Bus Voltage* falls to a level where it is no longer possible to communicate with the power stage the drive attempts to switch over to the external user 24 Vdc supply. If the 24 Vdc supply is not present then the drive will power down, otherwise it will continue to run off the 24 Vdc supply. The level at which the power stage powers down depends on whether the 24 Vdc supply is present or not. However this is usually below half the minimum for Pr **06.065** - *Standard Under Voltage Threshold*.
3. If the external user 24 Vdc supply is being used and Pr **05.005** - *DC Bus Voltage* rises above 95 % of the minimum for Pr **06.065** - *Standard Under Voltage Threshold* the drive attempts to switch to the AC supply.

The following should be noted:

1. Parameters can be saved by setting parameter **mm.xxx** = 1 or 1000 (whilst not in the *Under Voltage state*) or setting parameter **mm.xxx** = 1001 and initiating a drive reset (whilst in the *Under Voltage state*). Power down save parameters are saved when the Pr **06.065** - *Standard Under Voltage Threshold* becomes active.
2. If the drive is powered from the external user 24 Vdc supply and then the AC supply is activated but is not above 95 % of the minimum for Pr **06.065** - *Standard Under Voltage Threshold* then the drive will continue to be powered from the 24 Vdc supply. If the 24 Vdc supply is subsequently removed the drive will power down, however if the AC supply is high enough the drive will power up again on the AC supply.

If Pr **06.072** - *User Supply Select* = On (1), Pr **06.068** - *Low Voltage Supply Mode Enable* = Off (0), Pr **06.067** - *Low Under Voltage Threshold Select* = Off (0), the AC supply used is determined as follows for drive frame sizes 3 to 6.

1. The drive will still power up on the AC supply even if the external user 24 Vdc supply is not present. During power up the drive tries each power supply in turn to power up, however the drive will remain in the [PSU 24V](#) tripped state until the 24 Vdc supply is activated.
2. Parameters can only be saved by setting parameter **mm.xxx** = 1001 and initiating a drive reset.
3. Power-down save parameters are not saved when the *Under Voltage state* is active.

Where either Pr **06.068** - *Low Voltage Supply Mode Enable* = On (1) or Pr **06.067** - *Low Under Voltage Threshold Select* = On (1) and where the external user 24 Vdc supply must be connected Pr **06.072** - *User Supply Select* is no longer active and the 24 Vdc supply is automatically managed internally and always selected through the setting of Pr **06.068** - *Low Voltage Supply Mode Enable* or Pr **06.067** - *Low Under Voltage Threshold Select*.

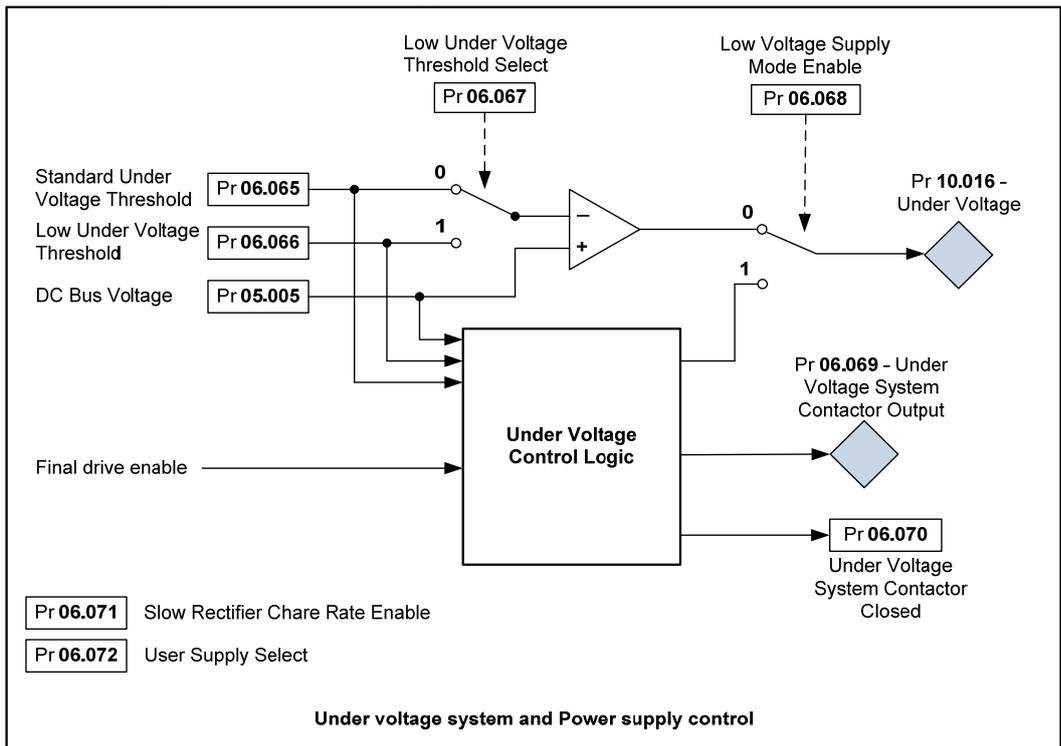
1. The drive will still power up on the AC supply even if the external user 24 Vdc supply is not present. During power up the drive tries each power supply in turn to power up, however the drive will remain in the [PSU 24V](#) tripped state until the 24 Vdc supply is activated.
2. Parameters can only be saved by setting parameter **mm.xxx** = 1001 and initiating a drive reset.
3. Power-down save parameters are not saved when the *Under Voltage state* is active.

Parameter	Pr 06.065 Standard Under Voltage Threshold		
Short description	Defines the standard under voltage threshold		
Minimum	-VM STD UNDER VOLTS	Maximum	VM STD UNDER VOLTS
Default	See exceptions below	Units	V
Type	16 Bit User Save	Update Rate	Background read
Display Format	Standard	Decimal Places	0
Coding	RW, VM, RA		

Drive model	Minimum Vdc	Pr 06.066 - Low Under Voltage Threshold	Pr 06.065 Standard Under Voltage Threshold	Maximum Vdc	Over voltage Vdc
200 Vac	24	* 24 to 175	175	339	415
400 Vac	24	* 24 to 330	330	679	830
575 Vac	24	* 24 to 435	435	813	990
690 Vac	24	* 24 to 435	435	976	1190

* For Low voltage DC operation Pr 06.066 - *Low Under Voltage Threshold* is setup based upon the external Low voltage DC power supply being used.

Under voltage system and AC supply control



Under Voltage System

The under voltage system controls the state of Pr 10.016 - *Under Voltage* which is used by the state machine. When Pr 10.016 - *Under Voltage* = On (1) the state machine will change to the *Under Voltage state* and during this time it is not possible to enable the drive. The under voltage system operates in different ways depending on the setting of Pr 06.068 - *Low Voltage Supply Mode Enable*.

Each under voltage threshold (Pr 06.065 - *Standard Under Voltage Threshold* and Pr 06.066 - *Low Under Voltage Threshold*) detection system includes a hysteresis of 5 % of the actual threshold level therefore,

Pr 05.005- DC Bus Voltage	Under Voltage Detection
Vdc	Active
Threshold \leq Vdc	No Change
Vdc \geq Threshold x 1.05 *	Not Active

* Hysteresis is 5 % subject to a minimum of 5 Vdc

It should be noted that the under voltage threshold and charging rate (Pr 06.071 - *Slow Rectifier Charge Rate Enable*) used with a thyristor based charge system (drive frame sizes 7 and larger) are automatically saved within the rectifier units each time the values are changed because these will be

required at the next power up before the drive control system is active. The values will be retained when they are changed up to 128 times, if any more changes are made between power up and power down the new values are not retained.

AC Supply Control

If Pr **06.068** - *Low Voltage Supply Mode Enable* = On (1) or Pr **06.067** - *Low Under Voltage Threshold Select* where Pr **06.066** - *Low Under Voltage Threshold* is being used the internal drive power supplies are automatically managed internally and normally powered from the external user 24 Vdc supply.

Setting Pr **06.072** - *User Supply Select* = On (1) is only required when operating from the AC supply and an external user 24 Vdc supply is connected to the drive for backup. Setting this parameter enables detection of loss of the 24 Vdc supply, and will result in the monitoring system generating [PSU 24V](#) a trip.

Standard Mode (Pr **06.068** - *Low Voltage Supply Mode Enable* = Off (0))

If Pr **06.067** - *Low Under Voltage Threshold Select* = Off (0) then the under voltage threshold is defined by Pr **06.065** - *Standard Under Voltage Threshold*. If Pr **06.067** - *Low Under Voltage Threshold Select* = On (1) then the under voltage threshold is defined by Pr **06.066** - *Low Under Voltage Threshold*.

Drives frame sizes 3 to 6

Drive frame sizes 3 to 6 have a DC Bus charge system based on a charge resistor and shorting contactor that is in circuit for both the AC and DC supply input connections to the drive. The charge system is generally active (shorting contactor open) when Pr **10.016** - *Under Voltage* = On (1) and inactive when Pr **10.016** - *Under Voltage* = Off (0). One exception is for the delay of 50 ms while the shorting contactor changes state and during these periods Pr **10.016** - *Under Voltage* = On (1).

If the DC Bus voltage is above the under voltage threshold and Pr **10.016** - *Under Voltage* = Off (0) a large surge of current can occur if the AC supply is removed and then reapplied to the drive. For a given level of supply voltage the worst case surge occurs when the power supply is applied at the point where one of the line voltages is at its peak. The surge is proportional to the difference between the DC Bus voltage before the AC supply is reconnected and the magnitude of the AC supply voltage.

The minimum setting and default for Pr **06.065** - *Standard Under Voltage Threshold* corresponds to the lowest DC Bus voltage level where the maximum allowed AC supply voltage can be applied without damaging the drive or rupturing the recommended AC supply fuses. Therefore it is safe to adjust the under voltage threshold using Pr **06.065** - *Standard Under Voltage Threshold*.

If the under voltage threshold needs to be lower than the minimum of Pr **06.065** - *Standard Under Voltage Threshold* then Pr **06.066** - *Low Under Voltage Threshold* should be used.

It is important that the difference between the under-voltage threshold level and the peak of the power supply voltage is never larger than the difference between the minimum Pr **06.065** - *Standard Under Voltage Threshold* and the peak of the maximum allowed AC supply voltage for the drive.

For example

Minimum Pr **06.065** - *Standard Under Voltage Threshold* for a 400 V drive = 330 V

Maximum allowed power supply voltage for this drive = 480 V + 10 %

Peak of the maximum allowed power supply voltage = $480 \times 1.1 \times \sqrt{2} = 747 \text{ V}$

Difference between the under voltage threshold and the peak power supply voltage $747 - 330 = 417 \text{ V}$

Therefore for this drive voltage rating the peak line to line voltage must never be higher than

Pr **06.066** - *Low Under Voltage Threshold* + 417 V

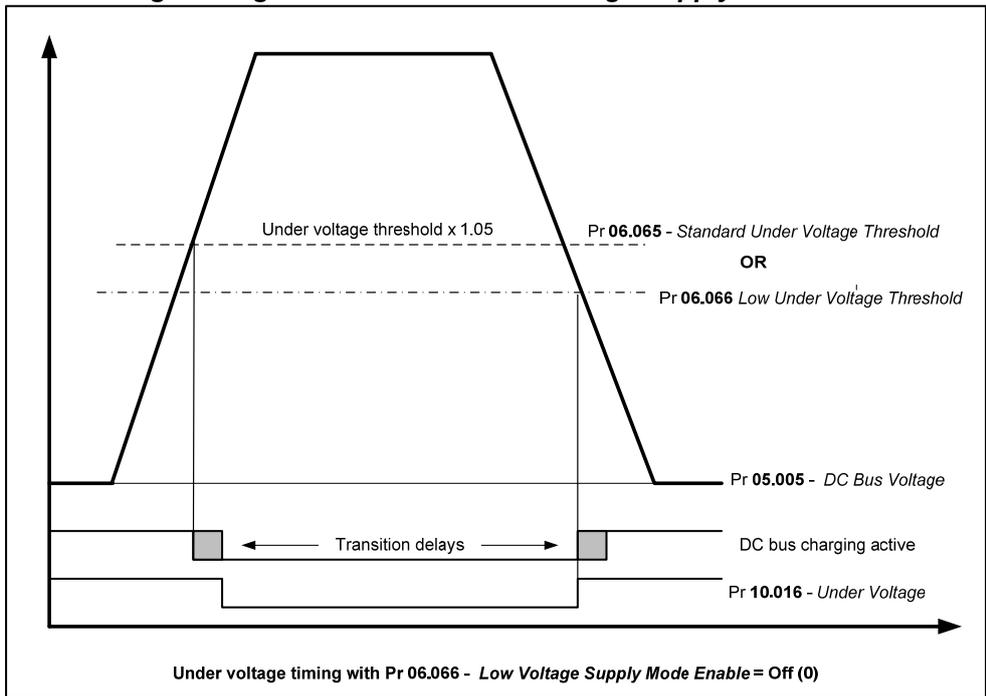
If Pr **06.067** - *Low Under Voltage Threshold Select* = On (1) and Pr **06.066** - *Low Under Voltage Threshold* is reduced below the variable maximum level VM_STD_UNDER_VOLTAGE [MIN] or if Pr **06.068** - *Low Voltage Supply Mode Enable* = On (1) an indication is stored in Pr **10.106** - *Potential Drive Damage Conditions* that cannot be cleared by the user. This marks the drive so that if it is damaged as a result of an input current surge, this can be detected by service personnel.

Voltage level	200 V	400 V	575 V	690 V
VM_STD_UNDER_VOLTS [MIN]	175	330	435	435

Drives frame sizes 7 and larger

Drive frame sizes 7 and larger use a DC Bus charge system based on a half controlled thyristor input bridge, the charge system is activated based on the level of the voltage at the AC supply terminals of the drive. The threshold for the charge system is set so that the rectified AC supply will give the required under voltage threshold level. The under voltage system operates in exactly the same way as for drive frame sizes 3 to 6 except that the delay during the transition out of the *Under Voltage state* is extended. For a single power module the delay is 1.0 s to allow the thyristor charge system to charge the DC Bus. For parallel power modules the delay is extended to 2.5 s to ensure that all power modules power up correctly.

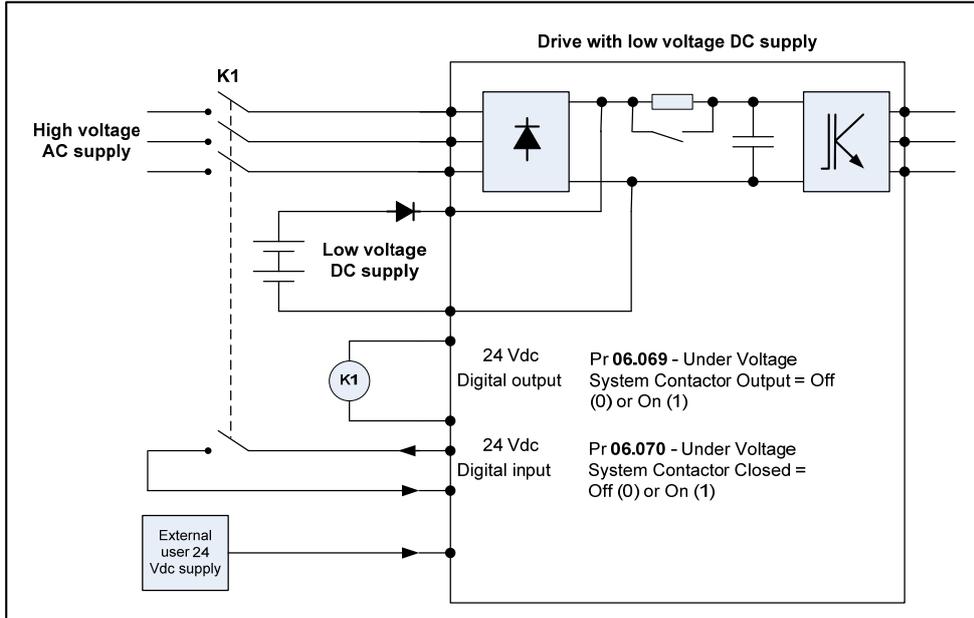
Under voltage timing with Pr 06.068 - Low Voltage Supply Mode Enable = Off (0)



Low voltage mode drive frame sizes 3 to 6 (Pr 06.068 - Low Voltage Supply Mode Enable = On (1))

Low voltage supply mode is intended to provide a smooth transition without disabling the drive, from the AC supply to a Low voltage DC supply. ***It is necessary to disable the drive for the transition back to the AC supply to allow the soft start circuit to become active.*** The following diagram is a simple representation of the power circuit required. This does not include the necessary circuit protection or battery charger etc.

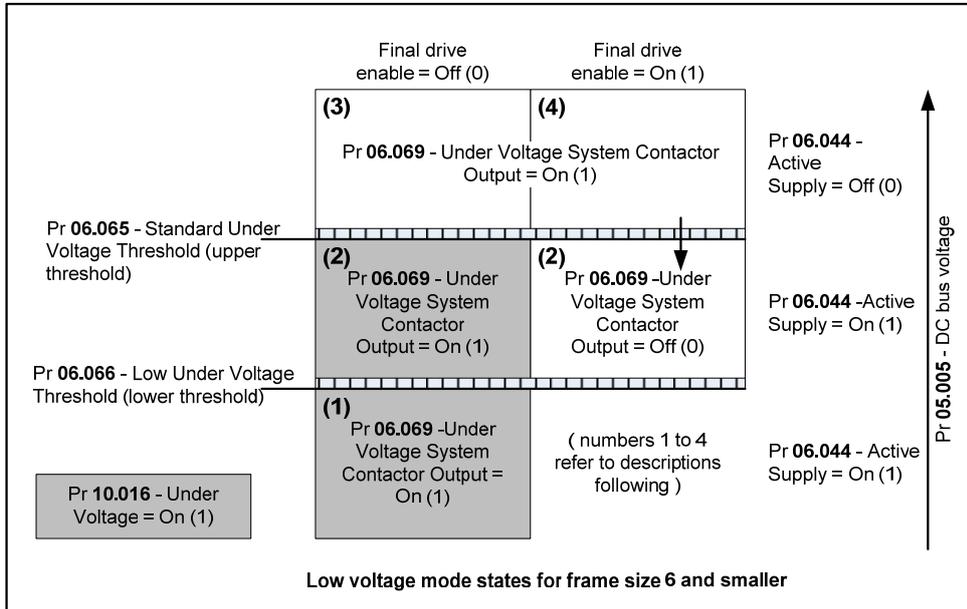
Low voltage mode for drive frame sizes 3 to 6



The following state diagram shows Pr **10.016 - Under Voltage**, the control signal to the external contactor Pr **06.069 Under Voltage Contactor Output** and Pr **06.044 - Active Supply**. When

Pr **06.068 - Low Voltage Supply Mode Enable** = On (1) a maximum is applied to Pr **06.066 - Low Under Voltage Threshold** to prevent this from being increased above Pr **06.065 - Standard Under Voltage Threshold / 1.1** so that the 5 % hysteresis band on the Pr **06.066 - Low Under Voltage Threshold** does not overlap the Pr **06.065 - Standard Under Voltage Threshold**.

Low voltage mode states for drive frame sizes 3 to 6



1. If Pr **05.005 - DC Bus Voltage** is below Pr **06.066 - Low Under Voltage Threshold** the drive is in the *Under Voltage state* and the internal charge system is active to limit the charging current from either the Low voltage DC supply or the AC supply. When Pr **06.069 - Under Voltage System Contactor Output** = On (1) it is possible for the AC supply to charge the DC Bus.

