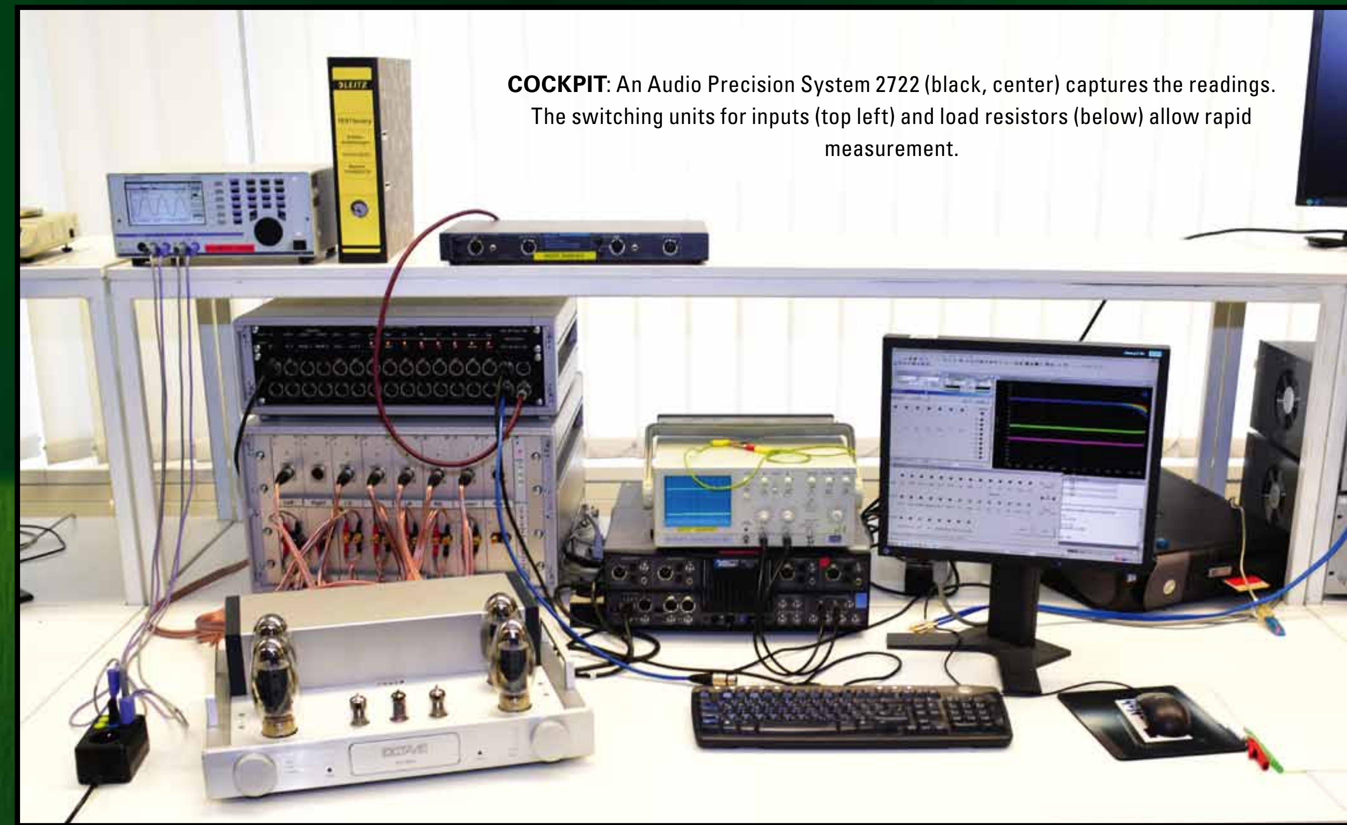
THE WAY AUDIO TESTS AUDIO

PART2: AMPLIFIERS

Amplifiers merely magnify small voltage input signals. The AUDIO Testlab measurements show the potential pitfalls this can involve. ■ by Bernd Theiss, Head of Testlab



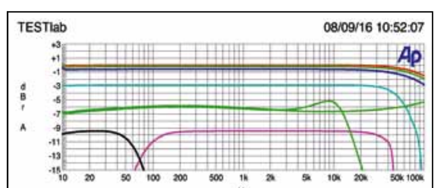
COCKPIT: An Audio Precision System 2722 (black, center) captures the readings. The switching units for inputs (top left) and load resistors (below) allow rapid measurement.

