Application Report

TAS5825M Design Considerations for EMC

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ABSTRACT

The TAS5825M Class-D audio power amplifier is the latest TI digital input amplifier that uses 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 this device. These techniques include the EMI suppression without the need for expensive inductor filters and the reduction of external component count.

Table of Contents

List of Figures

List of Tables

Trademarks

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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 TAS5825M Class-D audio power amplifier provides Class AB audio performance using only the PCB as heat sink due to its high efficiency. In addition, the TAS5825M 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 PCB size reduction.

Discussions in the following sections explain the PCB 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 PCB design guidelines for audio quality and EMC.
- Section 4 shows the EMC results.

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 TAS5825M 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 TAS5825M 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.

Figure 2-1 shows the topology of a conventional (nonspread-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 correspond to the input analog signal. The advantages of PWM switching topology is high efficiency, which provides low power consumption and small thermal design.

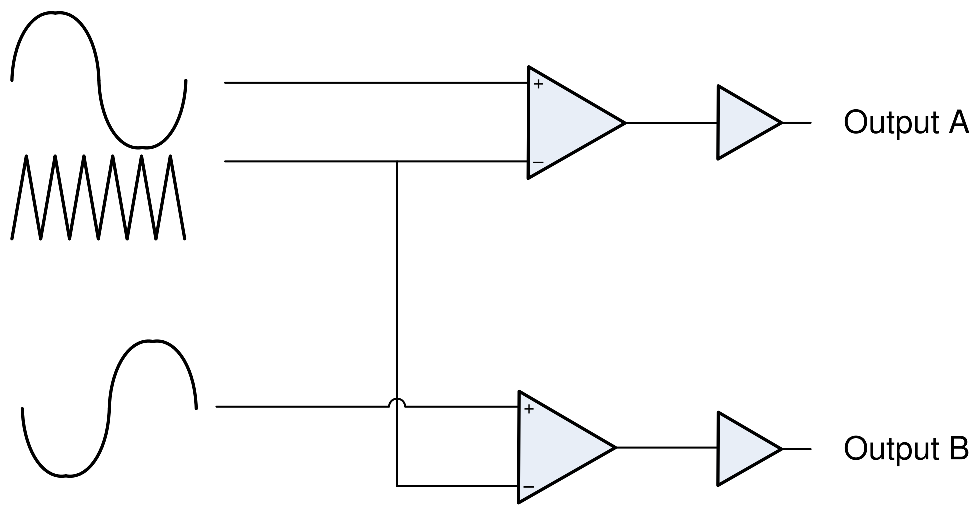


Figure 2-1. Class-D Audio Amplifier

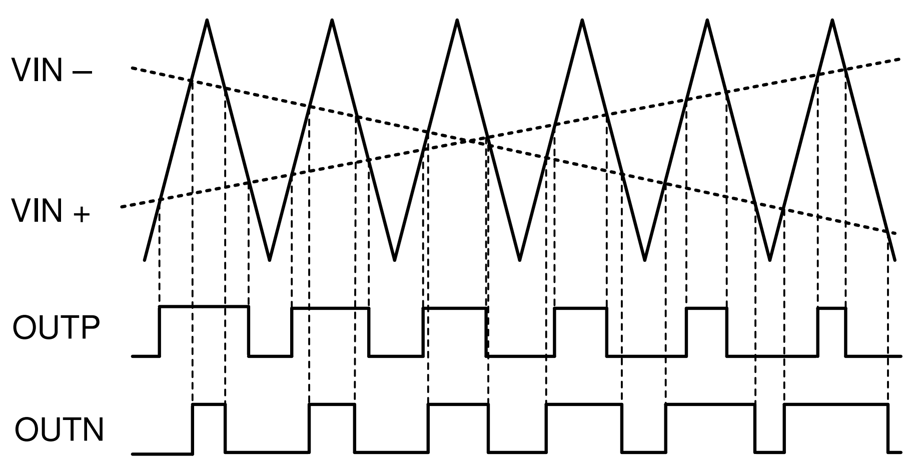


Figure 2-2. Fixed-Frequency Mode Modulation

The TAS5825M device features two modulation modes: fixed-frequency modulation mode (FFM) and spread spectrum modulation (SSM) mode. In the conventional FFM mode (Figure 2-1) the frequency of the triangular waveform is fixed as shown in Figure 2-2. In SSM mode, the frequency of the triangular waveform frequency varies cycle-to-cycle with a center frequency at switching frequency configured. 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 2-3 shows the effects of the frequency variation on the triangular waveform.

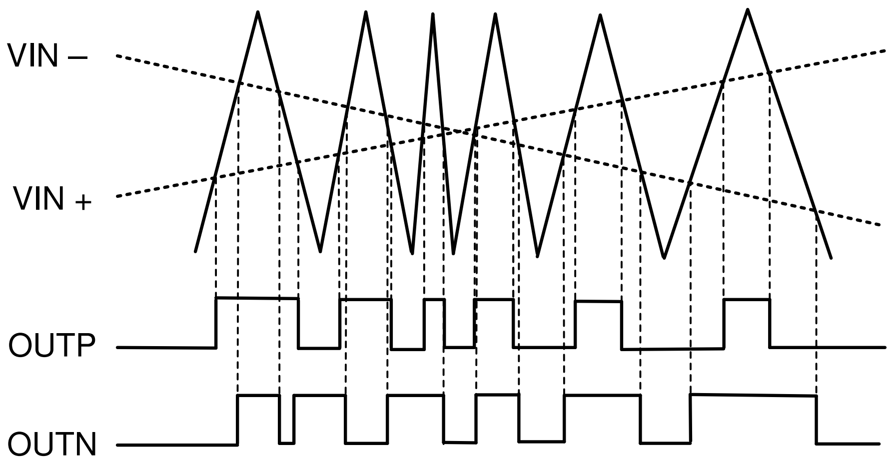
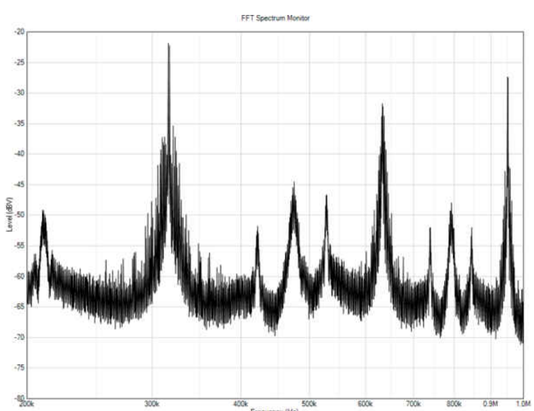
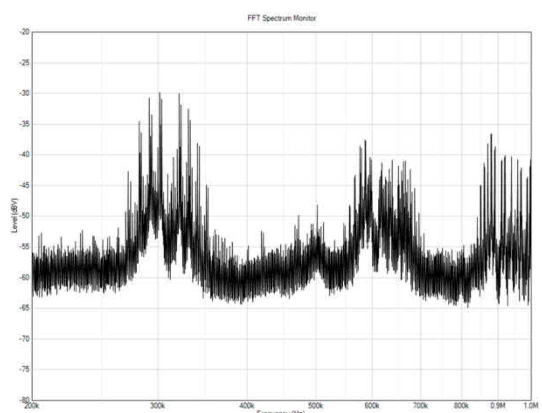


Figure 2-3. Spread Spectrum Mode Modulation

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



FFM Modulation



SSM Modulation

2.2 Dephase and Multi-Device Phase Synchronization

In addition to the spread spectrum technology, the TAS5825M 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 PVDD line because the output ripple current of the two audio channels will be out of phase, and the ripple peak current from the PVDD line will thus be reduced to half value.