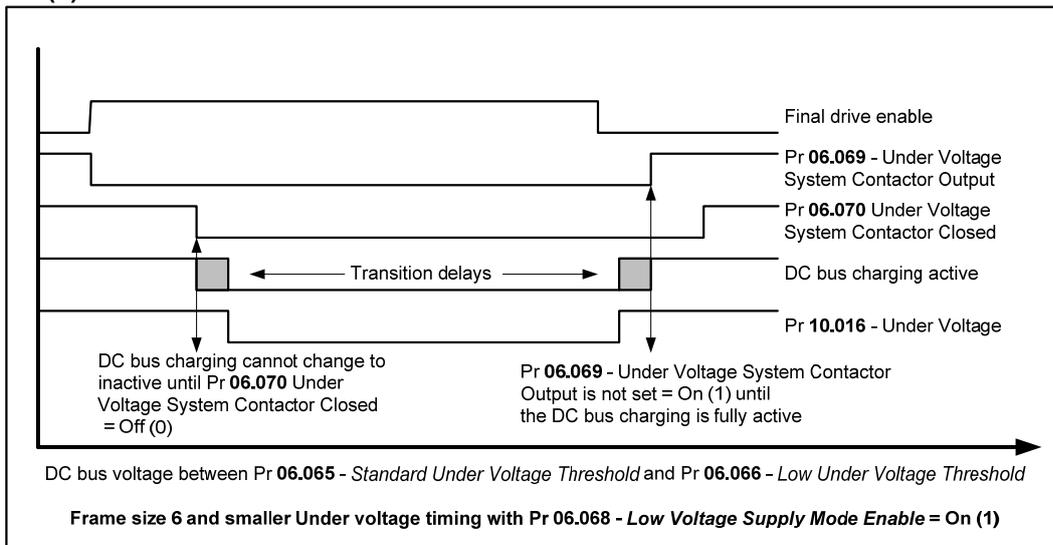
2. If Pr **05.005** - *DC Bus Voltage* is above Pr **06.066** - *Low Under Voltage Threshold* , but below Pr **06.065** - *Standard Under Voltage Threshold*, there are two possible states depending on whether the Final drive enable is Off (0) or On (1).
 - If the Final drive enable = Off (0) then Pr **10.016** - *Under Voltage* = On (1), the internal charge system is active and Pr **06.070** *Under Voltage System Contactor Closed* = On (1), so that the DC Bus can be charged by the AC supply.
 - If Final drive enable = On (1) then Pr **10.016** - *Under Voltage* = Off (0) and the internal charge system is inactive so that the drive can RUN from the Low voltage DC supply. Pr **06.069** - *Under Voltage System Contactor Output* = Off (0), so that it is not possible for the AC supply to charge the DC Bus.
3. If Pr **05.005** - *DC Bus Voltage* is above Pr **06.065** - *Standard Under Voltage Threshold* then Pr **10.016** - *Under Voltage* = Off (0) and Pr **06.070** *Under Voltage System Contactor Closed* = On (1) so the drive can RUN from the AC supply.
4. If Pr **05.005** - *DC Bus Voltage* subsequently falls below the Pr **06.065** - *Standard Under Voltage Threshold* and the Final drive enable = On (1), the drive can continue to RUN, but Pr **06.070** *Under Voltage System Contactor Closed* is set to Off (0) to open the AC supply contactor. The DC Bus voltage will fall until it reaches the Low voltage DC supply level. This gives a smooth changeover to the Low voltage DC supply without stopping the motor.

To ensure that the DC Bus charge system is in the correct state to protect the drive the following additional restrictions are applied,

1. The DC Bus charge system cannot change to the inactive state (i.e. internal shorting contactor closed) unless the DC Bus voltage is above Pr **06.065** - *Standard Under Voltage Threshold*, Pr **06.070** *Under Voltage System Contactor Closed* = Off (0). This is shown in the following diagram which shows the drive operation when the DC Bus voltage is between the Pr **06.065** - *Standard Under Voltage Threshold* and the Pr **06.066** - *Low Under Voltage Threshold* . When the Final drive enable becomes active the external contactor is opened to disconnect the AC supply because the drive is intended to run from the Low voltage DC supply. The DC Bus charge system should not be deactivated until the external contactor is opened because it is providing protection against surge currents due to the AC supply being re-applied. Once it is open the DC Bus charge system is deactivated (shorting contactor closed) and the drive can RUN. A side effect of this additional condition occurs when the DC Bus voltage falls and crosses the Pr **06.065** - *Standard Under Voltage Threshold* when the drive is running. There should be a smooth transition, but the delay between disabling the external contactor Pr **06.069** - *Under Voltage System Contactor Output* = Off (0) and confirmation of this Pr **06.070** *Under Voltage System Contactor Closed* = Off (0) when the DC Bus voltage crosses the threshold this will cause the DC Bus charge system to activate transiently giving a period with Pr **10.016** - *Under Voltage* = On (1). To prevent this problem the indication that the DC Bus voltage has fallen and crossed Pr **06.065** - *Standard Under Voltage Threshold* is delayed by 200 ms.
2. Pr **06.069** - *Under Voltage System Contactor Output* = Off (0) is not set to On (1) until the DC Bus charge system is fully active (shorting contactor is open) because the DC Bus charge system is required to prevent current surges from the power supply being applied. This is also shown in the diagram following.

The following diagram shows how the above restrictions are applied to the system timing when Pr **06.066** - *Low Under Voltage Threshold* \leq Pr **05.005** - *DC Bus Voltage*.

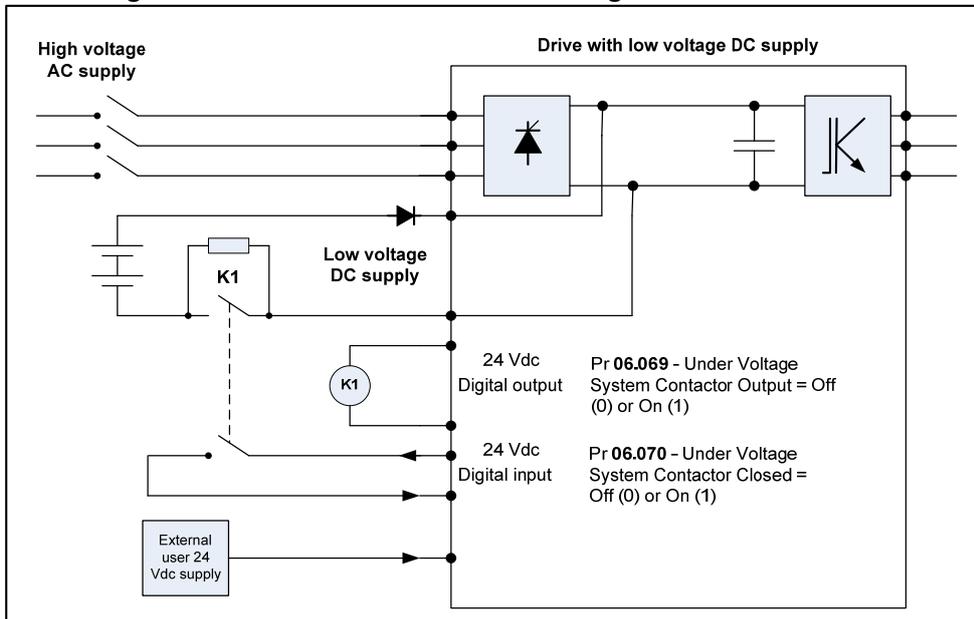
Drive frame sizes 3 to 6 under voltage timing, Pr 06.068 - Low Voltage Supply Mode Enable = On (1)



Low voltage mode drive frame size 7 and larger, Pr 06.068 - Low Voltage Supply Mode Enable = On (1)

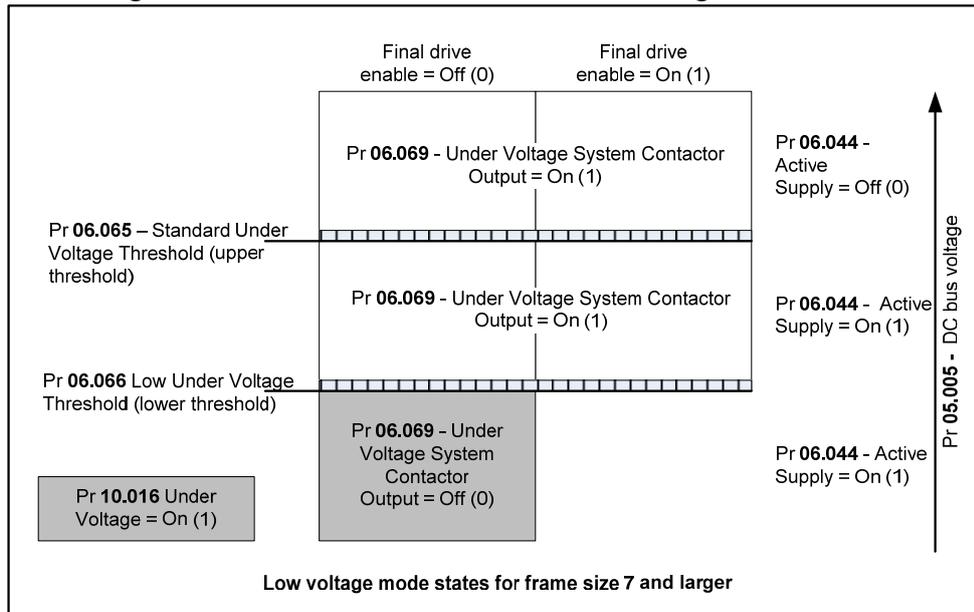
Low voltage mode is intended to provide a **smooth transition, without disabling the drive, from the AC supply to the Low voltage DC supply and vice versa**. The following diagram is a simple representation of the power circuit required. This does not include the necessary circuit protection or battery charger, etc.

Low voltage mode for drive frame size 7 and larger



The diagram overleaf shows the state of Pr 10.016 - Under Voltage and the control signal to the external contactor control and Pr 06.069 - Under Voltage System Contactor Output.

Low voltage mode states for drive frame size 7 and larger

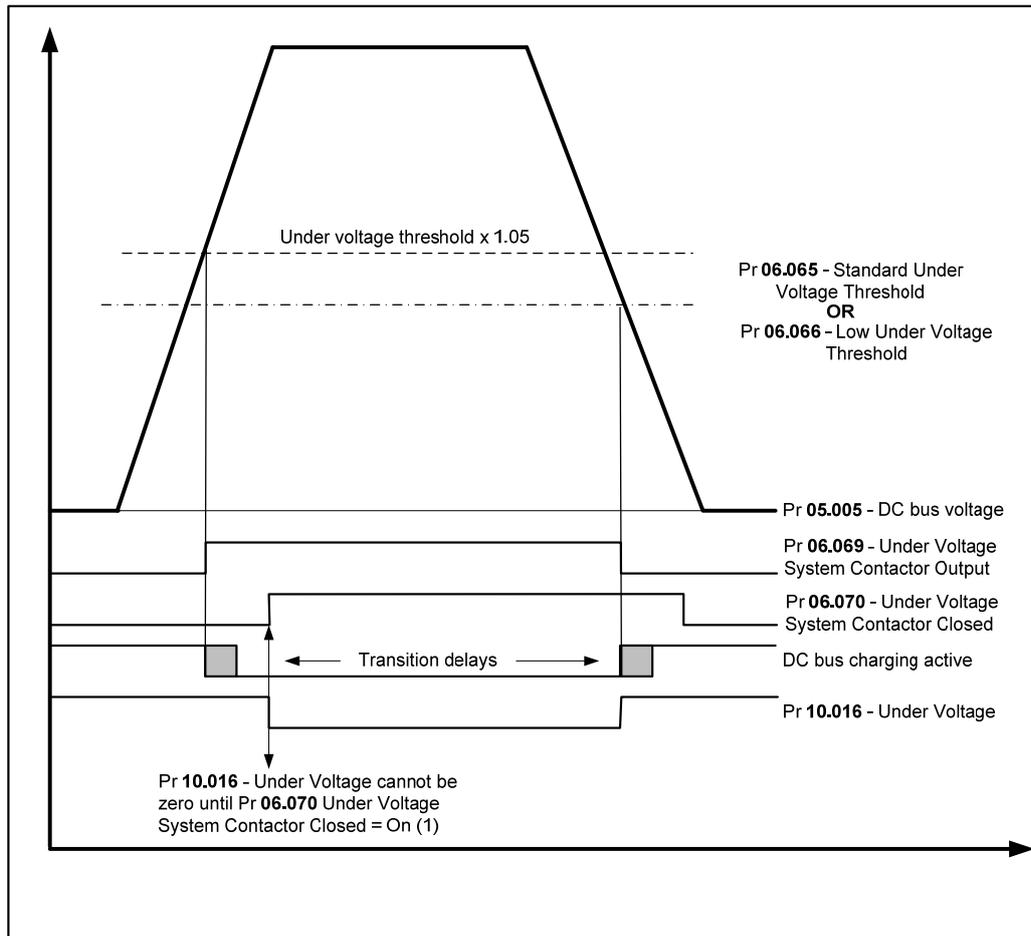


The low voltage supply system contactor is used to provide the charge system for the Low voltage DC supply. The charge system for the AC supply is provided by the half controlled thyristor input bridge within the drive. The system operates in a similar way to standard mode (i.e. Low voltage DC operation not enabled) with the following differences.

1. The thyristor charge system always uses a threshold voltage related to Pr **06.065** - *Standard Under Voltage Threshold*.
2. Pr **06.069** - *Under Voltage System Contact Output* is set to On (1) when the DC Bus voltage is above Pr **06.066** - *Low Under Voltage Threshold*.
3. Pr **10.016** - *Under Voltage* active cannot be Off (0) if Pr **06.070** *Under Voltage System Contactor Closed* = Off (0).

The following diagram shows how these differences apply to the system operation.

Drive frame size 7 and larger under voltage timing with Pr 06.068 - Low Voltage Supply Mode Enable = On (1)



Parameter	Pr 06.068 - Low Voltage Supply Mode Enable		
Short description	Set to 1 to enable the backup supply mode		
Minimum	Off (0)	Maximum	On (1)
Default	Off (0)	Units	Off (0) or On (1)
Type	1 Bit User Save	Update Rate	Background read
Display Format	Standard	Decimal Places	0
Coding	RW		

Pr 06.068 - Low Voltage Supply Mode Enable is used to select the low voltage supply mode. Note the under voltage system operates in different way when this parameter is enabled refer to Pr 06.065 - Standard Under Voltage Threshold for further information.

Pr 06.068 - Low Voltage Supply Mode Enable = On (1) a maximum is applied to Pr 06.066 - Low Under Voltage Threshold to prevent this from being increased above Pr 06.065 - Standard Under Voltage Threshold / 1.1 so that the 5 % hysteresis band on the Pr 06.066 - Low Under Voltage Threshold does not overlap the O11 Standard Under Voltage Threshold.

Refer to Pr 06.072 - User Supply Select and Pr 06.065 - Standard Under Voltage Threshold which provide details of when and how drive parameters can be saved, and when a PSU 24V trip could occur.

In Regen mode Pr 06.068 - Low Voltage Supply Mode Enable is not available, and so Low voltage DC supply mode cannot be selected.

Parameter	Pr 06.067 Low Under Voltage Threshold Select		
Short description	Set to On (1) to enable the low under voltage threshold in parameter O14		
Minimum	Off (0)	Maximum	On (1)
Default	Off (0)	Units	Off (0) or On (1)
Type	1 Bit User Save	Update Rate	Background read
Display Format	Standard	Decimal Places	0
Coding	RW		

If Pr **06.067** - *Low Under Voltage Threshold Select* = Off (0) then the under voltage threshold is defined by Pr **06.065** - *Standard Under Voltage Threshold*.

If Pr **06.067** - *Low Under Voltage Threshold Select* = On (1) then the under voltage threshold is defined by Pr **06.066** - *Low Under Voltage Threshold*.

Pr **06.065** - *Standard Under Voltage Threshold* is used to select the low under voltage threshold setup by the user for Low voltage DC operation in Pr **06.066** - *Low Under Voltage Threshold*.

It should be noted that the under voltage threshold used with a thyristor based charge system (drive frame sizes 6 and larger) is automatically saved within the rectifier units each time the value is changed as this will be required at the next power up before the drive control system is active. The value will be retained when it is changed up to 128 times, if any more changes are made between power up and power down the new value is not retained.

Also refer to Pr **06.072** - *User Supply Select* and Pr **06.065** - *Standard Under Voltage Threshold* which provide details of when and how drive parameters can be saved, and when a **PSU 24V** trip could occur.

Parameter	Pr 06.066 Low Under Voltage Threshold		
Short description	Defines the low under voltage threshold		
Minimum	-VM LOW UNDER VOLTS	Maximum	VM LOW UNDER VOLTS
Default	See exceptions below	Units	V
Type	16 Bit User Save	Update Rate	Background read
Display Format	Standard	Decimal Places	0
Coding	RW, VM, RA		

Pr **06.066** - *Low Under Voltage Threshold* is used to set the low under voltage threshold for Low voltage DC operation. The default settings for Pr **06.066** - *Low Under Voltage Threshold* is the same as the Pr **06.065** - *Standard Under Voltage Threshold*. Pr **06.067** *Low Under Voltage Threshold Select* is used to select Pr **06.066** - *Low Under Voltage Threshold*.

Drive model	Minimum Vdc	Pr 06.066 - Low Under Voltage Threshold	Pr 06.065 - Standard Under Voltage Threshold	Maximum Vdc	Over voltage Vdc
200 Vac	24	* 24 to 175	175	339	415
400 Vac	24	* 24 to 330	330	679	830
575 Vac	24	* 24 to 435	435	813	990
690 Vac	24	* 24 to 435	435	976	1190

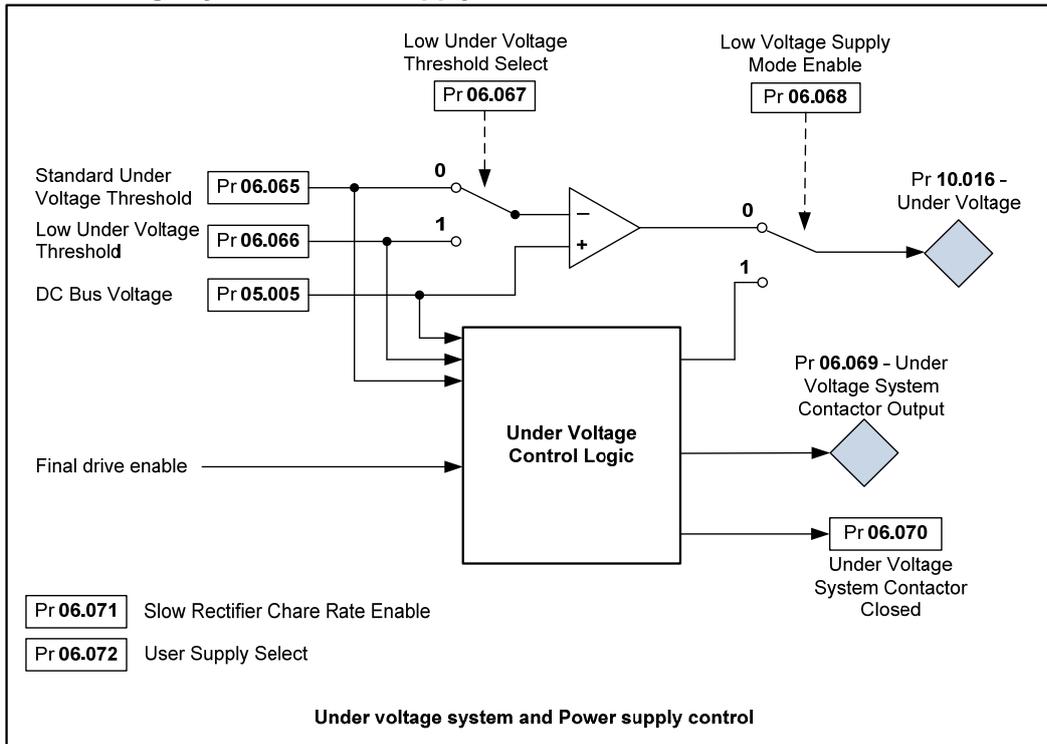
* For Low voltage DC operation Pr **06.066** - *Low Under Voltage Threshold* is setup based upon the external Low voltage DC power supply being used.

