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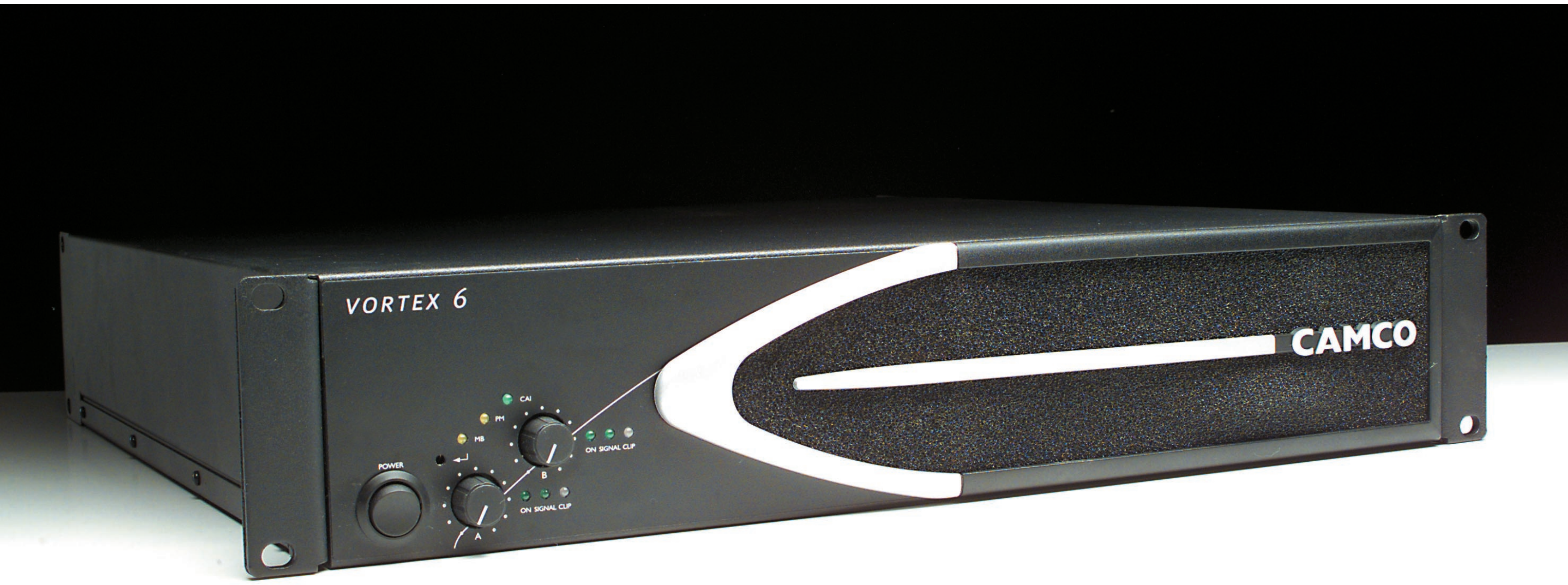


Camco Vortex 6 and Vortex 4

With their Vortex models the renowned power amp designers Camco from Germany are launching a newly designed power amp series based on switched mode power supplies and bipolar Class H amps.

In addition to their efficient power/weight ratio, these amps also feature sophisticated circuitry that requires some in-depth examination. For many years now the Wenden-based company Camco from the southern part of the German „Sauerland" region has made an excellent name for itself by marketing its own high-quality products, in addition to various other distribution activities. The Camco program includes dimmer packs of all sizes as well as Camco power amps, which are currently marketed under the names DL and DX. Both series enjoy a reputation as high-grade and indestructible workhorses, which are, however, not particularly light-weight and employ conventional power supply circuitry. At this year's Music Fair in Frankfurt Camco presented the first model of the new Vortex Series, the Vortex 6, which is a completely new design and follows the trend of the time. It was the first time that designer Carsten Wegner employed switched mode power supplies, without which a power amp from this performance category will hardly have any future. The goal was to get into the 6,000-watt range of total power, which makes quite stringent demands on the peripheral circuitry and protective devices used; after all, „normal wall outlets" can deliver a long-term maximum of 3,600 watts only.

Model description

From its outward appearance you could hardly tell that the Vortex provides so much power capacity, because it weighs in at a mere 12.4 kg packed in a 2U enclosure. The front panel is dominated by a well designed ventilation grille and plastic cover that make it possible to distinguish your Vortex from other amps even at a distance; yet, the

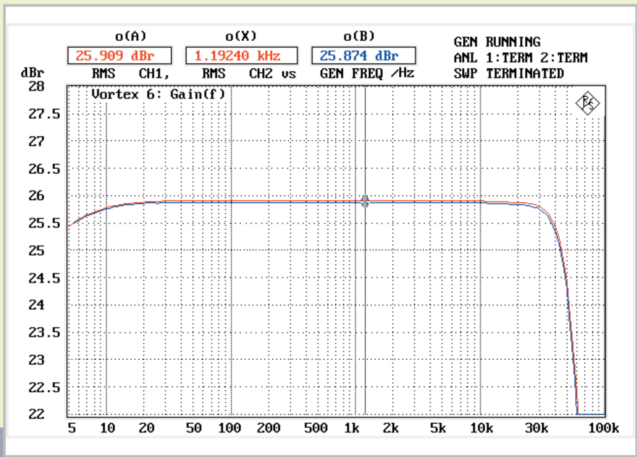


Fig. 1: Gain vs. frequency (CH1, CH2)

