UM3214

User manual

Getting started with the AEKD-STEREOAVAS integrated stereo AVAS solution

Introduction

Electric cars, hybrid cars, and fuel cell vehicles not only help to protect the environment, but they also provide a better quality of life in urban and rural areas. The innovative, whisper-quiet drive technologies can increase the risk of accidents under certain circumstances. The acoustic vehicle alerting system (AVAS) provides added safety wherever the noise of electric motors, which is too quiet, can become a hazard.

The AVAS simulates the engine noise of a combustion engine in the lower speed range to improve the safety of vulnerable road users (VRUs) such as pedestrians, cyclists, and children. Artificial vehicle sounds are generated using loudspeakers or actuators through the vibration of the vehicle structural elements proportional to vehicle parameters such as velocity, gas pedal position, and gear. Electric cars are barely audible, especially at low speeds, and can pose a safety risk. AVAS is a significant contribution to road safety. If a vehicle with alternative drive technology moves to a higher speed range, the rolling noise of the tires on the road is sufficient and AVAS is automatically deactivated. AVAS can be fitted not only on passenger cars, but also commercial vehicles and vehicles such as buses and garbage trucks.

Since July 2021, all new vehicle models registered in the EU must be equipped with an acoustic warning system as a mandatory requirement under EU Decision ECE R138. If a too-quiet car is traveling in traffic at a speed of less than 20 kilometers per hour, the acoustic warning system must give a signal. At speeds above 20 kilometers per hour, the audible warning system for electric vehicles automatically deactivates. In the US, the threshold is 19 mph (30 km/h).

Our AEKD-STEREOAVAS is an AutoDevKit acoustic vehicle alerting system (AVAS) demo.

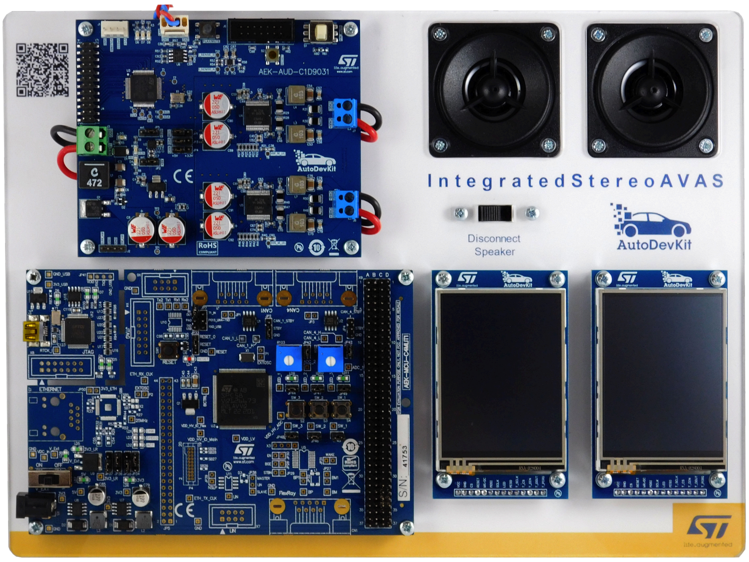
It consists of an AEK-AUD-C1D9031 compact AVAS board, an AEK-MCU-C4MLIT1 domain controller, and two AEK-LCD-DT028V1 display expansion boards, plus two loudspeakers and a switching button.

The AEK-AUD-C1D9031 communicates with the AEK-MCU-C4MLIT1 via CAN protocol, exchanging commands like start/stop to simulate alerting sounds used in e-vehicles. The sound is reproduced by the AEK-AUD-C1D9031 ECU through a pair of integrated loudspeakers.

Two AEK-LCD-DT028V1 boards with resistive touch allow the user to interact with the demo. The first screen shows a graphic simulation of the tachometer, while the second allows starting/stopping the demo and regulating the sound volume and the engine rpms.

Warning: *The AEKD-STEREOAVAS evaluation kit has not to be used in a vehicle as it is designed for R&D laboratory use only.*

