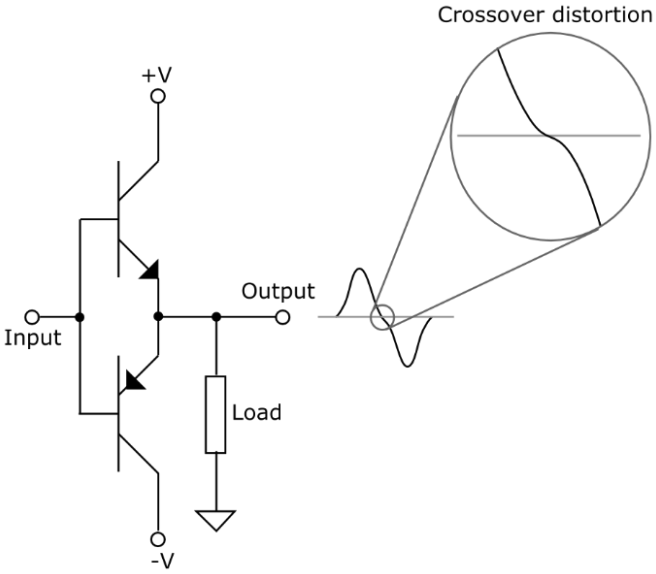
## Is CLASS A/B always the same, regardless components used?

## Transistor versus Hexfet/Mosfet.

In order to let a symmetrical power amplifier work as linear as possible, both power transistors need to be "conducting" a bit in order to let them work in the linear range. Even more important is that this is needed in order to avoid so called Crossover distortion. . This setting is known as class A/B.

If the idle current of a power amplifier is set too low, crossover distortion is shown. Nice phrase, but how does it present itself? If you connect an oscilloscope to the output of your amp and feed it with a sine wave signal, this distortion can be seen at the point where the sine crosses the zero point. This setting is known as class B.

Why does this happen?




If the idle current of the power stage is set to low (see figure on next page) neither of the transistors will "feed" the output, resulting in a short period of 0 Volts at the output. Actually at that point the speaker is "disconnected" and so out of control since both transistors are not conducting at all. In sound this could be explained as some rough edge around the overall sound, so most unwanted.

What to do to avoid this distortion?

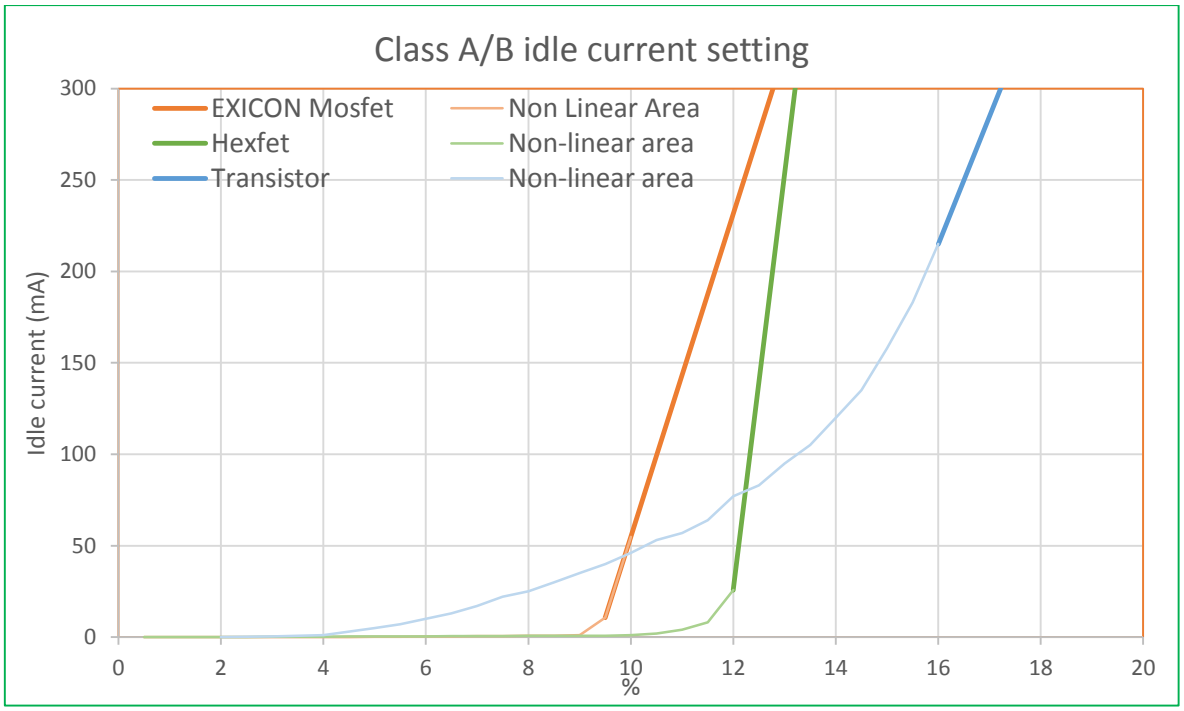
If we (and we do) want to avoid this distortion we need to make sure that both power transistors are conducting more or less. But how much? This can be done in different ways, and the final results are influenced by the linearity and quality of the components used. Below a table for REGULAR transistors where all info is given with the amp in idle state:

| | | |
|---|---|---|
| Class A | Power transistors are conducting around 50% | Extremely high sound quality, but very low efficiency or in other words: the amp will become really hot. Reference amps. |
| Class A/B | Power transistors are conducting around 15% | Very high sound quality with way better efficiency. HiFi/High-End amplifiers. |
| Class B | Power transistors are just conducting | Average sound quality with quite high efficiency (PA-amplifiers). |
| Class C | Power transistors are just NOT conducting | Very high efficiency, but bad sound quality. Used in RF-transmitter systems only. |
| Class "D" | Power transistors are switching very fast | Average sound quality with very high efficiency above 30% of rated output |

Around the millennium change, electronics became fast enough to fix this efficiency “problem” by introducing switching, or Class D amplifiers. We believe that with our approach, we are in between the commonly used class A/B and class D efficiency, BUT maintaining the superior sound quality of class A/B linear amplifier designs. That is: with average practical power of just above it.

But class A/B setting generates quite some heat, right? WRONG! Class A/B tells nothing about the energy an amplifier it is using; it only tells you in what way the power stage is set. How this has to be done, is strongly depending on what type of power transistors are used!

In the figure below I try to make this understandable:




Horizontal represents the % of conductance, vertical the current of the output stage (idle).

A regular power transistor (blue lines) has to be driven quite far in order to make it work in the “linear” range of this device, since the beginning of the curve (light blue) is very nonlinear. So we need to bring it into the dark blue zone (=A/B) by setting the idle current quite high (150-250mA). Unfortunately a regular power transistor is not linear at all, causing a lot of odd harmonics due to this. Humans (and cats and dogs!) experience this as unpleasant.

Another fact is, that regular power transistors can only handle up to 10A, so in high power (capable) amplifiers two or even more pairs of transistors are required. This results in the heat generating amplifier designs we all are aware of, also giving class A/B a bad name.

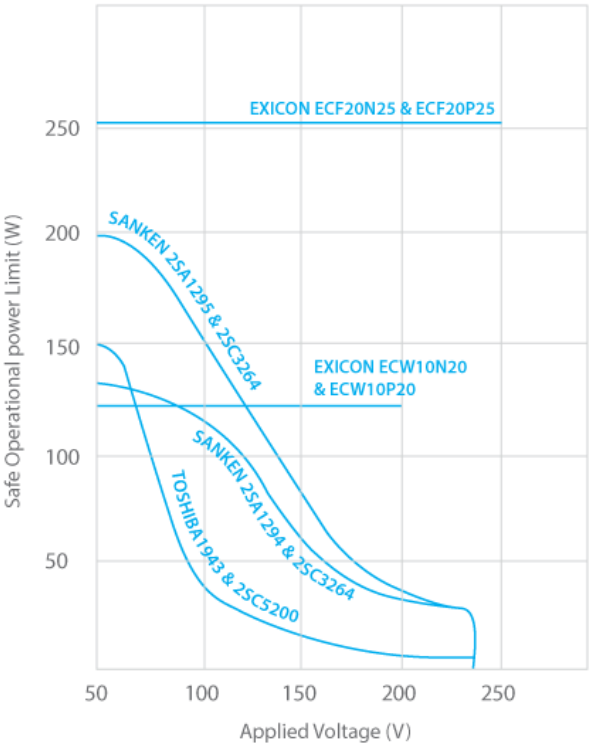
A Hexfet as we use them (green lines) is at first about hardly conducting at all, and then rising quite fast AND very linear immediately. This can be noticed if you adjust the idle current of our amplifiers. At first nothing happens at all while turning the trim potmeter. And then, it comes “alive” unexpectedly fast. With our models an idle current of 20-40mA brings it well inside the dark green A/B zone, so a Hexfet has a way lower class A/B point as a common Power transistor shows.

