ROTARY LASER RECEIVER WITH CAN, SAE J1939

USER MANUAL

P/N: AX064000

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VERSION HISTORY

Version	Date	Author	Modification
1.0.0.	Oct 15, 2021	Antti Keränen	Initial Draft, based on AX184000 UM v1.0.3
1.0.1	May 2, 2024	Antti Keränen	Several updates throughout the document.
1.0.2	May 8, 2024	M Ejaz	Marketing review Legacy updates Added Rev. P2 drawing Updated technical specification section

ACRONYMS

ACK	Positive Acknowledgement (from SAE J1939 standard)
BATT +/-	Battery positive (a.k.a. Vps) or Battery Negative (a.k.a. GND)
DM	Diagnostic Message (from SAE J1939 standard)
DTC	Diagnostic Trouble Code (from SAE J1939 standard)
EA	Axiomatic Electronic Assistant (A Service Tool for Axiomatic ECUs)
ECU	Electronic Control Unit (from SAE J1939 standard)
GND	Ground reference (a.k.a. BATT-)
MAP	Memory Access Protocol
NAK	Negative Acknowledgement (from SAE J1939 standard)
PGN	Parameter Group Number (from SAE J1939 standard)
SPN	Suspect Parameter Number (from SAE J1939 standard)
TP	Transport Protocol
RPS	Rotations Per Second
Vps	Voltage Power Supply (a.k.a. BATT+)

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REFERENCES

J1939	Recommended Practice for a Serial Control and Communications Vehicle Network, SAE, February 2010
J1939/21	Data Link Layer, SAE, December 2006
J1939/71	Vehicle Application Layer, SAE, March 2011
J1939/73	Application Layer-Diagnostics, SAE, February 2010
J1939/81	Network Management, SAE, March 2017
TDAX064000	Technical Datasheet, Laser Receiver with CAN, Axiomatic Technologies
UMAX07050x	User Manual, Axiomatic Electronic Assistant and USB-CAN, Axiomatic Technologies

This document assumes the reader is familiar with the SAE J1939 standard. Terminology from the standard is used, but not described in this document.

NOTE: This product is supported by Axiomatic Electronic Assistant V5.xx.yy and higher.

1. OVERVIEW OF THE LASER RECEIVER

The Laser Receiver has two standalone laser detection diode arrays consisting altogether 40 diodes. The diode array is 190mm in length and it can be configured to detect one rotating laser beam.

A *Windows*-based Axiomatic Electronic Assistant (EA) is used to configure the laser receiver via an USB-CAN (AX070501) device. Configurable properties, EA setpoints, are outlined in chapter 4. Setpoint configuration can be saved in a file which can be used to easily program the same configuration into another Laser Receiver. Throughout this document EA setpoint names are referred to with bolded text in double-quotes and the setpoint option is referred with italicized text in single-quotes. For example, "**CAN Signal Type**" setpoint set to option '*CAN signal continuous*'.

In this document the configurable properties of the Receiver are divided into function blocks, namely Laser Receiver Block, Diagnostic Function Block, CAN Transmit Message Function Block and CAN Receive Message Function Block. These function blocks are presented in detail in the next subchapters.

1.1. Laser Receiver Functionality

The Laser Receiver is designed to detect rotating laser beams. The two diode arrays consisting altogether 40 diodes allow the accurate beam detection over a window of 190mm, which simplifies the detection in machine installations, such as when the device is installed to an excavator boom.

The two diode arrays operate in combined mode by default, maximizing the beam detection angle. Due to the diode placement in the two diode arrays, full reception accuracy is only achieved if the beam is detected simultaneously by both diode arrays.

The Laser Reception algorithm has multiple configuration options to suit different installations.

"**Beam detection mode**" configures how the receiver reports detected beam. '*Combined*' mode combines the results of both arrays into a single measurement. The reported laser beam location is an average of the latest beam hits. '*Transmit on reception*' provides independent measurement results for both arrays. The detection result is transmitted to CAN bus at the reception event and is not filtered in any way.

Note, that when '*Transmit on reception*' is used, the detected laser beam data is not processed by the higher-level algorithm. Thus, the "**Trace specific laser beam**" and "**Maximum speed of rotation to detect**" setpoints are not affecting the measured data.

"**Trace specific laser beam**" defines whether the receiver should trace a specific laser beam. If a specific laser beam is to be detected, its parameters are defined in "**Speed of rotation to trace**" and "**Error threshold for speed of rotation**".

Note, that "**Trace specific laser beam**" function still allows the Laser Receiver to report the detected laser beam offset although the detected RPS would be outside the "**Error threshold for speed of rotation setting**". If the detected RPS is out of range, the reported laser beam status will be zero.

To make the detection process more robust, the "**Maximum speed of rotation to detect**" defines the maximum beam rotation speed to detect. Anything higher than this limit will not be considered as a valid laser beam.

"**Threshold voltage**" is the threshold voltage level for the laser diodes. Smaller value yields higher sensitivity but makes the overall sensing more prone to errors.

"**Detection auto-reset time**" specifies the time in milliseconds before the laser detection status is cleared when the laser beam is lost.

"**Laser beam offset polarity**" defines from which end of the diode array the offset calculation is done. '*Bidirectional*' mode uses the center of the diode array as zero level. This allows more freedom in the receiver mounting.

The laser receiver monitors the reception diode saturation status on both reception arrays. The setpoint "**Saturation threshold voltage**" defines a voltage limit for flagging receiver saturated status. In case the reception diodes saturate due to direct sunlight etc., the detection of the laser beam will fail. The saturation status can be broadcasted to the CAN bus as a part of proprietary PGN or as a

DM1 SPN, reporting to the rest of the system that the laser receiver is currently unable to reliably pick up the laser beam.

The detected laser beam offset, rotations per second (RPS) and beam detection status are reported by default in a CAN Transmit message. Depending on the receiver configuration ("**Beam detection mode**" setpoint), the Beam Status data as a Data Source has the configuration options (Data Number) listed in Table 1 and Table 2.

Beam detection mode: Combined

Status index	*Possible values*	*Meaning*
1	0 … 3	0 – no beam(s) detected 1 – beam #1 detected only on array 1 2 – beam #1 detected only on array 2 3 – beam #1 detected on both arrays.
2	0	not used in this mode.
3	0	not used in this mode.

Table 1 – Laser beam status values when configured when 'Combined' mode is used

Beam detection mode: Transmit on reception

Status index	*Possible values*	*Meaning*
1	0 … 2	0 – no beam detected 1 – beam detected on array 1 2 – beam detected on array 2
2	0	not used in this mode.
3	0	not used in this mode.

Table 2 – Laser beam status values when configured when 'Transmit on reception' mode is used

"**Override gain select**" specifies whether the diode state detection circuitry should use a specific gain value or the automatic one. The automatic gain selection is done by measuring the detected ambient light level. The values '*0'* and '*1'* described in Table 3 are also used by Selected Gain control source.

Override gain select value	*Meaning*
0	High gain for low ambient light conditions
1	Low gain for high ambient light conditions
2	Automatic gain select

Table 3 – Override gain select values

The Laser Receiver also contains a heater element inside the housing. By default, the heater is turned on for 5 minutes after bootup if the measured temperature is below 10°C. The temperature measurement is done at bootup using CPU's built in temperature sensor, so the value is just an approximation of the ambient temperature outside the Laser Receiver housing. Heater function can be configured using the "**Heater on threshold temperature**" and "**Heater on time**" setpoints.

1.2. Diagnostic Function Blocks

The Laser Receiver supports diagnostic messaging. DM1 message is a message, containing Active Diagnostic Trouble Codes (DTC) that is sent to the J1939 network in case a fault has been detected. A Diagnostic Trouble Code is defined by the J1939 standard as a four-byte value.

In addition to supporting the DM1 message, the following are supported:

SPN	Suspect Parameter Number	(user defined)
FMI	Failure Mode Identifier	(see Table 5 and Table 6)
CM	Conversion Method	(always set to 0)
OC	Occurrence Count	(number of times the fault has happened)

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

Fault detection and reaction is a standalone functionality that can be configured to monitor and report diagnostics of various controller parameters. The Laser Receiver supports 8 Diagnostics Definitions, each freely configurable by the user.

By default, the diagnostic blocks are configured for monitoring only power supply voltage, processor temperature and communications timeouts. All diagnostics blocks can be freely configured by the user to suit the application.

There are 4 fault types that can be used, '*Minimum and maximum error*', '*Absolute value error*', '*State error*' and '*Double minimum and maximum error*'.

'Minimum and maximum error' has two thresholds, "**MIN Shutdown**" and "**MAX Shutdown**" that have configurable, independent diagnostics parameters (SPN, FMI, Generate DTCs, delay before flagging status). In case the parameter to monitor stays between these two thresholds, the diagnostic is not flagged.

'Absolute value error' has one configurable threshold with configurable parameters. In case the parameter to monitor stays below this threshold, the diagnostic is not flagged.

'*State error*' is like the Absolute value error, the only difference is that State error does not allow the user to specify specific threshold values; thresholds '1' and '0' are used instead. This is ideal for monitoring state information, such as received message timeouts.

'*Double minimum and maximum*' error allows the user to specify four thresholds, each with independent diagnostic parameters. The diagnostic status and threshold values is determined and expected as show in Figure 1 below.

