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AUSTRALIA TELESCOPE NATIONAL FACILITY

12 mm RECEIVER
for
SHANGHAI
OBSERVATORY

Full documentation manual
held by Russell Gough

AUSTRALIA TELESCOPE NATIONAL FACILITY

12 mm RECEIVER for SHANGHAI OBSERVATORY

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1. INTRODUCTION

This manual describes the 12 mm receiver and horn built by the Australia Telescope National Facility (ATNF) for the Shanghai Observatory.

The receiver was designed to operate in the 22.1–22.6 GHz band which includes the water vapour line at 22.235 GHz. The receiver was also designed so that, with modification, it could be used to observe the ammonia lines at 23.694, 23.720 and 23.870 GHz.

The horn was designed to illuminate the first mirror in the telescope optics with minimum spillover.

This manual describes the system specification, the receiver system and the system performance. The appendix includes block diagrams, mechanical drawings, wiring lists circuit diagrams and manufacturer's data sheets.

2. SYSTEM SPECIFICATION

Horn	
Specification frequency range of horn	22–23 GHz
Edge taper of horn	-20 dB @ 8.36°
Spillover efficiency of horn (beyond 8.36°)	0.97–0.98
Cross polar sidelobe level of horn (45° plane)	<-30 dB
Return loss of horn	>23 dB (VSWR>1.15)
Frequency range for acceptable but degraded performance of horn	23–24.8 GHz
Receiver	
Receiver frequency range	22.1–22.6 GHz
Receiver system temperature	<100 Kelvin
Polarization	Dual circular
Ellipticity	<0.75 dB
Local oscillator	
Local oscillator frequency	21.6 GHz
Local oscillator reference frequency	100 MHz
Local oscillator reference power	0±3 dBm
IF output	
IF output band	0.5–1.0 GHz
IF output spectral power density	-61 dBm/MHz (compatible with VLBA data acquisition unit.)
IF output power	-34 dBm

3. RECEIVER SYSTEM DESCRIPTION

The receiver system is capable of operating in the 21-24 GHz band which includes the water vapour line at 22.235 GHz and the ammonia lines at 23.694, 23.720 and 23.870 GHz.

The intrinsic IF bandwidth of the RF module is 0.5–2.5 GHz. The IF bandwidth of the RF module is limited to 0.5–1.0 GHz by the 22.1–22.6 GHz image filter in the RF module.

Observations at the frequency of the ammonia lines, 23.7–23.9 GHz, can be made by changing the 22.1–22.6 GHz image filter but still using the 21.6 GHz local oscillator. The IF frequency would then be 2.1–2.3 GHz.

The frequency of the phase locked 21.6 GHz local oscillator can be adjusted by mechanically tuning the cavity, or by changing the 100 MHz reference frequency. But the phase locked oscillator has a filter which cuts off frequencies above 22 GHz.

Figs. 3–1 to 3–4 show photographs of the receiver package, the horn, the cooled HEMT amplifier and the RF module.

