Letter to the editor

Burkhard Vogel writes:

Dear editor,

Many thanks for the publication of Ovidiu's kind review on my new TSOS-2 book. Of course, in the next edition I will get back to his valued recommendations concerning the book's basic structure.

However, in this book there is one point not satisfyingly carried out: in the BJT Chapter (5), page 65, I only mentioned a rather new transistor with extremely low data sheet based $r_{bb'}$ of only 2Ω, the Toshiba 2SC3329 and its complementary version 2SA1316. At the time of writing I had no measurement results nor could I get Toshiba devices from the market.

In the meantime this has changed and I could get enough pieces from a German supplier (www.sh-halbleiter.de, rather cheap: < €0.50 ea at 100 pieces), allowing me to perform measurements with the MC phono-amp at Figs. 15.5 & 28.2. It is the one with 4 BJTs in parallel configuration at the input.

In addition, and for comparison reasons, I performed the same calculation and measurement with the BJTs Douglas Self has chosen in his recently published excellent Elektor Electronics MC phono-amp design, the Hitachi 2SA1085. I use its complementary version here, the 2SC2547.

The results and good news for the BJT aficionado are given in **table1 and 2**. To sum-up I can say that for MC cartridge preamp purposes the 2SC3329BL driven phono-amp hits the calculated RIAA equalized plus A-weighted SN values within ± 0.5dB. So I think that the $r_{bb'}$ = 2Ω value appears realistic. In addition, the measured SN values for the 2SC2545…7/2SA1083…5 families hit the calculated ones too. Thus, the calculated $r_{bb'}$ = 13.74Ω value for this type of Hitachi BJT seem realistic as well (see TSOS-2's sections 13.9 & 13.10).

1/A	B	C	D	E	F	G	H
2	i/p BJTs		h_{FE}	I_C	$r_{bb'}$	$SN_{ariaa.i}$	
3	type	Ts paral-leled		mA per dev.	Ω per dev.	calculated [dB(A)] ref. 0.5mV at **43Ω**	measured [dB(A)] ref. 0.5mV at **43Ω**
4	1/2 SSM2210	4	680		30.0	-79.5	-79.2
5	2SC2547E/2SA1085E	4	550	1.667	13.7	-79.8	-80.1
6	2SC3329BL/2SA1316 BL	4	550		2.0	-80.1	-80.6
7						calculated / measured at **20Ω**	
8	1/2 SSM2210	4	680		30.0	-81.6	-81.4
9	2SC2547E/2SA1085E	4	550	1.667	13.7	-82.2	-82.4
10	2SC3329BL/2SA1316 BL	4	550		2.0	-82.7	-82.8

Table 1 SN comparison of three types of input BJTs, selected for MC amplification purposes

All Table 1 calculations are based on the Fig. 15.5 input configuration and on my Mathcad Worksheet 16.7. The 1/f-noise corner frequencies are too low to play significant role in the calculation process. All measurements were carried out at 1.667mA emitter DC current per device (trimmed by Fig. 15.5's P1). However, and depending on the input load, all SNs could be further improved by additional trimming of P1. The measured SN results of Table 1 show the worst case values for both channels.

The dance of the un-weighted noise curve on the scope's screen is a strong indication of the heavy movements of the BJT's charge carriers at low frequencies. Here, I observed that the Hitachi transistors played the strongest (negative) role, followed by the SSM2010 and by less nervous Toshiba devices. The measurement process with A-weighting or S-filter impact (see Section 15.5) will fully suppress these movements. Only intensive audibility tests could indicate negative impact coming from this low-frequency noise production. Currently, it's beyond the scope of this LTE.

The main differences on some important phono-amp input related features are summed-up in **Table 2**.

1/A	B	C	D	E	F	G	H	I
2	i/p BJTs		h_{FE}	I_C [mA]	$r_{bb'}$ [W]	$e_{n.i}$	$SN_{ariaa.i}$	$i_{n.i}$
3 / 4	calculated:					i/p referred noise voltage density [pV/rtHz/1kHz]	i/p referred SN ref. 0.5mV/1kHz [dB(A)] (i/p shorted)	i/p referred noise current density [pA/rtHz/1kHz]
5	1/2 SSM2210	4 x	680	4 x 1.667	30/4	464.3	-85.6	2.27
6	2SC2547E/ 2SA1085E		550		13.7/4	384.8	-87.2	2.43
7	2SC3329BL/ 2SA1316BL		550		2/4	315.6	-88.9	2.43

Table 2 Important calculated input referred figures of the three different input devices

Additional note: A change of the emitter resistance from 3.32Ω to 1Ω would further improve all SNs and i/p referred noise voltage densities; eg. the Table 2 values in the boxes G -5, -6, -7 would improve to (from top to bottom): 420.8 & 331.0 & 247.2 pV/rtHz/1kHz and all SNs would also improve by 0.4dB rounded (with 20Ω i/p load). Of course, the components of the RIAA feedback network would need a significant adaptation too: Cs x 3.32, Rs / 3.32.

This leads to the question on the right number of paralleled input BJTs. There is no right answer; however, a chart could tell us where we would end up - if current consumption would play no role (**fig 1**). It shows the i/p referred noise voltage density $e_{n.tot}$ at 1kHz vs. the number n of paralleled input BJTs (each 2SC3329BL at I_C = 1.667mA) with only one 1Ω emitter resistor for all input devices.

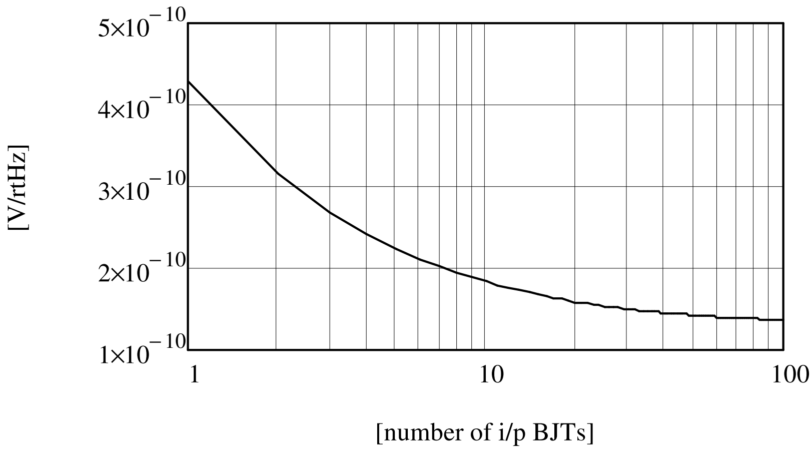

Fig. 1 Input referred noise voltage density at 1kHz vs. number of parallel input BJTs

The nasty disadvantage of paralleling BJTs > 4: the i/p noise current density grows with √n, thus more and more negatively influencing the SN figures with high-Z MC cartridges.

Burkhard Vogel,
Stuttgart, Germany