Development of Low Cost Home And Community TV and Radio Receive Only Earth Terminals for the Australian Domestic Satellite Communication System

DSS File No. 15ST.36100-0-0696
Contract Serial No. 0ST80-00071

SED SYSTEMS INC.

SED SYSTEMS INC.
P.O. Box 1464
Saskatoon, Saskatchewan
S7K 3P7 Canada

Phone (306) 244-0976
Telex 074-2495

Earth Stations: 244-3633
Telex: 074-2771
Telecommunications: 664-4455

DRAFT FINAL REPORT

DRAFT

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DATED:

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PREPARED FOR:

Department of Communications
Communications Research Centre
P.O. Box 11490, Station "H"
Ottawa, Ontario K2H 8S2
Scientific Authority: Mr. Eric Tsang

PREPARED BY:

R. Strother-Stewart
R. Strother-Stewart

for
H. Chou

APPROVED BY:

for
H.A. Grant, Vice President
Research and Development

PROPRIETARY INFORMATION

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DEVELOPMENT OF LOW COST HOME AND COMMUNITY TV AND RADIO RECEIVE ONLY EARTH TERMINALS FOR THE AUSTRALIAN DOMESTIC SATELLITE COMMUNICATION SYSTEM.

DSS File No. 15ST.36100-0-0696, Contract Serial No. OST 80-0071

EXECUTIVE SUMMARY

Prior to the issue of the RFT for earth stations for the ANSCS (Australian National Satellite Communications System), SED Systems Inc. had participated in the Canadian Hermes and ANIK B experimental programs in cooperation with, and under contract to, the Department of Communications. Specifically, SED had developed and manufactured the 12GHz LNC (low noise converter) for the DBT experiments. In addition, SED had developed and was manufacturing a line of high quality TV receivers for application with 6/4GHz satellites.

The prospect of significant export sales into the ANSCS system for home and community television reception was appealing. SED would be in a strong position to capture this export market if the technology in the LNC and 4GHz receiver could be advanced to the state required in the ANSCS HACBSS (Homestead and Community Broadcast Satellite Service) system.

The key technological factors that had to be addressed were the special requirements placed upon the long term and short term stability of the SHF oscillator in the LNC, the requirement to provide for reception of up to four SCPC audio channels, the conversion to the PAL television system and the achievement of a low cost implementation for operation in a harsh environment. These factors are in large part specific to the ANSCS HACBSS system and are not applicable in the case of North American

and European DBS systems. Although SED had the background and skills to develop earth stations for the HACBSS system, due to the high investment and high element of risk involved, SED could not have embarked on a development program to meet these requirements without external support.

In addition to technological factors, political and economic factors dictated that to be successful in marketing into Australia, SED had to have an Australian partner. SED established a relationship with CODAN Pty. Ltd. of Adelaide, South Australia for the joint manufacture of certain elements, the marketing, and after sales support of the HACBSS stations.

SED proposed to conduct the technology development phases of the program under contract to DOC. DSS granted a $200,000 development contract to SED on behalf of DOC for the purpose of developing the technology and in turn to support the SED tender in response to the ANSCS RFT for HACBSS stations. All objectives under the contract have been achieved.

A high stability, low cost SHF oscillator has been developed. It is of the dielectric resonator oscillator (DRO) type and features excellent long term stability and sufficient short term stability to allow home reception quality of SCPC FM audio program without AFC control other than that which is provided in normal consumer FM receivers. The DRO is low in power consumption (compared with those of the Gunn oscillator type) which alleviates the thermal problems associated with operating in extremely hot climate (to +50°C ambient).

A low-cost, high performance GaAs FET LNA has been developed, as well as an efficient mixer design.

The receiver incorporates a low cost dual conversion tuner with electronic tuning under microprocessor control. Very little tuning and alignment is required during manufacture as the filters are fixed and implemented in stripline. Threshold extension using FMFB techniques has been implemented since deep fading may be experienced in heavy rainfall areas of Australia and since consumer receivers are operated at lower C/N and video S/N than commercial receivers in the interests of the lower cost that accrues due to lowering of station G/T. The FMFB demodulator also affords a degree of AFC for video reception. Coarse AFC and channel selection is implemented via the microprocessor. The microprocessor is intended to drive a display as well which enhances consumer appeal and facilitates optional remote control.

Perhaps the single most important objective that has been achieved is that the development has been accomplished in a time scale consistent with the support of submission of a tender for the HACBSS stations. At the time of writing of this report, SED has been informed that it will be receiving an order for 34 HACBSS stations of varying G/T for evaluation by ANSCS authorities. SED is confident that the stations will receive a favorable evaluation due to the success of our development program and SED experience to date in demonstrating its terminal alongside those of non-Canadian competitors at trade shows. In turn, SED, along with CODAN Pty. Ltd., expects to capture a significant portion of the Australian HACBSS market when it materializes in early 1985.

The benefit to SED resulting from this development contract is self evident in the foregoing. Of even greater economic significance, however, is the North American market opportunity for interim DBS systems. The technology SED has acquired, in part through this contract, has allowed it to conclude an agreement with General Instruments Corporation (GIC) for the licensing of television receive only technology. The Jerrold Division of GIC in Toronto will manufacture the majority of the volume production hardware, while SED intends to manufacture a high volume of LNC's in an expanded operation in Saskatoon. Most of the hardware is for the export market, initially to the U.S., and later to Europe and elsewhere.

ACKNOWLEDGEMENT

SED Systems Inc. is grateful for the encouragement and support of the Department of Communications, especially to Wilf Thrienen, Bob Huck, Rene Douville and Eric Tsang.

As ambassadors to Canadian space industry the endeavors of the late Dr. John Chapman and of George Davies in Australia, including the conducting of convincing demonstrations via an ailing Hermes satellite, have been significant in helping SED and other Canadian manufacturers to be recognized in Australia and world-wide.

DEVELOPMENT OF LOW COST HOME AND COMMUNITY TV AND RADIO RECEIVE ONLY EARTH TERMINALS FOR THE AUSTRALIAN DOMESTIC SATELLITE COMMUNICATION SYSTEM.

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1.0 Introduction

This Final Report constitutes the final deliverable under DSS Contract No. OST 80-00071 on behalf of the Department of Communications. There are no hardware deliverables under the contract although all key subsystems comprising the eventual HACBSS station have been designed, breadboarded and tested.

Systems tradeoffs leading to the chosen hardware design approaches are discussed. LNC and receiver designs are described in detail, and theoretical and measured performance are described.

2.0 System Design

Introduction

This section contains analysis on signal levels, G/T and video and audio performance. Both video receiver and SCPC radio program service are covered.

2.1 System G/T

The receive system G/T is the ratio of antenna gain to system noise temperature and is a figure of merit for determining the sensitivity of the receive system.

The following was assumed to provide as an example of how the final system can be configured. The center beam and beam edge satellite EIRP's are 50 dBW and 47 dBW respectively. Also 0.9m and 1.2m diameter dishes are used correspondingly. The receiver noise figure of 3.5 dB includes that of the low noise converter (LNC), plus contributions due to cable loss and the indoor unit. A system G/T of 12.9 dB for center beam and 15.4 dB for beam edge is achieved. See Table 2.1 for details.

Table 2.2 shows the LNC input carrier levels C, the operating C/T and predicted C/N for an 18 MHz wide video receiver IF bandwidth. For beam center and beam edge the C/T is -144.1 dBW/°K and -144.6 dBW/°K respectively.

Table 2.3 presents similar information to that of Table 2.2 but for SCPC radio carriers. This carrier is backed off below the video carrier by 19.4 dB. For beam center and beam edge the C/T is -163.5 dBW/°K and -164.0 dBW/°K respectively.

2.2 Video Performance

Table 2.4 outlines the expected weighted video S/N for both center and beam edge cases. The expected video S/N is 41.7 dB and 41.2 dB respectively. This is based on the NTSC 525 line system. Values could be slightly different for a Pal 625 line system.

2.3 Audio Performance (TV program)

Table 2.5 details the analysis to determine the audio S/N for the 1.2 meter dish and beam edge. This assumes 50µs de-emphasis and Australian CCIR noise weighting. The expected audio S/N is 42.3 dB.

2.4 Audio S/N vs G/T and SHF Oscillator Noise

This section details the audio signal to noise ratio of the SCPC radio program receiver due to both C/T and the SHF oscillator noise. Since these carriers are low deviation compared to video, they are sensitive to LO noise. Table 2.6 shows the predicted audio S/N for both the center and beam edge conditions of 49.2 dB and 49.0 dB respectively. An implementation margin of about 3.0 dB includes SHF oscillator degradation.

The SHF oscillator in the LNC is not a PLO for economic reasons. A DRO oscillator is used due to a cost performance tradeoff. It is assumed to have a 150Hz RMS of FM as measured in a 15 KHZ audio bandwidth, 75µs de-emphasis and CBC program noise weighting. Figure 2.1 compares the expected audio S/N when using a PLO to using the DRO oscillator. The worse case operating point of 49 dB audio S/N corresponds to a 2 dB degradation over using a PLO.

2.5 System Block and Level

The system block and level diagram (Figure 2.2) gives the TV carrier levels throughout the receive system. The 1.2m dish is shown operating at beam edge. The outdoor LNC has 50 dB gain providing -38.3 dBm to the input of the IFL cable. A maximum 7 dB loss is allowed in this cable to provide -45.3 dBm to the IDU. The IDU has a loop thru coupler on its input to permit cascading IDU's. Upto 6 are recommended with the last output being terminated in 75 ohms.

Table 2.7 lists recommended IFL cables for various lengths between the LNC and IDU. Due to the higher operating frequency 950 to 1450 MHz cable loss and gain slope are significant. The IDU has about a 2 dB gain slope compensation built into it. Excessive IFL loss means insufficient drive to the IDU and reduced G/T of the terminal. For the lowest cost cable up to 15 meters of RG-59 cable is recommended. Longer lengths require more expensive cable. Andrew FHJ4-75 permits a 60 meter IFL run.

TABLE 2.1 HACBSS RECEIVE SYSTEM ANALYSIS

Suggested parameters for a typical receive system:
(Video Receiver)

	Beam Center	Beam Edge
Satellite EIRP	50 dBw	47 dBw
Antenna Size Diameter	0.9 m	1.2 m
Antenna Efficiency	.65	.65
Antenna Gain G	39.2 dB	41.7 dB
Receiver Nf	3.5 dB	3.5 dB
Receiver Temperature	360°K	360°K
Sky Noise	70°K	70°K
System Temperature T	430°K	430°K
System G/T	12.9 dB	15.4 dB

TABLE 2.2:

Video Receiver C/T and C/N

	Beam Center	Beam Edge
Satellite EIRP	50 dBw	47 dBw
Path Loss	-206.3 dB	-206.3 dB
Absorbtion	-.2 dB	-.2 dB
Pointing	-.5 dB	-.5 dB
Antenna Gain	39.2 dB	41.7 dB
C	-117.8 dBw	-118.3 dBw
T dB	26.3 dB	26.3 dB
C/T dBw/°K	-144.1	-144.6
C/No* dB/Hz	84.5	84.0
C/N* for 18 MHz BW	11.9 dB	11.4 dB

* C/No = C/T + 228.6 dB

* C/N = C/No - 10 log BW

TABLE 2.3: SCPC RADIO CARRIER C/T AND C/N

Assumed Transmit EIRP from Satellite (Radio is Video -19.4 dB)		Radio Program Receiver	
		Beam Center	Beam Edge
Satellite EIRP		30.6 dBw	27.6 dBw
Path Loss		-206.3 dB	-206.3 dB
Absorbtion		-.2 dB	-.2 dB
Pointing		-.5 dB	0.5 dB
Antenna Gain		39.2 dB	41.7 dB
	C	-138.4 dBw	-137.7 dBw
	T	26.3 dB	26.3 dB
	C/T dBw/°K	-163.5	-164.0
	C/No* dB/Hz	65.1	64.6
	C/N* @ 250 KHz BW	11.1 dB	10.6 dB

TABLE 2.4: VIDEO RECEIVER BASEBAND PERFORMANCE:

Transmission Parameters (NTSC ANALYSIS)

$\Delta f = 7$ MHz

$fm = 4.2$ MHz

$B = 18$ MHz (If Bandwidth)

$$M = 10 \log 3/2 \left(\frac{\Delta f}{fm}\right)^2 \left(\frac{B}{fm}\right) = 12.5 \text{ dB}$$

Beam	Center	Edge
Antenna Size	0.9 m	1.2 m
C/N	11.9 dB	11.4 dB
M	12.5 dB	12.5 dB
Weighting & Deemphasis	19.3 dB	19.3 dB
Implementation Margin	-2.0 dB	-2.0 dB
Expected Video S/N	41.7 dB	41.2 dB

TABLE 2.5: AUDIO S/C S/N FOR C/T = -118.3 dBw

Transmission Parameters

C/N at main If $(C/N)_1$ = 11.4 dB

BW of main If B_1 = 18 MHz

Subcarrier freq. F_1 = 6.2 MHz

Deviation of main carrier ΔF_1 = 1.4 MHz peak

Deviation of subcarrier ΔF_2 = 75 KHz peak

Subcarrier If BW B_2 = 190 KHz

Top Baseband frequency fm = 15 KHz

Subcarrier C/N $(C/N)_2$ = unknown

$$(C/N)_2 = (C/N)_1 + 10 \log B_1 - 20 \log\frac{(f1)}{(\Delta f1)} - 10 \log (2B_2)$$

$$(C/N)_2 = 11.4 \text{ dB} + 72.5 \text{ dB} - 12.9 \text{ dB} - 55.8 \text{ dB}$$

$$(C/N)_2 = 15.2 \text{ dB}$$

$$M = 10 \log 3/2 \, \frac{(\Delta f2)}{(fm)}^{2} \frac{(B2)}{(fm)}$$

$$M = 26.8 \text{ dB}$$

$(C/N)_2$ = 15.2 dB

M = 26.8 dB

50μs dephasis, Australian CCIR WTG. = 2.3 dB

Implementation margin = -2 dB

Expected audio S/N 42.3 dB

TABLE 2.6: RADIO PROGRAM RECEIVER BASEBAND PERFORMANCE

Transmission parameters

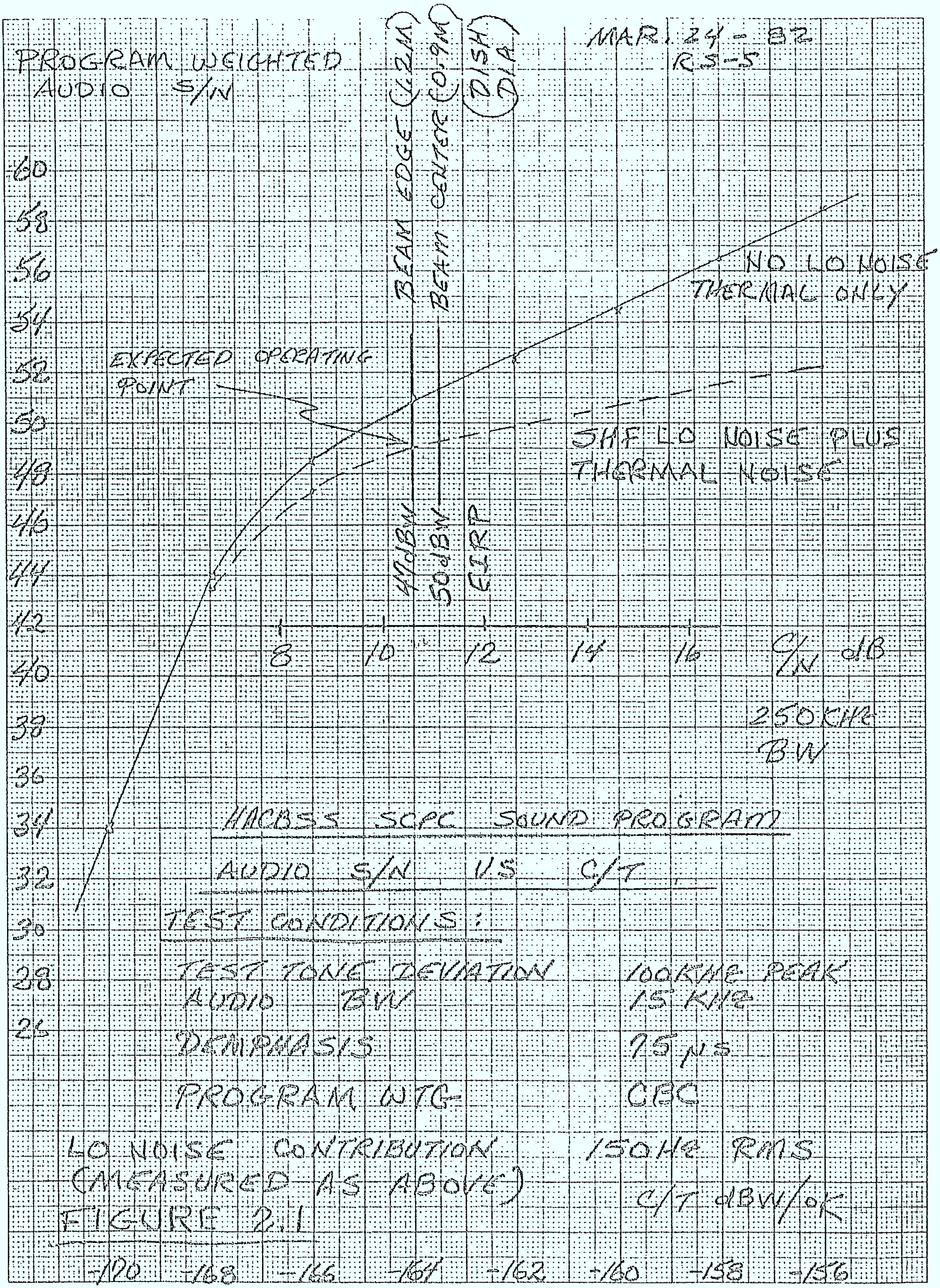
Δf = 100 KHz

fm = 15 KHz

B = 250 KHz

$$M = 10 \log (3/2) \frac{(\Delta f)^2}{(fm)} \frac{(B)}{(fm)} = 30.5 \text{ dB}$$

Beam	Center	Edge
Antenna Size	0.9 m	1.2 m
C/N	11.1 dB	10.6 dB
M	30.5 dB	30.5 dB
75 μs demphasis plus CBC program ETG.	10.6 dB	10.6 dB
Implementation Margin	-3.0 dB	-2.7 dB
Expected Audio S/N	49.2 dB	49.0 dB



HACBSS SCPC SOUND PROGRAM

AUDIO S/N VS C/T

TEST CONDITIONS:

TEST TONE DEVIATION	100KHz PEAK
AUDIO BW	15 KHz
DEMPHASIS	75 µs
PROGRAM WTG	CBC
LO NOISE CONTRIBUTION (MEASURED AS ABOVE)	150Hz RMS

FIGURE 2.1

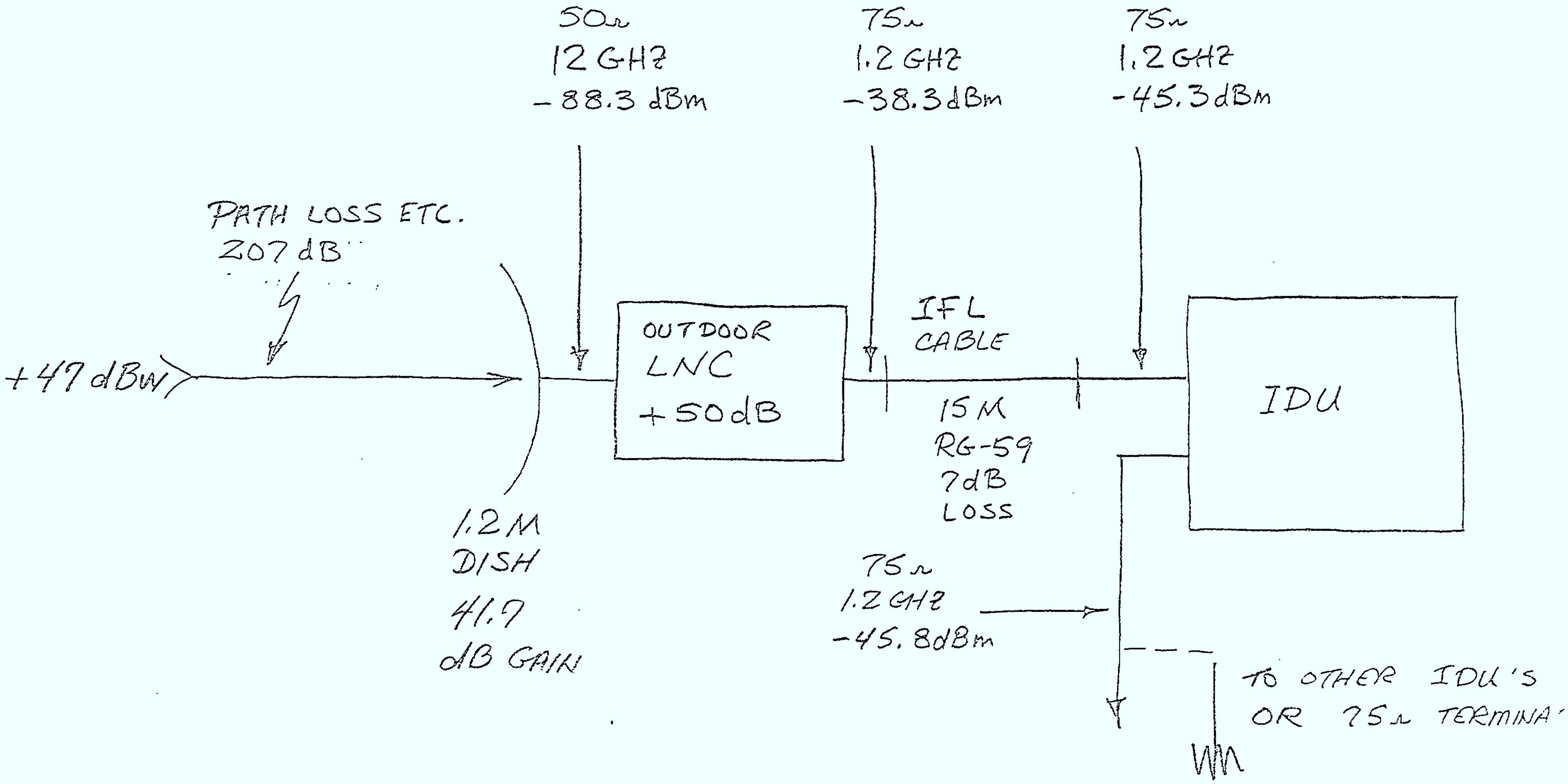


FIGURE 2.2 SYSTEM BLOCK & LEVEL DIAGRAM HACBSS DBT

TABLE 2.7: CABLES RECOMMENDED FOR IFL USE

Nominal loss 7 dB @ 1200 MHz.

Cable Type	Z Ohms	Length Max.	Loss @ 950 MHz	Loss @ 1450 MHz
RG-59	75	15 m	5.5 dB	8 dB
RG-213	50	20 m	5.6 dB	8.3 dB
Andrew FHJ1 ¼" FOAM DIEL.	50	30 m	6.5 dB	8 dB
Andrew FHJ4-75 ½" Foam Diel.	75	60 m	6 dB	8 dB

Nominal gain slope across the band is 2 dB.

Note: Normal impedance will be 75 ohms. 50 ohms will be a special.

Cable costs are increasing from top to bottom.

Nominal Loss Characteristics

CONDITIONS:
Ambient 20 C

Decibels Per Hundred Feet
Frequency In MHz

NOTE: Values above [illegible] considerably depending upon construction
See Application Notes for Attenuation Correction Factors due to ambient change

RG/U	10	50	100	200	400	1,000	3,000	5,000	10,000
5, 5A, 5B, 6A, 6B	.80	1.40	2.90	4.30	6.40	11.00	22.00	30.00	52.00
7	.66	1.50	2.20	3.20	4.60	9.00	19.00	28.00	47.00
8, 8A, 10A, 70, 213, 215	.66	1.50	2.20	3.20	4.60	9.00	19.00	28.00	47.00
9, 9A, 9B, 214	.66	1.50	2.20	3.20	4.60	9.00	19.00	28.00	47.00
11, 11A, 12, 12A, 13, 13A, 216	.66	1.50	2.20	3.20	4.60	9.00	19.00	28.00	—
14, 14A, 74, 74A, 217, 224, 293, 293A, 388	.41	1.00	1.40	2.10	3.10	5.80	13.00	19.00	31.00
17, 17A, 18, 18A, 177, 218, 219, 295	.23	.56	.81	1.20	1.90	3.80	9.00	13.50	—
19, 19A, 20, 20A, 147, 220, 221	.17	.43	.63	.94	1.50	3.00	7.00	—	—
21, 21A, 222	4.40	9.40	12.90	18.20	26.50	44.00	87.00	—	—
22, 22B, 111, 111A	1.20	2.80	4.20	6.30	9.50	—	—	—	—
29	1.35	3.00	4.30	6.00	8.80	16.50	36.00	51.00	85.00
34, 34A, 34B	.32	.90	1.40	2.10	3.30	5.80	16.00	28.00	—
35, 35A, 35B, 164	.24	.60	.90	1.30	2.00	3.70	8.90	15.00	—
54, 54A	.90	2.20	3.30	4.60	6.90	13.10	26.20	35.00	—
55, 55A, 55B, 223	1.35	3.00	4.30	6.00	8.80	16.50	36.00	51.00	85.00
57, 57A, 130, 131, 294, 294A	.65	1.60	2.40	3.60	5.20	10.00	21.20	—	—
58, 58B	1.20	3.10	4.60	7.00	10.00	17.50	38.00	—	—
58A, 58C	1.40	3.30	4.90	7.30	11.00	20.00	41.00	—	—
59, 59A, 59B	1.10	2.30	3.30	4.70	6.70	11.50	25.50	41.00	—
62, 62A, 71, 71A, 71B	.90	1.90	2.80	3.70	5.20	8.50	18.40	29.50	—
62B	.90	2.10	3.00	4.30	6.10	10.50	23.50	36.00	—
63, 63B, 79, 79B	.50	1.10	1.50	2.30	3.40	5.70	12.20	20.90	—
72, 125	.50	1.10	1.60	2.30	3.60	6.20	13.50	22.00	—
87A, 115, 115A, 116, 165, 166, 225, 227, 393, 397	.60	1.40	2.10	3.10	4.50	7.50	14.00	21.00	35.00
94	.60	1.30	2.00	2.90	4.20	7.10	13.00	19.00	33.00
94A, 226	.40	1.00	1.50	2.10	3.00	5.00	10.00	15.00	27.00
108, 108A	2.30	5.20	7.50	11.00	16.00	26.20	54.00	—	—
114, 114A	1.30	2.10	2.90	4.40	6.70	11.60	26.00	40.00	—
117, 117A, 118, 211, 211A, 228, 228A	.25	.61	.90	1.40	2.00	3.40	7.50	11.50	—
119, 120	.50	1.05	1.60	2.20	3.10	5.10	10.20	15.20	27.30
122	1.60	4.40	6.90	11.00	16.60	29.20	57.20	89.00	—
140 141,141A,142,142B,159,302,303,400,402	1.20	2.70	3.90	5.50	8.00	13.00	26.00	36.00	62.00
143, 143A, 304,401	.85	1.80	2.50	3.80	5.70	9.70	18.10	26.10	40.70
144	.38	1.00	1.60	2.30	3.80	7.00	15.10	—	—
161, 179, 179A, 179B, 187, 187A	5.00	7.90	9.80	12.70	15.80	25.00	43.00	62.50	135.00
174, 174A	3.80	6.50	8.90	12.00	17.50	31.00	64.30	97.00	185.00
178, 178A, 178B, 196, 196A, 403, 404	5.30	10.00	13.30	20.00	27.50	45.00	78.00	115.00	172.00
180, 180A, 180B, 195, 195A	3.10	4.20	5.10	7.30	10.40	16.50	36.00	49.50	89.00
183	.18	.38	.53	.78	1.20	1.90	3.70	5.00	—
188, 188A, 316	3.80	7.90	11.50	15.00	20.00	30.00	58.00	79.00	133.00
197, 232	.14	.31	.43	.63	.93	1.60	3.10	4.20	—
198	.23	.53	.78	1.20	1.70	2.80	5.10	6.80	10.00
199	.17	.28	.41	.58	.87	1.50	2.90	4.10	—
200	.07	.16	.23	.33	.51	.93	1.80	—	—
209, 281	.21	.63	1.00	1.60	2.30	4.00	7.60	10.50	18.00
231, 331, 210	.23	.58	.85	1.30	1.90	3.10	6.50	9.00	15.00
233, 240	.08	.17	.23	.33	.49	.85	1.80	—	—
234, 242	.04	.09	.13	.18	.28	.51	—	—	—
235	.60	1.40	2.10	3.10	4.50	7.50	14.00	21.00	35.00
236, 237	.25	.59	.82	1.25	1.80	2.90	5.30	7.20	—
244, 245	.23	.50	.71	1.10	1.60	2.50	4.80	6.30	12.00
246, 247	.13	.28	.39	.58	.83	1.50	2.80	4.00	—
248, 249	.07	.15	.22	.31	.48	.85	1.80	—	—
250, 251	.04	.08	.12	.18	.28	.52	—	—	—
252, 253	.23	.52	.70	1.05	1.50	2.40	4.60	6.50	12.00
254, 255	.13	.30	.42	.60	.86	1.40	2.70	4.00	—
256	.16	.35	.50	.71	1.00	1.70	3.40	4.90	—
257, 258	.07	.16	.23	.32	.46	.76	1.70	—	—
259	.40	.91	1.30	1.90	2.75	4.40	7.60	10.50	16.00
263	.20	.48	.70	1.00	1.50	2.50	4.50	6.00	9.00
265, 267, 270, 270A, 270B, 319, 319A	.06	.14	.20	.30	.44	.76	1.70	—	—
268, 366	.25	.59	.85	1.20	1.80	2.90	5.70	8.30	18.00
269, 269A, 297, 318	.12	.27	.38	.45	.80	1.35	2.60	4.00	—
279	1.40	3.30	4.90	7.30	11.00	20.00	41.00	—	—
280	.37	.90	1.30	2.00	2.90	4.70	9.60	14.00	25.00
282	1.50	3.70	5.20	7.60	11.00	18.00	34.00	48.00	80.00
284, 284A	.11	.25	.35	.44	.75	1.20	2.30	3.80	—
285A	.09	.19	.30	.41	.69	1.00	1.90	3.10	—
286, 292	.05	.13	.19	.29	.41	.55	1.30	—	—
288, 321, 322	.04	.10	.15	.20	.30	.50	—	—	—
289	.04	.10	.15	.20	.30	.50	—	—	—
306, 306A, 336	.15	.33	.52	.80	1.30	2.30	5.20	7.80	—
307, 307A	1.20	2.70	3.80	5.40	7.50	12.00	—	—	—
323, 324, 332, 333, 376	.15	.32	.50	.75	1.20	2.10	4.70	6.50	—
325	.36	.90	1.40	2.00	3.00	5.10	10.00	14.10	26.00
326	.24	.60	.90	1.30	1.80	3.20	6.20	8.40	—
327	.16	.42	.65	.93	1.40	2.50	4.70	—	—
334, 335	.25	.60	.85	1.20	1.90	3.50	7.00	10.00	18.00
360	.18	.40	.60	.90	1.50	2.50	5.30	7.50	—
367	.35	.80	1.20	1.80	2.30	4.00	7.50	10.00	—
369, 370	.34	.80	1.10	1.70	2.40	3.40	6.80	9.50	16.00
377	.28	.65	.92	1.30	1.90	3.10	5.70	7.80	13.00
385	.26	.65	.96	1.40	2.10	3.60	6.90	9.70	16.00
389, 189	.20	.46	.70	1.00	1.50	2.50	5.30	—	—

3.0 Outdoor Unit LNC

3.1 Description of the Low Noise Converter (LNC)

The outdoor LNC offered for the HACBSS is designed for low power satellites such as ANIK C. The basic design of the terminals began in 1976. The current design represents a third generation LNC. The system block diagram of the LNC is shown in Figure 3-1. The direct broadcast terminals employ a prime focus feed with the LNC mounted at the focus of the antenna. The LNC converts the entire 12.25 to 12.75GHz spectrum to the 950 - 1450MHz IF band.

