EXIDE TECHNOLOGIES | ENERGIZING A NEW WORLD

Solition AGV Battery User Manual

ESAGV2458 and **ESAGV4829**

About this manual

Please read this manual and instructions carefully before attempting to use this battery in your application. It contains important information, to ensure problem free performance of your batteries. Damage to the battery howsoever caused is not covered under the warranty.

Please ensure that you have the latest version of all technical materials by checking the site below or getting in contact with our Support Staff.

ttps://www.exidegroup.com

Release Date	Revision	Scope of Change
30/11/2022	V1	Initial release

Please read all contents of this User's Manual prior to the installation of Exide E-Solition Line Batteries.

Technical Support: Please contact your local Exide technical support team

Abbreviations and definitions

CANOpen	Controller Area Network Bus communication
J1939	Higher-layer CANbus protocol for data logging
OCV	Over Charge Voltage
AFE	Analog Front End
BMS	Battery Management System
CC	Constant Current
CID	Current Interrupt Device
COV	Cell Over Voltage
DOD	Depth of Discharge
OCC	Over Current Charge
LED	Light Emitting Diode
EOD	End of Discharge voltage
CCCV	Constant Current Constant Voltage
OTC	Over Temperature Charging
OTD	Over Temperature Discharging
TCO	Thermal Cutoff
SOT	Safety Over Temperature
SOC	State of Charge
OCV	Open Circuit Voltage
RT	Room Temperature
Ah	Ampere Hour
CUV	Charge Under Voltage
C	Nominal capacity of the battery
EOC	End of Charge voltage

CAPACITY DEFINITIONS

The capacity C of a cell is defined by the discharge current I and the discharge

time t: C = I * t

I = constant discharge current

t = duration from the beginning of discharge until the end of discharge voltage is reached

Nominal Capacity: The nominal capacity C denotes the capacity amount in Ah (Ampère hours) that the battery can deliver at the 5h discharge rate (0.2 C). The reference temperature is +22°C ± 3°C, if not otherwise stated and the final discharge voltage will also be stated.

Available Capacity:

Factors which affect the available capacity are:

- Rate of discharge
- End of discharge voltage
- Ambient temperature
- State of charge
- Battery age
- Cycle history of the battery

At higher than usual discharge rates the available capacity is accordingly reduced.

CURRENT DEFINITIONS

Charge and discharge rates may be given as multiples of the Rated Capacity (C) in Amperes (A) with the term C.

Example:

Rated Capacity C = 1000 mAh

0.1 C = 100 mA, 1 C (A) = 1000 mA

Nominal Discharge Current:

The nominal discharge current of an E-Solition battery is the 5-hour discharge current (0.2 C). It is the current at which the nominal capacity of a cell is discharged in 5 hours.

I = C/t = C/5 = 0.2 C when t = 5 h

Content

Abbreviations and definitions 3
Content 4
Safety Information 6
Emergency and First Aid Procedures 8
Battery Installation: 9
Torque Rating 10
POWER CABLES 11
Communication Cables 12
Battery Specifications 13
Product Dimensions 14
Communications 15
Parallel connections 16
Wake-Up & Ship Mode 19
Battery status 21
4 Charging 32
5 Errors 32
6 The CAN Protocol 33
Maintenance, Storage, and Disposal 37
Transporting Lithium-ion Batteries 38
Warranty Violations 40
Technical Support 41

Product Overview

The **Solition AGV Line** is a modular battery system featuring an Intelligent Battery Management System (BMS) that offers optimal safety protection for over/under voltage, overcharge/discharge current, short circuit and over/under temperature conditions for all harsh environments. This product provides incredible reliability, long cycle-life, and efficiency to maximize your power, performance, and runtime.

Safety Information

General hazard sources

If the following instructions for handling the device are not observed, this might lead to personal injury or damage to the battery or your device, for which Exide will accept no liability. Exide cannot control the environment where the battery is deployed and the following are not covered by the warranty: physical damage, electrical interference, moisture ingress, deliberate or repeated short circuit or failure conditions, electrical conditions which trigger the fuse protection etc.

WARNINGS AND GENERAL INFORMATION

- Observe these Instructions and keep them located near the battery for future reference.
- Work on the battery should only be carried out by qualified personnel.

- Do not smoke.
- Do not dispose of the batteries in a fire.
- Do not charge battery near flammable materials, liquids, and surfaces.

- While working on batteries wear protective eyeglasses and clothing.

- Explosion and fire hazard. Avoid short circuits.
- Avoid electrostatic charges and discharges/sparks.

- Caution – parts of the battery may carry dangerous voltages. Be careful when handling cables.

- Lithium batteries are heavy. Make sure they are installed securely.
- Handle with care, the batteries are sensitive to mechanical shock.
- Do not lift or pull up on the poles or communication cables.
- Do not wear any metallic items such as watches, bracelets, et cetera.
- Do not alter, disassemble, modify, or open battery. The electrolyte is very corrosive. During normal operation, contact with the electrolyte cannot happen.
- Do not crush, puncture, or drop the battery.
- Do not operate if battery has been damaged in any way during shipping.
- If the battery housing is damaged, any direct contact with the exposed electrolyte or powder might result in jury, as the material is corrosive.
- Don’t connect the modules in serial only in parallel.

- Keep the ventilation openings clear 5cm.
- Do not use with other types of batteries.
- Don´t connect the module or charger in reverse polarity.
- Do not short circuit the battery terminals.
- Do not operate or store the battery beyond the operating limits.
- Charging the Li-ion battery after it has been discharged below the cut-off voltage or if the Li-ion battery is damaged or taking it over the nominal charge then the Li-ion battery can release a harmful mixture of gasses.
- Use certified insulated safety tools for installation. Any work procedures and tools used should be in compliance to EN 60900 or similar standard.
- To be prepared for an emergency case the Instruction for Safe Handling of Lithium Batteries shall be read and understood.

- Battery may require recycling in accordance with local laws.
- Contact Exide or regulatory authorities for further informations.

- DO NOT dispose of the battery in normal waste.
- DO NOT include battery with Lead Acid battery recycling.

- Keep the battery dry.

- Pressure washing not allowed.

Emergency and First Aid Procedures

Emergency Procedures for a Smoking Battery

- If a battery begins to smoke or melt, remove charging source immediately.
- If possible, move the battery to a well-ventilated area, preferably outside.
- Submerse in water or douse with copious amounts of water.

First Aid Procedures for Human Contact/Exposure to Battery Content

In the event of exposure to battery contents, the following could occur:

- Vapor or mist could irritate eyes, mucous membranes and/or respiratory tract
- Irritation to eyes and skin
- Exposure can cause nausea, dizziness or headache.

In case of contact with the battery's electrolyte:

- Immediately flush eyes with copious amounts of water for at least 15 minutes
- Assure adequate flushing of the eyes by separating the eyelids with fingers
- Flush skin with water
- Remove and wash contaminated clothing promptly
- If inhaled, remove oneself to fresh air
- If swallowed, wash out mouth with water
- If not breathing or having difficulty breathing, seek first aid

Safety Overview on Battery Management System (BMS)

The battery contains three levels of safety, which is controlled by the BMS.

1st Level Protection for over voltage/ under voltage / over current / short circuit / over temperature / under temperature. It is controlled by the BMS software and is non-permanent.

2nd Level Protection for over voltage/ under voltage / over current / short circuit / over temperature/ under temperature. It is controlled by the BMS software and is permanent.

3rd Level Protection (passive) with current fuse on board.

