Transistor Analysis and Selection

FM ACOUSTICS products use fully discrete audio circuitry. This is more cumbersome and costly but then performance is far above IC based circuits. Despite some recent improvements, even the best precision IC's & op-amp's do not compare to FM ACOUSTICS discrete Class A circuitry. To achieve optimal reproduction, these enhanced Class A circuits, however, require perfect matching of components.
Other manufacturer claim to match semiconductors (or tubes) but the standards of matching components differ widely.
At FM ACOUSTICS all active and all passive parts are selected on specially built testing machines and high power curve-tracers. These selections are not just simple β tests as that is not sufficient for top performance (in a typical β test the HFE - the gain of the device - is measured only at one specific voltage and current. How the device performs at other voltage and currents is **not** tested)...
For truly optimal performance careful *dynamic* analysis of each individual semiconductor *in addition to* perfect matching is required. And this is necessary not just for the output stage but for every single amplification stage throughout the pre- or power amplifier.
At FM ACOUSTICS, each individual semiconductor goes through up to 5 different selection tests as the parts must pass multiple selection criteria. Only parts that are literally perfect are used, everything else (even parts with only the slightest of tolerance) is rejected.

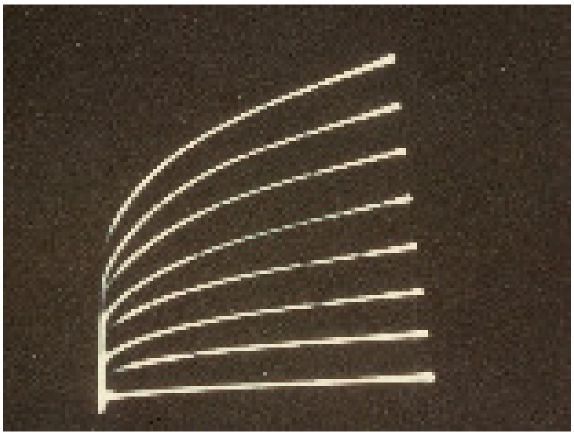
Dynamic matching means that each device is tested by hand, with careful observation how the device performs over the full voltage range (in power amps: 0-300V) and current (0 - 50A), a demanding and time-consuming task that needs full concentration. If then the transistor must be discarded as not meeting our standards, the value of that transistor has become nil; of course, the time analysing it has also been lost.
It is argued that this extreme care and time consuming procedures are not cost effective and massively increase the final price of the product. That is correct.
However, in reality tolerances of 50-300 % of the specified data are common within the same semiconductor type. 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, not to talk about lower reliability.

FM ACOUSTICS adheres to a "Zero tolerance/Zero compromise" philosophy. Experience by most demanding professional clients worldwide has proven the value of the philosophy of "use the best, then select it to achieve even better - whatever the cost".

The transfer curve pictures on the next pages are taken from actual transistor tests. Note that these pictures only depict the *static* situation (at a specific point in time). The unique *dynamic* testing procedures used at FM ACOUSTICS is much more revealing than a static test.However some differences are obvious even on static pictures as below.

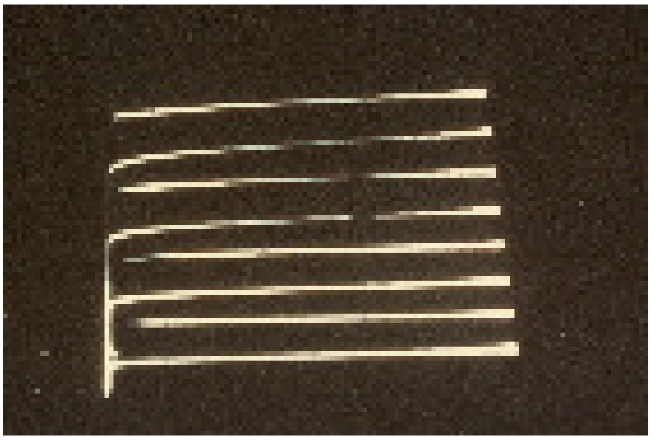
Picture 1

shows an FM 17417 transistor which was used in early models of our power amplifiers. This picture shows typical curves of a power transistor with reasonable distribution at higher voltage levels; somewhat upwards angled traces, requiring precise thermal control and compensation to avoid "thermal runaway". Some non-linearity is evident at low voltage which requires special circuit treatment.
These were pretty much the best transfer curves for a fast power transistor at that time.
Dynamic analyses shows a positive temperature coefficient which means that the transistor's current gain increases with temperature. If not carefully protected the device becomes thermally unstable, the cause of many ordinary amplifier failures.

