Product Specification

Polymer Li-ion Battery

3.7V 6350mAh 15C

(Model No.:SLPBA843126)

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1. 序言 PREFACE

此规格书适用于深圳风云电池有限公司的锂聚合物可充电电池产品

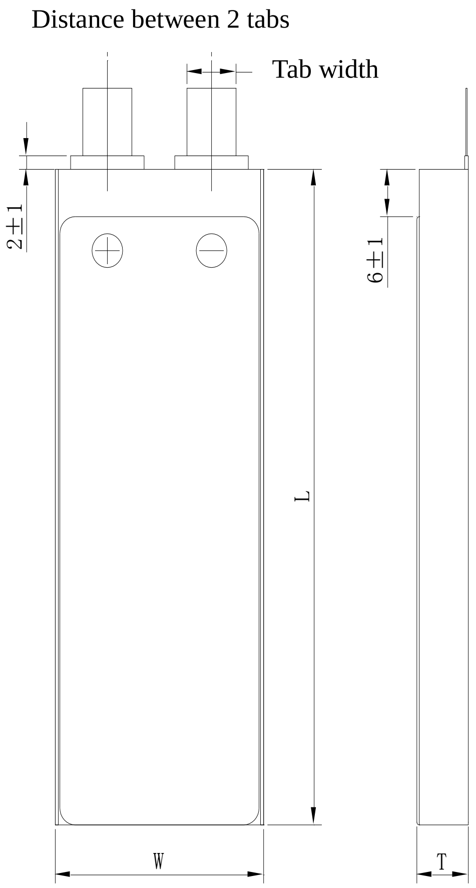
The specification is suitable for the performance of Lithium-Polymer (LIP) rechargeable battery produced by the SHENZHEN MELASTA BATTERY CO., LTD.

2. 型号 MODEL

SLPBA843126 6350mAh 15C 3.7V

3. 产品规格 SPECIFICATION

单颗电池规格 Specifications of single cell



◆标称容量 Typical Capacity①		6.35Ah
◆标称电压 Nominal Voltage		3.7V
◆充电条件 Charge Condition	最大电流 Max. Continuous charge Current	12.7A
	峰值充电 Peak Charge current	25.4A(≤1 sec)
	电压 Voltage	4.2V±0.03V
◆ 放电条件 Discharge Condition	Max Continuous discharge Current	95.25A
	Peak Discharge Current	127A
	Cut-off Voltage	3.0V
◆交流内阻 AC Impedance(mOHM)		≤2.0
◆循环寿命【充电:1.0C,放电:15C】 Cycle Life【CHA:1.0C,DCH:15C】		≥100cycles
◆使用温度 Operating Temp.	充电 Charge	0℃~45℃
	放电 Discharge	-20℃~60℃
◆ 电芯尺寸 Cell Dimensions	厚度 Thickness(T)	10.5±0.3mm
	宽度 Width(W)	42.7±0.5mm
	长度 Length(L)	127.5±0.5mm
	极耳间距 Distance between 2 tabs	21±1mm
◆ 极耳尺寸 Dimensions of Cell tabs	极耳宽度 Tab Width	15mm
	极耳厚度 Tab Thickness	0.2mm
	极耳长度 Tab Length	25mm
◆重量 Weight(g)		131±2
①标称容量：0.5CmA,4.2V~3.0V@23℃±2℃ Typical Capacity:0.5CmA,4.2V~3.0V@23℃±2℃		

4.电芯性能检查及测试 BATTERY CELL PERFORMANCE CRITERIA

在进行下例各项测试前每颗电池应用 0.5C 放至 3.0V。如果没有特别规定，测试应在电池交付 1 个月内按以下各项条件进行：

Before proceed the following tests, the cells should be discharged at 0.2C to 3.0V cut off. Unless otherwise stated, tests should be done within one month of delivery under the following conditions:

环境温度 Ambient temperature:　20℃±5℃

相对湿度 Relative Humidity:　65±20%RH

注意标准充放电为 Note Standard Charge/Discharge Conditions:

充电 Charge:　以 0.5C 电流恒流充电至限制电压 4.2V 时,改为恒压充电,直到截止电流为 0.05C 时停止充电;The battery will be charged to 4.2V with 0.5C from constant current to constant voltage, when the current is 0.05C, stop to charge.;

放电 Discharge:　0.5C to 3.0V/cell

测试项目 Test	单位 Unit	规格 Specification	条　件 Condition	备　注 Remarks
容量 Capacity	mAh	≥6350	标准充放电 Standard Charge / Discharge	允许循环 3 次 Up to 3 cycles are allowed
开路电压 Open Circuit Voltage (OCV)	V	≥4.15	标准充电后 1 个小时内 Within 1 hr after standard charge	单位颗 Unit cell
内阻 Internal Impedance (IR)	mΩ	≤2.0	充满电后用 1kHz 测试 Upon fully charge at 1kHz	*
高倍率放电 High Rate Discharge (15C)	min	≥3.6	标准充电/休息 5 分钟 用 15C 放电至 3.0V Standard Charge/rest 5min discharge at 15C to 3.0V	允许循环 3 次 Up to 3 cycles are allowed
低温放电 Low Temperature Discharge	min	≥210	标准充电后贮藏在-20±2℃环境中 2 小时 然后用 0.2C 放电 Standard Charge, Storage:2hrs at-2 0±2℃ 0.2C discharge at 0±2℃	3.0V/cell Cut-off
自放电 Charge Reserve	min	≥90% （初始容量 First Capacity）	标准充满电后 20 度贮藏 30 天， 标准 0.5C 放电 Standard charge Storage at 20 degree: 30days Standard discharge (0.5C)	3.0V/cell Cut-off
寿命测试 Cycle Life Test	Cycle	≥100	充电：1C 充电至 4.2V，放电，15C 放电至 3.0V，当放电容量降至初始容量的 80%时，所完成的循环次数定义为该电芯的循环寿命 Charge:0.5C to 4.2V ,Discharge: 1C to 3.0V, 80% or more of 1st cycle capacity at 15C discharge of Operation	Retention capacity 容量保持 ≥ 80% of initial capacity
短路测试 External Short Circuit	N/A	不着火不爆炸 No Fire and No Explosion	标准充电后，在 20℃±5 环境中用超过 0.75mm² 金属丝将单颗电池短路至电池恢复到常温。 After standard charge, short-circuit the cell at 20℃±5℃ until the cell temperature returns to ambient temperature.(cross section of the wire or connector should be more than 0.75mm²)	*

自由跌落测试 Free Falling(drop)	N/A	不着火不爆炸 No Fire and No Explosion	跌标准充电后，搁置 2 小时。从 50CM 高任意方向自由跌落 30MM 厚木板 3 次 Standard Charge,and then leave for 2hrs,check battery before / after drop Height: 50 cm Thickness of wooden board: 30mm Direction is not specified Test for 3 times	*

5. 贮存及其它事项 STORAGE AND OTHERS

5.1 环境温度 Ambient temperature: 20℃±5℃

相对湿度 Relative Humidity: 65±20%RH

5.2 请每隔 3 个月按下面方法激活电池一次:

Please activate the battery once every 3 months according to the following method:

0.2C 充电至 4.2V，休息 5 分钟，然后用 0.2C 放电至每颗电池 3.0V，休息 5 分钟，0.2C 充电 3.9V。

Charge at 0.2C to 4.2V, rest 5 min, then discharge with 0.2C to 3.0V/cell,rest 5 min, then charge at 0.2C to 3.9V.

6. 聚合物锂离子充电电芯操作指示及注意事项 HANDLING PRECAUTIONS AND GUIDLINE

声明一：

客户若需要将电芯用于超出文件规定以外的设备，或在文件规定以外的使用条件下使用电芯，应事先联系鸿星，因为需要进行特定的实验测试以核实电芯在该使用条件下的性能及安全性。

Note(1):

The customer is requested to contact MELASTA in advance, if and when the customer needs other applications or operating conditions than those described in this document. Additional experimentation may be required to verify performance and safety under such conditions.

声明二：

对于在超出文件规定以外的条件下使用电芯而造成的任何意外事故，风云公司概不负责

Note(2):

MELASTA will take no responsibility for any accident when the cell is used under other conditions than those described in this Document.

声明三：

如有必要，风云公司会以书面形式告之客户有关正确操作使用电芯的改进措施。
MELASTA will inform, in a written form, the customer of improvement(s) regarding proper use and handing of the cell, if it is deemed necessary.

6.1. 充电 Charging

6.1.1 充电电流 Charging current:

充电电流不得超过本标准书中规定的最大充电电流。使用高于推荐值电流充电将可能引起电芯的充放电性能、机械性能和安全性能的问题，并可能会导致发热或泄漏。

Charging current should be less than maximum charge current specified in the Product Specification. Charging with higher current than recommended value may cause damage to cell electrical, mechanical and safety performance and could lead to heat generation or leakage.

6.1.2. 充电电压 Charging voltage:

充电电压不得超过本标准书中规定的额定电压（4.2V/电芯）。4.25V 为充电电压最高极限，充电器的设计应满足此条件；电芯电压高于额定电压值时，将可能引起电芯的充放电性能、机械性能和安全性能的问题，可能会导致发热或泄漏。

Charging shall be done by voltage less than that specified in the Product Specification (4.2V/cell).

Charging beyond 4.25V, which is the absolute maximum voltage, must be strictly prohibited. The charger shall be designed to comply with this condition. It is very dangerous that charging with higher voltage than maximum voltage may cause damage to the cell electrical, mechanical safety performance and could lead to heat generation or leakage.

6.1.3. 充电温度 Charging temperature:

电芯必须在 0℃~45℃的环境温度范围内进行充电

The cell shall be charged within 0℃~45℃ range in the Product Specification.

6.1.4. 禁止反向充电 Prohibition of reverse charging:

正确连接电池的正负极，严禁反向充电。若电池正负极接反，将无法对电芯进行充电。同时，反向充电会降低电芯的充放电性能、安全性，并会导致发热、泄漏。

Reverse charging is prohibited. The cell shall be connected correctly. The polarity has to be confirmed before wiring, In case of the cell is connected improperly, the cell cannot be charged. Simultaneously, the reverse charging may cause damaging to the cell which may lead to degradation of cell performance and damage the cell safety, and could cause heat generation or leakage.

6.2．放电 Discharging

6.2.1. 放电电流 Discharging current

放电电流不得超过本标准书规定的最大放电电流，大电流放电会导致电芯容量剧减并导致过热。

The cell shall be discharged at less than the maximum discharge current specified in the Product Specification. High discharging current may reduce the discharging capacity significantly or cause over-heat.

6.2.2. 放电温度 Discharging temperature

电芯必须在-20℃~60℃的环境温度范围内进行放电。

The cell shall be discharged within -20℃~60℃ range specified in the Product Specification.

6.2.3. 过放电 Over-discharging:

需要注意的是，在电芯长期未使用期间，它可能会用其它自放电特性而处于某种过放电状态。为防止放电的发生，电芯应定期充电，将其电压维持在 3.6V 至 3.9V 之间。

过放电会导致电芯性能、电池功能的丧失。

充电器应有装置来防止电池放电至低于本标准书规定的截止电压。此外，充电器还应有装置以防止重复充电，步骤如下：

电池在快速充电之前，应先以一小电流（0.01C）预充电 15~30 分钟，以使（每个）电芯的电压达到 3V 以上，再进行快速充电。可用一记时器来实现该预充电步骤。如果在预充电规定时间内，（个别）电芯的电压仍未升到 3.0V 以上，充电器应能够停止下一步快速充电，并显示该电芯/电池正处于非正常状态。

It should be noted that the cell would be at over-discharged state by its self-discharge characteristics in case the cell is not used for long time. In order to prevent over-discharging, the cell shall be charged periodically to maintain between 3.6V and 3.9V.

Over-discharging may causes loss of cell performance, characteristics, or battery functions.

The charger shall be equipped with a device to prevent further discharging exceeding a cut-off voyage specified in the Product Specification. Also the charger shall be equipped with a device to control the recharging procedures as follows:

The cell battery pack shall start with a low current (0.01C) for 15-30 minutes, i.e.-charging, before rapid charging starts. The rapid charging shall be started after the (individual) cell voltage has been reached above 3V within 15-30 minutes that can be determined with the use of an appropriate timer for pre-charging. In case the (individual) cell voltage does not rise to 3V within the pre-charging time, then the charger shall have functions to stop further charging and display the cell/pack is at abnormal state.

6.3. 贮存 Storage:

电芯储存温度必须在-10℃~45℃的范围内,长期存储电池（超过 3 个月）须置于温度为 23±5℃、湿度为 65±20%RH 的环境中,贮存电压为 3.6V~3.9V

The cell shall be storied within -10℃~45℃ range environmental condition, If the cell has to be storied for a long time (Over 3 months),the environmental condition should be; Temperature: 23±5℃

Humidity: 65±20%RH, The voltage for a long time storage shall be 3.6V~3.9V range.

6.4. 电芯操作注意事项 Handling of Cells:

由于电芯属于软包装，为保证电芯的性能不受损害，必须小心对电芯进行操作。

Since the battery is packed in soft package, to ensure its better performance, it's very important to carefully handle the battery;

6.4.1. 铝箔包装材料易被尖锐部件损伤，诸如镍片，尖针。

The soft aluminum packing foil is very easily damaged by sharp edge parts such as Ni-tabs, pins and needles.

·禁止用尖锐部件碰撞电池;

Don't strike battery with any sharp edge parts;

·取放电芯时，请修短指甲或戴上手套;

Trim your nail or wear glove before taking battery；

·应清洁工作环境，避免有尖锐物体存在;

Clean worktable to make sure no any sharp particle;

6.4.2. 禁止弯折顶封边;

Don't bend or fold sealing edge;

6.4.3. 禁止打开或破坏折边;

Don't open or deform folding edge;

6.4.4. 禁止弯折极片;

Don't bend tab ;

6.4.5. 禁止坠落、冲击、弯折电芯;

Don't Fall, hit, bend battery body;

6.4.6. 任何时候禁止短路电芯，它会导致电芯严重损坏;

Short terminals of battery is strictly prohibited, it may damage battery;

6.5. 电池外壳设计 Notice Designing Battery Pack;

·电池外壳应有足够的机械强度以保证其内部电芯免受机械撞击;

Battery pack should have sufficient strength and battery should be protected from mechanical shock;

·外壳内安装电芯的部位不应有锋利的边角;

No Sharp edge components should be inside the pack containing the battery;

6.6. 电芯与外壳组装注意事项 Notice for Assembling Battery Pack

6.6.1.电芯的连接 Tab connection

建议使用超声波焊接或点焊技术来连接电芯与保护电路模块或其它部分。如使用手工锡焊，须注意以下事项，以保证电芯的功能：

Ultrasonic welding or spot welding is recommended to connect battery with PCM or other parts.If apply manual solder method to connect tab with PCM, below notice is very important to ensure battery performance.

a) 烙铁的温度可控能防静电；

The solder iron should be temperature controlled and ESD safe

b) 烙铁温度不能超过 350℃

Soldering temperature should not exceed 350℃

c) 锡焊时间不能超过 3 秒；

Soldering time should not be longer than 3s

d) 锡焊次数不能超过 5 次；

Soldering time should not exceed 5 times Keep battery tab cold down before next time soldering

e) 必须在极片冷却后再进行二次焊接；禁止直接加热电芯，高于 100℃会导致电芯损坏。

Directly heat cell body is strictly prohibited, Battery may be damaged by heat above approx.100℃

6.6.2. 电芯的安装 Cell fixing

·应将电芯的宽面安装在外壳内；

The battery should be fixed to the battery pack by its large surface area

·电芯不得在壳内活动。

No cell movement in the battery pack should be allowed

7.其它事项 OTHERS

7.1. 防止电池内短路 Prevention of short circuit within a battery pack

使用足够的绝缘材料对线路进行保护

Enough insulation layers between wiring and the cells shall be used to maintain extra safety protection.

7.2. 严禁拆卸电芯 Prohibition of disassembly

7.2.1. 拆卸电芯可能会导致内部短路，进而引起鼓气、着火及其它问题

The disassembling may generate internal short circuit in the cell, which may cause gassing, firing, or other problems.

7.2.2. 聚合物锂电池理论上不存在流动的电解液，但万一有电解液泄漏而接触到皮肤、眼睛或身体其它部位，应立即用清水冲洗电解液并就医

LIP battery should not have liquid from electrolyte flowing, but in case the electrolyte come into contact with the skin, or eyes, physicians shall flush the electrolyte immediately with fresh water and medical advice is to be sought.

7.3. 在任何情况下，不得燃烧电芯或将电芯投入火中，否则会引起电芯燃烧，这是非常危险的，应绝对禁止

Never incinerate nor dispose the cells in fire. These may cause firing of the cells, which is very dangerous and is prohibited.

7.4 不得将电芯浸泡液体，如淡水、海水、饮料(果汁、咖啡)等

The cells shall never be soaked with liquids such as water, seawater drinks such as soft drinks, juices coffee or others.

7.5 更换电芯应由电芯供应商或设备供应商完成，用户不得自行更换

The battery replacement shall be done only by either cells supplier or device supplier and never be done by the user.

7.6 禁止使用已损坏的电芯 Prohibition of use of damaged cells

电芯在运输过程中可能因撞击等原因而损坏，若发现电芯有任何异常特征，如电芯塑料封边损坏，外壳破损，闻到电解液气体，电解液泄漏等，该电芯不得使用。

有电解液泄漏或散发电解液气味的电池应远离火源以避免着火。

The cells might be damaged during shipping by shock. If any abnormal features of the cells are found such as damages in a plastic envelop of the cell, deformation of the cell package, smelling of electrolyte, electrolyte leakage and others, the cells shall never be used any more.

The cells with a smell of the electrolyte or a leakage shall be placed away from fire to avoid firing.

Feature

Construction :

Compact equipment
Acc. to VDE-DIN-EG- standards.
IP 65 protection against accidental contact with power connections.

Power electronics for (S1 operation) 125 A, 200 A,(peak 250A, 400A)
Input power range nom. 12 to 700 V =
Liquid cooling (special construction air cooling)
Unified digital controller electronics)
Independent 12/ 24V DC chopper power unit for auxiliary power.

Galvanic isolation
-Galvanic isolation between power connector, motor connector and all other control connectors
-Galvanic isolation between auxiliary voltage and all other voltages.
-Housing and radiator assembly are galvanically isolated from all electric parts.
-The air and creepage distances comply with VDE.
- No internal insulation monitor. Y2 capacitors to housing.

The following are used:
IGBT – power semi conductor
- Generously dimensioned.
- Only commercially available parts in industry standard.
- SMD –mounting
- 7 segment led indicators (option)

Features

* Battery connection 12 v = to 700 volts = (dc supply, observe limitations)
* Independent auxiliary supply 24 v = or 12 v =
* Digital interfaces RS 232, can- bus (additional option)
* 2 analog inputs, programmable differential inputs
* 4 digital in- out puts, programmable, optically isolated
* Reference value ramps linear, non linear (s – function)
* Release and limit -switch logic.
* BTB – operation ready, solid state relay contact.
* Position , rpm and torque control
* Resolver or encoder – incremental encoder TTL , SINCOS 1Vss,
* Rotor positon + bl tacho.
* Encoder output or 2. encoder input.
* Static and dynamic current limit
* Unified full digital regulator unit
* Safety shutdown in case of over voltage, under voltage and over temperature from motor.
* Self protected short circuit proof power part. processor independent hardware -shut down in case of short circuit, earth fault , over voltage and over temperature of amplifier.

Technical Data

Device for EC/AC-motors

Power supply voltage	12V= to 700V=
Auxiliary supply	12V= or (24V=) ± 10% / 4a (2a) Ripple voltage <10%, self-resttable fuse

Data BAMOCAR-D3-400- (700)-	dim.		125/250	200/400	125/250	200/400
Rated supply voltage	V=		24 bis max .400		24 bis max .700	
Rated output voltage	V~eff		to 3x260		to 3x450	
Continue current rms	A_{eff}		125	200	125	200
Peak current	A_{io}		250	400	250	400
Dissipation max.	kW		2	3	2.6	4
Clock frequency	kHz		8-24		8-16	
Level Over voltage	V=		440		800	
External fusing	A		160	250	160	250
Weight	kg		5.8	6,8	5.8	6.8
Dimension HxWxD	mm	403x250x145				
Size			2	2	2	2

Device for DC-Motors

Power supply voltage	12V= to 400V=
Auxiliary supply	12V= or (24V=) ± 10% / 4a (2a) Ripple voltage <10%, self-resttable fuse

Data BAMOCAR-D2-	dim.		125/250	200/400		
Rated supply voltage	V=	24 bis max. 400				
Rated output voltage	V=	20 to 360				
Continue current rms	A=		125	200		
Peak current	A_{io}		250	400		
Dissipation max.	kW		2	3		
Clock frequency	kHz	8-16				
Level Over voltage	V=	programable to max 440v				
External fusing	A		160	250		
Weight	kg		5.8	6,8		
Dimension HxWxD	mm	403x250x145				
Size			2	2		

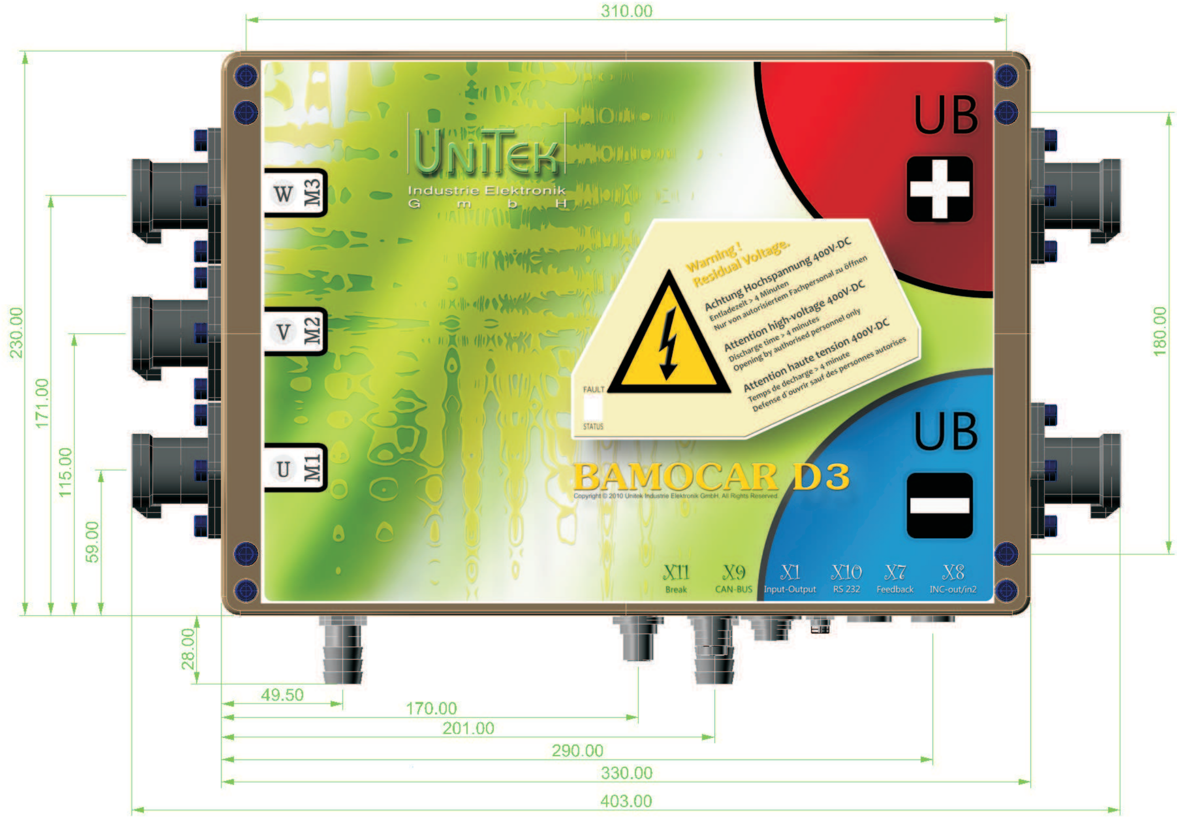
Input / Outpu	v	A	Funktion	Connector
Analog Input	± 10	0.005	Differential input	x1
Digital input ON OFF	10-30 <6	0.010 0	Logic io (opto)	x1
Digital output	+24	1	Transitor-output open emitter (opto)	x1
Resolver input			Differential input	x7
Encoder input	>3.6v		Opto	x7
Encoder output	>4.7v		Opto	x8
CAN-interface			Logik io (opto)	x9
RS232-interface			Logik io	x10

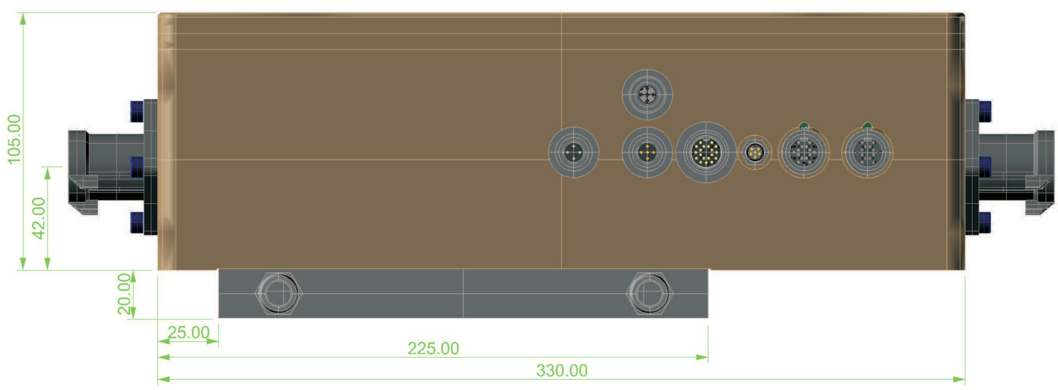
Ambient conditions	
Enclosure protection	IP65
Norms	EN 60204, ISO 16750
Ambient temperature	-10 to +45°C
Maximum ambient temperature	-30 to +65 ab +45°C to +65°C with power derating 2%/°C
Storage temperature	-30°c to +80°c
Humidity in operation	Klasse F rel. humidity <85% ,**no condensation !**
Site altitude	≤ 1000m ü.nn 100%, >1000m with power derating 2%/100m
Cooling	liquid cooler max 65°c , 12 l/min , precher max 1,3 bar
Mounting position	equal

Program	Type	Software-version	
BAMOCAR-D3(D2)-xx-rs	resolver		
BAMOCAR-D3-(D2)xx-in	encoder-ttl		
BAMOCAR-D3-(D2)xx-sc	encoder-sincos 1vss		
BAMOCAR-D3-(D2)xx-bl	rotorlage+bl-tacho		
BAMOCAR xx-DC	dc-tacho, armature voltage		

Note:
Power supply cables between the BAMOCAR and the battery must be as short as possible. Long cables cause dynamic voltage drops due to the line impedance and as a consequence the service life of the installed ELKOs would be reduced.

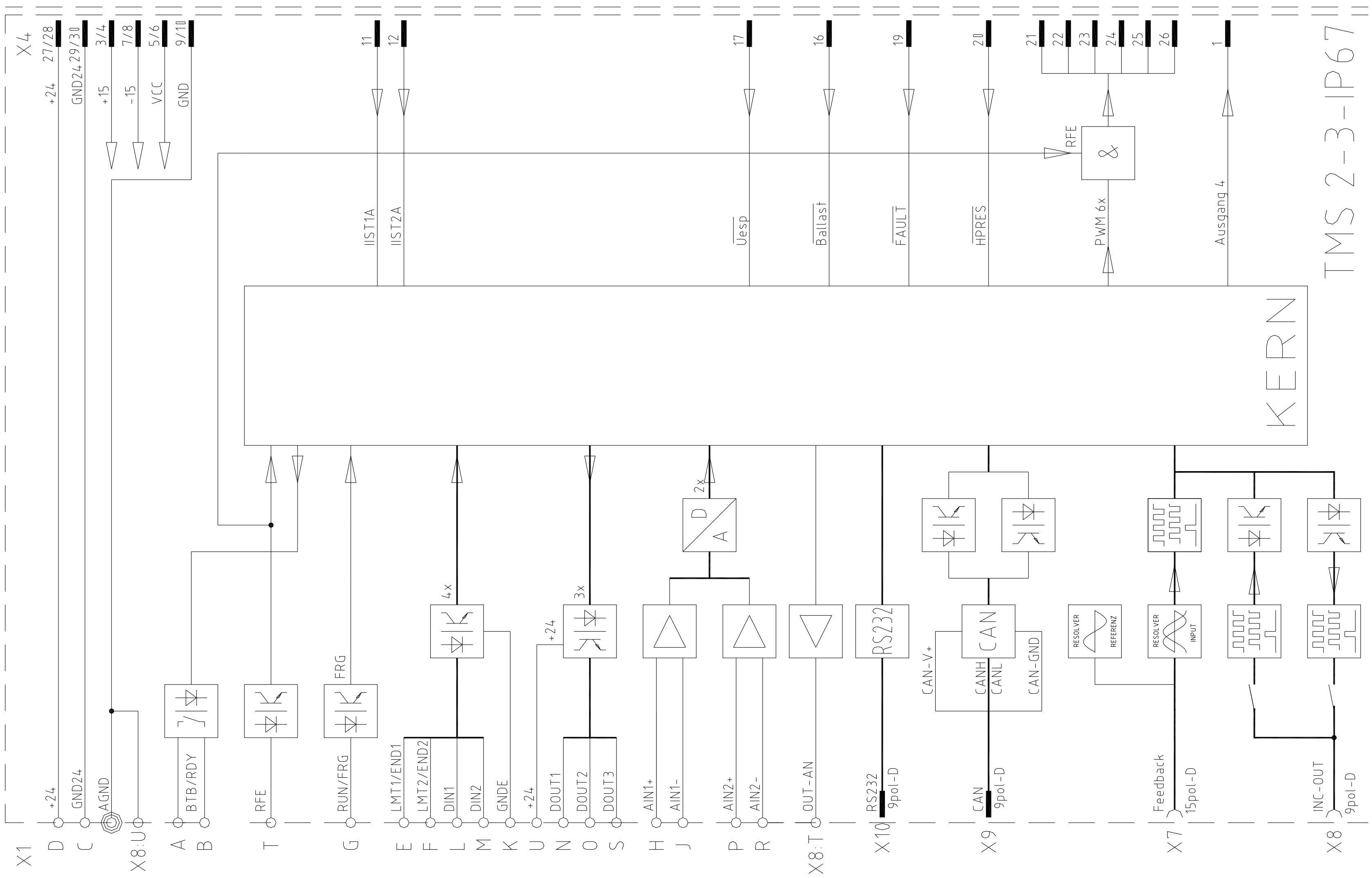
Dimensions

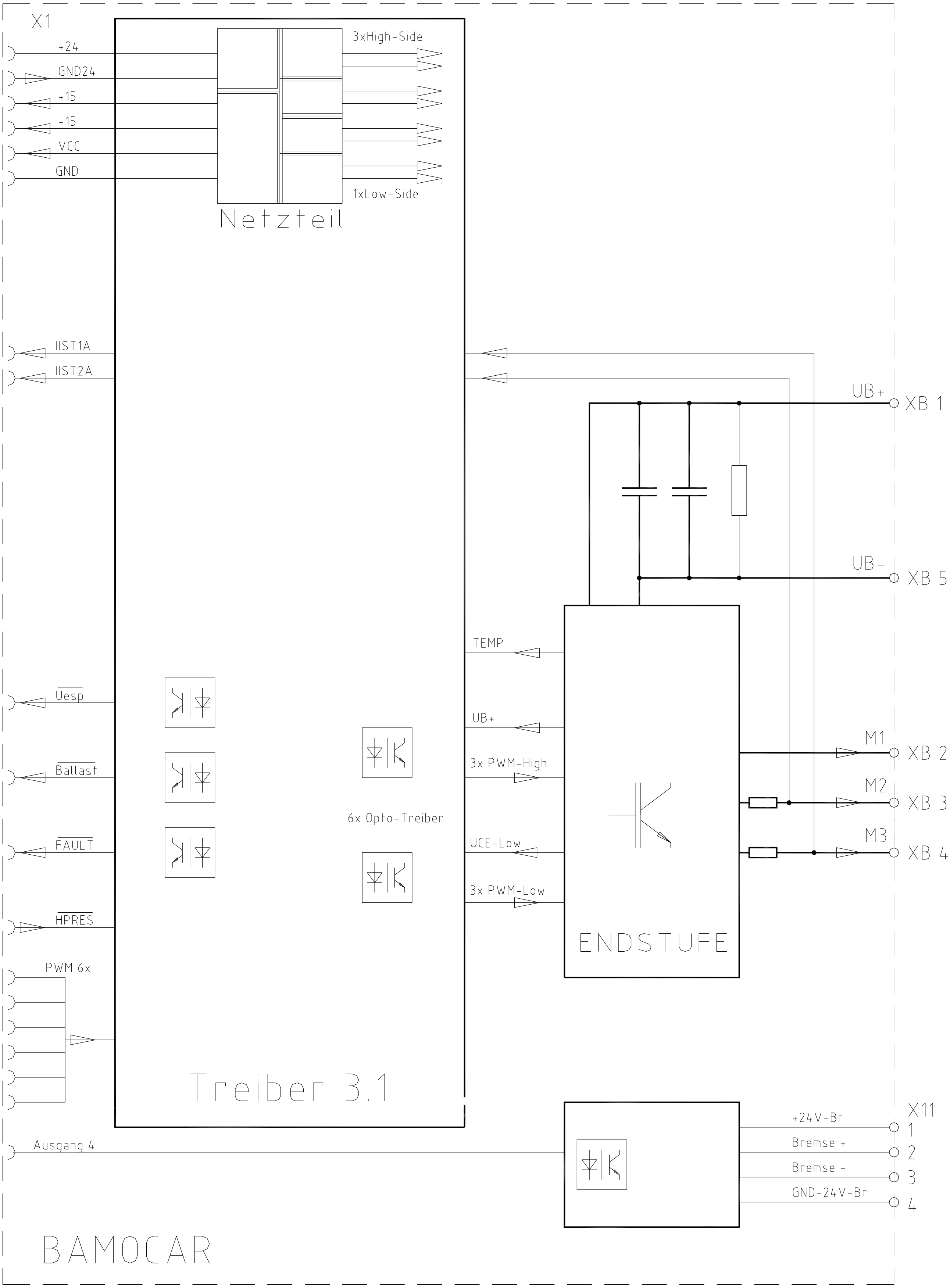




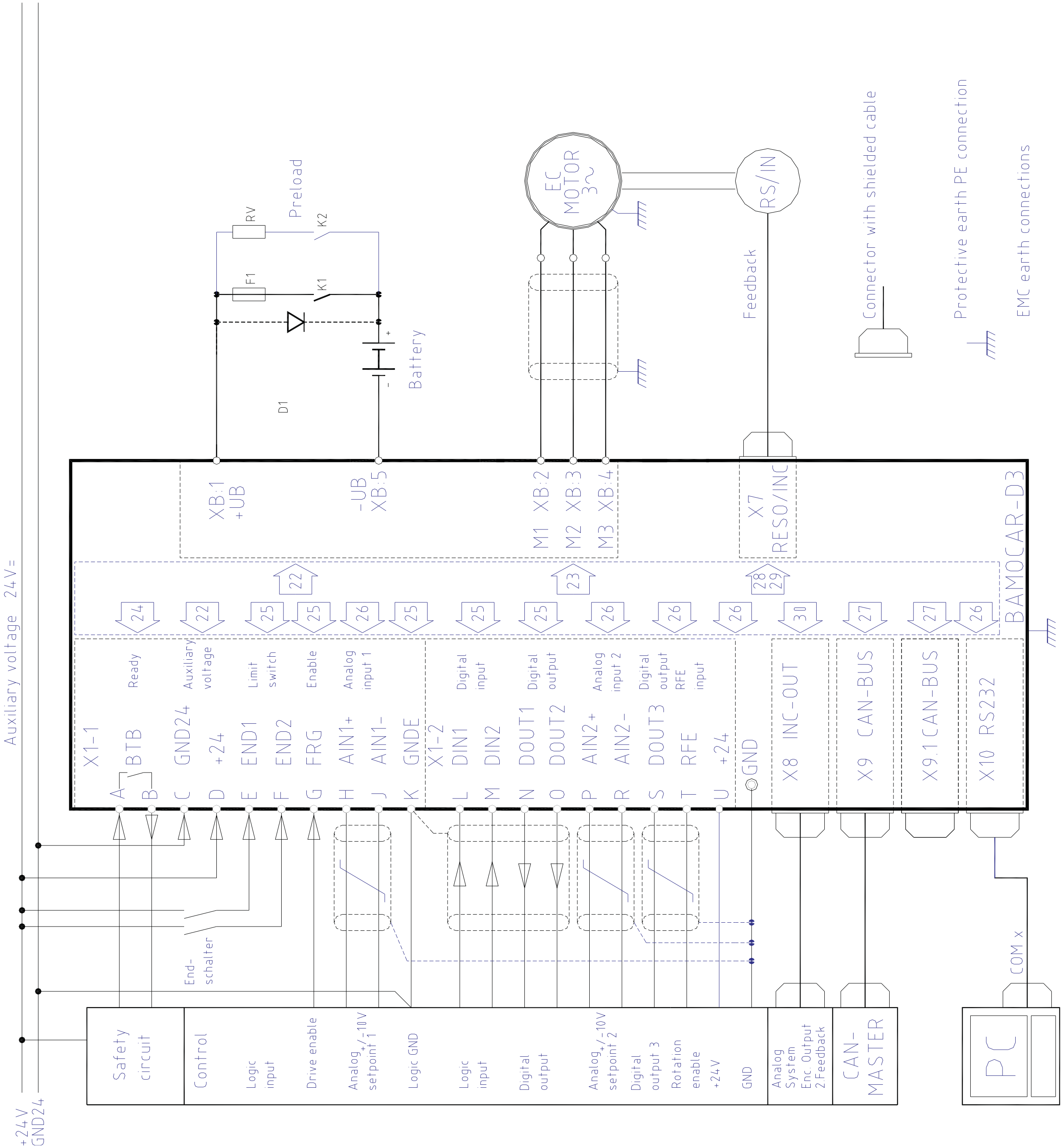
Screw for hex key   BAMOCAR

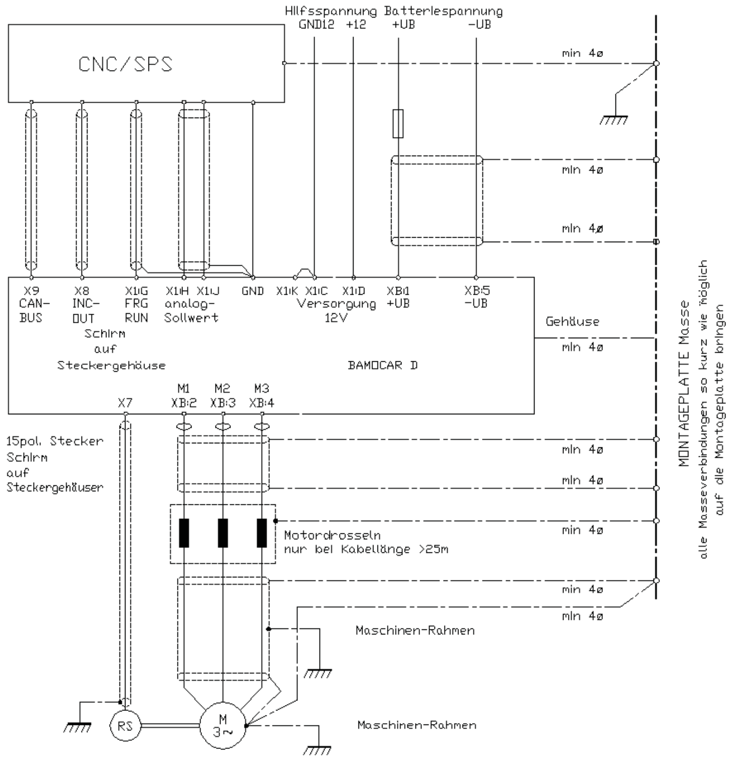
Block diagram




X1
+24
GND24
+15
-15
VCC
GND
3xHigh-Side
1xLow-Side
Netzteil
IIST1A
IIST2A
UB+
XB 1
UB-
XB 5
TEMP
UB+
3x PWM-High
UCE-Low
3x PWM-Low
ENDSTUFE
Uesp
Ballast
FAULT
HPRES
PWM 6x
6x Opto-Treiber
M1
XB 2
M2
XB 3
M3
XB 4
Treiber 3.1
X11
+24V-Br
Bremse +
Bremse -
GND-24V-Br
1
2
3
4
Ausgang 4
BAMOCAR

Connection diagram





Equipments comply with the EC- regulations 2004/ 108/ EG and standards EN 61800-3 according to the following installation and test conditions.

Mounting :
The equipment is conductingly mounted on a bare , aluminum plate with dimensions 500 x 500 x 5mm.
mounting plate corresponds to ground plane
(vehicle ground , control panel ground)
Motor casing above 10 mm^2 connected to ground .
Equipment ground x- agnd above 1.5 mm^2 connected to the mounting plate
(ground) .
Housing connected with mounting plate (ground)

Control connections:
Signal wires are screened, analog signal wires are twisted and screened .
Screen: surface contact with the mounting plate (ground)

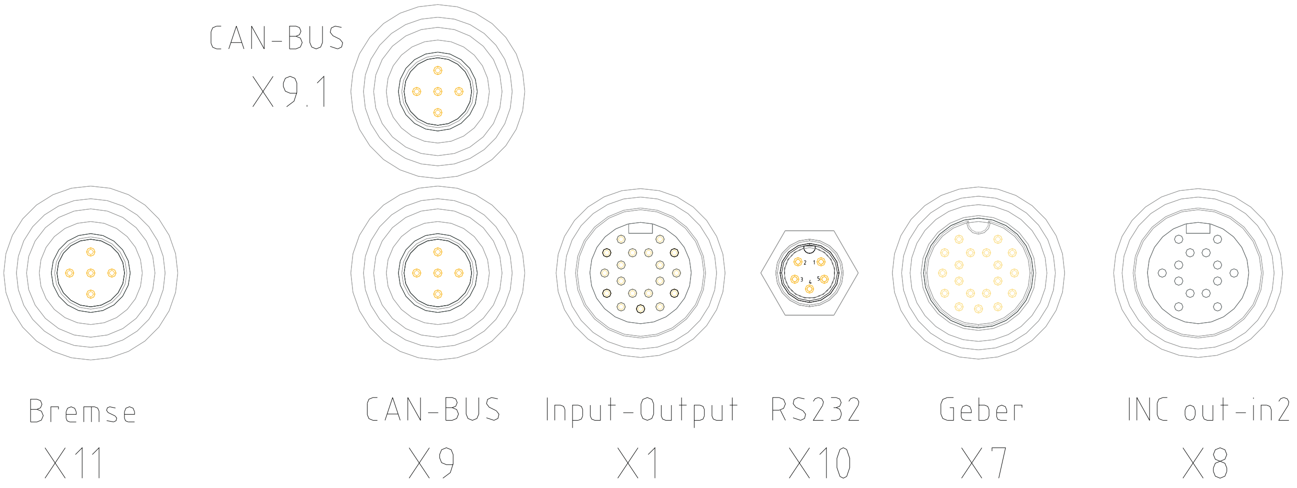
Battery connection:
360 V DC

Motor connection :
Motor cables are screened, and have surface contact with the mounting plate (ground)

In case of installation in machines and equipments , the commencement of operation of the equipment in accordance with the provisions is prohibited, till it is confirmed, that the machine or equipment complies with the ec – regulations 2006/ 42/ EG and the emc – regulations 2004/ 108/ eg,
in case of vehicles ECE-Rr83, ECE-R100.

A manufacturer’s declaration can be requested for.

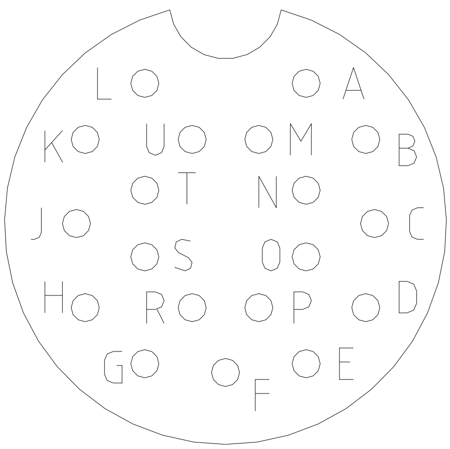
Connectors



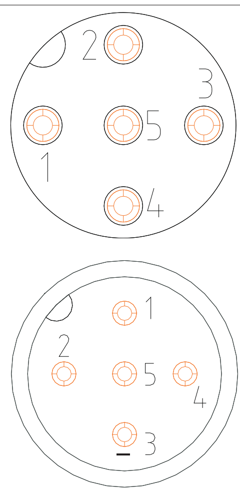
Connector X1 IN / Output

a brown	BTB	BTB-Ready
b red	BTB	
c pink	GND	Auxiliary voltage 0
d yellow	+24	Auxiliary voltage+
e gree	END1/LMT1	Limit switch1
f blue	END2/LMT2	Limit switch2
g violett	FRG/RUN	Enable
h gray	AIN1+	Analog-Input1
j white	AIN1-	
k black	GNDE	Logik-GND
l br-green	DIN1	Digital-Input1
m br-yellow	DIN2	Digital-Input2
n ws-green	DOUT1	Digital-Output1
o red-blue	DOUT2	Digital-Output2
p wh-yellow	AIN2+	Analog-Input2
r wh-red	AIN2-	
s wh-gray	DOUT3	Digital-Output3
t wh-black	RFE	Rotation Enable
u ws-blue	+24v	Auxiliary voltage +

Connector Binder 99-5662-15-19



Connector X9, X9.1
CAN-BUS

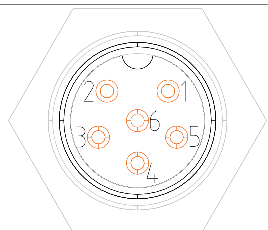


1	PE
2	(Voltage in)
3	CAN GND
4	CAN Hh
5	CAN LI

Connector X9
Binder 99-0436-14-05

Connector X9.1
Binder 99-0437-14-05

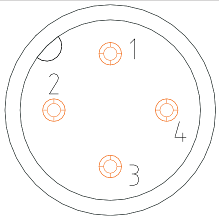
Connector X 10 RS232



1 brown	r2in
2 white	txd
3 blue	t2ou
4 black	t2ou
5 gray	rxd
6 pink	gnd

Connector Binder 79-3464-52-06

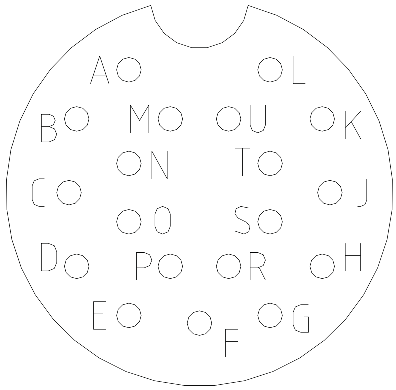
Connector X11 Brake



1	+24 v-br
2	Brake +
3	Brake -
4	GND-24V-Br

Connector Binder 99-0429-15-04

Feedback- connector X7



Connector Binder 99-5661-15-19

Connector X7 Resolver

a	
b	
c	sin1
d	
e	cos2
f	
g	ref2
h	temp signal
j	
k	ref1
l	temp gnd
m	cos1
n	
o	sin2
p	

Connector X7 ENC-TTL

a	canal a
b	canal /n
c	canal b
d	voltage +5v
e	canal n
f	canal /b
g	canal /a
h	temp signal
j	temp gnd
k	rotor 3
l	gnd
m	rotor2
n	
o	rotor1
p	

Connector X7 SIN/COS

a	canal ka+
b	canal kr+
c	canal kb+
d	voltage +5v
e	canal kr+
f	canal kb-
g	canal ka-
h	temp signal
j	temp gnd
k	canal kd-
l	voltage gnd
m	canal kc+
n	canal kd+
o	canal kc-

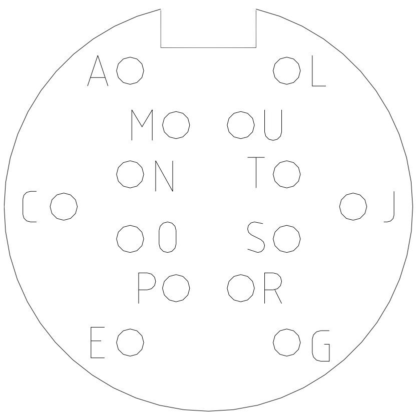
Connector X7 bl

a	mp-tacho
b	
c	tacho 1
d	voltage +15v
e	tacho 2
f	
g	tacho 3
h	temp signal
j	temp gnd
k	rotor 3
l	versorgung gnd
m	rotor2
n	
o	rotor 1
p	

Connector X8
Output / 2 Input ENC-TTL

a	voltage +5v
c	selekt in
e	canal a
g	canal n
j	canal b
l	canal /b
m	canal /n
n	canal /a
o	voltage GND
t	output dac1
u	GND dac1

Connector Binder 99-5651-15-14



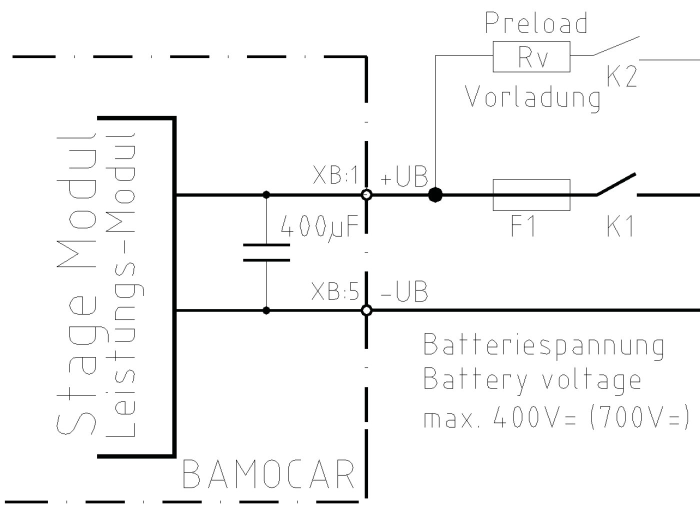
At all connectors: View the plug on solder-crimp side.

Power connectors 1000V / 400A

Connector socket plus	Pfisterer p1 (350 205-301 (-302))
Connector socket minus	Pfisterer p1 (350 205-301)
Motor connector socket	Pfisterer p1 (350 205-301)

Connector plug	plus	Pfisterer connector straight p1 (350205-002..) or connector angle p1 (350205-102)
Connector plug	minus	Pfisterer connector straight p1 (350205-001..) or connector angle p1 (350205-101)
Connector plugr	motor	Pfisterer connector straight p1 (350205-001) or connector angle p1 (350205-101)

Connection to the battery



Attention:

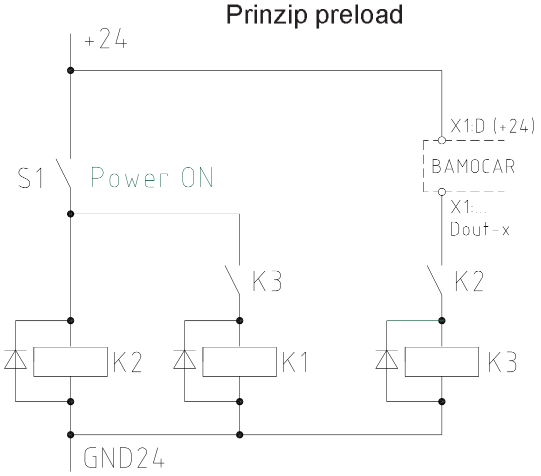
DC-Link
at 400V 800µF
at 700V 320µF

Resistor
Rv ca. 40 ohm 10w

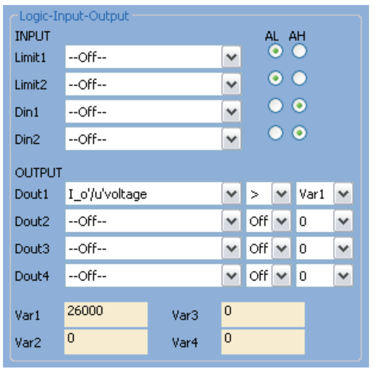
Inrush-current over k2
ca.10A

Enable (RUN) only at
switched main contactor K1

Prinzip preload



Programming example
Output dout1 switches the relay k3 when the dc link voltage (I_o/u voltage) is higher than the variable 1.



Warning

The max. supply voltage U + 400 (700) must not be exceeded at any time (not even for short intervals)!
Danger of damage!
F1 = safety fuses

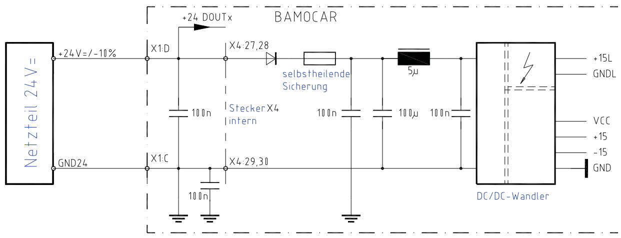
Connection has no protection against reverse polarity.
If the polarity of the connection is wrong, the device will be destroyed

Type		Connection cross-section mm2	AWG	Fuse A		
-125/250		25	2	160		
-200/400		35	1	250		
Battery connecting line <2m. For conductor lengths from 2 to 10m more powerful. Use an additional capacity for conductor lengths superior to 10m!!						

Auxiliary voltage

Auxiliary power connection
Mains independent Auxiliary dc voltage 12 V = up to 24 V = +/- 10 % / 4 up to 2 A

The Auxiliary voltage has
- galvanic connection to logic voltage
- internal self healing fuse
- emc filter
- external fuse only for line protection



Input voltage	12...24 V DC X 1: 4
	GND 24 X 1 :3
	Ripple 10 %
	Inrush current 4A
	Rated current in case of 12 v 1.4 A
	in case of 24 v 0.9 A

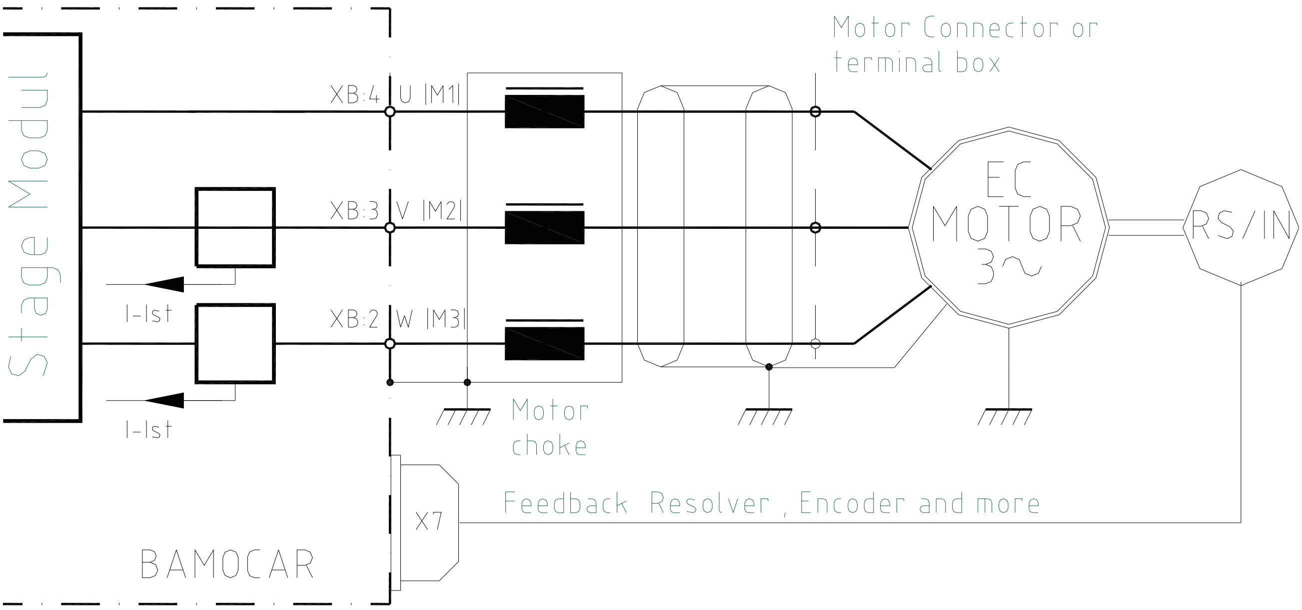
Attention : For internal power supply (1,4 A) , also the sum total currents of output (dout) has to be fed from the 12/24 V system.

Attention : In case of Auxiliary voltage less than 10 V, including during short time drop outs, the internal power supply system shuts down. Temporary data in ram memory are erased. Digital rpm and torque reference are reset to 0, fault indication 1 (hardware fault) .

Indication ok in status is off.

Brake

Motor – power connection
Use only UNITEK approved, electronically commutated synchronous motors (brushless dc motors, ec motors) with resolver or incremental encoder .
Refer Appendix A (motor specific connection and parameter guidelines)



Connection sequence

Cable indication		M1	M2	M3
Motor phase		U	V	W
Connector		xb:2	xb:3	xb:4
Correct wiring is essential !				

Motor cables,
3 wires + simply shielded protective earth conductor for 600V~, 1000V=, shield capacity 150pF/m.

Cable cross –section minimum.

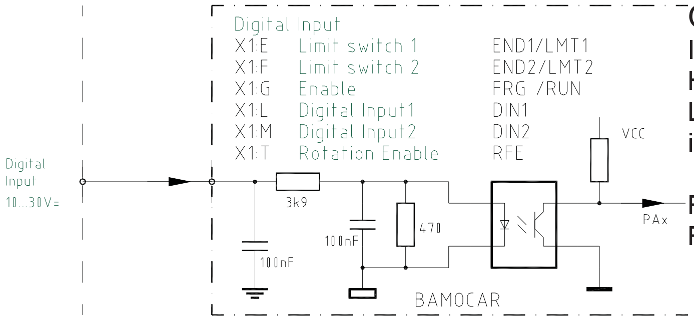
Type BAMOCAR -Dx	-125	-200		
Cable dim. mm^2	25	35		
Cable dim. AWG	2	1		

Motor choke.
Only required upwards of a shield capacity of >5nF. approx. 25m motor cable.

Magnetic rings
Against HF failures of the sensor systems. Slide the rings onto the motor lines.

Shielded connection:
Surface connection at entry to control cabinet. Surface or as short as possible connection at the motor end.

Digital inputs



Opto-input

Input voltage		
H-level	(ON)	+10 to +30V
L-level	(Off)	0 to +6V
input current		max. 14 mA
Ratet voltage/curen		+24V/10mA
Referenc ground		GNDE(X1:10)

The enable input- (FRG/RUN) and the input for rotary field release (RFE) are pre-fixed and cannot be programmed. Without FRG/RUN release , the servo is electronically blocked (no pwm pulses).

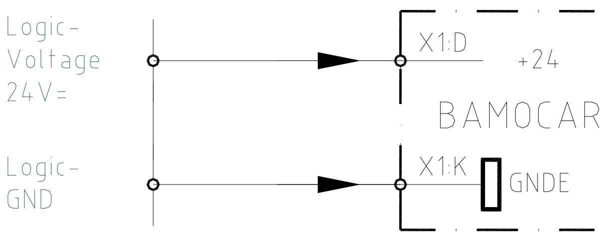
Without rotary field release RFE, the rotary field of the output stage is additionally blocked electronically. (second blocking channel). The drive is momentum free (no stop-moment).

The 4 additional digital inputs are freely programmable.

Inputs lmt 1 (x1: e) and lmt 2 (x1: f) are preferred and to be used as limit switch inputs .

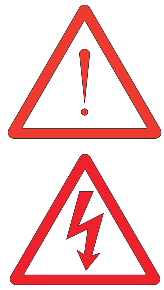
Input	Plug	Function	Status
FRG/RUN	X1.7	Enable	fix
RFE	X1:18	Rotation Enable	fix
END1/LMT1	X1:5	Limit switch 1/Dig. Input	programmable
END2/LMT2	X1:6	Limit switch 2/Dig. Input	
DIN1	X1:11	Digital Input 1	
DIN2	X1:12	Digital Input 2	

External power supply for inputs and outputs.



+24for	for the logic and the auxiliary voltage
GNDE	Logic reference

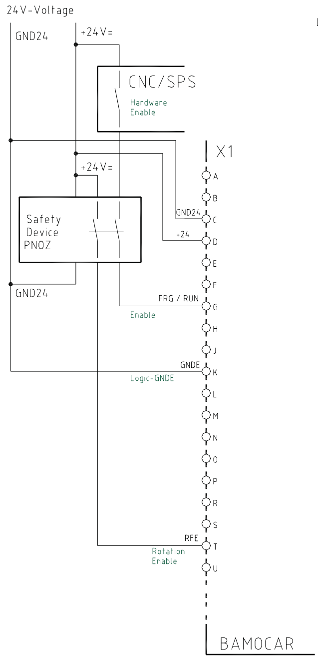
Safety – input RFE (rotary field – release)

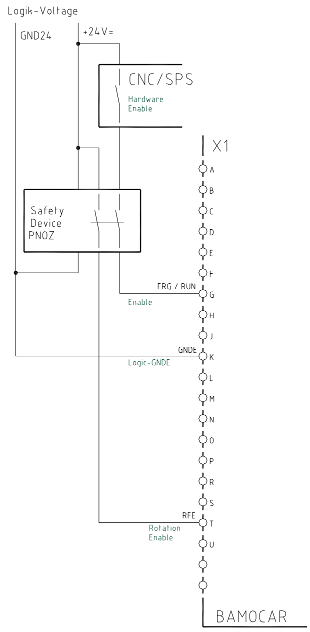


Attention : The drive is momentum-free , in case of disabled input release or rotary field release . If there are no mechanical brakes or blocks, the drive can stop or be in motion , the motor cables are not potential-free. Only the rotary field is blocked . The servo Amplifier has to be isolated from the mains to carry out work on the motor.

Operation with rfe input.
Two channel release – block by a safety device.
Enable - input FRG/RUN plus rotary field enable – input RFE

Switch on
Safety switch contacts closed
Enable FRG/RUN 0.5 seconds after RFE.

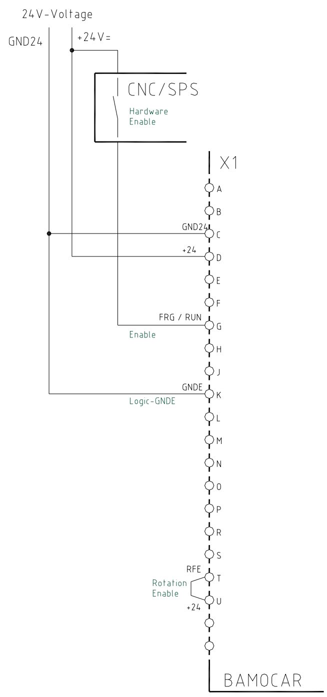




Safety shut-down.
Safety switch contacts open.
Absence of FRG/RUN signal -blocks the pwm pulses in the processor through the first blocking channel.
Absence of FRG signal blocks the pwm pulses after the processor through the second blocking channel .

Restarting :

Reset safety switch
Safety switch contacts closed.
The motor can start rotating, only after a renewed rotary field enable, followed by enble FRG/RUN ,



Operation without RFE -input

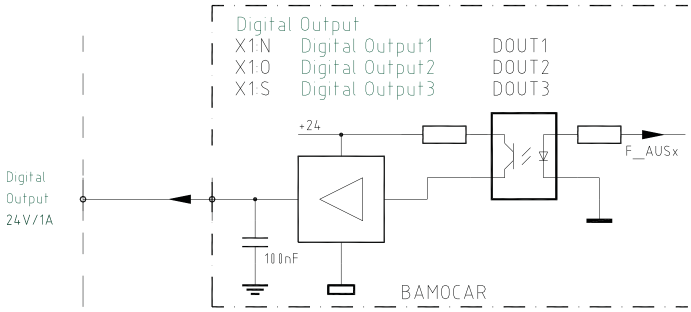
Input RFE has to be bridged with the logic voltage.

If the logic voltage and the supply voltage are the same, bridge the RFE input with +12V/ 24 V.

Enable FRG/RUN at lease 0.5 seconds after RFE –signal.

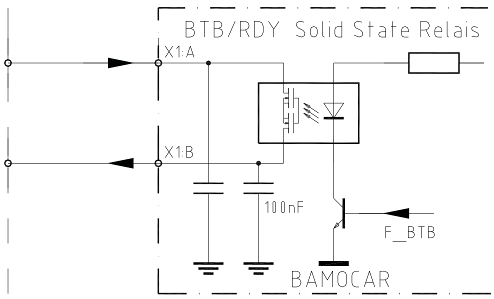
Digital logic- outputs (open- emitter)

Logic outputs 1 to 3 are for laid out for 12/ 24 V and 1 A . Short time 2 A.



Output voltage		
On-level	max.	+24V
Off-level		<1V
Output current	nom.	1A
Output current	max.	2A
Voltage reference		+24V (X1:4)
ground reference		GNDE(X1:10)

Attention : The auxiliary voltage is also the power supply for the logical outputs.
An energy saving program can be programmed. (clocked output).
Logic output 4 (brake 24 V, 3 A) is available at terminal X 11.



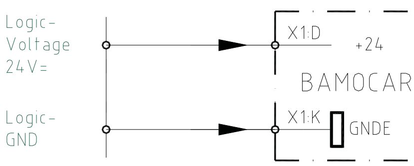
Contact for	max. 48V/0.2A
Capacitive load	max. 1myF
Contact resistance	max. 2 Ohm
external fuse	0.5Aff

The contact is closed when the device is r
eady for operation.
State signal via seven-segment LED

Signal operation ready (solid state relay) / ready BTB/RDY
Operation ready are off in case of fault indications, if Auxiliary voltage is low (<10 V)

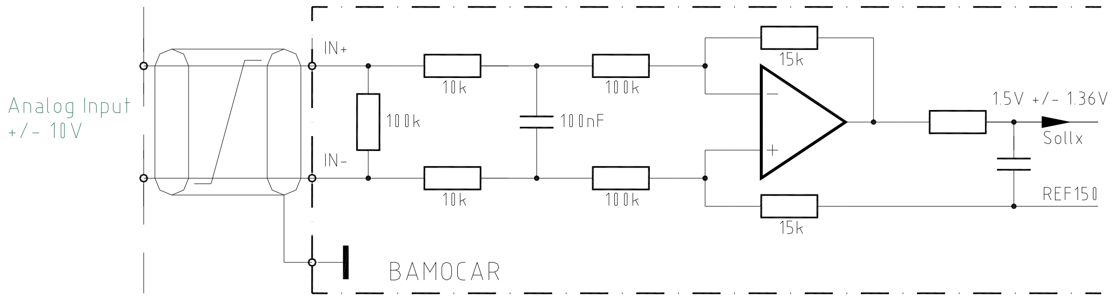
The function of indication „ under voltage in DC link ” can be programmed.
BTB with or without under voltage monitoring . (BTB-power)

Output	Plug	Funktion	Status	Parameter
BTB/RDY	x1:A, x1:b	Ready	fix /Relay	
DOUT 1	x1:n	Digital output 1	programmable	
DOUT 2	x1:o	Digital output 2	programmable	
DOUT 3	x1:s	Digital output 3	programmable	
DOUT 4	x11	Digital output 4	programmable	



+24V for the logic and the auxiliary voltage
Observe the sum of all output currents!
GNDE logic ground

Analog inputs +/- 10V



Inputs	Terminal	Basic function	Voltage	Status	Parameter
Ain1+,Ain1-	X1:h, X1:j	rpm – reference value	+/-10V	prog.	
Ain2+,Ain2-	X1:p, X1:r	current limit	+/-10V	prog.	

Characteristics

Differential input	Ain1+/Ain1-	Ain2+/Ain2-	
input impedance	70kOhm		
limit voltage	+/-12V		
resolution	11bit + sign		

The direction of rotation of the motor can be changed by reversing the +/- polarity at the differential input, by a logic- input or by programming .

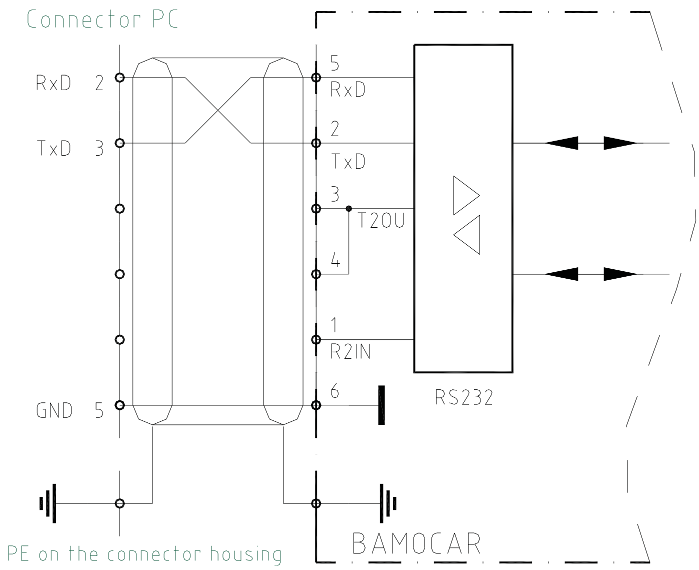
In case of digital reference value (RS 232, x bus), analog input Ain 1 can be programmed as external rpm limit and the Analog input Ain 2 can be programmed as external analog current limit.

Analog output +/- 10 V

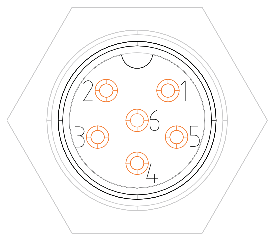
Output	Terminal	Basic function	Voltage	Status	Parameter
Aout1	x8:t	rpm- Actual value	+/-10v	prog.	
gnd	x8:u	signal-gnd	0v	fixed	

Serial interface RS232

The Amplifier BMOCAR-D3 is programmed and commissioned through the PC interface RS232 .

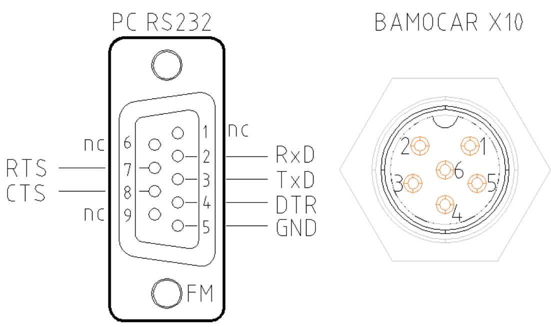


The serial interface is galvanically coupled with the device - zero (GND) .



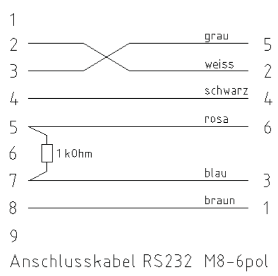
The software is described in the software-manual DS NDrive.
Connection between the BAMOCAR-D3 (d-connector X10) and the serial interface only through a null modem-cable.
Do not use null modem-link cable!
Cable to be plugged in only in de-energized condition.
Select the interface baud rate in NDrive as **115200**.

Null modem cable
Pin assignment. Solder side.
Contact shield with the plug housing.
Cable length max. 10m



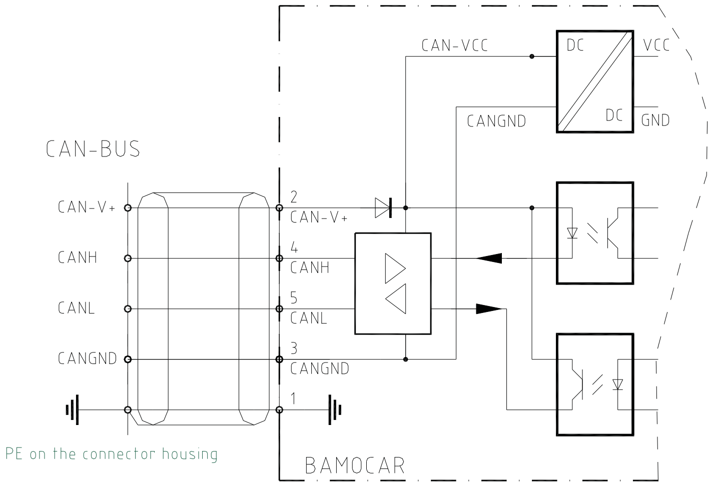
BAMOCAR

Connector X 10	**RS232**
1	R2in
2	Txd
3	T2ou
4	Dtr
5	Rxd



CAN-BUS

The CAN-BUS is a digital connection to the CNC control.
Optimum conditions are achieved with CNC controls and CAN components of LABOD electronic or CAN Open.
Programming and operation by means of the control panel via the CAN-BUS.
Interface complies with the standard ISO 11898.
Adjustment and programming see Manual DS-CAN

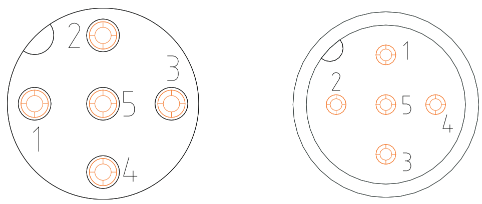


The CAN-BUS input is galvanically separated.
The power supply is from the intern DC/DC

.

CAN-BUS cable
Use a shielded bus conductor with a low shielding capacity.
Signal plus GND (+supply).
D-connector with a metal or metallized housing. LiYCY 4x0.25+shield.

Designation	Connector no. X9, X9.1 CAN-BUS	Cable colour
Sield	1	green-white
CAN-v+	2	brown
CAN-gnd	3	white
CAN-h	4	green
CAN-l	5	yellow



x9.1 Female

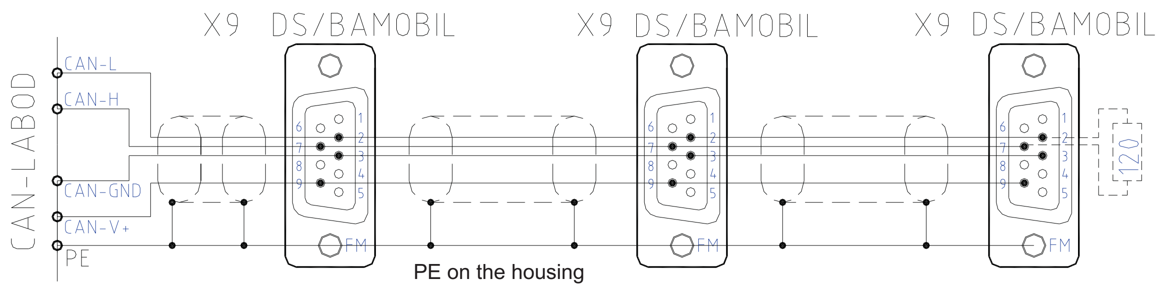
x9 Male

Pin assignment.
Solder side

Terminating resistor at the end of the bus line > 120Ohm between the CAN-H and CAN-L

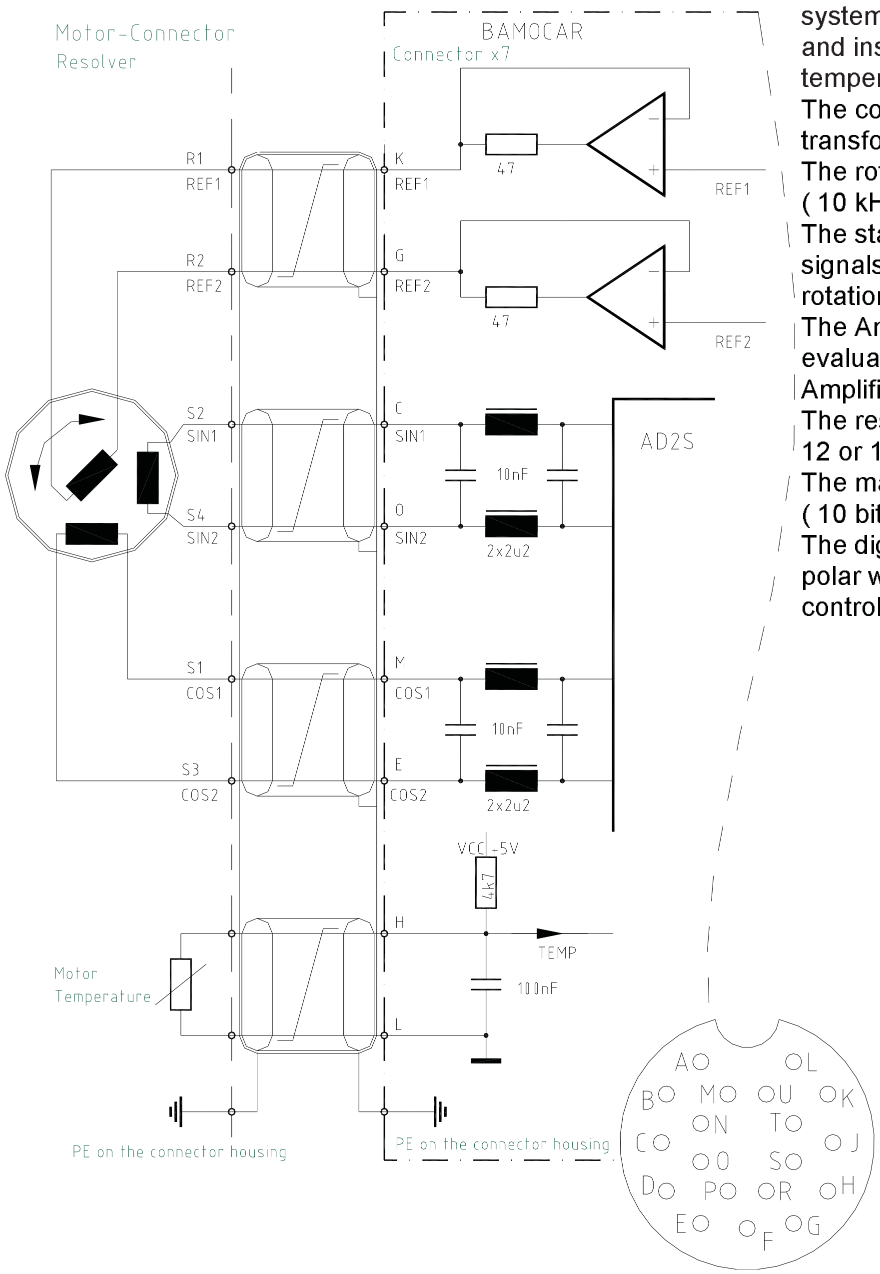
CAN-BUS connection with several BAMOCAR-D3

Master Address xx Address xx Address xx



Terminating resistor at the end of the bus line > 120Ohm between the CAN-H and CAN-L

Resolver - connection.
Applicable only for BAMOCAR D3 xx-RS



The resolver is an absolute measuring system for motor rotation. It is robust and insensitive against high motor temperatures.
The construction is similar to a rotating transformer.
The rotor is fed from the reference (10 kHz)
The stator delivers the sine and cosine - signals , that are modulated from the rotational frequency .
The Amplitudes of these signals will be evaluated and digitized in the servo Amplifier.
The resolution will be optimally set to 10, 12 or 14 bits automatically.
The maximum possible rpm is 50000 (10 bit)
The digitized signals are used for the polar wheel Angle, position and speed control and for incremental outputs.

Connector X7
Resolver

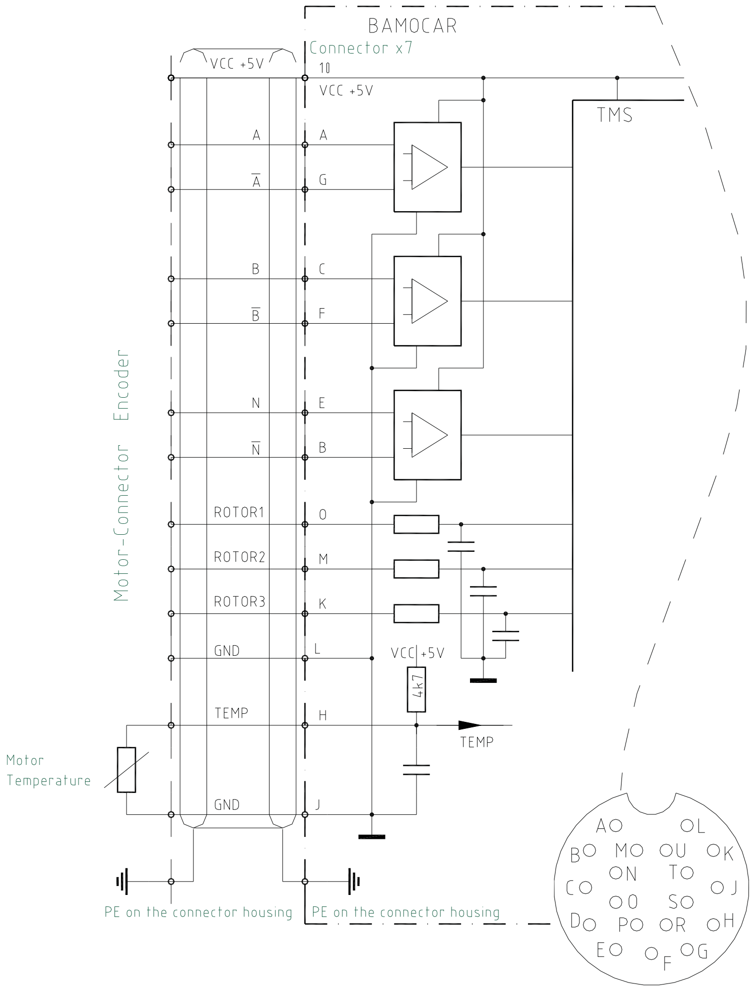
A	
b	
c	sin1
d	
e	cos2
f	
g	ref2
h	temperature signal
j	
k	ref1
l	temperature gnd
m	cos1
n	
o	sin2
p	

Use only UNITEK approved motors (Appendix A)with 2, 4, 6 or 8 pole resolver
Follow motor specific connection chart (RS)

Connector x7 :	19 pole round connector
Connecting cable :	4 x 2 core twisted pair and screened, plus total shield. In case of drag chain use only suitable cable.
Cable length:	In case of length > 25 m, use only high quality resolver cable with better screen properties .
Screen connection	At connector x7, connect all screens together with the casing . At the motor connector , connect the total shield with the connector housing.

Individual parameter refer software manual DS NDrive.

Encoder TTL Anschluß
only BAMOCAR-D3-IN



TTL encoder with 2 counter channels and one zero channel plus 3 rotor position channels . Counters with or without push-pull output.
In case of simple connection a, b, n , do not use the negated inputs.

Counter input complies with rs 485 maximum counter frequency 500 kHz.

The encoder is galvanically connected to the equipment earth (GND) .
Supply voltage is fed by the servo.

Connector X7
ENC-TTL

a	**canal a**
b	**canal /n**
c	**canal b**
d	**voltage +5v**
e	**canal n**
f	**canal /b**
g	**canal /a**
h	**temp signal**
j	**temp gnd**
k	**rotor 3**
l	**gnd**
m	**rotor2**
n	
o	**rotor1**
p	

To be used only with UNITEK approved motors (Appendix A) with ttl encoder and rotor position tracks.
observe motor specific connection chart (IN) .

Connector: X7 19 pole round connector

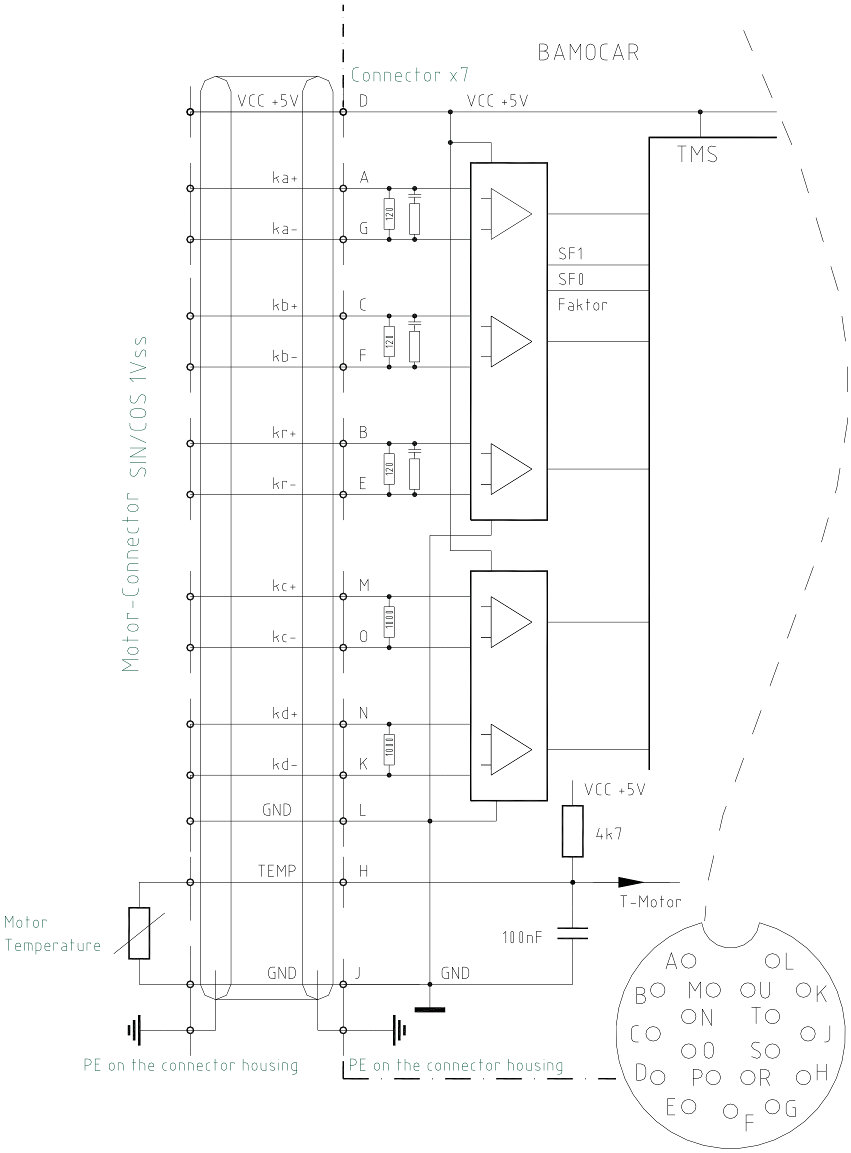
Connecting cable : 10 signal wires screened , minimum cross section 0.14mm
2 power supply wires , minimum cross section 0.5mm

In case of drag chain , use only suitable cables.
Cable length : one level more in case of cross section greater than 25m .

Screen connection : At connector X7, connect screen with connector casing

Individual parameter refer software manual DS NDrive.

SIN / COS 1Vss Anschluss
only BAMOCAR-D3-xx-SC



SIN COS 1Vss connection
only in case of
BAMOCAR-D3–xx-SC

Encoder with 2 analog sinusoidal counter track and a track zero plus two commutation tracks.
Differential signals 1 Vss signal difference
Maximum counter frequency 500 khz.
The encoder is galvanically connected to equipment ground (GND).
Servo feeds the supply voltage 5V

Optimum resolution will be automatically selected.

Connector X7
SIN/COS

a	canal ka+
b	canal kr+
c	canal kb+
d	voltage +5v
e	canal kr+
f	canal kb-
g	canal ka-
h	temp signal
j	temp gnd
k	canal kd-
l	voltage gnd
m	canal kc+
n	canal kd+
o	canal kc-

Use only UNITEK approved motors (Appendix A) with sin/ cos sensor (SC).
observe motor specific connection chart (SC)

Connection terminal X 7	19 pole round connector
Connecting cable	4 x core signal cable , drill –screened Minimum cross section 0.14mm 2 core signal screened cable minimum cross section 0.14 mm 4 core power supply cables, temperature minimum cross section 0.5 mm
Cable type :	(4x(2x0.14)+(4x0.14)c+4x0.5)c Use appropriate cable in case of drag chain.
Cable length	in case of length > 25m, cross section one step higher.
Screen connection casing.	At connector X 7 connect screen with the connector At motor connector connect screen with connector casing.

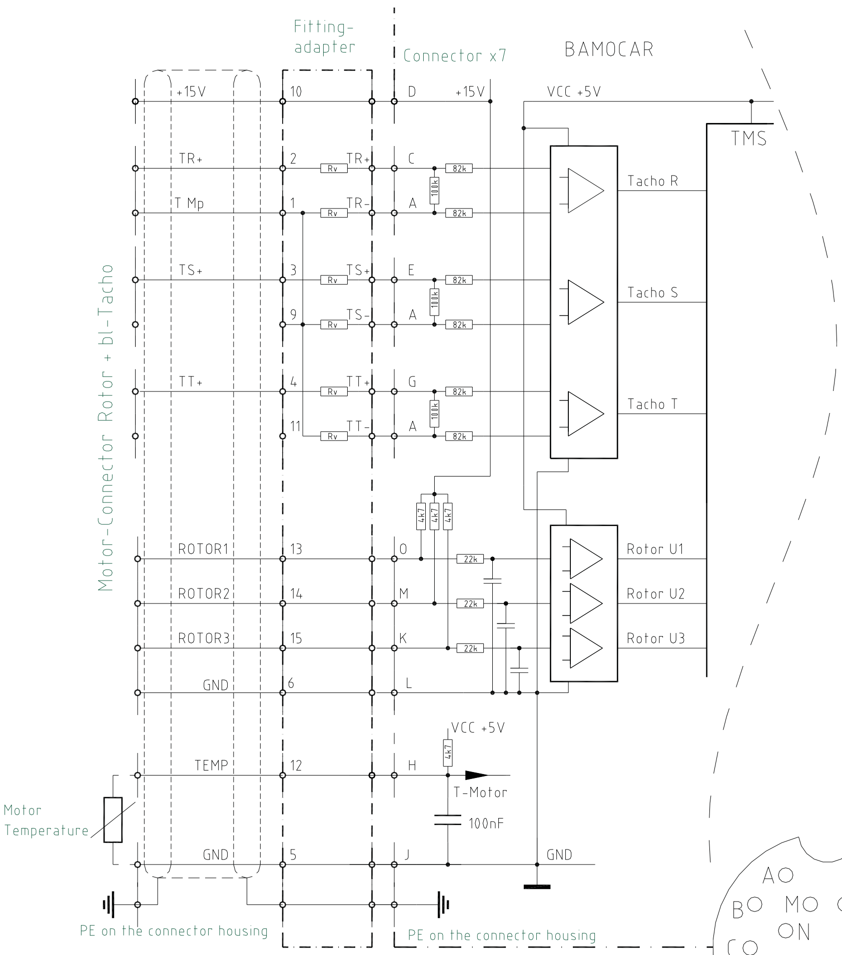
Individual parameter refer software manual DS NDrive.

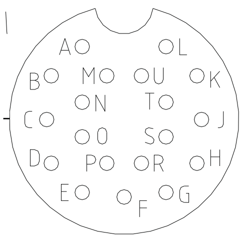
Rotor sensor Anschluss with bl-tacho
only BAMOCAR-D3- xx-bl

Rotor position indicator connection with bl-tacho
only in case of
BAMOCAR-D3 xx-bl

3 rotor position sensor signals (hall sensors) for commutation. With or without brushless tacho generator.

The rotor position sensor is galvanically connected with the equipment ground (gnd).
Supply voltage 15 v is from servo.
Adapter , when tacho voltage at nominal rpm is more than 10 volts .
In case of low tacho-voltages connect x7: pin 1,9 and 11.
Connect the centre point of the tacho with x7:1





Connector X7
bl

a	mp-tacho
b	
c	tacho 1
d	voltage +15v
e	tacho 2
f	
g	tacho 3
h	temp signal
j	temp gnd
k	rotor 3
l	versorgung gnd
m	rotor2
n	
o	rotor 1
p	

To be used only with motors approved by UNITEK (Appendix A) with rotor position sensor (bl).

Observe the motor-specific connection chart (bl).

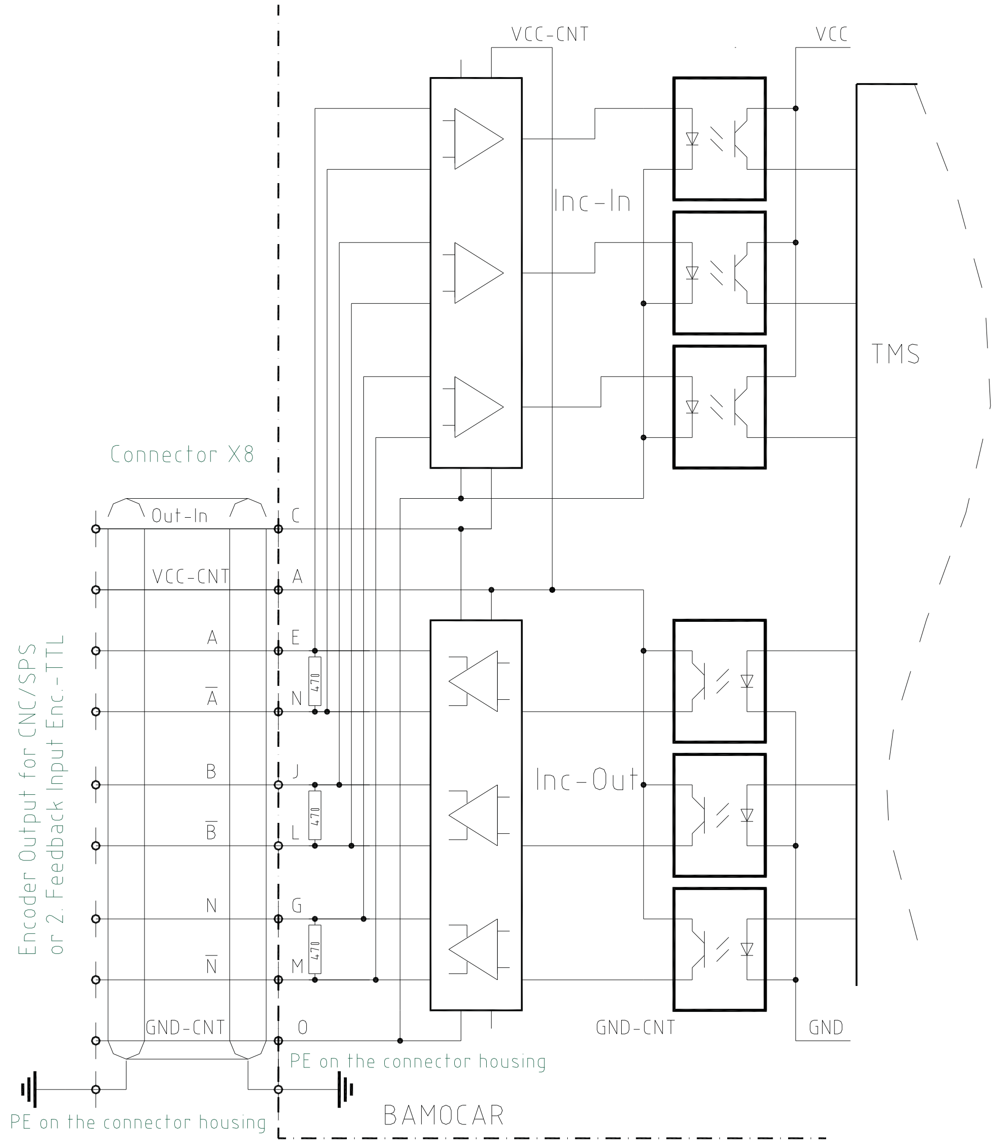
Terminal connector X7	19 pole round connector
Connecting cable	12 x signal cables , supply cables, temp Minimum cross-section 0.25 mm In case of pull chain use only suitable cable.
Cable length	In case of > 25 m diameter, one step more.
Screen connection	At connector x 7 , connect screen with the connector casing . Connect the screen with the connector casing at the motor connector end.

Individual parameters refer software manual DS NDrive.

X8 TTL- Encoder output or input (2)

The D- connector X8 will be operated as input or output(default).

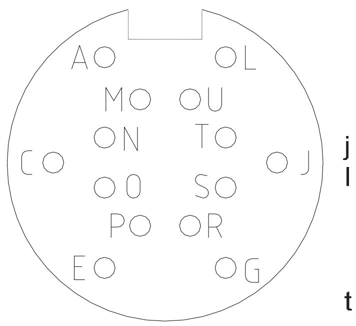
Output X8 pin c not used or connected with GND.
Input X8 pin c connected with + 5 v (x8: a)



Connector X8
Output / 2 Input
ENC-TTL

a	voltage +5v
c	selekt in
e	canal a
g	canal n
j	canal b
l	canal /b
m	canal /n
n	canal /a
o	voltage GND

output dac1



Attention **X8 as input**

Connect x8: C (select in) with x8:A (+ 5 V) within the connector .

FreeSB FSB-PR-02

Power Relay Management

Features

- **Manages up to 3 independent power outputs (DC coil contactor, fans...)**
- **Supports wide DC contactor coil voltage levels (2 ranges depending of supply reference: from 9V to 36V or from 18V to 75V)**
- **Supports wide input voltage levels from 10V to 75V**
- **Current measurement through external Hall effect current sensor**
- **Isolated CAN bus interface to adjacent devices**
- **Compliant with FreeSafe (Freemens Battery Management System) for complete battery management solution**
- Non isolated I^2C communication
- Contactor and fuse continuity tester
- Built-in self-tests
- High EMI immunity

Applications

- Electric and Hybrid Electric Vehicles
- High Power Portable Equipments
- Backup Battery Systems
- Electric Bicycles, Motorcycles, Scooters

Description

FreeSB-PR is a smart circuit breaker especially designed for high currents. FreeSB-PR can drive up to 3 external devices such as power switches or fans, powered by the supply dedicated to the circuit breaker (e.g. it is possible to wire two contactors and one light).

FreeSB-PR provides an easy to use solution to manage large packs of Li-Ion batteries. FreeSB-PR boards are easy and safe to connect or disconnect. FreeSB-PR supports a wide voltage supply range in order to drive a large range of DC contactor coils.

Current measurement is assured using external Hall effect sensor that must have a current output for the measurement. The accuracy of the measurements depends on the accuracy of the sensor. A ±12 V power supply is available for the sensor.

FreeSB-PR cuts off the current when a short circuit is detected: the cut off time depends on the switch off time of the power switch. FreeSB-PR can also react on over-current or over-temperature: these parameters are programmable as well as the time to react. FreeSB-PR protects the battery cells from over and under voltage based on the data received from FreeSafe Battery Management System.

The circuit breaker is continuously testing the fuse and power switch in order to assure the integrity of these devices.

To ensure that the battery is used properly, FreeSB-PR sends all the data to FreeSafe, which records all activities in an up to 10 years long data history file. The communication between FreeSafe and FreeSB-PR is realized through CAN bus. FreeSB-PR is delivered with a comprehensive CAN application layer.

While FreeSB-PR devices are "plug and play" for LFP batteries, specific applications and other chemistries require custom settings. FreeSB-PR parameters can be easily changed.

