Application Report
SLAA540B–June 2012–Revised June 2013

TLV320DAC3100-Q1 Diagnostic Test for Automotive Applications with Open Loads

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ABSTRACT

An open-load detection test can be implemented using headset-detection test of the TLV320DAC3100. This application note provides a summary of the headset-detection test with the TLV320DAC3100 EVM and how to use the headset-detection test to detect an open load.

1 Test for Detection of Headsets

Headset detection is normally used to determine if a headset has been inserted into the EVM. It can also determine the type of headset, either with or without a microphone. This detection is accomplished by observing the voltage on the MICDET input. See Figure 1 for schematic representation and Table 1 for threshold voltages.

Table 1. Voltage Threshold for Detection of Headsets

REGISTER 67 BITS D6-D5	REGISTER VALUE	DESCRIPTION	VOLTAGE THRESHOLD
00	0x80	No headset detected	MICDET > approx. 0.91 × MICBIAS[(1)(2)]
01	0xA0	Headset without microphone detected	MICDET < approx. 0.1 × MICBIAS
11	0xE0	Headset with microphone detected	Approx. 0.1 × MICBIAS < MICDET < approx. 0.9 × MICBIAS

(1) MICBIAS by default is powered to AVDD and can also be powered to 2.5 V, 2 V, or powered down.
(2) If MICBIAS is powered down, the voltage threshold is based on DVDD.

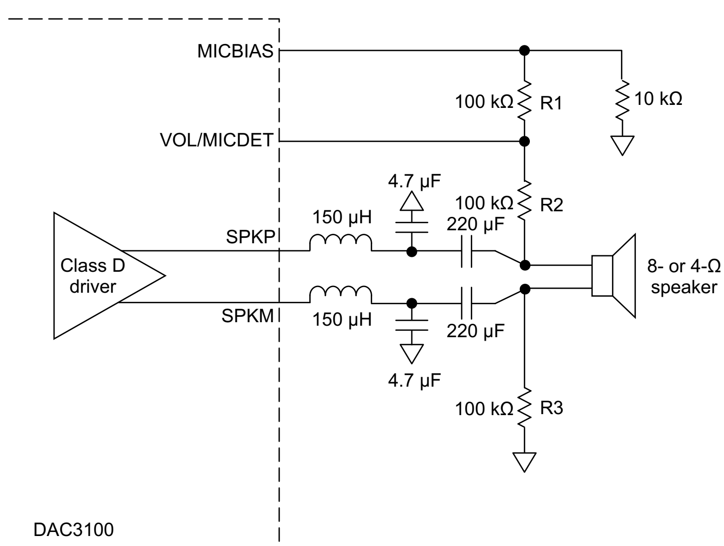

Figure 1. Test Layout for Detection of Open Loads

For the open-load test, the feature for headset detection makes a voltage measurement that can determine the continuity of the speaker circuit. The voltage on the MICDET pin is set by the divider consisting of R1, R2, R3, and the resistance of the speaker (see Figure 1). During an open circuit, the resistance of the speaker circuit is near infinity; therefore, the MICDET voltage is simply pulled to MICBIAS. During normal conditions, the resistance of the speaker circuit is near zero compared to the resistance of R1, R2, and R3, and thus the MICDET voltage is calculated according to formula. See Equation 1 for the calculation of MICDET.

$$V_{MICDET} = \left(\frac{R_2 + R_3}{R_1 + R_2 + R_3}\right) V_{MICBIAS}$$
$$V_{MICDET} = \left(\frac{100\ k\Omega + 100\ k\Omega}{100\ k\Omega + 100\ k\Omega + 100\ k\Omega}\right) 3.3\ V$$
$$V_{MICDET} = \left(\frac{2}{3}\right) 3.3\ V$$
$$V_{MICDET} = 2.2\ V \quad (1)$$

The detection feature must be specifically activated, because it is not enabled by default. To enable headset detection, see section 5.5.5 in the *Low-power Stereo Audio DAC with Mono Class-D Speaker Amplifier Data Manual*.

For additional details about the headset detection feature, see the *Headset Detection for TLV320AIC33 and TLV320AIC310x Family Application Report*.

2 Test for Detection of Open Loads

The layout of the test for detection of open loads is as seen in Figure 1.

When a load is detected, MICDET is pulled below the 0.91 × MICBIAS threshold (≈ 2.2 V in this case), which allows for a headset to be detected. When the load is disconnected, MICDET is pulled to MICBIAS, and no headset is detected. See Figure 2 for an example. Figure 3 shows the register values provided when using the EVM GUI Command Buffer prompt.