The LNC consists of a prime focus feed, a two stage low noise amplifier (LNA), a double balanced mixer, a four stage IF amplifier and a dielectric resonator stabilized FET oscillator (DRO). The LNC has its own power conditioning circuit. The two key components in the LNC are the LNA and the DRO. (The LNA sets the noise performance of the LNC). The DRO has to maintain a frequency stability of no more than 2MHz variation over -45°C to 55°C. For low power satellite earth terminals, the noise figures of the LNC's have to be in the range of 2.5 dB to 3.2 dB when used in conjunction with small 0.9 meter and 1.2 meter antenna dishes to meet the desired G/T of 14 dB/K. When larger antenna dishes are used, higher G/T values can be met.

3.2 Feed and Packaging Design

The prime focus feed used in the LNC is a high efficiency feed. It consists of a dielectric rod antenna excited by a TE_{11} mode field of a circular waveguide. The geometry of the dielectric rod is selected such that it equalizes the E and H-plane patterns of the feed and improves the aperture efficiency of a paraboloid reflector.

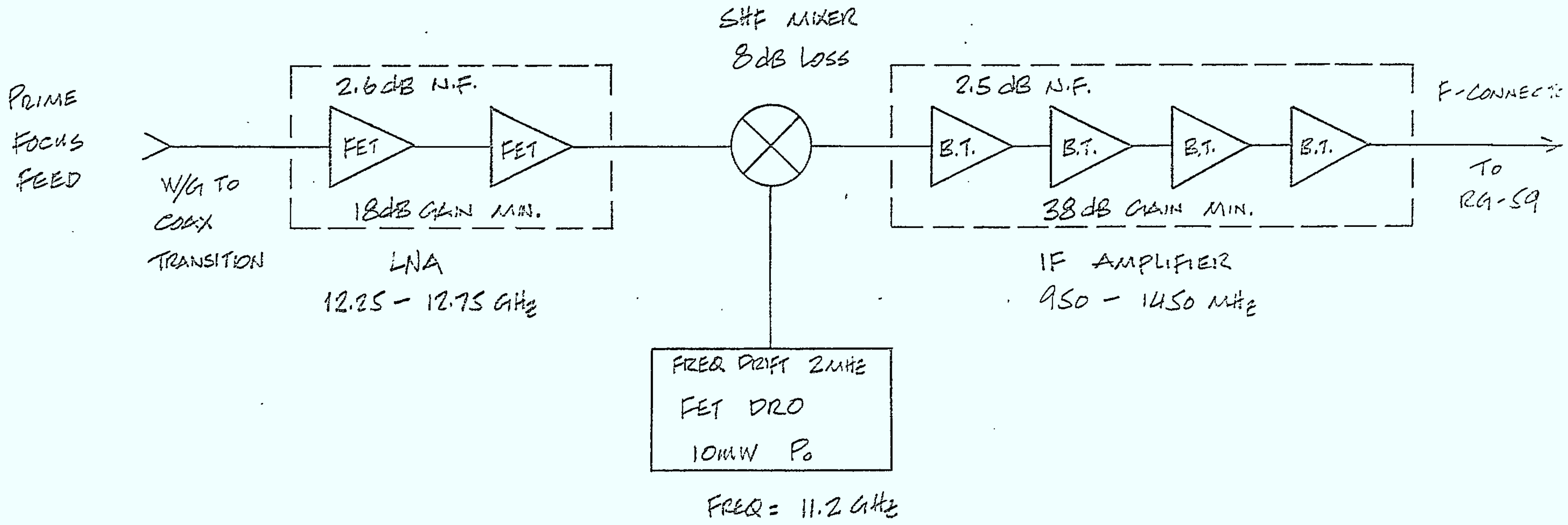


FIGURE 3-1 LNC BLOCK DIAGRAM

The design feed is optimized for illumination of a reflector with f/D = 0.375 and at a center frequency of 12.45GHz. Its operating band is 500MHz, within which the overall antenna efficiency is better than 70 percent. Attempts are made to select geometries that are simple to fabricate and which will result in a low fabrication cost. To meet environmental specifications and also for ease of fabrication the dielectric rod was selected to be an acrylic material with a relative dielectric constant of about 2.65 at 12GHz. This material is easy to machine and has environmental durability. It is also inexpensive and has a low electrical loss factor. The following is a summary of the dielectric feed design specifications:

1. Electrical specifications:

Frequency band	12.2-12.7GHz
VSWR	1.3:1
Reflector overall efficiency	70 - 75 percent
Cross-polarization	-25 dB
Side lobes and back lobes	-20 dB

2. Additional specifications:

Temperature range	-50°C to +60°C
Output impedance of antenna	50Ω coax
Local oscillator attenuation level (11.2GHz)	≃ -40 dB

To ensure the 40 dB local oscillator signal rejection, the diameter of the waveguide was selected to have a cut off frequency of 11.9GHz. As shown in Figure 3-2, the local oscillator signal attenuation at 11.2GHz is about 18 dB/in. Since the total length of the waveguide

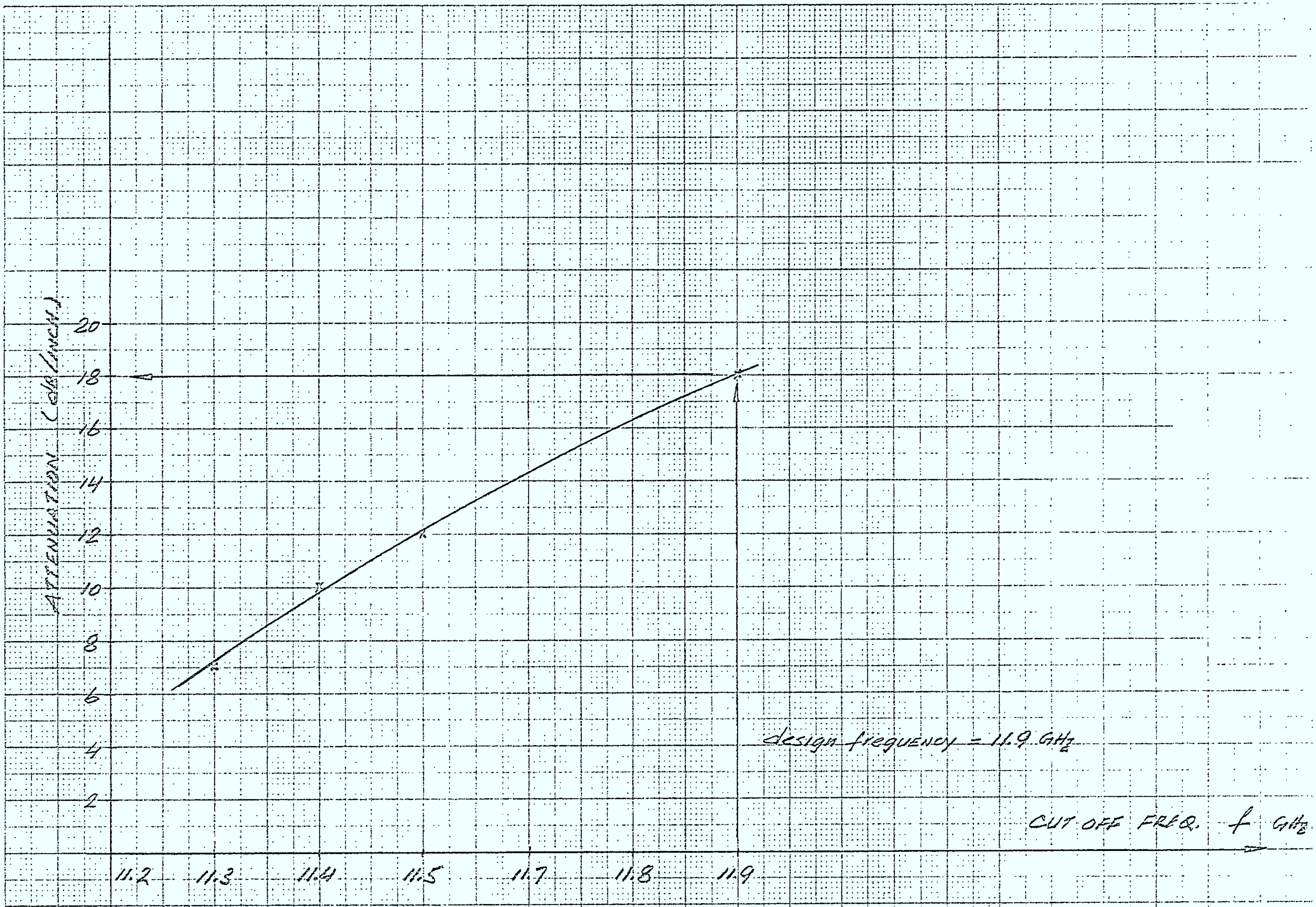


FIGURE 3-2 LOCAL OSCILLATOR SIGNAL ATTENUATION VERSUS CIRCULAR WAVEGUIDE CUT-OFF

available in the LNC is about 2 1/2 inches, the required local oscillator rejection of 40 dB is achieved. In order to have a waveguide cutoff at 11.9GHz, the waveguide diameter must be 14.8mm.

The antenna efficiency at three different frequencies within the band are shown in Figure 3-3. These curves indicate the feed is optimized for a reflector with an f/D ≅ 0.375. The cross-polar patterns are shown in Figure 3-4 to Figure 3-6. Within ±67°, the illumination angle of the reflector, the peak cross-polar level is below -30 dB, which exceeds the specified level of -25 dB. The co-polar patterns are shown in Figure 3-7 to Figure 3-12. The symmetry of the pattern is excellent and the side lobe levels are at least 20 dB down. Since the co-polar patterns of this feed are similar to the pattern of a corrugated feed, its reflector radiation patterns are expected to be the same as well.

The waveguide to microstrip transition is achieved by means of a waveguide end short-circuit, a probe extension of the 50Ω line center conductor, a small screw tuner and special shaping of the dielectric rod. This design is simple and does not require modification on the LNC housing. Figure 3-13 shows the measured return lost of the feed. Within the frequency band its return loss is below -19 dB. The VSWR of the feed is less than 1.25.

The geometry of the dielectric rod and the circular waveguide feed is shown in Figure 3-14. The geometry for the transition is shown in Figure 3-15.

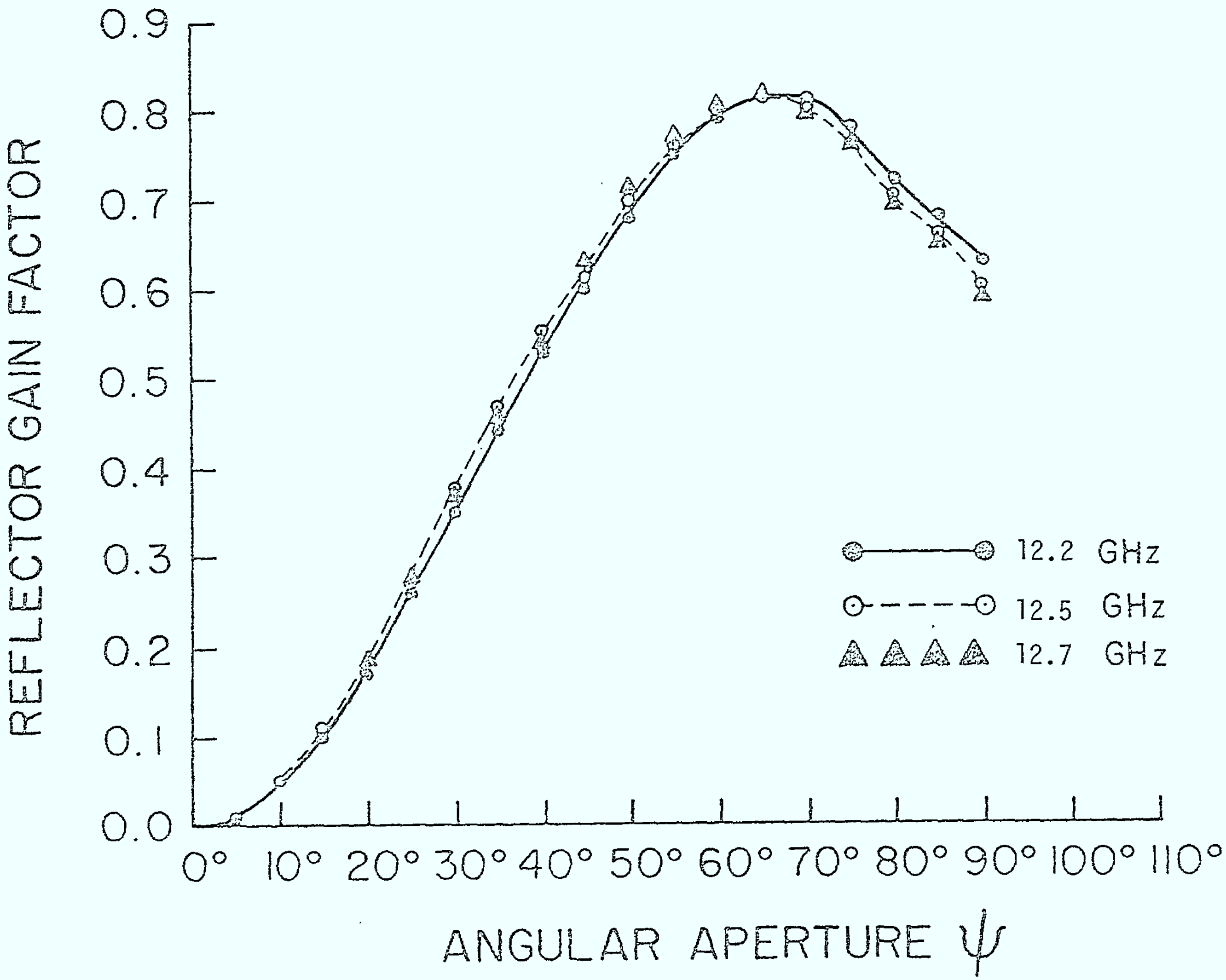


Figure 3-3: Reflector Efficiency.

Figure 3-4: Dielectric rod feed cross-polarization 12·25 GHz

Freq. 12·25 GHz

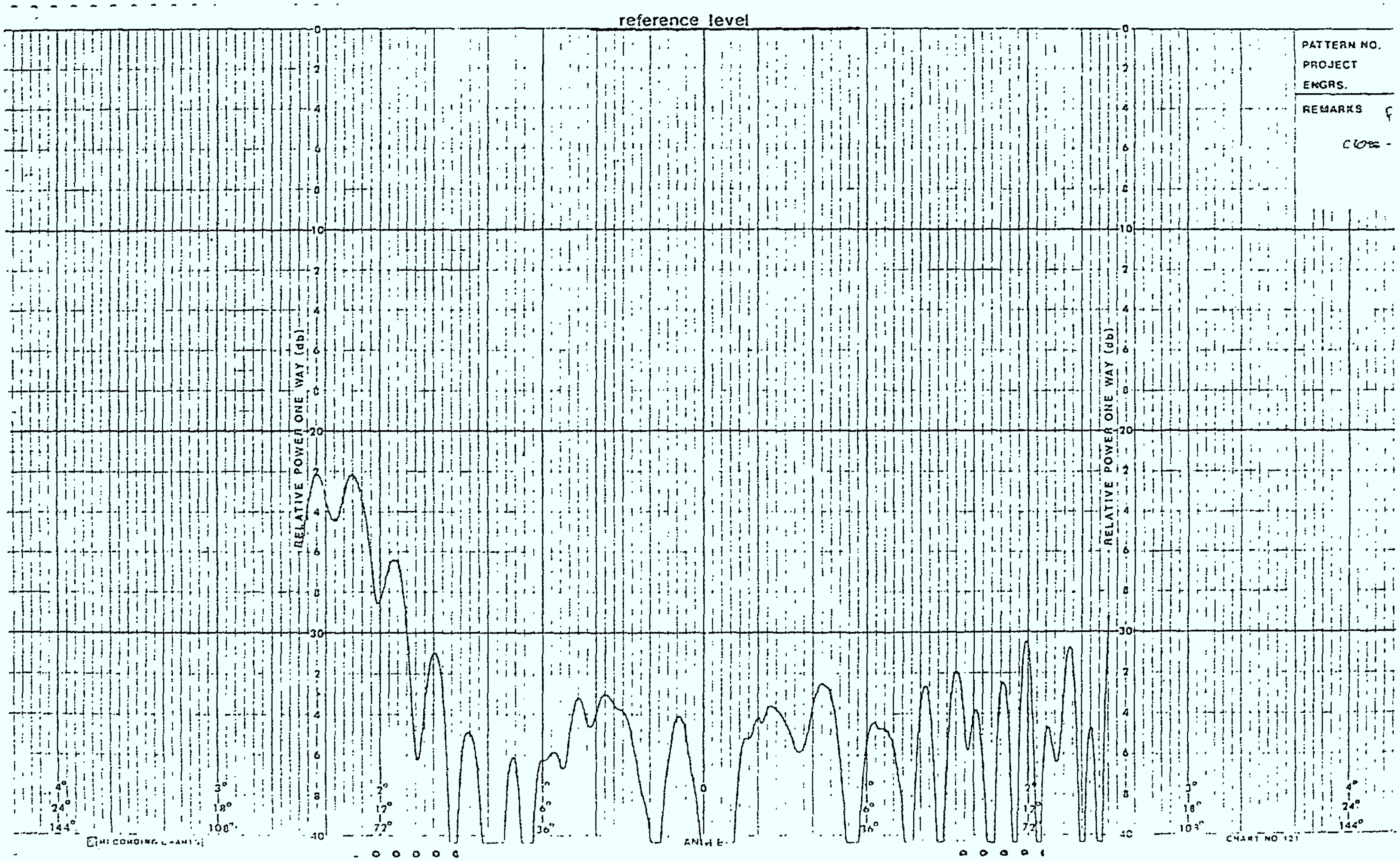


Figure 3-5: Dielectric rod feed cross-polarization at 12.45 GHz

Freq. 12.45 GHz

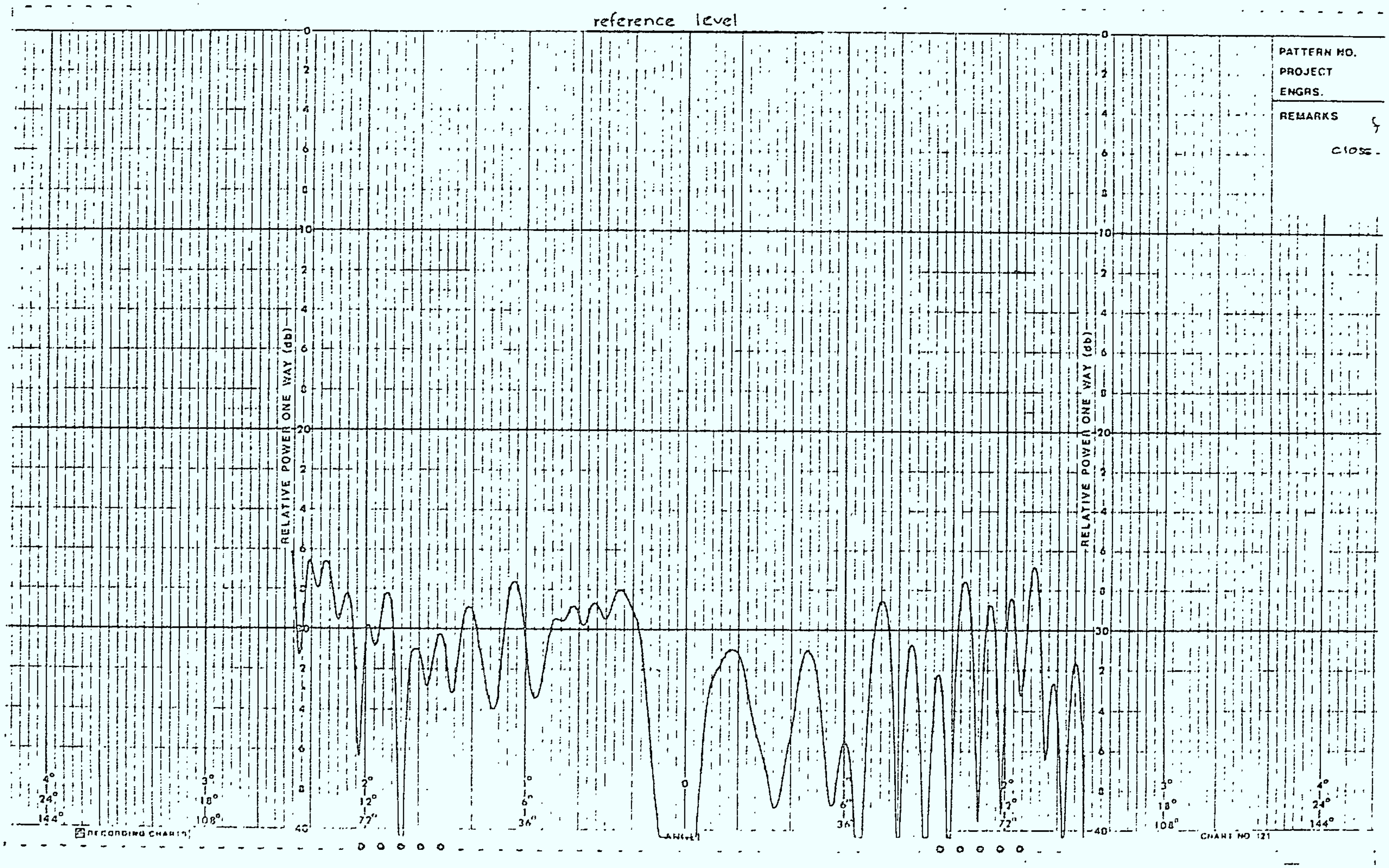
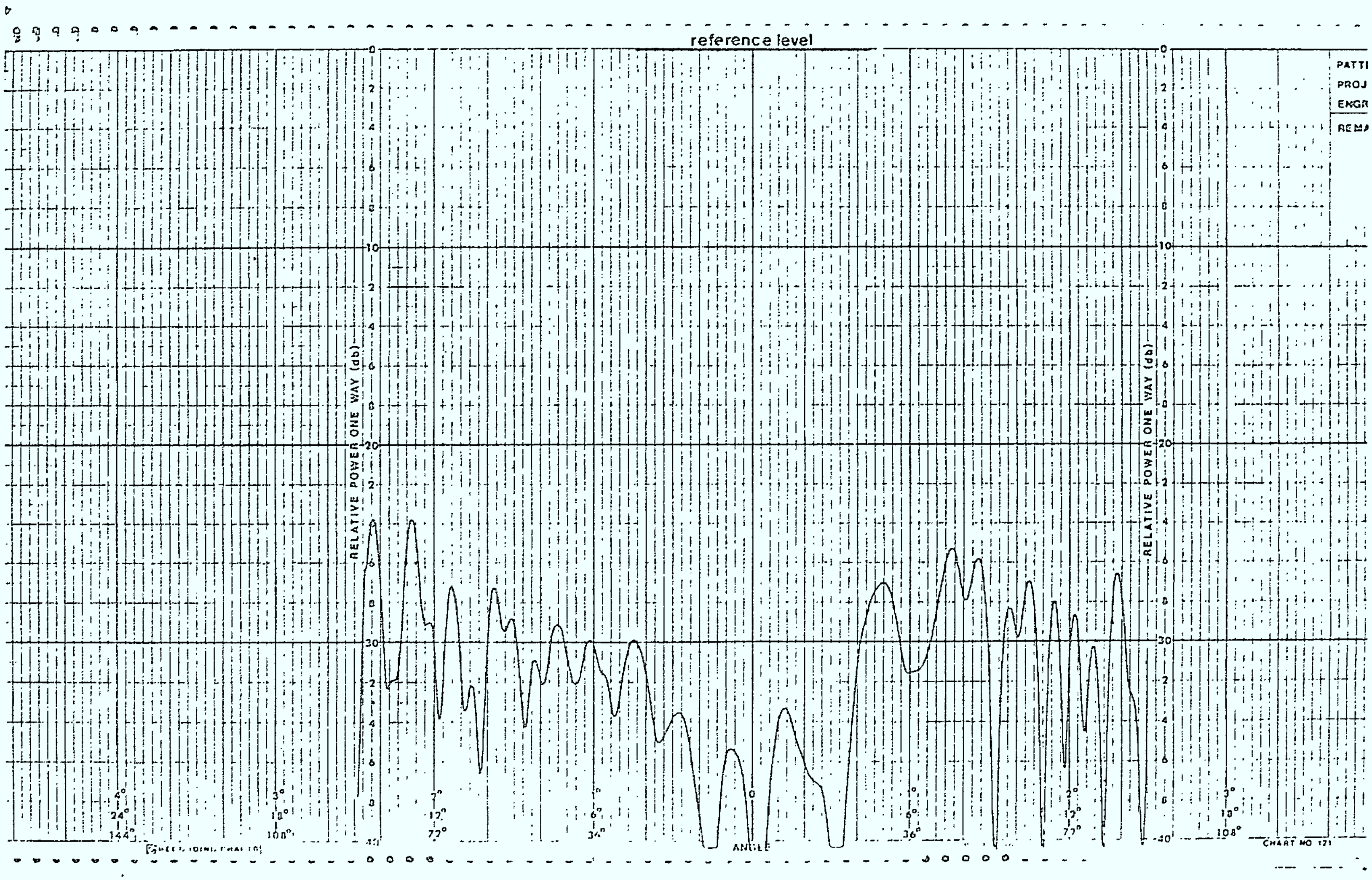


Figure 3-6: Dielectric rod cross-polarization at 12.75 GHz.

Freq. 12.75 GHz



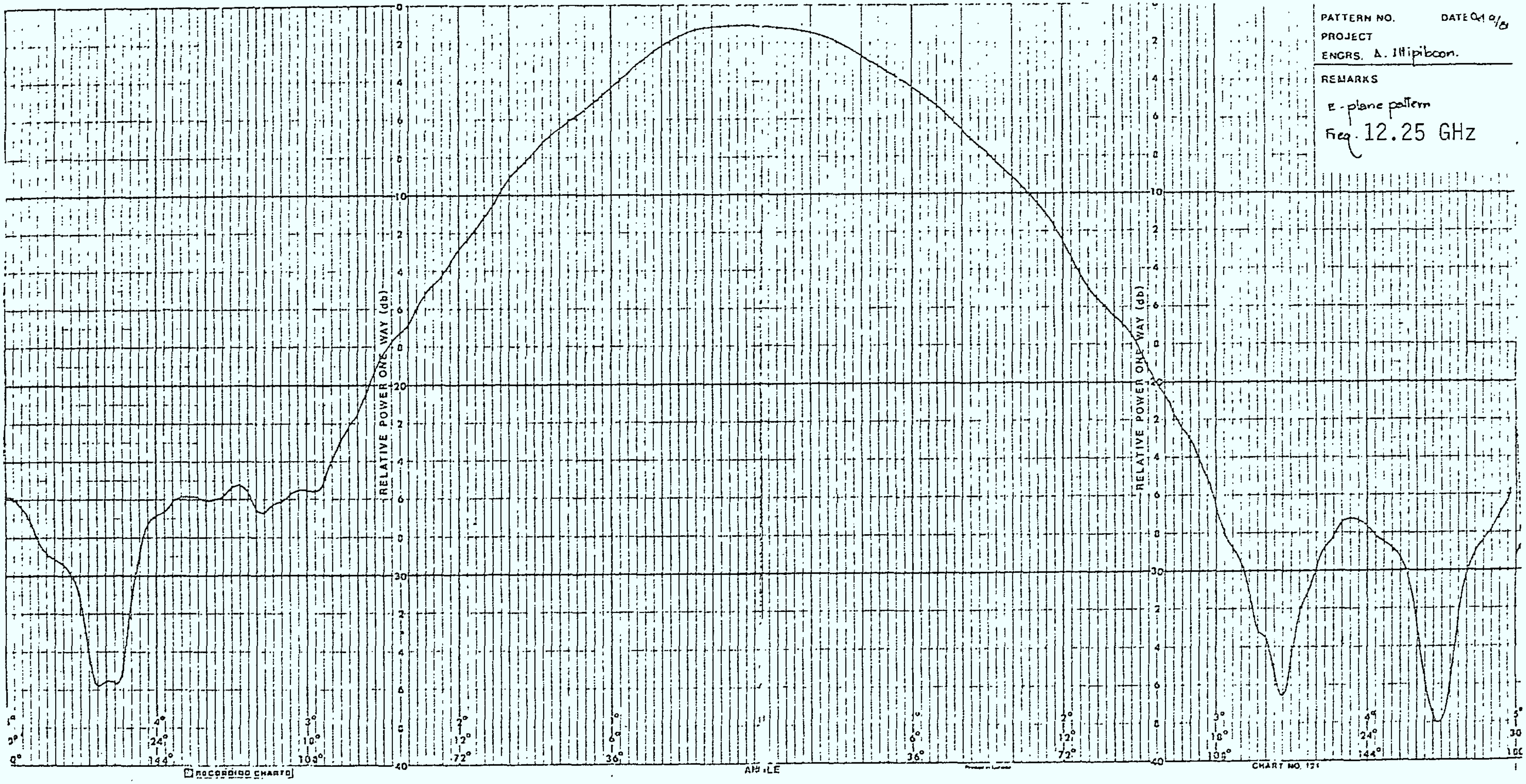


Figure 3-7: E-plane co-polar pattern at 12.25 GHz.

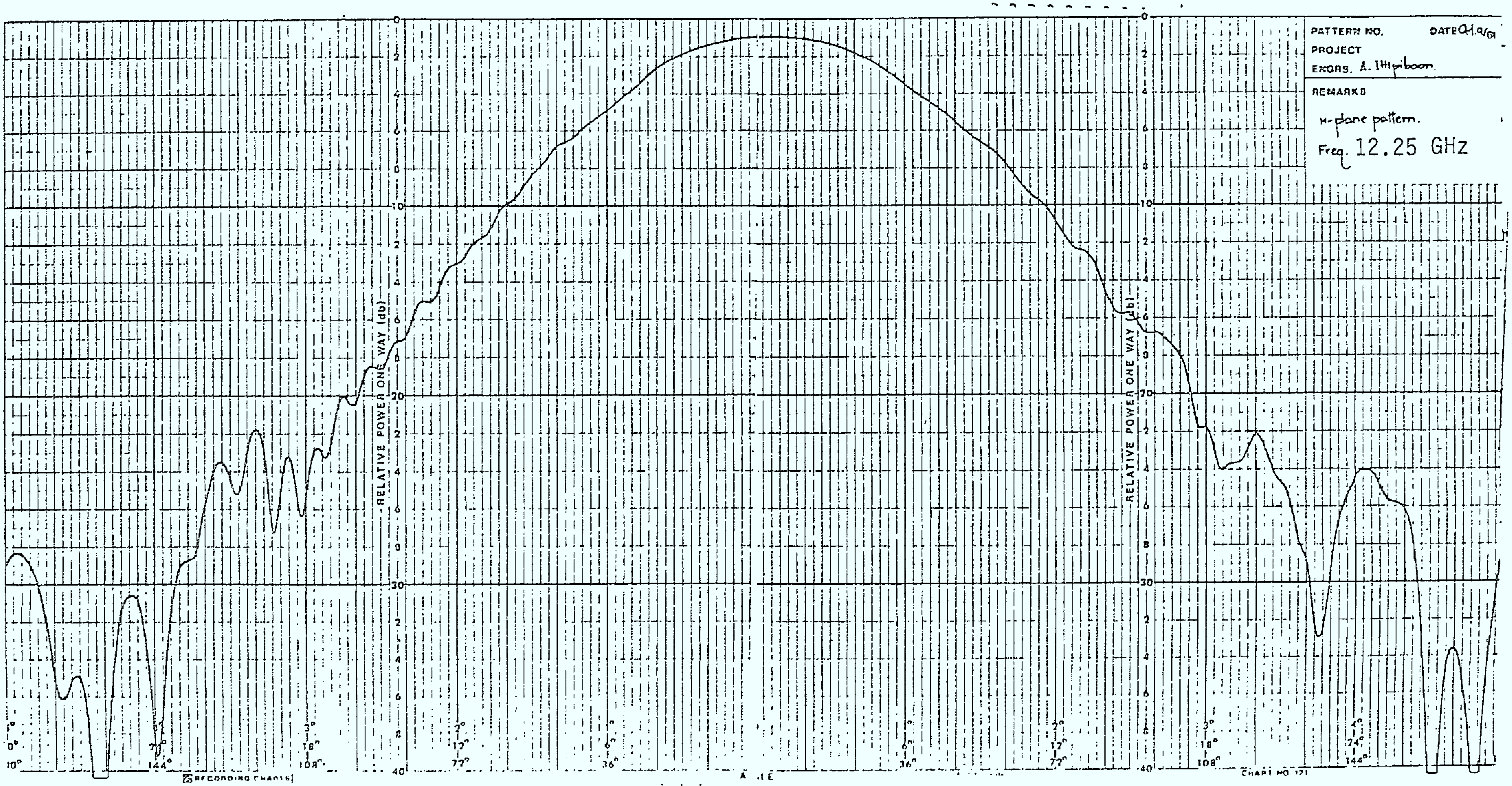


Figure 3-8: H-plane co-polar pattern at 12.25 GHz.

