SAE J2716 Interface

User Manual

Changes

Date	Description	Author	Review
15.12.2023	Note about using webserver when SENT Ethernet echo “As fast as possible” is used		
12.12.2023	RTC compensation		
25.10.2023	Log Converter, battery change, Windows 7 & 8 USB drivers		
20.10.2023	Defined speed class of MicroSD Card for logging		
7.9.2023	Draft release	KH	MM

Contents

List of Figures

List of Tables

List of Equations

1. About

This document describes the usage of the **SAE J2716 Interface**.

Product number: MACH-SENT-ETH

Product page: https://www.machsystems.cz/en/products/embedded-networking/gateways-and-bus-converters/sae-j2716-interface

2. Introduction

The **SAE J2716 Interface** is a device that acts as a SAE J2716 (SENT bus) gateway for Ethernet, USB, and CAN(/FD). Also, it can realize a USB-CAN(/FD) or Ethernet-CAN(/FD) interface simultaneously to its gateway function.

The device offers Ethernet, USB, and CAN(/FD) connection, and uses a standard RJ-45 connector and a USB Type-C connector (virtual serial port - Virtual COM port - VCP).

The MACH-SENT-ETH features four independent SENT channels and allows the user to configure SENT parameters, receive and transmit SENT frame including Short serial and Enhanced serial formats via the communication protocol. The device can also automatically transmit Slow messages with different Message Id over a SENT channel with the help of message buffers for slow message (up to 32 buffers). Device supports 8 data nibbles. Furthermore, the device can operate in SENT/SPC mode (Short PWM Code).

The gateway features four analogue output channels (12-bit DAC) with precise internal voltage reference (range 0 – 4.095 V). Each analogue channel (AO1, AO2, AO3, AO4) can be mapped on either SENT channel (SENT1, SENT2, SENT3, SENT4). The conversion settings are configurable by the user – StartBit, BitLength, linear transfer function: Multiplier, Offset, Min/Max voltage limits.

The gateway also features analogue input channels (12-bit ADC) that can be mapped to either SENT channel. Configuration settings are similar to analogue outputs except the Min/Max voltage limits.

The device can be configured to transmit SENT Fast and Slow Data frames over separated CAN identifiers, allowing a measurement system to easily process the data.

The interface can be used as a stand-alone logger that logs SENT bus activity to a MicroSD card. Those logs can later be replayed on the bus.

Configuration can be saved and loaded into a non-volatile memory.

Figure 1: Front and Rear Sides

3. Features

- 4 bi-directional SENT channels
  - Tick Time 0.5 to 90 µs
  - Fast frames of up to 8 nibbles
- SENT Short PWM Code (SPC) support
- Ethernet (10/100)
- CAN(/FD)
- USB 2.0
- 4 Multi-purpose I/Os (analogue input/output)
- MicroSD card slot (stand-alone SENT and/or CAN(/FD) data logger)
- RTC with battery backup
- Web interface for easy configuration
- Open communication protocol over Ethernet, USB, and CAN(/FD) for integration
- Can be used as a USB-CAN(/FD) or Ethernet-CAN(/FD) interface
- USB-powered or external 9 – 30 V DC
- Aluminium enclosure (86 x 82 x 33 mm)
- Firmware upgradable from PC
- DIN rail mounting (bracket sold separately)

4. Technical Specification

Communication channels	
Ethernet	1 Fast Ethernet (10BASE-T / 100BASE-TX, IEEE 802.3u)
CAN	CAN-HS channel with CAN FD support (ISO 11898-1:2015; CAN 2.0A/B; ISO CAN FD)
USB	USB 2.0 CDC (Virtual COM port)
Electrical	
Power	USB-powered over USB Type-C External 9 - 30 V DC power input (polarity and surge protection) over terminal block
Consumption	100 mA @ 12 V (approx. 1 W)
LEDs	6 dual-colour LEDs 2 ETH LEDs (RJ-45 connector) 1 Power LED
MCU	STM32H7 (1 MB Flash, 564 KB RAM)
Transceivers	CAN FD: MCP2562FD Ethernet: KSZ8041
Mechanical	
Connectors	SENT bus: 8-pin terminal block (TE) CAN bus, I/O, 5V output: 8-pin terminal block (TE) Power: 3-pin terminal block (TE) USB 2.0: USB Type-C Micro-SD card slot
Buttons and switches	1 push button
Dimensions (L x W x H)	86 x 82 x 33 mm
Weight	155 g
Operating temperature	-20 to 70 °C
Protection	IP20
Placement	Table (adhesive pads included)

	DIN-rail mount (sold separately)
Enclosure	Aluminium profile

Table 1: Technical specification

5. Device Description

5.1. Overview

The interface features six connectors, nine LEDs and one push button.

Figure 2: Top View

5.2. Power

The device can be powered over USB or externally via a 3-pin terminal block. The external power range is 9 – 30 V DC. All grounds are connected together.

TODO picture

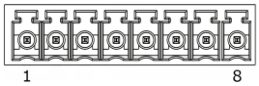
5.3. Connectors

5.3.1.Front Side Connectors

There are two 8-pin TE connectors (p/n: 284512-8).

Mating connector p/n: 284506-4 (two 4-pin ones).

Note: The mating connectors are included in the scope of delivery.

	Pin	Name	Description
 1 8 Terminal block Front view	1	Gnd	Ground
	2	Vout	5 V power output (max. 500 mA)
	3	IO1	Analogue input/output 1
	4	IO2	Analogue input/output 2
	5	IO3	Analogue input/output 3
	6	IO4	Analogue input/output 4
	7	CAN_L	CAN low

	8	CAN_H	CAN high

Table 2: TE Connector CN2 Pin Assignment

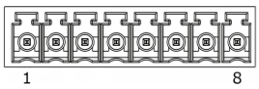
	Pin	Name	Description
 Terminal block Front view	1	SENT1 RX	SENT channel 1 RX
	2	SENT1 TX	SENT channel 1 TX
	3	SENT2 RX	SENT channel 2 RX
	4	SENT2 TX	SENT channel 2 TX
	5	SENT3 RX	SENT channel 3 RX
	6	SENT3 TX	SENT channel 3 TX
	7	SENT4 RX	SENT channel 4 RX
	8	SENT4 TX	SENT channel 4 TX

Table 3: SENT Connector Pin Assignment

5.3.2. Back Side Connectors

The 3-pin TE connector (p/n: 284512-3) can be used for power input.

Mating connector: p/n: 284506-3

Note: The mating connector is included in the scope of delivery.

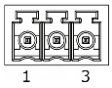
	Pin	Name	Description
 Terminal block Front view	1	Vin	Power input positive (7 – 30 V DC)
	2	Gnd	Power input negative
	3	Shield	Shield (connected to the conductive enclosure)

Table 4: Power Connector Pin Assignment

5.4. Button

The push button (a tactile switch) shall be used for firmware update. If the button is held during device's power-up, it enters the System Bootloader (not normally used). To enter the normal operation mode from the boot mode, the device should be powered off and on.

When the device is being used as a data logger on a MicroSD card, pressing the button closes the currently opened file and creates a new one on the card.

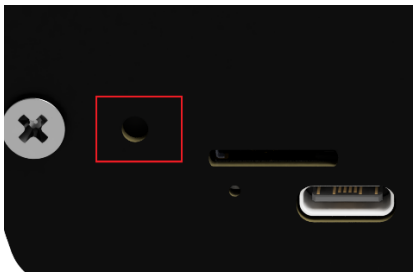


Figure 3: Button

5.5. LEDs

The device features 9 LEDs in total.

5.5.1.Front Panel

5 LEDs are on the front side.

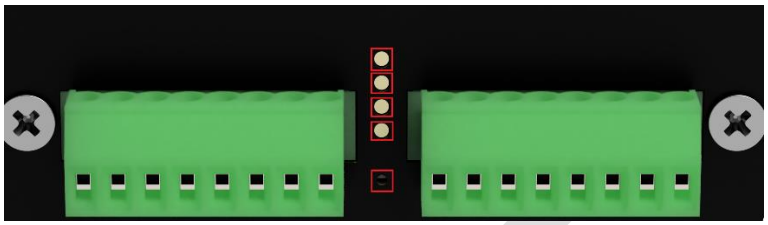


Figure 4: Front Side LEDs

LED Name	Note
SENT1 Status SENT2 Status SENT3 Status SENT4 Status	Off: Channel is stopped Green on: Channel is running Green blinking fast: SENT channel transmitting Green blinking slowly: SENT channel receiving Red blinking: Error frame received
CAN Activity / Error	Off: CAN channel stopped Green on: CAN channel started Green blinking: CAN activity (RX or TX) Red blinking: Error frame received Red on: CAN bus error

Table 5: Status LEDs on the Front Panel

5.5.2.Rear Panel

4 LEDs are on the rear panel.

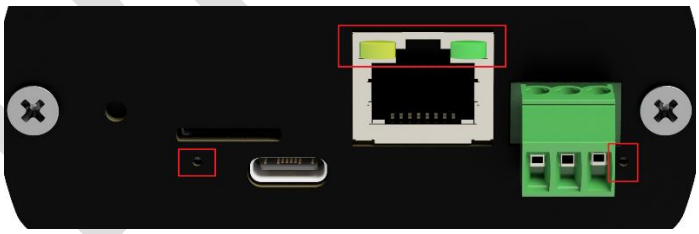


Figure 5: Back Side LEDs

LED Name	Note
SD LED	Green blinks one time: SD Card was mounted Green blinking slow: Device is logging Green blinking fast: SENT playback is active Red on: Recoverable SD Card error (e.g. mount failed) Red blinking: Irrecoverable SD Card error – device must be restarted (e.g. card removal during logging)
RJ-45 Left LED	Orange off: Link speed – 10 Mbps Orange on: Link speed – 100 Mbps

RJ-45 Right LED	Green off: No link Green on: Link active Green blinking: Ethernet activity
Power LED	Green off: The device is not powered Green on: The device is powered

Table 6: Status LEDs on the Back Panel

5.6. CAN Bus Termination

There are no internal termination resistors inside the device. Therefore, the user has to make sure the CAN bus is properly terminated at both ends of the network.

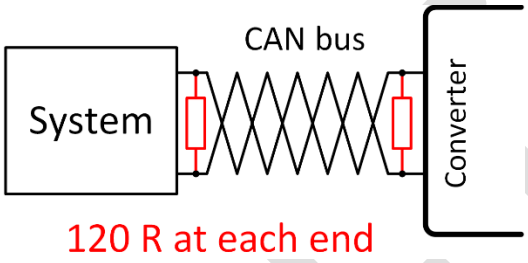


Figure 6: CAN bus termination

5.7. USB

USB Type-C connector uses the standard USB 2.0 pinout, and can be used for as a virtual COM port. Note that in order to use the virtual COM port with OS Windows 7 or Windows 8, you have to install the VCP driver separately. You can download it from the following link: www.machsystems.cz/support/en.stsw-stm32102.zip. Starting from Windows 10, usage of the native driver is recommended and nothing has to be installed separately.

5.8. Galvanic Isolation

The device does **not** have any galvanic isolation. All ground signals are connected. The user has to make sure there are no ground loops in his setup.

