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ADVANCED USER MANUAL

SigmaLITE Pump Controller

for Alternate Current induction motors (AC)
surface-mounted Permanent Magnet Synchronous motors (PMS)
Interior-mounted Permanent Magnet synchronous motors (IPM)

Modification History:

Revision	Issue Date	Author	Changes
1.0	03/11/2023	SM	First development
1.1	14/05/2024	SM	Update schematics. Add information on minimum and maximum duty cycle for digital outputs when controller Via CAN in “duty cycle” mode.
1.2	25/06/2024	SM	Add BMS node number for EMCY reaction. Add note about GND connection on 23-pole. New IPM and PMS error codes. Add parameters for enable/disable short circuit detection on digital outputs.

Contents

1 About this manual

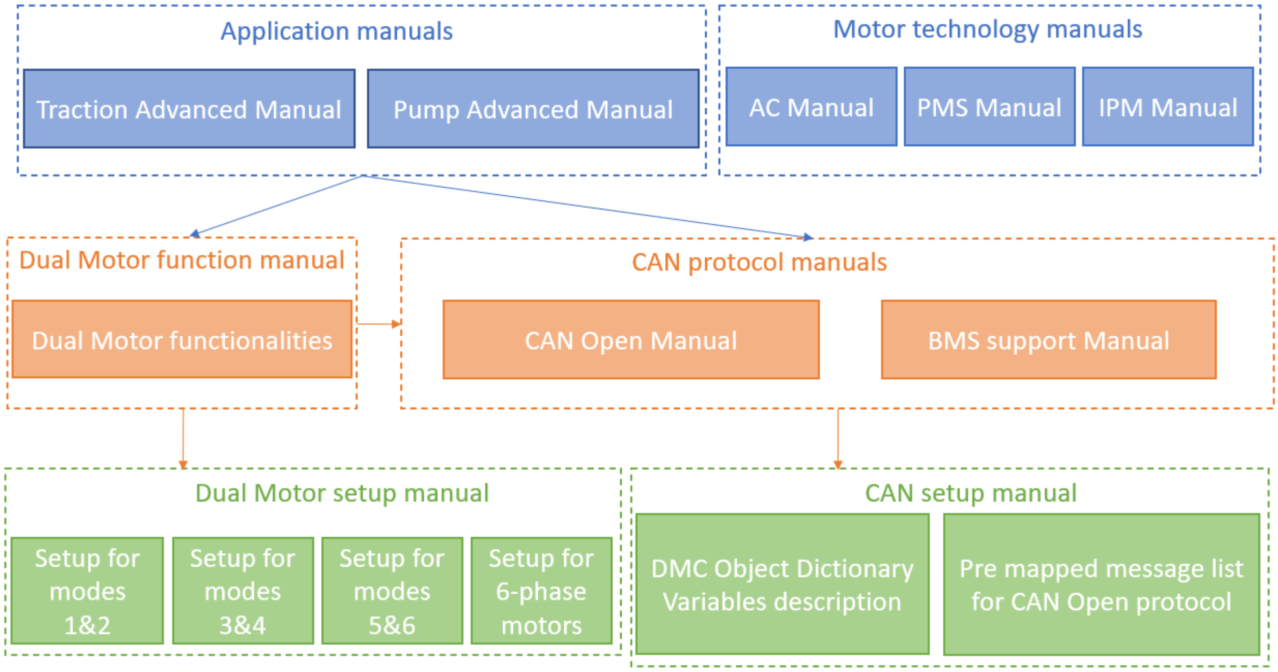
This manual can be used for a better understanding of controller's features, installation, settings and parameters. A detailed description of every parameter is reported. This manual is referred to software release V04.00.07 for AC, PMS and IPM motors pump applications.

1.1 References

[1] DMC Advanced CAN Open manual V1.6
[2] DMC Display manual V1.1
[3] DMC dual motor functionalities V1.4
[4] AC motor technology manual V1.4
[5] PMS motor technology manual V1.5
[6] IPM motor technology manual V1.5
[7] DMC Configurator user manual V1.1.5
[8] DMC BMS support V1.7
[9] DMC Object Dictionary Variables description V1.7

1.2 Navigate into DMC manuals

DMC manuals are structured with a hierarchical approach. The milestone for setting up a controller and the general overview is given in the "Application manuals", which embed a comprehensive description of the DMC SigmaLITE features, hardware configuration, parameters menu structure and monitoring possibilities. The "Motor technology" manuals should be used aside of the "Application manuals" to go further in details about configurable motor parameters and to run the autotuning procedure.
If the Dual Motor function is required, the user should refer to the "Dual Motor manual" for a deeper level of detail about the vehicle configuration capabilities. DMC also provides a basic sets of setup manuals for basic Dual Motor parameter configuration to be set in the two controller used for running this function.
In then the controller needs to operate in a CAN environment, the user should refer to the "CAN protocol" manual of interest, which will guide trough the CAN-related parameters and functions available.



1.3 How settings are numbered in this document

The settings (i.e. parameters) are labelled with the following format:

Mxx.yy-zz AAAAAAAAAAAA, "BBBBBBBBB"

Where:

- xx is the menu's number;
- yy is the sub-menu's number
- zz is the parameter's position in the menu;
- AAAAAAAAAAA is the parameter short description;
- BBBBBBBBBBBB is the text which appears on the DMC Calibrator's menu;

For example

M5.2-1 Motor temperature sensor type "MtempTyp"

- 5 is the calibrator menu number (in this case Menu 5 Limits Setup);
- 2 is the calibrator sub-menu number (in this case Sub-menu 2 Motor thermal limits)
- 1 is the setting number;
- "Motor temperature sensor type" is a short description of the parameter;
- "MtempTyp" is the text label appearing on the calibrator display;

1.4 How to correctly and time-efficiently setup a controller

This paragraph aims at briefly explaining the best procedure for a correct and time-efficient setup of a DMC SigmaLITE Controller .
The SigmaLITE has 9 parameter menus which can be set up. For a clear Controller tuning the following procedure should be adopted:

1) Enter "Menu 8.1 "Input/output assignment"" and assign the "Line Contactor" function to one of the available outputs. Setup a consistent pull-in and holding voltage for the line contactor coil in the corresponding Digital Output submenu. If an EMbrake is installed, do the same for the "EMbrake" function.
2) Enter the "Menu 5 "Limits Setup"" and set up the motor temperature, maximum and minimum voltage limitations.
3) Enter the "Menu 3 "Autotuning"" and set up the motor's basic set of parameters necessary to perform autotuning. Mind that the parameters "Maximum motor current" and "Maximum motor frequency" are very important, as they define the maximum current that will flow into the motor (and thus the maximum deliverable torque) and the maximum rotor speed, on which all the speed limits and ramps will be based. Those parameters are here reported without the associated number since it varies within different motor technologies. For more accurate information about those parameters and Autotuning procedure please refer to the motor technology manual of interest ([4] for AC, [5] for PMS and [6] for IPM).
4) Perform the autotuning.
5) Enter "Menu 8.1 "Input/output assignment"" again and assign to analogue and digital inputs the desired functional inputs. Do the same for digital outputs and functional outputs.
6) In case the DMC SigmaLITE Controller should operate in a CAN network, enter the "Menu 7 "CAN Bus Setup"" menu and setup all the CAN communication parameters. In case more complex CAN mapping is necessary, it is suggested to use the DMC Configurator PC tool to do so.
7) Connect the DMC SigmaLITE Controller on the CAN bus with other devices.
8) Enter the "Menu 2 "Controller Setup" for pump software" and setup the basic controller configuration. Parameters belonging to this menu modify the general controller's behavior.
9) Enter the "Menu 1 "Adjustment" for pump software" menu and setup all the necessary adjustments. It is very important to modify the settings in this menu only when the above steps have been completed, as several adjustments are available only when some combination of parameters in other menus are performed.
10) Finish setting up "Menu 5 "Limits Setup"" with auxiliary needed limitations

1.5 Warning and information notices

The reader of this document should pay special attention to any text contained in warning and information boxes which appears in this manual. The scope of the mentioned boxes are shown below, together with an example of their appearance.

WARNING!

A warning informs about possible dangerous installation methods and/or parameter's configurations which can lead to controller's damage and personal injuries.
DMC declines any responsibility about any hazardous or potential hazardous situations which may arise due to the not respect of these warnings.

NOTICE!

A notice informs about a specific condition in which a certain example applies and/or adds supplementary information about a topic, which is worth taking in consideration.

2 Product overview

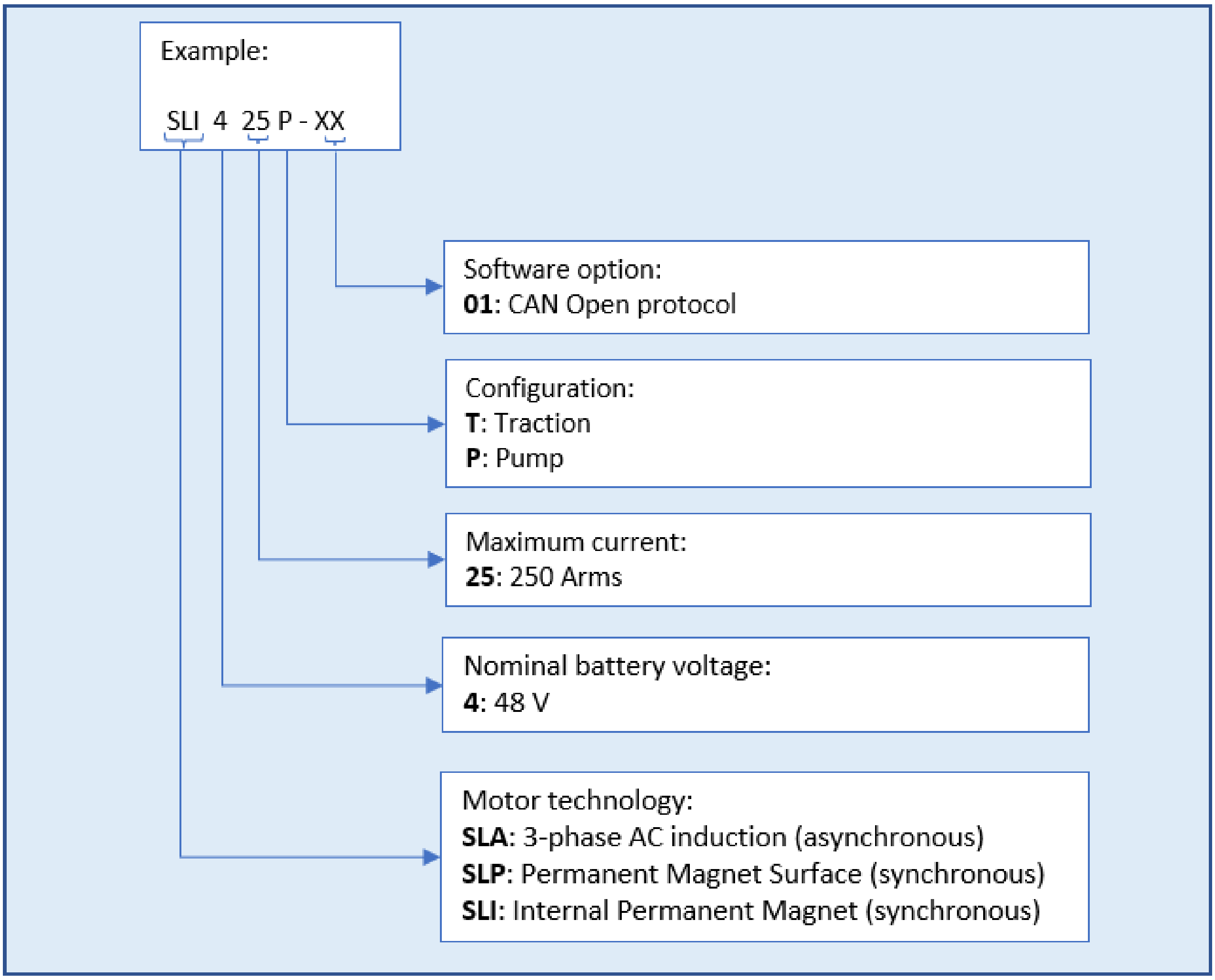
After the success of the SuperSigma2 Controller range, DMC has developed a new controller range, specially designed for small motors and cost effective applications with battery voltages in the range of 24V up to 48V, at nominal powers up to 6kW and peak powers up to 12kW.
The power board design includes latest mosfet technology, combining superior heat sinking of components and connections with unmatched vibration protection. The mechanical design is improved to IP67 and we incorporated the industry standard 23 way AMP-seal connector. The design is extremely compact to fulfil the market requirements in term of controller size.
The control logic PCB utilises state of the art 32bit microcontroller technology that enables us to offer features required for today's vehicle control. A completely new motor control module is introduced, using flux vector motor control for both AC induction and PMAC and IPM motor.
New Features on SigmaLITE are for example fully automated tuning of AC induction motors and PMS IPM without the need for manual fine tuning or using a PC. The advanced auto tuning algorithms allow motor tuning even if the motor is installed on the vehicle. Just entering the motor name plate data into the controller tuning menu is enough to obtain optimal tuning results. Even when the motor name plate data is unknown it is possible to get the system running smoothly!
On PMS and IPM we introduce automated motor sensor setup for sin/cos absolute position encoders and hall sensors, which significantly eases the production of PMAC motors, eliminating the costly need for adjusting sensor offsets.
Vehicle constructers now have the choice to use control via CAN with full CAN open compliancy and CAN J1939 compatibility. Optimized interfacing with battery management systems completes the SigmaLITE Controller range, allowing limiting battery current Via CAN, especially useful for vehicles using Lithium batteries.
Furthermore, a flexible function assignment on input and output pins and multifunctional inputs allows to meet all different application requirements even with limited number of pin on signal connector.
Safety requirements have been also considered in the design with a dual microcontroller architecture allowing to achieve proper safety performance level for the function Safe Stop 1, Safe Torque Off, prevent of travel and emergency stop.
Continuous monitoring on output and supplies pins have been enhanced introducing adjustable wire off and overload short circuit current thresholds.
On PMS and IPM we introduce automated motor sensor setup for sin/cos absolute position encoders and hall sensors, which significantly eases the production of PMAC motors, eliminating the costly need for adjusting sensor offsets.
Vehicle constructers now have the choice to use control via CAN or use the flexibility of software selectable active high or active low inputs. Optimized interfacing with battery management systems completes the SigmaLite controller range, allowing limiting battery current Via CAN, especially useful for vehicles using Lithium batteries.

2.1 Features

- ✓ 24V - 48V Operation
- ✓ 100% state of the art Mosfet technology
- ✓ IMS power PCB for superb thermal conduction
- ✓ Cooled power terminals
- ✓ Mechanical environmental protection IP67
- ✓ Powerful, State of the art 32 bit microprocessor control
- ✓ High frequency 16kHz (Silent Operation)
- ✓ Dual micro watchdog monitoring microprocessor operation
- ✓ Arc less contactor switching and built in coil suppression
- ✓ Protected, active high inputs switched to B+
- ✓ Thermally compensated current limit
- ✓ Selectable accelerator characteristics
- ✓ Adjustable creep speed
- ✓ Seat switch timer
- ✓ Power steer timer
- ✓ Electro-mechanical brake timer
- ✓ Walkie vehicle with belly switch operation support
- ✓ Regenerative braking
- ✓ Under- and Over-voltage protection
- ✓ Accelerator wire off, overload and short circuit detection
- ✓ Motor sensor wire off, overload short circuit detection
- ✓ Inching facilities
- ✓ Short circuit and open circuit contactors detect
- ✓ 3 traction cutback speeds
- ✓ 3 drive styles selectable
- ✓ Independent power steer speed and compensation settings
- ✓ Hardware and Software fail-safe systems with dual microcontroller architecture
- ✓ Safety function SS1, STO, SS1-SBC Prevent to travel, emergency brake, speed guard based on dual microprocessor architecture
- ✓ + 10V or +5V selectable output pin supply for motor encoder – speed sensor
- ✓ Incremental encoder, sine/cosinesensor and 3 hall sensor compatibility.
- ✓ Diagnostics with LED indication
- ✓ Remote diagnostic LED
- ✓ Adjustments made via a calibrator or DMC configurator programmer
- ✓ Full CAN Open compliant
- ✓ CAN J1939 compatible
- ✓ Hours count displaying key & giving power to the motor hours on calibrator
- ✓ BDI on Calibrator
- ✓ Dashboard display connectable
- ✓ Resettable Service and Fault logs
- ✓ Setup menu on calibrator to enable various options
- ✓ Dual motor options, with and without steering position feedback, Speed and torque mode.
- ✓ 4WD articulated vehicle driving option
- ✓ Generator mode function
- ✓ Synchronous motor 6-phase motor driving
- ✓ Shared Line Contactor feature
- ✓ Control Via CAN
- ✓ Battery current limitation static and via can
- ✓ Advanced full motor autotuning for AC- PMS -IPM
- ✓ Sensorless control available on request for AC-IPM and PMS
- ✓ Flexible thermal sensor type configuration (KTY, PT1000 or adjustable R/T curve)
- ✓ Flexible function assignment of I/O pins
- ✓ Flexible thermal sensor type configuration (KTY, PT1000 or adjustable R/T curve)

2.2 SigmaLITE Controller variants

Part number description



Available models

Model Nr.	Power ratings
AC TRACTION	
SLA425P-01x	24-48 250Arms
PMS TRACTION	
SLP425P-01x	24-48 250Arms
IPM TRACTION	
SLI425P-01x	24-48 250Arms

2.3 Original Equipment manufacturer responsibility

This DMC product is intended to drive an electric motor, which may be part of a wide variety of applications, ranging from electric vehicles to mechanical/hydraulic actuators.
The SigmaLITE inverter is provided to OEM's for the scope of integrating it in the system they are designing. It is therefore a OEM's task and responsibility to guarantee that the DMC device is installed and configured in a correct way and it is used for its designated purpose only. The main tasks to be accounted are:

- Make sure that the device is installed in a safe way;
- Make sure the device is configured in a way that it can provide maximum performance with respect to the needs;
- Make sure that the installation complies with the existing norms and regulations.

2.4 Technical support

With each product, DMC offers a package of first-line support to its direct customers and Original Equipment Manufacturers, providing additional information possibly not covered by this manual and suggestions on hardware installation and software parameterization. This is intended to guarantee proper behaviour of the DMC controller with reference to its scope. The tuning of the DMC Controllers for the specific application, as well as installation troubleshooting due to system integration are anyway outside of the scope of DMC technical support.
End customers and third parties should always refer to the reference OEMs or distributors, not to DMC directly.

2.5 Warranty

2.5.1 Product warranty

The warranty for factory-new controllers is valid for a period of 24 months from the date of delivery, including warehousing, exclusively on material. DMC cannot be held liable for any subsequent damages caused by product failure.
The warranty period for repairs and exchanged parts is 6 months, whereby this warranty only applies to the repaired or exchanged parts of a controller.

2.5.2 Return of material authorization (RMA)

Controllers which are subject to customer claim are to be send to DMC without delay, freight paid.
Prior returning a claim please contact your sales partner to obtain a DMC RMA number to be used throughout the complete claim process.
DMC needs the following information

- Customer contact information
- Fault description
- Part number
- Serial number
- Error codes including subcodes
- Application
- If possible the setting list and fault log.

Please use the DMC RMA form covering the above topics.
Following examination and acceptance of the claim, the parts are returned to the customer freight paid within a short period, and will be either repaired or replaced. We are not liable for subsequent damages caused by product failure.
If not accepted, customer needs to decide if DMC shall repair the damage part and reurn it or if it can be scrapped.

3 Controller wiring and integration

This section will take care of describing the controller's integration guidelines and its connections, to allow a proper installation of the device in the desired system.
The provided information are general in their nature, each specific case must be addressed and analysed in a system integration design phase.

WARNING!

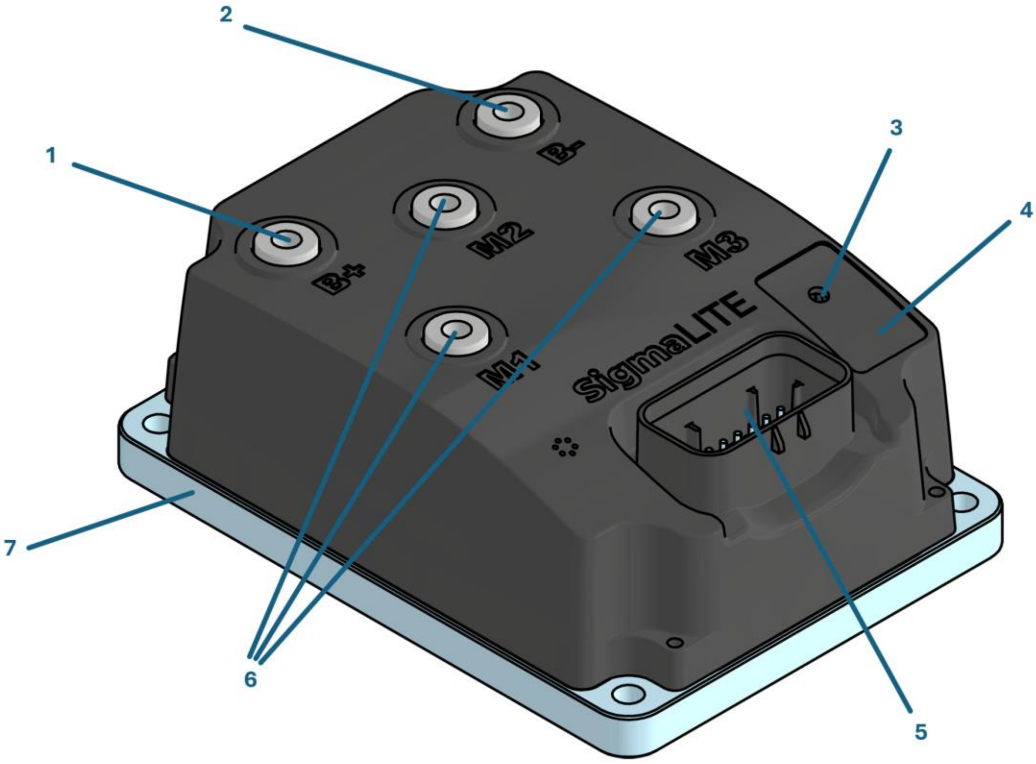
Voltage is exposed at each connection point of the DMC Controller. The B+ and B- terminals, as well as the motor connection terminals, should be properly isolated from any accidental contact which could result in personal injury.

WARNING!

Electrostatic discharges (EDS) can be a severe risk for electronic components and result in damages. While handling the DMC controller, one must be aware that the connection pins on the 23-pole connector must not be touched. The SigmaLITE Controller meets high standard for ESD protection, but those can not replace careful and professional handling of the device.

3.1 Controller's components description

The picture below should be taken as reference for the naming of the available terminals and connectors present on any DMC SigmaLITE Controllers.



Entry	Name	Entry	Name
1	B+ connection	5	23-pole AMPSEAL connector
2	B- connection	6	M1, M2, M3 phases connection
3	LED indication	7	Heatsink
4	Product label		

3.2 Signal wiring

This section aims at providing useful and complete information on the signal wire routing and specifications for a correct wiring of the DMC SigmaLITE controller.
Each connection pin will be described in detail, providing information about functions available to it and its current output capability.
Example wiring schematics will be provided in this section, to demonstrate a possible general purpose installation of the DMC SigmaLITE controller. Those schematics can not cover the whole wiring possibility range and it is therefore up to the system integrator to modify these generic wiring to adapt them to their requirements and needs.

3.2.1 Signal wires specifications

Signal 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.

3.2.2 Sizing of logic supply fuse

The logic supply fuse, always indicated in the example schematic provided by DMC, provides safety in case of abnormal power consumption trough the key line.
In case of multiple controller connection, it is up to the system integrator to use a single fuse for the whole number of controllers of to fuse each key line independently.

NOTICE!

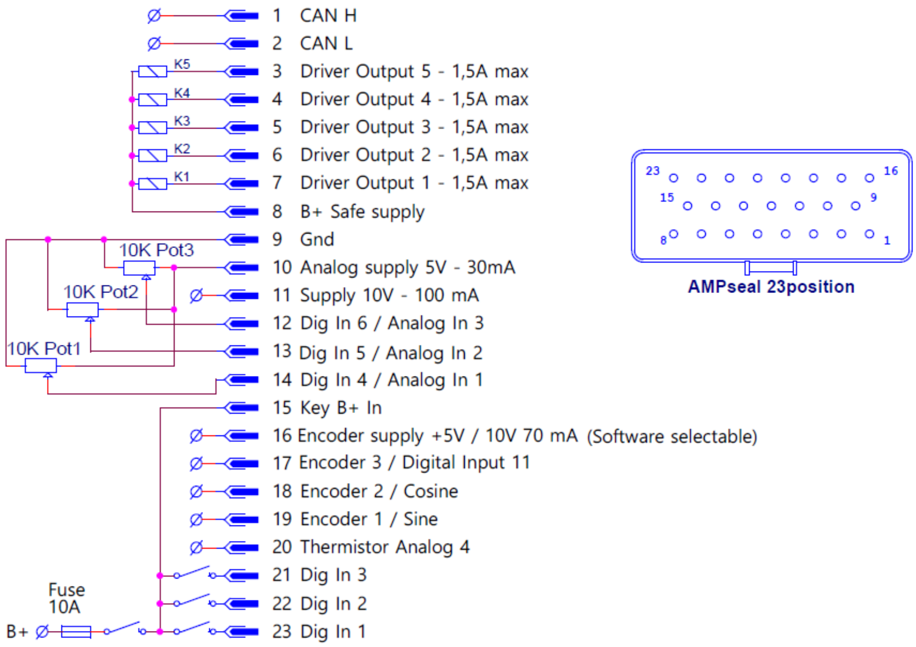
The voltage and current for the available digital outputs is directly derived trough the key line of the SigmaLITE controller. Take this into account when sizing the logic supply fuse, identifying how many outputs will be used and the respective power consumption

DMC suggest to use a slow acting fuse in the range of 8 to 10A, depending on the applied load.
The standard consumption of a SigmaLITE controller, with no active output and not energizing the motor is lower than 5W.

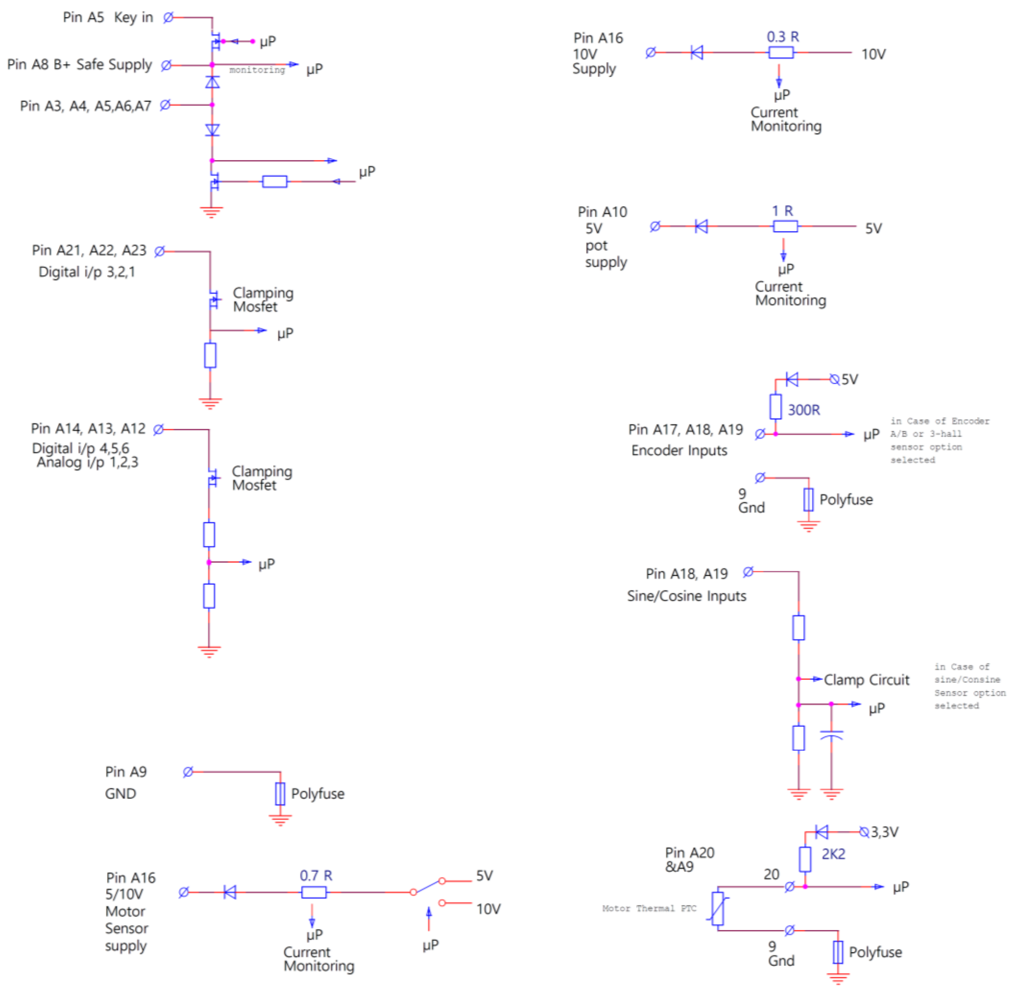
3.2.3 Signal wiring connector

The SigmaLITE controller is equipped with a 23-way AMPSEAL connector (connector A) used to carry the input/output signal. The plug housing is an AMP p/n 770680-1 and the contactor pins are AMP p/n 770520-3. The AMPSEAL connector will accept wires within the range 1.7 to 2.7 mm.
The AMPSEAL connector holds the functions for interfacing with the vehicle, the CAN communication and the motor feedback signals. The signals, associated to the pins of the connector, are digital inputs, analog inputs, communication inputs and digital outputs.
In this section the functions and features associated to each pin of the AMPSEAL 23-way connector, used for the controller light wiring will be described in details.

Connector A - Vehicle Interface - 23 Way (AMP SEAL Series)



Internal Circuits



Pin A1 CAN H

CAN High communications can line to the Calibrator, Display or other Controller(s)/CAN Devices. Mind that the can lines are isolated from B-. Isolated power supply for the CAN bus is automatically generated inside the controller.

Pin A2 CAN L

CAN Low communications can line to the Calibrator, Display or other Controller(s)/CAN Devices. Mind that the can lines are isolated from B-. Isolated power supply for the CAN bus is automatically generated inside the controller.

Pin A3 Digital Output 5

A current controlled output for proportional valve is available with 1,5 A current capability. This output is wire off and overload/short circuit protected. For adjustments see section Menu 8 “Input/Output configuration”.

Pin A4 Digital Output 4
Pin A5 Digital Output 3
Pin A6 Digital Output 2
Pin A7 Digital Output 1

These 1,5 A four driver outputs are available to be assigned to different functions (Line contactor, EM brake, Remote LED, Power steer trigger, fan control and so on). These outputs can be set up to deliver a reduced voltage compare to battery B+ (PWM chopped) and are wire off and overload/short circuit protected. For adjustments and configuration see section Menu 8 “Input/Output configuration”.

WARNING!

Avoid routing digital output signal cables with PWM chopped reduced voltage alongside motor sensor cables. The PWM frequency of the digital output might interfere with the feedback position sensor, causing control degradation and hazardous conditions.

Pin A8 Contactor B+ safe supply

This output is the positive supply to the vehicle’s contactors and coils. The voltage level of this supply corresponds to the key line’s voltage (“Pin A15 Key B+ ”). The maximum supply current from this pin is 10A. This safety supply that can be cut by both micro controllers to enhance safety level of driver output.

Pin A9 Analogue supply 0V

This pin is the ground connection motor sensor, motor thermal sensor and analogue inputs for potentiometers and pedals. Do not connect this pin to B-. Do not connect Pin A9 of different controllers together.

NOTICE!

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 at pin A9

WARNING!

If and when the sensor cable screen is connected to both the controller and the motor side, battery current will flow over the screen, disturbing the signal from the sensor to the controller, resulting in causing control degradation and hazardous conditions

Pin A10 Analogue supply – 5V / 30mA

A supply for 1-10kΩ Potentiometers is available to this pin with max 30mA capability for sourcing current.

Adjustable thresholds for Wire Off detection, overload and short circuit detection are available in " Menu 8.10 "Wireoff and Shortcircuit detection""

Pin A11 Analogue supply – 10V / 100mA

A 10V supply is available for electronic accelerator or potentiometers. The maximum supply current is 100mA. Adjustable thresholds for Wire Off detection, overload and short circuit detection are available in " Menu 8.10 "Wireoff and Shortcircuit detection""

Pin A12 Analogue Input 3 / Digital Input 6 (safe)
Pin A13 Analogue Input 2 / Digital Input 5 (safe)
Pin A14 Analogue Input 1 / Digital Input 4 (safe)

These pins can be set to be digital inputs active high connected to B+ or analogue inputs in the range 0-10V. These pins have an internal clamping circuit and even when set up as analogue they can hold full B+ battery voltage. The configuration of these pins is possible through the Menu 8 "Input/Output configuration". These pins are "safe inputs" since both microprocessors are reading the input value, thus it can be used for safety related functions.

Pin A15 Key B+ input

This input has to be connected to the switched side of the key switch. The other side of the key switch has to be connected to the battery positive supply, or to an independent supply.
A 10 A fuse has to be connected between the battery positive supply and the key switch. The position of the fuse should be as close as possible to the tap-off point for the key switch supply.

Pin A16 Sensor supply - 5V or 10V / 70mA

Supply output for motor position/speed sensor (analogue sine/cosine or hall sensor or encoder). It delivers 5V or 10V according to the motor sensor supply selected in "Menu 3 "Autotuning"". The maximum supply current is 70mA. Adjustable thresholds for Wire Off detection, overload and short circuit detection are available in " Menu 8.10 "Wireoff and Shortcircuit detection""

Pin A17 Motor sensor input Encoder 3 - Hall 3 / Digital input 11

WARNING!

Connecting this input to B+ voltage in AC motor technology applications may result is controller's damage and functionality issues.

The configuration of this pin is possible through the Menu 8 "Input/Output configuration".
By default, it has to be connected to the Hall sensor's channel #3, if the Hall sensor technology is selected in "Menu 4 "Autotuning".