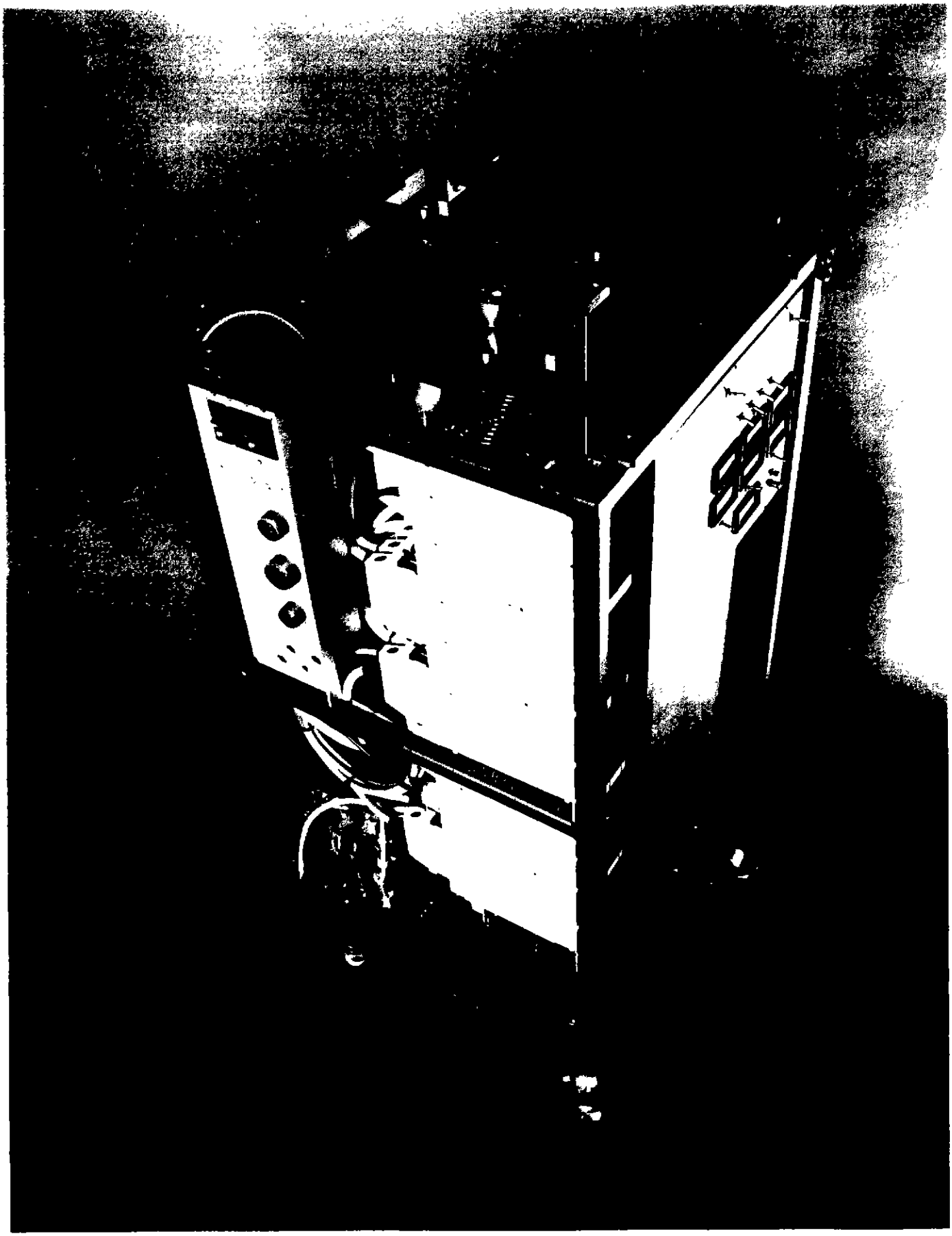

Fig. 3-1 12 mm band receiver for Shanghai Observatory

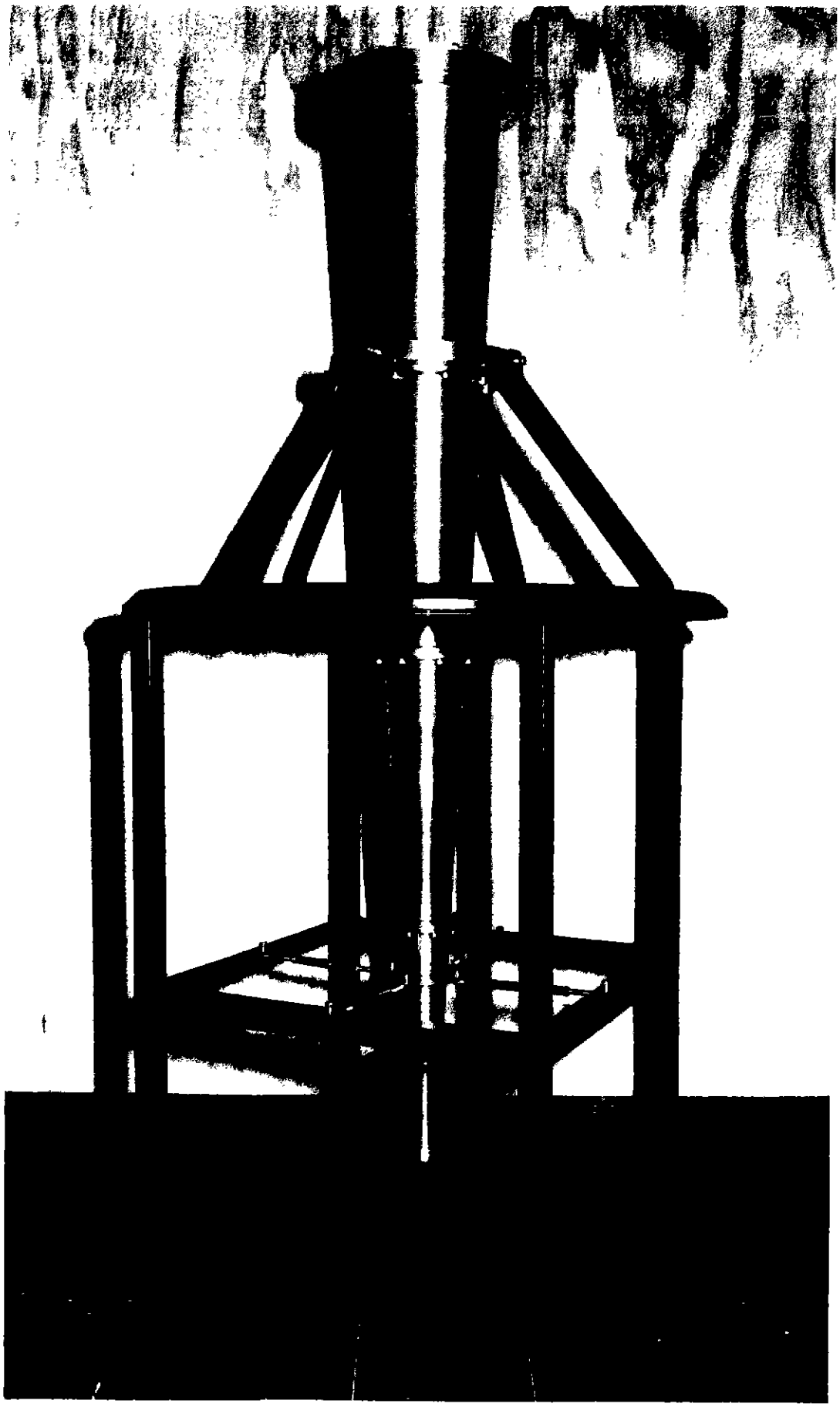

Fig. 3-2 12 mm band horn for Shanghai Observatory.