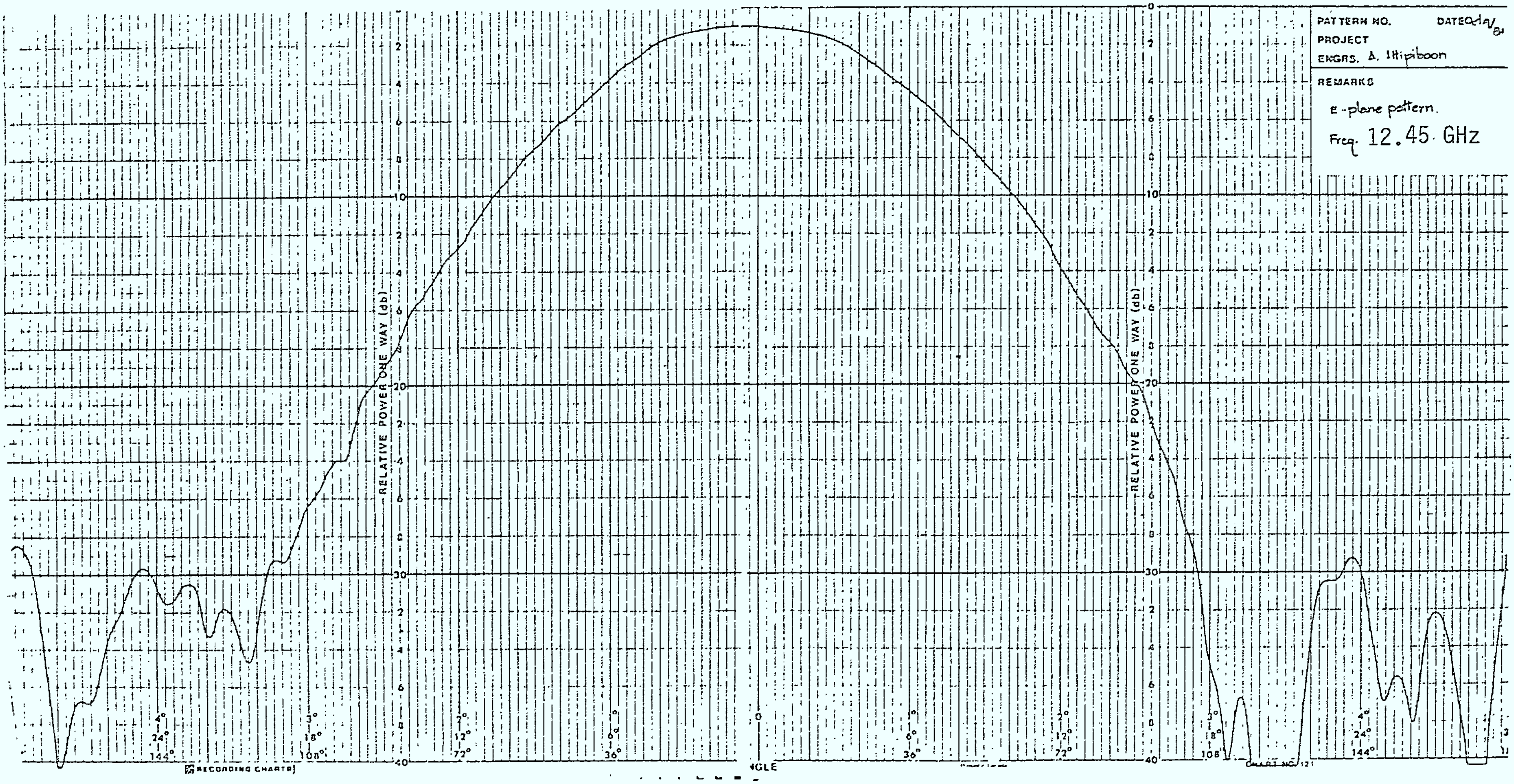


Figure 3-9: E-plane co-polar pattern at 12.45 GHz.

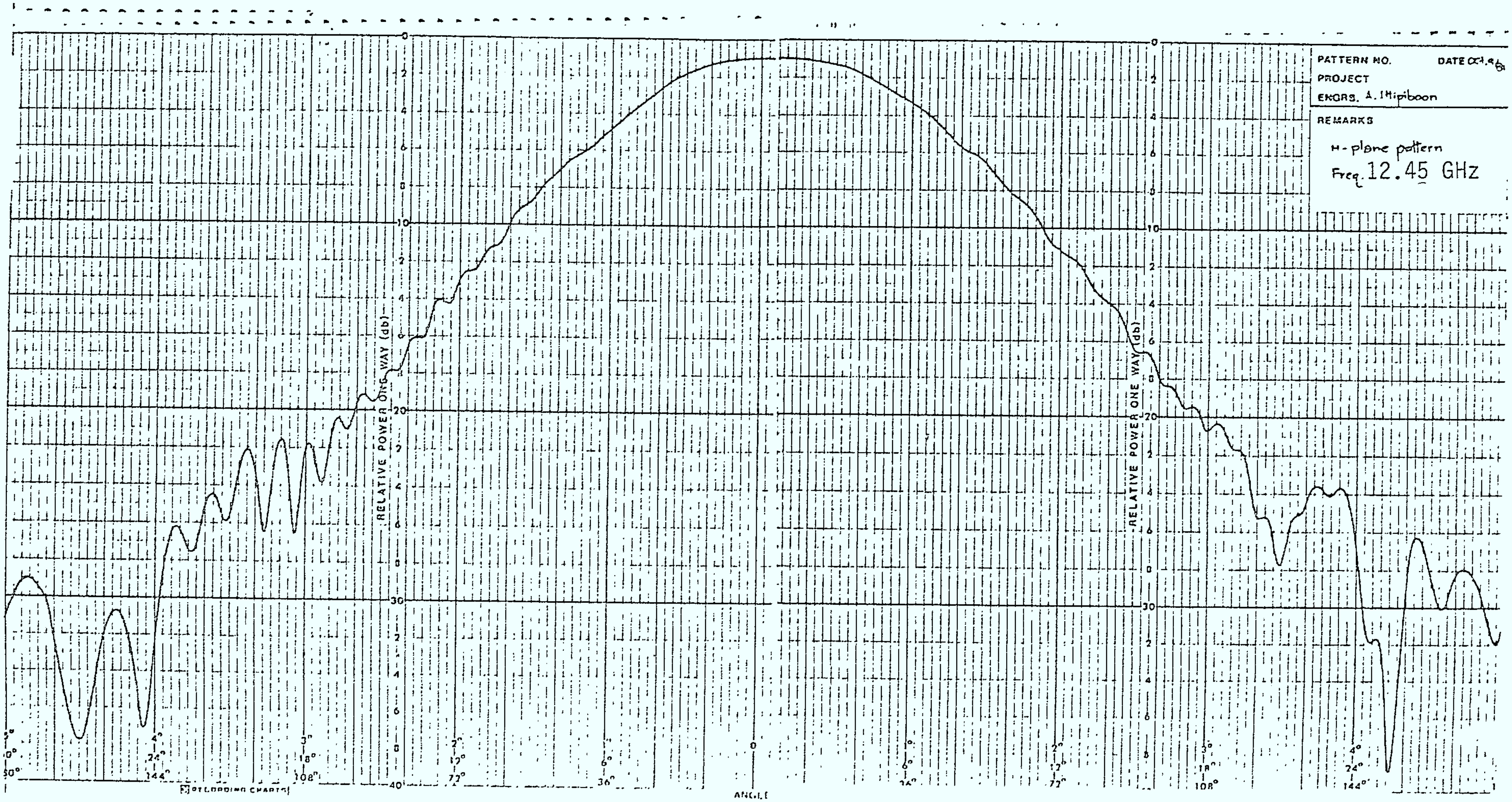


Figure 3-10: H-plane co-polar pattern at 12.45 GHz.

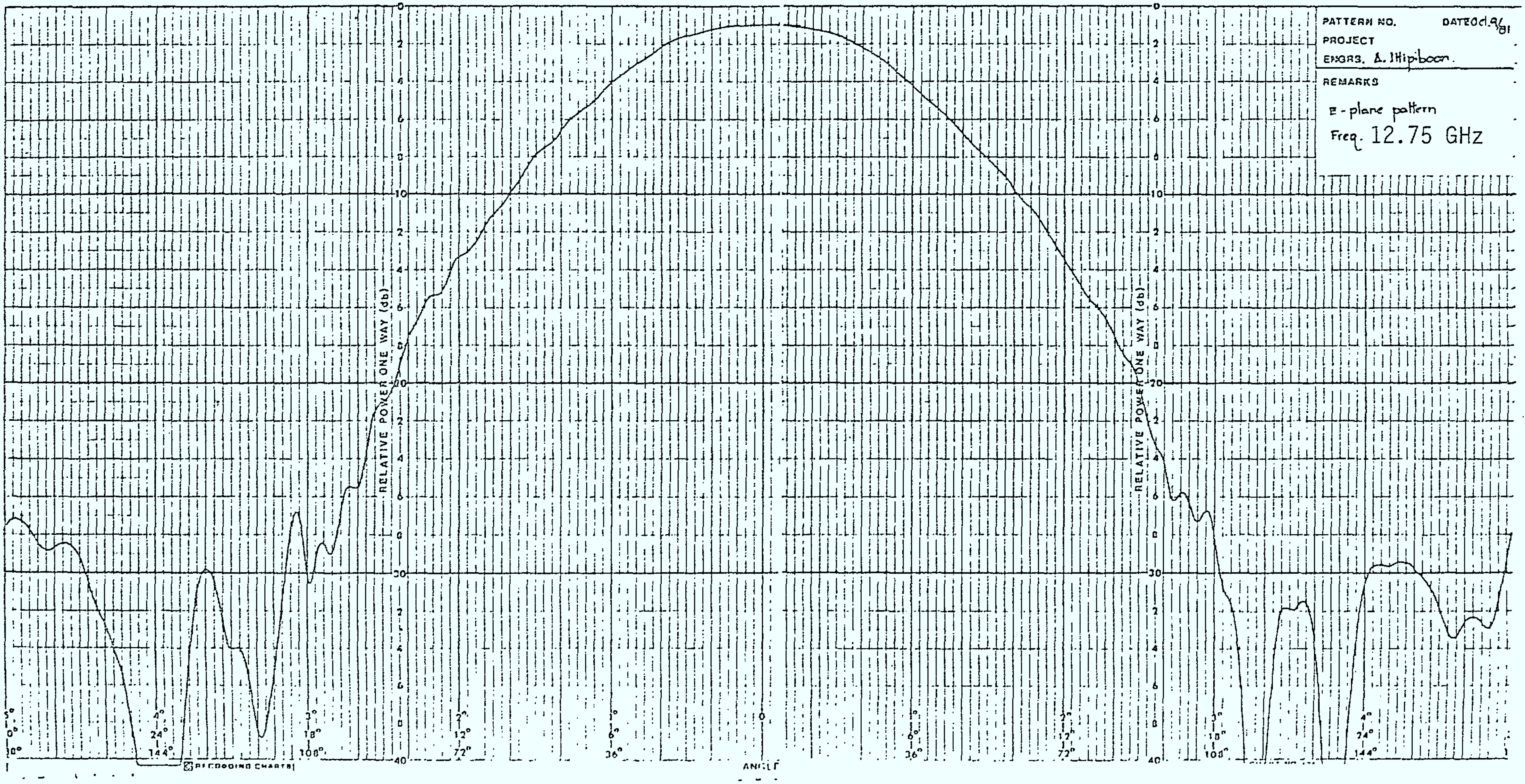


Figure 3-11: E-plane co-polar pattern at 12.75 GHz.

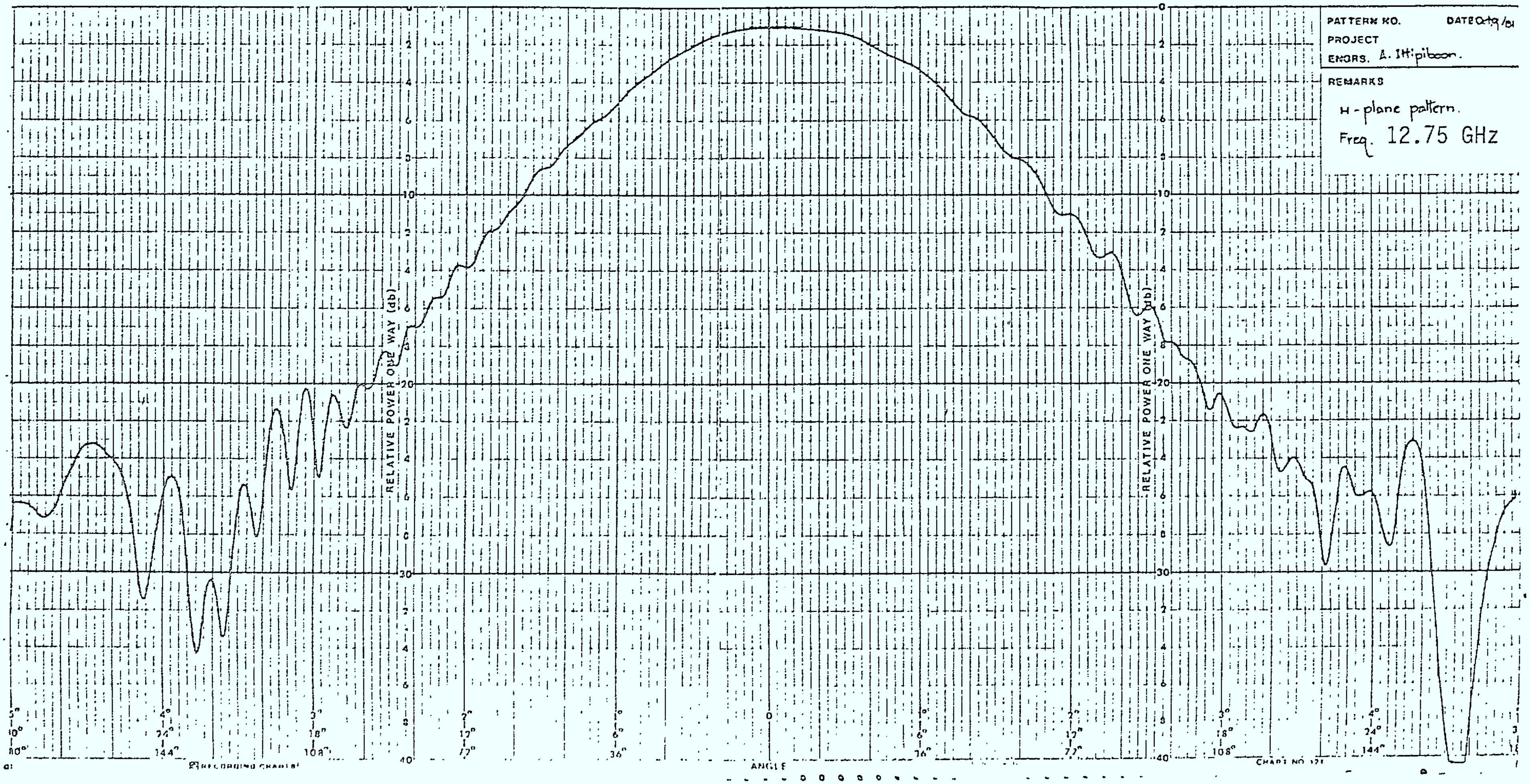


Figure 3-12: H-plane co-polar pattern at 12.75 GHz.

Figure 3-13: *Measured return loss of the feed.*

3.2.1 LNC Packaging

The outline of the LNC with the dielectric prime focus feed is shown in Figure 3-16. The LNC housing itself is about 4 inches long, 2 1/2 inches wide and 1 3/8 inches high. This physical dimension of the LNC creates a blockage of only 3.44 square inches. The prototype LNC housing is made out of a machined Aluminum block. It has a RF and a power supply compartment. The input of the LNC is a circular waveguide which accepts the prime focus feed described earlier. The output of the LNC is a F connector with O-ring and boot cover to keep moisture out. The F-connector accepts the RG-59 cable which carries the IF signal indoors and carries the power to the LNC from the indoor receiver. The DC voltage is routed to the power supply compartment via an arrangement of RF choke and DC block on the IF amplifier output circuit. Regulated voltages for the amplifiers and oscillator are provided to the RF circuit compartment via filter feed thru. Figure 3-17 shows the DC wiring of the LNC.

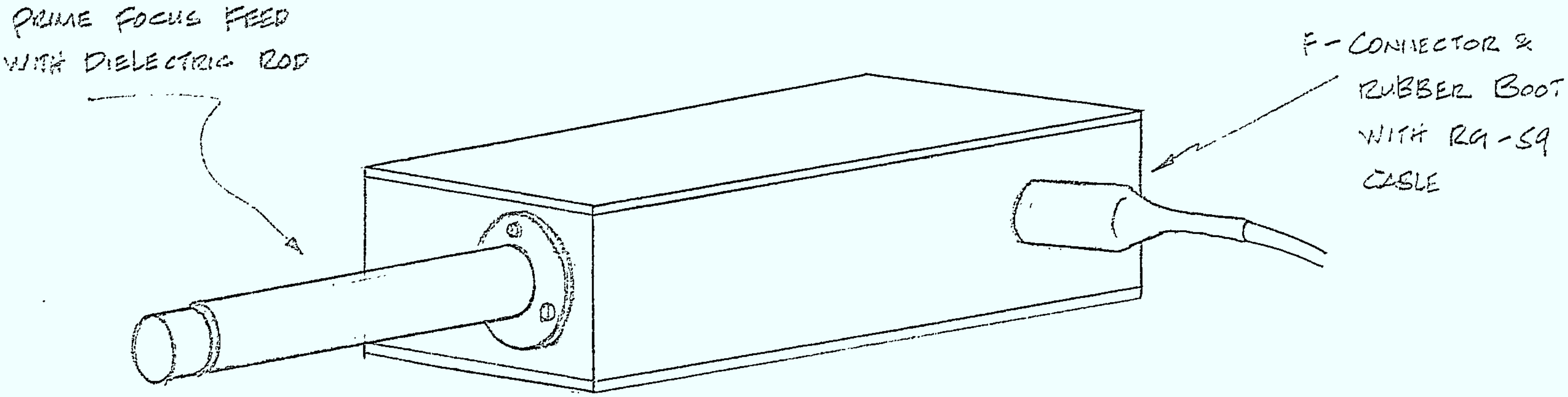


FIGURE 3-16 LNC OUTLINE

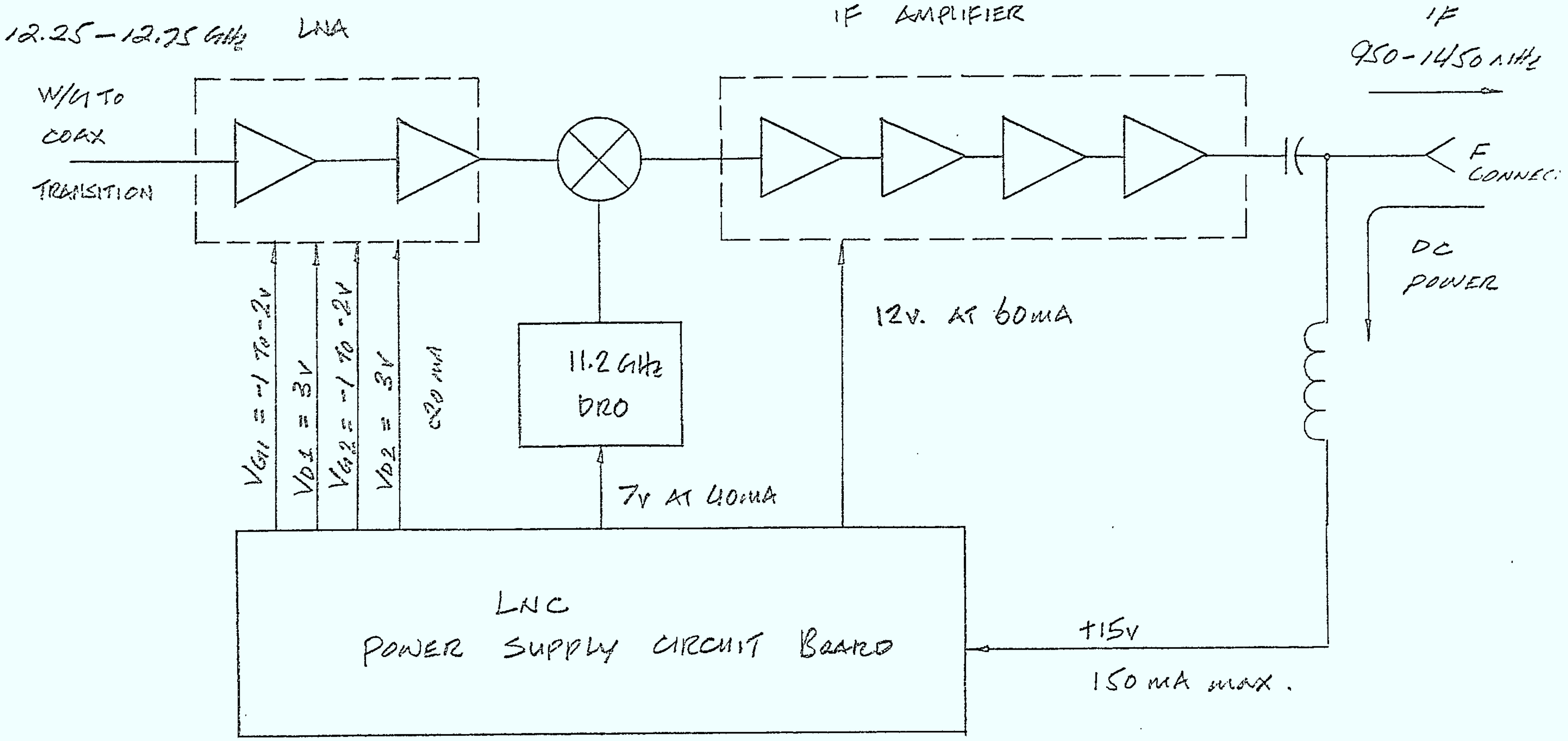


FIGURE 3-17 LNA POWER SUPPLY DISTRIBUTION

The IF circuit compartment is shown in Figure 3-18. The center conductor of the circular waveguide to coax transition launches the received signal to the microstrip 12GHz low noise amplifier. The amplified signal then enters the RF port of the SHF mixer for the down conversion process. The diode mixer LO port is driven by the dielectric resonator stabilized oscillator which is located next to the mixer. Partitions were used to avoid cross feedback between oscillator and amplifier. The IF output of the SHF mixer is fed to the four stage IF amplifier. This IF amplifier has over 40 dB of gain and has a 75Ω output impedance with a F connector.

Both the top and bottom lids of the LNC housing are sealed with epoxy to keep moisture away from the electronics. The F-connector has an O-ring seal for the same purpose. The connection between the feed and the LNC housing is carefully sealed also.

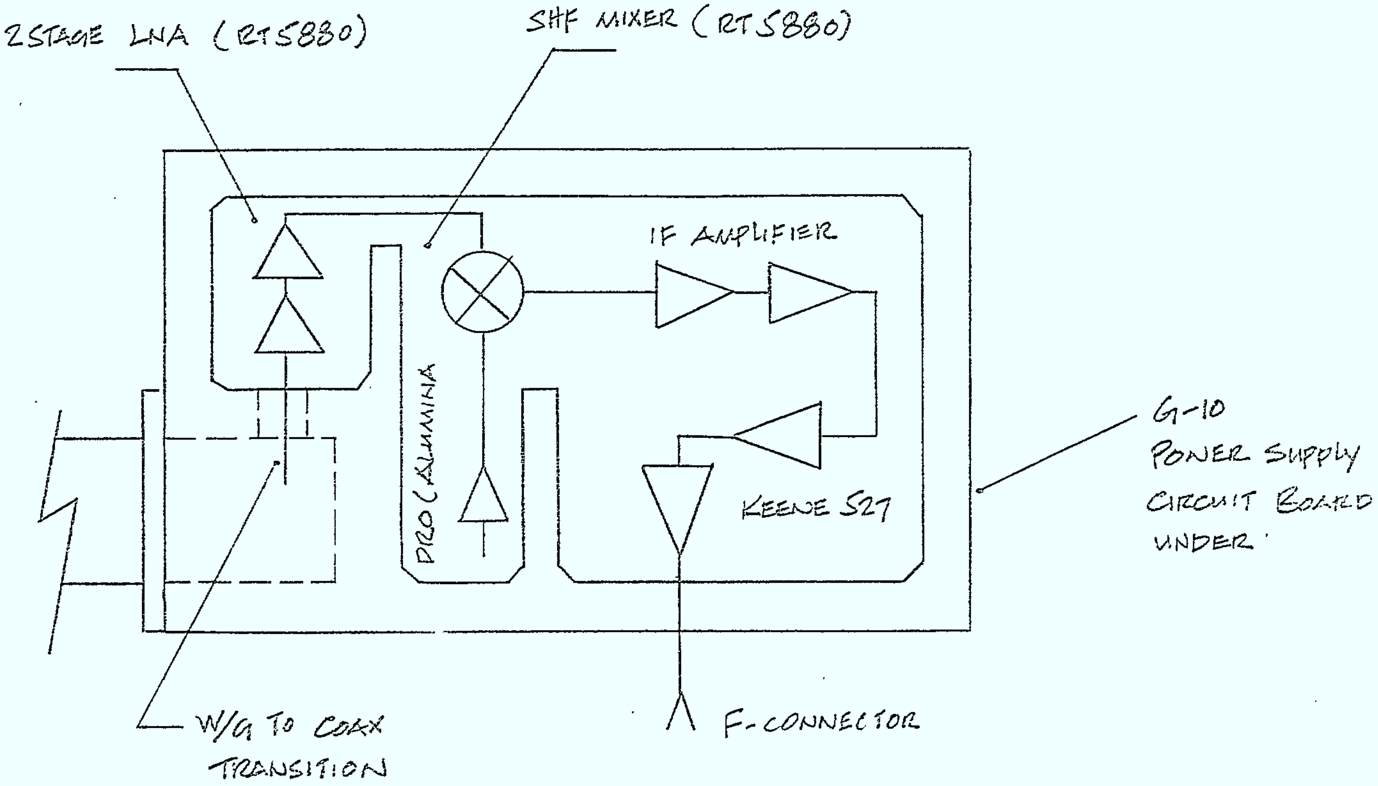


FIGURE 3-18 COMPONENT PACKAGING INSIDE THE LNC

3.3 Low Noise Amplifier 12GHz

The low noise amplifier (LNA) is the RF preamplifier which sets the noise performance of the LNC. Together with the antenna, they determine the G/T values of a receiving terminal. The following is the technical specifications for a two stage LNA which meets the G/T value of 14 dB/K when used in a 0.9 meter or 1.2 meter receiver system.

3.3.1 Electrical specifications

1.	Frequency range	12.25 - 12.75GHz
2.	Gain	18 dB min
3.	Gain flatness	±1 dB
4.	Noise figures at 25°C	2.9 dB max
5.	Output/input impedance	50Ω
6.	Output return loss	14 dB min
7.	Gain slope in any 40MHz band	0.02 dB/MHz
8.	Gain variation over temperature -40°C to +60°C	2 dB peak

3.3.2 Circuit Description

A simple two stage FET amplifier using Mitsubishi MGF 1403 low noise transistors was designed, fabricated and tested. The MIC pattern of the low noise amplifier is shown in exhibit 3-1. The substrate material for the microwave circuit board is Duroid RT 5880 which has a dielectric constant of 2.3 and a thickness of 0.010 inch. The duroid is a type of woven fibreglass teflon substrate. It is selected because of its low cost and good performance at Ku band. The circuit processing cost of these microwave substrate is very low. A 1/32 inch thick copper backing plate is added to the soft substrate to provide the required ridigity. Plated through holes are used to provide good grounding for the FET's.

The MGF 1403 low noise FET's used in the LNA are state of the art devices for Ku-band application. The device noise figure is better than 2 dB at 12GHz and the associated gain is no less than 9 dB for a DC biasing of 10 mA and 3V at the drain. Common source configuration is used for low noise performance. Automatic biasing circuitry is provided for the LNA. The RF circuit representation of the circuit is shown in Figure 3-19.

3.3.2 LNA Measured Performance

The measured performance of the two stage LNA is given in Table 3-1.

TABLE 3-1: MGF 1403 2-stage LNA measured performance biasing condition $V_{DS} = 3V$, $I_D = 10$ mA.

Frequency (GHz)	Gain (dB)	Noise Figures (dB)
12.25	20	2.1
12.35	21	2.2
12.45	21	2.3
12.55	21	2.5
12.65	21	2.6
12.75	19	2.9

The LNA actually covers a useful frequency band of 1GHz, starting from 11.7GHz up to 12.75GHz with the maximum noise figure of 3 dB at 11.7GHz and lowest gain of 16 dB. There is a different version of the LNA which

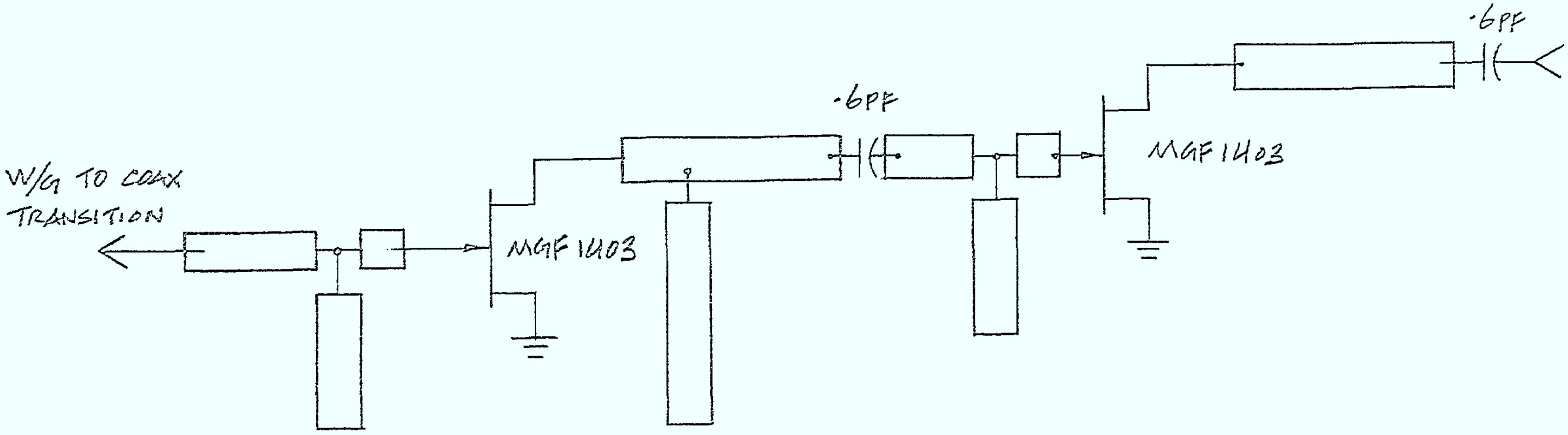


FIGURE 3-19 RF CIRCUIT REPRESENTATION OF THE LNA

is optimized for the North American 11.7GHz to 12.2GHz band. The output return loss of the amplifier is shown in Table 3.2. Reasonably good values are achieved by simply output matching.