Battery Installation:

Before You Start

Please read all the safety and warranty information provided in this document prior to installing and/or operating the battery.

IMPORTANT: Remove all jewelry or other metallic objects from your hands and body during the installation and removal of the battery packs and peripherals.

ESAGV E-Solition batteries should be professionally installed and handled. Please contact Exide Support (MPservice-germany@exidegroup.com) for a free consultation if you have any questions about the handling, operation or safe use of this battery before proceeding further.

Unpacking

- If possible, do not discard the packaging, both the cardboard box and interior inserts for the battery. This packaging is specifically designed for the safe transportation and can be used if the battery must be transported to a new location. (In case new packaging is required, please contact Exide Support for proper packaging instructions).

- Remove the protective battery terminal covers from the terminals. Retain these covers in the event that you need to remove or move the battery at some future time.

Visual Inspection

- Please inspect each battery carefully. Report any damage from shipping to Exide Power immediately.

Installation Requirements

- Do not connect other batteries in series. Connecting in series exceeds the voltage limit of the integrated protection circuitry, leaving the module without critical safety features such as over-voltage and over-temperature protection. (Special applications may require factory application consultation)
- Remove jewelry and other metal objects from your hands and body during installation of the battery.
- Do not install a ESAGV E-Solition Battery where liquid is likely to contact battery terminals or signal communication ports.

Torque Rating

Power cables are not provided by Exide as requirements differ in all use cases. Exide recommends using an M6 screw type for the negative terminal and an M8 screw type for the positive terminal. For connection of the modules an additional bus bar or wires with cable lug are needed.

Minus terminal

Connect the Power Minus of all modules in parallel. Tighten it with a torque of max 3.9 Nm. Please note the Power minus is marked with the symbol -. For connection of the modules an additional bus bar or a wires with cable lug is needed. Please use a M6 x 16 mm screw.

Plus terminal

Connect the Power Plus of all modules in parallel. Tighten it with a torque of max 9 Nm. Please note the Power Plus is marked with the symbol +. For connection of the modules an additional bus bar or a wires with cable lug is needed. Please use a M8 x 16 mm screw.

CAUTION: When using bolts to engage the battery's threaded holes, use the appropriate number of flat and lock washers to allow for as much thread

engagement as possible without bottoming out the bolt. Over-tightening battery terminal bolts could result in damage to battery terminals. Under-tightening battery terminals could result in excessive heating of the terminals.

POWER CABLES

Choose the appropriate power cable size based on the system load requirements. Cables are rated at ambient temperature of 30°C (86°F) per the table below. When connected in parallel configuration, it is preferable for all cables to be the same length size.

Copper Wire Gauge (AWG)	Coper Wire Gauge (mm^2)	Ampacity (A)
14	2.08	20
12	3.31	25
10	5.26	30
8	8.37	50
6	13.3	65
4	21.2	85
3	26.7	100
2	33.6	115
1	42.4	130
0 (1/0)	53.5	150
00 (2/0)	67.4	175

Communication Cables

The communication cables are not provided by Exide. It is recommended to use Tyco Amphenol LTW 12-05BMIA-SL8001 or similar. See page **Error! Bookmark not defined.** for the wire drawing.

The CAN termination resistor is not provided by Exide. Exide recommends using Phoenix Contact 1507816 or similar.

A system without CAN communication to the Host needs two CAN termination resistors of 120 Ohm each. One CAN termination resistor has to be connected to the M12 connector of the first module.

and one CAN termination resistor has to be connected to the M12 connector of the last module. In this way the resistors are placed at the physical ends of the CAN bus.

Systems with CAN communication to the Host only need to have one CAN termination resistor of 120 Ohm on the last module which is connected. In this case the Host needs its own termination resistor.

Please make sure that the system is terminated at both physical ends of the CAN Bus!

a. Charger

We recommend Exide approved chargers which are already programmed with compatible firmware and tested. The charger datasheets can be provided on request.

Battery Specifications

Specification	ESAGV 2458	ESAGV 4839
Cell Chemistry	Nickel Manganese Cobalt	Nickel Manganese Cobalt
State of charge at delivery	< 30 %	< 30 %
Voltage *(Nominal / Max Charge)*	25.9 V	51.8 V
Energy *(Rated Capacity)*	1,50kWh / 58Ah	1,50kWh / 29Ah
Continuous Current *(per module)*	58A	39A
Peak Pulse Discharge *(@ 25°C and <10secs)*	65A	65A
Cycle Life *(@ 25°C and 80% DoD)*	1,500 cycles	1,500 cycles
Charge Operating Temperature	0°C to +45°C	0°C to +45°C
Discharge Operating Temperature	-20°C to +55°C	-20°C to +55°C
Operating Humidity	25% to 85%	25% to 85%
Scalability	Parallel: 10 max	Parallel: 10 max
Weight *(max)*	9,6kg	9,6kg
Communication	CANopen	CANopen
Certifications	UN38.3 / IEC62133-2:2017 / Rohs / REACH	UN38.3 / IEC62133-2:2017 / UL2595 / IEC60335 / Rohs / REACH

Mechanical Features

ESAGV2458 – ESAGV4829

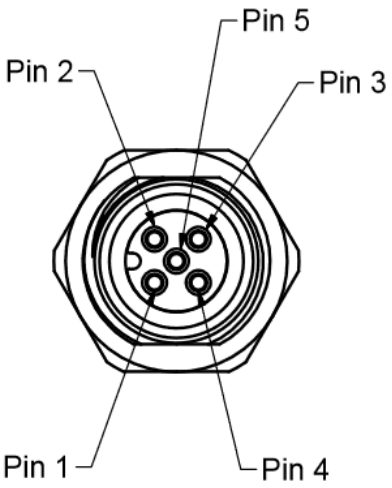
#	Description
1	Push Button
2	Status led indicator
3	M12 connectors for CAN coms
4	Positive Terminal M8
5	Negative Terminal M6
6	Fans

Product Dimensions

Specification ESAGV 2458 – ESAGV4829	
Length	330 mm
Width	80 mm
Height	230 mm

Communications

- Each E-Solition Line batteries uses two female Tyco Electronics M12 connectors to support signal communication with the host system.
- Communications are disabled until the battery is awakened.
- Voltage, current, temperature, capacity, full charge capacity and fault codes can be read from the battery using CANopen communication.
- A signal interface is used as the communication interface between the battery and a connected device.



If in doubt, please consult with Exide Technical Support on further instructions on the signal cable connections to the host system.

