DMC GmbH
Digital Motor Control

# SuperSigma2 ADM for Permanent Magnets Synchronous motors

## ADVANCED MANUAL V 1.5.6

**This user manual details the features of the standard controller range:**

PMS range 24-96V 250-600Arms

Preliminary information, we reserve the right to update and/or modify this manual at any time without prior notice.

**Modification History:**

| Revision | Issue Date | Author | Changes |
|---|---|---|---|
| 1.0 | 04-01-2017 | FM | Concept matching firmware V02.07.01 |
| 1.1 | 01-04- 2017 | FM | Match firmware V02.07.03 |
| 1.2 | 01-11-2017 | YS | Match firmware V02.08.00 |
| 1.2.1 | 19-02-2018 | RP | Corrected mechanical drawing Size 1 |
| 1.3 | 13-03-2018 | FM | V02.08.01 Improved the inching in traction, added Shared Line contactor compatible with Control Via CAN HMI, enable the creep ramp time for traction and pump, add serial numbers visible in About menu of calibrator. |
| 1.3.1 | 22-05-2018 | RP | Update Layout |
| 1.4 | 04-06-2018 | FM | V02.08.02 Improved F30 (overspeed) management (pump-traction). Increased available output voltage for AC motor(pump.traction). For traction: improved inching, footbrake operation, scale of accel pot in traction speed mode. Added adj 17 in traction for torque mode 3 for better end of braking in footbrake operation. Changed some default values. Included Park Icon for display.. Improved F12 and F13 management. Improved PC interface settings download. Improved the function inhibit of change of direction. |
| 1.4.1 | 24-08-2018 | FM | Update Layout and Cross-references. Minor textual errors corrected |
| 1.4.2 | 15-01-2019 | FM | Update Nominal RMS motor current for tuning |
| 1.5.0 | 04-09-2019 | SM | Match firmware V02.09.00, textual error corrected, updated layout |
| 1.5.1 | 04-10-2019 | FM | Review and fixed typos |
| 1.5.2 | 14-10-2019 | SM | Added F7 sub codes, minor graphical fixes in controller setup table |
| 1.5.3 | 03-11-2019 | AvB | Update Layout |
| 1.5.4 | 09-01-2020 | SM | Fixed M3-17T parameter description, fixed menus defaults and ranges |
| 1.5.5 | 15-01-2020 | SM | Updated reference to QRM manual, updated max speed limits defaults in Adjustment, AT and Limits menus. |
| 1.5.6 | 17-01-2020 | SM | Updated reference to QRM manual, added walkie-related parameters, added warnings for FW and RV inputs both active, modified F10 description |

 ©2019 DMC GmbH Herten Germany

# Contents


**1 ABOUT THIS MANUAL ..... 9**

1.1 REFERENCES ..... 9
1.2 HOW SETTINGS ARE NUMBERED IN THIS DOCUMENT ..... 9
1.3 HOW TO CORRECTLY AND TIME-EFFICIENTLY SETUP A CONTROLLER ..... 9

**2 CONTROL CONNECTIONS ..... 10**

*Pin 1 Forward i/p -- Pump Potentiometer Switch 1 ..... 10*
*Pin 2 Reverse i/p -- Pump Switch 2 ..... 10*
*Pin 3 Footswitch / Belly Button -- Pump Switch 3 ..... 10*
*Pin 4 Seat / Tiller -- Pump Switch 4 ..... 11*
*Pin 5 Speed Limit 1 / Inch Forward -- Pump Switch 5 ..... 11*
*Pin 6 Speed Limit 2 / Inch Reverse -- Pump Switch 6 (Power Steer Input) ..... 11*
*Pin 7 Speed Limit 3 / Handbrake -- Pump Inhibit ..... 12*
*Pin 8 Analogue supply 5V ..... 12*
*Pin 9 Analogue AD1 i/p Accelerator -- Potentiometer ..... 12*
*Pin 10 Analogue supply 0V ..... 12*
*Pin 11 Analogue AD2 -- Footbrake pot ..... 13*
*Pin 12 Analogue AD3 -- Steer pot ..... 13*
*Pin 13 Key i/p ..... 13*
*Pin 14 Contactor supply o/p ..... 13*
*Pin 15 Contactor 1 o/p (Line) ..... 13*
*Pin 16 Contactor 2 o/p (Magnet Brake - Fan control) ..... 14*
*Pin 17 Contactor 3 o/p (Powersteer - Fan control) ..... 14*
*Pin 18 Digital o/p -- Remote LED or Brake lights or Drive OK ..... 14*
*Pin 19 Supply 12V -- 70mA max. ..... 14*
*Pin 20 CAN +12V -- 70mA max. ..... 14*
*Pin 21 CAN H1 ..... 14*
*Pin 22 CAN L1 ..... 14*
*Pin 23 CAN 0V ..... 14*
*Pin 24 CAN 120R Link ..... 14*
*Pin 25 CAN H2 ..... 15*
*Pin 26 CAN L2 ..... 15*
*Pin 27 Sensor supply +5V / +12V ..... 15*
*Pin 28 Hall 1 i/p ..... 15*
*Pin 29 Hall 2 i/p ..... 15*
*Pin 30 Hall 3 i/p ..... 15*
*Pin 31 Sensor supply 0V ..... 15*
*Pin 32 Motor Sensor Sine ..... 15*
*Pin 33 Motor Sensor CoSine ..... 15*
*Pin 34 Thermistor AD4 i/p ..... 15*
*Pin 35 Thermistor 0V ..... 15*

2.1 LIGHT WIRING OF PMS CONTROLLER ..... 16

*2.1.1 Connectors' pin assignment for Traction ..... 16*
*2.1.2 Light wiring example for traction ..... 17*
*2.1.3 Connectors' pin assignment for Pump ..... 18*
*2.1.4 Light wiring example for pump ..... 19*

2.2 SELECTING ACTIVE LOW OR HIGH DIGITAL INPUTS ..... 20

*2.2.1 Active Low digital inputs ..... 20*
*2.2.2 Active High digital inputs ..... 21*

2.3 USE OF OHMIC POTENTIOMETERS AND ELECTRONIC POTENTIOMETERS ..... 21
2.4 POWER WIRING ..... 22

**3 MENU 1 "ADJUSTMENT" ..... 23**

3.1 MENU 1 "TRACTION ADJUSTMENTS" ..... 23

*M1-1T Acceleration delay "Accel" ..... 24*
*M1-2T Deceleration delay "Decel" ..... 25*


 ©2019 DMC GmbH Herten Germany

M1-3T Creep speed “Creep” ..... 25
M1-4T Creep speed Ramp “CreepRmp” ..... 25
M1-5T Maximum speed forward “SpdMaxF” ..... 25
M1-6T Maximum speed reverse “SpdMaxR” ..... 25
M1-7T Neutral Brake torque “NBrake” ..... 25
M1-8T Neutral brake ramp time “NBrkRamp” ..... 25
M1-9T Neutral brake-End delay “NBrkEnd” ..... 25
M1-10T Direction Brake torque “DBrake” ..... 26
M1-11T Direction brake ramp time “DBrkRamp” ..... 26
M1-12T Max. direction change speed “MxDbrkSp” ..... 26
M1-13T Foot brake torque “FBrake” ..... 27
M1-14T Foot brake ramp time “FbrkRamp” ..... 27
M1-15T Speed threshold to enter end of braking mode ”SpdThEbM” ..... 28
M1-16T Speed threshold Ramp time to zero speed ”SpdRmpTm” ..... 28
M1-17T Foot Brake Speed threshold Ramp time to zero speed “SpdRTmFB ..... 28
M1-18T Zero Speed Threshold to enter hill hold or neutral brake end ”ZSpdTh” ..... 28
M1-19T Hill hold time ”HHTime” ..... 28
M1-20T Restraint hill hold speed ”HHspeed” ..... 28
M1-21T Restraint hill hold torque threshold ”HHTrqTH” ..... 28
M1-22T Cutback speed 1 (I/O 5-6 set to Speed) “Speed1” ..... 36
M1-23T Inching speed (I/O 5-6 set to Inching) “InchSpd” ..... 36
M1-24T Acceleration delay 1 “Accel1” ..... 36
M1-25T Deceleration delay 1 “Decel1” ..... 36
M1-26T Maximum Drive Torque 1 (Torque Mode Only) “MxDrTrq1” ..... 36
M1-27T Neutral Brake Torque 1 (Torque Mode Only) “NBrkTrq1” ..... 36
M1-28T Neutral brake ramp time 1 “NBrkRmp1” ..... 36
M1-29T Direction Brake torque 1 (Torque Mode Only) “DBrkTrq1” ..... 36
M1-30T Direction brake ramp time 1 “DBrkRmp1” ..... 36
M1-31T Foot Brake Torque 1 (Torque Mode Only) “FBrkTrq1” ..... 36
M1-32T Foot brake ramp time 1 “FBrkRmp1” ..... 36
M1-33T Cutback speed 2 (I/O 5-6 set to Speed) “Speed2” ..... 37
M1-34T Inching time (I/O 5-6 set to Inching) “InchTime” ..... 37
M1-35T Acceleration delay 2 “Accel2” ..... 37
M1-36T Deceleration delay 2 “Decel2” ..... 37
M1-37T Maximum Drive Torque 2 (Torque Mode Only) “MxDrTrq2” ..... 37
M1-38T Neutral Brake Torque 2 (Torque Mode Only) “NBrkTrq2” ..... 37
M1-39T Neutral brake ramp time 2 “NBrkRmp2” ..... 37
M1-40T Direction Brake torque 2 (Torque Mode Only) “DBrkTrq2” ..... 37
M1-41T Direction brake ramp time 2 “DBrkRmp2” ..... 37
M1-42T Foot Brake Torque 2 (Torque Mode Only) “FBrkTrq2” ..... 37
M1-43T Foot brake ramp time 2 “FBrkRmp2” ..... 37
M1-44T Cutback speed 3 (I/O 7 set to speed3) “Speed3” ..... 37
M1-45T Handbrake On maximum Speed (I/O 7 set to Handbrake) “HandBrk” ..... 37
M1-46T Maximum Drive Torque speed 3 (I/O 7 set to Handbrake) “MxDrTrq3” ..... 37
M1-47T Speed limit ramp “SpLimRmp” ..... 37
M1-48T Drive torque reduction time “DTrqRtm” ..... 37
M1-49T Brake torque reduction time “BTrqRtm” ..... 38
M1-50T Power steer delay “PStrDly” ..... 38
M1-51T Electric brake delay “EBrkDly” ..... 38
M1-52T Accelerator pot minimum “AccMin” ..... 38
M1-53T Accelerator pot maximum “AccMax” ..... 38
M1-54T Brake pot minimum “BrkMin” ..... 38
M1-55T Brake pot maximum “BrkMax” ..... 38
M1-56T Steer pot minimum ”StrMin” ..... 39
M1-57T Steer pot middle point ”StrMid” ..... 39
M1-58T Steer pot maximum ”StrMax” ..... 39
M1-59T Wig/Wag fwd threshold ”FwdTH” ..... 39
M1-60T Wig/Wag rev threshold ”RevTH” ..... 39
M1-61T Dual motor cut out ”DMcut” ..... 40
M1-62T Dual motor angle 1 ”DMang1” ..... 40
M1-63T Dual motor angle 2 ”DMang2” ..... 40
M1-64T Dual motor angle 3 ”DMang3” ..... 40
M1-65T Dual motor speed 1 ”DMspd1” ..... 40
M1-66T Dual motor speed 2 ”DMspd2” ..... 40

 ©2019 DMC GmbH Herten Germany

*M1-67T Dual motor speed 3 "DMspd3"* ..... *40*
*M1-68T Speed ratio (display Kph) "SpdRatio"* ..... *42*
*M1-69T Vehicle max. Speed "VmaxSpd"* ..... *42*
*M1-70T Safe stop Torque (Torque mode only) "SfStTorque"* ..... *42*
*M1-71T Safe stop Ramp Time "SfStRmpTm"* ..... *42*
*M1-72T Belly switch speed "BellySpd"* ..... *42*
*M1-73T Belly switch time "BellyTim"* ..... *42*

3.2 MENU 1 "PUMP ADJUSTMENTS" ..... 43

*M1-1P Acceleration delay "Accel"* ..... *43*
*M1-2P Deceleration delay "Decel"* ..... *43*
*M1-3P Creep speed "Creep"* ..... *43*
*M1-4P Creep speed Ramp "CreepRmp"* ..... *43*
*M1-5P Maximum pot speed 1 "Potmax1"* ..... *43*
*M1-6P Speed 2 demand "Pspeed2"* ..... *43*
*M1-7P Speed 3 demand "Pspeed3"* ..... *43*
*M1-8P Speed 4 demand "Pspeed4"* ..... *44*
*M1-9P Speed 5 demand "Pspeed5"* ..... *44*
*M1-10P Speed 6 demand (power steer) "Pspeed6"* ..... *44*
*M1-11P Minimum motor speed in cutback conditions "MinSpeed"* ..... *44*
*M1-12P Acceleration delay for speed 6 demand (pwrStr) "Paccel6"* ..... *44*
*M1-13P Power steer delay "PStrDly"* ..... *44*
*M1-14P Accelerator pot minimum "AccMin"* ..... *44*
*M1-15P Accelerator pot maximum "AccMax"* ..... *44*
*M1-16P Speed threshold to enter in end of braking mode "SpdThEbM"* ..... *44*
*M1-17P Ramp time from SpdThSpC to zero "SpdRmpTm"* ..... *44*
*M1-18P Zero Speed threshold to end braking "ZSpdTh"* ..... *44*

**4 MENU 2 "STATUS" ..... 45**

4.1 STATUS TABLES ..... 46

*M2-3 BDI States table* ..... *46*
*M2-6 Drive and brake status table* ..... *46*
*M2-7 Speed limits table* ..... *46*
*M2-8 Torque limits table* ..... *46*
*M2-9 Motor limits table* ..... *46*

**5 MENU 3 "CONTROLLER SETUP" ..... 47**

5.1 MENU 3 "CONTROLLER SETUP FOR TRACTION" ..... 47

*M3-1T Accel. Characteristic "Lin/Curv"* ..... *49*
*M3-2T Control Mode "Spd/Torq"* ..... *49*
*M3-3T Proportional direction brake "Off /Bpro"* ..... *50*
*M3-4T Hill hold "Off/HH/S"* ..... *50*
*M3-5T I/O Pin 5 and 6 "Sp/In/Ad"* ..... *51*
*M3-6T I/O Pin 7 "Spd3/Hbk"* ..... *52*
*M3-7T Power steer trigger "PsF/FR/S"* ..... *52*
*M3-8T Vehicle type select "Ride/Wlk"* ..... *52*
*M3-9T Tiller Function "TillFunc"* ..... *53*
*M3-10T Belly switch disabled at zero speed and in neutral "BellFunc"* ..... *53*
*M3-11T Display Status field "Of/D/V/K"* ..... *53*
*M3-12T Accelerator type "AccelTyp"* ..... *53*
*M3-13T Accelerator Damping Factor "AccelDam"* ..... *54*
*M3-14T Single or Dual Motor "Si/DL/DR"* ..... *54*
*M3-15T Digital O/P 4 config "DO4Typ"* ..... *54*
*M3-16T Active low or high digital inputs "ActvL/H"* ..... *54*
*M3-17T Accelerator supply wire off detection "SplyWrOf"* ..... *55*
*M3-18T Standby timer "StdByDly"* ..... *55*
*M3-19T Driver output 2 configuration "Drv2Cfg"* ..... *55*
*M3-20T Driver output 3 configuration "Drv3Cfg"* ..... *55*
*M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"* ..... *55*
*M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"* ..... *55*
*M3-23T Line Contactor pull-in level "LCPlInLv"* ..... *56*

 ©2019 DMC GmbH Herten Germany

*M3-24T Line Contactor pull-in time out "LCPllnTO"* ..... *56*
*M3-25T Drive torque during braking "DTrq@Brk"* ..... *56*
*M3-26T Line Contactor Coil pull-in voltage "LCPllnVl"* ..... *56*
*M3-27T Line Contactor Coil holding voltage "LCHoldVl"* ..... *56*
*M3-28T Digital Output 2 pull-in voltage "Do2PllnV"* ..... *56*
*M3-29T Digital Output 2 hold voltage "Do2HoldV"* ..... *56*
*M3-30T Digital Output 3 pull-in voltage "Do3PllnV"* ..... *56*
*M3-31T Digital Output 3 hold voltage "Do3HoldV"* ..... *56*
*M3-32T n/a* ..... *56*
*M3-33T Calibration Data option "CalValue"* ..... *57*
*M3-34T Loading Default "LoadDefs"* ..... *57*

5.2 MENU 3 "CONTROLLER SETUP FOR PUMP" ..... 58

*M3-1P Accel. Characteristic "Lin/Curv"* ..... *59*
*M3-2P Speed 6 input normally closed or normally open "Sp6NO/NC"* ..... *59*
*M3-3P Inhibit input normally closed or normally open "HibNO/NC"* ..... *59*
*M3-4P Enable power up checks "Nchk/Chk"* ..... *59*
*M3-5P Enable pot with switch "NoSw/Sw"* ..... *59*
*M3-6P Display Status Field – "Of/D/V/K"* ..... *60*
*M3-7P Digital O/P 4 config "D04Typ"* ..... *60*
*M3-8P Active low or high digital inputs* "Actv L/H"* ..... *60*
*M3-9P Supply wire off detection "SplyWrOf"* ..... *60*
*M3-10P Line Contactor pull-in level "LCPllnLv"* ..... *60*
*M3-11P Line Contactor pull-in time out "LCPllnTO"* ..... *60*
*M3-12P Line Contactor Coil pull-in voltage "LCPllnVl"* ..... *60*
*M3-13P Line Contactor Coil holding voltage "LCHoldVl"* ..... *61*
*M3-14P Digital Output 2 pull-in voltage "Do2PllnV"* ..... *61*
*M3-15P Digital Output 2 hold voltage "Do2HoldV"* ..... *61*
*M3-16P Digital Output 3 pull-in voltage "Do3PllnV"* ..... *61*
*M3-17P Digital Output 3 hold voltage "Do3HoldV"* ..... *61*
*M3-18P Driver output 2 configuration "Drv2Cfg"* ..... *61*
*M3-19P Driver output 3 configuration "Drv3Cfg"* ..... *62*
*M3-20P Motor Temperature threshold (for output driver) "MotTmpTh"* ..... *62*
*M3-21P Controller Temperature threshold (for output driver) "CtrTmpTh"* ..... *62*
*M3-22P n/a* ..... *62*
*M3-23P Calibration Data option "CalValue"* ..... *62*
*M3-24P Load Defaults "LoadDefs"* ..... *62*

**6 PMS MOTOR AUTO TUNING ..... 63**

6.1 SETTING UP AUTO TUNING ..... 63
6.2 MENU 4 "PMS MOTOR AUTO TUNING" ..... 64

*M4-1 Number of motor poles "NmotPole"* ..... *64*
*M4-2 Sensor technology "SensType"* ..... *64*
*M4-3 Sensor supply voltage "SenSuppV"* ..... *65*
*M4-4 Number of sensor poles "NsnsPole""* ..... *65*
*M4-5 Reverse sensor reading "SpdRev"* ..... *65*
*M4-6 Reverse motor direction "MotorRev"* ..... *65*
*M4-7 Battery Voltage "BattV AT""* ..... *65*
*M4-8 RMS motor current For tuning "Ifor AT""* ..... *65*
*M4-9 Maximum RMS motor current "Imotmax"* ..... *65*
*M4-10 Back-EMF constant (KeV) "K emf""* ..... *65*
*M4-11 Motor phase to phase inductance "L ph-ph"* ..... *65*
*M4-12 Maximum demagnetizing (Field weakening) current "I demag"* ..... *65*
*M4-13 Maximum Motor Frequency "Fmotmax"* ..... *66*
*M4-14 Start Auto-tuning "AutoTune"* ..... *66*
*M4-15 Recalculation after changing one of the adjustments of this menu marked with one star "Recalcul"* ..... *66*
*M4-16 Sin/Cos Sensor Delay Angle at 100 Hz "SensDel"* ..... *66*
*M4-17 Auto Tuning Type "ATuneType"* ..... *66*

6.3 INITIATING AUTO TUNING ..... 67
6.4 AUTO TUNING ERRORS ..... 68
6.5 RECALCULATION ..... 69

 ©2019 DMC GmbH Herten Germany

6.6 FINE MOTOR TUNING ..... 69

*6.6.1 How to have more torque.* ..... *69*
*6.6.2 How to have more power.* ..... *69*
*6.6.3 How to have more speed* ..... *69*
*6.6.4 Motor is vibrating or driving unstable.* ..... *69*

**7 MENU 5 "PMS MOTOR SETUP"** ..... **70**

*M5-1 Proportional gain speed controller "Kp Spd"* ..... *70*
*M5-2 Integral gain speed controller "Ki Spd"* ..... *70*
*M5-3 Enable double PI settings for speed controller "SpdPIx2"* ..... *71*
*M5-4 Double PI speed threshold "SpdPITH"* ..... *71*
*M5-5 Proportional gain speed controller below threshold "KpSpdLow"* ..... *71*
*M5-6 Integral gain speed controller below threshold "KiSpdLow"* ..... *71*
*M5-7 Transition time between the two PI settings for the speed controller "TransTim"* ..... *71*
*M5-8 Speed limit tolerance "SpLimTol"* ..... *71*
*M5-9 Speed limit action ramp time "SpLimTim"* ..... *72*
*M5-10 Extra field weakening level referred to the ideal flux at maximum speed "FWextra"* ..... *72*
*M5-11 Speed Threshold for beginning field weakening "F_FW TH"* ..... *72*
*M5-12 Torque Reduction Map in field weakening range point 1 "TReduc1"* ..... *72*
*M5-13 Torque Reduction Map in field weakening range point 2 "TReduc2"* ..... *72*
*M5-14 Torque Reduction Map in field weakening range point 3 "TReduc3"* ..... *72*
*M5-15 Torque Reduction Map in field weakening range point 4 "TReduc4"* ..... *72*
*M5-16 Torque Reduction Map in field weakening range point 5 "TReduc5"* ..... *72*
*M5-17 Capacitor Voltage ramp Time CapVTime* ..... *72*
*M5-18 Voltage Limiter Filter Frequency FVlimFlt* ..... *72*

**8 MENU 6 "PMS MOTOR ADVANCED"** ..... **73**

*M6-1 Decouple Iq and Id controllers "Decouple"* ..... *73*
*M6-2 Enable software PWM algorithm delay compensation "PWMDelay"* ..... *73*
*M6-3 Limit torque controller during Voltage limiting "VoltSat"* ..... *73*
*M6-4 Speed Control Filter "SCFilter"* ..... *73*
*M6-5 Enable Voltage Limiter "VoltCtrl"* ..... *73*
*M6-6 Speed filter cut-off frequency "Fspdfilt"* ..... *73*
*M6-7 Percentage of correction for inductance value "DecoLeak"* ..... *73*
*M6-8 Back EMF correction factor "BEMFCorr"* ..... *73*
*M6-9 Speed estimator rate "Obs.Rate"* ..... *73*
*M6-10 Resistance compensation gain "R gain"* ..... *73*
*M6-11 Current compensation gain "CurrGain"* ..... *73*
*M6-12 Start Torque "StartTrq"* ..... *73*
*M6-13 Start Current "StartCur"* ..... *73*
*M6-14 Maximum radius voltage "Vmodmax"* ..... *73*

**9 MENU 7 "LIMITS SETUP"** ..... **74**

*M7-1 Motor Temp Sensor Type "MtempTyp"* ..... *74*
*M7-2 Motor Temp. Cutback start "TempStrt"* ..... *75*
*M7-3 I²t Nominal Motor Current "NomCurr"* ..... *75*
*M7-4 I²t Start Motor Temperature "I2tTemp"* ..... *75*
*M7-5 I²t Time "I2tTime"* ..... *75*
*M7-6 I²t Cutback1 "I2tCutB1"* ..... *75*
*M7-7 I²t Cutback2 "I2tCutB2"* ..... *75*
*M7-8 I²t Cutback3 "I2tCutB3"* ..... *75*
*M7-9 Performance Table Speed 1 "PTSpd1"* ..... *78*
*M7-10 Performance Table Speed 2 "PTSpd2"* ..... *78*
*M7-11 Performance Table Speed 3 "PTSpd3"* ..... *78*
*M7-12 Performance Table Cutback 1 "PTCutBk1"* ..... *78*
*M7-13 Performance Table Cutback 2 "PTCutBk2"* ..... *78*
*M7-14 Performance Table Cutback 3 "PTCutBk3"* ..... *78*
*M7-15 Low Voltage Cut Back start threshold "LVCBstrt"* ..... *80*
*M7-16 Low voltage cut back end threshold "LVCBend"* ..... *80*
*M7-17 Low voltage error threshold "LVerror"* ..... *80*
*M7-18 High Voltage Cut Back start threshold HVCBstrt* ..... *81*
*M7-19 High voltage cut back end threshold "HVCBend"* ..... *81*

 ©2019 DMC GmbH Herten Germany

*M7-20 High voltage error threshold "HVerror"* ..... *81*
*M7-21 Absolute maximum motor speed "AbsMaxSp"* ..... *82*
*M7-22 Torque Threshold for Stall Protection "TrqTHLim"* ..... *82*
*M7-23 Stall protection Time "StallTim"* ..... *82*
*M7-24 n/a* ..... *82*
*M7-25 n/a* ..... *82*
*M7-26 Timed Current Limit Timer "IthTime"* ..... *83*
*M7-27 Timed Current Limit max. Current threshold "CurrTh"* ..... *83*
*M7-28 Timed Current Limit Low current threshold "ImaxLow"* ..... *83*

**10 MENU 8 "BDI" BATTERY DISCHARGE INDICATOR ..... 84**

*M8-1 Battery Current Limit Via Can type "BlcCanMsg"* ..... *84*
*M8-2 Nominal battery voltage "NomBatV"* ..... *85*
*M8-3 BDI reset level "BDIreset"* ..... *85*
*M8-4 BDI empty level "BDIempty"* ..... *85*
*M8-5 BDI warning level "BDIwarn"* ..... *85*
*M8-6 BDI cut out level "BDIcut"* ..... *85*
*M8-7 BDI speed limit "BDIspeed"* ..... *85*
*M8-8 Drive Battery Current Limit (max. value) "IBattMax"* ..... *85*
*M8-9 Regen Battery Current Limit "IBattReg"* ..... *85*

**11 MENU 9 "CAN BUS SETUP" ..... 86**

*M9-1 CAN Node Number "CAN node"* ..... *87*
*M9-2 CAN bit rate "CANbitRt"* ..... *87*
*M9-3 Transmit/Receive CAN messages "CANMsgs"* ..... *87*
*M9-4 Shared Line Contactor "ShareLC"* ..... *87*
*M9-5 Last Node Sharing Line Contactor "LstNode"* ..... *88*
*M9-6 Can Control Type "CANCtTyp"* ..... *88*
*M9-7 CAN motor status transmit rate "CAN_MS"* ..... *88*
*M9-8 CAN controller status transmit rate "CAN_CS"* ..... *88*
*M9-9 CAN drive status transmit rate "CAN_DS"* ..... *88*
*M9-10 CAN controller timeout timer "CAN_TO"* ..... *88*
*M9-11 CAN Node ID via digital input "CAN_DIG"* ..... *88*

**12 DIAGNOSTICS ..... 89**

12.1 ERROR CODES ..... 89
12.2 PMS MOTOR SUB ERROR CODES ..... 94

**13 USE OF CALIBRATOR AND PC INTERFACE ..... 95**
**14 AVAILABLE APPLICATION NOTES AND MANUALS ..... 96**
**15 MECHANICAL DRAWINGS ..... 97**

15.1 SUPERSIGMA2 CONTROLLERS ..... 97

**16 CONTACT INFORMATION ..... 97**

 ©2019 DMC GmbH Herten Germany

# 1 About this manual

This manual can be used together with the SuperSigma2 PMS Quick Reference Manual V01.02.02 SW 02.09.01 for a better understanding of settings and parameters. A detailed description of every parameter is reported. This manual is referred to software release V02.09.01 for PMS traction and pump.

## 1.1 References

[1] SuperSigma2 PMS Quick Reference Manual V01.02.02 SW 02.09.01
[2] SuperSigma2 AN 160105 - SuperSigma2 Can HMI Protocol V1.7
[3] DMC Display - NEW Display V1.1
[4] AN181020 Super Sigma2 - PMS Sensorless V1.0

## 1.2 How settings are numbered in this document

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

Mxx-yyz AAAAAAAAAAA, “BBBBBBBBB”

Where:

- xx is the menu’s number;
- yy is the parameter’s position in the menu;
- z is a letter that can be either “T” or “P” and stands, respectively for Traction or Pump software;
- AAAAAAAAAAA is the parameter short description;
- BBBBBBBBBBB is the text which appears on the DMC Calibrator’s menu;

For example

M1.2T Deceleration delay “Decel”

- 1 is the calibrator menu number (in this case Menu 1 Adjustment Setup);
- 2 is the setting number inside the menu 1;
- T indicates that this parameter is present in Traction software;
- “Deceleration delay” is a short description of the parameter;
- “Decel” is the text label appearing on the calibrator display;

## 1.3 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 Supersigma2 Controller.
The SuperSigma2 has 9 parameter menus which can be set up, but several settings are displayed based upon the choice of other settings in different menus. For a clear Controller tuning the following procedure should be adopted:

1) Enter the “Menu 3 “Controller Setup”” and set up the basic controller settings. (Mind that the setting of several parameters such as “M3-16T Active low or high digital inputs ”ActvL/H”” should be coherent with the hardware wiring performed).
2) In case a Sigmagauge or a DMC Display is used, or the chopping on outputs 1, 2 or 3 is used, enter the “Menu 8 “BDI” Battery Discharge Indicator” menu and setup the parameters for BDI calculation.
3) Enter the “Menu 4 “PMS Motor Auto Tuning”” and set up the motor’s basic set of parameters necessary to perform autotuning. Mind that the parameters “M4-9 Maximum RMS motor current” and “M4-13Maximum 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.
4) Enter the “Menu 7 “Limits Setup”” and set up the desired limitations.
5) Perform the autotuning.
6) In case the controller should operate in a CAN network, enter the “Menu 9 “CAN Bus Setup”” menu and setup all the CAN communication parameters.
7) Enter the “Menu 1 “Adjustment”” 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.
8) If necessary, modify the parameters in “Menu 5 “PMS Motor Setup””.

 ©2019 DMC GmbH Herten Germany

# 2 Control Connections

In this section the functions and features associated to each pin of the Ampseal 35 way connector, used for the controller light wiring will be described in details. The connector ampseal holds the function for interfacing 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.
The features associated to the connector signals are different, according to the application software (traction or pump control). For each pin the specific function, related to the application software, will be described.

Pins 1-7 are digital inputs. The inputs become active when switched to the ground, if the option active low is selected, or when connected to the battery plus, if the option active high is selected. (See M3-16T Active low or high digital inputs "ActvL/H").

## Pin 1 Forward i/p -- Pump Potentiometer Switch 1

**Traction: Forward i/p**

Activating this input in conjunction with the Accelerator Analog Input and the foot switch (if "ride on" vehicle is selected - see "Pin 3 Footswitch / Belly Button -- *Pump Switch 3* and "M3-8T Vehicle type select "Ride/Wlk") a drive forward signal is demanded to the controller.

**WARNING!**
**If both Pin 1 (FW) and Pin 2 (RV) are active at the same time, the controller will detect and signal the fault with 1 second delay. Please notice that if the vehicle is in neutral and the accelerator is pressed, if both switched are active at the same time the vehicle will move for 1 second.**

***Pump: Potentiometer Switch 1***

A pump potentiometer can be used to lift the forks on a forklift truck. If the pump potentiometer has a switch, the switch has to be connected to this input. The programmable parameter "M3-5P Enable pot with switch "NoSw/Sw has to be set to 1. Under these conditions, the pump motor will drive if the input is active and the potentiometer is activated.

## Pin 2 Reverse i/p -- *Pump Switch 2*

**Traction: Reverse i/p**
Activating this input in conjunction with the Accelerator (if "ride on" vehicle is selected -see "Pin 3 Footswitch / Belly Button -- *Pump Switch 3*" and "M3-8T Vehicle type select "Ride/Wlk") a drive reverse operation is activated.

**WARNING!**
**If both Pin 1 (FW) and Pin 2 (RV) are active at the same time, the controller will detect and signal the fault with 1 second delay. Please notice that if the vehicle is in neutral and the accelerator is pressed, if both switched are active at the same time the vehicle will move for 1 second.**

***Pump: Pump Switch 2***
Pump Switch 2 is typically related to the forks tilting on a forklift truck.
When activated the pump speed is set to the programmable parameter "M1-6P Speed 2 demand "Pspeed2"".

## Pin 3 Footswitch / Belly Button -- *Pump Switch 3*

**Traction: Footswitch / Belly Button**

The function of this input can be selected according to the programmable parameter "M3-8TVehicle type select "Ride/Wlk". If set to Ride (0), then the vehicle's Footswitch should be connected to this pin, and must be activated to allow drive. If set to Walkie (1), then the vehicle's Belly Button switch should be connected to this pin. When the Belly Button switch is closed and the vehicle is running reverse, the vehicle will drive forward in the opposite direction for 1.5s.

***Pump: Pump Switch 3***

It is typically used for the lateral shifting of the forks on a forklift truck. When this input is activated the pump speed is set to the value of the programmable parameter "M1-7P Speed 3 demand "Pspeed3"

 ©2019 DMC GmbH Herten Germany

### Pin 4 Seat / Tiller -- *Pump Switch 4*

**Traction: Seat / Tiller**

The function of this input is related to a safety interlock. This could be a Seat switch on a "ride-on vehicle", a Tiller switch on a "walkie" vehicle or a general deadman's trigger on other vehicle types. The switch must be closed to allow drive. If it is opened while driving the vehicle will stop.

***Pump: Pump Switch 4***

It is typically used to operate an auxiliary pump function. When closed, this input will activate the pump speed set by the programmable parameter "M1-8P Speed 4 demand "Pspeed4".

### Pin 5 Speed Limit 1 / Inch Forward -- *Pump Switch 5*

**Traction Speed Limit 1 / Inch Forward**

The function of this input is defined by the programmable parameter "M3-5T I/O Pin 5 and 6 "Sp/In/Ad". If set to **"Spd" (0),** then this input is used to limit the speed of the vehicle to a value set by the programmable parameter M1-22T Cutback speed 1 (I/O 5-6 set to Speed) "Speed1". The speed limit will occur if the switch is open.

If parameter "M3-5T I/O Pin 5 and 6 "Sp/In/Ad" is set to **"Inch" (1),** then this input is used for "inching" the vehicle in the forward direction. Inching will occur when the switch is closed. The exact functionality of inching is set by the programmable parameters M1-23T Inching speed (I/O 5-6 set to Inching) "InchSpd", M1-34T Inching time (I/O 5-6 set to Inching) "InchTime".

if "M3-5T I/O Pin 5 and 6 "Sp/In/Ad" is set to **2 (Advanced mode)** Drive if the input is open the drive style 1 will be adopted and the set of parameter of drive style one will be adopted (refer to controller setup "M3-5TI/O Pin 5 and 6 "Sp/In/Ad" description).

If "M3-5T I/O Pin 5 and 6 "Sp/In/Ad" is set to **3 (Speed Limit and FootBrakeSwitch**) then this input is used to limit the speed of the vehicle to a value set by the programmable parameter M1-22T Cutback speed 1 (I/O 5-6 set to Speed) "Speed1". The speed limit will occur if the switch is open.

***Pump: Pump Switch 5***

Pump Switch 5 is for activating a generic auxiliary pump function. When the input is activated the pump will spin at a speed set by the programmable parameter "M1-9P Speed 5 demand "Pspeed5".

### Pin 6 Speed Limit 2 / Inch Reverse -- *Pump Switch 6 (Power Steer Input)*

**Traction Speed Limit 2 / Inch Reverse**

The function of this input is defined by the programmable parameter "M3-5T I/O Pin 5 and 6 "Sp/In/Ad":
If set to **"Spd" (0),** then this input can be used to limit the speed of the vehicle to a value set by the programmable parameter "M1-33T Cutback speed 2 (I/O 5-6 set to Speed) "Speed2"". The speed limit is active when the switch is open.
If set to **"Inch"(1),** then this input is used for "inching" the vehicle in the reverse direction. Inching will occur when the switch is closed. The functionality of inching is defined by the programmable parameters "M1-23T Inching speed (I/O 5-6 set to Inching) "InchSpd"" and "M1-34T Inching time (I/O 5-6 set to Inching) "InchTime"".

If "M3-5T I/O Pin 5 and 6 "Sp/In/Ad" is set to **2 (Advanced mode**) and if the switch input is open (and switch connected to input pin 5 closed) the set of parameters of drive style 2 will be adopted (refer to controller setup "M3-5T I/O Pin 5 and 6 "Sp/In/Ad" description).
If "M3-5T I/O Pin 5 and 6 "Sp/In/Ad" is set to **3 (Speed Limit and FootBrakeSwitch**) and if the switch input is closed (and switch connected to input pin 5 closed) a footbrake operation is demanded with 100% of the Foot Brake torque or foot brake ramp time (refer to controller setup "M3-5T I/O Pin 5 and 6 "Sp/In/Ad" and adjustment "M1-13T Foot brake torque "FBrake"", "M1-14T Foot brake ramp time "FbrkRamp"" description).

