New Trends in Cryogenic HEMT Amplifiers for Radio Astronomy

Isaac López-Fernández, Juan Daniel Gallego Puyol, Alberto Barcia Cancio, Francisco Colomer

ABSTRACT

The availability of very low noise InP HEMT devices manufactured by several groups have made possible the design of low noise cryogenic amplifiers for Radio Astronomy applications with excellent noise performance over large instantaneous bandwidths. An additional benefit of InP devices is the possibility of very low power dissipation, of importance when multiple cryogenic receivers are built in the same cryostat. This paper presents some representative results obtained in wideband cryogenic (15 K) amplifiers. The goal is to provide to SKA system designers an indication of the present state of the art.

Three amplifiers have been selected, with noise temperatures of 4 K in 4-8 GHz, 6.5 K in 8-12 GHz and and 9.5 K in 18-26 Ghz band. The devices employed were built by JPL-TRW and ETH. The results clearly demonstrate the possibility of using wide instantaneous bandwidths with excellent noise performance. In fact, bandwidth limitation in Radio Astronomy receivers is often caused by other components, like feeds or backends. Cryogenic isolators for 4-8 and 8-12 GHz band are already available by commercial manufacturers

Interference

One of the problems when using wide band amplifiers in crowded microwave bands is the possibility of interfering out-of-band signals appearing in the reception band due to intermodulation distortion. To avoid this, high Third Order Interception Point (TOIP or IP3) and 1 dB compression (P1dB) are needed. In order to get amplifiers less prone to intermodulation, it is possible to combine low noise InP devices in the first stages and GaAs devices in the last. Using this approach, an X band (8.4 GHz) amplifier with 3.5 K noise temperature and with P1dB=5 dBm and IP3=15 dBm has been demonstrated. This amplifier has been conceived for Deep Space Network ground stations.

References

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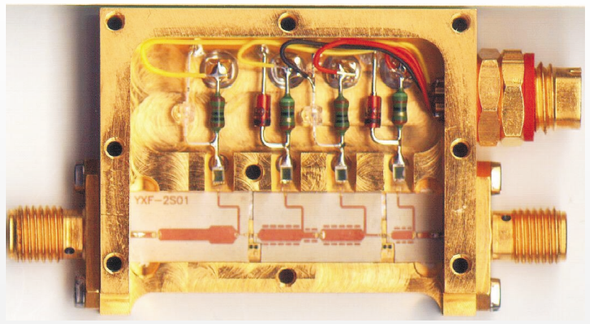
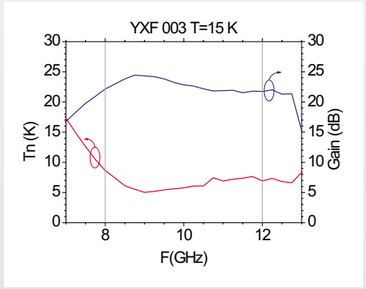
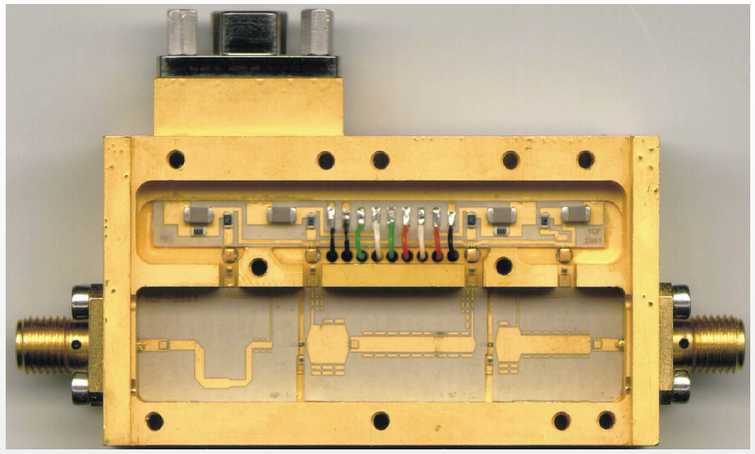


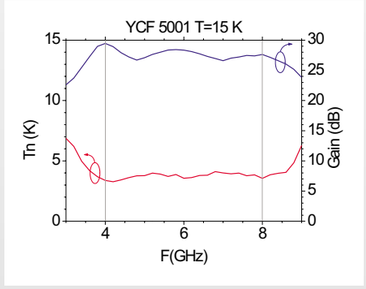


CHARACTERISTICS	
Working Band	8 – 12 GHz
Working Temperature	15 K
Dimensions	39 x 32 x 10.5 mm
Transistors	InP HEMT 0.1 x 160 μm (TRW)
PERFORMANCE	
Noise Temperature / Factor	6.5 K / 0.093 dB
Gain (variation)	22.9 dB (± 1.4 dB)
Output Reflection	>12.5 dB

8-12 GHz Demonstration Amplifier

First InP prototype built as a demonstration of the results obtainable in this band for FIRST-HERSCHEL. Finally, the 4-8 Ghz band was selected.

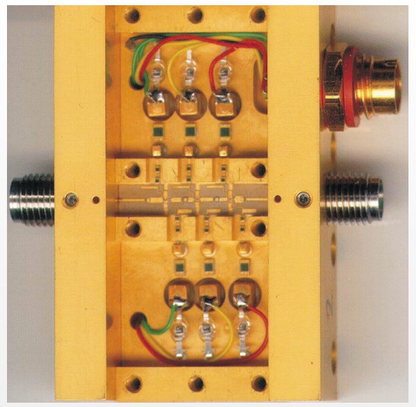


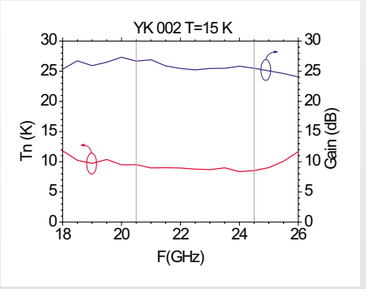


CHARACTERISTICS	
Working Band	4 – 8 GHz
Working Temperature	15 K
Dimensions	58 x 38 x 15 mm
Transistors	InP HEMT 0.1 x 200 μm (TRW)
PERFORMANCE	
Noise Temperature / Factor	3.4 K / 0.049 dB
Gain (variation)	27.3 dB (± 1.4 dB)
Output Reflection	>15.3 dB

4-8 GHz FIRST-HERSCHEL Amplifier

Developed for the IF of FIRST- HERSCHEL and conceived to be a space qualified unit for the spacecraft





CHARACTERISTICS	
Working Band	20.5 – 24.5 GHz
Working Temperature	15 K
Dimensions	32 x 48 x 13 mm
Transistors	InP HEMT 0.1 x 160 μm (TRW)
PERFORMANCE	
Noise Temperature / Factor	8.9 K / 0.13 dB
Gain (variation)	26.1 dB (± 1 dB)
Input / Output Reflection	>7 dB / >8.5 dB

18-26 GHz VLBI Amplifier

Initially designed for VLBI in the 20.5-24.5 Ghz band. However, the amplifier is usable with excellent noise in the complete WR42 waveguide band.

Centro Astronómico de Yebes, Observatorio Astronómico Nacional
Apartado 148, 19080 Guadalajara, SPAIN web: http://www.oan.es/cay/tech/ampl e-mail: ampl@oan.es

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