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Application Report

SLOA234A – June 2016 – Revised July 2018

TPA3136D2 and TPA3138D2 Design Considerations for EMC

Mid Power and Converters

ABSTRACT

The TPA3136D2 and TPA3138D2 Class D audio power amplifier are the latest TI analog input amplifiers that use advanced PWM switching techniques for reducing electromagnetic interference (EMI) without degrading audio performance. This application note describes the system design and printed circuit board (PCB) guidelines used to maximize the technology employed in the TPA3136D2/TPA3138D2 device. These techniques include the EMI suppression without the need for expensive inductor filters and the reduction of external component count.

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1 General Overview

The emphasis on green technologies and sleek-looking electronics (such as the flat-panel TV) has lead manufacturers to produce space-efficient and attractive products without sacrificing performance. The TPA3136D2/TPA3138D2 mono/stereo Class D audio power amplifier provides Class AB audio performance using only the PC board as a heat sink due to its high efficiency. In addition, the TPA3136D2/TPA3138D2 device has advanced PWM modulation and switching schemes that help reduce EMI while eliminating the need for the traditional Class D output filter. PWM filtering requires only smaller and less expensive RF filter components. No external heat sink and less RF filtering result directly in a smaller PC board.

Discussions in the following sections explain the PC board layout practice and external components selection in order to achieve optimal audio performance and pass electromagnetic compatibility (EMC) specification EN55022.

- Section 2 describes the advanced emission suppression techniques used to combat EMI.
- Section 3 discusses the PC board design guidelines for audio quality and EMC.
- Section 4 shows the EMC results for TPA3136D2 EVM.

2 Advanced Emission Suppression

2.1 Spread Spectrum Modulation

EMI is electromagnetic radiation emitted by electrical systems with fast-changing signals that are common to the outputs of a class D audio power amplifier. EMI encompasses two aspects: emission and susceptibility. Emission refers to the generation of unwanted electromagnetic energy by the equipment. Susceptibility, by contrast, refers to the degree in which the equipment is affected by the electromagnetic disturbances. EMC is achieved by addressing both emission and susceptibility issues. The TPA3136D2/TPA3138D2 device has advanced emission suppression technology which enables the device to run without an LC filter with speaker wires up to one meter long and still meet the EMI regulatory standards such as EN55022, CISPR 22, or FCC Part 15 Class B.

The TPA3136D2/TPA3138D2 device features an advanced spread-spectrum modulation mode with low EMI emission to lower the overall system cost. This reduced system cost is achieved by replacing large, expensive LC output filters with small, low-cost ferrite beads filters. The spread spectrum modulation scheme exhibits less EMI by flattening the wideband spectral components from the speaker cables and still retains the high-efficiency feature of a traditional class D amplifier such as the TPA3110D2 device.

Figure 1 shows the topology of a conventional (no spread spectrum) BD modulation class D amplifier. The BD switching technique uses an internally generated triangular waveform with a fixed frequency and a complementary signal pair at the input stage. The output PWM changes the duty cycle to generate a moving average of the signal that corresponds to the input analog signal. The advantages of PWM switching topology is high efficiency, which provides low power consumption and small thermal design.

