Application Report
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Pre-Filter Parallel Bridge-Tied Load (PBTL)

Robert Clifton

ABSTRACT

One solution to provide greater output power and efficiency is to run the device in parallel bridge tied load (PBTL) configuration. In this configuration two half-bridges are placed in parallel to supply twice the current and reduce the $R_{DS(on)}$, or on resistance, of the output MOSFETs. The difference between a pre-filter PBTL configuration and a post-filter PBTL configuration is where!~ the on the output the half-bridges are connected in parallel.

One of the more expensive parts in a Class-D amplifier is the inductors in the LC filters. In high powered Class-D amplifiers, these can also be large components, requiring a fair amount of PCB real estate.

With some older amplifiers, the amplifiers would be connected in parallel after the LC filters, requiring four inductors. Inductors are not typically cheap components and the cost burden can often time lead to other trade-offs in a project, or for that cost to passed on to the end customer. The TPA32xx family of devices however support pre-filter PBTL, which reduces the number of inductors needed by half.

These inductors must be larger to accommodate the increased current however, whether or not this increases or decreases the total area occupied by the inductor solution is dependent on the model of inductor. See the LC-Filter design application note for more information.

Trademarks

1 When to use Pre-Filter PBTL

1.1 Pre-Filter PBTL vs Post-Filter PBTL

There are four main considerations when choosing which PBTL output configuration to implement:

- Footprint
- Cost
- Performance
- Efficiency

1.1.1 Footprint

Pre-filter PBTL also has the advantage of having a smaller footprint than post-filter PBTL. As shown in Figure 1 and Figure 2, the back end of the amplifier has half the components and thus about half the board space being used. These inductors must be larger to accommodate the increased current however, whether or not this increases or decreases the total area occupied by the inductor solution is dependent on the model of inductor.