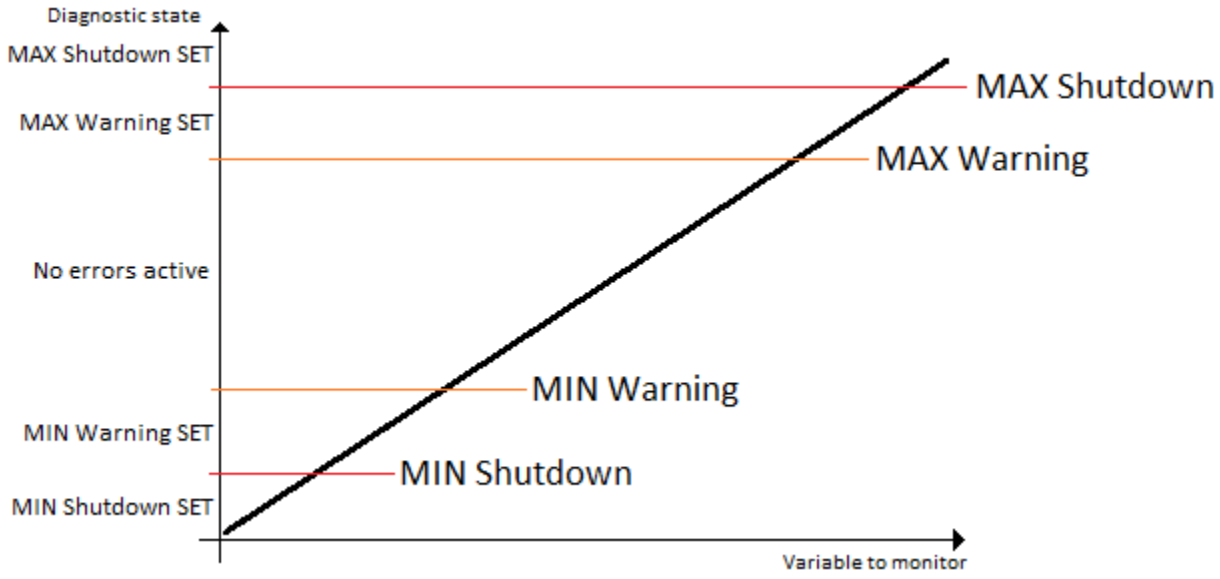


Figure 1 – Double Minimum and Maximum Error Thresholds

There are built in error status flags for power supply and CPU temperature monitoring. In case any of the diagnostics blocks is measuring these two parameters, the corresponding internal error status flags can be used for shutting down the unit in case of failure.

While there are no active DTCs, the Laser Receiver sends DM1 messages with no SPNs, at a rate of one message per second. If a previously inactive DTC becomes active, a DM1 will be sent immediately to reflect this. As soon as the last active DTC goes inactive, a DM1 indicating that there are no more active DTCs will be sent.

If there is more than one active DTC at any given time, the regular DM1 message will be sent using a multipacket message to the Requester Address using the Transport Protocol (TP).

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

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 Event is flagged**" timer for that Diagnostic function block. If the fault has remained present during the delay time, then the controller will set the DTC to active, and 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.

By default, the fault flag is cleared when error condition that has caused it goes away. The DTC is made Previously Active and is it is no longer included in the DM1 message. To identify a fault having happened, even if the condition that has caused is one away, the "**Event Cleared only by DM11**" setpoint can be set to '*True*'. This configuration enables DTC to stay Active, even after the fault flag

has been cleared, and be included in DM1 message until a Diagnostic Data Clear/Reset for Active DTCs (DM11) has been requested.

As defined by J1939 Standard the first byte of the DM1 message reflects the Lamp status. "**Lamp Set by Event**" setpoint determines the lamp type set in this byte of DTC. "**Lamp Set by Event"** setpoint options are listed in Table 4. By default, the '*Amber, Warning'* lamp is typically the one set be any active fault.

0	*Protect*
1	*Amber Warning*
2	*Red Stop*
3	*Malfunction*

Table 4 – Lamp Set by Event in DM1 Options

"**SPN for Event**" defines suspect parameter number used as part of DTC. The default value zero is not allowed by the standard, thus no DM will be sent unless "**SPN for Event**" in is configured to be different from zero. **It is user's responsibility to select SPN that will not violate J1939 standard.** When the "**SPN for Event**" is changed, the OC of the associated error log is automatically reset to zero.

0	*Data Valid But Above Normal Operational Range - Most Severe Level*
1	*Data Valid But Below Normal Operational Range - Most Severe Level*
2	*Data Intermittent*
3	*Voltage Above Normal, Or Shorted To High Source*
4	*Voltage Below Normal, Or Shorted To Low Source*
5	*Current Below Normal Or Open Circuit*
6	*Current Above Normal Or Grounded Circuit*
7	*Mechanical Error*
8	*Abnormal Frequency Or Pulse Width Or Period*
9	*Abnormal Update Rate*
10	*Abnormal Rate Of Change*
11	*Root Cause Not Known*
12	*Bad Component*
13	*Out Of Calibration*
14	*Special Instructions*
15	*Data Valid But Above Normal Operating Range – Least Severe Level*
16	*Data Valid But Above Normal Operating Range – Moderately Severe Level*
17	*Data Valid But Below Normal Operating Range – Least Severe Level*
18	*Data Valid But Below Normal Operating Range – Moderately Severe Level*
19	*Network Error*
20	*Data Drifted High*
21	*Data Drifted Low*
31	*Condition Exists*

Table 5 – FMI for Event Options

Every fault has associated a default FMI with them. The used FMI can be configured with "**FMI for Event**" setpoint, presented in Table 5. When an FMI is selected from Low Fault FMIs in Table 6 for a fault that can be flagged either high or low occurrence, it is recommended that the user would

select the high occurrence FMI from the right column of Table 6. There is no automatic setting of High and Low FMIs in the firmware, the user can configure these freely.

Low Fault FMIs	High Fault FMIs
FMI=1, Data Valid But Below Normal Operation 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 Level – 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 6 – Low Fault FMIs and corresponding High Fault FMIs

1.3. CAN Transmit Message Function Block

The CAN Transmit function block is used to send any output from another function block (i.e. input, CAN receive) to the J1939 network. The Laser Receiver has two CAN Transmit Messages and each message has four completely user defined signals.

1.3.1. CAN Transmit Message Setpoints

Each CAN Transmit Message setpoint group includes setpoints that affect the whole message and are thus mutual for all signals of the message. These setpoints are presented in this section. The setpoints that configure an individual signal are presented in the next section.

The "**Transmit PGN**" setpoint sets PGN used with the message. **Users should be familiar with the SAE J1939 standard and select values for PGN/SPN combinations as appropriate from section J1939/71**.

"**Transmit Repetition Rate**" setpoint defines the interval used to send the message to the J1939 network. If the "**Transmit Repetition Rate**" is set to zero, the message is disabled unless it shares its PGN with another message. In the case of a shared PGN, the repetition rate of the LOWEST numbered message is used to send the message 'bundle'.

At power up, transmitted message will not be broadcasted until after a 2 second delay. This is done to prevent any power up or initialization conditions from creating problems on the network.

By default, the first message is configured to report Laser beam offset, status, detected speed of rotation and diode saturation status.

1.3.2. CAN Transmit Signal Setpoints

Each CAN transmit message has four associated signals, which define data inside the Transmit message. "**Control Source**" setpoint together with "**Control Number**" setpoint define the signal source of the message. "**Control Source**" and "**Control Number**" options are listed in Table 7. Setting "**Control Source**" to '*Control Not Used'* disables the signal.

"**Transmit Data Size**" setpoint determines how many bits signal reserves from the message. "**Transmit Data Index in Array**" determines in which of 8 bytes of the CAN message LSB of the signal is located. Similarly, "**Transmit Bit Index in Byte**" determines in which of 8 bits of a byte the LSB is located. These setpoints are freely configurable, therefore **it is the User's responsibility to ensure that signals do not overlap and mask each other**.

"**Transmit Data Resolution**" setpoint determines the scaling done on the signal data before it is sent to the bus. "**Transmit Data Offset**" setpoint determines the value that is subtracted from the signal data before it is scaled. Offset and Resolution are interpreted in units of the selected source signal.

1.4. CAN Receive Function Block

The CAN Receive function block is designed to take any SPN from the J1939 network and use it as an input to another function block (i.e. Outputs).

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 disabled.

Once a message has been enabled, a Lost Communication fault will be flagged if that message is not received off the bud within the “**Receive Message Timeout**” period. This could trigger a Lost Communication event as described in section 0. 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 trigger a Lost Communication fault.

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 clock can be selected as the source of the control input for the output function blocks. When this is case, the “**Received Data Min (Off Threshold)**” and “**Received Data Max (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 CAN receive signal.

The Laser Receiver supports up to two unique CAN Receive Messages.

