



Technical specification

Studer BMS Protocol for Xcom-CAN

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1 INTRODUCTION

This technical specification describes the "Studer BMS Protocol" for the Xcom-CAN device used with batteries able to communicate on a CAN bus.

The protocol specifies how a battery/BMS should behave in terms of communication in order to be compatible with a Studer Xtender system installation.

The protocol is selected using the DIP switches inside the Xcom-CAN module. Refer to "Xcom-CAN user manual" available on our website.

1.1 CONVENTIONS USED IN THIS DOCUMENT

Numbers starting with a "0x" prefix are hexadecimal numbers, otherwise, there are decimal numbers.

1.2 LIST OF ACRONYMS

BMS	Battery Management System
MSB	Most Significant Byte
LSB	Least Significant Byte

2 CAN INTERFACE

Hereafter are all specifications regarding frame formats, CAN IDs, endianness and baudrate selection for the "Studer BMS Protocol".

2.1 CAN FRAME FORMAT

The Xcom-CAN "Studer BMS Protocol" uses CAN 2.0A frames (11 bits identifiers), also known as the standard format.

2.2 CAN ID RANGE

As this standard uses CAN 2.0A frames, the CAN identifiers are encoded on 11 bits on the bus. Below are the CAN ID ranges and their respective use.

CAN IDs range	Use
0x000 to 0x1FF	Reserved for "Studer BMS" protocol
0x200 to 0x7FF	Free (can be used for other protocols)

2.3 DATA ENDIANNESSE INSIDE A FRAME

When the data to send inside a frame is larger than 1 byte the encoding is big endian. It means that if a 2 byte value has to be sent, the first byte sent on the network will be the MSB.

Byte 0	Byte 1
16 bits unsigned value MSB	LSB

Byte 0 sent before Byte 1 on the network

As an example, if the 2 byte value to be sent is 0x1234, it will be sent on the network like this: 0x12 then 0x34.

2.4 ADJUSTABLE COMMUNICATION SPEED

The communication speed can be adjusted using the Xcom-CAN's DIP switch configuration. See the Xcom-CAN user manual for more information.

2.5 FRAME LENGTH

Some frames have optional parts or have less than 8 bytes of data. The battery's BMS should send the necessary/implemented bytes only. There is no need to send 8 bytes if 2 of them have no meaning.

2.6 PAUSE IN BETWEEN CAN FRAMES

There is no pause needed in between CAN frames sent by the battery's BMS. The Xcom-CAN is able to handle frames really quickly and it has an internal FIFO to prevent loss of frames.

3 CAN FRAME DEFINITION

This protocol has been designed to be easy to implement. The mandatory part of the communication protocol is unidirectional. It means that the battery's BMS just needs to send some frames on the CAN bus in a periodic or event based way.

Optionally, the battery's BMS can decode a heartbeat frame sent by the Xcom-CAN for monitoring purposes.

3.1 FRAME SENT BY THE BMS AND RECEIVED BY THE XCOM-CAN

Below are the frames that need to be sent from the battery's BMS to the Xcom-CAN. The part in grey is optional, the other is mandatory to be compatible.

Frame	CAN ID	Length	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Notification Frame	0x0A0	8	Status		Warnings		Errors		-	Protocol
Measure Frame 1	0x0B0	8	Battery voltage		Battery current		Battery temperature		State of Charge (SoC)	State of Health (SoH)
Measure Frame 2	0x0B1	4 or 8	Battery nominal capacity		Battery remaining capacity		Max cell temperature		Min cell temperature	
Charging Control Frame	0x0C0	6 or 8	Recommended charging current		Maximum charging current		Recommended charging voltage		End of charge limit voltage	
Discharging Control Frame	0x0C1	6	Recommended discharging Current		Maximum discharging current		End of discharge voltage limit		-	
Manufact. Name Frame	0x0D1	1 to 8	Manufacturer name (ASCII String)							
Battery Name Frame	0x0D2	1 to 8	Battery model name (ASCII String)							

3.2 FRAME SENT BY THE XCOM-CAN AND RECEIVED BY THE BMS

Below is the frame sent by the Xcom-CAN to the battery's BMS.

