Transistor Analysis and Selection in State of the Art Circuitry

All FM ACOUSTICS products use fully discrete audio circuitry. This is much more costly and cumbersome to manufacture but performance is far above any IC based circuit. Despite some recent improvements, even the best precision IC's & op-amp's are a **far** cry from what is possible with FM ACOUSTICS discrete Class A circuitry. However, to achieve optimal reproduction these enhanced Class A circuits require perfect matching of components. Several other manufacturer say that they are matching semiconductors (or tubes) but the standards of matching components differ widely.

At FM ACOUSTICS all active and most passive devices are selected on specially built testing machines and high powered curve-tracers. These selections are not just simple β (beta) tests (as is done by some other "high end" manufacturers). A simple β test is not adequate for top performance (in a β test the HFE - the gain of the device - is measured only at one single specific voltage and one specific current. How the device performs at other voltages and currents is not tested. For truly optimal performance careful *dynamic* analysis of each individual semiconductor plus perfect matching is required and this is in every single amplification stage.

At FM ACOUSTICS, each individual semiconductor goes through 5 different selection tests. The semiconductors under test have to pass a multitude of criteria. Only absolutely perfect semiconductors are used, everything else (even transistors with the slightest tolerance) is rejected.

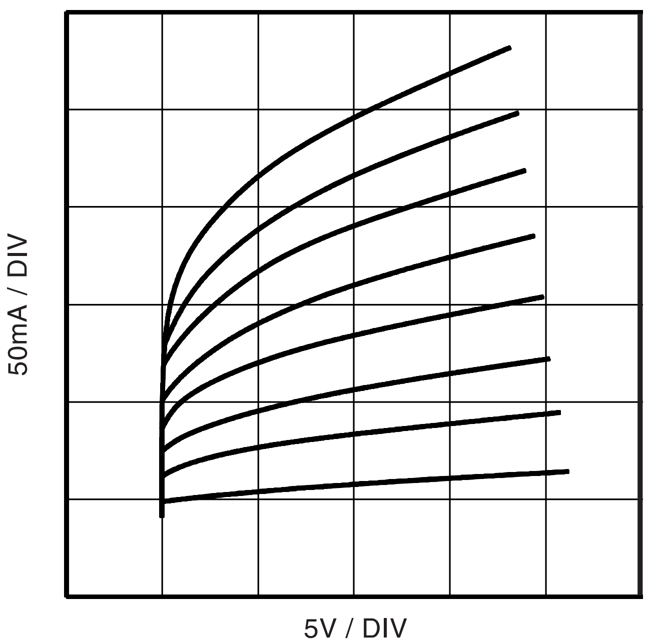
It is argued that this extreme care and time consuming procedures are not cost effective and massively increase the final price of the product. Correct. However, one has to bear in mind that within the same semiconductor type (and even within the same production run!) tolerances of 50-300 % of the specified data are common! The use of parts with such large tolerances is one reason why many commercial products have variations in sound and technical quality between individual units.

FM ACOUSTICS adheres to a "Zero tolerance"/"Zero compromise" philosophy. Worldwide experience proves the value of the philosophy of "use the best and then select to achieve even better whatever the cost".

Below are 6 graphs taken from a high power curve tracer. These are transfer curves of transistors. Note that these pictures can only depict the *static* situation at one specific point in time. This limitation is only on this paper as it allows dynamic observation of the device under test. The unique *dynamic* testing procedures that FM ACOUSTICS developed is much more revealing than this static test.