WARNING!

Avoid routing the sensor cabling along with high power motor or battery cables. High power cables frequency may interfere with the low power feedback signal from the motor sensor, causing control degradation and hazardous situations.

Alternatively, it can be assigned to a digital input function (i.e. Forward input, Reverse input, STO, SS1 and so on). In case of IPM and PMS motor technology, it is active high and have to be connected to B+ voltage. In case of AC motor technology, it is active low and has to be connected to B- (GND).

Pin A18 Motor sensor input 2 - Cosine / Encoder 2 / Hall 2

Depending on the sensor technology selected in "Menu 4 "Autotuning", This pin has to be connected to:

- the cosine output of a sine/cosine sensor;
- the encoder's channel B (channel #2);
- the Hall sensor's channel 2;

The motor encoder is normally a 'Quadrature' type, which has 2 outputs, 'A' and 'B'. Both outputs produce a symmetrical square wave. Between A signal and B signal a 90° phase shift has to be present.

WARNING!

Avoid routing the sensor cabling along with high power motor or battery cables. High power cables frequency may interfere with the low power feedback signal from the motor sensor, causing control degradation and hazardous situations.

Pin A19 Motor sensor input 1 - Sine / Encoder 1 / Hall 1

Depending on the sensor technology selected in "Menu 4 "Autotuning", This pin has to be connected to:

- the sine output of a sine/cosine sensor;
- the encoder's channel A (channel #1);
- the Hall sensor's channel 2;

The motor encoder is normally a 'Quadrature' type, which has 2 outputs, 'A' and 'B'. Both outputs produce a symmetrical square wave. Between A signal and B signal a 90° phase shift has to be present

WARNING!

Avoid routing the sensor cabling along with high power motor or battery cables. High power cables frequency may interfere with the low power feedback signal from the motor sensor, causing control degradation and hazardous situations.

Pin A20 Thermistor input

This pin has to be connected to the anode of KTY84-130 thermistor or to one side of and RTD 1000 ohm 0°C or 25°C thermal sensor. The motor thermal sensor type can be selected by parameter "M5.2-1 Motor temperature sensor type "MtempTyp"". Custom thermal sensors can be connected and configured in the overmentioned menu.

Pin A21 Digital Input 3 (safe)
Pin A22 Digital Input 2 (safe)
Pin A23 Digital Input 1 (safe)

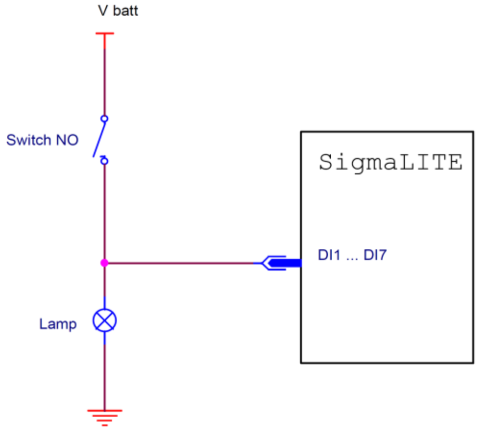
These pins are meant to be assigned to a digital input function (i.e. Forward input, Reverse input, STO, SS1 and so on). They are active high and have to be connected to B+ voltage. These pins are "safe inputs" since both microprocessors are reading the input value, thus they can be used for safety related functions. The configuration of these pins is possible through the Menu 8 "Input/Output configuration".

3.2.4 Wiring of digital inputs

The DMC SigmaLITE controller can only accept active high inputs.

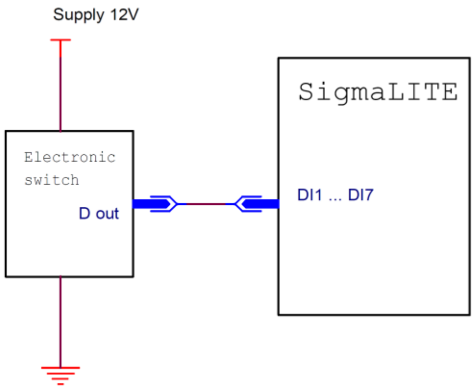
Using a mechanical switch

An active high digital input can be activated using a simple mechanical switch. The switch is wired between the B+ or Vbatt terminal and one of the digital inputs. To signal that the switch is activated, a lamp can be connected between the digital input and the B- or GND terminal.



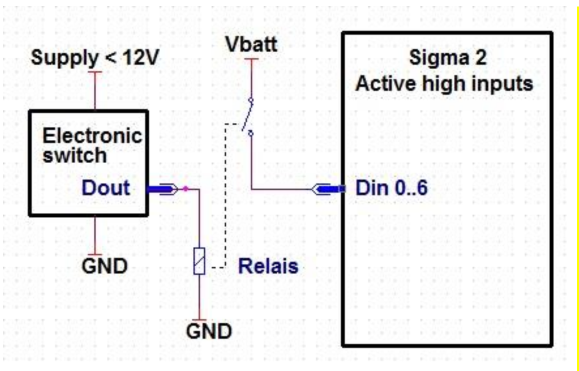
Using an electronic switch supplied with more than 12V

An active high digital input can be activated using an electronic switch. When the electronic switch is powered with a supply voltage greater than 12V, for example Vbatt, the digital output can be directly wired to one of the digital inputs.



Using an electronic switch supplied with less than 12V

An active high digital input can be activated using an electronic switch. When the electronic switch is powered with a supply voltage less than 12V, the digital output must drive a relay, which in turn switches the B+ or Vbatt voltage to one of the digital inputs.



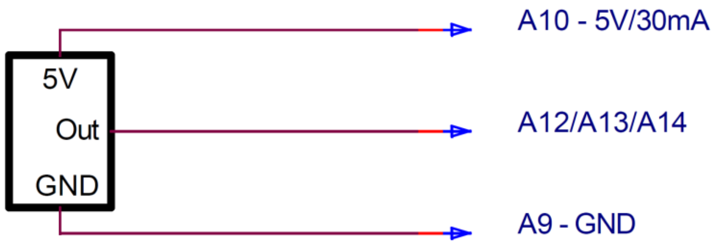
3.2.5 Wiring of analogue inputs

The SigmaLITE Controller has several wiring options for the three analogue inputs available. The wiring to be adopted depends on the desired wire-off detection capability.

The wire-off detection is available on both “Pin A10 Analogue supply – 5V / 30mA” and “Pin A11 Analogue supply – 10V / 100mA”. Depending on the chosen wiring, different wire-off detection configurations are possible.

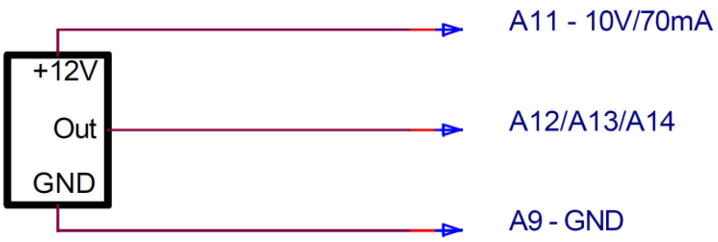
Wiring between +5V supply and GND

This option consists in connecting one terminal of the potentiometer to “Pin A10 Analogue supply – 5V / 30mA” and the other to “Pin A9 Analogue supply 0V”.
In this way, the wireoff can be detected trough “Pin A10 Analogue supply – 5V / 30mA”. Please setup “M8.10-5 5V supply wireoff threshold “5V WrOff”” correctly to guarantee an adequate threshold for wireoff. Details on wireoff tuning can be found in “APPENDIX D – Wireoff detection tuning”.



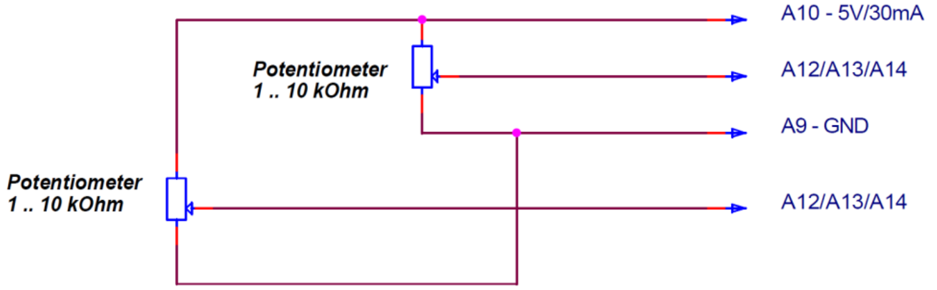
Wiring between +10V supply and GND

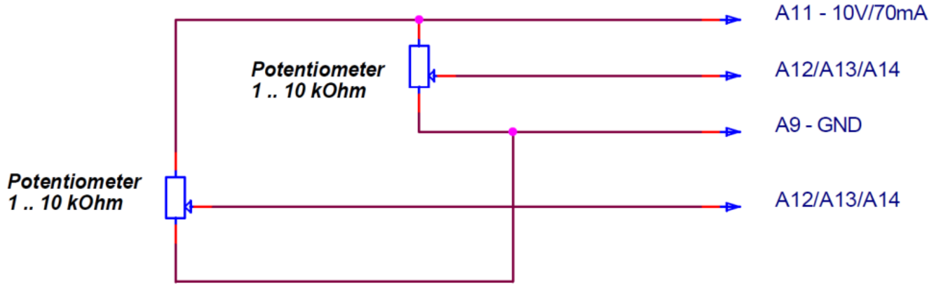
This option consists in connecting one terminal of the potentiometer to “Pin A11 Analogue supply – 10V / 100mA” and the other to “Pin A9 Analogue supply 0V”.
In this way, the wireoff can be detected trough “Pin A11 Analogue supply – 10V / 100mA”. Please setup “M8.10-3 10V supply wireoff threshold “10VWrOff”” correctly to guarantee an adequate threshold for wireoff. Details on wireoff tuning can be found in “APPENDIX D – Wireoff detection tuning”.



Wiring of multiple potentiometers

More than one potentiometer can be wired between "Pin A10 Analogue supply – 5V / 30mA" or "Pin A11 Analogue supply – 10V / 100mA" and "Pin A9 Analogue supply 0V". Details on wireoff tuning can be found in "APPENDIX D – Wireoff detection tuning".



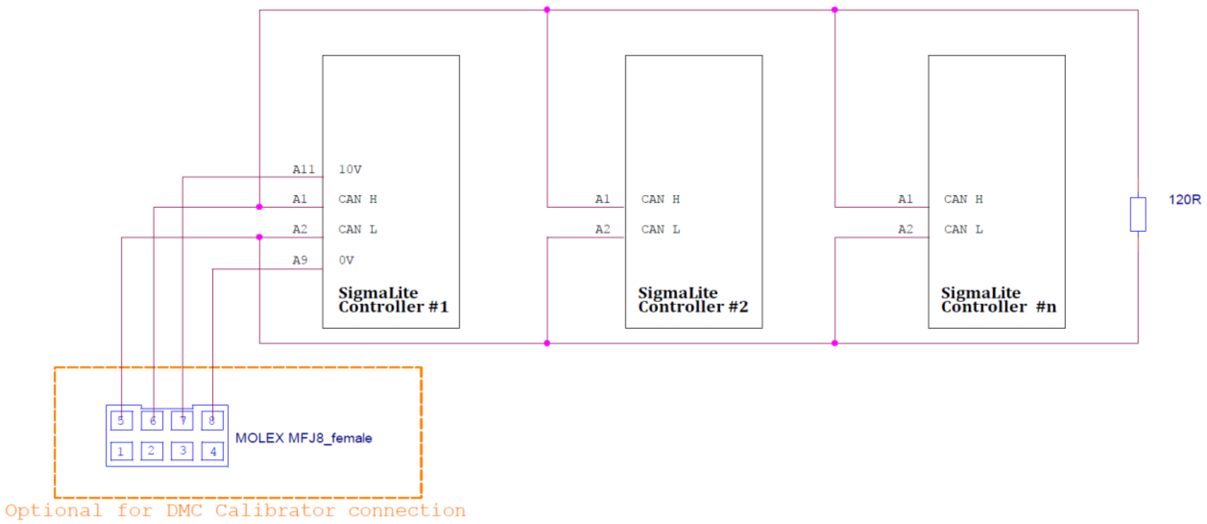


3.2.6 Wiring of the CAN bus

All DMC SigmaLITE Controller are equipped with a self-isolated CAN bus connection on “Pin A1 CAN H” and “Pin A2 CAN L”.
CAN bus wires should be terminated at both ends with a 120Ω resistor.
If a CAN bus network is installed in a machine, special care should be taken which two CAN nodes should have the build-in termination resistor connected. Make sure that only 2 termination resistors are active.
CAN bus should always be wired in a line, with no star connections. A twisted pair is strongly recommended. Shielded cables are suggested for best noise rejection.

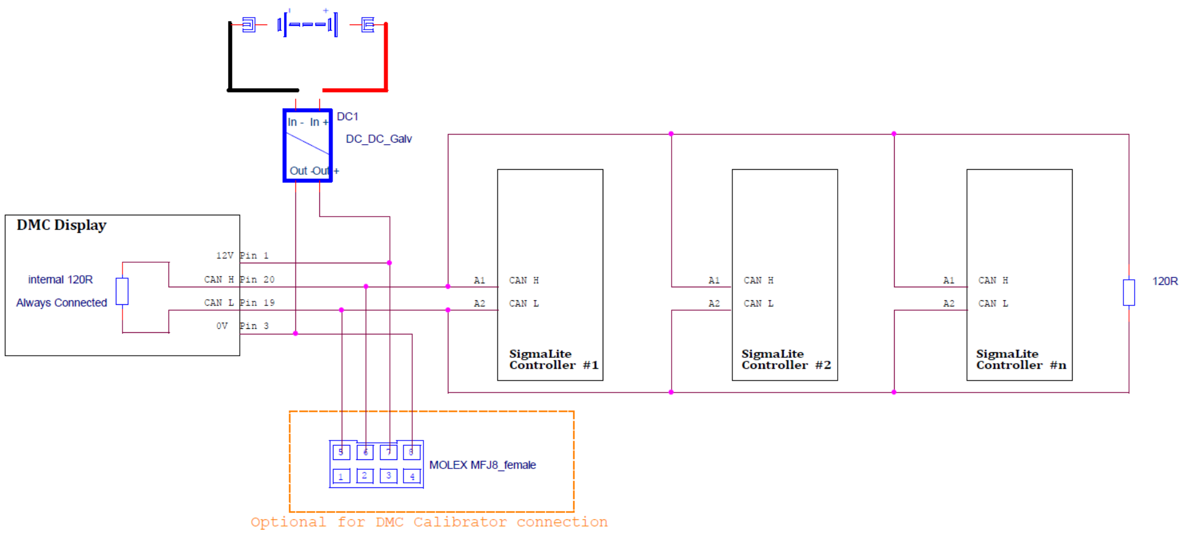
Wiring when no DC/DC converter is installed:

In case the vehicle is not equipped with a DC/DC converter providing an auxiliary 12V or 24V, it is possible to wire the DMC Calibrator to the SigmaLITE, drawing the power needed to supply it from “Pin A10 Analogue supply – 5V / 30mA” and “Pin A9 Analogue supply 0V”.
A DMC Lite Display cannot be connected to those same pins, as it would not be isolated from the power battery, possibly damaging the device.

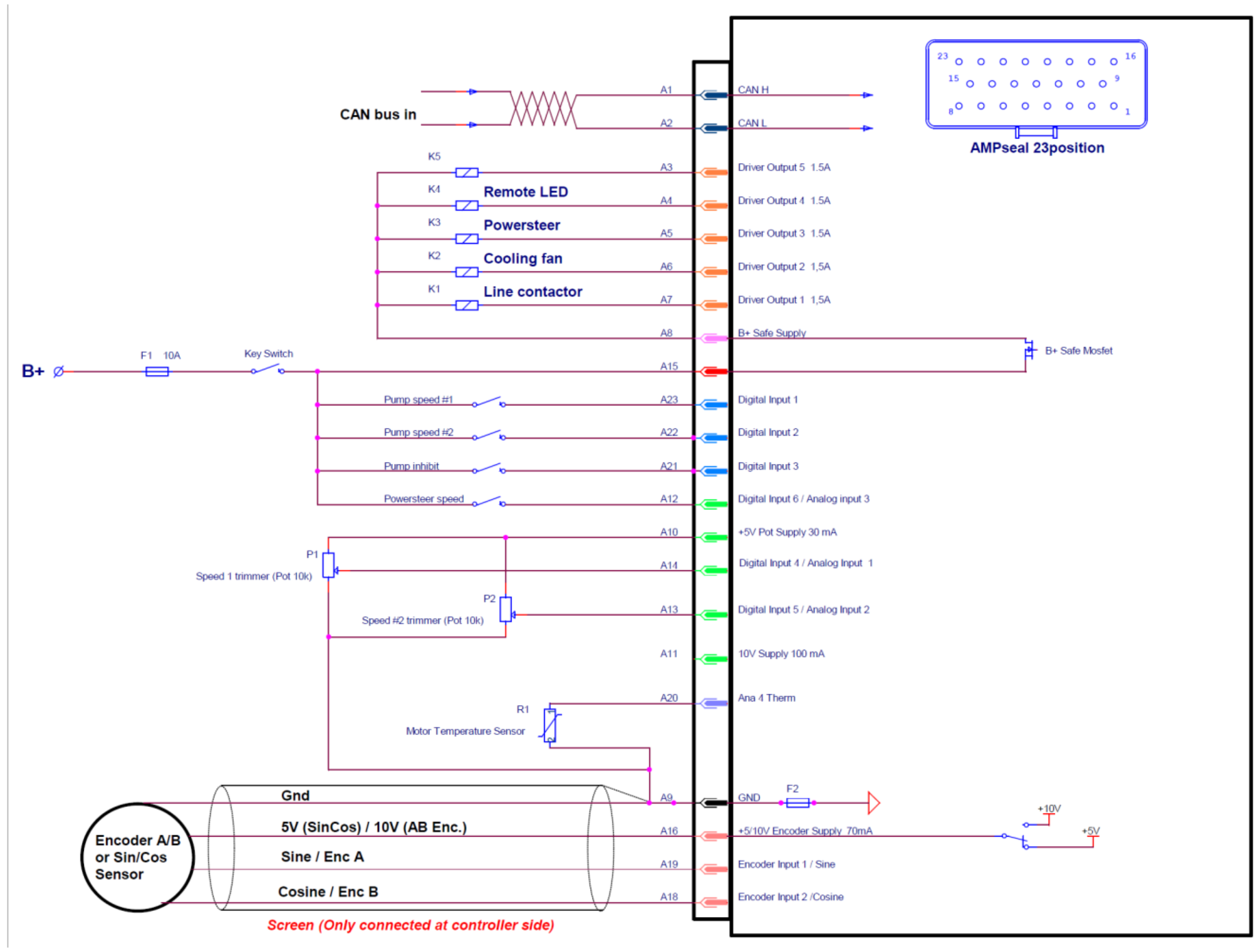


Wiring when a DC/DC converter is installed:

In case the vehicle is equipped with a DC/DC converter providing an auxiliary 12V or 24V, it is possible to wire the DMC Calibrator to the SigmaLITE, drawing the power needed to supply it the DC/DC converter.
In case a DMC Lite or Advanced Display is also installed on the vehicle, it is suggested to power it through the DC/DC converter as well.
In case a VCU is installed in the system, DO NOT CONNECT a (possibly present) CAN GND wire to “Pin A9 Analogue supply 0V”. This Pin is not isolated from the B- connector and would therefore spoils the CAN network isolation.



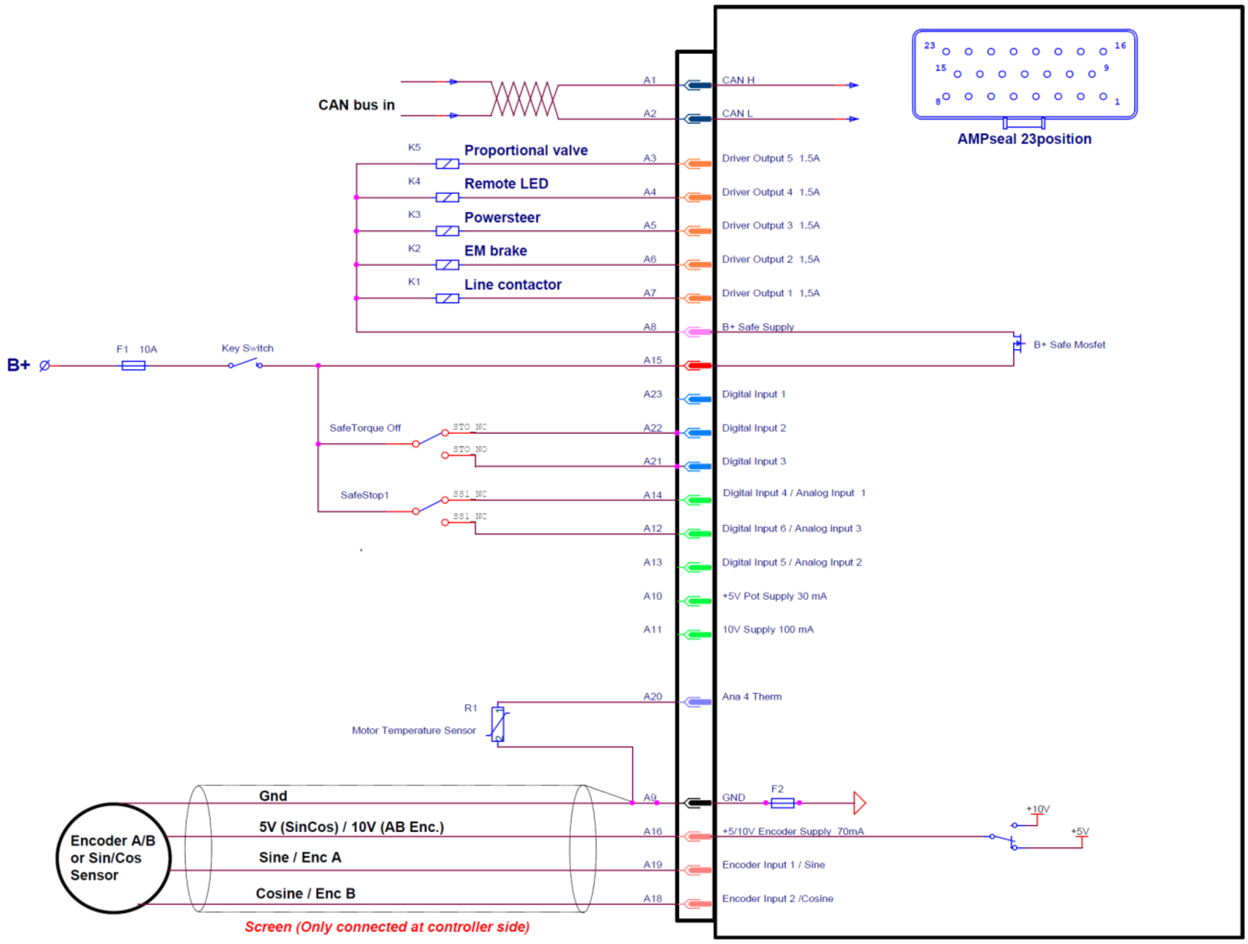
3.2.7 Signal wiring example pump application (factory setup)



NOTICE!

This wiring corresponds to factory setup of a Sigma Lite traction controller

3.2.8 Signal wiring example for pump control Via Can with Safe STO-SS1



NOTICE!

The reported wiring example implies a proper function assignment to input pins.

3.3 Power Wiring

The DMC SigmaLITE Controller has 5 high-power connection terminals. Two of them are used to connect the Controller to the battery pack providing the energy and three to connect the motor phases. They are identified on the Controller housing with **B+**, **B-**, **M1**, **M2** and **M3**.
Power connections should be made with flexible heat resisting cables of suitable cross-sectional area for the current to be carried. A general rule is to consider 4A/mm2 for continuous operation. These should be terminated in crimped lugs attached to controller and the contactors, properly isolated from water and moist. 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).

3.3.1 Safety recommendations

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.
Before working on the controller 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.
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 a 12 Volt on-board 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.

3.3.2 Line contactor

The line contactor of the SigmaLITE controller functions as the main power distribution device and also plays a key role in the interlock circuit as a power-removing device.
DMC always encourages to use a line contactor, to enable the controller to switch off in unsafe situations.
The contactor mounting plane can affect performance; contactors should never be mounted with their terminal studs vertically down.
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 SigmaLITE Controller is not compatible with line contactors which have embedded power saving circuits and/or economizers.
The SigmaLITE can be used with permanently-connected on-board chargers, as long as the maximum allowed voltage of the particular controller model is not exceeded. If the batteries should not be charged during operation, a change-over contactor as line contactor is a good solution to fit both the charger and the controller in the truck.
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 disconnection during power regeneration.

3.3.3 Power up delay and Internal Capacitors Precharge

At 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 key line is energized ("Pin A15 Key B+ input"), the precharge operation starts. When voltage over the capacitors is at the required level (see "M2-4 Precharge voltage threshold "PreChgLv""), the SigmaLITE Controller will activate the output meant to drive the line contactor (see "Menu 8 "Input/Output configuration""). Especially at 24V systems the time delay to charge the capacitor bank can be longer.
The following table reports a resume of the most meaningful parameter related to precharge.

Nominal voltage [V]	Size	Charge resistor [Ω]	Discharge resistor [Ω]	Capacitance [µF]
48	1	180	10000	6610

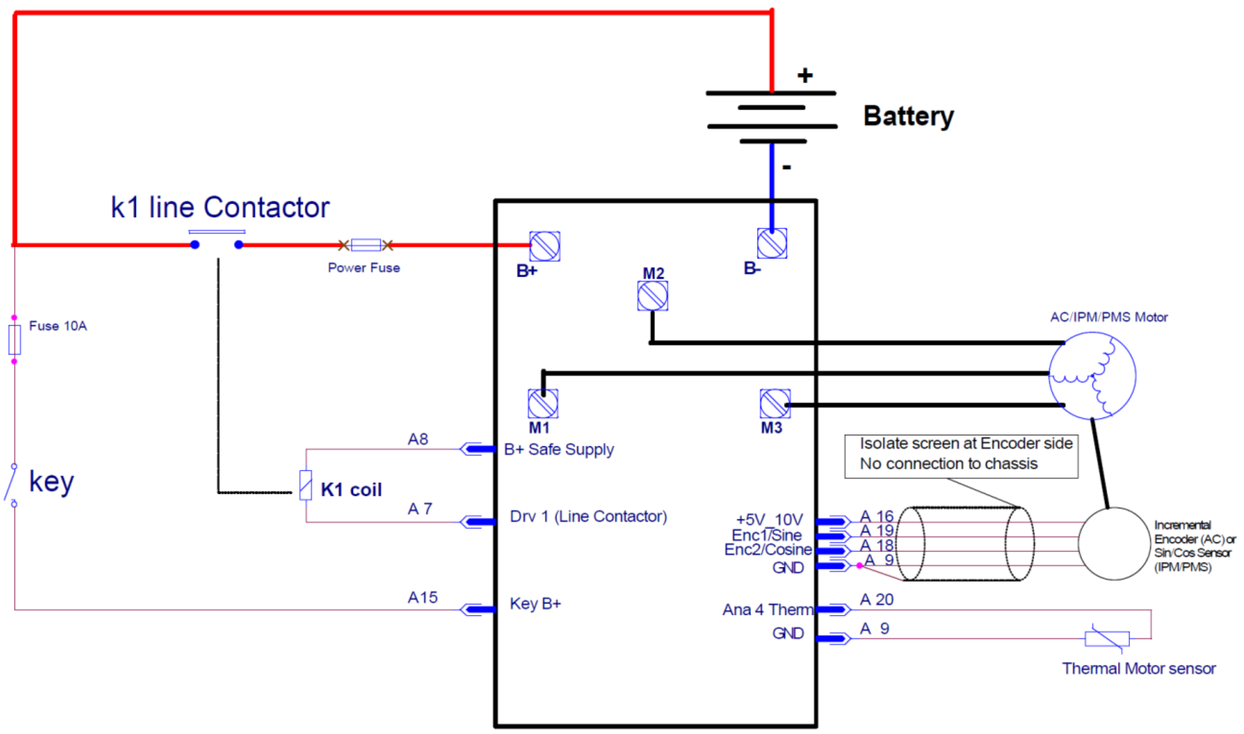
3.3.4 Power line fuse

DMC recommends to always install a properly sized fuse on the main B+ power line. This fuse is intended as a safety device to prevent fire ignition of the DMC SigmaLITE controller, not as an overload protection.
Always consider maintenance accessibility when placing the power line fuse.
The selection of an appropriate fuse rating is mandatory and must be carried out by the system integrator during the vehicle's study and prototyping. The fuse shall be sized according to the maximum current rating of the SigmaLITE controller and to the battery's current capability.
A general rule for fuse sizing is:

- Calculate the maximum current absorption/regeneration of the controller;
- Select a fuse which can hold the said current indefinitely;
- Select a fuse which blows within2s, when double of the overmentioned current is flowing through it.

3.3.5 Power wiring examples

Wiring example with self-driven line contactor (recommended)



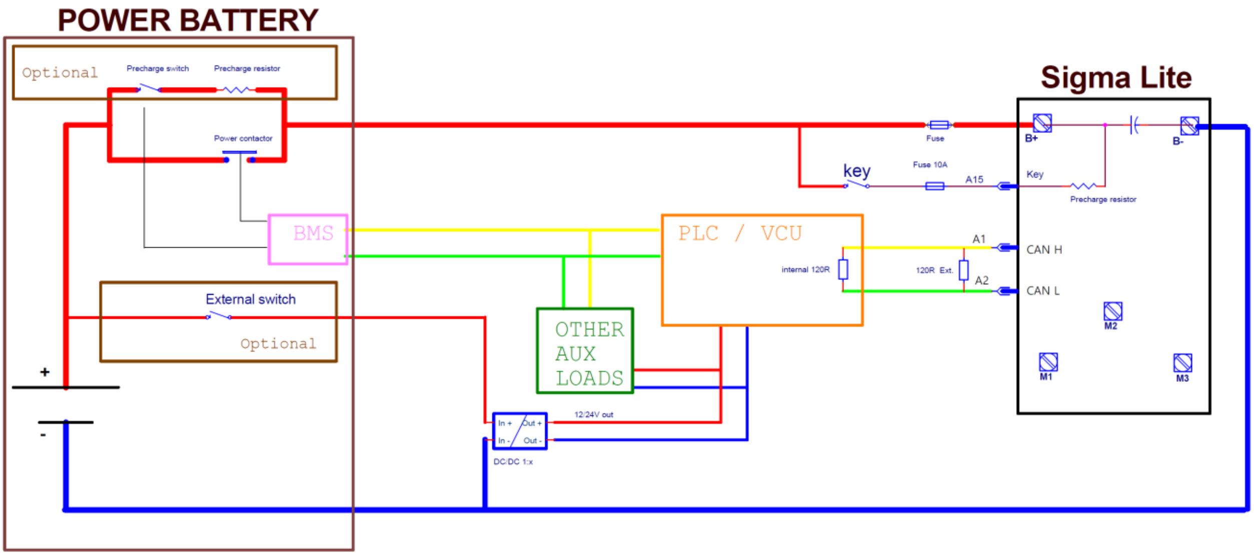
WARNING!

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 regenerative braking

WARNING!

No load other than the DMC Controller should be connected under the line contactor (between line contactor output and B+ terminal).

Wiring example with external line contactor management



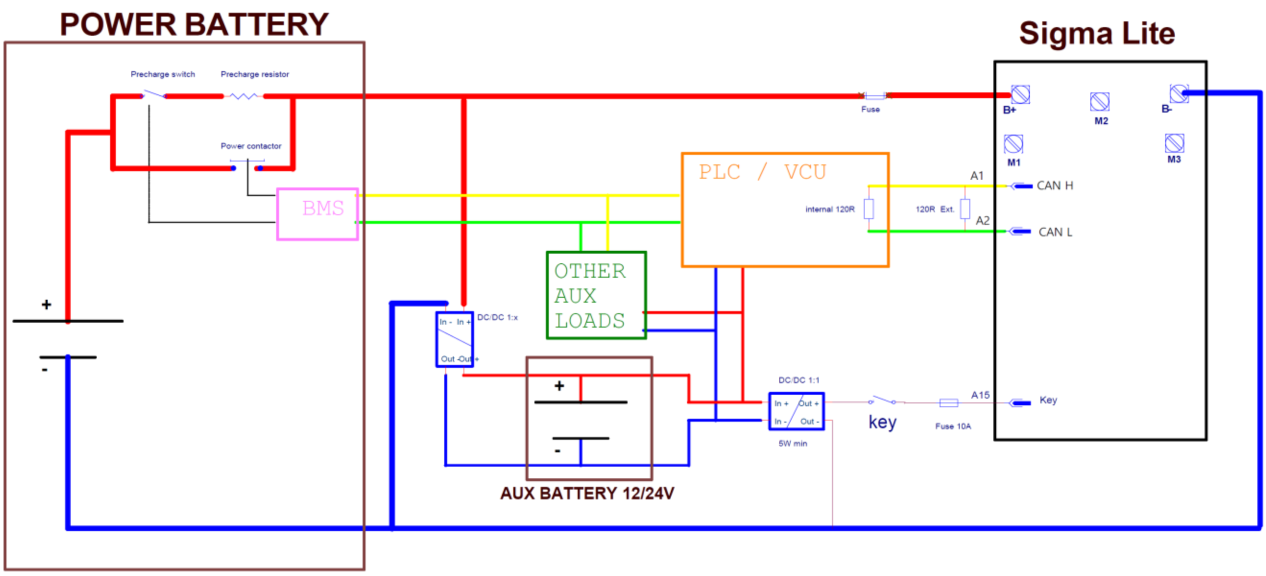
NOTICE!

The above scheme has to be followed strictly. Any variation must be agreed with DMC engineering.

Wiring examples with external line contactor management and independent logic supply

The following examples represents the suggested wiring for a situation in which the Key line for DMC SigmaLITE Controller is separated from the main power source.

Please notice that the DC/DC converter supplying the SigmaLITE key line must be at least capable of outputting 5W for supplying the control logic. In case the application needs the DMC Sigma Lite Controller to drive one or more Digital Outputs, the user should consider upsizing the overmentioned DC/DC converter taking into account 2A for each driven output. Mind that the outputs will be driven at Key line voltage.