The idle current causes a large part of the heat (read efficiency) produced, so in idle mode our amps just become warm slightly. Furthermore, our Hexfets can handle over twice as much power as a

regular transistor, so where a A/B set Hexfet amplifier uses 30mA, a similar transistor amplifier has to be set at 2x200=400mA…… This is about 15 times more.

A Hexfet produces very low level even harmonics like tubes do as well (but way higher levels). IF noticeable at all, we experience this as pleasant, also known as a "Tube" sound.

Just in September 2014 we discovered some unique power Mosfets, developed by a British company called EXICON (EXcellence In semiCONductors). They just and only develop and produce three types of power Mosfets, especially designed to be used in the **highest quality linear amplifiers** available. Besides the fact that these lateral Mosfets have unique linear behaviour without ANY irregularities transistors and Hexfets have, they start conducting at a unbeaten low level of just 10mA already. From that point on they behave extremely linear (=A/B), noticeable in about absence of harmonics.




Mosfets? They break down easily, right? Right so far. Former models of power Mosfets were known for their nice sound, but also for the fact that they break down easy. This was caused by a limited SOA (Safe Operating Area) range. With the EXICON's this problem is also solved; there simply is no SOA area as with all other power transistors, see the graph right coming from EXICON:

Compared to our more "common" Hexfets they are way more expensive though…….. We decided to use them in our new (H)RQ models, RQ =Reference Quality. Check our updated info's @ www.eltim.eu.

HQ is using the ECW10xxx TO247, 125W models

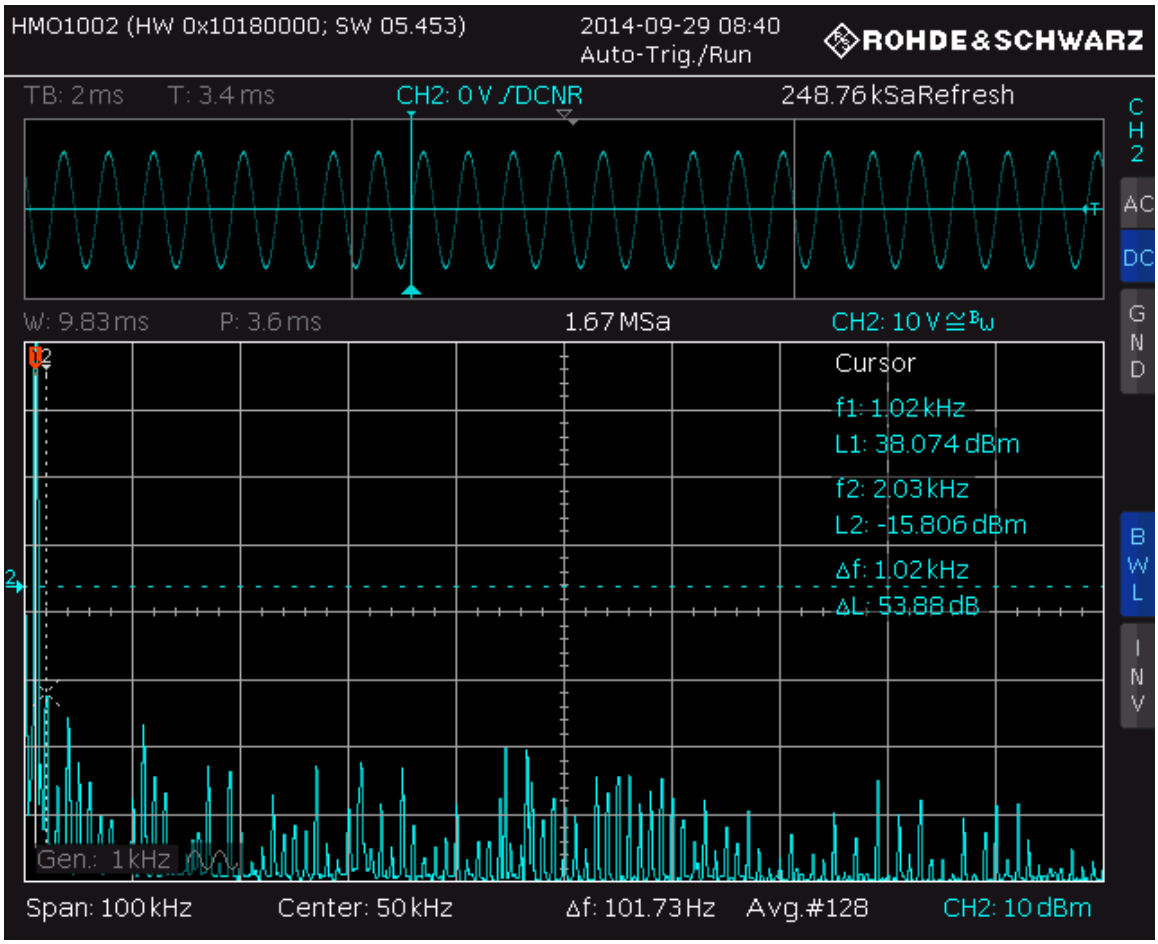
HRQ is using the ECF20 huge TO264, 250W models.