1.5. Available Control Sources

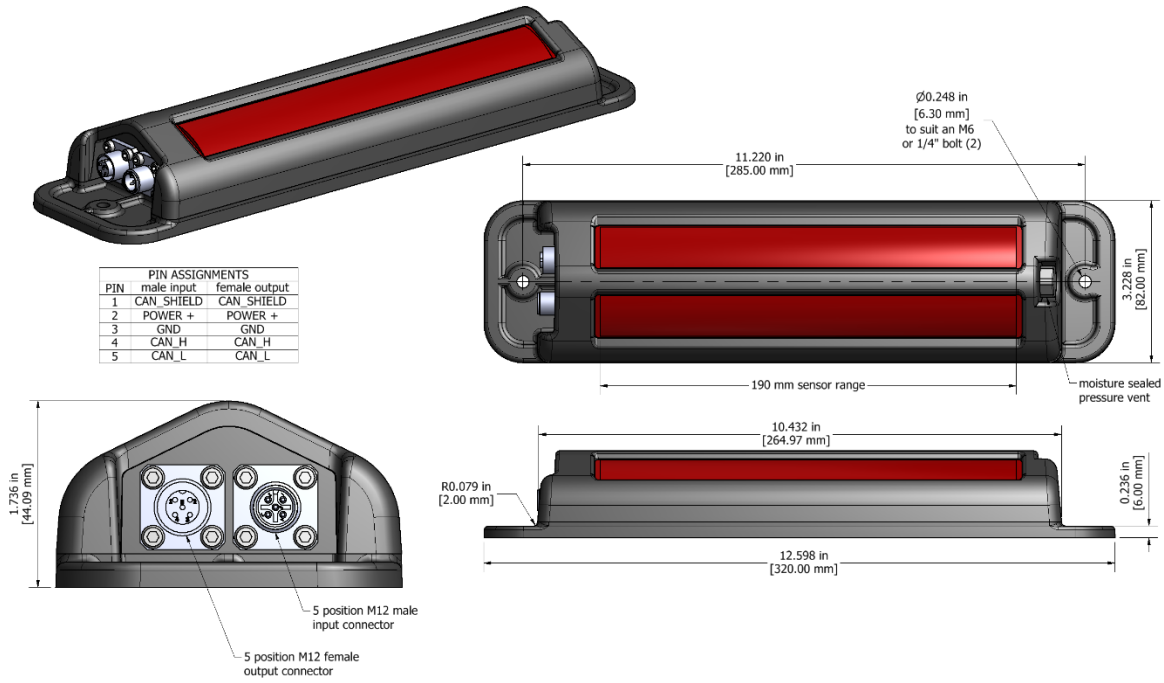
Many of the Function Blocks have selectable input signals, which are determined with "**[Name] Source**" and "**[Name] Number**" setpoints. Together, these setpoints uniquely select how the I/O of the various function blocks are linked together. "**[Name] Source**" setpoint determines the type of the source and "**[Name] Number**" selects the actual source if there is more than one of the same type. Available "**[Name] Source**" options and associated "**[Name] Number**" ranges are listed in Table 7. All sources are available for all blocks. Though input Sources are freely selectable, it must be remembered that not all options would make sense in all cases, and it is up to the user to program the controller in a logical and functional manner.

Sources	Number Range	Notes
0: Control Not Used	N/A	When this is selected, it disables all other setpoints associated with the signal in question.
1: Received CAN Message	1 to 2	User must enable the function block, as it is disabled by default.
2: Laser Beam Offset	1 to 2	See section 1.1 for details
3: Laser Beam Status	1 to 3	See section 1.1 for details
4: Laser Beam RPS	1 to 2	See section 1.1 for details
5: Power Supply Measured	1	Measured power supply value in Volts.
6: Processor Temperature Measured	1	Measured processor temperature in °C.
7: Saturation Status	1	See section 1.1 for details
8: Saturation Voltage Measured	1 to 2	See section 1.1 for details
9: Selected Gain	1 to 2	See section 1.1 for details
10: Heater Status	1	See section 1.1 for details
11: Receive Message Timeout	1	Status reads as '1' if CAN Rx message times out

Table 7 – Available Control Sources and Numbers

2. INSTALLATION INSTRUCTIONS

2.1. Dimensions and Pinout



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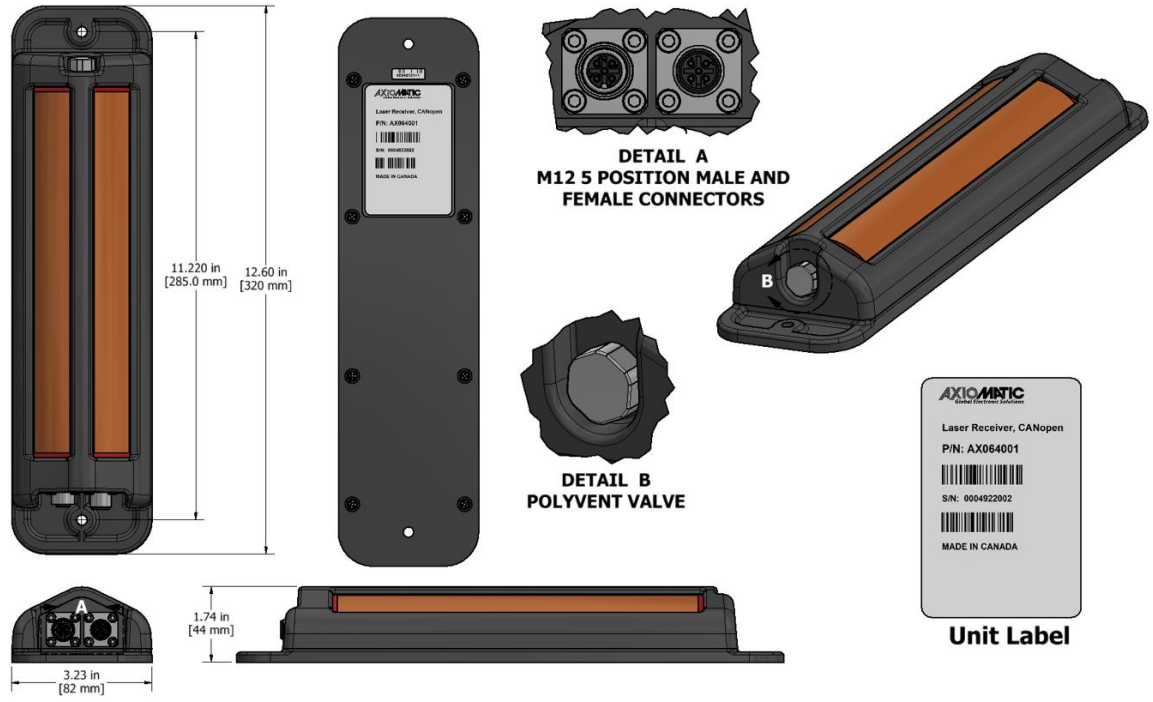

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Figure 2 – AX064000 Dimensional Drawing

M12 Male Connector PIN #	Function	M12 Female Connector PIN #	Function
1	CAN Shield	1	CAN Shield
2	Power +	2	Power +
3	GND	3	GND
4	CAN H	4	CAN H
5	CAN L	5	CAN L

Table 8 – AX064000 Connector Pinout

3. OVERVIEW OF J1939 FEATURES

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

- Configurable ECU Instance in the NAME (to allow multiple ECUs on the same network)
- Configurable Input Parameters
- Configurable PGN and Data Parameters
- Configurable Diagnostic Messaging Parameters, as required
- Diagnostic Log, maintained in non-volatile memory

3.1. Introduction to Supported Messages

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

From J1939-21 – Data Link Layer

• Request		59904	0x00EA00
• Acknowledgement		59392	0x00E800
• Transport Protocol – Connection Management		60416	0x00EC00
• Transport Protocol – Data Transfer Message		60160	0x00EB00
• Proprietary B	from	65280	0x00FF00
	to	65535	0x00FFFF

From J1939-73 – Diagnostics

• DM1 – Active Diagnostic Trouble Codes	65226	0x00FECA
• DM2 – Previously Active Diagnostic Trouble Codes	65227	0x00FECB
• DM3 – Diagnostic Data Clear/Reset for Previously Active DTCs	65228	0x00FECC
• DM11 – Diagnostic Data Clear/Reset for Active DTCs	65235	0x00FED3
• DM14 – Memory Access Request	55552	0x00D900
• DM15 – Memory Access Response	55296	0x00D800
• DM16 – Binary Data Transfer	55040	0x00D700

From J1939-81 – Network Management

• Address Claimed/Cannot Claim	60928	0x00EE00
• Commanded Address	65240	0x00FED8

From J1939-71 – Vehicle Application Layer

• Software Identification	65242	0x00FEDA

None of the application layer PGNs are supported as part of the default configurations, but they can be selected as desired for transmit 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 CAN network.

3.2. NAME, Address and Software ID

The Laser Receiver has the following default 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	3, Construction Equipment
Vehicle System Instance	0
Vehicle System	0, Non-specific system
Function	129, Axiomatic Laser Receiver
Function Instance	1, Axiomatic AX064000
ECU Instance	0, First Instance
Manufacture Code	162, Axiomatic Technologies
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 from one another when they are connected on the same network.

The default value of the “ECU Address” setpoint is 234 (0xEA), which is the preferred starting address for self-configurable ECUs as set by the SAE in J1939 tables B3 and B7. The EA will allow the selection of any address between 0 and 253. ***It is 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 Laser Receiver will continue select the next highest address until it finds one that it can claim. See J1939/81 for more details about address claiming.

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

Byte 1 is set to 5, and the identification fields are as follows.

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

The 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. ECU SETPOINTS ACCESSED WITH AXIOMATIC ELECTRONIC ASSISTANT

This section describes in detail each setpoint, and their default and ranges. Default values presented in tables are values used when setpoint in question is active. Many of the setpoints are dependent on other setpoints and they may not be active by default. Associated Figures show screen capture of initial operation, however some of the setpoints are not in default condition as they are set differently to activate more setpoints for the image. The setpoints are divided into setpoint groups as they are shown in EA. For more information on how each setpoint is used by the Laser Receiver, refer to the relevant section in this user manual.

4.1. J1939 Network Parameters

"**ECU Instance Number**" and "**ECU Address**" setpoints and their effect are defined in Section 3.2.