6. Usage

The device can be used as a SENT interface, data logger, CAN FD to CAN bridge, ETH/USB to CAN(/FD) interface. Analogue input and output can be mapped to a SENT channel or they can be used to interact with external peripherals.

Device can be controlled using protocol specified in Communication Protocol Specification document available from product webpage. The control messages can be sent to the device over Ethernet, USB or CAN. Device settings, SENT bus configuration, I/O mapping, logging and playback can also be configured and used conveniently from a web browser.

6.1. Nibble Endianness and Start Bit

Throughout this document the nibble endianness specifies the nibble order (e.g., not bit order). The following example depicts the endianness on 8 data nibbles when there is a variable FOO: Length = 12 bits, start bit = 0.

Note that the Start bit order also differs between little and big-endian formats.

Little-endian:

Nibble	0				1				2				3				4				5				6				7			
Bit position	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
FOO bits	0	1	2	3	4	5	6	7	8	9	10	11																				

Table 7: Little-endian Bit Mapping Example

Big-endian:

Nibble	0				1				2				3				4				5				6				7			
Bit position	28	29	30	31	24	25	26	27	20	21	22	23	16	17	18	19	12	13	14	15	8	9	10	11	4	5	6	7	0	1	2	3
FOO bits																					8	9	10	11	4	5	6	7	0	1	2	3

Table 8: Big-endian Bit Mapping Example

6.2. Website Description

Note: the HTTP interface was tested with the Chrome browser. Use of this interface with other browsers is not recommended and it can lead to unpredicted results.

On the device runs a webserver and after accessing device IP address via a browser, the device web page is shown (the default IP address is 192.168.1.100). This can be used for configuration and control of the device. Here we describe the website in detail.

Please note that when you use the webserver when echoing SENT frames on Ethernet with setting “As fast as possible”, there may be some packet drop. We recommend not to use the webserver when this setting is used.

On all the pages, there is a navigation panel. Also, you can view SENT channel status and also start / stop the channels:

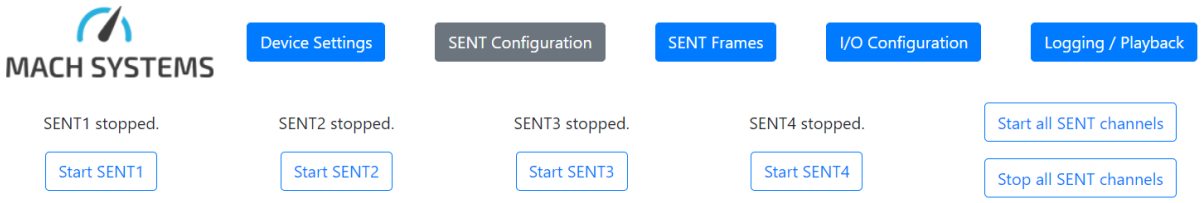


Figure 7: Website Header

At the bottom of all pages, there is a link to help page which shortly describes all the available pages.

6.2.1. Device Settings Page

On this page, basic device parameters can be changed. At the top, you can see device information that cannot be changed (product and serial number, MAC address, firmware version and HW info).

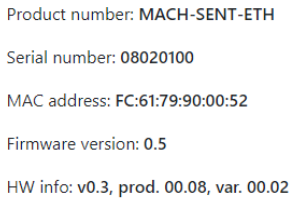


Figure 8: Device Information

In the next section, you can set time to the device RTC. When the device is logging, current timestamp will be saved to SENT logs. Note that there is not any time zone used, timestamp of the time you see on the screen is used.

Figure 9: RTC Setting

Below that, RTC compensation value can be written.

- CALM: calibration minus, decreases frequency of the calendar. Possible values: 0 to 511.
- CALP: calibration plus, increases frequency of the calendar.
- On the right side, there is a calculated number of subtracted/added seconds per day.

Calculation of resulting correction ratio:

$$100 * \left(1 + \frac{512*CALP - CALM}{2^{20} + CALM - 512*CALP}\right) [\%]$$

Equation 1: RTC Compensation Value

Result of this is RTC correction factor (99,9512909797 % to 100,0488519785 %, -487.1 to +488.5 ppm).

- One CALM step: negative correction of about 0.954 ppm, subtracting 0.082 second per day. Maximum CALM value: -487.090 ppm, subtracting 42.085 seconds per day.
- CALP is set: increase of about 488.520 ppm – adding 42.208 seconds per day. Using combinations of different values of those two settings, mentioned ppm range can be reached.

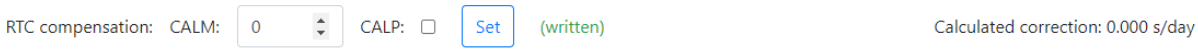


Figure 10: RTC Compensation

After this there are settings of device TCP configuration (IP address and mask, TCP port used for protocol communication, default gateway). Settings are automatically saved to non-volatile memory when you click the “Save” button but note that they take effect only **after device reboot.** You can

reboot the device (software reset) using the button below. Last buttons in this section are for USB and ETH bootloader respectively. Going to USB bootloader turns off the webserver. You can then update the device firmware using STM32CubeProgrammer (normally not used). ETH bootloader is another web page on the device that allows firmware update over web browser (see below).

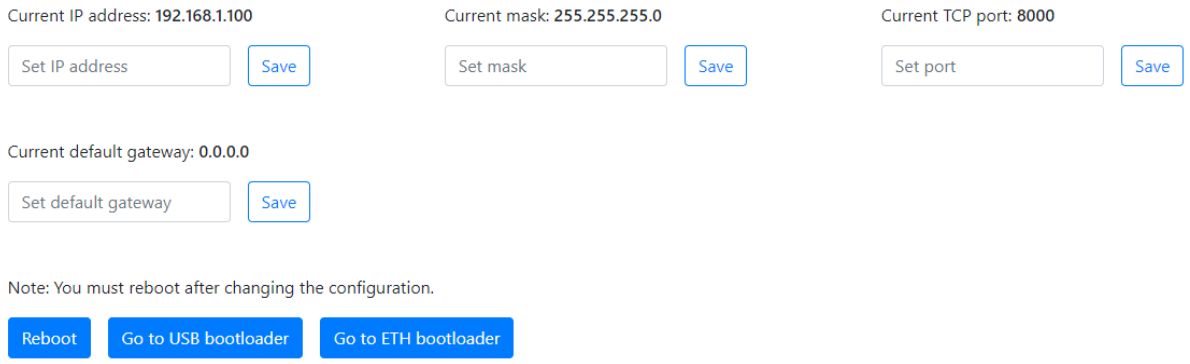


Figure 11: TCP Communication Configuration

In the last part, CAN configuration is changed (CAN baud rate and sample point and communication IDs for the protocol). When Data Baud Rate of 8M is selected, Arbitration Baud Rate should be set to 1M. For Data Baud Rate 4M, data sample point is rounded to lower multiple of 5 %. For Data Baud Rate 8M, data sample point is rounded to lower multiple of 10%. On the right side there are alternative SENT CAN IDs – used for additional echo of SENT frames when configured to non-zero value – see protocol documentation for more information.

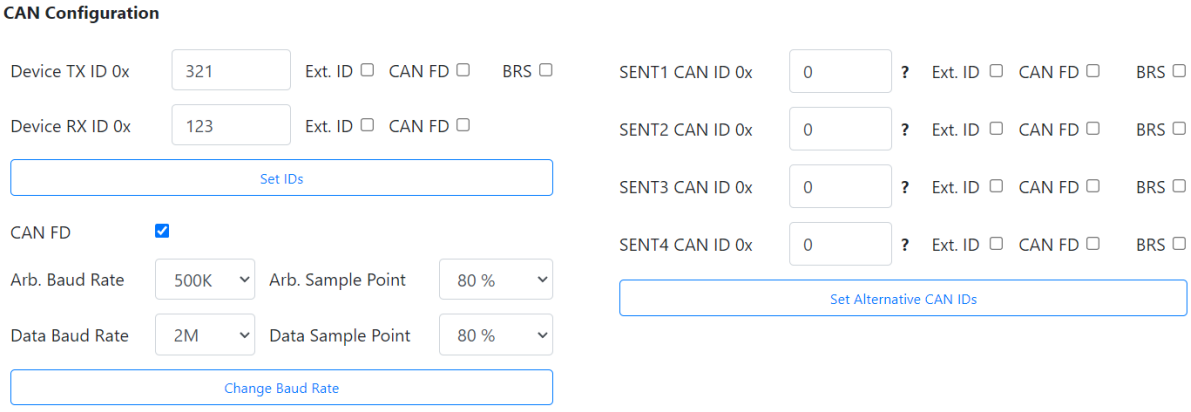


Figure 12: CAN Configuration

6.2.2.SENT Configuration Page

SENT bus settings are changed here. Settings are grouped to three sections – General, Advanced, SPC. Note that clicking “Write Configuration” writes settings to the volatile memory only. Configuration options are described below in more detail.

On the bottom of the page, SENT configuration can be exported to a JSON file or imported from one. Below this is possibility to load default settings and read / write it from / to non-volatile memory.

6.2.2.1. General SENT Configuration

SENT Channels

	SENT1	SENT2	SENT3	SENT4	Description
General					
Auto Start	☑	☑	☑	☑	Channel is automatically started when the device is powered. Note that when logging is enabled, this bit is not relevant
Direction	RX	TX	RX	TX	RX = receive SENT frames, TX = transmit frames
Tick Time	3	3	3	3	Unit time [us]
Nibble Count	6	6	6	6	Number of Data Nibbles
Pause Pulse	☐	☐	☐	☐	Pause Pulse Enabled
TX Pause Pulse Frame Period	0	0	0	0	Fixed SENT frame duration [Tick time], relevant for TX only
RX Forward Mode / TX Echo Mode	Fixed 100 ms	Fixed 100 ms	Fixed 100 ms	Fixed 100 ms	How to transmit RX and TX SENT messages to PC
Slow Channel Mode	Short Serial	Short Serial	Fast Channel only	Fast Channel only	Enable Slow messages (Short Serial and Enhanced Serial)
Slow TX Echo	☐	☐	☐	☐	Enable of TX echo for slow frames. This is relevant when Slow Channel Mode is not zero and channel is configured as TX
CRC Mode	SwCrc	SwCrc	HwCrc	HwCrc	HW = SAE J2716 CRC, SW = CRC incl. Status Nibble, Off = a device transmits CRC as defined by the user, Faulty - insert incorrect CRC

Figure 13: SENT Basic Configuration

Parameter	Description
Auto Start	Channel is started after device boot. When channel logging is enabled, it is started either way after reset.
Direction	Transmit or receive.
Tick Time	SENT Unit Time in microseconds. Valid range: 0.5 to 90.
Nibble Count	Number of nibbles in the fast SENT frame. Note that additionally to SAE J2716 specified 6 nibbles, device supports up to 8 nibbles.
Pause Pulse	Enable Pause pulse (next parameter relevant).
TX Pause Pulse Frame Period	Fixed SENT Frame duration in [Tick Time]. Valid range depends on selected Nibble Count. This is active only when Pause pulse checkbox is checked.
RX Forward Mode / TX Echo Mode	Frame echo configuration. There are three possibilities: • Fast as possible / No echo – TX frames are not echoed, RX frames as fast as possible. • Fixed 100 ms – Both TX and RX frames are echoed with fixed period of 100 milliseconds. • On change + 1 s – Both TX and RX frames are echoed every second and also when the data change.
Slow Channel Mode	Configures format of Slow Sent Frames. • Fast Channel Only – No slow frames possible. • Short serial – Slow frames in Short serial format (4-bit ID, 8-bit Data). • Enhanced serial – Slow frames in Enhanced serial format (8-bit ID, 12-bit Data or 4-bit ID, 16-bit Data).
Slow TX Echo	Enable TX echo for slow frames. This is active when channel is configured as TX and one of the Slow Serial modes is used.
CRC Mode	Method of calculating Fast Frame CRC. • Off – User-supplied CRC is added to the TX frames. For RX, CRC mismatch does not generate an error frame.

