USER MANUAL UMAX090690
Version V1.3

Dual 12V Li-ion BATTERY CHARGER

With SAEJ1939

USER MANUAL
P/N: AX090690

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ACCRONYMS

ACK	Positive Acknowledgement	(from SAE J1939 standard)
CAN	Controller Area Network	
DM	Diagnostic Message	(from SAE J1939 standard)
DTC	Diagnostic Trouble Code	
EA	Axiomatic Electronic Assistant (A Service Tool for Axiomatic ECUs)	
ECU	Electronic Control Unit	(from SAE J1939 standard)
FMI	Failure Mode Identifier	
NAK	Negative Acknowledgement	(from SAE J1939 standard)
PDU1	A format for messages that are to be sent to a destination address, either specific or global	(from SAE J1939 standard)
PDU2	A format used to send information that has been labeled using the Group Extension technique and does not contain a destination address.	
PGN	Parameter Group Number	(from SAE J1939 standard)
PropA	Message that uses the Proprietary A PGN for peer-to-peer communication	
PropB	Message that uses a Proprietary B PGN for broadcast communication	
PWM	Pulse Width Modulation	
OC	Occurrence Count	
SPN	Suspect Parameter Number	(from SAE J1939 standard)
VPS	Voltage Power Supply	

Note:

An Axiomatic Electronic Assistant KIT may be ordered as P/N: AX070502, or AX070506K

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1. INTRODUCTION

The battery charger is designed to autonomously charge dual sided batteries. The AX090690 model can charge dual 12V batteries with a maximum charging current of 1.25A

Once programmed, the charger does not require any operator's involvement in the charging process; the charger automatically recognizes the presence of the battery, charges the battery to the maximum capacity, and automatically maintains the battery charge if the charger is connected to the power line. The charger will continue to charge the battery even if disconnected from the J1939 CAN network.

When the charger is disconnected from the power line it automatically switches off, protecting the batteries from discharge.

There are three main charge modes – Precharge Mode, Bulk Charge Mode, and Constant Voltage Charge Mode – along with Float Mode for maintaining charge. Temperature sensing using an auxiliary temperature sensor or through the J1939 network protects batteries from overheating, shutting down the charging process if the battery temperature exceeds a certain level.

An internal red-green LED indicator on the front panel of the charger is used to monitor the internal state of the charger. The charger states and corresponding LED indications are described in Table 1.

LED State	Description
Red/Green (Flashing)	Idle.
Green (Flashing)	At least one charger is in the precharge, bulk charge, or constant voltage stage.
Green (Solid)	Both Chargers have completed charging and are in the Charge Termination (Float) stage.
Red (Solid)	At least one charger has experienced a fault.

Table 1 - Charger LED State Values

Note that the LED indication prioritizes Fault state above all else, followed by active charging. This means that for example, if Charger 1 is finished charging, but Charger 2 is still charging its battery, the LED will stay blinking green until both are finished.

If connected to the J1939 CAN network, the charger continuously transmits its internal state, charging current and the battery voltage. It can also use the J1939 network to acquire the battery temperature and to perform any user specific functions on demand. The battery charger also supports J1939 regular node functions, including address claiming, PGN responses, etc.

The RS232 interface of the charger allows the user to change the battery type, program battery charger setpoints, flash the new software, and watch an internal state of the charger using one of the standard terminal emulation software (Tera Term, Hyperterminal, etc.).

2. BATTERY CHARGER THEORY OF OPERATION

The battery charger implements a three-stage charging algorithm with an additional charge stage for maintenance.

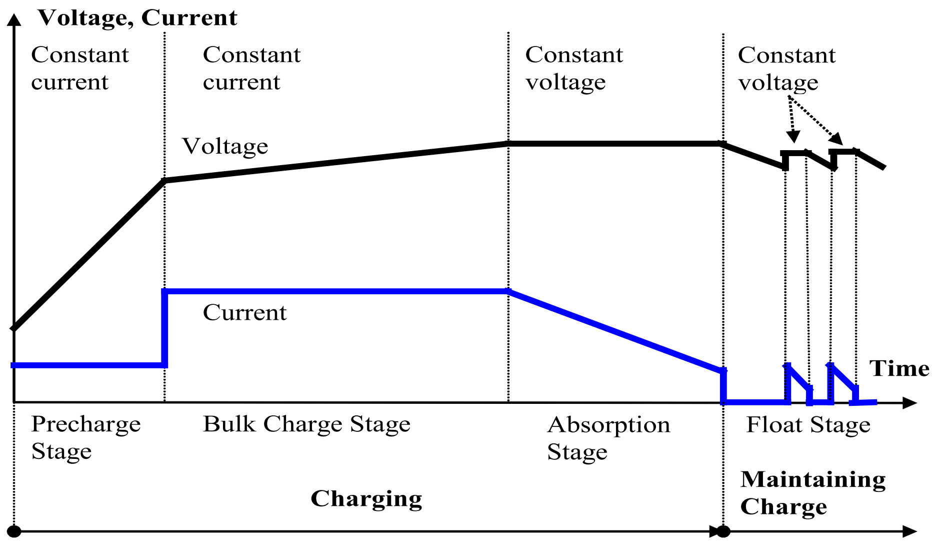


Figure 1. Battery Charger Algorithm Profile

The charging process starts from the Precharge Stage, then, when the battery voltage reaches a certain point, the charger switches to the Bulk Charge Stage, and the charging process is finalized in the Absorption (Constant Voltage Charge) Stage.

After the battery is fully charged, the charger maintains the battery charge in Float Mode.

2.1. Battery Charger Modes

Each stage of the charging process corresponds to one or two battery charger modes. There are also modes reflecting an idle or an error condition of the charger and a special power supply mode used for testing.

The charger starts functioning from Idle Mode. It stays in Idle Mode until the Charger is enabled, and a battery is connected to the charger.

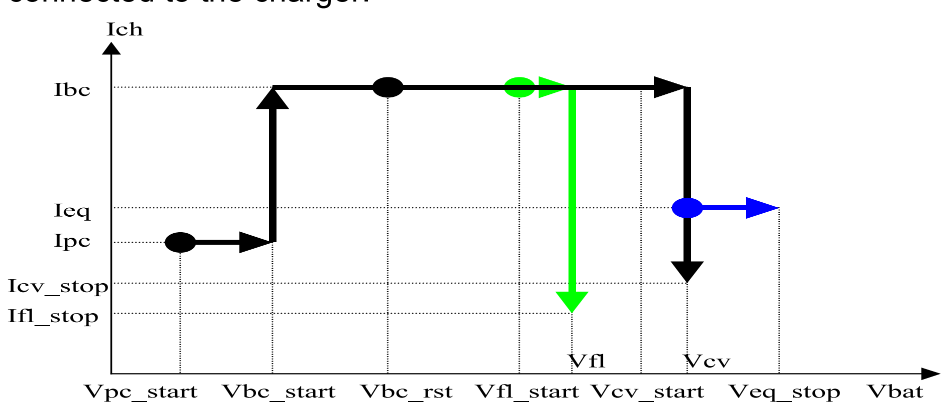


Figure 2. *Voltage-Current Charging Profile*

When the charger recognizes the battery, it starts analyzing the battery state. If the battery is deeply discharged and its voltage is between Vpc_start and Vbc_start (See section 2.2), the charger will start the precharging process, charging the battery with a relatively small constant current Ipc. The small current prevents a deeply discharged battery from damage, which otherwise could occur due to gas emission from the battery electrolyte at high current. The charger will stay in the **Precharge Mode** until the battery voltage reaches the Vbc_start voltage.

When the battery reaches Vbc_start voltage, the charger will enter the **Bulk Charge Mode** increasing the charging current to Ibc. It will charge the battery with the Ibc current until the battery voltage reaches Vcv_start. At this point the battery is around 75% charged and the charger can go to the **Constant Voltage Charge Mode** limiting the charging voltage to Vcv. This will cause a gradual drop of the charging current. When the charging current drops to Icv_stop, the battery is considered fully charged, and the charger will stop the charging process and go to **Standby Mode**.

In Standby Mode the charger only monitors the battery voltage. It will maintain the battery charge either by periodically recharging the battery when the battery voltage drops below Vbc_restart, or by maintaining the charge in **Float Mode**, if the voltage drops below Vfl_start voltage.

In Float Mode the charger limits the charging voltage to Vfl and the charging current Ibc. When the charging current drops below Ifl_stop, the charger returns to Standby Mode, keeping the battery voltage at a predefined level.

The charger stages can be used as signal sources for transmitting over CAN. The corresponding values to the stages are given in Table 2.

Value	Charger Mode
0	Idle Mode
1	Charge Termination (Float) Mode
2	Precharge Mode
3	Constant Current Mode
4	Constant Voltage Mode
5	Recharge Mode

Table 2 – Charger Mode Values

2.1.1. Charger Temperature

In addition to the charging profile parameters, each charger has a temperature sensor. The charger will turn off its output and go to Idle state if the temperature threshold is exceeded. The charger will remain in Idle state until the Temperature Hysteresis value is cleared.

In case of electronics failure, the charger will be locked in **Module Error Mode** until either the battery or the power is disconnected, and the charger goes to the initial Idle Mode.

2.1.2. Battery Temperature

Battery temperature can be measured using the RTD inputs. By default, the firmware is configured to use a PT1000 temperature sensor. The maximum battery temperature is configured through the

Miscellaneous Input setpoint "Shutdown Temperature". If no RTD is connected, ensure the **RTD Enable** setpoint is set to 'Disabled'.

2.2. Battery Charger State Diagram

A complete set of the charger modes and their relations to each other are shown on the Battery Charger State Diagram (Figure 3).

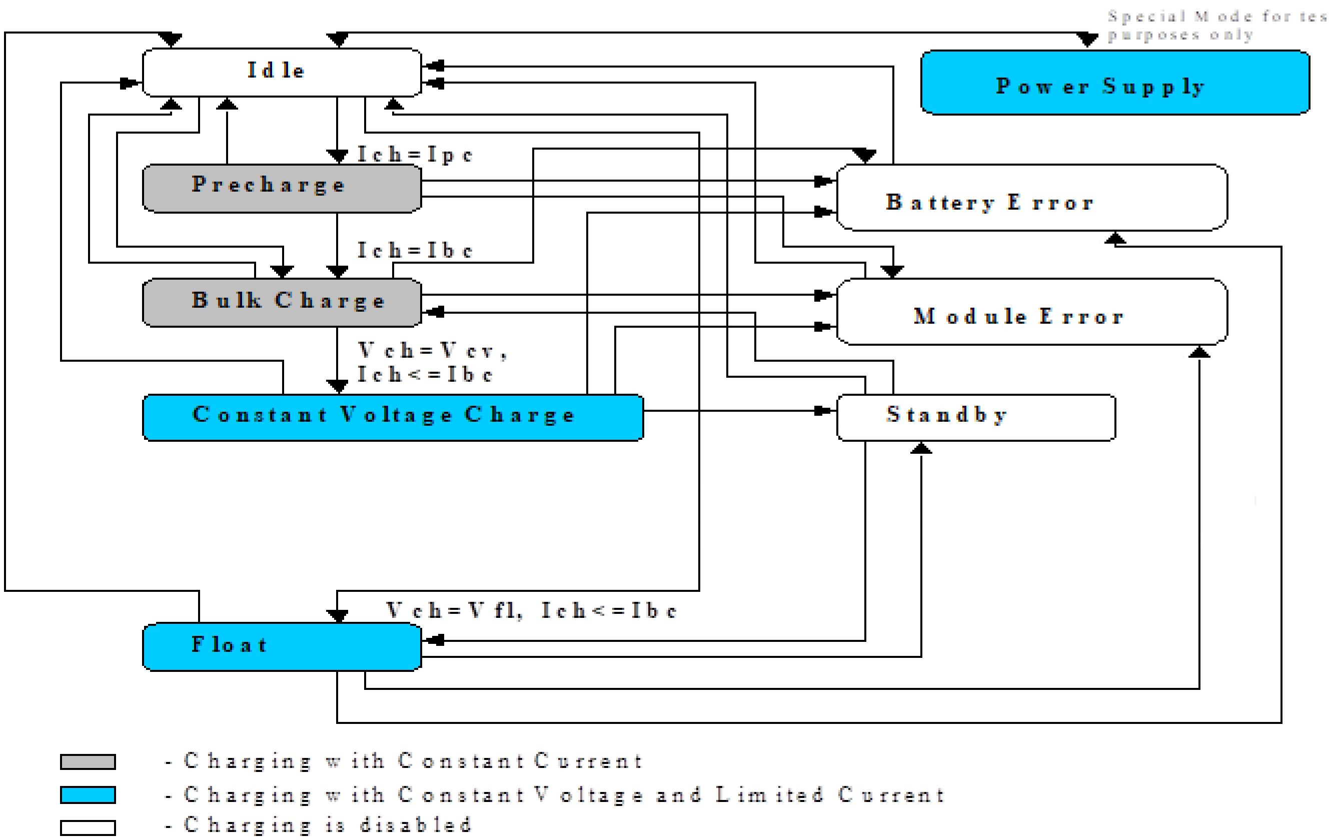


Figure 3. *Battery Charger State Diagram*

In order to avoid accidental switching of the charger from one mode to another due to noise, transients, etc., the condition causing the transition must stay on for at least 3 seconds.

