

# CANbus: TAO EMS connection with Victron products

The CAN (Controller Area Network) bus is a message-based protocol designed to allow electronic equipment found in automobiles and many other applications to communicate with each other in a reliable manner. The TAO EMS Monitor can send CAN messages in accordance with a number of standard protocols. Additional messages can be defined by the user to meet the requirements of proprietary protocols.



The Victron GX-device is the communication hub for all your Victron equipment such as inverter/chargers, solar chargers, battery monitor... The Victron products in your installation are connected to the GX-device and communicate using a Victron proprietary communication protocol.

The GX-device is the gateway to the outside world using the CAN protocol. So all communication from the EMS to the Victron network must go through the GX-device.

This document describes the procedure to connect and configure the TAO EMS Monitor so that it can send information and commands to the Victron GX-device using CANbus.

**Disclaimer:** The following information is provided as a guide to integrate the TAO EMS with Victron equipment using the CAN protocol. While the information here is believed to be correct at the time it is written, it is the user's responsibility to verify all aspects of the end application and the suitability of the following. TAO Performance limited has no affiliation with Victron and provides this information for informational purposes only and is not responsible for changes in specifications made by Victron. Consult the Victron user manuals for more details or contact your Victron installer..

The Victron GX-device uses the CAN SMA protocol to receive information and instructions from third party equipment. It can understand the following standard CAN SMA messages than are already setup in the EMS:

Message ID	Description
351	Maximum charge current, Maximum charge voltage, Maximum discharge current, Minimum discharge voltage
355	Battery state of charge and state of health
356	Battery voltage, current and temperature
35A	Error flags sent by the EMS
370	Name of the EMS

The Victron GX-device can be programmed to use that information (see the Victron manual for more details).

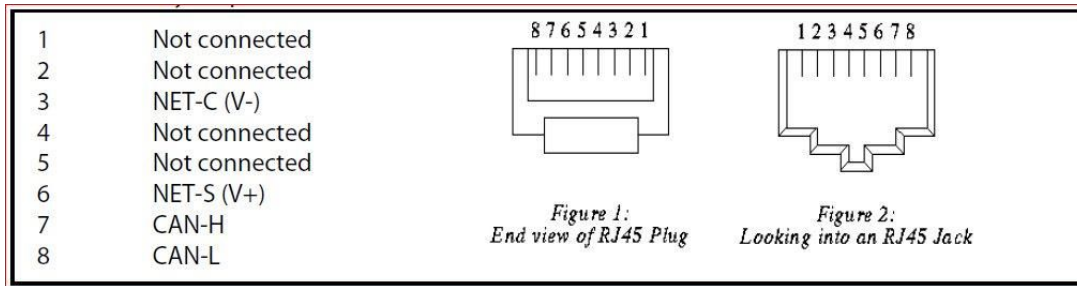
## CANbus connection:

A cable must be connected between the EMS Monitor and the GX-device. There are a number of different connectors that are used with CANbus, so instead of using a specific connector and having to buy special cables, TAO Performance has made the choice to use simple wire terminal for the CANbus connection.

Victron uses RJ45 connectors for the CANbus cable. The easiest is to get a standard Ethernet cable (with one RJ45 connector at each end) and cut-off one connector to expose the wires inside the cable.

Connect the RJ45 connector to one of the VE.Can connectors on the GX-device.

Victron CANbus connector specification:



Only the CAN-H and CAN-L wires need to be connected to the Monitor so you need to identify them. If the RJ45 plug is transparent you might be able to see the color of the wires. If that is not possible, use a multi-meter to check which wires are connected to pins 7 and 8. Label the wires as CAN-H and CAN-L.

Connect the wire CAN-L to the CANbus "L" terminal, and the wire CAN-H to the "H" terminal.

Use cable stress relief techniques to secure the CANbus cable close to the Monitor and close to the GX-device.

## CANbus network termination:

A CAN bus termination (of 120 Ohm resistance) must be present at the two physical end points of the CAN network. The CAN network has to be connected from one device to the other with a bus termination for each of the two end points.