Frame	CAN ID	Length	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Heartbeat Frame	0x0F0	7	Year		Month	Day	Hours	Minutes	Seconds	-

3.3 NOTIFICATION FRAME

This frame aims to notify the Studer Xtender system about some events within the battery system. These events could be either warnings, errors or status. They are all grouped together as notifications. In addition, the supported protocol is indicated. It has the following format:

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x0A0	Status 16 bits unsigned MSB LSB		Warnings 16 bits unsigned MSB LSB		Errors 16 bits unsigned MSB LSB		-	Protocol
								V R

- Status (mandatory)

This field indicates the status of the battery system. Each bit has a specific meaning.

- Warnings (mandatory)

This field indicates which warnings are currently present on the battery system. Each bit has a specific warning associated with it. A bit set to '1' indicates that the corresponding warning is present, a bit set to '0' indicates that the corresponding warning is absent.

- Errors (mandatory)

This field indicates which errors are currently present on the battery system. Each bit has a specific error associated with it. A bit set to '1' indicates that the corresponding error is present, a bit set to '0' indicates that the corresponding error is absent.

- Protocol (mandatory)

This field indicates the version and the revision of the supported protocol. It is coded on an 8 bits unsigned value. Bits 7 to 4 contain the version. Bits 3 to 0 contain the revision. Typically, the current protocol is 1.0. So this field will be coded 0x10.

As this frame contains critical information, it has to be sent by the battery's BMS as soon as a value changes and at least every second. So if values change quickly, the battery's BMS will send this frame faster than every second. If the values do not change, the battery's BMS will send this frame at least every second with identical values in it.

3.3.1 Warnings vs Errors

The battery's BMS can raise warnings/errors by setting/clearing bits in the notification frame.

Warnings and errors are two different ways for the battery's BMS to indicate problems. Basically, they have the same meaning (you will find the same bits in each field) but the meaning and the behaviour of both the battery's BMS and the Studer Xtender system can be different.

- Warnings

A warning is raised to indicate a problem and to prevent the battery from a disconnection. When the battery's BMS raises a warning, it expects that the Studer Xtender system will react and solve the problem by doing some action (e.g. reducing charging current). A warning should always be raised before an error and a warning should not cause the battery's BMS to disconnect the battery.

- Errors

When a warning is raised and the problem is not solved, an error must be raised before the battery's BMS can disconnect the battery for safety reasons. The error will just indicate what the reason of the disconnection is. Normally, it should never happen since the Studer Xtender system should already have reacted to the warning. Anyway, if an error is raised it means that the corresponding warning was not handled correctly.

For a given problem, the time between a warning and an error should be as long as possible in order to enable the Studer Xtender system to react properly. It cannot be specified here as it depends on the nature of the problem and on how it is treated by the battery's BMS.

3.3.2 List of Warnings & Errors

Below is a list of available warnings and errors and how they are encoded.

Designation	Description	Warning encoding	Error encoding
Battery overvoltage	Indicates that the voltage on the battery is too high. This will stop charging the battery.	Byte 2 bit 0	Byte 4 bit 0
Battery under voltage	Indicates that the voltage on the battery is too low. This will stop discharging the battery.	Byte 2 bit 1	Byte 4 bit 1
Battery charging overcurrent	Indicates that the charging current is too high. This will stop charging the battery.	Byte 2 bit 2	Byte 4 bit 2
Battery discharging overcurrent	Indicates that the discharging current is too high. This will stop discharging the battery.	Byte 2 bit 3	Byte 4 bit 3
Battery charging over temperature	Indicates that the temperature during charging is too high. This will stop charging the battery.	Byte 2 bit 4	Byte 4 bit 4
Battery discharging over temperature	Indicates that the temperature during discharging is too high. This will stop discharging the battery.	Byte 2 bit 5	Byte 4 bit 5
Battery charging under temperature	Indicates that the temperature during charging is too low. This will stop charging the battery.	Byte 2 bit 6	Byte 4 bit 6
Battery discharging under temperature	Indicates that the temperature during discharging is too low. This will stop discharging the battery.	Byte 2 bit 7	Byte 4 bit 7
Reserved	set to 0 by default	Byte 3 bit 0	Byte 5 bit 0
Reserved	set to 0 by default	Byte 3 bit 1	Byte 5 bit 1
Reserved	set to 0 by default	Byte 3 bit 2	Byte 5 bit 2
Reserved	set to 0 by default	Byte 3 bit 3	Byte 5 bit 3
Reserved	set to 0 by default	Byte 3 bit 4	Byte 5 bit 4
Reserved	set to 0 by default	Byte 3 bit 5	Byte 5 bit 5
Reserved	set to 0 by default	Byte 3 bit 6	Byte 5 bit 6
Reserved	set to 0 by default	Byte 3 bit 7	Byte 5 bit 7

