Sigmadrive Quick Reference Manual

This user manual details the features of the standard controller range:
(for more detailed information, download one of the full Manuals from www.dmcde.de)

1.	Pro-AC range	for AC Induction Motors	24-96V, 125-460Arms
2.	Pro-PMS range	for Permanent Magnet Synchronous Motors	24-96V, 125-460Arms
3.	Pro-SEM range	for Separately Exited Motors	24-96V, 125-650A
4.	Pro-PM4 range	for 4Q (brushed) Permanent Magnet Motors	24-96V, 125-650A
5.	Pro-Series range	for Series Wound Motors	24-96V, 125-650A
6.	Pro-Pump range	for Series wound Pump Motors	24-96V, 125-650A

Modification History:

Revision	Issue Date	Author	Changes
3.05.00f	05-10-2011	R.P.	AC Pump Release 3.06.00 – compatible with DMC PC interface
3.05.00g	01-03-2012	R.P.	Correction PMS CAN Messages
3.05.00h	04-04-2013	AJ de Vries	Series Traction updates on fast belly & tiller switch response, wig-wag, and TCL.
3.05.00i	26-04-2013	AJ de Vries	Configurable contactor outputs for PMS and PM4 controllers including support for Drive OK and Thermal High warnings.
3.05.00j	06-06-2013	AJ de Vries	Made explicitly clear that configurable contactor outputs are only for PM4 and not for SEM (for PMS nothing changes).
3.05.00k	04-08-2014	AJ de Vries	Added KTY81-110 for PMS.
3.05.00l	29-09-2014	RP	PMS CAN update – allow multiple PMS controller nodes
3.05.00m	6-7-2018	RP	Updated mechanical drawings

CONTENTS

1 DMC Philosophy – Introduction

DMC (Digital Motor Control) GmbH, is a company with a dedicated team of individuals with many years' experience in the design, manufacture, sales and aftermarket support of controllers predominately utilised in the electric vehicle industry. DMC has invested in a purpose built state of the art production facility. The Company has been formed with enthusiasm and professionalism to create and develop a unique new product range in this particular "niche" industry where specialist knowledge and experience are essential for success.

Utilising revolutionary power heat sinking technology called IMS (Insulated Metal Substrate) a new generation of highly efficient controllers for all popular motor types can now be offered from a single core design, in the 24V - 120V, 1KW - 24KW power range. Using 'flash memory' in the control electronics coupled with a unique design architecture, all powers and motor types including AC, PMS (PMAC), Separately Excited, Permanent Magnet and Series, can be accommodated within 3 standard power frames. Particular attention has been placed on providing high-resolution control circuitry and software, to provide fully optimised, highly efficient motor control.

The principle advantage of IMS technology (which can be visualised as a metal PCB) is that cost effective SMD Mosfet power devices can be mounted and soldered directly onto the IMS PCB, which provides immediate and excellent 'integral' heat sinking. Consequently, reliability and efficiency are significantly enhanced due to the power switching devices running cooler and therefore inherently more efficiently. This approach also leads to significantly improved continuous power delivery (1 hour current rating), as a ratio to peak power, with the controllers continuous rating normally being one of the most important aspects in determining the vehicles performance.

By using an innovative patented technique, DMC has fully exploited IMS technology to realise a unique controller design. The construction provides manufacturing simplicity and reliability by removing the need for any interconnections and using a minimal number of mechanical and electronic components. This gives a totally robust and environmentally sealed, space efficient controller.

An additional feature, a ground breaking concept which epitomises DMC's innovative spirit, is the Directly Integrated Current Control module. This module is at the heart of all DMC controllers and provides continuous, real time control, of motor power delivery, whilst at the same time providing full, instantaneous hardware protection, against any over current fault condition.

DMC's AC controller utilises a powerful dedicated motor control microprocessor together with rapid look up table based pre-calculations, to perform it's Sequential Phase Control (SPC) strategy. SPC uses it's Directly Integrated Current Control technology to independently measure all 3 phase currents every PWM cycle to provide totally balanced smooth and efficient vehicle control. SPC provides enhanced performance over standard slip control especially with dynamic loads, offering improved cost effective performance in between that of slip and more complex, costly flux vector systems.

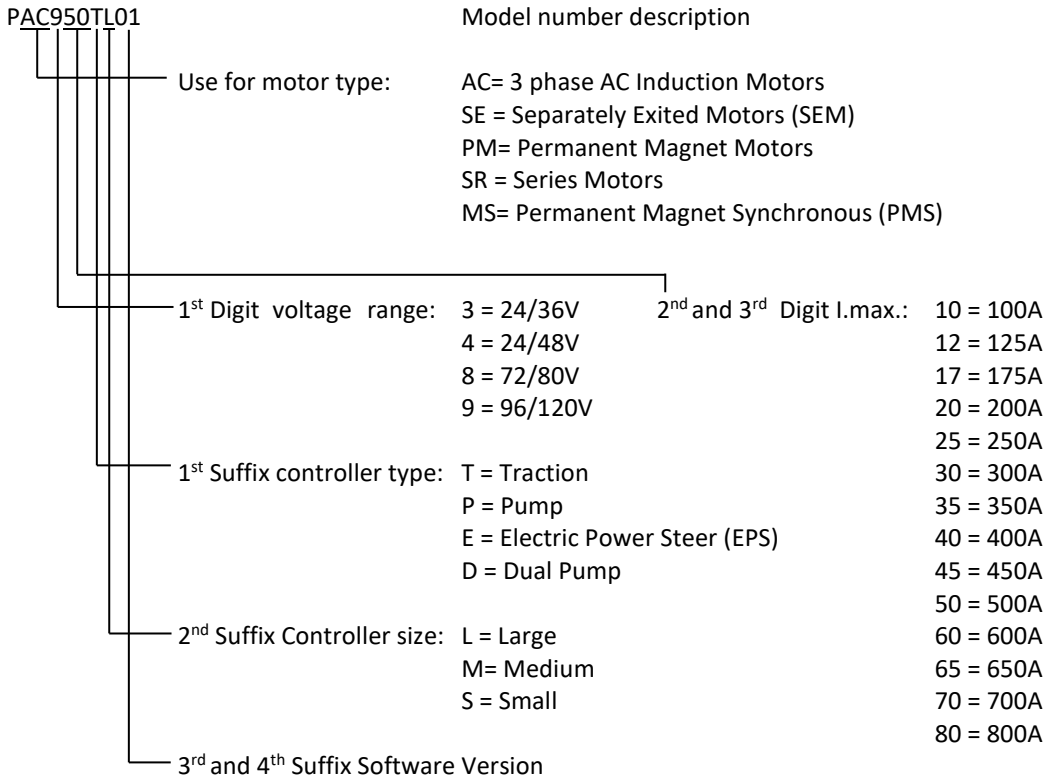
A full range of associated accessories and support infrastructure completes the DMC service.
To conclude, in our specialised purpose built facility, a fusion of creative thinking, collective experience and latest state of the art technology, has produced what we believe to be the most flexible and thermally advanced controller range available in the market place to date.

David Miller - Managing Director

DMC GmbH

2 Sigmadrive variants

2.1 Model code description



2.2 Available models

Model	Power	Configuration	Unit size (L*W*H)
PAC950TL**	96V 460Arms	AC Traction	320 x 200 x 56mm
PAC865TL**	72-80V 460Arms	AC Traction	320 x 200 x 56mm
PAC835TM**	72-80V 250Arms	AC Traction	225 x 200 x 56mm
PAC817TS**	72-80V 125Arms	AC Traction	177 x 155 x 38mm
PAC465TL**	24-48V 460Arms	AC Traction	320 x 200 x 56mm
PAC445TM**	24-48V 320Arms	AC Traction	225 x 200 x 56mm
PAC425TS**	24-48V 180Arms	AC Traction	177 x 155 x 38mm
PAC225TS**	24 V 180Arms	AC Traction	177 x 155 x 38mm
PAC950PL**	96V 460Arms	AC Pump	320 x 200 x 56mm
PAC865PL**	72-80V 460Arms	AC Pump	320 x 200 x 56mm
PAC835PM**	72-80V 250Arms	AC Pump	225 x 200 x 56mm
PAC817PS**	72-80V 125Arms	AC Pump	177 x 155 x 38mm
PAC465PL**	24-48V 460Arms	AC Pump	320 x 200 x 56mm
PAC445PM**	24-48V 320Arms	AC Pump	225 x 200 x 56mm
PAC425PS**	24-48V 180Arms	AC Pump	177 x 155 x 38mm
PAC225PS**	24 V 180Arms	AC Pump	177 x 155 x 38mm
PSE865TL**	72-80V 650A	SEM Traction	320 x 200 x 56mm
PSE835TM**	72-80V 350A	SEM Traction	225 x 200 x 56mm
PSE445TM**	24-48V 450A	SEM Traction	225 x 200 x 56mm
PSE425TS**	24-48V 250A	SEM Traction	177 x 155 x 38mm
PSE465TL**	24-48V 650A	SEM Traction	320 x 200 x 56mm
PSE225TS**	24 V 250A	SEM Traction	177 x 155 x 38mm
PPM835TM**	72-80V 350A	PM Traction	225 x 200 x 56mm
PPM465TL**	24-48V 650A	PM Traction	320 x 200 x 56mm
PPM445TM**	24-48V 450A	PM Traction	225 x 200 x 56mm
PPM425TS**	24-48V 250A	PM Traction	177 x 155 x 38mm
PSR865TL**	72-80V 650A	Series Traction Regen and Plugging	320 x 200 x 56mm
PSR850TM**	72-80V 500A	Series Traction Regen and Plugging	225 x 200 x 56mm
PSR465TM**	24-48V 650A	Series Traction Regen and Plugging	225 x 200 x 56mm
PSR445TM**	24-48V 450A	Series Traction Regen and Plugging	225 x 200 x 56mm
PSR425TS**	24-48V 250A	Series Traction Regen and Plugging	177 x 155 x 38mm
PSR865PL**	72-80V 650A	Series Pump	320 x 200 x 56mm
PSR865DL**	72-80V 650A+60A	Series Dual Pump (Pump and Power steer)	320 x 200 x 56mm
PSR850PM**	72-80V 500A	Series Pump	225 x 200 x 56mm
PSR465PM**	24-48V 650A	Series Pump	225 x 200 x 56mm
PSR445PM**	24-48V 450A	Series Pump	225 x 200 x 56mm
PSR445DM**	24-48V 450A+50A	Series Dual Pump (Pump and Power steer)	225 x 200 x 56mm
PSR425PS**	24-48V 250A	Series Pump	177 x 155 x 38mm
PPM425ES**	24-48V 250A	PM Electric Power Steer (EPS)	177 x 155 x 38mm
PPM817ES**	72-80V 175A	PM Electric Power Steer (EPS)	177 x 155 x 38mm

3 CONTROLLER FEATURES

Feature	Large	Medium	Small
	All variants	All variants	All variants
Number of Digital switch inputs.	7	7	7
Number of Analogue inputs	3	3	3
Number of Contactor drive outputs (3 Amps)	3	3	2
Number of signal only (DMC external driver module needed)	2	2	3
24V - 96V Operation	yes	yes	yes
Single PCB design, no internal connections	yes	yes	yes
IMS PCB for superb thermal conduction	yes	yes	yes
Heat sinked Power terminals	yes	yes	yes
Full automatic assembly	yes	yes	yes
Flash memory, easy software update	yes	yes	yes
Environmental protection IP 54 (PCB varnished)	yes	yes	yes
Microprocessor control	yes	yes	yes
High frequency (Silent Operation)	yes	yes	yes
Internal watchdog monitoring microprocessor operation	yes	yes	yes
Arc less contactor switching and built in coil suppression	yes	yes	yes
Low impedance, active low inputs switched to B-ve	yes	yes	yes
Thermally compensated current limit	yes	yes	yes
Selectable accelerator characteristics	yes	yes	yes
Adjustable creep speed	yes	yes	yes
Seat switch timer	yes	yes	yes
Power steer timer	yes	yes	yes
Electro brake timer	yes	yes	yes
Belly switch operation	yes	yes	yes
Regenerative and plug braking	yes	yes	yes
Braking proportional to accelerator position	yes	yes	yes
Braking in neutral	yes	yes	yes
Braking with brake pedal	yes	yes	yes
Under and Over-voltage protection	yes	yes	yes
Accelerator wire off detect	yes	yes	yes
Inching facilities	yes	yes	yes
Short circuit and open circuit contactor detect	yes	yes	yes
3 traction cutback speeds	yes	yes	yes
6 Pump speeds with Additive, Priority & Compensation	yes	yes	yes
Input to disable pump operation	yes	yes	yes
Independent Power steer speed and compensation settings	yes	yes	yes
Hardware and Software fail-safe systems	yes	yes	yes
+ 12V output pin	yes	yes	yes
Diagnostics with LED indication	yes	yes	yes
Remote LED on SEM and PM4, optional on Series controllers	yes	yes	yes
Adjustments made via a calibrator	yes	yes	yes
CAN communications	yes	yes	Optional
Hours count displaying Key & Pulsing hours on calibrator	yes	yes	yes
BDI on Calibrator	yes	yes	yes
Dashboard display connectable	yes	yes	Optional
Easy to use ‘icons’ for display information	yes	yes	Optional
Reset table Service and Fault logs	yes	yes	yes
Setup menu on calibrator to enable various options	yes	yes	yes

4 TECHNICAL SPECIFICATIONS

4.1 Electrical

4.1.1 Voltage specifications:

Model	Nominal battery voltage	Absolute operating voltage range	Reduced braking voltage levels (F4)	High Voltage cut out level (F22)
PXX2xxXX	24 V	15.0 – 34.0 V	29V - 32V	34V
PXX3xxXX	24-36V	15.0 - 50.0V	--	--
PXX4xxXX	24-48V	15.0 - 61.0V	60V – 63V	67V
PXX8xxXX	72-80V	40.0 - 98.0V	91V – 94V	98V
PXX9xxXX	96V	50 – 124.0V	117V – 121V	125V

4.1.2 Current specifications:

Model	Power	PM/SEM/SR Current limit (1 min)	AC & PMS Current limit (1 min)	Continuous current 1 hour rating. Unit mounted on an sufficient heat sink, at 20°C ambient.
PXX225XX	24V 250A	250A	180Arms	80A
PXX410XX	48V 100A	100A	--	45A
PXX412XX	48V 125A	125A	--	55A
PXX425XX	48V 250A	250A	180Arms	80A
PXX445XX	48V 450A	450A	320Arms	180A
PXX465XX	48V 650A	650A	460Arms	260A
PXX817XX	80V 175A	175A	120Arms	70A
PXX835XX	80V 350A	350A	250Arms	120A
PXX845XX	80V 450A	450A	320Arms	160A
PXX850XX	80V 500A	500A	--	180A
PXX865XX	80V 650A	650A	460Arms	240A
PXX965XX*	96V 650A	650A	460Arms*	240A

Switching Frequency: SR, PM, SEM: 14.5 KHz Traction/Regen/Pump Drive and 8KHz Plug Braking.
AC, PMS: Controller frequency is 8KHz (centre aligned pwm switching).
Motor frequency is 16KHz.

Electrical Isolation: Enclosure to any live part = 1KV. Controller internal insulation specified at >10MΩ @500V DC.

Reverse Battery Polarity: Not protected.

I/O details: See light wiring diagram.

4.2 Environmental

Impact Protection (IP): The enclosure is protected to IP54 (varnished PCB)

Vibration: 6G, 40-200Hz for 1 hour, in x, y and z planes.

Operating Temperature: -30^{O}C to +40^{O}C ambient around controller.

Storage Temperature: -40^{O}C to +70^{O}C.

Humidity: 95% maximum, non-condensing. (Varnished PCB)

Machine directive: EN1175-1

EMC: EN 61000-6-2:2001; EN 61000-6-4:2001 and EN 60950-1: 2001

4.3 Mechanical

Enclosure: Aluminium heat sink with ABS plastic cover.

Power connections: Vertical Copper studs.

Hexagonal: Recommended fixing torque 9.5Nm (Slot screws are recommended!)

Slot screw: Recommended, fixing torque 9.5Nm (Brass)

Bolt length: Max 16mm incl. Washer and spring washer

Weight: Small: 1.2Kg; Medium: 4.1Kg; Large: 6.1Kg

- **Always use a torque wrench when fixing the power terminals.**
- **Exceeding the maximum specified torque can cause serious damage to the controller and warranty might be void.**
- **Too long bolts damage the controller.**

5 INSTALLATION INSTRUCTIONS

5.1 Safety

Electric vehicles can be dangerous. All testing, fault-finding and adjustment should be carried out by competent personnel. The drive wheels should be off the floor and free to rotate during the following procedures. THE VEHICLE MANUFACTURER'S MANUAL SHOULD BE CONSULTED BEFORE ANY OPERATION IS ATTEMPTED.

THE BATTERY MUST BE DISCONNECTED AND THE INTERNAL CAPACITORS MUST BE DISCHARGED BEFORE REPLACING, MODIFYING OR ATTEMPTING ANY REPAIRS OF THE CONTROLS.
Before working on the controls disconnect the battery and connect the B+ and B- controller terminals via a 10 ohm 25 watt resistor to discharge the internal capacitors.
Never connect the controller to a battery with its vent caps removed as an arc may occur due to the controller's internal capacitance when it is first connected.

5.2 Mechanical installation and Cooling

The controller should be bolted down to a flat (0.2mm max. Deviation) paint free surface, eventually lightly coated with a thermal transfer compound, by the 4 fixing holes provided. Care should be taken not to trap any wires, etc., under the controller. The mounting surface MUST be a substantial metal section of the vehicle for the full controller ratings to be achieved. If there is no sufficient cooling surface available, then we advise to use a ripped aluminium heat sink supported by a fan, or mount the heat sink in such a way that the driving wind cools the system.

5.3 Power wiring

Power connections should be made with flexible heat resisting cables of suitable cross-sectional area for the current to be carried. These should be terminated in soldered or crimped lugs attached to controller and the contactors. Note that bolts and washers are supplied for the connections on the controller. Be careful not to use to long bolts, as they can damage the PCB. A battery-disconnect switch should be used (EC Directive).
Fixing torque for power connectors M8 terminals is 11NM, for M6 power connectors 9NM.
The controller wiring must be completely isolated from the chassis, NEVER CONNECT B- OR B+ TO THE CHASSIS OF THE VEHICLE. On road vehicles with an 12 Volt onboard electrical system, the 12 Volt system MUST be galvanic separated from the drive power system. This can be done via a DC-DC converter that charges the 12 Volt system from the drive battery system. Always use a line contactor, controlled by the DMC controller, to enable the controller to switch off in unsafe situations.

5.4 Light wiring

The controller may be supplied as a stand-alone unit or pre-wired onto a base-plate with contactors etc.
Control wiring connections should be made using 0.56mm² (AWG#20) or equivalent stranded wire. The correct pressure release crimping tools MUST be used for long term connection reliability.
The main battery cable should be fused with a suitable air-break fuse. The key switch line must also be fused at a level not exceeding 10 A when using the specified Ametek contactors.
The return wiring for the accelerators should be connected to the B- terminal on the controller to prevent large currents altering accelerator signals.

5.5 Speed sensor cabling

Avoid routing the sensor cabling along with high power motor or battery cables.
Special care should be taken when connecting the screen of the motor speed sensor cable. Be sure only to connect the screen on the controller side @ pin C6). When connected also to the motor side, current will flow over the screen, disturbing the signal from the sensor to the controller, this can result in dangerous situations.

5.6 Contactors

The contactor mounting plane can affect performance, contactors should never be mounted with their terminal studs vertically down. For further applications information on contactors, please consult DMC GmbH in Herten.
As blow-out magnets are fitted to contactors (except 24V) ensure that no magnetic particles can accumulate in the contact gaps and cause malfunction. Ensure that contactors are wired with the correct polarity to their power terminals as indicated by the + sign on the top moulding.
The Sigmadrive must NOT be used with permanently-connected on-board chargers or damage to the system may result. Using a change-over contactor as line contactor is a good solution to fit both the charger and the controller in the truck.

5.7 Flashing new software

When flashing the controller with a new software version, ALWAYS carefully check ALL parameters after flashing to be correct.

5.8 Power up Delay

At first power up the internal capacitor bank needs to be charged. The controller has a build in pre-charge resistor, and is monitoring the capacitor bank voltage. As soon as the voltage is at the required level, the line contactor will pull in. Specially at 24V systems using a Large size controller, the time delay to charge the capacitor bank can by up to 6 seconds (only at first power up). To reduce the capacitor charge time, an external resistor can be fitted over the line contactor. The below table indicates the standard charge time and the external charge resistor value required to minimize (first) power up time.

Model	Battery Voltage	Max standard charge time	Typical charge time	External charge resistor	Power external resistor (min.)	New charge time
	V	sec	sec	Ω	Watt	sec
Large	24V	6.44	3.2	330	5	1.1
	48V	2.7	1.4	1000	5	1.0
	72V	0.82	0.4	8200	2	0.7
	80 V	0.73	0.4	10000	2	0.6
Medium	24V	3.22	1.6	820	2	1.1
	48V	1.35	0.7	3900	2	0.9
	72V	0.41	0.2	8200	2	0.4
	80 V	0.37	0.2	10000	2	0.3
Small	24V	0.69	0.4	-	-	-
	48V	0.29	0.2	-	-	-
	72V	0.07	-	-	-	-
	80 V	0.06	-	-	-	-

6 EMC GUIDELINES

The following guidelines are intended to help vehicle manufacturers to meet the requirements of the EC directive 89/336/EEC for Electromagnetic Compatibility.
Any high speed switch is capable of generating harmonics at frequencies that are many multiples of its basic operating frequency. It is the objective of a good installation to contain or absorb the resultant emissions.
All wiring is capable of acting as a receiving or transmitting antenna. Wiring should be arranged to take maximum advantage of the structural metal work inherent in most vehicles. Vehicle metalwork should be electrically linked with conductive braids.

6.1 Power Cables

All cables should be routed within the vehicle framework and kept as low in the structure as is practical – a cable run within a main chassis member is better screened from the environment than one routed through or adjacent to an overhead guard. Power cables should be kept short to minimise emitting and receiving surfaces. Shielding by the structure may not always be sufficient – cables run through metal shrouds may be required to contain emissions.
Parallel runs of cables in common circuits can serve to cancel emissions – the battery positive and negative cables following similar paths is an example.
Tie all cables into a fixed layout and do not deviate from the approved layout in production vehicles. A re-routed battery cable could negate any approvals obtained.