Figure 1. **AEKD-STEREOAVAS evaluation kit**

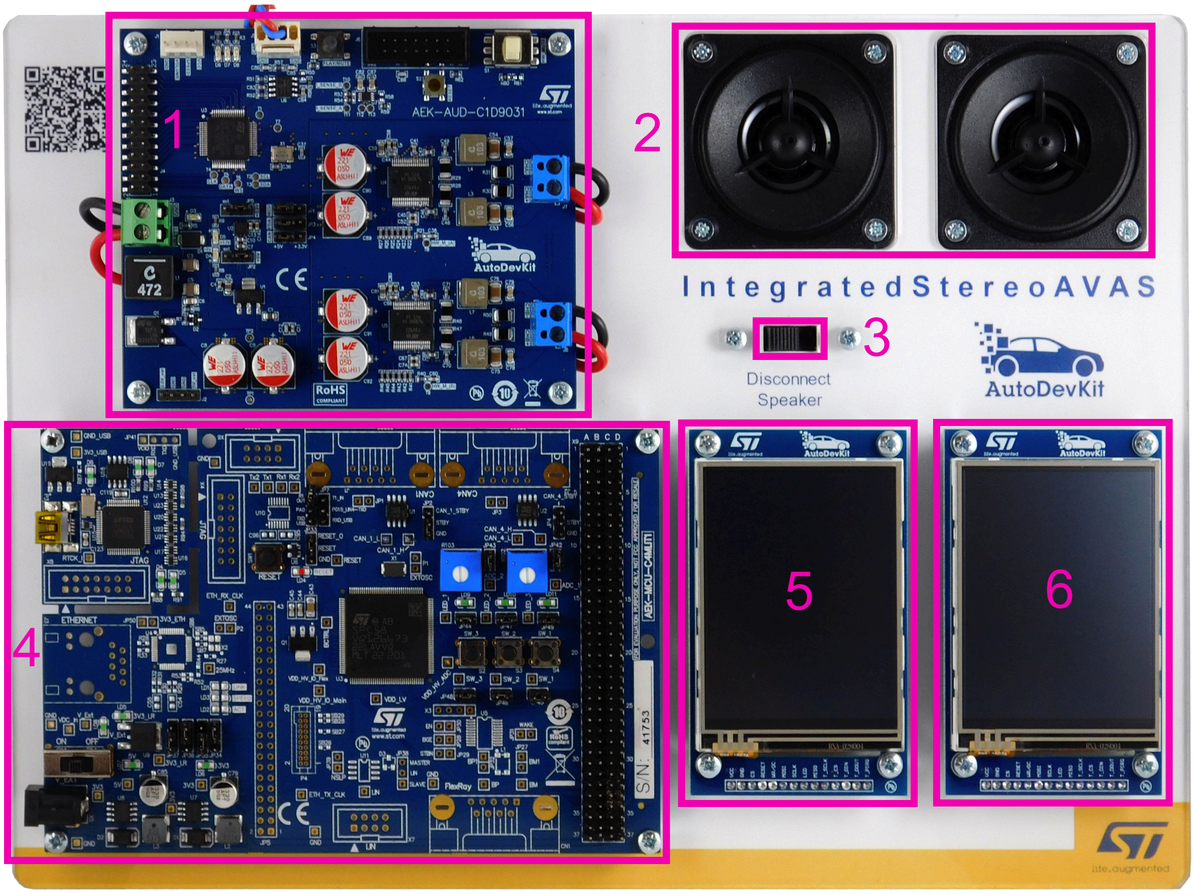


1 Hardware overview

1.1 Kit main components

1. AEK-AUD-C1D9031 compact AVAS board
2. Integrated loudspeakers
3. Disconnect speaker switch
4. AEK-MCU-C4MLIT1 domain zone controller board
5. AEK-LCD-DT028V1 display expansion board with resistive touch that shows a graphic simulation of the tachometer
6. AEK-LCD-DT028V1 that allows starting/stopping the demo and regulating the sound volume and the engine rpms