When Pr **06.068** - *Low Voltage Supply Mode Enable* = On (1) a maximum is applied to Pr **06.066** - *Low Under Voltage Threshold* to prevent this from being increased above Pr **06.065** - *Standard Under Voltage Threshold* / 1.1 so that the 5 % hysteresis band on the Pr **06.066** - *Low Under Voltage Threshold* does not overlap the Pr **06.065** - *Standard Under Voltage Threshold*.

Parameter	Pr 06.069 Under Voltage Contactor Close Output		
Short description	Low voltage DC supply control output		
Minimum	Off (0)	Maximum	On (1)
Default	Off (0)	Units	Off (0) or On (1)
Type	1 Bit Volatile	Update Rate	4ms write
Display Format	Standard	Decimal Places	0
Coding	RO, ND, NC, PT		

Refer to Pr 06.072 - User Supply Select and Pr 06.065 - Standard Under Voltage Threshold which provide details of how the contactor control system is carried out.

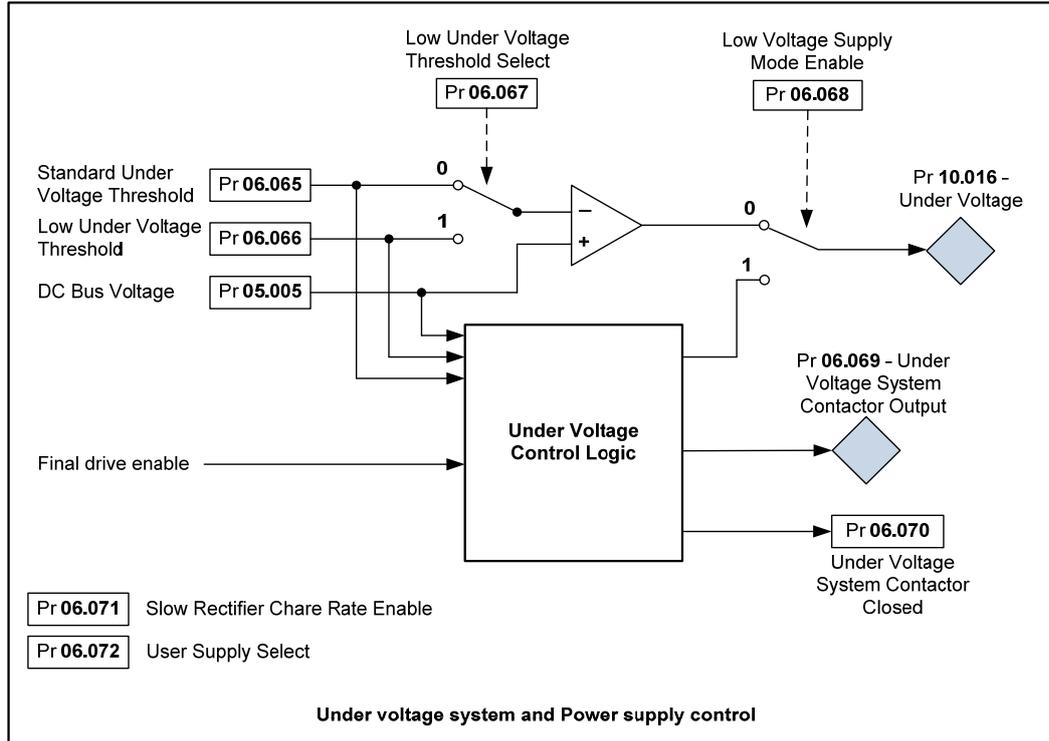
Under voltage system and AC supply control



Parameter	Pr 06.070 Under Voltage System Contactor Closed		
Short description	Low voltage DC supply external control input state		
Minimum	Off (0)	Maximum	On (1)
Default	Off (0)	Units	Off (0) or On (1)
Type	1 Bit Volatile	Update Rate	4ms read
Display Format	Standard	Decimal Places	0
Coding	RW		

Refer to Pr 06.072 - User Supply Select and Pr 06.065 - Standard Under Voltage Threshold which provide details of how the contactor control system is carried out.

Under voltage system and AC supply control



Parameter	Pr 06.071 Slow Rectifier Charge Rate Enable		
Short description	Enable to reduce the charge rate of the DC Bus and limit charging current		
Minimum	Off (0)	Maximum	On (1)
Default	Off (0)	Units	Off (0) or On (1)
Type	1 Bit User Save	Update Rate	Background read
Display Format	Standard	Decimal Places	0
Coding	RW		

For drive frame sizes 6 and larger which use a DC Bus charge system based on a half controlled thyristor input bridge the rate at which the drives DC Bus charges can be reduced by setting Pr **06.071 - Slow Rectifier Charge Rate Enable** = On (1).

Enabling the slow rectifier charging will limit the charging current which may be required for an external UPS or could also be required if there is additional capacitance added to the DC Bus of the drive which will also prevent input fuse failure during turn ON. The charging rate is extended by approximately 16 times when Pr **06.071 - Slow Rectifier Charge Rate Enable** = On (1).

It should be noted that the charging rate used with a thyristor based charge system (drive frame sizes 6 and larger) is automatically saved within the rectifier units each time the value is changed as this will be required at the next power up before the drive control system is active. The value will be retained when it is changed up to 128 times, if any more changes are made between power up and power down the new value is not retained.

Parameter	Pr 06.073 Braking IGBT Lower Threshold Pr 06.074 Braking IGBT Upper Threshold		
Short description	Defines the lowest level of the DC Bus voltage where the braking IGBT becomes active		
Minimum	-VM DC VOLTAGE SET	Maximum	VM DC VOLTAGE SET
Default	See exceptions below	Units	V
Type	16 Bit User Save	Update Rate	4ms read
Display Format	Standard	Decimal Places	0
Coding	RW, VM		

Pr **06.073** - *Braking IGBT Lower Threshold* defines the lowest level of DC Bus voltage where the braking IGBT will become active and Pr **06.074** - *Braking IGBT Upper Threshold* defines the level of DC Bus voltage where the braking IGBT will be ON continuously.

Drive model	Pr 06.074 Braking IGBT Lower Threshold	Pr 06.074 Braking IGBT Upper Threshold
200 Vac	390	390
400 Vac	780	780
575 Vac	930	930
690 Vac	1120	1120

When the braking IGBT is turned on it will remain ON for at least 1ms. The braking IGBT ON time is defined by the thresholds and the DC Bus voltage as given in the table below where;

L = Pr **06.073** - *Braking IGBT Lower Threshold*
U = Pr **06.074** - *Braking IGBT Upper Threshold*

DC Bus voltage level	ON time
Pr 05.005 - DC Bus Voltage	0 %
$L \leq \text{Pr } 05.005 - \text{DC Bus Voltage}$	$((\text{Pr } 05.005 - \text{DC Bus Voltage} - L) / (U - L)) \times 100 \%$
$\text{Pr } 05.005 - \text{DC Bus Voltage} \geq U$	100 %

As Pr **05.005** - *DC Bus Voltage* rises above the lower threshold Pr **06.073** - *Braking IGBT Lower Threshold* becomes active with an ON-OFF ratio of 1/100. As the voltage rises further the ON-OFF ratio increases until at Pr **06.074** - *Braking IGBT Upper Threshold* is on continuously.

If Pr **06.073** - *Braking IGBT Lower Threshold* \geq Pr **06.074** - *Braking IGBT Upper Threshold* then the braking IGBT is OFF when Pr **05.005** - *DC Bus Voltage* $<$ Pr **06.074** - *Braking IGBT Upper Threshold* and ON if Pr **05.005** - *DC Bus Voltage* \geq Pr **06.074** - *Braking IGBT Upper Threshold*.

The upper and lower voltage thresholds can be set up so that braking resistors in drives with parallel connected DC Bus connections will share the total braking load. Unless sharing between braking resistors is required the braking thresholds do not normally need to be adjusted. Care should be taken when reducing the thresholds because if either threshold is below the maximum value of the peak rectified AC supply voltage the braking resistor could take power from the supply.

The list below gives conditions that will disable the braking IGBT

1. Pr **06.074** - *Braking IGBT Upper Threshold* = 0
2. The drive is in the under voltage UV state.
3. A priority 1, 2 or 3 trip is active (see diagnostics and drive trip codes).
4. One of the following trips is active or would be active if another trip is not already active [OI Brake](#), [PSU](#), [Th](#), [Brake Res](#) or [Oht Inverter](#).
5. Pr **07.036** - *Percentage Of Drive Thermal Trip Level* = 100 %. This is an indication that some part of the drive is too hot.
6. [Brake R Too Hot](#) is active or the system has been set up to disable the braking IGBT based on the braking resistor temperature and the resistor is too hot (i.e. bit 2 of Pr **10.037** - *Action On Trip Detection* is set).

Parameter	Pr 06.075 Low Voltage Braking IGBT Threshold		
Short description	Defines the threshold used for low voltage braking		
Minimum	-VM DC VOLTAGE SET	Maximum	VM DC VOLTAGE SET
Default	0	Units	V
Type	16 Bit User Save	Update Rate	4ms read
Display Format	Standard	Decimal Places	0
Coding	RW, VM		

As default if Pr **06.076** - *Low Voltage Braking IGBT Threshold Select* = Off (0) the standard braking voltage thresholds are used in both parameter Pr **06.073** - *Braking IGBT Lower Threshold* and Pr **06.074** - *Braking IGBT Upper Threshold*.

If Pr **06.076** - *Low Voltage Braking IGBT Threshold Select* = On (1) then low voltage braking IGBT threshold is used. The braking IGBT is active (ON) with a minimum ON time of 1ms if the DC Bus voltage is above the level setup, or is inactive (OFF) if the DC Bus voltage is below this level.

Drive model	Pr 06.073 - <i>Braking IGBT Lower Threshold</i>	Pr 06.074 - <i>Braking IGBT Upper Threshold</i>	Pr 06.075- <i>Low voltage Brake IGBT Threshold</i>
200 Vac	390	390	390
400 Vac	780	780	780
575 Vac	930	930	930
690 Vac	1120	1120	1120

Low voltage braking voltage threshold is selected through parameter **D22** Low Voltage Braking IGBT Threshold Select

The list below details conditions which will disable the braking IGBT

1. Pr **06.076** - *Low Voltage Braking IGBT Threshold Select* = On (1) and Pr **06.075** - *Low Voltage Braking IGBT Threshold* = 0.
2. The drive is currently in the under voltage UV state.
3. A priority 1, 2 or 3 trip is active (refer to Pr **10.020** - *Trip 0*).
4. One of the following trips is active or would be active if another trip is not already active: [OI Brake](#), [PSU](#), [Th Brake Res](#) or [OHT Inverter](#)
5. Pr **07.036** - *Percentage Of Drive Thermal Trip Level* = 100 %. This is an indication that some part of the drive is too hot.
6. [Brake R Too Hot](#) is active or the system has been set up to disable the braking IGBT based on the braking resistor temperature and the resistor is too hot (i.e. bit 2 of Pr **10.037** - *Action On Trip Detection* is set).

Parameter	Pr 06.076 Low Voltage Braking IGBT Threshold Select		
Short description	Set to On (1) to enable low voltage IGBT braking threshold		
Minimum	Off (0)	Maximum	On (1)
Default	Off (0)	Units	Off (0) or On (1)
Type	1 Bit Volatile	Update Rate	4ms read
Display Format	Standard	Decimal Places	0
Coding	RW		

If Pr **06.076** - *Low Voltage Braking IGBT Threshold Select* = Off (0) the standard braking voltage thresholds are used in both Pr **06.073** - *Braking IGBT Lower Threshold* and Pr **06.074** - *Braking IGBT Upper Threshold*.

If Low Voltage Braking IGBT Threshold Select = On (1) then the low voltage braking IGBT threshold in Pr **06.075** - *Low Voltage Braking IGBT Threshold* is used. The braking IGBT is active (ON) with a minimum ON time of 1ms if the DC Bus voltage is above the level setup in Pr **06.075** - *Low Voltage Braking IGBT Threshold*, or is inactive (OFF) if the DC Bus voltage is below this level.

5 Electrical Installation

Many cable management features have been incorporated into the product to support both AC and DC power supply connections. This chapter details how to optimize these features and make the required connections to the drive.



Electric shock risk

The voltages present in the following locations can cause severe electric shock and may be lethal:

- AC power supply cables and connections
- DC power supply cables and connections
- Output motor cables and connections
- External braking resistor cables and connections
- Many internal parts of the drive, and any external option units

Unless otherwise indicated, control terminals are single insulated and must not be touched.



Isolation device

The AC and or DC supply must be disconnected from the drive using an approved isolation device before any cover is removed from the drive or before any servicing work is performed.



STOP function

The STOP function does not remove dangerous voltages from the drive, the motor, external braking resistor or any external option units.



Safe Torque Off (STO)

The Safe Torque Off (STO) function does not remove dangerous voltages from the drive, the motor, external braking resistor or any external option units.



Stored charge

The drive contains capacitors that remain charged to a potentially lethal voltage after the AC and or DC supply has been disconnected. If the drive has been energized, the AC and or DC supply must be isolated for at least ten minutes before work may continue. Normally, the capacitors are discharged by an internal resistor. Under certain, unusual fault conditions, it is possible that the capacitors may fail to discharge, or be prevented from being discharged by a voltage applied to the output terminals. If the drive has failed in a manner that causes the display to go blank immediately, it is possible the capacitors will not be discharged.

In this case, consult Emerson Industrial Automation or their authorized distributor.



Equipment supplied by plug and socket

Special attention must be given if the drive is installed in equipment which is connected to the AC supply by a plug and socket. The AC supply terminals of the drive are connected to the internal capacitors through rectifier diodes which are not intended to give safety isolation. If the plug terminals can be touched when the plug is disconnected from the socket, a means of automatically isolating the plug from the drive must be used (e.g. a latching relay).



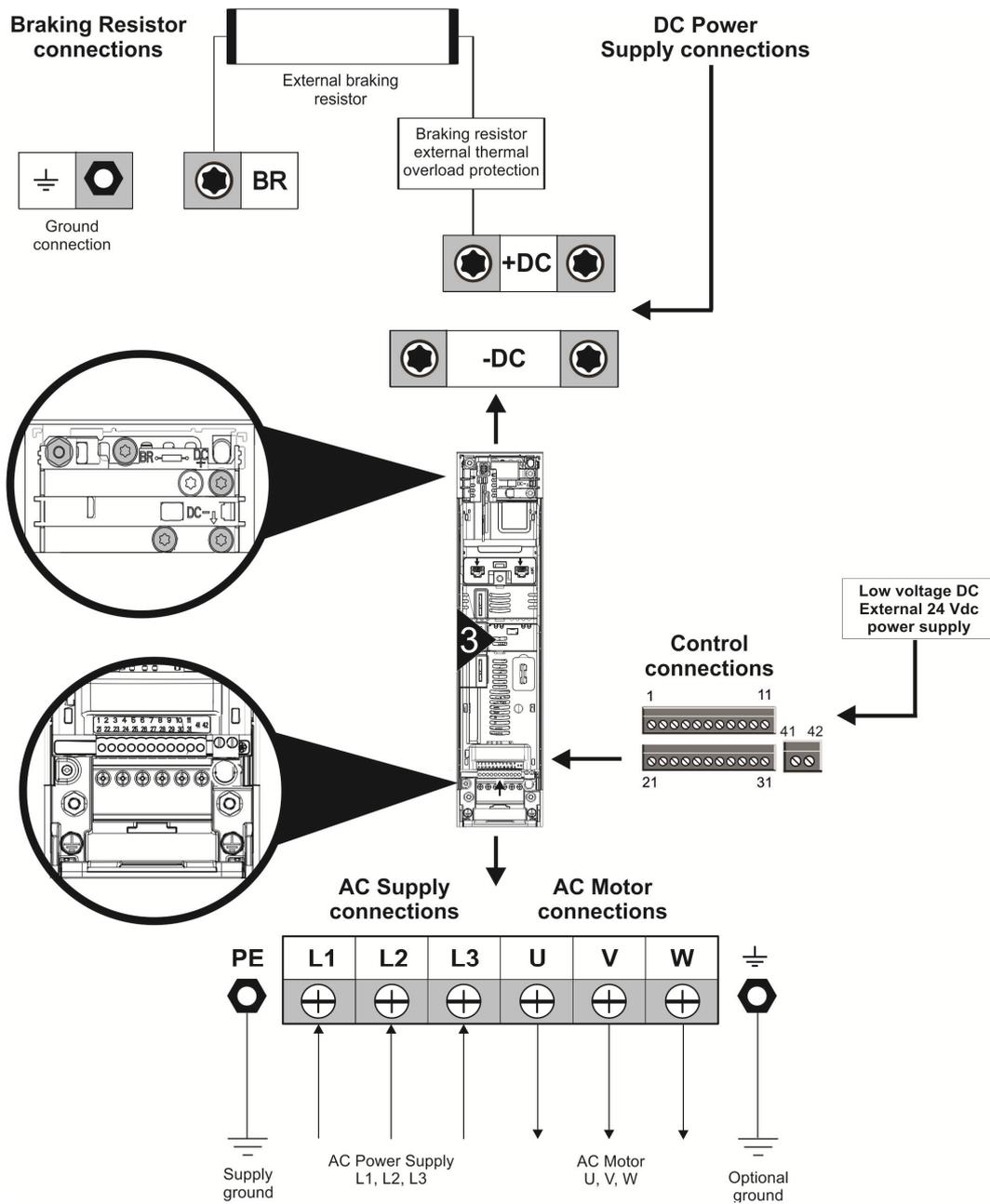
Permanent magnet motors

Permanent magnet motors generate electrical power if they are rotated, even when the supply to the drive is disconnected. If this occurs the drive will become energized through its motor terminals and connections.

If the motor load is capable of rotating the motor when the supply is disconnected, then the motor must be isolated from the drive before gaining access to any live parts.