6.2 Signal Cables

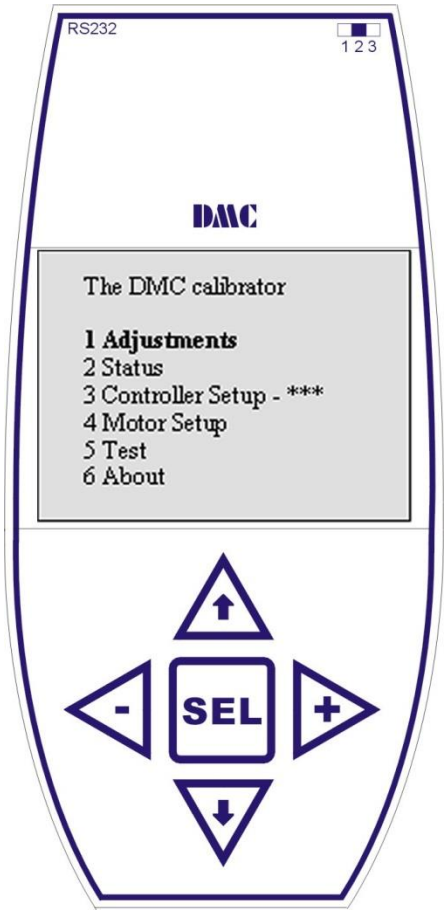
All wiring harnesses should be kept short. Wiring should be routed close to vehicle metalwork. All signal wires should be kept clear of power cables or made from screened cable. When using screened cable, make sure only to earth it to one point! Control wiring should be kept clear of power cables when it carries analogue information – for example, accelerator wiring. Tie all wiring securely and ensure wiring always follows the same layout.

6.3 Controller

Thermal and EMC (emissive) requirements tend to be in opposition. Additional insulation between the controller assembly and the vehicle frame work reduce capacitive coupling and hence emissions but tend to reduce thermal ratings. A working balance needs to be established by experiment. The complete installation should be documented, in detail, and faithfully reproduced on all production vehicles. When making changes, consider their effect on compliance ahead of any consideration of cost reduction or other “improvement”.

7 CALIBRATOR

7.1 The Calibrator



General

The DMC Calibrator is designed for Setting up the Pro-Series controller range. It also has a build-in interface for controller and calibrator software updates via RS232. This guarantees maximum flexibility and no waste of hardware when only the software must be updated.

Software updates

On the top-right-hand side a 3-way switch is used to select the operating mode. For normal operation it must be in position 2. For flashing new controller software it must be moved to position 1 and for new calibrator software it must be moved to position 3.
To be able to update the software it is necessary to have a software package installed and off course a copy of the new DMC software release. For detailed information on updating software please contact your DMC supplier.

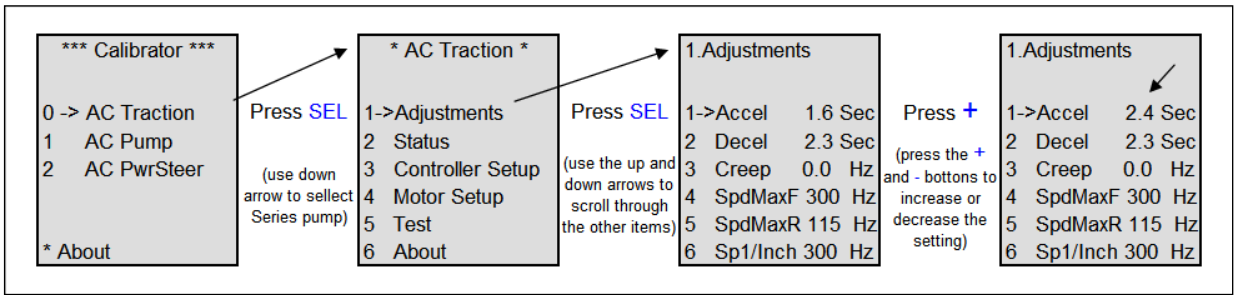
CAN Node Setup

When connecting the Calibrator to a controller it will 'scan' the CAN bus for all available Nodes, to enable calibration of all DMC controllers on the same bus. All controllers are by factory default set to Node 0. Therefore before using this feature, give all controllers on the bus a unique Node number. To do this, the calibrator must be plugged in to the controller you want to adjust the Node number on (menu item 3.17)

Adjustments

The calibrator is easy to use. The up and down buttons are used for scrolling up and down. Selections can be made with the SEL-button. The plus- and minus-buttons are used to increase or decrease the parameters.

7.2 Calibrator map

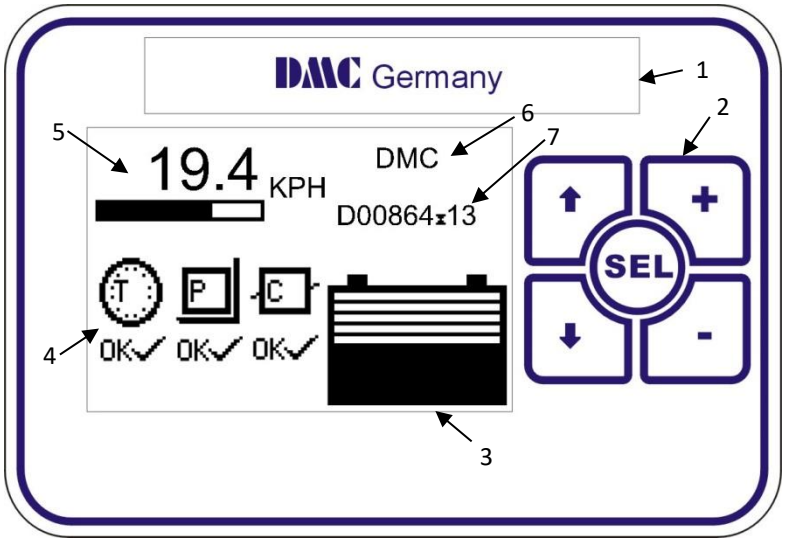


- **The calibrator remembers the cursor position in the submenus until key-off.**
- **When connecting more than 1 node to the CAN bus, the calibrator will react slightly slower.**

7.3 DMC PC Programmer

The PC programmer is available for download from our website in the download section (register first).
To be able to use the PC programmer software, the latest version of the DMC calibrator with USB connectivity is required. The PC programmer let you edit, store and print controller parameters on a windows based PC running XP, Vista or Windows7. Controllers with firmware version 3.05.00 and higher are compatible with the PC programmer. The firmware version can be found in the about menu.
The installation package includes a manual describing the features and functionality.
The PC programmer updates it's library automatically when new parameters are available.

8 DASHBOARD DISPLAY



The DMC dashboard display is specially designed to be as flexible as possible to meet customer requirements.
The display is CAN-Bus driven and gets its information from the DMC controllers and eventually from auxiliary equipment.
In the future the membrane buttons will allow selecting different performance settings to be selected.
Faults are indicated with Icons.
The Icons can be modified and even the customer's brand name and logo can be displayed to match the truck-identity.

8.1 General information

<1> Brand name window. When required DMC can fit the customer's name and logo here during production.
<2> Membrane buttons. Used for setting functions as Service interval timer, Hours counter and the Customer information field <6>.
<3> Battery Discharge Indicator. Indicates the battery discharge state set by CAN-Node 0 (master)
<4> Fault indication fields. Indicates the status of the traction- and pump controllers and other CAN-Nodes.
A number is displayed in the Icons next to the T, P and C to indicated which controller has a problem.
When a fault is indicated it replaces the 'OK' below the CAN-Node indicator with a fault icon.
Via the calibrator it is possible to select what failure types are displayed or ignored.
<5> General indication field. Calibrator selectable indicators for speed, motor voltage, accelerator demand and steering (from master)
<6> Free 2x9 character field to show a text. The text can be edited with the display buttons.
<7> Hours counter. Here either Work or Key hours are displayed, selectable with the display buttons.
The hours counter value is stored in the display. The controllers have their own separate counter.

8.2 Display setup menu

To access the display setup menu, hold the select button for 3 seconds.
Features as the Service interval timer, Hours counter and the Customer information field can be adjusted and optionally protected with a pin code.
Use the up and down arrows (**↑↓**) to choose the option, press **SEL**, then use the **+** and **–** butons to change the value.

8.3 Display Features Setup

Ref	Parameter	Submenu ref.	Sub menu description	Range & Action
1	Service timer	1. Svc interval	Set the time interval for next service	0– 32767 Hr. (Warning starts 40Hrs before service needed)
		2. Count hours	Set to count work or key hours	Work / Key Hrs.
		3. Reset timer	Resets the service interval timer	To confirm press **SEL**
		4. Svc time	Indication of the actual counter value	Indication only
2	Hours counter	1=Key, 2=Work	Select to indicate work or key hours	Select **↑↓** and confirm **SEL**
3	Information field	1. Adjust field	Free 2x9 character field to show a customised text.	**↑↓** for position, **+** / **–** change value, **SEL** to return to menu
4	Pincodes	1. Service timer	Sets pincode for service timer access	
		2. Information field	Sets pincode for information field access	
		3. Reset all pincodes	Reset all pincodes	(Only with DMC mastercode)
5	About	SW version & date	Indication of the software version & date	Indication only
6	Return to main screen	-	Select to return to the main menu	Select **↑↓** and confirm (**SEL**)

9 CANBUS MESSAGES

9.1 AC Controllers with firmware version V03.0x.xx and higher

From software release V03.0x.xx the controller supports transmitting of several dedicated CAN messages that hold information about the controller. With this feature, customers are able to gather information. For this purpose parameter is added to the controller setup menu at row 20.

3.20. CANMsgs = 0 No CAN messages.
3.20. CANMsgs = 1 Send message 1.
3.20. CANMsgs = 2 Send message 2.
3.20. CANMsgs = 3 Send both message 1 and 2.

CAN Message 1
CAN identifier = 0x220 and is OR-ed with the CAN node number (see example below).
Message is send every 100 ms.
Data length is 6 bytes:

- Byte 0 High byte of motor speed in rpm
- Byte 1 Low byte of motor speed in rpm
- Byte 2 High byte of motor current in Arms
- Byte 3 Low byte of motor current in Arms
- Byte 4 Accelerator output
- Byte 5 Error code

CAN Message 2
CAN identifier = 0x230 and is OR-ed with the CAN node number (see example below).
Message is send every second (1000 ms).
Data length is 4 bytes:

- Byte 0 Controller temperature in °C with offset + 51 °C (see explanation below).
- Byte 1 Motor temperature in °C with offset + 51 °C (see explanation below).
- Byte 2 Motor voltage in V
- Byte 3 Battery voltage in V

Example on OR-ing CAN node number
CAN node number is node 13 (3.17 = 13). It's hexadecimal equivalent is 0xD.
CAN message 1 is then send out on CAN identifier 0x22D.

Explanation on temperature in CAN message 2
Both controller and motor temperature have a reading between –51 °C and +151 °C. To fit it in an unsigned byte, a value of 51 is added to the temperature value. The range is then 0 to 202.
When reading this byte, the recipient should substract 51 of the value to get the real value.
For example, the controller temperature is –10 °C. A value of 41 is transported via CAN.

9.2 PMS Controllers with firmware version V02.29.0F and higher

We alternate two messages (0x220 and 0x230).
Message 1 is sent every main loop.
Message 2 is sent every 40th main loop.
The main loop is approximately 25 ms, yielding about 1 s.

Message 1:

- CAN identifier = 0x220 and is OR-ed with the CAN node number (see example below).
- Byte 0: MSB RPM, 1 rpm resolution, 0 – 9999 rpm.
- Byte 1: LSB RPM, 1 rpm resolution, 0 – 9999 rpm.
- Byte 2: MSB Speed in KPH, 0.1 KPH resolution, 0.0 – 999.9 KPH.
- Byte 3: LSB Speed in KPH, 0.1 KPH resolution, 0.0 – 999.9 KPH.
- Byte 4: Motor Voltage, 1 Vrms resolution, 0 – 125 Vrms.
- Byte 5: MSB Motor current, 1 Arms resolution, -999 – 999 Arms.
- Byte 6: LSB Motor current, 1 Arms resolution, -999 – 999 Arms.
- Byte 7: Accelerator position, 1 % resolution, 0 – 100%.

Message 2:

- CAN identifier = 0x220 and is OR-ed with the CAN node number (see example below).
- Byte 0: Controller Temperature, 1 °C resolution., 0 – 151 C.
- Byte 1: Motor Temperature , 1 °C resolution, 0 – 151 C
- Byte 2: Fault code (The one that appears as Fxx on line 9 of the status screen). If no fault, this is zero.
- Byte 3: Firmware Version Major (the “2” in 2.29.0F)
- Byte 4: Firmware Version Minor (the “29” in 2.29.0F)
- Byte 5: First character, in ASCII of Firmware Version Sub (the ‘0’ in 2.29.0F)
- Byte 6: Second character, in ASCII of Firmware Version Sub (the ‘F’ in 2.29.0FE)
- Byte 7: n/a

Example on OR-ing CAN node number
CAN node number is node 13 (3.18 = 13). It’s hexadecimal equivalent is 0xD.
CAN message 1 is then send out on CAN identifier 0x22D.

9.2.1 Important information

It is important to understand that the CAN node number is used solely to make a differentiation in the CAN messages when multiple PMS controllers are used on the same CAN bus. In fact, it resembles what is used in the AC and DC releases, but **it is not the same:** *it is not possible to use a DMC Display and/or calibrator on the same CAN bus when multiple nodes are used (since all controllers will send messages on the same addresses).*

	**To use a calibrator, the controller must first be disconnected from the CAN bus**

10 AC CONTROLLERS – Parameters & Instructions

10.1 AC Traction: Menu 1 – "Adjustments"

Cal Ref	Parameter	Calibrator text	Min. Adjust	Max. Adjust	Step size	DMC default	Actual setting
1	Acceleration delay	Accel	0.1 S	10.0 S	0.1 S	2.0 S	S
2	Deceleration delay	Decel	0.1 S	10.0 S	0.1 S	0.3 S	S
3	Creep speed	Creep	0 Hz	5 Hz	0.0625 Hz	0 Hz	Hz
4	Maximum speed forward	SpdMaxF	0 Hz	255 Hz	1.0 Hz	100 Hz	Hz
5	Maximum speed reverse	SpdMaxR	0 Hz	255 Hz	1.0 Hz	100 Hz	Hz
6	Cutback speed 1	Speed 1	0 Hz	255 Hz	1.0 Hz	100 Hz	Hz
	Inching speed *	InchSpd	0 Hz	100 Hz	1 Hz	0 Hz	Hz
7	Cutback speed 2	Speed 2	0 Hz	255 Hz	1.0 Hz	100 Hz	Hz
	Inching time *	InchTime	0.1 S	10 S	0.1 S	2 S	S
8	Cutback speed 3	Speed 3	0 Hz	255 Hz	1.0 Hz	100 Hz	Hz
9	Direction Regen Braking	Dbrake	0 % Hz	100 % Hz	1 % Hz	50 % Hz	% Hz
10	Neutral Regen Braking	Nbrake	0 % Hz	100 % Hz	1 % Hz	25 % Hz	% Hz
11	Foot brake Regen	Fbrake	0 % Hz	100 % Hz	1 % Hz	35 % Hz	% Hz
12	Direction brake ramp time	DbrkRamp	0.1 S	10 S	0.1 S	0.3 S	S
13	Neutral brake ramp time	NbrkRamp	0.1 S	10 S	0.1 S	0.3 S	S
14	Foot brake ramp time	FbrkRamp	0.1 S	10 S	0.1 S	0.3 S	S
15	Neutral brake-End delay	NbrkEnde	0.1 S	2.5 S	0.1 S	0.0 S	S
16	Sweep speed	SweepSpd	0.00 Hz	5.00 Hz	0.06 Hz	0.00 Hz	Hz
17	Drive Max. Current	MaxCurr	10 Arms	Unit max	10 Arms	Unit max.	A
18	Battery Voltage	BattV	24 V	Unit max.	2 V	Unit max.	V
19	Power steer delay	PstrDly	0 S	50 S	0.1 S	5 S	S
20	Electric brake	EbrkDly	0.0 S	50.0 S	0.1 S	0.5 S	S
21	Accelerator minimum	AccMin	0 V	5.0 V	0.1 V	3.3 V	V
22	Accelerator maximum	AccMax	0 V	5.0 V	0.1 V	0.2 V	V
23	Aux minimum	AuxMin	0 V	5.0 V	0.1 V	0.2 V	V
24	Aux maximum	AuxMax	0 V	5.0 V	0.1 V	4.8 V	V
25	DM*² Steerpot min.	StrMin	0.00 V	5.00 V	0.01 V	0.20 V	V
26	DM*² Steerpot mid.	StrMid	0.00 V	5.00 V	0.01 V	2.30 V	V
27	DM*² Steerpot max.	StrMax	0.00 V	5.00 V	0.01 V	4.80 V	V
28	Forw. Threshold wig/wag	FwdTH	0 V	5.0 V	0.1 V	3.0 V	V
29	Rev. Threshold Wig/wag	RevTH	0 V	5.0 V	0.1 V	2.0 V	V
30	Vehicle max. Speed	VmaxSpd	0 Kph	100 Kph	1 Kph	12 Kph	Kph
31	BDI reset level	BDIreset	18 V	Bat. +25%	0.1 V	Cells*2.09V	V
32	BDI empty level	BDIempty	12 V	Bat. +25%	0.1 V	Cells*1.73V	V
33	BDI warning level	BDIwarn	0 %	99 %	1.0 %	20%	%
34	BDI cut out level	BDIcut	0 %	99 %	1.0 %	0 %	%
35	BDI speed limit	BDIspeed	0 Hz	100 Hz	1.0 Hz	100 Hz	Hz
36	DM*² Cutback	Dmcut	0 %	100 %	1 %	10 %	%
37	DM*² Angle 1	Dmang1	0 %	100 %	1 %	10%	%
38	DM*² Angle 2	Dmang2	0 %	100 %	1 %	65%	%
39	DM*² Angle 3	Dmang3	0 %	100 %	1 %	75%	%
40	DM*² Speed 1	DMspd1	0 Hz	255 Hz	1.0 Hz	10 Hz	Hz
41	DM*² Speed 2	DMspd2	0 Hz	255 Hz	1.0 Hz	5 Hz	Hz
42	DM*² Speed 3	DMspd3	0 Hz	255 Hz	1.0 Hz	40 Hz	Hz
43	Standby Delay*³	StdByDly	0 Min. (off)	10 Min.	0,5 Min.	0 Min.	Min.

- **Depending on controller type and configuration some settings will be not available (N/A).**
- **Dual motor is now separated from the single motor software**
- *** Selectable multi-function.**
- ***² For dual motor only**
- ***³ Not in combination with shared line contactor & for single motor only**

10.2 AC Pump: Menu 1 "Adjustments"

Cal Ref	Parameter	Calibrator text	Min. Adjust	Max. Adjust	Step size	DMC default	Actual setting
1	Acceleration delay	Accel	0.1 S	10.0 S	0.1 S	2.5 S	S
2	Deceleration delay	Decel	0.1 S	10.0 S	0.1 S	0.3 S	S
3	Creep speed	Creep	0 Hz	5 Hz	0.0625 Hz	0 Hz	Hz
4	Pump Speed 1 (Pot. Max.)	Potmax1	0 Hz	255 Hz	1.0 Hz	0 Hz	Hz
5	Pump Speed 2	Pspeed2	0 Hz	255 Hz	1.0 Hz	0 Hz	Hz
6	Pump Speed 3	Pspeed3	0 Hz	255 Hz	1.0 Hz	0 Hz	Hz
7	Pump Speed 4	Pspeed4	0 Hz	255 Hz	1.0 Hz	0 Hz	Hz
8	Pump Speed 5	Pspeed5	0 Hz	255 Hz	1.0 Hz	0 Hz	Hz
9	Pump Speed 6 (Power steer)	Psteer6	0 Hz	255 Hz	1.0 Hz	0 Hz	Hz
10-15	N/A	n/a					
16	Power steer accel. / dec. Speed 6	Paccel 6	0.1 S	10.0 S	0.1 S	0.5 S	S
17	Max. Current	MaxCurr	10 A	Unit max	10 A	Unit max.	A
18	Battery Voltage	BattV	24 V	Unit max.	2 V	Unit max.	V
19	Power steer delay (spd 6)	PstrDly	0.1 S	50.0 S	0.1 S	5.0 S	S
20	N/A	n/a					
21	Accelerator minimum	AccMin	0 V	5.0 V	0.1 V	0.2 V	V
22	Accelerator maximum	AccMax	0 V	5.0 V	0.1 V	4.8 V	V
23-30	N/A	n/a					
31	BDI reset level	BDIreset	1.90 V/cell	2.20 V/cell	0.01V/cell	2.09 V/cell	V
32	BDI Empty level	BDIempty	1.50 V/cell	1.90 V/cell	0.01V/cell	1.73 V/cell	V
33	BDI Warning level	BDIwarn	0 %	99 %	1 %	20 %	%
34	BDI Cut-out level	BDIcut	0 %	99 %	1 %	0 %	%
35-43	N/A	n/a					

- **The pump inhibit input does not disable power steer (pump speed6)**
- **Depending on controller type and configuration some settings will be not available (N/A).**

10.3 AC Traction and Pump: Menu 2 – "Status"

The status menu shows various parameters from the controller which can be useful to help tune and optimise vehicle performance.