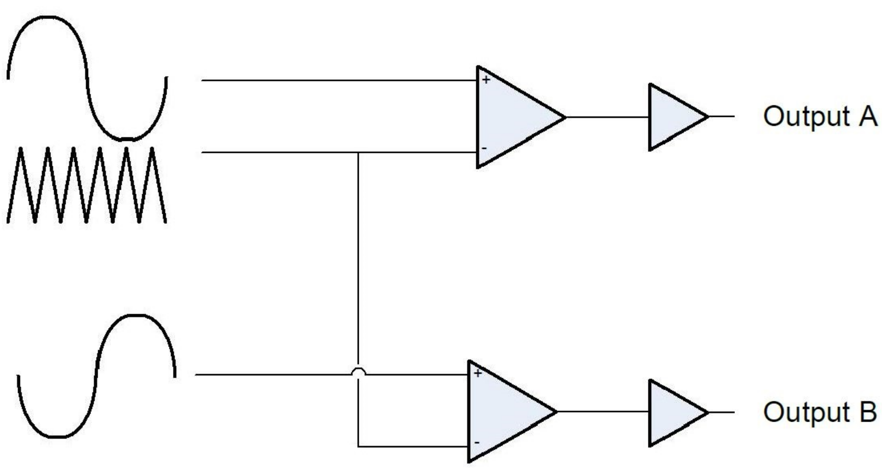

Figure 1. Class D Audio Amplifier

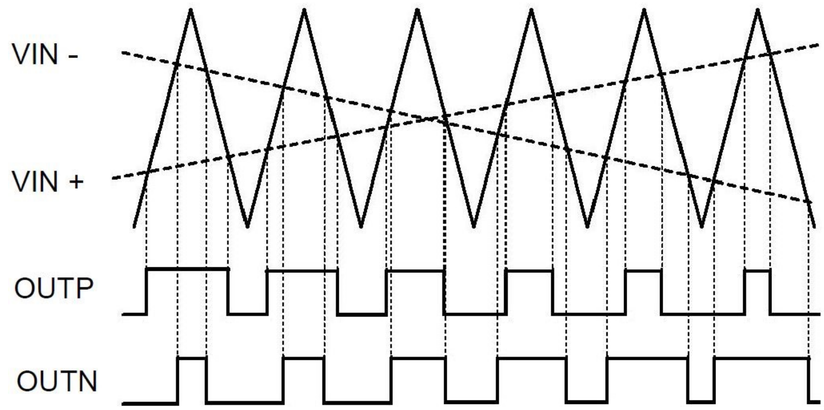

Figure 2. Fixed-Frequency Mode Modulation

The TPA3136D2/TPA3138D2 device has built-in spread spectrum modulation (SSM) control of the oscillator, which has improved EMI performance over conventional fixed-frequency modulation mode. In the FFM mode, the frequency of the triangular waveform is fixed as Figure 2 shows. In SSM mode, the frequency of the triangular waveform varies by ±10% cycle-to-cycle with a center frequency at about 315 kHz. SSM mode improves EMI emissions radiated by the speaker wires by spreading the energy over a larger bandwidth and reducing the wideband spectral content. On the other hand, FFM produces larger amounts of spectral energy at multiples of the PWM switching frequency. The cycle-to-cycle variation of the switching frequency does not affect the efficiency of the audio amplifier. Figure 3 shows the effects of the frequency variation on the triangular waveform.

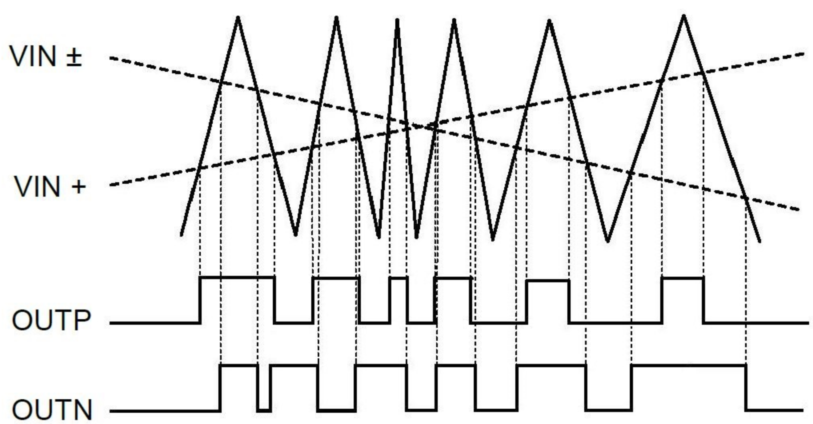

Figure 3. Spread-Spectrum Mode Modulation

Compared to the traditional FFM class D amplifier, the spread-spectrum scheme has reduced the peak energy of the switching frequency and lessens harmonics. Figure 4 shows a comparison of FFM and SSM modulation.

