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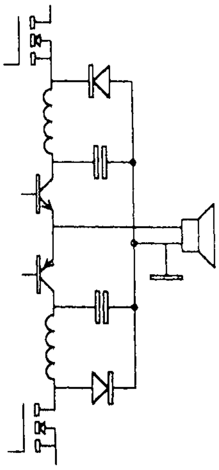
Introduction to the Class TD Technology

Class TD facts

- Class TD stands for Tracking Class D.
- Class TD is an evolution of the Class D technology. Class TD achieve a better sonic performance.
- Class TD is the solution to avoid all the drawbacks of Class D, but obtain close the same high efficiency as Class D.



Class TD simplified;
The Class AB output driving the loudspeaker

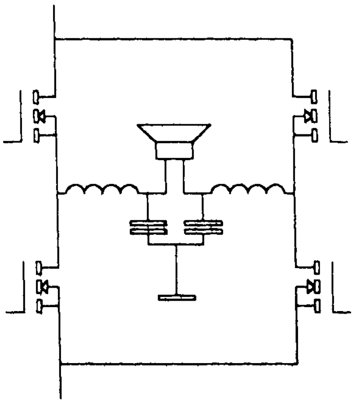
Class TD waveforms; the Class D converters tracks the audio signal

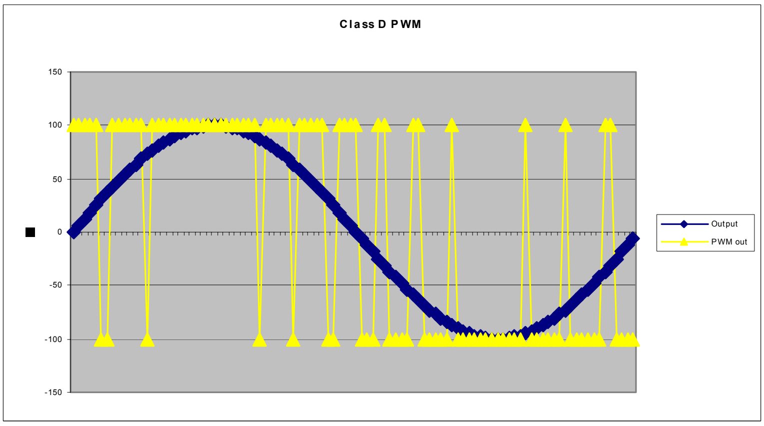
The Class TD power amplifier uses a conventional Class A, AB or B amplifier to drive the loudspeaker directly without any recovery filter as is necessary in the Class D amplifier. A dual Class D amplifier supplies the Class A, AB or B amplifier with rail voltages, which tracks the audio signal at full speed up to the highest audio frequencies. The Class A, AB or B part of the Class TD amplifier will perform with the same sonic quality as a conventional Class A, AB or B amplifier.
The Class A, AB or B amplifier part of the Class TD will also act as an active filter to reduce the radio interference noise created by the high switching frequency in the Class D amplifier.
A Class TD amplifier can therefore easily satisfy the EMC-requirements (Electro Magnetic Compability) without an extra output filter.

- The first tracking supply power amplifier was patented by Jensen back in 1969.
- The Jansen patent was a single ended Class A type of amplifier with high efficiency.
- Lab.gruppen applied for a patent for a Class TD solution in the 1990.
- Lab.gruppen holds patent today in the US and most European countries
- The Lab.gruppen solution achieved a low distortion and low radio interference high power amplifier.
- The Class TD is implemented in Lab.gruppen’s LAB 2000 and LAB 4000 and the new fP 3400 and fP 6400.

Class D facts

- Class D is a power-amplifier principle which using Pulse Width Modulation (PWM) to achieve high efficiency.
- The PWM signal consists of square waves, which minimize the power losses in the output stage of the power amplifier.





Class D simplified;
recovery filter driving the loudspeaker

Class D waveform; PWM signal driving the recovery filter

The efficiency of Class D can be up to 95% at full power.
This means that a Class D amplifier delivering 950W, only waste 50W in heat and consume 1000W. At normal music, the average power will be around 10dB down from full power. At such level the Class D efficiency will be around 80%. This is the value that can be compared with the Class AB efficiency of 20% or the Class H of 50% at normal music level.
<u>The high efficiency is the only benefit for the Class D compared to Class A, AB and B. There are no benefits in the sonic quality for the Class D over the Class A, AB and B amplifier!</u>

- Sullivan patented a Class D tube amplifier in 1961.
- Herbert developed the Class D power amplifier further in 1971, with the full bridge transistor topology. The full bridge topology improved the reliability for the Class D amplifier while driving reactive loads.

