

Issues when Grounding D.C. Coupled (Capless) Headphone Outputs

INTRODUCTION

In some situations, the headphone output of a product could be connected to another product, rather than headphones. In this situation it would appear that the “capless” (d.c. coupled) headphone mode, currently provided by the WM9711L, WM9712L, WM8750L, WM8751L and WM8955L, could not be used and large a.c. coupling capacitors would be needed instead. This application note looks at the issue of whether the output would be actually grounded by the connection or not, and therefore if a.c. coupling would be needed.

APPLICATION

AC-COUPLED HEADPHONE OUTPUT

The circuit diagram below shows how to connect a stereo headphone to the headphone output.

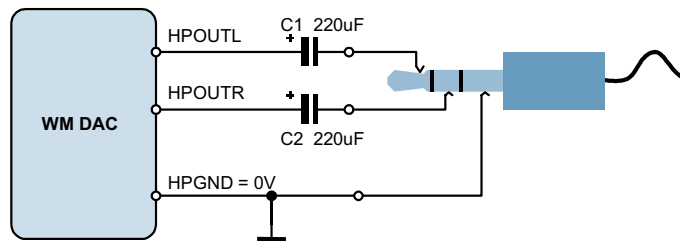


Figure 1 Simple Headphone Output Circuit Diagram

The DC blocking capacitors C1 and C2 together with the load resistance determine the lower cut-off frequency, f_c . Increasing the capacitance lowers f_c , improving the bass response. Smaller capacitance values will diminish the bass response. For example, with a 16 Ohm load and $C_1 = 220\mu\text{F}$:

$$f_c = 1 / 2\pi R_L C_1 = 1 / (2\pi \times 16\Omega \times 220\mu\text{F}) = 45 \text{ Hz}$$

DC COUPLED (CAPLESS) HEADPHONE OUTPUT

In the interest of saving board space and cost, it may be desirable to eliminate the 220µF DC blocking capacitors, with the added benefit of improved frequency response. This can be achieved by using OUT3 as a headphone pseudo-ground, as shown below.

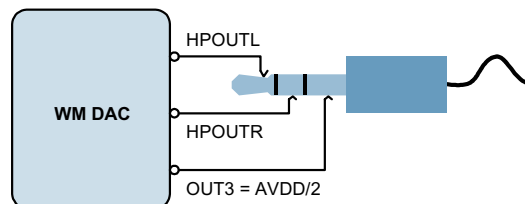


Figure 2 Capless Headphone Output Circuit Diagram

As the OUT3 pin produces a DC voltage of $AVDD/2$, there is no DC offset between HPOUTL/HPOUTR and OUT3, and therefore no DC blocking capacitors are required. However, this configuration has some drawbacks:

- The power consumption is increased, due to the additional power consumed in the OUT3 output buffer.
- If the DC coupled output is connected to the line-in of a grounded piece of equipment, then OUT3 becomes short-circuited. Although the thermal cut-out protection will prevent any damage to the IC, the audio signal will not be transmitted properly.

SOLUTIONS

HEADPHONE OUTPUT GROUND CASE 1

In the diagram below, the capless output is connected to a hi-fi amplifier, which is grounded. (This is only sometimes true.) In this case the DAC is powered by an isolated supply with no ground, like a typical plug-top PSU. Here it is acceptable to connect the headphone output to the amplifier, as there is no ground connection back to the DAC PSU to cause a short-circuit.

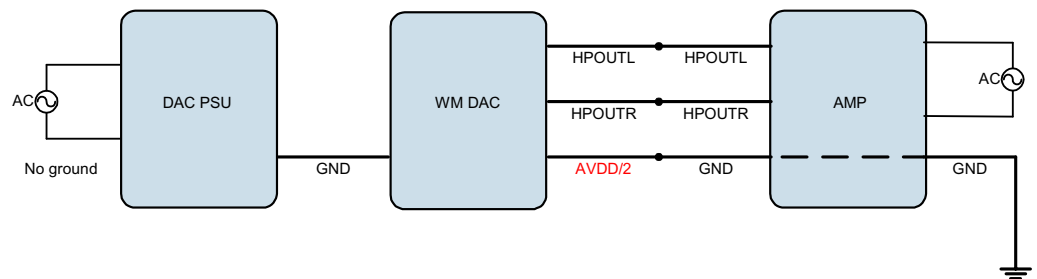


Figure 3 Acceptable Ground Connection 1

HEADPHONE OUTPUT GROUND CASE 2

In the diagram below, the capless output is connected to a mini PC amplifier, which is powered by an isolated supply with no ground, like a typical plug-top PSU. The DAC is inside a PC, which is grounded. In this case it is acceptable to connect the headphone output to the amplifier, as there is no ground connection back to the DAC PSU to cause a short-circuit.