***Pump Pump Switch 6***

This input should be connected to the pump's power steer trigger switch. Once activated, power steering will be available to the operator thanks to the fact that the pump is operating.
The polarity of the switch can be chosen by means of the parameter "M3-2P Speed 6 input normally closed or normally open "Sp6NO/NC".
If set to 0, the input is active when switch is closed.
If set to 1, the input is active when switch is open.
Many signals can be used to trigger this input: a hydraulic pressure switch used for steering, the seat switch, direction or foot switches can be used to provide the power steer trigger.
When pin 6 is activated, the pump will operate at a speed value settable with the parameter "M1-10P Speed 6 demand (power steer) "Pspeed6"".

 ©2019 DMC GmbH Herten Germany

### Pin 7 Speed Limit 3 / Handbrake -- *Pump Inhibit*

**Traction Speed Limit 3 / Handbrake**

This input is primarily intended to be used with a handbrake switch, however, its function can be set by the programmable parameter "M3-6T I/O Pin 7 "Spd3/Hbk"".

If set to Spd3 (0), then this input can be used to limit the speed of the vehicle to a value set by the programmable parameter. The speed limit will occur when the switch is open. The speed will be limited to the setting "M1-44T Cutback speed 3 (I/O 7 set to speed3) "Speed3"" .

If set to Hbk (1), then this input should be connected to the vehicle's handbrake switch. When the switch is closed, i.e. the handbrake is on, the vehicle's speed will be set by the parameters "M1-45T Handbrake On maximum Speed (I/O 7 set to Handbrake) "HandBrk"" and "M1-46T Maximum Drive Torque speed 3 (I/O 7 set to Handbrake) "MxDrTrq3"".

***Pump: Pump Inhibit***

This input can be used to inhibit pump operation. So when input 7 is active the pump is stopped.

The polarity of the switch can be set by means of parameter "M3-3P Inhibit input normally closed or normally open "HibNO/NC".

If set to 0, the input is active when switch is closed.

If set to 1, the input is active when switch is open.

### Pin 8 Analogue supply 5V

A supply for 5kΩ Potentiometers is available to this pin with max 10mA capability for sourcing current.

### Pin 9 Analogue AD1 i/p Accelerator -- *Potentiometer*

**Traction**

This is an analogue input that will accept a 3-wire 5kΩ potentiometer or a 0V to 5V voltage signal (electronic accelerator).

The active range of the accelerator input is defined by the programmable parameters, "M1-52T Accelerator pot minimum "AccMin"" and "M1-53T Accelerator pot maximum "AccMax"".

Two kinds of accelerator can be selected by means of parameter "M3-12T Accelerator type "AccelTyp"".

If AccelTyp is selected to (0) normal, the first parameter "AccMin" sets the voltage that relates to zero drive demand, the second, "AccMax" sets the voltage that corresponds to 100% drive demand.

If AccelTyp is selected to (1) WigWag, "AccMin" sets 100% reverse drive demand from the Throttle, "AccMax" to 100% forward drive demand from the Throttle.

If the operation of the wig-wag pot is reversed, swap the two supply leads of the potentiometer. Transposing the parameter values will result in a fault. The voltage admittable range is from 0.2V to 4.5V. Outside this range, a failure is signaled (F28 S004).

**Pump**

This is an analogue input that will accept a 3-wire 5kΩ potentiometer or a 0V to 5V voltage signal (electronic potentiometer).

This input has to be connected to the pump's potentiometer.

The active range of the input is defined by the programmable parameters "M1-14P Accelerator pot minimum "AccMin"" (0% Pump Speed) and "M1-15P Accelerator pot maximum "AccMax"" and it corresponds to the speed set in the parameter "M1-5P Maximum pot speed 1 "Potmax1"". The potentiometer is working in conjunction with input 1 "Pin 1 Forward i/p -- Pump Potentiometer Switch 1" if it is enabled.

### Pin 10 Analogue supply 0V

This input is the analog input ground for potentiometers.

 ©2019 DMC GmbH Herten Germany

### Pin 11 Analogue AD2 -- Footbrake pot

This pin is used only in traction application.

This is an analogue input that will accept a 3-wire 5kΩ potentiometer or a 0V to 5V voltage signal.

The active range of the footbrake input is defined by the programmable parameters “M1-54T Brake pot minimum “BrkMin”” (0%) and “M1-55T Brake pot maximum “BrkMax”” (100%).
If a Footbrake switch is used on the brake pedal instead of an analogue device, the switch should connect this input to the voltage corresponding to the value of parameter, “M1-55T Brake pot maximum “BrkMax”“ (100%) in order to effect full braking.

- **The brake pedal input overrides the accelerator pedal input.**
- **This analog input is deactivated if “M3-5T I/O Pin 5 and 6 ”Sp/In/Ad”” is selected to 3 (Speed Limit and Footbrake Switch). To activate a footbrake operation a foot brake switch must be connected to the “Pin 6 Speed Limit 2 / Inch Reverse -- Pump Switch 6 (Power Steer Input)”.**
- **If vehicle is rolling downhill (forward or backward), or in general motor spinning, controller not pulsing and footbrake demanded, controller will start pulsing and braking according to control Mode selection (see ”M3-2T Control Mode “Spd/Torq””). Controller keeps braking the motor until footbrake pressed and speed different from zero. The end of braking type and possible hill holding depends on setting (see ”M3-2T Control Mode “Spd/Torq”” and “M3-4T Hill hold ”Off/HH/S””**

### Pin 12 Analogue AD3 -- Steer pot

This pin is used only in traction applications.
The function is activated by means of parameter “M3-14T Single or Dual Motor ”Si/DL/DR”” in the Controller Set-up menu.
It is activated both if set to 1 (Dual Motor Left) or 2 (Dual Motor Right) or 3 (Single Motor with steer pot. Speed limit Right). The input can be connected to a 3-wire 5kΩ potentiometer that measures the steering angle of the vehicle.

The active range of the input, when used by a steering potentiometer, is defined by the following parameters:

- “M1-56T Steer pot minimum ”StrMin”” defines the voltage corresponding to the minimum steering angle (full left hand lock)
- “M1-57T Steer pot middle point ”StrMid”” corresponds to a 0° steering angle, i.e. the vehicle no steering
- “M1-58T Steer pot maximum ”StrMax””. defines the voltage corresponding to the minimum steering angle (full right hand lock)

### Pin 13 Key i/p

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.

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 14 Contactor supply o/p

This output is the positive supply to the vehicle’s contactors (line contactor, electro mechanical brake, power steer). The voltage level of this supply corresponds to the vehicle’s battery voltage. The maximum supply current from this pin is 9A.

### Pin 15 Contactor 1 o/p (Line)

This has to be connected to the negative side of the Line Contactor coil. The controller is driving this output. The maximum rating for this connection is 3A and it is fully protected for use with inductive loads.

 ©2019 DMC GmbH Herten Germany

### Pin 16 Contactor 2 o/p (Magnet Brake - Fan control)

This pin can have different configurations (see “Menu 3 “Controller Setup””).

In traction software only it can be connected to the negative side of the Electro Mechanical Brake Contactor coil. The maximum rating for this connection is 3A and it is fully protected for use with inductive loads.

In both traction and pump software it can be used to drive a cooling fan when motor and/or controller temperature sensors signal that the temperature is above a specified threshold.

- **If and electromagnetic brake is used connected to the Pin 16 the setting “M3-4T Hill hold ”Off/HH/S”” must be set to 0. Refer to parameter “M1-9T Neutral brake-End delay “NBrkEnd”” for further details.**

### Pin 17 Contactor 3 o/p (Powersteer - Fan control)

This pin can have different configurations (see “Menu 3 “Controller Setup””).

In traction software only it can be connected to the negative side of the Power Steer Contactor coil. The maximum rating for this connection is 3A and it is fully protected for use with inductive loads.

In both traction and pump software it can be used to drive a cooling fan when motor and/or controller temperature sensors signal that the temperature is above a specified threshold.

### Pin 18 Digital o/p -- Remote LED or Brake lights or Drive OK

The function of this output is set in “Menu 3 “Controller Setup”” for both traction and pump applications.

Depending on the application considered, it can be used or as a remote LED, or as a Dirve OK signal or, for traction only, as a brake light.

### Pin 19 Supply 12V -- 70mA max.

A 12V supply is available for electronic accelerator or potentiometers. The maximum supply current is 70mA.

### Pin 20 CAN +12V -- 70mA max.

A 12V supply is available for external CAN isolator modules or other loads. The maximum supply current is 70mA.

### Pin 21 CAN H1

CAN High communications can line to the Calibrator, Display or other Controller(s) CAN Devices.

- **The can communication lines are referred to battery ground.**

### Pin 22 CAN L1

CAN Low communications can line to the Calibrator, Display or other Controller(s)/CAN Devices.

- **The can communication lines are referred to the battery 0V (ground).**

### Pin 23 CAN 0V

Can communication lines 0V (ground) reference.

- **The can communication lines are referred to the battery 0V (ground).**

### Pin 24 CAN 120R Link

This pin is connected to a 120 Ohm resistor. If the controller is the CAN network wiring ending node, this pin could be connected to the pin 25 or pin 21. See [2] for further details.

 ©2019 DMC GmbH Herten Germany

### Pin 25 CAN H2

CAN High communications can line to the Calibrator, Display or other Controller(s) CAN Devices.

- **The can communication lines are referred to the battery 0V (ground).**

### Pin 26 CAN L2

CAN Low communications can line to the Calibrator, Display or other Controller(s)/CAN Devices.

- **The can communication lines are referred to the battery 0V (ground).**

### Pin 27 Sensor supply +5V / +12V

Supply output for motor position/speed sensor (Ananlog Sine/Cosine or Hall Sensor). It delivers 5V or 12V according to the parameter “M4-3 Sensor supply voltage “SenSuppV”” If it is set to 0 the supply is 5V, if set to 1 supply is 12V. The current capability is 70 mA.

### Pin 28 Hall 1 i/p

This pin has to be connected to Hall sensor channel 1 if Hall sensor technology is selected by means of “M4-2 Sensor technology “SensType”” (set to 1).

### Pin 29 Hall 2 i/p

This pin has to be connected to Hall sensor channel 2 if Hall sensor technology is selected by means of “M4-2 Sensor technology “SensType”” (set to 1).

### Pin 30 Hall 3 i/p

This pin has to be connected to Hall sensor channel 3 if Hall sensor technology is selected by means of “M4-2 Sensor technology “SensType”” (set to 1).

### Pin 31 Sensor supply 0V

This pin is the ground line for speed/position sensor.

### Pin 32 Motor Sensor Sine

This pin has to be connected to Sine output of analog sine cosine sensor if SineCos sensor technology is selected by means of “M4-2 Sensor technology “SensType”” (set to 0).

### Pin 33 Motor Sensor CoSine

This pin has to be connected to Cosine output of analog sine cosine sensor if SineCos sensor technology is selected by means of “M4-2 Sensor technology “SensType”” (set to 0).

### Pin 34 Thermistor AD4 i/p

This pin has to be connected to the anode of KTY84-130 thermistor or to one side of and Pt 1000 ohm 0°C thermal sensor. The motor thermal sensor type can be selected by parameter “M7-1 Motor Temp Sensor Type “MtempTyp””

### Pin 35 Thermistor 0V

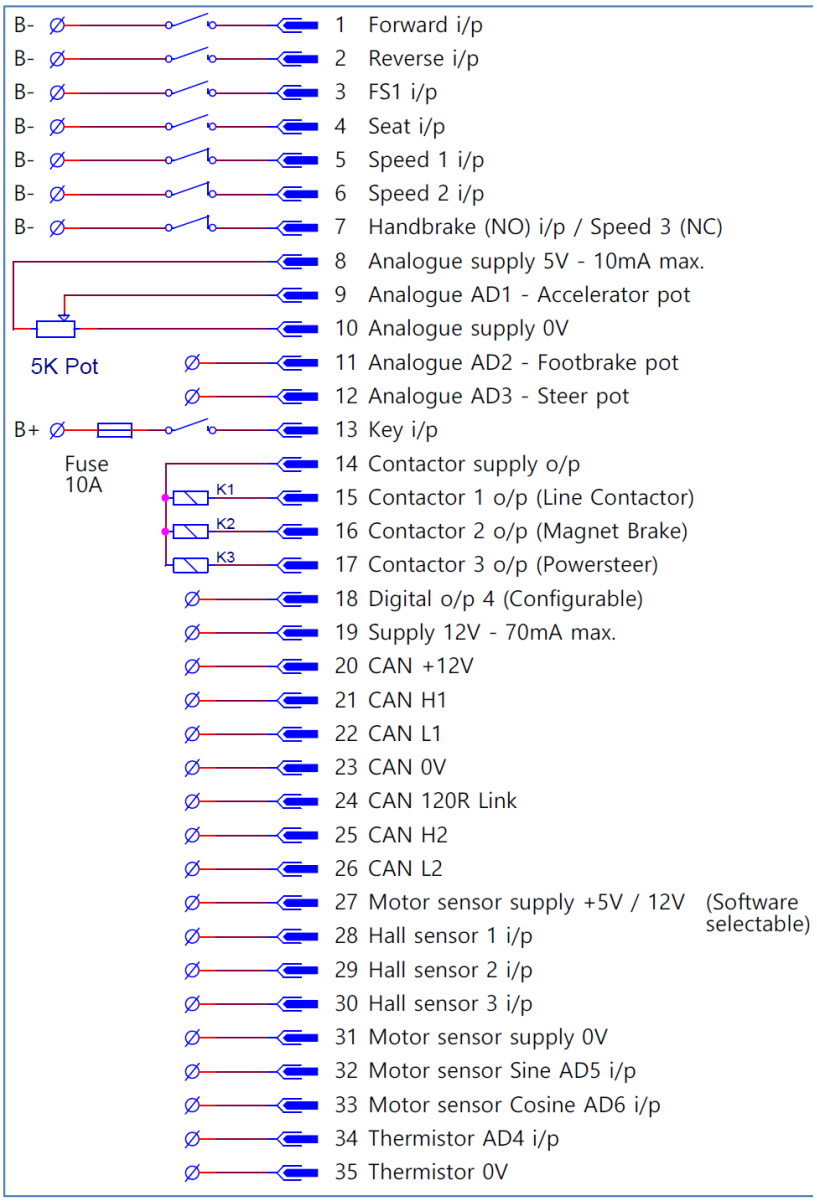
This pin has to be connected to the cathode (black lined side) of KTY84-130 thermistor or Pt 1000 ohm 0°C thermal sensor. The motor thermal sensor type can be selected by parameter “M7-1 Motor Temp Sensor Type “MtempTyp””

 ©2019 DMC GmbH Herten Germany

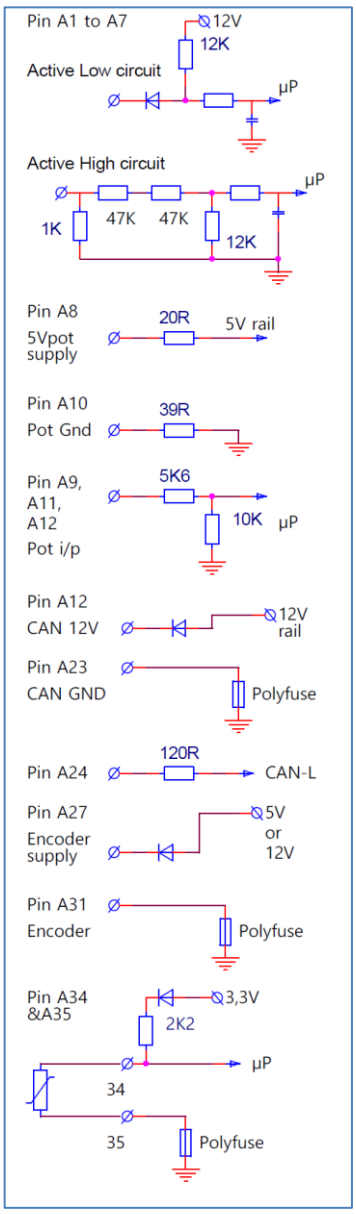
## 2.1 Light Wiring of PMS controller

### 2.1.1 Connectors' pin assignment for Traction

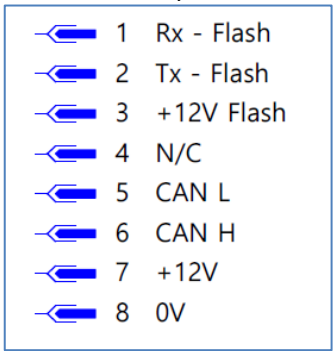
Connector A - Vehicle Interface - 35 Way (AMP SEAL Series):



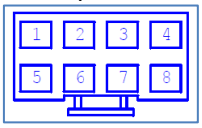

Internal circuits:



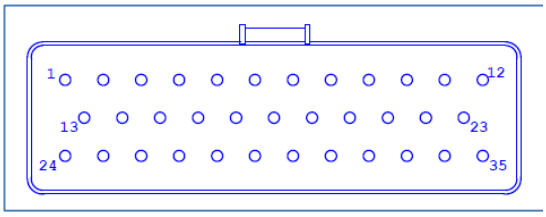

Connector B - Communications - 8 Way:




8 Way pin layout:



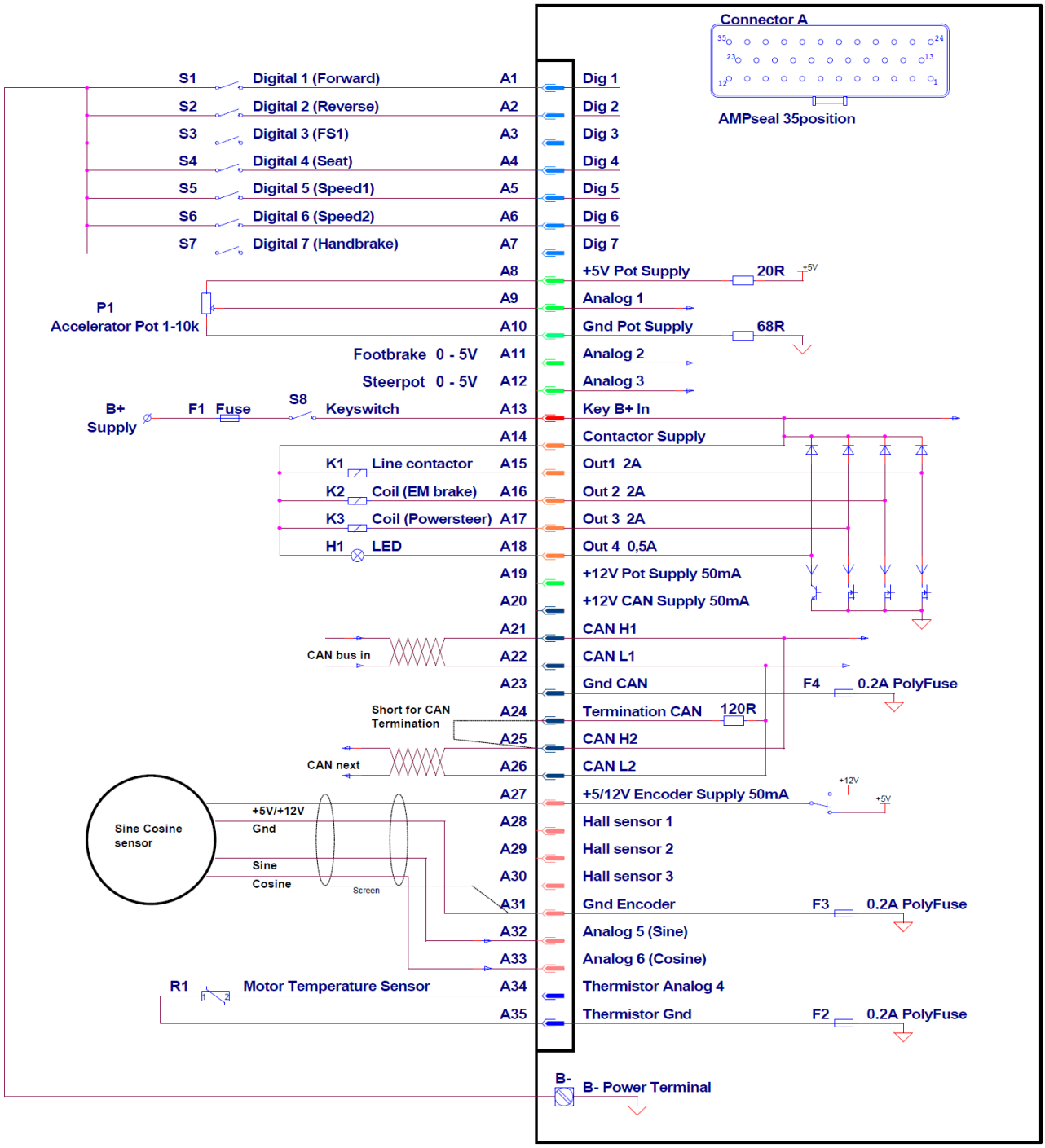

35 Way pin layout:




| | |
|---|---|
| | **Most inputs are Normally Open (NO) except for the speed inputs, these are Normally Closed (NC)** |

 ©2019 DMC GmbH Herten Germany

### 2.1.2 Light wiring example for traction

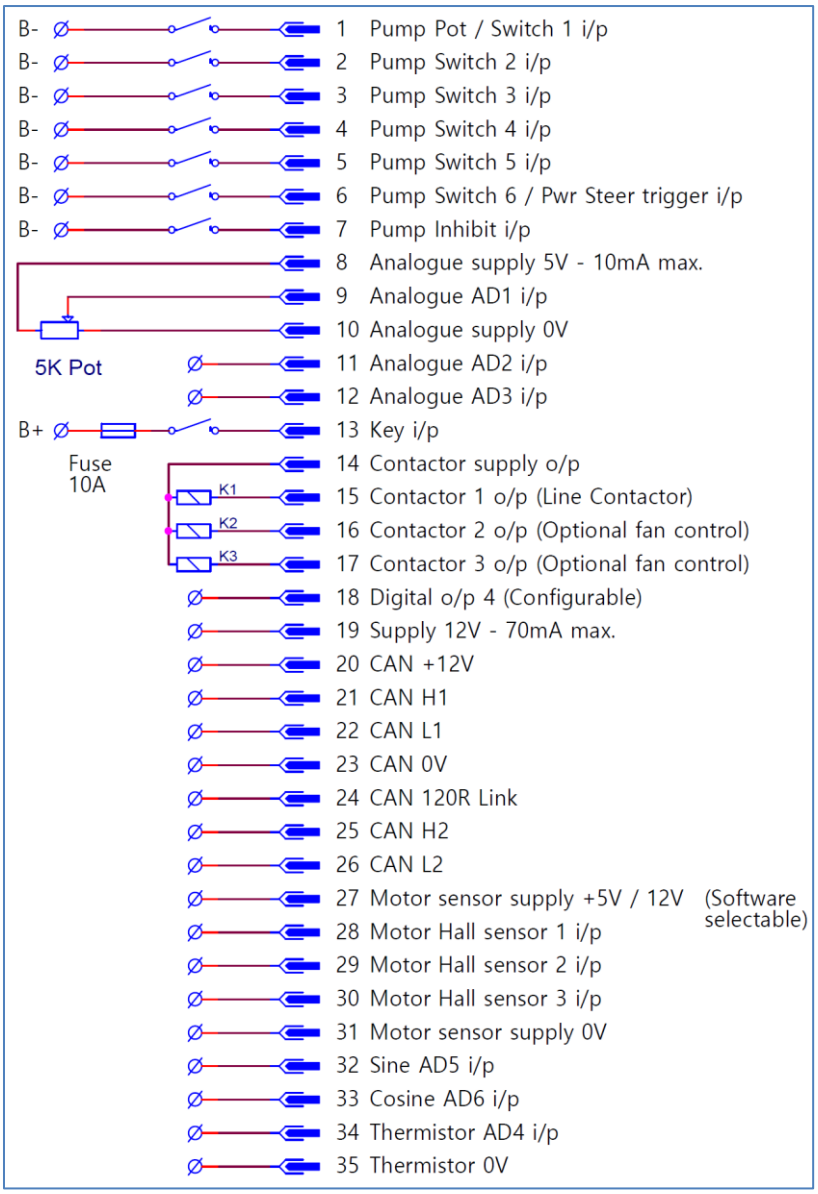



| | |
|---|---|
| | **The reported wiring example is referred to active low inputs** |

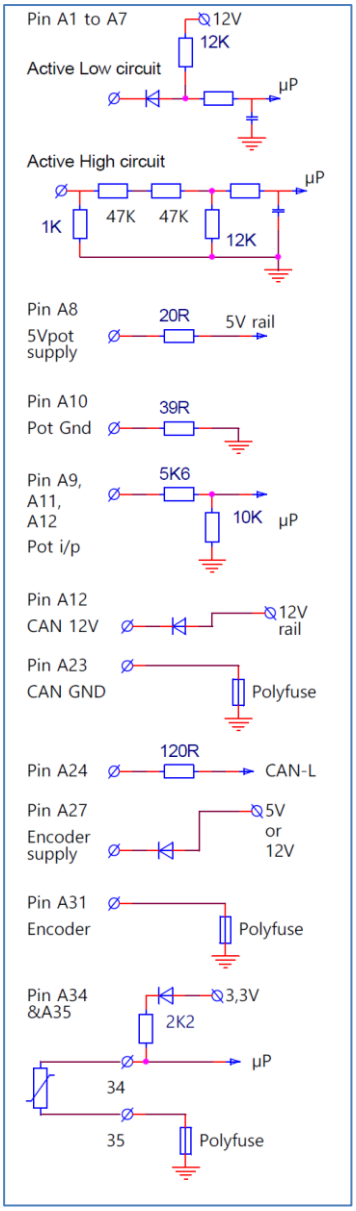
 ©2019 DMC GmbH Herten Germany

### 2.1.3 Connectors' pin assignment for Pump

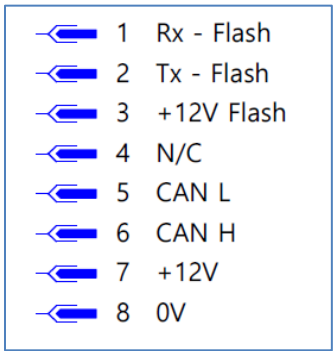
Connector A - Vehicle Interface - 35 Way (AMP SEAL Series):



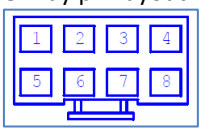

Internal circuits:



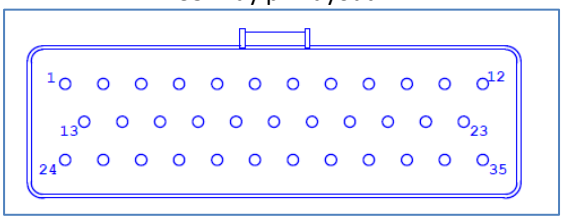

Connector B - Communications - 8 Way:




8 Way pin layout:



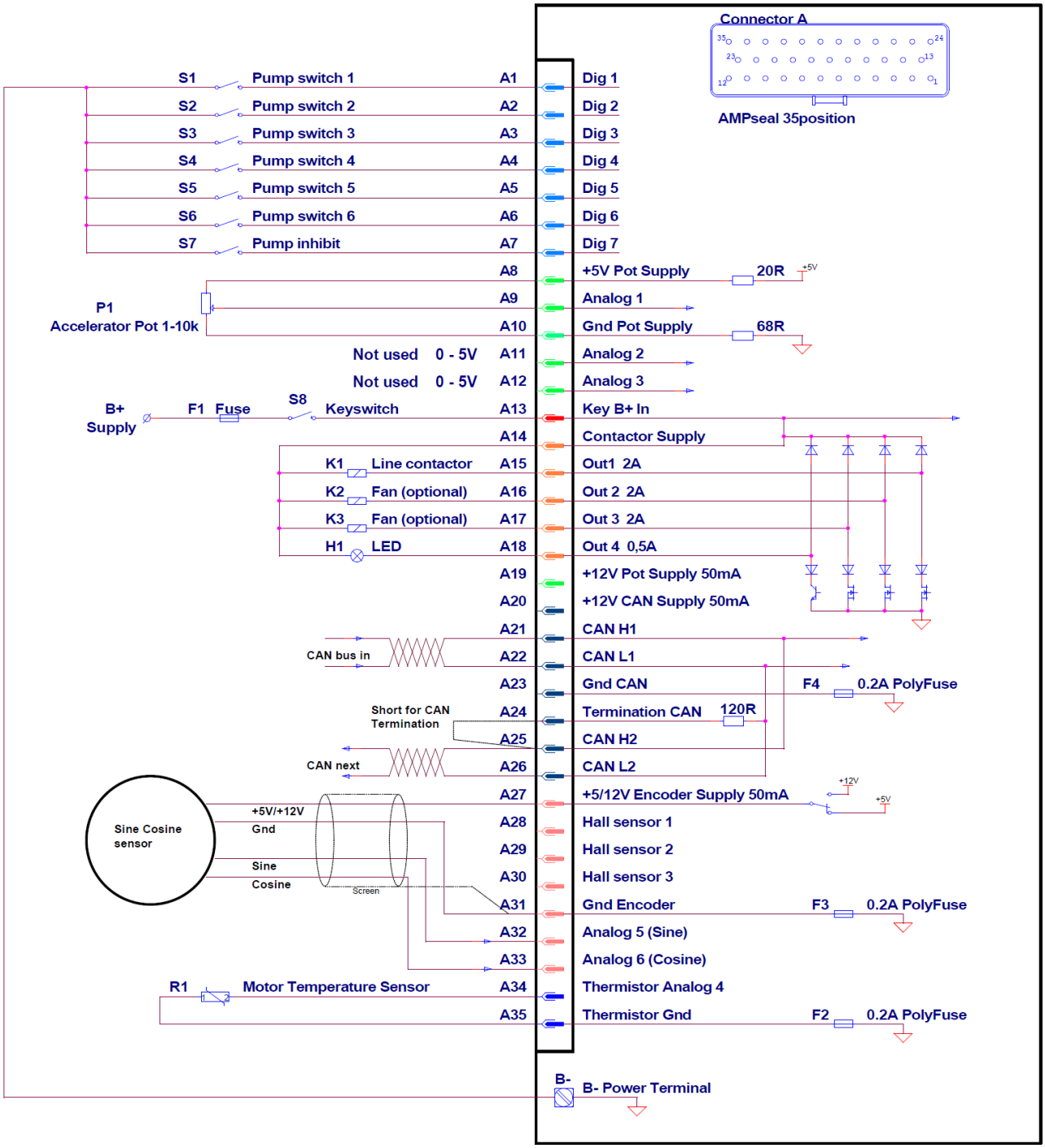

35 Way pin layout:




**For pump controllers "Pump switch 6" and "Pump inhibit" are active low. In "Menu 3 "Controller Setup for Pump"" it is possible to change them to active high.**

 ©2019 DMC GmbH Herten Germany

### 2.1.4 Light wiring example for pump




| | |
|---|---|
| | **The reported wiring example is referred to active low inputs** |

 ©2019 DMC GmbH Herten Germany

## 2.2 Selecting active Low or High digital inputs

The DMC Sigma2 controllers have the ability to set all digital inputs at runtime as active low or as active high. This setting is made in the controller setup menu.

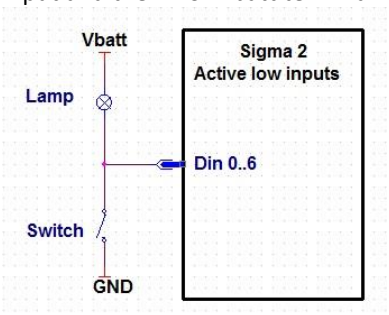
| | |
|---|---|
| | **It is not possible to mix active low and active high inputs.** |

### 2.2.1 Active Low digital inputs

For using Active Low digital input The DMC Sigma2 controller must be setup for active low digital inputs by setting the parameter “M3-16T Active low or high digital inputs ”ActvL/H”” to 0.

#### 2.2.1.1 Using a mechanical switch

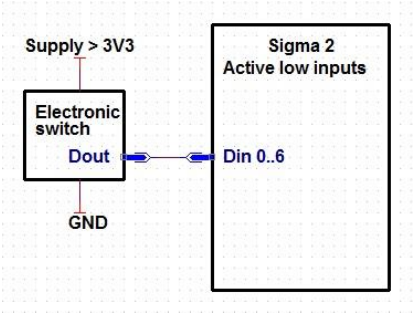
An active low digital input can be activated using a simple mechanical switch. The switch is wired between the B- or GND terminal and one of the digital inputs. To signal that the switch is activated, a lamp can be connected between the digital input and the B+ or Vbatt terminal.




(lamp is optional)

#### 2.2.1.2 Using an electronic switch

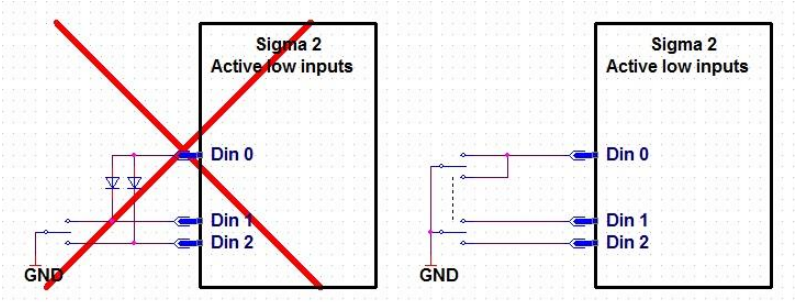
An active low digital input can be activated using an electronic switch. The electronic switch is powered with a supply voltage greater than 3V3. The digital output of this electronic switch is high when not activated, which results in an output voltage greater than 1,5V. When the electronic switch is activated the digital output becomes low, which results in an output voltage equal or lower than 0.3V.




#### 2.2.1.3 Using a double-throw switch and some diodes

In some cases one input depends on another input. Like the FS1 (Din 0) and the forward (Din 1) or reverse (Din 2) inputs. With some controllers it is possible to activate the common input (Din 0) using a diode from the other inputs. With the DMC Sigma2 controller this is not possible.

Use a double double-throw switch instead, as displayed in the schematic below. Both inputs are activated correctly.



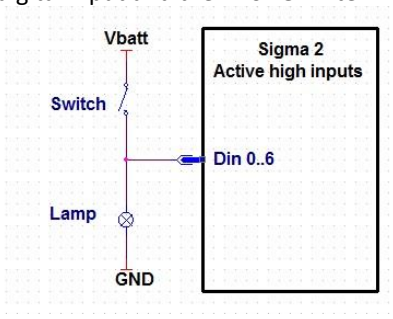

 ©2019 DMC GmbH Herten Germany

### 2.2.2 Active High digital inputs

For using Active High digital input The DMC Sigma2 controller must be setup for active high digital inputs by setting the parameter “M3-16TActive low or high digital inputs ”ActvL/H”” to 1.

#### 2.2.2.1 Using a mechanical switch

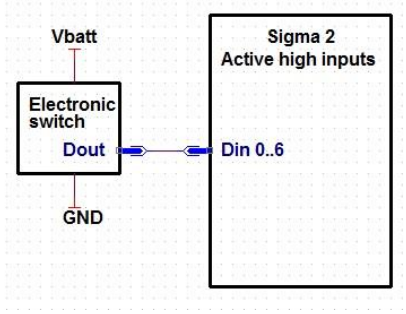
An active high digital input can be activated using a simple mechanical switch. The switch is wired between the B+ or Vbatt terminal and one of the digital inputs. To signal that the switch is activated, a lamp can be connected between the digital input and the B- or GND terminal.




(lamp is optional)

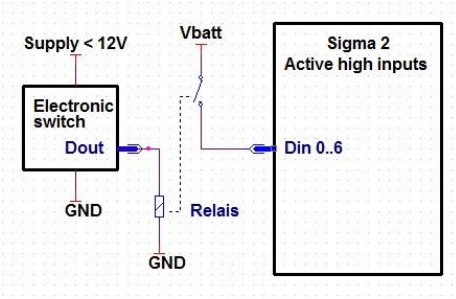
#### 2.2.2.2 Using an electronic switch supplied with more than 12V

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.




#### 2.2.2.3 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.

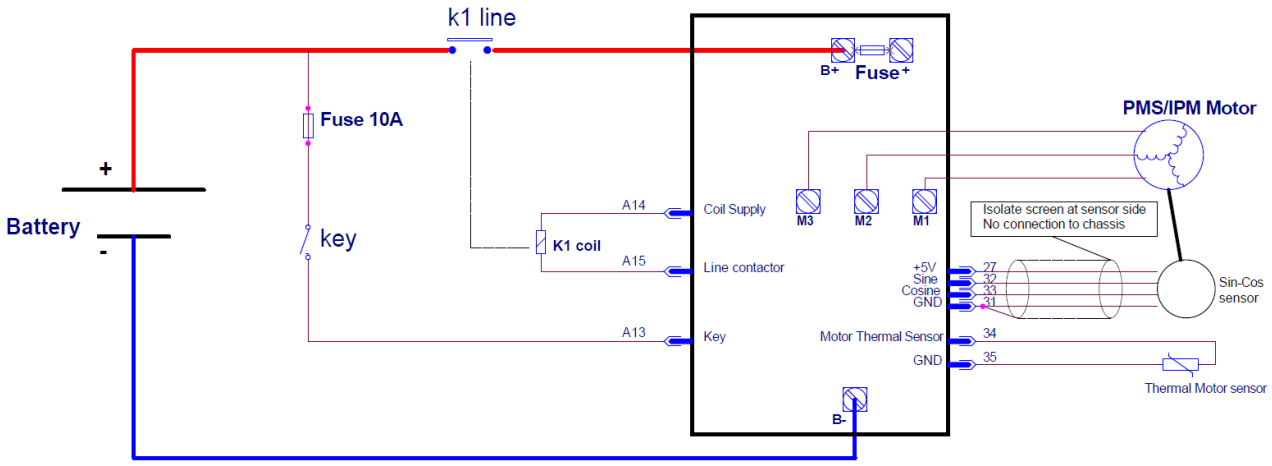



## 2.3 Use of Ohmic Potentiometers and Electronic Potentiometers

TO BE COMPLETED

 ©2019 DMC GmbH Herten Germany

## 2.4 Power Wiring




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

 ©2019 DMC GmbH Herten Germany

# 3 Menu 1 “Adjustment”

This menu includes all the adjustment for a more comfortable driving experience.
Please notice that the adjustment menu’s parameters are visible and adjustable on the calibrator according to the settings in “Menu 3 “Controller Setup””.
For example the dual motor parameters (from “M1-61T Dual motor cut out ”DMcut”” to “M1-67T Dual motor speed 3 ”DMspd3””) will be visible only if dual motor control is enabled (“M3-14T Single or Dual Motor ”Si/DL/DR””).
It is therefore important to properly set up and configure Controller’s settings in “Menu 3 “Controller Setup””, recycle the key and then move to Adjustment menu, where only active parameters will be visible.
DMC PC programmer interface is displaying always all parameters.