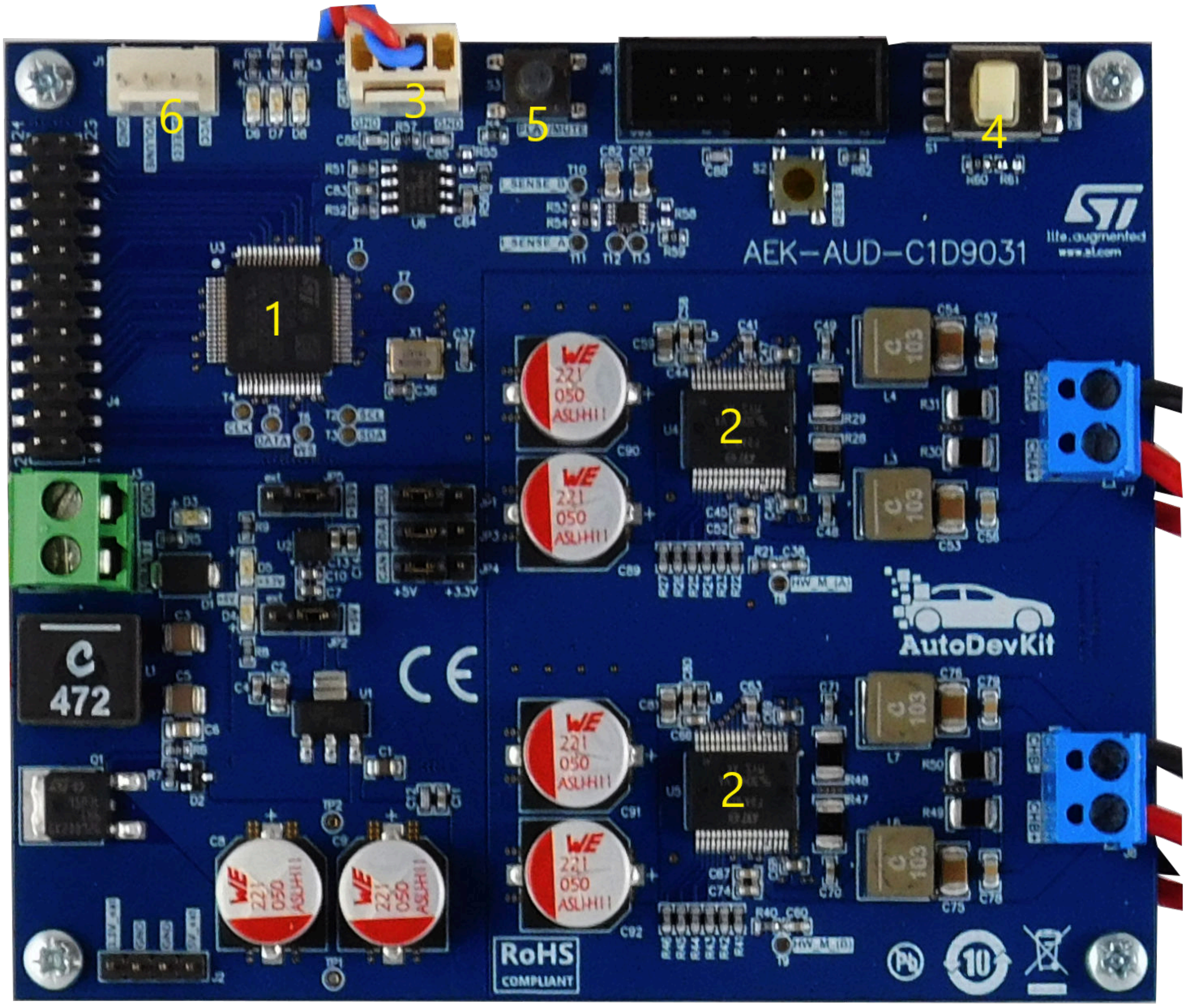
Figure 2. Kit components



1.1.1 AEK-AUD-C1D9031 overview

1. SPC582B60E1 automotive microcontroller
2. Class D FDA903D power amplifiers
3. CAN connector
4. Hardware mute switch
5. Turn on/off sound button
6. Connector compatible with AEK-AUD-C1D9031

Figure 3. AEK-AUD-C1D9031 components



The AEK-AUD-C1D9031 represents the core of our solution.

It is a very compact AVAS solution based on SPC582B60E1 Chorus family MCU and FDA903D Class D audio amplifiers that emits warning sounds to alert pedestrians of the presence of e-vehicles in the proximity.

The optimized board size allows installation of more than one AVAS module in an e-car to ensure that the warning sound is heard in any direction along the vehicle.

The board hosts the SPC582B60E1 automotive microcontroller belonging to the Chorus family, embedding a high performance e200z2 single core 32-bit CPU with 80 MHz clock, 1088 KB Flash and 96 KB SRAM, in a compact eTQFP64 package.

The microcontroller monitors and controls the two Class D FDA903D power amplifiers driving the loudspeakers.

The audio transmission from the microcontroller to the two audio amplifiers is implemented via I²S interface (simulated by an SPI peripheral), while I²C port and GPIOs are used to provide the necessary signals and communication lines to configure the power amplifiers.

The proposed AVAS solution is designed to be remotely controlled by a central ECU via CAN interface, using the on-board CAN connector. The board also features a hardware mute button and a button to turn on/off the sound.

In addition, a connector is present to plug a board with two sliders: one to manage the speed (engine rpm) and the other to manage the volume. A compatible version of these sliders is included in the AEK-AUD-C1D9031.

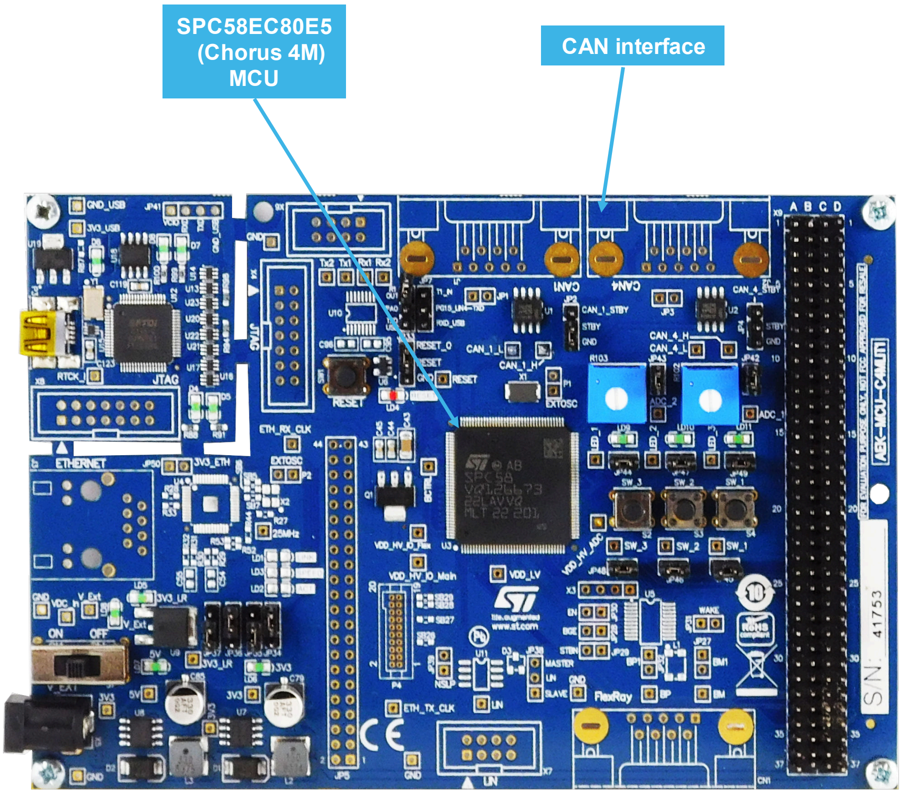
For further information on this board, refer to the related user manual.