Tyco Amphenol LTW 12-05BMIA-SL800

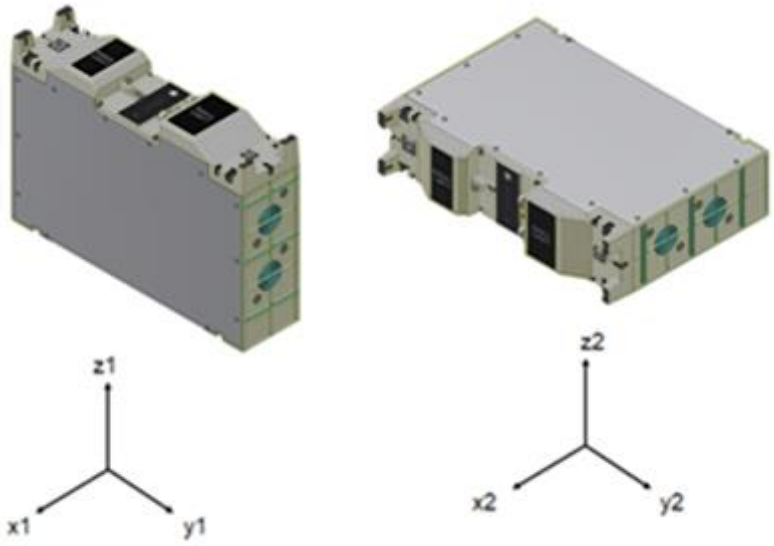
Pin Definition S-48V60-TRX

Pin #	Symbol	Description
1	VWAKE	Wake up input pin – active low to enable discharging
2	ON-Off	Used to turn the battery On or Off following the instructions
3	VGND	Pack signal ground used to pull Wake up and Interlock low
4	VCANH	CAN High for communication to the vehicle/machine or between modules
5	VCANL	CAN Low for communication to the vehicle/machine or between modules

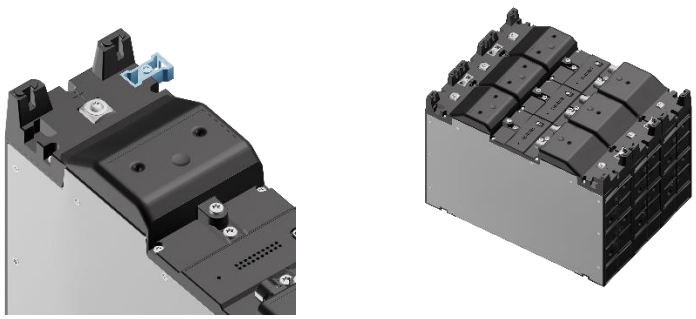
Parallel connections

Mechanical connection

Important! When installing the module in your application, it is important to ensure that load-bearing is evenly spread. Pressure or weight in a single area, especially on the metal plate is not allowed and may cause damage to the battery and internal components. For example, it is not allowed to fix the modules with a strap or similar where all of the weight could be carried in one small area. The pressure must be spread over the whole module.

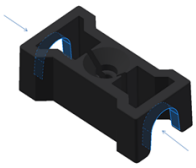


The modules can be connected in “x1” or “z2” direction. Place the module connectors inside the recess of two modules (see below picture). The module connectors are asymmetric and have a broad and a narrow side. If the orientation of the modules is wrong (e.g. in case of serial connection of the modules), the connectors will not fit properly. When the module connector is placed, insert a screw (Screw Wuerth Wueplast W1423 3x8, TX8 or Screw EJOT Delta PT WN5454 30x8, TX10) and tighten it with a torque of max 0.16 Nm). The module connector will expand and jam in the recess.

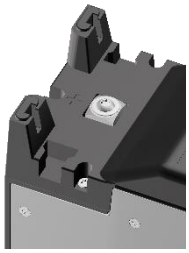


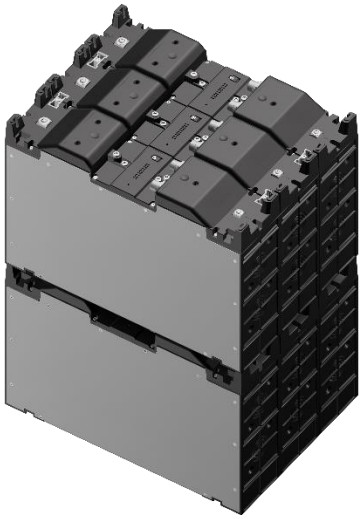
Important: The module connector will ensure correct position of the modules and add stability. The end user is responsible for creating sufficient stability of the battery system within the device with respect to the requirements of the application and variation of battery systems which can be assembled. In some cases it is necessary to consider that additional support of the module structure should be considered in the final design of the application.

For removal of the module connector loosen the screw and remove the module connector. If the connector is stuck, use a screwdriver for pulling it out of the recess via the side opening in the connector.



The modules can be connected in z1 directions. You can stack the batteries via the design features on the bottom and on the top of each module. (see below picture). Please note the stacking features are only for orientation and guidance not for fixation. The user is responsible, to make sure that the module can´t move during operation.





Below table shows the permitted layers in a specific direction:

Direction	Maximal Layers	Comments
Z1	3 layers	To avoid too much weight
Y1	1 layer	To ensure proper ventilation
Z2	5 layers	To avoid too much weight
Y2	1 layer	To ensure proper ventilation

Electrical connection

It is not allowed to connect the modules in series! Only connect the battery modules in parallel. Do not mix up 24V and 48V battery modules within a single system.

The next steps describe how to connect the battery modules in parallel.

Step 1: Minus terminal

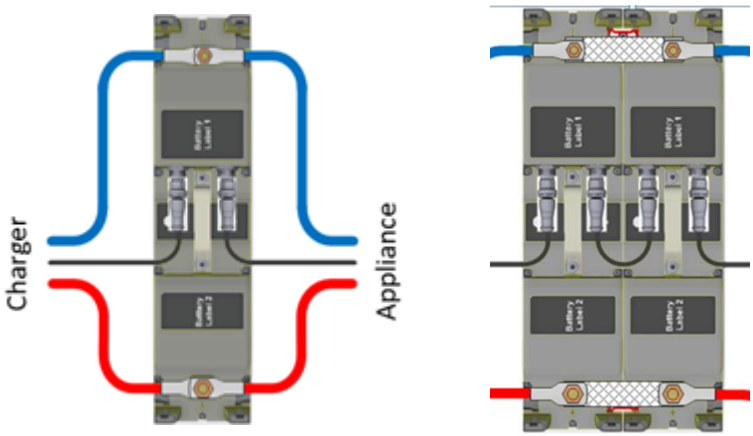
Connect the Power Minus of all modules in parallel. Tighten it with a torque of max 3.9 Nm. Please note the Power minus is marked with the symbol -. For connection of the modules an additional bus bar or a wires with cable lug is needed. Please use a M6 x 16 mm screw.

Step 2: Plus terminal

Connect the Power Plus of all modules in parallel. Tighten it with a torque of max 9 Nm. Please note the Power Plus is marked with the symbol +. For connection of the modules an additional bus bar or a wires with cable lug is needed. Please use a M8 x 16 mm screw.

Step 3: CAN cables

Connect the CAN cables. Tighten it with a torque of max 0.6 Nm. Connect always modules next to each other (see below picture).



Step 4: CAN termination resistor

Connect the CAN termination resistor or add a CAN termination into the connector. Please make sure that the system is terminated at both physical ends of the CAN Bus.

Wake-Up & Ship Mode

TO **WAKE UP** THE BATTERY

press the battery push button for 3 to 5 seconds until the LED is solid green

We recommend placing the battery in Ship Mode when it is not used to prevent self-consumption current drain and extend storage life.

TO PLACE IN **SHIP MODE**
twice quickly within one second

press the battery push button twice quickly within 1 second

First installation of a system

 Method 1: Push the Button (3 to 5 seconds) on one battery module (it does not matter which module) until the LED is solid green. The batteries will not turn on if the button is pushed longer than 5 seconds. This prevents turning on the battery accidentally if something blocks the button continuously.

 Method 2: Pull the ON / OFF Pin (Pin 2) of the CAN connector permanently to ground (Pin 3).

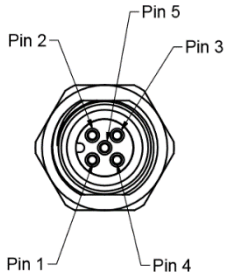
Start the battery/system

Step 1: Wake-up:

Note: Wake-Up by the external switch is prioritized. In case the battery has been turned off while the external switch was active and will be turned on again via the push button, the button only needs to be pressed for 500ms.

