National Centre for Radio Astrophysics
TATA INSTITUTE OF FUNDAMENTAL RESEARCH

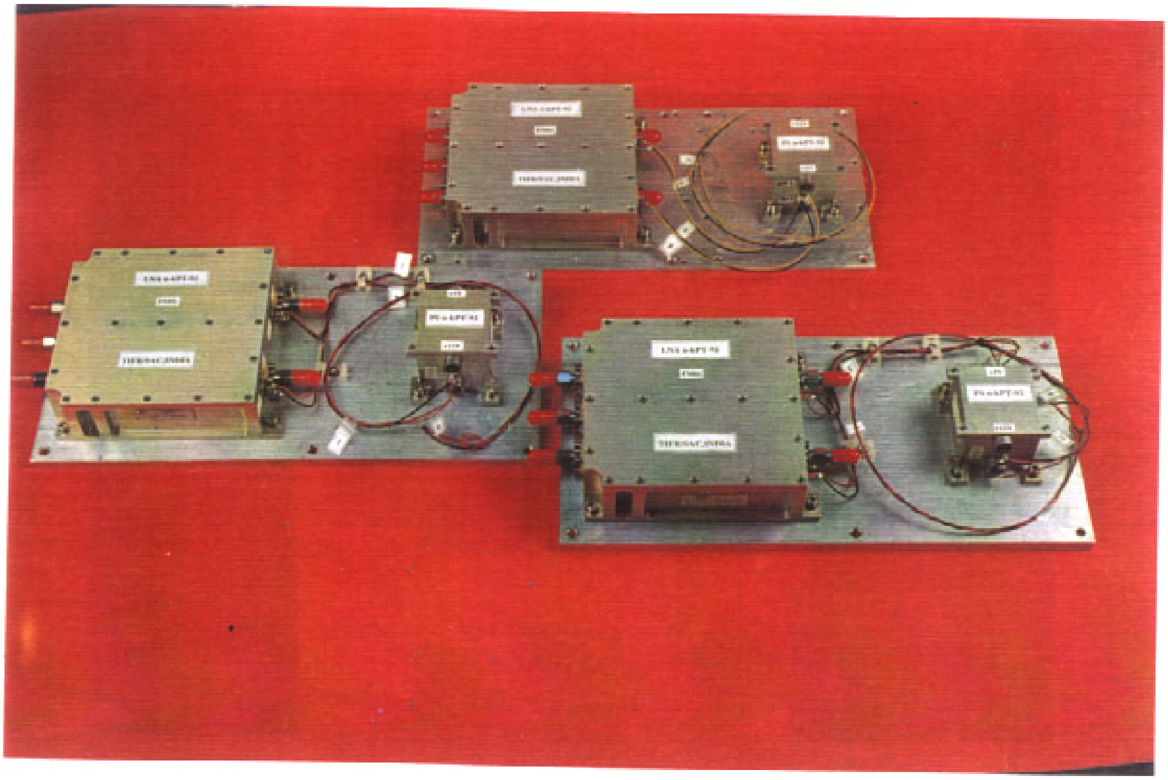
327 MHz Low Noise Amplifier for the Space Radio Telescope

RADIOASTRON

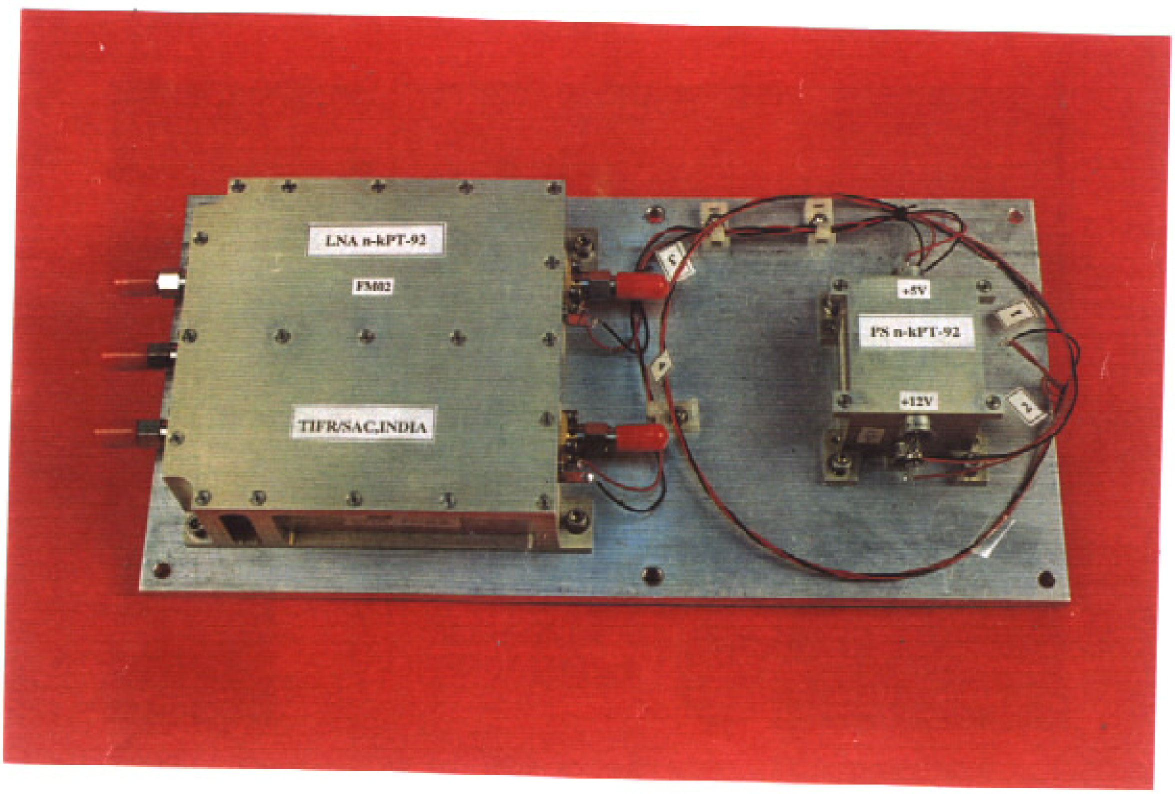
Design, Realization and Space Qualification

A.Praveen Kumar
M.Srinivas

Post Bag No.3, Ganeshkhind, University of Pune Campus, Pune – 411 007, India
Tel: +91 212 357107, 351384, 85; **Fax:** +91 212 355149; **Grams:** RASTRON; **e-mail:** root@gmrt.ernet.in

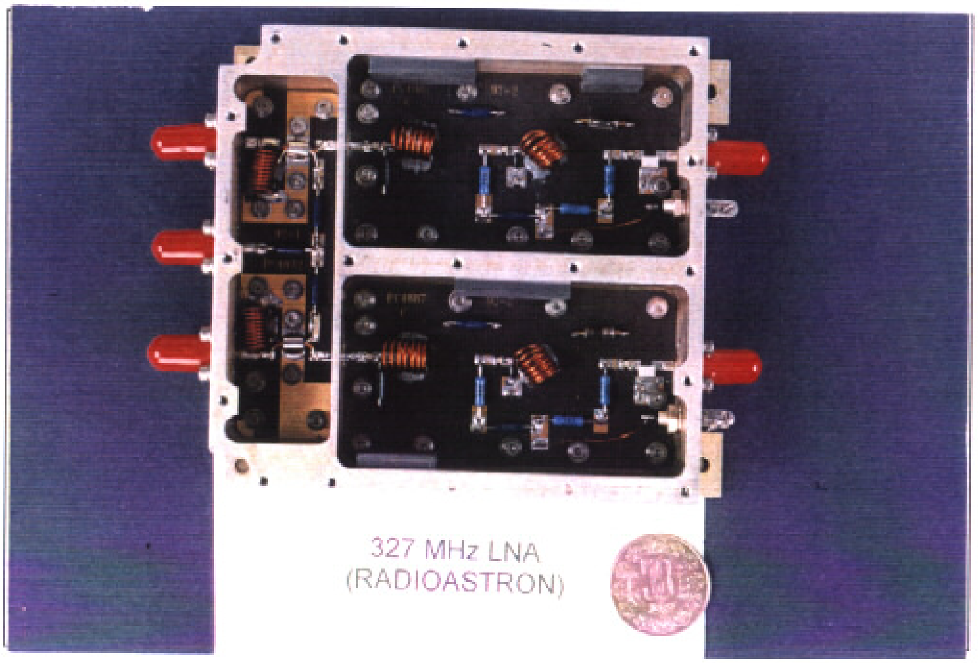


Payloads Delivered for RADIOASTRON Mission [1 Engineering Model & 2 Flight Models]

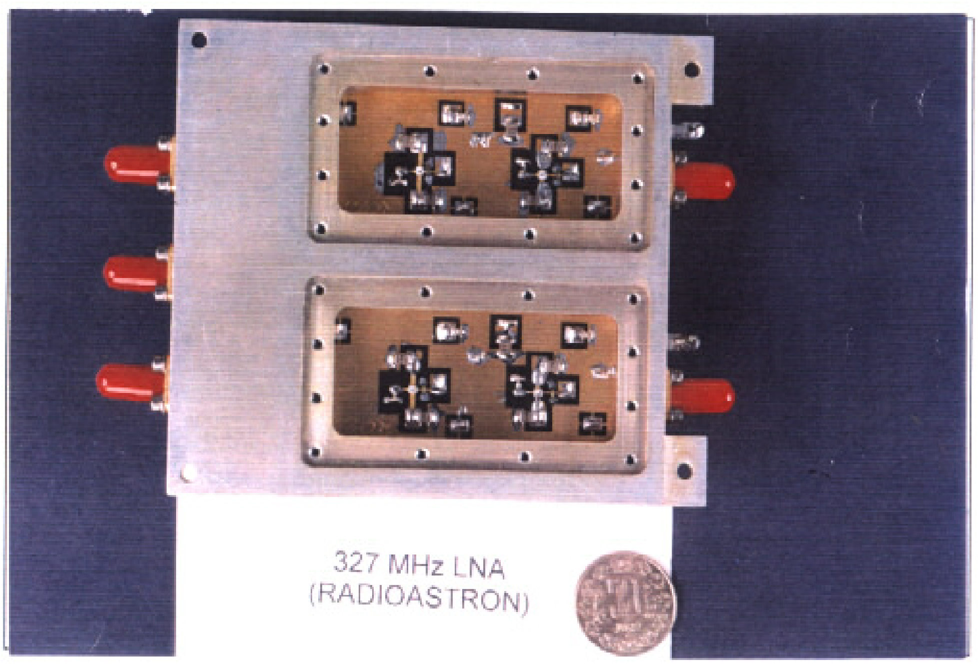


One of the Flight Models for RADIOASTRON Mission

327 MHz Low Noise Amplifier [LNA] for 92cm Receiver of RADIOASTRON Mission

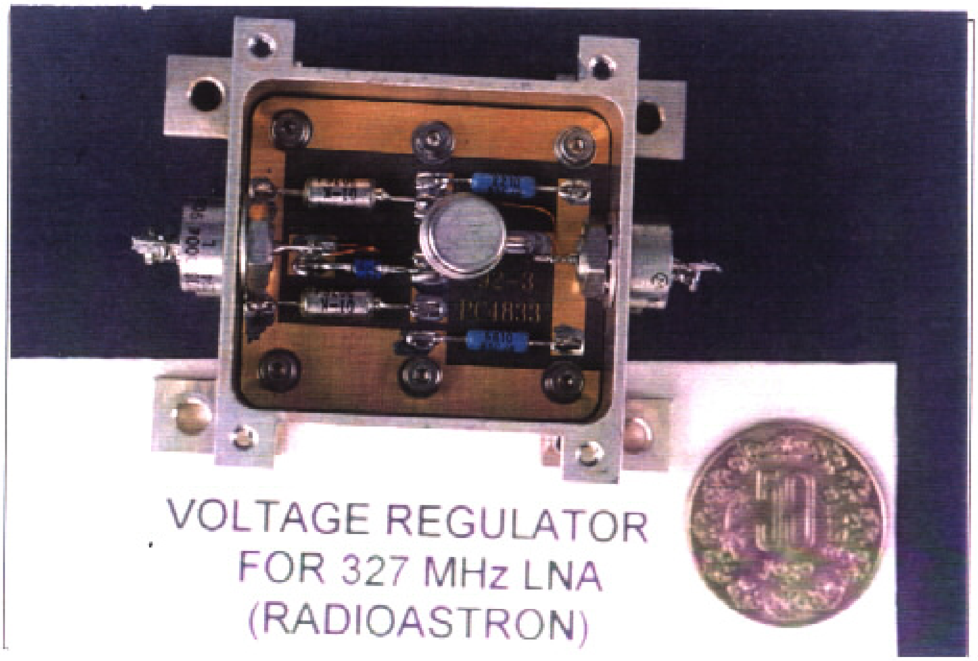


Top View

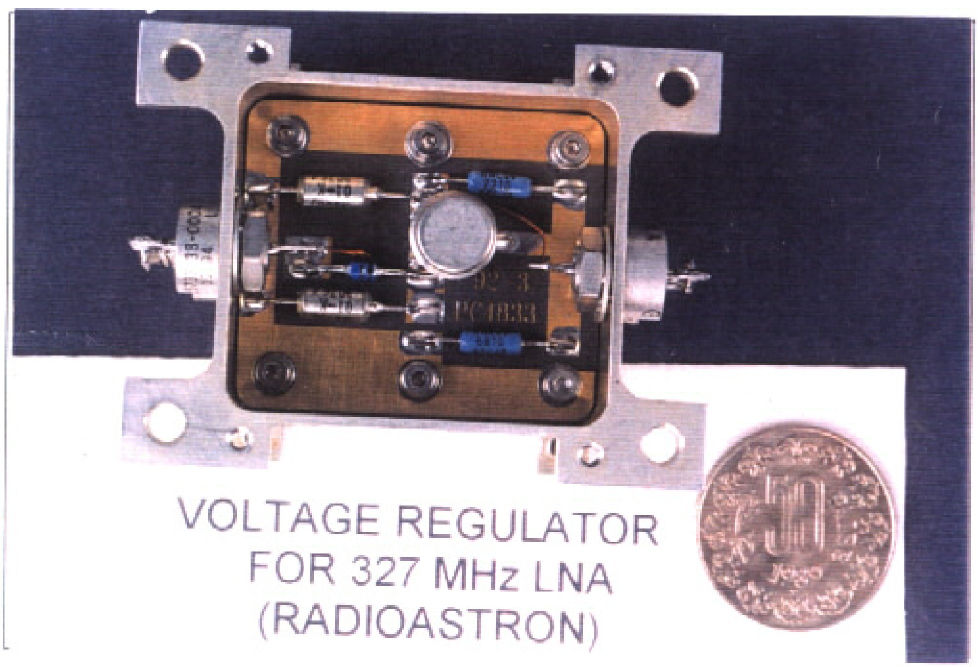


Bottom View

327 MHz Low Noise Amplifier [LNA] Unit



Top View



Bottom View

Power Supply [Voltage Regulator] Unit for the LNA

Contents

Preface

RADIOASTRON mission is a multinational, multifrequency radio astronomical satellite borne antenna project. It will operate at 327 MHz, 1.66 GHz, 4.8 GHz and 22 GHz frequency bands. On the basis of a 1988 Memorandum of Understanding (MoU) between Radio Astronomy Group of TIFR, India and Space Research Institute (IKI), Moscow, Russia, a space-qualified Engineering Model of a 327 MHz Low-Noise Front-End was delivered to Russians in 1991, as per the original specifications agreed upon. The frontend consisted of two-channel low noise amplifier (LNA) followed by bandpass filter and Post Amplifier, and also Directional Coupler for calibration noise injection. The whole front end package was planned to be enclosed in a thermostat for temperature control at 25°C. However, due to the delays suffered by the Radioastron project, the launch window of the Radioastron satellite had to be pushed to 1998. In the meanwhile, the Radioastron Project Management called for re-optimization of Payloads in order to conserve Spacecraft power and mass. As per the revised design, it was decided to have only LNA inside the thermostat and, the Bandpass Filter and the Post Amplifier within the rest of the 327 MHz Receiver Package. The new LNA had to be designed with new Electrical specifications in a smaller package. The bandpass filter which was originally built based on helical resonator technology has been replaced by a new compact dielectric ceramic resonator type filters offered by a firm in Russia. A new MoU was signed between TIFR's Radio Astronomy Group, India and the Astro Space Centre (ASC), Moscow, Russia in December 1992 for delivering an Engineering and two Flight models of the 327 MHz LNA with revised specifications.

This report aims at a comprehensive coverage of the design, implementation and space qualification of LNA package. Chapter 1 gives a brief description of the Radioastron Project in general. Chapter 2 describes the 327 MHz LNA at a block level with electrical, mechanical and environmental specifications. The basic design is covered in Chapter 3, and Chapter 4 describes the practical design aspects. Chapter 5 explains in detail the realization of the LNA package for high reliability and quality demanded by the space environment. Chapter 6 covers performance results, and chapter 7 attempts to present the space qualification tests and evaluation procedure. Operating instructions are given in Chapter 8. Various drawings associated with the package and related reports are all listed and attached at the end of the report.

January, 1997
Pune

A.Praveen Kumar
M.Srinivas

Acknowledgements

The 327 MHz LNA package is for use in deep space and therefore, the quantum of job involved is enormous. A work of this magnitude could not have been carried out without the help of numerous sources and people in the field. There are a number of agencies involved in the project, foremost among them being the lead centre, Astro Space Centre (ASC), Moscow; the funding agency, the Department of Science and Technology (DST), India; and the Space Applications Centre (SAC) of Indian Space Research Organisation, the key organisation which has fabricated and tested the package. Therefore, effective coordination between the various agencies involved is of paramount importance. We are indebted to Prof.S.Ananthakrishnan, TIFR, the principal investigator for the Indian involvement of the Radioastron Project, in this regard. Our special thanks to Dr.Kelvin J.Wellington of CSIRO, Australia, Chairman of the Radioastron Receiver group for his coordination and valuable suggestions. We gratefully acknowledge the active role played by SAC, Ahmedabad in realization and space qualification of the LNA package. We express our gratitude to Shri Pramod P.Kale, former Director of SAC who encouraged, provided timely suggestions and who was instrumental in bringing SAC involvement in this project. We wish to thank Dr.George Joseph, Director, SAC, Sri. O.P.N.Calla, Dr.K.N.Shankara for their continued support and encouragement.

We are greatly indebted to Dr.H.O.Gautam, the leader of the team for this project from SAC's side, who is primarily responsible in carrying out the job through his effective management of a large SAC team. We express our sincere thanks to the following groups at SAC, led by

1. Dr.H.O.Gautam, PRPD, Spacecraft Payload Group
2. Dr.P.Dhar, Reliability and Quality Assurance
3. Dr.R.K.Tyagi, Quality Control
4. Shri S.C.Bawa, Payload Fabrication Facility
5. Shri S.R.Naik, Technical Services Support Group.
6. Shri V.K.Manglik, Quality Assurance (Mechanical Division)
7. Shri S.K.Jain, Tests and Evaluation Committee
8. Shri K.J.Patel, MSS, Spacecraft Payload Group

Our special thanks are due to Mr.A.R.Srinivas of SAC, who has helped us in many ways during our stay at SAC and especially, for his contribution to the mechanical package design and analysis.

Back at TIFR, we thank our colleagues Shri N.G.Sreedharan, Shri M.N.Karthikeyan, Shri M.Gopinathan, Shri Sujit Uphadye and Shri S.N.Shiralkar for their support during the development stage of the LNA package. We wish to thank Shri Annabhat Joshi for his enthusiastic role in preparing this document. Finally we are thankful to Prof.V.K.Kapahi, Director NCRA–TIFR, Pune and Prof.Govind Swarup, Director GMRT Project, for their encouragement, support and guidance during the project.

January, 1997
Pune

A.Praveen Kumar
M.Srinivas

1. Introduction

1.1 General

RADIOASTRON mission consists of an orbiting 10 m diameter Radio Telescope in space operating in conjunction with several large ground based Radio Telescopes in standard Very Long Baseline Interferometry (VLBI) mode. This mission is aimed at achieving very high angular resolutions as fine as 35μas (at 22GHz). The space telescope is a centre fed prime focus antenna consisting of a deployable parabolic reflector made of 24 unfurlable reinforced carbon fiber panels with RMS surface accuracy of 0.5 mm. The total reflector surface accuracy will be less than 1mm RMS. The antenna F/D ratio is 0.43. The focal package is equipped with four dual circular polarization feeds and receivers at 92 cm (327 MHz), 18 cm (1.66 GHz), 6 cm (4.83 GHz) and 1.35 cm (22.2 Ghz). This package is supported by a quadripod attached to the fixed inner 3m diameter part of the reflector. The focal package is made of Aluminum (thickness 1.5 mm) and has a size of 74 cm × 110 cm (cylindrical). This package is filled with a gaseous medium rich in Nitrogen at a pressure of about 1.6 Std. Atm. and is hermetically sealed. The temperature of the gas within the focal container is expected to vary from 0°C to 40°C. The Low Noise Amplifier (LNAs) of the 327 MHz band is enclosed in a thermostat and maintained at a temperature of 23 ± 2°C using temperature control system. The LNAs of the other Receivers are cryogenically cooled to a temperature of 80°K. The feeds are of Running Wave Resonator (RWR) type at 327 MHz, 1.66 GHz and 4.83 GHz, and the 22 GHz feed is a horn. The feeds have a single phase centre and this frequency concentric feed arrangement provides the possibility to observe at two frequencies or two polarizations for a frequency band simultaneously. The Local Oscillator (LO) frequencies on board will be synthesized from a high stability reference signal transmitted from ground tracking stations equipped with hydrogen masers and is stable to about 1 part in 10^{14}. All the receiver bands are converted to an Intermediate Frequency (IF) of 512 MHz. A switching matrix receives the 8 IFs from the receiver and down converts using a second LO to a baseband with both upper and lower sideband outputs(video). At the baseband, any bandwidth among 2, 4 or 8 MHz can be chosen by appropriately selecting from four different second LO frequencies (500, 508, 516 and 524 MHz). The baseband signals are then sampled and formatted for transmission to the ground telemetry station at a rate of 128 M bit / sec (maximum). This data is relayed through a 15 GHz down link to the ground. The phase / Frequency reference signals are relayed via a two way (up and down) link at 7.2 / 8.47 GHz.

The mission life is normally 3 years. The attitude control system will provide pointing and tracking accuracy of 1 arc min (maximum error).

1.2 Scope

1.2.1 Identification

This document is on the 327 MHz Low Noise Amplifier realized for the Radioastron mission.

1.2.2 Purpose

The document deals with the design, implementation and space qualification of the LNA package developed for the 92 cm receiver payload of Radioastron satellite.

1.2.3 Applicable documents

i.	1987	General Technical Requirement Relating to Scientific Apparatus and Documentation for the `Radioastron' project Space Radio-Telescope (Blue Book).
ii.	May 1990	Scientific Objective Committee, Report to the 10th Review Meeting, Radioastron Project.
iii.	Dec 1992	Memorandum of Understanding between TIFR, India and Astro Space Center, Moscow.
iv.	Nov 1994	FE92CM-1, Electrical Specifications of 327 MHz LNA for Radioastron - Internal Report, TIFR.
v.	Nov 1994	FE92CM-2, Mechanical Specifications of 327 MHz LNA packagc for Radioastron - Internal Report, TIFR.
vi.	Nov 1994	FE92CM-3, Fabrication Sequence for 327 MHz LNA package of Radioastron - Internal Report, TIFR.
vii.	Apr 1995	FE92CM-4, Test Plan for 327 MHz LNA of Radioastron - Internal Report, TIFR.
viii.	Oct 1994	SAC-R&QA-RES-TR-47-94, Reliability Assessment for 327 MHz LNA Package for Radioastron Payload - SAC, ISRO.
ix.	Oct 1985	ISRO-PAX-301, Issue 2, Dcsign requirements for printed circuit board layout and artwork - ISRO.
x.	Dec 1983	ISRO-PAX-300, Issue 1, Workmanship standards for fabrication and clectronic package - ISRO.
xi.	Oct 1985	SAC-R&QA-RES-TN-22-85, Electrical parts stress derating requirements and application rules for INSAT-II TS Payloads - ISRO.
xii.	Nov 1996	92 LNA–TD, Technical description of 327 MHz LNA for Radioastron — Internal Report, TIFR.
xiii.	Nov 1996	92 LNA–OM–EMI, Operating Manual for 327 MHz LNA, Engineering Model — Technical Report, TIFR.
xiv.	Nov 1996	92 LNA–OM–FM1, Operating Manual for 327 MHz LNA, Flight Model # 1 — Internal Report, TIFR.
xv.	Nov 1996	92 LNA–OM–FM2, Operating Manual for 327 MHz LNA, Flight Model # 2 — Intcrnal Report, TIFR.
xvi.	Feb 1996	SAC–R&QA–RES–TR–09–96, Test & Evaluation Report, Engineering model — SAC, ISRO
xvii.	Feb 1996	SAC–R&QA–RES–TR–10–96, Test & Evaluation Report, Flight model — SAC, ISRO.

2. System Description

Figure 2.1 is a block level schematic of the 327 MHz (92 cm wavelength) LNA package. This consists of two-channel LNA (92-2-A and 92-2-B) and directional couplers (92-1) for injecting the calibration noise into the input of each LNA. The two channels named CH-1 and CH-2, receive left handed (LHCP) and right handed (RHCP) circular polarized astronomical signals from the feed. The LNAs are powered through voltage regulator (92-3-A and 92-3-B). The voltage regulators receive +12V DC power from the 327 MHz receiver package and generate + 5V DC regulated output voltage required for powering the LNAs.

The directional couplers and the two LNAs are housed in a single module of outer dimensions 114 × 101 × 32 mm. The two voltage regulators are packaged in a separate box of size 45.5 × 40.9 × 32 mm. The total package consumes 60 mA current at +12 V DC.

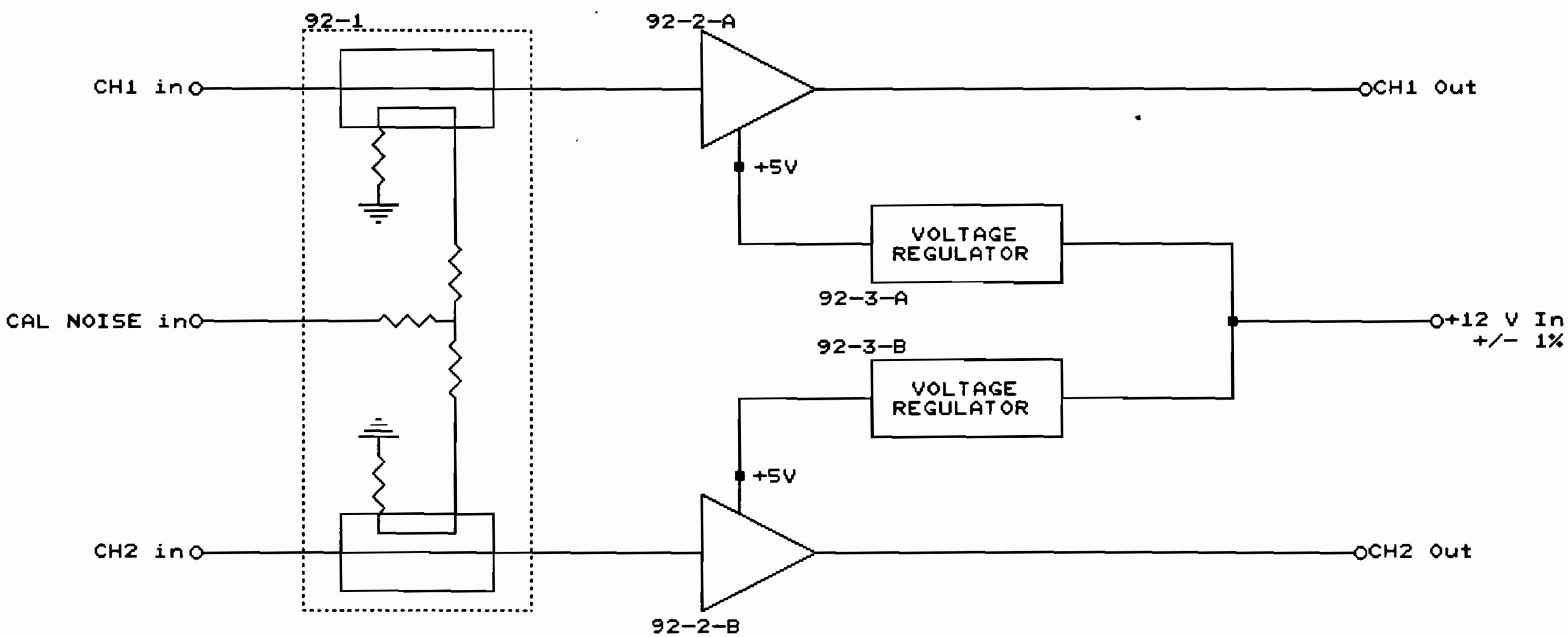
2.1 System Specifications

a. Electrical Specifications

- ☆ Center frequency 324 MHz.
- ☆ Gain at center frequency 30 ± 3 dB.
- ☆ Gain ripple over ± 4 MHz from the center frequency not more than ±0.25 dB.
- ☆ Difference in gain between the two channels not more than 1 dB.
- ☆ Input and output impedance, 50 ohms.
- ☆ Input VSWR to be optimized for low noise, but to be better than 1.6.
- ☆ Output VSWR better than 1.25.
- ☆ Noise temperature 25 ± 5 K.
- ☆ VSWR of noise calibration port better than 1.4.
- ☆ Isolation between two channels not less than 50 dB.
- ☆ Coupling of the calibration line including 6 dB resistive power divider 28 ± 1.5dB, coupling of directional coupler = 22 dB.
- ☆ DC supply voltage for the LNA +5 V and max current 50 mA per channel.
- ☆ DC supply available to the voltage regulator +12 V. ± 1% and maximum ripple 10mV, and current at least 60mA per channel.
- ☆ All RF connectors, SMA flange mount panel receptacles.
- ☆ Five SMA straight cable plugs for 0.141" semi rigid cable direct solder attachment type should be supplied - for all the ports.
- ☆ DC Bias voltage to the LNA through EMI Feedthru Filters.

b. Mechanical Specifications:

- ☆ Outside dimension for the LNA box including cover and excluding connectors and EMI feedthru filters: 105 (length) × 101 (width) × 32 (height) mm.
- ☆ Outside dimensions with mounting lugs for the LNA Box: 114 × 101 × 32mm.
- ☆ Mounting lugs should not project out along the width and the input side.
- ☆ The typical sketch of the Box is indicated in Fig. 2.2.
- ☆ The outside dimension for the voltage regulator Box including the covers and mounting lugs and excluding the EMI filters: 45.5 × 40.9 × 32mm. This is exactly as per the flight model drawings supplied by India, in 1991.



WIRELINE DIRECTIONAL COUPLER &

RESISTIVE POWER DIVIDER

Dir. Coupler-Coupling: 22 +/-1 dB

Net Coupling: 28 +/- 1.5 dB

LNA

G = 37 +/-3 dB
T = 25 +/- 5K

TIFR NCRA INDIA	RADIOASTRON	
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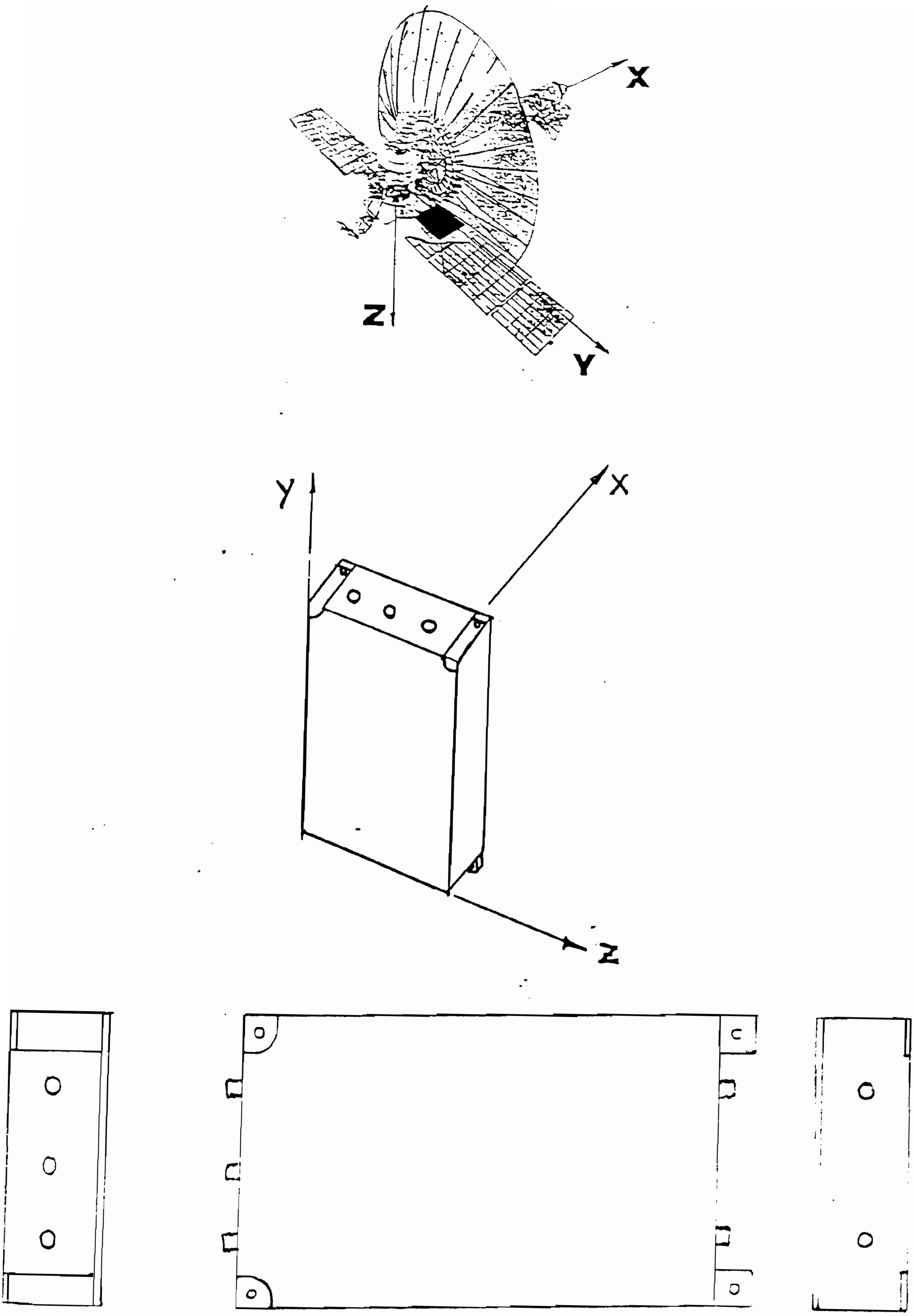


FIG. 2-2 LNA BOX CONFIGURATION AND ORIENTATION.

3. The basic design

In this section, the basic design of the Directional coupler and the Low Noise Amplifier (LNA) are described. This section covers

1. The choice of, the Directional Coupler and GaAsFET, the key components which determine the low noise performance of the LNA.
2. The technique of a combination of source inductance feedback and drain resistive loading, which ensures, low noise performance with power matching conditions and broadband stability of the LNA.

3.1 The Directional Coupler

The choice of the Directional Coupler is based on, dimensional constraint, which is a very important criterion in spaceborne packages, and very low insertion loss, so that the noise figure of LNA is not considerably degraded. Microstrip designs based on high-dielectric-constant-laminates could not meet the dimensional specification. Therefore, the WIRELINE™ drop-in coupler manufactured by Sage Laboratories, Inc, USA was chosen. These couplers, are tiny, low loss and have been successfully used in spacecrafts. A WIRELINE™ coupler consists of a pair of wires insulated from one another encased in a teflon insulator inside a metallic outer conductor. WIRELINE™ is essentially a four port parallel coupled TEM mode transmission line. A quarterwave electrical length of WIRELINE will be a 3dB directional coupler (Quadrature Hybrid) and, lengths less than quarter wavelength will yield looser coupling at appropriate frequency of design. JCT-1 series of WIRELINE™ (3.7 mm outer diameter), cut and trimmed to the required length are used for the design.

3.2 The GaAs MESFET

The NEC GaAsFET NE 13783 has been chosen for the design because this device has a proven reliability and space flight history. Grade C-(JAN TXV equivalent)-reliability grade devices in a hermetically sealed-package are used to meet the system reliability goal. The device features low noise figure and high associated gain (0.7 dB, G_A=14dB at 4 GHz) upto 18 GHz, by employing a recessed 0.5 micron gate. Using this high-gain, high-frequency GaAs MESFET, at 327 MHz, however, poses special problem of designing an amplifier such as for unconditional stability [1]. In particular the large gain at VHF, UHF frequencies make these devices inherently unstable. Another problem is in achieving both impedance match and low noise figure simultaneously since a minimum noise figure does not necessarily produce minimum input VSWR [2]. In a nutshell, the LNA design philosophy is to strike a solution that results in both optimum noise and power matching.

3.3 Source Inductance Series Feedback

Achieving the low noise figure from the device requires that the input matching network converts the 50 Ohm source impedance to the optimum reflection coefficient (Γ_{opt}) of the device. This leads to high VSWRs at 327 MHz, since Γ_{opt} and the complex conjugate of S_{11} differ significantly at these frequencies [2]. In other words, not only the 50 ohms source impedance should be transformed to GaAs FETs impedance for optimum noise matching (Z_{opt}) to get low noise performance, but also it should be transformed to the complex conjugate of its input impedance Z_{in} which is very much lower than Z_{opt}, for a low VSWR. The source inductance series feedback is incorporated, which has proved very effective in solving the matching problem mentioned above [3]. Adding this source inductance does not deteriorate the GaAsFET's noise performance. Compared with other matching techniques like use of an isolator or a balanced configuration, this method is simple and cost effective. The added inductance in the source of the FET provides negative feedback which increases the real part of the GaAsFET's input impedance, Re(Z_{in}) and make it close to the real part of the GaAsFET's impedance, Re(Z_{opt}), for optimum noise matching.

3.4 The Drain resistive loading

It is also essential that the amplifier is stable over wide range of frequencies, as any out-of-band oscillations will make it unusable. Though a source inductance provides good in-band noise performance and impedance matching at the input stage, and maintains the LNA stability, it may cause instability at higher (out-of-band) frequencies. To ensure stability over a wide band of frequencies, the drain is resistively loaded with 150 ohms which also improves the GaAsFETs output power matching to the second stage. The thermal noise added by this drain resistive loading is negligible. Also the combination of drain resistive loading and source inductance feedback decreases the gain of the GaAsFET by about 2 dB. This will not be a problem since, the device has enough gain for our application and gives an excellent low noise performance.

References

[1] Al Ward, "Low-Noise VHF and L-Band GaAsFET Amplifiers", RF Design, Feb. 1989 pp 38-46.

[2] A.J.Selvanayagam, A.Praveen Kumar, D.Nandagopal and T.Velusamy, "Sensitivity Boost to the Ooty Radio Telescope : A New Phased Array of 1056 Dipoles with 1056 Low Noise Amplifiers", IETE Technical Review,, Vol. 10, No.4, July-Aug, 1993, pp 333-339.

[3] D.R.Willams, W.Lum and S.Weinseb, "L-Band Cryognically - Cooled GaAsFET Amplifier" Microwave Journal, Vol. 28, Oct 1980, pp 73-76.

4. Practical design of the amplifier and its realization

In this section, the basic design of the amplifier described in the previous chapter is expanded to a real amplifier design and realization.

4.1 The Directional Coupler

Figure 4.1 shows the schematic of the Directional Coupler. The length of the WIRELINE™ required for the specified 22 dB coupling at 327 MHz is found to be 4.4 mm. The silver plated copper centre conductor pair (24 AWG each) should project out from either side of the above length by 6mm, for soldering on to the PCB pad. The thin layer of Kapton™ insulation has tô be removed from one of the centre conductors which has been coated with it, using notched cutting pliers supplied by the manufactures. The outer shield made of tinned copper has to be soldered to the PCB ground. The directional coupler has to couple calibration noise to the amplifier input and the isolated port has to be terminated in 50 ohms (R4 and R5). The resistive two way power divider configuring three 16.2 ohm resistor (R1, R2, R3) in a star network, injects calibration noise into both the channels. The RF chokes RFC-1 and RFC-2 at the input protects the LNA from any accidental DC voltages and static build-up. The Directional Coupler is realized on 78.5 mm x 22 mm substrate. (RT/Duriod 5880) of dielectric thickness 0.031 inch. Figure 4.2 shows the layout of PCB.

4.2 The Low Noise Amplifier

4.21 Figure 4.3 is the schematic of the Low Noise Amplifier. The design uses GaAsFETs in unipolar self-bias configuration with source resistors R1 and R2, for simplicity and the inherent transient protection associated with this technique, while turning the power ON. In the conventional two-supply bias technique, the biasing must be sequenced to prevent a large current from flowing through the GaAsFET. An additional merit of this bias configuration is it's DC negative feedback property which counteracts the effect of instability due to DC power supply fluctuations, if any. If there is an increase in the GaAsFET drain current due to DC voltage fluctuation, there will be an increase in the DC voltage drop across the source bias resistor. This means that the gate to source voltage V_{GS} becomes more negative (since the gate is held at DC ground) which in turn will decrease the drain current. At microwave frequencies NE-13783 is rated for minimum noise figure when operated at V_{DS} of 3 V and I_D of 10 mA. At UHF frequencies, however, it was found that lower noise figure is possible if the device is rebiased with a higher drain current and lower V_{DS}. Both the stages are biased in self-bias configuration and the optimum bias settings are as follows:

	V_{DS} (Volts)	I_D (mA)	Source bias Resistor
Ist stage	2.12	15	27 Ω
2nd Stage	2.5	11	39 Ω

The LNA is powered with +5 V DC. Resistors R3 and R4 are selected to provide the optimum V_{DS} for the GaAsFETs Q1 and Q2 respectively in combination the corresponding drain load resistors R5 and R6. The first stage drain load resistor R5 is choosen to be 150 Ω to match with the second stage input configuration. While the 2nd stage drain is loaded with a resistor of value 50 Ω (R6) to match the output port of the LNA. Also a 6dB chip attenuator (ATT) is incorporated at the output to improve the output port match and also to cut down the excess gain available from the LNA.

4.22 A simplest way to incorporate source inductance feedback is to use the device source leads. Source inductance feedback is provided in the first stage alone using 3 mm length of the two source leads of Q1 (See section 5.51, Fig.8). Gate inductors L1 and L4 are the crucial elements. L1 determines the frequency region in which the optimum noise performance exists. These inductors are handwound. To minimize mutual coupling between the inductors, L1 is wound in clockwise direction and L4 in counterclockwise direction (Fig. 5 and 6, Section 5.51). Inductor L4 is mounted at an angle of about 45° with respect to the axis of the Inductor L1 (Fig. 9 & 10 Section 5.51). To reduce the unwanted capacitive effects at the gate terminals, the ground plane of the PCB below the corresponding gate PCB pads are not provided. While designing the PCB layout ferrite beads (FB 1 and FB 2) are added in the drain leads of the device to suppress possible higher frequency oscillation or radiation. Two semi circular bottom pits each of width 1 mm (a) and diameter 2.5 mm (b) are machined on the PCB to hold the ferrite beads as illustrated in figure 3, and figure 11 in section 5.51. The ferrite beads are inserted vertically in the pit with the GaAsFET drain lead going through its ring.

4.23 The LNAs are realized on 74 mm x 41 mm substrate (Type RT / Duriod 5880 of dielectric thickness 0.031 inch, ε_r=2.2, Rogers Corporation, US). The 50 Ohm microstrip linewidths are 2.25 mm. The layout is designed to mount the GaAsFETs Q1, Q2 and the chip capacitors on the bottom side of the PCB containing the maximum portion of the ground plane and the rest of the components on the top side containing the microstrip lines. This arrangement assures the proper ground returns for the bypass capacitors, which is a critical factor in the construction. The method of using 'Z' wires through 'via' holes to connect the top ground plane to the bottom ground plane for bypassing the capacitors, was inadequate to provide the unconditional stability. Figure 4.4 shows the layout of the top side layout of the PCB and 4.5, the bottom side layout.

4.24 To eleminate possible cavity resonances, a few microwave absorbers are attached on the sidewalls of the top cavity and on the inner surface of the top cover. LNA PCBs are accessible from the bottom side also, since flush mounting chassis closing covers are provided under the LNA sections of the box.

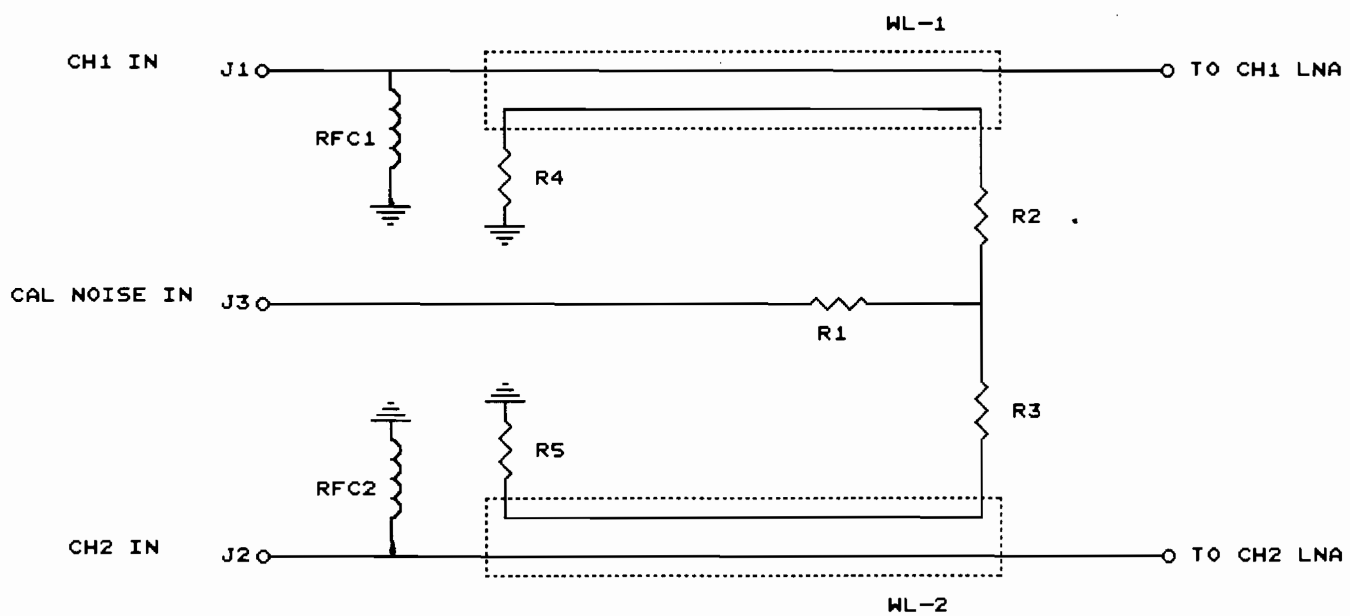
4.25 LNA Alignment and Tuning

The tuning elements are the gate inductors (L1 and L4) and the source inductance (L2 and L3). Since L2 and L3 has been frozen by providing the maximum possible source lead lengths of the GaAsFET (Q1), only L1 and L4 are available for tuning. As explained in section 3.3, the real part of input impedance, $Re(Z_{in})$, of Q1 is increased and brought close to real part of impedance for optimum noise match, $R_e(Z_{opt})$, because of the source inductance feedback. Therefore, the tuning target is to achieve a return loss of about 20 dB (VSWR 1.22) over the band of interest. This will automatically provide the optimum noise match. Inductor L1 has to be tuned to achieve this simultaneous input impedance and noise match. L1 can be compressed or expanded carefully and its position relative to the board surface can be varied to achieve this. Inductor L2 can be tuned in a similar fashion to achieve the optimum gain and frequency response.

4.3 The Voltage Regulator

Figure 4.6 illustrates the circuit of the voltage regulator. The function of the voltage regulators is to provide +5 V for the LNA package from +12V supply of the 92 cm receiver. Each channel LNA is being powered by a separate voltage regulator card, thereby making them more independent of each other. The voltage regulators are built around LM117 precision regulator and has reverse voltage protection by diodes at the input. The line filters provide the immunity against power line interference. Both regulator cards are housed in a single box, which will go into the rest of the receiver package. Figure 4.7 is the layout of the regulator PCB which has been realized on 33 mm × 38 mm substrate (RT / Duroid 5870) of dielectric thickness 0.062 inch.

Finally, figure 4.8 to 4.11 illustrate the component placement plan of all the PCBs associated with the package.



NOTES

WL-1, WL-2	: WIRELINE Directional couplers, 4.4 mm length of JCT1, SAGE LABORATORIES INC.
RFC1, RFC2	: RF Choke, Air-core type with ID. of 3mm, 10 turns of #20 AWG Magnet copper wire
R1, R2, R3	: 5023V- RNC55 type, 16.2 Ohms, +/-0.1%, 0.1W, 200V DC, MEPCO/CENTRALAB
R4, R5	: RM1505- RCWM5150 type, 49.9 Ohms, +/-1%, 150mW, 40V DC, Chip Resistors, DALE
J1, J2, J3	: SMA Flange Mount Jack Receptacle, OSM 2052-1132-00, OMNISPECTRA

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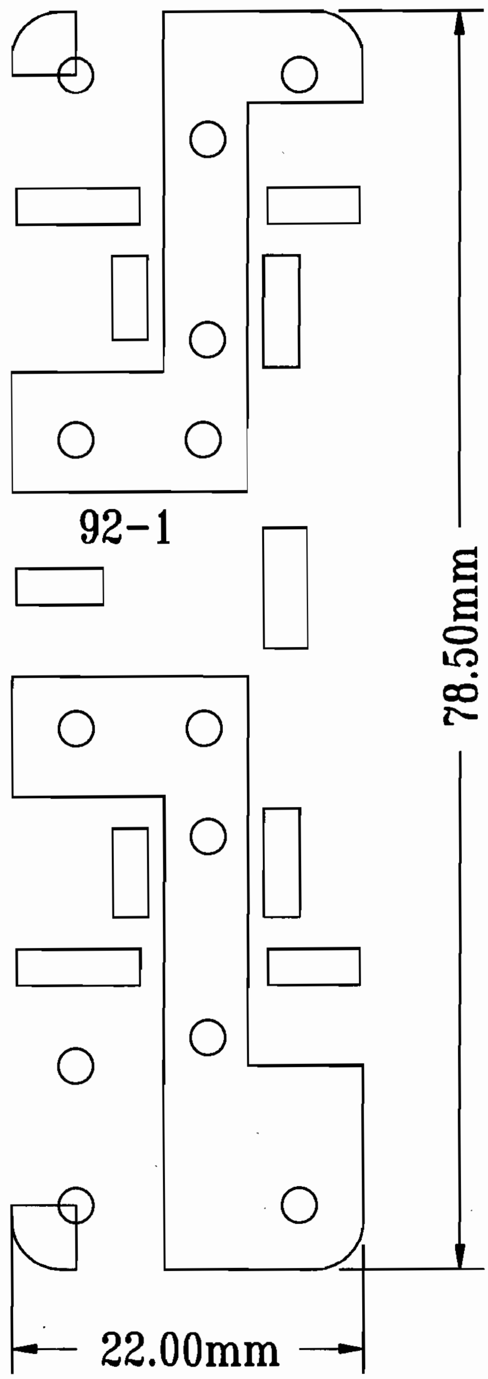
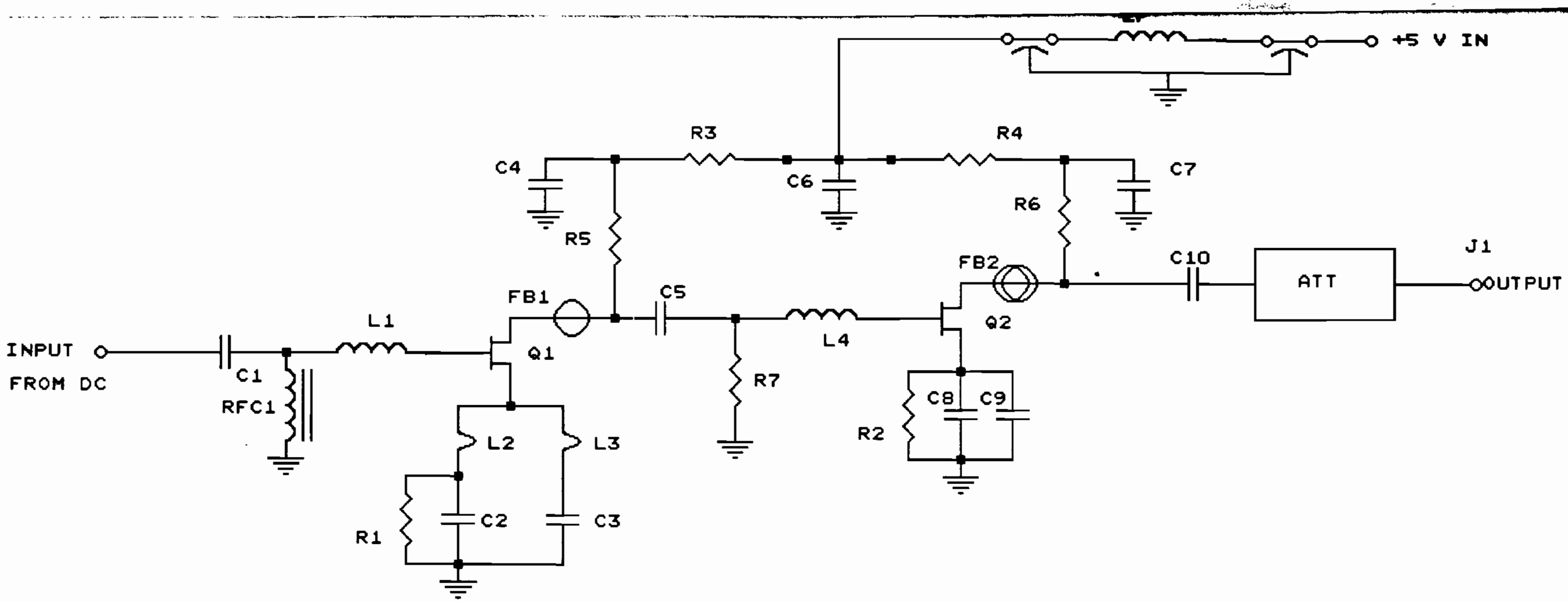


FIG. 4-2 Directional Coupler PCB layout



NOTES :

Q1,Q2	: GaAs MESFETs; NE13783, Grade-C, NEC/CEL,USA.
RFC1	: RF Choke 0.22 uH +/-10%, 1025mA rated, Axial lead; NYTRONICS M39010/8
L1	: Aircore inductor; 6.0 mm ID, close wound with 20 AWG Magnet Cu wire, 7 Turns
L2, L3	: Source inductance, 3 mm lead lengths in Q1
L4	: Air Core Inductor; 6.0 mm ID, close wound with 22 AWG Magnet Cu wire, 7 Turns
FB1, FB2	: Ferrite Beads, Torroidal Core, MICROMETALS T10-6
C2, C3, C6, C8, C9	: 680pF Chip Capacitor, +/-1%, WVDC 50V ATC CDR14, 0.110" [2.79 mm] square
C5	: 4.7pF Chip Capacitor, +/-0.1pF, WVDC 50V ATC CDR12, 0.055" [1.4mm] square
C1, C4, C7, C10	: 68pF Chip Capacitor, +/-1%, WVDC 50V ATC CDR12, 0.055" [1.4 mm] square
ATT	: 6dB Thin Film Chip Attenuator, +/-0.5 dB, 1.5W, PCAW-6 KDI
R1	: 27 Ohms, 5023V- RNC55 type, 125 mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R2	: 39.2 Ohms, 5023V- RNC55 type, 125mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R3	: 15 Ohms, 5023V- RNC55 type, 125 mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R4,R6	: 51.1 Ohms, 5023V- RNC55 type, 125 mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R5	: 150 Ohms, 5023V- RNC55 type, 125 mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R7	: RM1505- RCWM5150 type, 221 Ohms, +/-1%, 150mW, 40V DC Chip Resistor, DALE
EF	: Pi section EMI Filter, 1250-003 Bushing-mount, 1500 pF, 200V DC @ 85 C, 10 A, MURATA ERIE
J1	: SMA Flange Mount Jack Receptacle, OSM 2052-1132-00, OMNISPECTRA

TIFR NCRA INDIA	RADIOASTRON		
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	Size A	Document Number 92LNA-TD 92 - 2	REV 1