## 3.1 Menu 1 “Traction Adjustments”

| Cal. Ref. | Parameter | Calibrator text | Min. adjust | Max. adjust | Step size | Default |
|---|---|---|---|---|---|---|
| 1 | Acceleration delay | Accel | 0.1 s | 20.0 s | 0.1 s | 2.0 s |
| 2 | Deceleration delay | Decel | 0.1 s | 20.0 s | 0.1 s | 2.0 s |
| 3 | Creep speed | Creep | 0.0 % | 20.0 % | 0.1 % | 0.0 % |
| 4 | Creep speed ramp time | CreepRmp | 0.1 s | 20.0 s | 0.1 s | 2.5 s |
| 5 | Maximum speed forward | SpdMaxF | 0.0 Hz | 600.0 Hz | 0.1 Hz | 100.0 Hz |
| 6 | Maximum speed reverse | SpdMaxR | 0.0 Hz | 600.0 Hz | 0.1 Hz | 100.0 Hz |
| 7 | Neutral brake torque (torque mode only) | NBrake | 0 % | 100 % | 1 % | 10 % |
| 8 | Neutral brake ramp time | NBrkRamp | 0.1 s | 20.0 s | 0.1 s | 8.0 s |
| 9 | Neutral brake end delay | NBrkEnd | 0.0 s | 10.0 s | 0.1 s | 0.0 s |
| 10 | Direction brake torque (torque mode only) | DBrake | 1 % | 100 % | 1 % | 100 % |
| 11 | Direction brake ramp time | DBrkRamp | 0.1 s | 20.0 s | 0.1 s | 1.0 s |
| 12 | Max. direction change speed | MxDbrkSp | 1 % | 100 % | 1 % | 100 % |
| 13 | Foot brake torque (torque mode only) | FBrake | 0 % | 100 % | 1 % | 50 % |
| 14 | Foot brake ramp time | FbrkRamp | 0.1 s | 20.0 s | 0.1 s | 1.0 s |
| 15 | Speed threshold to enter end of braking mode | SpdThEbM | 0.1 % | 50.0 % | 0.1 % | 15 % |
| 16 | Ramp time from the speed threshold to zero | SpdRmpTm | 0.1 s | 20.0 s | 0.1 s | 3.0 s |
| 17 | Ramp time from the speed threshold to zero low TH | SpdRTmFB | 0.1 s | 20.0 s | 0.1 s | 0.4 s |
| 18 | Zero Speed threshold to enter hill hold or neutral brake end | ZSpdTh | 0.1 % | 10.0 % | 0.1 % | 0.2 % |
| 19 | Hill hold time | HHTime | 0 s | 60 s | 1 s | 5 s |
| 20 | Restraint hill hold speed | HHspeed | 0.0 Hz | 5.0 Hz | 0.1 Hz | 3.0 Hz |
| 21 | Restraint hill hold torque threshold | HHTrqTH | 0.1 % | 35.0 % | 0.1 % | 1.5 % |
| 22 | Cutback speed 1 (I/O 5-6 set to Speed) | Speed1 | 0.0 Hz | 600.0 Hz | 0.1 Hz | 100.0 Hz |
| 23 | Inching speed (I/O 5-6 set to Inching) | InchSpd | 0.0 Hz | 25.0 Hz | 0.1 Hz | 10.0 Hz |
| 24 | Acceleration delay 1 | Accel1 | 0.1 s | 20.0 s | 0.1 s | 3.0 s |
| 25 | Deceleration delay 1 | Decel1 | 0.1 s | 20.0 s | 0.1 s | 3.0 s |
| 26 | Maximum Drive Torque 1 (Torque Mode Only) | MxDrTrq1 | 0 % | 100 % | 1 % | 100 % |
| 27 | Neutral Brake Torque 1 (Torque Mode Only) | NBrkTrq1 | 0 % | 100 % | 1 % | 10 % |
| 28 | Neutral brake ramp time 1 | NBrkRmp1 | 0.1 s | 20.0 s | 0.1 s | 3.0 s |
| 29 | Direction Brake torque 1 (Torque Mode Only) | DBrkTrq1 | 0 % | 100 % | 1 % | 100 % |
| 30 | Direction brake ramp time 1 | DBrkRmp1 | 0.1 s | 20.0 s | 0.1 s | 3.0 s |
| 31 | Foot Brake Torque 1 (Torque Mode Only) | FBrkTrq1 | 0 % | 100 % | 1 % | 50 % |
| 32 | Foot brake ramp time 1 | FBrkRmp1 | 0.1 s | 20.0 s | 0.1 s | 3.0 s |
| 33 | Cutback speed 2 (I/O 5-6 set to Speed) | Speed2 | 0.0 Hz | 600.0 Hz | 0.1 Hz | 100.0 Hz |
| 34 | Inching time (I/O 5-6 set to Inching) | InchTime | 0.1 s | 10.0 s | 0.1 s | 2.5 s |
| 35 | Acceleration delay 2 | Accel2 | 0.1 s | 20.0 s | 0.1 s | 4.0 s |
| 36 | Deceleration delay 2 | Decel2 | 0.1 s | 20.0 s | 0.1 s | 4.0 s |
| 37 | Maximum Drive Torque 2 (Torque Mode Only) | MxDrTrq2 | 0 % | 100 % | 1 % | 100 % |
| 38 | Neutral Brake Torque 2 (Torque Mode Only) | NBrkTrq2 | 0 % | 100 % | 1 % | 10 % |

 ©2019 DMC GmbH Herten Germany

| Cal. Ref. | Parameter | Calibrator text | Min. adjust | Max. adjust | Step size | Default |
|---|---|---|---|---|---|---|
| 39 | Neutral brake ramp time 2 | NBrkRmp2 | 0.1 s | 20.0 s | 0.1 s | 4.0 s |
| 40 | Direction Brake torque 2 (Torque Mode Only) | DBrkTrq2 | 0 % | 100 % | 1 % | 100 % |
| 41 | Direction brake ramp time 2 | DBrkRmp2 | 0.1 s | 20.0 s | 0.1 s | 4.0 s |
| 42 | Foot Brake Torque 2 (Torque Mode Only) | FBrkTrq2 | 0 % | 100 % | 1 % | 50 % |
| 43 | Foot brake ramp time 2 | FBrkRmp2 | 0.1 s | 20.0 s | 0.1 s | 4.0 s |
| 44 | Cutback speed 3 (I/O 7 set to speed3) | Speed3 | 0.0 Hz | 600.0 Hz | 0.1 Hz | 100.0 Hz |
| 45 | Handbrake On maximum Speed (I/O 7 set to Handbrake) | HandBrk | 0.0 Hz | 400.0 Hz | 0.1 Hz | 10.0 Hz |
| 46 | Maximum Drive Torque speed 3 (I/O 7 set to Handbrake) | MxDrTrq3 | 0 % | 100 % | 1 % | 10 % |
| 47 | Speed limit ramp (torque control only) | SpLimRmp | 0.1 s | 20.0 s | 0.1 s | 10.0 s |
| 48 | Drive torque reduction time | DTrqRtm | 0.1 | 3.0 s | 0.1 | 0.8 s |
| 49 | Brake torque reduction time | BTrqRtm | 0.1 | 3.0 s | 0.1 | 0.8 s |
| 50 | Power steer delay | PStrDly | 0.0 s | 50.0 s | 0.1 s | 5.0 s |
| 51 | Electric brake delay | EBrkDly | 0.1 s | 50.0 s | 0.1 s | 0.5 s |
| 52 | Accelerator pot minimum | AccMin | 0.0 V | 10.0 V | 0.1 V | 0.2 V |
| 53 | Accelerator pot maximum | AccMax | 0.0 V | 10.0 V | 0.1 V | 4.6 V |
| 54 | Brake pot minimum | BrkMin | 0.0 V | 10.0 V | 0.1 V | 0.4 V |
| 55 | Brake pot maximum | BrkMax | 0.0 V | 10.0 V | 0.1 V | 4.6 V |
| 56 | Steer pot minimum | StrMin | 0.00 V | 10.00 V | 0.01 V | 0.20 V |
| 57 | Steer pot middle point | StrMid | 0.00 V | 10.00 V | 0.01 V | 2.50 V |
| 58 | Steer pot maximum | StrMax | 0.00 V | 10.00 V | 0.01 V | 4.80 V |
| 59 | Wig/Wag fwd threshold | FwdTH | 0.0 V | 10.0 V | 0.1 V | 3.0 V |
| 60 | Wig/Wag rev threshold | RevTH | 0.0 V | 10.0 V | 0.1 V | 2.0 V |
| 61 | Dual motor cut out | DMcut | 1 % | 100 % | 1 % | 10 % |
| 62 | Dual motor angle 1 | DMang1 | 1 % | 100 % | 1 % | 60 % |
| 63 | Dual motor angle 2 | DMang2 | 1 % | 100 % | 1 % | 70 % |
| 64 | Dual motor angle 3 | DMang3 | 1 % | 100 % | 1 % | 85 % |
| 65 | Dual motor speed 1 | DMspd1 | 0 % | 100 % | 1 % | 10 % |
| 66 | Dual motor speed 2 | DMspd2 | 0 % | 100 % | 1 % | 5 % |
| 67 | Dual motor speed 3 | DMspd3 | 0 % | 100 % | 1 % | 30 % |
| 68 | Speed ratio (display Kph) | SpdRatio | 1.0 | 999.9 | 0.1 | 120.0 |
| 69 | Vehicle max. speed | VmaxSpd | 0.0 KPH | 999.9 KPH | 0.1 KPH | 20.0 KPH |
| 70 | Safe stop Torque (Torque mode only) | SfStTorque | 0 % | 100 % | 1 % | 20 % |
| 71 | Safe stop Ramp Time | SfStRmpTm | 0.1 s | 10.0 s | 0.1 s | 1.0 s |
| 72 | Belly switch speed | BellySpd | 0 Hz | 600 Hz | 0.1 Hz | 50 Hz |
| 73 | Belly switch time | BellyTim | 0 s | 3 s | 0.1 s | 0.5 s |

### M1-1T Acceleration delay "Accel"

This sets the time taken to accelerate from zero torque demand to maximum torque demand in Torque Control mode, or zero speed to maximum speed in Speed Control mode (according to "M3-2T Control Mode "Spd/Torq"" selection).
The maximum torque demand is set by "M4-9 Maximum RMS motor current", and it is assumed correspond to 100% of deliverable Torque.
The maximum speed demand is set by "M4-13 Maximum Motor Frequency", and it is assumed correspond to 100% of speed.
Increasing the value results in a slower vehicle acceleration, while decreasing the value results in a faster vehicle acceleration.
If controller is in **torque mode** the acceleration delay correspond to the time, when accelerator fully pressed, for torque to rise from 0 % to 100%.
If controller is in **speed mode** the acceleration delay correspond to the time, when accelerator fully pressed, for speed to rise from 0 % to 100%.

**Important for speed control:**
**When speed control selected ("M3-2T Control Mode "Spd/Torq""=0) using a very low value of time will bring bumpy response to accelerator deflection.**

 ©2019 DMC GmbH Herten Germany

### M1-2T Deceleration delay "Decel"

This sets the time taken to decelerate from maximum torque demand to zero torque demand in Torque Control mode, or maximum speed to zero speed in Speed Control mode (according to "M3-2T Control Mode "Spd/Torq"" selection).
Increasing the value results in a slower vehicle deceleration, while decreasing the value results in a faster vehicle deceleration.
If controller is in **torque mode** the deceleration delay correspond to the time, when accelerator fully released (direction selected and brake not pressed), for torque to decrease from 100 % to 0%.
If controller is in **speed mode** the deceleration delay correspond to the time, when accelerator fully released (direction selected and brake not pressed), for speed to decrease from 100 % to 0%.

**Important for speed control:**
**When speed control selected ("M3-2T Control Mode "Spd/Torq""=0) using a very low value of time will bring bumpy response to accelerator release.**

### M1-3T Creep speed "Creep"

This effectively sets the initial speed or torque that the vehicle will adopt on entering drive.
Increasing the value will help minimize any delay from selecting drive to creeping the vehicle. The value corresponds to the minimum demand (speed or torque according to control mode selection "M3-2T Control Mode "Spd/Torq"").
In Torque control mode creep speed is expressed in
In Speed control mode creep speed is expressed in percentage over the minimum active speed limit. If no speed limit is active the percentage is calculated over the maximum speed defined by parameter "M4-13Maximum Motor Frequency".

### M1-4T Creep speed Ramp "CreepRmp"

This parameter set the ramp time for applying creep speed/torque. It is valid for both speed and torque control.

### M1-5T Maximum speed forward "SpdMaxF"

This limits the maximum forward speed of motor.
Maximum Forward Speed should not be set to a value higher than the parameter "M4-13 Maximum Motor Frequency "Fmotmax"". If "SpdMaxF" is set higher, the maximum forward speed of the vehicle will be the "M4-13 Maximum Motor Frequency "Fmotmax""

### M1-6T Maximum speed reverse "SpdMaxR"

This limits the maximum reverse speed of the motor.
Maximum Reverse Speed should not be set to a value higher than the parameter "M4-13 Maximum Motor Frequency "Fmotmax"". If "SpdMaxR" is set higher, the maximum forward speed of the vehicle will be the "M4-13 Maximum Motor Frequency "Fmotmax""

### M1-7T Neutral Brake torque "NBrake"

This parameter is active only in torque mode.
This sets the strength of the braking when the vehicle is in neutral, i.e. no drive signal in either direction and no brake pressed. The setting is a percentage of maximum motor torque. The maximum motor torque is defined by "M4-9 Maximum RMS motor current "Imotmax"" assumed to be 100% of torque.

### M1-8T Neutral brake ramp time "NBrkRamp"

In Torque Control mode this sets the time taken to ramp from null braking torque demand to full braking torque (100% of torque) when the vehicle enters neutral, i.e. no drive signal in either direction and no brake pressed.
Increasing the value gives a smoother but longer transition from drive to braking.
Example: if "Nbrake" is set to 10% and "NBrkRamp" is set to 10s the time to apply "Nbrake" torque is 1.0s.
In Speed Control mode this sets the time taken to ramp down the speed form 100% to zero (0%), when the vehicle enters neutral, i.e. no drive signal in either direction. Increasing the value gives a smoother but longer transition to zero speed.

**Important for speed control:**
**When speed control selected ("M3-2T Control Mode "Spd/Torq"" = 0) using a very low value of time will bring a very harsh neutral braking.**

### M1-9T Neutral brake-End delay "NBrkEnd"

This setting is normally associated with a Walkie type vehicle fitted with an electromechanical brake connected to the "Pin 16 Contactor 2 o/p (Magnet Brake - Fan control)" on the 35-Way Connector. This setting allows a time to hold the vehicle at zero speed when the zero speed is detected (speed lower than "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh""). The vehicle will be held to speed zero if "M3-2T Control Mode "Spd/Torq"" is set to 0 (Speed Mode) or 2 (Torque mode with speed mode for the end of braking) or 3. It is usually used in conjunction with the parameter "M1-51T Electric brake delay "EBrkDly"" to operate the electromechanical brake. This set is active if Hill Hold is disabled ("M3-4T Hill hold "Off/HH/S"" set to 0 ).

 ©2019 DMC GmbH Herten Germany

### M1-10T Direction Brake torque "DBrake"

This parameter is active only in torque mode.
This sets the strength of the braking upon a direction change, i.e. form forward to reverse.
The setting is a percentage of maximum motor torque. The maximum motor torque is defined by "M4-9 Maximum RMS motor current "Imotmax"".

### M1-11T Direction brake ramp time "DBrkRamp"

In Torque Control mode this sets the time taken to ramp from no braking torque to full braking torque, upon a change of direction. Increasing the value gives a smoother but longer transition from drive to direction braking.
In Speed Control mode this sets the time taken to ramp down the speed in the current direction to zero, upon a change of direction. After passing through zero speed, the normal acceleration time as described in "M1-1P Acceleration delay "Accel"" is applied. Increasing the value gives a smoother but longer transition to zero speed.

**Important for speed control:**
**When speed control selected ("M3-2T Control Mode "Spd/Torq"" = 0) using a very low value of time will bring a very harsh direction braking.**

### M1-12T Max. direction change speed "MxDbrkSp"

This parameter inhibits the change of direction if the speed is above a tunable threshold (between 0% and 100% of the max speed).
The default value for MxDbrkSp is 100%, which means this function is disabled and it is always allowed to change the direction while vehicle is moving.
If the value is set lower than 100% the details of the different situations will be described as follow:

***DIRECTION CHANGE OPERATION*** *(described for motor driving forward with forward direction applied)*

I. If the motor speed is below "MxDbrkSp" and reverse direction is selected, the direction change operation is allowed regardless of the accelerator position;
II. If the motor speed is above "MxDbrSp" and reverse direction is selected, the direction change operation is always denied, the motor is stopped according to neutral brake settings ("M1-8T Neutral brake ramp time "NBrkRamp"", "M1-7T Neutral Brake torque "NBrake"") and the controller signals a fault;
III. If the motor speed is above "MdDbrSp" and neutral is selected, the motor slows down according to neutral brake settings ("M1-8T Neutral brake ramp time "NBrkRamp"", "M1-7T Neutral Brake torque "NBrake""). When the speed drops below "MxDbrSp" it is possible to select the reverse direction only if the accelerator position is 0% (pedal fully released).
IV. If the motor speed is above "MdDbrSp" and the accelerator is released (forward direction still selected), the motor slows down according to "M1-8T Neutral brake ramp time "NBrkRamp"". When the speed drops below "MxDbrSp" it is possible to select the reverse direction regardless of the accelerator position.

In case of forward direction re-selection (with actual speed in forward direction) the Drive Forward condition is allowed regardless of the accelerator position.

The above examples apply also for motor driving reverse with reverse direction applied.

***FLYING RESTART***

Imagine the controller is not pulsing and the motor is already spinning (vehicle rolling downhill in neutral). If the controller is switched on and one of the direction switches (FW or RW) is activated from the neutral condition, one of the following situations will happen:

i. If the selected direction switch is consistent with the actual motor direction (for example FW switch selected and motor spinning forward), it is possible to give the Drive Condition in the proper direction.
Only if speed is above 80% of "M4-13 Maximum Motor Frequency" F30 S001 happens.
ii. If the selected direction switch is opposite to the actual motor direction and the speed is above "MdDbrSp", the controller stays in neutral condition and no direction request can be activated.
iii. If the selected direction switch is opposite to the actual motor direction and the speed is below "MdDbrSp", the selected direction switch can be activated regardless of the accelerator status.
Despite this, recall that when the vehicle is powered on the accelerator status should be pressed more than 50%, otherwise F13 S001 happens.

 ©2019 DMC GmbH Herten Germany

***ROLLING BACK REVERSE WITH FORWARD DRIVE SELECTED (or rolling forward with reverse drive selected)***

The vehicle is on an uphill slope, the driver reduce "accel pot" but the forward direction switch is still selected. The vehicle will slow down for the effect of the slope and start to roll back into reverse direction. While rolling back, even if the speed (absolute value) goes above the "Max. Direction change speed", the forward direction stays selected and vehicle can drive forward to a further pressing on accelerator pedal (of course if Forward Direction physical input it is kept selected).
If during roll back the reverse direction is selected the *DIRECTION CHANGE OPERATION* and *FLYING RESTART* operation conditions are considered.

***ROLLING FORWARD (or backwards) WITHOUT THE CONTROLLER PULSING***

If the vehicle is rolling forward with the controller not pulsing (thus controller in Neutral Status) the *FLYING RESTART* procedure has to be considered.

***FOOTBRAKE POT***

The "Footbrake Pot", when applied, always brakes the vehicle and has precedence over the other commands.

**SIGNALLING TO THE USER THE NOT CORRECT SEQUENCE**

If any RV switch is activated while driving forward and the speed is above the "Max. Direction change speed", F12 S011 occurs. The same happens for complimentary situation (FW switch activated while reverse driving with speed above threshold).
In general, every time an input switch is selected but is blocked by the "Inhibit the change of direction" algorithm F12 S011 occur.

| | |
|---|---|
| | **If "Inhibit the change of direction" function is activated by a selection of MxDbrkSp lower than 100%, the "Accelerator" must be tuned properly. In fact the drive direction change is allowed when speed is below the threshold and if accelerator is fully released (its value is 0%). To avoid strange behavior check if with accelerator fully released the signal is 0% by reading the line 9 and 10 of "Test menu" by means of calibrator. If not, the Adjustment 51 "AccMin" has to be increased.**<br>**For example if with accelerator fully released the volt value at line 10 of test menu "Accel Pot [V]" is 0,3V set 51 "AccMin" to 0,5V for a proper behavior of the function Inhibit the change of direction".** |

### M1-13T Foot brake torque "FBrake"

This parameter is active only in torque mode.
This sets the strength of the braking when the brake pedal is fully operated, i.e. the voltage from the footbrake potentiometer is equal to the setting of the parameter "M1-55T Brake pot maximum "BrkMax"". The setting is a percentage of maximum motor torque. The maximum motor torque is defined by "M4-9 Maximum RMS motor current ".

### M1-14T Foot brake ramp time "FbrkRamp"

In Torque Control mode this sets the time taken to ramp from no braking torque to full braking torque when the brake pedal is operated. Increasing the value gives a smoother but longer transition from drive to braking.
In Speed Control mode this sets the time taken to ramp down the speed from actual to zero, when the footbrake pedal is operated and fully pressed (100% value). In case neutral breaking torque was applied prior to pressing the footbrake, the ramp is decreased proportionally to the brake pedal position (see "Brake pot maximum "BrkMax"M1-55TBrake pot maximum "BrkMax"" for more explanation). Increasing the value gives a smoother but longer transition to zero speed.

| | |
|---|---|
| | **Important for speed control:**<br>**When speed control selected ("M3-2T Control Mode "Spd/Torq""=0) using a very low value of time will bring a very harsh foot braking.** |

 ©2019 DMC GmbH Herten Germany

# Parameters for “End of Braking” and “Hill hold” functions

The following parameters define the “End of braking” and “Hill hold” functions. Different behaviors of the motor can be achieved according to the settings of the following control setup:

- “M3-2T Control Mode “Spd/Torq”” 
- “M3-4T Hill hold ”Off/HH/S”” 

In the next pages all the possible configurations will be explained in detail. Configurations like “M3-2T Control Mode “Spd/Torq”” = 1 (Torque mode) and “M3-4T Hill hold ”Off/HH/S”” = 1 or 2 (Hill Hold active) can not be set.

### M1-15T Speed threshold to enter end of braking mode ”SpdThEbM”

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

### M1-16T Speed threshold Ramp time to zero speed ”SpdRmpTm”

This parameter is only active when “M3-2T Control Mode “Spd/Torq”” is set to 0, 2 or 3.
It defines the “rounded ramp” speed ramp time to reach zero speed once “End of breaking” mode is entered.

In case “M3-2T Control Mode “Spd/Torq”” is set to 3, it is the ramp applied when the footbrake is fully released. In case the footbrake is pressed, the ramp time to zero speed will be derived based on the brake pot value between this parameter and “M1-17T Foot Brake Speed threshold Ramp time to zero speed “SpdRTmFB”.

### M1-17T Foot Brake Speed threshold Ramp time to zero speed “SpdRTmFB

This parameter is only active when “M3-2T Control Mode “Spd/Torq”” is set to 3.
It defines the ramp time to reach zero speed when the footbrake is 100% pressed and motor enter in end of braking.

### M1-18T Zero Speed Threshold to enter hill hold or neutral brake end ”ZSpdTh”

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

### M1-19T Hill hold time ”HHTime”

This setting is only active when “M3-4T Hill hold ”Off/HH/S”” is set to 1 or 2.
It defines the time for which the vehicle has to be kept into hill hold mode.

### M1-20T Restraint hill hold speed ”HHspeed”

This setting is only active when “M3-4T Hill hold ”Off/HH/S”” is set to 1 or 2.
It defines the speed that the vehicle should adopt after the hill hold time has elapsed and the restraint hill hold mode is entered.

### M1-21T Restraint hill hold torque threshold ”HHTrqTH”

This setting is only active when “M3-4T Hill hold ”Off/HH/S”” is set to 1 or 2.
It defines the torque threshold to detect the “level ground” condition.

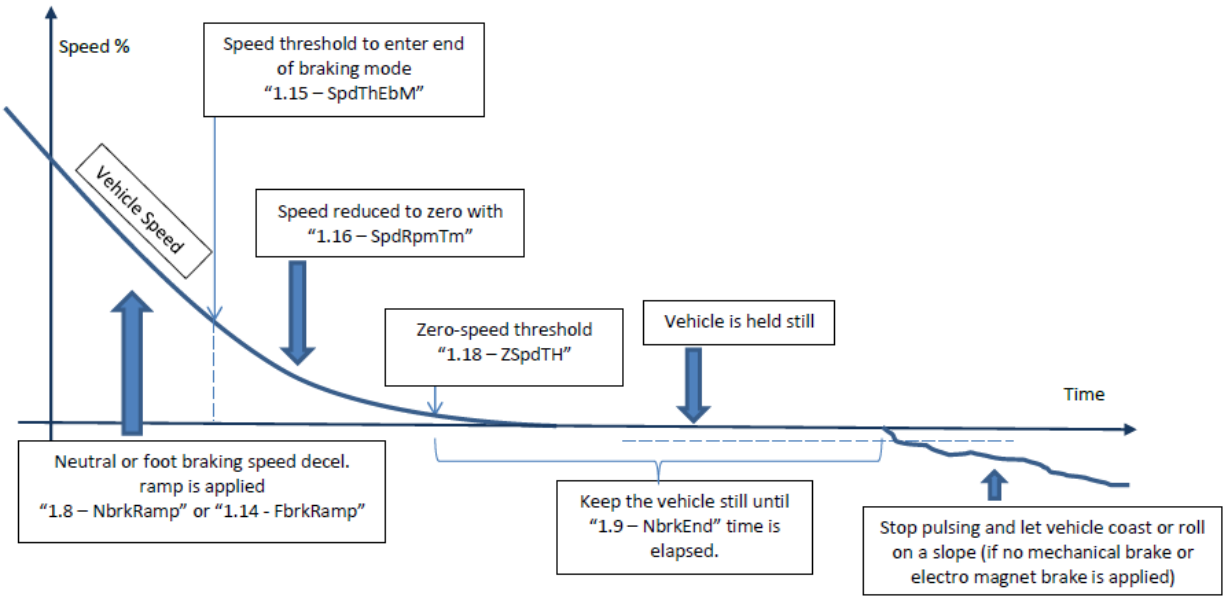
 ©2019 DMC GmbH Herten Germany

# End of Braking parameters examples of different situations

## Situation 1: "M3-2T Control Mode "Spd/Torq""= 0 (Speed control mode) and "M3-4T Hill hold "Off/HH/S""=0 (No Hill Hold)

In this case the controller acts to control the speed and no hill hold is selected, thus the parameters "M1-19T Hill hold time "HHTime"", "M1-20T Restraint hill hold speed "HHspeed"" and "M1-21T Restraint hill hold torque threshold "HHTrqTH"" won't be active.

The sequence of operation of the "end of braking" function is represented in the following figure.




### End of braking in Speed control Mode and no hill hold

The following list describes the "end of braking" steps:

1. the speed decreases according to "M1-8T Neutral brake ramp time "NBrkRamp"" (if neutral braking is happening) or "M1-14T Foot brake ramp time "FbrkRamp"" (if foot brake is operated);
2. when speed is below setting "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"", the controller reduces speed in a smooth way according to "M1-16T Speed threshold Ramp time to zero speed "SpdRmpTm"";
3. when speed is below "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"", the vehicle is held still until "M1-9T Neutral brake-End delay "NBrkEnd"" time is elapsed. The vehicle is kept still by means of speed control algorithm;
4. the controller stops pulsing and the vehicle is let coast or roll on slope (if any) unless mechanical brake or electromechanical brake is applied.

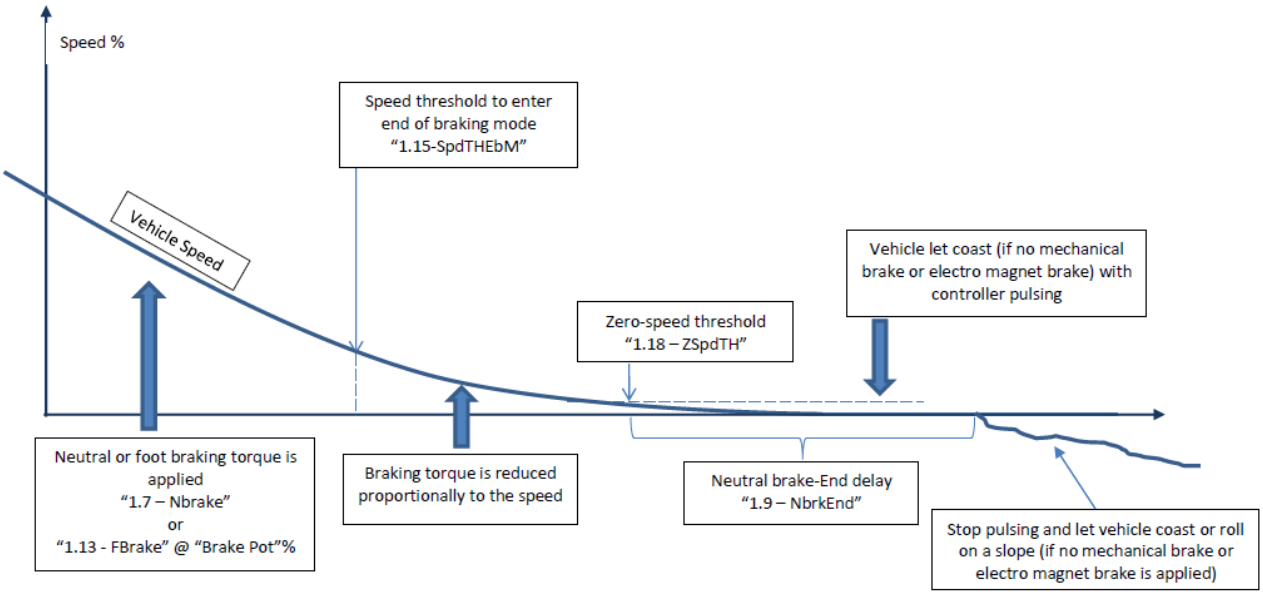
During the end of braking operation, If pedal brake is removed and a direction selected with accelerator pedal demand (add foot switch in case of ride vehicle) the vehicle will start to move in the selected direction.

 ©2019 DMC GmbH Herten Germany

### Situation 2: "M3-2T Control Mode "Spd/Torq"" = 1 (Torque control mode) and "M3-4T Hill hold "Off/HH/S""=0 (No Hill Hold)

In this case the controller acts to control the torque and no hill hold is selected, thus the parameters "M1-19T Hill hold time "HHTime"", "M1-20T Restraint hill hold speed "HHspeed"" and "M1-21T Restraint hill hold torque threshold "HHTrqTH"" won't be active.

The sequence of operation of the "end of braking" function is represented in the following figure.




#### End of braking in Torque control Mode and no hill hold

The following list describes the "end of braking" steps:

1. the speed decreases according to "M1-7T Neutral Brake torque "NBrake"" (if neutral braking is happening) or to "M1-13T Foot brake torque "FBrake"" and the "Brake pot %" value (refer to "M1-54T Brake pot minimum "BrkMin"" and M1-55T Brake pot maximum "BrkMax"") (if foot brake is operated);
2. when speed is below setting "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"", the controller reduces brake torque in a smooth way (proportionally to speed) to assure a smooth stop operation;
3. when speed is below "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"", the vehicle is let coast with the controller pulsing until "M1-9T Neutral brake-End delay "NBrkEnd"" time is elapsed;
4. the controller stops pulsing and the vehicle is let coast or roll on slope (if any) unless mechanical brake or electromechanical brake is applied.

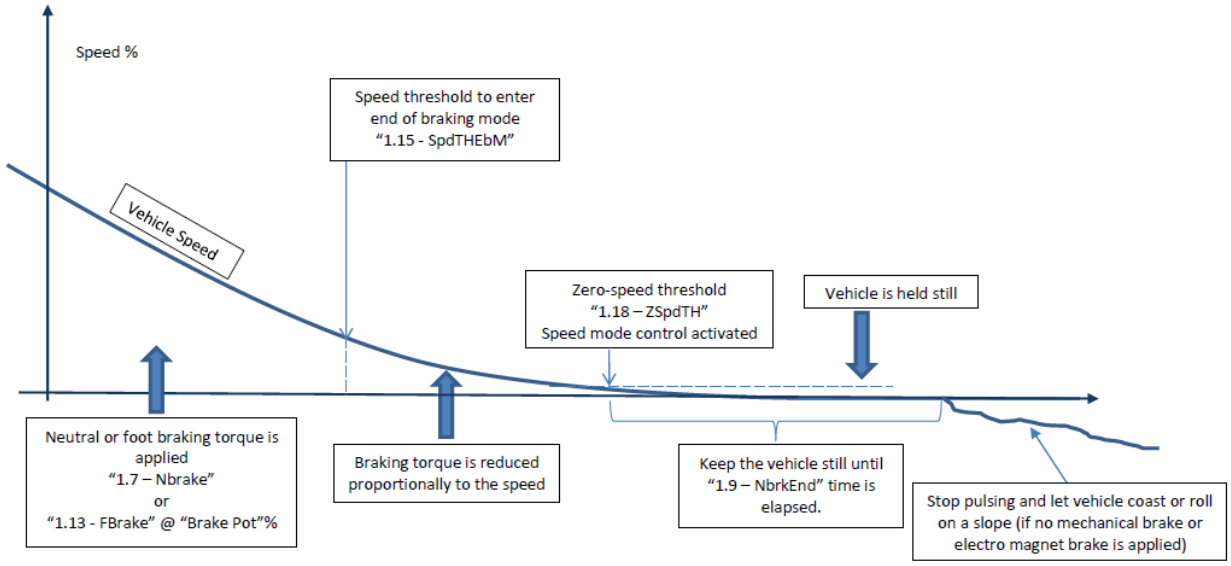
During the end of braking operation, If pedal brake is removed and a direction selected with accelerator pedal demand (add foot switch in case of ride vehicle) the vehicle will start to move in the selected direction.

 ©2019 DMC GmbH Herten Germany

### Situation 3: "M3-2T Control Mode "Spd/Torq"" = 2 (Torque control mode with speed mode at the end of braking) and "M3-4T Hill hold "Off/HH/S""=0 (No Hill Hold)

In this case the controller acts to control the torque in normal drive and to control the speed at the end of braking. No hill hold is selected, thus the parameters "M1-19T Hill hold time "HHTime"", "M1-20T Restraint hill hold speed "HHspeed"" and "M1-21T Restraint hill hold torque threshold "HHTrqTH"" won't be active.

The sequence of operation of the "end of braking" function is represented in the following figure.




**End of braking in Torque control Mode with Speed Mode at the end of braking and no hill hold**

The following list describes the "end of braking" steps:

1. the speed decreases according to "M1-7T Neutral Brake torque "NBrake"" (if neutral braking is happening) or to "M1-13T Foot brake torque "FBrake"" and the "Brake pot %" value (refer to "M1-54T Brake pot minimum "BrkMin"" and M1-55T Brake pot maximum "BrkMax"") (if foot brake is operated);
2. when speed is below setting "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"", the controller reduces brake torque in a smooth way (proportionally to speed) to assure a smooth stop operation;
3. when speed is below "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"", the controller starts to control speed, slowing linearly down to zero according to "M1-16TSpeed threshold Ramp time to zero speed "SpdRmpTm"".
4. when the vehicle stops, it is held still until "M1-9T Neutral brake-End delay "NBrkEnd"" time is elapsed. The vehicle is kept still by means of speed control algorithm;
5. the controller stops pulsing and the vehicle is let coast or roll on slope (if any) unless mechanical brake or electromechanical brake is applied.