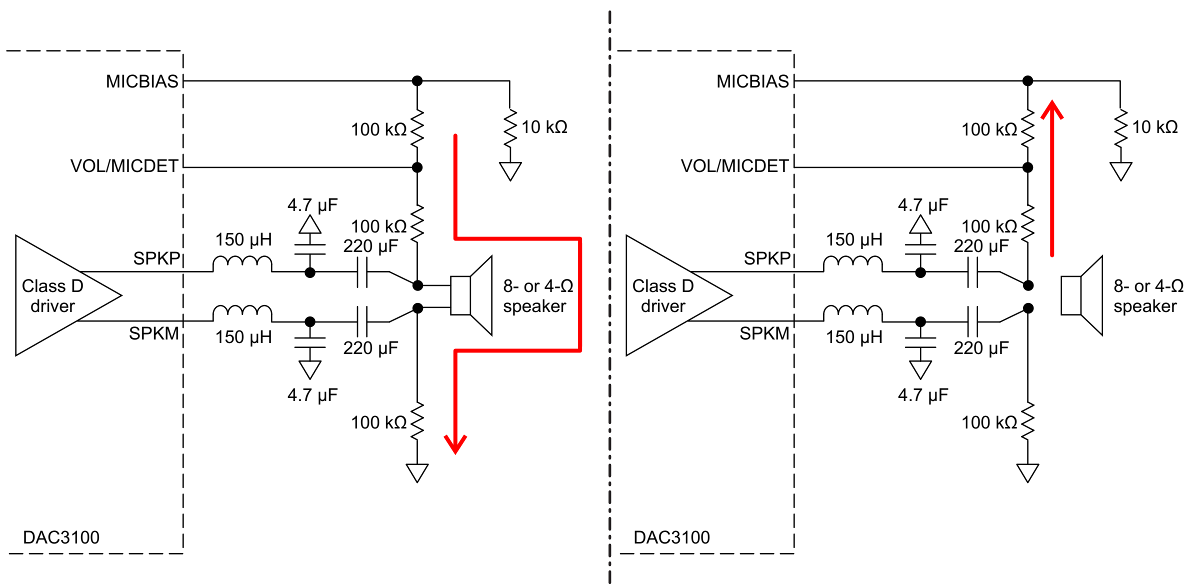

Figure 2. Voltage Flow of MICDET With and Without an Open Load

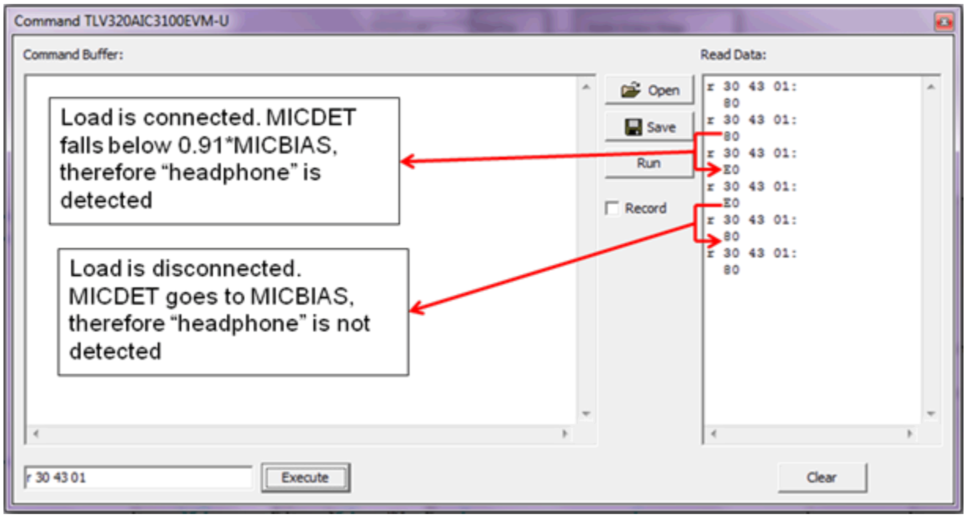

Figure 3. Register Values From the Command Prompt

The resistors between MICBIAS and MICDET to ground must be high, such as 100 kΩ, to reduce losses, limit the current, and ensure that the output is not being driven back into the input. The resistor from MICBIAS to ground can be any value, such as 10 kΩ, to complete the current path to ground.