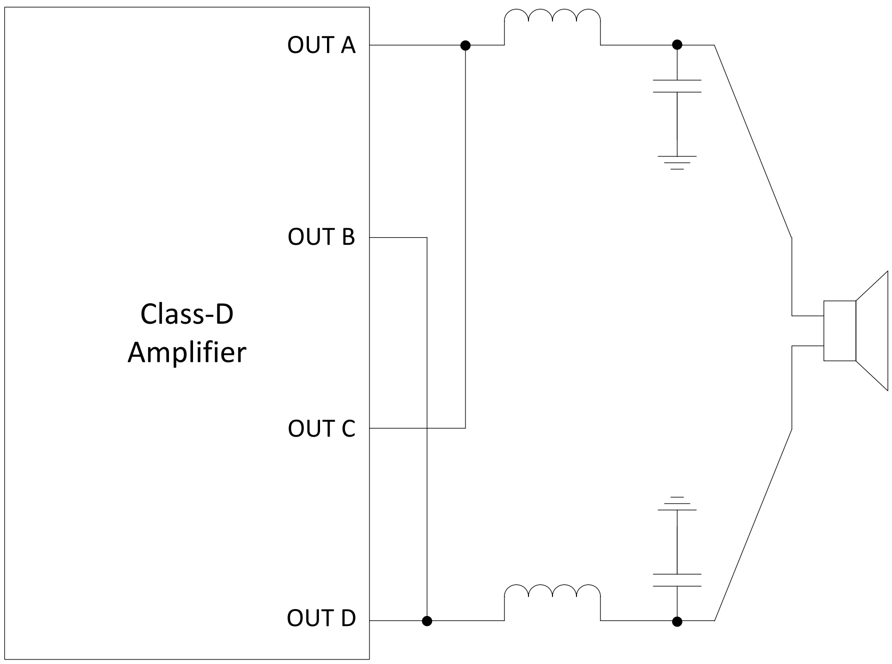

Figure 1. Pre-Filter PBTL

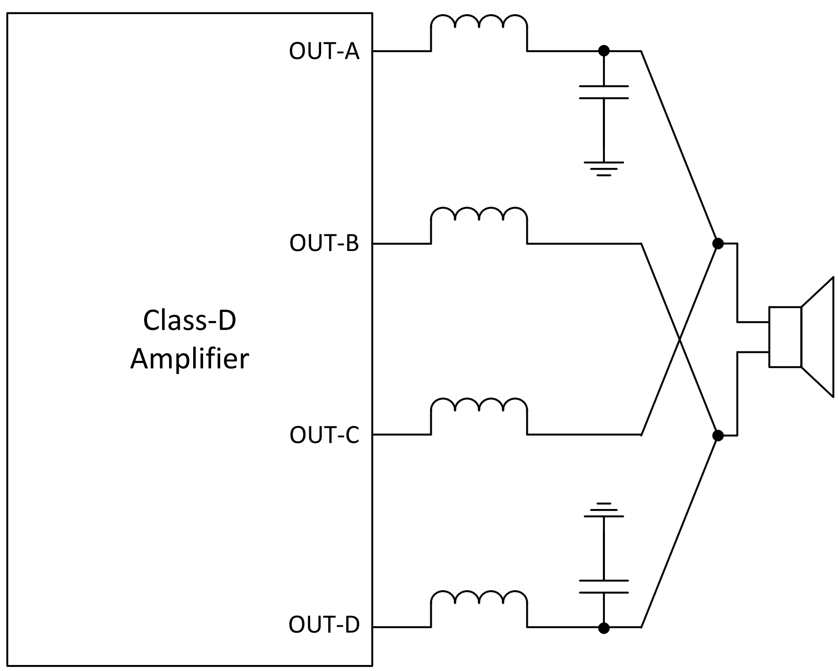

Figure 2. Post-Filter PBTL

1.1.2 Cost

Though an exact difference in cost is biased on what type of inductors and capacitors are used, pre-filter PBTL should be cheaper than post-filter PBTL due to having half as many components and requiring less area being used on the board. As mentioned before, the inductors that are used in pre-filter PBTL must have a higher current rating compared to post-filter PBTL since there is no longer a second inductor handling the current load. This could mean that the inductors are larger and/or is more expensive than the ones used in post-filter PBTL to support higher currents.

1.1.3 Performance

Pre-filter PBTL performance has the advantage compared to post-filter performance, having lower THD+N. Figure 3 shows the difference of the TPA3255 in pre-filter PBTL and post-filter PBTL performances across different power levels at a 1-kHz frequency. Pre-filter PBTL has a much lower THD+N at higher power levels. Figure 4 compares pre-filter PBTL and post-filter PBTL THD+N vs frequency at 1-W and 50-W output power levels. Notice for both output powers the pre-filter PBTL has lower THD+N.