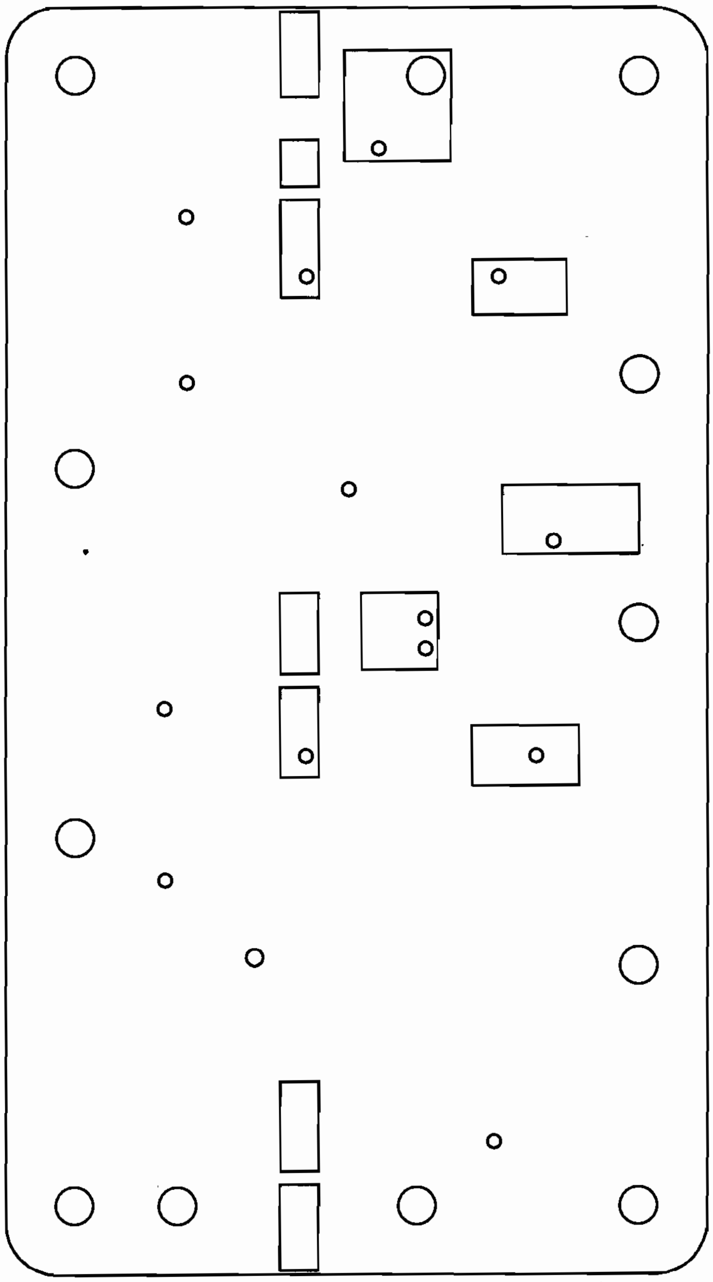


FIG. 4—4 Top Side of LNA PCB

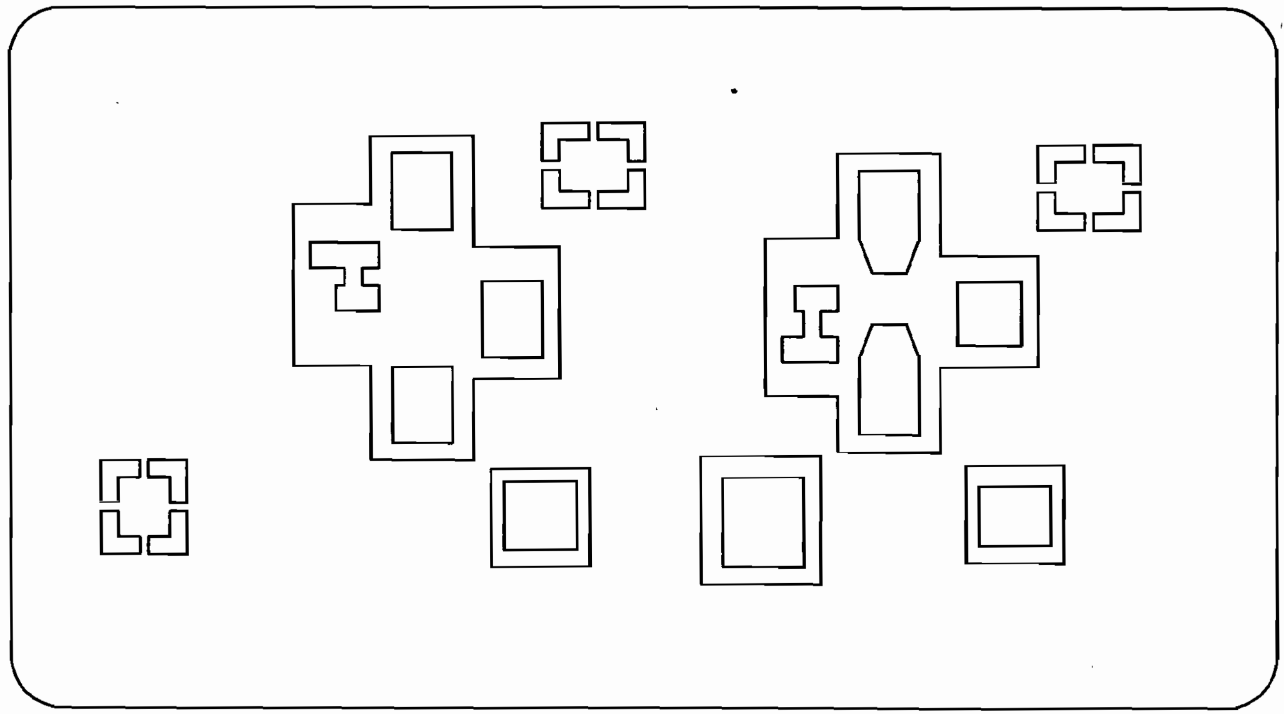
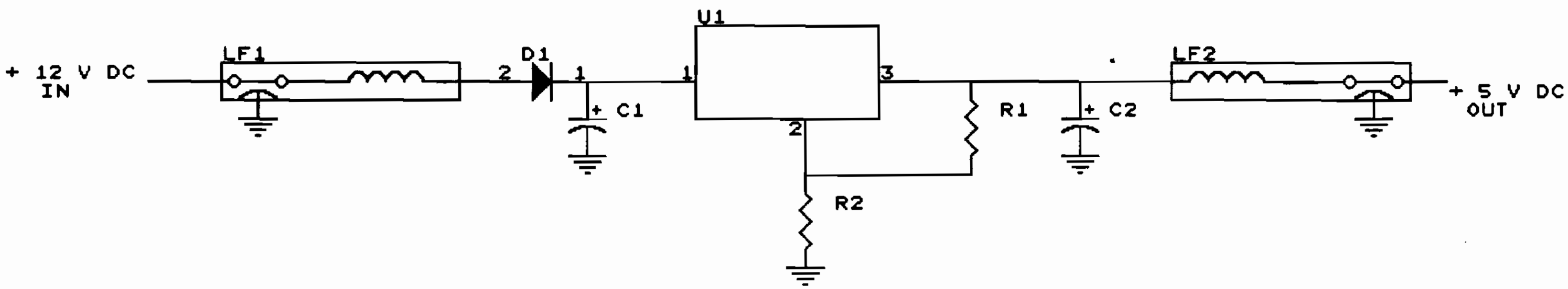


FIG. 4-5 Bottom side LNA PCB



NOTES

U1	: 3 Terminal Adjustable Voltage Regulator IC: JM 38510/11703 BXA, TO-39 style
D1	: Hermetically sealed glass case, Axial lead- Fast Recovery Rectifier Diode- JANTXV IN 5615, PIV 200V, Avg.I 1A @ 55 C, MICROSEMI
R1	: 5023V- RNC55 type, 221 Ohms Metal Film Resistor, +/-0.1%, 0.1 W, 200V DC, MEPCO/CENTRALAB
R2	: 5023V- RNC55 type, 681 Ohms Metal Film Resistor, +/-0.1%, 0.1 W, 200V DC, MEPCO/CENTRALAB
C1,C2	: 1uF, 50 V @ 85 C, CSR-13 Tantalum Capacitors, M39003/01/3076, KEMET
LF1, LF2	: Low Pass L Section EMI Filters with Bushing mount, 9051-100-0000/ 1.2 uF, 80V DC @ 85 C, 15 Amps, MURATA ERIE

TIFR NCRA INDIA	RADIOASTRON		
	Title: 92 cm LNA POWER-SUPPLY (VOLTAGE REGULATOR)		
	Size: A	Document Number: 92LNA-TD 92 - 3	REV: 0

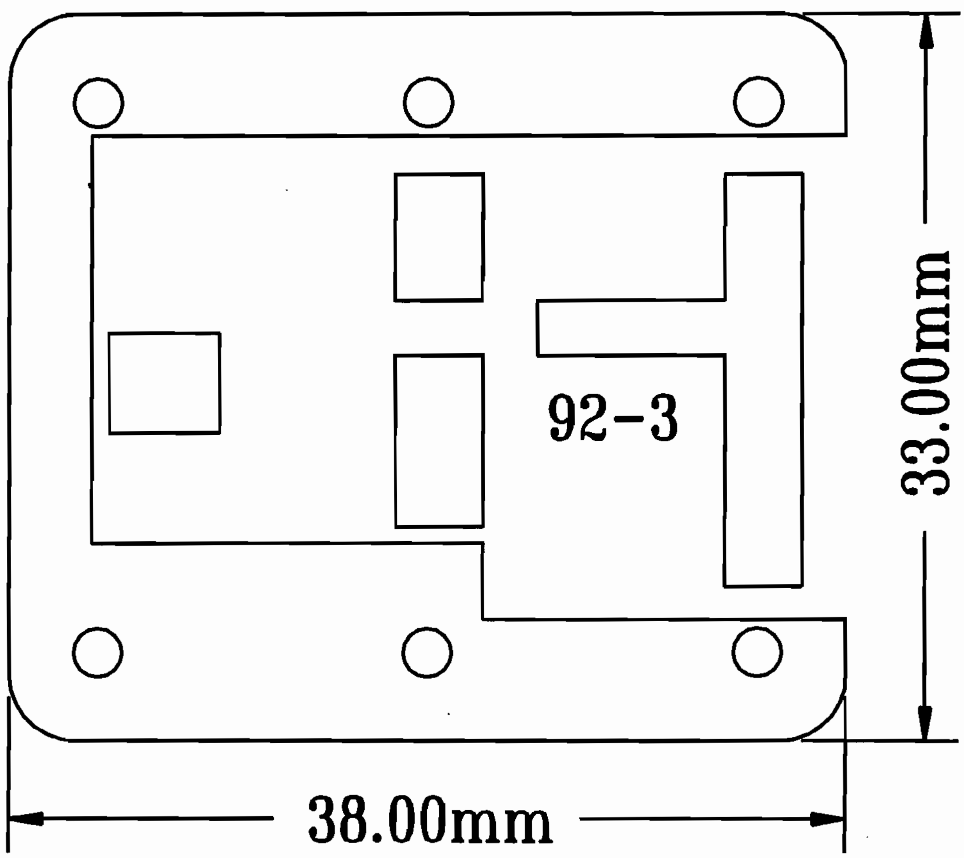


FIG. 4-7 Voltage Regulator PCB layout

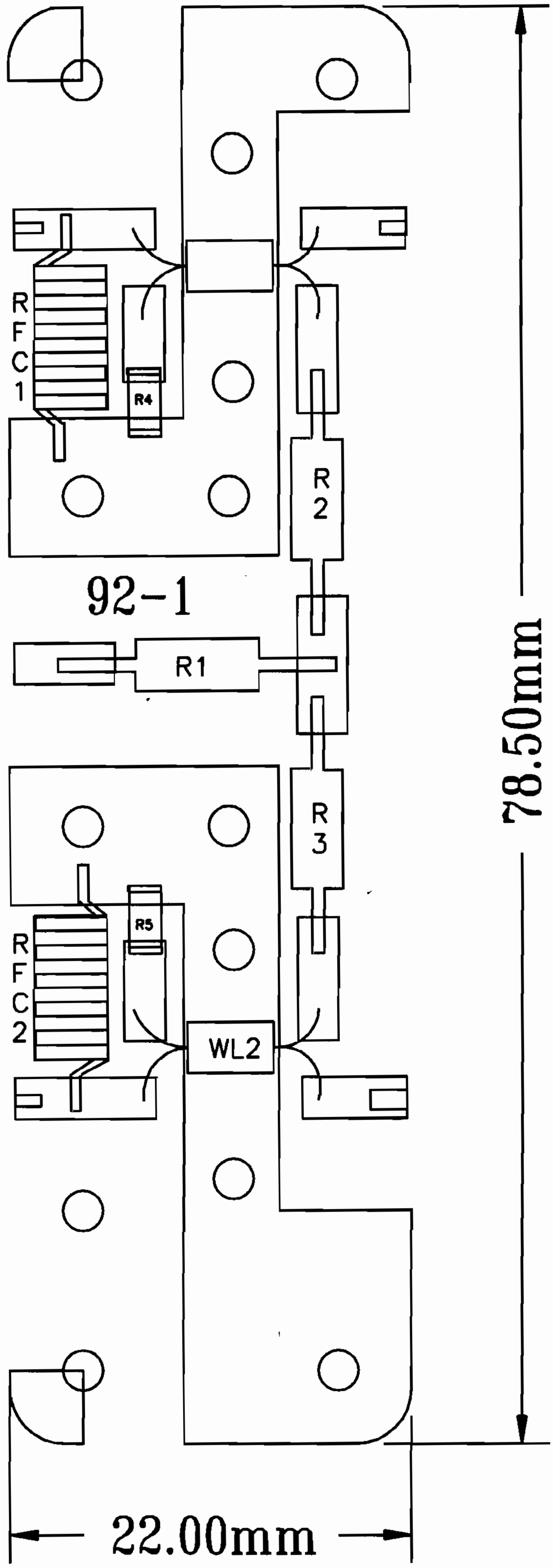


FIG. 4–8 Dir. Cplr. Component Placement

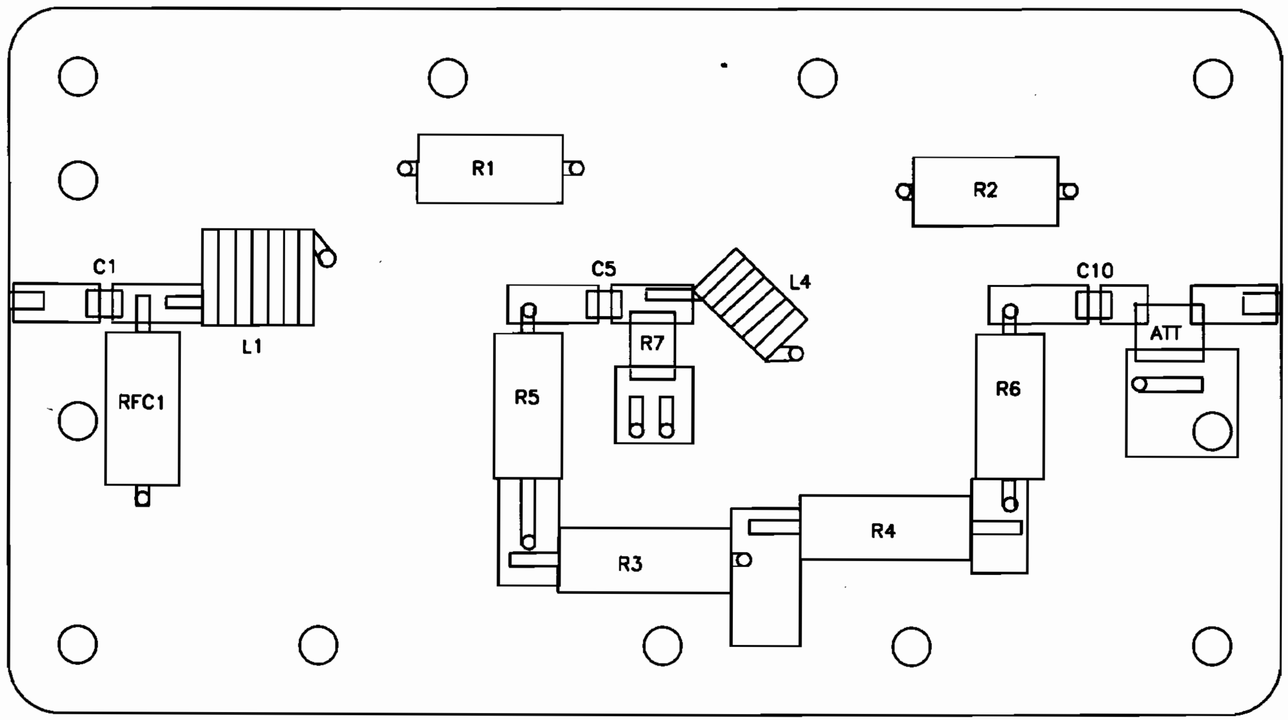


FIG. 4–9 Top Side Component Placement of LNA PCB

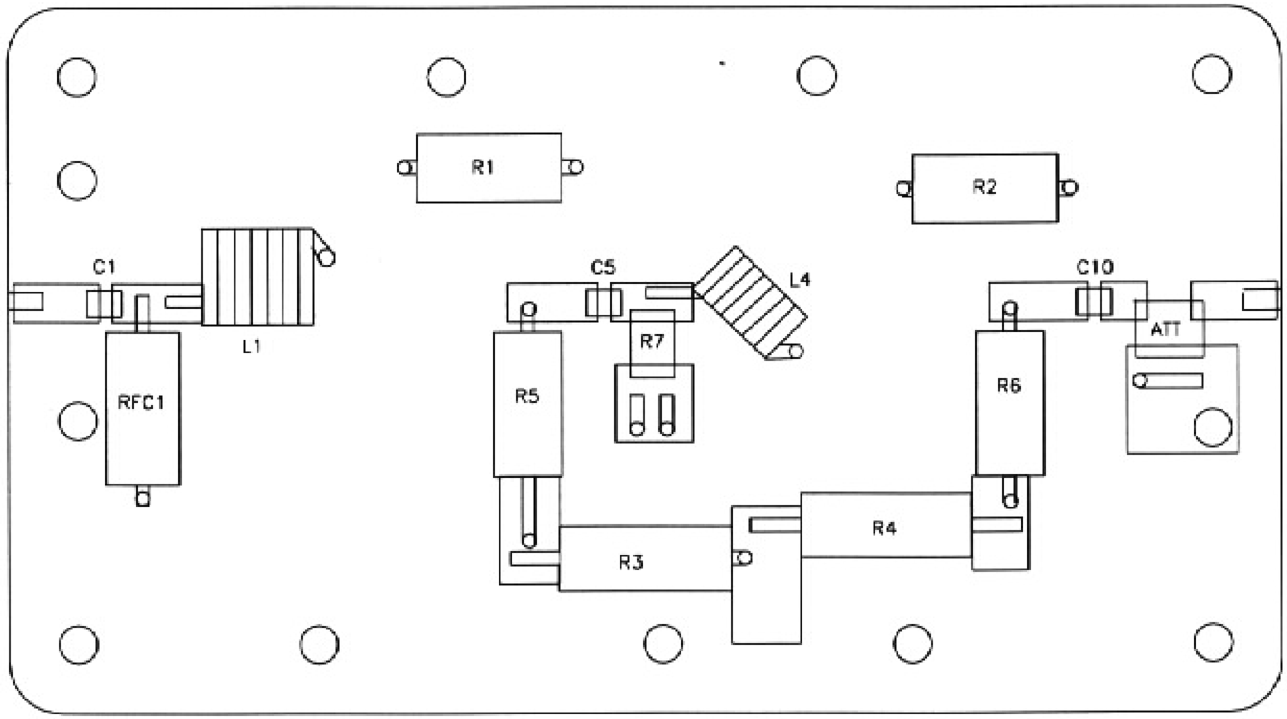


FIG. 4-9 Top Side Component Placement of LNA PCB

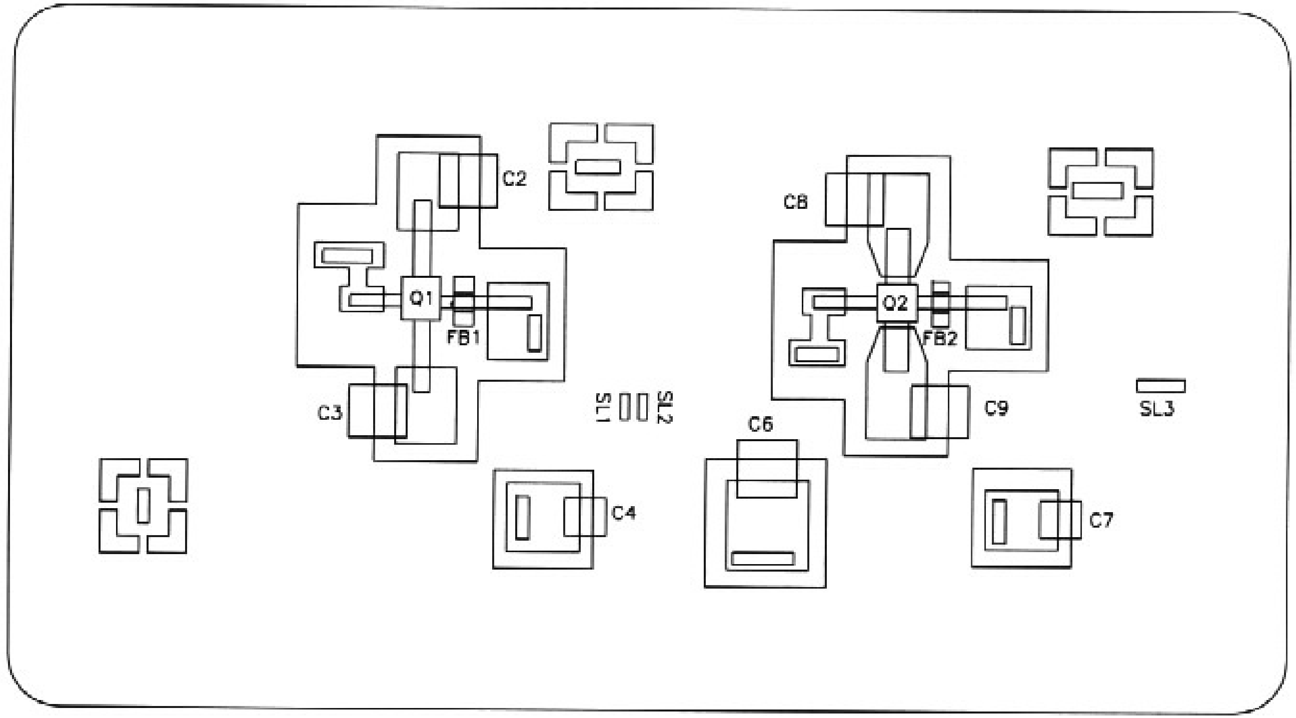


FIG. 4–10 Bottom Side Component Placement of LNA PCB

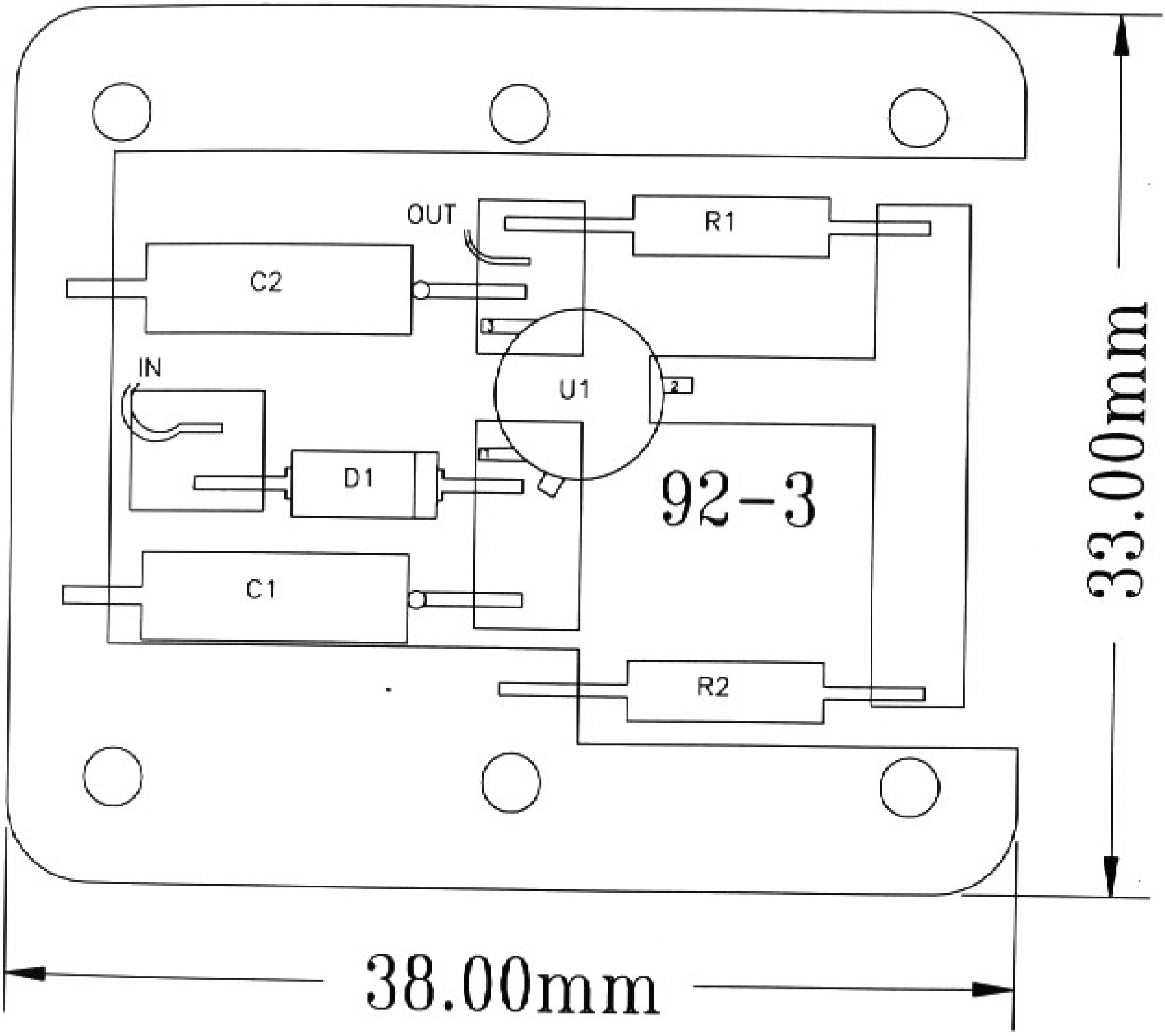


FIG. 4-11 Voltage Regulator Component Placement

5. Realization for High Reliability and Quality

The focus of this chapter is to present an overview of the methodologies and design practices to ensure reliability and quality demanded by the space environment and the methods adopted in the realization of the 327 MHz LNA package meeting the reliability goals. The flow chart for Reliability and Quality Assurance (R & QA) Plan shown in the next page describes the various R & QA activities under which realization of the LNA package was carried out at SAC, Ahmedabad.

5.1 Model Philosophy

An Engineering Model and two Flight Models have been fabricated and delivered to the Astro Space Center, Moscow. The Engineering Model construction is similar to Flight Model and the same quality of components were used. This model which has been integrated with the Engineering Model of the 327 MHz receiver at Russia will again undergo all the space qualification tests similar to those outlined in section 7.1.
Flight Model, after integration with the Flight Model of the receiver will be subjected to the acceptance level testing without extremes of temperature, stress or voltage. Worst case conditions are never applied.

5.2 Components and Materials Selection

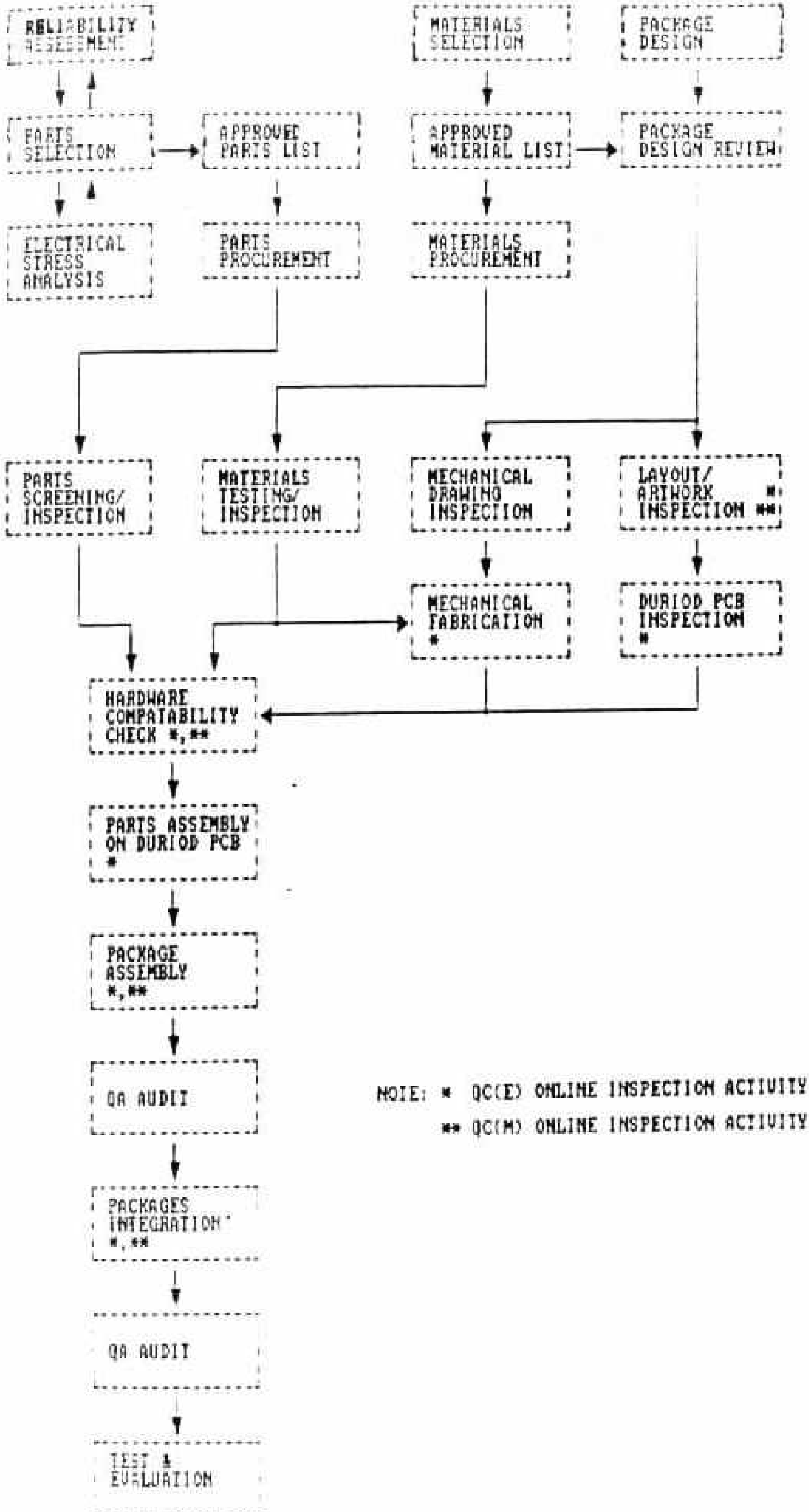
5.21 The first stage in ensuring high reliability is the selection and screening of every component used in the system. The steps in this direction are

- components of proven realibility and space history are chosen
- each component is tested (screened) individually to ensure that it meets the specification
- the active parts are subjected to destructive physical analysis on sample basis in accordance to MIL-STD-883 method 5009. For discrete semiconductor devices, the relavent tests are in accordance to MIL-STD-750.
- mechanical parts like fasteners are subjected to 100% go / no-go inspection
- material review - the materials are subjected to incoming inspection / testing on sample basis.

5.22 Components Quality

Component type	Quality
Integrated circuits	38510 Class B
GaAsMESFET	NEC Grade-C
Diodes	JAN TXV
Capacitors, Resistors and Inductors	'S' level
Line Filters	MIL-F-15733
Chip Attenuators	Meeting MIL-R-55342
RF Connectors	Hi-Rel

Appendix A2 gives component and material list.


RELIABILITY ASSESSMENT
MATERIALS SELECTION
PACKAGE DESIGN
PARTS SELECTION
APPROVED PARTS LIST
APPROVED MATERIAL LIST
PACKAGE DESIGN REVIEW
ELECTRICAL STRESS ANALYSIS
PARTS PROCUREMENT
MATERIALS PROCUREMENT
PARTS SCREENING/ INSPECTION
MATERIALS TESTING/ INSPECTION
MECHANICAL DRAWING INSPECTION
LAYOUT/ ARTWORK INSPECTION * **
MECHANICAL FABRICATION *
DURIOD PCB INSPECTION *
HARDWARE COMPATABILITY CHECK *,**
PARTS ASSEMBLY ON DURIOD PCB *
PACKAGE ASSEMBLY *,**
QA AUDIT
PACKAGES INTEGRATION *,**
QA AUDIT
TEST & EVALUATION
NOTE: * QC(E) ONLINE INSPECTION ACTIVITY
** QC(M) ONLINE INSPECTION ACTIVITY

FLOW CHART: [illegible]

5.3 Reliability Assessment

5.31 Reliability assessment has proven to be effective in the prevention, detection and correction of failures associated with design, fabrication and operation of a product. The assessment is done basically for two reasons.

a. To know what is the probability that the subsystem will still be working after a given time period.
b. We need to provide redundant components or subsystems where the probability of failure is very high, to be accepted.

There are two most commonly used assessment techniques

i. Parts count method
ii. Parts stress method

Parts stress method is employed for reliability predictions of the LNA package. This method takes into account the effects of environmental and other stresses on a part's failure rate. Each part's failure rate is based on a stress analysis of the design.

5.32 Reliability Mathematics

The reliability number or figure R is the probability of success.

$R = N_s / N$

where N_s is number of surviving components after a given time and N is the total number of components at the start of test period.

If N_f is the number of components that have failed after a given time t, then

$N_f(t) = N - N_s(t)$

Then, Reliability R(t) can be expressed as

$$R(t) = [N - N_f(t)] / N$$
$$= 1 - N_f(t) / N$$
$$= 1 - P_f(t)$$

where $P_f(t) = N_f(t) / N$ is the probability of failure.

Failure rate λ is a measure of the average number of failures expected from a group of items over a period of time. From this measure of failure rate λ, the reliability of a design can be expressed as

$R(t) = e^{-\lambda t}$

where t is the time interval over which reliability is measured. Mean time between failure, MTBF, is the reciprocal of failure rate.

i.e., $MTBF = 1/\lambda$

The overall relaibility of the 327 MHz LNA package is estimated to be
0.991 for 3 years mission time
0.994 for 2 years mission time.

Copy of the SAC document SAC/R&QA/RES/TR/47/94, Oct 94 for reliability assessment, in Appendix A3 gives detailed procedure, the reliability block diagram and the Mathematical model employed for the reliability prediction.

Failure rates for various parts are calculated as per the guidelines given by the U.S.Military reliability prediction document MIL-HDBK-217F published in December 1991.

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Then, Reliability R(t) can be expressed as

$$\begin{aligned} R(t) &= [N - N_f(t)] / N \\ &= 1 - N_f(t) / N \\ &= 1 - P_f(t) \end{aligned}$$

where $P_f(t) = N_f(t) / N$ is the probability of failure.

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Failure rates for various parts are calculated as per the guidelines given by the U.S.Military reliability prediction document MIL-HDBK-217F published in December 1991.

5.4 Electrical Stress Analysis

Electrical stress analysis has been carried out to improve the reliability of the LNA pacakge for each of the circuits. To improve reliability, one needs to reduce the effects of stress. At SAC, the stress analysis technique is based on derating criteria and design margins. Derating is based on the concept that operating electrical, thermal, mechanical and chemical stresses accelerate failures in a predictable manner, which if controlled, will improve reliability. For an electronic equipment, typical derating parameters include current, voltage, power, frequency, fanout and operating temperature. The method involves the operation of a part at a stress level less severe than that for which it is rated. This is accomplished by a combination of

a. reducing part stress and
b. selection of a part with a higher rated strength.

ISRO(SAC) document No.SAC/R&QA RES/TN/22/85 dated Oct 31, 1985 describes Electronic Parts Stress Derating guidelines for space applications. This document contains the Maximum Stress Ratio and additional requirements to be adhered to for all the stress parameters like voltage, power, current, junction temperature, for all types of electronic components. The Stress Ratio is the ratio of the actual operating stress-paramter value to the maximum rated value under the application conditions. For the 327 MHz LNA package, stress analysis was carried out and it was ensured that all the parts stress were held to as low a level as was consistent with SAC derating guidelines and circuit requirements.

5.5 Fabrication Sequence for the LNA Package

5.51 Fabrication sequence for LNA and Directional Coupler

5.52 Fabrication sequence for Power Supply (Voltage Regulator).

The pages 29 to 37 cover detailed fabrication sequence and methods.

5.6. Layout and Package Design Considerations

The layout design philosophy is to ensure electrical performance while adhering to high reliability requirement criteria. Methodology is to stress on prevention of defects rather than allowing for possible rework or repairs, even though the latter cannot be totally eliminated. Various procedures for placement, mounting and soldering of components have been arrived at, by experience and extensive analysis, and adherance to the procedures is mandatory to realize reliable operation of the package.

Given the dimensional constraint to start with, we had to design the layout of the PCB in the space left after incorporating basic mechanical design features like sufficient wall thickness, ribs, etc., for strength and rigidity of the package. The PCB layout design has to take into account

→ fabrication requirements like ease of mounting of components, soldering, cleaning and handling. The position and orientation of the components are decided such that any component can be removed from the card without disturbing the other components. Where the components are soldered to the ground plane, the soldering point has to be suitably relieved, by having "winged pads". This reduces warp, twist and blisters in the finished PCB. The width of pads for soldering components like chip capacitors and resistors are decided by requirements set by hi-rel procedures listed in the PCB layout design document ISRO-PAX-301. Similarly, there are guidelines for spacing between components, their mounting and soldering, specified in that document, which have been followed in designing the layout

→ mechanical requirements to withstand shock, acceleration, vibration, environmental effects, etc. The components are provided with stress relief to overcome these effects

→ electrical requirements like providing the shortest path to ground for the bypass capacitors; minimum pad size for soldering GaAsFET gate leads, to avoid capacitance effects; track width for 50 Ω transmission line, etc.

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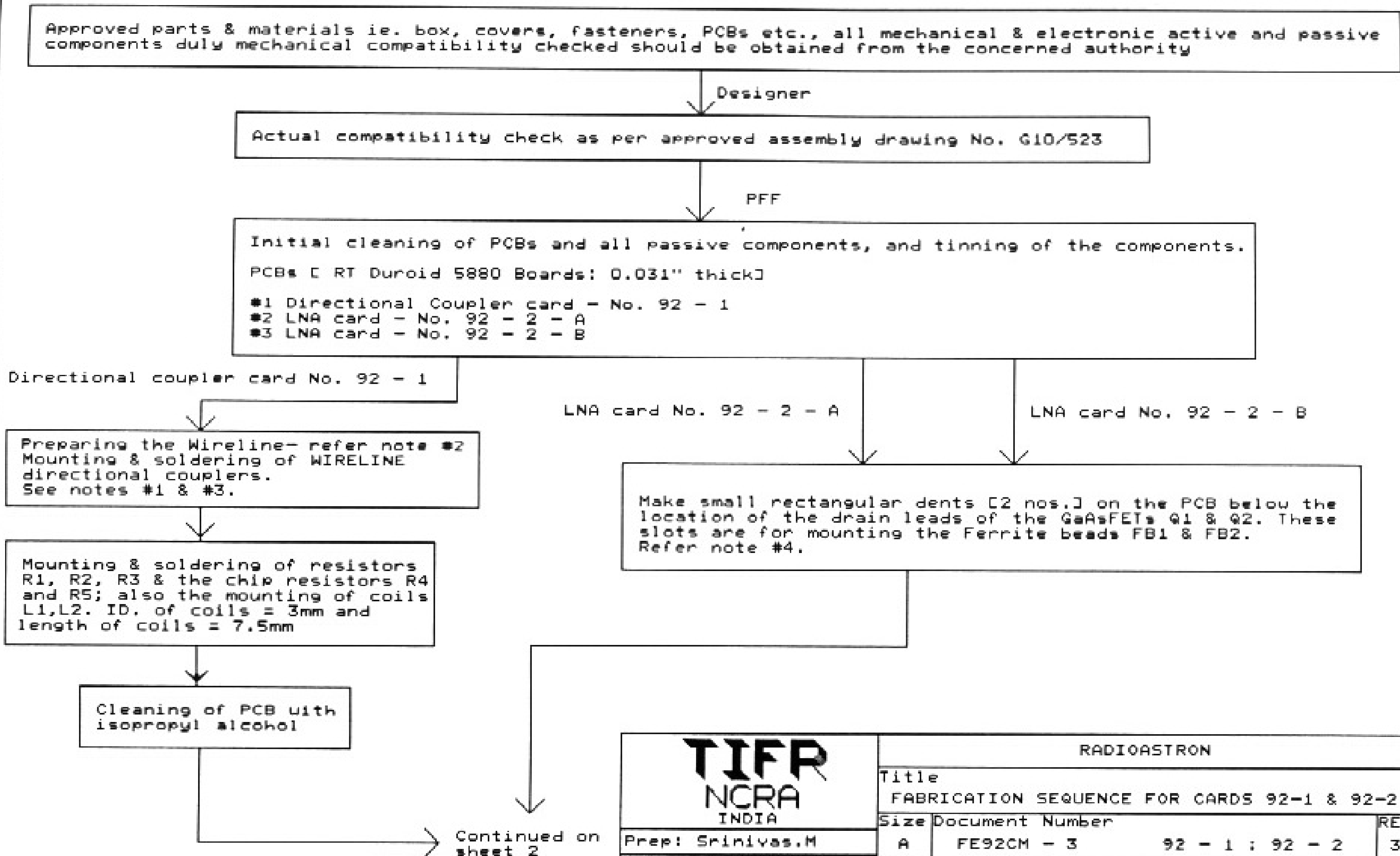

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	Size: A	Document Number: FE92CM - 3 92 - 1 ; 92 - 2	REV: 3
Prep: Srinivas.M			
Aprvd: A.Praveen Kumar	Date: November 1, 1994	Sheet 1 of 7	

Card 92 – 1

From sheet 1

Cards 92 – 2 A & B

Mounting and soldering of short links at three locations as shown in fig.4
Refer note #1 and #5.
The locations of the short links (SLs) are also shown in the component placement diagram accompanying this note.

↓

Mounting & soldering of chip capacitors [CDR12 type] C1,C4,C5,C7 and C10;
Mounting & soldering of chip capacitors [CDR14 type] C2,C3,C6,C8 and C9;
Mounting & soldering of the chip resistor R7 and attenuator ATT.

↓

Mounting and soldering of metal film resistors RNC55 type: R1,R2,R3,R4
R6 and RNC60 type resistor R5. Refer note #6 for mounting configuration

↓

Continued on sheet 3

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Aprvd: A.Praveen Kumar	Date: November 1, 1994	Sheet 2 of 7

Mounting and soldering of the RF Choke RFC1

Prepare inductor L1. Refer note #7.

Prepare inductor L4. Refer note #8.

Mount L4 assuring the coil is wound in the counterclockwise direction. Mount it as explained in note #11 and solder.

Mount inductor L1 as per note #12 assuring that the coil is wound in clockwise direction and solder.

Mounting & soldering of GaAs FET Q2. Refer note #9.

Mounting & soldering of GaAs FET Q1. See note #10.

Cleaning of PCB with isopropyl alcohol. The cards are now ready for integration with the box.

Fix the cards in appropriate cavities in the box with M2 screws. Ensure permanent torque is given.

Fix the card in the appropriate cavity in the box using M2 screws by giving permanent torque.

Card ready for integration with cards 92-2-A & 92-2-B.

Interconnect cards 92-1 & 92-2-A and also the cards 92-1 & 92-2-B using alpha 1223 tinned copper braids. The braid has to be mounted with stress relieving loop radius of 2mm and its length can be about 12mm. Mount the two EMI Filters on the side wall of the box after inserting the ground lugs. Tighten them with permanent torque.

Continued on sheet 4

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	Title: FABRICATION SEQUENCE FOR CARDS 92-1 & 92-2		
Prep: Srinivas.M	Size: A	Document Number: FE92CM - 3 92 - 1 : 92 - 2	REV: 2
Aprvd: A.Praveen Kumar	Date: November 1, 1994	Sheet 3 of 7	

Mount the five SMA connectors on the side walls and fix them with approved fasteners (M2 screws) with permanent torque.

↓

Solder the center pins of the 5 SMA connectors to the respective PCB tracks.

↓

Connect the 2 EMI Filters to the PCB tracks as shown in the HARNESS DRAWING G10/523 (sheet 1 of 3) with a single strand #30 AWG Cu Magnet wire.

↓

Fix covers with permanent torque after completing the tuning of LNA.

← Designer

Functional Tests

NOTES

#1 It is important to use throughout the construction 2% Ag bearing solder wire (62% Sn, 36% Pb, 2% Ag) and solder using flux or using 62% Sn, 36% Pb, 2% Ag flux cored solder wire.

#2 Preparing (cutting) WIRELINE:See Fig.1. An exact length of 16.5mm of thermal cycled Wireline is cut and the center conductors are bared for a length 6 cms on both the sides. The handling procedures are given more in detail in Annex 1. The length of the WIRELINE should be within a tolerance of +0.2mm/-0.5mm. The Kapton should be present up to the pad on which the lead is to be soldered.

#3 WIRELINE mounting: Refer Fig.2. The Wireline body should be soldered to the ground plane.

#4 Make small rectangular dents on the surface of the PCB which falls below the location of drain leads of Q1 & Q2 as shown in Fig.3. These slots are made for fixing in position the toroids FB1 & FB2.

(a) Mark with pencil on the PCB, the center point for making the slot as shown in Fig.3(a)
(b) Take a hand drilling circular hacksaw drill bit (of hacksaw tip width 0.8 mm to 1 mm). The drill bit is shown in Fig.3(b).
(c) Fix the drill bit in a hand drilling machine & hold it horizontally (not in the usual vertical orientation) and make a smooth rectangular dent at the marked point. The depression should be of size 2.5mm X 1 mm with a semicircular depth of 0.5 mm as shown in Fig.3(c)

Figure 11 shows the side view with the ferrite bead in position.

#5 Top to bottom grounding locations shown in Fig.4(a) are classified according to the manner in which they have to be bent and soldered.

(a) For the groundings at '*' marked locations refer Fig4(b)
(b) For '+' locations refer Fig.4(c)

#6 The leads of the MFRs R1,R2,R5 and R6 are to be terminated on the bottom side [Clinched]. The lead of R3 terminating at the power supply pad is to be clinched while the other end is to be surface mounted. R4 should be surface mounted. The mounting of these resistors are illustrated in the parts placement diagram.

#7 Prepare the inductor L1 as follows. It is an air core inductor with 7 turns of #20 AWG magnet Cu wire (polyamide coated) closely wound with 6 mm ID. Length of the coil is approx. 6 mm. It is important to wind this inductor in a clockwise direction (cw) as shown in Fig.5

#8 Prepare inductor L4 as shown in Fig.6. This inductor consists of 7 turns of #22 AWG magnet Cu wire closely wound with 6 mm ID. and approx. 4 mm long air-core type. It is important to wind this inductor in a counterclokwise (ccw) direction.

#9 It is very important that the mounting of GaAs FETs are done with antistatic workstation with grounding of the forceps, soldering iron etc. The soldering personnel must also ensure that their hands are static free. The gate & drain pads must be shorted to ground pad using short leads of Cu wires. The temperature

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Aprvd: A.Praveen Kumar	Date: November 1, 1994	Sheet 4 of 7		

of soldering is set to 280 deg.C. Maximum duration of soldering is 5 sec. After taking all precautions for static sensitive equipments, take GaAs FET Q2 & insert the toroidal core FB2 onto the drain lead as shown in Fig.7 Extra lengths on the drain, gate & source leads can be cut to the required lengths prior to soldering. The toroid must be fixed in the dent made on the substrate using proper expoxy compound. Now solder all the leads of the GaAsFET ensuring that the maximum duration of soldering is 5 sec. with the temperature of soldering iron set to a max of 280 deg.C

#10 After mounting Q2, insert the toroidal core FB1 onto the drain lead of GaAs FET Q1 as shown in Fig.8. It is very imprtant that 3 mm long lead on each source are exposed (not soldered to the pad) since the source inductances L1 & L2 are realized using these leads. The toroid FB1 is fixed on the substrate in the slot provided. Now solder all the leads of the GaAs FET Q1 following the same precautions as given in note #9.

#11 Mounting & soldering of the inductor L4 is done as per Fig.9

#12 Mounting & soldering of inductor L1 is illustrated in Fig.10

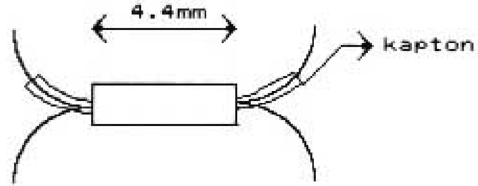

FIGURE 1 Config. of cut WIRELINE

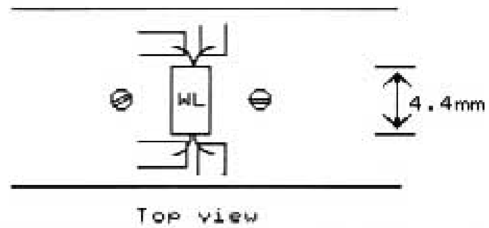

FIGURE 2 WIRELINE Mounting Configuration

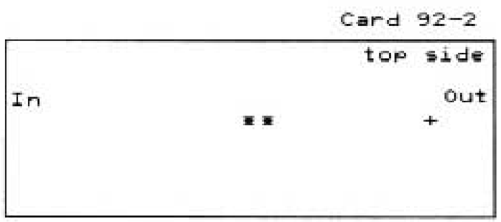

FIGURE 4(a) Top-bottom hole locations

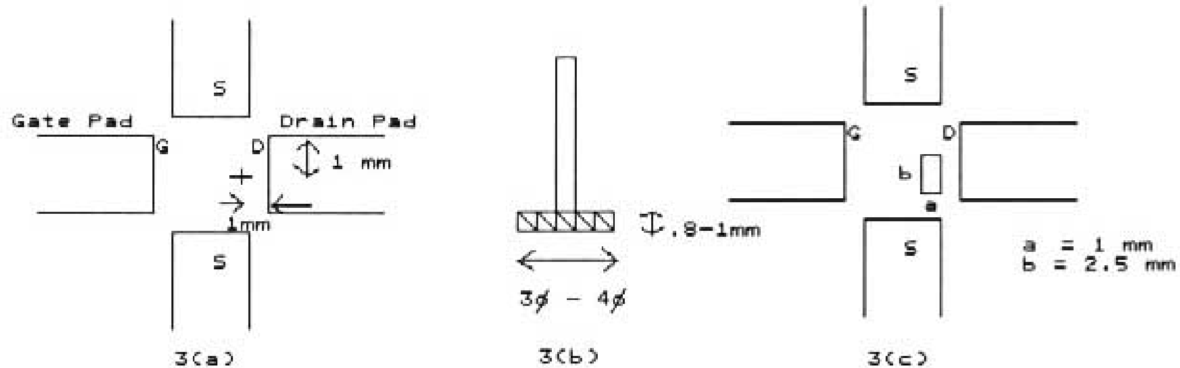

FIGURE 3

FIGURE 4(b) FIGURE 4(C)

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Aprvd: A.Praveen Kumar	Date:	November 1, 1994	Sheet 5 of	7

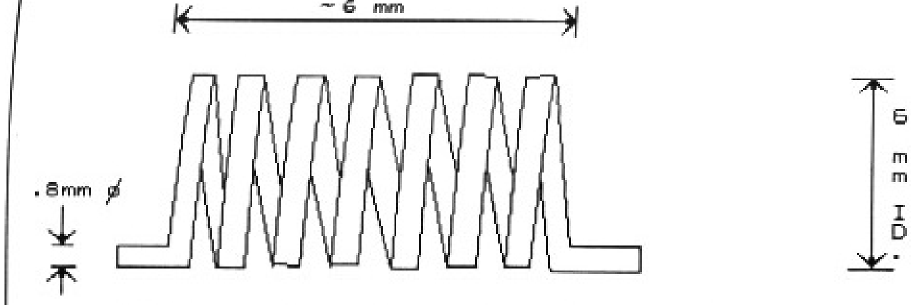


FIGURE 5 Inductor L1 wound in cw direction

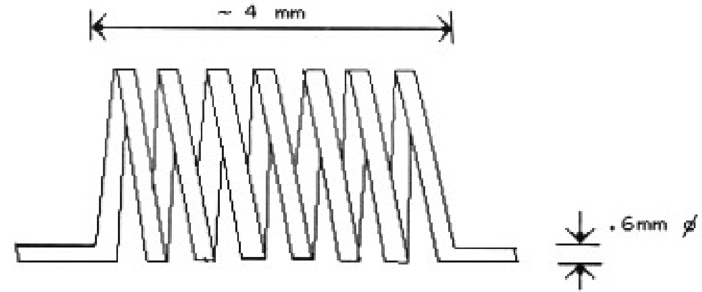


FIGURE 6 Inductor L4 wound in ccw direction

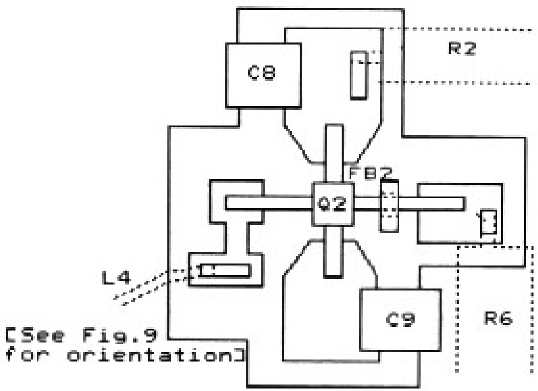


FIGURE 7. Mounting configuration for Q2

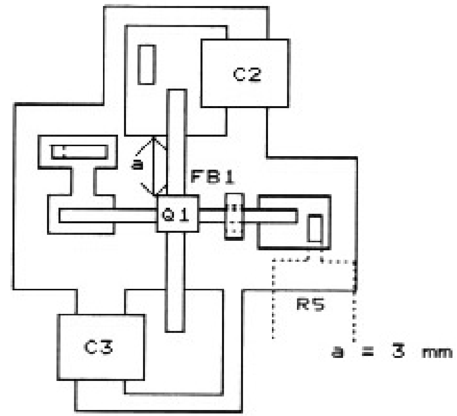


FIGURE 8. Mounting configuration for Q1

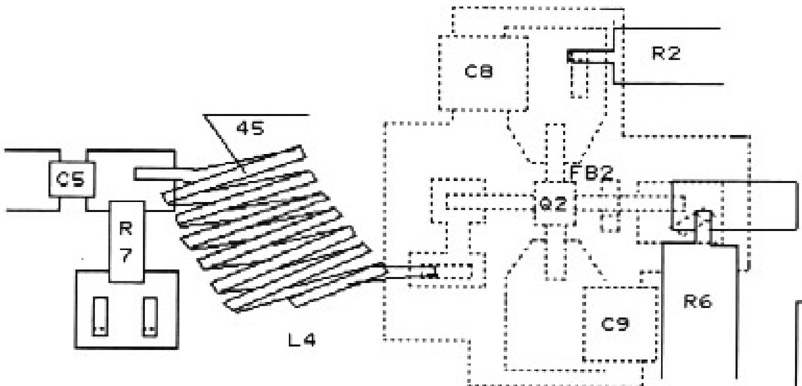


FIGURE 9. Mounting config. for L4

w.r.t. Fig 9:
Solid lines represent top side of the PCB
And dotted lines, the bottom side.

TIFR NCRA INDIA	RADIOASTRON		
	Title FABRICATION SEQUENCE FOR CARDS 92-1 & 92-2		
Prep: Srinivas M.	Size A	Document Number FE92CM - 3 92 - 1 : 92 - 2	REV 2
Aprvd: A.Praveen Kumar	Date: November 1, 1994	Sheet 6 of 7	

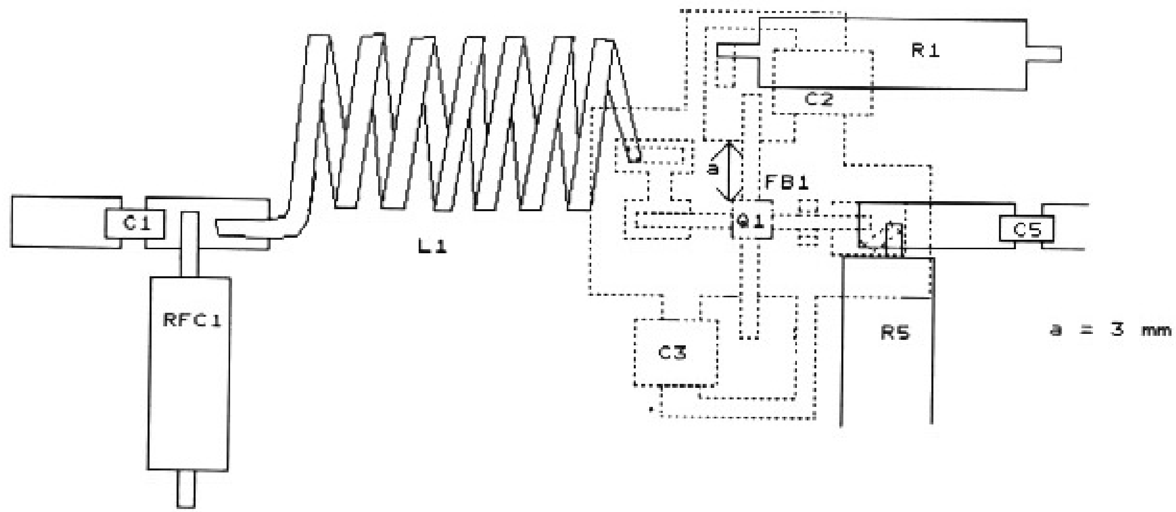


FIGURE 10. Mounting config. for L1

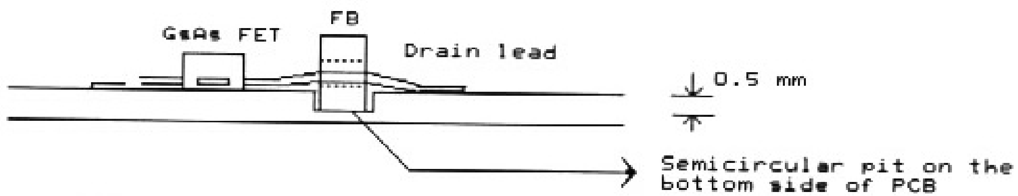


Fig.11 Mounting of ferrite bead

TIFR NCRA INDIA	RADIOASTRON		
	Title: FABRICATION SEQUENCE FOR CARDS 92-1 & 92-2		
Prep: Srinivas M.	Size: A	Document Number: FE92CM - 3 92 -1 : 92 - 2	REV: 2
Aprvd: A.Praveen Kumar	Date: November 1, 1994	Sheet 7 of 7	

5.5.2 FABRICATION SEQUENCE FOR RADIOASTRON - POWER SUPPLY BOX

Approved parts & materials i.e. box, covers, fastrs, PCBs etc., all mechanical & electronic active and passive components duly mechanical compatibilty checked should be obtained from the concerned authority

↓ Designer

Actual compatibilty check as per approved assembly drawing No. G10/462

↓ PFF

Initial cleaning of PCBs and all passive component, and tinning of the components.

PCBs [RT DURIOD Boards: 1.6 mm thick]

#1 Voltage Regulator card No. 92 - 3 - A
#2 Voltage Regulator card No. 92 - 3 - B

↓ Card Nos. 92 - 3 - A & 92 - 3 - B

Mounting and soldering of R1, R2, C1, C2 and D1

↓

Mount & solder the IC - 3 pin Voltage Regulator. Refer note #1.

↓

Cleaning of the PCBs with isopropyl alcohol

↓

Card ready for integration in box

↓

Continued on sheet 2

TIFR NCRA INDIA	RADIOASTRON		
	Title: FABRICATION SEQUENCE FOR CARDS 92-3 -A & -B		
	Size: A	Document Number: FE92CM - 3 92 - 3	REV: 1
Prep: Srinivas.M			
Chkd: A.Praveen Kumar	Date: November 1, 1994	Sheet 1 of 2	

From sheet 1

Fix the two cards in the respective cavities of the box using the approved fasteners by giving permanent torque.

Fix the four Line Filters on the side walls of the box followed by fixing of the ground lugs. Tighten these with permanent torque.

Interconnect the four Line Filters with the proper PCB tracks using #30 AWG magnet Cu wires. Insulation sleeves have to be used for the wires from F1 & F3 [Refer Dwg. G10/462 sheet 1 of 3].

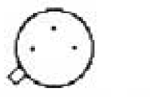
Fix top & bottom covers with permanent torque.

Designer

Subsystem ready for Functional testing.

