

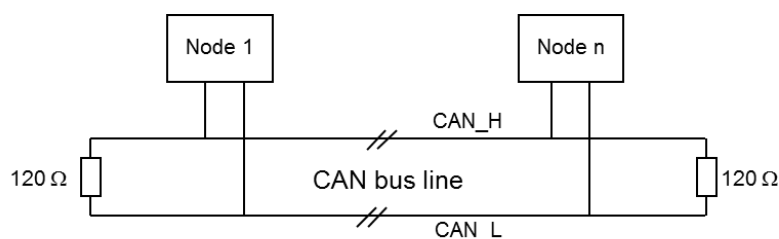
## Recording and Evaluating CAN Signals

|                                                |   |
|------------------------------------------------|---|
| Introduction                                   | 1 |
| Recording CAN Signals                          | 2 |
| General information                            | 2 |
| Recording the complete CAN signal with HEADlab | 3 |
| Creating a CAN sensor                          | 4 |
| Using the CAN sensor in HEAD Recorder          | 5 |
| Summary                                        | 6 |
| Decoding CAN Information in ArtemiS SUITE      | 6 |
| Note                                           | 9 |

### Introduction

The continuously increasing number of electrical components, motors, units and electronic systems in modern vehicles requires an increasing amount of wiring. To simplify the wiring harness and to save weight, the CAN bus (Controller Area Network) for the networking of control devices in vehicles was developed. There are two CAN bus types: high-speed and low-speed bus.

The CAN bus consists of a two-wire data line, to which all components are connected via short spur lines. That way, the bus wiring requires considerably fewer cable connections and contact points than conventional wiring systems. The standardization of communication among the control units via the CAN protocol even allows the monitoring of functions, i.e., the detection of errors and failures of control units, increasing the overall reliability of the system. The CAN bus implements a serial data transmission protocol using the two bus signal levels CAN\_High and CAN\_Low. On the CAN\_High line, a redundant, inverted signal compared to the CAN\_Low line is transmitted. When connecting additional control units, such as a CAN module, to this two-wire line, it is therefore important to check the polarity. The inversely symmetrical (differential mode) potential changes confer a high electrical interference resistance.



**Figure 1:** Schematic of a CAN bus

## Recording CAN Signals

### General information

With products from HEAD acoustics, you can record the data stream of a high-speed CAN bus according to ISO 11898-2. Basically, there are two possibilities for recording data from a CAN bus.

The first is to use a device that extracts, converts and outputs the desired information (e.g., engine RPM) from the input CAN signal. The extracted signals can then be recorded with a front end, such as HEAD*lab* or SQuadriga II. When using a converter box that outputs the extracted CAN information as TTL signals, the recording takes place via the RPM inputs of the front end. There are also devices that output CAN information as an analog quantity, which can be recorded via the analog inputs.

The second possibility is to record the complete CAN signal, e.g., with a HEAD*lab* system or a SQuadriga II. With SQuadriga II, the CAN signal can be recorded in stand-alone mode or in front-end mode (in connection with the Data Acquisition Module HEAD Recorder). For recording with a HEAD*lab* system, you need the HEAD Recorder software, too.

With SQuadriga II or with HEAD Recorder, it is possible to extract parameters from the complete CAN signal while recording. They can be used for triggering and can also be saved as separate channels if desired. Alternatively, the desired CAN parameters can be extracted after recording, from the saved complete CAN signal using ArtemiS SUITE.

Both the real-time extraction in HEAD Recorder while recording and the subsequent extraction in ArtemiS SUITE require the Data Preparation Module (ASM 24).

If your front end is not equipped with a CAN interface you can record CAN signals via an additional (separate) PCAN-USB interface from PEAK-System Technik GmbH<sup>1</sup>. The PCAN-USB interface is connected to the computer in combination with the front end via an additional USB port.

For connecting the above-mentioned devices to the CAN bus, a cable is required, which has a manufacturer-specific plug on one end<sup>2</sup>. When connecting the cable for a specific car manufacturer, it is important to observe the correct polarity regarding *CAN\_HIGH* and *CAN\_LOW*.