Also, TAS5825M supports 45° phase shifts between multiple channels to reduce EMI in multi-device systems. See more details in the TAS5825M datasheet.

3 Printed Circuit Board Design for EMC

3.1 Printed Circuit Board Layout

It is necessary to follow recommended PCB guidelines for EMC success. Proper PCB 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 PCB 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 PVDD 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 PCB.
- Proper filtering of the PCB 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. PCB traces and the speaker wire are the largest sources of emission.

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 ferrite bead 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 TAS5825M device include the NFZ2MSM series from Murata.

The trade-off of ferrite beads is their impedance and rated current. If the rated current can meet the system requirements, larger impedance means larger EMI margins for the EMI, especially for the 5 MHz to 50 MHz frequency range. 300 ohm @ 100 MHz is a typical value, which can pass EMI in most applications.

The trade-off of capacitors is their capacitance and idle current. Larger capacitance leads to larger idle current. Using 2.2 nF instead of 1 nF capacitors is helpful in the 5 MHz to 100 MHz range.

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.

When ferrite bead filters are used, an AC to DC adapter with an EMI filter is required to pass conducted EMI. Most applications (for example TVs, Voice Controlled Speakers, Wireless Speakers and Sound Bars) that need a 110 V / 220 V AC power supply usually have already included an EMI filter in the AC to DC adapter. Some applications use DC power supplies. They need a simple EMI filter on the PVDD supply. Refer to this application note: AN-2162 Simple Success With Conducted EMI From DC to DC Converters (SNVA489C).

3.4 TAS5825M Device Configurations

If ferrite bead filters are chosen as the output filters, we recommend to choose BD modulation, set the switching frequency to 384kHz and also have Spread Spectrum enabled. Refer to the TAS5825M datasheet for the recommended Spread Spectrum configurations.

4 TAS5825M EMI Test Results

The following sections show the EMI test results from a certified third-party vendor. The radiated and conducted EMI plots below are taken using a TAS58x5M EMI Test Board, which is a 2-layer board and has been designed specifically for EMI testing. In addition, a 12 V TV power supply is used to power the board in the conducted emission testing.

4.1 EN55022 Radiated Emission Results

TAS58x5M EMI Test Board, ferrite bead filter, BD modulation, PVDD = 12 V, 8 Ω + 56 uH load, 105 cm speaker cables, Spread Spectrum enabled, Fsw = 384 kHz, Po = 4 W per channel.