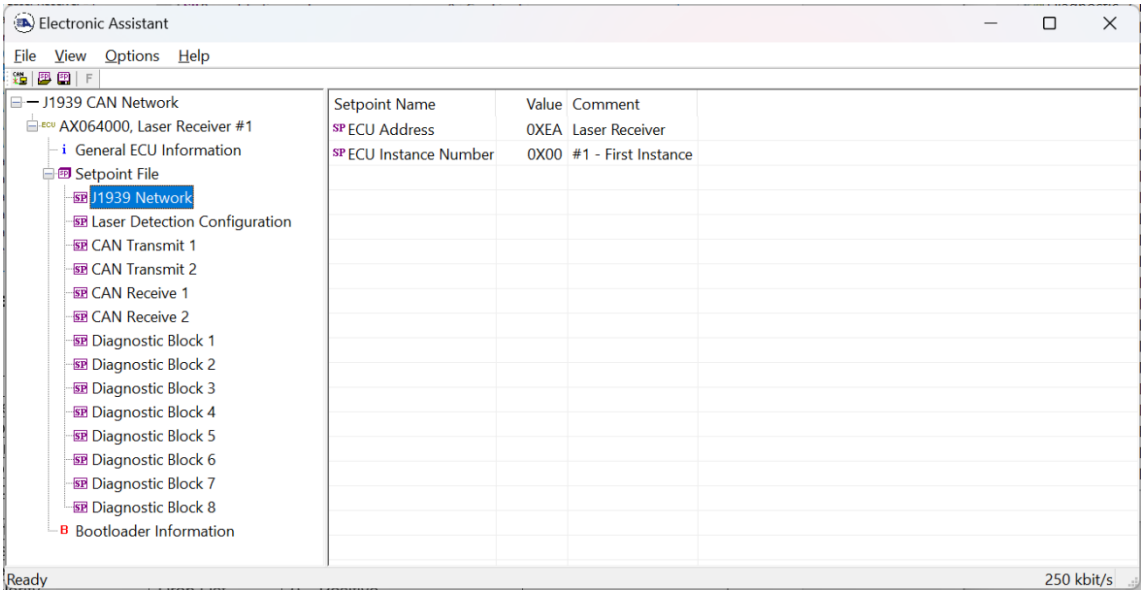


Figure 3 - Screen Capture of J1939 Setpoints

Name	Range	Default	Notes
ECU Address	0-253	0xEA	Preferred address for a Laser Receiver
ECU Instance	0-7	0x00	Per J1939-81

Table 9 – J1939 Network Setpoints

If non-default values for the **"ECU Instance Number"** or **"ECU Address"** are used, they will be mirrored during a setpoint file flashing, and will only take effect once the entire file has been downloaded to the unit. After the setpoint flashing is complete, the unit will claim the new address and/or re-claim the address with the new NAME. If these setpoints are changing, it is recommended to close and re-open the CAN connection on EA after the file is loaded so that only the new NAME and address are showing in the J1939 CAN Network ECU list.

4.2. Laser Detection Configuration Setpoints

The detailed description of laser detection parameters, please refer to section 1.1.

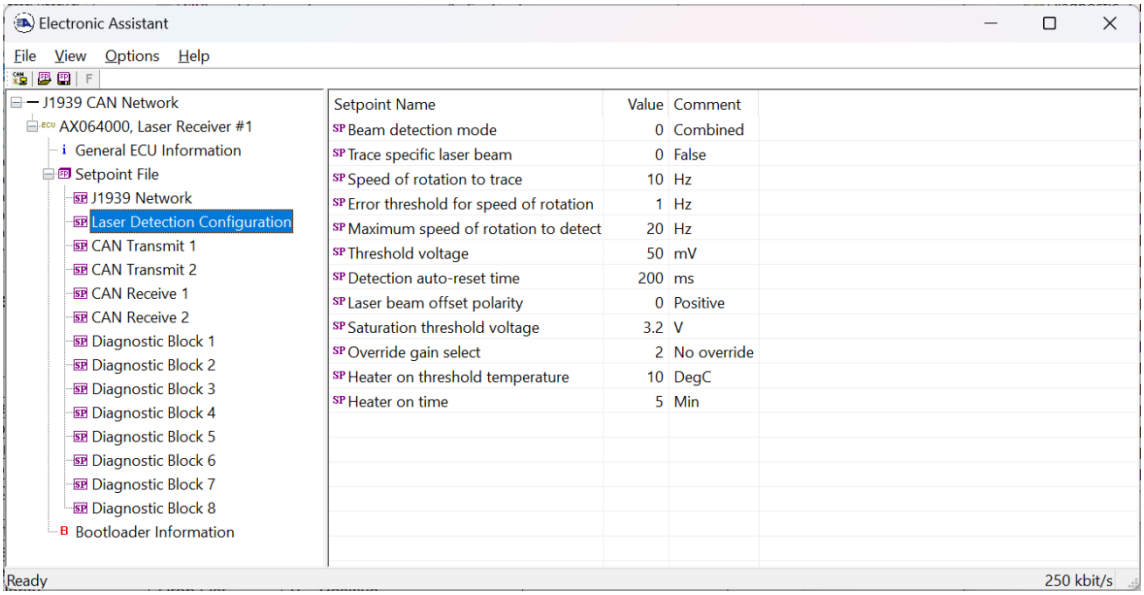


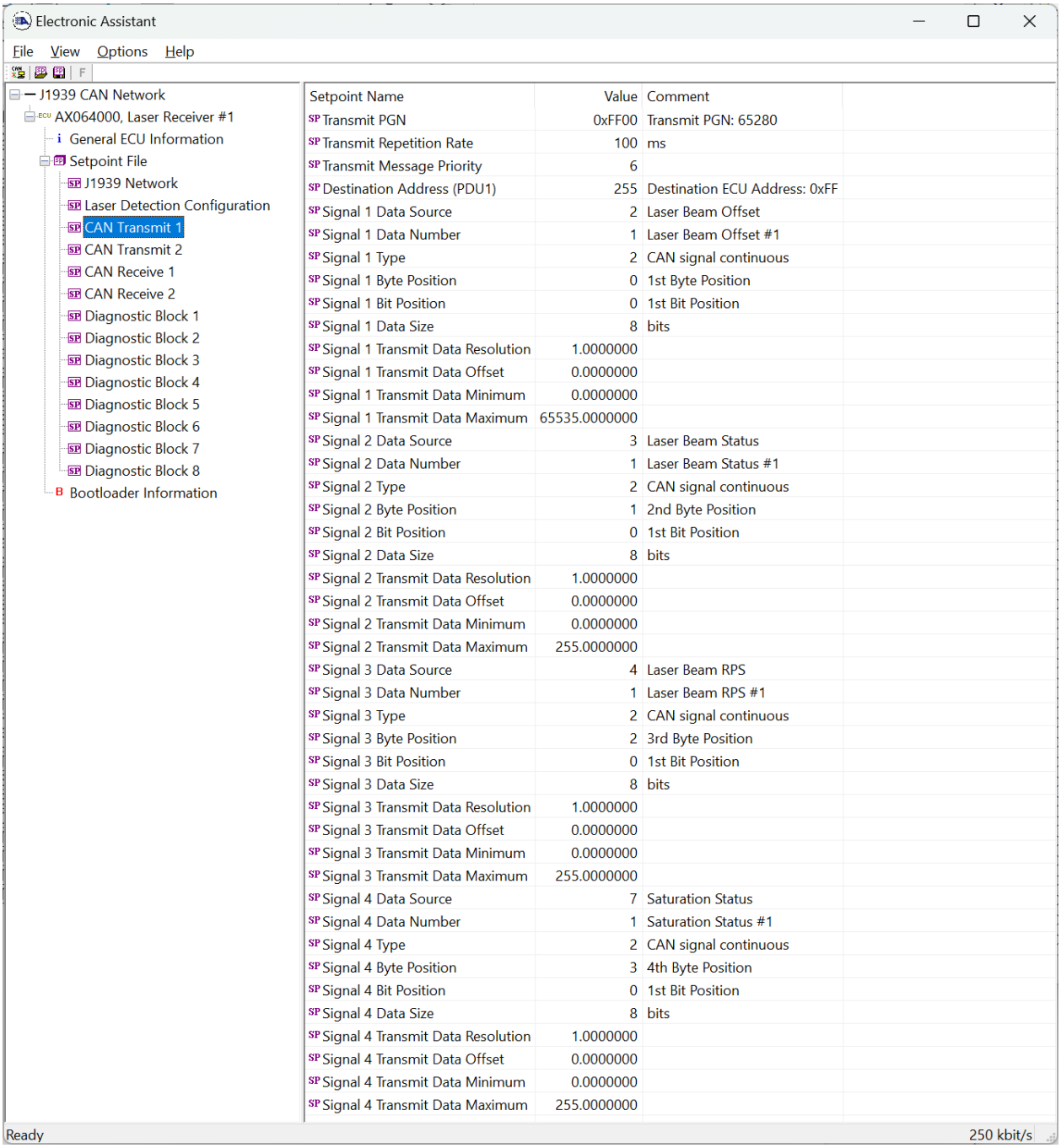
Figure 4 - Screen Capture of Laser Detection Configuration Setpoints

Name	Range	Default	Notes
Beam detection mode	0, 2	0 – Combined	See section 1.1
Trace specific laser beam	Drop List	0 – False	
Speed of rotation to trace	1…100	10	Hz
Error threshold for speed of rotation	0…5	1	Hz
Maximum speed of rotation to detect	1…20	20	Hz
Threshold voltage	0…3000	50	mV
Detection auto-reset time	50…5000	200	ms
Laser beam offset polarity	Drop List	0 – Positive	
Saturation threshold voltage	0…5	3.2	V
Override gain select	Drop List	2 – No override	
Heater on threshold temperature	-40…20	10	°C
Heater on time	0…10080	5	minutes

Table 10 – Laser Detection Configuration Setpoints

4.3. CAN Transmit Setpoints

Please refer to section 1.3 for detailed information how these setpoints are used. “**Transmit Repetition Rate**” is 100ms by default for Transmit #1 and 500ms for Transmit #2.



