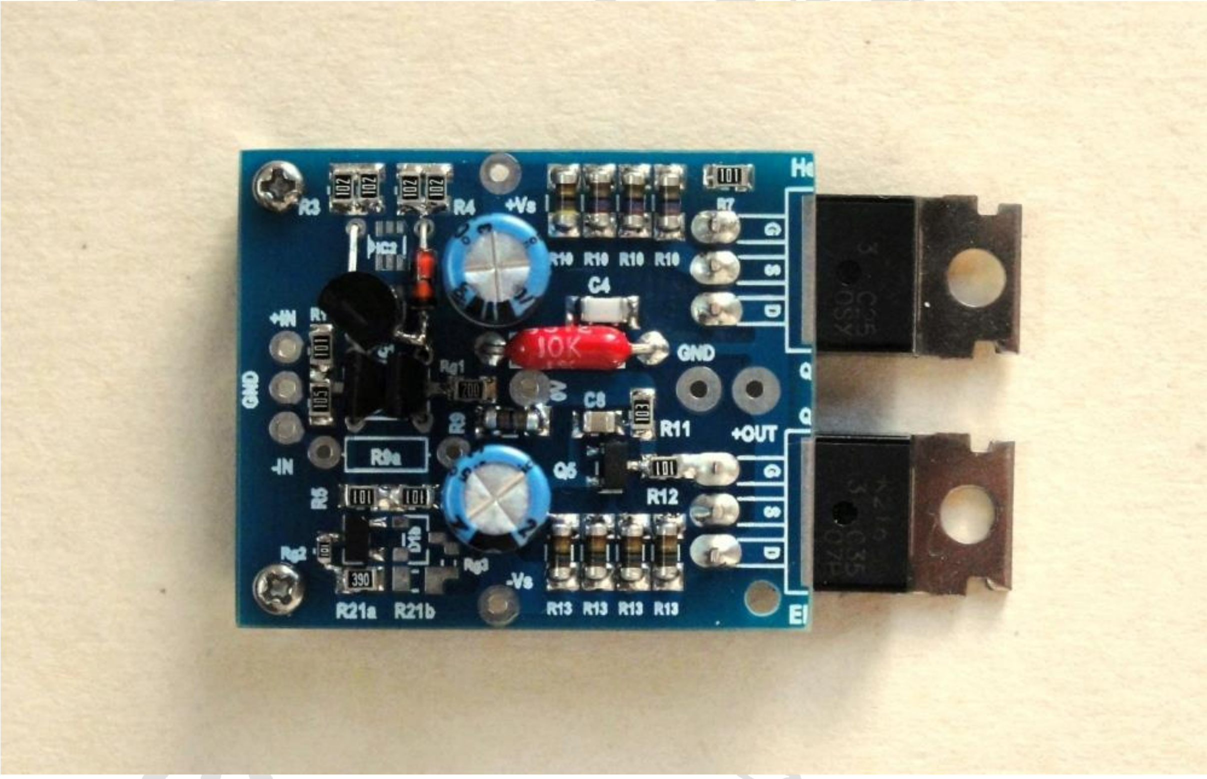
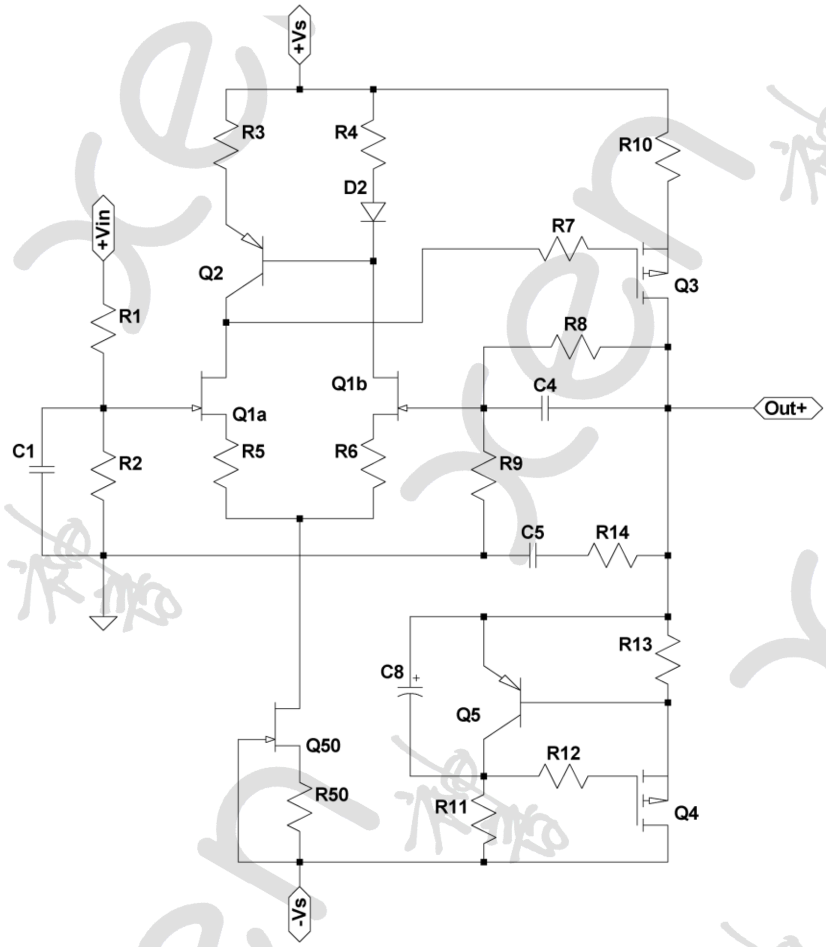
Borbely EB602/201 with Modulated Current Source
XEN Audio
May 2018



All PMOS

As the Renesas laterals have long been discontinued, they are becoming more difficult to get. For some reasons, the PMOS seems to be more available than the NMOS as of today. Since in the original EB602 only uses the NMOS as a constant current source, there is no reason why it cannot be replaced by an equivalent PMOS one.

