LOW TEMPERATURE TRANSFORMER READOUT ELECTRONICS

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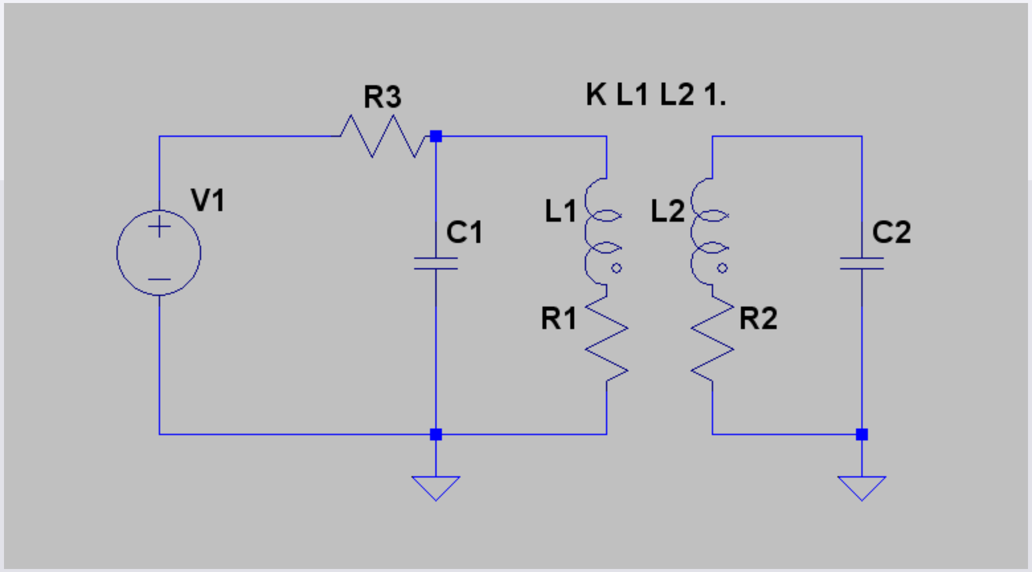
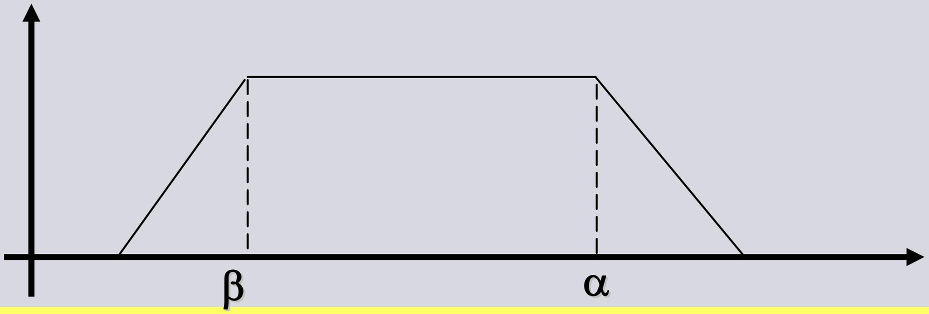
Introduction

- After some very preliminary test presented in LTD11, we fixed a few results on the use of transformers as passive elements for matching TES and conventional electronics.
- Not a new Idea (already used in the past)
- New -> Investigation for a very high noise performance and for a reliable circuital solutions for TES operation.
- Our work has been dedicated specifically to the DC operation with Voltage Bias at low frequency (10KHz).
- AC operation extension are under course (see MAX's talk) and very High-Frequencies seems to open new scenarios.