Setpoint Name	Value	Comment
Transmit PGN	0xFF00	Transmit PGN: 65280
Transmit Repetition Rate	100	ms
Transmit Message Priority	6	
Destination Address (PDU1)	255	Destination ECU Address: 0xFF
Signal 1 Data Source	2	Laser Beam Offset
Signal 1 Data Number	1	Laser Beam Offset #1
Signal 1 Type	2	CAN signal continuous
Signal 1 Byte Position	0	1st Byte Position
Signal 1 Bit Position	0	1st Bit Position
Signal 1 Data Size	8	bits
Signal 1 Transmit Data Resolution	1.0000000	
Signal 1 Transmit Data Offset	0.0000000	
Signal 1 Transmit Data Minimum	0.0000000	
Signal 1 Transmit Data Maximum	65535.0000000	
Signal 2 Data Source	3	Laser Beam Status
Signal 2 Data Number	1	Laser Beam Status #1
Signal 2 Type	2	CAN signal continuous
Signal 2 Byte Position	1	2nd Byte Position
Signal 2 Bit Position	0	1st Bit Position
Signal 2 Data Size	8	bits
Signal 2 Transmit Data Resolution	1.0000000	
Signal 2 Transmit Data Offset	0.0000000	
Signal 2 Transmit Data Minimum	0.0000000	
Signal 2 Transmit Data Maximum	255.0000000	
Signal 3 Data Source	4	Laser Beam RPS
Signal 3 Data Number	1	Laser Beam RPS #1
Signal 3 Type	2	CAN signal continuous
Signal 3 Byte Position	2	3rd Byte Position
Signal 3 Bit Position	0	1st Bit Position
Signal 3 Data Size	8	bits
Signal 3 Transmit Data Resolution	1.0000000	
Signal 3 Transmit Data Offset	0.0000000	
Signal 3 Transmit Data Minimum	0.0000000	
Signal 3 Transmit Data Maximum	255.0000000	
Signal 4 Data Source	7	Saturation Status
Signal 4 Data Number	1	Saturation Status #1
Signal 4 Type	2	CAN signal continuous
Signal 4 Byte Position	3	4th Byte Position
Signal 4 Bit Position	0	1st Bit Position
Signal 4 Data Size	8	bits
Signal 4 Transmit Data Resolution	1.0000000	
Signal 4 Transmit Data Offset	0.0000000	
Signal 4 Transmit Data Minimum	0.0000000	
Signal 4 Transmit Data Maximum	255.0000000	

Figure 5 - Screen Capture of CAN Transmit Message Setpoints

Name	Range	Default	Notes
Transmit PGN	0xff00 … 0xffff	Different for each	See Section 1.3.1
Transmit Repetition Rate	0 … 65000 ms	0ms	0ms disables transmit
Transmit Message Priority	0...7	6	
Destination Address	0...255	255	Not used by default
Signal 1 Data Source	Drop List	Different for each	See Table 7
Signal 1 Data Number	Drop List	Different for each	See 1.3.2
Signal 1 Type	Drop List	2	Continuous data
Signal 1 Byte Position	0-7	0	
Signal 1 Bit Position	0-7	0	
Signal 1 Data Size	Drop List	16 bits	
Signal 1 Transmit Data Resolution	-100000.0 to 100000	Different for each	
Signal 1 Transmit Data Offset	-10000 to 10000	0.0	
Signal 1 Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal 1 Transmit Data Maximum	-100000.0 to 100000	Different for each	
Signal 2 Data Source	Drop List	Different for each	See Table 7
Signal 2 Data Number	Drop List	Different for each	See 1.3.2
Signal 2 Type	Drop List	2	Continuous data
Signal 2 Byte Position	0-7	0	
Signal 2 Bit Position	0-7	0	
Signal 2 Data Size	Drop List	16 bits	
Signal 2 Transmit Data Resolution	-100000.0 to 100000	Different for each	
Signal 2 Transmit Data Offset	-10000 to 10000	0.0	
Signal 2 Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal 2 Transmit Data Maximum	-100000.0 to 100000	Different for each	
Signal 3 Data Source	Drop List	Different for each	See Table 7
Signal 3 Data Number	Drop List	Different for each	See 1.3.2
Signal 3 Type	Drop List	2	Continuous data
Signal 3 Byte Position	0-7	0	
Signal 3 Bit Position	0-7	0	
Signal 3 Data Size	Drop List	16 bits	
Signal 3 Transmit Data Resolution	-100000.0 to 100000	Different for each	
Signal 3 Transmit Data Offset	-10000 to 10000	0.0	
Signal 3 Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal 3 Transmit Data Maximum	-100000.0 to 100000	Different for each	
Signal 4 Data Source	Drop List	Different for each	See Table 7
Signal 4 Data Number	Drop List	Different for each	See 1.3.2
Signal 4 Type	Drop List	2	Continuous data
Signal 4 Byte Position	0-7	0	
Signal 4 Bit Position	0-7	0	
Signal 4 Data Size	Drop List	16 bits	
Signal 4 Transmit Data Resolution	-100000.0 to 100000	Different for each	
Signal 4 Transmit Data Offset	-10000 to 10000	0.0	
Signal 4 Transmit Data Minimum	-100000.0 to 100000	0.0	
Signal 4 Transmit Data Maximum	-100000.0 to 100000	Different for each	

Table 11 – CAN Transmit Message Setpoints

4.4. CAN Receive Setpoints

Please refer to section 1.4 for detailed information about how these setpoints are used. “**Receive Message Enabled**” setpoint is set to False by default.