Please wait at least 3 seconds before turning on the battery again after turning off to ensure internal capacitors are fully discharged.

Pin-out of the M12-5 connector (female connector on the battery) 23



Pin 1: Wake-Up
Pin 2: ON / OFF
Pin 3: GND
Pin 4: CAN High
Pin 5: CAN Low

Note: All connectors (and all pins) are connected in parallel. The Wake-Up signal (Pin 1) is used in a system to wake up all batteries by pushing the button of any battery in the system. The ON/OFF signal (Pin 2) is used to wake up all batteries in a system by an external switch.

After Wake-Up the battery is ready for discharge. Charging is only possible if an approved VARTA CAN charger is connected, or a suitable CAN-charger has been developed under the VARTA protocol.

Step 2: Check Battery Status

If all modules are activated, continue with Step 3.

 Method 1: Check if the green LED on all modules is solid green.

 Method 2: Read the Battery Status Register via CAN.

Step 3: Discharging or Charging

 Discharging: Discharging is going to start once a load is connected to the system. Discharging is possible without CAN communication to the device.

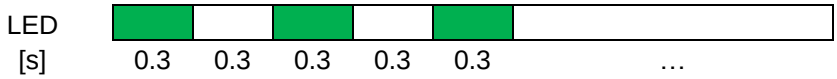
 Charging: Connect a VARTA approved CAN charger to the system. Charging starts once there is a CAN communication between Master and charger.

Battery status

The LED is able to show three different colors steady or blinking.

a. Switch from Deep Sleep to Active Mode

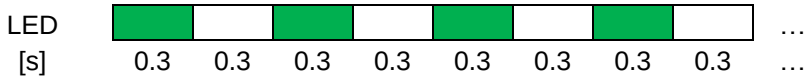
b. Switch from Active Mode to Deep Sleep



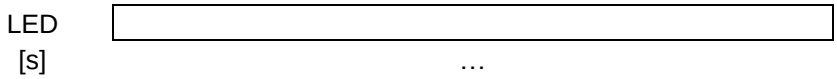
Note: As long as voltage is applied on the power terminals, the battery will continue the sequence

c. Active Mode and DSG FET or CHG FET is closed

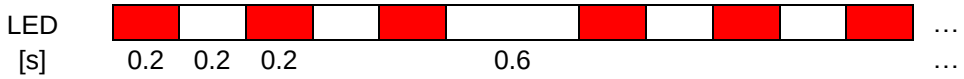
d. Active Mode and DSG FET and CHG FET opened



e. Deep Sleep

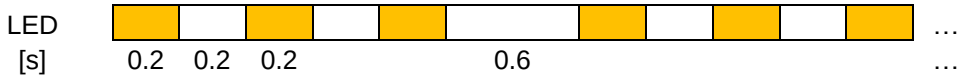


f. Irreversible error (e.g. defect fuse, defect FET, …)

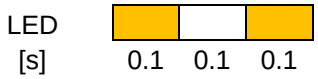


g. Reversible error (e.g. over-temperature, over-current, …)

h. No valid Node ID or double Node ID detected

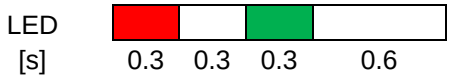


i. Switch to Bootloader Mode



j. Bootloader is active

k. Node ID assignment in process



Configuration of a system

It is necessary under the following conditions:

1. If the modules are connected the very first time.
2. If one or more modules are replaced with new module(s) in an already configured system.
3. If new modules are added to an already configured system.

Step 1: Turn on the system by pressing the button on any battery for 3s to 5s until the LEDs starts flashing orange. Alternatively, the ON/OFF signal (PIN 2) at the M12 connector can be connected to GND (PIN 3) by an external switch. LED will turn to orange (blinking).

Step 2: Press the button on any battery for at least 5s (but not longer than 10 sec.) until the LED on this battery turns red (300ms), off (300ms), green (300ms) and off (600ms) until the configuration is done (LED green). See also chapter **Error! Reference source not found.** k.

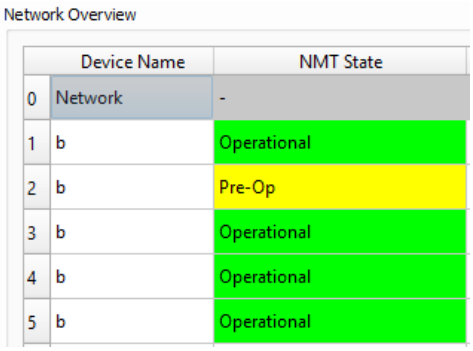
Technical details:

Each battery gets its own fixed Node ID while configuring the system. The range from 1 to 27 is reserved for fixed Node IDs, even if the system consists only of 3 batteries. Each battery sends this PDO consisting of its own value. The master sends additional PDOs with Node 27 consisting of the summary of the whole battery system.

Batteries which are not configured will not have a valid Node ID and will also not send any messages on the CAN bus. When configuring the system by pushing the button for at least 5s (but not longer than 10 sec.), the batteries will determine the master of the system depending on the highest serial number of the batteries. The Node IDs will be assigned in order of serial numbers. When all Node IDs are assigned, the

battery with Node ID 2 switches to Node ID 1 and becomes the master of the system. Because of this, there will never be an active Node ID 2 available in the system.

Example of system with four batteries in parallel:



Please switch the batteries off before adding new modules. After adding modules, start the system again. In case of orange blinking LEDs, press the push button of any battery for at least 5s to reconfigure the Node IDs.

Battery power modes:

Wake-up:

 Method 1: Push the Button (3 to 5 seconds) on one battery module (it does not matter which module) until the LED is solid green. The batteries will not turn on if the button is pushed longer than 5 seconds. This prevents turning on the battery accidentally if something blocks the button continuously.

 Method 2: Pull the ON / OFF Pin (Pin 2) of the CAN connector permanently to ground (Pin 3).

Shut-down

 Method 1: Push the Button on a module twice quickly within one second (it does not matter which module).

 Method 2: Switch off the battery with the external switch, which is connected to the ON / OFF pin in the CAN connector.

There are two conditions under which the battery enters automatically shut down mode.

Condition 1: Shut down timer and shut down current (Deadband)

If no charging / discharging below a set threshold (5A default) is detected within 3h, the single module shuts-down automatically. This 3h value and the current threshold is a default and can be changed in the CAN device settings.

The default value is 3h and the value of the shutdown timer can be set via object 0x3F00.4. The default value for the current is 5 A and can be set via object 0x3F00.5. For multi-module systems, to ensure individual modules remain in-sync, it is advised that the current thresholds for the timer function are not marginal or close to the limit of under/over current to trigger the shutdown. In such cases it could potentially bring the modules out of sync, if one module timer is triggered and another not.

Steps to follow for shutdown timer:

1. **Code for write permission:**

Write value 0x0717to object 0x2010.1

2. **Timer value (in seconds):**

Write value to object 0x3F00.4 (e.g. 604,800dec for 7 days)

3. **Save changed parameter permanently:**

Write 0x1c2b to object 0x2010.1

If you don´t want automatic shutdown, set the timer to the maximal value, which is 74444 hours (100 months).