Cal Ref	Item	Calibrator text	Dir. Polar.	Controller type	Step size	Service log info & Notes
1	Drive hours counter	Drive		All	0.1 Hrs	
2	Fault log (15F and above only)	Fault		All	Last fault	▷+ shows drive hours of the fault
3	Battery Discharge Indicator	BDI		All	1 %	
4	Vehicle Speed	Vehicle		AC Traction	1 Kph	
5	Controller Temperature	CtrlTemp	+/-	All	1 °C	◁- ▷+ min & max temperatures
6	Motor Temperature	MotTemp	+/-	All	1°C	◁- ▷+ min & max temperatures
	Steer position	StrPot	+/-	AC Dual Traction	1 %	+ = steering right, - = steering left
7	Battery Voltage	BatVolts		All	0.5 V	▷+ shows highest voltage
8	Capacitor Voltage	CapVolts		All	0.5 V	▷+ shows highest voltage
9	Accelerator demand	Accel		All	1 %	▷+ shows auxiliary i/p (footbrake)
10	Demand traction	DemandT	+/-	AC Traction	0,0625 Hz	**Extra controller status info: See next 19able "Status"**
	Demand pump	DemandP	+/-	AC Pump	0,0625 Hz	
11	Demand ramped	DemandR	+/-	All	0,0625 Hz	**Controller limit indication: See next tabel "Limit"**
12	Motor voltage	MotorV		All	0.1 Vrms	When '-' then not possible to increase V further due to lowVcap. **Override with Fxx fault codes**
						◁- ▷+ bits 0-242 %V 0-95
13	Motor Current	Motor	+/-	All	10 A	+ = Drive current / - = Brake current ◁ Instantaneous current (bits) ▷+ Average current (bits)
14	Motor (stator) speed	Motor	+/-	All	0,0625 Hz	+ = Forward / - = Reverse
15	Rotor speed	Rotor	+/-	All	0,0625 Hz	+ = Forward / - = Reverse ▷+ shows speed in rpm
16	Actual slip	Slip	+/-	All	0,0625 Hz	+ = Drive slip / - = Brake slip
17	Demanded slip	SlipDem	+/-	All	0,0625 Hz	+ = Drive slip / - = Brake slip
	Maximum slip	SlipDem	+/-	AC traction	0,0625 Hz	+ = Drive slip / - = Brake slip
18	Minimum rms voltage	VrmsMin		All	0.1 V	
19	Actual rms voltage	VrmsNow		All	0.1 V	
20	Maximum rms voltage	VrmsMax		All	0.1 V	
21-24	Debug (DMC internal use only)	Dbug		All		
	Service and fault log reset			**All**	**press + and – together to reset service log (only possible when controller in neutral)**	

Status	Description		Limit	Description for Traction limits	Description Pump limits
N	Neutral, no pulsing		SM	Speed max Fwd or Rev	Pot max speed
FD	Forward drive		S1	Speed 1	n/a
FL	Forward drive left		S2	Speed 2	Pump speed 2
FR	Forward drive right		S3	Speed 3 (or hand brake)	Pump speed 3
RD	Reverse drive		S4	n/a	Pump speed 4
RL	Reverse drive left		S5	n/a	Pump speed 5
RR	Reverse drive right		S6	n/a	Pump speed 6
DB	Direction regen braking		SI	Inching	Pump inhibit
NB	Neutral regen braking		SB	BDI speed limit	BDI speed limit
FB	Foot brake regen		SD	Dual motor speed limit	n/a
HH	Hill-hold		CL	Current limit	Current limit
HF	Restrained hill-hold forward		BL	Brake current limit	n/a
HR	Restrained hill-hold reverse		CT	Controller temperature	Controller temperature
SB	Standby		MT	Motor temperature	Motor temperature
			TL	Timed Current Limit	Timed Current Limit

10.4 AC Traction and Pump: Menu 3 "Controller Setup"

Change these settings to select the required options and I/O.

Cal Ref	Parameter	Calibrator text	Options (defaults are in bold)	Range	Actual setting
1	Accel. Characteristic	Lin/Curv	0= Acc Linear **1= Acc Curve2**	0 – 1	
2	Control mode (Traction)* *³	Spd/Torq	0=Speed, **1=Torque**	0 – 1	
3	proportional direction braking (Traction)	Off/Bpro	0=Fixed, **1=Proportional**	0 – 1	
	P-Steer I/P (Pump spd 6)	Sp6Lo/Hi	**0=Active Low,** 1=Active High	0 – 1	
4	Hill-hold (Traction)	Off/HH	**0=Coast,** 1=Hill-hold active, 2=DC Current Hill-hold	0 – 2	
	Pump Inhibit I/P (Pump)	HibLo/Hi	**0=Active Low ,**1=Active High	0 – 1	
5	I/O Pin 5 and 6 * *³ (Traction)	Spd/Inch	**0=Speed 1+2** , 1=Inching Fwd/Rev	0 – 1	
	Pump Power up (Pump)	NChk/Chk	**0=No Check,** 1= Chk sws at powerup	0 – 1	
6	I/O Pin 7 (Traction)	Spd3/Hbk	0=Speed3, **1=Handbrake** (If handbrake selected, set the required max. speed at Speed 3	0 – 1	
	Pot. & switch (Pump spd1)	NoSw/Sw	0=No Pot. switch **1=Pot & switch**	0 – 1	
7	Power steer trigger (Traction)	PsF/FR/S	**0=FS1**, 1=Fwd/Rev, 2= Seat switch, 3=FS1&motor_speed != 0.	0 – 3	
8	Vehicle type select * *³ (Traction)	Ride/Wlk	**0=Ride-on,** 1=Walkie, 2=Walkie with open tiller switch.	0 – 2	
9	Tiller switch function *³ (Traction)	TillFunc	**0=Normal response**, 1=fast brake, 2=immediate brake.	0 – 2	
10	Display fault indication	Of/M/M&W	0=None, 1=Main faults, **2=Main & Warning faults**	0 – 2	
11	Display Status field	Of/D/V/K	0=None, 1=Acc, **2=Motor RPM**, 3=Speed in Kph, 4=Steering, 5=Motor current	0 – 5	
12	Ignore F17 Fault	IgnreF17	0=normal operation, 1=ignore F17	0 – 1	
13	Motor thermistor type	MTempTyp	0=KTY81-220, **1=KTY84-130**	0 – 1	
14	Analogue I/P select *	Accel 8/9	0=Pin8 Accel Pot - Pin9 Aux Pot **1=Pin8 Aux Pot - Pin9 Accel Pot** 2=Pin9 wig-wag	0 – 2	
15	Dual motor select* (Traction)	Si/DL/DR	See below table for explanation	0 – 2	
		Aux AD i/p Pin A8 or A9	Steer / motor AD i/p Pin C4	Digital i/p Pin A5	Digital i/p Pin A6	FS1 required
	0 Single motor	Footbrake	Motor temp.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
	1 Dual motor pot. Left	Footbrake	Steer pot.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
	2 Dual motor pot. Right	Footbrake	Steer pot.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
16	I/O pin C3 mode	RL/BL	**0=Red LED**, 1=Footbrake light	0 – 1	
17	CAN node number*	CAN node	**0=node 0 (0=master)**, 1=node 1, ……15=node 15	0 - 15	
18	Shared Line Contactor* *²	ShareLC	**0=No Line contactor sharing** 1=Line contactor shared	0 - 1	
19	Last Sharing Node*	LstNode	Enter the highest node number that shares the same line contactor.	1 – 15	
20	CAN Messages	CANMsgs	**0= No CAN messages**, 1=Send message 1 only, 2=Send message 2 only, 3=Send messages 1&2	0 - 3	

- *** Reset to make changes active. Recycle the key switch (Also indicated on calibrator 'Key')**
- ***² Not in combination with Standby delay**
- ***³ Only available on single motor controllers**
- **Irrelevant options show N/A**

10.5 AC Traction and Pump: Menu 4 “Motor Setup”

The motor setup menu define the motor characteristics for the controller.
Only qualified engineers should change these settings.
Mistakes in the motor setup tables can cause serious accidents and/or defective controllers and/or motors. For AC motors the motor manufacture should provide this information.

Cal Ref	Parameter	Calibrator text	Min.	Max.	Step size	DMC default	Actual setting
1	Motor Temp. Cutback start	TempStrt	1	151(disables)	1	151	
2	Motor / Vehicle -speed ratio	SpdRatio	1.0	999.9	0.1	1.0	
3	Number of teeth *	SpdTeeth	0	255	2	80	
4	Number of motor poles *	SpdPoles	4	6	2	4	
5	Motor speed minimum	SPDmin	0 Hz	63 Hz	0.0625 Hz	0.00 Hz	Hz
6	Motor speed boost	SPDboost	0 Hz	255 Hz	1 Hz	10.00 Hz	Hz
7	Motor speed base	SPDbase	0 Hz	255 Hz	1 Hz	60.00 Hz	Hz
8	Motor speed max	SPDmax	0 Hz	255 Hz	1 Hz	125.00 Hz	Hz
9	Minimum Voltage	Vmin	0 Vrms	25.5 Vrms	0.1 Vrms	0.5 Vmrs	Vrms
10	Drive voltage minimum	D Vmin	0 Vrms	88.5 Vrms	0.1 Vrms	6.0 Vrms	Vrms
11	Drive voltage boost	D Vboost	0 Vrms	88.5 Vrms	0.1 Vrms	10.6 Vrms	Vrms
12	Drive voltage base	D Vbase	0 Vrms	88.5 Vrms	0.1 Vrms	30.0 Vrms	Vrms
13	Drive voltage max	D Vmax	0 Vrms	88.5 Vrms	0.1 Vrms	30.0 Vrms	Vrms
14	Drive slip minimum	D Smin	0 Hz	15.93 Hz	0.0625 Hz	2.00 Hz	Hz
15	Drive slip boost	D Sboost	0 Hz	15.93 Hz	0.0625 Hz	2.62 Hz	Hz
16	Drive slip base	D Sbase	0 Hz	15.93 Hz	0.0625 Hz	4.25 Hz	Hz
17	Drive slip max	D Smax	0 Hz	15.93 Hz	0.0625 Hz	6.00 Hz	Hz
18	Braking direction voltage min.	BDVmin	0 Vrms	25.5 Vrms	0.1 Vrms	2.0 Vrms	Vrms
19	Braking direction voltage boost	BDVboost	0 Vrms	88.5 Vrms	0.1 Vrms	3.0 Vrms	Vrms
20	Braking voltage base	B Vbase	0 Vrms	88.5 Vrms	0.1 Vrms	20.0 Vrms	Vrms
21	Braking voltage max	B Vmax	0 Vrms	88.5 Vrms	0.1 Vrms	20.0 Vrms	Vrms
22	Braking direction slip minimum	BDSmin	0 Hz	15.93 Hz	0.0625 Hz	2.00 Hz	Hz
23	Braking direction slip boost	BDSboost	0 Hz	15.93 Hz	0.0625 Hz	3.00 Hz	Hz
24	Braking slip base	B Sbase	0 Hz	15.93 Hz	0.0625 Hz	4.00 Hz	Hz
25	Braking slip max	B Smax	0 Hz	15.93 Hz	0.0625 Hz	5.00 Hz	Hz
26	Braking neutral voltage min.	BNVmin	0 Vrms	25.5 Vrms	0.1 Vrms	2.0 Vrms	Vrms
27	Braking neutral voltage boost	BNVboost	0 Vrms	100 Vrms	0.1 Vrms	3.0 Vrms	Vrms
28	Braking neutral slip minimum	BNSmin	0 Hz	15.93 Hz	0.0625 Hz	2.00 Hz	Hz
29	Braking neutral slip boost	BNSboost	0 Hz	15.93 Hz	0.0625 Hz	3.00 Hz	Hz
30	Braking speed base	BSPDbase	0 Hz	255 Hz	1 Hz	60.00 Hz	Hz
31	Proportional gain voltage	PgainV	1	16	1	2	Num
32	Proportional gain speed	PGainSpd	1	16	1	2	Num
33	Proportional gain torque	PGainTrq	1	16	1	8	Num
34	Ramp torque	Ramp Trq	0.1 S	10.0 S	0.1 S	0.1 S	Sec
35	Proportional gain speed neutral	PGainSpdN	1	16	1	6	Num
36	Current threshold	CurrTH	50 A	Unit max	10 A	Unit max	A
37	I-Max low	ImaxLow	50 A	Unit max	10 A	Unit max	A
38	I threshold time	IthTime	0 Sec(off)	60 Sec	1 Sec	0 Sec	Sec
39	Hill hold time	HHTime	0	60 Sec	1 Sec	5 Sec	Sec
40	Hill hold speed - restrained only	HHspeed	0 Hz	5.00 Hz	0.0625 Hz	3.0 Hz	Hz
41	Hill hold voltage minimum	HHVmin	0.0 Vrms	25.5 Vrms	0.1 Vrms	0.5 Vrms	Vrms
42	Hill hold brake end speed	BrkEndSp	0 Hz	5 Hz	0,0625 Hz	0 Hz	Hz

- *** Reset to make changes active. Recycle the key switch (Also indicated on calibrator ‘key’)**
- **Changes on parameter 5 up to 32 become active after selecting neutral**

10.6 AC Motor Setup Guide - without bench testing

If no detailed information is available, the motor label is used to do the motor setup.
The motor setup is divided in two sections; driving and braking to give maximum setup flexibility.
The setup is performed with the controller in torque mode.

10.6.1 Motor label

The motor manufacture usually labels the motor with basic technical information.
As example we use a motor label from a Chinese motor manufacture:

		Brand name			
Type:	132/4-195				
Power:	8kW	Frequency:	44Hz	Speed:	1280RPM
Voltage	34V	Current:	190A		
		Rating:	S2-60min	Insulation:	F

This motor has a nominal rating of 8kW for 60 minutes (S2 operation = Intermittent)
The 8 kW is delivered at 44Hz (rotor speed 1280rpm), 34Vrms, 190Amps.

It is important to first setup the number of pulses per revolution of the encoder and the number of poles in the motor. Then recycle the keyswitch. Wrong setting of the 'encoder-number-of-pulses' or the 'number-of-poles' is can result in high motor currents or possible runaway of the motor!

Example:

3	SpdTeeth	64	Key
4	SpdPoles	4	Key

10.6.2 Motor setup - Drive

10.6.2.1 Define speed points

The first step is to define the 4 speed points that form the motor graph for voltage and slip.
Each speed point has got a separate setting for the maximum voltage and maximum slip.

The 4 speed points are:

- (SPDmin) Minimum speed (Set to 0Hz)
- (SPDboost) Boost speed (Set to 70% base speed of the motor label, in this example 70% from 44Hz = 30Hz)
- (SPDbase) Base speed , (Set to base speed from motor label, in this example 44Hz)
- (SPDmax) Maximum speed (in this example 125Hz)(set minimal 10% higher as the maximum needed motor rpm)

Check the maximum Forward and Reverse speed settings 1.4 and 1.5 in the Adjustments menu. This settings must be lower than the SPDmax setting. If the actual motor speed is higher than the SPDmax setting, the controller is out of control and switches off with a F30 Fault.

Example settings:

- SPDmin: 0Hz
- SPDboost: 30Hz
- SPDbase: 44Hz
- SPDmax: 125Hz

10.6.2.2 Drive voltage setup

The drive voltage setup is linear from minimum speed up to boost speed.
The “Boost Voltage” , “Base Voltage” and “Maximum Voltage” are set to the voltage on the motor label

→ Boost voltage = Base voltage = Maximum voltage = 34V.

This motor is rated for 34Vrms. The battery is rated 48V. In an ideal situation it is possible to make 34Vac from an 48Vdc battery (48Vdc/ √2 = 34Vac). But practical an empty battery loaded with a few hundred amps is not 48V but lower. There are losses in the battery cable, motor cables and controller. That means in practice we have a maximum of 30Vac. Above boost speed the voltage can no longer be increased as there is no higher rms voltage available from the battery supply. Therefore the voltage levels at boost- base- and maximum speed are normally set the same.
The minimum voltage D Vmin should be about 10% from the rated motor voltage.
The absolute minimum voltage Vmin depends on motor type and application. If it is set too high then there are high motor currents in neutral heating up the motor and controller. Usually it is set between 0,5V and 1,5V to have sufficient start torque at zero speed.

Example settings:

- Vmin: 0,5V
- D Vmin: 3,4V
- D Vboost: 30V
- D Vbase: 30V
- D Vmax: 30V

10.6.2.3 Drive slip setup

The slip can be calculated from the motor label information.
In this example the rotor speed is 1280 rpm at 44Hz controller output frequency (=nominal power).

First convert the rotor speed from rpm to Hz.
Use the following rules:
Typical there are 3 types of motors; 2 pole, 4 pole and 6 pole.
For 2 pole motors the rotor speed must be divided by 60.
For 4 pole motors the rotor speed must be divided by 30.
For 6 pole motors the rotor speed must be divided by 20.

The most common motors are 4 pole, also the one in this example, therefore: 1280 rpm / 30 = 42,66Hz
The slip setting from minimum speed to base speed is: 44Hz – 42,66Hz = 1,33Hz

With this slip at base speed and 190 A motor current 8 kW output power can be obtained. For acceleration and to climb a ramp more power then the 8kW will be necessary. Because at base speed the maximum motor voltage (30Vac) is already setup, the only possibility to increase the current and the power at base speed is to increase the slip. If the controller has a maximum output current of 320 A, the slip can be increased until this maximum current is reached.

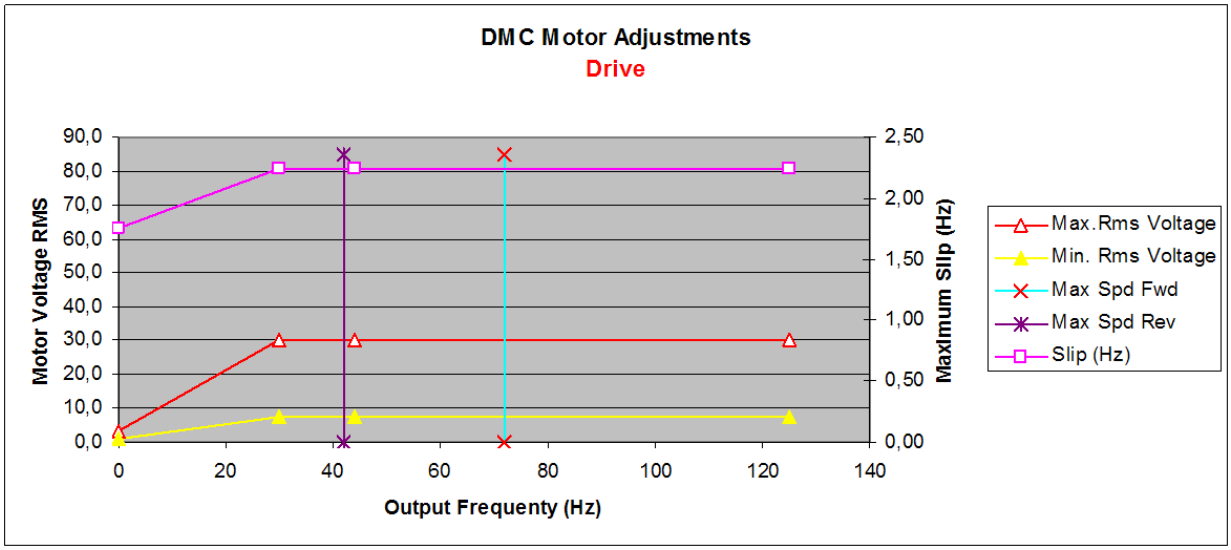
The slip at base speed can now be calculated.
For this example the speed base point is 44Hz.
Formula: Maximum current / Nominal current * nominal slip = maximum slip
→ 320A / 190A * 1,33 Hz = 2,24 Hz
Use this slip setting for Boost, Base and Maximum slip setting.
Set the minimum slip to 70% from the Base slip.
The relation between current and slip is not linear but with this calculation it is usually on the safe side for a first test.

Example settings:

- D Smin: 1,57Hz
- D Sboost: 2,24Hz
- D Sbase: 2,24Hz
- D Smax: 2,24Hz

10.6.2.4 AC motor setup, drive graphics

The example settings generate the following motor graph:



The basic motor setup for drive is now defined. Depending on the speed feed back from the speed encoder and the torque demand from the accelerator, the controller will vary the voltage between the yellow and red line. The slip will vary between 0Hz and the maximum setting for the given speed.

10.6.3 Motor setup – Brake

The voltage and slip settings for braking are basically lower compared to driving.
To get a "fluent braking feel" a separate base speed point is added for braking. This gives the possibility to setup a linear voltage line over the full speed range.
Three different braking torque levels are adjustable in the adjustment menu: direction braking, neutral braking and foot braking. Usually the direction braking is the highest torque level, therefore **set the direction braking level in the adjustments menu to 100% before starting setting up the motor braking table**.

10.6.3.1 Define base speed point

The base speed point for braking (parameter 4.30) is set about 1,5 x of the drive base speed.
In this example 44Hz x 1,5 = 66Hz.

- Example setting: BSPDbase: 66Hz

10.6.3.2 Brake slip setup

The brake slip settings at minimum, boost and maximum level should be set the same as for driving.
Set the slip at Brake speed base point so, that the brake slip graph is linear from the Boost to the Maximum point.

Example settings:

- B Smin: 1,57Hz
- B Sboost: 2,24Hz
- B Sbase: 2,24Hz
- B Smax: 2,24Hz

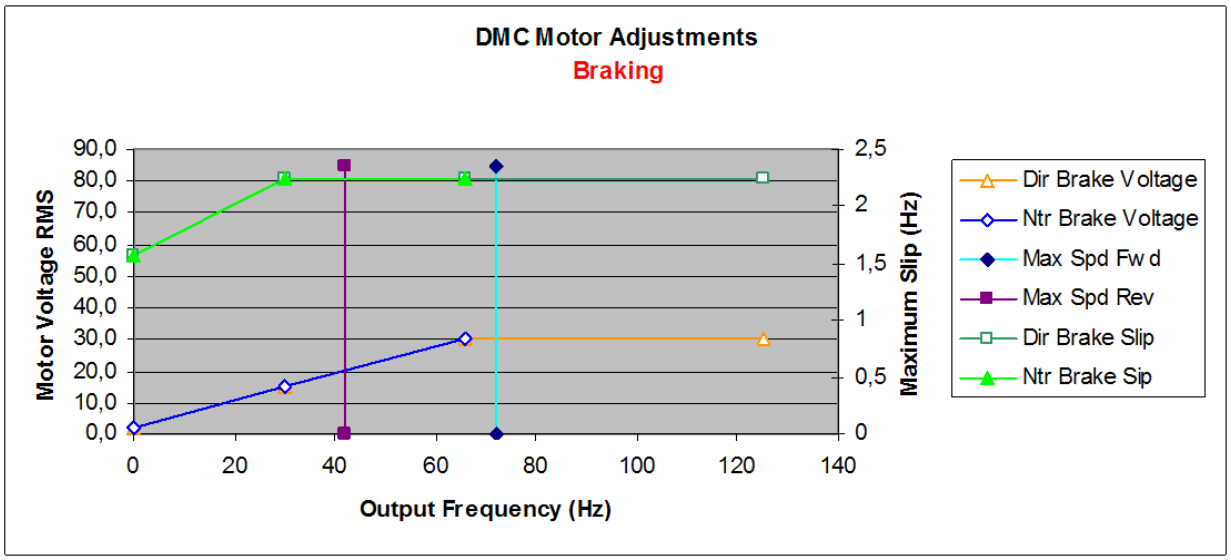
10.6.3.3 Brake voltage setup

For braking there are separate voltage level settings for neutral and direction braking at the minimum and boost speed point. This is done to soften the end of braking in neutral.
The foot brake uses the same motor setup as direction braking.
The direction brake voltage levels at minimum and boost level should be set at 50% of the drive voltage levels. For neutral braking the minimum and boost voltage level should be 50% of the drive voltage levels. At base and maximum the voltage levels are set the same as for driving.