Sounds simple: Take an input signal, amplify it twenty times and then output it. An amplifier has an easy job. Other components, in contrast, must convert mechanical or optical information into electrical signals, communicate with network protocols, or convert electrical energy into acoustic energy, depending on their function. All of this is more complex than the simple amplification of an analog signal. Nevertheless, amplifiers exert a magical fascination – perhaps also because there are widely divergent ways to build a good amplifier. The technical data reflect the different approaches, which is why the technology used by the test laboratory Testlab working for AUDIO is so interesting.

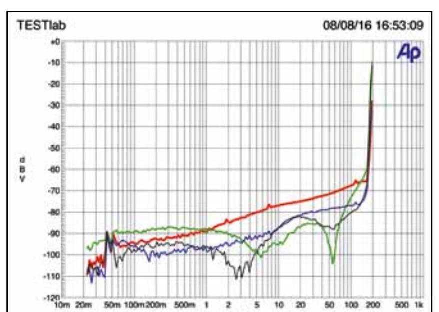
FREQUENCY RESPONSE

Fact is, there is a minimum consensus when it comes to magnitude frequency response, which is how the measurement task is actually called. It should be straight as a ruler in the listening range (about 16 Hz to 20 kHz), whereby deviations of 1dB are too small to be noticed. Many manufacturers exploit this by limiting the frequency response to below 20 Hz and above 20 kHz. This can be considered the „English school", as companies such as Quad and Naim upraised this as a sound enhancing practice. The slope to low frequencies reduces the costs for highquality coupling capacitors in the signal path and prevents extremely lowpitched musical parts or turntable rumble from causing extreme cone excursions – as this also generates distortions in the listening range. An early limitation of the low frequency bandwidth can however constrain the potential of speakers with deep bass and deprive recordings in large rooms of their spaciousness. The high frequency limitation prevents amplifiers, firstly, from being influenced by ubiquitous high frequency radio fields and, secondly, wards off the tendency to inaudible but extremely strenuous oscillations. Thirdly, the high frequency limitation reduces the approximate shortcircuitlike effects of capacitive loads, as displayed by some electrostatic loudspeakers. Proponents of frequency responses that extend far beyond the human hearing range, including the American pioneering company Spectral, with bandwidths ranging from under 1 to over 1 million Hertz (MHz), claim that they achieve increased resolution, improved brilliance in the high pitches and more natural breath in the lows. If the amp developer knows his craft, amplifiers with very high bandwidth can be used without highfrequency interference and without oscillation tendency, with capacitive loads. If not, Testlab has sometimes discreetly pointed out the problem detected to a manufacturer, giving him the chance to solve the issue.

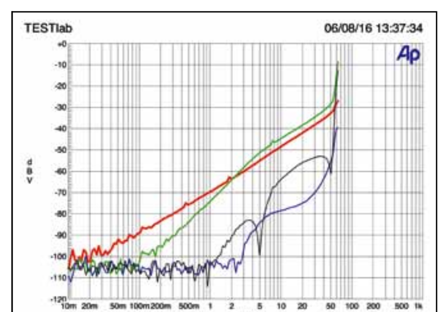
The frequency response of the phono input is woth to mention: It must follow the socalled RIAA curveamplify amplifying the bass more than high pitches, as signals are cut into the vinyl in the exactly reverse manner. This precorrection allows the avoidance of strong groove deflections at low frequencies. Most amplifiers manage the equalization very well, as MC input measurements prove. In MM systems, the amplifiers input capacitance combined with the cartridge inductance creates a self resonance, leading to sharp peak at high frequencies – with subsequent steep drop. This is shown by our measurement with repli-



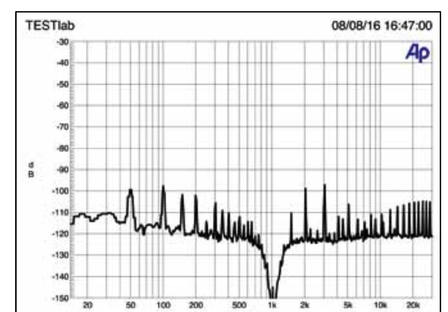
LINEAR DISTORTION: The frequency response is represented above at 8 (red), 4 (green) and 2 ohm (blue) load. The digital input (turquoise) shows anti-aliasing filering. The phono MM input (2 x green) shows a rise at 9 kHz with simulated standard system; without standard system, it doesn't. At the bottom you can see the frequency response in the sub/sat mode.