2.3. Battery Protection

To prevent a battery from damage, the battery charger has a time-out condition of 48 hours. The charger will return to Idle state if the charge time exceeds this value.

By default, the battery charger will not start charging a battery with a voltage less than the Precharge Mode Start Voltage. However, some batteries may contain a safety feature which disconnects the output when not charging. In this case, the battery may hold a charge, but the battery charger will read no voltage from the battery terminals. For this reason, the battery charger contains an additional function, **Precharge Mode Force Enable**. When enabled, the charger will bypass the battery voltage check, and attempt to charge the battery in Precharge mode.

3. OVERVIEW OF J1939 FEATURES

The software was designed to provide flexibility to the user with respect to messages sent to and from the ECU by providing:

- Configurable ECU Instance in the NAME (to allow multiple ECUs on the same network)
- Configurable Transmit PGN and SPN Parameters

3.1. Introduction to Supported Messages

The ECU is compliant with the standard SAE J1939, and supports the following PGNs

From J1939-21 - Data Link Layer

- Request 59904 ($00EA00)
- Acknowledgment 59392 ($00E800)
- Transport Protocol – Connection Management 60416 ($00EC00)
- Transport Protocol – Data Transfer Message 60160 ($00EB00)

Note: Any Proprietary B PGN in the range 65280 to 65535 ($00FF00 to $00FFFF) can be selected

From J1939-73 – Diagnostics

- DM1 – Active Diagnostic Trouble Codes 65226 ($00FECA)
- DM2 – Previously Active Diagnostic Trouble Codes 65227 ($00FECB)
- DM3 – Diagnostic Data Clear/Reset for Previously Active DTCs 65228 ($00FECC)
- DM11 – Diagnostic Data Clear/Reset for Active DTCs 65235 ($00FED3)

From J1939-81 - Network Management

- Address Claimed/Cannot Claim 60928 ($00EE00)
- Commanded Address 65240 ($00FED8)

From J1939-71 – Vehicle Application Layer

- Software Identification 65242 ($00FEDA)

None of the application layer PGNs are supported as part of the default configurations, but they can be selected as desired for either transmit or received function blocks.
Setpoints are accessed using standard Memory Access Protocol (MAP) with proprietary addresses. The Axiomatic Electronic Assistant (EA) allows for quick and easy configuration of the unit over the CAN network.

3.2. Name, Address and Software ID

3.2.1. J1939 Name

The battery charger ECU has the following defaults for the J1939 NAME. The user should refer to the SAE J1939/81 standard for more information on these parameters and their ranges.

Arbitrary Address Capable	Yes
Industry Group	0, Global
Vehicle System Instance	0
Vehicle System	0, Non-specific system
Function	141, Axiomatic Battery Charger
Function Instance	8, Axiomatic AX090690, Battery Charger
ECU Instance	**0, First Instance**
Manufacture Code	162, Axiomatic Technologies Corporation
Identity Number	Variable, uniquely assigned during factory programming for each ECU

The ECU Instance is a configurable setpoint associated with the NAME. Changing this value will allow multiple ECUs of this type to be distinguishable by other ECUs (including the Axiomatic Electronic Assistant) when they are all connected on the same network.

3.2.2. ECU Address

The default value of this setpoint is 128 (0x80), which is the preferred starting address for self-configurable ECUs as set by the SAE in J1939 tables B3 to B7. The Axiomatic EA supports the selection of any address between 0 to 253, and ***it is the user's responsibility to select an address that complies with the standard***. The user must also be aware that since the unit is arbitrary address capable, if another ECU with a higher priority NAME contends for the selected address, the battery charger will continue select the next highest address until it finds one that it can claim. See J1939/81 for more details about address claiming.

3.2.3. Software Identifier

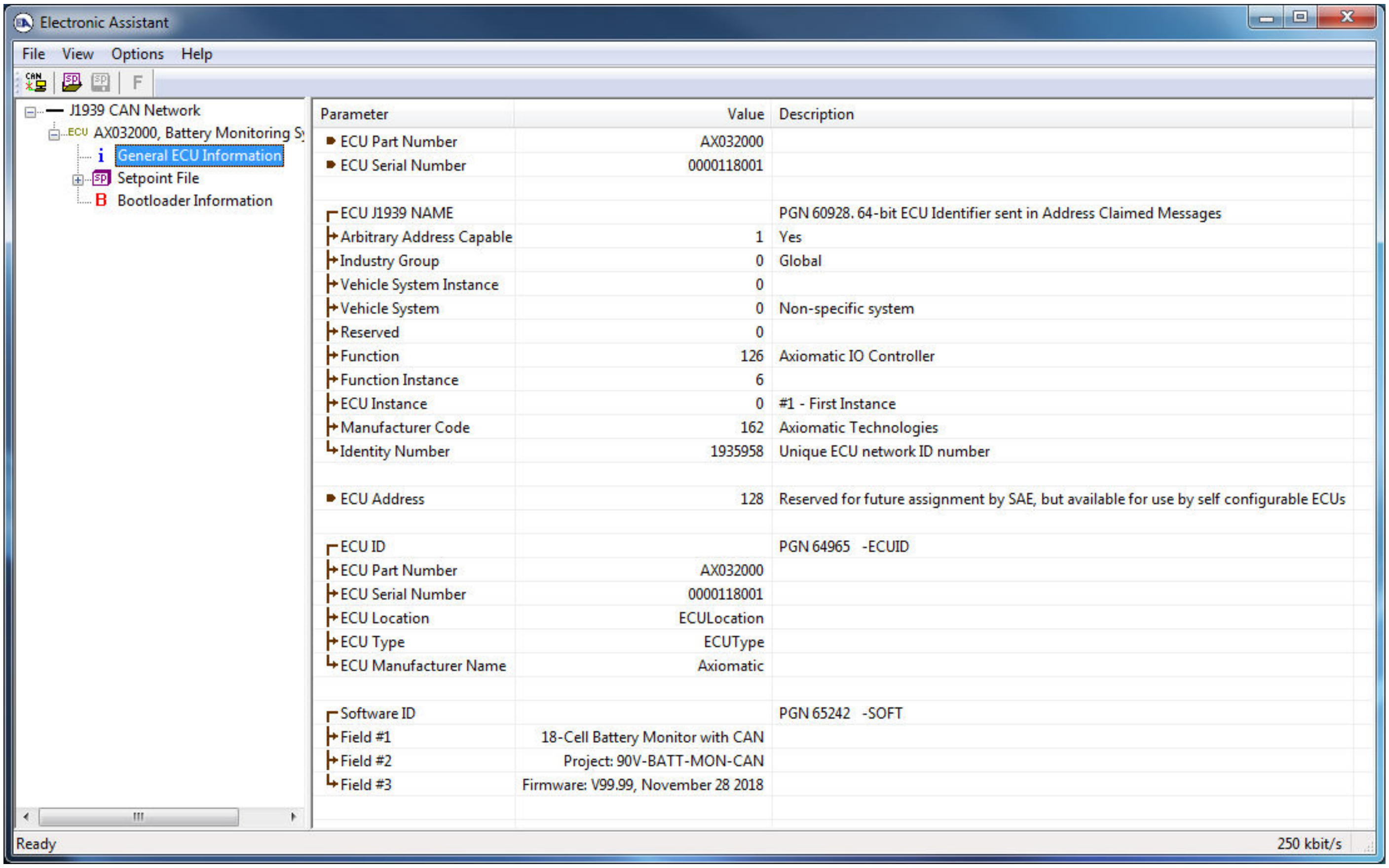
PGN 65242	Software Identification		- SOFT
Transmission Repetition Rate:	On request		
Data Length:	Variable		
Extended Data Page:	0		
Data Page:	0		
PDU Format:	254		
PDU Specific:	218 PGN Supporting Information:		
Default Priority:	6		
Parameter Group Number:	65242 (0xFEDA)		

Start Position	Length	Parameter Name	SPN
1	1 Byte	Number of software identification fields	965
2-n	Variable	Software identification(s), Delimiter (ASCII “*”)	234

For the battery charger ECU, Byte 1 is set to 5, and the identification fields are as follows

(Part Number)*(Version)*(Date)*(Owner)*(Description)

The Axiomatic EA shows all this information in “General ECU Information”, as shown below:



Note: The information provided in the Software ID is available for any J1939 service tool which supports the PGN -SOFT.

4. BATTERY CHARGER FUNCTION BLOCKS

4.1. Charging Profile Function Blocks

The Charging Profile function blocks are used to set all parameters needed in the battery charging algorithm. These parameters characterize the conditions which the charging algorithm will use to switch between charging modes. The Chargers can be disabled, enabled, or set to be controlled by CAN Rx messages.

Please refer to Section 2, where these parameters are described in detail.

4.2. Miscellaneous Input Function Block

The Miscellaneous Input function block is used to define parameters used in controlling the ECU.

The **Undervoltage Threshold, Overvoltage Threshold** and **Shutdown Temperature**, setpoints are used to determine the values at which the ECU generates the corresponding fault.

The CAN1 Diagnostic Setting determines the behaviour over CAN1. Diagnostic messages can be turned ON/OFF, as well as set to block empty diagnostic messages.

4.3. J1939 Network Function Block

The Network function block controls the way the battery charger communicates on the J1939 network. Further details on the J1939 network features are available in Section 5.

The Module Address (**ECU Address** in the Axiomatic EA), setpoint specifies the dynamic network address of the battery charger, which is claimed when the charger is connected to the network. This setpoint can be changed automatically in case the address is already taken by a higher priority in the ECU.

The ECU Instance (**ECU Instance Number** in the Axiomatic EA), setpoint should be set by the user if two or more battery chargers are present on the network.

4.4. Diagnostic Input Function Blocks

The Diagnostic Input function blocks are used to setup the diagnostic messages for the controller.

The 5 types of diagnostics supported by the battery charger are shown in Table 8.