Steps to follow for shutdown current (Deadband):

1. **Code for write permission:**

Write value 0x0717to object 0x2010.1

2. **Current value (in mA):**

Write value to object 0x3F00.5 (e.g. 10000 dec for 10000 mA)

3. **Save changed parameter permanently:**

Write 0x1c2b to object 0x2010.1

Condition 2: Keep power timer

Once battery is fully charged (100 % SOC), battery enters shut down mode after 5 minutes by default. This timer can be changed.

Steps to follow:

1. **Code for write permission**

Write value 0x0717 to object 0x2010.1

2. **Keep power timer (in seconds)**

Write value to object 0x3F00.9 (e.g. 360 dec for 6 minutes)

3. **Save changed parameter permanently**

Write 0x1c2b to object 0x2010.1

If you don´t want automatic keep power timer, set the timer to the maximal value, which is 0xffffffff.

User Specific Changeable Parameters

There is a specific area for “User Specific Changeable Parameters. These parameters can be accessed via CANopen Protocol and SDO transfer. For changing proceed the following steps:

Example:

1. **Get Write permission:**

Write “0x0717” in object 0x2010.1

2. **Change Current Value to e.g. 20A (=20,000 mA) in “Normal Temp Range”:**

Write “0x4e20” in object 0x3F00.6

3. **Save values permanent in EEPROM:**

Write “0x1c2b” in object 0x2010.1

4. **Reboot battery:**

New value is valid only after reboot (switch off and on the battery).

Below objects can be configured by the customer.

Object ID	Object Description	Write permission	Save value in EEPROM	Description	Format
0x3f00.1	Configuration String Customer	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	String for general purpose	32byte String
0x3f00.2	Serial Number Customer	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	Customer can add own Serial Number if needed	Unsigned32
0x3f00.3	Date Code Customer	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	Customer can add own Date Code if needed	Unsigned16

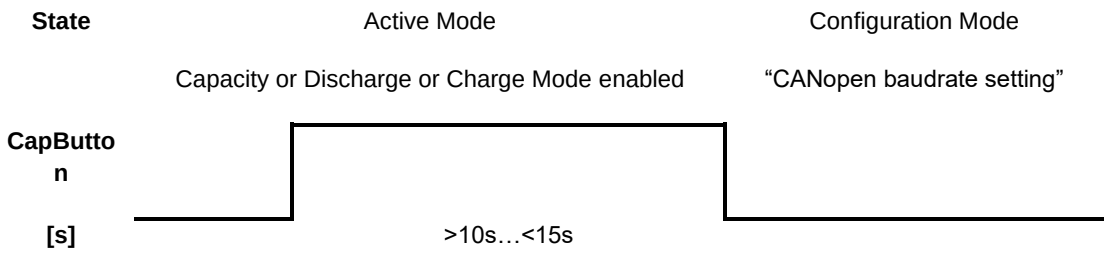
0x3f00.4	Shut down timer	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	Shutdown timer. If standby current of Application is less than the values which is defined in 0x3f00.4, the battery will switch off after expiration of the shutdown timer (default 10800s)	Unsigned32
0x3f00.5	Battery Discharge Current System Shutdown Delay Threshold	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	Deadband for the system. (Default 5000mA).	Unsigned32
0x3f00.6	Battery Charge Max Current Normal Temperature	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	Max current which is allowed in normal temperature range. Please note: It cannot exceed the protection threshold of the battery.	Unsigned32
0x3f00.7	Battery Charge Max Current High Temperature	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	Max current which is allowed in high temperature range. Please note: It cannot exceed the protection threshold of the battery.	Unsigned32
0x3f00.8	CAN baud rate	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	Baud rate can be change via this object. Default is 250 kbit/s. Possible baud rates are 125/250/500/1000	Unsigned16
0x3f00.9	Keep power timer	0x0717 in Object 0x2010.1	0x1c2b in Object 0x2010.1	Once battery is fully charged (100 % SOC), battery enters shut down mode after 5 minutes by default. This timer can be changed via this object.	Unsigned32

Baud rate

There are two possible ways to change the baud rate:

Option 1: via push button

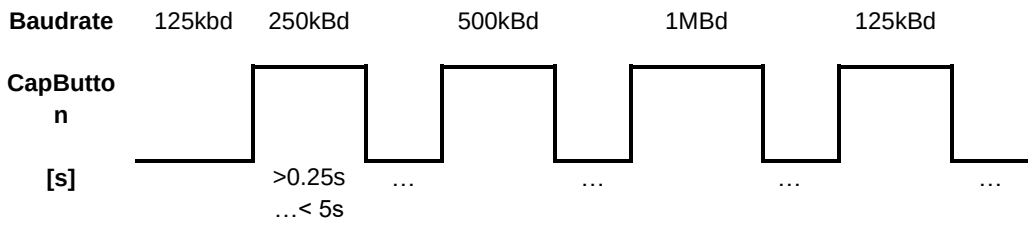
Switch into configuration mode “CANopen baud rate setting” while the BMS is in Active Mode it is possible to start this configuration mode by pressing the onBoard button a long time.



When **10s** are reached, the LED Display show a short Feedback to signalize that the button has to be released to start the configuration If the button is released within the mentioned time range the configuration mode starts. The BMS LED Display shows the state switch. The flag WARNING_REG_SET_CAN_BAUDRATE_PROCESS_ENABLE is set. The BMS waits for further key pressing to change the baudrate setting or to finish this configuration mode. All other kind of key pressing events (e.g. switch into DeepSleep Mode) and also events which occur on the External Signal GPIO where ignored during this configuration mode

Change baudrate during “CANopen baudrate setting.”

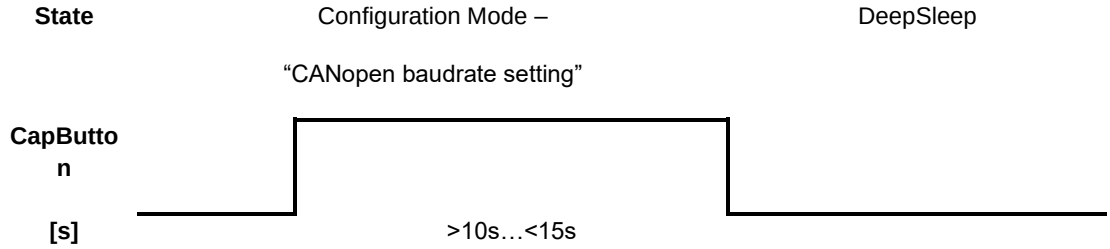
While the BMS is in the mentioned configuration mode it is possible to toggle between several baud rate settings by short pressing the onBoard button. There are 4 different fix baudrate settings possible which are changed with every key press in a circular method e.g. if the setting was 125kBd while the configuration mode was entered, after the first press 250kBd will be selected and so on.



The actual selected baud rate is shown via the BMS LED Display. This is only a preselection for an internal temporary table index during this configuration mode the CAN interface is not be influenced. CAN interface will only be reinitialized after the configuration is finished and the BMS will be restarted

Finish setting during “CANopen baudrate setting”

While the BMS is in the mentioned configuration mode it is possible to finish the configuration mode by pressing the onBoard button again for a long time.



When **10s** are reached, the LED Display show a short Feedback to signalize that the button has to be released to store the configuration. The corresponding CAN baudrate of the last selected table index is stored into the EEPROM to can be used after the next restart from DeepSleep Mode. If this restart is desired, it has to be initiated by the user e.g. double key press or software reset via CAN.

Abort setting during “CANopen baudrate setting”

If there is no button pressed within a timeout period of **60s** the configuration mode would be aborted without any changes concerning CAN baudrate setting and without any store into EEPROM.