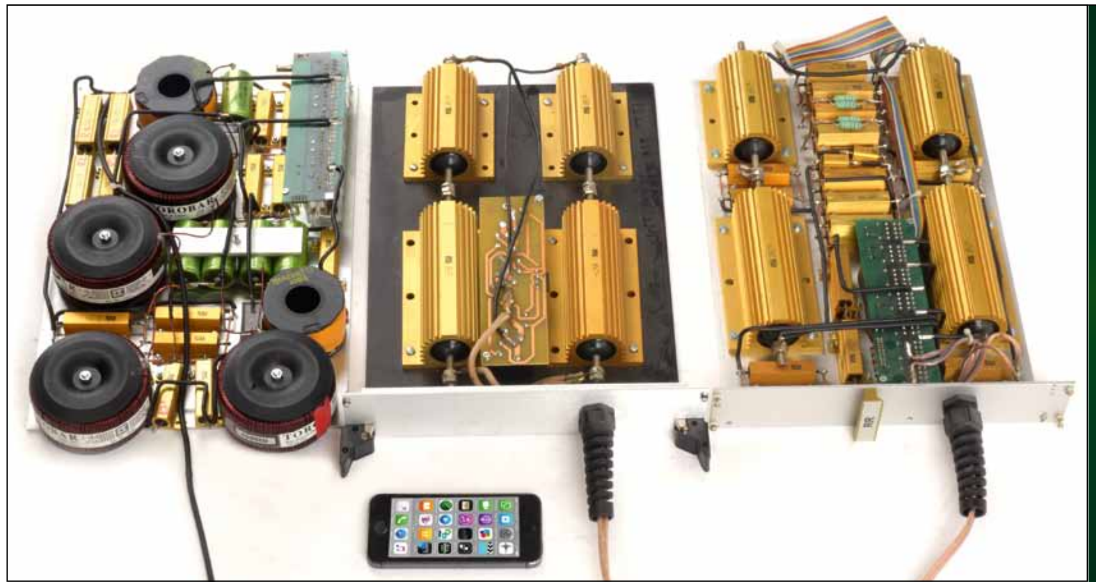
NON-LINEAR DISTORTION 1: The second (red), third (green), fourth (blue) and fifth (black) harmonics, as a function of the output power.



NON-LINEAR DISTORTION 2: A typical tube amplifier exhibits an early rising THD and therefore runs gently into clipping.



THD: The diagram shows, with filtered out fundamental wave (1 kHz), the harmonics at 2, 3, 4... kHz, the noisefloor at - 120 dB.



UNIVERSAL: To load amps in all typical variants, these switchable resistor networks are available for up to eight channels.

cated standard system. In the case of combination of MM system with phono stage, either the inductance of the system or the capacity of the MM input should be the as low as possible, to push the peak to very high frequencies. AUDIO publishes both values measured by Testlab.

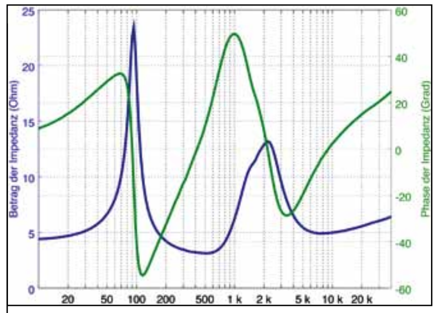
TOTAL HARMONIC DISTORTION

Nonlinear distortions are widely regarded as sounddefining in amplifiers: They are a measure of the harmonic content when playing a pure sinusoidal tone. Overtones that are a double, triple, or any integer multiple of the fundamental are called harmonics. Instruments also produce harmonics that are sometimes even stronger than the fundamental, with the sound level distribution being responsible for the timbre. If an amplifier changes this distribution, a part of this ability to differentiate instruments is lost. Testlab measures distortion on the basis of the output power (Figures „Nonlinear distortion 1+2“, double page above), where the second harmonic is shown in red, the following green, blue and gray.

A moderate second harmonic (also called k2) is known to subjectively changedynamics. If its proportion is dominant, it can also cover the effect of higher harmonics – often negatively perceived – and even make them inaudible. This makes the sound of tube amplifiers, and even more so single ended tubes with their dominant 2nd order harmonic rising with level, so appealing.

The strong feedback in most transistor amplifiers reduces distortion to an often extremely low level; only the power limit has greater tonal relevance here due to high level distortion (clipping). As the best music recordings contain levels up to 20 dB above averadge, and the harmonic distortion of clipping increases from 0.1% to almost 100% within a few watts, it is not advisable to use a transistor amp above his limit.