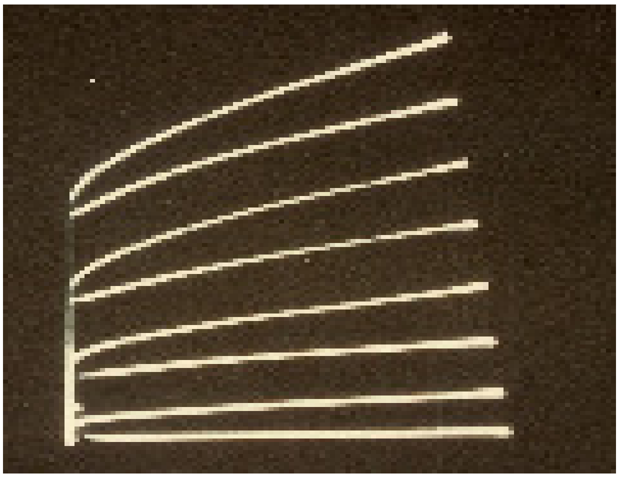


Picture 2

shows an FM 17418 power transistor. The transfer curves are much more linear and more even than those of the FM 17417. This transistor is thermally more stable and can stand higher temperatures for longer without thermal runaway.
Intensive R & D over several years resulted in this unique transistor that can handle high current at the same time as high voltage and this at very high speed, a combination that is unique to these FM ACOUSTICS power transistors.
It is a more stable choice providing considerably higher performance possibilities than ordinary power transistors.



In precision audio equipment only the labour-intensive ***complete*** *analyses* of the full operating range of the semiconductor yields optimal results. Precisely selected transistors are carefully matched not just in the output stage but in each stage of FM ACOUSTICS products. If transistors with identical characteristics are used in the positive as well as negative path of true Class A stages, the stage can be inherently distortion-free and does not require error correction. Obviously, an inherently distortion-free amplification stage provides a massive advantage over one that uses transistors that just passed a simple β-test - no matter what circuitry is used. An non-optimal stage is inherently compromised even when trying to compensate its limitations by error correction circuitry.
Part of the difference an FM ACOUSTICS makes is due to these comprehensive selection procedures and this can berather audible.

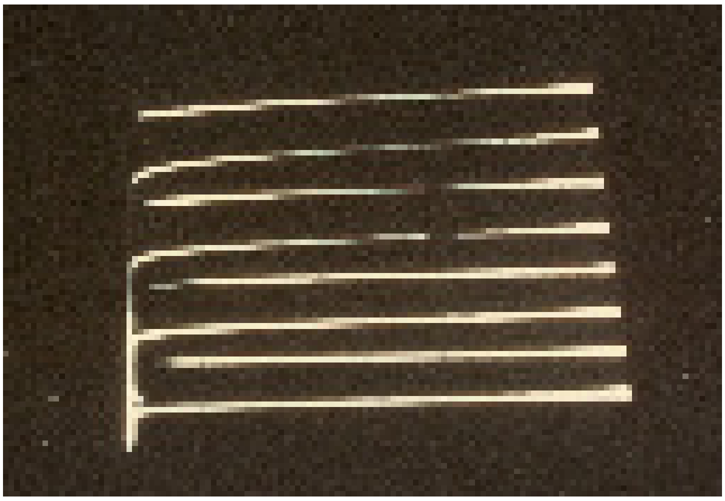


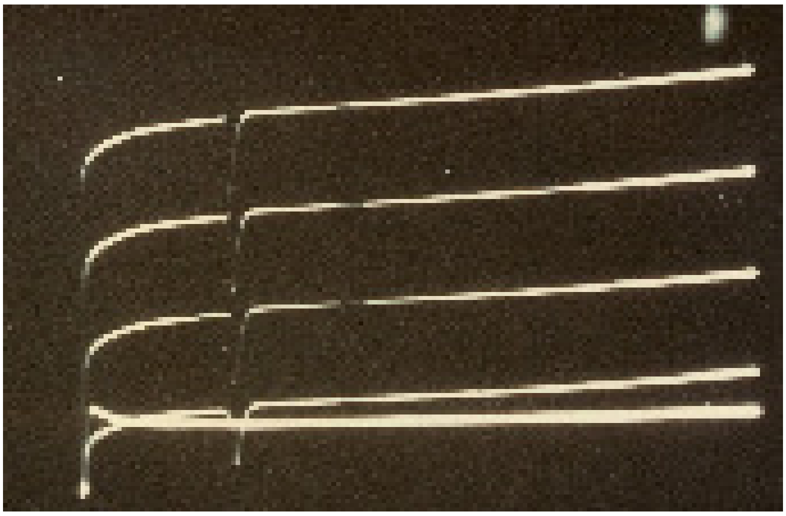
Picture 3

shows a medium power high-voltage transistor, that used to be available from several manufacturers. As usual, data are very basic and actual product characteristics vary tremendously. Each manufacturer’s version delivers quite different results.
Transfer curves on this example show a somewhat uneven β distribution and upslanting curves but otherwise they are reasonably clean.
This transistor was the best that could be supplied at that time.