We tested it by driving a CS-80 RQ for 24 hours/60W into a 2 ohms load while using a calculated way to small heat sink. Not the slightest problem, while it was about "red hot"……

Figures are always measured at full power, but in practise a listening level of not even 1 Watt is above normal speech level already. That would be about 90% of the way you use it, right? In that case our amps hardly draw current while a class D is switching and switching and….dying after a few years already. NOBODY mentions it, but Class-D efficiency is always related to full power use. Then it is 94% indeed. This indicates that f.e. a 100Wrms amp would dissipate around 6 Watts (duhhh) all the time. BUT this 6 watts is taken regardless what the amp is producing. At 1W output, efficiency is only 16%..... and more than our A/B designs do.

A 100Wrms ELTIM class A/B is then using around 6 watts as well, so in our opinion class-D only makes sense if it has to be small and/or performing >30% of rated power all the time. This cannot be done with regular power transistors. With today's components quality, one can build a fantastic sounding power amplifier, working in a very acceptable class A/B setting ! Why? Because the transistor A/B setting we have in our mind is not the same as Hexfet nor Mosfet A/B.

Below a frequency domain picture while testing this CS-80 RQ model:

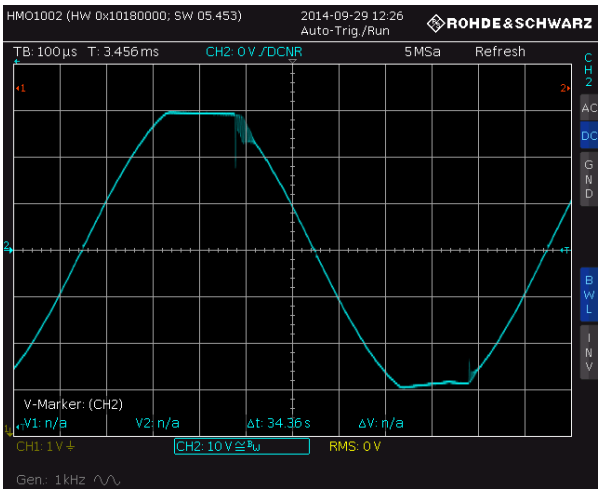



All “harmonics” are more than 50dB below the base signal of 1kHz, measured at full power.