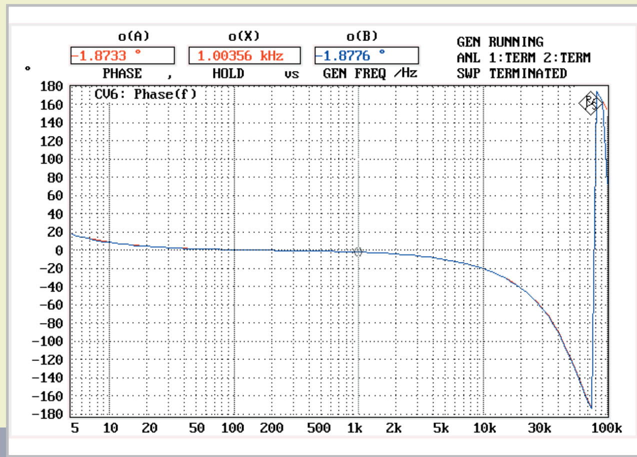


Fig. 2: Phase response vs. frequency (CH1, CH2)

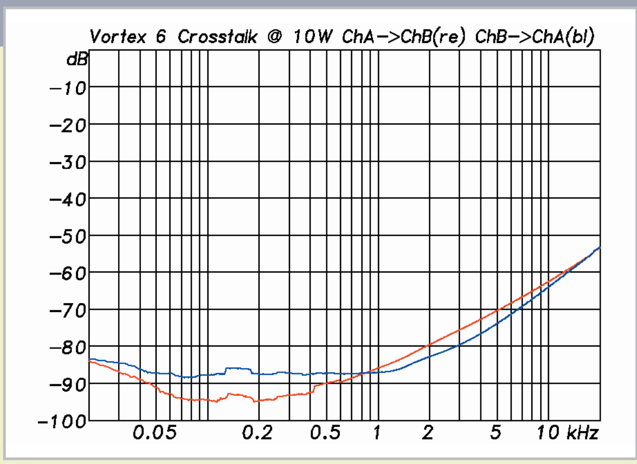


Fig. 3: Crosstalk attenuation (CH1→CH2, CH2→CH1)

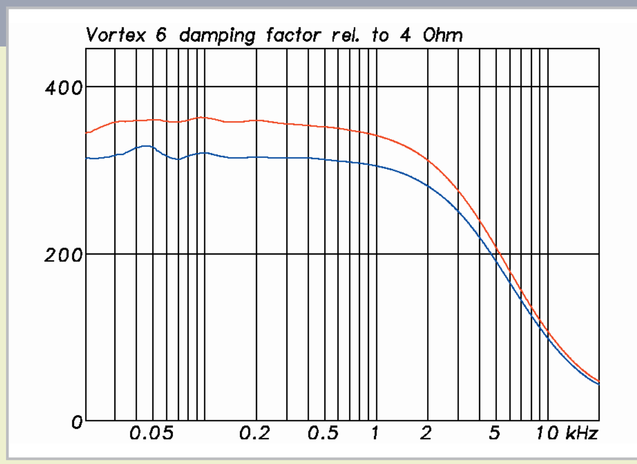


Fig. 4: Damping factor into 4-ohm load vs. frequency (CH1, CH2)

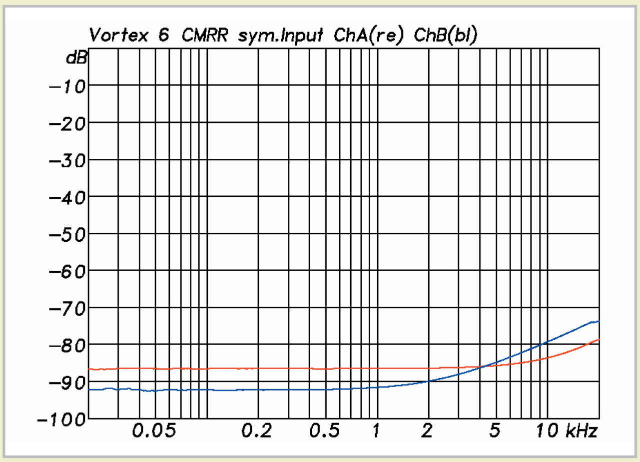


Fig. 5: Common mode rejection (CH1, CH2)