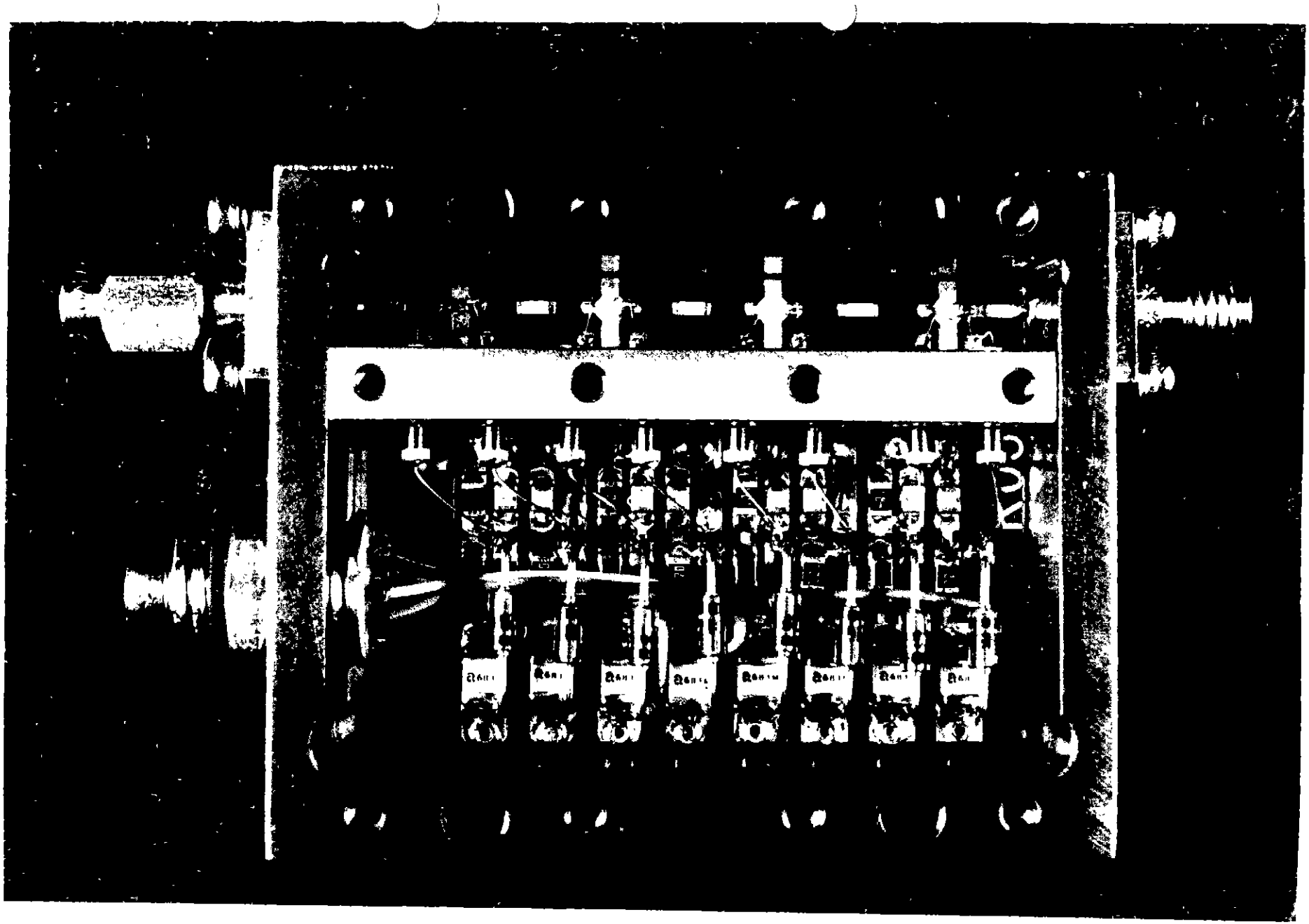

Fig. 3–3 Cooled HEMT amplifier for 12 mm band receiver

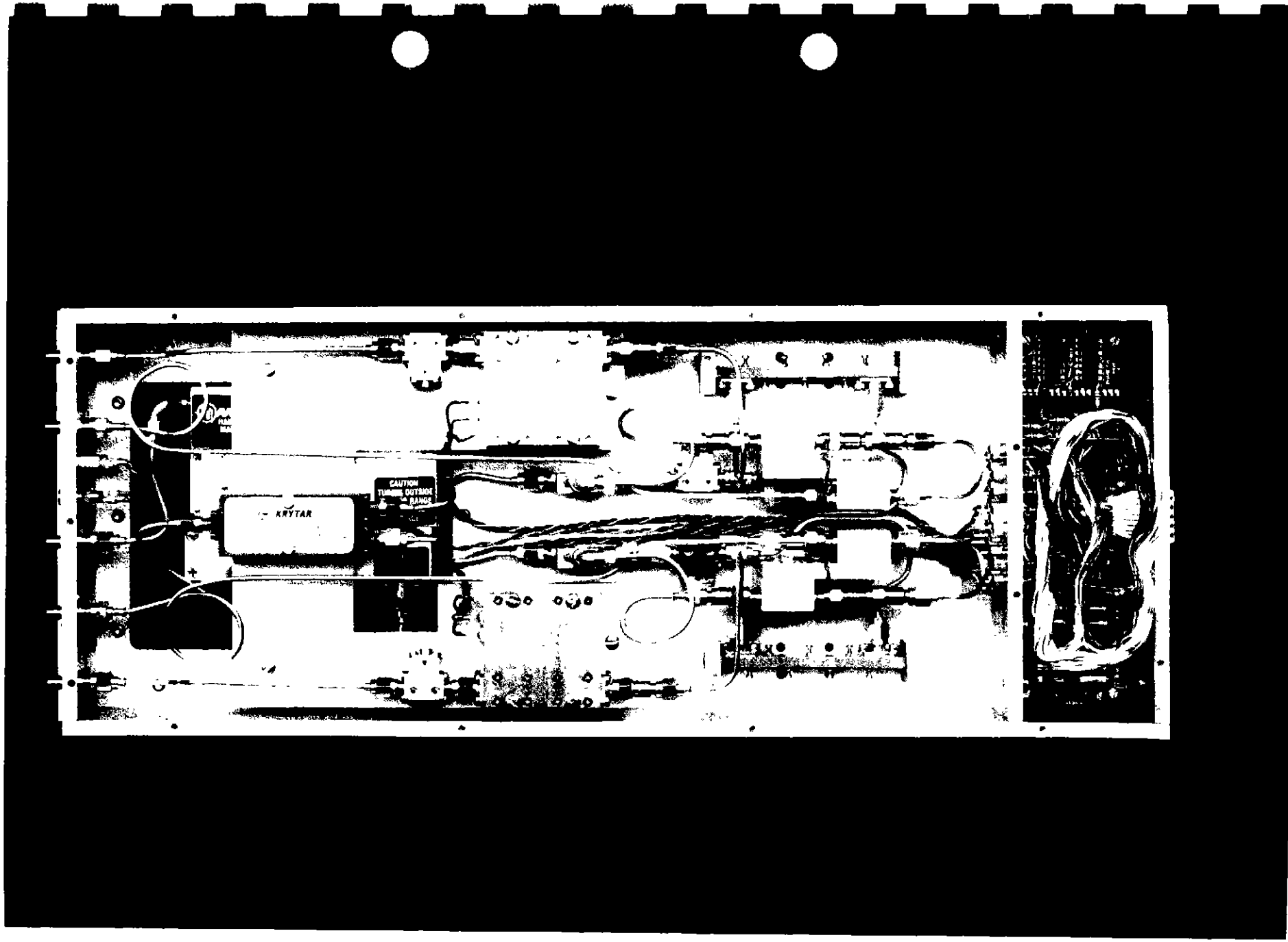

Fig 3.4 RF module for 12 mm band receiver

4. SYSTEM PERFORMANCE

4.1. Receiver System

The performance of the receiver and horn was measured in the laboratory before they were shipped to Shanghai Observatory. The noise temperature of the receiver plus horn was measured using hot and cold loads. Microwave absorber at room temperature was used as the hot load, and microwave absorber which had been imersed in liquid nitrogenwas used as the cold load.

The measured noise temperature of the receiver plus horn was 74 Kelvin for channel A and 80 Kelvin for channel B.

4.2. Low Noise Amplifiers

Figs. 4-1 and 4–2 show the cryogenic gain and noise performance of the two cooled HEMT amplifiers.

4.3. RF Module

Fig. 4-3 shows gain of both channels of the RF module.

The perfoprmance of the Shanghai RF module was checked by connecting it to the RF output of the ATNF 12 mm low noise amplifier system, which uses the same HEMT amplifiers as the Shanghai 12 mm receiver. Fig. 4–4 shows the spectrum of the output of both channels of the RF module with a 300 K load in front of the horn.

Figs. 4–5 and 4–6 show the frequency responses of the 22.1-22.6 GHz image filters.