Example settings:

- (Direction / foot brake) BDVmin: 2,0V
- (Direction / foot brake) BDVboost: 15V
- (Neutral braking) BNVmin: 2,0V
- (Neutral braking) BNVboost: 15V
- (all braking) B Vbase: 30V
- (all braking) B Vmax: 30V

10.6.3.4 AC motor setup, braking graphics



Now the basic setup for braking is defined.

10.6.3.5 Braking percentage levels

In neutral braking the controller will follow the motor setup curve for voltage and slip. To increase or decrease (soften) the neutral braking over the whole range, set the neutral braking level at the adjustments menu to a higher or lower percentage level of the motor setup.
The same kind of adjustment is available for foot brake and direction braking.
The foot brake can operate in two way's, either with a switch and a fixed braking torque, or proportional torque with a potentiometer.

10.7 Fine tuning AC drive

When the basic setup for nominal performance is finished, the truck can be tested carefully. First test the drive and brake performance at low speed, then increase the speed in a few steps towards full speed testing both drive and braking. To prevent too high speeds when testing, reduce temporarily the overall vehicle speed for both forward and reverse (parameter 1.4 and 1.5).
To get the right comfort feel the voltage levels can be tweaked in small steps.
Always check first at which frequency the performance must be tuned. The status menu can be used to determine that frequency. Also the DMC motor setup table can help to give a better feel for what kind of effect the motor setting change will have.

10.7.1 More torque needed?

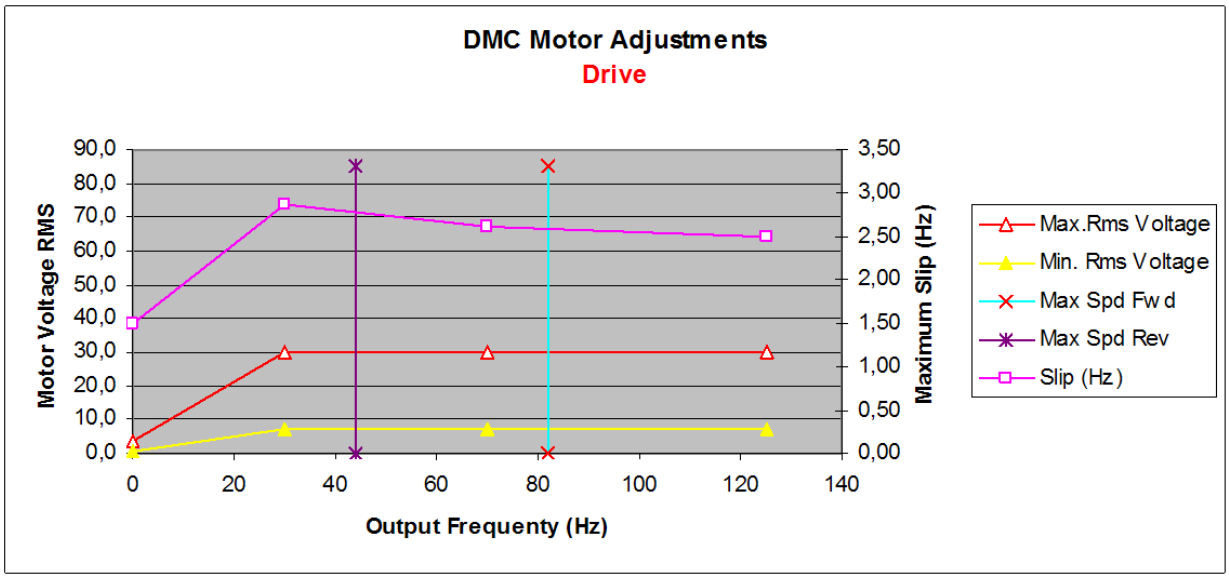
If the truck needs to be tuned for more power at pull away, block the motor and check the motor current. Increase the D Vmin setting in small steps until the maximum current is reached that is allowed for the motor or the controller. Now the D Smin setting can be increased. If the truck starts to lurch the slip is too high and the settings needs to be decreased.

With the following setup procedure, the maximum unloaded speed of the truck on the flat is optimised. The truck in this example has to drive unloaded 14kph and loaded with 1.5ton 13kph. With a gear ratio from 17,733:1 and a wheel radius from 28cm, the rotor speed is 80Hz. To set the maximum speed forward and reverse, the maximum slip of 2 Hz has to be added to this speed, so the value for the maximum speed forward and reverse is 82 Hz.
Drive the truck at full speed and check on the calibrator in the status menu 2.14 if the rotor speed reaches 80Hz. 80Hz is in between the base speed and maximum speed setting. By increasing or decreasing the slip value for this two points more or less torque and current can be obtained.
When the truck is driven with load. Check if the speed reached is 13kph (74Hz). If not, change the slope from the slip curve so that the truck drives 13kph with the lowest current. Maybe increase or decrease the base speed setting to have an acceptable slope curve.
If this is good, the truck can be tested on the ramp. Specification for this truck was 8 kph unloaded and 4 ~ 6 kph with load on a 15 % ramp. The speed is between the boost and base speed setting. By increasing the boost slip to 2,87 Hz the truck was driving with 8 kph at the lowest current up the ramp. The loaded speed up the ramp is between minimum and boost speed. If the torque is too low and increase from the slip has not enough result, check the motor current. If the motor current is not at the maximum, the boost speed setting can be decreased which will increase the motor current.
Changing speed points in the motor setup will also affect the braking curve. **After changing speed points carefully check the braking and driving again.**

10.7.2 The results after fine-tuning:

If more torque is needed to go up the ramp, the slip around boost speed can be increased. The full torque is not needed to get the maximum efficiency at full speed. Therefore the slip can be decreased around the base and maximum speed.

SPDmin		0,00	Hz
SPDboost		30	Hz
SPDbase		70	Hz
SPDmax		125	Hz
Vmin		0,6	Vrm
D Vmin		3,8	Vrm
D Vboost		30,0	Vrm
D Vbase		30,0	Vrm
D Vmax		30,0	Vrm
D Smin		1,50	Hz
D Sboost		2,87	Hz
D Sbase		2,62	Hz
D Smax		2,50	Hz



Always try to avoid 'hitting' the current limit (setting 1.17) as this could be sensed by the driver. The current measurement is just a protection setting to avoid over-current, and not used for control.

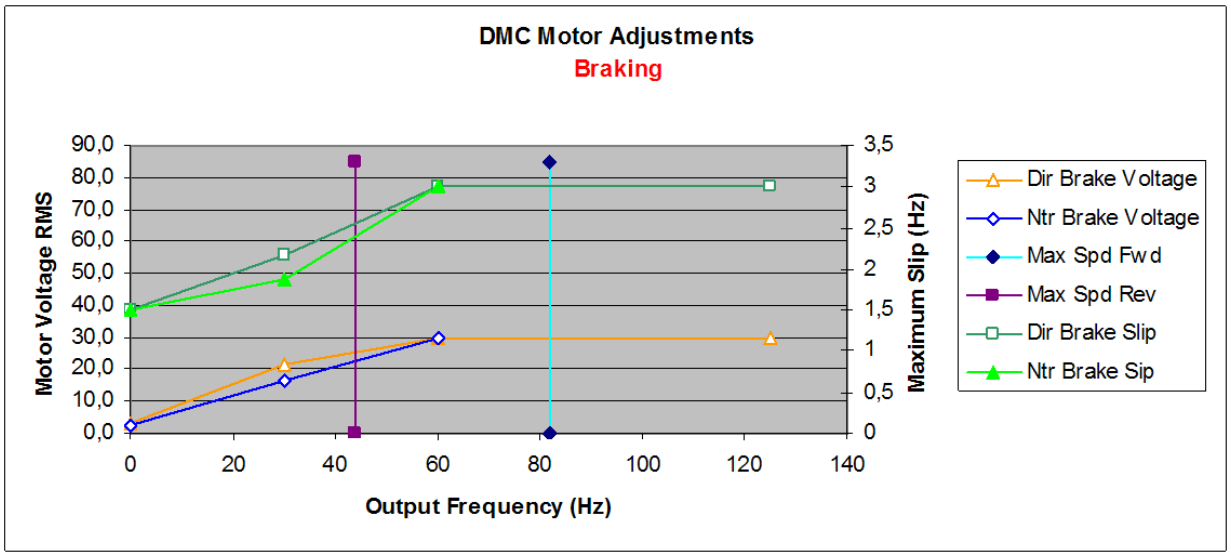
10.8 Fine tuning AC braking

Fine tuning for braking is different between Torque control (3.2=0) and Speed control (3.2=1).
If in torque control the torque curve is not linear then it can be noticed during braking. For example, if the torque is higher at boost speed then at minimum and base speed the braking is not constant if braking from base speed to zero. If higher braking torque is required, increase the minimum voltage and slip and the base slip. The setup is good if the braking torque is constant from the maximum speed to zero. After this the braking torque can be limited by changing the brake settings 1.9, 1.10 and 1.11 in the adjustment menu.

In speed control the braking is different: braking is time related, not torque related. It is not easy to fine tune the braking settings in speed control. A good way is to set it up in torque control and after that change to speed control.

NOTE BE VERY CAREFUL WHEN CHANGING FROM TORQUE TO SPEED MODE AS THE DELAY SETTINGS 1.2, 1.12, 1.13, 1.14 NEED TO BE SHORT WITH TORQUE CONTROL (e.g 0.3 s) OR LONGER FOR SPEED CONTROL (e.g 1.0 s)

Braking table after fine tuning:



10.8.1 Related Parameters

1.15 NBrkEnd e.g 0.5S Delay before controller stops pulsing once zero speed is reached. Prevents brake coming on to late when truck is still moving

1.20 EBrkDly e.g 0.2S Delay from pulsing started to Electro Brake being released. Helps prevent roll back on a Walkie truck when starting drive on a hill.

3. 2 Spd/Torq 0 selects Speed mode, 1 selects Torque mode.

3.4 Arol/Off 0 disables Hill Hold, 1 selects Hill Hold, 2 selects Hill Hold with DC current

4.31 PgainV default = 2, range 1-16. PI gain factor for Voltage. Voltage changes slowly (small numbers) or faster(Larger numbers). Vehicle drives smoother with smaller numbers or more responsively with larger numbers.

4.32 PgainSpd default = 2, range 1-16. PI gain factor for outer speed loop. Speed changes slowly (small numbers) or faster (Larger numbers). Vehicle approaches speed limit gradually with smaller numbers or more rapidly with larger numbers. No effect in Torque mode.

4.33 PgainTrq default = 8, range 1-16. PI gain factor for inner torque loop. Torque changes slowly (small numbers) or faster (Larger numbers). Vehicle drives smoother with smaller numbers or more rapidly with larger numbers. No effect in Torque mode.

4.34 RampTrq default = 0.1S, range 0.1S - 10.0S. PI ramp delay for inner torque loop. Torque changes rapidly (small numbers) or slower (Larger numbers). Vehicle drives smoother with larger numbers or more rapidly with smaller numbers. No effect in Torque mode.

4.35 PgainSpN default = 6, range 1-16. As 4.32 but applies only for neutral braking. Vehicle approaches zero speed gradually with smaller numbers or more rapidly with larger numbers. No effect in Torque mode.

4.39 HHtime delay until the vehicle goes into a restrained hill hold mode with adjustable speed.

4.40 HHspeed Adjustable speed in restrained hill hold mode

4.41 HHVmin Minimum voltage applied during Hill Hold
When using hill hold with DC current (option 2), set this parameter higher than Vmin (parameter 4.9)
When using zero speed hill hold (option 1) set this parameter the same or lower than Vmin.

11 PMS CONTROLLERS - Parameters & Instructions

11.1 PMS Traction: Menu 1 "Adjustments"

Cal Ref	Parameter	Calibrator text	Min. adjust	Max. adjust	Step size	DMC default	Actual setting
1	Acceleration delay	Accel	0.1 S	10.0 S	0.1 S	0.3 S	S
2	Deceleration delay	Decel	0.1 S	10.0 S	0.1 S	0.3 S	S
3	Creep speed	Creep	0 %V	10 %V	1.0 %V	0 %V	%V
4	Maximum speed forward	SpdMaxF	0 %V	100 %V	1.0 %V	100 %V	%V
5	Maximum speed reverse	SpdMaxR	0 %V	100 %V	1.0 %V	100 %V	%V
6	Cutback speed 1	Sp1/Inch	0 %V	100 %V	1.0 %V	100 %V	%V
	Inching speed *		0 Hz	100 Hz	1 Hz	0 Hz	Hz
7	Cutback speed 2	Sp2/Time	0 %V	100 %V	1.0 %V	100 %V	%V
	Inching time *		0.1 S	10 S	0.1 S	2 S	S
8	Cutback speed 3	Sp3	0 %V	100 %V	1.0 %V	100 %V	%V
9	Direction Regen Braking	DBrake	0 %	100 %	1 %	50 %	%
10	Neutral Regen Braking	NBrake	0 %	100 %	1 %	0 %	%
11	Foot brake Regen	FBrake	0 %	100 %	1 %	100 %	%
12	Direction brake ramp time	DBrkRamp	0.1 S	10 S	0.1 S	0.3 S	S
13	Neutral brake ramp time	NBrkRamp	0.1 S	10 S	0.1 S	0.3 S	S
14	Foot brake ramp time	FbrkRamp	0.1 S	10 S	0.1 S	0.3 S	S
15	Neutral brake-End delay	NBrkEnde	0.1 S	2.5 S	0.1 S	0.0 S	S
16	N/A						
17	Drive Max. Current	DMaxCurr	10 Arms	Unit max	10 Arms	Unit max.	A
18	Battery Voltage	BattV	24 V	Unit max.	2 V	Unit max.	V
19	Power steer delay	PStrDly	0 S	50 S	0.1 S	5 S	S
20	Electric brake	EBrkDly	0.0 S	50.0 S	0.1 S	0.5 S	S
21	Accelerator minimum	AccMin	0 V	5.0 V	0.1 V	3.3 V	V
22	Accelerator maximum	AccMax	0 V	5.0 V	0.1 V	0.2 V	V
23	Aux minimum	AuxMin	0 V	5.0 V	0.1 V	0.2 V	V
24	Aux maximum	AuxMax	0 V	5.0 V	0.1 V	4.8 V	V
25	Steerpot min.	StrMin	0 V	5.0 V	0.1 V	0.2 V	V
26	Steerpot max.	StrMax	0 V	5.0 V	0.1 V	4.8 V	V
27	Vehicle max. Speed	VmaxSpd	0 Kph	100 Kph	1 Kph	12 Kph	Kph
28	BDI reset level	BDIreset	0 V	Bat.+ 25%	0.1 V	Cells*2.09V	V
29	BDI empty level	BDIempty	0 V	Bat.+ 25%	0.1 V	Cells*1.73V	V
30	BDI warning level	BDIwarn	0 %	90 %	1.0 %	20%	%
31	BDI cut out level	BDIcut	0 %	90 %	1.0 %	10%	%
32	BDI speed limit	BDIspeed	0 %V	100 %V	1.0 %V	100 %V	%V
33-37	N/A						

- **Depending on controller type and configuration some settings will be not available (N/A).**
- *** Selectable multi-function.**

11.2 PMS Traction: Menu 2 "Status"

The status menu shows various parameters from the controller which can be useful to help tune and optimise vehicle performance.

Cal Ref	Item	Calibrator text	Dir. Polar.	Step size	Service log info & Notes
1	Drive hours counter	Drive		0.1 Hrs	+ shows key hours
2	Fault log (15F and above only)	Fault		Last fault	+ shows key hours of the fault
3	Battery Discharge Indicator	BDI		1 %	
4	Vehicle Speed	Vehicle		1 Kph	
5	Battery Voltage	Battery		0.5 V	+ shows highest voltage
6	Controller Temperature	Control+	+/-	1 °C	- + Min & max temperatures
7	Motor Temperature	Steer/M+	+/-	1 %°C	- + Min & max temperatures
	Steer position			1 %	
8	Accelerator demand	Accel		1 %	+ shows auxiliary i/p (footbrake)
9	DemandT	DemandT-	+/-	0,0625 Hz	**Extra controller status info: See next tabel "Status"**
10	DemandR	DemandR-	+/-	0,0625 Hz	**Controller limit indication: See next tabel "Limit"**
11	Motor	Motor		0.1 Vrms	- + Bits 0-242 / %V 0-95
12	Motor Current	Motor +	+/-	10 Arms	+ = Drive current / - = Brake current
13	Motor	Motor +	+/-	0,0625 Hz	+ = Forward / - = Reverse
14	Rotor RPM	Rotor	+/-	1 RPM	+ = Forward / - = Reverse
15	Position	Position	+/-	0.1 Deg	Incr nr = fwd dir / decr nr = rev dir
16	Power Factor compensation	PFcomp	+/-	0.1 Deg	
17	Capacitor Voltage	Cap		0.5 V	
18	M1	Vrms		0.5 V	Digital (0/1) or analogue values (0-125V)
19	M2	Vrms		0.5 V	Digital (0/1) or analogue values (0-125V)
20	M3	Vrms		0.5 V	Digital (0/1) or analogue values (0-125V)
21-24	Debug (DMC internal use only)	Dbug			
	Service and fault log reset				**press + and – together to reset service log (only possible when controller in neutral)**

Status	Description		Limit	Description for Traction limits	
N	Neutral, no pulsing		SM	Speed max Fwd or Rev	
FD	Forward drive		S1	Speed 1	
FL	Forward drive left		S2	Speed 2	
FR	Forward drive right		S3	Speed 3 (or hand brake)	
RD	Reverse drive		S4	n/a	
RL	Reverse drive left		S5	n/a	
RR	Reverse drive right		S6	n/a	
DB	Direction regen braking		Si	Inching	
NB	Neutral regen braking		SB	BDI speed limit	
FB	Foot brake regen		SD	Dual motor speed limit	
DP	Direction plugging (series only)		CL	Current limit	
NP	Neutral plugging (series only)		BL	Brake current limit	
FP	Foot brake plugging (series only)		CT	Controller temperature	
AB	Anti-roll off		MT	Motor temperature	
Fxx	Fault codes		PT	Performance table	
			TL	Timed Current Limit	

11.3 PMS Traction: Menu 3 "Controller Setup"

Change these settings to select the required options and I/O.

Cal Ref	Parameter	Calibrator text	Options (defaults are in bold)	Range	Actual setting
1	Accel. Characteristic	Lin/Curv	0= Acc & Aux both Linear **1= Acc Curve1 & Aux linear** 2= Acc Curve2 & Aux Linear 3= Acc Linear & Aux Curve1 4= Acc Curve1 & Aux Curve1 5= Acc Curve2 & Aux Curve1 6= Acc Linear & Aux Curve2 7= Acc Curve1 & Aux Curve2 8= Acc Curve2 & Aux Curve2	0 – 8	
2	Control mode	Spd/Torq	**1=Torque,** 2=Fast Torque	1 – 2	
3	Brake level proportional	Bpro/Off	1=Fixed, **0=Proportional**	0 – 1	
4	Anti-roll off	Arol/Off	**1=Coast,** 0=no function	0 – 1	
5	I/O Pin 5 and 6 *	Spd/Inch	**0=Speed 1+2** , 1=Inching Fwd/Rev	0 – 1	
6	I/O Pin 7	Spd3/Hbk	0=Speed3, **1=Handbrake** (If handbrake selected, set the required max. speed at Speed 3	0 – 1	
7	Power steer trigger	PsF/FR/S	**0=FS1**, 1=Fwd/Rev, 2= Seat switch	0 – 2	
8	Truck type select *	Ride/Wlk	**0=Ride-on,** 1=Walkie	0 – 1	
9	N/A				
10	Display fault indication	Of/M/M&W	0=None, 1=Main faults, **2=Main & Warning faults**	0 – 2	
11	Display Status field	Of/D/V/K	**0=None**, 1=Acc, 2=Motor V/RPM, 3=Speed in Kph, 4=Steering	0 – 4	
12	Contactor outputs 2 & 3 Configuration *	Conts23	See section 11.3.1.	0 – 11	
13	Motor temp. sensor type	MTempTyp	0=KTY81-220, **1=KTY84**, 2=KTY81-110	0 – 2	
14	Analogue I/P select *	Accel 8/9	0=Pin8 Accel Pot - Pin9 Aux Pot **1=Pin8 Aux Pot - Pin9 Accel Pot** 2=Pin9 wig-wag (on request only)	0 – 2	
15	Single/Dual motor select*	Si/DL/DR	See below table for explanation	0 – 4	

		Aux AD i/p Pin A8 or A9	Steer / motor AD i/p Pin C4	Digital i/p Pin A5	Digital i/p Pin A6	FS1 required
0	**Single motor**	Footbrake	Motor temp.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
1	Dual motor pot. Left	Footbrake	Steer pot.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
2	Dual motor pot. Right	Footbrake	Steer pot.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
3	Dual motor joystick left	Joystick pot.	Motor Temp.	Steer switch left	Steer switch right	No
4	Dual motor joystick right	Joystick pot.	Motor Temp.	Steer switch left	Steer switch right	No

16	Position / Direction	PosDir	0= motor turning clockwise, 1= motor turning counter clockwise	0 – 1	
17	Swap directions	SwapDirs	0 = Directions not swapped, 1 = Swap directions	0 – 1	
18	CAN node number* *3	CAN Node		0 – 15	0

*** Reset to make changes active. Recycle the key switch (Also indicated on calibrator 'key')**
***2 Not in combination with Standby delay**
***3 See section 9.2 for important information**
Irrelevant options show n/a

11.3.1 Contactor Driver Configuration

Using controller setup adjustment number 12 "Conts23" the two contactor drivers 2 & 3 can be configured to have one of the functions as in the table below.

Contactor output driver 2 is on pin 13 of connector A.
Contactor output driver 3 is on pin 14 of connector A.

Conts23 Setting	Contactor driver output 2	Contactor driver output 3
0 (= default)	EM-brake	Power steer
1	EM-Brake	Drive OK output
2	EM-Brake	Thermal High warning
3	Power steer	EM-Brake
4	Power steer	Drive OK output
5	Power steer	Thermal High warning
6	Drive OK output	EM-Brake
7	Drive OK output	Power steer
8	Drive OK output	Thermal High warning
9	Thermal High warning	EM-Brake
10	Thermal High warning	Power steer
11	Thermal High warning	Drive OK output

Of course, more than two functions (three when the line contactor is included) cannot be used at the same time.

11.4 PMS Traction: Menu 4 "Motor Setup"

The motor setup menu define the motor characteristics for the controller.
Only qualified engineers should change these settings.
Mistakes in the motor setup tables can cause serious accidents and/or defective controllers and/or motors. For PMS motors the motor manufacture should provide this information.