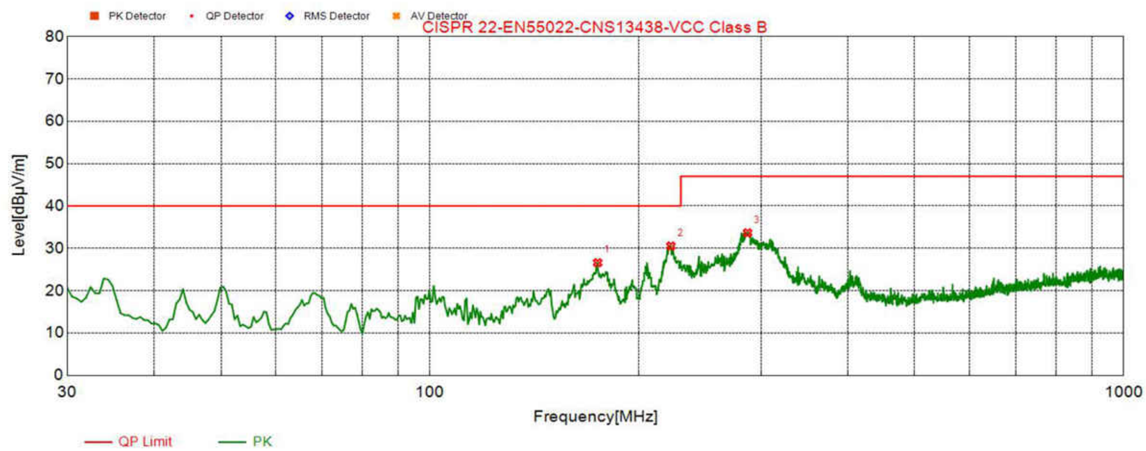


Figure 4-1. Radiated Emission - Horizontal Pre-Scan - BC Filter

Table 4-1. Radiated Emission Margins – Horizontal – BC Filter

NO.	Frequency [MHz]	Reading [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Level [dBµV/m]	Angle [°]
1	174.530	41.71	-15.10	40.00	13.39	200	26.61	259
2	222.545	47.31	-16.76	40.00	9.45	100	30.55	243
3	287.050	48.19	-14.52	47.00	13.33	100	33.67	313

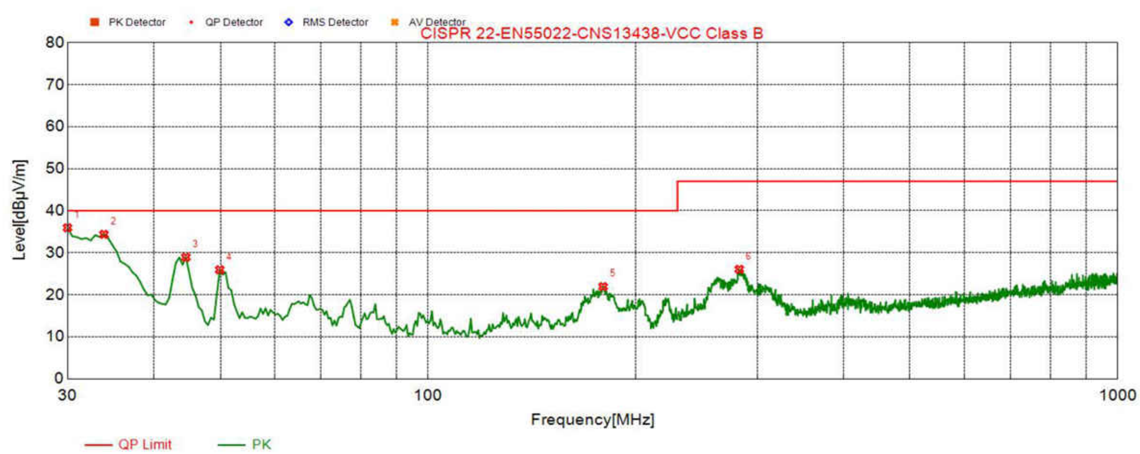


Figure 4-2. Radiated Emission - Vertical Pre-Scan - BC Filter

Table 4-2. Radiated Emission Margins – Vertical – BC Filter

NO.	Frequency [MHz]	Reading [dBµV/m]	Factor [dB]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Level [dBµV/m]	Angle [°]
1	30.000	51.99	-16.04	40.00	4.05	100	35.95	252
2	33.880	50.44	-16.05	40.00	5.61	100	34.39	61
3	44.550	44.66	-15.73	40.00	11.07	100	28.93	20

Table 4-2. Radiated Emission Margins – Vertical – BC Filter (continued)

NO.	Frequency [MHz]	Reading [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Level [dBμV/m]	Angle [°]
4	49.885	41.32	-15.36	40.00	14.04	100	25.96	233
5	179.380	37.47	-15.52	40.00	18.05	100	21.95	142
6	282.685	40.74	-14.68	47.00	20.94	200	26.06	356

TAS58x5M EMI Test Board, inductor filter, BD modulation, PVDD = 12 V, 8 Ω + 56 uH load, 105 cm speaker cables, Spread Spectrum disabled, Fsw = 768 kHz, Po = 4 W per channel.