3.4 SHF Mixer

The SHF mixer employed in the LNC is a single balanced mixer using a pair of Schottky barrier mixer diodes. The main advantages of the single balanced design over the single diode design are reduced spurious responses, cancellation of the DC component at IF output, and convenient seperation of LO and RF inputs. It also reduced the AM components.

The MIC pattern of the mixer is shown in Figure 3-20. A pair of matched diodes in a single package is used. The diodes are the Alpha DMF 6885A in the 295-012 package. The diodes are low cost and are easy to use. The IF bypass circuits are made up of two chip capacitors which resonate at the IF frequency of 1.2GHz. The chip capacitors are grounded through plated through holes.

3.4.1 Mixer Performance Specifications

The specifications of the SHF mixer are as follows:

RF Frequency Range	11.7 - 12.75GHz
LO Frequency Range	10.8 - 11.2GHz
IF Frequency Range	950 - 1450MHz
Conversion loss	8 dB max
Isolation	
L-R	15 dB min
L-I	25 dB min
Intercept point	+10 dBm
Nominal LO drive	+7 dBm

IF port VSWR	1:1.5
RF & LO port VSWR	1:1.5

3.4.2 Measured Performance of the SHF Mixer

The measured mixer RF performance is shown in Table 3-3. Conversion loss varies from 6 dB to 8 dB over the frequency band of 12.25 to 12.75GHz for a LO frequency of 11.2GHz. The drive level of the LO is at 10 mw.

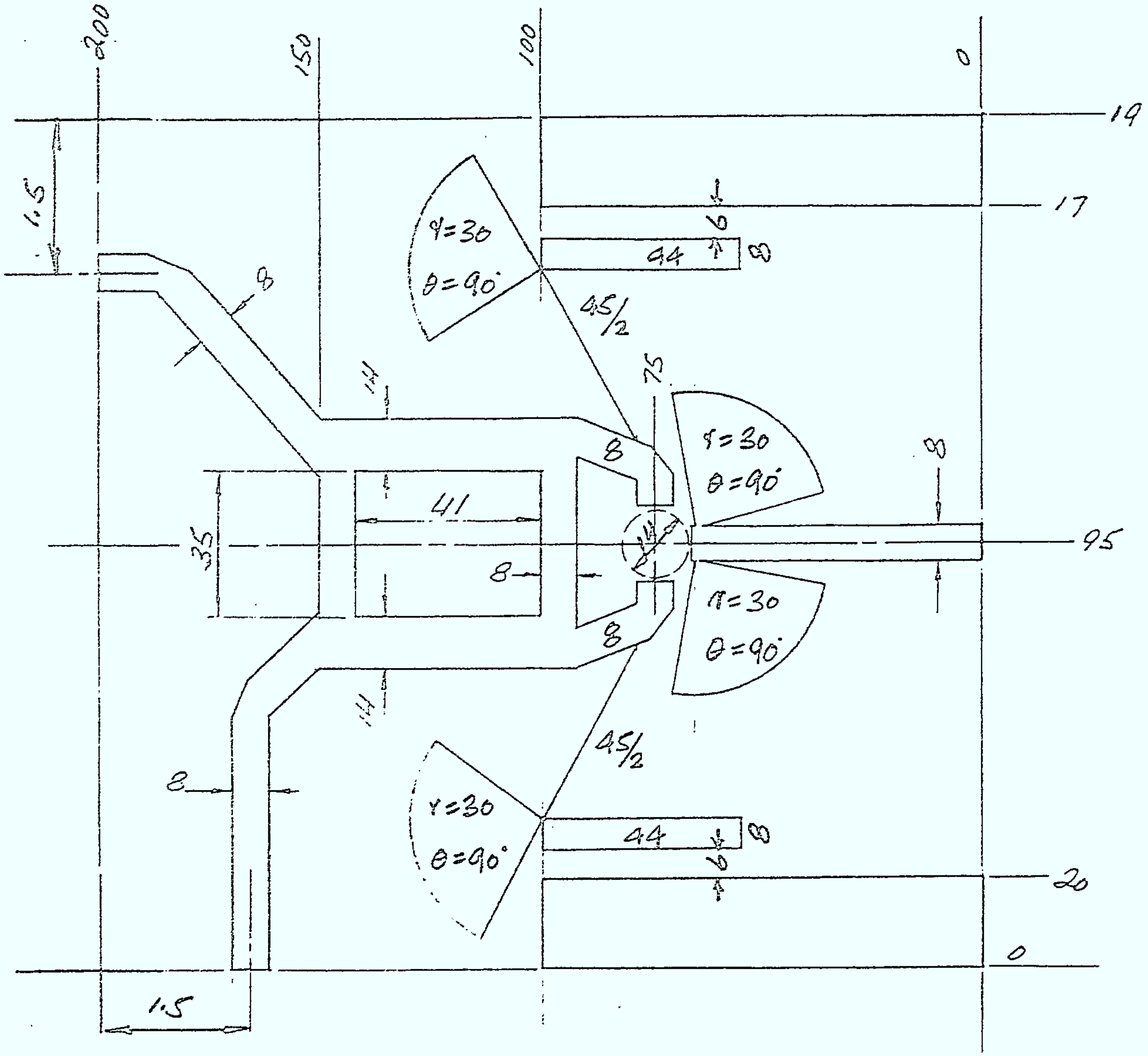
TABLE 3-3: Alpha Schottky Barrier Diodes Single Balanced Mixer Measured Performance Data LO Drive Level 10mw.

Frequency (GHz)	Conversion Loss (dB) IF 950 - 1450MHz	Isolation (dB) L-R	L-I
12.25	6.5	16	20
12.35	6.5	16	20
12.45	7.0	16	20
12.55	7.0	16	20
12.65	7.5	15	20
12.75	8.0	15	20

The measured output return loss at the IF port of the mixer is better than 14 dB. The input return loss at both the RF and LO ports are also better than 14 dB.

3.5 IF Amplifier

The IF amplifier designed and tested for the LNC has a useful bandwidth of more than 800MHz. It covers frequency from 800MHz up to 1600MHz with power gain of more than 38 dB. The gain flatness from 950MHz to 1450MHz is better than 2 dB peak to peak. The amplifier employs four very low cost bipolar transistors NE 21935. The noise figure of the amplifier is less than 3 dB for the band



PROJECT 432520

MIXER FOR 11.7-12.2

IF .95 TO 1.45

MATL: RT5880 DUROI
WITH .032" COPP
BACKING
DIELECTRIC THICK.
.010 INCH.

MAKE NEGATIVE 10X
REDUCED

DIODE PAIR

DMF 6885A
PKG 295-012

FIGURE 3-20 MIC PATTERN OF SHF MIXER

of interest. The output impedance of the amplifier was designed to be 75 ohm. It has an output return loss of at least 15 dB. The substrate used in the IF amplifier Keene 527. Plated through holes for ground points are to be used. Figure 3.21 shows the MIC pattern of the IF amplifier. At the input of the transistor, a high pass impedance matching structure is used to reduce the low frequency gain and thus achieve unconditional circuit stability. The final amplifier stage employs a resistive matching circuit to achieve good VSWR at 75 ohm. Although the maximum achieveable gain of the four stage amplifier is much more than 40 dB, the amplifier was designed to achieve good consistency in performance. Minimum amount of labour is required for the tuning of the IF amplifier. Table 3-4 shows the measured performance of the IF amplifier.

TABLE 3-4: Measured Performance of the 950-1450MHz IF Amplifier

Frequency (MHz)	Power Gain (dB)	Noise Figures (dB)	Return Loss (dB)
800	39	2.5	15
900	39	2.5	15
1000	39.5	2.5	16
1100	39.5	2.6	17
1200	40	2.6	18
1300	41	2.6	24
1400	41	2.6	20
1500	41	2.7	17

The transistor biasing artwork used in the IF amplifier is a resistive feedback type. The supply voltage is +12 volt. This is adequate for prototype purposes. In production runs, the RF transistors will be biased automatically by preset transistor feedback network. Such circuits will reduce the labour required for tuning the amplifier.

3.6 Dielectric Resonator Oscillator

A feedback type dielectric resonator stabilized FET oscillator was designed to meet the following design goals:

1. low cost
2. high reliability
3. high performance stability
4. low FM noise
5. low power consumption
6. wide tuning range 500MHz minimum
7. minimum output power of 9mw

The dielectric resonator is employed in the feedback path FET amplifier between the gate and the drain of the FET. The FET is selected over other semiconductor devices because of its efficiency and performance at SHF. The oscillator was designed around a low cost MGF 1400 FET from Mitsubishi. The dielectric resonator for the oscillator was made from a Transtech dielectric material D-8512 with physical dimensions of 5.5mm in diameter and 2mm in thickness. Figure 3-22 shows the MIC pattern of the dielectric resonator oscillator and the associated DC biasing circuitry. The biasing circuit is a single voltage supply design which simplifies the oscillator circuitry. The DC biasing circuit for the FET is shown in Figure 3-23. The 300 ohms feedback resistor stabilizes

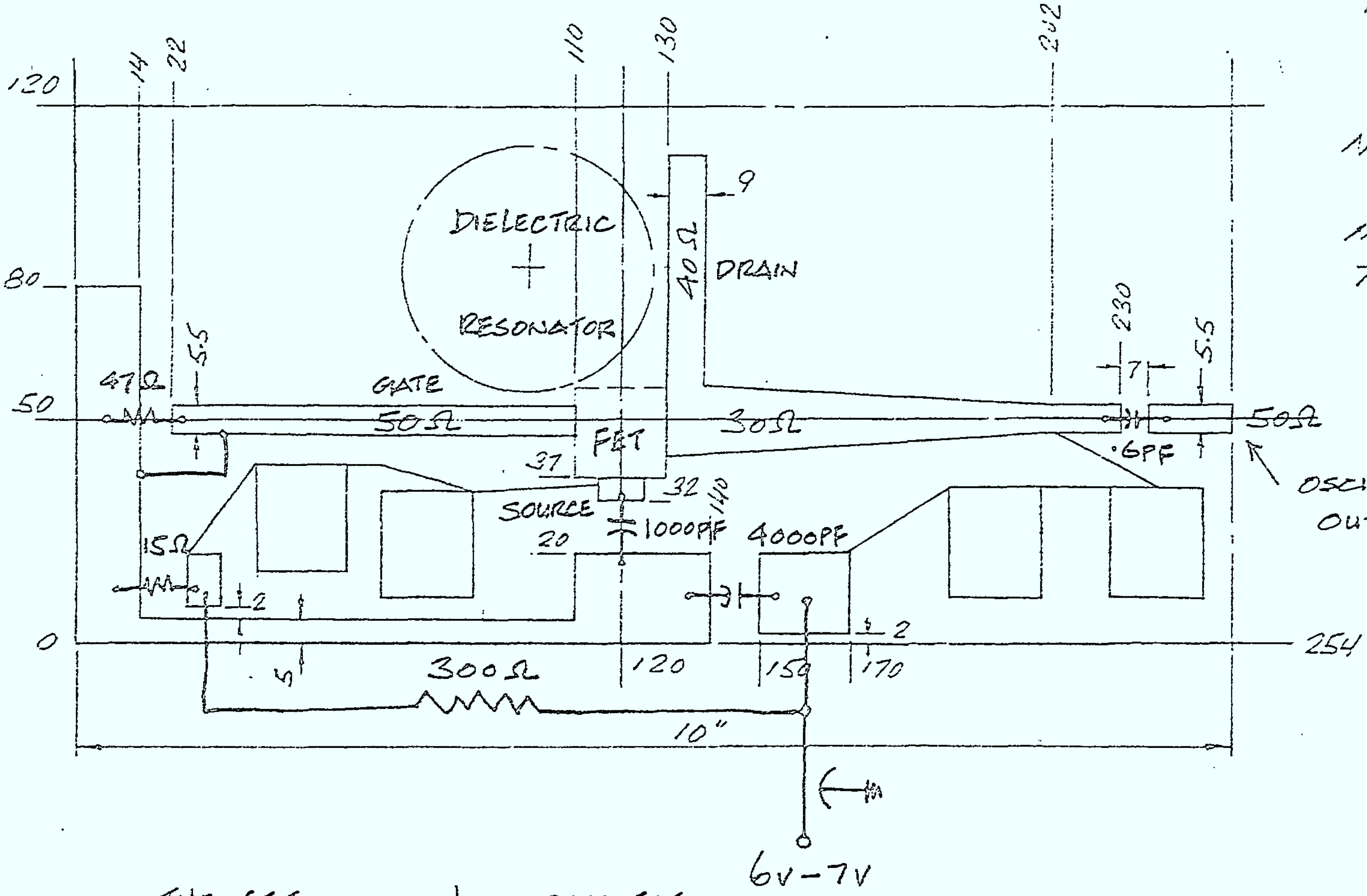
PROJECT # 432530

TITLE : 11.2 - 11.7 GHz
FET DRO

MATL : 0.025" ALUMINA

MAKE POSITIVE TEN
TIMES REDUCED

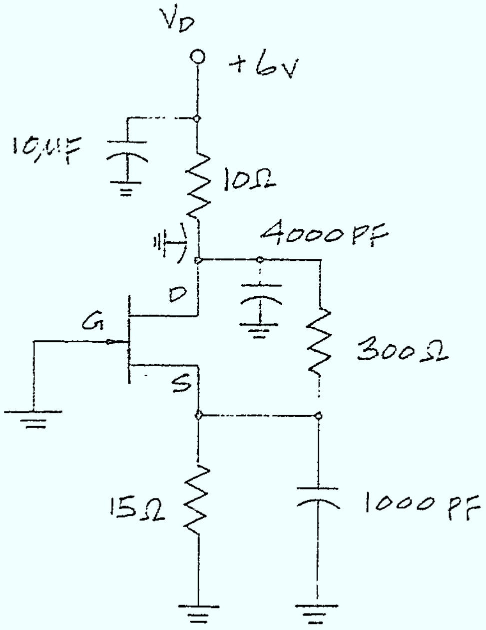
DATE : 15TH July 1981



THE FET IS A LOW COST FET
MITSUBISHI MGF 1400

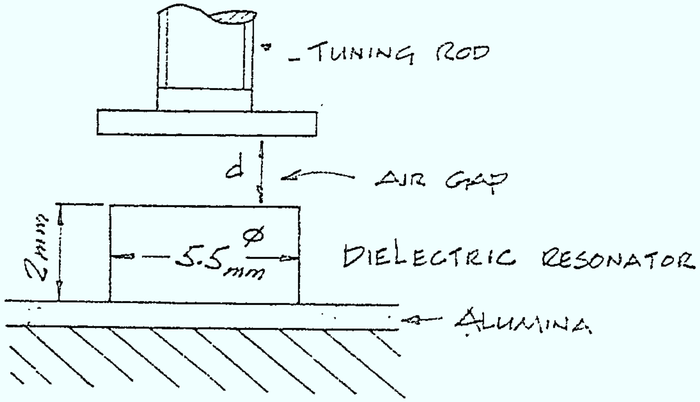
FIGURE 3-22

DIELECTRIC RESONATOR STABILIZED FET OSCILLATOR RF CIRCUIT



DC BIASING CIRCUIT

FIGURE 3-23



FREQUENCY TUNING ARRANGEMENT

FIGURE 3-24

the drain current over temperature. Experimental results show that the drain current varies only ±4% over the full range of -50°C to +50°C. The DRO circuit board was fabricated on a 12mm by 25mm alumina substrate. Alumina substrate is chosen for its thermal conductivity and mechanical stability. Frequency tuning is accomplished by adjusting the air gap over the dielectric resonator as shown in Figure 3-24. Due to combined thermal expansion coefficient offset over the expansion coefficient of the aluminum tuning screw, very small frequency drift in the oscillator is achieved.

3.6.1 Bias Dependence

The bias dependence of the FET oscillator characteristics is shown in Figure 3-25. The dependence of oscillation frequency on bias voltage appears to be linear between V_D = 6V and V_D = 9V. The pushing figure in this range of bias voltage is 2MHz/volt.

The output power of the oscillator peaks at about 9V and then further increase in supply voltage results only in reduced output power. At about 3V, the output power of the oscillator drops to 1mW. The efficiency of the oscillator increases with supply voltage and starts to decline after a bias voltage of 9V. At 3V bias voltage, the oscillator has the lowest efficiency.

It is observed, as shown in Figure 3, the drain current of the FET changes from 47mA to 79mA as the bias voltage varies from 3V to 10V.

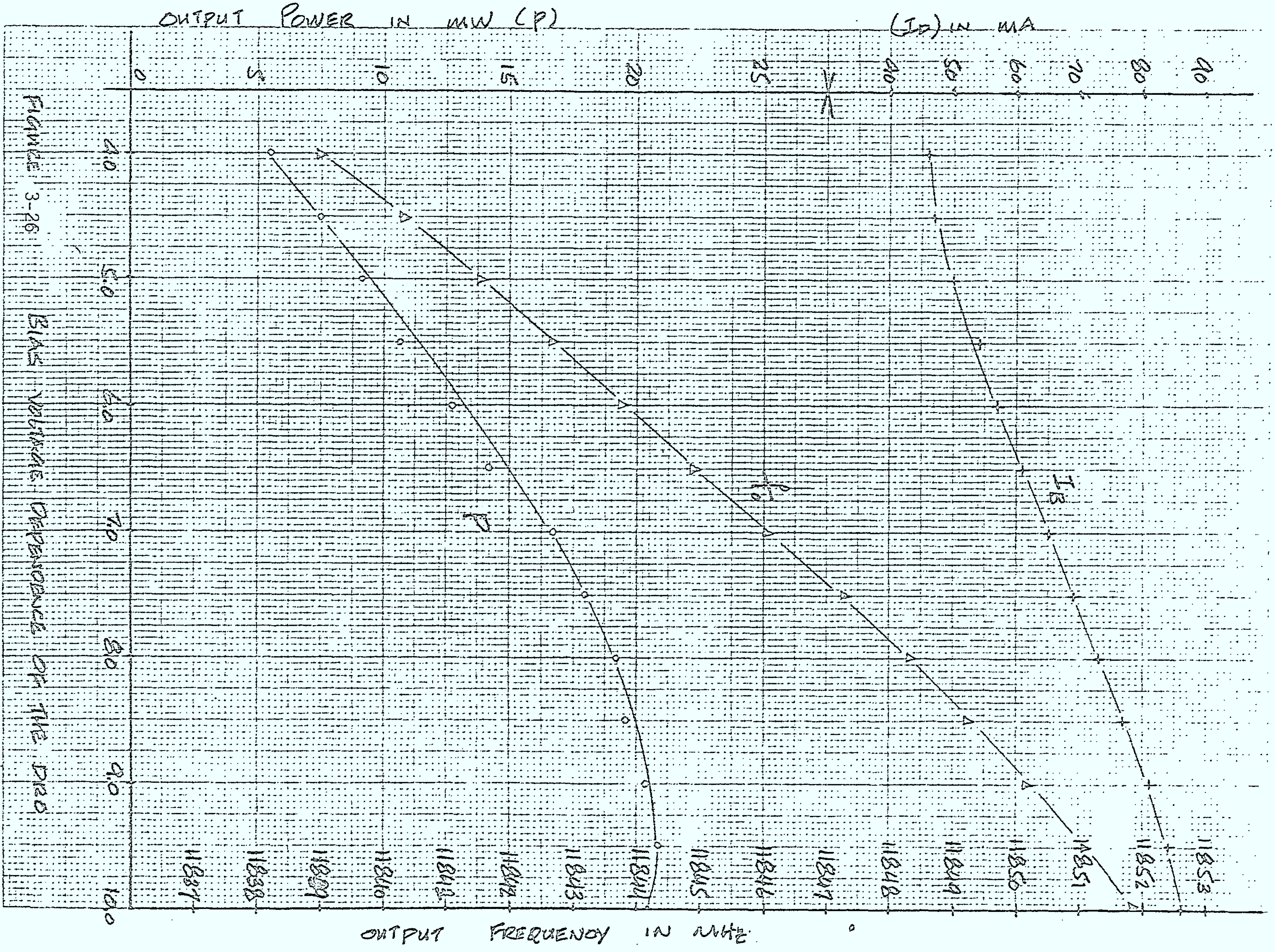


FIGURE 3-26 BIAS VOLTAGE DEPENDENCE OF THE DRO

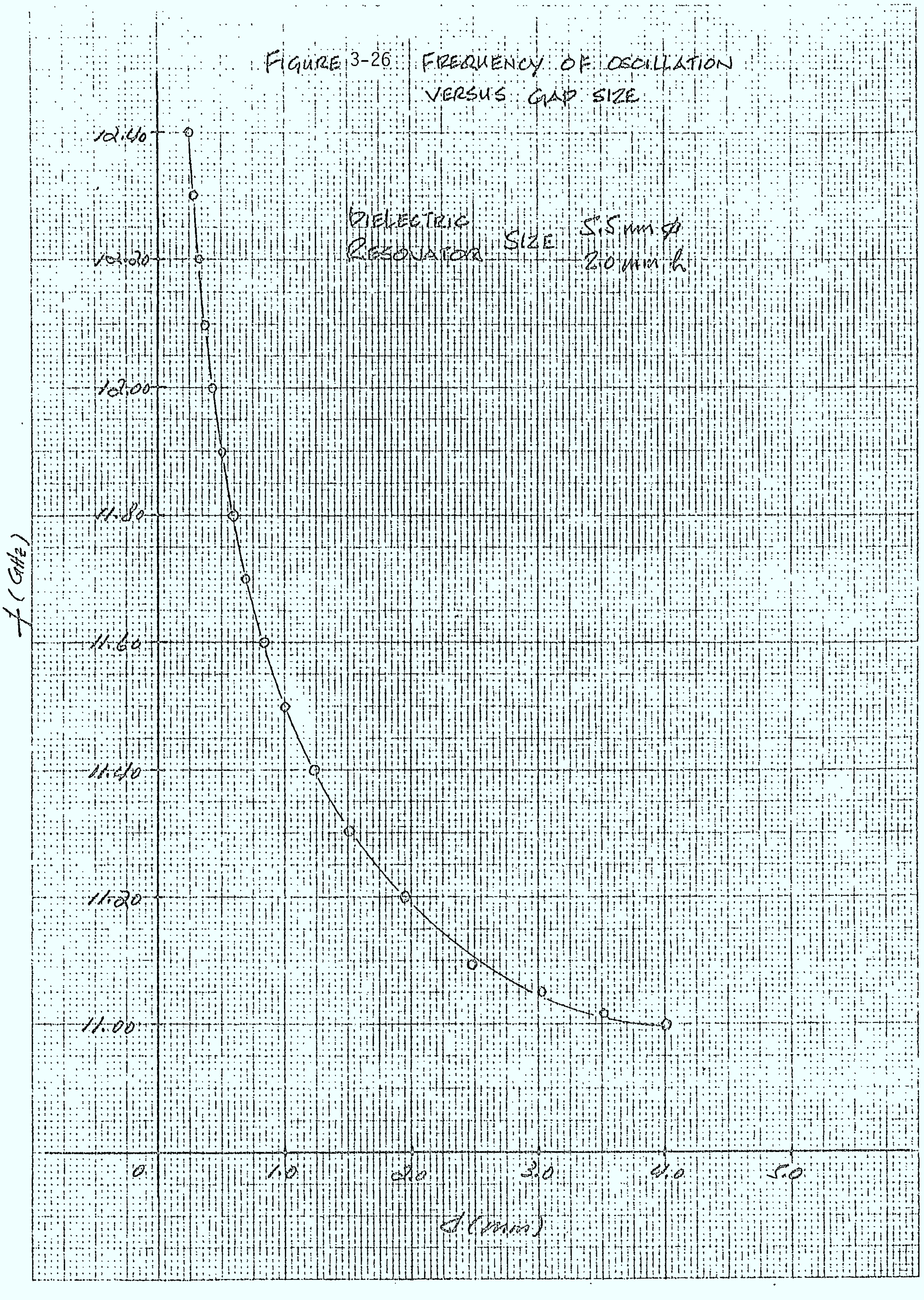


FIGURE 3-26 FREQUENCY OF OSCILLATION VERSUS GAP SIZE

3.6.2 Mechanical Tuning Performance

The oscillation frequency of the oscillator is adjusted by varying the air gap spacing between the dielectric resonator and the frequency tuning rod. Since the oscillator was designed to have at least 500MHz tuning range, the air gap spacing is allowed to vary over .15 inch. Figure 3-26 shows the oscillation frequency as a function the air gap spacing (d). The actual frequency tuning range obtained is 1300MHz. No hysteresis phenomon was observed over the tuning range in both prototypes.

3.6.3 Temperature Dependence

The oscillator temperature dependence is shown in Figures 3-27 and 3-28. Figure 3-27 shows the oscillator output frequency as a function of the ambient temperature Ta ranging from -50°C to +50°C, with bias voltage V_D as a parameter. Frequency stability of 1.8MHz over the temperature which is slightly voltage bias dependent. For bias voltage of 7V and 6V, the frequency stability remains almost unchanged. Temperature dependence of the oscillator output power is shown in Figure 3-28 with bias voltage as a parameter. The lower bias voltage shows slightly higher stability. However, the output power variation is only 1 dB for the full 100°C temperature range. This results in an output power stability of 0.01 dB/°C.

FIGURE 3-27

OSCILLATION FREQUENCY VERSUS AMBIENT TEMPERATURE

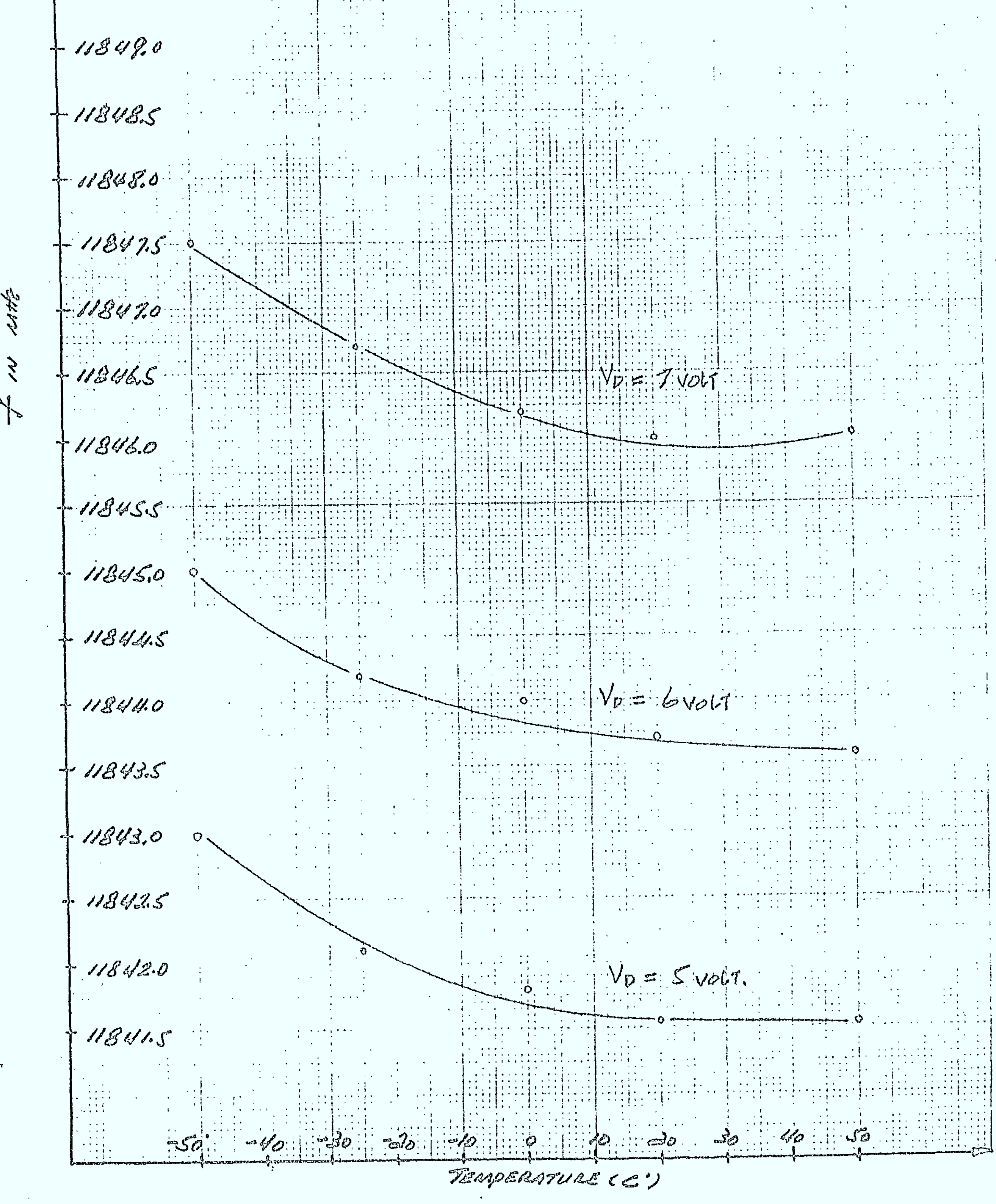
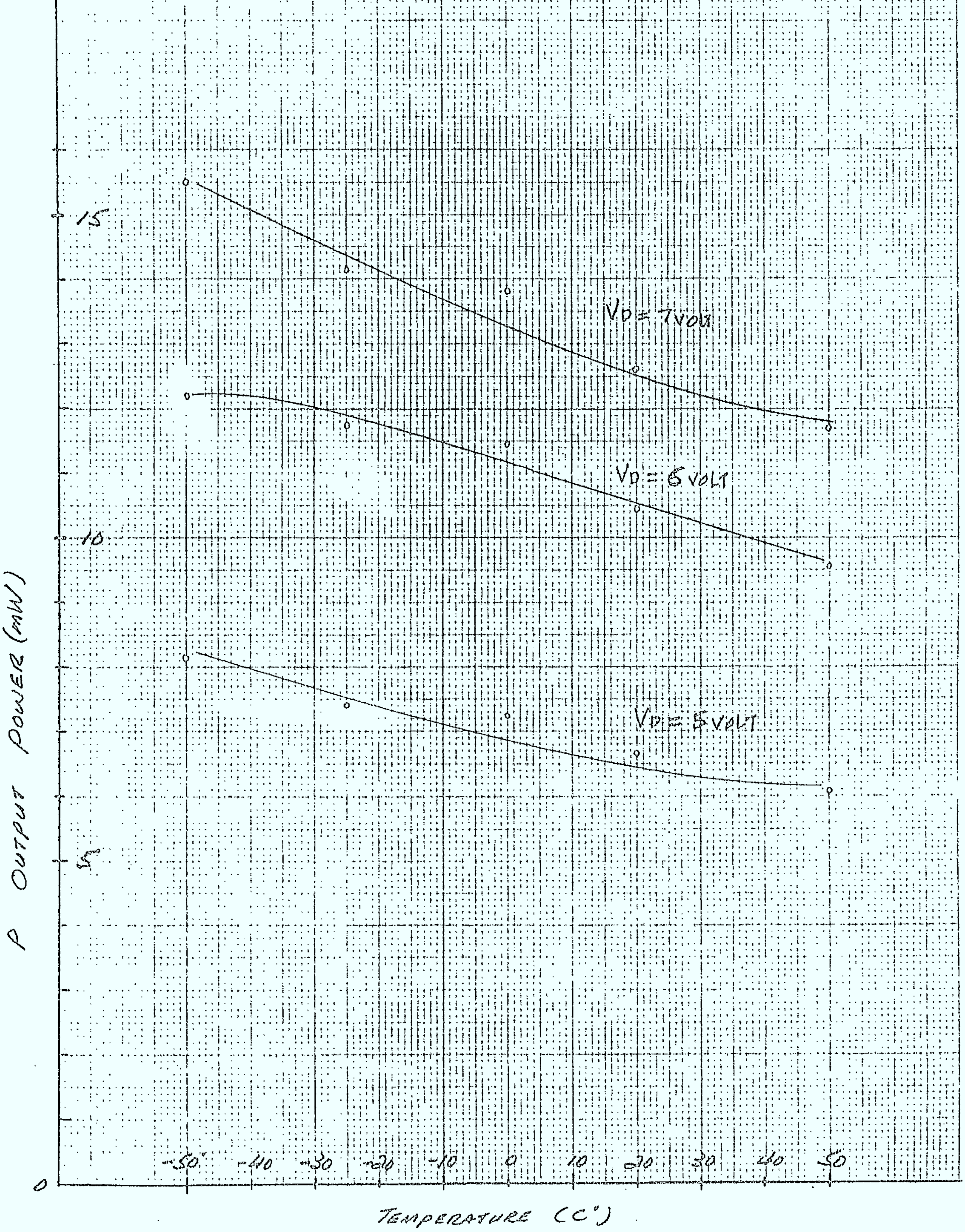


FIGURE 3-28 OUTPUT POWER VERSUS AMBIENT TEMPERATURE



3.6.4 Spectrum and Noise

FM noise was measured by means of a low noise phase locked oscillator as frequency reference. The FM noise of SED DRO #1 and #2 was measured. The FM noise of a Mitsubishi DRO and a frequency source DRO was also measured. The FM noise measurement results are given in the Appendix. As it turns out, the FM noise of the SED DRO seems to be lower than that of the Frequency Source DRO. Figure 3-29 shows the FM noise of the SED DRO as a function of frequency off carrier. The RMS frequency deviation $(\Delta f)_{n, rms}$ of FM noise is .23Hz/Hz at 100KHz off carrier. It was observed that bias voltages lower than 6V give slightly better noise performance. Also, using a FET with better noise figure improves the close in noise in the 100Hz to 1KHz region.

