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YCF 4001 – 4002
TEST AMPLIFIERS
REPORT

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YCF 4 4-8 GHz TEST AMPLIFIER REPORT

1. Introduction

YCF series 4 are C band, 4-8 GHz, 1 stage low noise cryogenic test amplifiers designed and built at the *Centro Astronómico de Yebes* for the development phase of the HERSCHEL project. Their original purpose was to assist in the modelling of the TRW InP transistors used in the DM amplifiers. They will also be used as a vehicle to perform radiation tests in these transistors. This document includes a description of the amplifiers and how to operate them, and certain relevant measurements to serve as a reference.

2. Description and operating conditions of the amplifier

The amplifier consist of a machined base with the microstrip circuits and chip components, and two flanges with the RF input and output connectors (K connectors) and DC bias connector (7 pin MICROTECH). The pinout is provided in figure 1. Note that the *output* RF connector is located on the same side as the DC. The serial number of the unit is stamped in one of the clear sides of the base. A **provisional cover** has been manufactured in aluminum to protect the components during transport and manipulation.

The external dimensions and mechanical interfaces of the amplifier are shown in figure 2. Four M2 holes are provided to attach the amplifier to the cold plate. The same holes are used from the other side to fasten the cover, which is usually removed during measurements.

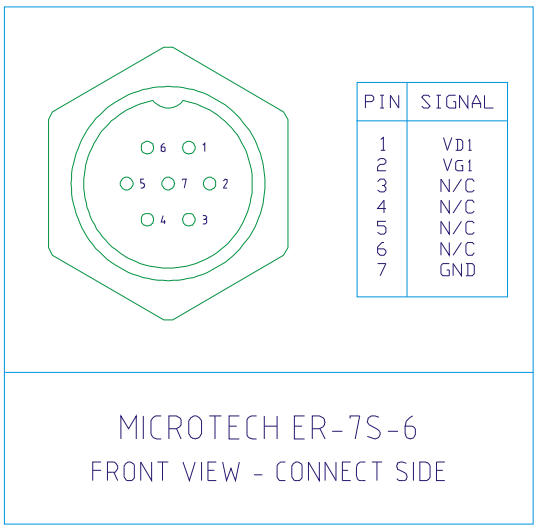

Figure 1: *DC Connector pinout*

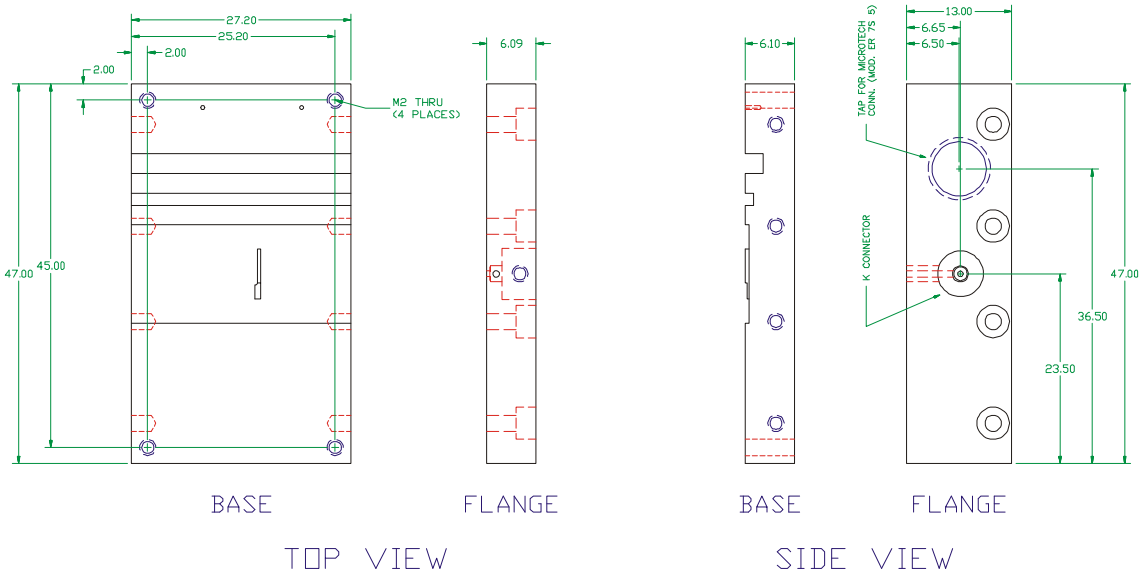

Figure 2: *YCF 6 envelope*

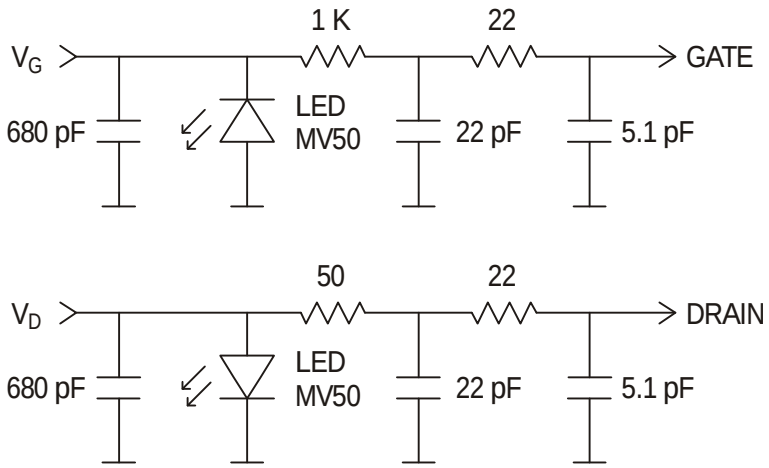

Figure 3: *YCF 4 bias circuits (inside the amplifier*

YCF 4 implement TRW[1] InP transistors. The InP devices are very **ESD sensitive**; cautions must be taken in its manipulation. The bias circuits built in the amplifier include LEDs (V_F 2 V @ 15 K) which limit the drain and gate voltages to prevent damage to the transistors. A schematic of these circuits is shown in figure 3. A separate document provides information on ESD prevention procedures, and safe unit handling and storage.

