

1 Introduction

Consumer electronics are required to comply with a plethora of governmental safety regulations. Although many of these regulations are either internationally standardized or comparable between different countries, some countries have unique requirements that present challenges to electronic manufacturers. An example of this is the German-based Geprüfte Sicherheit (“GS”) certification mark requirement for PC headphone outputs.

The purpose of this application note is to provide recommendations on how to design a PC’s headphone output circuits for compliance with both the Windows Hardware Logo Program Requirement (“WLP”) and GS Mark requirements. These recommendations are provided “As Is” and are based upon prior experiences with customers’ circuits. *IDT does not guarantee following these recommendations will result in compliance with GS Mark due to possible influence from other unknown system variables.* In some cases, slight modifications to these generic recommendations may be necessary for a particular application. IDT will provide additional system design support in these cases. Additionally, there are other requirements outlined in the GS Mark that are not discussed or covered by this paper. All recommendations in this application note are based on current regulatory specifications (as of September, 2008). Please contact the respective agencies for any updates to these regulations before beginning any new designs.

2 The GS Mark Requirement for Headphone Outputs

Geprüfte Sicherheit (“GS”) mark is a voluntary certification mark for technical equipment designating compliance with the German Equipment and Product Safety Act (“Geräte- und Produktsicherheitsgesetz”). It is a superset of all European-required CE marking safety requirements combined with ergonomic requirements and some additional safety requirements. Literally translated, Geprüfte Sicherheit means “Tested Safely” in English.

2.1. Headphone Specification of GS Mark

EK1-ITB 2000 is the document that specifies the requirements for GS-mark in IT equipment in combination with visual display units. In section A.2.9.34, it describes the setup for qualifying headphone as identical to the European Standard, EN50332:

“The requirements of EN 50332 for limitations of the sound pressure level of ear- / headphone outputs is [*sic*] expanded to include stationary products with ear- / headphone outputs because they are subject to the same dangers regarding hearing damage/hearing loss.”

EN 50332 is the European Standard for measuring headphone output level. The source used in the EN 50332 is borrowed from another standard—per EN 50332, section 5:

The test signal used to determine the maximum sound pressure level of headphones shall be programme [*sic*] simulation noise, as defined in IEC 60269-1. ...The programme simulation noise must have a crest factor ranging between 1.8 and 2.2. ...For digital recording media, 0 dB reference level defined as being the maximum amplitude of a sinusoidal signal corresponding to the full scale of the A/D converter (0 dB full scale): the test signal shall be recorded at an RMS value of -10dB (ref 0 dB full scale).

IEC 60269-1 is the IEC standard for general sound system equipment. The noise signal is based on an inverse loudness curve and is declared in terms of power spectral density with a specific tolerance for 1/3-octave intervals between 20 Hz and 20 kHz. The resultant power spectral density is shaped as shown in Figure 1.

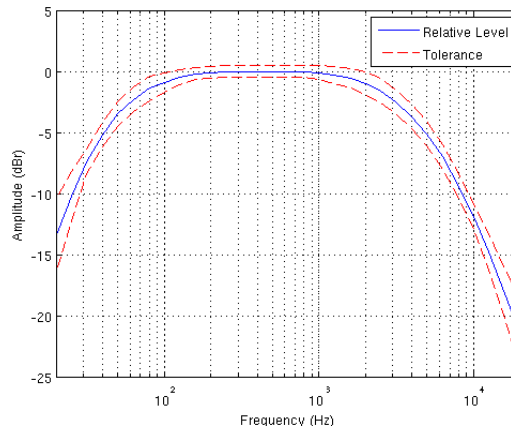


Figure 1 – Power Spectral Density Graph of the IEC 60269-1 Signal

In addition, section A.2.9.34 of EK1-ITB 2000 states the precise criteria for maximum output level for headphone outputs with standardized sockets as follows:

“In deviation to EN 50332 a measurement of the output voltage with adjustment of the volume control to center position has to be made with and without equalizer. During the measurements the equalizer is adjusted to its neutral or center position (factory setting). In case the reading is ≤ 150 mV the instructions for use must consider a warning note to fulfill the requirements according to EK1-ITB 2000. In case the reading is > 150 mV the requirements according to EK1-ITB 2000 are not fulfilled.”

It should be noted that the RMS level of the audio source in the aforementioned test is -10 dB FS, not 0 dB FS.