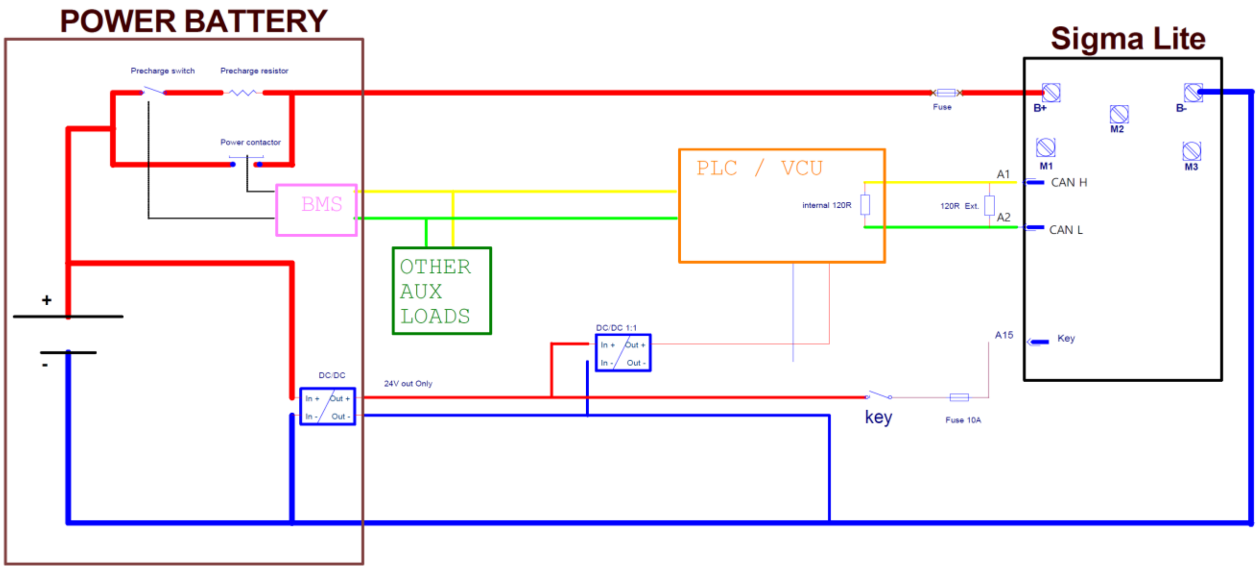


NOTICE!

The above scheme has to be followed strictly. Any variation must be agreed with DMC engineering.

The following example represents the case in which the power battery embeds a dedicated output at 12 or 24V and therefore an auxiliary battery is not needed. Notice that in this case this output must be capable of outputting enough power for satisfying the consumption of DMC SigmaLITE Controller and all the connected auxiliary devices.

The consideration at the begin of this section remain valid.



NOTICE!

The above scheme has to be followed strictly. Any variation must be agreed with DMC engineering.

3.4 Mechanical installation

3.4.1 Mounting the controller

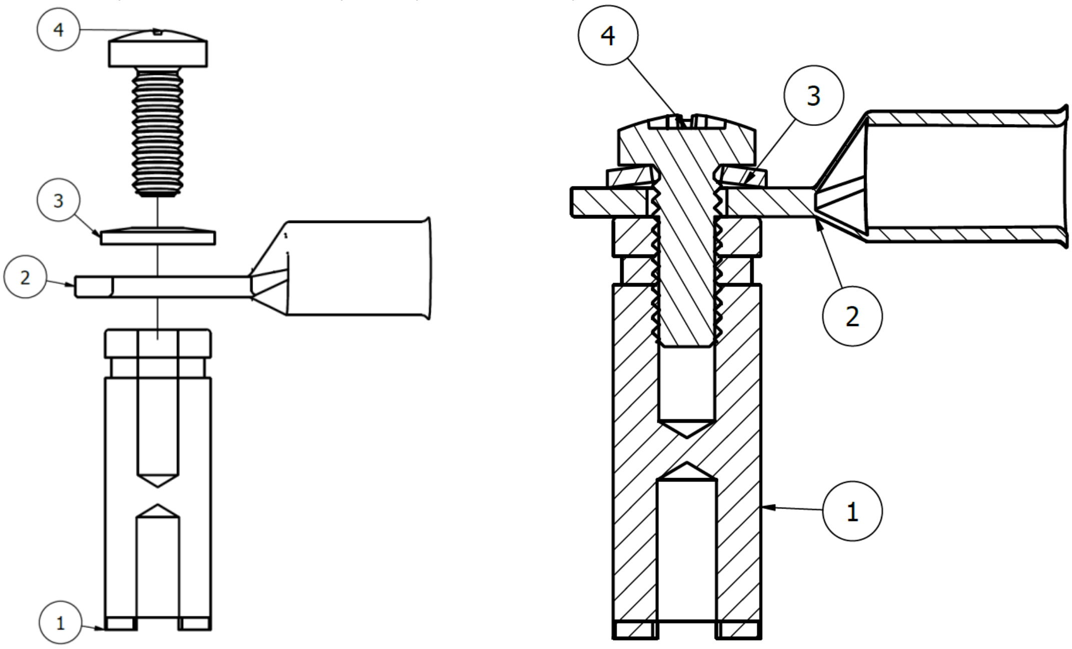
The DMC SigmaLITE Controller location should be carefully chosen taking into account its mechanical dimensions and the outline of its mounting holes. Avoid mounting the controller too close to heat sources as those can decrease the overall performance of the controller itself. Choose a mounting location which can prevent corrosion and leakage from happening, thus keeping the controller as safe as possible clean and dry. Make sure that all power terminals of the controller are properly protected from excessive water and moist.
Do not mount the controller on rough or curved surfaced, which can cause the distortion of the heatsink. Make sure the bolts keeping the controller in place are evenly tightened to the mounting surface. For proper cooling it is recommended to install the controller on a metal plate, with sufficient air ventilation against it and applying a layer of thermal paste to guarantee maximum heat transfer.

3.4.2 Lug assembly

Five M6 aluminium power terminals are present. The lug should be assembled as follow:

1. Place the lug on top of the power terminal. If more than one lug has to be placed on the same terminal, make sure that the one carrying lowest current is on top and that the surface are well in contact.
2. Place a safety washer on top of the lugs.
3. Insert a M6 bolt to fix the assembly together and tighten with 8 (± 0.5) Nm strength.

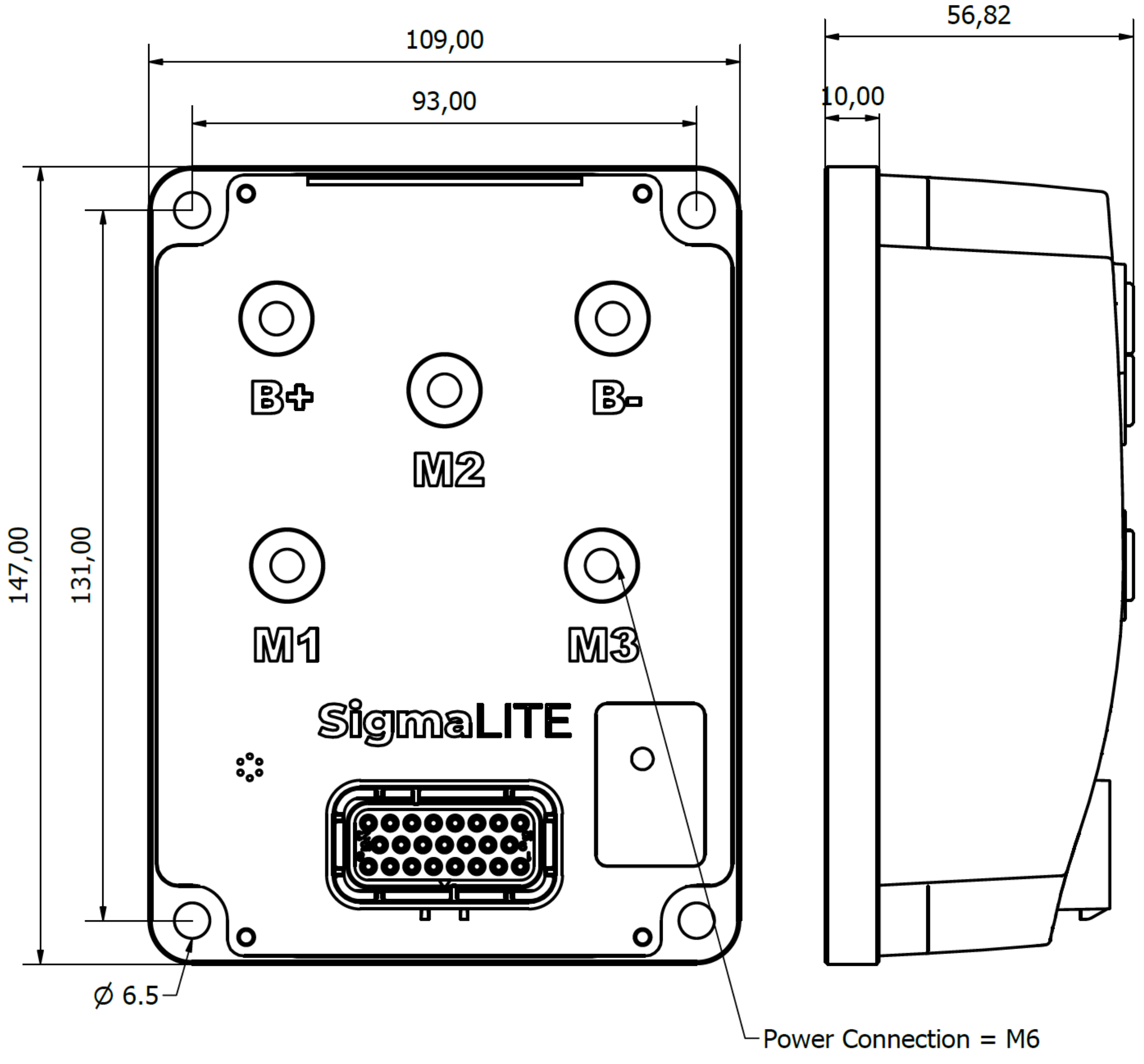
The picture below represents an assembly example of the components:



Entry	Name
1	Power terminal
2	Lug terminal M6, $35mm^2$
3	Washer (DIN 6796)
4	M6x16 bolt (ISO 7045)

3.4.3 Mechanical dimensions

The DMC SigmaLITE Controller family's mechanical dimensions are reported in the figure below:



3.4.4 Weight

The weight of the DMC SigmaLITE Controller family is 885 grams.

3.4.5 Water and dust protection

The SigmaLITE controller meets a mechanical IP67 protection level against dust and water.
it is anyway suggested to carefully choose the installation location to protect them harsh environment conditions, if possible.

3.4.6 Cooling

The Controllers should be bolted down to a flat (0.2mm max. Deviation) paint free surface, eventually lightly coated with a thermal transfer compound, by means of the 4 fixing M6 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.
For guaranteeing nominal 1h continuous current operating condition the heatsink must be kept at maximum 75°C, thus the cooling system should be able to dissipate the losses reported in the table below:

Unit	1h continuous current rating [A]	Losses to be dissipated [W]

XXX425Y1	130A	160W

4 Use of CAN Open Calibrator and DMC configurator

4.1 DMC CAN Open Calibrator

General

The DMC CAN Open Calibrator is designed for Setting up the SigmaLITE controller range. It also has a build-in dongle for setting up the controller via PC and DMC Configurator (for details see[7]). The calibrator must be wired to Connector A, using either the 10V supply available or providing an external 12-24V supply (see 3.2.6 Wiring of the CAN bus).

CAN protocol setup

The DMC CAN Open Calibrator is fully compatible with all CAN protocols used by DMC products (i.e. DMC CAN protocol, CAN Open compatible protocol and Full CAN Open protocol). By default, the DMC CAN Open Calibrator is setup in “Autoscan” mode, which automatically recognises the active CAN protocol of the network.

CAN node setup

When powering the DMC CAN Open Calibrator, it will “scan” the CAN bus for all available DMC SigmaLITE controllers, to enable calibration of all DMC controllers on the same bus. All controllers are by factory default set to Node 1. Therefore before using the DMC CAN Open Calibrator, all DMC SigmaLITE Controllers MUST be given a unique Node number. To do this, the DMC Calibrator must be plugged into a DMC SigmaLITE Controller one after the other to give it an unique node number.

CAN baud rate setup

When connecting the DMC CAN Open Calibrator into a CAN network, it will communicate at a selectable baud rate. By default the DMC Calibrator is set to use 250 kbit/s baud rate. In case the baud rate of DMC CAN Open Calibrator and DMC SigmaLITE Controllers are not consistent, they will not communicate. In case there is any device in the CAN network communicating at a baud rate different from the one set in the DMC Calibrator or any DMC SigmaLITE Controller, the communication can undergo several issues. Please make sure all devices in the CAN network are communicating with the same baud rate.

4.1.1 How to change the Calibrator’s baudrate:

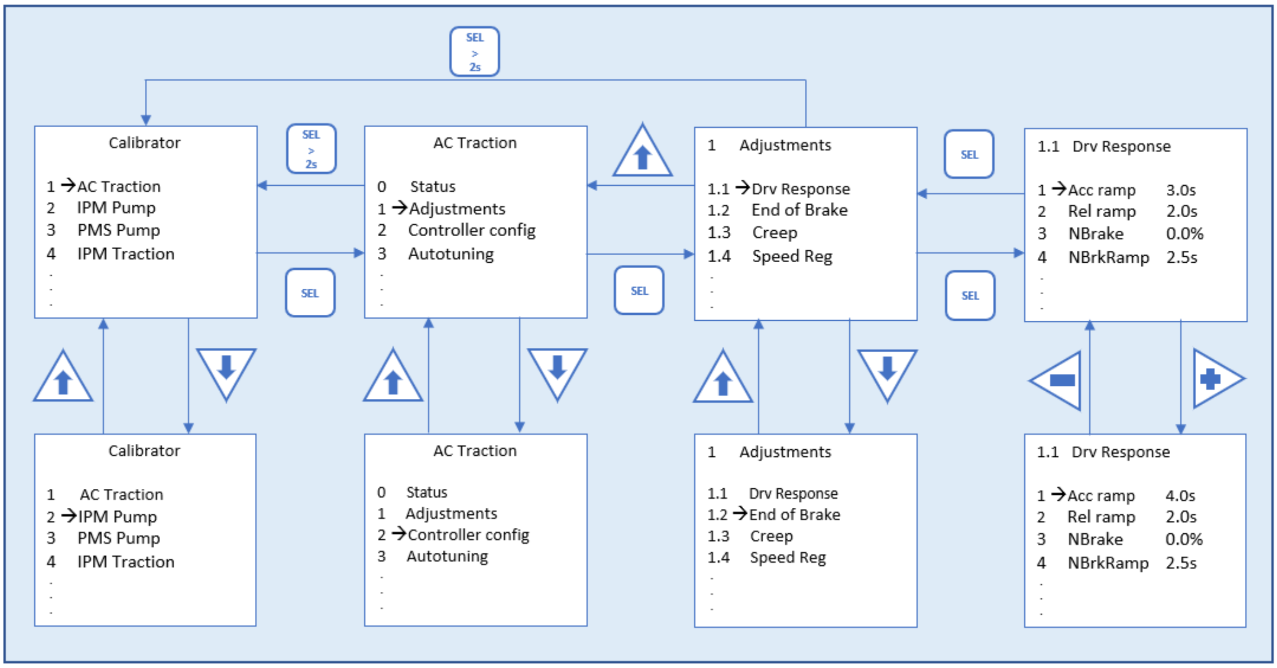
1) Press and hold the SEL button for more than 2 seconds in order to return to the calibrator’s main page.
2) Scroll with ⬇ button to “About & Setup” menu; this is the calibrator menu for info and bit rate setup.
3) Press ▷ and ◁ buttons at the same time and information about calibrator will appear.
4) Scroll with ⬇ button to “Bitrate” parameter.
5) Press ▷ or ◁ buttons to increase or decrease the Calibrator’s CAN bitrate.
6) When the desired bit rate is displayed press “SEL” button to confirm.
7) The calibrator will go back to the main screen and will operate on CAN bus at the selected bit rate.

4.1.2 How to change the Calibrator’s CAN protocol:

8) Press and hold the SEL button for more than 2 seconds in order to return to the calibrator’s main page.
9) Scroll with ⬇ button to “About & Setup” menu; this is the calibrator menu for info and bit rate setup.
10) Press ▷ and ◁ buttons at the same time and information about calibrator will appear.
11) Scroll with ⬇ button to “Protocol” parameter.
12) Press ▷ or ◁ buttons to select the new Calibrator’s protocol.
13) When the desired protocol is displayed press “SEL” button to confirm.
14) The calibrator will go back to the main screen and will operate on CAN bus with the selected protocol.

Adjustments and DMC Calibrator's map

The DMC Calibrator is easy to use. The "up" and "down" buttons are used for scrolling lists up and down. Selections can be made with the "SEL" button. The "plus" and "minus" buttons are used to increase or decrease the parameter's values.



NOTICE!

- **Press and hold the select button for 2 seconds to return to the first screen.**
- **The calibrator remembers the cursor position in the submenus until key-off.**

Where to plug the DMC Calibrator

The DMC Calibrator must be inserted in the CAN network wired from "Connector A - Vehicle Interface - 23 Way (AMP SEAL Series)".
Please refer to "3.2.6 Wiring of the CAN bus" for wiring examples.

4.2 DMC Configurator

DMC has developed a new and modern PC application that can be used to configure DMD Controllers and monitor data via the CAN bus.
This application takes the name of DMC Configurator and is available to download from the DMC website.
For more information about the DMC Configurator usage, please refer to [7].

5 Drive functions of DMC Controller

This section's aim is to describe how the majority of the available functions are activated in the DMC SigmaLITE Controller. It will also provide important insights on the relationship between physical inputs and "fictious" inputs which can be sent Via CAN.

5.1 Functional inputs

The DMC Controller embeds a number of so called "functional inputs", which are used to activate certain functions.
The DMC Controller can retrieve its functional inputs either from physical digital/analogue sources, either Via CAN.
In order for the DMC Controller to retrieve a functional input from one of its physical inputs, the user must correctly setup "Menu 8.1 "Input/output assignment"". For example, setting "M8.1-1 DI1 configuration "Ip 1 Cfg"" to 0, would correspond to assign the "Speed 1 activation" functional input to "Pin A23 Digital Input 1". Therefore, when "Pin A23 Digital Input 1" will be active, the DMC Controller will act as it is instructed to drive at the speed set by parameter "M1.1-1 Speed 1 demand (Accelerator speed #1) "Potmax1"".
In order for the DMC Controller to retrieve a functional input from the CAN bus, the user must map the said input to a CAN message, which must in turn be activated for reception. For example, mapping (i.e. including) object 0x3966 "HMI Speed 1 command" into RxPDO1, would assign the "Speed 1 activation" functional input to the variable received Via CAN.
The DMC Object dictionary ([9]) includes all the functional input objects.
For details on how to map a CAN message and how to activate it, please refer to the CAN manual ([1]).
In case a functional input is either assigned to a physical input and mapped in a CAN message, the information coming Via CAN will take precedence and the physical input value will be discarded.

Hereafter, a table containing all the available functional inputs and their description is reported:

Functional input name	Type	Normally Open/Close	Description	Mandatory	Assignable Via CAN
Speed 1 activation	Digital	NO		N	Y
Speed 2 activation	Digital	NO		N	Y
Speed 3 activation	Digital	NO		N	Y
Speed 4 activation	Digital	NO		N	Y
Speed 5 activation	Digital	NO		N	Y
Powersteer activation	Digital	NO		N	Y
Inhibit driving	Digital	NO		N	Y
STO with toggle	Digital	NC		N	N
STO normally open	Digital	NO		N	N
STO normally closed	Digital	NC		N	N
SS1 with toggle	Digital	NC		N	N
SS1 normally open	Digital	NO		N	N
SS1 normally closed	Digital	NC		N	N
Accelerator on speed 1	Analogue	--	Provides a proportional speed or torque demand, depending on the active control mode	Y	Y
Accelerator on speed 2	Analogue	--	Provides the steering angle of the vehicle	N	Y

5.2 Basic drive functions

With its standard configuration, the DMC Controller can drive in different modes, depending on the active inputs. Defining one or several mandatory functional inputs that need to be assigned is therefore a task that needs to be addressed depending on the desired behaviour. The pump application is designed to run in different modes:

- At fixed speeds, trough the activation of the following functional inputs: Speed2, Speed3, Speed4, Speed5; the lower speed number will take precedence;
- At a variable speed, trough the activation of the “Speed1” functional input and the “accelerator speed #1” functional input as trimming input;
- At a fixed speed, trough the activation of the “Powersteer” functional input.

Therefore, the minimum set of functional input can be represented as:

- 1x digital input (if a single fixed speed is desired)
- 1x digital input + 1x analogue input (if a variable speed is desired)

These 2 functional inputs (1x Digital, 1x Analogue), can be either wired or sent Via CAN. There is also the possibility for the controller to retrieve functional inputs from both sources simultaneously, but this case will not be deepened in this manual and will be described in [1].
Any other functional input is optional, thus not necessary to drive a motor.

5.2.1 Speed 1 activation

This functional input is used to activate the driving speed #1 configured by means of parameter “M1.1-1 Speed 1 demand (Accelerator speed #1) ”Potmax1””. The adopted speed will be then trimmed by the accelerator input (100% accelerator -> 100% speed).

5.2.2 Speed 2 activation

This functional input is used to activate the driving speed #2 configured by means of parameter “M1.1-2 Speed 2 demand (Accelerator speed #2) ”Pspeed2””. By default, the speed will be then be applied straight away. Optionally, there is the possibility to trim the speed by means of a secondary accelerator input (100% accelerator -> 100% speed). This behaviour can be configured by parameter “M1.7-3 Pump speed #2 enabling configuration “Spd2 Cfg”” and will need the assignment and usage of the “Accelerator speed #2” functional input.

5.2.3 Accelerator speed #1

This functional input must be assigned to an analogue input or mapped in a CAN message to provide the speed setpoint for the motor, trimming the value configured at “M1.1-1 Speed 1 demand (Accelerator speed #1) ”Potmax1””. Based upon the parameter selection applied at “M1.7-2 Pump speed #1 enabling configuration “Spd1 Cfg””, then the speed #1 must also be activated by means of a switch connected to the physical input or through a CAN command, instead of being applied immediately with some potentiometer signal.

5.3 Configurable auxiliary functions

Several functions are available in the DMC Controller, which are activated automatically when a functional input is assigned to a physical input of mapped in a CAN bus message.

5.3.1 Speed 3, speed 4, speed 5 activation

These functional inputs are used to activate the driving speed #3, driving speed #4 and driving speed #5 configured by means of parameters “M1.1-3 Speed 3 demand ”Pspeed3””, “M1.1-4 Speed 4 demand ”Pspeed4”” and “M1.1-5 Speed 5 demand ”Pspeed5””. The active speed will be applied straight away, with the lowest speed number having priority.
Example: both speed #3 and speed #5 are active, speed #3 is configured to 300RPM, speed #5 is configured to 1000RPM. Speed #3 will be adopted and the motor will run at 300 RPM.

5.3.2 Powersteer

This functional input is used to activate the driving at the so called “powersteer speed”, configured by means of “M1.2-2 Speed 6 demand (power steer speed) ”Pspeed6””. This functional input has an embedded shut-off delay which can be configured by means of “M1.2-3 Power steer delay ”PStrDly””, meaning that once the physical input is deactivated, the function will still remain active for a certain amount of time.
The powersteer speed activated by means of this functional input works as a “minimum” speed, which cannot be overridden by any other speed.

5.3.3 Inhibit

This functional input is used to inhibit the pump operation. When this input is active, then any other functional input will be disregarded, except from the “powersteer” functional input.

5.3.4 Accelerator speed #2

This functional input must be assigned to an analogue input or mapped in a CAN message to provide the speed setpoint for the motor, trimming the value configured at “M1.1-2 Speed 2 demand (Accelerator speed #2) ”Pspeed2””. Based upon the parameter selection applied at “M1.7-3 Pump speed #2 enabling configuration “Spd2 Cfg””, then the speed #2 will be applied directly or trimmed by means of the potentiometer.

5.3.5 No functional input assigned (analogue/digital)

When “no functional input assigned” selection is made for a digital/analogue input, the physical input value will still be monitored and its value assigned to a variable present in the object dictionary ([9]). This variable can be then mapped to any TxPDO, enabling the user to use the DMC SigmaLITE Controller as an “input reading” device.

5.4 Functional outputs

The DMC SigmaLITE Controller has 5 configurable physical digital outputs. Each digital output can be assigned to a different functional output calculated inside the DMC SigmaLITE Controller, as output of a specific function, or autonomously driven through a CAN command.
One functional output can be assigned to multiple physical outputs. Hereafter the available functions will be described.

5.4.1 Line contactor management

This function is ran inside the DMC SigmaLITE Controller to automatically drive the line contactor.
This function performs several checks at powerup, one of which is making sure that the Line contactor is not closed at powerup (i.e. Capacitors are not already charged) and manages the precharge state. When precharge all the checks are passed and precharge is over, it activate its functional output in order to be able to drive a physical output, which will in turn close the line contactor.
Furthermore, this function is continuously checking for active severe faults in the controller, making sure that when one of them is present, power from the motor is removed and the functional output is deactivated, so that line contactor is physically opened.
It is mandatory to have this function assigned to at least one physical digital output of the DMC SigmaLITE Controller. The only case in which this is not mandatory are:

- The DMC SigmaLITE controller is meant to be a “Shared line contactor slave”. Refer to “M7.3-1 Shared line contactor option “SharedLC””.
- The DMC SigmaLITE controller is meant to have an “External line contactor”. Refer to “Wiring example with external line contactor management” and “M7.3-1 Shared line contactor option “SharedLC””.

5.4.2 Power steer management

This function is ran inside the DMC SigmaLITE Controller to activate a powersteer.
The functional output activation condition is that the “Powersteer” functional input is active.

5.4.3 Motor fan/Controller fan/Combo fan

These functions are run inside the DMC SigmaLITE Controller to signal when the motor and/or controller temperature is above a configurable threshold. They are generally used to drive cooling fans.
The “motor fan” functional output is activated if **motor temperature** is higher than threshold “M1.8-1 Motor temperature threshold “MotTmpTh”” and deactivated when motor temperature gets lower than threshold “M1.8-1 Motor temperature threshold “MotTmpTh””- 8 °C of hysteresis.
The “controller fan” functional output is activated if **controller temperature** is higher than threshold “M1.8-2 Controller temperature threshold “CtrTmpTh””, and deactivated when controller temperature gets lower than threshold “M1.8-2 Controller temperature threshold “CtrTmpTh””- 8 °C of hysteresis .
The “combo fan” functional output is activated if **motor temperature** is higher than threshold “M1.8-1 Motor temperature threshold “MotTmpTh”” OR if **controller temperature** is higher than threshold “M1.8-2 Controller temperature threshold “CtrTmpTh””, while it is deactivated when motor temperature gets lower than threshold “M1.8-1 Motor temperature threshold “MotTmpTh””- 8 °C of hysteresis AND controller temperature gets lower than threshold “M1.8-2 Controller temperature threshold “CtrTmpTh””- 8 °C of hysteresis.

5.4.4 Remote LED

This function is ran inside the DMC SigmaLITE Controller to mimic the behaviour of the red LED on top of the controller.
Assigning this functional output to a physical output may be useful to drive an external blinking fault indicator.

5.4.5 Drive OK indicator

This function is ran inside the DMC SigmaLITE Controller to signal when an error code is active.
Assigning this functional output to a physical output may be useful indicate that the SigmaLITE controller has some active error. The functional output is activated when an error code is present.

5.4.6 No function assigned

When the selection “no function assigned” is performed for a digital output, then the DMC SigmaLITE Controller is expecting that the command to drive the corresponding output is being sent Via CAN from a VCU. This allows the user to use the DMC SigmaLITE Controller’s outputs to drive customized functions.
There is also the option to make the outputs to run as “PWM-controller”. In this case, the user must send Via CAN both the activation/deactivation command and the PWM duty cycle (in %) at which the output should be ran. Notice that, in this latter case, the output voltage will be a consequence of the specified PWM, ranging from 0V to the voltage present

at “Pin A15 Key B+ input”. The minimum applicable duty cycle is 6%, while the maximum applicable is 94% Below the minimum threshold, it will default to 0%, while above the maximum threshold it will default to 100%.

6 Configurable parameters

The SigmaLITE Controller's parameters are structured in a user-friendly menu/submenu approach. The menu represent the main hierarchical macro-areas of configuration, while the parameters are grouper by function in each submenu. The following table represents in a "tree view" all the menus and submenus.

Menu	Submenu
Menu 1 "Adjustment" for pump software	Menu 1.1 "Pump speeds"
	Menu 1.2 "Powersteer"
	Menu 1.3 "Drive response"
	Menu 1.4 "End Of Braking"
	Menu 1.5 "Creep"
	Menu 1.6 "Speed regulator"
	Menu 1.7 "Accelerator"
Menu 2 "Controller Setup" for pump software	
Menu 3 "Autotuning"	
Menu 4 "Motor Setup"	*Available submenus depend on motor technology, refer to proper manual (*[4] for AC, [5] for PMS and [6] for IPM*)*
Menu 5 "Limits Setup"	Menu 5.1 "Speed limits"
	Menu 5.2 "Motor thermal limits"
	Menu 5.3 "Voltage limits"
	Menu 5.4 "Battery current limits"
	Menu 5.5 "Performance table"
	Menu 5.6 "Timed current limit"
	Menu 5.8 "Stall protection"
	Menu 5.9 "Speed guard function"
	Menu 5.10 "Encoder noise detection"
Menu 6 "Battery setup"	
Menu 7 "CAN Bus Setup"	Menu 7.1 "CAN general"
	Menu 7.2 "PDO premap"
	Menu 7.3 "Shared line contactor"
	Menu 7.4 "Display"
	Menu 7.5 "Safe Stop 1"
Menu 8 "Input/Output configuration"	Menu 8.1 "Input/output assignment"
	Menu 8.2 "Analogue input 1 configuration"
	Menu 8.3 "Analogue input 2 configuration"
	Menu 8.4 "Analogue input 3 configuration"
	Menu 8.5 "Digital output 1 configuration"
	Menu 8.6 "Digital output 2 configuration"
	Menu 8.7 "Digital output 3 configuration"
	Menu 8.8 "Digital output 4 configuration"
	Menu 8.9 "Digital output 5 configuration"
	Menu 8.10 "Wireoff and Shortcircuit detection"
Menu 9 "Dual motor"	

Menu 1 “Adjustment” for pump software

This menu includes all the adjustments for tuning the pump application properly.

The following sub-menus are available:

- Menu 1.1 “Pump speeds”
- Menu 1.2 “Powersteer”
- Menu 1.3 “Drive response”
- Menu 1.4 “End Of Braking”
- Menu 1.5 “Creep”
- Menu 1.6 “Speed regulator”
- Menu 1.7 “Accelerator”

6.1.1 Menu 1.1 “Pump speeds”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Speed 1 demand (Accelerator speed #1) ”Potmax1”	0RPM – 9000RPM	5RPM	0RPM	0x2011	0x1
2	Speed 2 demand (Accelerator speed #2) ”Pspeed2”	0RPM – 9000RPM	5RPM	0RPM	0x2011	0x2
3	Speed 3 demand ”Pspeed3”	0RPM – 9000RPM	5RPM	0RPM	0x2011	0x3
4	Speed 4 demand ”Pspeed4”	0RPM – 9000RPM	5RPM	0RPM	0x2011	0x4
5	Speed 5 demand ”Pspeed5”	0RPM – 9000RPM	5RPM	0RPM	0x2011	0x5
6	Minimum motor speed in cutback conditions ”MinSpeed”	0RPM – 9000RPM	5RPM	1200RPM	0x2011	0x6

M1.1-1 Speed 1 demand (Accelerator speed #1) ”Potmax1”

This sets the maximum pump speed that can be reached when the potentiometer connected to the input to which “Accelerator speed #1” functional input is assigned (see “Menu 8.1 “Input/output assignment””) is at 100%. Depending on parameter “M1.7-2 Pump speed #1 enabling configuration “Spd1 Cfg””, a switch may be needed to activate the “Speed #1” function. The said switch must be wired to the physical digital input to which the “Speed 1 activation” function is assigned. Alternatively, either “Accelerator speed #1” and “Speed #1 activation” functional inputs may come Via CAN.

The potentiometer demand will be scaled between “M1.2-2 Speed 6 demand (power steer speed) ”Pspeed6”” (when the “Powersteer” functional input is active) and the value defined by this parameter.

Example: Powersteer speed is set to 200RPM, Speed #1 is set to 1400 RPM. If powersteer functional input is not active, a signal of 50% accelerator will correspond to 1400RPM*50%=700RPM. In case the powersteer input is active (and thus the minimum running speed is 200RPM, a value of 50% accelerator will correspond to 200RPM+(1400RPM-200RPM)*50%=800RPM.

When the “Speed #1” function is active, this speed demand has the highest priority and overrides all other speed requests, except for “M1.1-2 Speed 2 demand (Accelerator speed #2) ”Pspeed2””, when that is trimmed by a potentiometer and its resulting demand is higher (see “M1.7-3 Pump speed #2 enabling configuration “Spd2 Cfg””).

The motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

CONTROL VIA CAN - IMPORTANT NOTICE!

Notice that this parameter is also used when controlling Via CAN in “Setpoint mode”. This means that the maximum motor RPM will always be limited to the value specified by this parameter.

M1.1-2 Speed 2 demand (Accelerator speed #2) ”Pspeed2”

This sets the pump speed when the physical digital input to which the “Speed 2 activation” functional input is assigned (see “Menu 8.1 “Input/output assignment””) is active, or when the corresponding command is coming Via CAN.

In case “M1.7-3 Pump speed #2 enabling configuration “Spd2 Cfg”” is set greater than 0, this speed can be trimmed by means of a potentiometer connected to the input to which “2” functional input is assigned (see “Menu 8.1 “Input/output assignment””). Alternatively, either “Accelerator speed #2” and “Speed #2 activation” functional inputs may come Via CAN.

