

## Capless Headphone Virtual Ground Short-Circuit Protection for the ADAU1361 and ADAU1761 Low Power Codecs

by Jerad Lewis

### INTRODUCTION

The [ADAU1361](#) and [ADAU1761](#) are low power audio codecs, each with a stereo headphone amplifier that can be operated in a capless headphone mode. This means that the stereo headphone outputs can be used without series ac-coupling capacitors. When in capless headphone output mode, there is a virtual ground reference at  $AVDD/2$  generated by the codec instead of a true ground center. While this configuration works well for most applications, it could cause issues if the headphone jack is also used for line output and a load is connected that shorts the virtual ground to true ground. In this situation, high current flows and could damage the codec. This application note explains how to implement a ground sensing circuit when using the codec in capless headphone mode.

### FUNCTIONALITY

The capless headphone mode of the ADAU1361/ADAU1761 is enabled in the control registers of the codecs. In capless headphone mode, the outputs of the stereo headphone amplifier are connected directly to the headphone jack. The ADAU1361 and ADAU1761 data sheets explain the details on configuring the codecs' register settings to enable this mode.

$AVDD$  is a 1.8 V to 3.3 V supply that powers the headphone amplifier in the codec. The LHP, RHP, and MONOOUT output pins are biased at the common-mode voltage ( $AVDD/2$ ). In capless headphone mode, the MONOOUT is a virtual ground for the headphone load. The MONOOUT pin does not have any signal content, but is used as the return path for left and right headphone load currents.

Normally, headphones connected to the output amplifier of the codec are floating. However, a situation could arise where a ground-centered load is connected to the headphone jack. In this case, the MONOOUT amplifier is directly connected to ground and draws a high current from the amplifier.

To protect the virtual ground from being shorted to ground, a detection circuit can be implemented in the circuit. This detection circuit can do one of two things—a) send a flag to a microcontroller in the system to indicate that this short has occurred and the microcontroller can take appropriate action, or b) the detection circuit can disable the analog circuitry of the codec to prevent excessive current draw and potential damage to the IC.

The following sections describe three implementations of these solutions.

### OPTION 1—MICROCONTROLLER FLAG

Option 1 uses a general-purpose NPN transistor and three biasing resistors (see Figure 1).

Normally, with a floating load connected to the headphone jack, the base and emitter of the transistor are biased at  $AVDD/2$ , the common-mode (CM) voltage. The collector is connected to the IOVDD of the codec, which can range from 1.8 V to 3.3 V. The transistor is normally off because  $V_{BE} = 0$  V.

When a plug with a ground-connected sleeve is inserted into the headphone socket the emitter of the transistor is pulled to ground and with  $V_{BE} > 0.7$  V, the transistor turns on, pulling the collector to ground. This high-to-low level change can be detected by the system microcontroller to initiate a mute of the headphone amplifier. The  $AVDD/2$  dc bias of the MONOOUT pin cannot be disabled, so in this case the virtual ground is still shorted to true ground, even when the amplifier is muted.

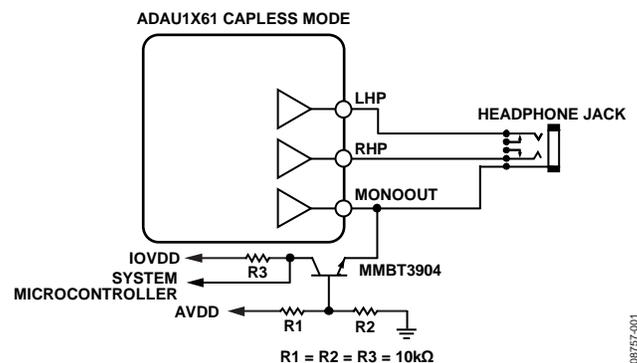


Figure 1. Headphone Jack Ground Detection Circuit (Option 1)

00757-001

### OPTION 2—CM DISABLE WITH BJT

The circuit in Figure 2 is similar to Option 1 except that the transistor turns off the analog circuitry of the codec rather than sending a flag to a microcontroller. In this circuit, the CM voltage of the ADAU1361/ADAU1761 is pulled to ground when ground is detected on the headphone jack in capless mode. When the CM voltage is pulled to ground, the dc bias on the headphone amplifier outputs are also pulled to ground. This reduces the current drawn from the MONOOUT amplifier. The current drawn from this circuit when in the fault condition is proportional to the bipolar junction transistor's (BJT)  $V_{CE}$  saturation. Choosing a BJT with a lower  $V_{CE}$  saturation lowers the amount of current drawn from AVDD (see Table 1).