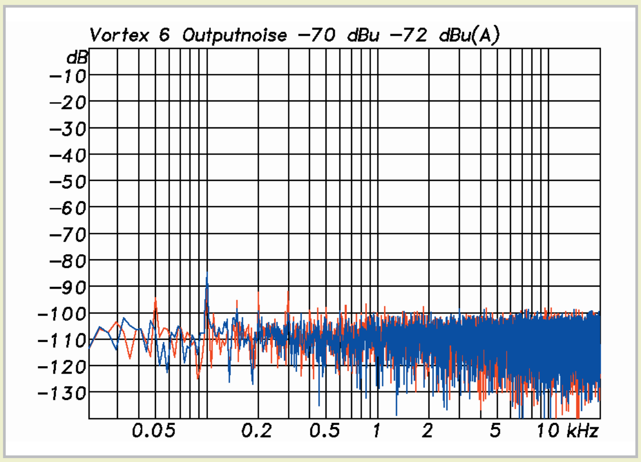


Fig. 6: Interference spectrum at output (CH1, CH2)

design is not too showy. In addition to a small power switch, which is of course not the main power switch, the front panel also features two level controls and one operating LED, one signal-present LED and one clip LED per channel. Three additional LEDS serve as status indicators informing the user about remote control activities and operating modes. Unfortunately, all front panel control elements are so densely packed in the lower left corner that you need plenty of light and have to get very close to the unit to be able to adjust them. Both conditions are less likely to be fulfilled in a power amp's „natural habitat", which is usually a dark corner somewhere behind large speaker stacks or underneath the stage. It may be mentioned already here, however, that this was the Vortex 6's only drawback we could find.

Just as the front panel, about 2/3 of the rear panel, too, are necessarily covered by ventilation slots. Located to the left of the slots are the RJ45 (Western Telecom jack) connectors for the remote control network and the speaker outputs, which are on two Speakon connectors. For safety reasons, there are no other connecting options available here, because the outputs can deliver voltage levels that may well be in the order of the mains voltage; thus, contact protection is a top-priority issue. Both channels are cross-connected and routed to both outputs, so that active systems can be directly connected to the power amp, using a 4-cond. Speakon cable.

The right-hand side of the rear panel accommodates the mounting slot for the E.U.I. (Extended User Interface), whose standard version is equipped with two balanced XLR inputs and two XLR link connectors. Above, there is a row of 4 slide switches, which allow you to set the ground lift, operating mode, limiter function and power amp gain. Available operating modes are: conventional 2-channel mode, mono-bridge mode and mono-parallel mode. It should be noted that the Vortex provides a real parallel mode, which has the outputs, too, connected in parallel, so as to enable the amp to deliver twice the current as in normal operating mode. The Gain switch allows you to set gain levels of 26 dB and 32 dB, which is standard on most professional amps today, and to adjust an input sensitivity of 1.4 Veff (nominal power), which corresponds to 37.7 dB of gain.

EN61000-3-2

In this context it may be interesting to know that the European Standard EN61000-3-2 has been ratified recently and will become effective early in 2001. This standard regulates the power and current consumption of electrical consumers, but does not stipulate a limitation of the harmonics contained in the mains current for consumers for professional uses, with more than 1 kW of power consumption under nominal conditions, i.e. for power amps loaded with bandwidth-limited pink noise and an averaged output power of 1/8 of their sine power. For smaller audio devices the existing limits shall be preserved. In the case of switched mode power supplies, this will usually mean the use of PFC (Power Factor Correction), which is, however, not mandatory according to the standard, as long as the limit values are achieved otherwise. This regulation does not apply to the Vortex, because under the given conditions it already draws more than 1 kW of nominal power from the mains. A standard for this device category is currently being discussed.

Circuit design

The fundamental design of the Vortex is based on conventional bipolar Class H circuitry with a 3-stage supply voltage, as this is the only way to achieve such high power capacities without having to wire tons of power semiconductors in parallel. The operating voltage of the power amp is adapted to the current demand by means of 3 stages, which allows drastically reducing the power dissipation at the semiconductors. Without Class H circuitry the worst-case power dissipation of such a power amp would be as high as that of a powerful radiator, in which case even massive heat sinks and fans would be of no avail. The Vortex is equipped with an unregulated switched mode power supply, which first rectifies the mains voltage to subsequently chop it at a much higher frequency. Then follows the mains transformer which can be much smaller and lighter considering the higher AC voltage frequency than it could be at 50 Hz mains voltage. The balanced 3-stage supply voltage for the power amp is finally produced by means of 6 secondary voltages. The actual filtering and energy storage is done after the mains rectifier at high voltage, because the energy stored in the electrolytic capacitors equals $^1/_2CU^2$. However, the capacitor size is merely proportional to CU. Owing to the square and the fact that the transformer transforms capacities to the power also in square, the design works well with relatively small filter capacities compared to conventional power supplies.

On the secondary side, there are a few filter capacitors, which can be dimensioned much smaller owing to the now considerably shorter recharging cycles. Compared to a conventional design the switched mode power supply of the Vortex is not only less heavy, its HF mains transformer also has a much lower internal resistance, which allows for very large reserves as long as the mains voltage is of appropriate stability. The power amp can draw currents of up to 57 A from the mains, without overloading the circuitry. Of course, this would be too much for the protective devices. More on this in the safety cutout simulation chapter (see below).

In the actual power amp circuit fast analog computers monitor the output voltages and currents and ensure the safe operating range of the power amp transistors. In critical situations they simply block the stepping up of the supply voltage or force the amp to step down. In extreme cases, e.g. overheating of the amp or short circuits at the output, the supply voltage and hence the entire channel affected is switched off completely. The Vortex 6 allows for a maximum output current of approximately 66 A.

