Knowledge Base Document

Technical Support Department, U79, Newtown

Title: **Introduction of Unidrive M Regen mode**

Document Category:	Application related	**Product Category:**	Uni M
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Revision History

Revision	Date	Revising Author	Authorised By	Comments
V1.0	22/4/14	GP		Initial version
V1.1	21/5/14	GP		Revised after review by RF

Summary of Contents

Regen mode has been implemented in Unidrive M firmware versions V01.08.00.00 and later. This document highlights the new features and improvements that have been made over and above those available with Unidrive SP.

Contents

Introduction

Regen mode has been implemented in Unidrive M firmware V01.08.00.00 and later. This document highlights the new features and improvements that have been made over and above those available with Unidrive SP. It is intended to be read by staff familiar with the basic concepts of Regen mode operation with Unidrive SP. It is suggested that those not familiar with Regen mode operation refer to the *Uni SP Regen Installation Guide* document available on CT support.

Parameters descriptions in this document have been limited to the short form descriptions and diagrams, for full parameter descriptions please refer to the appropriate *Parameter Reference Guide* document for the Unidrive M600 to M800 drive being used.

The Regen filter components listed in this document are the best match between the currently available filters and the new Unidrive M ratings. In some cases (see tables) it is necessary to reduce Pr5.007 (rated current) to avoid exceeding the filter current rating. It is likely that these filter components will be reviewed in the future to provide a better match in this respect. It should be noted that the filters currently available were originally designed for a minimum switching frequency of 3kHz. Increased heating of the regen inductor combined with increased capacitor current and less sinusoidal output current is likely to occur if the newly available 2kHz switching frequency is used.

NOTE
Internal EMC filters MUST be removed from all drives in a Regen system, please refer to the appropriate drive *User Guide* for details of how this is done.

Unidrive M100 to M400 frames 2 and 3 have permanent capacitors fitted internally for EMC compliance purposes. These drives cannot therefore be used as motoring drives in a Regen system (see Technical Bulletin T140304 for more details).

Parameters

Menu 3 – Regen Control

New features and improvements

Regen synchronisation modes

A new mode has been added (Pr3.004 = 3: Auto synchronise). This allows the drive to continue operating for short periods of time (2s max) during symmetrical (balanced) supply faults. Ride through of supply faults is a requirement of various grid codes. This functionality comes with several requirements; the direction of power flow must be regenerating (power flow into the supply) prior to the fault occurring. The d.c. link must be held at a suitable level during the fault period, either by an external system or by connecting a brake resistor. The control power for charge system contactors must be derived from a backed up power supply (i.e. a UPS) to prevent the supply contactors opening during the fault. Ride through of asymmetric (unbalanced) faults is a feature to be added in the future.

Power feed forward compensation

Power feed-forward compensation can be used to reduce the transient d.c. bus voltage produced when a fast load transient occurs on motoring drive(s) connected to the d.c. terminals of the regen drive. Previously only one motoring drive could be supported. The power feed forward system has now been improved to allow analogue signals from up to 3 motoring drives to be used. If the system has more than 3 motoring drives connected to the regen d.c. link, fast synchronous communications (i.e. using MCi-210 modules) can be used to write the total power value (in kW) to Pr3.018.

Reactive current / power control

A new reactive power control has been added to allow the reactive power in kVAr units to be controlled. Previously only reactive current could be controlled.

Voltage ramp time control

When a regen drive is enabled and has synchronised to the supply, the d.c. bus voltage is at a level equal to the peak line to line voltage. The voltage controller is then enabled and attempts to raise the d.c. bus voltage to the set-point defined by Voltage Set Point (Pr03.005). Previously this ramp time was fixed, it can now be controlled using Pr3.022 to allow shorter synchronization times if required.

Frequency limits

New frequency limits have been applied to the Regen system output (defined in Pr3.024 and Pr3.025). These are enabled as default. If the Regen system supply frequency is within approximately 5Hz of either limit for 100ms the system will not remain synchronised and will attempt to re-synchronise. The frequency limits are important if the supply is removed when the Regen system is active, as the system could remain active, particularly if energy is fed into the d.c. link, with an uncontrolled output frequency and voltage.

Voltage limits

New voltage limits are available (defined in Pr3.026 and Pr3.027). These are not enabled as default. If the voltage limits are active a Voltage Range trip is generated when the voltage is outside the range defined for 100ms. The voltage limits are important if the supply is removed when the Regen system is active, as the system could remain active, particularly if energy is fed into the d.c. link, with an uncontrolled output frequency and voltage.

Supply voltage detection mode

Previously the a.c. voltage applied during synchronisation was derived from the d.c. link voltage (after it had stopped rising or falling). This was ok for standard applications where the d.c. link voltage is Sqrt(2)x supply voltage but could result in issues during synchronisation in applications where the d.c. link voltage was not proportional to the supply voltage, a PV application for example. Two new supply voltage detection modes can now be selected in Pr3.029, resulting in a more robust and faster synchronisation process for these non standard applications.

Island detection

The purpose of this feature is to prevent unwanted islanded operation, where part of the power distribution network becomes separated from the power grid and is unintentionally maintained by an inverter.
An island detection system designed to meet the requirements of IEEE1547 and VDE 0126-1-1 has been implemented. Both IEEE and VDE standards describe an unintentional islanding test that uses a parallel resonant RLC load to create a worst case condition for the formation of unintentional islands. When the detection system is enabled a small reactive current is injected that allows the inverter to detect this resonant condition. A system has also been implemented that allows the reactive current injected by a number of regen drives to be synchronized to a suitable master clock (required in some large scale PV applications).

Synchronisation headroom

Pr3.035 has been added to allow more control to prevent over-voltage trips occurring during synchronisation due to non-standard filter components or high impedance power supply.

Menu 3 features to be implemented in the future

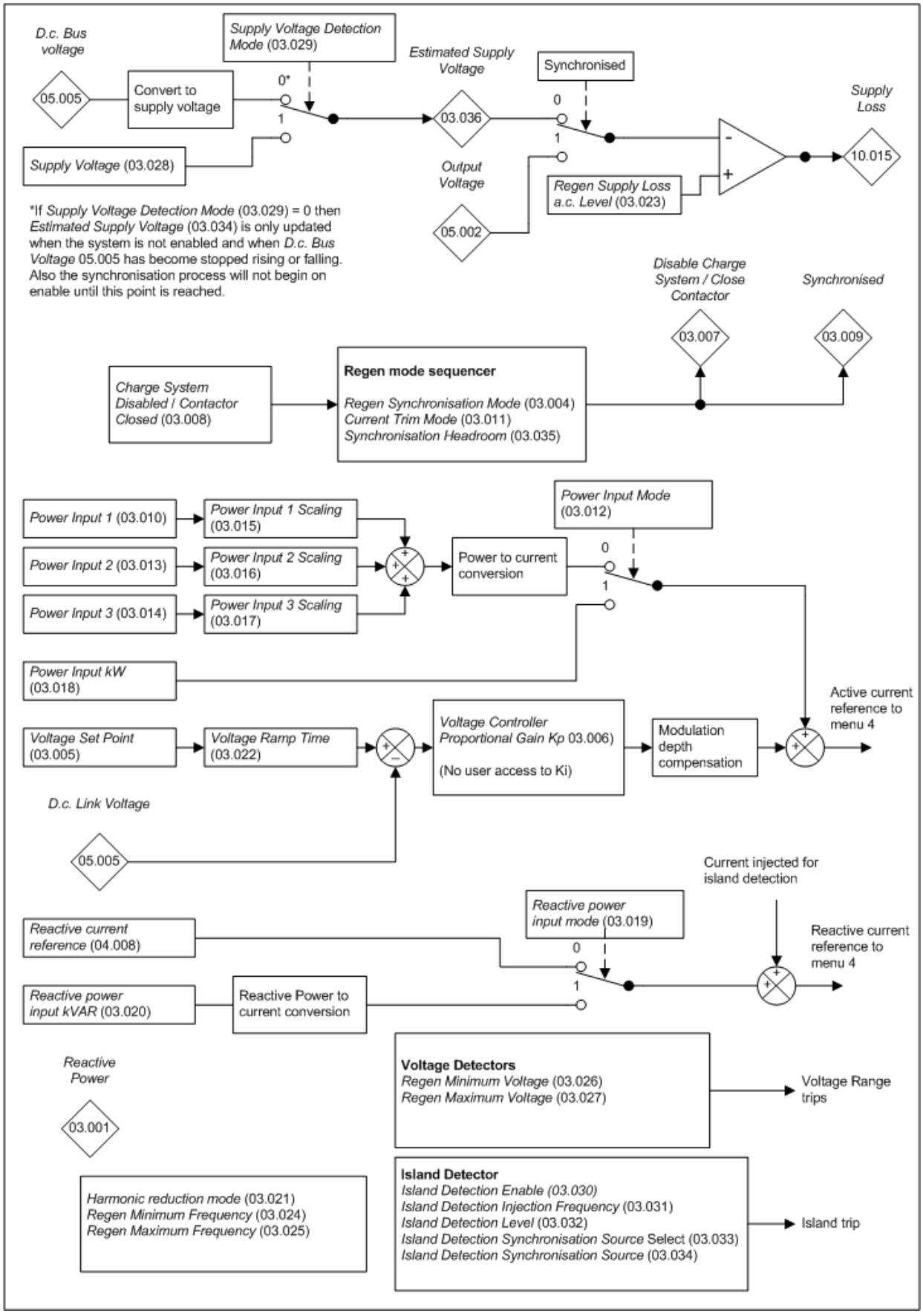
Harmonic reduction enable

The harmonic reduction enable parameter (Pr3.021) is currently visible but this feature is yet to be implemented. When implemented the regen drive will include an additional system to reduce imbalance, 3rd harmonics, 5th harmonics and 7th harmonics in the a.c. currents.

Ride through of asymmetric faults

Ride through of asymmetric (unbalanced) faults is a feature to be added in the future.

Menu 3 – *Regen Control* Parameters



Parameter		Range	Default	Type					
03.001	Reactive Power	±VM_POWER kVAr		RO	Num	ND	NC	PT	FI
03.004	Regen Syncronisation Mode	Re-syncronise (0), Delayed Trip (1), Trip (2), Auto-synchronise (3)	Re-syncronise (0)	RW	Txt				US
03.005	Voltage Set Point	±VM_DC_VOLTAGE_SET V	200V drive: 350 V 400V drive: 700 V 575V drive: 835 V 690V drive: 1100 V	RW	Num		RA		US
03.006	Voltage Controller Proportional Gain Kp	0 to 65535	4000	RW	Num				US
03.007	Disable Charge System / Close Contactor	Off (0) or On (1)		RO	Bit	ND	NC	PT	
03.008	Charge System Disabled / Contactor Closed	Off (0) or On (1)		RO	Bit	ND	NC		
03.009	Synchronised	Off (0) or On (1)		RO	Bit	ND	NC	PT	
03.010	Power Input 1	±100.0 %	0.0 %	RW	Num		NC		
03.011	Current Trim Mode	0 to 1	0	RW	Num				US
03.012	Power Input Mode	Off (0) or On (1)	Off (0)	RW	Bit				US
03.013	Power Input 2	±100.0 %	0.0 %	RW	Num		NC		
03.014	Power Input 3	±100.0 %	0.0 %	RW	Num		NC		
03.015	Power Input 1 Scaling	0.000 to 4.000	1.000	RW	Num				US
03.016	Power Input 2 Scaling	0.000 to 4.000	1.000	RW	Num				US
03.017	Power Input 3 Scaling	0.000 to 4.000	1.000	RW	Num				US
03.018	Power Input kW	±VM_POWER kW	0.000 kW	RW	Num		RA		
03.019	Reactive Power Input Mode	Off (0) or On (1)	Off (0)	RW	Bit				US
03.020	Reactive Power Input kVAR	±VM_POWER kVAr	0.000 kVAr	RW	Num		RA		US
03.021	Harmonic Reduction Enable	Off (0) or On (1)	On (1)	RW	Bit				US
03.022	Voltage Ramp Time	0.1 to 100.0 V/ms	1.0 V/ms	RW	Num				US
03.023	Regen Supply Loss a.c. Level	±VM_AC_VOLTAGE_SET V	200V drive: 75 V 400V drive: 150 V 575V drive: 225 V 690V drive: 225 V	RW	Num		RA		US
03.024	Regen Minimum Frequency	10 to 200 Hz	50Hz: 40 Hz 60Hz: 50 Hz	RW	Num				US
03.025	Regen Maximum Frequency	10 to 200 Hz	50Hz: 60 Hz 60Hz: 70 Hz	RW	Num				US
03.026	Regen Minimum Voltage	±VM_AC_VOLTAGE V	0 V	RW	Num		RA		US
03.027	Regen Maximum Voltage	±VM_AC_VOLTAGE V	0 V	RW	Num		RA		US
03.028	Supply Voltage	±VM_AC_VOLTAGE_SET V	200V drive: 230 V 400V drive 50Hz: 400 V 400V drive 60Hz: 460 V 575V drive: 575 V 690V drive: 690 V	RW	Num		RA		US
03.029	Supply Voltage Detection Mode	Measured (0), User (1), User Delayed (2)	User Delayed (2)	RW	Txt				US
03.030	Island Detection Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
03.031	Island Detection Injection Frequency	1 (0), 2 (1), 4 (2) Hz	1 (0) Hz	RW	Txt				US
03.032	Island Detection Level	0 to 100 %		RO	Num	ND	NC	PT	
03.033	Island Detection Synchronisation Source Select	Disabled (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4)	Disabled (0)	RW	Txt				US
03.034	Island Detect Synchronisation Source	Disabled (0), Slot 1 (1), Slot 2 (2), Slot 3 (3), Slot 4 (4)		RO	Txt	ND	NC	PT	
03.035	Synchronisation Headroom	0.0 to 25.0 %	5.0 %	RW	Num				US
03.036	Estimated Supply Voltage	±VM_AC_VOLTAGE V		RO	Num	ND	NC	PT	