Typical Application

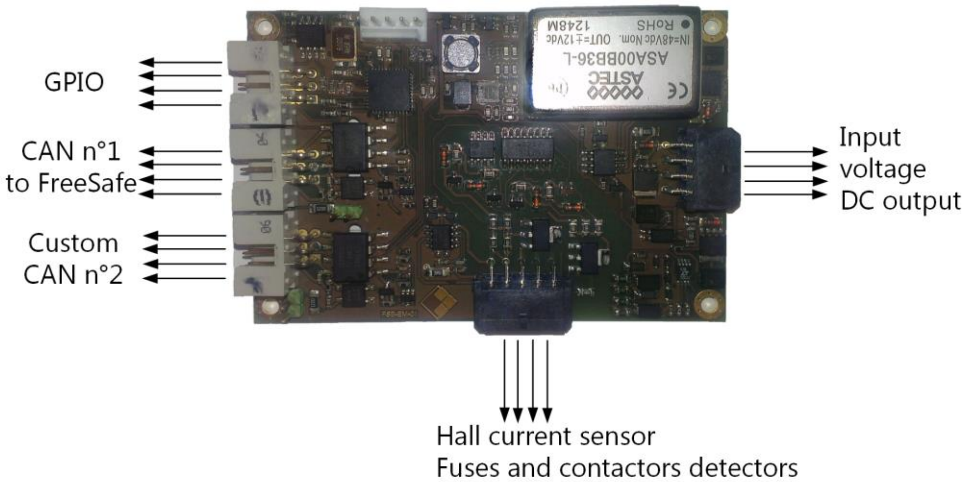


Figure 1 - FSB-PR board inputs and outputs

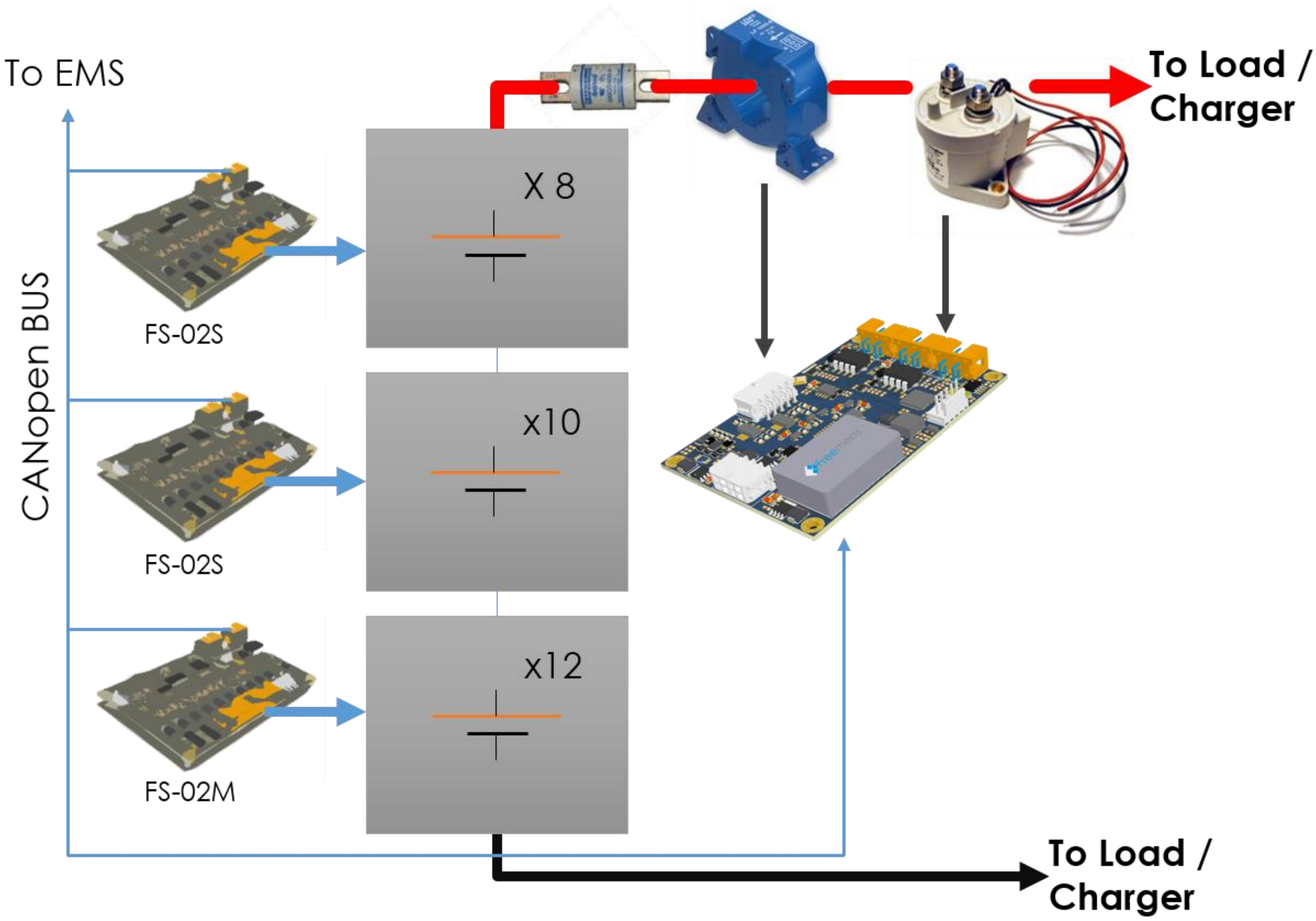


Figure 2 - Example of a battery management solution with 3 stacked FreeSafe boards, a FreeSB-PR and its peripherals

Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Maximum input supply voltage Maximum DC contactor coil voltage	Vin	36 or 75 *	V
Maximum allowed inrush current per power output		15	A
Maximum input current measurement provided by a Hall Effect sensor		±110	mA
Operating temperature range		-40 to 85	°C
Maximum CANbus supply current		200	mA
Maximum voltage for isolated continuity testers		400	V

* Input voltage is either 9-36V or 18-75V according to the supply reference onboard.

General description

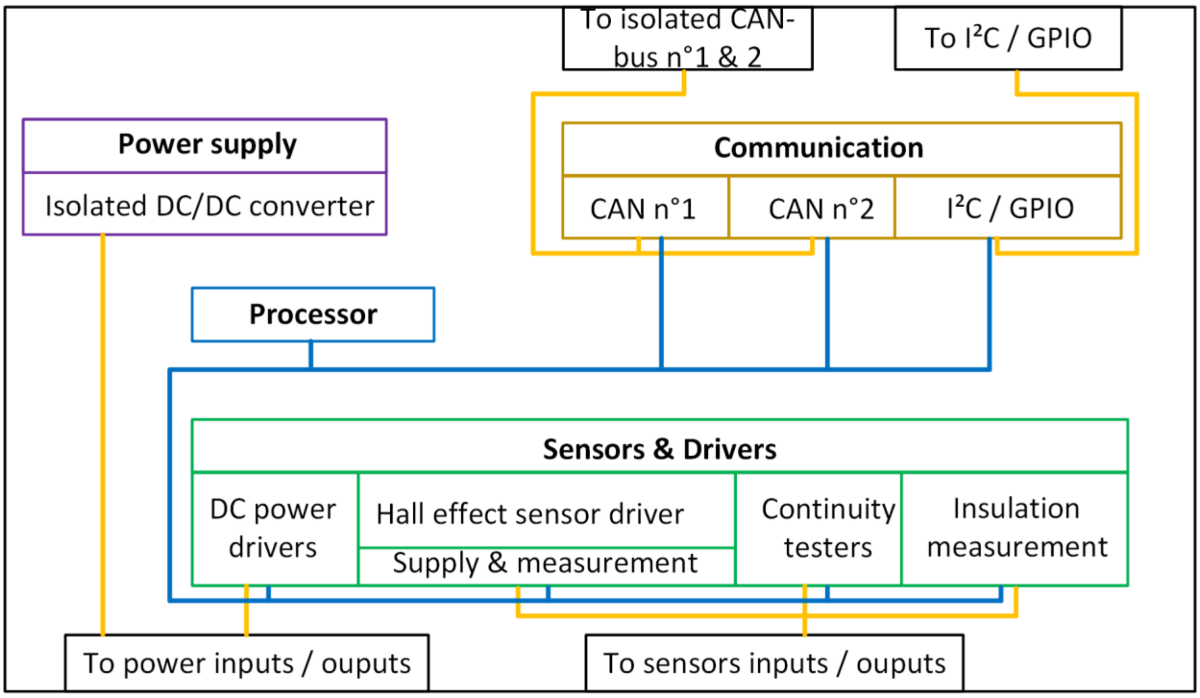


Figure 3 - Functional diagram

The following functional blocs are presented:

- Management (processor)
- Sensors & Drivers
- Power Supply
- Communication

Power supply unit

FreeSB-PR integrates its own Power Supply Unit (PSU) making the board fully standalone once connected to a wide range of DC sources. On board supplies are isolated ±12V_{DC}, 5V_{DC} and 3.3V_{DC}. By default, the PSU must be connected to a source with a voltage range between 18V and 75V. FreeSB-PR can also accept an input between 9V and 36V, if the reference of the PSU is adapted.

DC source design choices

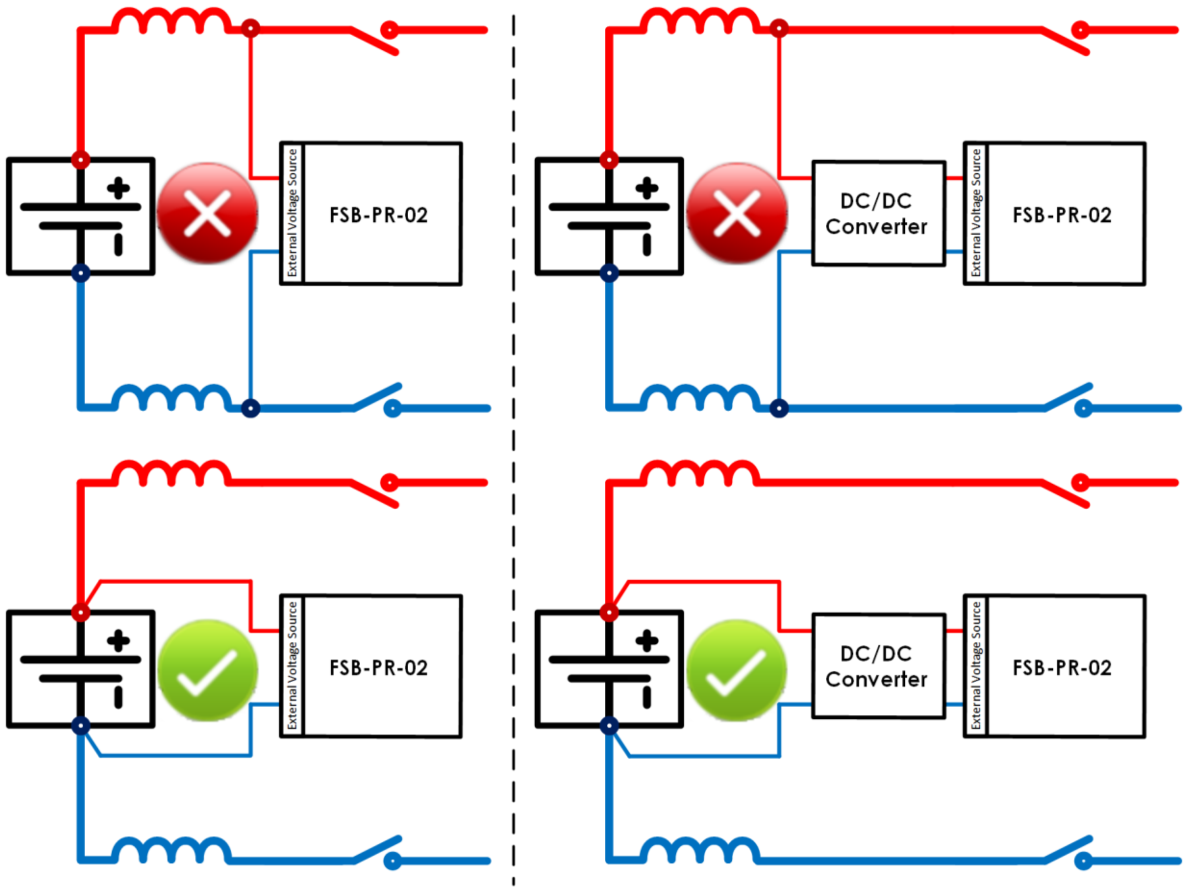
The DC source of FSB-PR must provide any voltage between 18V and 75V (or 9V and 36V). At least 6Wmax are needed to supply all the electronics on the board. The DC source must also provide enough current to be able to withstand the inrush current when driving DC contactor coils. The standard solution is a DC/DC converter directly plugged on the battery and designed to provide enough power. Another solution could be to plug FSB-PR directly to the main battery if the voltage concurs with the input limits. It is possible to use an intermediate point on the main battery as a DC source - for instance connecting FSB-PR between the ground and the 8th cell of a 15 cells 48V LiFePO4 battery provides a 20V to 29.2V supply. But this will unbalance the firsts 8 cells of the pack and an equalizer such as a FreeFlex (Freemens Flexible Power Supply) will be required.

There is another constraint in the choice of the DC source: the driving voltage of the DC contactor coil. The supply voltage will be directly reused to drive the contactor, so **all the devices must work with the same voltage level (source, contactor, fans, lamp, etc).**

Connecting FSB-PR to the DC source

The DC source must ensure a stable input voltage in the specified input range. For that the connection between FSB-PR and its source must be carefully considered.

If the DC source is the battery or a DC/DC converter (isolated or not) whose input is the battery, the connection to FSB-PR has to be a star connection as shown on the next figure. This star connection guarantees that the power current flowing to the application, or from the charger, will not trouble the input of FSP-PR from wire inductive or resistive perturbation.



Using the battery as the DC source for FSPB-PR-02:

Direct use if 9V<Vbat<75V Through a DC/DC converter

Figure 4 – Connection of the DC source to FSB-PR

Sensors & Drivers

The Sensors & Drivers block provides precise and reliable measurements related to the operating conditions. As a result, FreeSB-PR is able to sense power current and drives up to 3 independent power outputs. Current measurement is retrieved through an analog to digital conversion of the measurement given by a Hall Effect sensor device. In addition, FreeSB-PR includes sensors that measure the insulation resistor between the chassis and the battery contacts and also continuity testers that detect a fuse or power contactor fault.

Hall Effect sensor design choices

Two constraints guide the choice of a Hall Effect sensor working with FSB-PR. The first one is that the supply voltage provided by the board is a ±12V dual supply (±250mA max). The second one is that the sensor must be a current transducer that will provide an output current measurement, which is an image of the power current. This current measurement must be ±110mA max, otherwise, the measure will exceed the full scale measurement because of the default amplification gain on FSB-PR.

The gain of the Hall Effect sensor can be configured through the configuration file of FreeSafe. To modify the gain of the FSB-PR board – in order to change the limit of the full-scale measurement – a custom PCB design will be needed.

Example of recommended Hall Effect sensors:

- LEM LS 205-S/SP3: ±100A nominal current measurement, ±12V supply, closed loop current transducer (1:1000 ratio).

Datasheet: http://www.lem.com/docs/products/lf%20205-s%20sp3.pdf

- Tamura S23P50/100D15M1 with similar characteristics.

Datasheet: http://www.tamuracorp.com/clientuploads/pdfs/engineeringdocs/S23PXXXD15M1.pdf

Contactor (or fan or other peripheral) design choices

The power DC contactor as shown in Figure 5, must be designed to withstand the battery voltage, the nominal power current and to be able to cut over current or even, if needed, short-circuit current. The driving voltage of the coil and the supply voltage of the board must be the same. The maximum inrush current that drives the coil must be less than 15A during 100ms and the maximum continuous driving current must be less than 3.75A if only one output is supplying the current and 2.1A per output if all three outputs are working in the same time. Following these recommendations ensure the proper use of FSB-PR and its functions.

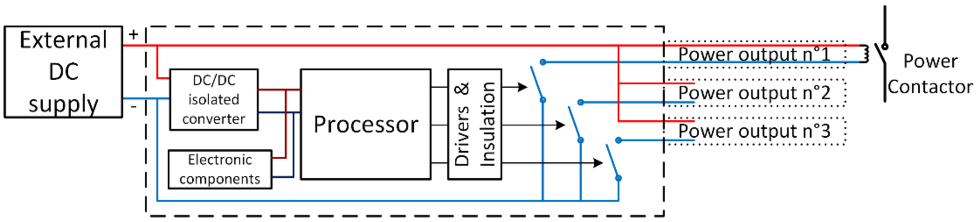


Figure 5 - functional diagram of the 3 DC power outputs and their supply

Example of recommended DC contactor:

- TE connectivity Kilovac EV200: 900Vdc max, 500Amax, 9V to 95V coil voltage. Datasheet:

http://www.te.com/catalog/pn/fr/1618002-7

Management

A powerful 16bits DSC (Digital Signal Controller) is used for the data processing. The DSC is the core of the system where most of the algorithms are implemented. It communicates and controls the other function of the BMS:

- Driving the 3 power outputs to change the states of the contactors, fans, etc.
- Measurements retrieval from all the sensors
- Estimators computing
- Wired system level communications

FreeSB-PR transmits its data (e.g. current measurement or events) to FreeSafe through CAN communications. All data related to the battery and the BMS operations are then stored and kept available for future use. Based on an embedded micro SD card of 4Gbits (default configuration), FreeSafe is able to record up to 10 years of data. Remote access is possible for the battery fleet control & monitoring thought proprietary FreeLab application and FreeData database.

Communication

FSB-PR includes hardware for CAN bus communication protocols to facilitate the communication between the BMS and the other control or power interfaces of the system. In particular, FreeSB-PR integrates an isolated CAN Bus allowing to communicate with other Freemens products (the FreeSafe solutions for instance). For the communication with other external devices, a second CAN bus is provided but this feature needs a custom development to implement the desired communication protocol. The extensive communication techniques allow FreeSB-PR to receive control orders, updated programs and parameters.

Connectors' Configuration

Two variants of the connectors' configuration of FSB-PR are possible. The first one is a version with wire-to-board connector and is designed for general use. The alternate version has board-to-board connectors and is designed to be plugged on a mother board. Between the two variants, all the connectors have the same pins configurations, the difference is based on the footprint and the mechanical characteristics of the connectors.

Wire-to-board version

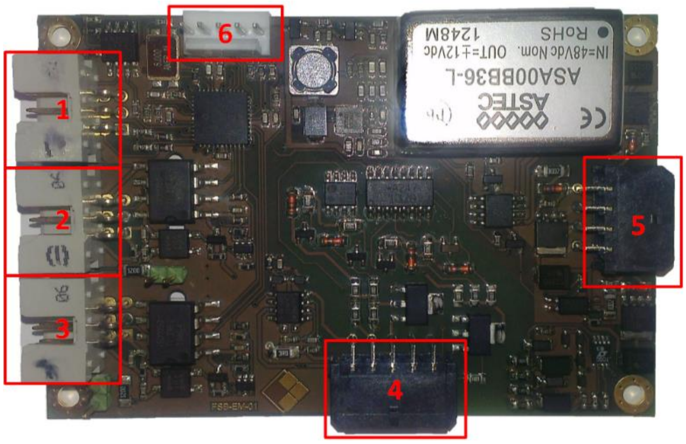


Figure 6 - FreeSB-PR top side view

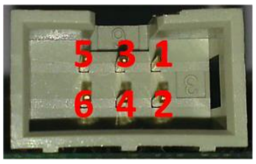
Connectors' description

Connector	**Description**
1	I^2C / GPIO connector
2	CAN bus n°1. Main CAN connected to FreeSafe Boards
3	CAN bus n°2. Secondary CAN for custom protocols
4	Connector for Hall sensor, continuity tester, insulation measurement
5	Input supply and output to contactors or fans
6	Programming connector

Connectors' references

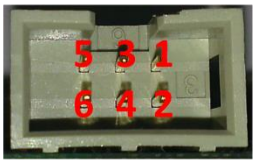
N°	**Onboard connector**		**Recommended complementary connector**	
	Manufacturer	Reference	Manufacturer	Reference
1, 2 & 3	Harting	09 18 506 7323	Harting	09 18 506 7803
			3M	3365/06
4	Molex	43045-1000	Molex	43025-1000
			Molex	46235-0001
5	Molex	43045-0800	Molex	43025-0800
			Molex	46235-0001

Connector n°1 - I²C / GPIO



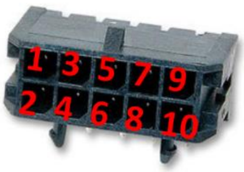
Pins	Description
1	Over Voltage signal
2	SDA
3	Digital I/O
4	SCL
5	Analog or digital I/O
6	NC

Connector n°2 & n°3 – CAN BUS



Pins	Description
1 – 2	5V output up to 200 mA
3	CAN L
4	CAN H
5 – 6	GND

Connector n°4 – Sensors inputs & outputs



Pins	Description
1	-12V output up to -250 mA
2	IM – Input measurement for Hall Effect sensor
3	Fn – Continuity testing input
4	+12V output up to 250 mA
5	Cp – Continuity testing input
6	Chassis
7	Cn – Continuity testing input
8	Fp – Continuity testing input
9	Bat+ – Continuity testing input
10	Bat- – Continuity testing input

Connector n°5 – Power inputs & outputs

Pins	Description
1	Power output negative – C3-
2	Power output positive - C3+
3	Power output negative - C2-
4	Power output positive - C2+
5	Power output negative- C1-
6	Power output positive - C1+
7	GNDsource
8	Vsource

Connector n°6 – Programming connector

Pins	Description
1	Reset
2	3.3V
3	GND
4	PGD
5	PDC

Alternative connector version

In this FreeSB-PR version, all connectors are replaced with standard pitch .100" (2.54mm) terminal strips enabling simple board-to-board interfacing. The pin configuration between the different versions is identical.

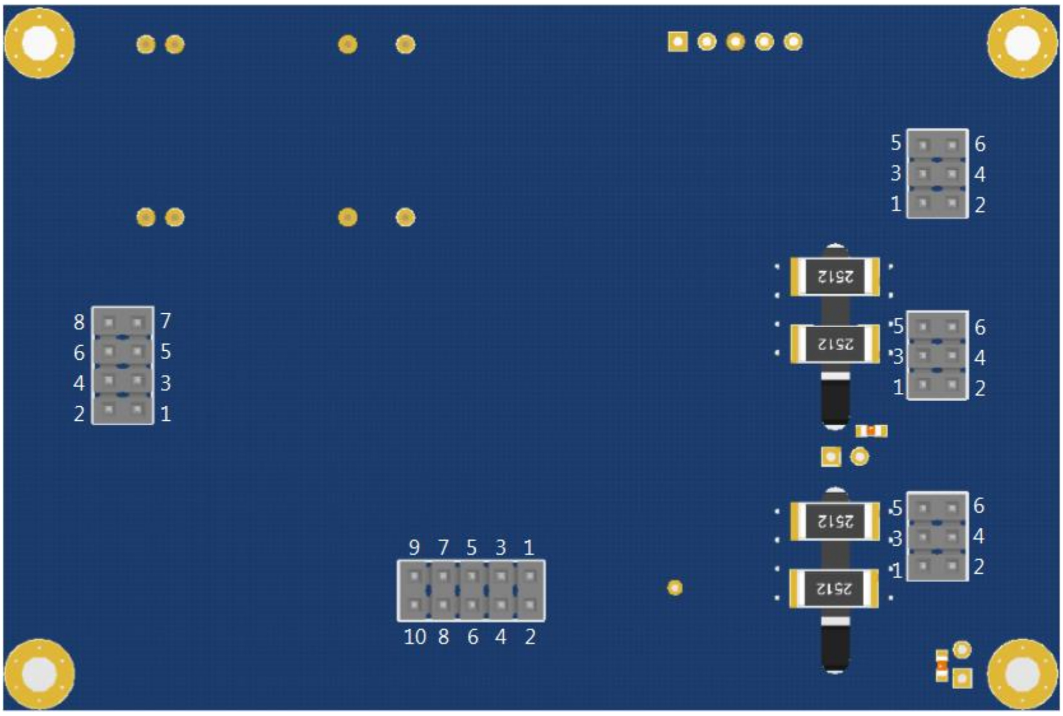


Figure 7 - FSB-PR alternate connector version. Bottom view.

	Onboard connector		Recommended complementary connector	
N°	Manufacturer	Part number	Manufacturer	Part number
1, 2 & 3	SAMTEC	TSW-103-07-T-D	SAMTEC	SSW-103-07-T-D
4	SAMTEC	TSW-105-07-T-D	SAMTEC	SSW-105-07-T-D
5	SAMTEC	TSW-104-07-T-D	SAMTEC	SSW-104-07-T-D
6	SAMTEC	TSW-105-07-T-S	SAMTEC	SSW-105-07-T-S

Connection procedure

Step	Connector	Comment
1	1, 2, 3 & 4	No particular steps are required for these connectors. FreeSB-PR will not start or power up before the power connector (n°5) is connected to the supply.
2	5	1 second after the connection, the initialization routine will close the main power contactor if no fault is detected.
Caution	6	Programming connector is only used when firmware update is necessary. Notice that pin 3 is referenced to the chassis terminal of the 4th connector. Caution must be taken when connecting a non-isolated debugger or programmer

Connection to the battery management system

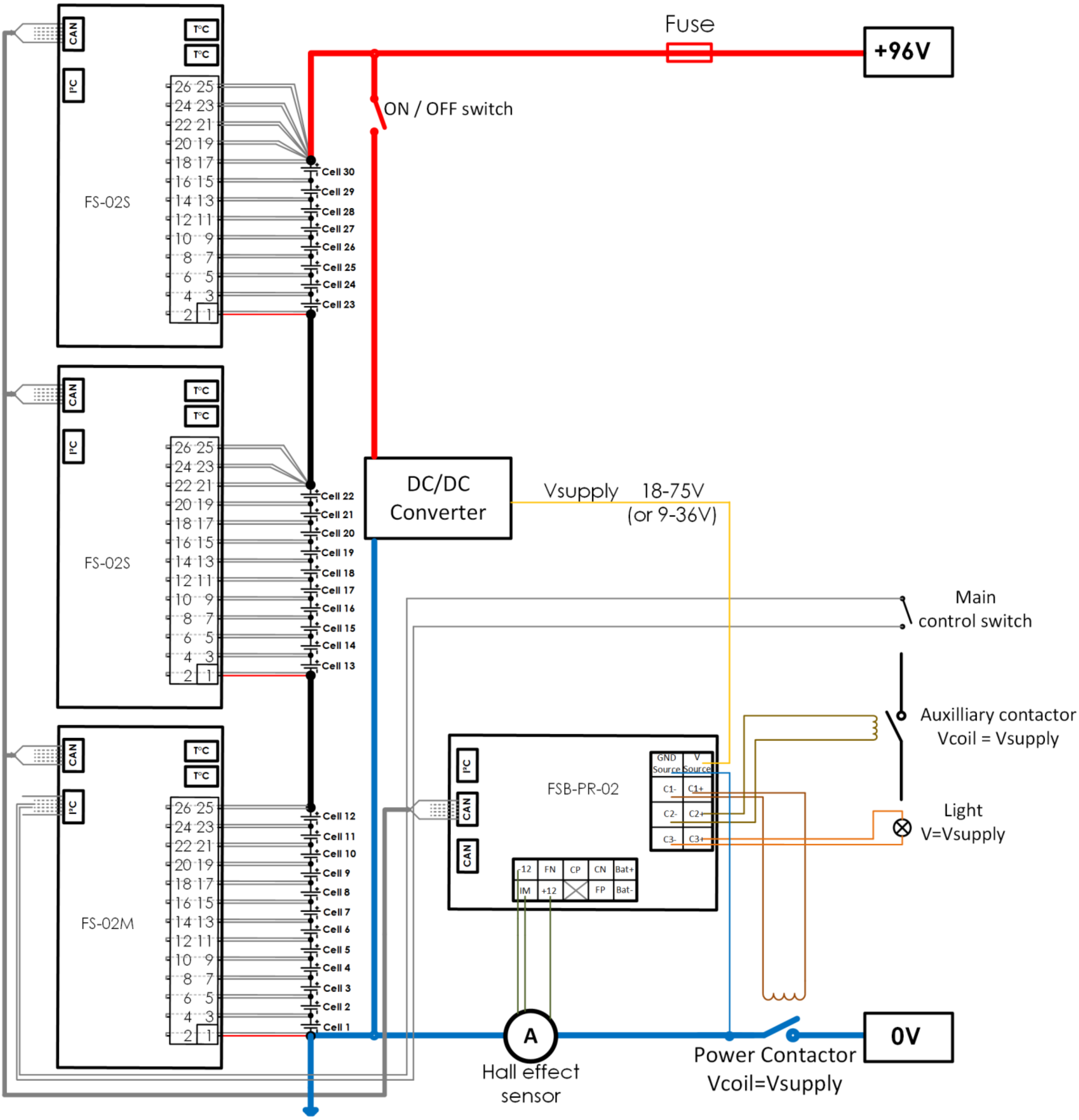


Figure 8 - A typical application for a 30 cells $LiFePO_4$ battery (96V), 12V DC contactors (power and auxiliary), warning light and on/off switch

v1.00

Electrical Characteristics

The following specifications apply to the full operating temperature range

Supply

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Voltage	V_{in}		10		75	V
Supply Current[1]	I_s	Sleep Mode (Vin = 10 V)		29		mA
		Normal Mode (Vin = 10 V)	29,5	30	31	mA
		Sleep Mode (Vin = 75 V)	6,5			mA
		Normal Mode (Vin = 75 V)[2]	5	7	8	mA

[1] More details on the current consumption are shown on Figure 9 below.

[2] Temperature max on the board: 35°C. The ambient temperature is 25°C.

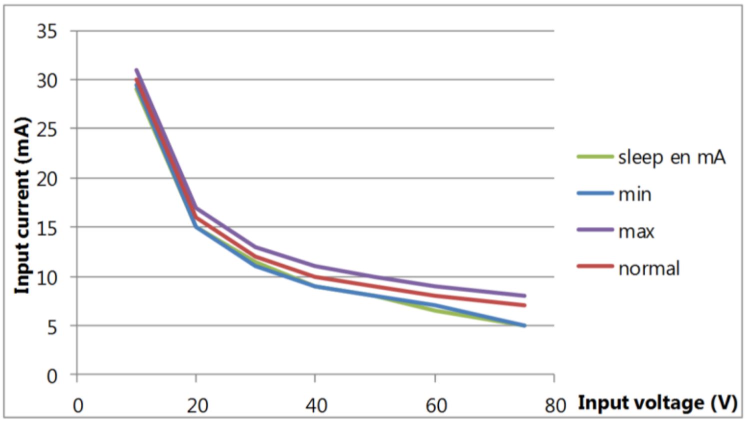


Figure 9 - Supply current vs input voltage

DC power output (for driving contactor, fan or other dc peripherals)

Parameter	Symbol	Conditions		Min	Typ	Max	Units
Output Voltage	V_{out}	$V_{out}=V_{in}$		10		75	V
Max peak current per output	I_{outmax}	Non repetitive t_{peak}=100ms				15	A
Max continuous current **per output**	I_{out}	Only **one** output working	T_{amb} =25°C			3.75	A
		All three outputs are working				2.1	A

CANBUS (main and custom secondary)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Voltage (Bus side)	V_{bus}	Power on the bus is provided by the first BMS of the string		5		V
Can Bus Output Voltage **(dominant)**	CAN_H	Vi = 0 V, R_L=60 Ohm	2.9	3.5	4.5	V
	CAN_L		0.8	1.2	1.5	V
Can Bus Output Voltage **(recessive)**		Vi = 2 V, R_L=60 Ohm	2	2.3	3	V
Can Bus High-level output current	I_{OH}	Driver	-70			mA
		Receiver	- 4			mA
Can Bus Low-level output current	I_{OL}	Driver			70	mA
		Receiver			4	mA
Can Bus Rate of Operation	F_{can}			1		Mbps

I²C / GPIO (not isolated)

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Max input / output voltage[3]				3.3	3.6	V
Min input / output voltage[3]			0			V

[3] inputs or outputs in 3.3V logic.

Hall Effect sensor

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply voltage	V_{hall}	Dual voltage supply	±11.6	±12	±12.4	V
Voltage ripple				120mV		
Max supply current[4]		Current consumption of Hall Effect sensor on ±12V supply			±250	mA
Max input current on FSB-PR	I_{hall}	Mandatory use of a current transducer Hall effect sensor			±110	mA
Internal ADC precision[5]		Output current of Hall sensor converted by a 12 bits ADC		0.054		mA

[4] the ±12V supply is short-circuit protected.

[5] the resolution of the conversion of the output current provided by the Hall Effect sensor. The 110mA max converted by a 12 bits ADC gives $110/2^{12}$=0.054mA/bit.

Operation

Standard peripherals

The use of FreeSB-PR requires the following devices:

- A configured FreeSafe system.

- A main contactor to allow or not the use of the battery. Connected on C1+ & C1- of connector n°5.

- A Hall Effect Sensor to measure the power current, to protect the battery and its application and to estimate some state indicators such as the State Of Charge (SOC) or the State Of Health (SOH) of the battery. Connected on ±12V & Im on connector n°4.

- Optional elements, such as an auxiliary contactor (connected on C2+ & C2- of connector n°5) to drive the external battery charger or a lamp indicator (connected on C3+ & C3- of the 5th connector) which is lighted when the SOC is less than 10%, are already provided in the standard operating version. If other functions are needed - e.g. fan driving or other operating logic for the contactors (power or auxiliary) - a custom firmware design will be necessary. The behavior of the peripherals on C2 and C3 output can easily be configured upon request before the firmware is loaded in the FSB-PR board. Further ongoing development will allow a fast configuration and reconfiguration through parameters stored on the memory card of FreeSafe without having to reload a new firmware.

Switches can be wired on FreeSafe to ensure some additional functionalities. The description of these functions are described in the FreeSafe datasheet and are resumed below.

- A switch to control the state of the main power contactor, the shutdown state and to re-engage the system when it enters in protection mode after a fault detection. The faults management is described in the section p14 "Fault management process". It is connected on the connector n°5 of FS-02M, between pins 2 and 3 (or between pin 2 and GND)

- An optional switch dedicated to the wake up function if needed by the application (example: the connection of a charger wakes the system up through the use of this function).

First connection

After its first connection to the main elements of the system (cf previous paragraph), the system starts if it is supplied. If no fault is detected - proper communication with the rest of the system, no over or under voltage or no over or under temperature of the battery - and if the main switch enable its operation, the main power contactor is driven and its contacts are closed to allow the use of the battery. Depending on the battery state (SOC<100% and no over voltage detected), the auxiliary contactor (if connected) is closed to allow a charge by the external charger. The lamp (if connected) is lighted as soon as the SOC falls under 10%. 10% is the default threshold, any over value can be configured before loading the firmware.

Tuning of the Hall Effect current sensor

The configuration file in the memory card of FreeSafe contains a few parameters enabling the current measurement:

- Id 9, CURRENT_MEAS_CONVENTION), enables the change of the convention sign of the current measurement. The convention for the current measurement of FSB-PR is to count positively the current that charge the battery and negatively the current that discharge the battery.

- Id 38, FSB_PR_LEM_GAIN, settles the gain of the chosen current sensor. For instance, with the LF 205-S/SP3 from LEM, FSB_PR_LEM_GAIN = 1000.
- Id 51, FSB_PR_REF_CURRENT, is the parameter that sets the value of the current reference to ensure that the measurement of a zero current value is truly on the 0A operating point.

The need of adjustment of the current measurement can be required in two cases. First, the sign of the current measurement does not match to the convention that the current charging the battery has to be positive. Second, the current measurement is not 0A when the power contactor is opened and must be adjusted.

In the first case, there are two solution: the current sensor can be re-wired in the other direction to be rotated by 180°, or the parameter CURRENT_MEAS_CONVENTION in the configuration file can be modified to fit the convention.

For the second case, the parameter FSB_PR_REF_CURRENT will be used to settle the internal reference of FSB-PR to get the right zero current measurement. The following method has to be applied:

- Ensure that no current is flowing in the battery through the current sensor
- Read the value of the current measured *Imes* (average value on a few seconds)
- Modify the parameter FSB_PR_REF_CURRENT in the configuration file according to the formula bellow

$$\mathrm{FSB\_PR\_REF\_CURRENT}\ (new\ value) = \mathrm{FSB\_PR\_REF\_CURRENT}\ (previous\ value) + \frac{Imes * 18618}{\mathrm{FSB\_PR\_LEM\_GAIN}}$$

- Reset FreeSafe to force the loading of the new value
- Check the modification by reading the new value of the 0A.

N.B. 1: after the modification of one or several parameters in the configuration file, a reset of FreeSafe is mandatory to insure that the new parameters are loaded.

N.B. 2: very low current values, under 1% of the nominal current, can be subject to noise perturbations and are not measured.

The battery is then ready to be used in its standard operation.

Standard operation

After the first connection, if no action on the battery (current consumption for example) is detected during 60 seconds, FreeSB-PR enters in a standby mode and the 3 power outputs are turned OFF to save energy. To exit the standby mode, the wake up switch or the main switch must be activated. It is also possible to activate the main switch to wake the system up and to turn the main contactor ON again.

When the battery is ready to be used, any current can be applied to charge or discharge it. Every 100ms, the state of the battery (including current measurement, coulomb counting and fault detection) is transmitted and updated between FreeSafe and FreeSB-PR via CAN communication.

The main switch has three functions. The first one is to change the state of the main power contactor (closed or opened). The second one affects the default mode and allows the user to restart the contactor after a fault management. This function is described in the section “Fault management process” below. The last function is to wake up the system or allow its shutdown.

Fault management process

Whenever a fault is detected (e.g over current or communication error), the standard fault management is started. The main power contactor is opened to protect the battery and its application. A manual action from the user - to acknowledge the fault detection, to find the error and if needed, to repair it - will be requested via the main control switch to allow FreeSB-PR to resume its operation.

There are three fault managements that are not included in this process: the short circuit, the under voltage and the communication faults. They are described in the next paragraphs.

Short circuit (i.e. hard current limit) management

Among the configuration parameters available in FreeSafe, a pair sets the positive and negative hard current limit ("**CURRENT_PIC**" and "**CURRENT_PIC_NEG**"). Beyond these limits, FreeSB-PR instantaneously opens the main DC contactor to protect the system. The time response of this protection depends on two elements: the response time of the current sensor chain and the response time of the contactor.

- Response time of the Hall Effect sensor. If the selected device has similar characteristics to the ones proposed in the "Sensors and drivers" section, it will be <10µs – they have a measurement bandwidth of 100 kHz.
- Response time of the analog to digital conversion and processor decision management. It will be less than 100µs as the whole process is calibrated to work at 10 kHz.
- Response time of the power DC contactor. If the selected device has similar characteristics to the one proposed in the "Sensors and drivers" section, it will be less than 12ms.

After detecting a short circuit and opening the power DC contactor, FreeSB-PR waits for the reboot switch to be activated in order to re-engage the power contactor and resume its operation.

Under voltage management

Like any over error, the standard fault management is applied. Normally, after a voltage fault the voltage returns to the standard values: for an overvoltage, as soon as the current stops, the cells' voltages decrease and stabilize to a value under the overvoltage limit. The same applies for the under voltage limit, as soon as the current stops, the cells' voltages rise and stabilize to a value higher than the under voltage limit.

When there are devices that cannot be disconnected by the main power contactor (for instance any critical device which must not be shut down like the battery management system or an emergency power supply), a problem with the under voltage management appears. Even if the main power contactor is opened, there is still some current that can be drawn and keep the battery cells under the voltage limit. The main contactor cannot be closed automatically and so it will not be possible to charge the battery without an external action from the user: the switch must be used to force the circuit closure. The contactor will be opened 60 seconds later if no charge current is measured. Any discharge current detected during this forced closure will lead to an immediate opening of the contactor to protect the battery.

Communication error management

If a communication error is detected, a retry is attempted 5 times, each 10ms. One second later, if FreeSB-PR still cannot exchange any information with FreeSafe, it will assume a communication fault and to protect the system will open the main power contactor until the communication is reestablished.

Over current (i.e. soft current limit) management

There are 3 configurable parameters: "**CURRENT_LIMIT**", "**CURRENT_TIME**" and "**CURRENT_NOMINAL**" for positive current and "**CURRENT_LIMIT_NEG**", "**CURRENT_TIME_NEG**" and "**CURRENT_NOMINAL_NEG**" for negative current.

CURRENT_NOMINAL is used to define the nominal current at which the system is designed to be used (i.e thermally stable). It can be the nominal current of the battery itself or the nominal current of its application.

CURRENT_TIME defines the allowed time of an overcurrent that exceeds the CURRENT_LIMIT value.

See chapter "Features being developed for next firmware release" for more details about the overcurrent management in the next firmware release.

Configuration

Thanks to the configuration file hosted on FreeSafe and its communication via CAN BUS, various software elements of FreeSB-PR can be configured. Among all the available parameters, the following list gives and briefly describes the ones related to FreeSB-PR configuration. The complete list of the parameters with their full description is available in the FreeSafe datasheet (section "configuration", table 13 in page 20 in the FreeSafe datasheet).

Mechanical Characteristics

This section presents the mechanical data of the two connector variants of FreeSB-PR: the wire-to-board connectors and the standard board-to-board. 100" pitch connector.

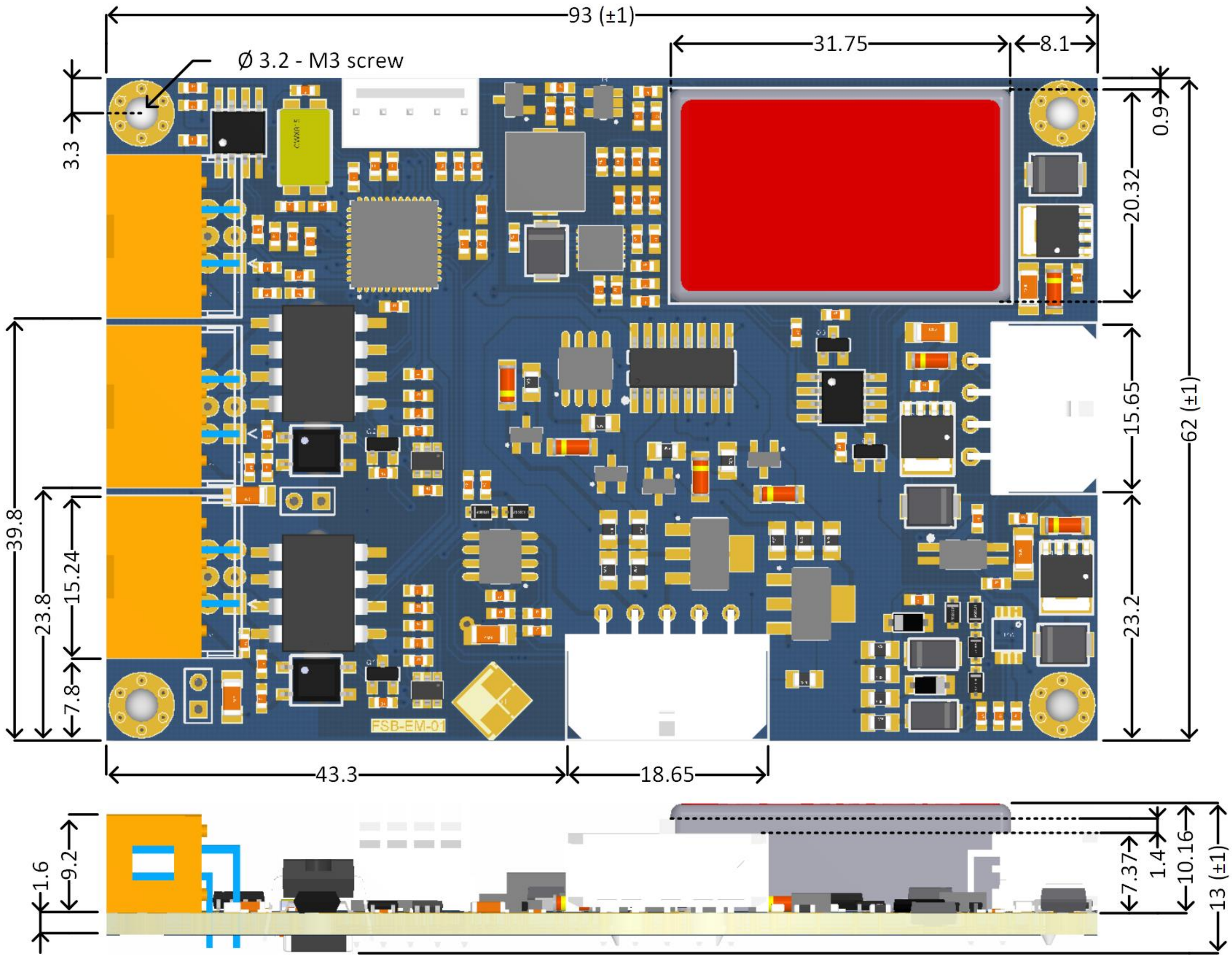


Figure 10 - Mechanical views (top and side views) of FSB-PR. Wire-to-board connector version.
All dimensions are in mm.

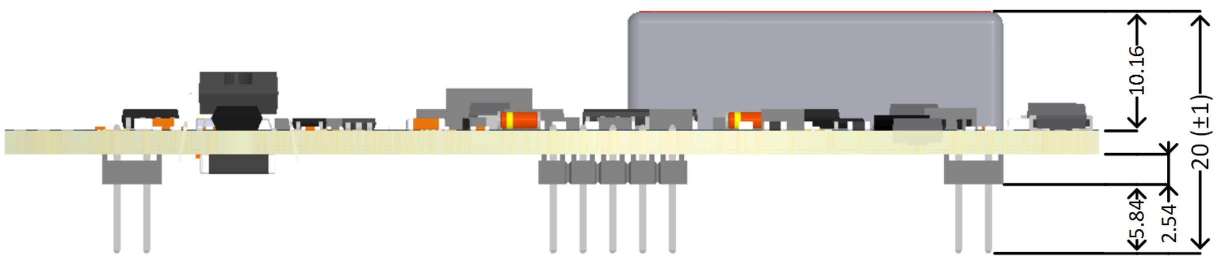
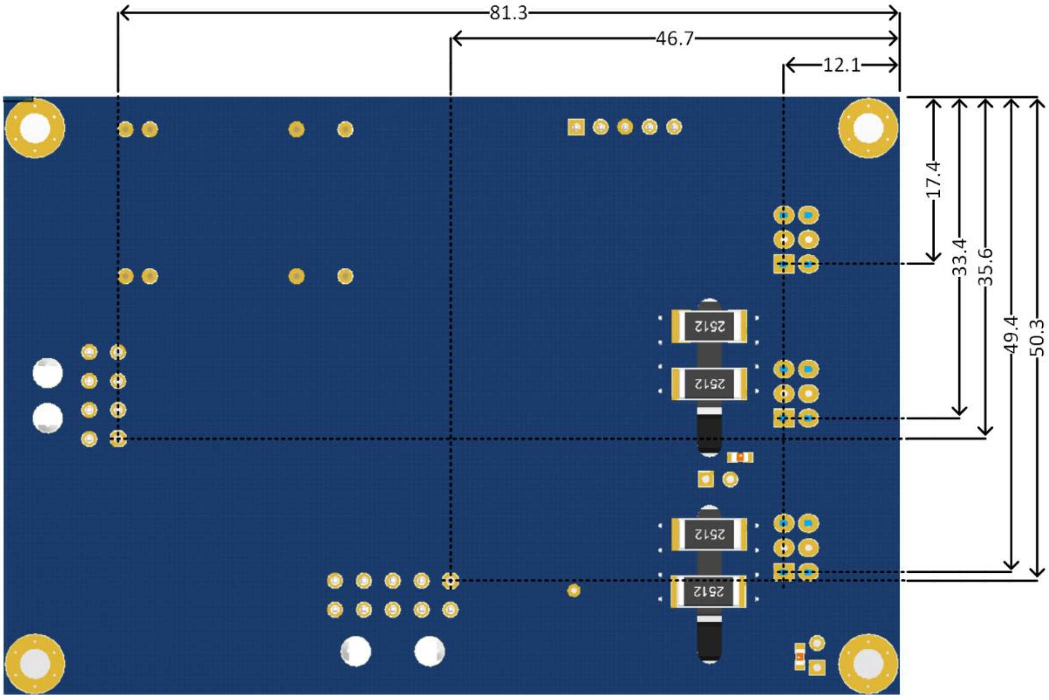


Figure 11 -Mechanical view (side view) of FSB-PR. Board-to-board connector version. All dimensions are in mm.

Wire-to-board version



Board-to-board version

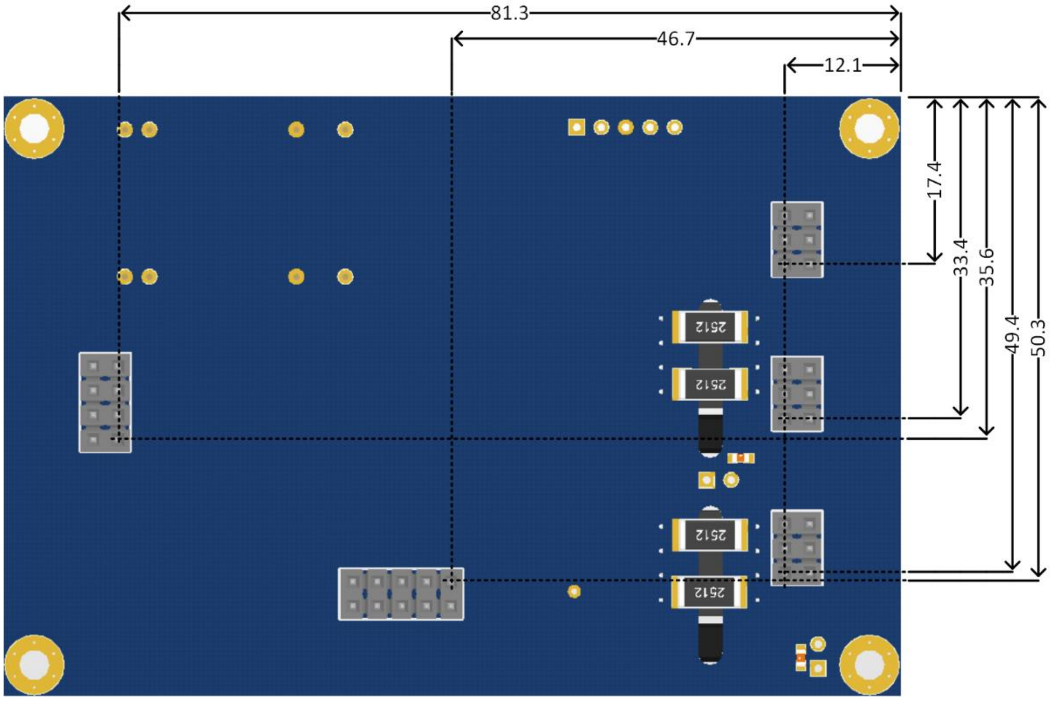


Figure 12 -Coordinates of the pin n°1 of each connector for the two connectors' variants. All dimensions are in mm.

The coordinates of the pins n°1 of each connector are the same for the two FSB-PR variants (wire-to-board and board-to-board). The differences occur on the pitch of the connectors: for connectors n°4 & 5 (power inputs & outputs and sensors & drivers) the pitch is 3mm for the wire-to-board version or 2.54mm for the board-to-board version.

Features being developed for the next firmware release

Fuse and contactor continuity tester

The continuity testers available in FSB-PR are specially designed to detect a continuity break on the positive or negative power line of the battery.

To use the continuity testers, some potentials must be wired to the system and are limited to the two power lines of the battery. In fact, the continuity between the Bat+ and Fp, Bat+ and Cp for the positive power line is tested. For the negative power line, the continuity between Bat- and Fn, Bat- and Cn is tested. Figure 13 shows a typical application with fuse and contactor protection on each power line.

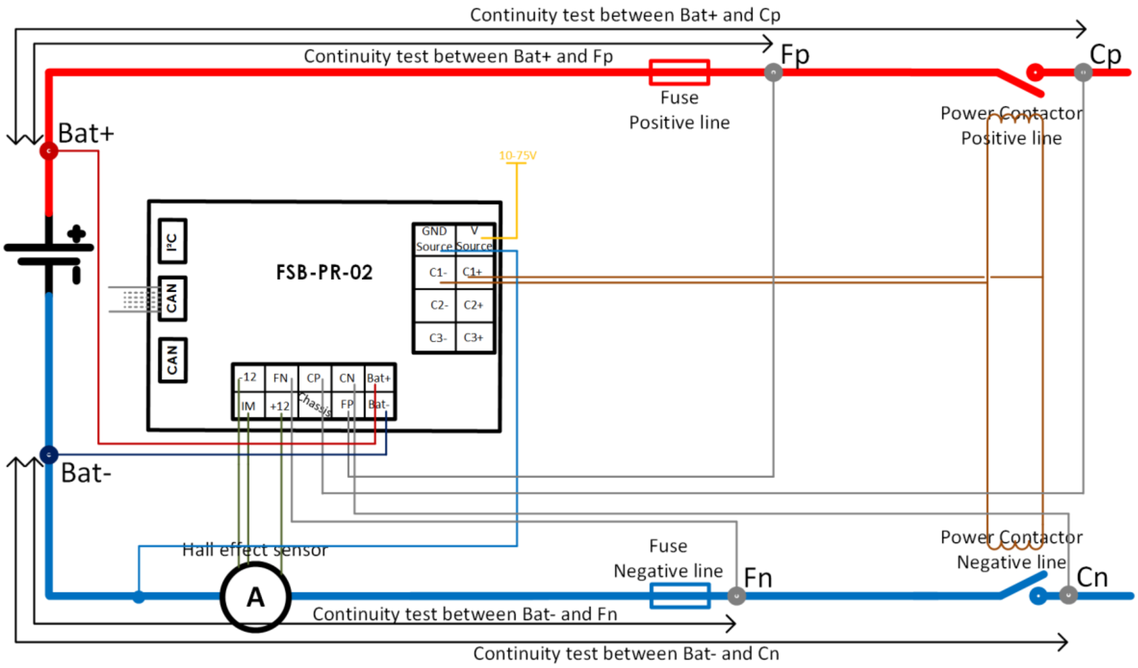


Figure 13 - Wiring (in grey lines) to test the fuse and contactor continuity with FSB-PR

As shown on Figure 13, there is a priority in the continuity of the tests. If the first element (tested between Bat+ and Fp) is opening the circuit, the second (tested between Bat+ and Cp) will be seen as opened even if it is closed. The table below summarizes these events. D_Fp is the logic output of the continuity tester on Fp (0 means no discontinuity detected, 1 means discontinuity detected), D_Cp for Cp, etc.

D_Fp	D_Cp	Positive fuse state	Positive contactor State
0	0	ON	ON
0	1	ON	OFF
1	X	OFF	X

D_Fn	D_Cn	Negative fuse state	Negative contactor State
0	0	ON	ON
0	1	ON	OFF
1	X	OFF	X

Standard operation of continuity testing

Each time after driving the main power contactor to close, a continuity test is performed. If a continuity fault is detected, it is transferred to FreeSafe, saved in its memory and the standard fault management is engaged.

In order to configure the continuity tester inside the FSB-PR software, there is a variable in the configuration file of FreeSafe: “**CONTINUITY_TEST**”. It is a 4 bits variable where each bit corresponds to a continuity test on Fp, Cp, Fn or Cn. 0 means the test is disabled and 1 means the test is enabled.

CONTINUITY_TEST	Bit 0	Bit 1	Bit 2	Bit 3
Enable test on	Fp	Cp	Fn	Cn

To disable the continuity test functions, it is recommended to set CONTINUITY_TEST=0000 and not to connect Bat+, Bat-, Fp, Cp, Fn and Cn. N.B: if the insulation measurement function is used, Bat+ and Bat- MUST be connected.

Over current (i.e. soft current limit) management

There are 3 configurable parameters: "**CURRENT_LIMIT**", "**CURRENT_TIME**" and "**CURRENT_NOMINAL**" for positive current and "**CURRENT_LIMIT_NEG**", "**CURRENT_TIME_NEG**" and "**CURRENT_NOMINAL_NEG**" for negative current.

CURRENT_NOMINAL is used to define the nominal current at which the system is designed to be used (i.e thermally stable). It can be the nominal current of the battery itself or the nominal current of its application.

CURENT_LIMIT defines an authorized pulse of constant current over the nominal current for a set CURRENT_TIME time.

To facilitate the writing of the used equation, the parameters are named in this document as following:

I_{nom} is the nominal current ("CURRENT_NOMINAL" parameter)

I_{oc} is the overcurrent limit ("CURRENT_LIMIT" parameter)

t_{oc} is the overcurrent allowed time ("CURRENT_TIME" parameter)

Isc is the short circuit limit ("CURRENT_PIC" parameter)

The management of overcurrent follows an I^2t logic. The parameters given in the initial configuration are used to set the reference: $(I_{oc} - I_{nom})^2 \cdot t_{oc}$, and then for any continuous current, it is possible to determine the maximum allowed time with $(I(t) - I_{nom})^2 \cdot t = (I_{oc} - I_{nom})^2 \cdot t_{oc}$. The next paragraph and Figure 14 show an example in order to support the comprehension.

For non-constant current, the I^2t logic is still followed thanks to the implemented integral method. It consists on the comparison between the reference $I_{oc}^2 t_{oc}$ and the integration of the measured current over time.

Example of hard and soft current limit management

We define a battery with I_{nom}=100A, I_{oc}=**150A**, t_{oc}=**10s** and the hard current limit I_{sc}=200A for its discharge characteristics. With only these parameters, FreeSB-PR can manage the overcurrent according to the explained method. For any constant current, the behavior of FreeSB-PR is resumed on the following curves Figure 14.

- Any current below the nominal current can operate for an infinite time – the safe operating area under the blue line in Figure 14.
- Any current between I_{nom} and I_{oc} can be maintained for a short amount of time – the overcurrent management area between the blue and red lines in Figure 14**Erreur ! Source du renvoi introuvable.**. For instance a 110A current (10% over the nominal) is allowed for 250s while a 175A current (75% over the nominal) is allowed for only 4.5s. This red curve is defined from I_{nom}, I_{oc} and t_{oc} parameters: $I(t) = \sqrt{\frac{(I_{oc}-I_{nom})^2 t_{oc}}{t}} - I_{nom}$ - comes from : $(I(t) - I_{nom})^2 \cdot t = (I_{oc} - I_{nom})^2 \cdot t_{oc}$

- Any current over the hard current limit (200A) is in the protected area where the power DC contactor is opened.

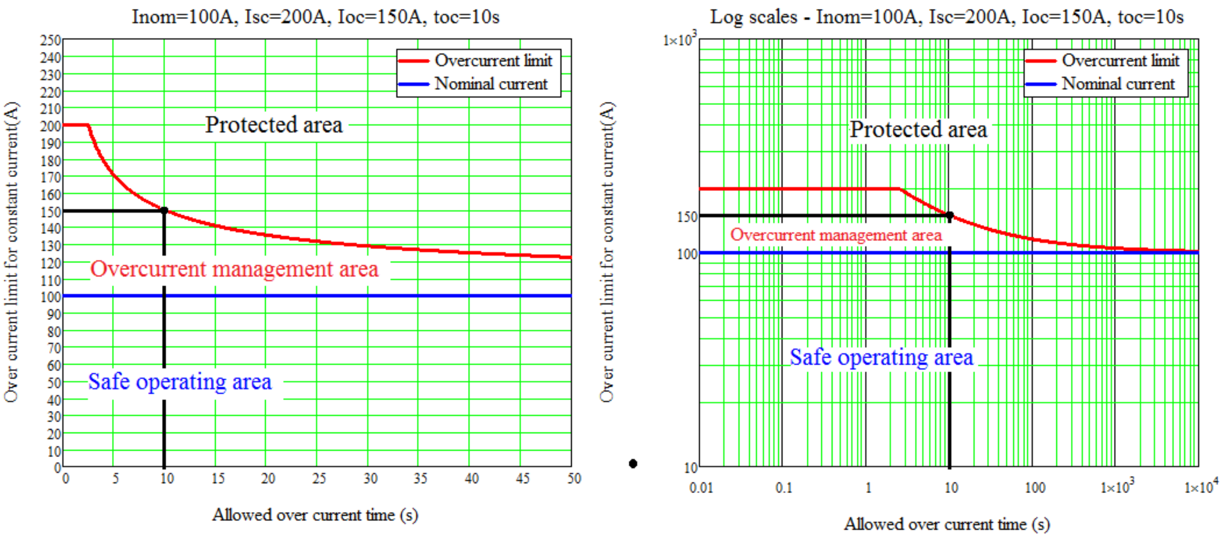


Figure 14 - Example of overcurrent management curves for constant current

Introducing

KILOVAC LEV100 Series 900 Vdc Contactor

with 1 form X contacts rated 100A continuous

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KILOVAC LEV100 Series 900 Vdc Contactor

PART NUMBERING

Typical Part Number	LEV100	A	4	A	N	G

Series:
LEV100 = 100A Contactor

Contact Arrangement:
A = 1 Form X (SPST-NO-DM)

Coil Voltage:
4 = 12VDC 5 = 24VDC 6 = 48VDC

Coil Wire Length:
A = 15 inches [.4M]

Coil Termination:
N = None – Stripped Wires

Mounting and Power Terminals:
G = Bottom Mount (2 x #8); M5 x 10 H = Side Mount (2 x #8); M5 x 10

NOTE: All part numbers are RoHS compliant.
Specifications are subject to change without notice.

PRODUCT OFFERING

- Bottom Mount Models

3-1618389-7	LEV100A4ANG	12Vdc coil	15”[.4m] leads
9-1618389-8	LEV100A5ANG	24Vdc coil	15”[.4m] leads
3-1618391-7	LEV100A6ANG	48Vdc coil	15”[.4m] leads

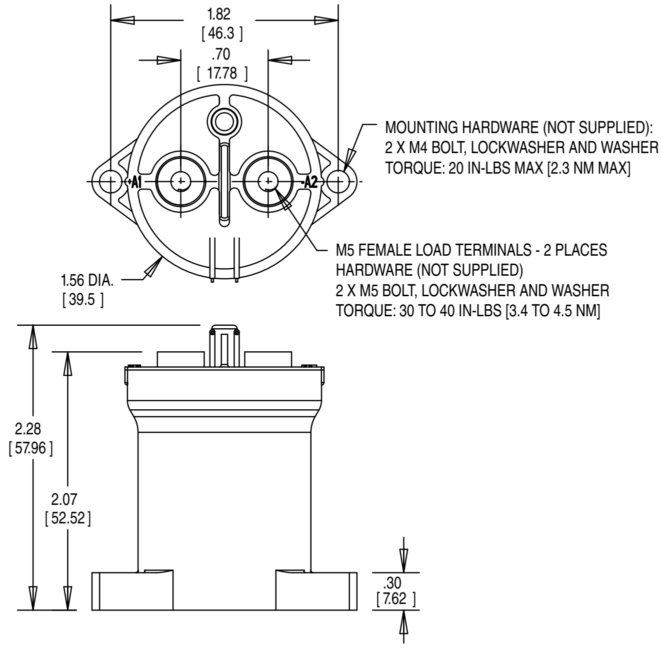
- Side Mount Models

4-1618391-0	LEV100A4ANH	12Vdc coil	15”[.4m] leads
4-1618391-1	LEV100A5ANH	24Vdc coil	15”[.4m] leads
4-1618391-2	LEV100A6ANH	48Vdc coil	15”[.4m] leads

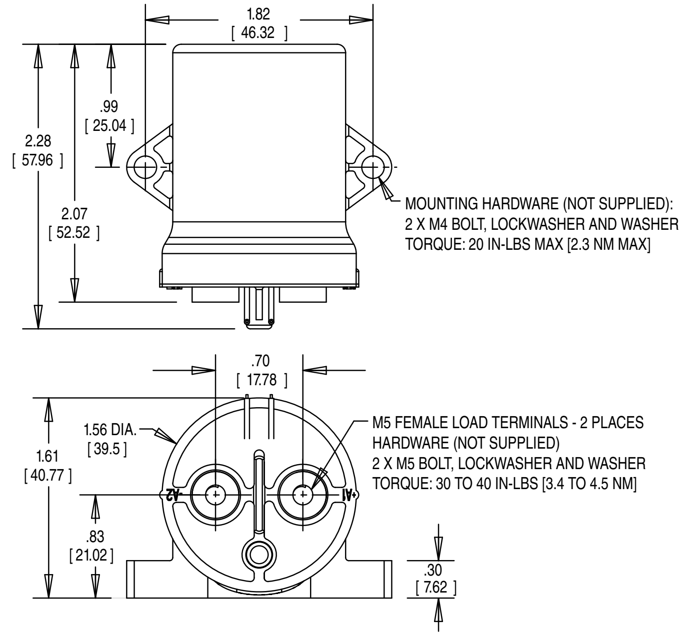
KILOVAC LEV100 Series 900 Vdc Contactor

PERFORMANCE DATA

Bottom Mount



Side Mount



KILOVAC LEV100 Series 900 Vdc Contactor

Tyco Electronics
Our commitment. Your advantage.

KEY FEATURES

Hermetically sealed — intrinsically safe. Operates in explosive/harsh environments without oxidation or contamination of contacts, including long periods of non-operation

8kV isolation between open contacts permits use for high voltage isolation and carry

12, 24 and 48 Vdc coils

Designed and built in accordance to AIAG QS9000

RoHS Ready

DESCRIPTION

Lowest cost, 900 Vdc 100 amp, hermetically sealed DC contactor in the industry

Compact package available in side- or bottom-mount configurations, not position sensitive

APPLICATIONS

Power/motor control circuit isolation, circuit protection and safety in industrial machinery

Automotive battery switching and backup

MECHANICAL

Compact epoxy-sealed resin enclosure occupies only about 4 in^3 (65.5 cm^3)

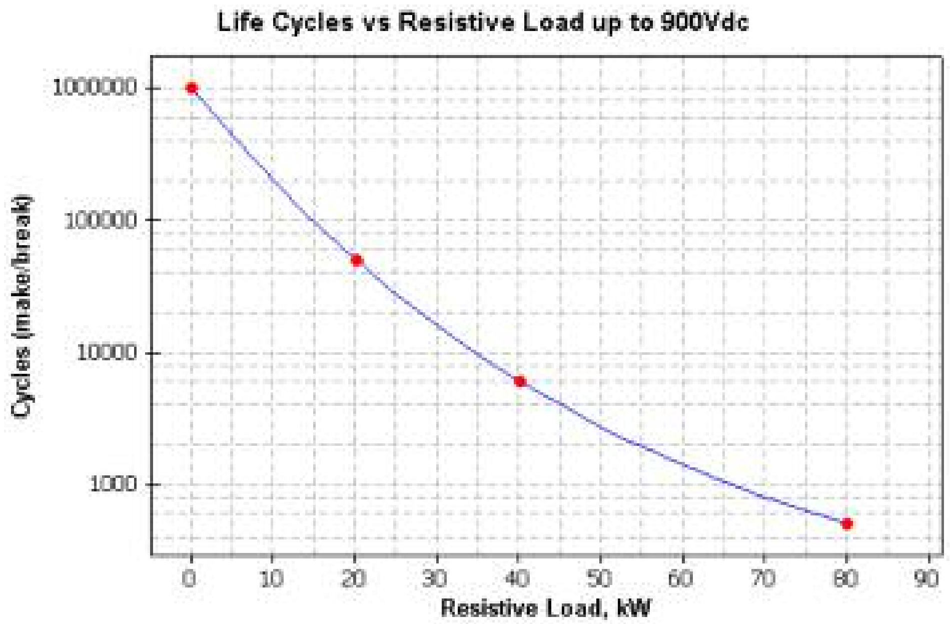
Robust integral mounting plate on either bottom or side of enclosure accepts two M4 screws

Inert gas filled contact chamber

Flying leads for coil connections

Load terminals threaded for M5 bolts (not included)

LOAD LIFE VS. RESISTIVE POWER SWITCHING



PERFORMANCE DATA

Physical Data	
Contact Arrangement: Main Contacts	SPST-NO-DM (1 Form X)
Dimensions	See drawings on page 4
Weight	6.7 oz (190g)

Contact Data	
Contact Arrangement: Main Contacts	SPST-NO-DM (1 Form X)
Voltage Rating: Main Contacts Switching (max)	900VDC
Current Rating: Main Contacts Switching	
Continuous (Note 1)	100A
Short Term -- 3 Minutes (Note 2)	200A
Hot Switching Performance (Polarity sensitive)	
50A make/break @ +400Vdc	50,000 cycles
100A make/break @ +400Vdc	6,000 cycles
100A make/break @ -400Vdc	1,000 cycles
200A make/break @ +400Vdc	500 cycles
1,000A break only @ +400Vdc	25 cycles
600A make only	25 cycles
Maximum Short Circuit Current (1/2 cycle, 60 Hz) (through closed contacts)	1,250A
Dielectric Withstand Voltage (Note 3)	
Between Open Contacts	5,600Vrms/8,000Vdc
Contacts to Coil	2,000Vrms/4,000Vdc
Insulation Resistance, Terminal to Terminal / Terminals to Coil	
When New	100 megohms, min. @ 500Vdc
At End of Life	50 megohms, min. @ 500Vdc
Mechanical Life	1 million cycles

Coil Operating Voltage (valid over temperature range)			
Nominal Voltage	12Vdc	24Vdc	48Vdc
Maximum Voltage	16Vdc	28Vdc	52Vdc
Pick Up Voltage (20°C)	8Vdc	16Vdc	33Vdc
Drop Out Voltage (20°C)	1.2Vdc	2.4Vdc	4.8Vdc
Coil Current (nominal at 20°C, 12vdc)	461mA	250mA	122mA
Coil Power Nominal @ Vnom, +20°C	5.5W	6.0W	6.0W
Pickup (close) Voltage Max.@85 ˚C	9.6Vdc	19.2Vdc	38.4Vdc
Coil Resistance Nominal @ +20°C ± 5% (ohms)	26	96	392

Operate & Release Time	
Operate Time Max.	25ms
Operate Bounce Max.	5ms
Release Time	10ms

Environmental Data	
Shock, 11ms 1/2 sine (operating)	20G peak
Sine Vibration, 20G peak	55-2,000 Hz.
Operating Temperature Range	-40°C to +85°C
Noise Emission (at 100 mm distance)	70dB(a)

Notes

Note 1: 8.4 mm^2 conductor. Current rating depends upon conductor size. Keep terminals below 175°C max continuous.

Note 2: 3 minutes at +40°C ambient with 8.4 mm^2 (#8 AWG) conductor.

Note 3: 2,000Vrms minimum under all conditions, until end of life.

FOR MORE INFORMATION

Technical Support

Internet:	www.tycoelectronics.com
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UK:	44-208-420-8341

Tyco Electronics Corporation
Harrisburg, PA

relays.tycoelectronics.com/kilovac

6-1773450-9 — 5M — A&D/CGX — 04-08

Tyco Electronics

Our commitment. Your advantage.

British BS 88 — 690V: 6-710A

CT, ET, FE, EET, FEE, FM, FMM, MT, MMT

Specifications
Description: BS 88 style stud-mount fuses.

Dimensions: See dimensions illustrations.

Ratings:

Volts: — 690Vac/500Vdc

Amps: — 6-710A

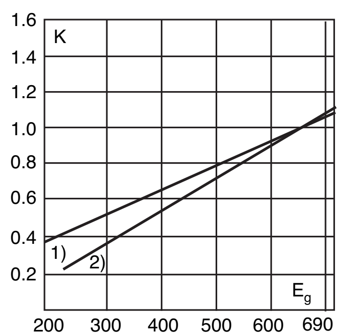
IR: — 200kA RMS Sym.

Agency Information: CE, Designed and tested to: BS 88 Part 4, IEC 269 Part 4, UL Recognized. MT and MMT — 350Vdc (IEC) rating. Consult Cooper Bussmann for UL Recognition status.

Electrical Characteristics

Total Clearing I²t

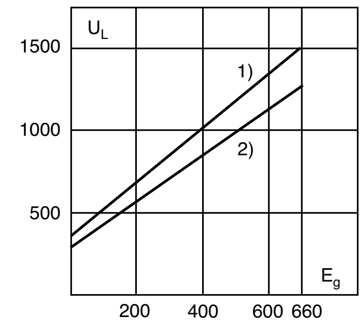
The total clearing I²t at rated voltage and at power factor of 15% are given in the electrical characteristics. For other voltages, the clearing I²t is found by multiplying by correction factor, K, given as a function of applied working voltage, E_g, (rms).



1) CT, ET, EET, FE, FEE, MT, MMT
2) FM, FMM

Arc Voltage

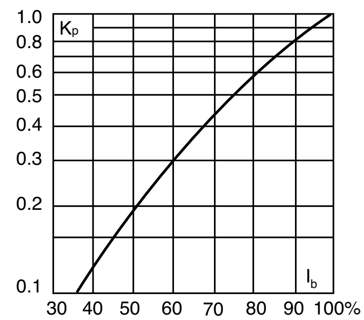
This curve gives the peak arc voltage, U_L, which may appear across the fuse during its operation as a function of the applied working voltage, E_g, (rms) at a power factor of 15%.



1) CT
2) ET, FE, EET, FEE, FM, FMM

Power Losses

Watts loss at rated current is given in the electrical characteristics. The curve allows the calculation of the power losses at load currents lower than the rated current. The correction factor, K_p, is given as a function of the RMS load current, Ib, in % of the rated current.



Features and Benefits

- Excellent cycling capability
- Excellent DC performance
- Low arc voltage and low energy let-through (I²t)
- Low watts loss

Typical Applications

- DC common bus
- DC drives
- Power converters/rectifiers
- Reduced voltage starters

High Speed Fuses

Dimensions (mm)

Fig. 1: CT

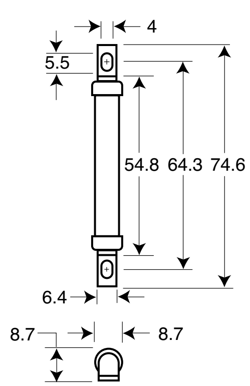


Fig. 2: ET, FE

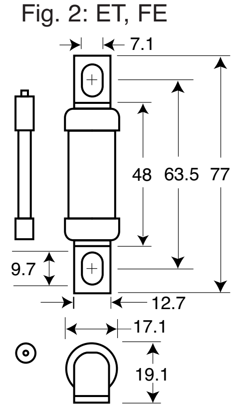


Fig. 3: EET, FEE

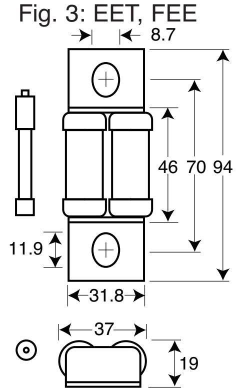


Fig. 4: FM, MT

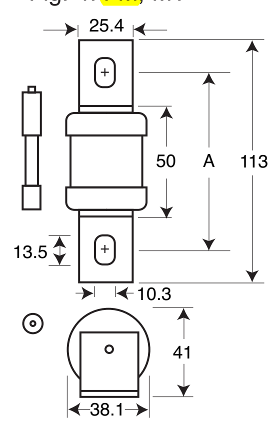
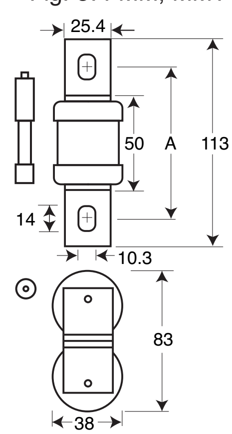


Fig. 5: FMM, MMT



1mm = 0.0394" / 1" = 25.4mm

Figs. 4 & 5 "A" Dimensions

Type	"A"
FM	80-85mm
FMM	80-85mm
MT	85mm
MMT	85mm

British BS 88 — 690V: 6-710A

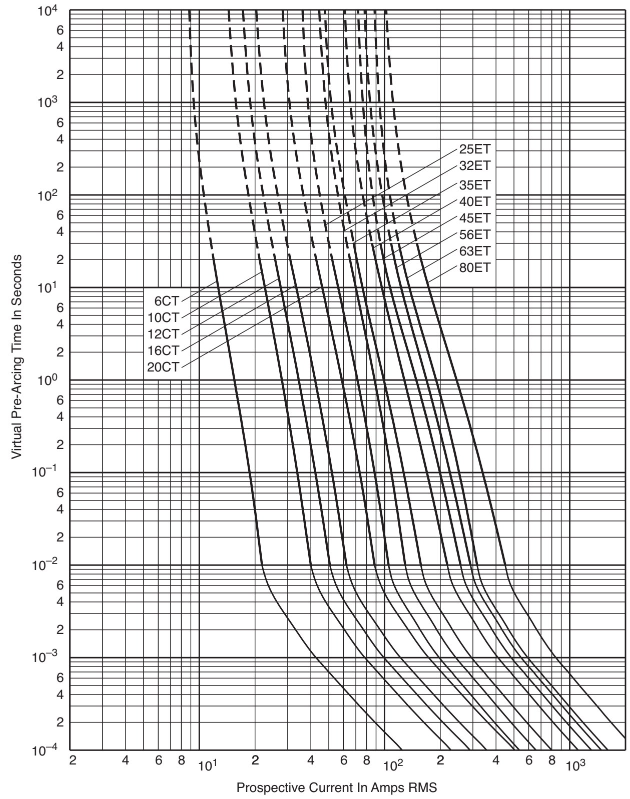
Catalog Numbers

Catalog Numbers	Type	Electrical Characteristics: Rated Current RMS-Amps	I²t (A² Sec): Pre-arc	I²t (A² Sec): Clearing at 415V	I²t (A² Sec): Clearing at 660V	Watts Loss
6CT	CT	6	1.8	8.5	12	2
10CT		10	7	30	48	3
12CT		12	10	40	65	3
16CT		16	16	66	110	7
20CT		20	32	150	220	7
25ET	ET	25	25	150	250	7
32ET		32	32	190	350	11
35ET		35	52	310	500	11
40ET		40	103	600	900	9
45ET		45	103	680	1100	11
56ET		56	135	950	1500	14
63ET		63	171	1200	2000	16
80ET		80	360	2500	4000	18
35FE	FE	35	33	130	200	9
40FE		40	52	180	300	9
45FE		45	76	270	450	11
50FE		50	103	380	600	11
63FE		63	135	480	750	12
71FE		71	210	600	950	17
80FE		80	250	900	1500	20
90FE		90	360	1300	2100	20
100FE		100	470	1800	2800	23
90EET	EET	90	490	3000	4500	19
110EET		110	600	4000	6500	27
140EET		140	1050	7000	12000	35
160EET		160	1500	10000	17000	39
100FEE	FEE	100	400	1600	2400	24
120FEE		120	540	1900	3100	32
140FEE		140	850	2500	3800	36
160FEE		160	1000	3700	5700	46
180FEE		180	1400	5300	8400	46
200FEE		200	1900	7100	11400	52
180FM	FM	180	1400	7500	13500	40
200FM		200	2600	10500	18500	40
225FM		225	3700	14500	26500	44
250FM		250	5200	20500	37500	48
280FM		280	7000	30500	55000	48
315FM		315	10000	40000	77000	55
350FM		350	15000	60000	105000	55
400FMM	FMM	400	10000	40000	72500	85
450FMM		450	15000	60000	105000	90
500FMM		500	20000	82000	150000	100
550FMM		550	30000	120000	215000	100
630FMM		630	45000	180000	310000	100
700FMM		700	60000	245000	420000	120
160MT	MT	160	2400	15000	25000	26
180MT		180	3800	25000	38000	26
200MT		200	6000	40000	58000	27
250MT		250	11500	80000	110000	32
280MT		280	16500	100000	150000	35
315MT		315	19000	125000	180000	42
355MT		355	22000	160000	200000	51
180MMT	MMT	180	1650	12000	18000	42
200MMT		200	2200	16000	23000	42
225MMT		225	3700	26000	40000	42
280MMT		280	6600	47000	70000	47
315MMT		315	8600	62000	91000	51
355MMT		355	13500	97000	140000	54
400MMT		400	21000	150000	220000	60
450MMT		450	30000	220000	320000	57
500MMT		500	42000	300000	450000	64
560MMT		560	60000	430000	640000	64
630MMT		630	68500	500000	720000	86
710MMT		710	78000	600000	850000	105

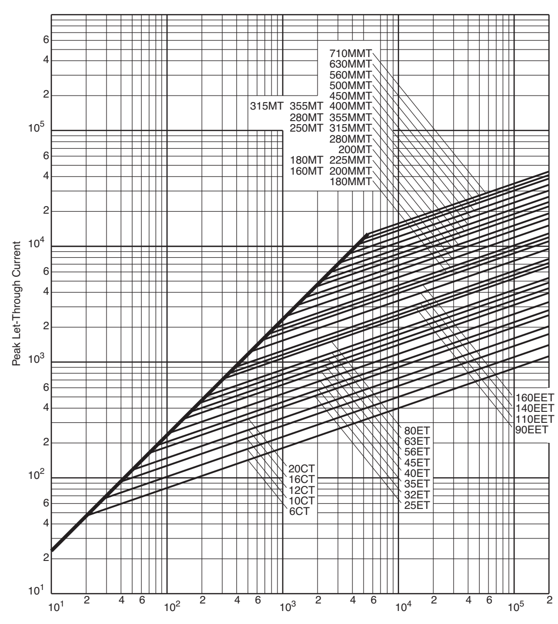
• Watts loss provided at rated current.
• Note: FC, 8ET, 12ET, 15ET, 20ET, 65EET and 75EET are available for replacement purposes on existing equipment.
• See accessories on page 195.

CT 6-20, ET 25-80A: 690V

Time-Current Curve



Peak Let-Through Curve



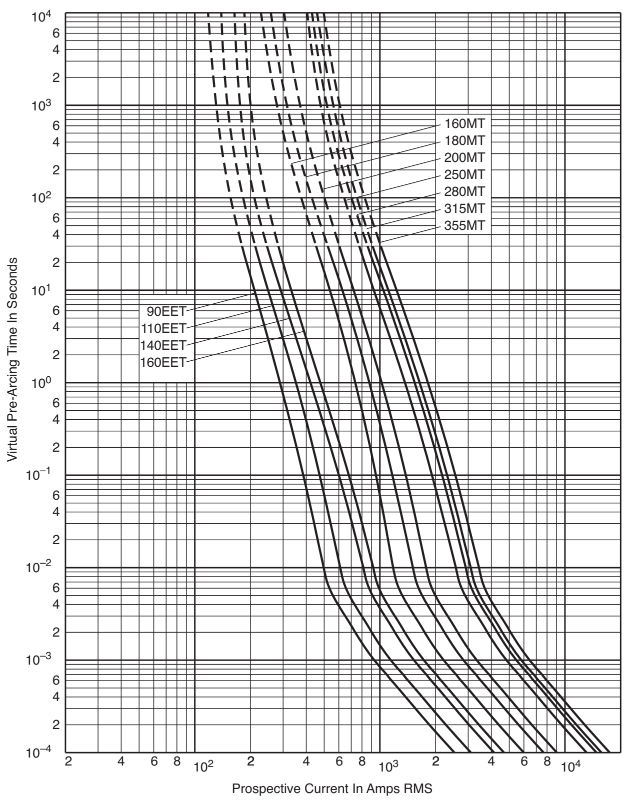
Data Sheet: 35785312

COOPER Bussmann

British BS 88 — 690V: 6-710A

EET 90-160A, MT 160-355A: 690V

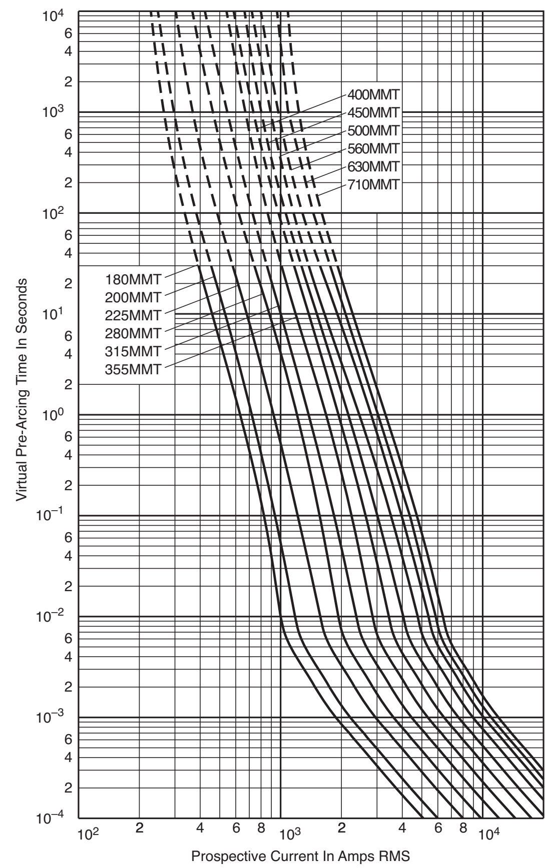
Time-Current Curve



Data Sheet: 35785313

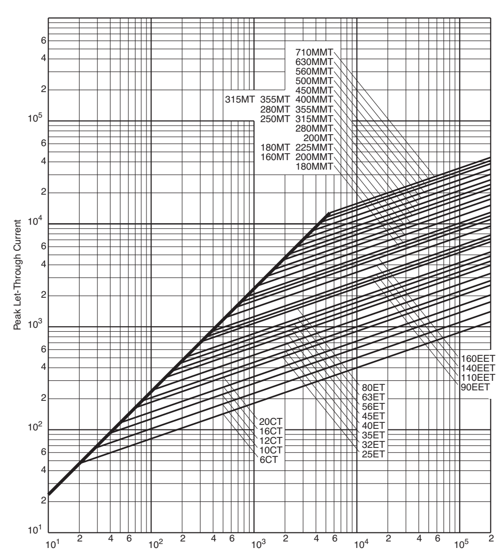
MMT 180-710A: 690V

Time-Current Curve



Data Sheet: 35785311

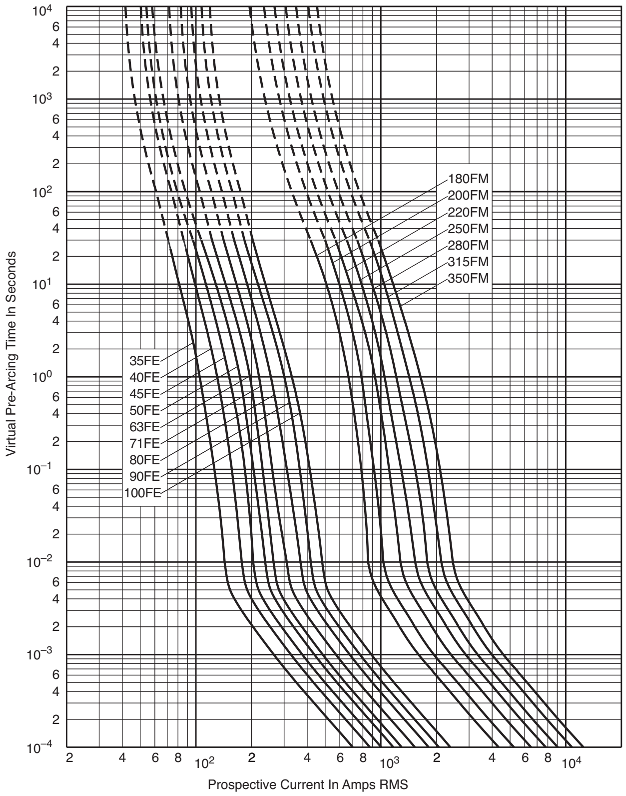
Peak Let-Through Curve



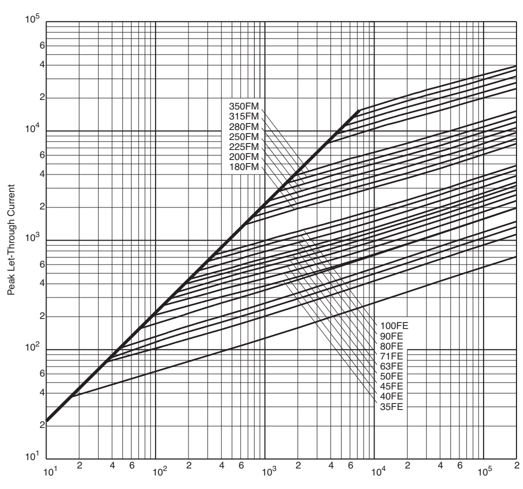
British BS 88 — 690V: 6-710A

FE 35-100A & FM 180-350A: 690V

Time-Current Curve



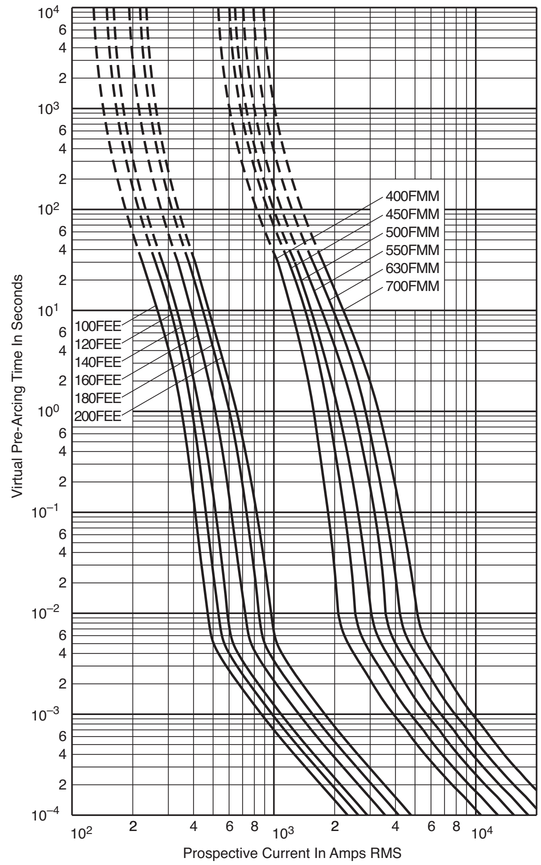
Peak Let-Through Curve



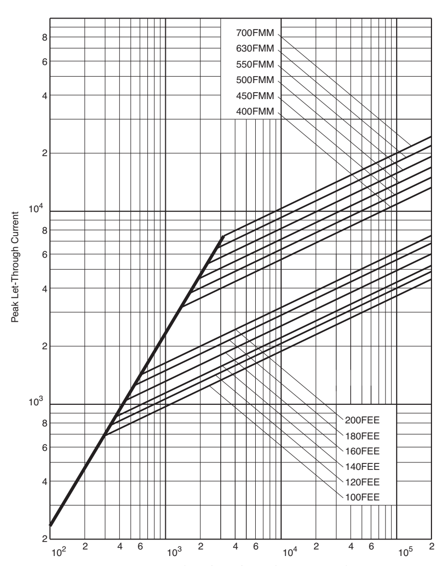
Data Sheet: 35785314

FEE 100-200A & FMM 400-700A: 690V

Time-Current Curve



Peak Let-Through Curve



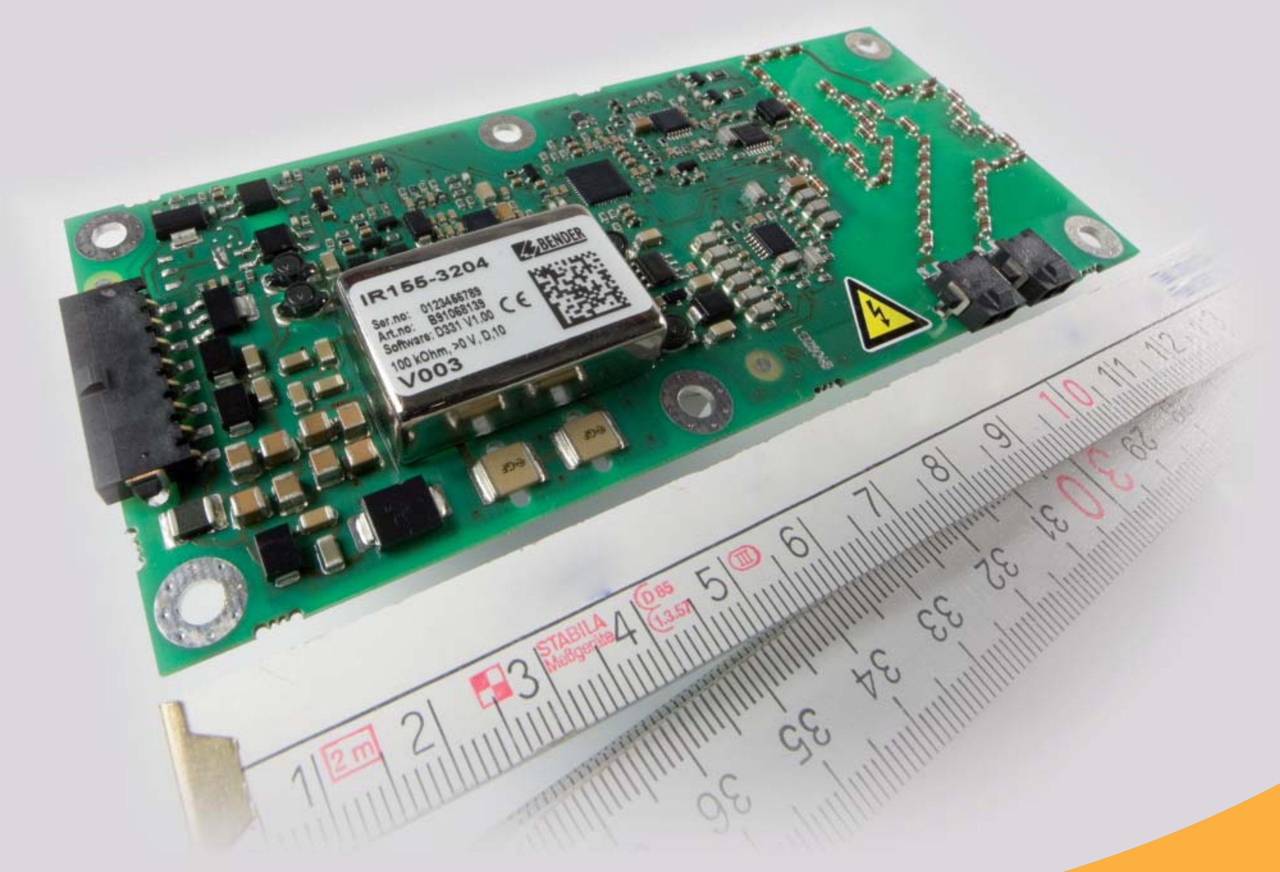
Data Sheet: 35785292

BENDER
The Power in Electrical Safety©

A-ISOMETER® IR155-3203 / IR155-3204

Insulation monitoring device (IMD) for unearthed DC drive systems (IT systems) in electric vehicles

Preliminary data sheet



TDB106028en / 12.2010

A-ISOMETER® IR155-3203 / IR155-3204

Insulation monitoring device (IMD) for unearthed DC drive systems (IT systems) in electric vehicles

A-ISOMETER® IR155-3204

Device features

- Suitable for 12 V and 24 V systems
- Automatic device self test
- Continous measurement of insulation resistance 0…10 MΩ
  - Response time < 2 s after power on for first estimated insulation resistance (SST)
  - Response time < 20 s for measured insulation resistance (DCP)
- Automatic adaptation to the existing system leakage capacitance (≤1 µF)
- Detection of ground faults and lost ground line
- Isolation monitoring of AC and DC insulation faults for unearthed systems (IT systems) 0 V…1000 V peak
- Low voltage detection for voltages below 500 V (value configurable EOL Bender)
- Short protected outputs for:
  - Fault detection (high side output)
  - Measurement value (PWM 5 % … 95 %) & status (f = 10 Hz…50 Hz) at high or inverted low side driver (M_{HS} / M_{LS} output)
- Conformal coating (SL1301ECO-FLZ)

Product description

The A-ISOMETER® iso-F1 IR155-3203/-3204 monitors the insulation resistance between the insulated and active HV-conductors of an electrical drive system (U_n = DC 0 V…1000 V) and the reference earth (chassis ground ▸ Kl.31). The patented measurement technology is used to monitor the condition of the insulation on the DC side as well as on the AC motor side of the electrical drive system. Existing insulations faults will be signalised reliably even under high system interferences which can be caused by motor control processes, accelerating, energy recovering etc.

Due to its space saving design and optimised measurement technology, the device is optimised for use in hybrid or fully electric vehicles. The device meets the increased automotive requirements with regard to the environmental conditions (e.g. temperatures and vibration, EMC…).

The fault messages (insulation fault at the HV-system, connection or device error of the IMD) will be provided at the integrated and galvanic isolated interface (high- resp. low-side driver). The interface consists of a status output (OK_{HS} output) and a measurement output (M_{HS} / M_{LS} output). The status output signalises errors resp. the “good” condition. The measurement output signalises the actual insulation resistance. Furthermore it’s possible to distinguish between different fault messages and device conditions, which are base frequency encoded.

Function

The A-ISOMETER® iso-F1 IR155-3203/-3204 generates a pulsed measuring voltage, which is superimposed on the IT system by the terminals L+/L- and E/KE. The currently measured insulation condition is available as a pulse-width-modulated signal at the terminals M_{HS} resp. M_{LS}. The connection between the terminals E/KE and the chassis ground (▸ Kl.31) is continuously monitored. Therefore it’s necessary to install two separated conductors from the terminals E resp. KE to chassis ground.

Once power is switched on, the device performs an initialisation and starts the SST measurement. The device provides the first estimated insulation resistance during a maximum time of 2 sec. The DCP measurement (▸ continuous measurement method) starts subsequently. Faults in the connecting wires or functional faults will be automatically recognised and signalled.

During operation, a self test is carried out automatically every fife minutes. The interfaces will not be influenced by these self tests.