The potentiometer demand will be scaled between “M1.2-2 Speed 6 demand (power steer speed) ”Pspeed6”” (when the “Powersteer” functional input is active) and the value defined by this parameter.

When the “Speed #2” function is active, it will override all other speed requests, except for “M1.1-1 Speed 1 demand (Accelerator speed #1) ”Potmax1””, when that is greater.

The motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

M1.1-3 Speed 3 demand ”Pspeed3”

This sets the pump speed when the physical digital input to which the “Speed 3 activation” functional input is assigned (see “Menu 8.1 “Input/output assignment””) is active, or when the corresponding command is coming Via CAN.
When pump speed #3 is active and neither pump speed #1 or pump speed #2 are active, it will override all other speed requests, except for the powersteer speed. When the “Powersteer” is active, the current speed demand will be the highest between Speed #3 and ”M1.2-2 Speed 6 demand (power steer speed) ”Pspeed6””.
The motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

M1.1-4 Speed 4 demand ”Pspeed4”

This sets the pump speed when the physical digital input to which the “Speed 4 activation” functional input is assigned (see “Menu 8.1 “Input/output assignment””) is active, or when the corresponding command is coming Via CAN.
When pump speed #44 is active and neither pump speed #1 or pump speed #2 or pump speed #3 are active, it will override all other speed requests, except for the powersteer speed. When the “Powersteer” is active, the current speed demand will be the highest between Speed #3 and ”M1.2-2 Speed 6 demand (power steer speed) ”Pspeed6””.
The motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

M1.1-5 Speed 5 demand ”Pspeed5”

This sets the pump speed when the physical digital input to which the “Speed 5 activation” functional input is assigned (see “Menu 8.1 “Input/output assignment””) is active, or when the corresponding command is coming Via CAN.
When pump speed #5 is active and neither pump speed #1 or pump speed #2 or pump speed #3 or pump speed #4 are active, it will override all other speed requests, except for the powersteer speed. When the “Powersteer” is active, the current speed demand will be the highest between Speed #3 and ”M1.2-2 Speed 6 demand (power steer speed) ”Pspeed6””.
The motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

M1.1-6 Minimum motor speed in cutback conditions ”MinSpeed”

If some performance limitation is active (Low voltage, Timed Current Limit, Motor Overtemperature, Controller Overtemperature, Performance Table or Battery drive current limit) and it is limiting the speed below this value, the motor is stopped and a failure is signalled (F26). This is necessary to protect pump from spinning too slow. This happens only in case the requested demand is greater than this parameter. If the actual requested demand is lower than this parameter and any of the overmentioned limitation is active, no fault is thrown.

6.1.2 Menu 1.2 “Powersteer”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Power steer input normally closed or normally open “Sp6NO/NC”	0 - 1	1	0	0x200C	0x3
2	Speed 6 demand (power steer speed) ”Pspeed6”	0RPM – 9000RPM	5RPM	0RPM	0x200C	0x4
3	Power steer delay ”PStrDly”	0s – 50s	1s	5s	0x200C	0x2
4	Accel/Decel ramp time for powersteer speed ”Paccel6”	0.1s – 10.0s	0.1s	5.0s	0x200C	0x5

M1.2-1 Power steer input normally closed or normally open “Sp6NO/NC”

This sets the active polarity for the powersteer functional input:

- If set to **0 (NO)**, the powersteer function will be active when the switch connected to the physical input to which the “Powersteer” function is assigned (see “Menu 8.1 “Input/output assignment””) is closed, or when the corresponding CAN command is 1.
- If set to **1 (NC)**, the powersteer function will be active when the switch connected to the physical input to which the “Powersteer” function is assigned (see “Menu 8.1 “Input/output assignment””) is open, or when the corresponding CAN command is 0.

M1.2-2 Speed 6 demand (power steer speed) ”Pspeed6”

This sets the pump speed when the physical digital input to which the “Powersteer” functional input is assigned (see “Menu 8.1 “Input/output assignment””) is active, or when the corresponding command is coming Via CAN When both the power steer trigger input and another speed input are active, the resultant speed demand will be the highest between the two.
The motor will accelerate or decelerate to the powersteer speed using the rates defined by parameter “M1.2-4 Accel/Decel ramp time for powersteer speed ”Paccel6””.

M1.2-3 Power steer delay ”PStrDly”

This sets the period for which the powersteer speed will remain active after the trigger source input will be deactivated. Please notice that the “Power steer management” functional output will remain active for the same amount of time and will not be deactivated as soon as the triggering source will be removed as well.

M1.2-4 Accel/Decel ramp time for powersteer speed ”Paccel6”

When the power steer trigger is active and its demand is prevailing, the controller uses this rate for acceleration and deceleration instead of those set by “M1.3-1 Acceleration ramp time “Acc Ramp”” and “M1.3-2 Deceleration ramp time ”Dec Ramp””.

6.1.3 Menu 1.3 “Drive response”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Acceleration ramp time “Acc Ramp”	0.1s - 10.0s	0.1 s	2.2 s	0x2000	0x1
2	Deceleration ramp time ”Dec Ramp”	0.1s - 10.0s	0.1 s	0.3 s	0x2000	0x2
3	Pump brake torque limit “BrkTqLim”	0% - 100%	1%	0%	0x2019	0x1

M1.3-1 Acceleration ramp time “Acc Ramp”

This sets the time taken to accelerate from zero speed to maximum speed. The maximum speed demand is set by “Maximum motor frequency” (adjustable in “Menu 3 “Autotuning””). Increasing the value results in a slower pump response, while decreasing the value results in a faster pump response.

M1.3-2 Deceleration ramp time ”Dec Ramp”

This sets the time taken to decelerate from maximum speed to zero speed. Increasing the value results in a slower pump deceleration, while decreasing the value results in a faster pump deceleration.
This parameter is active in case of partial reduction of the demand. When pump speed is required to be zero the controller let the motor pump coasting (no torque applied) and then the deceleration ramp will depend on the fluid dynamic friction in the hydraulic system.

M1.3-3 Pump brake torque limit “BrkTqLim”

This sets the strength of the braking when the vehicle is in neutral or deceleration. The setting is a percentage of maximum motor torque.
If set this parameter to 0%, there is no active brake torque available during braking.
For sensorless applications, the minimum brake torque is 15% even if this parameter is set to 0% or below 15%.

BRAKING IN PUMP SOFTWARE - IMPORTANT NOTICE!

Actively braking (with braking torque and regenerative current) is not normally allowed in pump software in order to not damage the pump itself.
There are two conditions when active braking is possible, even though “M1.3-3 Pump brake torque limit “BrkTqLim”**” is set to 0%.**

1) **In case of 20% overspeeding. If the speed of the motor is higher than 20% of Maximum speed set in the autotuning menu the controller starts to actively braking to limit the speed of the pump.**
2) **Pump is turning in reverse direction and the controller want to drive the motor in the forward direction. Forward direction is the only one allowed by pump software.**

Both cases can occur if the hydraulic system in some way is “dragging” the pump/motor system.

6.1.4 Menu 1.4 “End Of Braking”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Speed threshold to enter End-of-Braking (EoB) mode ”SpdThEbM”	0.1% - 50.0%	0.1%	5.0 %	0x2006	0x1
2	Zero speed threshold “ZSpdTh”	0.1% - 10.0%	0.1%	1.5 %	0x2006	0x2
3	Ramp time from the EoB speed threshold to zero ”SpdRmpTm”	0.1s – 20.0s	0.1s	0.1s	0x2006	0x4

M1.4-1 Speed threshold to enter End-of-Braking (EoB) mode ”SpdThEbM”

This parameter defines the speed threshold under which the “End of braking” function is activated.

M1.4-2 Zero speed threshold “ZSpdTh”

This setting defines the zero speed threshold to detect when the vehicle has reached stationary condition.

M1.4-3 Ramp time from the EoB speed threshold to zero ”SpdRmpTm”

It defines the “rounded ramp” maximum ramp time to reach zero speed once “End of braking” mode is entered.

6.1.5 Menu 1.5 “Creep”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Creep speed ”Creep”	0RPM – 9000RPM	5RPM	0RPM	0x2007	0x2
2	Creep ramp time “CreepRmp”	0.1s – 20.0s	0.1s	2.5 s	0x2007	0x3

M1.5-1 Creep speed ”Creep”

This effectively sets the initial speed that the pump will adopt on entering drive.
Increasing the value will help minimize any delay from selecting drive to creeping the pump. The value relates to the motor speed, i.e. the motor’s rotor frequency.

M1.5-2 Creep ramp time “CreepRmp”

This parameter sets the ramp time for applying creep speed.

6.1.6 Menu 1.6 "Speed regulator"

Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	Proportional gain speed controller "KpSpd"	0.1 – 63.9	0.1	14.0	0x2010	0x1
2	Integral gain speed controller "KiSpd"	0.1 – 1999.9	0.1	9.0	0x2010	0x2
3	Enable double PI gains for speed controller "SpdPIx2"	0 – 1	1	1	0x2010	0x3
4	Double PI speed threshold "SpdPITh"	0% - 50%	1%	8%	0x2010	0x4
5	Proportional gain speed controller below threshold "KpSpdLow"	0.1 – 63.9	0.1	8.0	0x2010	0x5
6	Integral gain speed controller below threshold "KiSpdLow"	0.1 – 1999.9	0.1	30.0	0x2010	0x6
7	Transition time between the double PI regulators for speed controller "TransTim"	0.01s – 5.00s	0.01 s	0.3s	0x2010	0x7

M1.6-1 Proportional gain speed controller "KpSpd"

In torque mode it determines how aggressively the speed controller limits the speed of the motor to the active speed limit value. Larger values provide tighter control.
If Kp is set too high, oscillations could arise when the controller starts to limit speed.
If Kp is set too low, the top speed might result higher than speed limit (overshoot).

In speed mode it determines how quickly the speed controller attempts to match the demanded speed. Larger values provide quicker control.
If Kp is set too high, oscillations may arise as the motor approaches demanded speed.
If Kp is set too low, the top speed might result higher than speed limit (overshoot) and the speed control might be very slow.

M1.6-2 Integral gain speed controller "KiSpd"

In torque mode it determines how quickly the speed steady state error is zeroed. In other words how quickly speed is stabilized to the active speed limit value. Larger values provide faster speed limiting.
If Ki is set too high, oscillations could arise when the controller starts to limit speed.
If Ki is set too low, it may take a long time before speed is stabilized to the speed limit value.

In speed mode it determines how quickly the speed steady state error is zeroed. In other words how quickly speed is stabilized to the speed demand value. Larger values provide faster speed stabilization.
If Ki is set too high, oscillations could arise when the controller starts to limit speed.
If Ki is set too low, it may take a long time before speed is stabilized to the speed limit value.

M1.6-3 Enable double PI gains for speed controller "SpdPIx2"

This setting enables a dual set of gains for speed controller.

- If set to **0** only one set of speed controller gains is adopted ("M1.6-1 Proportional gain speed controller "KpSpd"" and "M1.6-2 Integral gain speed controller "KiSpd"").
- If set to **1** two sets of speed controller gains are adopted. If the actual speed is below "M1.6-4 Double PI speed threshold "SpdPITh"" the low speed gains are adopted ("M1.6-1 Proportional gain speed controller "KpSpd"" and "M1.6-2 Integral gain speed controller "KiSpd""). If the actual speed is higher than "M1.6-4 Double PI speed threshold "SpdPITh"" the high speed gains are adopted ("M1.6-5 Proportional gain speed controller below threshold "KpSpdLow"" and "M1.6-6 Integral gain speed controller below threshold "KiSpdLow"").

M1.6-4 Double PI speed threshold "SpdPITh"

This parameter sets the speed threshold for speed control to move from low speed PI gains to high speed PI gains. It is referred to "Maximum motor frequency" set in "Menu 3 "Autotuning".

M1.6-5 Proportional gain speed controller below threshold "KpSpdLow"

This parameter has the same meaning of "M1.6-1 Proportional gain speed controller "KpSpd"". This is applied if "M1.6-3 Enable double PI gains for speed controller "SpdPIx2"" is set to 1 and actual speed is above "M1.6-4 Double PI speed threshold "SpdPITh"".

M1.6-6 Integral gain speed controller below threshold “KiSpdLow”

This parameter has the same meaning of “M1.6-2 Integral gain speed controller “KiSpd””. This is applied if “M1.6-3 Enable double PI gains for speed controller “SpdPIx2”” is set to 1 and actual speed is above “M1.6-4 Double PI speed threshold “SpdPITh””.

M1.6-7 Transition time between the double PI regulators for speed controller “TransTim”

This parameter sets the time is needed for moving from low-speed gains to high-speed gains and vice versa. A too small value can produce a bumpy transition.

6.1.7 Menu 1.7 "Accelerator"

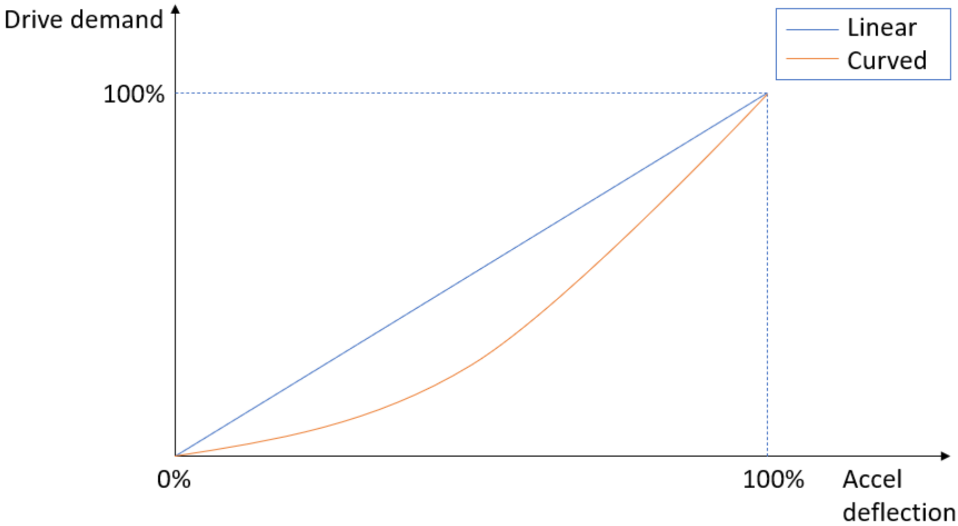
Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	Accelerator characteristic "Lin/Curv"	0 – 1	1	0	0x2009	0x1
2	Pump speed #1 enabling configuration "Spd1 Cfg"	0 – 2	1	0	0x2009	0x7
3	Pump speed #2 enabling configuration "Spd2 Cfg"	0 – 2	1	0	0x2412	0x0

M1.7-1 Accelerator characteristic "Lin/Curv"

This parameter defines the accelerator pedal characteristic: Linear or Curved.

- If set to **0**, the controller will apply a **linear** accelerator input.
- If set to **1**, the controller will apply a **curved** accelerator input.

The definition of each type is detailed below:
Linear: For input values of 0%, 50% and 100%, the output will be 0%, 50% and 100%.
Curved: For input values of 0%, 50% and 100%, the output will be 0%, 25% and 100%.



M1.7-2 Pump speed #1 enabling configuration "Spd1 Cfg"

This parameter allows to activate the "speed #1" function only when a switch is closed or when an enabling signal is coming Via CAN. This is helpful to provide some safety on the activation of the trimmed speed #1.

- If set to **0 (No switch)**, a potentiometer without an integrated switch connected can be used. The motor demand will be based exclusively on the signal applied to the analogue input to which the "Accelerator speed #1" functional input is assigned. The "Speed #1" function will therefore be activated as soon as there is some accelerator present.
- If set to **1 (With switch)**, then a potentiometer with a switch must be used. The "Speed #1" function will then be activated only in case the switch to which "Speed 1 activation" functional input is assigned is closed, or if the corresponding CAN signal is coming.
- Is set to **2 (Active on powersteer)**, then the "Speed #1" function will become active together with the "Powersteer" function, regardless of the status of the switch to which "Speed 1 activation" functional input is assigned. This allows the user to select an adjustable speed on top of "M1.2-2 Speed 6 demand (power steer speed) "Pspeed6"", with the typical delayed shut-off or powersteer.

M1.7-3 Pump speed #2 enabling configuration "Spd2 Cfg"

This parameter defines the activation condition of the "Speed #2" function:

- If set to **0 (standard switch)**, than the demand will match "M1.1-2 Speed 2 demand (Accelerator speed #2) "Pspeed2"" as soon as the physical input to which "Speed 2 activation" functional input becomes active, or the corresponding CAN command is received. The signal on the analogue input to which the "Accelerator speed #2" function is assigned, or the corresponding CAN command, is disregarded in this case.
- If set to **1 (trimmed with switch)**, than the demand will be trimmed between "M1.2-2 Speed 6 demand (power steer speed) "Pspeed6"" and "M1.1-2 Speed 2 demand (Accelerator speed #2) "Pspeed2"" according to the signal on the analogue input to which the "Accelerator speed #2" function is assigned. The analogue input reading will be active only when the physical digital input to which the "Speed 2 activation" function becomes active.
- If set to **2 (trimmed without switch)**, than the demand will be trimmed between "M1.2-2 Speed 6 demand (power steer speed) "Pspeed6"" and "M1.1-2 Speed 2 demand (Accelerator speed #2) "Pspeed2"" according to the signal on the analogue input to which the "Accelerator speed #2" function is assigned. The analogue input reading will always be active regardless of the status to which the physical digital input to which the "Speed 2 activation" function.

6.1.8 Menu 1.8 “Cooling”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Motor temperature threshold “MotTmpTh”	10°C – 127°C	1°C	70°C	0x2C03	0x1
2	Controller temperature threshold “CtrTmpTh”	10°C – 100°C	1°C	45°C	0x2C03	0x2

M1.8-1 Motor temperature threshold “MotTmpTh”
M1.8-2 Controller temperature threshold “CtrTmpTh”

These two settings represent the motor and controller temperature thresholds to activate the Digital Output configured as “Motor fan”, “Controller Fan” or “Combo fan”.
Assign the proper function to the output in “Menu 8.1 “Input/output assignment”” to activate the said functions.
Please notice that the deactivation threshold is 10 °C lower than the set parameter.
Example: “Motor fan” function is assigned to output 3. “M1.8-1 Motor temperature threshold “MotTmpTh”” is set to 80°C. DO3 will be activated when the motor threshold raises above 80°C. Once active, DO3 will only be deactivated when the motor temperature drops below 70°C (80°C-10°C).

Menu 2 "Controller Setup" for pump software

This menu embraces all the settings that are used to activate the DMC SigmaLITE Controller functions. It of extreme importance to set up this menu according to the desired functions required and then re-cycle the key to make changes active.

Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	Inhibit input Normally Open or Normally Close "HibNO/NC"	0 - 1	1	0	0x240B	0x0
2	Enable power up checks "Nchk/Chk"	0 - 1	1	0	0x240C	0x0
3	Dual motor configuration "DMconfig"	0 - 3	3	0	0x2403	0x0
4	Precharge voltage threshold "PreChgLv"	50% - 100%	1%	90%	0x2C00	0x1
5	Precharge timeout time "PreChgTO"	0s – 12s	1s	10s	0x2C00	0x2
6	Digital output PWM chopping frequency "DO freq"	0.1 kHz – 2 kHz	0.1 kHz	2 kHz	0x2413	0x0
7	Calibration data option "CalValue"	0 - 0	0	0	0x2409	0x0
8	Load defaults "LoadDefs"	0 - 1	1	0	0x240A	0x0

M2-1 Inhibit input Normally Open or Normally Close "HibNO/NC"

This sets the active polarity for the "Inhibit" functional input:

- If set to **0 (NO)**, the inhibit function will be active when the switch connected to the physical input to which the "Inhibit" function is assigned (see "Menu 8.1 "Input/output assignment"") is closed, or when the corresponding CAN command is 1.
- If set to **1 (NC)**, the inhibit function will be active when the switch connected to the physical input to which the "Inhibit" function is assigned (see "Menu 8.1 "Input/output assignment"") is open, or when the corresponding CAN command is 0.

If inhibit functional input becomes active, the pump is immediately stopped and a failure (F 03) is signalled. Notice that the inhibit function does not effecting the powersteer function. Therefore, in case both the powersteer and inhibit functions are active, then the pump will spin at "M1.2-2 Speed 6 demand (power steer speed) "Pspeed6"", while signalling F03.

M2-2 Enable power up checks "Nchk/Chk"

This sets whether or not the pump inputs and short circuit are checked at power-up.

- If set to **0 (NO check)**, then the following power-up safety checks will not be performed:
  i. Pump potentiometer > 0.5% or Speed 1 switch closed (depending on the setting of "M1.7-2 Pump speed #1 enabling configuration "").
  ii. Speed 2, 3, 4 or 5 closed.
- If set to **1 (Check)**, then the safety checks will be performed at power-up. If one of the inputs is active at power up the pump is kept locked and failure F12 is displayed. Input 6 "power steer" is not checked.

M2-3 Dual motor configuration "DMconfig"

This setting is used for enabling the Dual Motor function. For pump application only two possibilities are available:

- If set to 0 (single motor), the SigmaLITE Controller is used to drive a standard 3-phase motor.
- If set to 1 (Dual Motor Master), the SigmaLITE Controller has to be used in combo with another SigmaLITE Controller (with Traction SW configured in torque mode), to drive a 6-phase motor.

For details about Dual Motor applications refer to [3].

M2-4 Precharge voltage threshold "PreChgLv"

This set the Precharge voltage threshold for closing line contactor as a percentage of the battery voltage. The controller will close the line contactor when capacitor voltage is above the percentage the "Precharge voltage threshold".

M2-5 Precharge timeout time ”PreChgTO”

This parameter sets the time out for closing line contactor. If capacitor voltage does not reach “Precharge voltage threshold” within the time out a failure is signalled.

M2-6 Digital output PWM chopping frequency “DO freq”

This parameter can be used to change the chopping frequency used to lower the voltage applied at the digital outputs 1 to 4.

M2-7 Calibration data option “CalValue”

Not used yet.

M2-8 Load defaults “LoadDefs”

If this parameter is set to 1 (load defaults) all the setting in all menus will be restored to the default factory values.
This parameter requires a key cycle off-on to be effective.

Menu 3 "Autotuning"

The DMC SigmaLITE Controller embeds the possibility to perform an automatic tuning of the motor's sensor and parameters. Several feedback sensors can used and auto-tuned: Sin/Cos Encoder, Incremental encoder and Hall sensors. This feature allows the user to have plug-and-play configuration that ease the usage of the controller. A small set of data have to be entered for the procedure to be completed.
After initiating the auto tuning, the motor will spin: it is therefore important for the motor to have the possibility to spin freely. This reflects on traction software in the way that the vehicle must be lifted such that the wheels can rotate freely.
The auto tuning takes from 2 to 10 minutes to complete according to motor technology and autotuning option selected
After a successful auto tuning, all the parameters in the "Menu 4 - Motor setup" will have new values.
Please notice that there is the possibility to change the parameters of the "Menu 3 – AutoTuning" after the autotune procedure has been completed, but a "Recalculation" procedure must be performed or Autotuning should be run again.
In the next section only general information about the Autotuning feature will be reported. For proper setting description and more accurate information about Autotuning procedure please refer to the motor technology manual of interest ([4] for AC, [5] for PMS and [6] for IPM).

6.1.9 Setting up auto tuning

The auto tuning algorithm needs a basic set of parameters in order to get the best results. Usually these values are printed on the motor name plate or provided on a datasheet. This basic set consists of the following parameters:

Auto Tuning Parameter	Brief description
Number of motor poles	Set the number of poles
*Sensor technology	Choose the sensor type
*Number of sensor encoder teeth/waves	Set the number of teeth or sine waves per revolution
Sensor encoder supply voltage	Choose 5 volt or 12 volt sensor supply
Reverse sensor reading	Reverse the reading speed direction Clock Wise /Counter Clock Wise
Reverse motor direction	Reverse the motor direction assigned to Forward (swap ClockWise/CounterClockWise)
Nominal Battery Voltage	Set the nominal battery voltage
Nominal RMS motor current for autotuning	Set the nominal motor current FOR AUTOTUNING (suggested 1/3 of motor continuous current for PMS/IPM, Continuous current or S2 60min for AC))
Maximum RMS motor current	Set the maximum required motor current
*Maximum demagnetizing current	If field weakening is required, enter the maximum allowed motor current in field weakening. Set to 1 to disable. To high values will damage the motor magnets. Consult motor manufacture first! (ONLY FOR PMS)
*Nominal motor frequency	Set the motor nominal frequency (FOR AC only)
Maximum desired motor frequency	Set the maximum required motor frequency corresponding to maximum desired speed.

(*) Parameters marked with a star assume different meanings or may not be present at all in some motor technologies. Please refer to the specific manual of the employed motor technology for details.

6.1.10 Mandatory parameters

Some parameters of the AutoTuning menu are of crucial importance for a proper tuning of motor control.

Nominal battery voltage

This parameter repents the nominal voltage of installed battery pack. It must be set to the correct level to guarantee proper motor operation, especially in field weakening. The DMC SigmaLITE Controller is capable of compensating both over- and under-voltage swings of the power battery pack.
After autotuning it is possible to change this parameter if necessary, but a recycle of the key and a "Recalculation" procedure is required.

Maximum motor current

This parameter sets the maximum current that will be injected in the motor when 100% of torque will be required. It corresponds to the highest current limit for the motor.
After autotuning it is possible to change this parameter if necessary, but a recycle of the key and a "Recalculation" procedure is required

Nominal Frequency and current

This parameters are needed for AC motor technology.

Maximum motor frequency

This parameter sets the maximum rotor speed and it correspond to 100% of speed.

After autotuning it is possible to change this parameter if necessary, but a recycle of the key and a "Recalculation" procedure is required.

WARNING!

Maximum care must be taken when selecting the maximum motor frequency.
Especially on permanent magnets synchronous motors, consider that at very high speeds the motor rotation may produce a high back-EMF.
In case of faults at high rotational speeds, when line contactor is opened, the produced voltage reflects on the controller's internal capacitors, which, due to natural low power absorption capability, will rapidity increase in voltage and may blow.
DMC has developed the so called "overvoltage short-circuit protection" and can actively short-circuit the motor phases in case a fault happens at a speed which is considered to be critical. This feature has to enabled manually. Please see [6] for details.
DMC declines any responsibility for incorrect setup of this parameters.

Menu 4 “Motor Setup”

This menu embraces all the parameter related to the motor configuration. It is automatically set up by the Autotuning, but some parameters can be tuned manually to achieve an even better motor behaviour. For more information about these parameters and the possible option for the final user configuration, please refer to the motor technology manual of interest ([4] for AC, [5] for PMS and [6] for IPM).

Menu 5 “Limits Setup”

The following setup menu includes all the limits adjustable in the SigmaLITE Controller for assuring a proper behaviour within voltage, current and temperature operative range.

The following sub-menus are available:

- Menu 5.1 “Speed limits”
- Menu 5.2 “Motor thermal limits”
- Menu 5.3 “Voltage limits”
- Menu 5.4 “Battery current limits”
- Menu 5.5 “Performance table”
- Menu 5.6 “Timed current limit”
- Menu 5.8 “Stall protection”
- Menu 5.9 “Speed guard function”
- Menu 5.10 “Encoder noise detection”

6.1.11 Menu 5.1 “Speed limits”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Absolute maximum motor speed “AbsMaxSp”	0RPM – 9000RPM	5RPM	6000RPM	0x2600	0x1

M5.1-1 Absolute maximum motor speed “AbsMaxSp”

For safety reason a motor overspeed fault detection is active in software (both traction and pump). If speed is greater than this adjustment (Absolute maximum motor speed “AbsMaxSp”) a failure occurs (F30, see section “9.1 Main uP error codes”). For a proper tuning this parameter has to be set to 30% above the maximum speed set in the autotuning menu.

6.1.12 Menu 5.2 "Motor thermal limits"

Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	Motor temperature sensor type "MtempTyp"	0 - 3	1	0	0x2602	0x1
2	Motor temperature cutback start level "TempStrt"	0°C – 151°C	1°C	0°C	0x2602	0x2
3	Motor temperature cutback span "TempSpan"	0°C – 49°C	1°C	10°C	0x2602	0x3
4	Motor temperature high error level "TempErr"	0°C – 199°C	1°C	165°C	0x2602	0x4
5	Motor temperature offset "T offset"	-20°C – 20°C	1°C	0°C	0x2603	0x1
6	Sensor resistance at temperature 1 "Res at T1"	50Ω-10kΩ	10Ω	500Ω	0x2603	0x2
7	Motor temperature 1 "MTemp1"	-40°C – 200°C	1°C	0°C	0x2603	0x3
8	Sensor resistance at temperature 2 "Res at T2"	50Ω-10kΩ	10Ω	700Ω	0x2603	0x4
9	Motor temperature 2 "MTemp2"	-40°C – 200°C	1°C	50°C	0x2603	0x5
10	Sensor resistance at temperature 3 "Res at T3"	50Ω-10kΩ	10Ω	1kΩ	0x2603	0x6
11	Motor temperature 3 "MTemp3"	-40°C – 200°C	1°C	100°C	0x2603	0x7
12	Sensor resistance at temperature 4 "Res at T4"	50Ω-10kΩ	10Ω	1.25kΩ	0x2603	0x8
13	Motor temperature 4 "MTemp4"	-40°C – 200°C	1°C	150°C	0x2603	0x9
14	Sensor resistance at temperature 5 "Res at T5"	50Ω-10kΩ	10Ω	1.5kΩ	0x2603	0xA
15	Motor temperature 5 "MTemp5"	-40°C – 200°C	1°C	200°C	0x2603	0xB

M5.2-1 Motor temperature sensor type "MtempTyp"

This parameter select the type of motor temperature sensor connected:

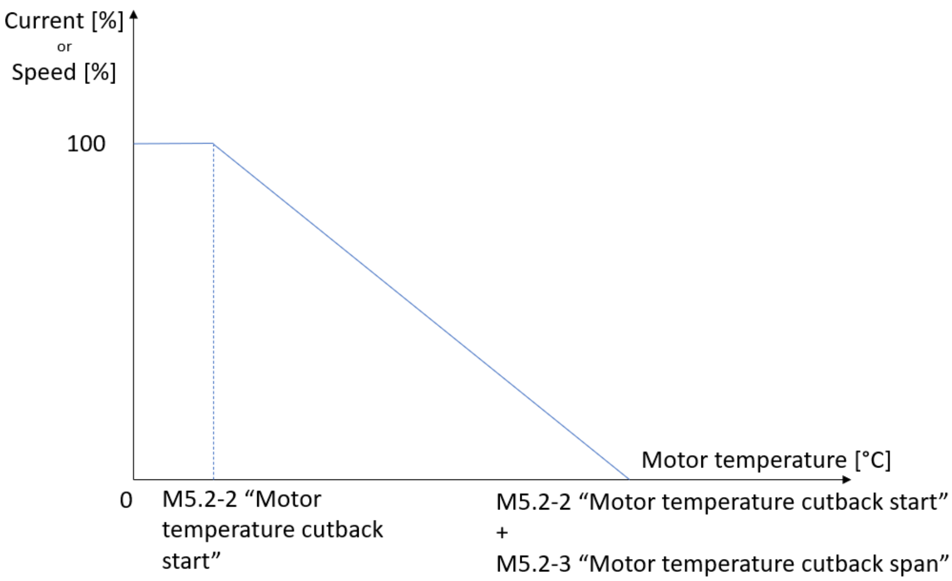
- if set to **0** a **KTY84-130** sensor has to be connected;
- if set to **1** a **Pt1000** sensor that has 1000 Ohm @0°C has to be connected;
- if set to **2** a **Pt1000** sensor that has 1000 Ohm @25°C has to be connected;
- If set to **3** a **configurable 5 point Resistance/Temperature curve temperature sensor** can be connected.

Refer to "Pin A20 Thermistor input" for details of connection.

M5.2-2 Motor temperature cutback start level "TempStrt"
M5.2-3 Motor temperature cutback span "TempSpan"
M5.2-4 Motor temperature high error level "TempErr"

High temperature cutback

This parameter sets the temperature at which the controller starts to cut back the motor current.
The maximum current/speed value is cut as soon as the motor temperature is above "M5.2-2 Motor temperature cutback start level "TempStrt"" and is cut back proportionally to the temperature between the starting point and an adjustable span above it, selectable by means of "M5.2-3 Motor temperature cutback span "TempSpan"".



Increasing “M5.2-3 Motor temperature cutback span “TempSpan”” allows for a smoother cut of motor current/speed, at the cost of motor temperature overshooting more above “M5.2-2 Motor temperature cutback start level “TempStrt””. A small value of “M5.2-3 Motor temperature cutback span “TempSpan”” assures an immediate cut/reduction of motor temperature, but with a more aggressive effect on motor current.
As maximum current, the setting “Maximum motor current” (adjustable in “Menu 3 “Autotuning””) is considered.
Example:
If the value of “M5.2-2 Motor temperature cutback start level “TempStrt”” is 150 °C, the value of “M5.2-3 Motor temperature cutback span “TempSpan”” is 10°C and the value of “Maximum motor current” (adjustable in “Menu 3 “Autotuning””) is 150A, the current will be limited to 75A when the motor temperature is 155 °C and to 0 when the motor temperature is 160 °C.
The current cut back is applied only to drive current/torque, thus it does not affect any breaking operation.
Current cut back based on motor temperature can be disabled by setting “M5.2-2 Motor temperature cutback start level “TempStrt”” at 151 °C.

High temperature error

Parameter “M5.2-4 Motor temperature high error level “TempErr”” defines a threshold above which the motor temperature is considered unacceptable and therefore an hard error is provoked. This parameter can be used, for example, in case a large value for “M5.2-3 Motor temperature cutback span “TempSpan”” is set (in order to have a smoother cut of motor current/speed), but the resulting cutback end level is an unacceptable temperature for the motor.

M5.2-5 Motor temperature offset “T offset”

This parameter is used to set an offset for the motor temperature measured by the sensor connected. It is useful to compensate sensor accuracy tolerance. It can be both positive and negative.