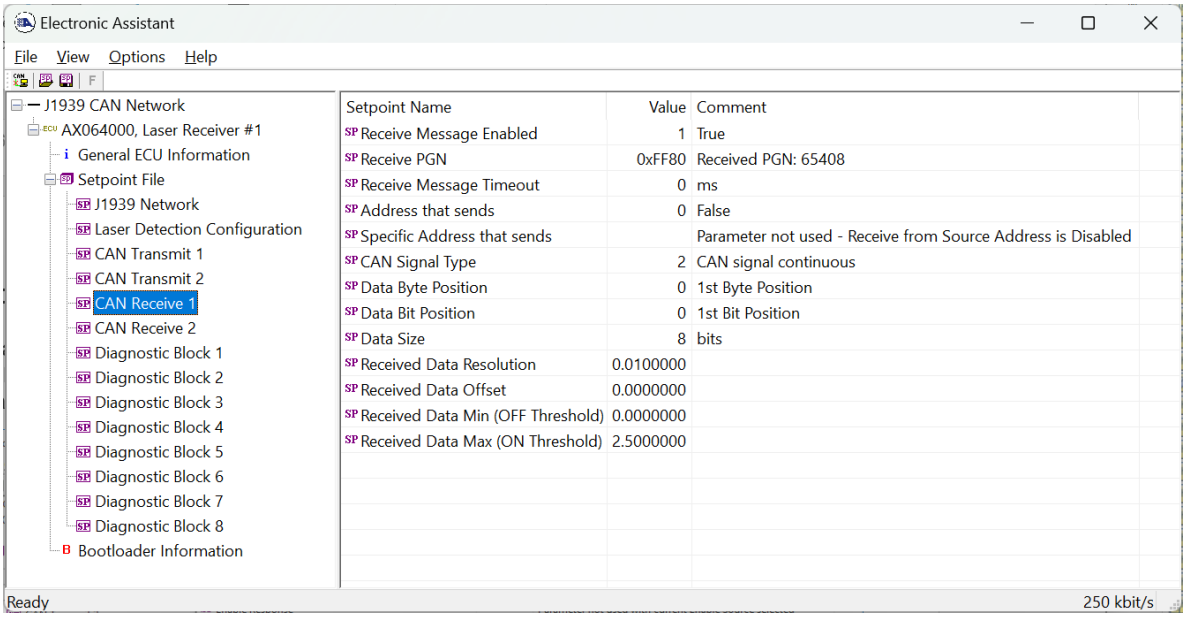


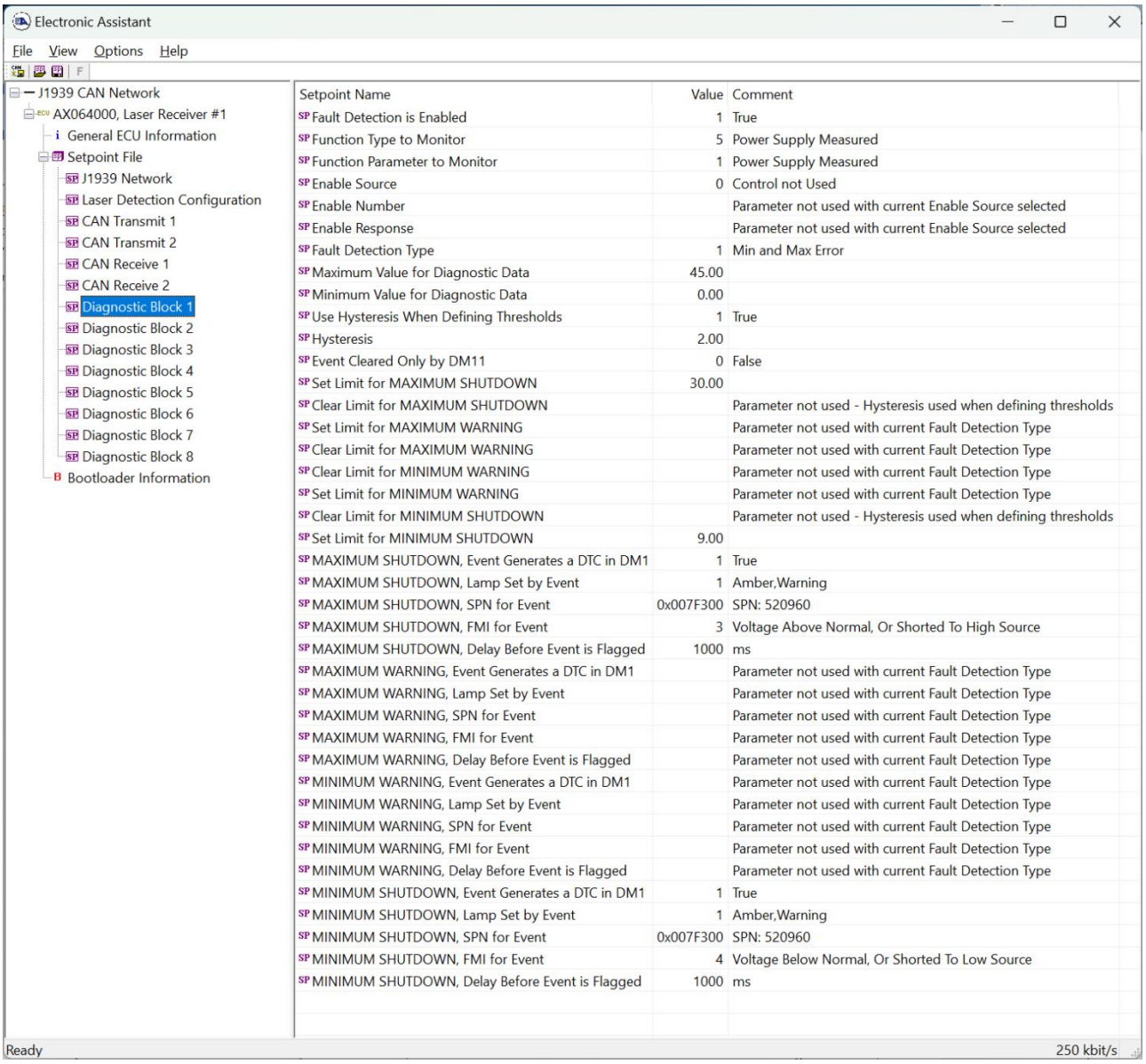
Figure 6 - Screen Capture of CAN Receive Message Setpoints

Name	Range	Default	Notes
Receive Message Enabled	Drop List	False	
Receive PGN	0 to 65536	Different for each	
Receive Message Timeout	0 to 60 000 ms	0ms	
Address that sends	Drop List	False	
Specific address that sends	0 to 255	254 (0xFE, Null Addr)	
CAN Signal Type	Drop List	2 – Continuous data	
Data Byte Position	0-7	0	
Data Bit Position	0-7	0	
Data Size	0-32	8 bits	
Received Data Resolution	-100000.0 to 100000	0.01	
Received Data Offset	-10000 to 10000	0.0	
Received Data Min (Off Threshold)	-1000000 to Max	0.0	
Received Data Max (On Threshold)	-100000 to 100000	2.5	

Table 12 – CAN Receive Setpoints

4.5. Diagnostics Blocks

There are 8 Diagnostics blocks that can be configured to monitor various parameters of the Controller. The Diagnostic Function Block is defined in section 0. Please refer there for detailed information how these setpoints are used.



Setpoint Name	Value	Comment
Fault Detection is Enabled	1	True
Function Type to Monitor	5	Power Supply Measured
Function Parameter to Monitor	1	Power Supply Measured
Enable Source	0	Control not Used
Enable Number		Parameter not used with current Enable Source selected
Enable Response		Parameter not used with current Enable Source selected
Fault Detection Type	1	Min and Max Error
Maximum Value for Diagnostic Data	45.00	
Minimum Value for Diagnostic Data	0.00	
Use Hysteresis When Defining Thresholds	1	True
Hysteresis	2.00	
Event Cleared Only by DM11	0	False
Set Limit for MAXIMUM SHUTDOWN	30.00	
Clear Limit for MAXIMUM SHUTDOWN		Parameter not used - Hysteresis used when defining thresholds
Set Limit for MAXIMUM WARNING		Parameter not used with current Fault Detection Type
Clear Limit for MAXIMUM WARNING		Parameter not used with current Fault Detection Type
Clear Limit for MINIMUM WARNING		Parameter not used with current Fault Detection Type
Set Limit for MINIMUM WARNING		Parameter not used with current Fault Detection Type
Clear Limit for MINIMUM SHUTDOWN		Parameter not used - Hysteresis used when defining thresholds
Set Limit for MINIMUM SHUTDOWN	9.00	
MAXIMUM SHUTDOWN, Event Generates a DTC in DM1	1	True
MAXIMUM SHUTDOWN, Lamp Set by Event	1	Amber,Warning
MAXIMUM SHUTDOWN, SPN for Event	0x007F300	SPN: 520960
MAXIMUM SHUTDOWN, FMI for Event	3	Voltage Above Normal, Or Shorted To High Source
MAXIMUM SHUTDOWN, Delay Before Event is Flagged	1000	ms
MAXIMUM WARNING, Event Generates a DTC in DM1		Parameter not used with current Fault Detection Type
MAXIMUM WARNING, Lamp Set by Event		Parameter not used with current Fault Detection Type
MAXIMUM WARNING, SPN for Event		Parameter not used with current Fault Detection Type
MAXIMUM WARNING, FMI for Event		Parameter not used with current Fault Detection Type
MAXIMUM WARNING, Delay Before Event is Flagged		Parameter not used with current Fault Detection Type
MINIMUM WARNING, Event Generates a DTC in DM1		Parameter not used with current Fault Detection Type
MINIMUM WARNING, Lamp Set by Event		Parameter not used with current Fault Detection Type
MINIMUM WARNING, SPN for Event		Parameter not used with current Fault Detection Type
MINIMUM WARNING, FMI for Event		Parameter not used with current Fault Detection Type
MINIMUM WARNING, Delay Before Event is Flagged		Parameter not used with current Fault Detection Type
MINIMUM SHUTDOWN, Event Generates a DTC in DM1	1	True
MINIMUM SHUTDOWN, Lamp Set by Event	1	Amber,Warning
MINIMUM SHUTDOWN, SPN for Event	0x007F300	SPN: 520960
MINIMUM SHUTDOWN, FMI for Event	4	Voltage Below Normal, Or Shorted To Low Source
MINIMUM SHUTDOWN, Delay Before Event is Flagged	1000	ms

Figure 7 - Screen Capture of Diagnostic Block Setpoints

Name	Range	Default	Notes
Fault Detection is Enabled	Drop List	False	
Function Type to Monitor	Drop List	0 – Control not used	
Function parameter to Monitor	Drop List	0 – No selection	
Fault Detection Type	Drop List	1 – Min and Max Error	See section 0
Maximum Value for Diagnostic Data	Minimum Value for Diagnostic Data … $4.28e^9$	5.0	
Minimum Value for Diagnostic Data	0.0 … Maximum Value for Diagnostic Data	0.0	
Use Hysteresis When Defining Thresholds	Drop List	False	
Hysteresis	0.0 … Maximum Value for Diagnostic Data	0.0	
Event Cleared only by DM11	Drop List	False	
Set Limit for MAXIMUM SHUTDOWN	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	4.8	
Clear Limit for MAXIMUM SHUTDOWN	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	4.6	
Set Limit for MAXIMUM WARNING	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.0	
Clear Limit for MAXIMUM WARNING	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.0	
Clear Limit for MINIMUM WARNING	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.0	
Set Limit for MINIMUM WARNING	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.0	
Clear Limit for MINIMUM SHUTDOWN	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.4	
Set Limit for MINIMUM SHUTDOWN	Minimum Value for Diagnostic Data … Maximum Value for Diagnostics Data	0.2	
MAXIMUM SHUTDOWN, Event Generates a DTC in DM1	Drop List	True	
MAXIMUM SHUTDOWN, Lamp Set by Event	Drop List	0 – Protect	See Table 4
MAXIMUM SHUTDOWN, SPN for Event	0...524287	520448 ($7F100)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.

MAXIMUM SHUTDOWN, FMI for Event	Drop List	3, Voltage Above Normal	See Table 5
MAXIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	
MAXIMUM WARNING, Event Generates a DTC in DM1	Drop List	True	
MAXIMUM WARNING, Lamp Set by Event	Drop List	0 – Protect	See Table 4
MAXIMUM WARNING, SPN for Event	0...524287	520704 ($7F200)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MAXIMUM WARNING, FMI for Event	Drop List	3, Voltage Above Normal	See Table 5
MAXIMUM WARNING, Delay Before Event is Flagged	0...60000 ms	1000	
MINIMUM WARNING, Event Generates a DTC in DM1	Drop List	True	
MINIMUM WARNING, Lamp Set by Event	Drop List	0 – Protect	See Table 4
MAXIMUM WARNING, SPN for Event	0...524287	520960 ($7F300)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MINIMUM WARNING, FMI for Event	Drop List	4, Voltage Below Normal	See Table 5
MINIMUM WARNING, Delay Before Event is Flagged	0...60000 ms	1000	
MINIMUM SHUTDOWN, Event Generates a DTC in DM1	Drop List	True	
MINIMUM SHUTDOWN, Lamp Set by Event	Drop List	Amber Warning	See Table 4
MINIMUM SHUTDOWN, SPN for Event	0...524287	521216 ($7F400)	It is the user's responsibility to select an SPN that will not violate the J1939 standard.
MINIMUM SHUTDOWN, FMI for Event	Drop List	4, Voltage Below Normal	See Table 5
MINIMUM SHUTDOWN, Delay Before Event is Flagged	0...60000 ms	1000	