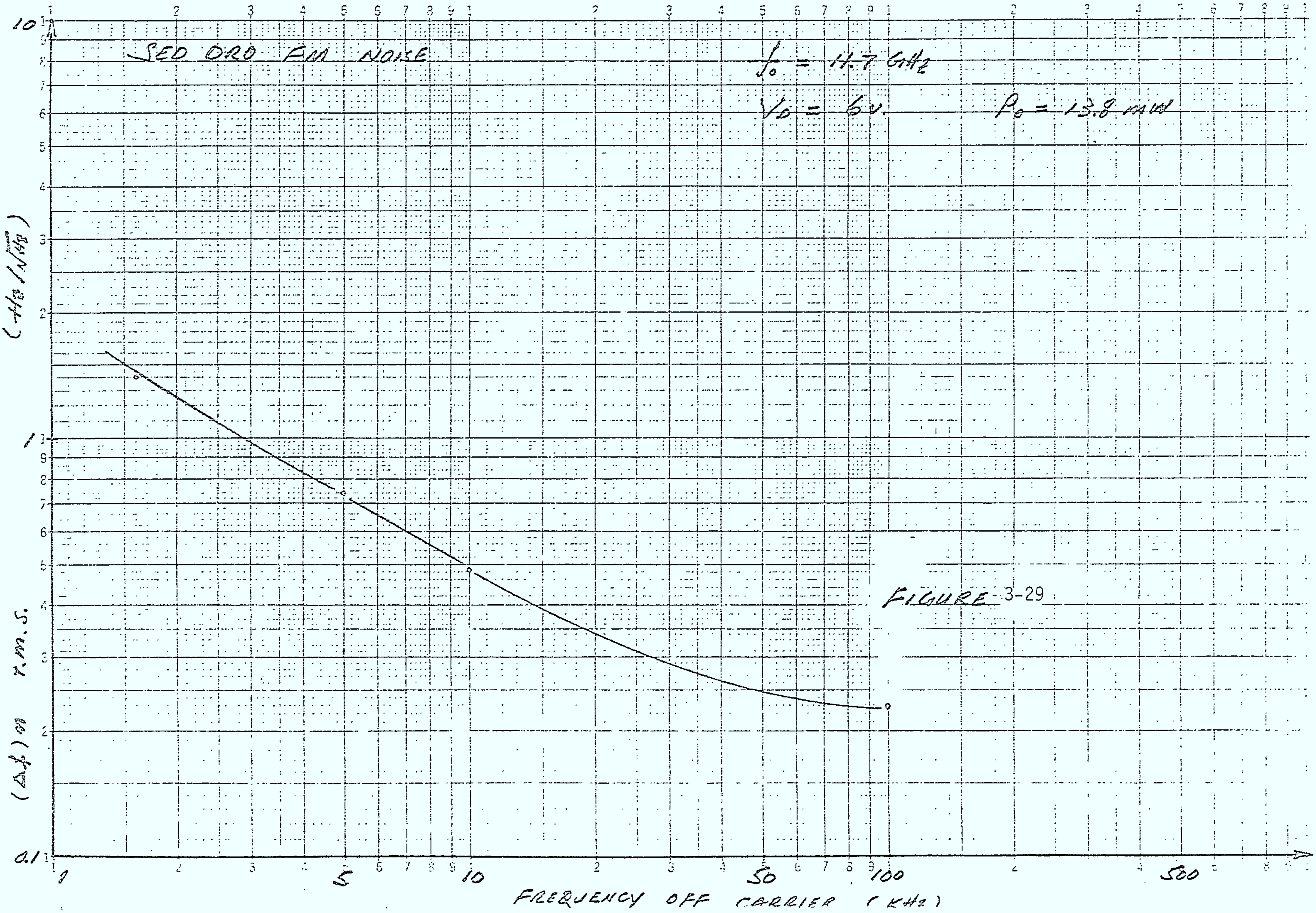

SED ORO FM NOISE
f_0 = 11.7 GHz
V_0 = 6v.
P_0 = 13.8 mW
10
1
0.1
(Δf) on r.m.s. (Hz/√Hz)
1
5
10
50
100
500
FREQUENCY OFF CARRIER (KHz)

FIGURE 3-29

3.7 Conclusion

A second generation LNC for Direct Broadcast Service has been designed and developed. The LNC was designed especially to meet the HACBSS requirement. The performance of the LNC demonstrated that it meets the proposed performance for the Australian system. The LNA's and the DRO's are already in production for the Canadian market. Their reliability and performance in production quality and quantity are very encouraging. LNC's with noise figures better than 2.5 dB are regularly available from production lines. The provision of Audio program reception in the HACBSS system requires that the Local Oscillator has very good close-in phase noise. The high close-in phase noise characteristic of the DRO is generally considered as not suitable for SCPC radio program reception. Phase locked oscillators are usually used in Commercial Radio Program receivers. However, the same performance standard for Commercial broadcast should not be applied to a very low cost substitute such as the LNC's with a DRO for consumer applications.

As it is pointed out in an earlier section of the report, when the system is operating near threshold, the degradation due to the phase noise of the DRO amounts only to 2 dB. On the other hand, the great difference in cost between the DRO and a PLO should be considered. It is a matter of performance against cost.

There is a comprimising alternative to the expensive phase locked oscillator. The alternative is a 5GHz bipolar dielectric resonator oscillator with a frequency doubler. The much better close-in phase noise characteristics of the bipolar transistor and the super high Q value of the dielectric resonator at 5GHz will make a much cleaner frequency possible. However, this oscillator is not a performance substitute of the phase locked oscillator, but is a compromise of trade-off between performance and cost.

The production cost of the LNC has been a subject of much speculation in the past. Cost analysis was performed on various occasions. Given the quantity of LNC's that Australia requires for HACBSS, it is hard to realize a production cost of less than 500 dollars Canadian. However, the North American market demand for LNC will be in very large volume in the 1983 to 1992 period. Any benefit from the capital investment and large volume material procurement will directly effect the Australian project. The die cast LNC housing for the North American market can be used in the Australian system. The volume procurement of FET's and semiconductor will also help to reduce the production cost of the Australian unit. Figure 3-2 shows a block diagram of the LNC with the associated production cost of each component. For an annual production rate of 50,000 units, the production is estimated to be 150 dollars Canadian for the years 1983 to 1984. The IF amplifier and the power supply will be in low cost thick film hybrid modules.

4.0 Indoor Unit (IDU)

Introduction

The IDU receives the translated 12GHz satellite band in the 950 to 1450 MHz band. It selects the wanted channel and demodulates the FM signal to recover the baseband modulation. A separate circuit processes the video and further demodulates the audio subcarrier to recover the TV audio. These video and audio outputs drive a VHF modulator to interface at the tuner terminals of a consumer TV receiver.

This section discusses tradeoffs to using various approaches to receiver design. Detailed block diagram description follows. Frequency plans and filter characteristics are given along with specifications and design details and packaging.

4.1 Discussion of Tradeoffs

Image reject mixer with 70MHz IF output:

This configuration (Figure 4.1) is very similar to that used by manufacturers of low cost 4GHZ receivers. The output IF is 70MHz which needs to go into an 18 MHz wide IF filter and IF amplifier. Demodulation is done with a 70MHz discriminator.

This block diagram is a workable receiver system but employs no new ideas and is just reworking a concept used by many others at 4GHz. In addition the image reject mixer employs 90° hybrids which operate over the 950 to 1450MHz band compared to the 3.7 to 4.2GHz band in other receivers. This requires more expensive hybrids due to the large tuning range. LO feedthrough to the input is a

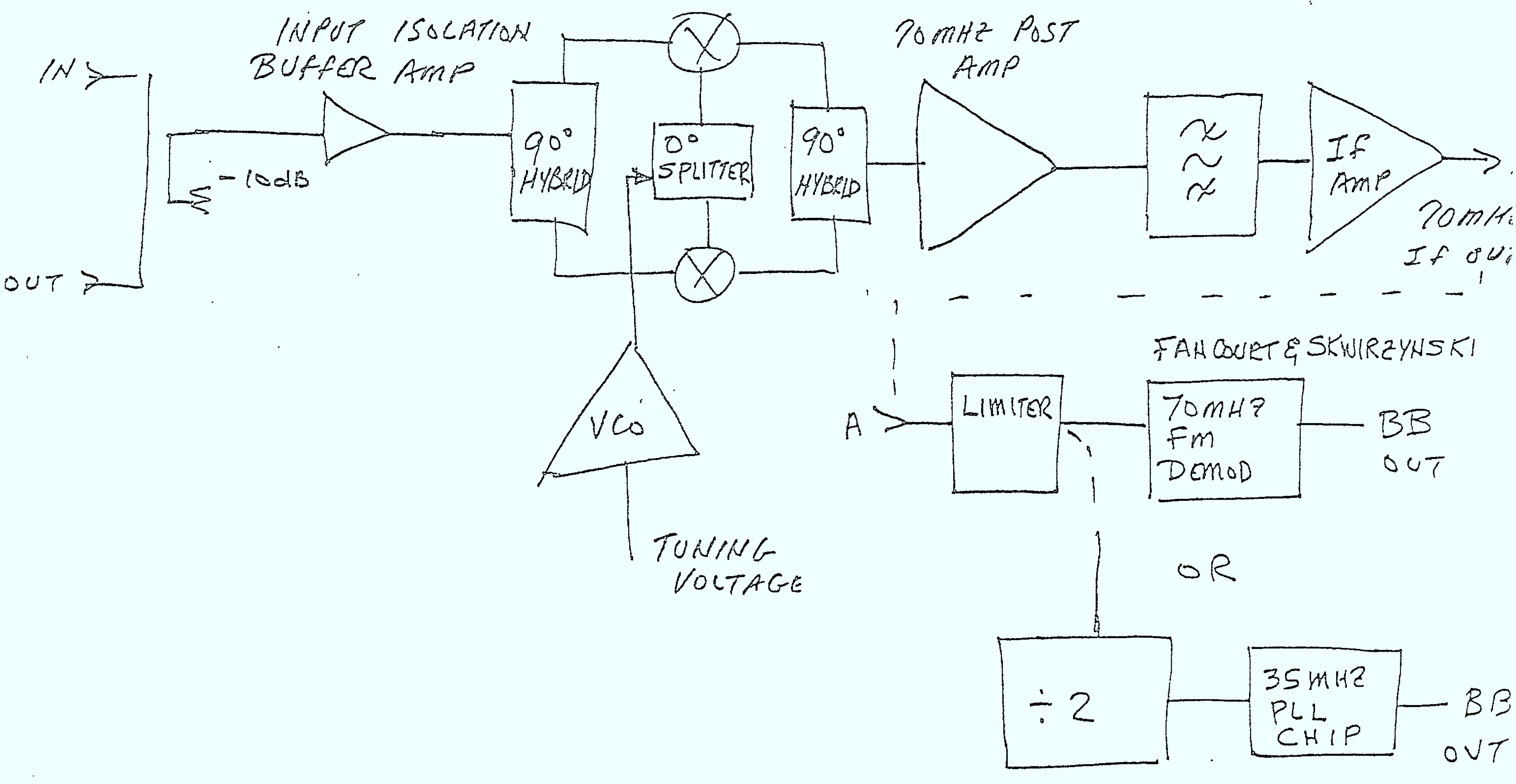


Image Reject Mixer With 70 mHz IF output :

Figure 4.1

problem, as the LO is inband. The solution to this requires a good quality input buffer amplifier. The low cost 4GHz, image reject mixer-based consumer receivers are intended to operate one per satellite antenna. However, people who operate two or more receivers per antenna experience the LO of one receiver interfering with another. The SED RX-01-33 receiver uses this system, but successfully, since sufficient expense and care was put into providing a good input buffer amplifier.

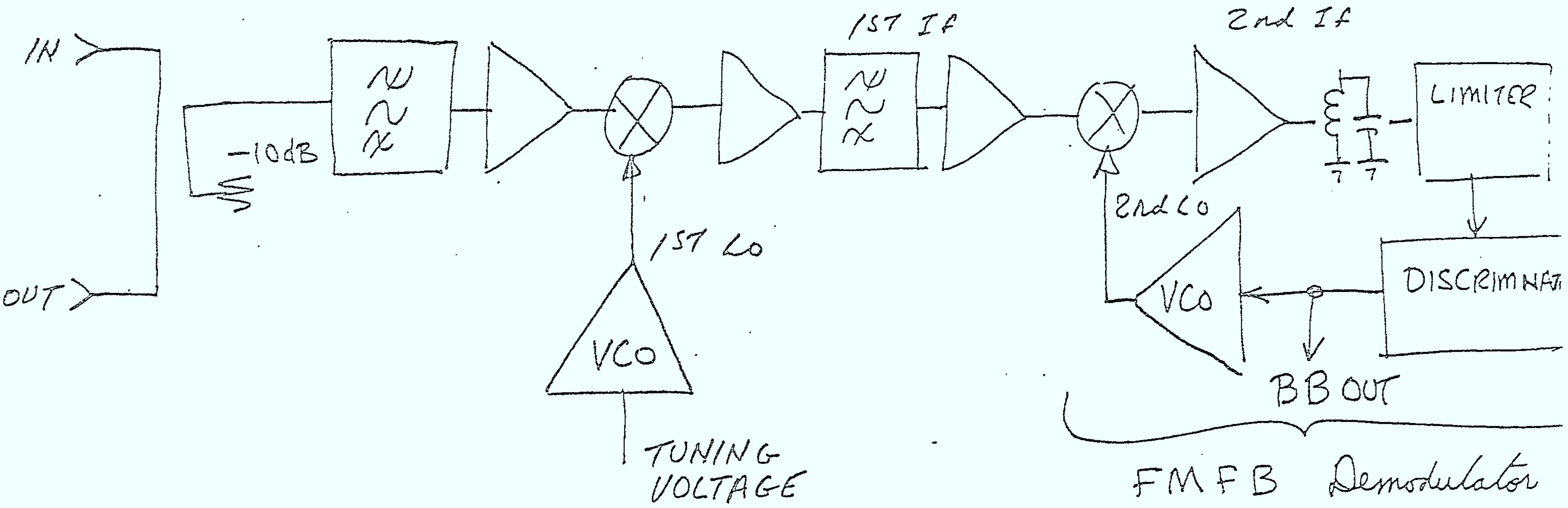
The image reject mixer provides a 70MHz output IF in one mixing process and permits conventional 70MHz IF technology and the selection of either a standard FM discriminator or PLL IC demodulator. A limiter followed by a Fancourt and Skivirzynski demodulator is similar to that used in current SED commercial receivers, providing normal threshold, but requiring complexity to work well. A PLL chip demodulator could be employed. Most of these do not work repeatably at 70MHz and therefore require a divide by two prescaler. Also, some IC chip selection may still be required as these units are being pushed to their upper limit in frequency. In addition these circuits provide acceptable pictures, but often produce some leading edge noise distortion on fast rising edges of objects in the picture, during black to white transitions.

In conclusion, using the previous approach employs no new ideas and basically would not produce a product design with a competitive edge in both price and performance.

Dual conversion receiver with Low/High IF output:

This configuration (Figure 4.2) uses a dual conversion principle to gain all the advantages of image and spurious free performance. This requires the 1st IF to be greater than the receiver tuning band width. A second LO is required to convert the 1st IF to a lower frequency, prior to demodulataon. The 1st IF frequency can be above or below the input band of 950 to 1450MHz. The 1st IF frequency was selected below the input band as the mixers are less expensive. Therefore a 612.5MHz IF was selected over a 1550MHz IF. The LO is out of band and presents no problems with multiple receivers operating from one antenna system.

The dual conversion system uses the second LO to convert the high IF (612.5MHz) to a lower IF for demodulation. This IF could be 70MHz and employ a conventional IF amplifier and 18MHz wide filter followed by a limiter discriminator. However, with negligible increase in complexity the BB output of the discriminator is fed back to the 2nd LO to modulate it and cause tracking of the input signal. This permits the FM demodulator to be upgraded to a superior system employing feedback or a classical FMFB demodulator. Doing this enables threshold extension and reduces the need for an 18MHz wide IF filter. The FMFB demodulator establishes its own demodulation bandwidth. Also, the 2nd IF within the demodulator is 160MHz. This allows the selectivity requirement on the 1st IF filter to be less stringent due to the fact that the image frequency of the second mixer is much higher than that for 70MHz.



Dual Conversion Receiver.

Figure 4.2

4.2 Detailed Description of Proposed Indoor Unit Configuration

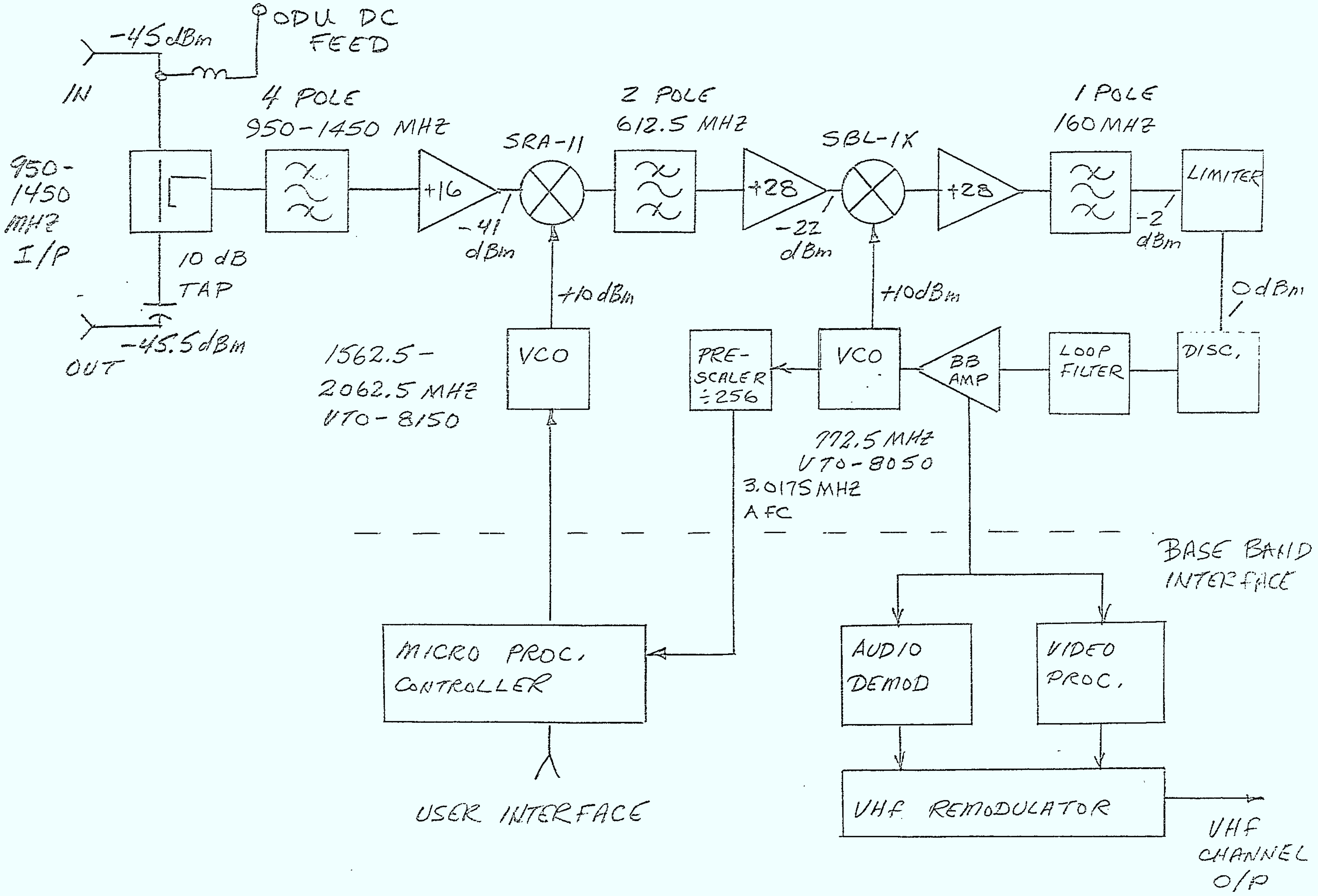
The indoor unit configuration (Figure 4.3) converts the 950-1450MHz input through to demodulated baseband (BB) output. The microprocessor controller, audio demodulator and video processing including overall packaging is not considered in this description.

The input of each indoor unit has a built-in 10 dB tap coupler. This permits cascading of indoor units up to about 6. The cost of the tap is not significant, but assumes most users will want to purchase second and third indoor units without the expense of a power splitter. Many families own more than one TV and will want to watch different channels at the same time. The tap also feeds DC power down the cable to power the outdoor LNC (low noise converter).

The coupled output of the 10 dB tap is filtered by a 950 to 1450MHz microstrip filter, amplified by a two stage bipolar amplifier. The receive carriers enter the SRA-11 double balanced mixer. The wanted carrier is mixed with the first LO frequency to be converted to 612.5MHz. The first LO is a voltage tuned oscillator covering the band 1562.5 to 2062.5MHz.

The SRA-11 IF output feeds the 612.5MHz IF strip consisting of a 30MHz 2 pole preselector filter followed by a Phillips OM 360 amplifier. At this point the wanted channel is selected.

The second mixer SBL-1X converts the 612.5MHz to 160MHz. The SBL-1X, 28 dB amp, limiter-discriminator and 2nd LO comprise the FMFB demodulator.



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MAR. 26-82

BLOCK DIAGRAM INDOOR UNIT
FIGURE 4.3

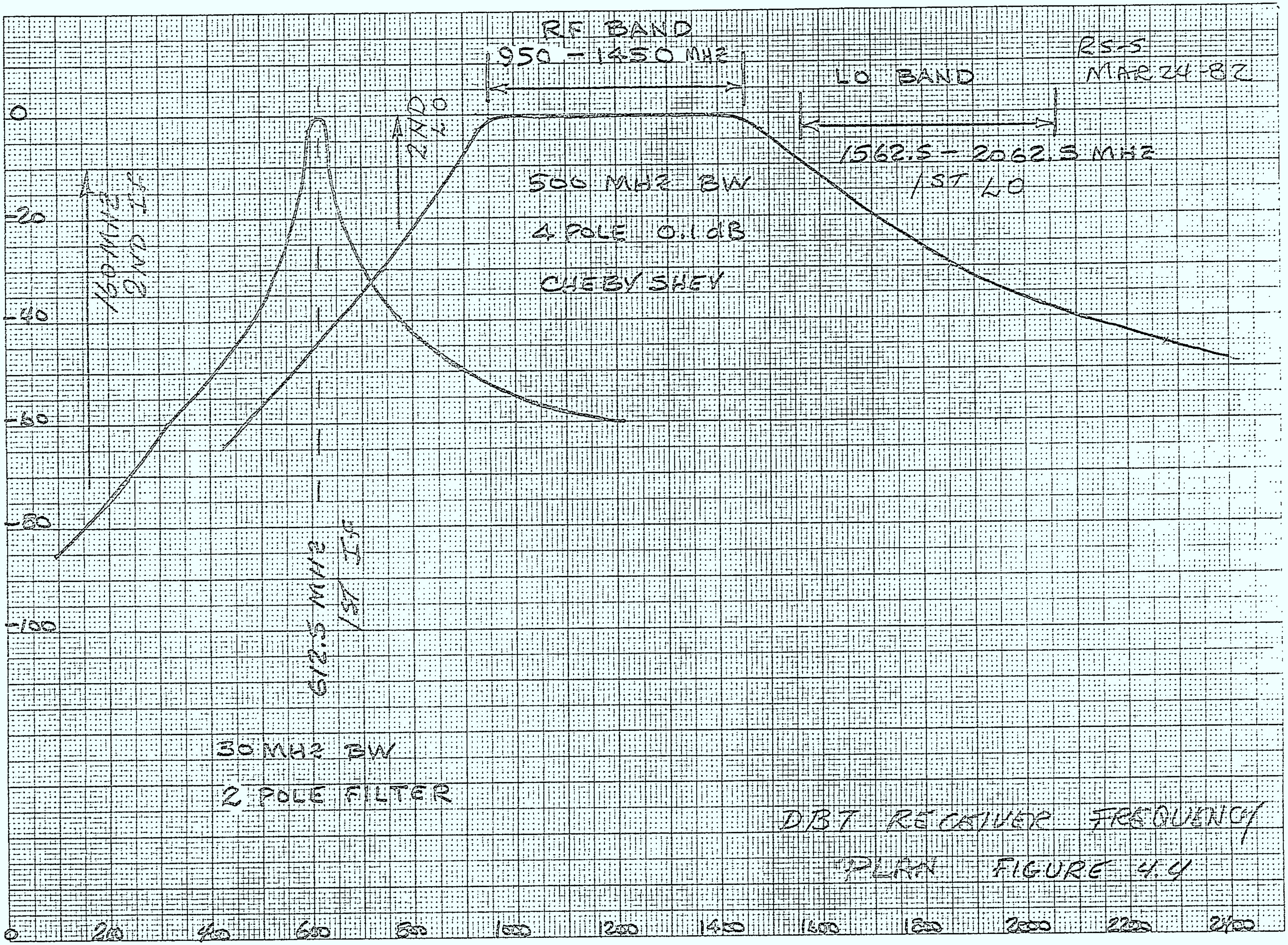
The FMFB demodulator provides a one to two dB threshold improvement, allowing a smaller antenna. The 2nd LO (772.5MHz) tracks the video signal, reducing the effective modulation as seen by the 160MHz IF. A one pole filter of about 14MHz bandwidth lowers the predetected noise bandwidth below the 18MHz otherwise used for a conventional 70MHz IF filter. Therefore, the discriminator sees both better C/N ratio and lower deviation, resulting in improved threshold and lower distortion. The 14MHz p-p deviation at 612.5MHz would be reduced to 4.7MHz p-p at 160MHz IF with 772.5MHz VCO being deviated 9.3MHz p-p. The demodulated baseband is taken from the 772.5MHz VCO tuning voltage as the unprocessed BB output. Figure 4.4 shows the frequency plan and filter characteristics for Figure 4.3.

Receiver Tuning:

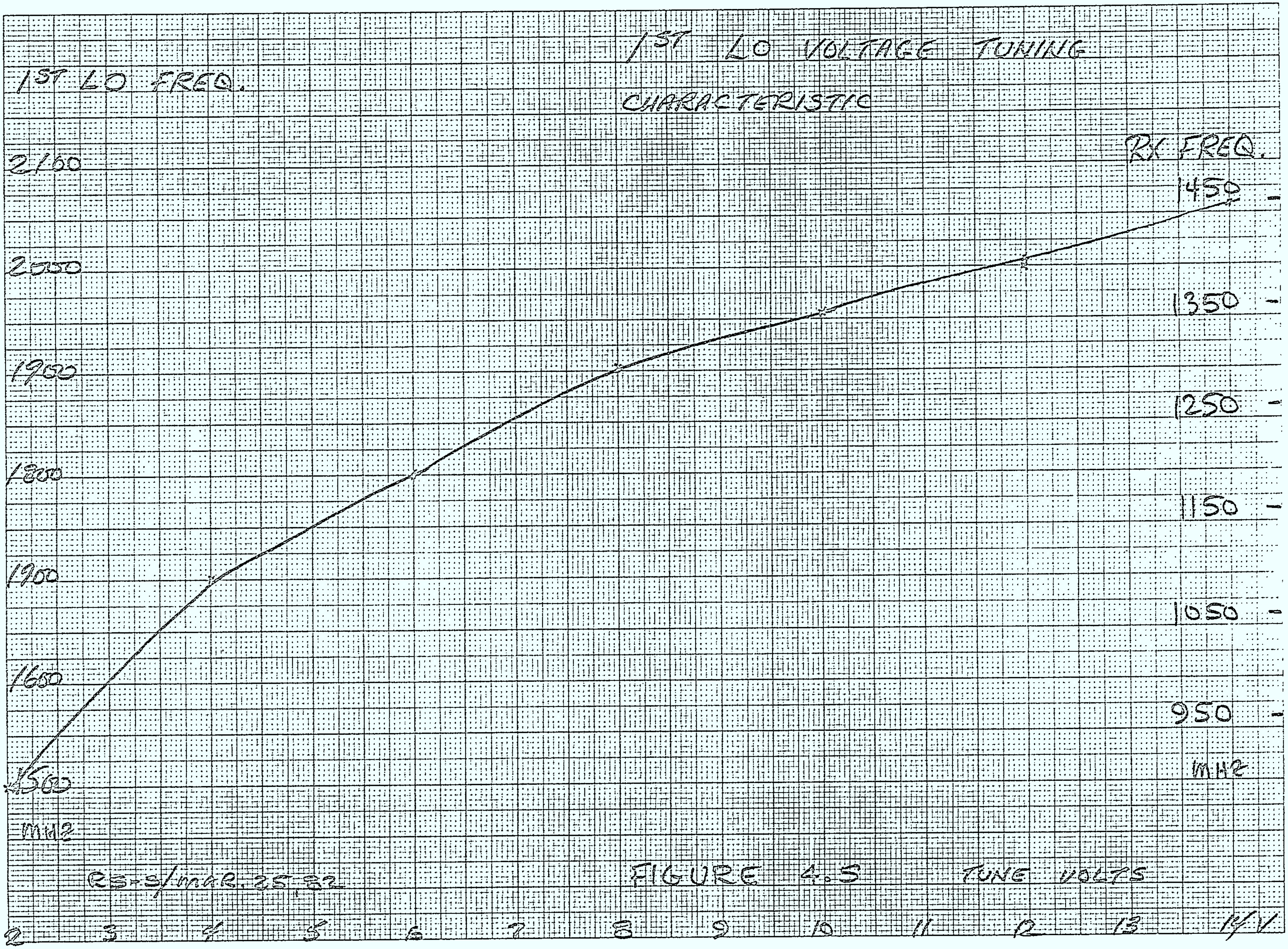
The receiver channel selection is accomplished through voltage tuning of the 1st LO. The microprocessor with D to A convertor and charge pump system tunes the LO to the prescribed input voltage corresponding to the given frequency plan. See Figure 4.5 for the tuning characteristic. This will place the desired video carrier within ±5MHz and the FMFB capture range. The output of the 772.5MHz VCO is counted down and the 1st LO tuning voltage is modified slightly using the microprocessor charge pump systems, which forces the wanted carrier onto center frequency through AFC action.