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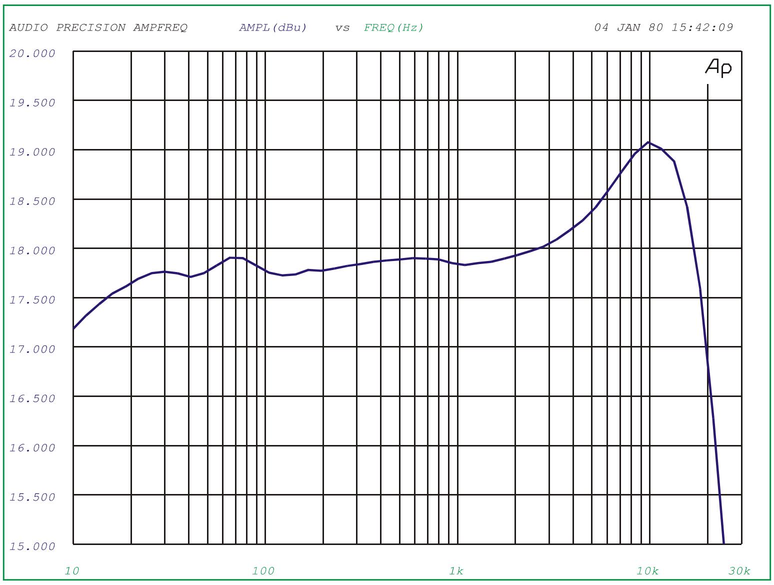
Class D drawbacks

The Class D power amplifier needs a recovery filter between the output stage and the load (loudspeaker) to filter out the audio signal from the PWM square wave signal.

This filter can only be optimised for one load impedance, which means that it will create a non-flat frequency response for reactive loads. This will colour the sound.



A 2-way passive loudspeaker driven by a commercial Class D power amplifier shows a non-flat frequency response

The recovery filter has to be steep filter slope to reduce the radio interference, which will be conducted via the speaker cables. To create a steep filter it requires several reactive components, which destroy the damping factor at high frequencies.
A steep filter also destroys the phase behaviour of the signal. Too much phase distortion minimizes the ability to compensate the output stage and filter with negative feedback.

Negative feedback is needed to minimize non-linearity that produce distortion and lower the output impedance to achieve a good damping factor.
The only way to use a simpler recovery filter in Class D power amplifiers is to increase the switch frequency. Most Class D amplifiers use frequencies from 200-500 kHz. A switch frequency around 3MHz (3000kHz) will be needed to get the same performance of the simpler filter. The problem is that there are no output transistors available today, which can switch at such high frequency at high power.
Class D power amplifier suffers from bad reliability, as the high switch frequency makes the positive and negative transistors to cross conduct. Special timing circuits have to be used to solve the problem. However, these circuits produce crossover distortion.
A full bridge Class D is a solution that can be reliable for reactive loads.

A bridged Class D power amplifier can't be bridged as a conventional Class AB, H or Class TD, as the Class D is already bridged. The exception is if the two bridged channels has separate power supplies.

A Class D amplifier needs a regulated power supply or some kind of ripple compensation. The power supply rejection used to be bad (<60dB) due to the low negative feedback around the Class D amplifier. A PWM modulated signal is very sensitive for power supply ripple, as the ripple will be multiplied with the audio signal and create intermodulation distortion.

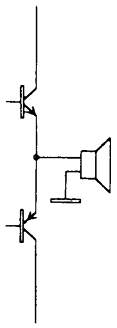
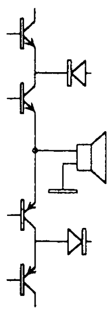
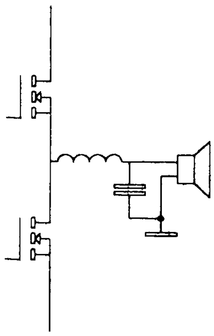
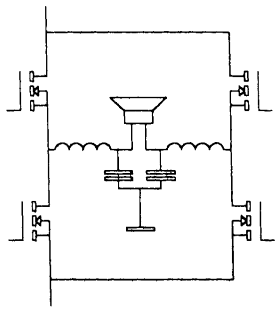
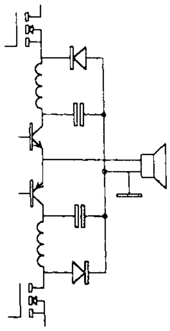
Class D vs. Digital Audio