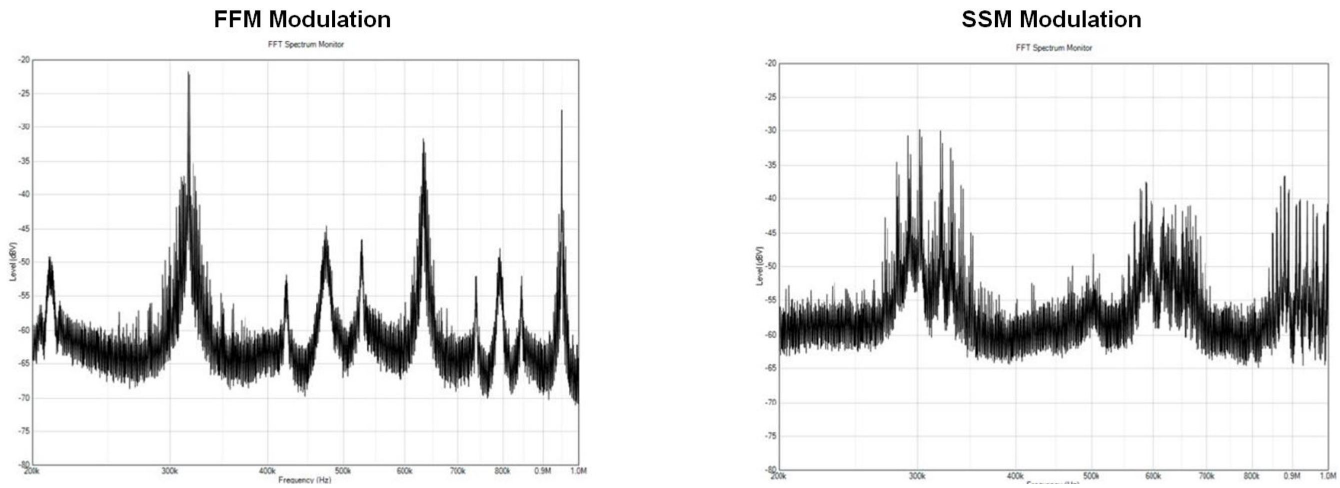

Figure 4. Comparison of FFM and SSM Modulation

2.2 Dephase

In addition to the spread spectrum technology, the TPA3136D2/TPA3138D2 device employs dephase circuits to further reduce electromagnetic emission without degrading audio performance.

The dephase circuit improves EMI and noise performance by interleaving the switching timing between the two audio channels. This improved EMI and noise performance reduces conducted emission on the PVCC line because the output ripple current of the two audio channels will be out of phase, and the ripple peak current from the PVCC line is reduced to half value.

3 Printed Circuit Board Design for EMC

3.1 Printed Circuit Board Layout

It is necessary to follow recommended PC board guidelines for EMC success. Proper PC board floor planning, component selection, component placement, and routing are all essential to counter EMI. Emissions are exacerbated by improper layout, components, and output trace length causing antenna effect. Practical PC board design guidelines for achieving EMC include:

- Place the high-frequency decoupling capacitors as close to the power pin and ground pin of the device as possible to reduce the parasitic inductance of the trace. To ensure low AC impedance over a wide frequency range for noise reduction, use good quality, low-ESR, 1-nF ceramic capacitors. For mid-frequency noise due to PWM transients, use another good quality, 0.1-µF ceramic capacitor placed as close as possible to the PVCC leads.
- Use a continuous ground plane and avoid voltage offset on the ground planes whenever possible.
- Low impedance routing back to source (return signal)
- Power planes should be away from the edges of the PC board.
- Proper filtering of the PC board connectors
- Place EMC snubbers and ferrite bead filters as close as possible to the IC. Minimize unfiltered loops and trace length as well as stray inductance.
- Keep amplifier output traces to the speaker as short as possible. PC board traces and the speaker wire are the largest sources of emission.

For more detailed information, use the TPA3136D2EVM user guide and the TPA3136D2EVM Gerber for reference.

- TPA3136D2EVM user guide (SLOU444)
- TPA3136D2EVM Gerber (http://www.ti.com/tool/TPA3136D2EVM)

3.2 Ferrite Bead Filter

Low-cost ferrite bead filters are used to suppress EMI. They are placed close to the amplifier output to minimize loop antennas. At low frequencies, ferrite beads act as 0-Ω resistors with no DC drop. However, the impedance of the ferrite beads increases significantly at frequencies above 1 MHz to suppress radiation. Ferrite beads also play a significant role on the THD+N of the system. Examples of ferrite beads which have been tested and worked well with the TPA3136D2 device include the NFZ2MSM series from Murata. If other ferrite beads are used, the EMC testing must be repeated to ensure compliance. The typical ferrite bead recommend for TPA3136D2 is NFZ2MSM601SN10 and NFZ2MSM301SN10. For Asia customers, some other suitable ferrite beads include: UPZ2012E601-2R0TF and UPZ2012E331-2R5TF.

3.3 Power Supply and Speaker Wires

When performing the conducted emission test, it is essential to keep the AC power cable away from the speaker cables. This prevents stray signals from coupling to power source and other potential unintended radiators or conductors.

In the cast of a DC power supply, not all customers need to pass conducted EMI because they use battery as the power supply source. When compared with an AC power supply module, DC power supply modules usually do not have any EMI filters. In order to achieve enough conducted EMI margin, add a simple EMI filter on PVCC for the TPA3136D2. Refer to *AN-2162 Simple Success With Conducted EMI From DCDC Converters* (SNVA489).

4 TPA3136D2 EVM EMI Results

The following sections show the EMI test results from a certified EMI test Lab with a TV power supply module which is widely used in the Asia market. The passing margins are greater than 10 dBuV, in most cases.