Menu 4 – Current Control

New features and improvements

Active current reference

Previously the active current reference was always defined by the d.c. bus voltage controller and the power feed-forward system. It is now possible for the user to define the active current reference via Pr4.009. It should be noted that the regen drive can no longer control its own d.c. bus voltage, and so this must be controlled by an external system e.g. the voltage master module in a SPV system.

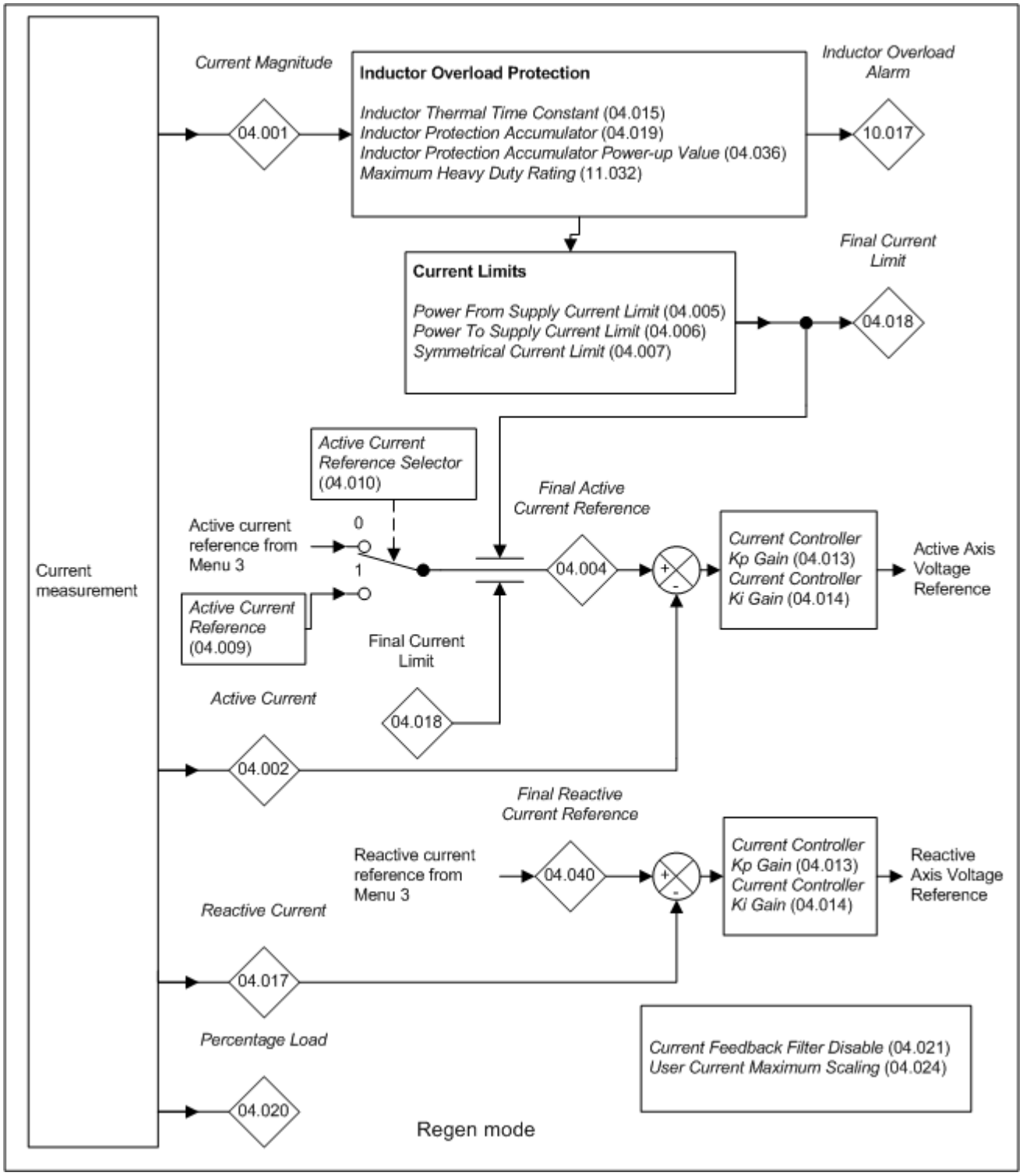
Inductor thermal protection

Read access to the inductor protection accumulator is now provided via Pr4.036.

Current feedback filter disable

The filtering applied to the active and reactive current parameters can now be disabled using Pr4.021. This is provided for SPV applications where the drive current measurement is used by an external controller.

Menu 4 – *Current Control* Parameters



Parameter		Range	Default	Type					
04.001	Current Magnitude	±VM_DRIVE_CURRENT_UNIPOLAR A		RO	Num	ND	NC	PT	FI
04.002	Active Current	±VM_DRIVE_CURRENT A		RO	Num	ND	NC	PT	FI
04.004	Final Active Current Reference	±VM_TORQUE_CURRENT %		RO	Num	ND	NC	PT	FI
04.005	Power From Supply Current Limit	±VM_MOTOR1_CURRENT_LIMIT %	0.0 %	RW	Num		RA		US
04.006	Power To Supply Current Limit	±VM_MOTOR1_CURRENT_LIMIT %	0.0 %	RW	Num		RA		US
04.007	Symmetrical Current Limit	±VM_MOTOR1_CURRENT_LIMIT %	0.0 %	RW	Num		RA		US
04.008	Reactive Current Reference	±VM_REGEN_REACTIVE %	0.0 %	RW	Num				US
04.009	Active Current Reference	±VM_USER_CURRENT %	0.0 %	RW	Num				US
04.010	Active Current Reference Selector	Off (0) or On (1)	Off (0)	RW	Bit				US
04.013	Current Controller Kp Gain	0 to 30000	90	RW	Num				US
04.014	Current Controller Ki Gain	0 to 30000	2000	RW	Num				US
04.015	Inductor Thermal Time Constant	1.0 to 3000.0 s	89.0 s	RW	Num				US
04.017	Reactive Current	±VM_DRIVE_CURRENT A		RO	Num	ND	NC	PT	FI
04.018	Final Current Limit	±VM_TORQUE_CURRENT %		RO	Num	ND	NC	PT	
04.019	Inductor Protection Accumulator	0.0 to 100.0 %		RO	Num	ND	NC	PT	PS
04.020	Percentage Load	±VM_USER_CURRENT %		RO	Num	ND	NC	PT	FI
04.021	Current Feedback Filter Disable	Off (0) or On (1)	Off (0)	RW	Bit				US
04.024	User Current Maximum Scaling	±VM_TORQUE_CURRENT_UNIPOLAR %	175.0 %	RW	Num		RA		US
04.036	Inductor Protection Accumulator Power-up Value	Power down (0), Zero (1), Real time (2)	Power down (0)	RW	Txt				US
04.040	Final Reactive Current Reference	±200.0 %		RO	Num	ND	NC	PT	FI

Menu 5 – Regen Status

New features and improvements

DC bus voltage high range

DC Bus Voltage High Range (Pr5.023) provides voltage feedback that has lower resolution and a higher range than d.c. Bus Voltage (Pr5.005) and so it is possible to determine the d.c. link voltage even if this exceeds the level of the over-voltage trip. This feature has been added for possible use in future SPV development.

Greater switching frequency range

2kHz to 16kHz switching frequency is now available on all ratings. Previously the lowest switching frequency was 3kHz and the highest limited to 6kHz on some ratings. This greater range offers potential improvements in inverter efficiency at the low end, reduced current distortion and acoustic noise at the high end. It should be noted that the filters currently available were originally designed for a minimum switching frequency of 3kHz. Increased heating of the regen inductor combined with increased capacitor current and less sinusoidal output current is likely to occur if the newly available 2kHz switching frequency is used.

Auto switching frequency change

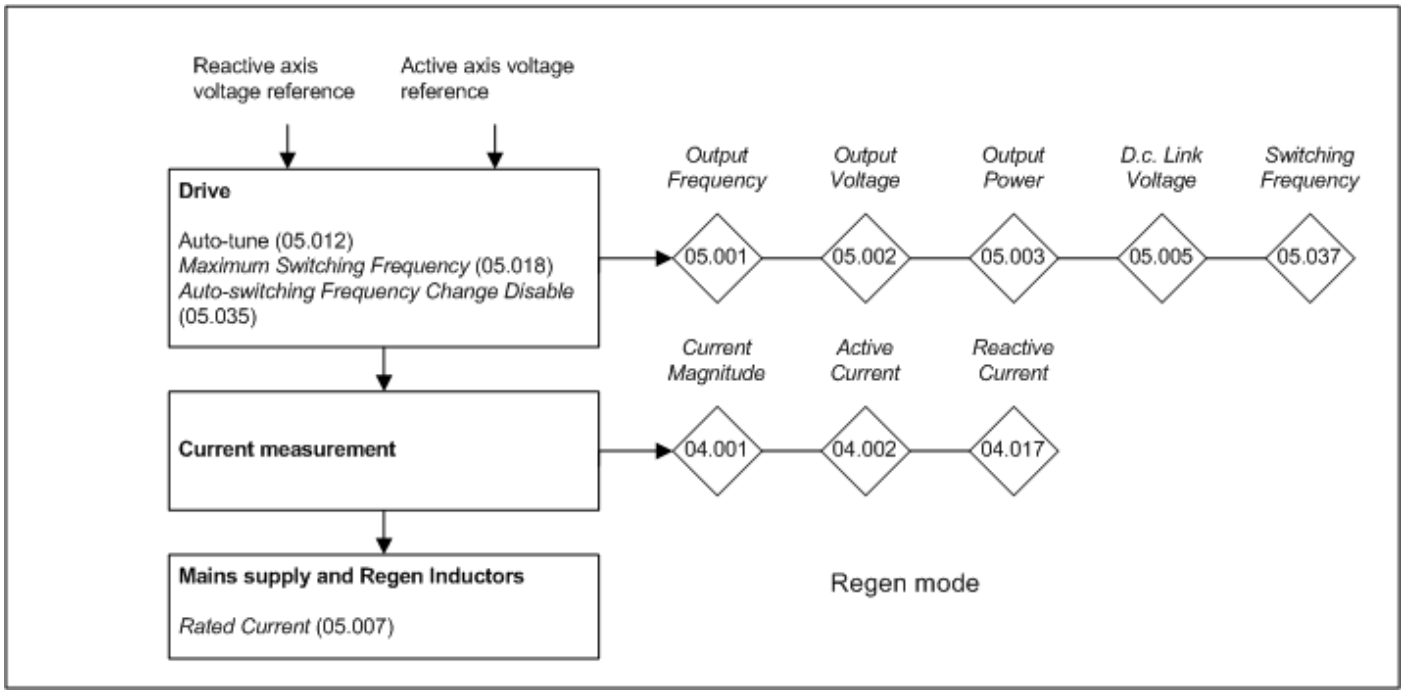
The system that automatically lowers the switching frequency where necessary to prevent damage to the power semiconductor devices is now much more configurable. See Pr5.035 for more details.