NOTES

#1 Mounting arrangement for IC U1 :



Pin #1 Input
Pin #2 Adjust
Pin #3 Output (case)

FIGURE 1(a) Pin Configuration of U1

Bend the pins by 90 in a direction going away from the center of the IC (See Fig. 1(b) below).
Bending should be done at approximate lead length of 3 mm from the base of the IC.

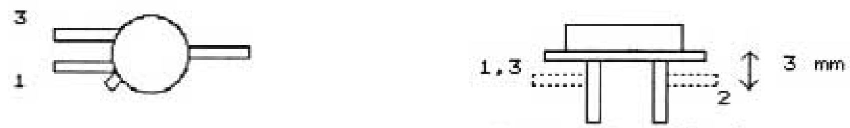


FIGURE 1(b) Views of U1 after bending the pins

TIFR NCRA INDIA	RADIOASTRON		
	Title FABRICATION SEQUENCE FOR CARDS 92-3 -A & -B		
Prep: Srinivas.M	Size A	Document Number FE92CM - 3 92 - 3	REV 1
Chkd: A.Praveen Kumar	Date: November 1, 1994	Sheet 2 of 2	

6. LNA Performance

The following table summarizes the performance of all the modules delivered to Astro Space Center, Moscow.

Electrical Parameters

Parameters	Specifications	Results					
		EM01		FM01		FM02	
		CH1	CH2	CH1	CH2	CH1	CH2
Gain @ 324 MHz	37±3 dB	38.7	37.9	38.1	37.6	37.7	36.6
Noise Temp.	25±5K	25	26	28	27	27	27
Input Return Loss	≥ 13dB	22	16	18	23	22	16.4
Cal port RL	≥ 16dB	18.4	18	18	18.2	18.4	18.4
Output RL	≥ 19dB	20	21	22	22	20.3	21.0
Isolation	≥ 50dB	76	63	70	69	65	71
Noise Coupling	28±1.5dB	25.6	26.4	27.4	26.3	26.6	26
Pass Band	> 8 MHz	> 8	> 8	> 8	> 8	> 8	> 8
DC Current (LNA+PS) @5V	50mA Max. (per channel)	35.4	34.6	33	37	28	27.5
Gain slope		1.5db over 8 MHz Pass band		1.3 db over 8 MHz Pass band		1.5dB over 8MHz Pass band	

The test reports SAC-R&QA-RES-TR-09-96 (of EM) and SAC-R&QA-RES-TR-10-96 (of FM1 & FM2) [refer Appendices 4 & 5] carry details of test conditions and results.

Mechanical Parameters

Box/ Unit	Parameter	Specification	Achieved
LNA	Outer Dimension (including cover & excluding connectors and feedthrus)	105×101×32mm	105×101×32mm
LNA	Outer Dimension (including mounting lugs)	114×101×32mm	114×101×32mm
Voltage Regulator	Outer Dimension (including covers and mounting lugs and excluding EMI filters)	45.5×40.9×32mm	45.5×40.9×32mm
LNA	Weight	No Specs.	445g
Voltage Regulator	Weight	No Specs.	80g
LNA	Contact area	No Specs.	10875 mm^2
Voltage Regulator	Contact area	No Specs.	1907.5 mm^2

The acceptance test report generated at the time of delivery of these models has been attached at the end of the report [Refer Appendix 6].

7. Tests and Evaluation for Space Qualification

7.1 Test Sequence for Space Qualification

The 92 cm receiver П-KPT-92 will undergo a series of space qualification tests for compliance to specified levels. The sequence for tests and evaluation (T & E) of the Engineering Model of the Receiver is briefly listed below

1. Physical Measurement
   a. Mass
   b. Centre of gravity
   c. Moments of Inertia
   d. Dimensions
   e. Footprint
   f. Surface Flatness
2. Electrical Functional Tests
   (Initial Bench Test)
3. EMI / EMC Tests
   EMC tests for compliance to the permissible levels specified for

   Radiated Emissions
   Radiated Susceptibility
   Conducted Emissions
   Conducted Susceptibility
4. Environmental Tests
   Temperature Storage (Cold and Hot)
   Humidity Storage
   Thermal Cycling (Operational)
5. Vibration Tests
   Resonance search (stiffness test)
   Steady-state (sine) vibration tests (x, y, z axes separately).
   Random vibration test
   (x, y, z axes separately)
   Static and Dynamic Overload tests
   Final Resonance Search (stiffness test)
6. Final Electrical Functional Tests

The details of all the tests and procedures and the acceptable levels for compliance are covered in the Radioastron 'Blue Book'.

For the LNA package alone, the above mentioned complete qualification tests need not be carried out since it will undergo these tests after integration with the receiver. Therefore, only the tests specified in the next section (7.2) have been performed for qualification, at Space Application Centre, Ahmedabad.

7.2 Test Program for 327 MHz LNA Package

7.21. Warm up period.

The LNA is switched on and operated for 100 hours. No measurement is to be done during this period. The environmental conditions are normal as below :

☆ Temperature	20 ± 5° C
☆ Humidity	<80%
☆ Pressure	1013±50 mbar

7.22 Test Equipment

1.	Vector Network Analyzer	HP8510B
2.	S Parameter Test Set	HP8515A
3.	Scalar Network Analyzer	HP8757C
4.	Noise Figure Meter	HP8970A
5.	Cal. Noise Source	HP346A(5dB ENR)
6.	Spectrum Analyzer	HP8562
7.	Dual Directional Coupler	HP11692
8.	Color Pro Plotter	HP7475A
9.	EATON Hot & Cold Noise Source	
10.	SWEEP Oscillator	HP8350B

The set ups for measuring the various parameters are shown in figures I through IV.

7.23 Initial Bench Test

This test shall be conducted at A/C laboratory conditions and all the specified electrical parameters (refer section 2.1 a) are to be measured for its compliance to the specifications.

I. Parameters to be measured

1. Noise Temperature
2. Input Return loss (or VSWR) at all input ports
3. Output Return loss at CH1 & CH2 output ports
4. Gain at C.F. for each channel
5. Frequency Response
6. Band Width
7. Phase Response
8. 1 dB Compression Point
9. Difference in gain between channels
10. Isolation between channels
11. Directional Coupling

II. Functional Tests

Apply +12V DC (±1%) from a regulated power supply and measure the supply voltage (+5V) going to the LNAs. Measure the DC currents drawn by both the channels.

(a) Noise Temperature Measurement

Figure I shows the set up for measuring the noise temperature. Measure the noise temperature of both the channels (with all the unused ports terminated) in the frequency range 320 MHz to 328 MHz, in steps of 2 MHz.

(b) Return Loss Measurement

Figure II shows the configuration for measuring the input and output return losses in the frequency range from 310 to 330 MHz. Terminate with 50 ohms loads, all the unused ports during the measurement. The responses are to be plotted.

(c) Gain Measurement

Measure and plot the frequency response in the freq. range 310 to 340 MHz using the set up shown in figure III, for both the channels (nominal input power level is -60dBm). The gain flatness in the pass band from 320 to 328 MHz for each channel is to be measured and the band width is to be determined. Record the gains of each channel in the pass band in 1 MHz steps. The gain difference between the channels at the C.F. (324 MHz) is to be noted, then.

(d) Phase Measurement

Measurement of phase response has to be done using the set up shown in figure II. Take a plot of the response in the frequency range 310 MHz to 340 MHz, for each of the channel.

(e) Measurement of Isolation between channels

Measure the isolation between the channels CH1 and CH2 by,

(i) by feeding -60 dBm power input to CH1 and measuring the forward transfer gain (S21) difference beteween the channels CH1 and CH2;

(ii) Similarly, measure the difference in the gains of the two channels for -60 dBm power level at CH2 input port. (Unused ports shall be kept terminated.) The test set up is same as the one used for the measurement of the gain response ie. Figure II.

(f) Measurement of Coupling

Terminate the CH1 and CH2 input ports with a 50 Ohms load and feed signal at the Cal. noise port and measure the gains in the frequency range from 320 to 328 MHz for each channel. Therein, derive how much the signal from Cal. Noise input gets attenuated compared to the signals if they had been fed from CH1 & CH2 inputs. The test set up is shown in Fig.III.

(g) 1 dB Compression Point Measurement

Measure the output 1dB compression point for both the channels, at the center frequency (C.F.). The measurement set up is same as that used for measuring gain.

7.24 Thermal Soak (Operational) Test

The unit has to undergo 4 thermal cycles in the temperature range 0°C to 40°C with 2 hours stabilization at each extreme temperature. It should be further followed by one (5th) cycle of 4 hours stabilization at each of the above extreme temperature. The unit shall be kept ON continuously during the test. During the last cycle (5th), the gain and phase stability have to be recorded for a duration of 4 hours, at every 1/2 hour interval. The heating & cooling rates are 2 deg. per min and 1 deg. per minute respectively. Refer figure IV for the soak test plan.

7.25 Vibration Test

This test is non-operational. The electrical functional tests shall be carried out before and after this test for its compliance to the specifications.

The unit shall be directly mounted on the vibration shaker and subjected to sine vibration of 2g at 25 Hz for 10 minutes in all the three axes.

7.26 Temperature Transportation Test [Storage test]

The LNA unit in the transportation package shall be kept at a temperature of -50°C for 24 hours. After this, normal conditions (room temperature) are to be created and the measurement of Noise temperature and VSWR are to be performed. Then, the package shall be kept at a temperature of 50°C for 24 hours, and the noise temperature and VSWR measurement are to be repeated, after the normal conditions are restored. The heating and the cooling rates are the same as mentioned in section 7.24. This test needs to be carried out only on the engineering model.

7.27 Final Bench Test

The final bench test shall be carried out in A/C laboratory conditions and all the specified electrical parameters (refer section 7.23) shall be measured.

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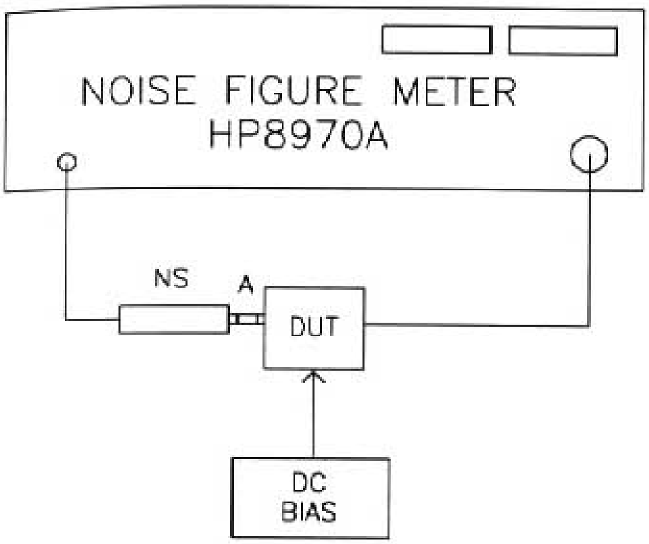

NS - 5dB ENR Noise Source [HP 346A]

DUT - Device Under Test [LNA Package]

A - Adapter [Type N to SMA]

FIGURE - I

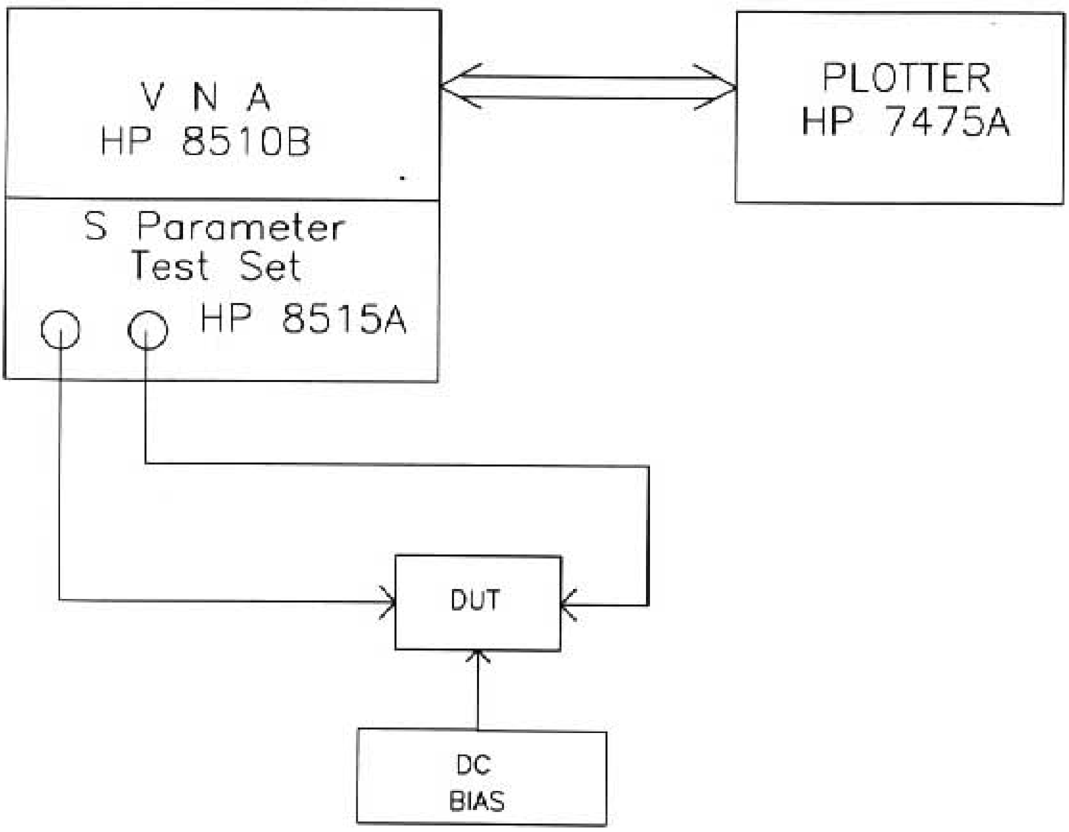

FIGURE - II

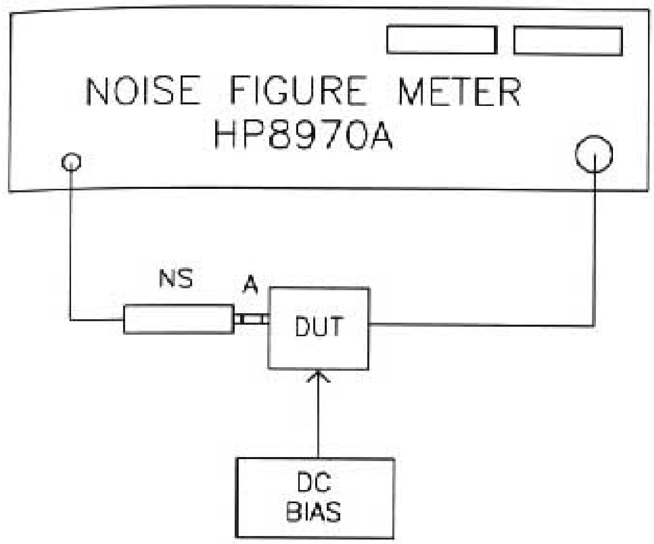

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FIGURE – I

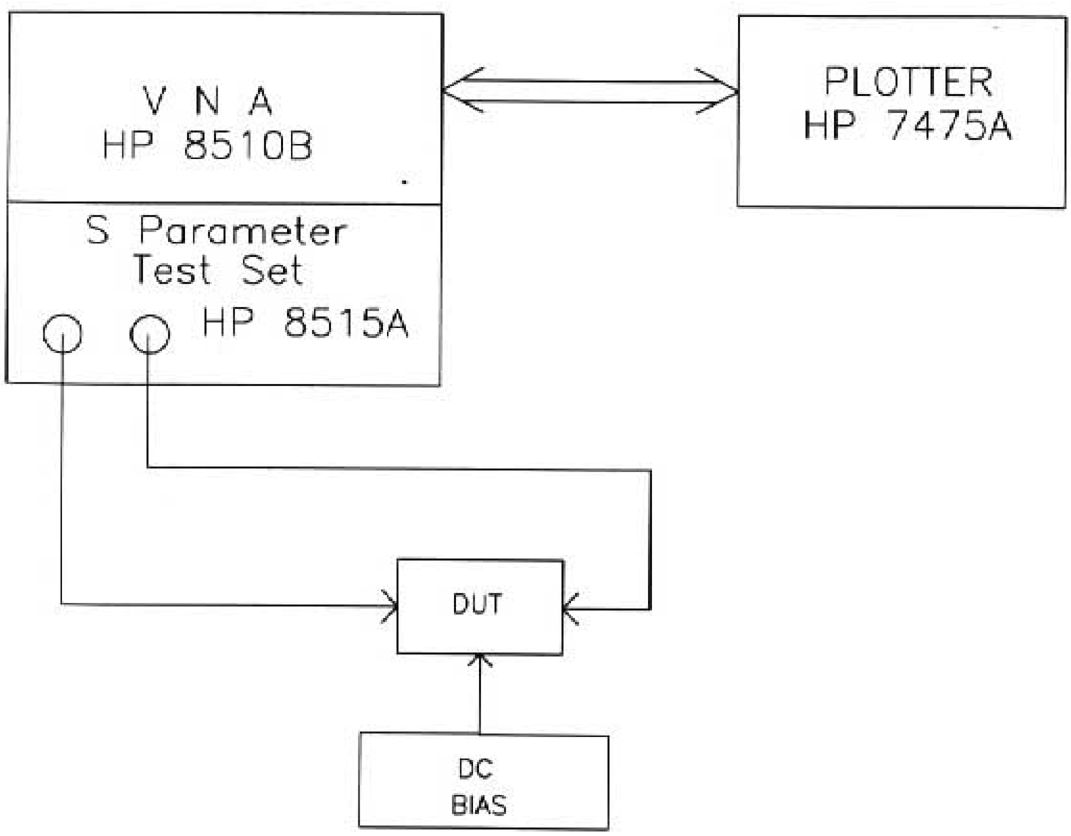


FIGURE – II

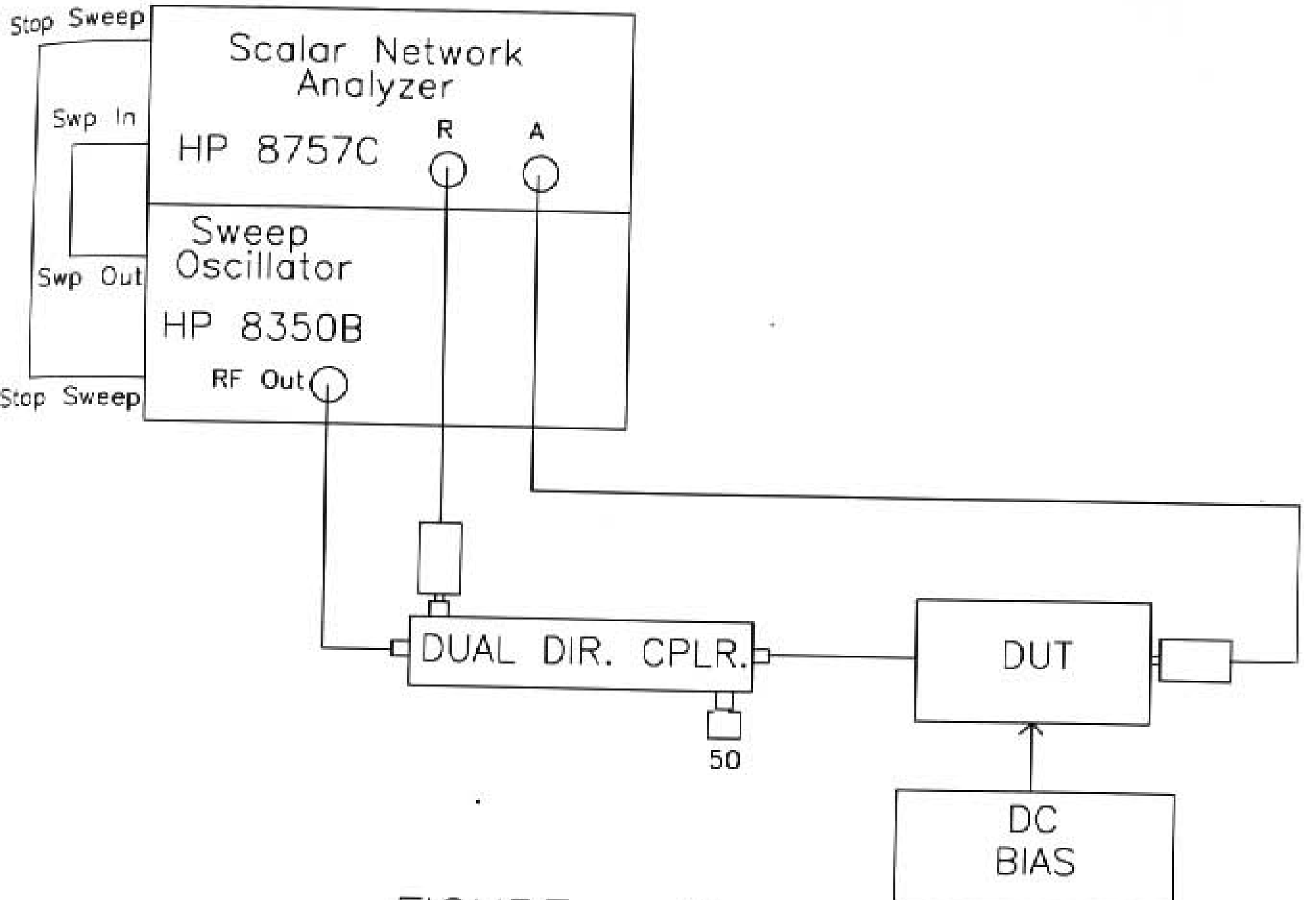


FIGURE — III

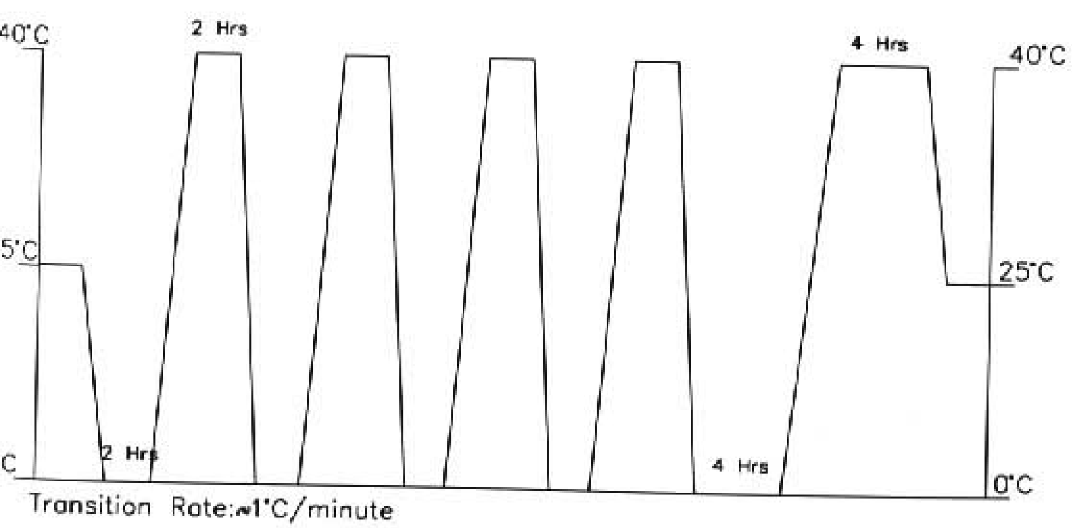


FIGURE — IV

8. Operating Manual for the 327 MHz LNA Package

8.1. Introduction

8.11 General Information

This document describes the operating instructions for the 92cm Low Noise Amplifier developed for the 92cm receiver of RADIOASTRON.

The 92cm LNA unit will be kept inside a thermostat where the temperature will be maintained at 23 ± 2°C. The unit will be integrated with 92cm receiver box which is inside the focal package of the 10m antenna. When 92cm band is not used, the receiver and the thermostat will be switched off. During this period, the temperature inside the thermostat will in the range of 0°C to 40°C.

8. 12. Initial Inspection .

Inspect the dedicated transport container for damage. In case of damage to the container or the cushioning material, first verify the contents are complete and then, perform electrical and mechanical inspections. The contents include 5 SMA straight cable plugs (direct solder attachment type) for 0.141" semi rigid cable, besides the LNA and the voltage regulator units.

8.13. ESD Caution

ESD can damage or destroy electronic components. The unit should be handled only in an ESD protected environment. Care should be taken while handling the DC wires leading to the voltage regulators and when not in use, should always be kept shorted. Avoid touching the center conductor of RF port connectors, without properly grounding yourself.

8.2. Description

8.21 System Identification

The 92cm Low Noise Amplifier and its voltage regulator have been mounted on a temporary baseplate, and their interconnections are shown in the ICD (dwg. No. RAD/ICD/

1, for EM; RAD/ICD/2, for FMs) enclosed.

The unit marked "LNA П-KPT-92" is the two channel LNA for the 92cm receiver system. The unit marked "PS П-KPT-92" is the voltage regulator which supplies the required +5V for biasing the LNAs.

The model numbers "EM01, FM01 & FM02", are pasted on the top cover for identification

8.22 Signal Ports Identification

The five RF ports in the LNA unit have been marked J1 to J5.

J1 - CH1 input port
J2 - CH2 input port

J1 and J2 receive the signals directly from the antenna terminals through 65cm long 0.141" semirigid cables.

J3 - CH1 output port
J4 - CH2 output port

J3 and J4 have to be connected to Dielectric resonator band pass filters that follow the LNAs in the receiver chain.

J5 - Port for injecting the calibration noise signal generated in the receiver.

8.23 DC Bias Points Identification

The +5V regulator gets +12V (±1%) from the receiver through the wires numbered "1" and "2". Refer the ICD enclosed for the details. The wires "3" and "4" carry +5V for channels CH1 and CH2, respectively.

The input side of the voltage regulator unit has been marked +12V whereas the output as +5V along with the channel identifications.

8.3. Power Requirements

Parameters	Model					
	EM		FM1		FM2	
	CH1	CH2	CH1	CH2	CH1	CH2
Voltage	+12V	+12V	+12V	+12V	+12V	+12V
Current* (mA)	35.4	34.6	33	37	28	27.5

* Total current drawn by the LNA & Regulator units.

8.4. Input RF Power Range

The nominal input power to the RF ports (J1, J2 & J5) should be around -60 dBm, while testing the unit for compliance. Power levels greater than -40 dBm at the input stress the unit as the LNAs then will be driven into saturation.

8.5. Visual Inspection

8.51 Check of appearance

8.52 Labels for connectors

8.53 Label of manufacturer & unit

Manufacturer - TIFR/SAC, India

LNA unit - LNA Π-KPT-92

PS unit - PS Π-KPT-92

Model No. - EM 01 or FM01 OR FM02

8.54 Protective connector covers

8.55 Quality of assembly

8.6. Mechanical Inspection

Refer the mechanical drawings attached with the document.

8.61 Outer Dimensions

LNA Box [including covers and excluding connectors and feedthroughs] — 105(length) × 101(width) × 32(height) mm

LNA Box [with mounting lugs] - 114 × 101 × 32 mm

Voltage Regulator Box [including covers, mounting lugs and excluding line filters] - 58.9 × 45.5 × 32 mm

8.62 Mounting Dimensions

LNA Box
Along box length - 105 mm
Along box width - 92 mm .

PS Box
Along box length - 49.9 mm
Along box width - 36.5 mm

8.63 Mass

LNA Box [completely assembled] — 445 grams

Voltage Regulator Box [assembled] — 80 grams

8.64 Center of gravity [Estimated]

Left most corner of the LNA and regulator boxes as mounted on the temporary baseplate is taken as respective origins for their coordinate axes system. The orientation of the three mutually perpendicular axes are as per the agreed drawing in the MoU [refer Figure 2-2].

LNA Box [x,y,z] — [12.86, 45.66, 51.54 mm]
Regulator Box [x,y,z] — [17.40, 14.98, 21.81 mm]

8.65 Moment of Inertia [Estimated]

For axes and origin definitions refer the note under section 8.64.

LNA Box
Ixx = 2.7 Kg-cm^2
Iyy = 3.2 Kg-cm^2
Izz = 2.9 Kg-cm^2

Voltage Regulator Box
Ixx = 0.08 Kg-cm^2
Iyy = 1.30 Kg-cm^2
Izz = 1.33 Kg-cm^2

8.66 Material of housing - Aluminum Alloy 6061 T6

8.67 Coating - Chromate conversion (8–12 m thick).

8.68 Contact area

LNA Box 10875 mm^2
Regulator Box 1907.5 mm^2

8.7 Electrical Performance

PARAMETERS		EM1	FM1	FM2
Center Frequency	[MHz]	324	324	324
Bandwidth	[MHz]	> 8	> 8	> 8
Gain at C.F of CH1	[dB]	39	38.1	37.7
Gain at C.F of CH2	[dB]	38.1	37.6	36.6
CH1 Noise Temperature	[K]	25	28	25
CH2 Noise Temperature	[K]	26	27	26
I/P Return Loss of CH1	[dB]	27	17.8	22.2
I/P Return Loss of CH2	[dB]	36	23.4	16.4
Ncal port Return Loss	[dB]	18.5	18.2	18.4
O/P Return Loss of CH1	[dB]	22	21.9	20.3
O/P Return Loss of CH2	[dB]	24.6	21.8	21
Coupling into CH1	[dB]	25.8	27.4	26.6
Coupling into CH2	[dB]	26.6	26.3	26
Isolation between Chs.	[dB]	> 65	> 69	> 65

8.8 Storage Conditions

The package should be stored in A/C laboratory conditions, ie.

Temperature	23 ±2°C
Humidity	< 50% RH
Pressure	1013 ±50 mbars

8.9 Drawings Enclosed

#1 Mechanical drawing of 92cm LNA box.
Drg. No. G10/523, sheet 2 of 3.

#2 Mechanical drawing of Voltage regulator box for the LNA.
Drg. No. G10/462, sheet 2 of 3.

#3 Assembly drawing of 92cm LNA box.
Drg. No. G10/523, sheet 1 of 3.

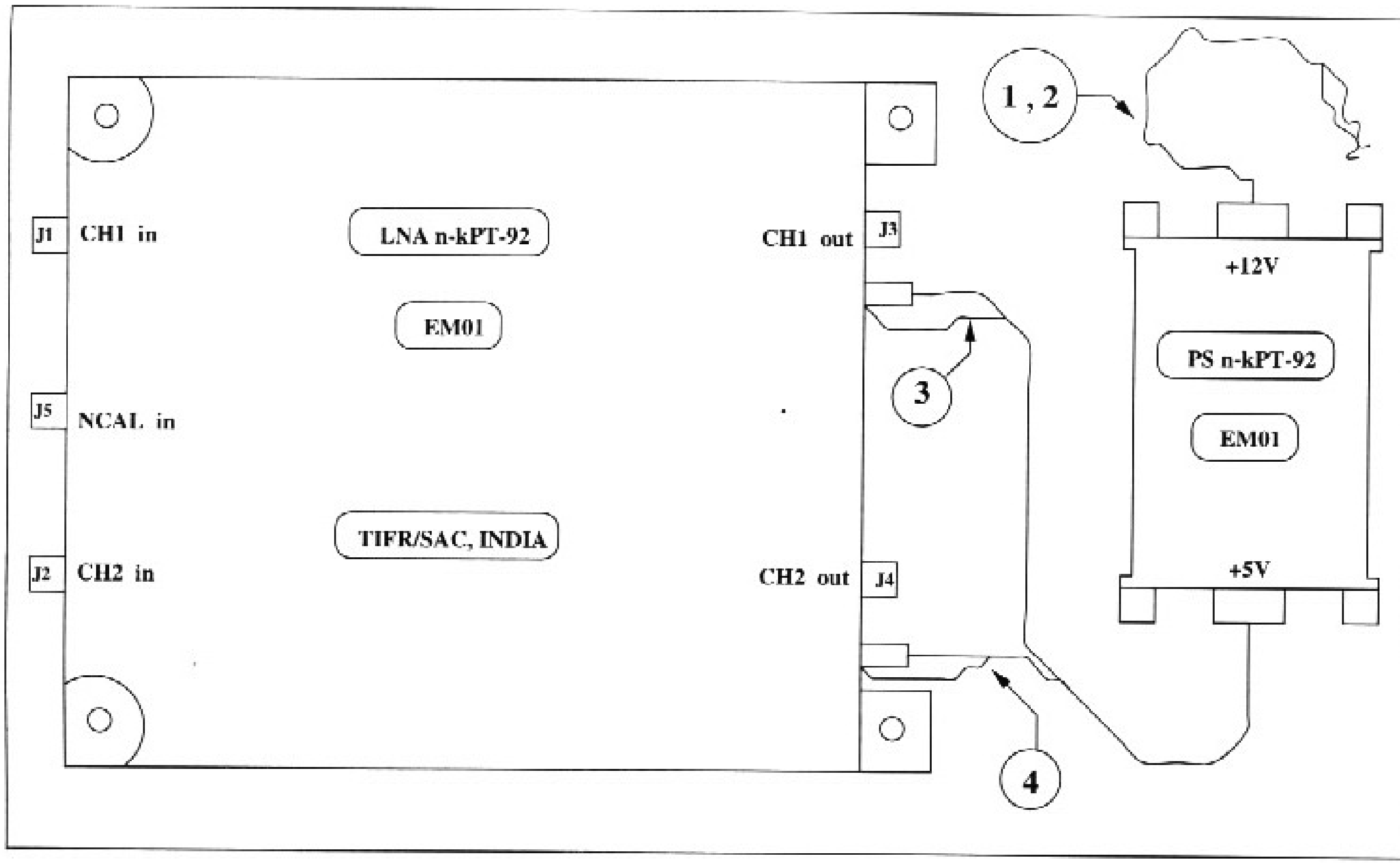
#4 Assembly drawing of the Voltage regulator box.
Drg. No. G10/462, sheet 1 of 3.

#5 Temporary baseplate Harness drawing.
Drg. No. RAD_ICD/1.

#6 Temporary baseplate Harness drawing.
Drg. No. RAD/ICD/2.

#7 PCB drawing of the LNA Box.
Drg. No. G10/523, sheet 3 of 3.

#8 PCB drawing of the Voltage regulator.
Drg. No. G10/462, sheet 3 of 3.



NOTES

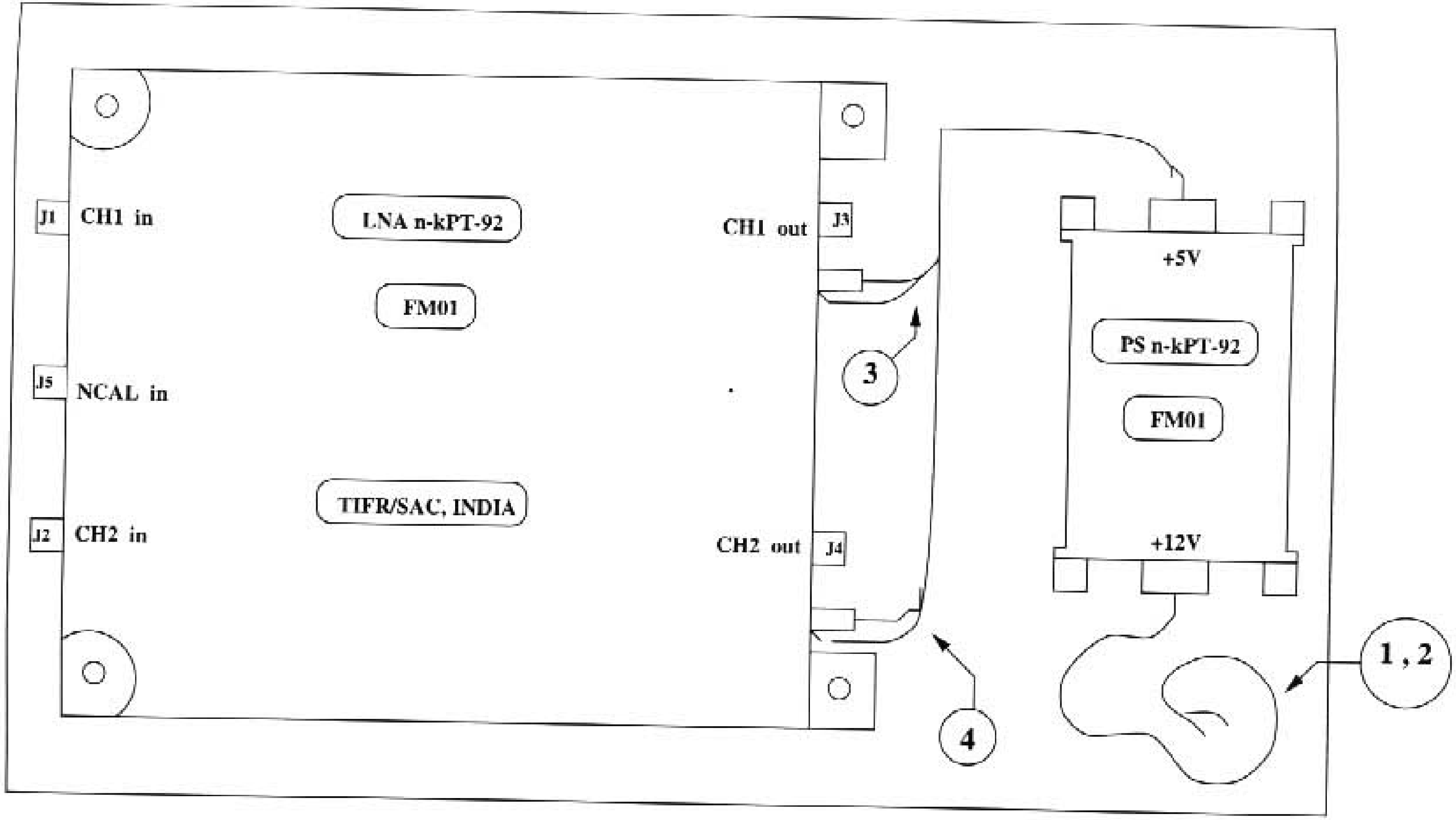
1. The yellow wires '1' & '2' are to be connected to +12V ; Black one is for ground.

2. The pair # 3 (from bottom regulator) is for CH1 LNA and pair # 4 (from the top regulator) is for CH2 LNA.

3. The ground connections are made through ground turrets mounted on the boxes.

5. The wire pairs '3' & '4' are approx. 150mm long; '1' & '2' are approx. 300mm long.

Dwg. #: RAD/ICD/1



NOTES

1. *The red wires '1' & '2' are to be connected to +12V ; Black one is for ground.*
2. *The pair # 3 (from bottom regulator) is for CH1 LNA and pair # 4 (from the top regulator) is for CH2 LNA.*
3. *The ground connections are made through ground turrets mounted on the boxes.*
5. *The wire pairs '3' & '4' are approx. 150mm long; '1' & '2' are approx. 300mm long.*

Dwg. #: RAD/ICD/2

9. Appendices

1 Memorandum of Understanding between TIFR, Indian and Astro Space Centre, Moscow, December 1992.

2 Approved Components and Material List for the LNA package.

3 Reliability Assessment for 327 MHz LNA package.

4 Final Test reports, after qualification at SAC.

5 Supplement to test reports generated by SAC.

6 Acceptance report dated 1.12.1996 generated after delivery of EM and FMs to Astro Space Centre, Moscow.

APPENDIX - 1

- 1992 MoU

ANNEX – A1

MEMORANDUM OF THE 92 cm LNA DISCUSSIONS

PUKHOV, MOSCOW

12 December 1992.

ESENT:

xander Praveen Kumar (TIFR)

mina A. (KB Gorizont)

makin S.(KB Gorizont)

hilin V. (KB Gorizont)

sh V. (ASC)

lkov V.(ASC)

On the basis of the memorandum of understanding between TIFR and KI (presently Astro Space Center Lebedev Physics Institute) and as per the specifications agreed upon during the 11-th RADIOASTRON review meeting held at Moscow October-November 1990 (Documented as Appendix R92 on the 92 cm LNA unit), a qualified Engineering model of the LNA 92 cm. Front End was delivered to the ASC, Moscow during October 1991.

However in order to conserve the spacecraft power required for the temperature controlling in the focal package of the Space Radio Telescope and to achieve lower noise figures currently attainable, the Russian side desired changes in the mechanical and electrical specifications. Under the new agreements, the Dielectric Resonator band pass filter of 8 MHz bandwidth and post amplifier for the two channels will be built by the "KB Gorizont" at Nizhnij Novgorod and ntegrated to the 92 cm receiver built by them.

TIFR, India will deliver one Engineering model to the October 1993 and two Flight models of the two channel LNA to the March 1994. The drawings of the LNA to be agreed to February 1993.

The detailed specification for the 92 cm LNA are as follows:

Electrical :

Center frequency 324 MHz.

Gain at center frequency 30 ± 3 dB.

Gain ripple over ± 4 MHz from the center frequency not more than ±0.25 dB.

Difference in gain between the two channels not more than 1 dB.

Input and output impedance 50 ohms.

Input VSWR to be optimized for low noise, but to be better than 1.6.

* Output VSWR better than 1.25.
* Noise temperature 25 ±5 K.
* VSWR of noise calibration port better than 1.4.
* Isolation between two channels not less than 50 dB.
* Coupling of the calibration line including 6 dB resistive power divider 28 ± 1.5dB, coupling of directional coupler ≅ 22 dB
* DC supply voltage for the LNA +5 V and max current 50 mA per channel.
* DC supply available to the voltage regulator +12 V. ± 1% and max

ripple 10mV$_{p-p}$, and current at least 60mA per channel.

All RF connectors SMA flange mount panel receptacles.

Five SMA straight cable plugs for 0.141" semi rigid cable direct solder attachment type should be supplied - for all the ports.

DC Bias voltage to the LNA through EMI Feedthru Filters.

. Mechanical:

Outside dimension for the LNA box including cover and excluding connectors and EMI feedthru filters 105 (length) x 101 (width) x 32 (height) mm.

Outside dimensions with mounting lugs for the LNA Box 114 x 101 x 32mm.

Mounting lugs should not project out along the width and the input side.

* The typical sketch of the Box is indicated in Fig. 1.

* The outside dimension for the voltage regulator Box including the covers and mounting lugs and excluding the EMI filters 45.5 x 40.9 x 32mm. This is exactly as per the flight model drawings supplied by India.

* Material for the Box 6061 - T6 Aluminium Alloy.

* Surface treatment: chromate conversion coating.

* The length of the two twisted pair wires (one for each channel) from:

a) LNA to the voltage regulator approximately 150 mm.

b) Voltage regulator to the power supply (The power supply end left free) approximately 300 mm.

- The LNA and the voltage regulator may supplied with both units mounted on a temporarybase plate.

- The engraving on the covers will include

a) IN CH-1, CH-2 and CAL., OUT CH-1 and CH-2, +5V DC for the LNA

b) +12 V IN and +5 V OUT for the voltage regulator

3. Environmental:

The LNA unit is uncooled.

It is placed inside a thermostat, which controls the temperature to +20° ±1 C and integrated to the 92 cm receiver Box which is located in the focal package of the 10 m Space Radio Telescope operating in four different frequency bands. When 92 cm band is not used, the receiver and the thermostat will be switched off. During this period, the operating temperature for the LNA is in the temperature range from 0°to 40°C.

The details of the other environmental conditions are given in the document "General Technical Requirements Relating to the Scientific Apparatus and Documentation for the RADIOASTRON Project"(Blue book).

Tests to be carried out for the LNA and the voltage regulator

The LNA and the voltage regulator will be integrated with the 92 cm Russian receiver and the entire integrated unit will undergo qualification test at "KB Gorizont" Nizhnij Novgorod. Thefore only the following tests should be conducted in India for the LNA:

* Warm up period of 100 hours.
* Physical measurements and markings.
* Isolation test.
* Complete functional tests.
* Vibration in X-direction (launch direction) at some frequency between 20 and 30 Hz with acceleration of 2 g for 30 min.
* Climatic test.
* Reliability (calculated).

The details of the test program are given in the Test Program document (~~Annexure A~~).

The following technical documentation must be supplied for the LNA:

1. Technical description.
2. Operating instruction.
3. Passport (for each unit).
4. Summary report on the ground testing is to be supplied.

11/12/92.

Alexander Praveen Kumar (TIFR)

Slysh V. (ASC)

11/12/92

: 11 December 1992 at Moscow

Vasilkov V. (ASC)

11.12.92.

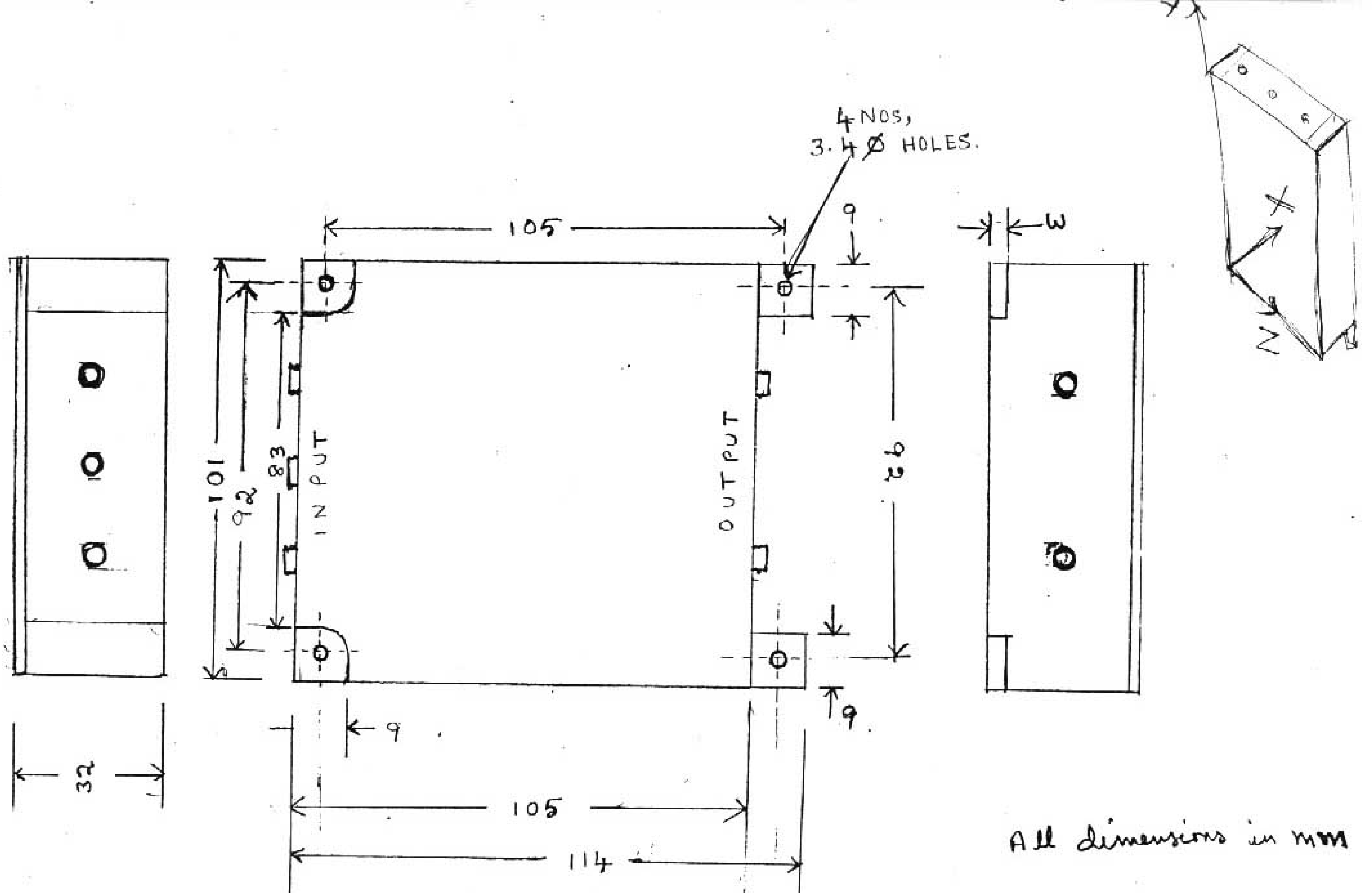


FIGURE-1 : TYPICAL SKETCH OF THE 92 CM LNA

ANNEX - A2

RADIOASTRON
LNA P-KRT-92
TEST PROGRAM

1. Warm up period.

The LNA is switched on and operated for 100 hours. No measurement are done during this period. The environmental conditions are normal:

* Temperature: 20±5°C
* Humidity: <80%
* Pressure: 1013±50 bar

2.1. Check complete set of the LNA unit and documents.

2.2. Check of conformity the LNA unit to designer documents.

* Outer dimension
* Mounting dimension
* Mass
* Center of gravity
* Moments of inertia
* Material of housing
* Coating material
* Contact area

2.3. Check of the appearance, quality of assembling, marking of the LNA unit.

* A visual inspection
* Marking of connectors
* Label of the manufacturer
* Red covers for the connectors.

3. Functional Tests.

Complete functional test should be done for two channel twice: in the beginning and the end of the whole testing program. The environmental conditions are normal during these tests. A stability of gain and a phase stability should be recorded for the temperature range from 0° to +40°C.

3.1. Noise Temperature.

3.2. Measurement of the VSWR.

3.3. Dynamic range.

3.4. Compatibility with the feed.
This test will be made in ASC.

3.5 Measurement of the gain

3.6. Stability of the gain.

3.7. Phase stability.

3.8 Frequency response.

3.9. Measurement the difference in gain between channels.

3.10. Measurement isolation between two channels.

3.11. Coupling of the calibration line including 6 dB resistive power divider.

4. Thermal cycling Test.

The LNA unit undergo by five thermosycle in the temperature range from 0° to 40°C.

5. Mechanical Tests.

An isolation and functional tests (Noise temperature and Measurement of the VSWR) should be carried out before and after each individual mechanical tests.

5.1. Vibration test.

LNA unit should be vibrated in X-direction (launch direction) at some frequency between 20 and 30 Hz with acceleration of 2 g for 30 min.

5.2. Static acceleration Transportation Test.

5.3. Shock Transportation Test.

While the LNA unit is in their transportation package, following impulses to be given to them:

* Acceleration 15 g, 5000 impulses
* Acceleration 10 g, 15000 impulses

The duration of one impulse is 5..10 ms.

6. Climatic Tests.

6.1. Temperature Transportation Test.

Minimum and maximum temperature are achieved during transportation.

The LNA unit in the transportation package to be kept at a temperature of -50°C for 10 hours. After the action, normal condition to be created and the measurement Noise temperature and VSWR to be performed.

The LNA unit in the transportation package to be kept at a temperature of +50°C for 10 hours. After the action, normal condition to be created and the measurement Noise temperature and VSWR to be performed.

7. Isolation Test (for normal condition).

8. Power consumption Test.

9. Reliability (calculated).

APPENDIX - 2

- Approved Parts List [APL]

-Approved Material List [AML]

SPACE APPLICATIONS CENTRE

AHMEDABAD

FROM : CHVVNS MURTHY

ENGINEER , QAED

TO : SHRI A . PRAVEENKUMAR .

TIFR , PUNE.

DATE : 15/03/'91

SUB : APPROVED MATERIAL LIST (AML) FOR RADIOASTRON PROJECT .

Please find enclosed Approved Material List for Radioastron Project. It is prepared based on the inputs given by project and the types of materials used in INSAT-II FM. Communication Transponder . Additions to this list or use of materials for different applications should be only after due approval from Q.A.

Regards .

(CHVVNS MURTHY)

CC : DR. H.O.GAUTAM.

SHRI.P.L.KUMAR.

SHRI.R.K.TYAGI.

Total 18 items Tickmarked m[illegible] and used.

pf[illegible] [illegible]/[illegible]/91

MATERIALS LIST FOR RADIOASTRON PROJECT

Material 1	Critical Property/ Condition 2	Shelf Life 3	Quality Information 4	Manufacturer 5	Application 6	Remarks 7
ESTRICTED MATERIALS :						
DER :						
Sn/37 Pb x cored der Wire	Wire,RMA flux cored M.P.:183 C (Eutectic)	NA	Sn 63 W RMA P2 * as per QQ-S-571 with test results & certificates for composition analysis.	-Multicore -Kester -Alpha -Indium	Soldering on Lugs, Feedthroughs,Electrical joints, plating.	* Specify gauge & Wt.
n/36Pb/2Ag cored er Wire	Wire,RMA Flux core M.P.:179 C	NA	Sn 62 W RMA P2 * as per QQ-S-571 with test results & certificates for composition analysis.	-Multicore -Kester -Alpha -Indium	Soldering of components on PCB with gold plating.	*Specify gauge & Wt. It is preferable to de gold before soldering. use smallest diameters wire (<22 AWG)solder as quickly as possible under 245 C.
IES & ADHESIVES :						
TEK H 74	Thermally conductive Two part epoxy Viscous paste Lap shear str:2500psi Mix Ratio (A/B) 10:1 Cure:5 min.at 150 C OR 45 min.at 80 C	1 YR	EPO-TEK H 74 With Outgassing TML < 1.0 % CVCM < 0.1 %	-Epoxy tech	As a thermally conductive Epoxy on gold plated RT / DUROID.	
TEK H 21 D	Electrically conductive Two part epoxy.Viscous paste Silver Filled Lap shear str:2500psi Mix Ratio (A/B) 10:1 Cure:15 min.at 120 C OR 90 min.at 80 C	1 YR	EPO-TEK H 21 D With Outgassing TML < 1.0 % CVCM < 0.1 %	-Epoxy tech.	As a conductive epoxy.	

MATERIALS LIST FOR RADIOASTRON PROJECT

Material	Critical property/ Condition	Shelf Life	Quality Information	Manufacturer	Application	Remarks
1	2	3	4	5	6	7
ESTRICTED MATERIALS :						
DER :						
Sn/37 Pb x cored der Wire	Wire, RMA flux cored M.P.:183 C (Eutectic)	NA	Sn 63 W RMA P2 * as per QQ-S-571 with test results & certificates for composition analysis.	-Multicore -Kester -Alpha -Indium	Soldering on Lugs, Feedthroughs, Electrical joints, plating.	* Specify gauge & Wt. 26 Aug /24 Aug.
n/36Pb/2Ag cored er Wire	Wire, RMA Flux core M.P.:179 C	NA	Sn 62 W RMA P2 * as per QQ-S-571 with test results & certificates for composition analysis.	-Multicore -Kester -Alpha -Indium Multicore	Soldering of components on PCB with gold plating. Soldering optics system electrical conn.	*Specify gauge & Wt. It is preferable to de gold before soldering. use smallest diameters wire (<22 AWG) solder as quickly as possible under 245 C.
... flux ... RMA 53 ...						
IES & ADHESIVES :						
TEK H 74	Thermally conductive Two part epoxy Viscous paste Lap shear str:2500psi Mix Ratio (A/B) 10:1 Cure:5 min.at 150 C OR 45 min.at 80 C	1 YR	EPO-TEK H 74 With Outgassing TML < 1.0 % CVCM < 0.1 %	-Epoxy tech	As a thermally conductive Epoxy on gold plated RT / DUROID.	
TEK H 21 D	Electrically conductive Two part epoxy. Viscous paste Silver Filled Lap shear str:2500psi Mix Ratio (A/B) 10:1 Cure:15 min.at 120 C OR 90 min.at 80 C	1 YR	EPO-TEK H 21 D With Outgassing TML < 1.0 % CVCM < 0.1 %	-Epoxy tech.	As a conductive epoxy.	

MATERIALS LIST FOR RADIOASTRON PROJECT

Material	Critical property/ Condition	Shelf Life	Quality Information	Manufacturer	Application	Remarks
1	2	3	4	5	6	7
EPO-TEK E 81	Electrically conductive Two part epoxy. Viscous paste Gold Filled Lap shear str:2000psi Mix Ratio (A/B) 10:1 Cure:15 min.at 120 C OR 40 min.at 80 C	1 YR	EPO-TEK E 81 with Outgassing TML < 1.0 % CVCM < 0.1 %	Epoxy tech.	As a conductive epoxy.	
POTTING & CONFORMAL COATING :						
CONFORMAL COATING CONTRANE CE-1155 CONAP S 6 (THINNER) DRY PURGE	Two component, solvent based polyurethane coating colour:clear Amber Mix Ratio:A:B : 10:7 Viscosity: 72cps Cure: 1hr at 100C OR 3hr at 60C Dry purge gas in container.	1YR	CONATHANE CE-1155 as per MIL-1-46058C Type UR with outgassing TML < 1.0 % CVCM < 0.1 %	-Conap	For conformal coating of packages and components.	
CLEANING SOLVENTS						
Isopropyl Alcohol (EL)	Cleaning solvent NVR < 10 ppm	NA	Electronic Grade Isopropyl Alcohol	-Sarabhai Chemical -Glaxo -Astron	For cleaning of PCB's package hardware.	(1)Final cleaning before conformal coating should be done with Freon TMS /Freon TF or Alpha cleaner
WIRES & CABLES :						
Single core Unshielded Wire	Light weight polymide Insulation Strands :19 Temp:-100C to 200C	NA	As per ESA/SCCG 3901-002	-HABIA -FILOTEX	For DC Bias wire application,Interboard connection package wiring.	

MATERIALS LIST FOR RADIOASTRON PROJECT

Material 1	Critical property/ Condition 2	Shelf Life 3	Quality Information 4	Manufacturer 5	Application 6	Remarks 7
Magnet. Copper wire. (Round)	Th. Class :200 Type K Modified Polyester or polyster-imide or polyester amide-imide over coated with polyamide imide coated.	NA	As per J-W-1177/14 B Mag. copper wire with outgassing TML < 1.0 % CVCM < 0.1 %	-Hudson -Essex -Rea Magnet -Phelps Dodge -Westing house -Belden Ind. -Anaconda -Canada wire	For making induction In LNA, Filter	*** Specify 18 to 38 AWG. & length as per catalogue.
Au ribbon width:20 mil thickness : 1mil	Au bonding ribbon stabilised with Ag-Cu.other single impurity element <20 ppm(max) Total impurity- <100 ppm (max) Temper:annealed	NA	Au Bonding ribbon with Certificate for all critical properties of Column :2	-Sigmund Cohn	For connection of LNA SMA connector to PCB track.	Specify spool size.
Semi-Rigid Co-axial Cable RG-402	Imp.:50+/-1.0 Ohms Temp.:-40C to +100C. Freq :20 GHZ Silvered copper - covered steel wire Out. Cond.:Copper/Tin	NA	P/N M 17/130-RG402-00001 as per MIL-C-17 F	-Precision Tube Co. -Uniform Tubes -Cable Wave -Stroms Product	For Interconnection of sub-systems.	
HEAT SHRINKABLE TUBING						
Kynar Heat Shrinkable tubing.	Transparent Insulation. Temp:-55C to 175C Shrink ratio : 2:1 at 178 C	NA	As per MIL-I-23053/8 With outgassing TML < 1.0 % CVCM < 0.1 % * * *	-RAYCHEM -ALPHA	For Insulation over Wire, Solder joint & bare conductor.	* * * Specify size and Length.

