Automotive Diagnostics Using TAS2505-Q1

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ABSTRACT

This document details automotive diagnostics and the benefits it brings to automotive system design and reliability. It clearly defines how to implement diagnostics in the TAS2505-Q1 system design. Some of the features discussed here are native to the device and others are shown how to solve externally at minimal size/cost impact to the design

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1 What are Diagnostics and Why are They Important?

Diagnostics are the ability of a system to identify an issue and communicate it back to the central host to decide what next steps need to be taken. This capability is important for automotive audio applications to ensure both the speaker and the amplifier are performing as expected. Below are some common diagnostics features:

Open Load—Verifies that the speaker connection to the amplifier is secure

Short Circuit—Identifies when a short to ground, short to power, or short between speaker terminals occurs in the system

Over-Temperature— Highlights when the temperature surpasses a set limit that could cause damage

All of these features are used commonly in applications such as Automotive Cluster and Emergency Call (eCall) to ensure quality and reliability of design. The remainder of this document specifically highlights how to implement these features in the TAS2505-Q1.

2 Diagnostics Features in TAS2505

2.1 Short Circuit Detection

TAS2505 detects and self protects against the following faults:

- Short to Ground
- Short to Power
- Short between Speaker terminals

When the amplifier detects these above errors, it shuts down and an internal flag is raised. This flag can be read via I^2C by looking at the register map as seen below in Table 1. When any of the above mentioned faults occur, Page1, 0x2D bit 1 is cleared to “0”. The host processor can monitor this bit during normal operation to detect the presence of a fault condition.

Table 1. Page 1, Register 45: Speaker Amplifier Control 1 – 0x01/0x2D

BIT	TYPE	RESET	DESCRIPTION
D7–D2	R	0000 00	Reserved. Write only reset values.
D1	R/W	0	Speaker Power Driver 0: SPK output driver is powered down (Bit Clear during normal operations indicates fault). 1: SPK output driver is powered up.
D0	R	0	Reserved. Write only reset values.

2.2 Over-Temperature Detection

The TAS2505-Q1 has an over-temperature protection feature for the speaker driver. The over-temperature protection feature is intended to protect the device and ensure reliable operation, and is always enabled. If the device exceeds the set temperature limit, then the output stops switching and an error flag is set as a read-only bit on page 0, register 45, bit D7.

3 External Diagnostics

3.1 Diagnostic Circuit #1

Diagnostics to detect an open load can be done externally with minimal impact to size and cost of the design. Figure 1 shows the first external load diagnostic circuit.