Menu 5 features to be implemented in the future

Auto Tune

The Auto-tune parameter (Pr5.012) is currently visible but this feature is yet to be implemented. When implemented, this feature will automatically set current controller gains for a particular power supply.

Menu 5 – *Regen Status* Parameters



Parameter		Range	Default	Type					
05.001	Output Frequency	±200.0 Hz		RO	Num	ND	NC	PT	FI
05.002	Output Voltage	±VM_AC_VOLTAGE V		RO	Num	ND	NC	PT	FI
05.003	Output Power	±VM_POWER kW		RO	Num	ND	NC	PT	FI
05.005	D.c. Bus Voltage	±VM_DC_VOLTAGE V		RO	Num	ND	NC	PT	FI
05.007	Rated Current	±VM_RATED_CURRENT A	0.000 A	RW	Num		RA		US
05.012	Auto-tune	0 to 1	0	RW	Num		NC		
05.018	Maximum Switching Frequency	0 to VM_SWITCHING_FREQUENCY kHz	3 (1) kHz	RW	Txt		RA		US
05.023	D.c. Bus Voltage High Range	±VM_HIGH_DC_VOLTAGE V		RO	Num	ND	NC	PT	FI
05.035	Auto-switching Frequency Change Disable	Enabled (0), Disabled (1), No Ripple Detect (2)	Enabled (0)	RW	Txt				US
05.036	Auto-switching Frequency Step Size	1 to 2	2	RW	Num				US
05.037	Switching Frequency	2 (0), 3 (1), 4 (2), 6 (3), 8 (4), 12 (5), 16 (6) kHz		RO	Txt	ND	NC	PT	
05.038	Minimum Switching Frequency	0 to VM_MIN_SWITCHING_FREQUENCY kHz	2 (0) kHz	RW	Txt				US
05.039	Maximum Inverter Temperature Ripple	20 to 60 °C	60 °C	RW	Num				US

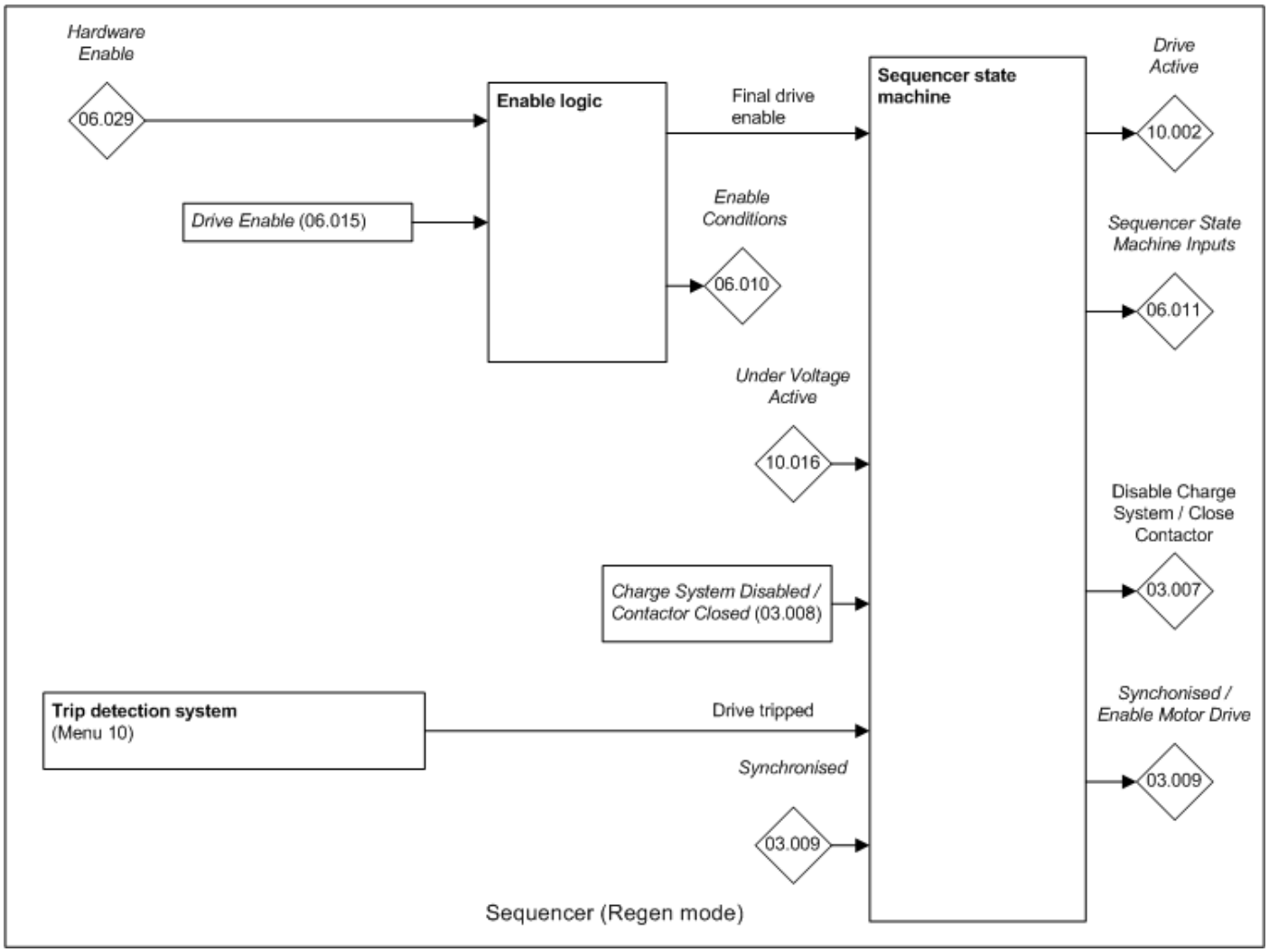
Menu 6 – Sequencer and Clock

New features and improvements

State machine inputs

Parameter 6.011(state machine inputs) has been added (along with Pr10.101 Drive status) to allow easier evaluation of the state the regen drive is in at a given time for diagnostic purposes.

Menu 6 – *Sequencer and Clock* Parameters



Parameter		Range	Default	Type					
06.010	Enable Conditions	000000000000 to 111111111111		RO	Bin	ND	NC	PT	
06.011	Sequencer State Machine Inputs	000000 to 111111		RO	Bin	ND	NC	PT	
06.015	Drive Enable	Off (0) or On (1)	On (1)	RW	Bit				US
06.016	Date	00-00-00 to 31-12-99		RW	Date	ND	NC	PT	
06.017	Time	00:00:00 to 23:59:59		RW	Time	ND	NC	PT	
06.018	Day Of Week	Sunday (0), Monday (1), Tuesday (2), Wednesday (3), Thursday (4), Friday (5), Saturday (6)		RO	Txt	ND	NC	PT	
06.019	Date/Time Selector	Set (0), Powered (1), Running (2), Acc Powered (3), Local Keypad (4), Remote Keypad (5), Slot 1 (6), Slot 2 (7), Slot 3 (8), Slot 4 (9)	Powered (1)	RW	Txt				US
06.020	Date Format	Std (0), US (1)	Std (0)	RW	Txt				US
06.021	Time Between Filter Changes	0 to 30000 Hours	0 Hours	RW	Num				US
06.022	Filter Change Required / Change Done	Off (0) or On (1)		RW	Bit	ND	NC		
06.023	Time Before Filter Change Due	0 to 30000 Hours		RO	Num	ND	NC	PT	PS
06.024	Reset Energy Meter	Off (0) or On (1)	Off (0)	RW	Bit				
06.025	Energy Meter: MWh	±999.9 MWh		RO	Num	ND	NC	PT	PS
06.026	Energy Meter: kWh	±99.99 kWh		RO	Num	ND	NC	PT	PS
06.027	Energy Cost Per kWh	0.0 to 600.0	0.0	RW	Num				US
06.028	Running Cost	±32000		RO	Num	ND	NC	PT	
06.029	Hardware Enable	Off (0) or On (1)		RO	Bit	ND	NC	PT	
06.041	Drive Event Flags	00 to 11	00	RW	Bin		NC		
06.042	Control Word	0000000000000000 to 1111111111111111	0000000000000000	RW	Bin		NC		
06.043	Control Word Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
06.044	Active Supply	Off (0) or On (1)		RO	Bit	ND	NC	PT	
06.045	Cooling Fan control	0 to 11	10	RW	Num				US
06.060	Standby Mode Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
06.061	Standby Mode Mask	0000000 to 1111111	0000000	RW	Bin				US
06.065	Standard Under Voltage Threshold	0 to VM_STD_UNDER_VOLTS V	200V drive: 175 V 400V drive: 330 V 575V drive: 435 V 690V drive: 435 V	RW	Num		RA		US
06.066	Low Under Voltage Threshold	0 to VM_LOW_UNDER_VOLTS V	330 V	RW	Num		RA		US
06.067	Low Under Voltage Threshold Select	Off (0) or On (1)	Off (0)	RW	Bit				US
06.071	Slow Rectifier Charge Rate Enable	Off (0) or On (1)	Off (0)	RW	Bit				US
06.072	User Supply Select	Off (0) or On (1)	Off (0)	RW	Bit				US
06.073	Braking IGBT Lower Threshold	0 to VM_DC_VOLTAGE_SET V	200V drive: 390 V 400V drive: 780 V 575V drive: 930 V 690V drive: 1120 V	RW	Num				US
06.074	Braking IGBT Upper Threshold	0 to VM_DC_VOLTAGE_SET V	200V drive: 390 V 400V drive: 780 V 575V drive: 930 V 690V drive: 1120 V	RW	Num				US
06.075	Low Voltage Braking IGBT Threshold	0 to VM_DC_VOLTAGE_SET V	0 V	RW	Num				US
06.076	Low Voltage Braking IGBT Threshold Select	Off (0) or On (1)	Off (0)	RW	Bit				
06.084	Date And Time Offset	±24.00 Hours	0.00 Hours	RW	Num				US

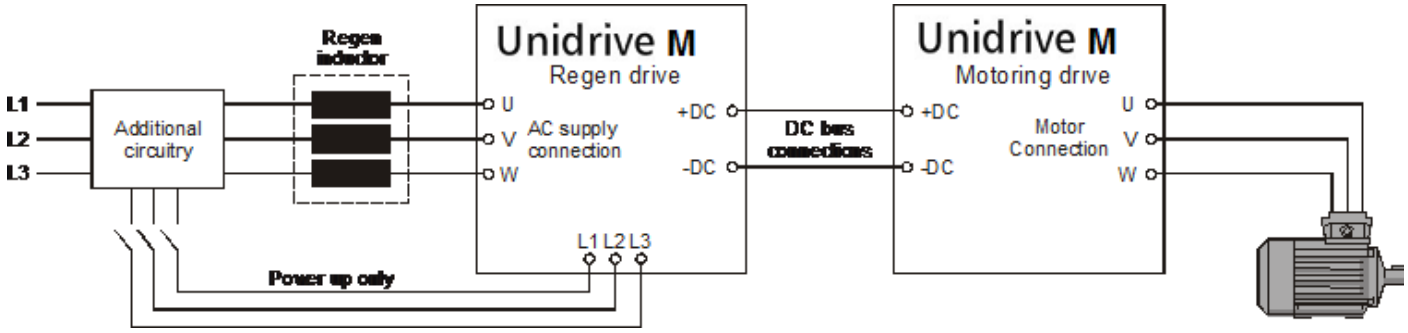
System diagrams

Unidrive M regen mode has been designed to be very similar to Unidrive SP with some additional features; therefore all of the system configurations possible previously are still possible. The following system diagrams are included for reference.