M5.2-6 Sensor resistance at temperature 1 “Res at T1”
M5.2-7 Motor temperature 1 “MTemp1”
M5.2-8 Sensor resistance at temperature 2 “Res at T2”
M5.2-9 Motor temperature 2 “MTemp2”
M5.2-10 Sensor resistance at temperature 3 “Res at T3”
M5.2-11 Motor temperature 3 “MTemp3”
M5.2-12 Sensor resistance at temperature 4 “Res at T4”
M5.2-13 Motor temperature 4 “MTemp4”
M5.2-14 Sensor resistance at temperature 5 “Res at T5”
M5.2-15 Motor temperature 5 “MTemp5”

Those parameters are visible only if “M5.2-1 Motor temperature sensor type “MtempTyp”” is set to 3. They define the Resistance/Temperature curve in 5 points for a temperature sensor connected that is not covered by the controller built in sensor types 0-1-2.
The curve might cover both “classical” and NTC (Negative Thermal Coefficient) thermal sensors. The sensor type will be automatically detected and managed by the entered curve. Please notice that it is only possible to enter only either ALL increasing resistance values (for classical thermal sensors) or ALL decreasing resistance values (for NTC thermal sensors).

6.1.13 Menu 5.3 "Voltage limits"

Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	Low voltage cutback start level "LVCBstrt"	16.0V - 60.0V	0.1V	20.0V	0x2604	0x1
2	Low voltage cutback end level "LVCBend"	16.0V - 60.0V	0.1V	16.0V	0x2604	0x2
3	Low voltage error level "LVerror"	15.0V - 60.0V	0.1V	15.0V	0x2604	0x3
4	High voltage cutback start level "HVCBstrt"	24.0V - 62.0V	0.1V	58.0V	0x2605	0x1
5	High voltage cutback end level "HVCBend"	24.0V - 62.0V	0.1V	62.0V	0x2605	0x2
6	High voltage error level "HVerror"	24.0V – 63.0V	0.1V	63.0V	0x2605	0x3

M5.3-1 Low voltage cutback start level "LVCBstrt"
M5.3-2 Low voltage cutback end level "LVCBend"
M5.3-3 Low voltage error level "LVerror"

Low voltages occur when the battery is discharged. Or when a large power (current) surge from the battery occurs, for example, the vehicle is about to drive.

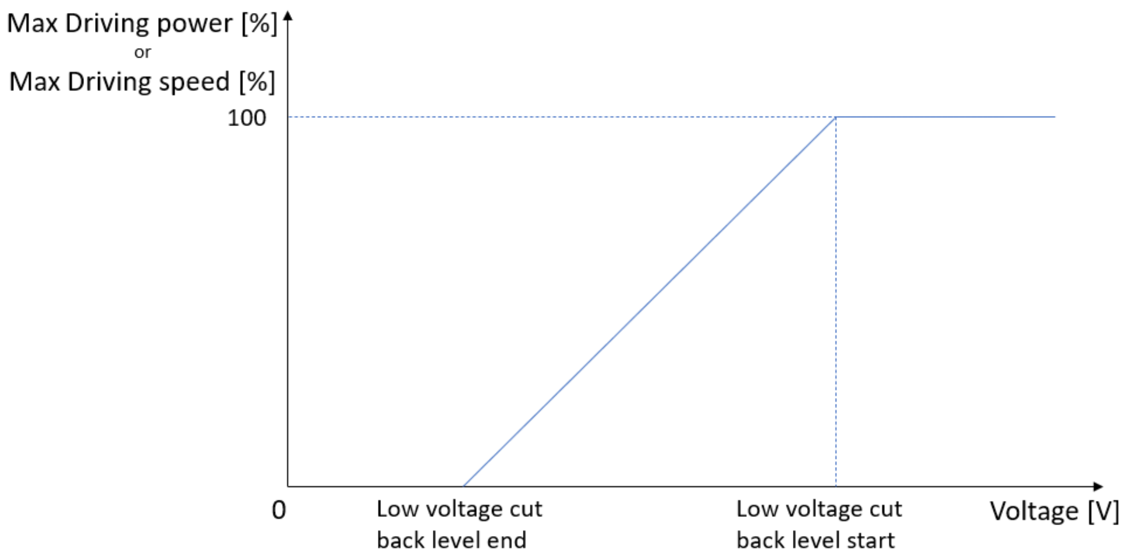
Low voltage cut back

When the voltage is getting low, the controller will limit the power withdrawn from the battery. It will do this by cutting back the maximum drive power with a percentage as shown in the graph below. Only drive power is cut back. Brake power is *not* cut back.

When there is no cut back, the maximum drive power is 100 %.
When the cut back is 100 %, the maximum drive power is at 0 %.

The maximum drive power is the drive power that is available to the user. As long as the user doesn't use this drive power, it will not be noticed. But when the user demands more drive power, the drive power is limited to the maximum drive power available. When this occurs, the Status menu of the controller shows the 'LV' limit indication. Also the error F02 is displayed during low voltage cut back.
The maximum drive power limit will run from 100 % (no cut back) to 0 % (full cut back). This is displayed also in the Status Menu at "DriveTqLim".

The low voltage start and end cut back levels are adjustable in the SigmaLITE controllers.



Low voltage limit

The low voltage limit is the absolute limit of the controller and the motor. When the voltage is below this level, the controller will immediate stop driving (and braking) the motor (stops with giving power to the motor) and will report an error F17.

Parameters
The controller will have a set of parameters with which the low voltage cut back can be tuned. The controller itself must be protected at all times, thus there is a lower limit which cannot be altered. The parameters can only be tuned ‘up’ to protect the battery and motor of the user.

The parameters are:

- Low voltage cut back start threshold
- Low voltage cut back end threshold
- Low voltage error threshold

The location, unit, range and step size of these adjustments can be found in the “Menu 5 “Limits Setup””.

M5.3-4 High voltage cutback start level “HVCBstrt”
M5.3-5 High voltage cutback end level “HVCBend”
M5.3-6 High voltage error level “HVerror”

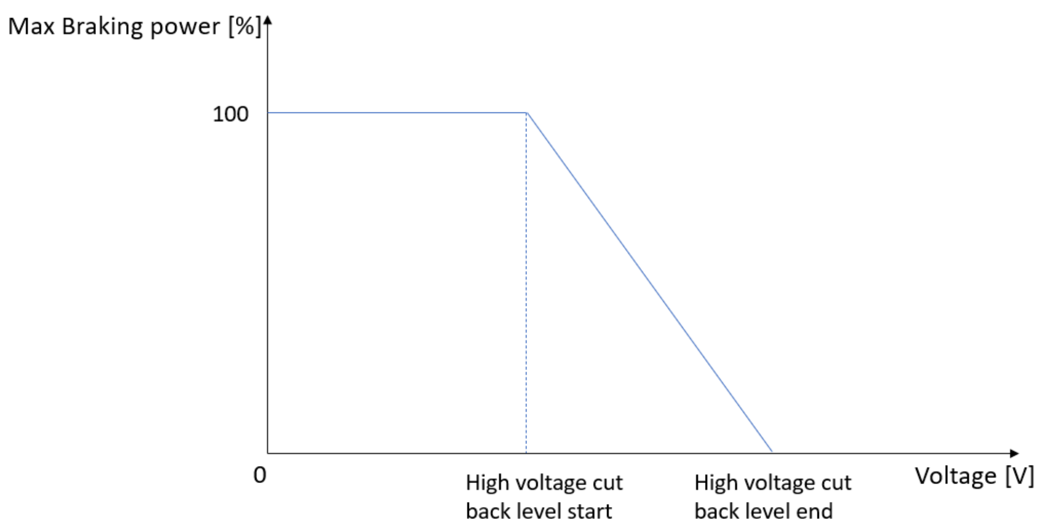
High voltage occurs when the battery is fully charged. Or when a large power (current) surge to the battery occurs, for example, the vehicle is braking hard.

High voltage cut back
When the voltage is getting high, the controller will limit the power withdrawn from the battery. It will do this by cutting back the maximum brake power with a percentage as shown in the graph below. Only brake power is cut back. Drive power is *not* cut back.

When there is no cut back, the maximum brake power is 100 %.
When the cut back is 100 %, the maximum brake power is at 0 %.

The brake maximum power is the power that is available to the user. As long as the user doesn’t use this brake power, it will not be noticed. But when the user demands more brake power, the brake power is limited to the maximum brake power available. When this occurs, the Status menu of the controller shows the ‘HV’ limit. Also the error F04 is displayed during high voltage cut back.

The maximum brake power limit will run from 100 % (no cut back) to 0 % (full cut back). This is displayed also in the Status Menu at “BrakeTqLim”.



High voltage limit
The high voltage limit is the absolute limit of the controller and the motor. When the voltage is above this level, the controller will immediate stop driving and braking the motor (stops with giving power to the motor) and will report an error F22.

Parameters

The controller will have a set of parameters with which the high voltage cut back can be tuned. The controller itself must be protected at all times, thus there is a higher limit which cannot be altered. The parameters can only be tuned 'up' to protect the battery and motor of the user.

The parameters are:

- High voltage cut back start threshold
- High voltage cut back end threshold
- High voltage error threshold

The location, unit, range and step size of these adjustments can be found in reference in the "Menu 5 "Limits Setup"".

Other limits

The controller may have other limits in effect (e.g. controller temperature limit or high voltage limit). The module which is limiting the most, will apply the limit. The 'DrvTqLim and 'BrkTqLim' will then show the limit of the corresponding module.

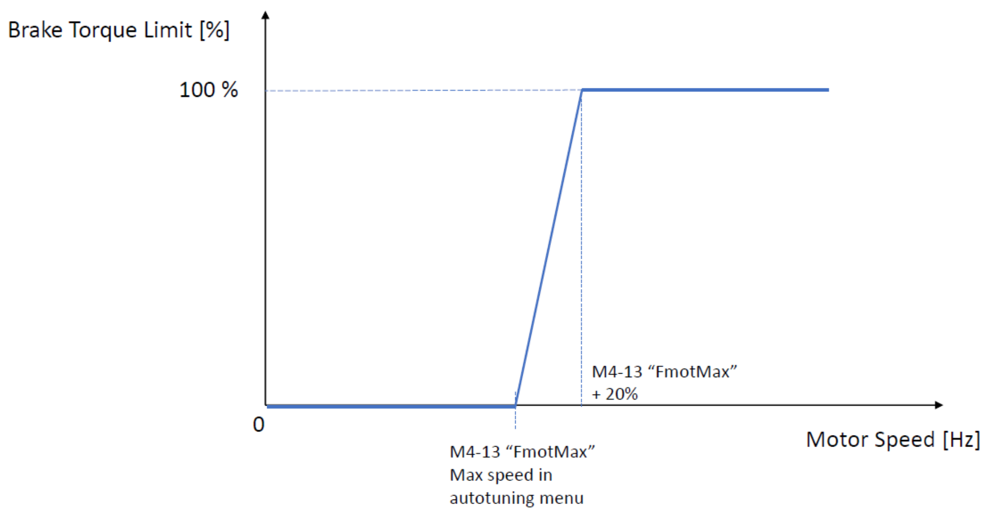
<u>Example</u>

- Controller temperature limit 50 %
- Low voltage cut back limit[1)] 70 %
- High voltage cut back limit[1)] 30 %
- Applicable <u>drive</u> limit → 50 % → 'CT'
- Applicable <u>brake</u> limit → 30 % → 'HV'

[1)] Of course, both a high voltage and a low voltage cut back should not occur simultaneously, but is done here to illustrate the applicable limits.

A note on drive and brake

A controller is able to drive and brake a motor. Pump application firmwarer is only driving motors and never braking, even during ramp down the speed, unless "M1.3-3 Pump brake torque limit "BrkTqLim"" is set different than 0%.
Since the pump application is using speed control, for safety reasons, the controller will brake the motor if speed is going above the 100% of maximum speed set in M4-13 Max motor Frequency "FmotMax". This should never happen unless the pump is moved by an active load. This is therefore a form of braking and the high voltage cut back applies. When "M1.3-3 Pump brake torque limit "BrkTqLim"" is set, the brake torque limit is always set to zero, unless the speed goes above M4-13 Max motor Frequency "FmotMax". The brake toque limit is increased up to 100% when speed is reaching the 120% of M4-13 Max motor Frequency "FmotMax" as reported in the following picture.



If in application no braking is desired the M4-13 Max motor Frequency “FmotMax” has to be defined sufficiently higher (120% for example) than maximum speed desired for the application.

6.1.14 Menu 5.4 “Battery current limits”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Drive battery current limit “IBattMax”	0A – 300A	1A	300A	0x2606	0x1
2	Regenerative battery current limit “IBattReg”	0A – 300A	1A	300A	0x2606	0x2
3	Battery current limit cut rate “ICutRate”	20 - 600	1	200	0x2606	0x7
4	Battery current limit cut rate fine adjustment “ICutRtFN”	10 - 200	1	20	0x2606	0x8
5	Regenerative BCL enabled during direction braking “BCLRegDB “	0 - 1	1	0	0x2606	0x9

M5.4-1 Drive battery current limit “IBattMax”
M5.4-2 Regenerative battery current limit “IBattReg”

These two settings define the static Batery Current Limits (BCL) for motor drive or regen current in the battery. They are active both for pump and traction software. If set to 700.0A (default value) the corresponding BCL is disabled.

The behavior of these values depend on setting “M7.2-4 Battery current limit via CAN enable “BclCanMs””.

M5.4-3 Battery current limit cut rate “ICutRate”

This setting is to tune how fast the battery current limit is acting. It sets the rate of action when the battery current is far from the battery current limit value.

Most of the times default values are fine. It has to be increased if the battery current limit is too slow in action. It has to be decreased if battery current limit when is start to be active is too harsh. This adjustment is active on both drive and regen battery current limits.

M5.4-4 Battery current limit cut rate fine adjustment “ICutRtFN”

This setting is to tune how fast the battery current limit is acting when the battery current value is close to the battery current limit one. Thus is setting the fine action on battery current limitation.

Most of the times default values are fine. It has to be adjusted if some battery current oscillation in the range of 5-15 A are noticed or if the drive feeling shows some oscillation when battery current limitation is active. In this case try first to increase and if not solve the oscillation try to reduce it. This adjustment is active on both drive and regen battery current limits.

M5.4-5 Regenerative BCL enabled during direction braking “BCLRegDB “

- If this parameter is set to **0, Regenerative battery current is not limited during Direction Braking** operation. This option is the default condition and is made to give the possibility to stop the motor, when spinning reverse since dragged by hydraulic system, in case of regenerative battery current limitation.
- If this parameter is set to **1, Regenerative Battery Current limit during Direction Braking is enabled**. This means that Regen Battery current limitation is always active for any braking condition.

WARNING!

If the setting is set to 1 the priority is given to the battery safe operation, so current limitation is done with priority on braking conditions. This option is better if controller is managed via CAN by a PLC or VCU that supervise driving functionality and/or the motor and controller are used as a generator.

If the setting is set to 0 the priority is given to the driving safe operation for avoiding possible roll back on slope.

NOTICE!

This parameter has a straight effect on the behaviour of a DMC Controller when:

- **It is used in a Master/Slave Dual Motor application.**

For details about those application and the impact of this parameter, please refer to the specific manual ([1]).

Resume of Battery Current Limit adopted in each situation

	BCL Via CAN or Via BMS	Static standard BCL (M5.4-1 and M5.4-2)
BCL Via CAN not enabled		×
BCL Via CAN enabled BCL Via CAN not timed out	×	
BCL Via CAN enabled BCL Via CAN timed out		×

BRAKING IN PUMP SOFTWARE IMPORTANT NOTICE!

Actively braking 8with braking torque and regenerative current) is not normally allowed in pump software in order to not damage the pump itself.

There are two conditions when active braking is possible.

3) **In case of 20% overspeeding. If the speed of the motor is higher than 20% of Maximum speed set in the autotuning menu the controller starts to actively braking to limit the speed of the pump.**
4) **Pump is turning in reverse direction and the controller want to drive the motor in the forward direction. Forward direction is the only one allowed by pump software.**

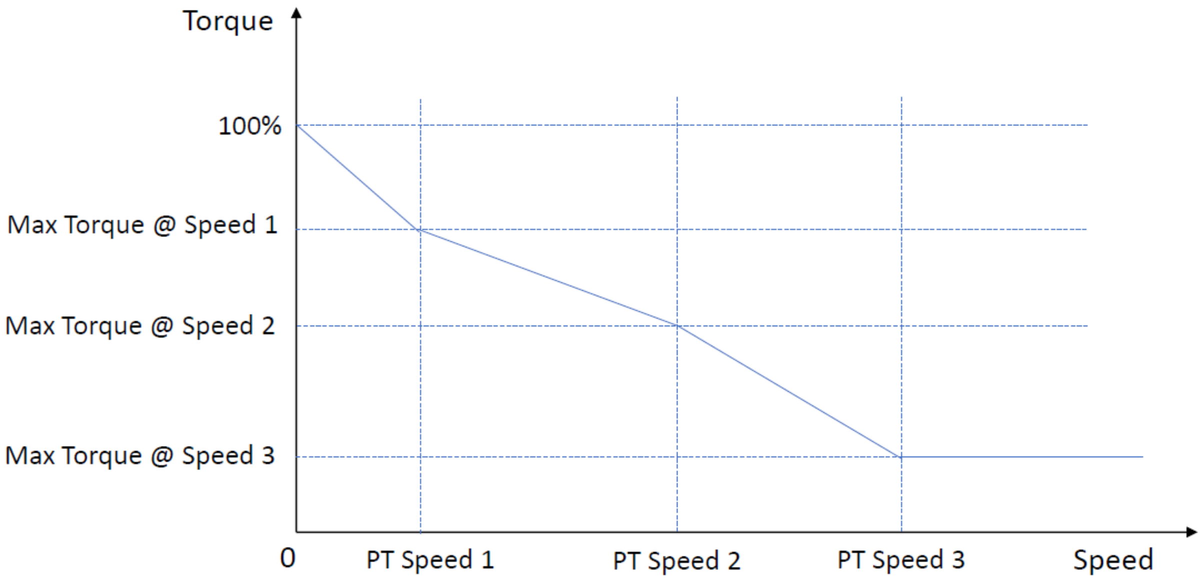
Both cases can occur if the hydraulic system in some way is “dragging” the pump/motor system.

6.1.15 Menu 5.5 “Performance table”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Performance table speed 1 “PTSpd1”	0% - 100%	1%	50%	0x2607	0x1
2	Performance table speed 2 “PTSpd2”	0% - 100%	1%	75%	0x2607	0x2
3	Performance table speed 3 “PTSpd3”	0% - 100%	1%	100%	0x2607	0x3
4	Performance table cutback 1 “PTCutBk1”	0% - 100%	1%	100%	0x2607	0x4
5	Performance table cutback 2 “PTCutBk2”	0% - 100%	1%	100%	0x2607	0x5
6	Performance table cutback 3 “PTCutBk3”	0% - 100%	1%	100%	0x2607	0x6

M5.5-1 Performance table speed 1 “PTSpd1”
M5.5-2 Performance table speed 2 “PTSpd2”
M5.5-3 Performance table speed 3 “PTSpd3”
M5.5-4 Performance table cutback 1 “PTCutBk1”
M5.5-5 Performance table cutback 2 “PTCutBk2”
M5.5-6 Performance table cutback 3 “PTCutBk3”

The Performance Table feature (setting from 5.5-1 to 5.5-6) is a Torque limiting feature: the maximum torque is limited with increasing speed.
The Performance Table sets a specified percentage of the maximum Torque for a specified speed as shown in the graph below. The Performance Table will only limit the drive torque/current, not the brake torque/current. The brake torque/current is limited as the drive current for speed below the 5% of the maximum motor speed that is expressed in the setting “FmotMax” in the Autotune menu.



The controller will have a set of parameters with which the Performance Table can be set up. The table consists of three speed settings and three current settings:

- Performance Table Speed 1 (5.5-1)
- Performance Table Speed 2 (5.5-2)
- Performance Table Speed 3 (5.5-3)
- Percentage of the maximum Torque at speed 1 (5.5-4)
- Percentage of the maximum Torque at speed 2 (5.5-5)
- Percentage of the maximum Torque at speed 3 (5.5-6)

***Note** that the performance table speed are percentage of* “Maximum motor current” *(adjustable in* “Menu 3 “Autotuning”*”).*
For example if Maximum motor frequency*is 200 Hz and the desired three Performance table speeds are: Speed1 50Hz, Speed2 130 Hz and Speed3 185Hz set PTSpeed 1 to 25% (50x100%/200) Speed2 to 65% (130x100%/200) and Speed 3 to 92% (185*100%/200)*

The limit will run from 100 % (no cut back) to 0 % (full cut back). This is displayed also in the Status Menu at "Drive Availability".
When the Performance Table is actually limiting the current with respect to the drive speed, the Status menu will show 'PT' limit indication.

Failure messages related to performance table
F7 S709 is the failure code related to performance table. It happens when performance table is being set not in the correct order. When finish to set up the performance table recycle the key. If F7 S709 is there it means that in the Performance table settings are not consistent.
Here the situations that gives F7 S709:

- if Performance Table Cutback 1 is lower than Performance Table Cutback 2 or Performance Table Cutback 2 is lower than Performance Table Cutback 3.
- it is also related to the performance table Speed 1, 2,3. In fact for a proper setting to avoid F07 S709 Speed1 must be lower than Speed 2 and Speed 2 must be lower than Speed 3

To solve F7 S709 make sure that Performance Table Cutback 1 is greater than Performance Table Cutback 2 and Performance Table Cutback 2 is greater than Performance Table Cutback 3. Furthermore check that Performance Table Speed 1 is lower than Performance Table Speed 2 and Performance Table Speed 2 is lower than Performance Table Speed 3.

Interaction with Other limits
The controller may have other limits in effect (e.g. controller temperature limit or high voltage limit). The module which is limiting the most, will apply the limit. The 'drive availability' will then show the limit of the corresponding module.

Example

- Controller temperature limit 50 %
- Performance Table 80 %
- Applicable limit → 50 %
- Applicable module → Controller temperature (indicated by 'CT').

Interaction with Motor Module performance table
The motor module current reduction map in field weakening is reducing current as a function of the speed too. See settings in motor set up menu field weakening. It means that the lower value for torque limiting between the Performance table and motor module torque reduction map is applied.

Disabling Performance Table
Performance Table Drive Torque Reduction is totally excluded when the three percentage of reduction settings are set to 100%.
To disable the torque cutback due to Performance Table; set the maximum torque at speed 1,2 ,3 to 100 % (setting 5.5-4 to 5.5-6)

6.1.16 Menu 5.6 "Timed current limit"

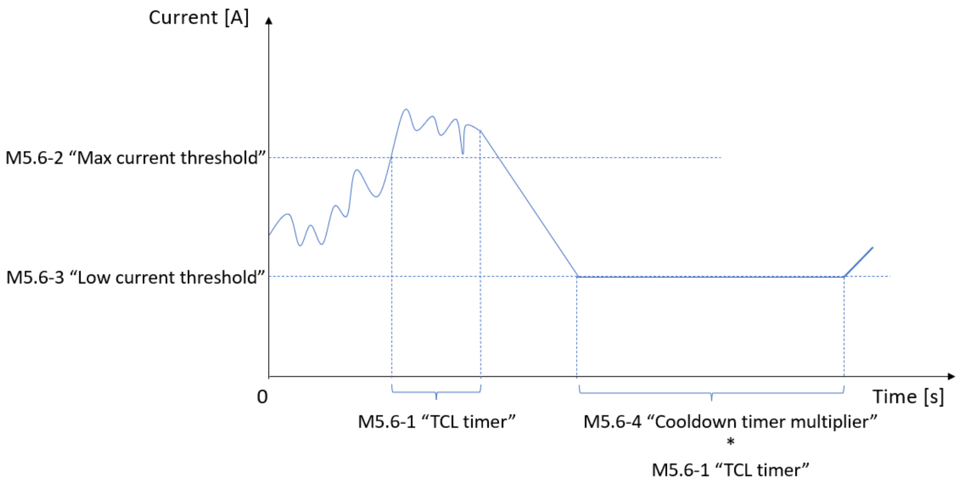
Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	Timed current limit timer "IthTime"	0s – 60s	1s	0s	0x2608	0x1
2	Timed current limit maximum current threshold "CurrTh"	10A - Max Amp	5A	Max Amp	0x2608	0x2
3	Timed current limit low current threshold "ImaxLow"	10A - Max Amp	5A	Max Amp	0x2608	0x3
4	Timed current limit cooldown time "CoolDwTm"	1.0 – 5.0	0.1	3.0	0x2608	0x4

M5.6-1 Timed current limit timer "IthTime"
M5.6-2 Timed current limit maximum current threshold "CurrTh"
M5.6-3 Timed current limit low current threshold "ImaxLow"
M5.6-4 Timed current limit cooldown time "CoolDwTm"

Timed current Limit

The graph below shows the parameters that are involved in setting up the Timed Current Limit. This feature can be used to protect the vehicle's motor(s) from overheating.

If the current rises above a set threshold ("M5.6-2 Timed current limit maximum current threshold "CurrTh"") for a specified period of time ("M5.6-1 Timed current limit timer "IthTime""), the controller can reduce the maximum current available to the motor to a lower current ("M5.6-3 Timed current limit low current threshold "ImaxLow""). After the reduction has occurred, the maximum current output will remain at the lower level for a period of "M5.6-4 Timed current limit cooldown time "CoolDwTm"" times the "M5.6-1 Timed current limit timer "IthTime"". If necessary, once this period has expired, the current can then be returned to its original level.



Example:

"M5.6-2 Timed current limit maximum current threshold "CurrTh"" is set to 420Arms
"M5.6-3 Timed current limit low current threshold "ImaxLow"" is set to 400Arms
"M5.6-1 Timed current limit timer "IthTime"" is set to 10s
"M5.6-4 Timed current limit cooldown time "CoolDwTm"" is set to 5s

If the motor current is above 420Arms for 10 seconds, then the controller will reduce the maximum current available to 400Arms for a period of 50 seconds (5 x 10 secs).

6.1.17 Menu 5.8 “Stall protection”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Torque threshold for stall protection “TrqTHLim”	1.0% - 100.0%	0.1%	100.0%	0x260A	0x1
2	Stall protection timer “StallTim”	0.0s – 120.0s	0.1s	60.0s	0x260A	0x2

M5.8-1 Torque threshold for stall protection “TrqTHLim”
M5.8-2 Stall protection timer “StallTim”

A motor stall protection is available to prevent to keep motor at full current and no speed for long time.

If the motor is stuck at zero speed with a toque greater than “Torque threshold for stall protection “TrqTHLim”” and for a time longer than “M5.8-2 Stall protection timer “StallTim”” the controller stops giving power to the motor and a motor stall condition is detected.

Setting to 100% the “Torque threshold for stall protection “TrqTHLim”” the function is disabled. As default stall protection is disabled.

6.1.18 Menu 5.9 “Speed guard function”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Speed control guard tracking error threshold “SpdGrdTH”	0% - 40%	1%	0%	0x260C	0x1
2	Speed control guard timer “SpdGrdTm”	0.1s – 12.0s	0.1s	0.1s	0x260C	0x2

M5.9-1 Speed control guard tracking error threshold “SpdGrdTH”
M5.9-2 Speed control guard timer “SpdGrdTm”

Those parameter define the “Speed guard function” behaviour.
The “Speed guard” function is enabled when parameter “M5.9-1 Speed control guard tracking error threshold “SpdGrdTH”” is set greater than 0.
This function provided an high safety level for vehicles controlled in speed mode, since it tracks the error between the demanded speed and the actual speed of the motor. If this error is above the set threshold for a time grated than “M5.9-2 Speed control guard timer “SpdGrdTm””, the motor stops and the EMbrake closes immediately.
Therefore if, for example, the vehicle is trying to climb a slope but is has not enough torque to succeed, the speed error will be very large and the function will recognise the “stall” condition, closing the EMbrake and avoiding the vehicle to roll back.

6.1.19 Menu 5.10 “Encoder noise detection”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Encoder noise detection “EncodND”	0 - 1	1	0	0x260B	0x1
2	Noise detection error threshold “Noise Err”	1 - 200	1	100	0x260B	0x2
3	Noise speed difference threshold “Noise Diff”	0 - 400	0.1	25	0x260B	0x3

M5.10-1 Encoder noise detection “EncodND”

This setting is used only in AC motor technology.

This set enable a check for excessive noise on motor encoder signals. If set to 1 the noise detection is enabled if set to 0 disabled. The noise detection threshold are adjustable and for detailed description see limit parameters “M7-24 Noise detection Threshold Error “Noise Err”” and “M7-25 Noise Speed Diff Threshold “Noise Diff””. This settings is not used with PMS motor technology

This parameter requires a key cycle off-on to be effective.

M5.10-2 Noise detection error threshold “Noise Err”
M5.10-3 Noise speed difference threshold “Noise Diff”

These two settings are active if “” is set to 1. When the measured speed present a variation in Hz greater than “M7-25 Noise Speed Diff Threshold “Noise Diff”” for a number of times greater than “M7-24 Noise detection Threshold Error “Noise Err”” in a time of 100 ms a failure is signaled (F28 S001). This happen for excessive noise on encode signal (sensor damaged or bad wiring).

! IMPORTANT The change of these settings is active if key cycle power off/on is performed

Menu 6 "Battery setup"

The following menu includes the settings for the BDI algorithm and for battery current limitation.

Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	BMS configuration "BMS cfg"	0 - 11	1	0	0x2803	0x0
2	BMS master controller "BMS Mast"	0 – 1	1	1	0x2804	0x0
3	BMS current repartition "ShareCur"	0% - 100%	1%	100%	0x2806	0x0
4	**Allow driving during BMS recharge "Drv@Chg"**	0 – 1	1	0	0x2807	0x0
5	BMS node number "BMS Node"	0 - 127	1	0	0x2808	0x0
6	Maximum BMS current "MaxBattA"	0A – 600A	1A	300A	0x2805	0x0
7	Nominal battery voltage "NomBattV"	12V – 72.5V	0.1V	48V	0x2800	0x1
8	BDI reset level "BDIreset"	12V – 72.5V	0.1V	48V	0x2801	0x1
9	BDI empty level "BDIempty"	12V – 72.5V	0.1V	48V	0x2801	0x2
10	BDI warning level "BDIwarn"	0% - 99%	1%	20%	0x2801	0x3
11	BDI cutout level "BDIcut"	0% - 99%	1%	0%	0x2801	0x4
12	BDI speed limit "BDIspeed"	0RPM – 4000RPM	5RPM	3000RPM	0x2802	0x0
13	Maximum BMS temperature "MaxBattT"	-20°C – 100°C	1°C	80°C	0x2016	0x1
14	Minimum BMS temperature "MinBattT"	-20°C – 100°C	1°C	0°C	0x2016	0x2

M6-1 BMS configuration "BMS cfg"

This setting specified whether the DMC SigmaLITE Controller is supposed to work in combination with a BMS. For details please refer to [8].

- If to **0 (No BMS)**, no BMS communication is assumed;
- If set to **1 (FlashBattery BMS)**, the SigmaLITE Controller will expect to communicate with a FlashBattery BMS system.
- If set to **2 (Micropower Ebrix BMS)**, the SigmaLITE Controller will expect to communicate with a Ebrix BMS system.
- If set to **3 (Cellpower BMS)**, the SigmaLITE Controller will expect to communicate with a Cellpower BMS system.
- If set to **4 (HyperDriveInnovation BMS)**, the SigmaLITE Controller will expect to communicate with a HyperDriveInnovation BMS system.
- If set to **5 (Lionic BMS)**, the SigmaLITE Controller will expect to communicate with a Lionic BMS system.
- If set to **6 (BatteryLabs BMS)**, the SigmaLITE Controller will expect to communicate with a BatteryLabs BMS system.
- If set to **7 (Vanguard SinglePack BMS)**, the SigmaLITE Controller will expect to communicate with a Single-pack Vanguard BMS system.
- If set to **8 (Vanguard DoublePack BMS)**, the SigmaLITE Controller will expect to communicate with a Double-Pack Vanguard BMS system.
- If set to **9 (Eleo BMS)**, the SigmaLITE Controller will expect to communicate with a Eleo BMS system.
- If set to **10 (Maxwell&Spark BMS)**, the SigmaLITE Controller will expect to communicate with a Maxwell&Spark BMS system.
- If set to **11 (Custom BMS)**, then the Sigma2N Rx messages must be configured by the user in order to communicate with a customized BMS. Details for this implementation will be given in [8].

M6-2 BMS master controller "BMS Mast"

This parameter is used to define if the DMC SigmaLITE Controller will act as a "BMS master". This implies that the following tasks will be performed:

1) Manage the NMT message to BMS (in case it is required by the adopted BMS);
2) Manage the SYNC message to the BMS (in case it is required by the adopted BMS);
3) Manage the RxPDOs messages to the BMS (in case it is required by the adopted BMS);
4) Manage the BMS information to be sent to the DMC Display.

Notice that, even if a DMC Controller has this parameter set to "0", it will receive all the BMS information and react to BMS warnings, errors and timeouts. Anyway, it will not manage the BMS itself (sending NMT, SYNC, etc..) and this might cause a misfunction.
In a CAN network with a BMS and only one DMC SigmaLITE Controller, it is mandatory that the DMC SigmaLITE Controller has this parameter set to "1".
In a CAN network with a BMS and more than one DMC SigmaLITE Controller, it is mandatory that **only one** Controller has this parameter set to "1". All other Controllers must have this parameter to "0".

M6-3 BMS current repartition "ShareCur"

This parameter defines the percentage of Drive/Regenerative battery current actually absorbed by the DMC SigmaLITE Controller among the total available Drive/Regenerative current value limited by the BMS. For examples and details please refer to [8].

M6-4 Allow driving during BMS recharge "Drv@Chg"

This parameter can be used to allow the SigmaLITE controller to drive even while the BMS is commanding a battery charge.
Mind that this situation may be dangerous, as the vehicle can be driven away with the battery charger still plugged in.
It is only suggested to enable it on stationary vehicles/actuators.

M6-5 BMS node number "BMS Node"

This parameter sets the BMS node number, it only works when set to > 0 and when the "General BMS" function is active ("M6-1 BMS configuration "BMS cfg"" set to #11").
If the above conditions are verified, the DMC controller will be able to receive CAN 1open EMCY messages (ID 0x80 + node nr) from the BMS and cut off power as soon as it receives it.