	• HwCRC – SAE J2716 way of calculating CRC is used. • SwCRC – Status nibble is added to the CRC calculation. This is a non-standard way of CRC calculation but it is used by some sensors. • Faulty – Insert a fault CRC to the fast SENT frames.

Table 9: SENT Basic Configuration

6.2.2.2. Advanced SENT Configuration

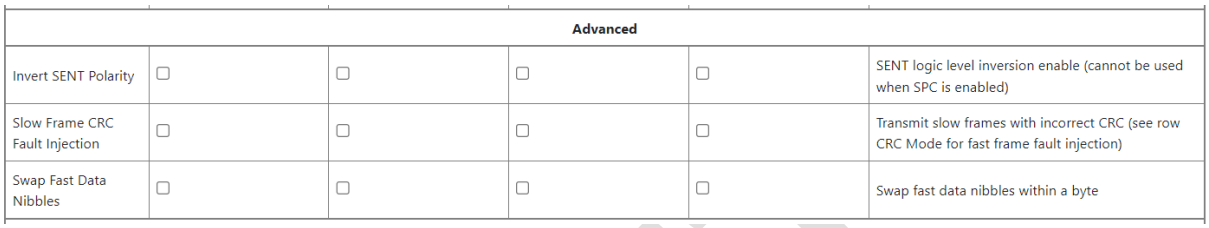


Figure 14: Advanced SENT Configuration

Parameter	Description
Invert SENT Polarity	SENT bus is inverted. Note that this is irrelevant when SPC mode is active.
Slow Frame CRC Fault Injection	Slow SENT frames are transmitted with deliberately set incorrect CRC.
Swap Fast Data Nibbles	Data nibbles are swapped within a Fast. Note that this is relevant both for RX and TX.

Table 10: Advanced SENT Configuration

6.2.2.3. SENT/SPC Configuration

Note that some hardware changes may be needed in order to properly use SENT/SPC mode (see below for more information).

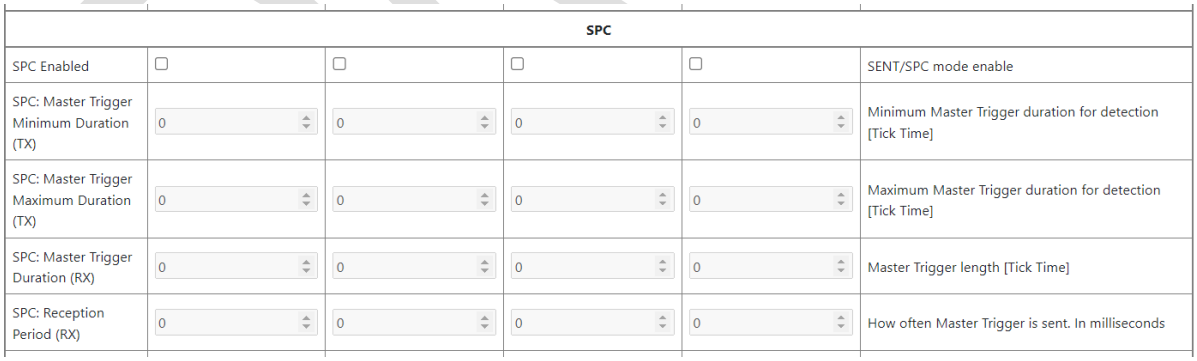


Figure 15: SENT/SPC Configuration

Parameter	Description
SPC Enabled	Activate SENT/SPC (Short PWM Code)
SPC: Master Trigger Minimum Duration (TX)	Minimum length of trigger in order for Slave to be triggered (for frame transmission).
SPC: Master Trigger Maximum Duration (TX)	Maximum length of trigger in order for Slave to be triggered (for frame transmission).

SPC: Master Trigger Duration (RX)	Length of the pulse that master uses for triggering slaves (for frame reception).
SPC: Reception Period (RX)	Millisecond period of Master Trigger. Note that when this is set to 0, period is not used.

Table 11: SENT/SPC Configuration

6.2.3.SENT Frames Page

This is used for transmission SENT Fast, Slow Frames on the bus and configuring rolling counter in the fast frame (per channel). On the top of the page, you can toggle if you want to see numbers in decimal or hexadecimal (relevant for Fast Frame Status and Data nibbles and Slow Frame ID and Data).

Figure 16: Number Format Selection

6.2.3.1. Frame Status

In this part, there are information about transmitted / received frames (dynamically changed according to channel direction).

Left tables represent fast frames, right tables represent slow frames (per channel). Fields can have few possible values:

- **Numerical value** – this represents the actual value sent/transmitted
- **Empty** – this means that this particular frame type was not received yet on the channel
- **N/A** – Not Applicable; this is used for data nibbles > Nibble Count and for slow frame values, when channel is in Fast Frame Only mode
- **NONE** – applicable for Error field only; this is to signify that there was no error
- **CRC / FRAMING / SYNC** – applicable for Error field only; this determines type of the error

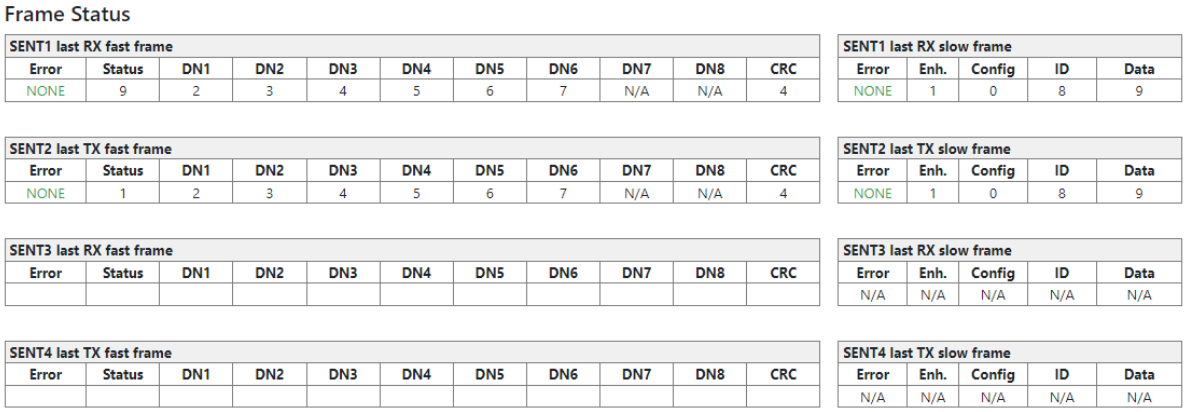


Figure 17: SENT Frame Status

6.2.3.2. Frame Transmission

There is shown only one of the channels for illustration. Everything in this section is runtime only. A necessary condition for all the tables in this section to be enabled is that the channel is configured as TX and running. Furthermore, for slow frame manipulation tables, channel must be in other mode than “Fast Channel Only”.

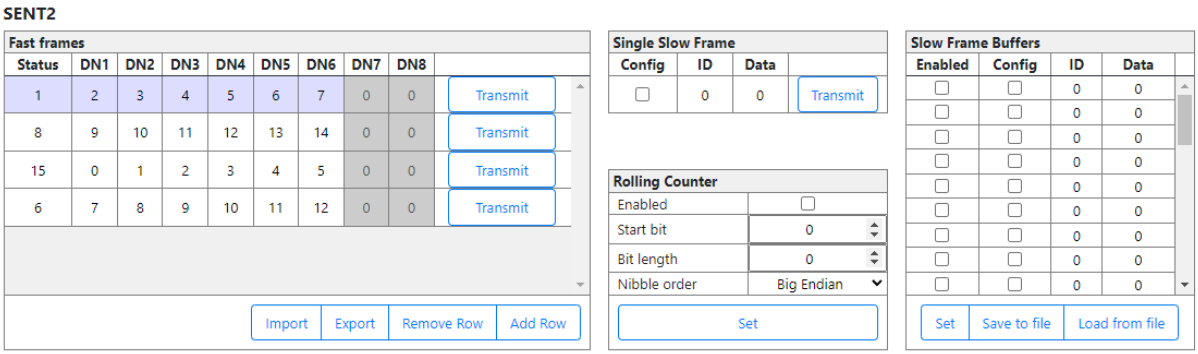


Figure 18: SENT Frame Control

- **Fast frames** – Transmit a fast frame. You can add and remove rows as you want. Only one fast frame is cycled at a time. Values of nibbles are 0 to 15 (0 to F when Hex is enabled). Rows can be imported / exported from / to a file in JSON format.
- **Single Slow Frame** – You can transmit a single slow frame on the bus. Maximum values in the forms are 255 and 65535 for ID and Data respectively (real max values depend on channel settings and config bit).
- **Rolling Counter** – Configuration of the rolling counter (RCNT) in the fast frame nibbles. Start bit, bit length and nibble order are configurable. Rolling counter overrides Analogue Input channel mapping.
- **Slow Frame Buffers** – There is a possibility to transmit multiple slow frames periodically (one after another). There are up to 32 configurable buffers. Buffer must be enabled in order to be transmitted. Constraints on the values are the same as in “Single Slow Frame”. Slow frame buffers can be imported / exported from / to a file in JSON format.

6.2.4.I/O Configuration Page

On this page, you can force analogue outputs and check values that are read on analogue inputs. Note that internally, input is connected to output, so when you force some value on the output, you can check it on the input. This is a quick way of checking that everything works properly.

Here you can also configure mapping of I/O to SENT frames. Clicking “Write Configuration (on all channels)” uses volatile memory.

On the bottom of the page, I/O configuration can be exported to a JSON file or imported from one. Below this is possibility to load default settings and read / write them from / to non-volatile memory. Note that read/write includes both settings on this page and SENT bus settings from the previous page.