Conclusion:

Dual conversion is selected in the view that no LO's are inband and that a dual conversion system is easier and less critical to build than a broadband image reject convertor. The input band 500 to 1000MHz was originally proposed but now has been raised to the generally acceptable 950 to 1450MHz band in order to avoid difficulty



DBT RECEIVER FREQUENCY PLAN FIGURE 4.4



1ST LO VOLTAGE TUNING CHARACTERISTIC

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FIGURE 4.5

FREQUENCY PLANS FOR ALTERNATE RECEIVE SYSTEMS

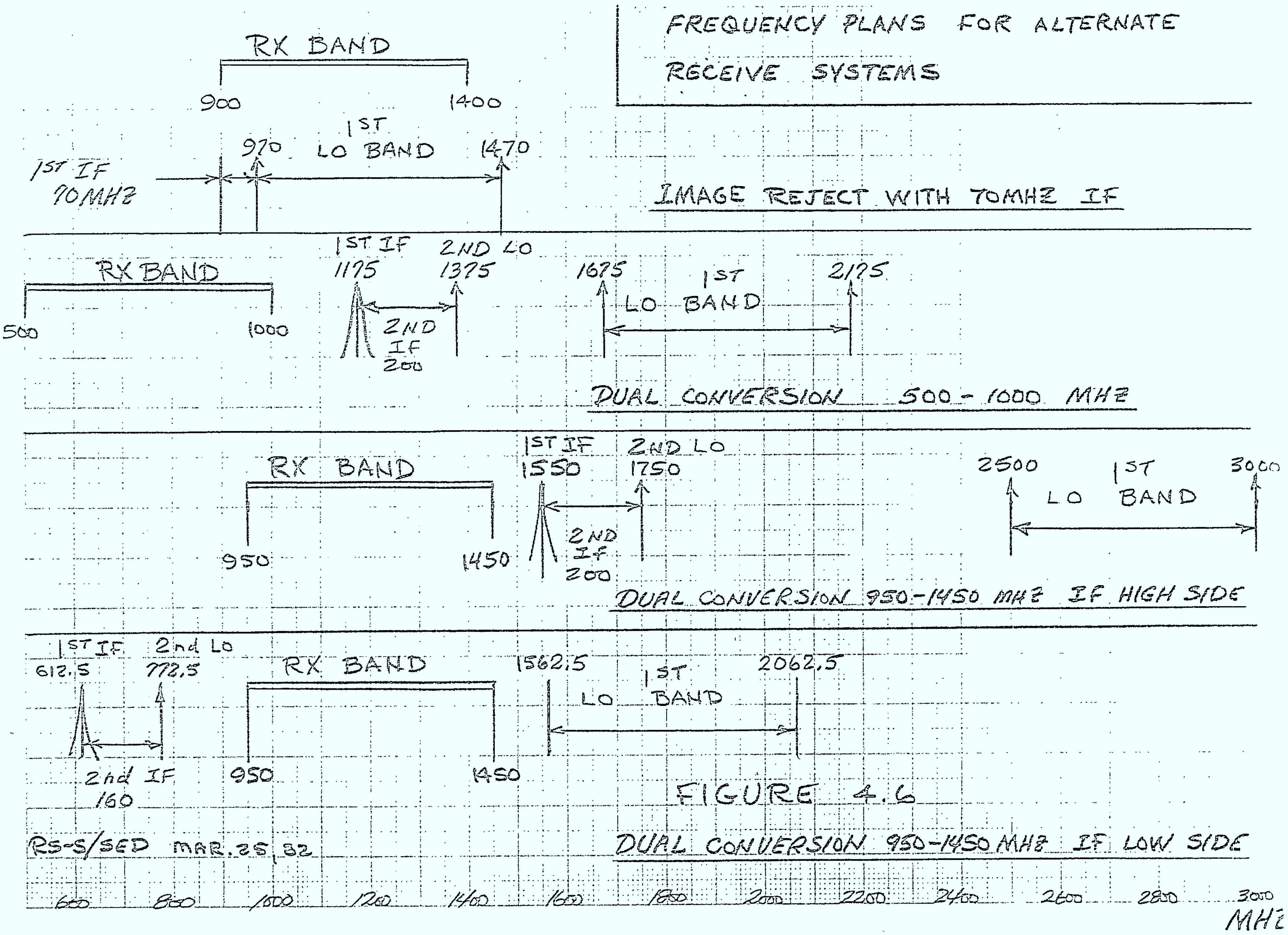


FIGURE 4.6

RS-S/SED MAR.25,82

in attaining FCC and DOC approval. In addition, the 1st IF, which otherwise could only be high side to keep the 1st LO out of band, can now be low side. This was selected in that the low side IF is the most economical. The FMFB demodulator was selected as providing the best cost/performance trade off and adapts very well into the receiver block diagram. See Figure 4.6 for a comparison of various frequency plans.

4.3 Packaging

The prototype HACBSS video receiver IDU packaging is shown in Figure 4.6. The cabinet (Figure 4.7) will be a Hammond 1458 G3 chassis. Dimensions are 3" high, 10" wide and 8" deep. This unit will contain a +20V AC power supply. Front panel controls consist of a 12 position channel switch, signal strength meter and power on-off switch with indicator. The rear panel will contain 950-1450MHz loop thru RF inputs with F connectors. The VHF output on Channel 1 or 6 will also be available at the rear panel. In addition, the power cord and fuse holder are mounted on the rear panel. The LNC will be powered through the IFL cable from the IDU.

Production packaging of the IDU will be the subject of further human engineering studies in conjunction with CODAN Pty. Ltd.

4.4 IDU Design Details

This section includes design data on selected portions of the IDU design. This includes the input coupler, 950-1450MHz filter and amplifier, 612.5MHz IF filter, 160MHz discriminator and FMFB loop characteristics.

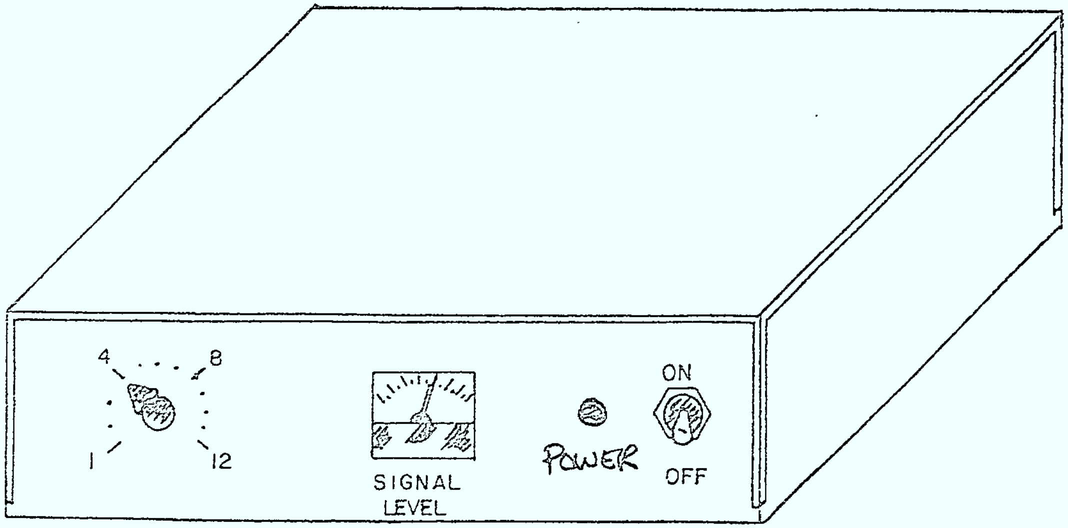


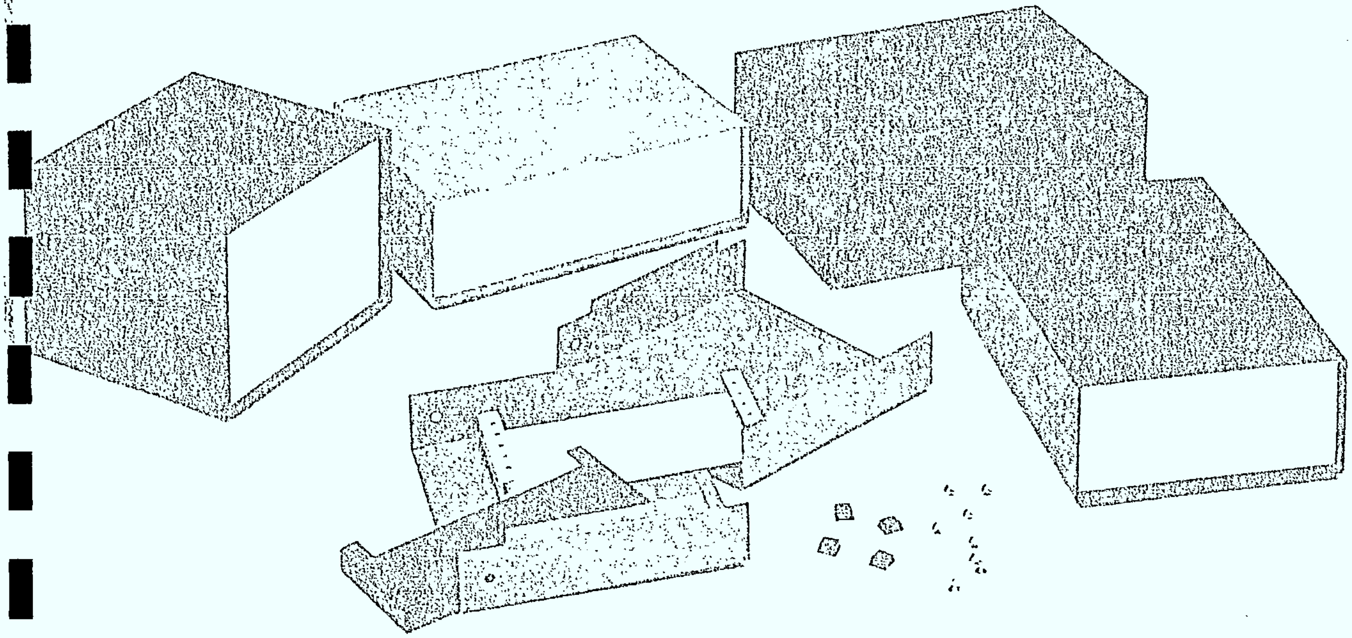
FIGURE : 4.6

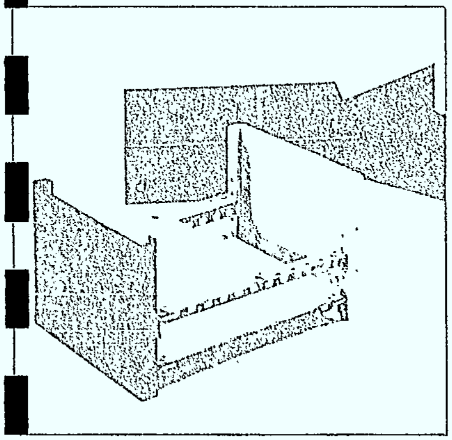
OUTLINE DRAWING

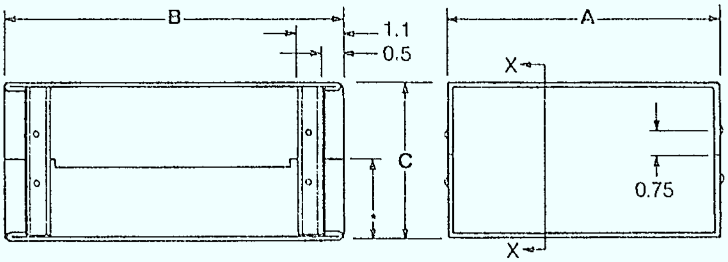
INDOOR UNIT

TELEVISION

458 series







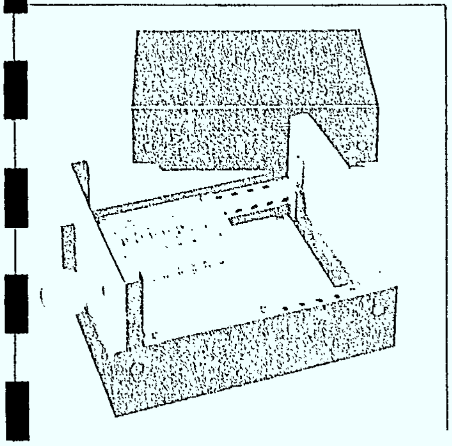
CROSS SECTION X-X

*Case is split in two equal halves

REAR VIEW

Vhen used with 1448 series rails, pg. 11 oth top and bottom covers can be emoved without affecting component to panel connections.

- 20 gauge CRS case with black or gulf blue baked-on textured finishes.
- .064" thick aluminum panels (one satin black and one smoke white for each case).
- symetrical design so either end can be front.
- 6-32 philips nickel plated screw and self-adhesive rubber feet included.



Blacktex Cat No	Bluetex Cat No	A	B	C
1458 D3	1458 D3B	8	8	3
1458 D4	1458 D4B	8	8	4
1458 D5	1458 D5B	8	8	5
1458 E3	1458 E3B	8	10	3
1458 E4	1458 E4B	8	10	4
1458 E5	1458 E5B	8	10	5
1458 G3	1458 G3B	10	8	3
1458 G4	1458 G4B	10	8	4
1458 G5	1458 G5B	10	8	5

FIGURE 4.7

Table 4.1 outlines the measured performance of the 1/4 wave microstrip coupler used in the receiver input for the 950 to 1450MHz band.

Figure 4.8 shows the computed response of the 950 to 1450MHz microstrip filter that follows the coupler. Figure 4.9 is the microstrip layout for G-10 circuit board material. The measured performance is close to the computed response. However, due to the close proximity of adjacent resonators the coupling track "C" had to be lengthened in a hairpin fashion to compensate for capacitive coupling between resonators. Included for completeness are copies of the computer run using the SED "Nodal" program showing line impedance and length, line interconnection and S parameter printout.

The 950 to 1450MHz amplifier follows the previous filter. Its predicted gain response and in-out return loss are given in Figure 4.10. The requirements for this amplifier are for about 16 dB gain with a +2 dB gain slope for IFL cable compensation. Also, the input return loss is to exceed 15 dB to provide a good match to the input filter. The output return loss exceeds 9 dB and is sufficient for driving a mixer. Figure 4.11 and 4.12 show design details of the amplifier including the computer printout.

The 612.5MHz IF filter is a two pole design with a bandwidth of 20 to 30MHz. Several types of designs were considered, including different means of coupling. Figure 4.13 and 4.14 shows the predicted responses. Figure 4.15 gives the computer predicted responses for three types of filter construction. Included are the three computer data files as follows:

TABLE 4.1 Characteristics of IDU Input 10 dB Coupler

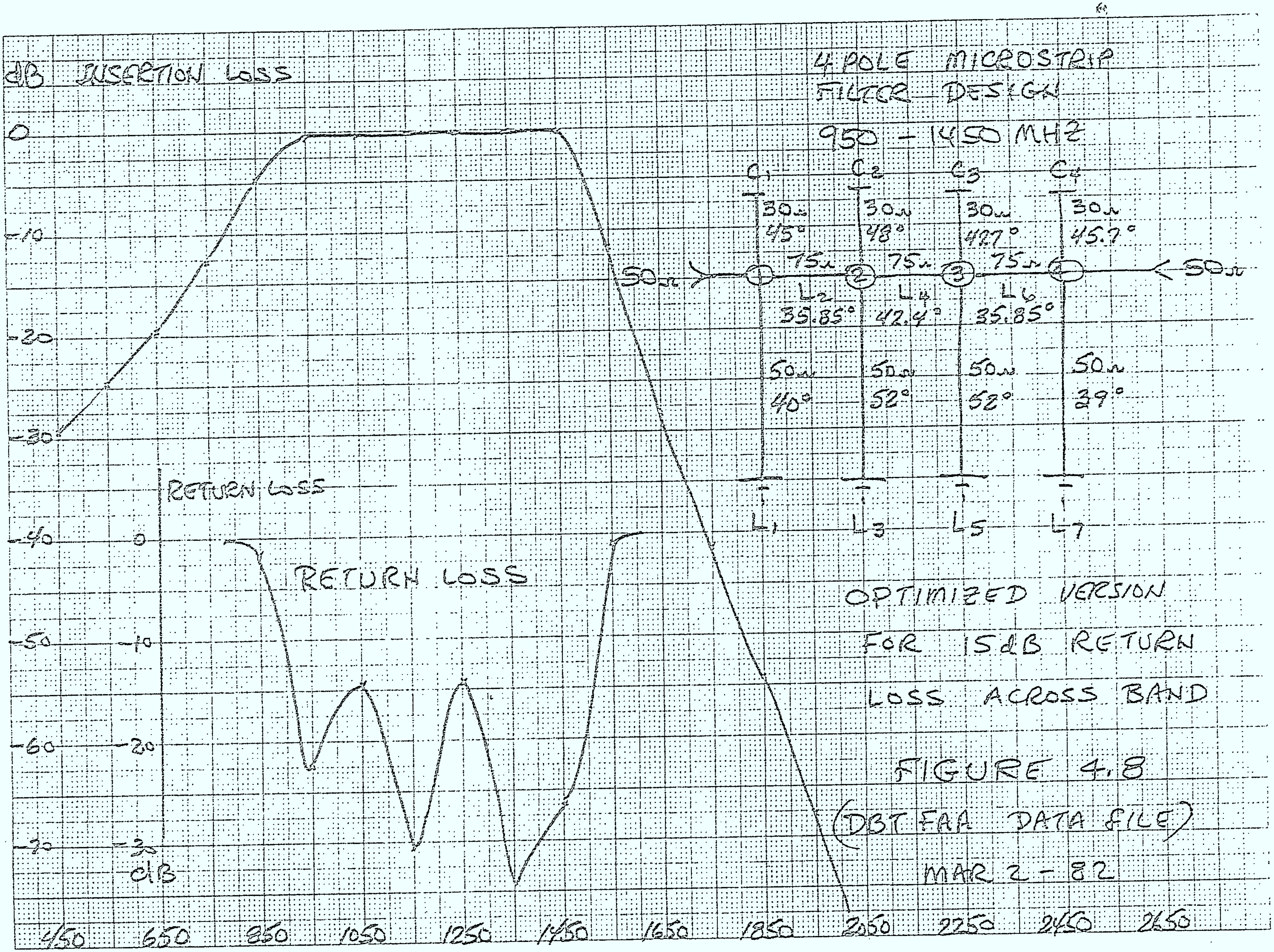
Frequency band	950 to 1450MHz
Loss (through ports)	-1 dB
Worse case return loss (through ports)	21 dB

Coupling to sample port forward direction:

Frequency	Coupling
950MHz	10 dB
1200MHz	10.5 dB
1450MHz	11.5 dB

Directivity of coupler:

Frequency	Directivity
950MHz	18 dB
1200MHz	19.5 dB
1450MHz	13.5 dB



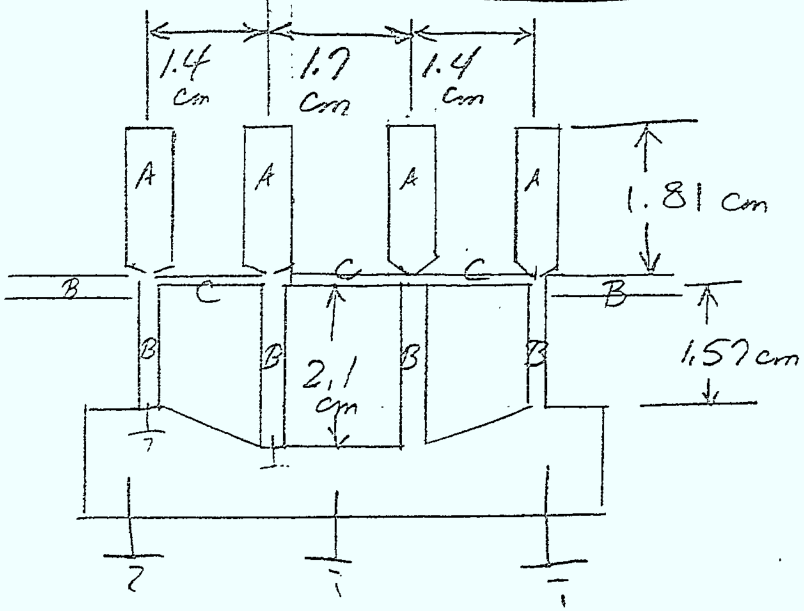
4 POLE MICROSTRIP
FILTER DESIGN
950 - 1450 MHZ

OPTIMIZED VERSION
FOR 15dB RETURN
LOSS ACROSS BAND

FIGURE 4.8
(DBT FAA DATA FILE)
MAR 2 - 82

4 POLE MICROSTRIP FILTER DESIGN

G-10 circuit board



A = 6.35 mm

B = 4.3 mm

C = 1.1 mm

FIGURE 4.9

```
  A603 LOAD MODULE DOES NOT EXIST

!TN1
  A603 LOAD MODULE DOES NOT EXIST

!EDIT  DBTFAA
EDIT HERE
#SE1F/.95 1.45/S/.45 2.45/#TY
    1.000 .45 2.45 .1 1.174 .06 0
#END

!FLAD NODAL
WITH>NODD

  MINIMUM FREQ =               .45000  GHZ

  MAXIMUM FREQ =              2.45000  GHZ

  FREQ INCREMENT =             .10000  GHZ

  THE TRANS. LINE ATEN =       .060  DB/WAVELENGHTH

  TRANS. LINE REF. FREQ =     1.174  GHZ

  OPTIMIZ. CONTROL NOPT =           0


  THE  ELEMENT DESCRIPTION IS AS FOLLOWS


  OST C1              30.000      45.000        .000         .000
  SST L1              50.000      40.000        .000         .000
  TRL L2              75.000      35.850        .000         .000
  OST C2              30.000      48.000        .000         .000
  SST L3              50.000      52.000        .000         .000
  TRL L4              75.000      42.400        .000         .000
  OST C3              30.000      47.700        .000         .000
  SST L5              50.000      52.000        .000         .000
  TRL L6              75.000      35.850        .000         .000
  OST C4              30.000      45.700        .000         .000
  SST L7              50.000      39.000        .000         .000
  END                   .000        .000        .000         .000


  NETWORK INTERCONNECTIONS BEGINS


  DEF AA   T2              4.000       1.000       4.000       .000        .000
       CON C1   T2            1           0           0
       CON L1   T2            1           0           0
       CON L2   T2            1           2           0
       CON C2   T2            2           0           0
       CON L3   T2            2           0           0
       CON L4   T2            2           3           0
       CON C3   T2            3           0           0
       CON L5   T2            3           0           0
       CON L6   T2            3           4           0
       CON C4   T2            4           0           0
       CON L7   T2            4           0           0
       END AA                 0           0           0
  ANL AA   S1            50.000        .000      50.000        .000        .000
  NTW                      .000        .000        .000        .000        .000


    FREQUENCY(GHZ)         S--PARAMETERS


          .45000             .01     65.55        -28.98     65.55        -28.98     65.55           .01
          .55000             .02    147.08        -24.48     57.21        -24.48     57.21           .02
          .65000             .07    135.47        -19.26     45.65        -19.26     45.65           .07
          .75000             .27    118.84        -12.78     26.93        -12.78     26.93           .27
          .85000            1.92     76.97         -4.72    -12.43         -4.72    -12.43          1.91
          .95000           22.67     -6.52          -.14    -88.15          -.14    -88.15         22.30
         1.05000           14.29   -124.72          -.26   -148.17          -.26   -148.17         14.29
         1.15000           30.92   -136.60          -.11    157.86          -.11    157.86         31.58
         1.25000           13.92   -171.52          -.30    102.76          -.30    102.76         13.91
         1.35000           34.44    -48.33          -.16     39.89          -.16     39.89         30.64
         1.45000           26.15   -109.02          -.29    -45.25          -.29    -45.25         26.62
         1.55000             .48    -82.48        -11.94   -171.85        -11.94   -171.85           .48
         1.65000             .07   -121.57        -28.34    148.83        -28.34    148.83           .07
         1.75000             .04   -139.06        -41.73    131.44        -41.73    131.44           .04
         1.85000             .03   -150.14        -54.39    120.59        -54.39    120.59           .03
         1.95000             .02   -158.28        -67.88    112.86        -67.88    112.86           .02
         2.05000             .02   -164.81        -84.47    107.23        -84.47    107.23           .02
         2.15000             .02   -170.39       -111.63    105.26       -111.63    105.26           .02
         2.25000             .02   -175.40       -133.17     90.70       -133.17     90.70           .02
         2.35000             .02    179.91       -146.21     30.89       -146.21     30.89           .02
         2.45000             .02    175.35        -95.89     80.54        -95.89     80.54           .02
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  *TYO-99
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SST L3      [illegible]      [illegible]      [illegible]      [illegible]
TRL L4      75.000      43.400      .000      .000
DST C3      34.000      47.700      .000      .000
SST L5      50.000      52.000      .000      .000
TRL L6      75.000      35.[illegible]      .000      .000
DST C4      30.000      45.700      .000      .000
SST L7      50.000      39.000      .000      .000
END           .000        .000      .000      .000


NETWORK INTERCONNECTIONS BEGINS


DEF AA  T2        4.000     1.000     4.000     .000     .000
   CON C1  T2       1         0         0
   CON L1  T2       1         0         0
   CON L2  T2       1         2         0
   CON C2  T2       2         0         0
   CON L3  T2       2         0         0
   CON L4  T2       2         3         0
   CON C3  T2       3         0         0
   CON L5  T2       3         0         0
   CON L6  T2       3         4         0
   CON C4  T2       4         0         0
   CON L7  T2       4         0         0
   END AA           0         0         0
 ANL AA  S1       50.000     .000    50.000     .000     .000
 NTW                .000     .000      .000     .000     .000

  FREQUENCY(GHZ)   --S--PARAMETERS

     .45000     .01    65.55    -20.98    65.55    -20.98    65.55     .01    155.97
     .55000     .02   147.08    -24.48    57.21    -24.48    57.21     .02    147.72    .000
     .65000     .07   135.47    -19.76    45.65     19.76    45.65     .07    125.58    .000
     .75000     .27   116.69    -12.78    26.93     12.78    26.93     [illegible]    [illegible]    .000
     .85000    1.92    74.97     -4.72   -12.43     -4.72   -12.43    1.91     79.73    .000
     .95000   22.67    -6.52      -.14   -88.15      -.14   -88.15   27.30    [illegible]    .000
    1.05000   14.29  -124.72      -.26   148.17      -.26  -148.17   14.29    119.37    .000
    1.15000   30.92  -136.40      -.11   157.86      -.11   157.86   31.58   -102.14    .000
    1.25000   13.92  -171.02      -.30   102.76       .30   102.76   13.91   -147.04    .000
    1.35000   34.44   -48.33      -.18    39.89      -.18    39.89   20.64   -145.80    .000
    1.45000   26.15  -109.02      -.29   -45.25      -.29   -45.25   26.82   -132.69    .000
    1.55000     .48   -82.48    -11.94  -171.85    -11.94  -171.85     .48     85.03    .000
    1.65000     .07  -121.57    -28.34   148.83    -29.34   148.83     .07   -134.22    .000
    1.75000     .04  -139.06    -41.73   131.44    -41.73   131.44     .04   -141.27    .000
    1.85000     .03  -150.11    -54.39   120.59    -54.39   120.59     .03   -152.17    .000
    1.95000     .02  -158.23    -67.08   112.86    -67.08   112.86     [illegible]    [illegible]    .000
    2.05000     .02  -164.81    -84.47   107.23    -84.47   107.23     .02   -166.54    .000
    2.15000     .02  -170.39   -111.63   105.26   -111.63   105.26     .02   -172.07    .000
    2.25000     .02  -175.40   -133.17    90.70   -133.17    90.70     .02    177.06    .000
    2.35000     .02   177.91   -146.21    30.89   -146.21    30.89     .02    178.24    .000
    2.45000     .02   175.35    -95.89    80.54    -95.89    80.54     .02    173.44    .000
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    3.000 SST L1 50 40
    4.000 TRL L2 75 35.85
```

C1
30~
45°

C2
30~
48°

C3
30~
47.7°

C4
30~
45.7°

```
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 2.05000               .02  -164.81      84.47   107.23      84.47   107.23        .0[illegible]  [illegible]         [illegible]
 2.15000               .02  -170.39    -111.63   105.26    -111.63   105.26        .0[illegible]  17[illegible]       .0[illegible]
 2.25000               .02  -175.40     133.17    90.70    -133.17    90.70        .0[illegible]  -177.06             .000
 2.35000               .02   179.91     146.21    30.89    -146.21    30.89        .02    178.24              [illegible]
 2.45000               .02   175.35     -95.89    80.54     -95.89    80.54        .02    17[illegible].[illegible]4   .000
*STOP*

!EDIT DBTFAA
EDIT HERE
*TY0-99
     1.000 .45 2.45 .1 1.174 .06 0
     2.000 OST C1 30 45
     3.000 SST L1 50 40
     4.000 TRL L2 75 35.85
     5.000 OST C2 30 48
     6.000 SST L3 50 52
     7.000 TRL L4 75 42.4
     8.000 OST C3 30 47.7
     9.000 SST L5 50 52
    10.000 TRL L6 75 35.85
    11.000 OST C4 30 45.7
    12.000 SST L7 50 39
    13.000 END
    14.000 DEF AA T2 4 I 4
    15.000 CON C1 T2 1 0
    16.000 CON L1 T2 1 0
    17.000 CON L2 T2 1 2
    18.000 CON C2 T2 2 0
    19.000 CON L3 T2 2 0
    20.000 CON L4 T2 2 3
    21.000 CON C3 T2 3 0
    22.000 CON L5 T2 3 0
    23.000 CON L6 T2 3 4
    24.000 CON C4 T2 4 0
    25.000 CON L7 T2 4 0
    26.000 END AA
    27.000 ANL AA S1 50 0 50 0
    28.000 NTW
    29.000 0.,1.,0.,0.,5.,
    30.000 -15.,-15.,-15.,-15.,-15.,-15.,
  --EOF HIT AFTER 30.
*END

 !SET F:5/DBTFAA

 !PLATEN 140

 !BYE

 CPU = 5.2406 CON= 01:38:00 TRD= 127 TWR= 1870 CORE= 206.7766 I/O= 588

 NET COST OF SESSION WAS $29.76


 SASKCOMP SIGMA 9 AT YOUR SERVICE
 14:23 MAR 02,'82   USER# 56    LINE# 15
 LOGON PLEASE: 0
```
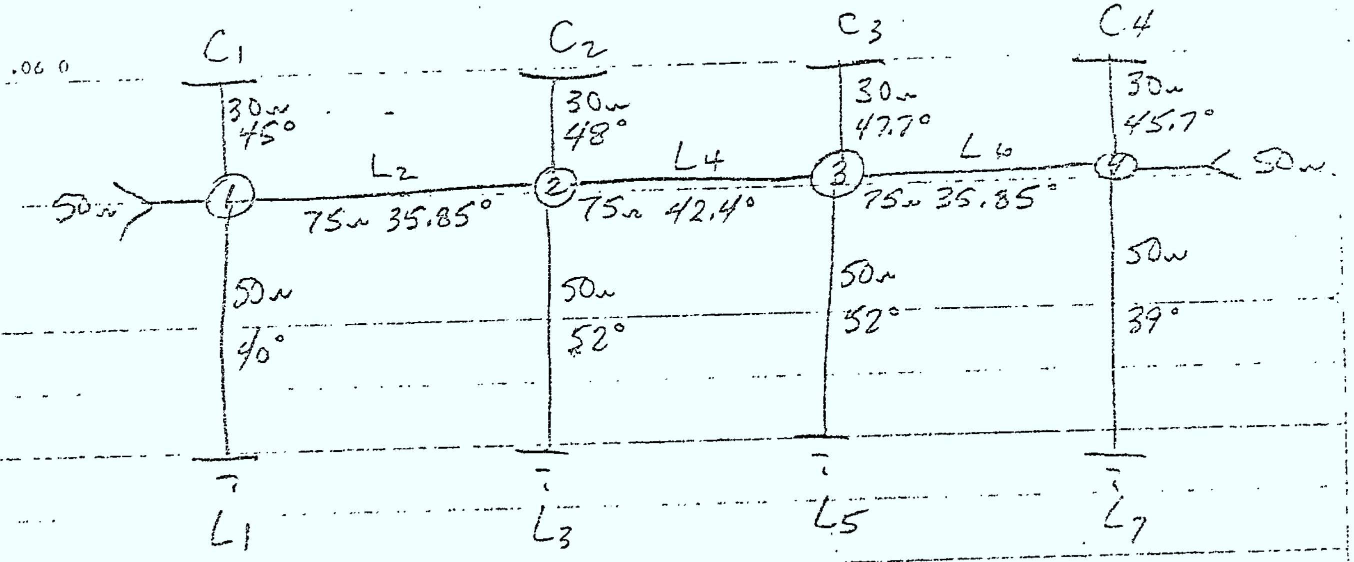