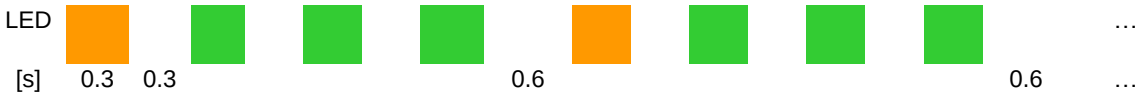
Battery is in configuration mode: “CANopen baudrate setting”

If the user started the configuration mode: “CANopen baudrate setting” by pressing the onBoard button. A feedback is given that the configuration mode is initiated. The baudrate can be selected by further user key press interaction and the LED shows which kind auf baudrate is actually selected:

- In case: **125 kBd** is selected.
  LED continuous flashing: 1 x orange – 1 x green - break…

- In case: **250 kBd** is selected.
  LED continuous flashing: 1 x orange - 2 x green - break …

- In case: **500 kBd** is selected.
  LED continuous flashing: 1 x orange – 3 x green - break …



- In case: **1 MBd** is selected.
  LED continuous flashing: 1 x orange - 4 x green - break …

Option 2: via customer objects

Steps to follow:

1. **Code for write permission.**

Write value 0x0717to object 0x2010.1

2. **2.Keep power timer (in kbit/s)**

Write value to object 0x3F00.8 (e.g. 125 dec for 125 kbit/s)

3. **Save changed parameter permanently.**

Write 0x1c2b to object 0x2010.1

Cooling concept

The ESAGV2458 and ESAGV 4839 have two radial fans to cool the battery in case of increasing temperature. You can see in below spreadsheet the performance of the fans, which depends on the temperature inside the battery. There are different thresholds for charging and discharging.

Discharging:	Charging:	Fan
<30°C	<30°C	off
30°C – 35°C	30°C – 32,5°C	25 %

35°C – 40°C	32.5°C – 35°C	50 %
40°C – 45°C	35°C – 37.5°C	75 %
>45°C	>37.5°C	100 %

Please note for a good circulation, the modules need at least a distance of 5 cm between the battery and the device on both sides (fan side and opposite side). If the batteries are built in into a compartment/enclosure, please ensure fresh air circulation (from outside via slots).

Pre charge circuitry

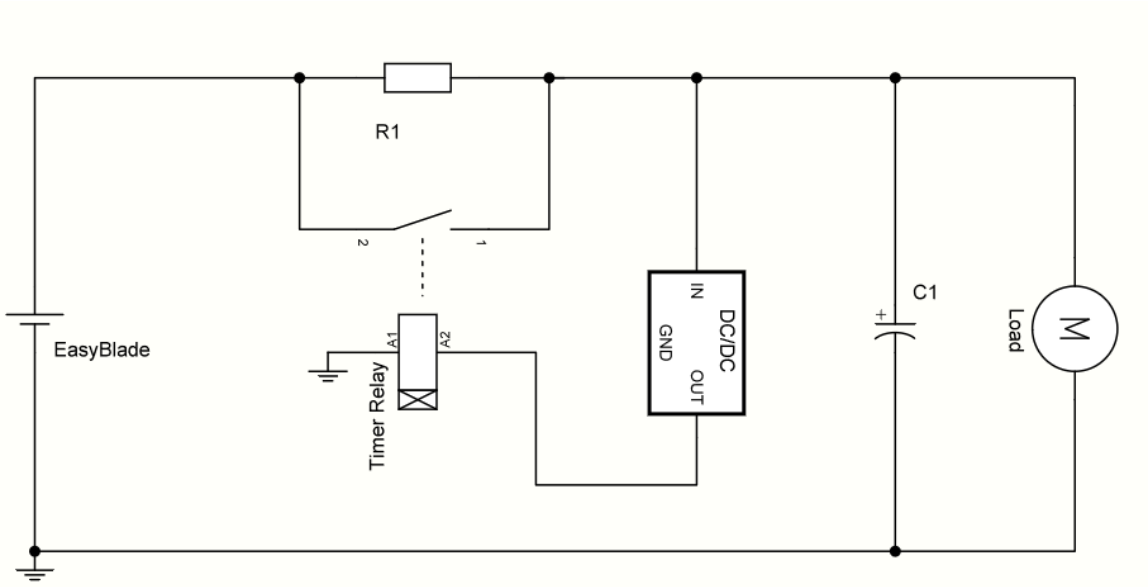
For applications with a high input capacitance, Exide recommends adding a pre-charge circuity into the device to limit the inrush currents as there is no build in pre-charge circuity in the Battery. High inrush currents might trigger the short circuit protection in the Easy Blade battery which lead to a shutdown of the system during start-up.

The short circuit protection in the battery will be enabled if a current of 300A for 300µs is exceeded.

Exide recommends following pre-charge circuitries:

Option 1: Via a series resistor

The input capacitor is pre-charged via a series resistor (R1). After a defined delay, which is pre-set in the timer relay, the main power path is enabled.



Please keep the pre-charge current as low as possible to reduce the cost for the pre-charge resistor. Typical pre-charge currents are in the range of 5A-15A.

Formula to calculate the pre-charging of a capacitor:

$$Uc(t)=U_0\times(1- e^{(- t/(R \times C))})$$

Uc(t): Capacitor Voltage after time t
U0: Battery voltage
t: time
R: resistance of pre-charge resistor
C: Input capacitance

Example for pre-charge resistor:

TE Connectivity HSC10010RJ 10Ohm (+/- 5%) 100W

Example for Timer Relay:

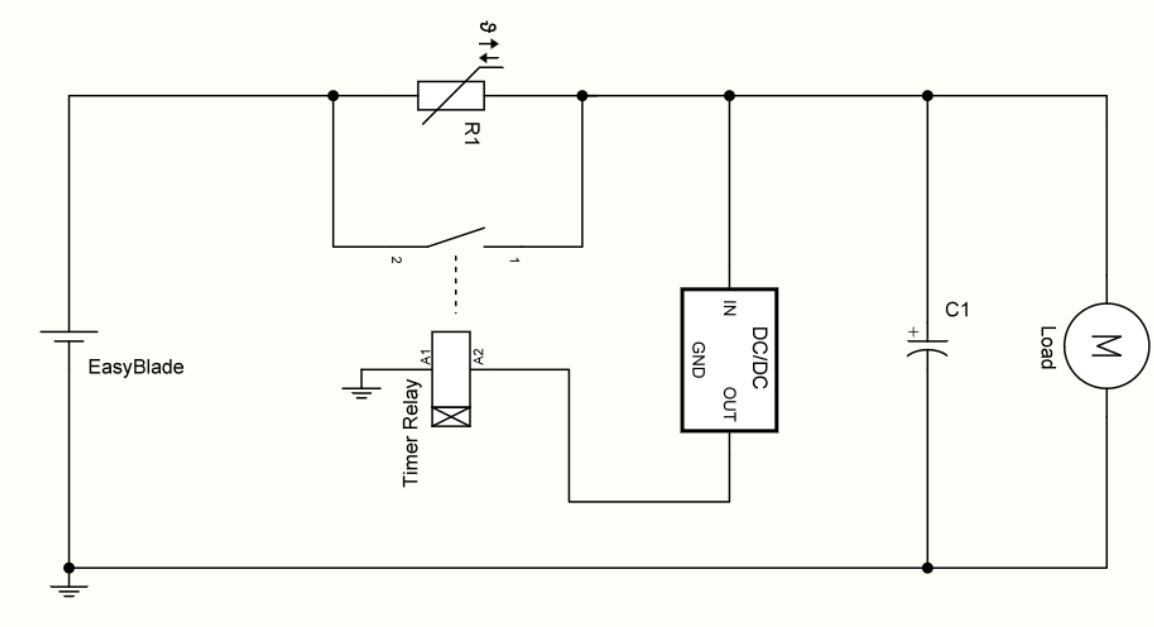
Phoenix Contact 2905814

Example for Relay in Main Power Path:

Siemens 3RT2026-1AP00

Option 2: Via a NTC

The input capacitor is pre-charged via a NTC (R1).