There is a slight disadvantage in using PMOS. In the NMOS solution, the LP filter R11/C8 is referenced to fixed voltages at both ends. This can no longer be the case in the PMOS solution. So the PMOS CCS suffers a bit in terms of dynamic output impedance. The lower transconductance of the PMOS contribute to that additionally. The driver PMOS has a bit more current to deliver, and the distortion is slightly impaired.



Modified Schematics of EB602/200 with PMOS Current Source

Modulated Current Source

It was already explained previously how the output current is limited in the negative swing. This can of course be improved significantly by modulating the output stage current source out-of-phase with the load current, i.e. in push-pull.

One way of doing this is to use the Taylor Current Source [1] to modulate the NMOS CS in the original schematics. But with the PMOS version shown above, the current source can be modulated much more simply. All that is required is to split R13 into two and place the upper part between Q3 and output.

The operation of this modulated current source (MCS) can be explained as follows :

The current of Q4 is being controlled by Q5, which senses the voltage across R13 and keeps it at Vbe, at approximately 0.65V. In the CCS version, All the current of Q4 also goes through R13. Hence the current is given by 0.65V / 3.9R = 167mA and is largely constant.

In the MCS, however, the current of Q4 only goes through R13b, whereas the driving current of Q3 goes through R13a. If we consider AC analysis only, and assuming Vbe is approximately constant,

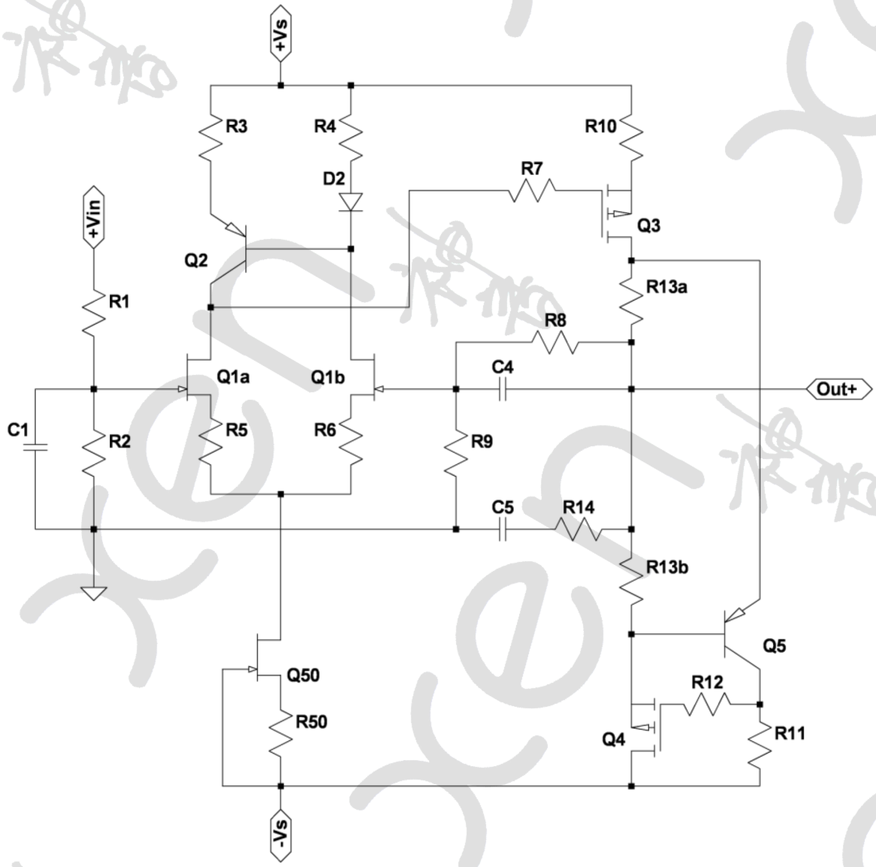
0 = i_Q3 x R13a + i_Q4 x R13b
i_out = i_Q3 – i_Q4

= i_Q3 x (1 + R13a / R13b)

In case R13a = R13b, for a given load, the output current is equally shared between Q3 and Q4, and the load on Q3 is essentially halved, thus lowering distortion. Note that as different to real push-pull, there is no even harmonic cancellation, and the distortion is mainly determined by Q3. Q4 is being forced to follow Q3 with the factor –(R13a/R13b) by the local feedback loop around Q5.

Distortion can of course be further lowered by increasing the ratio of R13a / R13b, as thus reduces the load to the driver Q3 further. But Class A current in Q4 is also limited. For maximum output current capability, 1:1 push-pull is still the optimum. In any case, it is a simple parameter to experiment with to suit individual taste.

The total DC bias is still given by Vbe / (R13a + R13b) as before.



Schematics of EB602/200 with PMOS Modulated Current Source

References :

1. https://www.tubecad.com/2004/blog0023.htm