Cal Ref	Parameter	Calibrator text	Min.	Max.	Step size	DMC default	Actual setting
1	Motor Temp. Cutback start	TempStrt	1	151(disables)	1	90	
2	Motor / Vehicle -speed ratio	SpdRatio	1.0	999.9	0.1	1.0	
3	Number of teeth *	SpdTeeth	0	255	2	0	
4	Number of motor poles *	SpdPoles	8 (lower on request)	56	2	8	
5	Motor speed minimum	SPDmin	0 RPM	7500 RPM	1 RPM	0	RPM
6	Motor speed boost	SPDboost	0 RPM	7500 RPM	10 RPM	0	RPM
7	Motor speed base	SPDbase	0 RPM	7500 RPM	10 RPM	0	RPM
8	Motor speed max	SPDmax	0 RPM	7500 RPM	10 RPM	0	RPM
9	Minimum Voltage	Vmin	0 Vrms	100 Vrms	0.1 Vrms	0	Vrms
10	Drive voltage minimum	D Vmin	0 Vrms	100 Vrms	0.1 Vrms		Vrms
11	Drive voltage boost	D Vboost	0 Vrms	100 Vrms	0.1 Vrms		Vrms
12	Drive voltage base	D Vbase	0 Vrms	100 Vrms	0.1 Vrms		Vrms
13	Drive voltage max	D Vmax	0 Vrms	100 Vrms	0.1 Vrms		Vrms
14	N/A						
15	Current Limit @ Boost Speed	CurBoost	0 Arms (off)	Unit Max.	10 Arms	0	Arms
16	Current Limit @ Base Speed	CurBase	50 Arms	Unit Max.	10 Arms	Unit Max.	Arms
17	Current Limit @ Max. Speed	CurMax	50 Arms	Unit Max.	10 Arms	Unit Max.	Arms
18	Unloaded Voltage @1000 RPM	U V/1000	0 Vrms	100 Vrms	0.1 Vrms		Vrms
19	ULV correction in mV per 1˚C	UVTcorr	0 mV	20 mV	1 mV	0 mV	mV/˚C
20	Braking Voltage @ 1000 RPM	B V/1000	0 Vrms	100 Vrms	0.1 Vrms		Vrms
21	Braking speed min	B SPDmin	0 RPM	7500 RPM	1 RPM		RPM
22	I^2T Current Cutback 1	CutBack1	0 %	100 %	1 %	80	%
23	I^2T Current Cutback 2	CutBack2	0 %	100 %	1 %	60	%
24	I^2T Current Cutback 3	CutBack3	0 %	100 %	1 %	40	%
25	Maximum Brake Current	MaxCurB	50A	Unit Max.	10A	½ unit max	A
26	Power Factor maximum	PFmax	0.0	90.0	0.1	50	Deg
27	Power Factor gain	PFgain	0	32	1	16	Num
28	Sensor Setup	SenSetup	0	1	1	0	Num
29	Sensor Angel Forward	SenAngF	45.0	135.0	0.1	85	Deg
30	Sensor Angel Reverse	SenAngR	45.0	135.0	0.1	85	Deg
31	Nominal Motor Current (I^2T)	NomCurr	50 Arms	Unit Max.	10 Arms	Unit dep.	Arms
32	I^2T Motor Temperature Start	TempI^2t	0 ˚C	100 ˚C	1 ˚C	70	˚C
33	I^2T Time (0sec disable feature)	I^2tTime	0 (off)	999 Sec	1 Sec	0 Sec	Num
34	Ramp torque	Ramp Trq	0.1 S	10.0 S	0.1 S	0.1 S	Sec
35	Proportional gain speed neutral	PGainSpN	1	16	1	6	Num
36	Ofset 1 (Factory setting)	Ofset1+				-1	bit
37	Gain 2 (Factory setting)	Gain 2				100	%
38	Ofset 3 (Factory setting)	Ofset3+				-1	bit

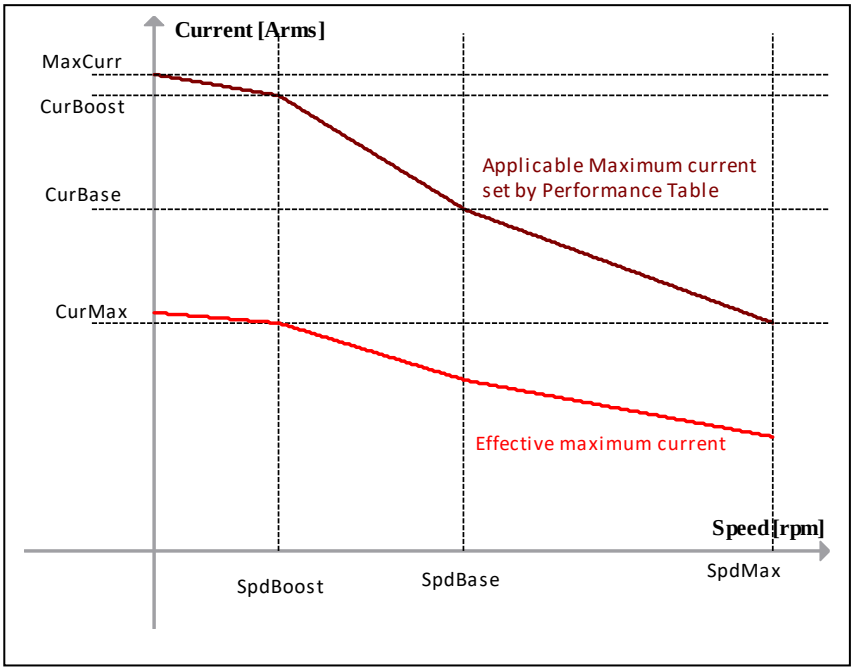
- *** Reset to make changes active. Recycle the key switch (Also indicated on calibrator 'key')**
- **Changes on parameter 5 up to 28 become active after selecting neutral and the controller stops pulsing.**

11.5 Thermal Motor Management & Performance table

The Performance Table sets a current for a specified speed as shown in the table below:

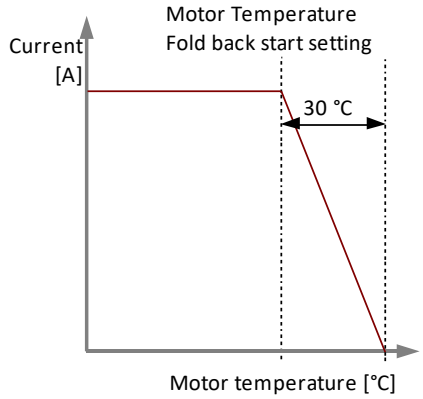
Speed	Maximum current allowed
Between minimum and boost speed.	Scale maximum current proportionally with speed between the maximum current from adjustments menu and the current setting at boost.
Between boost and base speed.	Scale maximum current proportionally with speed between the current settings at boost and base speed.
Between base and maximum speed.	Reduce current proportionally with speed between the current settings at base and max speed.

The Performance Table collaborate with the other current roll back functions. The current roll back on controller temperature, current roll back on motor temperature and the I^2t function.
The I^2t function have its settings in percentages, the same as the current roll back on controller and motor temperature. The function that has the highest roll back percentage, will be applied to the applicable maximum current, and will result in the effective maximum current as shown in the picture below (here the roll back is 50%).



For normal operation, the maximum current at boost speed is usually set the same as the maximum current from the adjustments menu.
This will then give a straight line from zero speed towards boost speed yielding maximum current at low speeds.
During operation, the controller will show “PT” at row 9 in the status menu.

11.5.1 Current roll back on motor temperature



The maximum current value is rolled back as soon as the motor temperature is above it’s starting point adjustment (parameter 1 in the motor setup). It is cut back proportionally between the starting point and 30 °C above the starting point as shown in the graph below.

11.5.2 Option to disable current roll back functions

To disable the current rollback features:

- current roll back on motor temperature; by setting the motor temperature start adjustment at 151 °C,
- I^2t function; by setting the I2tTime adjustment to 0.
- Performance Table; by setting the maximum current at boost speed adjustment to 0 A.

11.6 Adjusting the position sensor on a Perm-Motor PMS Motor.

(FOR INFORMATION ONLY, THE SENSORS ARE ALWAYS CALIBRATED WHEN MOUNTED)

This section describes how to adjust the sensor for a typical motor, in this case, the Perm-motor PMS motor, and applies to the following situations:

- the motor does not run at all,
- the motor runs the wrong way or
- the motor runs inefficient.

For the controller to be able to properly control the motor, it needs to know the exact position of the rotor. At one end of the motor shaft there is a 12-bit position sensor. This sensor counts up clockwise (CW) or counts down counter-clockwise (CCW). One mechanical revolution of the motor gives a sensor output from 0 to 360 degrees. This position can be read from the status menu at line #15 “Position”.

If the shaft is rotated clockwise (CW)  , the number should increase. If the shaft is rotated counter-clockwise (CCW)  , the number decreases.

For correct operation this sensor needs to be aligned to the exact rotor zero position. This is performed by putting the controller in the ‘sensor setup mode’. **The motor must be unloaded to be able to turn in the correct position.** The zero position of the shaft of the motor depends on the number of poles the motor has. The following table shows the zero position in (mechanical) degrees for the possible number of poles the controller supports:

Number of poles	4	8	12	16	20	24
Mechanical zero position (degrees)	90	45	30	22,5	18	15

If the sensor setup mode is enabled, a current flows through the motor field from M2 to M3 and no current through M1, then the rotor turns to a fixed position.

What is needed for the sensor setup

- motor with sensor,
- RS422 Interface for sensor,
- 1 controller,
- 1 calibrator,
- 1 battery,
- line contactor (same voltage as battery) and
- switchbox with minimum: key-switch, direction switch, FS1, seat-switch and accelerator potentiometer.

Connect the main wiring of the motor to the controller in the correct order. Perm-Motor cables are labeled with a white ring marked with a number from 1 to 3. Connect the cables 1/1 to the M1 terminal of the controller, cables 2/2 to M2 and cables 3/3 to M3.
Connect main wiring Line contactor to the controller.
Connect the switchbox to the controller.
Connect a calibrator to the controller.
Connect the sensor.
Connect B- to the B- terminals.

Sensor Setup Procedure

1. Set all switches to neutral and accelerator pot to minimum.
2. Switch on the key-switch.
3. To set the controller in the ‘sensor setup mode’, go to the motor setup menu and set at line #28 “SenSetup” to 1 (the motor speed must be 0, otherwise it is not possible to set SenSetup to 1). **The setup procedure is stopped when the key switch is recycled, and the SenSetup is automatically returned to 0 again.**
4. Go to the Status menu “Position” to check the position. Turn the shaft of the motor as close to its zero position (see the table above) (e.g. for an 8-pole motor this is 45 °).
5. Switch on the seat-switch.
6. Select forward with the direction-switch.
7. Switch on the FS1.
8. Turn up the accelerator pot while looking at the current in the status menu at line #12. The shaft of the motor will rotate to a fixed, optimal position. Turn up the accelerator **carefully** until the current reads about 50 % of the rated motor current.

9. Align the sensor as close as possible to the zero position in degrees (e.g. for an 8-pole motor this is 45.0 °, see the table above), and fix it with the screws.
10. Power off and on the controller.

Now try to run the motor at low speed in forward direction and check the motor current. If the shaft of the motor is not rotating but the currents are going high, try to inverse controller setup 3.16 “PosDir”. If this was 1, set it to 0, if it was 0, set it to 1. If the current is now positive and low, increase the speed. Try now in the reverse direction. If this also works and the shaft is rotating in the correct direction, mark the cables with M1, M2 and M3.
If the shaft is rotating correctly but it’s direction is reversed (e.g. when forward direction is chosen, the vehicle is driving reverse and vice versa), swap over two cables and perform all the steps of the Sensor Setup Procedure again.

11.7 Important notes for PMS systems

11.7.1.1 Parameter 4.18 (Unloaded Voltage @1000 RPM

Carefully set up this parameter. ALWAYS TAKE THE DRIVE WHEELS OF THE GROUND FIRST AND MAKE SURE THIS PARAMETER IS CORRECT. If one of the following occurs, the unloaded voltage per 1000 revolutions is not setup correctly and should be corrected:

- A too low voltage setting will keep the controller in braking when the potentiometer is at 0%
- A too high voltage setting will keep the controller in drive, giving torque even at a potentiometer level of 0% demand.
- At some point the controller internal safety will switch off the controller, indicating F26.

11.8 Fine tuning for optimal performance

Motor Parameter 28 is modified. The name changed from Sensor Offset to Sensor Angle Forward, and one setting is added; Sensor Angle reverse. The default value is changed from 80 to 85 degrees. If the sensor is not perfectly centred there will be small differences in performance between forward and reverse. If perfection is required you can follow this procedure:

- Set nr. 26 in the motor menu “PFmax” to 0
- Limit the motor speed to about 20%
- Press the accelerator and check the unloaded motor current in both directions and tune the current to be the lowest possible value, by making small corrective adjustments (on the fly) to parameter 29 (in forward) and parameter 30 (in reverse)
- When you have tuned both directions for the lowest possible unloaded current, set the speed back to normal
- Set the PFmax back to 50

11.9 Maintenance instruction

Over time, depending on how hard the motor is used, the magnets installed in PMS motors are ageing. Therefore it is important to check for ageing during regular service intervals. Take the traction wheels of the ground, choose direction (pins A1&2, close FS1 (Pin A3) and keep the accelerator at 0% demand. If the motor starts turning, the ULV/1000 voltage level (motor setup menu item 18) has to be lowered until the motor stops turning. Do this in several small steps. A safety feature (F26) is implemented to limit the motor torque at zero demand. F26 will switch off the controller and the vehicle should not be used until the fault is tuned out, adjusting 4.18.

11.10 Motor speed sensor & software compatibility

Controllers with software 2.29.0F and higher are backwards compatible with the previously used sensors. When using the previous 4-wire sensor model, connect controller pin C1 to B- to eliminate false F26 warnings

12 SEM & PM CONTROLLERS - Parameters & Instructions

12.1 SEM & PM Traction: Menu 1 "Adjustments"

Cal Ref	Parameter	Calibrator text	Min. adjust	Max. adjust	Step size	DMC default	Actual setting
1	Acceleration delay	Accel	0.1 S	10.0 S	0.1 S	2.0 S	S
2	Deceleration delay	Decel	0.1 S	10.0 S	0.1 S	0.3 S	S
3	Creep speed	Creep	0 %	25 %	1 %	0 %	%
4	Maximum speed forward	SpdMaxF	0 %	100 %	1 %	100 %	%
5	Maximum speed reverse	SpdMaxR	0 %	100 %	1 %	100 %	%
6	Cutback speed 1 *	Sp1/Inch	0 %	100 %	1 %	100 %	%
	Inching speed *		0 %	100 %	1 %	0 %	%
7	Cutback speed 2 *	Sp2/Time	0 %	100 %	1 %	100 %	%
	Inching time *		0.1 S	10 S	0.1 S	2 S	S
8	Cutback speed 3	Sp3	0 %	100 %	1 %	100 %	%
9	Direction Regen Braking	DBrake	10 A	Unit max.	10 A	Unit max./2	A
10	Neutral Regen Braking *	NBrake	10 A	Unit max.	10 A	Unit max./4	A
11	Foot brake Regen *	FBrake	0 A (off)	Unit max.	10 A	Unit max./4	A
12	Direction brake ramp time	DBrkRamp	0.1 S	10 S	0.1 S	2 S	S
13	Direction brake-End delay	DBrkEnd	0.1 S	10 S	0.1 S	0.3 S	S
14	Neutral brake ramp time	NBrkRamp	0.1 S	10 S	0.1 S	3 S	S
15	Neutral brake-End delay	NBrkEnde	0.1 S	10 S	0.1 S	0.7 S	S
16	Regen speed	RegSpd	0 %	100 %	1 %	10 %	%
17	Max. Current	MaxCurr	10 A	Unit max	10 A	Unit max.	A
18	Battery Voltage	BattV	24 V	Unit max.	2 V	Unit max.	V
19	Power steer delay	PStrDly	0 S	50 S	0.1 S	5 S	S
20	Electric brake	EBrkDly	0.0 S	50.0 S	0.1 S	0.5 S	S
21	Accelerator minimum	AccMin	0 V	5.0 V	0.1 V	3.3 V	V
22	Accelerator maximum	AccMax	0 V	5.0 V	0.1 V	0.2 V	V
23	Aux minimum	AuxMin	0 V	5.0 V	0.1 V	0.2 V	V
24	Aux maximum	AuxMax	0 V	5.0 V	0.1 V	4.8 V	V
25	Steerpot min.	StrMin	0 V	5.0 V	0.1 V	0.2 V	V
26	Steerpot max.	StrMax	0 V	5.0 V	0.1 V	4.8 V	V
27	Vehicle max. Speed	VmaxSpd	0 Kph	100 Kph	1 Kph	12 Kph	Kph
28	BDI reset level	BDIreset	0 V	Bat. +25%	0.1 V	Cells*2.09V	V
29	BDI empty level	BDIempty	0 V	Bat. +25%	0.1 V	Cells*1.73V	V
30	BDI warning level	BDIwarn	0 %	90 %	1.0 %	20%	%
31	BDI cut out level	BDIcut	0 %	90 %	1.0 %	10%	%
32	BDI speed limit	BDIspeed	0 %	100 %	1.0 %	100 %	%
33	DM*² Acceleration (joystick)	DMcut/Ac	0.1 S	10.0 S	0.1 S	0.5 S	S
	DM*² Cutback (3 wheeler)		0 %	100 %	1 %	10 %	%
34	DM*² Deceleration (joystick)	DMrev/De	0.1 S	10.0 S	0.1 S	0.5 S	S
	DM*² Reverse (3 wheeler)		0 %	100 %	1 %	70%	%
35	DM*² Speed limit	DMspeed	0 %	100 %	1.0 %	100 %	%
36	Standby Delay*³	StdByDly	0 Min. (off)	10 Min.	0,5 Min.	0 Min.	Min.

- **Depending on controller type and configuration some settings will be not available (N/A).**
- *** Selectable multi-function.**
- ***² DM= Dual motor**
- ***³ Not in combination with shared line contactor**

12.2 SEM & PM: Menu 2 "Status"

The status menu shows various parameters from the controller which can be useful to help tune and optimise vehicle performance.

Cal Ref	Item	Calibrator text	Dir. Polar	Controller type	Step size	Service log info & Notes
1	Drive hours counter	Drive		SEM & PM	0.1 Hrs	shows key hours
2	Fault log (15F and above only)	Fault		SEM & PM	Last fault	shows key hours of the fault
3	Battery Discharge Indicator	BDI		SEM & PM	1 %	
4	Vehicle Speed	Vehicle		SEM & PM	1 Kph	
5	Battery Voltage	Battery		SEM & PM	0.5 V	shows highest voltage
6	Controller Temperature	Control+	+/-	SEM & PM	1 °C	min & max temperatures
7	Motor Temperature	Steer/M+	+/-	SEM & PM	1 %°C	min & max temperatures
	Steer position			SEM & PM	1 %	
8	Accelerator demand	Accel		SEM & PM	1 %	shows auxiliary i/p (footbrake)
9	Motor demand	Demand	+/-	SEM & PM	1 %on	**Extra controller status info: See next tabel "Status"**
10	Motor %on	Motor	+/-	SEM & PM	1 %on	**Controller limit indication: See next tabel "Limit"**
11	Motor armature voltage	Motor		SEM	0.5 V	
	Motor voltage	Pluglev		PM	0.5 V	
12	Motor Current	Motor +	+/-	SEM & PM	10 A	+ = Drive current / - = Brake current
13	Demand field	DemFld +	+/-	SEM	1 A	
14	Motor field %on	MotFld -	+/-	SEM	1 %on	Speed RPM
	Motor speed RPM	Speed		PM	RPM	
15	Motor field voltage	MotFld		SEM	0.5 V	
16	Motor field current	MotFld +	+/-	SEM	1 A	
17	Capacitor Voltage	Cap		SEM & PM	0.5 V	
18	M1	M1		SEM & PM	0.5 V	Digital (0/1) or analog values 0-125V
19	M2	M2		SEM	0.5 V	Digital (0/1) or analog values 0-125V
20	M3	M3		SEM & PM	0.5 V	Digital (0/1) or analog values 0-125V
21-24	Debug (DMC internal use only)	Dbug		SEM & PM		
	Service and fault log reset			SEM & PM	**press + and – together to reset service log (only possible when controller in neutral)**	

Status	Description		Limit	Description for Traction limits	
N	Neutral, no pulsing		SM	Speed max Fwd or Rev	
FD	Forward drive		S1	Speed 1	
FL	Forward drive left		S2	Speed 2	
FR	Forward drive right		S3	Speed 3 (or hand brake)	
RD	Reverse drive		S4	n/a	
RL	Reverse drive left		S5	n/a	
RR	Reverse drive right		S6	n/a	
DB	Direction regen braking		Si	Inching	
NB	Neutral regen braking		SB	BDI speed limit	
FB	Foot brake regen		SD	Dual motor speed limit	
DP	Direction plugging (series only)		CL	Current limit	
NP	Neutral plugging (series only)		BL	Brake current limit	
FP	Foot brake plugging (series only)		CT	Controller temperature	
AB	Anti-roll off		MT	Motor temperature	
SB	Standby				
Fxx	Fault codes				

12.3 SEM & PM: Menu 3 "Controller Setup"

Change these settings to select the required options and I/O.