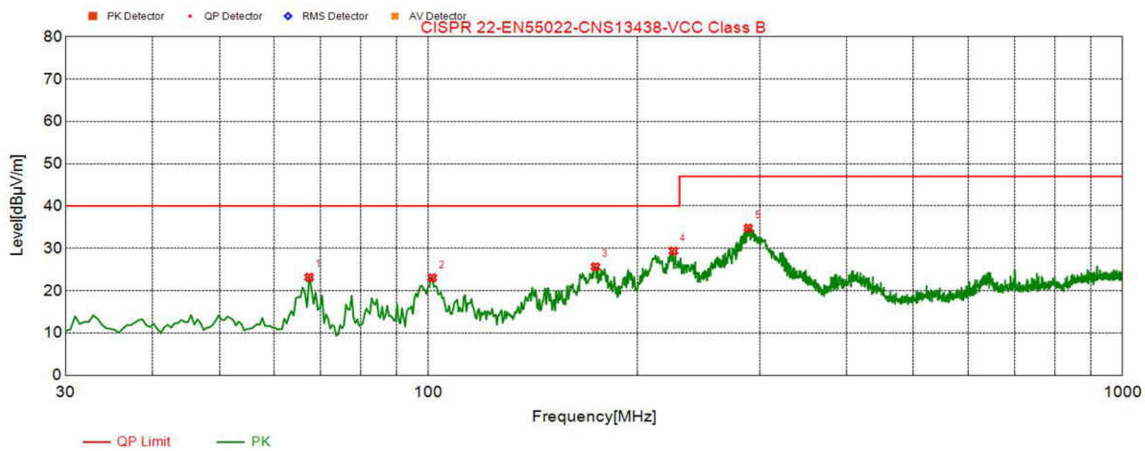


Figure 4-3. Radiated Emission - Horizontal Pre-Scan - LC Filter

Table 4-3. Radiated Emission Margins – Horizontal – LC Filter

NO.	Frequency [MHz]	Reading [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Level [dBμV/m]	Angle [°]
1	67.345	39.94	-16.77	40.00	16.83	200	23.17	352
2	101.295	41.42	-18.36	40.00	16.94	200	23.06	247
3	174.045	40.71	-15.06	40.00	14.35	200	25.65	45
4	225.455	46.07	-16.70	40.00	10.63	100	29.37	254
5	288.990	49.26	-14.46	47.00	12.20	100	34.8	223

