

Advances in Power Devices Driving Class-D Amplifier Progress

The success of class-D audio amplifiers in important home, in-car and portable markets has brought new opportunities for engineers to explore new design avenues and so differentiate their products from those of competitors. Class-AB amplifier design, on the other hand, now offers few such opportunities and brings size, weight and power penalties that are unwanted especially in portable or mobile applications.

By Jun Honda, International Rectifier Corp

As class-D design continues to progress, further improvements in audio output, physical size, energy efficiency and sound quality are closely linked to improvements in component performance.

Critical IC Improvements

The key components of a class-D amplifier are the PWM-control IC and the audio MOSFETs. The improvements in control ICs are mainly concerned with increasing noise immunity, to deliver a better listening experience for the end user. Chip makers such as IR are able to draw on experience gained in kilowatt-class switching motor drives to achieve this.

As far as MOSFET performance is concerned, device designers are optimising devices at the silicon level for better on-resistance \times gate-charge Figure of Merit (FoM) and tighter control over the gate charge and input/output capacitances to enhance switching speed and accuracy and so minimise audio distortion. In addition, multi-die integration in advanced packages such as DirectFET® is allowing devices dimensions to be reduced. The package technology is helping improve switching performance, power rating and efficiency by lowering stray inductance and promoting dual-sided cooling for increased power dissipation. The reference designs mentioned earlier are able to operate at high power outputs without the use of a separate heatsink.

Current practice for controller ICs can be seen by examining a device such as IR's IRS2092, a single-channel audio driver in 16-pin PDIP or SOIC package. Integrated on-chip are an error amplifier, PWM comparator, switching stage with deadtime insertion, shutdown and over-current protection, and click-noise reduction. Its 1.2/1.0A MOSFET gate-drive capability allows use with various digital audio MOSFETs covering applications from 50-500W audio output-power. The IRS2052, IRS2053 IRS2093, capable of driving two, three or four audio channels respectively with 0.5/0.6A MOSFET gate-drive capability, are closely related controllers in the MLPQ48 package. These devices provide a selection of additional features such as clip detection, temperature-sensor input, thermal shutdown, DC-offset protection and on-chip oscillator.

MOSFET Selection and Audio Power

To complete the amplifier design the controller is teamed with a pair of optimised digital audio MOSFETs capable of satisfying the audio output power requirements of the target application. Figure 1 shows how the output MOSFETs can be selected based on voltage rating and the target audio output power.

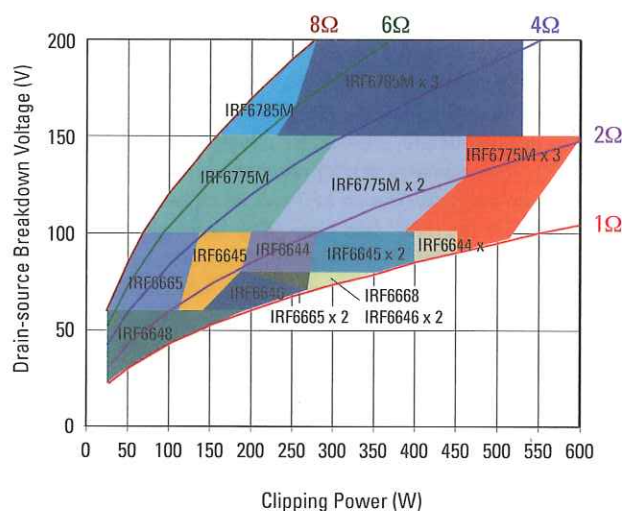


Figure 1: MOSFET selection based on voltage rating and audio output power

This approach, using highly integrated controller/driver ICs and discrete audio power MOSFETs, allows designers to use relatively straightforward component-selection processes not only to optimise audio performance but also to scale their amplifiers to achieve the desired number of audio channels and output power. Single- and multi-channel controller/driver ICs sharing a common package style and compatible pin-outs, and a growing choice of optimised digital audio MOSFETs offering various ratings in DirectFET® or other industry-standard packages such as the TO-220, permit re-use of a single topology, component layout and PCB to create a family comprising several differentiated amplifier products.

Reference design	Output power (4Ω)	Controller/driver IC	Audio output MOSFETs
IRAUDAMP5	2x120W	IRS2092	IRF6645
IRAUDAMP8	4x120W	IRS2093	IRF6665
IRAUDAMP10	2x300W	IRS2052	IRF6775
IRAUDAMP11	3x120W	IRS2053	IRF6665