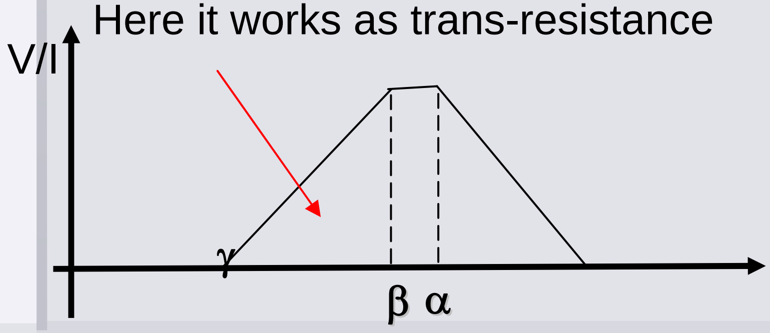
- Principle of operation

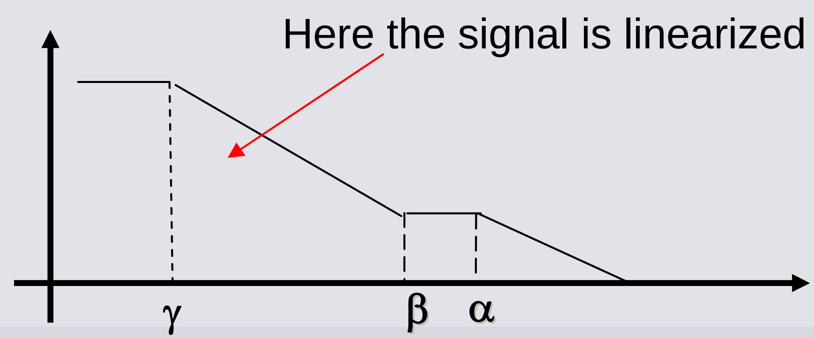


- $F(s) = n\ \tau\, \omega_0^2 [(s+\alpha)(s+\beta)]^{-1}$
- $\omega_0 = [L_s C]^{-1}$; $\tau = L_p/R_{TES}$; $M = [L_s L_p]^{1/2}$
- $\alpha = \tau\, \omega_0^2$; $\beta = \tau^{-1}$



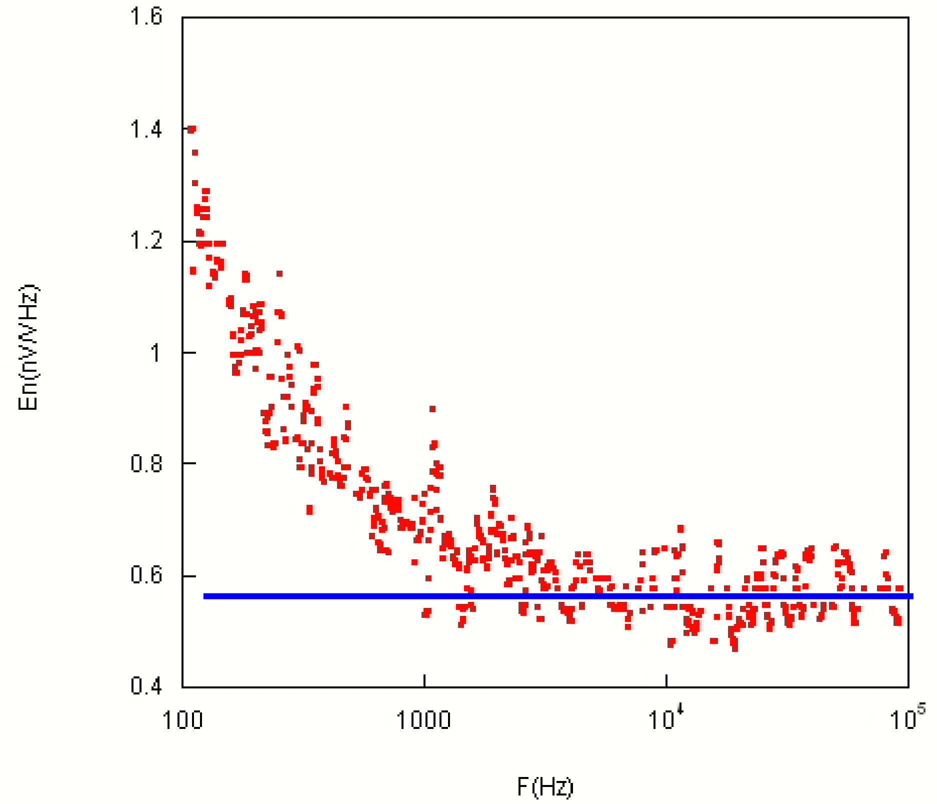
- Need to work in voltage BIAS-> $Z_{TES} > Z_{Lp}$
- Current signal is transferred at frequencies < β
- Increase β to cover detector bandwidth (10 KHz)
- Being L_p of typical transformer for low frequencies application at level of tenths of μH, Z_{TES} = 0.1-1 Ω