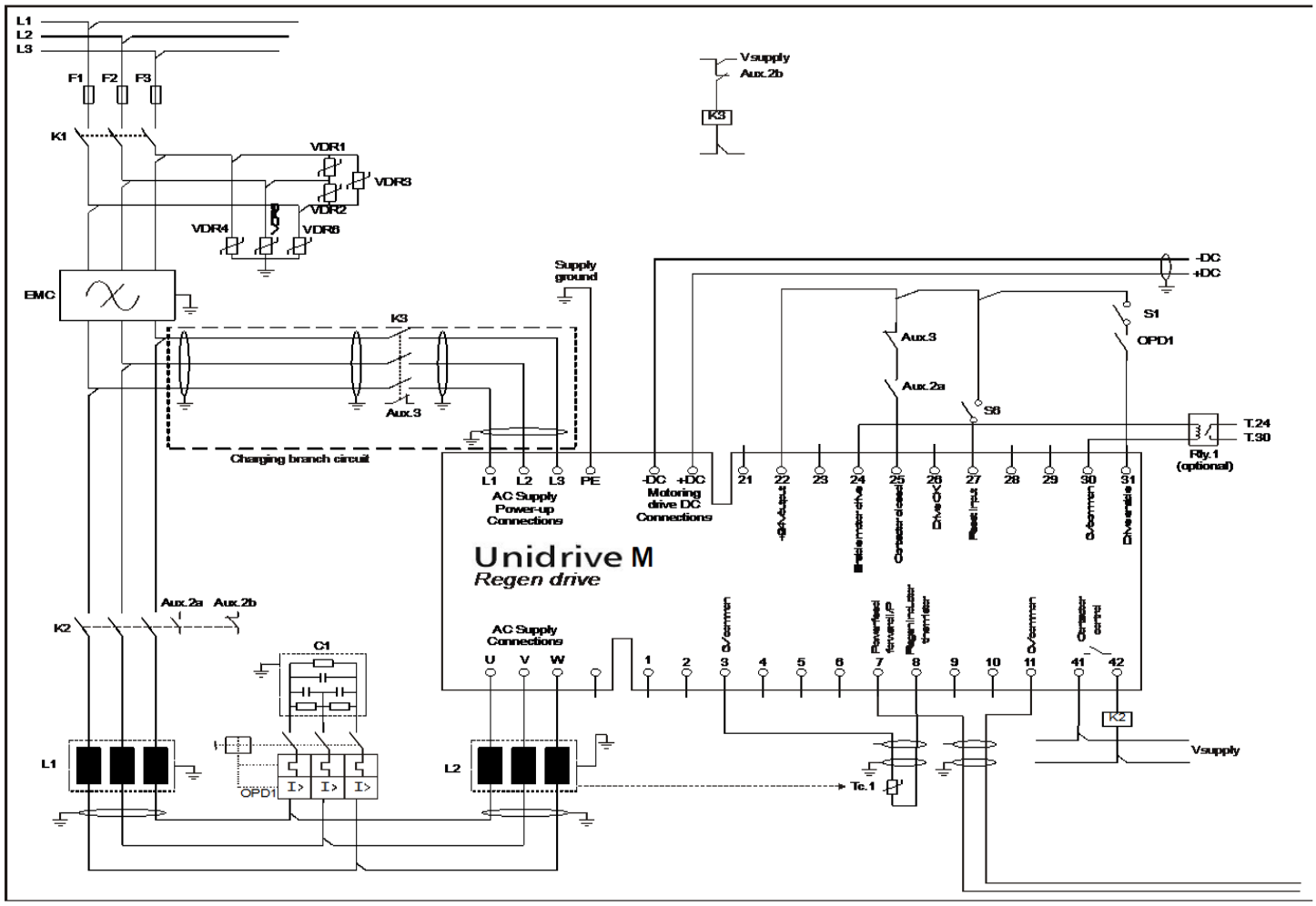
Single Regen, single motoring drive- simple diagram

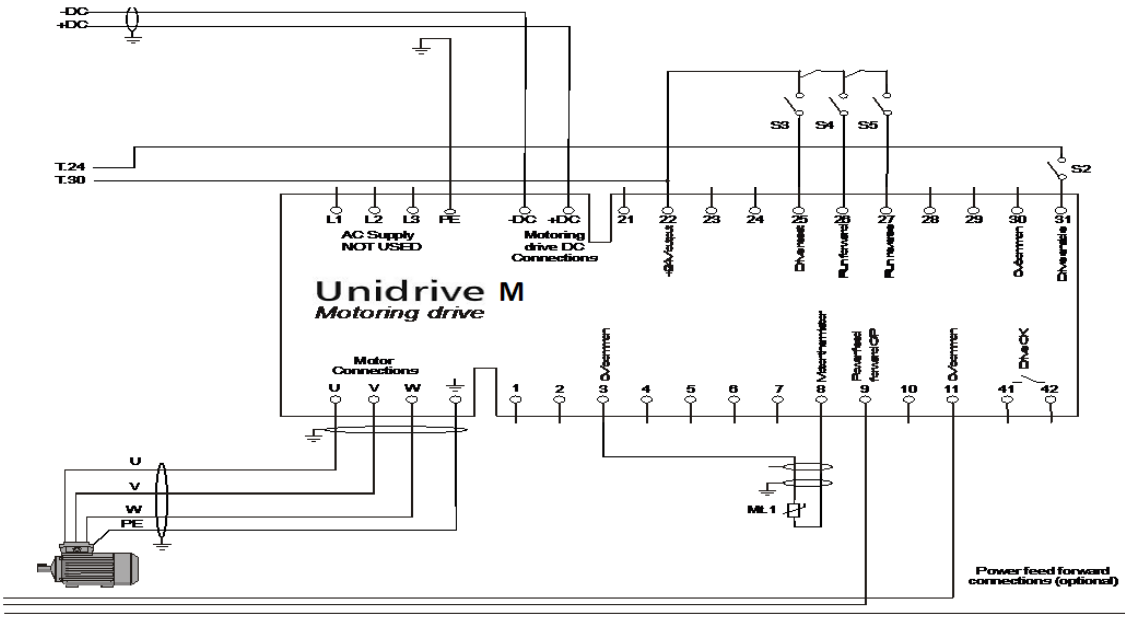
The diagram below shows a typical layout for a standard Regen system consisting of a single Regen drive and single motoring drive. In this configuration the Regen drive is supplying the motoring drive and passing the regenerative energy back to the AC supply voltage.

The power up connections to L1, L2, L3 of the Regen drive are only made during power-up. Once both drives are powered up, this is switched out and the main Regen supply switched in. The auxiliary on the charging circuit to the Regen drive's L1, L2, L3 connections for power up must be closed (charging supply removed) before the Regen drive can be enabled.



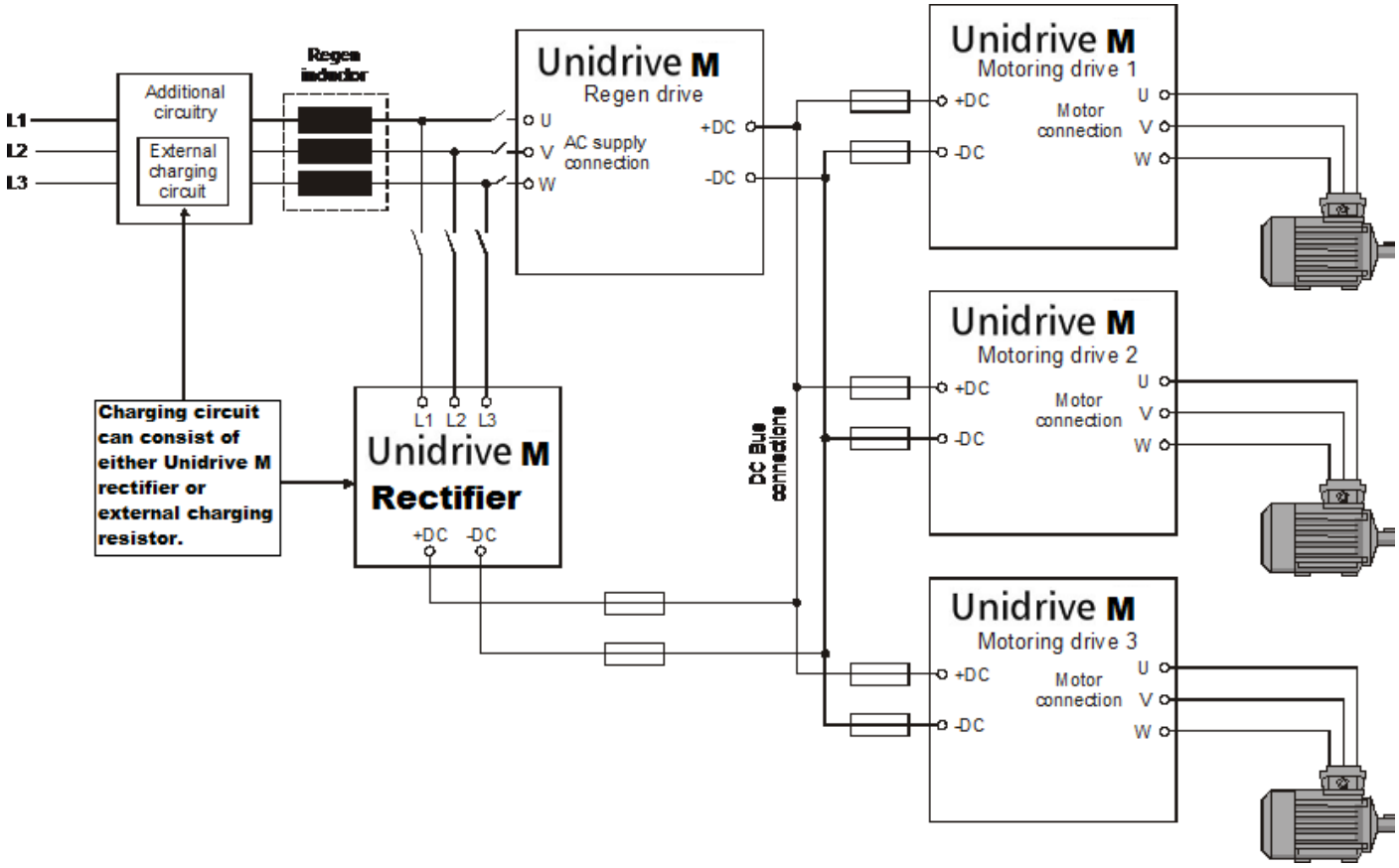
Single Regen, single motoring drive- detailed diagram



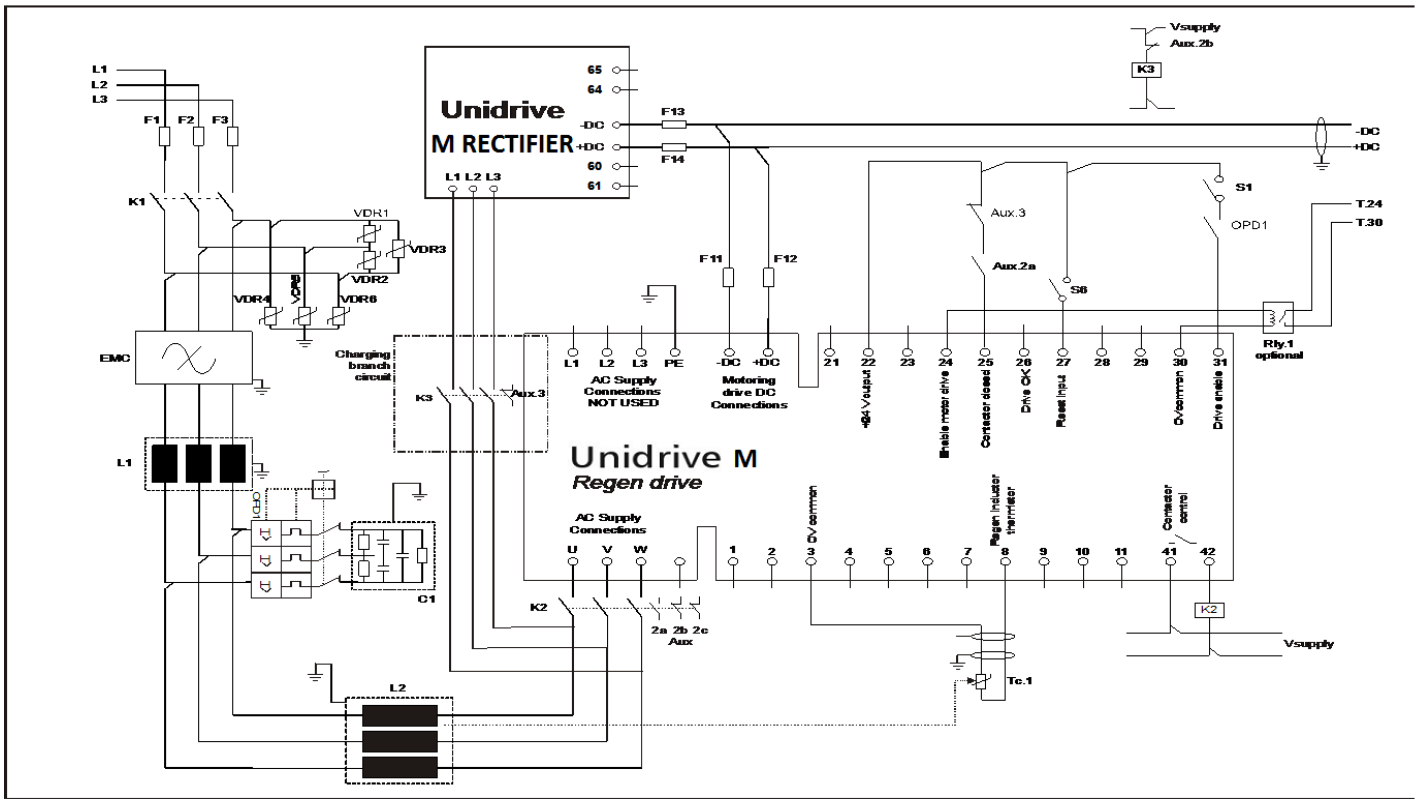

-DC
+DC
T.24
T.30
S3
S4
S5
S2
L1
L2
L3
PE
-DC
+DC
21
22
23
24
25
26
27
28
29
30
31
AC Supply
NOT USED
Motoring
drive DC
Connections
Unidrive M
Motoring drive
Motor
Connections
U
V
W
1
2
3
4
5
6
7
8
9
10
11
41
42
ML1
Power feed forward
connections (optional)