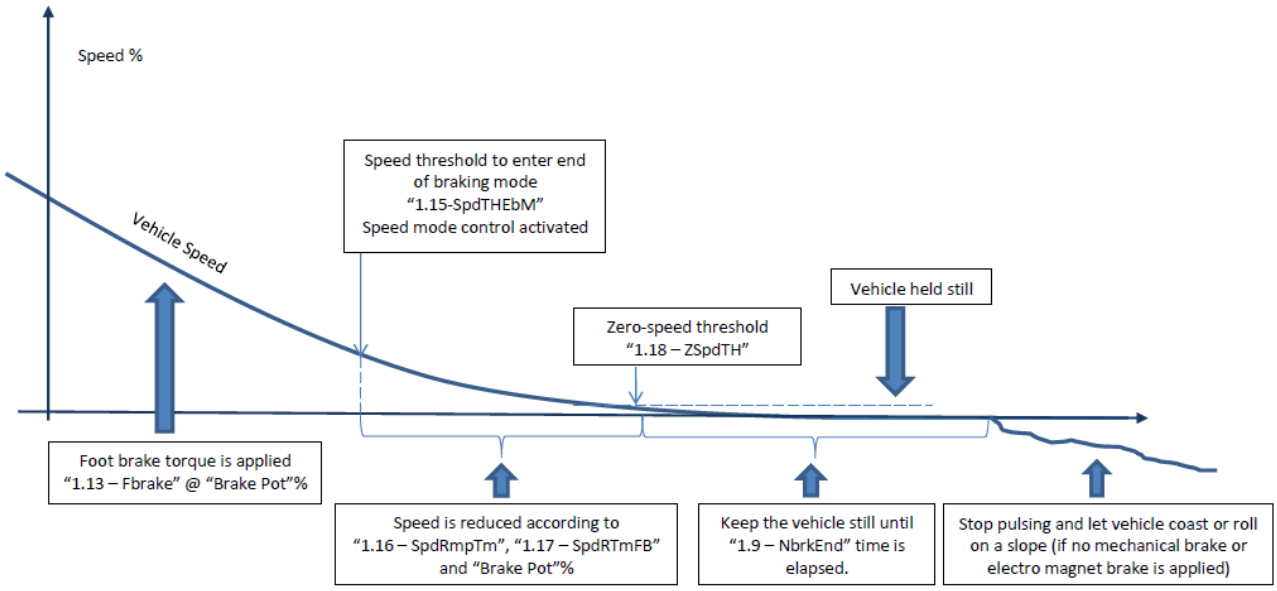
During the end of braking operation, If pedal brake is removed and a direction selected with accelerator pedal demand (add foot switch in case of ride vehicle) the vehicle will start to move in the selected direction.

 ©2019 DMC GmbH Herten Germany

### Situation 4: "M3-2T Control Mode "Spd/Torq"" = 3 (Torque control mode with speed mode at the end of braking and at the end of footbrake operation) and "M3-4T Hill hold "Off/HH/S"" = 0 (No Hill Hold)

In this case the controller acts to control the torque in normal drive and to control the speed at the end of braking and in footbrake operation. No hill hold is selected, thus the parameters "M1-19T Hill hold time "HHTime"", "M1-20T Restraint hill hold speed "HHspeed"" and "M1-21T Restraint hill hold torque threshold "HHTrqTH"" won't be active.

The sequence of operation of the "end of braking" function in case of neutral braking is the same of situation 3.
The sequence of operation of the "end of braking" function in case of footbrake operation is represented in the following figure.




#### End of braking in FOOT BRAKING in Torque control Mode with Speed Mode at the end of braking and at the end footbrake operation, no hill hold

The following list describes the "end of braking" steps:

1. the speed decreases according to "M1-13T Foot brake torque "FBrake"" and the "Brake pot %" value (refer to "M1-54T Brake pot minimum "BrkMin"" and M1-55T Brake pot maximum "BrkMax"");
2. when speed is below setting "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"", the controller starts to control speed. The ramp time to zero is derived according to the brake pot position between "M1-16T Speed threshold Ramp time to zero speed "SpdRmpTm"" and "M1-17T Foot Brake Speed threshold Ramp time to zero speed "SpdRTmFB".
3. when speed is below "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"", the controller continues to control speed, slowing linearly down to zero according to "M1-16TSpeed threshold Ramp time to zero speed "SpdRmpTm"".
4. when the vehicle stops, it is held still until "M1-9T Neutral brake-End delay "NBrkEnd"" time is elapsed and the footbrake has not been released. The vehicle is kept still by means of speed control algorithm;
5. the controller stops pulsing and the vehicle is let coast or roll on slope (if any) unless mechanical brake or electromechanical brake is applied.

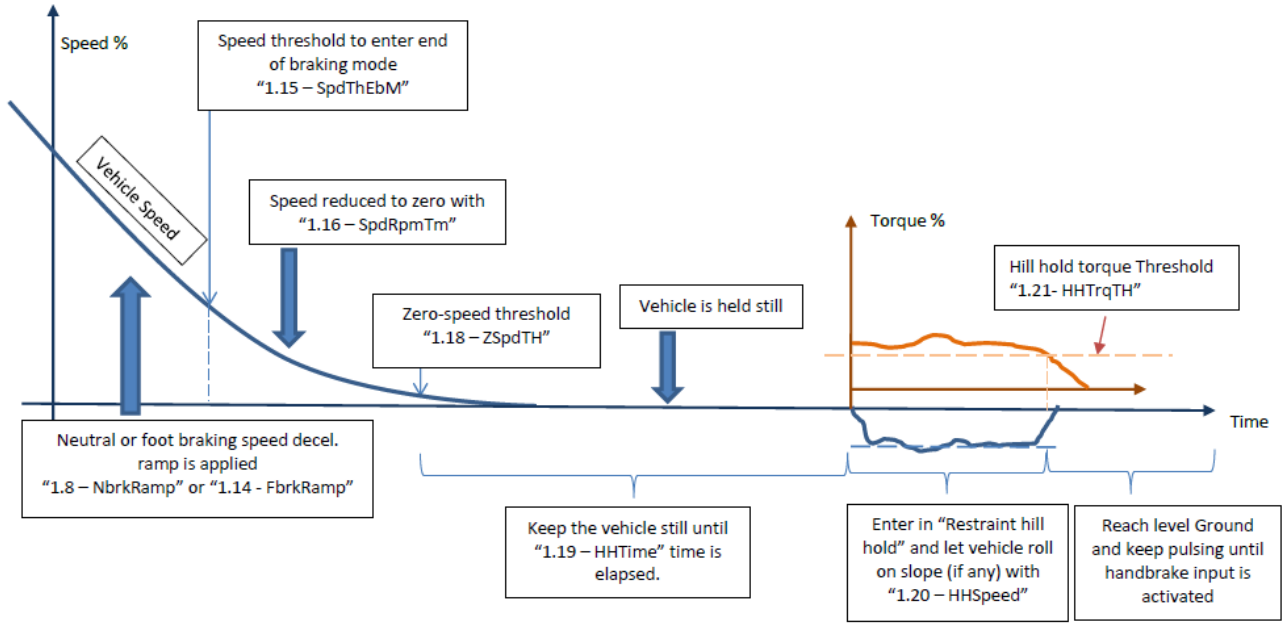
During the end of braking operation, If pedal brake is removed and a direction selected with accelerator pedal demand (add foot switch in case of ride vehicle) the vehicle will start to move in the selected direction.

 ©2019 DMC GmbH Herten Germany

### Situation 5: "M3-2T Control Mode "Spd/Torq"" = 0 (Speed Control Mode) and "M3-4T Hill hold "Off/HH/S"" =1 (Hill Hold)

In this case the controller acts to control the speed. Since hill hold is selected, the parameters "M1-19T Hill hold time "HHTime"", "M1-20T Restraint hill hold speed "HHspeed"" and "M1-21T Restraint hill hold torque threshold "HHTrqTH"" will be active.

The sequence of operation of the "end of braking" function is represented in the following figure.




**End of braking in Speed Control Mode at the end of braking and hill hold enabled**

The following list describes the "end of braking" steps:

1. the speed decreases according to "M1-8T Neutral brake ramp time "NBrkRamp"" (if neutral braking is happening) or "M1-14T Foot brake ramp time "FbrkRamp"" and the "Brake pot %" value (refer to "M1-54T Brake pot minimum "BrkMin"" and M1-55T Brake pot maximum "BrkMax"") (if foot brake is operated);
2. when speed is below setting "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"", the controller reduces speed in a smooth way according to "M1-16T Speed threshold Ramp time to zero speed "SpdRmpTm"";
3. when speed is below "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"", the vehicle is held still until "M1-19THill hold time "HHTime"" time is elapsed. The vehicle is kept still by means of speed control algorithm;
4. when "M1-19THill hold time "HHTime"" is elapsed, two situations are possible:
   I. if the vehicle is on a slope it will roll (back or forward according to the slope) at "M1-20T Restraint hill hold speed "HHspeed"" until level ground is detected, then it stops moving.
   II. If the vehicle is already at level ground the vehicle is held still.

   Level ground is detected when actual torque drops below "M1-21T Restraint hill hold torque threshold "HHTrqTH"".
5. The controller keep pulsing until handbrake input (digital input 7) becomes active. Otherwise the controller never stops pulsing until it is switched off! If digital input 7 is select as speed input 3 it never stops pulsing even if this is activated.

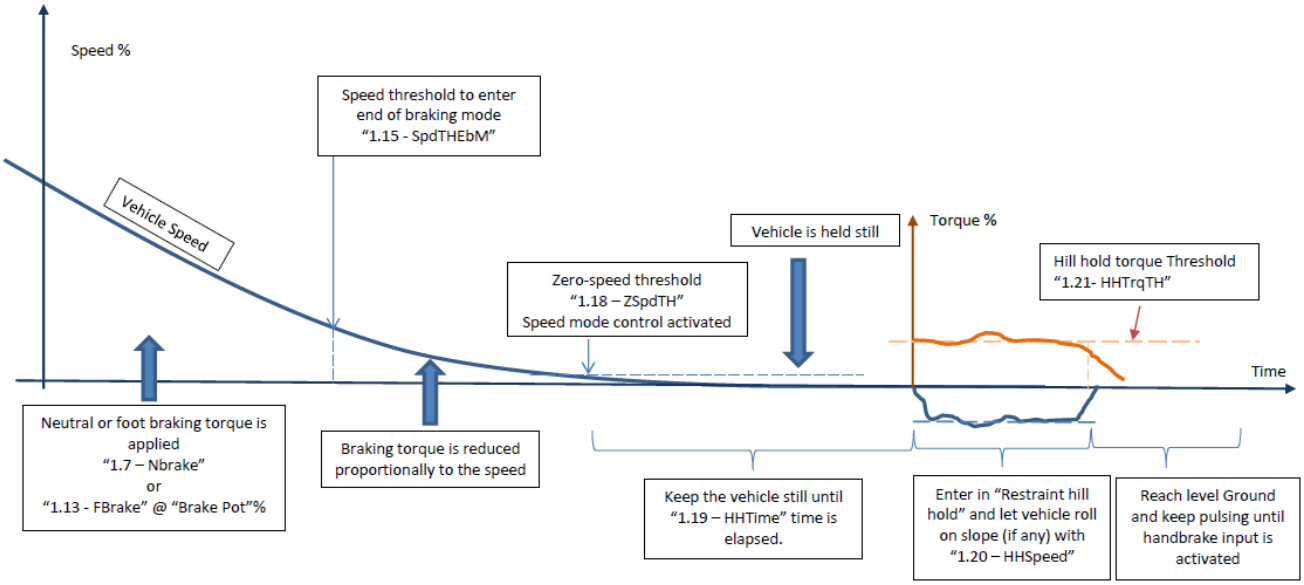
| | |
|---|---|
| | • **VERY IMPORTANT: If the braking has been commanded by setting the direction switches to neutral the step 3) of the above list use a different time. In other words the hill hold time is ignored and the "M1-9T Neutral brake-End delay "NBrkEnd"" time is used. After that time the vehicle will roll on the slope at the restraint hill hold speed.**<br>• **VERY IMPORTANT: Take care of consideration at step 5).** |

 ©2019 DMC GmbH Herten Germany

### Situation 6: "M3-2T Control Mode "Spd/Torq"" = 2 (Torque control mode with Speed Control Mode at the end of braking) and "M3-4T Hill hold "Off/HH/S"" =1 (Hill Hold)

In this case the controller acts to control the torque in normal drive and to control the speed at the end of braking. Since hill hold is selected, the parameters "M1-19T Hill hold time "HHTime"", "M1-20T Restraint hill hold speed "HHspeed"" and "M1-21T Restraint hill hold torque threshold "HHTrqTH"" will be active.

The sequence of operation of the "end of braking" function is represented in the following figure.




**End of braking in Torque control Mode with Speed Mode at the end of braking and hill hold enabled**

The following list describes the "end of braking" steps:

1. the speed decreases according to "M1-7T Neutral Brake torque "NBrake"" (if neutral braking is happening) or to "M1-13T Foot brake torque "FBrake"" and the "Brake pot %" value (refer to "M1-54T Brake pot minimum "BrkMin"" and M1-55T Brake pot maximum "BrkMax"") (if foot brake is operated);
2. when speed is below setting "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"", the controller reduces brake torque in a smooth way (proportionally to speed) to assure a smooth stop operation;
3. when speed is below "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"", the controller starts to control speed, slowing linearly down to zero according to "M1-16TSpeed threshold Ramp time to zero speed "SpdRmpTm"".
4. when the vehicle stops, it enters in Hill Hold mode and is held still until "M1-19THill hold time "HHTime"" time is elapsed. The vehicle is kept still by means of speed control algorithm;
5. when "M1-19THill hold time "HHTime"" is elapsed, two situations are possible:
   I. if the vehicle is on a slope it will roll (back or forward according to the slope) at "M1-20T Restraint hill hold speed "HHspeed"" until level ground is detected, then it stops moving.
   II. If the vehicle is already at level ground the vehicle is held still.

   Level ground is detected when actual torque drops below "M1-21T Restraint hill hold torque threshold "HHTrqTH"".
6. The controller keep pulsing until handbrake input (digital input 7) becomes active. Otherwise the controller never stops pulsing until it is switched off! If digital input 7 is select as speed input 3 it never stops pulsing even if this is activated.

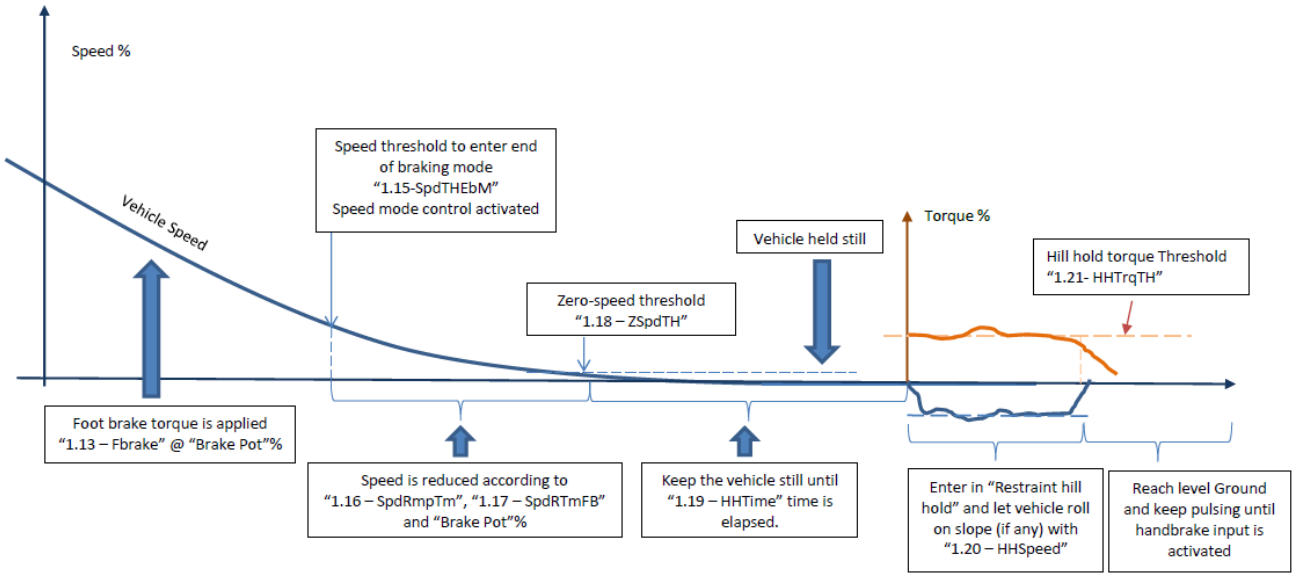
| | |
|---|---|
| | • **VERY IMPORTANT: If the braking has been commanded by setting the direction switches to neutral the step 4) of the above list use a different time. In other words the hill hold time is ignored and the "M1-9T Neutral brake-End delay "NBrkEnd"" time is used. After that time the vehicle will roll on the slope at the restraint hill hold speed.**<br>• **VERY IMPORTANT: Take care of consideration at step 6).** |

 ©2019 DMC GmbH Herten Germany

### Situation 7: "M3-2T Control Mode "Spd/Torq"" = 3 (Torque control mode with Speed Control Mode at the end of braking and at the end of footbrake operation) and "M3-4T Hill hold "Off/HH/S"" = 1 (Hill Hold)

In this case the controller acts to control the torque in normal drive and to control the speed at the end of braking and in footbrake operation. Since hill hold is selected, the parameters "M1-19T Hill hold time "HHTime"", "M1-20T Restraint hill hold speed "HHspeed"" and "M1-21T Restraint hill hold torque threshold "HHTrqTH"" will be active.

The sequence of operation of the "end of braking" function in case of neutral braking is the same of situation 6.
The sequence of operation of the "end of braking" function in case of footbrake operation is represented in the following figure.




**Footbrake operation in FOOT BRAKING in Torque control Mode with Speed Mode at the end of braking and at the end of footbrake operation, hill hold enabled**

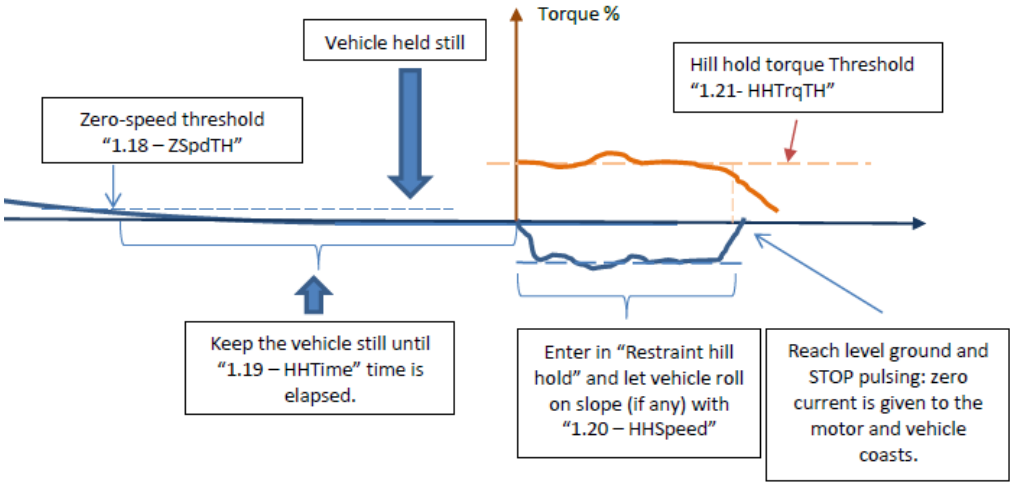
The following list describes the "end of braking" steps:

1. the speed decreases according to "M1-13T Foot brake torque "FBrake"" and the "Brake pot %" value (refer to "M1-54T Brake pot minimum "BrkMin"" and M1-55T Brake pot maximum "BrkMax"");
2. when speed is below setting "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"", the controller starts to control speed. The ramp time to zero is derived according to the brake pot position between "M1-16T Speed threshold Ramp time to zero speed "SpdRmpTm"" and "M1-17T Foot Brake Speed threshold Ramp time to zero speed "SpdRTmFB".
3. when speed is below "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"", the controller continues to control speed, slowing linearly down to zero according to "M1-16TSpeed threshold Ramp time to zero speed "SpdRmpTm"".
5. when the vehicle stops, it enters in Hill Hold mode and is held still until "M1-19THill hold time "HHTime"" time is elapsed. The vehicle is kept still by means of speed control algorithm;
6. when "M1-19THill hold time "HHTime"" is elapsed, two situations are possible:
   I. if the vehicle is on a slope it will roll (back or forward according to the slope) at "M1-20T Restraint hill hold speed "HHspeed"" until level ground is detected, then it stops moving.
   II. If the vehicle is already at level ground the vehicle is held still.

   Level ground is detected when actual torque drops below "M1-21T Restraint hill hold torque threshold "HHTrqTH"".
7. The controller keep pulsing until handbrake input (digital input 7) becomes active. Otherwise the controller never stops pulsing until it is switched off! If digital input 7 is select as speed input 3 it never stops pulsing even if this is activated.

 ©2019 DMC GmbH Herten Germany

| | |
|---|---|
| | **IMPORTANT for Situation 5, 6 and 7:**<br><br>**If "M3-4T Hill hold "Off/HH/S""= 2 (Hill Hold & Stop pulsing) the controller will stop pulsing when at the end of restraint hill hold the level ground is reached. The situation is described in the following picture.** |




**Stop pulsing and applying zero current on level ground if ""M3-4T Hill hold "Off/HH/S""= 2 (Hill Hold & Stop pulsing)**

### M1-22T Cutback speed 1 (I/O 5-6 set to Speed) "Speed1"

The function of this parameter is dependent on the setting of "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"" in the Controller Set-up menu, which sets whether pins 5 and 6 are used as speed limiting inputs or inching control inputs or advanced mode.

If set to 0 (Speed Limits), then "Speed 1" sets the maximum speed of the vehicle when the switch connected to input 5 on 35way connector is open. The speed limit is not applied when the switch is closed or a lower speed limit is in operation.
If set to 1 (Inching), this set is not used.
If set to 2 (Advanced Mode), then "Speed 1" sets the maximum speed of the vehicle when the switches connected to inputs 5 and 6 are configured to select Drive Style 1 (refer to Control set up "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"" for configuration details).
If set to 3 (Speed Limit and footbrake switch), this set is not active.

### M1-23T Inching speed (I/O 5-6 set to Inching) "InchSpd"

The function of this parameter is dependent on the setting of "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"" in the Controller Set-up menu, which sets whether pins 5 and 6 are used as speed limiting inputs or inching control inputs or advanced mode.

If set to 0 (Speed Limits),this set is not active.
If set to 1 (Inching), then "Inching Speed" sets the speed of the vehicle (in both directions), that will be active when a switch connected to pin 5 or pin 6 of 35-way connector is closed. The vehicle will not inch when the switch is open.
If set to 2 (Advanced Mode), this set is not active.
If set to 3 (Speed Limit and footbrake switch), this set is not active.

### M1-24T Acceleration delay 1 "Accel1"
### M1-25T Deceleration delay 1 "Decel1"
### M1-26T Maximum Drive Torque 1 (Torque Mode Only) "MxDrTrq1"
### M1-27T Neutral Brake Torque 1 (Torque Mode Only) "NBrkTrq1"
### M1-28T Neutral brake ramp time 1 "NBrkRmp1"
### M1-29T Direction Brake torque 1 (Torque Mode Only) "DBrkTrq1"
### M1-30T Direction brake ramp time 1 "DBrkRmp1"
### M1-31T Foot Brake Torque 1 (Torque Mode Only) "FBrkTrq1"
### M1-32T Foot brake ramp time 1 "FBrkRmp1"

These settings are active when Advanced drive mode is selected from controller setup "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"". They define the corresponding ramp times and torque levels for the different situations (driving and neutral/foot/direction braking) when the switches connected to inputs 5 and 6 are configured to select Drive Style 1 (refer to Control set up "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"" for configuration details).

 ©2019 DMC GmbH Herten Germany

### M1-33T Cutback speed 2 (I/O 5-6 set to Speed) "Speed2"

The function of this parameter is dependent on the setting of "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"" in the Controller Set-up menu, which sets whether pins 5 and 6 are used as speed limiting inputs or inching control inputs or advanced mode.

If set to 0 (Speed Limits), then "Speed 2" sets the maximum speed of the vehicle when the switch connected to input 6 on 35way connector is open. The speed limit is not applied when the switch is closed or a lower speed limit is in operation.
If set to 1 (Inching), this set is not active
If set to 2 (Advanced Mode), then "Speed 2" sets the maximum speed of the vehicle when the switches connected to inputs 5 and 6 are configured to select Drive Style 2 (refer to Control set up "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"" for configuration details).
If set to 3 (Speed Limit and footbrake switch), this set is not active.

### M1-34T Inching time (I/O 5-6 set to Inching) "InchTime"

The function of this parameter is dependent on the setting of "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"" in the Controller Set-up menu, which sets whether pins 5 and 6 are used as speed limiting inputs or inching control inputs or advanced mode.

If set to 0 (Speed Limits),this set is not active
If set to 1 (Inching), then "Inching Time" sets the time for which the vehicle will move (in either directions) when a switch connected to pin 5 or pin 6 of 35-way connector is closed. The vehicle will not inch when the switch is open.
If set to 2 (Advanced Mode), this set is not active.
If set to 3 (Speed Limit and footbrake switch), this set is not active.

### M1-35T Acceleration delay 2 "Accel2"
### M1-36T Deceleration delay 2 "Decel2"
### M1-37T Maximum Drive Torque 2 (Torque Mode Only) "MxDrTrq2"
### M1-38T Neutral Brake Torque 2 (Torque Mode Only) "NBrkTrq2"
### M1-39T Neutral brake ramp time 2 "NBrkRmp2"
### M1-40T Direction Brake torque 2 (Torque Mode Only) "DBrkTrq2"
### M1-41T Direction brake ramp time 2 "DBrkRmp2"
### M1-42T Foot Brake Torque 2 (Torque Mode Only) "FBrkTrq2"
### M1-43T Foot brake ramp time 2 "FBrkRmp2"

These settings are active when Advanced drive mode is selected from controller setup "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"". They define the corresponding ramp times and torque levels for the different situations (driving and neutral/foot/direction braking) when the switches connected to inputs 5 and 6 are configured to select Drive Style 2 (refer to Control set up "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"" for configuration details).

### M1-44T Cutback speed 3 (I/O 7 set to speed3) "Speed3"

This parameter is active if "M3-6T I/O Pin 7 "Spd3/Hbk"" is set to 0. If so, "Speed Limit 3" sets the maximum speed of the vehicle when the switch connected to input 7 on 35way connector is open. The speed limit is not applied when the switch is closed or a lower speed limit is in operation.

### M1-45T Handbrake On maximum Speed (I/O 7 set to Handbrake) "HandBrk"

This parameter is active if "M3-6T I/O Pin 7 "Spd3/Hbk"" is set to 1. If so, "HandBrk" sets the maximum speed of the vehicle when the switch connected to input 7 on 35way connector is closed. The speed limit is not applied when the switch is open or a lower speed limit is in operation.
Please note that even if this parameter is set to 0Hz the controller will continue to pulse if the switch connected "Pin 7 Speed Limit 3 / Handbrake -- *Pump Inhibit*" is closed and it is demanded to drive. This is designed to avoid rollback on gradients.

### M1-46T Maximum Drive Torque speed 3 (I/O 7 set to Handbrake) "MxDrTrq3"

This parameter is active if 3.6 I/O Pin 7 "Spd3/Hbk" is set to 1. If so, "MxDrTrq3" sets the maximum drive torque when the switch connected to input 7 on 35way connector is closed. The torque limit is not applied when the switch is open or a lower torque limit is in operation.

### M1-47T Speed limit ramp "SpLimRmp"

This parameter is active only in torque mode.
This sets the time taken to decelerate from maximum speed to zero speed when a speed limit (1,2 or 3) is activated.
The speed limit ramp time is applied only if the actual motor speed is higher than speed limit one.
Speed limit ramping is not applied when speed limit is removed.

### M1-48T Drive torque reduction time "DTrqRtm"

This parameter is active only in torque mode.
This sets the time taken to ramp down from full driving torque to zero torque when a brake operation is required (direction, footbrake, neutral). Increasing the value gives a smoother but longer transition from drive to braking.

 ©2019 DMC GmbH Herten Germany

### M1-49T Brake torque reduction time "BTrqRtm"

This parameter is active only in torque mode.
This sets the time taken to ramp down from full braking torque to zero torque when brake operation (direction, footbrake, neutral) is ended and a drive condition is detected. Increasing the value gives a smoother but longer transition from braking to driving.

### M1-50T Power steer delay "PStrDly"

This sets the period that the "Pin 17 Contactor 3 o/p (Powersteer - Fan control)" on 35-Way Connector, will remain active after the trigger source has been removed. The trigger source is set by the parameter "M3-7T Power steer trigger "PsF/FR/S"" in the Controller Set-up menu.

### M1-51T Electric brake delay "EBrkDly"

This setting is normally associated with a Walkie type vehicle fitted with an electromechanical brake connected to the "Pin 16 Contactor 2 o/p (Magnet Brake - Fan control)" of the 35-Way Connector. The value sets the delay between the entering of "end of braking mode" (speed lower than "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"") and the electric brake being applied. If the vehicle is detected at standstill (speed lower than "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"") before "M1-51T Electric brake delay "EBrkDly"" is elapsed, the EM brake is applied and therefore this has no effect.
Resuming: the EM brake is applied if "M1-51T Electric brake delay "EBrkDly"" is elapsed from the instant of entering in end of braking OR if zero speed is detected.
There is also a fixed period of 0.1s that sets the delay from when pulsing starts to the electric brake being released. This helps to prevent roll back of a Walkie truck when starting driving on a gradient.

### M1-52T Accelerator pot minimum "AccMin"

This sets the voltage on the Accelerator input that will correspond to zero speed or zero torque demand.
The type of Accelerator input (normal or wig wag) can be configured via the parameter "M3-12T Accelerator type "AccelTyp"".

### M1-53T Accelerator pot maximum "AccMax"

This sets the voltage on the Accelerator input that will correspond to maximum speed or maximum torque demand.
The type of Accelerator input (normal or wig wag) can be configured via the parameter "M3-12T Accelerator type "AccelTyp"".

When the accelerator is properly set, it reaches 100% when full pressed and sets the motor speed or torque demand according to parameter "M3-2TControl Mode "Spd/Torq"".

In "Speed Mode" when accelerator reaches 100%, the motor speed demand correspond to 100% of actual speed limiting. If, for example,"M1-22T Cutback speed 1 (I/O 5-6 set to Speed) "Speed1"" is active and set to 120Hz, then the speed demand corresponding to 100% of accelerator is 120Hz. Else if, for example, the motor is running reverse and "M1-6T Maximum speed reverse "SpdMaxR"" is set to 60Hz, the speed demand corresponding to 100% of accelerator is 60Hz.

In "Torque mode" the accelerator is scaled on the maximum current set in the autotuning menu. So when accelerator pedal is fully pressed (100%) the torque corresponding to maximum current is demanded to the motor. In case of "Advanced mode" activated, the 100% of accelerator corresponds to the torque limits for Drive style 1 and Drive Style2 (see "Advanced Mode" "M3-5TI/O Pin 5 and 6 "Sp/In/Ad"").

### M1-54T Brake pot minimum "BrkMin"

This sets the voltage on the Footbrake input that will correspond to begin footbrake operation. Notice that as soon footbrake is pressed and footbrake input voltage greater than "BrkMin", a foot brake operation is started.
If the controller is in torque mode, the brake torque applied will depend on Footbrake value;
If the controller is in speed mode, the footbrake deceleration ramp will depend on Footbrake value.

### M1-55T Brake pot maximum "BrkMax"

In "Torque mode", this sets the voltage on the Footbrake input that will correspond to the braking torque as set by the parameter "M1-13T Foot brake torque "FBrake"".
The brake torque is changed proportionally to "Brake Pot Value" (see brake pot value in test menu "M11-11 "BrakePot" [%]" and "M11-12 "BrakePot" [V]") from "M1-7T Neutral Brake torque "NBrake"" (when "Brake Pot" = 0%) to "M1-13T Foot brake torque "FBrake"" (when "Brake Pot" = 100%).

In "Speed Mode", this sets the voltage on the Footbrake input that will correspond to the braking ramp for speed as set by the parameter "M1-14T Foot brake ramp time "FbrkRamp"".
The ramp time for braking is changed proportionally to "Brake Pot Value" (see brake pot value in test menu M11-11 "BrakePot" [%], M11-12 "BrakePot" [V]) from "M1-8T Neutral brake ramp time "NBrkRamp""(when "Brake Pot" =0%) to "M1-14T Foot brake ramp time "FbrkRamp"" (when "Brake Pot" =100%).

 ©2019 DMC GmbH Herten Germany

### M1-56T Steer pot minimum "StrMin"

This parameter is active if the parameter "M3-14TSingle or Dual Motor "Si/DL/DR"", in the Controller Set-up menu, is set different from 0.

When active (dual motor left/dual motor right/single motor with steer pot speed limitation), this parameter sets the voltage on the Steering Pot input ("Pin 12 Analogue AD3 -- Steer pot"), which will correspond to the minimum steering angle. By convention, the minimum steering angle relates to the full left hand lock of the vehicle.

### M1-57T Steer pot middle point "StrMid"

This parameter is active if the parameter "M3-14TSingle or Dual Motor "Si/DL/DR"", in the Controller Set-up menu, is set different from 0.

When active (dual motor left/dual motor right/single motor with steer pot speed limitation), this parameter sets the voltage on the Steering Pot input ("Pin 12 Analogue AD3 -- Steer pot") which will correspond to 0° steering angle.

### M1-58T Steer pot maximum "StrMax"

This parameter is active if the parameter "M3-14TSingle or Dual Motor "Si/DL/DR"", in the Controller Set-up menu, is set different from 0.

When active (dual motor left/dual motor right/single motor with steer pot speed limitation), this parameter sets the voltage on the Steering Pot input ("Pin 12 Analogue AD3 -- Steer pot"), which will correspond to the maximum steering angle. By convention, the maximum steering angle relates to the full right hand lock of the vehicle.

### M1-59T Wig/Wag fwd threshold "FwdTH"

This parameter is active if the parameter "M3-12T Accelerator type "AccelTyp"", in the Controller Set-up menu, is set to 1.

This value sets the voltage on "Pin 9 Analogue AD1 i/p Accelerator -- *Potentiometer*" on 35-way connector from which forward drive commences. Together with "M1-60TWig/Wag rev threshold "RevTH", this parameter forms a 'dead band' in which the wig-wag assumes a neutral position.

### M1-60T Wig/Wag rev threshold "RevTH"

This parameter is active if the parameter "M3-12T Accelerator type "AccelTyp"", in the Controller Set-up menu, is set to 1.

This value sets the voltage on "Pin 9 Analogue AD1 i/p Accelerator -- *Potentiometer*" on 35-way connector from which reverse drive commences. Together with "M1-59T Wig/Wag fwd threshold "FwdTH"", this parameter forms a 'dead band' in which the wig-wag assumes a neutral position.

 ©2019 DMC GmbH Herten Germany

# Dual Motor parameters

**M1-61T Dual motor cut out ”DMcut”**
**M1-62T Dual motor angle 1 ”DMang1”**
**M1-63T Dual motor angle 2 ”DMang2”**
**M1-64T Dual motor angle 3 ”DMang3”**
**M1-65T Dual motor speed 1 ”DMspd1”**
**M1-66T Dual motor speed 2 ”DMspd2”**
**M1-67T Dual motor speed 3 ”DMspd3”**

These parameters define the Dual Motor function. For them to be active, the parameter “M3-14TSingle or Dual Motor ”Si/DL/DR” must be set to 1, 2 or 3 (if set to 3, only “DMcut”, “DMang3” and “DMspd3” will be active).
The parameters are working in conjunction with steering pot. The steering angle is expressed as percentage and is defined by the following parameters:

- “M1-56T Steer pot minimum ”StrMin”” sets -100% of steering angle
- “M1-57T Steer pot middle point ”StrMid”” sets 0% of steering angle
- “M1-58T Steer pot maximum ”StrMax”” sets 100% of steering angle

Parameter “M1-61T Dual motor cut out ”DMcut”” sets the steering angle at which the motor starts to reduce speed. If, for example, a value of 10% is chosen, then the speed reduction will commence if the steering potentiometer is outside of a central dead band of ± 10%.
In the central dead band, the inner motor speed is equal to the outer motor speed and corresponds to the driving speed of the vehicle.

When the setting “M3-14TSingle or Dual Motor ”Si/DL/DR” is set to 1 or 2, the relationship between parameters from M1-61T to M1-67T is explained below for both the inner and outer motors:

**Inner motor:**

- When the steering angle is between “M1-61T Dual motor cut out ”DMcut”” and “M1-62T Dual motor angle 1 ”DMang1”” settings, the motor starts to reduce speed towards “M1-65T Dual motor speed 1 ”DMspd1””, while it also reduces the torque towards zero.
- When the steering angle is between “M1-62T Dual motor angle 1 ”DMang1”” and “M1-63T Dual motor angle 2 ”DMang2”” the torque of the inner motor is zero, meaning it is able to freewheel and the speed is left free.
- When the steering angle is beyond “M1-63T Dual motor angle 2 ”DMang2”” and towards “M1-64T Dual motor angle 3 ”DMang3””, the inner motor reverses its spinning direction and torque is increased towards half the demanded torque. The speed of the inner motor starts at “M1-66T Dual motor speed 2 ”DMspd2”” and is increased towards half of the “M1-67T Dual motor speed 3 ”DMspd3”” setting.
- When steering beyond “M1-64T Dual motor angle 3 ”DMang3””, the torque of the inner motor is maintained at half the demanded torque and the speed is set to half of the “M1-67T Dual motor speed 3 ”DMspd3”” setting.