Limiter

The limiter switch provides three positions: Off, SpP and Clip SpP. The clip limiter is of a conventional design; in case of permanent clipping it reduces the input level so that only signal peaks are slightly cut back. The SpP limiter (Speaker Protect Limiter) is something very special in that it protects the speakers in case the power amp is overloaded. Power amps with multi-stage supply voltages (Class H) are protected internally against excess currents and/or power dissipation into low-resistance loads by stepping down the supply voltage. Thus, the output signal may contain square-wave surges that could reach and damage the speakers, in particular the tweeters, in the form of high-

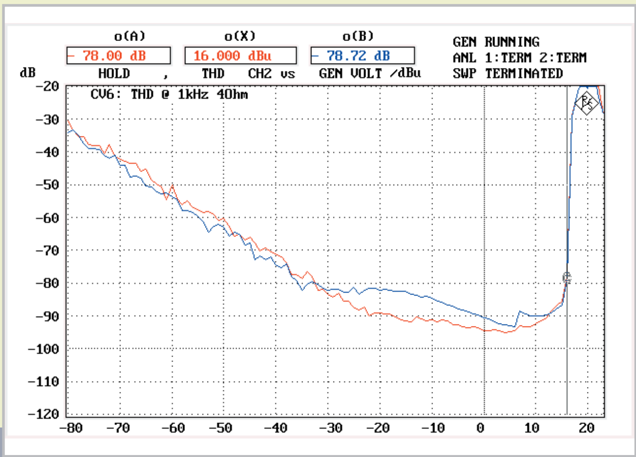


Fig. 7: Total harmonic distortion (THD) at 1 kHz and into 2x4-ohm load (CH1, CH2)

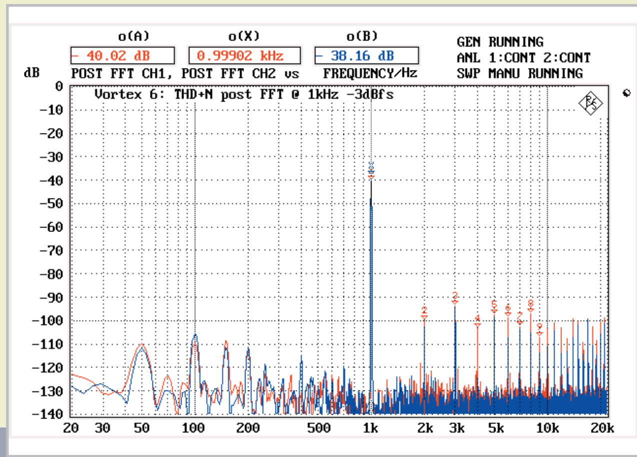


Fig. 8: Distortion spectrum at 1 kHz and into 2x4-ohm load (CH1,CH2), 3dB under full load (basic oscillation at 1 kHz attenuated by 40 dB)

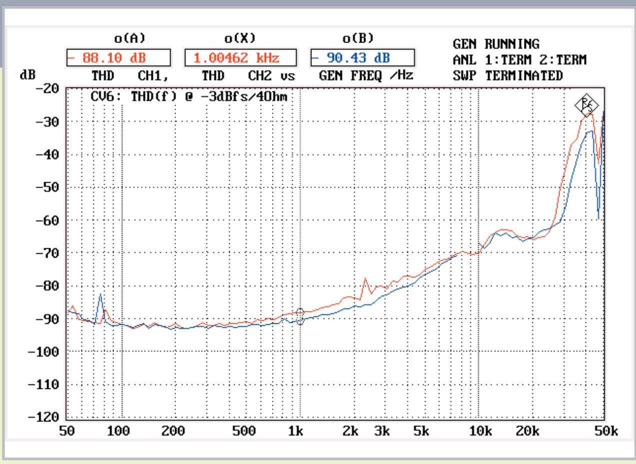


Fig. 9: Total harmonic distortion (THD) vs. frequency, 3dB under full load and into 2 × 4-ohm load (CH1, CH2)

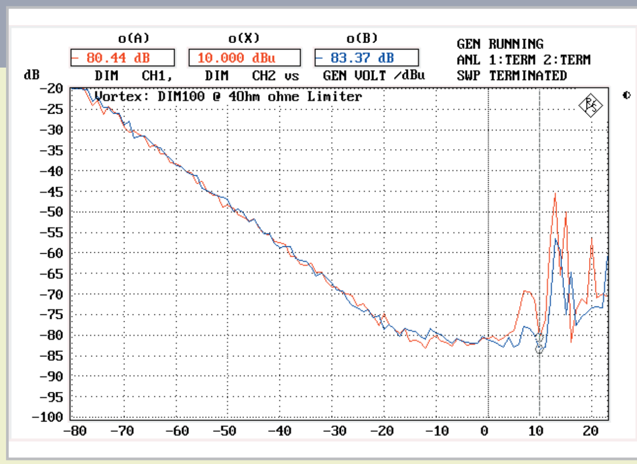


Fig. 10: Intermodulation distortion DIM 100 (3.15 kHz and 15 kHz) into 2 × 4-ohm load (CH1, CH2)