6.2.4.1. I/O Value Reading / Forcing

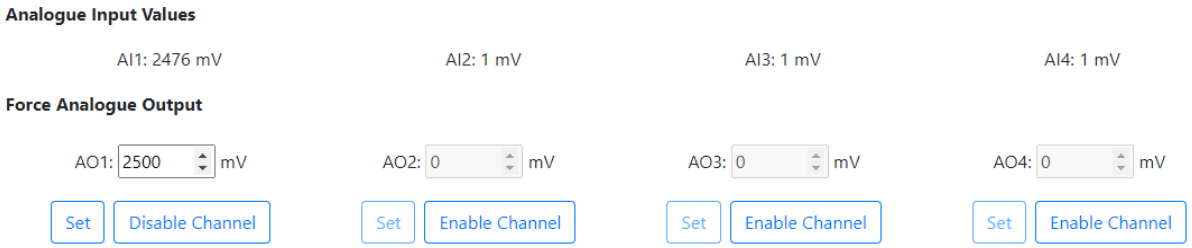


Figure 19: I/O Status

Input values are in millivolts and are automatically updated (read from device) every one second.

Forcing output and "Set" button become active when you enable the analogue channel. Maximum value that can be forced is 4095 millivolts. There may be some inaccuracy in the read value.

6.2.4.2. Configuration of Analogue Inputs

An analogue input channel can be mapped on any TX SENT channel.

This formula is used for calculation of the value:

$$RawValue = \frac{U_{in} - Offset}{Multiplier}$$

Equation 2: Analogue Input Conversion

Where U_{in} is in millivolts and *RawValue* is the resulting value that is sent on SENT. Offset and Multiplier parameters correspond to "Voltage Offset" and "Voltage Multiplier" on the website. "Bit Offset", "Bit Length" and "Nibble Order" together define position of the resulting data in the SENT frame. Lastly you can set SENT channel to which to Analogue Input channel is mapped to.

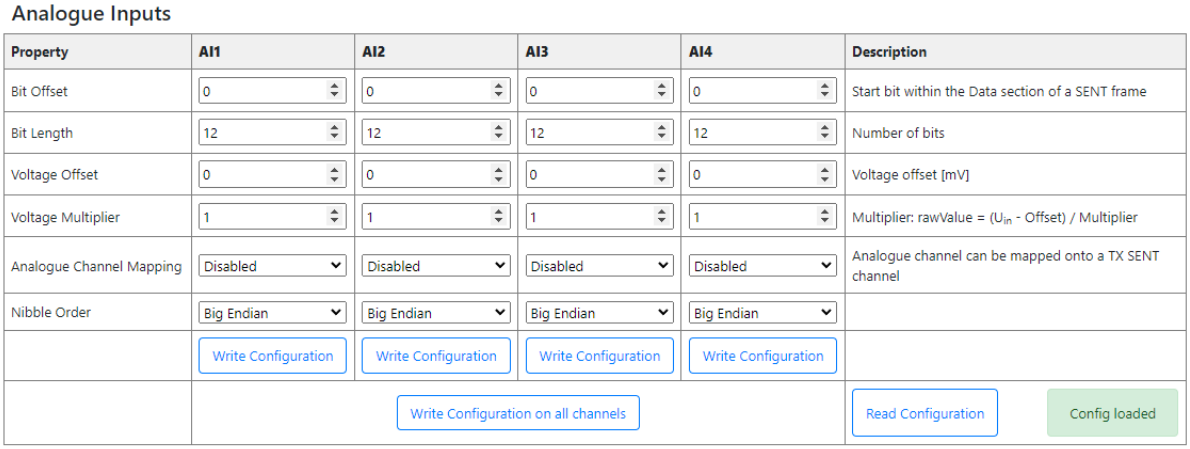


Figure 20: Analogue Input Configuration

Parameter	Notes
Bit Offset	Integer, 0 to 31
Bit Length	Integer, 0 to 32

Voltage Offset	Integer, 0 to 4094
Voltage Multiplier	Floating-point number – no limit (internally stored as IEEE-754 floating-point value)
Analogue Channel Mapping	Only a channel that is configured as SENT TX should be set.
Nibble Order	Nibble order in the SENT frame.

Table 12: Analogue Input Configuration

Note that when rolling counter is configured on the fast SENT frames, it has always priority over ADC input mapping (see page SENT Frames).

6.2.4.3. Configuration of Analogue Output

An analogue output channel can be mapped on any RX SENT channel.

This formula is used for calculation of the value:

$$U_{out} = \frac{RawValue * Multiplier}{1024} + Offset\ [mV]$$

Equation 3: Analogue Output Conversion

Where U_{out} is the millivolt value forced on the output. Offset and multiplier correspond to “Voltage Offset” and “Voltage Multiplier” on the website. Apart from physical range of the DAC (0 to 4.095 V), the range can be further limited using “Voltage Min” and “Voltage Max” parameters.

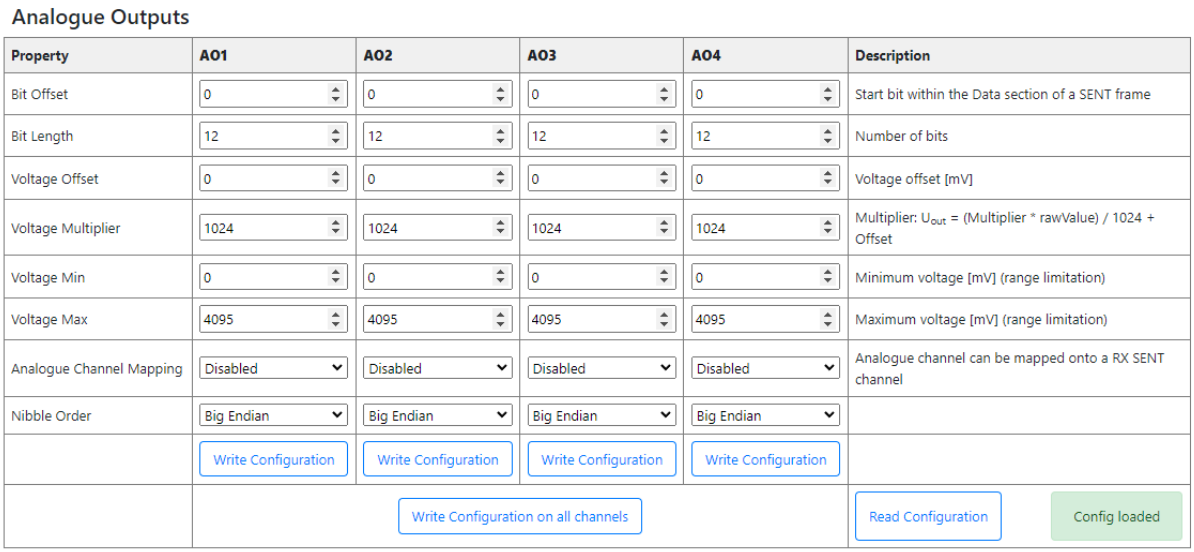


Figure 21: Analogue Output Configuration

Parameter	Notes
Bit Offset	Integer, 0 to 31
Bit Length	Integer, 0 to 32

Voltage Offset	Integer, -4095 to 4094
Voltage Multiplier	Integer, -4095 to 4095
Voltage Min	Integer, 0 to 4094
Voltage Max	Integer, 0 to 4095
Analogue Channel Mapping	Only channel that is configured as a SENT RX should be set.
Nibble Order	Endianness of nibbles in the SENT frame.

Table 13: Analogue Output Configuration

6.2.5.Logging / Playback Page

This page does control of logging and frame playback. As the interface can be used as a stand-alone datalogger, there is a possibility to configure channels for logging to start after device reset. When one of the channels has logging enabled (and MicroSD Card is inserted), logging is started when device boots up. Logging is start when starting the SENT channel.

Note that logging and playback on all four SENT channels was thoroughly tested with tick time of 3 µs (maximum speed as per SAE J2716 standard). Therefore, full functionality is guaranteed up to this speed (tick time 3 µs to 90 µs). MicroSD Card with interface UHS-1 and with classes C10 U1 (Speed Class 10 UHS Speed Class 3) was used for testing. User should use card with those or better properties.

SENT Channels logging configuration is normally written to volatile memory only. It can be saved with the whole SENT and I/O configuration to the non-volatile memory using buttons in the middle of the page. There is also a possibility to load default configuration:

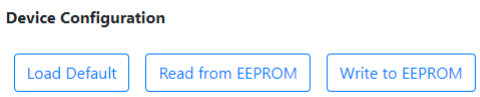


Figure 22: SENT Device Configuration Manipulation

Next sections are described below.

6.2.5.1. SENT Logging Configuration

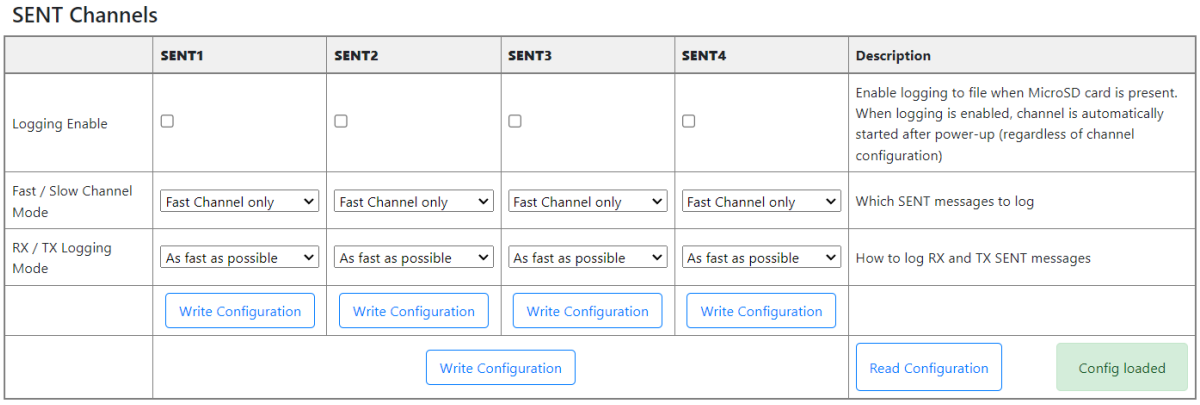


Figure 23: SENT Logging Configuration

Parameter	Description
Logging Enable	Enable logging on selected channel. When this is saved in non-volatile memory, logging on this channel is started after boot. Note that when you want to start logging in runtime, it is not enough to tick this box and click "Write Configuration", you must also "Start logging" at the top of the page.
Fast / Slow Channel Mode	Configuration which SENT frames to log – "Fast Channel Only", "Slow Channel Only" or "Both Channels".
RX / TX Logging Mode	This is similar to configuration of channel echo configuration – "As fast as possible", "Fixed 100 ms", "On change + 1 s". Meaning is self-explanatory.

Table 14: Logging Configuration

6.2.5.2. CAN(/FD) Logging Configuration

Device can also be used for CAN(/FD) logging. In the current implementation, logging can be enabled/disabled only. Similar to SENT, CAN(/FD) logging is started when the CAN(/FD) channel is started (device used as a CAN(/FD) interface). Buttons under the configuration table can be used for starting/stopping the channel and saving its configuration to EEPROM, respectively.