Table 1: Scaling amplifier designs by driver and MOSFET selection

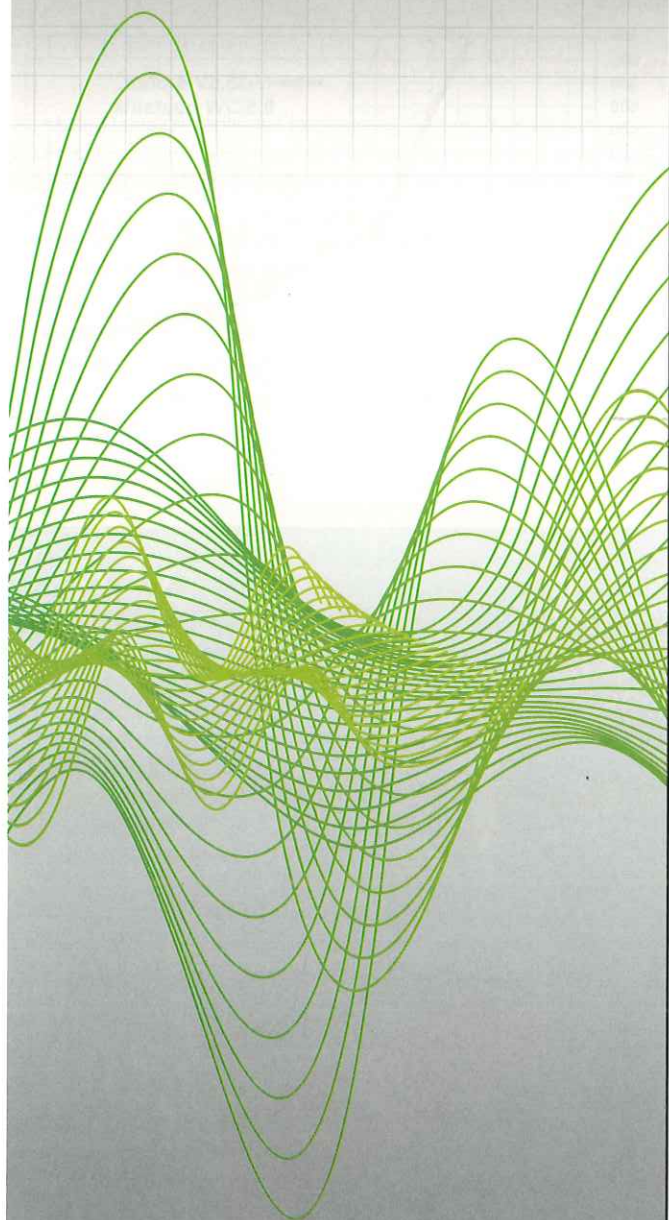
IR has completed a number of reference designs that speed up development and illustrate how designs can be scaled. The IRAUDAMP5 2x120W (into a 4Ω load) reference design combines the IRS2092 with two IRF6645 devices. This, and similar reference designs based on the multi-channel drivers are summarised in table 1.

emv



International Exhibition with Workshops
on Electromagnetic Compatibility (EMC)
Stuttgart, 5–7 March 2013

*Your EMC-marketplace
in Europe – be a part of it!*



Further information:
web: e-emc.com
phone: +49 711 61946 63
email: emv@mesago.com



Mesago
Messe
Frankfurt

mechanism. Clip detection is also featured on selected models. All devices can be operated from a single power supply or from a split-rail configuration.

Taking advantage of established experience with class-D amplifiers, these devices also prioritise efficient cooling for optimum MOSFET performance with smooth efficient switching for low distortion and high reliability. The latest devices use IR's 5mm x 6mm (for single-channel devices) or 7mm x 7mm PQFN low-profile power package, which features terminals connected to large exposed thermal pads for efficient heat dissipation.

Architecture and Peak-Power Duration

A major incentive for designers adopting class-D amplifiers is the opportunity to create compact designs, taking advantage of the inherently high efficiency of the switching amplifier principle to minimise the size and bulk of any heatsinks required. The single-package devices are able to operate with no heatsink for defined periods up to the maximum power, as figure 3a illustrates. This is for a 2x70W design using a 2-channel IC. Figure 3b shows how the maximum permissible operating time at high power outputs is extended by fitting a heatsink rated for 8.5°C/W.



Figure 4: Amplifier architecture selection by power duration

An alternative approach for extending the power duration is to use a different amplifier design combining two or more single-channel devices. For example, an amplifier built using two single-channel IR4301 devices can drive 2x70W for longer than the design of figure 3a/b built with a single IR4302. Figure 4 shows how the power duration can be adjusted by using single-channel or two-channel ICs in heatsink-free designs or with a heatsink fitted. It is worth noting that a discrete solution using external digital audio MOSFETs is recommended for applications requiring the best power duration.

Fully integrated class-D amplifiers allow designers to build products combining compact dimensions and very high audio performance, with THD+N as low as 0.02%. The resulting designs contrast starkly with traditional class-AB products, which typically require large, finned heatsinks even at relatively low audio power ratings. IR has compiled six PowIRaudio reference designs based on these devices, for applications ranging from 35W to 130W per channel.

Conclusion

The design and performance of class-D audio amplifiers continues to improve, closely linked to advances in optimised semiconductors. As efficiency and distortion move closer toward ideal values, and heatsink-free designs become feasible for some applications, engineers also have the choice of fully integrated amplifier ICs or a controller/driver with discrete digital audio MOSFETs to deliver competitively priced new products offering higher audio power, higher energy efficiency, smaller size and lower weight.

www.irf.com