Standards

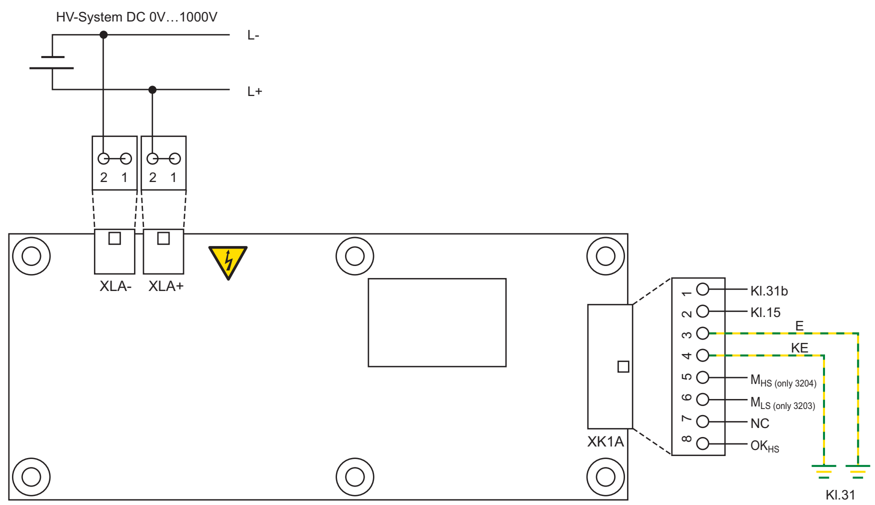
Corresponding norms and regulations

IEC 61557-1	2007-01
IEC 61557-8	2007-01
ISO 6469-3	2001-11
ISO 23273-3	2006-11
ISO 16750	2006 (E)
IEC 61010-1	2001-02
IEC 60664-1	2007-04
IEC 61326-2-4	2010
e1 acc. 72/245/EWG/EEC	

Abbreviations

DCP	Direct Current Pulse
SST	Speed Start Measuring

Wiring diagrams



Connector XLA+

Pin 1+2	L+	Line voltage

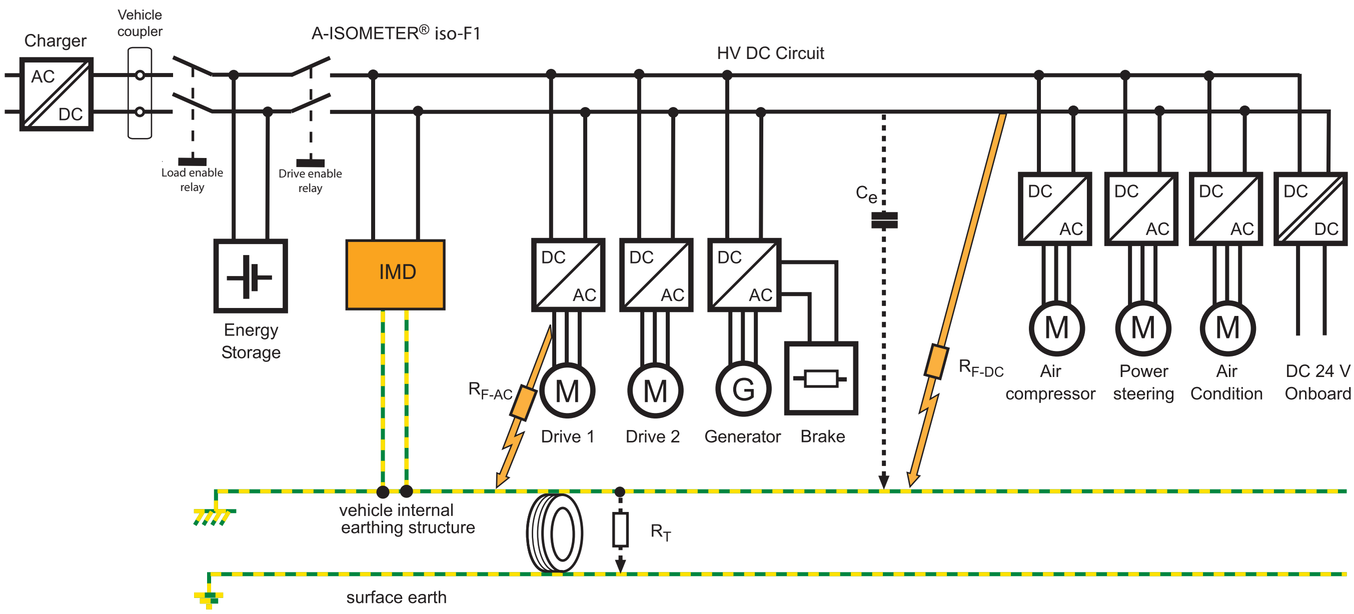
Connector XLA-

Pin 1+2	L-	Line voltage

Connector XK1A

Pin 1	Kl. 31b	Electronic ground
Pin 2	Kl. 15	Supply voltage
Pin 3	Kl. 31	Chassis ground
Pin 4	Kl. 31	Chassis ground (sep. line)
Pin 5	M_{HS}	Data Out, PWM (high side)
Pin 6	M_{LS}	Data Out, PWM (low side)
Pin 7	n.c.	
Pin 8	OK_{HS}	Status Output (high side)

Typical application

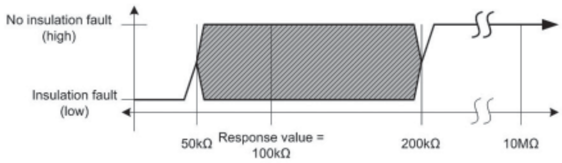


Technical data

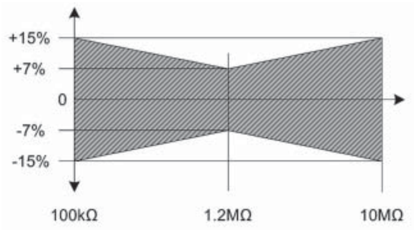
Supply voltage U_S	DC 10…36 V
Nominal supply voltage	DC 12 V / 24 V
Voltage range	10 V…36 V
Max. operational current I_S	150 mA
Max. current I_k	2 A 6 A / 2 ms Rush-In current
Power dissipation P_S	< 2 W
Line L+ / L- Voltage U_n	AC 0 V…1000 V peak; 0 V…660 V rms (10 Hz…1 kHz) DC 0 V…1000 V
Protective separation (reinforced insulation) between	(L+ / L-) – (Kl.31b, Kl.15, E, KE, M_{HS}, M_{LS}, OK_{HS})
Voltage test	AC 3500 V / 1 min
Under voltage detection	0 V…500 V; Default: 0 V (inactive)
System leakage capacity C_e	≤ 1 µF
Measuring voltage U_m	+/- 40 V
Measuring current I_m at $R_F = 0$	+/- 33 µA
Impedance Z_i at 50 Hz	≥ 1.2 MΩ
Internal resistance R_i	≥ 1.2 MΩ
Measurement range	0…10 MΩ
Measurement method	Bender DCP technologie
Factor averaging F_{ave} (Output M)	1…10 (default: 10; EOL Bender)
Relative error at SST (≤ 2s)	Good > 2 * R_{an}; Bad < 0.5 * R_{an}
Relative error at DCP	0…85 kΩ ▸ +/-20 kΩ 100 kΩ…10 MΩ ▸ +/-15 %
Relative error Output – M (base frequencies)	+/- 5 % at each frequency (10 Hz; 20 Hz; 30 Hz; 40 Hz; 50 Hz)
Relative error under voltage detection	U_n ≥100 V ▸ +/-10 %; at U_n ≥300 V ▸ +/-5 %
Response value hysteresis (DCP)	25 %
Response value R_{an}	100 kΩ…1 MΩ ▸ higher tolerances at R_{an} < 85 kΩ; (Default: 100 kΩ)
Response time t_{an} (OK_{HS}; SST)	t_{an} ≤ 2 s (typ. < 1 s at U_n > 100 V)
Response time t_{an} (OK_{HS}; DCP) (Changeover R_F: 10 MΩ ▸ R_{an}/2; at C_e = 1 µF; U_n = 1000 V DC)	t_{an} ≤ 20 s (at F_{ave} = 10*) t_{an} ≤ 17.5 s (at F_{ave} = 9) t_{an} ≤ 17.5 s (at F_{ave} = 8) t_{an} ≤ 15 s (at F_{ave} = 7) t_{an} ≤ 12.5 s (at F_{ave} = 6) t_{an} ≤ 12.5 s (at F_{ave} = 5) t_{an} ≤ 10 s (at F_{ave} = 4) t_{an} ≤ 7.5 s (at F_{ave} = 3) t_{an} ≤ 7.5 s (at F_{ave} = 2) t_{an} ≤ 5 s (at F_{ave} = 1) during self test ▸ t_{an} + 10 s

* F_{ave} = 10 is recommended for electric vehicles

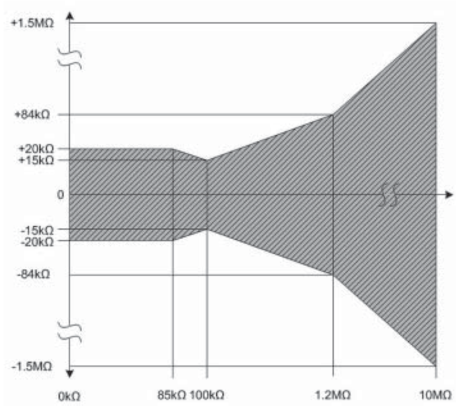
Switch-off time t_{ab} (OK_{HS}; DCP) (Changeover R_F: $R_{an/2}$ ▸ 10 MΩ; at C_e =1 µF; U_n = 1000V DC)	t_{ab} ≤ 40 s (at F_{ave} = 10) t_{ab} ≤ 40 s (at F_{ave} = 9) t_{ab} ≤ 33 s (at F_{ave} = 8) t_{ab} ≤ 33 s (at F_{ave} = 7) t_{ab} ≤ 33 s (at F_{ave} = 6) t_{ab} ≤ 26 s (at F_{ave} = 5) t_{ab} ≤ 26 s (at F_{ave} = 4) t_{ab} ≤ 26 s (at F_{ave} = 3) t_{ab} ≤ 20 s (at F_{ave} = 2) t_{ab} ≤ 20 s (at F_{ave} = 1) during self test ▸ t_{ab} + 10 s
Self test time	10 s (every 5 minutes; has to be added to t_{an} / t_{ab})
Relative error (SST)	"Good-Value" ≥ 2 * R_{an} "Bad-Value" ≤ 0.5 * R_{an}



Relative error (DCP)	100 kΩ ▸ +/-15 % 100 kΩ…1.2 MΩ ▸ +/-15 % to +/-7 % 1.2 MΩ ▸ +/-7 % 1.2 MΩ…10 MΩ ▸ +/-7 % to +/-15 % 10 MΩ ▸ +/-15 %



Absolute error (DCP)	0 Ω…85 kΩ ▸ +/-20 kΩ



Measurement Output (M)

M_{HS} switches to U_S – 2 V (3204)
(external load to ground necessary)

M_{LS} switches to Kl.31b +2 V (3203)
(external load to U_b necessary)

0 Hz ▸ Hi > short to U_b+ (Kl.15); Low > IMD off or short to Kl.31

10 Hz ▸ Normal Condition
Insulation measuring DCP;
starts 2 s after Power-On;
first successful insulation measurement at ≤ 17.5 s
PWM active 5 %...95 %

20 Hz ▸ Under voltage condition
Insulation measuring DCP (correct measurement);
starts 2 s after Power-On;
PWM active 5 %...95 %
first successful insulation measurement at ≤ 17.5 s
Under voltage detection 0 V...500 V
(EOL Bender configurable).

30 Hz ▸ Speed Start
Insulation measuring (only good/bad estimation);
Starts directly after Power-On; response time ≤ 2 s;
PWM 5 %...10 % (good) and 90 %...95 % (bad)

40 Hz ▸ IMD Error
IMD error detected; PWM 47.5%...52.5%

50 Hz ▸ Ground error
Error on measurement ground line (Kl. 31) detected
PWM 47.5%...52.5%

OK_{HS} Output

OK_{HS} switches to U_S – 2V
(external load to ground necessary)

High ▸ No fault; R_F > response value
Low ▸ Insulation resistance ≤ response value detected; IMD error; ground error, under voltage detected or IMD off
(ext. pull-down resistor required)

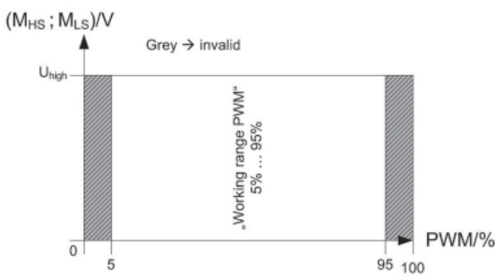
Operating principle PWM- driver

- Condition "Normal" and "Under voltage detected" (10Hz; 20Hz)

Duty cycle ▸ 5 % = >50 MΩ (∞)
Duty cycle ▸ 50 % = 1200 kΩ
Duty cycle ▸ 95 % = 0 kΩ

$$R_F = \frac{90\% \text{ x } 1200 \text{ k}\Omega}{dc_{meas} - 5\%} - 1200 \text{ k}\Omega$$

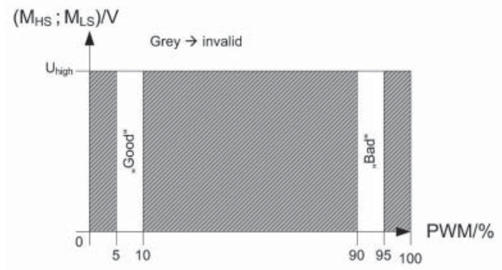
dc_{meas} = measured duty cycle (5 %...95 %)



Operating principle PWM- driver

- Condition "SST" (30Hz)

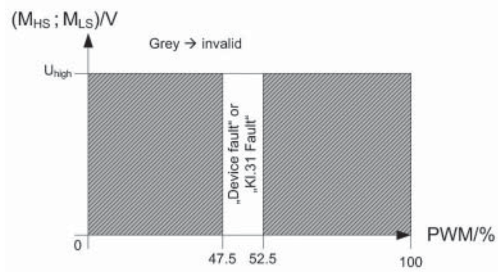
Duty cycle ▸ 5 %...10 % ("Good")
90 % ... 95 % ("Bad")



Operating principle PWM- driver

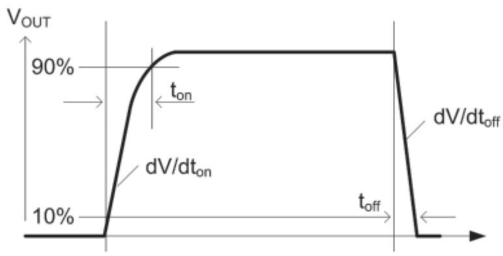
- Condition "Device error" and "Kl.31 fault" (40Hz; 50Hz)

Duty cycle ▸ 47.5 % ... 52.5 %



Load current I_L	20 mA
Turn-on time ▸ to 90 % V_{OUT}	Max. 125 µs
Turn-off time ▸ to 10 % V_{OUT}	Max. 175 µs
Slew rate on ▸ 10 to 30 % V_{OUT}	Max. 6 V/µs
Slew rate off ▸ 70 to 40 % V_{OUT}	Max. 8 V/µs

Timing 3204 (inverse of 3203)



Connectors	TYCO-MICRO MATE-N-LOK 1 x 2-1445088-8 (Kl.31b, Kl.15, E, KE, M_{HS}, M_{LS}, OK_{HS}) 2 x 2-1445088-2 (L+, L-)
Crimp contacts	TYCO MICRO MATE-N-LOK Gold 14x 1-794606-1
Necessary crimp tongs (TYCO)	91501-1
Operating mode / mounting	Continuous operation / any position
Temperature range	-40 °C...+105 °C
Voltage dropout	≤ 2 ms
Fire protection class acc. UL94	V 0

ESD protection

Contact discharge – directly to terminals	≤ 10 kV
Contact discharge – indirectly to environment	≤ 25 kV
Air discharge – handling of the PCB	≤ 6 kV

Mounting

Screw mounting: M4 metal screws with locking washers between screw head and PCB.

Torx, T20 with a max. tightening torque of 4 Nm for the screws. Furthermore max. 10 Nm pressure to the PCB at the mounting points.

Screw and washer kit attached. The max. diameter of the mounting points is 10 mm. Before mounting the device, ensure sufficient insulation between the device and the vehicle resp. the mounting points (min. 11.4 mm to other parts). If the IMD is mounted on a metal or conductive subsurface, this subsurface has to get ground potential (Kl.31; vehicle mass).

Deflection	max. 1 % of the length resp. width of the PCB
Conformal coating	Thick-Film-Laequer
Weight	52 g +/-2 g

Ordering information

Type		Art.No
IR155-3203	Fixed default parameters R_{an}: 100 kΩ Under voltage detection: 300 V F_{ave}: 10 Measurement output low side	B 9106 8138
IR155-3203	Parameters can be customised R_{an}: 100 kΩ…1 MΩ Under voltage detection: 0 V…500 V F_{ave}: 1…10 Measurement output low side	B 9106 8138C
IR155-3204	Fixed default parameters R_{an}: 100 kΩ Under voltage detection: 0 V (inactive) F_{ave}: 10 Measurement output high side	B 9106 8139
IR155-3204	Parameters can be customised R_{an}: 100 kΩ…1 MΩ Under voltage detection: 0 V…500 V F_{ave}: 1…10 Measurement output high side	B 9106 8139C

Example for ordering

IR155-3204-100kΩ-0V + B 9106 8139

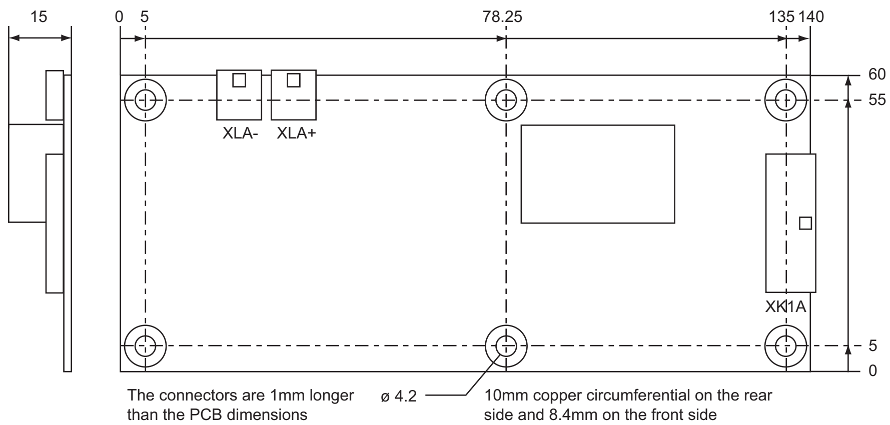
IR155-3204-200kΩ-100V + B 9106 8139C

The parameters acc. response value and under voltage protection have always to be added or included to an order.

Dimension diagram

Dimensions in mm

PCB dimensions (L x W x H) 140 mm x 60 mm x 15 mm



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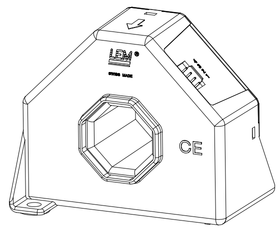
Current Transducer LA 305-S

I_{PN} = 300 A

For the electronic measurement of currents: DC, AC, pulsed..., with galvanic isolation between the primary circuit (high power) and the secondary circuit (electronic circuit).

16173



Electrical data

Symbol	Parameter	Condition					Unit
I_{PN}	Primary nominal current rms		300				A
I_{PM}	Primary current, measuring range		0 .. ± 500				A
			T_A = 70°C		T_A = 85°C		
R_M	Measuring resistance		$R_{M\ min}$	$R_{M\ max}$	$R_{M\ min}$	$R_{M\ max}$	
	with ± 12 V	@ ± 300 A $_{max}$	0	52	0	50	Ω
		@ ± 500 A $_{max}$	0	17	0	15	Ω
	with ± 15 V	@ ± 300 A $_{max}$	0	75	5	73	Ω
		@ ± 500 A $_{max}$	0	31	5	29	Ω
I_{SN}	Secondary nominal current rms		120				mA
K_N	Conversion ratio		1 : 2500				
V_C	Supply voltage (± 5 %)		± 12 .. 15				V
I_C	Current consumption		20 (@ ± 15 V) + I_S				mA

Accuracy - Dynamic performance data

Symbol	Parameter	Condition			Unit
X_G	Overall accuracy @ I_{PN}, T_A = 25°C		± 0.8		%
ε_L	Linearity error		< 0.1		%
			Typ	Max	
I_O	Offset current @ I_P = 0, T_A = 25°C			± 0.20	mA
I_{OM}	Magnetic offset current [1] @ I_P = 0 and specified R_M,				mA
	after an overload of 3 x I_{PN}			± 0.40	mA
I_{OT}	Temperature variation of I_O	- 10°C .. + 85°C	± 0.12	± 0.30	mA
t_{ra}	Reaction time @ 10 % of I_{PN}		< 500		ns
t_r	Response time [2] @ 90 % of I_{PN} step		< 1		µs
di/dt	di/dt accurately followed		> 100		A/µs
BW	Frequency bandwidth (- 3 dB)		DC .. 100		kHz

General data

Symbol	Parameter	Condition	Value	Unit
T_A	Ambient operating temperature		- 10 .. + 85	°C
T_S	Ambient storage temperature		- 40 .. + 90	°C
R_S	Secondary coil resistance	@ T_A = 70°C	35	Ω
		@ T_A = 85°C	37	Ω
m	Mass		200	g
	Standards		EN 50178: 1997	

Notes: [1] The result of the coercive force (Hc) of the magnetic circuit
[2] With a di/dt of 100 A/µs.

Features

- Closed loop (compensated) current transducer using the Hall effect
- Isolated plastic case recognized according to UL 94-V0.

Advantages

- Excellent accuracy
- Very good linearity
- Low temperature drift
- Optimized response time
- Wide frequency bandwidth
- No insertion losses
- High immunity to external interference
- Current overload capability.

Applications

- AC variable speed drives and servo motor drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Switched Mode Power Supplies (SMPS)
- Power supplies for welding applications.

Application domain

- Industrial.

Current Transducer LA 305-S

Isolation characteristics

V_d	Rms voltage for AC isolation test, 50 Hz, 1 min	6	kV
$\hat{V}_w$	Impulse withstand voltage 1.2/50 µs	20	kV
		Min	
dCp	Creepage distance	27	mm
dCI	Clearance distance	26.5	mm
CTI	Comparative Tracking Index (group IIIa)	225	

Applications examples

According to EN 50178 and IEC 61010-1 standards and following conditions:

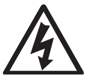
- Over voltage category OV 3
- Pollution degree PD2
- Non-uniform field

	EN 50178	**IEC 61010-1**
dCp, **dCI**, $\hat{V}_w$	Rated insulation voltage	Nominal voltage
Single insulation	2500 V	2500 V
Reinforced insulation	1250 V	1250 V

According VDE 0160 (1994): single insulation 3500 V
Reinforced insulation 1750 V

Safety

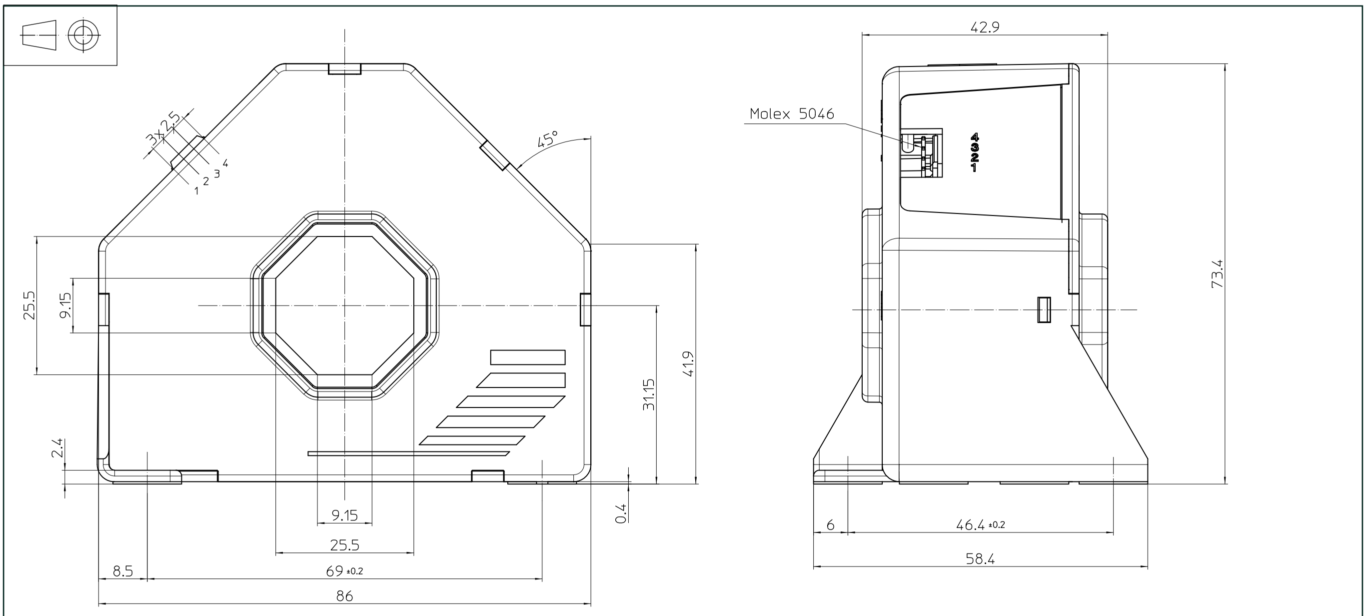
This transducer must be used in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the manufacturer’s operating instructions.

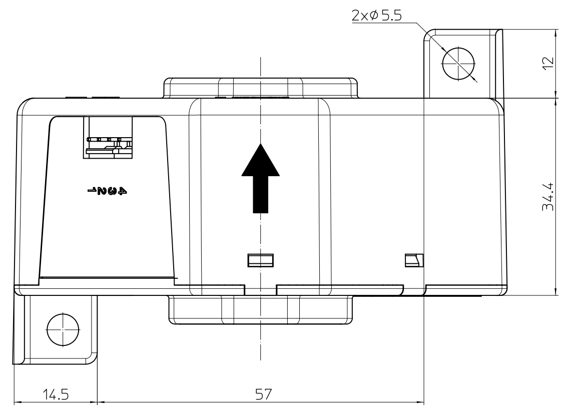


Caution, risk of electrical shock

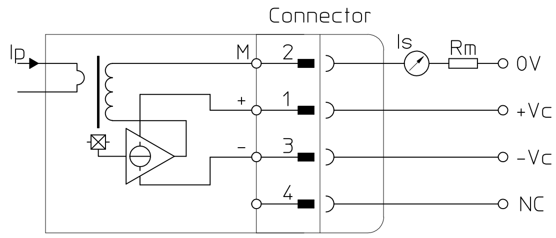
When operating the transducer, certain parts of the module can carry hazardous voltage (eg. primary busbar, power supply).
Ignoring this warning can lead to injury and/or cause serious damage.
This transducer is a build-in device, whose conducting parts must be inaccessible after installation.
A protective housing or additional shield could be used.
Main supply must be able to be disconnected.

Dimensions LA 305-S (in mm)





Connection



Mechanical characteristics

- General tolerance ± 0.5 mm
- Transducer fastening 2 holes Ø 5.5 mm
  2 M5 steel screws
  Recommended fastening torque 4 Nm
- Primary through-hole 25.5 x 25.5 mm
- Connection of secondary MOLEX 5046 4 pins
  tin plated

Remarks

- I_S is positive when I_P flows in the direction of the arrow.
- Temperature of the primary conductor should not exceed 100°C.
- Dynamic performances (di/dt and response time) are best with a single bar completely filling the primary hole.
- This is a standard model. For different versions (supply voltages, turns ratios, unidirectional measurements...), please contact us.

Product Specification

Polymer Li-ion Battery

3.7V 6600mAh 15C

(Model No.:SLPBB042126)

Shenzhen Melasta Battery Co.,Ltd

Tongfuyu Industrial Zone,Dalang,BaoAn District,Shenzhen,518109,China
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Http://www.melasta.com

Content

目录

1. 序言 PREFACE

此规格书适用于深圳市风云电池有限公司的锂聚合物可充电电池产品

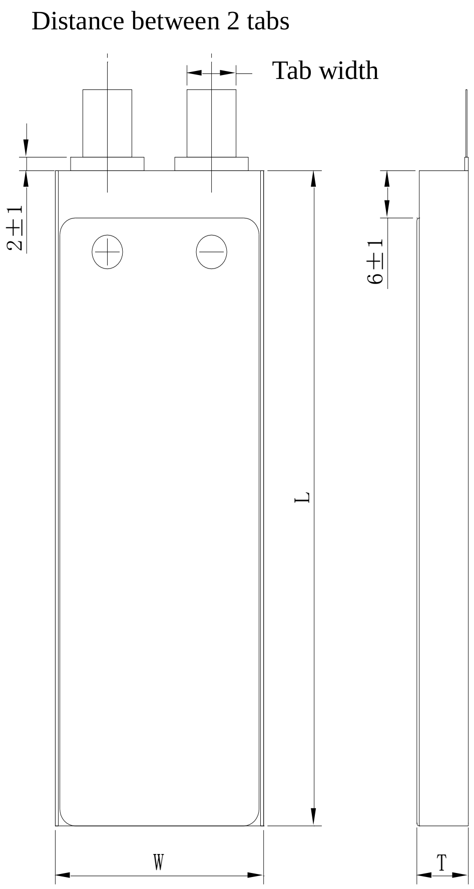
The specification is suitable for the performance of Lithium-Polymer (LIP) rechargeable battery produced by the SHENZHEN MELASTA BATTERY CO., LTD.

2. 型号 MODEL

SLPBB042126 6600mAh 15C 3.7V

3. 产品规格 SPECIFICATION

单颗电池规格 Specifications of single cell



◆标称容量 Typical Capacity①		6.6Ah
◆标称电压 Nominal Voltage		3.7V
◆ 充电条件 Charge Condition	最大电流 Max. Continuous charge Current	13.2A
	峰值充电 Peak charge current	26.4A(≤1sec)
	电压 Voltage	4.2V±0.03V
◆ 放电条件 Discharge Condition	Max Continuous Discharge Current	99A
	Peak Discharge Current	132A
	Cut-off Voltage	3.0V
◆交流内阻 AC Impedance(mOHM)		<1.5
◆循环寿命【充电:1.0C,放电:15C】 Cycle Life【CHA:1.0C,DCH:15C】		>100cycles
◆使用温度 Operating Temp.	充电 Charge	0℃~45℃
	放电 Discharge	-20℃~60℃
◆ 电芯尺寸 Cell Dimensions	厚度 Thickness(T)	10.4±0.3mm
	宽度 Width(W)	42±0.5mm
	长度 Length(L)	127.5±0.5mm
	极耳间距 Distance between 2 tabs	21±1mm
◆ 极耳尺寸 Dimensions of Cell tabs	极耳宽度 Tab Width	12mm
	极耳厚度 Tab Thickness	0.2mm
	极耳长度 Tab Length	Max 35mm
◆重量 Weight(g)		129±3.0
①标称容量：0.5CmA,4.2V~3.0V@23℃±2℃ Typical Capacity:0.5CmA,4.2V~3.0V@23℃±2℃		

4.电芯性能检查及测试 BATTERY CELL PERFORMANCE CRITERIA

在进行下例各项测试前每颗电池应用 0.5C 放至 3.0V。如果没有特别规定，测试应在电池交付 1 个月内按以下各项条件进行：

Before proceed the following tests, the cells should be discharged at 0.2C to 3.0V cut off. Unless otherwise stated, tests should be done within one month of delivery under the following conditions:

环境温度 Ambient temperature: 20℃±5℃

相对湿度 Relative Humidity: 65±20%RH

注意标准充放电为 Note Standard Charge/Discharge Conditions:

充电 Charge: 以 0.5C 电流恒流充电至限制电压 4.2V 时,改为恒压充电,直到截止电流为 0.05C 时停止充电;The battery will be charged to 4.2V with 0.5C from constant current to constant voltage, when the current is 0.05C, stop to charge.;

放电 Discharge: 0.5C to 3.0V/cell

测试项目 Test	单 位 Unit	规格 Specification	条 件 Condition	备 注 Remarks
容量 Capacity	mAh	≥6600	标准充放电 Standard Charge / Discharge	允许循环 3 次 Up to 3 cycles are allowed
开路电压 Open Circuit Voltage (OCV)	V	≥4.15	标准充电后 1 个小时内 Within 1 hr after standard charge	单位颗 Unit cell
内阻 Internal Impedance (IR)	mΩ	≤1.5	充满电后用 1kHz 测试 Upon fully charge at 1kHz	*
高倍率放电 High Rate Discharge (15C)	min	≥3.6	标准充电/休息 5 分钟 用 15C 放电至 3.0V Standard Charge/rest 5min discharge at15C to 3.0V	允许循环 3 次 Up to 3 cycles are allowed
低温放电 Low Temperature Discharge	min	≥210	标准充电后贮藏在-20±2℃环境中 2 小时 然后用 0.2C 放电 Standard Charge, Storage:2hrs at-2 0±2℃ 0.2C discharge at 0±2℃	3.0V/cell Cut-off
自放电 Charge Reserve	min	≥90% （初始容量 First Capacity）	标准充满电后 20 度贮藏 30 天， 标准 0.5C 放电 Standard charge Storage at 20 degree: 30days Standard discharge (0.5C)	3.0V/cell Cut-off
寿命测试 Cycle Life Test	Cycle times	≥100	充电：1C 充电至 4.2V，放电，15C 放电至 3.0V，当放电容量降至初始容量的 80%时，所完成的循环次数定义为该电芯的循环寿命 Charge:1C to 4.2V ,Discharge: 15C to 3.0V, 80% or more of 1st cycle capacity at 15C discharge of Operation	Retention capacity 容量保持 ≥ 80% of initial capacity
短路测试 External Short Circuit	N/A	不着火不爆炸 No Fire and No Explosion	标准充电后，在 20℃±5 环境中用超过 0.75mm² 金属丝将单颗电池短路至电池恢复到常温。 After standard charge, short-circuit the cell at 20℃±5℃ until the cell temperature returns to ambient temperature.(cross section of the wire or connector should be more than 0.75mm²)	*

自由跌落测试 Free Falling(drop)	N/A	不着火不爆炸 No Fire and No Explosion	跌标准充电后，搁置 2 小时。从 50CM 高任意方向自由跌落 30MM 厚木板 3 次 Standard Charge,and then leave for 2hrs,check battery before / after drop Height: 50 cm Thickness of wooden board: 30mm Direction is not specified Test for 3 times	*

5. 贮存及其它事项 STORAGE AND OTHERS

5.1 环境温度 Ambient temperature: 20℃±5℃

相对湿度 Relative Humidity: 65±20%RH

5.2 请每隔 3 个月按下面方法激活电池一次:

Please activate the battery once every 3 months according to the following method:

0.2C 充电至 4.2V，休息 5 分钟，然后用 0.2C 放电至每颗电池 3.0V，休息 5 分钟，0.2C 充电 3.9V。

Charge at 0.2C to 4.2V, rest 5 min, then discharge with 0.2C to 3.0V/cell,rest 5 min, then charge at 0.2C to 3.9V.

6. 聚合物锂离子充电电芯操作指示及注意事项 HANDLING PRECAUTIONS AND GUIDLINE

声明一：

客户若需要将电芯用于超出文件规定以外的设备，或在文件规定以外的使用条件下使用电芯，应事先联系风云公司，因为需要进行特定的实验测试以核实电芯在该使用条件下的性能及安全性。

Note(1):

The customer is requested to contact MELASTA in advance, if and when the customer needs other applications or operating conditions than those described in this document. Additional experimentation may be required to verify performance and safety under such conditions.

声明二：

对于在超出文件规定以外的条件下使用电芯而造成的任何意外事故，风云公司概不负责

Note (2):

MELASTA will take no responsibility for any accident when the cell is used under other conditions than those described in this Document.

声明三：

如有必要，风云公司会以书面形式告之客户有关正确操作使用电芯的改进措施。
MELASTA will inform, in a written form, the customer of improvement(s) regarding proper use and handing of the cell, if it is deemed necessary.

6.1. 充电 Charging

6.1.1 充电电流 Charging current:

充电电流不得超过本标准书中规定的最大充电电流。使用高于推荐值电流充电将可能引起电芯的充放电性能、机械性能和安全性能的问题，并可能会导致发热或泄漏。

Charging current should be less than maximum charge current specified in the Product Specification. Charging with higher current than recommended value may cause damage to cell electrical, mechanical and safety performance and could lead to heat generation or leakage.

6.1.2. 充电电压 Charging voltage:

充电电压不得超过本标准书中规定的额定电压（4.2V/电芯）。4.25V 为充电电压最高极限，充电器的设计应满足此条件；电芯电压高于额定电压值时，将可能引起电芯的充放电性能、机械性能和安全性能的问题，可能会导致发热或泄漏。

Charging shall be done by voltage less than that specified in the Product Specification (4.2V/cell).

Charging beyond 4.25V, which is the absolute maximum voltage, must be strictly prohibited. The charger shall be designed to comply with this condition. It is very dangerous that charging with higher voltage than maximum voltage may cause damage to the cell electrical, mechanical safety performance and could lead to heat generation or leakage.

6.1.3. 充电温度 Charging temperature:

电芯必须在 0℃~45℃的环境温度范围内进行充电

The cell shall be charged within 0℃~45℃ range in the Product Specification.

6.1.4. 禁止反向充电 Prohibition of reverse charging:

正确连接电池的正负极，严禁反向充电。若电池正负极接反，将无法对电芯进行充电。同时，反向充电会降低电芯的充放电性能、安全性，并会导致发热、泄漏。

Reverse charging is prohibited. The cell shall be connected correctly. The polarity has to be confirmed before wiring, In case of the cell is connected improperly, the cell cannot be charged. Simultaneously, the reverse charging may cause damaging to the cell which may lead to degradation of cell performance and damage the cell safety, and could cause heat generation or leakage.

6.2．放电 Discharging

6.2.1. 放电电流 Discharging current

放电电流不得超过本标准书规定的最大放电电流，大电流放电会导致电芯容量剧减并导致过热。

The cell shall be discharged at less than the maximum discharge current specified in the Product Specification. High discharging current may reduce the discharging capacity significantly or cause over-heat.

6.2.2. 放电温度 Discharging temperature

电芯必须在-20℃~60℃的环境温度范围内进行放电。

The cell shall be discharged within -20℃~60℃ range specified in the Product Specification.

6.2.3. 过放电 Over-discharging:

需要注意的是，在电芯长期未使用期间，它可能会用其它自放电特性而处于某种过放电状态。为防止放电的发生，电芯应定期充电，将其电压维持在 3.6V 至 3.9V 之间。

过放电会导致电芯性能、电池功能的丧失。

充电器应有装置来防止电池放电至低于本标准书规定的截止电压。此外，充电器还应有装置以防止重复充电，步骤如下：

电池在快速充电之前，应先以一小电流（0.01C）预充电 15~30 分钟，以使（每个）电芯的电压达到 3V 以上，再进行快速充电。可用一记时器来实现该预充电步骤。如果在预充电规定时间内，（个别）电芯的电压仍未升到 3.0V 以上，充电器应能够停止下一步快速充电，并显示该电芯/电池正处于非正常状态。

It should be noted that the cell would be at over-discharged state by its self-discharge characteristics in case the cell is not used for long time. In order to prevent over-discharging, the cell shall be charged periodically to maintain between 3.6V and 3.9V.

Over-discharging may causes loss of cell performance, characteristics, or battery functions.

The charger shall be equipped with a device to prevent further discharging exceeding a cut-off voyage specified in the Product Specification. Also the charger shall be equipped with a device to control the recharging procedures as follows:

The cell battery pack shall start with a low current (0.01C) for 15-30 minutes, i.e.-charging, before rapid charging starts. The rapid charging shall be started after the (individual) cell voltage has been reached above 3V within 15-30 minutes that can be determined with the use of an appropriate timer for pre-charging. In case the (individual) cell voltage does not rise to 3V within the pre-charging time, then the charger shall have functions to stop further charging and display the cell/pack is at abnormal state.

6.3. 贮存 Storage:

电芯储存温度必须在-10℃~45℃的范围内,长期存储电池（超过 3 个月）须置于温度为 23±5℃、湿度为 65±20%RH 的环境中,贮存电压为 3.6V~3.9V

The cell shall be storied within -10℃~45℃ range environmental condition, If the cell has to be storied for a long time (Over 3 months),the environmental condition should be; Temperature: 23±5℃

Humidity: 65±20%RH, The voltage for a long time storage shall be 3.6V~3.9V range.

6.4. 电芯操作注意事项 Handling of Cells:

由于电芯属于软包装，为保证电芯的性能不受损害，必须小心对电芯进行操作。

Since the battery is packed in soft package, to ensure its better performance, it's very important to carefully handle the battery;

6.4.1. 铝箔包装材料易被尖锐部件损伤，诸如镍片，尖针。

The soft aluminum packing foil is very easily damaged by sharp edge parts such as Ni-tabs, pins and needles.

·禁止用尖锐部件碰撞电池;

Don't strike battery with any sharp edge parts;

·取放电芯时，请修短指甲或戴上手套;

Trim your nail or wear glove before taking battery；

·应清洁工作环境，避免有尖锐物体存在;

Clean work table to make sure no any sharp particle;

6.4.2. 禁止弯折顶封边;

Don't bend or fold sealing edge;

6.4.3. 禁止打开或破坏折边;

Don't open or deform folding edge;

6.4.4. 禁止弯折极片;

Don't bend tab ;

6.4.5. 禁止坠落、冲击、弯折电芯;

Don't Fall, hit, bend battery body;

6.4.6. 任何时候禁止短路电芯，它会导致电芯严重损坏;

Short circuit terminals of battery is strictly prohibited, it may damage battery;

6.5. 电池外壳设计 Notice Designing Battery Pack;

·电池外壳应有足够的机械强度以保证其内部电芯免受机械撞击;

Battery pack should have sufficient strength and battery should be protected from mechanical shock;

·外壳内安装电芯的部位不应有锋利的边角;

No Sharp edge components should be inside the pack containing the battery;

6.6. 电芯与外壳组装注意事项 Notice for Assembling Battery Pack

6.6.1.电芯的连接 Tab connection

建议使用超声波焊接或点焊技术来连接电芯与保护电路模块或其它部分。如使用手工锡焊，须注意以下事项，以

保证电芯的功能：

Ultrasonic welding or spot welding is recommended to connect battery with PCM or other parts.If apply manual solder method to connect tab with PCM, below notice is very important to ensure battery performance.

a) 烙铁的温度可控能防静电；

The solder iron should be temperature controlled and ESD safe

b) 烙铁温度不能超过 350℃

Soldering temperature should not exceed 350℃

c) 锡焊时间不能超过 3 秒；

Soldering time should not be longer than 3s

d) 锡焊次数不能超过 5 次；

Soldering time should not exceed 5 times Keep battery tab cold down before next time soldering

e) 必须在极片冷却后再进行二次焊接；禁止直接加热电芯，高于 100℃会导致电芯损坏。

Directly heat cell body is strictly prohibited, Battery may be damaged by heat above approx.100℃

6.6.2. 电芯的安装 Cell fixing

·应将电芯的宽面安装在外壳内；

The battery should be fixed to the battery pack by its large surface area

·电芯不得在壳内活动。

No cell movement in the battery pack should be allowed

7.其它事项 OTHERS

7.1. 防止电池内短路 Prevention of short circuit within a battery pack

使用足够的绝缘材料对线路进行保护

Enough insulation layers between wiring and the cells shall be used to maintain extra safety protection.

7.2. 严禁拆卸电芯 Prohibition of disassembly

7.2.1. 拆卸电芯可能会导致内部短路，进而引起鼓气、着火及其它问题

The disassembling may generate internal short circuit in the cell, which may cause gassing, firing, or other problems.

7.2.2. 聚合物锂电池理论上不存在流动的电解液，但万一有电解液泄漏而接触到皮肤、眼睛或身体其它部位，应立即用清水冲洗电解液并就医

LIP battery should not have liquid from electrolyte flowing, but in case the electrolyte come into contact with the skin, or eyes, physicians shall flush the electrolyte immediately with fresh water and medical advice is to be sought.

7.3. 在任何情况下，不得燃烧电芯或将电芯投入火中，否则会引起电芯燃烧，这是非常危险的，应绝对禁止

Never incinerate nor dispose the cells in fire. These may cause firing of the cells, which is very dangerous and is prohibited.

7.4 不得将电芯浸泡液体，如淡水、海水、饮料(果汁、咖啡)等

The cells shall never be soaked with liquids such as water, seawater drinks such as soft drinks, juices coffee or others.

7.5 更换电芯应由电芯供应商或设备供应商完成，用户不得自行更换

The battery replacement shall be done only by either cells supplier or device supplier and never be done by the user.

7.6 禁止使用已损坏的电芯 Prohibition of use of damaged cells

电芯在运输过程中可能因撞击等原因而损坏，若发现电芯有任何异常特征，如电芯塑料封边损坏，外壳破损，闻到电解液气体，电解液泄漏等，该电芯不得使用。

有电解液泄漏或散发电解液气味的电池应远离火源以避免着火。

The cells might be damaged during shipping by shock. If any abnormal features of the cells are found such as damages in a plastic envelop of the cell, deformation of the cell package, smelling of electrolyte, electrolyte leakage and others, the cells shall never be used any more.

The cells with a smell of the electrolyte or a leakage shall be placed away from fire to avoid firing.

Advanced Contact Technology

Multi-Contact

STÄUBLI GROUP

Powerline

Industrie-Steckverbinder
Industrial Connectors
Connecteurs industriels

Rundsteckverbinder
Round Connectors
Connecteurs cylindriques

ungekapselt, einpolig, unisoliert / max. 6000A
unenclosed, single-pole, uninsulated / max. 6000A
enveloppe ouverte, unipolaires, non isolés / max. 6000A

1

Inhaltsverzeichnis | Contents | Table des matières

Allgemeine Angaben info

Farbcode
Für Artikel die in mehreren Farben erhältlich sind, schreiben Sie anstelle des im Katalog angegebenen Zeichens "*" den zweistelligen Farbcode hinter die Bestell-Nummer.

General information info

Colour code
For items available in various colours, replace the asterisk "*" with the appropriate colour code.

Généralités info

Code couleurs
Pour les articles disponibles en plusieurs couleurs, remplacez le signe "*" apparaissant dans les numéros de commande par le code couleurs à deux chiffres.

	20	21	22	23	24	25	26	27	28	29	33
Farbcode **Colour code** **Code couleurs**	grün-gelb green-yellow vert-jaune	schwarz black noir	rot red rouge	blau blue bleu	gelb yellow jaune	grün green vert	violett violet violet	braun brown brun	grau grey gris	weiss white blanc	transparent transparent transparent

Änderungen / Vorbehalte
Alle Daten, Abbildungen und Zeichnungen in diesem Katalog sind das Resultat sorgfältiger Prüfungen. Sie entsprechen dem Stand unserer Erfahrungen. Irrtum vorbehalten. Ebenfalls vorbehalten sind Änderungen aus konstruktions- bzw. sicherheitstechnischen Gründen. Es ist deshalb ratsam, bei Konstruktionen, in die unsere Bauteile einfliessen, nicht alleine auf die Katalogdaten abzustellen, sondern mit uns Rücksprache zu nehmen, um sicherzustellen, dass die neuesten Daten zur Anwendung kommen. Wir beraten Sie gerne.

Changes / Provisos
All data, illustrations and drawings in the catalogue have been carefully checked. They are in accordance with our experience to date, but no responsibility can be accepted for errors.
We also reserve the right to make modifications for design and safety reasons. When designing equipment incorporating our components, it is therefore advisable not to rely solely on the data in the catalogue but to consult us to make sure this information is up to date. We shall be pleased to advise you.

Modifications / Réserves
Les données, illustrations et dessins figurant dans ce catalogue ont fait l'objet de contrôles rigoureux. Ces informations correspondent à l'état actuel de notre expérience, et vous sont communiquées sous réserve d'erreurs et sous réserve également de modifications apportées pour des raisons constructives ou techniques. Il est donc conseillé, pour les conceptions faisant appel à nos composants, de ne pas seulement se référer aux données du catalogue, mais de faire appel à nos services pour vous assurer de la validité des données et pour vous permettre de disposer des informations les plus récentes. Nous nous tenons volontiers à votre service.

RoHS*ready*

Richtlinie 2002/95/EU zur Beschränkung der Verwendung bestimmter gefährlicher Stoffe in Elektro- und Elektronikgeräten

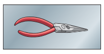
RoHS*ready*

Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment

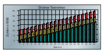
RoHS*ready*

Directive 2002/95/CE relative à la limitation de l'utilisation de certaines substances dangereuses dans les équipements électriques et électroniques

Piktogramme

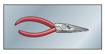

*Für diese Teile besteht eine Montageanleitung mit einer Nummer, **z.B. MA001***
Download:
www.multi-contact.com

info *Technische Hinweise*
Allgemeine Hinweise
Bestellhinweise


Derating-Diagramme


Übersichten

Pictograms


*These parts have assembly instructions with a number, **e.g. MA001***
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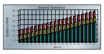
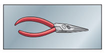
info *Technical information*
General information
Ordering information


Derating diagrams


Overviews

Pictogrammes


*Ces articles ont une notice de montage identifiée par un code, **par ex. MA001***
A télécharger:
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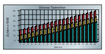
info *Informations techniques*
Généralités
Pour vos commandes


Diagrammes de derating


Vues d'ensemble

Was ist bei der Planung eines MC Steckverbinders zu beachten!

Points that must be observed when planning the use of an MC Connector!

Facteurs à prendre en compte dans le cadre de la mise en œuvre d'un connecteur MC!

1. Während dem Stecken oder Trennen dürfen keine Querkräfte auftreten.

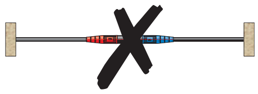
1. No transverse forces must be exerted during connection and disconnection.

1. Lors des phases d'embrochage et débrochage, les efforts radiaux ne sont pas tolérés.

2. Die Leitungen oder Kabel müssen die richtige Länge haben.

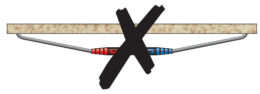
2. The leads or cables must be of adequate length.

2. Les cordons ou les câbles doivent avoir une longueur appropriée.

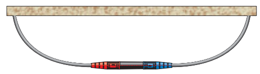


falsch / wrong / faux

richtig / correct



falsch / wrong / faux

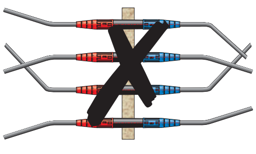


richtig / correct

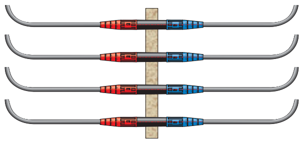
3. Wenn mehrere Steckverbinder nebeneinander liegen, sollte wenn immer möglich eine Kreuzung der Leitungen vermieden werden. Die Leitungen oder Kabel müssen genügend lang sein.

3. If a number of plug connectors are located side by side, crossing of the leads should be avoided as far as possible. The leads and cables must be of adequate length.

3. Lorsque plusieurs connecteurs sont mis côte à côte, le croisement de câbles doit être évité. Les cordons et câbles doivent être de longueur suffisante.



falsch / wrong / faux

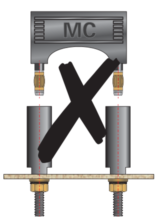


richtig / correct

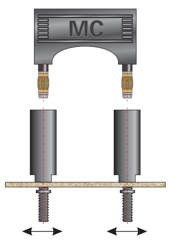
4. Im Falle von mehrpoligen Steckverbindern sollte immer eine Seite (Stecker- oder Buchsenseite) oder beide Seiten "schwimmend" befestigt sein um alle Konstruktionstoleranzen zu absorbieren.

4. In the case of multi-pole plug connectors, at least one side (socket or plug side) or both sides must be provided with a "floating" mounting that is capable of absorbing all design tolerances.

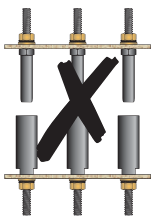
4. Dans le cas de connecteurs multipolaires, afin d'absorber les tolérances de construction, un côté (douille ou broche) ou les deux côtés devrai(en)t être monté(s) flottant(s).



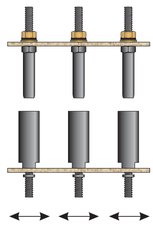
falsch / wrong / faux



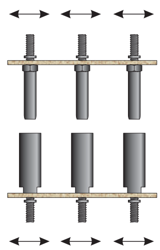
richtig / correct



falsch / wrong / faux



richtig / correct

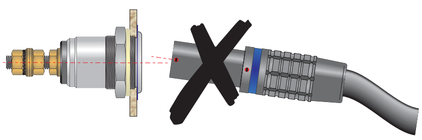


richtig / correct

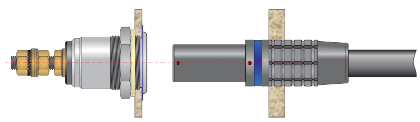
5. Schwere Steckverbinder erfordern eine Abstützung, oder die Steckseite muss "schwimmend" befestigt sein.

5. Heavy connectors need to be supported or the plugged side must be float mounted.

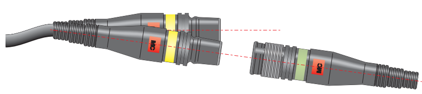
5. Les connecteurs lourds requièrent un guidage ou un montage flottant.



falsch / wrong / faux



richtig mit Abstützung
correct with support
correct avec guidage



richtig mit "schwimmender" Steckseite
correct with "floating mounting"
correct avec montage flottant

Einführung

Einpolige, nicht isolierte Rundsteckverbinder

Standardmässig sind Steckverbinder aus Messing (Crimpanschlüsse aus Cu) mit ca. 6µm Silberauflage gefertigt. Spezialsteckverbinder mit anderen Abmessungen oder Materialien, sowie Sonderversilberungen für hohe Steckzyklen, auf Anfrage.

Achtung: Vor dem ersten Gebrauch sollten alle Gewinde und aufeinandergleitenden Steckerteile mit einem dünnen Schmiermittelfilm versehen werden. (siehe Seite 38, Schmiermittel).

Introduction

Single-pole round connectors, uninsulated

The standard plug connections are made of brass (crimping sleeve is copper) and are silver plated approx. 6µm. Special connections with other dimensions or materials as well as special silver plating for a higher plugging frequency, are available on request.

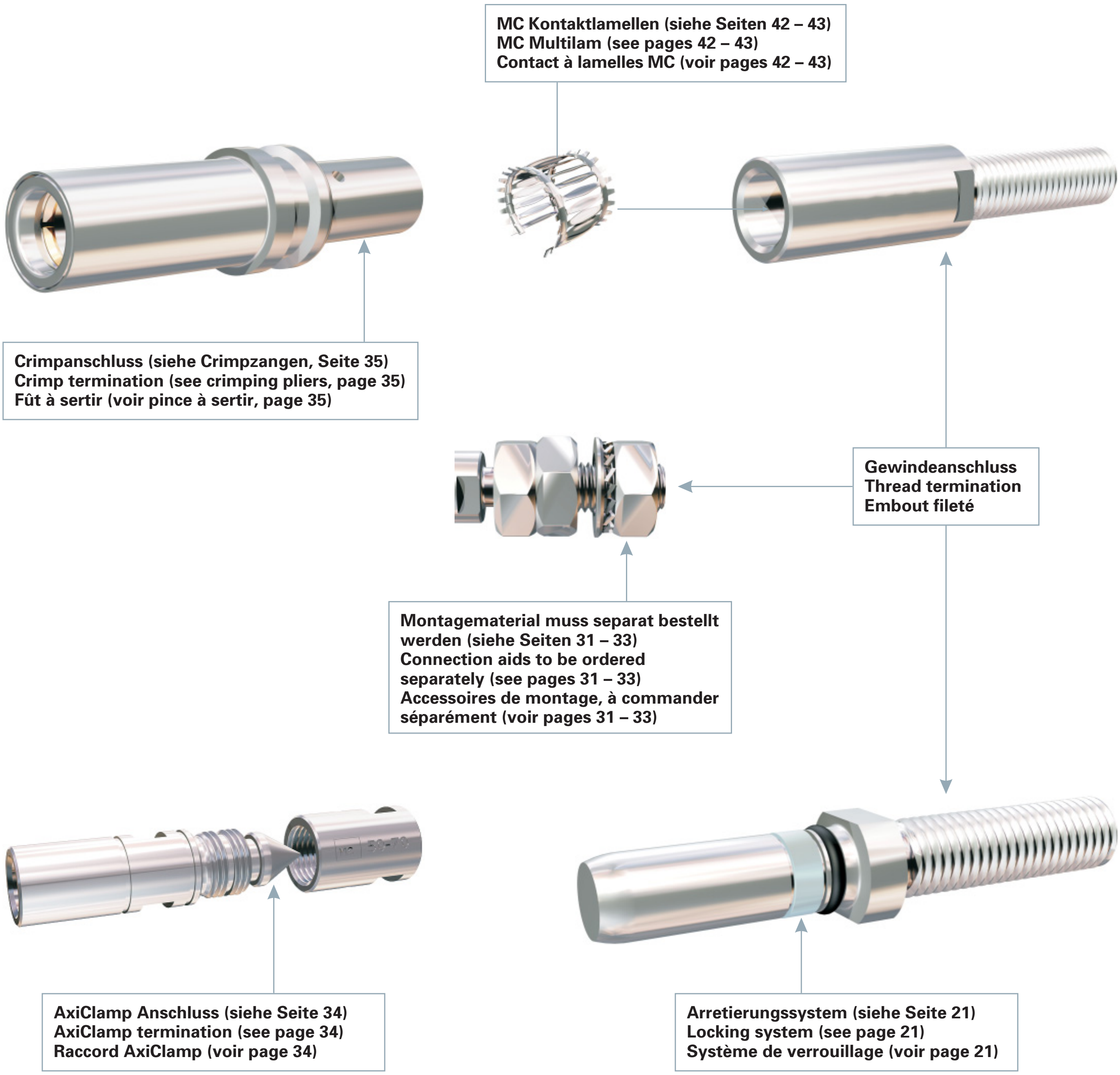
Attention: Before initial use, all threads and mating sliding surfaces of contact parts should be covered with a thin lubrication film (see page 38, Lubricant).

Introduction

Connecteurs unipolaires cylindriques, non isolés

Les corps de ces connecteurs sont en laiton (fûts à sertir en cuivre) argentés (épaisseur de environ 6µm).
Nous exécutons sur demande des connecteurs spéciaux avec d'autres dimensions, matériaux, ou des argentures spéciales, adaptées par exemple à un nombre important de cycles d'embrochages.

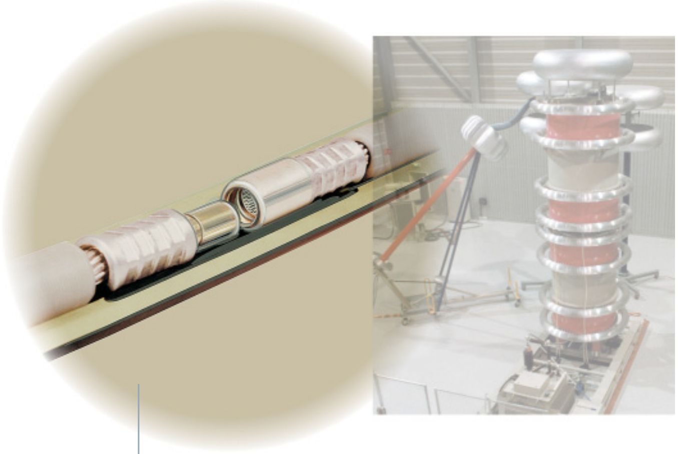
Attention: Avant la première utilisation, nous recommandons de graisser légèrement les parties filetées et les surfaces de contact (voir page 38, Lubrifiants).



Anwendungen

Applications

Applications

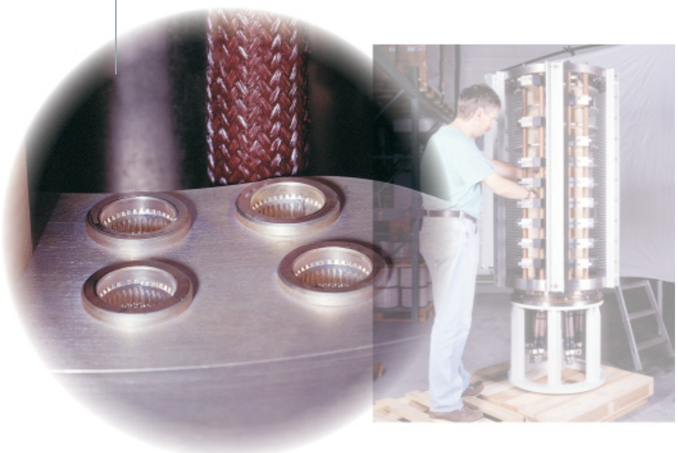


Kabelkupplung
Cable coupling
Raccordement de câbles

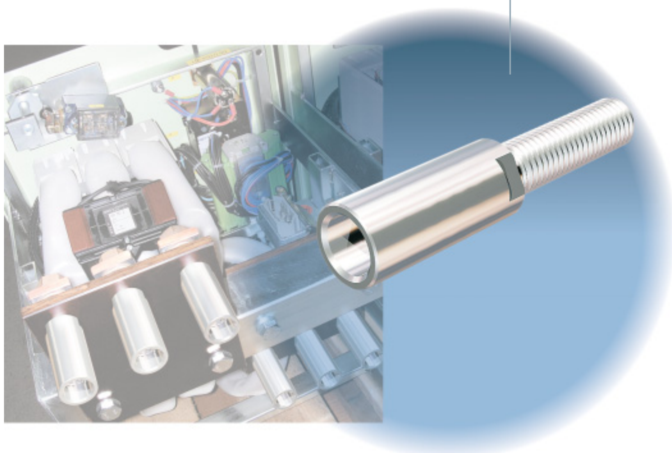
Umrüsten auf Steckanschluss
Changing into a plug connection
Transformation en connexion embrochable

Stromschienen Kontaktierung
Busbar connection
Connexion de jeux de barres

Einpressbuchsen
Press-in sockets
Douilles à emmancher



Für Einschubtechnik
For slide-in racks
Pour tiroirs embrochables



Rundsteckverbinder mit AxiClamp [1] Anschluss

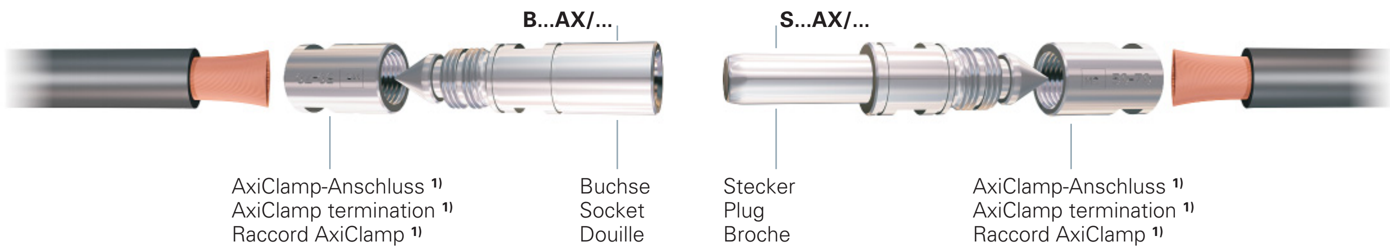
Überall einsetzbar wo auf schnelle und einfache Weise eine steckbare elektrische Verbindung gemacht werden muss.

Round connectors with AxiClamp [1] termination

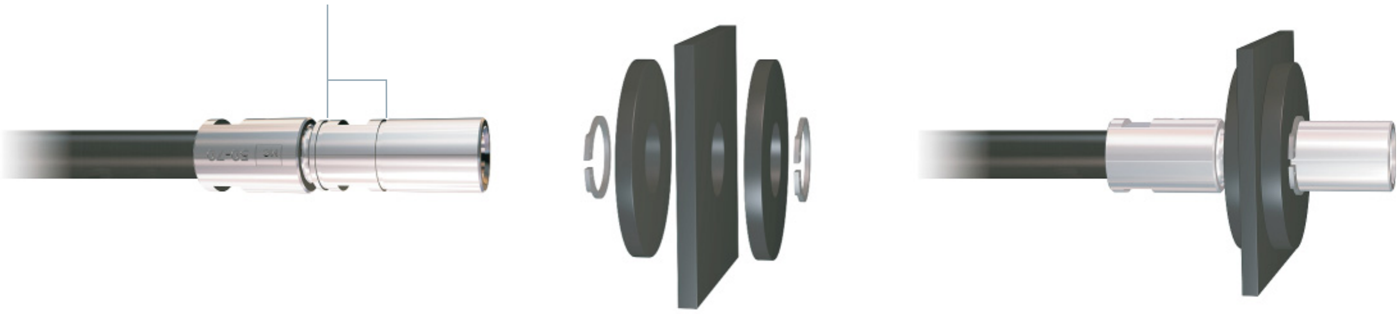
Everywhere applicable where on fast and simple way a pluggable electrical connection is required.

Connecteurs cylindriques avec raccord AxiClamp [1]

Applicable partout où une connexion enfichable électrique rapide et facile est requise.

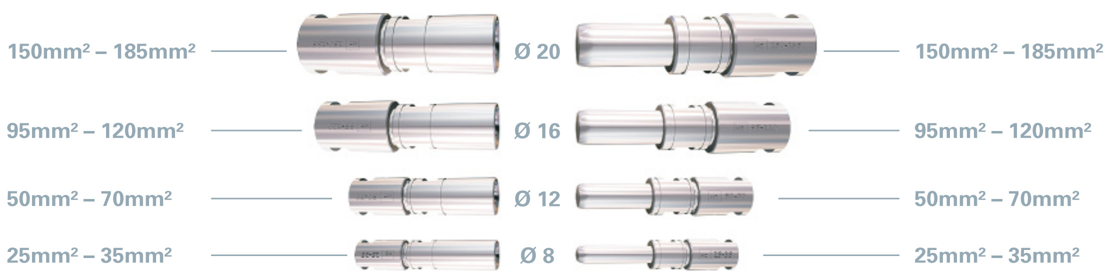


Einstiche für Seegerringe zur Einbaumontage
Grooves for circlips for panel mounting
Rainures pour circlips pour le montage sur panneau



Mit Schrumpfschlauch kann die Steckverbindung auch isoliert werden
With a form shroud tubing the connection can be insulated
Avec un manchon thermorétractable la connexion peut être isolée

4 Grössen lieferbar [2]
4 sizes can be supplied [2]
4 Tailles sont disponibles [2]



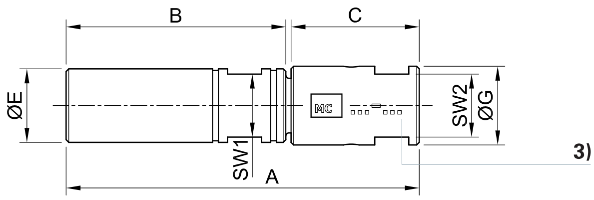
[1] Siehe Seite 34, Was ist AxiClamp?
[2] Grössere Grössen bis 300mm², auf Anfrage

[1] See page 34, what is AxiClamp?
[2] Bigger sizes up to 300mm², on request

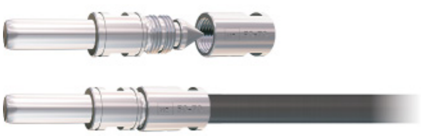
[1] Voir page 34, qu'est ce qu' AxiClamp?
[2] Tailles plus grandes jusqu'à 300mm², sur demande

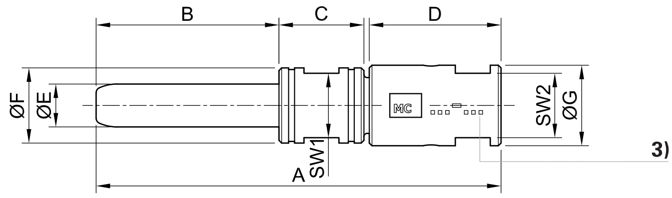
Allgemeine Angaben General data Données générales		Abmessungen (mm) Dimensions (mm) Dimensions (mm)									Mechanische und elektrische Daten Mechanical and electrical data Caractérist. mécaniques et électriques					
Typ Type Type	Bestell-Nr. Order No. No. de Cde										Auszugskraft Withdrawal force Force d'extraction	Bemessungsstrom [1] Rated current [1] Intensité assignée [1]	Kontaktwiderstand Contact resistance Résistance de contact	Kurzschlussstrom (1s) [2] Short-circuit current (1s) [2] Intensité de court-circuit (1s) [2]	Kurzschlussstrom (3s) [2] Short-circuit current (3s) [2] Intensité de court-circuit (3s) [2]	Stosskurzschlussstrom Rated peak withstand current Intensité de crête
		SW1	SW2	A	B	C	D	Ø E	Ø F	Ø G	N	A	µΩ	kA	kA	kA
B8AX/25-35	**01.0020**	12	12	67,5	42	24,5	–	14	–	15	20	130	60	4,5	3	17
B12AX/50-70	**01.0021**	15	16	72	42	29	–	18	–	19,4	30	230	40	7	5,5	25
B16AX/95-120	**01.0022**	19	22	88	48	39	–	22	–	26	65	350	25	13,5	10	40
B20AX/150-185	**01.0023**	24	27	97	52	44	–	28	–	32	80	450	15	17	12,5	50
S8AX/25-35	**04.0020**	12	12	75,3	34	15,8	24,5	8	14	15	20	130	60	4,5	3	17
S12AX/50-70	**04.0021**	15	16	84,4	34	20,4	29	12	18	19,4	30	230	40	7	5,5	25
S16AX/95-120	**04.0022**	19	22	101,4	38	23,4	39	16	22	26	65	350	25	13,5	10	40
S20AX/150-185	**04.0023**	24	27	113,8	42	26,8	44	20	28	32	80	450	15	17	12,5	50

B...AX/...



S...AX/...





AxiClamp-Anschlüsse **AxiClamp terminations** **Raccords AxiClamp**

Typ Type Type	Leiterquerschnitt Conductor cross section Section du conducteur	AWG	Max. Ø Einzellitze Max. Ø strand Ø maxi. des brins	Max. Leiter-Ø Max. cable-Ø Ø max. du câble	Abisolierlänge Stripping length Longueur de dénudage	Anzugsdrehmoment Tightening torque Couple de serrage
	mm²		mm	mm	mm	Nm
...AX/25-35	25 – 35	2	0,51	8,5	15	24
...AX/50-70	50 – 70	1; 1/0; 2/0	0,51	12,5	19	45
...AX/95-120	95 – 120	3/0; 4/0	0,51	16	26	78
...AX/150-185	150 – 185	5/0; 6/0	0,51	20	32	120

[1] Der Bemessungsstrom-Wert richtet sich auch nach dem verwendeten Leiterquerschnitt.

[2] Effektivwert

[3] An dieser Stelle ist der entsprechende Bereich des Leiterquerschnitts eingraviert.

[1] The rated current value depend also on the used conductor cross section.

[2] R.m.s. value

[3] On this place the respective range of the conductor cross section ist engraved.

[1] La valeur d'intensité assignée est aussi déterminée par le diamètre du câble utilisé.

[2] Valeur efficace

[3] A ce niveau sont gravées les plages de sections compatibles.

Leitungsverbinder mit AxiClamp [1] Anschluss

Überall einsetzbar wo auf schnelle und einfache Weise eine Leitungsverbindung gemacht werden muss z.B. bei defekten Leitungabschnitten oder bei Leitungsverlängerungen.

Cable connectors with AxiClamp [1] termination

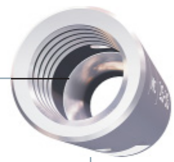
Everywhere applicable where on fast and simple way a cable connection is required e.g. for broken cables or for cable extensions.

Raccords de câble avec système de raccordement AxiClamp [1]

Applicable partout où une connexion du câble rapide et facile est requise, par exemple pour cause de rupture partielle de câble ou pour une prolongation de câble.

AX-BI...

AxiClamp-Anschlüsse [1]
AxiClamp terminations [1]
Raccords AxiClamp [1]

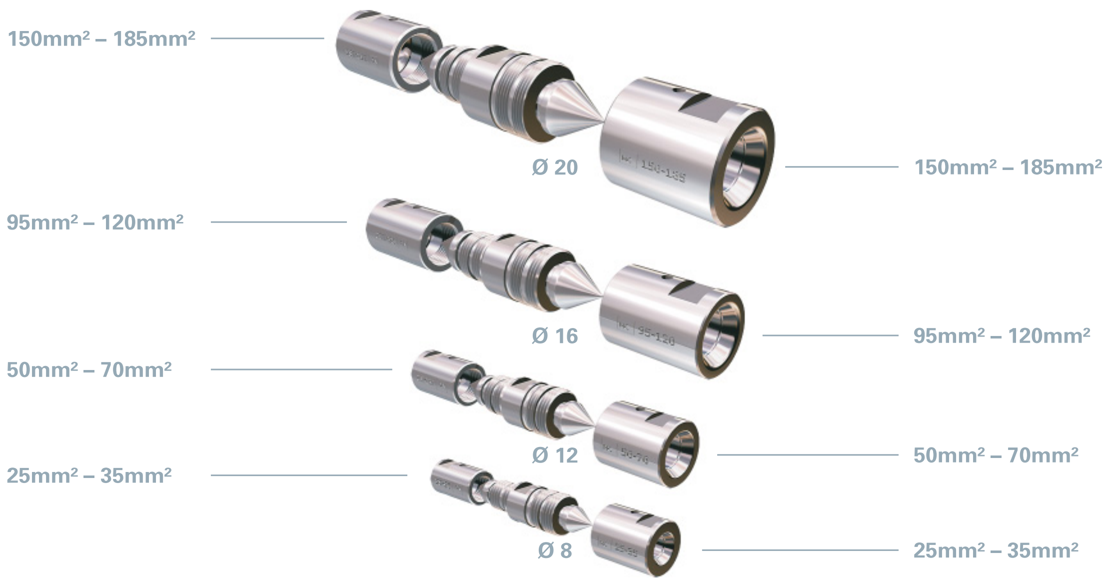


AxiClamp-Anschluss mit Drehring, verhindert, dass sich das Kabel mitdreht beim Anziehen.

AxiClamp termination with turnable ring, prevents rotation during screw clamping.

Raccord AxiClamp avec bague tournante, évite la rotation du câble pendant le serrage.

4 Grössen lieferbar [2]
4 sizes can be supplied [2]
4 Tailles sont disponibles [2]



[1] Siehe Seite 34, Was ist AxiClamp?
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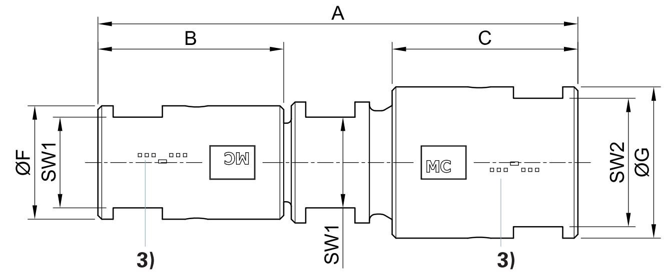
[2] Tailles plus grandes jusqu'à 300mm², sur demande

Allgemeine Angaben General data Données générales		Abmessungen (mm) Dimensions (mm) Dimensions (mm)							Elektrische Daten Electrical data Caractéristiques électriques			
Typ Type Type	Bestell-Nr. Order No. No. de Cde								Bemessungsstrom [1] Rated current [1] Intensité assignée [1]	Kurzschlussstrom (1s) [2] Short-circuit current (1s) [2] Intensité de court-circuit (1s) [2]	Kurzschlussstrom (3s) [2] Short-circuit current (3s) [2] Intensité de court-circuit (3s) [2]	Stosskurzschlussstrom Rated peak withstand current Intensité de crête
		SW1	SW2	A	B	C	Ø F	Ø G	A	kA	kA	kA
AX-BI/25-35	**07.1001**	12	17	63,3	24,5	24,5	15	20	130	4,5	3	17
AX-BI/50-70	**07.1002**	16	21	71,3	29	29	19,4	24	230	7	5,5	25
AX-BI/95-120	**07.1003**	22	24	93,3	39	39	26	29	350	13,5	10	40
AX-BI/150-185	**07.1004**	27	34	108	44	44	32	40	450	17	12,5	50

AX-BI/...

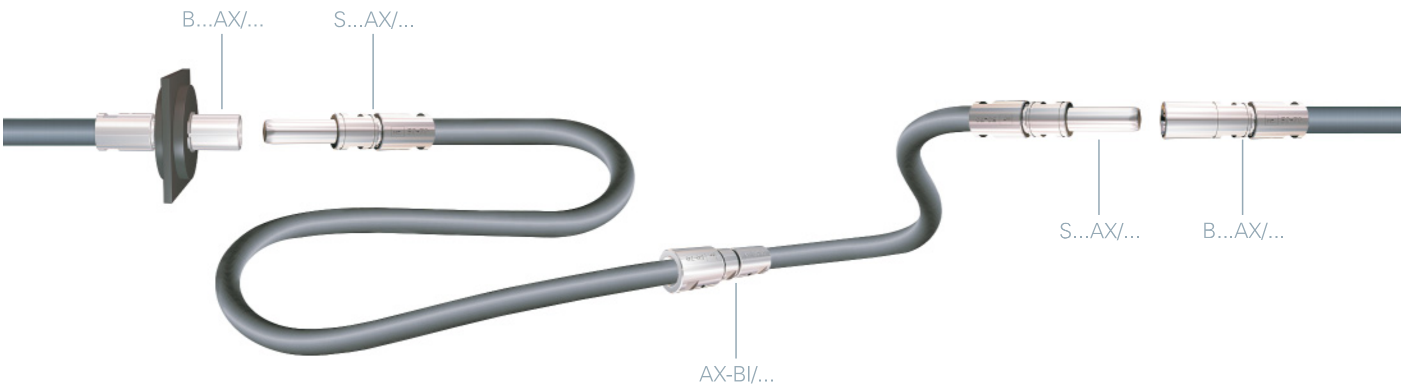


Der Leitungsverbinder kann mit Schrumpfschlauch isoliert werden
With a form shroud tubing the cable connectors can be insulated
Avec un manchon thermorétractable le raccord de câble peut être isolé

Hinweis:
Technische Daten zu AxiClamp-Anschlüssen, siehe Seite 9.

Note:
Technical data for AxiClamp terminations, see page 9.

Avis:
Caractéristiques techniques pour raccords AxiClamp, voir page 9.



[1] Der Bemessungsstrom-Wert richtet sich auch nach dem verwendeten Leiterquerschnitt.
[2] Effektivwert
[3] An dieser Stelle ist der entsprechende Bereich des Leiterquerschnitts eingraviert.

[1] The rated current value depend also on the used conductor cross section.
[2] R.m.s. value
[3] On this place the respective range of the conductor cross section ist engraved.

[1] La valeur d'intensité assignée est aussi déterminée par le diamètre du câble utilisé.
[2] Valeur efficace
[3] A ce niveau sont gravées les plages de sections compatibles.

Buchsen

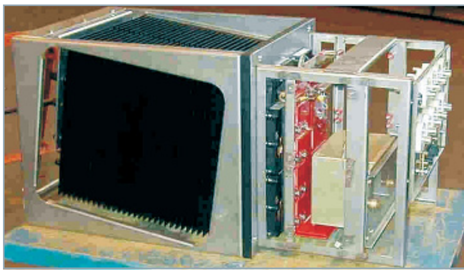
Buchsen B...N mit Gewindeanschluss

Sockets

Sockets B...N with thread termination

Douilles

Douilles B...N avec embout fileté

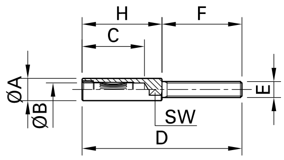


B...N Buchsen in einer Einschubeinheit

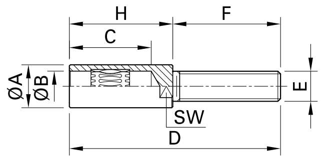
B...N sockets in a slide-in unit

Douilles B...N dans un système de tiroir embrochable

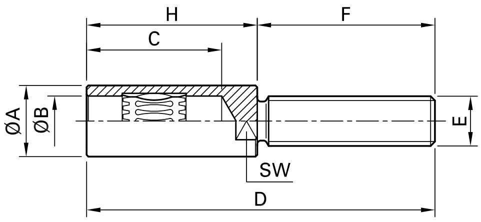
B2N – B6N



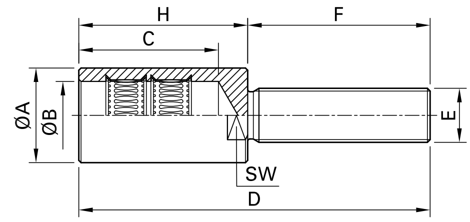
B8N – B10N



B12N – B20N



B25N – B40N



Übersteckbar mit Matching parts Contre-pièces	S...N (Seite/Page 18) SP...N (Seite/Page 20)

Montagematerial Connection aids Accessoires de montage	Seite/Page 31 – 33

Crimphülsen H...N/M... zum nachträglichen Umrüsten von Schraubanschluss auf Crimpanschluss, siehe Seite 29.

Crimping sleeves H...N/M... to change the thread termination to a crimp termination, see page 29.

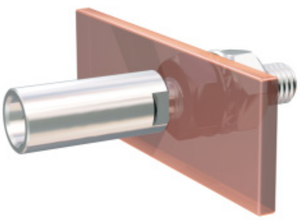
Fûts à sertir H...N/M... permettant de remplacer un raccordement à visser (embout fileté) par un raccordement à sertir, voir page 29.

Anschlussbeispiele

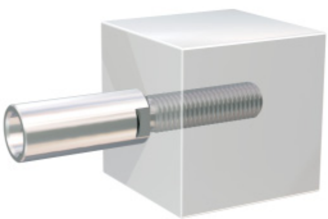
Termination examples

Exemples de raccordement

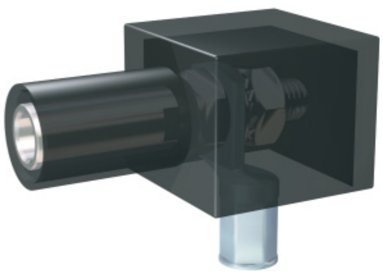
Kabelschuh
Cable lug
Cosse



Stromschiene
Busbar
Barre conductrice



Kontaktblock
Contact bloc
Bloc de contact



Isoliertes Gehäuse
Insulated housing
Boîtier isolant

Allgemeine Angaben General data Données générales			Abmessungen (mm) Dimensions (mm) Dimensions (mm)								Mechanische Daten Mechanical data Caractérist. mécaniques			
Typ Type Type	Bestell-Nr. Order No. No. de Cde	Lamellentyp Multilam Type de contact									Auszugskraft Withdrawal force Force d'extraction	Steckkraft Insertion force Force d'embrochage	Anzugsdrehmoment Tightening torque Couple de serrage	Gewicht Weight Poids
			Ø A	Ø B	C	D	E	F	H	SW	N	N	Nm	kg
B2N	**01.0001**	LAIII	5,5	2	16,5	36	M3	16	20	4	6	8	0,5	0,004
B3N	**01.0002**	LAIII	6	3	16,5	40	M4	20	20	5	8	10	1,2	0,005
B4N	**01.0003**	LAIII	7	4	19,5	50	M5	25	25	6	15	22	2,0	0,009
B5N	**01.0004**	LAIII	8,5	5	19,5	50	M5	25	25	7	15	22	2,0	0,011
B6N	**01.0005**	LAIII	10	6	19,5	53	M6	28	25	8	20	25	3,0	0,015
B8N	**01.0006**	LAI	14	8	34	78	M8	36	42	11	20	25	6,0	0,047
B10N	**01.0007**	LAI	16	10	34	84	M10	42	42	13	30	35	10	0,066
B12N	**01.0008**	LAI	18	12	34	90	M12	48	42	13	30	35	16	0,087
B14N	**01.0009**	LAI	20	14	38	98	M14	50	48	17	45	50	22	0,121
B16N	**01.0010**	LAI	22	16	38	106	M16	58	48	19	65	70	30	0,160
B18N	**01.0011**	LAI	25	18	42	110	M16	58	52	22	75	100	30	0,193
B20N	**01.0012**	LAI	28	20	42	122	M18	70	52	24	80	120	40	0,265
B25N	**01.0013**	2LAI	38	25	62	149	M20	74	75	32	80	120	52	0,588
B30N	**01.0014**	2LAI	42	30	62	156	M24x2	81	75	36	100	120	80	0,726
B35N	**01.0015**	2LAI	48	35	62	165	M30x2	90	75	41	120	150	150	1,057
B40N	**01.0016**	2LAI	52	40	62	180	M36x3	105	75	46	120	150	250	1,400

Allgemeine Angaben General data Données générales			Elektrische Daten Electrical data Caractéristiques électriques					
Typ Type Type	Bestell-Nr. Order No. No. de Cde	Lamellentyp Multilam Type de contact	Bemessungsstrom (80°C) [1] Rated current (80°C) [1] Intensité assignée (80°C) [1]	Bemessungsstrom (150°C) [1] Rated current (150°C) [1] Intensité assignée (150°C) [1]	Kontaktwiderstand Contact resistance Résistance de contact	Kurzschlussstrom (1s) [2] Short-circuit current (1s) [2] Intensité de court-circuit (1s) [2]	Kurzschlussstrom (3s) [2] Short-circuit current (3s) [2] Intensité de court-circuit (3s) [2]	Stosskurzschlussstrom Rated peak withstand current Intensité de crête
			A	A	μΩ	kA	kA	kA
B2N	**01.0001**	LAIII	35	50	300	0,5	0,4	2
B3N	**01.0002**	LAIII	40	55	200	0,8	0,65	3
B4N	**01.0003**	LAIII	65	90	200	1,2	0,9	4
B5N	**01.0004**	LAIII	70	100	150	1,5	1	5,5
B6N	**01.0005**	LAIII	100	180	100	2,5	1,5	8
B8N	**01.0006**	LAI	130	240	60	4,5	3	17
B10N	**01.0007**	LAI	200	350	50	5,5	4	20
B12N	**01.0008**	LAI	230	420	40	7	5,5	25
B14N	**01.0009**	LAI	300	500	35	11,5	8	35
B16N	**01.0010**	LAI	350	540	25	13,5	10	40
B18N	**01.0011**	LAI	400	640	20	15	11	45
B20N	**01.0012**	LAI	500	760	15	17	12,5	50
B25N	**01.0013**	2LAI	700	1100	10	27	20	100
B30N	**01.0014**	2LAI	900	1500	9	35	25	120
B35N	**01.0015**	2LAI	1200	2000	8	40	30	140
B40N	**01.0016**	2LAI	1500	2200	7	45	35	160

[1] Endtemperatur
[2] Effektivwert

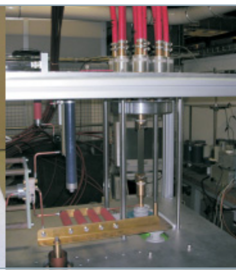
[1] End temperature
[2] r.m.s. value

[1] Température finale
[1] Valeur efficace

Buchsen BL...N mit Aussengewinde

Sockets BL...N with external thread

Douilles filetées BL...N

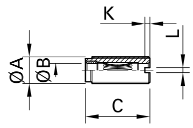


BL...N Buchsen für eine steckbare Hochstromverbindung

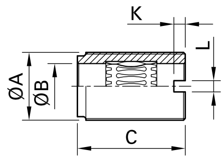
BL...N sockets for plug-in high current connection

Douilles BL...N pour connecteurs de puissance

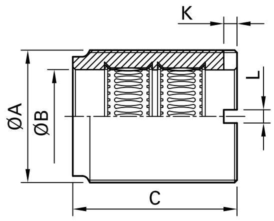
BL2N – BL6N



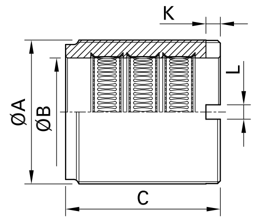
BL8N – BL20N



BL25N – BL50N



BL60N – BL100N



Übersteckbar mit Matching parts Contre-pièces	S...N (Seite/Page 18) SP...N (Seite/Page 20)

Montagematerial Connection aids Accessoires de montage	Seiten/Pages 31 – 33

Aufgrund des Aussengewindes müssen die BL-Buchsen stets gegen einen festen Anschlag geschraubt oder mit 2 Muttern und 2 Unterlagsscheiben in Stromschienen befestigt werden. Für extreme Belastungen und Einbauverhältnisse, bei denen kein Anschlag möglich ist, siehe Buchsen BL...A, Seiten 16 – 17.

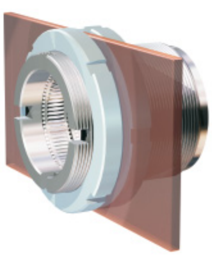
The BL-sockets with external thread must be screwed against a fixed stop, or screwed into the busbar with 2 nuts and washers. For extreme loads and mounting conditions and where a stop is not possible, a socket with external Multilam instead of a thread is available (see BL...A pages 16 – 17).

Les douilles BL...N doivent être bloquées en position contre une butée ou fixées sur une barre conductrice à l'aide de 2 rondelles et 2 écrous. Dans le cas de fortes contraintes et de conditions de montage difficiles, pour lesquelles aucune butée n'est envisageable, les douilles pourront également être livrées avec des contacts à lamelles extérieurs (voir BL...A pages 16 – 17).

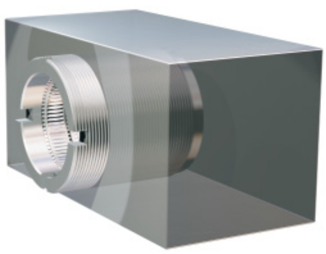
Anschlussbeispiele

Termination examples

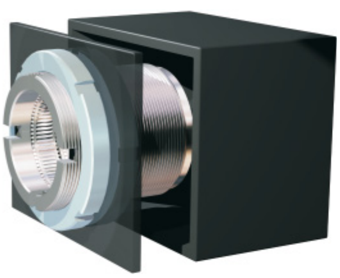
Exemples de raccordement



Stromschiene
Busbar
Barre conductrice



Kontaktblock (mit Anschlag)
Contact block (with stop)
Bloc de contact (avec butée)



Isoliertes Gehäuse
Insulated housing
Boîtier isolant

Allgemeine Angaben General data Données générales			Abmessungen (mm) Dimensions (mm) Dimensions (mm)					Mechanische Daten Mechanical data Caractérist. mécaniques				Elektrische Daten Electrical data Caractéristiques électriques					
Typ Type Type	Bestell-Nr. Order No. No. de Cde	Lamellentyp Multilam Type de contact						Auszugskraft Withdrawal force Force d'extraction	Steckkraft Insertion force Force d'embrochage	Anzugsdrehmoment Tightening torque Couple de serrage	Gewicht Weight Poids	Bemessungsstrom (80°C) [1] Rated current (80°C) [1] Intensité assignée (80°C) [1]	Bemessungsstrom (150°C) [1] Rated current (150°C) [1] Intensité assignée (150°C) [1]	Kontaktwiderstand Contact resistance Résistance de contact	Kurzschlussstrom (1s) [2] Short-circuit current (1s) [2] Intensité de court-circuit (1s) [2]	Kurzschlussstrom (3s) [2] Short-circuit current (3s) [2] Intensité de court-circuit (3s) [2]	Stosskurzschlussstrom Rated peak withstand current Intensité de crête
			ØA	ØB	C	K	L	N	N	Nm	kg	A	A	µΩ	kA	kA	kA
BL2N	**02.0001**	LAIII	M8x0,75	2	16,5	1,5	1,5	6	8	2,5	0,005	35	50	300	0,5	0,4	2
BL3N	**02.0002**	LAIII	M8x0,75	3	16,5	1,5	1,5	8	10	2,5	0,005	40	55	200	0,6	0,65	3
BL4N	**02.0003**	LAIII	M8x0,75	4	19,5	1,5	1,5	15	22	2,5	0,005	65	90	200	1,2	0,9	4
BL5N	**02.0004**	LAIII	M10x1	5	19,5	2	1,5	15	22	5	0,007	70	100	150	1,5	1	5,5
BL6N	**02.0005**	LAIII	M12x1	6	19,5	2,5	2	20	25	10	0,011	100	180	100	2,5	1,5	8
BL6AR-N [3]	**02.0201**	LAIII	M14x1	6	28	1,5	2	25	30	13	0,023	100		100	2,5	1,5	8
BL8N	**02.0006**	LAI	M14x1	8	34	2,5	2,5	20	25	13	0,021	130	240	60	4,5	3	17
BL10N	**02.0007**	LAI	M18x1	10	34	3,5	3,5	30	35	22	0,039	200	350	50	5,5	4	20
BL12N	**02.0008**	LAI	M20x1	12	34	3,5	3,5	30	35	30	0,043	230	420	40	7,0	5,5	25
BL14N	**02.0009**	LAI	M22x1	14	38	4	4	45	50	35	0,057	300	500	35	11,5	8	35
BL16N	**02.0010**	LAI	M24x1	16	38	4	4	65	70	35	0,063	350	540	25	13,5	10	40
BL18N	**02.0011**	LAI	M28x1	18	42	4	4	75	100	55	0,105	400	640	20	15	11	45
BL20N	**02.0012**	LAI	M30x1	20	42	4	5	80	120	65	0,114	500	760	15	17	12	50
BL25N	**02.0013**	2LAI	M42x1,5	25	62	5	5	80	120	150	0,394	700	1100	10	27	20	100
BL30N	**02.0014**	2LAI	M48x1,5	30	62	5	5	100	120	200	0,486	900	1500	9	35	25	120
BL35N	**02.0015**	2LAI	M50x1,5	35	62	5	5	120	150	220	0,427	1200	2000	8	40	30	140
BL40N	**02.0016**	2LAI	M55x1,5	40	62	6	6	120	150	275	0,472	1500	2200	7	45	35	160
BL45N	**02.0017**	2LAI	M60x2	45	62	6	6	120	150	430	0,502	1800	2500	7	50	40	175
BL50N	**02.0018**	2LAI	M65x2	50	62	8	7	130	150	500	0,558	2000	2800	6	55	45	195
BL60N	**02.0019**	3LAI	M80x2	60	86	8	8	300	350	750	1,357	3000	4000	6	70	55	320
BL70N	**02.0020**	3LAI	M90x2	70	86	8	8	400	450	1000	1,546	3700	4500	6	90	70	400
BL80N	**02.0021**	3LAI	M100x2	80	86	8	8	500	540	1500	1,702	4200	5400	5	110	80	450
BL90N [4]	**02.0022**	3LAI	M110x2	90	86	8	8	550	600	2000	1,873	4500	5800	5	130	110	500
BL100N [4]	**02.0023**	3LAI	M120x2	100	86	8	8	630	670	2500	2,094	5000	6300	5	150	120	550

1) Endtemperatur
2) Effektivwert
3) Mit Arretierung
4) Nur auf Anfrage, kein Lagerartikel

1) End temperature
2) r.m.s. value
3) With locking system
4) Only on request, not in stock

1) Température finale
2) Valeur efficace
3) Avec système de verrouillage
4) Uniquement sur demande, article non tenu en stock

Hinweis:
Die Gewinde sind vor dem Einbau unbedingt mit einem dünnen Schmiermittelfilm zu versehen, siehe unter Schmiermittel Seite 38.

Note:
Before assembly the threads must be covered with a thin lubricating film (see page 38, Lubricant).

Avis:
Avant montage, il est impératif de graisser le filetage (voir page 38, Lubrifiants).

Montageanleitung ***MA021***
www.multi-contact.com

Assembly instructions ***MA021***
www.multi-contact.com

Instructions de montage ***MA021***
www.multi-contact.com

Buchsen BL...A mit Aussenlamelle

Sockets BL...A with external Multilam

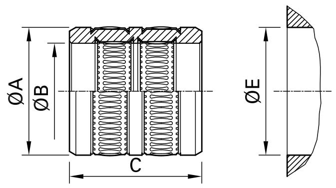
Douilles BL...A avec contacts à lamelles extérieurs

BL...A Buchse in einem Kontaktblock als Steckanschluss eingepresst

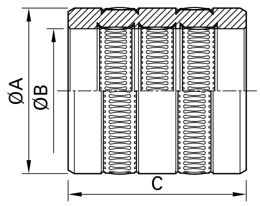
BL...A socket in a contact block pressed-in as a plug connection

Douille BL...A emmanchée et servant de plot de connexion dans un bloc de contact

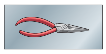
BL25A – BL45A



BL60A – BL70A



Übersteckbar mit Matching parts Contre-pièces	S...N (Seiten/Pages 18 – 19)

Montageanleitung Assembly instructions Instructions de montage		*MA035* Seite/Page 17 [1]

[1] Herunterladen unter: www.multi-contact.com

[1] Download: www.multi-contact.com

[1] A télécharger sous: www.multi-contact.com

Für eine optimale Kontaktierung sollten die Bohrungen mit einer Innenversilberung versehen werden. Es ist jedoch auch möglich blanke Materialien (auch legiertes Aluminium, z.B. AlMgSi0.5, EN-AW 6060) in nicht korrosiver Atmosphäre zu kontaktieren, wenn die Kontaktstellen durch Fette vor Oxydation und Feuchtigkeit geschützt werden (siehe Seite 38, Schmiermittel).

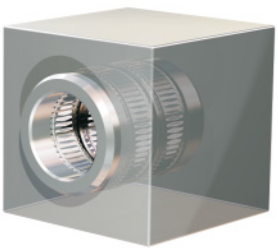
The holes should be silver-plated for an optimum contact. However, it is possible to make contact with unplated materials (also alloy aluminium, e.g. AlMgSi0.5, EN-AW 6060) in a non corrosive atmosphere when the contact surfaces are covered with grease and are kept free from oxidation and humidity (see page 38, Lubricant).

Pour garantir une bonne qualité de contact, les alésages devraient être argentés. La connexion de pièces non traitées (même en aluminium/alliage, par exemple AlMgSi0.5, EN-AW 6060) est possible, sous réserve toutefois de protéger les zones de contact de toute oxydation à l'aide d'une graisse adéquate (voir page 38, Lubrifiants).

Anschlussbeispiele

Termination examples

Exemples de raccordement



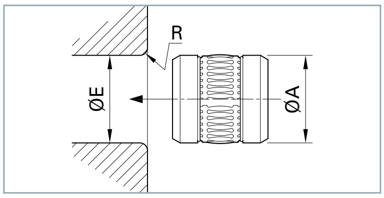
Kontaktblock
Contact block
Bloc de contact

Rohrstossverbinder
Tube connector
Liaison entre deux tubes

Montageanleitung MA035 für Einpressbuchsen

Assembly instructions MA035 for Press-In Sockets

Instructions de montage MA035 pour douille à emmancher



ILL. 1

(ILL. 1)
Überprüfung des Bohrungs-Ø:

Bohrung Ø E = Ø A $\pm^{0.1}_{0}$

Einfetten der Bohrung und Lamelle mit einem geeigneten Kontaktfett (siehe Seite 38)

(ILL. 1)
Checking the hole diameter:

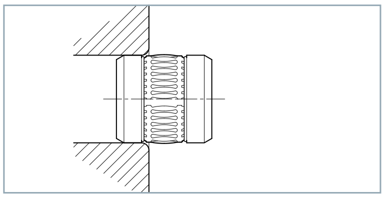
Hole Ø E = Ø A $\pm^{0.1}_{0}$

Lubricate hole and Multilam with an appropriate contact grease (see page 38)

(ILL. 1)
Vérification de l'alésage:

Perçage Ø E = Ø A $\pm^{0.1}_{0}$

Graissage de l'alésage et de la lamelle avec une graisse de contact adéquate (voir page 38).

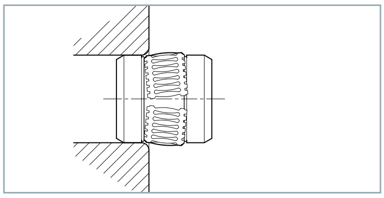


ILL. 2

(ILL. 2)
Die Buchse wird so tief wie möglich von Hand unter leichtem Drehen in die Bohrung eingebracht.
Die Buchse auf keinen Fall verkanten!
Der Kontaktlamellenring muss auf dem ganzen Umfang fest in der vorgesehenen Nut sitzen.

(ILL. 2)
The sockets are inserted by hand with a light twisting action as far as possible into the hole.
Under no circumstances should the socket be tilted!
The Multilam band must be seated over its complete circumference in the groove.

(ILL. 2)
La douille est enfoncée manuellement aussi loin que possible en exerçant un mouvement de rotation.
Respecter le centrage de la douille par rapport à l'alésage.
Le contact à lamelles doit être bien en position dans la rainure sur tout le pourtour.

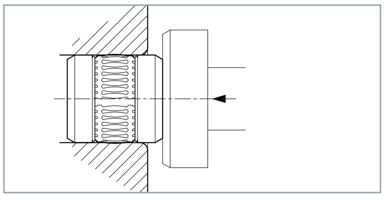


ILL. 3

(ILL. 3)
Unter keinen Umständen darf die Randzahnung des Kontaktlamellenrings aus der Nut ragen.

(ILL. 3)
Under no circumstances should the teeth of the Multilam band project out over the groove.

(ILL. 3)
En aucun cas les dents du contact à lamelles ne doivent sortir de la rainure.



ILL. 4

(ILL. 4)
Mit einer hydraulischen Presse oder einem Hammer und entsprechendem Schlagstempel wird die Buchse vollends eingetrieben.
Buchse stets zentrisch eintreiben. Nie direkt auf den Rand der Buchse schlagen.

(ILL. 4)
With the use of a hydraulic press or a hammer with the appropriate stamp drive the MC Socket fully in.
The socket must be correctly centred when drive in. Never strike the edge of the socket directly.

(ILL. 4)
A l'aide d'une presse hydraulique ou d'un poinçon et d'une cale à frapper, enfoncer la douille.
Respecter le centrage lors de l'emmanchement. Ne jamais taper directement sur le bord de la douille.

Allgemeine Angaben General data Données générales			Abmessungen (mm) Dimensions (mm) Dimensions (mm)				Mechanische Daten Mechanical data Caractérist. mécaniques				Elektrische Daten Electrical data Caractéristiques électriques					
Typ Type Type	Bestell-Nr. Order No. No. de Cde	Lamellentyp Multilam Type de contact					Auszugskraft Withdrawal force Force d'extraction	Steckkraft Insertion force Force d'embrochage	Einpresskraft Max. Assembling force Force d'emmanchement max.	Gewicht Weight Poids	Bemessungsstrom (80°C) [1] Rated current (80°C) [1] Intensité assignée (80°C) [1]	Bemessungsstrom (150°C) [1] Rated current (150°C) [1] Intensité assignée (150°C) [1]	Kontaktwiderstand Contact resistance Résistance de contact	Kurzschlussstrom (1s) [2] Short-circuit current (1s) [2] Intensité de court-circuit (1s) [2]	Kurzschlussstrom (3s) [2] Short-circuit current (3s) [2] Intensité de court-circuit (3s) [2]	Stosskurzschlussstrom Rated peak withstand current Intensité de crête
			Ø A	Ø B	C	Ø E	N	N	ca. kN	kg	A	A	µΩ	kA	kA	kA
BL25A	**02.0525**	2LAI	42	25	62	42	80	120	2,0	0,420	700	1100	10	27	20	100
BL30A	**02.0526**	2LAI	48	30	62	48	100	120	2,5	0,524	900	1500	9	35	25	120
BL35A	**02.0527**	2LAI	50	35	62	50	120	150	2,5	0,438	1200	2000	8	40	30	140
BL40A	**02.0528**	2LAI	55	40	62	55	120	150	2,7	0,491	1500	2200	7	45	35	160
BL45A	**02.0529**	2LAI	60	45	62	60	120	150	3,0	0,550	1800	2500	7	50	40	175
BL60A	**02.0531**	3LAI	80	60	86	80	300	350	4,0	1,440	3000	4000	6	70	55	320
BL70A	**02.0532**	3LAI	90	70	86	90	400	450	4,5	1,645	3700	4500	6	90	70	400

BL...A Buchsen fertigen wir auch mit Abmessungen nach Ihren Wünschen. Senden Sie uns einfach ein Anfrageformular (Download unter: www.multi-contact.com -> Über uns -> Online-Formulare -> Checklist) für eine Angebotsbearbeitung.

[1] Endtemperatur

[2] Effektivwert

Do you require special dimensions? BL...A special sockets can be made to your requirements. Just send us the inquiry form (download: www.multi-contact.com -> About us -> Online Forms -> Checklist)

[1] End temperature

[2] r.m.s. value

Les douilles BL...A spéciales peuvent être fabriquées aux dimensions souhaitées par le client. Pour cela, il vous suffit de nous communiquer le questionnaire (à télécharger sous: www.multi-contact.com -> A propos -> Formulaires en ligne Checklist) afin que nous puissions vous établir un devis.