The 220-µF capacitors are necessary to minimize dc bias of the detection circuit. These capacitors must be large in order to minimize any contribution to the series impedance of the speaker circuit.

The inductors, and specifically the 4.7-µF capacitors, act as output filters. Because the TLV320 family uses BD modulation, a capacitor (CBTL) is not needed between SPKP and SPKM as it usually is for AD modulation.

In Figure 1, the output filter (second-order Butterworth low-pass) is set to a cutoff frequency of 6 kHz with an 8-Ω load. See Equation 2 and Equation 3 for calculating the C and L values.

$$C = \frac{1}{\omega_0 \times R_L \times \sqrt{2}}$$

$$C = \frac{1}{2\pi f \times \left(\frac{R_L}{2}\right)^{*} \times \sqrt{2}}$$

$$C = \frac{1}{2\pi(6\ \text{kHz}) \times 4\ \Omega \times \sqrt{2}}$$

$$C = 4.689\ \mu\text{F} \approx 4.7\ \mu\text{F} \quad (2)$$

* R_L becomes R_L / 2 to account for analysis of the differential mode. See Figure 4 for the equivalent circuit.

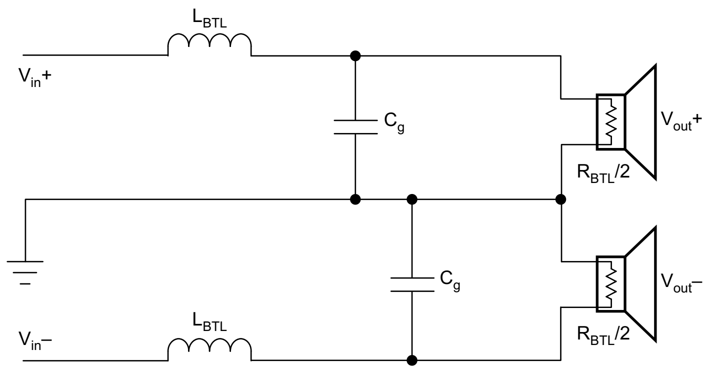

Figure 4. Equivalent Circuit for Analysis of the Differential Mode

$$L = \frac{R_L \times \sqrt{2}}{\omega_0}$$
$$L = \frac{\left(\frac{R_L}{2}\right) \times \sqrt{2}}{2\pi f}$$
$$L = \frac{4\Omega \times \sqrt{2}}{2\pi(6\text{ kHz})}$$
$$L = 150.053\ \mu H \approx 150\ \mu H \quad (3)$$

Further details regarding BD modulation and values for the inductors and capacitors can be found in: *Class-D LC Filter Design* (SLOA119).

3 Test Procedure for Detection of Open Loads

The following steps use the TLV320DAC3100 EVM and its corresponding GUI. A USB-to-mini USB cable is needed to connect the EVM to a computer or laptop.

3.1 Setup Considerations

To download the software, go to the TLV320DAC3120 EVM product folder under Related Products.

To install the GUI, first download the software. Then attach the EVM to the computer using the USB cable. Next, open the .exe file named *CodecControl* and choose *TLV320AIC3100EVM-U* when the *Select EVM* panel appears.

For hardware considerations, all of the jumpers on the EVM must be taken off the headers (W1, W2, W3), because the layout is manually pulling MICDET to MICBIAS. See Figure 5 for an example. Table 2 also lists the functionality of each header.