Function Block	Minimum Threshold	Maximum Threshold
Feedback Overcurrent Fault	N/A	Charge Profile Regulation Current Setting
VPS Undervoltage Fault	VPS Undervoltage	N/A
VPS Overvoltage Fault	N/A	VPS Overvoltage
Over Temperature Fault	N/A	Temperature Shutdown
Lost Communication Fault	N/A	Received Message Timeout (any)

Table 8 – Fault Detection Thresholds

If and only if the **Event Generates a DTC in DM1** parameter is set to true will the other setpoints in the function block be enabled. They are all related to the data that's is sent to the J1939 network as part of the DM1 message, Active Diagnostic Trouble Codes.

A Diagnostic Trouble Code (DTC) is defined by the J1939 standard as a 4-byte value which is a combination of:

SPN	Suspect Parameter Number	(first 19 bits of the DTC, LSB first)
FMI	Failure Mode Identifier	(next 5 bits of the DTC)
CM	Conversion Method	(1 bit, always set to 0)
OC	Occurrence Count	(7 bits, number of times the fault has happened)

In addition to supporting the DM1 message, the battery charger Controller also supports

DM2	Previously Active Diagnostic Trouble Codes	**Sent only on request**
DM3	Diagnostic Data Clear/Reset of Previously Active DTCs	**Done only on request**
DM11	Diagnostic Data Clear/Reset for Active DTCs	**Done only on request**

So long as even one Diagnostic function block has **Event Generates a DTC in DM1** set to true, the battery charger Controller will send the DM1 message every one second, regardless of whether there are any active faults, as recommended by the standard. While there are no active DTCs, the battery charger will send the "No Active Faults" message. If a previously active DTC becomes inactive, a DM1 will be sent immediately to reflect this. As soon as the last active DTC goes inactive, it will send a DM1 indicating that there are no more active DTCs.

If there is more than on active DTC at any given time, the regular DM1 message will be sent using a multipacket Broadcast Announce Message (BAM). If the controller receives a request for a DM1 while this is true, it will send the multipacket message to the Requester Address using the Transport Protocol (TP).

At power up, the DM1 message will not be broadcast until after a 5 second delay. This is done to prevent any power up or initialization conditions from being flagged as an active error on the network.

The Diagnostic function block has a setpoint **Event Cleared Only by DM11**. By default, this is set to false, which means that as soon as the condition that caused an error flag to be set goes away, the DTC is automatically made Previously Active, and is no longer included in the DM1 message. However, when this setpoint is set to true, even if the flag is cleared, the DTC will not be made inactive, so it will continue to be sent on the DM1 message. Only when a DM11 has been requested will the DTC go inactive. This feature may be useful in a system where a critical fault needs to be clearly identified as having happened, even if the conditions that caused it went away.

In addition to all the active DTCs, another part of the DM1 message is the first byte, which reflects the Lamp Status. Each Diagnostic function block has the setpoint **Lamp Set by Event in DM1** which determines which lamp will be set in this byte while the DTC is active. The J1939 standard defines the lamps as '*Malfunction*', '*Red Stop*', '*Amber, Warning*' or *'Protect'*. By default, the *'Amber, Warning'* lamp is typically the one set by any active fault.

By default, every Diagnostic function block has associated with it a proprietary SPN. However, this setpoint **SPN for Event used in DTC** is fully configurable by the user should they wish it to reflect a standard SPN define in J1939-71 instead. If the SPN is change, the OC of the associate error log is automatically reset to zero.

Every Diagnostic function block also has associated with it a default FMI. The only setpoint for the user to change the FMI is **FMI for Event used in DTC**, even though some Diagnostic function blocks can have both high and low errors. In those cases, the FMI in the setpoint reflects that of the low-end condition, and the FMI used by the high fault will be determined per Table 4. If the FMI is changed, the OC of the associate error log is automatically reset to zero.

FMI for Event used in DTC – Low Fault	Corresponding FMI used in DTC – High Fault
FMI=1, Data Valid But Below Normal Operational Range – Most Severe Level	FMI=0, Data Valid But Above Normal Operational Range – Most Severe Level
FMI=4, Voltage Below Normal, Or Shorted To Low Source	FMI=3, Voltage Above Normal, Or Shorted To High Source
FMI=5, Current Below Normal Or Open Circuit	FMI=6, Current Above Normal Or Grounded Circuit
FMI=17, Data Valid But Below Normal Operating Range – Least Severe Level	FMI=15, Data Valid But Above Normal Operating Range – Least Severe Level
FMI=18, Data Valid But Below Normal Operating Range – Moderately Severe Level	FMI=16, Data Valid But Above Normal Operating Range – Moderately Severe Level
FMI=21, Data Drifted Low	FMI=20, Data Drifted High

Table 9 – Low Fault FMI versus High Fault FMI

If the FMI used is anything other than one of those in Table 4, then both the low and the high faults will be assigned the same FMI. This condition should be avoided, as the log will still use different OC for the two types of faults, even though they will be reported the same in the DTC. It is the user's responsibility to make sure this does not happen.

When the fault is linked to a DTC, a non-volatile log of the occurrence count (OC) is kept. As soon as the controller detects a new (previously inactive) fault, it will start decrementing the **Delay Before Sending DM1** timer for the Diagnostic function block. If the fault has remained present during the delay time, then the controller will set the DTC to active, and it will increment the OC in the log. A DM1 will immediately be generated that includes the new DTC. The timer is provided so that intermittent faults do not overwhelm the network as the fault comes and goes, since a DM1 message would be sent every time the fault shows up or goes away.

4.5. CAN Transmit Function Block

The CAN Transmit function block is used to send data from the battery charger to the J1939 network.

Normally, to disable a transmit message, the **Transmit Repetition Rate** is set to zero. However, should the message share its Parameter Group Number (PGN) with another message, this is not necessarily true. In the case where multiple messages share the same **Transmit PGN**, the repetition rate selected in the message with the LOWEST number will be used for ALL the messages that use that PGN.

By default, all messages are sent on Proprietary B PGNs as broadcast messages. If all the data is not necessary, disable the entire message by setting the lowest channel using that PGN to zero. If some of the data is not necessary, simply change the PGN of the superfluous channel(s) to an unused value in the Proprietary B range.

Since the defaults are PropB messages, the **Transmit Message Priority** is always initialized to 6 (low priority) and the **Destination Address (for PDU1)** setpoint is not used. This setpoint is only valid when a PDU1 PGN has been select, and it can be set either to the Global Address (0xFF) for broadcasts or sent to a specific address as setup by the user.

Enabling the **Override Source Address**, allows the **Source Address** of the J1939 Identifier to be changed to any value between 0…255.

The **Transmit Data Size**, **Transmit Data Index in Array (LSB)**, **Transmit Bit Index in Byte (LSB)**, **Transmit Resolution** and **Transmit Offset** can all be used to map the data to any SPN supported message by the J1939 standard from any **Data Source** of the Transmit function block. Table 5 exhibits the possible **Data Sources** for use in CAN Transmits.

Value	Control Source
0	No Control Source
1	CAN Receive
2	Constant Discrete Signal
3	Constant Continuous Signal
4	Power Supply Voltage
5	Charger Feedback Voltage
6	Charger Feedback Current
7	Charger Configuration
8	Charger Mode (See Table 2)
9	Charger Temperature
10	Charger Error Signal

Table 3 – CAN Transmit Data Sources

The battery charger supports up to 5 unique CAN Transmit Messages, all of which can be programmed to send any available data to the CAN network. Each CAN Transmit Message is setup to send data from 4 configurable sources, and if each of the 4 sources is used, each source can have a size as large as 2-Bytes. Only the first 2 CAN Transmit Messages are configured by default, with the remaining 3 set to unused; the default list is shown in Table 4 below.

CAN Transmit 1	Default Transmit Data	Byte Position	Bit Position	PGN
1	Charger 1 Mode	1st	1st	0xFF00
2	Charger 1 Voltage	2nd	3rd	0xFF00
3	Charger 1 Current	3rd	5th	0xFF00
4	Charger 1 Temperature	4th	7th	0xFF00
CAN Transmit 2	**Default Transmit Data**	**Byte Position**	**Bit Position**	**PGN**
1	Charger 2 Mode	1st	1st	0xFF01
2	Charger 2 Voltage	2nd	3rd	0xFF01
3	Charger 2 Current	3rd	5th	0xFF01
4	Charger 2 Temperature	4th	7th	0xFF01

Table 4 – Default CAN Transmit Messages

4.6. CAN Receive Function Block

The CAN Receive function block is designed to take any SPN from the J1939 network and use it as a control/enable/override source for any relay outputs or CAN Transmits.

The **Receive Message Enabled** is the most important setpoint associated with this function block and it should be selected first. Changing it will result in other setpoints being enabled/disabled as appropriate. By default, all receive messages are enabled.

Once a message has been enabled, a Lost Communication fault will be flagged if that message is not received within the **Receive Message Timeout** period. This will trigger a Lost Communication event if the cell input associated with the CAN Receive message is set to User Controlled under Rx Timeout Setting. In order to avoid timeouts on a heavily saturated network, it is recommended to set the period at least three times longer than the expected update rate. To disable the timeout feature, simply set this value to zero, in which case the received message will never timeout and will never trigger a Lost Communication fault.

By default, all control messages are expected to be sent to the battery charger on Proprietary B PGNs. However, should a PDU1 message be selected, the battery charger can be setup to receive it from any ECY by setting the **Specific Address that sends the PGN** to the Global Address (0xFF). If a specific address is selected instead, then any other ECU data on the PGN will be ignored.

The **Receive Data Size**, **Receive Data Index in Array (LSB)**, **Receive Bit Index in Byte (LSB)**, **Receive Resolution** and **Receive Offset** can all be used to map any SPN supported by the J1939 standard to the output data of the Received function block.

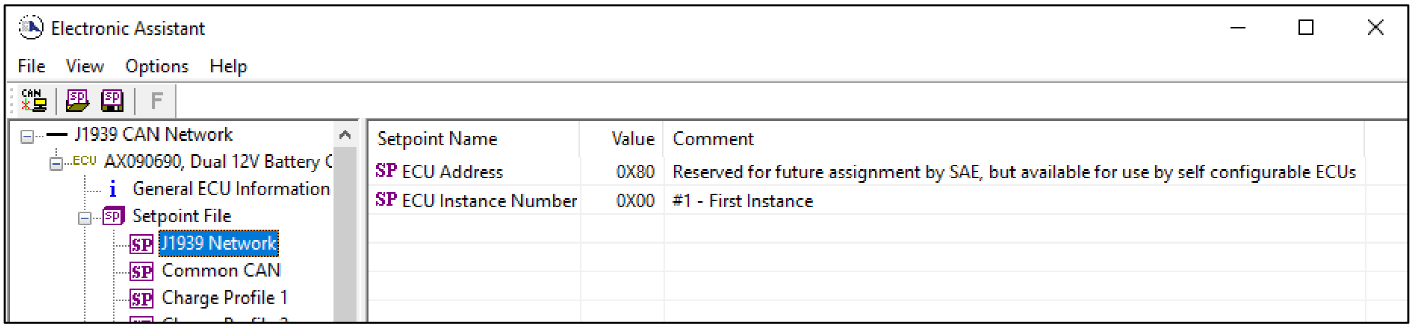
As mentioned earlier, a CAN receive function block can be selected as the source of the control input for the charger function blocks. When this is the case the **Receive Data Minimum** (Off Threshold) and **Receive Data Maximum** (On Threshold) setpoints determine the minimum and maximum values of the control signal. As the names imply, they are also used as the On/Off thresholds for digital output types. These values are in whatever units the data is AFTER the resolution and offset is applied to the CAN Receive signal.

5. ECU SETPOINTS ACCESSED WITH THE AXIOMATIC ELECTRONIC ASSISTANT

Many setpoints have been referenced throughout this manual. This section describes in detail each setpoint, their defaults and ranges. For more information on how each setpoint is used, refer to the relevant section of the user manual.

5.1. Network Setpoints

The Network function block is defined in Section 4. Please refer there for detailed information about how all these setpoints are used.



