Title: Expected degradation of performance in IF1 amplifiers using TRW 200 IHER1 transistors

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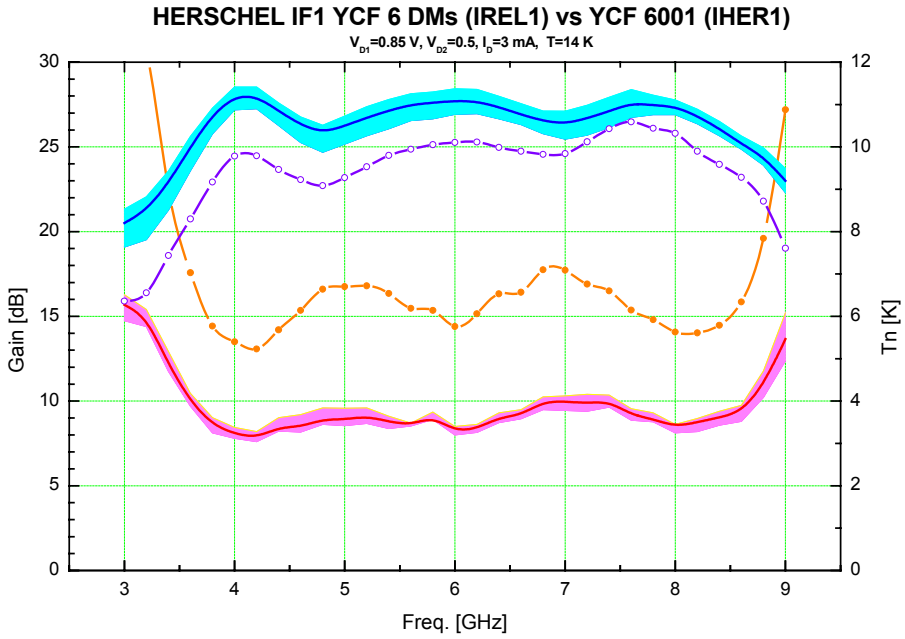
Introduction

A number of first-stage low noise cryogenic amplifiers for HIFI were manufactured and delivered by Yebes to SRON as IF1 Development Models. These LNAs used TRW 200 IREL1 transistors. The design and tuning of the amplifiers was optimized according to the results obtained with these transistors. Devices from other lots (CRYO4, CRYO7) were tested in the amplifiers yielding similar or better results. The lot finally qualified (IHER1 wafer 4200-071) had significantly different noise and S parameters than its predecessors. This report describes the impact in the performance of the flight amplifiers due to the degraded characteristics of the qualified transistors.

Noise temperature and gain

We compare the measurements of the 5 DMs (YCF 6) delivered to SRON with amplifier YCF 6001. YCF 6001 is a test amplifier used for measuring and comparing different transistors.

- Transistors.
  - The **DMs** use TRW **IREL1** transistors in both stages, whose characteristics are very similar to CRYO4 according to other measurements taken in YCF 6001.
  - The results presented of **YCF 6001** (configuration "10") correspond to a configuration with an **IHER1** transistor of wafer 4200-077 in the first stage and an IHER1 transistor of wafer 4200-071 in the second stage.
- Bias point.
  The bias point selected is the same for the DMs and YCF 6001 (V_{D1}=0.85 V, V_{D2} 2=0.5 V, I_D=3 mA). It optimizes noise, gain ripple and output reflection of the DMs keeping power dissipation below 4 mW.



Gain and noise measurements at 14 K with system 350. Colored bands are defined by worst and best values for all DMs with IREL transistors. Solid lines represent the average of the DMs. The dotted lines correspond to YCF 6001 with IHER transistors.

