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Page: 1	Varta Storage GmbH	
Date: 15-06-2022	Project: EasyBlade – Charger Protocol	Rev.: 1.8


**History:**

Rev	Date	History
1.0	12-12-2019	Initial
1.1	04-03-2020	4.1 updated
1.2	23-06-2020	5.2 updated
1.3	06-07-2020	Startup and PDO mapping updated
1.4	04-08-2020	Battery wake-up updated; 3-phase charger input added
1.5	04-09-2020	Fixed some phrasing, updated PDO tables (only designator)
1.6	11-09-2020	Added more details in section 5.1.1 Startup
1.7	26-11-2020	Connector type corrected
1.8	15-06-2022	Implementation steps modified to fit to new FW Version (V02.06.) More details added to start-up sequence

\*Changes between old and new rev are marked in yellow!

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## 1. Introduction

This document describes in detail the CANopen Protocol between the EasyBlade Battery and the charger.

CANopen Protocol is valid for below mentioned VKBs and FW Versions:

EasyBlade 48V	VKB 56654 799 092	FW Version: V02.06.00.00 and greater
EasyBlade 36V	VKB 56654 799 089	FW Version: V02.06.00.00 and greater
EasyBlade 24V	VKB 56654 799 098	FW Version: V01.21.00.00 and greater

## 2. Protocol Specification

### 2.1 Baud Rate

The Baud Rate is by default 250kbit/s but can be changed via SDO in the battery. So please make sure the correct Baud Rate is set before starting the Protocol implementation.

### 2.2 PDO Definition

Below PDOs are mandatory for a proper communication between the EasyBlade Battery and the charger.

#### 2.2.1 TPDO9


The battery sends TPDO9 (COB-ID 0x264) every 100ms.

PDO	COB-ID	Cycle	Data						
			Charge Control	SoC	NA	Charge Voltage Request	Charge Current Request	Battery Status	
TPDO9	0x264	100ms	uint8	uint8	Uint8	uint16 [1/256V]	uint16 [1/16A]	uint8	
Example	Hex	0x01	0x32	NA	0x19	0x1e	0x40	0x02	0x01
	Dec	1	50%		30.097V		36A		1

#### Charge Control:

Charge Control is 0 by default and before start of charging. The battery sets Charge Control to 1 once the SDO Initialization phase has successfully finished. Once Charge Control is set to 1, the battery is ready for charging. The charger shall only set Bit 12 or Bit 13 or both in the Extended charger Status (COB-ID 0x1e4) if Charge Control is 1. Charge control is set to 0 if the battery is fully charged. The charger shall disable the output (relay) if charge control changes to 0.

Please note: Charge Control and Battery Status Bits are set always in parallel, so there is no condition possible where only Charge Control is set or vice versa.

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**SoC:**

Contains the SoC of the Battery.

**Charge Voltage Request:**

Contains the requested charge voltage from the battery. Value depends on what Battery version is connected to the charger. Charge voltage request will not exceed 60V in case of a 48V battery. Once the battery is fully charged the charge voltage request changes to a value which is defined in Object 0x3000.3.

**Charge current Request:**

Contains the requested charge current from the battery. Value depends on what Battery version is connected to the charger. Charge current request is set based on the values in Object 0x3100.2 / 0x3100.3 / 0x3100.4. The request charge current follows a specific cc/cv charging scheme which is optimized for Varta EasyBlade.

**Battery Status:**

Battery Status is 0 by default and before start of charging. The battery sets Battery Status to 1 once the SDO Initialization phase has successfully finished. Once Battery Status is set to 1, the battery is ready for charging. The charger shall only set Bit 12 or Bit 13 or both in the Extended charger Status (COB-ID 0x1e4) if Battery Status is 1. Battery Status is set to 0 either if the heartbeat from the charger disappears for more than 2s or if the battery is fully charged. The charger shall disable the output (relay) if battery status changes to 0.

Please note: Charge Control and Battery Status Bits are set always in parallel, so there is no condition possible where only Charge Control is set or vice versa.