M6-6 Maximum BMS current "MaxBattA"

This parameter defines the maximum peak current that the battery can output. This is assumed equal to the maximum current that the battery can receive when the motor is braking.
This parameter assumes two different meanings, depending on the BMS adopted:

1) For scaling the dynamic maximum allowed Drive and regenerative current, in case the BMS is sending those values in percentage (BBS FLASH BATTERY).
NOTICE: when FlashBattery BBS is asking to reduce drive current by its maximum value, the current is not cut completely. It is possible to set a "minimum cut value" trough parameter "M5.4-1 Drive battery current limit "IBattMax"". This means that the drive current will be linearly cut between "M6-6 Maximum BMS current "MaxBattA"" and "M5.4-1 Drive battery current limit "IBattMax"". If you wish to cut drive current to 0 when the BBS is asking for "max reduction", set "M6-6 Maximum BMS current "MaxBattA"" to 0 or higher than "M5.4-1 Drive battery current limit "IBattMax"".
2) For limiting the Drive and Regenerative current, in case the BMS is sending only "Allow drive current" and "Allow regen current" bits (LIONIC BMS and ELEO BMS). Please notice that for ELEO BMS, regenerative current is set to 90% of this value.

M6-7 Nominal battery voltage "NomBattV"

Is the nominal value of the battery connected to the controller.

M6-8 BDI reset level "BDIreset"

This sets the voltage at which the BDI will reset to show a 100% charged battery on the Sigmagauge or the DMC Display. This setting only has an effect at power-up.
The adjustable range is from 18V to controller absolute maximum voltage, that corresponds to 125% of the nominal operating voltage of the controller.

M6-9 BDI empty level "BDIempty"

This sets the 0% state of charge level for the BDI. Whenever the battery voltage is equal to or less than "Nominal battery voltage "NomBattV"" battery voltage, the BDI value will start to decrease.

M6-10 BDI warning level "BDIwarn"

This sets the level of State Of Charge at which the BDI warning icon on the Sigmagauge and DMC Display will start to flash.
The calibrator displays the BDI warning condition in "Menu 0 "Status"".

M6-11 BDI cutout level “BDIcut”

This parameter can be disabled by setting it to 0.

In pump software if the level of State Of Charge is below which the pump speed will be limited to “M6-12 BDI speed limit “BDIspeed””, with the exception of the PowerSteer operation.

The calibrator displays the BDI cut condition in the “Menu 0 “Status””.

M6-12 BDI speed limit “BDIspeed”

This parameter fixed the maximum speed at which the pump is allowed to run in case the SOC is below the cutout level defined by “M6-11 BDI cutout level “BDIcut””.

M6-13 Maximum BMS temperature “MaxBattT”

This parameter defines the maximum battery temperature allowed. It used for scaling the battery temperature bargraph on the DMC Display. It only has to be configured in the DMC SigmaLITE Controller with parameter “M6-2 BMS master controller “BMS Mast”” set to 1.

Notice that only custom displays have the capability to display the BMS temperature. Refer to DMC for customization request

M6-14 Minimum BMS temperature “MinBattT”

This parameter defines the maximum battery temperature allowed. It used for scaling the battery temperature bargraph on the DMC Display. It only has to be configured in the DMC SigmaLITE Controller with parameter “M6-2 BMS master controller “BMS Mast”” set to 1.

Notice that only custom displays have the capability to display the BMS temperature. Refer to DMC for customization request

Menu 7 “CAN Bus Setup”

The SigmaLITE controller comes with a fully standard CAN Open protocol for sending and receiving information to and from other CAN nodes.
It is highly advisable to refer to the proper Application Note [1].
For the sake of simplicity, only the basic CAN parameters will be described in this section.
Detailed information about CAN Open protocol will be provided on request.
As default the CAN system is deactivated.

The following sub-menus are available:

- Menu 7.1 “CAN general”
- Menu 7.2 “PDO premap”
- Menu 7.3 “Shared line contactor”
- Menu 7.4 “Display”
- Menu 7.5 “Safe Stop 1”

6.1.20 Menu 7.1 "CAN general"

Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	CAN node number "CAN node"	1 - 127	1	1	0x2A03	0x0
2	CAN bit rate "CANbitRt"	0 - 3	1	2	0x2A04	0x0
3	Producer heartbeat time "CANOHrBt"	100ms – 1000ms	10ms	1000ms	0x1017	0x0
4	DualMotor and SharedLC messages on 29 or 11 bit IDs	0 - 1	1	0	0x2A0A	0x0
5	CAN communication powerup delay "PwrUpDly	0.0s – 5.0s	0.1s	0.0s	0x2A0B	0x0
6	CAN Open master SYNC produced enable	0 - 1	1	0	0x2A0F	0x0
7	SYNC generation time	10ms – 1000ms	10ms	100ms	0x2A10	0x0

M7.1-1 CAN node number "CAN node"

This sets the CAN node number for the controller. It must be uniquely assigned to each node of the netword. This is the ID on which SDO communication will be based.
In case "M7.2-1 PDO free mapping type "FreeMapT"" is set to 0 or 1, this is the node-ID that will be used for constructing the identifier of each message that the DMC SigmaLITE Controller will be able to send/receive.
In case "M7.2-1 PDO free mapping type "FreeMapT"" is set to 2 or 3, the user has the possibility to assign any node number to the message identifiers, but **SDO communication. DualMotor function and SharedLineContactor function will still be based upon this parameter**.

M7.1-2 CAN bit rate "CANbitRt"

It changes the Can communication rate of the controller:

- If set to **0**, the bitrate is 100 kbit/s
- If set to **1**, the bitrate is 125 kbit/s
- If set to **2**, the bitrate is 250 kbit/s
- If set to **3**, the bitrate is 500 kbit/s

The change is active only after a key power off-on cycle.

WARNING!

! VERY IMPORTANT if the bit rate of the controller is changed also the calibrator bit rate has to be changed to communicated again with the controller. If the calibrator bit rate and controller bit rate are set in a not consistent way the calibrator is not communicating with the controller. To change the calibrator bit rate, please follow the procedure "4.1.1 How to change the Calibrator's baudrate:**".**

M7.1-3 Producer heartbeat time "CANOHrBt"

This setting adjusts the transmit refresh rate or the Can Open Heartbeat messages.

M7.1-4 DualMotor and SharedLC messages on 29 or 11 bit IDs "DM&LC ID"

This parameter sets whether the CAN messages used to manage the DualMotor and Shared Line Contactor functions will be based on 11bit or 29bit CAN IDs.

- If set to **0 (29bit IDs)**, the Dual Motor and Shared Line Contactor functions will use the following CAN IDs:
  - 0x00000900 |Dual Motor Master Node Number
  - 0x00000900 | Dual Motor Slave Node Number
  - 0x00000A00 | Dual Motor Master Node Number
  - 0x00000A00 | Dual Motor Slave Node Number
  - 0x00000880 | Line Contactor Master Node Number
  - 0x00000880 | Line Contactor Slave #1 Node Number
  - 0x00000880 | Line Contactor Slave #n Node Number
- If set to **1 (11bit IDs)**, the Dual Motor and Shared Line Contactor functions will use the following CAN IDs:
  - 0x400 |Dual Motor Master Node Number
  - 0x400 | Dual Motor Slave Node Number
  - 0x500 | Dual Motor Master Node Number
  - 0x500 | Dual Motor Slave Node Number
  - 0x480 | Line Contactor Master Node Number
  - 0x480 | Line Contactor Slave #1 Node Number
  - 0x480 | Line Contactor Slave #n Node Number

Please notice that if using 11bit IDs for the said function, the user might create conflicts with the standard CAN Open IDs. Huge attention must be adopted when mapping the Controller's PDOs.

M7.1-5 CAN communication powerup delay "PwrUpDly"

This parameter sets a delay in starting any activity on the CAN bus. Until the delay is elapsed, the DMC Controller will not try to send and/or receive any message on the bus.

This delay is useful in case the CAN network is isolated and powered by a DC-DC converter. Under this condition, in case the DC-DC and Controller are powered up together with the same Key switch, it might happen that the DC-DC takes time to charge and actually provide output power, while the Controller is already "ready to run" and tries to start CAN bus activities. This would result in application errors, since the CAN bus could not be accessed (being it not powered).

M7.1-6 CAN Open master SYNC produced enable "SYNCprod"

This parameter instructs the Sigma2N or SigmaLITE controller to be a SYNC producer (role usually covered by a CAN Open Master). As default, the SYNC COB-ID follows the standard CAN Open specification (i.e. ID 0x080). This SYNC will be a message with DLC 1, containing an increasing counter from 0 to 255 and then rolling to 0.
Mind that in a CAN Open network, only one device should be set to be a SYNC producer.

M7.1-7 SYNC generation time "SYNCtime"

The parameter is used to set the timer for SYNC generation. The DMC Sigma2N or SigmaLITE controller will generate the SYNC message at this rate when setup to be a SYNC producer. Mind that in a CAN Open network, only one device should be set to be a SYNC producer.

6.1.21 Menu 7.2 “PDO premap”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	PDO free mapping type “FreeMapT”	0 - 3	1	0	0x2A06	0x0
2	RxPDO premapped configuration “RxPDOmap”	0 -6	1	0	0x2A07	0x0
3	TxPDO configuration “PDO cfg”	0 - 19	1	4	0x2A08	0x0
4	Battery current limit via CAN enable “BclCanMs”	0 - 1	1	0	0x2A09	0x0
5	Event timer TxPDO1 “TxPDO1Rt”	10ms – 9000ms	5ms	1000ms	0x1800	0x5
6	Event timer TxPDO2 “TxPDO2Rt”	10ms – 9000ms	5ms	100ms	0x1801	0x5
7	Event timer TxPDO3 “TxPDO3Rt”	10ms – 9000ms	5ms	100ms	0x1802	0x5
8	Event timer TxPDO4 “TxPDO4Rt”	10ms – 9000ms	5ms	1000ms	0x1803	0x5
9	Event timer RxPDO1 “RxPDO1TO”	10ms – 1000ms	5ms	150ms	0x1400	0x5
10	Event timer RxPDO2 “RxPDO2TO”	10ms – 1000ms	5ms	500ms	0x1401	0x5

M7.2-1 PDO free mapping type “FreeMapT”
M7.2-2 RxPDO premapped configuration “RxPDOmap”
M7.2-3 TxPDO configuration “PDO cfg”
M7.2-4 Battery current limit via CAN enable “BclCanMs”
M7.2-5 Event timer TxPDO1 “TxPDO1Rt”
M7.2-6 Event timer TxPDO2 “TxPDO2Rt”
M7.2-7 Event timer TxPDO3 “TxPDO3Rt”
M7.2-8 Event timer TxPDO4 “TxPDO4Rt”
M7.2-9 Event timer RxPDO1 “RxPDO1TO”
M7.2-10 Event timer RxPDO2 “RxPDO2TO”

For details about those parameters, please refer to the specific CAN Open manual [1].

6.1.22 Menu 7.3 "Shared line contactor"

Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	Shared line contactor option "SharedLC"	0 - 4	1	0	0x2A00	0x1
2	Shared line contactor reference node "Ref Node"	1 - 127	1	1	0x2A00	0x2
3	Shared line contactor refresh rate "SHLCRate"	15ms – 50ms	1ms	15ms	0x2A00	0x3

M7.3-1 Shared line contactor option "SharedLC"
M7.3-2 Shared line contactor reference node "Ref Node"
M7.3-3 Shared line contactor refresh rate "SHLCRate"

For details about those parameters, please refer to the specific CAN Open manual [1].

6.1.23 Menu 7.4 “Display”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Display node number “DispNode	1 - 127	1	1	0x2A01	0x1
2	Display status field “DispInfo”	1 - 7	1	7	0x2A01	0x2
3	Display refresh rate “RefRate”	100ms – 1000ms	10ms	200ms	0x2A01	0x3

M7.4-1 Display node number “DispNode”

If the DMC Controller is intended to communicate with a DMC Display, this parameter is used to set the node number of the DMC Display. It should be set coherently with the setting made inside the Display.
If the DMC Controller is intended to communicate with an iGauge, this parameter assumes different meanings depending on “M7.4-2 Display status field “DispInfo””:

- If the Controller is setup as an iGauge Master (“M7.4-2 Display status field “DispInfo”” set to 8), this parameter should indicate the node number of the last iGauge slave connected. In case no iGauge slave is connected, this parameter should match “M7.1-1 CAN node number “CAN node””.
- If the Controller is setup as an iGauge Slave (“M7.4-2 Display status field “DispInfo”” set to 9), this parameter should indicate the iGauge Master’s node number (which is in turn the iGauge node number).

NOTICE!

DMC Controller which are meant to communicate with an iGauge, should have consecutive node numbers, with the iGauge Master having the lowest node number between them.

M7.4-2 Display status field “DispInfo”

This sets the type of information that will appear in the General Indication Field of the DMC Display or how the Controller should behave with respect to the iGauge.

- If set to **0 (None)**, then the General Indication Field will be blank.
- If set to **1 (Accelerator/Demand)**, then the Accelerator/Demand as a percentage will be displayed, from 0% to 100%.
- If set to **2 (Motor Velocity)**, then the motor velocity-speed in units of RPM will be displayed, from 0 to the value set in “Maximum motor frequency” (adjustable in “Menu 3 “Autotuning””).
- If set to **3 (no info)**, then the General Indication Field will be blank.
- If set to **4 (no info)**, then the General Indication Field will be blank.
- If set to **5 (Motor Current)**, then the motor current in units of A will be displayed, from 0 to the maximum rated current of the controller.
- If set to **6 (Battery Current)**, then the battery current in units of A will be displayed, from 0 to the maximum rated current of the controller.
- If set to **7 (Disabled)**, then the DMC SigmaLITE Controller will not send any message to the DMC Display.

NOTICE!

If more than one DMC SigmaLITE Controller is in the CAN network, make sure only one of them has this parameter set between 1 and 6. This will be the DMC SigmaLITE Controller sending the drive and BDI information to the Display (and therefore the Display Master).
In case of Dual motor configuration, the Dual Motor master must be also the Display master (i.e. the one with this parameter set different than 0).

M7.4-3 Display refresh rate “RefRate”

This parameter sets the refresh rate of the messages used to communicate with the DMC Display or with the iGauge master/slaves. It is not suggested to change this value unless there is too much traffic on the CAN bus.

6.1.24 Menu 7.5 “Safe Stop 1”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	SafeStop1 enable “SfStEnab”	0 - 1	1	0	0x2A02	0x1
2	SafeStop1 torque “SfStTorque”	1 - 127	1	1	0x2A02	0x2
3	SafeStop1 ramp time “SfStRmpTm”	30ms – 120ms	10ms	50ms	0x2A02	0x3

M7.5-1 SafeStop1 enable “SfStEnab”
M7.5-2 SafeStop1 torque “SfStTorque”
M7.5-3 SafeStop1 ramp time “SfStRmpTm”

These settings are active if Control Via CAN HMI is enabled (“M7.2-3 TxPDO configuration “PDO cfg”” set lower than 4 and pre-mapping mode OR any variable mapped in RxPDOs in free-mapping mode).
For details about those parameters, please refer to the specific CAN Open manual [1].

Menu 8 “Input/Output configuration”

The menu embeds the assignment of functional inputs and the configuration for the available physical inputs and outputs.

The following sub-menus are available:

- Menu 8.1 “Input/output assignment”
- Menu 8.2 “Analogue input 1 configuration”
- Menu 8.3 “Analogue input 2 configuration”
- Menu 8.4 “Analogue input 3 configuration”
- Menu 8.5 “Digital output 1 configuration”
- Menu 8.6 “Digital output 2 configuration”
- Menu 8.7 “Digital output 3 configuration”
- Menu 8.8 “Digital output 4 configuration”
- Menu 8.9 “Digital output 5 configuration”
- Menu 8.10 “Wireoff and Shortcircuit detection”

6.1.25 Menu 8.1 "Input/output assignment"

Cal. Ref.	Parameter name "Calibrator text"	Range	Step size	Default	Index	Sub-index
1	DI1 configuration "Ip 1 Cfg"	0 - 23	1	0	0x2F82	0x1
2	DI2 configuration "Ip 2 Cfg"	0 - 23	1	1	0x2F82	0x2
3	DI3 configuration "Ip 3 Cfg"	0 - 23	1	2	0x2F82	0x3
4	AI1/DI4 configuration "Ip 4 Cfg"	0 – 33	1	24	0x2F82	0x4
5	AI2/DI5 configuration "Ip 5 Cfg"	0 – 33	1	25	0x2F82	0x5
6	AI3/DI6 configuration "Ip 6 Cfg"	0 – 33	1	3	0x2F82	0x6
7	DI7 configuration "Ip 7 Cfg"	0 – 12	1	11	0x2F82	0x19
8	DO1 configuration "Op 1 Cfg"	0 – 10	1	0	0x2F82	0x7
9	DO2 configuration "Op 2 Cfg"	0 – 10	1	1	0x2F82	0x8
10	DO3 configuration "Op 3 Cfg"	0 – 10	1	2	0x2F82	0x9
11	DO4 configuration "Op 4 Cfg"	0 – 10	1	3	0x2F82	0xA
12	DO5 configuration "Op 5 Cfg"	0 - 11	1	11	0x2F82	0x17

M8.1-1 DI1 configuration "Ip 1 Cfg"
M8.1-2 DI2 configuration "Ip 2 Cfg"
M8.1-3 DI3 configuration "Ip 3 Cfg"
M8.1-4 AI1/DI4 configuration "Ip 4 Cfg"
M8.1-5 AI2/DI5 configuration "Ip 5 Cfg"
M8.1-6 AI3/DI6 configuration "Ip 6 Cfg"
M8.1-7 DI7 configuration "Ip 7 Cfg"

These parameters are used to assign "functional inputs" to physical inputs of the SigmaLITE controller. Please refer to the tables below for the corresponding enumerators.
Notice that, in case the same "functional input" is assigned to both a physical input and a CAN message, the physical input will be disregarded.

DI1, DI2, DI3 config	Description
0	Speed 1 activation
1	Speed 2 activation
2	Speed 3 activation
3	Speed 4 activation
4	Speed 5 activation
5	Powersteer speed activation
6	Inhibit driving
7	STO NO
8	STO NC
9	STO toggle
10	SSI NO
11	SS1 NC
12	SS1 toggle
13	No function (digital)

AI1/DI4, AI2/DI5, AI3/DI6 config	Description
0	Speed 1 activation
1	Speed 2 activation
2	Speed 3 activation
3	Speed 4 activation
4	Speed 5 activation
5	Powersteer speed activation
6	Inhibit driving
7	STO NO
8	STO NC
9	STO toggle
10	SSI NO
11	SS1 NC
12	SS1 toggle
13	No function (digital)
14	Speed #1 accelerator
15	Speed #2 accelerator
16	No function (analogue)
31	Generator BCL
32	Dual accelerator
33	No function (analogue)

DI7 config	Description
0	Speed 1 activation
1	Speed 2 activation
2	Speed 3 activation
3	Speed 4 activation
4	Speed 5 activation
5	Powersteer speed activation
6	Inhibit driving
7	Encoder 3
8	No function (digital)

M8.1-8 DO1 configuration "Op 1 Cfg"
M8.1-9 DO2 configuration "Op 2 Cfg"
M8.1-10 DO3 configuration "Op 3 Cfg"
M8.1-11 DO4 configuration "Op 4 Cfg"
M8.1-12 DO5 configuration "Op 5 Cfg"

These parameters are used to assign "functional outputs" to physical outputs of the SigmaLITE controller. Please refer to the tables below for the corresponding enumerators.

Notice that, in case the same "functional output" is assigned both to more than one physical output, both physical outputs will be activated at the same time.

D01 config	Description
0	Line contactor
1	Powersteer
2	Motor fan
3	Controller fan
4	Combo fan
5	Remote LED
6	Drive OK
7	No function – available Via CAN
8	No function – available Via CAN, PWM control

D02 config	Description
0	Line contactor
1	Powersteer
2	Motor fan
3	Controller fan
4	Combo fan
5	Remote LED
6	Drive OK
7	No function – available Via CAN
8	No function – available Via CAN, PWM control

D03 config	Description
0	Line contactor
1	Powersteer
2	Motor fan
3	Controller fan
4	Combo fan
5	Remote LED
6	Drive OK
7	No function – available Via CAN
8	No function – available Via CAN, PWM control

DO4 config	Description
0	Line contactor
1	Powersteer
2	Motor fan
3	Controller fan
4	Combo fan
5	Remote LED
6	Drive OK
7	No function – available Via CAN
8	No function – available Via CAN, PWM control

DO5 config	Description
0	Line contactor
1	Powersteer
2	Motor fan
3	Controller fan
4	Combo fan
5	Remote LED
6	Drive OK
7	No function – available Via CAN
8	No function – available Via CAN, PWM control
9	Proportional output control

6.1.26 Menu 8.2 “Analogue input 1 configuration”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Analogue Input 1 minimum voltage level “AI1 min”	0.0V – 10V	0.1V	0.4V	0x200A	0x8
2	Analogue Input 1 maximum voltage level “AI1 max”	0.0V – 10V	0.1V	4.6V	0x200A	0x9

6.1.27 Menu 8.3 “Analogue input 2 configuration”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Analogue Input 2 minimum voltage level “AI2 min”	0.0V – 10V	0.1V	0.4V	0x200A	0x8
2	Analogue Input 2 maximum voltage level “AI2 max”	0.0V – 10V	0.1V	4.6V	0x200A	0x9

6.1.28 Menu 8.4 “Analogue input 3 configuration”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1:	Analogue Input 3 minimum voltage level “AI3 min”	0.0V – 10V	0.1V	0.4V	0x200A	0xA
2:	Analogue Input 3 maximum voltage level “AI3 max”	0.0V – 10V	0.1V	4.6V	0x200A	0xB

M8.2-1 Analogue Input 1 minimum voltage level “AI1 min”

M8.3-1 Analogue Input 2 minimum voltage level “AI2 min”

M8.4-1 Analogue Input 3 minimum voltage level “AI3 min”

- If the input is configured as “**Accelerator**”, this sets the voltage on the analogue input *X* that will correspond to zero speed demand.

For tuning this parameter refer to “APPENDIX C – Analogue Input tuning”.

M8.2-2 Analogue Input 1 maximum voltage level "AI1 max"

M8.3-2 Analogue Input 2 maximum voltage level "AI2 max"

M8.4-2 Analogue Input 3 maximum voltage level "AI3 max"

- If the input is configured as "**Accelerator**", this sets the voltage on the analogue input *X* that will correspond to maximum speed

For tuning this parameter refer to "APPENDIX C – Analogue Input tuning".

6.1.29 Menu 8.5 “Digital output 1 configuration”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Digital output 1 pull-in voltage ”Do1PlInV”	7V – 48V	1V	12V	0x2C00	0x3
2	Digital output 1 holding voltage ”Do1HoldV”	7V – 48V	1V	12V	0x2C00	0x4
3	Digital output 1 wireoff enable “WireOff1”	0 – 1	1	0	0x2C00	0x6
4	Digital output 1 shortcircuit enable “ShortCt1”	0 – 1	1	0	0x2C00	0x7

6.1.30 Menu 8.6 “Digital output 2 configuration”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Digital output 2 pull-in voltage ”Do2PlInV”	7V – 48V	1V	12V	0x2C01	0x2
2	Digital output 2 holding voltage ”Do2HoldV”	7V – 48V	1V	12V	0x2C01	0x3
3	Digital output 2 wireoff enable “WireOff2”	0 – 1	1	0	0x2C01	0x5
4	Digital output 2 shortcircuit enable “ShortCt2”	0 – 1	1	0	0x2C01	0x6

6.1.31 Menu 8.7 “Digital output 3 configuration”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Digital output 3 pull-in voltage ”Do3PlInV”	7V – 48V	1V	12V	0x2C02	0x2
2	Digital output 3 holding voltage ”Do3HoldV”	7V – 48V	1V	12V	0x2C02	0x3
3	Digital output 3 wireoff enable “WireOff3”	0 – 1	1	0	0x2C02	0x4
4	Digital output 3 shortcircuit enable “ShortCt3”	0 – 1	1	0	0x2C02	0x5

6.1.32 Menu 8.8 “Digital output 4 configuration”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Digital output 4 pull-in voltage ”Do4PlInV”	7V – 48V	1V	12V	0x2C04	0x2
2	Digital output 4 holding voltage ”Do4HoldV”	7V – 48V	1V	12V	0x2C04	0x3
3	Digital output 4 wireoff enable “WireOff4”	0 – 1	1	0	0x2C04	0x6
4	Digital output 4 shortcircuit enable “ShortCt4”	0 – 1	1	0	0x2C04	0x7

6.1.33 Menu 8.9 “Digital output 5 configuration”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Digital output 5 pull-in voltage ”Do5PlInV”	7V – 48V	1V	12V	0x2C05	0x1
2	Digital output 5 holding voltage ”Do5HoldV”	7V – 48V	1V	12V	0x2C05	0x2

M8.5-1 Digital output 1 pull-in voltage ”Do1PlInV”

M8.6-1 Digital output 2 pull-in voltage ”Do2PlInV”

M8.7-1 Digital output 3 pull-in voltage ”Do3PlInV”

M8.8-1 Digital output 4 pull-in voltage ”Do4PlInV”

M8.9-1 Digital output 5 pull-in voltage ”Do5PlInV”

It sets the Digital Output X pull in voltage applied for 1s.
If this parameter is set to its maximum value (i.e. the nominal battery voltage for each SigmaLITE Controller size), the actual battery voltage will be applied, even if it is higher than the nominal battery voltage.
Example:
Nominal battery voltage = 48V, Parameter set to 48V, Actual battery voltage = 52V. The applied voltage is 52V.
Nominal battery voltage = 48V, Parameter set to 47V, Actual battery voltage = 52V. The applied voltage is 47V.

M8.5-2 Digital output 1 holding voltage ”Do1HoldV”

M8.6-2 Digital output 2 holding voltage ”Do2HoldV”

M8.7-2 Digital output 3 holding voltage ”Do3HoldV”

M8.8-2 Digital output 4 holding voltage ”Do4HoldV”

M8.9-2 Digital output 5 holding voltage ”Do5HoldV”

It sets the Digital Output X holding voltage applied after 1s is elapsed from the initial closing command.
If this parameter is set to its maximum value (i.e. the nominal battery voltage for each SigmaLITE Controller size), the actual battery voltage will be applied, even if it is higher than the nominal battery voltage.
Example:
Nominal battery voltage = 48V, Parameter set to 48V, Actual battery voltage = 52V. The applied voltage is 52V.
Nominal battery voltage = 48V, Parameter set to 47V, Actual battery voltage = 52V. The applied voltage is 47V.

M8.5-3 Digital output 1 wireoff enable “WireOff1”

M8.6-3 Digital output 2 wireoff enable “WireOff2”

M8.7-3 Digital output 3 wireoff enable “WireOff3”

M8.8-3 Digital output 4 wireoff enable “WireOff4”

This parameter is used to enable the wireoff detection on Digital Output X:

0: Wireoff **disabled** on Digital Output X.
1: Wireoff **enabled** on Digital Output X.

M8.5-4 Digital output 1 shortcircuit enable “ShortCt1”

M8.6-4 Digital output 2 shortcircuit enable “ShortCt2”

M8.7-4 Digital output 3 shortcircuit enable “ShortCt3”

M8.8-4 Digital output 4 shortcircuit enable “ShortCt4”

This parameter is used to enable the shortcircuit and overcurrent detection on Digital Output X:

0: Shortcircuit **disabled** on Digital Output X.
1: Shortcircuit **enabled** on Digital Output X.

6.1.34 Menu 8.10 “Wireoff and Shortcircuit detection”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Motor sensor wireoff threshold “MotWrOff” Motor sensor wireoff threshold “MotWrOff”	0mA – 100mA	1mA	0mA	0x2F83	0x1
2	Motor sensor shortcircuit threshold “MotShortC”	0mA – 100mA	1mA	100mA	0x2F83	0x2
3	10V supply wireoff threshold “10VWrOff”	0mA – 100mA	1mA	0mA	0x2F83	0x3
4	10V supply shortcircuit threshold “10VShortC”	0mA – 100mA	1mA	100mA	0x2F83	0x4
5	5V supply wireoff threshold “5V WrOff”	0mA – 100mA	1mA	0mA	0x2F83	0x5
6	5V supply shortcircuit threshold “5V ShortC”	0mA – 100mA	1mA	100mA	0x2F83	0x6

M8.10-1 Motor sensor wireoff threshold “MotWrOff”
M8.10-2 Motor sensor shortcircuit threshold “MotShortC”
M8.10-3 10V supply wireoff threshold “10VWrOff”
M8.10-4 10V supply shortcircuit threshold “10VShortC”
M8.10-5 5V supply wireoff threshold “5V WrOff”
M8.10-6 5V supply shortcircuit threshold “5V ShortC”

Menu 9 “Dual motor”

Cal. Ref.	Parameter name “Calibrator text”	Range	Step size	Default	Index	Sub-index
1	Dual motor failure option “DMFailOpt”	0 - 2	1	0	0x2E08	0x0
2	Dual motor fail speed “DMMFlSpd”	0RPM – 9000RPM	5RPM	500RPM	0x2E09	0x0
3	Dual motor slave’s limitations affect master “DMlimMas”	0 - 1	1	0	0x2E0A	0x0

M9-1 Dual motor fail speed “DMMFlSpd”

For a complete description of dual-motor related parameters please refer to [3].

M9-2 Dual motor failure option “DMFailOpt”

This sets the behaviour of the Master and Slave controllers when dual motor configuration is active and one of the two controllers is in fault.
For more details about the Dual Motor feature, parameters and setup please refer to [3].
This parameter requires a key cycle off-on to be effective.

M9-3 Dual motor slave’s limitations affect master “DMlimMas”

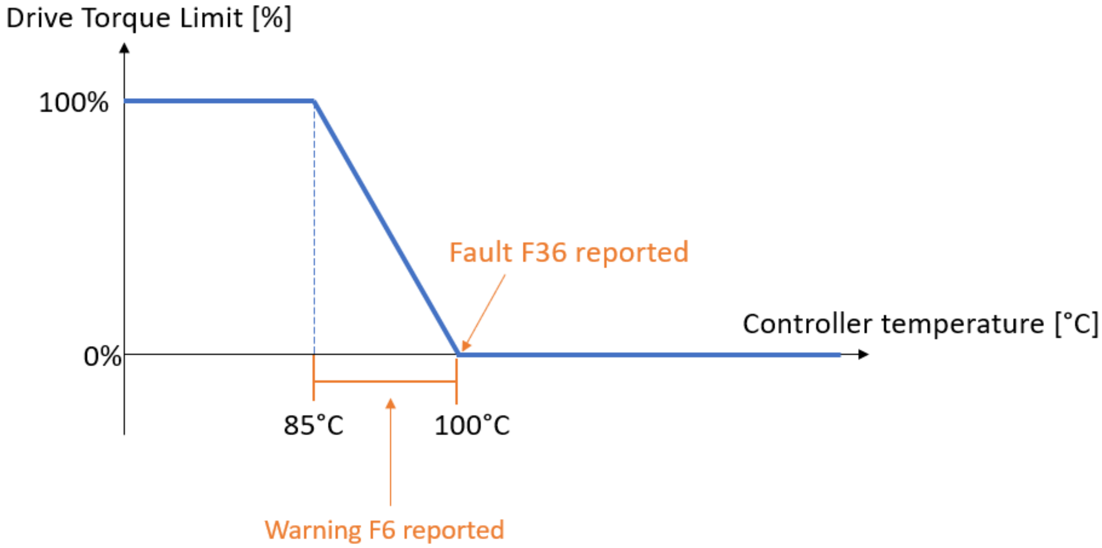
This parameter is active only if “M2-3 Dual motor configuration “DMconfig”” is set to 4.
As better described in [3], a torque/speed limitation in a controller working with dual motor functionality also affects the other controller. If this setting is set to **0 (Limit in slave does not limit master)**, the master is not influenced at all by limitations happening in slave controller.

7 Safety related functions

The SigmaLITE motor controller has some safety related functions that can be enable to enhance the application safety. The following list resumes the main function related to safety.

Controller overheating protection

DMC Sigma2N controllers have a built-in overheating protection. This function is meant to cut the available drive torque to the motor in case the controller is overheating, to avoid hardware damage. The following diagram shows how motor drive torque is cut as a function of controller temperature:



It is worth noticing that brake torque is never cut to guarantee the motor/vehicle is always able to stop. The only exception of this is when the controller is driving in torque mode. In this case, brake torque is limited linearly starting from controller's 90°C.

Motor Stall function

During vehicle operation it might happen that motor can be stuck and not able to start due to excessive load torque. Regardless of the fact that torque mode or speed mode is employed, it could happen that the controller is "pushing" full current in the motor for several seconds and the motor is applying full torque. This can be dangerous for motor quick overheating and for the mechanical transmission. There is a function that can detect a "motor stall" situation. To enable it please refer to "M5.8-1 Torque threshold for stall protection "TrqTHLim"" and "M5.8-2 Stall protection timer "StallTim"".

Motor Feedback wire off and noise detection

Motor speed feedback is a key information for proper motor control. In case of sensor wire off or excessive electrical noise on feedback signals, the motor must be stopped and an error must be signalled for a proper diagnostic coverage. For PMS and IPM motor technology the wire off and noise detection is enabled by default. For AC motor technology please refer to "M5.9-1 Speed control guard tracking error threshold "SpdGrdTH"" and "M5.9-2 Speed control guard timer "SpdGrdTm"" for enabling the noise detection function.

Safe Torque Off (STO) and Safe Stop 1 (SS1)

Safe Torque Off (STO) and Safe Stop 1 (SS1) are standard safety functions available in the SigmaLITE controller, meant to work in conjunction with the "Control via can" function. They are designed according to the guidelines of EN IEC 60204-1/2006. They represent, respectively, safe stops of category 0 and 1. Safety level is guaranteed by hardware and software design architecture, taking the norms reported in EN ISO 13849/2015 as reference.
STO function in SigmaLITE controller meets safety level PLd CAT 3.
SS1 function in SigmaLITE controller meets safety level PLd CAT 2.

Potentiometers supply wire off and short-circuit detection

Is it possible to enable the detection for the wire off or short-circuit of potentiometer supplies. Both 5V and 10V outputs are protected against wire off and short-circuits. The corresponding parameters can be found under “Menu 8.10 “Wireoff and Shortcircuit detection””. Possible wiring solutions to cover multiple potentiometer wire off and/or short-circuit can be found under “APPENDIX D – Wireoff detection tuning”.