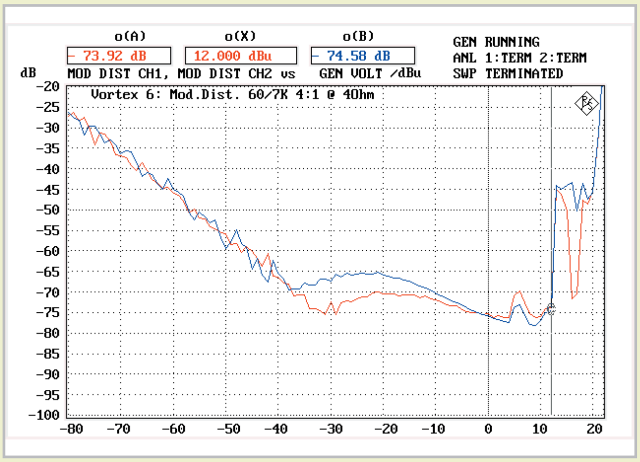


Fig. 11: Modulation distortion according to SMPTE (60 Hz and 7 kHz) into 2 × 4-ohm load (CH1, CH2)

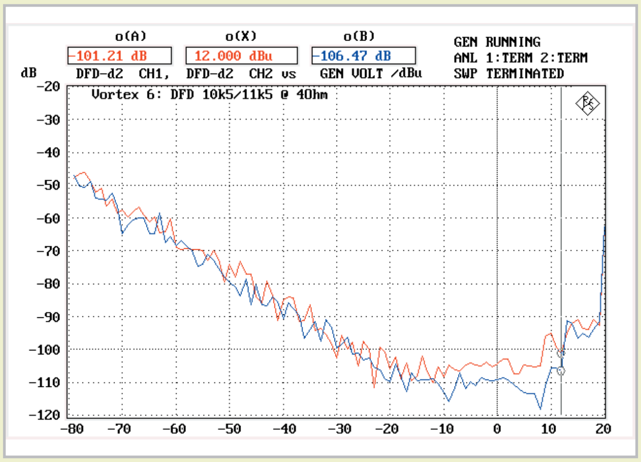


Fig. 12: Difference tone distortion (10.5kHz and 11.5kHz) into 2 × 4-ohm load (CH1, CH2)

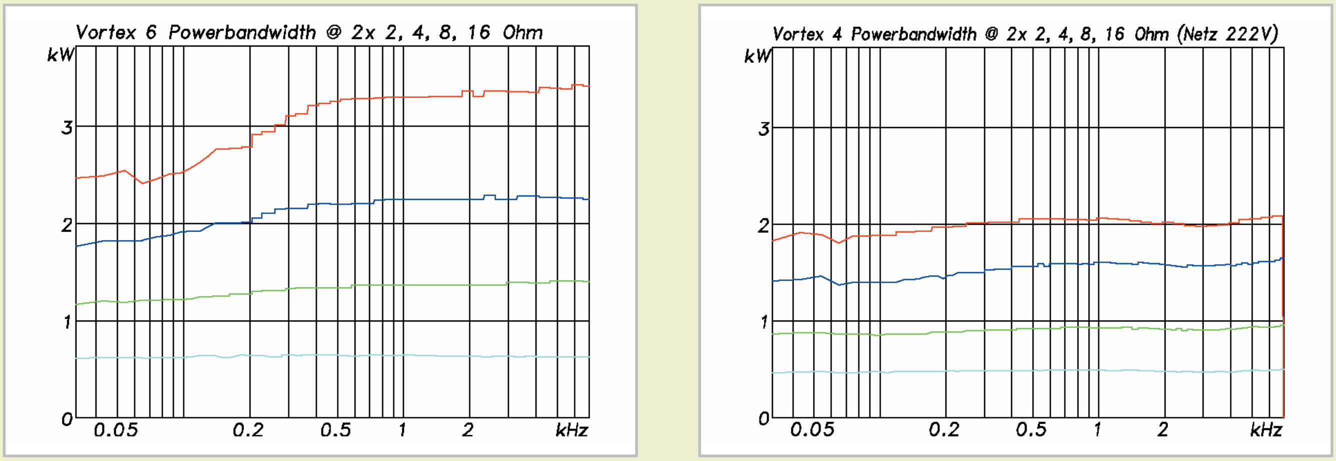


Fig. 13: Two-channel cont. power at 1% THD into 2 (red), 4 (blue), 8 (green) and 16(light blue) ohms (left: Vortex 6; right: Vortex 4)

frequency distortion. Such problems are quite natural in any Class H design like the Vortex. The more the stages are spaced apart, i.e. the lower the number of stages, the more crucial such problems become. Now, the SpP limiter detects this condition and reduces the signal level accordingly, if the power amp steps down repeatedly into a rising signal edge to protect itself against overloading.

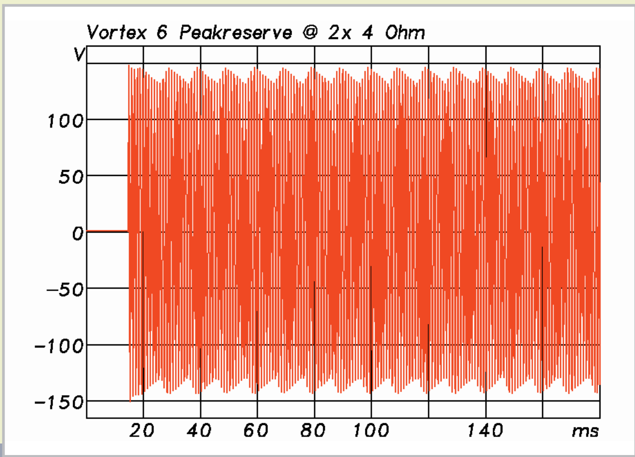
Other protections

The heart of all protective circuits in the Vortex is a microprocessor, which controls all parameters from the mains voltage adaptation via the gain setting to the limiter. After power-up, the entire peripheral circuitry is activated from a small-voltage mains supply. The microprocessor checks the mains voltage to select an operating range of 115 or 230 V and then activates the power supply and the amp itself in a controlled manner. Once all components of the power amp have reached their proper operating states, and neither internal nor external malfunctions have been detected, the microprocessor turns up the volume level to the adjusted value.