**2.2.2 RPDO1**

The charger shall send a PDO with COB-ID 0x1e4 to the Battery every 200ms.



PDO	COB-ID	Cycle	Data			
RPDO1	0x1e4	200ms	Charging Current	Charging Voltage	Max. available Charging Current	Extended Charger Status
			uint16 [1/256]A	uint16 [1/256]V	uint16 [[1/16]A	uint16

Example	Hex	0x00	0x18	0x19	0x1e	0x80	0x01	0x00	0x10
	Dec	24.000A		30.097V		24A			

**Charging Current:**

Actual charging current measured by the charger.

**Charging Voltage:**

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Actual charging voltage measured by the charger.

**Max. available Charging Current:**

Max. Available Charging Current from the charger.

**Extended Charger Status:**

Contains extended Status Bits from the Charger. The Status Bits are legacy for Delta Q charger. Please refer to the Delta Q charger datasheet (Object 0x4218.1) for a detailed description of the Status Bits.

The battery only checks if Bit 12 (0x1000) or Bit 13 (0x2000) or both Bits (0x3000) are set. Once any of the mentioned Bits are set, the battery immediately changes to charge mode.

Please note: For protocol implementation at new chargers, it is recommended to set only Bit 12.

### 2.3 SDO Definition

Following SDOs are mandatory in the charger for a proper initialization.

Index	Subindex	Name	Type	Access	Unit	Comment
0x2276	0	Voltage Request	uint16	RW	(1/256)V	i.e.: $10752 * (1/256)V = 42V$ (Q8)
0x6000	0	Battery Status	uint8	RW	-	Byte = 0 Battery not ready (no power output of the charger (relais open)), Byte = 1 Battery ready (power output of charger (relais closed))
0x6070	0	Charge current Request	uint16	RW	(1/16)A	i.e.: $160 * (1/16)A = 10A$ (Q4)
0x4208	0	Maximum Charging Voltage	uint16	RW	(1/256)V	Maximum Charging Voltage possible by charger (Q8)
0x4212	0	Maximum Charging Current	uint16	RW	(1/16)A	Maximum Charging current possible by charger (Q4)
0x4200	0	Charge Control	uint8	RW	-	Value = 0x0: battery is not ready, charger output shall be disabled (electronic side) Value = 0x01: battery ready to be charged, charger shall enable electronic output

### 2.4 NMT Role

- Charger needs to be defined as CANOpen Node Id 100<sub>dez</sub>
- The charger needs to be a heartbeat producer with a timer of 1000ms
- Charger needs to be heartbeat consumer for Node ID 1 with a Timeout of 2000ms
- Charger needs to be a self-starting NMT-Slave, means it does not need to be set to operational mode by an NMT master
- If the charger does not receive a Heartbeat from Node ID 1 within 2000ms, charging should be stopped and charger shall open its output relay



## 2.5 Battery status register

### 2.5.1 Battery Charge Control Status Register

The Status of Charging is sends via Master TPDO8 (COB-ID 0x49B). Below is a detailed explanation of the Status Bits.

Battery Charge Control Status Register		
Bit	Description	additional info
15	Charger supply conditions ready	Set if HB is present AND Master_charger_control_charging_ready (Bit14) is set AND Bit12   Bit13   both Bits are set in RPDO1 (COB-ID 0x1e4)
14	Master charger control charging ready	Set if HB is present AND SDO Initialization sequence has finished
13	Charge FET disable temp range cells	Set if battery temperature exceeds the maximum allowed charging temperature
12	Charge Master set charger output off	Set if battery is fully charged and keep power timer has expired
11	charge max charge cell voltage request	Set if requested charge voltage is at maximum
10	charge max charge current request	Set if requested charge current is at maximum
9	reserved	
8	charge current high temp range	Set if battery temperature is within high temp range
7	charge current normal temp range	Set if battery temperature is within normal temp range
6	charge current low temp range	Set if battery temperature is within low temp range
5	charge current keep power	Condition1: Set if HB is present and Bit12 or Bit13 or both Bits are not yet set Condition2: Set if HB is present and battery has reached fully charged state
4	charge current enable	Set if HB is present AND SDO Initialization sequence has finished
3	reserved	
2	reserved	
1	charge voltage keep power	Condition1: Set if HB is present and Bit12 or Bit13 or both Bits are not yet set Condition2: Set if HB is present and battery has reached fully charged state
0	charge voltage enable	Set if HB is present AND SDO Initialization sequence has finished

## 2.5.2 Battery Information Status Register

The FET states as well as the full / empty states can be found in the Battery Information Status Register.