2.2. Impact of GS Mark Headphone Specification on WLP

The Microsoft Windows Hardware Logo Program Requirements (“WLP”) also include a specification for the level of a headphone output signal. However, this specification addresses the *minimum* level for headphone outputs. The standard device requirements for analog headphone outputs at full-scale output voltage for both premium desktop and premium mobile implementations are:

Output Load	Required Value for Premium Desktop	Required Value for Premium Mobile
320 ohm	≥ 1 V rms	≥ 0.707 V rms
32 ohm	≥ 300 mV rms	≥ 300 mV rms

Table 1 - WLP Headphone Output Requirements

The importance here is that WLP specifies a minimum level (with a full scale sine wave input and full volume) and GS mark specifies a maximum level (with a -10 dB FS weighted noise input and half-volume) for headphone output with a 32 ohm load. PC manufacturers must have a way to adjust their headphone output to within that range in order to fulfill both sets of the requirements.

3 Recommended Solution

A direct solution to the aforementioned problem is to increase the value of the series resistor of the headphone output circuit. Figure 2 depicts a standard headphone output circuit. Although the recommended values vary slightly between codecs, the basic circuit is common. The codec's headphone amplifiers connect to a small series resistor. Next, a large DC-blocking capacitor is placed in series to prevent remove the DC bias from the amplifiers' output. Then, small ferrite beads are placed in series to impede the high-frequency artifacts. Finally, a small capacitor to ground is placed in parallel with the output jack to provide a basic filter for further attenuation of high-frequency artifacts.

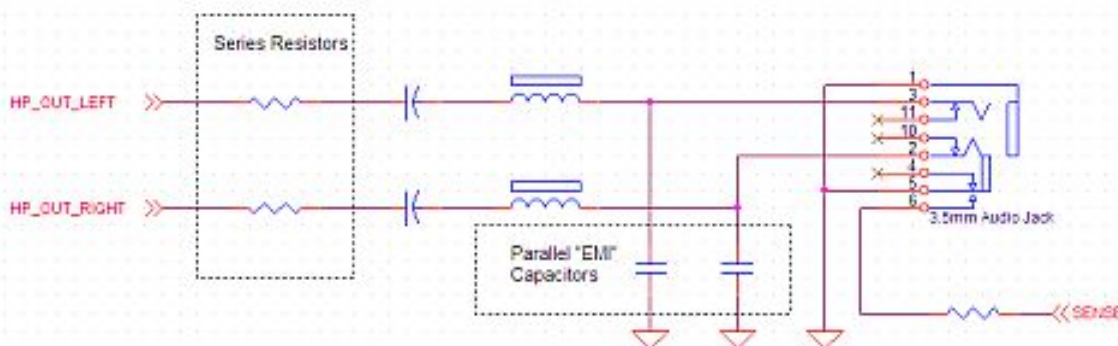


Figure 2 – Schematic of Standard Headphone Output Circuit

IDT offers two hardware solutions that vary the component values of the above circuit to achieve GS mark compliance. The first solution, “50% Volume Level”, is designed to meet the bare minimum GS requirements for at a -6dB volume setting (“center position”). The second solution, “100% Volume Level”, is a more aggressive alternative designed to meet the GS requirements at any volume setting. This solution is offered for customers who have concerns about the interpretation of the “center position [of volume control]” specification of the EK1-ITB 2000 specification. Both solutions fulfill the WLP requirement for 32 ohm loads; however, the 100% volume settings may have some difficulty meeting the requirement for desktop for 320 ohm loads. In some cases, it is also necessary to change the value of the parallel capacitor when the series resistor is changed. Please refer to Table 2 for a list of recommended filter components' values for specific IDT products.

Codec	Non-GS Mark Products		GS Mark Products (50% Volume Level)		GS Mark Products (100% Volume Level)	
	Series Resistor	Parallel Capacitor	Series Resistor	Parallel Capacitor	Series Resistor	Parallel Capacitor
92HD81x (port A)	5.1 ohm	10,000 pF	10 ohm	10,000 pF	56 ohm	2,200 pF
92HD81x (port B)	5.1 ohm	0.1 uF	10 ohm	47,000 pF	56 ohm	10,000 pF
92HD83x;	5.1 ohm	0.1 uF	10 ohm	47,000 pF	56 ohm	10,000 pF
92HD73x; 92HDW74x	5.1 ohm	22,000 pF	8.2 ohm	15,000 pF	47 ohm	3,300 pF
All others	5.1 ohm	10,000 pF	8.2 ohm	10,000 pF	47 ohm	2,200 pF

Table 2 - Recommended Filter Components' Values

Significantly increasing the value of the existing series resistor will create a resistor-divider that will attenuate the headphone output whenever a headphone is connected as seen in Figure 3. For the 50% volume level case, that decrease will be about -20% (-2 dB); for the 100% volume case, that decrease will be about -60% (-8 dB). The attenuation is linear, so the output level will be reduced for all input levels (refer to the transfer function in Figure 4). This means that while a -17 dB FS input might produce a “comfortable listening level” of 0.5 mW of output power using the original solution, this GS-compliant solution might only produce 0.1 mW of output power with those same volume settings.