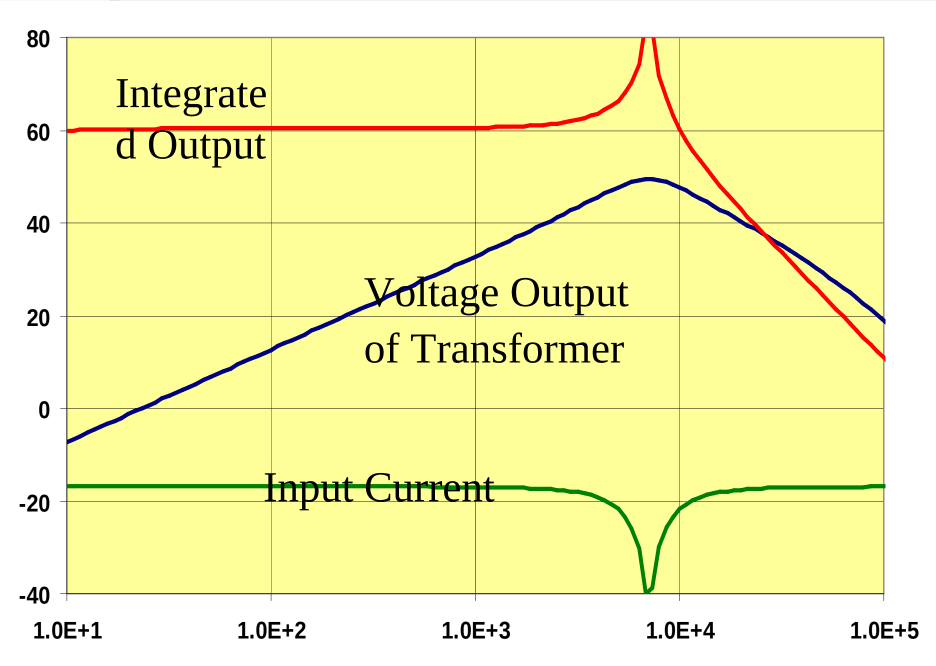


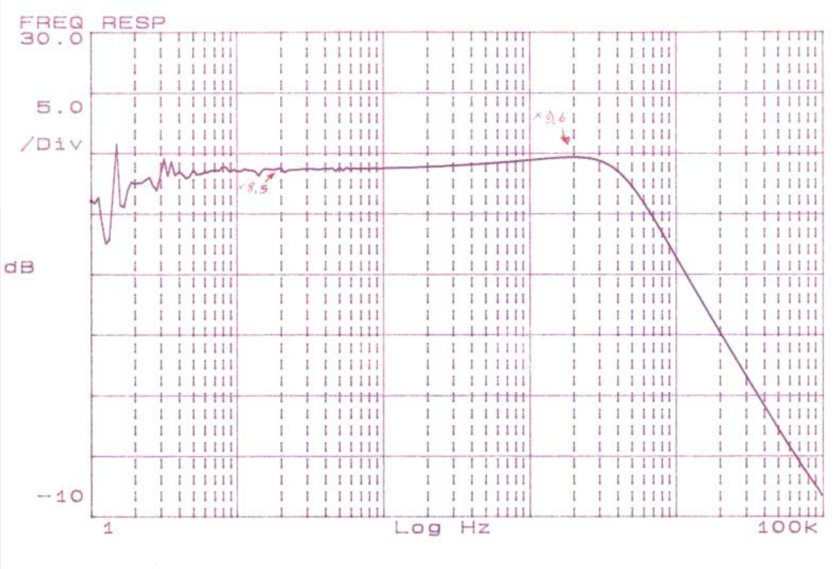
- Need of integration amplifier like Hi-Fi Amplifier for the pick-up coil signal