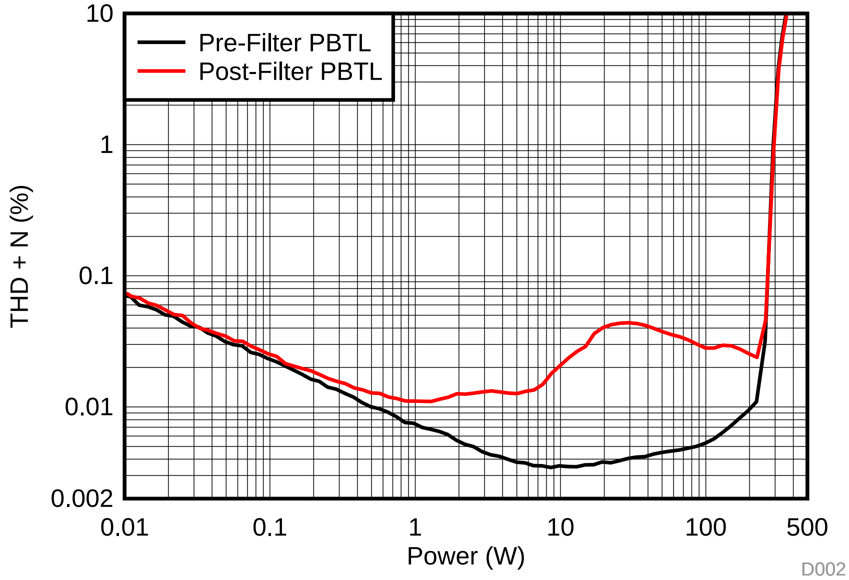

Figure 3. TPA3255: Total Harmonic Distortion + Noise vs Output Power

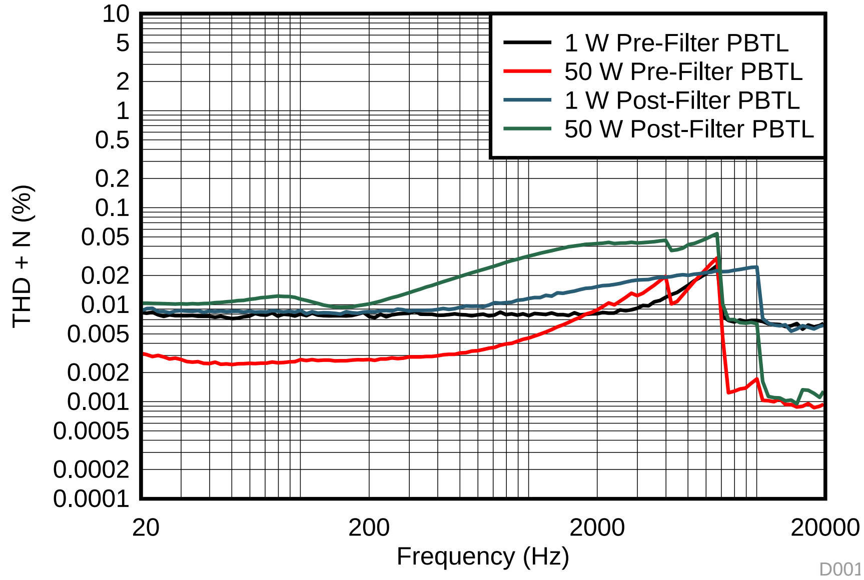

Figure 4. TPA3255: Total Harmonic Distortion + Noise vs Frequency

1.1.4 Efficiency

The efficiency is another consideration to take when choosing different PBTL configurations. The data shown in Table 1 was taken on two EVM boards configured in post-filter and pre-filter PBTL mode. The current consumption was significantly higher for the PVDD rail (51 V).

Table 1. Efficiency (TPA3255, 2Ω)

Config.	Power (W)	Current (A)		
		PVDD	VDD/GVDD	Total
Post-Filter	1	0.092	0.112	0.204
	50	1.286	0.113	1.399
	100	2.44	0.115	2.555
	200	4.76	0.127	4.887
	300	7.18	0.134	7.314
	400	9.66	0.131	9.791
Pre-Filter	1	0.074	0.112	0.186
	50	1.262	0.113	1.375
	100	2.412	0.113	2.525
	200	4.686	0.118	4.804
	300	7.036	0.125	7.161
	400	9.412	0.127	9.539

1.2 1 x BTL vs PBTL

Despite the fact that TI's TPA32xx devices can be configured to support two bridge-tied loads (BTL) amplifiers, it is not uncommon to see only one BTL channel used to drive a speaker and the other left unused. However, by using pre-filter PBTL the designer now has the option to connect both amplifiers before the filter, and improve the efficiency of the amplifier.

Adding all of the additional components to use post-filter PBTL mode on the TPA32xx devices to improve efficiency does not always make sense from a cost/benefit analysis perspective. Inductors are expensive components. In a design where a single BTL channel is used and the other is disabled, the option of using pre-filter PBTL to improve efficiency becomes more realistic.

Using the exact same load, and inductors, pre-filter PBTL improves the efficiency of a single BTL channel by nearly 10%, and the power loss per channel is reduced by 40 W both at full output when compared to a single BTL channel. This means less heat generated by the amplifier, and therefore smaller heatsink required. In products where space is a premium, pre-filter provides a clear advantage over a single BTL channel.

1.3 Single-Rail vs Dual-Rail Designs

All of the high power Class D amplifiers currently available from TI are single rail designs. Dual rail devices typically have a larger voltage differential and have the benefit of having no DC offset on the output. While this seems advantageous in single ended mode, this advantage disappears in BTL when the differential outputs of a single rail device have identical dc offsets. There is an unfortunate perception amongst some that the dual rail devices are able to deliver more power due to their ability to deliver greater voltage differentials. However this assumption is just that. These dual rail devices are often limited in their ability to deliver current.

Typically speaking, the single rail devices are the reverse. They are limited in the voltage swing that they can provide, but the current they are able to deliver is much greater.

The following example demonstrates the difference between a single and dual rail device given a power supply voltage where Vdd =|Vee|=PVDD

The dual rail device can output a maximum voltage swing of ±64 V RMS but because of its current limitations, an 8-Ω speaker is the minimum load. This means that the power dissipated by the load is 256 W.

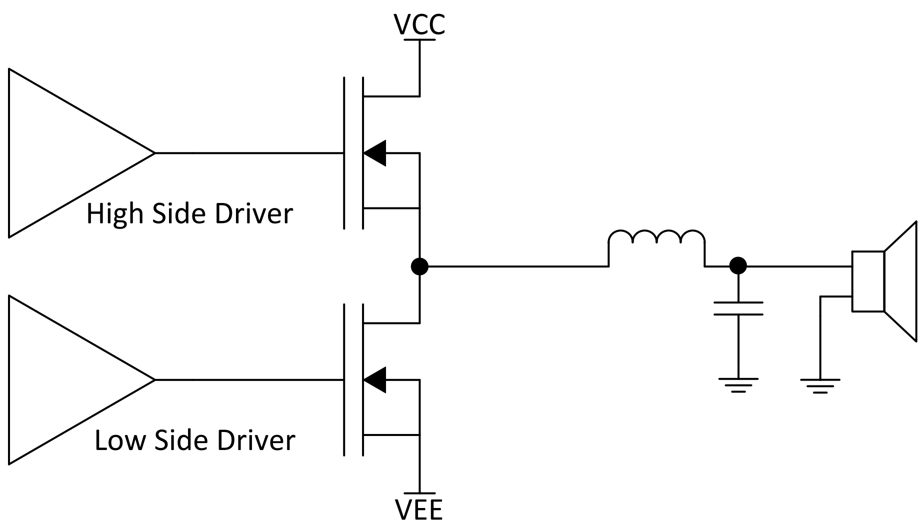

Figure 5. Dual Rail Device

The single rail device can only provide a maximum output voltage swing of ±32 V, but because it has the ability to deliver more current a 2-Ω load can be used. And the power dissipated by the load is identical to the dual rail device at 256 W.