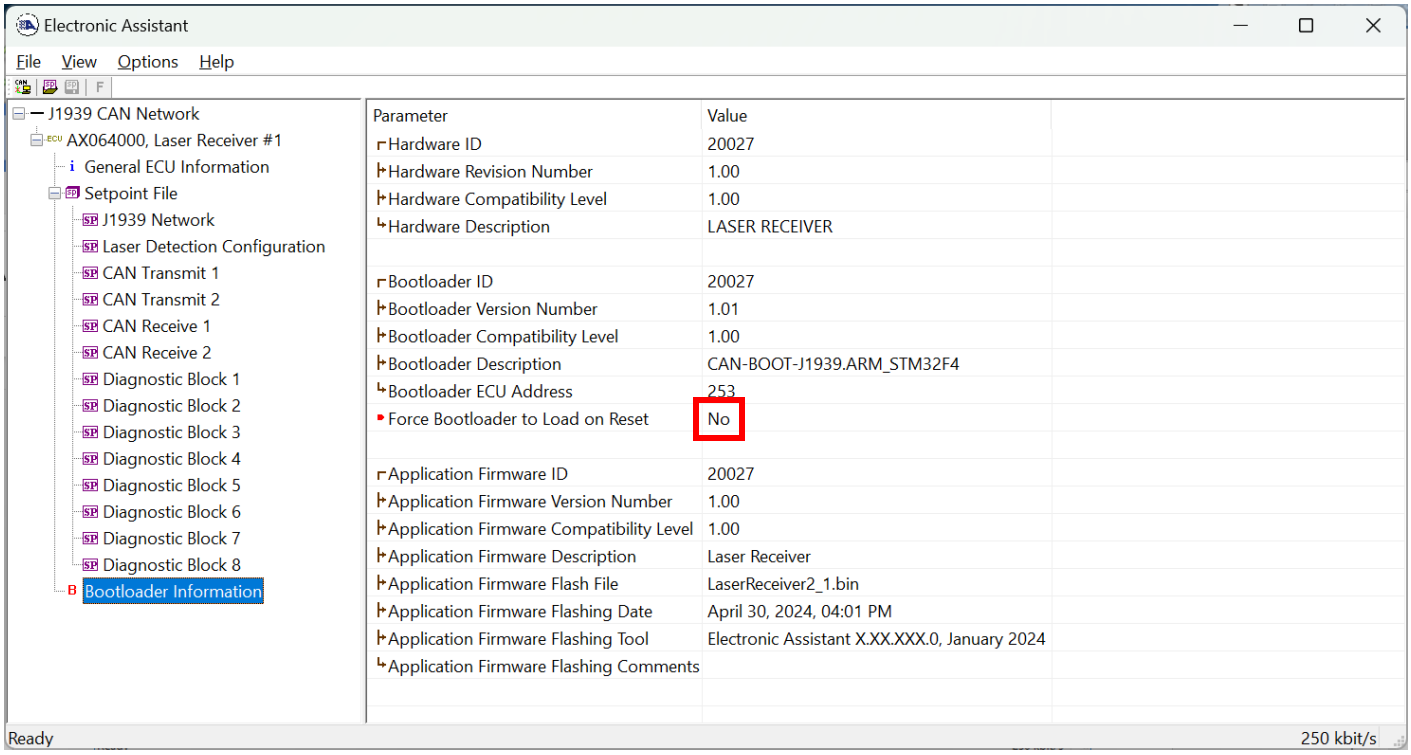
Table 13 – Diagnostic Block Setpoints

5. REFLASHING OVER CAN WITH EA BOOTLOADER

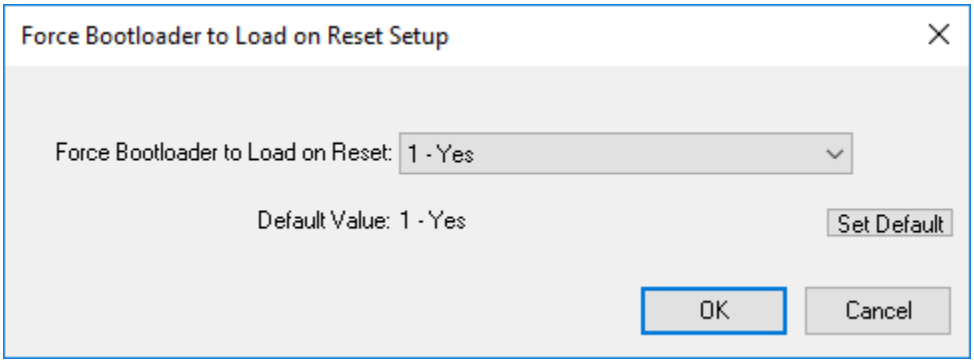
The AX064000 can be upgraded with new application firmware using the **Bootloader Information** section. This section details the simple step-by-step instructions to upload new firmware provided by Axiomatic onto the unit via CAN, without requiring it to be disconnected from the J1939 network.

Note: To upgrade the firmware use Axiomatic Electronic Assistant V5.xx.yy.0 or higher.

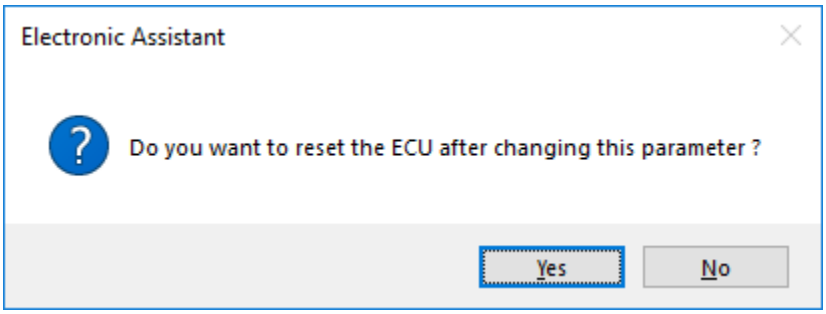
1. When EA first connects to the ECU, the **Bootloader Information** section will display the following information.



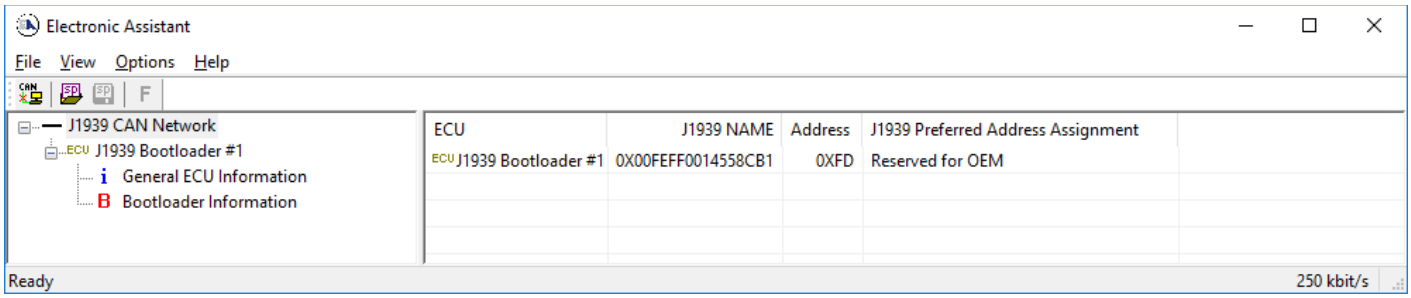
2. To use the bootloader to upgrade the firmware running on the ECU, change the variable **"Force Bootloader To Load on Reset**" to *Yes.*