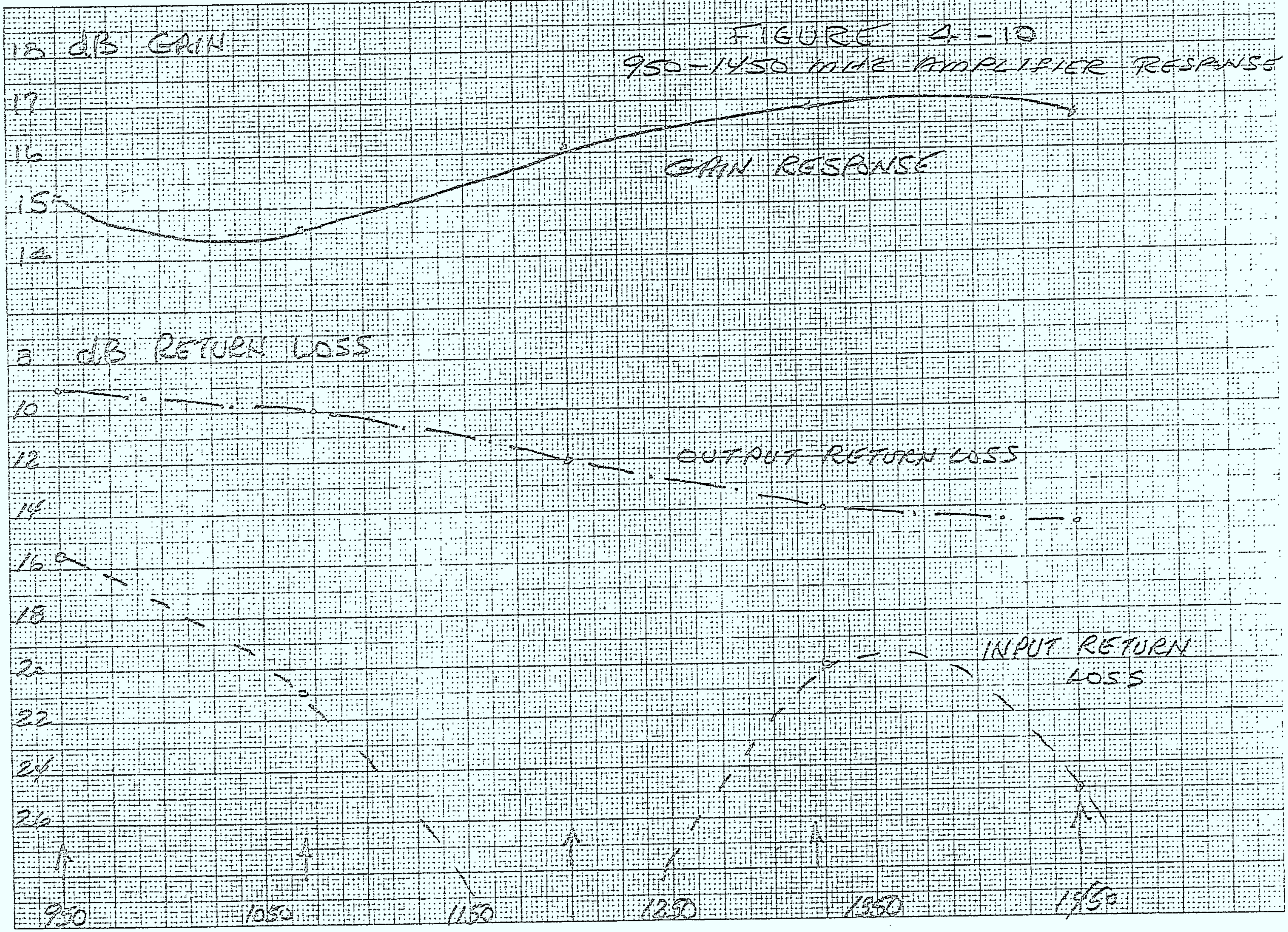


FIGURE 4-10
950-1450 MHZ AMPLIFIER RESPONSE

```
     FREQ.   GAIN    STBL.   GRP.DEL.   IRETL.    FNOISE.  SLOPE.    ORETL.
     (GHZ)   (DB)    (NUM.)   (NSEC)     (DB)      (DB)    (DB/MHZ)   (DB)
       .95  15.345 201.719     .000    17.490     2.300     .0000     9.078
      1.07  14.619 111.732     .000    21.082     2.495     .0000    10.013
      1.20  16.144  49.592     .000    31.008     2.503     .0000    11.921
      1.32  16.969  24.559     .000    20.073     2.713     .0000    14.062
      1.45  16.716  14.516     .000    24.507     2.796     .0000    14.771
    *STOP*

  !EDIT DA
  EDIT HERE
  *TYO-99
     1.000 1.2,22.,.95,1.45,5.,.06,
     2.000 2.,4.,5.,10.,2.,9.,2.,13.,2.,10.,7.,5.,10.,2.,9.,13.,2.,10.,7.,5.,2.,10.,
     3.000 30.,.06,
     3.100 75.,.27,
     3.200 17.,
     3.300 1000.,
     3.400 50.,.04,
     4.000 10.,
     4.500 50.,.04,
     5.000 4.5,-165.,-25.2,41.,16.9,82.,9.47,-59.,
     6.000 4.7,-178.,-24.4,42.,14.2,76.,11.06,-57.,
     7.000 4.7,172.,-23.4,42.,13.0,70.,11.40,-59.,
     8.000 4.7,165.,-22.5,43.,11.6,65.,11.80,-62.,
     9.000 4.7,158.,-21.5,43.,10.00,61.,13.00,-64.,
    10.000 .5,.4,-.26,1.2,
    11.000 .5,.5,-.30,1.2,
    12.000 .4,.5,-.32,1.3,
    13.000 .4,.5,-.35,1.4,
    14.000 .4,.6,-.46,1.5,
    14.500 50.,.04,
    15.000 300.,
    15.500 -21.2,
    26.000 -.57,
    27.000 1000.,
    27.500 50.,.04,
    28.000 0.,
    35.000 4.5,-165.,-25.2,41.,16.9,82.,9.47,-59.,
    36.000 4.7,-178.,-24.4,42.,14.2,76.,11.06,-57.,
    37.000 4.7,172.,-23.4,42.,13.0,70.,11.40,-59.,
    38.000 4.7,165.,-22.5,43.,11.6,65.,11.80,-62.,
    39.000 4.7,158.,-21.5,43.,10.00,61.,13.00,-64.,
    40.000 .5,.4,-.26,1.2,
    41.000 .5,.5,-.30,1.2,
    42.000 .4,.5,-.32,1.3,
    43.000 .4,.5,-.35,1.4,
    44.000 .4,.6,-.46,1.5,
    49.000 50.,.04,
    50.000 300.,
    50.100 -17.,
    50.200 -.93,
    50.250 50.,.04,
    50.300 100.,
    51.000 1.,0.,0.,0.,1.,
    52.000 15.,15.5,16.,16.5,17.,
    53.000 END
  --EOF HIT AFTER 53.
  *END

  !BYE

  CPU = 3.2153 CON= 01:01:00 TRD= 151 TWR= 1076 CORE= 88.8699 I/O= 383

  NET COST OF SESSION WAS $16.76
```

18.86 nhy
.565pf

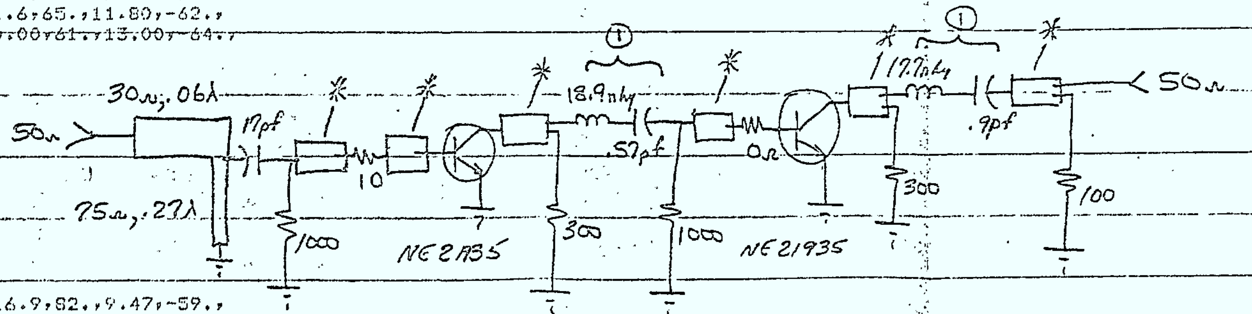
17.65 nhy
.93 pf

18.9 nhy

DIA = 0.04"
LENGTH = 0.1"
8 TURNS
#36 BUSS

17.7 nhy

DIA = 0.04"
LENGTH = 0.1"
7 TURNS
#36 BUSS



* 50Ω, .04λ PAD

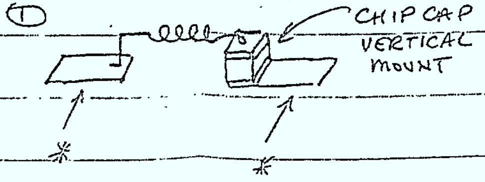
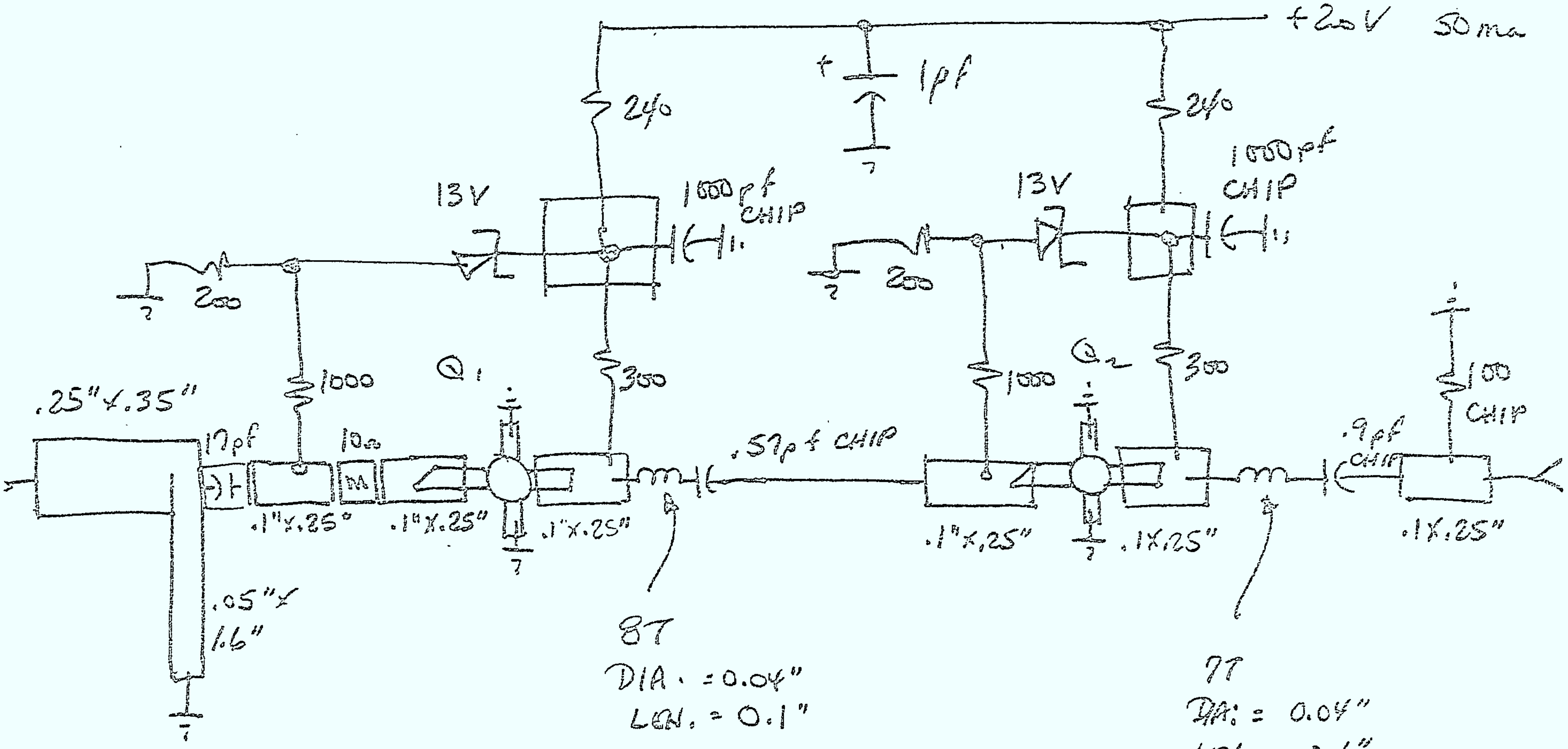
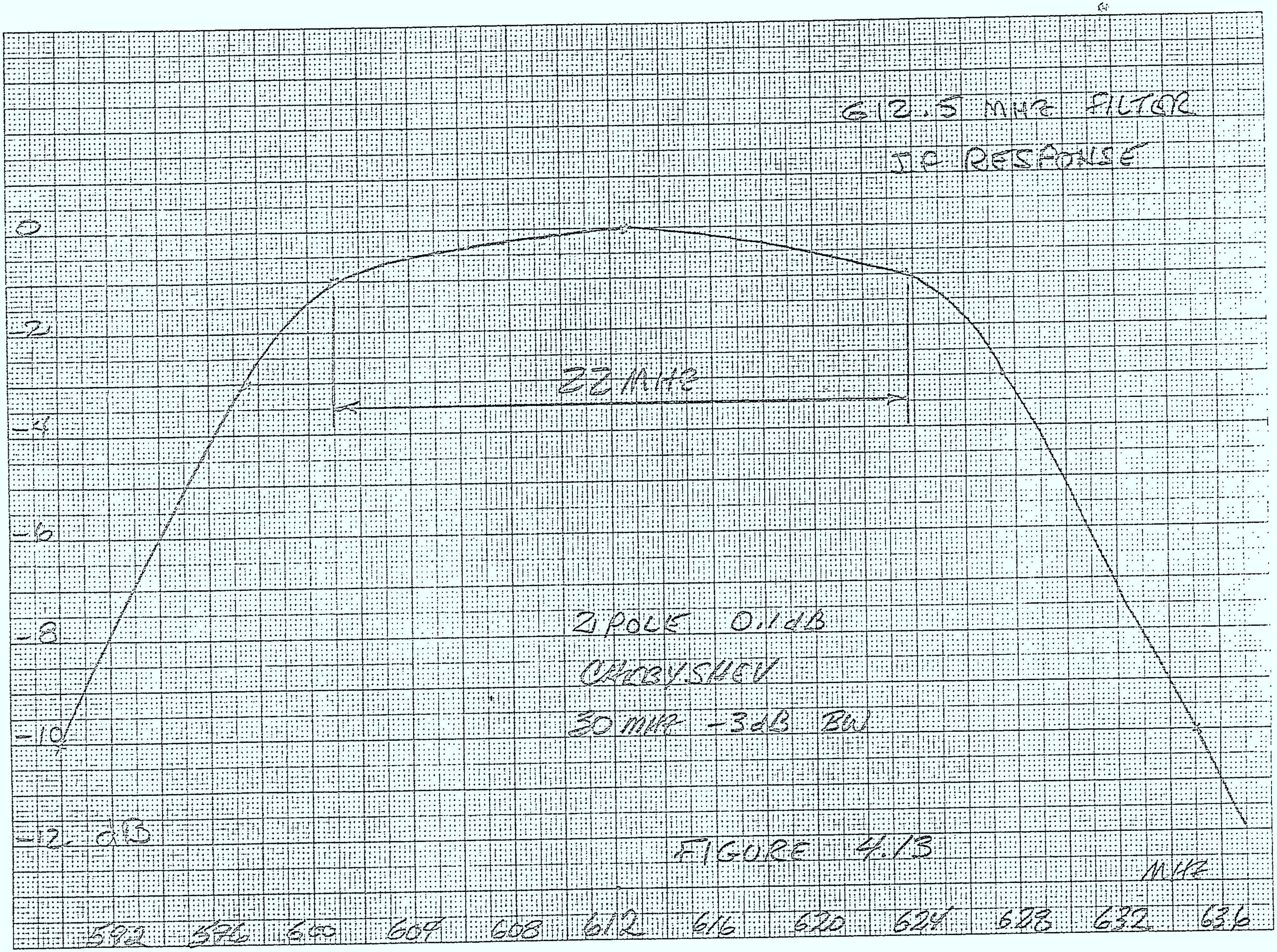


FIGURE 4.12



Q_1 & Q_2 = NE21935

FIGURE 4.11



612.5 MHz FILTER

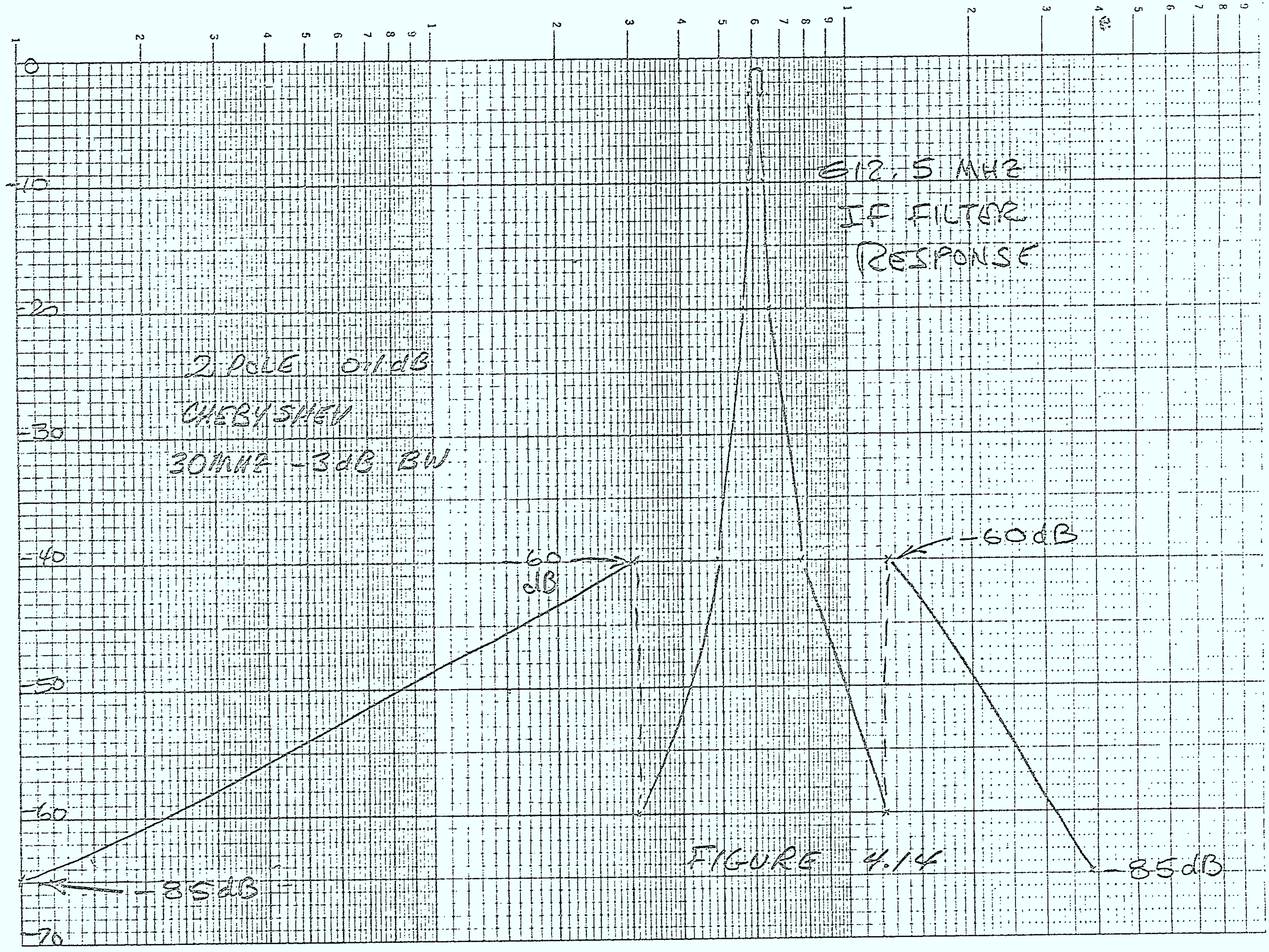
IF RESPONSE

2 POLE 0.1dB

CHEBYSHEV

30 MHz -3dB BW

FIGURE 4.13



612.5 MHZ
IF FILTER
RESPONSE

FIGURE 4.14

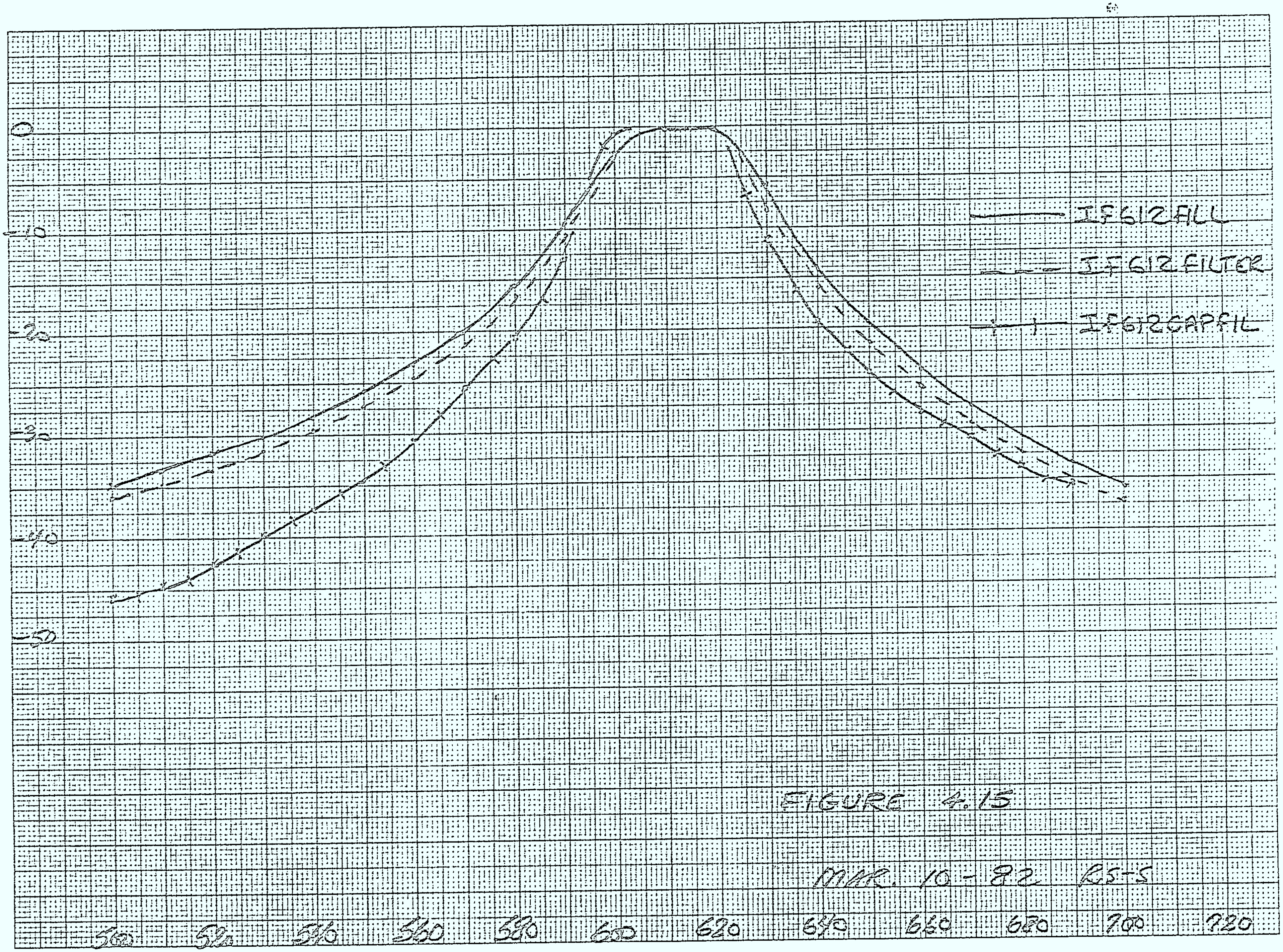
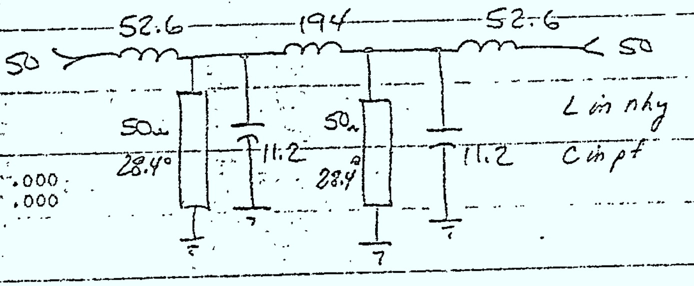


FIGURE 4.15

MAR. 10-82 RS-S

```
TRANS. LINE REF. FREQ =        .612  GHZ

OPTIMIZ. CONTROL NOPT =           0

THE  ELEMENT DESCRIPTION IS AS FOLLOWS

IND L1                52.600       .000        .000        .000
SST L2                50.000     28.400        .000        .000
CAP C1                11.200       .000        .000        .000
IND L3               194.000       .000        .000        .000
CAP C2                11.200       .000        .000        .000
SST L4                50.000     28.400        .000        .000
IND L5                52.600       .000        .000        .000
END                     .000       .000        .000        .000

NETWORK INTERCONNECTIONS BEGINS

DEF AA   T2              4.000      1.000      4.000       .000       .000
   CON L1  T2              1          2          0
   CON L2  T2              2          0          0
   CON C1  T2              2          0          0
   CON L3  T2              2          3          0
   CON C2  T2              3          0          0
   CON L4  T2              3          0          0
   CON L5  T2              3          4          0
   END AA                  0          0          0
 ANL AA   S1            50.000       .000     50.000       .000       .000
 NTW                      .000       .000       .000       .000       .000
```

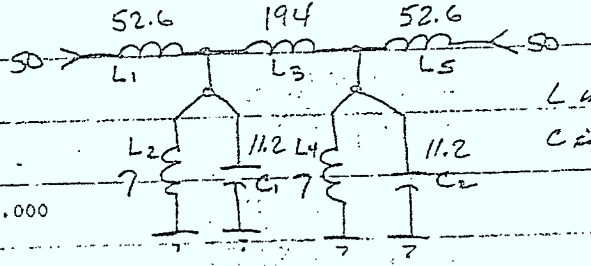
IF 612 FILTER DATA FILE



```
 FREQUENCY(GHZ)     S--PARAMETERS

  .50000            .01    -67.01          -36.07    -67.01          -36.07    -67.01          .01     23.34      .000
  .51000            .01     21.98          -34.74    -68.41          -34.74    -68.41          .01     21.98      .000
  .52000            .01     20.46          -33.25    -69.96          -33.25    -69.96          .01     20.46      .000
  .53000            .01     18.73          -31.54    -71.75          -31.54    -71.75          .01     18.73      .000
  .54000            .02     16.65          -29.56    -73.87          -29.56    -73.87          .02     16.65      .000
  .55000            .02     14.10          -27.24    -76.52          -27.24    -76.52          .02     14.10      .000
  .56000            .04     10.71          -24.46    -80.02          -24.46    -80.02          .04     10.71      .000
  .57000            .06      5.84          -21.01    -85.07          -21.01    -85.07          .06      5.84      .000
  .58000            .15     -2.10          -16.55    -93.29          -16.55    -93.29          .15     -2.10      .000
  .59000            .54    -18.03          -10.45   -109.80          -10.45   -109.80          .54    -18.03      .000
  .60000           4.17    -60.98           -2.68   -154.62           -2.68   -154.62         4.17    -60.98      .000
  .61000          18.19     35.36            -.39    128.95            -.39    128.95        18.19     35.36      .000
  .62000           9.89    139.48            -.94     55.90            -.94     55.90         9.89    139.48      .000
  .63000            .84     79.36           -8.56     -8.51           -8.56     -8.51          .84     79.36      .000
  .64000            .17     57.60          -16.08    -31.09          -16.08    -31.09          .17     57.60      .000
  .65000            .06     47.98          -21.61    -41.07          -21.61    -41.07          .06     47.98      .000
  .66000            .03     42.48          -25.92    -46.77          -25.92    -46.77          .03     42.48      .000
  .67000            .02     38.86          -29.46    -50.53          -29.46    -50.53          .02     38.86      .000
  .68000            .01     36.24          -32.48    -53.24          -32.48    -53.24          .01     36.24      .000
  .69000            .01     34.23          -35.11    -55.32          -35.11    -55.32          .01     34.23      .000
  .70000            .01     32.62          -37.46    -56.98          -37.46    -56.98          .01     32.62      .000
 *STOP*
```

```
[illegible]

TRANS. LINE REF. FREQ =        .61   GHZ

OPTIMIZ. CONTROL NOPT =            0

THE ELEMENT DESCRIPTION IS AS FOLLOWS


IND L1            52.600      .000      .000      .000
IND L2             7.000      .000      .000      .000
CAP C1            11.200      .000      .000      .000
IND L3           194.000      .000      .000      .000
CAP C2            11.200      .000      .000      .000
IND L4             7.000      .000      .000      .000
IND L5            52.600      .000      .000      .000
END                 .000      .000      .000      .000


NETWORK INTERCONNECTIONS BEGINS


DEF AA   T2            4.000      1.000      4.000       .000       .000
   CON L1   T2         1          2          0
   CON L2   T2         2          0          0
   CON C1   T2         2          0          0
   CON L3   T2         2          3          0
   CON C2   T2         3          0          0
   CON L4   T2         3          0          0
   CON L5   T2         3          4          0
   END AA              0          0          0
 ANL AA   S1          50.000       .000     50.000       .000       .000
 NTW                    .000       .000       .000       .000       .000


  FREQUENCY(GHZ)       S--PARAMETERS

                                                                                          .00    22.60
     .50000        .00   -67.40    -34.88   -67.40    -34.88   -67.40       .00    21.20     .000
     .51000        .00   -21.20    -33.57   -68.80    -33.57   -68.90       .00    19.63     .000
     .52000        .00    19.63    -32.09   -70.37    -32.09   -70.37       .00    17.82     .000
     .53000        .00    17.82    -30.40   -72.18    -30.40   -72.18       .01    15.68     .000
     .54000        .01    15.68    -28.45   -74.32    -28.45   -74.32       .01    13.00     .000
     .55000        .01    13.00    -26.15   -77.00    -26.15   -77.00       .02     9.47     .000
     .56000        .02     9.47    -23.41   -80.53    -23.41   -80.53       .04     4.39     .000
     .57000        .04     4.39    -20.02   -85.61    -20.02   -85.61       .12    -3.85     .000
     .58000        .12    -3.85    -15.66   -93.85    -15.66   -93.85       .49   -20.22     .000
     .59000        .49   -20.22     -9.74  -110.22     -9.74  -110.22      3.87   -63.46     .000
     .60000       3.87   -63.46     -2.29  -153.46     -2.29  -153.46     19.47    43.46     .000
     .61000      19.47    43.46      -.05   133.46      -.05   133.46     14.47   157.60     .000
     .62000      14.47   157.60      -.16    67.60      -.16    67.60      1.11    88.18     .000
     .63000       1.11    88.18     -6.46    -1.82     -6.46    -1.82       .17    61.66     .000
     .64000        .17    61.66    -14.15   -28.34    -14.15   -28.34       .05    50.45     .000
     .65000        .05    50.45    -19.83   -39.55    -19.83   -39.55       .02    44.23     .000
     .66000        .02    44.23    -24.24   -45.77    -24.24   -45.77       .01    40.19     .000
     .67000        .01    40.19    -27.85   -49.81    -27.85   -49.81       .00    37.31     .000
     .68000        .00    37.31    -30.91   -52.69    -30.91   -52.69       .00    35.12     .000
     .69000        .00    35.12    -33.58   -54.88    -33.58   -54.88       .00    33.38     .000
     .70000        .00    33.38    -35.95   -56.62    -35.95   -56.62
  *STOP*

 !EDIT IF612FILTER
 EDIT HERE
```