The following radiated EMI plots are taken with standard EVM configuration and BOM components.

The conducted EMI plots are taken using the same EVM configuration but with a TV power supply.

4.1 EN55013 Radiated Emission Results

TPA3136D2 EVM, PVCC = 12 V, 8-Ω load, up to 1-meter speaker cable, Po = 4 W, ferrite bead is UPZ2012E601-2R0TF.

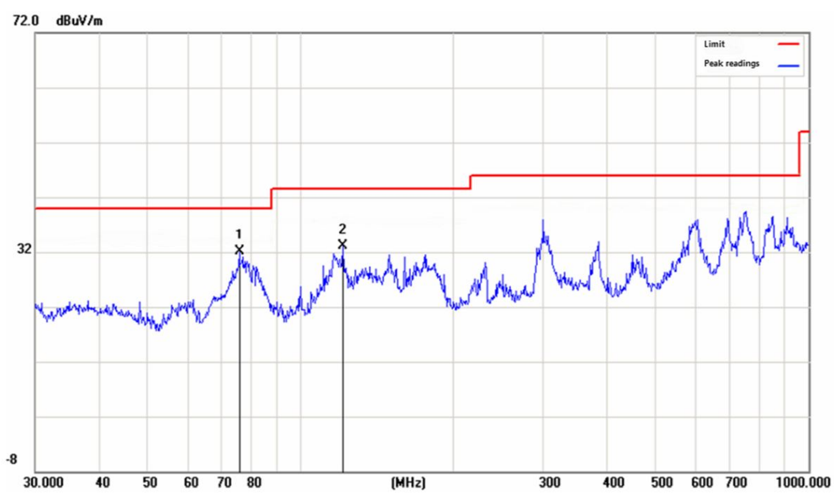

Figure 5. Radiated Emission – Horizontal Pre-Scan

Table 1. Radiated Emission Margins – Horizontal

Frequency (MHz)	Limit (dBuV/m)	Q-Peak (dBuV/m)	Margin (dB)
75.7114	40.00	32.19	–7.81
121.1231	43.50	33.19	–10.31

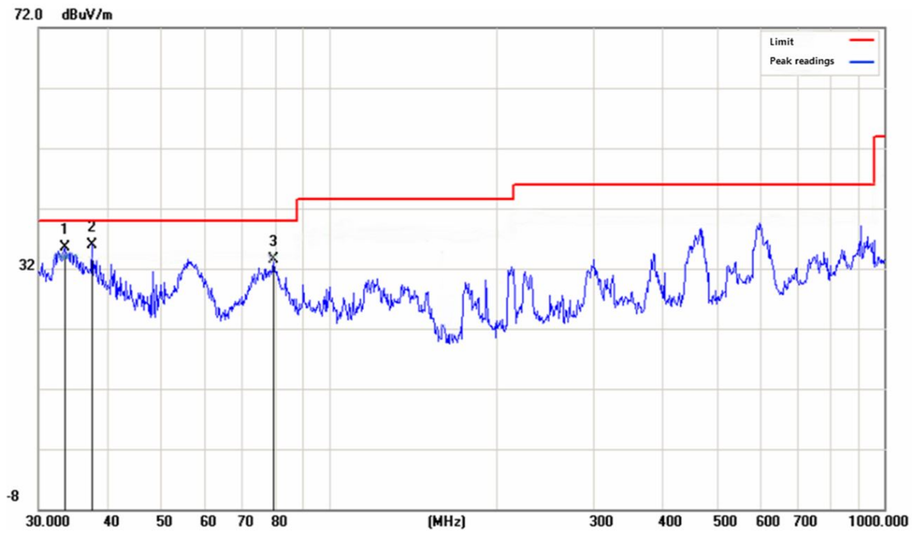

Figure 6. Radiated Emission – Vertical Pre-Scan

Table 2. Radiated Emission Margins – Vertical

Frequency (MHz)	Limit (dBuV/m)	Q-Peak (dBuV/m)	Margin (dB)
33.4449	40.00	35.49	–4.51
37.4165	40.00	36.00	–4.00
79.5209	40.00	33.41	-6.59

4.2 EN55022 Conducted Emission Results

TPA3136D2 EVM, PVCC = 12 V, 8-Ω speakers, Po = 4 W , ferrite bead is UPZ2012E601-2R0TF.

