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ULTRA HIGH-POWER AMPLIFIERS: THE RATIONALE

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BACKGROUND

For a number of years, nearly all power amplifiers have been limited to producing a maximum of around 600 watts into 8 ohms, about 1kW into 4 ohms, and from around 1.6 up to (in theory) 4 times these powers when two channels are bridged. While bridging doubles voltage swing, it is not always suitable, for a variety of technical and operational reasons.

At least two amplifiers capable of over 1kW into 8 ohms *per channel* (i.e. without bridging two channels) have seen some limited use in sound reinforcement in the past fifteen years [1]. But these have disappeared. Besides, one was a Class G & H amplifier, which can produce higher transient 'power' levels, good for HF and the midrange. But for bass reproduction, the low peak-to-mean ratio (PMR) of much music program - as low as 6dB - makes conventional Class A-B amplifiers preferable, for being rated to deliver their maximum power on a sustained basis. Now new amplifier designs having this order of power delivery are reappearing. *Crown's VZ-5001* was launched earlier this year, while *C-Audio* in the UK and *Crest* in the USA are committed to launching similarly rated amplifiers. When bridged, they will all be capable of delivering up to 4kW into an 8 ohm drive unit. But can anyone make use of such powers?

ACOUSTIC BENEFITS

A doubling or quadrupling in amplifier power delivery is of most benefit in large music reinforcement systems. In smaller installations, and large but diversified systems, extra amplifier capability may provide welcome headroom, but it may not be possible to use fewer amplifiers, as each amplifier often does a different job. In fixed installations focused on speech, an optimum two amplifiers should ideally handle any particular physical area and frequency band, so if any one amplifier fails only a partial loss in sound level occurs. But in large scale music events, ten or even 100 amplifiers may be involved in delivering one frequency band for one of only two (L + R) or three (+ centre) speaker arrays. In this situation, and given the poor acoustics of most venues for high amplitude percussive music, the benefit of having the least number of acoustic sources in compact or point source arrays comes strongly into play. However, the applicability of higher power delivery hinges on having loudspeakers that can effectively translate that power into sound. With modern music, a good 60% of the power spectrum is in the bass, i.e. < 300Hz.

12" and larger (up to 24") cone drive units used for bass have limited efficiency, as no one has yet created an LF compression driver. So the cone driver's relatively low efficiency - typically 102dB @ 1w @ 1m - has had to be accepted. Alas these same drivers have also been limited to handling at best 400 watts, AES rated. If, having employed finely tuned horn loading, efficiency can't be improved, then the number of drive units required can only be reduced by making a larger electrical input deliver higher SPLs. In the past, many high power drive units just soaked up the power

More recently, a number of the major driver unit makers have released models with increased ratings, up to 1kW, AES rated. To make full use of such a driver's abilities, and at worst to manifest the driver's soft thermal compression - rather than amplifier clipping - during music transients, amplifier powers of 2x to 5x the AES rating may

be used, and indeed are required to make full use of the system capability. For this reason, amplifier powers of up to 5kW are valid now, and will become increasingly useful. The benefit of the 2x to 3x increase in amplifier output *and* drive unit handling should be a pro-rata two- to threefold reduction in the number of acoustics sources (and amplifiers and cabling) needed in the LF and mid sections of multi-kilowatt, single & point source sound reinforcement systems.

CONCLUSION

Overall, the appropriate use of multi-kilowatt-per-channel amplifiers in conjunction with the new class of higher-rated drive units will help (in some combination) to:

(i) Increase headroom
(ii) Simplify acoustic calculations
(iii) Improve calculations' predictive quality
(iv) Improve music's sonic quality
(v) Reduce install time - vital for touring
(vi) Reduce system weight and size
(vii) Reduce operating costs
(viii) Improve reliability - either because fewer amplifiers are needed, or because each amplifier is driven less hard.

However, realising these potential benefits to the full is in the hands of PA system 'box' designers. It is not often that three inter-linked frontiers of technology have the opportunity to go forward in such unison.

APPENDIX A: DESIGN LIMITATIONS

The power delivery of audio amplifiers has been driven by demand, but it's also long been restricted by what semiconductor makers can offer. Output and driver transistor voltage rating is the primary limiting factor. For a decade or more, both bipolar transistors and MOS-FET power devices available in complementary pairs (N & P) have had an absolute rating ceiling of 200 to 230 volts. This remains true today. With conventional technologies, this breakdown voltage rating (Vbr) limits the voltage swing to at most Vbr/2 x 0.7, i.e. 81v rms for 230v. After losses and safety factors have been accounted for, the practical limit is about 65v rms, or about 600 watts into 8 ohms.

Voltage swing capability can be increased in three ways. As the highest current rated bipolar transistors above 230v are mainly NPN types, some increase in voltage swing can be gained by abandoning the elegance of having a complementary output (and maybe driver) stage. But as device current ratings and/or speed are reducing rapidly at this point, performance will suffer further compromise. Next, swing can be doubled at one stroke, without changing any transistors, by making each channel a bridged amplifier. By using isolated power supplies, each channel can still be bridged to the other. This approach [1] calls for at least double the number of power devices, as does the third option: Voltage swing can be doubled by tiering two output stages, in a process known as 'wobbling' in the UK or 'bootstrapping' in the USA (not to be confused with bootstrapping using capacitors). It is to early to comment on the practical success of these contrasting approaches.

APPENDIX B: ECONOMICS

For some years power amplifier costs have remained quite steady. Although in £/watt they range widely between £0.5/watt for low budget types to £2.50/watt and more for 'cost no object' designs, the ballpark average price is £1/watt. But much depends on which watt is taken. What is certain is that higher powered amplifiers are generally pro-rata cheaper to make, though slightly more costly to pack and ship.

APPENDIX C: SAFETY

Power amplifiers have long been capable of producing voltages that are considered reasonably hazardous, i.e. above 50v to 70v AC per channel. When bridged, the new class of amplifiers will be capable of producing voltages

approaching European mains potentials (200 or 230v AC rms), albeit that this is only likely to be a transient condition. Front-line makers can be relied upon to fit suitably rated and shrouded outlet sockets, Neutrik's *Speakon*, for example. But thereafter, installers wiring in bridge mode will have to adopt practices commensurate with the line's potentially lethal voltage. For example, all speaker and speaker line connectors will need to be shrouded hermaphrodite or (in opposition to the XLR convention), female at the output end. In the long run, users of the new class of amplifiers who are outdoors and/or using towers will feel safer when outputs are fitted with differential current monitoring (alias *current balance* monitoring) to shut down the amplifier if any output current 'escapes' and flows through scaffolds, trusses or people.

Connector mating current rating will need serious consideration too. For example, delivering 4kW into 8 ohms implies a worst case rms heating current of 22 Amperes. Proportionately much higher transient currents are occasionally inevitable when driving loudspeakers with music. Accordingly, at C-Audio the new amplifier prototype has been fitted with Neutrik *Speakons* with circuits 1 + 2 paralleled.

REFERENCES:

1). Ben Duncan, Which Power Amplifier Technology?, Part 2, 3, 4. Jan, Feb, March '89 Studio Sound