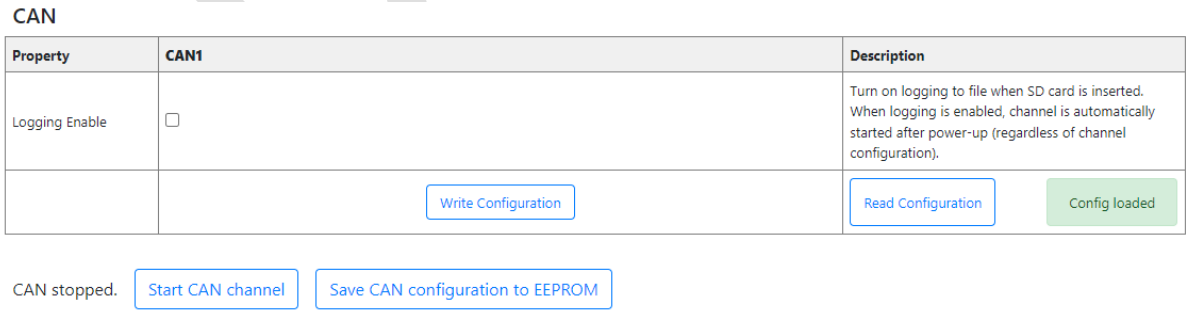


Figure 24: CAN Logging Configuration

6.2.5.3. Playback of Log Files

As a first step, you must click the "Load Log Files from Device" button:

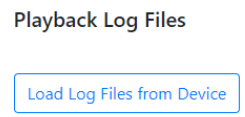


Figure 25: Playback Step 1

Then a table with available log files appears:

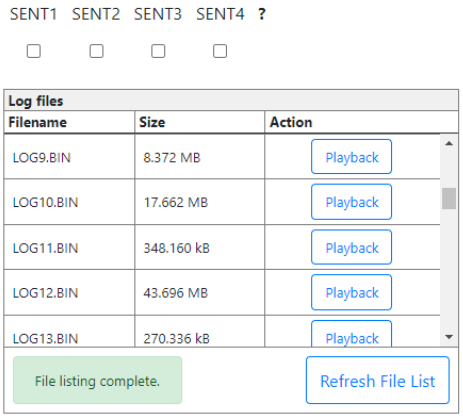


Figure 26: Playback Step 2

You can select an appropriate channel that should be played back (it should be configured as TX!), click “Playback” on the desired file and the playback will be started. Progress bar is shown to signalize how far in the file the playback currently is.

6.3. SAE J2716 Interface Tool

Except the webserver that can be accessed via a web browser, there is also a SAE J2716 Interface Tool Windows application. The application is provided free-of-charge and allows to configure SENT Channels and analogue output/input channels, save and load the runtime and non-volatile configuration, receive and transmit Fast and Slow SENT messages and analyse signals defined in the frames’ data.

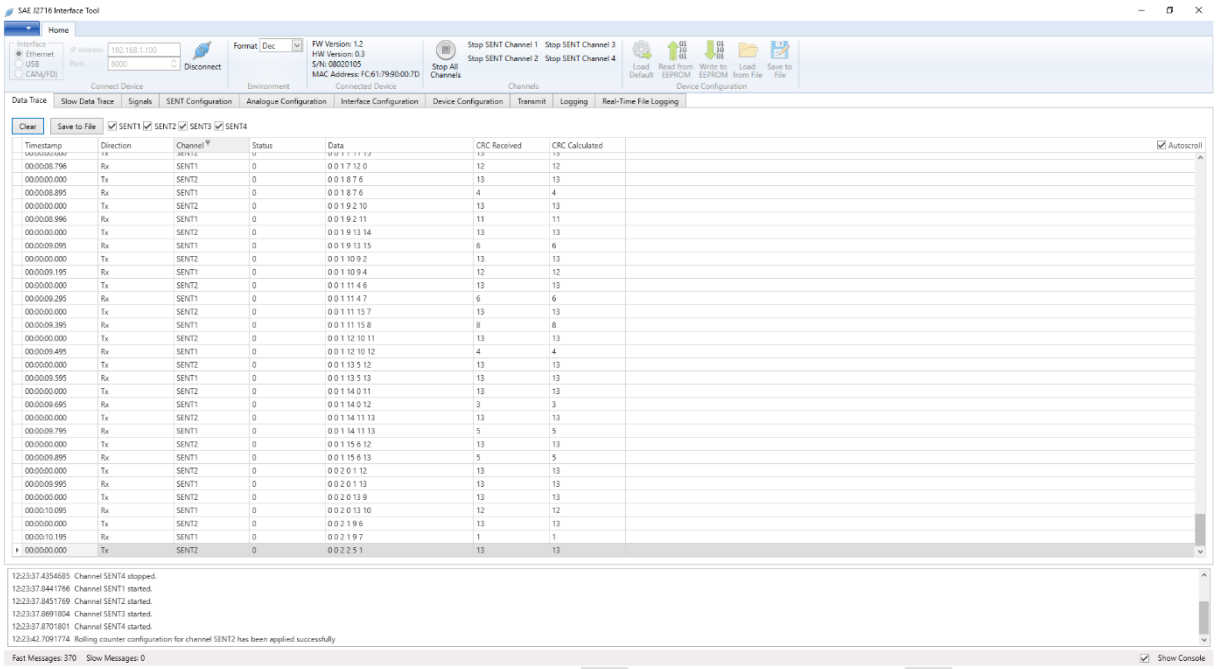


Figure 27: SAE J2716 Interface Tool Overview

6.3.1. Connection

Device can be connected either using Ethernet, USB, CAN or CAN FD. Default settings for Ethernet are IP address 192.168.1.100 and port 8000. Default USB baud rate us 115 200 baud. Default CAN connection parameters are: CAN (no CAN FD), baud rate 500K, sample point 80%

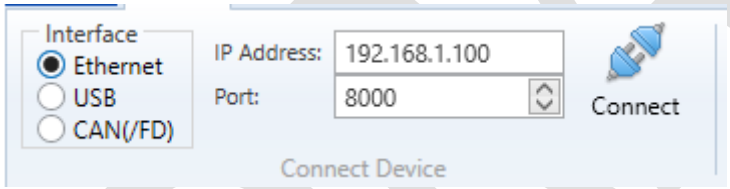


Figure 28: Ethernet Connection Parameters

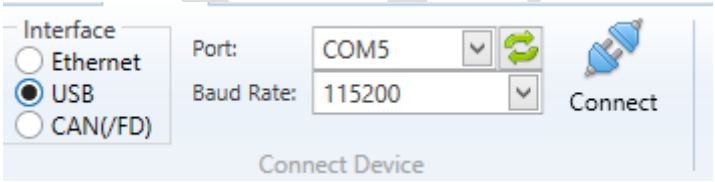


Figure 29: USB Connection Parameters

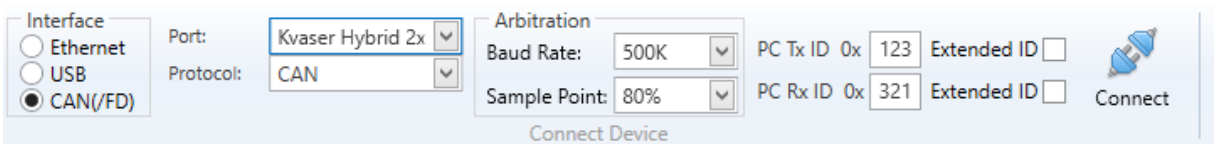


Figure 30: CAN Connection Parameters

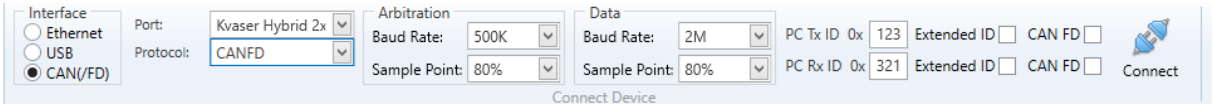


Figure 31: CAN FD Connection Parameters

If the interface is correctly connected, its firmware and hardware version, serial number and MAC address will be shown.

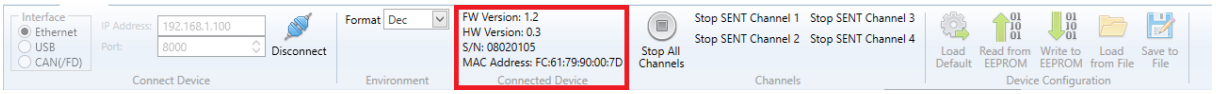


Figure 32: Device Connection

6.3.2.SENT Channel Configuration, Analogue Configuration, Transmit, Logging

Those tabs work the same as on the web, so see above for the detailed explanation. Note that channel reconfiguration can be done only if the channels are stopped. If you want to write the configuration to a non-volatile memory, remember to click “Write to EEPROM” in the upper panel. This makes the gateway load this configuration on power-up.

Note that slow buffers can be exported in an XML format (on the web it is JSON).

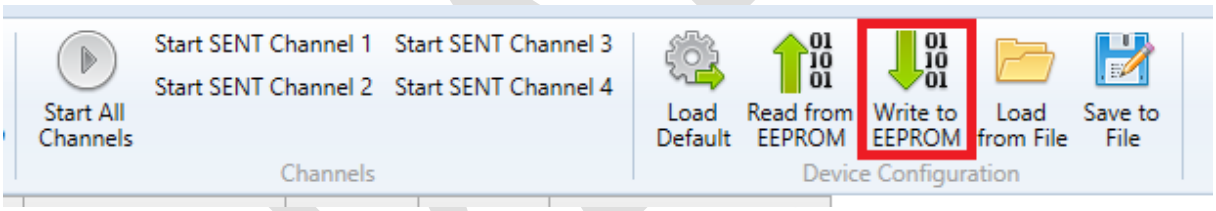


Figure 33: Writing Settings to EEPROM

6.3.3.Data Analysis

In the Data Trace tab, you can see received and transmitted SENT messages. Same applies for the Slow Data Trace tab.