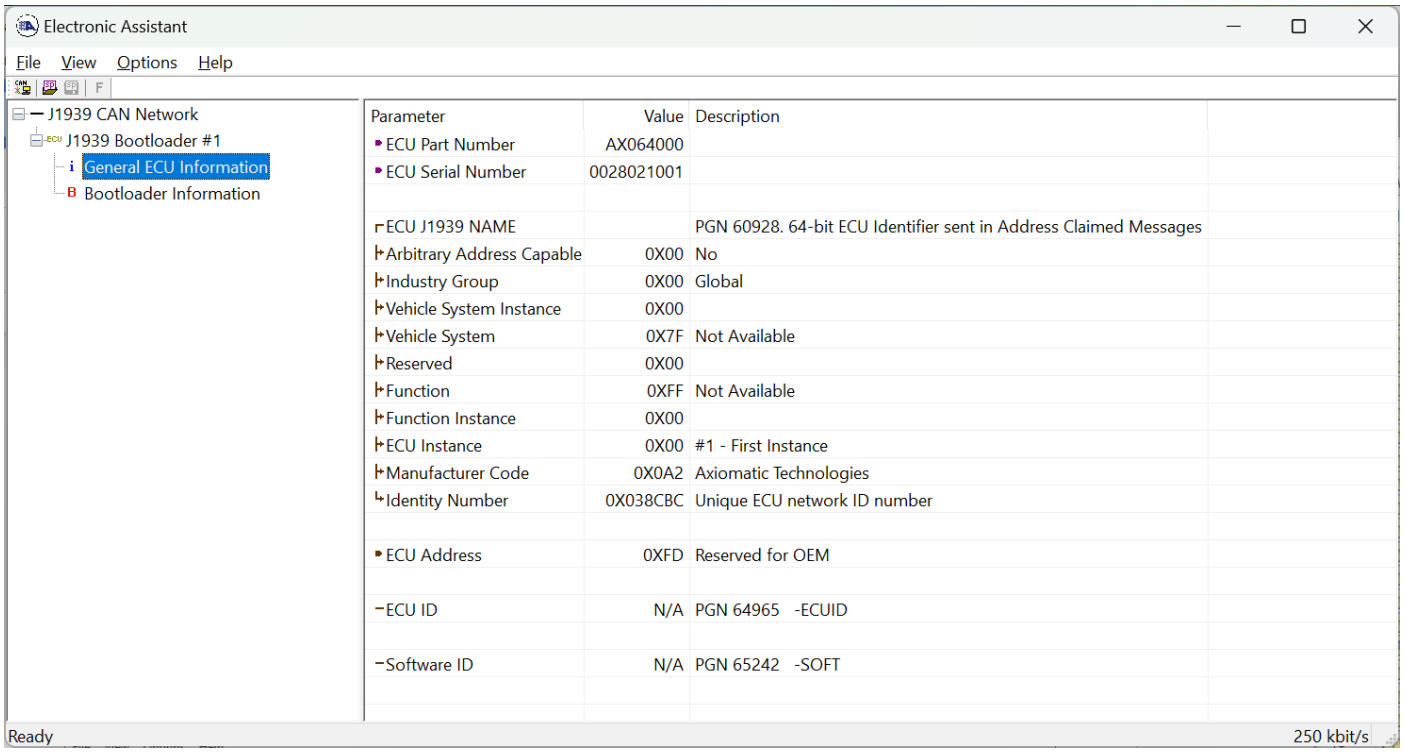


3. When the prompt box asks if you want to reset the ECU, select *Yes*.



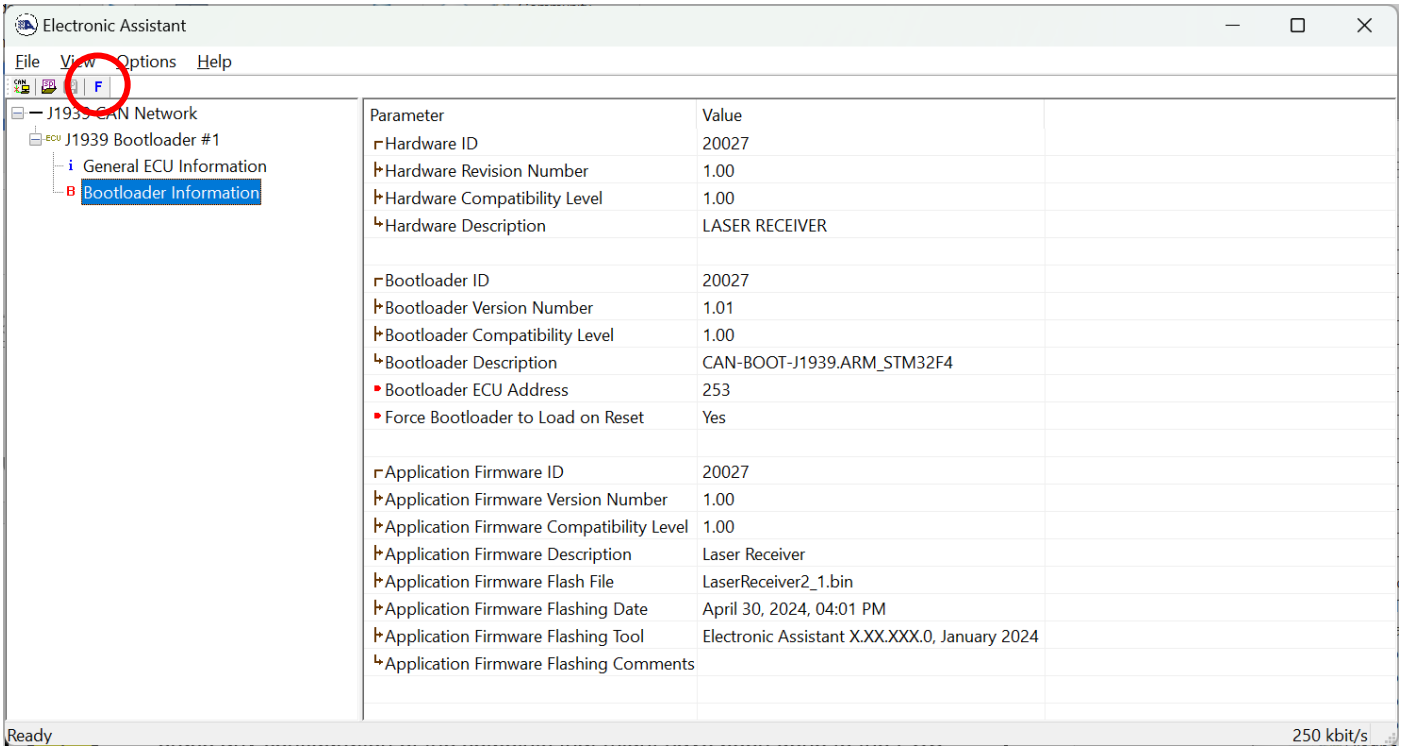
4. Upon reset, the ECU will no longer show up on the J1939 network as an AX064000 but rather as **J1939 Bootloader #1**.





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.

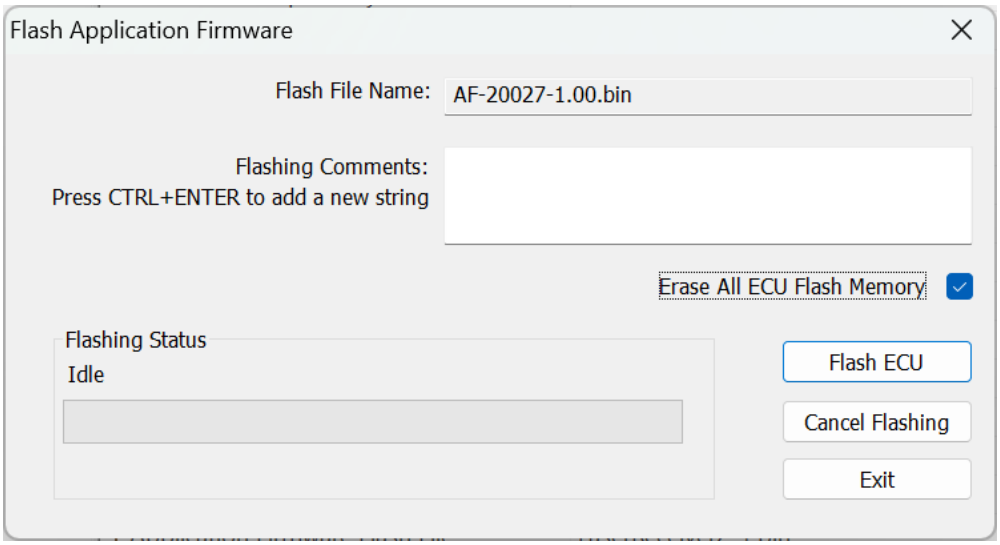
5. When the **Bootloader Information** section is selected, the same information is shown as when it was running the AX064000 firmware, but in this case the **F**lashing feature has been enabled.



6. Select the **F**lashing button and navigate to where you had saved the **AF-20027-x.yy.bin** file sent from Axiomatic. (Note: only binary (.bin) files can be flashed using the 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.

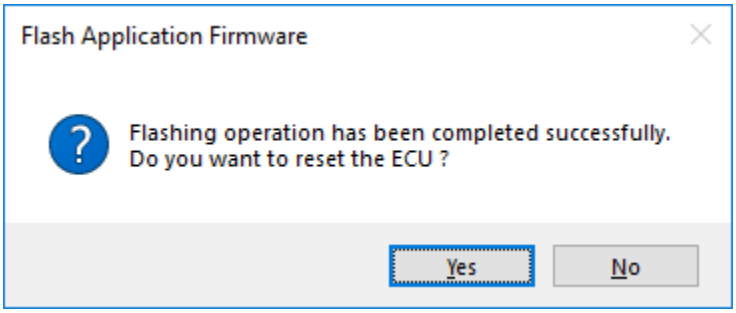
   Note: You do not have to date/time-stamp the file, as this is done automatically by the EA tool when you upload the new firmware.



NOTE: It is good practice to tick the “Erase All ECU Flash Memory” box. Please note, that selecting this option 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. In case the controller contains custom settings, those settings need to be saved to PC before reflashing.

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.

Once the firmware has finished uploading, a message will pop up indicating the successful operation. If you select to reset the ECU, the new version of the AX064000 application will start running, and the ECU will be identified as such by EA. Otherwise, the next time the ECU is power-cycled, the AX064000 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.

APPENDIX A - TECHNICAL SPECIFICATION

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/.

All specifications are typical at nominal input voltage and 25°C unless otherwise specified.

Power Input	8 to 36 Vdc (12 or 24 Vdc nominal)
CAN Port	1 SAE J1939 250 kbit/s, 500 kbit/s, 667 kbit/s, and 1 Mbit/s with auto-baud-rate detection CANopen® Model: AX064001
Interface with Laser Beam	160-degree beam detection 190 mm (7.5 in.) beam detection height range Detects rotational lasers with rotation speed between 2 to 20 RPS. Detects rotational lasers within 630 nm to 850 nm and 1 m to 150 m Reports RPS of the received laser beam Resolution is 2.3 mm. Precision 3 mm (0.1 in.)
User Interface	The Axiomatic Electronic Assistant (P/Ns **AX070502** or **AX070506K**) is a Windows-based graphical user interface that allows interfacing with the device. It can be used to flash new firmware too.
EMI Compliance	CE / UKCA marking
Enclosure	Plexiglass Refer to the dimensional drawing.
Protection	IP67
Vibration	Contact Axiomatic
Shock	Contact Axiomatic
Weight	1.0 lb. (0.453 kg)
Operating Temperature	-40 to 85°C (-40 to 185°F)
Storage Temperature	-50 to 90°C (-58 to 194°F)

Notes:
CANopen® is a registered community trademark of CAN in Automation e.V.

OUR PRODUCTS

AC/DC Power Supplies

Actuator Controls/Interfaces

Automotive Ethernet Interfaces

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CAN Controls, Routers, Repeaters

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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 rma@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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