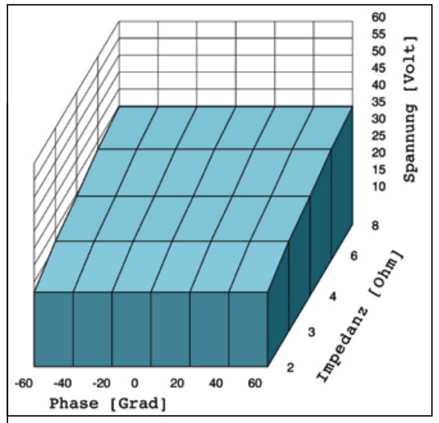
Another perspective on nonlinear distortion is offered by the distortion spectrum measured at a fixed signal level (diagram „THD“), where the first harmonic is filtered out at 1020 Hz. It also shows background noise and mains hum in integer multiples of 50 Hz, as well as interactions between the signals (intermodulation).



VOLATILE: A speaker loads the amp very differently depending on the frequency, the frequently cited nominal impedance refers only to the minimum value.

OUTPUT POWER

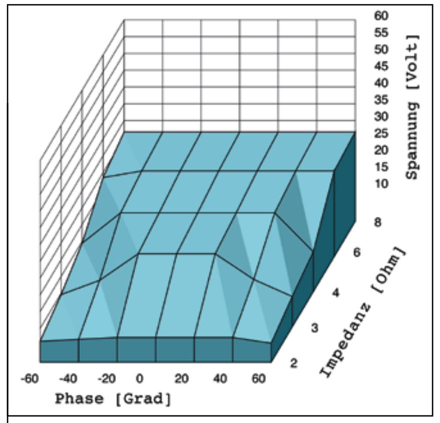
One thing is clear: Operating an amplifier outside its power limits causes dramatic distortions. But what actually are these limits? This depends on the speaker, whose impedance can be significantly less than 2 ohms, as in early Infinity or Apogee speakers, but can also be a magnitude higher, or even more. The former places high demands on the power supply capability, the latter on the maximum output voltage of the amplifier. The speaker impedance response on page 158 („volatile“) shows that both factors can come together. The minimum impedance is somewhat higher that 3 ohms, while the maximum is less than 25 ohms. In addition, phase shifts occur: The maximum current does not flow simultaneously with the maximum voltage at the speaker terminals. That places high demands on the amplifier, as is shown in Testlab's custom designed load in its worldwide unique cube measurement. Here, socalled music power (peak power measured in short bursts) is measured at 8, 6, 4, 3 and 2 ohms, where the phase shift between voltage and current is varied from - 60 degrees to +60 degrees in 20 degree increments. The cube then shows the maximum voltage which the amplifier can produce in each instance without clipping. The output power can easily be calculated from this value.



POWER-TEST: The power cube shows how steadily an amplifier delivers its output voltage at varying impedances and phase shifts.

Amps are challenged hard by some loud-speakers

STABLE MAINS SUPPLY: For measurements up to 3.6 kW (230 volts/16 amps or 115 V/32 A), the power supply is stabilized to the exact voltage in order to avoid measurement errors.



AMPLIFICATION TO THE LIMIT: The current capacity of this amplifier is adequate from 3ohm upwards at 0 degree phase shift, but is brought to its knees by phase shifts for loads lower than 6 ohm.

Amplifiers with high output impedance or limited current capacity show a more or less forward sloping cube with reduced output at low load impedances. Consequently, it is preferable to combine such amplifiers with high impedance speakers.

Amplifiers whose cube drops to the right and left of the zero degree phase line are also difficult to combine, as they have difficulties in delivering their maximum power to speakers with strong phase shifts in the impedance. This is shown by an uneven impedance response with great leaps within smaller frequency bands and it ti very common for popular loudspeakers

As a helping hand for the combination of amplifiers and loudspeakers, Testlab calculates the AUDIO indicator from the 35 individual readings of the amplifier output power. For speakers, this is calculated from the efficiency, the speaker's ability to convert the input power into sound pressure, the impedance minimum, and the maximum phase shifts of the impedance response. If the AUDIO indicator of the amplifier is greater than that of the speaker, the amplifier can easily drive the speaker, even at high volume levels.

CONCLUSION

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When it comes to frequency response, the choice between bandwidth limited tuning or a wide bandwidth is a matter of taste, as is the preference for higher distortion with dominating second harmonic, typical of tube amplifiers, as against minimum distortions. For moving magnet pickups however the phono input should have a low input capacitance. Even more important is that the amplifier is able to deliver the expected power to the speaker. For loudspeakers with strongly fluctuating, low impedances, an AUDIO power cube with flat surface is required; the power should be appropriate for the efficiency, so that the amplifier is capable to explore the loudspeakers potential.