[1] Températures finales

[2] Valeur efficace

Stecker

Stecker S...N mit
Gewindeanschluss

Plugs

Plugs S...N with
thread termination

Broches

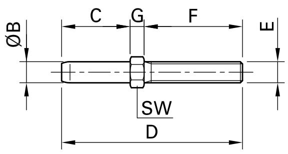
Broches S...N avec
embout fileté

Stecker S...N als Netzanschluss auf einer Einschubeinheit

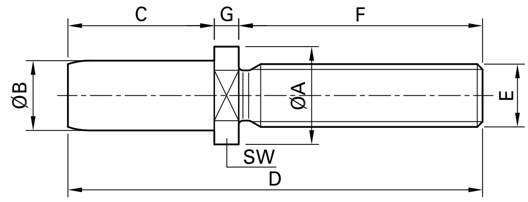
Plugs S...N as power supply connection for a slide-in rack unit

Broches S...N servant à la connexion de l'alimentation sur un rack

S2N – S10N



S12N – S50N



Übersteckbar mit Matching parts Contre-pièces	B...N (Seiten/Pages 12 – 13) BL...N (Seiten/Pages 14 – 15) BL...A (Seiten/Pages 16 – 17)

Montagematerial Connection aids Accessoires de montage	Seiten/Pages 31 – 33

Crimphülsen H...N/M... zum nachträglichen Umrüsten von Schraubanschluss auf Crimpanschluss, siehe Seite 29.

Crimping sleeves H...N/M... to change the thread termination to a crimp termination, see page 29.

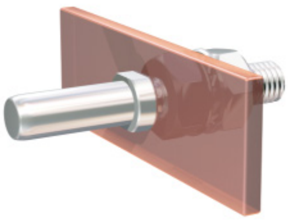
Fûts à sertir H...N/M... permettant de remplacer un raccordement à visser (embout fileté) par un raccordement à sertir, voir page 29.

Anschlussbeispiele

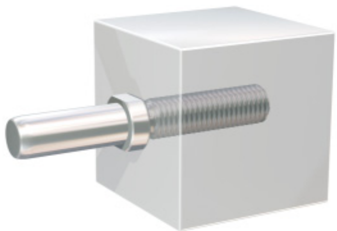
Termination examples

Exemples de raccordement

Kabelschuh
Cable lug
Cosse



Stromschiene
Busbar
Barre conductrice



Kontaktblock
Contact block
Bloc de contact

Isolierte Platte oder Gehäuse
Insulated panel or housing
Panneau ou boîtier isolant

Allgemeine Angaben General data Données générales		Abmessungen (mm) Dimensions (mm) Dimensions (mm)								Technische Daten Technical data Caractéristiques techniques			
Typ Type Type	Bestell-Nr. Order No. No. de Cde									Anzugsdrehmoment Tightening torque Couple de serrage	Gewicht Weight Poids	Bemessungsstrom (80°C) 1) Rated current (80°C) 1) Intensité assignée (80°C) 1)	Bemessungsstrom (150°C) 1) Rated current (150°C) 1) Intensité assignée (150°C) 1)
		Ø A	Ø B	C	D	E	F	G	SW	Nm	kg	A	A
S2N	**04.0001**		2	16,5	35,5	M3	16	3	4	0,5	0,002	35	50
S3N	**04.0002**		3	16,5	40	M4	20	3,5	5	1,2	0,003	40	55
S4N	**04.0003**		4	19,5	48,5	M5	25	4	6	2,0	0,006	65	90
S5N	**04.0004**		5	19,5	48,5	M5	25	4	7	2,0	0,008	70	100
S6N	**04.0005**		6	19,5	51,5	M6	28	4	8	3,0	0,012	100	180
S8N	**04.0006**		8	34	75	M8	36	5	11	6,0	0,030	130	240
S10N	**04.0007**		10	34	81	M10	42	5	13	10	0,050	200	350
S12N	**04.0008**	18	12	34	87	M12	48	5	13	16	0,077	230	420
S14N	**04.0009**	20	14	38	95	M14	50	7	17	22	0,118	300	500
S16N	**04.0010**	22	16	38	103	M16	58	7	19	30	0,166	350	540
S18N	**04.0011**	25	18	42	107	M16	58	7	22	30	0,199	400	640
S20N	**04.0012**	28	20	42	119	M18	70	7	24	40	0,265	500	760
S25N	**04.0013**	38	25	62	145	M20	74	9	32	52	0,496	700	1100
S30N	**04.0014**	42	30	62	152	M24x2	81	9	36	80	0,730	900	1500
S35N	**04.0015**	48	35	62	162	M30x2	90	10	41	150	1,126	1200	2000
S40N	**04.0016**	52	40	62	178	M36x3	105	11	46	250	1,623	1500	2200
S45N	**04.0017**	60	45	62	217	M42x3	140	15	50	350	2,635	1800	2500
S50N	**04.0018**	65	50	62	217	M48x3	140	15	55	450	3,345	2000	2800

1) Endtemperatur

1) End temperature

1) Température finale

Hinweis auf andere MC Kataloge

Reference to other MC Catalogues

Renvoi à d'autres catalogues MC

Rundsteckverbinder
Round Connectors
Connecteurs cylindriques

Ø 6mm, einpolig, isoliert / max. 600V, 125A
Ø 6mm, single-pole, insulated / max. 600V, 125A
Ø 6mm, unipolaires, isolés / max. 600V, 125A

2 Power*line*

Rundsteckverbinder
Round Connectors
Connecteurs cylindriques

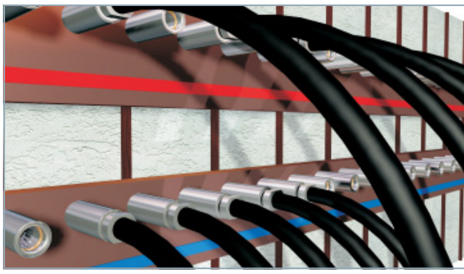
Ø 10mm – 30mm, einpolig, isoliert / max. 1000V, 1000A
Ø 10mm – 30mm, single-pole, insulated / max. 1000V, 1000A
Ø 10mm – 30mm, unipolaires, isolés / max. 1000V, 1000A

3 Power*line*

Stecker SP...N mit Crimpanschluss

Plugs SP...N with crimp termination

Broches SP...N avec fût à sertir

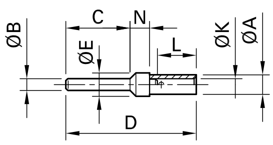


Stecker SP...N zur Kontaktierung von Stromschienen

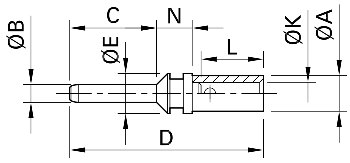
Plugs SP...N to contact busbars

Broches SP...N pour connecter des jeux de barres

SP3N/4 – SP4N/6



SP4N/10 – SP8N/25



Übersteckbar mit Matching parts Contre-pièces	B...N (Seiten/Pages 12 – 13) BL...N (Seiten/Pages 14 – 15)

Reduzierhülsen Reduction sleeves Fûts de réduction	Seite/Page 30

Crimpanschluss für flexible und hochflexible Cu-Leiter Klasse 6 (nach IEC 60228). MC empfiehlt Sechskantcrimpung. Dornkerbung und Lötanschluss sind möglich. Verdichtete Leiter benötigen spezielle Crimphülsen.
Crimpzangen siehe Seite 35.

Crimp termination for flexible and highly flexible Cu-cables class 6 (according to IEC 60228). MC recommends a hexagonal crimp. Indent crimping and soldering is also possible. Cables with compacted conductors need a special crimping sleeve.
Crimping pliers see page 35.

Fût à sertir pour câbles souples et extra-souples de classe 6 (selon CEI 60228). MC préconise un sertissage à six pans, un poinçonnage étant toutefois possible. Pour les câbles à conducteurs compacts, l'utilisation de fûts spéciaux est nécessaire.
Pince à sertir voir page 35.

Allgemeine Angaben General data Données générales		Abmessungen (mm) Dimensions (mm) Dimensions (mm)								Technische Daten Technical data Caractérist. techniques		
Typ Type Type	Bestell-Nr. Order No. No. de Cde									Gewicht Weight Poids	Kabelquerschnitt Cu Cable cross section Cu Section du câble Cu	Bemessungsstrom (80°C) 2) Rated current (80°C) 2) Intensité assignée (80°C) 2)
		Ø A	Ø B	C	D	Ø E	Ø K	L	N	kg	mm²	A
SP3N/4	**05.0003**	5	3	16,5	33,5	6	3	10	5	0,004	4	30
SP3N/6	**05.0004**	6	3	16,5	33,5	6	4	12	5	0,004	6	35
SP4N/6	**05.0005**	6	4	19,5	38	6	4	12	4,5	0,005	6	40
SP4N/10 1)	**05.0006**	8	4	19,5	43,5	9	5	14	8	0,009	10	50
SP5N/10 1)	**05.0007**	8	5	19,5	43	9	5	14	7,5	0,011	10	60
SP6N/10 1)	**05.0009**	8	6	19,5	42,5	9	5	14	7	0,012	10	80
SP6N/16 1)	**05.0010**	9	6	19,5	42,5	9	6	14	7	0,011	16	100
SP8N/16 1)	**05.0012**	9	8	34	56	9	6	14	6	0,020	16	100
SP8N/25 1)	**05.0013**	11	8	34	65	9	8	17	12	0,030	25	120

Weitere Abmessungen, passend zu den Buchsen B...N, BL...N und BL...A, auf Anfrage

1) Zu diesen Steckern sind auch farbige Kabeltüllen lieferbar, siehe Seite 21.

2) Endtemperatur

Other dimensions for sockets B...N, BL...N and BL...A, on request

1) For these plugs coloured sleeves are avaliable, see page 21.

2) End temperature

Autres dimensions, se rapportant aux douilles B...N, BL...N et BL...A, sur demande

1) Des manchons isolants de couleur peuvent être montés sur ces broches, voir page 21.

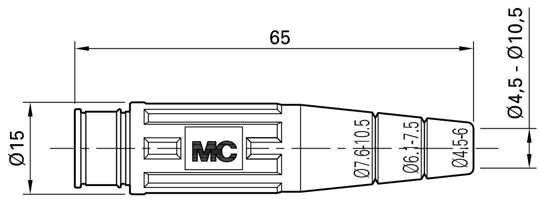
2) Température finale

Kabeltüllen T6N zu den Steckern SP4N/10 bis SP8N/25 für Leiteraussendurchmesser von 4,5mm – 10,5mm.
Siehe Katalog 2 Power*line*.

Sleeve T6N for plugs SP4N/10 up to SP8N/25A. For cable outer diameter 4,5mm – 10,5mm.
See catalogue 2 Power*line*.

Manchon pour broches SP4N/10 jusqu'à SP8N/25. Pour diamètre extérieur du câble de 4,5mm à 10,5mm.
Voir catalogue 2 Power*line*.

T6N



MC Arretierungssystem (AR-System)

Das MC Arretierungs – (AR) – System funktioniert nach der Art einer "Push-pull-Kupplung" einer selbsttätig (beim Steckvorgang) verriegelnden Schnellkupplung, bei der die Entriegelung durch einen axial verschiebbaren Kupplungsring erfolgt. Zum Lösen erst drücken (push), dann ziehen (pull).
Verschmutzte Teile sollten vor dem Stecken mit Industrialkohol gereinigt werden.

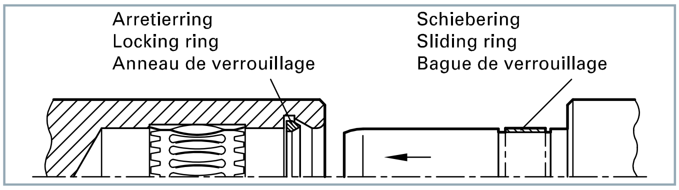
MC Locking system (AR-system)

The MC Locking system (AR) operates on the "push-pull" principle.
It is self-locking when connected. Disconnection is effected by an axially displaceable coupling ring: first push, then pull to disconnect.
Dirty parts should be cleaned with industrial alcohol before connecting.

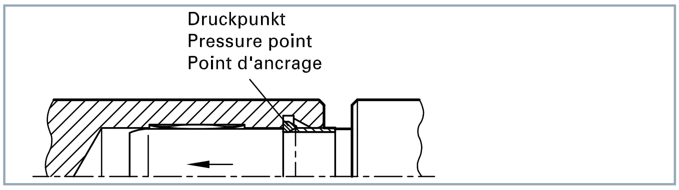
Système de verrouillage MC (système-AR)

Le système de verrouillage MC fonctionne d'après le principe d'un raccordement "Push-pull", un système de verrouillage rapide et automatique, le déverrouillage se faisant par le glissement axial d'une bague.
Pour déconnecter, il suffit de pousser (push), puis de tirer (pull).
Des pièces sales doivent être nettoyées avec de l'alcool industriel avant connexion.

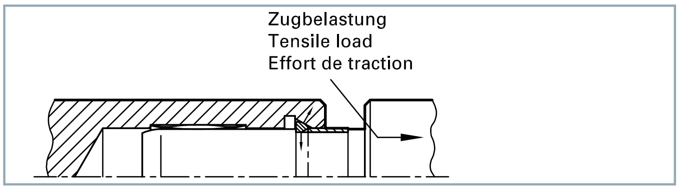
Arretieren / Locking / Verrouillage



Stecker in die Buchse schieben ...
Insert plug into socket...
Introduire la broche dans la douille ...
ILL. 1

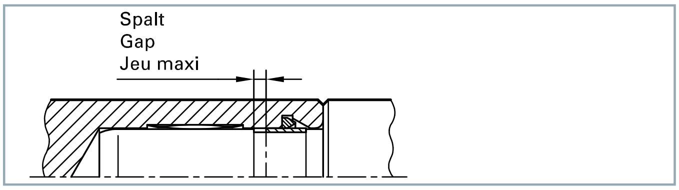


... und arretieren!
... and lock!
... puis verrouiller!
ILL. 2

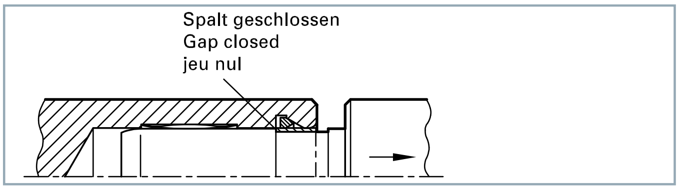


Zur Prüfung: Verbindung auf Zug belasten!
To check: Apply tensile load!
Pour contrôler: Appliquer un effort de traction!
ILL. 3

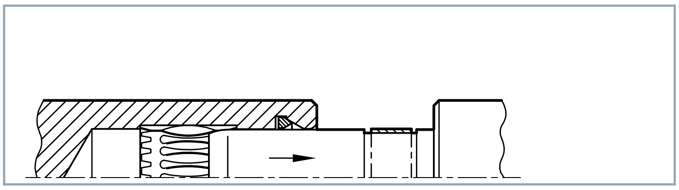
Lösen / Releasing / Déverrouillage



Zum Lösen zunächst tiefer stecken ...
To release, push plug further in ...
Pour déverrouiller, pousser à fond ...
ILL. 4



... danach ziehen!
... and pull!
... puis retirer!
ILL. 5



Die Verbindung ist gelöst!
The connection is released!
La connexion est débrochée!
ILL. 6

Buchsen

Buchsen B...AR-N mit Arretierung und Gewindeanschluss

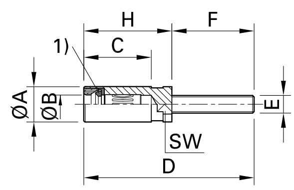
Sockets

Sockets B...AR-N with snap-in lock and thread termination

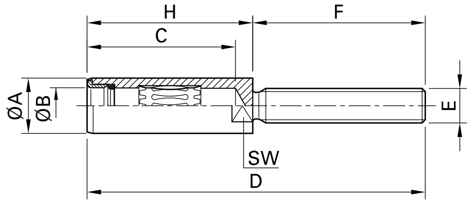
Douilles

Douilles B...AR-N avec verrouillage et embout fileté

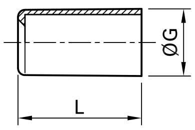
B6AR-N-S



B10AR-N – B14AR-N



IH



1) Kunststoffring aus POM

1) Plastic ring (POM)

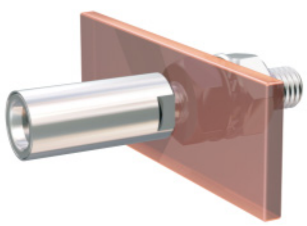
1) Bague en plastique (POM)

Übersteckbar mit Matching parts Contre-pièces	S...AR-N (Seite/Page 26) SP...AR-N (Seite/Page 27) SIG...AR-N (Seite/Page 28)

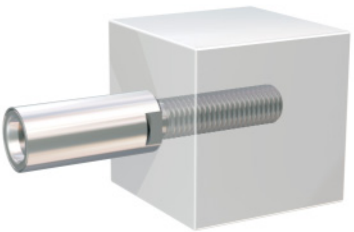
Montagematerial Connection aids Accessoires de montage	Seiten/Pages 31 – 33

Anschlussbeispiele **Termination examples** **Exemples de raccordement**

Kabelschuh
Cable lug
Cosse



Stromschiene
Busbar
Barre conductrice



Kontaktblock
Contact block
Bloc de contact

Isolierte Platte oder Gehäuse
Insulated panel or housing
Panneau ou boîtier isolant

Allgemeine Angaben General data Données générales			Abmessungen (mm) Dimensions (mm) Dimensions (mm)								Mechanische Daten Mechanical data Caractérist. mécaniques			
Typ Type Type	Bestell-Nr. Order No. No. de Cde	Lamellentyp Multilam Type de contact									Auszugskraft Withdrawal force Force d'extraction	Steckkraft Insertion force Force d'embrochage	Anzugsdrehmoment Tightening torque Couple de serrage	Gewicht Weight Poids
			Ø A	Ø B	C	D	E	F	H	SW	N	N	Nm	kg
B6AR-NS	**01.0200**	LAIII	12	6	23	58	M6	28	30	10	25	30	3	0,026
B10AR-N	**01.0202**	LAI	16	10	43	98	M10	50	48	13	35	40	10	0,072
B14AR-N	**01.0203**	LAI	21	14	43	98	M14	50	48	17	50	55	22	0,127

Allgemeine Angaben General data Données générales			Elektrische Daten Electrical data Caractéristiques électriques				
Typ Type Type	Bestell-Nr. Order No. No. de Cde	Lamellentyp Multilam Type de contact	Bemessungsstrom (80°C) [1] Rated current (80°C) [1] Intensité assignée (80°C) [1]	Kontaktwiderstand Contact resistance Résistance de contact	Kurzschlussstrom (1s) [2] Short-circuit current (1s) [2] Intensité de court-circuit (1s) [2]	Kurzschlussstrom (3s) [2] Short-circuit current (3s) [2] Intensité de court-circuit (3s) [2]	Stosskurzschlussstrom Rated peak withstand current Intensité de crête
			A	μΩ	kA	kA	kA
B6AR-NS	**01.0200**	LAIII	100 (80) [3]	100	2,5	1,5	8
B10AR-N	**01.0202**	LAI	200 (180) [3]	50	5,5	4	20
B14AR-N	**01.0203**	LAI	300 (300) [3]	35	11,5	8	35

[1] Endtemperatur
[2] Effektivwert
[3] Mit Isolierhülse IH...

[1] End temperature
[2] r.m.s. value
[3] With insulating sleeve IH...

[1] Température finale
[2] Valeur efficace
[3] Avec manchon isolant IH...

Isolierhülsen IH...
für Buchsen B...AR-N

Insulating sleeves IH...
for sockets B...AR-N

Manchons isolants IH...
pour douilles B...AR-N

Einzelteile / Individual parts / Pièces détachées					
Typ Type Type	Bestell-Nr. Order No. No. de Cde	für Buchsen for sockets pour douilles	Abmessungen (mm) Dimensions (mm) Dimensions (mm)		Farben Colours Couleurs
			L	Ø G	
IH6AR	14.5006-*	B6AR-NS	26,5	14	21 22 23 24 25 28 29
IH10AR-L	14.5012-*	B10AR-N	36,5	18,5	21 22 23 24 25
IH10AR-K	14.5013-*	B10AR-N	21	18,5	21 22 23 24 25
IH14AR	14.5032-*	B14AR-N	32	23,5	21 22 23 24 25 29

* Bitte den Farbcode angeben

* Add the desired colour code

* Indiquer le code couleurs souhaité

Beispiel:
B6AR-NS mit Isolierhülse IH6AR

Example:
B6AR-NS with insulating sleeve IH6AR

Exemple:
B6AR-NS avec manchon isolant IH6AR

Buchsen BP...AR-N mit Arretierung und Crimpanschluss

Sockets BP...AR-N with snap-in lock and crimp termination

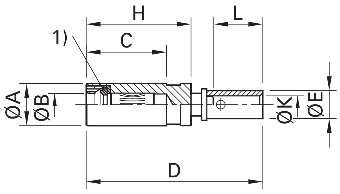
Douilles type BP...AR-N avec verrouillage et fût à sertir

Buchse BP und Stecker SP mit angepresstem verdichtetem Al-Leiter

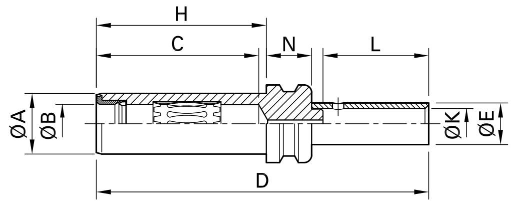
Socket BP and plug SP with a crimped compacted Al-conductor

Douille BP et broche SP serties sur des conducteurs rigides en Alu

BP6AR-N/10S – BP6AR-N/25-S



BP10AR-N/25 – BP14AR-N/120



[1] Kunststoffring aus POM

[1] Plastic ring (POM)

[1] Bague en plastique (POM)

Übersteckbar mit Matching parts Contre-pièces	S...AR-N (Seite/Page 26) SP...AR-N (Seite/Page 27) SIG...AR-N (Seite/Page 28)

Reduzierhülsen Reduction sleeves Fûts de réduction	Seite/Page 30

Crimpanschluss für flexible und hochflexible Cu-Leiter Klasse 6 (nach IEC 60228). MC empfiehlt Sechskantcrimpung. Dornkerbung und Lötanschluss sind möglich. Verdichtete Leiter benötigen spezielle Crimphülsen.
Crimpzangen, siehe Seite 35.
Zu diesen Buchsen sind auch Isolier- und Kabeltüllen lieferbar (siehe unten).

Crimp termination for flexible and highly flexible Cu-cables class 6 (according to IEC 6028). MC recommends a hexagonal crimp. Indent crimping and soldering is also possible. Cables with compacted conductors need a special crimping sleeve.
Crimping pliers, see page 35.
Insulating sleeves and cable insulators are also available for these sockets, (see below).

Fût à sertir pour câbles souples et extra-souples de classe 6 (selon CEI 60228). MC préconise un sertissage à six pans, un poinçonnage étant toutefois possible. Pour les câbles à conducteurs compacts, l’utilisation de fûts spéciaux est nécessaire.
Pinces à sertir, voir page 35.
Des manchons isolants de couleur peuvent se monter sur ces douilles, (voir ci-dessous).

IH6 **T6N**

 + 

Typ Type Type	für Buchsen for sockets pour douilles	für Leiteraussen-Ø for cable outer-Ø pour Ø du câble exterieur	siehe Katalog see catalogue voir catalogue
IH6 + T6N	BP6...	4,5 – 13mm	2 Powerline

Allgemeine Angaben / General data / Données générales			Abmessungen (mm) / Dimensions (mm) / Dimensions (mm)									Mechanische Daten / Mechanical data / Caractérist. mécaniques			
Typ / Type / Type	Bestell-Nr. / Order No. / No. de Cde	Lamellentyp / Multilam / Type de contact										Auszugskraft / Withdrawal force / Force d'extraction	Steckkraft / Insertion force / Force d'embrochage	Gewicht / Weight / Poids	Kabelquerschnitt Cu / Cable cross section Cu / Section du câble Cu
			Ø A	Ø B	C	D	Ø E	Ø K	H	L	N	N	N	kg	mm²
BP6AR-N/10-S	**01.0310**	LAIII	12	6	23	48,5	8	5	28	14		25	30	0,026	10
BP6AR-N/16-S	**01.0311**	LAIII	12	6	23	48,5	9	6	28	14		25	30	0,026	16
BP6AR-N/25-S	**01.0312**	LAIII	12	6	23	54,5	11	8	28	16		25	30	0,026	25
BP10AR-N/25	**01.0303**	LAI	16	10	43	76	11	8	45	15	12	35	40	0,083	25
BP10AR-N/35	**01.0304**	LAI	16	10	43	81	13	9	45	20	12	35	40	0,084	35
BP10AR-N/50	**01.0305**	LAI	16	10	43	88	14,5	11	45	27	12	35	40	0,089	50
BP14AR-N/50	**01.0306**	LAI	21	14	43	93	14,5	11	45	27	17	50	55	0,145	50
BP14AR-N/70	**01.0307**	LAI	21	14	43	93	17	13	45	27	17	50	55	0,149	70
BP14AR-N/95	**01.0308**	LAI	21	14	43	95	20	15	45	29	17	50	55	0,163	95
BP14AR-N/120	**01.0309**	LAI	21	14	43	96	22	17	45	30	17	50	55	0,168	120

Allgemeine Angaben / General data / Données générales			Elektrische Daten / Electrical data / Caractéristiques électriques				
Typ / Type / Type	Bestell-Nr. / Order No. / No. de Cde	Lamellentyp / Multilam / Type de contact	Bemessungsstrom (80°C) [1] / Rated current (80°C) [1] / Intensité assignée (80°C) [1]	Kontaktwiderstand / Contact resistance / Résistance de contact	Kurzschlussstrom (1s) [2] / Short-circuit current (1s) [2] / Intensité de court-circuit (1s) [2]	Kurzschlussstrom (3s) [2] / Short-circuit current (3s) [2] / Intensité de court-circuit (3s) [2]	Stosskurzschlussstrom / Rated peak withstand current / Intensité de crête
			A	µΩ	kA	kA	kA
BP6AR-N/10-S	**01.0310**	LAIII	80	100	1,2	0,7	8
BP6AR-N/16-S	**01.0311**	LAIII	100	100	2	1	8
BP6AR-N/25-S	**01.0312**	LAIII	130	100	2,5	1,5	8
BP10AR-N/25	**01.0303**	LAI	130	50	3	1,5	20
BP10AR-N/35	**01.0304**	LAI	150	50	4	2,5	20
BP10AR-N/50	**01.0305**	LAI	180	50	5,5	3	20
BP14AR-N/50	**01.0306**	LAI	190	35	5,5	3	40
BP14AR-N/70	**01.0307**	LAI	240	35	8	5	40
BP14AR-N/95	**01.0308**	LAI	280	35	11,5	6,5	40
BP14AR-N/120	**01.0309**	LAI	300	35	12	8	40

[1] Endtemperatur
[2] Effektivwert

[1] End temperature
[2] r.m.s. value

[1] Température finale
[2] Valeur efficace

Stecker

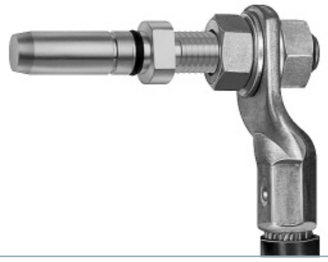
Stecker S...AR-N mit Arretierung und Gewindeanschluss

Plugs

Plugs S...AR-N with snap-in lock and thread termination

Broches

Broches S...AR-N avec verrouillage et embout fileté

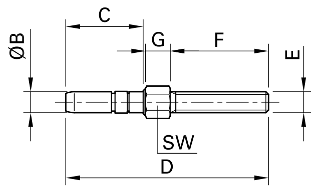


Stecker S14AR-N als Kabelschnellanschlussstecker

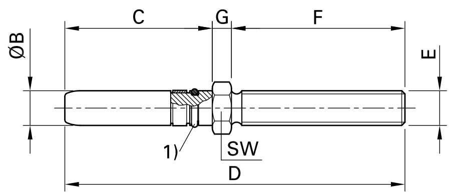
Plug S14AR-N as a quickconnecting plug cable

Broche S14AR-N utilisée comme broche de connexion rapide de câble

S6AR-N



S10AR-N – S14AR-N



[1] O-Ring aus NBR

[1] O-ring made of NBR

[1] Joint torique en NBR

Übersteckbar mit Matching parts Contre-pièces	B...AR-N (Seiten/Pages 22 – 23) BP...AR-N (Seiten/Pages 24 – 25)

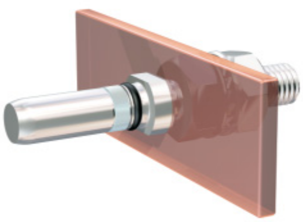
Montagematerial Connection aids Accessoires de montage	Seiten/Pages 31 – 33

Anschlussbeispiele

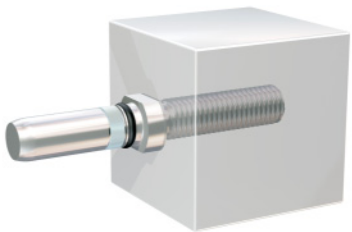
Termination examples

Exemples de raccordement

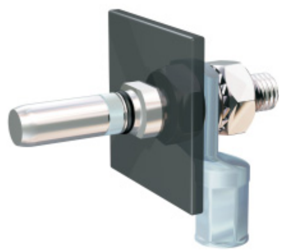
Kabelschuh
Cable lug
Cosse



Stromschiene
Busbar
Barre conductrice



Kontaktblock
Contact block
Bloc de contact



Isolierte Platte oder Gehäuse
Insulated panel or housing
Panneau ou boîtier isolant

Allgemeine Angaben General data Données générales		Abmessungen (mm) Dimensions (mm) Dimensions (mm)							Technische Daten Technical data Caractérist. techniques		
Typ Type Type	Bestell-Nr. Order No. No. de Cde								Anzugsdrehmoment Tightening torque Couple de serrage	Gewicht Weight Poids	Bemessungsstrom (80°C) [2] Rated current (80°C) [2] Intensité assignée (80°C) [2]
		B	C	D	E	F	G	SW	Nm	kg	A
S6AR-N	**04.0201**	6	22	58	M6	28	7	8	3	0,014	100
S10AR-N	**04.0202**	10	42,5	98	M10	50	5,5	13	10	0,060	200
S14AR-N	**04.0203**	14	43	100	M14	50	7	17	22	0,123	300

[2] Endtemperatur

[2] End temperature

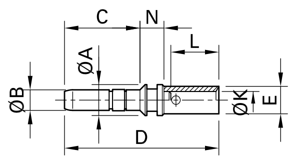
[2] Température finale

Stecker SP...AR-N mit Arretierung und Crimpanschluss

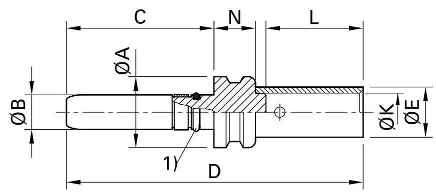
Plugs SP...AR-N with snap-in lock and crimp termination

Broches SP...AR-N avec verrouillage et fût à sertir

SP6AR-N/10 – SP6AR-N/25



SP10AR-N/25 – SP14AR-N/120



¹⁾ O-Ring aus NBR

¹⁾ O-ring made of NBR

¹⁾ Joint torique en NBR

Übersteckbar mit Matching parts Contre-pièces	B...AR-N (Seiten/Pages 22 – 23) BP...AR-N (Seiten/Pages 24 – 25)

Reduzierhülsen Reduction sleeves Fûts de réduction	Seite/Page 30

Crimpanschluss für flexible Cu-Leiter Klasse 5 und hochflexible Cu-Leiter Klasse 6 (nach IEC 60228). MC empfiehlt Sechskantcrimpung. Dornkerbung und Lötanschluss sind möglich. Verdichtete Leiter benötigen spezielle Crimphülsen. Crimpzangen, siehe Seite 35. Zu diesen Steckern sind auch Kabeltüllen lieferbar (siehe Katalog 2 Power*line*).

Crimp termination for flexible Cu-cables class 5 and highly flexible Cu-cables class 6 (according to IEC 60228). MC recommends a hexagonal crimp. Indent crimping and soldering is also possible. Cables with compacted conductors need a special crimping sleeve. Crimping pliers, see page 35. Insulating sleeves are also available for these plugs, (see catalogue 2 Power*line*).

Fût à sertir pour câbles souples en cuivre de classe 5 et extra-souples en cuivre de classe 6 (selon CEI 60228). MC préconise un sertissage à six pans, un poinçonnage étant toutefois possible. Pour les câbles à conducteurs compacts, l'utilisation de fûts spéciaux est nécessaire. Pince à sertir, voir page 35. Des manchons isolants de couleur peuvent se monter sur ces broches, (voir catalogues 2 Power*line*).

Allgemeine Angaben General data Données générales		Abmessungen (mm) Dimensions (mm) Dimensions (mm)								Technische Daten Technical data Caractérist. techniques		
Typ Type Type	Bestell-Nr. Order No. No. de Cde									Gewicht Weight Poids	Kabelquerschnitt Cu Cable cross section Cu Section du câble Cu	Bemessungsstrom (80°C) ²⁾ Rated current (80°C) ²⁾ Intensité assignée (80°C) ²⁾
		Ø A	Ø B	C	D	Ø E	Ø K	L	N	kg	mm²	A
SP6AR-N/10	**05.0201**	9	6	22	45	8	5	14	7	0,012	10	80
SP6AR-N/16	**05.0202**	9	6	22	45	9	6	14	7	0,013	16	100
SP6AR-N/25	**05.0210**	9	6	22	51	11	8	20	7	0,016	25	130
SP10AR-N/25	**05.0203**	20,5	10	42,5	73,5	11	8	16	12	0,066	25	130
SP10AR-N/35	**05.0204**	20,5	10	42,5	78,5	13	9	21	12	0,073	35	150
SP10AR-N/50	**05.0205**	20,5	10	42,5	85,5	14,5	11	28	12	0,074	50	180
SP14AR-N/50	**05.0206**	25	14	43	91	14,5	11	27	17	0,133	50	190
SP14AR-N/70	**05.0207**	25	14	43	91	17	13	27	17	0,138	70	240
SP14AR-N/95	**05.0208**	25	14	43	93	20	15	29	17	0,150	95	280
SP14AR-N/120	**05.0209**	25	14	43	94	22	17	30	17	0,158	120	300

²⁾ Endtemperatur

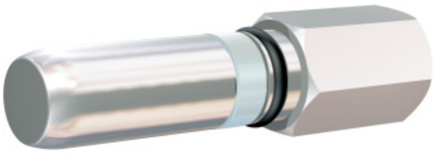
²⁾ End temperature

²⁾ Température finale

Stecker SIG...AR-N mit Arretierung und Anschluss über Innengewinde

Plugs SIG...AR-N with snap-in lock and internal thread termination

Broches SIG...AR-N avec verrouillage et embout

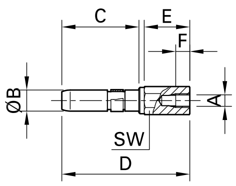


Umwandlung eines Schraubbolzenanschlusses in einen Steckanschluss

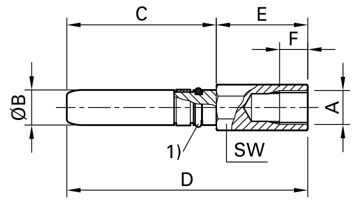
Changing a bolt connection into a plug connection

Transformation d’une connexion par tige filetée en connexion embrochable

SIG6AR-N/3 – SIG6AR-N/6



SIG10AR-N/8 – SIG14AR-N/14



[1] O-Ring aus NBR

[1] O-ring made of NBR

[1] Joint torique en NBR

Übersteckbar mit Matching parts Contre-pièces	B...AR-N (Seiten/Pages 22 – 23) BP...AR-N (Seiten/Pages 24 – 25)

Allgemeine Angaben General data Données générales		Abmessungen (mm) Dimensions (mm) Dimensions (mm)							Technische Daten Technical data Caractérist. techniques		
Typ Type Type	Bestell-Nr. Order No. No. de Cde								Anzugsdrehmoment Tightening torque Couple de serrage	Gewicht Weight Poids	Bemessungsstrom (80°C) [2] Rated current (80°C) [2] Intensité assignée (80°C) [2]
		A	Ø B	C	D	E	F	SW	Nm	kg	A
SIG6AR-N/3	**06.0001**	M3	6	22	36,5	13	4	8	0,5	0,011	16
SIG6AR-N/4	**06.0002**	M4	6	22	36,5	13	4	8	1,2	0,012	25
SIG6AR-N/5	**06.0003**	M5	6	22	36,5	13	5	8	2	0,011	40
SIG6AR-N/6	**06.0004**	M6	6	22	36,5	13	5	8	3	0,011	75
SIG10AR-N/8	**06.0006**	M8	10	42,5	68,5	26	6	13	6	0,056	130
SIG10AR-N/10	**06.0007**	M10	10	42,5	68,5	26	8	13	10	0,054	180
SIG14AR-N/10	**06.0009**	M10	14	43	69	26	8	17	10	0,102	180
SIG14AR-N/12	**06.0010**	M12	14	43	69	26	10	17	16	0,099	230
SIG14AR-N/14	**06.0011**	M14	14	43	69	26	10	17	22	0,094	300

[2] Endtemperatur

[2] End temperature

[2] Température finale

Zubehör

Crimphülsen H...N/M... mit Schraubgewinde

Accessories

Crimping Sleeves H...N/M... with thread

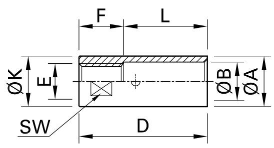
Accessoires

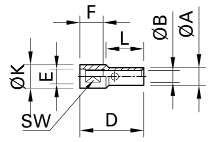
Fûts à sertir H...N/M... taraudés

Umrüsten eines Steckers S5N von Schraub- auf Crimpanschluss

Changing a plug S5N with thread termination into a crimp termination

Transformation du raccordement par filetage d'une broche S5N en un raccordement par sertissage





MC Crimphülsen H...N/M... eignen sich zum nachträglichen Umrüsten aller Buchsen B...N und B...AR-N sowie aller Stecker S...N und S...AR-N vom Schraubanschluss zum Crimpanschluss. Der Gewindebolzen muss dann auf das Mass max. F gekürzt und die Crimphülse aufgeschraubt und gesichert werden. Die Crimphülsen eignen sich vorzugsweise für flexible und hochflexible Cu-Leiter Klasse 6 (nach IEC 60228). MC empfiehlt Sechskantcrimpung, Dornkerbung möglich. Verdichtete Leiter benötigen spezielle Crimphülsen. Crimpzangen, siehe Seite 35.

MC Crimping sleeves H...N/M... are suitable for changing all sockets B...N and B...AR-N and plugs S...N and S...AR-N from thread termination to a crimp termination. The thread termination have to be shortened accordingly to the size max. F and then the crimping sleeves can be screwed on and secured. The crimping sleeves are suitable for flexible and highly flexible Cu-cables (according to IEC 60228). MC recommends a hexagonal crimp. Indent crimping is possible. Cables with compacted conductors need a special crimping sleeve. Crimping pliers, see page 35.

Les fûts à sertir MC du type H...N/M... permettent le raccordement par sertissage de câbles sur les douilles B...N et B...AR-N et les broches S...N et S...AR-N équipées d'un embout fileté. Ces fûts se vissent sur l'embout fileté (racourci au préalable sur la longueur max. F) et doivent être bloqués en fond de filet. Les fûts à sertir sont prévus pour des câbles souples et extra-souples en cuivre de classe 6 (selon CEI 60228). MC préconise un sertissage à six pans, un poinçonnage étant toutefois possible. Pour les câbles à conducteurs compacts, l'utilisation de fûts spéciaux est nécessaire. Pince à sertir, voir page 35.

Allgemeine Angaben General data Données générales		Abmessungen (mm) Dimensions (mm) Dimensions (mm)								Mechanische Daten Mechanical data Caractérist. mécaniques		
Typ Type Type	Bestell-Nr. Order No. No. de Cde									Anzugsdrehmoment Tightening torque Couple de serrage	Gewicht Weight Poids	Kabelquerschnitt Cu Cable cross section Cu Section du câble Cu
		A	B	D	E	F	K	L	SW	Nm	kg	mm²
H2,5N/M3	**07.0002**	4,2	2,3	19	M3	9	5,5	8	4,5	0,5	0,002	2,5
H4N/M4	**07.0003**	5	3	20	M4	8	7	10	6	1,2	0,004	4
H6N/M5	**07.0005**	6	4	22	M5	8	8	12	7	2	0,004	6
H16N/M5	**07.0008**	9	6	21	M5	7,5	9	14	8	2	0,005	16
H16N/M6	**07.0009**	9	6	24	M6	8,5	10	14	8	3	0,007	16
H25N/M8	**07.0012**	11	8	27	M8	10	12	19	10	6	0,015	25
H25N/M10	**07.0013**	11	8	35	M10	16	14	17	12	10	0,020	25
H50N/M10	**07.0017**	14,5	11	41	M10	13	14,5	28	12	10	0,028	50
H50N/M12	**07.0018**	14,5	11	44	M12	13	16	28	14	16	0,028	50
H70N/M12	**07.0020**	17	13	43	M12	15	17	28	14	16	0,040	70
H95N/M14	**07.0022**	20	15	48	M14	18	20	30	17	22	0,064	95
H120N/M16	**07.0025**	22	17	50	M16	20	22	30	19	30	0,065	120
H150N/M16	**07.0026**	25	19	54	M16	21	25	33	22	30	0,115	150
H185N/M18	**07.0029**	27	21	62	M18	25	27	37	24	40	0,135	185
H240N/M20	**07.0032**	30	24	69	M20	27	30	42	26	52	0,196	240

Weitere Abmessungen, passend zu den Buchsen B...N, und Steckern S...N, auf Anfrage

Further dimensions for sockets B...N and plugs S...N, on request

Autres dimensions, se rapportant aux douilles B...N et aux fiches S...N, sur demande

Reduzierhülsen RH...

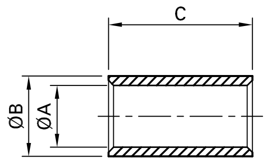
Zur Verwendung in Crimphülsen um einen kleineren Anschlussleiterquerschnitt zu ermöglichen.
Material: Cu, versilbert, crimpbar.
Crimpzangen, siehe Seite 35.

Reducing sleeves RH...

Allows smaller cable cross sections to be crimped in the crimping sleeves.
Material: Cu, silver plated, crimpable.
Crimping pliers, see page 35.

Fûts de réduction RH...

Se montent dans des fûts à sertir pour permettre le raccordement de câbles de section inférieure.
Matière: Cu, argenté, à sertir.
Pince à sertir, voir page 35.



Typ Type Type	Bestell-Nr. Order No. No. de Cde	Reduktion (von/auf) Reduction (from/to) Réduction (de/à)	Abmessungen (mm) Dimensions (mm) Dimensions (mm)		
		mm²	Ø A	Ø B	C
RH6-2,5 AG	05.5114	6/2,5	2,3	3,8	10
RH10-2,5 AG	05.5113	10/2,5	2,3	4,8	11
RH10-4 AG	05.5103	10/4	3	4,8	12
RH10-6 AG	05.5102	10/6	4	4,8	11
RH16-6 AG	05.5111	16/6	4	5,8	12
RH16-10 AG	05.5112	16/10	5	5,8	12
RH25-16 AG	05.5108	25/16	6	7,8	14
RH50-16 AG	05.5104	50/16	6	10,8	26
RH50-25 AG	05.5105	50/25	8	10,8	26
RH50-35 AG	05.5106	50/35	9	10,8	26
RH70-50 AG	05.5115	70/50	11	12,8	26
RH95-70 AG	05.5110	95/70	13	14,8	28
RH120-95 AG	05.5107	120/95	15	16,8	29
RH150-120 AG	05.5109	150/120	17	18,8	32

Hinweis auf andere MC Kataloge

Reference to other MC Catalogues

Renvoi à d'autres catalogues MC

Lamellenstecker
Multilam plugs
Fiches à lamelles

Ø 2mm – 4mm, unisoliert / max. 50A
Ø 2mm – 4mm, uninsulated / max. 50A
Ø 2mm – 4mm, non isolées / max. 50A

5 Power*line*

Muttern, Unterlagsscheiben, Fächerscheiben

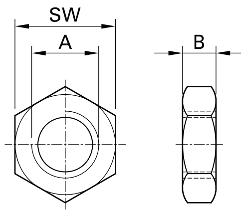
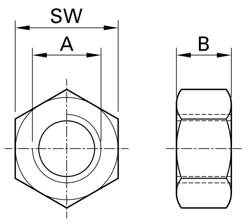
Muttern MU, Unterlagsscheiben U und Fächerscheiben F passen auf die Gewindebolzen der Buchsen B...N und B...AR-N sowie Stecker S...N und S...AR-N.
Muttern MUE und Unterlagsscheiben UE passen zu unseren Einbaubuchsen BL...N zum Einschrauben in Stromschienen. Alle Typen MU und U sind aus Messing gefertigt und versilbert. Fächerscheiben sind aus Stahl, verzinkt.

Nuts, Washers, Serrated lock washers

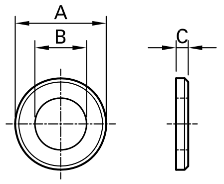
Nuts MU, washers U and serrated lock washers F fit for the thread terminations of sockets B...N and B...AR-N and plugs S...N and S...AR-N.
Nuts MUE and washers UE are suitable for screwing the mounting sockets BL...N into bus-bars. All the MU and U type nuts and washers are made of brass and silver plated. Serrated lock washers are made of steel, zinc plated.

Ecrous et rondelles

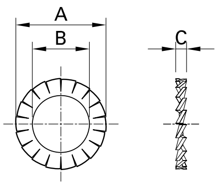
Les écrous MU, rondelles U et rondelles éventail F sont adaptés aux filetages des douilles B...N et B...AR-N ainsi qu'à ceux des broches S...N et S...AR-N.
Les écrous MUE et rondelles UE sont par contre adaptés au montage des douilles BL...N sur des barres conductrices. Tous les types MU et U sont en laiton argenté. Les rondelles éventail sont en acier zingué.

Typ Type Type	Bestell-Nr. Order No. No. de Cde	Abmessungen (mm) Dimension (mm) Dimension (mm)							DIN DIN DIN	Abbildung Illustration Illustration
		A	B	SW						
MU0,5D/M3	08.0001	M3	1,8	5,5					439	
MU0,5D/M4	08.0002	M4	2,2	7					439	
MU0,5D/M5	08.0003	M5	2,7	8					439	
MU0,5D/M6	08.0004	M6	3,2	10					439	
MU0,5D/M8	08.0005	M8	4	13					439	
MU0,5D/M10	08.0006	M10	5	17					439	
MU0,5D/M12	08.0007	M12	6	19					439	
MU0,5D/M14	08.0008	M14	7	22					439	
MU0,5D/M16	08.0009	M16	8	24					439	
MU0,5D/M18	08.0010	M18	9	27					439	
MU0,5D/M20	08.0011	M20	10	30					439	
MU0,5D/M24x2	08.0012	M24x2	12	36					439	
MU0,5D/M30x2	08.0013	M30x2	15	46					439	
MU0,5D/M36x3	08.0014	M36x3	18	54					439	
MU0,8D/M3	08.0101	M3	2,4	5,5					934	
MU0,8D/M4	08.0102	M4	3,2	7					934	
MU0,8D/M5	08.0103	M5	4	8					934	
MU0,8D/M6	08.0104	M6	5	10					934	
MU0,8D/M8	08.0105	M8	6,5	13					934	
MU0,8D/M10	08.0106	M10	8	17					934	
MU0,8D/M12	08.0107	M12	10	19					934	
MU0,8D/M14	08.0108	M14	11	22					934	
MU0,8D/M16	08.0109	M16	13	24					934	
MU0,8D/M18	08.0110	M18	15	27					934	
MU0,8D/M20	08.0111	M20	16	30					934	
MU0,8D/M24x2	08.0112	M24x2	19	36					934	
MU0,8D/M30x2	08.0113	M30x2	24	46					934	
MU0,8D/M36x3	08.0114	M36x3	29	55					934	

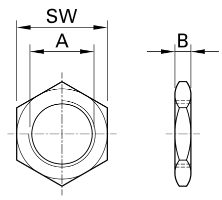
Typ Type Type	Bestell-Nr. Order No. No. de Cde	Abmessungen (mm) Dimension (mm) Dimension (mm)			DIN DIN DIN	Abbildung Illustration Illustration
		A	B	C		
U/M3	08.0301	7	3,2	0,5	125	
U/M4	08.0302	9	4,3	0,8	125	
U/M5	08.0303	10	5,3	1	125	
U/M6	08.0304	12	6,4	1,6	125	
U/M8	08.0305	16	8,4	1,6	125	
U/M10	08.0306	20	10,5	2	125	
U/M12	08.0307	24	13	2,5	125	
U/M14	08.0308	28	15	2,5	125	
U/M16	08.0309	30	17	3	125	
U/M18	08.0310	34	19	3	125	
U/M20	08.0311	37	21	3	125	
U/M24x2	08.0312	44	25	4	125	
U/M30x2	08.0313	56	31	4	125	
U/M36x3	08.0314	66	37	5	125	



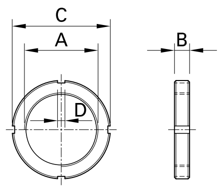
F/M3	08.0701	6	3,2	1,2	6798	
F/M4	08.0702	8	4,3	1,5	6798	
F/M5	08.0703	9	5,1	1,5	6798	
F/M6	08.0704	11	6,4	2,1	6798	
F/M8	08.0705	14	8,2	2,4	6798	
F/M10	08.0706	18	10,5	2,7	6798	
F/M12	08.0707	20,5	12,5	3	6798	
F/M14	08.0708	24	14,5	3	6798	
F/M16	08.0709	26	16,5	3,6	6798	
F/M18	08.0710	30	19	4,2	6798	
F/M20	08.0711	33	21	4,2	6798	



Typ Type Type	Bestell-Nr. Order No. No. de Cde	Abmessungen (mm) Dimension (mm) Dimension (mm)					passend zu fits to convient pour	Abbildung Illustration Illustration
		A	B	C	D	SW		
MUE/M8x0,75	08.0201	M8x0,75	3			11	BL2N, BL3N, BL4N	
MUE/M10x1	08.0202	M10x1	3			13	BL5N	
MUE/M12x1	08.0203	M12x1	3			17	BL6N	
MUE/M14x1	08.0204	M14x1	4			19	BL6AR-N, BL8N	
MUE/M18x1	08.0205	M18x1	4			24	BL10N	
MUE/M20x1	08.0206	M20x1	4			27	BL12N	
MUE/M22x1	08.0207	M22x1	6			30	BL14N	
MUE/M24x1	08.0208	M24x1	6			32	BL16N	
MUE/M28x1	08.0209	M28x1	6			36	BL18N	
MUE/M30x1	08.0210	M30x1	8			41	BL20N	
MUE/M42x1,5	08.0211	M42x1,5	8			55	BL25N	



MUER/M48x1,5	08.0212	M48x1,5	10	65	6		BL30N
MUER/M50x1,5	08.0213	M50x1,5	10	70	6		BL35N
MUER/M55x1,5	08.0214	M55x1,5	12	75	6		BL40N
MUER/M60x2	08.0215	M60x2	12	80	6		BL45N
MUER/M65x2	08.0216	M65x2	12	85	8		BL50N
MUER/M80x2	08.0217	M80x2	12	105	8		BL60N
MUER/M90x2	08.0218	M90x2	15	115	8		BL70N
MUER/M100x2	08.0219	M100x2	15	125	10		BL80N
MUER/M110x2 [1)]	08.0220	M110x2	15	135	10		BL90N
MUER/M120x2 [1)]	08.0221	M120x2	15	145	10		BL100N

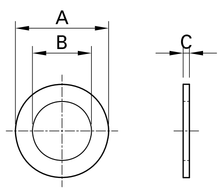


[1)] Nur auf Anfrage, kein Lagerartikel

[1)] Only on request, not in stock

[1)] Uniquement sur demande, article non tenu en stock

UE/M8x0,75	08.0401	16	8,5	1
UE/M10x1	08.0402	18	10,5	1
UE/M12x1	08.0403	22	12,5	1
UE/M14x1	08.0404	25	14,5	1,5
UE/M18x1	08.0405	30	19	2
UE/M20x1	08.0406	34	21	2
UE/M22x1	08.0407	38	23	2
UE/M24x1	08.0408	40	25	2
UE/M28x1	08.0409	45	29	3
UE/M30x1	08.0410	52	31	3
UE/M42x1,5	08.0411	68	43	3



Was ist AxiClamp?

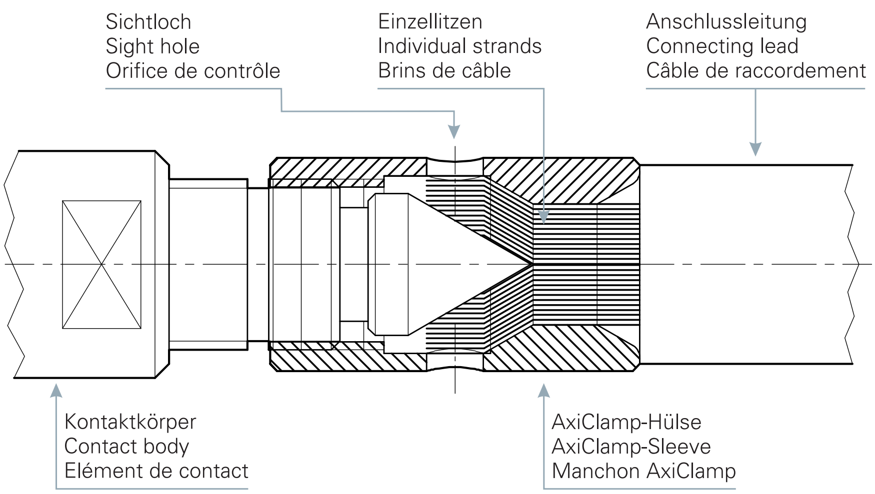
Das patentierte Leitungs-Anschluss-System zur elektrischen und mechanischen Verbindung von Cu-Leitern 6mm² – 300mm² Klasse 5 und Klasse 6 nach DIN VDE 0295, IEC 60228.
Die Einzellitzen der Anschlussleitung werden mittels einer konischen Schraubhülse gegen einen Metallkegel geschraubt und festgeklemmt. Der Metallkegel ist Bestandteil des Kontaktkörpers. Dies ergibt eine solide Klemmverbindung, die gleichwertige Übergangswiderstände wie die Crimpverbindung bietet und noch zusätzliche Vorteile hat.

What is AxiClamp?

The patented lead connecting system for electrical and mechanical connection of Cu leads 6mm² – 300mm² class 5 and class 6 according to DIN VDE 0295, IEC 60228.
The individual strands of the connecting lead are screw-clamped against a metal cone by means of a tapered threaded sleeve. The metal cone is part of the contact body. This gives a firm clamp connection with an equally good transition resistances compared to a crimp connection and additional advantages besides.

Qu'est ce qu'AxiClamp?

Le système de raccordement breveté électrique et mécanique de câbles Cu de section 6mm² – 300mm² de classe 5 et classe 6 selon DIN VDE 0295, CEI 60228.
Les brins composant le câble de raccordement sont plaqués et serrés, par l'intermédiaire d'un manchon à visser contre un cône métallique, qui fait partie intégrante du corps de contact. Ce principe permet d'établir une liaison fiable, dont la résistance de passage est équivalente à celle d'une liaison sertie, tout en offrant des avantages complémentaires.



Elektrische und thermische Prüfungen:
DIN EN 61238-1 (VDE 0220 Teil 100), Pressverbinder und Schraubverbinder für Starkstromkabel für Nennspannungen bis einschliesslich 30kV (Um = 36kV).

Mechanische Prüfungen:
DIN EN 60068-2-6, Umweltprüfungen, Prüfung Fc: Schwingen, sinusförmig.

Prüfparameter:

g-Belastung:	10g
Amplitude:	0,75mm
Frequenz:	10 bis 500Hz
Zeit:	3 x 112min.

Electrical and thermal tests:
DIN EN 61238-1, Compression and mechanical connectors for power cable for rated voltages up to 30kV (Um = 36kV).

Mechanical tests:
DIN EN 60068-2-6, environmental tests, test Fc: vibration, sinusoidal.

Test parameter:

g-load:	10g
Amplitude:	0,75mm
Frequency:	10 up to 500Hz
Time:	3 x 112min.

Tests électriques et thermiques:
DIN EN 61238-1, raccords sertis et à serrage mécanique pour câbles d'énergie de tensions assignées inférieures ou égales à 30kV (Um = 36kV).

Tests mécaniques:
DIN EN 60068-2-6, essais environnementaux. Essai Fc: vibrations, sinusoïdales.

Paramètres de test:

Accélération g:	10g
Amplitude:	0,75mm
Fréquence:	10 jusqu'à 500Hz
Durée:	3 x 112min.

Vorteile gegenüber konventionellen Crimpverbindungen:

1. Weder Crimpzange noch Crimpeinsatz erforderlich.
2. Leitung kann gelöst werden, d.h. bei Leitungsaustausch können die AxiClamp Anschlussteile wiederverwendet werden.
3. An einer AxiClamp-Grösse können unterschiedliche Leitungsquerschnitte angeschlossen werden.
4. Zeit- und kostensparend.

Advantages over conventional crimp terminations:

1. No crimping pliers or crimping inserts etc. required.
2. Lead can be disconnected, i.e. AxiClamp can be re-used in event of lead being replaced.
3. One AxiClamp size can be used for different cable cross sections.
4. Time- and cost saving.

Avantages par rapport aux connexions serties classiques:

1. Mise en oeuvre simple. Pas de pince à sertir requise.
2. Le câble peut être démonté (possibilité de remplacer le câble).
3. Un même modèle est adapté à différentes sections de câble.
4. Gain de temps = intérêt économique.

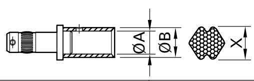
Von MC empfohlene Crimpzangen und Crimp-Einsätze

MC recommended Crimping pliers and crimping inserts

Pinces à sertir et matrices recommandées par MC

	 1	 2	 3	 4
Type Type Type	DMC PV-CZL	BEKU Apparatebau M-PZ13	Elpress M-PZ-T2600	Elpress V1311C
Bestell-Nr. Order No. No. de Cde	32.6001	18.3700	18.3710	[1]
Für Leiterquerschnitt For conductor cross section Pour section du conducteur	2,5mm² – 6mm²	6mm² – 25mm²	10mm² – 95mm²	10mm² – 300mm²
Crimpform Crimp form Forme de matrice	Achtdornpressung Eight indent crimp Sertissage à huit pans	6-kant Hexagonal 6 pans	6-kant Hexagonal 6 pans	6-kant Hexagonal 6 pans
Antrieb / Tractive system / Mise en oevre: Hand Hand A la main	X	X	X	X
Antrieb / Tractive system / Mise en oevre: Hand-Hydraulisch Hand-Hydraulic A la main-Hydraulique				X
Bedienungsanleitung [2] Operating instructions [2] Mode d'emploi [2]		MA224	MA226	MA069

Einsätze **Inserts** **Matrices**

					Crimphülsenmasse für Leiterklasse 6 [3] Sizes of crimp sleeves for conductor class 6 [3] Dimensions des fûts à sertir pour classe conducteur 6 [3]		
Leiterquerschnitt Conductor cross section Section du conducteur		Crimpzange Crimping pliers Pince à sertir	Einsatz Insert Matrice	Bestell-Nr. Order No. No. de Cde			X = Prüfmass X = Control dimension X = Cote de contrôle
mm²	AWG				Ø A mm	Ø B mm	X mm
6	8	**2**	MES-PZ-TB5/6	18.3701	4	6	–
10	6	**2**	MES-PZ-TB8/10	18.3702	5	8	6,3
16	4	**2**	MES-PZ-TB9/16	18.3703	6	9	7,3
25	2	**2**	MES-PZ-TB11/25	18.3704	8	11	8,8
35	1	**3**	TB9-13 (KRF)	18.3712	9	13	10,2
50	1/0	**3**	TB11-14,5 (KRF)	18.3713	11	14,5	11,4
70	3/0	**3**	TB8-17 (KRF)	18.3711	13	17	13,4
95	4/0	**3**	TB20 (KRF)	18.3714	15	20	16,4
120		**4**	B22 (KRF)	[1]	17	22	16,3
150		**4**	B25 (KRF)	[1]	19	25	20,3
185		**4**	13CB27 (KRF)	[1]	21	27	20,5
240		**4**	13CB30 (KRF)	[1]	24	30	23,3

[1] Nicht von MC geliefert. Bestell-Unterlagen unter: www.multi-contact.com > Produkte > Industrie-Steckverbinder > Technische Info > Crimpzangen

[2] siehe www.multi-contact.com

[3] Gemäss IEC 60228, DIN VDE 0295, Crimphülsenmasse für Leiterklasse 5, auf Anfrage.

[1] Not delivered by MC. Download of ordering informations: www.multi-contact.com > Products > Industrial Connectors > Technical Info > Crimping pliers

[2] see www.multi-contact.com

[3] According to IEC 60228, DIN VDE 0295, sizes of crimp sleeves for conductor class 5, on Request.

[1] N'est pas livré par MC. Informations de commande sous: www.multi-contact.com > Produits > Connecteurs Industriels > Fiches Techn. > Pince à sertir

[2] voir www.multi-contact.com

[3] Selon CEI 60228, DIN VDE 0295, dimensions des fûts à sertir pour classe de conducteur 5, sur demande.

Derating Diagramme

für PVC-isolierte Cu-Leitungen (70°C) von 2,5mm² – 240mm² nach DIN VDE 0298 Teil 4.

Verwendung von Kabeln und isolierten Leitungen für Starkstromanlagen.

Teil 4: Empfohlene Werte für die Strombelastbarkeit von Kabeln und Leitungen für Verlegung frei in Luft in Gebäuden und von flexiblen Leitungen.

Derating Diagrams

for PVC-insulated Cu-wires (70°C) 2,5mm² – 240mm² acc. to DIN VDE 0298 part 4.

Utilisation of cables and cords in power installations.

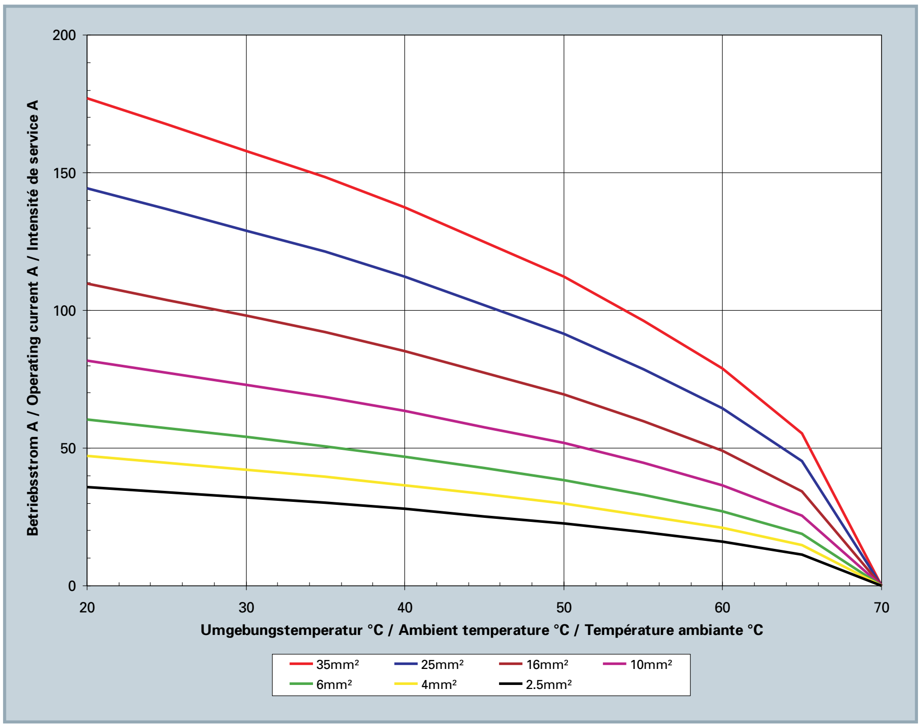
Part 4: Recommended current-carrying capacity for sheathed and nonsheathed cables for free in air in buildings and for flexible cables and cords.

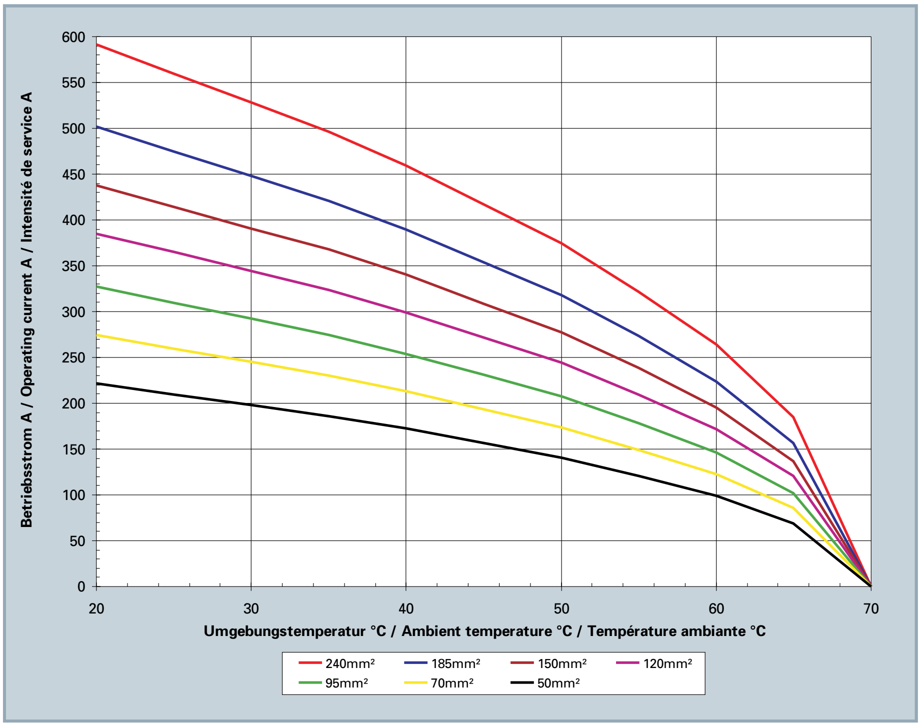
Diagrammes de derating

pour câbles en Cu à isolation PVC (70°C) 2,5mm² – 240mm² selon DIN VDE 0298 partie 4.

Utilisation de câbles et de cordons dans des installations de puissance.

Partie 4: Intensité de courant maximale admissible recommandée pour câbles posés à demeure dans des bâtiments et pour cordons souples.

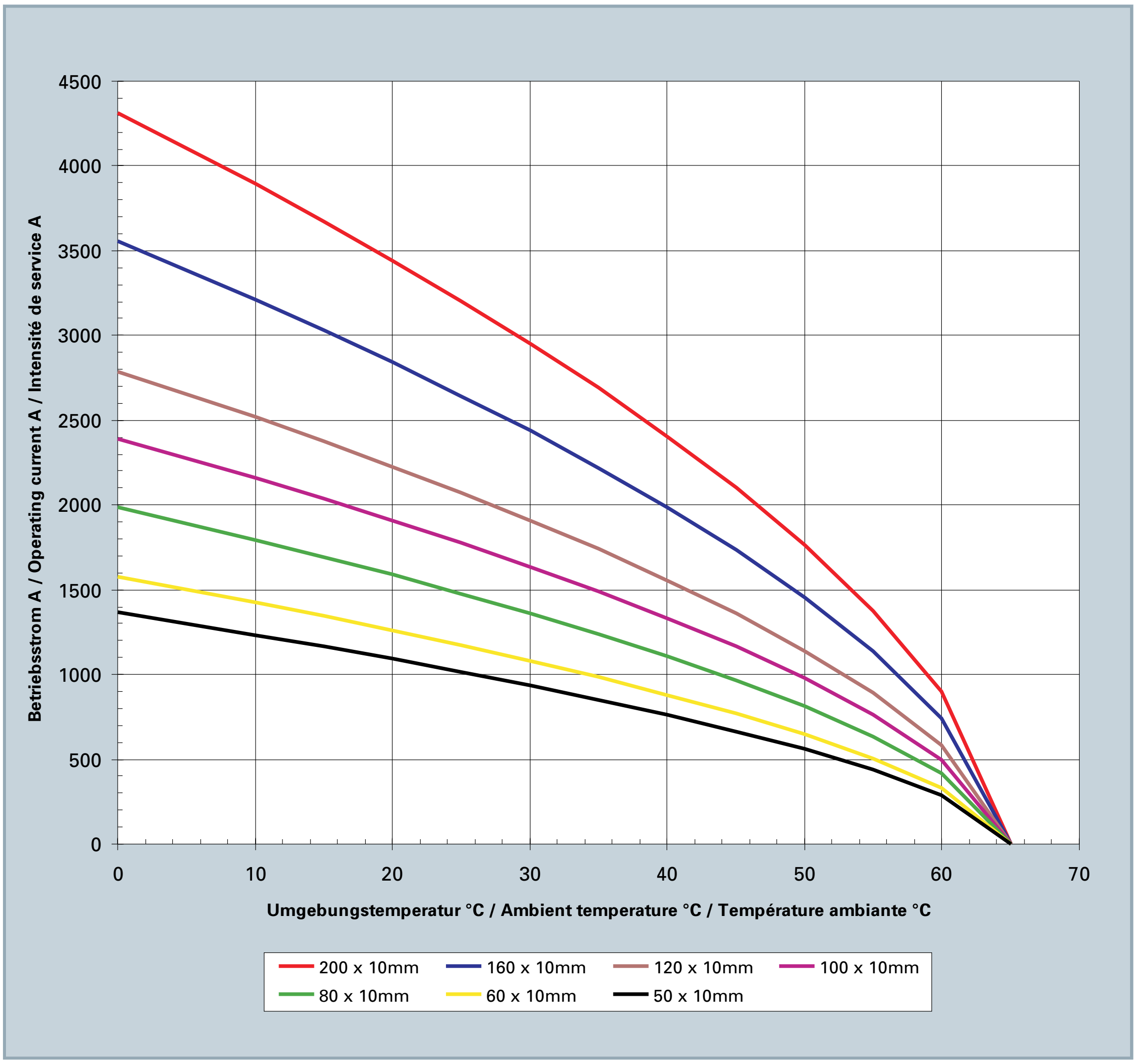




für rechteckige 10mm
Cu-Profile gemäss DIN 43671

for 10mm rectangular section
Cu-Busbars acc. to DIN 43671

pour jeux de barres Cu rectangulaires 10mm selon DIN 43671



Technische Hinweise info

Lamellentyp
Eine technische Beschreibung von elektrischen Kontakten mit Lamellen siehe Schrift:
"Das MC Kontaktlamellenprinzip".

Auszugs- und Steckkraft
Angegebene Werte sind Kräfte nach 20 bis 30maliger Betätigung bei dünnem Schmiermittelfilm. Im Neuzustand liegen die Kräfte höher.

Anzugsdrehmomente
Die Drehmomente gelten für saubere, leicht gefettete Bolzen, Muttern und Unterlagsscheiben.

Bemessungsstrom (IEC 61984)
Von MC festgelegter Strom, bei einer Umgebungstemperatur von 20°C, den der Steckverbinder dauerhaft (ohne Unterbrechung) führen kann und der gleichzeitig durch sämtliche Kontakte fliesst, die an die grösstmöglichen festgelegten Leiter angeschlossen sind und dabei die obere Grenztemperatur nicht überschritten wird.

Kontaktwiderstand
ist an der Berührungsstelle zweier Kontaktflächen auftretende Widerstand. Sein Wert wird über den gemessenen Spannungsabfall beim Bemessungsstrom berechnet.

Technical information info

Multilam type
For a technical description of electrical contacts with multilams, see publication: "The Multilam principle".

Withdrawal and mating forces
The stated figures refer to forces after 20 – 30 mating cycles with a thin film of lubricant present. Forces are greater in the new condition.

Tightening torques
The torque figures apply for clean, lightly lubricated bolts, nuts and washers.

Rated current (IEC 61984)
Current value determined by MC which the connector can carry continuously (without interruption) and simultaneously through all its contacts wired with the largest specified conductor, at an ambient temperature of 20°C, without the upper limiting temperature being exceeded.

Contact resistance
is the resistance occuring at the contact point of two contact surfaces. Ist value is calculated from the measured voltage drop at the rated current.

Informations techniques info

Type de lamelles
Description technique des contacts électriques à lamelles, consulter la brochure
"Principe des contacts à lamelles MC".

Efforts d'embrochage et de débrochage
Les valeurs indiquées sont celles obtenues après 20 à 30 cycles d'embrochage-débrochage, les contacts étant légèrement graissés. A l'état neuf, les efforts sont plus importants.

Couples de serrage
Ces valeurs s'appliquent à des tiges filetées, écrous et rondelles propres, et légèrement graissés.

L'intensité assignée (CEI 61984)
Valeur du courant assigné par MC, que le connecteur peut supporter en continu (sans interruption) et simultanément à travers tous ses contacts cablés avec le conducteur maximal spécifié, à une température ambiante de 20°C, sans que la température limite supérieure soit dépassée.

La résistance de contact
est la résistance qui se crée au point de contact de deux surfaces. Sa valeur est calculée à partir de la chute de tension mesurée sous intensité assignée.

Kurzzeichen Symbol Symbole	Werkstoffbezeichnung Material description Désignation de matière	Temperatur °C Temperature °C Température °C
POM	Polyoxymethylen / Polyoxymethylene / Polyoximéthylène	-40...+100
NBR	Acrylnitril-Butadien-Elastomer / Acrylonitrile-Butadine-Elastomer	-30...+100
PA	Polyamid / Polyamide / Polyamide	-30...+ 90

Schmiermittel
Von MC empfohlene Schmiermittel:
Fett (allgemeine el. Kontakte):
Klüberlectric KR44-402-50ML (73.1056)
Kontasynth BA100 Spray (73.1051)*
Gleitfett in SF6-Gas:
Barrierta I EL-102*
Einpress- und Abdichtfett:
Barrierta I S-402 oder Barrierta I MI-202*
* von Klüber Lubrication, München

Steckzyklen
Die maximale Steckhäufigkeit der Standardsteckverbindung beträgt 1000 bis 5000 je nach Einsatzbedingungen. Voraussetzung ist ein dünner Schmiermittelfilm auf den Kontakten vor dem ersten Steckvorgang. Höhere Steckzyklen stellen besondere Anforderungen an die Oberfläche, die Führung und die Schmierung und bedingen immer spezielle Abklärungen und Sonderausführungen. Sonderausführungen sind unsere Spezialität, fragen Sie uns wir beraten Sie gerne.

Crimpanschlüsse
Für die Leiteranschlüsse empfehlen wir für unsere Crimphülsen Sechskantcrimpung. Dornkerbung ist möglich. Unsere Crimphülsen sind ausgelegt für flexible

Lubricant
MC recommends the following lubricants:
Grease (general elec. contacts):
Klüberlectric KR44-402-50ML (73.1056)
Kontasynth BA100 Spray (73.1051)*
Sliding grease in SF6-gas:
Barrierta I EL-102*
Assembly and sealing grease:
Barrierta I S-402 or Barrierta I MI -202*
* from Klüber Lubrication, Munich

Mating cycles
The maximum number of mating cycles of the standard plug-in connections is between 1000 and 5000, depending on duty conditions. Precondition is a thin film of lubricant on the contacts prior to initial mating. Because higher cycle numbers call for special surface treatment, guiding and lubrication measures, each case must be individually investigated to establish the required measures. Please enquire, we'll be glad to advice you.

Crimp terminations
For conductor terminations, we recommend hexagonal crimping for our crimp sleeves. Afterwards the sleeve can be notched with a drift. Our crimp sleeves

Lubrifiants
Recommandé par MC:
Graisse (contacts courants):
Klüberlectric KR44-402-50ML (73.1056)
Kontasynth BA100 Spray (73.1051)*
Graisse pour contact sous gaz SF6:
Barrierta I EL-102*
Graisse de sertissage et d'isolation:
Barrierta I S-402 ou Barrierta I MI-202*
* de la société Klüber Lubrication, Munich

Cycle d'embrochage-débrochage
Le nombre maximal de cycles d'une connexion standard est de 1000 à 5000 en fonction des conditions d'utilisation, sous réserve de graisser légèrement les contacts avant le premier embrochage. Des valeurs plus importantes peuvent être atteintes dans certaines conditions: état de surface, guidage, graissage spéciaux. Chaque cas implique une réalisation particulière selon des critères à définir. Nous sommes à votre disposition pour vous proposer une réalisation spéciale.

Raccordements par fût à sertir
Pour le raccordement de conducteurs à ses cosses, MC preconise un sertissage six pans, un poinçonnage étant toutefois possible. Les fûts à sertir sont pré-

und hochflexible Cu-Leitungen. Verdichtete Leiter benötigen spezielle Crimphülsen.
Crimpzangen, siehe Seite 35.
Übrigens: MC fertigt auch komplett konfektionierte Leitungen und Kabel!

Sicherheitshinweise

Grundsatz für den Schutz gegen elektrischen Schlag [IEC, DIN EN 61140 (VDE 0140 Teil 1) Pt. 4]
Gefährliche aktive Teile dürfen nicht berührbar sein, und berührbare leitfähige Teile dürfen nicht gefährlich aktiv sein:
- weder unter normalen Bedingungen (ohne Fehler, bei bestimmungsgemässer Verwendung),
- noch unter Bedingungen eines Einzelfehlers, z.B. fehlerhafte Basisisolierung.

UL 1977 "Bauteil-Steckverbinder zur Anwendung bei Datenverkehr, Signalüberwachung und Strom"
Es muss eine Luft- oder Kriechstrecke von mindestens 3,2mm (1/8 inch) eingehalten werden bei einem Gerät mit bis zu 600V zwischen einem nicht isolierten, stromführenden Teil und:
a) einem nicht isolierten, stromführenden Teil mit entgegengesetzter Polung.
b) einem nicht isolierten geerdeten Metallteil.
c) einem nicht stromführenden Metallteil, das mit Personen in Berührung kommen könnte, wenn das Gerät installiert und bestimmungsgemäss benutzt wird.

IEC 61984 "Steckverbinder – Sicherheitsanforderungen und Prüfungen"
Diese internationale Norm gilt für Steckverbinder für Bemessungsspannungen von 50V bis 1000V und Bemessungsströme bis 125A je Kontakt, für die es entweder keine Bauartspezifikation (DS – detail specification) gibt, oder wenn sich deren Bauartspezifikation hinsichtlich der Sicherheit auf die vorliegende Norm bezieht.

Auszüge aus IEC 61984: Juni 2001 und Bemerkungen [DIN VDE 0627]

1) Steckverbinder
Kontakte sind beim Verbinden oder Trennen spannungsfrei und ohne Last/Strom. Eine elektrische oder mechanische Verriegelung, kann verhindern, dass Kontakte unter Spannung stehen, bevor der Steckverbinder gesteckt oder herausgezogen wird. Mit einem Mikroschalter kann eine Verriegelung erstellt werden.

Schutz gegen elektrischen Schlag für ungekapselte Steckverbinder
Der Schutz wird vom Kunden durch das Endprodukt sichergestellt, in das die Steckverbinder eingebaut werden. Oder es liegt eine Sicherheitskleinspannung (SELV – safety extra low voltage) an.

ar designed for flexible or higly flexible Cu-conductors. Cables with compact conductors need a special crimping sleeve. Crimping pliers, see page 35.
By the way: MC also manufactures lead and cable assemblies complete with connectors!

Safety notes

Fundamental rule of protection against electric shock [IEC 61140 Pt. 4]
Hazardous-live-parts shall not be accessible and accessible conductive parts shall not be dangerous to touch:
- either under normal conditions (operation in intended use and in the absence of a fault,
- or under single-fault conditions, e.g. failure of basic insulation.

UL 1977 "Component connectors for use in data, signal control and power applications"
There shall be an air- or greepage distance over surface of 3,2mm (1/8 inch) or more for a device rated at up to 600V between an uninsulated live part and:
a) an uninsulated live part of opposite polarity.
b) an uninsulated grounded metal part.
c) a non-current carrying metal part that is exposed to contact by persons when the device is installed and used in the intended manner.

IEC 61984 "Connectors – Safety requirements and tests"
This international standard applies to connectors with rated voltages above 50V and up to 1000V and rated currents up to 125A per contact, for which either no detailed specification (DS) exists for which the DS refers to this standard with regard to safety.

Extracts from IEC 61984: June 2001 and remarks

1) Connectors
Connectors should not be under voltage or under load/current when connection is made. An electrical or mechanical interlock prevent the contacts of a connector from becoming live before it is in proper engagement, or from being withdrawn while its contacts are live.
An interlock can be obtained by micro switch.

Protection against electric shock for unenclosed connectors.
Protection against electric shock is provided by the customer by the enclosure of the equipment in which the connector is mounted. Or a safety extra low voltage (SELV) is applied.

vus pour des câbles souples et extra-souples en cuivre. Pour les câbles à conducteurs compacts, l'utilisation de fûts spéciaux est nécessaire.
Pinces à sertir, voir page 35.
Attention: MC fabrique également des cordons tout assemblés.

Renseignements de sécurité

Règle fondamentale de protection contre les chocs électriques [CEI 61140 Pt. 4]
Les parties actives dangereuses ne doivent pas devenir accessibles et les parties conductrices accessibles ne doivent pas devenir dangereuses:
- ni dans les conditions normales (fonctionnement en usage prévu et absence de défaut),
- ni dans les conditions de simple défaut, par exemple défaillance de l'isolation principale.

UL1977 "Composants-Connecteurs utilisés dans le cadre d'applications de transfert de données, de contrôle de signal et de puissance".
Pour tout appareil de tension assignée jusqu'à 600V, une distance dans l'air ou ligne de fuite d'au moins 3,2mm (1/8 inch) doit être garantie entre une partie active non isolée et:
a) une pièce active non isolée de polarité opposée.
b) une pièce métallique non isolée raccordée à la terre.
c) une pièce métallique non conductrice accessible aux personnes lorsque l'appareil est installé et utilisé dans les règles de l'art.

CEI 61984 "Connecteurs – prescriptions de sécurité et essais"
Cette norme s'applique aux connecteurs de tensions assignées comprises entre 50V et 1000V et de courants assignés jusqu'à 125A par contact, pour lesquels soit il n'existe pas de spécifications particulières (SP), soit la SP fait appel aux aspects de sécurité.

Extraits de la norme CEI 61984: Juin 2001 et remarques

1) Connecteurs
Des dispositifs de verrouillage mécanique ou électrique permettent d'éviter que le connecteur ne soit inséré ou extrait sous tension. Un verrouillage peut être obtenu à l'aide d'un micro-rupteur.

Protection contre les chocs électriques de connecteurs à enveloppe ouverte
La protection est assurée par le client au travers du produit final, dans lequel est monté le connecteur. Ou son utilisation est limitée à la très basse tension (SELV – safety extra low voltage).

Schutz gegen elektrischen Schlag für gekapselte Steckverbinder

- gesteckter Zustand: Luft- und Kriechstrecken sind zwischen spannungsführenden Teilen und dem IEC Prüffinger mit der Prüfkraft von 20N zu messen.
- Ungesteckter Zustand, Kontaktöffnungen: Luft- und Kriechstrecken werden nicht betrachtet.

Bei einem Steckverbinder mit Schaltleistung sind die Luft- und Kriechstrecken durch die Öffnungen zwischen den spannungsführenden Teilen und der Steckgesichtsebene zu messen.

2) Steckvorrichtung

Kontakte sind beim Verbinden oder Trennen nur spannungsführend; Kontakte sind aber nicht unter Last, sie führen keinen Strom.
Steckvorrichtungen müssen die angegebene Schaltleistung besitzen oder müssen so aufgebaut sein, dass sie nur im lastfreien Zustand (ohne Strom) zusammengesteckt und getrennt werden können. Dies kann mit einer Verriegelung, z.B. mit einem Mikroschalter, erreicht werden.

- Gesteckter Zustand: Luft- und Kriechstrecken sind zwischen spannungsführenden Teilen und dem IEC Prüffinger zu messen.
- Ungesteckter Zustand: Kontaktöffnungen Luft- und Kriechstrecken sind zwischen spannungsführenden Teilen und der Steckgesichtsebene des Steckverbinders zu messen.
  Ausgenommen ist der männliche Teil des Steckverbinders.

3) Steckvorrichtung (CBC)

(CBC = connector with breaking capacity). Kontakte sind beim Verbinden oder Trennen spannungsführend und Strom (Last) fliesst über die Kontakte. MC Steckverbinder sind nicht geeignet, unter Last gesteckt oder getrennt zu werden. Es kann keine Schaltleistung spezifiziert werden.

Protection against electric shock for enclosed connectors

- Mated condition: clearance and creepage distances are measured between live parts and the IEC probe with a test force of 20N.
- Unmated condition, contact openings (lead-ins) in the mating face: clearance and creepage distances are not taken into account.

For a plug connector, clearance and creepage distances shall be measured through openings between the live parts and the plane of the mating face.

2) Plug device

During connection or disconnection, contacts are under voltage only; however, the contacts are not under load, they carry no current.
Plug devices must have the stated breaking capacity or must be so designed that they can only be inserted and withdrawn without load (current). This can be achieved by an interlock device such as a micro switch.

- Mated condition: clearance and creepage distances must be measured between live parts and the IEC test probe.
- Unmated condition: contact openings (lead-in) clearance and creepage distances are measured between live parts and the mating face plane of the plug device. This does not apply to the male part of the connector.

3) Connector with breaking capacity (CBC)

Contacts are under voltage and current (load) during connection and disconnection. MC plug devices are not suitable for connection or disconnection under load. No breaking capacity can be specified.

Protection contre les chocs électriques de connecteurs à enveloppe fermée

- à l'état connecté: les distances dans l'air et les lignes de fuite doivent être mesurées entre les parties conductrices et le doigt d'épreuve CEI sous une force d'essai de 20N.
- à l'état déconnecté: les distances dans l'air et les lignes de fuite ne sont pas prises en compte.

Pour les connecteurs, les lignes de fuite et distances dans l'air doivent être mesurées à travers les ouvertures entre les parties sous tension et le plan de la surface d'accouplement.

2) Dispositif de connexion

Les contacts sont lors de la connexion ou déconnexion uniquement sous tension; ils ne sont pas sous charge, il n'y a pas passage de courant. Les dispositifs de connexion doivent avoir le pouvoir de coupure spécifié ou doivent être conçus de sorte à n'être connecté ou déconnecté sans qu'il y ait passage de courant. (par l'intermédiaire par exemple d'un dispositif de verrouillage tel un micro-rupteur, monté sur la partie fixe).

- à l'état connecté: les distances dans l'air et les lignes de fuite doivent être respectées entre les parties sous tension et le doigt d'épreuve CEI.
- à l'état déconnecté: les distances dans l'air et les lignes de fuite doivent être respectées entre les parties sous tension et le plan de la face d'accouplement. La partie mâle du connecteur en est exclue.

3) Connecteur à pouvoir de coupure (CPC)

Connecteur spécialement conçu, dans une utilisation normale, pour être connecté ou déconnecté lorsqu'il est alimenté ou sous charge. Les connecteurs MC ne sont pas conçus à cet effet. Aucun pouvoir de coupure ne peut être spécifié.

Alphabetisches Register

Alphabetic index

Index alphabétique

MC Kontaktlamellen Das unübertroffene Kontaktsystem

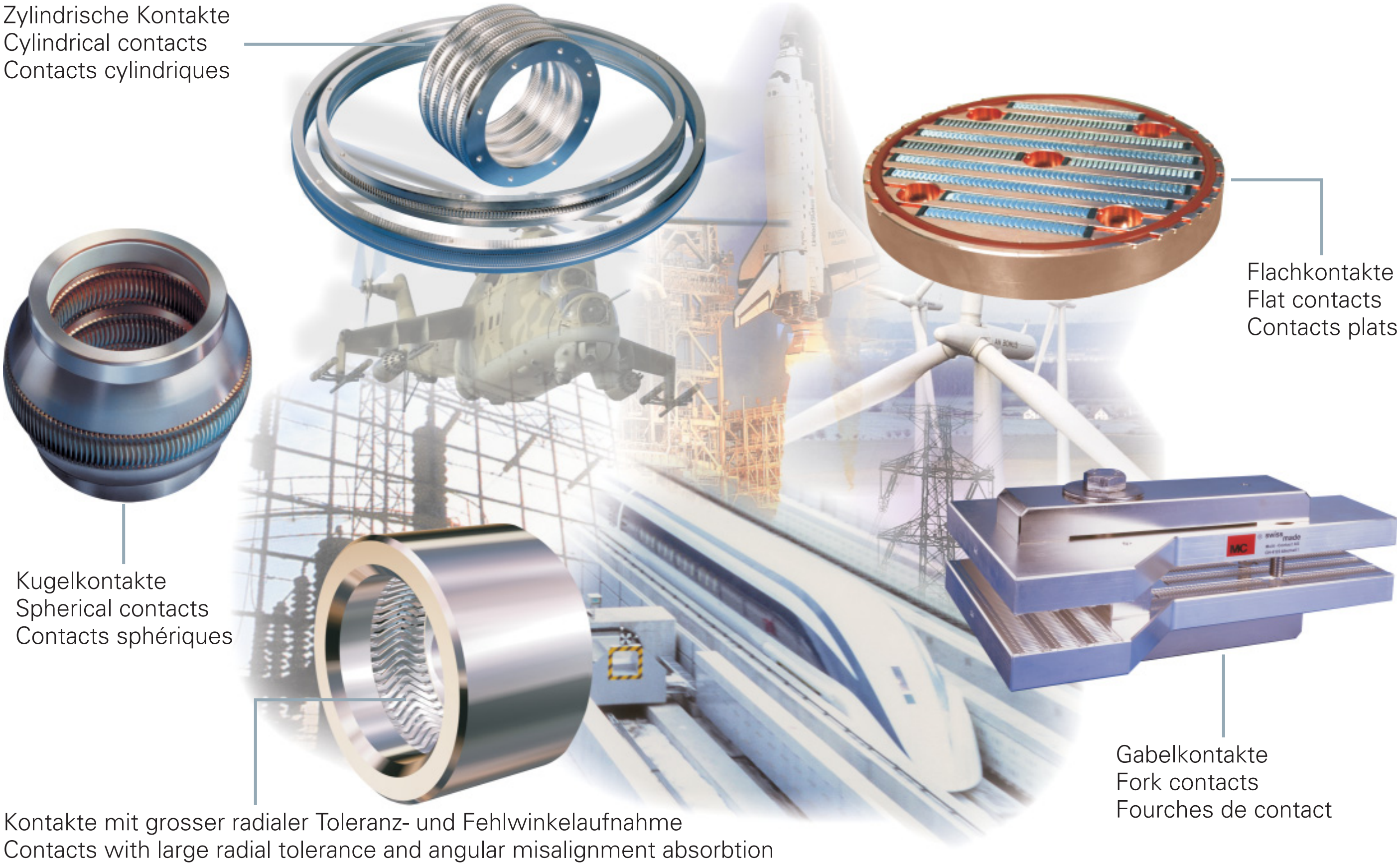
MC Kontaktlamellen basieren auf der Entwicklung speziell geformter Hartkupferblechstreifen.
Multi-Contact bietet eine ganze Auswahl diverser Kontaktlamellen an, welche in unterschiedlicher Form in Projekte einfliessen.

MC Multilam The contact system that is second to none

MC Multilam's are based on the development of specially formed hard copper strips.
Multi-Contact can supply a complete range of these Multilam's that is being continually expanded to meet the needs of new projects.

Contacts à lamelles MC Le système de contact inégalé

Les contacts à lamelles MC sont basés sur le développement d'éléments de contact en cuivre, spécialement formés.
Multi-Contact propose une large gamme de contacts à lamelles, qui s'étoffe régulièrement au travers de nouveaux projets.



Eigenschaften:
- Minimaler Kontaktwiderstand
- Minimaler Spannungsabfall
- Erlaubt hohe spezifische Stromdichte
- Grosse Anzahl Kontaktpunkte
- Selbstreinigungseffekt im Kontaktbereich
- Minimaler Leistungsverlust

Vorteile:
- Minimale Erwärmung
- Energiesparend
- Weniger Materialkosten
- Hohe Stromtragfähigkeit
- Geringe Wartungskosten
- Tausende von Steckzyklen möglich
- Lange Lebensdauer der Produkte

Features:
- Minimal contact resistance
- Minimal voltage drop
- Allows high specific current density
- Large number of contact points
- Self-cleaning in contact area
- Minimal power loss

Benefits:
- Minimal heat build-up
- Energy savings
- Lower material costs
- High specific current capacity
- Low maintenance costs
- Perfect function over thousands of mating operations
- Longer product life

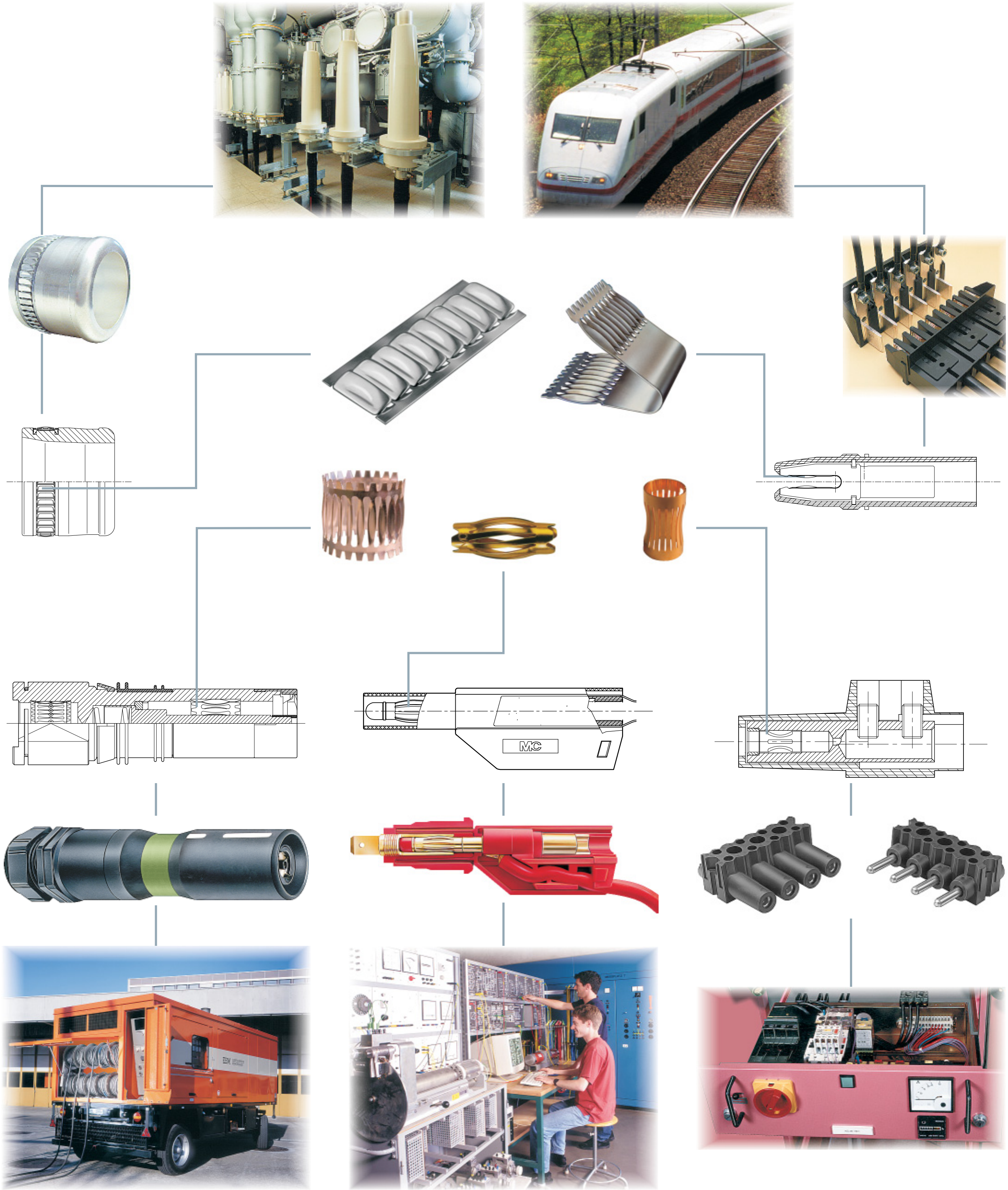
Caractéristiques:
- Résistance de contact minimale
- Chute de tension minimale
- Forte densité de courant
- Grand nombre de points de contact
- Effet autonettoyant dans la zone de contact
- Perte de puissance minimale

Avantages:
- Réduction de l'échauffement
- Economies d'énergie
- Economies de coûts de matière
- Haute conductibilité électrique
- Coûts de maintenance réduits
- Endurance: des milliers de cycles d'embrochage possibles
- Durée de vie prolongée

MC Kontaktlamellen
Vielseitige Grundlage neuer Entwicklungen

MC Multilam
The versatile basis for new developments

Contacts à lamelles MC
La base de multiples nouveaux développements



In unserer Schrift **Multilam** *Technology*, die Sie bei uns anfordern können, finden Sie zusätzlich viele nützliche Informationen.

You will find much more useful information in our publication **Multilam** *Technology*, which we will supply on request.

Vous trouverez de nombreuses informations complémentaires dans notre brochure **Multilam** *Technology*.

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Features

- Manages from 6 to 24 battery cells
- Cell voltage up to 5V
- Stackable architecture based on slave boards, up to 1080V battery pack
- Support multiple battery chemistries and supercapacitors
- Redundant analog and digital protections
- Below 400µA supply current in power saving mode
- Embedded smart power supply
- State of Charge (SOC) and State of Health (SOH) estimations based on advanced algorithms
- Stores up to 20 years of data history
- CAN-bus interface
- Wi-Fi 802.11 monitoring capabilities
- Fully configurable
- Manages 4 independent power outputs (DC coil contactor, fans) up to 75V
- Current measurement through external Hall effect current sensor
- Embedded passive cell balancing up to 2.5W per cell
- 2 onboard temperature sensor and 4 thermistor inputs for external sensing
- Built-in self - tests
- High EMI immunity

Applications

Mobility and stationary electrical storage equipment:

- Electric and hybrid electric vehicles
- High power portable equipment
- Backup battery systems
- Electric bicycles, motorcycles, scooters

Description

FreeSafe Extended (FS-XT) is a battery management system providing high standard of security, optimal battery life-span, precise SOC (state of charge) and SOH (state of health) estimations and external data management (telemetry and onboard memory card). FreeSafe Extended has three main features: battery cells management, power line management and advanced communications functionalities.

Cells managements: FreeSafe Extended is an easy to use solution to manage large packs of batteries. The boards are easy and safe to connect or disconnect from the batteries.

Multiple FreeSafe Slaves boards can be used together to manage any number of cells in series for up to 1080V battery stack.

FreeSafe Extended protects the batteries from over-voltage and under-voltage using redundant analog and digital safety features. A 2.5W cell balancing is used to equalize the cells voltages or SOC.

The built-in high efficiency smart DC converter of FreeSafe Extended enables self-sufficient operations without the need of external power supply. It also spares energy consumption by adapting to the battery conditions of use, down to 13mW in a 48V battery stack configuration.

While FreeSafe Extended devices are "plug and play" for $LiFePO_4$ batteries, specific applications and other chemistries require custom settings. FreeSafe Extended can be easily adapted to specific applications by modifying the parameters on the configuration file of the BMS.

Communications: To ensure the proper use of the battery, FreeSafe Extended records all activities in an up to 20 years data history file. The communication between FreeSafe Extended and others devices is assured by CAN bus and 802.11 physical layers. FreeSafe Extended includes a comprehensive and universal opened CAN application layer and Wi-Fi protocol application libraries.

Power line management: FreeSafe Extended is also a smart circuit breaker especially designed for high currents. The board can drive up to 4 external devices such as power switches or fans, powered by the supply dedicated to the circuit breaker (an external power source or the battery itself).

The current measurement is assured by an external Hall Effect sensor that must have a voltage output for the measurement. The accuracy of the measurements depends on the accuracy of the sensor. A 5V power supply is available for the sensor.

FreeSafe Extended cuts off the current when a short circuit is detected. The board can also react on over-current or over-temperature: these parameters are custom adapted as well as the time to react.

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1 Introduction

1.1 Overview

FreeSafe Extended (FS-XT) is a Battery Management System (BMS) providing high standard of security, optimal battery life-span and state of charge (SOC) / state of health (SOH) estimations. FS-XT is versatile ultra-low power and adapted to high voltage applications. FS-XT also includes modern communication functionalities and can emulate the Energy Management System (EMS) function. The main features of FreeSafe Extended are:

- BMS/EMS functions
- Management of up to 24 cells with cells voltage below 5V, voltage measurement and passive balancing channels for each cells
- Over and under voltage protection for each cell
- Scalable architecture from 9V up to 1080V battery pack with the use of slave boards (maximum of 16 slave boards – each slave manages up to 12 cells - , i.e. up to 216 total cells)
- Easy to configure and to set up for many chemistries and applications
- 2 onboard temperature measurements and 4 external inputs for temperature sensors
- Powered directly from the battery (self-powered of the managed cells) or from an external DC supply
- Drives up to 4 independent power outputs (75V/2A max) for peripherals as contactors and fans
- Up to 8GB internal data storage
- Wi-Fi and CAN bus communications with opened protocols
- Ready to use with qualified external components (sensors, contactors, etc.)