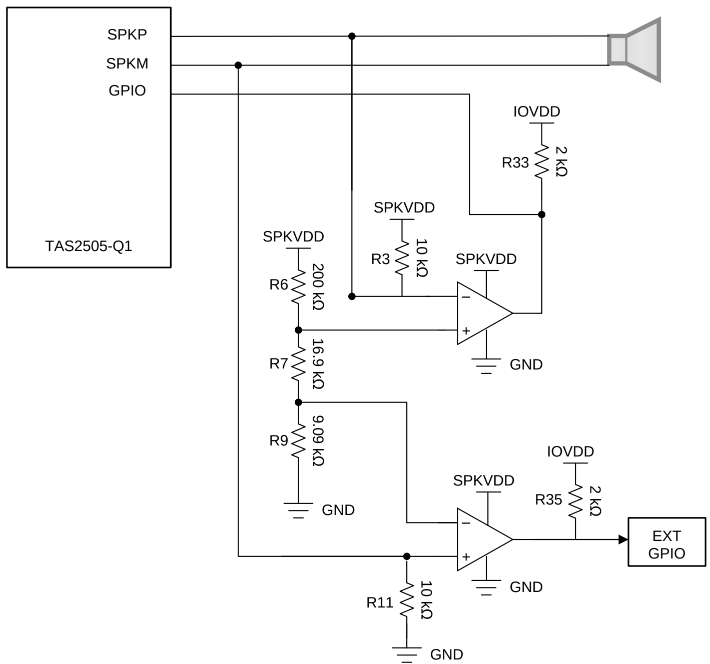

Figure 1. Diagnostic Circuit #1 Schematic

The speaker must be connected to the SPKP and SPKM output points on J5 and J4 for this circuit to function properly. The circuit detects load faults by monitoring the non-inverting speaker line (SPKP) and the inverting speaker line (SPKM) of each channel. Abnormal voltages on each output line are identified by comparing reference voltages created by the resistor network of R6, R7, and R8 to the voltages on the output lines with a LM2903-Q1 dual comparator. If the voltage on one of the output lines is too high or too low, then the output of the comparator pulls the GPIO to ground. The output of the comparator is normally pulled high to IOVDD, and is pulled low when a fault occurs. The GPIO pin on the TAS2505-Q1 can be programmed as an input and then used to detect this change.

The output of the first comparator is connected to the TAS2505-Q1 as a GPIO input. Since the TAS2505-Q1 only has one GPIO input, the output of the second comparator can be connected to an external GPIO input of the MCU or ignored. Only one comparator is necessary for open load detection, but using two allows you to differentiate between the potential faults: short to power, short to ground, short between the speaker terminals, and open load. Table 2 andTable 3 show the fault conditions and the corresponding state of the comparators and registers.

To limit power draw during operation and minimize effects on audio performance, R3, R6, R7, R9, and R11 are high-impedance resistors. The value of R7 determines the reference voltages that the speaker terminals (SPKP and SPKM) are compared to for fault detection. This reference window is crucial for open load detection and therefore resistorances with 1% or less tolerance should be used. The comparator goes low if the negative input is greater than the positive input.

3.2 Communication to Host & Action

Information regarding short and open load fault conditions for the speakers of the TAS2505-Q1 amplifier can be accessed through two integrated registers via I^2C. External host can poll the two registers (register 62 and 46) to see if an error occurred. See Table 2 to interpret the error. There is no requirement on how often to poll these registers as the device self protects on the event of an error.

To determine whether or not a short has occurred, host reads register 45 of page 1. If bit D1 of this register is low, then a short condition exists in the amplifier and has caused it to shut down. The fault condition needs to be fixed and the device needs to be reset before it can operate again. If this bit is high, then no short circuit condition has been detected.

The other primary type of output fault condition, open load, can also be read through I^2C. To do this, the first output of the LM2903 dual comparator is routed back to the GPIO/DOUT pin. Additionally, you should first mute the amplifier to stop switching at the outputs. To do this, set bit D1 of register 45 from page 1 to "0." You should then write "00001000" or "0x08" to register 52 of page 0. This sets the GPIO/DOUT control register to its general input setting. The first output of the comparator is then automatically written to this register and stored in bit “D1” as a high or low bit. You can then read back register 52 of page 0 at any time and, comparing its D1 bit with the D1 bit of register 46 on page 1, determine if an open load fault has occurred. Once diagnostic reading is complete, make sure to reset D1 of register 45, page 1 back to "1" to re-enable the amplifier. If a fault was detected, it needs to be corrected and the amplifier reset before sound can be played again. Table 2 demonstrates the register information that corresponds to each primary state of amplifier operation.

Table 2. Primary Operation States and Fault Detection: I^2C

Amplifier State	Page 0, Register 52, Bit D1	Page 1, Register 46, Bit D1
No Fault	1	1
Short Circuit	X	0
Open Load	0	1

Table 3. Complete Operation States and Fault Detection: I^2C and LEDs

Amplifier State	Comparator Out 1	Comparator Out 2	Page 1, Reg 46, Bit 1
No Fault	1	1	1
Short to GND	1	0	0
Short to Power	0	1	0
Shorted Load	1	1	0
Open Load	0	0	1

3.3 Diagnostic Circuit #2

Figure 2 shows the second diagnostic circuit, which consists of only two transistors and a few resistors. The first step is to mute the amplifier via software. The GPIO is set to an output, and pulling the GPIO high enables the circuit by biasing the BJT which turns on the p-channel MOSFET and allows current to flow from SPKVDD, across the speaker, and through the voltage divider created by R40 and R41. If the speaker is disconnected and there is an open circuit, then the voltage at the voltage divider is zero, but if there is a speaker connected and there is no fault, then the voltage divider is approximately 1.2 V. This voltage can be read from an external ADC such as an analog input pin from a MCU to determine if there is an open circuit fault or not. The circuit should be disable by pulling the GPIO low before unmuting the amplifier and resuming normal operation.