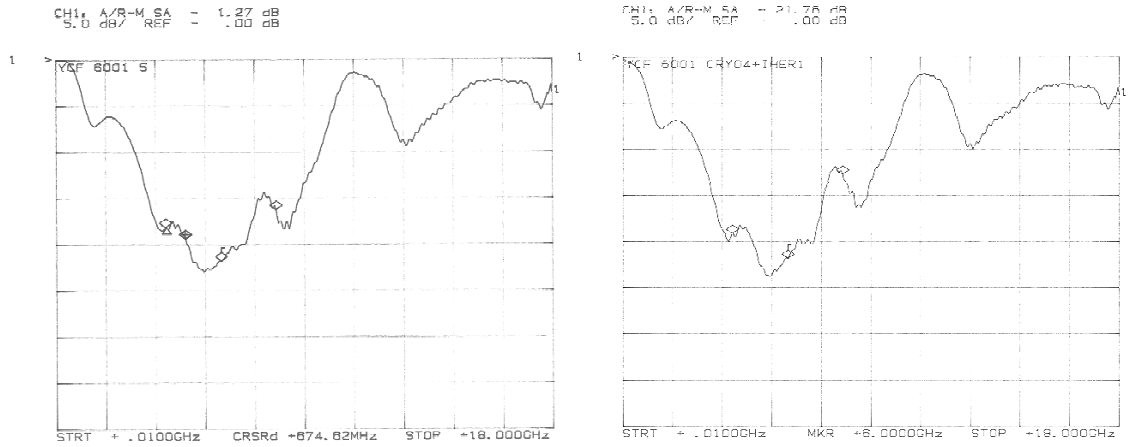
	MEAN NOISE TEMP. [K] (in the band)			MEAN GAIN [dB] (in the band)			PEAK TO PEAK GAIN [dB] (in the band)		
YCF 6001	**6.26**			**24.99**			**3.77**		
IF1 DMs	Best	Aver.	Worst	Best	Aver.	Worst	Best	Aver.	Worst
	3.46	**3.57**	3.72	27.7	**27.11**	26.26	1.96	**2.19**	2.46

Output reflection

We compare the measurements of YCF 6001 with two different configurations.

- Transistors.
  - Configuration "5" uses TRW **IREL1** transistors in both stages, whose characteristics are very similar to CRYO4 according to other measurements taken in YCF 6001.
  - Configuration "9" uses a TRW **CRYO4** transistor in the first stage and an **IHER1** transistor of wafer 4200-071 in the second stage.
- Bias point.
  The bias point selected is the same for both configurations, and identical to the noise results one. It optimizes noise, gain ripple and output reflection with IREL transistors keeping power dissipation below 4 mW.

We believe that the major contribution to the shape of the output reflection curve is in the second stage transistor. The results presented below are quite representative of the expected degradation, although the dispersion in output reflection is greater than in noise or gain.



*SNA measurements of output return losses at 14 K. On the left, the results with IREL1 transistors: worst value in the band is **14.8 dB**. On the right, the results with CRYO4+IHER1 transistors: worst value in the band is **12 dB**.*

Gain fluctuations

We compare the measurements of YCF 6001 with configurations "5" (IREL1) and "10" (IHER1 wafer 4200-077 + IHER1 wafer 4200-071) as described previously, and at the nominal bias point of V_{D1}=0.85 V, V_{D2} 2=0.5 V, I_D=3 mA. Taking into account the usual dispersion in the results of these measurements for transistors of the same lot, there is no significant degradation or improvement to report. The results – spectral density of the normalized gain at 1 Hz in $1/Hz^{\alpha}$ – are 12E-5 for IREL1 and 8.7E-5 for IHER1. The average for the DMs is 9.4E-5.

Conclusions

The main consequences of using IHER1 transistors will be degradation in the noise temperature (2.5 K more), gain flatness (±0.7 dB more) and output reflection (3 dB worse). Only a limited number of transistors have been tested, and no bias or circuit optimization has been carried out. However, it is no expected to obtain a significant improvement with optimization. Accordingly, we propose a modification the specifications for the FMs in the following way:

	ACTUAL IF1 SPECS	PROPOSED IF1SPECS with IHER1 transistors
Average Noise Temperature (4-8 GHz) (goal) [K]	5	6.5
Average Gain (4-8 GHz) [dB]	22	22
Gain ripple (4-8 GHz) (goal) [dB]	±1.5	±2
Minimum Return loss (4-8 GHz) (goal) [dB]	-15	-10
Normalized Gain fluctuations @ 1 Hz (goal) [1/Hz$^{\alpha}$]	14E-5	14E-5