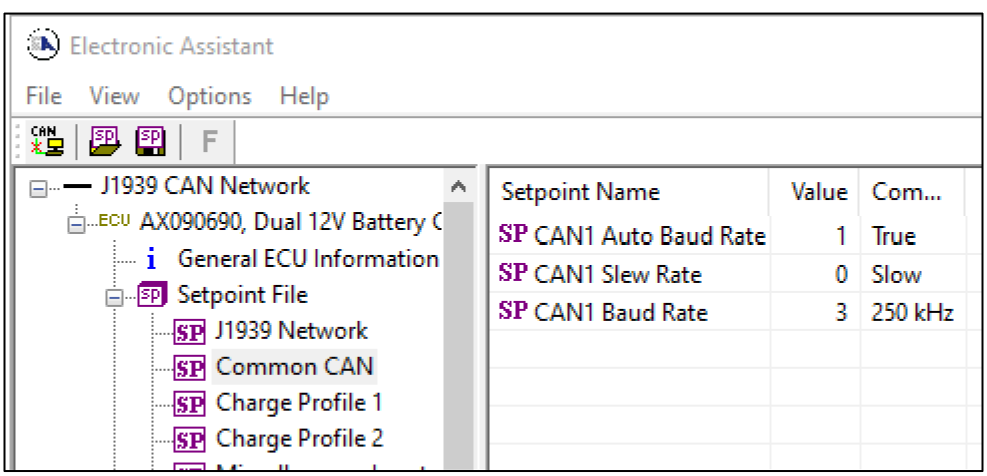
Screen Capture of Default Network Setpoints

Name	Range	Default Value
ECU Address	0…253	128
ECU Instance	0…6	0; 1st Instance

Table 5 – Default Network Setpoints

5.2. Common CAN Setpoints

The Common CAN function block Controls the CAN parameters, **Baud Rate**, **Slew Rate**, and **Auto-Baud Rate** setting.



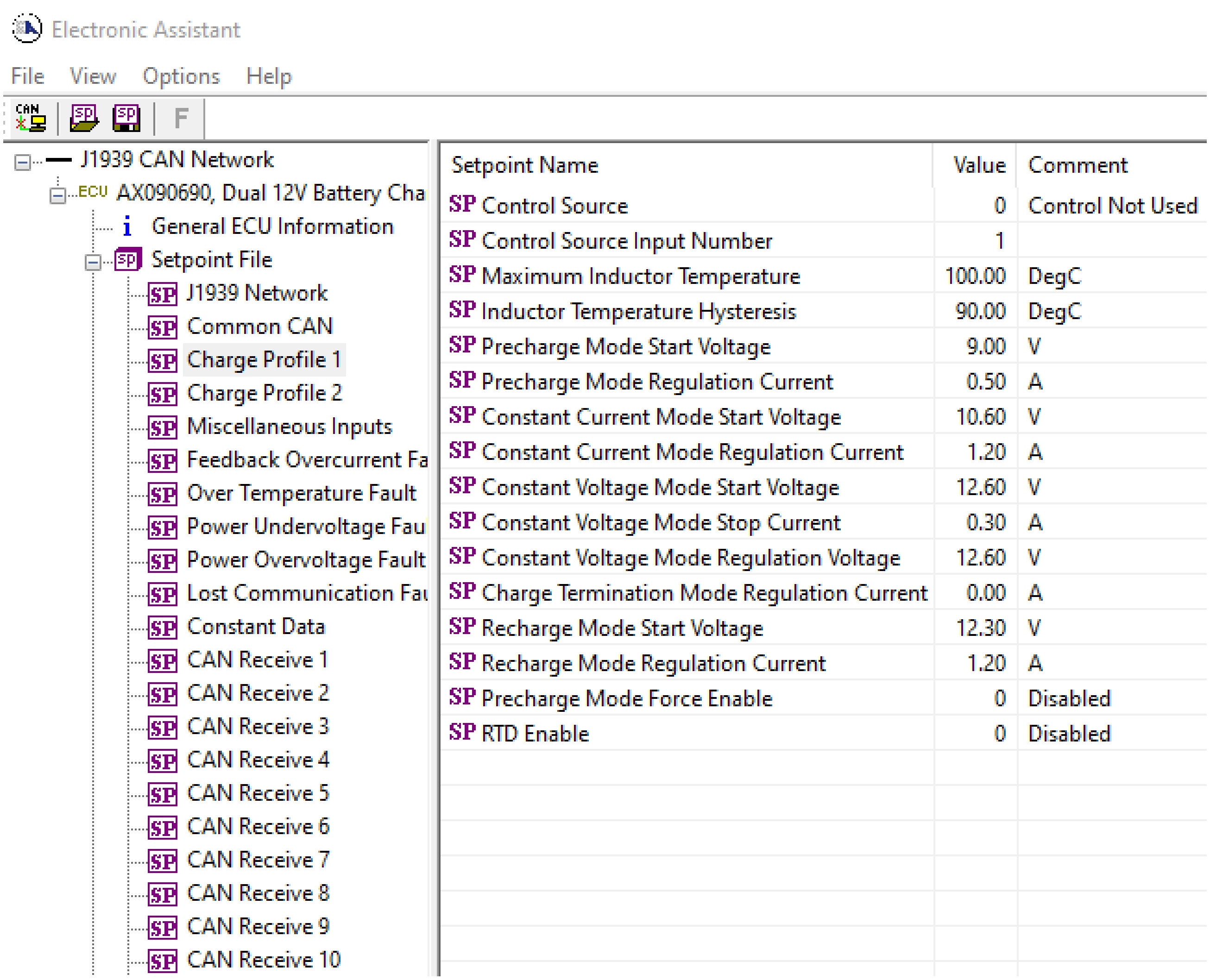
Screen Capture of Common Control Setpoints

Name	Range	Default Value
CAN1 Auto Baud Rate	False/True	1; True
CAN1 Slew Rate	Slow/Fast	0; Slow
CAN1 Baud Rate	0…8	3; 250 kHz

Table 6 – Default Common Control Setpoints

5.3. Charging Profile Setpoints

The Charging Profile function block is defined in Section 2. Please refer to that section for detailed information on how these setpoints are used. The AX090690 model has two charging profiles, for 12V and 24V batteries respectively. The Float Mode Enable setpoint is moved to the next setpoint group for AX090690 units.



Setpoint Name	Value	Comment
SP Control Source	0	Control Not Used
SP Control Source Input Number	1	
SP Maximum Inductor Temperature	100.00	DegC
SP Inductor Temperature Hysteresis	90.00	DegC
SP Precharge Mode Start Voltage	9.00	V
SP Precharge Mode Regulation Current	0.50	A
SP Constant Current Mode Start Voltage	10.60	V
SP Constant Current Mode Regulation Current	1.20	A
SP Constant Voltage Mode Start Voltage	12.60	V
SP Constant Voltage Mode Stop Current	0.30	A
SP Constant Voltage Mode Regulation Voltage	12.60	V
SP Charge Termination Mode Regulation Current	0.00	A
SP Recharge Mode Start Voltage	12.30	V
SP Recharge Mode Regulation Current	1.20	A
SP Precharge Mode Force Enable	0	Disabled
SP RTD Enable	0	Disabled

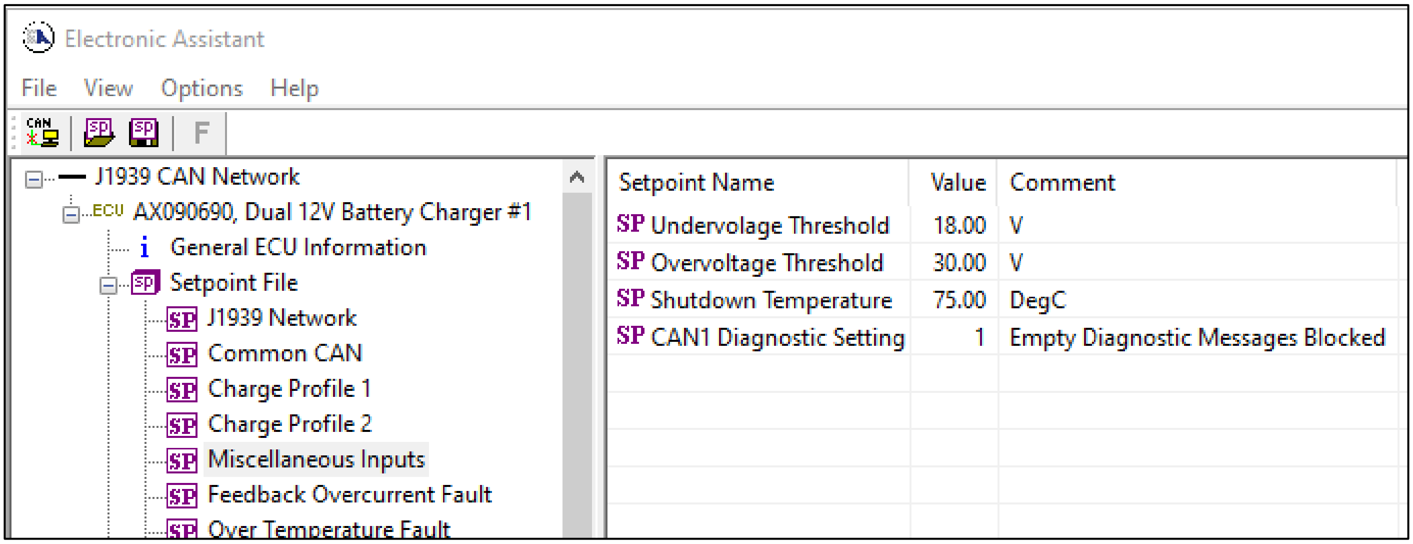
Screen Capture of Default Charging Profile Setpoints

Name	Range	Default Value
Control Source	0…3	0 (Disabled)
Control Number	0…10	(Only applies to CAN rx)
Maximum Inductor Temperature	0…100.0	100 Deg C
Inductor Temperature Hysteresis	0.0…Max	90 Deg C
Precharge Mode Start Voltage	2.5…10.6	9.0 Volts
Precharge Mode Regulation Current	0.0…1.2	0.5 Amps
Constant Current Mode Start Voltage	4.5…12.6	10.6 Volts
Constant Current Mode Regulation Current	0.5…1.2	1.2 Amps
Constant Voltage Mode Start Voltage	10.6…12.6	12.6 Volts
Constant Voltage Charge Mode Stop Current	0.0…1.2A	0.3 Amps
Constant Voltage Mode Regulation Voltage	10.6…12.6	12.6 Volts
Charge Termination Mode Regulation Current	0.0…0.3	0.0 Amps
Recharge Mode Start Voltage	10.6…12.6	12.3 Volts
Recharge Mode Regulation Current	0.3…1.2	1.2 Amps
Precharge Mode Force Enable	0…1	0 (Disabled)
RTD Enable	0…1	0 (Disabled)

Table 7 – Default Charging Profile Setpoints

5.4. Miscellaneous Input Setpoints

The Misc. Input block is defined in Section 4.2. Please refer there for detailed information about how all these setpoints are used.