Battery Information Status Register		
Bit	Description	additional info
15	reserved	
14	reserved	
13	reserved	
12	reserved	
11	reserved	
10	reserved	
9	reserved	
8	reserved	
7	reserved	
6	all modules / this module fully charged	Set if individual module or master is fully charged
5	reserved	
4	bypass FET on	Set if bypass FET is on. Only in FW Version V01.21. or greater. Bypass FET is on in the transition from DSG to CHG Mode and vice versa.
3	all modules / this module DSG FET closed	Set if DSG FET is closed
2	all modules / this module CHG FET closed	Set if CHG FET is closed
1	all modules / this module almost empty	Set if individual module or master is almost empty.
0	all modules / this module empty	Set if individual module or master is empty.

### 3. Start-up sequence

Below start-up sequence has to be followed to be able to charge a Varta EasyBlade Battery.

The charger must be configured to Node ID 100<sub>dez.</sub> and must send a heartbeat in intervals of at least 1s. This will be recognized by the BMS and triggers the initialization phase.

Line 156: First heartbeat from charger received.

```

153)      6219.2 Rx          039B 8  18 79 00 00 78 67 00 00
154)      6220.1 Rx          049B 8  08 00 00 00 00 00 00 00
155)      6220.6 Rx          0481 8  08 00 00 00 00 00 91 00
156)      6258.6 Rx          0764 1  05
157)      6293.7 Rx          0664 8  2F 00 60 00 01 00 00 00
-----

```

Battery starts with the SDO initialization sequence directly after receiving the first heartbeat from the charger.

Line 157: Battery sets the Battery Status to 1 in Charger Object 0x6000.0

Line 159: Battery sets the Charge Control to 1 in Charger Object 0x4200.0

Line 161: Battery sets the initial charge voltage request in Charger Object 0x2276.

Line 163: Battery sets the initial charge current request in Charger Object 0x6070.

Line 166: Battery reads the maximum charging voltage from the Charger Object 0x4208.0. The maximum possible charging voltage of the charger shall be sent to the battery.

Please note: There must be a response from the charger within 50ms to each SDO request, otherwise the Battery sends an Abort Code Message.

```

155)      6220.6 Rx          0481 8  08 00 00 00 00 00 91 00
156)      6258.6 Rx          0764 1  05
157)      6293.7 Rx          0664 8  2F 00 60 00 01 00 00 00
158)      6299.0 Rx          05E4 8  60 00 60 00 00 00 00 00
159)      6299.5 Rx          0664 8  2F 00 42 00 01 00 00 00
160)      6309.0 Rx          05E4 8  60 00 42 00 00 00 00 00
161)      6309.6 Rx          0664 8  2B 76 22 00 33 35 00 00
162)      6319.0 Rx          05E4 8  60 76 22 00 00 00 00 00
163)      6319.6 Rx          0664 8  2B 70 60 00 20 00 00 00
164)      6320.1 Rx          0481 8  18 00 00 00 00 00 91 00
165)      6329.0 Rx          05E4 8  60 70 60 00 00 00 00 00
166)      6329.6 Rx          0664 8  40 08 42 00 00 00 00 00
167)      6338.9 Rx          05E4 8  4B 08 42 00 00 39 00 00

```

After a successful SDO initialization, the Battery Charge Control Status Register in Master TPDO8 (COB-ID 0x49B) changes to 0x0033.


```

169)      6420.0 Rx          049B 8  18 00 00 00 00 00 33 00

```

Transmit of TPDO9 (COB-ID 0x264) starts directly after.