The figures 2 to 4 show an example for the connection of the manufacturer-specific cable to the CAN bus of a car.



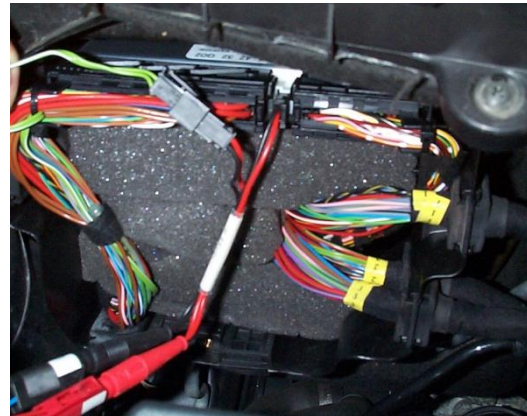
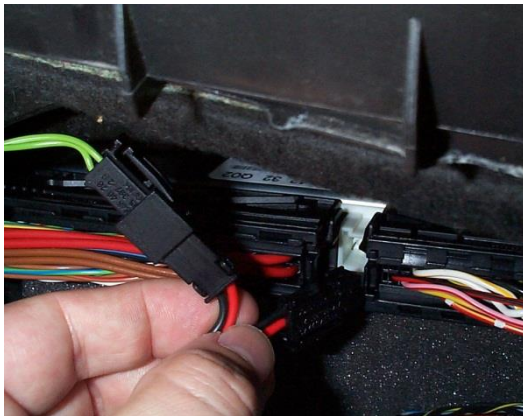
**Figure 2:** CAN bus connector

<sup>1</sup> CAN recording with a PCAN-USB interface is supported in combination with the following front ends: SQuadriga (I), HMS III/IV, ASIO soundboards (RME boards of the HSDP series), DATARec4.

<sup>2</sup> For recording CAN signals with SQuadriga II, you need the CAN bus adapter CLD VII.1. For recording CAN signals with *labDX*, you need the adapter cable CMD 0.12.



**Figure 3:** Disconnecting the existing CAN plug



**Figure 4:** Connecting the manufacturer-specific cable to the CAN bus

The following describes the recording of CAN signals with a HEADlab system (connection to the CAN interface of *labCTRL* I.2). The use and configuration of a *SQuadriga II* or the connection to the CAN interface of the HEADlab module *labDX* are done accordingly.<sup>3</sup>

### Recording the complete CAN signal with HEADlab

First connect your HEADlab system to your measurement PC via USB or Ethernet, then connect the CAN bus to the CAN input of the *labCTRL* I.2<sup>4</sup>.

Now start the Data Acquisition Module (HEAD Recorder) and open the channel list of the front end with the keyboard shortcut [Ctrl]+[L]. According to your front end configuration, the CAN channel is displayed in addition to the Line and Pulse channels.

Clicking on the  button displays all columns of the channel list. Among them is a column labeled **Baud rate**, where the pulses-per-second rate of the CAN bus must be entered. Furthermore, the option **Listen only** can be (de-)activated. When recording CAN bus data this option should be activated, since the recording front end is supposed only to listen to the CAN data stream, not to communicate actively.

**Caution (important!):** If you want to disable the **Listen Only** option, make sure that the correct baud rate for your CAN bus is configured before connecting the CAN bus with the front end. Otherwise, the entire communication on the CAN bus can be disrupted and control devices connected to the bus can fail!

As soon as you activate the CAN channel in the channel list, the complete CAN signal may be recorded. If you want to access specific CAN parameters while recording (e.g., for triggering the recording), you must create an additional CAN sensor and add it to the channel list.

<sup>3</sup> See the included manual of the respective product for detailed instructions and safety notes.