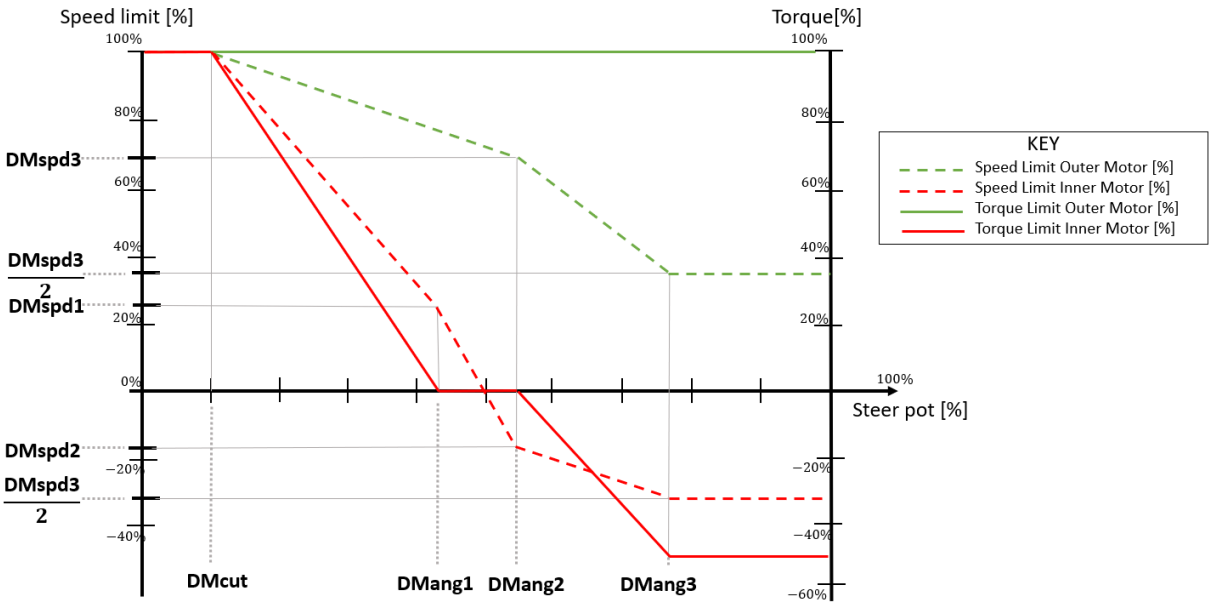
**Outer motor**:

- When the steering angle is between “M1-61T Dual motor cut out ”DMcut”” and “M1-62T Dual motor angle 1 ”DMang1”” settings, the speed of the outer motor is reduced towards “M1-67T Dual motor speed 3 ”DMspd3””.
- When the steering angle is between “M1-62T Dual motor angle 1 ”DMang1”” and “M1-63T Dual motor angle 2 ”DMang2”” the speed of the outer motor is reduced from “M1-67T Dual motor speed 3 ”DMspd3”” towards half of the “M1-67T Dual motor speed 3 ”DMspd3”” setting.
- Steering beyond the “M1-64T Dual motor angle 3 ”DMang3”” setting maintains the speed of the outer motor at half the “M1-67T Dual motor speed 3 ”DMspd3”” setting.
- The torque of the outer motor is maintained at the demanded torque in the whole steering range.

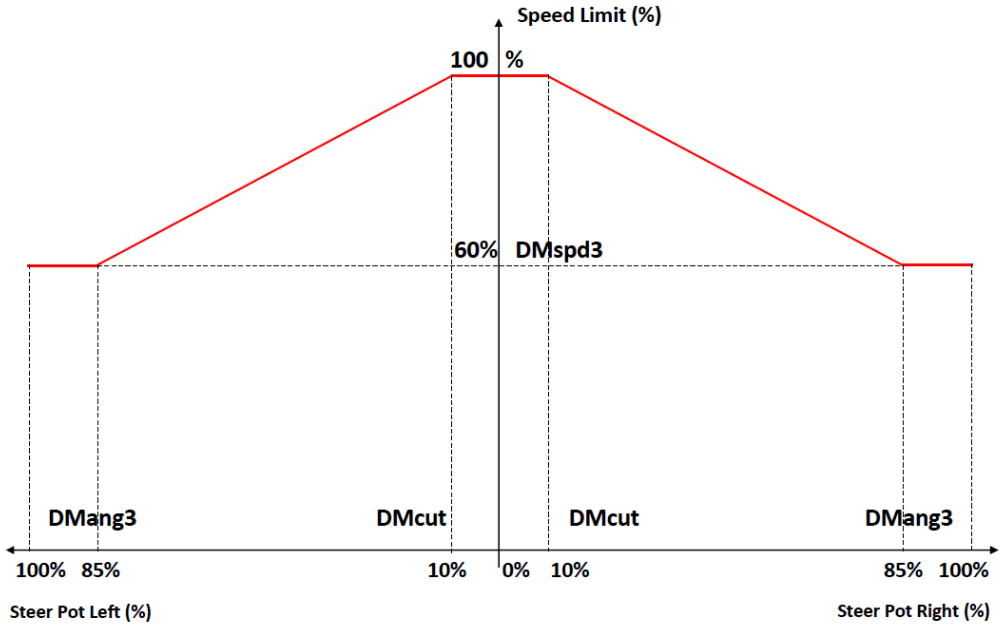
The reason because both inner and outer motors are maintaining a speed which is half of “M1-67T Dual motor speed 3 ”DMspd3”” above the “M1-67T Dual motor speed 3 ”DMspd3”” setting, is that they are spinning in opposite direction: this therefore produces a total speed which is twice that of one motor.
The torque of the inner motor is halved to prevent a sudden increase in speed when steering rapidly beyond the “M1-63T Dual motor angle 2 ”DMang2”“ setting.

 ©2019 DMC GmbH Herten Germany

The following graph shows an example of how these settings work with each other.




When the setting “M3-14TSingle or Dual Motor ”Si/DL/DR” is set to 3, the speed is limited according to the following figure:




**Speed limiting when “M3-14T Single or Dual Motor ”Si/DL/DR”, is set to 3**

In the figure an example is reported for “M1-61T Dual motor cut out ”DMcut”” =10%, “M1-64T Dual motor angle 3 ”DMang3”” 85% and “M1-67T Dual motor speed 3 ”DMspd3”” 60%.

- If the steering pot is between ±10%, the speed limit is kept to 100% and it corresponds to a central dead band.
- If the steering pot. is between 10% and 85% (left or right) the speed limit is reduced gradually to 60%.
- If steering pot is greater than 85% speed limit is kept to 60%.

The speed limit is expressed as percentage of parameter “M4-13 Maximum Motor Frequency”. In fact, if for example “M4-13 Maximum Motor Frequency” is set to 140Hz and “M1-67T Dual motor speed 3 ”DMspd3”” is set to 60%, the speed limit with steering pot at 100% (left or right) will be 84 Hz.

| | |
|---|---|
| | **! IMPORTANT If any speed limit is active the percentage of speed will refer to that speed limit and not to the “M4-13 Maximum Motor Frequency “Fmotmax””.** |

 ©2019 DMC GmbH Herten Germany

### M1-68T Speed ratio (display Kph) ”SpdRatio”

This set the ratio between the motor speed in RPM. and the vehicle speed in km per hour (KPH) or miles per hour (MPH). For example if the actual motor speed is 3000 RPM and ”SpdRatio” is set to 100, the Vehicle Speed value that can be seen in the status menu or in the DMC display is 30.0 Kph.

### M1-69T Vehicle max. Speed ”VmaxSpd”

This set the full scale indication on the Sigmagauge LCD or Display bargraph speed indicator.
Setting the parameter to 0kph means that there will be no indication of speed shown on the Sigmagauge LCD.

### M1-70T Safe stop Torque (Torque mode only) “SfStTorque”

### M1-71T Safe stop Ramp Time “SfStRmpTm”

These two settings are active if Control Via CAN HMI is enabled (“M9-3 Transmit/Receive CAN messages “CANMsgs”” set lower than 4) and safe stop function is enabled (ref to “M9-6 Can Control Type “CANCtTyp””).
For details refer to application note:1
SuperSigma2 AN 160105 - SuperSigma2 Can HMI Protocol V1.7”.

### M1-72T Belly switch speed “BellySpd”

### M1-73T Belly switch time “BellyTim”

These two settings are active if Walkie-type vehicle is enabled (“M3-8T Vehicle type select ”Ride/Wlk”” set higher than 0).
In a vehicle of this kind, if input “Pin 3 - Footswitch / Belly Button -- *Pump Switch 3*” is activated while driving reverse or when the vehicle is in neutral, the vehicle immediately stops and performs an emergency drive forward.
These parameters define, respectively, the speed at which the vehicle will drive forward if the belly switch gets activated and the time for which the vehicle will drive forward.
Notice that if any of these two parameters is set to 0 (or if both are set to 0), the Emergency Drive Forward will not be performed and the vehicle only performs the Emergency stop.
Notice also that the fault related to Belly Switch button will only be displayed after the “Belly Switch time “BellyTim”” is elapsed.

 ©2019 DMC GmbH Herten Germany

## 3.2 Menu 1 “Pump Adjustments”

| Cal. Ref. | Parameter | Calibrator Text | Min. adjust | Max. adjust | Step size | Default |
|---|---|---|---|---|---|---|
| 1 | Acceleration delay | "Accel " | 0,1 s | 10 s | 0,1 s | 2,5 s |
| 2 | Deceleration delay | "Decel " | 0,1 s | 10 s | 0,1 s | 0,3 s |
| 3 | Creep speed | "Creep " | 0,1 Hz | 600 Hz | 0 Hz | 0 Hz |
| 4 | Creep speed Ramp | “CreepRmp” | 0,1 s | 10,0 s | 0,1 s | 2,5 s |
| 5 | Maximum pot speed 1 | "Potmax1 " | 0,1 Hz | 600 Hz | 0 Hz | 0 Hz |
| 6 | Speed 2 demand | "Pspeed2 " | 0,1 Hz | 600 Hz | 0 Hz | 0 Hz |
| 7 | Speed 3 demand | "Pspeed3 " | 0,1 Hz | 600 Hz | 0 Hz | 0 Hz |
| 8 | Speed 4 demand | "Pspeed4 " | 0,1 Hz | 600 Hz | 0 Hz | 0 Hz |
| 9 | Speed 5 demand | "Pspeed5 " | 0,1 Hz | 600 Hz | 0 Hz | 0 Hz |
| 10 | Speed 6 demand | "Pspeed6 " | 0,1 Hz | 600 Hz | 0 Hz | 0 Hz |
| 11 | Minimum motor speed in cutback conditions | "MinSpeed" | 0,1 Hz | 600 Hz | 0 Hz | 40 Hz |
| 12 | Acceleration for speed 6 demand (pwrStr) | "Paccel6 " | 0,1 s | 10 s | 0,1 s | 5 s |
| 13 | Power steer delay | "PStrDly " | 0 s | 50 s | 0 s | 5 s |
| 14 | Accelerator pot minimum | “AccMin” | 0 V | 10 V | 0 V | 0,2 V |
| 15 | Accelerator pot maximum | “AccMax” | 0 V | 10 V | 0 V | 4,6 V |
| 16 | Speed threshold to enter end of braking | “SpdThEbM” | 0 % | 50 % | 0,1 % | 5 % |
| 17 | Ramp time from SpdThEbMto zero | “SpdRmpTm” | 0,1 s | 10 s | 0 s | 1,5 s |
| 18 | Zero Speed threshold to end braking | “ZSpdTh” | 0 % | 10,0% | 0,1 % | 1,0 % |

### M1-1P Acceleration delay “Accel”

This sets the time taken to accelerate from zero speed to maximum speed. The maximum speed demand is set by “M4-13 Maximum Motor Frequency”. Increasing the value results in a slower pump response, while decreasing the value results in a faster pump response.

### M1-2P Deceleration delay ”Decel”

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.

### M1-3P 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.

### M1-4P Creep speed Ramp “CreepRmp”

This parameter sets the ramp time for applying creep speed.

### M1-5P Maximum pot speed 1 ”Potmax1”

This sets the pump speed when the switch wired to pin 1 of 35-way Connector is active.
When the pump potentiometer is active, this speed demand has the highest priority and overrides all other speed requests, except for the power steer trigger input (pin 6 of 35-wy connector). When the power steer trigger input is active, the current speed demand will be the higher between Speed 1 and Speed 6. The pump motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

### M1-6P Speed 2 demand ”Pspeed2”

This sets the pump speed when the switch wired to pin 2 of 35-way Connector is active.
When pump speed 2 is active and the pump potentiometer is not active, it will override all other speed requests, except for the power steer trigger input (pin 6 of 35-wy connector). When the power steer trigger input is active, the current speed demand will be the higher between Speed 2 and Speed 6. The pump motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

### M1-7P Speed 3 demand ”Pspeed3”

This sets the pump speed when the switch wired to pin 3 of 35-way Connector is active.
When pump speed 3 is active and the pump potentiometer and Speed 2 are not active, it will override all other speed requests, except for the power steer trigger input (pin 6 of 35-wy connector). When the power steer trigger input is active, the current speed demand will be the higher between Speed 3 and Speed 6. The pump motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

 ©2019 DMC GmbH Herten Germany

### M1-8P Speed 4 demand "Pspeed4"
This sets the pump speed when the switch wired to pin 4 of 35-way Connector is active.
When pump speed 4 is active and the pump potentiometer, Speed 2 and Speed 3 are not active, it will override all other speed requests, except for the power steer trigger input (pin 6 of 35-wy connector). When the power steer trigger input is active, the current speed demand will be the higher between Speed 4 and Speed 6. The pump motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

### M1-9P Speed 5 demand "Pspeed5"
This sets the pump speed when the switch wired to pin 5 of 35-way Connector is active.
When pump speed 5 is active and the pump potentiometer, Speed 2, Speed 3 and Speed 4 are not active, it will set the speed requests, except for the case in which the power steer trigger input (pin 6 of 35-wy connector) is active. When the power steer trigger input is active, the current speed demand will be the higher between Speed 5 and Speed 6. The pump motor will accelerate or decelerate to the new speed demand using the programmed Acceleration and Deceleration rates.

### M1-10P Speed 6 demand (power steer) "Pspeed6"
This sets the pump speed when the switch wired to pin 6 of 35-way Connector is active.
When both the power steer trigger input and another speed input are active, the resultant speed demand will be the higher between the two. The pump motor will accelerate or decelerate to the speed demand from input 6 using the rates defined by parameter "M1-12P Acceleration delay for speed 6 demand (pwrStr) "Paccel6"".

### M1-11P Minimum motor speed in cutback conditions "MinSpeed"
If some performance limitation is active (Low voltage, I2T, Performance Table, Motor Overtemperature, Controller Overtemperature, Undervoltage) and it is limiting the speed below this value, the motor is stopped and a failure is signaled (F26). This is necessary to protect pump from spinning too slow.

### M1-12P Acceleration delay for speed 6 demand (pwrStr) "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 "M1-1P Acceleration delay "Accel"" and "M1-2P Deceleration delay "Decel"".

### M1-13P Power steer delay "PStrDly"
This sets the period that the Power Steer speed 6 will remain active after the trigger source input, pin 6 on 35-Way Connector, has been deactivated.

### M1-14P Accelerator pot minimum "AccMin"
This sets the voltage on the Potentiometer input that will correspond to zero speed.

### M1-15P Accelerator pot maximum "AccMax"
This sets the voltage on the Potentiometer input that will correspond to maximum speed.
This setting is used in conjunction with parameter "M1-5P Maximum pot speed 1 "Potmax1"".

### M1-16P Speed threshold to enter in end of braking mode "SpdThEbM"
See setting "M1-15T Speed threshold to enter end of braking mode "SpdThEbM"" for traction control.

### M1-17P Ramp time from SpdThSpC to zero "SpdRmpTm"
See setting "M1-16T Speed threshold Ramp time to zero speed "SpdRmpTm"" for traction control.

### M1-18P Zero Speed threshold to end braking "ZSpdTh"
See setting "M1-18T Zero Speed Threshold to enter hill hold or neutral brake end "ZSpdTh"" for traction control.

 ©2019 DMC GmbH Herten Germany

# 4 Menu 2 "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 | Fxx | ◁ | Show fault time | ▷ | Sub code |
| 3 | Battery Discharge Indicator | BDI | 1 % | ◁ | Raw BDI value incl. state (WO & CO) | ▷ | BDI states (see "M2-3 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 "M2-6 Drive and brake status table" | | | |
| 7 | Speed Limit | SpeedLim | -- | See "M2-7 Speed limits table" | | | |
| 8 | Torque Limit | TrqLimit | -- | See "M2-8 Torque limits table" | | | |
| 9 | Motor Limit | MotorLim | -- | See "M2-9 Motor limits table" | | | |
| 10 | Battery Voltage | BatVolts | 0.1 V | | | ▷ | Max. Voltage |
| 11 | Capacitor Voltage | CapVolts | 0.1 V | | | ▷ | Max. Voltage |
| 12 | Battery current | I_batter | 0.1 A | | | | |
| 13 | Motor current | I_Motor | 0.1 Arms | ◁ | Id Current | ▷ | Iq Current |
| 14 | Motor voltage | V_Motor | 0.1 Vrms | ◁ | Reactive Power | ▷ | Motor Power |
| | | | | ◁ | Reached maximum output voltage (VL) | | |
| 15 | Stator speed | StatorSpd | 0.1 Hz | | | | |
| 16 | Rotor speed | RotorSpd | 0.1 Hz | | | ▷ | RPM speed |
| 17 | Accelerator demand | Accel | 0.1 % | ◁ | Steer pot demand | ▷ | Foot brake demand |
| 18 | Target demand | DemTrgt | 0.1 % | + | CW | – | CCW |
| 19 | Ramped demand | DemRampd | 0.1 % | + | CW | – | CCW |
| 20 | Speed limit % | | | | | | |
| 21 | Drive torque limit | DrvTrqL | 0.1 % | | | ▷ | Torque limit CW |
| 22 | Brake torque limit | BrkTrqL | 0.1 % | | | ▷ | Torque limit CCW |
| 23 | Actual torque | TrqAct | 0.1 % | ◁ | Actual torque in Nm | ▷ | Maximum torque in Nm |
| | | | | + | CW | – | CCW |
| 24 | Actual speed | SpeedAct | 0.1 % | + | CW | – | CCW |
| 25 | Actual Flux | FluxDem | 0.1 % | | | ▷ | Actual Flux |
| 26 | Filtered capacitor voltage | | | | | | |
| 27 | Vehicle Speed | Vehicle | 1 Kph | | | | |

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

 ©2019 DMC GmbH Herten Germany

## 4.1 Status tables

### M2-3 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) |

### M2-6 Drive and brake status table

| Status | Description |
|---|---|
| NC | No Configuration |
| N | Neutral, not pulsing |
| FD | Forward drive |
| RD | Reverse drive |
| DB | Direction braking |
| NB | Neutral braking |
| FB | Foot braking |
| FB | Hill hold |
| HF | Forward restraint hill hold |
| HR | 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 pulsing |
| KF | Key fault is found |
| NK | Not known |

### M2-7 Speed limits table

| Limit | Description |
|---|---|
| MS | Motor speed |
| SM | Speed limit forward or reverse |
| S1 | Speed 1 limit |
| S2 | Speed 2 limit |
| S3 | Speed 3 limit |
| S4 | Speed 4 limit |
| S5 | Speed 5 limit |
| S6 | Speed 6 limit |
| SI | Inching |
| SB | BDI speed limit |
| SH | Hand brake speed limit |
| SV | Control Via CAN HMI limit |
| CS | Controller over temperature limit |
| SS | Steering Pot Speed Limit |

### M2-8 Torque limits table

| Limit | Description |
|---|---|
| CT | Controller temperature |
| MT | Motor temperature |
| PT | Performance table current limit |
| TC | Timed Current Limit |
| T1 | $I^2t$ current limit step 1 |
| T2 | $I^2t$ current limit step 2 |
| T3 | $I^2t$ current limit step 3 |
| HV | High Voltage limit |
| LV | Low Voltage limit |
| HB | Hand brake limit |
| S1 | Advanced mode speed 1 active |
| S2 | Advanced mode speed 2 active |
| BM | Battery current limit maximum |
| BR | Battery current limit regen |

### M2-9 Motor limits table

| Limit | Description |
|---|---|
| TL | Torque Limit |
| SL | Speed Limit |
| TH | Not able to hold torque |
| SH | Not able to hold speed |
| FH | Not able to hold flux |
| IH | Not able to hold flux current |
| CH | Not able to hold circle limitation |
| HL | Not able to hold hexagon limit |
| OL | Circle limitation |

 ©2019 DMC GmbH Herten Germany

# 5 Menu 3 "Controller Setup"

## 5.1 Menu 3 "Controller Setup for Traction"

| Cal. Ref. | Parameter | Calibrator text | Options (defaults are in bold) | Range |
|---|---|---|---|---|
| 1 | Accel. Characteristic | Lin/Curv | **0 = Accelerator linear**<br>1 = Accelerator curved | 0 – 1 |
| 2* | Control mode | Spd/Torq | 0 = Speed mode<br>**1 = Torque mode**<br>2 = Torque mode & end of braking in speed mode<br>3 = Torque mode & end of braking and footbrake operation in speed mode | 0 – 3 |
| 3 | Proportional direction brake | Off /Bpro | 0 = Fixed, **1 = Proportional** | 0 – 1 |
| 4 | Hill hold | Off/HH/S | **0 = Coast**<br>1 = Hill hold<br>2 = Hill Hold with stop pulsing on flat ground | 0 – 2 |
| 5* | I/O Pin 5 and 6 | Sp/In/Ad | **0 = Speed** 1+2<br>1 = Inching Fwd/Rev<br>2= Advanced Mode<br>3= Speed Limit and Foot Brake Switch | 0 – 3 |
| 6 | I/O Pin 7 | Spd3/Hbk | 0 = Speed3<br>**1 = Handbrake**<br>(If handbrake selected, set the required max. speed when handbrake applied at Speed 3 | 0 – 1 |
| 7 | Power steer trigger | PsF/FR/S | **0 = FS1**<br>1 = Fwd/Rev<br>2 = Seat switch<br>3 = FS1 and rotor speed<br>4 = FS1, Fwd/Rev, FootBrake in (AN or DIG) | 0 – 4 |
| 8* | Vehicle type select | Ride/Wlk | **0 = Ride-on**<br>1 = Walkie<br>2 = Walkie (allows to drive slowly @ speed 3 speed with tiller switch open and only when speed 3 is active) | 0 – 2 |
| 9* | Tiller Function | TillFunc | **0 = Normal response**<br>1 = fast response<br>2 = immediate response | 0 – 2 |
| 10* | Belly switch disabled at zero speed | BellFunc | **0 = Enabled**<br>1 = Disabled | 0-1 |
| 11 | Display Status field | Of/D/V/K | 0 = None<br>1 = Accelerator [%]<br>2 = Motor Velocity [RPM]<br>**3 = Speed in Kph**<br>4 = Steering position [%]<br>5 = Motor current [A]<br>6 = Battery current [A] | 0 – 6 |
| 12* | Accelerator type | AccelTyp | **0 = Normal accelerator**, 1 = Wig-wag | 0 – 1 |
| 13 | Accelerator Damping Factor | AccelDamp | **1 = No damping**<br>2 to 120 multiplies the acceleration and deceleration delay, linear reduced to 1 at 75% demand. | 1 - 120 |
| 14* | Single or Dual Motor | Si/DL/DR | **0 = Single**<br>1 = Dual Left<br>2 = Dual Right<br>3 = Single with Steer Pot limit | 0 – 3 |
| 15* | Digital O/P 4 config | DO4Typ | **0 = Remote LED**, 1= Drive OK 2 = Brake light | 0 – 2 |
| 16* | Active low or high digital inputs | Actv L/H | **0 = Active low digital inputs**<br>1 = Active high digital inputs | 0 – 1 |

 ©2019 DMC GmbH Herten Germany

| Cal. Ref. | Parameter | Calibrator text | Options (defaults are in bold) | Range |
|---|---|---|---|---|
| 17* | Accelerator supply wire off detection | SplyWrOf | **0 = No supply wire off detection**<br>1 = 0V wire off detection enabled<br>2 = 5V wire off detection enabled<br>3 = Both 0V and 5V wire off detection | 0 – 3 |
| 18 | Standby timer | StdByDly | Adjustable from 0 to 10 Minutes.<br>**Default is 0** (0=Off) | 0 - 10 |
| 19 | Drive output 2 Configuration | Drv2Cfg | **0 = EM brake function**<br>1 = motor temperature cooling enabled<br>2 = controller temperature cooling enabled<br>3 = both motor and controller temperature cooling enabled | 0 – 3 |
| 20 | Drive output 3 Configuration | Drv3Cfg | **0 = Power Steer function**<br>1 = motor temperature cooling enabled<br>2 = controller temperature cooling enabled<br>3 = both motor and controller temperature cooling enabled | 0 – 3 |
| 21 | Drive Output Motor Temp TH | MotTmpTh | Adjustable from 10 to 127 °C. **Default is 70 °C** | 10 – 127 °C |
| 22 | Drive Output Controller Temp TH | CtrTmpTh | Adjustable from 10 to 100 °C. **Default is 45 °C** | 10 – 100 °C |
| 23 | Line Contactor pull-in level | LCPlInLv | Adjustable from 50% to 100% Ubatt.to limit inrush current. **Default is 90%** | 50-100% |
| 24 | Line Contactor pull-in time out | LCPlInTO | Line Contactor pull in time out. **Default is 10sec**. | 0-12 sec |
| 25 | Drive torque during braking | DTrq@Brk | **0 = no drive torque allowed during brake**<br>1 = drive torque is allowed during brake | 0 - 1 |
| 26 | Line Contactor Coil pull-in Voltage | LCPlInVl | Adjustable from7% to 100% Ubatt **Default is 100%** | 7-100% |
| 27 | Line Contactor Coil Holding voltage | LCHoldVl | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 28 | Digital output 2 pull-in voltage | DO2PlInV | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 29 | Digital output 2 hold voltage | DO2HoldV | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 30 | Digital output 3 pull-in voltage | DO3PlInV | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 31 | Digital output 3 hold voltage | DO3HoldV | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 32 | n/a | n/a | | |
| 33 | Calibration Data Options | CalValue | Not active | --- |
| 34* | Loading Default | LoadDefs | **0 = Don't load defaults**<br>1 = Load defaults | 0 – 1 |

**(*) Recycle the key switch to make changes active. (Also indicated on calibrator 'key')**

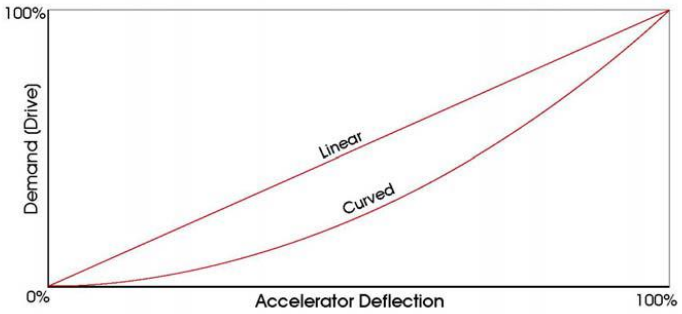
 ©2019 DMC GmbH Herten Germany

### M3-1T Accel. 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%.




### M3-2T Control Mode "Spd/Torq"

This sets whether the controller has to provide speed type control or torque type control:

- If set to **0**, the controller will apply speed control.
- If set to **1**, the controller will apply torque control.
- If set to **2**, the controller will apply torque control with speed control at end of braking.
- If set to **3**, the controller will apply torque control with speed control at end of braking and the end of footbrake operation

The definition of each type is detailed below:

**Speed control** means that the Accelerator input is used as a speed demand between zero and the programmed maximum speed for the direction of drive. Speed control results in a constant drive speed for a given demand (Accelerator deflection), regardless of load.
**Torque control** means that the Accelerator input is used to set a torque demand between zero and the programmed maximum torque. Torque control has the feel of a car: as the load increases, the vehicle will slow and more demand (Accelerator deflection) must be applied to keep speed constant.
The programmable options are 0 and 3:

Please refer to parameters from "M1-15TM1-26T Speed threshold to enter end of braking mode "SpdThEbM"" to "M1-21T Restraint hill hold torque threshold "HHTrqTH"" and End Of Breaking function description in Adjustment menu for detailed description about setting 2 and 3.

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

| | |
|---|---|
| | **VERY IMPORTANT:**<br>• **If a torque mode (1 or 2) is selected the vehicle must have mechanical brake!**<br>• **If speed mode (0) is selected vehicle must have at least electromagnet brake!**<br>• **If a torque mode (3) is selected the vehicle must have at least electromagnet brake!** |

 ©2019 DMC GmbH Herten Germany

### M3-3T Proportional direction brake "Off /Bpro"

This sets how the strength of the direction regenerative braking is controlled.
The behavior in direction braking also depends on the parameter "M3-2T Control Mode "Spd/Torq"":

**Torque Control**

- If set to **0 (Fixed)**, the braking strength is as set by the parameter "M1-10T Direction Brake torque "DBrake"", regardless of Accelerator potentiometer position.
- If set to **1 (Proportional)**, the braking strength depends on the Accelerator potentiometer position. At the minimum Accelerator potentiometer position, the braking strength will be as set by the parameter "M1-7T Neutral Brake torque "NBrake"", while at the maximum Accelerator potentiometer position the braking strength will be as set by the parameter "M1-10T Direction Brake torque "DBrake"". Between minimum and maximum, the braking strength is a value between the neutral and direction braking settings, proportional to the Accelerator potentiometer position.

**Speed Control**

- If set to **0 (Fixed)**, the direction braking ramp time (i.e. deceleration rate in direction braking) is as set by the parameter "M1-11T Direction brake ramp time "DBrkRamp"", regardless of Accelerator potentiometer position.
- If set to **1 (Proportional)**, the direction braking ramp time depends on the Accelerator potentiometer position. At the minimum Accelerator potentiometer position, the direction braking ramp time will be as set by the parameter "M1-8T Neutral brake ramp time "NBrkRamp"", while at the maximum Accelerator potentiometer position the braking ramp will be as set by the parameter, "M1-11T Direction brake ramp time "DBrkRamp"". Between minimum and maximum, the braking strength is a value between the neutral and direction braking settings, proportional to the Accelerator potentiometer position.
  Be Aware: If Direction brake ramp time is set larger than Neutral brake ramp time the Neutral brake ramp time will de adopted during direction braking and the Accelerator position won't have effect on the direction brake ramping time.

### M3-4T Hill hold "Off/HH/S"

This sets whether there is a hill-hold function when the vehicle is at rest. Hill hold can be activated if "M3-2T Control Mode "Spd/Torq"" is set to 0 (Speed Mode) or 2 (Torque mode with speed mode for the end of braking).

- If set to **0 (Coast),** then there is no restraint function and the vehicle is free to coast when zero speed is reached and "M1-9T Neutral brake-End delay "NBrkEnd"" time is elapsed.
- If set to **1 (Hill Hold & Restraint),** the controller at the end of braking will manage the vehicle with hill hold function. Following neutral braking (by opening Foot switch in Ride On vehicle or selecting Neutral in Walkie vehicle type, refer to "M3-8T Vehicle type select "Ride/Wlk"" for more information about this) the vehicle will enter and remain in Hill Hold mode for a period set by the parameter "M1-19T Hill hold time "HHTime"". During this period, the vehicle will remain stationary. After this time has elapsed, the vehicle will enter in "Restraint Hill Hold mode" and move at speed set by the parameter "M1-20T Restraint hill hold speed "HHspeed"".
  On Ride On vehicle ("M3-8T Vehicle type select "Ride/Wlk""=0), if neutral braking is operated by means of selecting neutral with direction switch but the accelerator pedal is still pressed (Foot Switch still active), the Hill Hold mode is skipped and the Restraint hill hold is applied directly.
  If the vehicle reaches level ground and the vehicle is no longer moving the controller will reduce current applied to the motor to save battery power.
  Level ground is detected when torque necessary to hold vehicle in restraint Hill hold is lower than "M1-21T Restraint hill hold torque threshold "HHTrqTH""
  If the motor begins to move again, without Accelerator demand being applied, then the controller will re-enter in Restraint Hill Hold mode until the handbrake is applied.
  When the Handbrake is applied the controller stops pulsing to save battery power.
  If hand brake is released again the vehicle will coast unless accelerator is pressed and one direction input is active.
  In case Hand brake function is not active ("M3-6T I/O Pin 7 "Spd3/Hbk"" set to 0), the controller will keep pulsing and will exit from Hill Hold mode only if accelerator is pressed and one direction input is active.
- If Set to **2 (Hill Hold & Stop Pulsing on level ground)**, it has the same features when set 1 (Hill Hold & Restraint) except the following:
  - **i.** If the vehicle reaches level ground and the vehicle is no longer moving, the controller stop pulsing and reduce current applied to the motor to zero.
  - ii. If the motor begins to move again, without Accelerator demand being applied, then the controller let the motor coast until accelerator is applied again.

 ©2019 DMC GmbH Herten Germany

### M3-5T I/O Pin 5 and 6 "Sp/In/Ad"

This sets the function of the input pins 5 and 6 on 35-way Connector.

- If set to **0 (Speed Limit)**, then the inputs 5 and 6 can be used to limit the speed of the vehicle via the parameters "M1-22T Cutback speed 1 (I/O 5-6 set to Speed) "Speed1"" and "M1-33T Cutback speed 2 (I/O 5-6 set to Speed) "Speed2"". The input pins are normally closed, so speed limit will be activated if input switches are opened.
- If set to **1 (Inching)**, then the inputs 5 and 6 can be used to "inch" the vehicle. Thus if the input 5 is activated (input switch closed) the vehicle will move forward at speed "M1-23T Inching speed (I/O 5-6 set to Inching) "InchSpd"" for a time defined by "M1-34T Inching time (I/O 5-6 set to Inching) "InchTime"". If the input 6 is activated (input switch closed) the vehicle will move reverse at speed "M1-23T Inching speed (I/O 5-6 set to Inching) "InchSpd"" for a time defined by "M1-34T Inching time (I/O 5-6 set to Inching) "InchTime"".
  After moving forward or reverse the vehicle stops.
  Input 5 and 6 will operate for inching function as normally open switches.

| | |
|---|---|
| | **! IMPORTANT**<br>**For ease of adjustment, reduce the value of "M1-23T Inching speed (I/O 5-6 set to Inching) "InchSpd"" before programming this parameter.** |

- If set to **2 (Advanced mode)**, then the inputs 5 and 6 will be used to select three different drive styles: Normal Drive Styles, Drive Style 1 and Drive Style 2. For each drive style it is possible to set up different ramp times for torque and speed and different driving and braking torque level.
  Inputs 5 and 6 will operate as normally closed switches input.
  For the three different drive styles the following set of parameters are adopted:

  i. **Normal Drive Style** (input 5 closed & input 6 closed)**:**

  M1-1T Acceleration delay "Accel"
  M1-2T Deceleration delay "Decel"
  M1-7T Neutral Brake torque "NBrake"
  M1-8T Neutral brake ramp time "NBrkRamp"
  M1-9T Neutral brake-End delay "NBrkEnd"
  M1-10T Direction Brake torque "DBrake"
  M1-11T Direction brake ramp time "DBrkRamp"
  M1-13T Foot brake torque "FBrake"
  M1-14T Foot brake ramp time "FbrkRamp"

  The maximum drive torque in Normal drive style is set to 100%.

  ii. **Drive Style 1** (input 5 open & input 6 closed OR input 5 open & input 6 open)**:**

  M1-24T Acceleration delay 1 "Accel1"
  M1-25T Deceleration delay 1 "Decel1"
  M1-26T Maximum Drive Torque 1 (Torque Mode Only) "MxDrTrq1"
  M1-27T Neutral Brake Torque 1 (Torque Mode Only) "NBrkTrq1"
  M1-28T Neutral brake ramp time 1 "NBrkRmp1"
  M1-29T Direction Brake torque 1 (Torque Mode Only) "DBrkTrq1"
  M1-30T Direction brake ramp time 1 "DBrkRmp1"
  M1-31T Foot Brake Torque 1 (Torque Mode Only) "FBrkTrq1"
  M1-32T Foot brake ramp time 1 "FBrkRmp1"

  The maximum drive torque is adjustable by "M1-26T Maximum Drive Torque 1 (Torque Mode Only) "MxDrTrq1"".

  iii. **Drive Style 2** (input 5 closed & input 6 open):

  M1-35T Acceleration delay 2 "Accel2"
  M1-36T Deceleration delay 2 "Decel2"
  M1-37T Maximum Drive Torque 2 (Torque Mode Only) "MxDrTrq2"
  M1-38T Neutral Brake Torque 2 (Torque Mode Only) "NBrkTrq2"
  M1-39T Neutral brake ramp time 2 "NBrkRmp2"
  M1-40T Direction Brake torque 2 (Torque Mode Only) "DBrkTrq2"

 ©2019 DMC GmbH Herten Germany

M1-41T Direction brake ramp time 2 “DBrkRmp2”
M1-42T Foot Brake Torque 2 (Torque Mode Only) “FBrkTrq2”
M1-43T Foot brake ramp time 2 “FBrkRmp2”

The maximum drive torque is adjustable by “M1-26T Maximum Drive Torque 1 (Torque Mode Only) “MxDrTrq1””.

- If set to **3 (Speed Limit and Foot Brake Switch)**, then the input 5 can be used to limit the speed of the vehicle via the parameter “M1-22T Cutback speed 1 (I/O 5-6 set to Speed) “Speed1””, while input 6 can be used as Foot Brake Swtich.
  The input pin 5 is normally closed, so speed limit will be activated if input switch is open.
  The input pin 6 is normally open, so footbrake operation will be activated if input switch is closed. See “M1-13T Foot brake torque “FBrake”” and 1.14 Foot brake ramp time “FbrkRamp” for setting up the footbrake behavior.