Cal Ref	Parameter	Calibrator text	Options (defaults are in bold)	Range	Actual setting
1	Accel. Characteristic	Lin/Curv	0= Acc & Aux both Linear **1= Acc Curve1 & Aux linear** 2= Acc Curve2 & Aux Linear 3= Acc Linear & Aux Curve1 4= Acc Curve1 & Aux Curve1 5= Acc Curve2 & Aux Curve1 6= Acc Linear & Aux Curve2 7= Acc Curve1 & Aux Curve2 8= Acc Curve2 & Aux Curve2	0 – 8	
3	Brake level proportional	Bpro/Off	0=**Proportional**, **1**=Fixed (EPS: Fixed only)	0 – 1	
	P-Steer I/P (Pump spd 6)	Sp6Lo/Hi	**0=Active Low,** 1=Active High	0 – 1	
4	Anti-roll off	Arol/Off	**0**=Anti Roll Off**,** 1=**Coast**Anti Roll Off	0 – 1	
	Pump Inhibit I/P (Pump)	HibLo/Hi	**0=Active Low ,**1=Active High	0 – 1	
5	I/O Pin 5 and 6 *	Spd/Inch	**0=Speed 1+2** , 1=Inching Fwd/Rev	0 – 1	
	Pump Power up (Pump)	NChk/Chk	**0=No Check,** 1= Chk sws at powerup	0 – 1	
6	I/O Pin 7	Spd3/Hbk	0=Speed3, **1=Handbrake** (If handbrake selected, set the required max. speed at Speed 3	0 – 1	
	Pot.& switch (Pump spd1)	NoSw/Sw	0=No Pot. switch **1=Pot & switch**	0 – 1	
7	Power steer trigger	PsF/FR/S	**0=FS1**, 1=Fwd/Rev, 2= Seat switch	0 – 2	
8	Truck type select *	Ride/Wlk	**0=Ride-on,** 1=Walkie	0 – 1	
9	N/A				
10	Display fault indication	Of/M/M&W	0=None, 1=Main faults, **2=Main & Warning faults**	0 – 2	
11	Display Status field	Of/D/V/K	**0=None**, 1=Acc, 2=Motor V/RPM, 3=Speed in Kph, 4=Steering	0 – 4	
12	Contactor outputs 2 & 3 Configuration *	Conts23	See section 12.3.1.	0 – 11	
13	Motor temp. sensor type	MTempTyp	0=KTY81-220	0 – 255	
14	Analogue I/P select *	Accel 8/9	0=Pin8 Accel Pot - Pin9 Aux Pot **1=Pin8 Aux Pot - Pin9 Accel Pot** 2=Pin9 wig-wag (on request only)	0 – 2	
15	Single/Dual motor select*	Si/DL/DR	See below table for explanation	0 – 4	

		Aux AD i/p Pin A8 or A9	Steer / motor AD i/p Pin C4	Digital i/p Pin A5	Digital i/p Pin A6	FS1 required
0	**Single motor**	Footbrake	Motor temp.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
1	Dual motor pot. Left	Footbrake	Steer pot.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
2	Dual motor pot. Right	Footbrake	Steer pot.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
3	Dual motor joystick left	Joystick pot.	Motor Temp.	Steer switch left	Steer switch right	No
4	Dual motor joystick right	Joystick pot.	Motor Temp.	Steer switch left	Steer switch right	No

16	I/O C3 driver select: Electric brake / Field weakening / Balance contactor	EB/FW/BC	**0=Electric Brake**, 1=Field Weakening, 2=Balance Contactor (Series only)	0 – 2	
17	CAN node number	CAN node	**0=node 0 (0=master)**, 1=node 1, ……15=node 15	0 - 15	
18	Shared Line Contactor *²	ShareLC	**0=No Line contactor sharing** 1=Line contactor shared	0 - 1	
19	Last Sharing Node	LstNode	Enter the highest node number that shares the same line contactor.	1 - 15	

- *** Reset to make changes active. Recycle the key switch (Also indicated on calibrator 'key')**
- ***² Not in combination with Standby delay**
- **Irrelevant options show n/a**

12.3.1 PM only - Contactor Driver Configuration

This feature is only available to standard PM4 controllers. SEM controllers do not have this feature.

Using controller setup adjustment number 12 "Conts23" the two contactor drivers 2 & 3 can be configured to have one of the functions as in the table below.

Contactor output driver 2 is on pin 13 of connector A.
Contactor output driver 3 is on pin 14 of connector A.

Conts23 Setting	Contactor driver output 2	Contactor driver output 3
0 (= default)	EM-brake	Power steer
1	EM-Brake	Drive OK output
2	EM-Brake	Thermal High warning
3	Power steer	EM-Brake
4	Power steer	Drive OK output
5	Power steer	Thermal High warning
6	Drive OK output	EM-Brake
7	Drive OK output	Power steer
8	Drive OK output	Thermal High warning
9	Thermal High warning	EM-Brake
10	Thermal High warning	Power steer
11	Thermal High warning	Drive OK output

Of course, more than two functions (three when the line contactor is included) cannot be used at the same time.

12.4 SEM: Menu 4 "Motor Setup"

Cal Ref	Parameter	Calibrator text	Min.	Max.	Step size	DMC default	Actual setting
1	Motor Temp. Cutback start	TempStrt	1	151(disables)	1	151	
2	Motor / Vehicle -speed ratio	SpdRatio	1.0	999.9	0.1	1.0	
3	Number of teeth *	SpdTeeth	0	255	1	0	
4	Armature current Min.	ArmMin	10 A	Unit max A	10 A		A
5	Armature current Mid.	ArmMid	10 A	Unit max A	10 A		A
6	Armature current Max.	ArmMax	10 A	Unit max A	10 A		A
7	Field current Min.	FldMin	2 A	10% max A	0.2 A		A
8	Field current Mid.	FldMed	2 A	10% max A	0.2 A		A
9	Field current Max.	FldMax	2 A	10% max A	0.2 A		A
10	Field current Anti roll off	FldArol	2 A	Unit max A	0.2 A		A
11	Anti-roll off time	ArolTime	0 Sec (always on)	60 Sec	1 Sec	5 Sec	Sec
12	Field weakening deceleration time	FWdecel	0.1 S	10.0 S	0.1 S	2.5 S	
//	*Cal.Ref. 13 up to 32 are N/A*	n/a					

12.4.1 SEM - Motor setup description

With the parameters 4 to 9 a map is created for the armature and field current relation.
Parameters 10 and 11 are used to fine tune the anti rol off feature.
Caution: When the Anti-roll off time elapse the vehicle will coast

12.5 PM: Menu 4 "Motor Setup"

Cal Ref	Parameter	Calibrator text	Min.	Max.	Step size	DMC default	Actual setting
1	Motor Temp. Cutback start	TempStrt	1	151(disables)	1	151	
2	Motor / Vehicle -speed ratio	SpdRatio	1.0	999.9	0.1	1.0	
3	Number of teeth *	SpdTeeth	0	255	1	0	
//	*Cal.Ref. 4 up to 29 are n/a*	n/a					
30	Current Threshold level	CurrTh	50 A	Unit Max. A	10 A		
31	I-Max Low level (reduced)	Imaxlow	50 A	Unit Max. A	10 A		
32	I Threshold Time (0=disabled)	IthTime	0 Sec	60 Sec	1 Sec		

13 SERIES CONTROLLERS - Parameters & Instructions

13.1 Series Traction: Menu 1 "Adjustments"

Cal Ref	Parameter	Calibrator text	Min. adjust	Max. adjust	Step size	DMC default	Actual setting
1	Acceleration delay	Accel	0.1 S	10.0 S	0.1 S	2.0 S	S
2	Deceleration delay	Decel	0.1 S	10.0 S	0.1 S	0.3 S	S
3	Creep speed	Creep	0 %	25 %	1 %	0 %	%
4	Maximum speed forward	SpdMaxF	0 %	100 %	1 %	100 %	%
5	Maximum speed reverse	SpdMaxR	0 %	100 %	1 %	100 %	%
6	Cutback speed 1 *	Sp1/Inch	0 %	100 %	1 %	100 %	%
	Inching speed *		0 %	100 %	1 %	0 %	%
7	Cutback speed 2 *	Sp2/Time	0 %	100 %	1 %	100 %	%
	Inching time *		0.1 S	10 S	0.1 S	2 S	S
8	Cutback speed 3	Sp3	0 %	100 %	1 %	100 %	%
9	Direction Regen Braking	Dbrake	10 A	Unit max.	10 A	Unit max./2	A
10	Neutral Regen Braking *	Nbrake	0 A (off)	Unit max.	10 A	Unit max./4	A
11	Foot brake Regen *	Fbrake	0 A (off)	Unit max.	10 A	Unit max./4	A
12	Direction Plugging *	Dplug	0 %	100 %	1 %	50 %	%
13	Neutral Plugging *	Nplug	0 % (off)	100 %	1 %	25 %	%
14	Footbrake Plugging	Fplug	0 % (off)	100 %	1 %	50 %	%
15	Belly switch maximum speed	BellySpd	50 %	100 %	1 %	100 %	%
16	Regen delay	RegDly	0 mS (off)	400 mS	10 mS	150 mS	mS
17	Max. Current	MaxCurr	10 A	Unit max	10 A	Unit max.	A
18	Battery Voltage	BattV	24 V	Unit max.	2 V	Unit max.	V
19	Power steer delay	PstrDly	0 S	50 S	0.1 S	5 S	S
20	Electric brake	EbrkDly	0.0 S	50.0 S	0.1 S	0.5 S	S
21	Accelerator minimum	AccMin	0 V	5.0 V	0.1 V	3.3 V	V
22	Accelerator maximum	AccMax	0 V	5.0 V	0.1 V	0.2 V	V
23	Aux minimum	AuxMin	0 V	5.0 V	0.1 V	0.2 V	V
24	Aux maximum	AuxMax	0 V	5.0 V	0.1 V	4.8 V	V
25	Wig-wag forward threshold	FwdTH	0 V	5.0 V	0.1 V	0.2 V	V
26	Wig-wag reverse threshold	RevTH	0 V	5.0 V	0.1 V	4.8 V	V
27	Vehicle max. Speed	VmaxSpd	0 Kph	100 Kph	1 Kph	12 Kph	Kph
28	BDI reset level	BDIreset	0 V	Bat. +25%	0.1 V	Cells*2.09V	V
29	BDI empty level	BDIempty	0 V	Bat. +25%	0.1 V	Cells*1.73V	V
30	BDI warning level	BDIwarn	0 %	90 %	1.0 %	20%	%
31	BDI cut out level	BDIcut	0 %	90 %	1.0 %	10%	%
32	BDI speed limit	BDIspeed	0 %	100 %	1.0 %	100 %	%
33	DM*² Acceleration (joystick)	Dmcut/Ac	0.1 S	10.0 S	0.1 S	0.5 S	S
	DM*² Cutback (3 wheeler)		0 %	100 %	1 %	10 %	%
34	DM*² Deceleration (joystick)	Dmrev/De	0.1 S	10.0 S	0.1 S	0.5 S	S
	DM*² Reverse (3 wheeler)		0 %	100 %	1 %	70%	%
35	DM*² Speed limit	Dmspeed	0 %	100 %	1.0 %	100 %	%
36	N/A						

- **Depending on controller type and configuration some settings will be not available (N/A).**
- *** Selectable multi-function.**
- ***² DM= Dual motor**

13.2 Series Pump & Dual Pump: Menu 1 "Adjustments"

Cal Ref	Parameter	Calibrator text	Controller type	Min. adjust	Max. adjust	Step size	DMC default	Actual setting
1	Acceleration delay	Accel	All	0.1 S	10.0 S	0.1 S	2.0 S	S
2	Deceleration delay	Decel	All	0.1 S	10.0 S	0.1 S	0.3 S	S
3	Creep speed	Creep	All	0 %	25 %	1 %	0 %	%
4	Speed 1 (Pot. Maximum)	Potmax1	All	0 %	100 %	1 %	0 %	%
5	Speed 2	Pspeed2	All	0 %	100 %	1 %	0 %	%
6	Speed 3	Pspeed3	All	0 %	100 %	1 %	0 %	%
7	Speed 4	Pspeed4	All	0 %	100 %	1 %	0 %	%
8	Speed 5	Pspeed5	SinglePump	0 %	100 %	1 %	0 %	%
	Power steer base speed	Psteer5	Dual Pump	0 %	100 %	1 %	20 %	%
9	Speed 6 (Power steer)	Psteer6	SinglePump	0 %	100 %	1 %	0 %	%
	Power steer max speed		Dual Pump	0 %	100 %	1 %	60 %	%
10	Compensation speed 1 *	Pcomp 1	All	0 (off)	100 %	1 %	0 %	%
11	Compensation speed 2 *	Pcomp 2	All	0 (off)	100 %	1 %	0 %	%
12	Compensation speed 3 *	Pcomp 3	All	0 (off)	100 %	1 %	0 %	%
13	Priority/additive speed 4 *	Padd 4	All	0 (Priority)	1(additive)	1	0	
14	Priority/additive speed 5 *	Padd 5	SinglePump	0 (Priority)	1(additive)	1	0	
	N/A	n/a	Dual Pump					
15	Compensation speed 6 *	Pcomp 6	All	0 (off)	100 %	1 %	0 %	%
16	Accel./ deceleration Spd 6	Paccel 6	All	0.1 S	10.0 S	0.1 S	0.3 S	S
17	Max. Current	MaxCurr	SinglePump	10 A	Unit max	10 A	Unit max.	A
	Main Pump Max. Current		Dual Pump	10 A	Unit max	10 A	Unit max.	A
18	Battery Voltage	BattV	All	24 V	Unit max.	2 V	Unit max.	V
19	Powersteerdelay (speed6)	PStrDly	All	0.1 S	50.0 S	0.1 S	10.0 S	S
20	Electric brake delay	EBrkDly	All	0.1 S	50.0 S	0.1 S	10.0 S	S
21	Accelerator minimum	AccMin	All	0 V	5.0 V	0.1 V	3.3 V	V
22	Accelerator maximum	AccMax	All	0 V	5.0 V	0.1 V	0.2 V	V
23	Aux minimum	AuxMin	All	0 V	5.0 V	0.1 V	0.2 V	V
24	Aux maximum	AuxMax	All	0 V	5.0 V	0.1 V	4.8 V	V
25	Steer pot min.	StrMin	All	0 V	5.0 V	0.1 V	0.2 V	V
26	Steer pot max.	StrMax	All	0 V	5.0 V	0.1 V	4.8 V	V
27	N/A		All					
28	BDI reset level	BDIreset	All	1.90 V	2.20 V	0.01V	2.09 V	V
29	BDI Empty level	BDIempty	All	1.50 V	1.90 V	0.01V	1.73 V	V
30	BDI Warning level	BDIwarn	All	0 %	100 %	1 %	20 %	%
31	BDI Cut-out level	BDIcut	All	0 %	100 %	1 %	10 %	%
32	N/A	n/a	All					
33	N/A	n/a	SinglePump					
	Sec. Pump Max. Current	MaxCurr2	Dual Pump	0 A	Unit max	1 A	Unit max.	A
34	N/A	n/a	SinglePump					
	Sec. Pumppot.Max. Speed	Pot2max	Dual Pump	0 %	100 %	1 %	100 %	
35	N/A	n/a						
36	N/A	n/a						

- **The pump inhibit input does not disable power steer**
- **Depending on controller type and configuration some settings will be not available (N/A).**
- *** Selectable multi-function.**

13.3 Series: Menu 2 "Status"

The status menu shows various parameters from the controller which can be useful to help tune and optimise vehicle performance.

Cal Ref	Item	Calibrator text	Dir. Polar	Controller type	Step size	Service log info & Notes
1	Drive hours counter	Drive		Series	0.1 Hrs	+ shows key hours
2	Fault log (15F and above only)	Fault		Series	Last fault	+ shows key hours of the fault
3	Battery Discharge Indicator	BDI		Series	1 %	
4	Vehicle Speed	Vehicle		Series	1 Kph	
5	Battery Voltage	Battery		Series	0.5 V	+ shows highest voltage
6	Controller Temperature	Control+	+/-	Series	1 °C	- + min & max temperatures
7	Motor Temperature	Steer/M+	+/-	Series	1 %°C	- + min & max temperatures
	Steer position			Series	1 %	
8	Accelerator demand	Accel		Series	1 %	+ shows auxiliary i/p (footbrake)
9	Motor demand	Demand	+/-	Series	1 %on	**Extra controller status info: See next tabel "Status"**
10	Motor %on	Motor	+/-	Series	1 %on	**Controller limit indication: See next tabel "Limit"**
11	Motor voltage	Pluglev		Series	0.5 V	
12	Motor Current	Motor +	+/-	Series	10 A	+ = Drive current / - = Brake current
13	Plugging level	Pluglev		Series		
	Secondary pump demand	SPDem		Dual Pump	1 %on	As 9
14	Motor speed RPM	Speed		Series	RPM	
	Secondary pump motor %on	SPMot		Dual Pump	1 %on	As 10
15	Secondary pump motor voltage	SPMot		Dual Pump	0.5 V	
16	Secondary pump motor current	SPMot		Dual Pump	1 A	
17	Capacitor Voltage	Cap		Series	0.5 V	
18	N/A					
19	M2	M2		Series	0.5 V	Digital (0/1) or analog values 0-125V
20	N/A					
21-24	Debug (DMC internal use only)	Dbug				
	Service and fault log reset			**Series**	**press + and – together to reset service log (only possible when controller in neutral)**	

Status	Description		Limit	Description for Traction limits	Description Pump limits
N	Neutral, no pulsing		SM	Speed max Fwd or Rev	Pot max speed
FD	Forward drive		S1	Speed 1	n/a
FL	Forward drive left		S2	Speed 2	Pump speed 2
FR	Forward drive right		S3	Speed 3 (or hand brake)	Pump speed 3
RD	Reverse drive		S4	n/a	Pump speed 4
RL	Reverse drive left		S5	n/a	Pump speed 5
RR	Reverse drive right		S6	n/a	Pump speed 6
DB	Direction regen braking		Si	Inching	Pump inhibit
NB	Neutral regen braking		SB	BDI speed limit	n/a
FB	Foot brake regen		SD	Dual motor speed limit	n/a
DP	Direction plugging (series only)		CL	Current limit	Current limit
NP	Neutral plugging (series only)		BL	Brake current limit	n/a
FP	Foot brake plugging (series only)		CT	Controller temperature	Controller temperature
AB	Anti-roll off		MT	Motor temperature	Motor temperature
SB	Standby				
Fxx	Fault codes				

13.4 Series: Menu 3 "Controller Setup"

Change these settings to select the required options and I/O.

Cal Ref	Parameter	Calibrator text	Options (defaults are in bold)	Range	Actual setting
1	Accel. Characteristic	Lin/Curv	0= Acc & Aux both Linear **1= Acc Curve1 & Aux linear** 2= Acc Curve2 & Aux Linear 3= Acc Linear & Aux Curve1 4= Acc Curve1 & Aux Curve1 5= Acc Curve2 & Aux Curve1 6= Acc Linear & Aux Curve2 7= Acc Curve1 & Aux Curve2 8= Acc Curve2 & Aux Curve2	0 – 8	
3	Brake level proportional	Bpro/Off	0=**Proportional**, **1=**Fixed (EPS: Fixed only)	0 – 1	
	P-Steer I/P (Pump spd 6)	Sp6Lo/Hi	**0=Active Low,** 1=Active High	0 – 1	
4	Anti-roll off	Arol/Off	**0=**Anti Roll Off**,** 1=**Coast**Anti Roll Off	0 – 1	
	Pump Inhibit I/P (Pump)	HibLo/Hi	**0=Active Low ,**1=Active High	0 – 1	
5	I/O Pin 5 and 6 *	Spd/Inch	**0=Speed 1+2** , 1=Inching Fwd/Rev	0 – 1	
	Pump Power up (Pump)	NChk/Chk	**0=No Check,** 1= Chk sws at powerup	0 – 1	
6	I/O Pin 7	Spd3/Hbk	0=Speed3, **1=Handbrake** (If handbrake selected, set the required max. speed at Speed 3	0 – 1	
	Pot.& switch (Pump spd1)	NoSw/Sw	0=No Pot. switch **1=Pot & switch**	0 – 1	
7	Power steer trigger	PsF/FR/S	**0=FS1**, 1=Fwd/Rev, 2= Seat switch	0 – 2	
8	Truck type select *	Ride/Wlk	**0=Ride-on,** 1=Walkie	0 – 1	
9	Tiller switch function	TillFunc	**0=Normal**, 1=immediate brake	0 – 1	
10	Display fault indication	Of/M/M&W	0=None, 1=Main faults, **2=Main & Warning faults**	0 – 2	
11	Display Status field	Of/D/V/K	**0=None**, 1=Acc, 2=Motor V/RPM, 3=Speed in Kph, 4=Steering	0 – 4	
12	Belly switch response function *3	BellyRes	**0=normal**, 1=fast.	0 – 1	
13	Motor temp. sensor type	MTempTyp	0=KTY81-220	0 – 255	
14	Analogue I/P select *	Accel 8/9	0=Pin8 Accel Pot - Pin9 Aux Pot **1=Pin8 Aux Pot - Pin9 Accel Pot** 2=Pin9 wig-wag	0 – 2	
15	Single/Dual motor select*	Si/DL/DR	See below table for explanation	0 – 4	

		Aux AD i/p Pin A8 or A9	Steer / motor AD i/p Pin C4	Digital i/p Pin A5	Digital i/p Pin A6	FS1 required
0	**Single motor**	Footbrake	Motor temp.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
1	Dual motor pot. Left	Footbrake	Steer pot.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
2	Dual motor pot. Right	Footbrake	Steer pot.	Speed 1 /Inch Fwd	Speed 2 /Inch Rev	Yes
3	Dual motor joystick left	Joystick pot.	Motor Temp.	Steer switch left	Steer switch right	No
4	Dual motor joystick right	Joystick pot.	Motor Temp.	Steer switch left	Steer switch right	No

16	I/O C3 driver select: Electric brake / Field weakening / Balance contactor	EB/FW/BC	**0=Electric Brake**, 1=Field Weakening, 2=Balance Contactor (Series only)	0 – 2	
17	CAN node number	CAN node	**0=node 0 (0=master)**, 1=node 1, ……15=node 15	0 - 15	
18	Shared Line Contactor *2	ShareLC	**0=No Line contactor sharing** 1=Line contactor shared	0 - 1	
19	Last Sharing Node	LstNode	Enter the highest node number that shares the same line contactor.	1 - 15	

- *** Reset to make changes active. Recycle the key switch (Also indicated on calibrator 'key')**
- ***2 Not in combination with Standby delay**
- ***3 Overrides NBrake to 0 % and RegenDelay 0 ms and uses plugging only**
- **Irrelevant options show n/a**

13.5 Series: Menu 4 "Motor Setup"

Cal Ref	Parameter	Calibrator text	Min.	Max.	Step size	DMC default	Actual setting
1	Motor Temp. Cutback start	TempStrt	1	151(disables)	1	151	
2	Motor / Vehicle -speed ratio	SpdRatio	1.0	999.9	0.1	1.0	
3	Number of teeth *	SpdTeeth	0	255	1	0	
4	Direction Plugging start level	DPlugSta	0 %	100 %	1 %	71 %	
5	Direction Plugging end level	DPlugEnd	0 %	100 %	1 %	71 %	
6	Neutral Plugging start level	NPlugSta	0 %	100 %	1 %	71 %	
7	Neutral Plugging end level	NPlugEnd	0 %	100 %	1 %	71 %	
8	Neutral Plug %on (at start)	NPlug%on	1 %	20 %	1 %	10 %	
9	Reverse plug. Compensation	RPlugCmp	0 %	200 %	1 %	100 %	
10	Regen start level	RegenSta	10 A	100 A	5 A	50 A	
11	Field weakening pull in	FWeakin	0 A	Unit max A	10 A		
12	Field weakening drop out	Fweakout	0 A	Unit max A	10 A		
//	*Cal.Ref. 13 up to 31 are N/A*	n/a					
29	Regen step PWM	RegStep	1 bit	10 bit	1 bit	3 bit	
30	TCL Current Treshold	CurrTH	50 A	Unit max	10 A	Unit max	A
31	TCL I-Max low	ImaxLow	50 A	Unit max	10 A	Unit max	A
32	TCL I threshold time	IthTime	0 s	60 s	1 s	5 s	s

14 EPS (Electronic Power Steer assist): Menu 1 "Adjustments"

Cal Ref	Parameter	Calibrator text	Min. adjust	Max. adjust	Step size	DMC default	Actual setting
1	Acceleration delay	Accel	25 ms	1000 ms	25 ms	100 ms	Ms
2	Deceleration delay	Decel	25 ms	1000 ms	25 ms	100 ms	Ms
3	N/A						
4	Maximum speed forward	SpdMaxF	0 %	100 %	1 %	100 %	%
5	Maximum speed reverse	SpdMaxR	0 %	100 %	1 %	100 %	%
6	Forward Threshold	FwdTH	0.0V	5.0V	0.1V	3.5V	V
7	Reverse Threshold	RevTH	0.0V	5.0V	0.1V	1.5V	V
8	Cutback speed 3	Sp3	100 %	100 %	0 %	100 %	%
9	Direction Regen Braking	DBrake	5 A	Unit max.	5 A	35 A	A
10	Neutral Regen Braking *	Nbrake	5 A	Unit max.	5 A	35 A	A
11	Foot brake Regen *	Fbrake	0 A (off)	Unit max.	10 A	Unit max./4	A
12	Direction brake ramp time	DbrkRamp	25 ms	1000 ms	25 ms	100 ms	Ms
13	Direction brake-End delay	DbrkEnd	0.1 S	10 S	0.1 S	0.1 S	S
14	Neutral brake ramp time	NbrkRamp	0.1 S	10 S	0.1 S	2.0 S	S
15	Neutral brake-End delay	NbrkEnde	0.1 S	10 S	0.1 S	0.1 S	S
16	N/A						
17	Max. Current	MaxCurr	5 A	Unit max	5 A	50 A	A
18	Battery Voltage	BattV	24 V	Unit max.	2 V	Unit max.	V
19	Power steer delay	PstrDly	0.1 S	10.0 S	0.1 S	5.0 S	S
20	Current threshold	CurrentTH	5 A	Unit max	5 A	30 A	A
21-24	N/A						
25	Steerpot min.	MotMin	0 V	5.0 V	0.1 V	0.2 V	V
26	Steerpot max.	MotMax	0 V	5.0 V	0.1 V	4.8 V	V
27-36	N/A						

- **Depending on controller type and configuration some settings will be not available (N/A).**
- *** Selectable multi-function.**
- ***² DM= Dual motor**

15 GENERAL MENU'S – Apply to all controllers

15.1 Fault Log

The fault log remembers the last occurred fault and stores the key hours when the fault happened. To reset the fault- and service log press the + and – button at the same time when the controller is in neutral. (See also the status menu)

15.2 Test Menu 5 "Test"

The test menu shows I/O information, useful for fault finding.