8 Monitoring

Menu 0 “Status”

The status menu shows various parameters from the controller which can be useful to help tune and optimize vehicle’s performance. By pressing the decrement (◁) or the increment (▷) button on the calibrator extra information about the selected status variable are displayed.

Cal. Ref.	Item	Calibrator text	Step size	Service log info & Notes			
1	Drive hours counter	Drive	0.1 Hrs	▷	shows key hours		
2	Current Fault code	CurFault		◁	SuP error code	▷	Current sub code
3	Battery Discharge Indicator	BDI	1 %	◁	Raw BDI value incl. state (WO & CO)	▷	BDI states (see “M0-1 BDI States table”)
4	Controller Temperature	CtrlTmp	0.1 °C	◁	Min. temperature	▷	Max. temperature
5	Motor Temperature	MotTemp	0.1 °C	Shows N/A when disabled.			
				◁	Min. temperature	▷	Max. temperature
6	Drive State	DriveSta	--	See “M0-2 Drive and brake status table”			
7	Speed Limit	SpeedLim	--	See “M0-3 Speed limits table”			
8	Torque Limit	TrqLimit	--	See “M0-4 Torque limits table”			
9	Motor Limit	MotorLim	--	See “M0-5 Motor limits table”			
10	Battery Voltage	BatVolts	0.1 V			▷	Max. Voltage
11	Capacitor Voltage	CapVolts	0.1 V			▷	Max. Voltage
12	DS301 status	DS301Sts	--	See “M0-6 **DS301 status table**”			
13	DS402 status	DS402Sts	--	See “M0-7 **DS402 status table**”			
14	Battery current	I_batter	0.1 A				
15	Motor current	I_Motor	0.1 Arms	◁	Id Current	▷	Iq Current
16	Motor voltage	V_Motor	0.1 Vrms	◁	Reactive Power	▷	Motor Power
17	Stator speed	StatorSpd	0.1 Hz				
18	Rotor speed	RotorSpd	0.1 Hz			▷	RPM speed
19	Accelerator demand	Accel	0.1 %	◁	Steer pot demand	▷	Foot brake demand
20	Target demand	DemTrgt	0.1 %	+	CW	–	CCW
21	Ramped demand	DemRampd	0.1 %	+	CW	–	CCW
22	Speed limit %						
23	Drive torque limit	DrvTrqL	0.1 %			▷	Torque limit CW
24	Brake torque limit	BrkTrqL	0.1 %			▷	Torque limit CCW
25	Actual torque	TrqAct	0.1 %	◁	Actual torque in Nm	▷	Maximum torque in Nm
26	Actual speed	SpeedAct	0.1 %	+	CW	–	CCW
27	Actual Flux	FluxDem	0.1 %			▷	Actual Flux
28	Filtered capacitor voltage						
29	Vehicle Speed	Vehicle	1 Kph				
30	Motor RPM speed	RPMspeed	1 rpm				
31	Mapping error F7 S64 specifier	MapErr	--	◁	Input assignment F7 S107 specifier	▷	Duplicate mapping F7 S65 specifier

To reset the max and min temperatures logged data, press the + and – button at the same time when the controller is in neutral.

M0-1 BDI States table

BDI States	Description
0	Initializing
1	OK
2	BDI is getting low Warning (WO)
3	BDI is too low Cut out (CO)

M0-2 Drive and brake status table

Status	#	Description
NC	0	No Configuration
HW	1	Waiting for HW ready
N	2	Neutral, not giving power to the motor
FD	3	Forward drive
RD	4	Reverse drive
DB	5	Direction braking
NB	6	Neutral braking
FB	7	Foot braking
FB	8	Hill hold
HF	9	Forward restraint hill hold
HR	10	Reverse restraint hill hold

Shared Line Contactor Status table

Status	Description
ST	Starting up
RC	Ready to close Line Contactor
CS	Is closing line contactor
PS	Start giving power to the motor
KF	Key fault is found
NK	Not known

M0-3 Speed limits table

Limit	#	Description
--	0	No limitation active
MS	1	Max motor speed limit
SM	2	Max speed limit forward or reverse
S1	3	Speed limit 1
S2	4	Speed limit 2
S3	5	Speed limit 3
S4	6	Speed limit 4
S5	7	Speed limit 5
S6	8	Speed limit 6
SI	9	Inching speed limit
SB	10	BDI speed limit
SC	11	Controller over temperature limit
SH	12	Hand brake speed limit
SV	13	Speed Limit Via CAN
SS	14	Steering Pot Speed Limit
S?	15	Unknown speed limit
SD	16	Speed limit from AI2/3
VS	17	Speed limit from low voltage
CT	18	Speed limit from high controller °C
MT	19	Speed limit from high motor °C
DS	20	Speed limit from other motor
SF	21	Dual motor fail speed limit
DB	22	Unknown speed limit

M0-4 Torque limits table

Limit		Description
--	0	No limitation active
CT	1	Controller temperature
MT	2	Motor temperature
PT	3	Performance table current limit
TC	4	Timed Current Limit
T1	5	I^2t current limit step 1
T2	6	I^2t current limit step 2
T3	7	I^2t current limit step 3
HV	8	High Voltage limit
LV	9	Low Voltage limit
HB	10	Hand brake limit
S1	11	Advanced mode speed 1 active
S2	12	Advanced mode speed 2 active
BM	13	Battery current limit maximum
BR	14	Battery current limit regeneration
??	15	Other torque limit
SL	16	Torquer limit to hold speed limit
ND	17	No drive torque during braking
RH	18	Restraint hill hold
AA	19	Advanced mode speed 1 or 2 and torque from AI2/3 limits
AN	20	Torque limit from AI2/3
TV	21	Torque limit Via CAN
DD	22	Drive torque limit from other motor
DB	23	Brake torque limit from other motor
GL	24	Generator torque limit

M0-5 Motor limits table

Limit	#	Description
--	0	No limit active
TL	1	Torque Limit
SL	2	Speed Limit
TH	3	Not able to hold torque
SH	4	Not able to hold speed
FH	5	Not able to hold flux
IH	6	Not able to hold flux current
CH	7	Not able to hold Voltage Limitation
HL	8	Not able to hold PWM Limit
OL	9	Circle limitation
PH	10	Unable to do positioning

M0-6 DS301 status table

BDI States	Description
STOP	Node state stopped
PRE-OP	Node state pre operational
OP	Node state operational

M0-7 DS402 status table

BDI States	Description
STARTUP	Startup
SOD	Switch on disabled
RTSO	Ready to switch on
SO	Switched on
OE	Operation enabled
QS	Quick stop
FR	Fault reset
F	Fault

Menu 10 “Test” for traction software

8.1.1 Menu 10.1 “Test Hardware”

This menu is primarily used to investigate the HW input status functionality of the SigmaLITE controller.

Cal. Ref.	Item	Calibrator Text	Unit	Min. Display	Max. Display	◁	▷
1	Digital input 1	DI1	Input	0	1	--	* See below
2	Digital input 2	DI2	Input	0	1	--	* See below
3	Digital input 3	DI3	Input	0	1	--	* See below
4	Digital input 4	DI4	Input	0	1	--	* See below
5	Digital input 5	DI5	Input	0	1	--	* See below
6	Digital input 6	DI6	Input	0	1	--	* See below
7	Analogue input 1 [V]	AI1	V	0 V	10.0 V	ADC bits	ADC volt
8	Analogue input 1 [%]	AI1	Input %	0 %	100 %	--	* See below
9	Analogue input 2 [V]	AI2	V	0 V	10.0 V	ADC bits	ADC volt
10	Analogue input 2 [%]	AI2	Input %	0 %	100 %	--	* See below
11	Analogue input 3 [V]	AI3	V	0 V	10.0 V	ADC bits	ADC volt
12	Analogue input 3 [%]	AI3	Input %	0 %	100 %	--	* See below
13	Digital output 1	DigOut1	Output	0	1	ADC bits	Pin reading
14	Digital output 2	DigOut2	Output	0	1	ADC bits	Pin reading
15	Digital output 3	DigOut3	Output	0	1	ADC bits	Pin reading
16	Digital output 4	DigOut4	Output	0	1	ADC bits	Pin reading
17	Digital output 5	DigOut5	Output	0	1	ADC bits	Pin reading
18	Speed Sensor	SpeedSen	Input	0	1	--	--
19	Speed direction	SpeedDir	Input	0	1	--	--
20	Encoder 3 input	Encoder3	Input	0	1	--	--
21	M3 positive over current	M3Pos_OC	Input	0	1	--	--
22	M3 negative over current	M3Neg_OC	Input	0	1	--	--
23	M1 positive over current	M1Pos_OC	Input	0	1	--	--
24	Internal temperature	IntTempS	Deg	-40 °C	125 °C	ADC bits	ADC volt
25	Internal reference voltage	intVref	mV	0 mV	3300 mV	ADC bits	--
26	+5 V power supply	+5V	V	0.00 V	5.10 V	ADC bits	ADC volt
27	+14 V power supply	+14V	V	0.00 V	14.00 V	ADC bits	ADC volt
28	M1 current sensor output	I_M1	mV	0 mV	5000 mV	ADC bits	--
29	M3 current sensor output	I_M3	mV	0 mV	5000 mV	ADC bits	--
30	M1 voltage	M1 Volts	V	0.0 V	200.0 V	ADC bits	Raw AD Volts
31	M3 voltage	M3 Volts	V	0.0 V	200.0 V	ADC bits	Raw AD Volts
32	Sensor Sine Voltage	SineSens	mV	0 mV	3300 mV	ADC bits	--
33	Sensor Cosine Voltage	CosineSn	mV	0 mV	3300 mV	ADC bits	--
34	Sin/Cos Angle	Angle SC	Deg	0.0°	360.0 °	--	--
35	Sensor supply output	SensSuppl	Output	0	1	Enable (out)	Feedback (ip)
36	OE2 feedback	OE3 fbk	Input	0	1	--	OE1 (op)
37	B+Safe feedback	BsafeFbk	Input	0	1	--	B+Safe fbk (op)
38	WD1 output	WD1 out	Output	0	1	--	--
39	SuP reset command	SuP rest	Output	0	1	--	--
40	SuP digital input 1	SuP_DI1	Input	0	1	--	SuP OE1 fbk (ip)
41	SuP digital input 2	SuP_DI2	Input	0	1	--	--
42	SuP digital input 3	SuP_DI3	Input	0	1	--	SuP B+Safe fb (ip)
43	SuP analogue input 1	SuP_AI1	V	0 V	10.0 V	SuP_DI4	ADC bits
44	SuP analogue input 2	SuP_AI2	V	0 V	10.0 V	SuP_DI5	ADC bits
45	SuP analogue input 3	SuP_AI3	V	0 V	10.0 V	SuP_DI6	ADC bits
46	Power board identifier	PowerTyp	Num	0	0	--	--

Cal. Ref.	Item	Calibrator Text	Unit	Min. Display	Max. Display	◁	▷
47	5V current supply	5V curr	mA	0 mA	30 mA	--	ADC bits
48	10V current supply	10V curr	mA	0 mA	100 mA	--	ADC bits
49	Motor sensor current	5/10V EN	mA	0 mA	70 mA	--	ADC bits
50	DO5 positive current	DO5 pos	mA	0 mA	2000 mA	DO5 differential current	ADC bits
51	DO5 negative current	DO5 neg	mA	0 mA	2000 mA	--	--
52	DO5 differential current	DO5 curr	mA	0 mA	2000 mA	--	--
53	Raw speed	Raw Spd	%	-100%	100%	--	ADC bits

*Note for entries #1 to #6, #8, #10 #12:
When pressing the ▷ button, the following can be shown:

- Function assigned to the corresponding digital/analogue input. In this case the value shown, be it analogue (in %) or digital (0 or 1), is the function status.
  Example: in case "Speed1" function is assigned to DI3 and the input is high. When no button is pressed the DI3 status is shown (1, as it is high/closed). In case the ▷ button will be pressed, the text will show "Speed1" and the function status will be visualized (0 in this case, as the function is "normally open", therefore inactive).
- N/A in case no function is assigned to the corresponding digital/analogue input.

8.1.2 Menu 10.2 "Test Software"

This menu is primarily used to investigate the SW functional input status of the SigmaLITE controller.

Cal. Ref.	Item	Calibrator Text	Unit	Min. Display	Max. Display	◁	▷
1	Pump speed 1 input	Speed1	fcn	0	1	*See below	°See Below
2	Pump speed 2 input	Speed2	fcn	0	1	*See below	°See Below
3	Pump speed 3 input	Speed3	fcn	0	1	*See below	°See Below
4	Pump speed 4 input	Speed4	fcn	0	1	*See below	°See Below
5	Pump speed 5 input	Speed5	fcn	0	1	*See below	°See Below
6	Pump powersteer input	PwrSteer	fcn	0	1	*See below	°See Below
7	Inhibit input	Inhibit	fcn	0	1	*See below	°See Below
8	STO toggle input	STO Togg	fcn	0	1	*See below	°See Below
9	STO NO input	STO NO	fcn	0	1	*See below	°See Below
10	STO NC input	STO NC	fcn	0	1	*See below	°See Below
11	SS1 toggle input	SS1 Togg	fcn	0	1	*See below	°See Below
12	SS1 NO input	SS1 NO	fcn	0	1	*See below	°See Below
13	SS1 NC input	SS1 NC	fcn	0	1	*See below	°See Below
14	Speed 1 accelerator input	Accel 1	Input %	0.0 %	100.0 %	*See below	°See Below
15	Speed 2 accelerator input	Accel 2	Input %	0.0 %	100.0 %	*See below	°See Below

*When pressing the ◁ button, the functional input coming Via CAN is visualized.

- In case the unit is "N/A", it means that the corresponding variable is not mapped.
- In case the input name is substituted with "N/A" it means that the corresponding functional input is not available in CAN mapping at all.

°When pressing the ▷ button, the functional input name is replaced with the physical input to which it is assigned and the corresponding physical input status is visualized.

- In case the unit is "N/A", it means that the corresponding functional input is not assigned to any physical input.

Menu 12 “About”

The table reported hereafter is just an example.

Cal. Ref.	Information Field	Example	
1	Customer name	Cust.	Standard
2	Application	App.	Standard
3	Controller type	Ctrl.	IPM Pump
4	Product name	Prod	SigmaLITE
5	Software type	Swtyp	SLI425P-01
6	Software version	SW	V04.00.01
7	Degault type	Def	Standard
8	Software Date	Date	23-01-2024
9	Hardware type	HWtype	Size 1 48V
10	Hardware BOM	HWbom	V3.02
11	BSP Version	BSP	Vxx.yy.zz
12	IPM/PMS/AC FOC version	IPMFOC	Vxx.yy.zz
13	Product serial number	SN P	AABBCCCC
14	Logic serial number	SN L	AABBCCCC
15	Logic version and variant	HWver	V3.02-STD
16	Product tested and calibrated	HWcal	Y Y HW LEM
17	Safety uP version	SUP	Vxx.yy.zz
18	Bootloader version	BOOT	Vxx.yy.zz

9 Diagnostics

9.1 Main uP error codes

The following tables describe all the error codes that the controller will display. The presence of an error can be detected by means of a red led flashing on controller (number of flashes correspond to base error code) and investigated in "Menu 0 "Status"".
The error codes are divided in four different categories, based upon the severity of the faults.

Base fault Code	Description	Sub fault code	Description
Controller warning faults - Reduces only performance - Fault will reset itself (if possible)			
0	No error	-	-
1	N/A	-	
2	Voltage getting low	1	Battery voltage below absolute minimum
		2	Capacitor voltage below absolute minimum
		3	Battery voltage below LV cut back adjustment (drive cut back active)
		4	Capacitor voltage below LV cut off adjustment (drive cut back active)
3	Inhibit drive/ BDI Cut / BLC via can	1	BDI Cut out (Battery below BDI cut Level)
		2	Pump inhibit input active (Only Pump Software)
		3	BCL via CAN message time out
		4	BCL via CAN message toggle security bit fail
		5	--
		6	BMS timeout after initialization
		7	BMS not found at powerup
		8	BMS inhibit driving
		9	BMS charger connected drive forbidden
4	Voltage getting high	1	Battery voltage above absolute maximum
		2	Capacitor voltage above absolute maximum
		3	Battery voltage above High Voltage cut back adjustment (brake cut back active)
		4	Capacitor voltage above High Voltage cut back adjustment (brake cut back active)
5	Motor temperature high	-	
6	Controller temperature high	-	
7	Adjustment out of range	001	N/A
		002	Shared line contactor master is not receiving an answer from one of the slaves during initialization. Make sure that the "reference node" set in the controller meant to be Shared line contactor master equals the last sharing slave. Check that all the controllers supposed to be Shared line contactor slaves are configured as that, with the shared line contactor master's node number set as reference node.
		003	N/A
		004	N/A
		005	N/A
		006	N/A
		007	N/A
		008	N/A
		009	N/A
		010	N/A
		011	N/A
		012	N/A
		013	N/A

Base fault Code	Description	Sub fault code	Description
	F7 Adjustment out of range	014	Can Node ID via digital input enabled but control but Control Via CAN HMI is not enabled.
		015	N/A
		016	Shared Line contactor master's CAN node number is higher/equal than the last node the controller is supposed to be checking for faults. This happens in the controller with the setting "ShareLC" = 1 if "CAN node" >= "RefNode", that is a non-sense. Solution: check node assignment, and make sure "CAN node" < "RefNode"
		017	Shared Line contactor slave's CAN node is lower/equal than Shared Line contactor "master" node (defined in "RefNode"). This happens in the controller with the setting "ShareLC" = 2 if "CAN node" <= "RefNode", that is a non-sense. Solution: check node assignment, and make sure "CAN node" > "RefNode"
		018	Wrong node number for master controller: make sure DM master has node < 126
		019	Wrong node number for slave controller: make sure DM slave has node nr > 1
		020	Dual Motor setting not consistent between controller pair. Make sure parameter "M2-3 Dual motor configuration "DMconfig"" form an admissible pair between controllers (Master 1/Slave 2 both in speed mode, Master 1/Slave 2 both in torque mode, Master 3/Slave 4, Master 5/Slave 6, Master 7/Slave 8, Master 9/Slave 11 both in speed mode, Master 10/Slave 11 both in speed mode).
		021	N/A
		022	N/A
		023	PC interface request controller to stop giving power to the motor
		024	N/A
		025	N/A
		026	N/A
		027	--
		028	--
		029	--
		030	--
		031	N/A
		032	N/A
		033	N/A
		034	Dual Motor Slave mode 4 with failure option active (parameter "M3-18 Failure option" different from 0) when Dual Motor Master mode 3 has parameter "M3-8 RideOn, Walkie, E-Vehicle" or "M3-5 DI5/6 configuration" set different from 0. Either disable Slave failure option (set parameter "M3-18 Failure option" to 0) or disable Master functions (parameters "M3-8 RideOn, Walkie, E-Vehicle" or "M3-5 DI5/6 configuration" both set to 0).
		035	N/A
		036	N/A
		037	N/A
		038	N/A
		039	Two or more controllers acting as "Display master". Tune the Controllers to have only one "Display master". Refer to "M7.4-2 Display status field "DispInfo"" for details.
		040	Parameter "M3-37T AI2 configuration" or "M3-38T AI3 configuration" not consistent between two controllers pair. Set "M3-37T AI2 configuration" and "M3-38T AI3 configuration" consistent between controllers
		041	N/A

Base fault Code	Description	Sub fault code	Description
		042	N/A
		043	N/A
		044	Wrong setup of custom motor temperature mapping. Make sure that the resistance values are either all decreasing or all increasing.
		045	--
		046	--
		047	Dual motor SS1 cross-check failure. SS1 must be enabled in either none or both controllers. Make sure that in either both or none controllers involved in the Dual Motor function, there is a physical input (or an input couple for NO/NC) meant to trigger theSafe Stop 1 function.
		048	N/A N/A
		049	N/A
		050	N/A
		051	Control Via CAN active and AI2/AI3 configured different than “Brake Pot”/”Steer Pot”
		052	N/A
		053	Control Via Can HMI or Can Control Type and Dual Motor function set as single motor with steerpot speed limiting not compatible.
		054	N/A
	F7 Adjustment out of range	055	N/A
		056	N/A
		057	N/A
		058	Dual Motor Slave mode 5 with failure option when Dual Motor Master mode 4 is In speed mode and it is controlled Via CAN trough “Setpoint mode”. Either disable Slave failure option or change Master’s control mode (i.e. to “remote input” mode).
		059	N/A
		060	N/A
		061	N/A
		062	N/A
		063	BCL configuration not consistent between controller pair. Make sure both controllers have the same setting (“M5.4-5 Regenerative BCL enabled during direction braking “BCLRegDB “”)
		064	Error in PDO mapping. Check if incompatible variables have been mapped. Check if appropriate message counter, CRC and checksum variables have been mapped to Tx/Rx PDOs. Check if a non-mappable object was mapped (object 0x386A is automatically substituted in place of the non-mappable object). Check that number of mapped items (Index 0x1600 to 0x1607 and 0x1A00 to 0x1A07, subindex 0) actually corresponds to the number of objects mapped (Index 0x1600 to 0x1607 and 0x1A00 to 0x1A07, subindex 1 to 8). Check that mapped object length does not exceed 64bit for each PDO. The error comes with a specifier, stored in object 0x3893. By monitoring this object, the user can know details about the message, containing the error, its byte position and causing object’s index. Check [9] for object 0x3893 decoding details. The mentioned command specifier can also be found in the Calibrator’s status menu.
		065	Duplicate mapping. The same RW variable has been mapped in more than one RxPDOs. The error comes with a specifier, stored in object 0x3892. By monitoring this object, the user can know details about the message, containing the error, its byte position and causing object’s index. Check [9] for object 0x3892 decoding details. The mentioned command specifier can also be found in the Calibrator’s status menu.
		066	N/A

Base fault Code	Description	Sub fault code	Description
	F7 Adjustment out of range	067	Non admissible COB-ID. Check the COB-ID inserted or activate Advanced Free Mapping
		068	Not admissible node ID. Node ID has been restored to Controller nodes' number automatically. Either check for tuning inconsistency or enable Advanced Free mapping
		069	Duplicate message ID. The same message ID has been assigned to multiple PDOs.
		070	Dual motor steer speed limit not consistent between controller pairs
		071	"External Line contactor" option selected, but ControlWord not mapped in any RxPDO
		072	BMS option selected different from 0 (BMS active), but BCL message active or BDI, Drive Battery Current Limit or Regenerative Battery current limit mapped in any RxPDO.
		073	Dual motor BMS activation not consistent between controller pairs
		074	Dual motor and Shared Line contactor ID message option (11/29 bit IDs) incompatible with PDO mapping.
		075	Driver output 1 option selected different from Line contactor function, but Line contactor is needed for the application.
		076	For one or more digital outputs, either command Via CAN mapped and driver configuration option not correctly setup OR driver configuration selected to "No software function" and no command Via CAN mapped.
		077	Dual motor external line contactor activation not consistent between controller pairs.
		078	DMC Controller is setup with the same node nr as DMC Display
		079	N/A
		080	Indipendent logic supply option selected (external precharge active) but no Battery Voltage found in RxPDO mapping
		081	N/A
		082	N/A
		083	4WD left motors are setup to be on the same axle or 4WD master-slave couple setup on different axle.
		084	Analog Input 3 is set up as accelerator second channel and not compatible with dual motor or single motor using steer pot input on Analog input 3
		085	Walkie vehicle type and dual pot/signals accelerator not compatible. AI2/3 cannot be set as accelerator second channel if walkie vehicle type selected.
		086	Control Via CAN enabled and SafeStop 1 function, but no Footswitch bit mapped. DI4 is working as STO, thus Footswitch bit must come Via CAN. If using "remote input mode" or using "mixed inputs control mode", map either object 0x3806, 0x380C or 0x3872. Otherwise map any "setpoint mode" command, like 0x3833, 0x3835, 0x6071, 0x60FF. Please notice that in case the control commands come by means of analogue/digital inputs, but some variable is still mapped (like DO commands and/or Customer variables), this falls under the case of "mixed inputs control mode" and the enable bit must be send Via CAN
		087	Control Via CAN enabled, but no Seat Switch/interlock bit mapped. DI4 is working as STO, thus Seat Switch/interlock bit must come Via CAN. If using "remote input mode" or using "mixed inputs control mode", map either object 0x3806, 0x380B or 0x3872. Otherwise map any "setpoint mode" command, like 0x3833, 0x3835, 0x6071, 0x60FF. Please notice that in case the control commands come by means of analogue/digital inputs, but some variable is still mapped (like DO commands and/or Customer variables), this falls under the case of "mixed inputs control mode" and the enable bit must be send Via CAN.

Base fault Code	Description	Sub fault code	Description
		088	Custom BMS enabled but premapped CAN message configuration active. This is not possible by function design, as a custom BMS requires customization of incoming CAN messages.
		089	Custom BMS enabled, but no BCL mapped. Be sure to map either a drive BCL or regenerative BCL at least to make the function worth it.
		90	The required safety level is not compatible with the EM brake option at parameter “”. The required safety level would in fact lead to EMbrake closing at even high speeds, while the EMbrake function would avoid it. Either didsable the safety level or select an EMbrake option which allows for brake to close at high speeds.
		91	N/A
		92	N/A
		93	Safe Torque Off and/or Safe Stop 1 functional input assigned to one or more physical inputs, but Control Via CAN is not enabled.
		94	N/A
		95	N/A
		96	Wig-wag accelerator type selected and minimum voltage reading level configured greater than maximum voltage reading level for the physical analogue input to which the accelerator functional input is assigned.
		97	“STO NO” functional input assigned to a physical input, but no “STO NC” assigned, or vice-versa. Make sure either both or none of the two functional inputs are assigned to physical inputs.
		98	“SS1 NO” functional input assigned to a physical input, but no “SS1 NC” assigned, or vice-versa. Make sure either both or none of the two functional inputs are assigned to physical inputs.
		99	N/A
		100	N/A
		101	N/A
		102	Digital input 7 has a functional input different from “Hall sensor #3” assigned, but the Hall sensor is selected as motor feedback.
		103	N/A
		104	N/A
		105	N/A
		106	N/A
		107	Error in input assignment performed in “Menu 8.1 “Input/output assignment””. The error comes with a specifier, stored in object 0x3896. By monitoring this object, the user can know details about which parameter is inconsistent and which configuration is forbidden. Check [9] for object 0x3896 decoding details. The mentioned error specifier can also be found in the Calibrator’s status menu.
		108	N/A
		109	N/A
		110	“Safe Stop 1” function activation is not consistent in Dual Motor couple. Make sure either all controllers have this function active or none of them have it.
		111	“Safe Torque Off” function activation is not consistent in Dual Motor couple. Make sure either all controllers have this function active or none of them have it.
		112	“Bellyswitch” function activation is not consistent in Dual Motor couple. Make sure either all controllers have this function active or none of them have it.
		998	Logic PCB doesn’t match firmware
		999	Power PCB doesn't match firmware

Base fault Code	Description	Sub fault code	Description
		>999	Parameter found out of range and set to default. This information can be stored in two different objects: Object index 0x3842 subindex 0x0 (Fault subcode extended), embeds this information in the format XXYYZZ, where XX is the menu number, YY is the submenu number and ZZ is the item number. This is what the DMC calibrator shows. Object index 0x3841 subindex 0x0 (Fault subcode), embeds this information in the format XYYZZ (if X <=6) or XYZZ (if X > 6), where X is the menu number, YY or Y is the submenu number and ZZ is the item number.
8	Default adjustments used	-	
Drive error faults - Commences graceful neutral brake – Requires a neutral recycle action to reset fault			
9	Memory chip fault	> 0	Contact DMC
10	Both forward and reverse inputs active	-	Both direction switches are active at the same time. Notice that this fault is detected with 1s delay.
11	Drive not allowed	0	Ride-on: Seat switch not closed or timed out Walkie: Tiller switch not closed
		2	Timed Speed Limit 3 time out
		4	BMS inhibit driving
12	Power up sequence fault	1	Traction: FS1 switch active at power up
		2	Traction: Forward switch active at power up
		3	Traction: Reverse switch active at power up
		4	Pump: speed 1 or pump pot active at power up
		5	Pump: speed 2 active at power up
		6	Pump: speed 3 active at power up
		7	Pump: speed 4 active at power up
		8	Pump: speed 5 active at power up
		9	Inching: Forward switch active at power up
		10	Inching: Reverse switch active at power up
		11	Inhibit direction change fault
		12	CAN HMI Safety Stop 1 switch inactive fault
		13-14	Reserved
		15	First message sent with demand different from 0 when Control Via CAN is active. Make sure that first message is sent empty. Refer to [1] for details.
		16	Dual Motor Master controller with demand, but slave not in operational
		17	Dual Motor Slave not in operational or Master not started with first demand inputs different than zero when Control Via CAN is active
		18	N/A
		19	Safe Torque Off function activated with “toggling input” type, but the input has not been toggled. Make sure that the input has recognised a “raising edge” (low to high signal) before sending a drive demand.
		20	Safe Stop 1 function activated with “toggling input” type, but the input has not been toggled. Make sure that the input has recognised a “raising edge” (low to high signal) before sending a drive demand.
13	Accelerator more than 50% at power up	1	Normal accelerator type high at power up
		2	Wig-wag high at power up
14	Inching sequence faults	1	Forward switch active when inching
		2	Reverse switch active when inching
		3	FS1 switch active when inching
		4	Seat switch active when inching
		5	Foot Brake switch active when inching

Base fault Code	Description	Sub fault code	Description
	Inching sequence faults	6	Handbrake requested while inching
		7	Both inching FW and RV switches active
		8	Inching requested while normal driving
Soft error faults - Immediately stops pulsing - Requires a neutral recycle action to reset fault			
15	Supply voltage fault	1	+5 V supply voltage too low
		2	+5 V supply voltage too high
		3	+14 V supply voltage too low
		4	+14 V supply voltage too high
		5	+11 V supply voltage too low
		6	+11 V supply voltage too high
16	Dual motor soft error	0	Other motor in soft error
		1	Other motor short circuited
		2	One or both motors on other axle short circuited
17	Battery voltage too low	1	Battery voltage below Low Voltage absolute minimum
		2	Capacitor voltage below Low Voltage absolute minimum
		3	Battery voltage below Low Voltage error adjustment
		4	Capacitor voltage below Low Voltage error adjustment
18	High sided mosfets short circuit	1	M1 mosfets
		2	M2 mosfets
		3	M3 mosfets
19	Motor stall protection	1	Motor stalling. Please check parameters in “Menu 5.8 “Stall protection””. Make sure motor is free to rotate and it is wired properly (no loose screws, no lack of isolation).
		2	Guard function intervention. Please check parameters in “Menu 5.9 “Speed guard function””. Investigate the cause why the motor can not keep up with the demand: which limitation is active? What is it caused by? Does the motor have enough torque capability?
Hard error faults - Immediately stops giving power to the motor and open line contactor – Reset only by a key switch recycle			
20	Hardware over current detected	1	N/A
		2	N/A
		3	N/A
		4	N/A
		5	N/A
		6	M1 positive overcurrent during initialization
		7	M3 positive overcurrent during initialization
		8	M3 negative overcurrent during initialization
		9	M1 positive overcurrent during running
		10	M3 positive overcurrent during running
		11	M3 negative overcurrent during running
21	Contactor coil driver fault (e.g. short circuit)	1	N/A
		2	N/A
		3	N/A
		4	N/A
		5	N/A
		6	N/A
		7	N/A
		8	N/A
		9	N/A
		10	N/A
		11	N/A
		12	N/A

Base fault Code	Description	Sub fault code	Description
		13	N/A
		14	Driver output 1 short-circuit detected. Make sure the load is not short-circuited.
		15	Driver output 2 short-circuit detected. Make sure the load is not short-circuited.
		16	Driver output 3 short-circuit detected. Make sure the load is not short-circuited.
		17	Driver output 4 short-circuit detected. Make sure the load is not short-circuited.
22	Battery voltage too high	1	Battery voltage above High Voltage absolute maximum
		2	Capacitor voltage above High Voltage absolute maximum
		3	Battery voltage above High Voltage error adjustment
		4	Capacitor voltage above High Voltage error adjustment
23	Low sided mosfets short circuit in neutral	1	M1 mosfets
		2	M2 mosfets
		3	M3 mosfets
24	Hardware fail safe fault	1	N/A
		2	N/A
		3	N/A
		4	N/A
		5	N/A
		6	N/A
		7	Main loop is stuck. Refer to DMC.
		8	Software watchdog caused a reset. Refer to DMC.
		9	N/A
		10	N/A
		11	N/A
		12	N/A
		13	N/A
		14	Safety uP hardware initialization failure. Refer to DMC
		15	Safety uP communication initialization data failure. Refer to DMC
		16	Safety uP communication initialization timeout. Refer to DMC
		17	Safety uP communication establishment failure. Refer to DMC
		18	N/A
		19	N/A
		20	N/A
		21	N/A
		22	N/A
		23	N/A
		24	N/A
		25	N/A
		26	N/A
		27	N/A
		28	N/A
		29	N/A
		30	N/A
		31	N/A
		32	N/A
		33	N/A
		34	Safety uP data exchange corruption. Message counter or checksum failure. Refer to DMC.
		40	Safety uP peripheral not initialized yet
		41	Safety uP failed to recognize WD1 toggling

Base fault Code	Description	Sub fault code	Description
		42	Main uP reading OE2 high during WD1 toggling
		43	Safety uP failed to recognize WD1 stop toggling
		44	Main uP reading OE2 low when WD1 stop toggling
		45	Safety uP failed to recognize WD1 toggling again
		46	Main uP reading OE2 high when Safety uP set OE2 to 0
		47	Safety uP reading OE1 high when Main uP set OE1 to 0
		48	Main uP reading OE2 low when Safety uP set OE2 to 1
		49	Safety uP reading OE1 low when Main uP set OE1 to 1
		50	Rotor speed is above zero speed threshold before applying short circuit
		51	Main uP reading OE2 high when Safety uP set OE2 to 0 during second check
		52	Safety uP reading OE1 high when Main uP set OE1 to 0 during second check
		53	Main uP reading B+Safe pin high when it is set to 0
		54	Safety uP reading B+Safe pin high when Main uP set it to 0
		55	Safety uP reading M2 voltage too low before applying short circuit
		56	Safety uP reading B+Safe pin low before applying short circuit
		57	Safety uP reading both M2 voltage too low and B+Safe pin low before applying short circuit
		58	Safety uP reading M2 voltage and B+Safe pin timeout before applying short circuit
		59	Main uP reading OE2 low after Safety uP set OE2 to 1 when Main uP applying short circuit
		60	Safety uP reading M2 voltage too high after Main uP applying short circuit
		61	Main uP reading B+Safe pin high after Safety uP set OE2 to 1 when Mian uP applying short circuit
		62	Safety uP reading M2 voltage too low after OE2 is set to 1
		63	Safety uP reading B+Safe pin high after OE2 is set to 1
		64	Safety uP reading M2 voltage too low and B+Safe pin high after OE2 is set to 1
		65	Main uP reading OE2 high before normal running
		66	Safety uP fails to enter normal running state
		67	An error occurs during normal running, refer to Safety uP error codes
		68	Safety uP reading M2 voltage and B+Safe pin timeout before releasing short circuit
		69	Safety uP communication configuration failure, refer to DMC
25	Line contactor fault (e.g. short circuit)	1	Could not discharge the capacitor bank before closing the line contactor. Line contactor might be stuck close or battery voltage might be directly applied to B+ terminal.
		2	Capacitor bank did not charge sufficiently to safely close the line contactor. Precharge cannot be finalized. Check the precharge voltage level set by “M2-4 Precharge voltage threshold ”PreChgLv””. Make sure the controller is wired according to diagrams in “3.3.5 Power wiring examples”. Make sure no device is connected between the line contactor and the B+ connector of the SigmaLITE controller.
		3	Line contactor opened inadvertently. Battery voltage (voltage at the key line “Pin A15 Key B+ input”) dropped too low and line contactor could not be provided with enough holding voltage.
		4	Trying to start autotuning with line contactor open
		5	Capacitor bank did not charge sufficiently to safely perform powerup checks. Precharge cannot be finalized. Make sure the controller is wired according to diagrams in “3.3.5 Power wiring examples”. Make sure no device is connected between the line contactor and the B+ connector of the SigmaLITE controller.
26	Thermal shutdown fault	1	N/A
		2	N/A

Base fault Code	Description	Sub fault code	Description
		3	N/A
		4	N/A
		5	N/A
		6	N/A
		7	Motor high temperature shutdown
27	Low sided mosfets short circuit during power up and before line contactor is closed	1	M1 mosfets
		2	M2 mosfets
		3	M3 mosfets
28	Wire off detected	1	Quadrature encoder sensor wire off detected (AC only).
		2	5 V supply wire off detected. Check wire connection and eventually wire off detection threshold at “M8.10-5 5V supply wireoff threshold “5V WrOff””.
		3	N/A
		4	N/A
		5	Motor Temperature Sensor wire off
		6	N/A
		7	N/A
		8	Motor temperature sensor short-circuit
		9	N/A
		10	N/A
		11	N/A
		12	B+ Safe feedback signal is missing. Refer to DMC.
		13	Driver output 1 wire off detected. Make sure the load is connected, otherwise disable the check by means of parameter “M8.5-3 Digital output 1 wireoff enable “WireOff1””.
		14	Driver output 2 wire off detected. Make sure the load is connected, otherwise disable the check by means of parameter “M8.6-3 Digital output 2 wireoff enable “WireOff2””
		15	Driver output 3 wire off detected. Make sure the load is connected, otherwise disable the check by means of parameter “M8.7-3 Digital output 3 wireoff enable “WireOff3””.
		16	Driver output 4 wire off detected. Make sure the load is connected, otherwise disable the check by means of parameter “M8.8-3 Digital output 4 wireoff enable “WireOff4””.
		17	Motor feedback sensor wire off detected. Check cable connection, sensor status and eventually configuration of parameter “M8.10-1 Motor sensor wireoff threshold “MotWrOff””.
		18	Motor feedback sensor short-circuit detected. Check sensor status and eventually configuration of parameter “M8.10-2 Motor sensor shortcircuit threshold “MotShortC””.
		19	10V supply wire off detected. Check cable connection and eventually configuration of parameter “M8.10-3 10V supply wireoff threshold “10VWrOff””
		20	10V supply short-circuit detected. Check connected device’s status and eventually configuration of parameter “M8.10-4 10V supply shortcircuit threshold “10VShortC””
		21	5V supply short-circuit detected. Check connected device’s status and eventually configuration of parameter “M8.10-6 5V supply shortcircuit threshold “5V ShortC””
		22	Safety uP Digital input 1 inconsistency. Refer to DMC.
		23	Safety uP Digital input 2 inconsistency. Refer to DMC.
		24	Safety uP Digital input 2 inconsistency. Refer to DMC.
		25	Safety uP Digital input 4 / Analogue input 1 inconsistency. Refer to DMC.

