

Power Amplifier with Distortion Removal Circuit

<http://www.ne.jp/asahi/evo/amp/Dnfb/edc.htm>

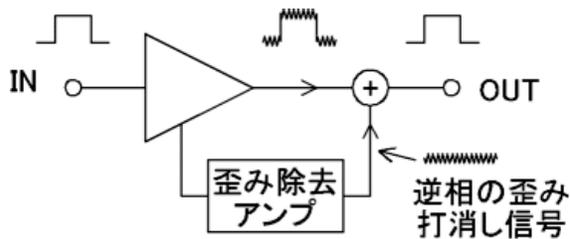
While researching various distortion cancellation mechanisms, I came across an equivalent circuit of a pure non feedback circuit in an article in "Technology Forefront Vol.14" of the May 1985 issue of the magazine MJ Radio and Experiment, titled 'Distortion Reduction in Non Feedback Amplification'. After some thoughts, the following is my experiment of this idea.

In the pure non feedback circuit, distortion occurring in voltage amplifier circuit is removed by feeding forward a negative image of the distortion to the output using a distortion cancellation amplifier. Denon (known as Nippon Columbia Music Entertainment K.K. in Japan) made a name for itself earlier with such a system of distortion free amplification.

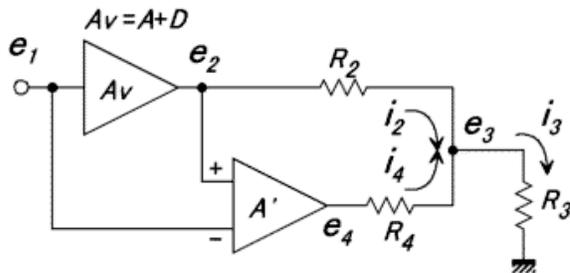
Similar basic principle was also implemented in commercial products such as the Yamaha ZDR (Zero Distortion Rule).

The NFB amplifier reduces distortion by subtraction, as opposed to by division in the feedback case. In the latter case, distortion is brought close to zero, but it is never exactly zero. Using the distortion removal amplifier, it is possible to make this 0. For this to happen, the cancellation signal has to retain its phase and amplitude. Since the distortion removal amplifier is not totally distortion free, its efficiency becomes questionable. Critics will say that it does not solve the essential problem, but only transfers the problem from the main amplifier to the distortion removal amplifier.

Basic circuit of pure non feedback circuit



Equivalent circuit of pure non feedback circuit



- A_v : 実際の増幅度
- A : 無歪み理想増幅度
- D : 歪み発生分
- A' : 歪み除去アンプの増幅度

$$\begin{aligned}
e_2 &= A_V e_1 \\
e_4 &= A(e_1 - e_2) = A'(1 - A_V) \\
i_2 &= (e_2 - e_3) / R_3 \\
i_4 &= (e_4 - e_3) / R_4 \\
e_3 &= i_3 R_3 = (i_2 + i_4) R_3 \\
&= \left(\frac{R_4 - R_2 A'}{R_2 R_4} \right) A_V e_1 R_3 + \frac{A'}{R_4} e_1 R_3 - \left(\frac{1}{R_2} + \frac{1}{R_4} \right) e_3 R_3
\end{aligned}$$

$$R_4 = R_2 A' \text{ ならば}$$

$$e_3 = \frac{A'}{R_4} e_1 R_3 - \left(\frac{1}{R_2} + \frac{1}{R_4} \right) e_3 R_3$$

As above, if $R_4 = R_2 \times A'$, it can be proven that the term involving A_V which includes the distortion term is eliminated.

However if sarcasm especially there is the distortion in A' , because that distortion is added anew, enlarging R_2 , it makes A' small and must decrease the influence of the distortion of A' . But when the distortion of A_V is large, because large output is required to A' , as for A_V it is necessary to be the amplifier where the originally distortion is small. If it is the amplifier whose A_V the distortion is small, as for A' because it becomes possible to be the small output amplifier, as for A' the operation where the distortion is little becomes possible, from the distortion decreases.

This system was adopted in Denon's POA-8000 power amplifier.

Experimental circuit

The experimental circuit is shown in the schematics below.

The pure non feedback circuit of the front end is equivalent to A_V of the equivalent circuit. The power stage is a Class A follower Q7, and the distortion cancellation circuit is formed by Q6 and Q8 which is equivalent to A' , which generates the distortion cancellation voltage via the source resistance of Q7 by the drain current of Q8.

As for the circuit when it does at first glance, the output step seems like the false complimentary push pull circuit which allots the inverted Darlington circuit underneath, but the hitting turning off of the distortion is possible by the fact that VR3 is adjusted.

The output DC voltage can be zeroed with VR₁, and the bias current is to be adjusted to 0.8A with VR₂.

VR₃ is adjusted such that the distortion is equal at no load and when loaded. The reasoning for that is that the distortion at no load is largely contributed to the voltage amplification stage. If the distortion at the output becomes equal with and without load, the output stage can be considered distortion free.

THD with 1kHz, 8Ω load is 0.025% at 1W, and 0.06% at 4W. Zo is about 0.3Ω.

Q₁ 2SK246 GR Q₃ 2SA1360 Y Q₅ 2SC1775A E Q₇ 2SK1529
 Q₂ 2SJ103 GR Q₄ 2SC3423 Y Q₆ 2SA1360 Y Q₈ 2SK1529

