CAN data acquisition: Challenges and solutions

CSS Electronics specializes in CAN data acquisition solutions. The company offers CAN data loggers, sensor-to-CAN modules, and free open-source software/API tools - as well as customer support and know-how.

CSS Electronics frequently offers new guides and videos on CAN topics. Recently, the company added a 45-minutes webinar focused on how to log CAN data. Below are seven use case examples on how CAN data logging can be done using the company's CANedge data loggers:

- *Blackbox for diagnostics and warranty disputes:* Many OEMs install the CANedge data logger as a blackbox in their vehicles and machines. With cyclic logging and filters, pre-scalers, and compression, this allows them to have a rolling window of e.g. the last 12 months of CAN data available on an SD card. This can be valuable if an intermittent issue arises or a customer warranty dispute occurs. The data can also be encrypted for confidentiality and integrity.
- *Mixed vehicle fleet data logging:* The loggers can also be used in mixed fleets (e.g. trucks, buses, tractors, or cars) and after-market deployments. For example, the raw J1939 data can be recorded and decoded using the available J1939 DBC (data base CAN) across different vehicle brands, models, and years. Similarly, in car fleets, the OBD2 DBC can be used to extract various signals.
- *Warehouse telematics and predictive mainte-nance:* The CANedge2 is suited for deployment in warehouses, e.g. to collect data from forklifts and AGVs (automated guided vehicles). Here, the devices log data to the SD and auto-offload the data when in range of a Wifi router. Data can be sent to the user's own cloud or self-hosted server (e.g. on a local network). A popular use case is predictive maintenance, where log files are auto-processed upon upload via the Python API or Matlab. In simple use cases, signals are evaluated against thresholds (e.g. for temperatures) and trigger SMS/email alerts to avoid asset damage or downtime. More advanced use cases involve models such as 'digital twins' and machine-learning-based estimates of remaining-useful-life. See for example a recent case study on how the CANedge2 is deployed across 250+ AGVs to enable warehouse predictive maintenance.
- *Marine telematics (NMEA 2000):* Collecting data from maritime vessels can be key in reducing emissions, optimizing energy consumption, diagnosing issues, and more. Here, the logger can be used to record the raw J1939/NMEA 2000 data to an SD card for later analysis. Further, with the CANedge2, data can be automatically offloaded e.g. via an onboard Wifi network to a local server, or via a 3G/4G router to a remote cloud when the vessel is within coverage. The NMEA 2000 data can be decoded using the NMEA 2000 DBC.

Figure 1: For fleet management, the raw J1939 data can be recorded and decoded using the available J1939 DBC file (Source: CSS Electronics)

- *CAN dashboard visualization:* To visualize data from vehicles or machines in dashboards, log files from the CANedge can be integrated with Grafana, enabling users to set up free customized dashboards. This can be helpful in diagnosing issues, benchmarking performance, or offering services towards end customers. The data can also be auto-pushed to a server and visualized in near real-time.
- *Reverse engineering:* In many applications, the CAN data is proprietary and only known to the manufacturer. The CLX000 (e.g. CL2000) serves as a CAN logger and USB interface in one device. This makes it suitable for ad hoc analysis, such as CAN reverse engineering. With the SavvyCAN GUI tool, it is possible to send, receive, and replay data in real-time, DBC-interpret it, and create real-time signal plots. The tool also offers the "sniffer view" feature for reverse-engineering discrete signals such as door locks, seat belts, buttons (etc.) or continuous signals such as SOC (state of charge), RPM, etc.
- *Replacing CAN/LIN hardware:* The CANedge is designed to offer professional-grade specifications at a lower cost and smaller form factor vs. comparable devices. This makes it an alternative in particular for use in OEM late-stage fleet testing and diagnostics. The logger uses the standardized MDF (*.MF4) file format and comes with converters for turning files into Vector ASC, Peak TRC, Excel CSV, etc. The MF4 format is also natively supported in Matlab's Vehicle Network Toolbox. As a result, the device can be deployed as a supplement to existing hardware solutions without having to learn new software tools.

