

GO GREEN WITH CLASS D 100W+ AUDIO POWER AMPS

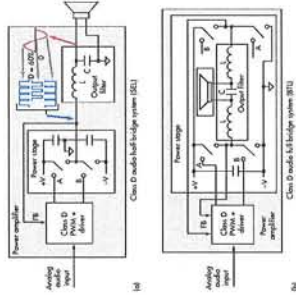
The efficiency and size advantages of Class D audio amplification in battery-powered devices are well known. These advantages are now extended to amplifiers up to 500W, made possible by solid-state driver ICs designed specifically for Class D. Systems based on these new ICs outperform Class AB in THD+N measurements, and simplify the designer's job by accepting ground-based analog audio inputs.

Features such as overcurrent protection for both rails and programmable dead time make these drivers additionally attractive. In this article, we examine the performance, size, and cost benefits of Class D versus Class AB topologies for medium power levels.

THE HISTORY

Audio amplification requires that a speaker (also called a driver) is driven back and forth in opposite directions, moving air to produce a sound wave that's decipherable

enlarge



1. Class D power amplifiers use either a half-bridge (a) or full-bridge (b) topology. The half-bridge amplifier requires a split-rail power supply, having positive and negative voltages of equal magnitude and two power switches between them.

with the human ear. To accomplish this, a voltage of alternating polarity is impressed upon the speaker by means of either a half-bridge or full-bridge topology, as shown in Figure 1 for Class D topologies. The half-bridge amplifier requires a split-rail power supply, having positive and negative voltages of equal magnitude, and two power switches between them. When the load is tied between the common switch point and system ground, it's referred to as a single-ended load (SEL).

The full-bridge amplifier, referred to as a bridge-tied load (BTL), is

by Alex Mihalka, International Rectifier

made up of two half bridges with the load tied between their center points. The switches are turned ON and OFF in such a way that the speaker moves to recreate the audio output, which must average to zero. BTL configurations produce higher power for a given switch rating, and a single power supply and output capacitor allows it to be ground-referenced, simplifying input controls at the expense of two more power switches and gate drivers. An SEL or BTL topology is used for either Class AB or Class D.

Class A was the earliest audio amplifier design, whereby both switches were ON simultaneously, although not fully, to produce the required voltage at the load (Fig. 2). This produced excellent audio performance, but very poor efficiencies of about 15%, resulting in large and expensive systems.

Class B followed, where only one switch at a time was turned ON. While efficiency improved to approximately 75%, it was hampered by significant problems at the zero crossing of the output waveform; instead of crossing smoothly through zero, Class B had a flat section, or zero volt-

DATASHEET PRESS RELEASE

International Rectifier
THE POWER MANAGEMENT LEADER
IR Introduces Integrated and Protected Class D Audio Chipset for Small, High Performance Amplifiers

The IRS2092 integrated driver IC with protected PWM switching and IR's digital audio MOSFETs deliver a flexible chipset that can scale for Class D amplifier applications from 50W to 500W.

www.irf.com

cover

editorial

news

power
design

technology

hot
topicswhat's
new?design
ideas

applications

peace
porridge

save

print

e-mail
to a friend

close

age, between the positive and negative halves of the waveform, producing high distortion.

Class AB compromised the two by turning on both switches simultaneously. Yet, the switch not carrying load current was only minimally ON so that the nonlinearity due to the loss of gain at the zero crossing was greatly reduced. This improved zero-crossing distortion to acceptable levels and boosted efficiency over Class A, but still an overall Class AB efficiency of 30% was typical.

These three topologies vary the bridge output voltage with the audio frequency, and are, therefore, relatively low-frequency designs. Class AB dominates the field of linear amplifiers, and bipolar transistors are typically used as the control devices.

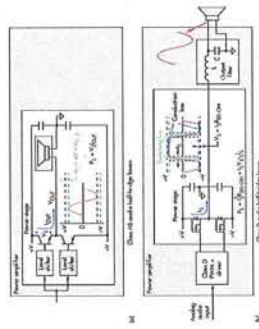
CLASS D AMPLIFICATION

Today's switching power supplies are far smaller and lighter than the linear, line-frequency supplies of the past due to the advent of high-frequency power conversion, made possible by improvements in power silicon, control ICs, magnetics, and capacitors. Likewise, thanks to the continuous

improvements of key electrical components, Class D amplifiers decrease the size, weight, and system cost of audio amplifiers by switching at 200 to 800kHz instead of being linearly driven by 20 to 200kHz audio frequency signals. MOSFETs are commonly used as the switches due to their fast switching speeds.