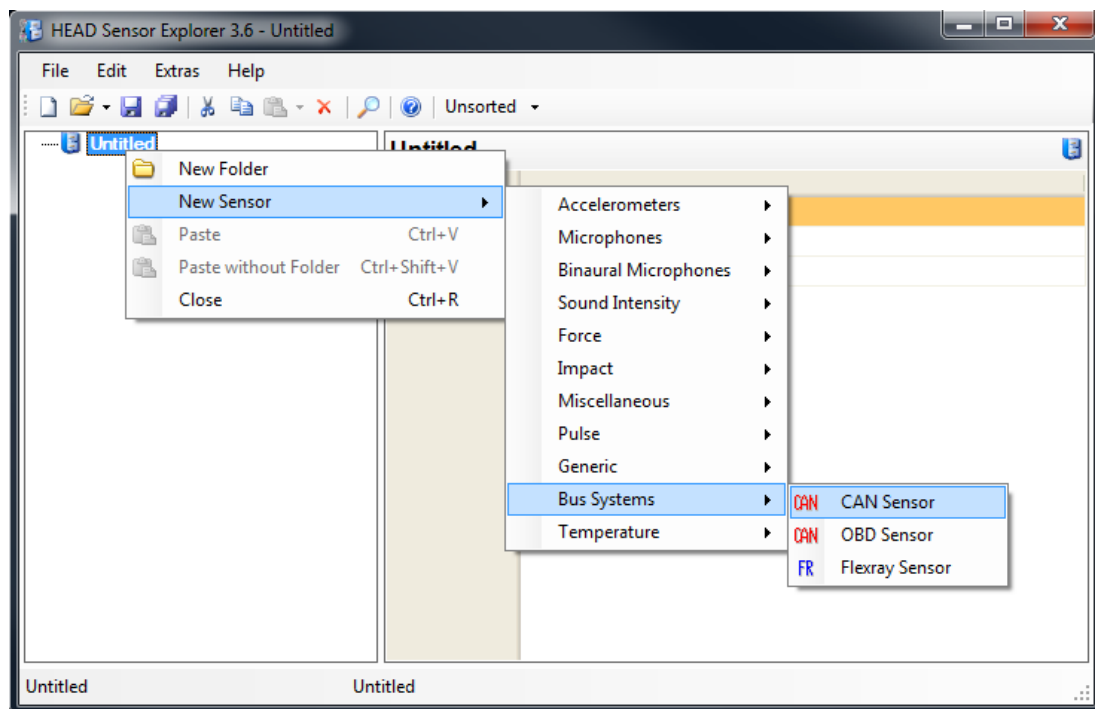
<sup>4</sup> Please read the safety notes in the manual to ensure a safe connection.

### Creating a CAN sensor

A CAN sensor can be created in the HEAD Sensor Explorer 3<sup>5</sup>. After starting the application, either open a new sensor list (keyboard shortcut [Ctrl]+[N]) or an existing sensor list, to which you want to add the CAN sensor (keyboard shortcut [Ctrl]+[O]). Then right-click on the sensor list to add a new CAN sensor (see figure 5).

Once this sensor has been selected, the Sensor Explorer opens a window for selecting a database in DBC format. This is a manufacturer- and vehicle-specific database containing information about the type, name, unit and data format of the signals on the CAN bus. By default, this information is managed by the users via a database software from Vector CANtech Inc. in the USA (in Japan: Vector Japan Co. Ltd., in Germany: Vector Informatik). Since this information is usually confidential and protected, such a database is not included with the HEAD Sensor Explorer – it can only be obtained from the car manufacturers. The information in this database is required for extracting the CAN data during the recording (as well as for the offline extraction in ArtemiS SUITE).

After selecting a DBC database, a list with the available CAN information appears in the lower part of the window (see figure 6).



**Figure 5:** Inserting a new CAN sensor in HEAD Sensor Explorer 3

<sup>5</sup> As of ArtemiS SUITE 7.0 you can also create CAN sensors in a sensor library (see section "Setting up a CAN sensor" in the Help System of ArtemiS SUITE).