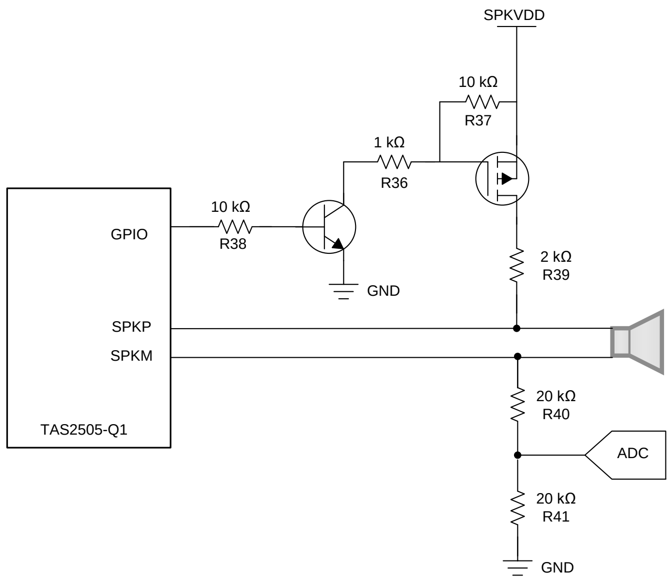

Figure 2. Diagnostic Circuit #2 Schematic

3.4 Diagnostic Circuit #3

Figure 3 shows the third diagnostic circuit, which is similar to diagnostic circuit #2 but only removes the BJT transistor used to control the MOSFET. The control logic is the inverse of circuit #2, so GPIO must be HIGH to disable the diagnostic circuit and set the device into Normal Operation; setting GPIO to LOW enables the circuit and open load test can be performed.

There is a tradeoff on removing the BJT, which is an increase in current consumption. For example, when TAS2505-Q1 is off, there is still current drawn if SPKVDD is on.

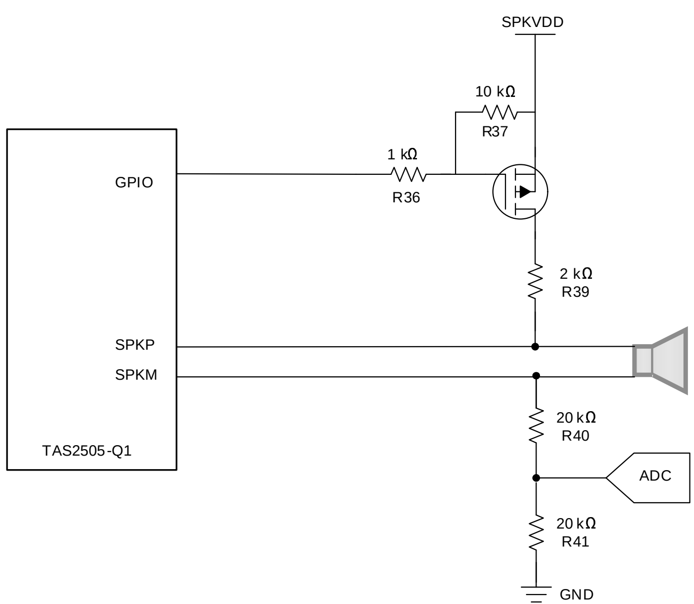

Figure 3. Diagnostic Circuit #3

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from A Revision (October 2017) to B Revision	Page
• Edited application report for clarity.	1
• Replaced Open Load Detection section with the Diagnostic Circuit #1 section from TIDUDN3.	3
• Added Diagnostic Circuit #2 section from TIDUDN3.	4
• Added section about Diagnostic Circuit #3.	5

Changes from Original (July 2017) to A Revision	Page
• Added additional information to *Communication to Host & Action* section.	4

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