1.1.2 AEK-MCU-C4MLIT1 overview

The AEK-MCU-C4MLIT1 represents the domain controller of our solution. It is designed to address automotive and transportation applications requiring automotive safety and security levels.

The board exploits the functionality of SPC58EC80E5 32-bit automotive grade ASIL-B microcontroller with 4 MB flash, full access to the two MCU cores, GPIOs and peripherals such as ISO CAN FD (with transceiver) and UART at a very competitive price. The board hosts a PLS debugger/programmer and an extension connector (4x37 pins) for functional interaction across boards that are compatible with the AutoDevKit ecosystem. The PLS Universal Debug Engine (UDE) software is available for free download and includes a free perpetual 256 Kbyte debugging/programming license.

Figure 4. AEK-MCU-C4M1LIT1 MCU board



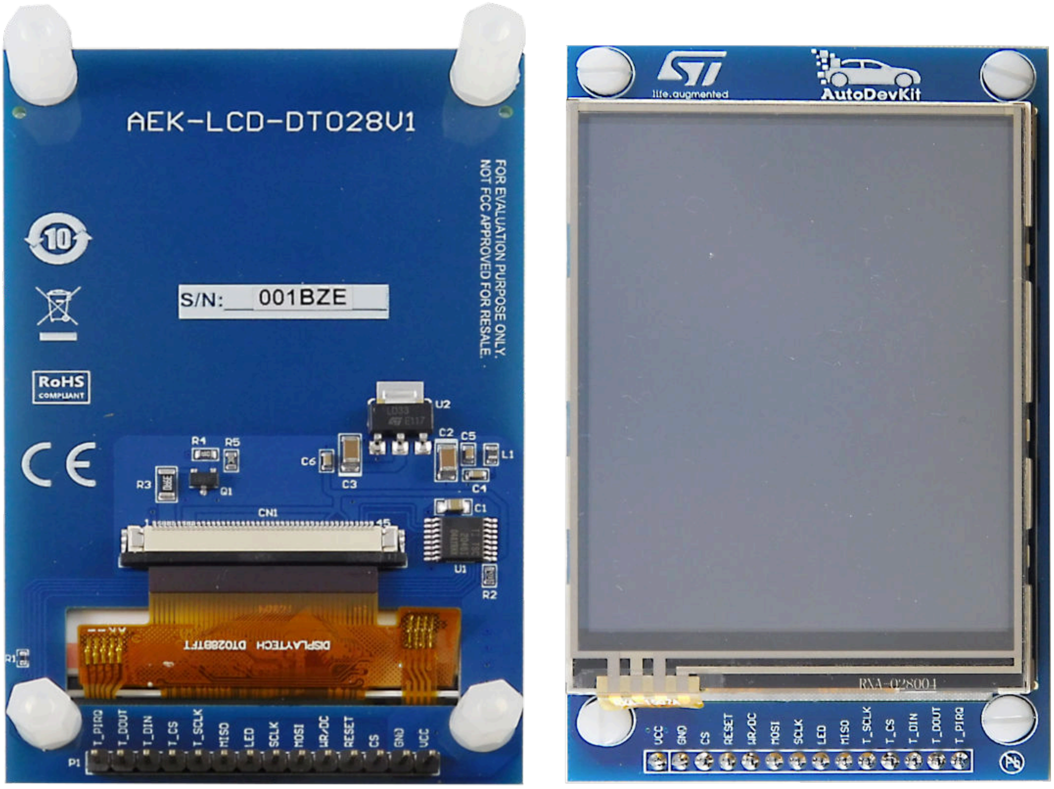
For further information on this board, refer to the related user manual.

1.1.3 AEK-LCD-DT028V1 overview

The AEK-LCD-DT028V1 display expansion board hosts a 2.8” LCD display with resistive touch (resolution of 240x320 pixels), managed by an on-board SPI touch screen controller.

The two LCD screens hosted in our solution show a graphical representation of a tachometer and the way it changes according to the engine simulated rpm.

Figure 5. **AEK-LCD-DT028V1 display expansion board**



Note that these LCD are based on low-cost touch-resistive technology. Therefore multi-touch or quick continuous touches are not allowed.

At system start-up, to avoid hang-ups, make sure that the drawings are completed before using the touch screen.

For further information on this board, refer to the related user manual and to the LVGL libraries here https://lvgl.io/.