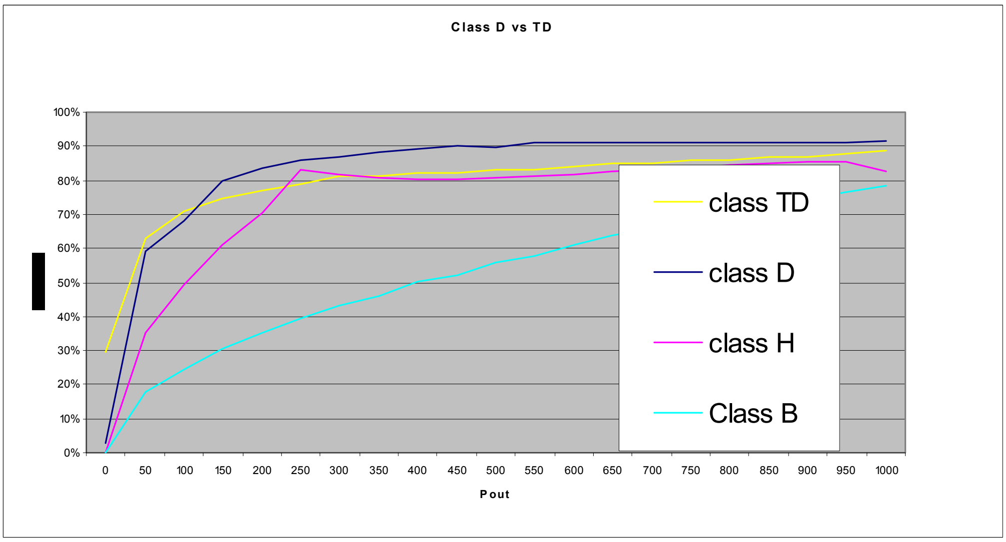
Digital Audio has been respected as the highest quality system for reproduced sound. This has been the public opinion since 1985. This has to do with the acceptance of the digital CD, introduced in the beginning of the 80's. Before that the public was used to the sound quality of the Vinyl LP disc. Different Classes for power amplifiers, such as Class A, AB, B and C has its origin back in the 20's among the tube (valve) technology. The operating Class determined the operation point of the bias system in the circuit. The operating point therefore determined the use of the circuit and its characteristics.
It's just by coincidence that the D in "Class D" is the first letter in "Digital". It's just a marketing trick by Class D amplifier manufacturer to link the quality stamp of Digital Audio to their Class D amplifier.
The principle for Class D is PWM, which is an analogue modulation method. The input signal to any power amplifier can be in the digital format, such as bit-streams or digital words, but they have to be converted by a DAC (Digital to Analogue Converter) to an analogue- or to a PWM- signal before amplification. The driving signal from a power amplifier to the loudspeaker has to be analogue, as all loudspeakers so far requires an analogue current and/ or voltage.

As long as we have to drive electromechanical loudspeakers we don't need any digital amplifier!!
The fact that the input signal is in the digital format doesn't imply that the power amplifier is digital.

Appendix

Comparison between different audio power amplifier topologies.

Comparison between different audio power amplifiers principles.					
	Standard analogue Class B	Multiple rail analogue Class H	Half bridge PWM Class D	Full bridge PWM Class D	Half bridge PWM + analogue Class TD
					
Efficiency	low	ok at high impedance	high	high	high
Output impedance at high frequency	low	low	high	high	low
Reliability	ok at high impedance	ok at high impedance	cross conduction possible	cross conduction possible	high
Handling of reactive loads	ok att low power	ok at high impedance	bad	good	good
Bridge mod operation	yes	yes	yes	no	yes
Noise and distortion	low	low	high	high	low
Constant power output	no	no	yes	yes	yes



The efficiency compared between different power amplifier principles and classes. These curves show 1000 watts amplifiers. The area of interest is between 50 and 300 watts, There the normal operation average power levels are for music and speech.