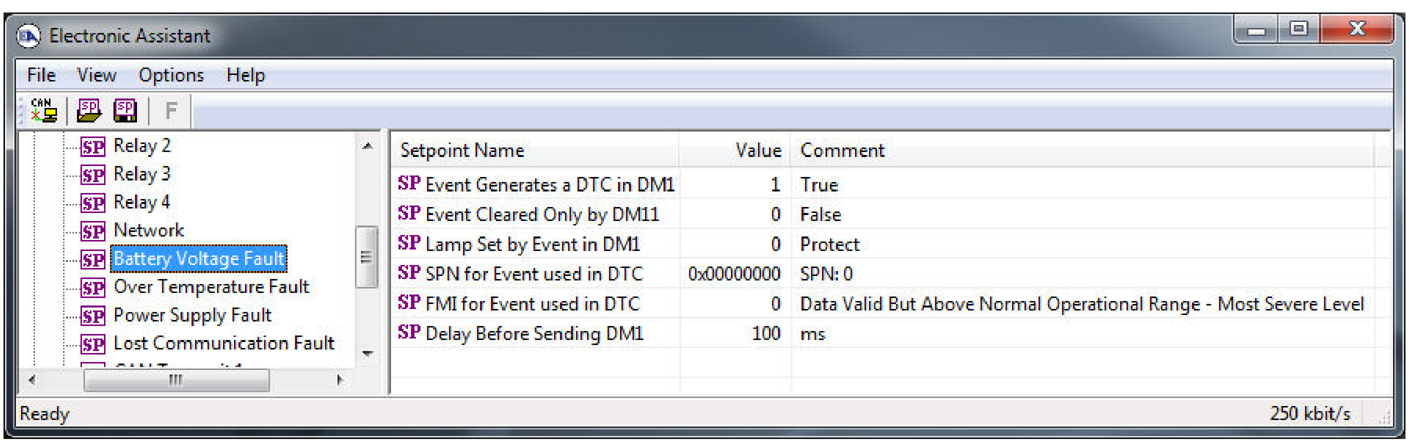
Screen Capture of Display Board Setpoints

Name	Range	Default Value
Undervoltage Threshold	8.0…29.9	18.00 V
Overvoltage Threshold	18.1…36.0	30.00 V
Shutdown Temperature	-40.0…85.0	50 Deg C
CAN1 Diagnostic Setting	0…3	1;

Table 8 – Default Display Board Setpoints

5.5. Diagnostic Input Setpoints

The Diagnostic Input function block is defined in Section 4.4. Please refer to that section for detailed information about how all these setpoints are used.



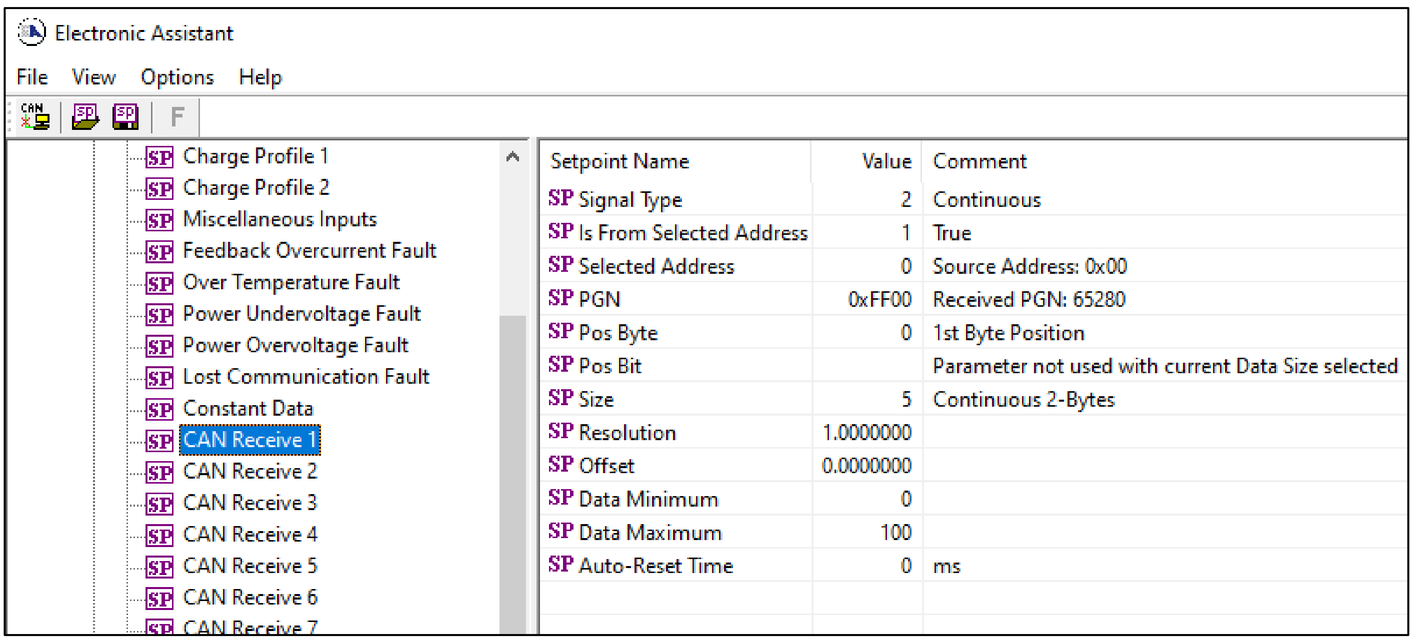
Screen Capture of Diagnostic Input Setpoints

Name	Range	Default
Event Generates a DTC in DM1	False/True	1; True
Event Only Cleared by DM11	False/True	0; False
Lamp Set by Event in DM1	Drop List	0
SPN for Event used in DTC	0…524287	0
FMI for Event used in DTC	Drop List	0
Delay Before Sending DM1	0…60000	100

Table 21 – Default Diagnostic Input Setpoints

5.6. CAN Receive Setpoints

The CAN Receive function block is defined in Section 4.6. Please refer to that section for detailed information about how all these setpoints are used.



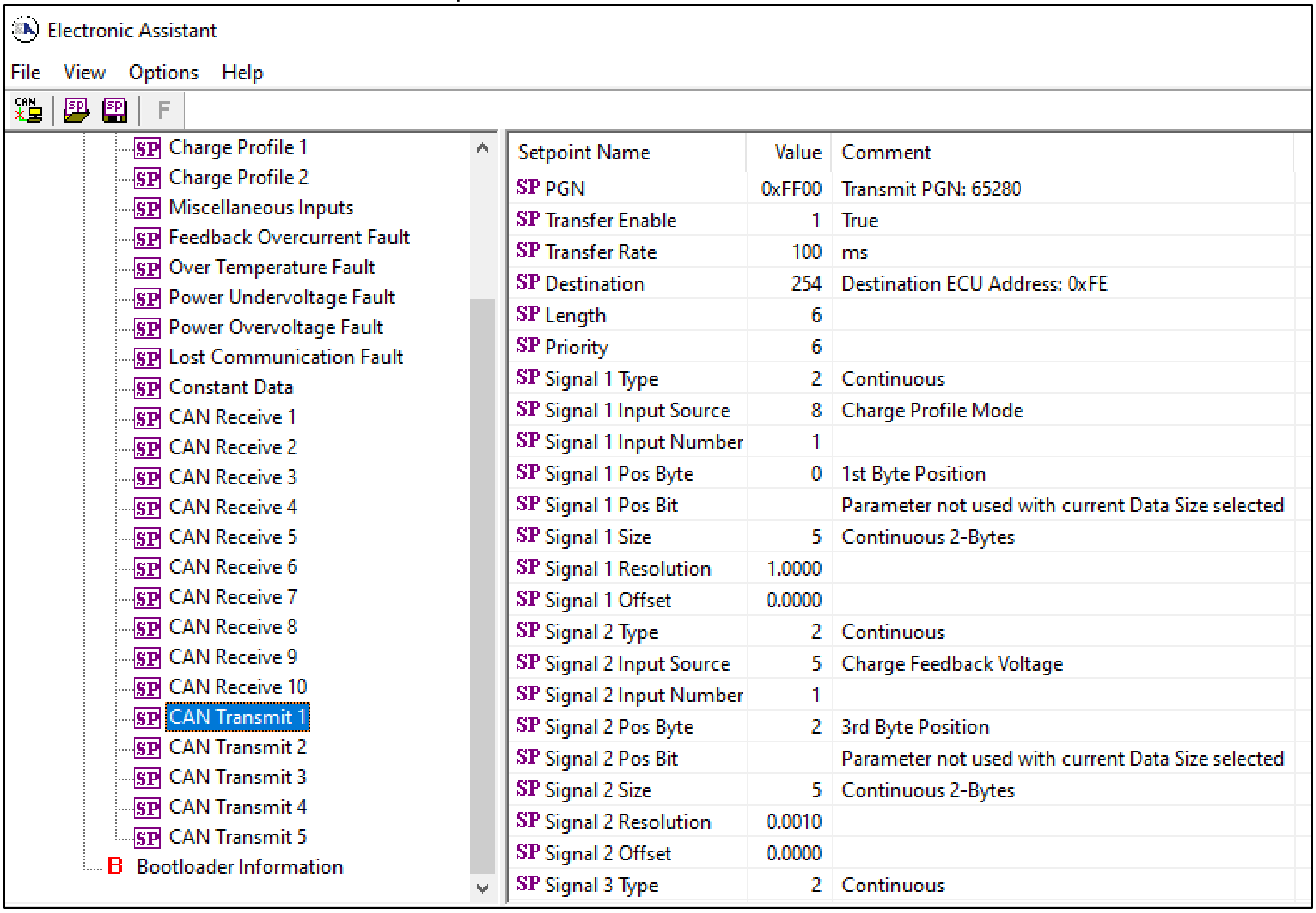
Screen Capture of CAN Receive Setpoints

Name	Range	Default
Signal Type	0…2	2 – Continuous
Is From Selected Address	True/False	1; True
Selected Address	0…255	0x00
Receive PGN	0…65535	65280 ($FF00)
Pos Byte	0-6	0; 1st Byte Position
Pos Bit	Drop List	N/A
Receive Data Size	Drop List	Continuous 2-Byte
Receive Data Resolution	-10^6 to 10^6	1
Receive Data Offset	-10^4 to 10^4	0
Receive Data Minimum	-0xFFFFFFFF…DataMax	0
Receive Data Maximum	DataMin…0xFFFFFFFF	100
Receive Message Timeout	0…60000	0 [ms]

Table 9 – Default CAN Receive Setpoints

5.7. CAN Transmit Setpoints

The CAN Transmit function block is defined in Section 4.5. Please refer to that section for detailed information about how all these setpoints are used.



Screen Capture of CAN Transmit Setpoints

Name	Range	Default
Transmit PGN	0…65535	65280 ($FF00)
Transmit Repetition Rate	0…60,000	50
Transmit Message Priority	0…7	6
Destination Address (PDU1)	0…255	254
Override Source Address	False/True	0; False
Source Address	0…255	0
Signal x Data Source	Drop List	Depends on signal number
Signal x Transmit Data Size	Drop List	Depends on signal number
Signal x Transmit Data Index in Array (LSB)	0 to 8-DataSize	Depends on signal number
Signal x Transmit Bit Index in Byte (LSB)	0 to 8-DataSize	Depends on signal number
Signal x Transmit Data Resolution	-10^6 to 10^6	1.0
Signal x Transmit Data Offset	-10^4 to 10^4	0

Signal x Transmit Data Minimum	-0xFFFFFFFF…DataMax	0
Signal x Transmit Data Maximum	DataMin…0xFFFFFFFF	Depends on signal number

Table 10 – Default CAN Transmit Setpoints

6. BATTERY CHARGER ERROR CODES

If the charging process fails, the battery charger will switch to either Battery Error or Module Error Mode, and an error code specifying the error will be generated.

The error code can be viewed through the J1939 network by Transmitting the Code over CAN Transmit.