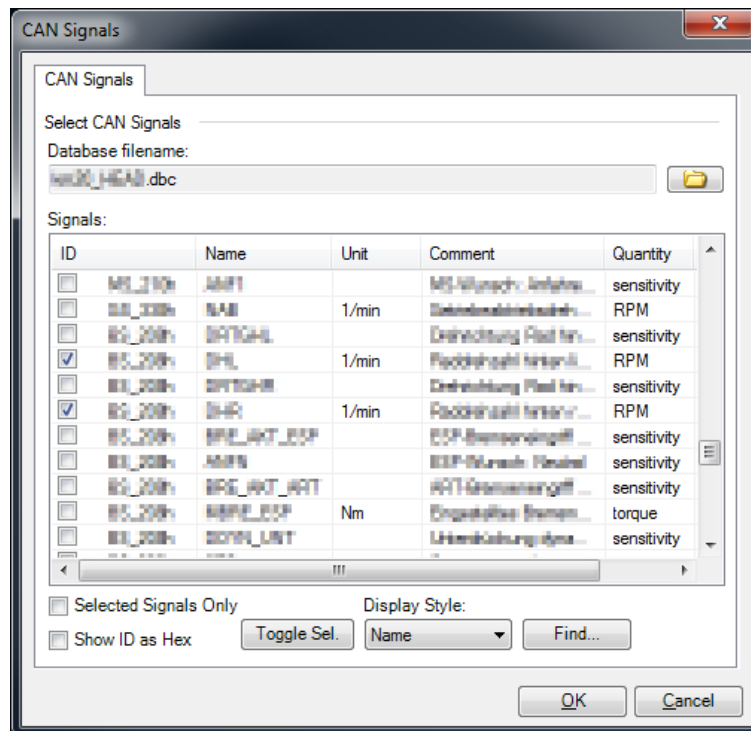


Figure 6: Selecting the CAN parameters extracted during the recording

In this list, individual channels can be selected for real-time extraction. Each of the selected channels is available as a control signal during recording and can be integrated into the recording as a separate channel.

## Using the CAN sensor in HEAD Recorder

To use the CAN sensor, first open the channel list in HEAD Recorder (e.g. by using the keyboard shortcut [Ctrl]+[L]) and right-click on the socket icon in the line with the CAN channel. Then select the sensor list containing the CAN sensor you created in HEAD Sensor Explorer, and connect it. Instead of the usual BNC socket icon, a red CAN label appears in the list, and the channels selected before are offered, for example, for triggering the recording.

Furthermore, the selected channels can be displayed in the **Online Monitor**, analysis selection **RPM vs. time**) or with the **Tachometer** for monitoring during the recording.

The extracted data may be used for controlling the recording and can be saved in addition to the entire CAN signal as separate channels. For this purpose the option **Tools -> Options -> Application -> File generation -> Save decoded channels from pulse channels or CAN in recorded file** must be activated (see figure 7).

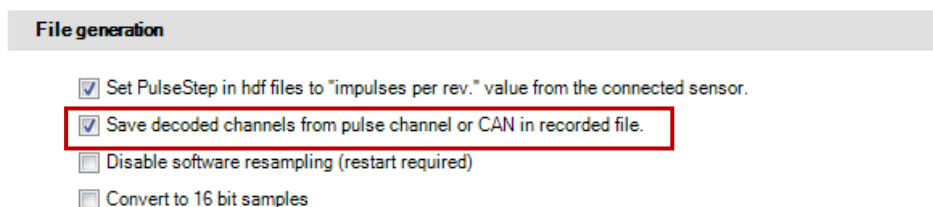


Figure 7: Application Options in HEAD Recorder

## Summary

The complete CAN signal can be recorded without a DBC database. However, if a specific CAN parameter is to be extracted from the CAN data stream while recording, the DBC database is required for the configuration of the CAN sensor in HEAD Sensor Explorer 3<sup>6</sup>. Furthermore, access to the DBC database must be ensured during the recording, and the software license of HEAD Recorder must include the Data Preparation Module (ASM24).

HEAD Recorder always records the entire CAN data stream: a.) even if the license does not include ASM24, and b.) with ASM24 present, whether or not individual parameters are extracted during the recording as control signals. It should be avoided to select too many CAN parameters for decoding during the recording, because considerable CPU power is required for extracting and decoding the information “on the fly”. Consequently the selection should be restricted to the main, needed number of signals.