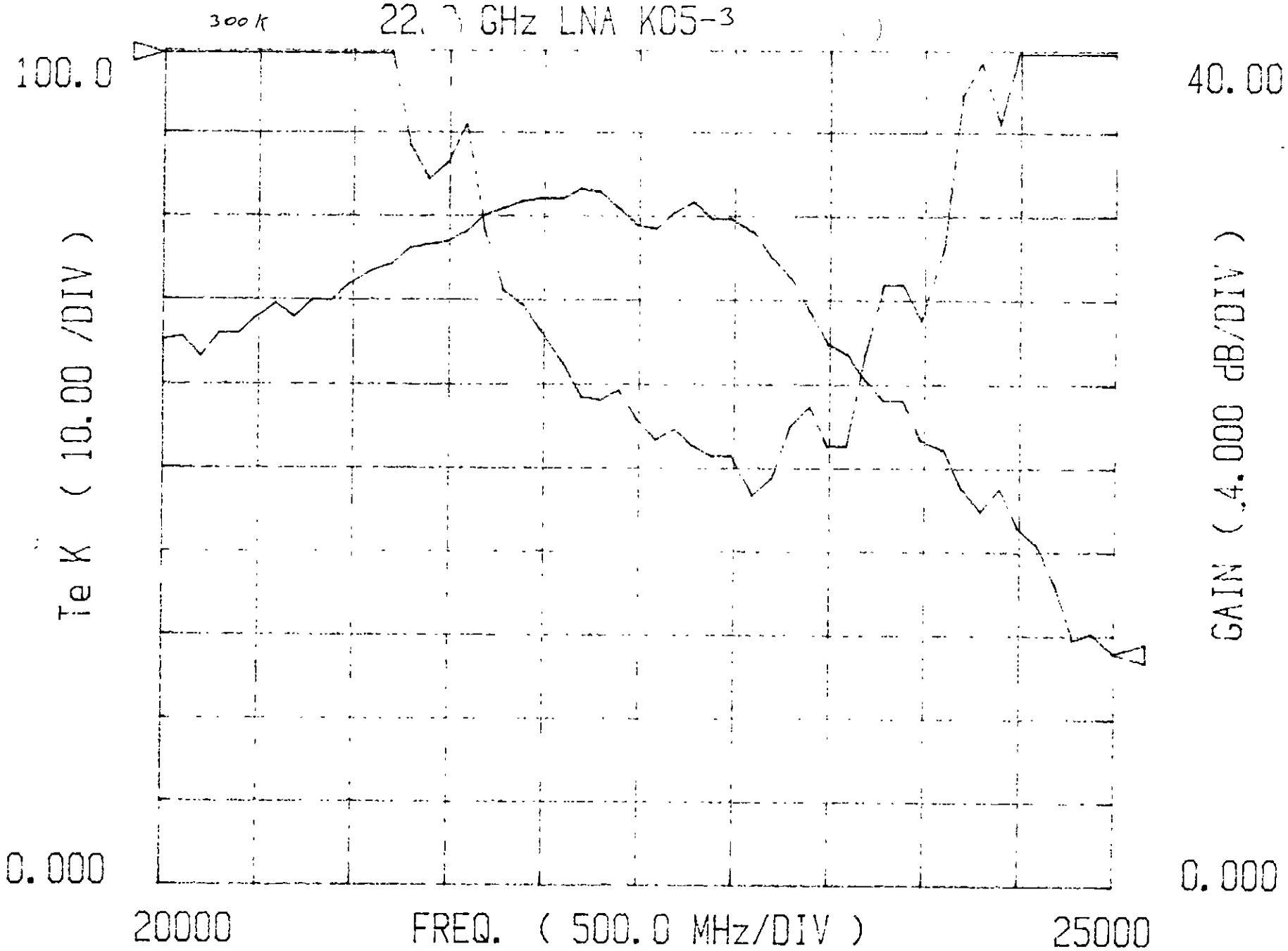

Fig. 4–1 Gain and noise of HEMT amplifier K05-3 when operating at 15 Kelvin.

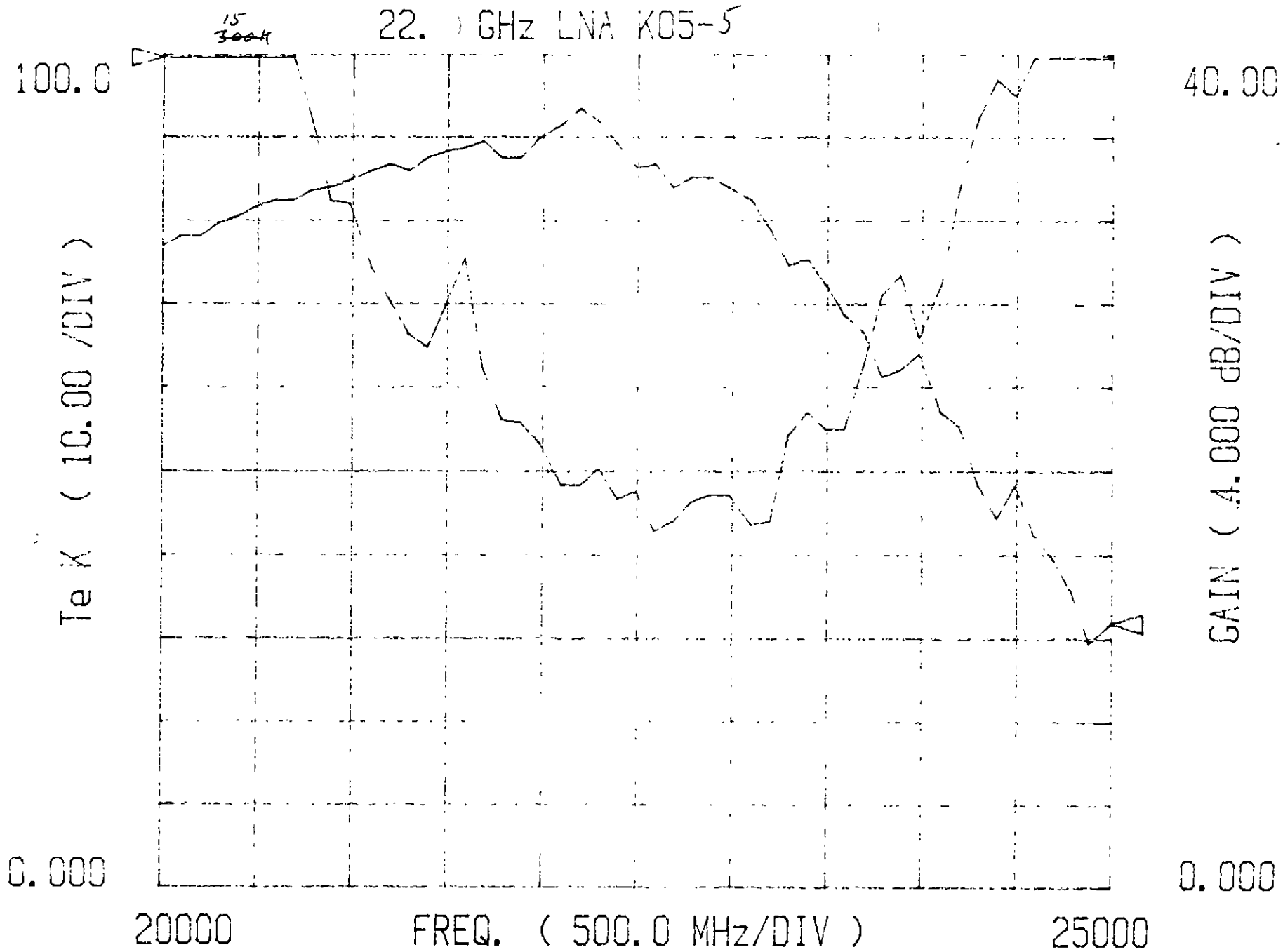

Fig. 4–2 Gain and noise of HEMT amplifier K05-5 when operating at 15 Kelvin.