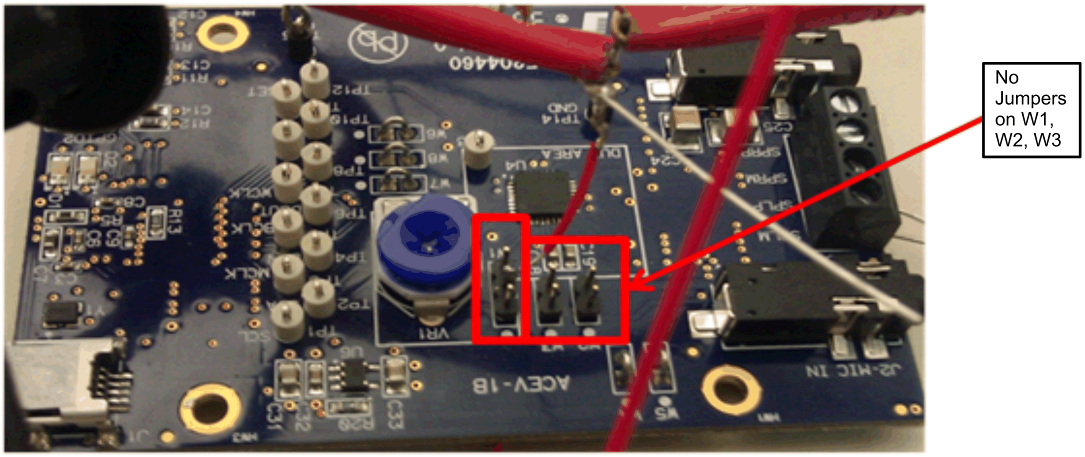

Figure 5. EVM Board With No Jumpers

Table 2. Description of Headers

HEADER	DESCRIPTION
W1 (pins 1–2)	Analog volume control
W1 (pins 2–3)	Microphone detection
W2	Apply right-channel MICBIAS voltage to microphone connector
W3	Apply left-channel MICBIAS voltage to microphone connector

One can use pin 2 on header W1 to measure MICDET and R17 (on the back of the EVM) to measure MICBIAS.

3.2 Steps in the GUI for Detection of Open Loads

There are four steps when using the GUI to test for open loads, assuming the speaker is already connected to the EVM.

1. Enable headset detection (Page 0, Register 67, bit D7 should be set to 1).
2. Read the register (Register should read E0 or A0, as both detect a headset; see Table 1).
3. Disconnect the speaker by removing leads.
4. Read the register (Register should read 80).

3.2.1 Enable Headset Detection

Headset detection can be enabled through either Register Inspector or Command. It is not necessary to enable headset detection using both Register Inspector and Command. Once changes have been enabled using either process, the GUI automatically updates the information, which is reflected in the other.

NOTE: If MCLK is not used in the application, the internal oscillator must be enabled first before performing the following steps. To enable the internal oscillator, use the Register Inspector. Go to Page 3, Register 16, and change Bit 7 from 1 to 0.

To enable headset detection through Register Inspector, go to View → Register Inspector. Next, scroll down to Register 67 and click on the 0 in column 67 to change it to a 1. The number turns red when transitioning from one value to another to indicate the change. The advantage in using this process is ease of use.

To enable headset detection through Command, go to View → Command. Then in the command buffer, type *w 30 43 80* and click *Run*. *w* indicates write and *30*,*43*, and *80* indicate the device address, register (Register 67 in this instance), and data value, respectively, written in hex. The advantage in using this process is the ability to insert multiple manual instructions as desired.

See Figure 6 and Figure 7 to enable headset detection using Register Inspector and Command, respectively.