Picture 1

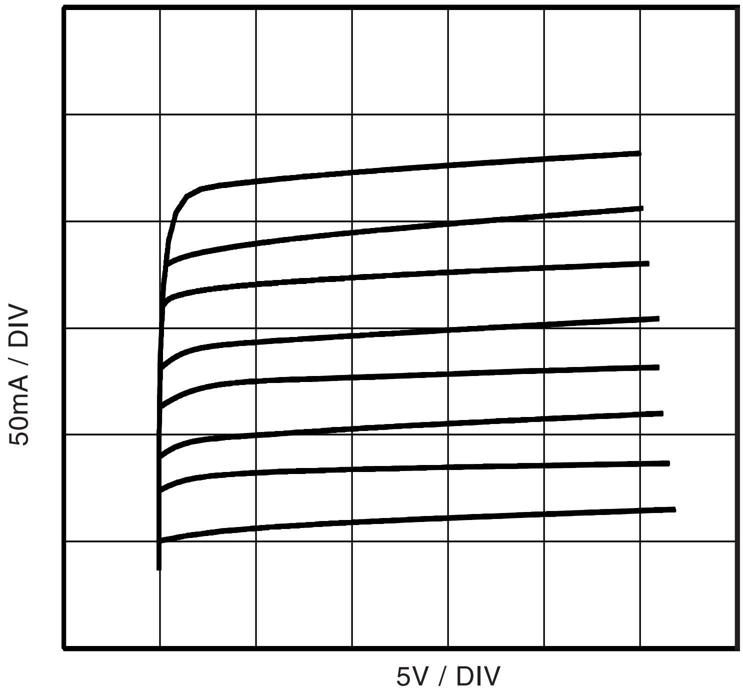
shows an FM 17417 transistor which was used in early models of FM ACOUSTICS power amplifiers (until early 1980ies). This picture shows typical curves of a power transistor with reasonable distribution at higher voltage levels; somewhat upwards angled traces, requiring precise thermal compensation to avoid "thermal runaway". Some non-linearity is evident at low voltage. These were the best transfer curves for a power transistor at that time. Dynamic analyses shows a positive temperature coefficient. This means that, as the transistor's temperature rises, the transistor's β (= current gain) increases. If not carefully protected this could make the device to be thermally unstable, a characteristic that is the cause of many an amplifier failure.



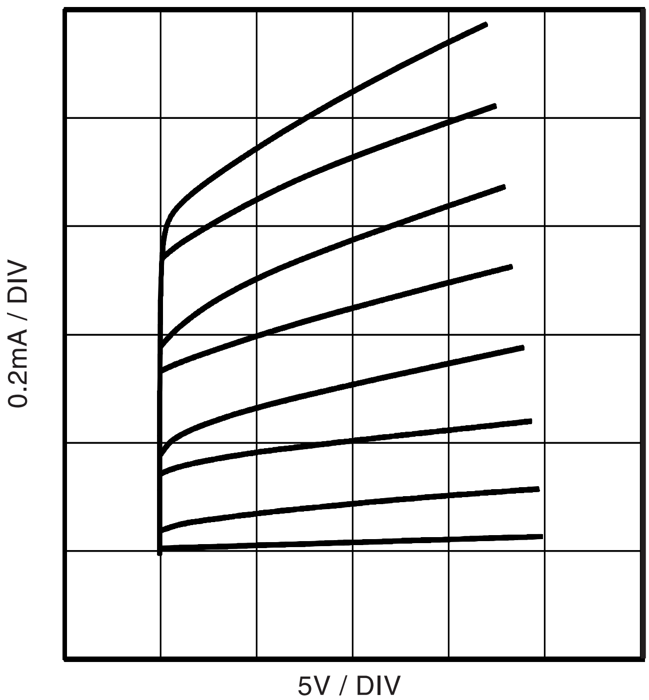
In precision audio equipment the labour-intensive **complete** analyses of the full operating range of the semiconductor yields truly optimal results:

Picture 2

shows an FM 17418 power transistor used in more recent years. The transfer curves are much more linear and spread more evenly than those of the FM 17417. The temperature coefficient has been optimized so that this transistor is thermally much more stable and can stand high temperatures for much longer without thermal runaway.
R+D over many years resulted in this unique transistor that handles high current at the same time as high voltage and this at very high speed, a combination that is unique to FM ACOUSTICS transistors. It is a more stable choice providing considerably higher performance possibilities than any ordinary power transistor.