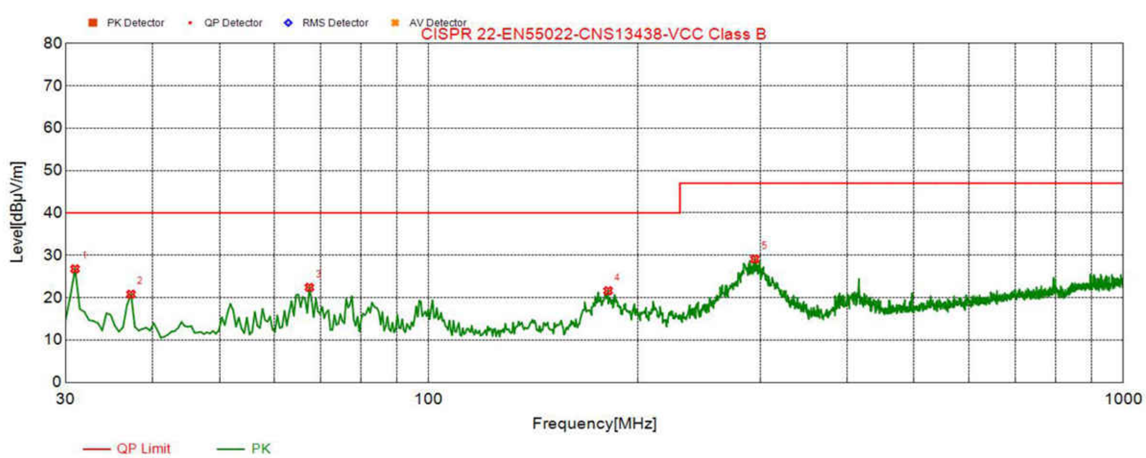


Figure 4-4. Radiated Emission - Vertical Pre-Scan - LC Filter

Table 4-4. Radiated Emission Margins – Vertical – LC Filter

NO.	Frequency [MHz]	Reading [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Level [dBμV/m]	Angle [°]
1	30.970	42.84	-16.05	40.00	13.21	100	26.79	278
2	37.275	36.85	-16.04	40.00	19.19	100	20.81	281

Table 4-4. Radiated Emission Margins – Vertical – LC Filter (continued)

NO.	Frequency [MHz]	Reading [dBμV/m]	Factor [dB]	Limit [dBμV/m]	Margin [dB]	Height [cm]	Level [dBμV/m]	Angle [°]
3	67.345	39.20	-16.77	40.00	17.57	200	22.43	204
4	181.320	37.34	-15.70	40.00	18.36	100	21.64	148
5	294.810	43.37	-14.25	47.00	17.88	100	29.12	278

4.2 EN55022 Conducted Emission Results

TAS58x5M EMI Test Board, ferrite bead filter, BD modulation, PVDD = 12 V, 8 Ω + 56 uH load, Spread Spectrum enabled, Fsw = 384 kHz, Po = 4 W per channel.

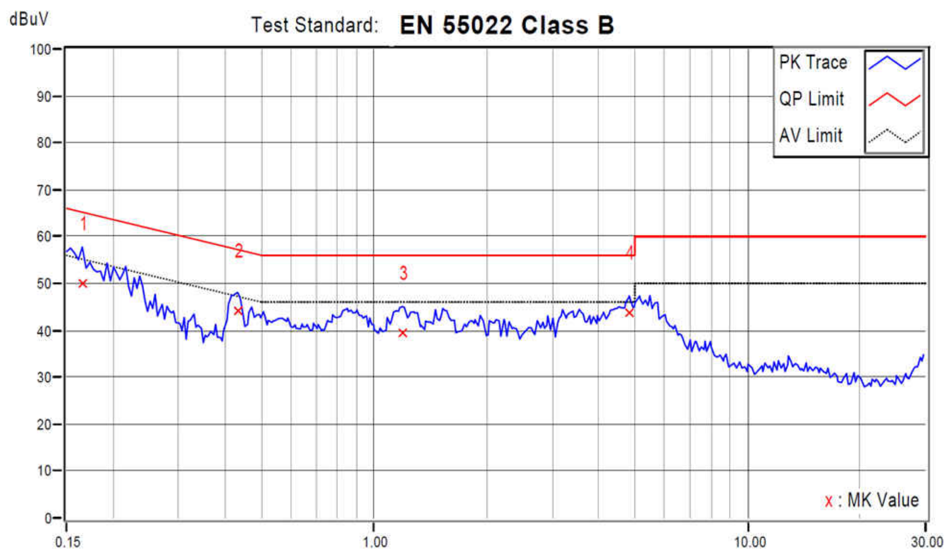


Figure 4-5. Conducted Emission – Line Pre-Scan – BC Filter

Table 4-5. Conducted Emission Margins – Line – BC Filter

NO.	Frequency [MHz]	Corr. Factor [dB]	QP Limit [dBμV]	AV Limit [dBμV]	AV Reading [dB]	AV Margin [dB]	QP Reading [dBμV]	QP Margin [dB]
1	0.16564	9.60	65.18	55.18	23.85	-21.73	40.34	-15.24
2	0.43152	9.60	57.22	47.22	27.66	-9.96	34.40	-13.22
3	1.19550	9.60	56.00	46.00	22.95	-13.45	29.89	-16.51
+4	4.82398	9.63	56.00	46.00	27.57	-8.80	34.06	-12.31