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

### M3-6T I/O Pin 7 ”Spd3/Hbk”

This sets the function of input pin 7 on 35-Way Connector.

- If set to **0 (Speed Limit 3)**, then the input can be used to limit the speed of the vehicle to a level set by the parameter “M1-44T Cutback speed 3 (I/O 7 set to speed3) “Speed3””. The limit will be applied when the switch connected to pin 7 of 35-Way Connector is open.
- If set to **1 (Handbrake)**, then the input can be used to limit the speed and drive torque of the vehicle to a level set by the parameters “M1-45T Handbrake On maximum Speed (I/O 7 set to Handbrake) “HandBrk”” and “M1-46T Maximum Drive Torque speed 3 (I/O 7 set to Handbrake) “MxDrTrq3””, respectively. The limits will be applied when the switch connected to pin 7 of 35-Way Connector is closed.
  When the switch is closed, the Sigmagauge and DMC Display will show a ‘parked’ icon.
  Handbrake input is used in conjunction with Hill Hold function (refer to parameter “M3-4T Hill hold ”Off/HH/S””).

### M3-7T Power steer trigger ”PsF/FR/S”

This sets the trigger source for the power steer contactor. When the vehicle has stopped driving, a timer sets a delay for the power steering to remain active. The length of the delay is set by the parameter “M1-50T Power steer delay “PStrDly””.

- If set to **0 (Footswitch)**, then the power steer contactor is driven at the instant the Footswitch (pin 3 of 35-Way Connector) is closed.
- If set to **1 (Forward/Reverse)**, then the power steer contactor is driven at the instant either the Forward Switch (pin 1 of 35-Way Connector) or the Reverse Switch (pin 2 of 35-Way Connector) is closed.
- If set to **2 (Seat)**, then the power steer contactor is driven at the instant the Seat Switch (pin 4 of 35-Way Connector) is closed.
- If set to **3 (Footswitch & Motor Speed)**, then the power steer contactor is driven either by the Footswitch as described above or when the motor speed is greater than zero. So if vehicle is moving power steer trigger output is active.
- If set to **4 (FS1, Fwd/Rev, Footbrake)**, then the power steer contactor is driven either by the Footswitch or forward and reverse input or Foot Brake operation.

### M3-8T Vehicle type select ”Ride/Wlk”

This sets the function of the input pins 3 and 4 on 35-Way Connector.

- If set to **0 (Ride-on)**, then pin 3 will be a Footswitch input and pin 4 will be a Seat Switch input.
- If set to **1 (Walkie)**, then pin 3 will be a Belly Button input and pin 4 will be a Tiller Switch input. With this configuration the vehicle can be moved only when the tiller switch is closed. Please refer to parameters “M1-72T Belly switch speed “BellySpd”” and “M1-73T Belly switch time “BellyTim”” to tune the Belly Button functionality.
- If set to **2 (Walkie – allow drive with open tiller switch**), the pin configuration is the same as described for option ‘1’. However, an additional functionality allows the driver to operate the vehicle with the tiller switch open if input pin 7 on 35 Way Connector is open and setting “M3-6T I/O Pin 7 ”Spd3/Hbk”” is set to 0. This allows to drive and the speed is limited to “M1-44T Cutback speed 3 (I/O 7 set to speed3) “Speed3””; this function can assist drivers to maneuver in smaller areas, such as truck platforms.
  Please refer to parameters “M1-72T Belly switch speed “BellySpd”” and “M1-73T Belly switch time “BellyTim”” to tune the Belly Button functionality.

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

 ©2019 DMC GmbH Herten Germany

### M3-9T Tiller Function "TillFunc"

This sets the function of the tiller switch when "M3-8T Vehicle type select "Ride/Wlk"" is set to 1 or 2 (Walkie).

- If set to **0**, the controller will apply neutral braking when the tiller switch is open. Once zero speed has been reached electro-mechanical brake will be applied when the "M1-51T Electric brake delay "EBrkDly"" is elapsed; the vehicle will be held still for "M1-9T Neutral brake-End delay "NBrkEnd"".
- If set to **1**, the controller will apply neutral braking when the tiller switch is opened. This will be performed with a fixed 0.5s Neutral Braking Ramp time. As soon as the controller has reached zero speed, the electro-mechanical brake will be applied without any delay. The controller will stop pulsing after "M1-9T Neutral brake-End delay "NBrkEnd"".
- If set to **2** the electro-mechanical brake will be applied as soon as the tiller switch is opened. The controller will neutral brake with a fixed 0.5 s Neutral Braking Ramp time and will stop pulsing after the "M1-9T Neutral brake-End delay "NBrkEnd"".
  Mind that the electro-mechanical brake will not be applied when 35-Way Connector pin 7 is open (Speed 3 active).

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

### M3-10T Belly switch disabled at zero speed and in neutral "BellFunc"

This sets the function of the belly switch when "M3-8T Vehicle type select "Ride/Wlk"" is set to 1 or 2 (Walkie).

- If set to **0**, the belly switch will provoke an Emergency Drive Forward at any time, also when the vehicle is in neutral and/or at zero speed.
- If set to **1**, the belly switch will provoke an Emergency Drive Forward only when the vehicle is moving, thus the Emergency Drive Forward will not be performed with vehicle in neutral and/or at zero speed.

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

### M3-11T Display Status field "Of/D/V/K"

This sets the type of information that will appear in the General Indication Field of the Sigmagauge or the DMC Display.

- 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 "M4-13 Maximum Motor Frequency".
- If set to **3 (Vehicle Speed)**, then the vehicle speed in units of KPH or MPH (depending on the choice set in the DMC Color Display setting menu, see [3]DMC Display - NEW Display V1.1 for details) will be displayed, from 0 to the value set in "M1-69T Vehicle max. Speed "VmaxSpd"".
  Mind that is MPH is chosen in the DMC Color Display menu, one must take care of including in the calculation of the parameter "M1-68T Speed ratio (display Kph) "SpdRatio"" the scaling from KPH to MPH.
- If set to **4 (Steering)**, then the vehicle's steering angle will be displayed using crosshairs.
- 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.

### M3-12T Accelerator type "AccelTyp"

This set the acceleration type.

- If set to **0 (normal)**, a normal accelerator that can operate with direction switches is selected.
- If set to **1 (wig-wag)**, a Wig Wag accelerator is selected and no direction switches are required. The voltage admitted range is from 0.2V to 4.5V. For a proper operation wig-wag potentiometer connected to "Pin 9 Analogue AD1 i/p Accelerator -- *Potentiometer*" has to operate within this range. Also parameter "M1-52T Accelerator pot minimum "AccMin"" has to be higher than 0.2V and parameter "M1-53T Accelerator pot maximum "AccMax"" has to be lower than 4.5V. Both have to correspond to the actual wig wag potentiometer accelerator range.

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

 ©2019 DMC GmbH Herten Germany

### M3-13T Accelerator Damping Factor "AccelDam"

- If set to **1 (no damping)**, means no effect on accelerator.
- If set **greater than 1 (damped)**, the accelerator is "damped" in the range between 0% and 75% according to the number. This can help to avoid aggressive and vibrating response at low pedal demand with light vehicles and high torque motors.
  If it is necessary to use it, for torque mode the suggested values are between 2 and 4, while for speed mode it is suggested to use values from 4 to 7.

### M3-14T Single or Dual Motor "Si/DL/DR"

This sets if controller is used as single traction motor or if it is the left or right hand unit in a dual motor system.

- If set to **0 (Single Motor)**, the dual motor parameters (from "M1-61T Dual motor cut out "DMcut"" to "M1-67T Dual motor speed 3 "DMspd3"") and the steering potentiometer input won't be used (35-Way connector "Pin 12 Analogue AD3 -- Steer pot").
- If set to **1 (Dual Motor Left)**, then the speed and torque demand will be managed according to the vehicle's Steering potentiometer, which will feed back the angle of the steered wheels. The controller will be assigned as the left hand unit.
- If set to **2 (Dual Motor Right)**, then the speed and torque demand will be managed according to the vehicle's Steering potentiometer, which will feed back the angle of the steered wheels. The controller will be assigned as the right hand unit.
- If set to **3 (Single Motor with steer pot. Speed limit Right)**, the dual motor parameters (from "M1-61T Dual motor cut out "DMcut"" to "M1-67T Dual motor speed 3 "DMspd3"") won't be used, but the speed limit depends upon the steering potentiometer input value. The settings "M1-64T Dual motor angle 3 "DMang3"", "M1-67T Dual motor speed 3 "DMspd3"" and "M1-61T Dual motor cut out "DMcut"" are therefore active and used to set up the speed limit as a function of steering potentiometer.

When a Dual Motor selection is made, the speed and torque when steering, will change as described by the parameters from "M1-61T Dual motor cut out "DMcut"" to "M1-67T Dual motor speed 3 "DMspd3"".

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

| | |
|---|---|
| | **! IMPORTANT Dual motor selection is only available in Torque Mode.** |

### M3-15T Digital O/P 4 config "DO4Typ"

This sets the function of the output associated with "Pin 18 Digital o/p -- Remote LED or Brake lights" on 35-Way Connector and whether the output is used as an external fault indicator or as a brake light.

- If set to **0 (Remote LED)**, then the output may be used to drive an external fault indicator.
- If set to **1 (DRIVE OK)**, then DO4 is configured as an enabling output. When no failure code the DO4 is inactive, else the D04 is acting pulling down to ground the "Pin 18 Digital o/p -- Remote LED or Brake lights".
- If set to **2 (Brake Light)**, then the output may be used to drive a brake light. The brake light will only be active during Foot braking.

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

### M3-16T Active low or high digital inputs "ActvL/H"

This sets whether the digital inputs are active low or active high.

- If set to **0 (Digital inputs Active low)**, the digital inputs will be considered active when the input is tied to battery ground and inactive when not connected. An internal pull up resistor will be enabled.
- If set to **1 (Digital inputs Active high)**, the digital inputs will be considered active when the input is tied to battery plus and inactive when not connected. An internal down resistor will be enabled.

For the Digital Inputs connection and wiring details refer to section "2.2 Selecting active Low or High digital inputs".
The change of this parameters is actuated after a key power off-on cycle.
This parameter requires a key cycle off-on to be effective.

 ©2019 DMC GmbH Herten Germany

### M3-17T Accelerator supply wire off detection "SplyWrOf"

This sets how the wire off detection for accelerator is detected.

- If set to **0**, no wire off detection on accelerator potentiometer supply lines is active.
- If set to **1**, 0V wire off detection is enabled ("Pin 10 Analogue supply 0V" of 35-Way connector).
- If set to **2**, 5V wire off detection is enabled ( "Pin 8 Analogue supply 5V" of 35-Way connector).
- If set to **3**, both 0V and 5V wire off detection are enabled.

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

### M3-18T Standby timer "StdByDly"

This sets a period of time after which the Line Contactor will be de-energized if there is no drive activity and the seat or tiller switch is open.
When the seat or tiller switch is closed, the controller powers up, performs all necessary hardware and software checks and closes the line contactor.

- If set to **0**, then the feature is deactivated and no timer is used.
- If set from **0.5** to **10** [minutes] the stand-by timer is considered and active.

### M3-19T Driver output 2 configuration "Drv2Cfg"

This sets the configuration for Driver Output 2.

- If set to **0**, standard electro-magnetic brake function is assigned to digital output driver 2 ("Pin 16 Contactor 2 o/p (Magnet Brake - Fan control)") in 35 way connector)
- If set to **1**, digital output 2 is activated if motor temperature is higher than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"" and deactivated when motor temperature gets lower than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh""- 8 °C of hysteresis.
- If set to **2**, digital output 2 is activated if controller temperature is higher than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"", and deactivated when controller temperature gets lower than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh""- 8 °C of hysteresis .
- If set to **3**, digital output 2 is activated if motor temperature is higher than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"" OR if controller temperature is higher than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"", while it is deactivated when motor temperature gets lower than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh""- 8 °C of hysteresis AND controller temperature gets lower than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh""- 8 °C of hysteresis.

### M3-20T Driver output 3 configuration "Drv3Cfg"

This sets the configuration for Driver Output 3.

- If set to **0**, standard Power Steer function is assigned to digital output driver 3 ("Pin 17Contactor 3 o/p (Powersteer - Fan control) in 35 way connector)
- If set to **1**, digital output 3 is activated if motor temperature is higher than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"" and deactivated when motor temperature gets lower than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh""- 8 °C of hysteresis.
- If set to **2**, digital output 3 is activated if controller temperature is higher than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"", and deactivated when controller temperature gets lower than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh""- 8 °C of hysteresis .
- If set to **3**, digital output 3 is activated if motor temperature is higher than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"" OR if controller temperature is higher than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"", while it is deactivated when motor temperature gets lower than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh""- 8 °C of hysteresis AND controller temperature gets lower than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh""- 8 °C of hysteresis.

### M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"
### M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"

These two settings represent the temperature thresholds to drive output 2 and/or 3 according to setting "M3-19T Driver output 2 configuration "Drv2Cfg"" and "M3-20T Driver output 3 configuration "Drv3Cfg"".

 ©2019 DMC GmbH Herten Germany

### M3-23T Line Contactor pull-in level "LCPlInLv"
This set the voltage pull-in level 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 pull-in voltage.

### M3-24T Line Contactor pull-in time out "LCPlInTO"
This parameter sets the time out for closing line contactor. If capacitor voltage does not reach the voltage pull-in level within the time out a failure is signaled.

### M3-25T Drive torque during braking "DTrq@Brk"
This set is active only in speed mode.

- If set to **0 (no drive torque allowed during braking)**, the controller won't apply drive torque during deceleration speed ramp. In vehicles equipped with mechanical brake, set this to zero to avoid speed control to fight against mechanical brake during braking.
- If set to **1 (drive torque allowed during braking)**, the controller can apply drive torque if necessary to follow the deceleration speed ramps (neutral, inversion and foot brake). This option is suggested for vehicle without mechanical brakes and with electromagnetic brake.

### M3-26T Line Contactor Coil pull-in voltage "LCPlInVl"
It sets the line contactor coil pull in voltage applied for 1s for closing line contactor. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.

Example:
"M8-2 Nominal battery voltage "NomBatV"" is set to 48V and the desired line contactor coil pull in voltage is 36V for 1s.
The percentage to be set in "M3-26T Line Contactor Coil pull-in voltage "LCPlInVl"" has to be: 100%*36V / 48V =75%.
If it set to 100% the full battery voltage will be applied for 1 s.

### M3-27T Line Contactor Coil holding voltage "LCHoldVl"
It sets the line contactor coil holding voltage applied when the line contactor is closed and 1 s of time is elapsed. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.

Example:
"M8-2 Nominal battery voltage "NomBatV"" is set to 48V and the desired line contactor coil holding voltage is 24V.
The percentage to set in the "M3-27T Line Contactor Coil holding voltage "LCHoldVl"" has to be 100%*24V / 48V = 50%.
If it set to 100% the full battery voltage will be applied.

### M3-28T Digital Output 2 pull-in voltage "Do2PlInV"
It sets the Digital Output 2 pull in voltage applied for 1s. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.
If it set to 100% the full battery voltage will be applied.

### M3-29T Digital Output 2 hold voltage "Do2HoldV"
It sets the Digital Output 2 holding voltage applied when the line contactor is closed and 1 s of time is elapsed. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.
If it set to 100% the full battery voltage will be applied.

### M3-30T Digital Output 3 pull-in voltage "Do3PlInV"
It sets the Digital Output 3 pull in voltage applied for 1s. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.
If it set to 100% the full battery voltage will be applied.

### M3-31T Digital Output 3 hold voltage "Do3HoldV"
It sets the Digital Output 3 holding voltage applied when the line contactor is closed and 1 s of time is elapsed. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.
If it set to 100% the full battery voltage will be applied.

### M3-32T n/a
This settings is not used with PMS motor technology

 ©2019 DMC GmbH Herten Germany

### M3-33T Calibration Data option "CalValue"

Not used yet. For future development

### M3-34T Loading Default "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.

 ©2019 DMC GmbH Herten Germany

## 5.2 Menu 3 "Controller Setup for Pump"

A pump controller is always in speed control mode. Other changes to the Controller Setup compared to the traction controller setup are:

| Cal. Ref. | Parameter | Calibrator text | Options (defaults are in bold) | Range |
|---|---|---|---|---|
| 1 | Accel. Characteristic | Lin/Curv | **0 = Accelerator linear**<br>1 = Accelerator curved | 0 – 1 |
| 2 | Speed 6 input normally closed or normally open | Sp6NO/NC | 0 = Normally open<br>**1 = Normally closed** | 0 – 1 |
| 3 | Inhibit input normally closed or normally open | HibNO/NC | **0 = Normally open**<br>1 = Normally close | 0 – 1 |
| 4 | Enable power up checks | Nchk/Chk | **0 = Don't check**<br>1 = Check | 0 – 1 |
| 5 | Enable pot with switch | NoSw/Sw | 0 = No switch<br>**1 = With switch** | 0 – 1 |
| 6 | Display Status field | Of/D/V/K | **0 = None**<br>1 = Accelerator [%]<br>2 = Motor Velocity [RPM]<br>3 = no effect<br>4 = no effect<br>5 = Motor current [A]<br>6 = Battery current [A] | 0 – 6 |
| 7 | Digital O/P 4 config | DO4Typ | **0 = Remote LED**<br>1 = Drive OK | 0 – 1 |
| 8* | Active low or high digital inputs | Actv L/H | **0 = Active low digital inputs**<br>1 = Active high digital inputs | 0 – 1 |
| 9 | Accelerator supply wire off detection | SplyWrOf | **0 = No supply wire off detection**<br>1 = 0V wire off detection enabled<br>2 = 5V wire off detection enabled<br>3 = Both 0V and 5V wire off detection | 0 – 3 |
| 10 | Line Contactor pull-in level | LCPlInLv | Adjustable from 50% to 100% Ubatt.to limit inrush current. **Default is 90%** | 50-100% |
| 11 | Line Contactor pull-in time out | LCPlInTO | Line Contactor pull in time out. **Default is 10sec**. | 0-12 sec |
| 12 | Line Contactor Coil pull-in Voltage | LCPlInVl | Adjustable from 5% to 100% Ubatt **Default is 100%** | 7-100% |
| 13 | Line Contactor Coil Holding voltage | LCHoldVl | Adjustable from 5% to 100% Ubatt **Default is 100%** | 7-100% |
| 14 | Digital output 2 pull-in voltage | DO2PlInV | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 15 | Digital output 2 hold voltage | DO2HoldV | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 16 | Digital output 3 pull-in voltage | DO3PlInV | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 17 | Digital output 3 hold voltage | DO3HoldV | Adjustable from 7% to 100% Ubatt **Default is 100%** | 7-100% |
| 18 | Drive output 2 Configuration | Drv2Cfg | **0 = no function**<br>1 = motor temperature cooling enabled<br>2 = controller temperature cooling enabled<br>3 = both motor and controller temperature cooling enabled | 0 – 3 |
| 19 | Drive output 3 Configuration | Drv3Cfg | **0 = no function**<br>1 = motor temperature cooling enabled<br>2 = controller temperature cooling enabled<br>3 = both motor and controller temperature cooling enabled | 0 – 3 |
| 20 | Drive Output Motor Temp TH | MotTmpTh | Adjustable from 10 to 127 °C. **Default is 70 °C** | 10 – 127 °C |

 ©2019 DMC GmbH Herten Germany

| Cal. Ref. | Parameter | Calibrator text | Options (defaults are in bold) | Range |
|---|---|---|---|---|
| 21 | Drive Output Controller Temp TH | CtrTmpTh | Adjustable from 10 to 100 °C. **Default is 45 °C** | 10 – 100 °C |
| 22 | n/a | | | |
| 23 | Calibration Data Options | CalValue | Not active | --- |
| 24* | Loading Default | LoadDefs | **0 = Don't load defaults**<br>1 = Load defaults | 0 – 1 |
| | **(*) Recycle the key switch to make changes active. (Also indicated on calibrator 'key')** | | | |

### M3-1P Accel. Characteristic "Lin/Curv"
See "M3-1T Accel. Characteristic "Lin/Curv"" in the paragraph 5.1 Menu 3 "Controller Setup for Traction".

### M3-2P Speed 6 input normally closed or normally open "Sp6NO/NC"
This sets the active polarity of input pin 6 on 35-Way Connector.

- If set to **0 (NO)**, the input will be active when a switch connected to pin 6 is closed.
- If set to **1 (NC)**, the input will be active when a switch connected to pin 6 is open.

### M3-3P Inhibit input normally closed or normally open "HibNO/NC"
This sets the active polarity of input pin 7 on 35-Way Connector.

- If set to **0 (NO)**, the input will be active when a switch connected to pin 7 is closed.
- If set to **1 (NC)**, the input will be active when a switch connected to pin 7 is open.

If inhibit input ("Pin 7 Speed Limit 3 / Handbrake -- *Pump Inhibit*") becomes active, it immediately stops the pump and signals failure (F 03). Inhibit input is not active on input 6 (Power steer), thus if input 6 is active and inhibit is activated the pump is still work signaling failure (F 03).

### M3-4P 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. Line contactor short circuit test.
  ii. Pump potentiometer > 0.5% or Speed 1 switch closed (depending on the setting of "M3-5P Enable pot with switch "NoSw/Sw").
  iii. 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.

### M3-5P Enable pot with switch "NoSw/Sw"
Some lift levers are fitted with an integrated switch. This parameter allows the option of checking the switch or pump potentiometer at power-up.

- If set to **0 (NoSw)**, a potentiometer without an integrated switch connected to pin 1 can be used.
- If set to **1 (Sw)**, then a potentiometer with a switch can be connected to pin 1.

 ©2019 DMC GmbH Herten Germany

### M3-6P Display Status Field – "Of/D/V/K"

This sets the type of information that will appear in the General Indication Field of the Sigmagauge or the DMC Display.

- 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 "M4-13 Maximum Motor Frequency".
- 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.

### M3-7P Digital O/P 4 config "D04Typ"

This sets the function of the output associated with "Pin 18 Digital o/p -- Remote LED or Brake lights" on 35-Way Connector and whether the output is used as an external fault indicator or as a brake light.

- If set to **0 (Remote LED)**, then DO4 is configured as remote led repeating the flashing code of Red Led
- If set to **1 (DRIVE OK)**, then DO4 is configured as an enabling output. When no failure code the DO4 is inactive, else the D04 is acting pulling down to ground the "Pin 18 Digital o/p -- Remote LED or Brake lights".

### M3-8P Active low or high digital inputs* "Actv L/H"

This sets whether the digital inputs are active low or active high.

- If set to **0 (Digital inputs Active low)**, the digital inputs will be considered active when the input is tied to battery ground and inactive when not connected. An internal pull up resistor will be enabled.
- If set to **1 (Digital inputs Active high)**, the digital inputs will be considered active when the input is tied to battery plus and inactive when not connected. An internal pull down resistor will be enabled.

For the Digital Inputs connection and wiring details refer to section "2.2 Selecting active Low or High digital inputs".
This parameter requires a key cycle off-on to be effective.

### M3-9P Supply wire off detection "SplyWrOf"

This sets how the wire off detection for accelerator is detected.

- If set to **0**, no wire off detection on accelerator potentiometer supply lines is active.
- If set to **1**, 0V wire off detection is enabled ("Pin 10 Analogue supply 0V" of 35-Way connector).
- If set to **2**, 5V wire off detection is enabled ( "Pin 8 Analogue supply 5V" of 35-Way connector).
- If set to **3**, both 0V and 5V wire off detection are enabled.

### M3-10P Line Contactor pull-in level "LCPlInLv"

This set the voltage pull-in level for closing line contactor as a percentage of the battery voltage. The controller will close the line contactor when capacitor voltage is above the pull-in voltage.

### M3-11P Line Contactor pull-in time out "LCPlInTO"

This parameter sets the time out for closing line contactor. If capacitor voltage does not reach the voltage pull-in level within the time out a failure is signaled.

### M3-12P Line Contactor Coil pull-in voltage "LCPlInVl"

It sets the line contactor coil pull in voltage applied for 1s for closing line contactor. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.

Example:
"M8-2 Nominal battery voltage "NomBatV"" is set to 48V and the desired line contactor coil pull in voltage is 36V for 1s.
The percentage to be set in "M3-26T Line Contactor Coil pull-in voltage "LCPlInVl"" has to be: 100%*36V / 48V =75%.
If it set to 100% the full battery voltage will be applied for 1 s.

 ©2019 DMC GmbH Herten Germany

### M3-13P Line Contactor Coil holding voltage "LCHoldVl"

It sets the line contactor coil holding voltage applied when the line contactor is closed and 1 s of time is elapsed. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.

Example:
"M8-2 Nominal battery voltage "NomBatV"" is set to 48V and the desired line contactor coil holding voltage is 24V.
The percentage to set in the "M3-27T Line Contactor Coil holding voltage "LCHoldVl"" has to be 100%*24V / 48V = 50%.
If it set to 100% the full battery voltage will be applied

### M3-14P Digital Output 2 pull-in voltage "Do2PlInV"

It sets the Digital Output 2 pull in voltage applied for 1s. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.
If it set to 100% the full battery voltage will be applied.

### M3-15P Digital Output 2 hold voltage "Do2HoldV"

It sets the Digital Output 2 holding voltage applied when the line contactor is closed and 1 s of time is elapsed. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.
If it set to 100% the full battery voltage will be applied.

### M3-16P Digital Output 3 pull-in voltage "Do3PlInV"

It sets the Digital Output 3 pull in voltage applied for 1s. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.
If it set to 100% the full battery voltage will be applied.

### M3-17P Digital Output 3 hold voltage "Do3HoldV"

It sets the Digital Output 3 holding voltage applied when the line contactor is closed and 1 s of time is elapsed. It is expressed as percentage of the "M8-2 Nominal battery voltage "NomBatV"" in the BDI menu.
If it set to 100% the full battery voltage will be applied.

### M3-18P Driver output 2 configuration "Drv2Cfg"

This sets the configuration for Driver Output 2.

- If set to **0**, no function is assigned to digital output driver 2 (pin 16 in 35 way connector)
- If set to **1**, digital output 2 is activated if motor temperature is higher than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"" and deactivated when motor temperature gets lower than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh""- 8 °C of hysteresis.
- If set to **2**, digital output 2 is activated if controller temperature is higher than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"", and deactivated when controller temperature gets lower than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh""- 8 °C of hysteresis .
- If set to **3**, digital output 2 is activated if motor temperature is higher than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"" OR if controller temperature is higher than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"", while it is deactivated when motor temperature gets lower than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh""- 8 °C of hysteresis AND controller temperature gets lower than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh""- 8 °C of hysteresis.

 ©2019 DMC GmbH Herten Germany

### M3-19P Driver output 3 configuration "Drv3Cfg"

This sets the configuration for Driver Output 3.

- If set to **0**, no function is assigned to digital output driver 3 (pin 16 in 35 way connector)
- If set to **1**, digital output 3 is activated if motor temperature is higher than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"" and deactivated when motor temperature gets lower than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh""- 8 °C of hysteresis.
- If set to **2**, digital output 3 is activated if controller temperature is higher than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"", and deactivated when controller temperature gets lower than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh""- 8 °C of hysteresis .
- If set to **3**, digital output 3 is activated if motor temperature is higher than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh"" OR if controller temperature is higher than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh"", while it is deactivated when motor temperature gets lower than threshold "M3-21T Motor Temperature threshold (for output driver) "MotTmpTh""- 8 °C of hysteresis AND controller temperature gets lower than threshold "M3-22T Controller Temperature threshold (for output driver) "CtrTmpTh""- 8 °C of hysteresis.

### M3-20P Motor Temperature threshold (for output driver) "MotTmpTh"

### M3-21P Controller Temperature threshold (for output driver) "CtrTmpTh"

These two settings represent the temperature thresholds to drive output 2 and/or 3 according to setting "M3-19T Driver output 2 configuration "Drv2Cfg"" and "M3-20T Driver output 3 configuration "Drv3Cfg"".

### M3-22P n/a

This setting is not active in PMS software

### M3-23P Calibration Data option "CalValue"

Not used yet. For future development

### M3-24P 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.

 ©2019 DMC GmbH Herten Germany

# 6 PMS Motor Auto Tuning

The SuperSigma2 is capable of performing auto tuning of the motor parameters and, on PMS models, it also does auto-setup of several motor feedback sensors (Sin/Cos, Hall sensors and Resolvers).
The auto tuning only needs a basic set of parameters to be entered. 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 and pump in this way:

- For **traction** the vehicle must be lifted such that the wheels can rotate freely.
- For **pump** the motor must be able to rotate freely (unloaded).

The auto tuning takes about 2 minutes to complete.
After a successful auto tuning, all the parameters in the motor setup and motor advanced menus will have new values.
It is possible to modify several parameters in the PMS Autotune setup menu after the autotune has been completed, but in that case a recalculation must be performed. Please read the next section for more details.
Parameters in the advanced menu are for indication only and cannot be changed manually.

- **Traction controller auto tuning: THE TRACTION WHEELS MUST BE OF THE GROUND**
- **Pump controller auto tuning: THE PUMP MOTOR MUST BE ABLE TO SPIN UNLOADED**

## 6.1 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 analogue Sin/Cos sensor or Hall sensors |
| Sensor encoder supply voltage | Choose 5 volt or 12 volt sensor supply |
| Reverse sensor reading | Try set to 1 if auto tuning diagnostics return an error 6 |
| Reverse motor direction | Try set to 1 if auto tuning diagnostics return an error 6 and motor direction is reversed (or counter clock wise) |
| 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) |
| Maximum RMS motor current | Set the maximum required motor current |
| Back e.m.f. constant | Set the Ke voltage constant (motor rms voltage (phase to phase) per 1000rpm) (if Autotuning Type selected to 0) |
| Motor phase to phase inductance | Set the motor inductance in **micro henry (µH)** (if Autotuning Type selected to 0) |
| 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! |
| Maximum desired motor frequency | Set the maximum required motor frequency |

 ©2019 DMC GmbH Herten Germany

## 6.2 Menu 4 "PMS Motor Auto Tuning"

| Cal. Ref. | Parameter (Param.) | Calibrator text | Min. adjust | Max. adjust | Step size | Default |
|---|---|---|---|---|---|---|
| 1 | Number of motor poles | Nmotpole | 2 | 48 | 2 | 8 |
| 2 | Sensor technology [1)] | SensTech | 0 | 2 | 1 | 0 |
| 3 | Sensor supply voltage | SenSuppV | 0 | 1 | 1 | 0 |
| 4 | Number of sensor poles | NsnsPole | 2 | 48 | 2 | 2 |
| 5 | Reverse sensor reading | SpdRever | 0 | 1 | 1 | 0 |
| 6 | Reverse motor direction | MotorRev | 0 | 1 | 1 | 0 |
| 7* | Battery Voltage | BattV AT | 12. 0 V | Units Umaxnom | 1V | 24V |
| 8** | RMS motor current For tuning | I for AT | 1 Arms | Units Imax Arms | 1 Arms | ½ max current |
| 9* | Maximum RMS motor current | Imotmax | 1 Arms | Units Imax Arms | 1 Arms | Max current |
| 10* | Back e.m.f. constant (KeV) | K emf | 0.0 V/krpm | 144.0 V/krpm | 0.1 V/krpm | 10.0 V/krpm |
| 11* | Motor phase to phase inductance | L ph-ph | 0 µH | 3200.0 µH | 1 µH | 120 µH |
| 12* | Maximum demagnetizing (Field weakening) current | I demag | 1 Arms (disabled) | 600 Arms | 1 Arms | 1 Arms |
| 13* | Maximum Motor Frequency | Fmotmax | 0.0 Hz | 700.0 Hz | 0.1 Hz | 100.0 Hz |
| 14 | Start Auto-tuning | AutoTune | 0 | 1 | 1 | 0 |
| 15 | Recalculation after changing one of the adjustments of this menu marked with one star * | Recalcul | 0 | 1 | 1 | 0 |
| 16 | Sin/Cos Sensor Delay Angle at 100 Hz | SensDel | 0,0 deg | 15,0 deg | 0,1 deg | 3,6 deg |
| 17 | Auto Tuning Type:<br>0= Standard auto tuning (position sensor tuning)<br>1= Full autotuning (position sensor + Inductance and Ke mesurment) | ATuneType | 0 | 1 | 1 | 0 |

| | |
|---|---|
| | **(*) If a parameter with one star is changed, recalculation is required.<br>Recalculation is performed after setting the recalculation parameter to 1 and recycling the key.** |
| | **(7**) The nominal current for autotuning "Inom" have to be set not higher than 30-40% of motor continuous current. Higher values can overheat and or damage the motor.<br><br>(**) Changes to parameters with two stars are only considered when performing auto tuning after recycling the key !** |

Note [1)]: sensorless options available on request. Refer to DMC.

### M4-1 Number of motor poles "NmotPole"

Number of motor poles.

### M4-2 Sensor technology "SensType"

- If set to **0 (Analog Sine Cosine)**, an analog sine-cosine sensor must be connected. The sensor has to give two signals: one sine wave and one cosine wave per revolution of the motor shaft. The signal must be between 0 and 5V and have an offset around 2.5 V.
- If set to **1 (Hall sensor)**, a three channel position hall sensor must be connected. Selection to 1 is available on request. Refer to DMC for details.
- If set to **2 (Sensorless)**, no sensor is required. This Selection is available on request. Refer to DMC for details.

 ©2019 DMC GmbH Herten Germany

### M4-3 Sensor supply voltage "SenSuppV"

This parameter sets the voltage at which the sensor is supplied.

- If set to 0, the sensor is supplied at 5V.
- If set to 1, the sensor is supplied at 12V.

Analog Sine-Cosine sensors are supplied by 5V so select 0 in this case.
Hall sensors technology can be suppied by either 5V or 12V, so check the sensor specifications.

### M4-4 Number of sensor poles "NsnsPole""

Starting from release V02.08.05b8 is possible to use sin/cos sensor with a number of sine and cosine wave couples per mechanical revolution greater than 1. So standard situation with one sine wave per mechanical revolution means a number of sensor poles equal to 2. This is the setting default value. Different sensor number of poles and number of motor poles combination are possible. The condition of a integer ratio between NofMotorPoles/NofSensorPols must be fulfilled, otherwise motor control will inhibit driving (see error code list).

### M4-5 Reverse sensor reading "SpdRev"

This parameters changes the sign of the value read from the speed sensor. Setting it to one might be necessary if the sensor's wires are not connected properly.
In case of Sine-Cosine sensor it corresponds to swapping the speed sensor channels.
In Case of Hall sensor is like swapping any two channels.
For sensorless this setting has no effects.

### M4-6 Reverse motor direction "MotorRev"

This parameter changes the motor direction (CW or CCW) corresponding to Fw or Rv. Setting it to 1 might be necessary if two motor phases power cable connections are swapped.

### M4-7 Battery Voltage "BattV AT""

This parameter sets the nominal battery voltage. It is read by the controller only after key cycle power off-on and will have effect only after the first auto tuning procedure is performed. If a change is required it is necessary to cycle the key and repeat the auto tuning procedure.

### M4-8 RMS motor current For tuning "Ifor AT""

This parameter sets the motor nominal current for autotuning. It has to be set equal to 30-40% of motor continuous current. It is read by the controller only after key cycle power off-on and will have effect only after the first auto tuning procedure is performed. If a change is required it is necessary to cycle the key and repeat the auto tuning procedure.

**VERY IMPORTANT**
**The nominal current for autotuning "Inom" have to be set not higher than 30-40% of motor continuous current. Higher values can overheat and or damage the motor.**

### M4-9 Maximum RMS motor current "Imotmax"

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.

### M4-10 Back-EMF constant (KeV) "K emf""

This parameter sets the back-electro motive force constant expressed in VoltRms per 1000 rpm. The rms voltage is considered phase to phase.
According to autotuning type selected, see "M4-17 Auto Tuning Type", this to be enter (Auto Tuning Type = 0) or will be calculated automatically (Auto Tuning Type = 1)

### M4-11 Motor phase to phase inductance "L ph-ph"

It is the motor inductance between two phases expressed in microHenry.
According to autotuning type selected, see "M4-17 Auto Tuning Type", this to be enter (Auto Tuning Type = 0) or will be calculated automatically (Auto Tuning Type = 1)

### M4-12 Maximum demagnetizing (Field weakening) current "I demag"

This parameter sets the maximum current that will be injected into the motor when it is working in the field weakening region. If field weakening is not required this value must be set to 1, otherwise a proper value should be entered. Refer to motor manufacturer for proper value.

 ©2019 DMC GmbH Herten Germany

**VERY IMPORTANT**
**This value has to be set lower than current level that can damage rotor magnets.**

### M4-13 Maximum Motor Frequency "Fmotmax"

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.

### M4-14 Start Auto-tuning "AutoTune"

Setting this parameter to 1 will cause the autotuning procedure to start.

### M4-15 Recalculation after changing one of the adjustments of this menu marked with one star "Recalcul"

After changing a parameter in the "auto tuning menu" or in the "motor menu" that is indicated with one star (*) the recalculation procedure is required.
To perform recalculation, set this parameter to 1 and key power off-on cycled. The internal motor parameters will be optimized considering the changes in the motor or autotuning menus.

### M4-16 Sin/Cos Sensor Delay Angle at 100 Hz "SensDel"

This setting corresponds to the angle delay at 100 Hz of the sine cosine position sensor. As default is set to 3.6° (degrees). Refer to sensor manufacturer documentation for this information. This value is needed for setting up the sensor delay compensation algorithm.