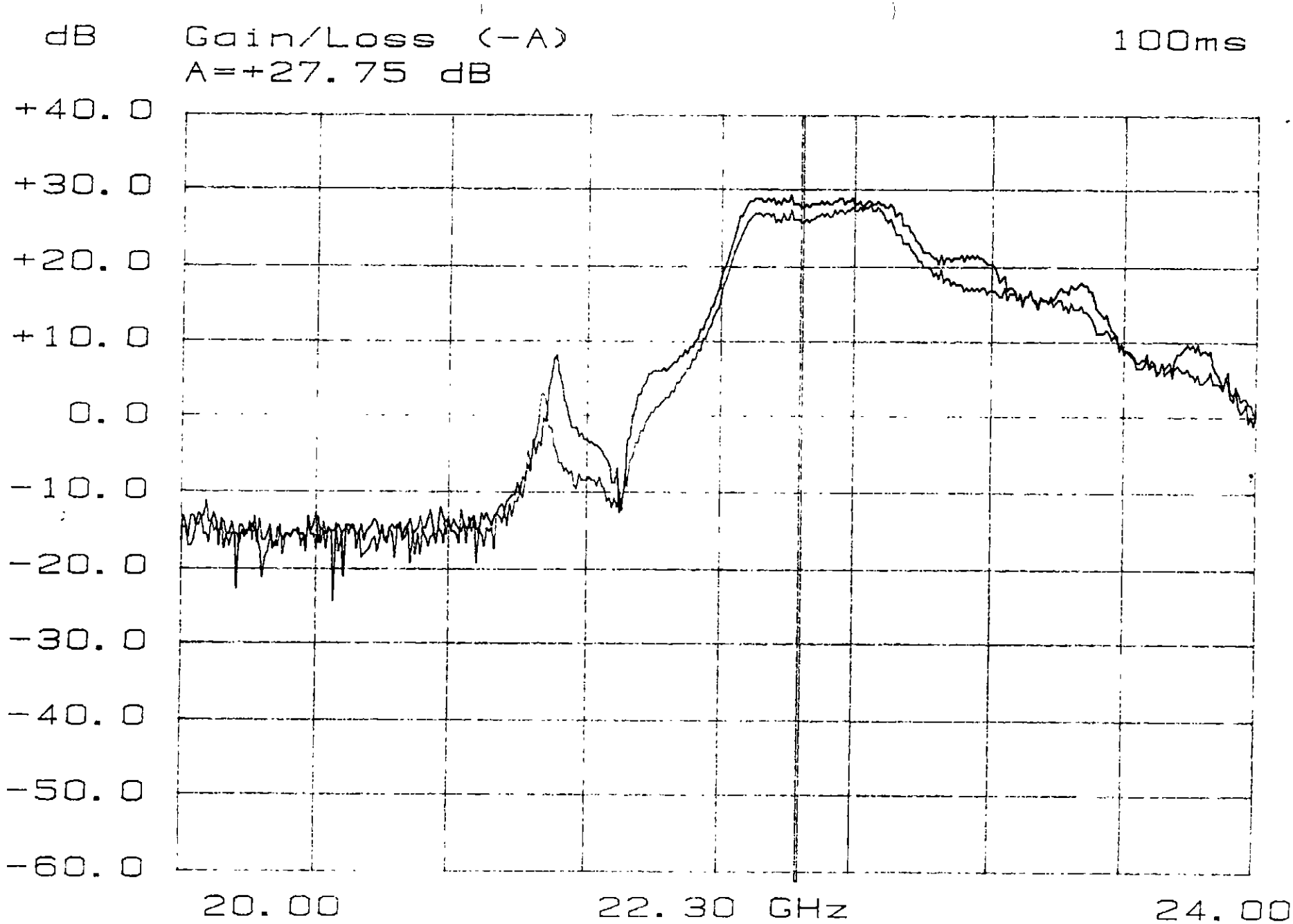

Fig. 4-3 Gain of RF module.