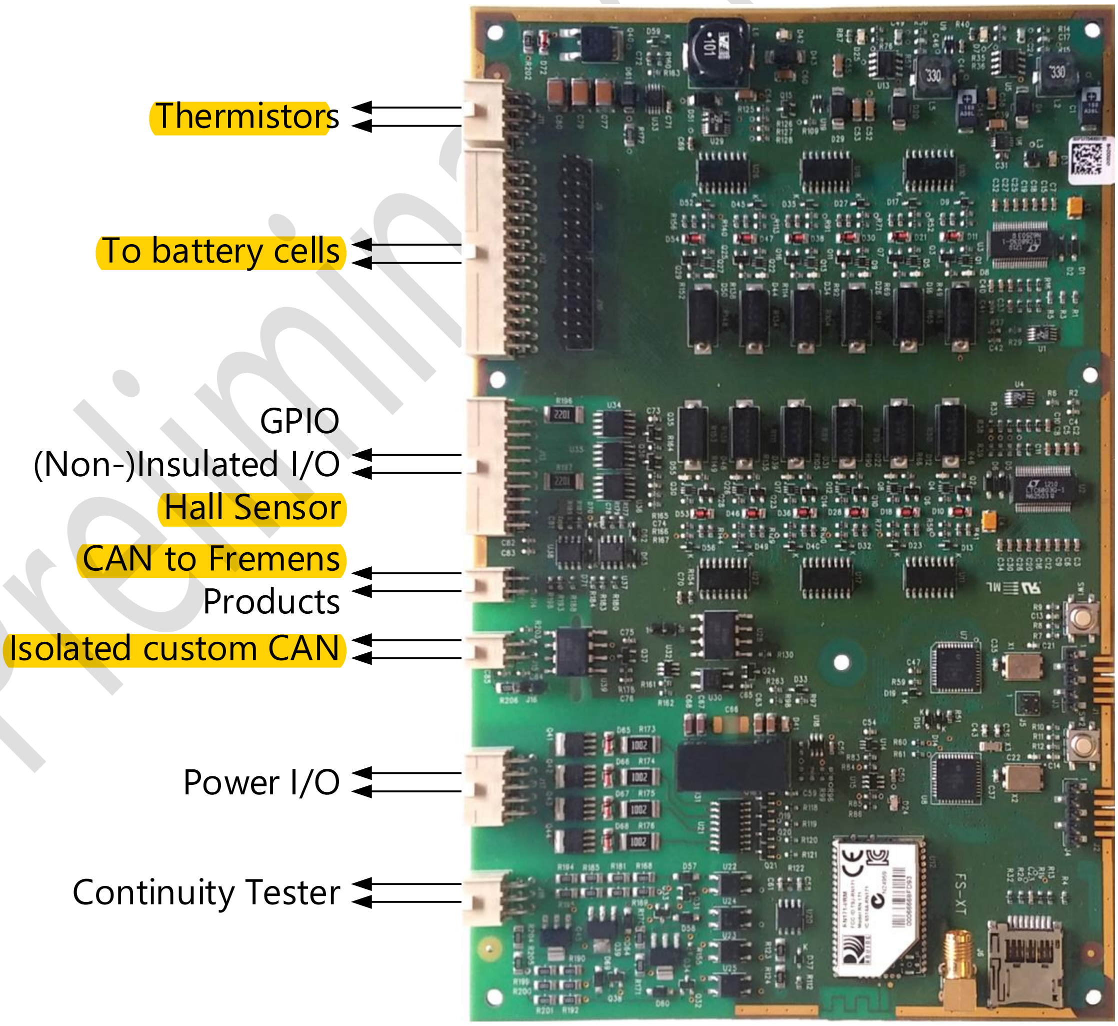


Figure 1: FreeSafe Extended board inputs and outputs

1.2 General description

1.2.1 Organization of the FreeSafe Extended board

The following functional diagram presents the main management features of FreeSafe Extended and their organization:

- Sensors & Drivers for cells management. See *Cells management* p34.
- Sensors & Drivers for power management. See *Power Line management* p44.
- Communications. See *Interfaces* p53.
- Power supply. See *Power supply unit* p90.

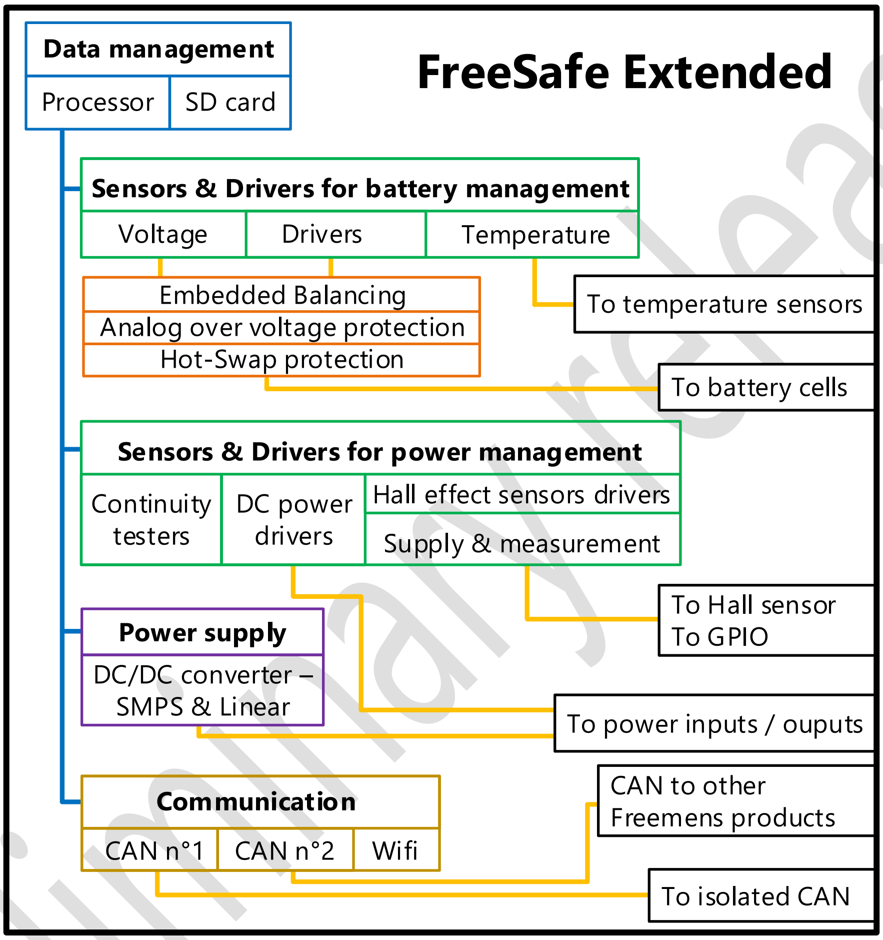


Figure 2: Functional diagram

Two powerful 16bits DSCs (Digital Signal Controller) are used for the data processing. They are the core of the system where most of the algorithms are implemented. One of the DSCs is dedicated to the cells management and the communication functions:

- Regulation of internal power consumption and power supply strategy
- Measurements acquisition from all the cells sensors (voltage and temperature)
- Algorithms computing
- Wired communications with other Freemens products (CAN bus)
- Wireless communications (Wi-Fi)
- Balancing control
- Estimators computing

The second DSC is dedicated to the battery power line management:

- Driving the 4 power outputs to change the states of contactors, fans, etc.
- Measurements retrieval from the Hall and continuity sensors
- Wired system level communications (isolated CAN) with external devices

FreeSafe Extended also includes mass data storage capabilities to keep available the information related to the battery and to the BMS operations. Based on an embedded micro SD card of 4GB (default configuration), FreeSafe Extended is able to record up to 20 years of data. Data can be retrieved directly from the SD card and decrypted with the proprietary FreeLab application.

1.2.2 Sensors & Drivers for cells management

The Sensors & Drivers block provides precise and reliable measurements related to the operating conditions (see *Voltage Monitoring* p*86*). As a result, FreeSafe Extended is able to sense from 6 up to 24 cell voltages and up to 4 external temperatures per device Current measurement is retrieved numerically by the power management unit and can also be additionally sampled by an analog input located in the GPIO port (a custom development will be required). In addition, there are internal sensors measuring the self-power consumption and two onboard temperatures.

Embedded Balancing

FreeSafe Extended includes a low power embedded balancing unit able to dissipate up to 2.5 W per cell at 25°C ambient temperature. The balancing is realized by connecting power resistors to over-charged battery cell. The balancing control is obtained at the processor level based on the comparison of the cells' voltages. With each resistor able to dissipate up to 2.5W, thermal regulation at board level is provided to reach an optimal balancing capacity and to ensure the device integrity. The maximum balancing current of 500mA requires the use of adapted wiring between FreeSafe and the battery stack.

Redundant Analog Protection

The over-voltage detection is achieved both at digital and analog level. If the sensors or processors fail to detect an overvoltage situation, a hard wired analog detection system can trigger a 3.3V TTL level on the GPIO port.

1.2.3 Sensors & Drivers for power line management

The Sensors & Drivers block provides precise and reliable measurements related to the operating conditions. As a result, FreeSafe Extended is able to sense the power current and drives up to 4 independent power outputs. Current measurement is retrieved through an analog to digital conversion of the measurement realized with a Hall Effect sensor.

1.2.4 Communication

FreeSafe Extended includes several hardware and their corresponding communication protocols allowing to facilitate and open wide the communication between the BMS and the other control or visualization interfaces of the system. In particular, FreeSafe Extended integrates two CAN Bus. One is dedicated to the communication with other Freemens products. It allows to stack BMS slave devices without any constraints (up to 16 slave boards) for the hardware and the data. The second one is an isolated CAN Bus which allows digital communication with any other external device. In addition, for remote or wireless access to the BMS, FreeSafe Extended includes a Wi-Fi hardware and software interface.

1.2.5 Power supply unit

FreeSafe Extended integrates its own Power Supply Unit PSU as a default configuration. The electronics is self-powered once the battery cells are connected. In addition, it performs optimal supply based on intelligent control and extensive use of switch mode power supplies with efficiencies above 85%. This feature makes FreeSafe Extended a low power BMS capable of ultra-low power operation in Power Saving Mode. To operate, the voltage of the cells connected to FS-XT must be at least 10V and up to 120V.

As shown on *Figure 39* p*44*, FS-XT must also have an external power source to supply the peripheral devices (contactors for instance) driven by the power outputs. If the voltage is compatible (9V to 75V), it is possible to directly use the battery as the source supplying the power outputs. An optional DC/DC converter can also be mounted on the board to power the electronics from this external source instead of using the self-power of the battery.

2 Connectors and pins configuration

2.1 General description

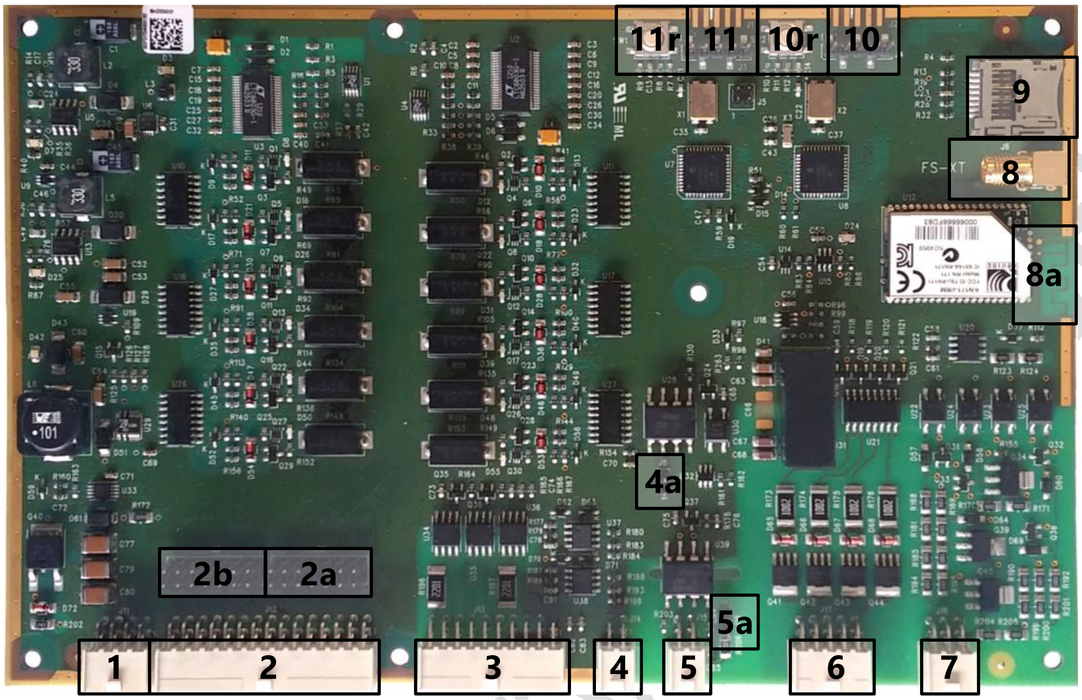


Figure 3: FreeSafe Extended connectors - top view

Table 1: FreeSafe pins & connectors

N°	Connector	Pins	Description
1	**Thermistors connector**	8	Connect to 10k NTC resistor for temperature sensing
2	**Cells connector**	30	Connect to battery cell terminals
2a	**Cells shunt connector A**	14	Used for wiring if the battery has less than 24 cells. See *Connecting the battery cells to FS-XT* p*18*.
2b	**Cells shunt connector B**	14	
3	**GPIO connector**	20	Digital, analog isolated and non-isolated I/O. More details *Figure 10*.
4	**Freemens CAN**	4	Non isolated (ground connected to the battery negative terminal) CAN bus for Freemens product. See *Connection of FreeSafe CAN buses* p*20*.
5	**Isolated CAN**	4	Isolated CAN bus (1500V) for communication with external devices
4a	**Terminal resistor connector**	2	Used with a jumper to connect 120Ω resistor on CAN H & L for noise immunity. See *Terminal resistor* p*20* for more details.
5a	**for CAN bus**		
6	**Power Outputs**	10	Power input: external DC source for the power outputs and for the optional board supply. Power outputs: contactors, fan, etc.
7	**Continuity tester**	6	Unused.
8	**Wi-Fi antenna extension**	-	For optional additional external Wi-Fi antenna
8a	**Wi-Fi PCB antenna**	-	Onboard printed Wi-Fi antenna. Do not cover
9	**micro SD card**	-	
10	**Programming connector M**	-	
10r	**Reset M**	-	Button used to reset the cells management processes
11	**Programming connector S**	-	
11r	**Reset S**	-	Button used to reset the power line management processes

All connectors used on the front side of FreeSafe Extended (n°1 to 7) are from the IPL1 series by SAMTEC. Their complementary are the IPD1 series with the CC79L crimp contact (or MMSD for the complete wire cable assembly).

Table 2: Recommended complementary connectors

Onboard connector			Recommended complementary connector	
N°	Manufacturer	Part number	Manufacturer	Part number
1	SAMTEC	IPL1-104-01-L-D-RA-K	SAMTEC	IPD1-04-D
				CC79L
				MMSD-04-20-L-60.00-S-K
2	SAMTEC	IPL1-115-01-L-D-RA-K	SAMTEC	IPD1-15-D
				CC79L
				MMSD-15-20-L-60.00-S-K
3	SAMTEC	IPL1-110-01-L-D-RA-K	SAMTEC	IPD1-10-D
				CC79L
				MMSD-10-20-L-60.00-S-K
4 & 5	SAMTEC	IPL1-102-01-L-D-RA-K	SAMTEC	IPD1-02-D
				CC79L
				MMSD-02-20-L-60.00-S-K
6	SAMTEC	IPL1-105-01-L-D-RA-K	SAMTEC	IPD1-05-D
				CC79L
				MMSD-05-20-L-60.00-S-K
7	SAMTEC	IPL1-103-01-L-D-RA-K	SAMTEC	IPD1-03-D
				CC79L
				MMSD-03-20-L-60.00-S-K

2.2 Pins configuration

2.2.1 Cell connector

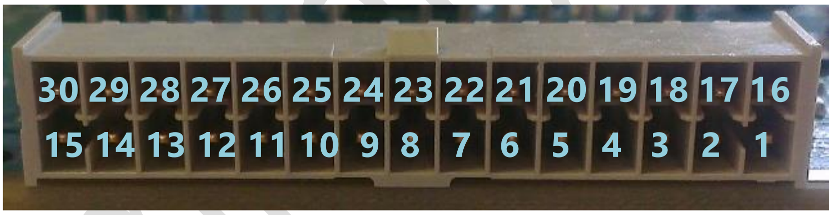


Figure 4: Cell connector front side

See *Wiring and connection recommendations* for additional connection information.

Table 3: Cell connector pins description

Pins	Description	Pins	Description
1	Cell 1 -	**23**	Cell 15 + / Cell 16 -
16	Cell 1 + / Cell 2 -	**9**	Cell 16 + / Cell 17 -
2	Cell 2 + / Cell 3 -	**24**	Cell 17 + / Cell 18 -
17	Cell 3 + / Cell 4 -	**10**	Cell 18 + / Cell 19 -
3	Cell 4 + / Cell 5 -	**25**	Cell 19 + / Cell 20 -
18	Cell 5 + / Cell 6 -	**11**	Cell 20 + / Cell 21 -
4	Cell 6 + / Cell 7 -	**26**	Cell 21 + / Cell 22 -
19	Cell 7 + / Cell 8 -	**12**	Cell 22 + / Cell 23 -
5	Cell 8 + / Cell 9 -	**27**	Cell 23 + / Cell 24 -
20	Cell 9 + / Cell 10 -	**13**	Cell 24 +
6	Cell 10 + / Cell 11 -	**28**	NC
21	Cell 11 + / Cell 12 -	**14**	NC
7	Cell 12 + / Cell 13 -	**29**	NC
22	Cell 13 + / Cell 14 -	**15**	NC
8	Cell 14 + / Cell 15 -	**30**	NC

2.2.2 Cell shunt connector

When FreeSafe Extended is not connected to its maximal number of cells (24), the remaining and unused contacts on the cell connector have to be short-circuited. This can be done directly with the wiring or through this connector with any 2.54mm pitch jumpers. See Figure 16 in the section *Connecting the battery cells to FS-XT* for more details.

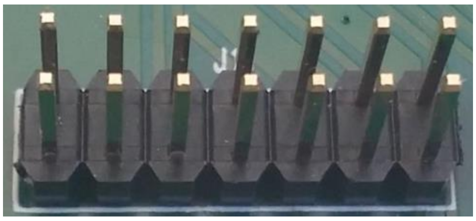


Figure 5: Cell shunt connector – standard 2.54mm (100mils) pitch

Figure 6: SPC20479 Single Shunt Jumper with Handle 2.54mm Spacing from Multicomp

2.2.3 NTC connector

NTC resistor terminals can be connected as described below. The thermistors do not have polarity and can be wired freely. See *Temperature* protection thresholds p*37* for more details about thermal management.

Figure 7: NTC connector

Table 4: NTC connector pins description

Pins	Description
1 – 5	NTC 4
2 – 6	NTC 3
3 – 7	NTC 2
4 - 8	NTC 1

2.2.4 CAN connector for Freemens CAN

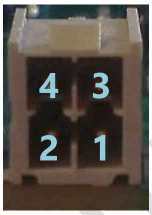


Figure 8: CAN-bus connector front side

Table 5: CAN-bus connector pins description

Pins	Description
1	5V (provided by FS-XT)
2	CAN L
3	CAN H
4	GND (Battery negative terminal)

See *Connection of FreeSafe CAN buses* p*20* for more details.

2.2.5 CAN connector for isolated CAN

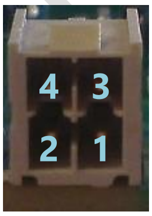


Figure 9: CAN-bus connector front side

Table 6: CAN-bus connector pins description

Pins	Description
1	5V (must be provided by an external isolated source)
2	CAN L
3	CAN H
4	GND (isolated reference for the isolated CAN)

See *Connection of FreeSafe CAN buses* p*20* for more details.

2.2.6 GPIO connector

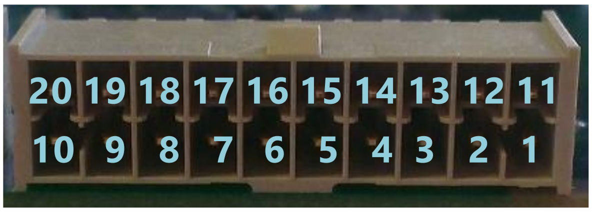


Figure 10: GPIO connector front side

Table 7: GPIO connector pins description

Pins	Description	
1	5VHall – 5V supply for Hall Effect sensors only	
11	GND (cell 1 negative terminal)	
2	VM1 - Hall Effect sensor n°1 voltage measurement	See *Hall Effect current sensor design choices* p*96* for more details.
12	VM2 - Hall Effect sensor n°2 – unused by default	
3	AN2 - Analog input n°2	Non-isolated input (referenced to the battery negative terminal), 3.3Vmax.
13	AN1 - Analog input n°1	
4	3.3V supply from FS-XT.	
14	IN1- - Digital isolated input.	See *Digital I/O connections* p*22* for more details about the isolated I/O and their connections. See *GPIO connector* p*61* for more details about the available functionalities.
5	IN1+ - Digital isolated input.	
15	IN0- - Digital isolated input.	
6	IN0+ - Digital isolated input.	
16	VDD0 - External VDD for isolated output.	
7	VSS0 - External VSS for isolated output.	
17	OUT0 – Isolated output.	
8	VDD1 - External VDD for isolated output.	
18	VSS1 - External VSS for isolated output.	
9	OUT1 – Isolated output.	
19	S_Reset_ISO+ - Isolated input for resetting the power line management	
10	Reset_ISO- - Common isolated input for reset (negative terminal)	
20	M_Reset_ISO+ - Isolated input for resetting the cells management	

2.2.7 Power Outputs Connector

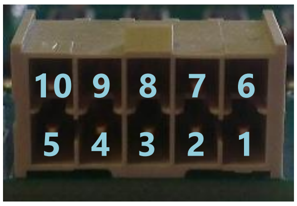


Figure 11: Power I/O connector front side

Table 8: power I/O connector pins description

Pins	Description		
1	C1+ - power output 1 positive terminal	Pre-charge contactor	See *Power peripherals design* choices p*94* for more details about the peripherals that can be driven by FS-XT: peripherals types, references recommendations, configurations, etc.
6	C1- - power output 1 negative terminal		
2	C2+ - power output 2 positive terminal	Main discharge contactor	
7	C2- - power output 2 negative terminal		
3	C3+ - power output 3 positive terminal	Charge contactor	
8	C3- - power output 3 negative terminal		
4	C4+ - power output 4 positive terminal	Fan	
9	C4- - power output 4 negative terminal		
5	+VExt – External DC source positive terminal		See *External DC source design choices* p*90* for more details.
10	-VExt – External DC source negative terminal		

2.2.8 Continuity tester connector

Figure 12: continuity tester connector front side

Table 9: continuity tester connector pins description

Pins	Description	
1	-VBat	Battery negative terminal
2	Cp	testing of the contactor continuity on negative line
3	Fp	testing of the fuse continuity on positive line
4	Cn	testing of the contactor continuity on positive line
5	Fn	testing of the fuse continuity on negative line
6	+VBat	Battery positive terminal

N.B.: by default this connector is not used and its functionalities are not activated.

2.2.9 Wi-Fi antenna extension connector

FreeSafe Extended already has a printed Wi-Fi antenna on its PCB, but for specific uses (e.g. the card is in an electromagnetically shielded box or the Wi-Fi device is out of range) an external antenna can be added.

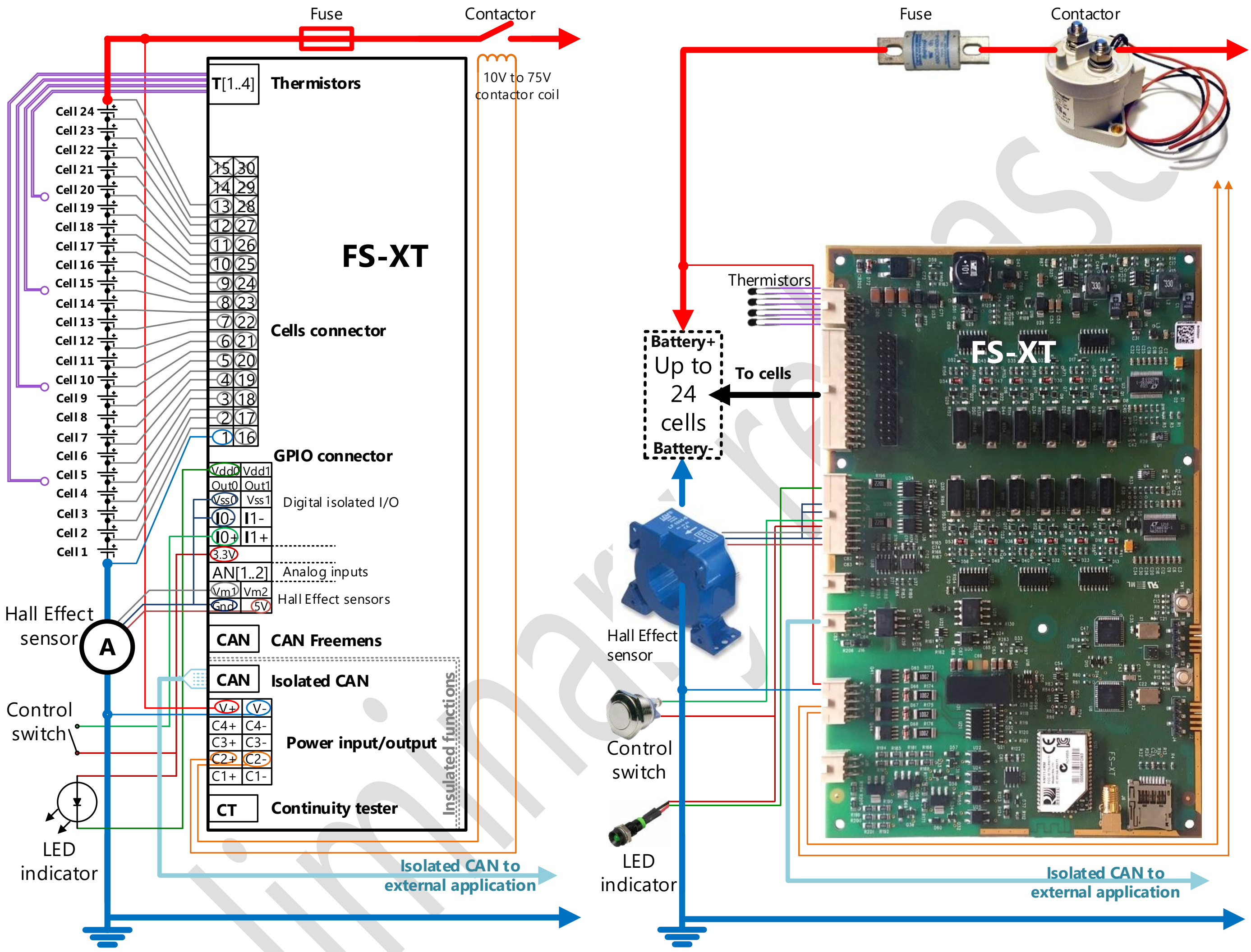
Figure 13: SMA connector for the antenna extension

This connector is optional and the onboard complementary SMA connector may not be mounted by default on the standard version of FreeSafe Extended.

3 Wiring and connection recommendations

3.1 Example: full wiring for typical 24 cells application

The following figure shows an example of a complete wiring for a 24 cells battery with its classical peripherals.



a. Full schematic of the FreeSafe Extended solution

b. Schematic with pictures of the FreeSafe

Figure 14: Battery Management System connection diagram for a typical 24 cells application

3.2 Connecting the battery cells to FS-XT

To wire the cells to FS-XT, it is recommended to manage them in two groups of equal number (±1 cell) of cells (up to 12 cells per group). The first group is wired to the pins n°1 to 13 and each non used pin has to be short circuited to its neighbor. The same goes for the second group with the pins n°13 to 25. It is recommended to connect and to shunt the unused cells to the top the group.

3.2.1 Standard connection using wires to shunt the missing cells

Each wire coming from an unused connection must be connected to the top of its group. The next figure shows an example for 8, 12, 18 and 24 cells.

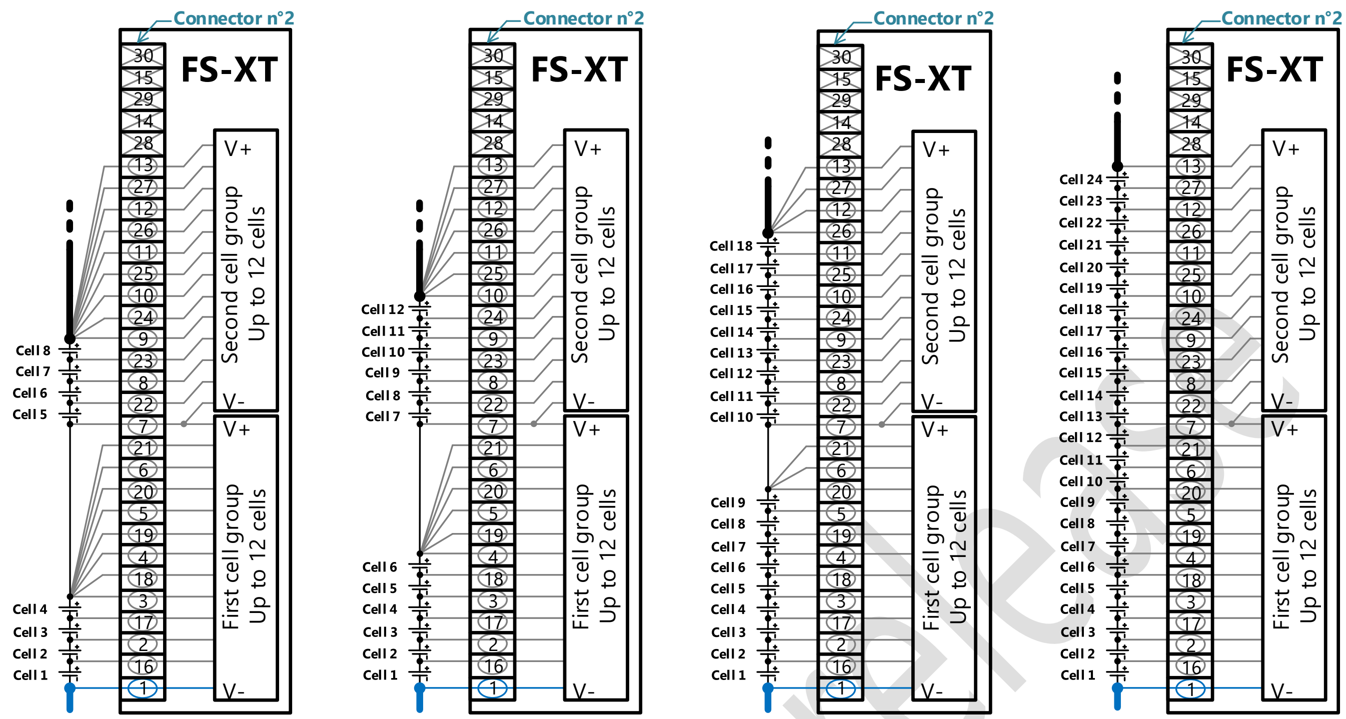


Figure 15: standard wiring examples for 8, 12, 18 and 24 cells

3.2.2 Connection using jumpers to shunt the missing cells

For an easier wiring, it is possible to directly connect jumpers on the FS-XT board to make the short circuit connections onboard instead of having an additional wiring step. If the used connector is pre-wired, the unused wires can be left unconnected or can be cut.

The jumper connectors are designed to simplify the wiring of a stack of 12 to 24 cells. For a stack of less than 12 cells, some unused cells will have to be shunt with wires as described in the previous paragraph or shown on the next figure for the 8 cells battery stack example. The next figure shows an example for 8, 12, 18 and 24 cells.

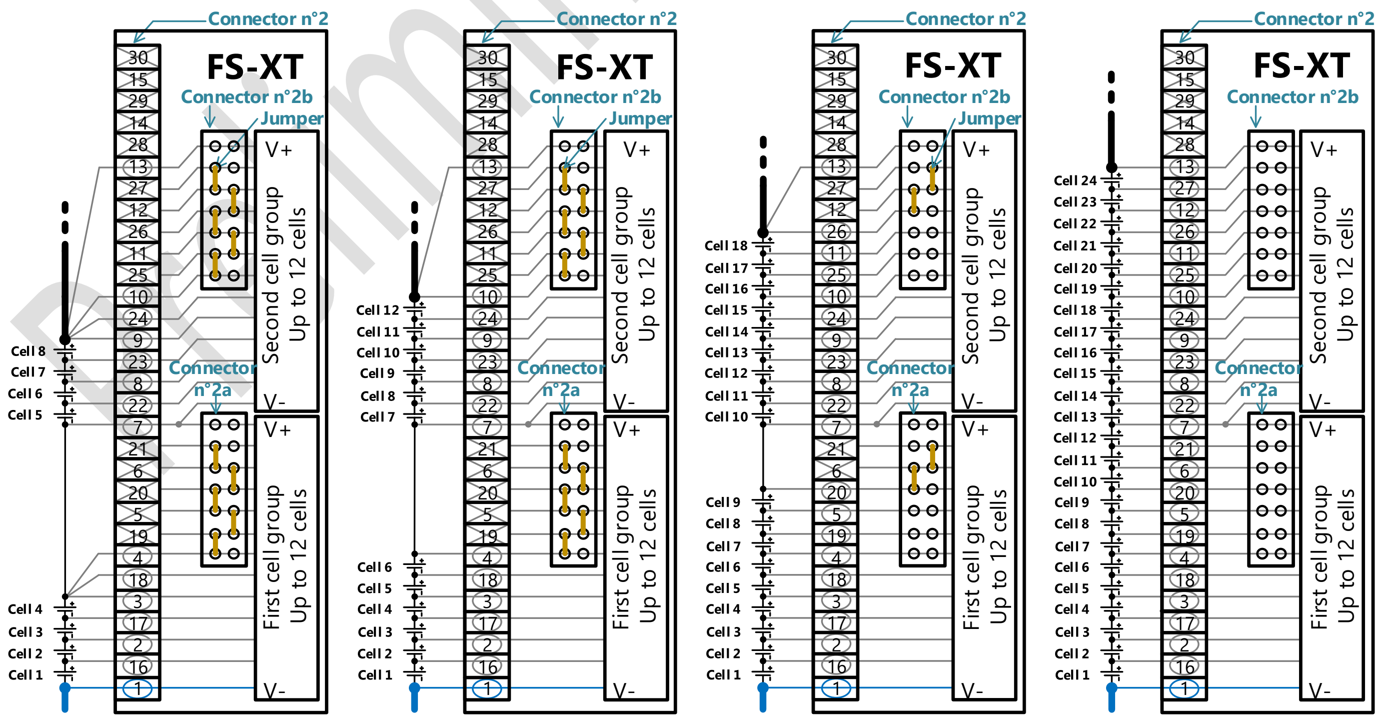


Figure 16: wiring examples using the board jumpers for 12, 18 and 24 cells

3.3 Connection of FreeSafe CAN buses

3.3.1 General description

FreeSafe Extended is delivered with its own CAN solution: one CAN is dedicated to the communication with other Freemens products (ex: slave boards used to manage more than 24 cells, see *Application with more than 24 cells* p*79*), the other one is an isolated CAN provided for the communication with an external application.

Terminal resistor

To ensure noise immunity for the CAN standard operation, the differential impedance between CAN H and CAN L must be maintained at a low level (60Ω). This is achieved by connecting two 120Ω (±10%) at each end of the bus. See next figure for a principle diagram.

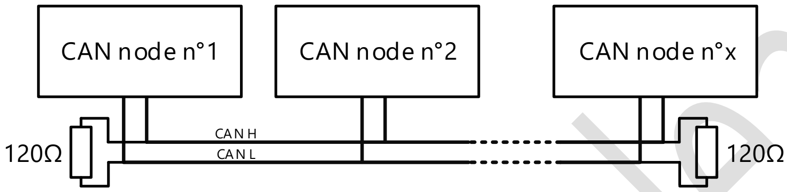


Figure 17: CAN bus electrical topology with terminal resistor

The FS-XT board already has a 120Ω resistor mounted on its PCB for its 2 CAN buses. They are not connected by default: additional jumpers are required in order to connect the resistors (connector n°4a & 5a, see Figure 3).

3.3.2 External isolated CAN bus

The external isolated CAN bus uses the connector n°5 and 5a.

External CAN bus power supply

There are two possible supply management for the external CAN bus:

- If the full insulation of the external CAN is required, it needs to be supplied by an external isolated supply. The supply must be managed to respect the CAN standard: 5V±5%. See Figure 19.
- The second solution is to use the FS-XT internal supply. **In this case, the insulation is lost** but there is no need for an additional and external supply. To connect and use the internal supply for the CAN bus, two onboard connections must be made by welding 0Ω resistor (standard 2512 SMD package) on the location under the connector n°5 shown on Figure 18.

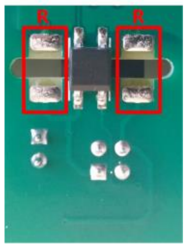
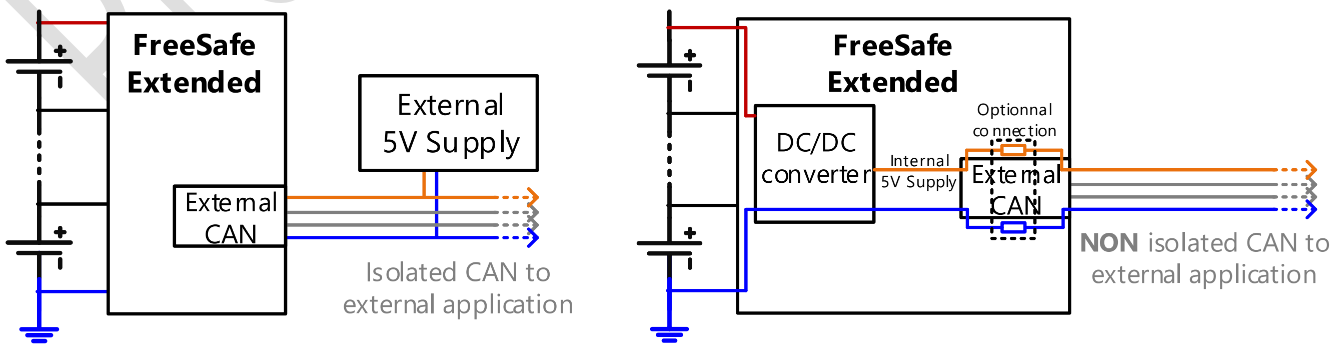


Figure 18: location of the connection for using the internal supply of FS-XT with the external isolated CAN bus

The next figure shows the supply principle for the external CAN bus in its isolated or internal supplied configurations.



a. Isolated and external supplied   b. Non isolated and internal supplied

Figure 19: Connection principle of the external CAN bus for the FS-XT solution

External CAN bus terminal resistor

If FS-XT external CAN bus is the first or the last electrical node, it needs a 120Ω terminal resistor connected on CAN H and CAN L lines. This resistor is already mounted on the FS-XT board, but not connected by default. To connect it, a jumper must be plugged on the connector n°5a.

The jumper used for connecting the 120Ω resistor is the same used when shunting the cells connection: it is a 2.54mm pitch jumper as shown on Figure 6.

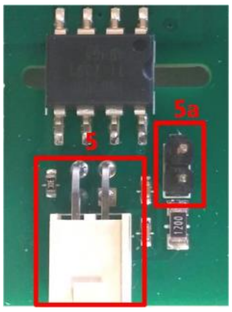


Figure 20: External CAN connector (n°5) with its terminal 120Ω resistor connector (n°5a)

3.3.3 Dedicated CAN bus for Freemens products

Power supply

The CAN dedicated for Freemens products provides its own supply with its custom power management to limit the power consumption on the battery. This 5V supply is referenced to the negative terminal of the battery cells managed by FS-XT.

External CAN bus terminal resistor

If multiple Freemens boards use their dedicated CAN bus, it is recommended to locate FS-XT on the first or the last electrical node: it has an onboard 120Ω terminal resistor that can be connected with a jumper on connector n°4a.

3.4 Position of the Hall Effect current sensor

The BMS is designed to monitor the charge current as a positive current and the discharge current as a negative current. When the sensor is installed, its orientation must be checked to operate according to the described current convention.

In case of a mechanical design choice or an orientation error during the installation that does not respect the measurement convention of the BMS, it is possible to configure the BMS to change its convention. It is achieved thanks to the parameter "currentMeasConvention" in the configuration file.

- currentMeasConvention = 0 means the current sensor is oriented according to the BMS convention
- currentMeasConvention =1 inverts the measure convention sign

Figure 21: example of convention measurement mark on the HASS 100-S Hall Effect sensor.
The arrow in the red circle shows the orientation of the positive current measurement.

3.5 Digital I/O connections

3.5.1 General description

As described in the *GPIO connector* paragraph p*16*, the GPIO connector possesses:

- 2 inputs VM1 & VM2 for current sensor (only VM1 is used by default)
- 5V output only used to supply the current sensor
- 3.3V output. It can be used to supply the isolated inputs but the insulation will be lost.
- 2 non isolated I/O AN1 & AN2. By default, they are not used but can be customized as digital I/O or analog 3.3V inputs.
- 2 independent digital isolated input, IN0 & IN1. **IN0 is used by default for a control switch** described in the section *Control signal for contactors states* p*62*. **IN1 is used by default for shutting down the Wi-Fi module** of the BMS ; see *Control signal for Wi-Fi deactivation* p*63*.
- 2 independent digital isolated output, OUT0 & OUT1. **OUT0 is used by default to provide a state indicator signal**. See *State indicator signal* p*63* for more details.
- 2 isolated input for the reset functions

For more information about the I/O customization, contact Freemens.

The principle schematics of the opto-isolated I/O are shown on the next figure.

a. Isolated input n°x principle
b. Isolated output n°x principle

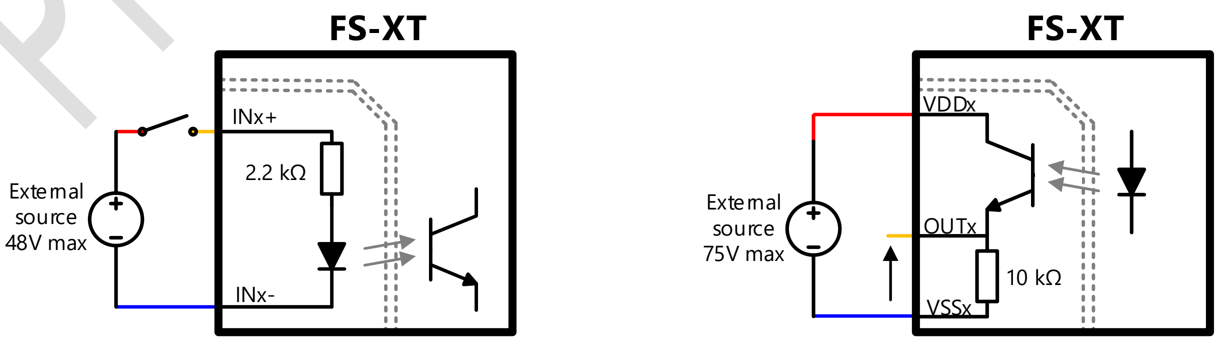
Figure 22: FreeSafe Extended isolated I/O

3.5.2 Voltage supply

The voltage supplies needed to use the isolated I/O must be provided by the external application.

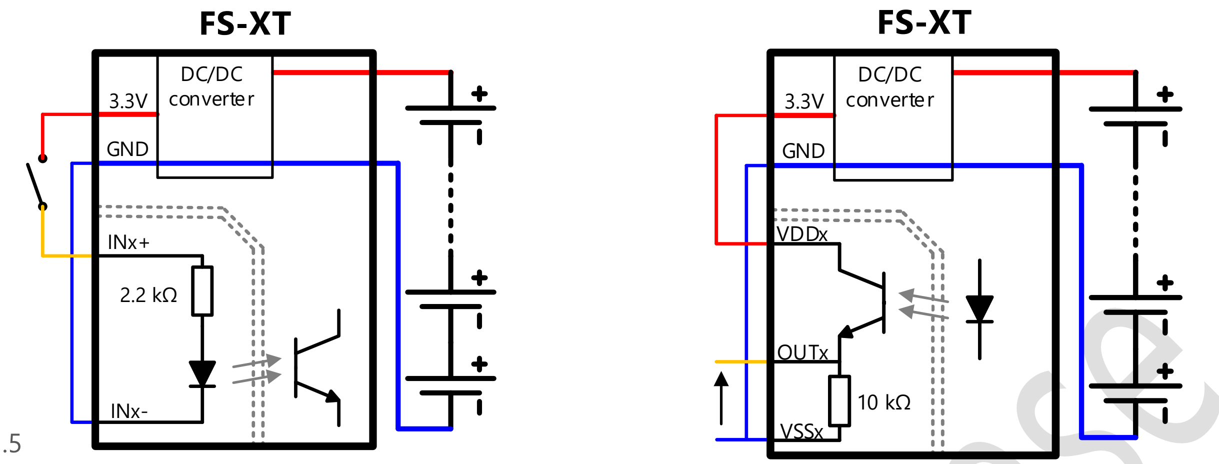
- Up to 48V for the isolated inputs. An additional serial resistor is required for any voltage over 48V to limit the power dissipated in the 2.2kΩ resistor at 1W max. See *Isolated input: additional resistor design choices* p*100* for more details.
- 75V max for the isolated output.

If the insulation is not required, the supply of these I/O can come from the FS-XT onboard power supply: the GPIO connector offers a 3.3V supply.



a. Connection example for isolated input
b. Connection example for isolated output

Figure 23: connection example for the digital opto-isolated I/O with external supply



a. Example for input without insulation

b. Example for output without insulation

Figure 24: connection example for the digital I/O with the onboard supply – insulation is lost

3.6 Start up procedure

3.6.1 Wiring check-list

Before plugging any connector on the FS-XT board, the following steps must be checked.

Table 10: check list before start-up

Step N°	Description
1	Confirm the external DC source is turned OFF or disconnected. Optional: if used, confirm the external supplies of the external CAN bus and the isolated I/O are turned off.
2	Confirm the NTC are connected and properly set up on the cells.
3	Confirm the current sensor is on the power line between the battery positive terminal and the contactors. Confirm it is oriented to measure the charge current as a positive current.
4	Confirm the micro SD card contains the file “config.xml” and is plugged.
5	Confirm the control switch is wired on connector n°3 and turned OFF.
6	If the external CAN bus and/or the Freemens dedicated CAN bus are used and are the first or last electrical node, confirm that a jumper is plugged on the connector 4a and/or 5a.

Figure 25 shows the FS-XT board with all its connections. The jumpers on connectors 2a & 2b (see Table 1) and the micro SD card on connector 9 are visible. The external isolated CAN bus are the Freemens dedicated CAN bus are not used, thus not connected (connector 4 & 5).

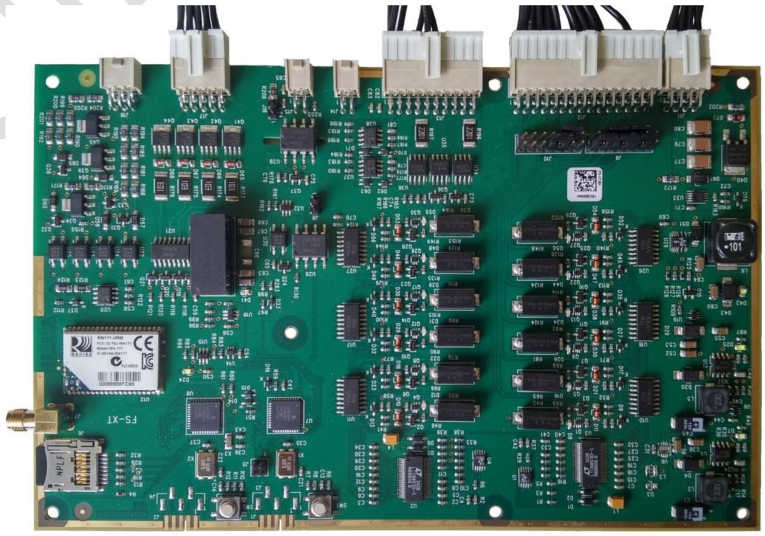


Figure 25: FS-XT wired for a typical 48V implementation

3.6.2 Connection procedure

Before plugging any connector, confirm the wiring check list has been validated.

Table 11: connection procedure (see *Table 1* for more details about the connectors and their roles)

Step	Connector	Comment
1	1, 2a, 2b, 3, 4, 4a, 5, 5a, 7, 8, 9	As FreeSafe Extended is not supplied, no particular steps are required for these connectors.
2	2	Balancing LEDs may blink at the connection.
3	6	Turn on the external DC source to allow the BMS to drive the power peripherals.
Caution	10 ,11	Programming connectors are only used when firmware update is necessary. Notice that the connector is referenced to the negative terminal of the lowest stack cell. Caution must be taken when connecting a non-isolated debugger or programmer

N.B.: do not connect the connector n°2 (cells connector) or do not turn the DC source ON before checking and connecting the other connectors. If FS-XT is supplied before every step is checked, the BMS will start and enter in an initialization error state described quickly in the next paragraph (3.6.3).

3.6.3 First connection

As soon as the cells connector (n°2) is connected, the BMS begins its operation. It will first enter an initialization routine to check the configuration of the system.

If no error is detected – the configuration of the system is correct and initialized, the right number of cells is detected, no voltage, current or temperature error are detected etc.-, the BMS will. If an initializing error is detected, the initialization process will enter in a fail and retry mode: the BMS is in an initialization error state and wait for 120s before rebooting. It possible to manually reset the BMS by pressing the button 10r and 11r (see *Figure 3* p*13*) to shorten this phase.

Another confirmation that the BMS has started correctly is the presence of the BMS Wi-Fi network: the FreeView application can be connected to monitor the parameters of the battery.

4 Typical implementation: 48V $LiFePO_4$ battery

4.1 Specification

This example describes the installation of the FS-XT BMS on an application with a 48V battery. This battery is a 100A.h $LiFePO_4$. As the nominal voltage of a $LiFePO_4$ cell is 3.2V, the total number of cells in series is 15.

All the characteristics presented in this example are chosen arbitrarily to present a general case, but can be configured to any specific application. See *Configuration file* p*72* for more details about the configuration of the BMS parameters, and *Design guide for* the BMS and its peripherals p*90* for the general installation guide.

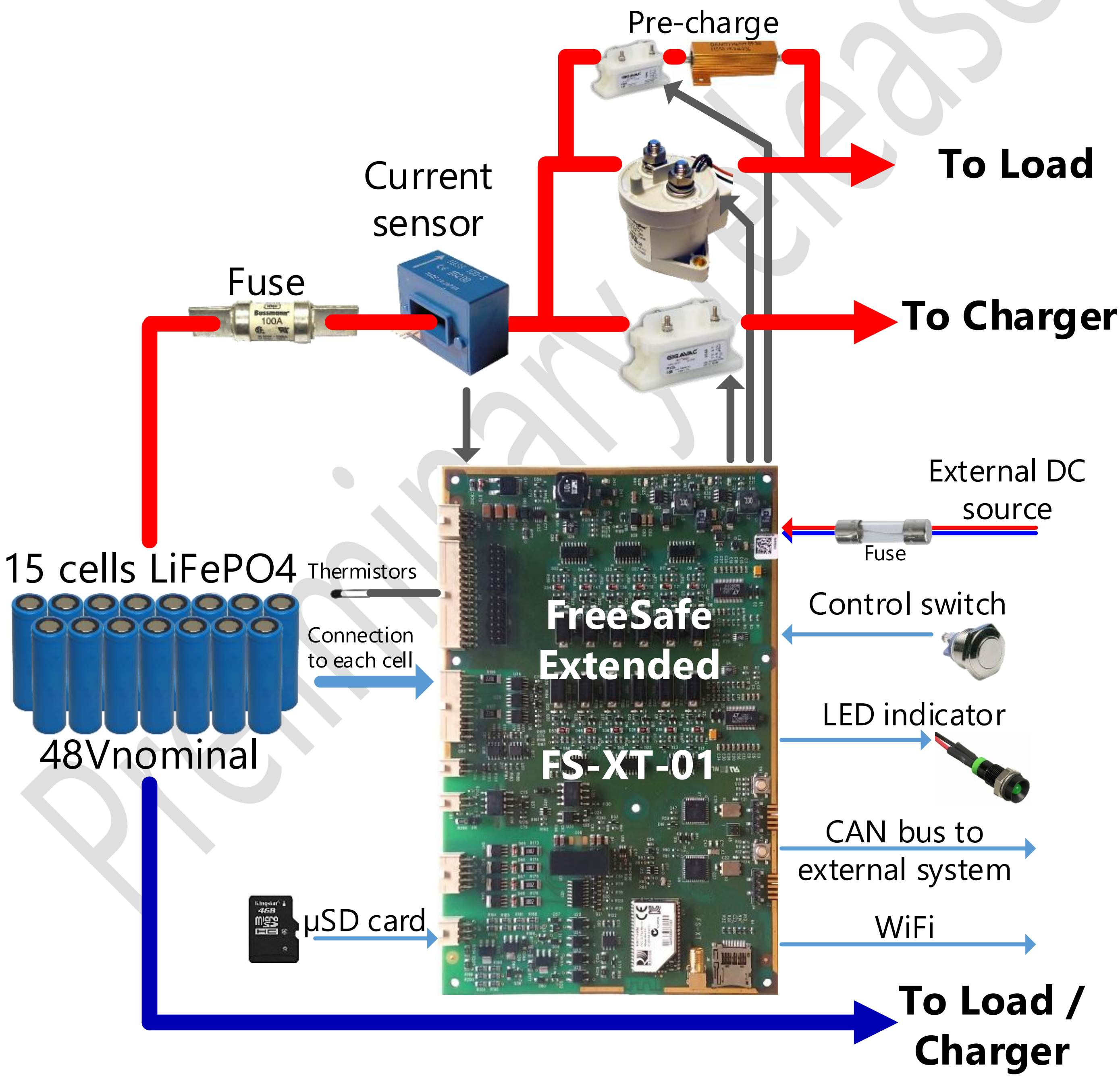


Figure 26: typical application for a 48V $LiFePO_4$ battery

The main characteristics of the application and the main functions of the BMS for this example are the following ones:

- The battery will present two power lines. One is dedicated to the recharge of the battery, the other one to the general use (discharge) of the battery. The discharge power line has also a pre-charge line to limit the inrush current when the battery is connected to its application.
- The pre-charge circuit is sized to charge a 1mF capacitor under 1s.
- The minimum and maximum voltage of the cells are set to 2.5V and 3.65V. If a cell falls under 2.5V, the discharge power line will be opened. If a cell voltage rises over 3.65V, all the contactors will be opened to avoid an overcharge (see *Over voltage management* p*65* for more details) and the balancing stabilizes the cells voltages under 3.65V.
- The nominal discharge current of the application is 50A, but bursts of 100A are allowed for 5 seconds. Any current over 150A will be considered as short-circuit and the battery must be secured by opening the contactors. A fuse can also be added as a last link in the safety chain.
- The charging current is 30A (about C/3).
- Up to 4 NTC thermistors can be connected to the BMS. If the temperature read on the thermistors are under -10°C or over 45°C, the BMS will open the contactors.
- The isolated CAN of the BMS can be used to communicate with a charger or to read the characteristics of the battery: voltages, current, temperatures, BMS states, etc. See *External CAN communication* p*53* for more details.
- A control signal (generated by a push button in this example) is required to control the states of the contactors and the BMS. For more details on the control switch function, *Control signal for contactors states* p*62*.
- An optional LED can be used to visually indicate the battery state and contactors state. See *State indicator signal* p*63* for more details.

4.2 Peripherals and connectors

4.2.1 Peripherals

The references of the chosen peripherals are presented in this section. For more detail about design choices and references examples, see the chapter *Design guide for* the BMS and its peripherals p*90*.

Contactors

This implementation example requires 3 contactors: their characteristics and references are presented on the next table. The main discharge contactor must carry up to 150A, the charge contactor will carry 30A and the pre-charge one 5A max.

Table 12: contactors and references

Contactor	Chosen reference	Manufacturer	Comments
Discharge contactor	Kilovac EV200AAANA	Tyco Electronics	500A, 900V, 12V coil
Pre-charge contactor	MiniTactor P105BDA	Gigavac	50A, 1200V, 12V coil
Charge contactor	MiniTactor P105BDA	Gigavac	50A, 1200V, 12V coil

Precharge resistor

A 100Ω, 4W min resistor will allow a pre-charge of à 1mF capacitor with 48V in 0.3s.

Table 13: pre-charge resistor reference

Resistor	Chosen reference	Manufacturer	Comments
Power pre-charge resistor	RH005100R0FE02	Vishay Dale	100Ω, 7.5W

Current sensor

The current sensor must measure current between -30A (charge) and +150A (max discharge allowed current).

Table 14: current sensor reference

Current sensor	Chosen reference	Manufacturer	Comments
Hall Effect current sensor	HASS 50-S	LEM	5V supply, 50A nominal, 150A max

Thermistors

The 4 thermistors must be 10kΩ NTC.

Table 15: thermistor reference

Thermistors	Chosen reference	Manufacturer	Comments
10kΩ NTC	ND06P00103K	AVX	R_0=10kΩ, T_0=25°C, β=4220

Control switch

Table 16: switch reference

Switch	Chosen reference	Manufacturer	Comments
Push button switch	MP0042/3	Bulging	SPST type

Fuse

Fuses are required to protect the main power line of the battery and the external DC input of FS-XT.

Table 17: fuses references

Fuse	Chosen reference	Manufacturer	Comments
Power line fuse	200FM	Bussmann	200A fuse
External source fuse	0217005.MXP	Littelfuse	5A fuse
External source fuse holder	A003300AAB	Arcolectric	

Micro SD card

The BMS stores the data and the states of the battery, but also the configuration of the system in a memory card:

Table 18: micro SD card reference

Micro SD card	Chosen reference	Manufacturer	Comments
Micro SDHC card	SDC4/4Gb	Kingston	4GB

Light indicator

In this example, the LED is supplied from the onboard 3.3V. A serial resistor of 470Ω is added to the LED in order to limit the supply current to about 5mA. Any LED reference that is bright enough with a 5mA supply can be used to duplicate this example.

4.2.2 FreeSafe Extended connectors

External connector

For this example, the following additional connectors will be needed to connect the system to the FS-XT:

Table 19: external connectors' references

Connector n°	Chosen reference	Manufacturer	Comments
1	IPD1-04-D + CC79L		Thermistors connector
2	IPD1-15-D + CC79L		Cells connector
3	IPD1-10-D + CC79L	SAMTEC	GPIO connector
5	IPD1-02-D + CC79L		Isolated CAN connector
6	IPD1-05-D + CC79L		Power I/O connector

The assembly "IPD1 + CC79L" can be ordered directly assembled through the reference MMSD at SAMTEC.

Onboard connector

If the battery has less than 24 cells, the 2a and 2b connectors can be used to shunt the missing cells with 2.54mm pitch jumpers (ex: SPC20479 from Multicomp). See *Connecting the battery cells to FS-XT* p*18* for more details about cells wiring recommendations.

The 5a connector is used to connect a 120Ω terminal resistor on the CAN bus. See *External CAN bus terminal resistor* p*21* for more details about the CAN bus wiring recommendations.

4.3 Wiring preparations and connections

This section describes the pins configuration and wiring connections needed for this typical application. As soon as all connectors are prepared properly and the system is ready for powering, please refer to the *Start up procedure* p*30*.

4.3.1 Cells connection to FS-XT

FS-XT manages the battery in 2 groups, up to 12 cells per group. In this example, the 15 serial cells will be managed in 2 groups of 8 and 7 cells (see *Connecting the battery cells to FS-XT* p*18* for more details). Figure 27 shows the connection diagram of this example.

N.B.: as the unused connections are shunted, **extreme care must be taken** to ensure there are no errors that can short-circuit one or more battery cells when the cell connector is plugged.

4.3.2 Power I/O connection

In this example, 3 contactors and their DC supply must be connected on connector n°6 of FS-XT. The Figure 28 shows the connection diagram.

For this example the external DC supply is the 12V output of a DC/DC converter supplied form the battery.

4.3.3 GPIO connection

The current sensor and the push button are connected on the GPIO connector. The current sensor is directly supplied by 5V provided by the FS-XT board.

Control switch

As the button uses the isolated input IN0 (details in *Digital I/O connections* p*22*), it is mandatory to use a voltage source to transmit its signal. In this example, the onboard 3.3V source is used. **N.B.**: in this example, the input is not insulated anymore as it use the onboard supply, but it remains resistant to perturbations.

Current sensor position

The current sensor must be placed on the power line of the battery where it can monitor all the current flow. As shown on Figure 29, this example places the current sensor between the battery positive terminal and the contactors for two main reasons:

- monitor every current that enters or quits the battery through the charge or discharge power channels,
- ensure there is no current flow when the contactors are opened to calibrate the current sensor offset automatically.

The current sensor must be oriented in order to measure the charge current as a positive current and the discharge current as a negative current.

Light indicator

The LED uses the isolated output OUT0 (details in *Digital I/O connections* p*22*). Its use is optional but it is recommended for any test or prototype application as it can provide precious information of the BMS state and errors. **N.B.**: in this example, the input is not insulated anymore as it use the onboard supply, but it remains resistant to perturbations.

4.3.4 NTC connection

The NTC resistors do not have polarity for their connections. Figure 30 shows their connection diagram.

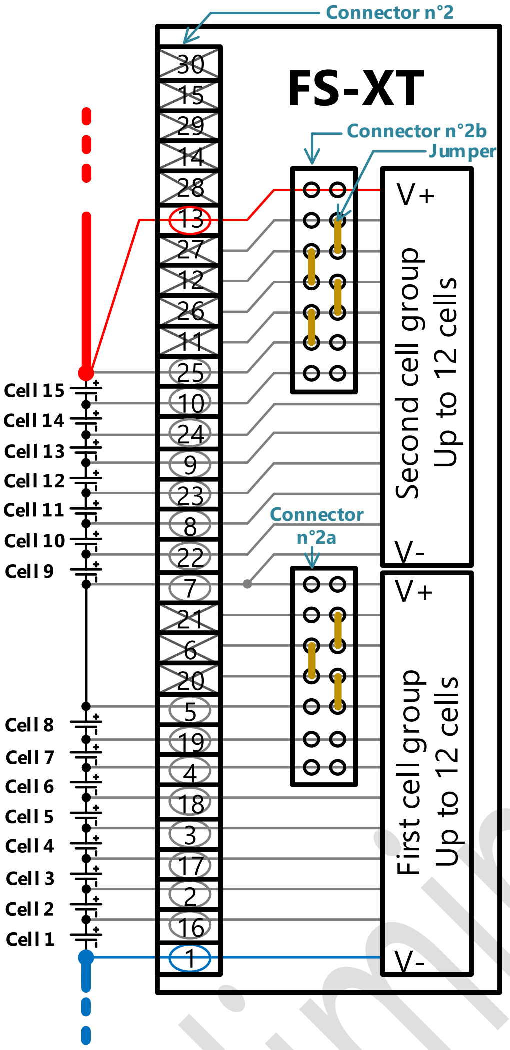


Figure 27: typical cells connection diagram for a 48V LiFePO4 battery

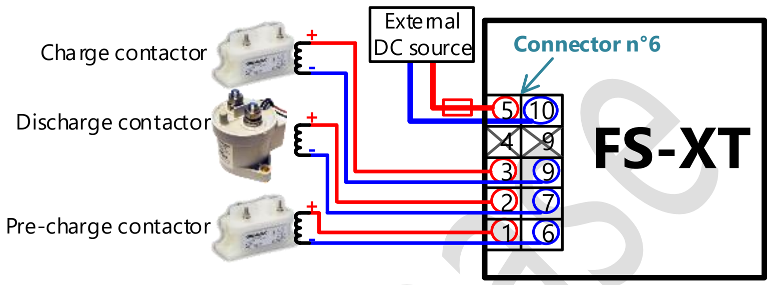


Figure 28: Power I/O connection diagram

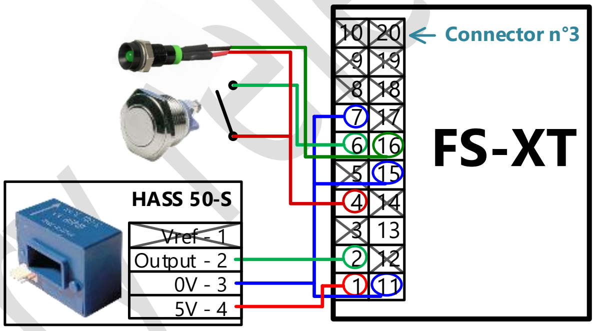


Figure 29: typical GPIO connection diagram

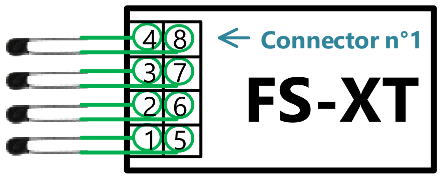


Figure 30: thermistors connection diagram

4.3.5 CAN connection

The connection of the external isolated CAN is not described in this example because it is optional and used only if the external system needs to get the real-time battery characteristic or for an external CAN bus driven charger. See *External isolated CAN bus* p20 for more detail about the isolated CAN connections.

4.4 Configuration

The configuration file for this example is presented below. For more details, see *Configuration file* section p72. For more details about the design choices or recommendations, see *Design guide for the BMS and its peripherals* p90.

Table 20: configuration file for the typical 48V application

```xml
<!-- type 0:bool, 1:string, 2:int, 3:long, 4:float -->


<BMSparam>
 <systemParam>
  <variable id="0" type="1" value="0N0L3FFM;0N1L1FM" name="cellPosition"/>
  <variable id="1" type="1" value="0N0L3M;0N1L3M" name="tempSensorPosition"/>
  <variable id="2" type="4" value="100" name="d1Cap"/>
 </systemParam>
 <powerManagmentParam>
  <variable id="4" type="2" value="30" name="sleepActivationTimer"/>
  <variable id="5" type="2" value="10" name="sleepDuration"/>
  <variable id="6" type="0" value="0" name="internCBLowPower"/>
  <variable id="63" type="0" value="1" name="buttonActivityIgnore"/>
  <variable id="64" type="0" value="1" name="externalCanresistorsSoldered"/>
 </powerManagmentParam>
 <RN171Param>
  <variable id="7" type="1" value="FreeSafeAP-TypApp48V" name="accesPointName"/>
  <variable id="8" type="1" value="FreeSafe1212" name="accesPointPass"/>
  <variable id="9" type="1" value="9" name="accesPointEmissionChannel"/>
  <variable id="10" type="1" value="freemensAP" name="wlanSSID"/>
  <variable id="11" type="1" value="0" name="authMode"/>
  <variable id="12" type="1" value="none" name="wlanPass"/>
  <variable id="13" type="1" value="0" name="wlanChan"/>
  <variable id="14" type="1" value="0.0.0.0" name="ftpAddr"/>
  <variable id="15" type="1" value="default" name="ftpUser"/>
  <variable id="16" type="1" value="none" name="ftpPass"/>
  <variable id="17" type="1" value="ftp" name="ftpDir"/>
 </RN171Param>
 <SDRecordParam>
  <variable id="18" type="2" value="10" name="voltageVarRecordThrehold"/>
  <variable id="19" type="2" value="10" name="temperatureVarRecordThrehold"/>
  <variable id="20" type="4" value="0.5" name="currentVarRecordThrehold"/>
  <variable id="21" type="4" value="0.5" name="SOCVarRecordThrehold"/>
  <variable id="22" type="4" value="0.01" name="SOHVarRecordThrehold"/>
  <variable id="23" type="3" value="7200" name="maxRecordPeriod"/>
  <variable id="24" type="3" value="10000000" name="maxFileSize"/>
 </SDRecordParam>
 <balancingParam>
  <variable id="25" type="2" value="20" name="balancingActivationThreshold"/>
  <variable id="26" type="2" value="100" name="balancingDesactivationThreshold"/>
  <variable id="27" type="2" value="3650" name="forceBalancingThresold"/>
  <variable id="28" type="2" value="3000" name="stopBalancingThreshold"/>
  <variable id="59" type="4" value="10" name="currentStopBalanceThreshold"/>
 </balancingParam>
 <voltageParam>
  <variable id="29" type="2" value="3650" name="overVoltageThreshold"/>
  <variable id="30" type="2" value="2600" name="underVoltageThreshold"/>
  <variable id="31" type="2" value="3620" name="SOCMaxRecalibrationThreshold"/>
  <variable id="32" type="2" value="2620" name="SOCMinRecalibrationThreshold"/>
  <variable id="49" type="2" value="3630" name="hysteresisMaxVoltageCharge"/>
  <variable id="50" type="2" value="3400" name="hysteresisMinVoltageCharge"/>
  <variable id="60" type="4" value="1" name="currentSOCCalibrationThreshold"/>
  <variable id="61" type="2" value="2700" name="endOfDischargeThreshold"/>
 </voltageParam>
 <temperatureParam>
  <variable id="33" type="2" value="550" name="maxBalancingTemp"/>
  <variable id="34" type="2" value="450" name="cellOverTemperatureThreshold"/>
  <variable id="35" type="2" value="-100" name="cellUnderTemperatureThreshold"/>
  <variable id="36" type="4" value="298.15" name="temperatureSensorT0"/>
  <variable id="37" type="4" value="10000" name="temperatureSensorR0"/>
  <variable id="38" type="4" value="4220" name="temperatureSensorBeta"/>
 </temperatureParam>
 <currentParam>
  <variable id="39" type="0" value="0" name="currentMeasConvention"/>
  <variable id="40" type="4" value="150" name="positiveShortCircuitThreshold"/>
  <variable id="41" type="4" value="-55" name="negativeShortCircuitThreshold"/>
  <variable id="42" type="4" value="125000" name="SOPCapacity"/>
  <variable id="43" type="4" value="50" name="SOPChargeNominal"/>
  <variable id="44" type="4" value="50" name="SOPDischargeNominal"/>
  <variable id="45" type="4" value="16" name="currentSensorSensitivity"/>
  <variable id="46" type="2" value="2048" name="currentRef"/>
  <variable id="47" type="4" value="0.2" name="noCurOffsetThreshold"/>
  <variable id="48" type="2" value="10" name="currentMeasurementError"/>
 </currentParam>
 <CBChargerParam>
  <variable id="51" type="4" value="54" name="maxVoltageChargerCB"/>
  <variable id="52" type="4" value="30" name="maxCurrentChargerCB"/>
 </CBChargerParam>
 <snapshotParam>
  <variable id="53" type="2" value="0" name="snapshotShortTimer"/>
  <variable id="54" type="2" value="0" name="snapshotLongTimer"/>
  <variable id="65" type="0" value="0" name="ExtCanIdType"/>
 </snapshotParam>
 <powerOutputParam>
  <variable id="3" type="0" value="0" name="dissociateChargePowerLine"/>
  <variable id="55" type="2" value="20" name="powerOutputPrecharge"/>
  <variable id="56" type="2" value="400" name="fanActTempThreshold"/>
  <variable id="57" type="2" value="350" name="fanDeactTempThreshold"/>
  <variable id="58" type="2" value="2" name="fanSourceTrigger"/>
  <variable id="62" type="0" value="1" name="autoEngageDuringCharge"/>
 </powerOutputParam>
</BMSparam>
```

4.5 Start up procedure

4.5.1 Check-list

Before connecting the battery cells to the BMS and using the battery, the following steps must be followed.

Table 21: Wiring check list before start-up

Step N°	Description
1	Confirm the external DC source is turned OFF or disconnected
2	Confirm the NTC are connected and properly set up on the cells
3	Confirm the current sensor is on the power line between the battery positive terminal and the contactors. Confirm it is oriented to measure the charge current as a positive current.
4	Confirm the micro SD card contains the file “config.xml” and is plugged.
5	Confirm the control switch is wired on connector n°6 and turned OFF.
6	If the external CAN bus is used and is the first or last electrical node, confirm that a jumper is plugged on the connector n°5a.

The connection procedure is described on the following table.

Table 22: connection procedure

Step	Connector	Comment
1	1, 2a, 2b, 3, 4, 4a, 5, 5a, 7, 8, 9	As FreeSafe Extended is not supplied, no particular steps are required for these connectors.
2	2	Balancing LEDs may blink at the connection before the initialization routine.
3	6	If the external DC source is turned OFF, connector 6 can be connected during step 1.
Caution	10 ,11	Programming connectors are only used when firmware update is necessary. Notice that the connector is referenced to the negative terminal of the lowest stack cell. Caution must be taken when connecting a non-isolated debugger or programmer

N.B.: do not connect the connector n°2 (cells connector) or do not turn the DC source ON before checking the rest of the system. Else, the BMS can start and enter an initialization error state described quickly in the next section *First connection.*

Figure 31 shows the FS-XT board with all its connections. The jumpers on connectors 2a & 2b and the micro SD card on connecter 9 are visible. The external isolated CAN bus is not used, thus not connected (connector 5).

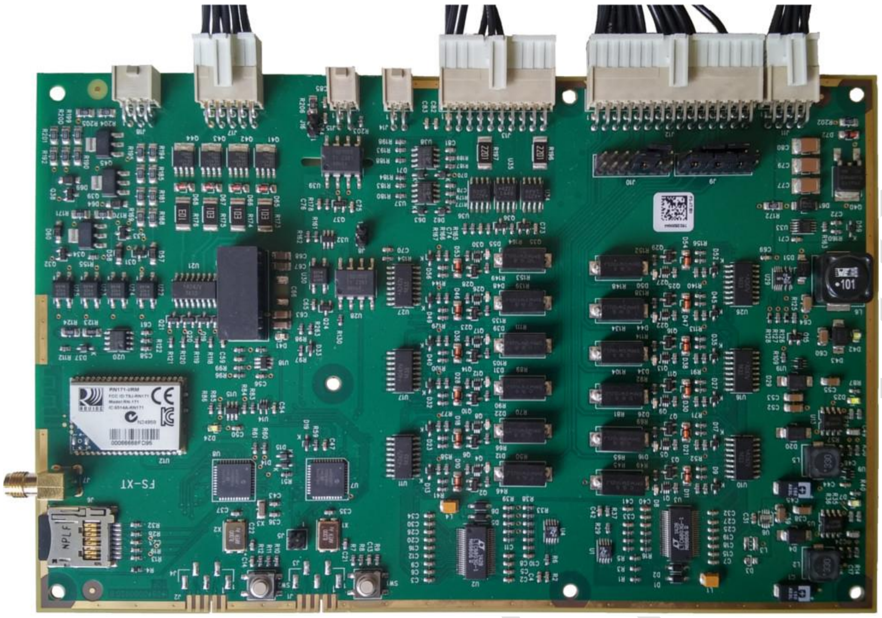


Figure 31: FS-XT wired a typical 48V implementation

4.5.2 First connection

As soon as the cells connector (n°2) is connected, the BMs will start. If no error is detected (the configuration of the system is correct and initialized, no voltage, current or temperature error are detected etc.), the BMS will. In case an initializing error is detected, the initialization process will enter in a fail and retry mode: the BMS will enter in an initialization error state and wait for 120s before rebooting.

Another confirmation that the BMS has started correctly is the presence of the BMS Wi-Fi network: the FreeView application can be connected to monitor the parameters of the battery.

4.5.3 Real time monitoring

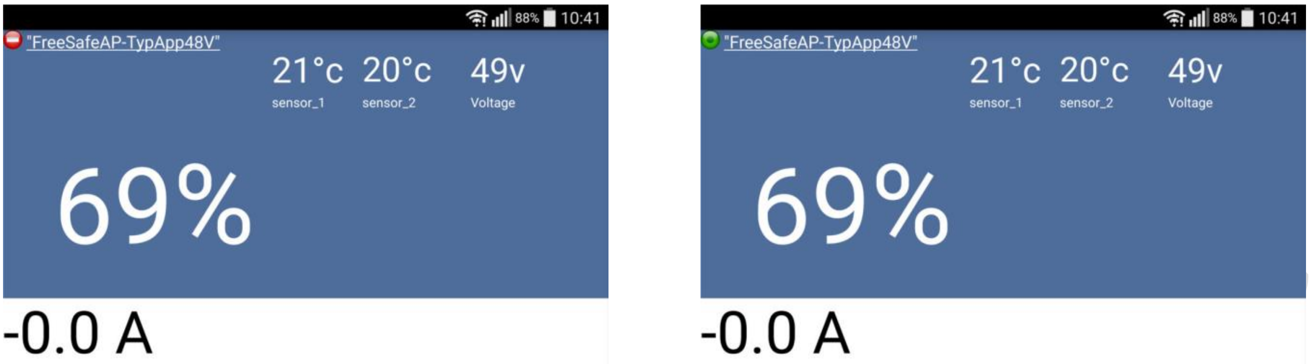
The battery characteristics can be visualized at real time with Freemens' proprietary application FreeView connected by Wi-Fi to FreeSafe Extended. FreeView can be used as a dashboard included in Freemens' PC software FreeLab or as a standalone Android application. This example presents the use of FreeView as an Android application. See the FreeView documentation for more details.

Once the BMS is started, a new Wi-Fi network appears. Any device can be connected to the Wi-Fi network of the BMS. The name of the network and the password are configurable in the SD card and can be easily modified by the user. The next table describes the steps required in order to establish a connection between FreeSafe XT and FreeView.

Table 23: FreeView usage

Step N°	Action	Comments
1	Connect to the BMS	In the Wi-Fi parameters of the Android device connect to the BMS Wi-Fi network. In this example, the network name is "FreeSafeAP-TypApp48V" and the password is "FreeSafe1212".
2	Launch FreeView	At the launch of FreeView, wait for the up-left icon to change from red to green before starting to use the application. See Figure 32 for an example. This icon shows the connection status between the BMS and the Android device.

3	The dashboard is usable	For more information about how to use FreeView refer to the FreeView user guide.



The Wi-Fi connection is not yet established: the up-left icon is red

The Wi-fi communication is working: the up-left icon is green. FreeView can be used

Figure 32: FreeView home screen

Figure 33: FreeView screen for the voltage of 15 LiFePO4 cells

4.6 Data management

4.6.1 Micro SD card files

The files stored on the micro SD card contain the configuration of the system and the complete history data of the operation of the battery and the BMS.

To extract the files stored, the standard method is to unplug the card from its slot on the FS-XT board and to connect it to a computer with a micro SD card reader. The files on the micro SD card are described in the next table.

Table 24: micro SD files details

File name	Description
BMS.TXT	Contains the complete data history of the battery and its BMS
BMSn.TXT	n=1, 2, 3, etc. Same contents as BMS.TXT. A new file is created if the previous is too large or each time the BMS resets.
CONF.XML	Configuration file of the battery, the BMS and the complete system.
CONFIG.TXT	Information file about the BMS.
EVEN.TXT	Log of critical events. E.g.: resets, communication time-out, errors, etc.
LASTREC.TXT	Log of the current state of the battery as the date, SOC, etc.

For more details about these files, see *Micro SD card files* p*68*.

4.6.2 Reading the battery history files

FreeLab is a proprietary PC software used to manage the data stored in the BMS. The data extracted from the SD card of the BMS can be visualized with FreeLab. It also includes a dash board module similar to FreeView. See FreeLab documentation for more details.

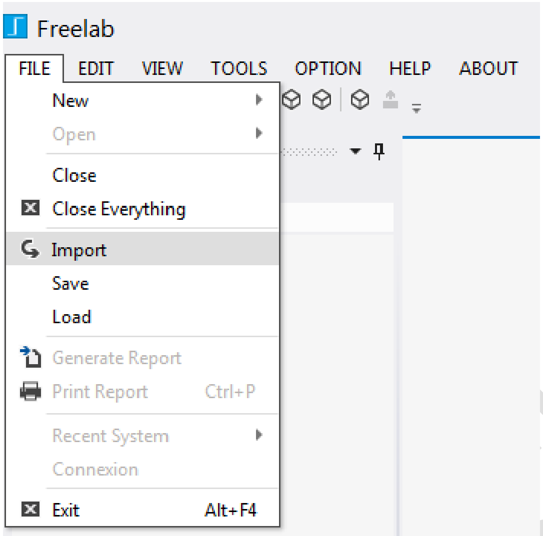


Figure 34: Import menu of FreeLab

5 Cells management

5.1 Running mode

5.1.1 General description

Running modes enable better power consumption control by minimizing FreeSafe Extended activity when heavy algorithm such as SOC estimation, balancing control or wireless communication are not needed. FreeSafe Extended is able to select the mode of operation to improve battery autonomy and self-preservation during storage or long term non-use.

There are two modes of operation: Normal Mode and Power Saving Mode.

The selection of the running mode depends of the states of the battery, the BMS state and its inputs (and particularly the isolated input IN0, see *Control signal for contactors states* p62). The next paragraphs (0 & 5.1.3) describe these conditions.

Table 25: Functions overview in normal and power saving modes

Function name	Operating mode	
	Normal Mode	Power saving Mode
Voltage acquisition period	1s	"sleepDuration"
Balancing actualization period	1s	-
SOC (and current) actualization period	0.1s	-
Internal main DC/DC supply	ON	OFF
External communications (Wi-Fi & CAN)	ON	OFF
Typical power consumption	1.1W	13mW[1]
State of the contactors	ON or OFF	OFF

[1] It depends on the sleep duration parameter and the battery voltage. 13mW is the ideal consumption for a 48V battery. See *Optimization of the internal power supply unit consumption in sleep mode* p92.

5.1.2 Normal Mode

By default, FreeSafe will run in Normal Mode when connected to the battery stack for the first time. After a configurable period of inactivity (parameter "sleepActivationTimer"), the BMS will go into Power Saving Mode.
When FreeSafe is in Normal mode, the subsequent events will reset the inactivity timer:

- Logical high level input on the isolated input IN0 of the GPIO connector
- Current detected on the power line.
- Active Wi-Fi communication
- Balancing activation

In Normal mode, FreeSafe Extended performs all the monitoring and communication tasks at maximum speed. Cell voltages, current and state of charge will be refreshed 1 time per second. In this mode, FreeSafe Extended will become an Access Point for Wi-Fi devices. If the Android FreeView application is connected to the BMS, it will display the variables in real-time.

5.1.3 Power Saving Mode

In this mode, FreeSafe Extended will be unreachable via Wi-Fi until the BMS returns in Normal Mode; the contactors and the balancing are turned off.

In Power Saving Mode, FreeSafe Extended will perform a basic checkup on the battery variables every "sleepDuration" seconds. If changes are noticed, a data logging operation may occur. If no action on the battery is required after the checkup, the BMS stay in Power Saving Mode for another cycle of "sleepDuration" seconds.

When FreeSafe Extended is in Power Saving Mode, the subsequent events will wake up the module:

- Balancing activation. If a balancing is required, as it is only possible in Normal Mode, the BMS is waked up.
- Logical high level input on the isolated input IN0 of the GPIO connector.

5.1.4 Configuration

These parameters control the length of the loop in the power saving mode and the minimum inactivity timeframe that will put FreeSafe Extended in this mode. Adjusting "sleepDuration" will allow to reduce the overall power consumption but will slow down the refresh rate of the voltage and temperature and their recording on the SD card.

Table 26: Power management configuration

Name	Id	Unit	Type	Example	Range	Comment
sleepActivationTimer	4	s	int	300	10-10000	Inactivity duration before going into power saving mode
sleepDuration	5	s	int	5	10-1000	Refresh interval for any BMS variable in power saving mode
internCBLowPower	6	-	bool	0	0 - 1	Aggressive energy management of the internal CAN bus. 0=inactive, 1=active
buttonActivityIgnore	63	-	bool	1	0 – 1	Ignore the state of the control switch to start the sleep activation timer
externalCanResistorsSoldered	64	-	bool	0	0 – 1	Specify if the external CAN supply is connected to the onboard supply. Used for the sleep mode behavior.

The parameter "buttonActivityIgnore" allows the BMS to ignore the state of IN0 when checking the conditions for entering sleep mode. It means that, in maintain mode, if "buttonActivityTimer"=1 then the BMS can enter its sleep mode if there is no activity even if a high level logical state is detected on IN0.

The parameter "externalCanResistorsSoldered" allows the BM to know if the onboard 5V supply is connected and used for supplying the external CAN bus. The BMS can then adapts its behavior to manage the supply and the loss of isolation.

5.2 Configuration

All the parameters described in this section are located in the configuration file of the BMS, named CONF.XML, in the micro SD memory card. See the chapter *Configuration file* p*72* for more details.

5.2.1 Battery specifications

The parameters in this paragraph are used to configure the expected number of cells, their positions on the connector and, if needed (see *Application with more than 24 cells* p*79*), the global distribution of slave boards. They also define the temperature sensors (NTC thermistors) that are used by the BMS.

These parameters are used at the primary initialization. If the number of cells or their positions do not match the configuration, FreeSafe Extended will periodically reboot until the correct amount of cells is detected. The configured number of slave board is used to guarantee that all the boards are correctly configured and operational. The last parameter "d1Cap" is the initial nominal capacity of the battery. It is used for SOC and SOH calculations.

Table 27: Battery Configuration

Name	id	Unit	Type	Example	Range	Comment
cellPosition	0	-	char*	"0N0LFFFM"		format xNyLzM (x: id BMS board, y: id cell group, z: cell position mask)
tempSensorPosition	1	-	char*	"0N0L3M"		format xNyLzM (x: id BMS board, y: id cell group, z: NTC position mask)
d1Cap	2	Ah	float	100	-	Initial nominal battery capacity

The "cellPosition" and "tempSensorPosition" parameters are described in the next paragraphs.

Cells positions configuration

The "cellPosition" parameter is a string that defines:

- the number of printed circuit board used for the FreeSafe BMS solution
- the position (i.e. the wiring) of the cells on the boards

The BMS manages the battery by group of 12 cells max. For each group, a string "xNyLzM" must be defined:

- 'x' is the board number. 0 for the 1st board, 1the the 2nd, etc.
- 'y' is the group ID of the group managed by the board. The first group (up to 12 cells) number of FS-XT is 0, the second is 1. For boards that manage only 1 group, y=0.
- 'z' is the hexadecimal mask that represents the cells positions on the connector n°2. The hexadecimal value comes from a 12 bits string that represents the 12 cells group. Each bit indicate if there is a cell (bit=1) at a given position or if the connection is shorted (bit=0). The LSB represents the first cell of the group (lower voltage potential). For instance, for a 9 cells group with all the highest connections shorted, the bit string is '000111111111' and 'z' will be '1FF'.
- 'N', 'L' and 'M' are separator characters.

If there are more than 1 group of cell, each string "xNyLzM" must be separated with a semicolon ';'.

Table 28: Examples of "cellPosition" parameter

Battery cell number	BMS cards (cells groups)	"cellPosition" parameter
15 cells	1 FS-XT (10+5 cells)	0N0L3FFM; 0N1L1FM
30 cells	1 FS-XT (10+10)+ 1 FS slave (10)	0N0L3FFM; 0N1L3FFM; 1N0L3FFM
42 cells	1 FS-XT (12+12) + 2 FS slaves (12+6)	0N0LFFFM; 0N1LFFFM; 1N0LFFM; 1N0L3FM

Temperature sensors configuration

The "tempSensorPosition" parameter is a string that defines the number of NTC sensors used for each board of the BMS.

For **each group of 12 cells**, there are **2 NTC** that must be configured with the "xNyLzM" string:

- 'x' is the board number. 0 for the 1st board, 1the the 2nd, etc.
- 'y' is the group ID of the group managed by the board. The first group (up to 12 cells) number of FS-XT is 0, the second is 1. For boards that manage only 1 group, y=0.
- 'z' is the hexadecimal mask that represents the NTC positions for each 12 cells group. The hexadecimal value comes from a 2 bits string that represents the 2 NTCs per cells group. Each bit indicate if there is a NTC connected (bit=1) at a given position or not (bit=0). The LSB represents the first NTC of the group. *Table 29* shows some examples.
- 'N', 'L' and 'M' are separator characters.

FS-XT can manages up to 24 cells in two groups and up to 4 NTC (2 per group) can be connected. As shown on *Figure 7* and *Table 4* in *NTC connector* p*15*, there are 4 NTC connection numbered from 1 to 4. NTC 1 & 2 are link to the 1st group of cells and NTC 3 & 4 to the 2nd group.

Table 29: examples of configuration for "tempSensorPosition" parameter

NTC used and connected				**"tempSensorPosition" parameter**
Group 1		Group 2		
NTC1	NTC2	NTC3	NTC4	
no	no	no	no	0N0L0M; 0N1L0M
yes	no	yes	no	0N0L1M; 0N1L1M
yes	yes	yes	yes	0N0L3M; 0N1L3M
no	no	no	yes	0N0L0M; 0N1L2M

5.2.2 Voltage protection thresholds

Digital configurable over and under voltage thresholds

The over and under voltage thresholds are mandatory to operate lithium batteries. Extra care must be taken when modifying these parameters. If these thresholds are reached, FreeSafe Extended will drive the power contactor off to cutoff the battery from the application/charger. See *Over voltage management* p*65* for more details about the fault management.

Table 30: Voltage management configuration

Name	Id	Unit	Type	Example	Range	Comment
overVoltageThreshold	29	mV	int	3650	0-10000	Over voltage threshold
underVoltageThreshold	30	mV	int	2600	0-10000	Under voltage threshold

Analog hardware over voltage threshold

The BMS board also has an analog detection circuit on each cell for detecting an over voltage. The voltage threshold is set by a 4.7V Zener diode.

In a standard operation and configuration of the battery, this threshold must never be reached: the configurable overvoltage threshold described previously has to be set to force the BMS to enter an overvoltage error before reaching this analog threshold. If any BMS malfunction causes a cell to reach this analog threshold, the BMS opens the contactors. As it is a last resort protection only a software reset can allow the clearance of this error.

For a custom analog over voltage threshold, hardware reference customizations are needed. Contact Freemens for more details.

5.2.3 Current protection thresholds

These parameters define the overcurrent and short-circuit limits. Extra care must be taken when modifying these parameters. If these thresholds are reached, FreeSafe Extended will drive the power contactor off to cutoff the battery from the application/charger. See *Power Line management* p*44* for more details.

Table 31: current protection configuration

Name	id	Unit	Type	Example	Range	Comment
positiveShortCircuitThreshold	40	A	float	250	-	Positive instantaneous current limit
negativeShortCircuitThreshold	41	A	float	-250	-	Negative instantaneous current limit
currentChargeNominal	43	A	float	50	-	Positive nominal current
currentDischargeNominal	44	A	float	-100	-	Negative nominal current
deltaI2t	42	$A^2.s$	float	25000	-	I^2t value used to define the overcurrent limits. Typical value calculated with $(I^2_{DischargeOvercurrent}-I^2_{DischargeNominal}).t_{overcurrent}$

5.2.4 Temperature protection thresholds

The over and under temperature thresholds ("cellOverTemperatureThreshold" and "cellUnderTemperatureThreshold") are mandatory to operate lithium batteries. Extra care must be taken when modifying these parameters. If these thresholds are reached, FreeSafe Extended will drive the power contactor off to cutoff the battery from the application/charger.

"maxBalancingTemp" is the maximum onboard temperature over which no balancing is allowed.

Table 32: Thermal sensor configuration

Name	Id	Unit	Type	Example	Range	Comment
maxBalancingTemp	33	0.1°C	int	600	-20 to +85	Maximum reachable board temperature due to cell balancing
cellOverTemperatureThreshold	34	0.1°C	int	450	-180 to 180	Cells over temperature threshold
cellUnderTemperatureThreshold	35	0.1°C	int	-200	-180 to 180	Cells over temperature threshold

The temperature sensors must be NTC thermistors (10kΩ recommended). To ensure correct temperature readings, sensors must be placed as close as possible to the monitored cell. For example, they can be directly placed onto screws used for power connection. Parameters example for AVX – ND06P00103K thermistor are given in the next table.

Figure 35 : AVX - ND06P00103K

Table 33: NTC configuration parameters example

Name	id	Unit	Type	Example	Range	Comment
temperatureSensorR0	37	Ω	float	10000	-	NTC resistance at T0
temperatureSensorT0	36	K	float	298	-	NTC reference temperature
temperatureSensorBeta	38	K	float	4220	-	β coefficient of the NTC temperature vs resistance equation

Equation 1: NTC temperature and resistance calculation

$$\frac{1}{T} = \frac{1}{T_0} + \frac{1}{\beta} \cdot ln\left(\frac{R}{R_0}\right)$$

5.3 Cell balancing

5.3.1 General description

FreeSafe Extended includes a low power embedded balancing unit. By connecting 10Ω power resistors to over-charged battery cell, the balancing unit is able to dissipate up to 2.5 W per cell at 25°C ambient temperature. The maximum balancing current of 500mA, reached for a 5V cell voltage, requires the use of adapted wiring between FreeSafe and the battery stack.

The balancing control is obtained at the processor level based on the individual cell SOC estimation or the voltage comparison. With each resistor able to dissipate up to 2.5W, thermal regulation at board level is provided to reach an optimal balancing capacity and to ensure the device integrity.

5.3.2 Configuration

Passive balancing can be configured according to two methods used independently and simultaneously. It can be activated upon reaching a voltage threshold with the "forceBalancingThresold" parameter. It can also be activated upon reaching a voltage difference between any cell of the battery and the one with the lowest voltage superior to "balancingActivationThreshold". In this case, passive balancing will be disabled when the voltage difference decreases below the "balancingDesactivationThreshold" threshold. Balancing will never occur if the cells voltage is below the "stopBalancingThreshold" value.

The passive balancing is disabled if:

- The onboard over temperatures exceed "maxBalancingTemp". The dissipated power, generated by the passive balancing, increases the board temperature. The "maxBalancingTemp" threshold protects the board of over temperature due to the balancing.
- The charge or discharge battery current exceeds "currentStopBalanceThreshold". As the battery power current can change the cell voltage measurement (continuous voltage drop due to the cell internal resistance contribution for instance), the "currentStopBalanceThreshold" parameter ensures the BMS that the cell voltages measured are not perturbed by the power current. Under this current threshold the BMS can rely on its measurement to compare them to the balancing voltage thresholds.

Table 34: Balancing configuration

Name	id	Unit	Type	Example	Range	Comment
balancingActivationThreshold	25	mV	int	20	0-10000	Activation of balancing threshold
balancingDesactivationThreshold	26	mV	int	10	0-10000	Deactivation of balancing threshold
forceBalancingThreshold	27	mV	int	3650	0-10000	Cell voltage threshold triggering forced balancing
stopBalancingThreshold	28	mv	int	3300	0-10000	Cell voltage threshold at which passive balancing is disabled
currentStopBalanceThreshold	59	A	float	1		Current threshold under which the balancing is disabled

5.3.3 Balancing scenario example

The following figure presents an example of voltage evolution scenario of two cells in order to illustrate how and when the voltage thresholds activate a balancing event. The voltages depicted on this figure do not reflect the voltage evolution of real cells.

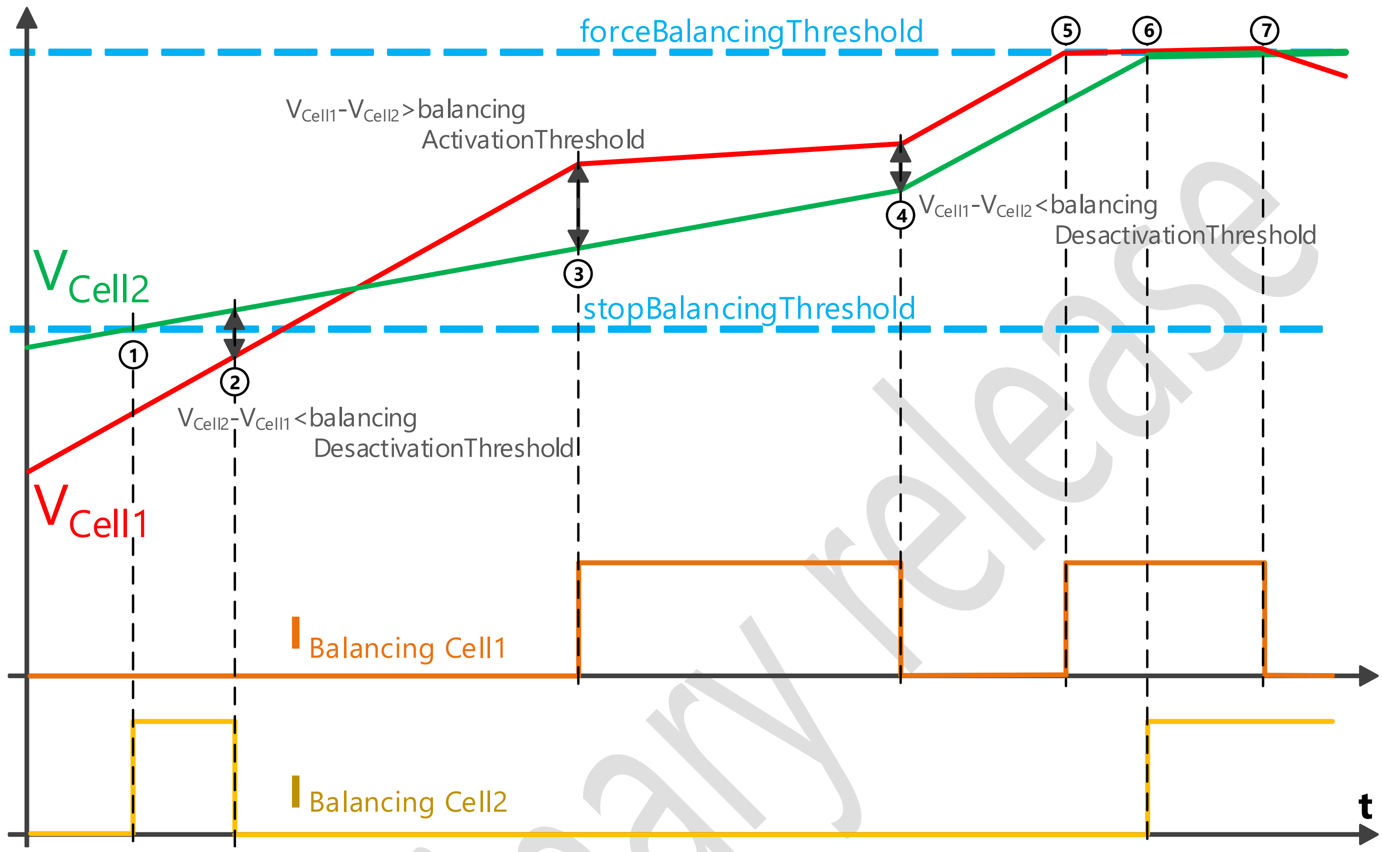


Figure 36: cell balancing - scenario example for two cells

Figure 36 shows the following events:

1. V_{Cell2} exceeds *"stopBalancingThreshold"* and V_{Cell2}-V_{Cell1}>*"balancingActivationThreshold"*, the balancing of cell2 starts.
2. V_{Cell2}-V_{Cell1}<*"balancingDeactivationThreshold"*, the balancing of cell2 stops.
3. V_{Cell1} is over *"stopBalancingThreshold"* and V_{Cell1}-V_{Cell2}>*"balancingActivationThreshold"*, the balancing of cell1 starts.
4. V_{Cell1}-V_{Cell2}<*"balancingDeactivationThreshold"*, the balancing of cell1 stops.
5. V_{Cell1} exceeds *"forceBalancingThreshold"*, the balancing of cell1 starts.
6. V_{Cell2} exceeds *"forceBalancingThreshold"*, the balancing of cell2 starts.
7. V_{Cell1} drops below *"forceBalancingThreshold"*, the balancing of cell1 stops.

5.4 Charger management

5.4.1 General description

With the configuration of some dedicated parameters, FS-XT can drive a CAN bus charger. If the charger is not CAN driven, it is still possible to drive the charge contactor to allow or not the battery charge.

The main difference between a CAN charger and a charger driven by the charge contactor lies in the end of charge management. While the CAN charger can be driven by the BMS to reduce the end of charge current or even to regulate the charging voltage, the other chargers can only operate in an "all or nothing" mode.

5.4.2 Charge contactor configuration

The following parameters are used to configure the charge contactor behavior regardless of the system configuration (single or two contactors used, CAN bus charger used or not).