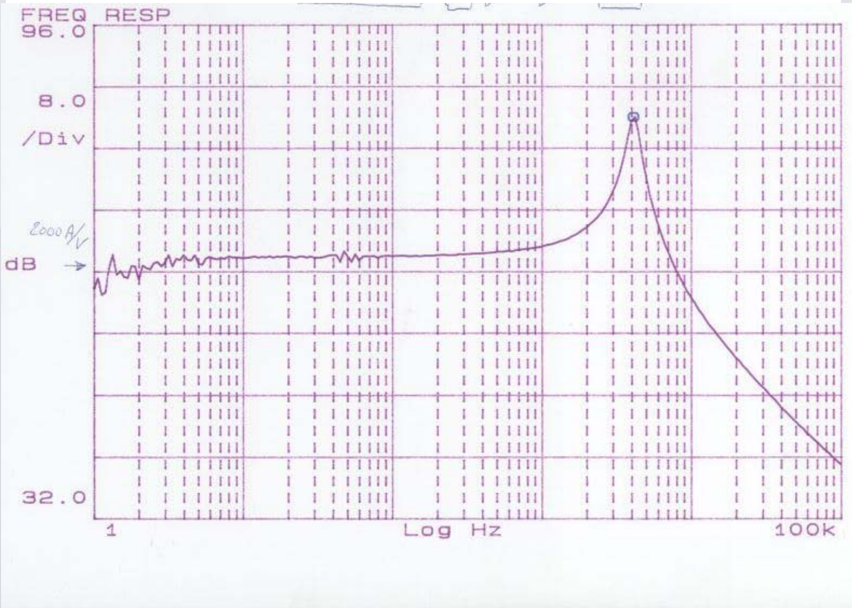
- The choice of the transformer is imposed by the noise performance of the amplifier
- We used room temperature amplifiers with 0.6 nV/√Hz
- Transf. gain in the range 300-900 (turns ratio)
- High μ core and capability to work in 0.1-4 K range.
- Transformer is on he Mix-Chamber, few cm from TES.