6.1. Battery Error Codes

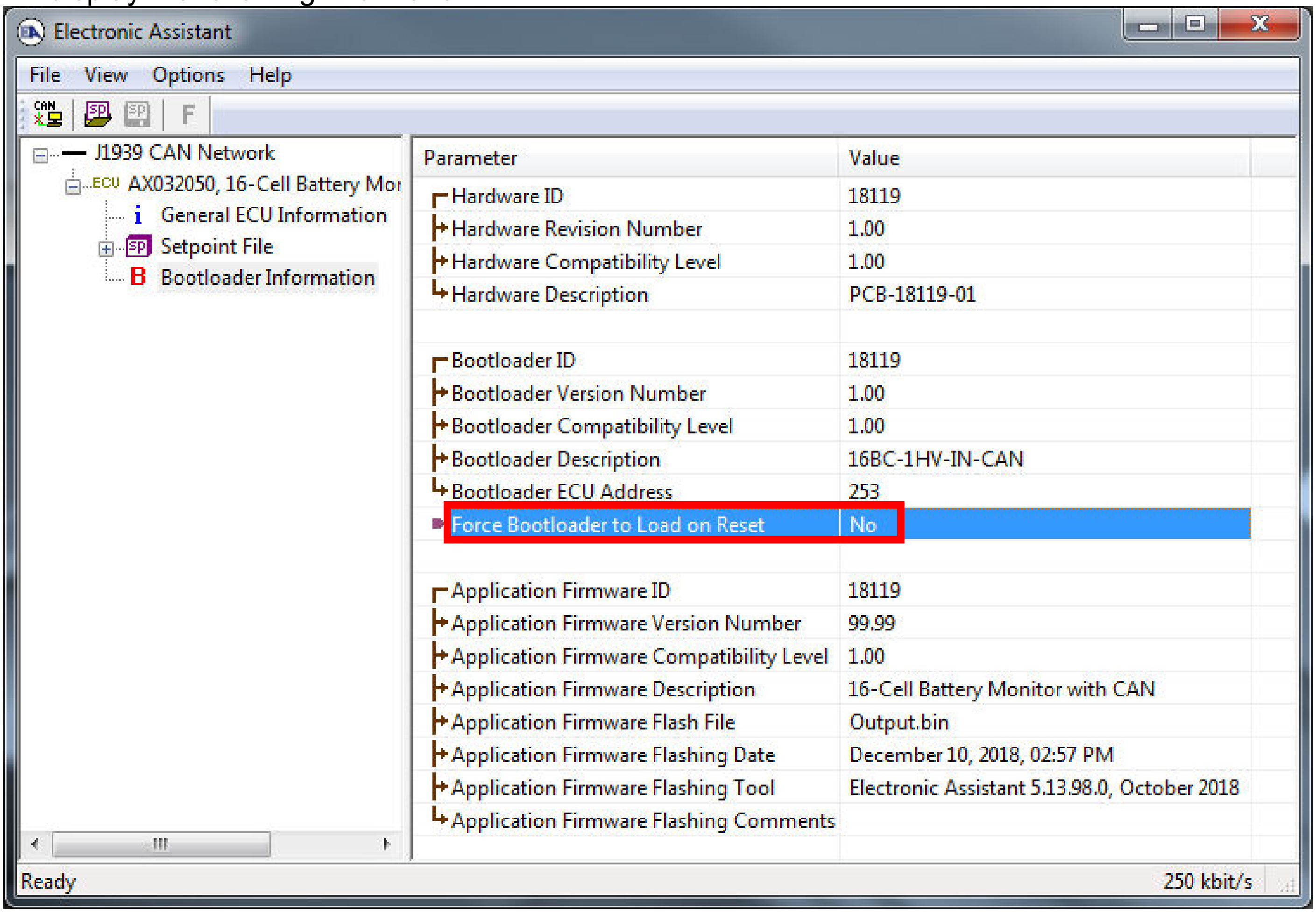
Error Code Name	Error Code Value
NO_ERROR	0
BATTERY_OVERTEMPERATURE_IN_PRECHARGE_MODE_ERROR	1
INDUCTOR_OVERTEMPERATURE_IN_PRECHARGE_MODE_ERROR	2
OVERVOLTAGE_IN_PRECHARGE_MODE_ERROR	3
OVERCURRENT_IN_PRECHARGE_MODE_ERROR	4
TIMEOUT_IN_PRECHARGE_MODE_ERROR	5
TIMEOUT_OVER_TOTAL_CHARGE_ERROR	6
LOW_POWER_IN_PRECHARGE_MODE_ERROR	7
BATTERY_OVERTEMPERATURE_IN_CONSTANT_CURRENT_MODE_ERROR	8
INDUCTOR_OVERTEMPERATURE_IN_CONSTANT_CURRENT_MODE_ERROR	9
OVERVOLTAGE_IN_CONSTANT_CURRENT_MODE_ERROR	10
OVERCURRENT_IN_CONSTANT_CURRENT_MODE_ERROR	11
TIMEOUT_IN_CONSTANT_CURRENT_MODE_ERROR	12
LOW_POWER_IN_CONSTANT_CURRENT_MODE_ERROR	13
BATTERY_OVERTEMPERATURE_IN_CONSTANT_VOLTAGE_MODE_ERROR	14
INDUCTOR_OVERTEMPERATURE_IN_CONSTANT_VOLTAGE_MODE_ERROR	15
OVERVOLTAGE_IN_CONSTANT_VOLTAGE_MODE_ERROR	16
OVERCURRENT_IN_CONSTANT_VOLTAGE_MODE_ERROR	17
TIMEOUT_IN_CONSTANT_VOLTAGE_MODE_ERROR	18
LOW_POWER_IN_CONSTANT_VOLTAGE_MODE_ERROR	19
BATTERY_OVERTEMPERATURE_IN_CHARGE_TERMINATION_MODE_ERROR	20
INDUCTOR_OVERTEMPERATURE_IN_CHARGE_TERMINATION_MODE_ERROR	21
OVERVOLTAGE_IN_CHARGE_TERMINATION_MODE_ERROR	22
OVERCURRENT_IN_CHARGE_TERMINATION_MODE_ERROR	23
TIMEOUT_IN_CHARGE_TERMINATION_MODE_ERROR	24
LOW_POWER_IN_CHARGE_TERMINATION_MODE_ERROR	25
BATTERY_OVERTEMPERATURE_IN_RECHARGE_MODE_ERROR	26
INDUCTOR_OVERTEMPERATURE_IN_RECHARGE_MODE_ERROR	27
OVERVOLTAGE_IN_RECHARGE_MODE_ERROR	28
OVERCURRENT_IN_RECHARGE_MODE_ERROR	29
TIMEOUT_IN_RECHARGE_MODE_ERROR	30
LOW_POWER_IN_RECHARGE_MODE_ERROR	31

Table 11 – Error Codes

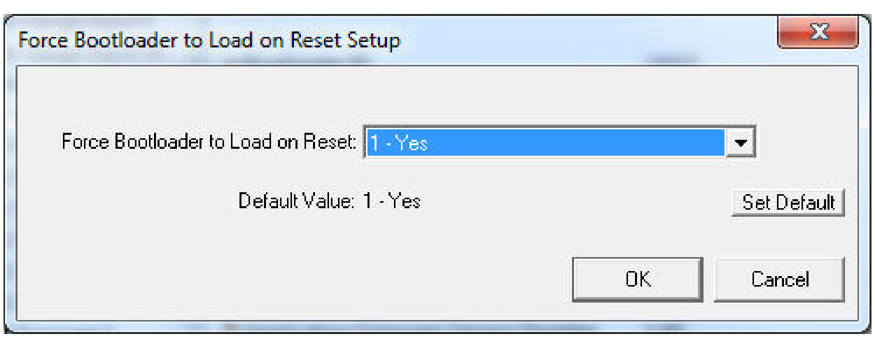
REFLASHING OVER CAN WITH THE AXIOMATIC EA BOOTLOADER

The AX090690 unit can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

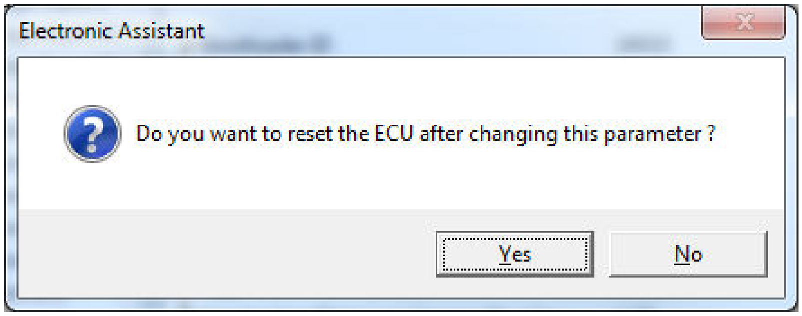
1. When the Axiomatic EA first connects to the ECU, the **Bootloader Information** section will display the following information.



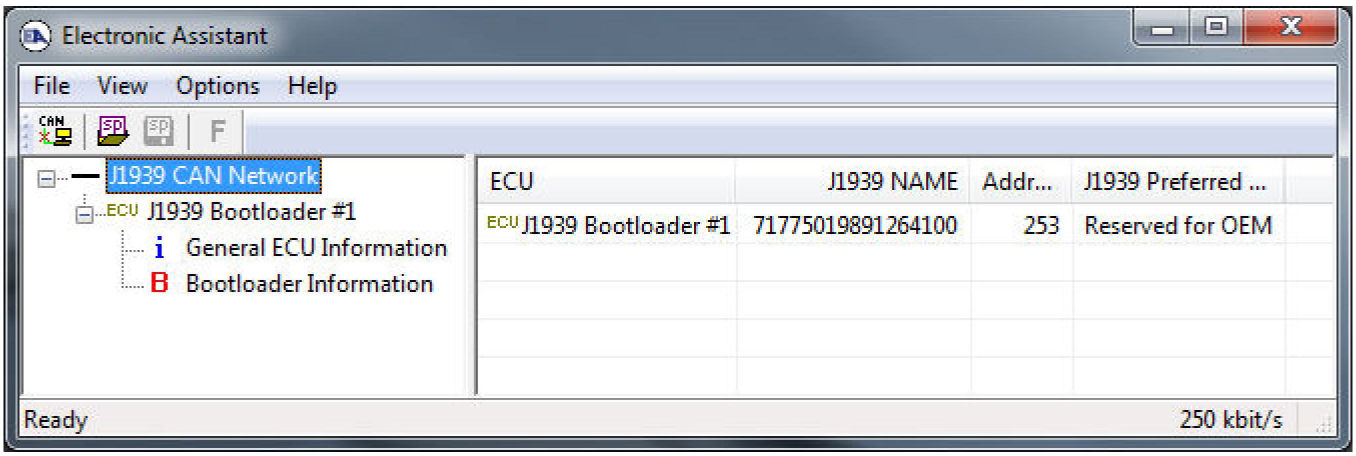
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable **"Force Bootloader to Load on Reset**" to *Yes*.