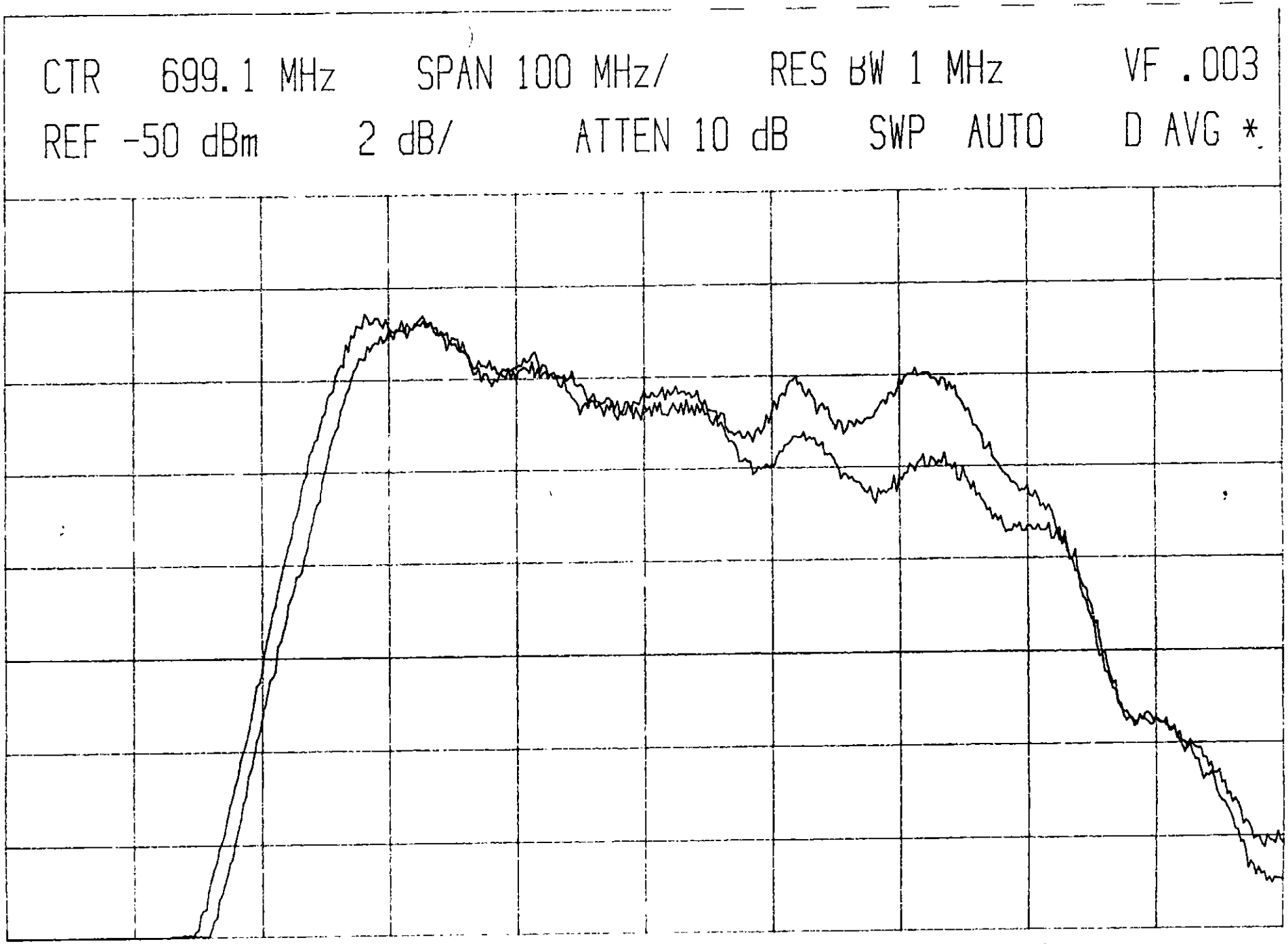

Fig. 4–4 Spectrum of output of RF module with 300 K load termination on horn.