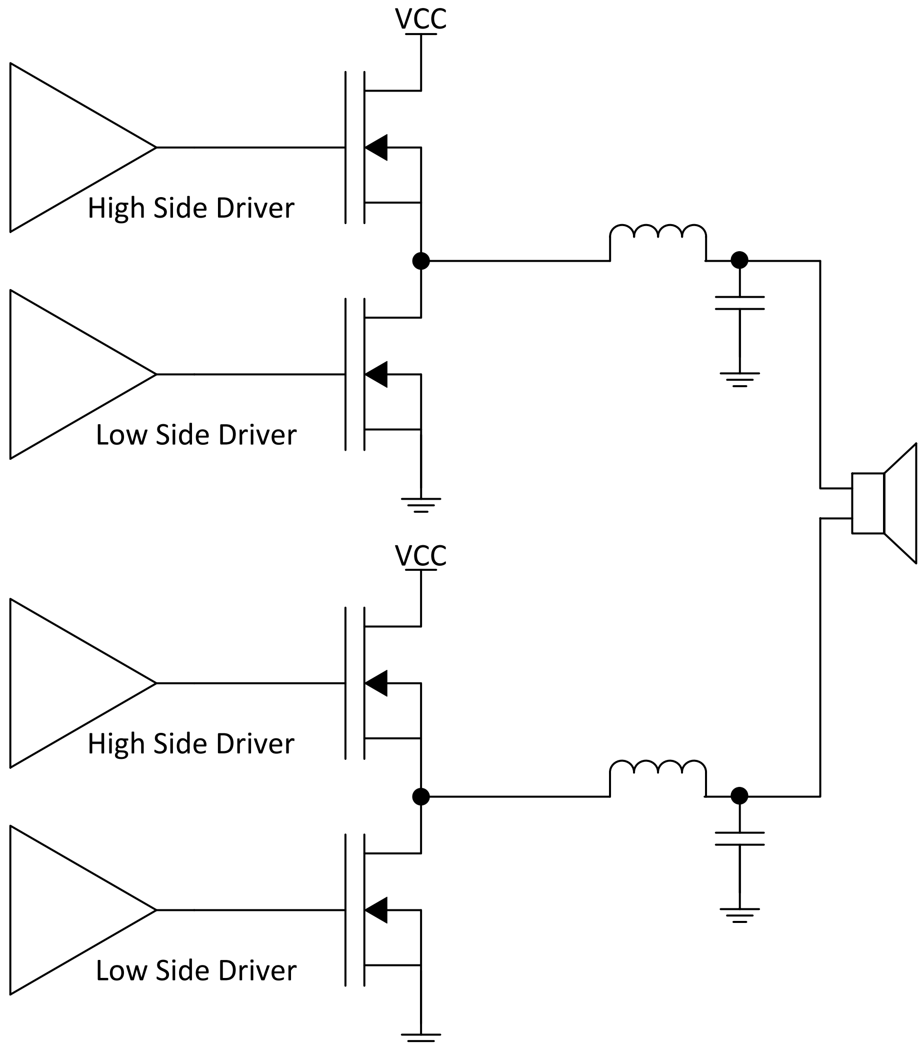

Figure 6. Single Rail Device

This is only a quick estimation of course and the actual deliverable power may vary by device, but this is just to show that there is no inherent advantage, or disadvantage to single or dual rail devices, when considering only power. There may instances where the preference of the designer or the convention of the market dictate the impedance of the speaker, and this would certainly be the deciding factor.

A pre-filter PBTL device provides an even alternative to dual rail devices that contain two SE amplifiers or one BTL amplifier.

1.4 Pad Down Devices

With the design of high powered audio speakers and amplifiers becoming more and more compact, the size of a design matters more than ever. Many manufacturers are turning to Pad down devices, eliminating bulky heatsinks in favor of a thick ground plane on a PCB. In these scenarios using a TI device in pre-filter PBTL mode reduces the effective $R_{DS(on)}$ of the output devices, increasing the efficiency and thus reducing the heat produced. Additionally, because the entire die is being used the thermal transfer is more efficient. Thus, less heat is produced, and it is more efficiently dissipated.

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