The gain potentiometers are not directly wired as part of the signal path, but only provide the control voltage, which is then evaluated and passed on to a DCA (Digitally Controlled Attenuator) in the form of a 12-bit control variable. In this way, the input signal can also be controlled by the power-up delay, limiter and remote control functions. Other control variables are sent to the microprocessor from thermal sensors on the heat sinks and the transformer, DC detectors at the output and from a fast analog computer which monitors the safe operating range of the power transistors. If the power amp is overloaded, the microprocessor can use the limiter function (if activated) to cut back the output power. If the limiters are off, only the power amp itself can limit the output power by stepping down the supply voltage to protect itself. An exception to this rule is the main current limiter, which is always on and also uses the limiter to control the output power. More on this below. In extreme situations the microprocessor can also switch off the entire power supply, for instance, if the mains voltage permanently exceeds 260 V or if the unit suffers from an internal malfunction.

Live test

As a kind of acid test, two Vortex 6 had to prove their quality during 16 hours of conti-



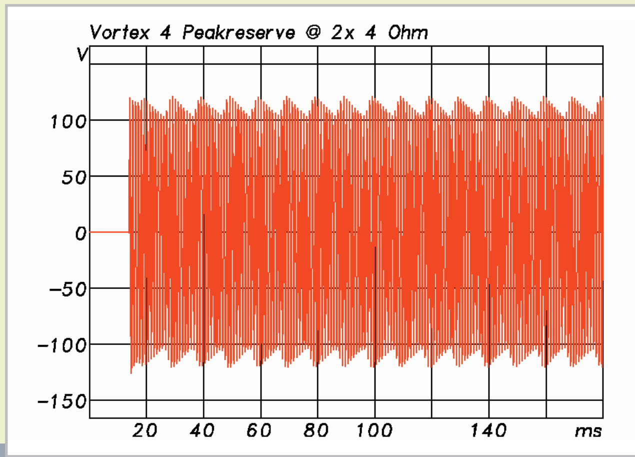
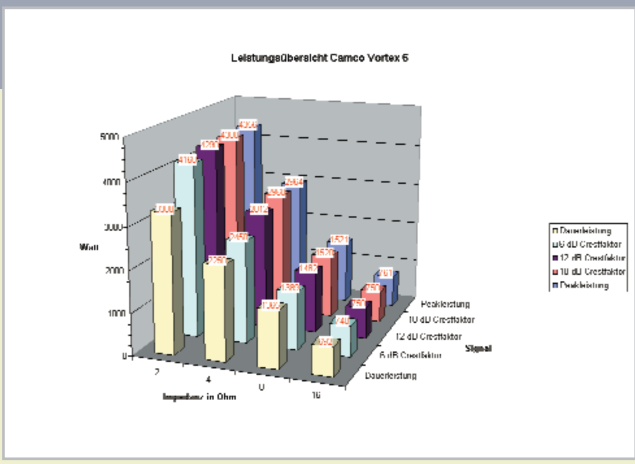


Fig. 14: Peak reserves, 2-channel, into 4-ohm load (left: Vortex 6; right: Vortex 4)



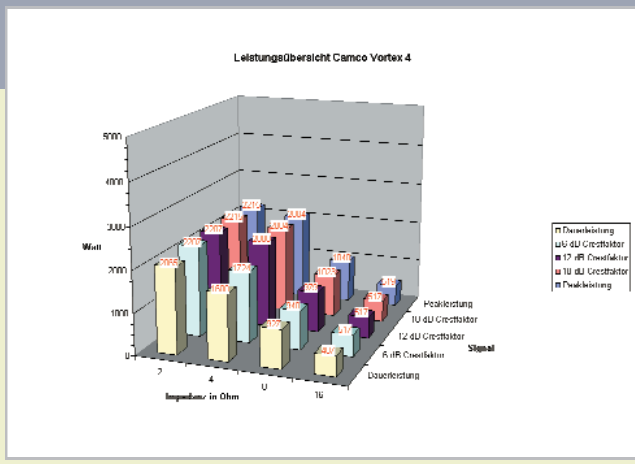


Fig. 15: Performance diagram for one channel with simultaneous load applied to all channels (left: Vortex 6; right: Vortex 4)