Example for NTC:

EPC B57364-S100 10Ohm, 5.1W

Charging

Charge algorithm is controlled by the battery itself.

Only Exide-approved charger can be used, charging will not start without CAN communication.

Modules accept regenerative charging with below specified limits:

- If current is below 65A for 5s.
- If battery voltage is below:

Products	System voltage [V]
ES-AGV 24-58	29.7
ES-AGV 48-29	59.5

Errors

In case of an unexpected behavior of the battery or if any threshold limit is violated, the battery will store an internal error event. The LED of the battery will be steady red if the operating state does not change. This means, that the battery will be operating again, if the cause of the error is not present anymore and the battery is turned off and on again. In case of a non-reversible error, the LED will blink red and the battery cannot be used anymore.

If an error occurs while charging, the charger will be commanded to shut down the charge current and the Charge FET will be opened to prevent any further charging. If an error occurs while discharging, the discharge FET will be opened to prevent any further discharging.

The battery saves the record of every individual error in the internal memory which can be read via CAN from object 0x201A sub 1 to sub 64. The history of the error which occurred can be read from object 0x2018 sub 1 to sub 16 which stores the last 16 events.

The CAN Protocol

The communication between all batteries in the system, the charger and the application (optional) is done via the standardized CAN-open protocol. For more detailed information about CAN-open please visit the official website from “CAN in Automation” (CiA) at https://www.can-cia.org/canopen/.

At normal operation, all necessary data is transmitted via PDOs in cyclic intervals. If the application needs more information, more data can be accessed via SDO request to the master battery. Please note: Data via SDO shall not be requested during normal operation, only in service cases.

The CAN PDO list can below

There is no customized Service software available. Exide recommends the standard CAN-open Software for debugging / read-out of CAN Objects, which is CAN Device Explorer from Peak-systems https://www.peak-system.com/PCAN-Explorer-6.415.0.html?&L=1

CAN EDS file is available on demand to preconfigure the CAN Device Explorer Tool.

1.1 Communication within the battery system

All data, which is needed to operate a battery system, is transferred via Process Data Objects (PDOs). Each battery transmits data in cyclic intervals with the following definition based on Node ID 1. PDOs sent by other Node IDs increase the CAN-ID, e.g. TPDO_1 sent by Node ID 4 has CAN-ID 0x184.

PDO	CAN-ID	Type	Node-ID	Data		Event
				Battery Voltage	Battery Average Current	
TPDO_1	0x181	PDO	1	uint32 [mV]	int32 [mA]	1s

PDO	CAN-ID	Type	Node-ID	Data				Event
				Max. FET Temp.	Max. Cell Temp.	Charge Voltage Req.	Charge Current Req.	
TPDO_2	0x281	PDO	1	int16 [0.1°C]	int16 [0.1°C]	uint16 [mV]	uint16 [mA]	1s

PDO	CAN-ID	Type	Node-ID	Data				Event
				Battery Cap.	Battery Full Cap.	Battery Rem. Cap.	not used	
TPDO_3	0x381	PDO	1	uint16 [mAh]	uint16 [mAh]	uint16 [mAh]		1s

PDO	CAN-ID	Type	Node-ID	Data				Event
				Information Status	Warning Status	Error Status	Charge Control Status	
TPDO_4	0x481	PDO	1	uint16	uint16	uint16	uint16	100ms

1.2 Communication sent by the battery master (for application)

The battery, which is configured as the master, sends cyclic data of the complete system. Every state of each module is summarized in TPDO_8. In this way only one PDO needs to be checked in case of monitoring the system for faults and errors.

PDO	CAN-ID	Type	Node-ID	Data		Event
				Master Voltage (Max. Battery Voltage)	aster Current (sum of all module	
TPDO_5	0x19B	PDO	1	uint32 [mV]	int32 [mA]	1s

PDO	CAN-ID	Type	Node-ID	Data				Event
				Max. FET Temp.	Max. Cell Temp.	Master Design Cap.		
TPDO_6	0x29B	PDO	1	int16 [0.1°C]	int16 [0.1°C]	uint32 [mAh]		1s
PDO	CAN-ID	Type	Node-ID	Data				Event
				Master Full Charge Capacity		Master Remaining Cap.		
TPDO_7	0x39B	PDO	27	uint32 [mAh]		uint32 [mAh]		1s
PDO	CAN-ID	Type	Node-ID	Data				Event
				Information Status	Warning Status	Error Status	Charge Ctrl Stat.	
TPDO_8	0x49B	PDO	1	uint16	uint16	uint16	uint16	200ms

Battery Information Status Register	
Bit	Description (master / slave)
15	-
14	-
13	-
12	-
11	-
10	-
9	-
8	-
7	-
6	all modules / this module fully charged
5	-
4	bypass FET on
3	all modules / this module DSG FET closed
2	all modules / this module CHG FET closed
1	all modules / this module are almost empty
0	all modules / this module empty

Battery Warning Status Register	
Bit	Description
15	unknown
14	set node ID process enable
13	-
12	set deactivation enable
11	can network failed
10	-
9	-
8	-
7	max charge condition recuperation
6	-
5	-
4	over- or untertemperature charge
3	over- or undertemperature discharge
2	reserve SOC
1	low SOC
0	low voltage

Battery Error Status Register	
Bit	Description
15	unknown
14	module defect
13	over- or undertemperature discharge
12	over- or undertemperature charge
11	overcharge alarm
10	undercharge alarm
9	max. discharge current alarm
8	max. charge current alarm
7	charge FET error
6	discharge FET error
5	max. voltage alarm (pack)
4	shortcircuit discharge alarm
3	shortcircuit charge alarm
2	overcharge condition recuperation
1	error lock flag charge
0	error lock flag discharge

Battery Charge Control Status Register	
Bit	Description
15	Charger supply conditions ready
14	Master charger control charging ready
13	Charge FET disable temp range cells
12	charge Master set charger outpuff off
11	charge max charge cell voltage request
10	charge max charge current request
9	-
8	charge current high temp range
7	charge current normal temp range
6	charge current low temp range
5	charge current keep power
4	charge current enable
3	-
2	-
1	charge voltage keep power
0	charge voltage enable

Register description in TPDO_8 is similar to TPDO_4 with following interpretation:

Information Register: every state of each module is **"AND-ed"** in this PDO and shows the summary of the system
Warning Register: bit 15…3 of every module is **"OR-ed";** bit 2..0 is calculated by master
Error Register: every state of each module is **"OR-ed"** in this PDO and shows the summary of the system
Charge Control Register: every state of each module is "OR-ed" in this PDO and shows the summary of the system

1.3 Communication sent by the battery master (for charger)

The master also sends the system´s requirements for charging to the charging device

PDO	CAN-ID	Type	Node-ID	Data								Event
				Charge Control	SoC		Charge Voltage Req.		Charge Current Req.		Battery Status	
TPDO_9	0x264	PDO	100	uint8	uint8	uint8	uint16 [1/256 V]		uint16 [1/16 A]		uint8	100ms
Example				0x01	0x64	0x00	0x19	0x1E	0x40	0x02	0x01	
					100%		30.097 V		36 A			

The battery master will initialize the charger to the appropriate voltage and current needed to charge the battery system. The voltage and current values requested from the charger will be sent every 100ms. In case of a fully charged battery, the battery will set its “fully charged” flag in the battery information status register (bit 6) and opens its charge FET. When all batteries of the system are fully charged, the master sets its “fully charged” flag and sets the charger to a standby value for the time, which is defined in the object 0x3F00.9 (keep power timer). After this delay, the battery system will shut down. Please see spreadsheet below for the batteries with fixed value in the keep power timer, which cannot be changed. For batteries, which are not fixed the value can be changed see chapter 0.