2 Software overview

Download the latest release of AutoDevKit Studio.

When you import an existing application in the tool, you can find a list of available demos.

The demos to be uploaded on the kit are two:

- one for the AEK-AUD-C1D9031, “SPC582Bxx_RLA_AEK_AUD_C1D9031 - Avas Compact - Test Application”
- one for the AEK-MCU-C4MLIT1, “SPC582Bxx_RLA_MainEcuForAVAS Integrated - Test Application”

Both demos are already pre-loaded on the respective boards of the kit.

The first demo shows how to simulate the car engine sound, performing diagnostic in real-time, in two different states: play and mute. The demo provides an example of how to manage the two FDA903D audio amplifiers with a driver dedicated to an AEK-AUD-C1D9031 board. The detection of the open load in play mode depends on the sound characteristics (refer to the FDA903D datasheet for details).

The board is ready to be tested. If you need to download the firmware again, use SPC5-UDESTK programmer plugged on the JTAG connector. The source code is present from AutoDevKit 1.4.0. To upload the demo into the microcontroller, refer to UM2719, Section 7.2.1 How to upload the demos for AEK-AUD-C1D9031.

To start and stop the sound, use the dedicated button. While in stop status, the LED D6 turns on. When the open load fault is detected, LED D8 turns on, while LED D7 is turned on when pushing the hardware Mute button.

By default, this demo is controlled via CAN by an external MCU/ECU. It is possible to simulate the car engine acceleration/deceleration using commands via CAN. The file CANCommunication.h under the source folder contains the information (SID and Value) related to the messages managed by the demo.

You can find further details on the algorithm implemented to simulate the car engine sound and how to load the sound on the microcontroller board in UM2719.

The second demo manages the inputs coming from the displays (for example, start and stop, accelerate, decelerate, etc.) and sends the related CAN messages to the AVAS ECU.

At the same time, this demo can also manage diagnostic messages coming from the AVAS ECU. Refer to section 6 for more details.

3 How to upload the demos for AEK-AUD-C1D9031

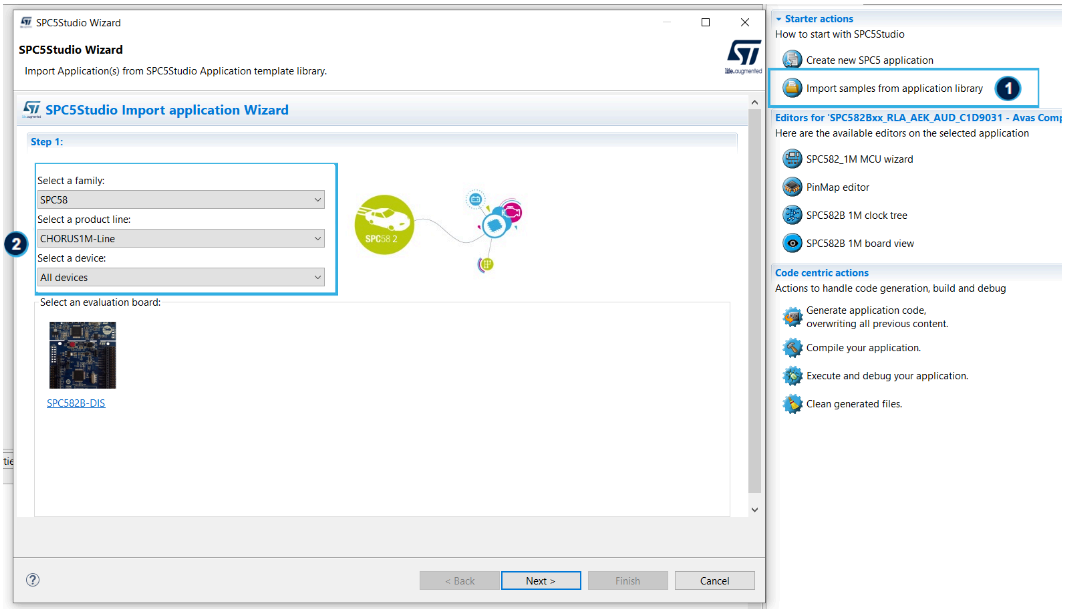
Follow the procedure below to import the demos into AutoDevKit Studio.

Step 1. Select [Import samples from application library] from the Common tasks pane. An Import application Wizard appears.

Step 2. In the Import application Wizard, insert the appropriate product family details.

- **Step 2a.** Import samples task button
- **Step 2b.** Product family selection panel

Figure 6. AutoDevKit Studio Import application Wizard



Step 3. Select the desired application from the library.