Sensor-to-CAN modules

CANmod.gps module produces GNSS (global navigation satellite system) position and 3D inertial data (via a gyroscope and accelerometer) and outputs it via configurable CAN frames. It supports untethered dead reckoning (UDR) meaning that even if the GNSS signal is lost, the module can deliver continuous positioning through IMU-based estimates (no external inputs required). In addition to position, it produces signals such as speed, odometer, heading, pitch, roll, acceleration rates, and more.

CANmod.temp module produces temperature data from four thermocouple sensors and outputs it via CAN. The module supports all thermocouple types (B, E, J, K, N, R, S, T) and can be daisy-chained for 8, 12, 16, and more channels.

CANmod.input module produces analog, digital and pulse measurements from eight input channels and outputs the data via CAN. The compact device offers high-accuracy and high-frequency sampling as well as configurable input ranges and digital thresholds.

The devices can be integrated with any CAN network due to the customizable bit rate and CAN-IDs. Users can install them standalone to inject sensor data into e.g. a vehicle or machine CAN network. The devices can also be used as extensions for CAN data acquisition hardware e.g. by connecting CANmod modules to the CANedge's second port. This way, the CANedge can record e.g. vehicle data via channel 1 and e.g. time-synced GNSS/IMU and temperature data via channel 2.

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Record CAN/LIN and GPS/IMU data

CANedge is a two-channel CAN/LIN data logger with an SD card dedicated for automotive, maritime, or industrial applications. Recently, CSS Electronics has released the versions of the CANedge1/CANedge2 that include a GPS/IMU (global positioning system/inertial measurement unit) module. This is effectively similar to combining the CANedge with another product by CSS Electronics, the CANmod.gps (a GPS-to-CAN module), but with lower costs and in a more compact way. The device comes with free open-source software/API tools and offers Wifi connectivity for uploading log files to remote servers.

Added features are more than 40 GNSS/IMU signals including position, speed, trip distance, XYZ acceleration, roll, pitch, yaw, and more. The device also supports 'sensor fusion', combining the GPS data and 3D IMU data. This enables three-times higher positioning accuracy and enables consistent data even in GNSS-hostile areas (e.g. parking lots, tunnels, mines, etc.).

All GNSS/IMU signals can be output at up to 5 Hz. Users can customize which messages to record and at what frequency. The device comes with a CAN database (DBC file) to enable easy decoding of the internally generated data. As a bonus, the CANedge can use the internally generated GNSS/IMU signals to control whether to start/stop logging/transmission of data on both CAN channels. It can also use the high-precision, GPS-based timestamp to synchronize the real-time clock. This enables precise synchronization of time across all devices. The manufacturer also updated the enclosure of the device, adding mounting flanges and making it more compact (8 cm x 5 cm x 2 cm).

Figure: 2 CANedge2 including a GPS/IMU module (Source: CSS Electronics)

Example use cases

Combining CAN/LIN data and GNSS/IMU data is useful in many practical use cases. For example, one user deploys the CANedge2 incl. GNSS/IMU to log data from two CAN networks of prototype luxury cars during field tests, providing time-synchronized details on the vehicle dynamics in parallel with the CAN data. The combined data is visualized in open-source Grafana dashboards, enabling quick sharing of information across team members for optimization and diagnostics.

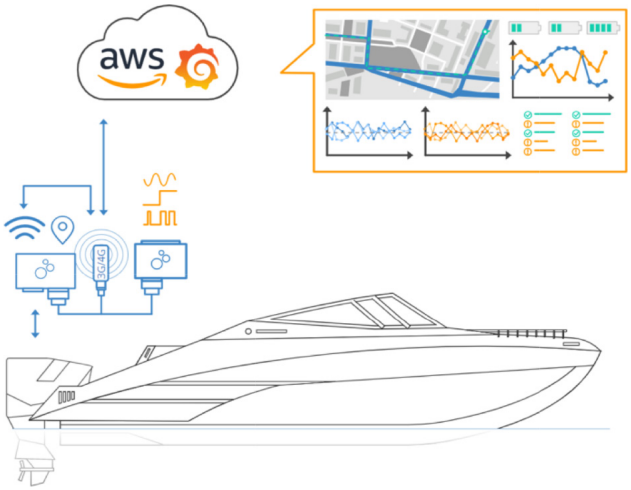

Figure 3: NMEA 2000 data along with GNSS/IMU data can be offloaded via a 3G/4G WiFi router to the user's own AWS cloud server (Source: CSS Electronics)

Another use case involves measuring state of charge, speed, positioning, and more across a fleet of more than 30 vehicles, consisting of a mix of electric cars (e.g. VW ID4) and non-electric cars. This use case focuses on evaluating the potential electrification of a vehicle fleet, which requires data collection for more than a year. Due to GDPR and privacy concerns, the data must be collected offline in encrypted form, for which the CANedge1 incl. GNSS/IMU is suitable. The use case also leverages the support for geofences to determine the "time spent" within electric vehicle charging zones.