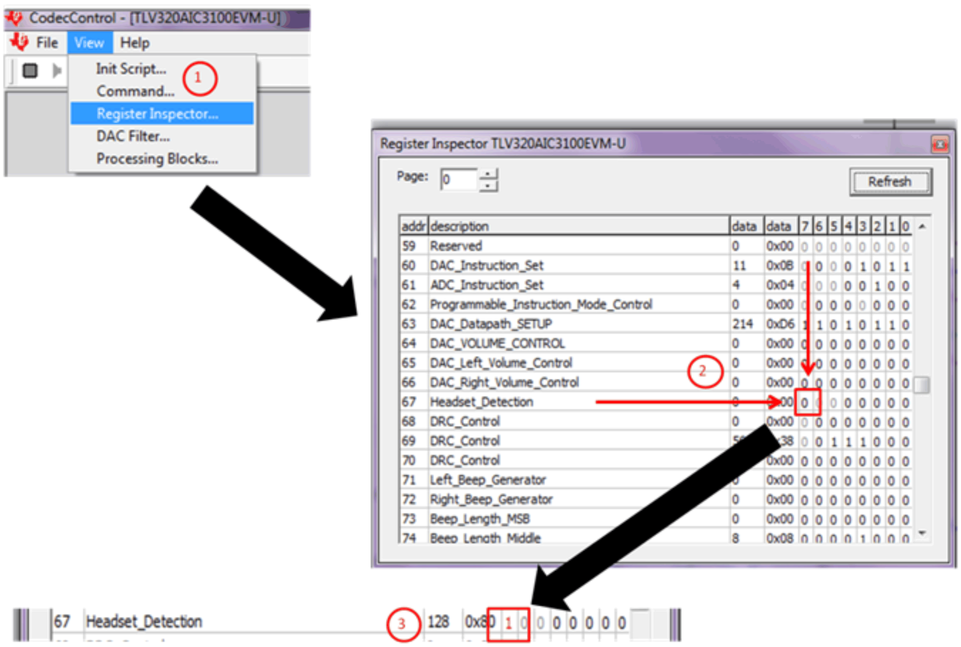

Figure 6. Enabling Headset Detection Using Register Inspector

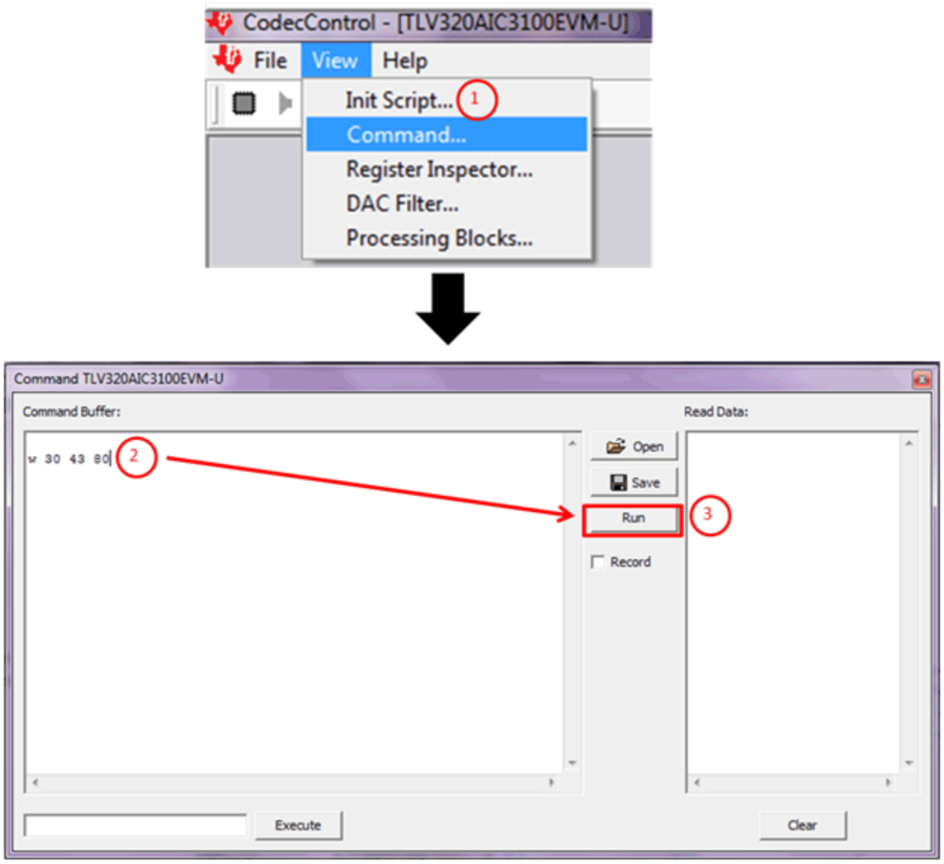

Figure 7. Enabling Headset Detection Using Command

3.2.2 Read Register

The easiest way to read a register value is through Command. In the text box, write *r 30 43 01*. *r* indicates read and *30* and *43* indicate the device address and register (Register 67 in this instance) once again. *01* indicates the number of bytes read from the register. Click on *Execute* and the data appears in the *Read Data* box. See Figure 8 for reading a register value from Command. Figure 3 shows the register values transitioning between detecting a speaker and an open load.