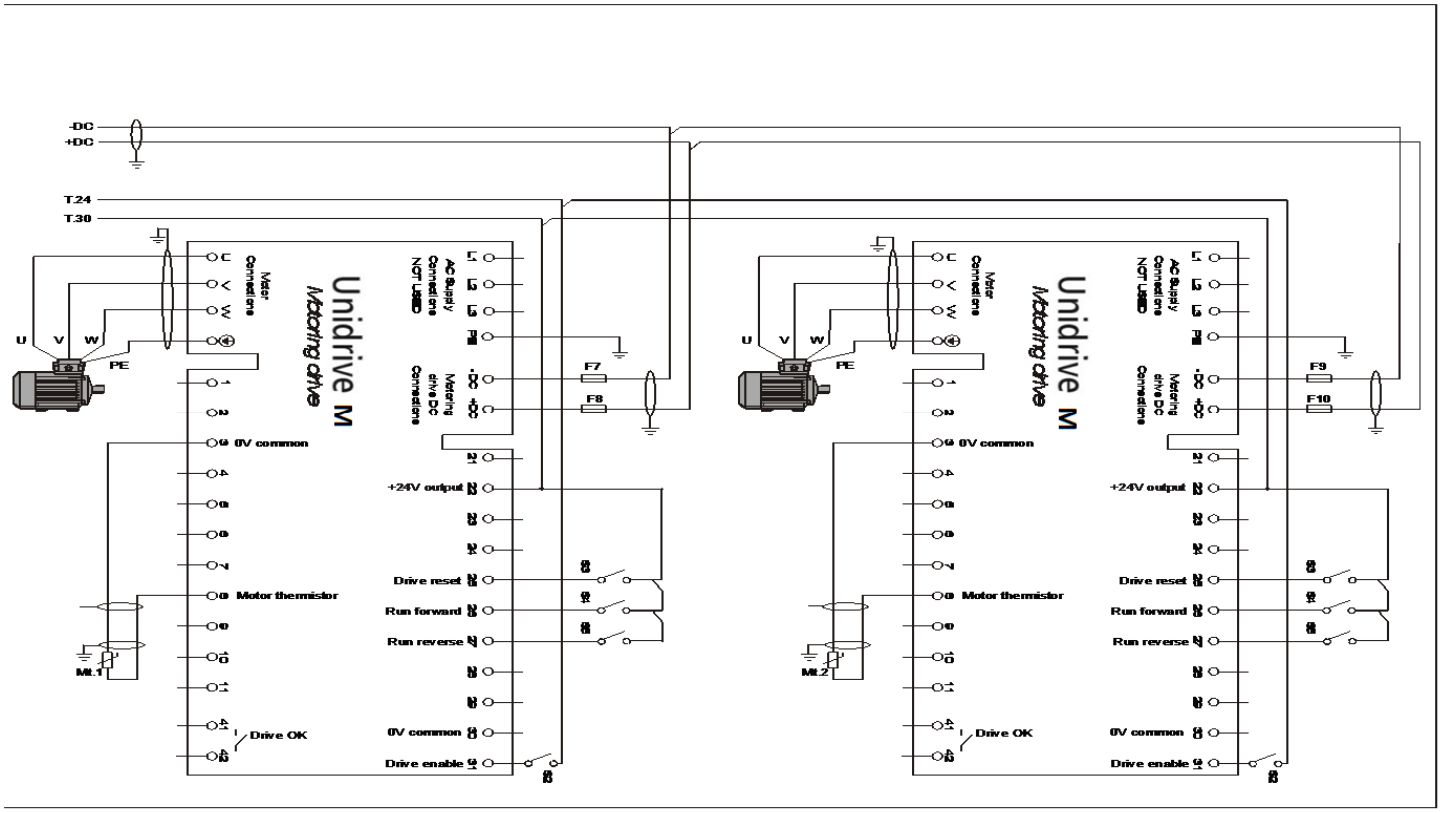
Single Regen, multiple motoring system using external rectifier- simple diagram

The diagram below shows the layout for a Regen system consisting of a single Regen drive with multiple motoring drives. In these configurations the Regen drive is sized to the total power of all motoring drives.

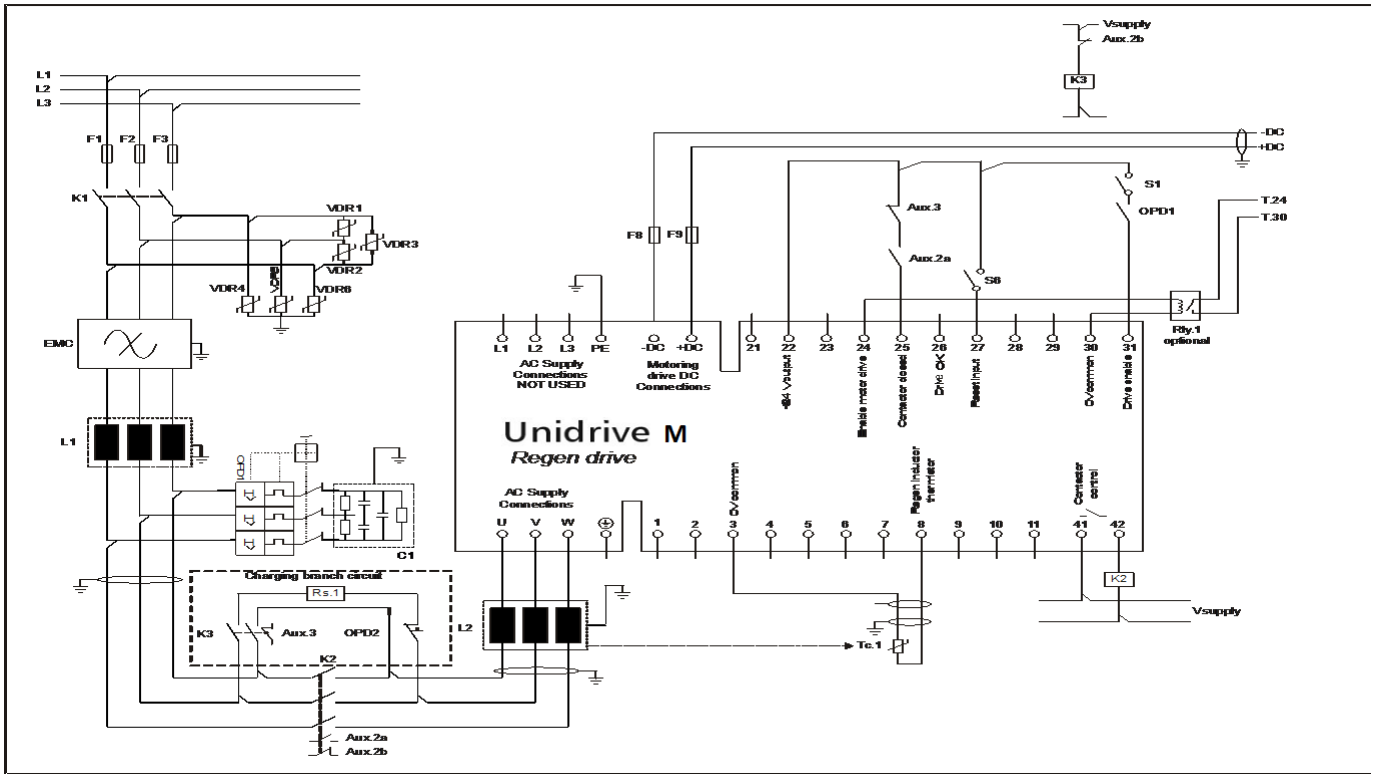


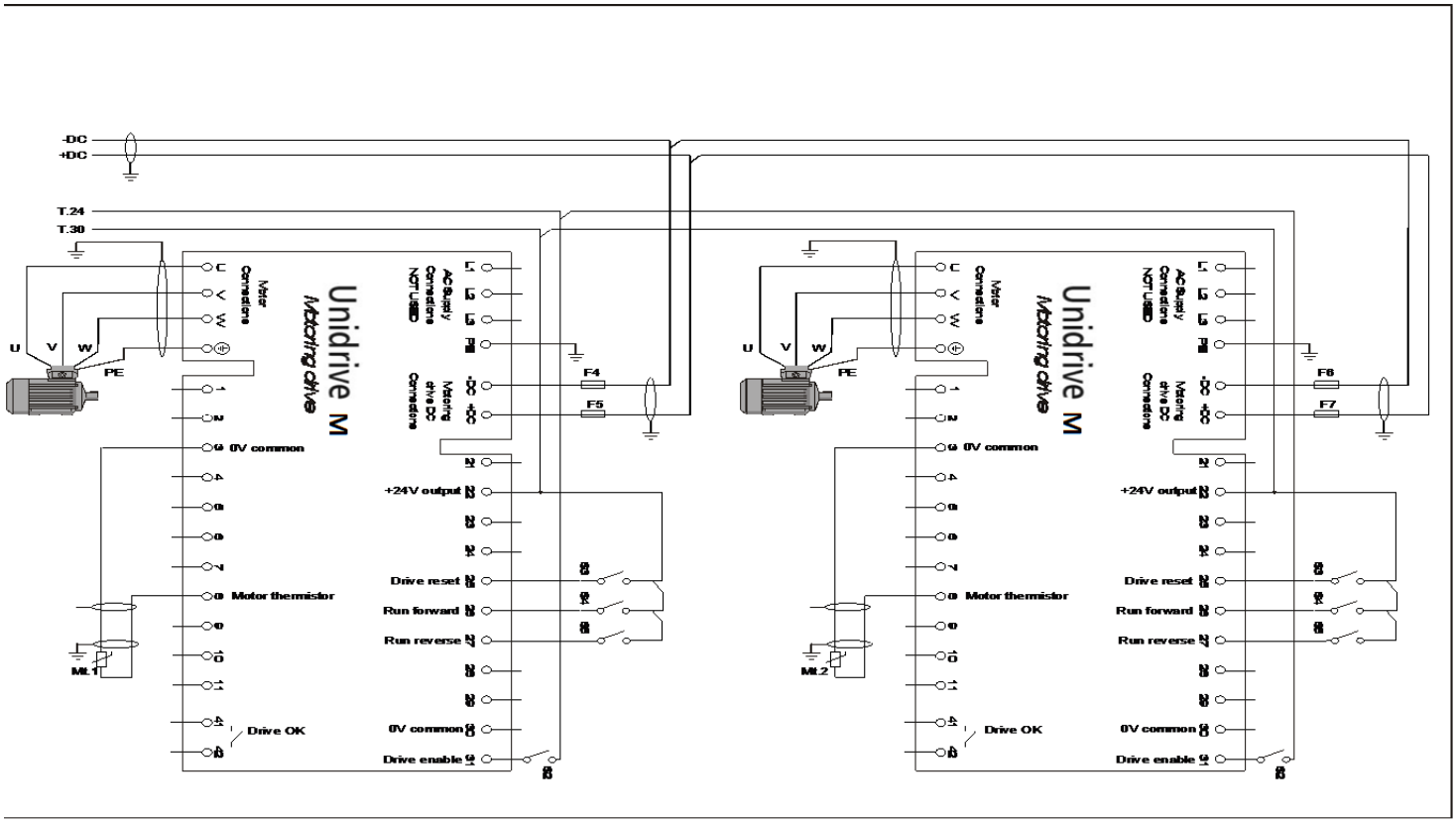
Single Regen, multiple motoring system using external rectifier- detailed diagram