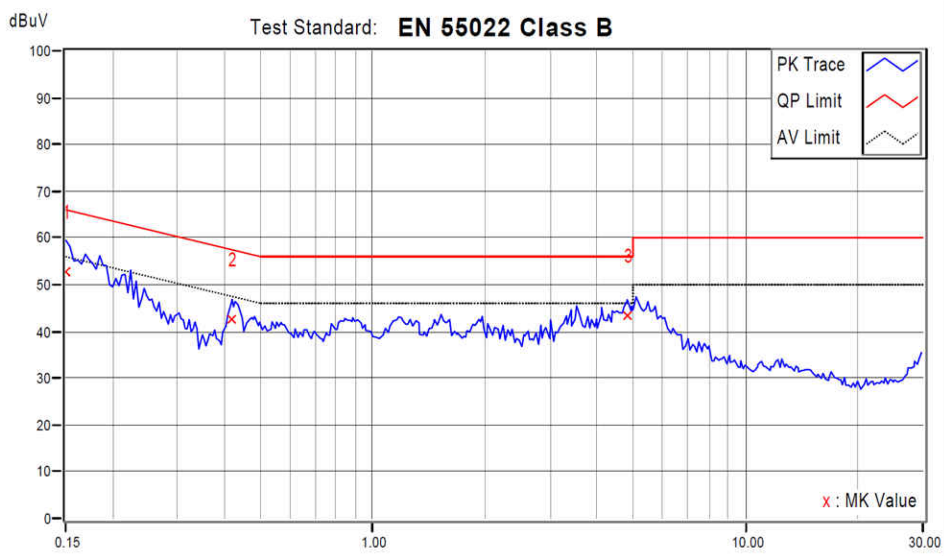


Figure 4-6. Conducted Emission – Neutral Pre-Scan – BC Filter

Table 4-6. Conducted Emission Margins – Neutral – BC Filter

NO.	Frequency [MHz]	Corr. Factor [dB]	QP Limit [dBμV]	AV Limit [dBμV]	AV Reading [dB]	AV Margin [dB]	QP Reading [dBμV]	QP Margin [dB]
1	0.15000	9.60	66.00	56.00	23.32	-23.08	42.96	-13.44
2	0.41979	9.60	57.45	47.45	25.92	-11.93	32.88	-14.97
+3	4.82398	9.63	56.00	46.00	26.94	-9.43	33.55	-12.82

TAS58x5M EMI Test Board, inductor filter, PVDD = 12 V, BD modulation, 8 Ω + 56 uH load, Spread Spectrum disabled, Fsw = 768 kHz, Po = 4 W per channel.