For a simple installation with only the EMS Monitor and the GX-device, a termination must be installed at both devices.

**Victron GX-device:** insert a Victron "VE.Can RJ45 terminator" in the second VE.Can connector.

**EMS Monitor:** insert the jumper on the right side of the CANbus terminal connector.

**Important:** More complex CAN networks must be designed by a professional with CANbus experience. Most CANbus problems come from improper network design or terminations.



# Configuration of TAO EMS:

In order to configure the CANbus functionalities of the EMS, the TAO Monitor must be connected to a WiFi network (either an existing network or an Access Point created by the Monitor itself). Connect to the TAO Monitor using a browser on a computer, phone or tablet to is on the same WiFi network as the EMS Monitor. Find connection details in the TAO Monitor user manual.

Once your browser is connected to the Monitor, select the following options in the Configuration menu:

## 1. CAN parameters

Set the options per the screenshot and click on the "Save" button

CAN parameters

General

**Enable CAN messages:**  Yes  No

**CAN bus bit rate (kb/s):**  125 Kb/s  250 Kb/s  500 Kb/s  1 Mb/s

**Preferred address (decimal):**  0x82

**Battery instance:**  (1 - 10)

**BMS instance:**  (0 for single BMS or for master BMS)

**Mini time between messages:**  ms

## 2. CAN messages

All the required messages to communicate with the Victron GX-device are already created and you just need to enable them.


In the selection box under the "Group" header, select "SMA Victron" to only display the relevant messages:

CAN messages backup restore save

Group	Send	Ext.	ID / PGN (hex)	Description	Bytes	Freq. (ms)	Action
SMA Victron	✓	✗	351	charge & discharge limits	8	950	✎ + 🗑
SMA Victron	✓	✗	355	soc & soh	6	950	✎ + 🗑
SMA Victron	✓	✗	356	voltage, current & temperature	6	950	✎ + 🗑
SMA Victron	✓	✗	35A	alarms & warnings	8	950	✎ + 🗑
SMA Victron	✓	✗	370	BMS name	7	10000	✎ + 🗑

For each message, click the icon in the "Send" column until it is a check mark ( ) to enable it. Your screen should look like the above screenshot. If it does not, check the Monitor user manual to learn how to restore the factory defaults.





**That is all you need to do for a standard installation.**

If you change the factory default triggers or if the Victron specification changes, you may need to edit some CAN message definition. Do so by clicking on the corresponding  icon. After editing a message, click the "Save" button.

For reference, here are the message definition screens for each of the "SMA Victron" default messages:




Edit CAN message: 351 charge & discharge limits x

Number of data bytes:

#	bytes	endian	type	value	signed	mult.	div.	add
1	2	small	field	max charge voltage	no	1	10	
2	0							
3	2	small	field	max charge current	no	10	1	
4	0							
5	2	small	field	max discharge current	no	10	1	
6	0							
7	2	small	field	min discharge voltage	no	1	10	
8	0							




Edit CAN message: 355 soc & soh x

Number of data bytes:

#	bytes	endian	type	value	signed	mult.	div.	add
1	2	small	field	SOC	no	1	100	
2	0							
3	2	small	field	SOH	no	1	100	
4	0							
5	2	small	field	SOC	no	1	1	
6	0							

Edit CAN message: 356 voltage, current & temperature x

Number of data bytes:

#	bytes	endian	type	value	signed	mult.	div.	add
1	2	small	field	voltage	no	1	1	
2	0							
3	2	small	field	current	yes	1	10	
4	0							
5	2	small	field	temperature.	no	1	1	
6	0							

**Important note:** the message ID **0x35A** is expected by the Victron GX-device. We could not find any information on how the Victron GX-device uses the information received in that message. We have set it up using information from different sources. **In the factory CAN message definition, the alarm and warning bits are set based on the state of the EMS triggers as defined for the factory default EMS triggers. If the triggers are modified, you must modify the definition of this CAN message accordingly**

Definition for each byte and bits in the CAN message ID

0x35A: Bytes 1 to 4 are for alarms:

**SMA Message definition**

**Message ID 0x35A**

Byte	bit	Type	Description	Default
1	0	Alarm	General alarm ON	0
1	1	Alarm	General alarm OFF	0
1	2	Alarm	Battery High Voltage alarm ON	0
1	3	Alarm	Battery High Voltage alarm OFF	0
1	4	Alarm	Battery Low Voltage alarm ON	0
1	5	Alarm	Battery Low Voltage alarm OFF	0
1	6	Alarm	Battery High Temp alarm ON	0
1	7	Alarm	Battery High Temp alarm OFF	0
2	0	Alarm	Battery Low Temp alarm ON	0
2	1	Alarm	Battery Low Temp alarm OFF	0
2	2	Alarm	Battery High Temp Charge ON	0
2	3	Alarm	Battery High Temp Charge OFF	0
2	4	Alarm	Battery Low Temp Charge ON	0
2	5	Alarm	Battery Low Temp Charge OFF	0
2	6	Alarm	Battery High Current ON	0
2	7	Alarm	Battery High Current OFF	0
3	0	Alarm	Battery High Charge Current ON	0
3	1	Alarm	Battery High Charge Current OFF	0
3	2	Alarm	Contactora ON	0
3	3	Alarm	Contactora OFF	0
3	4	Alarm	Short Circuit alarm ON	0
3	5	Alarm	Short Circuit alarm OFF	0
3	6	Alarm	EMS Internal Error ON	0
3	7	Alarm	EMS Internal Error OFF	0
4	0	Alarm	Cell Imbalance ON	0
4	1	Alarm	Cell Imbalance OFF	0
4	2	Alarm	Reserved	0
4	3	Alarm	Reserved	0
4	4	Alarm	Reserved	0
4	5	Alarm	Reserved	0
4	6	Alarm	Reserved	0
4	7	Alarm	Reserved	0

Bytes 5 to 8 are for warnings:

**SMA Message definition**

**Message ID 0x35A**

Byte	bit	Type	Description	Default
5	0	Warning	General ON	0
5	1	Warning	General OFF	0
5	2	Warning	Battery High Voltage ON	0
5	3	Warning	Battery High Voltage OFF	0
5	4	Warning	Battery Low Voltage ON	0
5	5	Warning	Battery Low Voltage OFF	0
5	6	Warning	Battery High Temp ON	0
5	7	Warning	Battery High Temp OFF	0
6	0	Warning	Battery Low Temp ON	0
6	1	Warning	Battery Low Temp OFF	0
6	2	Warning	Battery High Temp Charge ON	0
6	3	Warning	Battery High Temp Charge OFF	0
6	4	Warning	Battery Low Temp Charge ON	0
6	5	Warning	Battery Low Temp Charge OFF	0
6	6	Warning	Battery High Current ON	0
6	7	Warning	Battery High Current OFF	0
7	0	Warning	Battery High Charge Current ON	0
7	1	Warning	Battery High Charge Current OFF	0
7	2	Warning	Contactor ON	0
7	3	Warning	Contactor OFF	0
7	4	Warning	Short Circuit ON	0
7	5	Warning	Short Circuit OFF	0
7	6	Warning	EMS Internal Error ON	0
7	7	Warning	EMS Internal Error OFF	0
8	0	Warning	Cell Imbalance ON	0
8	1	Warning	Cell Imbalance OFF	0
8	2	Warning	Reserved	0
8	3	Warning	Reserved	0
8	4	Warning	Reserved	0
8	5	Warning	Reserved	0
8	6	Warning	Reserved	0
8	7	Warning	Reserved	0

The CAN message ID 0x35A must have each of its 8 bytes defined as "bits":

Edit CAN message: 35A alarms & warnings

Number of data bytes:

#	bytes	endian	type	value	signed	mult.	div.	add
1	1		bits	0				
2	1		bits	0				
3	1		bits	0				
4	1		bits	0				
5	1		bits	0				
6	1		bits	0				
7	1		bits	0				
8	0							

To modify the definition of a byte click on the corresponding icon and you can define individual bit:

Edit data byte: 1 of message: 35A alarms & warnings

Data type:

bit	type	value
0	constant	0
1	constant	0
2	trigger ON	1
3	trigger OFF	1
4	trigger ON	4
5	trigger OFF	4
6	trigger ON	6
7	trigger OFF	6

Click on a bit type or value to make a change. These are the different bit types that can be used with the corresponding meaning for the "value" field:

bit Type	Meaning of "Value" field
constant	can be 0 or 1
trigger ON	trigger number (1-20) - set to "1" when the trigger is activated
trigger OFF	trigger number (1_20) - set to "1" when the trigger is not activated
output ON	output number (1-6) - set to "1" when the output is activated
output OFF	output number (1-6) - set to "1" when the output is not activated
EMS ON	n/a - set to "1" when the EMS is switched ON
EMS OFF	n/a - set to "1" when the EMS is switched OFF

The bits are set to "0" except in the conditions listed above

### 3. CAN charge / discharge limits

This configuration screen allows to define the values that are sent as part of the CAN message 0x351 (charge & discharge limits).

**You must define each value in this table based on your system's capabilities and the desired limits to manage your installation.**

The first line (Trigger 0) is the default setting when no trigger is active. Then for each trigger you can define the limits sent in the CAN message.

In the example below:

- the default maximum charge current is 120A and maximum charge voltage is 13.85V
- the default maximum discharge current is 150A and the minimum discharge voltage is 12.00V
- the charge current is reduced to 2A if a cell voltage reaches 3.55 V (trigger #5)
- the charge current is reduced to 50A if there is a cell differential voltage above 100 mV (trigger #9)

CAN bus current and voltage limits

save

Trigger	Description	Current (A)		Voltage (V)	
		Charge	Discharge	Max	Min
0	defaults - no trigger	120	150	13.85	12.00
1	cell voltage > 3.650 V	0	150	0.00	12.00
5	cell voltage > 3.550 V	2	150	13.85	12.00
6	cell voltage < 2.950 V	120	0	13.85	12.00
2	cell voltage < 2.850 V	120	0	13.85	12.00
9	cell voltage differential > 0.100 V	50	50	13.85	12.00
3	cell temperature > 45 °C	35	35	13.85	12.00
7	cell temperature > 40 °C	50	50	13.85	12.00
8	cell temperature < 5 °C	25	80	13.85	12.00
4	cell temperature < 0 °C	0	80	0.00	12.00
10	cell temperature differential > 4 °C	50	50	13.85	12.00
11	not defined	0	0	0.00	0.00
12	not defined	0	0	0.00	0.00
13	not defined	0	0	0.00	0.00
14	not defined	0	0	0.00	0.00
15	not defined	0	0	0.00	0.00
16	not defined	0	0	0.00	0.00
17	not defined	0	0	0.00	0.00
18	not defined	0	0	0.00	0.00
19	not defined	0	0	0.00	0.00
20	not defined	0	0	0.00	0.00

Click on a value to change it  
Click "Save" before leaving this screen

**Important note:** These instructions are sent by the EMS and do not directly impact charge and discharge conditions. Your Victron equipment must be configured to properly use that information. These settings have no impact on equipment not connected to the GX-device or any other equipment not connected to the CANbus.

**Very important note:** You must always plan for a backup in case the CAN network is down, or the Victron GX-device is not properly programmed. The backup can be a combination of actions that are driven by the EMS outputs:

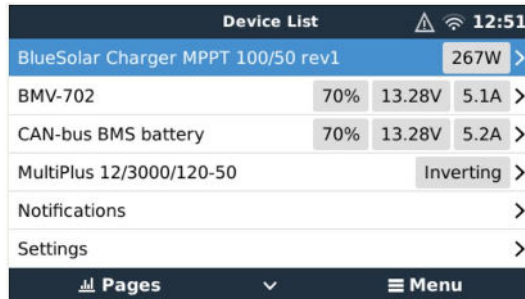
- contactors that open the charge and/or load bus(es)
- contactor to disconnect the lithium battery
- direct remote switch ON and OFF of equipment that have that functionality
- relay between solar panel and solar regulator
- relay on the field or ignition wire of alternators
- relay to disconnect shore power
- ....