-DC
+DC
T.24
T.30
U
V
W
PE
Unidrive M
Motoring drive
Motor Connections
AC Supply Connections NOT USED
Motoring drive DC Connections
F7
F8
F9
F10
0V common
+24V output
Drive reset
Run forward
Run reverse
Motor thermistor
Drive OK
Drive enable
ML1
ML2

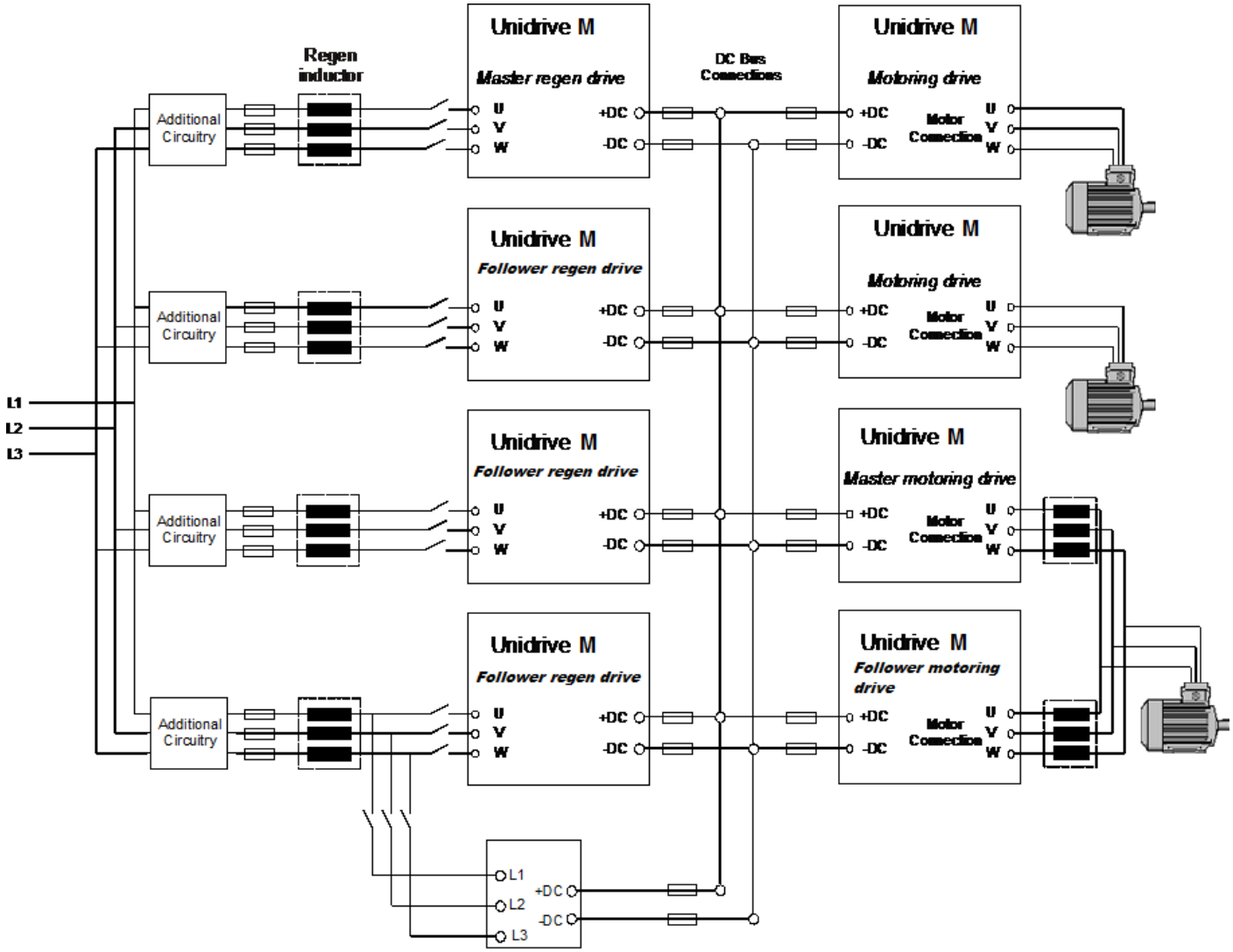
Single Regen, multiple motoring system using external charging resistor- detailed diagram



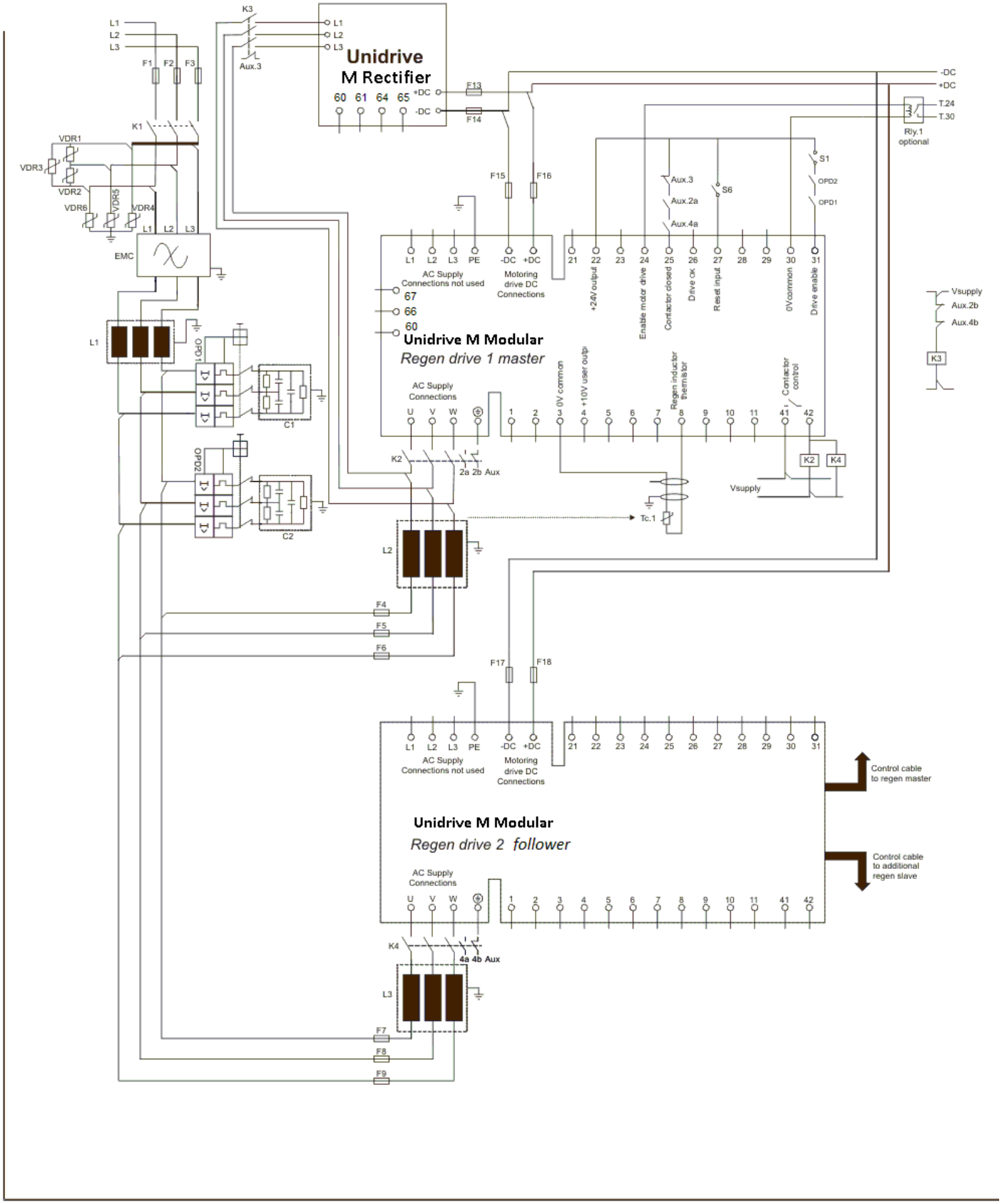

-DC
+DC
T.24
T.30
U
V
W
PE
Unidrive M
Motoring drive
Motor Connections
AC Supply Connections NOT USED
Motoring shared DC Connections
F4
F5
F6
F7
0V common
+24V output
Drive reset
Run forward
Run reverse
Motor thermistor
Drive OK
0V common
Drive enable
Mt.1
Mt.2

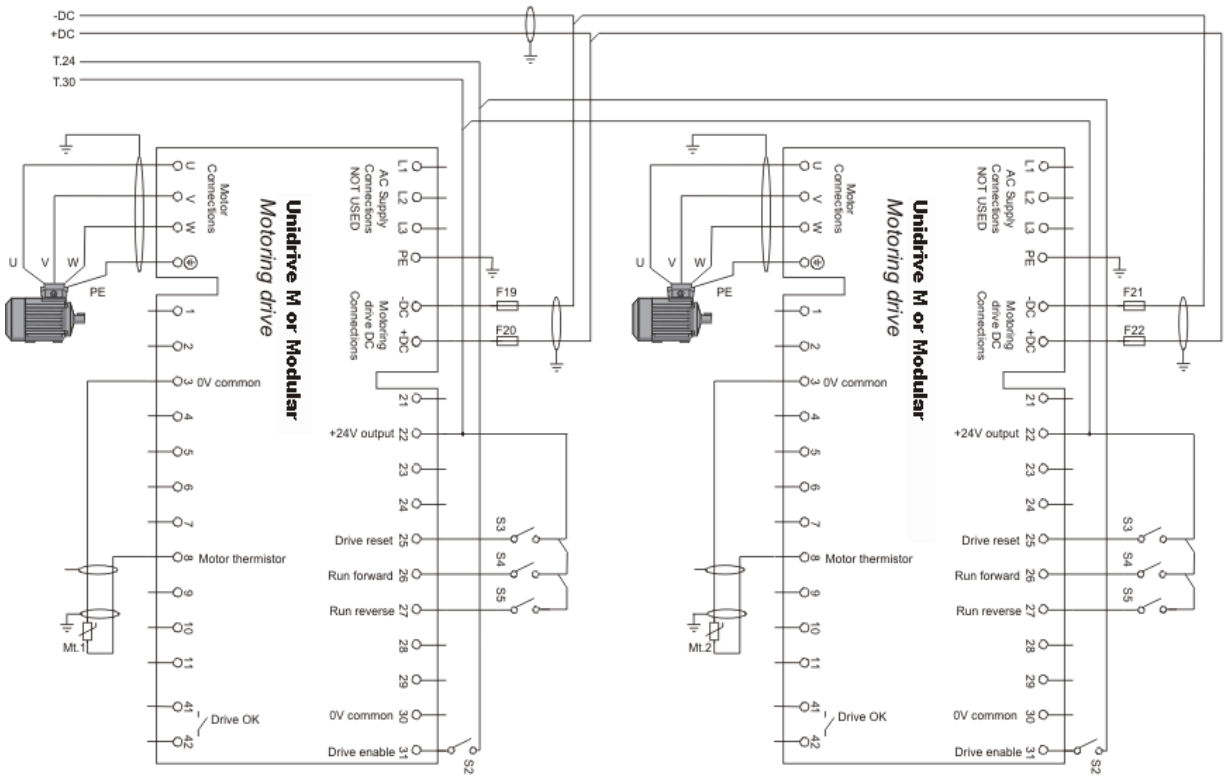
Multiple Regen, multiple motoring system using external rectifier- simple diagram

The diagram below shows a multiple Regen drive system with multiple motoring drives. For this configuration the Regen drives are sized to the total power requirement of all motoring drives. The multiple Regen configuration is only possible with Unidrive M modular drives in master / follower configuration.