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```

173)      6539.2  Rx      0264  8  01 55 00 33 35 20 00 01
174)      6559.0  Rx      01E4  8  21 00 25 36 67 01 50 00

```

Usually charge control and battery status are already 1 in the first transmit of TPDO9.

Charge current request and charge voltage request are initially set to the values which are in Object 0x3100.5 (Charge Standby Current) and Object 0x3000.3 (Charge Standby Voltage). Please refer to the eds file for further information.

After a short delay, the Battery Charge Control Status Register in Master TPDO8 (COB-ID 0x49B) changes to 0x4033.

```

176)      6620.1  Rx      049B  8  14 00 00 00 00 00 33 40
177)      6620.6  Rx      0481  8  14 00 00 00 00 00 91 40

```

As soon as the charger sets Bit 12 or Bit 13 or both Bits in the Extended Charger Status in RPDO 1 (COB-ID 0x1e4), the Battery Charge Control Status Register in Master TPDO8 (COB-ID 0x48B) changes to 0xC011.

In below example Bit 13 is set in RPDO1 (0x2172).

```

624)      16830.2  Rx      049B  8  14 00 00 00 00 00 33 40
625)      16830.7  Rx      0481  8  14 00 00 00 00 00 91 40
626)      16839.3  Rx      0264  8  01 55 00 33 35 20 00 01
627)      16930.2  Rx      0481  8  14 00 00 00 00 00 91 40
628)      16939.2  Rx      0264  8  01 55 00 33 35 20 00 01
629)      16960.5  Rx      01E4  8  00 00 07 38 59 01 72 21
630)      17031.1  Rx      049B  8  14 00 00 00 00 00 11 C0

```

Charge current request and charge voltage request starts to increase right after.

```

634)      17131.2  Rx      0481  8  14 00 00 00 00 00 91 C0
635)      17139.3  Rx      0264  8  01 55 00 33 3C 21 00 01


```

Charge current request increases up to the value which is set in Object 0x3F00.6 or 0x3F00.7 depending in which temperature range the battery is.

Charge voltage request increases up to the value which is set in Object 0x3000.1.

#### 4. End of charge

Once the battery reaches 100% SoC (line 32867), the Battery Charge Control Status Register in TPDO8 (COB-ID 0x49B) changes to 0xC033 which means the battery sets the requested voltage and current to the standby values which are defined in Object 0x3100.5 and 0x3000.3.

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```

32864) 822403.8 Rx 0264 8 01 63 00 33 3C 13 00 01
32865) 822458.9 Rx 01E4 8 75 01 0B 3A 71 01 72 11
32866) 822503.6 Rx 0181 8 A5 E2 00 00 67 06 00 00
32867) 822504.6 Rx 0264 8 01 64 00 33 35 20 00 01
32868) 822505.6 Rx 0481 8 58 00 00 00 00 00 91 C0
32869) 822506.5 Rx 049B 8 58 00 00 00 00 00 33 C0

```

Bit 6 in Battery Information Status Register is set to indicate that the battery is fully charged.

```

32869) 822506.5 Rx 049B 8 58 00 00 00 00 00 33 C0

```

Once the keep power timer has elapsed (300s by default, but can be changed via Object 0x3F00.9), the Charge Control and Battery Status in TPDO9 (COB-ID 0x264) are set to 0.

```

44428) 1111798.8 Rx 0264 8 00 64 00 00 00 00 00 00

```

In addition, the Battery status changes to 0xC000 which means the requested charge current and requested charge voltages changes to 0.

```

44430) 1111800.8 Rx 049B 8 58 00 00 00 00 00 00 C0

```

Further 10s later, the Battery status changes to 0xD000, which means the battery disables the output and enter shutdown.

```


44831) 1121813.0 Rx 049B 8 58 00 00 10 00 00 00 D0

```

Please note: In some end applications it might lead to problems if the battery disables the output once the keep power timer has elapsed. To avoid a shutdown of the battery, Varta recommends to extend the timer. The Timer can be changed by customer via Object 0x3F00.9. Please refer to the EasyBlade manual for further information.