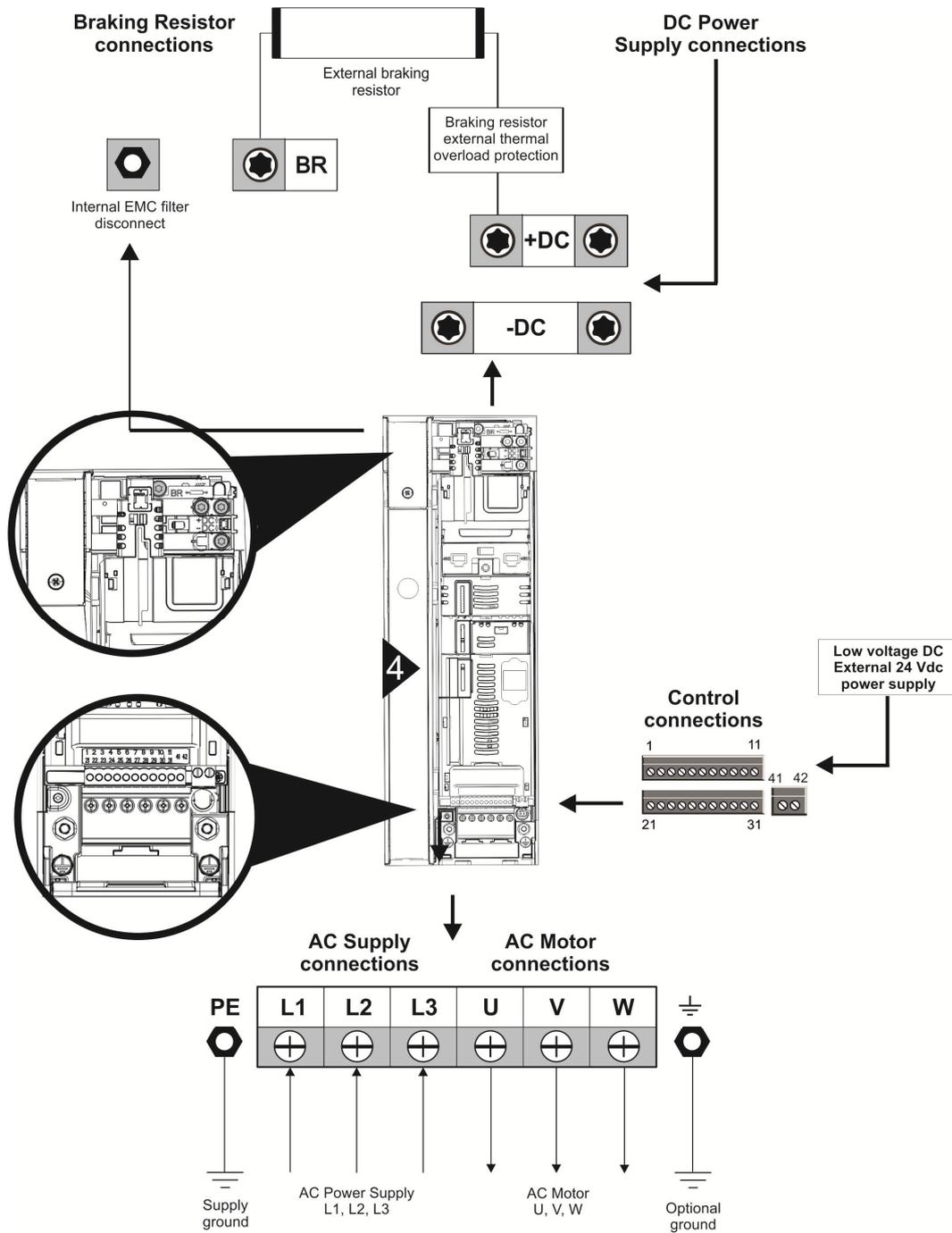
5.1 Power Connections

Drive frame size 3 power connections Internal DC Bus reactor

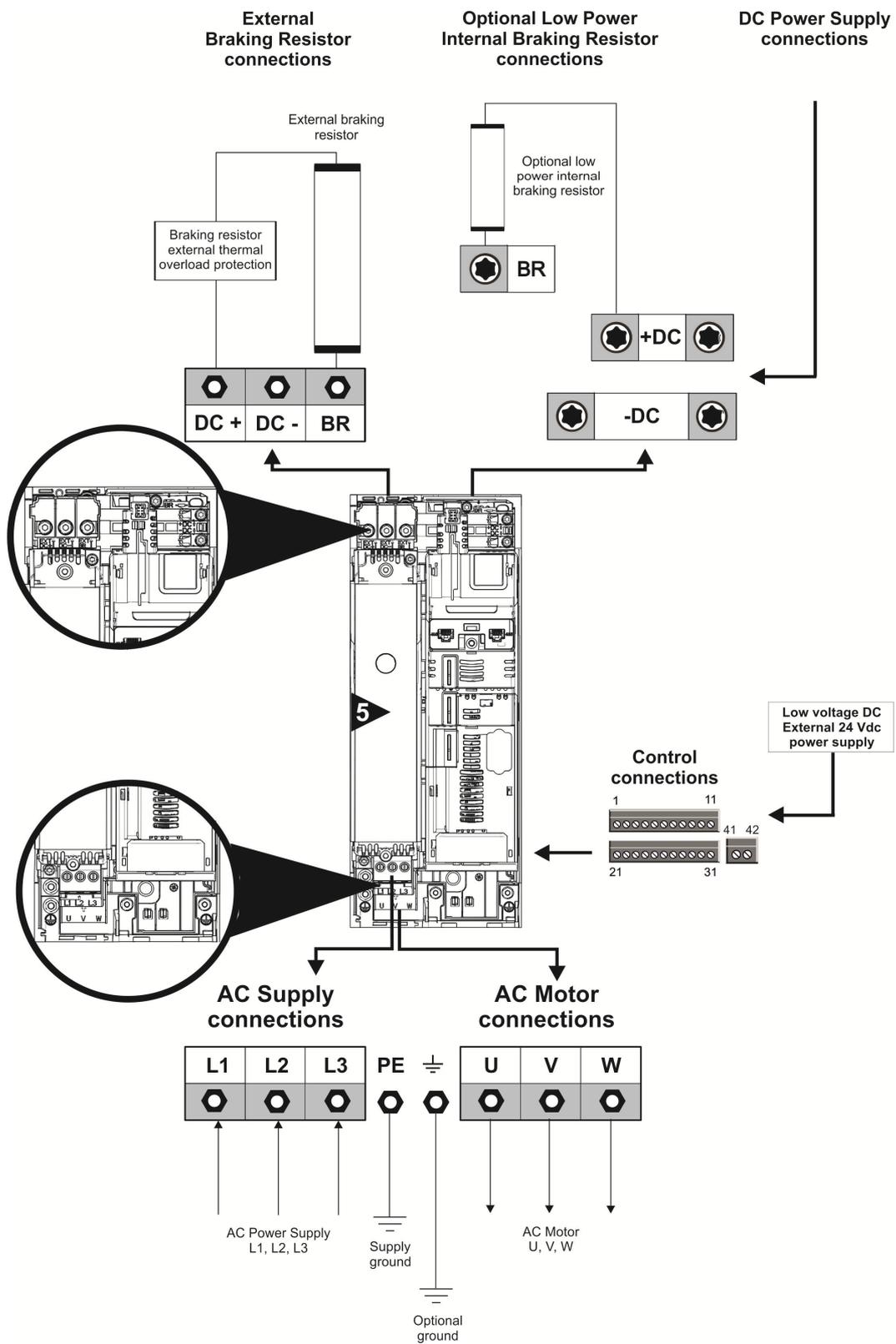


Drive frame size 4 power connections

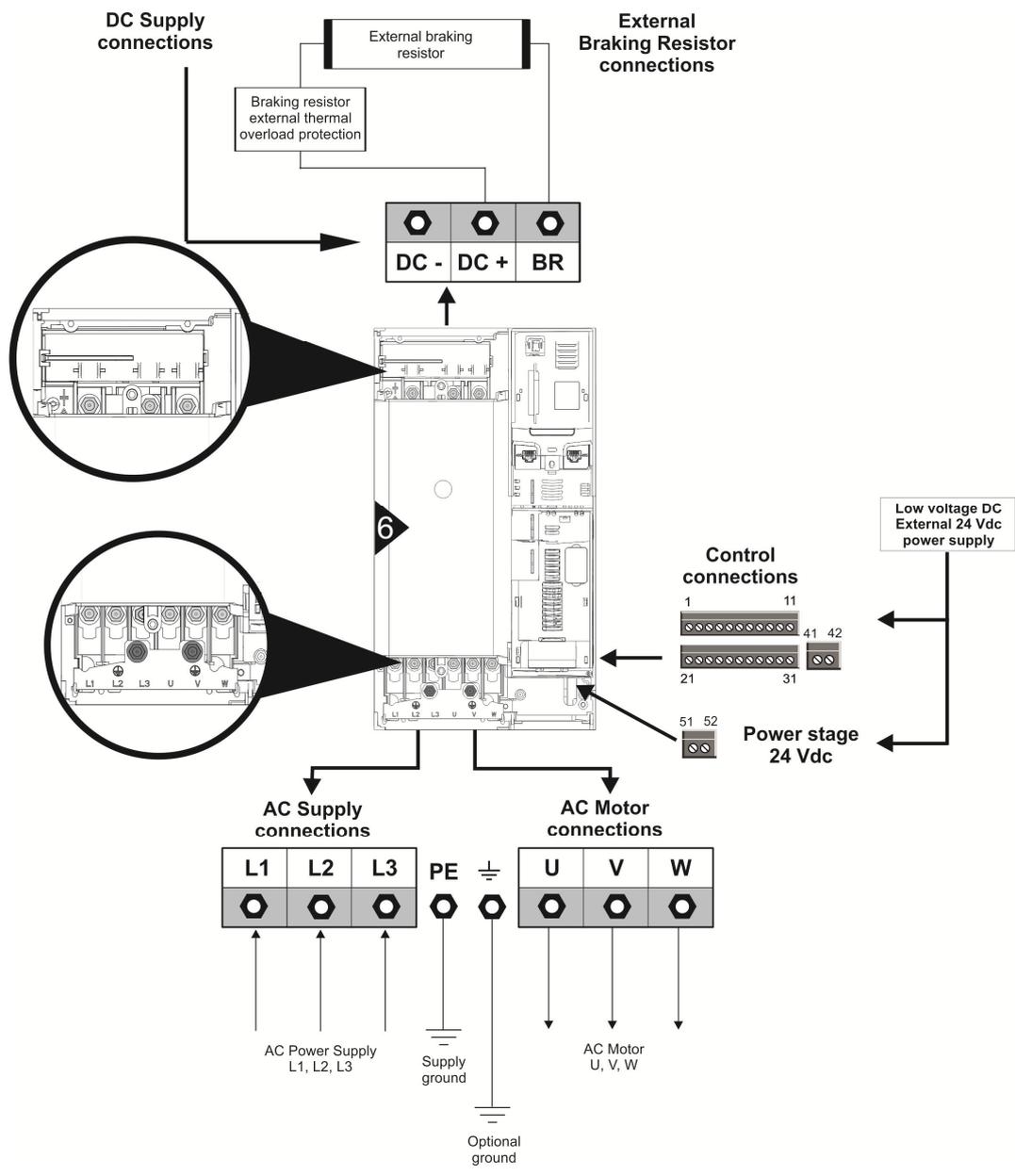
Internal DC Bus reactor



Drive frame size 5 power connections
Internal DC Bus reactor



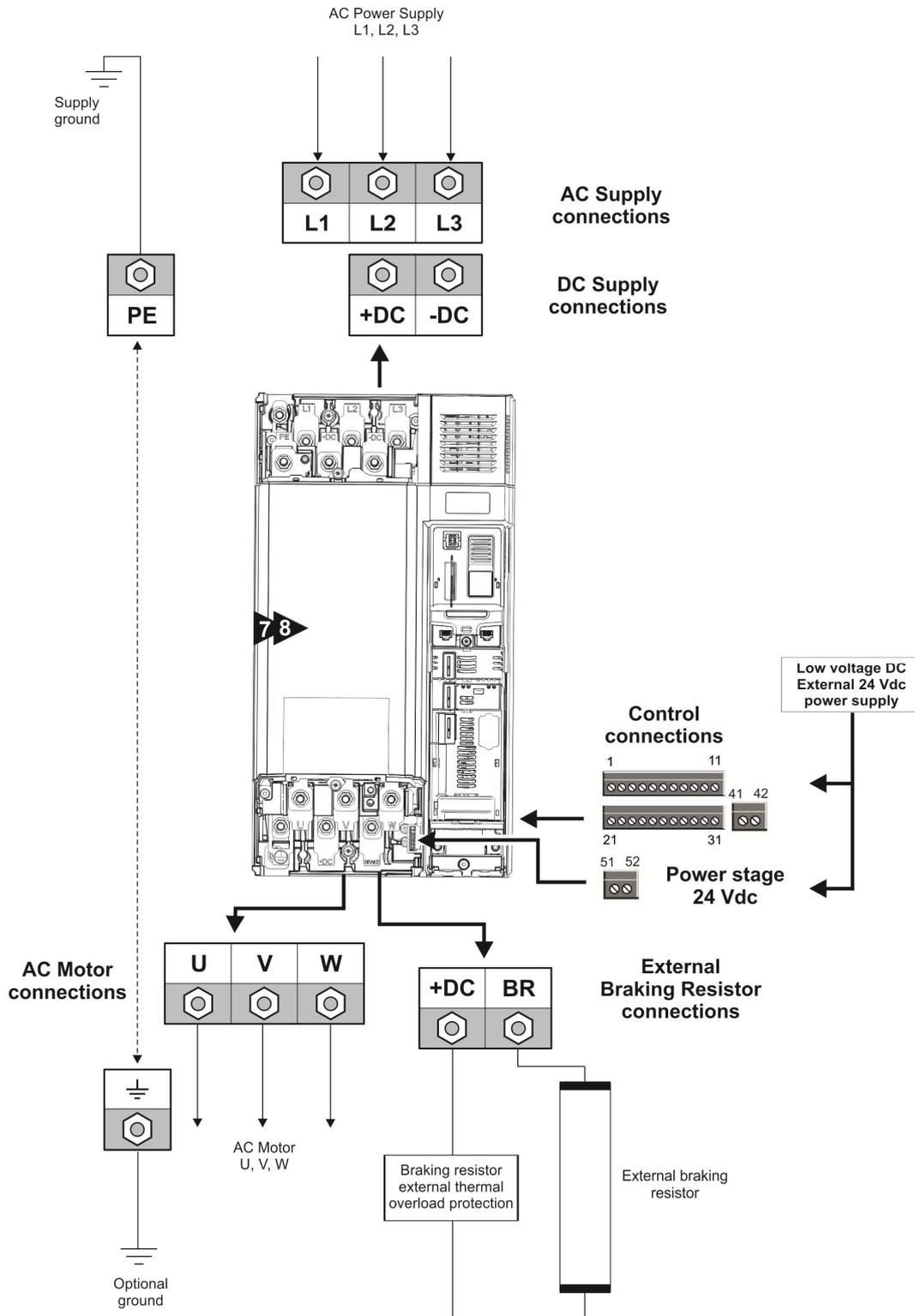
Drive frame size 6 power connections
 Internal DC Bus reactor



Drive frame size 7 and 8 power connections

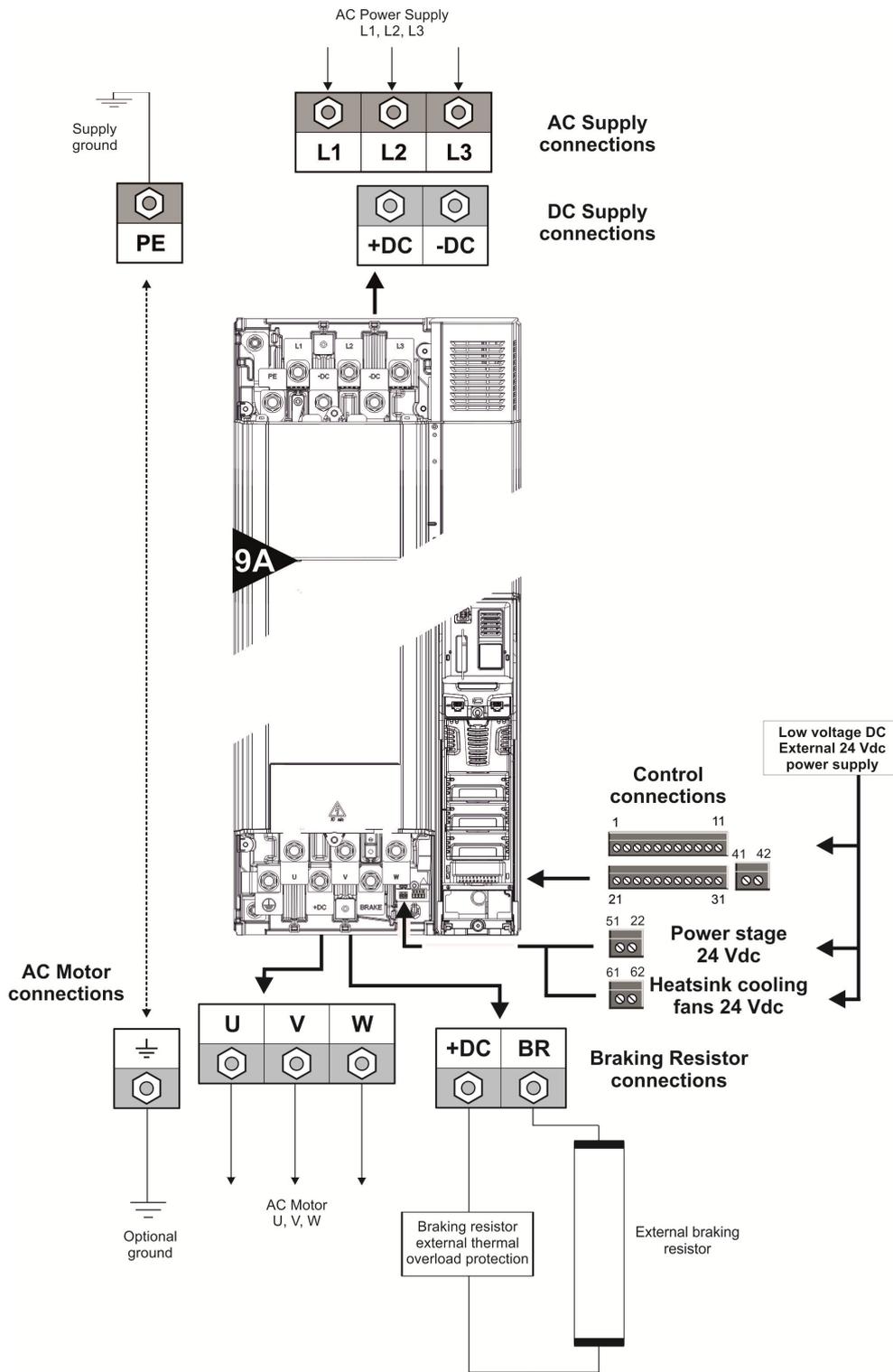
Drive frame 7 Internal DC Bus reactor

Drive frame 8 Internal AC line reactor



For drive frame sizes 7 and larger when operating with a single phase UPS the power supply should be connected to L1 and L2. L3 should be connected directly to L2 to avoid a supply loss fault, and to allow the half controlled rectifier to start up and limit the inrush current with the UPS.

Drive frame size 9A power connections
Internal AC line reactor

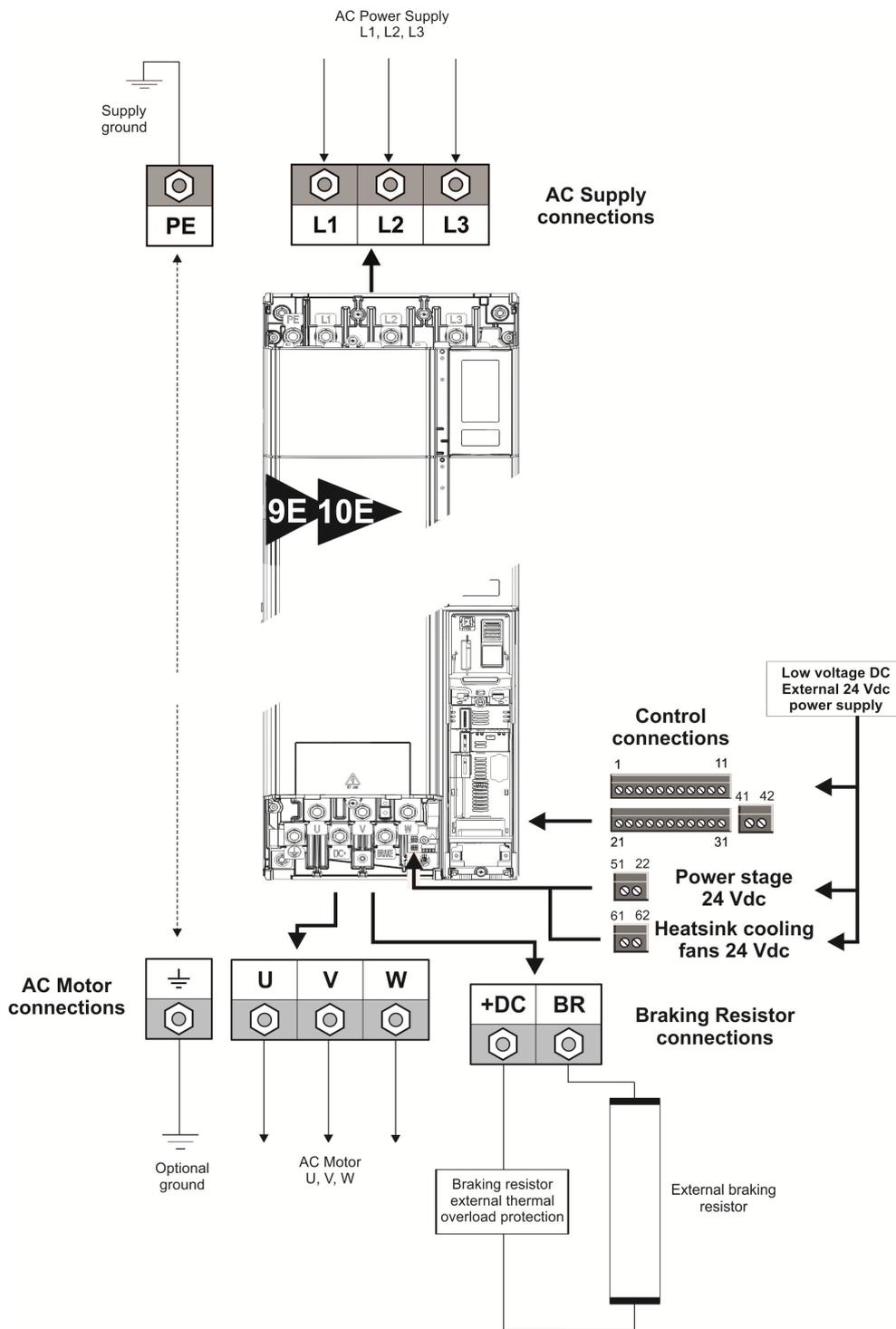


For drive frame sizes 7 and larger when operating with a single phase UPS the power supply should be connected to L1 and L2. L3 should be connected directly to L2 to avoid a supply loss fault, and to allow the half controlled rectifier to start up and limit the inrush current with the UPS.