Base fault Code	Description	Sub fault code	Description
		26	Safety uP Digital input 5 / Analogue input 2 inconsistency. Refer to DMC.
		27	Safety uP Digital input 6 / Analogue input 3 inconsistency. Refer to DMC.
		28	Safe Torque Off toggle timeout. The physical input to which the "Safe torque off toggle" functional input is assigned is recognised to be toggled by the main uP, but the Safety uP is not acknowledging it. Refer to DMC.
		29	Safe Stop 1 toggle timeout. The physical input to which the "Safe Stop 1 toggle" functional input is assigned is recognised to be toggled by the main uP, but the Safety uP is not acknowledging it. Refer to DMC.
		30	Safe torque Off NO/NC inconsistency. The physical input to which the "Safe torque off NO" functional input is assigned and the physical input to which the "Safe torque off NC" functional input is assigned are both open or both closed. The status of those inputs should always be opposite.
		31	Safe Stop 1 NO/NC inconsistency. The physical input to which the "Safe Stop 1 NO" functional input is assigned and the physical input to which the "Safe Stop 1 NC" functional input is assigned are both open or both closed. The status of those inputs should always be opposite.
		32	Bellyswitch NO/NC inconsistency. The physical input to which the "Bellyswitch NO" functional input is assigned and the physical input to which the "Bellyswitch NC" functional input is assigned are both open or both closed. The status of those inputs should always be opposite.
29	CAN node fault	1	Shared Line Contactor master time out fault. The Shared line contactor master does not get any answer from one of the sharing slaves. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly.
		2	N/A
		3	N/A
		4	Shared Line Contactor slave time out fault. The Shared line contactor slave does not get any message from the function's master. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly.
		5	Control Via CAN timeout. The node is not receiving one or more of the active RxPDOs within the timer specified for each of them individually. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly. Make sure the VCU is senting those message with a consistent refresh rate (normally 1/3 of the timeout time).
		6	Control Via CAN Rollover counter error. The node is not receiving a correct rollover counter value from VCU. Make sure all active Rollover counters embedded in RxPDOs are correctly managed by the VCU.
		7	Safe torque off function triggered. The physical input to which the "Safe torque off toggle" functional input is assigned was opened or the physical inputs to which the "Safe torque off NO" and "Safe torque off NC" functional inputs are assigned are, respectively, closed and open.
		8	Dual Motor master/slave main message timeout, other controller not responding. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly.
		9	Dual Motor master/slave data corruption error. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly.
		10	Dual Motor master/slave other controller in fault. Check the root cause of the fault in the other controller.
		11	Can Node ID via digital inputs is detected to be #0. Check digital input status.
		20	Shared Line Contactor Master hard failure recognised by Slave.
		21	Shared Line Contactor Slave hard failure recognised by Master.

Base fault Code	Description	Sub fault code	Description
		22	Shared Line Contactor Slave hard failure recognised by another Slave.
		23	Dual Motor master/slave extra message timeout, other controller not responding. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly.
		24	Control Via CAN Checksum error. The node is not receiving a correct checksum value from VCU. Make sure all active Rollover counters embedded in RxPDOs are correctly managed by the VCU.
		25	Control Via CAN checksum/counter error. The node is not receiving a correct rollover checksum and counter values from VCU. Make sure all active Rollover counters embedded in RxPDOs are correctly managed by the VCU.
		30	BMS timeout during operation. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly.
		31	BMS commanded immediate stop for safety.
		40	CAN bus error. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly.
		41	TxPDO overload. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly. Make sure that some device is present on the CAN bus further than the DMC Controller in case the latter is configured to output any TxPDO.
		42	TxSDO overload. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly. Make sure that some device is present on the CAN bus further than the DMC Controller in case the latter is configured to output any TxSDO.
		43	Network messages overload. Check for CAN bus occupation and timing. Check for CAN bus disturbances. Make sure CAN bus is wired properly. Make sure that some device is present on the CAN bus further than the DMC Controller in case the latter is configured to output any HEARTBEAT or EMCY messages.
		44	Rx messages overload. The DMC Controller received more than 20 messages in 10ms. Reduce message refresh rate or one or more messages.
		45	CAN bus Tx error counter above critical threshold. The CAN peripheral could not transmit the messages on the bus. Check CAN bus wiring and CAN bus occupation, make sure the CAN bus is wired properly and that other devices are active on the bus (i.e. the DMC Controller is not the only device on the bus).
		46	CAN bus Rx error counter above critical threshold. The CAN peripheral received too many corrupted messages from the bus. Check CAN bus wiring and CAN bus occupation, make sure the CAN bus is wired properly and that other devices are active on the bus (i.e. the DMC Controller is not the only device on the bus).
		47	Unknown CAN bus error
		50	Safe Stop 1 function triggered. The physical input to which the “Safe Stop 1 toggle” functional input is assigned was opened or the physical inputs to which the “Safe Stop 1 NO” and “Safe Stop 1 NC” functional inputs are assigned are, respectively, closed and open.
30	Motor overspeeding	1	Motor speed is too high to commence safely giving power to the motor (speed is > 80 % of maximum motor speed). On-fly restart is disabled.
		2	Motor speed is higher than absolute maximum speed. Check configuration of “M5.1-1 Absolute maximum motor speed “AbsMaxSp””.
		3	Maximum motor speed is so high that causes motor to be short circuited when not controlling the motor.
		4	Motor speed is not 0 at powerup, hardware safety checks cannot be performed.

Base fault Code	Description	Sub fault code	Description
31	Motor fault	> 0	See table "Motor sub error codes"
32	Motor Module initialization error	> 0	See table "Motor sub error codes"
33	Motor Module configuration inconsistency	> 0	See table "Motor sub error codes"
34	Motor Module parameter inconsistency	> 0	See table "Motor sub error codes"
35	Current sensor calibration fault	1	Could not initialize the calibration
		2	Time out during calibration
36	Controller temperature over 100 degree	-	
37	--		
38	--		
39	Generic time out	1	Time out on configuration upload
		2	Time out on getting stable inputs
		3	Time out on motor ready. Make sure precharge sequence has succeeded by checking battery and capacitor voltage as read by the controller. Possibly check any F7 configuration error. Disable shared line contactor configuration for proper investigation of the issue.
40	System Fault	<700	Internal system error Contact DMC
		700	Safety uP FW is not compatible with current main uP FW
		710	The current FW is not compatible with the HW.

9.1.1 AC Motor sub error codes

Sub Code	Description
0	No errors in the motor module.
1	The motor module could not be initialized. Internal init failure: load default and reparametrize. If persist refer to DMC.
2	The motor could not be fluxed in time or motor not connected, *Check motor wiring.*
3	A motor overcurrent is detected. *Check motor wiring and motor cable isolation. Be sure controller is properly tuned*
4	Internal unrecoverable Failure: Refer to DMC.
5	Wrong maximum current: selected maximum current is lower than expected nominal current for the controller size: *Increase Maximum Current in the Autotune menu and recycle the key until error disappear and autotune again. If a lower maximum current is required first finish autotuning with a consistent max current and then lower the maximum current and autotune again.*
6	internal error. Refer to DMC.
7	internal error. Refer to DMC.
8	Internal error load default and reparametrize by means of autotuning. If persist refer to DMC.
9	internal error: load default and reparametrize by means of autotuning. If persist refer to DMC.
10	internal error: load default and reparametrize by means of autotuning. If persist refer to DMC.
11	internal error: load default and reparametrize by means of autotuning. If persist refer to DMC.
12	internal error: load default and reparametrize by means of autotuning. If persist refer to DMC.
13	Wrong settings: min flux demand is greater than max flux demand. Check setting number #in the Motor Setup menu it must be greater or equal to setting #in Motor setup Menu.
14	internal error: load default and reparametrize by means of autotuning.. If persist refer to DMC.
15	Unable to calculate motor curves: → decrease motor nominal frequency (do autotuing again) → increase nominal current (do autotuning again) → decrease maximum current (do autotuing again).
16	Unable to recalculate motor parameters because unable to find the frequency base point for field weakening within the set max frequency: *a. reduce maximum current in the autotuning menu (do auto-tuning again)* b. *increase max. frequency parameter in the autotuning menu (do auto-tuning again).*
17	Unable to re calculate motor parameters because calculated flux is out of range: → *perform auto tuning again decreasing rated current.*
18	Unable to re calculate parameters (perform again auto tuning starting from default and check motor connection and if motor is free to spin)
19	Unable to recalculate: *increase nominal motor frequency cycle key and launch autotuning again*
20	Unable to recalculate limit curves. The maximum current in the autotuning menu is too high for the motor. *Reduce Maximum current in the autotuning menu and perform recalculation.*
21	Unable to recalculate limit curves, the maximum frequency in the autotuning menu is too high for the motor. *Reduce maximum frequency in the autotuning menu and perform recalculation.*
22	Autotuning results value are corrupted. *Do autotuning again or download a consisted setup list*.
23	Nominal Frequency and Or Maximum frequency re-calculated by autotuning are greater than 400Hz (absolute maximum). *Decrease "BattV AT" in AT menu and recalculate again.*
24	An internal unknown error occurred: refer to DMC.

9.1.2 PMS motor error subcodes

Sub Code	Description
0	No errors in the motor module.
1	The motor module could not be initialized. Load Default Parameter and key cycle
2	An motor overcurrent is detected. Check if motor tuned properly, check motor wiring (lack of isolation)..
3	Internal error refer to DMC
4	Wrong current setup: current for Autotuning is set greater than maximum current. Check current setup in tha autotuning menu.
5	Wrong number of motor poles. An odd number has been set to Nof motor poles in the autotuning menu.
6	Internal error refer to DMC
7	Internal error refer to DMC
8	Sine signal is out of range: check sin cos sensor wiring, sensor supply and sensor
9	Cosine signal is out of range: check sin cos sensor wiring, sensor supply and sensor
10	No Hall sensor signals; check hall sensor wiring.
11	Number of motor poles and sin cos sensor number of teeth (poles) are not consistent. The ratio between number of motor poles and sin cos sensor number of teeth must me a integer.
12	Unable to perform recalculation: motor calculated maximum speed exceeds maximum allowed frequency. Check motor parameters. If parameters are right, reduce battery voltage in the autotuning menu and recalculate.
13	Unable to recalculate controller gains: check motor parameters (Ls, Ke, Fmax, Idemag) and perform recalculation or do autotuning again.
14	Unable to recalculate: base frequency too low. Check settings in autotuning menu (Ls, Ke, Fmax, V battery Idemag), if they are right Reduce maximum current in the autotuning menu and recalculate.
15	Unable to recalculate: demag current not enough, Increase if possible Idemag. This error occur if field weakening option is selected by using a Idemag current greater than 1 A.
16	Unable to recalculate limit curves: reduce max frequency in autotuning menu and recalculate
17	Unable to recalculate limit curves: reduce max current and or battery voltage too low for the motor, and recalculate
18	Unable to recalculate limit curves: reduce max frequency, reduce max current and recalculate.
19	Field weakening enabled (I demag greater than 1A) but Volt control option is not enabled. Enable Volt Control Option in Advanced Motor menu.
20	One or more motor phase missing. Check cable connection.
21	Internal error refer to DMC

9.1.3 IPM motor error subcodes

Sub Code	Description
0	No errors in the motor module
1	The motor module could not be initialized. *Report to DMC*
2	An overcurrent is detected: *Motor is overloaded or wrong position sensor settings*
3	Internal error *Report to DMC*
4	Wrong current: rated motor current is greater than maximum*: Check setting 8 and 7 in the autotune menu*
5	Wrong poles number.
6	Internal error *Report to DMC*
7	Internal error *Report to DMC*
8	Sine signal is out of range: check connection and sensor
9	Cosine signal is out of range: check connection and sensor
10	No Hall sensor signal; check connection and sensor
11	Unable to perform recalculation: motor calculated maximum speed exceeds 500 Hz: *; check motor parameters (LD,LQ Ke, Fmax) in auto tune menu.*
12	Unable to perform recalculation: two or more speed points are equal. The maximum current set is too high for the motor. Decrease the Maximum current in the Autotune menu and perform a recalculation.
13	In one point or several points of the tables the total current (Sqrt(Id^2+Iq^2)) exceed the maximum current set in the autotuning menu. Current Tables are not consistent with autotuning menu. How to eliminate this error: 1) Do a recalculation procedure 2) Set in advanced Motor menu "M6-9 Angle/Idq Table Control "IDQTblCn"" to 0 and if it is possible do motor autotuning again (full type 0 or type 2). Set back "M6-9 Angle/Idq Table Control "IDQTblCn"" to 1 once autotuning succeed.
14	Sensor number of poles is inconsistent with motor poles. Possible combination of Motor poles and sensor poles are the ones give integer ratio between NMotorPole/NSensPole. Example: NMotorPoles 8 NSensorPoles 4 ratio= 2 (8/4) allowed NMotorPoles 8 NSensorPoles 6 ratio= 1,33 (8/6) NOT allowed
15	One or more motor phase missing. Check cable connection.
16	Advanced recalculation can not be performed. Run an autotuning type 2 with "advanced autotuning" enabled first.
17	Internal error *Report to DMC.*

9.2 Supervisor uP error codes

The supervisor uP is able communication its error code trough the Main uP. This error code can be investigate by means of the DMC CAN Open Calibrator in "Menu 0 "Status"", or by retrieving object 0x38A1 via CAN.

The SuP error code is represented by means of a 32-bit bit-significant double word, with the following meaning:

Bit	Description
0	Input 1 inconsistency. SuP is reading a different input value than MuP.
1	Input 2 inconsistency. SuP is reading a different input value than MuP.
2	Input 3 inconsistency. SuP is reading a different input value than MuP.
3	Input 4 inconsistency. SuP is reading a different input value than MuP.
4	Input 5 inconsistency. SuP is reading a different input value than MuP.
5	Input 6 inconsistency. SuP is reading a different input value than MuP.
6	N/A
7	N/A
8	Input 1 toggle check error. SuP recognised the input toggling, while MuP did not acknowledge it.
9	Input 2 toggle check error. SuP recognised the input toggling, while MuP did not acknowledge it.
10	Input 3 toggle check error. SuP recognised the input toggling, while MuP did not acknowledge it.
11	Input 4 toggle check error. SuP recognised the input toggling, while MuP did not acknowledge it.
12	Input 5 toggle check error. SuP recognised the input toggling, while MuP did not acknowledge it.
13	Input 6 toggle check error. SuP recognised the input toggling, while MuP did not acknowledge it.
14	N/A
15	N/A
16	Input 1 function safety function triggered. The safety function assigned to input 1 has been triggered (STO or SS1) or has failed (Prevent To Trave, Travel Control).
17	Input 2 function safety function triggered. The safety function assigned to input 2 has been triggered (STO or SS1) or has failed (Prevent To Trave, Travel Control).
18	Input 3 function safety function triggered. The safety function assigned to input 3 has been triggered (STO or SS1) or has failed (Prevent To Trave, Travel Control).
19	Input 4 function safety function triggered. The safety function assigned to input 4 has been triggered (STO or SS1) or has failed (Prevent To Trave, Travel Control).
20	Input 5 function safety function triggered. The safety function assigned to input 5 has been triggered (STO or SS1) or has failed (Prevent To Trave, Travel Control).
21	Input 6 function safety function triggered. The safety function assigned to input 6 has been triggered (STO or SS1) or has failed (Prevent To Trave, Travel Control).
22	SuP CRC or counter error.
23	N/A
24	SuP communication timeout
25	SuP communication timeout
26	Speed limit guarding error
27	MuP hardware watchdog failure
28	STO Normally Open and Normally Close inconsistency recognised.
29	SS1 Normally Open and Normally Close inconsistency recognised.
30	Emergency Drive Forward Normally Open and Normally Close inconsistency recognised.
31	N/A

Please notice that more than one fault might be active at a time.

Menu 11 “Fault log”

The fault log remembers the last 10 faults and stores the key hours when the fault happened.
Holding the (-) button shows the registered hours counter time when the fault occurred.
Holding the (+) button shows the fault sub error code.

NOTICE!

To reset the fault log data, press the + and – button at the same time when the controller is in neutral.

10 Software updates

DMC reserves the right to issue Software Updates without prior notice.

Software Updates are intended to introduce new functionalities, update existing ones or fix bugs in the application or motor module.

In case an update has to be performed on a DMC SigmaLITE Controller, this must be carried out trough the CAN network using the DMC Configurator.

11 DMC Displays

11.1 DMC Lite Display

Developed as a the new generation for the DMC Display, the DMC Lite Display maintains the flexibility of its predecessor, introducing a brand new graphical design.
The DMC Lite Display still operates on the CAN bus and has the capability of showing the information of up to 6 DMC SigmaLITE Controllers at the same time.
The DMC Lite Display features 5 different pages to display all the available information:

1) The Main page displays Drive and BDI information of the "Display Master Controller" and, if any, the active faults of every DMC Controller in the Network configured to send messages to the DMC Display.
2) The Second Page shows a detailed status of each DMC SigmaLITE Controller configured to send messages to the DMC Display.
3) The Third page shows the drive and key hour counters, plus a configurable vehicle number to uniquely identify the machine.
4) The Fourth page shows a fault logger, gathering the fault of every DMC SigmaLITE Controller.
5) The Fifth page displays information about Display SW and HW.

In addition to this, a setup menu is present and can be accessed from every page by pressing the central button.

For more information about the DMC Lite Display please refer to the dedicated Application Note ([2]).

11.2 DMC Advanced Display

Developed as a plug-in vehicle dashboard, the DMC Advanced Display represents the state-of-art of vehicle monitoring. It features a modern graphical design, combined with the capability of interacting with up to 8 nodes, further than with a BMS.
All driving information are easily visible in the main page, while service information about each controller connected can be accessed in auxiliary pages.

For more information about the DMC Advanced Display please refer to the dedicated Application Note ([2]).

APPENDIX A - Technical specifications

Electrical

Voltage specifications:

Model	Nominal battery voltage	Absolute operating voltage range	Reduced braking voltage levels (*low threshold adjustable*)	Minimum operating voltage	High Voltage trip level
XXX425Y	24V – 52V	15.0V – 63.0V	58.0V – 62.0V	15V	63V

Note: These voltage levels are used to set the voltage levels in the Limits menu.

Current specifications:

Model	Power	Current limit (1 min 30 sec)	Continuous current 1 hour rating. Unit mounted on an sufficient heat sink, at 20°C ambient.
XXX425Y	24/48V 250A	250Arms	130Arms

Power losses

Model	Current [A]	Losses [W]
XXX425Y	50A	45W
	100A	95W
	150A	170W
	200A	300W
	250A	410W

The above data is recoded in thew following conditions:

- Output frequency: 70Hz
- Power factor: 0.86
- PWM modulation index: 100%

Data might vary up to ±20% according to the actual operating conditions.

Other specifications:

PWM switching Frequency	8 kHz
Motor PWM equivalent frequency	16 kHz
Maximum encoder/hall sensor frequency	75 kHz
Maximum sin/cos frequency	2 kHz
Electrical Isolation	
Reverse Battery Polarity	Yes, if Line Contactor installed
I/O details	AMPSEAL 23-pole connector
Power consumption	5W
CAN chip current	
Key line inrush current	
Precharge current	

Environmental

Mechanical Impact Protection (IP) rating	IP67 (with AMPSEAL 23-pole connector fitted)
Vibration	16 kHz
Storage ambient temperature	-40 °C to +70 °C (-40 °F to 158 °F)
Operating ambient temperature	-40 °C to +50 °C (-40 °F to 122 °F)
Internal operating temperature	-40 °C to +95 °C (-40 °F to 203 °F)
Vibration	
Humidity	95% maximum, non-condensing
EMC	Designed to the requirements of EN12895:2015

Mechanical

Power connectors	5 vertical aluminium studs (B+, B-, M1, M2, M3)
Dimensions (W x L x H)	109 x 147 x 56 mm (4.29 x 5.79 x 2.2 inches)
Weight	0.885 kg (1.95 lbs)
Baseplate material	Aluminium
Mounting holes	4x Ø6.5
Enclosure material	ABS plastic

APPENDIX B – EMC guidelines

The following guidelines are intended to help vehicle manufacturers to meet the requirements of the EC directive Electromagnetic Compatibility. The SigmaLITE Controller range is designed to meet EN61000-6-2 (industrial immunity), EN61000-6-3 (residential emissions, Class B).
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.

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 minimize 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.

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.

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”.

APPENDIX C – Analogue Input tuning

This short guide will explain how to tune an analogue input.

WARNING!

These procedures are to be followed with wheels off the ground and vehicle in neutral (no direction switches selected).

Tuning of single channel Accelerator pedal

1. Assign the "accelerator" functional input to any analogue physical input in "Menu 8.1 "Input/output assignment"".
2. Enter "Menu 10.1 "Test Hardware"";
3. With the accelerator fully released, take note of the voltage value al line:
   - #7, in case the "accelerator" functional input was assigned to AI1;
   - #9, in case the "accelerator" functional input was assigned to AI2;
   - #11, in case the "accelerator" functional input was assigned to AI3;
4. With the accelerator fully pressed, take note of the voltage value al line:
   - #7, in case the "accelerator" functional input was assigned to AI1;
   - #9, in case the "accelerator" functional input was assigned to AI2;
   - #11, in case the "accelerator" functional input was assigned to AI3;
5. Depending on which analogue input the functional input "accelerator" has been assigned, set
   - "M8.2-1 Analogue Input 1 minimum voltage level "AI1 min"" in case the "accelerator" functional input was assigned to AI1
   - "M8.3-1 Analogue Input 2 minimum voltage level "AI2 min"" in case the "accelerator" functional input was assigned to AI2
   - "M8.4-1 Analogue Input 3 minimum voltage level "AI3 min"" in case the "accelerator" functional input was assigned to AI3

   as the voltage level found at point 3).

6. Depending on which analogue input the functional input "accelerator" has been assigned, set
   - "M8.2-2 Analogue Input 1 maximum voltage level "AI1 max"" in case the "accelerator" functional input was assigned to AI1
   - "M8.3-2 Analogue Input 2 maximum voltage level "AI2 max"" in case the "accelerator" functional input was assigned to AI2
   - "M8.4-2 Analogue Input 3 maximum voltage level "AI3 max"" in case the "accelerator" functional input was assigned to AI3

   as the voltage level found at point 4).

APPENDIX D – Wireoff detection tuning

The DMC SigmaLITE Controller has tuneable current threshold for guaranteeing wire-off detection on both its "Pin A10 Analogue supply – 5V / 30mA", "Pin A11 Analogue supply – 10V / 100mA" and "Pin A16 Sensor supply - 5V or 10V / 70mA" supply outputs.
Is it given for granted that, in case any load is connected to the mentioned pins, it will absorb a certain amount of current.
The parameters "M8.10-5 5V supply wireoff threshold "5V WrOff"", "M8.10-3 10V supply wireoff threshold "10VWrOff"" and "M8.10-1 Motor sensor wireoff threshold "MotWrOff"" define, respectively, the current threshold below which the load is considered disconnected, as too low current absorption is measured.
Please notice that setting a value of 0mA to the mentioned parameters, corresponds in disabling the wire-off detection.
Hereafter a procedure for tuning the wire-off detection parameter is reported:

1- Perform the final wiring of the machine. This point is very important, as more than 1 load can be connected at the same time under one supply. Changing the machine wiring might lead to spoiling the setup of the wire-off related parameter.

2- Enter "Menu 10.1 "Test Hardware"".

3- Scroll down to line:

  - #47 for tuning the wire-off related to "M8.10-5 5V supply wireoff threshold "5V WrOff"".

  - #48 for tuning the wire-off related to "M8.10-3 10V supply wireoff threshold "10VWrOff"".

  - #49 for tuning the wire-off related to "M8.10-1 Motor sensor wireoff threshold "MotWrOff"".

4- Take note of the current absorption value reported. Please notice that, in case a potentiometer is connected to the supply output, different absorption can be noticed at different potentiometer level. The minimum absorption value should be noted down. In case multiple potentiometers are connected to one supply, the minimum absorption value should be investigated.

5- Enter "Menu 8.10 "Wireoff and Shortcircuit detection""

6- Set:

  - "M8.10-5 5V supply wireoff threshold "5V WrOff"" in case wire-off for "Pin A10 Analogue supply – 5V / 30mA" is being tuned.

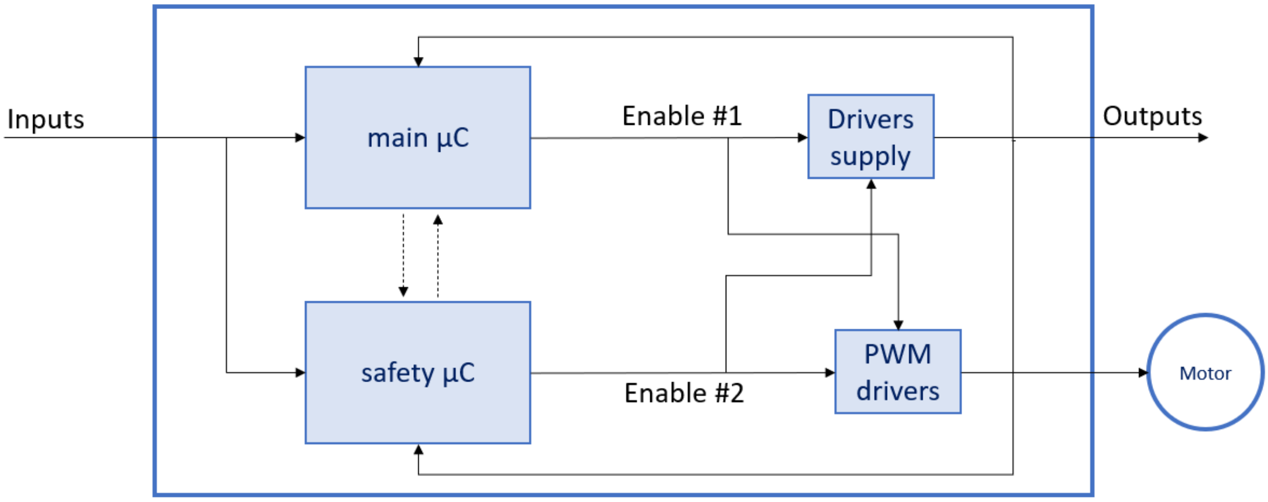
  - "M8.10-3 10V supply wireoff threshold "10VWrOff"" in case wire-off for "Pin A11 Analogue supply – 10V / 100mA" is being tuned.

  - "M8.10-1 Motor sensor wireoff threshold "MotWrOff"" in case wire-off for "Pin A16 Sensor supply - 5V or 10V / 70mA" is being tuned.

  to the current value noted at point 4).

APPENDIX E – Safety compliance to EN 13849

The DMC SigmaLITE controller is designed to meet the highest standards with respect to vehicle construction safety. The European Machinery Directive states that the guidelines defined by EN 13849 must be followed when designing safety-related parts of control systems, and the said systems must be proven to comply to the norm.
EN 13849 introduces the concept of safety Performance Level (PL), which is achieved through an appropriate hardware design, the requirement of high enough Mean Time To Dangerous Failure (MTTFd) and adequate Diagnostic Coverage (DC). Based on these elements, vehicle manufacturers can calculate the Performance Level for each function which requires it.
DMC guaranteed the compliancy with EN 13849 using advanced hardware design and modern monitoring techniques. A "safety" microcontroller (SμC) has been introduced, acting in parallel to the "main" microcontroller (MμC), providing redundancy on input reading, function activation and monitoring and output management. This hardware design can be represented by the block scheme reported below.



Both SμC and MμC run diagnostic checks at every powerup and system reset to guarantee hardware, software and memory integrity. Once this has been proved, their normal operation is made completely independent from one another to guarantee maximum safety redundancy. In case these initial checks fail, power is never applied to the system and drive will be inhibited.
At runtime a communication exists between the two μC, guaranteeing live input status cross-check, drive information exchange and system status cross-feedback at a rate exceeding 40 times per second. This communication is implemented according to safety communication design guidelines, introducing independently calculated checksum for each message. In case any fault is found during runtime communication
In case some input inconsistency, communication error or safety function activation need or failure is found, both μC are able to perform a safe shutdown of the motor and the controller, disabling both PWM drivers and all driver outputs (resulting in Line Contactor opening and, if present, Electromechanical Brake closing) within 100 mS.

Several safety-related functions are implemented in the DMC Sigma2N controller, either related to Control Via CAN (Safe Torque Off and Safe stop 1), either related to general driving conditions (Prevent To Travel, Travel Control, Emergency Drive Forward).
The former (STO and SS1) fall under the definitions provided by EN 60204-1/2006 with Stop Category, respectively, 0 and 1.
The latter (PTT, TC, EDF), fall under the definitions provided by EN 1175-1/1998 and EN1175-1/2020 and assure that no unintended movement can be performed. The compliancy with the mentioned safety norm, specific to battery-powered industrial vehicles, provides the basic requirements to guarantee compliancy with the European Machine Directive. The "Travel Control" and "Prevent To Travel" safety functions guarantee that the following hazardous situations can be avoided:

- Uncommanded motion
- Faulted accelerator giving wrong inputs
- Faulted direction switches commanding an incompatible direction input (i.e. both FW and RV at the same time)
- Faulted interlock switch commanding a "fake" operator presence

- Incorrect direction of motion

The table reported below lists the implemented safety functions implemented in the DMC SigmaLITE controller, alongside with the useful parameters that OEM's may need to check the overall safety compliancy of their product.

Safety function	PL	Category	MTTFd
Safe Torque Off	d	3	
Safe Stop 1	d	2	
Prevent To Travel	d	2	
Travel Control	d	2	
Emergency Drive Forward	d	2	