MATERIALS LIST FOR RADIOASTRON PROJECT

Material	Critical property/ Condition	Shelf Life	Quality Information	Manufacturer	Application	Remarks
1	2	3	4	5	6	7
MISCELLANEOUS						
SOLDER LUGS 909,916,917 7314,7315, 7316	Solder Lugs Brass Tinned	NA	As per MIL-T-55155	-Keystone	For terminating ground shielding on package	
Tinned Copper Flat Braid width : 1.38 mm	Tinned Copper Braid Rolled Flat Const:36/16/48 Thickness :0.5 mm Approx AWG :19	NA	Tinned Copper Braid as per Fed. Spec. QQ-B-575 B and individual strands as per 343E and ASTM-B-33.	-Alpha -Standard wire co.	For Interconnection of Directional Coupler PCB to LNA PCB.	Recommended to use the material within 2 Years as tin plating tarnishes.
RT\Duroid 5870	Mat:Glass microfiber reinforced PTFE Copper Clad Laminate Dissipation factor: .0005 at 1 MHz Vol.Resis:2X10MOhm cm Sp.gravity:2.2 Th.Cond.:.26W/M/K	NA	RT\Duroid micro-wave laminate as per MIL-P-13949 TYPE GRN Class Of Thickness 4 with outgassing TML < 1.0 % CVCM < 0.1 %	-Rogers Corp.	As substrate for fabrication of PCB's	Card fabrication should be done at qualified facility.
RESTRICTED MATERIALS						
POTTING COMPOUND						
Dow corning 3145 RTV primer Dow corning 1204	Silicon adhesive One part paste Non-corrosive Moisture cure Colour: Grey cure:72 hrs.at 25 C.	1/2 YR	Dow corning 3145 RTV with outgassing TML < 1.0 % CVCM </= 0.27 %	Dow corning	For localised potting on components & for additional support.	

MATERIALS LIST FOR RADIOASTRON PROJECT

Material	Critical property/ Condition	Shelf Life	Quality Information	Manufacturer	Application	Remarks
1	2	3	4	5	6	7
CABLE TIE MOUNTING DEVICES						
Tie Mount (Screw applied) TM 1 S 4 TM 1 S 6	Material:Nylon Colour:Natural	NA	Tie mount with screw applied fixing with outgassing TML </=1.73 % CVCM < 0.1 %	Panduit	Tie mount for securing wires.	
Low Profile Mount LPMS-8B	Material:Nylon Low profile tie mount with screw applied fixing. Colour:Natural	NA	Low profile tie mount. with outgassing TML </=1.73 % CVCM < 0.1 %	Panduit	Tie mount for securing wires.	

For Harness tying. Alpha USA

LC 136 Lacing Tape (Wax coated)

Araldite AV138 HV998

1 yr. from D/O Manf. shear strength TML CVCM

CIBA GEIGY

CIBATAC

Supporting the wires Saddle fixing Cooking the bottom screws.

TX-904 Tex wipe

Texwipe clean paper (Lint free)

SUB: MECHANICAL MATERIAL LIST USED IN [illegible] FRONT END - ETM

S.NO:	DESCRIPTION	MAIN BODY (BOXES &COVERS)	FASTENERS	VENDOR/MANUFACTURER
1.	LNA-1 & DC	AL.ALLOY 6061 T6	SS304	INDAL, BOMBAY
2.	POWER SUPPLY	AL.ALLOY 6061 T6	SS304	-do-
3.	LNA-2	AL.ALLOY 6061 T6	SS304	-do-
4.	FILTERS (BOTH)	AL.ALLOY 6061 T6	SS304	-do-
5.	BASEPLATE	AL.ALLOY 6061 T6	SS304	-do-
6.	HELICOILS	------------	SS304	FSH AEROSPACE.
7.	INSERTS	SS304 (GOLD PLATED)	-------	LOCAL
8.	COIL FORMERS	TEFLON	-------	-do-
9.	NUTS & WASHERS	------	SS304	-do-
10.	MOUNTING SCREWS	------	SS304	-do-
11.	Tunning screws for filters (with locking nuts)		SS304 (GOLD PLATED)	-do-

ONLY TWO BOX MOUNTING SCREWS OF M3 TITANIUM ARE USED IN ETM BECAUSE OF NON AVAIL REQUIRED LENGTH IN SS304. THE EXACT QUANTITIES & SIZES ARE AVAILABLE IN DRAWINGS.

(A.R.SRINIVAS)

Srinivas M.

PAGE : 1 | APPROVED PARTS LIST FOR FLIGHT MODEL OF FRONT END F R SAC-TIFR RADIOASTRON PROJECT | PAGE NO : 1

[illegible] DATE : [illegible]

PART TYPE	DESCRIPTION	PACKAGE STYLE	PROCUREMENT SPECIFICATIONS	QNTY PER MODEL	VENDOR/MANUFACTURER	REMARKS
[illegible]	METAL FILM RESISTORS ESTABLISHED RELIABILITY TEMP.COEF.: +/- 25 ppm/C F.R. : 1% / 1000 HRS ('M' LEVEL)	RNC60	AS PER MIL-R-5518 2 RNC60J*****M VALUES: 150 ohms	2	(1) DALE ELECTRONICS INC., USA (2) MEPCO/CENTRALAB INC., USA (3) IRC, INC., USA (4) VAMISTOR CORP., USA	*****SPECIFY [illegible] % TOL. [illegible] CATALOG.
160-2051-02-05-00	SOLDER TERMINALS TURRET, THREAD MOUNT SOLDER PLATED	160-2051	160-2051-02-05-00	TBD	INTERCONNECTION PRODUCTS (CAMBION), USA	

Klmehta
(. MEHTA)

Shri M R Vaghmare
Sci/Engr, GAED

Dr. H. C. Gautam
Head, PRPD

Approved Material List (AML) for Radioastron Project.

Refer to your letter dated 7th July regarding the inclusion of materials in AML for Radioastron project, please find enclosed Approved Material List. It is prepared based on the given by the project and the types of materials used in INSAT-II FM Communication Transponder. You are requested to send us the details of deposition of the materials in Bonded store (Date of deposition, corresponding Is No., compliance certificates from manufacturer if available etc).

Regards.

(M. R. Vaghmare)

cc Shri P. DHAR, Head R&QA

	Material	Critical Property	Quality Information	Vendor	Applications	Remarks
1	RT Duroid 5880	Mat : Glass Microfiber reinforced PTFE Copper Clad laminate Dissipation factor : 0.0005 at 1 MHz	RT duroid Microwave laminate as per MIL-P-13949 with outgassing properties TML ≤ 1.0 % & CVCM ≤ 0.1 %.	— Roger's	For the fabrication of PCB.	Card fabrication should be done at qualified facility.
2	Sage Wire JCS 1 type for Wireline directional [illegible]	Wire type JCS-1 type Length - 4.5 mm long Centre Conductor - copper case as per QQ-W-343	JCS-1 type with outgassing properties TML ≤ 1.0 %. CVCM ≤ 0.1 %.	— Sage labs.	For the directional coupler card of the LNA Module.	Specify type No & length while ordering
3	Copper Braid Alpha 1223	Tinned Copper Braid rolled flat Construction : 36/14/24 AWG : 22 Thickness : 0.5 mm	Tinned Copper Braid as per Fed-Spec. QQ-B-575 B and individual strands as per 343 E & ASTM-B-33	— Alpha	For PCB interconnections.	Specify type & while ordering

(signature)
(M.R. Vaghmare)
23/8/94

SPACE APPLICATION CENTRE
RELIABILITY AND QUALITY ASSURANCE
AHMEDABAD-[illegible]

March 8th, [illegible]

From: K.N.Murli
Member Project Team,
SAC-TIFR RADIOASTRON PROJECT.

To:

Shri R.K.Tyagi,Manager
Shri S.C Bawa, Dy.manager PFF/Member Project Team.
Dr. H.O.Gautam, Project Team Leader
Shri V.K.Manglik Head, QAMD
Shri P.L.Kulkarni, Head, RES
Shri A.Praveenkumar, Engr, TIFR
Shri V.L.Joshi, Engineer, QAED
Shri CHVVNS Murthy, Engineer, QAED
Shri J.P.Shivhare,Member Project Team

Sub: Approved part list.(APL) for Engineering Model Front End of SAC-TIFR RADIOASTRON PROJECT.

Please find enclosed Approved Parts List finalised with desiginers for Fabrication of Engineering Model for Front End of SAC-TIFR Radioastron Project.

Regards,

(K. N. Murli)

C. C. to - Shri S. R. Naik, Head R & QA
- Dr. K. N. Shankara, GPD, INSAT-II ICP

[illegible] MODEL OF FRONT END FOR [illegible] RADIOASTRON PROJECT

[illegible]	DESCRIPTION	PACKAGE STYLE	PROCUREMENT SPECIFICATIONS	QNTY/ MODEL	VENDOR/MANUFACTURER	[illegible] REMARKS
[illegible]	3 TERMINAL ADJUSTABLE POSITIVE VOLTAGE REGULATOR	TO 39	AS PER MIL-STD 883 CLASS B	2	(1)NATIONAL SEMICONDUCTORS,USA. (2)LINEAR TECHNOLOGY,U.S.A.	[illegible]
[illegible]	[illegible] LOW NOISE [illegible]	PKG. CODE 83	NE13783 GRADE-C	8	NEC/CEL,U.S.A.	
[illegible]	FAST RECOVERY RECTIFIER DIODE [illegible] 1 AMP. [illegible]	AS PER MFG.CATALOG	AS PER MIL-S-19500/429 JAN 1N5615	2	(1) MICROSEMI CORPORATION,USA. (2) UNITRODE CORP. (3) SEMTECH CORP. (4) GENERAL INST.CORP.	[illegible]
[illegible]	CAPACITORS,FIXED,CHIP MULTILAYER,CERAMIC DIELECTRIC,ESTABLISHED RELIABILITY [illegible] 50 V F.R.:1%/1000 HRS (M LEVEL)	CDR12	AS PER MIL-C 55681 CDR12BP***AFUM VALUES: 3.3pf 4.7pf 5.6pf 68pf 680pf	 4 4 4 16 24	ATC,USA	*** SPECIFY VALUE CODE AS PER CATALOG
[illegible]	CAPACITORS,FIXED,CHIP MULTILAYER,CERAMIC DIELECTRIC,ESTABLISHED RELIABILITY [illegible] F.R.:1%/1000 HRS (M LEVEL)	CDR14	AS PER MIL-C-55681 CDR14BP***AFUM 68pf 680pf	 16 24	ATC,USA	*** SPECIFY VALUE CODE AS PER CATALOG
[illegible]	CAPACITORS,FIXED TANTALUM (SOLID) DIELECTRIC ESTABLISHED RELIABILITY F.R.:1%/1000 HRS (M LEVEL) TOL: +/-10%	CSR 13	AS PER MIL-C-39003 CSR 13 M39003/01/**** VALUE: 1ufd/50 VOLTS	 6	(1)KEMET(UNION CARBIDE)U.S.A. (2)SPRAGUE ELECTRIC CO.U.S.A. (3)MEPCO/CENTRALAB INC,U.S.A	**** SPECIFY VALUE CODE AS PER CATALOG
M39010/[illegible]	FIXED,NON SHIELDED INDUCTORS ESTABLISHED RELIABILITY F.R.:1%/1000 HRS (M LEVEL) TOL: +/-10% [illegible]	AXIAL LEAD	AS PER MIL-C-39010 M39010/08[illegible]22KM	17	NYTRONICS,U.S.A	**** SPECIFY VALUE CODE AS PER CATALOG

[illegible]	[illegible]	PACKAGE STYLE	PROCUREMENT SPECIFICATIONS	QNTY/ MODEL	VENDOR/MANUFACTURER	[illegible]
[illegible]	METAL FILM RESISTORS ESTABLISHED RELIABILITY TEMP.COEFF.+/- 25 ppm/C [illegible]	RNC55	AS PER MIL-R-55182 RNC55J*****M VALUES: 15 ohms 16 ohms 22 ohms 24 ohms 37.4 ohms 51 ohms 68.1 ohms 150 ohms 221 ohms 681 ohms	 3 3 8 16 8 6 8 8 10 2	(1) DALE ELECTRONICS INC,USA (2) MEPCO/CENTRALAB INC.USA (3) TRW, USA (4) VAMISTOR CORP.USA	**** [illegible]
[illegible]	[illegible] FILM CHIP RESISTORS ESTABLISHED RELIABILITY TEMP.COEFF.+/- [illegible] ppm/C [illegible]	RM1505	AS PER MIL-R-55342 M55342/0[illegible]****FRM VALUE:50 ohms 221 ohms	 2 4	DALE ELECTRONICS INC.U.S.A.	**** [illegible]
[illegible]	[illegible]		MEETING/ EXCEEDING MIL F 55342 PCAW 5 PCAW 6 PCAW 7	 4 4 4	[illegible] PYROFILM,USA	
[illegible]	LOW PASS EMI FILTER ([illegible] SECTION)	BUSHING MOUNT	MIL-F-15733 M15733/[illegible]-0004	4	MURATA ERIE NORTH AMERICA LTD. CANADA	
[illegible]	LOW PASS EMI FILTER ([illegible] SECTION)	BUSHING MOUNT	MIL F 15733 M15733/28-0001	4	MURATA ERIE NORTH AMERICA LTD. CANADA	

PART NO.	DESCRIPTION	PACKAGE STYLE	PROCUREMENT SPECIFICATIONS	QNTY/ MODEL	VENDOR/MANUFACTURER	
[illegible]	FLANGE MOUNT JACK RECEPTACLE CAPTURED CENTRE CONTACT	SMA	2052-1132-00	7	M/A-COM OMNI SPECTRA INC.U.S.A	
2001-5003-00	STRAIGHT CABLE PLUG FOR 0.141" SEMIRIGID CABLE SELECT SOLDER ATTACHMENT	SMA	2001-5003-00 MODEL NO: 207-1 WITH CONTACT	11	M/A-COM OMNI SPECTRA INC.U.S.A	
2052-0[illegible]0-00 2052-1215-00	FLANGE MOUNT JACK RECEPTACLE CAPTURED CENTRE CONTACT [illegible] TERMINAL	SMA	2052-0[illegible]0-00 2052-1215-00 MODEL NO: 204-B232A	4	M/A-COM OMNI SPECTRA INC.U.S.A	
[illegible]	STRAIGHT CABLE PLUG FOR 0.141" SEMIRIGID CABLE	SMA	2007-5054-00 MODEL NO: 221-1A	4	M/A-COM OMNI SPECTRA INC.U.S.A	
[illegible]	TOROIDAL CORE		T10 6 *** O.D. : 2.46mm I.D. : 1.12mm Ht. : 0.76mm AL. : 1.15nH/N²	8	MICROMETALS, USA	*** SPECIFY, OTHER DETAILS AS PER CATALOG

COMPONENT LIST

PROJECT: RADIOASTRON MODEL: ENGINEERING SYSTEM: 92-cm FRONT END. SUBSYSTEM: DIRECTIONAL COUPLER + POWER DIVIDER SECTION :

CARD CODE/FUNCTION: 92-1

PAGE NO: 1 REV. NO.: 1

CHECKED BY:
APPROVED BY PROJECT LEADER

I. EL	PKG STYLE	TYPE/ VALUE	ALT VALUE	TOL.	RATINGS	PROCUREMENT INFORMATION	TEST SELECT SR. No.	MFGR/ VENDOR	REMARKS DGNR	FAB	QC	QC	[illegible]
-1	JCT-1	WIREL	INE (E)	DIREC	TIONAL COU	PLER cut to	4.4 mm length.	SAGE LABORATORIES INC., USA.					
2	JCT-1	WIRELIN	E (E) DIRE	CTIONAL	COUPLER	cut to 4.4	cm length	SAGE LABORATORIES INC., USA.					
1	5023 V	RNC55 16.2 Ω		±0.1%	1/8 W @ 70°C 200 VDC.	MIL-R-55182 RNC55J16R2BS		MEPCO/ CENTRALAB, USA.					
2	5023 V	RNC55 16.2 Ω		±0.1%	1/8 W @ 70°C 200 VDC	MIL-R-55182 RNC55J16R2BS		,,					
3	5023 V	RNC55 16.2 Ω		±0.1%	1/8 W @ 70°C 200 VDC.	MIL-R-55182 RNC55J16R2BS		,,					
	KH1505	RCWM 5150 49.9 Ω		±1.0%	40 VDC 150 mW	MIL-R-55342 M55342/4K49R9 FRR		DALE, USA.					

COMPONENT LIST

PROJECT: RADIOASTRON MODEL: ENGINEERING SYSTEM: 92 CM FRONT END. SUBSYSTEM: DIRECTIONAL COUPLER + POWER DIVIDER. SECTION :

CARD CODE/FUNCTION: 92-1 PAGE NO: 2 REV. NO.: 1

CHECKED BY:

APPROVED BY PROJECT

[illegible]	PKG STYLE	TYPE/ VALUE	ALT VALUE	TOL.	RATINGS	PROCUREMENT INFORMATION	TEST SELECT SR. No.	MFGR/ VENDOR	REMARKS DGNR	FAB	QC	[illegible]
R5	RH150S	RCWH 5150 49.9Ω		±10%	40 V DC 150 mW	MIL-R-55342 M 55342/4 KARQ-FRE		DALE, U.S.A.				
RFC1	RF Choke,		10 turns of		3 mm dia.,	#20 AWG	magnet	Cu wire				
RFC2	RF choke,		10 turns of		3 mm dia.,	#20 AWG,	magnet Copper wire.					

COMPONENT LIST

PROJECT: RADIOASTRON MODEL: ENGINEERING SYSTEM: 92 CM FRONT-END SUBSYSTEM: LOW NOISE AMPLIFIER SECTION :

CARD CODE/FUNCTION: 92-2 PAGE NO: 1 REV. NO.: 1 CHECKED BY: APPROVED BY PROJECT LE

SL. NO.	PKG STYLE	TYPE/ VALUE	ALT VALUE	TOL.	RATINGS	PROCUREMENT INFORMATION	TEST SELECT SR. No.	MFGR/ VENDOR	REMARKS DGNR	FAB	QC	QC	Q
Q1	83	NE1378			3V/10 mA	GRADE-C		NEC/CEL USA					
Q2	83	NE19783			3V/10mA	GRADE-C		NEC/CEL, USA					
RFC1	AXIAL LEAD	M39010/08-0.22MH		±10%	1025 mA	MIL-C-39010/08 BR22KR		NYTRONICS USA					
C1	P	CDR-12 68pF		±1%	50V DC	MIL-C-55681/4/5 CDR12BP680AFUS		A.T.C, USA					
C2	P	CDR-14 680pF		±1%	50 V DC	MIL-C-55681/4/5 CDR14BP681AFUS		A.T.C, USA					
C3	P	CDR-14 680pF		±1%	50 V DC	MIL-C-55681/4/5 CDR14BP681AFUS		ATC, USA					

COMPONENT LIST

PROJECT: CARDIASTRON MODEL: ENGINEERING SYSTEM: 92 cm FRONT END. SUBSYSTEM: LOW NOISE AMPLIFIER SECTION :

CARD CODE/FUNCTION: 92-2 PAGE NO: 2 REV. NO.: 1 CHECKED BY: APPROVED BY PROJECT

[illegible]	PKG STYLE	TYPE/ VALUE	ALT VALUE	TOL.	RATINGS	PROCUREMENT INFORMATION	TEST SELECT SR. No.	MFGR/ VENDOR	REMARKS			
									DGNR	FAB	QC	QC
C4	P	CDR-12 68 pF		±1%	50 VDC	MIL-C-55681/4/5 CDR12BP680AFUS		A.T.C, U.S.A				
C5	P	CDR-12 4.7 pF		±0.1%	50 V DC	MIL-C-55681/4/5 CDR12BA4R7ABUS		A.T.C, U.S.A				
C6	P	CDR-14 680 pF		±1%	50 V DC	MIL-C-55681/4/5 CDR14BP681AFUS		,,				
C7	P	CDR-12 68pF		±1%	50 V DC	MIL-C-55681/4/5 CDR12BP680AFUS		,,				
C8	P	[illegible]		±1%	50 VDC	MIL-C-55681/4/5 CDR14BP681AFUS		,,				
C9	P	CDR-14 [illegible]		±1%	50 VDC	MIL-C-55681/4/5 CDR14BP681AFUS		,,				

COMPONENT LIST

PROJECT: RADIOASTRON MODEL: ENGINEERING SYSTEM: 92 cm FRONT END. SUBSYSTEM: LOW NOISE AMPLIFIER SECTION :

CARD CODE/FUNCTION: 92-2 PAGE NO: 2 REV.NO.: 1 CHECKED BY:

APPROVED BY PROJECT I

REF DES	PKG STYLE	TYPE/ VALUE	ALT VALUE	TOL.	RATINGS	PROCUREMENT INFORMATION	TEST SELECT SR.No.	MFGR/ VENDOR	REMARKS DGNR	FAB	QC	QC
C4	P	CDR-12 68 pF		±1%	50 VDC	MIL-C-55681/4/5 CDR12BP680AFUS		A.T.C, U.S.A.				
C5	P	CDR-12 4.7 pF		±0.1%	50 V DC	MIL-C-55681/4/5 CDR12BA4R7ABUS		A.T.C, U.S.A				
C6	P	CDR-14 680 pF		±1%	50 V DC	MIL-C-55681/4/5 CDR14BP681AFUS		,,				
C7	P	CDR-12 68pF		±1%	50 V DC	MIL-C-55681/4/5 CDR12BP680AFUS		,,				
C8	P	CDR-14 680 pF		±1%	50 VDC	MIL-C-55681/4/5 CDR14BP681AFUS		,,				
C9	P	CDR-14 [illegible]		±1%	50 VDC	MIL-C-55681/4/5 CDR14BP681AFUS		,,				

COMPONENT LIST

PROJECT: RADIOASTRON MODEL: ENGINEERING SYSTEM: 92 CM FRONT END SUBSYSTEM: LOW NOISE AMPLIFIER SECTION :

CARD CODE/FUNCTION: 92-2

PAGE NO: 4 REV. NO.: 1

CHECKED BY:

APPROVED BY PROJECT

[illegible]	PKG STYLE	TYPE/ VALUE	ALT VALUE	TOL.	RATINGS	PROCUREMENT INFORMATION	TEST SELECT SR. No.	MFGR/ VENDOR	REMARKS DGNR	REMARKS FAB	REMARKS QC	REMARKS QC
R4	SD23 ✓	RNC55 51 Ω		±0.1%	1/8 W @ 70°C 200 V DC	MIL-R-55182 RNC55J51R0BS		MEPCO/ CENTRALAB, U.S.A.				
R5	SD23 ✓	RNC55 150 Ω		±0.1%	1/8 W @ 70°C 200 V DC	MIL-R-55182 RNC55J1500BS						
R6	SD23 ✓	RNC55 51 Ω		±0.1%	1/8 W @ 70°C 200 V DC	MIL-R-55182 RNC55J51R0BS		MEPCO/ CENTRALAB, U.S.A.				
R7	RM1505	RCW11 5150 221 Ω		±1%	150 mW 40 V DC.	MIL-R-55342/A M55342/4 K2210-FKR.		DALE, U.S.A.				
CF	[illegible] MOUNT [illegible] FEEDTHRU	1250 [illegible] 1500 pF			200 V DC @ 85°C 10 Amps.	MIL-F-15733 M15733/28-0001		MURATA ERIE, CANADA				

COMPONENT LIST

PROJECT: [illegible] MODEL: ENGINEERING SYSTEM: 92 C— FRONT-END SUBSYSTEM: POWER SUPPLY SECTION : (VOLTAGE REGULATOR)

CARD CODE/FUNCTION: 92-3 PAGE NO: 1 REV.NO.: 0 CHECKED BY:

APPROVED BY PROJECT LEADER

CKT. SMBL	PKG STYLE	TYPE/ VALUE	ALT VALUE	TOL.	RATINGS	PROCUREMENT INFORMATION	TEST SELECT SR.No.	MFGR/ VENDOR	REMARKS				
									DGNR	FAB	QC	QC	QA
U1	TO-39	LM117H				MIL-M-38510/ 11703BXA		NSC, USA					
D1	Hermetically sealed glass case; axial lead	IN5615			PIV = 200V I_O = 1A @ 55°C (av)	~~[illegible]~~ MIL-S-19500/427 JANTXV IN5615		MICRO SEMI, USA					
C1	CSR-13	CSR 13 1 μF			50 V @ 85°C	M39003/01/3076		KEMET, USA					
C2	CSR-13	CSR 13 1 μF			50 V @ 85°C	M39003/01/3076		KEMET, USA					
R1	SD23V	RNC55J 221 [illegible]		1.0 %	⅛ W @ 70°C 200V DC	MIL-R-55182 RNC55J2210BS		DALE, USA					
R2	SD23V	RNC55 [illegible]		1.0 %	⅛ W @ 70°C 200V DC	MIL-R-55182 RNC55J6810BS		DALE, USA					
[illegible]	[illegible]	[illegible]			80 V DC @ 85°C 15 Amps	MIL-F-15733 M15733/38-0004		MURATA-ERIE, CANADA					
[illegible]	[illegible]	[illegible]			80V DC @ 85°C			[illegible]					

COMPONENT LIST

PROJECT: [illegible] MODEL: ENGINEERING SYSTEM: 92 c— FRONT-END SUBSYSTEM: POWER SUPPLY SECTION (VOLTAGE REGULATOR) :

CARD CODE/FUNCTION: 92-3 PAGE NO: 1 REV.NO.: 0 CHECKED BY:

APPROVED BY PROJECT LEADE

CKT. SMBL	PKG STYLE	TYPE/ VALUE	ALT VALUE	TOL.	RATINGS	PROCUREMENT INFORMATION	TEST SELECT SR.NO.	MFGR/ VENDOR	REMARKS DGNR	FAB	QC	QC	QA
U1	TO-39	LM117H				MIL-M-38510/ 11703BXA		NSC, USA					
D1	Hermetically sealed glass case; axial lead	IN5615			PIV = 200V I_O = 1A @ 55°C (av)	~~[illegible]~~ MIL-S-19500/427 JANTXV IN5615		MICRO SEMI, USA					
C1	CSR-13	CSR 13 1 µF			50V @ 85°C	M39003/01/3076		KEMET, USA					
C2	CSR-13	CSR 13 1 µF			50V @ 85°C	M39003/01/3076		KEMET, USA					
R1	SD23V	RNC55 221 [illegible]		1%	1/8 W @ 70°C 200V DC	MIL-R-55182 RNC55J 2210BS		DALE, USA					
[illegible]	SD23V	RNC55 [illegible]		1%	1/8 W @ 70°C 200V DC	MIL-R-55182 RNC55J 6810BS		DALE, USA					
[illegible]	[illegible]	[illegible]			80 V DC @ 85°C 15 Amps	MIL-F-15733 M15733/38-0004		HOPATA-ERIE, CANADA					
[illegible]	[illegible]	[illegible]			80V DC @ 85°C			[illegible]					

APPENDIX - 3

- Reliability Report

अन्तरिक्ष उपयोग केन्द्र
SPACE APPLICATIONS CENTRE

अहमदाबाद-380 053.
AHMEDABAD-380 053.

RELIABILITY ASSESSMENT FOR 324 MHZ LOW NOISE FRONT END FOR RADIOASTRON PAYLOAD DEVELOPED FOR TIFR, PUNE

OCT 1994

भारतीय अन्तरिक्ष अनुसंधान संगठन
INDIAN SPACE RESEARCH ORGANISATION

SPACE APPLICATIONS CENTRE
AHMEDABAD

DOCUMENT CONTROL & DATA SHEET

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2.	TITLE & SUBTITLE	:	TEST & EVALUATION REPORT ON RELIABILITY ASSESSMENT FOR 324 MHz LOW NOISE FRONT END FOR RADIOSTRON PAYLOAD DEVELOPED FOR THE PUNE, OCT, 1994.
3.	TYPE OF REPORT	:	TECHNICAL
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6.	AUTHOR(S)	:	RES GROUP
7.	ORIGINATING UNIT	:	RES,R & QA
8.	CORPORATE AUTHOR(S)	:	-
9.	ABSTRACT	:	THIS REPORT DESCRIBES THE RELIABILITY ASSESSMENT FOR 324 MHz LOW NOISE FRONT END FOR RADIOSTRON PAYLOAD.
10.	KEY WORDS	:	RELIABILITY, PAYLOAD, RADIOSTRON, ASSESSMENT, APPORTION,
11.	DISTRIBUTION	:	WITHIN ISRO

C O N T E N T S

INTRODUCTION

This report discusses the reliability assesement for the flight model of 324 MHz Low Noise Front End for Radioastron payload developed by the TIFR. The assumptions made for carrying out reliability estimations and other relevant details are mentioned in para 2.0. The failure rate analysis, alongwith the parts stress is given in Table-1. Finally, the conclusion is given in para 4.0 of the report.

ASSUMPTIONS

The reliability assessment was carried out based on the following Assumptions.

1. Failure rate for various parts are calculated as per MIL-HDBK-217F. Notice-1 (the latest version)

2. Part Stress method is employed.

3. Quality factors are taken in accordance with Flight approved parts list (APL).

4. The mission time for the payload is considered as 3 years /2 years with 100 % duty cycle.

5. Inter connections and the interfaces of the payload with other spacecraft are not considered.

6. The operating temp. is considered as $25^{0}C \pm 5^{0}C$.

7. The apportioned reliability goal of this circuit is 0.95 for 3 years.

8. Mission success indicates the functioning of Low Noise Front End for RCP & LCP inputs together, with in specifications.

RELIABILITY ASSESSMENT

The Fig. no. 1 represent the functional block diagram of the Radiostron 324 Low Noise Front End and fig. no. 2A, 2B & 2C represent the circuit diagram of 324 MHz Low Noise Amplifier, LNA Power supply & Directional coupler. The reliability block diagram and the Mathematical Model for the payload is shown in figure no. 3.

The table-1 below gives the deteails of part types, part quantity & failure rate break-up for various devices comprised by the Radiostron Front End.

TABLE - 1

Environment - SF Spaceflight Part Qty: 78

Temperature : $25^0C \pm 5^0C$

Sr. No.	Part Number	Type	Qty.	Total Part failure rate/ 10 E + 6 hrs.
01	LM 117	MED	2	0.012468
02	NE 13783	SEMI	4	0.052420
03	1N 5615	SEMI	2	0.001106
04	CSR 13	CAP	4	0.000018
05	CDR12/CDRI4	CAP	20	0.000140
06	RNC55 / 60	RES	19	0.000064
07	RM1505 CHIP	RES	4	0.000044
08	RFC	IND	2	0.007800
09	AIR CORE INDUCTOR	IND	6	0.011172
10	LINEFILTER	EMI FILTER	4	0.005660
11	CHIP ATTENUATOR	RES	2	0.008622
12	OSM-SMA CONNECTOR	CON.	5	0.001374
13	DIRECTIONAL COUPLER	MICROWAVE	2	0.240000
14	FEED THROUGH	EMI FILTER	2	0.002830
	Overall F.R./ 10^6Hrs =			0.343718

Overall Reliability of the payload

for 3 years mission time = 0.991

for 2 years mission time = 0.994

....3

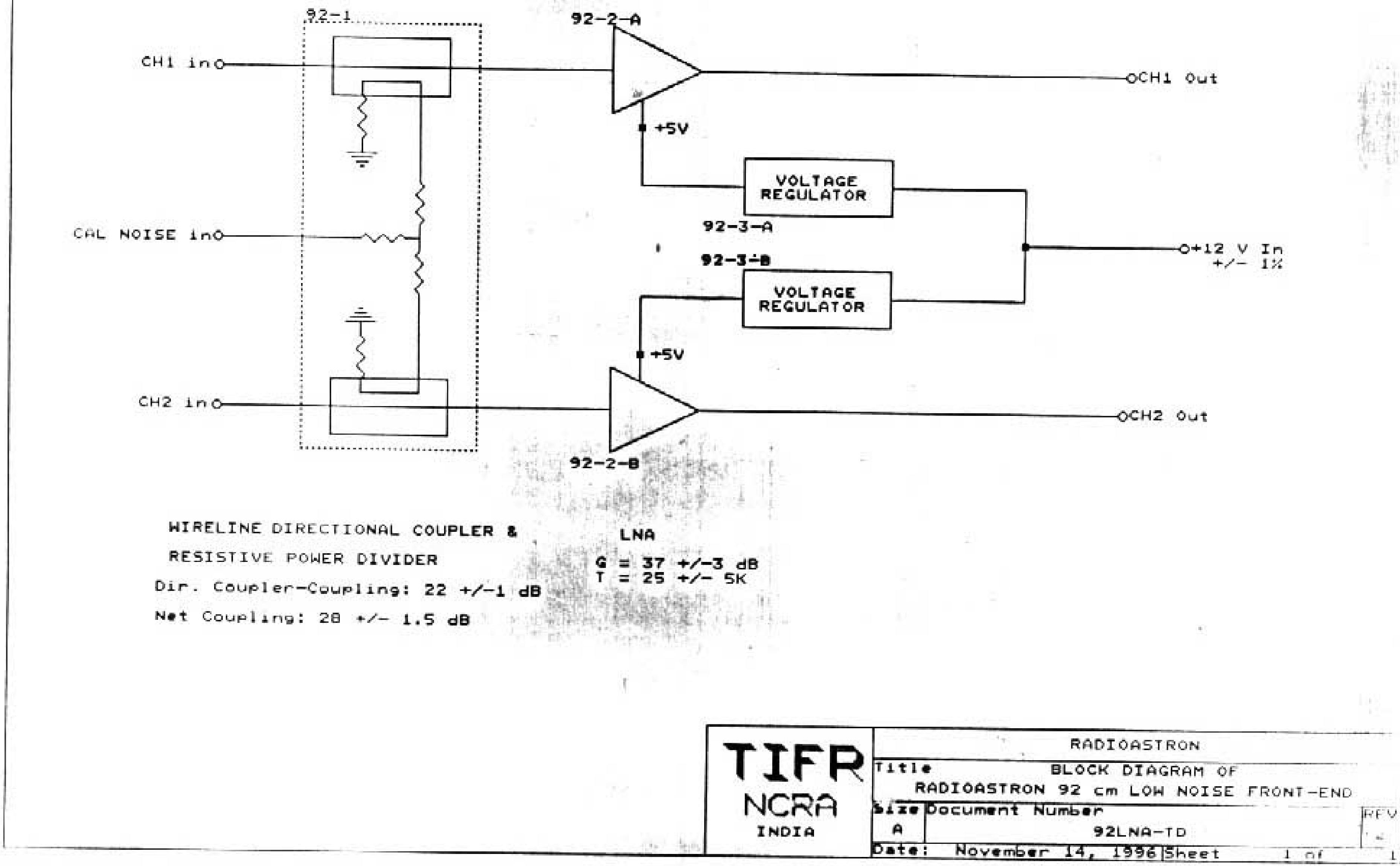
92-1
CH1 in
CAL NOISE in
CH2 in
92-2-A
92-2-B
+5V
+5V
VOLTAGE REGULATOR
VOLTAGE REGULATOR
92-3-A
92-3-B
CH1 Out
CH2 Out
+12 V In
+/- 1%
WIRELINE DIRECTIONAL COUPLER &
RESISTIVE POWER DIVIDER
Dir. Coupler-Coupling: 22 +/-1 dB
Net Coupling: 28 +/- 1.5 dB
LNA
G = 37 +/-3 dB
T = 25 +/- 5K
TIFR
NCRA
INDIA
RADIOASTRON
Title
BLOCK DIAGRAM OF
RADIOASTRON 92 cm LOW NOISE FRONT-END
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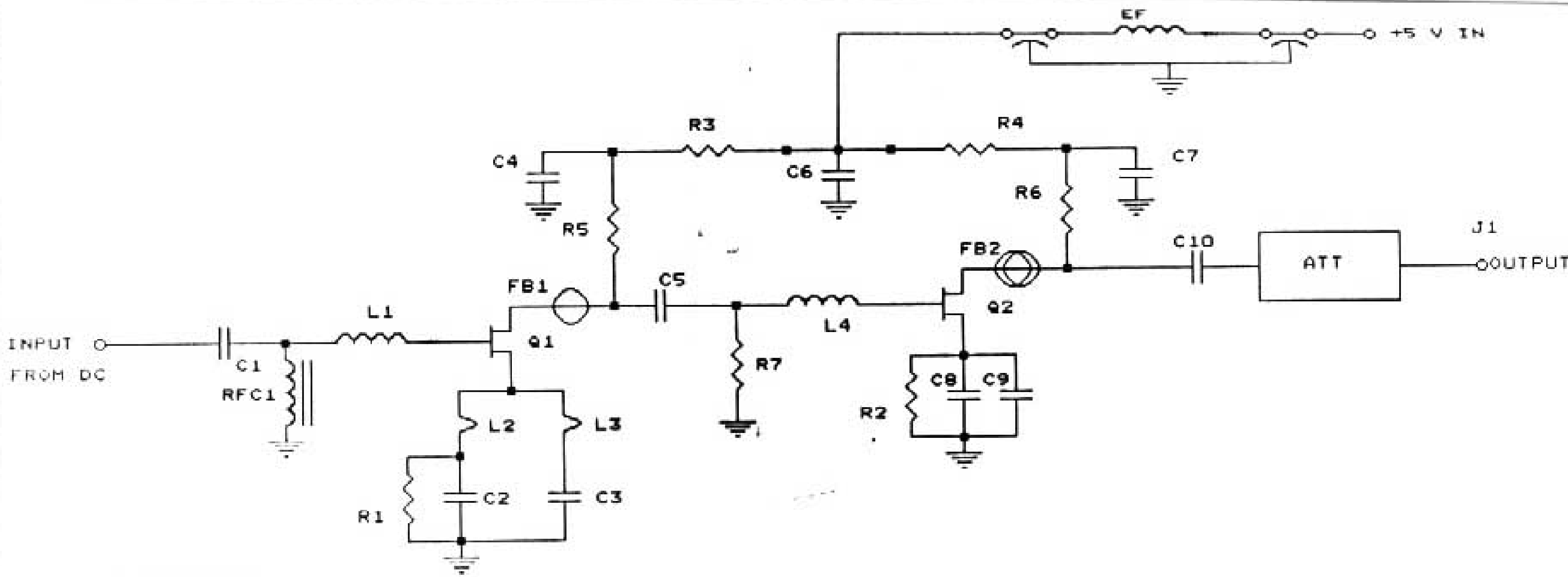
Fig. 1



NOTES :

Q1,Q2	: GaAs MESFETs; NE13783, Grade-C, NEC/CEL,USA.
RFC1	: RF Choke 0.22 uH +/-10%, 1025mA rated, Axial lead; NYTRONICS M39010/8
L1	: Aircore inductor; 6.0 mm ID, close wound with 20 AWG Magnet Cu wire, 7 Turns
L2, L3	: Source inductance, 3 mm lead lengths in Q1
L4	: Air Core Inductor; 6.0 mm ID, close wound with 22 AWG Magnet Cu wire, 7 Turns
FB1, FB2	: Ferrite Beads, Torroidal Core, MICROMETALS T10-6
C2, C3, C6, C8, C9	: 680pF Chip Capacitor, +/-1%, WVDC 50V ATC CDR14, 0.110" [2.79 mm] square
C5	: 4.7pF Chip Capacitor, +/-0.1pF, WVDC 50V ATC CDR12, 0.055" [1.4mm] square
C1, C4, C7, C10	: 68pF Chip Capacitor, +/-1%, WVDC 50V ATC CDR12, 0.055" [1.4 mm] square
ATT	: 6dB Thin Film Chip Attenuator, +/-0.5 dB, 1.5W, PCAW-6 KDI
R1	: 27 Ohms, 5023V- RNC55 type, 125 mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R2	: 39.2 Ohms, 5023V- RNC55 type, 125mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R3	: 15 Ohms, 5023V- RNC55 type, 125 mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R4,R6	: 51.1 Ohms , 5023V- RNC55 type, 125 mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R5	: 150 Ohms, 5023V- RNC55 type, 125 mW, +/-0.1%, 200V DC, MEPCO/CENTRALAB
R7	: RM1505- RCWM5150 type, 221 Ohms, +/-1%, 150mW, 40V DC Chip Resistor, DALE
EF	: Pi section EMI Filter, 1250-003 Bushing-mount, 1500 pF, 200V DC @ 85 C, 10 A, MURATA ERIE
J1	: SMA Flange Mount Jack Receptacle, OSM 2052-1132-00, OMNISPECTRA

TIFR NCRA INDIA	RADIOASTRON		
	Title: 92 cm LOW NOISE AMPLIFIER		
	Size: A	Document Number: 92LNA-TD 92 - 2	REV 1
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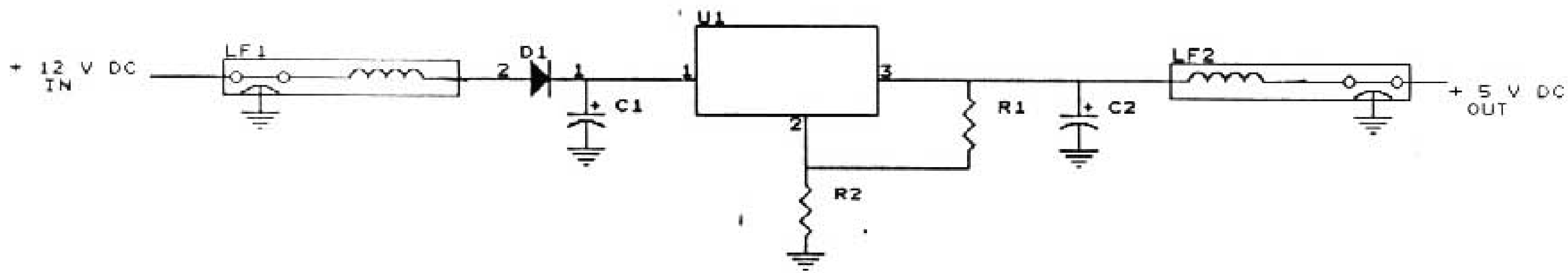
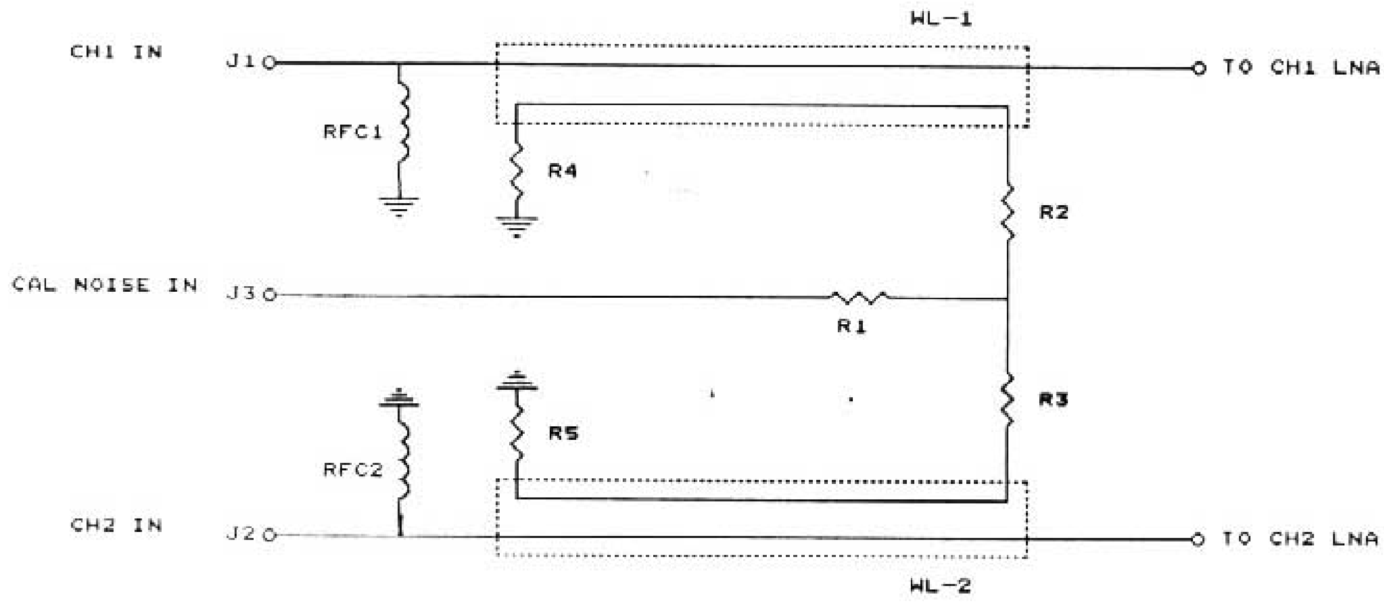
Fig. 2.0



NOTES

U1	: 3 Terminal Adjustable Voltage Regulator IC: JM 38510/11703 BXA, TO-39 style
D1	: Hermetically sealed glass case, Axial lead- Fast Recovery Rectifier Diode- JANTXV IN 5615, PIV 200V, Avg.I 1A @ 55 C, MICROSEMI
R1	: 5023V- RNC55 type, 221 Ohms Metal Film Resistor, +/-0.1%, 0.1 W, 200V DC, MEPCO/CENTRALAB
R2	: 5023V- RNC55 type, 681 Ohms Metal Film Resistor, +/-0.1%, 0.1 W, 200V DC, MEPCO/CENTRALAB
C1,C2	: 1uF, 50 V @ 85 C, CSR-13 Tantalum Capacitors, M39003/01/3076, KEMET
LF1, LF2	: Low Pass L Section EMI Filters with Bushing mount, 9051-100-0000/ 1.2 uF, 80V DC @ 85 C, 15 Amps, MURATA ERIE

TIFR NCRA INDIA	RADIOASTRON		
	Title: 92 cm LNA POWER SUPPLY (VOLTAGE REGULATOR)		
	Size: A	Document Number: 92LNA-TD 92 - 3	REV: 0
	Date: November 14, 1996	Sheet of	



NOTES

WL-1, WL-2	: WIRELINE Directional couplers, 4.4 mm length of JCT1, SAGE LABORATORIES INC.
RFC1, RFC2	: RF Choke, Air-core type with ID. of 3mm, 10 turns of #20 AWG Magnet copper wire
R1, R2, R3	: 5023V- RNC55 type, 16.2 Ohms, +/-0.1%, 0.1W, 200V DC, MEPCO/CENTRALAB
R4, R5	: RM1505- RCWM5150 type, 49.9 Ohms, +/-1%, 150mW, 40V DC, Chip Resistors, DALE
J1, J2, J3	: SMA Flange Mount Jack Receptacle, OSM 2052-1132-00, OMNISPECTRA

TIFR NCRA INDIA	RADIOASTRON
	Title: 92 cm DIRECTIONAL COUPLER
	Size: A — Document Number: 92LNA-TD 92 - 1 — REV: 1
	Date: November 14, 1996 — Sheet of

.0 CONCLUSION

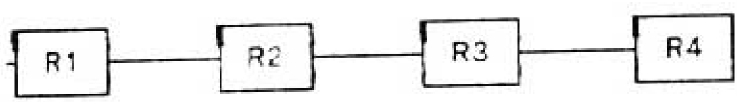
he reliability figure of the RADIOSTRON payload [illegible] ission time is given bellow:

Mission time	Reliability figure
3 Years	0.991
2 Years	0.994

It is observed that the mission time stipulated by th project, the reliability of the Radiostron is found meeting the apportioned goal of 0.95.

1	2	3	4
	LCP		RCP
Directional Coupler	LNAs, & Voltage Regulator	Directional Coupler	LNAs, & Voltage Regulator
0.125282	0.047693	0.125282	0.047693

Reliability Block diagram.



Mathematical Model :

R (t) = R1 X R2 X R3 X R4

= 0.9910

FIGURE - 3

APPENDIX - 4

- T&E Plan
- T&E Report of EM
- T&E Report of FMs

SPACE APPLICATIONS CENTRE
AHMEDABAD

E/110/95 12 DEC. 95

Summary Record of the T&E Committee meeting held on 11 Dec. 95 to finalise the Test Document on 327 MHz Front End LNA for Radioastron Project.

Following were present:

Shri V.H. Bora	Shri Srinivas
" N.V.Shah	" Surinder Singh
" Anil Shah	" A.L. Vadodaria
" S.K.Jain	" Abhay Khetarpal

Following points were discussed:

1.0 Designer briefed the members about the LNA and the Radioastron Project.

2.0 One ETM and two FM units of LNA are fabricated and offered for T&E.

3.0 It was informed that no specifications are available for the following parameters:

- Gain slope
- Phase Stability
- Gain ripple
- Gain Stability

However, these parameters will be measured during the FBT.

4.0 During thermal cycling test, the last (fifth) cycle will be extended from 2 hrs. to 4 hrs. at each temperature extreme to ensure temperature stabilization prior to the measurements.

5.0 During vibration test, the ETM unit will be subjected to GO/NO GO type electrical check after each axis vibration and detailed electrical measurement after all three axes vibration. The FM units will undergo electrical measurements only after all the three axes vibration.

6.0 Designer was requested to verify the need for dc terminal resistance measurement prior to and after the vibration test. Members felt that this measurement across the line filters will not yield any useful result.

7.0 Environmental testing will be carried out as per the test plan which has been prepared by TIFR in consultation with Astro Space Centre, Moscow and SAC R&QA. Test plan for ETM and FM models is given in Table-1 & 2 respectively.

...2

3.0 T&E is likely to start on 15 Dec, 95.

Prepared by :

(Abhay Khetarpal)
Member, T&E Committee
327 MHz FrontEnd LNA for
Radiostron Project.

Reviewed by:

(S. K. Jain)
Chairman

To: All the T&E committee members

cc: Head R&QA/RES
Project Leader/Gr.Dir.,SPG/Dy.Dir,SCA
Director, SAC.

ENVIRONMENTAL TEST PLAN AND TENTATIVE SCHEDULE FOR 327 MHz FRONT END LNA FOR RADIOSTRON PROJECT

TABLE - 1 (ETM UNIT)

Sr. No.	Date	Test	Remarks
1.	15.12.95	IBT	: A/C Lab.
2.	18.12.95	Cold storage	: -50 deg.C, 10 Hrs.
3.	19.12.95	Hot storage	: 50 deg.C, 10 Hrs.
4.	20.12.95	Sine vibration	: 25 Hz, 2g, 10 min. each axis
5.	21.12.95	Thermal cycling	: Four cycles of Cold(0 deg.C, 2Hrs) and Hot(40 deg.C,2Hrs) followed by one cycle of Cold (0 deg.C, 4Hrs) and Hot (40 deg.C, 4Hrs).
6.	22.12.95	FBT	: A/C lab.

TABLE - 2 (FM UNITS)

Sr. No.	Date	Test	Remarks
1.	26.12.95	IBT	: A/C Lab.
2.	27.12.95	Sine vibration	: 25 Hz, 2g, 10 min. each axis
3.	28.12.95	Thermal cycling	: Four cycles of Cold(5 deg.C, 2Hrs) and Hot(35 deg.C,2Hrs followed by one cycle of Cold (5 deg.C, 4Hrs) and Hot (35 deg.C, 4Hrs).
4.	29.12.95	FBT	: A/C lab.

SAC-R&QA-RES-TR-09-96

TEST & EVALUATION REPORT
ON
327 MHz FRONT END LNA (EM)
OF
RADIOASTRON PROJECT

FEBRUARY, 1996

APPROVED BY : T&E COMMITTEE

SUBMITTED TO : DIRECTOR, SAC

RELIABILITY AND QUALITY ASSURANCE
SPACE APPLICATIONS CENTRE
GOVERNMENT OF INDIA
AHMEDABAD-380 053.

SPACE APPLICATIONS CENTRE
AHMEDABAD

DOCUMENT CONTROL & DATA SHEET

1.	REPORT NO. & PUBLICATION DATE	: SAC-R&QA-RES-T&E-09-96 FEBRUARY, 1996
2.	TITLE & SUBTITLE	: TEST & EVALUATION REPORT ON 327 MHz FRONT END LNA (EM) OF RADIOASTRON PROJECT
3.	TYPE OF REPORT	: TECHNICAL
4.	PAGES	: THREE + Appendices
5.	NO. OF REFERENCE	: --
6.	AUTHOR(S)	: RES GROUP
7.	ORIGINATING UNIT	: RES/R & QA
8.	CORPORATE AUTHOR(S)	: -
9.	ABSTRACT	: THIS REPORT DESCRIBES THE QUALIFICATION LEVEL TESTING AND EVALUATION CARRIED OUT ON 327 MHz FRONT END LNA (EM) OF RADIOASTRON PROJECT.
10.	KEY WORDS	: T&E, QUALIFICATION LEVEL TESTING, EM, 327 MHz LNA, RADIOASTRON
11.	SECURITY CLASSIFICATION	: FOR ISRO AND TIFR, PUNE USE ONLY.
12.	DISTRIBUTION	: WITHIN ISRO AND TIFR, PUNE

ACKNOWLEDGEMENT

T & E committee gratefully acknowledges the contributions from the following.

* SAC Fabrication team
* Payload Fabrication Facility
* TIFR Designers team, Pune
* Electronics test facility
* Climatic and Mechanical test facility
* Quality Assurance (Mechanical) Division
* Quality Assurance (Electronics) Division
* Quality Control (Group)

CONTENTS

APPENDICES

Photograph of the 327 MHz Front End LNA

1.0 INTRODUCTION

RadioAstron is a space radio-telescope having receivers at 1.35 cm, 6 cm, 18 cm, and 92 cm wavelengths to be launched by Russia. Indian participation in the mission is with regard to the development and delivery of onboard 327 MHz Frontend LNA (Low Noise amplifier) for 92 cm receiver. The other portion of the receiver will be supplied by other global participants in RADIOASTRON mission. The 327 MHz LNA will be housed in focal container which is heremetically sealed with inert gas at ambient pressure.

While the design has been finalised by TIFR group at Pune, the fabrication, testing and space qualification have been carried out at SAC, Ahmedabad.

This report describes the qualification level Test & Evaluation carried out on this unit, performance observed during testing, evaluation of the test results and recommendations.

Test & Evaluation was carried out by the T&E committee constituted by Director, SAC (ref. Appendix-I). A report on test results and deviations submitted by Electronics test facility (ETF) is attached in Appendix-II. Relevent notes and waivers given for this unit are provided in Appendix-III. QA/QC certificates are provided in Appendix-IV. List of test equipments used during T&E is given in Appendix-V.

2.0 BRIEF DESCRIPTION OF UNIT

The 327 MHz low noise front-end consists of a LNA and a Voltage regulator (power supply). This is a dual channel LNA with RF inputs for CH#1 and CH#2, and a third input for calibration noise injection. The calibration noise is injected into each channel through a resistive power divider and a directional coupler. The operating frequency range is from 321MHz to 328 MHz. The DC supply to the LNAs comes through +5V regulators which gets +12V inputs from the spacecraft supply.

3.0 GENERAL COMMENTS

3.1 All the electrical parameters were measured as per the test document which was finalized by the T&E committee.

3.2 It was ensured that electronic test equipments and environmental chambers were in calibrated conditions prior to starting the test.

3.3 T & E for the subsystem has been started after receiving the necessary clearances from QA/QC (Electronics and Mechanical).

3.4 The environmental tests were carried out as per the Test plan which has been prepared by TIFR in consultation with Astro Space Centre, Moscow and R&QA, SAC.

3.5 During the environmental tests, only the Gain, Isolation and Noise Temperature parameters were measured.

3.6 Stability test was carried out for 4 Hrs at ambient to determine the Gain and Phase stability.

3.7 All the measurements were carried out with SMA connector savers.

3.8 Measurements during the initial and final bench tests were taken using HP 8510 vector network analyzer. However, during the other tests, HP 8757 scalar network analyzer was used.

Noise temperature was measured using 5 dB ENR Noise source and HP 8970 Noise figure meter. Noise temperature was also verified using EATON Hot & Cold Noise source.

4.0 TESTS CONDUCTED

Following tests were conducted on the unit as per the test document which was finalised by the T&E committee.

a) Initial bench test	:	A/c Lab.
b) Cold storage	:	-50 deg.C, 10hrs.
c) Hot storage	:	+50 deg.C, 10hrs.
d) Sine vibration	:	25 Hz, 2g, 10min. in all the three axis
e) Thermal cycling	:	4 cycles of cold (0 deg.C, 2Hrs) and Hot (40 deg.C, 2Hrs) followed by one cycle of cold (0 deg.C, 4Hrs) and Hot (40 deg.C, 4Hrs).
f) Final bench test	:	A/c lab.

5.0 PARAMETERS MEASURED

* 1. Gain at 324 MHz (centre freqency)

* 2. Isolation from channel 1 to 2 and 2 to 1.

* 3. Noise temperature.

4. Input return loss

5. Output return loss

6. Noise port coupling at 324 MHz.

7. Noise port return loss

* Parameters measured during environmental tests

Note: a. These parameters were measured for both CH#1 & CH#2.
b. Stability run was carried out for 4Hrs at ambient.

6.0 PERFORMANCE

All the specified parameters were measured and found to be within specifications during the tests conducted except the following worst case deviations.

6.1 DEVIATION

During FBT, Noise port coupling was observed to be 25.62 dB and 26.39 dB for CH#1 and CH#2 respectively against the specifications of 26.5 dB min.

ANALYSIS AND ACTION TAKEN

This deviation was considered as minor.

6.2 Gain Slope was measured as an additional parameter in FBT and found to be 0.18 dB/MHz in CH#1 and 0.17 dB/MHz in CH#2.

Besides, Gain stability and Phase stability were found to be 0.014 dB (p-p) and 0.08 deg. (p-p) respectively during the 4 Hrs stability tests at ambient on CH#1.

7.0 CONCLUSION

Based on the performance given in the above paragraph, this unit is cleared for further integration.

APPENDIX - I

SPACE APPLICATIONS CENTRE
AHMEDABAD

Ref: DIR/7.23(A)/91 June 19, 199

MEMORANDUM

SAC has undertaken the responsibility of fabrication and spac qualification of Radioastron Front-end for TIFR, Pune. Th Electrical Thermal Model (ETM) of Front-end is fabricated. Test Evaluation of this has to be carried out as per the T&E pla (SAC/R&QA/FP/20/91) generated by R&QA Division, SAC. The follow ing team has been constituted to carry out this task.

1.	Shri S.K.Jain	(R&QA)	Chairman
2.	Shri A.L.Vadodariya	(CMTF)	Member
3.	Shri N.V.Shah	(ETF)	Member
4.	Shri R.B.Bavaria	(PRPD)	Member
5.	Shri V.K.Jain	(PRPD)	Member
6.	Shri V.H.Bora	(MSDG)	Member
7.	Shri S.M.Srivastava	(ESGHG)	Member
8.	Shri Surender Singh.	(PRPD)	Co-ordinator

Dr.H.O.Gautam, Team Leader, SAC-TIFR Radioastron Project will provide electrical performance specification & test results of the Front-end to the T&E Committee.

The Committee shall submit the T&E report to the undersigned.