Step 3a. application selector

Step 3b. confirmation buttons

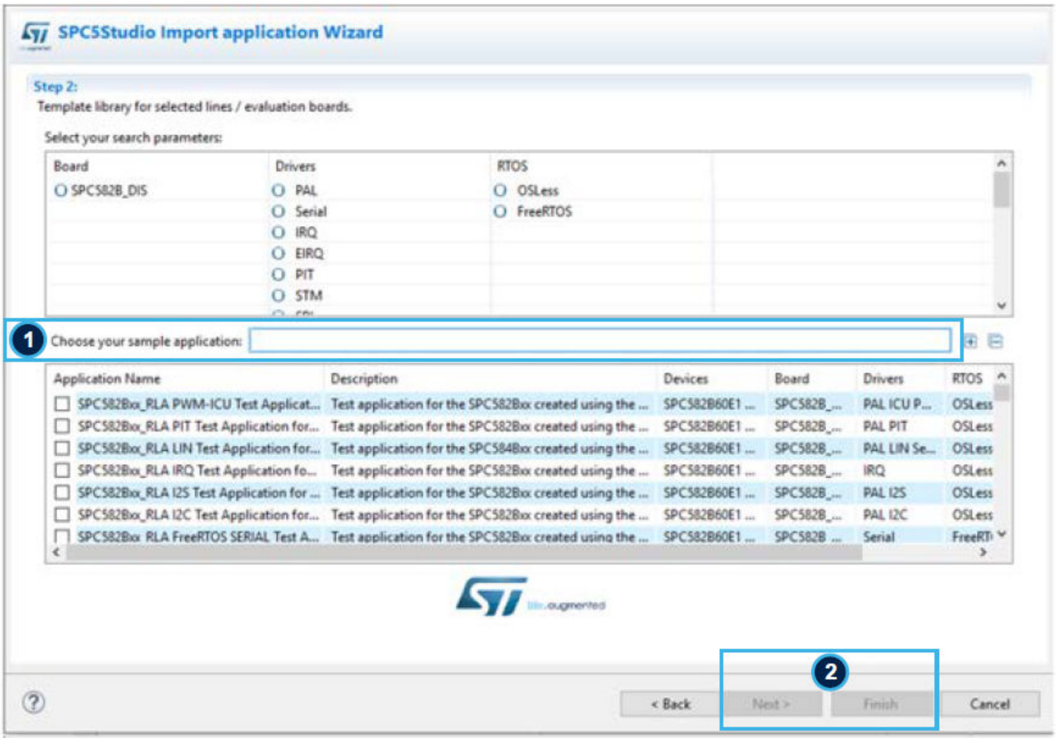


Figure 7. AutoDevKit Studio application library

4 How to use the solution

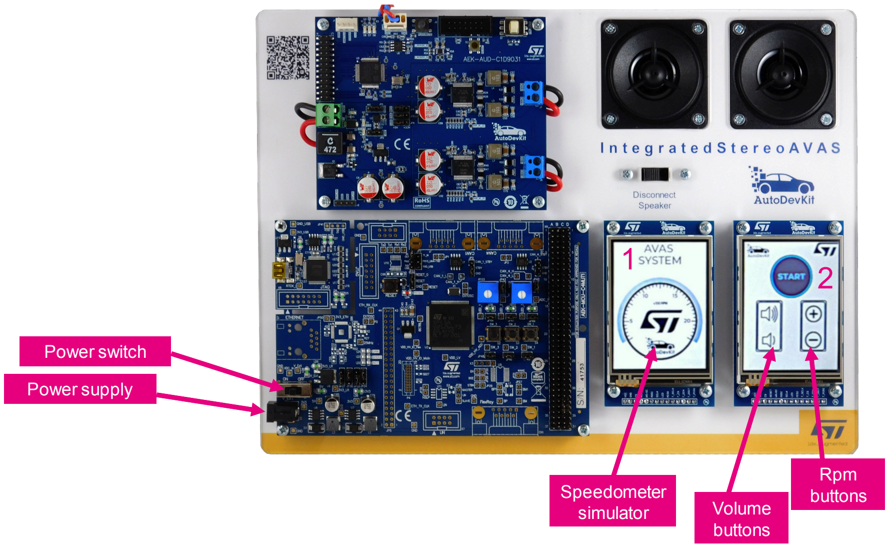
To start the demo:

Step 1. Connect a 12 V power supply.

Step 2. Switch the demo on through the power switch on the AEK-MCU-C4MLIT1.

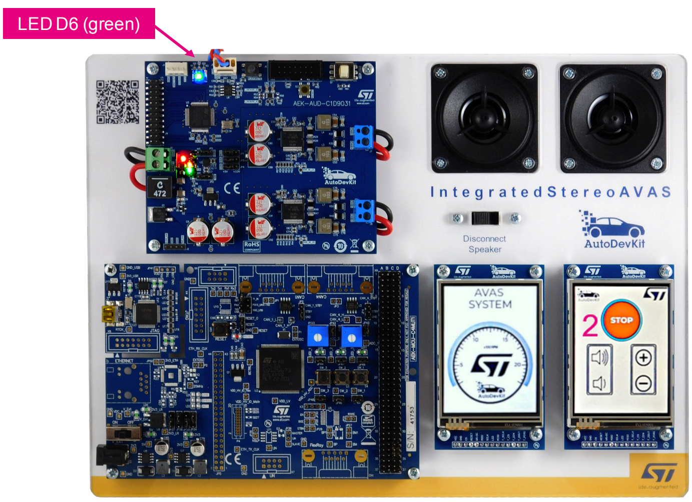
Step 3. Press the start button on display 1 to reproduce the engine sound. Then, on display 2, press the left-hand side buttons to regulate the volume and the right-hand side buttons to regulate the engine rpm. Display 1 simulates a vehicle tachometer and it varies according to the rpm button pressure.