### M4-17 Auto Tuning Type "ATuneType"

This parameter allows to choose which autotuning type must be performed:

- If set to **0 (Standard)**, only position sensor tuning will be performed, thus the inductance value ("M4-11 Motor phase to phase inductance") and the Back-EMF constant ("M4-10 Back-EMF constant (KeV)") must be input and they must correspond to the motor ones.
- It set to **1 (Full autotuning)**, the procedure will tune the position sensor and perform the measurements of inductance and Back-EMF.

**VERY IMPORTANT**
**In both cases the motor must spin totally free of load.**

 ©2019 DMC GmbH Herten Germany

## 6.3 Initiating auto tuning

After setting up the basic parameters for the auto tuning, the auto tuning can be started.
This is done by setting the parameter “M4-14 Start Auto-tuning” to '**1**'. The calibrator will now show the following screen:

```
*** AUTO   TUNING ***

Have you set the
parameters?
********************
```

This is shown to alert the user auto tuning is starting.
This confirm, press and hold the + and - button of the calibrator for at least 5 seconds.
Then the calibrator shows the following screen:

For Traction controllers

```
*** AUTO    TUNING ***

Is the motor able to spin
unloaded?
********************
```

For Pump controllers

```
*** AUTO    TUNING ***

Are the wheels
off the ground?
********************
```

Again, confirm by pressing and holding the + and - button for at least 5 seconds.

When Auto Tuning has started the following screen is shown:

```
*** AUTO    TUNING ***

In progress  54 %
(select to cancel)
********************
```

Auto tuning can be stopped at any time by pressing any calibrator button.

After the auto tuning process is finished the following screen will be shown:

```
*** AUTO    TUNING ***

finished. Press
select to return

********************
```

In case of errors the following screen will be shown:

```
*** AUTO    TUNING ***

failed with code  4
(select to return)
********************
```

In case of an error, verify the error code in the next section.

 ©2019 DMC GmbH Herten Germany

## 6.4 Auto tuning errors

It is possible that the auto tuning algorithm has encountered an error. This list provides the possible errors during auto tuning, together with a short description which might be helpful for solving them.

| Error | Description |
|---|---|
| 0 | No errors in the Auto tuning Motor Module |
| 1 | The rated battery voltage set is not consistence with the measured one and auto tuning cannot be performed<br>Solution: Set a proper number in “M4-7 Battery Voltage”. |
| 2 | The battery is too low and auto tuning cannot be performed<br>Solution: Check power connections (+ and B+), check battery state of charge, check line contactor wiring. |
| 3 | An overcurrent is detected (maybe short circuit or wrong wiring) |
| 4 | No current is flowing in the motor: no or wrong motor connection. |
| 5 | No Sensor feedback reading: it means no sensor is connected or that the motor is locked<br>Solution: check for the sensor supply voltage setting being correct, check sensor wiring and check if the motor is free to spin. |
| 6 | Error in speed measurement (only for Sin/Cos): direction measured is not consistent with motor direction<br>Solution: if motor spins in forward direction during autotuning change “M4-5 Reverse sensor reading”.<br>if motor spins in reverse direction during autotuning change “M4-6 Reverse motor direction”. |
| 7 | Wrong number of poles set in “M4-1 Number of motor poles” (only for Sin/Cos) |
| 8 | Unable to finish calculation (rotor resistance too low or too high) |
| 9 | Unable to finish motor measurements<br>Probably causes:<br>1) Motor is loaded: remove mechanical load<br>2) Nominal current it is set to low: increase “M4-8RMS motor current For tuning”<br>3) Motor inductance is too low |
| 10 | Sine/Cosine signal is not detected: check wiring or Sensor Supply “M4-3 Sensor supply voltage”. |
| 11 | Sine signal is not in the same range as the cosine signal: check wiring and sensor |
| 12 | Cosine signal is not in the same range as the sine signal: check wiring and sensor |
| 13 | Sine/Cosine signals are in range but very different: Check sensor mechanical alignment and wiring. |
| 14 | One of the three Hall sensor signal is missing. |
| 15 | Two of the three Hall sensor signals are missing. |
| 16 | All hall sensors signals are missing |
| 17 | Hall sensor configuration incorrect.<br>Probably causes :<br>1) the motor is loaded<br>2) sensors wrong wiring<br>3) Nominal current is set too low: increase “M4-8RMS motor current For tuning” |
| 18 | Unable to calculate the PI gains: Perform auto tuning again starting from default values (if Autotune type 1 has been chosen), Check Ke and Lph-ph values. |
| 19 | Motor calculated maximum speed exceeds 500Hz: Refer to DMC |
| 20 | Unable to calculate limit curves. Check motor parameters (Fmotmax, I demag) in the auto tuning menu |
| 21 | Unable to Measure Ke (e.m.f. constant). Check if motor is loaded or locked. If not reduce the speed control PI gains in “Motor Setup” Menu. |
| 22 | An unknown error occurred: Refer to DMC |

 ©2019 DMC GmbH Herten Germany

## 6.5 Recalculation

It is possible to alter one or more parameters, for example the maximum desired motor current, after an autotuning procedure has been performed. To gain advantage of this change it is possible to do another auto tuning, but it is also possible to perform a recalculation of the parameters based upon this change.
For the recalculation process it is necessary (after changing the desired parameters) to set the "M4-15 Recalculation after changing one of the adjustments of this menu marked with one star" to 1 and switch off the controller. Then wait a few seconds, switch on the controller and wait for line contactor to close and for the OK message on the Calibrator's first page.

The recalculation process is suggested after changing one or more of the following parameters:

| Cal. Ref. | Parameter | Calibrator text |
|---|---|---|
| 9 | "M4-9 Maximum RMS motor current" | Imotmax* |
| 10 | "M4-10 Back-EMF constant (KeV)" | K emf* |
| 11 | "M4-11 Motor phase to phase inductance" | L ph-ph * |
| 12 | "M4-12 Maximum demagnetizing (Field weakening) current" | I demag* |
| 13 | "M4-13 Maximum Motor Frequency" | Fmotmax* |

**! VERY IMPORTANT**
**If a failure occurs during autotuning (Failure code greater than 15 see 13.1 Error Codes) autotuning stops.**
**If a failure is present before starting autotuning it is not possible to init the autotuning procedure.**

## 6.6 Fine Motor Tuning

### 6.6.1 How to have more torque.

If the starting torque or the full torque is not strong enough do the actions indicated in the following list.

1) Be sure that autotuning procedure has been executed and ended properly with no failure code.
2) If "M4-9 Maximum RMS motor current" is lower than controller maximum current increase it and execute recalculation procedure (see paragraph "6.5 Recalculation"). This operation is possible in case the motor can manage an higher current.

### 6.6.2 How to have more power.

If the maximum power is not enough check the following:

1) Be sure that autotuning procedure has been executed properly with no failure code.
2) If "M4-9 Maximum RMS motor current" is lower than controller maximum current increase it and execute recalculation procedure (see paragraph "6.5 Recalculation"). This operation is possible in case the motor can manage an higher current.
3) Increase parameter "M6-14 Maximum radius voltage "Vmodmax"" and execute recalculation procedure (see paragraph "6.5 Recalculation").

### 6.6.3 How to have more speed

If the autotuning procedure has been completed successfully, increase "4.12* Maximum Motor Frequency" and perform a recalculation.

### 6.6.4 Motor is vibrating or driving unstable.

**Torque mode**

1) Be sure that autotuning procedure has been executed and ended properly with no failure code.

**Speed Mode**

1) Be sure that autotuning procedure has been executed and ended properly with no failure code.
2) Reduce PI Speed gains (settings "M5-1 Proportional gain speed controller "Kp Spd"", "M5-2 Integral gain speed controller "Ki Spd"", "M5-5 Proportional gain speed controller below threshold "KpSpdLow"" and "M5-6 Integral gain speed controller below threshold "KiSpdLow"") in Menu 5 "PMS Motor Setup".

 ©2019 DMC GmbH Herten Germany

# 7 Menu 5 "PMS Motor Setup"

| | |
|---|---|
| | **The PMS motor setup menu defines the motor characteristics for the controller.**<br>**Parameters from 10 to 16 are calculated by the auto tuning algorithm or recalculation process.**<br>**If it is necessary to tune these parameters, please consult DMC first.**<br>**Mistakes in the motor setup tables can cause serious accidents and/or defective controllers and/or defective motors.** |

| Cal. Ref. | Parameter | Calibrator text | Min. | Max. | Step size | Default |
|---|---|---|---|---|---|---|
| 1 | Proportional gain speed controller | Kp Spd | 0.1 | 63.9 | 0.1 | 10.0 |
| 2 | Integral gain speed controller | Ki Spd | 0.1 | 1999.9 | 0.1 | 10.0 |
| 3 | Enable double PI settings for speed controller | SpdPIx2 | 0 | 1 | 1 | 1 |
| 4 | Double PI speed threshold | SpdPITH | 0 % | 50 % | 1% | 15 % |
| 5 | Proportional gain speed controller below threshold | KpSpdLow | 0.1 | 63.9 | 0.1 | 5.0 |
| 6 | Integral gain speed controller below threshold | KiSpdLow | 0.1 | 1999.9 | 0.1 | 10.0 |
| 7 | Transition time between the two PI settings for the speed controller | TransTim | 0.01 s | 5.00 s | 0.01 s | 0.1 s |
| 8 | Speed limit tolerance | SpLimTol | 0% | 40% | 1% | 0 |
| 9 | Speed limit action ramp time | SpLimTim | 0.01 s | 8 s | 0.01s | 0.1 |
| 10 | Extra field weakening level referred to the ideal flux at maximum speed | FWextra | 0 % | 40 % | 1% | 0 % |
| 11 | Speed Threshold for beginning field weakening | F_FW TH | 20 % | 100 % | 1 % | 100 % |
| 12 | Torque Reduction Map in field weakening range point 1 | TReduc1 | 10% | 100% | 1% | 90% |
| 13 | Torque Reduction Map in field weakening range point 2 | TReduc2 | 10% | 100% | 1% | 80% |
| 14 | Torque Reduction Map in field weakening range point 3 | TReduc3 | 10% | 100% | 1% | 70% |
| 15 | Torque Reduction Map in field weakening range point 4 | TReduc4 | 5% | 100% | 1% | 60% |
| 16 | Torque Reduction Map in field weakening range point 5 | TReduc5 | 5% | 100% | 1% | 50% |
| 17 | Capacitor Voltage ramp Time | CapVTime | 0.1 s | 20.0 S | 0.1 S | 0.1 S |
| 18 | Voltage Limiter Filter Frequency | FVlimFlt | 0.1 Hz | 100.0 Hz | 0.1 Hz | 100.0 Hz |

## M5-1 Proportional gain speed controller "Kp Spd"

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.

## M5-2 Integral gain speed controller "Ki Spd"

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.

 ©2019 DMC GmbH Herten Germany

### M5-3 Enable double PI settings 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 ("M5-1 Proportional gain speed controller "Kp Spd"", "M5-2 Integral gain speed controller "Ki Spd"").
- If set to **1** two sets of speed controller gains are adopted. If the actual speed is below "M5-4 Double PI speed threshold "SpdPITH"" the low speed gains are adopted ("M5-5 Proportional gain speed controller below threshold "KpSpdLow"" and "M5-6 Integral gain speed controller below threshold "KiSpdLow""). If the actual speed is higher than "M5-4 Double PI speed threshold "SpdPITH"" the following speed gains are adopted (M5-1 Proportional gain speed controller "Kp Spd", "M5-2 Integral gain speed controller "Ki Spd"").

### M5-4 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.

### M5-5 Proportional gain speed controller below threshold "KpSpdLow"

This parameter has the same meaning of "M5-1 Proportional gain speed controller "Kp Spd"". This is applied if "M5-3 Enable double PI settings for speed controller "SpdPIx2"" is set to 1 and actual speed is above "M5-4 Double PI speed threshold "SpdPITH"".

### M5-6 Integral gain speed controller below threshold "KiSpdLow"

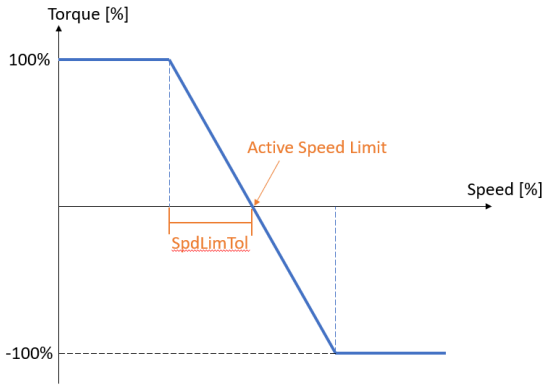
This parameter has the same meaning of "M5-2 Integral gain speed controller "Ki Spd"". This is applied if "M5-3 Enable double PI settings for speed controller "SpdPIx2"" is set to 1 and actual speed is above "M5-4 Double PI speed threshold "SpdPITH"".

### M5-7 Transition time between the two PI settings for the 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.

## Parameters for "smooth speed limiting" function

A second speed limiting function is available..
The new speed limiting feature is active in both speed and torque mode with different effects, with the goal to keep the drive feeling of the vehicle more comfortable and avoid bumps caused by rough ground conditions.




### M5-8 Speed limit tolerance "SpLimTol"

This parameter is active in both speed and torque mode for traction control. It is not active for pump control.
It sets the error tolerance in % around a speed limitation. It is defined as: $\frac{"SpLimTol" \times "Fmotmax"}{100}$, thus setting this parameter to 0 would deactivate the function.

**Example**: if "SpLimTol" is set to 10% and the active speed limit is 100 Hz, the speed will be allowed to vary in range of 90-110 Hz.

To have a smooth speed limitation without overshoot it is suggested to set this parameter between 5% and 15%. Too large values will allow a very smooth action but the speed variation around the limit may be very large. Too small values will give a tighter speed limitation but it may result more aggressive and bumpy.

In speed mode this function allows to avoid continuous adjustment of current while driving on flat ground with vehicle unloaded, thus reducing the heating up of motor and controller.

 ©2019 DMC GmbH Herten Germany

### M5-9 Speed limit action ramp time "SpLimTim"

This parameter is active only if torque mode is selected ("M3-2T Control Mode "Spd/Torq"" = 1, 2 or 3) in traction control and "M5-8 Speed limit tolerance "SpLimTol"" is set greater than zero.
It sets the time taken for speed limitation to become active when the speed reaches the limitation.
To have a good drive feeling it is suggested to set this parameter between 1.0s and 2.0s. Too large values make the speed limitation unstable and provoking overshoots. Too small values make speed limitation fast but more aggressive.

## Parameters for "Field weakening" operation

### M5-10 Extra field weakening level referred to the ideal flux at maximum speed "FWextra"

This parameter is calculated by autotuning and should not be modified.

### M5-11 Speed Threshold for beginning field weakening "F_FW TH"
### M5-12 Torque Reduction Map in field weakening range point 1 "TReduc1"
### M5-13 Torque Reduction Map in field weakening range point 2 "TReduc2"
### M5-14 Torque Reduction Map in field weakening range point 3 "TReduc3"
### M5-15 Torque Reduction Map in field weakening range point 4 "TReduc4"
### M5-16 Torque Reduction Map in field weakening range point 5 "TReduc5"

These settings from define the motor control torque current limiting map and they correspond to the motor reduction current map in field weakening.

Since the PMS motor field weakening capability is limited, in order to achieve a wide speed range a torque current limitation map is introduced with the name of motor torque current reduction map.. It is automatically calculated at the end of autotuning and the settings are available in "Motor Setup Menu" (see figure below). It is also adjusted every time a recalculation is selected after one of the settings indicated with the * in the Autotuning Menu is changed.
If the "M4-13 Maximum Motor Frequency" is set higher than the maximum frequency achievable without field weakening, it is automatically reduced.
The performance table is designed to exploit the maximum torque capability of the motor in the field weakening range, assuring a stable driving and a good efficiency. In most of the cases it doesn't need a tuning. It is not good to increase the value of the map points since more current would flow in the motor without increasing the output torque, thus the efficiency would drop.
If the motor shows unstable conditions at high frequency or low efficiency it is possible to reduce the settings 5.10 to 5.14

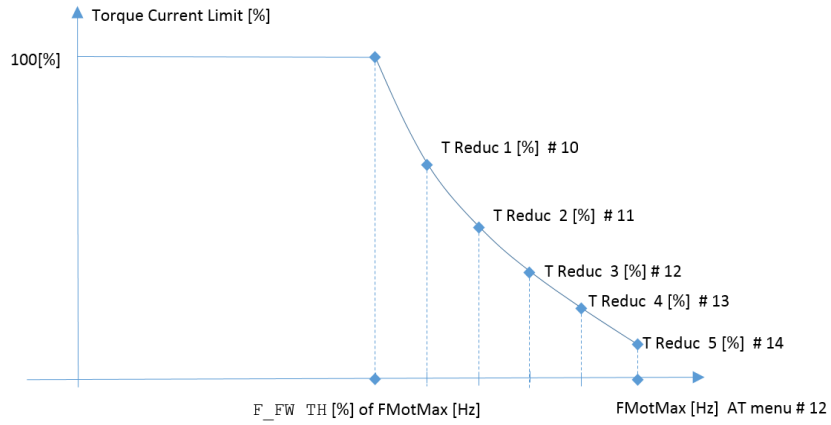



**Figure Torque current Limitation Map**

| | |
|---|---|
| | **VERY IMPORTANT**<br>**never increase the values of these settings, just reduce only if necessary.** |

### M5-17 Capacitor Voltage ramp Time CapVTime

This parameter is calculated by autotuning and should not be modified.

### M5-18 Voltage Limiter Filter Frequency FVlimFlt

This parameter is calculated by autotuning and should not be modified.

 ©2019 DMC GmbH Herten Germany

# 8 Menu 6 "PMS Motor Advanced"

These parameters are reported for indication only and it is not possible to modify them without the assistance of DMC engineers.

| Cal. Ref. | Parameter | Calibrator text | Min. | Max. | Step size | Default |
|---|---|---|---|---|---|---|
| 1 | Decouple Iq and Id controllers | Decouple | 0 | 1 | 1 | 0 |
| 2 | Enable software PWM algorithm delay compensation | PWMDelay | 0 | 1 | 1 | 1 |
| 3 | Limit torque controller during Voltage limiting | VoltSat | 0 | 1 | 1 | 0 |
| 4 | Speed Control Filter | SCFilter | 0 | 1 | 1 | 1 |
| 5 | Enable Voltage Limiter | VoltCtrl | 0 | 1 | 1 | 0 |
| 6 | Speed filter cut-off frequency | Fspdfilt | 4 Hz | 400 Hz | 1 Hz | 80 Hz |
| 7 | Percentage of correction for inductance value | DecoLeak | 0 % | 180 % | 1 % | 100 % |
| 8 | Back EMF correction factor | BEMFCorr | 0 % | 180 % | 1 % | 100 % |
| 9 | Speed estimator rate | Obs. Rate | 2% | 65% | 1% | 30% |
| 10 | Resistance compensation gain | R. Gain | 70% | 100% | 1% | 70% |
| 11 | Current compensation gain | Curr. Gain | 0% | 60% | 1% | 28% |
| 12 | Start Torque | StartTrq | 0% | 100% | 1% | 40% |
| 13 | Start Current | StartCur | 0% | 50% | 1% | 30% |
| 14 | Maximum radius voltage | Vmodmax | 90% | 102% | 1% | 102% |

### M6-1 Decouple Iq and Id controllers "Decouple"
### M6-2 Enable software PWM algorithm delay compensation "PWMDelay"
### M6-3 Limit torque controller during Voltage limiting "VoltSat"
### M6-4 Speed Control Filter "SCFilter"
### M6-5 Enable Voltage Limiter "VoltCtrl"
### M6-6 Speed filter cut-off frequency "Fspdfilt"
### M6-7 Percentage of correction for inductance value "DecoLeak"
### M6-8 Back EMF correction factor "BEMFCorr"

These parameters are only for advanced DMC servicing.

### M6-9 Speed estimator rate "Obs.Rate"
### M6-10 Resistance compensation gain "R gain"
### M6-11 Current compensation gain "CurrGain"
### M6-12 Start Torque "StartTrq"
### M6-13 Start Current "StartCur"

These parameters are used in Sensorless applications [4]. Refer to DMC for details.

### M6-14 Maximum radius voltage "Vmodmax"

From SW release V02.08.05 it is possible to deliver full PWM voltage output to motor for achieving maximum possible voltage from the battery. This is possible by increasing the value of this setting. If set to 102% full PWM wave will be provided at high speed.
To take advantage of this there are two chances:

1) Set "Vmodmax" to 102% before doing autotuning.
2) Set "Vmodmax" to 102% and do recalculation.

Suggested option is number 1)

If after increasing the "Vmodmax" the motor behavior becomes unstable at high speed bring back "Vmodmax" to 95% and perform recalculation.

 ©2019 DMC GmbH Herten Germany

# 9 Menu 7 "Limits Setup"

The following setup menu includes all the limits adopted for the controller safety.

| Cal. Ref. | Parameter | Calibrator text | Min. | Max. | Step size | Default |
|---|---|---|---|---|---|---|
| 1 | Motor Temp Sensor Type<br>(0 = KTY84-130<br>1 = Pt1000 1000 Ohm @0°c<br>2 = Pt1000 1000 Ohm @25°c ) | MtempTyp | 0 | 2 | 1 | 0 |
| 2 | Motor Temp. Cutback start | TempStrt | 0 °C | 151 °C (disables) | 1 °C | 140 °C |
| 3 | I²t Nominal Motor Current | NomCurr (I2tInom | 0 Arms | Unit max. | 1 Arms | 0 Arms |
| 4 | I²t Start Motor Temperature | I2tTemp | 0 °C | 100 °C | 1 °C | 0 °C |
| 5 | I²t Time | I2tTime | 0 s (disables) | 2000 s | 1 s | 0 s (disabled) |
| 6 | I²t Cutback1 | I2tCutB1 | 0 % | 100 % | 1 % | 100 % |
| 7 | I²t Cutback2 | I2tCutB2 | 0 % | 100 % | 1 % | 100 % |
| 8 | I²t Cutback3 | I2tCutB3 | 0 % | 100 % | 1 % | 100 % |
| 9 | Performance Table Speed 1 | PTSpd1 | 0.0 % (disables) | 100.0 % | 0.1 % | 50.0 % |
| 10 | Performance Table Speed 2 | PTSpd2 | 0.0 % | 100.0 % | 0.1 % | 70.0 % |
| 11 | Performance Table Speed 3 | PTSpd3 | 0.0 % | 100.0 % | 0.1 % | 100.0 % |
| 12 | Performance Table Cutback 1 | PTCutBk1 | 0 % | 100 % | 1 % | 100 % |
| 13 | Performance Table Cutback 2 | PTCutBk2 | 0 % | 100 % | 1 % | 100 % |
| 14 | Performance Table Cutback 3 | PTCutBk3 | 0 % | 100 % | 1 % | 100 % |
| 15 | Low Voltage Cut Back start threshold | LVCBstrt | 16.0 V | Unit max. | 0.1 V | 20.0 V |
| 16 | Low voltage cut back end threshold | LVCBend | 16.0 V | Unit max. | 0.1 V | 16.0 V |
| 17 | Low voltage error threshold | LVerror | 14.0 V | Unit max. | 0.1 V | 14.0 V |
| 48 V units | | | | | | |
| 18 | High Voltage Cut Back start threshold | HVCBstrt | 24.0 V | 67.5 V | 0.1 V | 60.0 V |
| 19 | High voltage cut back end threshold | HVCBend | 24.0 V | 67.5 V | 0.1 V | 67.5 V |
| 20 | High voltage error threshold | HVerror | 24.0 V | 70.0 V | 0.1 V | 70.0 V |
| 96 V units | | | | | | |
| 18 | High Voltage Cut Back start threshold | HVCBstrt | 24.0 V | 138.5 V | 0.1 V | 130.0 V |
| 19 | High voltage cut back end threshold | HVCBend | 24.0 V | 138.5 V | 0.1 V | 138.5 V |
| 20 | High voltage error threshold | HVerror | 24.0 V | 140.0 V | 0.1 V | 140.0 V |
| Generic | | | | | | |
| 21 | Absolute maximum motor speed | AbsMaxSp | 0.0 Hz | 700.0 Hz | 0.1 Hz | 200.0 Hz |
| 22 | Torque Threshold for Stall Protection | TrqTHLim | 1.0% | 100.0% | 0.1% | 100.0% |
| 23 | Stall protection Time | StallTim | 0.0 sec | 120.0 sec | 0.1 sec | 60.0 sec |
| 24 | n/a | | | | | |
| 25 | n/a | | | | | |
| 26 | Timed Current Limit Threshold Timer | IthTime | 0 sec | 60 sec | 1 sec | 0 sec |
| 27 | Timed Current Limit Current Threshold | CurrTh | 10 A | Unit max. | 1A | Unit max. |
| 28 | Timed Current Limit Lower Maximum Current | ImaxLow | 10 A | Unit max. | 1A | Unit max. |

## M7-1 Motor Temp Sensor Type "MtempTyp"

This parameter select the type of motor temperature sensor connected to pins 34 and 35 of the 35 Way connector:

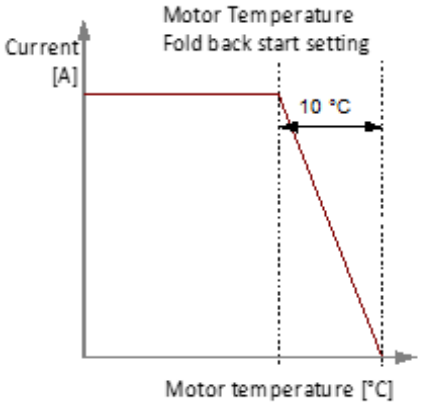
- if set to **0** a KTY84-130 sensor has to be connected;
- if set to **1** a Pt1000 sensor that has 1000 Ohm @0°C has to be connected;
- if set to **2** a Pt1000 sensor that has 1000 Ohm @25°C has to be connected.

Refer to "Pin 34 Thermistor AD4 i/p" and "Pin 35 Thermistor 0V" for details of connection.

 ©2019 DMC GmbH Herten Germany

### M7-2 Motor Temp. Cutback start "TempStrt"

This parameter sets the temperature at which the controller starts to cut back the motor current.
The maximum current value is cut as soon as the motor temperature is above this value and is cut back proportionally to the temperature between the starting point and 10 °C above it, as shown in the graph below.




As maximum current, the setting "M4-9 Maximum RMS motor current" is considered.

**Example:**
If the value of "M7-2 Motor Temp. Cutback start "TempStrt"" is 150 °C and the value of "M4-9 Maximum RMS motor current" 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 "M7-2 Motor Temp. Cutback start "TempStrt"" at 151 °C.

### M7-3 $I^2t$ Nominal Motor Current "NomCurr"
### M7-4 $I^2t$ Start Motor Temperature "I2tTemp"
### M7-5 $I^2t$ Time "I2tTime"
### M7-6 $I^2t$ Cutback1 "I2tCutB1"
### M7-7 $I^2t$ Cutback2 "I2tCutB2"
### M7-8 $I^2t$ Cutback3 "I2tCutB3"

These settings are part of $I^2t$ function (pronounce as "I-squared-t"), that is a current limiting feature: the maximum current is limited with time.
A detailed description of the function and how to set its parameters is following.

**Heat dissipation**

When current is flowing through the motor some electrical losses are present (since the motor is not ideal) and they result in heating up the motor. The heat dissipation is a squared function of the current multiplied by the motor's resistance, as shown in the following equation:

$$P_{diss} = I^2 \cdot R$$

The resistance of the motor is a constant factor (although it would increase with a temperature rise). The heat dissipation will heat up the motor. The longer heat is dissipated, the more the motor will heat up. How fast the motor heats up depends on the amount of current flowing through the motor. A large current will heat up the motor faster than a smaller current.

**Insulation classes**

The heat dissipation results in increasing the motor temperature. The maximum allowable operation temperature of the motor depends on the insulation class the motor is designed for. The rule here is that there is a 'temperature rise' upon the reference ambient temperature (often 40 °C). Often an allowance for 'hot spot' winding is also taken into consideration (usually 10 °C). This results in the following equation:

$$T_{max} = T_{ambient} + T_{rise} + T_{hotspot} = 50\ °C + T_{rise}$$

When completing this for several insulation classes, it leads to the following table.

 ©2019 DMC GmbH Herten Germany

| Insulation class | Maximum allowable operation temperature $T_{max}$ [°C] | Allowable temperature rise $T_{rise}$ [°C] |
|---|---|---|
| A | 105 | 60 |
| B | 130 | 80 |
| F | 155 | 105 |
| H | 180 | 125 |

**Nominal motor current**

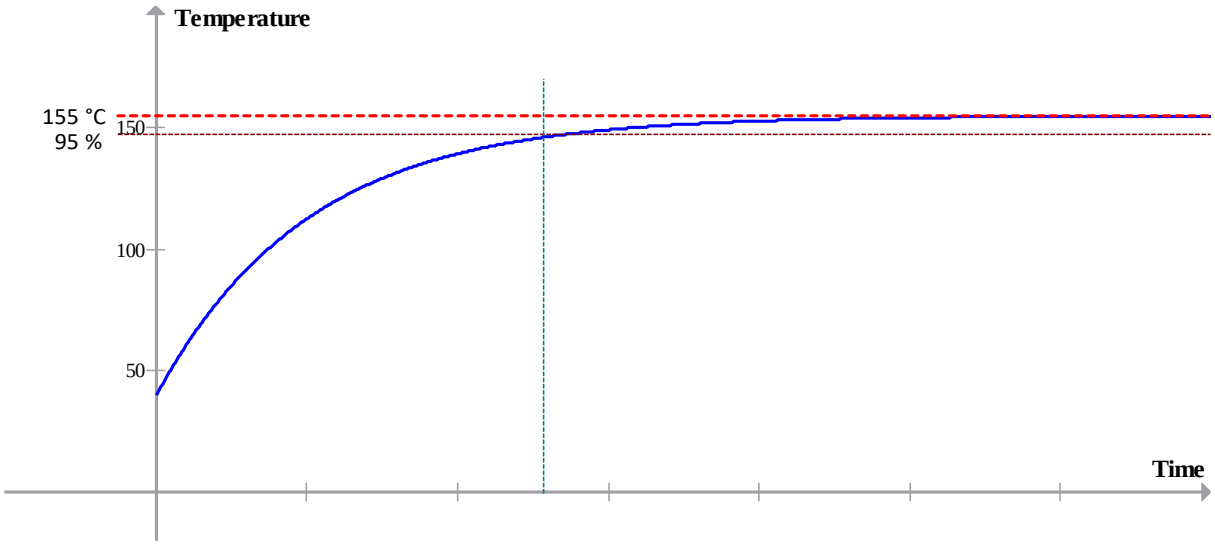
A motor is usually constructed according to an insulation class. Also, the motor is rated a 'nominal current'. When the motor has a temperature equal to the ambient temperature and starts to run, it will be heated up proportional with the current flowing through the motor.

By definition, when the current flowing through the motor is equal to the nominal rated current, the motor temperature will rise to a temperature which is equal to the maximum allowable operation temperature for that insulation class.

Example

- Insulation class of the motor: F
- Nominal current of the motor: 100 A
- Ambient temperature: 40 °C

When the motor is running continuously for an infinite time, the motor temperature will rise to a temperature of 155 °C and will stabilize there. See also the graph below.




**Cooling**

Of course, cooling will have an influence in the maximum allowable operation temperature. It may happen that with sufficient cooling the maximum allowable operation temperature is not reached. Or, in a worse case, the temperature rises *beyond* the maximum allowable operation temperature. In that case, the user must make sure there is enough cooling (e.g. increase in air flow, water cooling, etc.).

**The factor time**

The allowable temperature rise is thus a known value. The *rise time* in which the motor temperature has increased this amount is an important factor. This time depends on the cooling characteristics (e.g. type and amount of cooling) of the motor.

By definition, the *rise time* is that time in which the motor temperature rises from the reference (ambient) temperature to the maximum allowable operation temperature when the motor is drawing a constant current which is twice the nominal rated current of the motor.

This rise time must be measured or calculated.

Example

- Nominal rated current 90 A
- Insulation class F
- Rise time 50 s

Thus, the motor heats up 105 °C in 50 s when 180 A is drawn, the providing starting temperature is 40 °C.

## Parameters

The controller will have a set of parameters with which the $I^2t$ feature can be set up:

- Nominal rated current of the motor.
- The temperature rise time.
- Percentage of the maximum drive current 1.
- Percentage of the maximum drive current 2.
- Percentage of the maximum drive current 3.

The location, unit, range and step size of these adjustments can be found in the "Menu 7 "Limits Setup"".

This rise time must be established by trial and error. Once this time is established, it sets a time in which the surplus of the nominal current may flow through the motor. After that time, the $I^2t$ function will limit the motor current in three steps.

There is Microsoft Excel sheet (available on request) which can be used to setup the $I^2t$ parameters in the "Menu 7 "Limits Setup"" of the Sigma2 controller. In this sheet various current settings and the time can be filled in the white boxes (see also the example below). The figures in bold in the dark green box are the actual current limit value in percentages. These need to be configured in the "Menu 7 "Limits Setup"" of the controller.

A limit will run from 100 % (no cut back) to 0 % (full cut back). This is displayed also in the "Status Menu" at "Drive torque limit".

When the $I^2t$ feature is actually limiting the current, the "Status menu" will show 'T1', 'T2' or 'T3' limit indication, depending in which phase the $I^2t$ function currently is.

> *The reason that percentages are used instead of real currents, is that all other limit features such as low voltage limit and controller temperature limit are also in percentages.*

***Note** that the maximum current is specified by the maximum RMS current in the Motor Autotune menu ("*Menu 4 "PMS Motor Auto Tuning"*).*

Example
An example of the MS Excel sheet is given below.

**Setting up I2t parameters**

| | | | | | | |
|---|---|---|---|---|---|---|
| Motor Setup Menu | Maximum Torque current in drive | ImotMax | 400 | Arms | ***To use in Motor Limits Menu*** | |
| Menu Motor Limits | Nominal motor current | NomCurr | 100 | Arms | **100** | Arms |
| | $I^2t$ Time | I2TTime | 180 | sec | **180** | sec |
| | $I^2t$ Cut Back Current 1 | I2TCutB1 | 250 | Arms | **63%** | % |
| | $I^2t$ Cut Back Current 2 | I2TCutB2 | 160 | Arms | **40%** | % |
| | $I^2t$ Cut Back Current 3 | I2TCutB3 | 120 | Arms | **30%** | % |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | $I^2 x t$ | 1800000 | A^2s | | |
| | | **Step** | **0** | **T1** | **T2** | **T3** |
| | | I_max [A] | **400** | **250** | **160** | **120** |
| | | I_offset [A] | 300 | 150 | 60 | 20 |
| | | t [s] | 20,00 | 80,00 | 500,00 | 4500,00 |
| | | t [min] | 0,33 | 1,33 | 8,33 | 75,00 |
| | | t [h] | 0,01 | 0,02 | 0,14 | 1,25 |

According to the sheet, 400 Arms is allowed to flow through the motor for a maximum time of 20 s. After that the $I^2t$ will cut back the current to the first step (63 %, 250 Arms).

 ©2019 DMC GmbH Herten Germany

Then 250 Arms is allowed to flow through the motor for a maximum time of 80 s. Then the $I^2t$ function will cut back current to the second step (40 %, 160 Arms).
To reach the final step, 160 Arms is allowed to flow for 500 s, and after that, 120 Arms for 75 min.

**The $I^2t$ starting temperature**

The $I^2t$ function will only be in operation when the temperature of the motor is above this starting temperature.
When the motor temperature is below this starting temperature, the $I^2t$ function is completely reset. Thus, the maximum drive current is allowed for the maximum time as set by the $I^2t$ step 0.

**Disabling the $I^2t$ function**

The $I^2t$ function can be disabled by setting the "$I^2t$ time" in the "Menu 7 "Limits Setup"" to zero (0) seconds.

**Other limits**

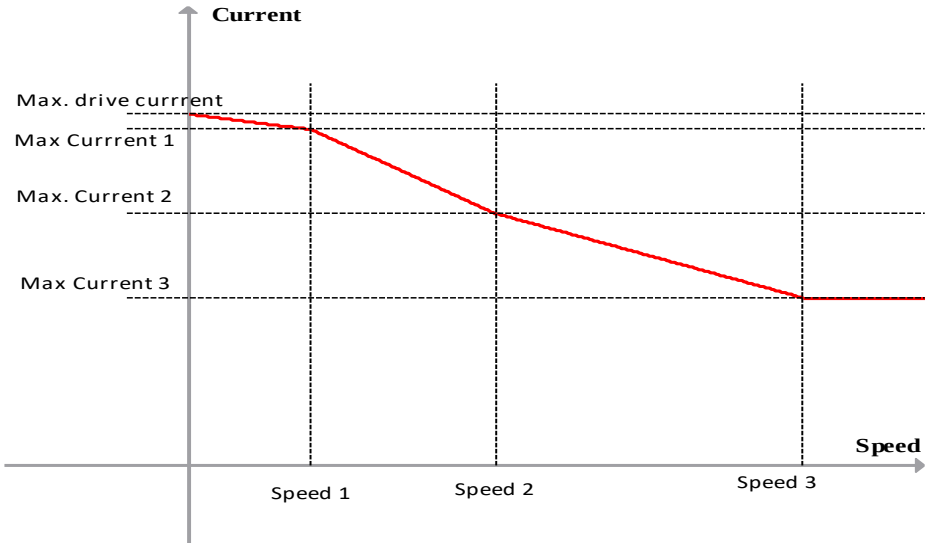
The controller may have other limits in effect (e.g. controller temperature limit, motor temperature limit or low voltage limit). The module which is limiting the most, will apply the limit. The "Drive torque limit" will then show the limit of the corresponding module.