(Pramod Kale)
Director

To : All Committee Members

cc : Project Team
Steering Committee

SPACE APPLICATIONS CENTRE
RELIABILITY AND QUALITY ASSURANCE
AHMEDABAD

TE/110/95

Date 11-12-95

Following engineers are co-opted as members of the T & committee for 324MHz FRONT END LNA for RADIOASTRON pro ject.
(Ref. Dir/7.23(A)/91 dt. June 19, 1991)

1. Shri Abhay Khetrapal RES/R&QA

2. Shri Anil Shah, ETF/EnTF

(S. K. JAIN)
Chairman T&E committee,
324MHz FRONT END LNA fo
RADIOASTRON project.

To: Shri Abhay Khetrapal,
Shri Anil Shah.

cc: Head RES/R&QA/PRPD
Manager ETF/EnTF
Gr.Dir., SPG
Director, SAC.

SAC/ETF/T&E
JAN 25, 1996

APPENDIX - II

REPORT OF
TEST RESULTS & DEVIATIONS
ON
327 MHz FRONT END LNA
FOR RADIOASTRON
(ETM)

TESTING TEAM

A.K.SHAH	**ETF**
S.N.LAKHIA	
SRINIVAS M.	**PROJECT**

PREPARED BY : A.K.SHAH | ETF

REVIEWED BY : ------------
(H.S.RAINA)
MANAGER ETF

ELECTRONIC TEST FACILITY
EnTF/TSSG
SPACE APPLICATIONS CENTRE
AHMEDABAD 380 053

...is report describes the test results of the 327 MHz FRONT END for RADIOASTRON project (ETM). A comparative chart of the ...st results of important tests has been prepared and is at-...ached in table -I. Results of other tests are available with ...TF.

Test comments :

All tests were conducted as per test Document finalized by T&E committee.

Limited parameters were measured during environmental test as decided by T&E committee.

IBT & FBT were conducted on HP 8510 Vector Network Analyzer and other tests were conducted using HP8757 Scalar Network Analyzer.

All the measurements were carried out with SMA connector saver.

...4 Hrs. stability test was conducted on one channel.

...oise temp was measured using 5 dB ENR Noise Source & HP 8970 ...oise figure meter. ±7 °K is the accuracy of Noise figure ...eter in Noise temp measurement. Noise temp was measured with ...ype N-SMA adapter at LNA input. Noise temp was verified using ...ATON Hot & Cold Noise source.

...uring IBT Noise port coupling was measured using HP 8757 Scalar ...etwork Analyzer.

...0.2 dB is the accuracy of HP 8757 Scalar Network Analyzer in ...lative measurement.

...0.02 dB is the accuracy of HP 8510 Vector Network Analyzer in ...lative measurement.

Deviations:

...ollowing worst case Deviations were observed.

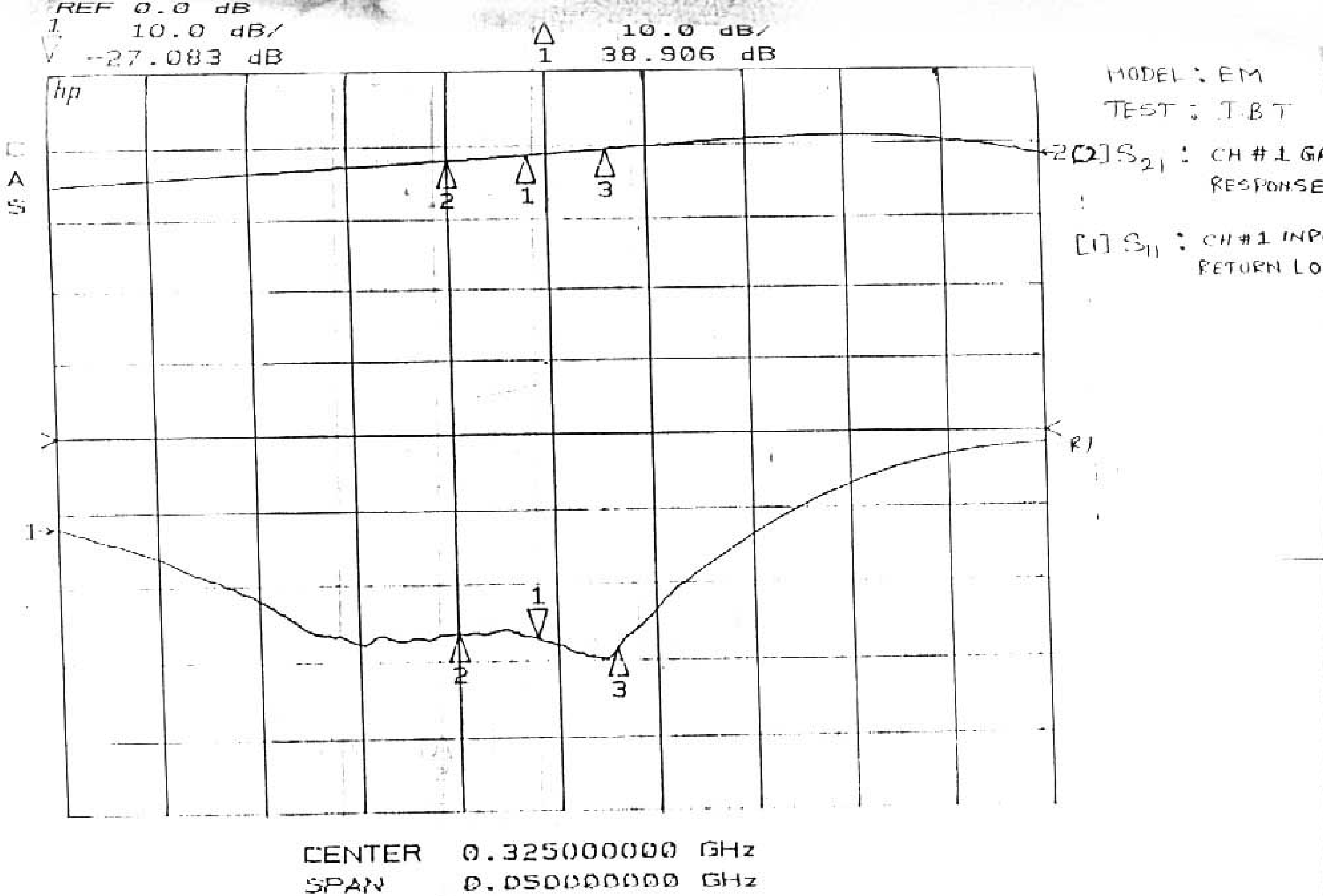
MODEL	TEST	CH#	PARAMETER	MEAS.VALUE	SPEC.
ETM	FBT	1	NOISE PORT COUPLING	25.62 dB	26.50 dB (min)
ETM	FBT	2	NOISE PORT COUPLING	26.39 dB	26.50 dB (min)

TABLE-1
SUMMARY OF TEST RESULTS

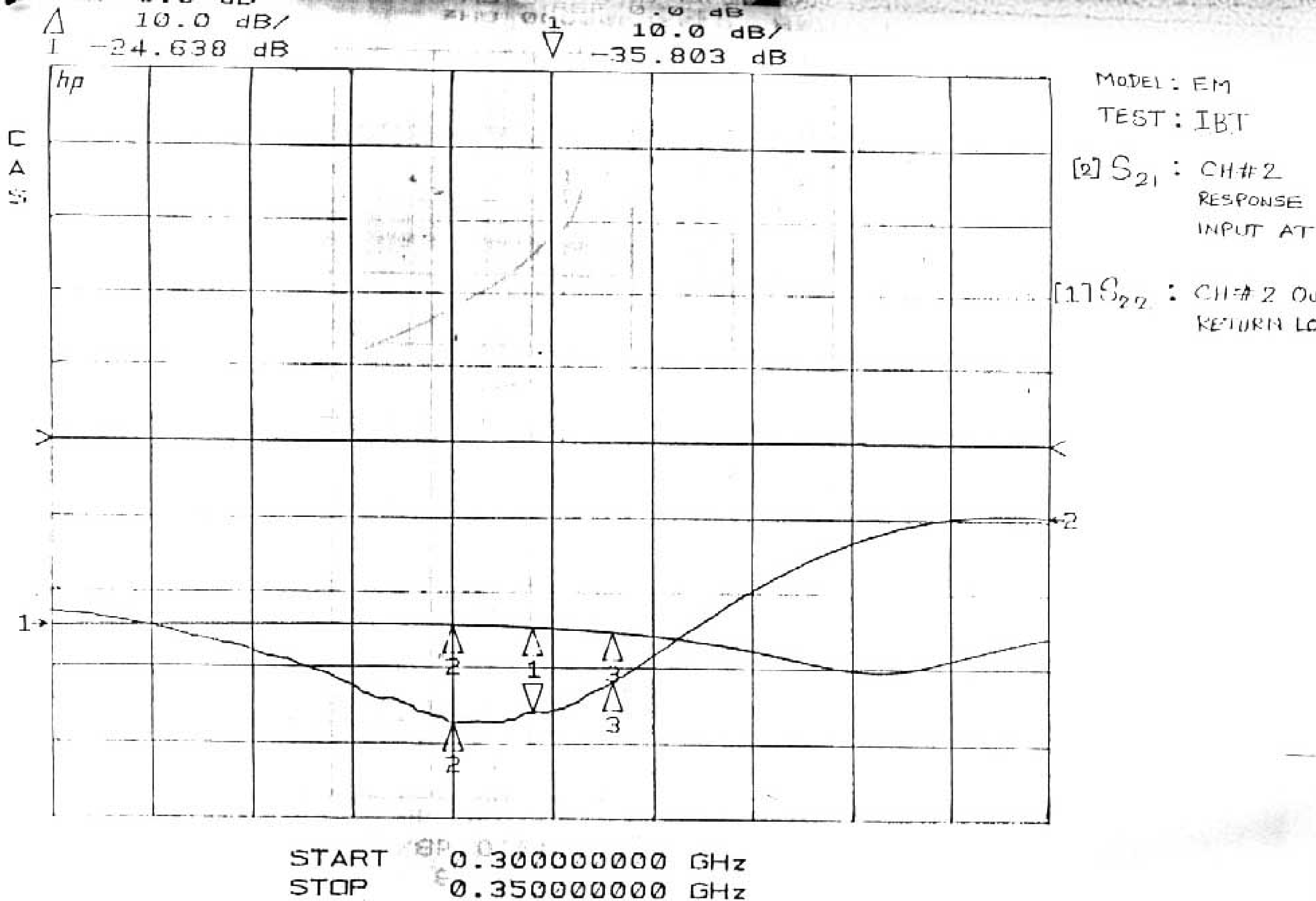
PROJECT : RADIOASTRON
MODEL : ETM
UNIT : 327 MHz FRONT END LNA

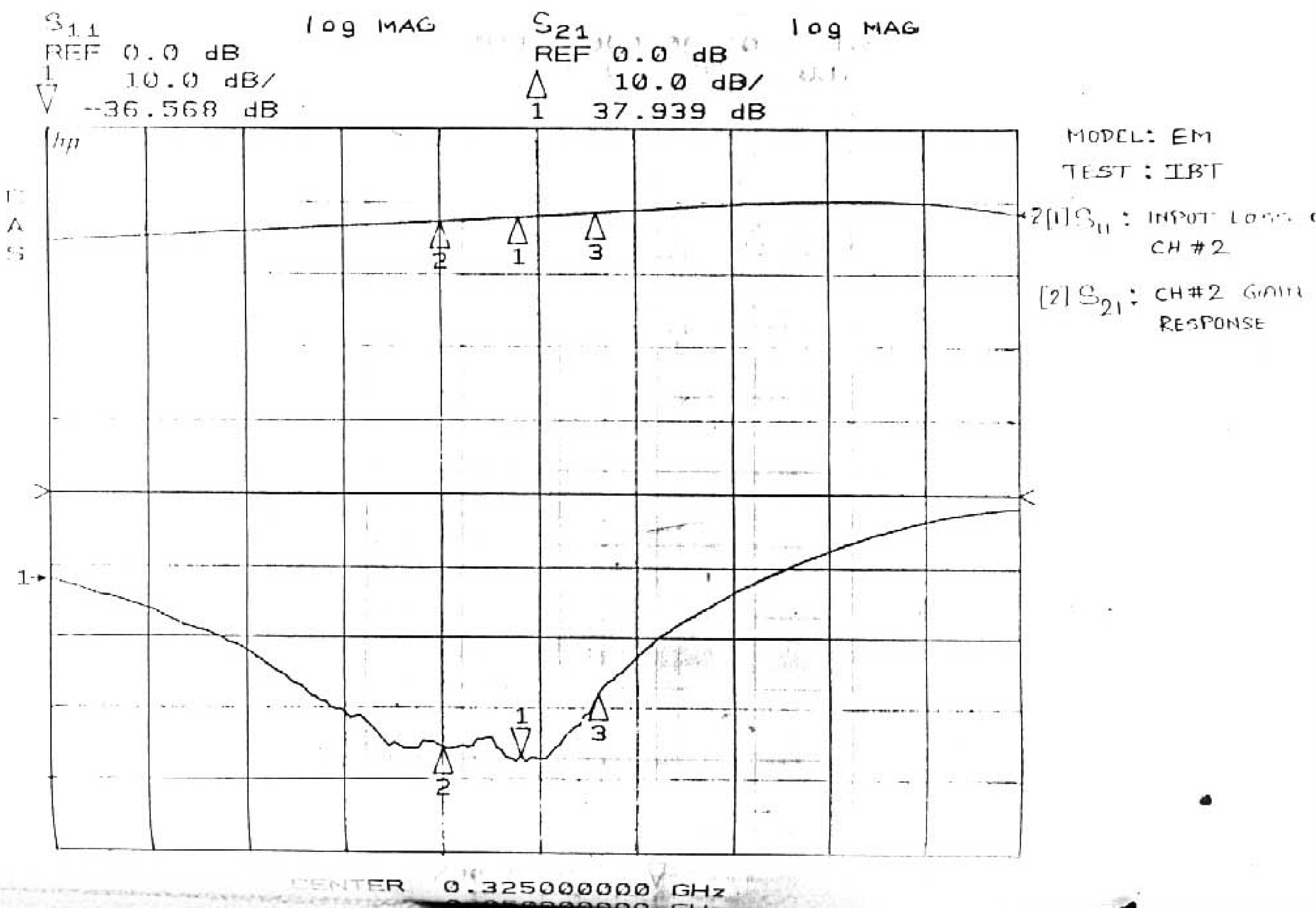
PREPARED BY : A.K.SHAH
ETF/EnTF/TSSG

SR. NO	PARAMETERS	SPECIFI-CATIONS	INITIAL BENCH TEST	POST COLD STORAGE (-50°C)	POST HOT STORAGE (50°C)	POST VIB & PRE THERMAL	COLD THERMAL (0 °C)	HOT THERMAL (40 °C)	POST THERMAL	
	DATE		20.12.95	20.12.95	21.12.95	22.12.95	02.01.96	02.1.96	03.01.96	03.
1	GAIN (IN dB) AT 324 MHz CH#1 CH#2	37±3	38.90 37.93	38.37 37.44	38.46 37.44	38.50 37.47	39.04 37.76	38.42 36.70	38.56 37.42	38 37
2	ISOLATION (IN dB) AT 324 MHz CH#1 wrt. CH#2 CH#2 wrt. CH#1	50.00 (min)	74.70 63.62	>45.00 >45.00	>45.00 >45.00	>45.00 >45.00	>45.00 >45.00	>45.00 >45.00	>45.00 >45.00	75 63
3	NOISE TEMP. (IN °K) AT 324 MHz CH# 1 CH# 2	25±5	26.5 27.4	25.3 25.0	25.2 24.7	24.3 24.7	25.2 25.5	29.7 27.8	26.2 26.8	25 25
4	I/P R/L (IN dB) CH# 1 CH# 2	12.74 (min)	27.08 36.56	- -	- -	- -	- -	- -	- -	27 38
5	O/P R/L (IN dB) CH# 1 CH# 2	19.08 (min)	22.13 24.63	- -	- -	- -	- -	- -	- -	21 24
6	NOISE PORT COUPLING (IN dB) AT 324 MHz CH # 1 CH # 2	28±1.5	26.13 26.77	- -	- -	- -	- -	- -	- -	25 26
7	NOISE PORT R/L (IN dB)	15.56 (min)	-	-	-	-	-	-	-	18

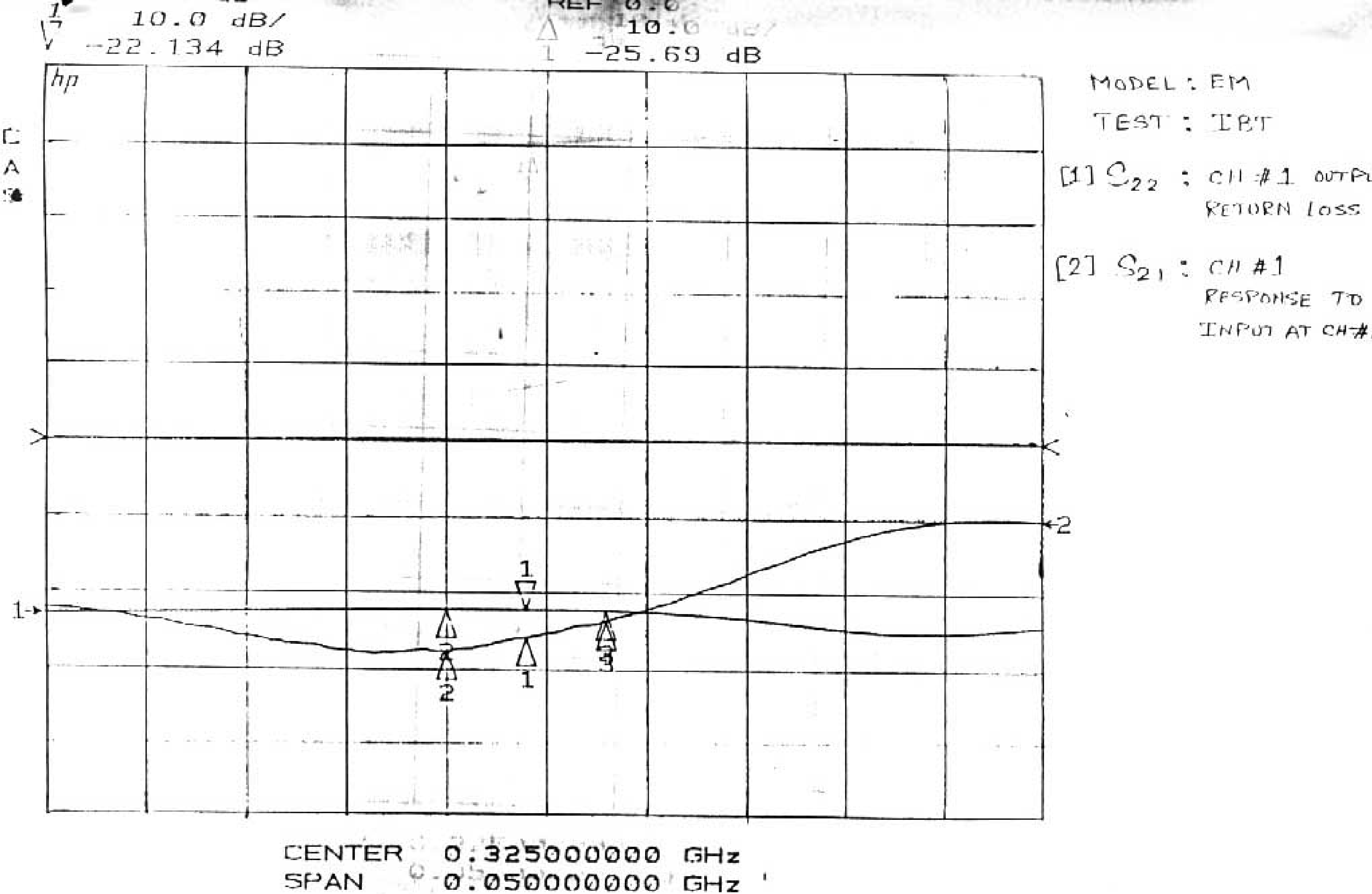

REF 0.0 dB
1 10.0 dB/
V -27.083 dB
Δ 1 10.0 dB/
38.906 dB
hp
A
S
2
1
3
R1
1
2
3
1
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz
MODEL : EM
TEST : TBT
[2] S_{21} : CH #1 GA
RESPONSE
[1] S_{11} : CH #1 INPU
RETURN LOS

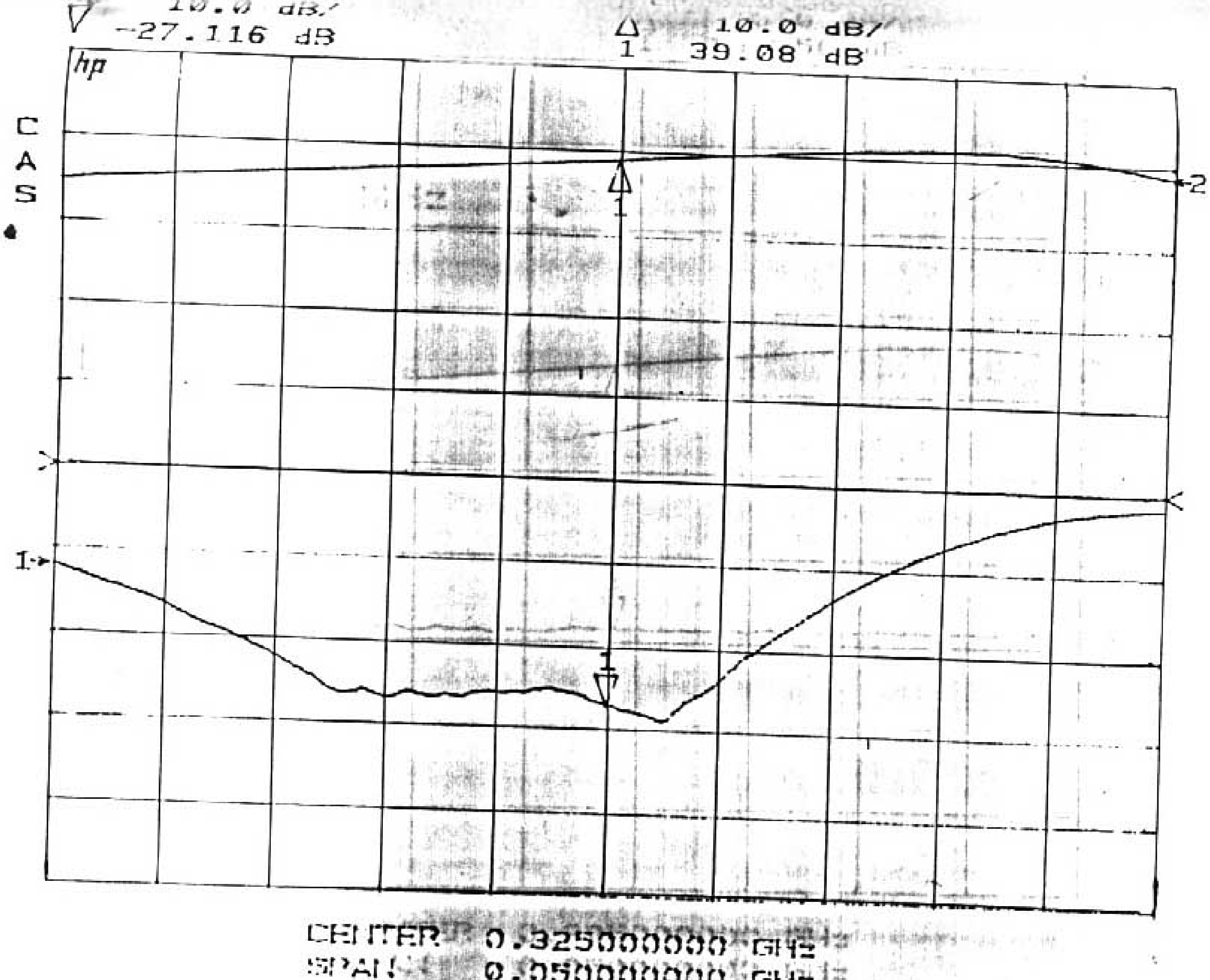
20, Dec, 1995


10.0 dB/
-24.638 dB
10.0 dB/
-35.803 dB
hp
C
A
S
1
2
3
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL: EM
TEST: IBT
[2] S_{21} : CH#2
RESPONSE T
INPUT AT C
[1] S_{22} : CH#2 OUT
RETURN LOS



S11 log MAG
REF 0.0 dB
10.0 dB/
-36.568 dB
S21 log MAG
REF 0.0 dB
10.0 dB/
1 37.939 dB
MODEL: EM
TEST : IBT
[1] S11 : INPUT LOSS
CH #2
[2] S21 : CH#2 GAIN
RESPONSE
CENTER 0.325000000 GHz


10.0 dB/
-22.134 dB
REF 0.0
10.0
-25.69 dB
hp
C
A
1-
2
1
2
1
3
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz
MODEL : EM
TEST : IBT
[1] S22 : CH #1 OUTPUT
RETURN LOSS
[2] S21 : CH #1
RESPONSE TO
INPUT AT CH#2

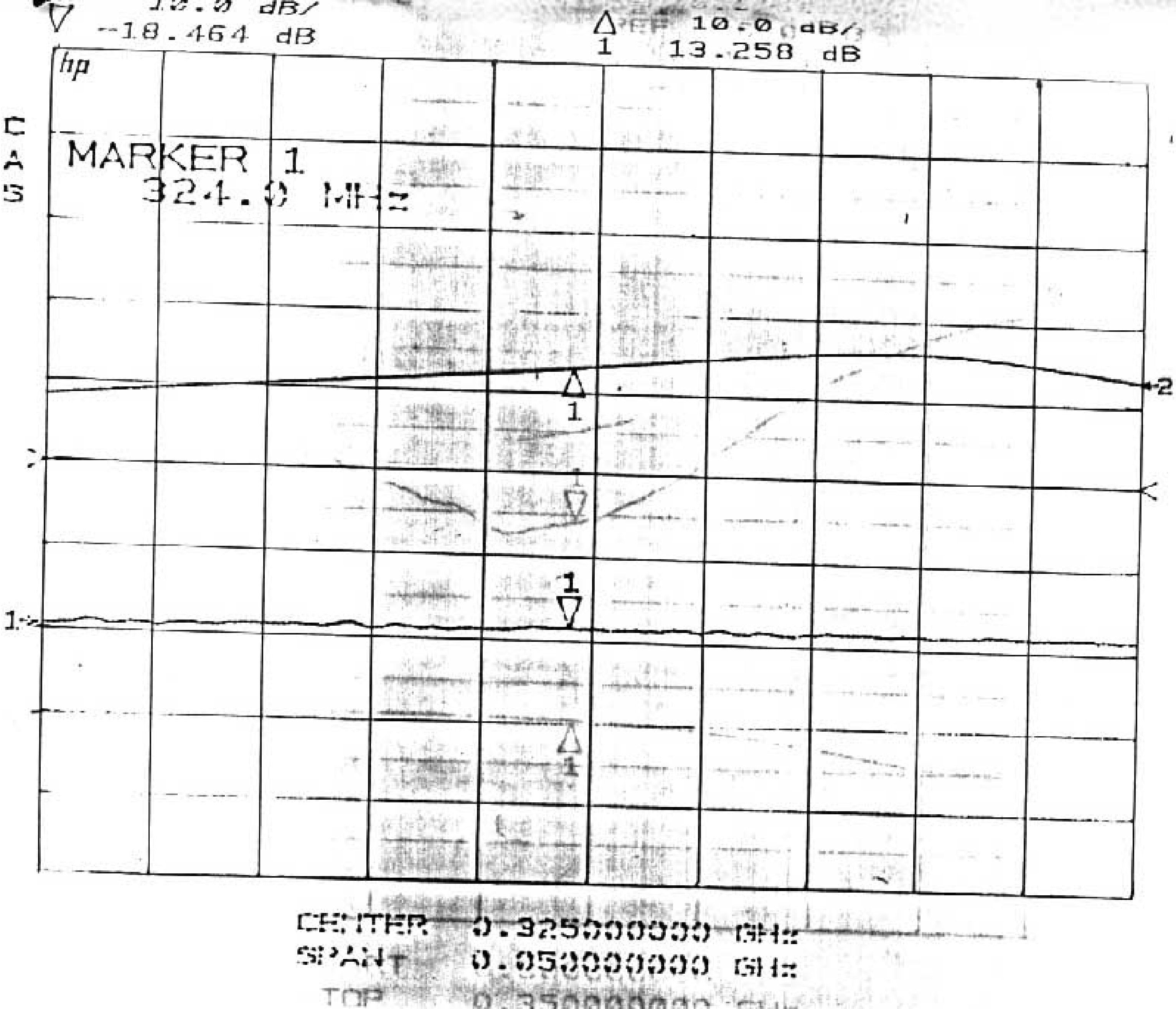


MODEL : EM

TEST : FBT

[1] S_{11} : CH #1
INPUT RETURN LOSS.

[2] S_{21} : CH #1
GAIN RESPONSE

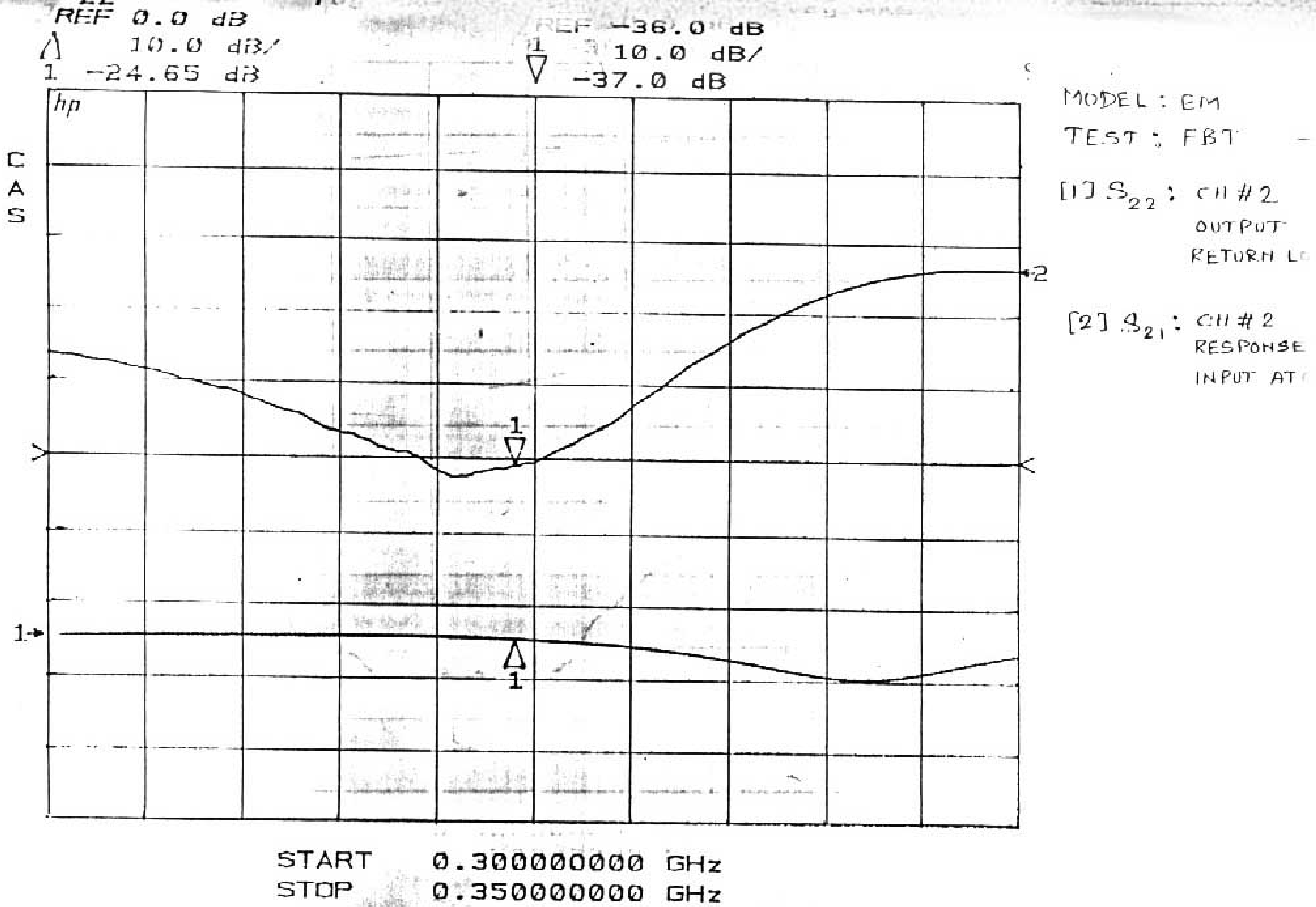


MODEL : EM

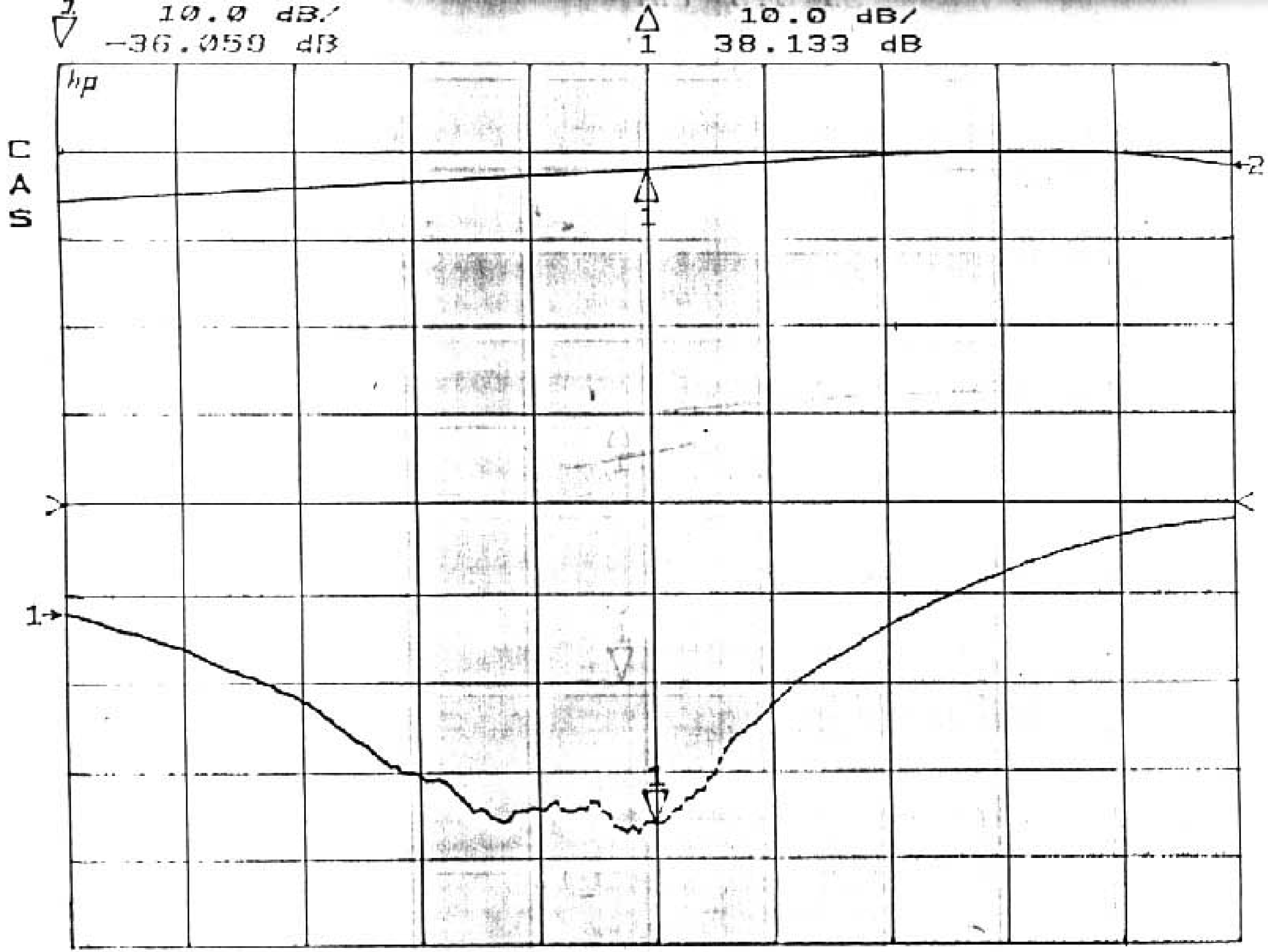
TEST : FBT

[1] S_{11} : Noise Port
Return Los

[2] S_{21} : Response
of CH # 1
To Input
Noise Cal
Port

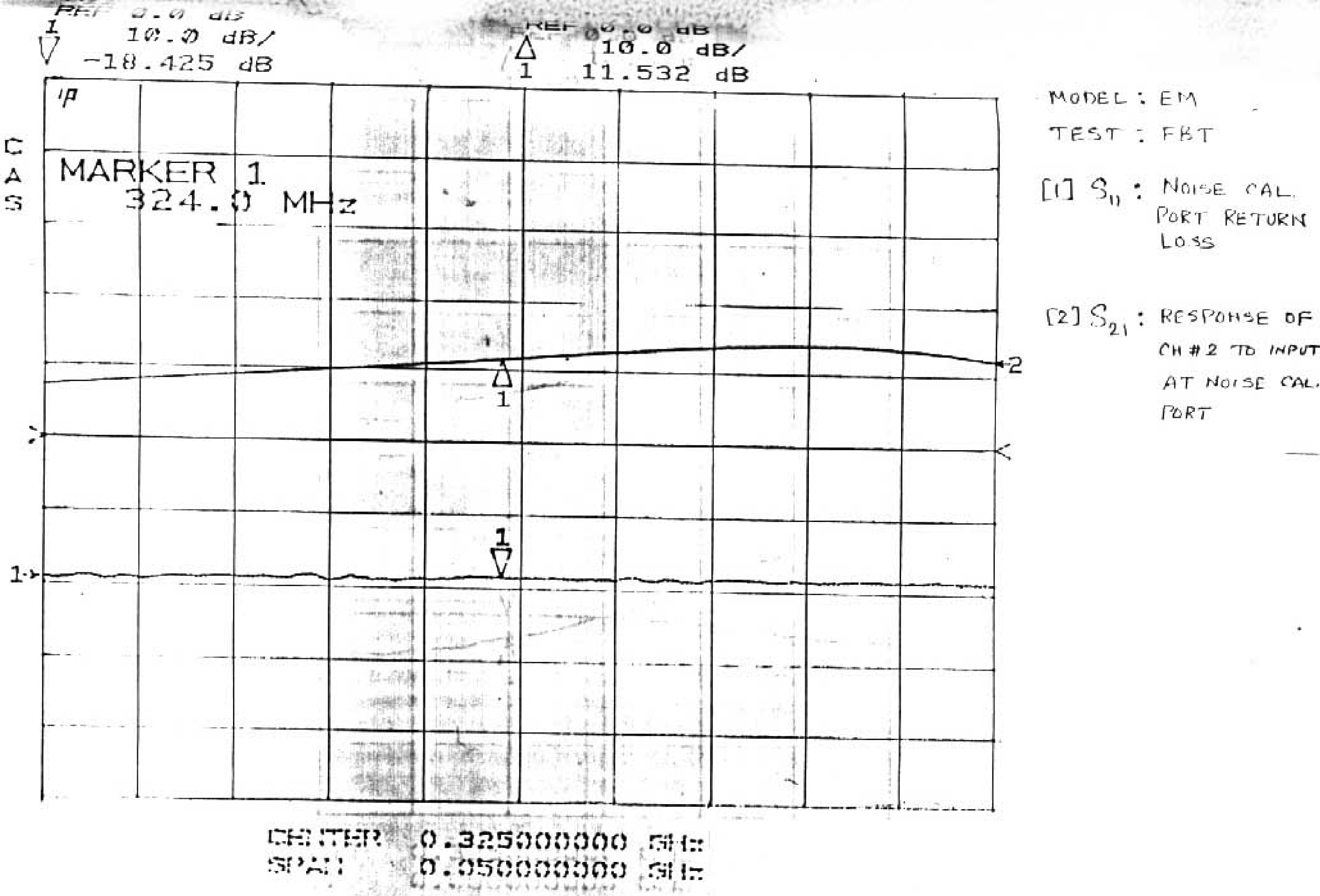


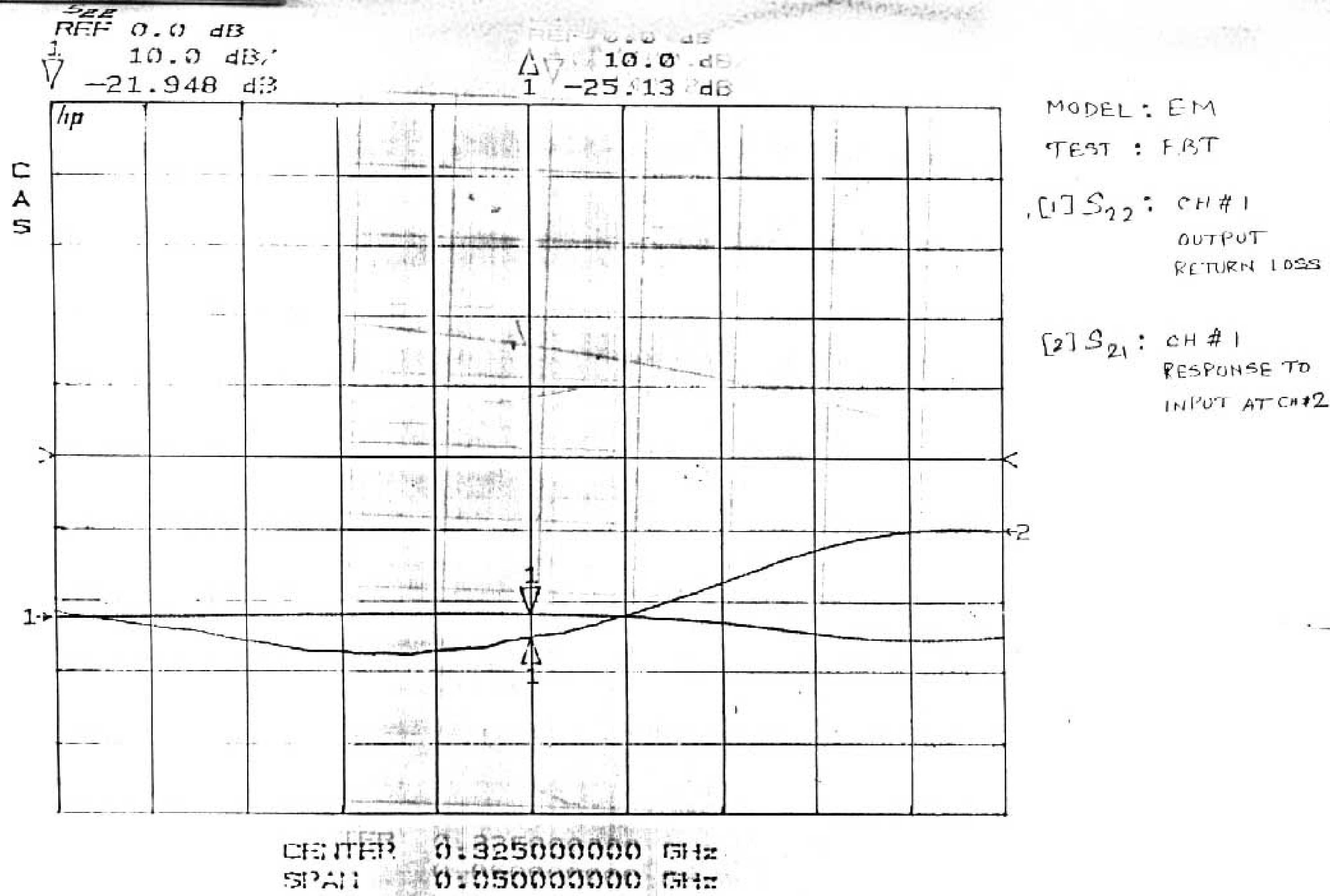
REF 0.0 dB
10.0 dB/
1 -24.65 dB
REF -36.0 dB
10.0 dB/
-37.0 dB
hp
C
A
S
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : EM
TEST : FBT
[1] S_{22} : CH #2
OUTPUT
RETURN L
[2] S_{21} : CH #2
RESPONSE
INPUT AT

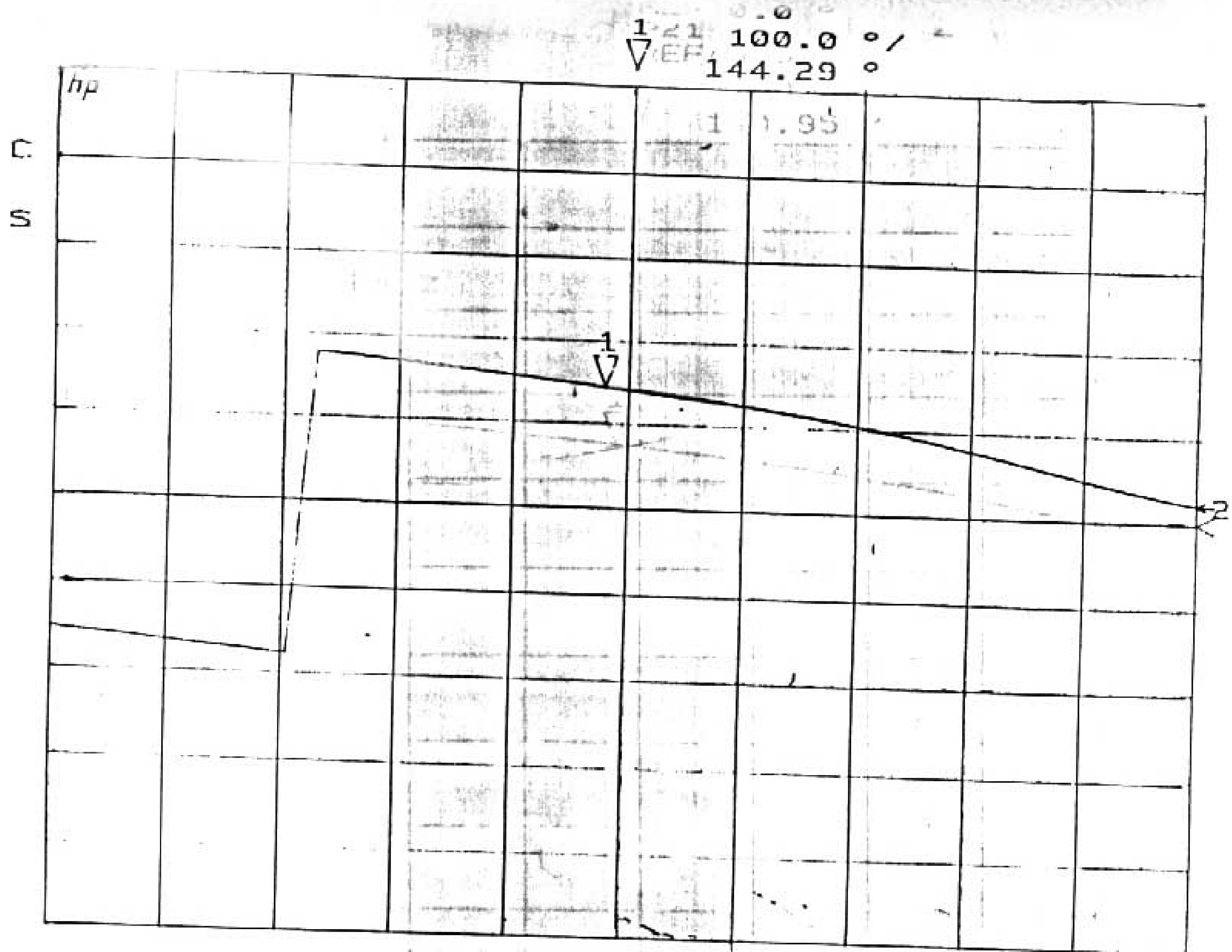


CENTER 0.325000000 GHz
SPAN 0.050000000 GHz

MODEL: EM
TEST : FBT
[1] S_{11} : CH # 2 INPUT RETURN LOSS
[2] S_{21} : CH # 2 GAIN RESPONSE


REF 0.0 dB
10.0 dB/
-18.425 dB
REF 0.0 dB
10.0 dB/
11.532 dB
CAS
MARKER 1
324.0 MHz
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz
MODEL : EM
TEST : FBT
[1] S11 : NOISE CAL PORT RETURN LOSS
[2] S21 : RESPONSE OF CH #2 TO INPUT AT NOISE CAL. PORT

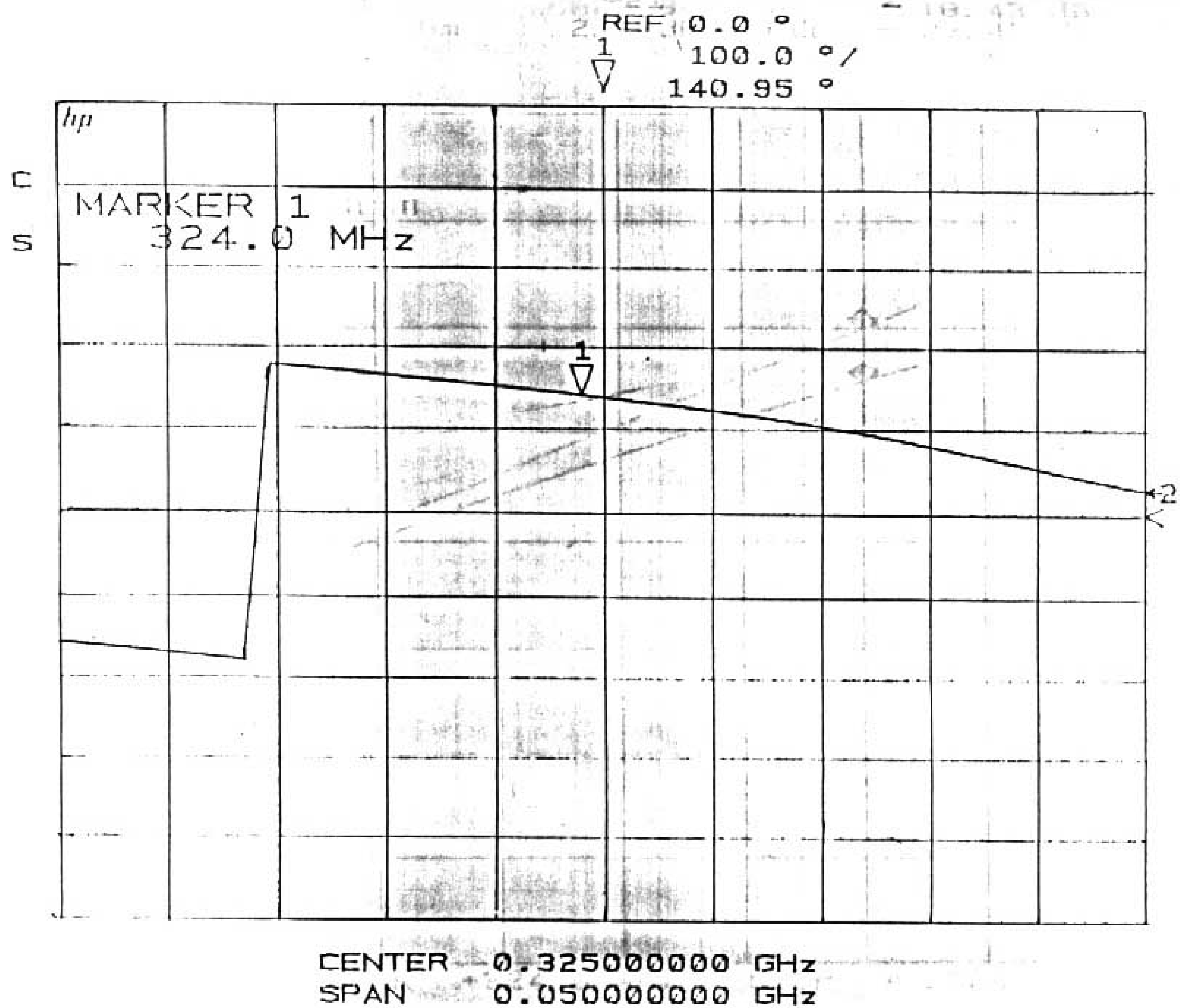

S22
REF 0.0 dB
10.0 dB/
−21.948 dB
10.0 dB
1 −25.13 dB
C
A
S
1
2
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz
MODEL : EM
TEST : FBT
[1] S_{22} : CH # 1
OUTPUT
RETURN LOSS
[2] S_{21} : CH # 1
RESPONSE TO
INPUT AT CH#2



CENTER 0.325000000 GHz
SPAN 0.050000000 GHz

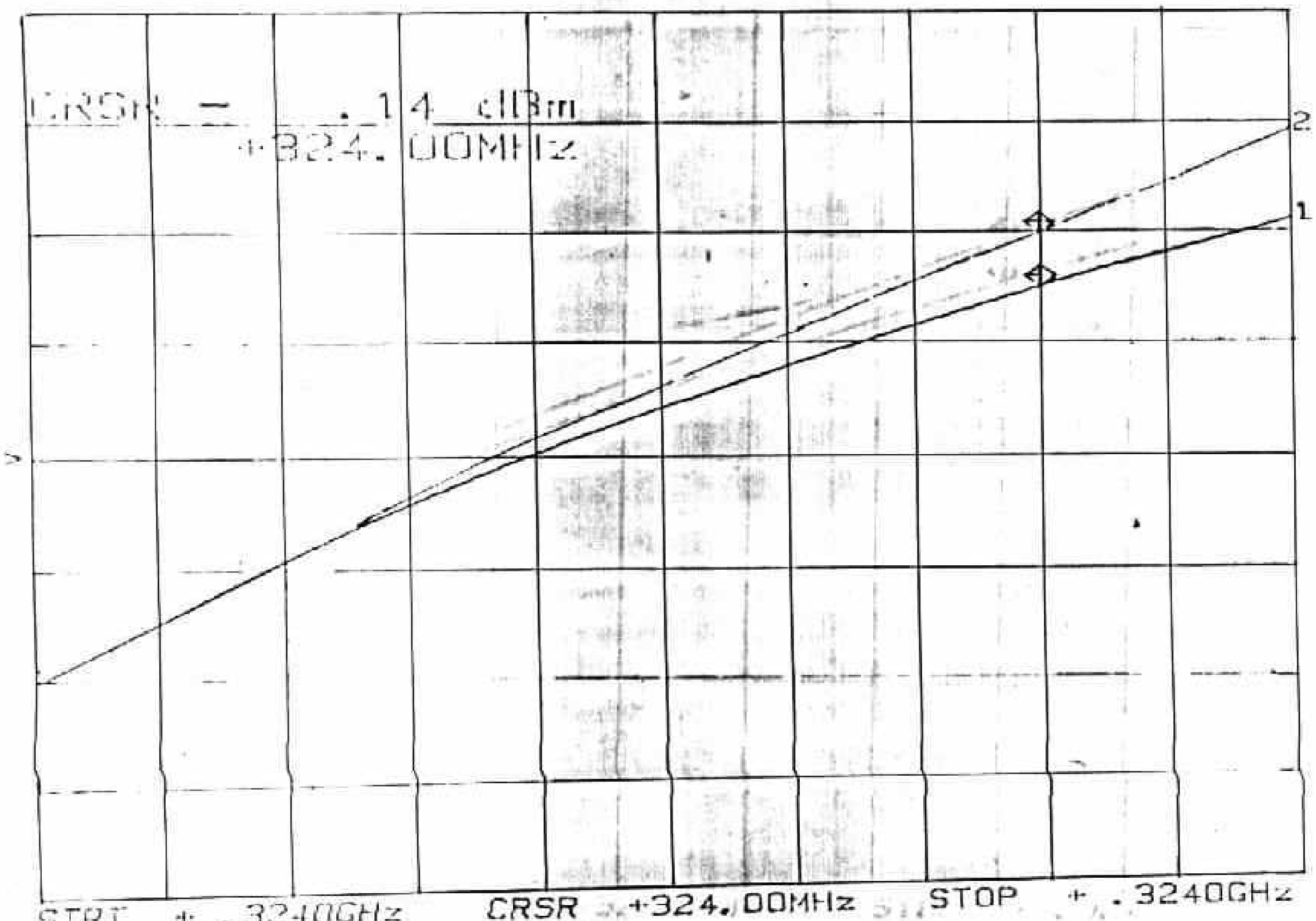
MODEL: EM
TEST: FBT
[2] S_{21}: CH #1
PHASE
RESPONSE

3, Jan 1996



MODEL : EM
TEST : FBT
[2] S_{21} : CH #2
PHASE
RESPONSE

CH1: A - .14 dBm   CH2: B - 18.43 dBm
2.0 dB/ REF - 3.16 dBm   2.0 dB/ REF - 22.43 dBm



MODEL : FM

TEST : FBT

[1] I/O CURVE OF CH #1 LNA

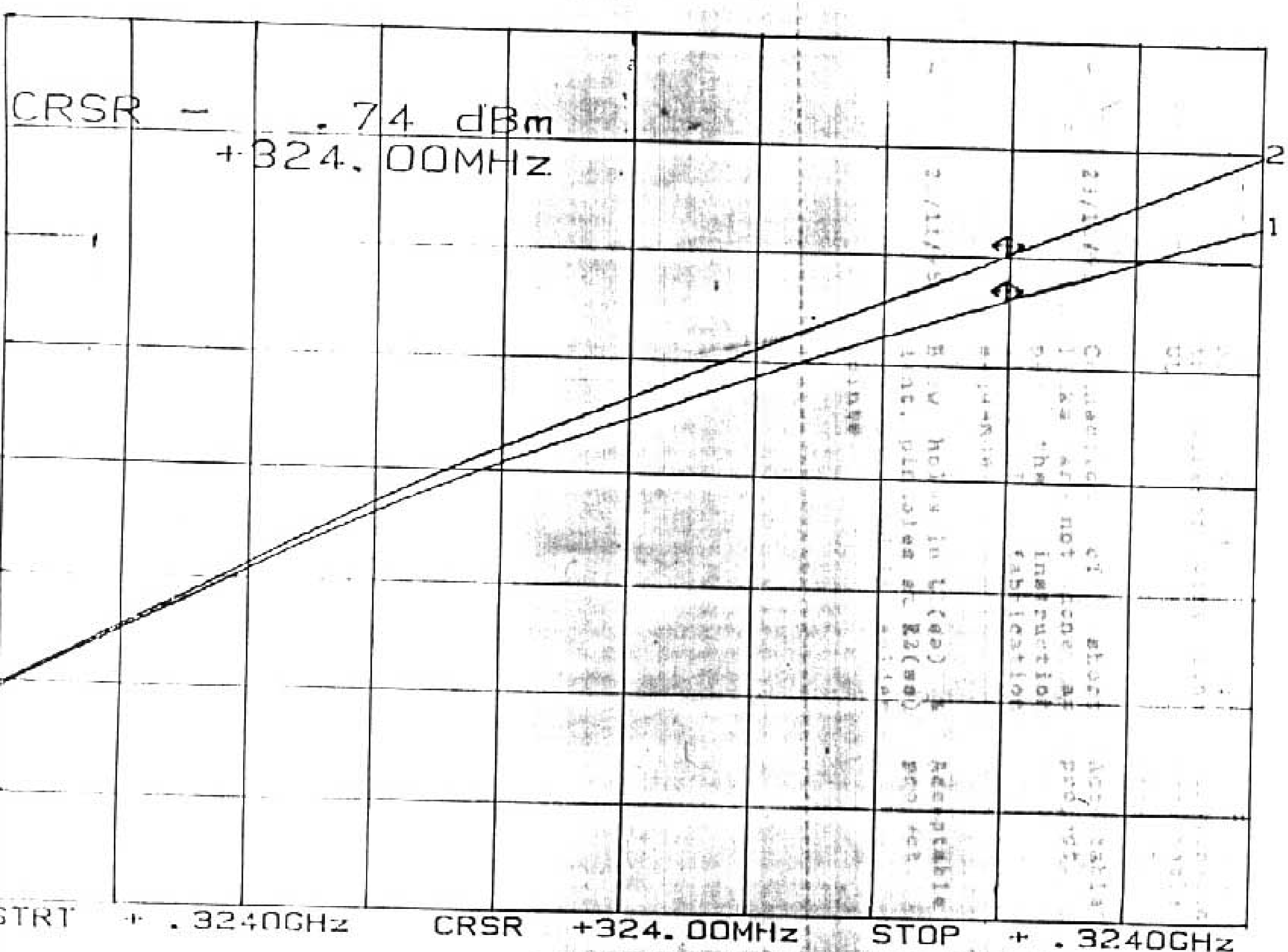
[2] HP8757- DETECTOR RESPONSE

P_{1dB} @ O/P = -0.14 dBm

CH1: A SA − .74 dBm
2.0 dB/ REF − 3.95 dBm

CH2: B SA − 18.42 dBm
2.0 dB/ REF − 22.47 dBm

15:24:21 04 JAN 96



MODEL : EM

TEST : FBT

[1] I/o CURVE OF LNA − CH #2

[2] HP8757 DETECTOR RESPONSE.