Figure 8. **Operating the demo**



To stop the demo, just press the stop button on display 2. In this scenario, the green LED (D6) on the AEK-AUD-C1D9031 will light up.

Figure 9. **Stopping the demo**



Important: *The touch screen is resistive. Therefore multi-touch does not work To avoid hang-ups, make sure that the action completes before touching the screen again.*

5 Open load detection

An important safety feature implemented in our demo consists of the open load detection in play or mute state.

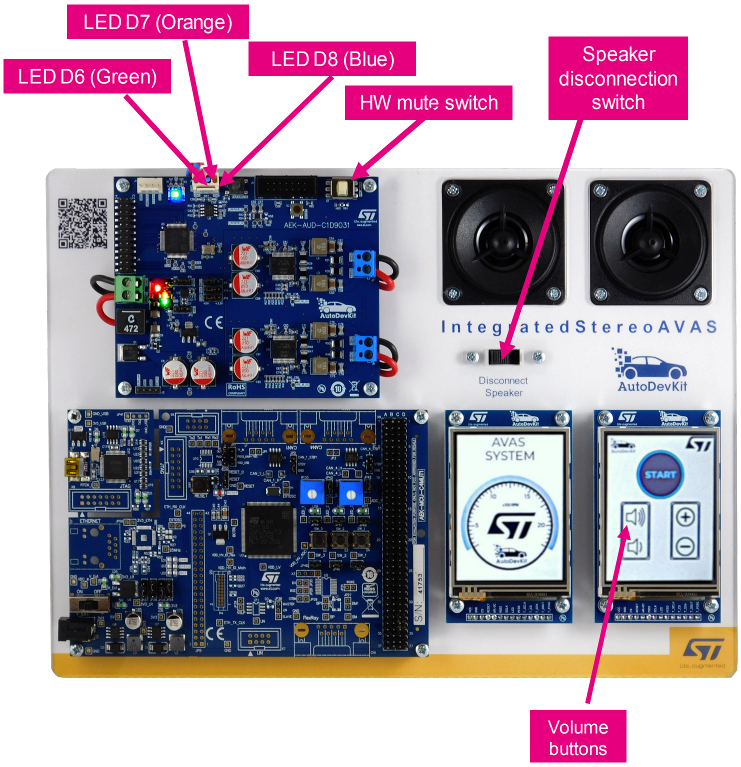
By toggling the “disconnect speaker” switch, the FDA903D embedded in the AEK-AUD-C1D9031 detects the open load in play or in mute and the blue LED lights up.

The open load detection depends on the sound amplitude. If the blue LED does not light up, turn the volume up through the dedicated button.

By switching on the HW mute button on the AEK-AUD-C1D9031 board, an orange LED (D7) turns on to indicate that the system is in the HW mute state.

Note: See UM2719, section 3, and the FDA903D datasheet, section 11.4.5, for further information on the open load detection.

Figure 10. Open load detection



6 CAN messages sent by the domain control MCU to the ECU MCU

The *SPC582Bxx_RLA_AEK_AUD_C1D9031 - Avas Compact 2.0 - Test Application* demo can also manage diagnostic messages coming from the AVAS ECU.

To enable them, uncomment the following code lines, included in the main.c file of the demo:

//sendCanMessage(FAULT_OPEN_LOAD_MUTE,SID_SEND_MESSAGE);

//sendCanMessage(NO_FAULT_MUTE,SID_SEND_MESSAGE);

//sendCanMessage(FAULT_OPEN_LOAD_PLAY,SID_SEND_MESSAGE);

//sendCanMessage(NO_FAULT_PLAY,SID_SEND_MESSAGE);

Then, set the DISTRIBUTED_AVAS_SYSTEM variable in the main.c as follows:

#define DISTRIBUTED_AVAS_SYSTEM TRUE

Recompile the code and download it onto the AVAS ECU.

The following table lists the commands sent by the AEK-MCU-C4MLIT1 to the AEK-AUD- C1D9031.

Table 1. CAN messages from the domain controller to the ECU

SID name	SID value	Command name	Command value
START_STOP_SID	0x7f0U	PLAY_SOUND	0xAABBCCDDUL
		STOP_SOUND	0xDDEEFFAAUL
CHANGE_RPM_SID	0x7f1U	TURN_UP_RPM	0xBBAACCDDUL
		TURN_DOWN_RPM	0xBBAADDCCUL
VOLUME_SID	0x7f2U	No CMD Name	0 < Volume value < 100

The following table lists the commands sent by the AEK-AUD-C1D9031 to the AEK-MCU-C4MLIT1.