Each power switch of opposite polarity is fully turned ON or OFF one at a time with dead time between the ON states, and the $I^2 \times R_{DS(on)}$ conduction and $V_{DS}I_{DS}f_s$ switching losses are far less than the $(V_{RAIL} - V_{OUT}) \times I$ loss of the linear Class AB. Even though switching losses increase with frequency, Class D efficiencies of 90 to 96% for medium power are now achievable.

enlarge



2. Half-bridge losses are substantially different between Class AB (a) and Class D (b).

A Class D amplifier half-bridge output produces a rail-to-rail switched digital power signal (see the waveform in Fig. 2); switching losses occur in the green areas and conduction losses in the blue areas. The analog output is reconstructed at the load by an output filter's LC stages.

The duty-cycle D of the powered signal determines the filtered output voltage, as shown in the Fig. 1 half bridge. As D approaches unity, the output voltage approaches the positive rail or positive peak of the waveform; when D is 50%, the output voltage is zero; and when D approaches zero, the output voltage approaches the negative rail, or negative peak of the waveform. At switching frequencies of 400kHz and above, a single stage output filter can be used, comprised of one inductor and one capacitor.

Note that for the case shown, feedback is from the switch node only. To achieve the THD curves of Fig. 3, a Class D motherboard containing the output filter and a two-channel, power-stage daughtercard was plugged into a commercial Class AB stereo receiver.

DATASHEET

PRESS RELEASE

International
IR Rectifier
THE POWER MANAGEMENT LEADER

IR Introduces Integrated and Protected Class D Audio Chipset for Small, High Performance Amplifiers

The IRS2092 integrated driver IC with protected PWM switching and IR's digital audio MOSFETs deliver a flexible chipset that can scale for Class D amplifier applications from 50W to 500W.

www.irf.com

Having an identical power supply and input controls (Fig. 4), the power specs and noise floor are identical, permitting fair measured performance comparisons. The Class D metal mounting plate covers the large heat sink of the original Class AB amplifier.

The Class D two-channel, half-bridge daughtercard shown in orange is rated at 120W/channel in still air without a heat sink, made possible by dedicated Class D MOSFETs (IRF6645). This packaging has low inductance, resulting in cleaner switching waveforms and better performance.

CLASS D GATE DRIVER

Many medium power applications use the lower-cost, half-bridge power stage vs. the full bridge since it requires fewer active elements. But, inputs and feedback are easier to manipulate if ground-based rather than if referenced to the negative rail.

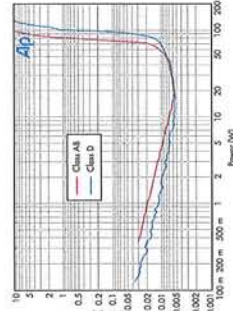
Grounded input capability in Class D drivers greatly simplifies design by providing level shifters to drive upper and lower switches from signals referenced to system ground. If necessary, the input to these drivers can be referenced to

the negative rail in SEL mode, or to ground in BTL configuration.

Dedicated Class D drivers for medium power are now available with either pulse-width-modulation (PWM) or analog audio inputs. An integrated error amplifier provides PWM, further simplifying design, reducing cost, increasing density, and improving performance by eliminating EMI around an external PWM.

The switching frequency of Class D gate drivers can be configured for self-oscillation, removing switching noise from the audio frequency band (noise shaping). Self-oscillation provides higher effective loop gain than Class D fixed-frequency PWM switching, providing improved performance over both fixed-frequency Class D and Class AB.

3. This chart compares THD+N between Class AB and Class D.



This becomes more pronounced at higher power levels, as shown in Fig. 3. Switching frequency decreases as power increases, aiding efficiency. There's no Class AB counterpart for this feature.

Some Class D drivers offer programmable dead time, or the time when both switches are OFF. The time between the ON state of the switches is adjusted to allow them to adequately turn ON. This is important because switches used for various power levels have a wide range of total gate charge, and need varying amounts of time to turn ON and OFF. Programmable dead-time optimisation reduces THD and increases efficiency.