3.3.3 Status List

Designation	Description	Status encoding
Charging not allowed	Charging the battery is not allowed. Contactor could be open or could open if charging starts/continues.	Byte 0 bit 0
Discharging not allowed	Discharging the battery is not allowed. Contactor could be open or could open if discharging starts/continues.	Byte 0 bit 1
Charging recommended	The battery's BMS recommends to charge the battery. It is just a recommendation. The Studer Xtender system will do its best to follow it.	Byte 0 bit 2
Discharging recommended	The battery's BMS recommends to discharge the battery. It is just a recommendation. The Studer Xtender system will do its best to follow it.	Byte 0 bit 3
Full charging recommended	The battery's BMS recommends to do a full charge of the battery for internal needs. It is just a recommendation. The Studer Xtender system will do its best to follow it.	Byte 0 bit 4
Reserved	set to 0 by default	Byte 0 bit 5
Reserved	set to 0 by default	Byte 0 bit 6
Reserved	set to 0 by default	Byte 0 bit 7
Battery damaged	Indicates that there is some damage inside the battery. It could be any cell problem or battery problem. This will need a technician intervention in any case. Charging and discharging will be stopped immediately.	Byte 1 bit 0
Contactor problem	Indicates that a contactor has a problem (e.g. cannot switch correctly). An intervention by a technician is needed. Charging and discharging will be stopped immediately.	Byte 1 bit 1
BMS Internal Problem	Indicates that the battery's BMS has a problem. It could be an electronic damage, a loss of calibration, a failed internal test, etc. Charging and discharging will be stopped depending on the status "Charging not allowed" and "Discharging not allowed".	Byte 1 bit 2
Cell imbalance	Indicates that there is an imbalance between the cells. Charging and/or discharging will be stopped depending on "Charging not allowed" and "Discharging not allowed".	Byte 1 bit 3
Short-circuit	Indicates that a short-circuit has been detected by the battery's BMS. Charging and discharging will be stopped immediately.	Byte 1 bit 4
Soon disconnected	Indicates that the battery is going to disconnect soon for any problem/issue that has not been solved automatically. The Xcom-CAN will have the time to perform a few more operations on the installation (basically turning off some devices) prior to battery disconnection.	Byte 1 bit 5
Reserved	set to 0 by default	Byte 1 bit 6
Reserved	set to 0 by default	Byte 1 bit 7

3.4 MEASURE FRAME 1

This frame aims to inform the Studer Xtender system about the battery's most important physical measures. This information will be used in order to pilot the Studer Xtender system (Xtender, VarioTrack and VarioString). It has the following format:

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x0B0	Battery voltage 16 bits unsigned Unit: 0.1V MSB LSB		Battery current 16 bits signed Unit: 0.1A MSB LSB		Battery temperature 16 bits signed Unit: 0.1°C MSB LSB		State of Charge 8 bits unsigned Unit: 1%	State of Health 8 bits unsigned Unit: 1%

- Battery voltage (mandatory)

This field indicates the measured voltage of the battery system. It is coded on a 16 bits unsigned value. The unit is 0.1V. A value of 1 in this field represents 0.1V.

- Battery current (mandatory)

This field indicates the measured current of the battery system. The value is positive when charging the battery. The value is negative when discharging the battery. It is coded on a 16 bits signed value. The unit is 0.1A. A value of 1 in this field represents 0.1A.

- Battery temperature (mandatory)

This field indicates the measured temperature of the battery system. It is coded on a 16 bits signed value. The unit is 0.1°C. A value of 1 in this field represents 0.1°C.

- State of Charge (mandatory)

This field indicates the processed state of charge of the battery system. It is coded on an 8 bits unsigned value. The unit is 1%. A value of 1 in this field represents 1%.

- State of Health (mandatory)

This field indicates the processed state of health of the battery system. It is coded on an 8 bits unsigned value. The unit is 1%. A value of 1 in this field represents 1%.

This frame has to be sent by the battery's BMS at least every second. It can be sent more often if the battery's BMS manufacturer believes it is relevant to do it.

