Letters to the editor

Dear Editor,
With the following points I would like to comment to Joachim Gerhard's very interesting article in Linear Audio Vol 0, "Down the Rabbit Hole – Adventures in the Land of Phonostages", pp 31:

1. Figure 3: $r_{bb}' = 1.7\ \Omega$ of 2SA1085 and 2SC2547

Both transistors belong to the Hitachi (H) 2SA 1083 …. 1085 and 2SC2545 …. 2547 family with equal r_{bb}' values. I could determine $r_{bb}' = 13.74\Omega$ by calculation and the measurement result became appr. 14Ω. Please, could Joachim provide the source of his astonishingly low value? Or is it simply a printing bug without the "3" between the "1" and the decimal point?

2. Figure 3: $r_{bb}' = 2\Omega$ of 2SB737

I've found the same 2Ω value in Douglas Self's new book "Small signal audio design". Although the 2SB737 Rohm data sheet shows the same value, I am very much mistrustful of it. A look on Fig. 13 of the data sheet tells a different story. With these values and a bit of quadratic equation solving we will get $r_{bb}' = 7.5\Omega$ (rounded) at $I_C = 10$mA. This difference could only be explained by a solution I found on the data-sheet: below Fig. 15 we find equations on the input referred noise voltage. We can see, that an additional transistor internal resistance r_e plays a major role. It is some kind of emitter resistance and its value depends on the emitter current, hence it has not a fixed value at all.

For verification purposes I've gone through the calculation of Self's improved MC phono-amp that is driven by 3 input 2SB737s. Based on measurements with a 400Hz hp-filter and without A-weighting and RIAA equalization his measurement results are given in Table 8.3 of the above mentioned book. The main result: EIN = -141.0dBu. I could achieve a calculation result with $r_{bb}' = 7.5\Omega$: $EIN_{7.5}$ = -141.58dBu. I guess the difference comes from the 400Hz-hp (I've taken the 400Hz as the low corner frequency of an equivalent noise bandwidth) and the assumption I've made according to the hFE of the 3 transistors (400). In addition, I didn't include a calculation on the noise voltage of the collector

resistor in conjunction with the input noise voltage of the following stage.

With $r_{bb}' = 2\Omega$ the difference becomes worse: $EIN_{2.0} = -142.24$dBu. Consequently, $r_{bb}' = 2\Omega$ should not be used in calculations. It is simply marketing and does not reflect reality. However, with a realistic $r_{bb}' = 7.5\Omega$ the 2SB737 ranks 3rd in my list of single lowest-noise small signal transistors (1st is the 2SC3329, 2nd is the BFW16A with $h_{FE} > 40$ and a measured $r_{bb}' = 4\Omega$). I assume the same applies to the 2SD786.

3. On page 37, end of 3rd paragraph:

There is a tiny bug: the dynamic range of a DMM is -72dB(A). The equivalent non-weighted dynamic range would become -70dB, provided that there is no hum infection in B_{20k}.

Burkhard Vogel, Stuttgart, Germany.

Joachim Gerhard replies:

I thank Burghard Vogel for his astute comments, as well as for the subsequent discussions we have had over these issues. I got the information on the r_{bb} value of low noise bipolar transistors from the datasheets and other sources on the
Internet. I did not measure the values myself but will do that in the future. Mr Vogel and I have discussed how I can modify my measurement jig so that we talk the same language in the future. I was happy that we agreed on 2 Ω r_{bb} of the 2SA1316 and 2SC3329 so these specimen are really outstanding. When first told that the
2SB737 has a higher r_{bb} than in the datasheet and you derived your value from back calculating the noise in the Self stage I thought that the rather low standing current that Mr. Self uses was the reason for the discrepancy. I am now convinced that this value is correct, also for higher currents. I run my stages on much higher current because my users have usually cartridges with impedance lower than 10 Ω. For the 40 Ω Denon DL103 it is fine though. Still I will do my own measurements because I got curious. There are of cause other noise sources in bipolar transistors, foremost shot noise, which can be quite annoying if not selected out even when the transistors have very low r_{bb}. We have also started to discus how to measure that. Sorry that I forgot the A in the dB range of a DMM record; yes that value is in dBA. Measured in unweighted dB there could have been the impression that the dBA value is up to 2dB better.
By the way, I am looking forward to the 2nd edition of "The Sound of Silence" which comes out next year. By what Mr Vogel told me it has a quite mouth-watering content and 30% more pages than the 1st Edition. I wish I could be that productive! (this is an interesting remark from someone who comes up, on average, with several innovative circuit designs per month! – ed).