The unit is expected to be biased by a **servo controlled power supply** (NRAO style), which sets the gate voltage for any given drain current. One bias condition has been selected for the amplifier, for test and modelling purposes (see table 1). Never exceed a drain voltage/current of 1.5 V / 10 mA for InP transistors.

[1] Transistors provided by TRW under contract with JPL, as a contribution to HIFI.

	V_D (V)	I_D (mA)	V_G (V)
ROOM TEMPERATURE BIAS	1.25	10	4001: 0.16 4002: 0.12
CRYOGENIC TEMPERATURE BIAS	0.5	3	4001: 0.21 4002: 0.17

Table 1: *Reference bias point for YCF 4 amplifiers.*

3. Measurements

We include two plots for each amplifier, corresponding to room and cryogenic temperature measurements of S parameters taken with an HP vector analyser at the bias points specified in the preceding table. Room temperature measurements were taken outside the cryostat. No de-embedding or post processing was applied to the cryogenic measurements, which are intended only to be a reference for future comparisons.

ESD AND POWER SUPPLY LEAKAGE PROTECTION OF InP CRYOGENIC HEMT AMPLIFIERS

Introduction

Cryogenic amplifiers made with InP HEMTs have been found very sensitive to ESD (electrostatic discharges) and leakage from the power supplies. The handling of these devices requires especial precautions beyond the normal care taken with cryogenic amplifiers made with commercial GaAs HEMTs. Especial procedures should be followed during assembly of the amplifiers as well as during tests and operation to avoid permanent damage to the devices. The most common mode of failure is the total or partial destruction of the gate of the transistors. Partially damaged devices may loose one or more gate fingers and show poor or no pinch off, even if the gate junction still show diode characteristics. Totally damaged devices may appear as a short circuit (or low resistance) from drain to source. Sometimes, but not often, the device may appear as an open circuit.