Multiple Regen, multiple motoring system using external rectifier- detailed diagram





Regen filter components

The Regen filter components listed in this document are the best match between the currently available filters and the new Unidrive M ratings. In some cases (see tables) it is necessary to reduce Pr5.007 (rated current) to avoid exceeding the filter current rating. It is likely that these filter components will be reviewed in the future to provide a better match in this respect. It should be noted that the filters currently available were originally designed for a minimum switching frequency of 3kHz. Increased heating of the regen inductor combined with increased capacitor current and less sinusoidal output current is likely to occur if the newly available 2kHz switching frequency is used.

200V systems

Drive			Calculations		Regen inductor			Filter inductor			SFF capacitor				
Model	Heavy / normal duty	Current rating (A)	nearest available regen filter current rating (A)	check filter current rating is sufficient for drive	Regen inductor (mH)	Current rating (A)	CT part no.	Filter inductor (mH)	Current rating (A)	CT part no.	Capacitor value(µF)	Nominal voltage (Vac)	CT part no.	Capacitor current per can (Arms) See Note1	MCB setting (A)
3200066	N	8	9.6	ok	3.5	9.6	4401-0310	0.88	9.6	4401-1310	7	400	1664-1074	1.6	2.5
3200080	H	8	9.6	ok	3.5	9.6	4401-0310	0.88	9.6	4401-1310	7	400	1664-1074	1.6	2.5
3200080	N	11	11	ok	2.7	11.0	4401-0311	1.5	11.0	4401-1311	7	400	1664-1074	1.8	2.8
3200106	H	10.6	11	ok	2.7	11.0	4401-0311	1.5	11.0	4401-1311	7	400	1664-1074	1.8	2.8
3200106	N	12.7	11	modify Pr5.007 to 11	2.7	11.0	4401-0311	1.5	11.0	4401-1311	7	400	1664-1074	1.8	2.8
4200137	H	13.7	15.5	ok	2.2	15.5	4401-0312	1.1	15.5	4401-1312	7	400	1664-1074	2.0	3.1
4200137	N	18	15.5	modify Pr5.007 to 15.5	2.2	15.5	4401-0312	1.1	15.5	4401-1312	7	400	1664-1074	2.0	3.1
4200185	H	18.5	15.5	modify Pr5.007 to 15.5	2.2	15.5	4401-0312	1.1	15.5	4401-1312	7	400	1664-1074	2.0	3.1
4200185	N	25	22	modify Pr5.007 to 22	1.6	22	4401-0313	0.70	22	4401-1313	17	400	1664-2174	3.8	5.9
5200250	H	25	22	modify Pr5.007 to 22	1.6	22	4401-0313	0.70	22	4401-1313	17	400	1664-2174	3.8	5.9
5200250	N	30	31	ok	1.10	31	4401-0314	0.50	31	4401-1314	17	400	1664-2174	4.4	6.8
6200330	H	33	31	modify Pr5.007 to 31	1.10	31	4401-0314	0.50	31	4401-1314	17	400	1664-2174	4.4	6.8
6200330	N	50	56	ok	0.6	56	4401-0316	0.30	56	4401-1316	32	525	1665-8324	8.1	13
6200440	H	44	42	modify Pr5.007 to 42	0.81	42	4401-0315	0.40	42	4401-1315	17	400	1664-2174	5.2	8.0
6200440	N	58	56	modify Pr5.007 to 56	0.6	56	4401-0316	0.30	56	4401-1316	32	525	1665-8324	8.1	13
7200610	H	61	56	modify Pr5.007 to 56	0.6	56	4401-0316	0.30	56	4401-1316	32	525	1665-8324	8.1	13
7200610	N	75	80	ok	0.4	80	4401-0318	0.20	80	4401-1318	32	525	1665-8324	9.9	15
7200750	H	75	80	ok	0.4	80	4401-0318	0.20	80	4401-1318	32	525	1665-8324	9.9	15
7200750	N	94	105	ok	0.32	105	4401-0319	0.16	105	4401-1319	64	400	1664-2644	15.8	24
7200830	H	83	80	modify Pr5.007 to 80	0.4	80	4401-0318	0.20	80	4401-1318	32	525	1665-8324	9.9	15
7200830	N	117	105	modify Pr5.007 to 105	0.32	105	4401-0319	0.16	105	4401-1319	64	400	1664-2644	15.8	24
8201160	H	116	105	modify Pr5.007 to 105	0.32	105	4401-0319	0.16	105	4401-1319	64	400	1664-2644	15.8	24
8201160	N	149	156	ok	0.22	156	4401-0321	0.11	156	4401-1321	64	400	1664-2644	19.2	30
8201320	H	132	156	ok	0.22	156	4401-0321	0.11	156	4401-1321	64	400	1664-2644	19.2	30
8201320	N	180	192	ok	0.18	192	4401-0322	0.088	192	4401-1322	2*64	400	2*1664-2644	15.2	23
9201760	H	176	192	ok	0.18	192	4401-0322	0.088	192	4401-1322	2*64	400	2*1664-2644	15.2	23
9201760	N	216	192	modify Pr5.007 to 192	0.18	192	4401-0322	0.088	192	4401-1322	2*64	400	2*1664-2644	15.2	23
9202190	H	219	192	modify Pr5.007 to 192	0.18	192	4401-0322	0.088	192	4401-1322	2*64	400	2*1664-2644	15.2	23
9202190	N	266	250	modify Pr5.007 to 250	0.14	250	4401-0323	0.068	250	4401-1323	2*64	400	2*1664-2644	16.8	26
10201760	H	176	192	ok	0.18	192	4401-0322	0.088	192	4401-1322	2*64	400	2*1664-2644	15.2	23
10201760	N	216	192	modify Pr5.007 to 192	0.18	192	4401-0322	0.088	192	4401-1322	2*64	400	2*1664-2644	15.2	23
10202190	H	219	192	modify Pr5.007 to 192	0.18	192	4401-0322	0.088	192	4401-1322	2*64	400	2*1664-2644	15.2	23
10202190	N	266	250	modify Pr5.007 to 250	0.14	250	4401-0323	0.068	250	4401-1323	2*64	400	2*1664-2644	16.8	26
10202830	H	283	312	ok	0.11	312	4401-0324	0.055	312	4401-1324	2*64	400	2*1664-2644	19.2	30
10202830	N	325	312	modify Pr5.007 to 312	0.11	312	4401-0324	0.055	312	4401-1324	2*64	400	2*1664-2644	19.2	30
10203000	H	300	312	ok	0.11	312	4401-0324	0.055	312	4401-1324	2*64	400	2*1664-2644	19.2	30
10203000	N	360	350	modify Pr5.007 to 350	0.10	350	4401-0325	0.048	350	4401-1325	2*64	400	2*1664-2644	20.5	32

Notes

1) SFF capacitor current is the total RMS line current per can, calculated at 240V +10% 60Hz, max cap tolerance (+10%), and 3kHz SF

400V systems

Drive			Calculations		Regen inductor			Filter inductor			SFF capacitor				
Model	Heavy / normal duty	Current rating (A)	nearest available regen filter current rating (A)	check filter current rating is sufficient for drive	Regen inductor (mH)	Current rating (A)	CT part no.	Filter inductor (mH)	Current rating (A)	CT part no.	Capacitor value (µF)	Nominal voltage (Vac)	CT part no.	Capacitor current per can (Arms) See Note1	MCB setting (A)
3400078	H	7.8	9.5	ok	6.3	9.5	4401-0001	3.16	9.5	4401-0162	8	525	1610-7804	3.3	5.0
3400078	N	10.4	9.5	modify Pr5.007 to 9.5	6.3	9.5	4401-0001	3.16	9.5	4401-0162	8	525	1610-7804	3.3	5.0
3400100	H	10	9.5	modify Pr5.007 to 9.5	6.3	9.5	4401-0001	3.16	9.5	4401-0162	8	525	1610-7804	3.3	5.0
3400100	N	12.3	12	modify Pr5.007 to 12	5.00	12	4401-0002	2.50	12	4401-0163	8	525	1610-7804	3.3	5.2
4400150	H	15	16	ok	3.75	16	4401-0003	1.875	16	4401-0164	8	525	1610-7804	3.5	5.4
4400150	N	18.5	16	modify Pr5.007 to 16	3.75	16	4401-0003	1.875	16	4401-0164	8	525	1610-7804	3.5	5.4
4400172	H	17.2	16	modify Pr5.007 to 16	3.75	16	4401-0003	1.875	16	4401-0164	8	525	1610-7804	3.5	5.4
4400172	N	24	25	ok	2.40	25	4401-0004	1.20	25	4401-0165	8	525	1610-7804	4.1	6.3
5400270	H	27	25	modify Pr5.007 to 25	2.40	25	4401-0004	1.20	25	4401-0165	8	525	1610-7804	4.1	6.3
5400270	N	30	34	ok	1.76	34	4401-0005	0.88	34	4401-0166	32	525	1665-8324	13.0	20
5400300	H	30	34	ok	1.76	34	4401-0005	0.88	34	4401-0166	32	525	1665-8324	13.0	20
5400300	N	31	34	ok	1.76	34	4401-0005	0.88	34	4401-0166	32	525	1665-8324	13.0	20
6400350	H	35	34	modify Pr5.007 to 34	1.76	34	4401-0005	0.88	34	4401-0166	32	525	1665-8324	13.0	20
6400350	N	38	40	ok	1.5	40	4401-0006	0.75	40	4401-0167	32	525	1665-8324	13.1	20
6400420	H	42	40	modify Pr5.007 to 40	1.5	40	4401-0006	0.75	40	4401-0167	32	525	1665-8324	13.1	20
6400420	N	48	46	modify Pr5.007 to 46	1.3	46	4401-0007	0.65	46	4401-0168	32	525	1665-8324	13.3	21
6400470	H	47	46	modify Pr5.007 to 46	1.3	46	4401-0007	0.65	46	4401-0168	32	525	1665-8324	13.3	21
6400470	N	63	60	modify Pr5.007 to 60	1.0	60	4401-0008	0.50	60	4401-0169	32	525	1665-8324	13.9	21
7400660	H	66	70	ok	0.78	70	4401-0009	0.39	70	4401-0170	32	525	1665-8324	14.8	23
7400660	N	79	70	modify Pr5.007 to 70	0.78	70	4401-0009	0.39	70	4401-0170	32	525	1665-8324	14.8	23
7400770	H	77	70	modify Pr5.007 to 70	0.78	70	4401-0009	0.39	70	4401-0170	32	525	1665-8324	14.8	23
7400770	N	94	96	ok	0.63	96	4401-0010	0.315	96	4401-0171	39	525	1665-8394	18.1	28
7401000	H	100	96	modify Pr5.007 to 96	0.63	96	4401-0010	0.315	96	4401-0171	39	525	1665-8394	18.1	28
7401000	N	112	124	ok	0.48	124	4401-0011	0.24	124	4401-0172	39	525	1665-8394	20.1	31
8401340	H	134	124	modify Pr5.007 to 124	0.48	124	4401-0011	0.24	124	4401-0172	39	525	1665-8394	20.1	31
8401340	N	155	156	ok	0.38	156	4401-0012	0.19	156	4401-0173	39	525	1665-8394	22.7	35
8401570	H	157	156	modify Pr5.007 to 156	0.38	156	4401-0012	0.19	156	4401-0173	39	525	1665-8394	22.7	35
8401570	N	184	180	modify Pr5.007 to 180	0.33	180	4401-0013	0.165	180	4401-0174	39	525	1665-8394	24.8	38
9402000	H	200	202	ok	0.30	202	4401-0014	0.135	202	4401-0175	2*39	525	2*1665-8394	18.4	28
9402000	N	221	202	modify Pr5.007 to 202	0.30	202	4401-0014	0.135	202	4401-0175	2*39	525	2*1665-8394	18.4	28
9402240	H	224	202	modify Pr5.007 to 202	0.30	202	4401-0014	0.135	202	4401-0175	2*39	525	2*1665-8394	18.4	28
9402240	N	266	300	ok	0.24	300	4401-0015	0.10	300	4401-0176	2*39	525	2*1665-8394	20.1	31
10402000	H	200	202	ok	0.30	202	4401-0014	0.135	202	4401-0175	2*39	525	2*1665-8394	18.4	28
10402000	N	221	202	modify Pr5.007 to 202	0.30	202	4401-0014	0.135	202	4401-0175	2*39	525	2*1665-8394	18.4	28
10402240	H	224	202	modify Pr5.007 to 202	0.30	202	4401-0014	0.135	202	4401-0175	2*39	525	2*1665-8394	18.4	28
10402240	N	266	300	ok	0.24	300	4401-0015	0.10	300	4401-0176	2*39	525	2*1665-8394	20.1	31
10402700	H	270	300	ok	0.24	300	4401-0015	0.10	300	4401-0176	2*39	525	2*1665-8394	20.1	31
10402700	N	320	300	modify Pr5.007 to 300	0.24	300	4401-0015	0.10	300	4401-0176	2*39	525	2*1665-8394	20.1	31
10403200	H	320	300	modify Pr5.007 to 300	0.24	300	4401-0015	0.10	300	4401-0176	2*39	525	2*1665-8394	20.1	31
10403200	N	361	350	modify Pr5.007 to 350	0.16	350	4401-0205	0.08	350	4401-1205	2*39	525	2*1665-8394	25.4	39