# Configuration of the Victron GX-device:

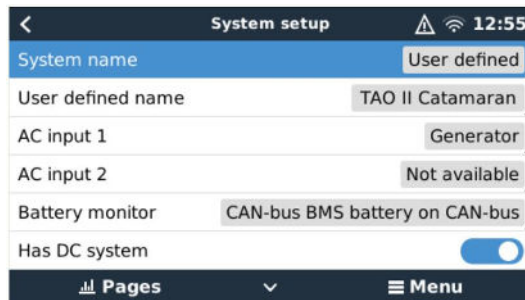
You must enable the GX-device to support a CANbus enabled EMS.

After the GX-device is connected to the CAN network (using the VE.Can port), use the Victron configuration application. Refer to Victron documentation on how to install and use that application).



## 1. System setup:

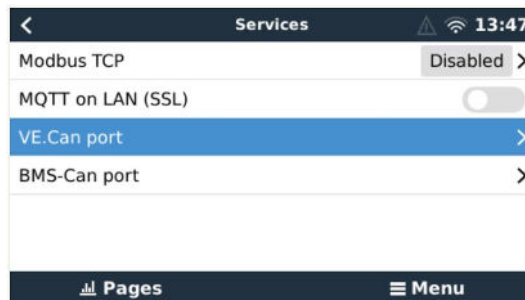
Select menu options "Settings" then "System setup":



- For the "Battery Monitor" select "CAN-bus EMS battery on CAN-bus"

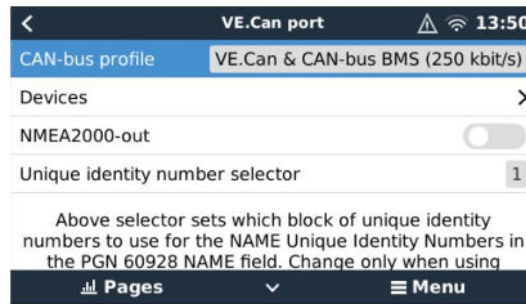
## 2. CAN-bus setup

Select menu options "Settings" then "Services":



- EMS-Can port should be disabled

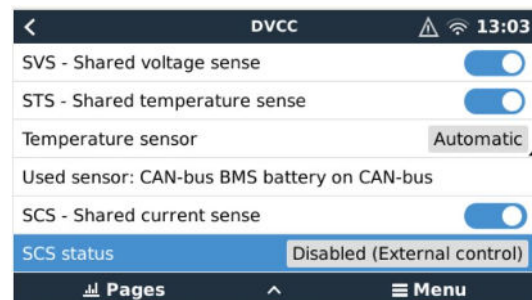
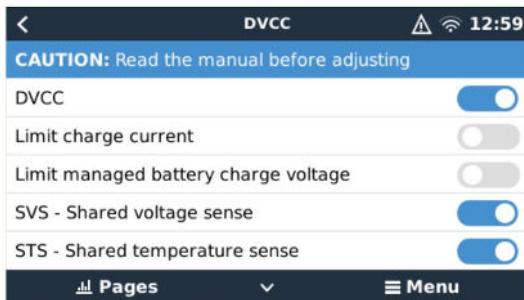
- VE.Can port should be set to "VE.Can & CAN-bus EMS" - the speed must match the speed you selected on the EMS CAN configuration screen (250 kbits/s in the example)



### 3. DVCC

This setup is to tell the GX-device to use the data (voltage, temperature, current) from the EMS as the reference data for all the Victron connected equipment. Read the Victron before adjusting so that you understand the implications.

Select menu options "Settings" then "DVCC":



- DVCC, SVS and STS must be ON, and "Limit charge current" must be OFF. Other settings depend on your installation.
- "Used sensor" should show "CAN-bus EMS battery on CAN-bus"

On the main 'Device list' screen of the GX-device you should now see a line with "CAN-bus EMS battery". That is the TAO EMS. The data on that line is updated as it is received from the EMS.

### Validate the configuration:

Run EMS simulations to activate each trigger you have defined and validate that the outcome is the expected behavior.