Drive frame size 9E 10E power and control connections

External AC line reactor required

No direct DC supply connections

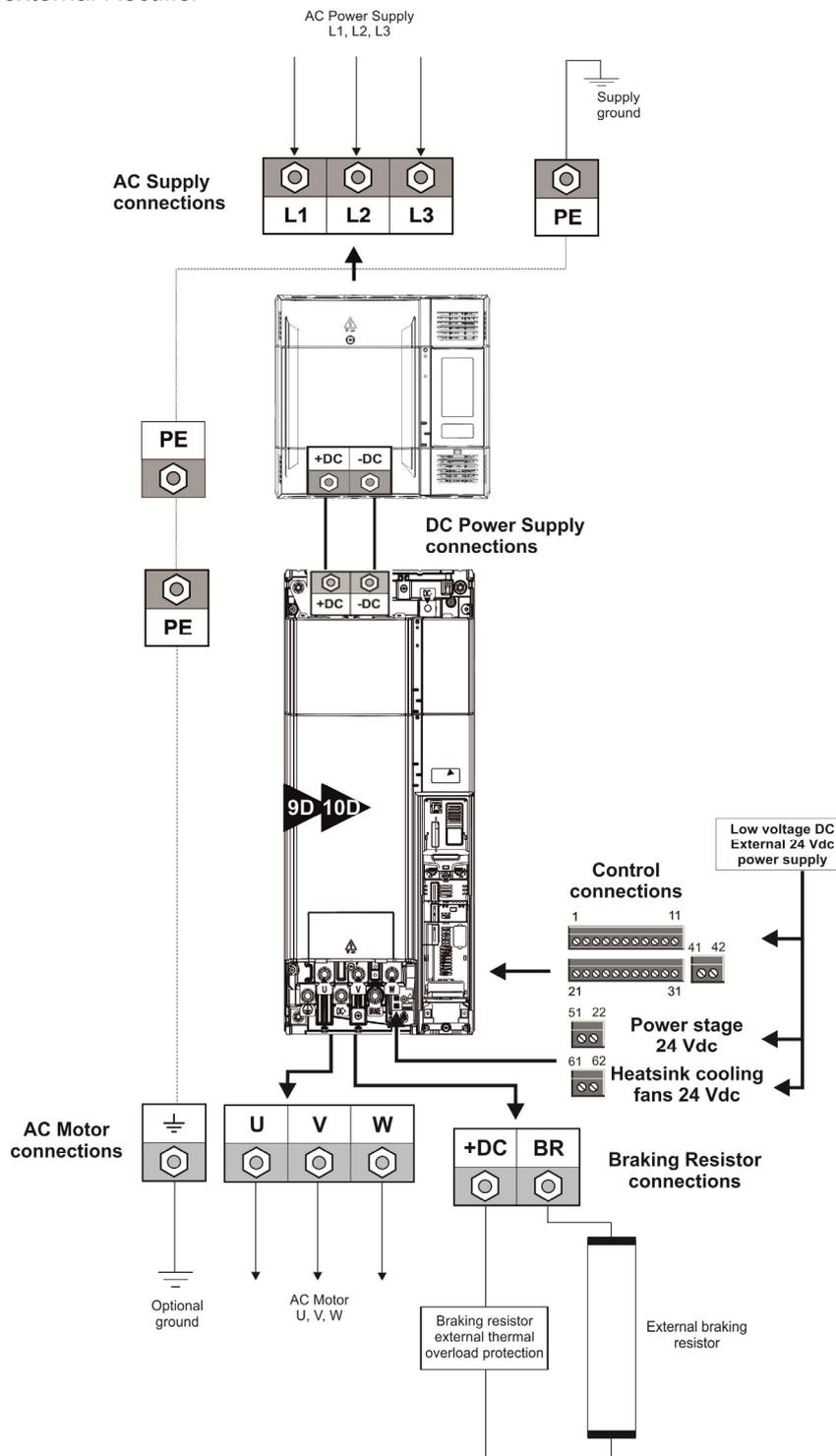


For drive frame sizes 7 and larger when operating with a single phase UPS the power supply should be connected to L1 and L2. L3 should be connected directly to L2 to avoid a supply loss fault, and to allow the half controlled rectifier to start up and limit the inrush current with the UPS.

Drive frame size 9D 10D power and control connections

External AC line reactor required

AC supply via external Rectifier



For drive frame sizes 7 and larger when operating with a single phase UPS the power supply should be connected to L1 and L2. L3 should be connected directly to L2 to avoid a supply loss fault, and to allow the half controlled rectifier to start up and limit the inrush current with the UPS.

5.2 AC Supply Requirements

Number of phases:	3
Maximum AC supply imbalance:	2 % negative phase sequence (equivalent to 3 % voltage imbalance between phases).
Frequency range:	45 to 66 Hz

Drive model	AC supply voltage rating
200 Vac	200 to 240 \pm 10 %
400 Vac	380 to 480 \pm 10 %
575 Vac	500 to 575 \pm 10 %
690 Vac	500 to 690 \pm 10 %

For UL compliance only, the maximum supply symmetrical fault current must be limited to 100 kA

All drives are suitable for use on any AC supply type i.e. TN-S, TN-C-S, TT and IT.

- AC supplies with a voltage up to 600 V may have grounding at any potential, i.e. neutral, centre or corner ("grounded delta")
- AC supplies with voltage above 600 V may not have corner grounding
- If an SI-Applications Plus module is installed in the drive, then the drive must not be used on a corner grounded or centre grounded delta supply if the supply voltage is above 300 V. If this is required, please contact the supplier of the drive for more information.
- Operation with IT (ungrounded) supplies: Special attention is required when using internal or external EMC filters with ungrounded supplies, because in the event of a ground (earth) fault in the motor circuit the drive may not trip and the filter could be over loaded. In this case, either the EMC filter must not be used (removed) or additional independent motor ground fault protection must be provided.

A ground fault in the AC supply has no effect in any case. If the motor must continue to run with a ground fault in its own circuit then an input isolating transformer must be provided and if an EMC filter is required it must be located in the primary circuit.

Drives are suitable for use on supplies of installation category III and lower, according to IEC60664-1. This means they may be connected permanently to the supply at its origin in a building, but for outdoor installation additional over-voltage suppression (transient voltage surge suppression) must be provided to reduce category IV to category III.

5.2.1 AC supplies requiring input line reactors

AC input line reactors reduce the risk of damage to the drive resulting from poor phase balance or severe disturbances on the supply network which can result from the following factors,

- Power factor correction equipment connected close to the drive.
- Large DC drives having no or inadequate line reactors connected to the supply.
- Across the line (DOL) started motor(s) connected to the supply such that when any of these motors are started, the voltage dip exceeds 20 %.

These supply disturbances can cause excessive peak currents to flow in the input power circuit of the drive causing nuisance tripping, or in extreme cases, failure of the drive.

When AC input line reactors are required, each drive must have its own reactor. Three individual reactors or a single three-phase reactor should be used.

Drive frame sizes 082001160 to 08600860 have internal AC line reactors so they do not require AC line reactors except for cases where they must comply with EN 12015:2014 Electromagnetic compatibility or where there is excessive phase unbalance or extreme supply conditions.

Drives of low power rating may also be susceptible to disturbance when connected to supplies with a high rated capacity. Line reactors are particularly recommended for use with the following drive models when one of the above factors exists, or when the supply capacity exceeds 175 kVA

03200050, 03200066, 03200080, 03200106,
03400025, 03400031, 03400045, 03400062

Note the current rating of the AC input line reactors should be as follows:

Current rating = Not less than the drives continuous Heavy Duty input current rating
Peak current rating = Not less than twice the drives continuous Heavy Duty input current rating

5.3 DC supplies

The following section provides guidance for the selection of a suitable DC supply for use with the drive. The working voltage range of the low voltage DC supply is as follows:

DC operating supply voltage range and levels						
Drive model	Min Vdc	Pr 06.066 - Low Under Voltage Threshold	Pr 06.065 - Standard Under Voltage Threshold	Standard supply loss level	Max Vdc	Over voltage trip
200 Vac	24	175	175	205	339	415
400 Vac	24	330	330	410	679	830
575 Vac	24	435	435	540	813	990
690 Vac	24	435	435	540	976	1190

For UL compliance only, the maximum supply symmetrical fault current must be limited to 100 kA

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

5.2.1 Low voltage DC supply types

The Low voltage DC supply may be connected to ground or left floating. In the event of a contactor sticking, high voltage would be present at the negative terminal of the drive. The instructions following ensure user safety in both cases.

5.2.2 Systems with an isolated DC supply

The 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 would have no fault path to ground.

In this case:

- The user 24 Vdc, +DC, -DC Bus terminals of the drive and DC terminals of the Low voltage DC supply must be protected from user contact.
- The Low voltage DC supply must be able to withstand mains potential with respect to ground and be suitable for use in an industrial environment (category 2 supplies).
- Cables rated for the voltage of the rectified AC supply must be used to connect the drive to the Low voltage DC supply.

In the event of a fault the user 24 Vdc, +DC, -DC Bus terminals of the drive and DC terminals of the Low Voltage DC source (including any wiring between) could be at a potentially lethal voltage.

5.2.3 Systems with a grounded DC supply

If the I^2t of the ground connection is not greater than that of the fuses used, then the external user 24 Vdc supply terminal and associated wiring could be at a potentially lethal voltage in the event of a fault.

The ground connection for the supply must be a high constant current connection with an I^2t rating greater than the fuses. 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 Low voltage DC supply path.

- The wiring from the drive to fuses must be protected to a voltage rating equal to or exceeding the rectified AC supply voltage.
- The wiring from the fuse to the supply must be rated correctly for the supply

5.2.4 UPS supply

Not all UPS sources are suitable for all applications. Their common disadvantage is a relatively short runtime with most data sheets stating runtime at half load. For some small consumer grade unit's half load runtime can typically be in the region of 13-20 minutes dependent upon selection.

Note the characteristic is not linear and at full load you may get only 1/3 of half-load runtime.

Note most suppliers of smaller UPS supplies publish their systems with a volt-ampere (VA) rating. A typical maximum real power in watts of such a UPS supply is only 60 % of its nameplate VA rating. So, when you are selecting a UPS supply, ensure the net wattage of your loads does not exceed 60 % of the UPS VA rating.

To estimate your system wattage you could add the load currents of all devices to be supplied from the UPS supply and multiply this by 120, giving the volt-amps rating, note where the loads have a near unity power factor, watts will be roughly the same as the VA rating..

For example, if the system including all loads consumes 10 A, then this equates to $10 \times 120 = 1200$ VA. In this example you could select a UPS supply rated for at least $1200 / 0.6 = 2000$ VA.

5.4 External user 24 Vdc supply requirements

For operation in Low voltage DC mode and backup operation of the drive an external user 24 Vdc supply is required. The 24 Vdc supply is used to supply power to the control circuit PCB for drive frame sizes 3 and larger it also supplies power to the Power Stage for drive frame sizes 6 and larger, and for drive frame sizes 9 and larger it supplies the drives heatsink cooling fans.

The location of the external user 24 Vdc supply connection to the drives frame sizes 3 to 10 can be seen in section 5.1 *Power Connections*.

The external user 24 Vdc supply connected to the drive for Low voltage DC mode and backup operation supports the following functions:

External user 24 Vdc supply

Function	Frame size 3 to 5	Frame size 6 to 8	Frame size 9 to 10
Control PCB Low voltage DC mode	Control terminal T.1 and T.2	Control terminal T.1 and T.2	Control terminal T.1 and T.2
Supplement Control PCB internal supply	Control terminal T.1 and T.2	Control terminal T.1 and T.2	Control terminal T.1 and T.2
Power Stage Low voltage DC mode	N/A	Control terminal T.51 and T.52	Control terminal T.51 and T.52
Heatsink fans Low voltage DC mode	N/A	N/A	Control terminal T.61 and T.62

The external user 24 Vdc supply connected to the Control PCB can be sequenced with the Low voltage DC supply or can remain connected and active during normal operation where the AC supply is powering the drive.

The external user 24 Vdc supply connected to the Power Stage can be sequenced with the Low voltage DC supply or can remain connected and active during normal operation where the AC supply is powering the drive.

The external user 24 Vdc supply connected to the Power Stage for the heatsink cooling fans can be sequenced with the Low voltage DC supply or can remain connected and active during normal operation where the AC supply is powering the drive.

The working voltage range of Low voltage DC mode is as follows:

External user 24 Vdc supply specification

24 Vdc supply requirements		
Nominal operating		24.0 Vdc
Minimum operating	(Frame 6) (Frame 3 to 5 & 7 to 10)	18.6 Vdc 19.2 Vdc
Maximum operating	(Frame 3 to 6) (Frame 7 to 10)	28.0 Vdc 30.0 Vdc (IEC), 26.0 Vdc (UL)
Minimum start-up voltage	(Frame 6) (Frame 3 to 5 & 7 to 10)	18.4 Vdc 21.6 Vdc
Maximum power	(Frame 3 to 6) (Frame 7 to 10)	40 W 60 W
Recommended fuse	(Frame 3 to 5) (Frame 6 to 10)	3 A, 50 Vdc 4 A, 50 Vdc

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

5.5 Ground Connections

The location of the ground connections for drive frame sizes 3 to 10 can be seen in Power connections. Electromechanical corrosion of grounding terminals is possible. Ensure that the grounding terminals are protected against corrosion i.e. such as caused by condensation

On drive frame size 3 and 4, the supply and motor ground connections are made using the M4 studs located either side of the drives main plug in power connector.

On drive frame size 5, the supply and motor ground connections are made using the M5 studs located close to the main plug in power connector.

On a drive frame size 6, the supply and motor ground connections are made using the M6 studs located close to the main plug in power connector.

On a drive frame size 7, the supply and motor ground connections are made using the M8 studs located close to the main plug in power connector.

On drive frame sizes 8, 9 and 10 drives the supply and motor ground connections are made using the M10 studs located close to both the AC Supply connections and the AC Motor connections.

Ground connection cables

Input phase conductor size	Minimum ground conductor size
$\leq 10 \text{ mm}^2$	Either 10 mm^2 or two conductors of the same cross-sectional area as the input phase conductor
$> 10 \text{ mm}^2$ and $\leq 16 \text{ mm}^2$	The same cross-sectional area as the input phase conductor
$> 16 \text{ mm}^2$ and $\leq 35 \text{ mm}^2$	16 mm^2
$> 35 \text{ mm}^2$	Half of the cross-sectional area of the input phase conductor

6 System Design

6.1 Low voltage DC supply

The external DC supply for Low voltage DC operation should be selected based upon the power requirements of the drive system. The Low voltage DC supply can be connected directly to the drives DC Bus connections with (a) Blocking diode (b) Fuse protection (c) Soft start circuit (drive frame sizes 7 and larger) and (d) Contactor for isolation and to allow correct transition from the AC supply to the Low voltage DC and vice versa.

When selecting the Low voltage DC supply the following points must be considered,

- Is the Low voltage DC supply required to supply power to the complete electrical panel which includes the drive, Elevator controller + any Auxiliary control
- Is the Low voltage DC supply required to supply full power to the motor and its mechanical brakes
- Is the Low voltage DC supply required to supply power to the lighting within the Elevator car along with the door controller
- How long will the Low voltage DC supply be required to power to the drive, is this required just for recovery operation, or is this required for continued operation. Consider the duration of operation and the lifetime of the Low voltage DC supply
 - The drive supports load measurement during start and or travel allowing the drive to provide an indication to the Elevator controller during Low voltage DC operation to travel in the direction of least load. This means the power rating of the Low voltage DC supply could be optimized
 - The drive supports protection for a UPS when used in Low voltage DC mode, this prevents the UPS from being overloaded during operation, preserving lifetime. This is typically used with the load measurement at start and or travel.
- The drive system mechanical design and shaft efficiency along with loading will have an influence on the required power and rating of the external Low voltage DC supply.

Therefore power consumption for selection of the Low voltage DC supply should include,

1. Power consumption of the drive and associated components, refer to the *User Guide*
2. Elevator controller and auxiliary control within the electrical panel
3. Other system auxiliary components within the drive system (car lighting, door controller ...)
4. Motor operation (Rescue operation or continuous operation)
5. Motor brake control, lifting and holding
6. Motor power consumption (consider operation in direction of load or against direction of load)

Blocking diode D1

A blocking diode should be fitted in the external connection from the external Low voltage DC supply to the DC Bus of the drive. This blocking diode is used to prevent energy from being returned back from the motor and drive into the external Low voltage DC supply during operation.

This blocking diode can be omitted if the external Low voltage DC supply has inbuilt protection to prevent this power flow back from the motor and drives DC Bus during operation.

Drive voltage rating	Diode type	Working current (A)	Maximum operating DC Bus voltage (Vdc)
200 V	Standard recovery	2 x Drive rated current	415
400 V			830
575 V			990
690 V			1190

A suitable supplier for the blocking diode can be Semikron™ with the SKKE isolated base module diode. The diode must be mounted on a suitable heatsink, refer to the manufacturer's data sheet for further details on selection and details of suitable heatsinks for mounting.

6.2 AC, DC supply protection

6.2.1 AC supply fusing (F1, F2, F3)

Fuses are always required on AC connections, and must be of IEC class gG or gR, or UL class J, for further detail refer to the *Drive User Guide* for recommended AC supply fuses.

The AC supply fuses detailed in the *Drive User Guide* are based on the maximum input current to the drive which can be affected by the supply voltage and supply impedance. The typical input current is given based on the highest level of continuous output current and provided to aid calculations for maximum power flow and power loss. The values of typical input current are also stated for a balanced AC supply. In the event of failure, the fusing will prevent fire by limiting the amount of energy allowed into the drive and take into consideration maximum peak accelerating current and continuous rms current.

6.2.2 UPS supply fusing

As with the AC supply fusing the UPS AC supply fuses are also always required on the AC supply connections, and should be of the correct IEC class gG or gR, or UL class J, refer to the UPS supplier user documentation for the recommended AC supply fuses.

The AC supply fuses used for the UPS must be the recommended fuses based upon the UPS rated current and voltage rating. In the event of failure, the fusing will prevent fire by limiting the amount of energy allowed into the UPS from a potential internal or output fault.