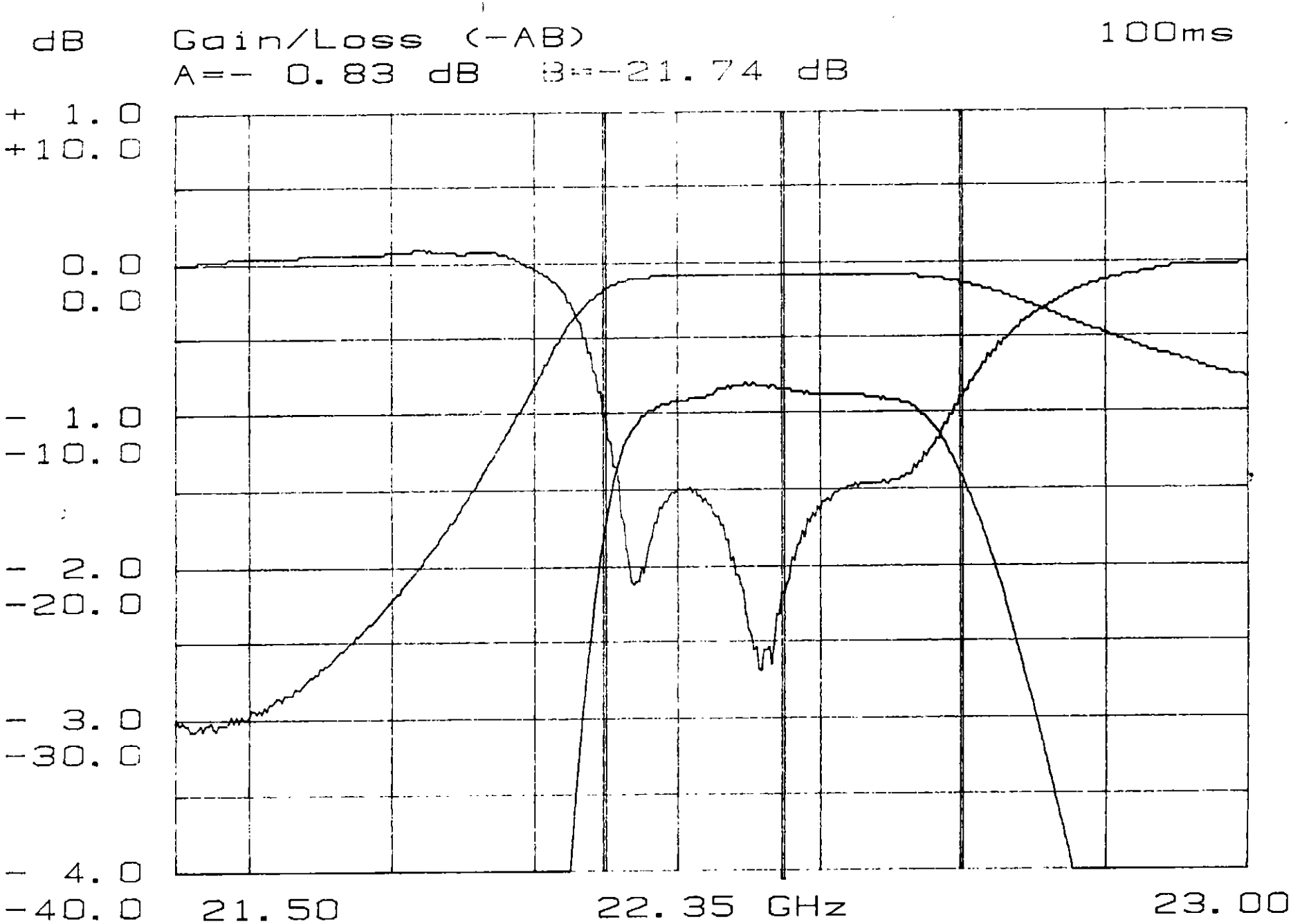

Fig. 4–5 Frequency response of the A-polarization 22.1-22.6 GHz image filter.

FILTER B

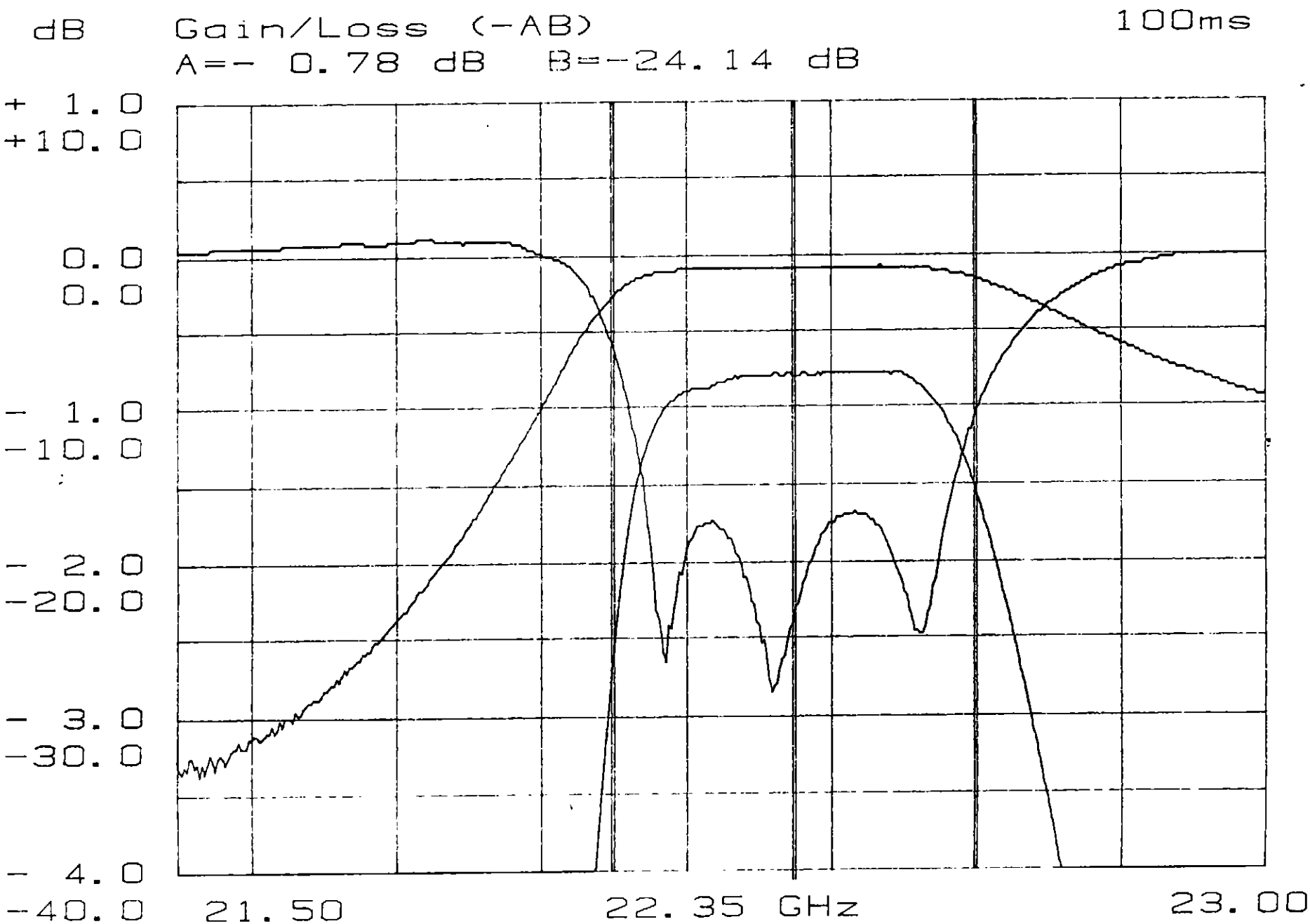

Fig. 4–6 Frequency response of the B-polarization 22.1-22.6 GHz image filter.