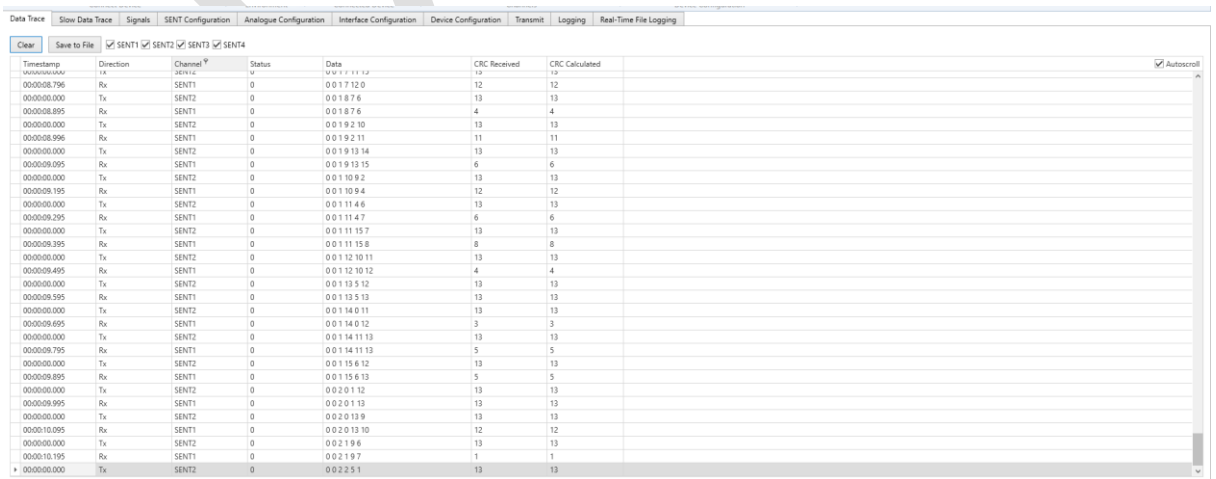


Figure 34: Data Trace

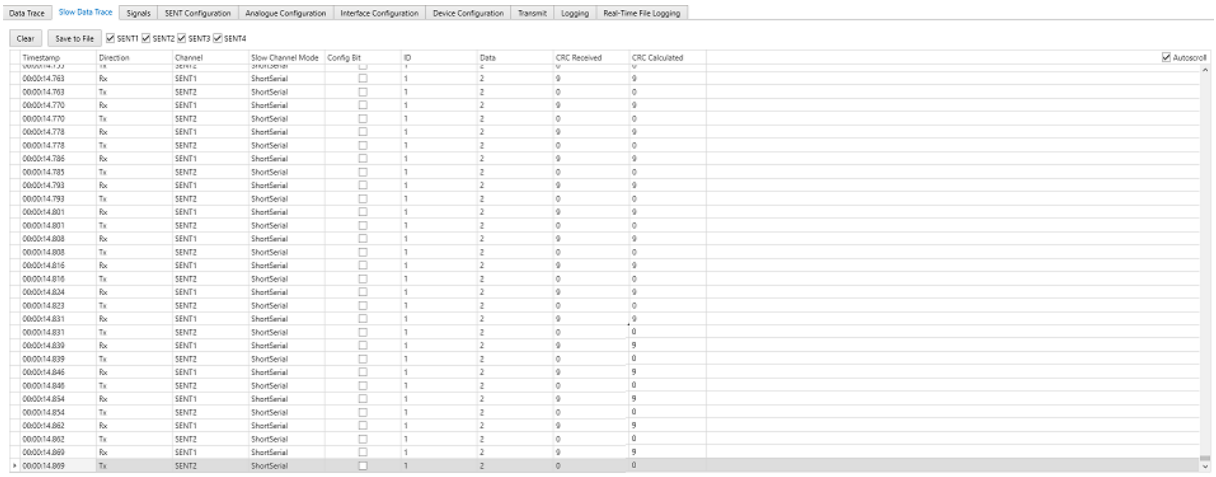


Figure 35: Slow Data Trace

6.3.3.1. Signals

Application enables decoding of signals that are in the data nibbles of the frame.

Data | Definitions

Add Row | Delete Row | Export to File | Import from File

Name	Slow Channel	Slow ID	Channel	Start Bit	Bit Length	Encoding	Multiplier	Offset	Unit
Signal 1	☐	0	Any	0	8	Motorola	1	0	mm
Signal 2	☐	0	Any	16	8	Intel	1	0	°C

Figure 36: Signal Definition Example

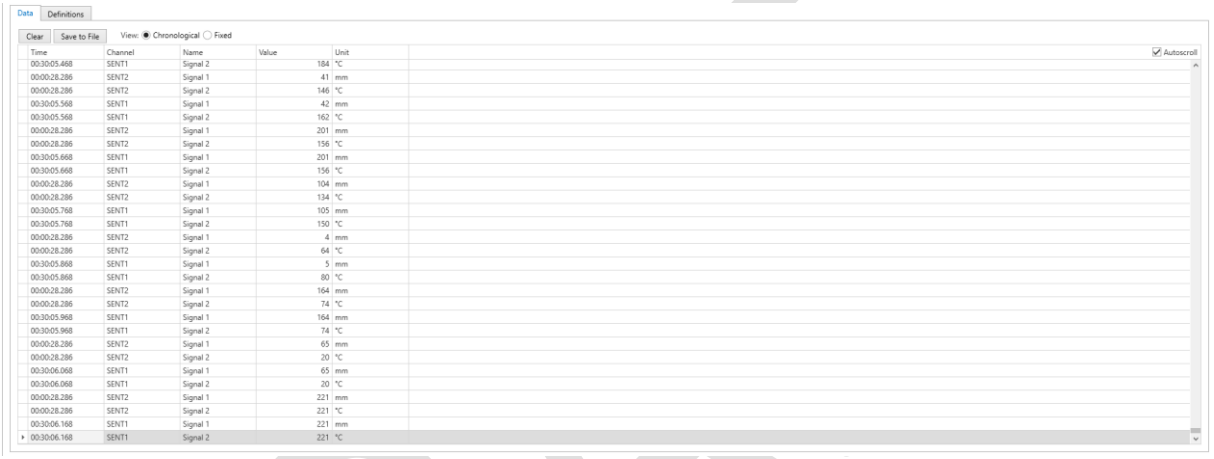


Figure 37: Signal Decoding Example

6.3.4. Interface and Device Configuration

There are two additional configuration tabs. Interface configuration serves for Ethernet (IP Address, Mask, Port and Default Gateway) and CAN(/FD) (baud rate, sample point, CAN IDs) protocol configuration. Device configuration in this case means setting of RTC timestamp. Refresh button loads the current timestamp from the device and “Set Current Time from PC” sets the currently configurated time. Please note that RTC settings are available for devices with HW version 1.0 or higher.

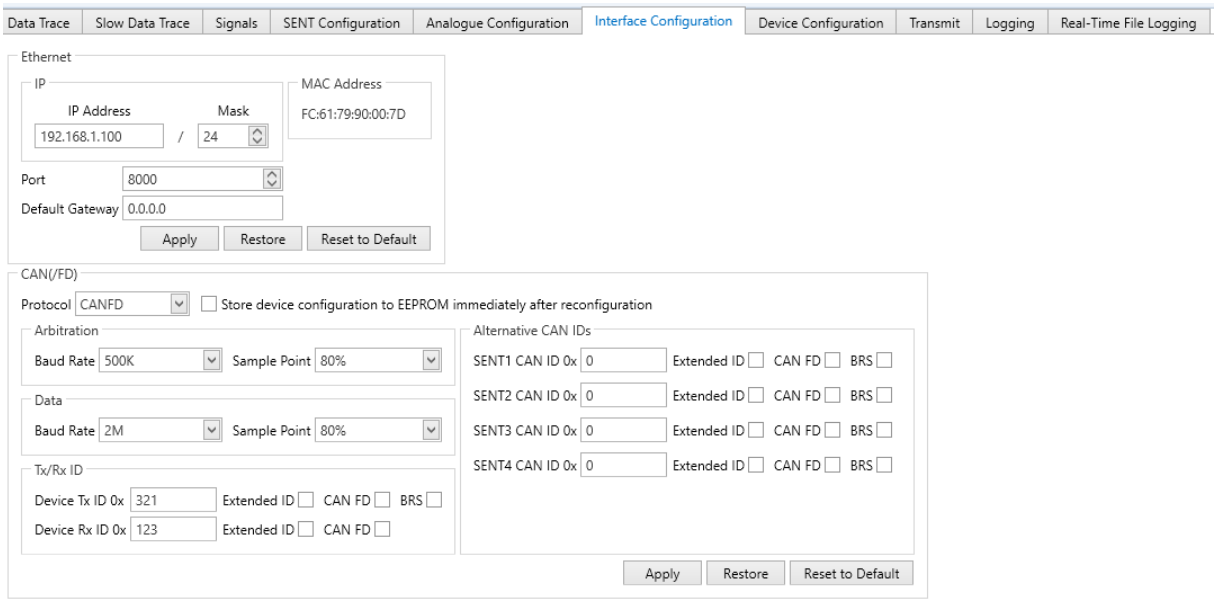


Figure 38: Interface Configuration

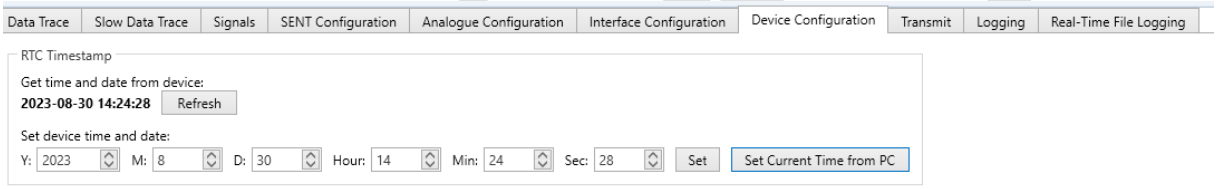


Figure 39: Device Configuration (RTC)

6.3.5. Real-Time File Logging

Last tab that is added in the Interface Tool is Real-Time File Logging. This logs SENT traffic directly to a file in the host PC.

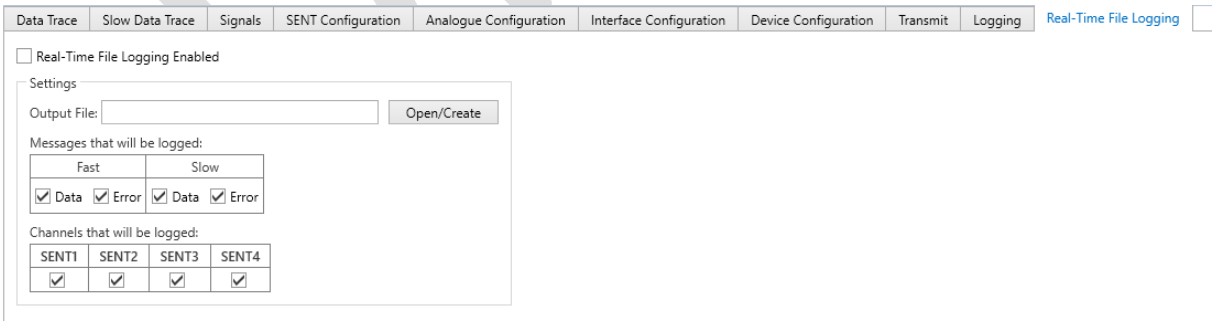


Figure 40: Real-Time File Logging

6.4. SAE J2716 Log Converter

Log converter is a Windows application that converts logs from the device to CSV format.

Usage: open Log File you want to convert, select checkboxes of the data you want and click Convert.

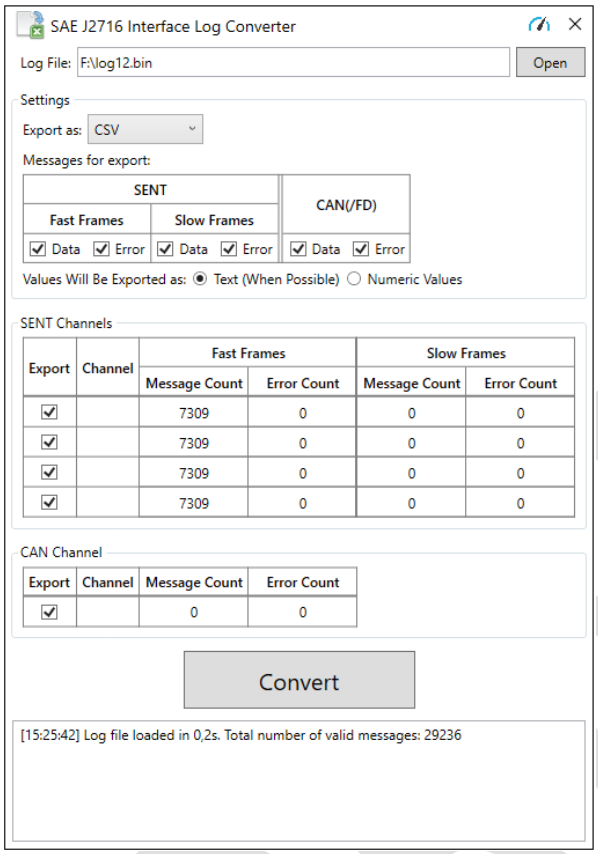


Figure 41: SAE J2716 Log Converter Overview

6.5. SENT/SPC Mode Hardware Changes

In order to use SENT/SPC mode, some hardware changes must be done to the device. Namely, there are two solder bridges for each SENT channel that must be shorted for SPC mode to work properly. Basically, short both the bridges that are there for the channel. See table for exact location on the board.