3.5 MEASURE FRAME 2

This frame aims to inform the Studer Xtender system about the battery's "less important" physical measures. This information will not be used to pilot the Studer Xtender system and is only for information. It has the following format:

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x0B1	Battery nominal capacity 16 bits unsigned Unit: 1Ah MSB LSB		Battery remaining capacity 16 bits unsigned Unit: 1Ah MSB LSB		Max Cell temperature 16 bits signed Unit: 0.1°C MSB LSB		Min Cell temperature 16 bits signed Unit: 0.1°C MSB LSB	

- Nominal battery capacity (mandatory)

This field indicates the nominal capacity of the battery system. It corresponds to the amount of capacity the battery system has by design, so this value will not change with time. The battery's BMS would have to compute it if the battery system is composed of several battery units put in parallel or in series. It is coded on a 16 bits unsigned value. The unit is 1Ah. A value of 1 in this field represents 1Ah.

- Remaining battery capacity (mandatory)

This field indicates the remaining capacity of the battery system. This value changes dynamically. The battery's BMS should process it depending on the SOC and on the SOH. It is coded on a 16 bits unsigned value. The unit is 1Ah. A value of 1 in this field represents 1Ah.

- Max Cell temperature (optional)

This field indicates the maximum cell temperature of the battery system. It is coded on a 16 bits signed value. The unit is 0.1°C. A value of 1 in this field represents 0.1°C.

- Min Cell temperature (optional)

This field indicates the minimum cell temperature of the battery system. It is coded on a 16 bits signed value. The unit is 0.1°C. A value of 1 in this field represents 0.1°C.

As this frame does not contain any critical information, it has to be sent by the battery's BMS at least every 5 seconds. It can be sent more often if the battery's BMS manufacturer believes it is relevant to do it.

3.6 CHARGE CONTROL FRAME

This frame aims to inform the Studer Xtender system about the battery system charging limits and set points. This information will be used in order to pilot the Studer Xtender system (Xtender, VarioTrack, VarioString).

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x0C0	Recommended charging current 16 bits unsigned Unit: 0.1A		Maximum charging current 16 bits unsigned Unit: 0.1A		Recommended charging voltage 16 bits unsigned Unit: 0.1V		End of charge limit voltage 16 bits unsigned Unit: 0.1V	
	MSB	LSB	MSB	LSB	MSB	LSB	MSB	LSB

- Recommended charging current (mandatory)

This field indicates the recommended current required by the battery system when charging. The Studer Xtender system considers it as a target current and will try to follow it. It can change dynamically as the battery's BMS will adapt it depending on the battery's charging characteristics. It is coded on a 16 bits unsigned value. The unit is 0.1A. A value of 1 in this field represents 0.1A.

- Maximum charging current (mandatory)

This field indicates the maximum current allowed by the battery system when charging. The Studer Xtender system considers it as a limit, not as a target. This value should be higher than the "recommended charging current" and should not be exceeded. If exceeded, the battery's BMS should raise a warning. It is coded on a 16 bits unsigned value. The unit is 0.1A. A value of 1 in this field represents 0.1A.

- Recommended charging voltage (mandatory)

This field indicates the recommended voltage required by the battery system when charging. The Studer Xtender system considers it as a target voltage and will try to follow it. It can change dynamically as the battery's BMS will adapt it depending on the battery charging characteristics. It is coded on a 16 bits unsigned value. The unit is 0.1V. A value of 1 in this field represents 0.1V.

- End of charge limit voltage (optional)

This field indicates the limit voltage of the battery system when charging. The Studer Xtender system considers it as a limit, not as a target. This value should be higher than the "target charging voltage" and should not be exceeded. If exceeded, the battery's BMS should raise a warning. It is coded on a 16 bits unsigned value. The unit is 0.1V. A value of 1 in this field represents 0.1V.

Recommended charging current vs maximum charging current

The recommended charging current could be, depending on the battery's manufacturer, lower than the maximum charging current. For instance, a battery can have a recommended charging current of 1C and a maximum charging current of 3C. It means that it supports 3C, but 1C will be better for the battery lifetime.

This frame has to be sent at least every second by the battery's BMS. It can be sent more often if the battery's BMS manufacturer believes it is relevant to do it.

3.7 DISCHARGE CONTROL FRAME

This frame aims to inform the Studer Xtender system about the battery system discharging limits and set points. This information will be used in order to pilot the Studer Xtender system (Xtender, VarioTrack, and VarioString).