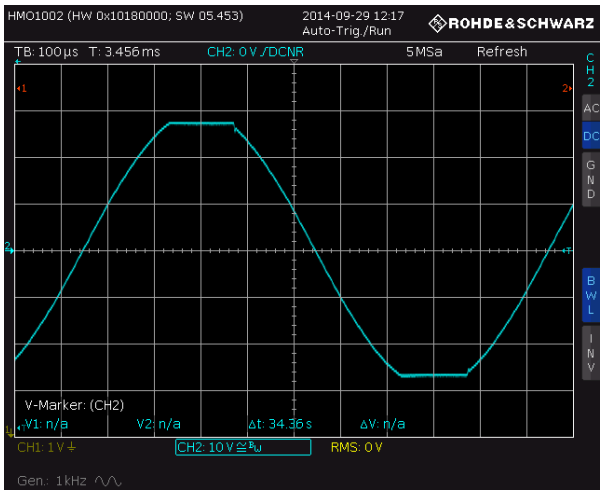
Please note that your volume control of your amplifier only has a 60dB range or less, just to give you an idea about the difference in level. A transistor design not even comes close to these figures.

| **Pro’s & Contras of Transistors, Hexfets and EXICON Mosfets** | | | |
|---|---|---|---|
| | | | |
| | **Transistor** | **Hexfet** | **EXICON Mosfet** |
| Knowledge | High | Low | Very low |
| Way to drive | Commonly known | Easy, but different and how? | |
| Frequency range | Average | High | Very high |
| Impulse power | Average/modest | Very high | High |
| Impulse response | Modest | Accurate | Precise |
| Slew Rate | Modest | Very high | Extremely high |
| Peak power | Average | Very high | High |
| Break down | Easy | Hardly | Not |
| Efficiency | Modest | High | Average |
| Linearity | Average | High | Very high |
| Sound quality | “Technical”, explained as A/B | Tube like open sound | Clean linear |
| Harmonics | Odd (unnatural) and average | Even (natural) and low | About none |
| Clipping behaviour | Huge harmonics | Small HF-oscillation around signal peaks | Soft clipping without any irregularities |
| Temp. stability | Low (pos. temp. coeff.) | Very high (neg. temp coeff.) | |
| Paralleling | Most difficult | Very easy | Most easy |
| Availability | High | Low (esp. P-channel) | About not |

We believe the “Clipping behaviour” text needs some more explanation:




A Hexfet tends to show some high frequency oscillation when driven into clipping (Vout reaches voltage rails levels). as visible just after the positive top.




A EXICON Mosfet is totally free from any irregularities when driven this way.
Notice the slight (2-4V) voltage drop over Mosfets

A Hexfet can be driven closer to the voltage power rails (+-30V here) and can so deliver more power with the same voltages applied. This also indicates a higher efficiency of Hexfets around full power.

A regular transistor can show the strangest effects while driven into clipping and even collapse sometimes.

Due to the way we build our amplifiers and the quality of the components used, you could drive them in class A as well actually. However we don’t see why we should, since the specs will hardly become any better. It’s just the thought: “Class A is better” with old transistor behaviour in mind….. We hope that with the explanation above you understand that this is no longer true.

Today we see the use of Class D amplifiers more and more, which is actually a shame. We believe that if more people had worked on amplifiers using these fantastic Hexfets and Mosfets, Class D amps would not become the “hype” it is known for today, all for the sake of saving a few Watts of power consumption. A class D only consumes less power itself while used above 30% of the maximum power. Please note that while playing just above speech level your amp not even delivers 1 watt, which is at least 90% of the time you are using your amp!

And then think of this one: the amp is in your living room, not outside, so the energy isn’t lost at all ! It’s just helping your heating system a tiny bit……

With our designs we proof that it is not necessary to use class D in order to “save the planet”. In fact, in regular daily use our designs spend less energy that modern class D designs do.

**We produce and sell products lasting for many years, not just “jumping” over the warranty period.**

**Please check our website [www.eltim.eu](http://www.eltim.eu) about these fantastic performing amplifier designs.**

**We provide them as DIY kits, hand built modules AND hand built ready amplifiers (soon…)**

**ELTIM, Louis Timmers 2014**