P_{1dB} @ o/p = −0.74

APPENDIX - III

LIST OF WAIVERS GIVEN TO QA(E)
FOR RADIOASTRON PROJECT

SUBSYSTEM : 324 MHz FRONT END LNA & POWER SUPPLY
MODEL : ETM
DRAWING NO. : G10/523 & G10/462

NO.	WAIVER NO	DATE OF WAIVER	QA COMMENTS	JUSTIFICATION FROM PROJECT
1.	-	23/11/95	Stress relief bend is not provided to one of the wire of wire line WL1.	The current configuration WL1 wireline i acceptable to project.
2.	-	23/11/95	Connection of short links are not done as per the instruction given in fabrication sequence.	Acceptable to project.
3.	-	23/11/95	Blow holes in L1(ss) & dent, pinholes at R2(ss) are observed in solder joints.	Acceptabl[illegible] project.

TO : CHAIRMAN T & E COMITTE
RADIOASTRON PROJECT

SAPCE APPLICATIONS CENTRE
RELIABILITY AND QUALITY ASSURANCE

SAMD/QAED CERTIFICATE

PROJECT : RADIOASTRON

DATE : 18/12/95.

MODEL : ETM

CER. No: QA/95/01

SUBSYSTEM / SUBASSEMBLY : 324 MHz FRONT END LNA AND POWER SUPPLY.

DRAWING No. : (1) G10/523 (2) G10/462

THE ABOVE UNITS ARE CLEARED FOR TEST AND EVALUATION SUBJECT TO THE WAVIERS GIVEN BY PROJECT.

(K. B. VYAS)
Engr. SAMD

(V. L. JOSHI)
ENGR./QAED

TO : CHAIRMAN T & E COMITTE
RADIOASTRON PROJECT
SAC.

Appendix - V

LIST OF TEST EQUIPMENTS

1.	Scalar Network analyser	HP 8757
2.	Vector network analyser	HP 8510
3.	Spectrum Analyser	HP 8562
4.	Synthesized RF sweeper	HP 8341
5.	Plotter	HP 7475
6.	Directional coupler	HP 11692
7.	Noise figure meter	HP 8970
8.	Noise Source (5dB ENR)	HP 346A
9.	EATON Hot & Cold Noise Source	

SAC-R&QA-RES-TR-10-96

TEST & EVALUATION REPORT
ON
327 MHz FRONT END LNA (FM1 & FM2)
OF
RADIOASTRON PROJECT

FEBRUARY, 1996

APPROVED BY : T&E COMMITTEE

SUBMITTED TO : DIRECTOR, SAC

RELIABILITY AND QUALITY ASSURANCE
SPACE APPLICATIONS CENTRE
GOVERNMENT OF INDIA
AHMEDABAD-380 053.

SPACE APPLICATIONS CENTRE
AHMEDABAD

DOCUMENT CONTROL & DATA SHEET

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7.	ORIGINATING UNIT	: RES/R & QA
8.	CORPORATE AUTHOR(S)	: -
9.	ABSTRACT	: THIS REPORT DESCRIBES THE ACCEPTANCE LEVEL TESTING AND EVALUATION CARRIED OUT ON 327 MHz FRONT END LNA (FM1 & FM2) OF RADIOASTRON PROJECT.
10.	KEY WORDS	: T&E, ACCEPTANCE LEVEL TESTING, FM1, FM2, 327 MHz LNA, RADIOASTRON
11.	SECURITY CLASSIFICATION	: FOR ISRO AND TIFR,PUNE USE ONLY.
12.	DISTRIBUTION	: WITHIN ISRO AND TIFR,PUNE

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T & E committee gratefully acknowledges the contributions from the following.

* SAC Fabrication team
* Payload Fabrication Facility
* TIFR Designers team, Pune
* Electronics test facility
* Climatic and Mechanical test facility
* Quality Assurance (Mechanical) Division
* Quality Assurance (Electronics) Division
* Quality Control (Group)

CONTENTS

APPENDICES

1.0 INTRODUCTION

RadioAstron is a space radio-telescope having receivers at 1.35 cm, 6 cm, 18 cm, and 92 cm wavelengths to be launched by Russia. Indian participation in the mission is with regard to the development and delivery of onboard 327 MHz Frontend LNA (Low Noise amplifier) for 92 cm receiver. The other portion of the receiver will be supplied by other global participants in RADIOASTRON mission. The 327 MHz LNA will be housed in focal container which is heremetically sealed with inert gas at ambient pressure.

While the design has been finalised by TIFR group at Pune, the fabrication, testing and space qualification have been carried out at SAC, Ahmedabad.

This report describes the acceptance level Test & Evaluation carried out on the 327 MHz front-end LNAs (FM01 and FM02) for Radioastron project, performance observed during testing, evaluation of the test results and conclusion derived.

Test & Evaluation was carried out by the T&E committee constituted by Director, SAC (ref. Appendix-I). A report on test results and deviations submitted by Electronics test facility (ETF) is attached in Appendix-II. Relevent notes and waivers given for this unit are provided in Appendix-III. QA/QC certificates are provided in Appendix-IV. List of test equipments used during T&E is given in Appendix-V.

2.0 BRIEF DESCRIPTION OF UNIT

The 327 MHz low noise front-end consists of a LNA and a Voltage regulator (power supply). This is a dual channel LNA with RF inputs for CH#1 and CH#2, and a third input for calibration noise injection. The calibration noise is injected into each channel through a resistive power divider and a directional coupler. The operating frequency range is from 321MHz to 328 MHz. The DC supply to the LNAs comes through +5V regulators which gets +12V inputs from the spacecraft supply.

3.0 GENERAL COMMENTS

3.1 All the electrical parameters were measured as per the test document which was finalized by the T&E committee.

3.2 It was ensured that electronic test equipments and environmental chambers were in calibrated conditions prior to starting the test.

3.3 T & E for the subsystem has been started after receiving the necessary clearances from QA/QC (Electronics and Mechanical)

3.4 The environmental tests were carried out as per the Test plan which has been prepared by TIFR in consultation with Astro Space Centre, Moscow and R&QA, SAC.

3.5 During the environmental tests, only the Gain, Isolation and Noise Temperature parameters were measured.

3.6 All the measurements were carried out with SMA connector savers.

3.7 Measurements during the initial and final bench tests were taken using HP 8510 vector network analyzer. However, during the other tests, HP 8757 scalar network analyzer and HP 8562 spectrum analyzer were used.

Noise temperature was measured using 5 dB ENR Noise source and HP 8970 Noise Figure meter. Noise temperature was also verified using EATON Hot & Cold Noise source.

4.0 TESTS CONDUCTED

Following tests were conducted on the unit as per the test document which was finalised by the T&E committee.

a) Initial bench test : A/c Lab.

b) Sine vibration : 25 Hz, 2g, 10min. in all the three axes

c) Thermal cycling : 4 cycles of cold (5 deg.C, 2Hrs) and Hot (35 deg.C, 2Hrs) followed by one cycle of cold (5 deg.C, 4hrs) and Hot (35 deg.C, 4Hrs).

d) Final bench test : A/c lab.

PARAMETERS MEASURED

* 1. Gain at 324 MHz (centre freqency)

* 2. Isolation from channel 1 to 2 and 2 to 1.

* 3. Noise temperature.

4. Input return loss

5. Output return loss

6. Noise port coupling at 324 MHz.

7. Noise port return loss

* Parameters measured during environmental tests

Note: a. These parameters were measured for both CH#1 & CH#2.

6.0 PERFORMANCE

All the specified parameters were measured and found to be within specifications during the tests conducted except the following worst case deviations.

6.1 DEVIATION

During FBT, Noise port coupling was observed to be 26.26 dB and 26.04 dB for FMO1 and FM02 respectively for CH#2 against the specifications of 26.5 dB min.

ANALYSIS AND ACTION TAKEN

This deviation was considered as minor.

6.2 Gain Slope was measured as an additional parameter in FBT and observed as under :

FM01 unit :- CH#1 : 0.15 dB/MHz and CH#2 : 0.15 dB/MHz

FM02 unit :- CH#1 : 0.16 dB/MHz and CH#2 : 0.14 dB/MHz

7.0 CONCLUSION

Based on the performance given in the above paragraph, this unit is cleared for further integration.

APPENDIX - I

SPACE APPLICATIONS CENTRE
AHMEDABAD

Ref: DIR/7.23(A)/91 June 19, 1991

MEMORANDUM

SAC has undertaken the responsibility of fabrication and space qualification of Radioastron Front-end for TIFR, Pune. The Electrical Thermal Model (ETM) of Front-end is fabricated. Test & Evaluation of this has to be carried out as per the T&E plan (SAC/R&QA/FP/20/91) generated by R&QA Division, SAC. The following team has been constituted to carry out this task.

1.	Shri S.K.Jain	(R&QA)	Chairman
2.	Shri A.L.Vadodariya	(CMTF)	Member
3.	Shri N.V.Shah	(ETF)	Member
4.	Shri R.B.Bavaria	(PRPD)	Member
5.	Shri V.K.Jain	(PRPD)	Member
6.	Shri V.H.Bora	(MSDG)	Member
7.	Shri S.M.Srivastava	(ESGHG)	Member
8.	Shri Surender Singh	(PRPD)	Co-ordinator

Dr.H.O.Gautam, Team Leader, SAC-TIFR Radioastron Project will provide electrical performance specification & test results of the Front-end to the T&E Committee.

The Committee shall submit the T&E report to the undersigned.

(Pramod Kale)
Director

To : All Committee Members

cc : Project Team
Steering Committee

SPACE APPLICATIONS CENTRE
RELIABILITY AND QUALITY ASSURANCE
AHMEDABAD

TE/110/95 Date 11-12-95

Following engineers are co-opted as members of the T & E committee for 324MHz FRONT END LNA for RADIOASTRON project.
(Ref. Dir/7.23(A)/91 dt. June 19, 1991)

1. Shri Abhay Khetrapal RES/R&QA

2. Shri Anil Shah, ETF/EnTF

(S. K. JAIN)
Chairman T&E committee,
324MHz FRONT END LNA for RADIOASTRON project.

To: Shri Abhay Khetrapal,
Shri Anil Shah.

cc: Head RES/R&QA/PRPD
Manager ETF/EnTF
Gr.Dir., SPG
Director, SAC.

APPENDIX – II

REPORT OF TEST RESULTS & DEVIATIONS ON 327 MHz FRONT END LNA FOR RADIOASTRON (FM)

TESTING TEAM

A.K.SHAH	ETF
S.N.LAKHIA	
SRINIVAS M.	PROJECT

PREPARED BY : A.K.SHAH | ETF

REVIEWED BY : ------------

(H.S.RAINA)
MANAGER ETF

ELECTRONIC TEST FACILITY
EnTF/TSSG
SPACE APPLICATIONS CENTRE
AHMEDABAD 380 053

This report describes the test results of the 327 MHz FRONT END LNA for RADIOASTRON project (FM). A comparative chart of the test results of important tests has been prepared and is attached in table -I. Results of other tests are available with ETF.

.0 Test comments :

.1 All tests were conducted as per test Document finalized by T&E committee.

.2 Limited parameters were measured during environmental test as decided by T&E committee.

.3 IBT & FBT were conducted on HP 8510 Vector Network Analyzer and other tests were conducted using HP8757 Scalar Network Analyzer.

.4 All the measurements were carried out with SMA connector saver.

.5 Noise temp was measured using 5 dB ENR Noise Source & HP 8970 Noise figure meter. ±7 °K is the accuracy of Noise figure meter in Noise temp. measurement. Noise temp. measurement was taken with type N-SMA adapter at the LNA input. Noise temp was verified using EATON Hot & Cold Noise Source.

6 ±0.2 dB is the accuracy of HP 8757 Scalar Network Analyzer in relative measurement.

7 ±1.0 dB is the accuracy of HP 8562 Spectrum Analyzer in Absolute measurement.

8 ±0.02 dB is the accuracy of HP 8510 Vector Network Analyzer in relative measurement.

0 Deviations:

1 Following worst case Deviations were observed.

MODEL	TEST	CH#	PARAMETER	MEAS.VALUE	SPEC.
FM-1	FBT	2	NOISE PORT COUPLING	26.26 dB	26.50 dB (min)
FM-2	FBT	2	NOISE PORT COUPLING	26.04 dB	26.50 dB (min)

ROJECT : RADIOASTRON
ODEL : IM-1
NIT : 327 MHz FRONT END LNA

R. O	PARAMETERS	SPECIFI-CATIONS	INITIAL BENCH TEST	POST VIB & PRE THERMAL	COLD THERMAL (5 °C)	HOT THERMAL (35°C)	POST THERMAL	FINAL BENCH TEST
	DATE		16.01.96	19.01.96	20.01.96	20.01.96	22.01.96	22.01.96
1	GAIN (IN dB) AT 324 MHz CH # 1 CH # 2	37±3	38.13 37.59	37.54 36.55	37.80 36.94	37.40 36.43	37.54 36.55	38.12 37.60
2	ISOLATION (IN dB) AT 324 MHz CH #1 wrt. CH # 2 CH #2 wrt. CH # 1	50.00 (min)	60.95 67.20	62.66 68.66	62.33 69.17	62.17 67.16	63.00 70.00	69.90 69.14
3	NOISE TEMP. (IN °K) AT 324 MHz CH # 1 CH # 2	25±5	26.8 26.1	26.2 29.2	21.4 26.1	26.4 27.5	27.0 29.1	27.6 26.5
4	I/P R/L (IN dB) CH # 1 CH # 2	12.74 (min)	17.81 23.34	- -	- -	- -	- -	17.83 23.35
5	O/P R/L (IN dB) CH # 1 CH # 2	19.08 (min)	21.10 20.81	- -	- -	- -	- -	21.85 21.81
6	NOISE PORT COUPLIN G(IN dB)AT 324 MHz CH # 1 CH # 2	28±1.5	27.26 26.31*	- -	- -	- -	- -	27.39 26.26*
7	NOISE PORT R/L (IN dB)	15.56 (min)	18.04	-	-	-	- -	18.20 18.40

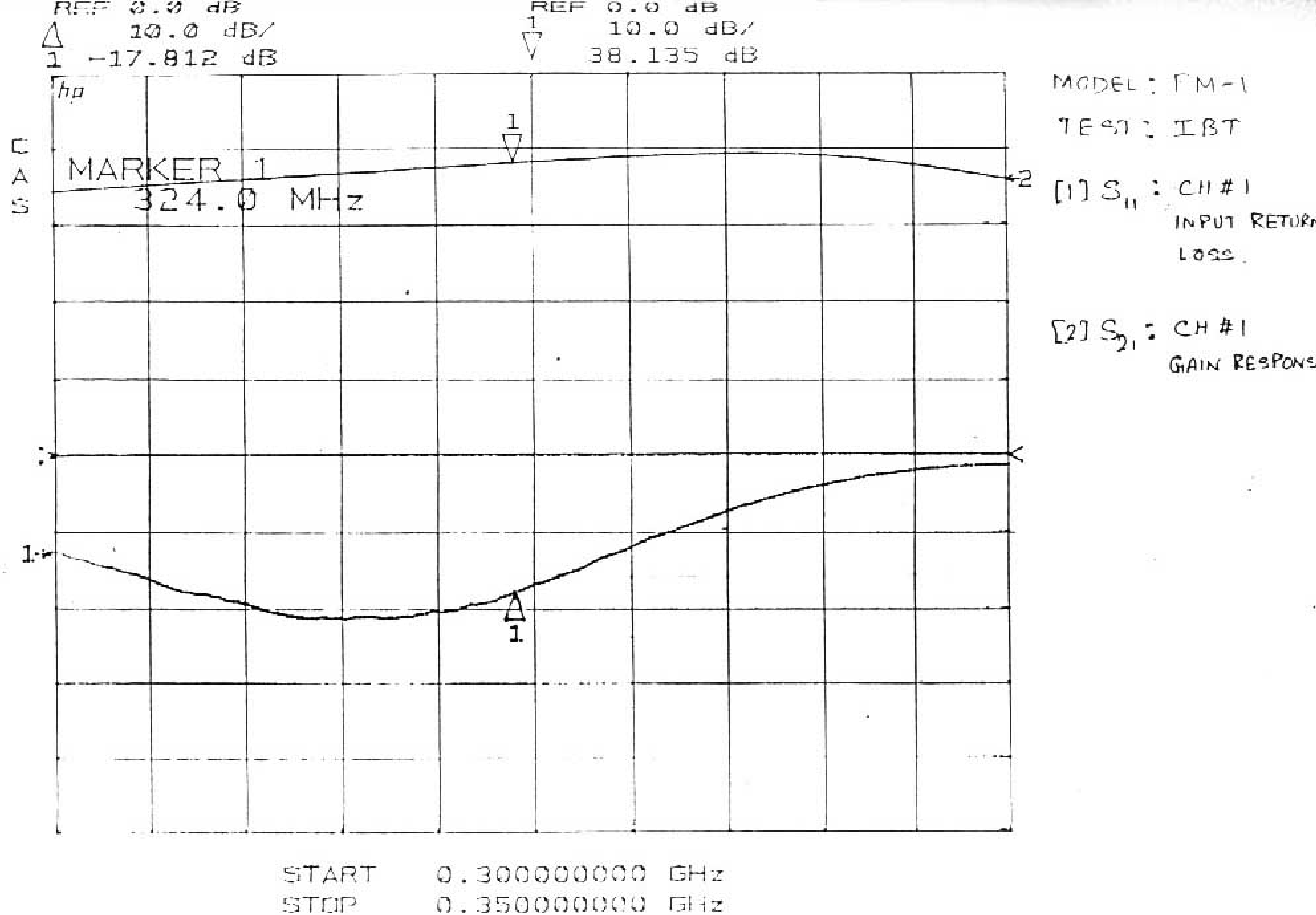
* indicates out of specification value

PROJECT : RADIOASTRON
MODEL : FM-2
UNIT : 327 MHz FRONT END LNA

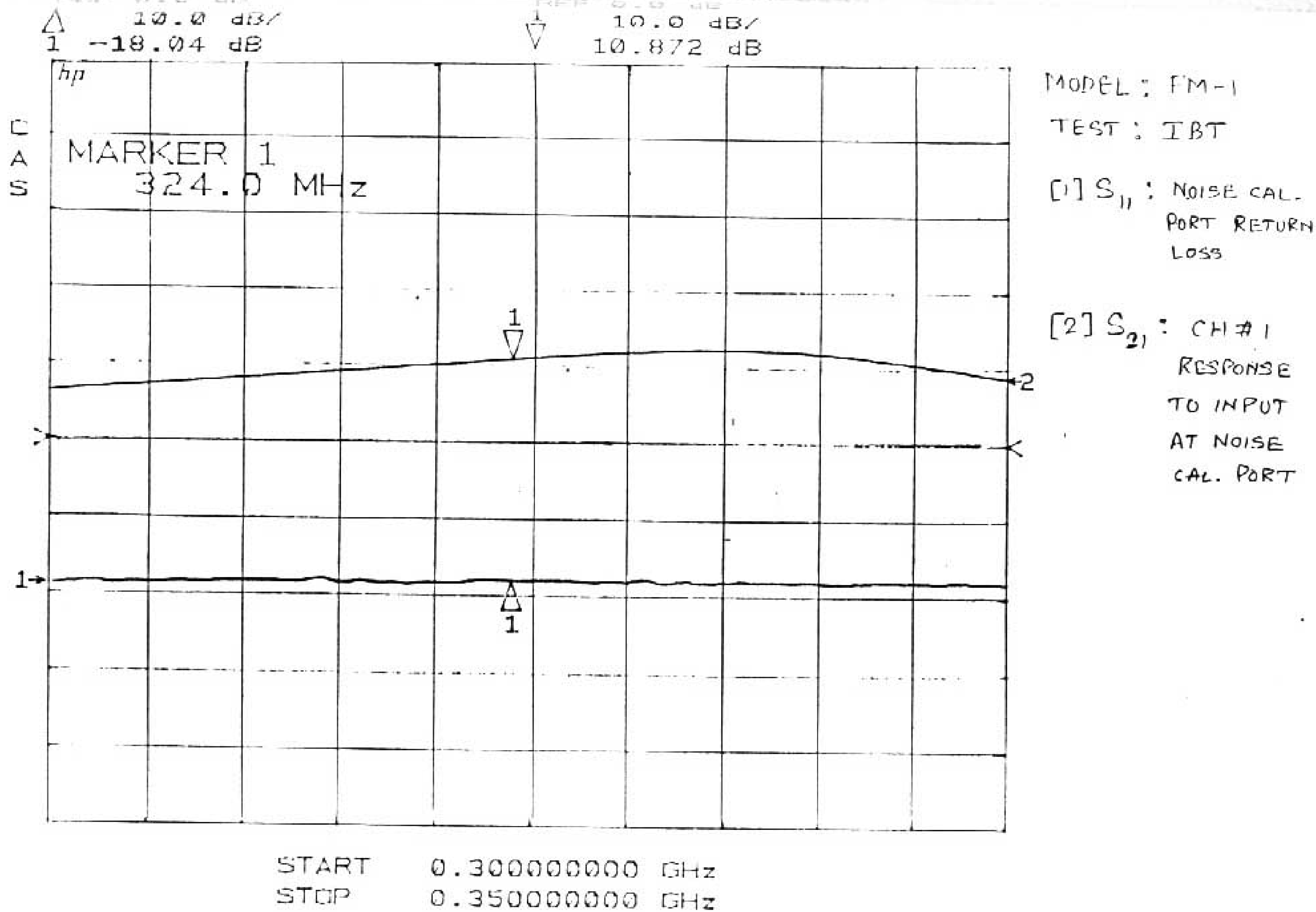
TABLE-I
SUMMARY OF TEST RESULTS

PREPARED BY : A.K.SHAH
ETF/EnTF/TSSG

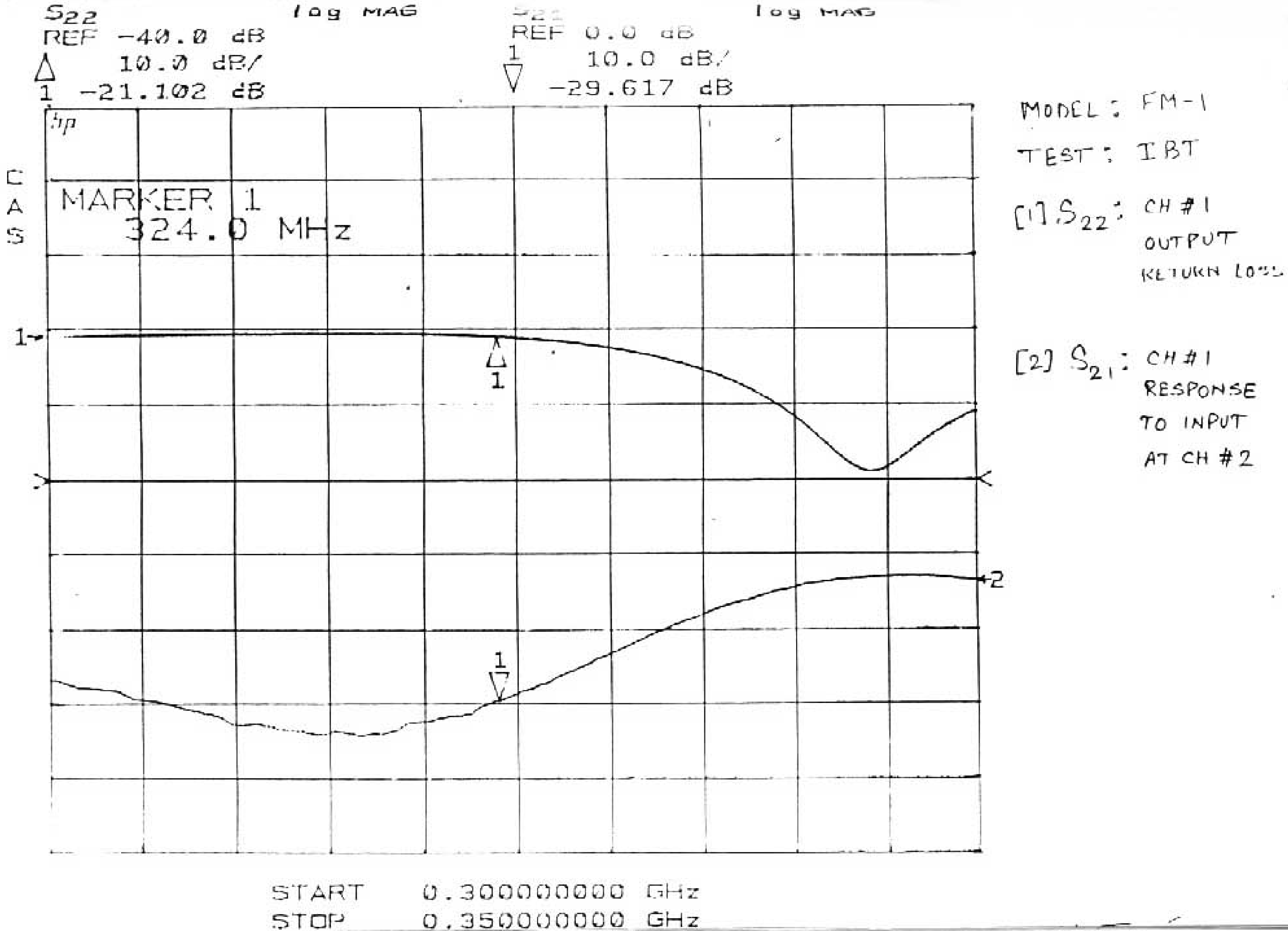
SR. NO	PARAMETERS	SPECIFICATIONS	INITIAL BENCH TEST	POST VIB & PRE THERMAL	COLD THERMAL (5 °C)	HOT THERMAL (35°C)	POST THERMAL	FINAL BENCH TEST
	DATE		16.01.96	19.01.96	20.01.96	20.01.96	22.01.96	22.01.96
1	GAIN (IN dB) AT 324 MHz	37±3						
	CH # 1		37.60	37.31	37.61	37.16	37.24	37.67
	CH # 2		36.55	36.21	36.62	36.28	36.39	36.60
2	ISOLATION (IN dB) AT 324 MHz	50.00 (min)						
	CH #1 wrt. CH # 2		65.17	61.00	64.66	64.33	63.33	65.08
	CH #2 wrt. CH # 1		65.54	76.50	76.88	76.17	75.50	71.34
3	NOISE TEMP.(IN °K) AT 324 MHz	25±5						
	CH # 1		26.8	26.2	21.4	29.8	27.3	24.8
	CH # 2		27.2	25.8	23.2	28.7	27.5	25.6
4	I/P R/L (IN dB)	12.74 (min)						
	CH # 1		22.56	-	-	-	-	22.16
	CH # 2		15.89	-	-	-	-	16.39
5	O/P R/L (IN dB)	19.08 (min)						
	CH # 1		20.15	-	-	-	-	20.33
	CH # 2		21.28	-	-	-	-	21.03
6	NOISE PORT COUPLING (IN dB) AT 324 MHz	28±1.5						
	CH # 1		26.51	-	-	-	-	26.57
	CH # 2		26.05*	-	-	-	-	26.04*
7	NOISE PORT R/L (IN dB)	15.56 (min)	18.42	-	-	-	-	18.40



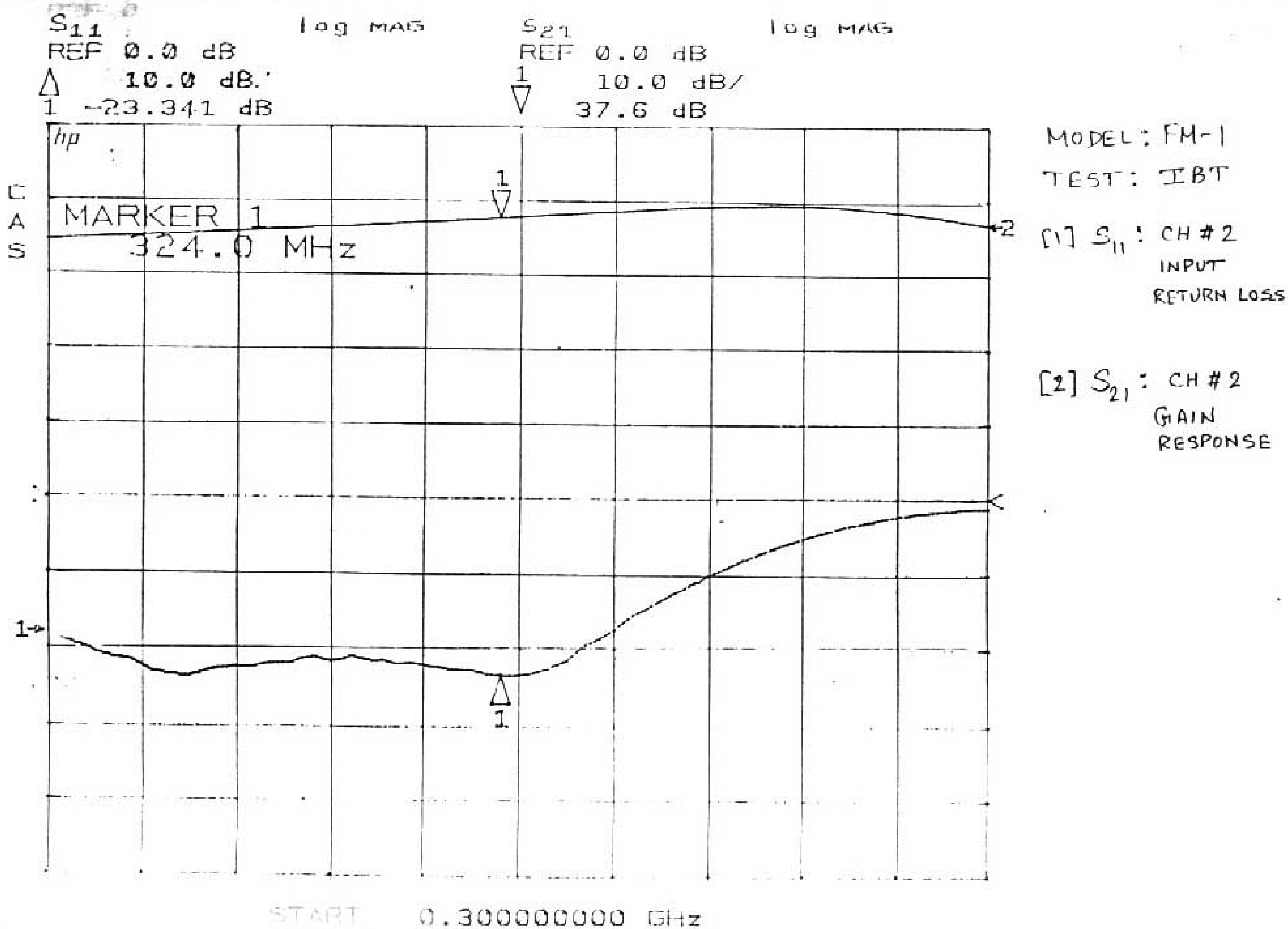
REF 0.0 dB
△ 10.0 dB/
1 -17.812 dB
REF 0.0 dB
1 ▽ 10.0 dB/
38.135 dB
hp
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : FM-1
TEST : IBT
[1] S11 : CH #1
INPUT RETURN
LOSS.
[2] S21 : CH #1
GAIN RESPONSE



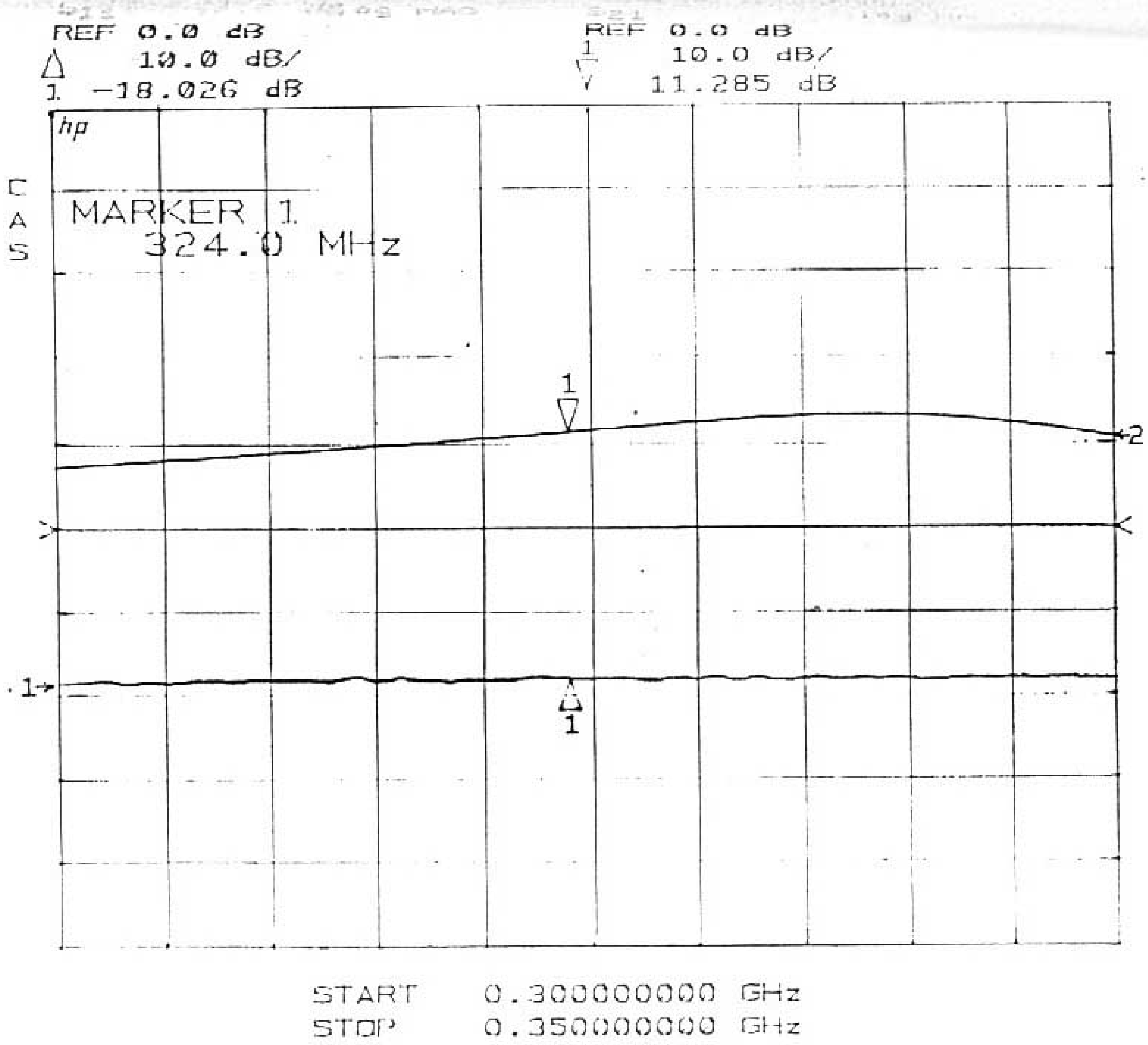
△ 10.0 dB/
1 −18.04 dB
▽ 10.0 dB/
10.872 dB
hp
C
A
S
MARKER 1
324.0 MHz
1
2
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : FM-1
TEST : IBT
[1] S11 : NOISE CAL. PORT RETURN LOSS
[2] S21 : CH #1 RESPONSE TO INPUT AT NOISE CAL. PORT



S22 log MAG
REF -40.0 dB
10.0 dB/
1 -21.102 dB
S21 log MAG
REF 0.0 dB
10.0 dB/
1 -29.617 dB
hp
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL: FM-1
TEST: IBT
[1] S22: CH #1 OUTPUT RETURN LOSS
[2] S21: CH #1 RESPONSE TO INPUT AT CH #2



S11 log MAG
REF 0.0 dB
10.0 dB/
1 -23.341 dB
S21 log MAG
REF 0.0 dB
10.0 dB/
37.6 dB
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
MODEL: FM-1
TEST: IBT
[1] S11: CH #2
INPUT
RETURN LOSS
[2] S21: CH #2
GAIN
RESPONSE



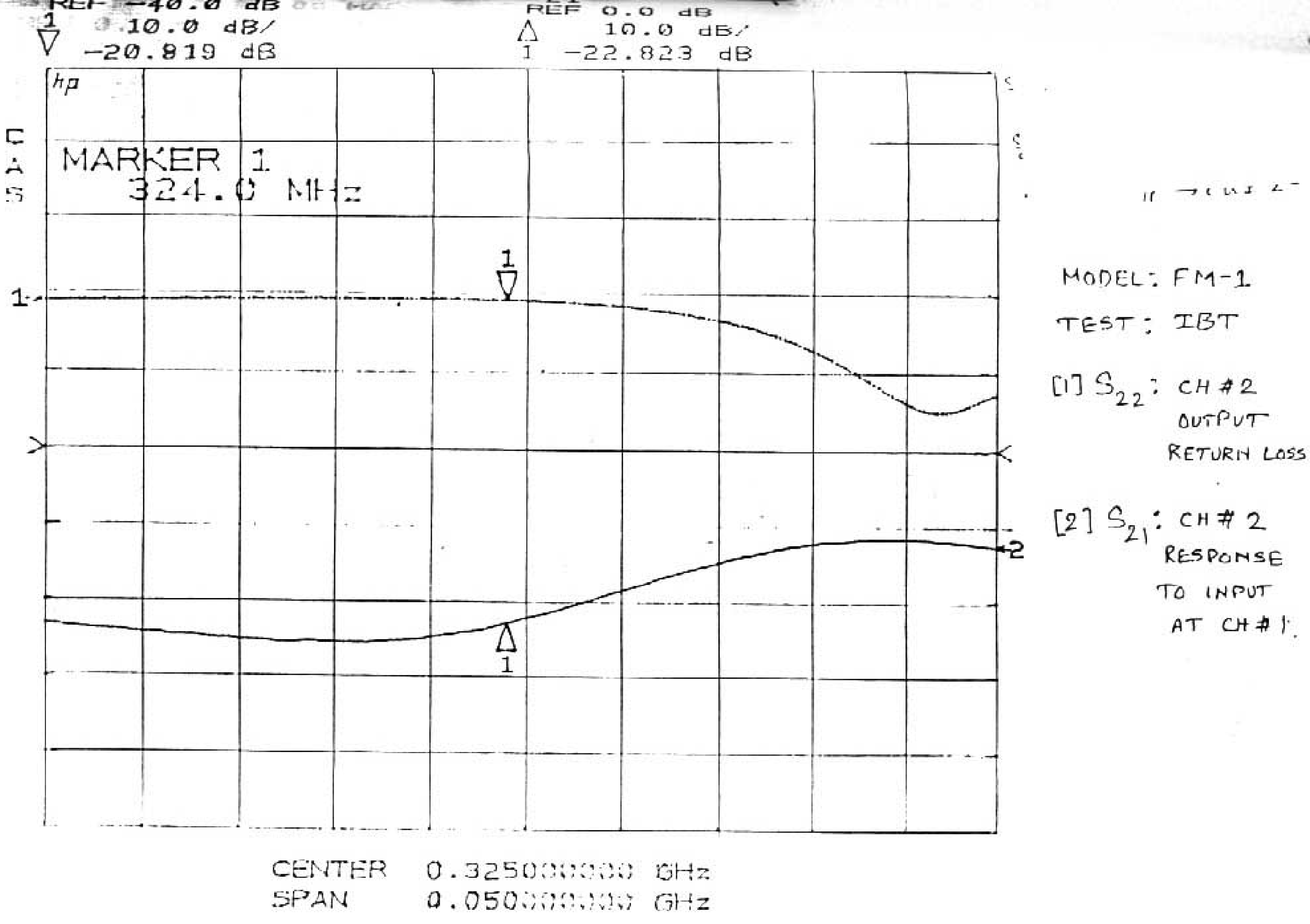
MODEL : FM-1

TEST : IBT

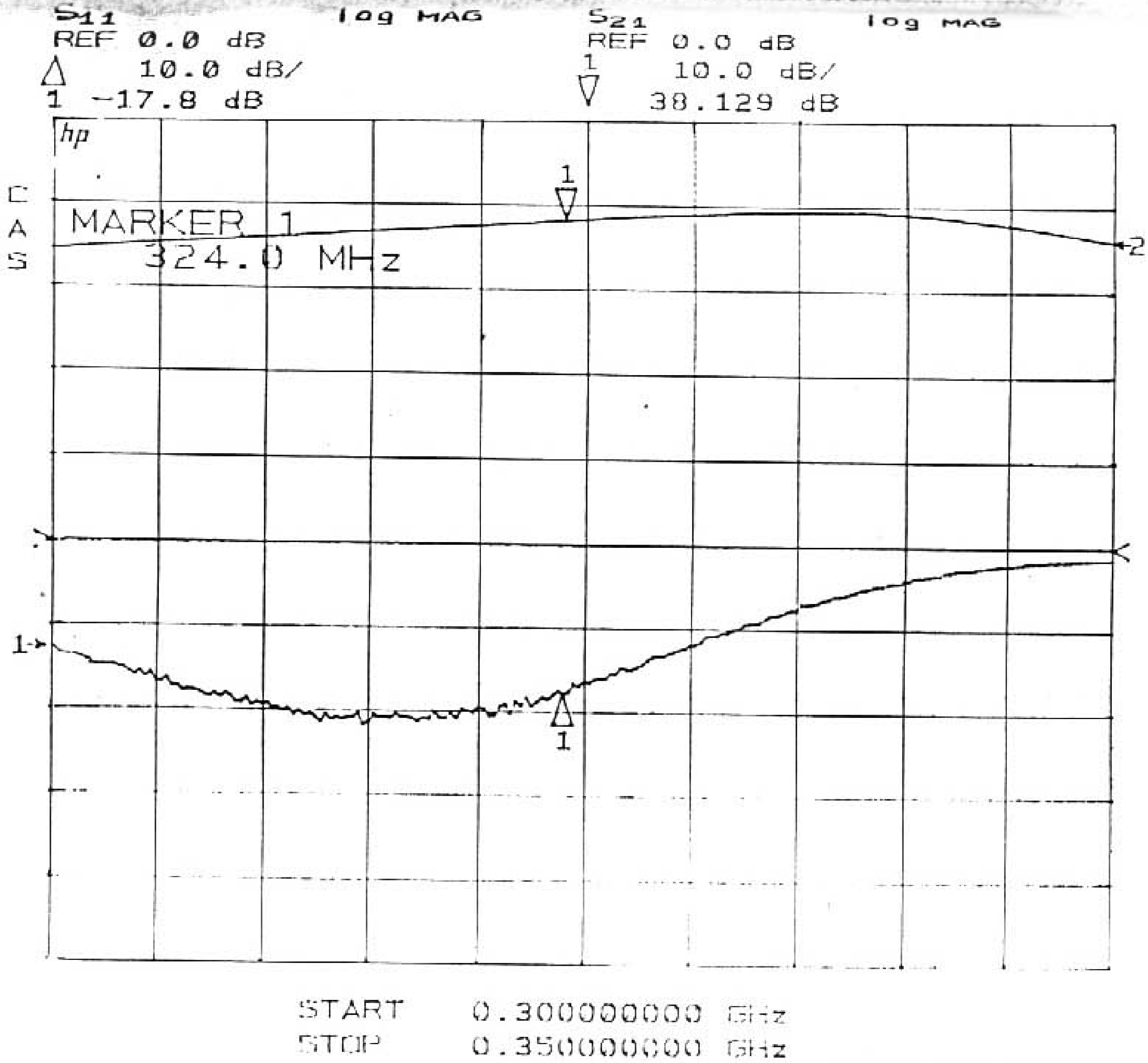
[1] S_{11} : NOISE CAL PORT RETURN LOSS

[2] S_{21} : CH #2 RESPONSE TO INPUT AT NOISE CAL PORT.

16, Jan '96



REF -40.0 dB
1 10.0 dB/
-20.819 dB
REF 0.0 dB
1 10.0 dB/
-22.823 dB
hp
MARKER 1
324.0 MHz
1
2
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz
MODEL: FM-1
TEST: IBT
[1] S22: CH #2
OUTPUT
RETURN LOSS
[2] S21: CH # 2
RESPONSE
TO INPUT
AT CH # 1.

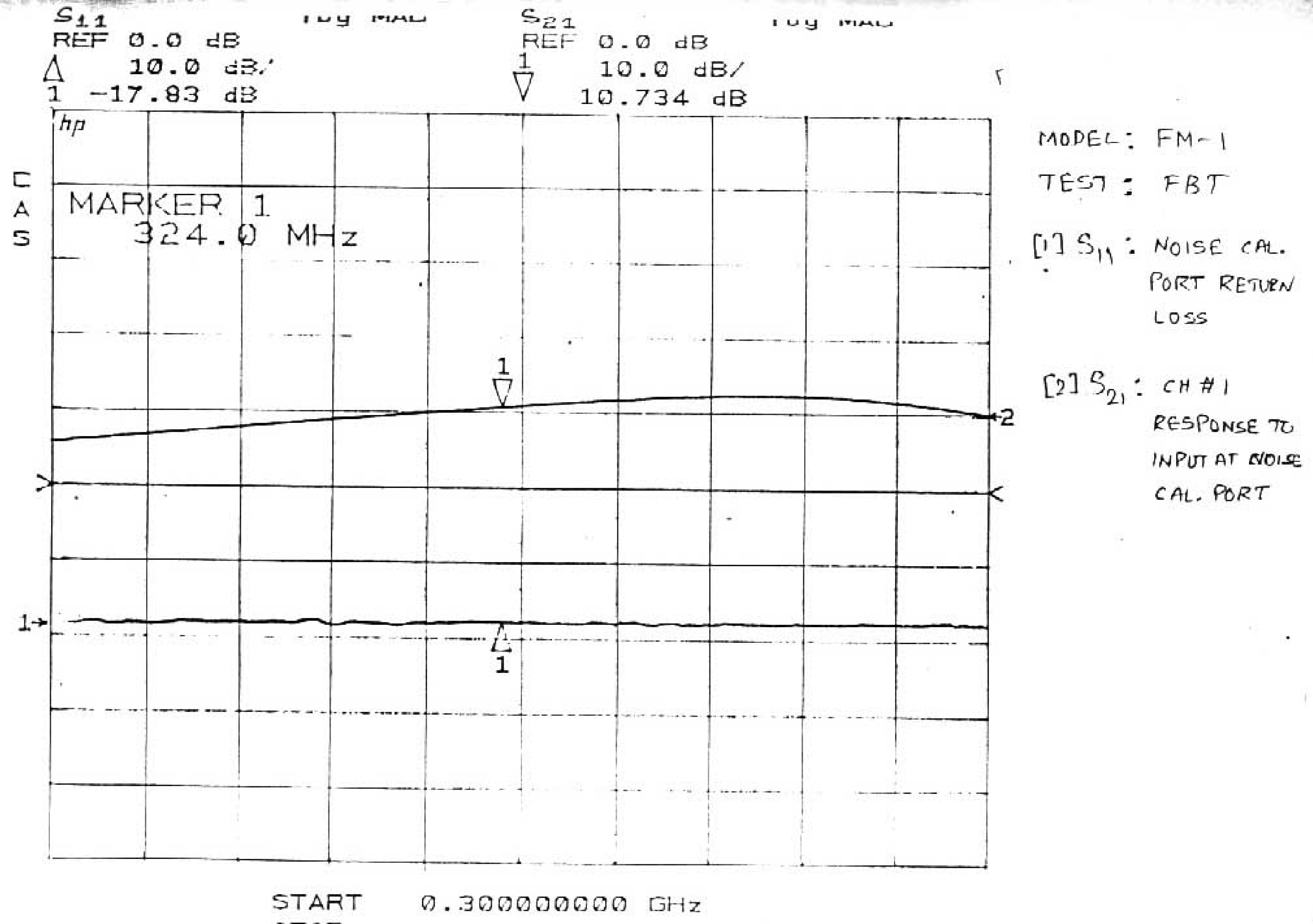


MODEL : FM-1

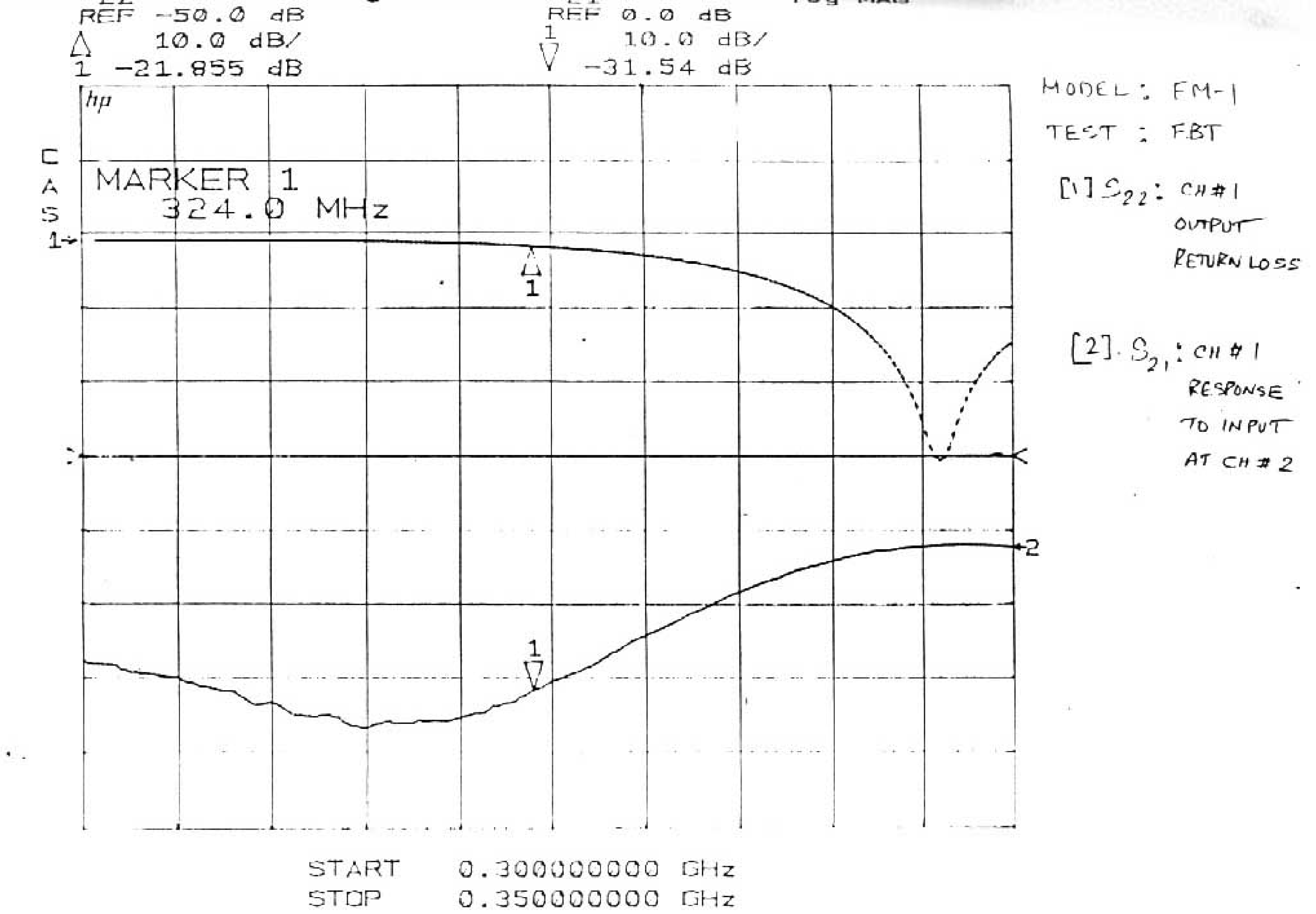
TEST : FBT

[1] S_{11} : CH #1 INPUT RETURN LOSS

[2] S_{21} : CH #1 GAIN RESPONSE

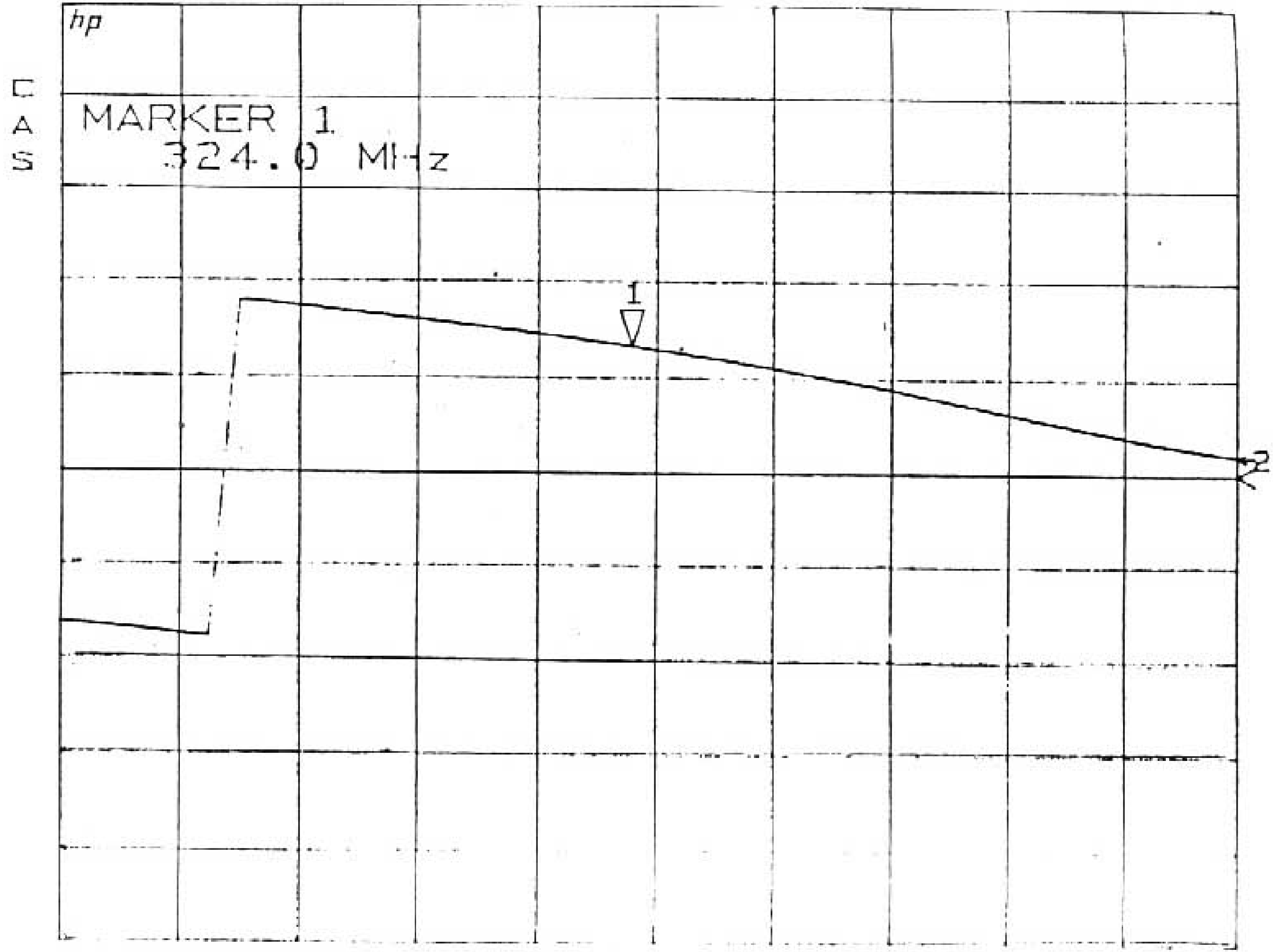


S11 log MAG
REF 0.0 dB
10.0 dB/
1 -17.83 dB
S21 log MAG
REF 0.0 dB
10.0 dB/
10.734 dB
hp
C A S
MARKER 1
324.0 MHz
START 0.300000000 GHz
MODEL: FM-1
TEST: FBT
[1] S11: NOISE CAL. PORT RETURN LOSS
[2] S21: CH #1 RESPONSE TO INPUT AT NOISE CAL. PORT



REF -50.0 dB
△ 10.0 dB/
1 -21.855 dB
REF 0.0 dB
▽ 10.0 dB/
-31.54 dB
hp
C
A
S
MARKER 1
324.0 MHz
MODEL : FM-1
TEST : FBT
[1] S22 : CH#1
OUTPUT
RETURN LOSS
[2]. S21 : CH#1
RESPONSE
TO INPUT
AT CH#2
START 0.300000000 GHz
STOP 0.350000000 GHz