Table 35: parameters for charge contactor

Name	Id	Unit	Type	Example	Range	Comment
hysteresisMaxChargeVoltage	49	mV	int	3650	0-5000	Max cell voltage allowed by the charge contactor
hysteresisMinChargeVoltage	50	mV	int	3450	0-5000	Lower voltage threshold to turn back on the charge contactor
autoEngageDuringCharge	62	-	bool	1	0 - 1	Allows the automatic re-engagement of the charge contactor at the end of discharge.

Depending on the value of "autoEngageDuringCharge", the following behavior is activated or not.

The charge contactor operates according to a hysteresis behavior. As soon as a cell voltage exceeds the parameter "hysteresisMaxChargeVoltage", the BMS turns the contactor off. When every cell voltages drop below "hysteresisMinChargeVoltage", the contactor is turned back on.

The voltage difference between these two thresholds must be chosen carefully:

- If the gap is too small, the cell relaxation after a charging phase or the cells' balancing will bring the voltages below "hysteresisMinChargeVoltage" and allow the charge contactor to be closed again,
- If the difference is too high, the cell voltage will not drop until the battery is discharged enough.

N.B.: if the charger is driven by CAN bus by the BMS, the charge contactor will normally never reach these thresholds. The BMS will drive the charger to stop or restart the charge before these thresholds are reached in order to reduce the number of contactor manipulations.

5.4.3 CAN bus charger configuration

If the selected charger can communicate with the BMS through CAN communication, FS-XT can drive the current and voltage used to charge the battery.

N.B.: only CAN charger from the manufacturer "TC Charger", and few other references, are supported. Contact Freemens to know if a specific CAN charger is supported or if a custom development will be required.

Table 36: charge parameters for CAN charger

Name	Id	Unit	Type	Example	Range	Comment
maxVoltageChargerCB	51	V	float	54.0		Battery charging voltage
maxCurrentChargerCB	52	A	float	30.0		Battery charging current

"maxVoltageChargerCB" and "maxCurrentChargerCB" are the charging voltage and the charging current that the BMS sends to the charger.

To minimize the number of manipulations on the charge contactor (and so, to maximize its life span), the CAN charger is also driven on or off on hysteresis cell voltage based on the parameters based shown on *Table 35* p*40*:

- Max charge cell voltage allowed by CAN charger = Max cell voltage allow by the charge contactor – 10mV
- Low voltage threshold to restart the CAN charger = Low voltage threshold to drive the charge contactor

After a cell reaches the "hysteresisMaxChargeVoltage" threshold, the charging current is set to 0 until the "hysteresisMinChargeVoltage" voltage is reached. The charge restarts, but the charging current is divided by 2 and the process is repeated until the charging current is divided to reach 1A (if the current gets under 1A it will be set to 1A).

5.4.4 Charging process

The following figure presents an example of voltage evolution of two cells during a charge. The voltages depicted on this figure are not voltage evolution of real cells but a representation to illustrate the charging process with a CAN capable charger.

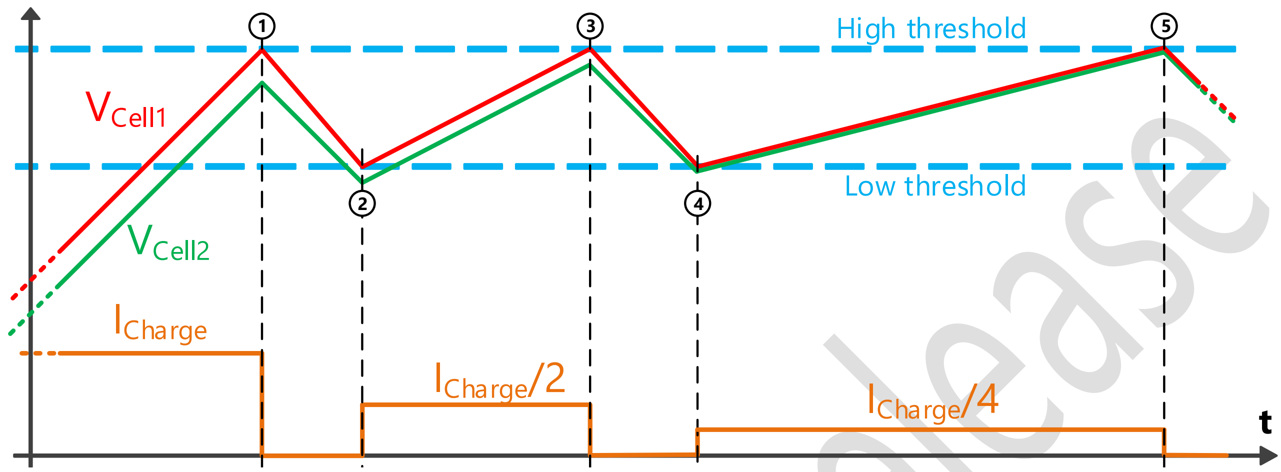


Figure 37: Charging process - scenario example for two cells

Figure 37 shows the following events:

1. V_{Cell1} reaches the high threshold, the charge stops.
2. V_{Cell1} & V_{Cell2} drop below the low threshold, the charge restart.
3. V_{Cell1} reaches the high threshold, the charge stops.
4. V_{Cell1} & V_{Cell2} drop below the low threshold, the charger restart.
5. V_{Cell1} & V_{Cell2} reaches the high threshold, the charge stops.

Depending on the presence of a CAN charger or not, the stopping and restarting events are performed by piloting the CAN charger or by opening/closing the charge contactor.

If the selected charger is CAN capable, the BMS will change the charging current (it divides the current by 2) after each restart. Else, the charging current is completely controlled by the charger.

During each relaxation phase (after the charge stops and before it restarts), as the BMS is balancing the cells, V_{Cell1} has a quicker voltage drop than V_{Cell2}. If there is no activity during the relaxation phase and all the conditions are reached, the BMS can enter its sleep mode after “sleepActivationTimer” seconds and the charge is ended.

5.5 SOC calibration

5.5.1 Operation principle

The State of Charge is mainly calculated by coulomb counting: the BMS integrates the current value over the time.

The method is sensitive because of the sensor measurement errors: for instance, a 1A offset error on the current measurement will make the BMS increase the SOC by 1A.h every hour, regardless of the battery usage. In reality, most of the current sensor ensure a 1% precision measurement error, so the SOC drift is maintained at a low level, but it still exits.

To eliminate this drift, the BMS wait for the end of a complete battery discharge or charge to calibrate the SOC. It is set at 0% at the end of the discharge and to 100% if the conditions are met at the end the charge.

5.5.2 Voltage calibration threshold

“SOCMaxRecalibrationThreshold” and “SOCMinRecalibrationThreshold” are the thresholds used to set a SOC recalibration. Default values recommended for LiFePO4 batteries are shown in the next table.

Table 37: SOC calibration voltage thresholds

Name	Id	Unit	Type	Example	Range	Comment
SOCMaxRecalibrationThreshold	31	mV	int	3640	0-10000	Cell upper voltage threshold used to force an end of charge SOC
SOCMinRecalibrationThreshold	32	mV	int	2600	0-10000	Cell lower voltage threshold used to force 0% SOC
currentSOCCalibrationThreshold	60	A	float	1		Current threshold over which no calibration can be done

End of discharge recalibration

As soon as a cell reaches the lower threshold "SOCMinRecalibrationThreshold", the SOC is set to 0%.

End of charge recalibration

To force a recalibration of the **SOC at 100%**, **two conditions** must be filled. First, all the cells voltages must **exceed the "SOCMaxRecalibrationThreshold" threshold**. Second, the **average charging current** during the last minute must be **under "currentSOCCalibrationThreshold" threshold**.

When the upper voltage threshold for recalibration is reached, if the current is higher than the current threshold set in the "currentSOCCalibrationThreshold" parameter, the BMS recalibrates the SOC according to the current rate. For instance, if a $LiFePO_4$ battery is charged at 1C current rate, when the threshold is reached the SOC is set at about 90%.

If the battery goes in successive charging phases, the coulomb counting can continues to increments the SOC. In this case, the SOC cannot exceed 99% and will be locked at this value until the 100% recalibration conditions are reached or until the battery enters a discharging phase.

5.6 Voltage thresholds summary and recommendations

There are 6 high level voltage thresholds and 2 low level voltage thresholds. Their value must be set to appropriate and coherent values (some thresholds **MUST** be greater or lower than other thresholds) in order to ensure an optimal BMS operation.

The following figure shows the order that must be respected on the voltages thresholds.

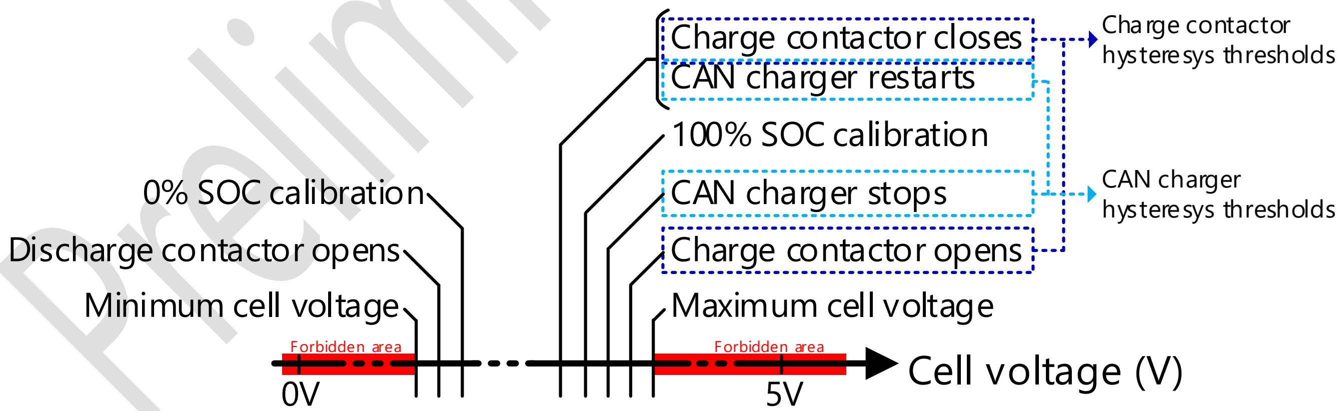


Figure 38: voltage thresholds order

As long as the voltage thresholds are kept in the order presented on Figure 38, they can be set to any value between 0V and 5V.

The voltage threshold of the CAN charger are more tightened than the voltage threshold of the charge contactor in order to force the CAN charger to stop before a contactor manipulation is needed. In the case a CAN charger is present, these thresholds limit the contactor maneuvers and maximize its life span.

The voltage thresholds for driving the CAN charger are directly defined from the charge contactor thresholds:

- Max charge cell voltage allowed by CAN charger = Max cell voltage allow by the charge contactor – 10mV
- Low voltage threshold to restart the CAN charger = Low voltage threshold to drive the charge contactor

The next table is an example for $LiFePO_4$ cells.

Table 38: voltage thresholds example for $LiFePO_4$ cells

Name	Id	Unit	Type	Example	Range	Comment
overVoltageThreshold	29	mV	int	3700	0-5000	Maximum cell Voltage. Over voltage threshold
hysteresisMaxChargeVoltage	49	mV	int	3650	0-5000	Max cell voltage allow by the charge contactor
SOCMaxRecalibrationThreshold	31	mV	int	3635	0-5000	Cell upper voltage threshold used to force 100% SOC
hysteresisMinChargeVoltage	50	mV	int	3450	0-5000	Low voltage threshold to turn back on the charge contactor
SOCMinRecalibrationThreshold	32	mV	int	2600	0-5000	Cell lower voltage threshold used to force 0% SOC
endOfDischargeThreshold	61	mV	int	2550	0-5000	Low voltage threshold to open the discharge contactor
underVoltageThreshold	30	mV	int	2500	0-5000	Minimum cell voltage. Under voltage threshold

6 Power Line management

6.1 Prerequisites

6.1.1 General description

To manage the power line, FreeSafe Extended requires some basic peripherals and a valid configuration file on its SD card. These peripherals allow FS-XT to connect or disconnect the battery and its application (charge and/or discharge) while the configuration parameters set its behavior.

6.1.2 Power peripherals

General description

The connector n°6 (power outputs) can drives up to 4 distinct power peripherals: 3 outputs are dedicated to contactors (pre-charge, discharge, charge) and the last output is for a driving a fan system. For any other need, a firmware customization will be required, contact Freemens.

As shown on Figure 39, these power outputs use the external DC source of FS-XT to supply the power peripherals. The voltage of the external source must be compatible with the power peripherals. The maximum pulse current per output is 15A. The maximum continuous current per output is 2.1A (or 3.75 if only one output is used). Following these recommendations ensures the proper use of FS-XT and its functions.

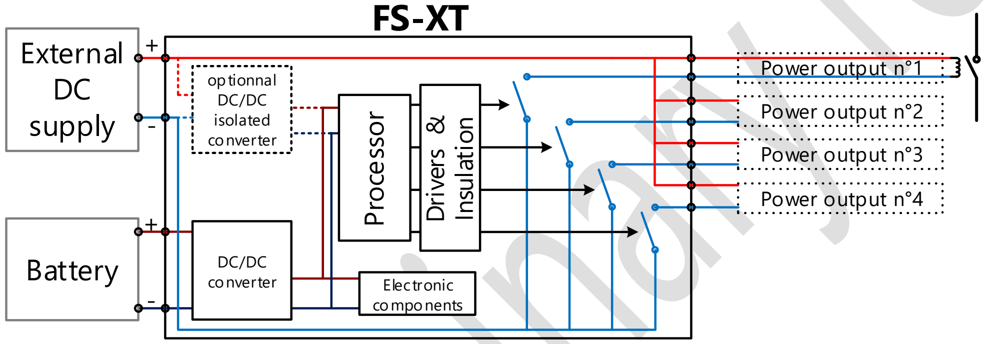


Figure 39: Functional diagram of the 4 DC power outputs and their supply

Table 39: Power outputs current capabilities

Number of used outputs	Max current per output (A)	
	Continuous	Peak for 100ms
1	3.75	15
2, 3 or 4	2.1	15

Contactors. Roles and wiring.

FS-XT can drives up to 3 distinct contactors, each of them as a specific role. They are connected on the connector n°6 as describe below. If a customization on the connections is required, contact Freemens for a custom Firmware.

- Pre-charge contactor. Connected on C1+ & C1-, it allows FS-XT to drives a pre-charge circuit. See *Pre-charge resistor design choices* p95 for more details about the need of a pre-charge circuit.
- Main power contactor. Connected on C2+ & C2-, it is the main contactor that (dis)connect the battery and its application.
- Charge contactor. Connected on C3+ & C3-, it manages the charge circuit.

N.B.: the contactors must be chosen to sustain the nominal voltage and current of the battery and its application. See *Contactor design choices* p94 for more details about the contactors design choices.

N.B.²: the pre-charge and charge contactors may be optional depending on the specifications of the battery and its application. There is no required action on the BMS to acknowledge the presence/absence of these contactors.

Pre-charge contactor configuration

In the configuration, there is one parameter concerning the pre-charge delay:

Table 40: pre-chare contactor delay configuration

Name	id	Unit	Type	Example	Range	Comment
powerOutputPrecharge	55	0.1s	int	10	0-32766	Pre-charge duration in 1/10th of seconds

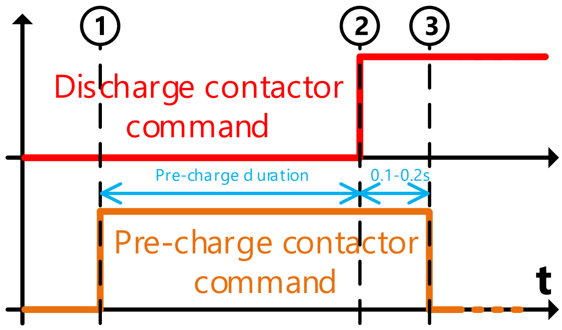


Figure 40: pre-charge contactor command principle

Figure 40 shows the following list of events:

1. The control signal send an order to turn on the power contactor. The pre-charge contactor is closed.
2. After the pre-charge duration set by "powerOutputPrecharge", the power contactor is closed.
3. After an internal delay of 100 to 200ms, the pre-charge contactor is turned off.

Fan

The last output on connector n°6 (C4+ & C4-) is used for driving fan(s). They are optional and are turned on or off depending on the thermal parameters in the configuration file of the BMS. If one of the NTC temperatures reaches "fanActTempThreshold", the fan is turn on. It is turned off when the temperatures drop under "fanDeactTempThreshold".

The parameter "fanSourceTrigger" selects the temperature sensor that are used as the temperature source for driving the fan. "fanSourceTrigger" can has the following value:

- 0: no source is selected, the fan will not be driven regardless of the temperatures.
- 1: the external sensors (NTC temperatures) are selected as source.
- 2: internal sensors (onboard temperatures) are selected as source.
- 3: both external and internal sensor are selected.

Table 41: configuration parameters for fan regulation

Name	Id	Unit	Type	Example	Range	Comment
fanActTempThreshold	56	0.1°C	int	450	-	Fan activation threshold
fanDeactTempThreshold	57	0.1°C	int	400	-	Fan deactivation threshold
fanSourceTrigger	58		int	1	0-3	Define the threshold source for the fan

6.1.3 Sensor and control peripherals

Current sensor

A current censor is required to measure the power current. It is used to protect the battery and its application, and also to estimate some state indicators such as the State of Charge (SOC) or the State of Health (SOH) of the battery. Wired on connector n°3, it uses the 5V onboard supply and returns its measurement (a voltage between 0 and 5V) to FS-XT.

There are four parameters to configure for ensuring a good use of the current sensor by FS-XT: the measurement sensitivity, the measurement offset, the noise level and the measurement convention. By default, the convention measurement is set to 0 and expects the sensor to be wired to measure the charging current as positive current and the discharging current as a negative current. If the position is inverted, the parameter must be set to 1.

See *Hall Effect current sensor design choices* p*96* for more details and examples

Table 42: configuration parameters for current sensor

Name	Id	Unit	Type	Example	Range	Comment
currentSensorSensitivity	45	mV/A	float	12.5	-	Current sensor sensitivity
currentRef	46	-	int	2048	-1 to 4096	Reference value for 0A current
noCurOffsetThreshold	47	A	float	0.5	-	Noise current threshold.
currentMeasConvention	39	-	bool	0	0 or 1	Current measurement convention.

Tuning of the Hall Effect current sensor

The configuration file in the memory card of FreeSafe contains parameters enabling a fine tuning of the current measurement:

- The measurement sensitivity of the sensor (mV/A). It can be found in the manufacturer's datasheet.
- The offset of the measurement chain. Set to -1, it allows FS-XT to automatically measure and calibrate the 0A reference when all the contactors are opened. Set to a value between 0 and 4096, it forces FS-XT to use $'\frac{\text{currentRef}}{4096} \cdot 5V'$ as the voltage reference for the 0A current.
- The parameter "noCurOffsetThreshold" is a level used to filter very low current values (typically under 1% of the nominal current) that can be subject to noise measurement perturbations. Any current (charge or discharge) under this threshold is considered as a 0A current.
- The measurement convention. The default convention for the current measurement of FS-XT is to count positively the current that charge the battery and negatively the current that discharge the battery. If the sign of the current measurement does not match to the convention that the current charging the battery has to be positive, there are two solutions. First, the current sensor can be re-wired so that the current flows into the sensor in the right sense. Second, the parameter "currentMeasConvention" in the configuration file can be set to 1 to fit the convention.

Input signal for controlling the contactors' states

The isolated input IN0 on the GPIO connector (connector n°3) can be used to control the state of the contactors. Usually it is a switch button that generates this signal, but it can also be the digital output of an external control unit. The expected signal on IN0 is described in *Control signal for contactors states* p62.

6.2 Current protection thresholds

6.2.1 General description

There are two main parameter sets for the configuration of the protections thresholds. One is dedicated to the cell voltages and thermal management (see the *Configuration section* p35 of the chapter *Cells management*), the second is the power line management described in the section below.

The main goal of these parameters is to define the operating limits for the normal running mode (current under its nominal value), the short allowed overload (overcurrent) and the hard limit current (maximum instantaneous current).

6.2.2 Current management configuration

These parameters, found and set in the configuration file on the SD card of the BMS, define the overcurrent and short-circuit limits. Extra care must be taken when modifying these parameters. If these thresholds are reached, FreeSafe Extended will drive the contactors off to cutoff the battery from the application/charger.

Table 43: Current management configuration

Name	id	Unit	Type	Example	Range	Comment
positiveShortCircuitThreshold	40	A	float	250	-	Positive instantaneous current limit
negativeShortCircuitThreshold	41	A	float	-250	-	Negative instantaneous current limit
currentChargeNominal	43	A	float	50	-	Positive nominal current
currentDischargeNominal	44	A	float	-100	-	Negative nominal current
deltaI2t	42	$A^2.s$	float	25000	-	I^2t value used to define the overcurrent limits. Typical value calculated with $(I^2_{DischargeOvercurrent}-I^2_{DischargeNominal}).t_{overcurrent}$

6.3 Operating modes and current management

6.3.1 Normal mode

After the first connection or after exiting the power saving mode, if no action on the battery (communication or current consumption for example) is detected during "sleepActivationTimer" seconds, FreeSafe Extended enters in a power saving mode and the 4 power outputs are turned off to save energy and for security. To exit the power saving mode or to reset "sleepActivationTimer", a high level logic input on the isolated input IN0 is required. See *Control signal for contactors states* p*62* for more details about the control signal used on the isolated input IN0.

When the battery is in its normal operating mode, any current can be applied to charge or discharge it. The BMS runs the operating mode for the current management as following:

- Every 400µs the current is measured and the BMS checks if it exceeds the maximum current limits ("positiveShortCircuitThreshold" or "negativeShortCircuitThreshold"). If no limit is reached, it stay in normal mode, else it enters the short circuit management (see §*6.3.2*).
- Every 100ms, all the previous current measurement performed each 400µs are collected to be integrated. The result is the average current of the last 100ms. It is used for coulomb counting and for detecting the presence of an overload to enter the overcurrent management (see §*6.3.3*).
- Every 1s, the complete state of the battery (including current measurement, coulomb counting and fault detection) is transmitted over the external isolated CAN bus and updated on the SD card.

6.3.2 Short circuit (i.e. hard current limit) management

The parameters "positiveShortCircuitThreshold" or "negativeShortCircuitThreshold" set the positive and negative hard current limit. Beyond these limits, FS-XT instantaneously opens the contactors to protect the system.

The response time of this protection depends on two elements: the response time of the current sensor chain and the response time of the contactors.

- Response time of the Hall Effect sensor. If the selected device has similar characteristics to the ones proposed in this document (see *Peripherals* p*26* or the chapter *Design guide for the BMS and its peripherals* p*90* for example), it will be <10µs – they have a measurement bandwidth of at least 100 kHz.
- Response time of the analog to digital conversion and processor decision management. It will be less than 400µs as the whole process is calibrated to work at 2.5 kHz in its slowest configuration.
- Response time of the power DC contactor. The typical release time of electromechanical contactors is about 10ms.

After detecting a hard current limit exceeded and opening the power DC contactor, FS-XT waits for the control signal to send a turn on order to re-engage the power contactors and resume its operation.

6.3.3 Overcurrent (i.e. soft current limit) management

In this paragraph, to facilitate the writing of the equation, some parameters are named as following:

- I_{DSGnom} is the nominal discharge current
- I_{CHGnom} is the nominal charging current
- I_{oc} is a discharge overcurrent limit
- t_{oc} is the overcurrent allowed time for I_{oc}
- I_{DSGsc} is the short circuit limit in discharge
- I_{CHGsc} is the short circuit limit in charge

General description

The overcurrent management is based on a thermal approach. Knowing the nominal current (i.e. thermally stable) of the system and an allowed overcurrent for a defined time, the BMS can operate with an I^2t principle.

In the configuration file, there are 3 parameters used for the overcurrent management: "deltaI2t", "currentChargeNominal" and "currentDischargeNominal".

"currentChargeNominal" is used to define the reference current in discharge (i.e. a thermally stable operating point) over which the overcurrent current process is engaged. This reference can be the nominal discharge current of the battery itself or the nominal current of its application.

"currentDischargeNominal" has the same role for the charging current.

"deltaI2t" is the I^2t value used by the BMS to manage the overcurrent events. It is defined in *Equation 2*.

Example of "deltaI2t" definition and overcurrent values

Equation 2: "deltaI2t" definition

$$deltaI2t = (I^2_{DischargeOvercurrent} - I^2_{DischargeNominal}).t_{overcurrent} = (I^2_{ChargeOvercurrent} - I^2_{ChargeNominal}).t_{overcurrent}$$

For $I_{DischargeNominal}$=100A, if the system allows $I_{DischargeOvercurrent}$=150A for $t_{overcurrent}$=10s, it means deltaI2t = 125000. It also means that, for $I_{ChargeNominal}$=20A and $t_{overcurrent}$=10s, the allowed overcurrent in charge is $I_{ChargeOvercurrent}$=112A.

Mathematical description for overcurrent detection

This paragraph focuses its description only on the discharge case. In charge, the operation is similar and uses deltaI2t with the charge nominal current.

The overcurrent management follows an I^2t logic. From the reference $deltaI2t = ({I_{oc}}^2 - {I_{DSGnom}}^2) \cdot t_{oc}$, it is possible to determine the maximum allowed time t for any continuous current I with $(I^2 - {I_{DSGnom}}^2) \cdot t = deltaI2t$.

The next paragraph shows an example to support the comprehension.

For non-constant real current, the I^2t logic is still followed by the implemented of an integral method. It consists on the integration of the difference between the nominal reference and the measured current over time. As soon as the integrated value reaches $deltaI2t$, the contactors are opened.

Resuming the operation after an overcurrent

Once the contactors are opened, as the measured current drops back to 0A, the integrated value "$(I(t)^2 - {I_{DSGnom}}^2) \cdot t$" decreases over time. As it reaches 0, the contactors are allowed to be turned back ON and the BMS normal operation is resumed.

The time to resume t_{resume} the normal operation is $t_{resume} = \frac{deltaI2t}{I^2_{DSGnom}}$

Example of hard and soft current limit management

For this example, a battery with the following parameters is defined:

Table 44: value examples of current parameters

Name	Value
positiveShortCircuitThreshold	100
negativeShortCircuitThreshold	200

Name	Value
currentChargeNominal	20
currentDischargeNominal	100
deltaI2t	125000

deltaI2t is defined from : I_{DSGnom}=**100A**, I_{oc}=**150A**, t_{oc}=**10s**. The other parameters values are I_{CHGnom}=**20A**, I_{CHGsc}=100A and I_{DSGsc}=200A. With these parameters, FS-XT can manage the overcurrent according to the explained method. For any constant current, the behavior of FS-XT is resumed on the curves on the following *Figure 41* and *Figure 42*:

- Any current I between the nominal currents (I_{DSGsc}<I<I_{CHGnom}) can operate for an infinite time as the system is thermally stable. On the figures, it is the safe operating area in blue.
- Any current between "positiveShortCircuitThreshold" and "currentChargeNominal" (or between "negativeShortCircuitThreshold" and "currentDischargeNominal") can be maintained for a short amount of time. It is the overcurrent management area in red on the next curves. For instance, a 110A discharge current (10%

over the discharge nominal) is allowed for 60s while a 175A discharge current (75% over the nominal) is allowed for only 6s. This red curves are defined from I_{DSGnom}, I_{CHGnom} and "deltal2t" parameters:

$I_{DSGlimit}(t) = \sqrt{\frac{deltaI2t}{t} + I_{DSGnom}{}^2}$ for the discharge and $I_{CHGlimit}(t) = \sqrt{\frac{deltaI2t}{t} + I_{CHGnom}{}^2}$ for the charge.

- Any current over the hard current limits ("positiveShortCircuitThreshold" and "negativeShortCircuitThreshold") is directly in the forbidden area where the DC contactors are instantaneously opened.

The delay to resume the normal operation after an overcurrent is $t_{resume} = \frac{deltaI2t}{I_{DSGnom}^2} = 12.5s$.

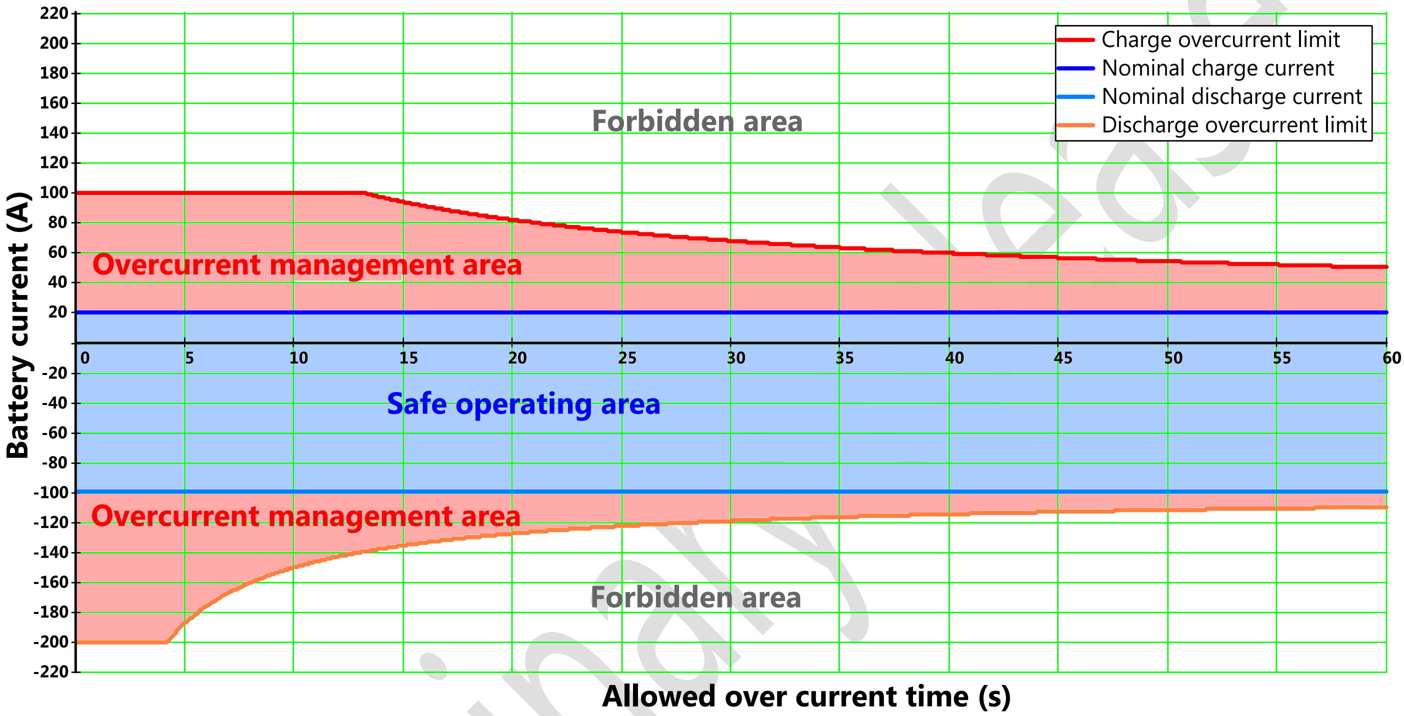
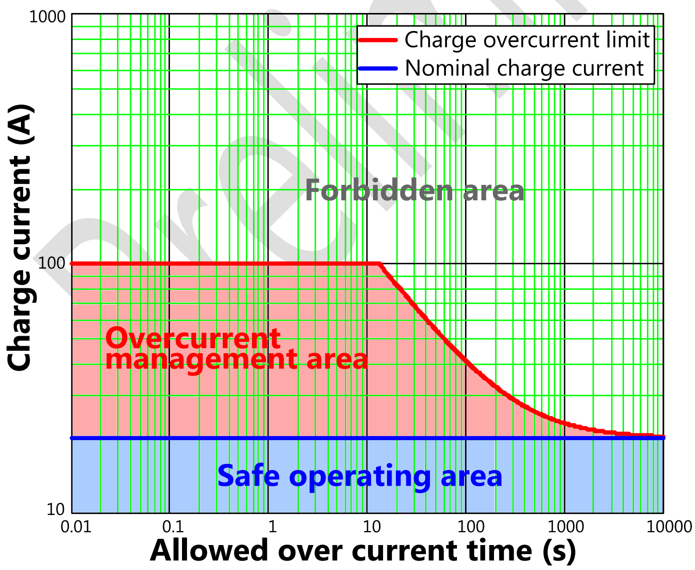
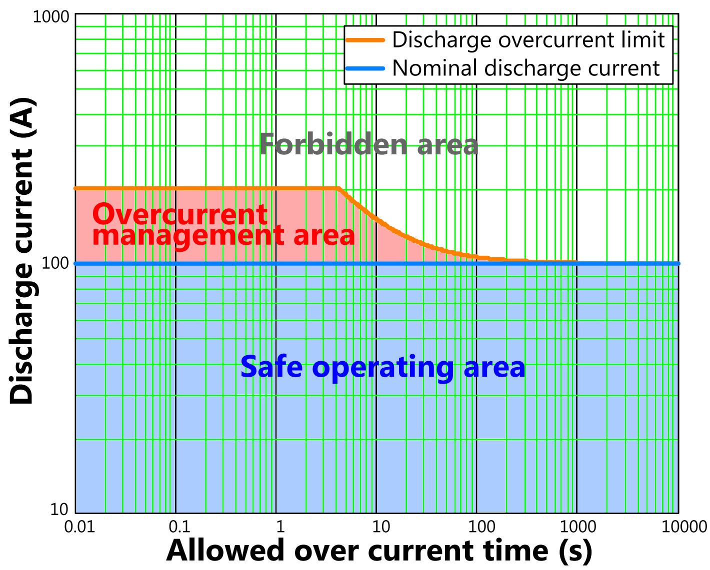


Figure 41: Example of overcurrent management curves for constant current



Charge



Discharge

Figure 42: Example of overcurrent management curves for constant current (log scales)

6.3.4 Fault management process

Whenever a fault is detected (e.g. overvoltage or overcurrent), a fault management is started and the supply of all the contactors coils is cut off to force them in their opened state to protect the battery and its application. The BMS emits an error code from the isolmated output OUT0 (see *State indicator signal* p63 for more details). There are then two possible answers for the fault management process:

- The BMS automatically restart the contactors as soon as the error is cleared. This automatic restart is only available for non-critic errors.
- The BMS waits for an order from the control signal (see *Control signal for contactors states* p62) to exit its error state and close the contactors.

For all the error types, as soon as the error conditions are cleared, the contactors can be turned back ON. The description and management of the all the faults are described in the dedicated chapter *Fault management* p65.

6.4 Operation with a single power switch

6.4.1 General description

In this document everything is described for the standard configuration with two power switches: one for the charge and one for the discharge. It is possible to operate with a single power switch with small changes in the system operation.

Configuration

To disable the dedicated charge contactor and to allow a single contactor operation, the parameter "dissociateChargePowerLine" in the configuration file must be set to 0.

Table 45: charge contactor usage configuration

Name	id	Unit	Type	Example	Range	Comment
dissociateChargePowerLine	3	-	bool	0	0-1	0=no charge contactor, 1=the system uses a dedicated charge contactor.

Contactor wiring

The wiring of the power output used to drive the contactor are the same as described in p. the only difference is on the charge contactor wiring: this contactor is not connected.

Table 46: power I/O connector (n°6) wiring for the one power switch operation

Pins	Description	
1	C1+ - power output 1 positive terminal	Used for pre-charge contactor – **Optional, it depends on the need of a pre-charge**
6	C1- - power output 1 negative terminal	
2	C2+ - power output 2 positive terminal	Used for main discharge contactor
7	C2- - power output 2 negative terminal	
3	C3+ - power output 3 positive terminal	Used for charge contactor – **Unused**
8	C3- - power output 3 negative terminal	
4	C4+ - power output 4 positive terminal	Used for fan - **Optional**
9	C4- - power output 4 negative terminal	
5	+VExt – External DC source positive terminal	
10	-VExt – External DC source negative terminal	

Security management

Instead of having the security managed by the two contactors, all the events are managed by only one power switch. It means the use of the battery is less flexible in its security management.

For instance, in case of an under voltage with the standard two contactors installation, the discharge contactor will be turned OFF while the charge contactor will remain in the ON state to allow a recharge at any given time without constraint. In a single contactor installation, the circuit will be totally open: the only ways to recharge the battery is to wait for the error to clear by itself or to engage the override under voltage mode described in the next paragraph.

There is the same need for an override mode at the end the charge phase: if a cell voltage gets over the end of charge voltage threshold, the contactor will be kept open and there is no way to discharge the battery but to wait for the voltage to naturally drops back under the low hysteresis threshold of the charge voltage. See *Voltage thresholds summary and recommendations* p*42* for more details about the cell voltages thresholds.

6.4.2 Override mode for over discharged battery

Description

In case one or more battery cells have a voltage under the "endOfDischargeThreshold", the only power contactor will be opened by the BMS in order to secure the battery and to prevent any further discharge that may lead the cells to an under voltage error.

This can happen for instance when the battery has been fully depleted and has not been recharge before being stored: the cell auto discharge and the BMS consumption, although their value are extremely small (few hundreds of µA), can maintain the cell voltages permanently under "endOfDischargeThreshold". In order to allow the battery to be recharged, the override mode will allow the power contactor to be closed. In this mode, after few seconds of inactivity or if there is a current discharging the battery, the BMS will opened the contactor to ensure the battery safety.

In case the battery is in under voltage error, i.e. a cell voltage is under the "underVoltageThreshold", no override is available and an external intervention is required.

Usage conditions

When one or more battery cells have a voltage under the "endOfDischargeThreshold", the standard action on the control signal (see *Control signal for contactors states* p*62*) is required to enter the override mode. During the override mode, the contactor will be driven OFF as soon as one of the following conditions is reached:

- there is no charging current during a full 10s period,
- there is a discharging current over 2% of the nominal discharge current.

During the override mode, the state indicator signal (see *State indicator signal* p*63*) will generate a 200ms period square signal permanently.

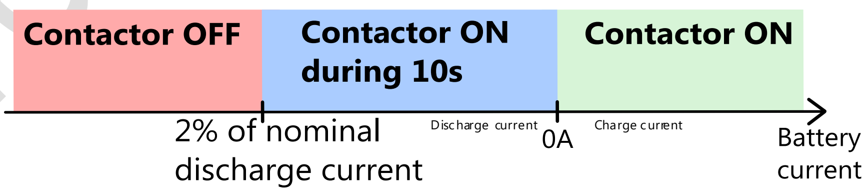


Figure 43: current and time threshold for maintaining the contactor ON during the override mode

Security against misuses

In override mode, if a current is drawn from the battery or if there is no activity, the contactor is driven OFF as soon as possible. However, if nothing prevents it, the override mode can be entered again and again by a command sent through the control signal. If each time a small amount of charges is drawn from the battery, the over discharge can only get worse.

To prevent this phenomenon, the override mode can only be activated successively 3 times. After the third time, the use of the override mode is locked for 60s. Once this 60s cool down is over, the override mode can be activated again once before been locked again for the next 60s in case of misuse.

6.4.3 Override mode for over charged battery

It is similar to the override mode for an over discharge battery. In case one or more battery cells have a voltage over the "hysteresisMaxVoltageCharge" threshold, the only power contactor will be opened by the BMS in order to secure the battery and to prevent any over charge that may lead the cells to an overvoltage error.

In case the battery is in overvoltage error, i.e. a cell voltage is over the "overVoltageThreshold", no override is available and an external intervention may be required.

The usage condition and the security against misuses are the same as the ones described in the previous paragraph.

6.4.4 End of charge management and override

The end of charge behavior described in *Charger management* p*39* is not replicated for safety issues. As there is only one contactor and so one current path, there is no guaranty that the battery is not connected to its application during the charge: an automatic closing of the contactor can lead to a non-controlled behavior of the devices that are connected back to the battery.

In the single contactor operating mode, as soon as the end of charge voltage threshold ("hysteresisMaxVoltageCharge") is reached, the contactor is opened.

If there is a cell voltage over "hysteresisMinVoltageCharge", the standard action on the control signal force the BMS to close the contactor and to enters an override: only a battery discharge is allowed, any charging current will stop the override mode and the contactor will be opened.

As soon as all the cell voltage drop back under "hysteresisMinVoltageCharge", the BMS leaves the override mode for the normal operating mode and a charging phase is allowed again.

6.4.5 Voltage thresholds summary in single contactor mode

The voltage thresholds on the next figure are the same as the ones presented in *Voltage thresholds summary and recommendations* p*42*. The only difference is the presence of the override mode at the end of the charge and end of discharge thresholds.

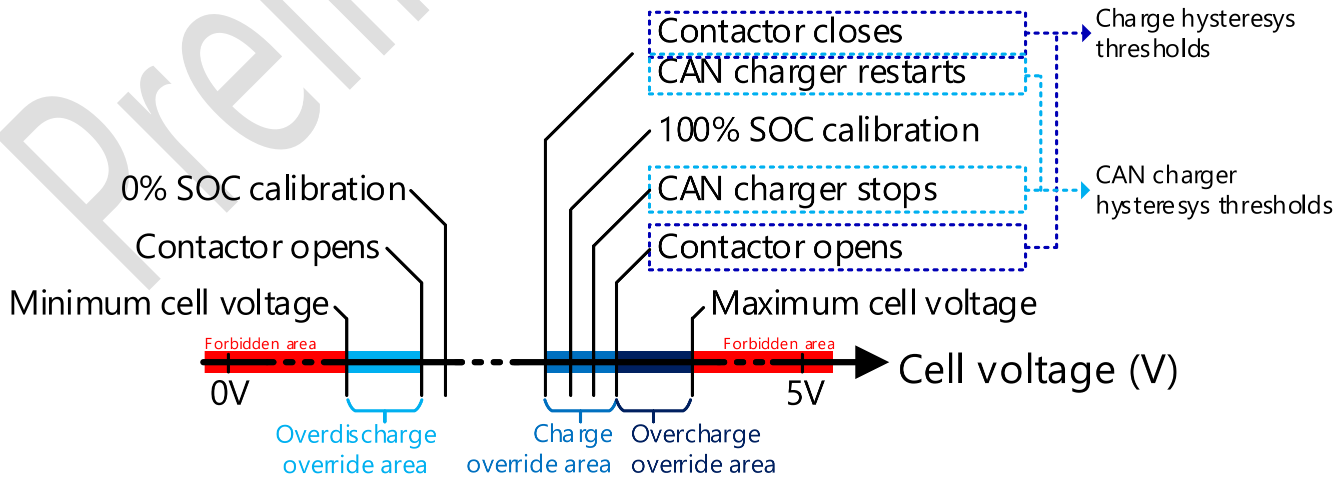


Figure 44: voltage thresholds and override areas in single contactor mode

7 Interfaces: CAN, Wi-Fi, isolated I/O

7.1 External CAN communication

This section exclusively cover the use of the external isolated CAN bus as the other CAN connector is dedicated to Freemens products usage only.

7.1.1 Recommendations for connecting and operating the external isolated CAN bus

Connections recommendations

The complete details are available in *CAN connector for isolated CAN* p*15* and in *Connection of FreeSafe CAN buses* p*20*.

The main recommendations are the following ones:

- The isolated external CAN bus is designed to be primarily used with an external 5V supply. FS-XT 5V onboard supply can be used, but at the cost of the insulation. See §*3.3.2*.
- Two 120Ω terminal resistors are need at each end of the bus to ensure noise immunity for the CAN operation. FS-XT already has a 120Ω resistor that can be connected (or not) with a 2.54mm jumper. See §*3.3.2*.

Operation recommendations

The continuous usage of this CAN bus can lead to change in the sleep mode entering conditions and sleep consumption.

- If there is several devices communicating on the CAN bus, FS-XT will be kept awake (or awaken if previously in sleep mode) each time a frame is exchanged to check if the message is addressed to itself or not.
- If there is no communication, the BMS will enter its sleep mode. **If the 5V supply is maintained, the power consumption of FS-XT in sleep mode will be increased by 1.8mA** (typical value) as the CAN bus module of the BMS will be continuously supplied.

To ensure an optimal sleep mode power consumption, it is recommended to deactivate the 5V supply on the external CAN bus when it is not needed.

7.1.2 General description

Operating mode

The external CAN bus operates under a default broadcast mode. Each second the BMS emits a message containing all the data described in the paragraph *Broadcast messages list* p*54*. A "keep alive" message can be sent periodically to the BMS to explicitly prevent it to enter its sleep mode and force it to continue to broadcast messages (see *Keep alive message* p*56*).

The CAN bus frequency is set at **250Kbps** by default.

The parameter "ExtCanIdType" (id n°65) configure the address type of the CAN bus. Set to 0, it operates with extended ID (see §*7.1.3* for message details in extended ID mode). Set to 1, it operates with short standard ID (see §*7.1.5* for message details in short ID mode).

For any other operating mode or another bus frequency of the external CAN bus, a custom development or configuration will be needed: contact Freemens for more details.

CAN bus details: extended data frame message

FreeSafe Extended uses the **SAEJ1939 Standard**. This standard is based on the 2.0B physical layer and transmits "**Extended Data Frame**" messages.

Table 47: CAN 2.0B Message Frame

SOF (1 bit)	ARBITRATION (32 bits)	CONTROL (6 bits)	DATA (0-64 bits)	CRC (16 bits)	ACK (2 bits)	EOF (7 bits)

Table 48: CAN 2.0B Message Frame (detailed)

	Field	Size (bits)	Description	Default
ARBITRATION	ID	11	Message identifier (part 1)	
	SRR	1	Substitute remote request	1
	IDE	1	Identifier Extension	1
	Ext ID	18	Message identifier (part 2)	
	RTR	1	Remote Transmit Request	0
CONTROL	RB0	1		
	RB1	1		0
	DLC	4	Data length code	
DATA	DATA	DLC*8	Data bytes	
CRC	CRCS	15	CRC	
	CRCD	1	CRC Delimiter	
ACK	ACKS	1	Used for receiver to ACK msg. Sent as recessive.	
	ACKD	1	ACK Delimiter	
EOF	EOF	7	End of Frame. Sent as recessive	

Table 49: SAE J1939 Message Frame Identifier

<table>
<tr><th colspan="4">ID</th><th></th><th></th><th colspan="3">Extended ID</th><th></th></tr>
<tr><td rowspan="2">Priority
(3 bits)</td><td rowspan="2">R
(1 bit)</td><td rowspan="2">DP
(1 bits)</td><td>PF (<7:2>)</td><td>SRR</td><td>IDE</td><td>PF (<1:0>)</td><td rowspan="2">PS
(8 bits)</td><td rowspan="2">SA
(8 bits)</td><td rowspan="2">RTR</td></tr>
<tr><td colspan="4">(8 bits)</td></tr>
</table>

	Values	Description
Priority	0 - 7	8 priority levels. 0 : highest, 7 : lowest
Reserved	0	0 is mandatory
Data Page	0 - 1	Page format selection. Stays at 0 for our internal protocol
PDU Format (PF)	0 - 255	Message type
PDU Specific (PS)	0 - 255	If PF > 240(0xF0): the message is a broadcast, PS will be used as PF extension. Si PF < 240(0xF0): the message is peer to peer, PS will be used as destination address.
Source Address (SA)	0 - 255	Source address of controller application

The resulting ID will be as follow:

<table>
<tr><th colspan="6">ID</th></tr>
<tr><td>Priority</td><td>R</td><td>DP</td><td>PF</td><td>PS</td><td>SA</td></tr>
<tr><td>Priority</td><td colspan="4">PGN</td><td>SA</td></tr>
</table>

PGN (Parameter Group Number) identifies a Parameter Group. A Parameter Group defines the characteristics of a message type (PF) (Number of bytes, bytes descriptions, periodicity, priority, etc…).

7.1.3 Broadcast messages list – extended ID

The message detailed in this section are available only if the parameter “ExtCanIdType” is set to 0.

For each message, if a variable is coded on more than 1 byte, the most significant byte is transmitted first and the least significant byte is transmitted last.

Voltages messages

Table 50: essential voltages message

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value		Application Value		Resolution Signal	Unit	Note
										Min	Max	Min	Max			
Tx	Tot Voltage Msg		0x18FF01D0	extended				8	1000							
		Battery Voltage			0		4			0	100000	0	1000	1	mV	Total battery voltage
		Min Voltage			4		2			-10000	10000	-10000	10000	1	mV	Minimum cell voltage
		Max Voltage			6		2			-10000	10000	-10000	10000	1	mV	Maximum cell voltage

The BMS provides 3 voltages: the total voltage of the battery, the maximum and minimum cell voltages.

Current messages

Table 51: current message

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value		Application Value		Resolution Signal	Unit	Note
										Min	Max	Min	Max			
Tx	Current Msg		0x18FF02D0	extended				4	100							
		Battery Current			0		4			(float min)	(float max)	(float min)	(float max)	(float resolution)	A	Current measured by a 12 bits ADC

The resolution of the measured current depends on the voltage signal provided by the current sensor and on the ADC resolution of FS-XT. The voltage resolution of FS-XT is $5V/2^{12}$=1.22mV. For instance for a LEM HTFS 200-P, the current resolution is 0.195A. See *Hall Effect current sensor design* choices p*96* for more detail about the Hall Effect current sensor.

Cell temperatures messages

Table 52: cell temperatures message

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value		Application Value		Resolution Signal	Unit	Note
										Min	Max	Min	Max			
Tx	Cell Temperature Msg		0x18FF03D0	extended				6	1000							
		Max temperature			0		2			-1000	1000	-100	100	0.1	°C	Minimum NTC temperature
		Min temperature			2		2			-1000	1000	-100	100	0.1	°C	Maximum NTC temperature
		Average temperature			4		2			-1000	1000	-100	100	0.1	°C	Average NTC temperature

If the BMS manages more than 24 cells, it has slave boards providing additional temperatures sensors. The Min/Max/Average temperatures provided on the CAN bus come from the complete NTC array of “FS-XT+slaves”.

Board temperatures messages

Table 53: board temperatures message

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value		Application Value		Resolution Signal	Unit	Note
										Min	Max	Min	Max			
Tx	Board Temperature Msg		0x18FF04D0	extended				6	1000							
		Max temperature			0		2			-1000	1000	-100	100	0.1	°C	Minimum onboard temperature
		Min temperature			2		2			-1000	1000	-100	100	0.1	°C	Maximum onboard temperature
		Average temperature			4		2			-1000	1000	-100	100	0.1	°C	Average onboard temperature

If the BMS manages more than 24 cells, it has slave boards providing additional temperatures sensors. The Min/Max/Average temperatures provided on the CAN bus come from the every board in the system

Battery state messages

Table 54: battery state message

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value		Application Value		Resolution Signal	Unit	Note
										Min	Max	Min	Max			
Tx	Battery State Msg		0x18FF05D0	extended				4	1000							
		State Of Charge			0		2			0	10000	0	100	0.01	%	SOC : State of Charge of the battery
		State Of Health			2		2			0	10000	0	100	0.01	%	SOH : State of Health of the battery

Error messages

Each error message has the same format, described on the next table. The message ID depends on the error ID.

Table 55: error message

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value Min	Physical Value Max	Application Value Min	Application Value Max	Resolution Signal	Unit	Note
Tx	Error state Msg		0x18FF1nD0	extended				5	1000							n correpond to error ID (0 to 8)
		Error state			0		1			0	255	1	3			0: no error, 1 : entering error, 2: error, 3: leaving error
		Error cool down counter			1		4			0	1000000	0	1000000			remaining delay of the leaving error state before clearing error (s)

If used by the fault management process, “Error cool down counter” is a timer indicating the remaining time before the contactor can be turned back ON after the fault clearance.

The error IDs and meanings are presented on the next table.

Table 56: error IDs – extended ID mode

Error n°	Error ID	Error Type	Notes
0	0x18FF10D0	Overvoltage	
1	0x18FF11D0	Under voltage	
2	0x18FF12D0	Over temperature	
3	0x18FF13D0	Under temperature	
4	0x18FF14D0	Overcurrent	
5	0x18FF15D0	Short circuit	
6	0x18FF16D0	Battery parameter time-out	SD card not detected or monitoring error
7	0x18FF17D0	Board values up to date	Refresh error on voltage, current or temperature values
8	0x18FF18D0	Current up to date	Current sensor and digital process state

Events messages

Table 56: events message

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value Min	Physical Value Max	Application Value Min	Application Value Max	Resolution Signal	Unit	Note
Tx	State BitField Msg		0x18FF07D0	extended				3	1000							
		Power output 0 state			0	0				0	1	false	true			Current state of the power output 0 (0: OFF, 1: ON)
		Power output 1 state			0	1				0	1	false	true			Current state of the power output 1 (0: OFF, 1: ON)
		Power output 2 state			0	2				0	1	false	true			Current state of the power output 2 (0: OFF, 1: ON)
		Power output 3 state			0	3				0	1	false	true			Current state of the power output 3 (0: OFF, 1: ON)
		Isolated input 0 state			0	4				0	1	false	true			Current state of the isolated input 0 (0: OFF, 1: ON)
		Isolated input 1 state			0	5				0	1	false	true			Current state of the isolated input 1 (0: OFF, 1: ON)
		Input command start req			0	6				0	1	false	true			Power output line state request (0: do not enable, 1: enable)
		Wifi activity flag			0	7				0	1	false	true			Indicate if a Wi-Fi command has been received during the last 5s
		System running state			1	0				0	1	false	true			Operating mode of the system (1: normal running, 0: sleeping)
		Balancing flag			1	1				0	1	false	true			Indicate if one or more cells are been balanced
		Sd conf loaded flag			1	2				0	1	false	true			Indicate if the conf file is loaded
		External power supply state			1	3				0	1	false	true			Indicate if the external power supply is powered
		Isolated CAN supply state			1	4				0	1	false	true			0: isolated CAN bus not powered, 1: isolated CAN bus powered
		Isolated CAN keep alive received			1	5				0	1	false	true			Indicate if a keep alive message has been received during the last
		Sd conf file opening error			1	6				0	1	false	true			Indicate if is an error occured while trying to read SD conf file
		Sd conf file param error			1	7				0	1	false	true			Indicate if at least one of the conf file param is not correct
		Sd init flag			2	0				0	1	false	true			Indicate if the SD card is initialized
		No error detected			2	1				0	1	false	true			1: no error detected, 0: at least 1 error detected

The column “bit position” is the number of the bit (i.e. the desired error flag) in the received byte. For instance, the flag “Power output 2 state” if the on the bit n°2 in the byte n°0 of the event message.

“Power output x state” (with x = {0, 1, 2, 3}) is the state of the FS-XT output that drives the charge, discharge or pre-charge contactor or the fan.

“Input command start req” is the state of the request sent by the control signal. 0=the contactor are driven OFF, 1=the contactor are driven ON if there are no fault.

7.1.4 Keep alive message – extended ID

The keep alive message is only available in extended ID format. It can always be received by the BMS regardless of the ID configuration of the broadcast messages (extended or short).

Table 57: keep alive message

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value Min	Physical Value Max	Application Value Min	Application Value Max	Resolution Signal	Unit	Note
Rx	Keep Alive Msg		0x180AD0--	extended				0	1000							Reset the sleep activation timer

The “keep alive” message has two main uses:

- Awake the BMS through a CAN bus request
- Reset the sleep activation timer (“sleepActivationTimer” parameter) to force the BMS to stay awaken in order to maintain the data information broadcast.

This message can be sent periodically to the BMS in order to prevent it from enter in sleep mode or to awake it. If the conditions to enter sleep mode are OK, this message must be sent at least once every 2s (every 1s is recommended) to ensure the reset of the sleep activation timer and to prevent the system to enter in sleep mode after this duration.

This message does need any data to fulfill its role: as long as the ID is correct the sleep activation timer will be reset.

7.1.5 Broadcast messages list – short ID

The message detailed in this section are available only if the parameter “ExtCanIdType” is set to 1.

For each message, if a variable is coded on more than 1 byte, the most significant byte is transmitted first and the least significant byte is transmitted last.

Table 58: messages in short ID mode

Rx /Tx	Message Name	Signal Name	ID	ID type	Start Byte	Bit Position	Byte Lenght	DLC	Transmit Time (ms)	Physical Value Min	Physical Value Max	Application Value Min	Application Value Max	Resolution Signal	Unit	Note
Rx	Keep Alive Msg		0x180AD0--	extended				0	1000							Reset the sleep activation timer
Tx	Tot Voltage Msg		0x001	short				8	1000							
		Battery Voltage			0		4			0	100000	0	1000	1	mV	Total battery voltage
		Min Voltage			4		2			-10000	10000	-10000	10000	1	mV	Minimum cell voltage
		Max Voltage			6		2			-10000	10000	-10000	10000	1	mV	Maximum cell voltage
Tx	Current Msg		0x002	short				4	100							
		Battery Current			0		4			(float min)	(float max)	(float min)	(float max)	(float resolution)	A	Current measured by a 12 bits ADC
Tx	Cell Temperature Msg		0x003	short				6	1000							
		Max temperature			0		2			-1000	1000	-100	100	0.1	°C	Minimum NTC temperature
		Min temperature			2		2			-1000	1000	-100	100	0.1	°C	Maximum NTC temperature
		Average temperature			4		2			-1000	1000	-100	100	0.1	°C	Average NTC temperature
Tx	Board Temperature Msg		0x004	short				6	1000							
		Max temperature			0		2			-1000	1000	-100	100	0.1	°C	Minimum onboard temperature
		Min temperature			2		2			-1000	1000	-100	100	0.1	°C	Maximum onboard temperature
		Average temperature			4		2			-1000	1000	-100	100	0.1	°C	Average onboard temperature
Tx	Battery State Msg		0x005	short				4	1000							
		State Of Charge			0		2			0	10000	0	100	0.01	%	SOC : State of Charge of the battery
		State Of Health			2		2			0	10000	0	100	0.01	%	SOH : State of Health of the battery
Tx	State BitField Msg		0x007	short				3	1000							
		Power output 0 state			0	0				0	1	false	true			Current state of the power output 0 (0: OFF, 1: ON)
		Power output 1 state			0	1				0	1	false	true			Current state of the power output 1 (0: OFF, 1: ON)
		Power output 2 state			0	2				0	1	false	true			Current state of the power output 2 (0: OFF, 1: ON)
		Power output 3 state			0	3				0	1	false	true			Current state of the power output 3 (0: OFF, 1: ON)
		Isolated input 0 state			0	4				0	1	false	true			Current state of the isolated input 0 (0: OFF, 1: ON)
		Isolated input 1 state			0	5				0	1	false	true			Current state of the isolated input 1 (0: OFF, 1: ON)
		Input command start req			0	6				0	1	false	true			Power output line state request (0: do not enable, 1: enable)
		Wifi activity flag			0	7				0	1	false	true			Indicate if a Wi-Fi command has been received during the last 5s
		System running state			1	0				0	1	false	true			Operating mode of the system (1: normal running, 0: sleeping)
		Balancing flag			1	1				0	1	false	true			Indicate if one or more cells are been balanced
		Sd conf loaded flag			1	2				0	1	false	true			Indicate if the conf file is loaded
		External power supply state			1	3				0	1	false	true			Indicate if the external power supply is powered
		Isolated CAN supply state			1	4				0	1	false	true			0: isolated CAN bus not powered, 1: isolated CAN bus powered
		Isolated CAN keep alive received			1	5				0	1	false	true			Indicate if a keep alive message has been received during the last
		Sd conf file opening error			1	6				0	1	false	true			Indicate if is an error occured while trying to read SD conf file
		Sd conf file param error			1	7				0	1	false	true			Indicate if at least one of the conf file param is not correct
		Sd init flag			2	0				0	1	false	true			Indicate if the SD card is initialized
		No error detected			2	1				0	1	false	true			1: no error detected, 0: at least 1 error detected
Tx	Error state Msg		0x01n	short				5	1000							n correpond to error ID (0 to 8)
		Error state			0		1			0	255	1	3			0: no error, 1 : entering error, 2: error, 3: leaving error
		Error cool down counter			1		4			0	1000000	0	1000000			remaining delay of the leaving error state before clearing error (s)

The error IDs in short ID mode are detailed in the next table.

Table 56: error IDs – short ID mode

Error n°	Error ID	Error Type	Notes
0	0x010	Overvoltage	
1	0x011	Under voltage	
2	0x012	Over temperature	
3	0x013	Under temperature	
4	0x014	Overcurrent	
5	0x015	Short circuit	
6	0x016	Battery parameter time-out	SD card not detected or monitoring error
7	0x017	Board values up to date	Refresh error on voltage, current or temperature values
8	0x018	Current up to date	Current sensor and digital process state

7.2 Wi-Fi communication

7.2.1 General description

The Wi-Fi communications of FS-XT can operate in two different modes: infrastructure and access point.

The infrastructure mode is not activated by default. When available, it will be activated with a firmware upgrade in order to allow FS-XT to connect to the Freemens servers and upload the information and data of the battery and the system it manages.

The access point mode is always available, except when FS-XT is in sleep mode. It allows the user to connect the FreeView or FreeLab application to monitor the battery. By using the described commands, any user can develop its own application.

7.2.2 Wi-Fi infrastructure mode

Important: this operating mode is actually not available. However, its configuration is described in this section as the parameters are already reserved on the configuration file.

General description

In this mode, FreeSafe Extended connects to an Access Point. The SSID, the authentication mode, and the key/password and channel must be provided in the configuration file in the SD Card.

Multiple authentication modes are supported:

- WEP64 & WEP128
- WPA-PSK
- WPA1-PSK (TKIP only)
- WPA2-PSK (AES only)

FreeSafe Extended IP-address is provided by the Access point and can be retrieved in the router connected devices list. Infrastructure Mode is required for Internet connectivity and Remote operation with online databases.

Wi-Fi infrastructure Mode configuration parameters

Table 59: Wi-Fi configuration parameters in infrastructure mode

Name	Id	Unit	Type	Example	Range	Comment
wlanSSID	10	-	char*	"freemensAP"	32 char max	SSID name of target infrastructure access point
authMode	11	-	char*	“0”	1 char max	Authentication mode of target infrastructure access point. 0= WPA2
wlanPass	12	-	char*	“none”	64 char max	Password of target infrastructure access point
wlanChan	13	-	char*	“0”	2 char max	Channel of target infrastructure access point
ftpAddr	14	-	char*	“0.0.0.0”	15 char max	FTP address of target server
ftpUser	15	-	char*	“default”	16 char max	FTP login of target server
ftpPass	16	-	char*	“none”	16 char max	FTP password of target server
ftpDir	17	-	char*	“ftp”	32char max	FTP directory of target server
snapshotShortTimer	53	s	int	0		Reserved
snapshotLongTimer	54	s	int	0		Reserved

7.2.3 Wi-fi access point mode

General description

In this mode, FreeSafe Extended will provide an open Wi-Fi access point for adjacent devices such as computers, mobile phones and tablets. These devices will be able to connect to the BMS – if the access point name and its WPA2 password are known - and to communicate through TCP protocol to get information on the battery managed by FreeSafe Extended. The configuration and the command used for the communication are detailed in the next paragraphs.

Configuration

The accessibility parameters for Wi-Fi in local access point mode can be modified to fit customer and application requirements. FreeSafe Extended automatically activates the access point while in normal mode (i.e. not in sleep mode). Peripherals such as android mobile phone or tablet are then able to reach FreeSafe Extended by connecting to the corresponding SSID name. Communications over Wi-Fi are considered as "wake-up events" preventing FreeSafe Extended from entering sleep mode (which is a power saving mode). In power saving mode, the Wi-Fi is disabled.

Table 60: Wi-Fi configuration parameters in access point mode

Name	Id	Unit	Type	Example	Range	Comment
accesPointName	7	-	char*	"FreeSafeAP"	Char[32] a-z;0-9	Wi-Fi SSID name of the BMS in access point mode.
accesPointPass	8	-	char*	"FreeSafe1212"	Char[64] a-z;0-9	WPA2 Wi-Fi password
accesPointEmissionChannel	9	-	char*	"1"	1 - 11	Channel of emission in AP Mode

N.B.: it is recommended to adapt the emission channel if the battery or the application is in an environment where a lot of Wi-Fi access points are detected so that FreeSafe Extended is the only device on his own channel. It will prevent potential communication troubles.

Commands list and associated answers

To communicate with the BMS, a command is sent: it is a text string with an additional character to specify the end of the sentence. The BMS then responds with a text string with a specific ending character.

- Client device command: "commandString+". '+' is the ending character of the command.
- BMS response: "answerStringÿ". ÿ is the ending character of the answer.

Table 61: cell voltages command and answer

Command String	Answer String	Answer details
"get volt+"	"XXXX xxxx … nnnn ÿ"	XXXX: voltage of the 1st cell xxxx: voltage of the 2nd cell nnnn: voltage of the nth cell

N.B.: Voltages are given on 4 character and are in mV. For example, an answer with "3375" means the cell has a voltage of 3.375V.

Table 62: temperatures command and answer

Command String	Answer String	Answer details
"get temp+"	"XXX xxx … nnn ÿ"	XXX: temperature of the 1st sensor xxx: temperature of the 2nd sensor nnn: temperature of the nth sensor

N.B.: the integer value sent is the temperature in 0.1°C. FS-XT is designed to have 6 sensors (3 sensors per group of 12 cells: 2 external thermistors and 1 internal board sensors). On a FreeSafe Extended board with a slave, an example of answer to the command "get temp+" can be: "305 350 400 310 282 450 290 300 397 ÿ". After translation, it becomes:

Sensor	Temperature	Sensor	Temperature	Sensor	Temperature
1st thermistor	30.5°C	3rd thermistor	31.0°C	5th thermistor (slave)	29.0°C
2nd thermistor	35.0°C	4th thermistor	28.2°C	6th thermistor (slave)	30.0°C
1st FS-XT onboard	40.0°C	2nd FS-XT onboard	45.0°C	1st slave onboard	39.7°C

Table 63: current command and answer

Command String	Answer String	Answer details
"get curr+"	"±xxx.xxxÿ"	The decimal separator is a dot There is always a sign + or – The current is in A. Ex : "+135.100ÿ means a positive 135.1A current

Table 64: State of Charge command and answer

Command String	Answer String	Answer details
"get SOC+"	"xxx.xxÿ"	The decimal separator is a dot The returned value is the SOC in %. Ex : "035.10ÿ" means a 35.1% SOC

Table 65: State of Health command and answer

Command String	Answer String	Answer details
"get SOH+"	"xxx.xxÿ"	The decimal separator is a dot The returned value is the SOH in %. Ex : "095.50ÿ" means a 95.5% SOH

Table 66: command and answer for downloading any stored file on the SD card

Command String	Answer String	Answer details
"get file xxxxxxxx.xxx+"	"xxxx…xxxxÿ"	xxxxxxxx.xxx is the name of the file in the 8.3 format xxxx…xxxx is the content of the specified file in the SD card

N.B.: As the command "get file" expect a 12 characters argument, if the file name is shorter than 8 characters, it must be completed with "space characters" after the 3 extension characters. Example: to get the file bms.txt, the command "get file bms.txt   +" with 5 space characters after ".txt" must be used (there are 5 spaces between 't' and '+').

Warning: as the BMS stays in sending mode during the file uploading, if the file requested is too large, the normal operation can be frozen during a long time. The uploading transmission rate is about a few KB/s.

7.3 GPIO connector

On the GPIO connector (connector n°3), there are 3 main available functionalities: the Hall Effect current sensor, the isolated digital I/O and the reset inputs. The Hall Effect sensor is not describe in this section, see *Hall Effect current sensor design choices* p*96* more details.

7.3.1 Isolated I/O

As described in the *GPIO connector* paragraph p*16*, the GPIO connector possesses:

- 2 independent digital isolated input, IN0 & IN1.
- 2 independent digital isolated output, OUT0 & OUT1
- 2 isolated input for the reset functions

The schematic principle of these I/O are described in *FreeSafe Extended isolated I/O* p*22*.

IN0 is used by default with an external control signal (typically a switch) that drives the state of the charge and discharge contactor.

OUT0 is used by default to generate a state indicator signal that can drive a LED or a digital input of an external device.

IN1 & OUT1 are not used but can be customized. Contact Freemens for more information about customization.

7.3.2 Isolated inputs for reset

As shown by the next figure there are 2 reset inputs:

- M_Reset is the one dedicated the cells management process reset (e.g.: voltage and temperature monitoring, data logging, SOC algorithm). See the chapter *Cells management* p*34* for more information.
- S_Reset is used for the power line management reset (e.g.: current monitoring, overcurrent fault management, contactors driving). See the chapter *Power Line management* p*44* for more details.

The photo diodes of the two inputs have their cathode in common.

To be acknowledge, the opto-isolated reset input must be supplied for at least 1ms (100ms recommended).

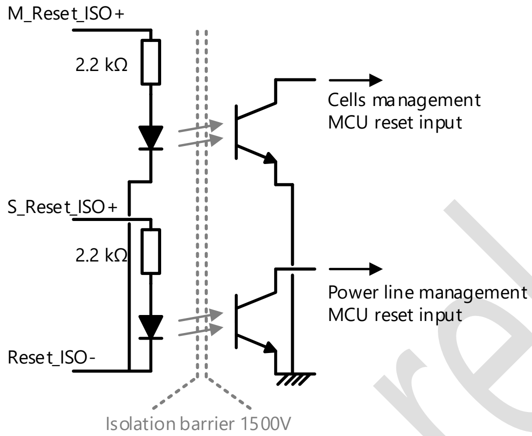


Figure 45: isolated reset inputs

7.3.3 Control signal for contactors states

General description

By default, the isolated input n°0 (IN0) drives the state of the charge and discharge contactors. The signal sent into IN0 typically comes from a toggle switch or a push button that supplies the digital isolated input, but can also be produced, for instance, by the digital output of an external control unit.

This control signal must be a square wave and it can be operated under two available mode: pulse mode, maintained mode. If the square duration is between 0.1 and 2s, the BMS enters the pulse mode operation. Over 2s square wave signal, it enter the maintained mode operation.

Pulse mode

The signal on the input n°0 must be a square wave of a duration between 0.1s and 2s, typically generated by a push button.

At the first pulse, the BMS drives the contactors ON. The second pulse drives the contactors OFF. Each pulse is an order to change the contactors' state. If an event on the system turns the contactors OFF (security event like overcurrent, communication error, etc.), a new pulse is need to acknowledge the error and a second pulse will turn the contactors ON again.

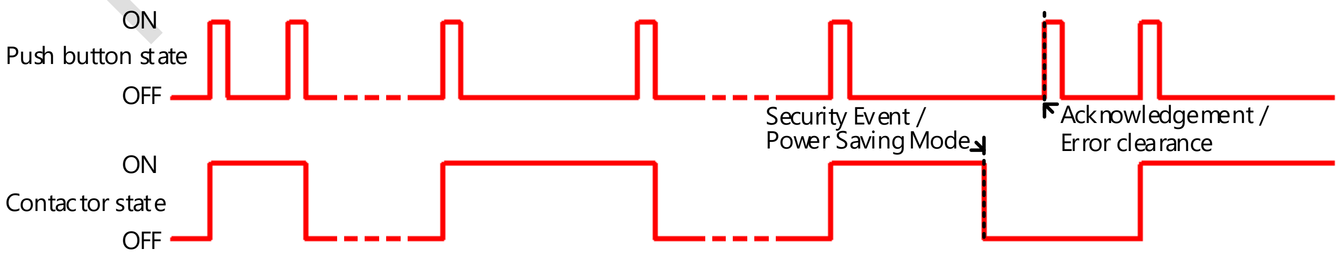


Figure 46: example of a push button use for controlling the contactor states

Maintained mode

The signal on the input n°0 must be a square ware any duration over 2s, typically generated by a toggle switch.

As soon as the toggle button is turned ON, the contactors are driven ON too. The button must be maintained in ON position at least 2s otherwise the BMS will operate in pulse mode management. When the toggle button is turn OFF, the contactors are turned OFF. If an event on the system turns the contactors OFF (security event like overcurrent, communication error, etc.), the toggle button must be turn OFF to acknowledge the error and then ON again to drive the contactor back on the ON position.

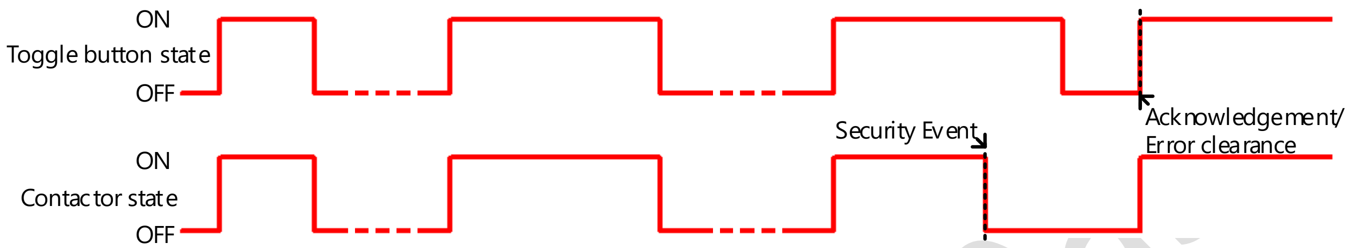


Figure 47: example of a toggle button use for controlling the contactor states

Effect on the running mode selection

As described in *Running mode* p*34*, the state of IN0 has a direct impact of the running mode selection:

- A logical high level on IN0 will wake up and maintain the BMS into its Normal Mode
- A logical low level on IN0 will allow the BMS to enter Power Saving Mode if all the other conditions are cleared.

A direct consequence of this operation of IN0 is that, **in pulse mode**, if the **battery is not used** and there are **no BMS activity**, the **BMS will enter the Power Saving Mode** and turns off the contactors after the "sleepActivationTimer" duration. The next pulse will wake up the BMS and close the contactor again.

The parameter n°63 "buttonActivityIgnore" allows the BMS to ignore the state of IN0 when checking the conditions for entering sleep mode. It means that, in maintain mode, if "buttonActivityTimer"=1 then the BMS can enter its sleep mode if there is no activity even if a high level logical state is detected on IN0.

7.3.4 Control signal for Wi-Fi deactivation

A control signal sent into the IN1 input drives the Wi-Fi module deactivation.

By default, if the isolated input IN1 is not used (not wired or not supplied), the Wi-Fi module is operational and active. If IN1 is supplied, the Wi-Fi module is turned off.

N.B.: when the BMS enters its sleep mode, the Wi-Fi module is deactivated regardless of IN1 state. It means that it is not mandatory to maintain the supply of IN1 during sleep mode. In fact it is even recommended to stop the IN1 supply in sleep mode as it can increase the global energy consumption of the complete system during its sleep mode.

7.3.5 State indicator signal

General description

By default, the isolated output n°0 (OUT0) drives a signal that provides a state indicator of the battery. The state indicator is a digital signal that can be used to drive a LED or can directly be read by any device with a digital input.

State indicator codes

The signal waveform presents three states: ON, OFF and pulsed.

The pulsed state has a 5s period. Each pulse is 200ms long and can be repeated every 400ms. The number of pulses generated every 5s gives the event code.

During the override under voltage mode (see *Override mode* p*51*), a square signal of 200ms period is generated.

The following tables summarize the details of the state indicator signal and show its waveforms.

Code	State indicator signal	Operating mode	Contactors states	Details

			Discharge	Charge	
ON	Always ON	Normal	ON		No error, the contactors are ON.
ON-1	ON with 1 pulse OFF / 5s	Normal	**OFF**	ON	No error, charge contactor is OFF (end of discharge reached)
ON-2	ON with 2 pulses OFF / 5s	Normal	ON	**OFF**	No error, discharge contactor OFF (end of charge reached)
OFF	Always OFF	Sleep	OFF		No error, the system is in sleep mode
IDLE	1 pulse ON / 5s	Normal	OFF		No error, the BMS is not in sleep, the contactors are OFF.
ERR-SC	2 pulses ON / 5s	Error	OFF		Short-circuit detected
ERR-OC	3 pulses ON / 5s	Error	OFF		Overcurrent detected
ERR-V	4 pulses ON / 5s	Error	OFF		Over or under voltage detected
ERR-T	5 pulses ON / 5s	Error	OFF		Over or under temperature detected
ERR-D	6 pulses ON / 5s	Error	OFF		Data error: monitoring variables are obsolete
ERR-M	7 pulses ON / 5s	Error	OFF		Miscellaneous errors
OVR	0.1s pulse / 0.2s	Override	ON		Mode only available in single contactor mode

Figure 48: state indicator signal codes and details

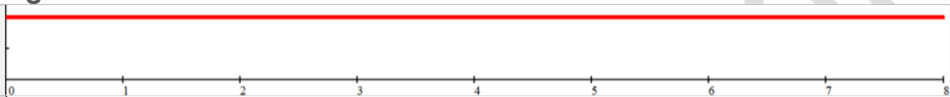
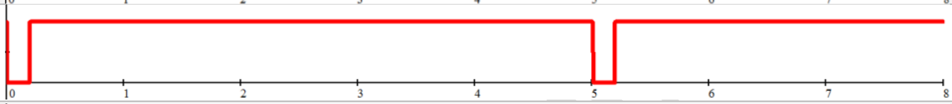
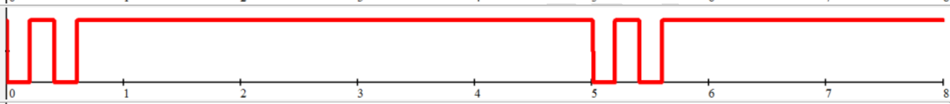
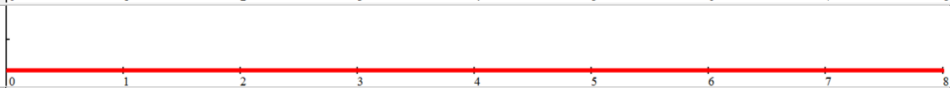
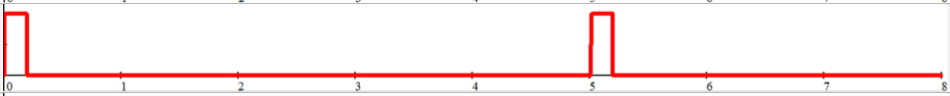
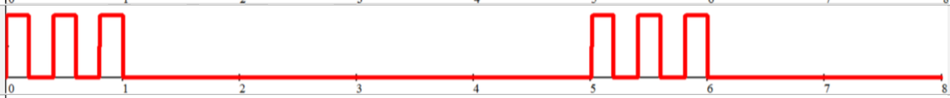
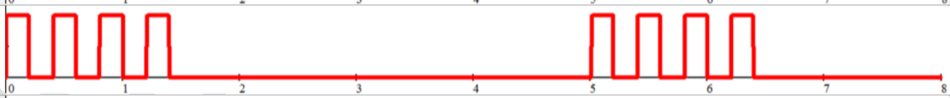
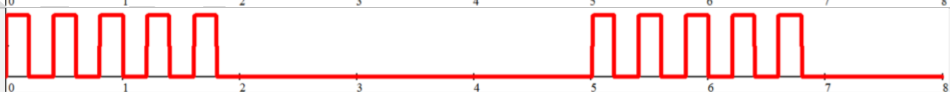
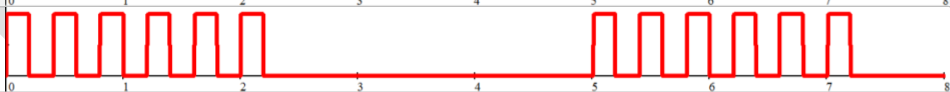
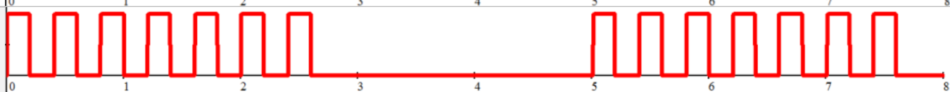
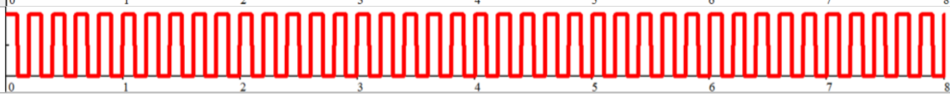
State	**Signal waveform**	**Details**
ON		No error. Normal mode. Contactors are closed.
ON-1		No error. Normal mode. Discharge contactor OFF, charge ON.
ON-2		No error. Normal mode. Discharge contactor ON, charge OFF.
OFF		No error. Sleep mode. Contactors are opened.
IDLE		No Error. Normal mode. Contactors are opened.
ERR-SC		Short-circuit. Contactors are opened.
ERR-OC		Overcurrent. Contactors are opened.
ERR-V		Over / under voltage. Contactors are opened.
ERR-T		Over / under temperature. Contactors are opened.
ERR-D		Data error. Contactors are opened.
ERR-M		Miscellaneous errors.
OVR		Override mode. Contactor is closed.

Table 67: Waveforms of the state indicator signal. The horizontal axis is in seconds.

8 Fault management

8.1 Fault management process

Whenever a fault is detected (e.g. overcurrent), a fault management is started and the supply of all the contactors coils is cut off to protect the battery and its application. While no new order from the control signal is received (see *Control signal for contactors states* p62), the BMS keeps the contactors opened and the state indicator signal (see *State indicator signal* p63) displays the associated error code. The error must be acknowledge first before a new closing order is transmitted:

- In pulsed mode, as shown on *Figure 46*, a first pulse acknowledge and clear the error, a second pulse restart the contactors.
- In maintained mode (see *Figure 47*), when the control signal is released back to a low level, the error is acknowledge and cleared. When the control signal gets back in a high level state, the contactors are turned back ON.

The only exceptions in this behavior concern the internal faults specific to the BMS: communications and monitoring updates. For these errors, there is no action needed, the BMS will drive back ON the contactors when the problem is cleared. These two case are described in *Communication error management* and *Obsolete battery variables fault*.

The description and management of the main faults are described in the next paragraphs. The table below summarizes the faults are their management.

Table 68: faults management quick summary

Fault name	Automatic operation resuming	Ending conditions of the error
Over voltage	NO	Voltage drops under threshold, countdown over
Under voltage	NO	Voltage returns over threshold, countdown over
Communication fault	**YES / NO**	Communication restored. The criticality of the communication fault determines if there is an automatic operation resuming.
Over temperature	NO	Temperature drops back under threshold
Under temperature	NO	Temperature returns back over threshold
Short circuit	NO	External control signal orders to resume operation
Overcurrent	NO	I^2t countdown finished
Obsolete battery physical variables	**YES**	The battery physical variables (voltage, current, temperature) are updated

8.2 Over voltage management

If an over voltage is detected, no external action is required. As soon as a cell voltage exceeds the maximum cell voltage threshold, the charge and discharge contactor are opened and the fault management process is started. As soon as the control signal acknowledge and ask for a restart, if the error is cleared (i.e. the voltage dropped back under an acceptable value), the contactors are driven back to ON state.

As described in *Analog hardware over voltage threshold* p37, a second overvoltage threshold is present. It is a hardware set threshold that freezes the contactors in an opened state. Only a software reset can clear this state when the overvoltage disappears.

8.3 Under voltage management

The under voltage errors are managed like the over voltage errors. In case the threshold is crossed, the contactors are opened. As soon as the voltage gets back into correct values and the control signal has acknowledge the error, the contactors can be driven ON when the control signal send the order.

8.4 Communication error management

If an onboard (between critical components of the FS-XT board) or internal (between the slave boards and the master board of FS-XT) communication anomaly is detected (time-out, CRC error, etc.), retries are attempted. The number and the time limit of the retries vary according to the criticality of communication buses and their data.

If no communication is correctly reestablished during the retry phase, then an error is declared and to protect the system, the BMS will open the contactors. According to the criticality of the error, the BMS enters one of the following fault managements:

- Obsolete battery variables fault. In this case, the contactors are automatically closed as soon as the fault disappears.
- Miscellaneous fault. In this case, an action on the control signal is needed to close back the contactors when the fault conditions are cleared.

8.5 Over and under temperature error management

The over an under temperature management of the external sensors follows the standard process. As soon as the minimum or maximum temperature threshold is reached, the charge and discharge contactors are opened. The contactors can be closed back with a control signal order when the temperature level gets back into the authorized range with a 1°C hysteresis.

8.6 Short circuit management

The parameters "positiveShortCircuitThreshold" and "negativeShortCircuitThreshold" in the configuration file set the positive and negative hard current limit. Beyond these limits, FS-XT instantaneously opens the contactors to protect the system.

After detecting a short circuit fault and opening the power contactors, FS-XT waits for the control signal to send an acknowledgement then a turn on order to re-engage the power contactors and resume its operation.

See *Short circuit (i.e. hard current limit) management* p*47* for more details.

8.7 Overcurrent (i.e. soft current limit) management

The overcurrent management is based on a thermal approach. Knowing the nominal current (i.e. a thermally stable operating point) of the system and an allowed overcurrent for a given time, the BMS can operate with an I^2t principle.

There are 3 configurable parameters in the configuration file:

- "currentChargeNominal" and "currentDischargeNominal" define the thermally stable operating points in charge and discharge over which the overcurrent current process is engaged. These references can be the nominal current of the battery itself or the nominal current of its application.
- "deltaI2t" is used to set the allowed time for a given overcurrent. "deltaI2t" can be calculated with *Equation 2* in *Overcurrent (i.e. soft current limit) management* p*47*. The overcurrent management then follows an I^2t logic. With the parameters given in the initial configuration, it is possible to determine the maximum allowed time for a given overcurrent.

The contactors can be driven ON when the error is cleared. The overcurrent error cannot be cleared instantaneously: the BMS waits for the system to cool down according to the same I^2t principle used to detect the fault.

8.8 Obsolete battery variables fault

During the normal mode operation of the BMS, the cell voltages, the battery current and the temperatures are updated every 0.1s to 1s. In case there is over a 2s delay during each update, these variables will be considered as obsolete by the BMS and a fault will be declared. The system then enters a fault process: the contactors will be turned OFF and the BMS waits for the monitoring to successfully update these variables before automatically resuming its normal operations.

N.B.: a problem on the SD card reading can cause this obsolete battery variables fault as the BMS is unable to know if the parameters located in the configuration file in the SD card are valid.

8.9 Miscellaneous fault

Any non-classical error that needs to put the battery in a safe state generates a miscellaneous fault (for instance, a critical onboard communication error). The contactors can be closed again with an action on the control signal when the errors conditions are cleared.

9 Internal memory card

9.1 General description

All the battery management data – e.g.: cells voltages, battery current, state indicator (SOC or SOH), operating mode (for instance: normal or sleeping operation mode, over voltage or current error), communication errors, etc. – is stored on the BMS micro SD card. For a 12 cells battery, a 4GB SD card can store up to 20 years of data.

The data stored in the SD card can be read via the FreeLab PC software provided by Freemens. FreeLab allows the user to visualize the information about battery management: details of the elements that make up the battery, graphs of the cells voltages and the battery current, state of the system, etc. More details are available on the FreeLab documentation.

9.2 Micro SD card files

9.2.1 File List

The files stored on the micro SD card contain the configuration of the system and the complete history data of the operation of the battery and the BMS.

To extract the files stored, the standard method is to unplug the card from its slot on the FS-XT board and to connect it to a computer with a micro SD card reader. The files on the micro SD card are described in the next table.

Table 69: micro SD files details

File name	Description
BMS.TXT	Contains the complete data history of the battery and its BMS
BMSn.TXT	n=1, 2, 3, up to 99999. Same contents as BMS.TXT. A new file is created if the previous is too large or each time the BMS resets.
CONF.XML	Configuration file of the battery, the BMS and the complete system.
CONFIG.TXT	Information file about the BMS.
EVENT.TXT	Log of critical events. E.g.: resets, communication time-out, errors, etc.
LASTREC.TXT	Log of the current state of the battery as the date, SOC, etc.

9.2.2 Required files for startup

Mandatory file

Only the configuration file (CONF.XML) is required for the first startup of the BMS. Every other file will be generated by the BMS if it does not exists on the SD card.

Optional

If the file LASTREC.TXT does not exist at the first startup, itis generated automatically by the BMS. However, instead of using the default parameters, it can be manually created or edited to tune some parameters (SOC, date for instance) at the start of the system.

9.2.3 BMS.TXT, BMSn.TXT

The files BMS.TXT and BMSn.TXT contains the complete data history of the battery and its BMS. Even if the files can be open by any text editor software, the information stored can only be read by the proprietary software FreeLab.

At each restart of the BMS (reset) or when the file reaches at given data volume, a new file is created and its number is incremented. The max file size is specified in the configuration file with the parameter "maxFilesize".

Table 70: content example of BMS.TXT


```
7F15091400165028FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF0F7E0F840F870F880F7F0F8A0F870F850F850F7F0F780F870FF00FF90FF70FF10FEB0FF90FF40FF60FF70FED0FFD0FE8
0FFC0FF10FEB0FFC0FED0FF30FF60FF410020FFD1000100310000FFD0F900FFD10090FEA0F480FFC10020FFA0FF60FFF10150FF70FF610030FF710020FF90FEE10020FFF0FF110
000FF40FF10FF30FF70FF30FF00FF40FF30FED0FF40FEA0FED0FF00FF00FF00FF00FF00FE20FED0FD90FE20FEB0FE10FE80FFA0FF60FF00FF40FF70FE70FF60FF10FEA0FF10FEE
0FF0100010090FFC100F100610050FFF10020FF910050FF60FF7100210000FF00FFC0FFF0FF90FED0FFD0FF40FF30FFF0FFDFFFFFFFC010A000001D90114000001FC0105000002
1D010B0000023700FB0000022011A0000028B010A0000028F0115000000273010A00000265010E0000020FF2000020C2C80EA001300000000000010000000000000000000101400
00000002100131FFF000FFF000FFFFFFFFFFF0000000F700F750F790F7B0F720F7B0F790F780F760F720F690F790FED0FE20FDE0FEE0FDE0FE40FE70FE20FF10FEE0FF30FF610
020FED0FE80FF60FE80FF30FE80FE10FF10FEE0FE20FF10FE80FE40FE40FEA0FE40FE10FE70FE50FDE0FE70FDB0FDF0FE40FE20FE10FE20FE10FD60FDF0FCC0FD50FDE0FD50FDB
0FEE0FEA0FE40FE50FEA0FD90FEA0FE40FDC0FE40FE20FE10000000094FF29080D
```

9.2.4 CONF.XML

This file contains the complete configuration for the BMS and the battery management. It is completely described in the next chapter *Configuration file* p*72*. The parameters presented in this paragraph concern the data management.

The main data volume is generated by the cells monitoring. To avoid redundant data and to save memory space, new monitoring data will be saved only if the variation between two measurements exceeds a configurable threshold. This configuration affects the data logging of the following parameters: voltages, currents, temperatures, SOC and SOH.

It is recommended to keep the default parameters.

Table 71: Data logging configuration

Name	Id	Unit	Type	Example	Range	Comment
voltageVarRecordThrehold	18	mV	int	10	3-10000	Minimal difference between two voltage measurements which triggers a SD-Card data recording.
temperatureVarRecordThrehold	19	0.1°C	int	10	2-10000	Minimal difference between two temperature measurements which triggers a SD-Card data recording.
currentVarRecordThrehold	20	0.05 A	int	10		Minimal difference between two current measurements which triggers a SD-Card data recording.
SOCVarRecordThrehold	21	0.01 %	in	10		Minimal difference between two SOC measurements which triggers a SD-Card data recording.
SOHVarRecordThrehold	22	0.01 %	int	10		Minimal difference between two SOH measurements which triggers a SD-Card data recording.
maxRecordPeriod	23	s	long	3600		Maximum permitted period between two recordings
maxFileSize	24	Byte	long	10485760	0 – 1073741824	Specify the maximum data file size. If a data file exceed this size a new one will be created

The parameter "maxRecordPeriod" affects the data logging when the BMS is in power saving mode or in normal mode if nothing happened (no voltage, current, temperature, state change is observed): the BMS forces a record on the SD card if there was record during the last "maxRecordPeriod" seconds.

The parameter "maxFileSize" is the size limit of the files BMS.TXT. As soon as the file reach this limit, a new BMS.TXT file is created. This parameter allow the user to choose the size of the file it will have to manage once downloaded.

9.2.5 CONFIG.TXT

This file contains general information about the BMS: software and hardware version number, software activated options or customization.

9.2.6 EVENT.TXT

Every event logged in EVENT.TXT is also recorded in the BMS.TXT files. The EVENT.TXT file only logs the critical events (such as errors) of the BMS operation in a readable format for the user. It is mainly used to quickly access some of the main problems of a system in order to provide a quick diagnostic.

The events that can be recorded in the EVENT.TXT file are the following:

Table 72: list of the possible recorded events in EVENT.TXT

Message	Comment
bad conf param number	The number of parameters read is not the excepted number
unable to open config file	The BMS cannot read the configuration file
Error while reading delay string	The format of a delay parameter is not correct
Error while reading file size string	The format of a file size parameter is not correct
LASTREC file bigger than expected	The LASTREC file size exceeds the maximum authorized size. See *0*.
Recalibration SOC	A SOC recalibration has been sent via the Wi-Fi command
Wi-Fi reset CMD	A reset has been requested via the Wi-Fi command
time-out "xxx"	A communication time out happened between the onboard Wi-Fi module and the DSP. “xxx” is the message that trigger the time out
ADC buffer rollover	The buffer used for the internal consumption current measurement has been exceeded. Some values have been lost for the calculation of the internal power consumption of the BMS.
Oscillator Fail	Critical error of the oscillator
Address Error	Critical addressing error
Stack Error	Critical stack error
Math Error	Critical calculation error
DMA Error	Critical DMA addressing error
TXBO error flag set	Operating error of the CAN bus module
RBOVIF error flag set	Operating error of the CAN bus module
U2STAbits.FERR bit set	Operating error of the UART module
RCON bits "xxx" bit set	Message recorded at each reset of the BMS DSP
Time Out communication (id:0x%x%x%x)	Communication time out recorded by the DSP

9.2.7 LASTREC.TXT

This files contains the last recorded state of the system: date, cell voltages, current, SOC and SOH. The file is not required to start the BMS: a default one will be generated if there is none on the SD card. However, it is recommended to include a custom LASTREC.TXT file to ensure the BMS has a correct state as soon as it starts.

The LASTREC.TXT file contains 7 lines presented in the table below:

Table 73: format of LASTREC.TXT

LASTREC.TXT lines contents	String size
`YYDDMM hhmmss`	`13 char`
`aaaa`	`4 char max`
`mmmm`	`4 char max`
`MMMM`	`4 char max`
`scccc.cc`	`8 char max`
`CCC.CC`	`6 char max`
`HHH.HH`	`6 char max`

‘YYDDMM HHMMSS’ is the date and time. ‘YY’ the year, ‘MM’ the month, ‘DD’ the day, ‘hh’ the hours, ‘mm’ the minutes and ‘ss’ the seconds. The date and time are separated by a space character. On the default generated file, it will be the date and time of creation of the firmware.

‘aaaa’ is the average cell voltage in mV.

‘mmmm’ is the minimal cell voltage in mV.

‘MMMM’ is the maximal cell voltage in mV.

'sccc.cc' is the battery current in A. 's' is the sign of the current: '-' if the current is negative and no character if the current is positive.

'CCC.CC' is the state of charge expressed in %. The default value on the automatically generated file is 000.00.

'HHH.HH' is the state of health expressed in % and 2710 is 100.00%. The default value on the automatically generated file is 100.00.

The example in the next table set the BMS date and time on November 20th 2015 at 14h35m27s with a SOC of 57.10% and a SOH of 100%. In the last recorded state of battery pack, the current is 10.55A, the minimal cell voltage is 3.26V, the maximal is 3.489V and the average is 3.354V.

Table 74: content example of LASTREC.TXT

```
151120 143527
3354
3260
3489
10.55
57.10
100.00
```

10 Configuration file

10.1 General description

FreeSafe Extended can be easily configured to meet various applications requirements. All the editable parameters of the BMS are available in a XML configuration file stored on the micro SD card. At the initialization of the BMS, the configuration file is parsed by FreeSafe and all the parameters are loaded into the embedded software. If the configuration file is corrupted or missing, the initialization process will enter in a fail and retry mode: the BMS will enter in an initialization error state and wait for 120s before rebooting.

A complete configuration file example can be seen on *Table 91* p*77*.

The following sections describes quickly the configurable parameters and their impact on the BMS operation.

10.2 Battery specifications

The parameters in this section are used to configure the total expected number of cells, their wiring positions and the global distribution of slave boards. These parameters are used at the primary initialization. If the number of cells does not match the configuration, FS-XT will enter in an initialization error state and periodically (120s) reboot until the correct amount of cells is detected. The configured number of slave is used to guarantee that all the boards are correctly configured and operational. The last parameter is the initial nominal capacity of the battery d1Cap. It is used for SOC and SOH calculations

Table 75: Battery Configuration

Name	id	Unit	Type	Example	Range	Comment
cellPosition	0	-	char*	"0N0LFFFM"		format xNyLzM (x: id BMS board, y: id cell group, z: cell position mask)
tempSensorPosition	1	-	char*	"0N0L3M"		format xNyLzM (x: id BMS board, y: id cell group, z: NTC position mask)
d1Cap	2	Ah	float	100	-	Initial nominal battery capacity

See *Battery specifications* p*35* for more details about definition of the “cellPosition” and “tempSensorPosition” parameters.

10.3 BMS configuration

10.3.1 Internal power management

These parameters control the length of the loop in the power saving mode and the minimum inactivity timeframe that will put FreeSafe Extended in this mode. Increasing “sleepDuration” will allow to reduce the overall power consumption but will slow down the refresh rate of the voltage and temperature and their recording on the SD card.

Table 76: Power management configuration

Name	Id	Unit	Type	Example	Range	Comment
sleepActivationTimer	4	s	int	300	10-32768	Inactivity duration before going into power saving mode
sleepDuration	5	s	int	5	10-32768	Refresh interval for voltage and temperature in power saving mode
internCBLowPower	6	-	bool	0	0 - 1	Aggressive management of internal CAN bus energy. 0=inactive, 1=active
buttonActivityIgnore	63	-	bool	1	0 - 1	Ignore the state of the control switch to start the sleep activation timer
externalCanResistorsSoldered	64	-	bool	0	0 - 1	Specify if the external CAN supply is connected to the onboard supply. Used for the sleep mode behavior.

See *Control signal for contactors states* p62 for more details about the “buttonActivityIgnore” parameter.

N.B.: the parameter “internCBLowPower” is actually unused. The functionality that manage the energy consumption of the internal Freemens dedicated CAN bus is not implanted yet.

10.3.2 Wi-Fi access point configuration

The accessibility parameters for Wi-Fi in local access point mode can be modified to fit customer and application requirements. FreeSafe Extended automatically activates the access point while in normal mode (i.e. not in sleep mode). Peripherals such as android mobile phone or tablet are then able to reach FreeSafe Extended by connecting to the corresponding SSID name. Communications over Wi-Fi are considered as “wake-up events” preventing FreeSafe Extended from entering sleep mode and disabling the Wi-Fi.

Table 77: Wi-Fi configuration parameters in access point mode

Name	Id	Unit	Type	Example	Range	Comment
accesPointName	7	-	char*	"FreeSafeAP"	Char[32] a-z;0-9	Wi-Fi SSID name of the BMS in access point mode.
accesPointPass	8	-	char*	"FreeSafe1212"	Char[64] a-z;0-9	WPA2 Wi-Fi password
accesPointEmissionChannel	9	-	char*	“1”	1 - 11	Channel of emission in AP Mode

N.B.: it is recommended to configure the emission channel if the battery or the application is in an environment where a lot of Wi-Fi access points are detected so that FreeSafe Extended is the only device on his own channel. It will prevent any potential communication troubles.

10.3.3 Wi-Fi infrastructure configuration

By default this mode is not activated. In this mode, FreeSafe Extended connects to an Access Point. The SSID, the authentication mode, and the key/password and channel must be provide. The Freemens FTP server details are also provided in these configuration parameters to allow FS-XT to upload the battery data on the Freemens database.

Table 78: Wi-Fi configuration parameters in infrastructure mode

Name	Id	Unit	Type	Example	Range	Comment
wlanSSID	10	-	char*	"freemens AP"	32 char max	SSID name of target infrastructure access point
authMode	11	-	char*	“0”	1 char max	Authentication mode of target infrastructure access point. 0= WPA2
wlanPass	12	-	char*	“none”	64 char max	Password of target infrastructure access point
wlanChan	13	-	char*	“0”	2 char max	Channel of target infrastructure access point
ftpAddr	14	-	char*	“0.0.0.0”	15 char max	FTP address of target server
ftpUser	15	-	char*	“default”	16 char max	FTP login of target server
ftpPass	16	-	char*	“none”	16 char max	FTP password of target server
ftpDir	17	-	char*	“ftp”	32 char max	FTP directory of target server
snapshotShortTimer	53	s	int	0		Shortest time between 2 snapshots
snapshotLongTimer	54	s	int	0		Longest time between 2 snapshots

The ftp and snapshot parameters are used for functionalities that are actually not operational yet in the BMS. They are actually present in the configuration file to anticipate the future implementation of internet WiFi communications: it will allow data collection and battery remote monitoring.