Table 2. CAN messages from the ECU to the domain controller

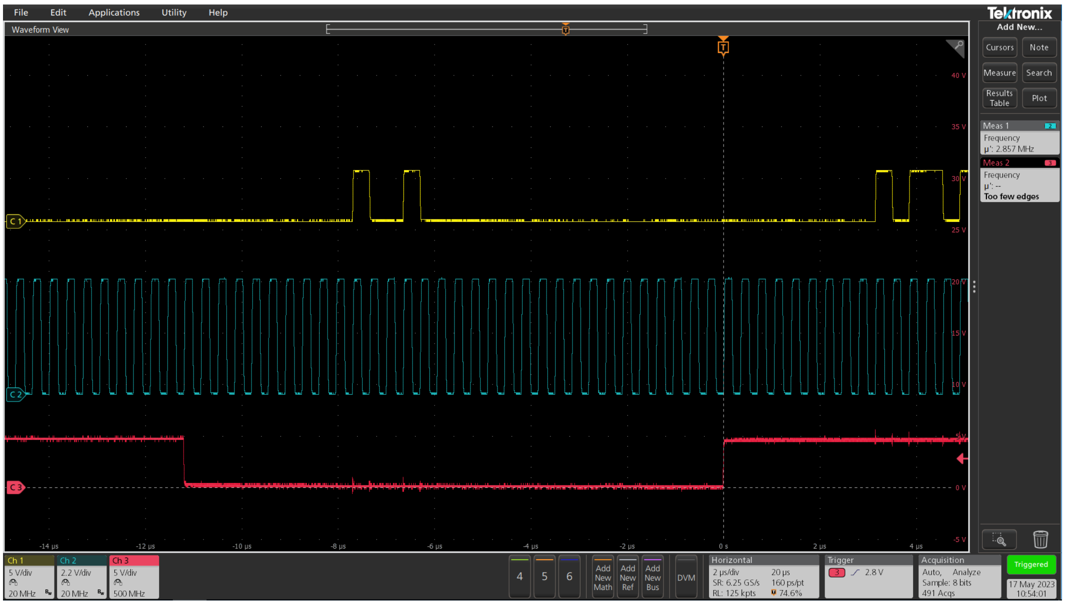
SID name	SID value	Command name	Command value
SID_SEND_MESSAGE	0x7f0U	FAULT_OPEN_LOAD_PLAY	0x1A1B1C1DUL
		FAULT_OPEN_LOAD_MUTE	0x2A2B2C2DUL
		NO_FAULT_PLAY	0x3A3B3C3DUL
		NO_FAULT_MUTE	0x4A4B4C4DUL

7 Waveforms

The following figures show the SPI signals that simulate the I²S protocol.
The yellow line (at the top) represents the data to play (MOSI signal).
The light blue line (in the middle) represents the clock signal.
The red light (at the bottom) represents the chip select.

Figure 11. I²S simulated signal

Figure 12. I²S simulated signal (zoom)



8 Schematic diagrams

Schematic diagrams of boards included in AEKD-STEREOAVAS kit are available at relevant schematic links:

AEK-AUD-C1D9031

AEK-MCU-C4MLIT1

AEK-LCD-DT028V1

9 Bill of materials

Bill of materials of boards included in AEKD-STEREOAVAS kit are available at relevant links:

AEK-AUD-C1D9031

AEK-MCU-C4MLIT1

AEK-LCD-DT028V1

10 Kit versions

Table 3. **AEKD-STEREOAVAS versions**

PCB version	Schematic diagrams	Bill of materials
AEKD$STEREOAVASA (1)	AEKD$STEREOAVASA schematic diagrams	AEKD$STEREOAVASA bill of materials

1. *This code identifies the AEKD-STEREOAVAS evaluation kit first version. The kit consists of a AEK-AUD-C1D9031 whose version is identified by the code AEK$AUD-C1D9031A, a AEK-MCU-C4MLIT1 whose version is identified by the code AEK$MCU-C4MLIT1A and a AEK-LCD-DT028V1 whose version is identified by the code AEK$LCD-DT028V1A.*

11 Regulatory compliance information

Notice for US Federal Communication Commission (FCC)

For evaluation only; not FCC approved for resale

FCC NOTICE - This kit is designed to allow:

(1) Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine

whether to incorporate such items in a finished product and

(2) Software developers to write software applications for use with the end product.

This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter 3.1.2.

Notice for Innovation, Science and Economic Development Canada (ISED)

For evaluation purposes only. This kit generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to Industry Canada (IC) rules.

À des fins d'évaluation uniquement. Ce kit génère, utilise et peut émettre de l'énergie radiofréquence et n'a pas été testé pour sa conformité aux limites des appareils informatiques conformément aux règles d'Industrie Canada (IC).

Notice for the European Union

This device is in conformity with the essential requirements of the Directive 2014/30/EU (EMC) and of the Directive 2015/863/EU (RoHS).

Notice for the United Kingdom

This device is in compliance with the UK Electromagnetic Compatibility Regulations 2016 (UK S.I. 2016 No. 1091) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (UK S.I. 2012 No. 3032)

Revision history

Table 4. **Document revision history**

Date	Revision	Changes
17-Jul-2023	1	Initial release.

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