NOTE:

It is the responsibility of the system designer and installer to ensure the correct AC fuse protection is fitted for the UPS supply and connections to the drive.

6.2.3 Low voltage DC supply fusing (F4, F5)

For the Low voltage DC supply, DC fuses are required to protect both the Low voltage DC supply and the connections to the drive. Ensure the DC fuses are placed in both the “+” and “-” DC Bus connections to the drive. The fuse protection should be placed as close as possible to the drive to provide protection for both the Low voltage DC supply and the cable connections to the drive.

The DC fuse selection should be based on the current and voltage rating of the Low voltage DC supply taking into consideration the cable ratings for the connection from the Low voltage DC supply to the drive.

NOTE:

It is the responsibility of the system designer and installer to ensure the correct fuse protection is fitted for the Low voltage DC supply and connections to the drive.

6.2.4 External user 24 Vdc fusing (F6)

For operation in Low voltage DC mode and backup operation of the drive an external user 24 Vdc supply is required. The 24 Vdc supply is used to supply power to the control circuit PCB for drive frame sizes 3 and larger it also supplies power to the Power Stage for drive frame sizes 6 and larger, and for drive frame sizes 9 and larger it supplies the drives heatsink cooling fans.

Refer to section 5.4 for recommended fuse protection.

NOTE:

It is the responsibility of the system designer and installer to ensure the correct cables are selected for the connections from the external user 24 Vdc supply to the drive considering the recommended fuse protection.

6.3 External contactors

The drive in Low voltage DC mode uses external contactors for selection of the power supply, these power supplies being the AC supply, Low voltage DC supply, UPS supply and External user 24 Vdc supply.

The external contactors are also required to support the drives seem-less external contactor control for safe operation from the AC supply to the Low voltage DC supply, refer to System 3 and System 4 in section 6.5 following for further details and Pr **06.068**, Pr **06.069** and Pr **06.070**

External contactors

Ref	Description	Notes
K1	AC supply contactor + feedback	Contactor to connect and disconnect AC supply to the drive. Feedback on this contactor is required for seem-less control from the drive
K2	Low voltage DC supply contactor + feedback	Contactor to connect and disconnect Low voltage DC supply to the drive. Feedback on this contactor is required for seem-less control from the drive
	UPS supply contactor	Contactor to connect and disconnect UPS supply, controlled from Elevator controller, must be synchronized with the AC supply (K1) to the drive.
K3	External user 24 Vdc supply contactor	Optional contactor allows Low voltage DC to be disabled and external user 24 Vdc to be isolated. Should be synchronized with selection of Pr 06.072 , Pr 06.067 and Pr 06.068

The external contactor selection is not detailed in this document, selection of the external contactors are being dependent upon many factors such as the power supplies and the drive system specifications such as operating voltage and current and profile duty.

NOTE:

It is the responsibility of the system designer and installer to select the correct external contactors for Low voltage DC operation based upon the drive system and power supplies.

6.4 External soft start circuit

6.4.1 Drive frame sizes 3 to 6

When drive frame sizes 3 to 6 operate from either an AC or DC supply there is an internal soft start circuit with charging resistor which limits the inrush current when the power supply is connected. In this case no external soft start circuit is required for correct operation.

For correct operation with the drive frame sizes 3 to 6 when switching from the Low voltage DC supply to the AC supply the drive must go into an *Under Voltage state* which will enable the internal soft start circuit and limit the inrush current.

NOTE:

It is the responsibility of the system designer and installer to select the correct external contactors for Low voltage DC operation based upon the drive system and power supplies.

6.4.2 Drive frame sizes 7 and larger

When drive frame sizes 7 and larger operate from an AC supply the drives internal half controlled rectifier limits the inrush current when the supply is connected. This internal half controlled rectifier also limits the inrush current when operating with a UPS supply.

For operation with a Low voltage DC supply connected directly to the drives DC Bus an external soft start circuit is required to limit the inrush current. Failure to fit an external soft start circuit may result in permanent damage to the Drive, Low voltage DC supply and circuit. The external soft start circuit required should be selected based upon the external Low voltage DC supply.

NOTE:

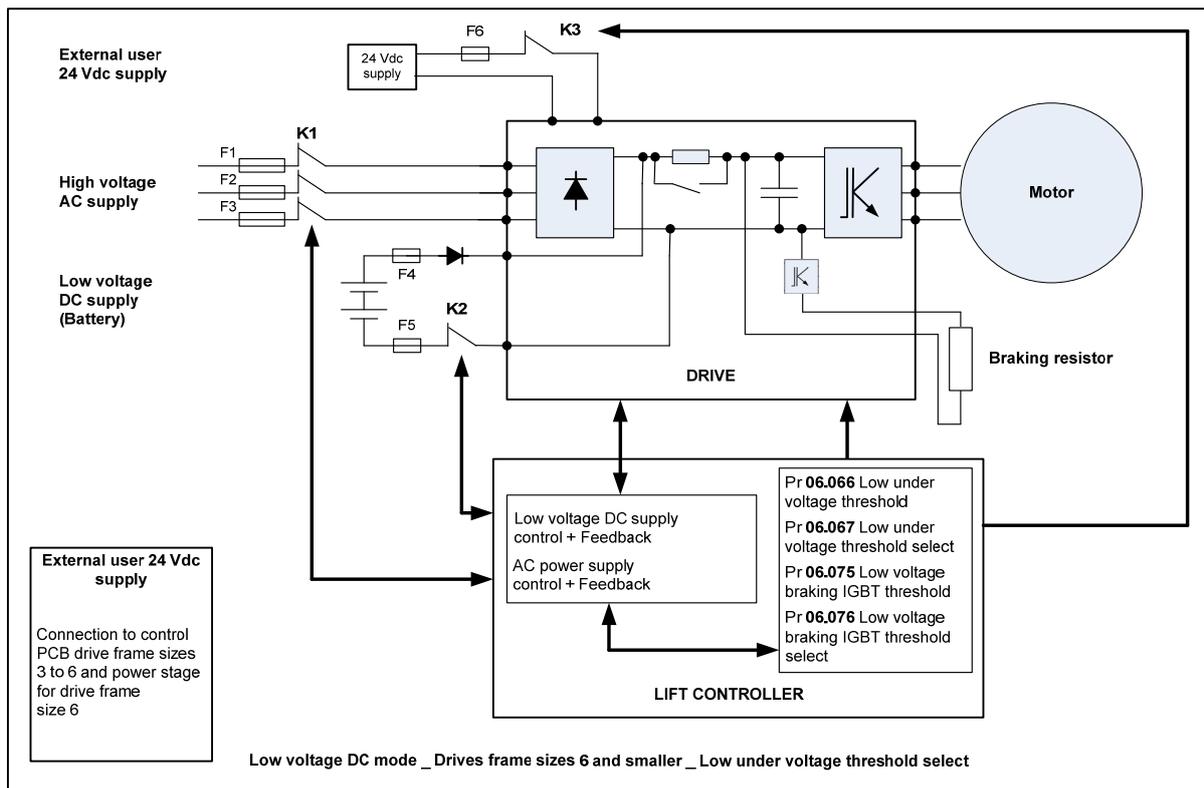
It is the responsibility of the system designer and installer to select the correct external soft start circuit for drive frame sizes 7 and larger for Low voltage DC operation where the Low voltage DC supply is connected directly to the drives DC Bus.

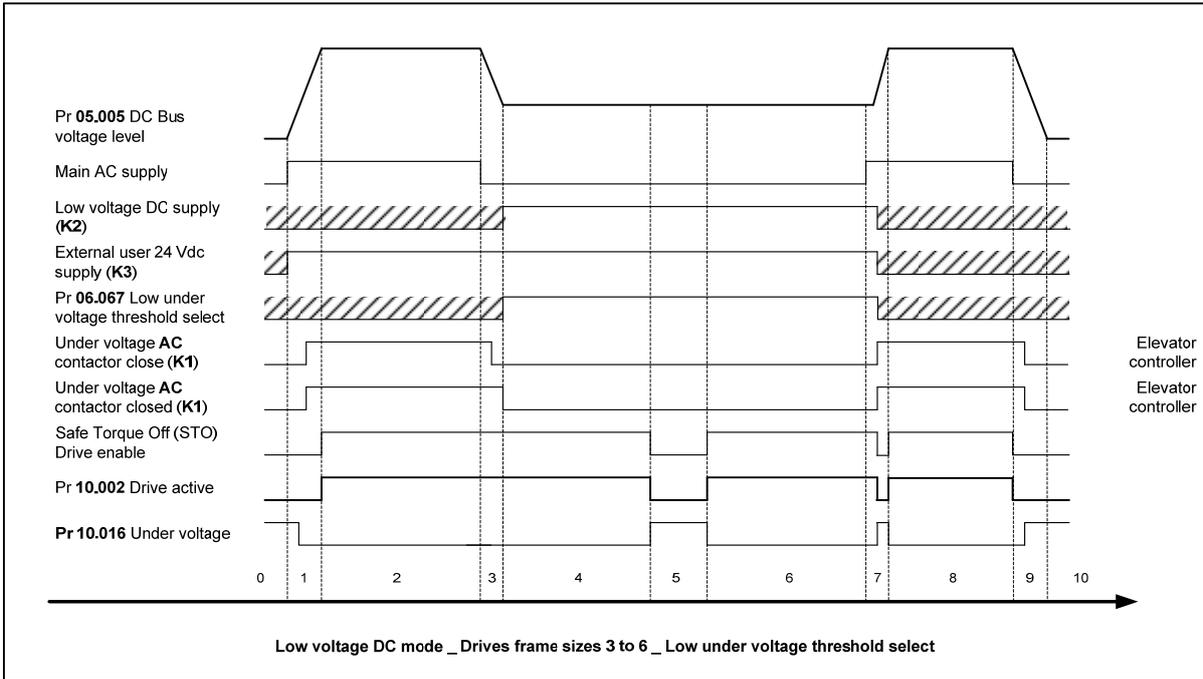
6.5 System configurations

The following diagrams show examples of different system configurations possible with the drive and Low voltage DC mode using either external batteries or an external UPS. The choice of system configuration depends on the drive frame size, Low voltage DC supply and preferred control during operation (drive managing seem-less control or Elevator controller managing transition from AC supply to Low voltage DC supply).

6.5.1 System 1 _ Low under voltage threshold select drive frame sizes 3 to 6 (Battery)

The following configuration can be used where the Elevator controller is managing the selection of both the AC supply and Low voltage DC supply. Soft start and inrush current is managed internally by the drive for connection of both the AC supply and Low voltage DC supply. Discharging time of the DC Bus when going from the Low voltage DC supply to the AC supply must be managed by the Elevator controller ensuring the drives internal soft start is active.



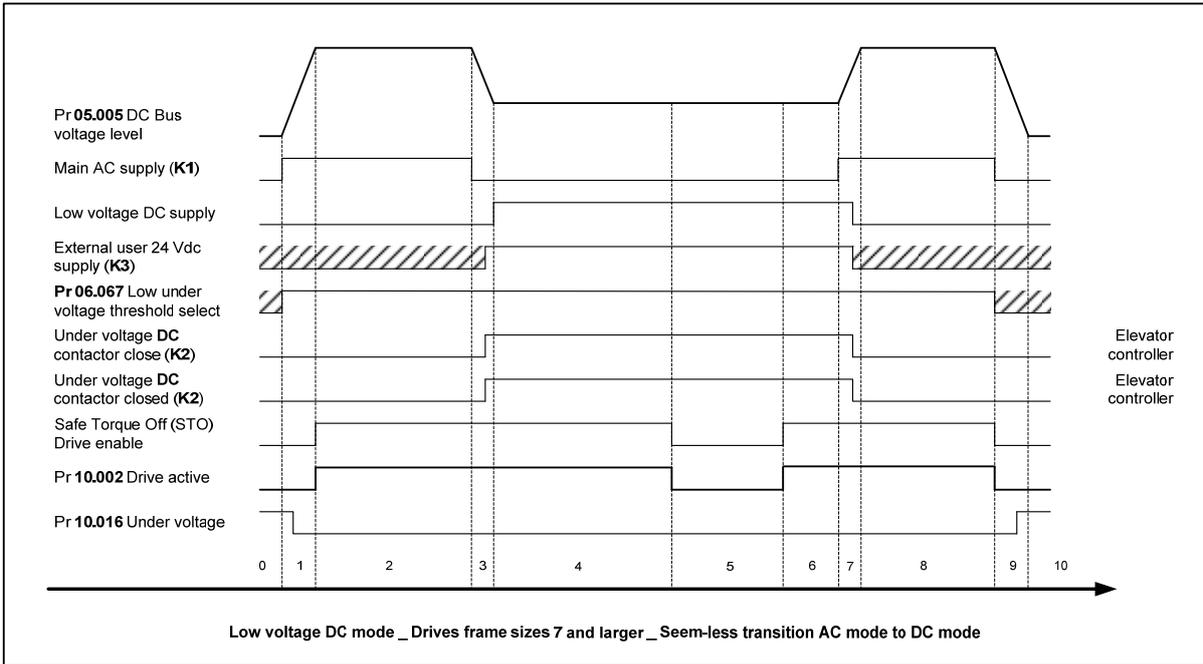
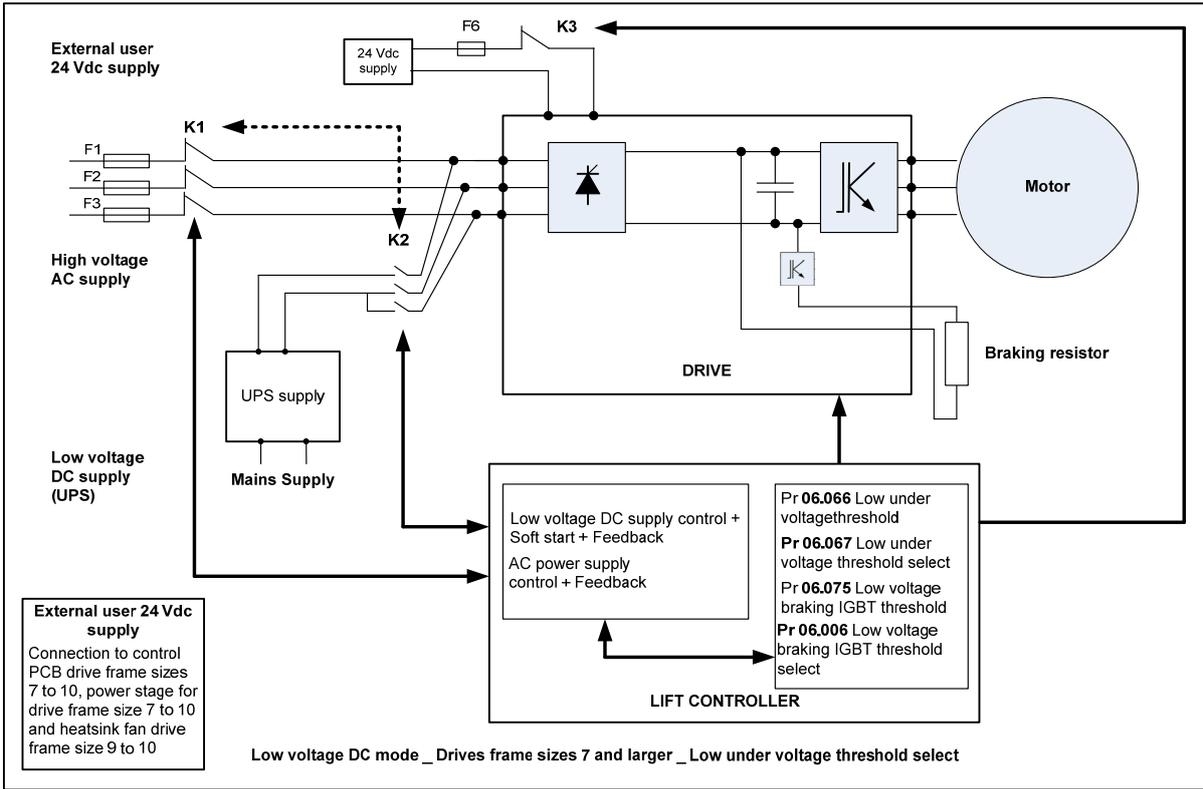


Low voltage mode can be enabled and disabled if required along with connection of the external user 24 Vdc supply by the Elevator controller following transition to the Low voltage DC supply either via the drives digital inputs and comms.

Pr 06.044	Active supply	Power supply status
Pr 06.065	Standard under voltage threshold	
Pr 06.066	Low under voltage threshold	
Pr 06.067	Low under voltage threshold select	Low voltage DC operation using Low under voltage threshold select
Pr 06.073	Braking IGBT lower threshold	Brake control voltage setup and low voltage braking select.
Pr 06.074	Braking IGBT upper threshold	
Pr 06.075	Low voltage braking IGBT threshold	
Pr 06.076	Low voltage braking IGBT threshold select	

6.5.2 System 2 _ Low under voltage threshold select drive frame sizes 7 to 10 (Battery)

The following configuration can be used where the Elevator controller is managing the selection of both the AC supply and Low voltage DC supply. Soft start and inrush current is managed internally by the drive for connection of the AC supply. An external soft start circuit is required for connection of the Low voltage DC supply.