1.4 Safety thresholds

Fuse: Siba 5005038.100 (one shot – 100A)
Short circuit protection: 300A / 0.3 ms (reacts faster than the fuse)
Over discharge current protection 1: 65A / 5s
Over discharge current protection 2: 85A / 50ms
Over charge current protection 1: 65A / 5s
Over charge current protection 2: 85A / 50ms

ESAGV2458:

- Over voltage protection: 29.75 V / 4s
- Under voltage protection: 18.2 V / 2s

ESAGV4839:

- Over voltage protection: 59.5 V / 4s
- Under voltage protection: 36.4 V / 2s

Maintenance, Storage, and Disposal

Maintenance Charging

E-Solition Line batteries can be stored in an environment with temperatures between -20°C and +45°C and between 25% and 85% relative humidity, non-condensing. For long storage periods it is recommended to check the battery SOC every 12 months. If batteries are stored charge the battery annually. It is recommended to charge the batteries when SOC falls below 10%.

Battery Case Visual Inspection

Please perform regular visual inspections of the battery case. If the battery case is found to have dents, discoloration, or appears to be damaged in any way, DISCONTINUE USE IMMEDIATELY. Please contact Exide for assistance with evaluating the product for continued usability.

Battery Storage

Battery should be stored between 30-50% SOC.

- Store in an open, well ventilated, and dry area <30°C for maximum life.
- Do not expose the battery to extreme temperature or sunlight.
- Do not expose the battery to direct sunlight or moisture and/or precipitation.
- Handle each battery carefully to avoid sharp impacts or extreme pressure on the case.
- Do not store a fully discharged battery. Recharge battery after every use.

Minimum Temperature	Maximum Temperature	Duration
-20°C (-4°F)	45°C	1 to 3 months
-20°C (-4°F)	24°C	24 months

Transporting Lithium-ion Batteries

This section discusses the regulations governing the transportation of lithium-ion cells and batteries both within the United States and internationally. You should read and understand all relevant regulations discussed in this section before shipping Exide E-Solition batteries.

Lithium batteries are classified as Class 9 when transporting by air or ground. When shipping by air, all lithium batteries are required to have a 30% state of charge or less. Lithium batteries with capacity greater than 300 Wh and exceed 30kg (66lbs), are considered Class 9 when shipping by ground. For more information on shipping Lithium Batteries, please see your freight carrier's requirements.

NOTE: The regulations discussed in this manual apply to lithium-ion cells and batteries. Once the Exide E-Solition battery is integrated into a host system, the host may be subject to additional transportation regulations that require additional certification testing. Since Exide cannot anticipate every possible configuration and application, you must verify that your system integrated with our E-Solition battery system is compliant with all local ordinances and regulations.

Transporting Batteries for Installation

- Place the battery terminal protective caps on the battery terminals prior to removing the battery from its current location, to prevent accidental shorts or arcing from occurring if a terminal touches a metal object.
- Battery handle must be in the close position prior to assembly.
- Avoid heavy vibration during transportation.
- Avoid throwing, dropping, rolling and excessive stacking during loading and transportation.
- Make sure that all cables and external connectors are disconnected and properly removed from the battery prior to transporting it.
- Do not hang or hook battery handle with sharp device or at one corner only.

Transporting Batteries to a Different Location

If the battery needs to be shipped to a different location or sent back to Exide for any

reason:

1. Disconnect all cables, both power and communications from the batteries. *(reference section "Disconnecting the Battery" for proper disconnection procedure)*

2. Place the protective caps on the battery terminals prior to removing the battery from its current location, to prevent accidental shorts or arcing from occurring if a terminal touches a metal object.

3. All large lithium-ion batteries are considered "Dangerous Goods" by the US Department of Transportation, and as a result, transporting them by common carrier (whether by ground or by air) requires compliance with UN DOT regulations UN3480, Class 9
- "Dangerous Goods".

4. Pack the batteries in "Dangerous Goods" certified boxes and packaging materials as specified by the Department of Transportation (DOT). The packaging must protect the contents from reasonable handling damage and prevent short circuits from taking place. Ideally, one would use the original box if it's still in good condition.

5. The package should be prepared for shipment and shipping documents should be signed by an individual who is certified to handle and prepare the paperwork and products that have been designated as "Dangerous Goods" for shipment.

IMPORTANT: Each E-Solition battery is shipped in a specially designed box to provide maximum protection for the contents. We strongly recommend that
you save this box and use it whenever you need to transport or ship the battery. Please follow all local laws/regulations regarding the shipment of lithium-Ion batteries.

Following UN and DOT Regulations

Failure to comply with UN and DOT regulations while transporting Class 9 Hazardous Materials (Dangerous Goods) may result in substantial civil and criminal penalties.

Warranty Violations

CAUTION: Performing any of the following actions will immediately void your warranty on the product and could lead to a potentially dangerous situation

1. Breaking the lid and exposing the circuit boards and battery assemblies.
2. Incorrect battery wiring and/or installation. Verify polarity at all connections with a standard voltmeter
3. Operating the battery in an environment where the temperature exceeds the specified limits.
4. Modifying or tampering with the TE M12 connector and communication interface and internal data logging functions.
5. Connecting E-Solition battery in series configuration.
6. Verify polarity at all connections with a standard voltmeter before energizing the system.
7. Pairing the battery with incompatible equipment. Use of accessories not recommended or sold by the manufacturer may result in a risk of fire, electric shock, or injury to persons and will Void the Warranty.
8. Exceeding the maximum continuous discharge rate or charge rate can damage and void the E-Solition battery.

Exide does NOT cover product damage caused by mishandling or improper use per the Installation Manual, Integration Guides and Warranty, exposure to liquids, impacts from falling objects or being dropped, or attempts to repair the battery by any party other than Exide.

The complete list of Warranty Exclusions is included in the Exide Battery Warranty document.

If you believe that in the course of using the E-Solition battery, you will conflict with any of the above listed conditions or any other safety precautions listed in this manual, please
DO NOT proceed any further.

Contact Exide immediately for guidance and information.

Exide batteries are recyclable and should not be disposed of as household or landfill waste. Do not incinerate or dispose of the battery. Return end-of-life or defective batteries to your nearest recycling center as per the appropriate local regulations. For information about recycling, please visit our website at: **www.exide.com**

The EPA classifies spent batteries as “universal wastes” instead of “dangerous goods.” The shipping requirements for universal wastes are available at the EPA website at: **www.epa.gov**

Technical Support

If you have any technical questions regarding the E-Solition battery, please contact our technical support team at:

Phone: +496042810

E-mail: mpservice-germany@exidegroup.com