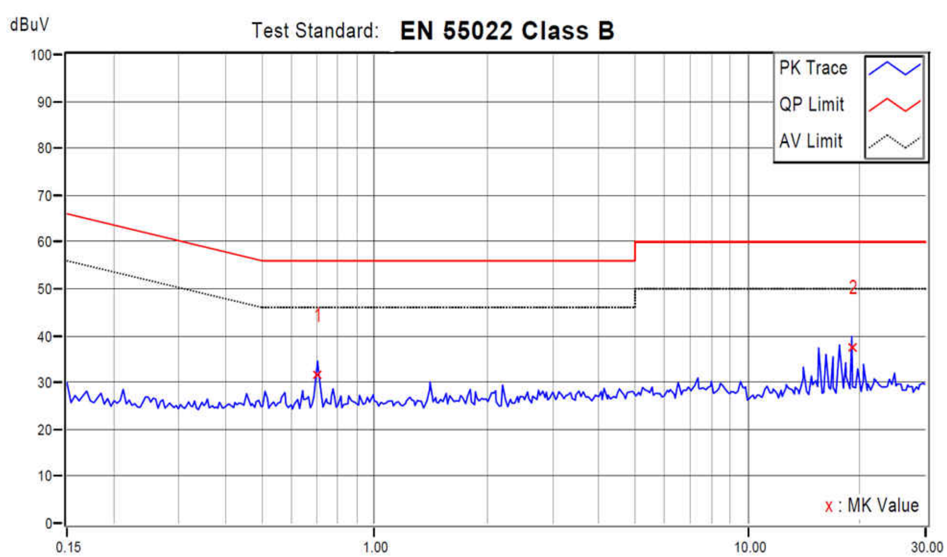


Figure 4-7. Conducted Emission – Line Pre-Scan – LC Filter

Table 4-7. Conducted Emission Margins – Line – LC Filter

NO.	Frequency [MHz]	Corr. Factor [dB]	QP Limit [dBμV]	AV Limit [dBμV]	AV Reading [dB]	AV Margin [dB]	QP Reading [dBμV]	QP Margin [dB]
+1	0.70522	10.40	56.00	46.00	19.28	-16.32	21.29	-24.31
2	19.02819	10.80	60.00	50.00	19.77	-19.43	26.74	-22.46

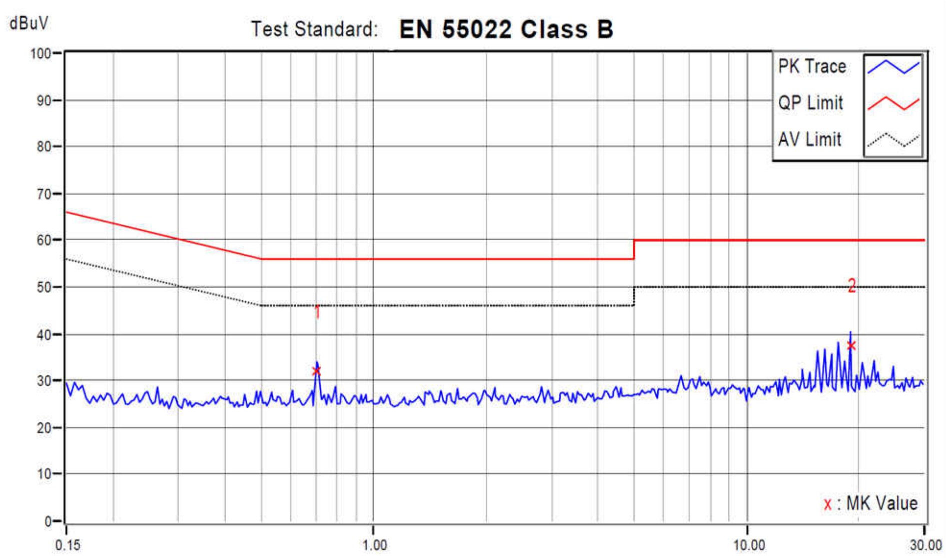


Figure 4-8. Conducted Emission – Neutral Pre-Scan – LC Filter

Table 4-8. Conducted Emission Margins – Neutral – LC Filter

NO.	Frequency [MHz]	Corr. Factor [dB]	QP Limit [dBμV]	AV Limit [dBμV]	AV Reading [dB]	AV Margin [dB]	QP Reading [dBμV]	QP Margin [dB]
+1	0.70522	10.40	56.00	46.00	19.68	-15.92	21.69	-23.91
2	19.03210	10.90	60.00	50.00	19.44	-19.66	26.42	-22.68

4.3 Conclusions

The TAS5825M device has the proven advanced RF emission suppression technology that helps to design an EMI-compliant audio system without compromising cost and performance. By adhering to the guidelines discussed in this report, EMI requirements are met and costly PCB rework is avoided.

Please note that we usually recommend inductor filters so that customers can make good use of TAS5825M features and capabilities.

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

5 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (July 2018) to Revision A (July 2021) **Page**

- Updated the numbering format for tables, figures and cross-references throughout the document...................2