10.4 Data logging

The main data volume is generated by the cells monitoring. To avoid redundant data and to save memory space, new monitoring data will be saved only if the variation between two measurements exceeds a configurable threshold. This configuration affects the data logging of the following parameters:

- Voltage
- Current
- Temperature
- SOC
- SOH

It is recommended to keep the default parameters.

Table 79: Data logging configuration

Name	Id	Unit	Type	Example	Range	Comment
voltageVarRecordThrehold	18	mV	int	10	3-10000	Minimal difference between two voltage measurements which triggers a SD-Card data recording.
temperatureVarRecordThrehold	19	0.1°C	int	10	2-10000	Minimal difference between two temperature measurements which triggers a SD-Card data recording.
currentVarRecordThrehold	20	A	float	0.5	-	Minimal variation between two current measurements to trigger a recording.
SOCVarRecordThrehold	21	%	float	0.5	-	Minimal difference between two SOC measurements which triggers a SD-Card data recording.
SOHVarRecordThrehold	22	%	float	0.1	-	Minimal difference between two SOH measurements which triggers a SD-Card data recording.
maxRecordPeriod	23	s	long	3600		Maximum permitted period between two recordings
maxFileSize	24	Byte	long	10485760	0 - 1073741824	Specify the maximum data file size. If a data file exceed this size a new one will be created

10.5 Balancing

These parameters allow a fine tuning of the balancing management.

“balancingActivationThreshold” and “balancingDesactivationThreshold” set the differential voltage thresholds to start and stop cell balancing.

“forceBalancingThresold” is a threshold used to force the balancing of any cell that rises over this voltage. “stopBalancingThreshold” is the lowest voltage at which any balancing can be done.

Table 80: Balancing configuration

Name	Id	Unit	Type	Example	Range	Comment
balancingActivationThreshold	25	mV	int	20	0-10000	Activation of balancing threshold
balancingDeactivationThreshold	26	mV	int	10	0-10000	Deactivation of balancing threshold
forceBalancingThresold	27	mV	int	3650	0-10000	Cell voltage threshold triggering forced balancing
stopBalancingThreshold	28	mV	int	3300	0-10000	Voltage threshold to disable passive balancing.
currentStopBalanceThreshold	59	A	float	1		Current threshold under which the balancing is disabled

10.6 Protection and monitoring threshold

10.6.1 Voltage

The over and under voltage thresholds are mandatory to operate lithium batteries. Extra care must be taken when modifying these parameters. If these thresholds are reached, FreeSafe Extended will drive the power contactor off to cutoff the battery from the application/charger.

"SOCMinRecalibrationThreshold" and "SOCMaxRecalibrationThreshold" are used to recalibrate SOC and SOH estimations. Default values recommended for LiFePO4 batteries are shown in the next table.

Table 81: Voltage management configuration

Name	Id	Unit	Type	Example	Range	Comment
overVoltageThreshold	29	mV	int	3650	0-5000	Over voltage threshold
underVoltageThreshold	30	mV	int	2600	0-5000	Under voltage threshold
SOCMaxRecalibrationThreshold	31	mV	int	3620	0-5000	Cell upper voltage threshold used to recalibrate SOC at 100%
SOCMinRecalibrationThreshold	32	mV	int	2620	0-5000	Cell lower voltage threshold used to recalibrate SOC at 0%
currentSOCCalibrationThreshold	60	A	float	1	-	The average (on 1 minute) and instantaneous current must be under this threshold to allow a SOC recalibration at 100%.
endOfDischargeThreshold	61	mV	int	2600	0-5000	Lower cell voltage threshold to open the contactor to end the discharge.

10.6.2 Current

These parameters define the overcurrent and short-circuit limits. Extra care must be taken when modifying these parameters. If these thresholds are reached, FreeSafe Extended will drive the power contactor off to cutoff the battery from the application/charger. See *Power Line management* p*44* for more details.

Table 82: Voltage management configuration

Name	id	Unit	Type	Example	Range	Comment
positiveShortCircuitThreshold	40	A	float	250	-	Positive instantaneous current limit
negativeShortCircuitThreshold	41	A	float	-250	-	Negative instantaneous current limit
currentChargeNominal	43	A	float	50	-	Positive nominal current
currentDischargeNominal	44	A	float	-100	-	Negative nominal current
deltaI2t	42	$A^2.s$	float	25000	-	I^2t value used to define the overcurrent limits. Typical value calculated with $(I^2_{DischargeOvercurrent}-I^2_{DischargeNominal}).t_{overcurrent}$

10.6.3 Temperature

The over and under temperature thresholds ("cellOverTemperatureThreshold" and "cellUnderTemperatureThreshold") are mandatory to operate lithium batteries. Extra care must be taken when modifying these parameters. If these thresholds are reached, FreeSafe Extended will drive the power contactor off to cutoff the battery from the application/charger.

"maxBalancingTemp" is the maximum onboard temperature over which no balancing is allowed.

Table 83: Thermal sensor configuration

Name	Id	Unit	Type	Example	Range	Comment
maxBalancingTemp	33	0.1°C	int	600	-40 to 85	Maximum reachable board temperature due to cell balancing
cellOverTemperatureThreshold	34	0.1°C	int	450		Cells over temperature threshold
cellUnderTemperatureThreshold	35	0.1°C	int	-200		Cells under temperature threshold

10.7 Sensors' configuration

10.7.1 Temperature sensors

To ensure correct temperature readings, sensors must be placed as close as possible to the monitored cell. For example, they can be directly placed onto screws used for power connection.

The parameters of the sensors are defined thanks to R0, T0 & BETA for the NTC sensor. For a maximum temperature measurement precision, it is recommended to use 10kΩ NTC thermistor.

Table 84: Thermal sensor configuration

Name	Id	Unit	Type	Example	Range	Comment
temperatureSensorT0	36	K	float	298	0-32766	NTC reference temperature
temperatureSensorR0	37	Ω	float	10000		NTC resistance at T0
temperatureSensorBeta	38	K	float	4220	0-32766	β coefficient of the NTC equation temperature vs resistance

10.7.2 Hall Effect current sensor

Table 85: Current management configuration

Name	Id	Unit	Type	Example	Range	Comment
currentSensorSensibility	45	mV/A	float	12.5	-	Current sensor gain
currentMeasConvention	39	-	bool	0	0-1	0: the current sensor is oriented according to the BMS convention 1: invert the measure convention sign
currentRef	46	-	int	2048	-1 to 4096	Set the ADC reference value for 0A current. See *Tuning of the Hall Effect current* sensor p*46* for more details.
noCurOffsetThreshold	47	A	float	0,5	-	The current that is measured below this value is considered as noise and set to 0A
currentMeasurementError	48	1/1000	int	20	0-1000	Reserved parameter – actually unused

10.8 Charger configuration

10.8.1 Charge contactor

As described on *Figure 38* p*42*, the charge contactor will be opened and closed at the end of the charge depending on cell voltages thresholds.

Table 86: parameter for the charge contactor

Name	Id	Unit	Type	Example	Range	Comment
hysteresisMaxChargeVoltage	49	mV	int	3650	0-5000	Max cell votage allowed by the charge contactor
hysteresisMinChargeVoltage	50	mV	int	3450	0-5000	Low voltage threshold to turn back on the charge contactor

10.8.2 CAN charger

If the selected charger can communicate with the BMS through CAN communication, FS-XT can drive the current and voltage used to charge the battery. See *Charger management* p*39* for more details about the charging processes with a CAN charger.

N.B.: only CAN charger from TC Charger, and few other references, are supported. Contact Freemens to know if a specific CAN charger is supported or if a custom development will be needed.

Table 87: charge parameters for CAN charger

Name	Id	Unit	Type	Example	Range	Comment
maxVoltageChargerCB	51	V	float	54.0		Charging voltage
maxCurrentChargerCB	52	A	float	30.0		Charging current

To minimize the number of manipulations on the charge contactor (and so, to maximize its life span), there are also hysteresis cell voltage thresholds defined from the parameters in *Table 86*:

- Max charge cell voltage allowed by CAN charger = Max cell voltage allow by the charge contactor – 10mV
- Low voltage threshold to restart the CAN charger = Low voltage threshold to drive the charge contactor

10.9 Power Outputs configuration

FS-XT has 4 power outputs that can be used for various features such as driving power contactors for precharge, charge or discharge, and for driving fan(s). Each of these features are associated to a specific power output. The configuration of these features is assured by the parameters in the configuration file.

10.9.1 General description

The connector n°6 (power outputs) can drives up to 4 distinct power peripherals: 3 outputs are dedicated to contactors (pre-charge, discharge, charge) and the last output is for a driving a fan system. For any other need, a firmware customization will be required, contact Freemens. See the *Power peripherals* paragraph p*44* in the chapter *6* "*Power Line management*" for more details about the power line management and the peripherals driven by the BMS.

10.9.2 Contactors parameters

Table 88: parameters for the contactors

Name	Id	Unit	Type	Example	Range	Comment
dissociateChargePowerLine	3	-	bool	1	0-1	Indicate the use of a dedicated charge contactor. 0=No dedicated charge contactor, 1=charge contactor used.
powerOutputPrecharge	55	0.1s	int	5	-	Pre-charge duration in 1/10th of seconds

10.9.3 Fan parameters

Table 89: parameters for the fan

Name	Id	Unit	Type	Example	Range	Comment
fanActTempThreshold	56	0.1°C	int	450	-	Fan activation threshold
fanDeactTempThreshold	57	0.1°C	int	400	-	Fan deactivation threshold
fanSourceTrigger	58	-	int	1	0 - 3	Define the temperature source
autoEngageDuringCharge	62	-	bool	1	0 – 1	Automatic driving of the charge contactor during the end of charge.

10.10 External CAN bus configuration

The messages broadcasted by the external CAN bus can be configured to be in short or extended ID mode.

Table 90: parameter for the CAN bus configuration

Name	Id	Unit	Type	Example	Range	Comment
ExtCanIdType	65	-	bool	0	0 – 1	CAN Id mode (0=extended, 1=short)

10.11 Configuration file example

The configuration file for this example is presented in the chapter *Typical implementation: 48V LiFePO4 battery* p25.

Table 91: configuration file for the typical 48V application

```xml
<!-- type 0:bool, 1:string, 2:int, 3:long, 4:float -->



<BMSparam>
 <systemParam>
  <variable id="0" type="1" value="0N0L3FFM;0N1L1FM" name="cellPosition"/>
  <variable id="1" type="1" value="0N0L3M;0N1L3M" name="tempSensorPosition"/>
  <variable id="2" type="4" value="100" name="d1Cap"/>
 </systemParam>
 <powerManagmentParam>
  <variable id="4" type="2" value="30" name="sleepActivationTimer"/>
  <variable id="5" type="2" value="10" name="sleepDuration"/>
  <variable id="6" type="0" value="0" name="internCBLowPower"/>
  <variable id="63" type="0" value="1" name="buttonActivityIgnore"/>
  <variable id="64" type="0" value="1" name="externalCanresistorsSoldered"/>
 </powerManagmentParam>
 <RN171Param>
  <variable id="7" type="1" value="FreeSafeAP-TypApp48V" name="accesPointName"/>
  <variable id="8" type="1" value="FreeSafe1212" name="accesPointPass"/>
  <variable id="9" type="1" value="9" name="accesPointEmissionChannel"/>
  <variable id="10" type="1" value="freemensAP" name="wlanSSID"/>
  <variable id="11" type="1" value="0" name="authMode"/>
  <variable id="12" type="1" value="none" name="wlanPass"/>
  <variable id="13" type="1" value="0" name="wlanChan"/>
  <variable id="14" type="1" value="0.0.0.0" name="ftpAddr"/>
  <variable id="15" type="1" value="default" name="ftpUser"/>
  <variable id="16" type="1" value="none" name="ftpPass"/>
  <variable id="17" type="1" value="ftp" name="ftpDir"/>
 </RN171Param>
 <SDRecordParam>
  <variable id="18" type="2" value="10" name="voltageVarRecordThrehold"/>
  <variable id="19" type="2" value="10" name="temperatureVarRecordThrehold"/>
  <variable id="20" type="4" value="0.5" name="currentVarRecordThrehold"/>
  <variable id="21" type="4" value="0.5" name="SOCVarRecordThrehold"/>
  <variable id="22" type="4" value="0.01" name="SOHVarRecordThrehold"/>
  <variable id="23" type="3" value="7200" name="maxRecordPeriod"/>
  <variable id="24" type="3" value="10000000" name="maxFileSize"/>
 </SDRecordParam>
 <balancingParam>
  <variable id="25" type="2" value="20" name="balancingActivationThreshold"/>
  <variable id="26" type="2" value="100" name="balancingDesactivationThreshold"/>
  <variable id="27" type="2" value="3650" name="forceBalancingThresold"/>
  <variable id="28" type="2" value="3000" name="stopBalancingThreshold"/>
  <variable id="59" type="4" value="10" name="currentStopBalanceThreshold"/>
 </balancingParam>
<voltageParam>
  <variable id="29" type="2" value="3650" name="overVoltageThreshold"/>
  <variable id="30" type="2" value="2600" name="underVoltageThreshold"/>
  <variable id="31" type="2" value="3620" name="SOCMaxRecalibrationThreshold"/>
  <variable id="32" type="2" value="2620" name="SOCMinRecalibrationThreshold"/>
  <variable id="49" type="2" value="3630" name="hysteresisMaxVoltageCharge"/>
  <variable id="50" type="2" value="3400" name="hysteresisMinVoltageCharge"/>
  <variable id="60" type="4" value="1" name="currentSOCCalibrationThreshold"/>
  <variable id="61" type="2" value="2700" name="endOfDischargeThreshold"/>
 </voltageParam>
 <temperatureParam>
  <variable id="33" type="2" value="550" name="maxBalancingTemp"/>
  <variable id="34" type="2" value="450" name="cellOverTemperatureThreshold"/>
  <variable id="35" type="2" value="-100" name="cellUnderTemperatureThreshold"/>
  <variable id="36" type="4" value="298.15" name="temperatureSensorT0"/>
  <variable id="37" type="4" value="10000" name="temperatureSensorR0"/>
  <variable id="38" type="4" value="4220" name="temperatureSensorBeta"/>
 </temperatureParam>
 <currentParam>
  <variable id="39" type="0" value="0" name="currentMeasConvention"/>
  <variable id="40" type="4" value="150" name="positiveShortCircuitThreshold"/>
  <variable id="41" type="4" value="-55" name="negativeShortCircuitThreshold"/>
  <variable id="42" type="4" value="125000" name="SOPCapacity"/>
  <variable id="43" type="4" value="50" name="SOPChargeNominal"/>
  <variable id="44" type="4" value="50" name="SOPDischargeNominal"/>
  <variable id="45" type="4" value="16" name="currentSensorSensitivity"/>
  <variable id="46" type="2" value="2048" name="currentRef"/>
  <variable id="47" type="4" value="0.2" name="noCurOffsetThreshold"/>
  <variable id="48" type="2" value="10" name="currentMeasurementError"/>
 </currentParam>
 <CBChargerParam>
  <variable id="51" type="4" value="54" name="maxVoltageChargerCB"/>
  <variable id="52" type="4" value="30" name="maxCurrentChargerCB"/>
 </CBChargerParam>
 <snapshotParam>
  <variable id="53" type="2" value="0" name="snapshotShortTimer"/>
  <variable id="54" type="2" value="0" name="snapshotLongTimer"/>
  <variable id="65" type="0" value="0" name="ExtCanIdType"/>
 </snapshotParam>
 <powerOutputParam>
  <variable id="3" type="0" value="0" name="dissociateChargePowerLine"/>
  <variable id="55" type="2" value="20" name="powerOutputPrecharge"/>
  <variable id="56" type="2" value="400" name="fanActTempThreshold"/>
  <variable id="57" type="2" value="350" name="fanDeactTempThreshold"/>
  <variable id="58" type="2" value="2" name="fanSourceTrigger"/>
  <variable id="62" type="0" value="1" name="autoEngageDuringCharge"/>
 </powerOutputParam>
</BMSparam>
```

11 Application with more than 24 cells – FreeSafe Slave boards

11.1 Overview

FreeSafe Extended can manage up to 24 cells in series. For a battery pack with more than 24 cells, additional FreeSafe slave boards are required. Each slave board has to be connected to the group of cells it manages and to the CAN bus dedicated for Freemens products in order to send to FreeSafe Extended the voltage and temperature measurements and to receive the balancing orders.

FreeSafe Extended can support up to 16 additional slaves board. Each slave board can manage up to 12 cells. The maximum number of cells that the BMS can manage is 216.

There are 3 main connections to the FreeSafe Slave board:

- Cells. From 4 to 12 serial cells per board.
- Temperature sensors. They are NTC thermistors. See the datasheet of FreeSafe Extended for more details.
- Isolated CAN bus. Used to connect the slaves to the master board.

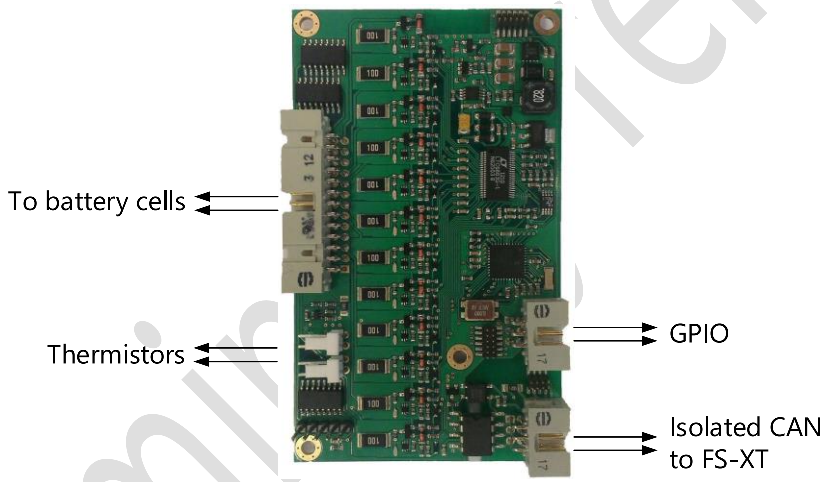


Figure 49: FreeSafe Slave board inputs and outputs

11.2 Connectors and pins configuration

11.2.1 General description

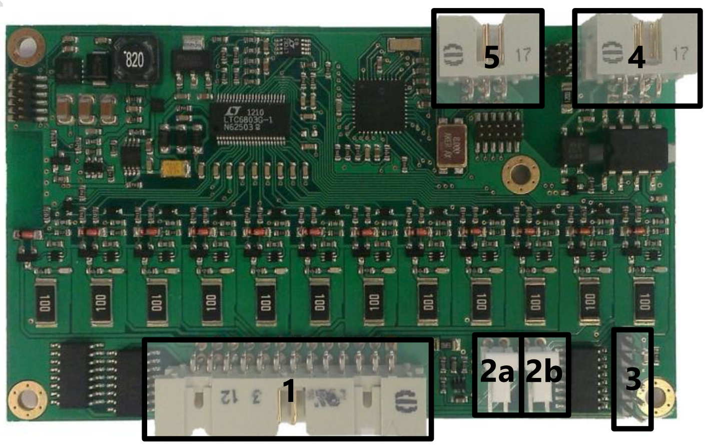


Figure 50: FreeSafe Slave connectors – top view

Table 92: FreeSafe Slave pins & connectors

N°	Connector	Pins	Description
1	**Cell connector**	26	Connect to battery cell terminals.
2a	**NTC connector n°1**	2	Connect to 10k NTC resistor for temperature sensing.
2b	**NTC connector n°2**	2	
3	**Programming connector**		
4	**Isolated CAN bus connector**	6	Connect to FreeSafe Extended connector n°4 ("Freemens CAN").
5	**GPIO connector**	6	Reserved for future uses.

Table 93: FreeSafe Slave recommended complementary connectors

Onboard connector			**Recommended complementary connector**	
N°	Manufacturer	Part number	Manufacturer	Part number
1	Harting	09 18 526 7323	Harting	09 18 526 7813
			3M	3365/26
2a* & 2b*	TE CONNECTIVITY	640457-2	TE CONNECTIVITY	3-640441-2
4 & 5	Harting	09 18 506 7323	Harting	09 18 506 7803
			3M	3365/06

*Other equivalent references for the complementary connector n°2: Molex 22-01-3027 + 08-50-0114

11.2.2 Pin configuration

Cell connector

Figure 51: Slave cell connector front side

See *Connection of multiple boards to the battery* p*81* for additional connection information and recommendations.

Table 94: Cell connector pins description

Pins	Description	Pins	Description
1 – 2	Cell 1 -	**15 – 16**	Cell 7 + / Cell 8 -
3 – 4	Cell 1 + / Cell 2 -	**17 – 18**	Cell 8 + / Cell 9 -
5 – 6	Cell 2 + / Cell 3 -	**19 – 20**	Cell 9 + / Cell 10 -
7 – 8	Cell 3 + / Cell 4 -	**21 – 22**	Cell 10 + / Cell 11 -
9 – 10	Cell 4 + / Cell 5 -	**23 – 24**	Cell 11 + / Cell 12 -
11 – 12	Cell 5 + / Cell 6 -	**25 – 26**	Cell 12 +
13- 14	Cell 6 + / Cell 7 -		

NTC connector

NTC resistor terminals can be connected as described below. The thermistors do not have polarity and can be wired freely. See *Temperature* protection thresholds p*37* for more details about thermal management.

Figure 52: Salve NTC connector

Table 95: NTC connector pins description

Pins	Description
1 – 2	10kΩ NTC terminals – no polarity

CAN connector for Freemens CAN

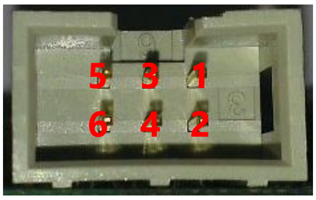


Figure 53: salve CAN connector font side

Table 96: CAN-bus connector pins description

Pins	Description
1 – 2	5V (provided by FS-XT)
3	CAN L
4	CAN H
5 – 6	GND (Battery negative terminal, provided by FS-XT)

See *CAN bus connections recommendations for FreeSafe Slaves* p82 for more details.

11.3 FreeSafe slaves wiring recommendations

11.3.1 Connection of multiple boards to the battery

The unused cell connector pins must be connected in short circuit to the last positive cell terminal. Cell 1- & Cell 12+ must always be directly connected as close as possible to the cell terminal with a dedicated wire. To ensure correct voltage readings, all the **cell connector** pins must be connected as close as possible to the cell terminals.

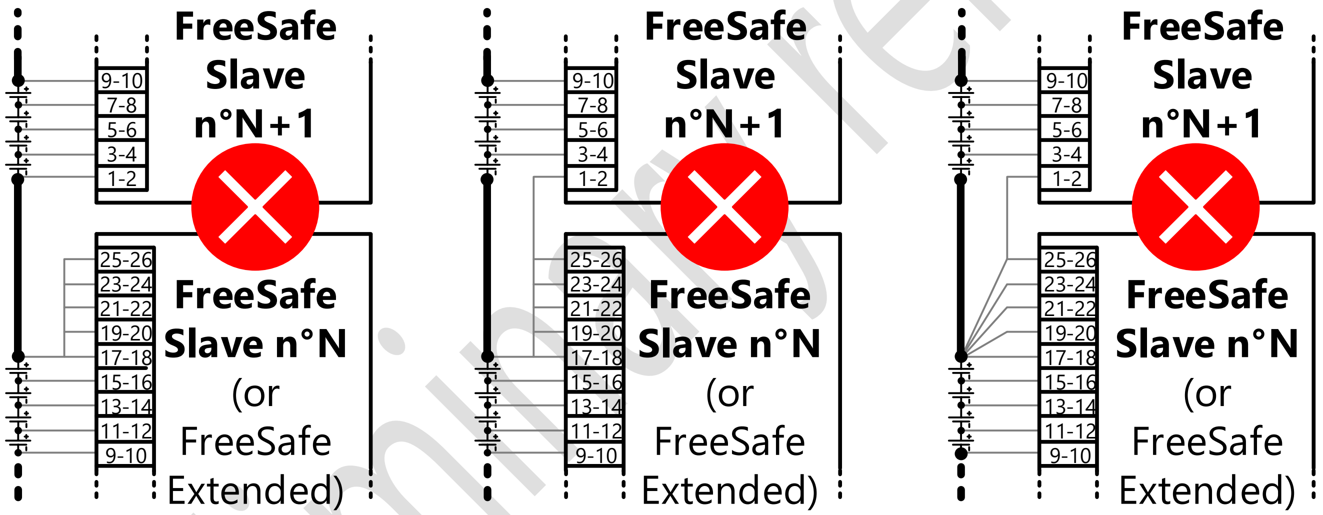


Figure 54: incorrect wiring to cell stack

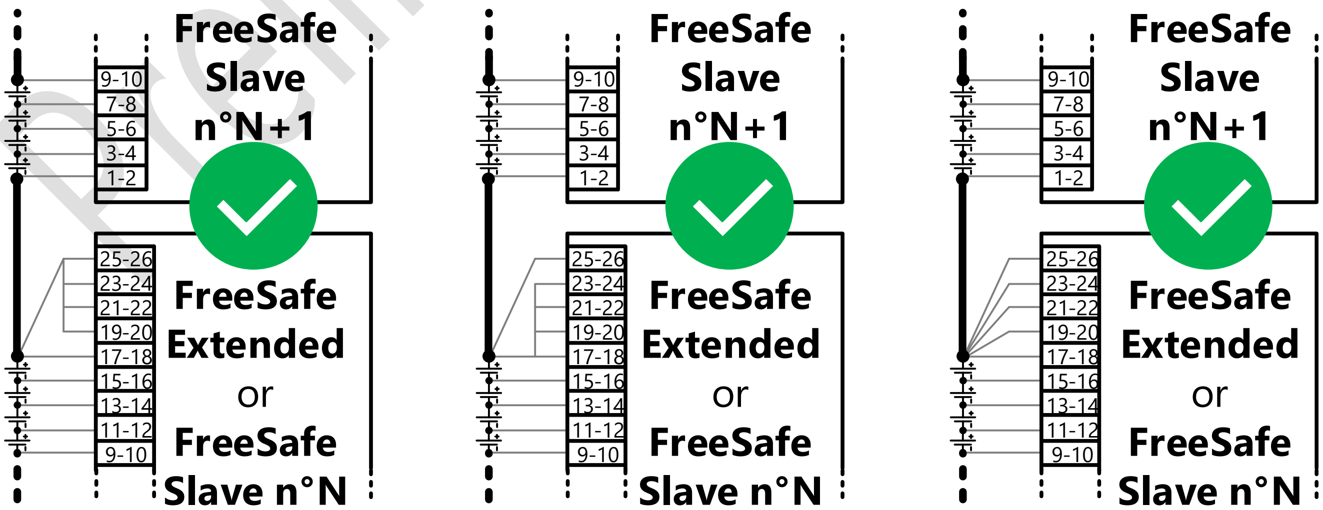


Figure 55: correct wiring to cell stack

11.3.2 CAN bus connections recommendations for FreeSafe Slaves

Typical connections of the dedicated Freemens CAN bus

FreeSafe Extended provides the 5V supply to the Freemens' products dedicated CAN bus. As described in *Connection of FreeSafe CAN buses* p*20*, the CAN bus requires terminal 120Ω resistors on the first and last nodes. Each FreeSafe boards, Extended and slave, already have a mounted onboard terminal resistor. The connection of this resistor is described in the next paragraphs.

The typical CAN connection of FreeSafe Extended to the FreeSafe slave boards is presented below.

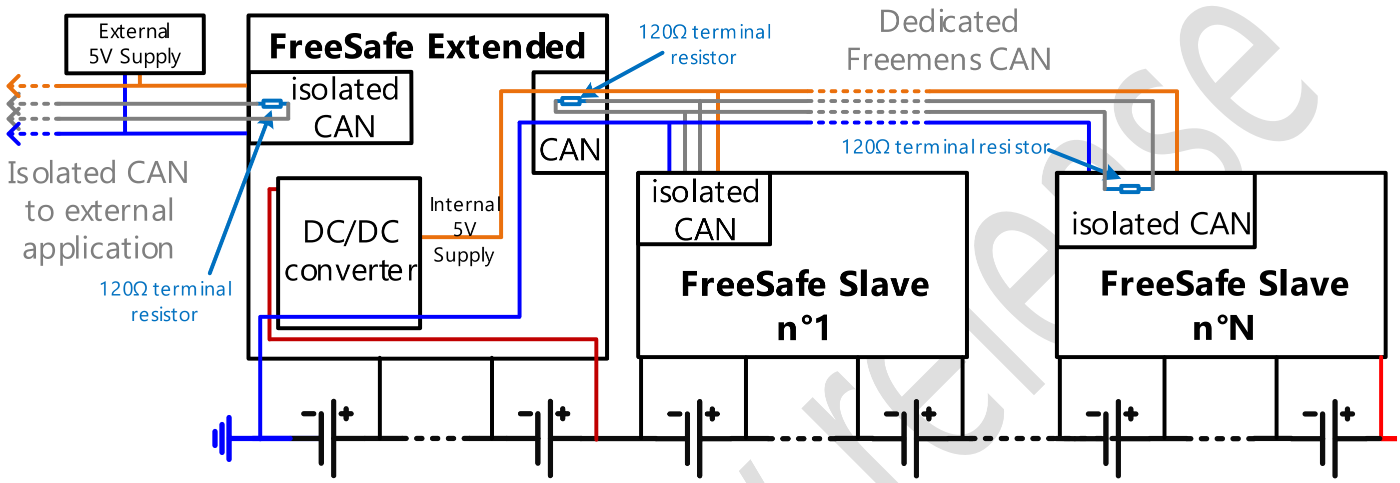


Figure 56: typical connection of the dedicated Freemens CAN buses

FreeSafe Extended terminal resistor for Freemens' dedicated CAN bus

The 120Ω terminal resistor can be connected by using a jumper on the connector n°4a. The Figure 57 shows the connector where the jumper must be plugged.

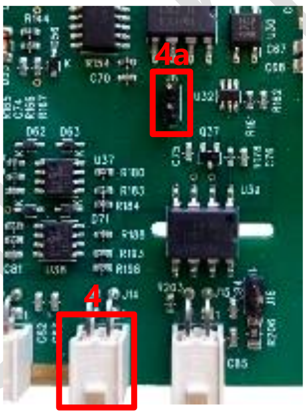


Figure 57: CAN connector (n°4) for Freemens products with its terminal resistor connector (n°4a)

Figure 58: example of 2.54mm jumper - SPC20479 from Multicomp

FreeSafe Slave CAN bus terminal resistor

To connect the 120Ω terminator resistor on a FreeSafe slave, the easiest method is to plug a jumper (for instance Archer M50 1.27mm Pitch Jumper Socket - *http://cdn.harwin.com/pdfs/60page107.pdf* - or any equivalent) on the pins 1 & 2 of the connector shown on the next figure.

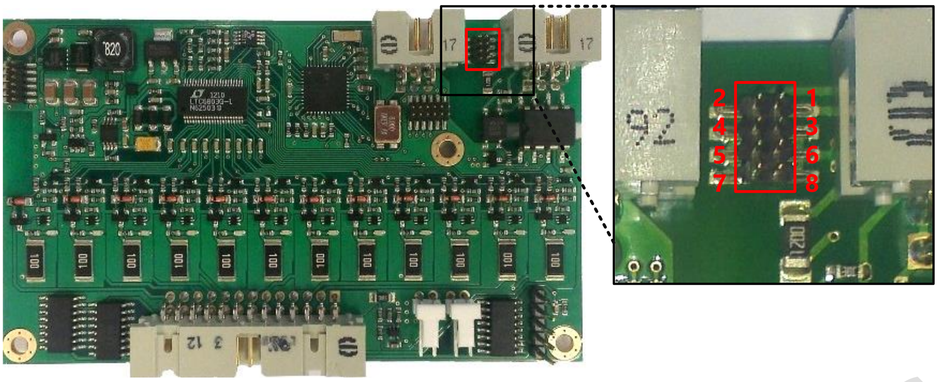


Figure 59: jumper location (pin 1 & 2) for connecting the 120Ω terminator resistor on FreeSafe Slave (top face)

There is also another possibility: a 0Ω resistor (0603 SMD package) can also be weld on the bottom layer of the board on the location indicated below to make the terminal resistor active.

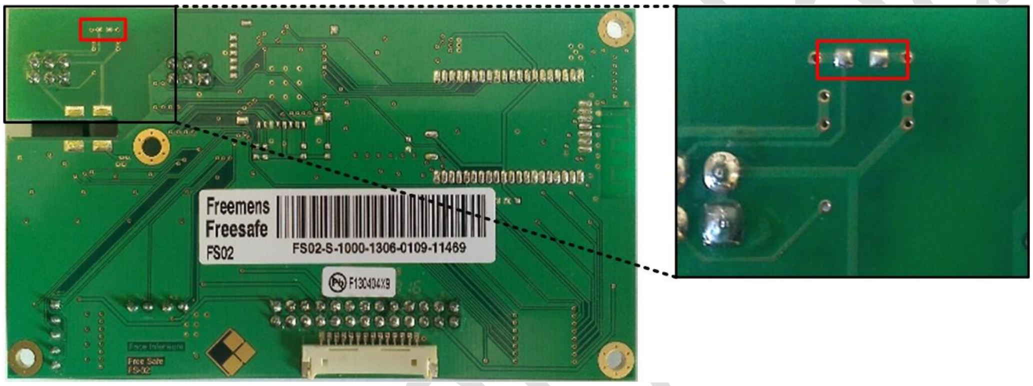


Figure 60: 0Ω resistor location for the connection of the 120Ω terminator resistor on FreeSafe Slave (bottom face)

11.4 FreeSafe slave boards characteristics

11.4.1 FreeSafe slave board absolute maximum electrical ratings

Parameter	Symbol	Value	Units
Maximum Cells Voltage	V_{celln}	–0.3V to Min (8 • n, 75)	V
Maximum Balancing Control Voltage	B_{Cn}	–0.3V to Min (8 • n, 75)	V
Maximum Current Measurement Input Voltage	I_{mes}	3.3	V
Operating Temperature Range	T_{range}	-40 to 105	°C
Maximum CAN-bus supply current	I_{can}	250	mA
Maximum Voltage on Imes input	I_{mes}	3.6	V
Maximum Balancing Power Dissipation per Cell	P_{bal}	1.5	W
Maximum Total Power Dissipation	P_{balmax}	5	W

11.4.2 FreeSafe slave board mechanical characteristics

All dimensions are in mm.

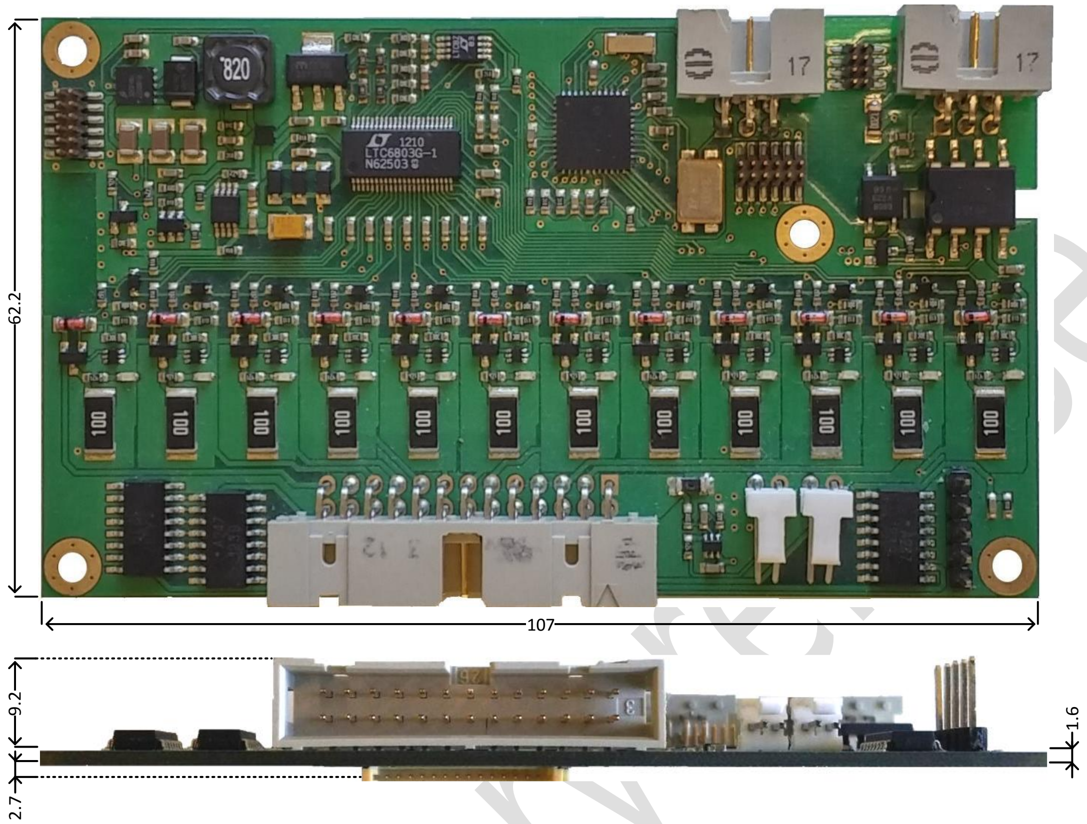


Figure 61: Mechanical views (side, top)

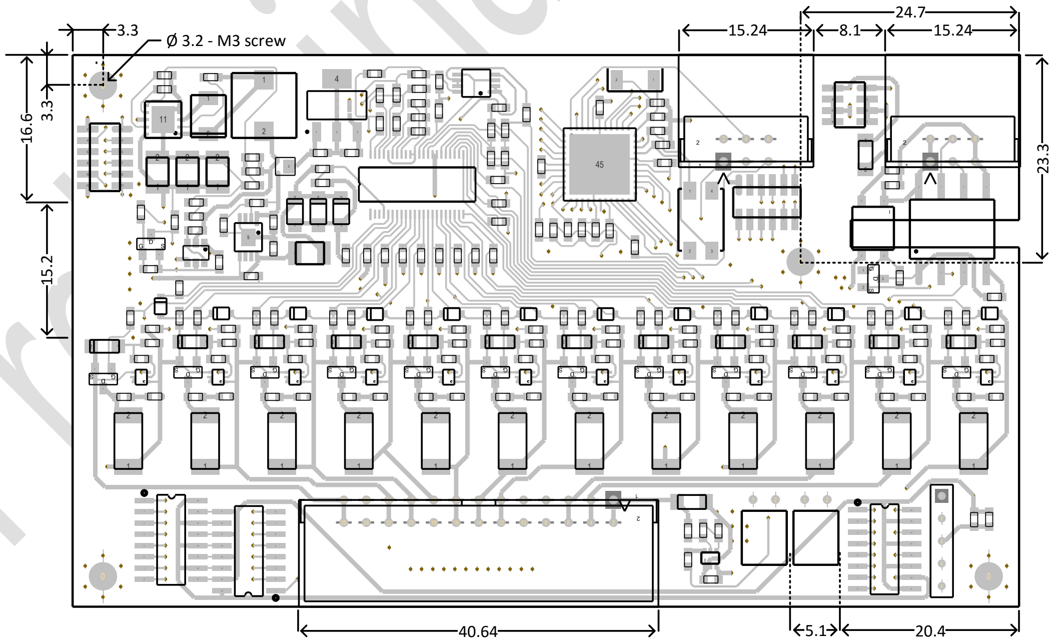


Figure 62: Mechanical view bottom side

12 Characteristics

12.1 Mechanical characteristics

On Figure 63 & Figure 64, all dimensions are in millimeters.

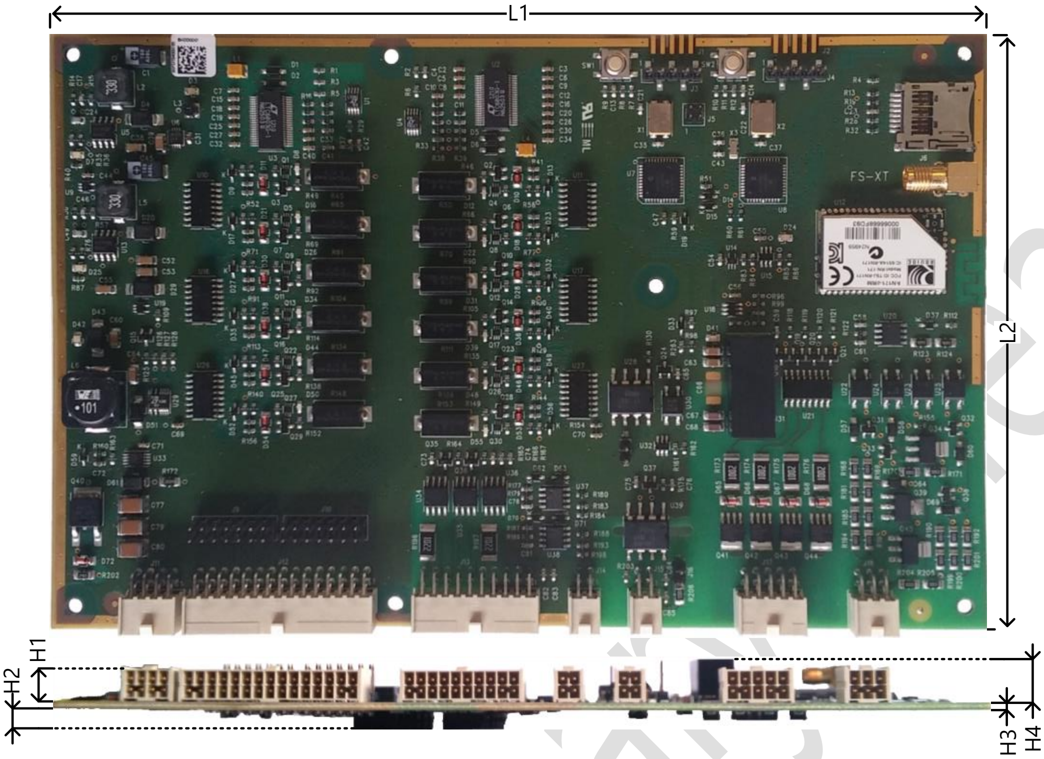


Table 97: external dimensions (mm) of FS-XT

L1	200
L2	130
H1	6.35
H2	5
H3	1.6
H4	11.2

Figure 63: Mechanical view (top and front side) – external dimensions of the board

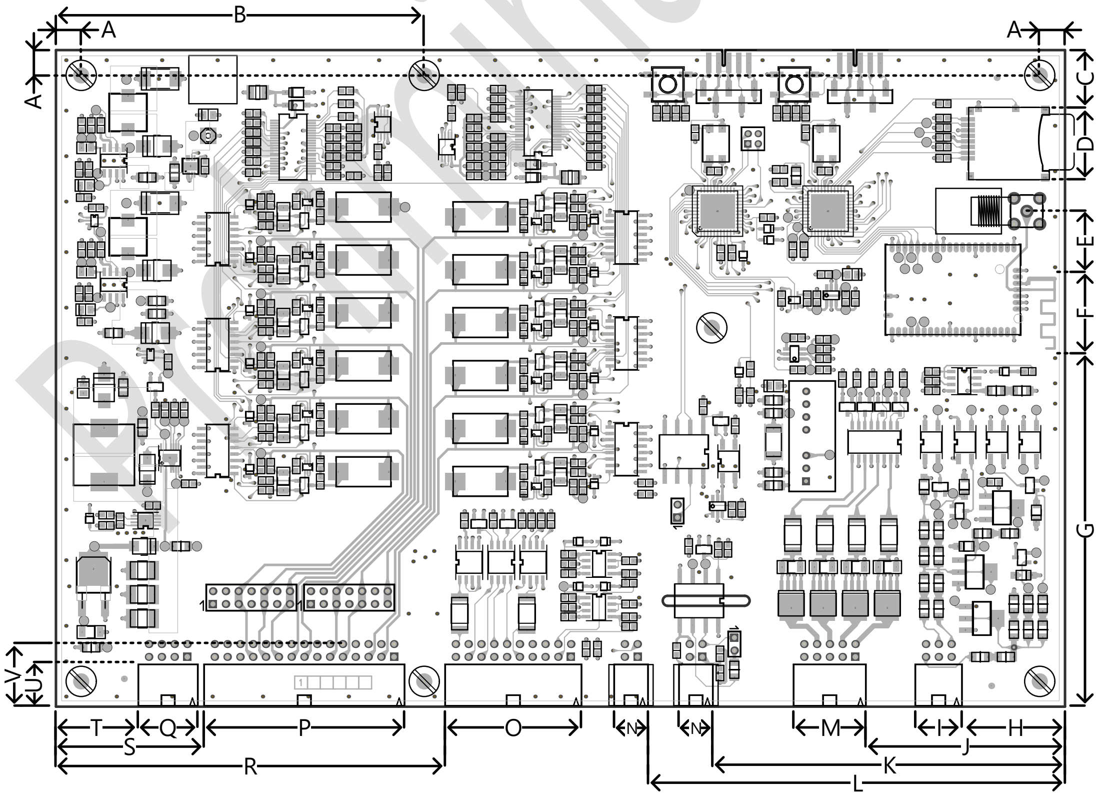


Table 98: FS-XT dimensions (mm)

A	5
B	77.1
C	11.4
D	14.3
E	12.4
F	15.5
G	70.2
H	20.4
I	9.2
J	39.5
K	69.8
L	82.7
M	14.2
N	6.6
O	26.9
P	39.6
Q	11.7
R	77.1
S	29.3
T	16.4
U	8.4
V	12.4

Figure 64: Mechanical view (top side) – connectors and mounting holes positions

12.2 Electrical characteristics

The following specifications apply over the full operating temperature range.

12.2.1 Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Maximum Cells Voltage	V_{celln}	5	V
Maximum Battery Voltage	V_{Bat}	120	V
Maximum Current Measurement equivalent Input Voltage	V_{mes}	5	V
Operating Temperature Range	T_{range}	-40 to 85	°C
Maximum CAN-bus supply current	I_{can}	250	mA
Maximum Voltage on analog inputs	I_{mes}	3.6	V
Insulation voltage for isolated I/O	V_{iso}	3000	V
Maximum Balancing Power Dissipation per Cell	P_{bal}	3	W
Maximum Total Power Dissipation	P_{balmax}	20	W

12.2.2 Voltage Monitoring

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Battery Stack Voltage	V_{bat}		10		120[2]	V
Measurement Resolution	V_{lsb}			1.5		mV
ADC Offset			-0.5		0.5	mV
ADC Gain Error			-0.22		0.22	%
Total Measurement Error	V_{err}	V_{cell} <5V	-9	±2.5	9	mV
Cell Voltage Range	V_{cell}		-0.3		5	V
Supply Power	I_s	Sleep Mode[1]	2	13	40	mW
		Short Cycle		1.1		W

[1] Min is for a 10V battery, Max for 100V and Typical for 48V. See *Sleep mode power consumption* for more details.

[2] This maximum threshold refers to a battery with FreeSafe Extended alone. This limitation can be pushed back to 1080V by using slave boards.

12.2.3 Cell Balancing

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Internal Balancing Resistor	R_{bal}	T_{amb} = 25°C	9.5	10	10.5	Ω
Internal Balancing current	I_{bal}	T_{amb} = 25°C ; V_{cell} =3.6V	342	360	378	mA

12.2.4 CANBUS for Freemens devices

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Voltage (Bus side)	V_{bus}	Power on the bus is provided by the first BMS of the string	4.75	5	5.25	V
Can Bus Output Voltage (dominant)	CAN_H	Rl=60 Ohm	2.9	3.5	4.5	V
	CAN_L	Rl=60 Ohm	0.8	1.2	1.5	V
Can Bus Output Voltage (recessive)		Rl=60 Ohm	2	2.3	3	V
Can Bus Output Current	I_{can}	Rl=60 Ohm			250	mA
Can Bus Rate of Operation	F_{can}			250		Kbps

12.2.5 External Coulomb Counting

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Analog to digital converter resolution	AD_{res}	A_{Vdd}=3.3V A_{Vss}=0V		10		bits
ADC Integral Nonlinearity	AD_{In}	A_{Vdd}=3.3V A_{Vss}=0V	-1.5		+1.5	LSb
ADC Differential Nonlinearity	AD_{Dn}	A_{Vdd}=3.3V A_{Vss}=0V	>-1		<1	LSb
ADC Gain Error	AD_{Ge}	A_{Vdd}=3.3V A_{Vss}=0V		3	6	LSb
ADC Offset Error	AD_{Oe}	A_{Vdd}=3.3V A_{Vss}=0V		2	5	LSb
ADC Input Voltage	AD_{Vin}	A_{Vdd}=3.3V A_{Vss}=0V	-0.3		3.6	V
Recommended Impedance of Analog Voltage Source	I_{can}	R_l=60 Ohm		200		Ohm
Can Bus Rate of Operation	F_{can}			1		Mbps

12.2.6 DC power output (for driving contactor, fan or other dc peripherals)

Parameter	**Symbol**	**Conditions**		**Min**	**Typ**	**Max**	**Units**
Output Voltage	V_{out}	V_{out} = External DC source V_{in}		9		75	V
Max peak current per output	I_{outmax}	Non repetitive t_{peak}=100ms				15	A
Max **continuous** current **per output**	I_{out}	Only **one** output working	T_{amb} =25°C			3.75	A
		All **four** outputs are working				2.1	A

12.2.7 CANBUS (for Freemens devices and for external custom applications)

Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply Voltage (Bus side)	V_{bus}		4.75	5	5.25	V
Can Bus Output Voltage **(dominant)**	CAN_H	Vi = 0 V, R_L=60 Ohm	2.9	3.5	4.5	V
	CAN_L		0.8	1.2	1.5	V
Can Bus Output Voltage **(recessive)**		Vi = 2 V, R_L=60 Ohm	2	2.3	3	V
Can Bus High-level output current	I_{OH}	Driver	-70			mA
		Receiver	- 4			mA
Can Bus Low-level output current	I_{OL}	Driver			70	mA
		Receiver			4	mA
Can Bus Rate of Operation	F_{can}		0.01		1	Mbps

12.2.8 GPIO (isolated I/O)

Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Input voltage		No external additional resistor	0		48	V
Output voltage			0		75	V

12.2.9 Hall Effect sensor

Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Units**
Supply voltage	V_{hall}	Single voltage supply	4.75	5	5.25	V
Max supply current[2]		Consumption on the 5V supply		25	250	mA
Input Voltage on FS-XT			0		5	V
Internal ADC precision[3]		12 bits ADC		1.22		mV

[2] the 5V supply (for CAN bus and Hall Effect sensor) is short-circuit protected (there is a thermal protection and the maximum current is internally limited).
[3] the resolution of the conversion of the output current provided by the Hall Effect sensor. The 5Vmax converted by a 12 bits ADC gives $5/2^{12}$=1.22mV.

12.2.10 External DC Supply

The external DC Supply provides the power for the devices driven by the power outputs (contactors) and an optional supply for the FS-XT board. See *Power supply unit* p*90* for more details on the power supply topology of FS-XT.

N.B.: the supply current consumption presented on the table and figure below only shows the onboard electronics consumption.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Input Voltage	V_{in}	The default reference has a 18-75V input. A 9-36V variant can be used.	9		75	V
Supply Current[4]	I_s	Normal Mode (Vin = 24 V)		13		mA
		Normal Mode (Vin = 48 V)		6.5		mA

[4] More details on the current consumption are shown on Figure 65.

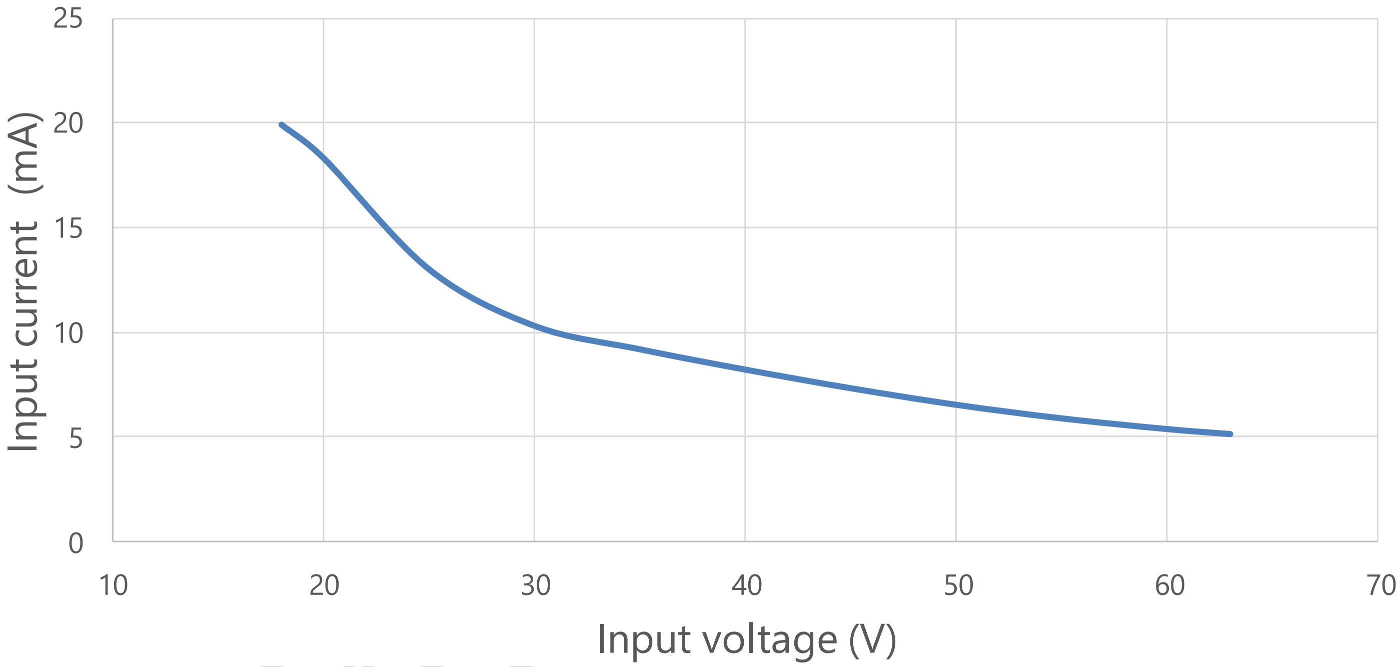


Figure 65: Supply current of FS-XT in sleep mode vs input voltage with a 18-75V input external DC converter

The consumption of the electronics of FS-XT is optimal and minimized when the board is directly self-supplied from the battery. See the next paragraph *Internal power supply unit* for more details.

12.2.11 Internal power supply unit

The internal power supply uses the battery cells managed by FS-XT to supply the onboard electronics. DC/DC switching converters and smart designs allow an optimization of the power consumption according to the running mode of the FS-XT board: normal or sleep mode.

Sleep mode power consumption

During the sleeping period, the current is supplied with a low quiescent linear regulator: from 10V to 100V battery voltage, FreeSafe Extended only draw between 200µA and 400µA when in sleep mode.

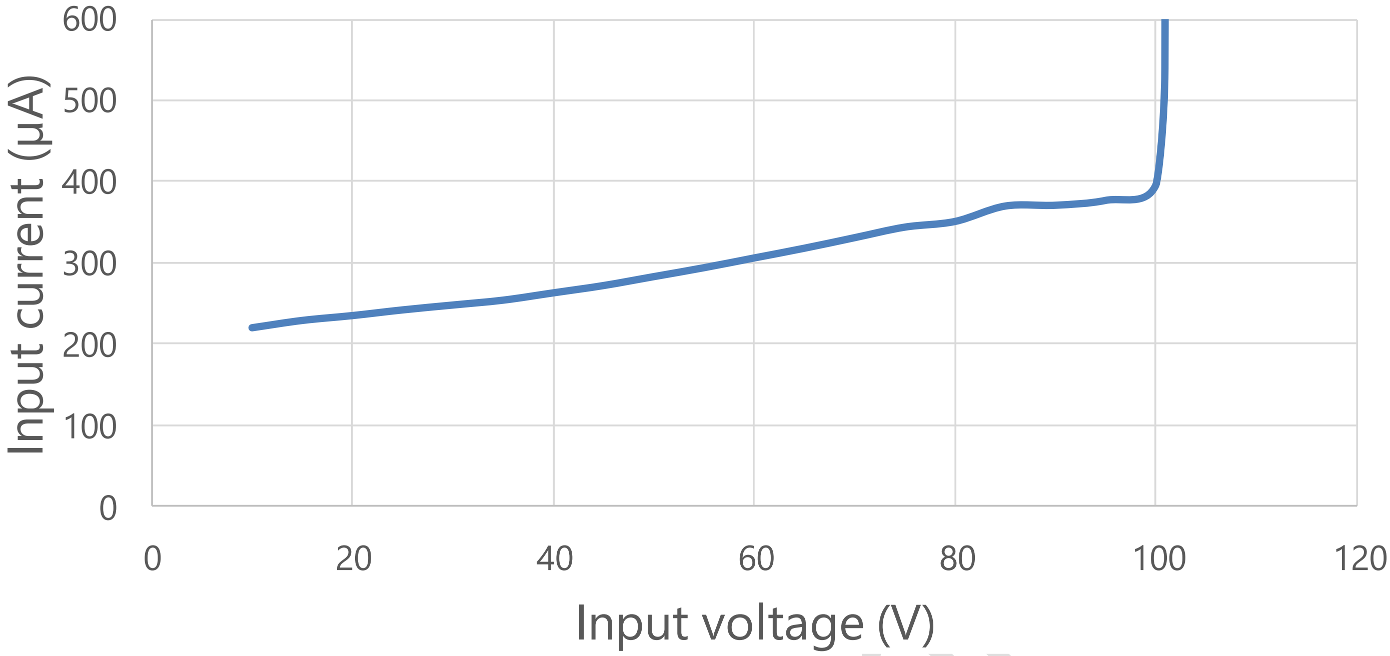


Figure 66: Battery current consumption in sleep during power saving mode depending on the battery voltage

The consumption peak seen at 100V is due to the overvoltage input protection of the board.

This sleep mode power consumption can be compared to the self-discharge of the battery managed by FS-XT. If the self-consumption is SC (%capacity/month), the cell capacity C (A.h) and tm is the month duration (h), then the self-consumption current is: $i_{SC} = \frac{C \cdot SC}{tm}$.

For instance, a self-consumption current of 400µA equals the self-discharge of a 30A.h battery which loses 1% of its capacity every month, i.e. this 30A.h battery will lose about 0.3A.h per month because of self-discharge and only 0.3A.h because of the self-consumption of FS-XT.

13 Design guide for the BMS and its peripherals

13.1 Power supply unit

13.1.1 General description

FreeSafe Extended integrates its own Power Supply Unit (PSU) to supply the onboard electronics. As soon as a source is connected to the PSU, FS-XT can perform the cell management, the power line management and the communication management. The PSU can be supplied by two different sources: the battery cells managed by FS-XT or, optionally, the external DC source used for the contactors.

- The electronics is self-powered once FS-XT is connected to the battery cells. In addition, it performs optimal supply based on intelligent control and extensive use of switch mode power supplies with efficiencies above 85%. This feature makes FreeSafe Extended a low power BMS capable of ultra-low power operation. On board supplies are 5V DC and 3.3V DC. To operate, the BMS must be connected to a battery with at least 10V output DC voltage and up to 120V.
- As shown on the next figure, FS-XT must also have an external power source to supply the devices driven by the power outputs (contactors for instance). As described later in *Choosing the external DC source*, the external DC source can be the battery itself. An optional DC/DC converter can also be mounted on the board to power the electronics from this external source instead of using the battery cells connected to the BMS.

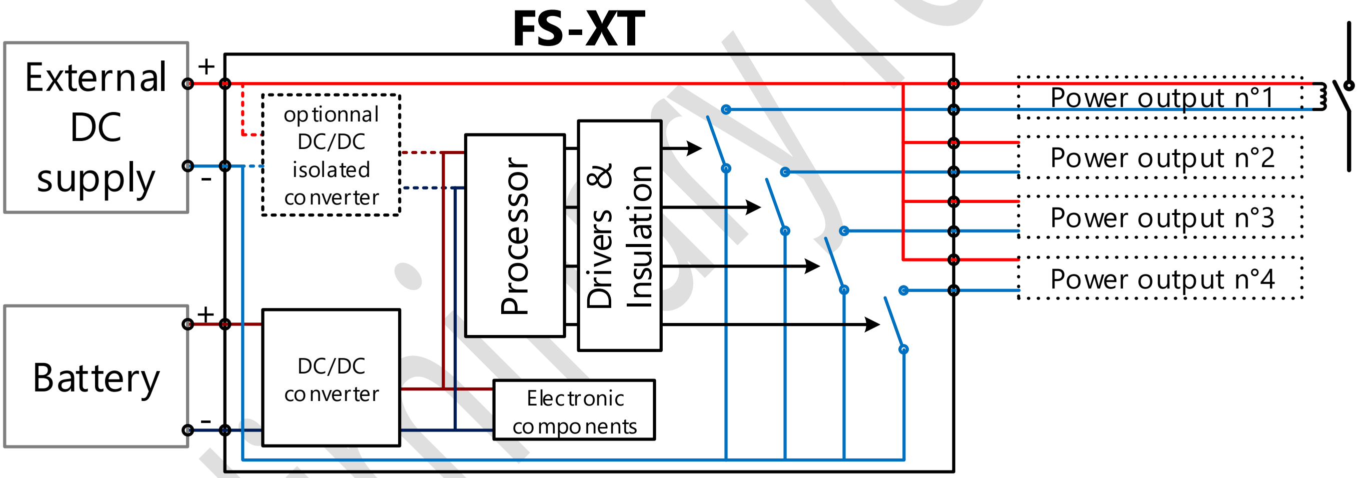


Figure 67: principle diagram of the FreeSafe Extended PSU

13.1.2 External DC source design choices

Electrical constraints

The external DC source input (pin n°5 & 10 of the connector n°6 – see *Power Outputs Connector* p*16*) of FS-XT accepts any voltage up to 75V.

This external DC source can be used to power an optional onboard isolated DC/DC converted that will supply the onboard electronics. It must be able to provide at least 6Wmax. This isolated DC/DC converter can be selected between three converter references depending on the voltage of the external DC source; the next table presents their characteristics.

Table 99: Voltage ranges for the external DC source

	External DC Source voltage	
Onboard converter reference	min (V)	max (V)
48VDC nominal (default reference)	36	75
24VDC nominal	18	36
12VDC nominal	9	18

The external DC source is mainly used to supply the power peripheral driven by the BMS (contactors and fan). There are two design constraints:

- The DC source must provide enough power to be able to withstand the inrush current when driving the DC contactor coils.
- As the external source voltage will be directly reused through the power outputs to supply the peripherals, all the devices must work with the same voltage level (source, contactor coils and fan).

Choosing the external DC source

As long as the voltage and power requirement are satisfied, any source can be used. Three typical case of external DC source can be distinguished:

- A secondary battery, such as a 12V battery used to power the internal embedded network of a vehicle.
- The main battery cells managed by FS-XT. If the battery stack has a compliant voltage it can directly be connected on the external DC input to power the peripherals. Figure 68 describes this case.
- If the total battery cells voltage is not compliant, an additional DC/DC converter can use the battery as a source to create a 9V-75V source. This source can even be used by the rest of the system.

N.B.: in the two last cases (and if the DC/DC converter is not an isolated one), the insulation between the battery cells and the power peripherals is lost.

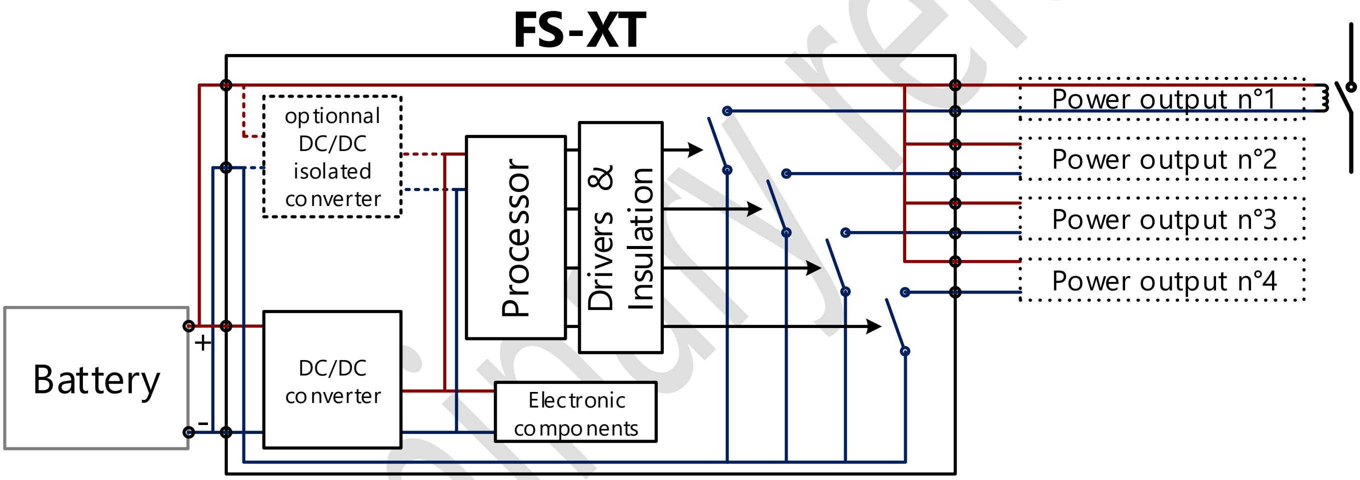


Figure 68: using the battery managed by FS-XT as the external DC source

Connecting FS-XT to the external DC source

The external DC source must ensure a stable input voltage in the specified input range (cf. *Electrical constraints*). For that the connection between FS-XT and its source must be carefully considered.

If the DC source is the battery or a DC/DC converter (isolated or not) whose input is the battery, the connection to FS-XT has to be a star connection as shown on the next figure. This star connection guarantees that the power current flowing to the application, or from the charger, will not trouble the input of FS-XT from wire inductive or resistive perturbation.

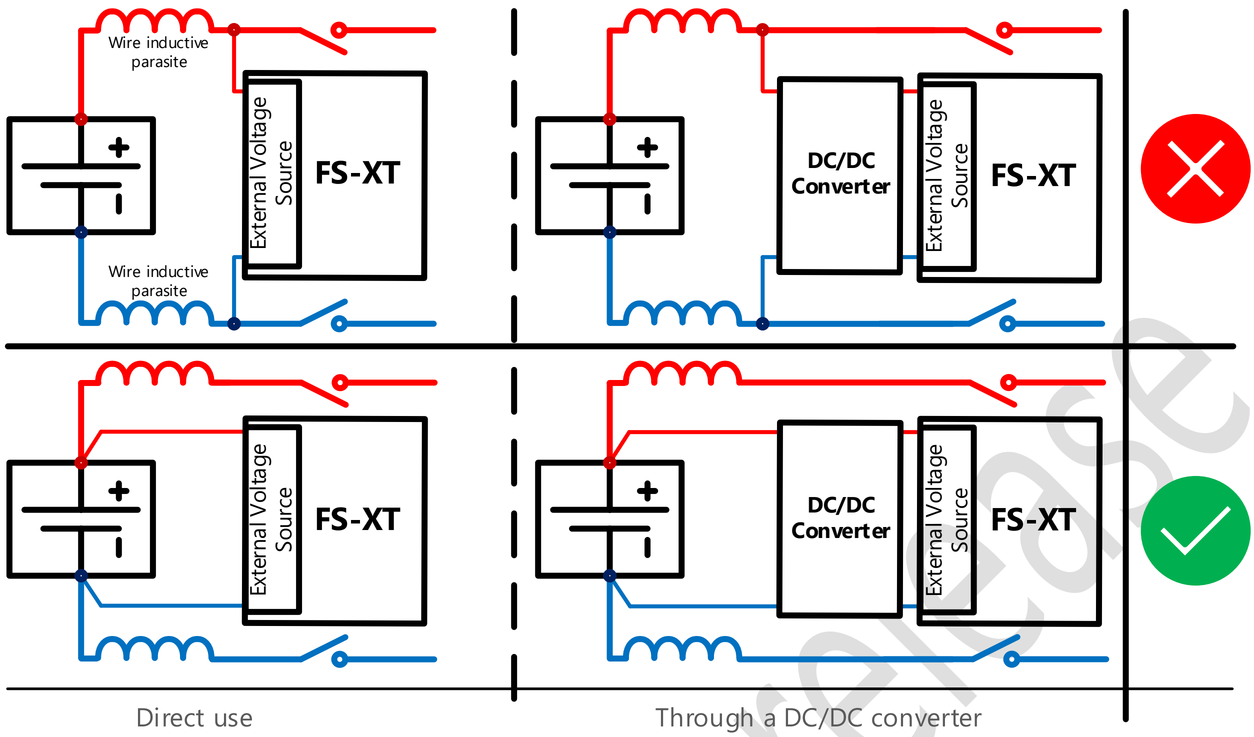


Figure 69: using the battery as the external DC source for FS-XT - connection of the DC source to FS-XT

13.1.3 Optimization of the internal power supply unit consumption in sleep mode

Power saving mode parameters specified through the CONF.XML file in the SD card

Table 100: Power management parameters

Name	Id	Unit	Type	Example	Range	Comment
sleepActivationTimer	4	s	int	120	10-32768	Inactivity duration before going into power saving mode
sleepDuration	5	s	int	60	10-32768	Refresh interval for voltage and temperature in power saving mode
maxRecordPeriod	24	s	long	3600		Maximum allowed period between two recording

FreeSafe Extended wait for “sleepActivationTimer” seconds that there is no activity on the system (no voltage, current, temperature or state change) to enter into sleep mode. In sleep mode, FreeSafe Extended will perform a basic checkup on the battery variables every “sleepDuration” seconds. In this mode, FreeSafe Extended will shut down everything and will be unreachable via Wi-Fi until the BMS returns in normal mode.

If nothing has been recorded on the SD card during the last “maxRecordPeriod” seconds, the BMS will force a recording.

The control signal on the isolated input IN0 (see *Control signal for contactors states* p62) will wake up the BMS when the order to turn on the contactors is detected.

Sleep mode power management configuration

The sleep duration parameter (see *Table 100*) control the duration of the loop of the power saving mode and the minimum inactivity timeframe that will put FreeSafe Extended in this mode. Increasing “sleepDuration” will reduce the overall power consumption but will slow down the refresh rate of the voltage and temperature and their recording on the SD card during sleep mode.

The power consumption of the BMS in sleep mode depends on the duration ratio of the following operating phases:

- The power consumed when FS-XT is completely shut down. It is named *SleepPower* in this paragraph.

- The power consumed when FS-XT wakes up for a short time after “sleepDuration” seconds to perform a checkup. If nothing changed compared to the last checkup (no voltage or temperature change, “maxRecordPeriod” is not reached), the BMS re-enter in sleep mode immediately. Else it performs a record of the new variables on the SD card before entering sleep mode.

The following variables are used describes the sleep mode power consumption (see *Equation 3*):

- $t_0 = SleepTime =$ “sleepDuration” = configurable parameter to optimize
- $P_0 = SleepPower = Sleep\ Current * Battery\ Voltage = 280\mu A * 48V = 13.4mW$. The *SleepPower* can be found with the *Figure 66*: *Battery current consumption in sleep during power* saving mode depending on the battery voltage. For a 48V battery, as 280µA are drawn, the board consumption is 13.4mW.
- $P_1 = ShortWakeUpPower = 0.56W$, $T_1 = ShortWakeUpTime = 30ms$
- $P_2 = SdRecordWakeUpPower = 0.78W$, $T_2 = SdRecordWakeUpTime = 300ms$
- $t_3 =$ duration between 2 record on the SD card (up to “maxRecordPeriod”)

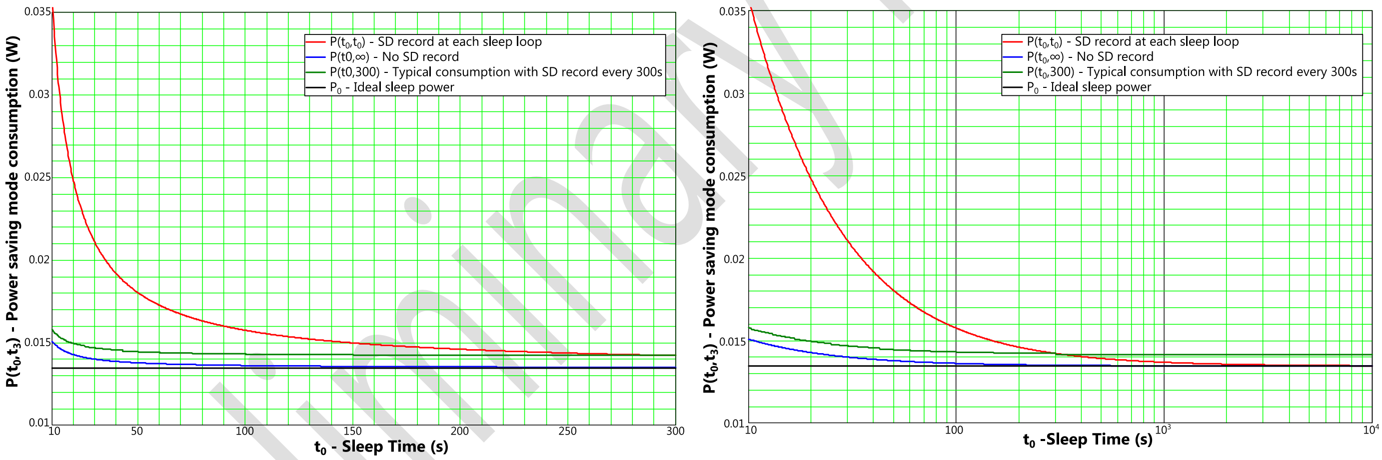
The power consumed by the BMS in sleep mode is then:

Equation 3: sleep mode power consumption

$$P(t_0, t_3) = \frac{P_0 \cdot t_3 + T_2 \cdot P_2 + n(t_0, t_3) \cdot T_1 \cdot P_1}{t_3 + T_2 + n(t_0, t_3) \cdot T_1}$$

Where $n(t_0, t_3) = floor\left(\frac{t_3}{t_0}\right) - 1$ is the number of sleep loop without SD record during t_3

Using *Equation 3*, the next figure and table show the sleep mode power consumption depending on *SleepTime.*



Linear scales – zoom on the first 300s | Log scales

Figure 70: power consumption during power saving mode for a 48V battery

Table 101: power consumption examples during sleep mode with various “sleepDuration” and “maxRecordTime”

sleepDuration (s)	maxRecordTime (s)	Power consumption (mW)	Increase over the 13.4mW ideal sleep consumption
10	300	15.8	+17%
20	300	15	+11%
60	300	14.4	+7.3%
300	300	14.2	+5.7%
60	3600	13.6	+2.5%
300	3600	13.8	+0.9%

It clearly appears that the consumption in sleep mode decrease directly with a longer sleep time. However, for a sleep timer longer than 60s, the gain is not significant enough to justify a slower regular checkup of the battery state in sleep mode.

In order to ensure the sleep consumption is low (under 5% increase on the ideal sleep consumption) and the battery still perform regular checkups and records, it is recommended that the default values of the “sleepDuration” and “maxRecordTime” parameters are 60s and 3600s.

13.2 Power peripherals design choices

13.2.1 Contactor design choices

Electrical characteristics for contactors choice

The power DC contactor must be designed to withstand the maximum battery voltage, the nominal power current of the application and to be able to cut overcurrent or even, if needed, short-circuit current.

As shown in *Figure 71* below or previously on *Figure 67*, the driving voltage of the coil and the external supply voltage must be the same. The maximum inrush current that drives the coil must be less than 15A during 100ms and the maximum continuous driving current must be less than 3.75A if only one output is supplying the current and 2.1A per output if all four outputs are working at the same time. Following these recommendations ensures the proper use of FS-XT and its functions.

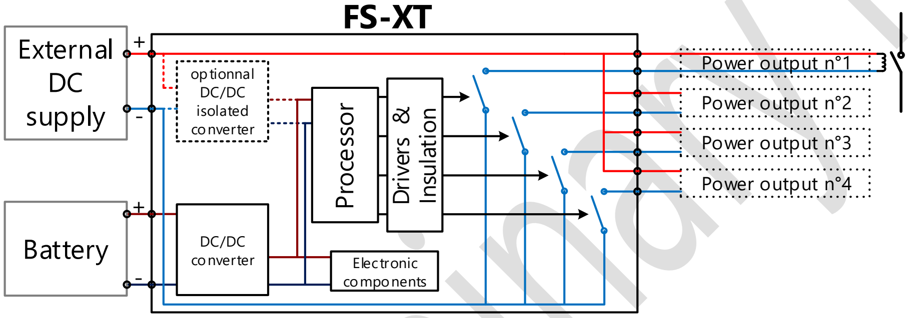


Figure 71: Functional diagram of the 4 DC power outputs and their supply

Table 102: Power outputs current capabilities

Number of used outputs	Max current per output (A)	
	Continuous	Peak for 100ms
1	3.75	15
2 or more	2.1	15

Figure 71 shows a standard implementation with an external power source to supply the devices driven by the power outputs. AS described on *Figure 68*, it is also possible to directly use the battery as a power source; the only recommendation is to match the input voltage of the driven devices with the battery voltage.

Example of recommended DC contactor

Any contactor compliant with the voltage and current of the battery application and with the voltage of the external DC source can be used. Contact Freemens if a confirmation for a specific contactor reference is needed.

Table 103: references and parameters example for contactors

Reference	Manufacturer	Max continuous current (A)	Max voltage (V)	Coil voltage (V)
Kilovac EV200AAANA	TE connectivity	500	900	9 – 36
Kilovac LEV200A4NAA	TE connectivity	500	900	9.6 – 13.2
GX23B	Gigavac	350	800	8 – 16
P105C	Gigavac	50	1200	15 – 32

Datasheets available on the manufacturer website:

- Kilovac EV200, *http://www.te.com/catalog/pn/fr/1618002-7.*
- Kilovac LEV200, *http://www.te.com/usa-en/product-1618387-3.html*.
- Gigavac P105, *http://www.gigavac.com/old-site/pdf/ds/pp/p105.pdf*.
- Gigavac GX23, *http://www.gigavac.com/sites/default/files/files/catalog/spec_sheet/gx23_1.pdf*.

13.2.2 Pre-charge resistor design choices

Freemens does not provide the pre-charge circuit: this section aims to provide help for designing a correct pre-charge circuit.

Role

The pre-charge resistor role is to limit the inrush current that appear when connecting the battery to its application. Caused by the input capacitors of the application, this inrush current can be high enough to carry a power potentially destructive, or at least that can damage the equipment (battery, contactors, capacitors, sensors, etc.) on the long term.

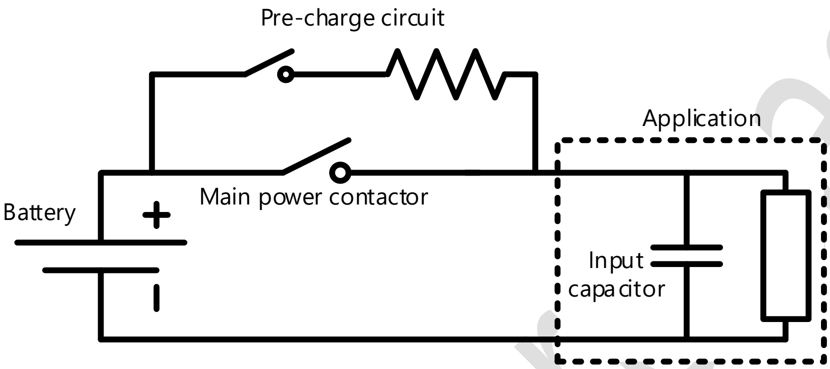


Figure 72: schematic diagram of the elements intervening the pre-charge

Simplified example of natural and uncontrolled inrush current

All the figures presented in this example do not necessarily come from real data but present the good order of magnitude for a typical 48V 100A.h application.

The inrush current is only limited by the electrical resistance of all the serial elements:

- The battery cells. For a $LiFePO_4$ 48V 100A.h battery, there are 15 serial cells. Each cell has a 1mΩ internal DC resistance.
- The power contactor. For a Kilovac EV200, the power contact resistance is 0.2mΩ.
- The natural resistance of the wires. For a 2m long, $10mm^2$ copper wire, the resistance is 3.5mΩ.
- The resistance of electrical contacts between each element of the circuit. For simplicity sake, it is neglected in this example.

The total serial resistance is then **18.7mΩ** which gives, for a **48V** source, an inrush current of **2567A**. The value of the capacitor charged by this inrush current only change the response time, thus the total energy, but the peak current is still the same and it shows the need of a pre-charge resistor to limit the inrush current.

Electrical characteristics

C is the input capacitor value of the application that is connected on the battery,

Vbat is the battery voltage,

R is the pre-charge resistor value.

Equation 4: pre-charge

Tpchg is the duration of the pre-charge. If the duration is set to charge 95% of the input capacitor $$Tpchg = 3RC$$

Pmax is the initial instantaneous power peak on the pre-charge resistor $$Pmax = \frac{Vbat^2}{R}$$

Epchg is the energy needed to charge the input capacitor (and sustained by the pre-charge resistor) $$Epchg = \frac{1}{2}C \cdot Vbat^2$$

Ppchg is the pre-charge power the resistor need to dissipate $$Ppchg = \frac{Epchg}{Tpchg} = \frac{Vbat^2}{6R}$$

Design choices

There are two main constraints to choose a pre-charge resistor:

- The pre-charge duration
- The power sustained by the resistor

These two constraints are directly set by the capacitor value and are also linked together: the longer the pre-charge is, the lower the power constraint will be as the resistor will have a higher value.

The design can be start by two different beginning:

1. If cost and/or dimension are the main constraints, set the power of the pre-charge resistance first as it is the main parameter for dimensions and cost. Once chosen, it will give the resistor value and the pre-charge duration.
2. Set pre-charge duration if it is the performance constraint. Once chosen, it will give the resistance value and then the power it must sustain.

Design examples

This example focuses on a 48V battery with a 1mF input capacitor for its application.

1. The pre-charge resistor power is set to **1W**. So, the pre-charge resistor value is$R = \frac{Vbat^2}{6Ppchg} = 384\Omega$. In the E12 series, the nearest resistor value is R=**390Ω**. The pre-charge duration is then *Tpchg*=3*RC*=**1.17s** and the initial power the resistance must withstand is $Pm=V^2/R=$**5.9W**.
2. The pre-charge duration is set to **0.2s**. The resistor value is $R = \frac{Tpchg}{3C} = 66.7\Omega$. In the E12 series, the nearest resistor value is R=**68Ω**. The pre-charge power is then *P*=*E*/*Tpchg*=**5.8W** and it must withstand the initial instantaneous $Pm=V^2/R=$**33.9W**.

References example of power resistor

Contact Freemens if a confirmation for a specific pre-charge resistor is needed.

Table 104: references and parameters example for pre-charge resistor

Reference	Manufacturer	Power dissipation (W)		Power overload (W) for 1s	Max working voltage (V)
		With heatsink	Without heatsink		
HSA25	TE connectivity	25	12.5	625	550
HSC200	TE connectivity	200	50	5000	1900

13.2.3 Fans

FS-XT, just as contactors, can drives fans. The fans are supplied by the same voltage as the external DC source and must be chosen accordingly.

The fan must be connected on the output n°4 (pins C4+ and C4- on connector n°6, see *Power Outputs Connector* p*16*).

The power output used to drive the fans has a maximum continuous current capability of 2.1A.

Table 105: references and parameters example fans

Reference	Manufacturer	Voltage supply (V)	Supply current (A)
MEC0251V1-000U-A99	Sunon	12V	0.451

13.3 Sensors

13.3.1 Hall Effect current sensor design choices

Design choices

Two constraints guide the choice of a Hall Effect current sensor working with FS-XT.

- The supply voltage provided by the FS-XT board is a 5V single supply (100mA max). The current sensor must be compatible with this voltage.
- The sensor output must be a voltage directly proportional of the power current. This voltage measurement must be between 0 and 5V, otherwise it will exceed the full scale measurement capabilities of FS-XT.

Sensitivity configuration

The sensitivity (mV/A) of the Hall Effect sensor has to be configured in the configuration file of FreeSafe Extended (parameter "currentSensorSensibility"). To find and write in the configuration file the value of the sensitivity, there are two case:

- The parameter is in the datasheet of the sensor. For instance, the reference HO 50-S of LEM has a sensitivity of 16mV/A.
- The parameter is not directly provided and must be calculated with other equivalent information. For example, the reference HASS 50-S of LEM gives on its datasheet the complete equation (see Equation 5 below) that describes its output voltage measure and correspond to a sensitivity of 12.5mV/A.

HASS 50-S example:

Equation 5: HASS 50-S voltage output

The output voltage measurement is described with:

$$Vout = Vref + 0.625\frac{I}{In}$$

Vout is the output measurement voltage provided to FS-XT

Vref is the voltage reference for the 0A current. By default *Vref*=2.5V.

In is the nominal current of the sensor. Here, *In*=50A.

I is the measured current

Regardless of the voltage reference, for a current of 50A, the sensor output voltage will increase by 625mV which corresponds to a sensitivity of $\frac{625mV}{50A} = 12.5mV/A$.

0A reference configuration

The parameter "currentRef" (integer value only) in the configuration file is used to tune the reference voltage used by FS-XT to calibrate the 0A measurement. There are two possible cases:

- currentRef is set to -1 to allow FS-XT to automatically measure and calibrate the reference. FS-XT measure regularly the voltage provided by the hall sensor effect when all the contactors are opened (to be sure there is no current) and use this value as the reference.
- currentRef is set to a value between 0 and 4096.It is proportional to the reference voltage, 0V is 0 and 5V is 4096. For any reference voltage between 0 and 5V: currentRef= $4096 \cdot \frac{Vref}{5}$. In this case, FS-XT will be forced to use this reference and will not recalibrate it automatically.

Noise level configuration

The measurement of very low current can be subject to noise perturbations. In order to filter and not to measure this noise, the parameter "noCurOffsetThreshold" set the level under which the current is considered as 0A.

This level is typically set to avoid the noise and offset of the measurement chain of FS-XT:

- Hall Effect current sensor offset error. Typically under 1% of the nominal current of the sensor.
- Hall Effect sensor output noise voltage. See the manufacturer's datasheet.
- ADC measurement error. It is less than 1‰ (typically under 2/4096) of the 5V full scale measurement input.

Equation 6: noise level configuration

$$NoiseLevel\ (A) = \frac{\sum NoiseSource\ (mV)}{SensorSensitivity\ (\frac{mV}{A})}$$

Example for HASS 50-S sensor with a sensitivity of= 12.5mV/A:

Electrical offset voltage < 15mV,

Output voltage noise < 40mV,

FS-XT ADC error < 2.4mV.

The noise level must be (15+40+2.4)/12.5= 4.5A or less. In reality, as the data provided on the datasheet are the maximum error possible, the noise level will be far less than the one calculated and can be experimentally adjusted.

Example of compatible Hall Effect sensors

Any current sensor compliant with the 5V voltage supply and voltage input of FS-XT can be used. Contact Freemens if a confirmation for a specific current sensor reference is needed.

Table 106: references and parameters example for current sensors

Reference	Manufacturer	Nominal current (A)	Max measuring range (A)	Reference voltage (V)	Sensitivity (mV/A)
HASS 50-S	LEM	50	±150	2.5	12.5
HASS 400-S	LEM	400	±900	2.5	1.56
HO 50-S	LEM	50	±125	2.5	16
HO 200-S	LEM	200	±500	2.5	4

Datasheets available on the manufacturer website:

- LEM HASS 50..600 S series, *http://www.lem.com/docs/products/hass_50_600-s.pdf*.
- LEM HO 50..250-S series, *http://www.lem.com/docs/products/ho-s_series.pdf*.

13.3.2 Temperature sensors

Equation

FS-XT temperature sensor can be any NTC thermistor. It is strongly recommended to use a **10kΩ** NTC to operate with maximum precision. FS-XT measures the resistive value of the NTC to calculate the temperature with:

Equation 7: resistive value of a NTC according to the temperature

$$\frac{R}{R_0} = e^{\beta \cdot (\frac{1}{T} - \frac{1}{T_0})}$$

R (in Ohm) is the measured resistance of the NTC at the temperature T (in Kelvin).

R_0 (in Ohm) is the resistance of the NTC at the temperature T_0 (in Kelvin) provided by the manufacturer.

β (in Kelvin) is a coefficient provided by the manufacturer.

The parameters R_0, T_0 and β must be set in the configuration file at the value provided by the manufacturer. See *Temperature sensors* p*76* in the configuration file chapter for more details.

References example

Contact Freemens if a confirmation for a specific NTC thermistor is needed.

Table 107: references and parameters example for NTC thermistors

Reference	Manufacturer	R_0 (Ω)	T_0 (K)	β (K)
ND06P00103K	AVX	10000	298.15 (=25°C)	4220

13.4 Micro SD card

General description

FreeSafe Extended supports up to 8Go SDHC card to store configuration file, data and events recordings.

Formatting

Before its first use with FreeSafe Extended, the micro SD card must be formatted in **FAT32**. The recommended cluster size for maximizing the performances of FS-XT is **1024 bits**.

Recommended references

Table 108: references and parameters example for micro SD cards

Reference	Manufacturer	Size (GB)	Class
SDC4/4Gb	Kingston	4	4

13.5 Fuses

13.5.1 General description

As shown on the next figure, it is recommended to use fuses on the battery and the external DC source input. As they are the last link in the security chain, these fuse will never be used in normal operating mode. However, in case of a major failure – accident due to external causes, wrong wiring causing short circuit, mechanical or electrical failure of some part of the system (battery, BMS or application) – these fuses will put the battery in a safe state.

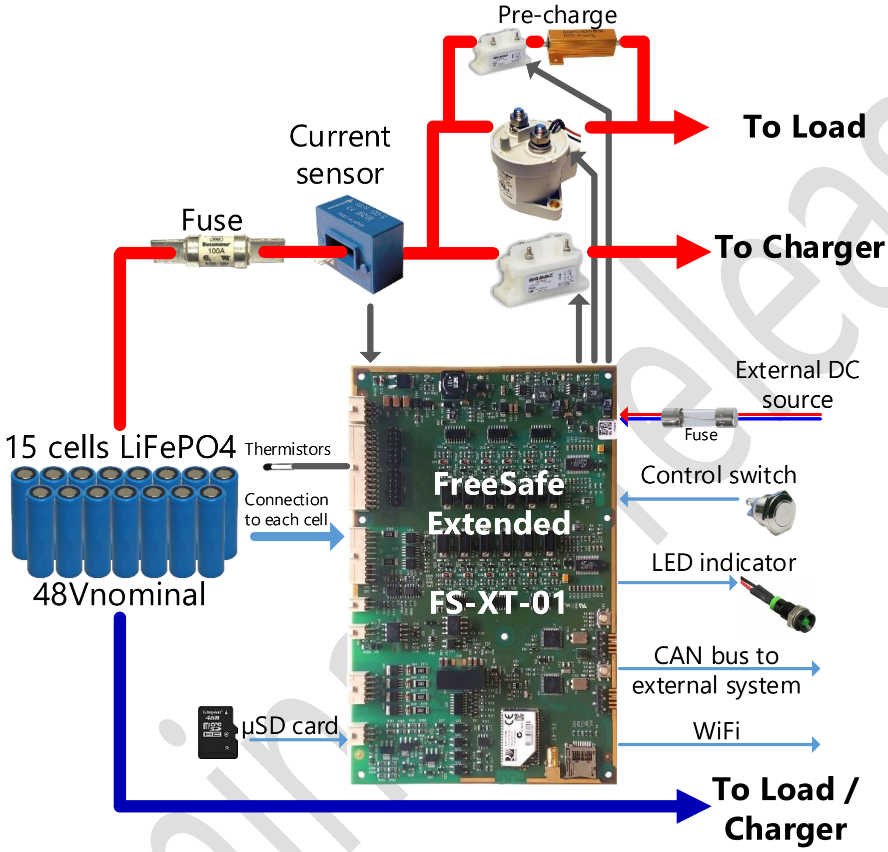


Figure 73: fuses usage - typical 48V application

13.5.2 Power battery fuse

Design constraints

As this fuse is connected in series, it must be compatible with the voltage and current of the battery and its application.

For the voltage, as long as the fuse maximum voltage is over the battery voltage, there is no design difficulty.

For the current, as FS-XT already has current limits (parameters "positiveShortCircuitThreshold" and "negativeShortCircuitThreshold", see *Protection and monitoring threshold* p75) at which the contactor are instantly opened, the fuse limit current must be chosen to be superior.

Reference example

Table 109: references and parameters example for power battery fuses

Reference	Manufacturer	Rated current (A)	Max DC voltage (V)
250FM	Bussmann	250	500

13.5.3 Fuse for external DC source input

Design constraints

The external DC source is mainly used to supply the power peripherals such as contactor and fans. The fuse must be designed to carry the current of these peripherals and to protect FX-XT input in case of short-circuit.

The inrush currents of the contactors coils must not open the fuse. For instance, the typical current for a Kilovac EV200 (TE connectivity) 12V contactor coil is 3.8A; the holding current is 0.13A.

Reference example

Table 110: references and parameters example for the external DC source input fuses

Reference	Manufacturer	Rated current (A)	Max DC voltage (V)
KLKD15	Littlefuse	15	600

13.5.4 Fuses accessories

The main accessories are fuse blocks or fuse holders. The power fuses used for the power circuit of the battery do not need a holder as they already have power contact that can be screwed directly on the battery and/or the wires. The smaller fuses used for the external DC source input may need such holders. The choice of the holder is dictated by the current to carry and the dimension of the selected fuse.

Reference example

Table 111: references and parameters example for fuses' accessories

Reference	Manufacturer	Comment
BM6031SQ	Bussmann	Fuseblock 600V 30Amax for $\frac{13}{32}$" x $1\frac{1}{2}$" fuse

13.6 Isolated input: additional resistor design choices

General characteristics

As presented in *Digital I/O connections* p*22*, the digital isolated input is the input of an opto-isolator with a 2.2kΩ serial resistor. The voltage source that can be used to supply these inputs ranges from 3V to 48V. The 48v limit comes from the 2.2kΩ resistor power limit: as the voltage increases to 48V, the current gets to 20mA – the maximum allowed by the photo-diode - and the power dissipated by the resistor increase to 1W – the maximum of the resistor package.

Design hints

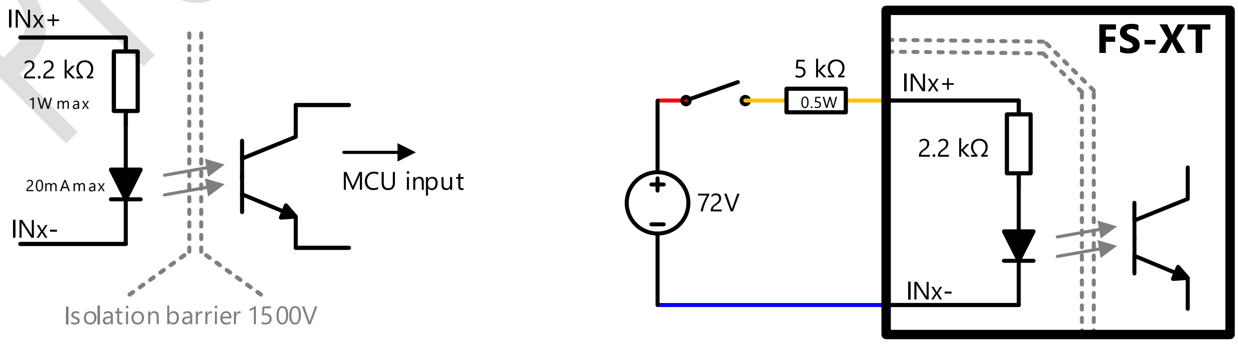
To use higher voltage source, an additional serial resistor must be wired externally to FS-XT in order to decrease the current and power constraint on the isolated input. This additional resistor must be chosen to keep the supplied current between 1mA and 20mA to ensure the photo-diode is working correctly.

Example

The voltage source is 72V. The supply current in the isolated input is set to 10mA. With these two parameters and neglected the photo-diode dropout, it gives the additional resistor a value of 5kΩ and a maximum dissipated power of 0.5W.

Equation 8: additional resistor value and power for isolated input

$$i_{input} = \frac{V_{input} - V_{photodiode}}{R_{input} + R_{external}}$$



a. Isolated input principle

b. Example with a 72V source

Figure 74: FS-XT isolated input with a voltage source over 48V

14 Index of figures, tables and equations

14.1 Figures

14.2 Tables

14.3 Equations

Freemens
Engineering tomorrow's energy

FreeSafe FS02-M/S

Battery Management System

Features

- **Manages from 2 to 12 battery cells per device (cell voltage up to 5V)**
- **Stackable architecture up to 600V battery pack**
- **Supports multiple battery chemistries and supercapacitors**
- **Redundant analog and digital protections**
- **Below 400µA power saving mode supply current**
- **Embedded smart power supply**
- **State of charge (SoC) and state of health (SoH) estimations based on advanced algorithms**
- **Stores up to 10 years of data history**
- **CAN-bus interface to adjacent devices**
- **Wi-Fi 802.11 monitoring capabilities (M-Series)**
- **Operates with FreeSB (Freemens Smart Breaker) battery circuit breaker**
- **Fully configurable with proprietary software "FreeLab" (Freemens Battery Management Software)**
- Embedded passive cell balancing up to 1W per cell
- Ability to drive external passive or active balancing devices
- Onboard temperature sensor and thermistor inputs
- Safe with random connection of cells
- Built-in self - tests
- High EMI immunity

Applications

Mobility and stationary electrical storages such as :

- Electric and hybrid electric vehicles
- High power portable equipment
- Backup battery systems
- Electric bicycles, motorcycles, scooters

Description

FreeSafe is a 2nd generation battery management system which provides high standard of security, optimal battery life-span and precise SOC (state of charge) and SOH (state of health) estimations.

FreeSafe provides an easy to use solution to manage large packs of Li-Ion batteries. FreeSafe boards are easy and safe to connect or disconnect from the batteries. Multiple FreeSafe boards can be used together to manage any number of cells in series for up to 600V battery stack.

FreeSafe protects the batteries from over-voltage and under-voltage using redundant analog and digital safety features

To ensure that the battery has been used properly, FreeSafe records all activities in an up to 10 years data history file. Communication between FreeSafe and others devices can be accomplished through CAN bus and 802.11 physical layers. FreeSafe includes a comprehensive and universal CANopen application layer and Wi-Fi protocol application libraries.

FreeSafe built-in high efficiency smart DC converter enables self-sufficient operations without the need of external power supply. It also spares energy consumption by adapting to the battery conditions of use, down to 15mW in a fully loaded 12 cells battery stack configuration.

While FreeSafe devices are "plug and play" for LiFePO4 batteries, specific applications and other chemistries require custom settings. FreeSafe parameters can be easily adapted with a step-by-step configuration manager provided in our PC software FreeLab.

FreeSafe devices are compliant with FreeData technology allowing a remote data management. New embedded software release will enable remote firmware upgrade, calibration and predictive maintenance.