- Simulated and measured Transfer Functions



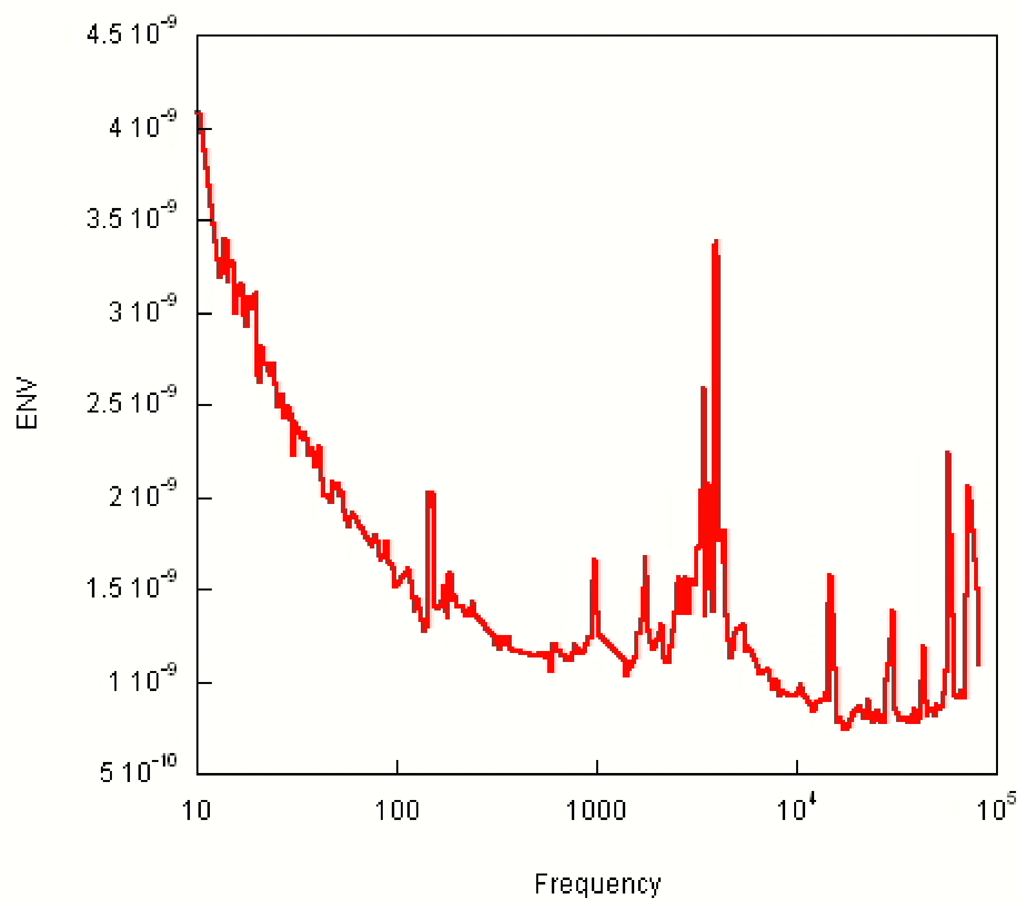




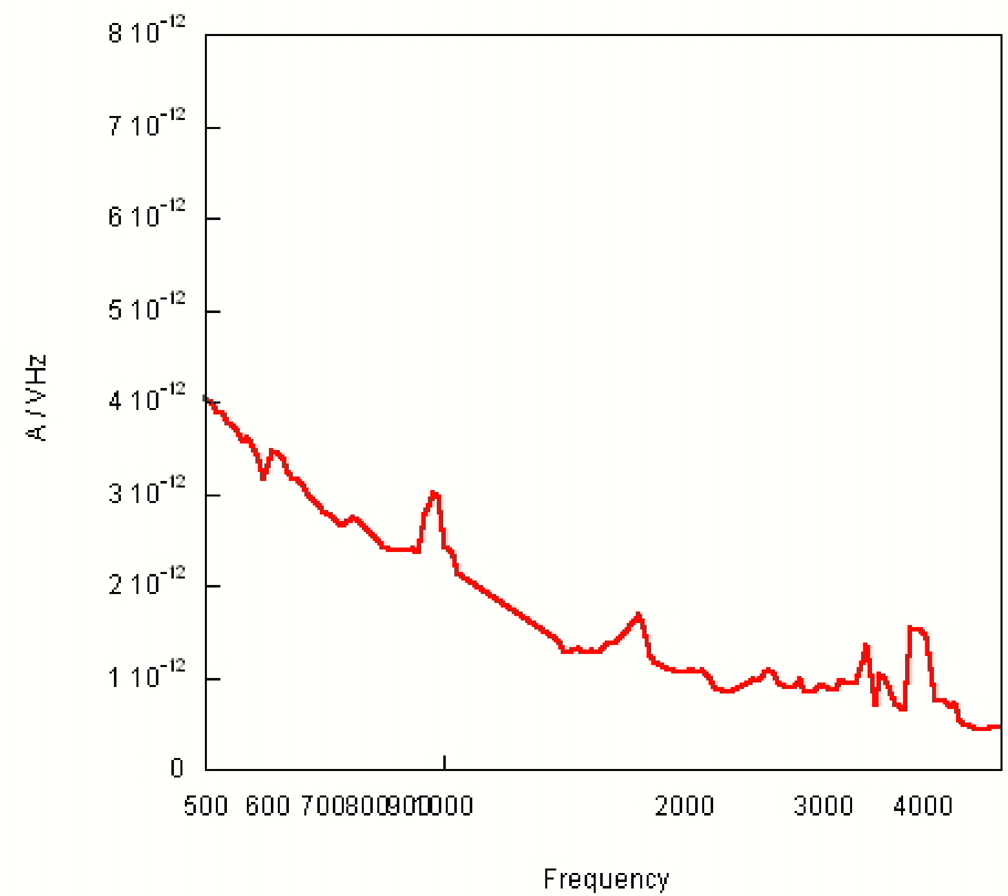
Transf Core selection

Core	F_{max}300K	F_{max} 77K	θ(77K)	μ77/μ300	μ4/μ300	Exc noise
Met.glass	>100Khz	>100Khz	89.6	76%		yes
“	>100Khz	>100Khz	80.8	77%		yes
“	9.6KHz	19Khz	80.0	64%		yes
Mu-metal	31 Hz	282 Hz	80.0	50%		huge
“	20 Hz	58 Hz	80.0	73%		huge
ferrite	>100Khz	>100Khz	83.0	8%		yes
“	57Khz	>100Khz	81.0	6%		yes
“	>100Khz	51Kz	80.0	84%	82%	yes
spinglass	10.8Khz	9.63kHz	80.0	84%	50%	no
Unknown	>100Khz	>100Khz	88.4	99%		small
“	>100Khz	>100Khz	86.0	93%		small

