Riding The (Moving) Rails

Detailing Class-G and Class-H amp topologies

By Tommy O'Brien

Among lesser-known amplifier classes – yet viable and employed in pro audio applications – are *Class-G* and *Class-H* topologies. Unlike some of the "hybrid" designs touted as "unique" topologies by some in the amplifier development community, these two designs are fairly distinct.

That said, there is some disagreement among the amplifier "experts" on the exact definitions of Class-G and Class-H. For purposes of general discussion, when more than one rail voltage is employed, or pairs of rail voltages in the bipolar supply case, the unit fits a "multi-rail" designation, which is Class-G or Class-H.

Class-H can be thought of as a more refined version of Class-G. Some claim if the transistors for each rail are connected in series, then it's Class-G, and if the transistors for each rail are connected in parallel, it's Class-H.

Yet some say that if the rail voltage is switched, it's Class-G. If the rail voltage is modulated, it's Class-H. (We'll talk about moving rails a bit later.), However, when the transistors are in series, it can be said that the lower transistor is actually running from a modulated supply.

The two points of view presented here disagree, and there are others not included. And some even say Class-G and Class-H represent the same thing.

The general consensus is that Class-G runs from a low voltage rail until the signal goes beyond a certain voltage, and a higher rail (or rails) is switched in. Class-H refines this to use a variable higher voltage rail (or rails), also known as a modulated rail. Let's simplify the matter and refer to both Class-G and Class-H as "multiple rail amplifiers."

Both are actually forms of Class-A or Class-AB as used in audio applications: Class-G and Class-H require multiple rail voltages, and both are intended to improve upon the efficiency of Class-A or Class-AB. (Note that Class-A is impractical for this type of amplifier because we're trying to improve efficiency.)

Multiple rail amplifiers usually allow significantly higher efficiency than single-rail Class-AB designs, and thus the interest in these sub-classes. The more rail levels are used, the higher the efficiency, assuming they're spaced properly. While impossible in reality, efficiencies can reach 100 percent with an infinite number of voltage rails.

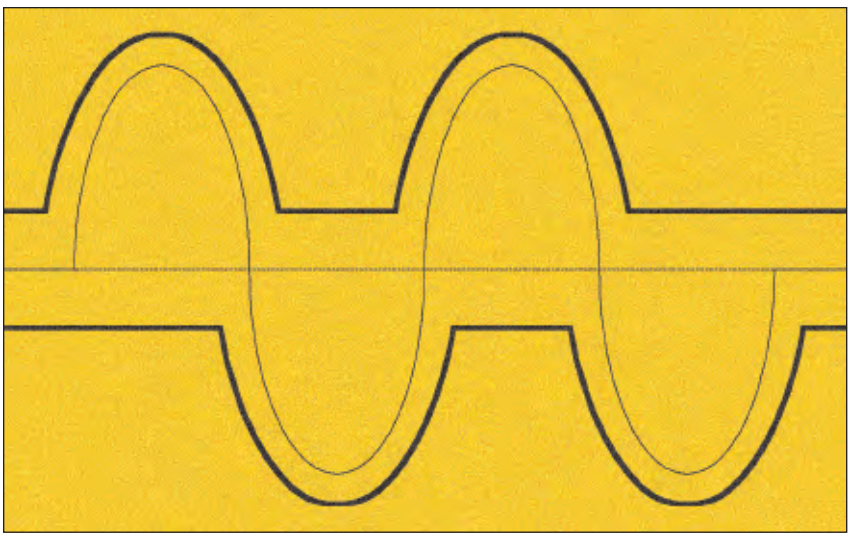
Multiple rail amplifiers typically use only two voltage rails, which amounts to more than 80 percent theoretical efficiency at maximum power. Using more rails becomes impractical due to added power supply complexity, but with four rail voltages, efficiency at maximum power can reach 90 percent (again, theoretically).

More common in high-power pro amplifiers, the sonic characteristics of multiple rail amplifiers are varied due to the wide array of possible implementations. (They're said to be similar to Class-AB when good design practices are used.)

However, multiple rail amplifiers suffer from the same problems as single rail amplifiers when it comes to driving reactive loads. The added dissipation usually occurring in one output transistor simply migrates another.

What does moving rail design really mean? Simply, the voltage rail moves with respect to the signal being reproduced – "tracking" it, in a sense. There are many particulars to this type of design, but the idea is to minimize the voltage across the output transistors and approach 100 percent efficiency.

Keep in mind that this is the effi-



A simplistic illustration of moving rail design.

ciency of the output stage only. The power supply driving the output stage has its own efficiency, and the compound efficiency of the amplifier as a total package depends largely on the power supply (particularly in this type of amplifier).

There are other caveats to contend with, such as the unpredictability of the input signal and the complexity of the power supply. The power supply rails in a moving rail amplifier can also cross zero in some implementations, allowing the output stage to act as a low-voltage amplifier at all times, regardless of output amplitude. Facilitating this type of operation is not trivial and can be quite expensive.

The power supply of a moving rail amplifier can be of the linear or switching variety as well, adding to the confusion. In the audio world, moving rail amplifiers are either modified Class-A or modified Class-AB, and suffer from the same problems when driving reactive loads. It should be noted, however, that the lowered voltage across the transistors minimizes these problems.

Using a linear power supply in a moving rail design more or less defeats the increased efficiency goal due to dissipation in the supply itself. There are many variations of switching supplies used to drive moving rail amplifiers, but one thing holds true for all of them. They must be fast enough to track the audio signal eliminating many common switching power supply topologies from the list of practical solutions. In a moving rail design, the complexity of the system migrates to the power supply.

Mulitple-rail and moving-rail amplifiers are in competition with Class-D amplifiers for a high-efficiency solution. The major disadvantage of Class-D in this case is the output filter requirement, because audio performance for all topologies has improved significantly over the years.

The hidden problem is that the power supply itself may be affected by load reactance since it has to drive the output stage. This is where the choice of power supply implementation has a profound effect on real world efficiency, and switching supplies are often the clear choice. ■

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