CalRef	Pin number	Displayed for standard traction controllers	I/O	Displayed for standard pump controllers	I/O	Min. Display	Max. Display
1	Pin A1	Forward	Input	Pump Pot. switch 1	Input	0	1
2	Pin A2	Reverse	Input	Pump switch 2	Input	0	1
3	Pin A3	FS1 / Belly	Input	Pump switch 3	Input	0	1
4	Pin A4	Seat / Tiller	Input	Pump switch 4	Input	0	1
5	Pin A5	Speed1 / Inch Fwd / Steer Lft	Input	Pump switch 5	Input	0	1
6	Pin A6	Speed2 / Inch Rev / Steer Rgt	Input	Pump switch 6	Input	0	1
7	Pin A7	Speed3 / Handbrake	Input	Pump inhibit	Input	0	1
8	Pin A8 or A9	Footbrake switch	Input	N/a		0	1
9	Pin A8 or A9	Accelerator potentiometer	% Input	Pump pot.	% Input	0 %	100 %
10	Pin A8 or A9	Accelerator potentiometer	Voltage	Pump pot.	Voltage	0 V	5.1 V
11	Pin A9 or A8	Aux. potentiometer	% Input	Aux. pot.	% Input	0 %	100 %
12	Pin A9 or A8	Aux. potentiometer	Voltage	Aux. pot.	Voltage	0 V	5.1 V
13	Pin C4	Steer pot.	% Input	Aux. pot.	% Input	0 %	100 %
14	Pin C4	Steer pot.	Voltage	Aux. pot.	Voltage	0 V	5.1 V
15	Pin A12	Line contactor	Output	Line contactor	Output	0	1
		Forward contactor (Series)	Output				
16	Pin A13	Electric brake	Output	Power steer contactor	Output	0	1
		Reverse contactor (Series)	Output				
17	Pin A14	Power steer contactor	Output	LED driver (*)(*²)	Output	0	1
		Regen contactor (Series)	Output				
18	Pin C1	Speed encoder	Input	Speed encoder	Input	0	1
19	Pin C2	Direction encoder (AC)	Input	N/a		0	1
		Red remote LED (*²)	Output				
		Power steer (*²)(Series)	Output				
		Position clock (PMS)	Output				
20	Pin C3	Position data (PMS)	Input	N/a		0	1
		Remote LED (AC)	Output				
		Electric brake (*²)(Series)	Output				
		Field weakening (*²)(*³) Series	Output				
		Balance contactor (*²)(*³) Series	Output				
21	N/A	Red Led	Output	Red Led	Output		
22	N/A	Green Led	Output	Green Led	Output		
23	N/A	Contactor driver feedback	Input	Contactor driver feedback	Input		
24	N/A	+ 12V	Input	+ 12V	Input		

- **As with the adjustments, only relevant tests will be shown determined by configuration.**
- **(*) On controller models Pxx000TS and Pxx000PS (small) this is a digital output only.**
- **(*²) Use the optional driver module to amplify this signal if required.**
- **(*³) Activate in the setup menu (calibrator reference 3.16)**

15.3 About Menu 6 "About"

Cal Ref	Information Field	Example	
1	Customer name	Cust	Standard
2	Application	App	Standard
3	Motor type	Motor	SEM
4	Controller type	Type	PSE865TL01
5	Hardware Voltage and current	HW	80V 650A 65A
6	Software version	SW	3.01.00 190805

15.4 Calibration Menu 7 "Calibration"

The calibration menu is used to calibrate the hardware during manufacturing.
These are factory settings and should not be touched.
Changing these settings can have dangerous effects, cause accidents or damage the controller and warranty will be void.

Cal Ref	Parameter	Calibrator text AC	Calibrator text SEM & PM	Calibrator text Series	Min.	Max.	Step size	Actual setting
1	Load Defaults	LoadDefs	n/a	n/a	0	1	1	
2	Offset 1	OsetM1	Oset1R +	n/a	-20	+20	1	XXXXXX
3	Offset 2	OsetM2	Oset2A +	Oset2A	-20	+20	1	XXXXXX
4	Offset 3	OsetM3	Oset3F +	n/a	-20	+20	1	XXXXXX
5	Gain 1	GainM1	Gain1R	n/a	85 %	115 %	1 %	XXXXXX
6	Gain 2	GainM2	Gain2A	Gain2A	85 %	115 %	1 %	XXXXXX
7	Gain 3	GainM3	Gain3F	n/a	85 %	115 %	1 %	XXXXXX

- Load defaults: minimal "Dealer Calibrator" or authorization level 3
- Offset & Gain: only available with "Super Calibrator".

16 DIAGNOSTICS

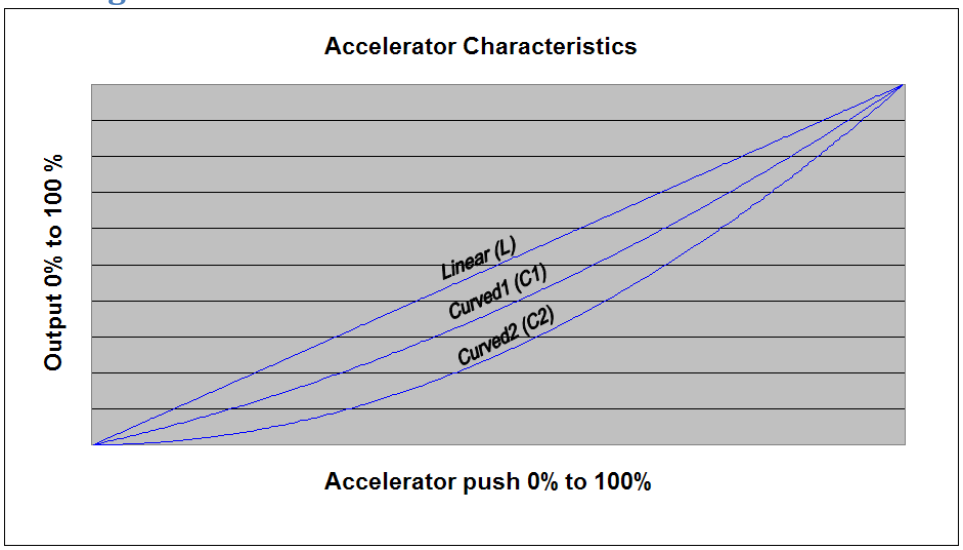
	Calibrator Message	Display	Led	Description	Action needed if faulty
			W a r n i n g F a u l t s		
0	None (lowest priority)	OK	On (*)	Controller operational and OK	No action required
1	Handbrake on	P	On	Handbrake switch closed	Release handbrake
2	Voltage getting low		2F	Battery voltage getting low (normally during driving)	Reduce drive levels
3	Pump inhibit		3F	Pump inhibit active	Check switch input
4	Voltage getting high	OK	4F	Battery voltage getting too high (normally during braking)	Reduce braking levels or vehicle Speed
5	Motor hot	°C	5F	Thermal cutback, allow the motor to cool down	Use vehicle within it's specifications
5	Motor brush wear		5F	Motor brushes ware out.	Replace the brushes
6	Controller hot	°C	6F	Thermal cutback, allow the controller to cool down	Check heat sinking and specifications
7	Adjustments out of range	R	7F	One or more adjustments are out of range (see status 2.22 dbug2, for adjustment nr.)	Check all adjustments, look for errors
8	Default settings restored	F	8F	Default settings restored	Check adjustments for correct values

The diagnostics continue on the next page…

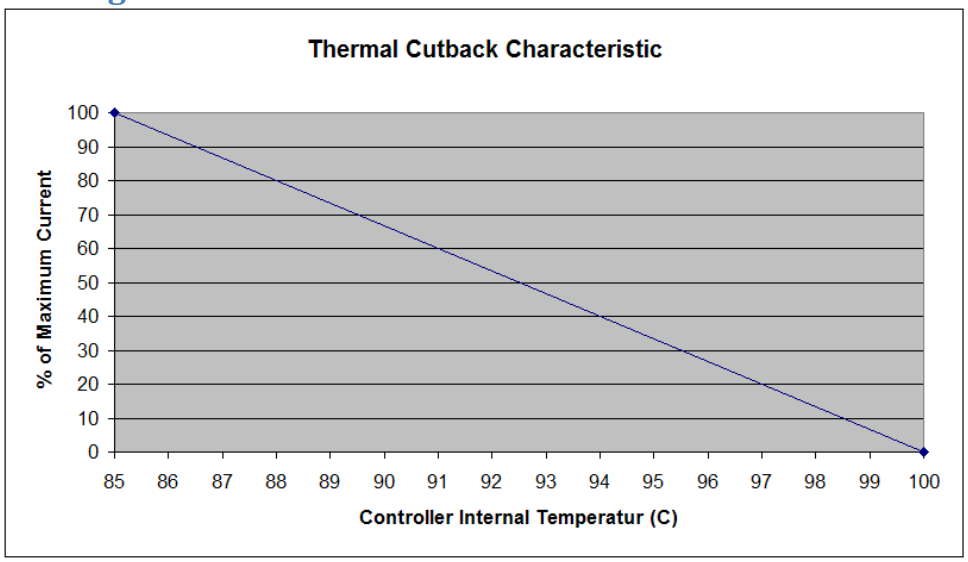
	Calibrator Message	Display	Led	Description	Action needed if faulty
				M a i n F a u l t s (Recycle to neutral)	
9	E-eprom cannot be accessed		9F	E-eprom not accessible	Internal supply voltage below12 volt. Call DMC if this problem occurs
10	2 Direction fault		10F	Both forward and reverse selected. Recycle both directions and FS1.	Check direction switch and wiring.
11	Seat- or tiller switch open		11F	Seat- or tiller switch not closed or timed out	If faulty, check wiring or timer
12	Sequence fault		12F	Forward / reverse or FS1 closed at key on. (EPS: Steering wheel outside dead band)	First key on, then close switches. (EPS: Adjust)
13	Accelerator high at first power up		13F	Accelerator voltage > 50% at key on. (EPS: Steering wheel outside dead band)	Check controller settings and accelerator mechanics. (EPS: Adjust)
14	Inching or belly fault		14F	Forbidden input selected with inching (FS1/Seat/Handbrake) or belly switch timeout	Open switches / check wiring
15	Voltage too low		15F	Internal 12V supply low.	Check battery capacity / charge level / controller voltage rating / settings
17	Voltage too low		17F	Battery voltage too low	Check battery capacity / charge level / controller voltage rating / settings
18	High sided Mosfet short circuit		18F	High sided Mosfet short circuit	Check motor insulation and line contactor, if OK replace controller
19	Low sided Mosfet short circuit (drive)		19F	Low sided Mosfet short circuit in drive	Check motor insulation, if OK replace controller
20	Hardware over current (DC)		20F	Hardware over current circuit active	Check adjustments and motor setup
				H a r d F a u l t s (Recycle key-switch)	
20	Hardware over current (AC)		20F	Hardware over current circuit active	Check adjustments and motor setup
21	Contactor coil short circuit		21F	Contactor coil S/C or driver or wiring open circuit	Check contactor coils and wiring
22	Voltage too high		22F	Battery voltage too high (normally during braking)	Reduce braking levels or vehicle Speed
23	Low sided Mosfet short circuit (neutral)		23F	Low sided Mosfet short circuit in neutral	Check motor insulation and line or regen contactor, if OK replace controller
24	HWFS not working		24F	Hardware failsafe cannot disable hardware	Check wiring / replace controller
25	Contactor fault		25F	Contactor open- or short circuit	Check all contactors for open- and short-circuit
26	Current measurement fault		26F	Current measurement system faulty.	Replace controller
27	Low side Mosfet short circuit		27F	Low sided Mosfet short circuit before line contactor closed	Check motor insulation and line contactor, if OK replace controller
28	Wire off detected		28F	Wire off detected or potentiometer value out of range **(WigWag Pot only)**	Check wiring and potentiometer or set the correct potentiometer settings
29	CAN Node time out		29F	CAN Wiring broken or one of the slave controllers didn't power up	Check CAN wiring, check slave controller, check setting 19 (controller setup)
30	Over speed		30F	Over speed or wrong encoder teeth setting	Max speed setting must be lower as motor max speed (motor setup), or check encoder teeth setting.
31	Sensor Wire off fault		31F	One or more motor sensor wires not connected **(PMS only)**	Check and repair the wiring
32	Sensor Mechanical fault		32F	The motor speed sensor mechanically lose **(PMS only)**	Re-mount and then adjust the sensor to the motor
33	Incorrect polarity		33F	@ demand 0 drive current > 50A. In Braking the current must be negative **(PMS only)**	PMS: lower setting 4.18 ULV/1000, or motor demagnetized

17 Graphics & Schematics

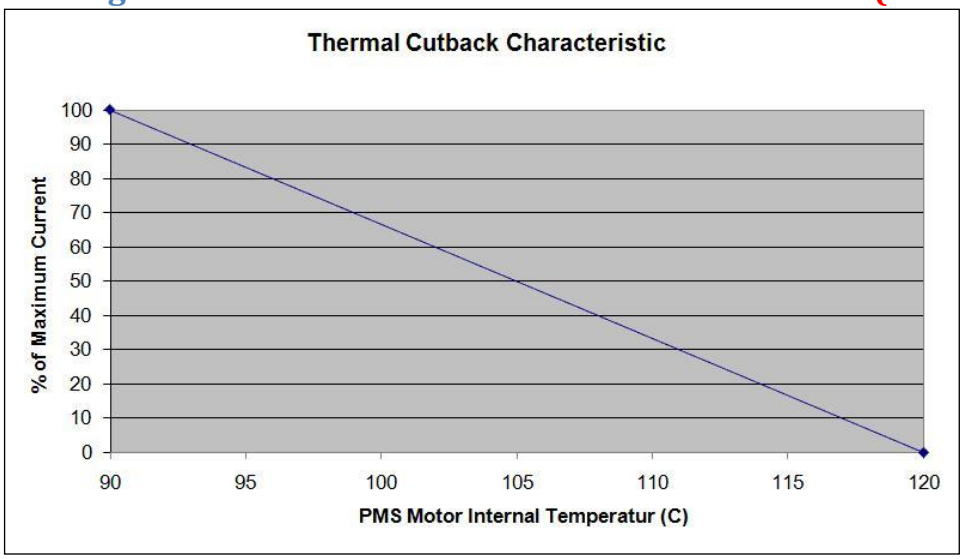
17.1 Figure 1 Accelerator Characteristics



17.2 Figure 2 Controller Thermal Cutback Characteristic



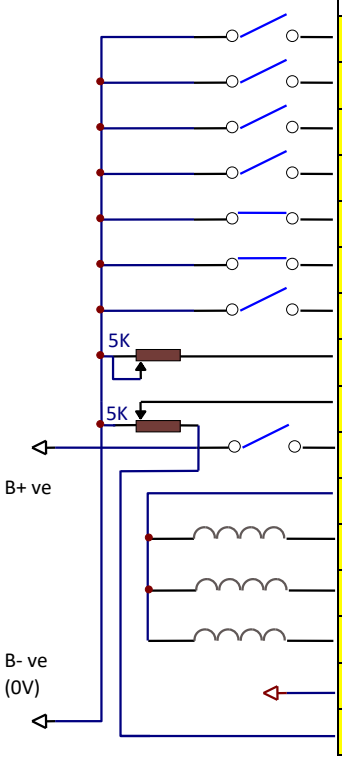
17.3 Figure 3 Motor Thermal Cutback Characteristic (PMS only)

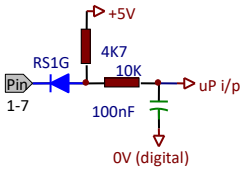
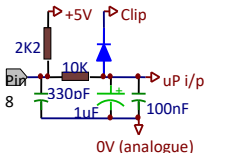
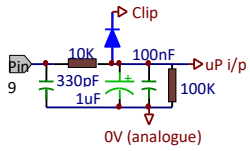
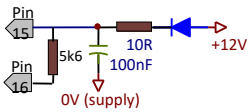


*** The cutback start temp. is set to 90˚C as standard.**
At Cutback start temperature +30˚C the power is reduced to zero.

Figure 4 Light Wiring (all variants)

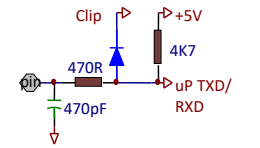
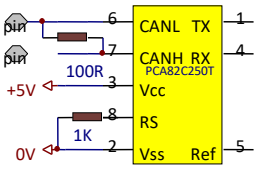
Connector A - Vehicle Interface - 16 Way (Molex SMD Micro Fit 3.0 Series)



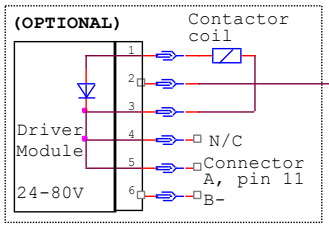
Pin No.	Traction Function	Pump Function	Notes	Controllers typical internal circuit.
1	Fwd Sw. i/p	P.Pot Sw.1	Active Low, low impedance digital i/p's. 0V = active, n/c = inactive. Max V range - 0 – 127V.	
2	Rev Sw. i/p	Pump Sw.2		
3	FS1 / Belly Sw. i/p	Pump Sw.3		
4	Seat / Tiller Sw. i/p	Pump Sw.4		
5*	Spd1 / Inch Fwd / Str left	Pump Sw.5 DP: Pwr St Sw 5		
6*	Spd2 / Inch Rev / Str right	Pwr Steer trigger DP: Pwr St Sw 6		
7*	Speed 3 / Handbrk Sw. i/p	Pump Inhibit		
8	F.Brake Pot/Sw AD i/p	Acc. i/p DP: Main Pump	3,5-0V (0-5V max)	
9	Accelerator Pot. AD i/p /or Joystick	Acc. i/p DP: Sec. Pump	0-5V	
10	Key Sw i/p	As Traction	Max 0 - 127V.	
11	Cont. Coil supply o/p	As Traction		
12	SE,AC,PM: Line Contactor SR: Forward Contactor	Line Contactor	3A Contactor Drivers. Protected & suppressed.	
13	SE,AC,PM: Electric Brake Cont. SR: Reverse Contactor	Powersteer Contactor		
14*2	SE,AC,PM: Power steer Cont. SR: Regen contactor	Remote LED		
15	+12V o/p	As Traction	Max 20mA.	
16	Supply for 5K pot (3 wire)	As Traction		

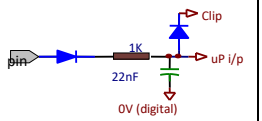
Connector B - Communications - 8 Way (Molex SMD Micro Fit 3.0 Series)

Connect to other CAN Node's if required (Maximum of 16 Node's)

PinNo	Traction Function	Pump Function	Notes	Controllers typical internal circuit.
1	RXD	As Traction	TTL level RS232	
2	TXD	As Traction	TTL level RS232	
3	+12V Flash Prog. i/p	As Traction	Select & program Flash memory.	
4	Monitor i/o line.	As Traction		
5	CAN L	As Traction	CAN Communications	
6	CAN H	As Traction		
7	+12V o/p	As Traction	Max 20mA.	
8	0V o/p	As Traction		

Connector C – Motor Feedback - 6 Way (Molex SMD Micro Fit 3.0 Series)