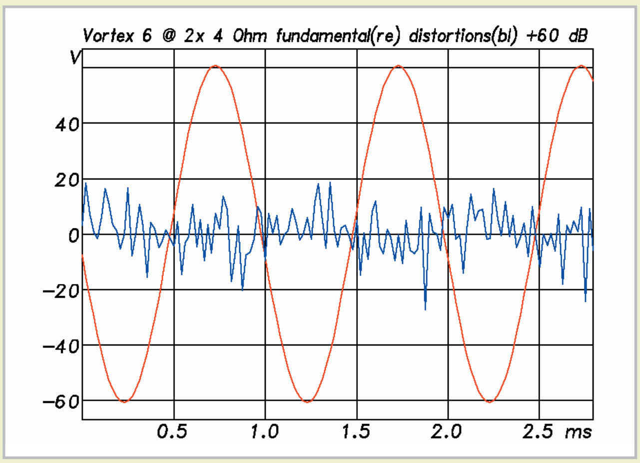


Fig. 16: 1 kHz basic oscillation and distortion components (50 dB enlarged)

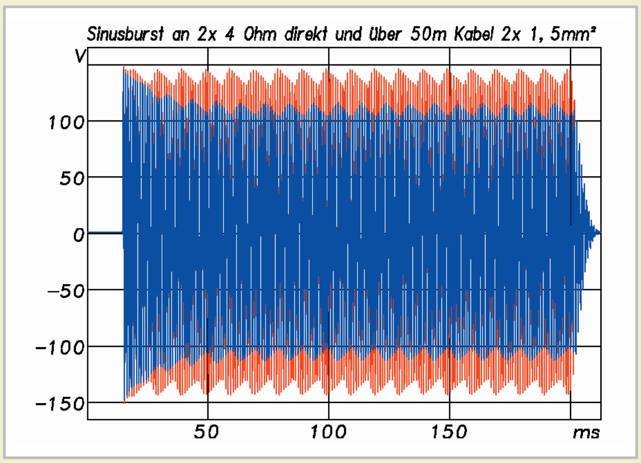


Fig. 17: Vortex 6 response when connected to stable power supply (red), and via 50-m cable (blue)

nuous operation at this year's Mayday event, which took place in the Dortmund Westfalenhallen. In hall 1, both amps were used to drive one of the towers comprising 8 EAW SB750 subwoofers, so that all channels had to process music material with lots of bass frequencies in tough 2-ohm mode and with a low crest factor. Despite high ambient temperatures, both amps were fully stable and showed no signs of weakness. To be fair, it must be said that none of the other power amps used showed any signs of weakness either, just as none of the speakers got damaged.

Safety cutout simulation

As already mentioned, the Vortex 6 is dimensioned internally in such a way that it draws 57 A of current with 2-ohm loads connected to both channels and a maximum output current of approximately 66 A per channel (which corresponds to an output power of 4.3 kW). Naturally, such an amount of current would not take long to trigger any 16-A safety cutout and also blow the internal 25-A fuse. Still, the amp is capable of handling this extreme current at least temporarily. The thermal time constant of a safety cutout is so high that 24-A currents are permitted for 1 to 1.5 hours. The Vortex therefore includes another small analog computer, which evaluates the mains current and uses appropriate time constants to simulate the behavior of fuse and safety cutout. If a critical condition 'just-below-threshold' is detected, the analog computer uses a control variable instructing the microprocessor to activate the limiter. This is the only limiter function that cannot be disabled, which does make sense though, because otherwise the amp would trigger its safety cutout or blow the internal fuse.

Measurements

The measurements of the linear transmission behavior (fig. 1 and 2) show that the Vortex is completely neutral over the entire audible spectrum. Its frequency response at 20 Hz and 20 kHz deviates from the value at 1 kHz by a mere 0.1 dB. The phase shift at 20 kHz is about 40°, caused by the high-slope 60-kHz low-pass filter (3rd order) at the input of the power stage. The low-pass filter is particularly crucial in Class H power amps, because high-frequency or high-slope signal portions could overstrain the supply voltage change-over, which would lead to distortion. Yet, at 60 kHz the low-pass filter has no audible effect whatsoever on the actual audio signal.

The Vortex achieved excellent results in terms of crosstalk attenuation (fig. 3), common mode rejection of the balanced inputs (fig. 5) and interference immunity (fig. 6). With an unweighted dynamic range of as much as 113 dB, interference noise won't be much of a problem. Additionally, the gain can be set to a maximum value of 26 dB, which allows for adapting the power amp to the output voltage of most controllers and mixing consoles, without major losses in terms of dynamic range. The damping factor (fig. 4), measured at the Speakon connectors, is as high as 300-350, at 1 kHz and into 4 ohms, even though it drops considerably towards the high-frequency end (about 100 at 10 kHz); still, this is more than enough. The distortion measurements in fig. 7-12 also show very good results, from which we can conclude that the design concept of the Vortex is convincing and logical throughout. The THD values drop to -95 dB, even though the distortion spectrum shows that it mainly includes odd and high-frequency portions. The THD vs. frequency response (fig. 9) is approximately -90 dB up to about 1 kHz, and then starts to rise by 6 dB/oct. or 20 dB/dec., which is quite typical. The hefty increase in distortion above 25 kHz, which was 3 dB below clipping during this series of measurement, could be due to the switched supply voltage, which tries to stay on its highest level, but is forcefully cut back every now and then by the current limiter. A similar effect can be seen from the intermodulation distortion diagram (fig. 10), where there is no steep rise at the clip level, but sporadically varying values caused by the current limiter, which is activated temporarily.