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x0C1	Recommended discharging current 16 bits unsigned Unit: 0.1A MSB LSB		Maximum discharging current 16 bits unsigned Unit: 0.1A MSB LSB		End of discharge voltage limit 16 bits unsigned Unit: 0.1V MSB LSB		-	

- Recommended discharging current (mandatory)

This field indicates the recommended current when discharging the battery system. The Studer Xtender system considers it as a target current and will try to follow it. It can change dynamically as the battery's BMS will adapt it depending on the battery discharging

characteristics. It is coded on a 16 bits unsigned value. The unit is 0.1A. A value of 1 in this field represents 0.1A.

- Maximum discharging current (mandatory)

This field indicates the maximum current allowed by the battery system when discharging. The Studer Xtender system considers it as a limit, not as a target. This value should be higher than the "recommended discharging current" and should not be exceeded. If exceeded, the battery's BMS should raise a warning. It is coded on a 16 bits unsigned value. The unit is 0.1A. A value of 1 in this field represents 0.1A.

- End of discharge voltage limit (mandatory)

This field indicates the limit voltage of the battery system when discharging. It is not an absolute limit value. This means that the battery should still have a bit of energy when reaching this limit, but the Xtender system should not discharge the battery anymore. If this limit is reached, the battery's BMS should raise a warning. It is coded on a 16 bits unsigned value. The unit is 0.1V. A value of 1 in this field represents 0.1V.

Recommended discharging current vs maximum discharging current

The recommended discharging current could be, depending on the battery's manufacturer, lower than the maxim discharging current. For instance, a battery can have a recommended discharging current of 1C and a maximum discharging current of 3C. It means that it supports 3C, but 1C will be better for the battery lifetime.

This frame has to be sent at least every second by the battery's BMS. It can be sent more often if the battery's BMS manufacturer believes it is relevant to do it.

3.8 MANUFACTURER NAME FRAME

This frame specifies an ASCII name for the manufacturer of the battery system. If sent by the battery's BMS, it will be displayed on the RCC. It has the following format:

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x0D1	Manufacturer Name (ASCII String)							

- Manufacturer Name

The name (or short name) of the battery's manufacturer encoded in ASCII on 8 bytes. Note that as it is strict ASCII, and not Extended ASCII, there will be no accent on the letters.

This frame is optional. If sent by the battery's BMS, it has to be sent at least every 10 seconds.

3.9 BATTERY MODEL NAME FRAME

This frame specifies an ASCII name for the battery model. If sent by the battery's BMS, it will be displayed on the RCC. It has the following format:

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x0D2	Battery model name (ASCII String)							

- Battery model name

The name (or short name) of the battery model encoded in ASCII on 8 bytes. Note that as it is strict ASCII, and not Extended ASCII, there will be no accent on the letters.

This frame is optional. If sent by the battery's BMS, it has to be sent at least every 10 seconds.

3.10 HEARTBEAT FRAME

This frame is sent by the Xcom-CAN to the battery's BMS in order to indicate that the Studer Xtender system is running. The battery's BMS can use this frame in order to do some monitoring. Optionally, the battery's BMS can use the content of this frame if needed. Date and time of the Studer Xtender system are transmitted within this frame. It has the following format:

CAN ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0x0F0	Year 16 bits unsigned MSB LSB		Month 8 bits unsigned	Day 8 bits unsigned	Hours 8 bits unsigned	Minutes 8 bits unsigned	Seconds 8 bits unsigned	-

- Year

This field indicates the year of the Studer Xtender system internal date and time. It is directly encoded in a 16 bits unsigned value. A value of 2016 in this field represents 2016.

- Month

This field indicates the month of the Studer Xtender system internal date and time. It is directly encoded on an 8 bits unsigned value. It can have a value from 1 to 12. A value of 12 in this field represents December.

- Day

This field indicates the day of the Studer Xtender system's internal date and time. It is directly encoded on an 8 bits unsigned value. It can have a value from 1 to 31.

- Hours

This field indicates the hours of the Studer Xtender system's internal date and time. It is directly encoded on an 8 bits unsigned value. It can have a value from 0 to 23.

- Minutes

This field indicates the minutes of the Studer Xtender system's internal date and time. It is directly encoded on an 8 bits unsigned value. It can have a value from 0 to 59.

- Seconds

This field indicates the seconds of the Studer Xtender system's internal date and time. It is directly encoded on an 8 bits unsigned value. It can have a value from 0 to 59.