ESD is not the only problem. Leakage of soldering irons, bonding machines and even power supplies of the amplifiers has produced many failures. All the equipment used in the assembly test and operation of the amplifiers should be checked for leakage. Most of the field problems detected have been caused by 50 Hz current leakage of input transformers of floating DC power supplies. This leakage is due to the capacitive coupling between primary and secondary of the transformers and it is always present unless there is a grounded faraday shield between the two windings or other especial precautions are taken

Procedure for assembly of the amplifiers

1. Technicians manipulating amplifiers should wear grounded wrist straps.
2. The bench for the assembly of the amplifiers should have a dissipative map connected to ground.
3. A short circuit should be put in the power connector of the amplifier at all times during assembly (the short circuit should short all pins together to the case). The short circuit will only be removed for testing the amplifier or when connected for operation.
4. Coaxial SMA short circuits should be connected to input and output RF connectors at all times during assembly. The short circuits will only be removed for testing the amplifier or when connected for operation.
5. The soldering irons used for assembly should be adequately grounded. It should be checked that no voltage respect to ground is measured on the tip with the soldering iron on and off. The maximum voltage allowed will be 0.020 Vrms respect to ground measured with a high input impedance (> 10 M) voltmeter in AC mode.
6. The tip of the bonding and welding machines used for assembly of the amplifier should be adequately grounded. It should be checked that no voltage respect to ground is measured with machines on or off. The maximum voltage allowed will be 0.020 Vrms respect to ground measured with a high input impedance (> 10 M) voltmeter in AC mode.
7. Be very careful with any measurement instrument used during assembly. If ohmmeters are used for verification of internal cabling, battery operated units are preferred. Make all necessary verifications before the assembly of the transistors when possible. The assembly of the transistors should be the last operation to avoid unnecessary risks.

Procedure for test and operation of the amplifiers

1. The amplifier should be kept with a short circuit in the power connector when not in use. The short circuit should short all pins together and to the case. The short circuit should only be removed if adequate ESD and leakage protection precautions have been taken.
2. Most failures in cryogenic amplifiers are produced when connecting or disconnecting the amplifier to/from the power supply. **A very careful procedure should be followed**.
3. Make sure that the power supply is **off** before connecting or disconnecting the power supply cable to/from the amplifier.
4. Make sure that the power supply and the amplifier are connected to the same protective ground before connecting or disconnecting the power supply cable to/from the amplifier.
5. Very especial care should be taken in case of a DC power supply floating respect to the protective ground. This produces most failures. It is safer to connect the **return** terminal at the output of the DC power supply to the protective **ground** permanently on the power supply side. If this is not possible (for example to avoid ground loops with long cables), a provisional connection from the return of the power supply to the amplifier case should be **made prior to any connection or disconnection** of the power supply cable. Always make sure that there is no voltage between the return of the power supply and the protective ground (case of the amplifier) before connecting the power supply cable. The maximum allowed voltage will be 0.020 Vrms measured with a high input impedance (> 10 M) voltmeter in AC mode.
6. The power supply should have adequate built in protection to avoid excessive voltage and currents in the transistors in case of power supply failure and during the transients produced when the power supply is switched on or off. Adequate Zenner diodes can be used in parallel with the outputs, and adequate series resistors in series. If the protections are designed adequately, the amplifier will survive even in case of errors in the connections of the cables.

Storage of the amplifiers

1. The amplifiers should be stored in a clean dry anti-static environment.
2. The amplifier should be stored with short circuits in the power and RF connectors.
3. For permanent storage desiccators with less than 20% relative humidity should be used. The preferred method of storage is in dry nitrogen containers.
4. For transportation, and for short-term storage, anti-static plastic bags with silica gel bags to keep low relative humidity should be used.