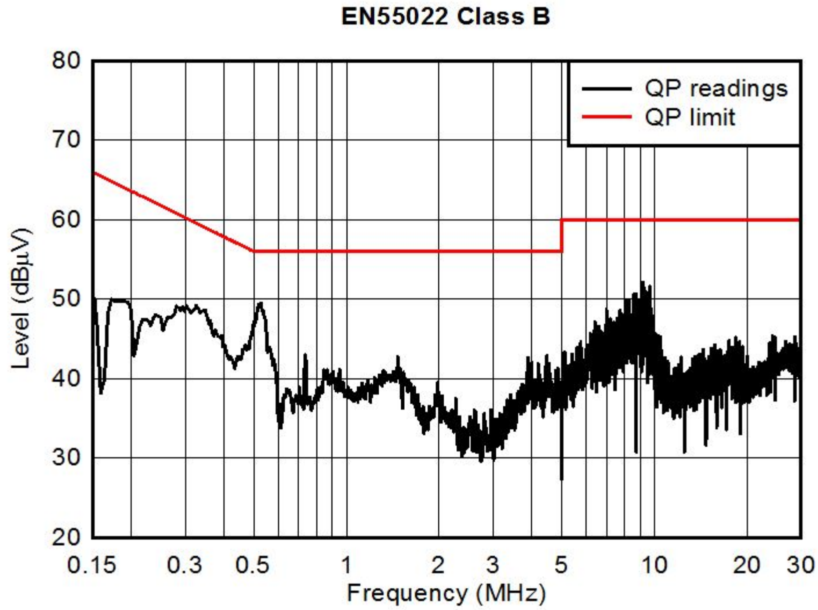

Figure 7. Conducted Emission – Line Pre-Scan

Table 3. Conducted Emission Margins – Line

Frequency (MHz)	QP Limit (dBuV/m)	QP Readings (dBuV/m)	QP Margin (dB)
0.1500	66.00	46.4	–19.60
0.1815	64.40	46.4	–18.00
0.3300	59.50	45.1	–14.40
0.5270	56.00	45.4	–10.60
1.4675	56.00	38.5	–17.50
9.1895	60.00	48.8	–11.20

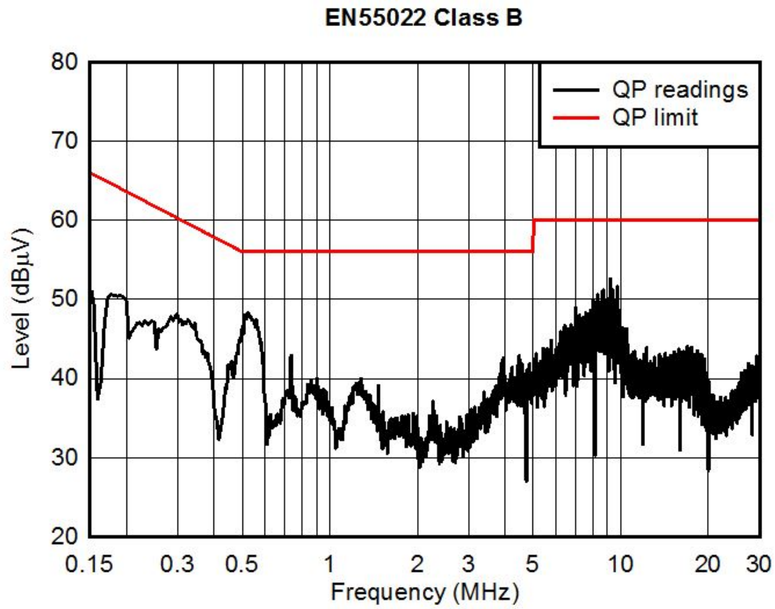

Figure 8. Conducted Emission – Neutral Pre-Scan

Table 4. Conducted Emission Margins – Neutral

Frequency (MHz)	QP Limit (dBuV)	QP Readings (dBuV)	QP Margin (dB)
0.1815	64.40	46.5	–17.90
0.5360	56.00	44.2	–11.80
0.7385	56.00	38.7	–17.30
4.4735	56.00	36.4	–19.60
9.1895	60.00	49.1	–10.90
9.7115	60.00	43.8	–16.20

5 Conclusions

The TPA3136D2/TPA3138D2 device has the advanced RF emission suppression technology that helps to design an EMI-compliant audio system without compromising cost and performance. The TPA3136D2EVM User's Guide (SLOU444) and TPA3138D2 User's Guide (SLOU503provides the details of the schematic and BOM. By adhering to the guidelines discussed in this report, EMI requirements can be met and costly PC board rework may be avoided.

For further questions and discussions on this topic, go to the TI E2E Forums (http://e2e.ti.com/).