REF 0.0 °
100.0 °/
132.22 °



MODEL : FM-1

TEST : FBT

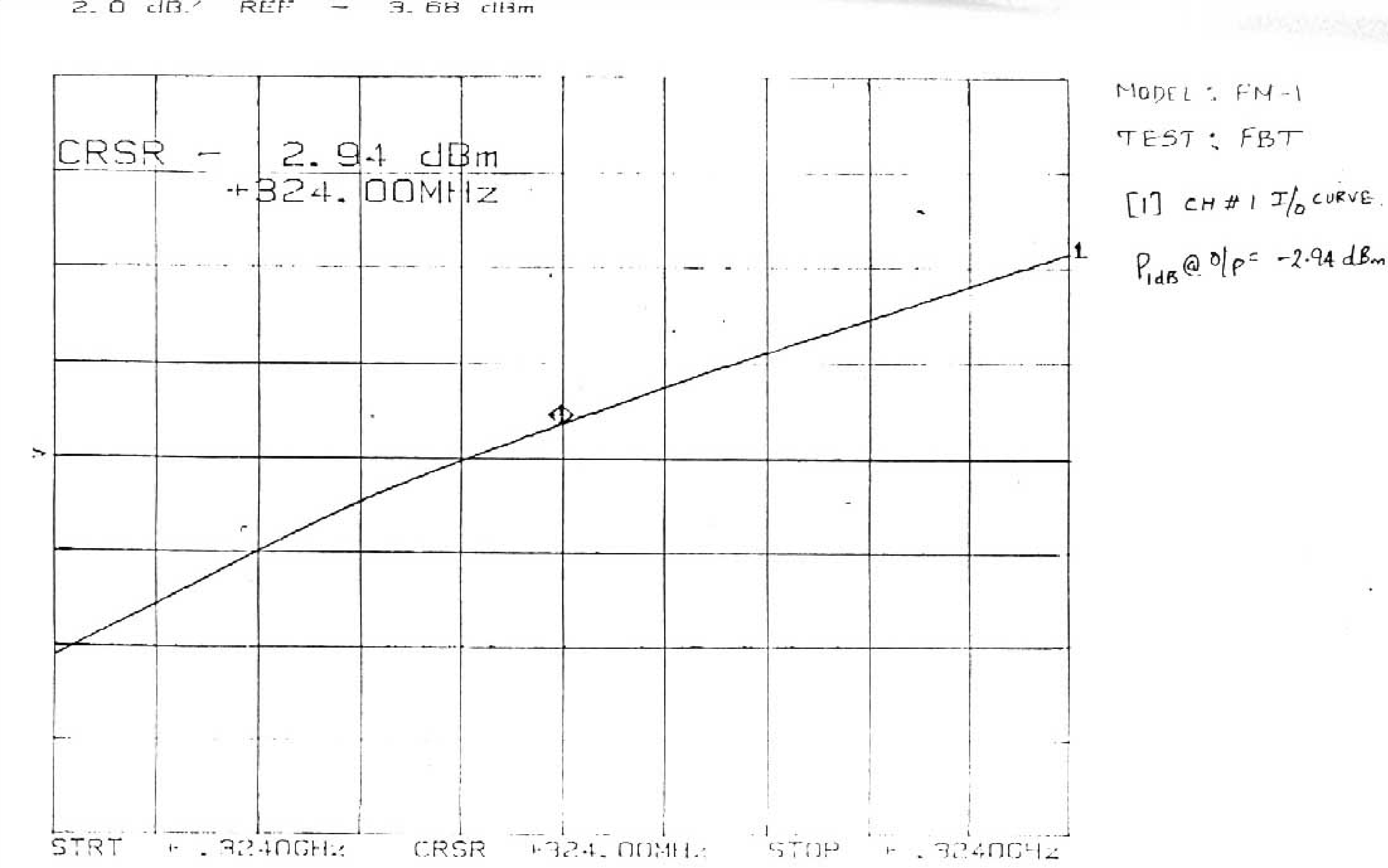
[2] S_{21} : CH #1

PHASE

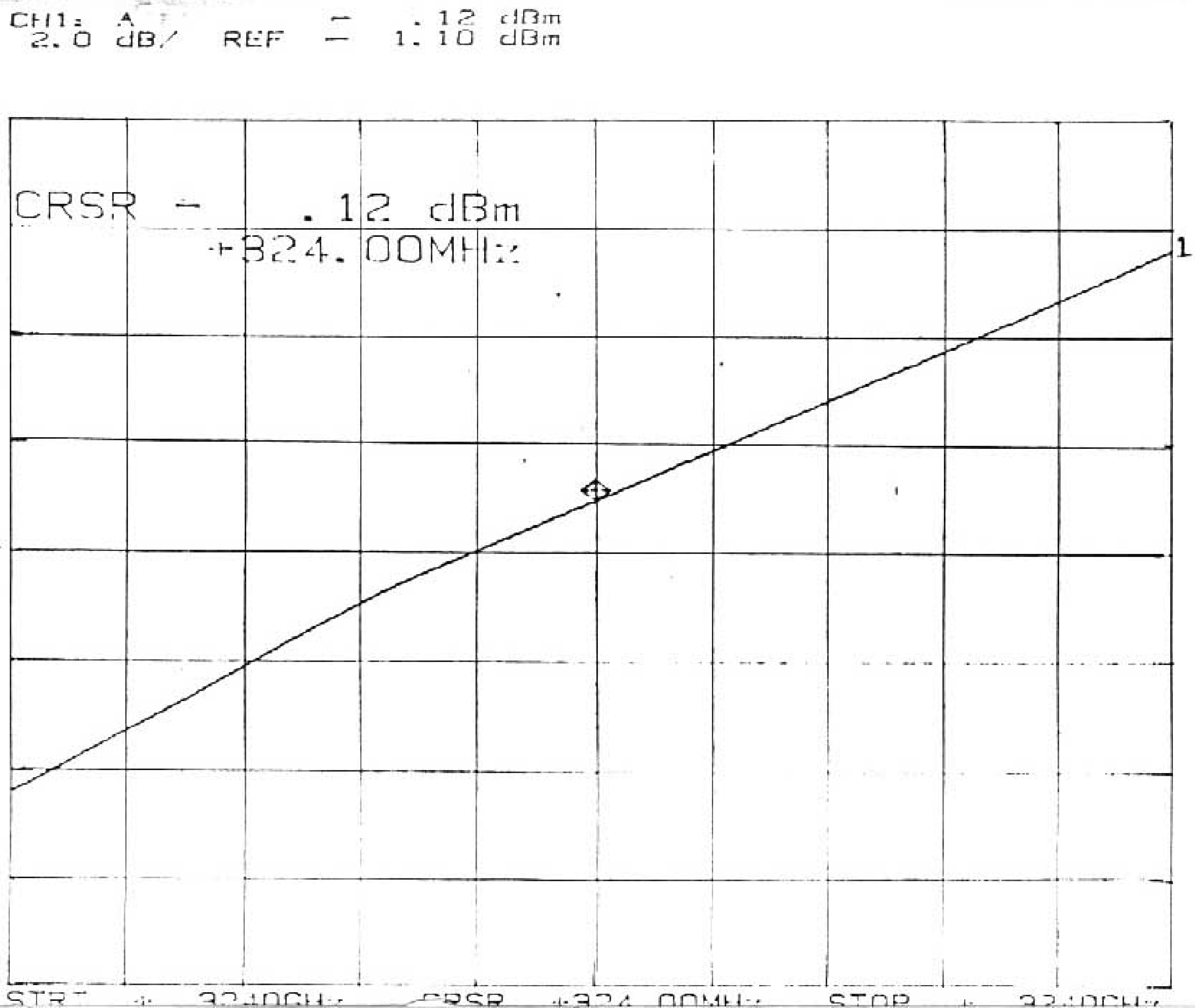
RESPONSE

START 0.300000000 GHz

STOP 0.350000000 GHz

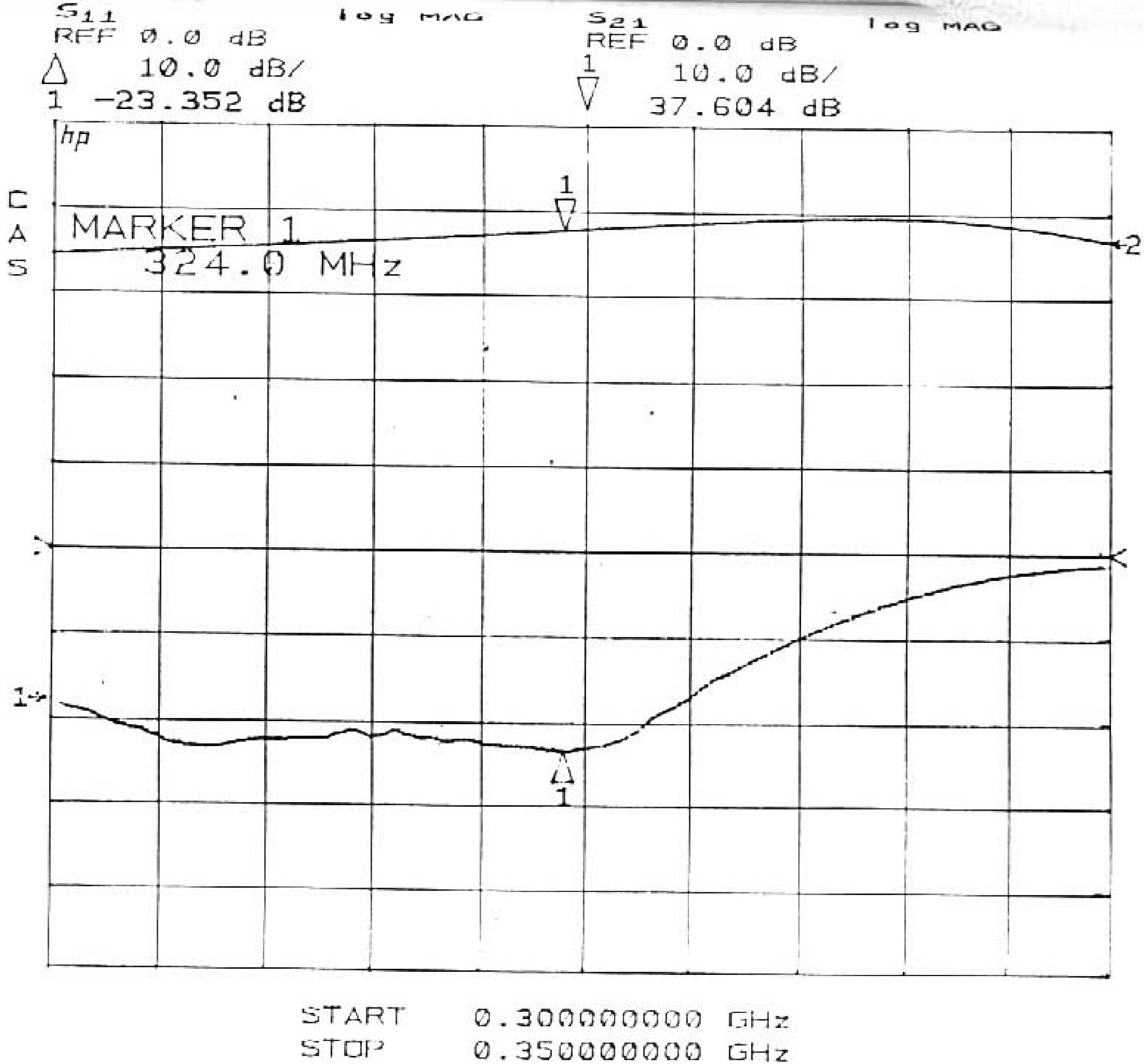


2.0 dB/ REF – 3.68 dBm
CRSR – 2.94 dBm
+324.00MHz
1
STRT +.3240GHz
CRSR +324.00MHz
STOP +.3240GHz
MODEL : FM-1
TEST : FBT
[1] CH #1 I/O CURVE
P_{1dB} @ O/P = -2.94 dBm



[1] DETECTOR RESPONSE
OF HP 8757 SNA

* TO BE USED WITH
THE EARLIER PLOT

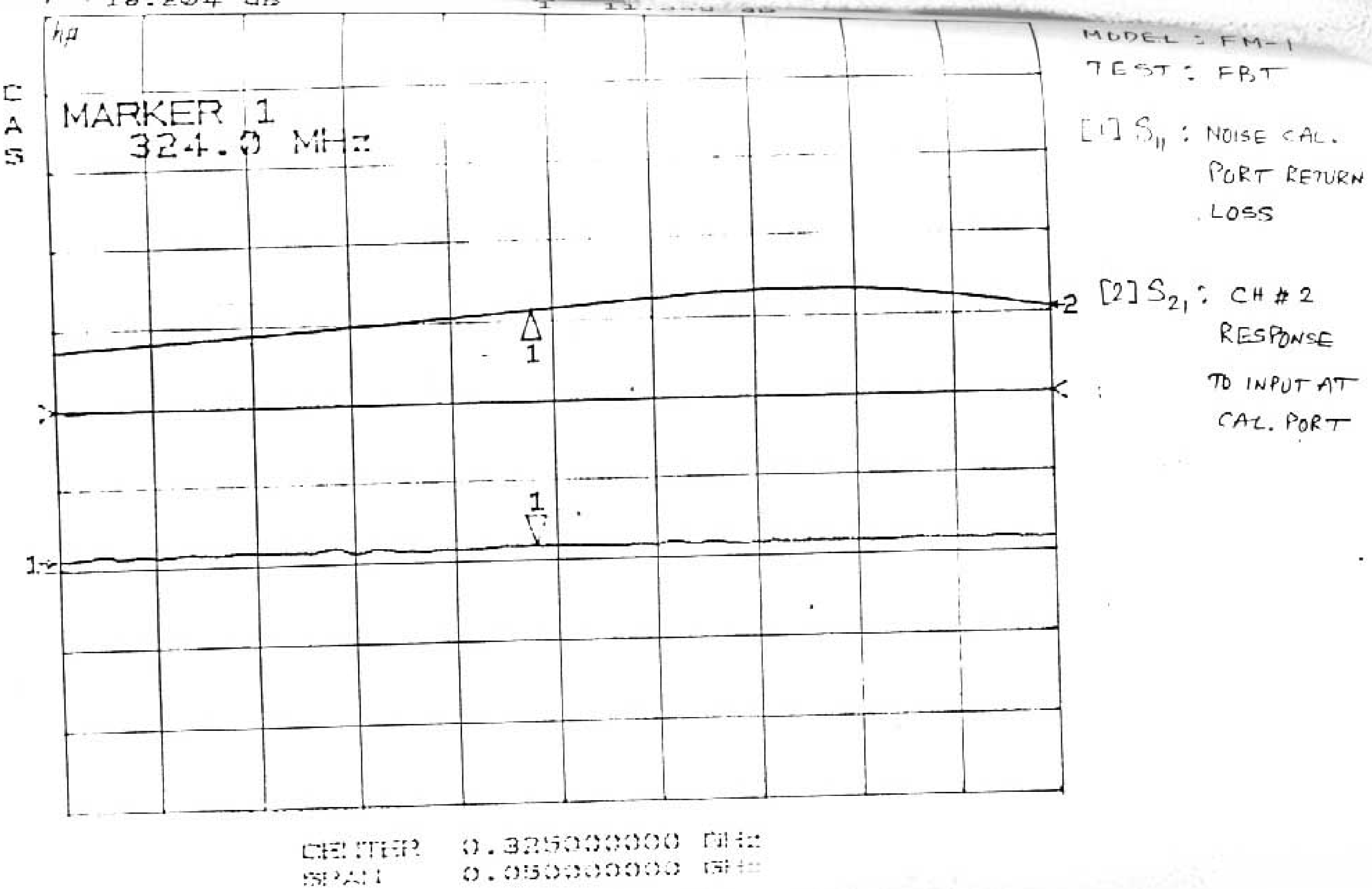


MODEL : FM-1

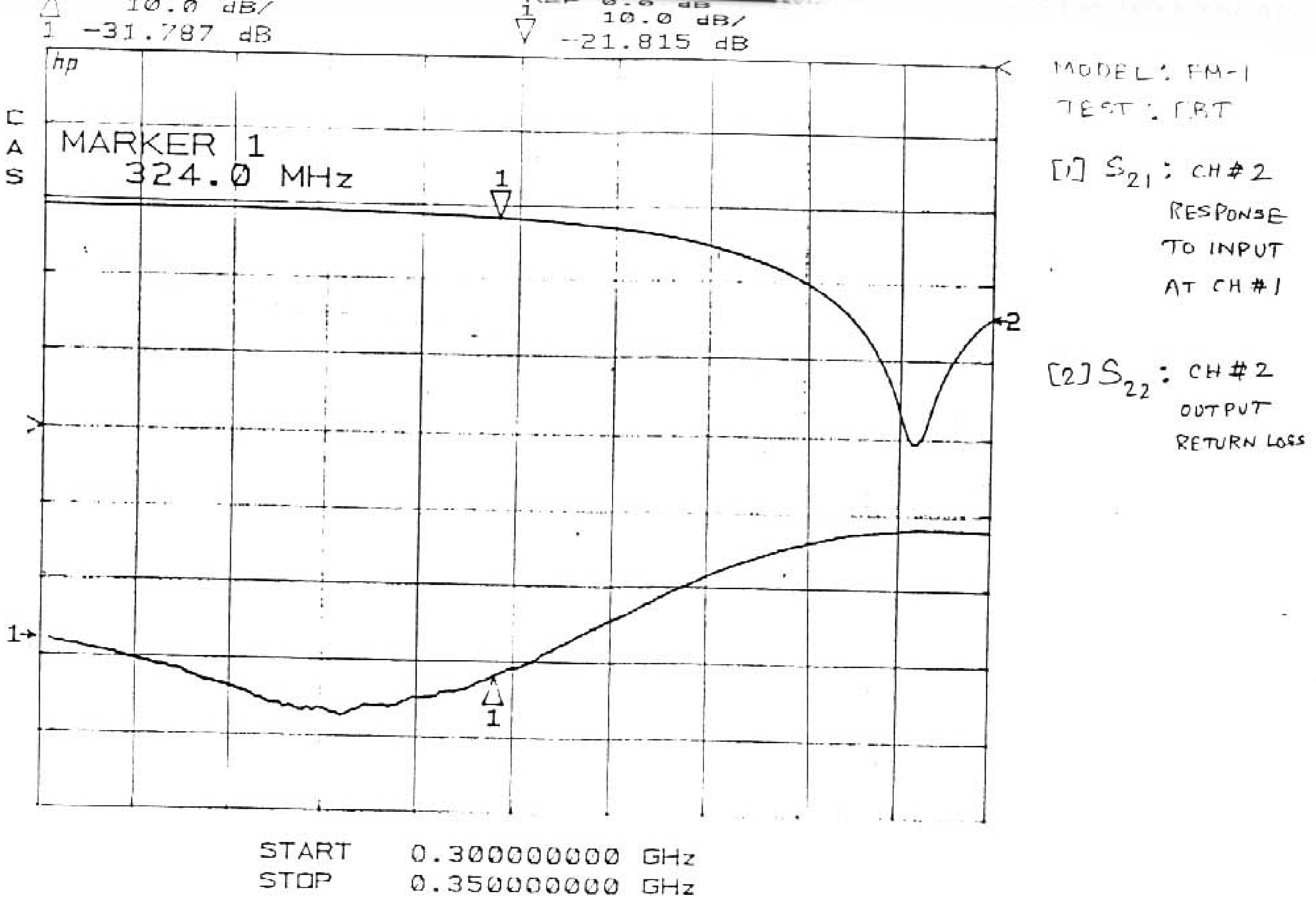
TEST : FBT

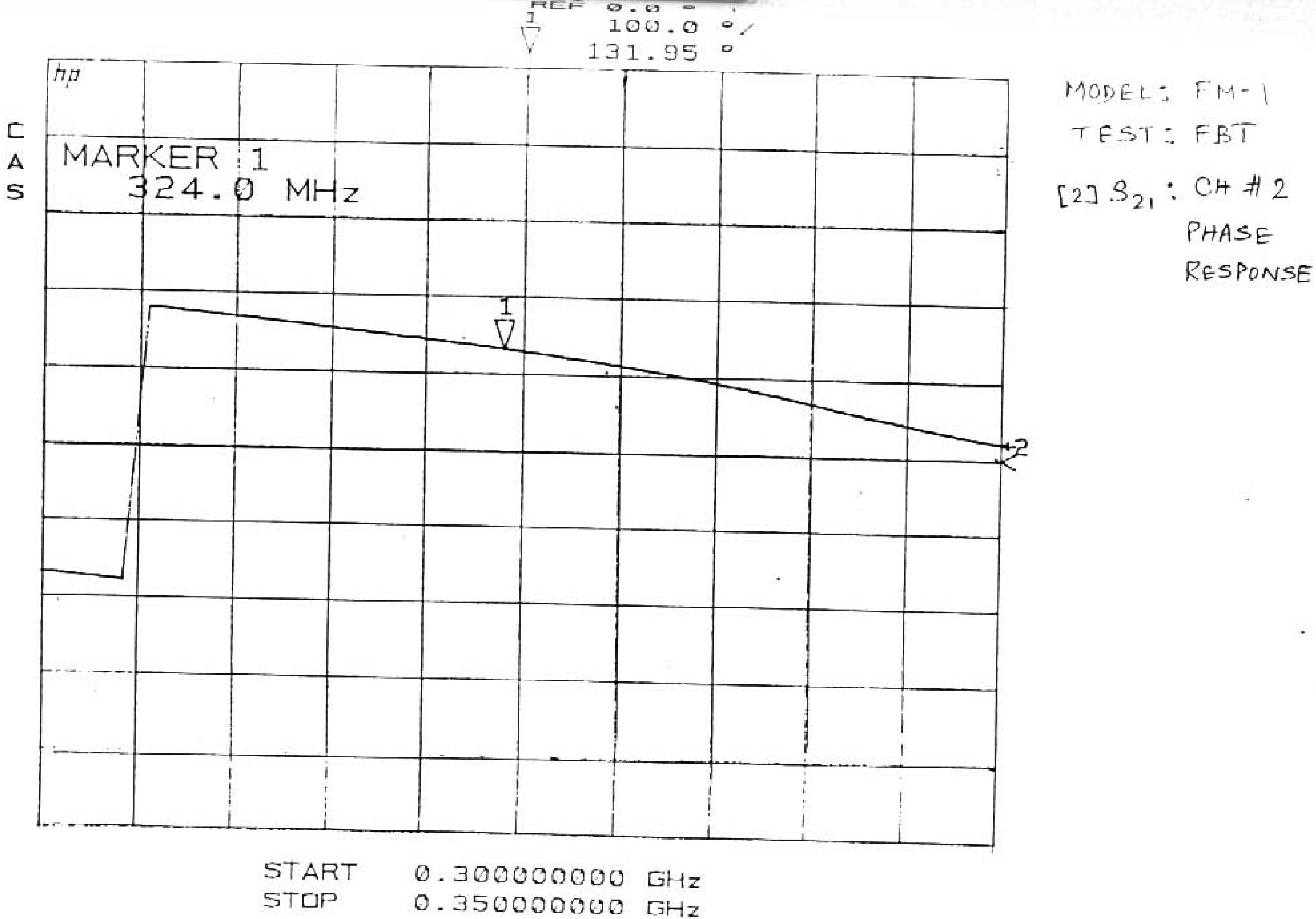
[1] S_{11} : CH #2 INPUT RETURN LOSS

[2] S_{21} : CH #2 GAIN RESPONSE

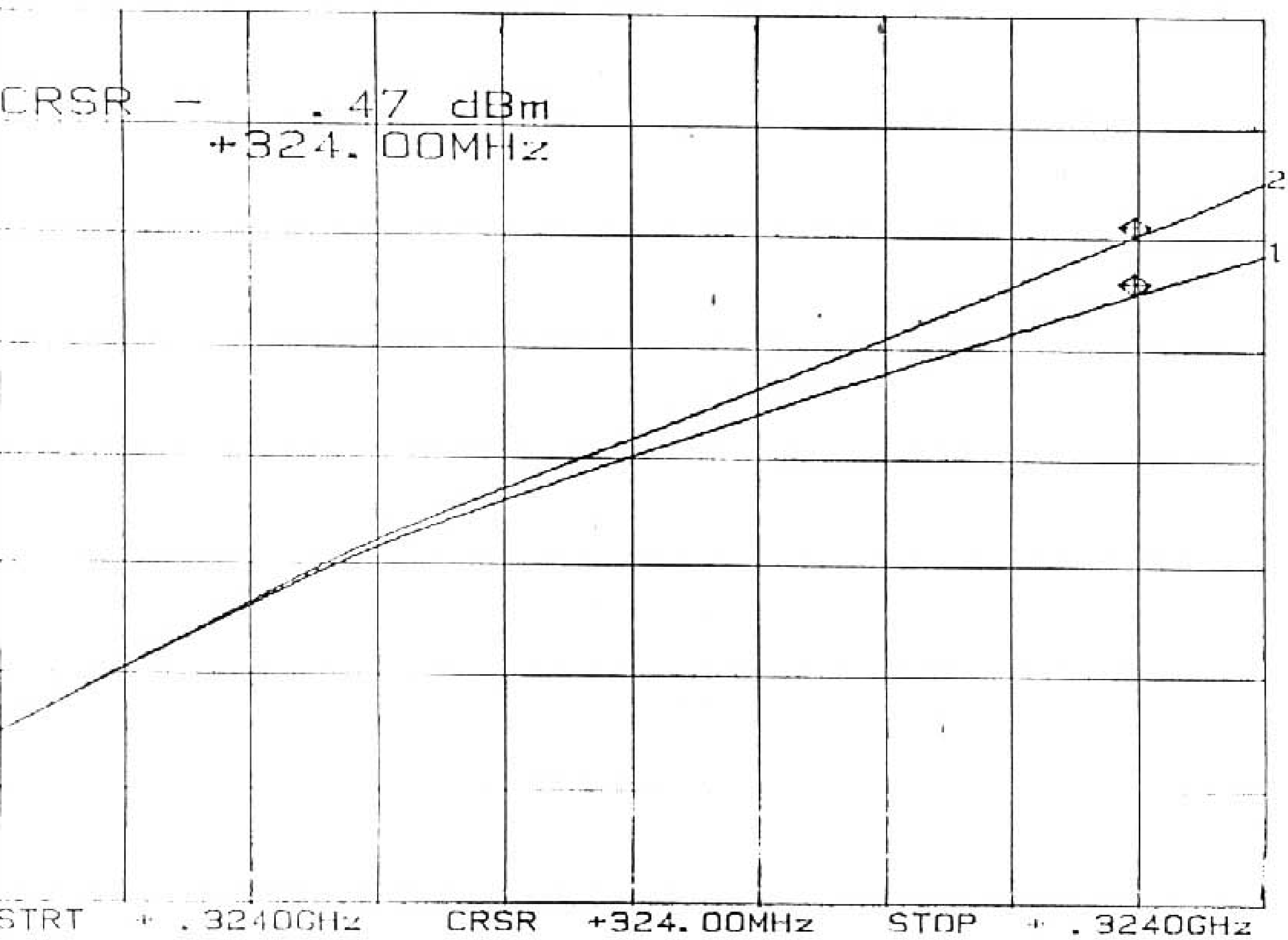


CAS
hp
MARKER 1
324.0 MHz
1
1
2
1
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz
MODEL : FM-1
TEST : FBT
[1] S_{11} : NOISE CAL. PORT RETURN LOSS
[2] S_{21} : CH # 2 RESPONSE TO INPUT AT CAL. PORT


10.0 dB/
-31.787 dB
10.0 dB/
-21.815 dB
hp
C
A
S
MARKER 1
324.0 MHz
1
1
2
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL: FM-1
TEST: FRT
[1] S_{21}: CH#2
RESPONSE
TO INPUT
AT CH#1
[2] S_{22}: CH#2
OUTPUT
RETURN LOSS


REF 0.0 °
100.0 °/
131.95 °
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL: FM-1
TEST: FBT
[2] S_{21}: CH #2
PHASE
RESPONSE

CH1: A — .47 dBm
2.0 dB/ REF — 3.46 dBm
CH2: B — 17.39 dBm
2.0 dB/ REF — 21.43 dBm



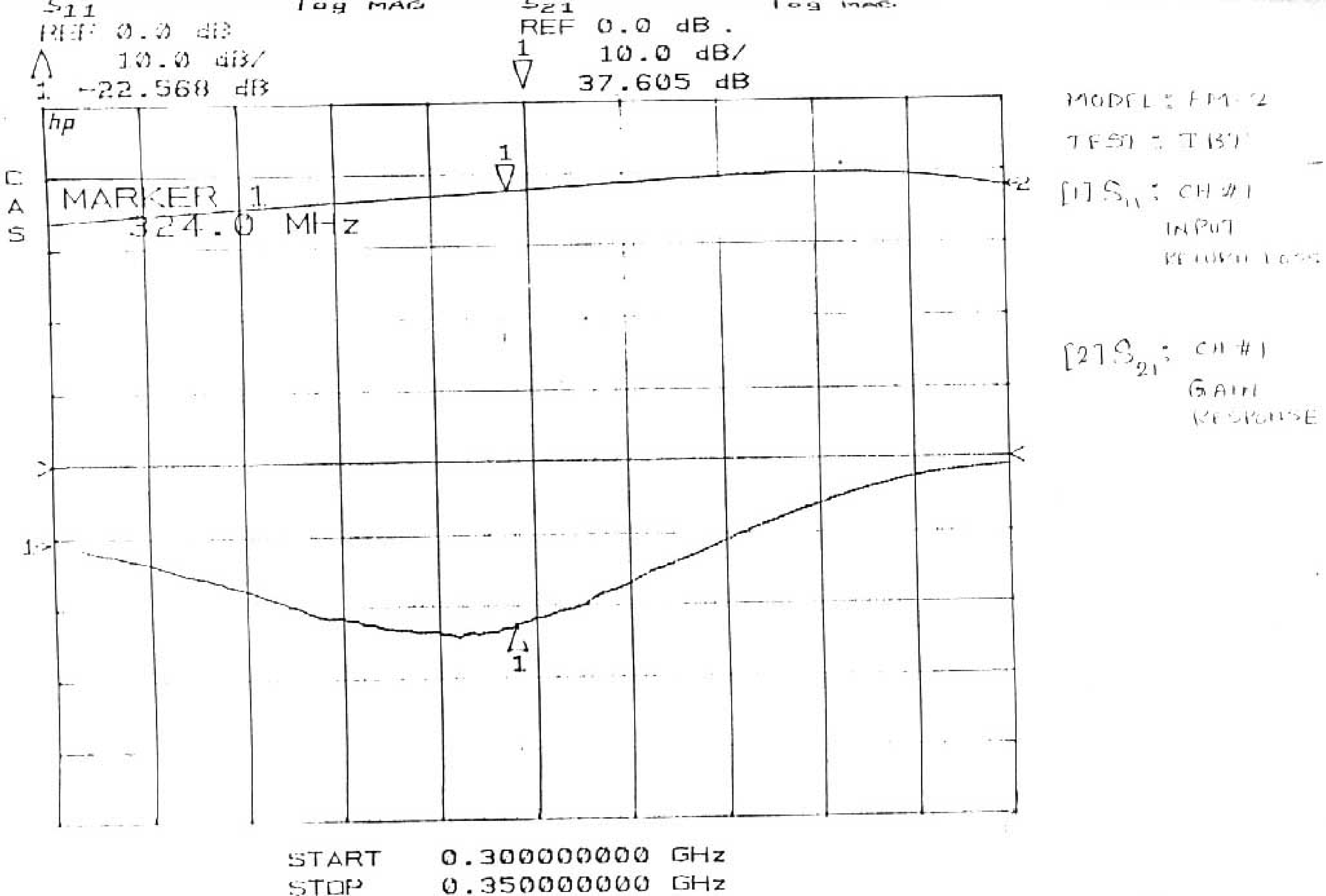
MODEL : FM-1

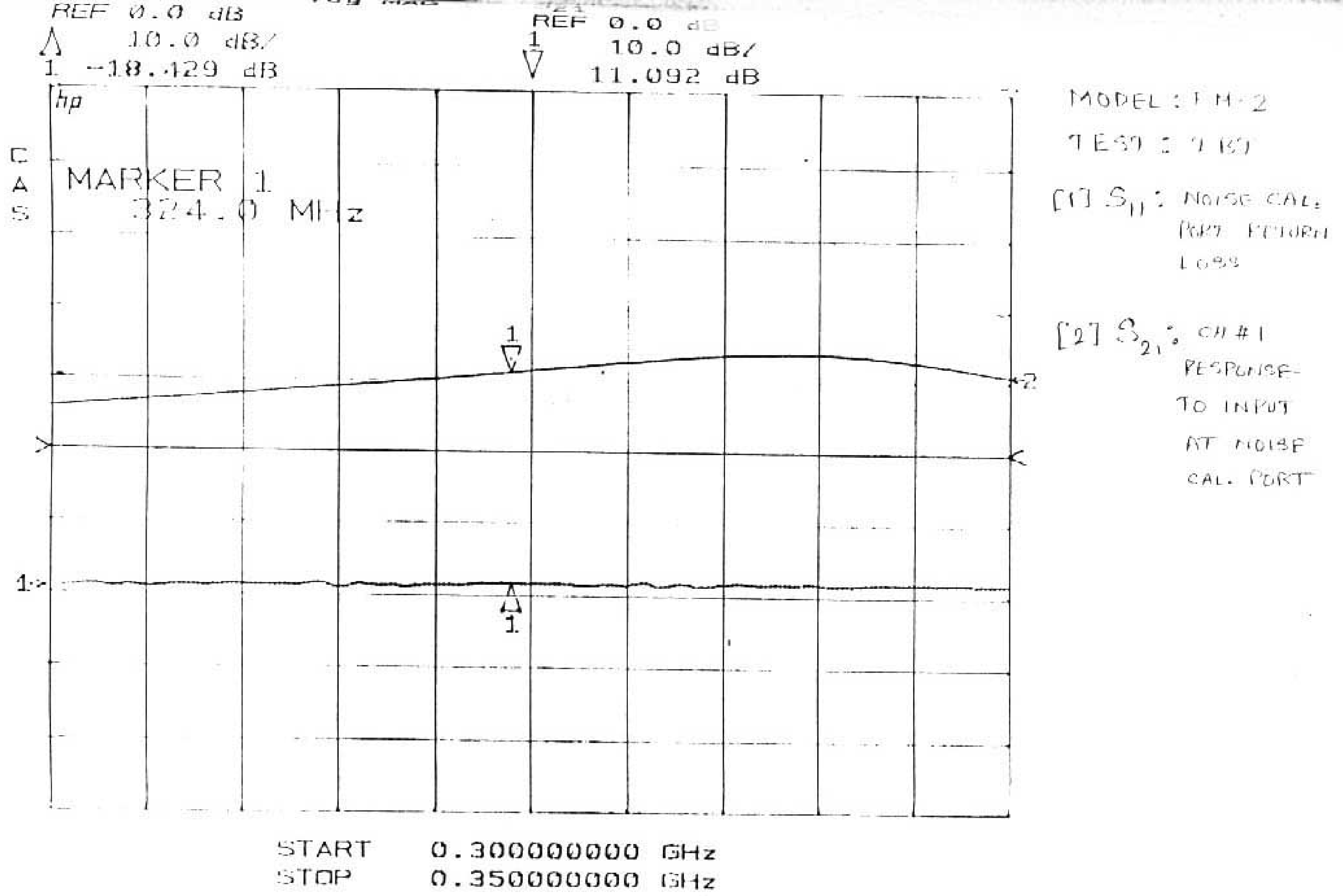
TEST : FBT

[1] CH #2 I/O CURVE

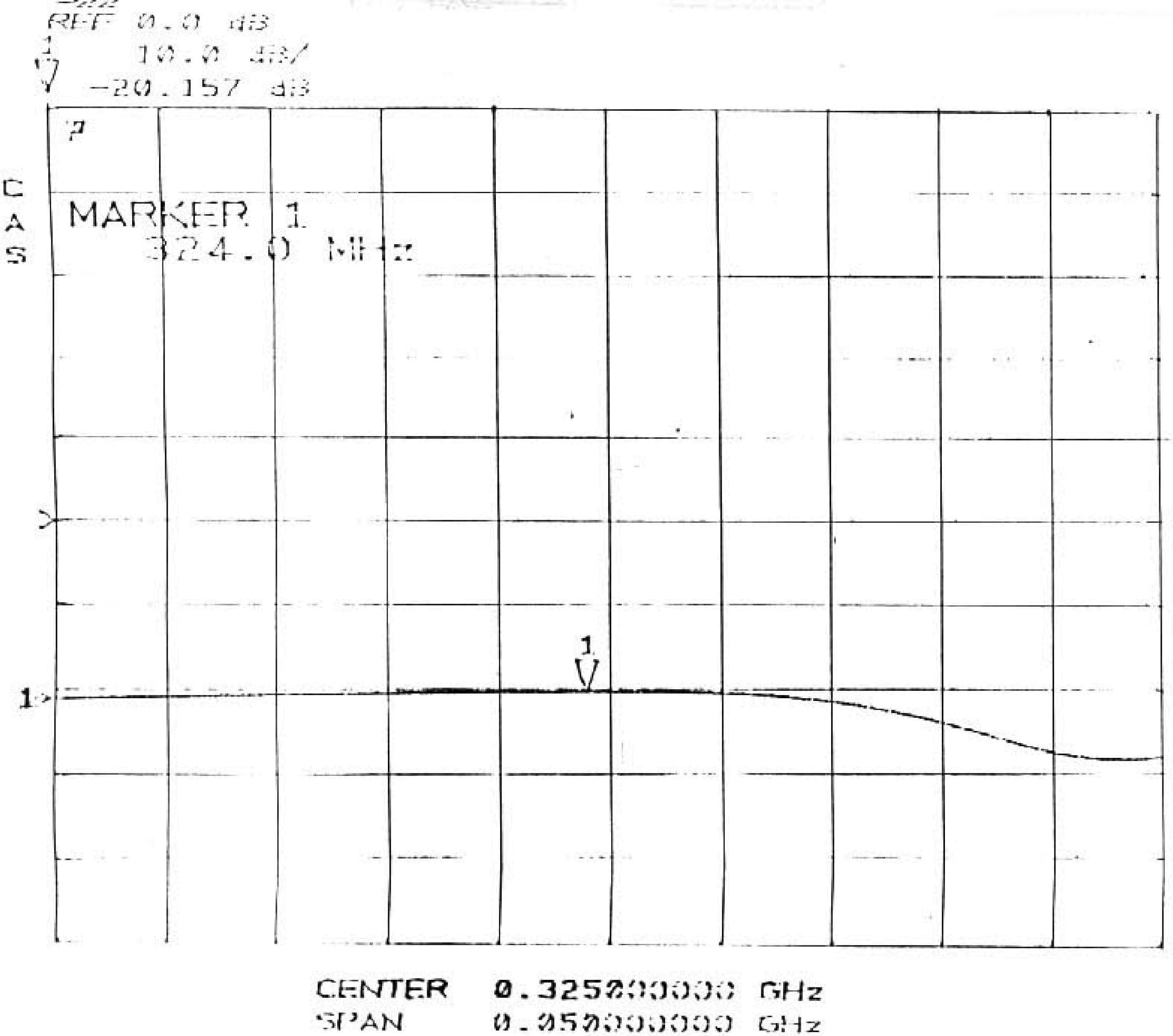
[2] HP8757 DETECTOR (REF). RESPONSE

P_{1dB} @ o/p = -0.47 dBm


S_{11} log MAG
REF 0.0 dB
10.0 dB/
1 -22.568 dB
S_{21} log MAG
REF 0.0 dB
10.0 dB/
37.605 dB
hp
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : FM-2
[1] S_{11} : CH #1
INPUT
[2] S_{21} : CH #1
GAIN
RESPONSE

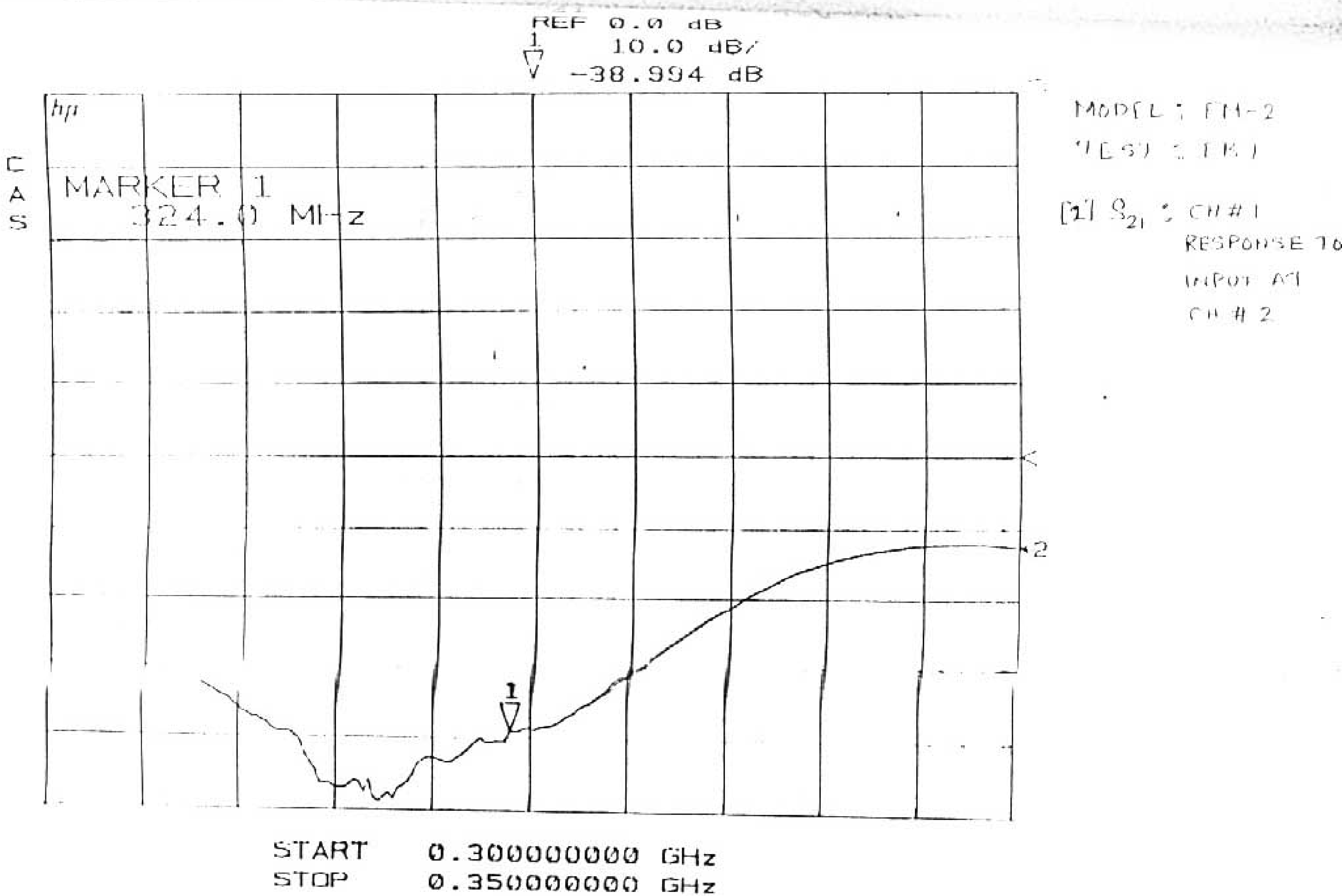


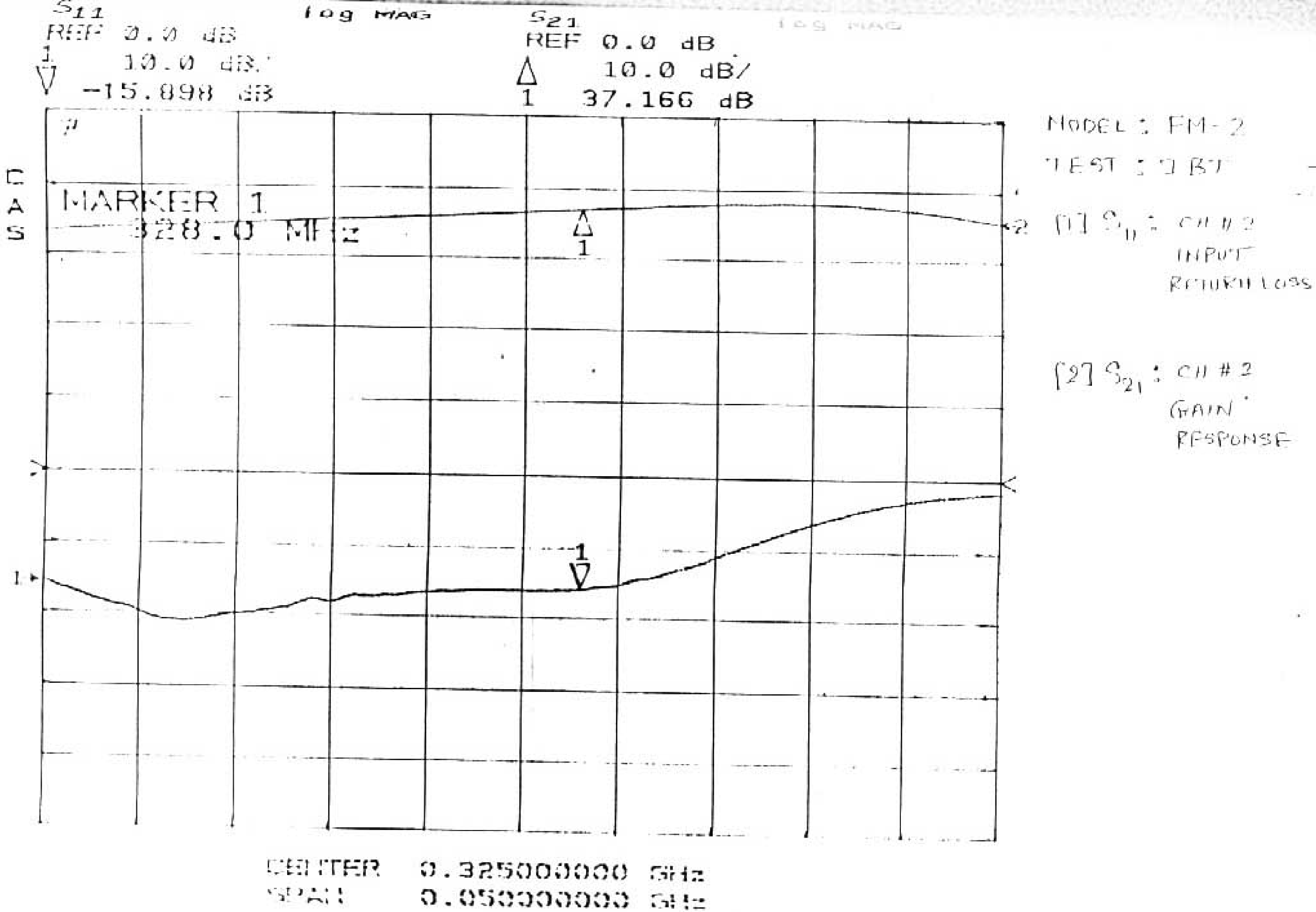
REF 0.0 dB
10.0 dB/
1 -18.429 dB
REF 0.0 dB
10.0 dB/
11.092 dB
hp
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : FM-2
TEST : T.1(?)
[1] S_{11} : NOISE CAL. PORT RETURN LOSS
[2] S_{21} : CH #1 RESPONSE TO INPUT AT NOISE CAL. PORT



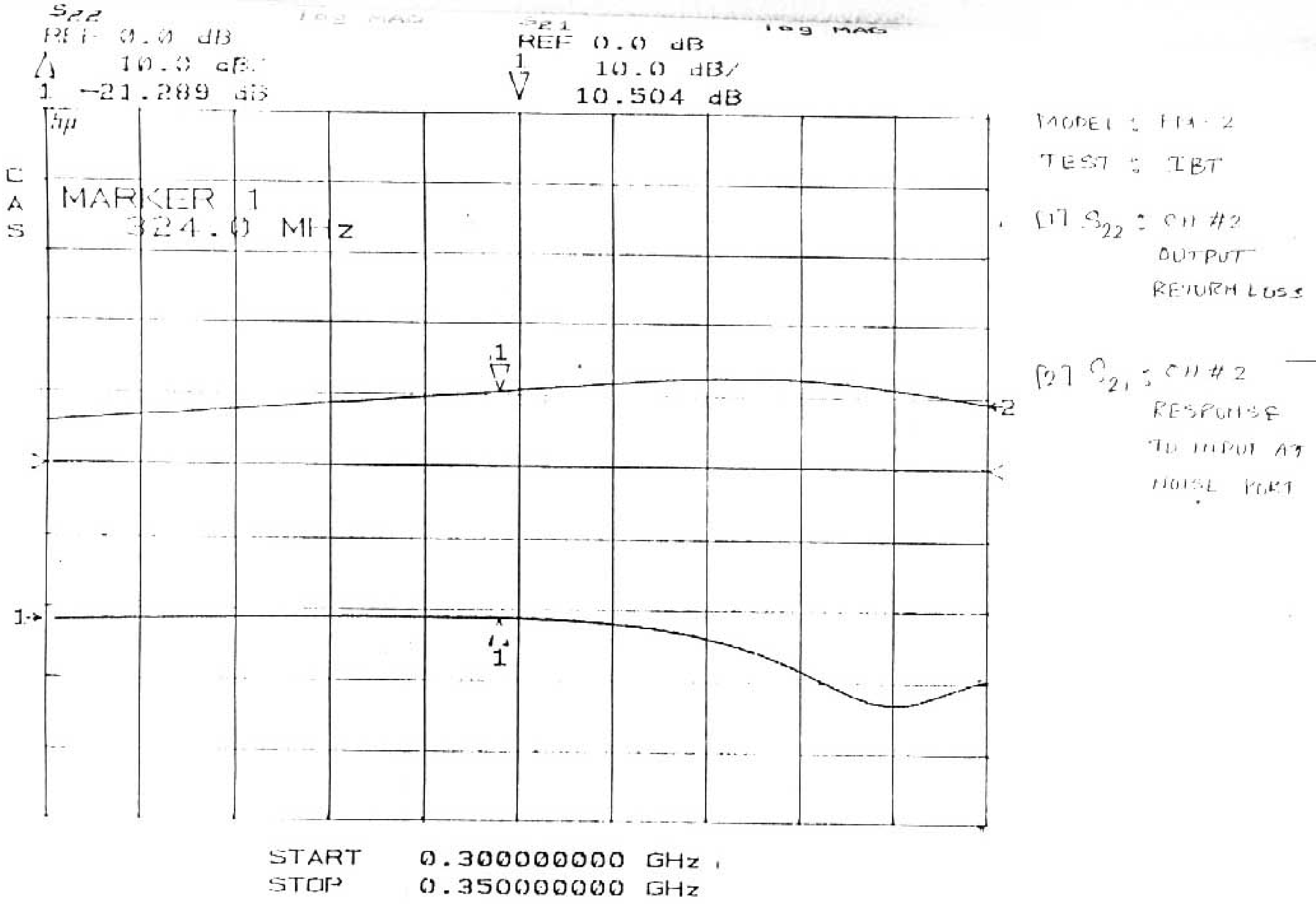
MODEL : FM-2
TEST : 9/83

[1] S_{22} : CH #1
OUTPUT
RETURN LOSS

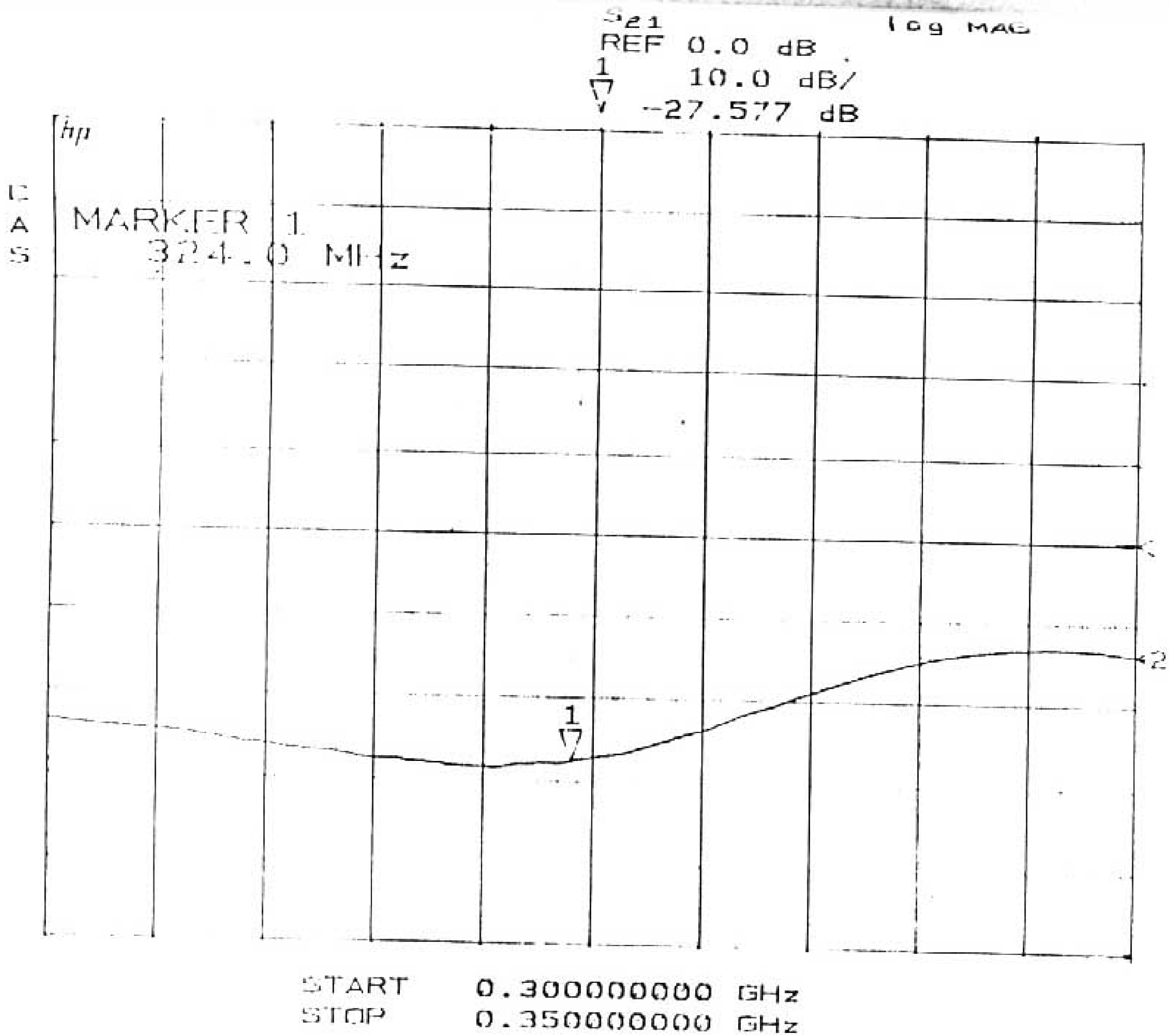

REF 0.0 dB
10.0 dB/
-38.994 dB
hp
C
A
S
MARKER 1
324.0 MHz
MODEL : FM-2
TEST : FR1
[1] S21 : CH#1
RESPONSE TO
INPUT AT
CH #2
START 0.300000000 GHz
STOP 0.350000000 GHz



S11
REF 0.0 dB
10.0 dB/
-15.898 dB
log MAG
S21
REF 0.0 dB
10.0 dB/
1 37.166 dB
C A S
MARKER 1
328.0 MHz
MODEL : FM-2
TEST : 3 BT
[1] S11 : CH #2
INPUT
RETURN LOSS
[2] S21 : CH #2
GAIN
RESPONSE
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz



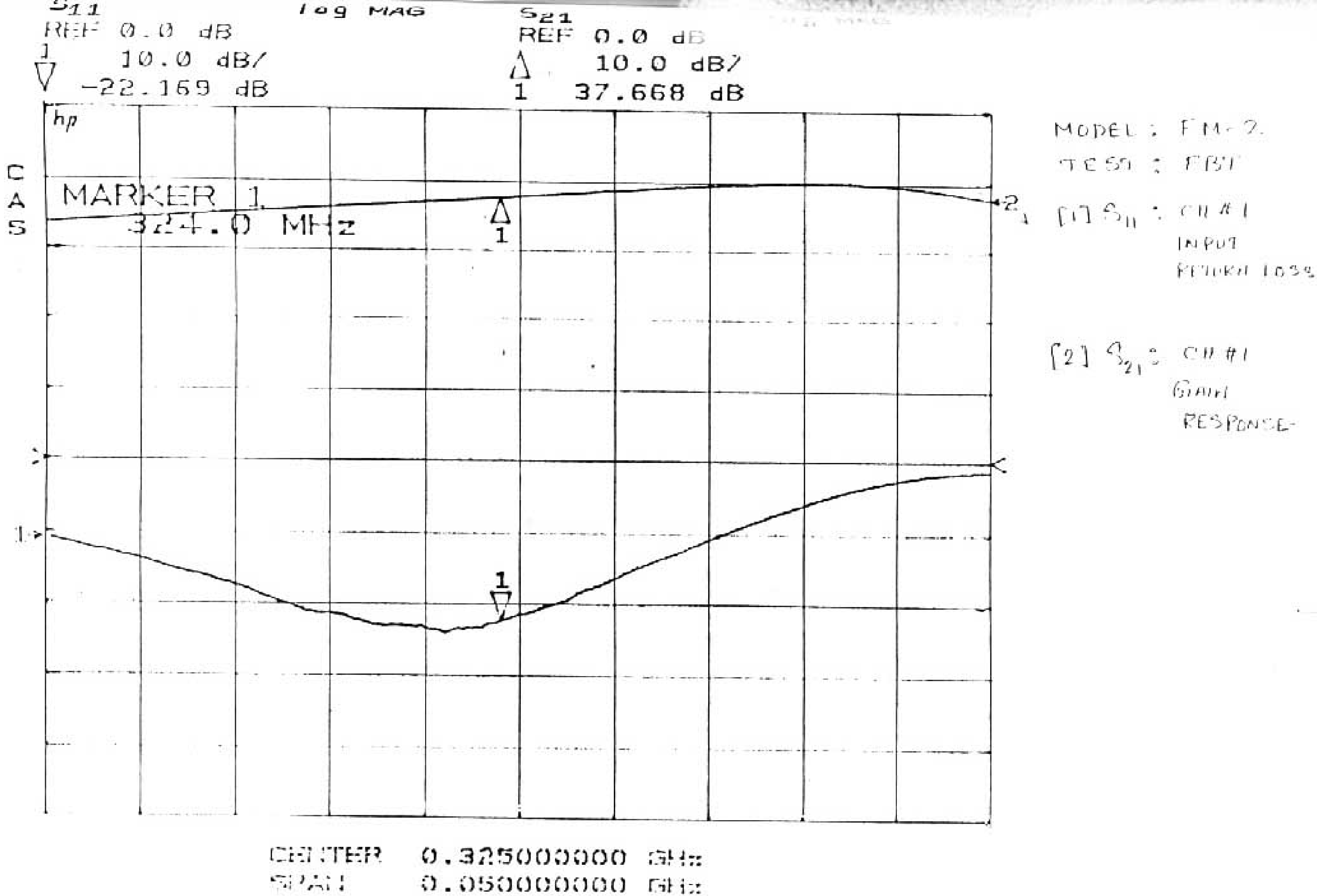
S22
log MAG
REF 0.0 dB
10.0 dB/
1 −21.289 dB
S21
log MAG
REF 0.0 dB
10.0 dB/
10.504 dB
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : FH-2
TEST : IBT
[1] S_{22} : CH #2
OUTPUT
RETURN LOSS
[2] S_{21} : CH #2
RESPONSE
TO INPUT AT
NOISE PORT