In each and every stage of FM ACOUSTICS products (not just in the output stage!) only precisely selected transistors are used in carefully matched pairs. If transistors with identical transfer curves are used in the positive as well as negative side of true Class A stages, distortion within this stage is cancelled out. The stage can be inherently distortion-free and will not need feedback or error correction. Obviously an inherently distortion-free amplification stage has huge advantages over the same stage that makes use of transistors that just went though a simple β-test, no matter what circuitry is used. An inaccurate stage is further compromised when one tries to compensate its limitations by error correction, the usual frequency-dependent feedback or other measures as found in other power amplifier designs.
Part of the difference to an FM ACOUSTICS makes is due to these comprehensive procedures selection and this is very audible.

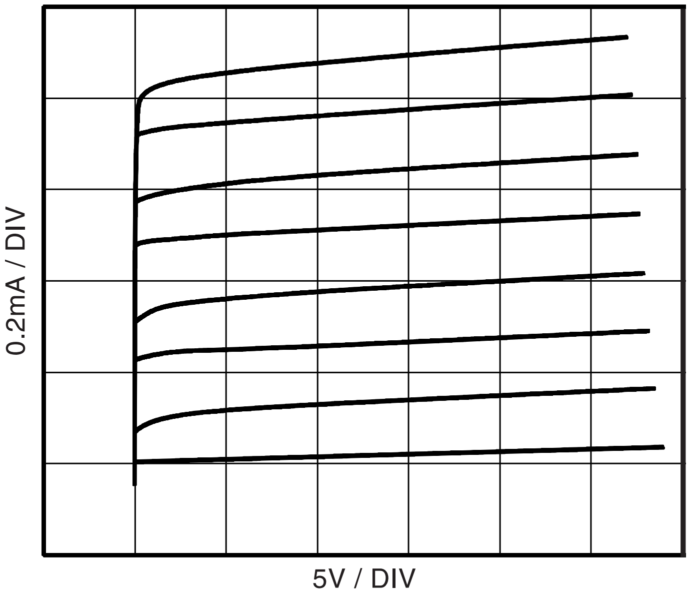


Picture 3

shows an RCA 2N 5416 metal can transistor, a high voltage transistor available from several manufacturers. Transfer curves show a somewhat uneven β distribution but otherwise they are reasonably clean.
This transistor was the best that could be supplied some years ago.

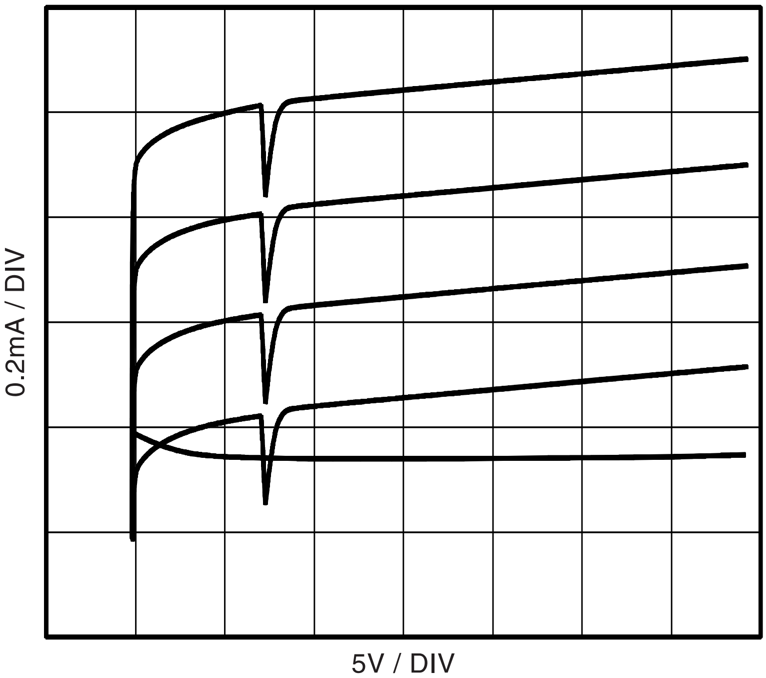
Picture 4

shows the same 2N 5416 used at FM ACOUSTICS in recent years. The differences are obvious: much improved transfer curves and much better linearity plus better performance when analysing dynamically.



