Impedance Compensation (Zobel Network) for Ground Referenced Outputs

INTRODUCTION

Many Wolfson audio devices now have ground referenced headphone and line outputs, incorporating an innovative dual-mode charge pump architecture (Wolfson 'Class-W') - to optimise efficiency and power consumption during playback.

The ground referenced output is achieved using an internal charge pump to power the headphone amplifier and means that there can be a direct connection between the Wolfson device output and the headphone load. This has several advantages compared to a VMID referenced output, including improved power consumption, better pop-click performance, and reduced overall cost of external components.

For stable audio performance with all types of headphone, a zobel network is required at any ground referenced output. If the zobel network is omitted, it is possible that charge pump switching frequency effects will affect audio performance.

This document describes why the zobel network is recommended and how the zobel network can work in the application.

CHARGE PUMP

The Wolfson ground-referenced amplifiers incorporate a dual-mode charge pump which generates the supply rails for the output drivers. The charge pump has a single supply input, CPVDD, and generates split rails VPOS and VNEG according to the selected mode of operation. The charge pump connections are illustrated in Figure 1. An input decoupling capacitor is also required at CPVDD, depending upon the system configuration. External component requirements for the capacitors in Figure 1 are detailed in WAN0214 "External Component requirements for ground referenced outputs".
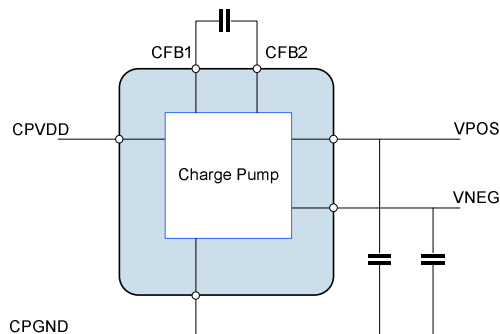

Figure 1 Charge Pump

The charge pump switches the CPVDD supply at a high frequency rate, as specified in the device datasheet. The switching frequency is derived from MCLK, which is also used for clocking the CODEC and other circuits within the device.

Switching noise arising from the charge pump can be observed on the VPOS/VNEG lines, and can pass through to the output of the amplifier. External components are used to filter the switching noise effects in the audio signal paths. The switching noise ripple is highest when the output load impedance is high. A typical headphone impedance vs frequency plot is illustrated in Figure 2. It can be seen that, for a typical headphone, the impedance above 50kHz is very high, and the impedance of headphone increases rapidly above 50kHz.
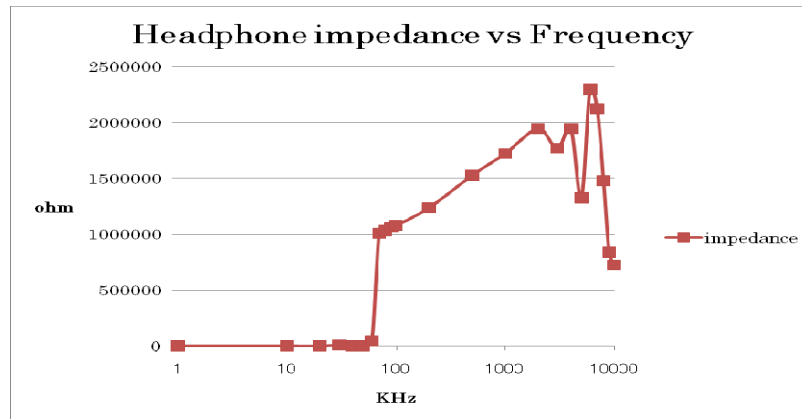
Figure 2 Headphone Impedance vs Frequency

For best performance, the high frequency impedance of the load must be reduced, in order to stabilise the headphone output and reduce the charge pump switching noise. Even a small level of switching noise may be audible with some headphones. The use of a zobel network is recommended in order to reduce the load impedance and reduce switching noise.

ZOBEL NETWORK

To stabilise the headphone output and reduce high frequency charge pump switching noise, it is recommended to connect a zobel network to each ground-referenced output. The recommended zobel network components are illustrated in Figure 3. The zobel network should comprise a 20Ω resistor and 0.1µF capacitor in series with each other, as illustrated.
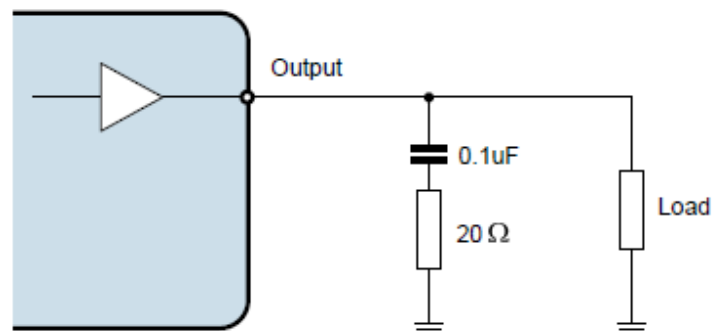

Figure 3 Zobel Network

The zobel network components should be connected to each ground-referenced output pin if the output is to be used. For example, on WM8903, these pins are called HPOUTL, HPOUTR, LINEOUTL and LINEOUTR .

The components of the zobel network have the effect of dampening high frequency oscillations and instabilities that can arise outside the audio band under certain conditions. Possible sources of these instabilities include the inductive load of a headphone coil or an active load in the form of an external line amplifier. The capacitance of lengthy cables or PCB tracks can also lead to amplifier instability.

If any Ground-referenced output pin is not required:

1. The zobel network components can be omitted from that output pin, and the pin can be left floating.

2. Care should be taken that the application software does not enable the output. Enabling any Ground-referenced output which has no zobel network can affect the stability of other Ground-referenced outputs on the same device.

CONCLUSION

On all ground-referenced amplifier outputs, it is recommended to include zobel network components in order to reduce the high frequency impedance of the load. The specified audio performance cannot be guaranteed if these components are omitted.

APPLICATION SUPPORT

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

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Additional information may be made available on our web site at:

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