Performance profile

As with all power amps from this performance category, a sufficiently stable mains supply had to be provided so as to be able to measure the performance profile of the Vortex 6. Although it has no regulation, the switched mode power supply of the Vortex is extremely hard and hardly shows any internal resistance blocking the current flow between wall outlet and power amp circuitry. The only difference to a regulated switched mode power supply is the fact that the Vortex does not make up for a decrease in mains voltage by increasing its power consumption, so as to be able to maintain a steady level of power consumed. Certainly, such a behavior is a benefit in unstable mains networks, when the power amp does not respond to a mains voltage drop by an increase in power consumption, which could possibly make things even worse and sooner or later trigger one of the safety devices.

A preliminary sine burst measurement with the Vortex connected to an ordinary wall outlet yielded an output voltage response that was very similar to that of an amp with a conventional power supply (blue curve in fig. 17). With the filter capacitors fully charged, the amp initially delivered a peak voltage of 150 volts at the output to subsequently drop to an average value of approximately 110 V. In a conventional power amp this effect is primarily caused by the internal resistance of the mains transformer irrespective of the performance category. However, the Vortex should actually show no such effect. During a second measurement, the mains voltage showing the response described above was measured in parallel. Thus, it was clear that the measurement showing the response of the power amp to a sine burst did not reflect the behavior of the amp itself, but that of the mains power supply. A second measurement, during which

^ Survey Vortex 6

Max. continuous power into 4 ohms, 2-channel, 1% THD: 2259 W
Peak reserves (4 ohms): 2964 W
Gain: 26/32/37,7 dB
Dynamic range (unweighted): 113 dB
Dynamic range (A-weighted): 115 dB
(Dynamic range referenced to pulse output power at 18 dB crest factor)
Remote control option: CAI
Weight/HU: 12,4 kg / 2 HU
Power/Weight: 453 W/kg
(into 4 Ohm, both channels summed at 12 dB crest factor)
Price/Performance: DM 1,40 /W
(into 4 Ohm, both channels summed at 12 dB crest factor)
Price: approx. DM 7.876 incl. 16% VAT
S.Nro.: 15092 (Vortex 6)

Load	2	4	8	16
Cont.	3300	2250	1365	692
6 dB	4160	2450	1389	740
12 dB	4290	2812	1482	750
18 dB	4300	2960	1520	750
Peak	4356	2964	1521	761

Output power in watts with 2-channel load, 1% THD and signals with different crest factors. Mains voltage 228 V, measured with 3 dB crest factor.

the Vortex was directly connected to a 63-A sub-distributor confirmed this conclusion, as can be seen from the red curve in fig. 17. So, the switched mode power supply and the power amp circuitry are absolutely stable, and once the initial peak is over the output voltage drops by a mere 2-3 volts.
In practice, this will be of less significance, because we're talking here of real sine continuous power, which no power amp must handle in real life, even with highly compressed music signals featuring crest factors of approximately 9 dB.
The performance survey of the Vortex 6 (fig. 15), measured with the amp connected to a stable mains supply, shows a response that is largely independent of the signal shape and/or crest factor, and is limited by the mains current limiter (measured into 2- and 4-ohm loads, continuous power, 6 dB crest factor, 2-channel operation). In the case of the 2-ohm load the power amp's own current limiter comes on and limits the continuous power to approximately 3,300 watts per channel.
The performance bandwidth curves in fig. 13 show an increasing power drop towards the low-frequency end, if decreasing load impedances are connected. This effect could be caused by mains harmonics that are superimposed on the output signal; however, the higher the measured frequency, the less important this effect becomes.

Addendum Vortex 4

Shortly before the editorial deadline, the editors were informed that the smaller Vortex 4 had been completed as well. Consequently, this test report was revised at short notice to include a few basic data of this brand-new model. From a technical point of view, the Vortex 4 is identical to the bigger Votex 6, but has a smaller power supply that handles only 131 V instead of 155 V; as a result, the power semiconductors are designed for currents that are not as high as in the case of the Vortex 6. As regards the measured values, it can be concluded that there are no significant differences to expect in terms of frequency response, phase shift, interference, damping factor, etc. The THD response should be similar, yet show a slightly lower clip limit. To avoid getting drowned in a sea of measured values, we only included the performance diagrams of the Vortex 4 in this test report, as these show the substantial differences between both amps. The Vortex 4 weighs 12.4 kg and hence
features a performance/weight of 337 watts/kg; with a price of DM 6,020 its price/performance ratio is DM 1.44 per watt.

Summary

Camco's new Vortex Series delivers highest performance in a compact and low-weight enclosure, which can ultimately be seen from the impressive performance/weight ratio of 453 watts/kg. However, what makes this result really exceptional are the excellent distortion values, the very good S/N ratio and the variety of sophisticated protections. Actually, there is nothing negative to say about this power amp, which has already been confirmed by the impressive sales numbers in the most recent past. The secret of the Vortex is the successful combination of classic circuit designs with latest switched mode power supply technology and an ingeniously designed microprocessor controller that makes it possible to get the most out of the circuitry and still stay well below the limits of what is safe. So, you don't have to be clairvoyant to predict the Vortex Series a successful future.

Text and measurements: Anselm Goertz
Photos: Dieter Stork