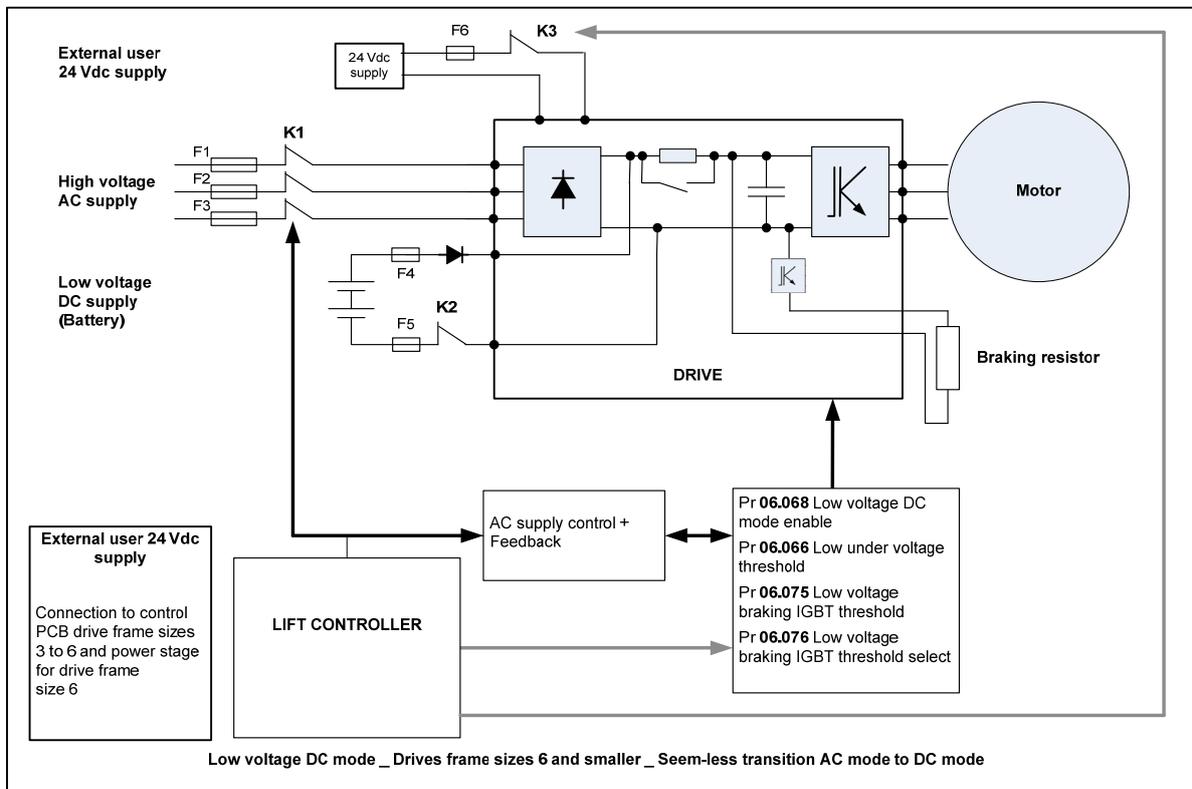


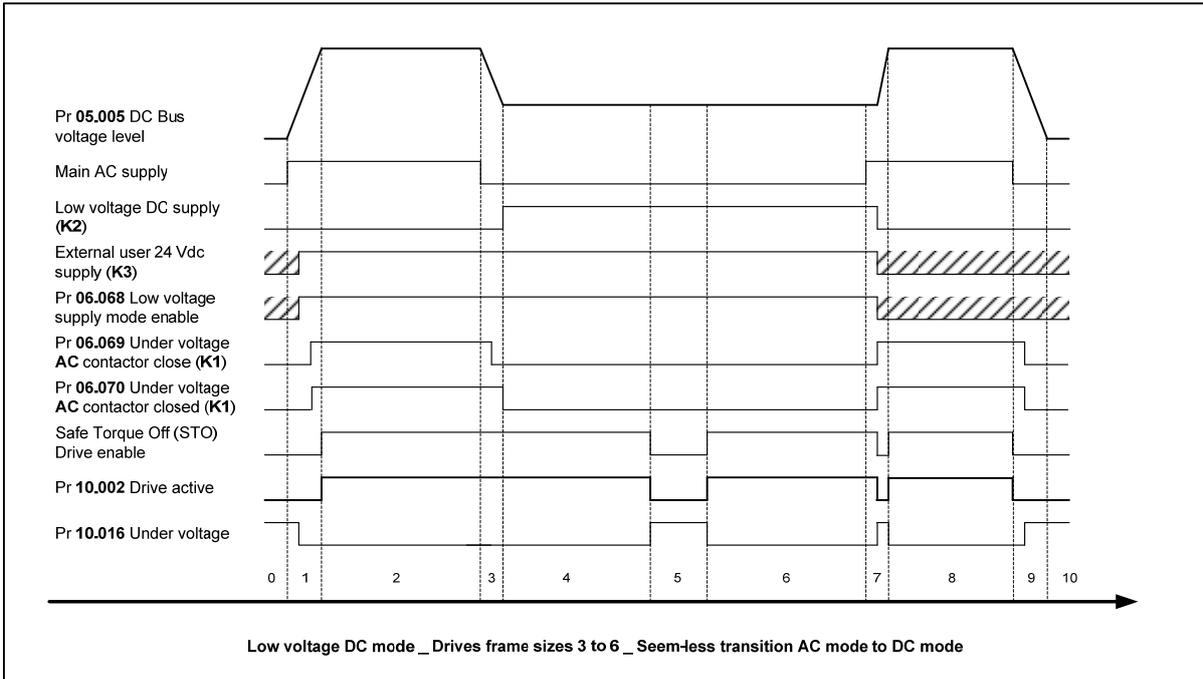
Low voltage mode can be enabled and disabled if required along with connection of the external user 24 Vdc supply by the Elevator controller following transition to the Low voltage DC supply either via the drives digital inputs and comms..

Pr 06.044	Active supply	Power supply status
Pr 06.065	Standard under voltage threshold	
Pr 06.066	Low under voltage threshold	
Pr 06.067	Low under voltage threshold select	Low voltage DC operation using Low under voltage threshold select
Pr 06.073	Braking IGBT lower threshold	Brake control voltage setup and low voltage braking select.
Pr 06.074	Braking IGBT upper threshold	
Pr 06.075	Low voltage braking IGBT threshold	
Pr 06.076	Low voltage braking IGBT threshold select	

6.5.3 System 3 _ Seem-less transition AC to DC mode drive frame sizes 3 to 6 (Battery)

The following configuration can be used where the drive is managing the selection of both the AC supply and Low voltage DC supply. Soft start and inrush current is managed internally by the drive for connection of both the AC supply and Low voltage DC supply. Discharging time of the DC Bus when going from the Low voltage DC supply to the AC supply is managed by the drive ensuring the internal softstart is active.



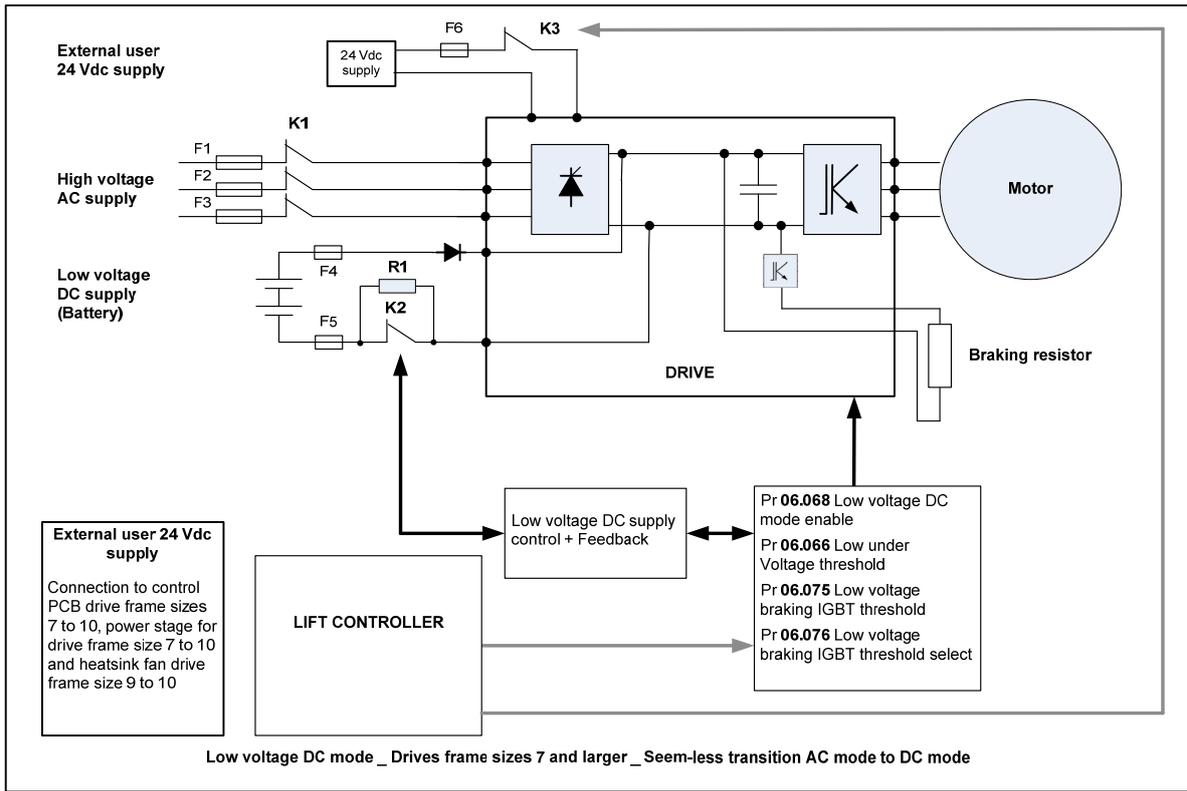


Low voltage mode can be enabled and disabled if required along with connection of the external user 24 Vdc supply by the Elevator controller following transition to the Low voltage DC supply either via the drives digital inputs and comms.

Pr 06.044	Active supply	Power supply status
Pr 06.065	Standard under voltage threshold	
Pr 06.066	Low under voltage threshold	
Pr 06.067	Low under voltage threshold select	Low voltage DC operation using Low under voltage threshold select
Pr 06.073	Braking IGBT lower threshold	Brake control voltage setup and low voltage braking select.
Pr 06.074	Braking IGBT upper threshold	
Pr 06.075	Low voltage braking IGBT threshold	
Pr 06.076	Low voltage braking IGBT threshold select	

6.5.4 System 4 _ Seem-less transition AC to DC mode drive frame sizes 7 to 10 (Battery)

The following configuration can be used where the drive is managing the selection of both the AC supply and Low voltage DC supply. Soft start and inrush current is managed internally by the drive for connection of the AC supply. An external soft start circuit is required for connection of the Low voltage DC supply.



Low voltage mode can be enabled and disabled if required along with connection of the external user 24 Vdc supply by the Elevator controller following transition to the Low voltage DC supply either via the drives digital inputs and comms..

Pr 06.044	Active supply	Power supply status
Pr 06.065	Standard under voltage threshold	
Pr 06.066	Low under voltage threshold	
Pr 06.067	Low under voltage threshold select	Low voltage DC operation using Low under voltage threshold select
Pr 06.073	Braking IGBT lower threshold	Brake control voltage setup and low voltage braking select.
Pr 06.074	Braking IGBT upper threshold	
Pr 06.075	Low voltage braking IGBT threshold	
Pr 06.076	Low voltage braking IGBT threshold select	

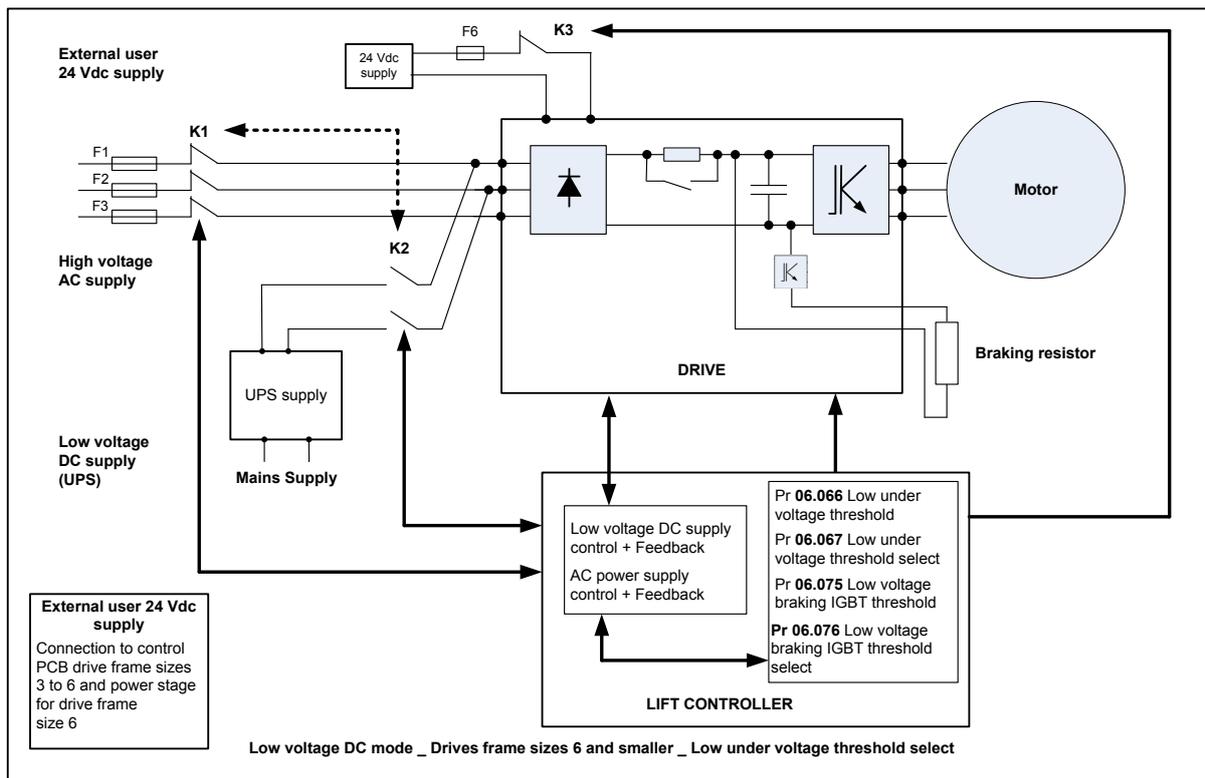
6.5.5 System 5

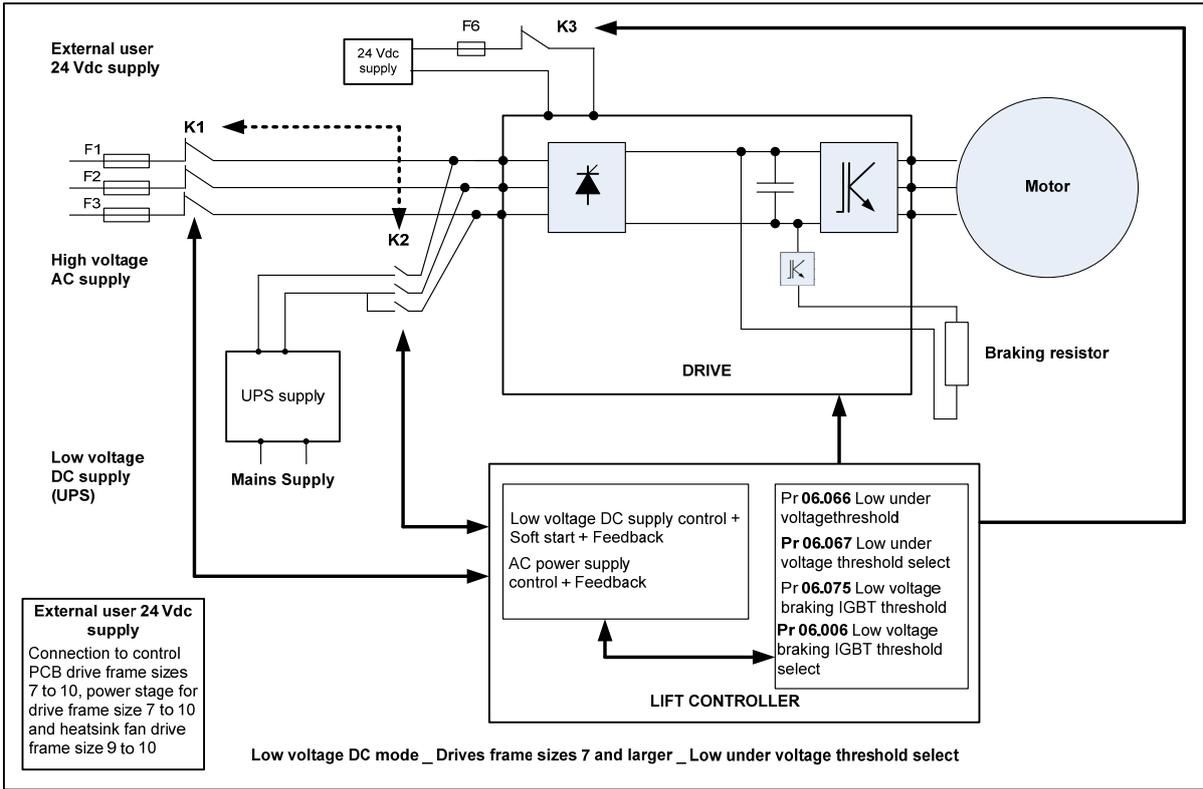
Low under voltage threshold select drive frame sizes 3 to 6 (UPS supply)

The following configuration can be used where the Elevator controller is managing the selection of both the AC supply and UPS supply. Soft start and inrush current is managed internally by the drive for connection of both the AC supply and UPS supply. Discharging time of the DC Bus when going from the Low voltage DC supply to the AC supply must be managed by the Elevator controller ensuring the drives internal soft start is active.

Low under voltage threshold select drive frame sizes 7 to 10 (UPS supply)

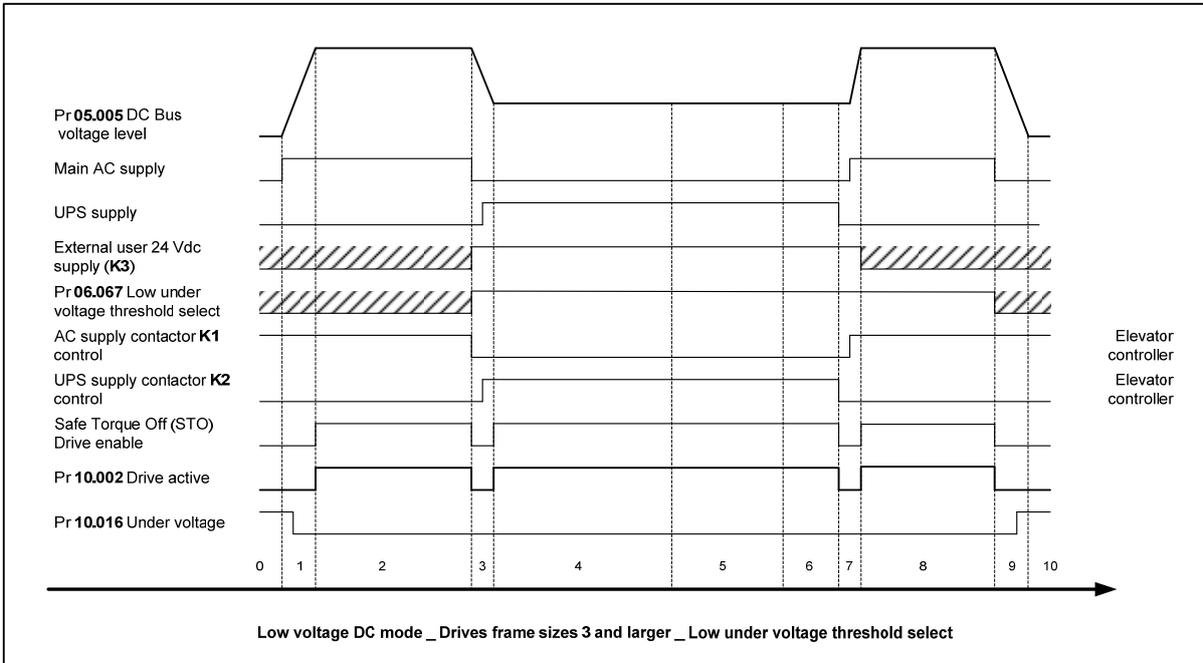
The following configuration can be used where the Elevator controller is managing the selection of both the AC supply and UPS supply. Soft start and inrush current is managed internally by the drive for connection of the AC supply and the UPS supply. To overcome rectifier phase loss trips L2 and L3 should be connected together and Pr **06.048** - *Phase Loss Input Detection Level* should be disabled.





NOTE:

For drive frame sizes 7 and larger as shown above, when operating with a single phase UPS the power supply should be connected to L1 and L2. Input L3 should be connected directly to L2 to avoid a supply loss fault, and to allow the half controlled rectifier to start up and limit the inrush current for operation with the single phase UPS.



Low voltage mode can be enabled and disabled if required along with connection of the external user 24 Vdc supply by the Elevator controller following transition to the UPS supply either via the drives digital inputs and comms.