Typical Application

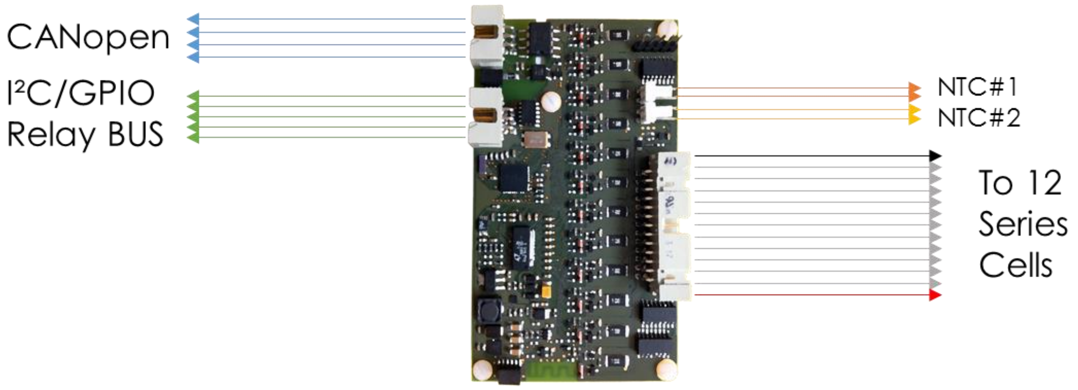


Figure 1: Battery management solution with 3 stacked FreeSafe boards and a FreeSB–PR relay driver

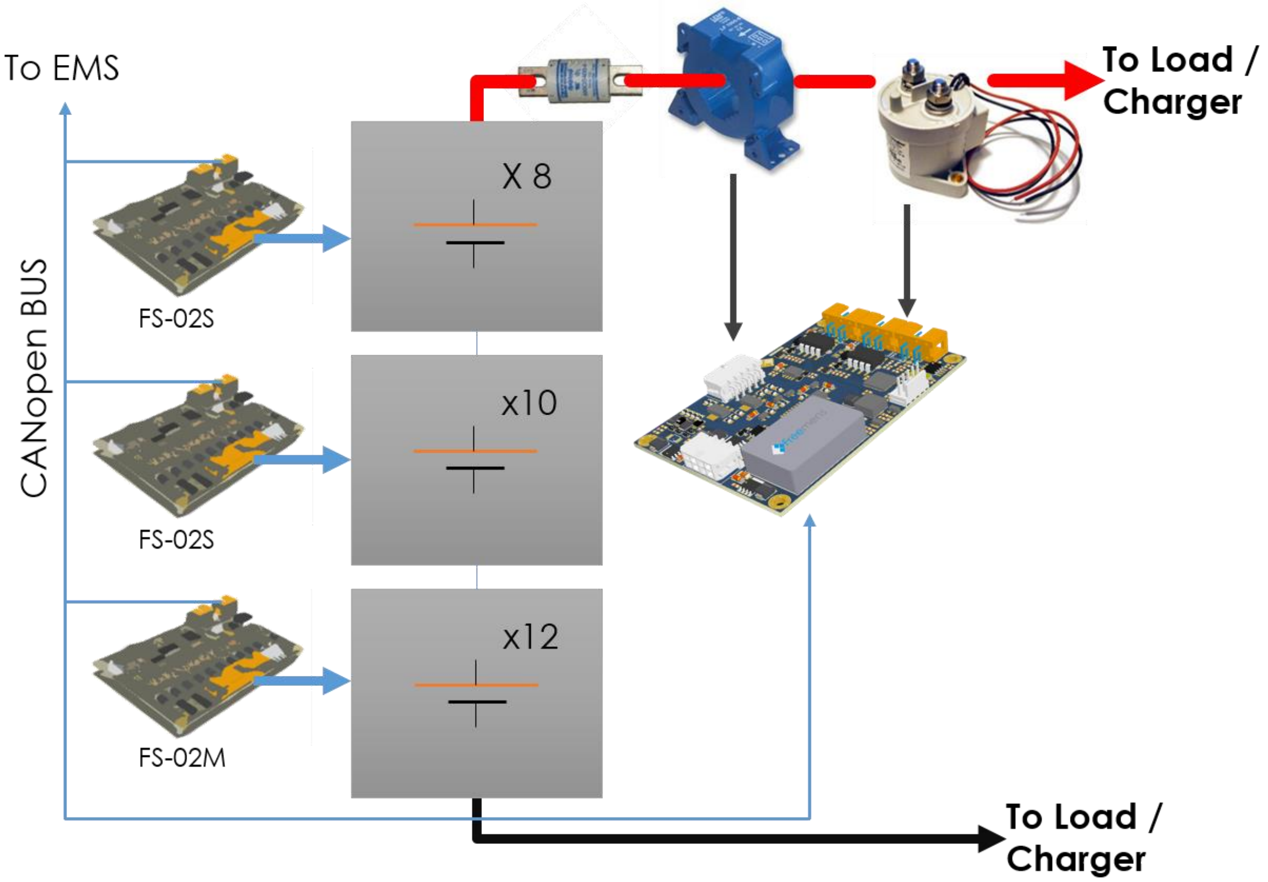


Figure 2 : Typical application, light electric vehicle with 100V LFP battery

Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Maximum Cells Voltage	V_{celln}	–0.3V to Min (8 • n, 75)	V
Maximum Balancing Control Voltage	B_{Cn}	–0.3V to Min (8 • n, 75)	V
Maximum Current Measurement Input Voltage	I_{mes}	3.3	V
Operating Temperature Range	T_{range}	-40 to 105	°C
Maximum CAN-bus supply current	I_{can}	250	mA
Maximum Voltage on Imes input	I_{mes}	3.6	V
Maximum Balancing Power Dissipation per Cell	P_{bal}	1.5	W
Maximum Total Power Dissipation	P_{balmax}	5	W

Electrical Characteristics

The following specifications apply over the full operating temperature range

Voltage Monitoring

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Battery Stack Voltage	V_{bat}		10		55	V
Measurement Resolution	V_{lsb}			1.5		mV/Bit
ADC Offset			-0.5		0.5	mV
ADC Gain Error			-0.22		0.22	%
Total Measurement Error	V_{err}	V_{cell} <5V	-9	+-2.5	9	mV
Cell Voltage Range	V_{cell}		-0.3		5	V
Supply Current	I_s	Sleep Mode (12 cells)	7	10	15	mW
		Long Cycle (12 cells)	20	25	35	mW
		Short Cycle (12 cells)	0.9	1	1.2	W

Cell Balancing

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Internal Balancing Resistor	R_{bal}	T_{amb} = 25°C		10		Ω
Maximum Internal Balancing current	I_{bal}	T_{amb} = 25°C ; V_{cell} =3.6V	340	360	385	mA
External Balancing Control Voltage	$SV_{bal}n$	Output High Level without common mode		$V_{cell}n$		V
		Output Low Level without common mode		0		V
External Balancing Control Current	$SI_{bal}n$	Sourced Current T_{amb} = 25°C ; V_{cell} =3.6V		1.2		mA
		Sinked Current T_{amb} = 25°C ; V_{cell} =3.6V		1.2		mA

CANBUS

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Voltage (Bus side)	V_{bus}	Power on the bus is provided by the first BMS of the string	3		5.5	V
Can Bus Output Voltage (dominant)	CAN_H	Rl=60 Ohm	2.9	3.5	4.5	V
	CAN_L	Rl=60 Ohm	0.8	1.2	1.5	V
Can Bus Output Voltage (recessive)		Rl=60 Ohm	2	2.3	3	V
Can Bus Output Current	I_{can}	Rl=60 Ohm				
Can Bus Rate of Operation	F_{can}			250		Kbps

External Coulomb Counting

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Analog to digital converter resolution	AD_{res}	A_{Vdd}=3.3V A_{Vss}=0V		10		bits
ADC Integral Nonlinearity	AD_{In}	A_{Vdd}=3.3V A_{Vss}=0V	-1.5		+1.5	LSb
ADC Differential Nonlinearity	AD_{Dn}	A_{Vdd}=3.3V A_{Vss}=0V	>-1		<1	LSb

ADC Gain Error	AD_{Ge}	A_{Vdd}=3.3V A_{vss}=0V		3	6	LSb
ADC Offset Error	AD_{Oe}	A_{Vdd}=3.3V A_{vss}=0V		2	5	LSb
ADC Input Voltage	AD_{Vin}	A_{Vdd}=3.3V A_{vss}=0V	-0.3		3.6	V
Recommended Impedance of Analog Voltage Source	I_{can}	R_{l}=60 Ohm		200		Ohm
Can Bus Rate of Operation	F_{can}			1		Mbps

Mechanical Characteristics (millimeters)

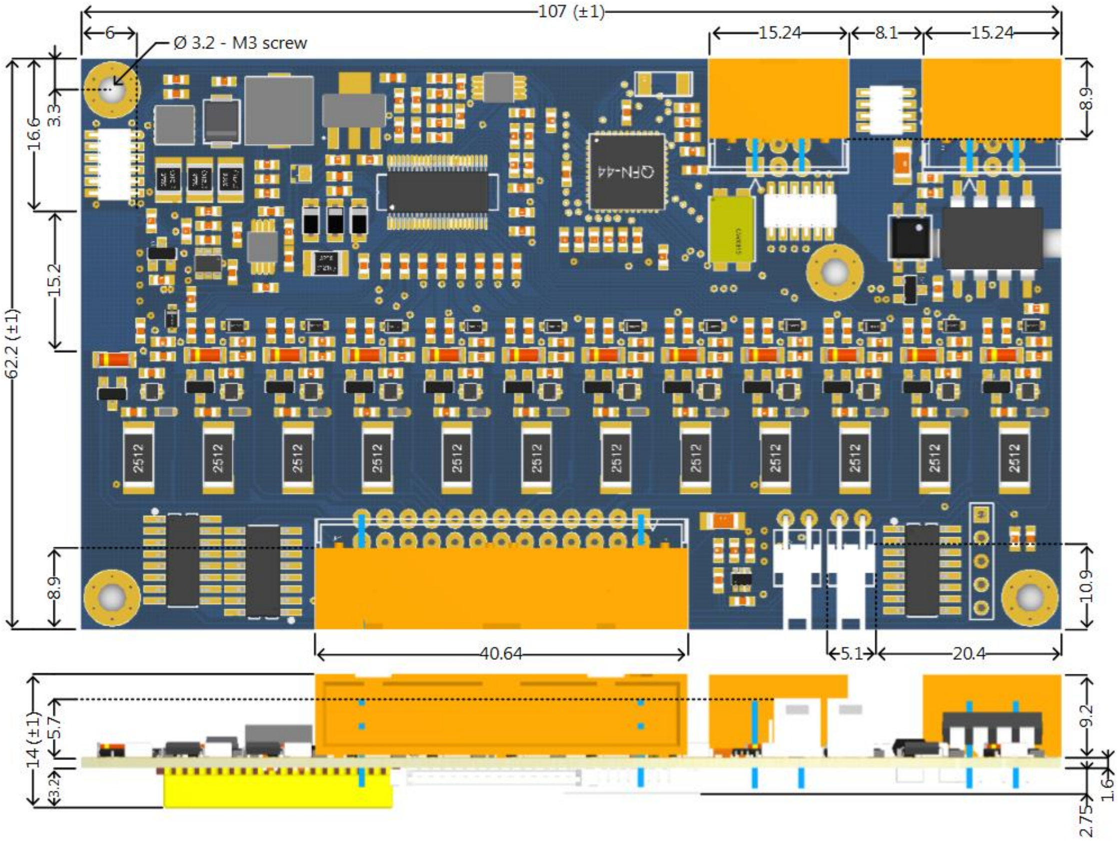


Figure 3: Mechanical views (side, top)

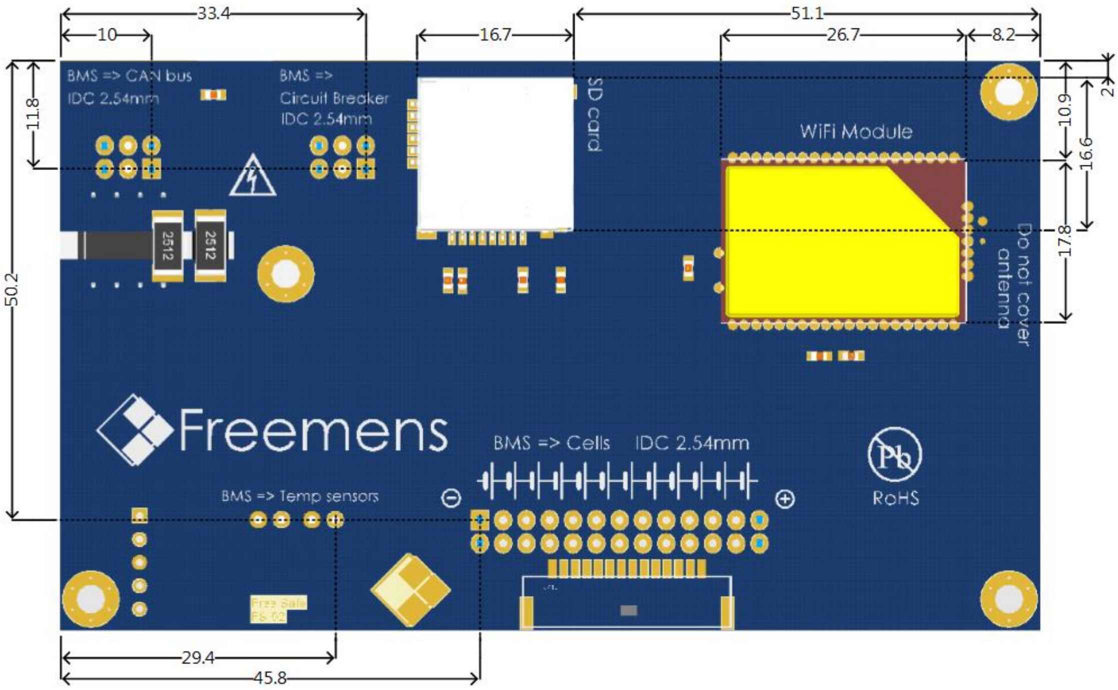


Figure 4: Mechanical view bottom side

General description

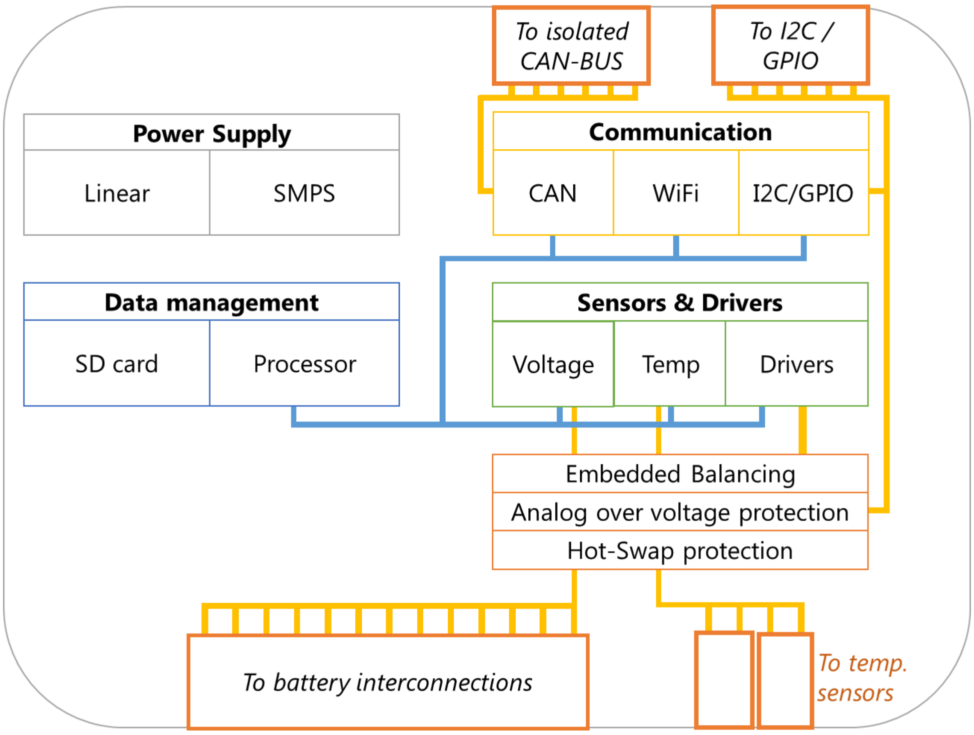


Figure 5 : Functional diagram

The following functional blocs are presented

- Data Management
- Sensors & Drivers
- Embedded Balancing
- Redundant Analog Protection
- Power Supply
- Communication

Data management

A power full 16bits DSC (Digital Signal Controller) is used for the data processing. The DSC is the core of the system where most of the algorithms are implemented. It communicates and controls the other function of the BMS.

- Regulation of power consumption and power supply strategy
- Measurements acquisition from all the sensors
- Algorithms computing
- Wired system level communications
- Wireless communications
- Balancing control

FreeSafe includes mass data storage capabilities to keep the available information related to the battery and the BMS operations. Based on an embedded micro SD card of 4Gbits (default configuration), FreeSafe is able to record up to 10 years of data. Remote access is possible for battery fleet control & monitoring thought proprietary FreeLab application and FreeData database. Data can also be retrieved and decrypted directly from the SD card if wireless connectivity is an issue.

Sensors & Drivers

The Sensors & Drivers block provides precise and reliable measurements related to the operation conditions. As a result, FreeSafe is able to sense from 2 up to 12 cell voltages and up to 3 temperatures per device. Current measurement is usually retrieved numerically through a FreeSB device, but can be additionally sampled by an analog input located in the GPIO port. In addition, the sensors measure the self-power consumption and the board level temperature.

Embedded Balancing

FreeSafe includes a low power Embedded Balancing Unit able to dissipate up to 1 W per cell at 25°C ambient temperature. The balancing is made by connecting power resistors to over-charged battery cell. The balancing control is obtained at the processor level based on the individual cell SOC estimation rather than the voltage comparison. With each resistor able to dissipate up to 1W, the thermal regulation at the board level is provided to reach an optimal balancing capacity and to ensure the device integrity. The maximum balancing current of 400mA requires the use of adapted wiring between FreeSafe devices and the battery stack.

Redundant Analog Protection

The over-voltage detection is achieved both at digital and analog level. If the sensors or processors fail to detect an overvoltage situation, a hard wired analog detection system will trigger a 3.3V TTL level on the GPIO port.

Power supply unit

FreeSafe integrates its own Power Supply Unit DSU as a default configuration making the board fully standalone once connected to the battery. In addition, it performs optimal supply thanks to an intelligent control and extensive use of switch mode power supplies with efficiencies above 85%. This feature makes FreeSafe a low power BMS device capable of ultra-low power operation. On board supplies are 12V DC, 5V DC and 3.3V DC. To operate, the DSU must be connected to a battery with at least 9V output DC voltage and up to 55V.

Communication

FreeSafe includes several hardware and corresponding communication protocols in order to facilitate and open wide the communication between the BMS and the other control or power interfaces of the system. In particular, FreeSafe integrates an Isolated CAN Bus, which allows to stack BMS devices at no risk for the hardware but also for the data. In addition and for local and wired communication, FreeSafe integrates I2C and SPI protocols. Finally, for remote or wireless access to the battery BMS, FreeSafe includes a Wi-Fi hardware and software interface. Thanks to these extensive communications FreeSafe can receive control orders, updated programs and parameters. FreeSafe can communicate through wired isolated or non-isolated communication interfaces to drive and sense FreeSafe units or associated FreeSB smart breaker and almost any device implementing CAN, I2C, SPI or Wi-Fi.

Pin Configuration and connectors

Two connector configurations are available.

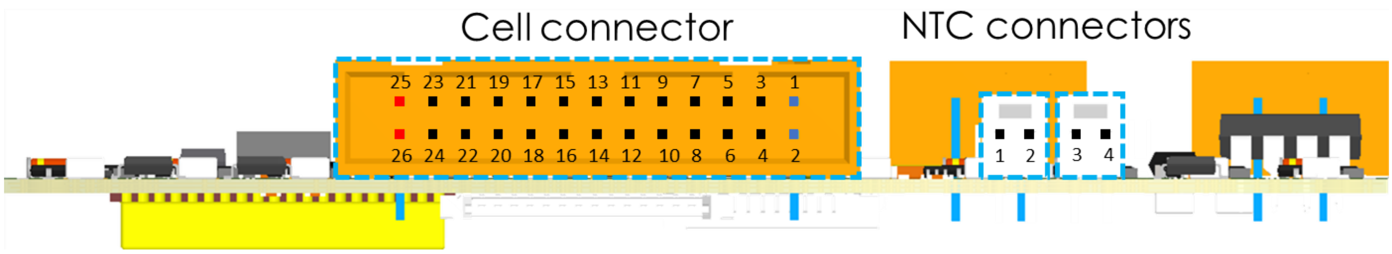


Figure 6: FreeSafe FS02-M front side

Figure 7: FreeSafe FS02-S back-side

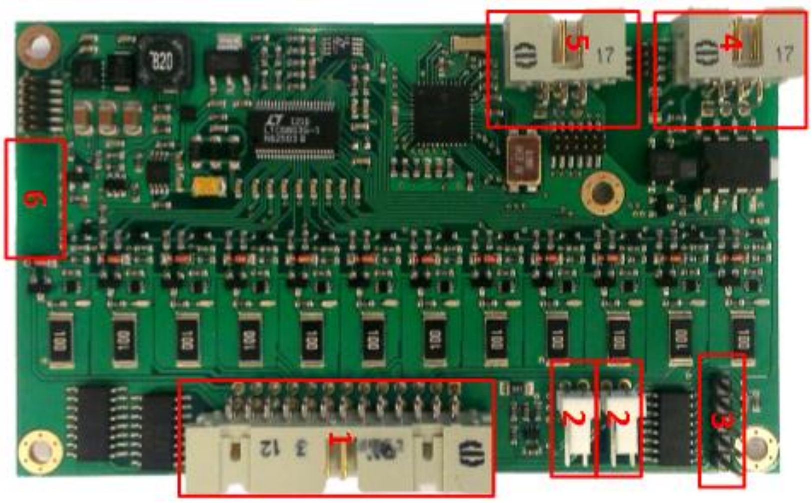


Figure 8: FreeSafe top side

Table 1: FreeSafe pins & connectors

Num.	Connector	Pin	Description
1	**Cell connector**	26	Connect to battery cell terminals
2	**NTC connector # 1**	2	Connect to 10k NTC resistor
2 bis	**NTC connector # 2**	2	Connect to 10k NTC resistor
3	**CAN-bus connector**	6	Connect to CAN-bus
4	**I2C/GPIO connector**	6	Connect to I2C/Reset/Wake-up
5	**Programming connector**	5	-
6	**Wi-Fi antenna**	1	Onboard printed Wi-Fi antenna. Do not cover.

Table 2: Recommended complementary connectors for onboard connector version

Onboard connector			Recommended complementary connector	
N°	Manufacturer	Part number	Manufacturer	Part number
1	Harting	09 18 526 7323	Harting	09 18 526 7813
			3M (or AMPHENOL SPECTRA-STRIP)	3365/06-100 (or 191-2801-126)
2	TE CONNECTIVITY	640457-2	TE CONNECTIVITY	3-640441-2
			AVX	ND06P00103K
3 & 4	Harting	09 18 506 7323	Harting	ND06P00103K
			3M	09 18 506 7803
5	Harwin Inc	M20-9990546	Molex	22-01-2057
			Molex	08-50-0114

Cell connector

Figure 9: Cell connector front side

See Figure 14: Incorrect & correct wiring to cell stack for additional connection information.

Table 3: Cell connector pins description

Pins	Description
1 – 2	Cell 1 -
3 – 4	Cell 1 + / Cell 2 -
5 – 6	Cell 2 + / Cell 3 -
7 – 8	Cell 3 + / Cell 4 -
9 – 10	Cell 4 + / Cell 5 -
11 – 12	Cell 5 + / Cell 6 -
13 – 14	Cell 6 + / Cell 7 -
15 – 16	Cell 7 + / Cell 8 -
17 – 18	Cell 8 + / Cell 9 -
19 – 20	Cell 9 + / Cell 10 -
21 – 22	Cell 10 + / Cell 11 -
23 – 24	Cell 11 + / Cell 12 -
25 – 26	Cell 12 +

NTC connectors

NTC resistor terminals can be connected indiscriminately to connector pins.

CAN-connector

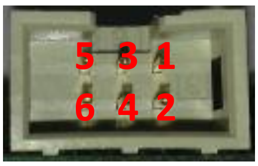


Figure 10: CAN-bus connector front side

Table 4: CAN-bus connector pins description

Pins	Description
1 – 2	5V
3	CAN L
4	CAN H
5 – 6	Cell 1 Negative terminal

I2C/GPIO connector

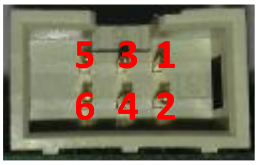


Figure 11: I2C/GPIO connector front side

Table 5: I2C/GPIO connector pins description

Pins	Description
1	Analog OverVoltage signal
2	SDA
3	Digital I/O
4	SCL
5	Analog / digital I/I
6	NC

Programming connector

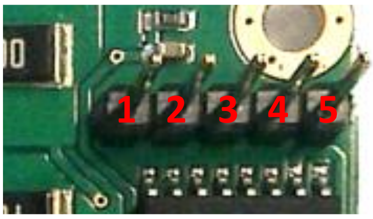


Figure 12: Programming connector front side

Table 6: Programming connector pins description

Pins	Description
1	Reset
2	3.3V
3	Cell 1 Negative terminal
4	PGD
5	PGC

Connection procedure

Step	Connector	Comment
1	2, 3&4	No particular steps are required for these connectors. FreeSafe will not start or power up before the Cell connector is connected to the battery cells.
2	1	Balancing LEDs may blink at the connection before the initialization routine.
Caution	5	Programming connector is only used when firmware update is necessary. Notice that pin 3 is referenced to the negative terminal of the lowest stack cell. Caution must be taken when connecting a non-isolated debugger or programmer

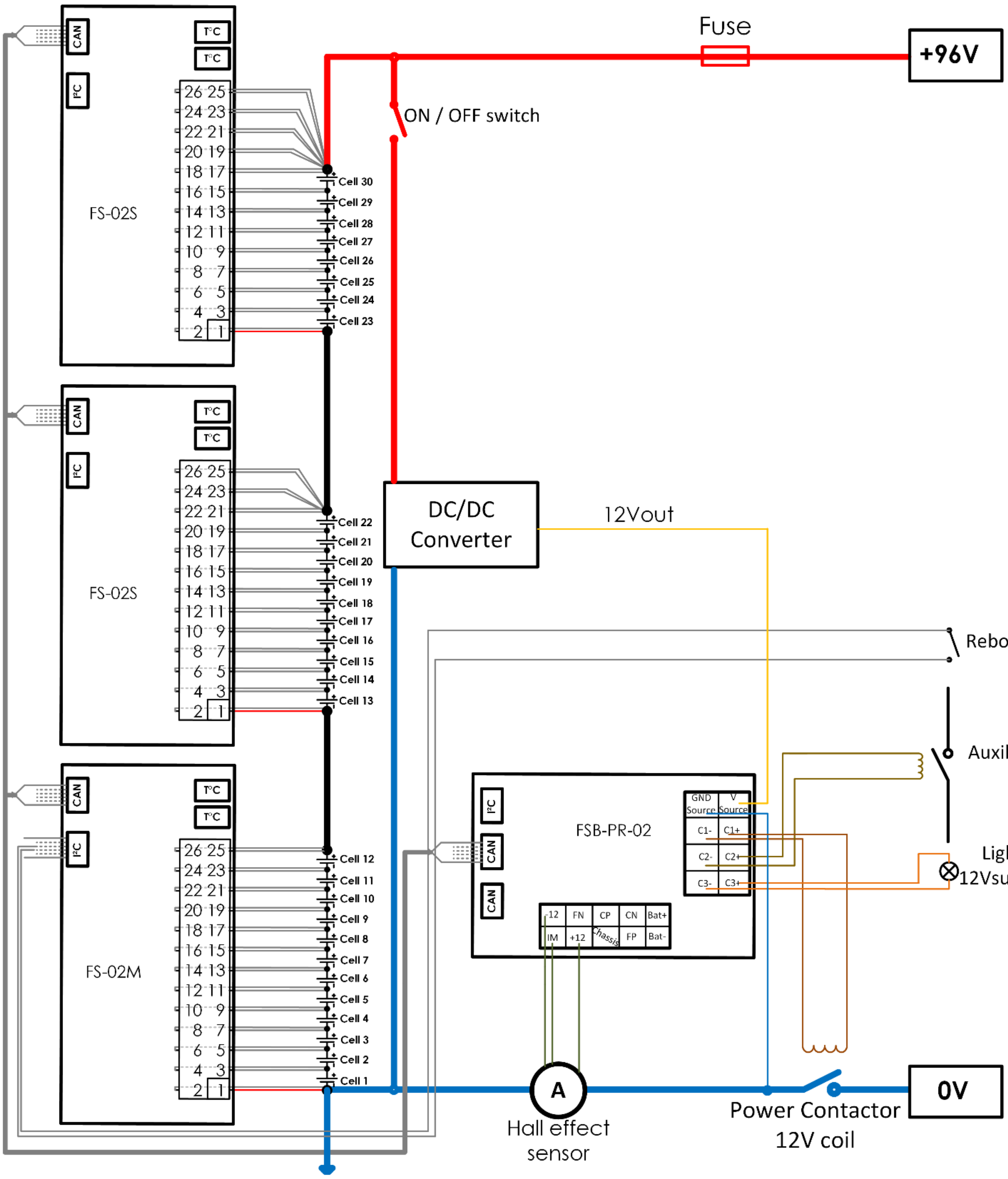


Figure 13: Typical Battery management system connection diagram for a 100V application

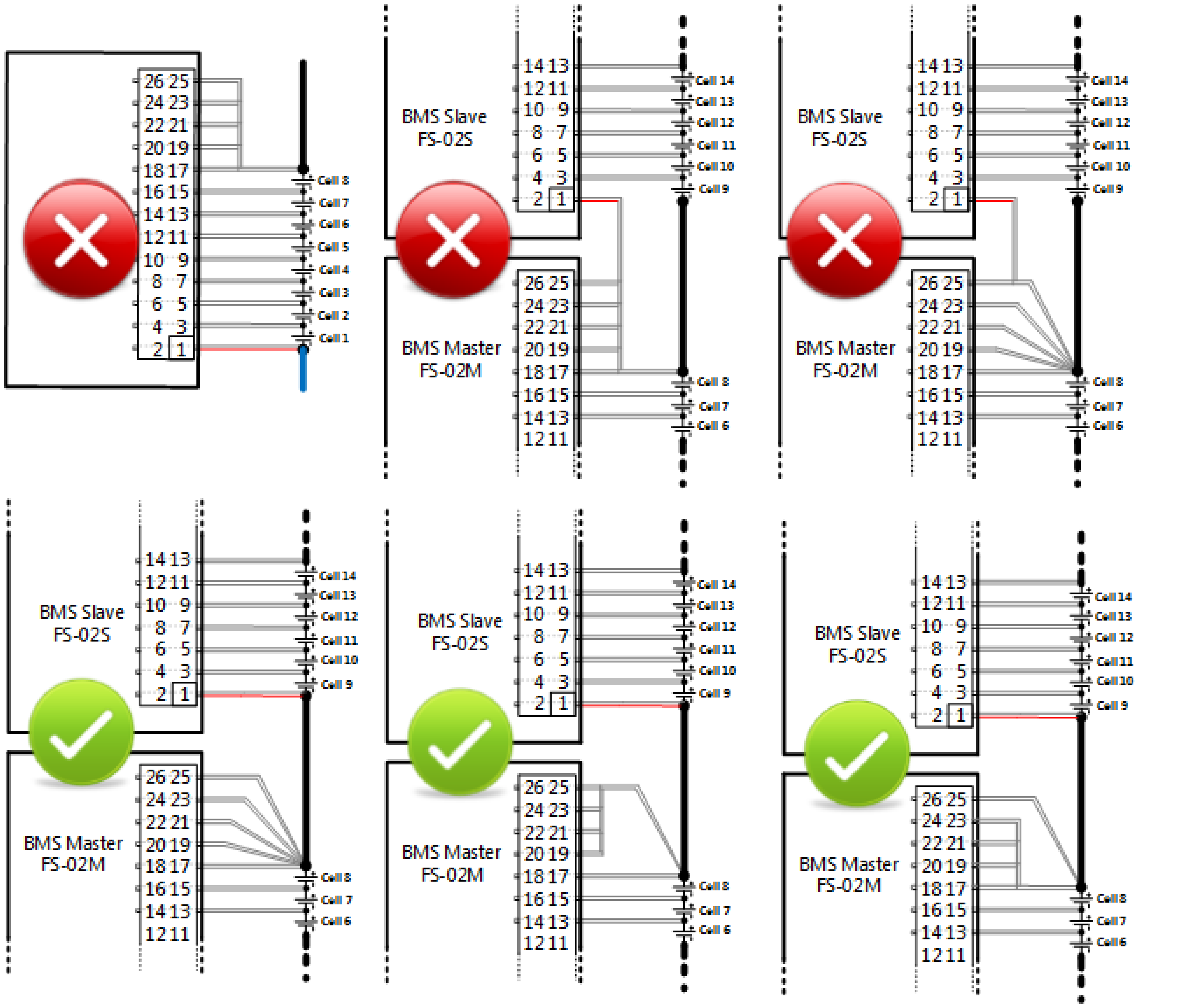


Figure 14: Incorrect & correct wiring to cell stack

The unused cell connector pins must be connected in short circuit to the last positive cell terminal. Cell 1- & Cell 12+ must always be directly connected as close as possible to the cell terminal with a dedicated wire.

To ensure correct voltage readings, all the **cell connector** pins must be connected as close as possible to the cell terminals.

Operation

Running modes

Running modes enable better power consumption control by minimizing FreeSafe activity when heavy algorithm such as SOC estimation, balancing control or wireless communication are not needed.

FreeSafe is able to select the mode of operation to improve battery autonomy and self-preservation during storage or long term non-use.

There are two modes of operation:

- Normal Mode
- Power Saving Mode

By default, FreeSafe will run in Normal Mode when connected to the battery stack for the first time. After POWER_SAVING_TIMER seconds of inactivity, the BMS will go into Power Saving Mode.
When FreeSafe is in Normal mode, the subsequent events will reset the inactivity timer:

- Current detected on the power line.
- Active Wi-Fi communication
- Short circuit between pin 2 & 4 of I2C GPIO connector
- Balancing activation

The inactivity timer will be held in reset in these states:

- Short circuit between pin 2 & 4 of I2C GPIO connector and FORCE_PWR_SAVING option is set to 0 (default is 1).
- Balancing is active

When FreeSafe is in Power Saving Mode, the subsequent events will wake up the module:

- Balancing activation
- Short circuit between pin 2 & 4 of I2C GPIO connector and FORCE_PWR_SAVING option is set to 0 (default is 1).

Stimuli thresholds and mode durations are fully configurable within the BMS configuration file.

Table 7: Functions overview in normal and power saving modes

Function	Mode	
	Normal	Power saving
Voltage acquisition period	1s	POWERSAVING_DURATION
Balancing actualization period	1s	✗
Current acquisition period	100ms	✗
State of charge actualization period	1s	✗
5V Canbus power supply	✓	20ms/min (if Slave)
Wi-Fi Module	✓	✗
Typical power consumption	320mW	20mW

Normal mode

In Normal mode, FreeSafe performs all the monitoring and communication tasks at maximum speed. Cell voltages, current and state of charge can be refreshed up to 1 time per second.

In this mode, FreeSafe will become an Access Point for Wi-Fi devices. The Android FreeSafe application will automatically connect to the BMS and display the variables in real-time.

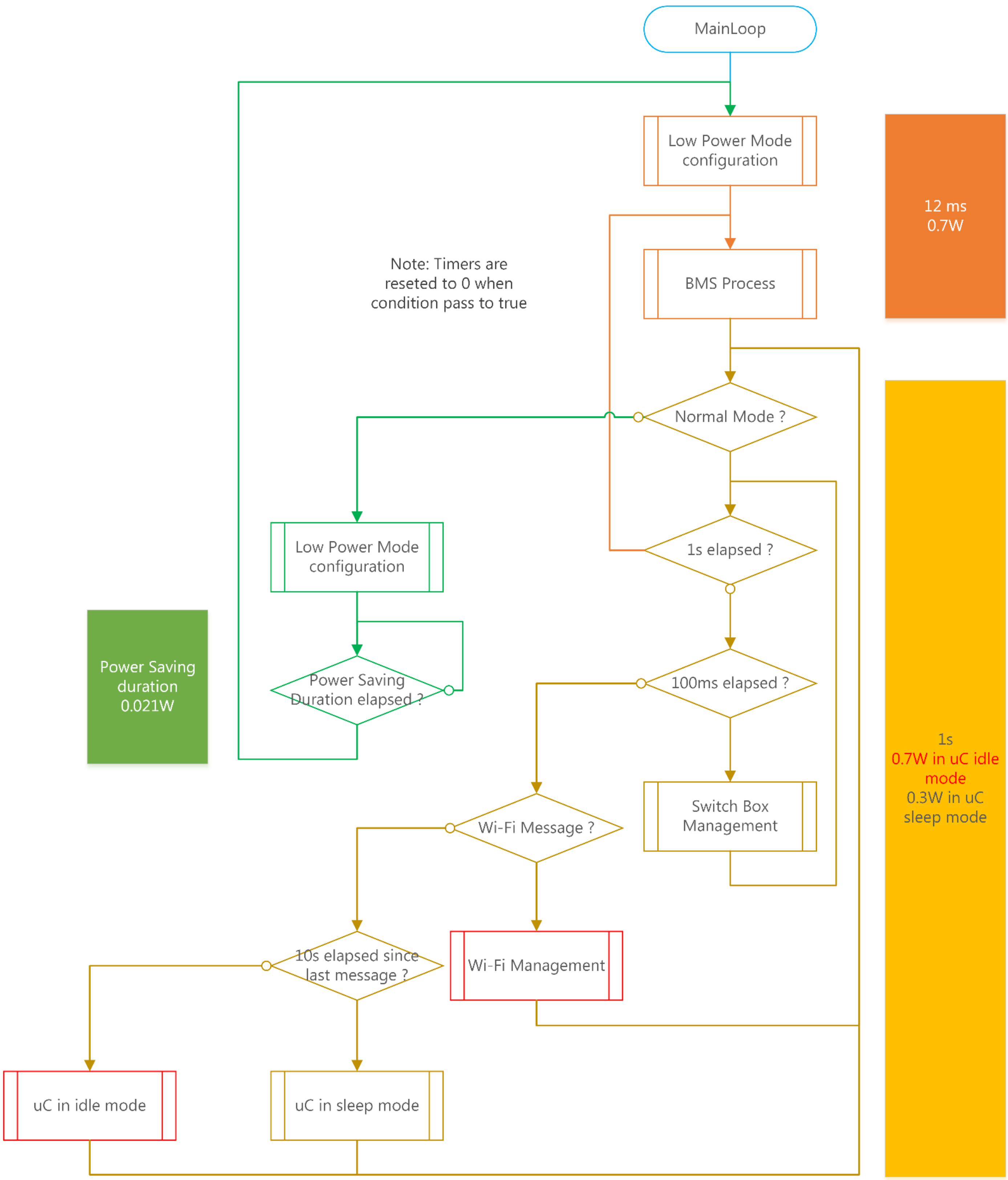


Figure 15: Global process diagram

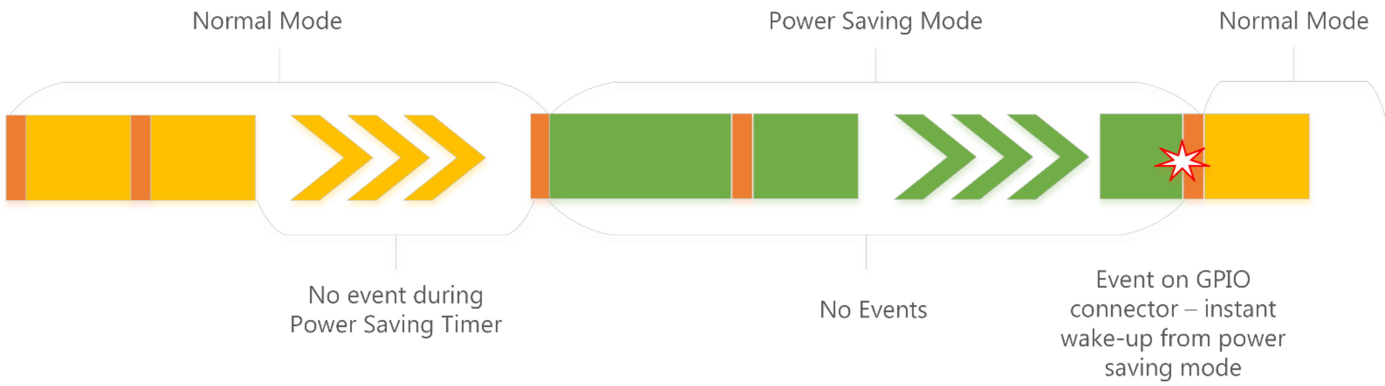


Figure 16: Global process typical timeline

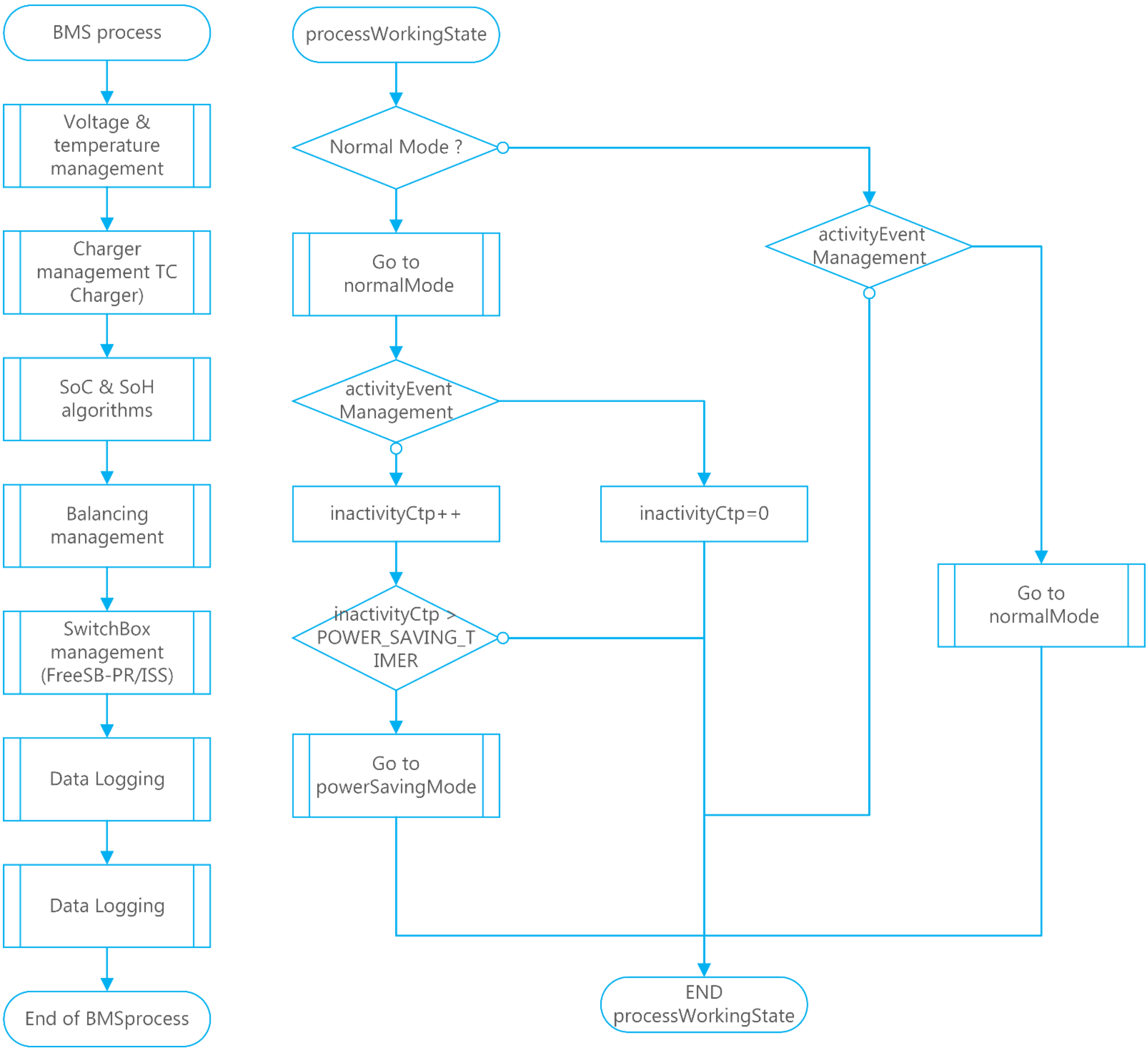


Figure 17: Operation flow-chart of the BMS process

Power Saving mode

In Long Sleep mode, FreeSafe will perform a basic checkup on the battery variables every POWERSAVING_DURATION seconds.

In this mode, FreeSafe will be unreachable via Wi-Fi until the BMS returns in Full Speed or Short Sleep Mode.

It is recommended to install a switch dedicated to wake up the battery when needed between the pin 2 & 4 of the I2C/GPIO connector.

Configuration

FreeSafe can be easily configured to fit precisely to the needs of various applications. All the editable parameters of the BMS are grouped in a XML configuration file stored on the SD card. At initialization the configuration file is parsed by FreeSafe and all the parameters are loaded into the embedded software. If the configuration file is corrupted or missing, the initialization process will enter a fail and retry mode.

In this section, all the parameters of the BMS will be detailed for the 100V LIFEPO4 LEV scenario. Additional scenarios can be found on our website www.freemens.fr on the FreeSafe webpage.

Battery specifications

The parameters in this section are used to configure the expected number of cells [CELL_NUMBER] and the global distribution of slave boards [SLAVE NUMBER]. These parameters are used at the primary initialization. If the number of cells does not match the configuration, FreeSafe will periodically reboot until the correct amount of cells is detected. The configured number of slave is used to guarantee that all the boards are correctly configured and operational. The last parameter is the initial nominal capacity of each parallel string [D1C]. It is used for SOC and SOH calculations. See

Table 8: Battery Configuration

Name	id	Unit	Type	Example	Range	Comment
CELL_NUMBER	0	-	int	30	4-96	Number of series cells
SLAVE_NUMBER	1	-	int	2	0-15	Number of FreeSafe Slaves
D1CAP	2	Ah	int	100	0-10000	Initial nominal battery capacity

Power Management

These parameters control the length of the loop in the power saving mode and the minimum inactivity timeframe that will put FreeSafe in this mode. Adjusting POWER_SAVING_DURATION will allow to reduce the overall power consumption but will slow down the refresh rate of the voltage and temperature and their recording on the SD card.

In our example the power consumption in power saving mode will be:

$$EnergyConsumed = \frac{SleepPower * SleepTime + ProcessPower * ProcessTime}{SleepTime + ProcessTime}$$

During the sleeping period, the current is supplied with a low quiescent linear regulator:

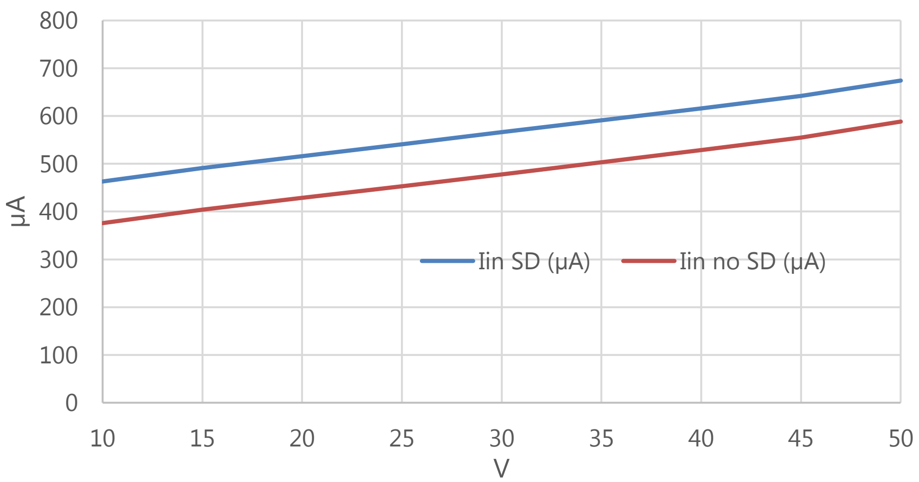


Figure 18: Consumption in sleep during power saving mode

$$SleepPower = SleepCurrent * Battery\ Voltage$$

For a mean 35V per board:

$$SleepPower = 600 * 35 = 0.021W$$

In this example the power consumption in power saving mode will be:

$SleepPower = 0.021W$

$SleepTime = POWER\_SAVING\_DURATION$

$ProcessPower = 0.75W$

$ProcessTime = 20ms$

$$EnergyConsumed = \frac{0.021 * 5 + 0.75 * 0.02}{5{,}02} = 0.023W$$

Table 9: Power management configuration

Name	id	Unit	Type	Example	Range	Comment
POWER_SAVING_TIMER	3	s	int	300	10-10000	Inactivity duration before going into power saving mode
POWER_SAVING_DURATION	4	s	int	5	10-1000	Interval between voltage and temperature refresh in power saving mode
ON_OFF_CAN_BUS	5	-	bool	0	0 - 1	Reserved

Data Logging

FreeSafe master supports up to 32Go SDHC card to store configuration file, data and events recordings.

Recommended SDHC card models:

- KINGSTON 4GB MICROSDHC CLASS 4
- KINGSTON 8GB MICROSDHC CLASS 4
- KINGSTON 4GB MICROSDHC CLASS 10
- KINGSTON 8GB MICROSDHC CLASS 10

To avoid redundant data and to save memory space, new data will be saved only if the variation between two measurements exceeds a configurable threshold. The following parameters will be saved:

- Voltage
- Current
- Temperature
- SOC
- SOH

It is recommended to keep the default parameters.

Table 10: Data logging configuration

Name	id	Unit	Type	Example	Range	Comment
CURRENT_MEAS_CONVENTION	8	-	String	OUT	OUT/IN	Current is counted positively in discharge (OUT) or charge (IN)
VOLTAGE_DIFFERENCE	9	mV	Uint	6	3-10000	Minimal difference between two voltage measurements which triggers a SD-Card data recording.
TEMPERATURE_DIFFERENCE	10	°C	Uint	2	2-10000	Minimal difference between two temperature measurements which triggers a SD-Card data recording.

CURRENT_DIFFERENCE	11	A	float	0,1	0,1-1000	Minimal difference between two current measurements which triggers a SD-Card data recording.
SOC_DIFFERENCE	12	%	float	0,5	0,5-100	Minimal difference between two SOC measurements which triggers a SD-Card data recording.
SOH_DIFFERENCE	13	%	Uint	1000	0-1000	Reserved
BACKUP_PERIOD		s	Uint	3600	10-10000	Maximum permitted period between two recordings

Balancing management

Passive balancing can be configured according to two methods used independently and simultaneously. It can be activated upon reaching a voltage threshold with the FORCE_BALANCING parameter. It can also be activated upon reaching a voltage difference between any cell of the battery and the one with the lowest voltage superior to BALANCING_DELTA_LIMIT_UP. In this case, passive balancing will be disabled when the voltage difference decreases below the BALANCING_DELTA_LIMIT_DOWN threshold. Balancing will never occur if the cells voltage is below the STOP_BALANCING value. Over temperature will prevent balancing if it exceeds 80°C.

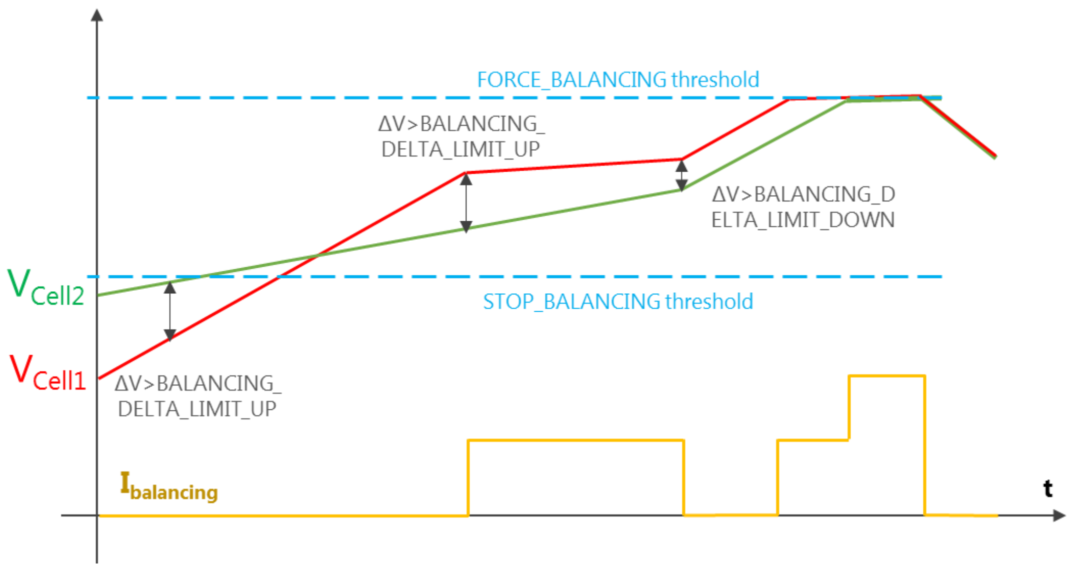


Figure 19: Balancing management

Table 11: Balancing configuration

Name	id	Unit	Type	Example	Range	Comment
BALANCING_DELTA_LIMIT_UP	14	mV	int	10	0-10000	Activation of balancing threshold
BALANCING _DELTA_LIMIT_DOWN	15	mV	int	2	0-10000	Deactivation of balancing threshold
FORCE_BALANCING	18	mV	int	3650	0-10000	Cell voltage threshold triggering forced balancing
STOP_BALANCING	19	mv	int	3300	0-10000	Cell voltage threshold at which passive balancing is disabled

Voltage management

The over and under voltage thresholds are mandatory to operate lithium batteries. Extra care must be taken when modifying these parameters. Default values are recommended for LiFePO4 batteries. If these thresholds are reached, FreeSafe will ask FreeSB to cutoff the battery from the application/charger. V_CAL_BOT and V_CAL_SUP are used to recalibrate SOC and SOH estimations. Default values recommended for LiFePO4 batteries are shown in Table 12: Voltage management configuration

Table 12: Voltage management configuration

Name	id	Unit	Type	Example	Range	Comment
MAX_VOLTAGE	16	mV	int	3650	0-10000	Over voltage threshold
MIN_VOLTAGE	17	mV	int	2600	0-10000	Under voltage threshold
V_CAL_SUP	20	mV	int	3620	0-10000	Cell voltage threshold used to recalibrate SOC and SOH
V_CAL_BOT	21	mV	int	2620	0-10000	Cell voltage threshold used to recalibrate SOC and SOH

Current Management

For more information please refer to FreeSB datasheet. For parameters example see Table 13: Current management configuration

Table 13: Current management configuration

Name	id	Unit	Type	Example	Range	Comment
CURRENT_PIC	26	A	int	250	0-32766	Positive instantaneous current limit
CURRENT_LIMIT	27	A	int	120	0-32766	Positive over current reference
CURRENT_PIC_NEG	28	A		-250	0-32766	Negative instantaneous current limit
CURRENT_LIMIT_NEG	29	A		-120	0-32766	Negative over current reference
CURRENT_NOMINAL		A	int	80	0-32766	Positive nominal current
CURRENT_NOMINAL_NEG		A	int	80	0-32766	Negative nominal current
CURRENT_LIMIT_TIME	30	A		10	0-32766	Thermal time reference
LEGACY_GAIN	31	-	Int	1		Legacy
LEGACY_R_SHUNT	32	-	Int	1		Legacy
FSB_PR_LEM_GAIN	33	-	Int	1000	0-32766	LEM current sensor gain for FreeSB-PR application

Thermal management

The over and under temperature thresholds are mandatory to operate lithium batteries. Extra care must be taken when modifying these parameters. Default values are recommended for LiFePO4 batteries. To ensure correct temperature readings, sensors must be placed as close as possible to the monitored cell. For example, they can be directly placed onto screws used for power connection. Parameters example for AVX – ND06P00103K thermistor (Figure 18) are given in Table 14: Thermal management configuration.

Figure 20: AVX - ND06P00103K

Table 14: Thermal management configuration

Name	id	Unit	Type	Example	Range	Comment
MAX_TEMP	22	°C	Uint	50	-180 - 180	Over Temperature threshold
MIN_TEMP	23	°C	int	-10	-180 - 180	Under Temperature threshold
MAX_BOARD_TEMP		°C	Uint	60	0 - 95	Over Temperature threshold on FreeSafe boards

R0	24	-	int	10000	0-32766	External temperature sensor parameter
BETA	25	-	int	4220	0-32766	External temperature sensor parameter

Wi-Fi access point

The accessibility parameters for Wi-Fi in local mode can be modified to fit customer and application requirements. FreeSafe automatically activates the access point while in normal mode. Peripheral such as android mobile phone or tablet (with FreeView application) are then able to reach FreeSafe by connecting to the corresponding SSID name. Communications over Wi-Fi are considered as "wake-up events" preventing FreeSafe from entering in Power Saving Mode. In power saving mode, the Wi-Fi is disabled. Protocol in local AP mode is described in the communication section.

Table 15: WiFi configuration in local mode

Name	id	Unit	Type	Example	Range	Comment
ACCESS_POINT_NAME	6	-	String	FreeSafeAP	Char[33] a-z;0-9	Wi-Fi SSID name of the BMS in access point mode.
ACCESS_POINT_PWD	7	-	String	freemens	Char[33] a-z;0-9	Channel of emission in AP Mode
CHANEL_EMISSION	8	-	String	1	Char[3]	Channel of emission in AP Mode

All parameters are written with the following tags:

<variable name="NAME" id=ID_NUMBER value="VALUE">

Implemented in future software release						
HYSTERESIS_LOW_CHARGER	34	mV	Int	3400	0-32766	Charger cutoff voltage threshold
WLAN_SSID	35	-	String	D-LinkAP		SSID name of target infrastructure access point
AUTH_MODE	36	-	String	WPA2		Authentication mode of target infrastructure access point
WLAN_PASS	37	-	String	azerty00		Password of target infrastructure access point
WLAN_CHAN	38	-	Int	0		Channel of target infrastructure access point
FTP_ADDR	39	-	String	192.168.0.100		FTP address of target server
FTP_USER	40	-	String	boris		FTP login of target server
FTP_PASS	41	-	String	freemens		FTP password of target server
FTP_DIR	42	-	String	.		FTP directory of target server
TIMER_FTP_UPLOAD	43	-	Int	7		Reserved
SIZE_FTP_UPLOAD	44	-	int	50		Reserved

Communication

Wi-Fi Infrastructure Mode

In this mode, FreeSafe connects to an Access Point provided it is reachable and correctly configured (SSID, authentication mode, key/password and channel) in the SD Card.

Multiple authentication modes are supported:

- WEP64 & WEP128
- WPA-PSK

- WPA1-PSK (TKIP only)
- WPA2-PSK (AES only)

FreeSafe IP-address is provided by the Access point and can be retrieved in the router connected devices list. Infrastructure Mode is required for Internet connectivity and Remote operation with online databases.

Wi-Fi Access Point Mode

In this mode, FreeSafe will provide an open Wi-Fi access point for adjacent portable devices such as mobile phones and tablets. These devices will be able to connect to the BMS via the IP-address: 1.2.3.4 and to communicate through TCP protocol

Command	Name	Unit	Type	Description
get raw param+	D1C	Ah	Int	Cell nominal capacity
	maxCurrent	A	Int	Over current threshold
	maxVoltage	mV	Int	Cell over voltage threshold
	minVoltage	mV	Int	Cell under voltage threshold
	maxTemp	°C	Int	Over temperature threshold
	minTemp	°C	Int	Under temperature threshold
	slaveNumber	-	Int	Number of connected FreeSafe slaves
get SOC+	SOC unit	-	float	Returns SOC
get raw temp+	numTemp	-	int	Returns the number of temperature sensors
	valueTemp	C°	int[numTemp]	Temperature value
get volt+	numCell	-	int	Returns the number of cells
	valueVoltage	mV	int[numCell]	Returns the voltage of all the cells
get curr+	valueCurrent	A	Float	Returns the value of the ingoing or outgoing current
get CCS flag+	TCchargerFlag	-	int	Returns 1 if the charger is connected, 0 else.
get file confbms.xml				Returns configuration file
get file event.txt				Returns events file
get file info.txt				Returns information file

CAN-bus

FreeSafe uses the **SAEJ1939 Standard**. This standard is based on the 2.0B physical layer and transmits "**Extended Data Frame**" messages. The bus frequency is set at **250Kbps**.

Table16: CAN 2.0B Message Frame

SOF (1 bit)	ARBITRATION (32 bits)	CONTROL (6 bits)	DATA (0-64 bits)	CRC (16 bits)	ACK (2 bits)	EOF (7 bits)

Table 17: CAN 2.0B Message Frame (detailed)

	Field	Size (bits)	Description	Default
ARBITRATION	ID	11	Message identifier (part 1)	
	SRR	1	Substitute remote request	1
	IDE	1	Identifier Extension	1
	Ext ID	18	Message identifier (part 2)	
	RTR	1	Remote Transmit Request	0
CONTROL	RB0	1		
	RB1	1		0
	DLC	4	Data length code	
DATA	DATA	DLC*8	Data bytes	
CRC	CRCS	15	CRC	
	CRCD	1	CRC Delimiter	
ACK	ACKS	1	Used for receiver to ACK msg. Sent as recessive.	
	ACKD	1	ACK Delimiter	
EOF	EOF	7	End of Frame. Sent as recessive	

Table 18: SAE J1939 Message Frame Identifier

<table>
<tr><td colspan="4">ID</td><td></td><td></td><td colspan="3">Extended ID</td><td></td></tr>
<tr><td rowspan="2">Priority
(3 bits)</td><td>R</td><td>DP</td><td>PF (<7:2>)</td><td>SRR</td><td>IDE</td><td>PF (<1:0>)</td><td>PS</td><td>SA</td><td rowspan="2">RTR</td></tr>
<tr><td>(1 bit)</td><td>(1 bits)</td><td colspan="4">(8 bits)</td><td>(8 bits)</td><td>(8 bits)</td></tr>
</table>

	Values	**Description**
Priority	0 - 7	8 priority levels. 0 : highest, 7 : lowest
Reserved	0	0 is mandatory
Data Page	0 - 1	Page format selection. Stays at 0 for our internal protocol
PDU Format (PF)	0 - 255	Message type
PDU Specific (PS)	0 - 255	If PF > 240(0xF0): the message is a broadcast, PS will be used as PF extension. Si PF < 240(0xF0): the message is peer to peer, PS will be used as destination address.
Source Address (SA)	0 - 255	Source address of controller application

The resulting ID will be as follow:

<table>
<tr><td colspan="6">ID</td></tr>
<tr><td>Priority</td><td>R</td><td>DP</td><td>PF</td><td>PS</td><td>SA</td></tr>
<tr><td>Priority</td><td colspan="4">PGN</td><td>SA</td></tr>
</table>

PGN (Parameter Group Number) identifies a Parameter Group. A Parameter Group defines the characteristics of a message type (PF) (Number of bytes, bytes descriptions, periodicity, priority, etc…).

Table 19: Reserved peripheral addresses

Peripheral	Adress	Hex value
Custom LCD Display	160	A0
FreeSafe S	176-191	B0-BF
FreeSB	192	C0
Reserved	193-207	C1-CF
TC Charger	229	E5

FreeSafe M	244	F4
FreeFlex	255	FF

Typical Internal Canbus operations

In a 36 cells battery configuration, 3 FreeSafe boards are used (1 Master & 2 Slaves) with a FreeSB PR (Smart Breaker for Power relays). FreeSafe M will initiate every CANbus communication by sending message frames (except initialization requests from certain peripherals). FreeSafe Slave and FreeSB PR will only acknowledge and answer to those requests. Also FreeSafe M will provide a 5 V power supply for each isolated drivers of Freemens peripherals.

/!\ the 5 V CANbus power supply provided by FreeSafe M should not be used to power foreign peripherals.

Communication FreeSafe Master – FreeSafe Slave

At FreeSafe master powers up, an initialization message is sent to the slaves to check the battery pack global integrity.

Table 20: Identifier description: Cell number verification request

Period : Once at startup		Value (Hex)	Comment
ID = 18 04 B0 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	04	Number of connected cells verification request
	PS	B0	FreeSafe S Address
	SA	F4	FreeSafe M Address
DATA = 0 Byte			

Table 21: Identifier description: Cell number verification answer

Period : Once at startup		Value (Hex)	Comment
ID = 18 05 F4 B0	P	6	Default Value
	R	0	-
	DP	0	-
	PF	05	Number of connected cells verification request
	PS	F4	FreeSafe M Address
	SA	B0	FreeSafe S Address
DATA = 3 Bytes			
	Bytes 1 & 2	xx x0	**Bit Field** Bit 0: **1 : cell 1 detected**, **0 : no cell** Bit 1: 1 : cell 2 detected, 0 : no cell Bit 11: 1 : cell 12 detected, 0 : no cell -
	Byte 3	xx	Total number of connected cells to the FreeSafe S Board

In Normal and Power Saving mode, FreeSafe M will periodically ask each slave of its cells voltages and temperatures.

Table 22: Identifier description: voltage and temperature request

Period : 1s / xxs		Value (Hex)	Comment
ID = 18 01 B0 F4	**P**	6	Default Value
	R	0	-
	DP	0	-
	PF	01	Voltage and temperature request

	PS	B0	FreeSafe S Address
	SA	F4	FreeSafe M Address
DATA = 0 Bytes			

Table 23: Identifier description: voltage and temperature answer (Frame 1)

Period : 1s / xxs		Value (Hex)	Comment
ID = 18 01 F4 B0	P	6	Default Value
	R	0	-
	DP	0	-
	PF	01	voltage and temperature answer (Frame 1)
	PS	F4	FreeSafe M Address
	SA	B0	FreeSafe S Address
DATA = 8 Bytes			
	Byte 1 & 2	0x xx	Cell 1 Voltage of Slave SA (big endian)
	Byte 3 & 4	0x xx	Cell 2 Voltage of Slave SA (big endian)
	Byte 5 & 6	0x xx	Cell 3 Voltage of Slave SA (big endian)
	Byte 7 & 8	0x xx	Cell 4 Voltage of Slave SA (big endian)

Table 24: Identifier description: voltage and temperature answer (Frame 2)

Period : 1s / xxs		Value (Hex)	Comment
ID = 18 02 F4 B0	P	6	Default Value
	R	0	-
	DP	0	-
	PF	02	voltage and temperature answer (Frame 2)
	PS	F4	FreeSafe M Address
	SA	B0	FreeSafe S Address
DATA = 8 Bytes			
	Byte 1 & 2	0x xx	Cell 5 Voltage of Slave SA (big endian)
	Byte 3 & 4	0x xx	Cell 6 Voltage of Slave SA (big endian)
	Byte 5 & 6	0x xx	Cell 7 Voltage of Slave SA (big endian)
	Byte 7 & 8	0x xx	Cell 8 Voltage of Slave SA (big endian)

Table 25: Identifier description: voltage and temperature answer (Frame 3)

Period : 1s / xxs		Value (Hex)	Comment
ID = 18 03 F4 B0	P	6	Default Value
	R	0	-
	DP	0	-
	PF	03	voltage and temperature answer (Frame 3)
	PS	F4	FreeSafe M Address
	SA	B0	FreeSafe S Address
DATA = 8 Bytes			

	Byte 1 & 2	0x xx	Cell 9 Voltage of Slave SA (big endian)
	Byte 3 & 4	0x xx	Cell 10 Voltage of Slave SA (big endian)
	Byte 5 & 6	0x xx	Cell 11 Voltage of Slave SA (big endian)
	Byte 7 & 8	0x xx	Cell 12 Voltage of Slave SA (big endian)

Table 26: Identifier description: voltage and temperature answer (Frame 4)

Period : 1s / xxs		Value (Hex)	Comment
ID = 18 04 F4 B0	P	6	Default Value
	R	0	-
	DP	0	-
	PF	04	voltage and temperature answer (Frame 4)
	PS	F4	FreeSafe M Address
	SA	B0	FreeSafe S Address
DATA = 8 Bytes			
	Byte 1 & 2	0x xx	External temperature sense 1 (big endian)
	Byte 3 & 4	0x xx	External temperature sense 2 (big endian)
	Byte 5 & 6	0x xx	Internal slave board temperature (big endian)
	Byte 7 & 8	0x xx	Cell 12 Voltage of Slave SA (big endian)

After an internal processing the FreeSafe Master Board will dispatch the balancing orders if required.

Table 27: Identifier description: Balancing orders dispatching

Period : 1s / xxs		Value (Hex)	Comment
ID = 18 20 B0 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	20	Balancing Order
	PS	B0	FreeSafe S Address
	SA	F4	FreeSafe M Address
DATA = 2 Bytes			
	Byte 1 & 2	0x xx	**Bit Field** Bit 0: 1 : Balance Cell 1 0 : no balancing Bit 1: 1 : Balance Cell 2 0 : no balancing Bit 11: 1 : Balance Cell 3 0 : no balancing -

Communication FreeSafe Master – FreeSB PR

When FreeSB is powered up and connected to CANbus, it will begin its initialization by requesting the configuration parameters from the FreeSafe Master.

Table 28: Identifier description: FreeSB initialization request

Period : Once at startup		Value (Hex)	Comment
ID = 18 06 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	06	Initialization request

	PS	F4	FreeSafe M Address
	SA	C0	FreeSB PR Address
DATA = 0 Byte			

Table 29 Identifier description: FreeSB initialization answer (frame 1)

Period : Once at startup		Value (Hex)	Comment
ID = 18 06 C0 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	06	Initialization Parameters (frame 1)
	PS	C0	FreeSB PR Address
	SA	F4	FreeSafe M Address
DATA = 8 Bytes			
	Byte 1 & 2	0x xx	Charge over current limit (A) (big endian)
	Byte 3 & 4	0x xx	Discharge over current limit (A) (big endian)
	Byte 5 & 6	0x xx	Positive instantaneous current limit (A)
	Byte 7 & 8	0x xx	Negative instantaneous current limit (A)

Table 30: Identifier description: FreeSB initialization answer (frame 2)

Period : Once at startup		Value (Hex)	Comment
ID = 18 07 C0 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	07	Initialization Parameters (frame 2)
	PS	C0	FreeSB PR Address
	SA	F4	FreeSafe M Address
DATA = 8 Bytes			
	Byte 1 & 2	0x xx	Over current time limit (s) (big endian)
	Byte 3 & 4	0x xx	Battery capacity (Ah) (big endian)
	Byte 5 & 8	0x xx	Shunt value (float, Ohm, big endian)

Table 31 : Identifier description: FreeSB initialization answer (frame 3)

Period : Once at startup		Value (Hex)	Comment
ID = 18 08 C0 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	08	Initialization Parameters (frame 3)
	PS	C0	FreeSB PR Address
	SA	F4	FreeSafe M Address
DATA = 6 Bytes			

	Byte 1 & 2	0x xx	State of change sampling rate (sample/s, big endian)
	Byte 3 & 6	0x xx	Current Sense Gain (big endian float)

When FreeSafe is in normal mode, it will request an update every 100ms of current value. At the same time FreeSafe will communicate its state to FreeSB.

Table 32: Identifier description: current value request

Period : 100ms		Value (Hex)	Comment
ID = 18 0A C0 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	0A	Current value request
	PS	C0	FreeSB PR Address
	SA	F4	FreeSafe M Address
DATA = 1 Byte			
	Byte 1	0x xx	Bit field corresponding to various FreeSafe state flags

Table 33: Identifier description: current value answer

Period : 100ms		Value (Hex)	Comment
ID = 18 0A F4C0	P	6	Default Value
	R	0	-
	DP	0	-
	PF	0A	Current value
	PS	F4	FreeSafe M Address
	SA	C0	FreeSB PR Address
DATA = 3 Bytes			
	Byte 1&2	xx xx	Current value (10mA, big endian)
	Byte 3	xx xx	Bit Field corresponding to various FreeSB state flags

Every Second FreeSafe M requests an updated value of FreeSB coulomb counting

Table 34: Identifier description: coulomb counting value request

Period : 100ms		Value (Hex)	Comment
ID = 18 09 C0 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	09	Coulomb counting value
	PS	C0	FreeSB PR Address
	SA	F4	FreeSafe M Address
DATA = 1 Byte			
	Byte 1	0x xx	Bit field corresponding to various FreeSafe state flags

Table 35: Identifier description: coulomb counting value answer

Period : 100ms		Value (Hex)	Comment
ID = 18 0A F4C0	P	6	Default Value
	R	0	-
	DP	0	-
	PF	0A	Coulomb Counting value
	PS	F4	FreeSafe M Address
	SA	C0	FreeSB PR Address
			DATA = 3 Bytes
	Byte 1 - 4	xx xx xx xx	Coulomb counting value (C, big endian, float)

Communication FreeSafe Master – LCD Display

FreeSafe master will periodically send a message frame that will refresh the LCD display parameters.

Table 36 : Identifier description: LCD display parameters

Period : 100ms		Value (Hex)	Comment
ID = 18 0A A0 F4	P	6	Default Value
	R	0	-
	DP	0	-
	PF	0A	LCD display parameters
	PS	A0	LCD Display Address
	SA	F4	FreeSafe M Address
			DATA = 6 Bytes
	Byte 1	xx	**Bit Field** Bit 0: 1: Under Voltage 0: - Bit 1: 1: Low SOC (10%) 0: - -
	Byte 2	xx	SOC Value (%, big endian)
	Byte 3-4	xx xx	Total battery voltage (V*10, big endian)
	Byte 5-6	xx xx	Battery current (A*10, big endian)

Broadcast messages

When FreeSafe is in power saving mode, it will poll every slaves periodically in order to refresh the battery parameters. To reduce the power consumption after the data has been retrieved, it will shut down the CANbus power supply. Before doing so a broadcast message is sent to warn all the peripheral powered by FreeSafe M that the bus will go offline.

Table 37 : Identifier description: CANbus shutdown broadcast

Period : 100ms		Value (Hex)	Comment
ID = 18	P	6	Default Value
	R	0	-
	DP	0	-

	PF	FF	CANbus shutdown Broadcast warning
	PS	AA	
	SA	F4	FreeSafe M Address
DATA = 0 Byte			

WESTCODE
An IXYS Company

Date:-10 Sep, 2013

Data Sheet Issue:-1

Ultra Rapid
Semiconductor Protection Fuse
DIN 43653 Round Body Type Fuses 690V

German Standard DIN 43653/00C
Voltage Rating – 690V
gR and aR Characteristics
Current ratings from 12 to 100A
Size 17 x 49

Key Features:

- Extremely high interrupting rating fuses for the protection of power semiconductors in accordance with IEC Standard 269.1 and 4.
- 690V voltage rating (current rating 12-100A) complying IEC 33, according to IEC 269.4
- Non magnetic construction
- gR Characteristics for current ratings from 12 to 90A as per VDE 636-23
- aR Characteristics for current rating 100A as per VDE 636-23 and IEC 269.4

Main Characteristics:

Size	Voltage U_N (V)	Ref:		Current Rating I_N (A)	Pre-arcing I^2t @ 1 ms $I^2t_p(kA^2s)$	Total Clearing I^2t @ 1 ms $I^2t_p(kA^2s)$	Power Losses 0.8I_N	I_N	Tested Interrupting Rating
17 x 49	690	069FREA0012N		12	4,2	30	1,95	3,5	200kA @ 690V
		069FREA0016N		16	9,6	65	2,2	4	
		069FREA0020N		20	17,1	110	3,0	5,5	
		069FREA0025N		25	26,8	170	4,4	8	
		069FREA0032N		32	52,5	330	5,0	9	
		069FREA0035N		35	69	430	5,2	9,5	
		069FREA0040N		40	96	610	5,8	10,5	
		069FREA0045N		45	130	820	6,3	11,5	
		069FREA0050N		50	154	970	7,2	13	
		069FREA0055N		55	210	1320	7,4	13,5	
		069FREA0063N		63	310	1950	8,0	14,5	
		069FREA0075N		75	520	3250	8,8	16	
		069FREA0080N		80	620	3900	9,4	17	
		069FREA0090N		90	840	5300	11	20	
		069FREA0100N *		100	965	6150	13	23,5	

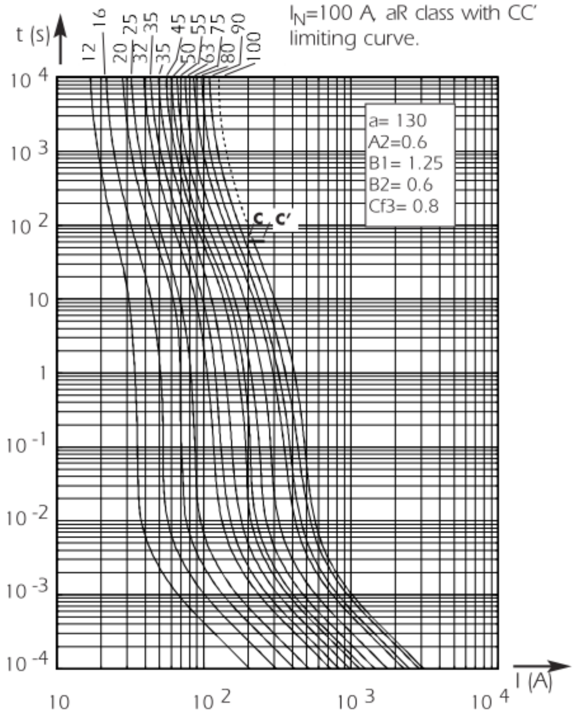
* aR Characteristics

Electrical Characteristics:

Times vs current characteristics

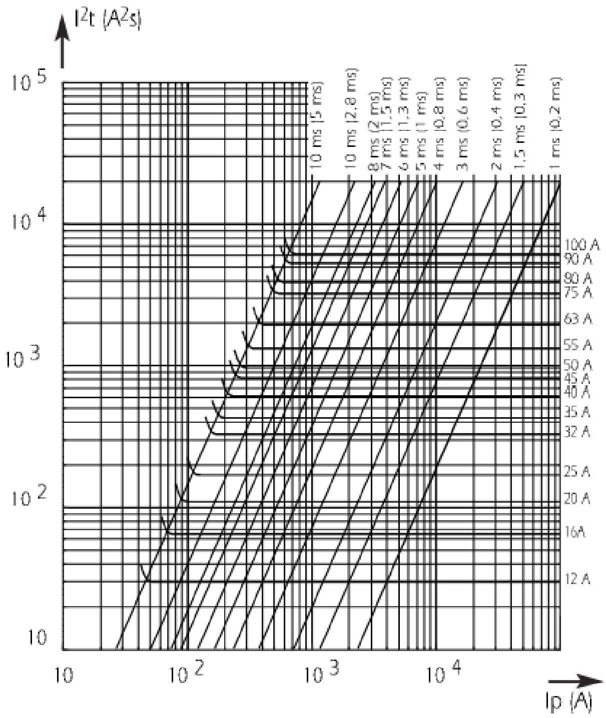
The following curves indicate, for each rated current, pre-arcing time as a function of RMS value of pre-arcing current I.

Tolerance form mean pre-arcing current ±9%



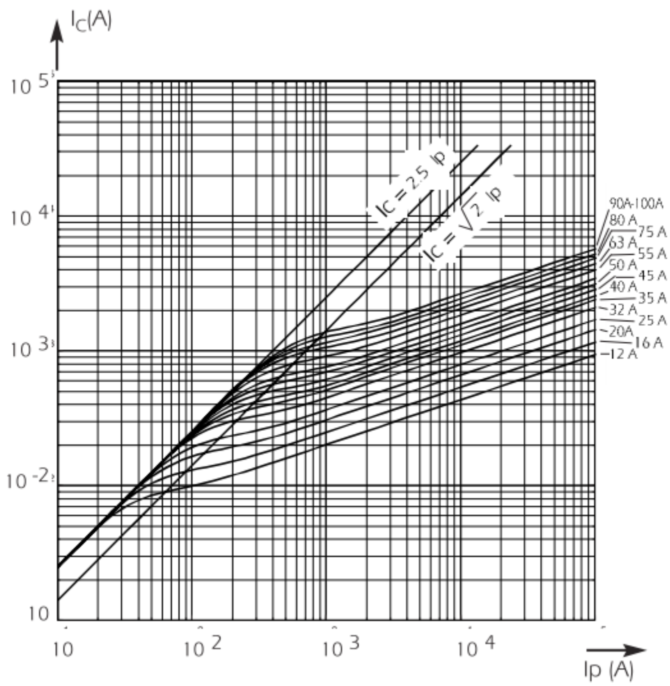
Total clearing I^2t:

Horizontal curves show maximum values of total clearing I^2t (I^2t_t) for each rated current as a function of prospective current I_P @ 690V cos=0.15. Oblique lines indicate total clearing duration Tt, with associated pre-arcing duration in brackets.

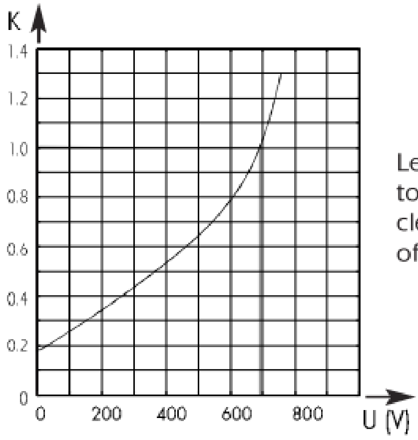


Cut off Characteristics:

The curves below show, for each rating, value of peak let-trought current I_C as a function of available falut current I_P.

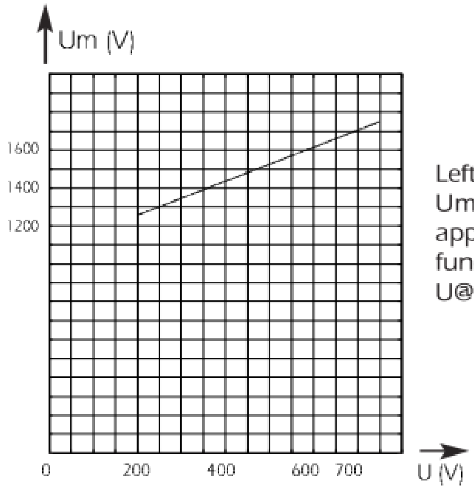


Corrective factor:



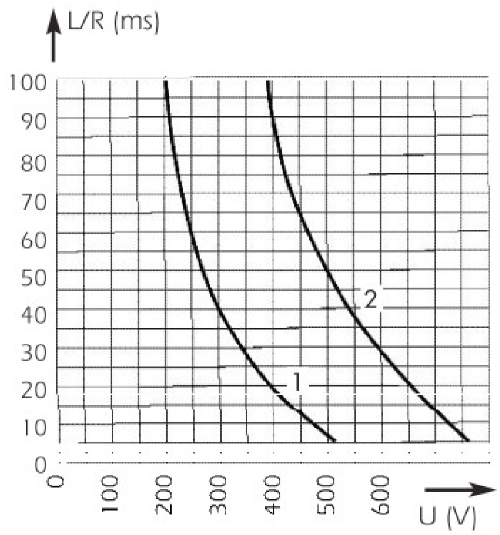
Left: Curve shows variation of total clearing time (I^2t_t) and total clearing duration T_t as a function of operating voltage U.

Peak Arc Voltage:



Left: Curve shows peak value Um of arc voltage which appears across fuse-link as a function of operating voltage U@ cos φ = 0.15

DC Application Data:



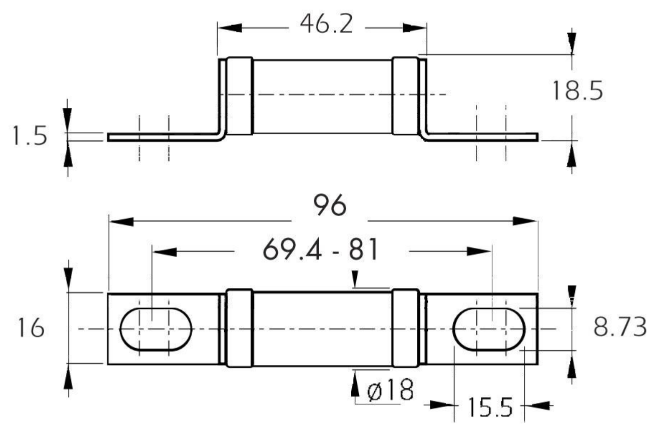
Above: Curves indicate permissible value of time constant L/R as a function of DC working voltage

Curve 1:
I_P >= 1.6xIN only for fuses gR
(current rating from 12 to 90A)

Curve 2:
I_P >= 8xIN for fuses gR and aR.

Outline Drawing & Ordering Information

069FREAxxxxN: 42gm (10 pcs)



ORDERING INFORMATION		(Please quote code as below)		
Style	**Voltage**	**Current Rating (A)**	**Type**	**Trip Indicator**
17x49	690V	0012 – 0100	FREA	

Order code: e.g. 069FREA0050N = 50 Amp DIN 43653 Round Body Type Fuse

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E-mail: service@ixyslongbeach.com

NEW

Service Plug for 200A Applications

EM30MSD Series

■Features

1.High-current service plug for use up to 200A

2.Vibration-resistant with multi-point contact design

Vibration testing meets the following standards :
For vehicles JASO D014-3/ISO16750-3 Test Ⅸ
For railroads JIS E 4031 Division 2

3.The signal contact functions as an interlock switch to detect mated state.

4.Water-proof performance (IP68 compliant water resistance in mated condition)

IP68 : No water intrusion, while submerged in 2m water depth for 14 days in mated condition

5.Finger protection IP2X

6.UL TÜV application pending

■Product Specifications

Ratings	Rated current	Power contact side : 200A* Signal contact side : 1A	Operating temperature range	-40 to +105℃
	Rated voltage	Power contact side : AC/DC 1500V Signal contact side : AC/DC 250V	Storage humidity range	-10 to +60℃

*When 100mm² or more wire is used

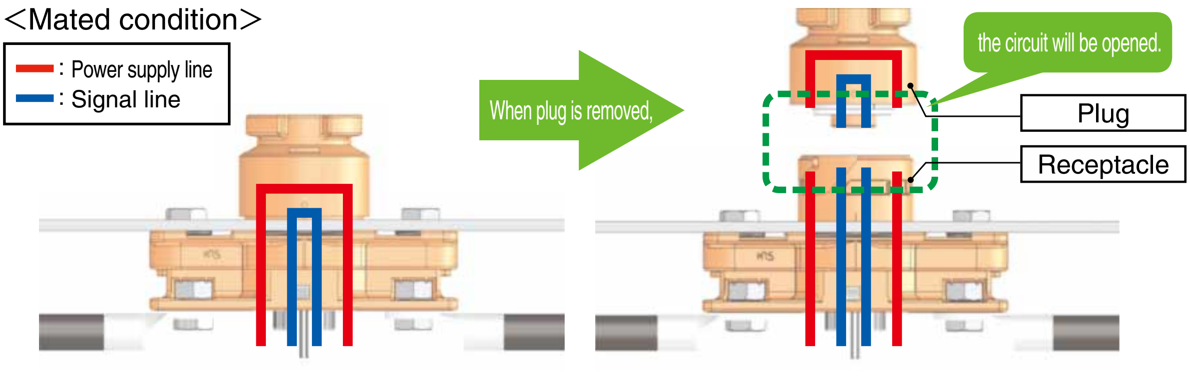
Items	Specifications	Conditions
1. Contact resistance	Between power contacts : 0.5mΩ or less Between signal contacts : 90mΩ or less	Measured at DC 1A
2. Insulation resistance	5000MΩ or more	Measured at DC 500V
3. Withstanding voltage	No flashover or breakdown	Between power contacts : AC 4500V for 1 minute Between signal contacts : AC 750V for 1 minute
4. Vibration resistance	No electrical discontinuity of 10μs or more	10 to 55 to 10Hz/cycle, half amplitude 0.75mm 5 minutes/cycle, 10 cycles in each of the three axial directions 10 to 2000Hz, average acceleration 57.9m/s² 8 hours in three axial directions (ISO16750-3)
5. Shock resistance	No electrical discontinuity of 10μs or more	Acceleration : 490m/s², duration : 11ms, and half-sine wave in 3 directions, 3 cycles for each
6. Repeated operation	Contact resistance Between power contacts : 0.75mΩ or less Between signal contacts : 150mΩ or less	50 times (EM30MSD between plug and receptacle) 30 times (EM30MSD-GT8E (between signal connectors) ※
7. Temperature cycles	Insulation resistance : 5000MΩ or more	-40℃ : 30 minutes → Room temperature : 2 to 3 minutes → +125℃ : 30 minutes → Room temperature : 2 to 3 minutes, 5 cycles
8. Humidity resistance	Insulation resistance Minimum of 50MΩ (at high humidity) Minimum of 500MΩ (dry environment)	Left at a temperature of 40℃ and in humidity of 90 to 95% for 96 hours.
9. Waterproofness	No water intrusion inside connector	Submerged in 2m water depth for 14 days in mated condition.

※Refer to page 3 for signal connector (GT8E connector).

■What is Service Plug?

The connector ensures to disconnect the electric circuit, to ensure the safety of workers in high-voltage areas.

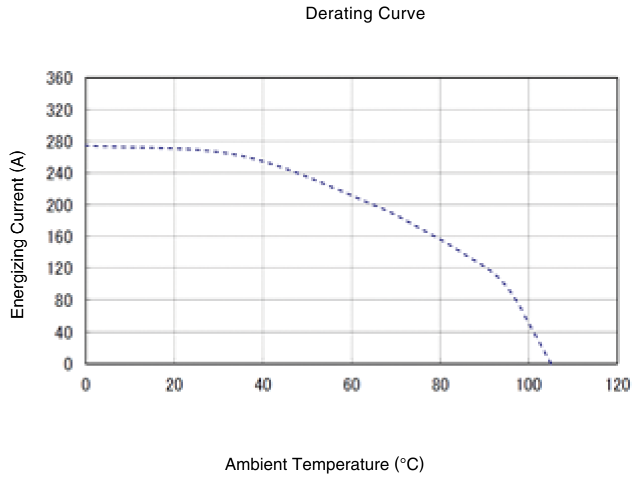
<Mated condition>

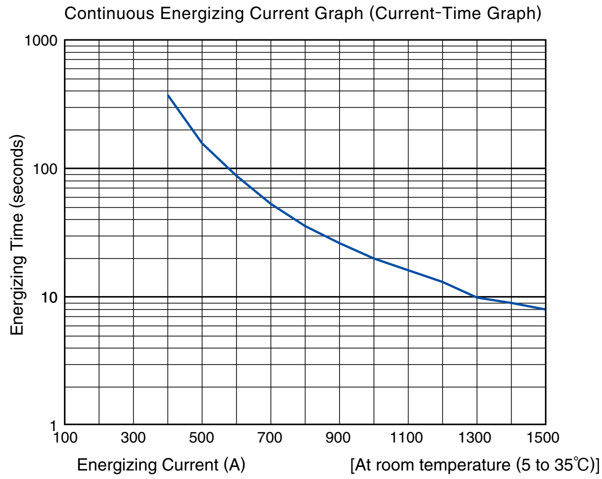


When the connector is unmated, the circuit is physically disconnected, ensuring the safety of workers.

[Reference] Derating Curve Graph and Continuous Energizing Current Graph (Current-Time Graph)

Measurement was performed by connecting a 100mm² wire in the mated state.





Operation below the derating curve (dotted line) is recommended.

Note : Derating curve could vary depending on cable type and measurement even under the same conditions.
Therefore, the data noted above are reference values, not connector specifications.
The continuous energizing current graph is reference data used for current values exceeding the rated values for a short time.

■Materials / Finish

Item	Materials	Finish and color	Remarks
Insulator	PBT resin	Orange, black	UL94V-0
Contact	Copper alloy	Power contact side : Silver-plated	―――
		Signal contact side : Tin plated	―――
Screw	Brass	Nickel plated	―――
O-ring	Hydrogenated nitrile rubber	Black	―――

■Product Number Structure

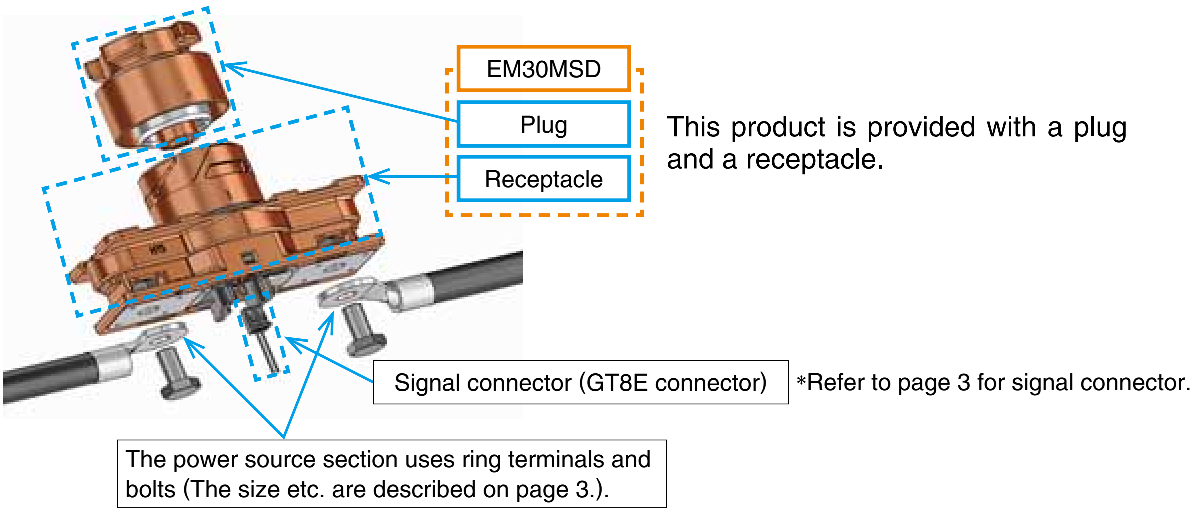
Refer to the chart below when determining the product specifications from the product number.
Please select from the product numbers listed in this catalog when placing orders.

EM 30 MSD – A (**)
❶ ❷ ❸ ❹ ❺

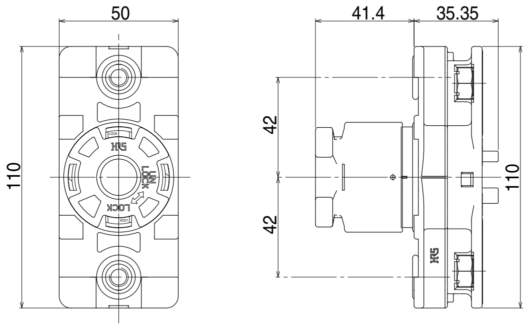
❶Series name : EM
❷Shell size : 30
❸Type: MSD (Manual Service Disconnect)=Service plug
❹Serial symbol : Unmarked: Standard product -A : Products which can withstand a different number of repetitive operations (200 times for EM30MSDs between the plug and the receptacle)
❺Specification : When different types of specifications are provided, attach (01), (02), …for identification.

■Product Composition

This product is provided with a plug and a receptacle.
The signal section uses a separately sold GT8E connector.



■Service Plug



Part No.	HRS No.	Remarks
EM30MSD	138-0200-0 00	Signal contact : Tin plated
EM30MSD(02)	138-0200-0 02	Signal contact : Gold plated
EM30MSD-A	138-0206-0 00	Signal contact : Tin plated
EM30MSD-A(02)	138-0206-0 02	Signal contact : Gold plated

✻This product does not contain fuses.

■Signal Connector : Main Body

Part No.	HRS No.	Remarks
GT8E-2S-2C	758-0030-6 00	———

■Signal Connector : Applicable Crimp Contacts

Part No.	HRS No.	Remarks
GT8E-2022SCF	758-0033-4 00	Tin plated (10,000pcs/reel)
GT8E-2022SCF(01)	758-0033-4 01	Gold plated (10,000pcs/reel)
GT8E-2428SCF	758-0055-7 00	Tin plated (10,000pcs/reel)
GT8E-2428SCF(01)	758-0055-7 01	Gold plated (10,000pcs/reel)
GT8E-2022SC	758-0101-2 00	Tin plated (10,000pcs/pack)

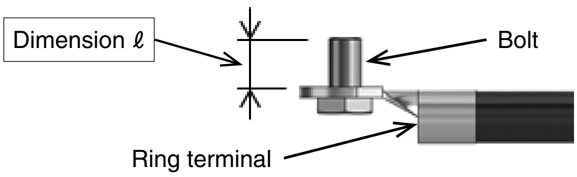
◆Signal Connector : Wiring Tools

Part No.	HRS No.	Remarks
CM-105C	901-0001-0	Press
AP105-GT8-2022S	901-5144-8 00	GT8E-2022SCF for applicator
AP105-GT8B-2428S	901-5172-3 00	GT8B-2428SCF for applicator
HT-304/GT8E-2022S	780-0042-6 00	GT8E-2022SC for hand crimping tool

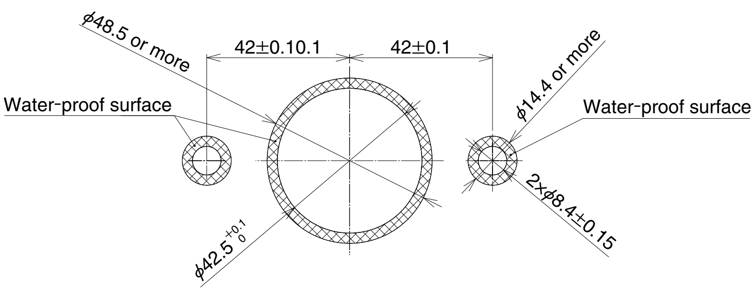
◆Applicable Bolt and Circular Contact Sizes

Secure positions	Bolt			R-form contact	
	Nominal designation of screw thread	Pitch	Length	Thickness	Hole diameter
To secure the housing	M8	1.25	10 to 12mm	———	———
To secure the ring terminal	M8	1.25	12 to 15mm	2.5 to 3.0mm	ϕ8.4

✻If you use any ring terminal with the thickness different from those shown in the above table, change the length of the bolt so that the dimension of ℓ on the right Figure is 9 to 12.5mm.



◆Panel Mount Dimensions



Recommended panel thickness t=2 to 4.5mm
Ensure that the surface roughness of the water-proof surface is √ Rz3.2.

◆Safety Notes!

⚠ Warning

●For safety, never carry out insertion / withdrawal operations when a connector is in an energized state.
The signal contacts of this product have a sequence structure which disconnects the contact in the order shown below. For this reason, this product can be used with a circuit built for preventing operations with live wires in the power source circuit.
In order to prevent accidents during operations with live wires, be sure to use this product with a circuit built in to prevent operations with live wires.

●Be sure to check that the product is securely locked.
The following figure shows the outward appearance when the lock is complete.

Table : Circuit-Connecting Order

Between A and B Power supply line
Between C and D Signal line

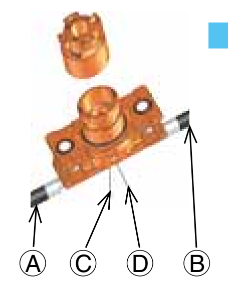
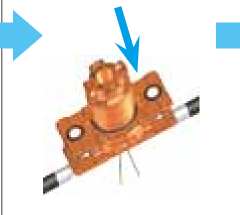
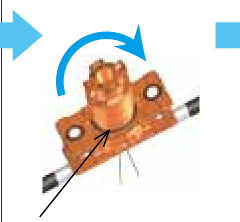
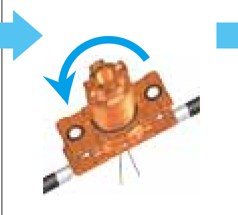
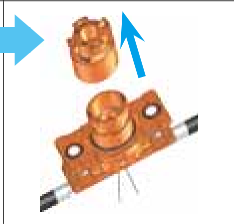
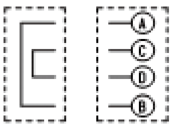
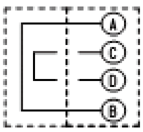
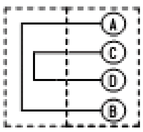
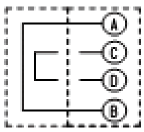
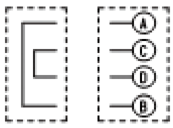
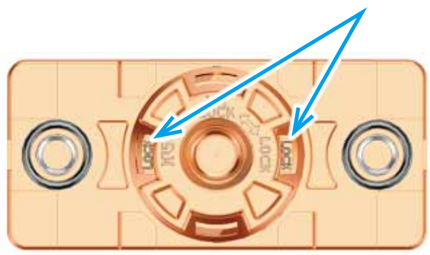
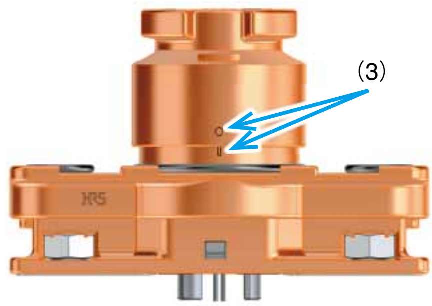
Status	①Not mated	②Plug inserted	③Rotation/lock completed	④Lock released	⑤Unmated
Outward appearance/ operation		 Insert the plug into the receptacle.	 Rotate the plug clockwise. Lock is complete at the position matching the shown place.	 Rotate the plug counter-clockwise.	 Pull out the plug out of the receptacle.
Connection		Power supply line is closed. When the signal line is open, no current flows.	The signal line is closed, and current flows in the power supply line.	The signal line is opened. No current flows in the power supply line.	
Circuit diagram	 Plug Receptacle	 Plug Receptacle	 Plug Receptacle	 Plug Receptacle	 Plug Receptacle

Figure : Outward appearance of the completely locked state

Front View



Side View



(1) HRS display and LOCK / UNLOCK display follow the positional relationship shown in the Figure.
(2) LOCK display is visible.

(3) The position marks shown of the plug and the receptacle match with each other.

Plug position mark	Circular concave shape
Receptacle position mark	Rectangular concave shape

Creative Links to World Electronics ®
HRS

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