Picture 4

shows the curves of the same transistor type of a later production.
This has been selected and is what is used at FM ACOUSTICS.
The differences are obvious: much improved transfer curves and better linearity.
Again, this is a picture that depicts only the *static* situation. Under *dynamic* analyses (carefully performed by hand) much better performance than the device in Picture 3 is obvious.





Picture 5

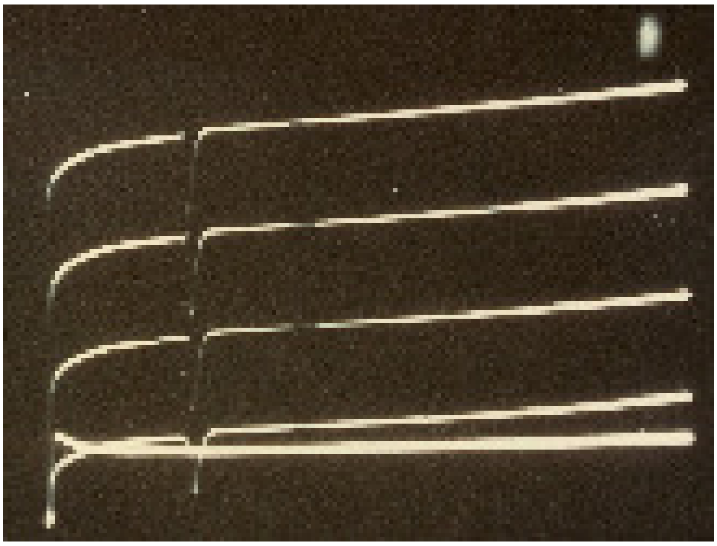
Shows the same transistor that has quite satisfying transfer curves, but a sharp spike can be observed. This spoils the quality of this transistor for precision audio. The spike may not be a problem if the transistor is used in non-audio applications. However, in an amplification stage, these spikes create distortion below clipping. The ear will be disturbed by such unnatural artifacts which are not present in the original music signal - the result is listening fatigue.

With the usual - rather crude - audio measurements an amplifier using such "spiky" transistors may show normal readings. However, despite the normal reading, the sharp spikes are detected by ear (the standard audio measurements techniques are often meaningless to reasonably quantify audio quality. One issue is that these measurements are *static* instead of what would be a more realistic *dynamic* analyses. After all, music signals are hugely complex with constantly changing harmonics, colour, dynamics etc. (well, maybe not absolutely all music, but the music worth listening to...).
However, no established measurement procedures for dynamic distortion exist.
Such differences are detectable by ear as an artificial and rather unpleasant mid- high frequency reproduction, a characteristic that has helped to provoke the negative term "transistor sound".

When using carefully selected components (and if designed correctly),well executed transistor circuitry can achieve superior results with absolute freedom of harshness, colouration - and with unmatched dynamic range and fine delineation of micro dynamics.
But, just like in musical instruments, it is careful *selection* and craftsmanship that make all the difference.

Picture 6

shows another example of the same semiconductor as in Picture 5. Here, spikes appear at a somewhat different voltage (and in dynamic analyses also show some overshoot).
Only because of the *complete dynamic* selection which is performed by hand on each individual transistor - can such inconsistencies be noticed. In usual amplifiers such defects go undetected with the consequence of compromised or outright poor sound.
These are reliable and fast high voltage transistors, but only when they passed careful static and dynamic curve-trace analysis do they become a top class device for audio applications.



These selection procedures add considerable expense to our products. But FM ACOUSTICS does not compromise and always selects all of its parts with special - in-house designed - test equipment (the exception is the MIL spec. metal-film resistors which do not need to be selected as their tolerances are very tight and the failure rate is less than 1 part per 5 million pieces).

Fact is, that with the standard audio measurement techniques, not all anomalies and distortion types will show up - despite that these are detectable by ear. The above gives an indication why it is essential that components in general - and semiconductors in particular - must be analysed individually with the utmost of care.
A quick check with a β-meter to "pair" transistors is what others are boasting about. It is far from satisfactory as such a test only depicts the result of a single value at one voltage and one current.

Only precisely matched semiconductors that have been thoroughly analysed *dynamically* over their entire range of voltage and current will detect non-linearity, spikes, discontinuity etc. that could play havoc with the music signal.
These are obviously time consuming, tiresome and "non-economic" procedures, but they pay off in much higher accuracy of music reproduction.

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