Parameter	Description	Notes
Pr 06.044	Active supply	Power supply status
Pr 06.072	User supply select	External user 24 Vdc supply
Pr 06.065	Standard under voltage threshold	
Pr 06.066	Low under voltage threshold	
Pr 06.067	Low under voltage threshold select	Low voltage DC operation using Low under voltage threshold select
Pr 06.073	Braking IGBT lower threshold	Brake control voltage setup and low voltage braking select.
Pr 06.074	Braking IGBT upper threshold	
Pr 06.075	Low voltage braking IGBT threshold	
Pr 06.076	Low voltage braking IGBT threshold select	

6.6 Important considerations

- 1 Electrical connections and configuration can change for the different drive frame sizes.
 - Drive frame size 3 to 6 have a diode rectifier input stage with an internal soft start circuit which can be limit the inrush current for both AC and DC connected supplies
 - Consider inrush current in control sequence
 - Drive frame sizes 7 and larger have a half controlled rectifier which limits the inrush current for AC supplies only, for Low voltage DC supplies an external soft start circuit is required
 - External soft start circuit required for Low voltage DC supply
 - Consider inrush current in control sequence
- 2 The power supplies required for Low voltage DC operation can include the following
 - AC supply
 - UPS supply or Low voltage DC supply
 - External user 24 Vdc power supply
 - Control PCB (drive frame sizes 3 and larger)
 - Power Stage (drive frame sizes 6 and larger)
 - Heatsink cooling fans (drive frame sizes 9 and larger)
 - External contactors are required to transition between power supplies
 - Fuse protection must be supplied to protect power supplies and cabling
- 3 Low voltage DC operation can be configured in the following configurations
 - Low voltage DC mode with selection of Low under voltage threshold with Low voltage DC supply, batteries
 - Sequencing controlled by the Elevator controller
 - Low voltage DC mode with selection of Low under voltage threshold using UPS supply
 - Sequencing controlled by Elevator controller
 - Low voltage DC mode using drive on-board control to manage seam-less control from AC supply to Low voltage DC supply, batteries
 - Sequencing of the power supplies controlled by drive
 - This mode does not currently support operation with a Vac UPS supply
- 4 Configuration both the AC supply and Low voltage DC supply may be connected at the same time for seam-less change over from AC mode to DC mode with all drive frame sizes.
 - Seamless changeover from DC mode to AC mode is possible with drive frame size 7 and larger.
 - Seamless changeover is not supported on the drive for operation with an AC supply and Vac UPS supply.
 - The drive does NOT have to be disabled during change over from the AC supply to the Low voltage DC supply.
 - Drive frame sizes 3 to 6 must be disabled for the change over from the Low voltage DC supply to the AC supply in order to allow the internal soft start circuit to become active and limit the AC supply inrush.

- For Low voltage DC operation with a loss of the AC supply all relays and contactors must be driven from a maintained supply.
- 5 As the drives DC Bus voltage varies the motor power available varies in proportion to the voltage.
 - The Low voltage DC supply should be selected to deliver both the required power to the motor along with and additional loads within the drive system.
 - 6 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 Low voltage DC mode, the brake resistor value must be reduced in proportion to the voltage during Low voltage DC operation.
 - 7 During Low voltage DC operation standard power down save parameters are not saved. Where the external user 24 Vdc is connected to the drives Control PCB power down save parameters are also not saved.
 - To save parameters whilst in Low voltage mode or backup mode where the external user 24 Vdc supply is connected to the drives Control PCB set parameter **mm.xxx = 1001**

7 Diagnostics

7.1 Keypad

The keypad display provides information on Trip, Alarm and Status indications for further details refer to the *Drive User Guide*.

NOTE: Drive trips can be manually reset using the KI-Keypad, using communication protocols or using the drives auto reset feature. The manual drive reset is carried out pressing the RED reset button on the KI-Keypad.

The drive has a status LED on the front of the drive which provides a visual indication of the drive status. The status LED indicator will flash with a 0.5 s duty cycle if the drive has tripped.

1. Non-flashing: Normal status
2. Flashing: Trip status

Pr **10.001**- Drive OK parameter provides the drive Status, and the drive Trips can be read in Pr **10.020** - Trip 0 the most recent, through to Pr **10.027** - Trip 9.

7.2 Trip indications

The drive status LED indicator will flash during a drive trip and the keypad will display the trip code. During a trip condition where a keypad is being used, the upper row of the display indicates that a trip has occurred and the lower row displays the trip string. Some trips have a sub trip number to provide additional information about the trip. If a trip has a sub trip number, the sub trip number is flashed alternately with the trip string unless there is space on the second row of the keypad display for both the trip string and the sub trip number in which case both the trip string and sub trip information are displayed and separated by a decimal place.

7.3 Displaying trip history

The drive stores all drive trips along with date and time stamping information in Menu 10.

Trip log

Pr **10.020** - Trip 0 through to Pr **10.027** - Trip 9 store the 10 most recent trips that have occurred where Trip 0 (Pr **10.020**) is the most recent and Trip 9 (Pr **10.027**) is the oldest. When a new trip occurs and is captured it is written to Pr **10.020** - Trip 0 and all the other trips move down the log, with oldest being lost.

Sub trip numbers

Some trips have sub-trip numbers which provide more detail on the possible cause for the trip. If a trip has a sub trip number its value is stored in the sub trip log, i.e. Pr **10.070** - Trip 0, sub trip number to Pr **10.079** - Trip 9, sub trip number. If the trip does not have a sub-trip number zero will be stored in the sub-trip log.

Date and time

The date and time when each trip occurs is stored in the date and time log for all trips from Trip 0 through to Trip 9. The format of the date and time stamping is as follows. The date and time are taken from Pr **06.016** - Date and Pr **06.017** - Time.

Date: date - month - year 31 - 12 - 99
 Time: hours : minutes : seconds 23 : 59 : 59

Powered up time

When a trip occurs the time in milliseconds since the drive was powered up is also stored in Pr **10.013** - Trip Time Identifier since powered up. The time will roll over when it reaches $2^{31} - 1$, if the time is 0 a value of 1 is written.

7.4 Behaviour of drive when tripped

If a drive trip occurs, the following read only parameters are frozen until the trip is reset. This is to assist in diagnosing the cause of the trip. If the parameter freeze is not required this can be disabled with Pr **10.037** - Action On Trip Detection.

Parameter	Description	Parameter	Description
Pr 03.003	Speed Loop Error	Pr 05.002	Output Voltage
Pr 03.004	Speed Loop Output	Pr 05.003	Output Power
Pr 04.001	Total Output Current	Pr 05.005	DC Bus Voltage
Pr 04.002	Torque Producing Current	Pr 07.001	T5 T6 Analog Input 1
Pr 04.017	Magnetization Current	Pr 07.002	T7 Analog Input 2
Pr 05.001	Output Frequency	Pr 07.003	T8 Analog Input 3

Drive trips can be manually reset using the KI-Keypad, using communication protocols or using the drives auto reset feature. The manual drive reset is carried out pressing the RED reset button on the KI-Keypad. To reset a drive trip using communication protocols set Pr **10.033** - Drive Reset = On (1) followed by Off (0).

Auto reset drive trip

An auto reset can be set-up in the drive to reset a trip normally reset through the keypad or using a communication protocol. The auto reset feature can be configured to carry out a number of auto reset attempts, along with a defined time between each of the auto reset attempts.

Pr **10.034** = 0 No auto reset attempts are made
 Pr **10.034** = 1 to 4 1 to 4 auto reset attempts are carried out
 Pr **10.034** = 6 Internal reset counter is held at zero and the number of auto reset attempts is infinite

The internal auto reset counter is only incremented when the trip being reset is the same as the previous trip otherwise the counter is reset to 0. When the internal reset counter reaches the programmed value any further trip of the same value will not cause another auto reset. Pr **10.035** - Auto Reset Delay defines the time in seconds between each auto reset attempt.

NOTE:

An auto reset will not occur after any trips with priority levels 1, 2 or 3 and if there has been no trip for 5 minutes the internal auto reset counter is cleared,

NOTE:

When a manual reset is carried out the auto reset counter is reset to zero.

Priority	Category Trips	Comments
1	Internal fault, HF01 - HF20	These are internal faults which cannot be reset, all drive features are rendered inactive. If a keypad is installed this will display the active HF trip. Trips are not stored.
1	Stored HF trip	This trip can only be cleared by entering 1299 into parameter mm00 followed by a reset.
2	Non-re-settable trip, trip numbers 218 to 247	These trips cannot be reset.
3	Volatile memory fault, EEPROM Fail	This trip can only be cleared by entering to 1233 or 1244 into parameter mm00 or if Load Defaults is set to a non-zero value.
4	Internal 24 Vdc supply, PSU 24 V	
5	NV Media Card trips, trip numbers 174, 175 and 177 to 188	These trips are priority 6 during power up.
5	Position feedback power supply, Encoder 1	This trip can override Encoder 2 to Encoder 6 trips.
6	Trips with extended reset times OI ac, OI Brake and OI dc	These trips can only be reset 10 s after the trip was initiated.
6	Phase loss and DC Bus protection, Phase Loss and Oht DC Bus	The drive will attempt to stop the motor before tripping phase loss unless disabled. The drive will attempt to stop the motor before tripping Oht DC Bus.
6	Standard trips, All other trips	

Status indications

Upper row string	Description	Drive output stage
Inhibit	The drive is inhibited and cannot be run. The Safe Torque Off (STO), Drive enable signal is not applied to Control terminal 31	Disabled
Ready	The drive is ready to run, with the drive enable applied, but the drive is not active as the run signal has not been applied	Disabled
Run	The drive is active and running	Enabled
Supply Loss	Supply loss condition has been detected	Enabled
Deceleration	The motor is being decelerated to zero speed / frequency following removal of the speed selection / direction / run signal.	Enabled
Trip	The drive has tripped and the motor is stopped. The trip code appears in the lower display	Disabled
Under voltage	The drive is in an under voltage state (low voltage or high voltage mode)	Disabled
Phasing	The drive is performing a 'phasing test on enable'	Enabled

Option module, NV Media Card and other status indications

First row string	Second row string	Status
Booting	Parameters	Parameters are being loaded
Drive parameters are being loaded from a NV Media Card		
Booting	Option Program	User program is being loaded
User program is being loaded from a NV Media Card to the option module in slot X		
Writing To	NV Card	Data is being written to the NV media card
Data is being written to a NV media card to ensure that its copy of the drive parameters is correct because the drive is in Auto or Boot mode		
Waiting For	Power Systems	Waiting for power stage
The drive is waiting for the processor in the power stage to respond after power up		
Waiting For	Options	Waiting for an option module
The drive is waiting for the options modules to respond after power up		
Uploading From	Options	Loading parameter database
At power up, it may be necessary to update the parameter database held by the drive because an option module has changed or because an applications module has requested changes to the parameter structure. This may involve data transfer between the drive and option modules.		

Alarm indications

Alarm string	Description
Brake Resistor	Brake resistor overload, <i>Braking Resistor Thermal Accumulator</i> (Pr 10.039) in the drive has reached 75.0 % of the value at which the drive will trip.
Motor Overload	<i>Motor Protection Accumulator</i> (Pr 04.019) in the drive has reached 75.0 % of the value at which the drive will trip and the load on the drive is > 100 %.
Drive Overload	Drive over temperature. <i>Percentage Of Drive Thermal Trip Level</i> (Pr 07.036) > 90 %.
Autotune	The autotune procedure has been initialized and an autotune in progress

In any mode, an alarm is an indication given on the display by alternating the alarm string with the drive status string on the first row and showing the alarm symbol in the last character in the first row. If an action is not taken to eliminate a alarm except "Autotune" the drive may eventually trip. Alarms are not displayed when a parameter is being edited, but the user will still see the alarm character on the upper row.

7.5 Troubleshooting and Identifying Faults

The following section provides some guidance for troubleshooting and fault finding within the Low voltage DC system and operation.

Reported fault	Root cause	Recommended actions										
Under voltage state	AC supply loss Low voltage DC supply loss UPS supply loss	Power supply has been lost and the drives DC Bus voltage has dropped below the active under voltage threshold in either Pr 06.065 - <i>Standard under voltage threshold</i> or Pr 06.066 - <i>Low under voltage threshold</i> . Pr 06.066 - <i>Low under voltage threshold</i> is active when Pr 06.068 - <i>Low voltage supply mode enable</i> = On (1). or Pr 06.067 - <i>Low under voltage threshold</i> = On (1). Recommended actions: <ul style="list-style-type: none"> • Check power supply connections and drive configuration 										
	Low voltage DC supply loss	During operation with a Low voltage DC supply and where Pr 06.068 - <i>Low voltage supply mode enable</i> = On (1) for drive frame sizes 3 to 6 the drive will remain in the under voltage state waiting for the drive enable for Low voltage DC operation. Recommended actions: <ul style="list-style-type: none"> • Carry our start ... Speed, Direction, Drive enable ... 										
	Low voltage DC with seem-less transition from AC mode to DC mode	During operation with a Low voltage DC supply and where Pr 06.067 - <i>Low under voltage threshold select</i> = On (1) or Pr 06.068 - <i>Low voltage supply mode enable</i> = On (1) ensure Pr 06.066 - <i>Low under voltage threshold</i> is setup to the correct level for the Low voltage DC operation. Recommended actions: <ul style="list-style-type: none"> • Check supply voltage level and under voltage threshold 										
Phase loss trip	AC supply loss	Ensure external contactor control is connected and contactor control is correct from the drive when Pr 06.068 - <i>Low voltage supply mode enable</i> = On (1), also ensuring feedback is connected to the drive Recommended actions: <ul style="list-style-type: none"> • Check both Pr 06.069 and Pr 06.070 for contactor control 										
		This trip indicates an input phase loss or large supply imbalance has been detected. Phase loss can be detected from the supply for drives with a half controlled thyristor input stage, drive frame size 7 and above. If phase loss is detected the drive trips immediately and the xx part of the sub-trip is set to 01. In all frame sizes of drive phase loss is also detected by monitoring the DC Bus voltage ripple. In this case the drive attempts to stop before tripping unless bit 2 of Pr 10.037 - <i>Action On Trip Detection</i> = 1. When phase loss is detected by monitoring the DC Bus voltage ripple the xx part of the sub-trip is zero. <table border="1"> <thead> <tr> <th>Source</th> <th>xx</th> <th>y</th> <th>zz</th> </tr> </thead> <tbody> <tr> <td>Control system</td> <td>00</td> <td>0</td> <td>00: Phase loss detected from DC Bus ripple level</td> </tr> <tr> <td>Power system (1)</td> <td>01</td> <td>Rectifier number</td> <td>00: Phase loss detected directly from the power supply</td> </tr> </tbody> </table> <p>(1) Input phase loss detection can be disabled when the drive is required to operate from the Low voltage DC supply or from a single phase UPS supply in Pr 06.047 - <i>Input Phase Loss Detection Mode Enable</i>.</p> Recommended actions: <ul style="list-style-type: none"> • Check the AC supply voltage balance and level at full load. • Check the DC Bus ripple level with an isolated oscilloscope. • Check connection of L2 ⇒ L3 for UPS supply with drive frame sizes 7 and larger • Check the output current stability. • Reduce the motor load. • Disable the input phase loss detection 	Source	xx	y	zz	Control system	00	0	00: Phase loss detected from DC Bus ripple level	Power system (1)	01
Source	xx	y	zz									
Control system	00	0	00: Phase loss detected from DC Bus ripple level									
Power system (1)	01	Rectifier number	00: Phase loss detected directly from the power supply									

Reported fault	Root cause	Recommended actions
PSU 24 trip on power up for Low voltage DC operation	External user 24 Vdc supply loss to Control PCB	<p>Failure to connect the external user 24 Vdc supply on the Control PCB of drive frame sizes 3 and larger with Pr 06.072 - <i>User Supply Select</i> = On (1) or 012 - <i>Low Voltage Supply Mode Enable</i> = On (1), or Pr 06.067 - <i>Low Under Voltage Threshold Select</i> = On (1) will result in a "PSU 24" trip.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Connect the external user 24 Vdc supply to Control PCB connections 1 / 2 • Connect the external user 24 Vdc supply to supplement the internal 24 Vdc supply
	External user 24 Vdc supply overloaded	<p>An external user 24 Vdc supply is required for Low voltage DC operation and dependent upon drive frame size can supply the Control, Power and Heatsink cooling fans</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Ensure the external user 24 Vdc supply is sufficiently rated
Power down parameters not saved	Drive operating in Low voltage DC mode	<p>Power down save parameters will not be saved during Low voltage DC operation where the DC Bus voltage is below the level set in Pr 06.065 - <i>Standard under voltage threshold</i> and does not pass through this level prior to power down.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • To save parameters set parameter mm.xxx = 1001.
	Drive operating with external user 24 Vdc supply connected to Control PCB	<p>Power down save parameters will not be saved during Low voltage DC operation where the external user 24 Vdc is connected to the Control PCB.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • To save parameters set parameter mm.xxx = 1001.
Seem-less Low voltage DC operation from Elevator drive not operating	External contactor control	<p>For seem-less control an external supply contactor is required in either the AC supply connection (drive frame sizes 3 to 6) or DC supply connection (drive frame sizes 7 and larger).</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Ensure the external contactor is connected correctly and is being sequenced correctly, also refer to parameter Pr 06.069 - <i>Under Voltage System Contactor Output</i> and Pr 06.065 - <i>Standard Under Voltage Threshold</i> and Section 6.5 System configurations
	External contactor feedback	<p>For seem-less control by the drive feedback from the AC supply contactor (drive frame sizes 3 to 6) or DC supply contactor (drive frame sizes 7 and larger) is required.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Ensure the feedback from the external supply contactor is connected correctly to the drive and is sequenced correctly, refer to Pr 06.070 <i>Under Voltage System Contactor Closed</i> and Pr 06.065 - <i>Standard Under Voltage Threshold</i> and Section 6.5 System configurations
I/O overload at drive power up / during operation	Drive internal 24 Vdc supply is being overloaded	<p>The drives internal user 24 Vdc supply has been overloaded from control terminal 22 (24 Vdc 100 mA) and control terminal 24 if common connection delivering 24 Vdc 200 mA.</p> <p>Ensure the Low voltage DC circuit is not resulting in the internal 24 Vdc supply being overloaded due to the loading on the drives control I/O. Connect the external user 24 Vdc supply which will supplement the internal 24 Vdc supply.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Ensure no faults on the control circuit to the drive being supplied from the drives internal 24 Vdc supply. • Ensure the Low voltage DC circuit and any auxiliary loads are not resulting in the overload trip. • Connect the external user 24 Vdc supply if the overload is present with only control terminal 22 (24 Vdc 100 mA) being used for the control circuit.

Reported fault	Root cause	Recommended actions
Waiting For Power Systems on power up for Low voltage DC operation	External user 24 Vdc supply loss to Power Stage	<p>Failure to connect the external user 24 Vdc supply on the Power Stage of drive frame sizes 6 and larger will result in "Waiting For Power Systems" to be displayed on the drives keypad.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Connect the external user 24 Vdc supply to Power Stage of the drive, connections 51 / 52
Incorrect direction Speed error Distance error	Elevator incorrect operating direction	<p>Following a start and brake release the Elevator moves in the incorrect direction resulting in a speed or distance error. This could be the result of motor torque on brake release or the load measurement.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Ensure the Low voltage DC supply or UPS are not being overloaded due to the car loading • Ensure the motor is fully magnetised
	Roll back and stalling on brake release	<p>Following a start and brake release the Elevator moves in the incorrect direction resulting in a speed or distance error. This could be the result of motor torque on brake release.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Ensure the Low voltage DC supply or UPS are not being overloaded resulting in reduced starting torque • Use the Load measurement feature to move in the direction of least load.
	Elevator fails to reach contract speed	<p>Following a start and brake release the Elevator moves in the correct direction however a speed or distance error occurs during acceleration to the final speed demand. This could be the result of the Low voltage DC supply or UPS.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Ensure the Low voltage DC supply or UPS are not being overloaded due to the car loading • Ensure the Low voltage DC supply or UPS are not being overloaded due to the speed demand being too high
OI ac on removal of 24 Vdc for Low voltage DC operation	Disabling external user 24 Vdc supply to Power Stage, drive frame sizes 6 and larger	<p>On drive frame sizes 6 and larger removing the external user 24 Vdc supply alone to the Power Stage connections 51 / 52 may result in an OI ac trip.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • Ensure the external user 24 Vdc supply is being removed from the Power Stage 51 / 52 and the Control PCB 1 / 2 at the same time.
OHT power during Low voltage DC operation	Heatsink cooling fans	<p>On drive frame sizes 9 and larger an external user 24 Vdc supply is required for the heatsink cooling fans during operation with a Low voltage DC supply or UPS where the final DC Bus level is lower than the AC supply loss.</p> <p>Recommended actions:</p> <ul style="list-style-type: none"> • On drive frame sizes 9 and larger ensure the external user 24 Vdc supply is connected to the Power Stage 61 / 62 for the heatsink cooling fans • Ensure the external user 24 Vdc supply is sufficiently rated for the heatsink cooling fans

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