Example

- Controller temperature limit 50 %
- $I^2t$ feature 80 %
- Applicable limit → 50 %
- Applicable module → Controller temperature (indicated by 'CT').

### M7-9 Performance Table Speed 1 "PTSpd1"
### M7-10 Performance Table Speed 2 "PTSpd2"
### M7-11 Performance Table Speed 3 "PTSpd3"
### M7-12 Performance Table Cutback 1 "PTCutBk1"
### M7-13 Performance Table Cutback 2 "PTCutBk2"
### M7-14 Performance Table Cutback 3 "PTCutBk3"

The Performance Table feature (setting from 7.9 to 7.14) is a current limiting feature: the maximum current is limited with increasing speed. With higher speeds, the electrical losses are increasing.
The Performance Table sets a specified percentage of the maximum drive current for a specified speed as shown in the graph below. The Performance Table will only limit the drive current, not the brake current.
The brake 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.




 ©2019 DMC GmbH Herten Germany

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:

- Maximum drive current ("ImotMax" in Autotune Menu)
- Performance Table Speed 1 (7.9)
- Performance Table Speed 2 (7.10)
- Performance Table Speed 3 (7.11)
- Percentage of the maximum drive current at speed 1 (7.12)
- Percentage of the maximum drive current at speed 2 (7.13)
- Percentage of the maximum drive current at speed 3 (7.14)

***Note*** *that the maximum current corresponding to 100% of Performance table cutback is specified by the maximum current in the Autotuning menu* ("M4-9 Maximum RMS motor current").

***Note*** *that the performance table speed are percentage of maximum speed expressed in Autotune Menu "M4-13* Maximum Motor Frequency*".*
*For example if 4.10 is 200 Hz and the desired three Performance table speeds are: Speed 1 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 5.14 to 5.18. It means that the lower value for current limiting between the Performance table and motor module current reduction map is applied.

 ©2019 DMC GmbH Herten Germany

**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 current rollback due to Performance Table; set the maximum current at speed 1,2 ,3 to 100 % (setting 7.9, 7.10 and 7.11)

### M7-15 Low Voltage Cut Back start threshold "LVCBstrt"
### M7-16 Low voltage cut back end threshold "LVCBend"
### M7-17 Low voltage error threshold "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.

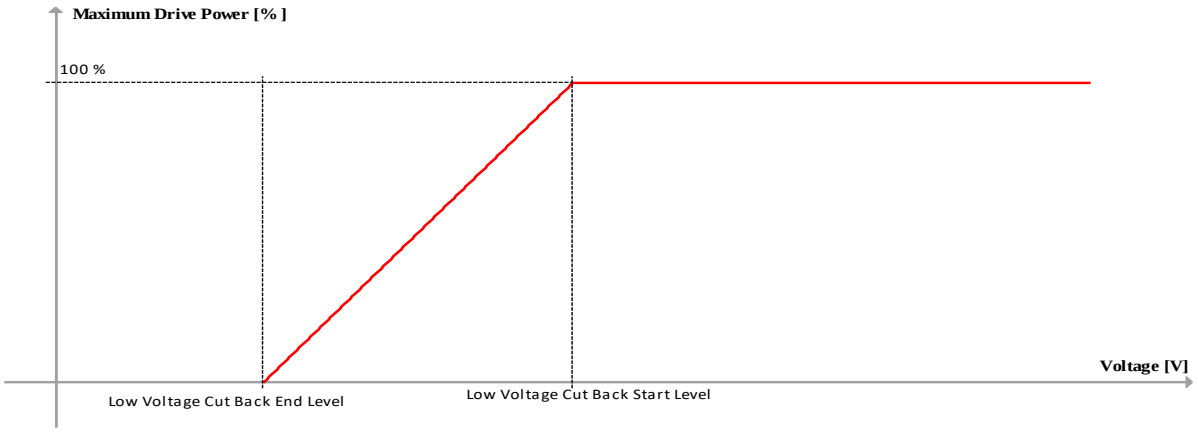
**Low voltage cut back**

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 Sigma2 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 pulsing) 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 7 "Limits Setup"".

 ©2019 DMC GmbH Herten Germany

### M7-18 High Voltage Cut Back start threshold HVCBstrt
### M7-19 High voltage cut back end threshold "HVCBend"
### M7-20 High voltage error threshold "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.

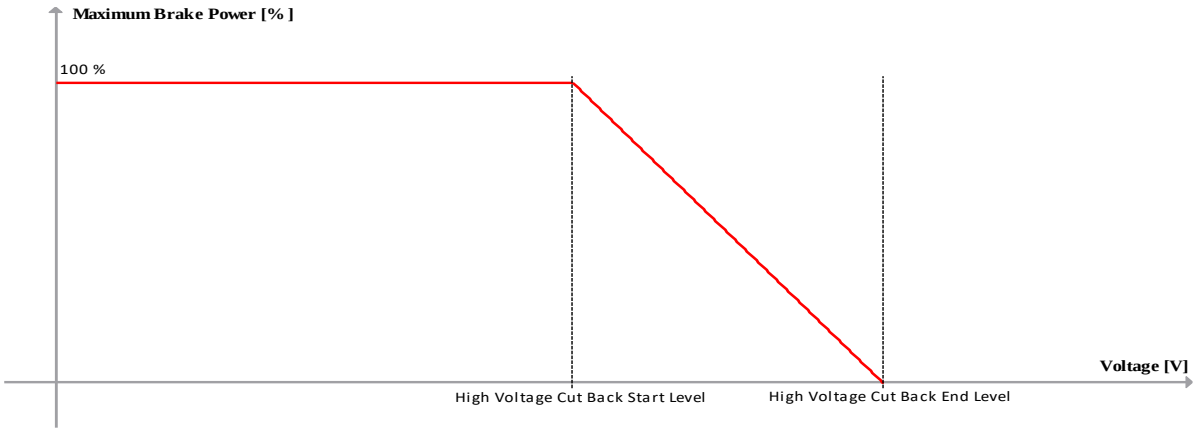
**High voltage cut back**

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 pulsing) 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 7 "Limits Setup"".

 ©2019 DMC GmbH Herten Germany

### 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.

Example

- Controller temperature limit 50 %
- Low voltage cut back limit[1)] 70 %
- High voltage cut back limit[1)] 30 %
- Applicable drive limit → 50 % → 'CT'
- Applicable brake 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 traction controller is able to drive and brake a motor. Driving can be demanded by the user, for example, forward drive or reverse drive. Braking can also be demanded by the user, for example, neutral brake and foot brake. However, when the user changes the direction from, say forward to reverse, the vehicle must first come to a stop before the actual direction can be changed. The controller will then use 'direction braking'.

But there is more. When the controller is using speed control, or is in a speed limit, the user is thinking he is driving the motor, but it is possible that the controller is braking the motor in order to control the speed. This is also a form of braking and here the high voltage cut back applies as well.

### M7-21 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 7.21 Absolute maximum motor speed "AbsMaxSp" a failure occurs (F30, see section "12.1 Error Codes"). For a proper tuning this parameter has to be set to 30% above the maximum speed set in the adjustment menu.

### M7-22 Torque Threshold for Stall Protection "TrqTHLim"
### M7-23 Stall protection Time "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 "M7-22 Torque Threshold for Stall Protection "TrqTHLim"" and for a time longer than "M7-23 Stall protection Time "StallTim"" the controller stops pulsing and a motor stall condition is detected.

Setting to 100% the "M7-22 Torque Threshold for Stall Protection "TrqTHLim"" the function is disabled. As default stall protection is disabled.

### M7-24 n/a
### M7-25 n/a

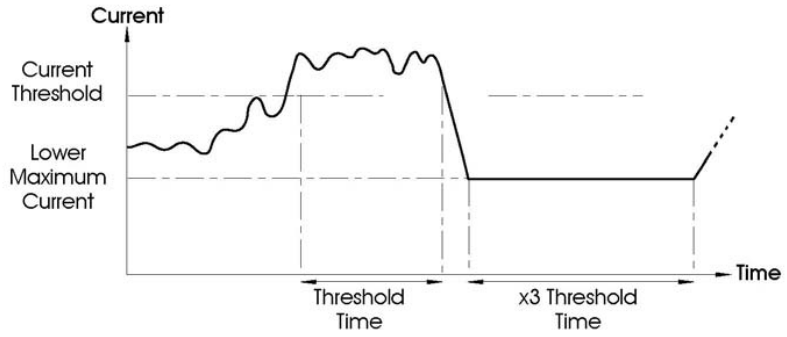
These two settings are not active in PMS software

 ©2019 DMC GmbH Herten Germany

## M7-26 Timed Current Limit Timer "IthTime"
## M7-27 Timed Current Limit max. Current threshold "CurrTh"
## M7-28 Timed Current Limit Low current threshold "ImaxLow"

**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 ("M7-27 Timed Current Limit max. Current threshold "CurrTh"") for a specified period of time ("M7-26 Timed Current Limit Timer "IthTime""), the controller can reduce the maximum current available to the motor to a lower current ("M7-28 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 3 times the "M7-26 Timed Current Limit Timer "IthTime"". If necessary, once this period has expired, the current can then be returned to its original level.




**Example**

This sets the period of time, which if exceeded, will initiate a reduction in the controller's maximum current output. A programmed value of zero disables the Timed Current Limit feature.
The adjustable range is 0s to 60s in 1s steps.

Example:
"M7-27 Timed Current Limit max. Current threshold "CurrTh"" is set to 420Arms
"M7-28 Timed Current Limit Low current threshold "ImaxLow"" is set to 400Arms
"M7-26 Timed Current Limit Timer "IthTime"" is set to 10s

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 30 seconds (3 x 10 secs).

 ©2019 DMC GmbH Herten Germany

# 10 Menu 8 "BDI" Battery Discharge Indicator

The following menu includes the settings for the BDI algorithm.

| Cal. Ref. | Parameter | Calibrator text | Min. adjust | Max. adjust | Step size | Default 48V | Default 96V |
|---|---|---|---|---|---|---|---|
| 1 | Battery Current Limit Via Can type | BlcCanMsg | 0 | 3 | 1 | 0 | 0 |
| 2 | Nominal battery voltage | NomBatV | 12. 0 V | Uabsmax | 1 V | 48 V | 96 V |
| 3 | BDI reset level | BDIreset | 12. 0 V | Uabsmax | 0.1 V | 50.2 V | 100.3 V |
| 4 | BDI empty level | BDIempty | 12. 0 V | Uabsmax | 0.1 V | 38.9 V | 77.8 V |
| 5 | BDI warning level | BDIwarn | 0 % | 99 % | 1 % | 20 % | 20 % |
| 6 | BDI cut out level | BDIcut | 0 % | 99 % | 1 % | 0 % | 0 % |
| 7 | BDI speed limit (traction only) | BDIspeed | 0.0 Hz | 400.0 Hz | 0.1 Hz | 100.0 Hz | 100.0 Hz |
| 8 | Drive Battery Current Limit (max. value) | IBattMax | 0.0 A | 700.0 A | 0.1 A | 700.0 A | 700.0 A |
| 9 | Regen Battery Current Limit | IBattReg | 0.0 A | 700.0 A | 0.1 A | 700.0 A | 700.0 A |

### M8-1 Battery Current Limit Via Can type "BlcCanMsg"

This setting can be used to enable the dynamic Battery Current Limits (BCL) via Can.

- If set to **0** Standard Battery with or without static battery current limit according to the setting "M8-8 Drive Battery Current Limit (max. value) "IBattMax"", "M8-9 Regen Battery Current Limit "IBattReg"". BDI (State of Charge Value) value is calculated inside controller as standard (typical for lead acid battery).
- If set to **1** Battery with BCL via can enabled. BDI value is calculated inside controller as standard (if standalone controller set as master or received via DMC can protocol from the master controller if multimotor and set as slave).
- If set to **2** Battery with BCL via can enabled. BDI value is received VIA can in the BCL message if controller is standalone set as master. If slave control receive BDI value from master controller. This option is compatible with DMC display multimotor application.
- If set to **3** Battery with BCL via can enabled. BDI value is received VIA can in the BCL regardless is master control or slave. This option is compatible with multi controller multi battery application (NO DMC display).
  If BCL via CAN is enabled controller expect to receive BCL can message.
  A timeout timer is enabled in the controller for detecting if BCL can message is coming.
  The time out time is fixed to 1s. The suggested refresh rate of BCL message for external BMS or VCU is 400-500ms.
  If a new message is not coming within 1s timeout controller signals F03 S003. It keep pulsing since BCL is not related to safety. F03 S003 is self-recovery as soon a new BCL message is back.
  If BCL is missing the battery current limits set in "M8-8 Drive Battery Current Limit (max. value) "IBattMax"" and "M8-9 Regen Battery Current Limit "IBattReg"" are adopted.
  In BCL Can message is required VCU/BMS send a toggling security bit. If toggling security bit error occurs F03 S004 is signaled the battery current limits set in "M8-8 Drive Battery Current Limit (max. value) "IBattMax"" and "M8-9 Regen Battery Current Limit "IBattReg"" are adopted.

In following table the format of BLC can message is detailed

| ID | *DLC* | | Format | unit | min | max | Gain | Bytes | Start Bit |
|---|---|---|---|---|---|---|---|---|---|
| ***0XF1x*** **x = CAN node number** ***(BCL Via CAN)*** | *8* | **Drive/Delivering Battery Max current Limit** | unsigned int | **A** | 0 | 7000 | 1/10 | 0,1 | 0 |
| | | **Brake/Regen Battery current Limit** | unsigned int | **A** | 0 | 7000 | 1/10 | 2,3 | 16 |
| | | **BDI Value / S.O.C.** | unsigned int | **%** | 0 | 1000 | 1/10 | 4,5 | 32 |
| | | **Spare not used** | unsigned char | | 0 | 255 | 1 | 6 | 48 |
| | | **Bit 0 Toggle Security Bit** | bool | | 0 | 1 | 0 | 7 | 56 |

The unsigned int data assume Motorola data format.
The current limits has a resolution of 0.1 A. The BDI Value/ SOC is in percentage and has a resolution of 0.1%.

 ©2019 DMC GmbH Herten Germany

### M8-2 Nominal battery voltage "NomBatV"
Is the nominal value of the battery connected to the controller.

### M8-3 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.

### M8-4 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 "M8-2 Nominal battery voltage "NomBatV"" battery voltage, the BDI value will start to decrease.

### M8-5 BDI warning level "BDIwarn"
This sets the level of battery voltage at which the BDI warning icon on the Sigmagauge and DMC Display will start to flash. The value is set as a percentage, where 100% corresponds to parameter "M8-3 BDI reset level "BDIreset"" and 0% corresponds to parameter "M8-4 BDI empty level "BDIempty"".
The calibrator displays the BDI warning condition in "Menu 2 "Status"".

### M8-6 BDI cut out level "BDIcut"
This parameter has a different effect between traction and pump software and can be disabled by setting it to 0.

In traction software, this sets the level of battery voltage at which the speed of the vehicle will be limited to a value set by the parameter "M8-7 BDI speed limit "BDIspeed"".
The value is set as a percentage, where 100% corresponds to parameter "M8-3 BDI reset level "BDIreset"" and 0% corresponds to parameter "M8-4 BDI empty level "BDIempty"".

In Pump software if the level of battery voltage is below "M8-6 BDI cut out level "BDIcut"" the pump is stopped, with the exception of the Speed6/PowerSteer operation.
The calibrator displays the BDI cut condition in the "Menu 2 "Status"" at lines 2 (F03) and line 3 (Bdi valule and BDI status), by pressing + or – buttons.

### M8-7 BDI speed limit "BDIspeed"
This set is active only for traction software. It is not active for pump software.
This sets the maximum speed of the vehicle if the BDI level is below the value set by the parameter "M8-6 BDI cut out level "BDIcut"".

### M8-8 Drive Battery Current Limit (max. value) "IBattMax"
### M8-9 Regen 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 "M8-1 Battery Current Limit Via Can type "BlcCanMsg"".

 ©2019 DMC GmbH Herten Germany

# 11 Menu 9 "CAN Bus Setup"

The SuperSigma2 controller uses our own CAN bus protocol for sending and receiving information to and from other CAN nodes. The protocol is designed for the SuperSigma2 to act as a slave in an existing CAN environment. Detailed information about the protocol will be provided on request. See [2] for further details.

As default the CAN system is deactivated.

| Cal. Ref. | Parameter | | Calibrator text | Options (defaults are in bold) | | Default |
|---|---|---|---|---|---|---|
| 1 | CAN Node Number | | CAN node | Node number **0** to 15 | | 0 |
| 2 | CAN bit rate | | CANbitRt | CAN bus speed:<br>**0 = 100kbps**<br>1 = 125kbps<br>2 = 250kbps | | 0 |
| 3 | Transmit/Receive CAN messages<br><br>Used short descriptions: | | CANMsgs | 0= DC & DS<br>1 = DC & DS & MS<br>2 = DC & DS & CS<br>3 = DC & DS & CS & MS<br>**4= no CAN message**<br>5= DS only<br>6= MS only<br>7= DS & MS<br>8= CS only<br>9= CS & DS<br>10= CS & MS<br>11= CS & MS &DS | (Receive &Transmit)<br>(Receive &Transmit)<br>(Receive &Transmit)<br>(Receive &Transmit)<br><br>(Transmit only)<br>(Transmit only)<br>(Transmit only)<br>(Transmit only)<br>(Transmit only)<br>(Transmit only)<br>(Transmit only) | 4 |
| | DC : drive command<br>DS : drive status<br>MS : Motor status<br>CS : controller status | (receive)<br>(transmit)<br>(transmit)<br>(transmit) | | | | |
| 4 | Shared Line Contactor | | ShareLC | **0 = No shared line contactor**<br>1 = Shared line contactor<br>2 = Shared line contactor CAN HMI master<br>3 = Shared line contactor CAN HMI slave | | 0 |
| 5 | Last Node Sharing Line Contactor | | LstNode | Node number **1** to 15 | | 1 |
| 6 | Can Control Type<br>(only Traction Software) | | CANCtTyp | **0 Speed Limit Via Can Disabled, Safe Stop 1 Disabled**;<br>1 Speed Limit Via Can Enabled, Safe Stop Disabled;<br>2 Speed Limit Via Can Disabled, Safe Stop Enabled;<br>3 Speed Limit Via Can Enabled, Safe Stop Enabled; | | 0 |
| 7 | CAN motor status transmit rate | | CAN_MS | 100 to 1000ms | | 100ms |
| 8 | CAN controller status transmit rate | | CAN_CS | 100 to 1000ms | | 1000ms |
| 9 | CAN drive status transmit rate | | CAN_DS | 100 to 1000ms | | 100ms |
| 10 | CAN controller timeout timer | | CAN_TO | 100 to 500ms | | 150ms |
| 11 | CAN node ID Via digital Inputs | | CAN_DIG | **0 standard node ID**<br>1 Can node identification via DigInp 1,2,3 and 5 (active only if "CANMsgs" < 4) | | 0 |

**Recycle the key switch to make changes active. (Also indicated on calibrator 'key')**

 ©2019 DMC GmbH Herten Germany

### M9-1 CAN Node Number "CAN node"

This sets the CAN node number for the controller.

- If set to **0 (Master)**, then this controller is responsible for the following:
  - I. Manage the General Indication Field as described in "M3-11T Display Status field "Of/D/V/K"" (Traction) or "M3-6P Display Status Field – "Of/D/V/K"" (Pump);
  - II. Transmit the BDI information to the Sigmagauge or DMC Display;
  - III. Transmit the BDI information to all other controllers (slaves), attached to the CANbus;
  - IV. Check the state of all slaves when a shared line contactor is used;
  - V. Control the line contactor when a shared line contactor is used;
  - VI. Transmit device, fault code and sub code and pulsing information to the Sigmagauge or the DMC Display.
- If set from 1 to 15, the controller will be a slave.

In multiple controller systems, it is essential that all CAN nodes have a unique number.
A slave uses the BDI information received from the master, so it disregards its own BDI Menu and associated settings; however its own BDI cut-out levels "M8-6 BDI cut out level "BDIcut"" and "M8-7 BDI speed limit "BDIspeed"" still apply. In this way all devices in the CAN network have the same BDI information, but each controller can set up its own cut-out and speed levels.
All slaves send out their device, fault code and sub code and pulsing information to the Sigmagauge or DMC Display.
In a non-CANbus system, the controller(s) should have this parameter set to 0. This is particularly important if the BDI is used, as the BDI calculation will not work when a controller is set up as a slave.

### M9-2 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

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

**! 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.**

To change the calibrator bit rate follow this procedure:

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 SEL and information about calibrator will appear.
4) Press ▷ or ◁ to increase or decrease the CAN bitrate.
5) When the desired bit rate is displayed cycle the key of controller for resetting the calibrator.
6) The calibrator at new power up will operate on CAN bus at the selected bit rate.

**! VERY IMPORTANT If the calibrator bit rate and controller bit rate are set in a not consistent way the calibrator is not communicating with the controller.**

### M9-3 Transmit/Receive CAN messages "CANMsgs"

This setting allows to select the activation of the CAN HMI protocol.

- If it is set to **4**, the CAN HMI (Human Machine Interface) is not active. If it is set different from 4 shared line contactor, sigmagauge, DMC Display and multicontroller BDI management are not available.
- If it is set **from 5 to 11**, CAN HMI messages will display several information on CAN BUS.
- If it is set **from 0 to 3**, CAN HMI allows Control Via Can of the Supersigma2 Controller.

Using CAN HMI messages allows to insert the controller in an existing CAN network with third party devices. Refer to [2] for all details.

### M9-4 Shared Line Contactor "ShareLC"

This sets whether the controller has to share a line contactor with another controller(s) in a CANbus network. The "Shared Line Contactor" function is managed by the Controller which is set up to be the Master ("M9-1 CAN Node Number "CAN

 ©2019 DMC GmbH Herten Germany

node"" set to 0). It is in charge ok regularly checking all slaves that share the line contactor, in addition to controlling the line contactor itself. If the Master Controller or one of the slaves reports a hard error (Fault code > 15), or if one of the slave controllers fails to respond to him, it will open the line contactor and send a warning message to each of the slaves that are sharing it to go into a 'safe' mode.
If parameters are set up incorrectly, the Master Controller will issue an error.
The first two options (0 and 1) are valid only if CAN HMI messages are disabled ("M9-3 Transmit/Receive CAN messages "CANMsgs""set to 4).

- If set to **0 (No Sharing)**, then each controller must have a separate line contactor.
- If set to **1 (Sharing)**, then the Slave Controllers on the CAN network will be able to use the line contactor managed by the Master Controller.
  Mind that the Slave Controllers MUST be set up with CAN ID starting from 1 without skipping any node number.
  If this value is selected, then the parameter "M9-5 Last Node Sharing Line Contactor "LstNode"" must also be set on the Master Controller. Setting this parameter on a slave has no effect.
- If set to **2 (Sharing with CAN HMI active, Master)**, refer to [2].
- If set to **3 (Sharing with CAN HMI active, Slave)**, refer to [2].

### M9-5 Last Node Sharing Line Contactor "LstNode"

This setting is used to indicate which is the last node sharing the line contactor managed by the master. If the CAN HMI is not used ("M9-3 Transmit/Receive CAN messages "CANMsgs""set to 4) and therefore "M9-4 Shared Line Contactor "ShareLC"" is set to 0 or 1, only the Master Controller uses this setting. Setting it on a slave controller has therefore no influence.
This should be set to the highest node number of controllers sharing the line contactor.

**Example**: if there are four controllers connected and they have node numbers of 0, 1, 2 and 3, then this parameter should be set to 3.

If "M9-4 Shared Line Contactor "ShareLC"" is set to 2 or 3 please refer to [2] for configuration.

### M9-6 Can Control Type "CANCtTyp"
### M9-7 CAN motor status transmit rate "CAN_MS"
### M9-8 CAN controller status transmit rate "CAN_CS"
### M9-9 CAN drive status transmit rate "CAN_DS"
### M9-10 CAN controller timeout timer "CAN_TO"

All these settings allow to use the controller in a CAN network with third party devices. They are active if parameter "M9-3 Transmit/Receive CAN messages "CANMsgs"" is set different from 4 thus enabling CAN HMI messages.
Refer to [2] for further details.

### M9-11 CAN Node ID via digital input "CAN_DIG"

This allow to assign the Controller's Node Number from physical inputs. To make this active, also control Via Can HMI must be activated ("M9-3 Transmit/Receive CAN messages "CANMsgs"" set lower than 4) and the Can Node assigned by physical digital input must be between 1 and 15.
If some of the mentioned conditions are not fulfilled (F7 S014, F29 S013) will appear (see error code list).
The Can node ID number is assigned by means of the pins reported in the following list

- DI 1 (pin 1) (LSB)
- DI 2 (pin 2)
- DI 3 (pin 3)
- DI 5 (pin 5) (MSB)

With the following logic:

Can Node Number = 8*DI5 + 4* DI3 + 2* DI2 + DI 1

Inputs have to be considered normally open (if switch connected open DIx=0, if switch connected closed Dix=1).
The node number is assigned only once at power up.

 ©2019 DMC GmbH Herten Germany

# 12 Diagnostics

## 12.1 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 2 “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 |
| 4 | Voltage getting high | 1 | Battery voltage above absolute minimum |
| | | 2 | Capacitor voltage above absolute minimum |
| | | 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 | 1 | Master does not share the line contactor but any one of the slave does |
| | | 2 | Master shares the line contactor but one of the requested slave doesn’t |
| | | 3 | A slave node number larger than last sharing node also share the line contactor |
| | | 4 | WigWag is enabled but walkie is not |
| | | 5 | inching and walkie are both enabled |
| | | 6 | dual motor with speed control mode |
| | | 7 | shared LC and Control Via CAN HMI both active |
| | | 8 | Inching and Control Via CAN HMI both active |
| | | 9 | Walkie and Control Via CAN HMI both active |
| | | 10 | Control Via CAN HMI enabled and CAN node number set as master |
| | | 11 | Hill hold Enabled and Torque control enabled |
| | | 12 | --- |
| | | 13 | CAN control type options are active but Control Via CAN HMI is not enabled. |
| | | 14 | Can Node ID via digital input enabled but control but Control Via CAN HMI is not enabled. |
| | | 15 | means Shared Line Contactor HMI option is activated (“ShareLC”>=2) on but not control via CAN HMI active (CANMsgs>=4). Solution set CANMsgs < 4. |

**Errors continue at next page…**

 ©2019 DMC GmbH Herten Germany

… Errors continue from previous page

| Base fault Code | Description | Sub fault code | Description |
|---|---|---|---|
| 7 | Adjustment out of range | 16 | Shared Line contactor HMI “master node” (“CAN node”) is higher/equal than last node (“LstNode”). This happens in the controller with the setting “ShareLC”=2 if “CAN node”>= “LstNode”, that is a non-sense. Solution: check node assignment, and make sure “CAN node” < “LstNode |
| | | 17 | Shared Line contactor HMI “slave node” “CAN node”) is lower/equal than Shared Line contactor HMI “master” node (defined in “LstNode”). This happens in the controller with the setting “ShareLC”=3 if “CAN node”<= “LstNode”, that is a non-sense. Solution: check node assignment, and make sure “CAN node” > “LstNode” |
| | | 18 | Safe Stop 1 and CAN node ID Via digital Inputs not compatible |
| | | 19 | PC interface request controller to stop pulsing |
| | | < 999 | First digit: menu number<br>Last 2 digits: adjustment number within menu |
| | | 999 | Power PCB doesn't match firmware |
| 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 | Ride-on: Seat switch not closed or timed out<br>Walkie: Tiller switch not closed | - | |
| 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 | 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 |
| | | 6 | Hand Brake active when inching |
| | | 7 | Both inching buttons active when inching |
| | | 8 | Inching buttons active when normal drive |
| | Belly switch active | - | |

Errors continue at next page…

 ©2019 DMC GmbH Herten Germany

… Errors continue from previous page

| Base fault Code | Description | Sub fault code | Description |
|---|---|---|---|
| **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 |
| 16 | N/A | | |
| 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 | - | |
| **Hard error faults - Immediately stops pulsing and open line contactor – Reset only by a key switch recycle** | | | |
| 20 | Hardware over current detected | 1 | Positive overcurrent detected during initialization |
| | | 2 | Negative overcurrent detected during initialization |
| | | 3 | Positive overcurrent detected |
| | | 4 | Negative overcurrent detected |
| | | > 4 | Contact DMC |
| 21 | Contactor coil driver fault (e.g. short circuit) | 1 | Digital contactor output 1 short circuit during initialization |
| | | 2 | Digital contactor output 1 short circuit at closing |
| | | 3 | Digital contactor output 1 short circuit when closed |
| | | 4 | Digital contactor output 2 short circuit during initialization |
| | | 5 | Digital contactor output 2 short circuit at closing |
| | | 6 | Digital contactor output 2 short circuit when closed |
| | | 7 | Digital contactor output 3 short circuit during initialization |
| | | 8 | Digital contactor output 3 short circuit at closing |
| | | 9 | Digital contactor output 3 short circuit when closed |
| | | 10 | Digital output 4 short circuit during initialization |
| | | 11 | Digital output 4 short circuit at closing |
| | | 12 | Digital output 4 short circuit when closed |
| | | 13 | Unknow fault |
| 22 | Voltage is 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 |

Errors continue at next page…

 ©2019 DMC GmbH Herten Germany

… Errors continue from previous page

| Base fault Code | Description | Sub fault code | Description |
|---|---|---|---|
| **Hard error faults - Immediately stops pulsing and open line contactor – Reset only by a key switch recycle** | | | |
| 24 | Hardware fail safe fault | 1 | Cannot finish checking the hardware fail safe |
| | | 2 | Hardware fail safe feedback is low at startup |
| | | 3 | Hardware fail safe feedback is high during toggling |
| | | 4 | Hardware fail safe feedback is low after toggling stops |
| | | 5 | Hardware fail safe encountered an unknown error |
| | | 6 | Hardware fail safe is not alive during normal run |
| | | 7 | Main loop is stuck |
| | | 8 | Software watchdog caused a reset. Recalculation is disabled now! |
| 25 | Line contactor fault (e.g. short circuit) | 1 | Could not discharge the capacitor bank |
| | | 2 | Capacitor bank dit not charge sufficiently to safely close the line contactor |
| | | 3 | Line contactor opened inadvertently |
| 26 | Thermal shutdown fault (only for minimum pump speed fault) | 1 | Pump thermal shutdown |
| | | 2 | Pump low voltage shotdown |
| 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 or noise detected (AC only) |
| | | 2 | 5 V supply wire off detected |
| | | 3 | 0 V supply wire off detected |
| | | 4 | Wig-wag out of safety range |
| | | 5 | Motor Temperature Sensor wire off |
| 29 | CAN node fault | 1 | shared Line Contactor slave time out fault |
| | | 2 | shared Line Contactor Master fails to broadcast to slaves |
| | | 3 | shared Line Contactor requested slave is not found by master |
| | | 4 | shared Line Contactor master time out fault |
| | | 5 | Control Via CAN HMI timeout (not receive CAN Drive Command Message from VCU) |
| | | 6 | Control Via CAN HMI security bit error (VCU fails to toggle security bit) |
| | | 7 | Control Via CAN HMI enable switch/wire is not connected |
| | | 13 | Can Node ID via digital inputs is detected to 0, check input status |
| 30 | Motor overspeeding | 1 | Motor speed is too high to commence safe pulsing (speed is > 80 % of maximum motor speed) |
| | | 2 | Motor speed is higher than absolute maximum speed (Check Absolute Maximum Speed) |
| 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" |

Errors continue at next page…

 ©2019 DMC GmbH Herten Germany

… Errors continue from previous page

| Base fault Code | Description | Sub fault code | Description |
|---|---|---|---|
| **Hard error faults - Immediately stops pulsing and open line contactor – Reset only by a key switch recycle** | | | |
| 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 | - | |
| 39 | Generic time out | 1 | Time out on configuration upload |
| | | 2 | Time out on getting stable inputs |
| | | 3 | Time out on motor ready |
| 40 | System Fault | > 0 | Internal system error Contact DMC |

 ©2019 DMC GmbH Herten Germany

## 12.2 PMS Motor sub error codes

| Sub Code | Description |
|---|---|
| 0 | No errors in the motor module. |
| 1 | The motor module could not be initialized. |
| 2 | An overcurrent is detected |
| 3 | Internal error refer to DMC |
| 4 | Wrong current: rated motor current is greater than max |
| 5 | Wrong poles number (is odd) |
| 6 | Wrong settings: rated motor voltage is too high in relation with the battery voltage capability. Check battery voltage set in autotuning menu. Load defaults and reparmetrize |
| 7 | Internal error refer to DMC |
| 8 | Internal error refer to DMC |
| 9 | Sine signal is out of range: check connection and sensor |
| 10 | Cosine signal is out of range: check connection and sensor |
| 11 | No Hall sensor signals; check connection and sensor |
| 12 | Unable to perform recalculation: motor calculated maximum speed exceeds 500 Hz. Check motor parameters. |
| 13 | Unable to perform recalculation: limit curves; check motor parameters (Ls, Ke, Fmax, Idemag) in auto tune menu. |
| 14 | Unable to calculate controller gains: check motor parameters (Ls, Ke, Fmax, Idemag) and perform recalculation or do autotuning again. |
| 15 | Internal error refer to DMC |

 ©2019 DMC GmbH Herten Germany

# 13 Use of Calibrator and PC interface

| | |
|---|---|
| | Starting from V02.07.01 the V01.02.08 DMC PC interface or later for SuperSigma2 has to be used. V01.02.08 DMC PC interface can open setting list generated with previous releases.<br><br>V01.02.08 DMC PC interface is dedicated to SuperSigma2 generation but it is still compatible with Sigma Drive controllers. |

 ©2019 DMC GmbH Herten Germany

# 14 Available Application Notes and Manuals

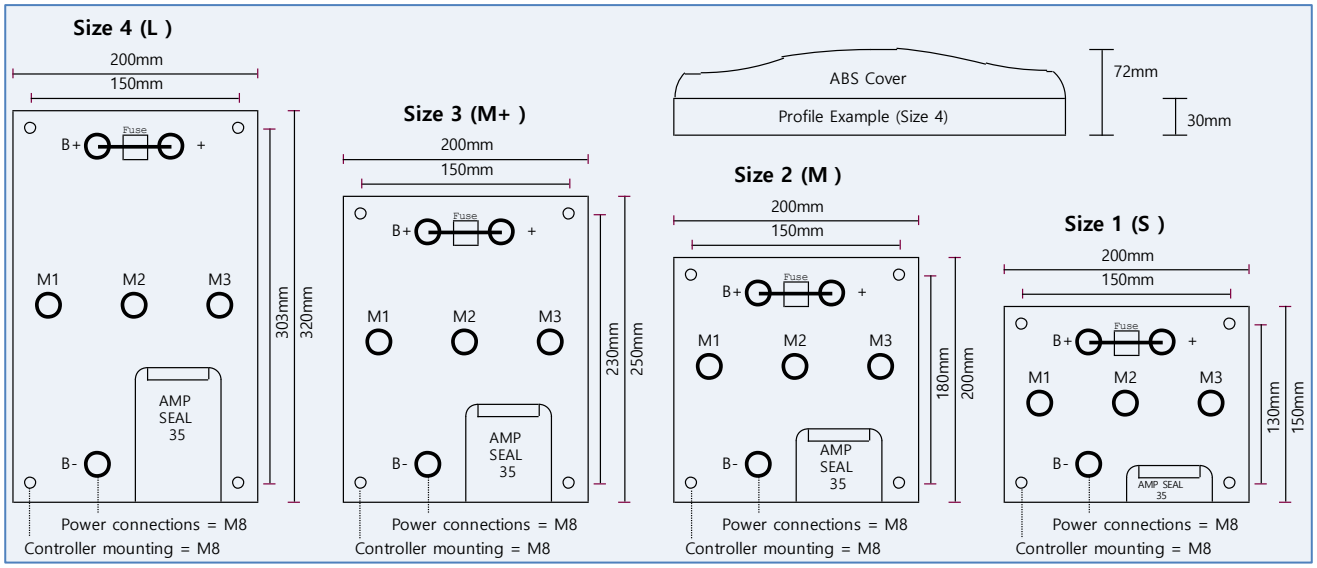
**The following application notes/ manuals are available upon request.**

| AN | Title | Version |
|---|---|---|
| 160208 | SuperSigma2 – Flash Programmer Demo - Description | V1.0 |
| | DMC_PC_Interface_Manual_V1.3 | |
| 130102 | Sigma2 - AN 130102 - I2t Setup | |
| 160105 | AN 160105 SuperSigma2 - CAN Messages_V2_8 | V2.8 |
| 160105 | Sigma2 AN 160105 - SuperSigma2 Can HMI Protocol V1.7 | V1.7 |
| | SuperSigma2 PMS Quick Reference Manual V01.02.02 SW 02.09.0 | V01.02.00 |

 ©2019 DMC GmbH Herten Germany

# 15 Mechanical Drawings

## 15.1 SuperSigma2 Controllers




# 16 Contact information

DMC GmbH
Auf dem Hochstück 11
45701 Herten Germany

Tel: +49 (0) 2366 10070
Fax: +49 (0) 2366 100750
Email: info@dmcde.de
Web: www.dmcde.de