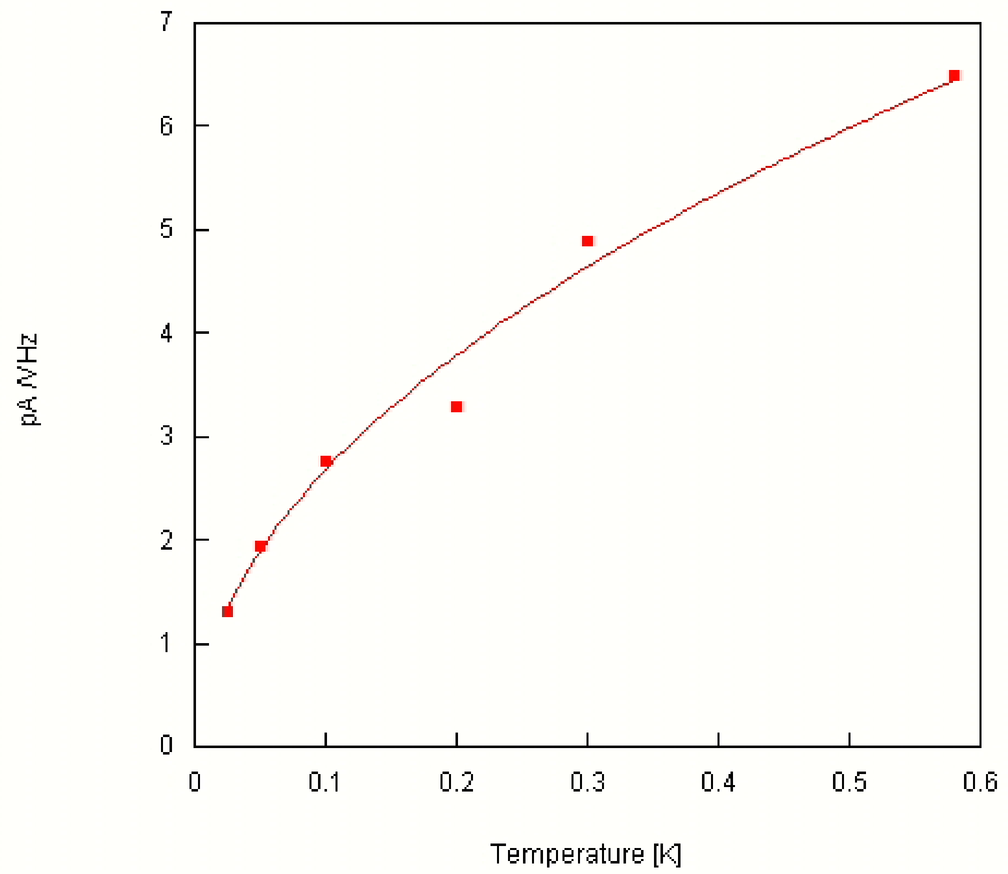
- Noise spectrum from 1 Ω at Low T. Minimum detectable signal when R is at 25mK, about 1.4 pA/√Hz.



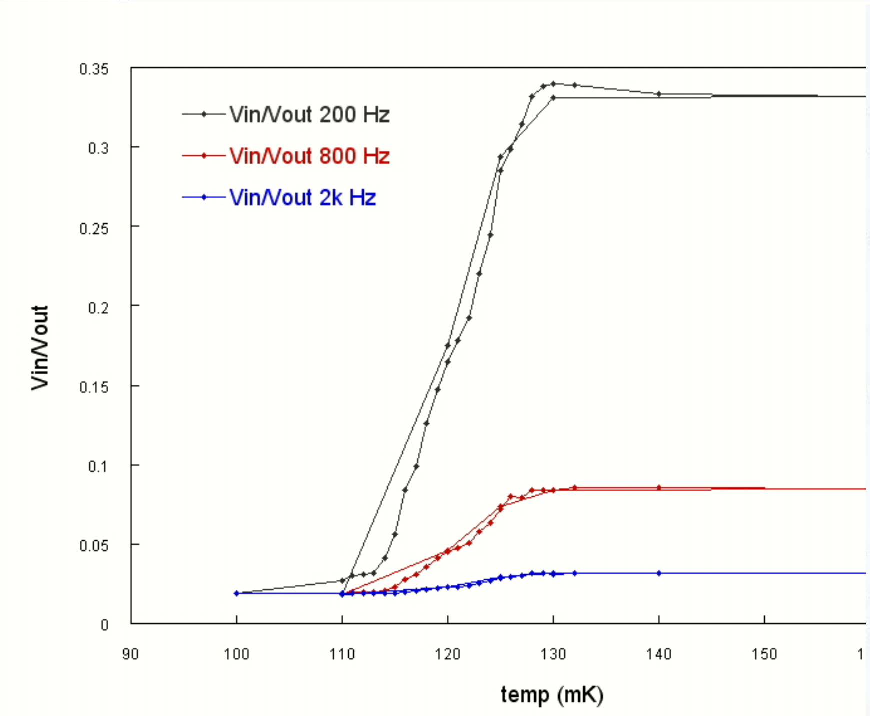
- In a limited region (0.5-5Kz) the current noise equivalent to the input of the transformer is in pA/VHz range.