One of the most frustrating parts of audio amp design is removing the ON/OFF click noise, or speaker "pops." A relay is often used to eliminate this problem, but cost, size, and reliability suffer. Class D drivers now integrate click noise reduction, significantly reducing this annoyance.

PROTECTION

One challenge when driving a switching audio amplifier is that great care must be taken to

DATASHEET

PRESS RELEASE

International
IR Rectifier
THE POWER MANAGEMENT LEADER

IR Introduces Integrated and Protected Class D Audio Chipset for Small, High Performance Amplifiers

The IRS2092 integrated driver IC with protected PWM switching and IR's digital audio MOSFETs deliver a flexible chipset that can scale for Class D amplifier applications from 50W to 500W.

www.irf.com

cover

editorial

news

power
design

technology

hot
topics

what's
new?

design
ideas

applications

pease
porridge

save

print

e-mail
to a friend

close

cover

editorial

news

power
design

technology

hot
topicswhat's
new?design
ideas

applications

pease
porridge

save

print

e-mail
to a friend

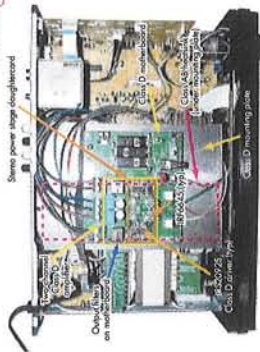
close

ensure that each switch of a half bridge doesn't exceed its current rating due to a low load impedance or shorted output. Rugged amplifier design, therefore, includes overcurrent protection (OCP) for both rails. OCP in a dedicated Class D driver is simply accomplished by sensing the $I \times R_{DS(on)}$ voltage drop across the FETs, providing an indirect measurement of power dissipation. The trip point is set for the minimum load impedance, taking into account the FET's maximum $R_{DS(on)}$ and temperature coefficient. Internal IC level shifting alerts the controlling circuitry of a fault.

OCP circuits in Class AB systems require monitoring both the current and voltage of the control device and multiplying these values together, which calls for many parts or use of an impedance bridge. By contrast, providing OCP in a dedicated Class D driver IC is significantly simpler, shortens design time, increases reliability, and reduces cost.

A Class D driver also provides undervoltage lockout protection (UVLO) for the control power supplies of both switches, ensuring enough energy to drive the gates.

enlarge



4. In this state-of-the-art packaging technique, a 125-W/channel stereo Class D motherboard and daughtercard was plugged into a commercial Class AB receiver. The daughtercard is outlined in orange.

WHAT'S THE COST?

Class D's main advantage over Class AB is its operating efficiency. However, consider a 100W example in terms of power loss. Class AB dissipates 70W of heat versus 5W for Class D—a 14-fold difference. Multiply this by two or more channels and heat management becomes an even greater design issue. For the same output power as Class AB, Class D needs a much smaller heat sink, or, depending on power level, no heat sink at all and no labor costs for mounting power switches (Fig. 4, again). With the cost of the heat sink comes the expense of machining and labour for installa-

tion, and of a larger enclosure to accommodate it. Integrating level-shifting and protection circuits reduces board space, and dedicated Class D drivers that accept analog inputs and provide PWM contribute to further cost reduction.

IN CONCLUSION

Dedicated Class D IC drivers for medium-power audio amplifiers enable efficiencies three or more times greater than Class AB, and they reduce power loss by an order of magnitude or more per channel. Class D amplifiers have equal or better performance, higher density, and lower cost than Class AB. With ground-referenced analog or digital inputs, programmable dead time, OCP, UVLO, and click noise reduction, these ICs enable fully protected products that are easy to design, fast to market, highly reliable, and environmentally friendly. ■

ALEX MIHALKA is a technical education engineer at International Rectifier

NEXT: Avoid the bird flu with proper FPGA migration

DATASHEET

PRESS RELEASE

International
IR Rectifier
THE POWER MANAGEMENT LEADER

IR Introduces Integrated and Protected Class D Audio Chipset for Small, High Performance Amplifiers

The IRS2092 integrated driver IC with protected PWM switching and IR's digital audio MOSFETs deliver a flexible chipset that can scale for Class D amplifier applications from 50W to 500W.

www.irf.com