In addition, the DBC database is required for offline extraction of CAN signals in ArtemiS SUITE after the recording (see section “Decoding CAN Information in ArtemiS SUITE” below).

When recording the CAN signal, there may be a delay between the CAN channels and the audio channels for technical reasons. If the CAN signals are recorded with HEAD/ab or SQuadriga II and HEAD Recorder, the delay is reduced to less than 10 ms during recording, and preserved in the recorded file. This also applies to recordings with SQlab III or DATaRec 4 and HEAD Recorder. In most cases (e.g. recording RPM information for an order analysis), such a small delay is acceptable.<sup>7</sup>

For recording rapid RPM changes or RPM information for a high-resolution order analysis (e.g., of gear wheels), extracting RPM information from the CAN data stream is not a suitable method. For these applications, RPM data must be acquired with optical sensors, or onto an analog channel from magnetic sensors.

## Decoding CAN Information in ArtemiS SUITE<sup>8</sup>

With HEAD/ab or SQuadriga II, it is possible to record all data from one or several CAN bus systems in one channel per bus. The information in these channels is saved in the original CAN data format. In ArtemiS SUITE, any number of individual CAN parameters can be subsequently extracted from the complete CAN signal and saved to separate channels. Since the complete data stream is always recorded, all parameters are available for subsequent extraction.

Decoding the CAN information requires the database files (\*.dbc) mentioned above. It is possible to use more than one DBC database for the extraction.

To extract the CAN parameters in ArtemiS SUITE, first open a **Decoder Project** via **Start -> New -> Decoder Project**. In this project you will find three Pools structured in a similar way as the Pools in a Pool Project. In the Source Pool on the left side, insert the time-domain signals containing the encoded CAN information. In the Decoder Pool (middle column or Pool, which is comparable to the Analysis Pool), select the DBC database for decoding and configure the decoding. And in the Destination Pool on the right, specify the format for the new file containing the decoded CAN parameters. The available export formats to choose from are HDF, ATFX and UFF.

In a Decoder Project, all input signals are always active. You can also activate multiple decoders at once for a calculation.

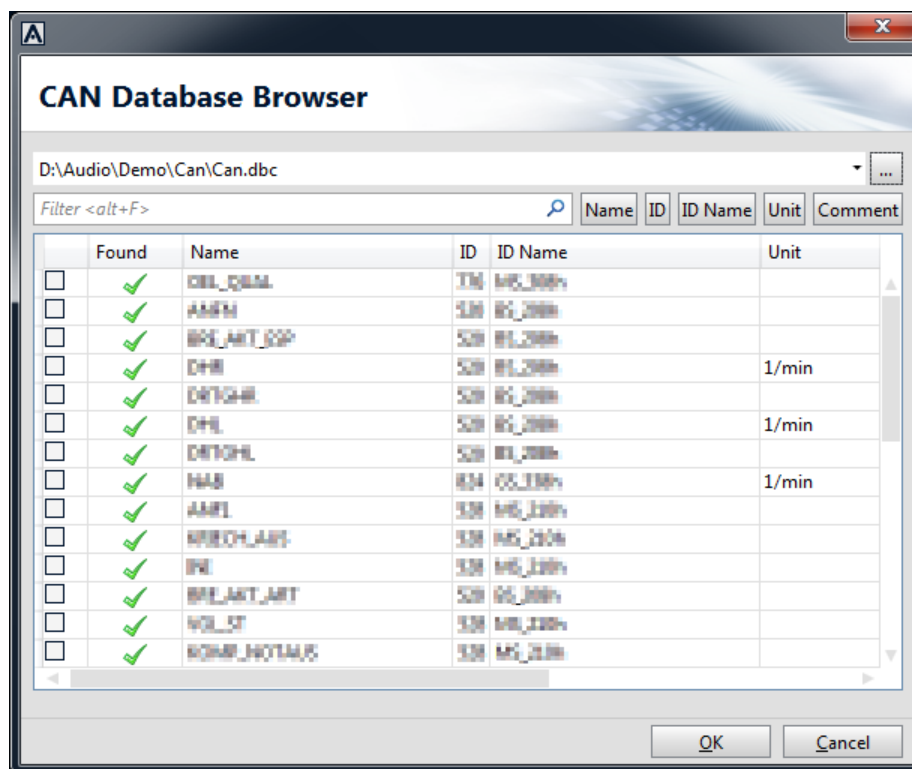
To select the DBC database for decoding, click on the Button **Insert CAN Decoder** in the Decoder Pool. ArtemiS SUITE then opens the **CAN Database Browser**. Click on the button with three dots and select