In the maritime industry, the new solution enables easy recording of NMEA 2000 data along with GNSS/IMU data. Some users further combine the recent CANedge with e.g. the CANmod.input to add analog, digital, or pulse signals from various sensors into the same log file. Data can be offloaded via e.g. a 3G/4G Wifi router to the user's own AWS cloud server.

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Available software and API tools

The following overview shows some of the software/API tools available for products from CSS Electronics. The tools are free and open source. Most of them can be tried out without a device by using the manufacturer's CAN sample data, DBC files, and playground links.

For device and file management

Config editor enables users to configure the CANedge/CANmod devices via a simple browser-based GUI (graphical user interface).

CANcloud lets users login to their own S3 server and manage connected CANedge2 devices and uploaded log files. Users can track devices in the field via the status dashboard and perform over-the-air configuration and firmware changes.

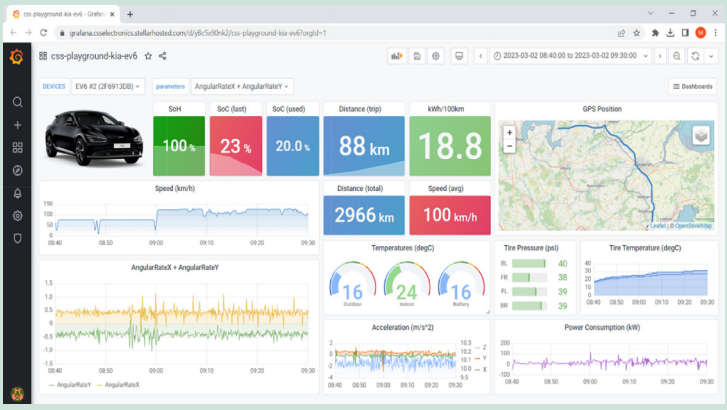

Figure: Grafana tool enables to set up custom browser dashboards for visualizing data from the CANedge units (Source: CSS Electronics)

For data processing and visualization

MF4 converters let users convert log files to other formats enabling easy loading in e.g. Peak's PCAN-Explorer or Vector CANalyzer.

Asammdf GUI is a general-purpose analysis tool for viewing the log files in raw form (showing the CAN frames), as well as for DBC decoding the data to physical values. The CANedge MF4 log files can be natively loaded in this Windows/Linux GUI tool. The tool also enables visualization of data via plots, including time synced GPS position plots. Further, the tool can export raw or decoded data into various formats such as Excel *.csv or Matlab *.mat.

Grafana lets users set up custom browser dashboards for visualizing data from the CANedge units. This is suitable e.g. for quick analyses, diagnostics, sharing insights, offering services towards end customers, and more. The setup takes less than 15 minutes and can be tested out with company's sample data.

Python API allows to list, load, and DBC-decode log files from the CANedge - from local disk or directly from the S3 server. The API exposes data in the popular 'pandas dataframe' format. API example scripts to get started are available. The API is convenient for processing large amounts of data, extracting statistical insights or automating processing (e.g. for setting up alerts or predictive maintenance).

Matlab (API) is familiar for many engineers within the automotive industry. Here, a toolbox called the 'Vehicle Network Toolbox' can be used to natively load MF4 log files from the CANedge for further processing. CSS Electronics also provides plug-and-play Python scripts for converting the CANedge log files to *.mat files.

For USB streaming

SavvyCAN: The CLX000 CAN loggers with a USB interface let the user send, receive, and replay CAN data in real-time via USB. The device integrates with the open-source SavvyCAN tool to view raw CAN data in real-time, as well as perform live DBC decoding and signal plots. Sensor data from the CANmod can also be streamed with SavvyCAN.

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