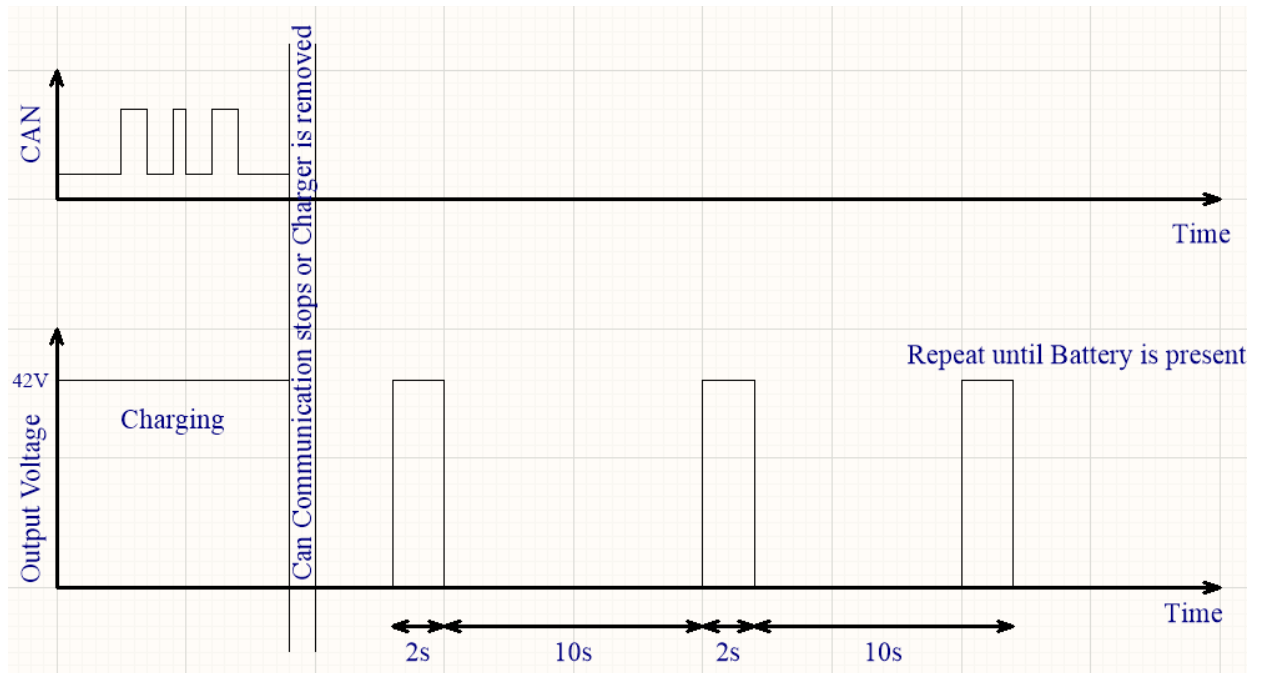
## 5. Error Handling

Battery Error Status Register can be found in Master TPDO8 (COB-ID 0x49B). If any Bit is set in the Battery Error Status Register, the charger shall disabled the output as long as the Error Flag is reset by the battery.

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## 6. Battery Wake-up

It is possible to wake-up the battery via the charger even if the battery is not switched on. The battery wakes up if the charger provides a voltage of greater than 20V for 2s. This cycle shall be repeated every 10s until a communication is established.



Another method to wake-up the battery from sleep mode is to connect pin 2 (battery ON/OFF) of the M12-5 connector to GND (pin 3) or to battery minus. The voltage level on pin 2 is almost the same as the voltage level of the battery pack, e.g. at a fully charged 48V Easy Blade battery, the voltage level is 58.8V. By connecting this pin to GND or battery minus, a current of about 210 $\mu$ A will flow. This current increases with the amount of batteries in a system, but will not exceed about 6mA. For an completely discharged 24V EasyBlade, the current will only be about 37 $\mu$ A.

## 7. Output voltage limitation

If the battery opens the charging FET and interrupts the charging current due to an Error the output voltage of the charger is not allowed to exceed 60V at any case otherwise the BMS in the battery might be damaged.