<sup>6</sup> As of ArtemiS SUITE 7.0 you can also create CAN sensors in a sensor library. Before you can use a sensor library created with ArtemiS SUITE in the channel list of the HEAD Recorder (as of version 7.0) you have to import the library. One advantage of using sensor libraries is that the information needed for the decoding are saved with the sensor library, thus after the sensor creation the DBC file is not needed anymore.

<sup>7</sup> When recording with a PCAN-USB interface, the CAN data is acquired via a second USB port. Since the USB ports of a computer are not synchronized with each other, such a measurement setup can lead to much longer delays. The delay can differ from recording to recording even when using the same front end and the same configuration. The delay can be up to 100 ms, but is significantly shorter in most cases.

<sup>8</sup> The descriptions in this Application Note refer to version 8.0. The general procedures also apply to other versions. However, the scope of functionality and the user interface may differ.

the desired DBC database. The lower part of the browser now shows a list of the parameters available in this database. Activate the parameters you need by clicking on their checkboxes at the beginning of each line (see figure 8). In order to facilitate the search you can filter the displayed CAN information via an input field.



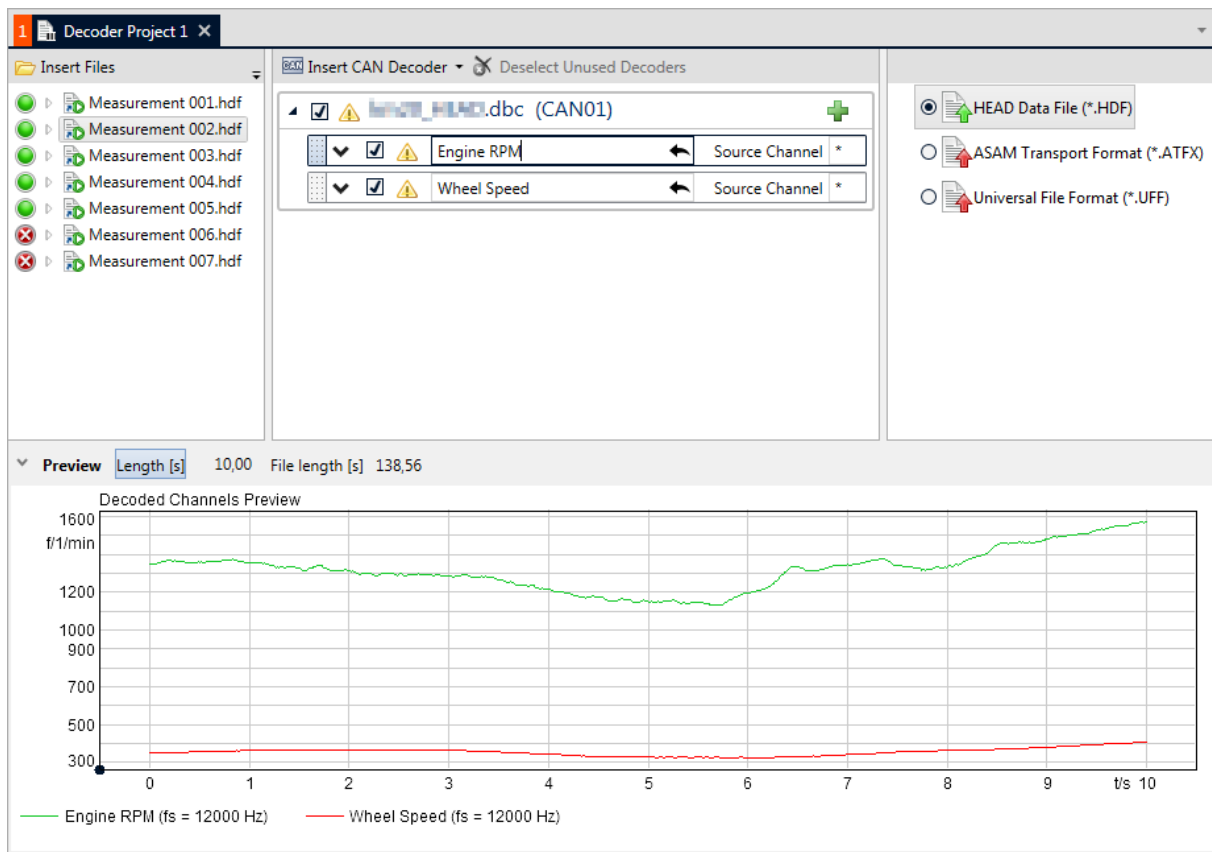
**Figure 8: CAN Database Browser**

Clicking on **OK** closes the browser. The Decoder Pool then shows the name of the DBC database and the names of the selected CAN parameters. If you need to add additional parameters subsequently, click on the **+** icon to open the list of available OBD-2 parameters again.

The names of the parameters can be edited and are later used as channel names for the new channels with the decoded CAN parameters. The order of the decoded channels in the results file depends on their order in the Decoder pool. You can drag and drop the items in the Decoder Pool to arrange the channels in your preferred order.

Figure 9 shows an example of a Decoder Project. The left column contains seven recordings; the DBC database CAN.dbc was inserted in the middle column, from which the parameters *Engine RPM* and *Wheel Speed* have been selected for extraction. In the last column, an HDF file is selected as the destination.

ArtemiS SUITE checks immediately whether the selected parameters are available in the source files and indicates this with a green "LED" icon next to the file name in the source file pool. If decoding is not possible, a red "LED" with an X is displayed. The same applies to the active items in the Decoder Pool. Here, too, a red "LED" appears if none of the source files contains the desired parameter.