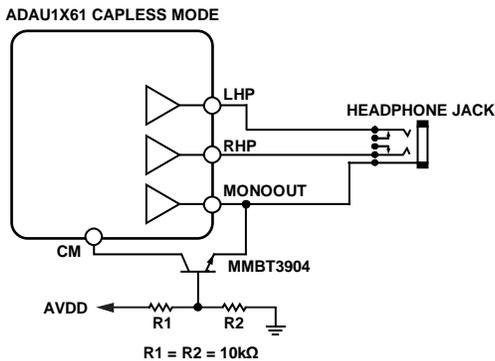


Figure 2. Headphone Jack Ground Detection Circuit (Option 2)

It is important to note that when CM is pulled to ground, none of the analog inputs or outputs of the codec are functional, as these pins are all biased at the CM voltage.

Table 1. Current Draw with BJT Protection Circuit

AVDD	AVDD Supply Current	$V_{CE}$ Saturation
1.8 V	78 mA	40 mV
3.3 V	115 mA	42 mV

### OPTION 3—CM DISABLE WITH MOSFET

Options 2 and Option 3 are similar, but Option 3 uses a MOSFET transistor instead of a BJT (see Figure 3). A MOSFET pulls the CM voltage closer to 0 V than a BJT can, so the current drawn from AVDD in the short circuit condition is lower. The current drawn from the AVDD supply is inversely proportional to the degree of which the MOSFET is turned on. Table 2 shows the current draw for the circuit in Figure 3 with MOSFET  $R_{DS} = 90 \text{ M}\Omega$  and  $V_{GS}$  threshold = 0.7 V to 0.9 V. The disadvantage of using this circuit is that it cannot be used when  $AVDD = 1.8 \text{ V}$  because  $V_{GS}$  is too small to sufficiently turn on the MOSFET.

Table 2. Current Draw with MOSFET Protection Circuit

AVDD	AVDD Supply Current	$V_{DS}$	$V_{GS}$
1.8 V	N/A	N/A	N/A
3.3 V	10 mA	4.3 mV	1.65 V

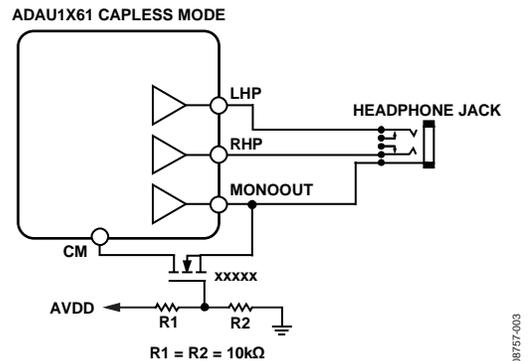


Figure 3. Headphone Jack Ground Detection Circuit (Option 3)

### CONCLUSION

Table 3 shows the advantages and disadvantages of each option. If a microcontroller is available in the system then Option 1 is recommended. If a microcontroller is not available, then Option 3 is preferred over Option 2, because of the lower overall current draw from AVDD in the short-circuit condition.

Table 3. Advantages and Disadvantages

Option	Advantages	Disadvantages
Option 1	Lowest current drawn from AVDD in short-circuit condition. The other analog blocks of the codec can remain functional in the short-circuit condition.	Microcontroller needed for implementation. Virtual ground still shorted to true ground.
Option 2	Cheapest solution.	Current in fault mode depends on the $V_{CE}$ saturation of the BJT. Disables all of the analog functionality of the codec.
Option 3	Lower AVDD current than Option 2 in short-circuit condition.	Does not work at $AVDD = 1.8 \text{ V}$ . MOSFET more expensive than BJT. Disables all of the analog functionality of the codec.