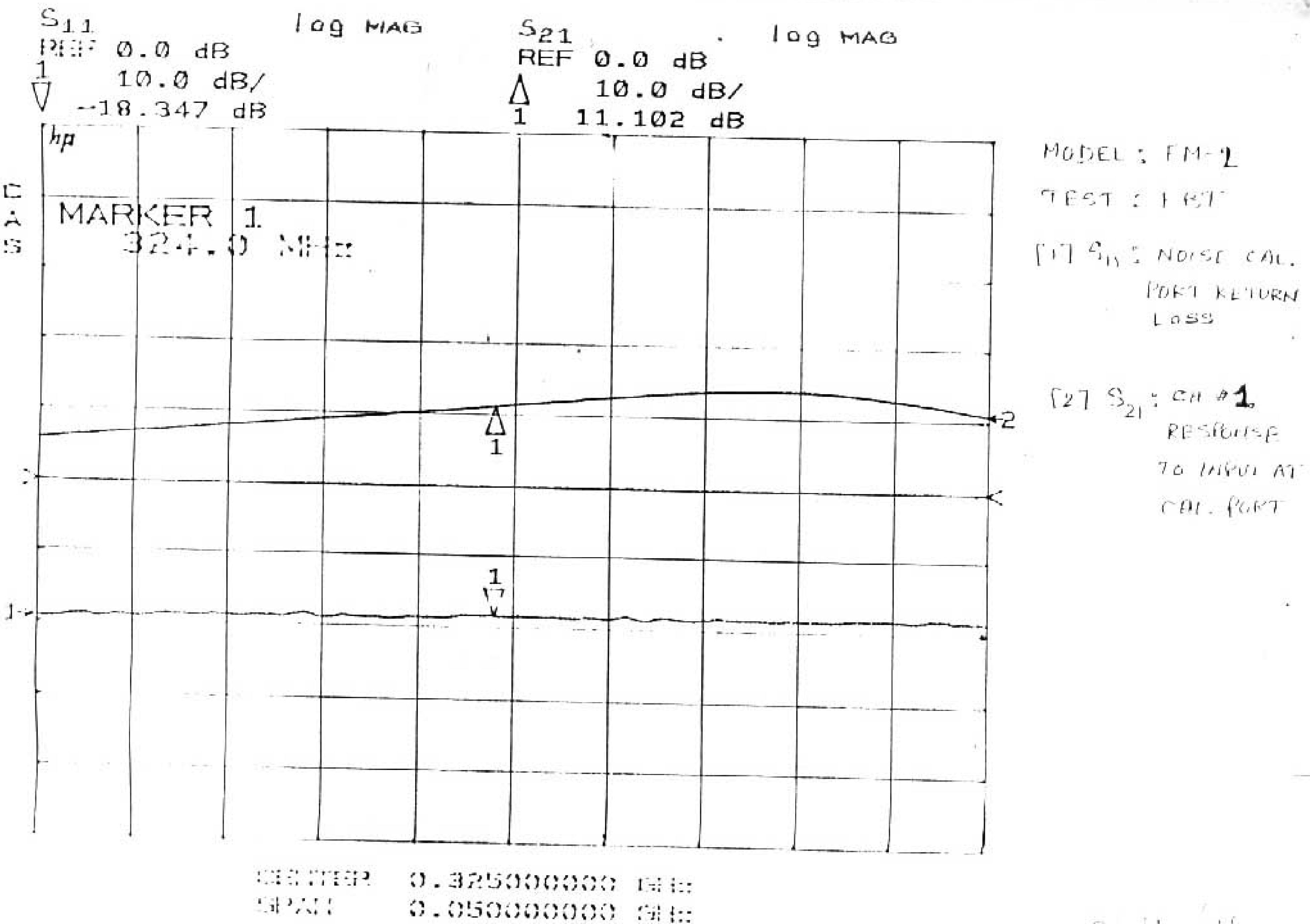


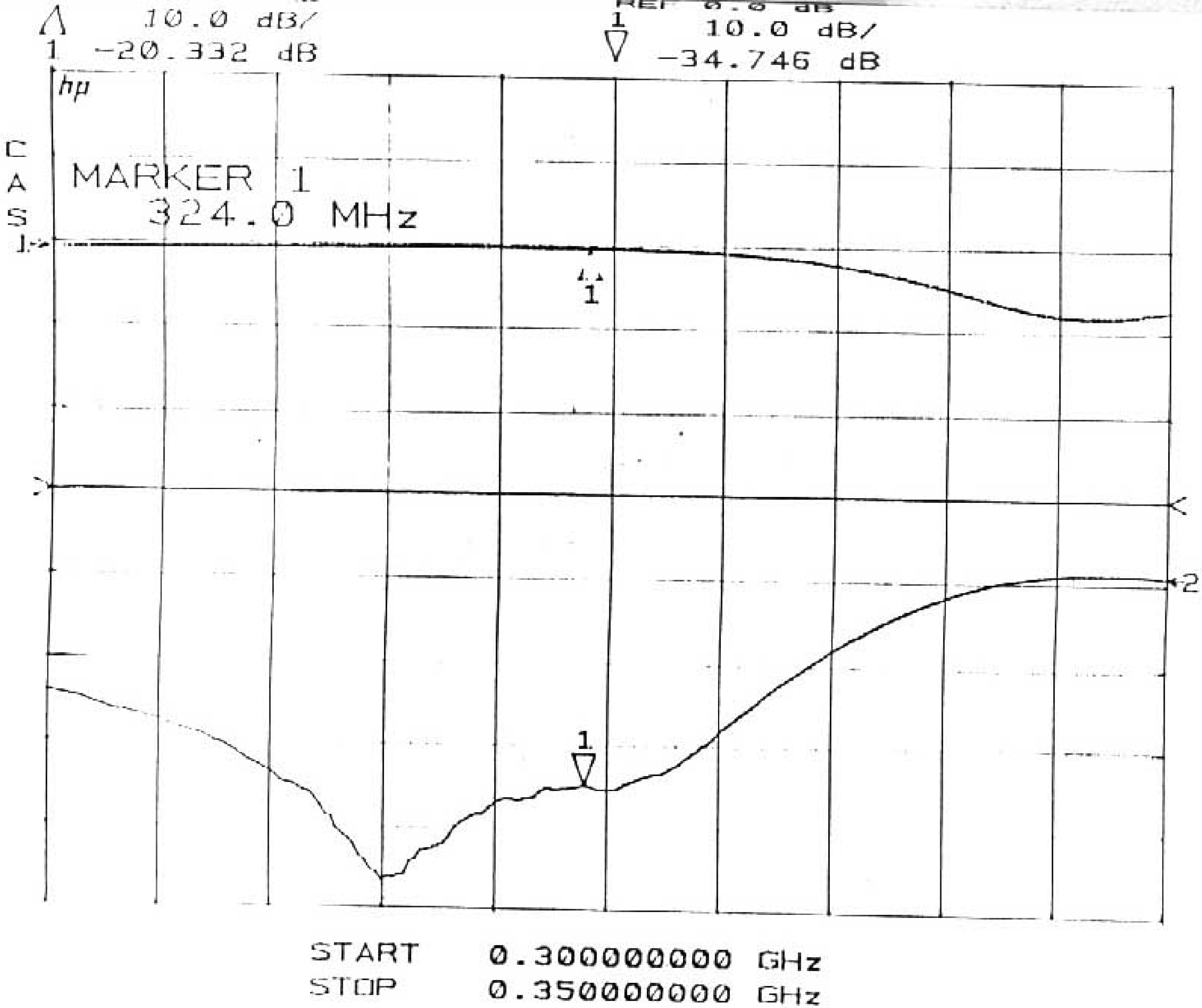
MODEL : FM 2

TEST : 2BT

[2] S_{21} : CH # 2 RESPONSE TO INPUT AT CH # 1


S11
REF 0.0 dB
10.0 dB/
-22.169 dB
log MAG
S21
REF 0.0 dB
10.0 dB/
37.668 dB
hp
C
A
S
MARKER 1
324.0 MHz
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz
MODEL : FM-2
TEST : FBT
[1] S11 : CH #1
INPUT
RETURN LOSS
[2] S21 : CH #1
GAIN
RESPONSE


S11 log MAG
REF 0.0 dB
10.0 dB/
-18.347 dB
S21 log MAG
REF 0.0 dB
10.0 dB/
11.102 dB
hp
C A S
MARKER 1
324.0 MHz
CENTER 0.325000000 GHz
SPAN 0.050000000 GHz
MODEL : FM-1
TEST : FBT
[1] S11 : NOISE CAL. PORT RETURN LOSS
[2] S21 : CH #1 RESPONSE TO INPUT AT CAL. PORT

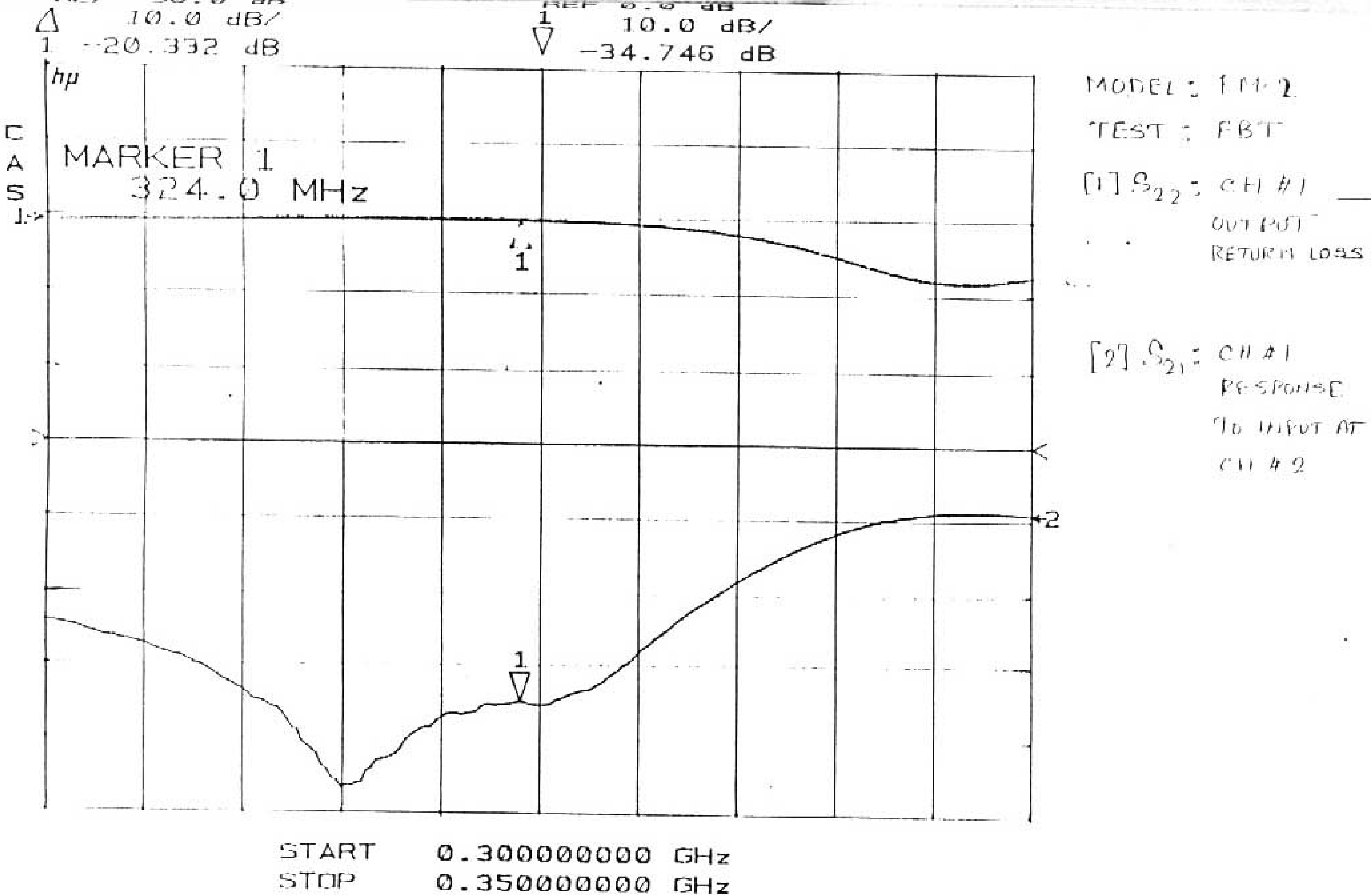


MODEL : FM-1

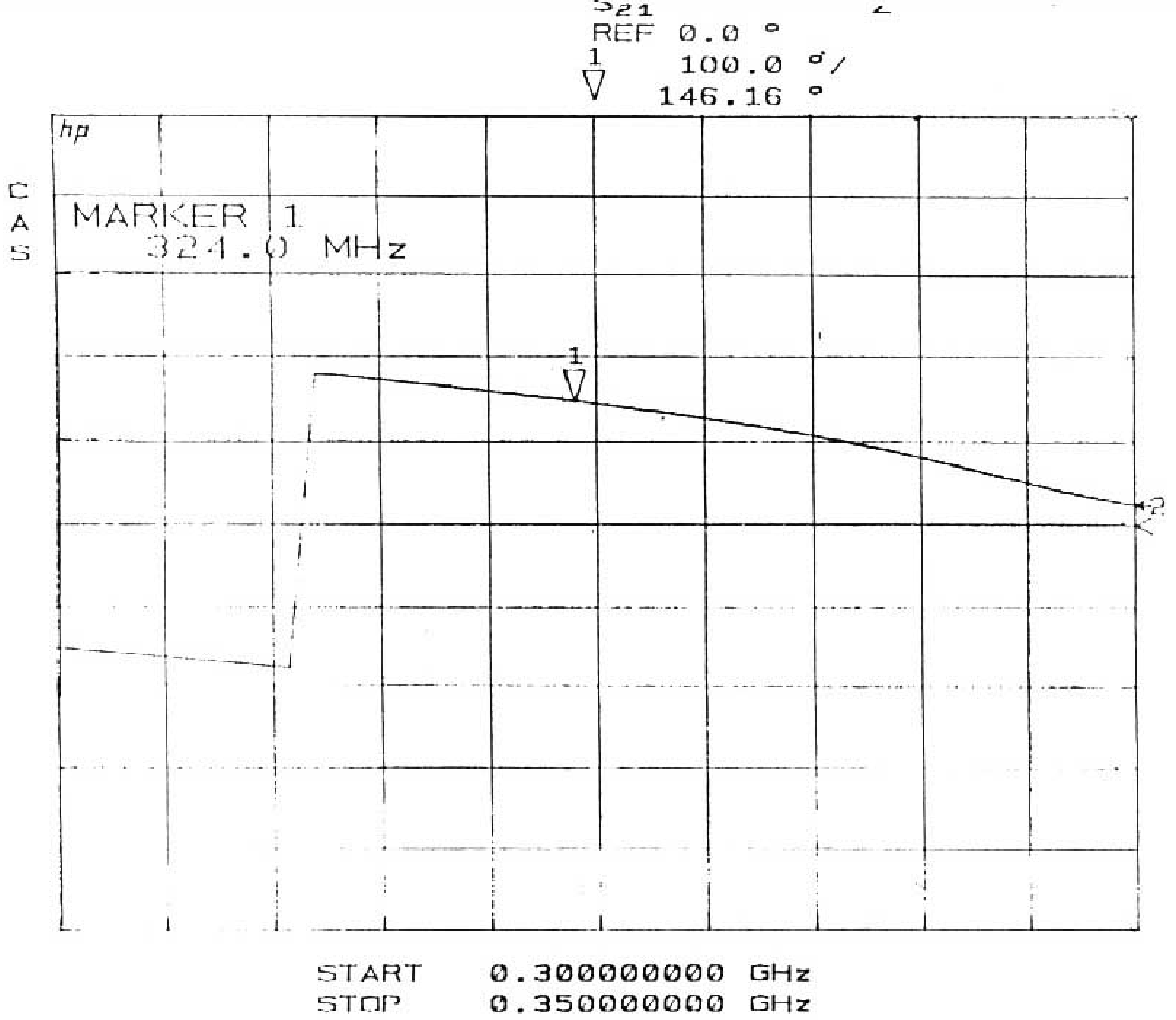
TEST : FBT

[1] S_{22} : CH #1
OUTPUT
RETURN LOSS

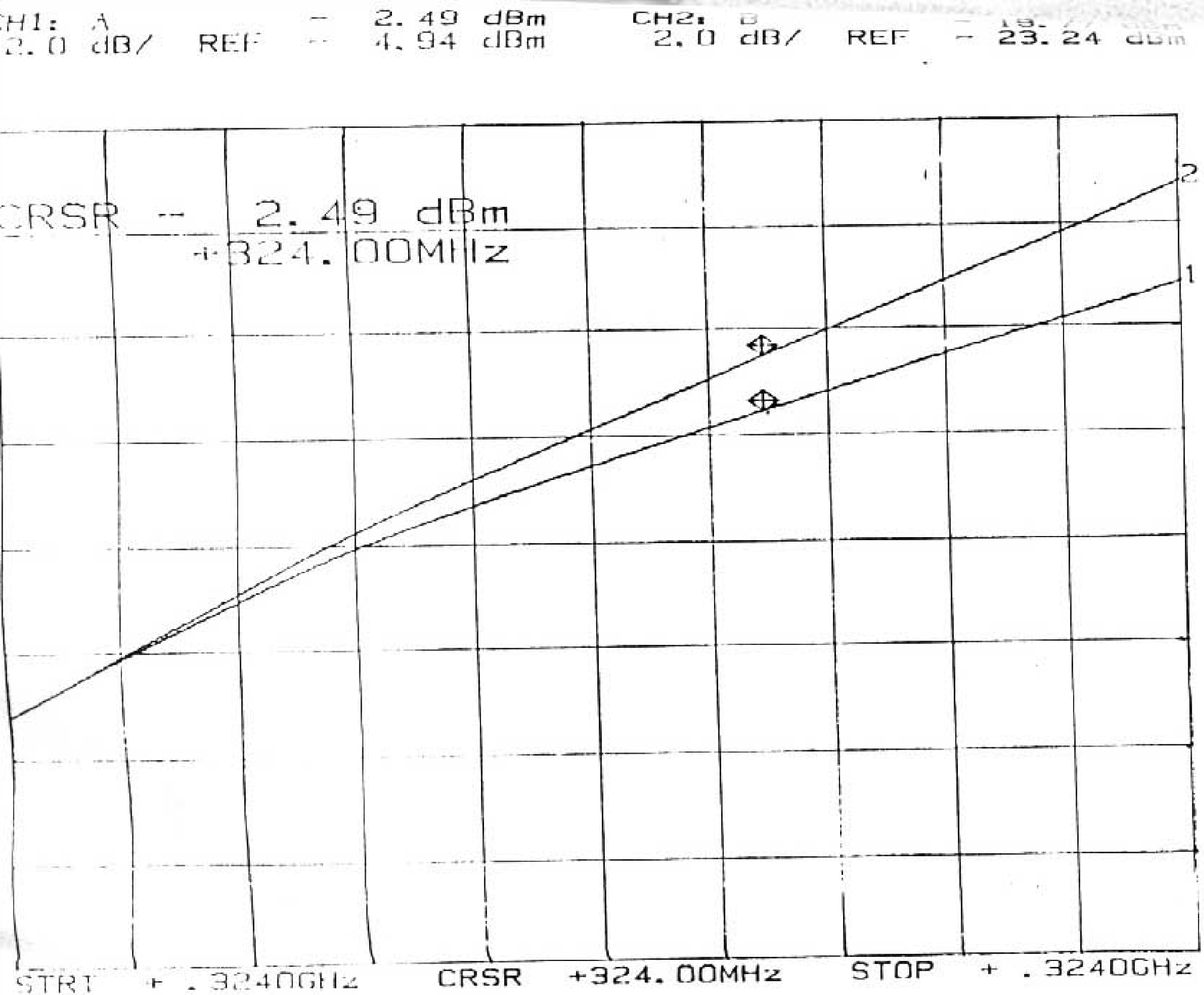
[2] S_{21} : CH #1
RESPONSE
TO INPUT AT
CH # 2



△ 10.0 dB/
1 -20.332 dB
1 ▽ 10.0 dB/
-34.746 dB
hp
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : FM-2
TEST : FBT
[1] S_{22} : CH #1
OUTPUT
RETURN LOSS
[2] S_{21} : CH #1
RESPONSE
TO INPUT AT
CH #2



MODEL : FM-2
TEST : FBT
(11 S_{21}) : CH #1
PHASE
RESPONSE



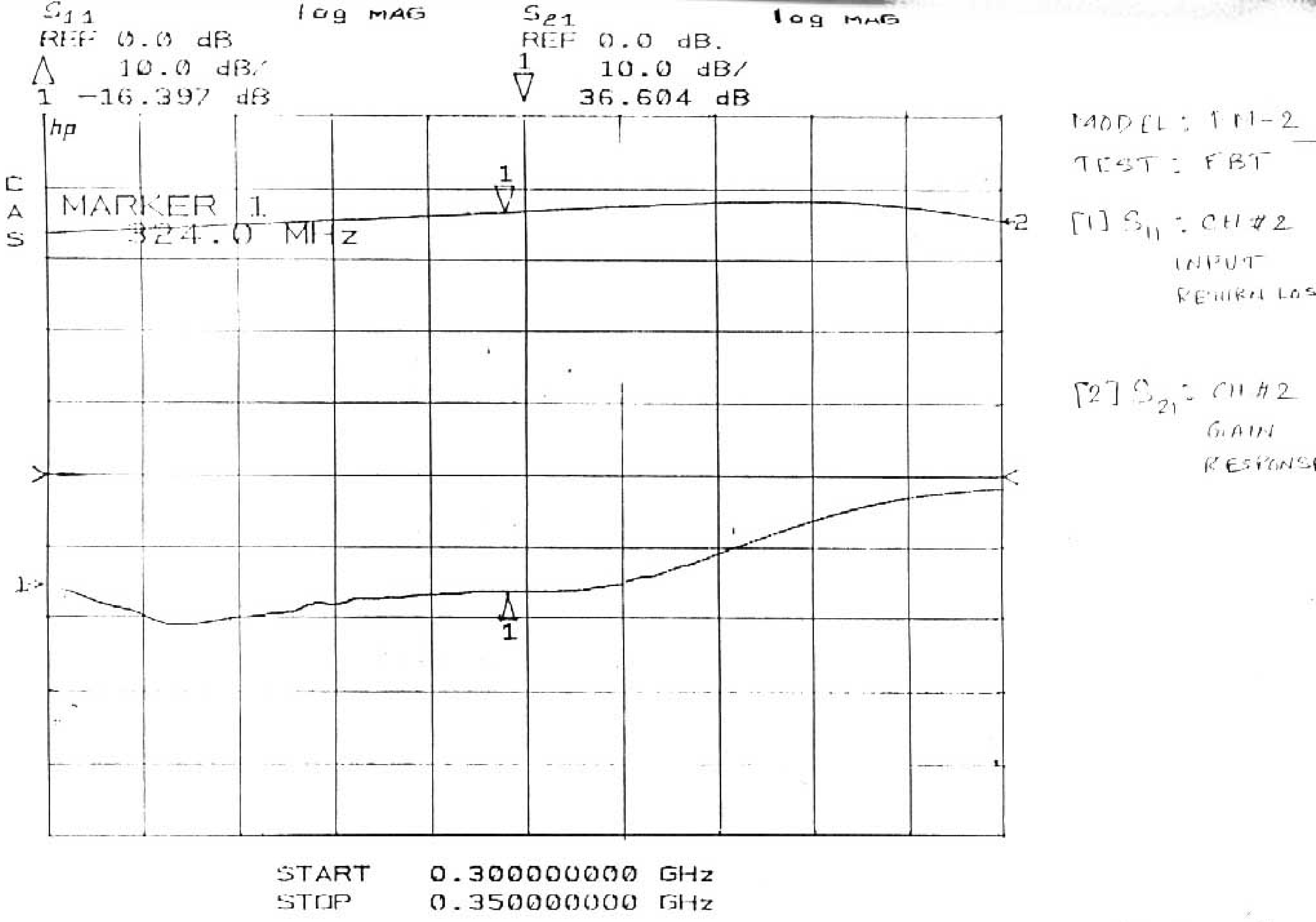
MODEL : FM-2

TEST : FBT

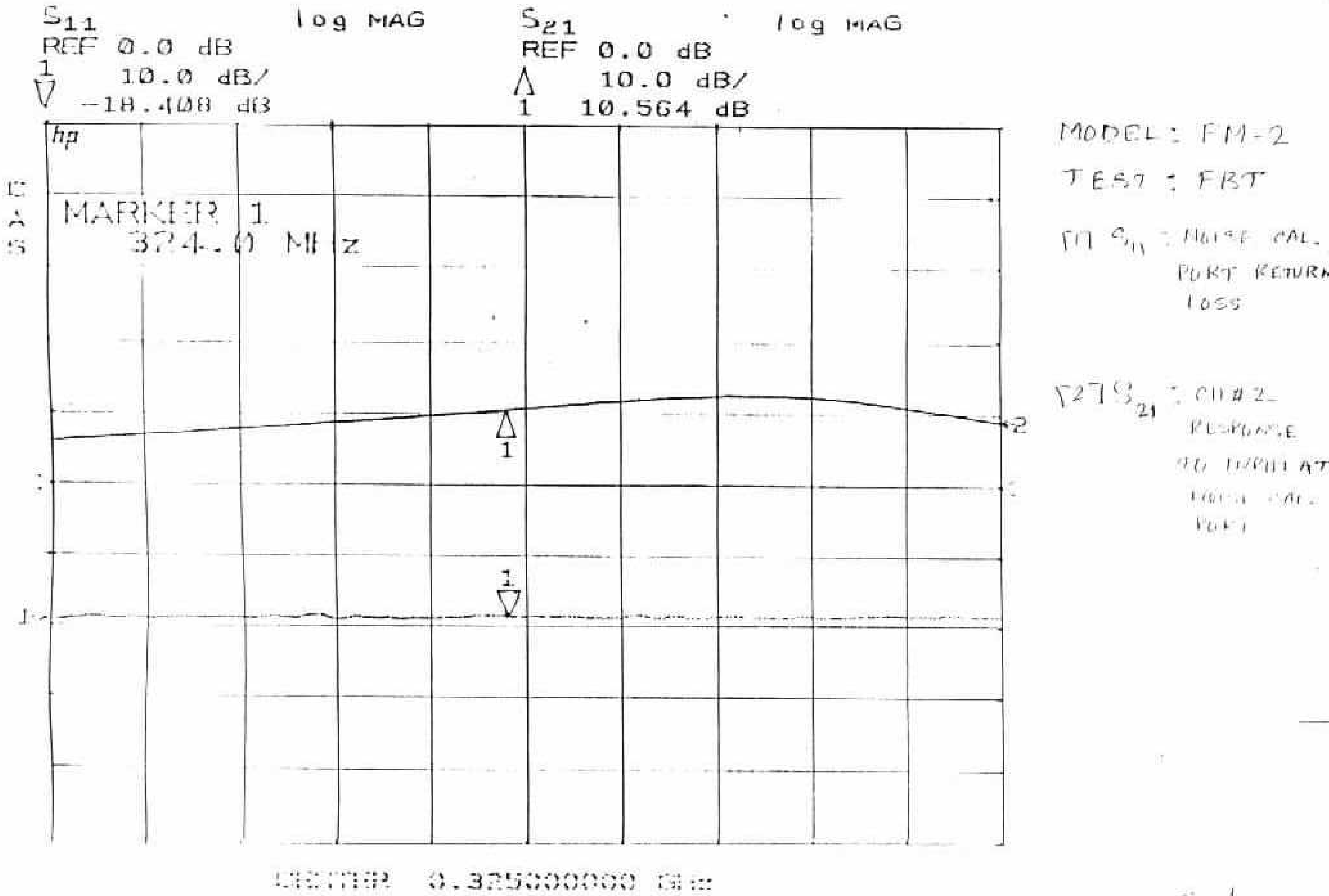
[1] CH A I T/D CURVE

[2] HP 8757 SMA DETECTOR RESPONSE

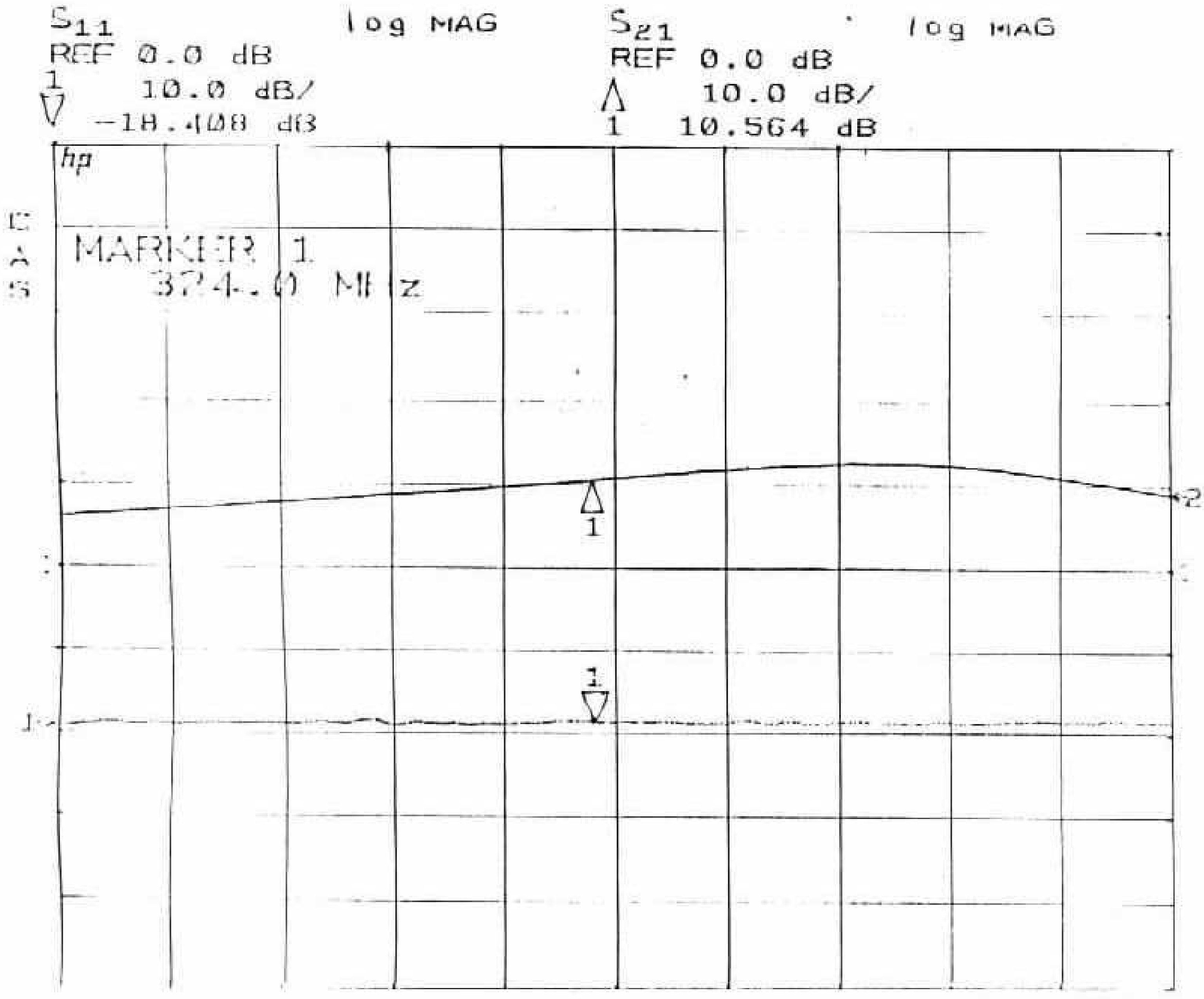
P_{1dB} @ o/p = -2.49 dBm



S_{11} log MAG
REF 0.0 dB
10.0 dB/
1 −16.397 dB
S_{21} log MAG
REF 0.0 dB.
10.0 dB/
36.604 dB
hp
C A S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : TM-2
TEST : FBT
[1] S_{11} : CH #2
INPUT
RETURN LOSS
[2] S_{21} : CH #2
GAIN
RESPONSE



S_{11} log MAG
REF 0.0 dB
10.0 dB/
-18.408 dB
S_{21} log MAG
REF 0.0 dB
10.0 dB/
10.564 dB
MARKER 1
374.0 MHz
MODEL : FM-2
TEST : FBT

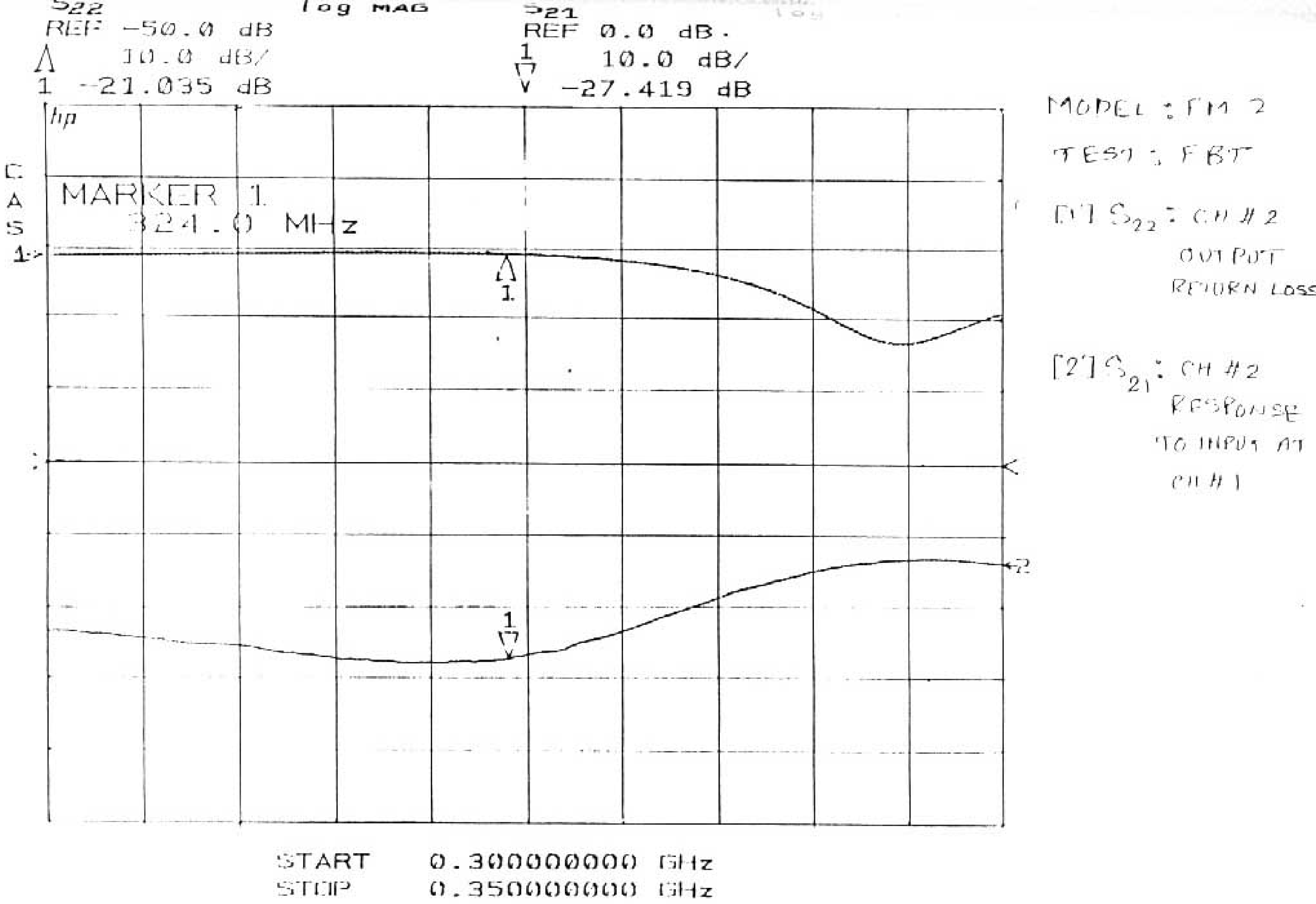


MODEL : FM-2

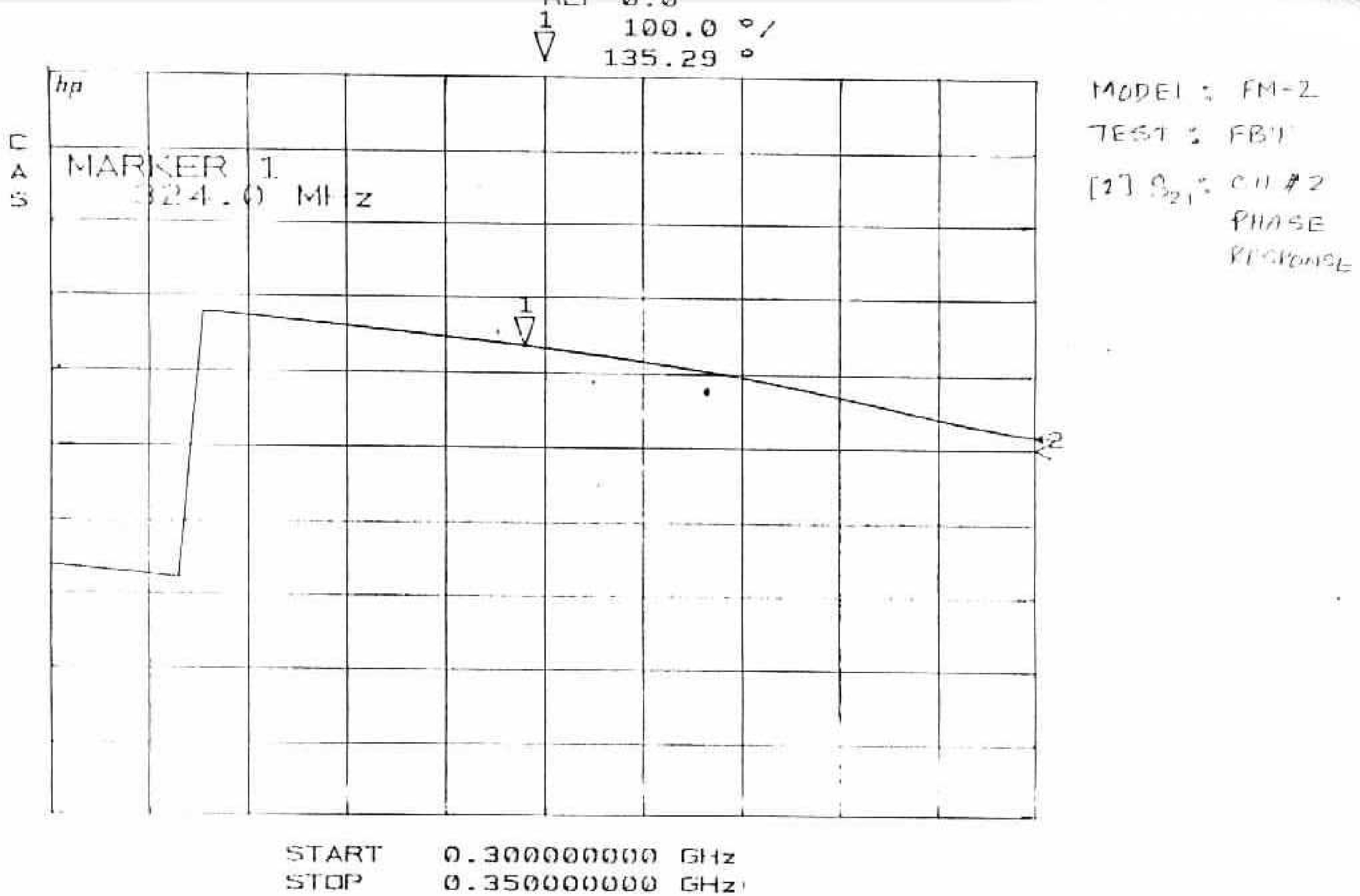
TEST : FBT

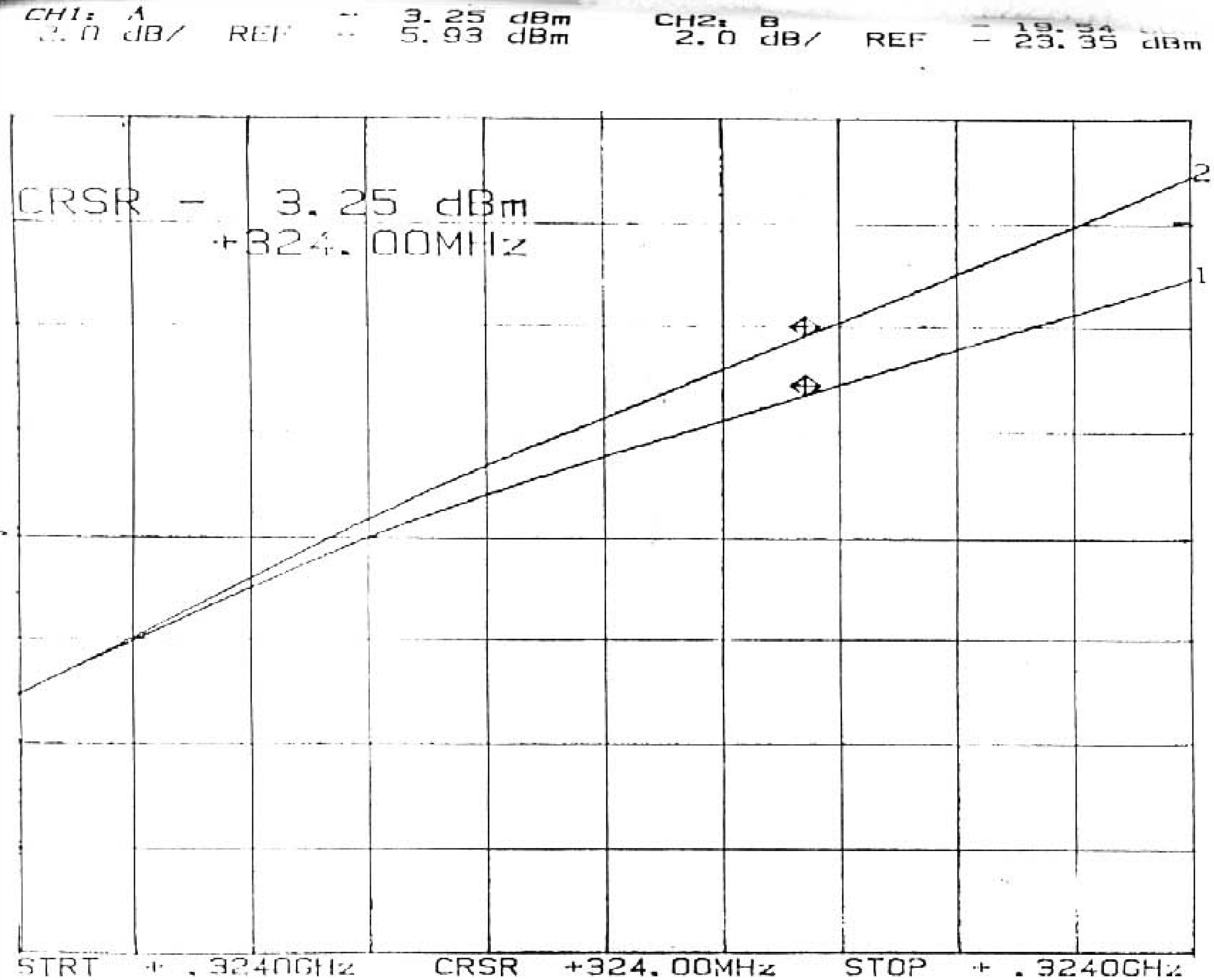
[1] S_{11} : NOISE CAL. PORT RETURN LOSS

[2] S_{21} : CH #2 RESPONSE TO INPUT AT [illegible] CAL. PORT



S22
REF -50.0 dB
10.0 dB/
1 -21.035 dB
log MAG
S21
REF 0.0 dB.
10.0 dB/
-27.419 dB
hp
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : FM 2
TEST : FBT
[1] S_{22} : CH #2
OUTPUT
RETURN LOSS
[2] S_{21} : CH #2
RESPONSE
TO INPUT AT
CH #1


1
100.0 °/
135.29 °
hp
C
A
S
MARKER 1
324.0 MHz
START 0.300000000 GHz
STOP 0.350000000 GHz
MODEL : FM-2
TEST : FBT
[2] S21 : CH #2
PHASE
RESPONSE



MODEL : FM-2

TEST : FBT

[1] CH # 2 T/O CURVE

[2] HP 8757 SAD

DETECTOR RESPONSE

APPENDIX - III

LIST OF WAIVERS GIVEN TO GAIE

FOR RADIOASTRON PROJECT

SUBSYSTEM : 324 MHz FRONT END LNA & POWER SUPPLY

MODEL : FM

DRAWING NO. : G10/322 & G40/[illegible]

NO.	WAIVER NO.	DATE OF WAIVER	QA COMMENTS	[illegible] FROM PROJECT
1.	-	9/1/96	Bulging of PCB on component side due to cavity formation on solder side, which was required for FET ferrite core fixing. Cavity formation in duroid PCB is not a qualified process.	Acceptable to project.
2.	-	9/1/96	Local potting spread over observed on J1 SMA connector pin solder area.	Acceptable to project.
3.	-	9/1/96	In wire line WL-2 crack in one of the wire is observed & also in WL-1 crack is observed in one of the wire.	Acceptable to project.

APPENDIX — V

SPACE APPLICATIONS CENTRE
RELIABILITY & QUALITY ASSURANCE

SAMD/ QAED CERTIFICATE

PROJECT : RADIOASTRON DATE : [illegible]

MODEL : FM CERT. NO. : [illegible]

SUBSYSTEMS
SUBASSEMBLY : 1) [illegible] [FM01 and FM02]
2) POWER SUPPLY

DRAWING NO. : 1) G10/523
2) G10/462

THE ABOVE UNITS ARE CLEARED FOR TEST AND EVALUATION SUBJECT TO TH

WAIVERS GIVEN BY PROJECT.

([illegible])
ENGR. QAED

(V. [illegible] JOSHI)
ENGR. QAED

TO :

CHAIRMAN T&E COMMITTEE
RADIOASTRON PROJECT
SAC.

Appendix - V

LIST OF TEST EQUIPMENTS

1.	Scalar Network analyser	HP 8757
2.	Vector network analyser	HP 8510
3.	Spectrum Analyser	HP 8562
4.	Synthesized RF sweeper	HP 8341
5.	Plotter	HP 7475
6.	Directional coupler	HP 11692
7.	Noise figure meter	HP 8970
8.	Noise Source (5dB ENR)	HP 346A
9.	EATON Hot & Cold Noise Source	

APPENDIX - 5

- Supplement to T&E Reports

INTRODUCTION

This report contains results of tests performed by the designer and the test & evaluation committee, but not listed in the summary sheet of Test & Evaluation Report [# SAC-R&QA-RES-TR-09-96] of the Engineering Model and the Flight Models [# SAC-R&QA-RES-TR-10-96].

TESTS PERFORMED

1 Gain & Noise temperature Vs Frequency -

Table 1 and 2 give the gain and noise temperature variation over the pass band ie. 320 to 328 MHz, in 1 MHz steps for all the models.

2 Test for Unconditional Stability -

The unconditional stability of the LNAs over a frequency range of 100 KHz to 3 GHz have been checked with a 65cm long 0.141" semirigid cable at the input side. No spurious line has been found when tested with a 20cm long adjustable shorted stub connected to the free end of the semirigid cable.

3 Output 1dB Compression Point -

The output 1dB compression points of the LNAs is as follows:

EM01[CH1]	-0.14 dBm
EM01[CH2]	-0.74 dBm
FM01[CH1]	-2.94 dBm
FM01[CH2]	-0.47 dBm
FM02[CH1]	-2.49 dBm
FM02[CH2]	-3.25 dBm

Refer the T&E documents for the plots.

4 Gain & Phase Vs Temperature -

Table 3 shows the gain and phase variation with temperature. The gain variation is about -0.01 dB/°C and the phase variation is about 0.1 deg/°C in the temperature range of 0 °C to 40 °C.

5 Gain & Phase Stability -

The gain stability over a four hour period was measured and the phase stability over the same period but in 10 minutes interval. The results are in Table 4.

RADIOASTRON PROJECT --- 92 cm FRONT END

GAIN Vs. FREQUENCY MEASUREMENTS
(FINAL BENCH TEST)

FREQ in MHz	FRONT END GAIN IN dB					
	MODEL = ETM		MODEL = FM-1		MODEL = FM-2	
	CH1	CH2	CH1	CH2	CH1	CH2
320	38.20	37.35	37.55	37.02	37.03	36.08
321	38.36	37.48	37.68	37.15	37.18	36.20
322	38.52	37.62	37.83	37.29	37.39	36.33
323	38.73	37.80	38.01	37.48	37.53	36.49
324	38.87	37.92	38.12	37.60	37.67	36.60
325	39.08	38.13	38.31	37.78	37.87	36.78
326	39.27	38.27	38.46	37.95	38.05	36.93
327	39.45	38.43	38.60	38.10	38.21	37.08
328	39.63	38.58	38.72	38.24	38.33	37.20

RADIOASTRON PROJECT --- 92 cm FRONT END

NOISE TEMPERATURE Vs. FREQUENCY MEASUREMENTS
(FINAL BENCH TEST)

FREQ in MHz	FRONT END NOISE TEMP IN deg K					
	MODEL = ETM		MODEL = FM-1		MODEL = FM-2	
	CH1	CH2	CH1	CH2	CH1	CH2
320	25.80	26.90	27.30	28.50	25.10	26.50
321	27.20	27.00	28.20	28.70	25.20	25.60
322	25.80	26.10	28.00	28.20	24.50	25.50
323	25.80	25.80	27.50	27.20	24.80	25.60
324	25.30	25.70	27.60	26.50	24.80	25.60
325	25.10	25.10	28.10	27.80	24.20	24.50
326	25.20	26.30	27.00	27.30	24.30	25.00
327	24.30	24.80	27.20	27.50	24.60	24.80
328	25.30	25.10	27.70	27.20	24.10	25.00

RADIOASTRON PROJECT --- 92 cm FRONT END

(GAIN & PHASE) Vs. TEMPERATURE MEASUREMENTS
(FINAL BENCH TEST)

TEMP in deg C	MODEL=ETM; FREQ=324 MHz			
	GAIN (dB)		PHASE (deg)	
	CH1	CH2	CH1	CH2
0	38.16	37.97	105.30	102.00
25	37.90	37.78	109.00	104.80
40	37.60	37.44	111.00	106.40

RADIOASTRON PROJECT --- 92 cm FRONT END

(GAIN & PHASE) STABILITY MEASUREMENTS
(FINAL BENCH TEST)

TIME ELAPSED in (HR:MIN)	MODEL=ETM; FREQ=324 MHz; CHANNEL = CH1	
	GAIN (dB) CH1	PHASE (deg) CH1
00:00	38.860	143.61
00:30	38.858	144.25
00:40	--	144.28
00:50	--	144.31
01:00	38.854	144.31
01:10	--	144.32
01:20	--	144.32
01:30	38.851	144.32
02:00	38.848	144.33
02:30	38.846	144.32
03:00	38.844	144.33
03:30	38.844	144.33
04:00	38.844	144.33

APPENDIX - 6

- Acceptance Protocol
- Acceptance Report

Acceptation of EM 01, FM 01& FM 02 of the RADIOASTRON 92cm LNA

After the functional tests according to the technical requirement "LNA -MUY-92 Test Program " in the MoU between the ASC, Moscow and TIFR, India dated 12th December, 1992, the following items :

#1 Engineering Model EM01 of LNA (MUY -92)
#2 Flight Model FM01 of LNA (MUY -92)
#3 Flight Model FM02 of LNA (MUY-92)

were handed over from Tata Institute of Fundamental Research, India to Astro Space Center, Moscow.

[1] The above units were accepted by the Astro Space Center.
The acceptance tests were conducted in 'KB Gorizont', Nizhnij Novogord .

[2] The units were supplied with -
#1 Operating Manuals
#2 Technical Description
#3 Passports for each unit
#4 Test report
#5 SMA straight plug connectors (direct solder attachment) - 20 nos.
#6 SMA connector savers - 10 nos.

[3] The positive results of the functional tests of the LNAs indicate that the units have sustained the transportation test as they were carried by car, train and flight , from Pune to Moscow. This protocol was required by ASC as the transportation and shock tests couldn't be conducted by TIFR at India.

[4] The engineering model of the LNA was integrated with the 92cm receiver KPT -92 of KB Gorizont and the measurement results were acceptable to ASC.

[5] In the Passports of the units, "Acceptance Certificate" and "Warranty Certificate" have to be duly corrected by TIFR, India and handed over to ASC, by December 1996.

[6] The following deviations were noticed while conducting the acceptance tests on the models :
(a) The LNAs have a gain slope of about 1.5dB over the passband 320 to 328 MHz
(b) The gain of the LNAs were about 38dB against the specification of 33dB (Max).
But these deviations were acceptable to the ASC and the receiver group of KB Gorizont.

[7] TIFR, India will try to explore the possibility of providing a SMA torque wrench for use with the LNAs. This is based on a request from the receiver group of KB Gorizont.

Place: ASC, Moscow.

Date:December 2, 1996

Srinivas Meenakshi Sundaram
TIFR, INDIA

Dr. V. Slysh

Dr. V. Andreyanov

V. Vasilkov

ASC, Moscow

ACCEPTANCE TEST RESULTS OF 327 MHz LNA [Engineering Model]

Date: 26th - 29th November, 1996
Place: 'KB' GORIZONT, Nijzhni Novgorod, Russia

Members Present:
ASC Representative: Valeri Vasilkov
TIFR Representative: Srinivas M
KB Gorizont Representatives: Albina N. Fomina, Kozminykh V.G, Lomakin S.V, Tagunov M.N.

INPUT VSWR	320	325	330[MHz]
CH1	1.40	1.31	1.41
CH2	1.22	1.29	1.32

OUTPUT VSWR	320	324	328	[MHz]
CH1	1.20	1.21	1.21	
CH2	1.15	1.15	1.16	

NCal Port VSWR @ 324MHz = 1.30

GAIN	320	324	328	[MHz]
CH1	38.4	39.3	39.9	[dB]
CH2	37.5	38.4	38.8	[dB]

GAIN SLOPE: ~ 1.5dB over 8MHz pass band

Noise Cal. COUPLING -

CH1	29.4 dB
CH2	27.1 dB

ISOLATION Between Channels -

CH1 wrt CH2	62 dB
CH2 wrt CH1	72 dB

DC Power consumption [@ +12V] -

CH1 Current	36 mA
CH2 Current	35 mA

INTEGRATION of LNA [EM] with Receiver П-KPT-92 -

Noise temperature measured with H/C body and output deflections recorded using a microvoltmeter [MICROVOLTOMIERZ SELECKTYWNY "INCO", Type DMS-4].

[T_c = 87 °K
T_h = 298 °K]

NOISE TEMPERATURE -

CH1	20 ±2 °K
CH2	19 ±2 °K

OTHER REMARKS:

Unconditional stability check has been done with the inputs open, shorted and terminated and the output observed on a spectrum analyzer from DC - 1.5GHz.

The integrated response of the LNA and the Dielectric resonator Filter was found to be acceptable.

ACCEPTANCE TEST RESULTS OF 327 MHz LNA [Flight Model 01]

Date: 27th - 29th November, 1996
Place: 'KB' GORIZONT, Nijzhni Novgorod, Russia

Members Present:
ASC Representative: Valeri Vasilkov
TIFR Representative: Srinivas M
KB Gorizont Representatives: Albina N. Fomina, Kozminykh V.G, Lomakin S.V, Tagunov M.N.

INPUT VSWR	320	324	330[MHz]
CH1	1.35	1.43	1.51
CH2	1.45	1.49	1.49

OUTPUT VSWR	320	324	328	[MHz]
CH1	1.22	1.22	1.22	
CH2	1.22	1.22	1.23	

NCal Port VSWR @ 324MHz = 1.324

GAIN	320	324	328	[MHz]
CH1	37.9	38.6	39.2	[dB]
CH2	37.3	38.0	38.6	[dB]

GAIN SLOPE: ~ 1.3dB over 8MHz pass band

Noise Cal. COUPLING -

CH1	27.6 dB
CH2	26.77 dB

ISOLATION Between Channels -

CH1 wrt CH2	64 dB
CH2 wrt CH1	60 dB

DC Power consumption [@ +12V] -

CH1 Current	33 mA
CH2 Current	37 mA

NOISE TEMPERATURE -

Noise temperature measured with H/C body and output deflections recorded using a microvoltmeter [MICROVOLTOMIERZ SELECKTYWNY "INCO", Type DMS-4].

[T_c = 83.5 °K
T_h = 296.5 °K]

CH1	16 ±3 °K
CH2	16 ±3 °K

OTHER REMARKS:

Unconditional stability check has been done with the inputs open, shorted and terminated and the output observed on a spectrum analyzer from DC - 1.5GHz.

The integrated response of the LNA and the Dielectric resonator Filter was found to be acceptable.

ACCEPTANCE TEST RESULTS OF 327 MHz LNA [Flight Model 02]

Date: 27th - 29th November, 1996
Place: 'KB' GORIZONT, Nijzhni Novgorod, Russia

Members Present:
ASC Representative: Valeri Vasilkov
TIFR Representative: Srinivas M
KB Gorizont Representatives: Albina N. Fomina, Kozminykh V.G, Lomakin S.V, Tagunov M.N.

INPUT VSWR	320	324	330[MHz]
CH1	1.28	1.34	1.43
CH2	1.49	1.56	1.63

OUTPUT VSWR	320	324	328	[MHz]
CH1	1.25	1.25	1.25	
CH2	1.22	1.23	1.23	

NCal Port VSWR @ 324MHz = 1.32

GAIN	320	324	328	[MHz]
CH1	37.9	38.6	39.4	[dB]
CH2	37.0	37.7	38.4	[dB]

GAIN SLOPE: ~ 1.5dB over 8MHz pass band

Noise Cal. COUPLING -

CH1	27.6 dB
CH2	27.3 dB

ISOLATION Between Channels -

CH1 wrt CH2	> 75 dB
CH2 wrt CH1	61 dB

DC Power consumption [@ +12V] -

CH1 Current	28 mA
CH2 Current	28 mA

NOISE TEMPERATURE -

Noise temperature measured with H/C body and output deflections recorded using a microvoltmeter [MICROVOLTOMIERZ SELECKTYWNY "INCO", Type DMS-4].

[T_c = 83.5 °K
T_h = 296.5 °K]

CH1	16 ±3 °K
CH2	16 ±3 °K

OTHER REMARKS:

Unconditional stability check has been done with the inputs open, shorted and terminated and the output observed on a spectrum analyzer from DC - 1.5GHz.

The integrated response of the LNA and the Dielectric resonator Filter was found to be acceptable.