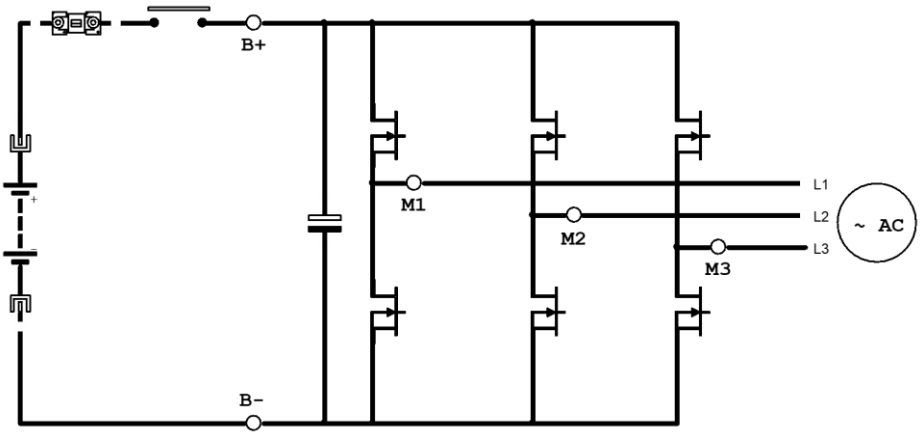


PinNo	Traction Function	Pump Function	Notes	Controllers typical internal circuit.
1	Speed encoder i/p	Speed enc. i/p	For all Controllers	
2	AC: Dir. encoder i/p SE,PM: Remote LED SR: Power steer cont. PMS: Pos. Data input	n/a	AC Motor SEM & PM4 Series	
3	AC: Remote LED PMS: Position clock o/p SR: Electric Brake, Field Weakening or Balance con	n/a		
4	Motor Temperature pot. or dual motor pot. or EPS steering pot.	As Traction		As AD i/p (pin 9)
5	+12V o/p	As Traction	Max 20mA.	As +12V o/p (pin 15)
6	0V o/p	As Traction		

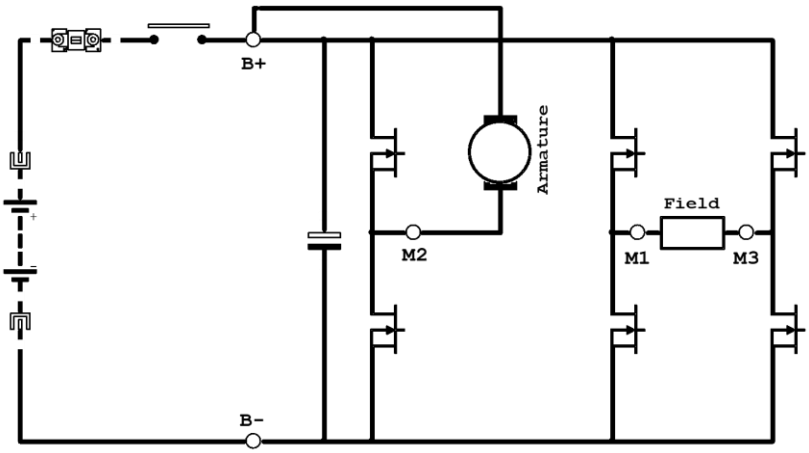
- **For pump controllers pump switch 6 and pump inhibit are standard active low. Via the setup menu it is possible to change to active high.**
- *** All inputs are Normally Open (NO). The speed inputs are Normally Closed (NC)**
- ***2 Driver 3 is not available on small controllers, use** DMC **driver module instead.**

17.3.1.1

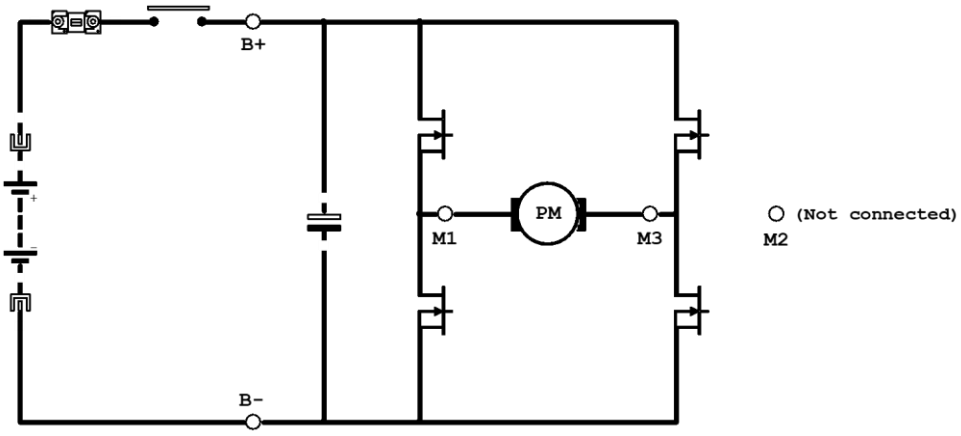
17.4 Figure 5 Power Wiring – AC & PMS



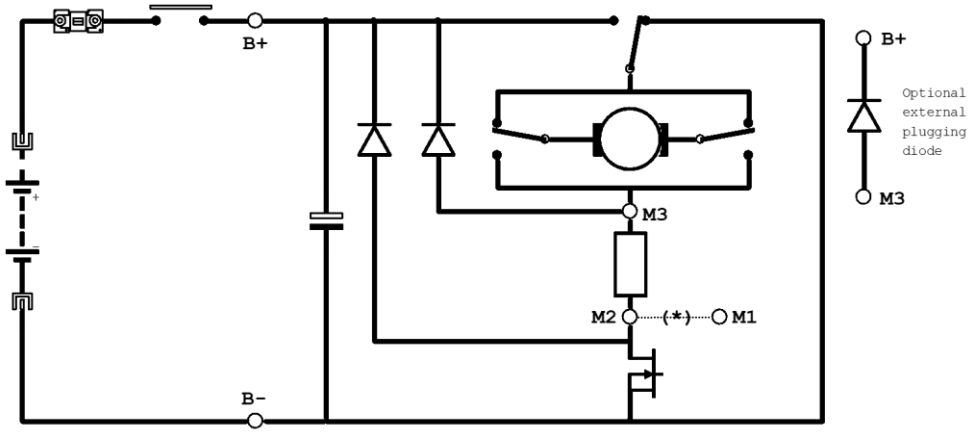
17.5 Figure 6 Power Wiring – SEM



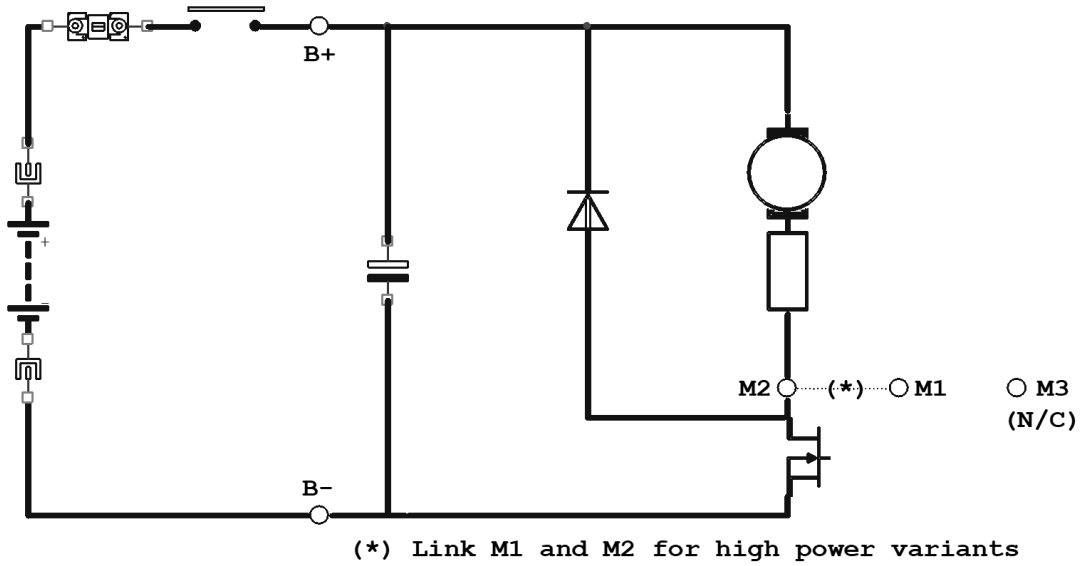
17.6 Figure 7 Power Wiring – PM4



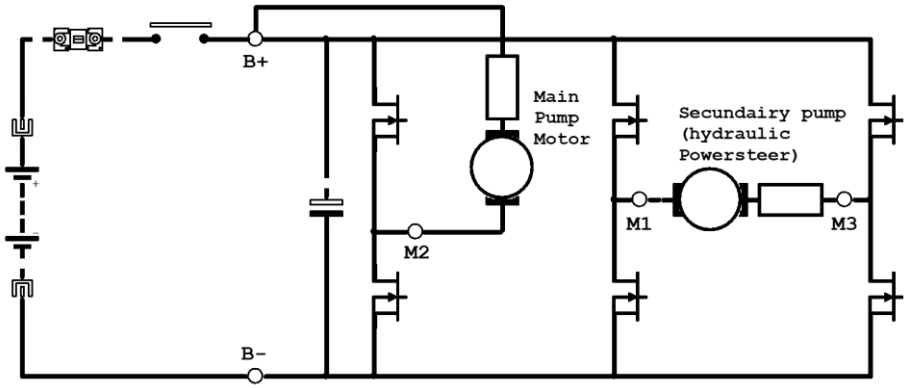
17.7 Figure 8 Power Wiring – Series



17.8 Figure 9 Power wiring Series Pump



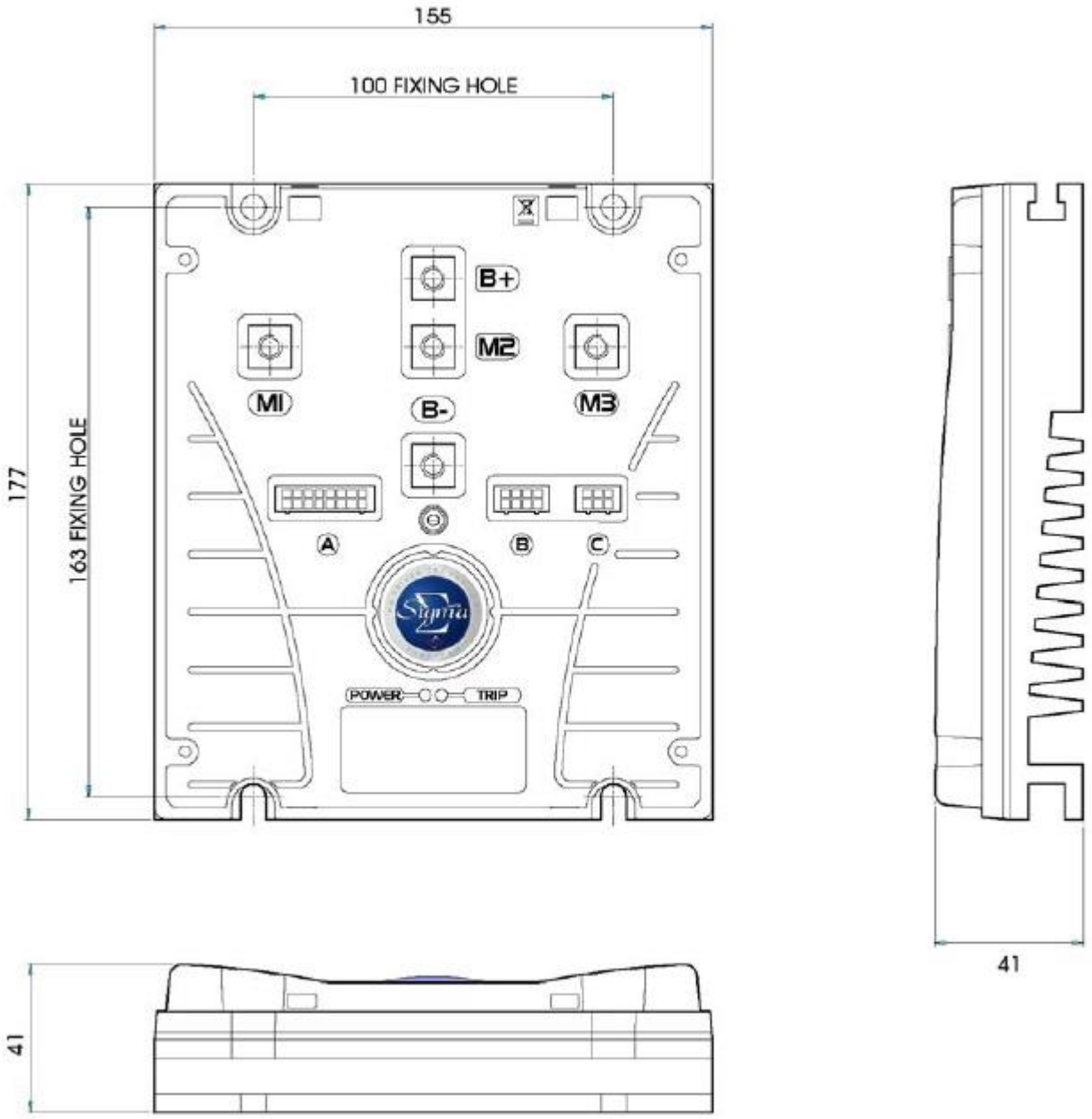
17.9 Figure 10 Power wiring Dual Pump



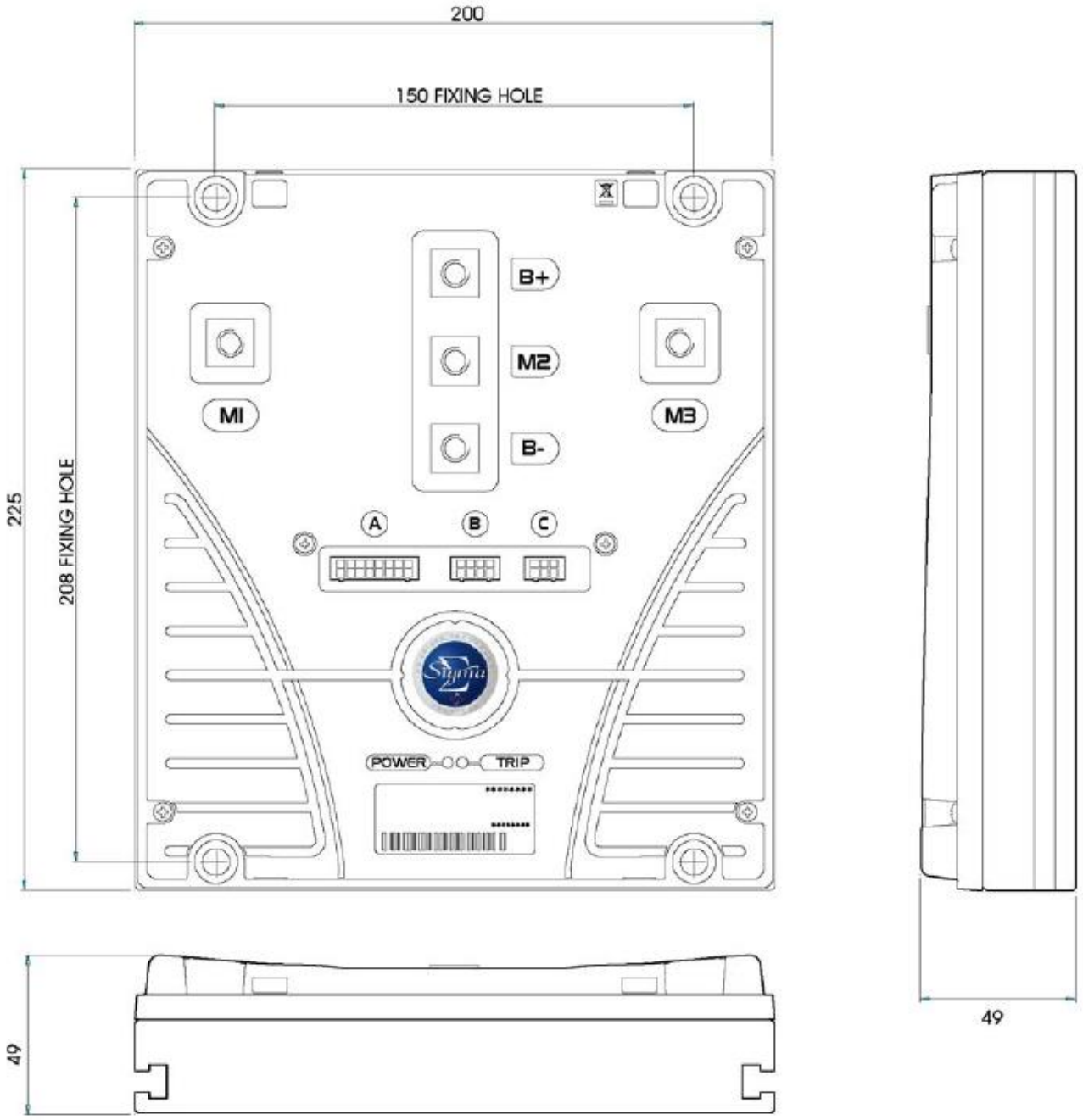
	**When an emergency battery disconnect switch is fitted, the key switch must be fed through an auxiliary switch to prevent over voltage damage due to disconnect during regen.**

18 Mechanical Drawings

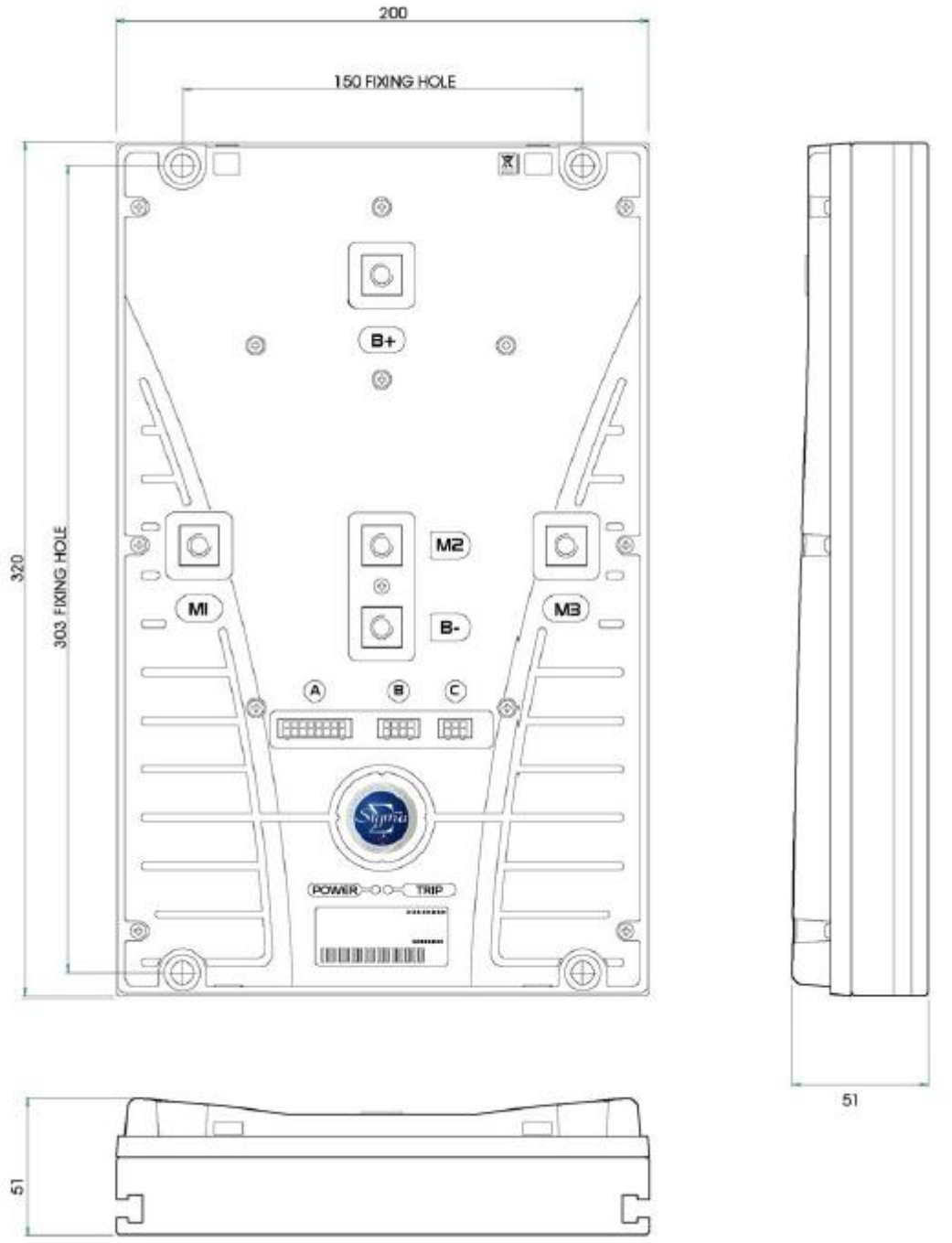
18.1 Sigmadrive Small



18.2 Sigmadrive Medium

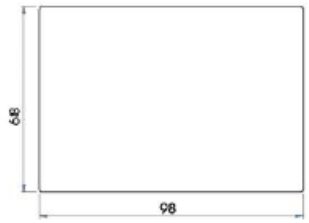


18.3 Sigmadrive Large



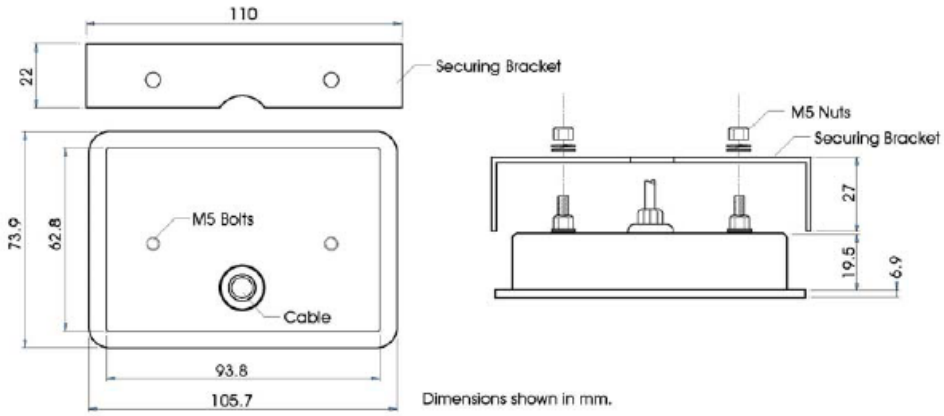
18.4 DMC Advanced Display

Mounting the Sigmagauge module requires a rectangle to be cut into the vehicle dashboard, allowing the module to rest on the surface of the dash.



Dimensions shown in mm.

Before cutting the hole, ensure that enough room is available within the dash for the area of the module and the Securing Bracket. Access to the back of the dash will be required to secure the Sigmagauge.



Dimensions shown in mm.

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