SENT Channel	Solder bridges

SENT1	SJ5 SJ1	
SENT2	SJ6 SJ2	
SENT3	SJ7 SJ3	
SENT4	SJ8 SJ4	

Table 15:Hardware Changes for SENT/SPC

6.6. Hardware Changes for Tick Time under 1 µs

In order to use SENT with Tick Time under 1 µs, some hardware changes must be done to the device. Namely, there is one solder bridge for each SENT channel that must be shorted for this fast Tick Time to work properly. See table for exact location on the board.

SENT Channel	Solder bridges

SENT1	SJ1	
SENT2	SJ2	
SENT3	SJ3	
SENT4	SJ4	

Table 16: Hardware Changes for Tick Time under 1 µs

6.7. Changing the Battery

Device includes a 3V CR1220 battery. Steps for changing it:

- Open the enclosure by removing the screws

Figure 42: Screw Removal

- Use a flat tool to change the battery, it is located on the bottom side of the board

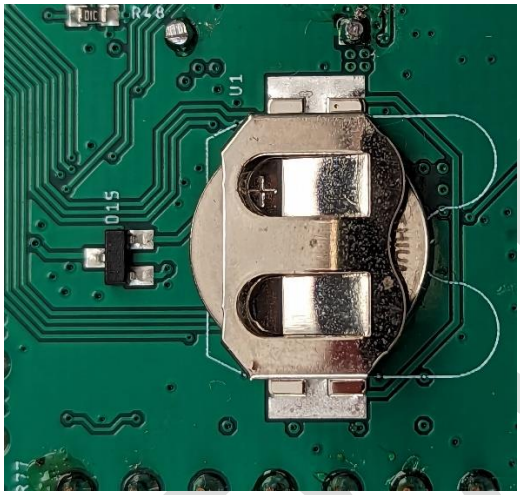


Figure 43: CR1220 Battery

6.8. Firmware Update

The STM32H7 contains a system bootloader that is pre-programmed in ROM during manufacture. It supports loading over USB; it is not normally used. Second and main possibility is using HTTP bootloader over a web browser.

Please note that HTTP (Ethernet) bootloader has reserved the first flash sector (0x8000000 to 0x801FFFF). Binary is loaded at address 0x8020000.

6.8.1.Ethernet Bootloader

With Ethernet bootloader, new firmware can be easily uploaded to the device with only a web browser. No additional software is needed. Recommended web browser for firmware upload is Google Chrome. After entering the Ethernet bootloader, the page in Figure 44: Ethernet Bootloader is shown. Users can select a file with firmware and upload it, switch to the system bootloader or go back to the application. The file with firmware must be in binary format (.bin).

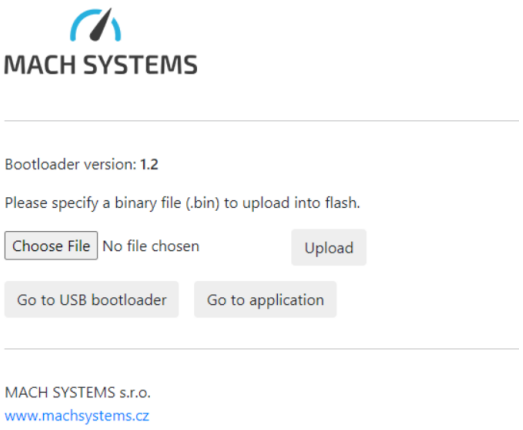
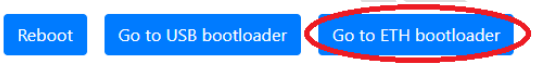


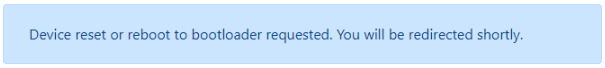
Figure 44: Ethernet Bootloader

There are four ways of starting Ethernet Bootloader:

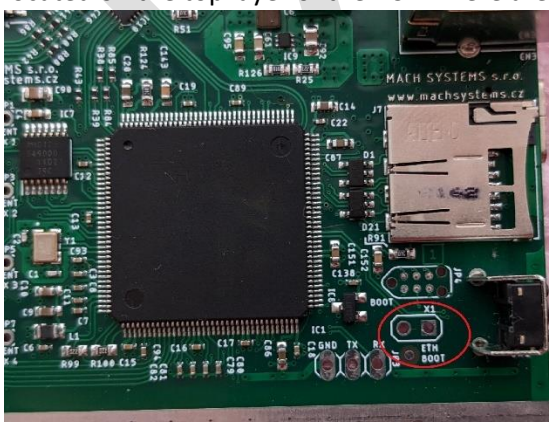
- **With internet browser:** See above for description on the web server, that is running on the device. Simplest way to go to the bootloader is by clicking “Go to ETH bootloader” on the website title page:

  Intermediate loading page will be shown:

  Device will then reboot to bootloader and user is redirected to its page. Binary file can be loaded.
- **Send protocol message:** Ethernet bootloader can be started using Mach System communication protocol with appropriate message ID (0xFE). See Communication Protocol Specification for more information.
- **By hardware:** To enter the bootloader, open the enclosure to access the boot-enable pads located on the top layer of the PCB. There are two pads marked “ETH BOOT” (see picture).

  The steps for booting into the bootloader are following:
  - Disconnect the USB and the external power supply; wait a while until the capacitors are discharged and device is completely off

  - Open the enclosure
  - Short the ETH BOOT pads together (a pair of tweezers can be used)
  - The device will enter the Ethernet bootloader
  - Connect the power supply - either USB or external
  - Connect the Ethernet cable
  - Release the boot pads
  - Firmware can be flashed
  - Close the enclosure
- **Programmatically from application:** If the user wants to load his own firmware to the device, he can jump to the address of Ethernet bootloader (0x8000000) from his program.

7. Delay Measurements

This chapter describes measurements of frame delay. All measurements have been done for SENT frames with 6 data nibbles and with Tick Time of 3 µs.

7.1. SENT to CAN

A typical delay between the end of a SENT Frame and the Start-of-Frame (SOF) of a CAN frame (that forwards that SENT frame information onto the CAN bus) is:

$$T_{asc} = 8.1\ \mu s\ \pm 0.45\ \mu s$$

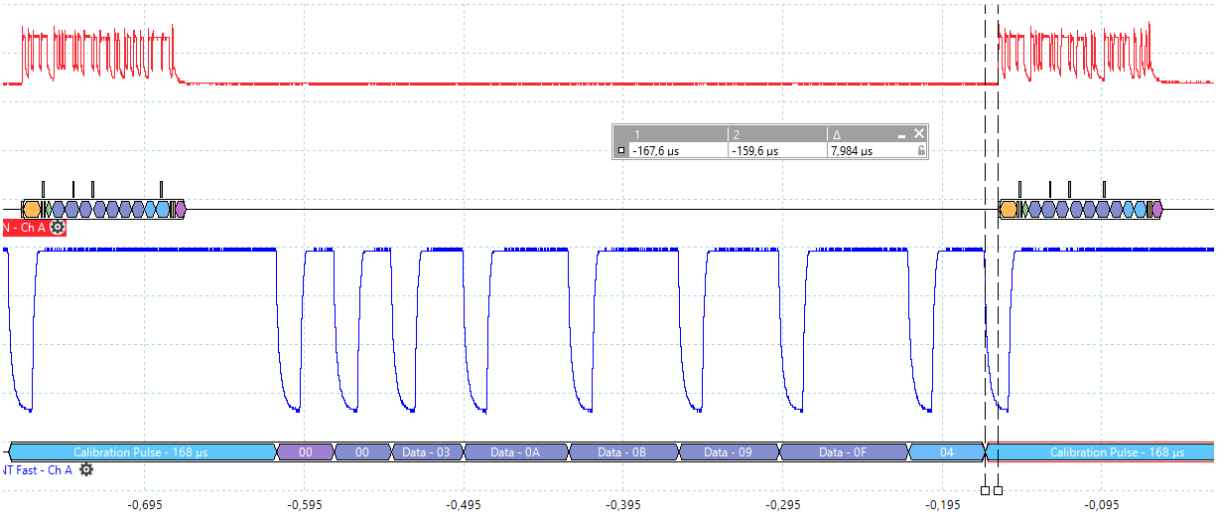


Figure 45: TdSC Measurement Illustration

7.2. CAN to SENT

A typical delay between the End-of frame (EOF) of a CAN frame and the start of a SENT frame is:

$$T_{dCS} = 13.58\ \mu s\ \pm 0.68\ \mu s$$

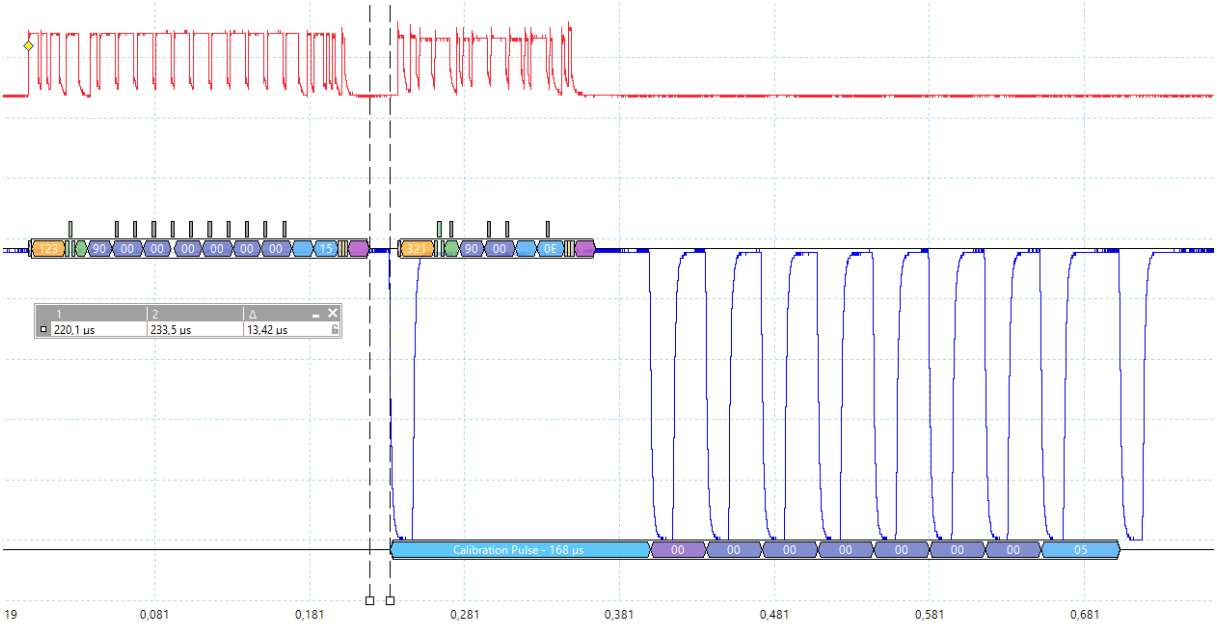


Figure 46: TdCS Measurement Illustration

7.3. SENT to Analogue

A typical delay between the end of a SENT frame and the setting time of an analogue output is:

$$T_{dSA} = 17.33\ \mu s\ \pm 0.92\ \mu s$$

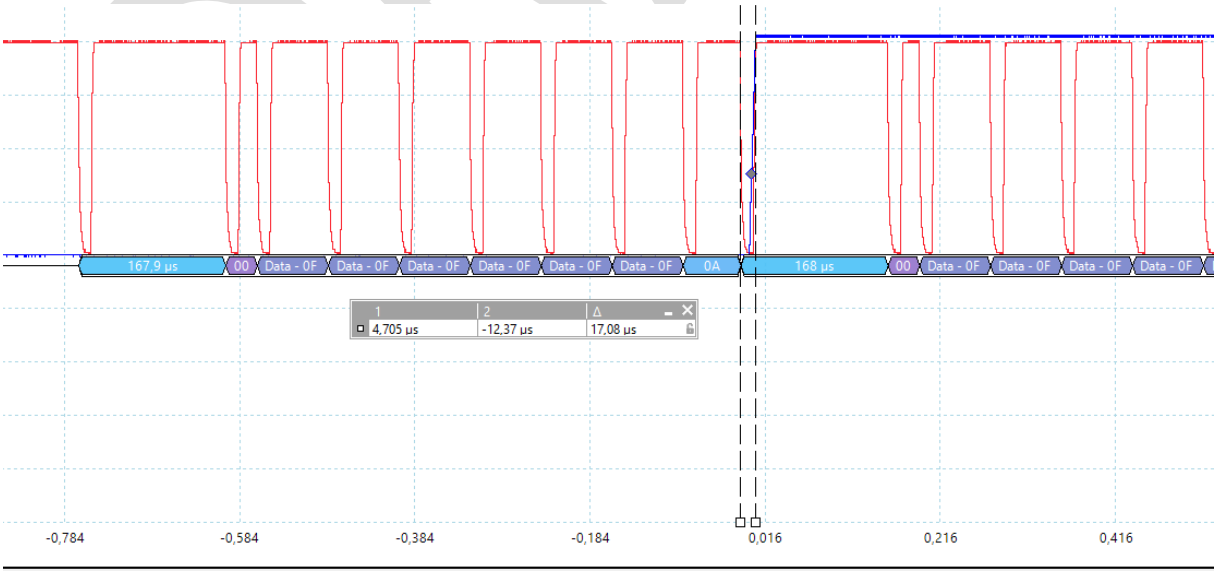


Figure 47: TdSA Measurement Illustration

7.4. Analogue to SENT

A typical delay between the setting time of an analogue input and end of a SENT frame is:

$$T_{dAS} = 1.71\ ms\ \pm 0.16\ ms$$

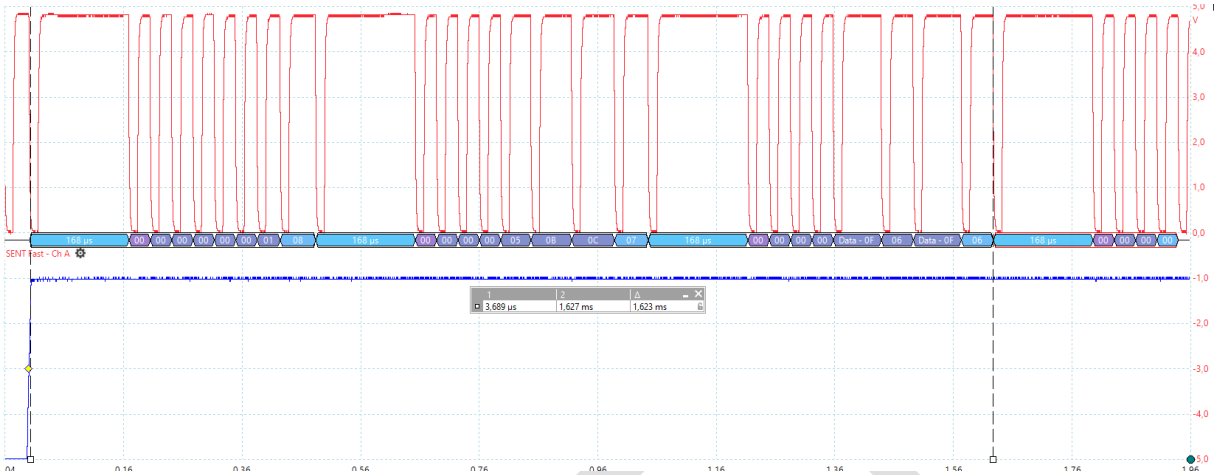


Figure 48: TdAS Measurement Illustration

8. Legal Information

8.1. Usage Warning

WARNING FOR ALL USERS

WARNING! - YOUR USE OF THIS DEVICE MUST BE DONE WITH CAUTION AND A FULL UNDERSTANDING OF THE RISKS!

THIS WARNING IS PRESENTED TO INFORM YOU THAT THE OPERATION OF THIS DEVICE MAY BE DANGEROUS. YOUR ACTIONS CAN INFLUENCE THE BEHAVIOR OF A DISTRIBUTED EMBEDDED SYSTEM, AND DEPENDING ON THE APPLICATION, THE CONSEQUENCES OF YOUR IMPROPER ACTIONS COULD CAUSE SERIOUS OPERATIONAL MALFUNCTION, LOSS OF INFORMATION, DAMAGE TO EQUIPMENT, AND PHYSICAL INJURY TO YOURSELF AND OTHERS. A POTENTIALLY HAZARDOUS OPERATING CONDITION IS PRESENT WHEN THE FOLLOWING TWO CONDITIONS ARE CONCURRENTLY TRUE: THE PRODUCT IS PHYSICALLY INTERCONNECTED TO A REAL DISTRIBUTED EMBEDDED SYSTEM; AND THE FUNCTIONS AND OPERATIONS OF THE REAL DISTRIBUTED EMBEDDED SYSTEM ARE CONTROLLABLE OR INFLUENCED BY THE USE OF THE CAN NETWORK. A POTENTIALLY HAZARDOUS OPERATING CONDITION MAY RESULT FROM THE ACTIVITY OR NON-ACTIVITY OF SOME DISTRIBUTED EMBEDDED SYSTEM FUNCTIONS AND OPERATIONS, WHICH MAY RESULT IN SERIOUS PHYSICAL HARM OR DEATH OR CAUSE DAMAGE TO EQUIPMENT, DEVICES, OR THE SURROUNDING ENVIRONMENT.

WITH THIS DEVICE, YOU MAY POTENTIALLY:

- CAUSE A CHANGE IN THE OPERATION OF THE SYSTEM, MODULE, DEVICE, CIRCUIT, OR OUTPUT.
- TURN ON OR ACTIVATE A MODULE, DEVICE, CIRCUIT, OUTPUT, OR FUNCTION.
- TURN OFF OR DEACTIVATE A MODULE, DEVICE, CIRCUIT, OUTPUT, OR FUNCTION.
- INHIBIT, TURN OFF, OR DEACTIVATE NORMAL OPERATION.
- MODIFY THE BEHAVIOR OF A DISTRIBUTED PRODUCT.
- ACTIVATE AN UNINTENDED OPERATION.
- PLACE THE SYSTEM, MODULE, DEVICE, CIRCUIT, OR OUTPUT INTO AN UNINTENDED MODE.

ONLY THOSE PERSONS WHO:

(A) ARE PROPERLY TRAINED AND QUALIFIED WITH RESPECT TO THE USE OF THE DEVICE,

(B) UNDERSTAND THE WARNINGS ABOVE, AND

(C) UNDERSTAND HOW THIS DEVICE INTERACTS WITH AND IMPACTS THE FUNCTION

AND SAFETY OF OTHER PRODUCTS IN A DISTRIBUTED SYSTEM AND THE APPLICATION FOR WHICH THIS DEVICE WILL BE APPLIED, MAY USE THE DEVICE.

PLEASE NOTE THAT YOU CAN INTEGRATE THIS PRODUCT AS A SUBSYSTEM INTO HIGHER-LEVEL SYSTEMS. IN CASE YOU DO SO, MACH SYSTEMS s.r.o. HEREBY DECLARES THAT MACH SYSTEMS s.r.o.'s WARRANTY SHALL BE LIMITED TO THE CORRECTION OF DEFECTS, AND MACH SYSTEMS s.r.o. HEREBY EXPRESSLY DISCLAIMS ANY LIABILITY OVER AND ABOVE THE REFUNDING OF THE PRICE PAID FOR THIS DEVICE, SINCE MACH SYSTEMS s.r.o. DOES NOT HAVE ANY INFLUENCE ON THE IMPLEMENTATIONS OF THE HIGHER-LEVEL SYSTEM, WHICH MAY BE DEFECTIVE.

8.2. Disposal and Recycling Information

When this product reaches its end of life, please dispose of it according to your local environmental laws and guidelines.

9. References

[1] “STM32CubeProgrammer Web Site,” [Online]. Available: https://www.st.com/en/development-tools/stm32cubeprog.html.

10. Ordering Information

TODO

Product Number	Description
MACH-SENT-ETH	SAE J2716 (SENT) interface, simulator, stand-alone data logger. 4 bi-directional SENT channels with SPC support, 10/100 Ethernet port, CAN(/FD) channel, USB, microSD slot, RTC, 4 multi-purpose I/Os, free-of-charge PC application, web site for configuration, open communication protocol for easy integration over Ethernet, USB, CAN(/FD); Can also be used as an Ethernet-CAN(/FD) or USB-CAN(/FD) interface.
MACH-SENT-ETH-NET-SDK	.NET SDK API (DLL) for MACH-SENT-ETH to access the device over Ethernet, USB (VCP) and CAN/FD. The API allows to access the SENT channels: configure, transmit and receive fast and slow messages. Also, the API allows to use MACH-SENT-ETH device as an Ethernet-CAN(/FD) or USB-CAN(/FD) interface. A royalty-free perpetual license, licensed per company location.
DIN-BRACKET-UNI	A universal DIN rail mounting bracket that allows to mount many types of enclosures on a DIN rail. The plate contains many holes and slots for various ways of fixing the enclosure. The bracket comes with a velcro tape to fix the enclosure on the plate.

Table 17: Product Numbers

11. Contact

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