Notes

1) SFF capacitor current is the total RMS line current per can, calculated at 480V +10% 60Hz, max cap tolerance (+10%), and 3kHz SF

575V systems

Drive			Calculations		Regen inductor			Filter inductor			SFF capacitor				
Model	Heavy / normal duty	Current rating (A)	nearest available regen filter current rating (A)	check filter current rating is sufficient for drive	Regen inductor (mH)	Current rating (A)	CT part no.	Filter inductor (mH)	Current rating (A)	CT part no.	Capacitor value(µF)	Nominal voltage (Vac)	CT part no.	Capacitor current per can (Arms) See Note1	MCB setting (A)
6500150	H	15	19	ok	5.3	19	4401-0210	1.40	22	4401-1211	11.2	690	1666-8113	5.2	8.0
6500150	N	17	19	ok	5.3	19	4401-0210	1.40	22	4401-1211	11.2	690	1666-8113	5.2	8.0
6500190	H	19	19	ok	5.3	19	4401-0210	1.40	22	4401-1211	11.2	690	1666-8113	5.2	8.0
6500190	N	22	22	ok	4.6	22	4401-0211	1.40	22	4401-1211	11.2	690	1666-8113	5.2	8.1
6500230	H	23	22	modify Pr5.007 to 22	4.6	22	4401-0211	1.40	22	4401-1211	11.2	690	1666-8113	5.2	8.1
6500230	N	27	27	ok	3.8	27	4401-0212	1.40	36	4401-1213	11.2	690	1666-8113	5.3	8.2
6500290	H	29	27	modify Pr5.007 to 27	3.8	27	4401-0212	1.40	36	4401-1213	11.2	690	1666-8113	5.3	8.2
6500290	N	34	36	ok	2.8	36	4401-0213	1.20	43	4401-1214	11.2	690	1666-8113	5.6	8.7
6500350	H	35	36	ok	2.8	36	4401-0213	1.20	43	4401-1214	11.2	690	1666-8113	5.6	8.7
6500350	N	43	43	ok	2.4	43	4401-0214	1.00	52	4401-1215	11.2	690	1666-8113	5.9	9.1
7500440	H	44	43	modify Pr5.007 to 43	2.4	43	4401-0214	1.00	52	4401-1215	11.2	690	1666-8113	5.9	9.1
7500440	N	53	52	modify Pr5.007 to 52	1.9	52	4401-0215	0.80	63	4401-1216	11.2	690	1666-8113	6.4	9.8
7500550	H	55	52	modify Pr5.007 to 52	1.9	52	4401-0215	0.80	63	4401-1216	11.2	690	1666-8113	6.4	9.8
7500550	N	73	63	modify Pr5.007 to 63	1.6	63	4401-0216	0.60	85	4401-1217	11.2	690	1666-8113	6.9	11
8500630	H	63	63	ok	1.6	63	4401-0216	0.60	85	4401-1217	11.2	690	1666-8113	6.9	11
8500630	N	86	85	modify Pr5.007 to 85	1.20	85	4401-0217	0.50	100	4401-1218	11.2	690	1666-8113	8.2	13
8500860	H	86	85	modify Pr5.007 to 85	1.20	85	4401-0217	0.50	100	4401-1218	11.2	690	1666-8113	8.2	13
8500860	N	108	100	modify Pr5.007 to 100	1.00	100	4401-0218	0.40	125	4401-1219	22.5	690	1666-8223	12.5	19
9501040	H	104	100	modify Pr5.007 to 100	1.00	100	4401-0218	0.40	125	4401-1219	22.5	690	1666-8223	12.5	19
9501040	N	125	125	ok	0.80	125	4401-0219	0.35	144	4401-1220	22.5	690	1666-8223	13.8	21
9501310	H	131	125	modify Pr5.007 to 125	0.80	125	4401-0219	0.35	144	4401-1220	22.5	690	1666-8223	13.8	21
9501310	N	150	144	modify Pr5.007 to 144	0.70	144	4401-0220	0.30	168	4401-1221	22.5	690	1666-8223	14.9	23
10501040	H	104	100	modify Pr5.007 to 100	1.00	100	4401-0218	0.40	125	4401-1219	22.5	690	1666-8223	12.5	19
10501040	N	125	125	ok	0.80	125	4401-0219	0.35	144	4401-1220	22.5	690	1666-8223	13.8	21
10501310	H	131	125	modify Pr5.007 to 125	0.80	125	4401-0219	0.35	144	4401-1220	22.5	690	1666-8223	13.8	21
10501310	N	150	144	modify Pr5.007 to 144	0.70	144	4401-0220	0.30	168	4401-1221	22.5	690	1666-8223	14.9	23
10501520	H	152	144	modify Pr5.007 to 144	0.70	144	4401-0220	0.30	168	4401-1221	22.5	690	1666-8223	14.9	23
10501520	N	200	192	modify Pr5.007 to 192	0.53	192	4401-0222	0.21	192	4401-1223	2*22,5	690	2*1666-8223	12.2	19
10501900	H	190	192	ok	0.53	192	4401-0222	0.21	192	4401-1223	2*22,5	690	2*1666-8223	12.2	19
10501900	N	200	192	modify Pr5.007 to 192	0.53	192	4401-0222	0.21	192	4401-1223	2*22,5	690	2*1666-8223	12.2	19

Notes

1) SFF capacitor current is the total RMS line current per can, calculated at 575V +10% 60Hz, max cap tolerance (+5%), and 3kHz SF

690V systems

Drive			Calculations		Regen inductor			Filter inductor			SFF capacitor				
Model	Heavy / normal duty	Current rating (A)	nearest available regen filter current rating (A)	check filter current rating is sufficient for drive	Regen inductor (mH)	Current rating (A)	CT part no.	Filter inductor (mH)	Current rating (A)	CT part no.	Capacitor value (µF)	Nominal voltage (Vac)	CT part no.	Capacitor current per can (Arms) See Note1	MCB setting (A)
7600190	H	19	19	ok	5.3	19	4401-0210	1.40	22	4401-1211	8.3	800	1668-7833	4.7	7.3
7600190	N	23	22	modify Pr5.007 to 22	4.6	22	4401-0211	1.40	22	4401-1211	8.3	800	1668-7833	4.8	7.4
7600240	H	24	22	modify Pr5.007 to 22	4.6	22	4401-0211	1.40	22	4401-1211	8.3	800	1668-7833	4.8	7.4
7600240	N	30	27	modify Pr5.007 to 27	3.8	27	4401-0212	1.40	36	4401-1213	8.3	800	1668-7833	5.0	7.7
7600290	H	29	27	modify Pr5.007 to 27	3.8	27	4401-0212	1.40	36	4401-1213	8.3	800	1668-7833	5.0	7.7
7600290	N	36	36	ok	2.8	36	4401-0213	1.40	36	4401-1213	8.3	800	1668-7833	5.5	8.5
7600380	H	38	36	modify Pr5.007 to 36	2.8	36	4401-0213	1.40	36	4401-1213	8.3	800	1668-7833	5.5	8.5
7600380	N	46	43	modify Pr5.007 to 43	2.4	43	4401-0214	1.20	43	4401-1214	8.3	800	1668-7833	5.8	9.0
7600440	H	44	43	modify Pr5.007 to 43	2.4	43	4401-0214	1.20	43	4401-1214	8.3	800	1668-7833	5.8	9.0
7600440	N	52	52	ok	1.90	52	4401-0215	1.00	52	4401-1215	8.3	800	1668-7833	6.6	10
7600540	H	54	52	modify Pr5.007 to 52	1.90	52	4401-0215	1.00	52	4401-1215	8.3	800	1668-7833	6.6	10
7600540	N	73	63	modify Pr5.007 to 63	1.60	63	4401-0216	0.80	63	4401-1216	8.3	800	1668-7833	7.3	11
8600630	H	63	63	ok	1.60	63	4401-0216	0.80	63	4401-1216	8.3	800	1668-7833	7.3	11
8600630	N	86	85	modify Pr5.007 to 85	1.2	85	4401-0217	0.60	85	4401-1217	16.6	800	1668-8163	11.6	18
8600860	H	86	85	modify Pr5.007 to 85	1.2	85	4401-0217	0.60	85	4401-1217	16.6	800	1668-8163	11.6	18
8600860	N	108	100	modify Pr5.007 to 100	1.0	100	4401-0218	0.50	100	4401-1218	16.6	800	1668-8163	12.8	20
9601040	H	104	100	modify Pr5.007 to 100	1.0	100	4401-0218	0.50	100	4401-1218	16.6	800	1668-8163	12.8	20
9601040	N	125	125	ok	0.81	125	4401-0219	0.40	125	4401-1219	16.6	800	1668-8163	14.5	22
9601310	H	131	125	modify Pr5.007 to 125	0.81	125	4401-0219	0.40	125	4401-1219	16.6	800	1668-8163	14.5	22
9601310	N	150	144	modify Pr5.007 to 144	0.70	144	4401-0220	0.35	144	4401-1220	2 * 16,6	800	2*1668-8163	10.9	17
10601040	H	104	100	modify Pr5.007 to 100	1.0	100	4401-0218	0.50	100	4401-1218	16.6	800	1668-8163	12.8	20
10601040	N	125	125	ok	0.81	125	4401-0219	0.40	125	4401-1219	16.6	800	1668-8163	14.5	22
10601310	H	131	125	modify Pr5.007 to 125	0.81	125	4401-0219	0.40	125	4401-1219	16.6	800	1668-8163	14.5	22
10601310	N	155	144	modify Pr5.007 to 144	0.70	144	4401-0220	0.35	144	4401-1220	2 * 16,6	800	2*1668-8163	10.9	17
10601500	H	150	144	modify Pr5.007 to 144	0.70	144	4401-0220	0.35	144	4401-1220	2 * 16,6	800	2*1668-8163	10.9	17
10601500	N	172	168	modify Pr5.007 to 168	0.60	168	4401-0221	0.30	168	4401-1221	2 * 16,6	800	2*1668-8163	11.6	18
10601780	H	178	168	modify Pr5.007 to 168	0.60	168	4401-0221	0.30	168	4401-1221	2 * 16,6	800	2*1668-8163	11.6	18
10601780	N	197	192	modify Pr5.007 to 192	0.53	192	4401-0222	0.26	192	4401-1222	2 * 16,6	800	2*1668-8163	12.4	19

Notes

1) SFF capacitor current is the total RMS line current per can, calculated at 690V +10% 60Hz, max cap tolerance (+5%), and 3kHz SF

Varistors

Drive rating	Voltage rating Vrms	Energy rating J	Quantity per system	Configuration	CT part number
200V (200V to 240V±10%)	550	620	3	Line to line	2482-3291
	680	760	3	Line to ground	2482-3211
400V (380V to 480V±10%)	550	620	3	Line to line	2482-3291
	680	760	3	Line to ground	2482-3211
500V (500V to 575V±10%)	680	760	3	Line to line	2482-3211
	1000	1200	3	Line to ground	2482-3218
690V (500V to 690V±10%)	385	550	6	2 in series line to line	2482-3262
	1000	1200	3	Line to ground	2482-3218