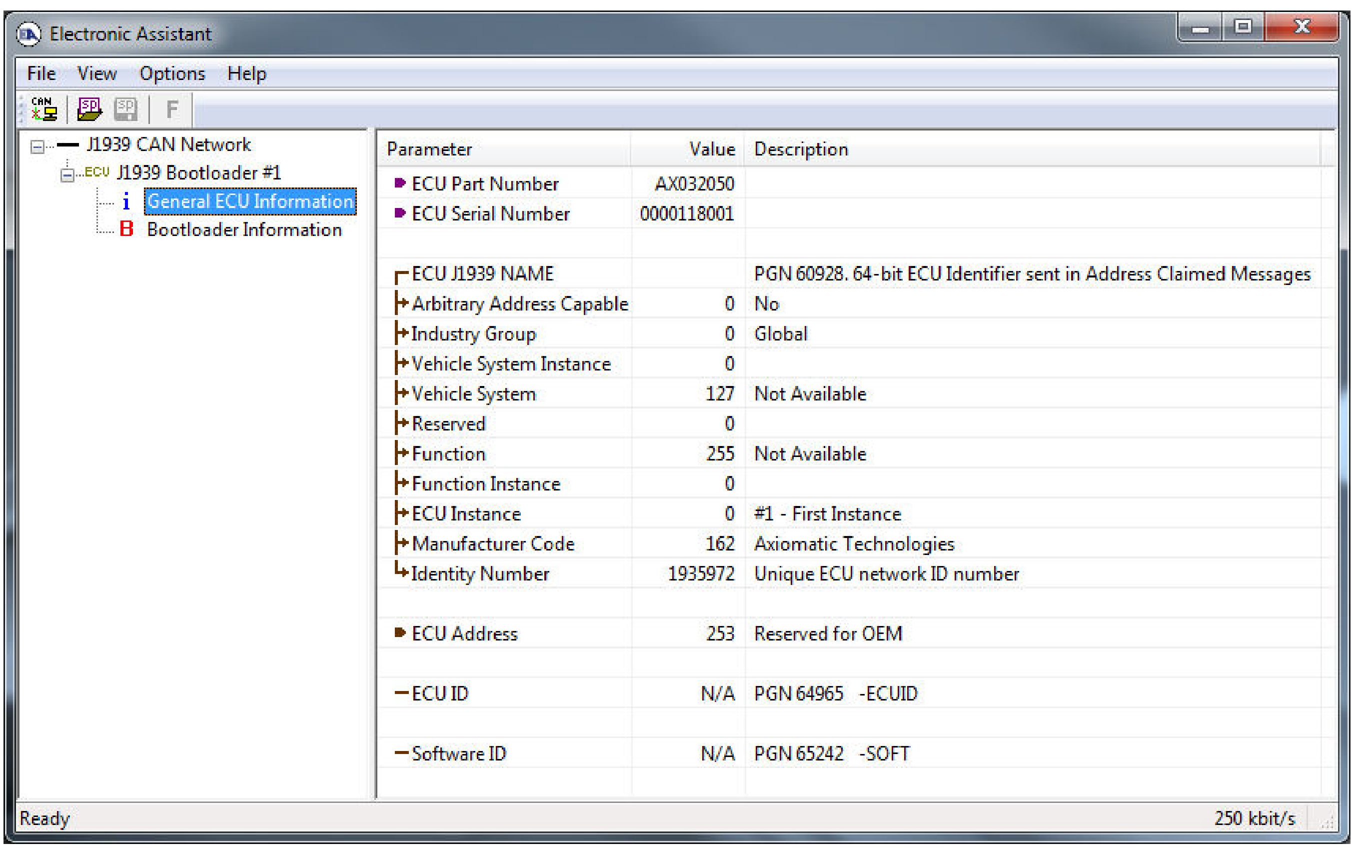


3. When the prompt box asks if you want to reset the ECU, select *Yes*.



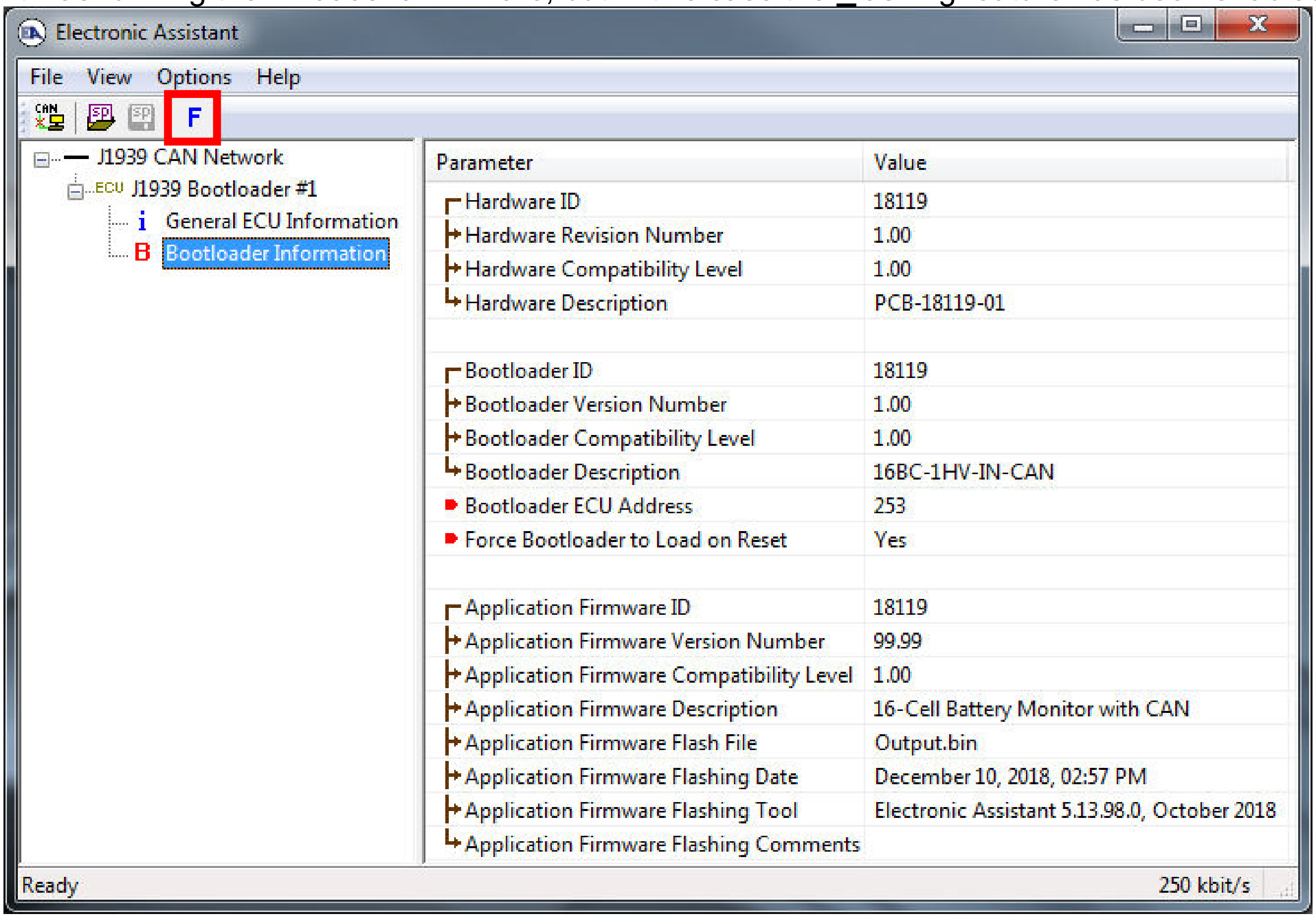
4. Upon reset, the ECU will no longer show up on the J1939 network as an AX0905x0 but rather as **J1939 Bootloader #1**.





Note that the bootloader is NOT Arbitrary Address Capable. This means that if you want to have multiple bootloaders running simultaneously (not recommended) you would have to manually change the address for each one before activating the next, or there will be address conflicts, and only one ECU would show up as the bootloader. Once the 'active' bootloader returns to regular functionality, the other ECU(s) would have to be power cycled to re-activate the bootloader feature.

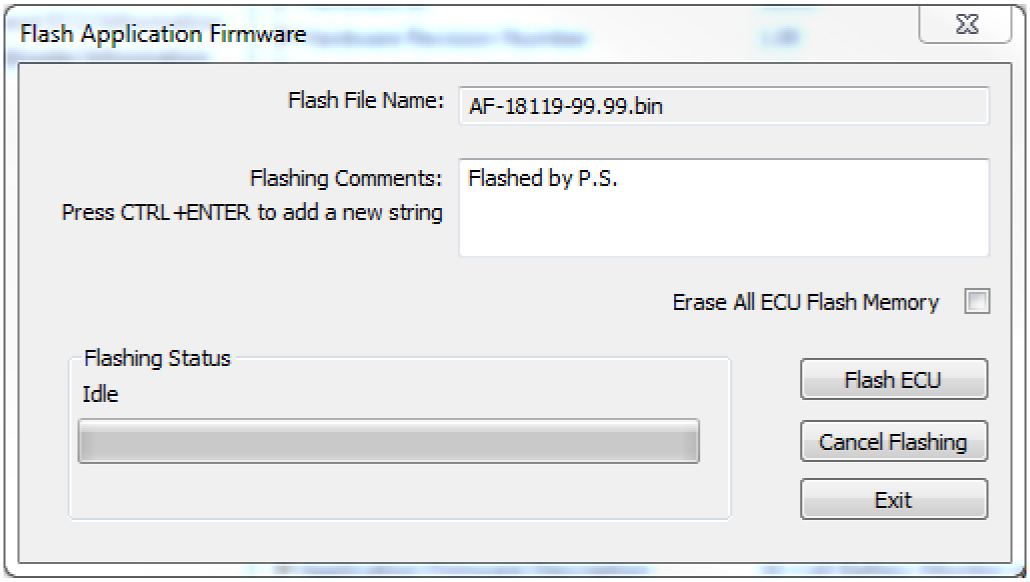
5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX0905x0 firmware, but in this case the <u>F</u>lashing feature has been enabled.



6. Select the <u>F</u>lashing button and navigate to where you had saved the **AF-18123-x.yy.bin** or **AF-19146-x.yy.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the Axiomatic EA tool)

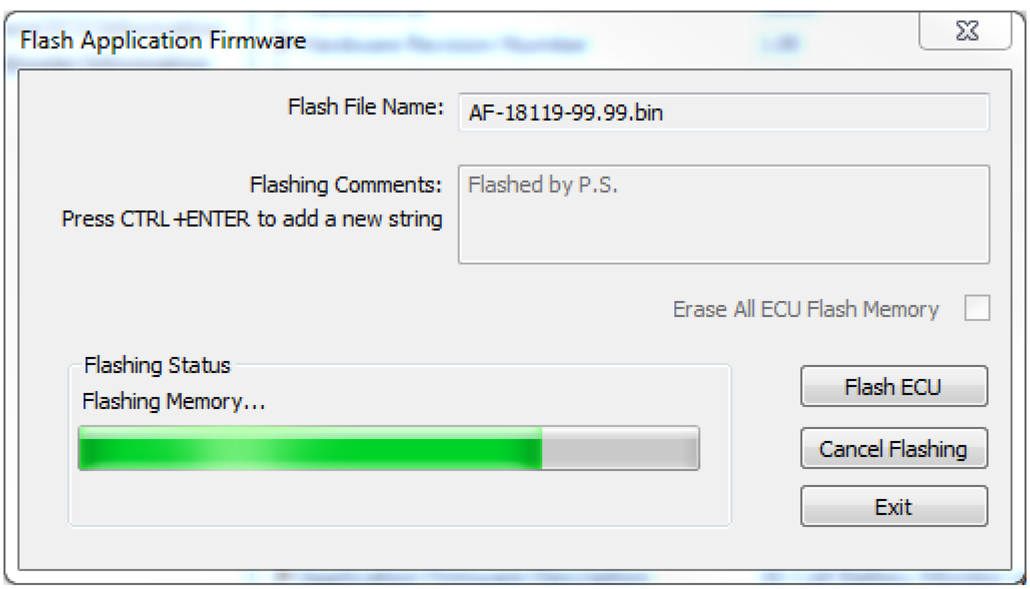
7. Once the Flash Application Firmware window opens, you can enter comments such as "Firmware upgraded by [Name]" if you so desire. This is not required, and you can leave the field blank if you do not want to use it.

   Note: You do not have to date/time-stamp the file, as this is done automatically by the Axiomatic EA tool when you upload the new firmware.

