

If one chooses to use a 2-transistor or 4-transistor current mirror, and does not want to do matching, then PMP5201 would be a good choice. Alternatively, for even lower noise, one can also use matched 2SA1312 instead.

When using 2SK332 or 2SK209, degeneration ($R_{5,6}$, P_1) can be reduced to 10R to recover the loss in open loop gain due to the lower Y_{fs} (12mS at 2mA). The much reduced source degeneration of the LTP also reduces sensitivity of input pair to CM noise (Groner ^[14]). The closed loop performance of the modified circuit, on the other hand, is still essentially identical to the original even under different loading conditions.

A 4-BJT Wilson mirror with matched h_{fe} should actually give lower distortion and also lower DC offset. With 150mA bias, it will still be capable of $\pm 3.5V$ at 30 ohm 200mW, $\pm 7V$ at 65R 370mW, $\pm 11V$ above 100R 600mW. Note that most high-end headphones are specified at 200mW, so this fits well. The emitter resistors in the current mirror $R_{3,4}$ are not absolutely necessary in a full Wilson mirror, so they may be replaced by 0R jumpers or reduced in value, should one wish to further minimise voltage headroom required.

If one happens to have a 100R headphone, and wants to be able to swing $\pm 10V$ (500mW rms) with low distortion, then one can consider swapping R_{10} with an Osram power TOPLED (LS G6SP). The LED adds another 1.8V to the voltage headroom for the current mirror, even at no current, thus ensuring that even a full Wilson mirror will always function. However the LED is rated at 200mA maximum, so it is wise to reduce the bias to 100mA as described in the original article ($R_{13} = 6.8R$).

Further Prototypes

Two more prototypes were built, using matched 2SK209GR for the LTP as well as for the CCS, 4x matched 2SA1312BL for the Wilson mirror, with $R_{3,4}$ reduced to 250R. The rest was the same as the original version. A slightly heavier Zobel network of 9R--22n was used also.

The same set of measurements were performed, and the results were essentially identical, with a slightly lower bandwidth of 700kHz due to the heavy Zobel. Even with 27R load, the -3dB bandwidth is still 550kHz. But if you know for sure that you shall only use the amplifier with $<50R$ load, you may well use the original values as specified by Borbely.

DC offsets were also around -20mV without trimming, even with slightly worse matching of the LTP ($6\mu A I_{dss}$) and much less degeneration. The clipping behaviour with 27R load was also identical with the original version. So there is no measureable disadvantage with the 4-transistor current mirror, except perhaps for slightly increased noise.

For those who do not wish to do any matching at all, a Plug & Play version can then be built on the same PCB, using 2SK332 (or LSK389 in TO-71) and PMP5201.

References :

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