**Figure 9:** Example of a Decoder project

Before you can start decoding, any unsuitable source files or decoders must be removed with the commands **Remove Unused Files** and **Deselect Unused Decoders** in the context menu. If decoding is not possible for all source files or with all decoders, a warning triangle with an exclamation mark is displayed (see figure 9, Decoder Pool). The decoding process can be started nevertheless.

For each CAN parameter in the Decoder Pool, you can specify additional properties after clicking on the **▼** button. These include, for example, the interpolation type and the physical unit. Detailed instructions can be found in the Help System of ArtemiS SUITE in the section "CAN Decoder".

In the **Preview** (lower part of figure 9), ArtemiS SUITE displays a graphical preview of the first 10 seconds of the CAN channels of the active source file for a quick check of your settings. Depending on your needs, you can change the length of the preview in the **Length** field or display the whole file length by clicking on the **File Length** button. The data decoded for the preview only serve for checking the settings, but are not stored.

To start decoding, click on the abacus button or double-click on the corresponding Destination Pool item. During the decoding process, ArtemiS SUITE creates a new file containing both the encoded CAN channel and the selected CAN parameters as separate channels. In the Properties dialog of the Destination Pool item, you can specify where the new file is to be saved and how the file name should be created.

In order to re-use your configurations of the CAN decoder for further decodings save your Decoder Project, e.g., by clicking the **Save** button.

## Note

For the applications presented in this Application Note, you need the following ArtemiS SUITE modules: **ASM 00** ArtemiS SUITE Basic Framework (code 5000), **ASM 04** ArtemiS SUITE Data Acquisition Module (code 5004) and **ASM 24** ArtemiS SUITE Data Preparation Module (code 5024). For exporting the decoded data to the UFF format you additionally need **ASM 23** Advanced Import & Export Module (code 5023).

The database files in DBC format mentioned above are not included with Artemis SUITE, but must be obtained from the vehicle manufacturer.

Do you have any questions or remarks? Please write to:

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We look forward to receiving your response!