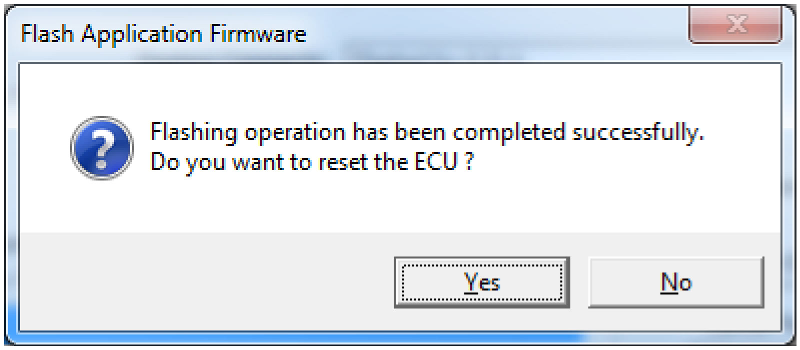


WARNING: Do not check the "Erase All ECU Flash Memory" box unless instructed to do so by your Axiomatic contact. Selecting this will erase ALL data stored in non-volatile flash. It will also erase any configuration of the setpoints that might have been done to the ECU and reset all setpoints to their factory defaults. By leaving this box unchecked, none of the setpoints will be changed when the new firmware is uploaded.

8. A progress bar will show how much of the firmware has been sent as the upload progresses. The more traffic there is on the J1939 network, the longer the upload process will take.

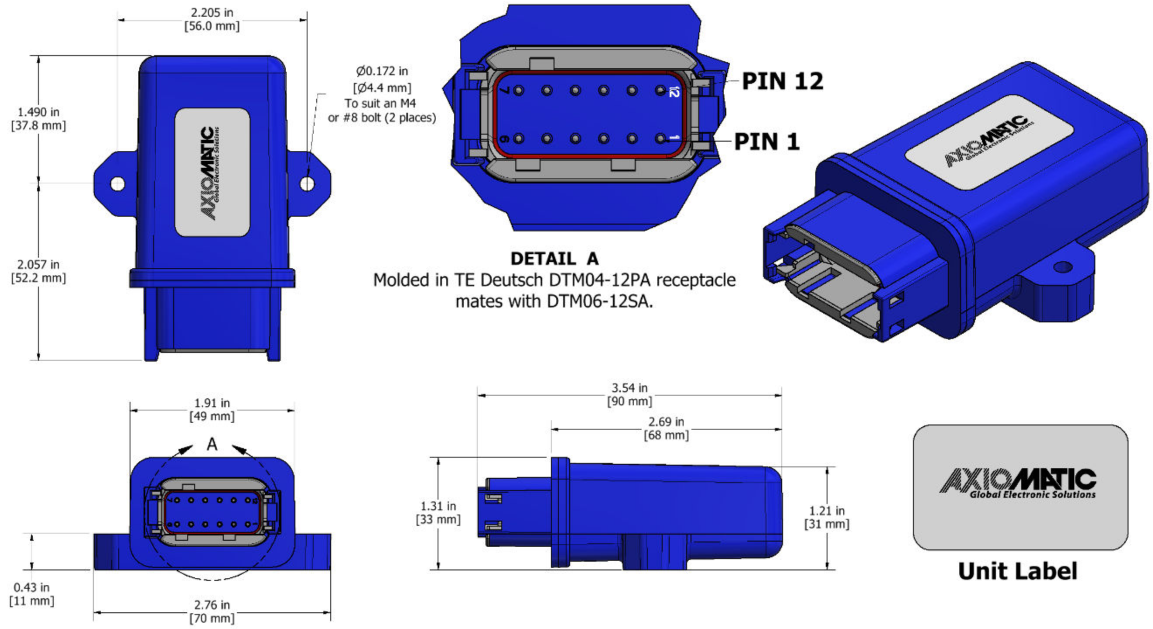


9. Once the firmware has finished uploading, a message will popup indicating the successful operation. If you select to reset the ECU, the new version of the AX0905x0 application will start running, and the ECU will be identified as such by the Axiomatic EA. Otherwise, the next time the ECU is power-cycled, the AX0905x0 application will run rather than the bootloader function.



Note: If at any time during the upload the process is interrupted, the data is corrupted (bad checksum) or for any other reason the new firmware is not correct, i.e. bootloader detects that the file loaded was not designed to run on the hardware platform, the bad or corrupted application will not run. Rather, when the ECU is reset or power-cycled the **J1939 Bootloader** will continue to be the default application until valid firmware has been successfully uploaded into the unit.

7. INSTALLATION INSTRUCTIONS



<table>
<tr><td>Electrical Connections</td><td>Integral 12-pin receptacle (equivalent TE Deutsch P/N: DTM04-012PA)
18 AWG wire is recommended for use with contacts 0462-201-16141.

<table>
<tr><th>PIN #</th><th>FUNCTION</th></tr>
<tr><td>1</td><td>V IN-</td></tr>
<tr><td>2</td><td>BATT 1 -</td></tr>
<tr><td>3</td><td>BATT 2 -</td></tr>
<tr><td>4</td><td>BATT 1 RTD -</td></tr>
<tr><td>5</td><td>BATT 2 RTD -</td></tr>
<tr><td>6</td><td>CAN L</td></tr>
<tr><td>7</td><td>CAN H</td></tr>
<tr><td>8</td><td>BATT 2 RTD +</td></tr>
<tr><td>9</td><td>BATT 1 RTD +</td></tr>
<tr><td>10</td><td>BATT 2 +</td></tr>
<tr><td>11</td><td>BATT 1 +</td></tr>
<tr><td>12</td><td>V IN+</td></tr>
</table></td></tr>
<tr><td>Mating Connectors</td><td>PL-DTM06-12SA Mating Plug Kit is comprised of 1 DTM06-12SA, 1 WM-wedge, 10 0462-201-20141 contacts, and 2 0413-204-2005 Sealing Plugs.</td></tr>
<tr><td>Mounting</td><td>Mounting holes are sized for #8 or M4 bolts. The bolt length will be determined by the end-user’s mounting plate thickness. The mounting flange of the controller is 0.425 inches (10.8 mm) thick. It should be mounted with connectors facing left or right to reduce likelihood of moisture entry. All field wiring should be suitable for the operating temperature range. Install the unit with appropriate space available for servicing and for adequate wire harness access (6 inches or 15 cm) and strain relief (12 inches or 30 cm).</td></tr>
</table>

8. TECHNICAL SPECIFICATIONS

Specifications are indicative and subject to change. Actual performance will vary depending on the application and operating conditions. Users should satisfy themselves that the product is suitable for use in the intended application.
All our products carry a limited warranty against defects in material and workmanship. Please refer to our Warranty, Application Approvals/Limitations and Return Materials Process as described on https://www.axiomatic.com/service/.

8.1. Input Specifications

Power Supply Input	24 Vdc nominal (21…28 Vdc)
Maximum Input Current	1.7 ADC @ 20 Vdc
Engine Load Dump	Designed to meet load dump conditions (up to 120 Vdc)
Reverse Voltage Protection	Provided
Under-voltage Shutdown	20 Vdc typical
Over-voltage Shutdown	29 Vdc typical

8.2. Output Specifications

Nameplate Rating (Output Power)	15 W nominal
Output Voltage and Current	User configurable Voltage: 12.6Vdc ± 2% Current: 1.2 A continuous
Recommended Battery Type	Li-ion batteries
Protection Against Reverse Battery Connection	Provided
Over-voltage Protection	Provided
Output Voltage Ripple	$V_{O(RIPPLE)} \leq$ 100 mVpp
Turn-on time (at full load)	<100 ms typical
Stability	Stable at all loads (no minimum load requirement)
Short Circuit Current	Protection provided Self-recovery 1.6A current limit
Thermal Protection	A connection point is provided for two external RTD's (not supplied) to protect the battery.

8.3. General Specifications

Microprocessor	STM32F405RGT7 1 MB Flash Program Memory
Control Logic	Standard embedded software Battery charger setpoints can be viewed and configured through the CAN bus using the Axiomatic Electronic Assistant (EA).
LED Indicator	Provided
Quiescent Current	30 mA @ 24Vdc typical preliminary
CAN Interface	1 CAN port (SAE J1939)
Baud rate	SAE J1939, 250kbit/s, 500kbit/s, 667kbit/s, 1Mbit/s. Automatic Baud Rate Detection

Operating Temperature	-40 to 70 °C (-40 to 158 °F)
Protection Rating	IP67
Efficiency	89% in buck and boost modes; 83% in buck-boost mode
Weight	0.15 lb. (0.068 kg) preliminary
Vibration	MIL-STD-202G, Method 204D test condition C (Sine) and Method 214A, test condition B (Random) 10 g peak (Sine) 7.65 Grms peak (Random)
Shock	MIL- STD-202G, Method 213B, test condition A 50g (half sine pulse, 9ms long, 8 per axis)
Enclosure	Molded Enclosure, integral connector Nylon 6/6, 30% glass, Ultrasonically welded 3.47 x 2.75 x 1.31 inches (88.2 x 70.0 x 33.3 mm) L x W x H including integral connector Refer to the dimensional drawing.

9. VERSION HISTORY

Version	Date	Author	Modifications
1	April 22, 2022	Jordan Wilbur	Initial Draft
1.1	May 20, 2022	Amanda Wilkins, Sabrina Tang	Added dimensional drawing and Technical Spec
1.2	June 1, 2022	Jordan Wilbur	Added information on RTDs and “Precharge Mode Force Enable” function.
1.3	September 7, 2023	Kiril Mojsov	Performed Legacy Updates

OUR PRODUCTS

AC/DC Power Supplies

Actuator Controls/Interfaces

Automotive Ethernet Interfaces

Battery Chargers

CAN Controls, Routers, Repeaters

CAN/WiFi, CAN/Bluetooth, Routers

Current/Voltage/PWM Converters

DC/DC Power Converters

Engine Temperature Scanners

Ethernet/CAN Converters, Gateways, Switches

Fan Drive Controllers

Gateways, CAN/Modbus, RS-232

Gyroscopes, Inclinometers

Hydraulic Valve Controllers

Inclinometers, Triaxial

I/O Controls

LVDT Signal Converters

Machine Controls

Modbus, RS-422, RS-485 Controls

Motor Controls, Inverters

Power Supplies, DC/DC, AC/DC

PWM Signal Converters/Isolators

Resolver Signal Conditioners

Service Tools

Signal Conditioners, Converters

Strain Gauge CAN Controls

Surge Suppressors

OUR COMPANY

Axiomatic provides electronic machine control components to the off-highway, commercial vehicle, electric vehicle, power generator set, material handling, renewable energy and industrial OEM markets. ***We innovate with engineered and off-the-shelf machine controls that add value for our customers.***

QUALITY DESIGN AND MANUFACTURING

We have an ISO9001:2015 registered design/manufacturing facility in Canada.

WARRANTY, APPLICATION APPROVALS/LIMITATIONS

Axiomatic Technologies Corporation reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. Users should satisfy themselves that the product is suitable for use in the intended application. All our products carry a limited warranty against defects in material and workmanship. Please refer to our Warranty, Application Approvals/Limitations and Return Materials Process at https://www.axiomatic.com/service/.

COMPLIANCE

Product compliance details can be found in the product literature and/or on axiomatic.com. Any inquiries should be sent to sales@axiomatic.com.

SAFE USE

All products should be serviced by Axiomatic. Do not open the product and perform the service yourself.

> This product can expose you to chemicals which are known in the State of California, USA to cause cancer and reproductive harm. For more information go to www.P65Warnings.ca.gov.

SERVICE

All products to be returned to Axiomatic require a Return Materials Authorization Number (RMA#) from sales@axiomatic.com. Please provide the following information when requesting an RMA number:

- Serial number, part number
- Runtime hours, description of problem
- Wiring set up diagram, application and other comments as needed

DISPOSAL

Axiomatic products are electronic waste. Please follow your local environmental waste and recycling laws, regulations and policies for safe disposal or recycling of electronic waste.

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