Picture 5

shows another 2N 5418
In these generally quite satisfying transfer curves a sharp spike can be observed and spoils the quality of the transistor . This spike may not be a problem if the transistor is not used in audio applications. However, in an amplification stage, these spikes create a nasty distortion below clipping. The ear will be disturbed by such unnatural artifacts which are not present in the original music signal resulting in listening fatigue.



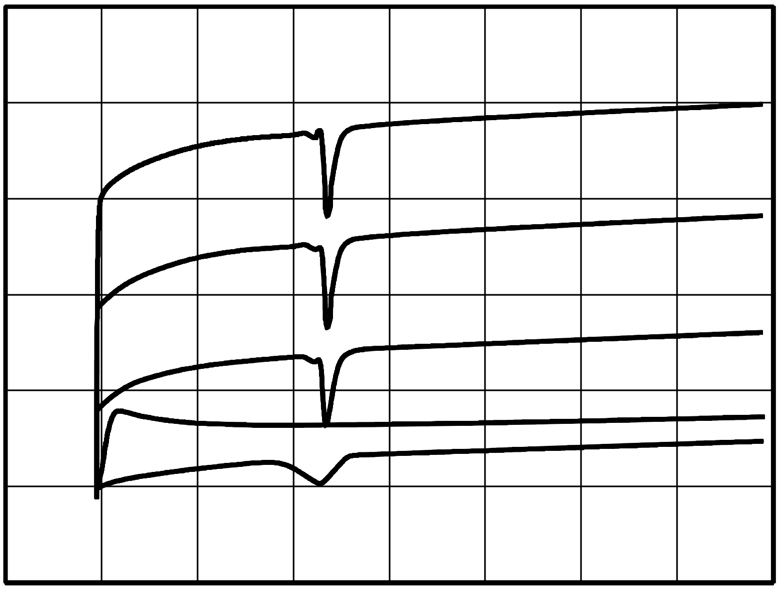
With the usual measurements an amplifier using "spiky" transistors may test normal and show low distortion readings but despite the low distortion reading, the tiny sharp spikes are detected by ear despite the low distortion reading (distortions measurements are static instead of the much more revealing *dynamic* distortions which are detectable by ear). The result of such spiky devices is an artificial and rather unpleasant high frequency sound, a characteristic that has provoked the negative term "transistor sound".

However, if designed correctly and using carefully selected components, a well executed transistor power amplifier can achieve superior results with absolute freedom of harshness, colouration and unmatched dynamic range. But, like in musical instruments and other precision devices, careful material and component selection is required.

Picture 6

shows another example of a 2N 5416 transistor out of the same series. Here, the spikes appear at a different voltage and also show some overshoot.

Only because of the complete dynamic selection over the full voltage and current range that is performed by hand on each individual transistor can such inconsistencies of transistors be noticed. In other amplifiers such transistors go undetected with the consequence of mediocre or outright poor sound. No other manufacturer performs static and dynamic analysis of each individual transistor as is done at FM ACOUSTICS.



The 2N 5416 is a generally available, reliable and reasonably fast high voltage transistor, but only when it has passed the most careful static and dynamic curve-trace analysis as well as additional proprietary selection procedures does it become a top class device for audio applications.

Fact is that with standard measurement techniques, not all distortions and anomalies will show up, despite that they are detectable by ear. The above examples give an indication why it is essential that components in general - and semiconductors in particular - must be selected and analysed individually and with the utmost of care.
A quick test with a β-meter is the "selection" that other "high end" manufactures are boasting about. It is far from satisfactory as the transistor is only tested at one single voltage and one single current. Performance tests over the full voltage and current range are neglected and non-linearity, spikes, discontinuity etc. play havoc with the music signal.

Only precisely matched pairs that have been thoroughly analysed over their entire range of voltage and current will yield pristine reproduction. It is obviously an expensive and time consuming procedure, but it pays off in much higher accuracy of music reproduction.

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