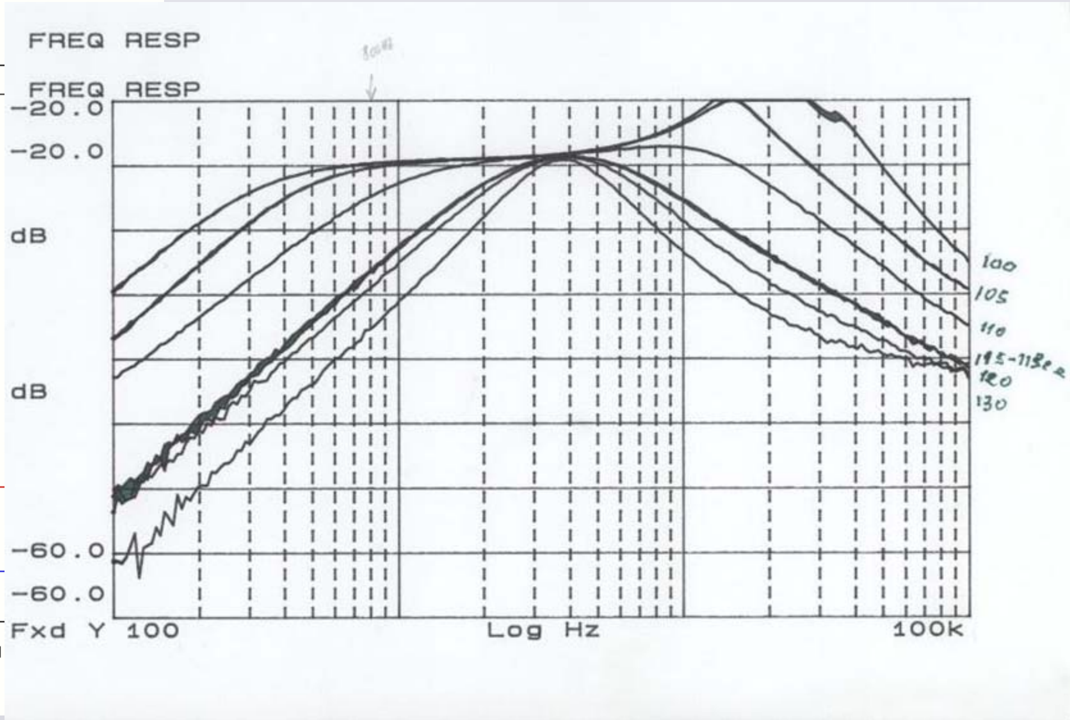


- The input noise density given by R= 1Ω @ 4KHz is measured at different temperatures: it scales as the $T^{1/2}$, as expected.



- Dc bias will require TES working at a proper R value
- The Transf. Functions along the transition suggests that AC bias should be preferable (see Geleazzi talk)





Conclusions

- The method of passive cold transformer read-out in trans-resistance configuration is effective (or competitive in term of noise quality) in a limited bandwidth (1 decade: 0.5-5KHz)

- Cold passive electronics, room temperature conventional electronics.

- AC bias configuration should improve the performance, taking the advantage of MUX capability and possibility to extent the bias frequency up to hundreds of MHz.