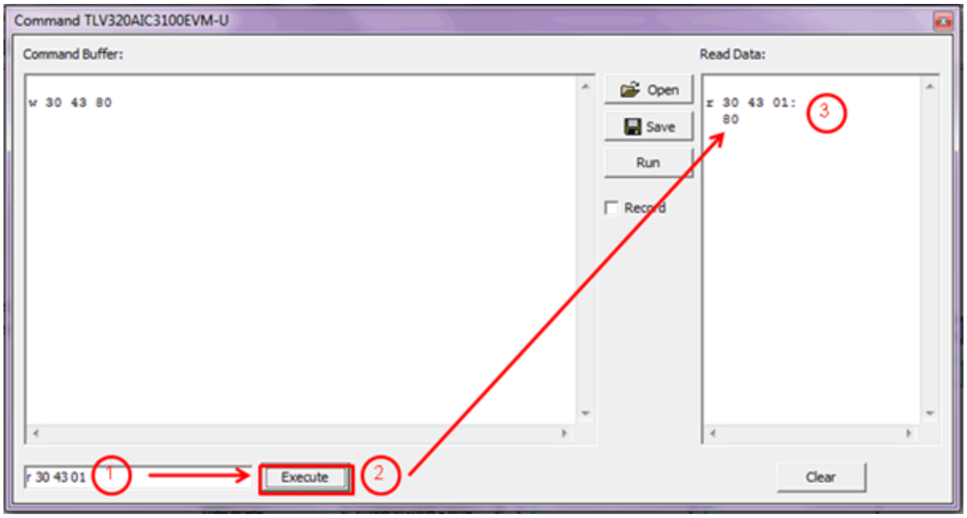

Figure 8. Reading a Register Using Command

4 Other Considerations

There are two factors to take into consideration when using the headset-detection circuitry: the capacitors and the volume level of the device.

4.1 Capacitor Considerations

For capacitor considerations, see the 220-µF dc-blocking capacitors in Section 2. When picking capacitors, the larger the capacitor, the more efficiently dc bias is eliminated, and there is less chance for a false reading: false reading meaning the register reads that a speaker is connected when it is actually disconnected and vice versa. However, the charge and discharge times are also longer. This timing means that when the speaker is disconnected, it takes a longer period of time before MICDET reaches 0.91 x MICDET and is considered disconnected.

The same logic goes to smaller capacitors. Whereas smaller capacitors have faster charge and discharge times, and therefore detect a disconnected speaker more quickly, these capacitors also block dc bias less efficiently with a greater chance for false readings.

Based off the headset-detection circuitry and using a Mirage 5.1 Nanosat or equivalent speaker, the minimum capacitor value is 10-µF, though the capacitor value should be chosen based on the system and speakers used.

4.2 Volume Level Considerations

As the purpose of the capacitors is to block out dc bias, the ac signal will passes through the capacitors into the speakers. Therefore, some ac signal can also be seen on the MICDET pin. To ensure that the MICDET pin does not exceed absolute maximum (AVDD + 0.3 V, or 3.6 V in this case), the ac signal on the MICDET pin must be limited to 0.3 V_{peak} at the most.

To help limit the ac signal seen on the MICDET pin, either the Class-D Speaker Driver, Analog Attenuation, or both (see Figure 9) must be moderated so that neither of the two is at the highest setting. See Table 3 for a summary of Class-D Speaker Driver levels versus Analog Attenuation levels as to not exceed absolute maximum rating for MICDET.

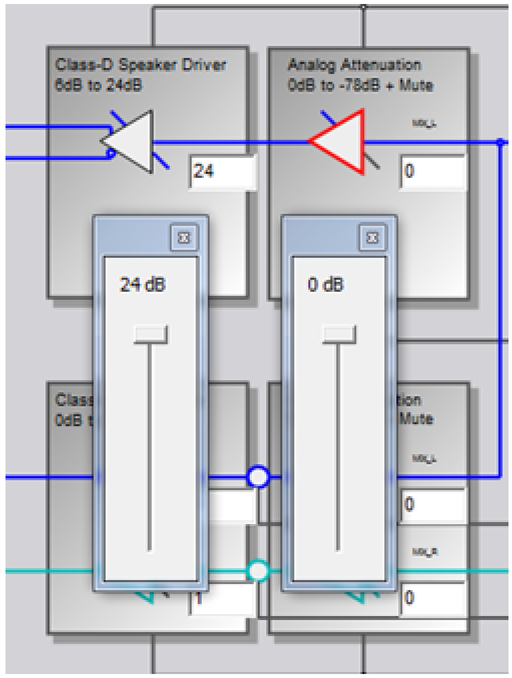

Figure 9. Volume Level Section of EVM GUI

Table 3. Class-D Speaker Driver and Analog Attenuation Levels for MICDET

Class-D Speaker Driver (dB)	Analog Attenuation (max) (dB)
6	0
12	0
18	–10
24	–10

5 Summary

Open loads can be detected using the EVM GUI by first enabling headset detect, then reading register 67.

Headset detection works by having MICDET pulled to MICBIAS. When a headset is inserted, MICDET drops to ground. The test for detection of open loads works in the same way by using the function for headset detection to indicate load connectivity.

Revision History

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

Changes from A Revision (March 2013) to B Revision	Page
• Added REGISTER VALUE column to table	1
• Changed *connector* to *cable* in Section 3	4
• Added note to Section 3.2.1	5