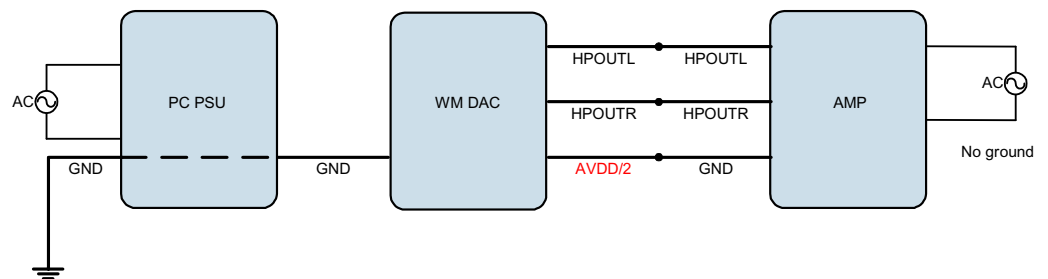


Figure 4 Acceptable Ground Connection 2

HEADPHONE OUTPUT GROUND CASE 3

In the diagram below, the capless output is connected to an amplifier, which is powered by a grounded supply. The DAC is inside a PC, which is also grounded. In this case it is *not* acceptable to connect the headphone output to the amplifier as there *is* a ground connection back to the DAC PSU, which will cause a short-circuit.

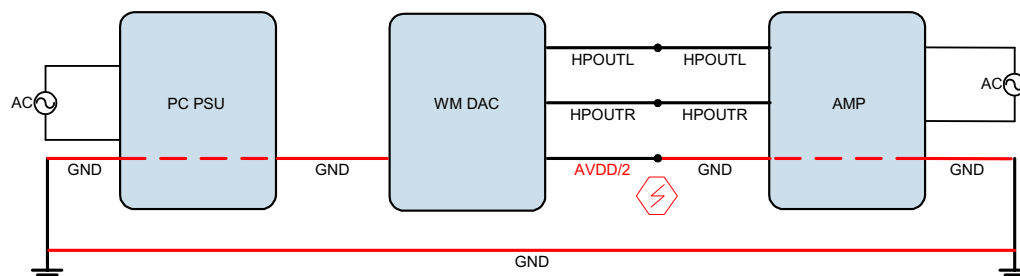


Figure 5 Bad Ground Connection 1

HEADPHONE OUTPUT GROUND CASE 4

In the diagram below, the capless output is connected to an amplifier, which is powered by a grounded supply. The DAC is inside a battery-powered CD player, which is grounded because it is powered by a non-isolated car charger. In this case it is *not* acceptable to connect the headphone output to the amplifier as there *is* a ground connection back to the DAC PSU, which will cause a short-circuit.

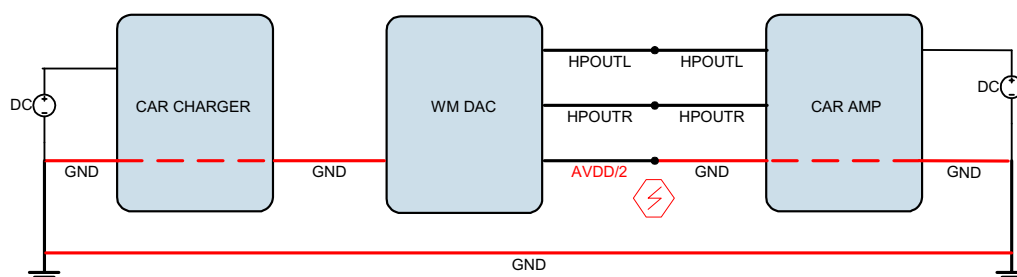


Figure 6 Bad Ground Connection 2

CONCLUSION

In most systems where the capless headphone output is used, it is safe to connect it to another piece of powered equipment, instead of headphones. In the rare case where both units are powered by a grounded supply, there will be a short-circuit, which will result in badly distorted sound output. In this case the thermal cut-out protection circuitry will stop any damage to the IC.

APPLICATION SUPPORT

If you require more information or require technical support please contact Wolfson Microelectronics Applications group through the following channels:

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