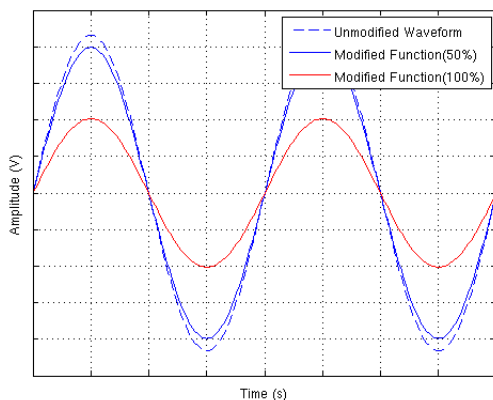


Figure 3 - Waveform of the Hardware-Based Solution (32 ohm Load)

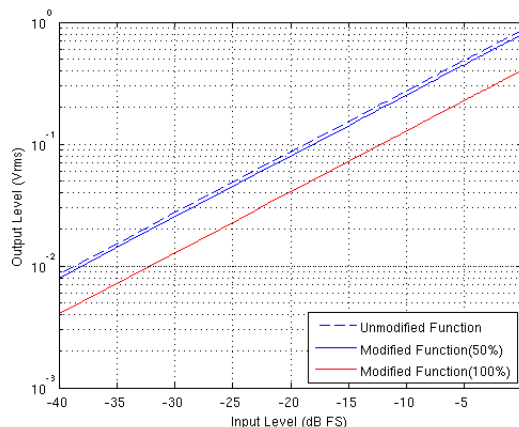


Figure 4 – Transfer Function of Hardware-Based Solution (32 ohm Load)

Finally, it should be noted that, since the attenuation is caused by an $I \cdot R$ drop, this hardware solution has the added benefit that it will not affect the output level with high impedance loads (i.e., line-output). For example: using the 100% Volume Level configuration from Table 2, at full scale the output a circuit with a 1 Vrms amplifier-output and 32 ohm load will be

$$V_{out} = V_{amp} * \left(\frac{R_{load}}{R_{load} + R_{series}} \right) = 1 \text{ Vrms} * \left(\frac{32\text{ohm}}{32\text{ohm} + 47\text{ohm}} \right) = 405 \text{ mVrms}$$

However, if that same jack is used as a line-out for a device with a 10 kohm load impedance, the output level will be:

$$V_{out} = V_{amp} * \left(\frac{R_{load}}{R_{load} + R_{series}} \right) = 1 \text{ Vrms} * \left(\frac{10\text{kohm}}{10\text{kohm} + 47\text{ohm}} \right) = 995 \text{ mVrms}$$

3.1. Advantages to the Recommended Solution

- The transfer function is still linear, so audio performance is not degraded
- When a high-impedance load is connected to the headphone jack, the voltage drop across the resistor will become negligible

3.2. Disadvantages to the Recommended Solution

- Requires manufacturers to either accommodate two different PCB assemblies (one for GS mark required regions and one for others) or accept the lower output level of the GS mark-compliant PCB assemblies for all regions
- Overall gain is decreased, so the headphones will sound quieter

4 Summary & Conclusions

- 1) GS mark is a voluntary safety certification for technical equipment. GS mark specifies a maximum output level for headphone outputs; this requirement is a concern to PC manufacturers.
- 2) Microsoft specifies a minimum output level for headphone outputs for WLP, so PC manufacturers wishing for both GS mark and WLP certification need to design their headphone jacks to comply with requirements in both two standards.
- 3) By default, all IDT PC audio evaluation boards and reference schematics are configured for maximum output (i.e., not fulfilling GS mark requirements). However, all IDT solutions can be modified to meet the GS mark requirements while maintaining the WLP requirements using either a hardware or a software implementation.
- 4) The hardware-based solution involves increasing the series resistor on the headphone output circuit to form a resistor-divider. This solution provides the best audio performance, but it requires the manufacturers to accommodate two separate PC assemblies.
- 5) The software-based solution involves programming the software limiter/compressor to limit the maximum level to the headphone. This solution requires only one PC assembly, but it degrades audio performance slightly.

5 References

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- International Electrotechnical Commission. CEI/IEC 268-1. Sound System Equipment. Part 1: General. Second edition, 1985.
- Microsoft. Windows Hardware Logo Program Requirements. Audio Devices. March 21, 2008.

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