IF 612 FILL DATA FILE

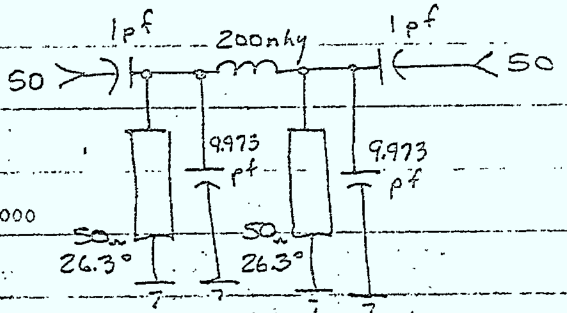


L in nhy
C in pf

LUMPED ELEMENTS

```
OPTIMIZ. CONTROL NOPT =          0

THE  ELEMENT DESCRIPTION IS AS FOLLOWS

CAP C1              1.000        .000         .000         .000
CAP C2              9.973        .000         .000         .000
SST L1             50.000      26.320         .000         .000
IND L2            200.000        .000         .000         .000
SST L3             50.000      26.320         .000         .000
CAP C3              9.973        .000         .000         .000
CAP C4              1.000        .000         .000         .000
END                  .000        .000         .000         .000

NETWORK INTERCONNECTIONS BEGINS

DEF AA   T2               4.000       1.000       4.000        .000        .000
   CON C1   T2            1           2           0
   CON C2   T2            2           0           0
   CON L1   T2            2           0           0
   CON L2   T2            2           3           0
   CON L3   T2            3           0           0
   CON C3   T2            3           0           0
   CON C4   T2            3           4           0
   END AA                 0           0           0
ANL AA   S1              50.000        .000      50.000        .000        .000
NTW                        .000        .000        .000        .000        .000

 FREQUENCY(GHZ)       S-PARAMETERS

      .50000                .00  -111.34      -46.44  -111.34      -46.44  -111.34        .00   -20.94
      .51000                .00   -21.78      -44.43  -112.21      -44.43  -112.21        .00   -21.78      .000
      .52000                .00   -22.73      -42.24  -113.21      -42.24  -113.21        .00   -22.73      .000
      .53000                .00   -23.83      -39.84  -114.38      -39.84  -114.38        .00   -23.83      .000
      .54000                .01   -25.19      -37.17  -115.80      -37.17  -115.80        .01   -25.19      .000
      .55000                .01   -26.89      -34.13  -117.60      -34.13  -117.60        .01   -26.89      .000
      .56000                .01   -29.18      -30.59  -120.03      -30.59  -120.03        .01   -29.18      .000
      .57000                .03   -32.55      -26.30  -123.62      -26.30  -123.62        .03   -32.55      .000
      .58000                .07   -38.31      -20.79  -129.77      -20.79  -129.77        .07   -38.31      .000
      .59000                .34   -51.43      -12.94  -143.82      -12.94  -143.82        .34   -51.43      .000
      .60000               7.35  -103.96       -1.66   156.55       -1.66   156.55       7.35  -103.96      .000
      .61000               5.55   -21.51       -1.82    68.52       -1.82    68.52       5.55   -21.51      .000
      .62000               7.04    63.09       -1.69   -18.52       -1.69   -18.52       7.04    63.09      .000
      .63000                .40    12.55      -12.13   -75.19      -12.13   -75.19        .40    12.55      .000
      .64000                .10     -.57      -19.30   -89.18      -19.30   -89.18        .10     -.57      .000
      .65000                .04    -6.36      -24.21   -95.36      -24.21   -95.35        .04    -6.36      .000
      .66000                .02    -9.76      -27.92   -98.96      -27.92   -98.96        .02    -9.76      .000
      .67000                .01   -12.06      -30.88  -101.40      -30.88  -101.40        .01   -12.06      .000
      .68000                .01   -13.76      -33.35  -103.21      -33.35  -103.21        .01   -13.76      .000
      .69000                .01   -15.11      -35.45  -104.63      -35.45  -104.63        .01   -15.11      .000
      .70000                .01   -16.22      -37.27  -105.79      -37.27  -105.79        .01   -16.22      .000
  %STOP%

 !END
```

IF612CAPFIL DATA FILE



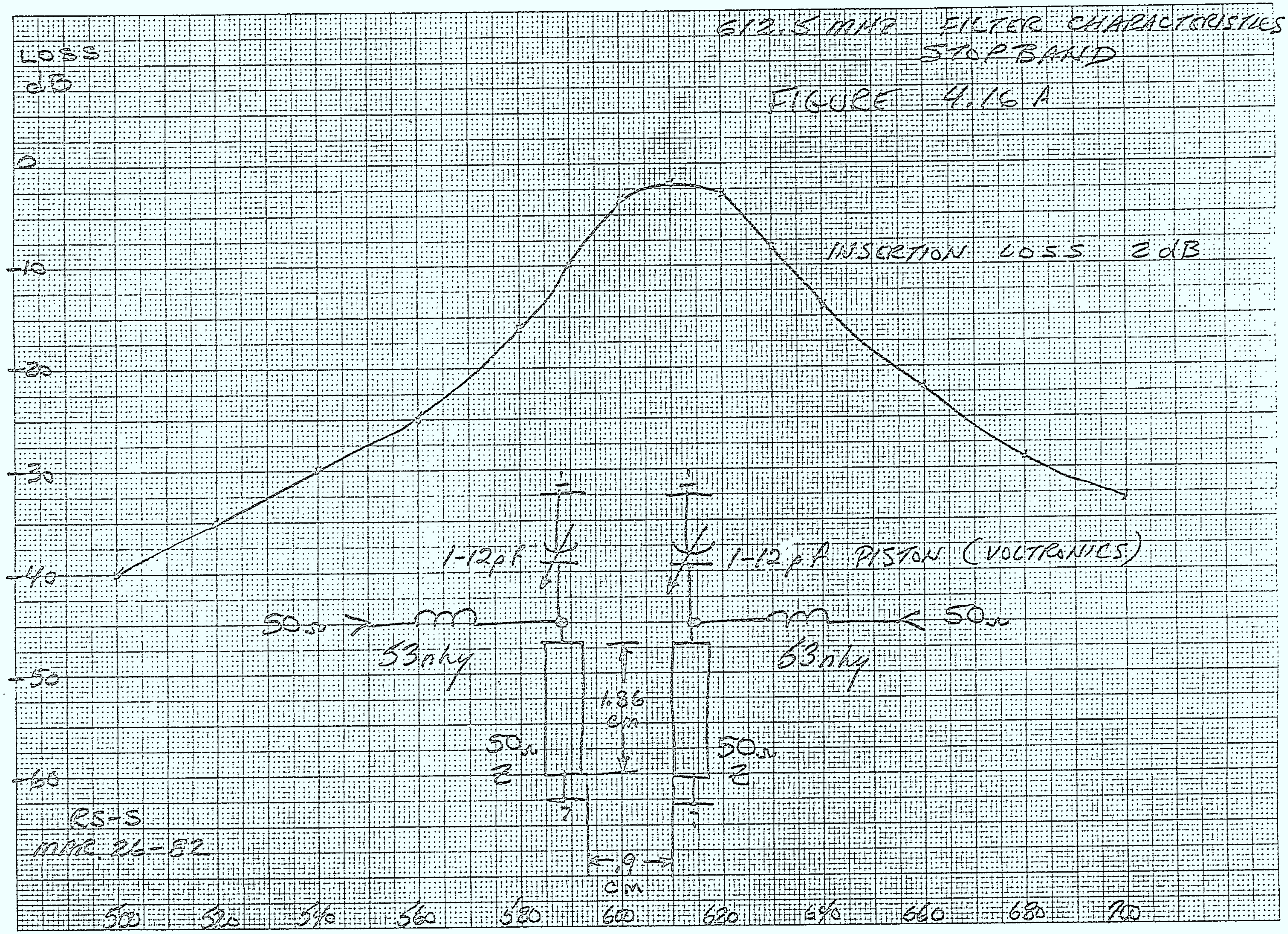
```
[illegible]
EDIT HERE
*TY0=99
    1.000 .5 .7 .01 .6125 .06 0
    2.000 CAP C1 1
    3.000 CAP C2 9.9732
    4.000 SST L1 50 26.32
    5.000 IND L2 200
    6.000 SST L3 50 26.32
    7.000 CAP C3 9.9732
    8.000 CAP C4 1
    9.000 END
   10.000 DEF AA T2 4 1 4
   11.000 CON C1 T2 1 2
   12.000 CON C2 T2 2 0
   13.000 CON L1 T2 2 0
   14.000 CON L2 T2 2 3
   15.000 CON L3 T2 3 0
   16.000 CON C3 T2 3 0
   17.000 CON C4 T2 3 4
   18.000 END AA
   19.000 ANL AA S1 50 0 50 0
   20.000 NTW
   21.000 0.,1.,0.,0.,5.,
   22.000 -12.,-14.,-10.,-14.,-12.,
--EOF HIT AFTER 22.
*END

!PCL
PCL FOO:HERE
<LIST
A           ABC         ANTENNA     ARCHIVE-00  ARCHIVE-01  CASCADE     CASNODE     CHK         CIRC        COUPLEFILT  DA
DATA1       DBFILE      DBTFAA      DUMMYU      EQU         EVOD        FETI        FF          FILTER      FLAG        FREQ
HAIRPIN1    IF612CAPFIL IF612FILL   IF612FILTER IMPED       INT         INTDIO      INTEDIG     ITEDIG      MATCH       MICFILT
MICIMP      MICROWAVE   MICSIR      MICZOZE     MIC1        MIC1A       MIC2        MIC3        MIC4        MIC5        MIC5A
NEW         NEWFILE     NF          NODAL       NTAKE       NTAKE1      PAULA       QPSKF       RUTH        SAVE        SIR
SYSTEM      TEMPO       TEMPP       TEST        TH          TRIAL       TSTS        TT          TTO         WAVLEN      WHSH
ZOZE
.. 73 FILES LISTED
<END
-
!BYE

CPU = 1.7234 CON= 00:38:00 TRD= 68 TWR= 620 CORE= 67.5674 I/O= 227

NET COST OF SESSION WAS $8.55



SASKCOMP SIGMA 9 AT YOUR SERVICE
10:08 MAR 10,'82   USER# 2F    LINE# 15
LOGON PLEASE: 
```

IF 612 FILL	- lumped element design with inductive coupling.
IF 612 FILTER	- 50 ohm transmission line resonators with inductive coupling
IF 612 CAPFIL	- 50 ohm transmission line resonators with capacitive input-output matching and inductive coupling between poles.

The final version of filter was built and tested as in Figure 4.16A and B and meets fairly closely that predicted by the computer. However, the inter-resonator coupling of 200nhy was removed as sufficient coupling was present between resonators because of their physical proximity.

The 772.5MHz 2nd LO characteristic is given in Figure 4.17. An Avantek VTO-8060 is used in this case. The VCO gain is 16.6MHz/V.

The 160MHz discriminator follows the MC1660 MECL limiter (Figure 4.18). Transistor Q1 is the driver amplifier. Transformers T1 and T2 are resonators peaked at 150 and 170MHz respectively. The discriminator output is "A". This is offset by +12V bias for driving the video amplifier. Figure 4.19 is the "S" curve for the discriminator as measured at "A" offset by 12V. This is a high level discriminator with high sensitivity of 66mV/MHz.



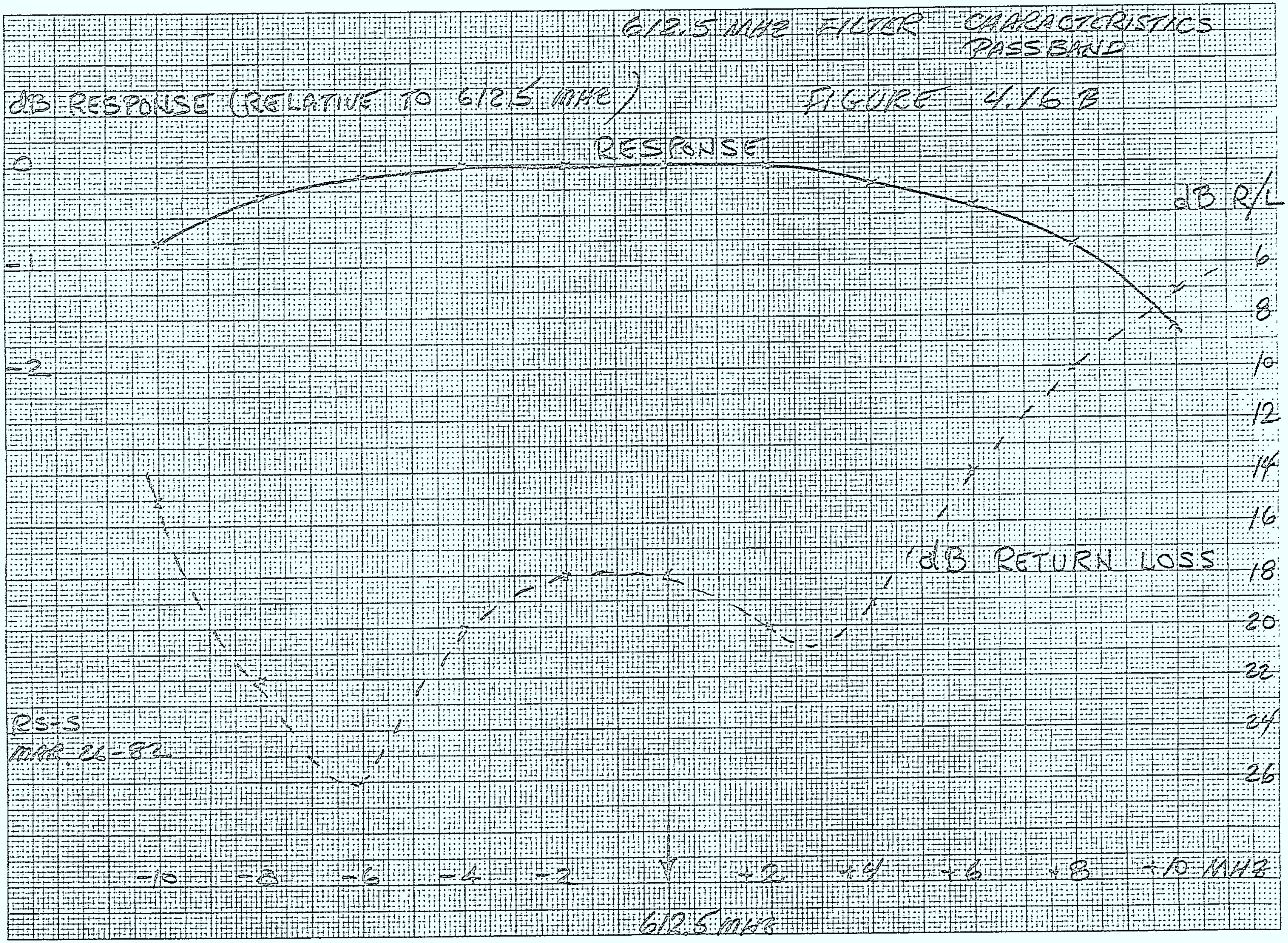
612.5 MHZ FILTER CHARACTORISTICS
STOPBAND

FIGURE 4.16 A

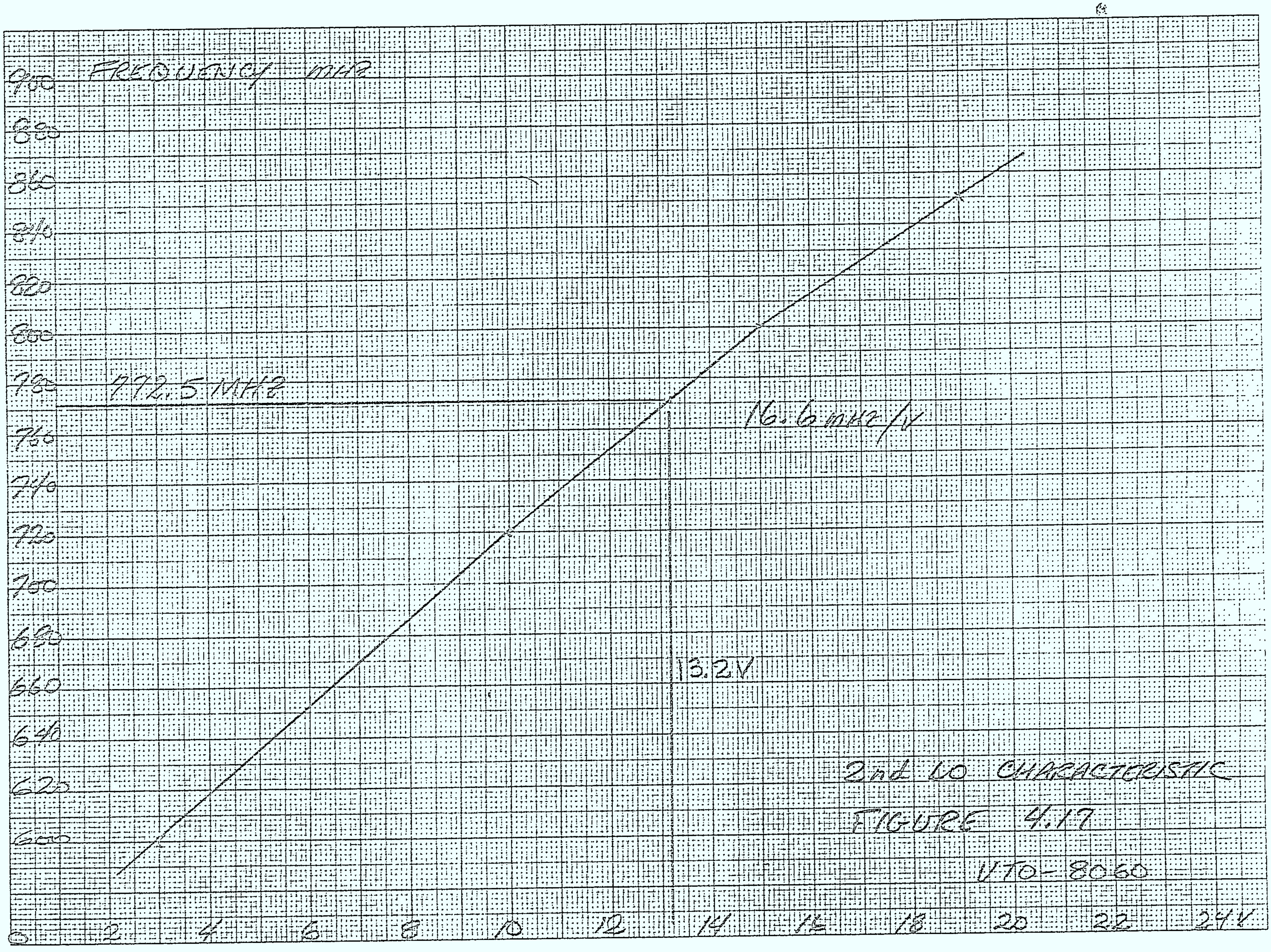
RS-S
MAR. 26-82

612.5 MHz FILTER CHARACTERISTICS
PASSBAND

FIGURE 4.16 B



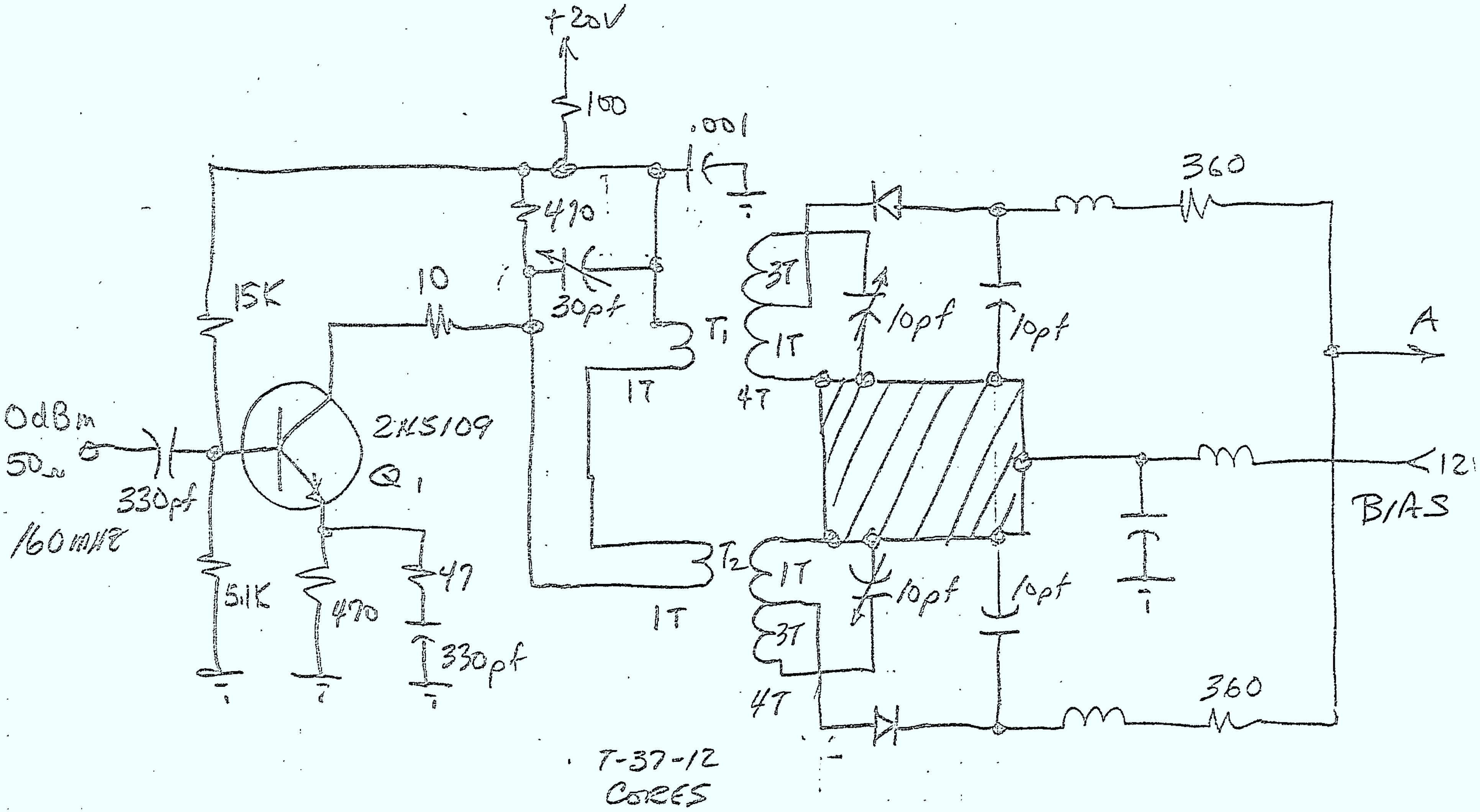
RS-S
MAR-26-82



2nd LO CHARACTERISTIC

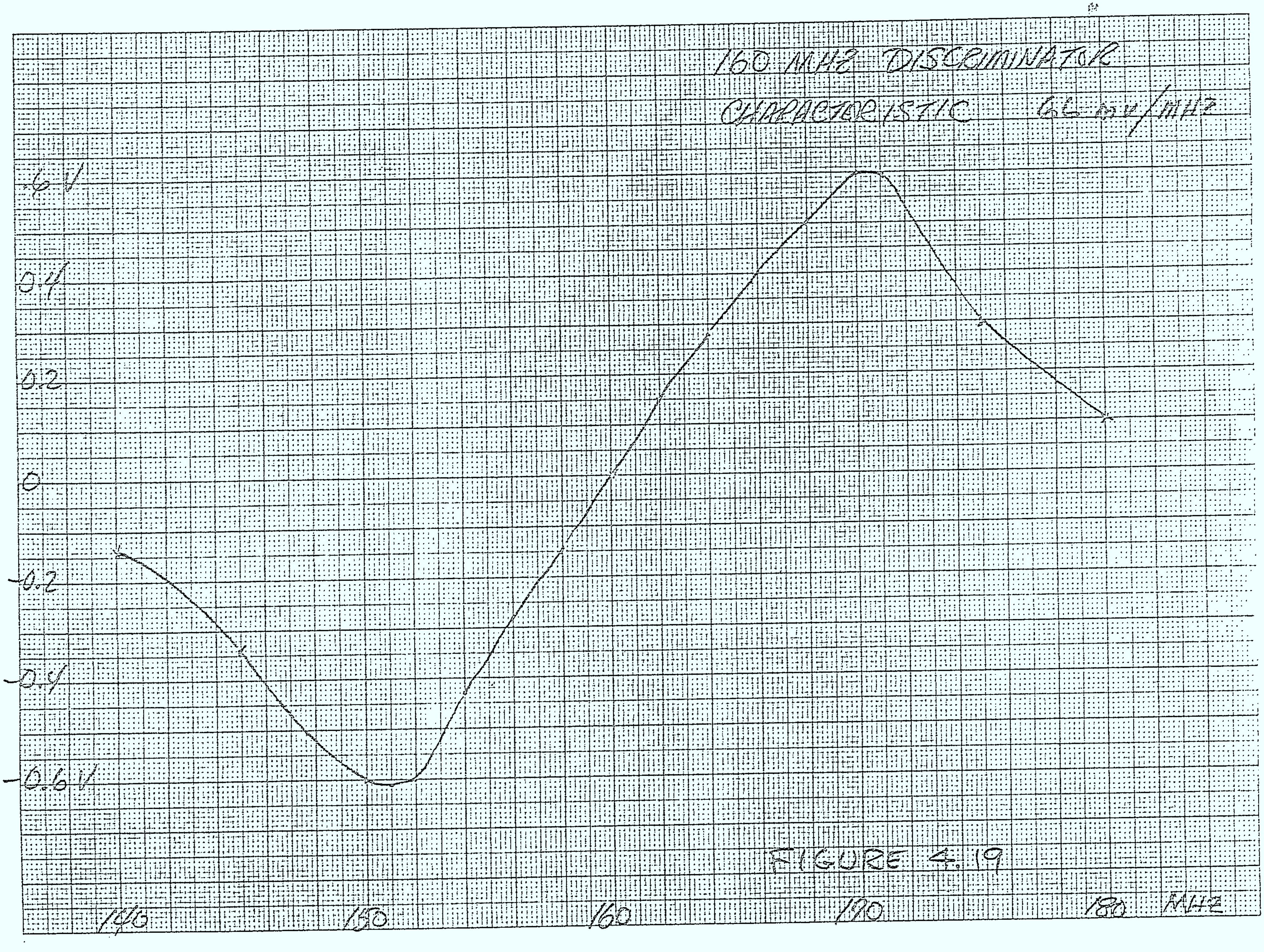
FIGURE 4.17

VTO-8060



160 MHz DISCRIMINATOR

FIGURE 4.18

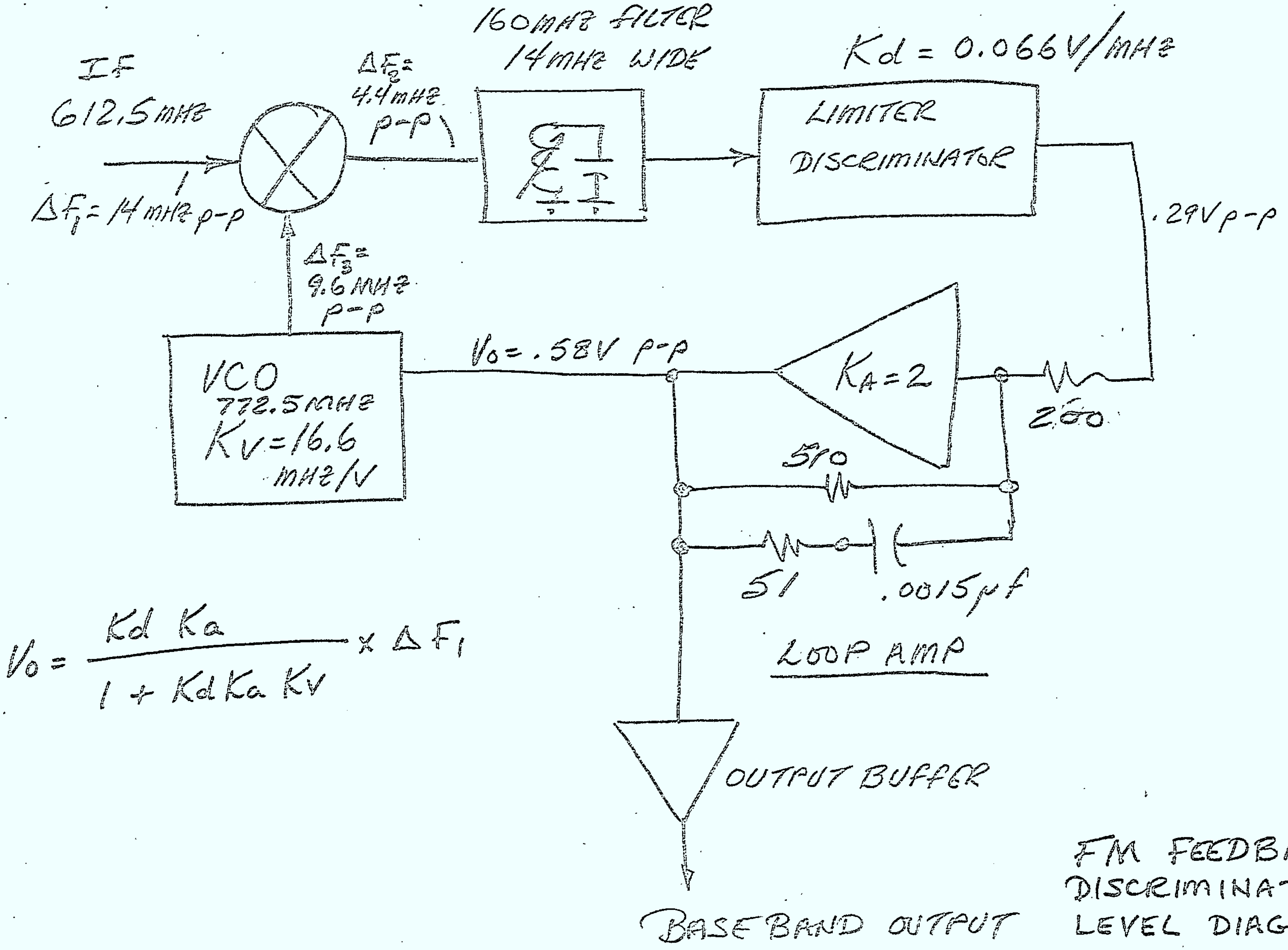


160 MHZ DISCRIMINATOR CHARACTORISTIC 62 mV/MHZ

FIGURE 4.19

The FM feedback loop discriminator design parameters are given in Figure 4.20. This circuit converts the 612.5MHz IF to 160MHz before demodulation and feedback to the 772.6MHz VCO. The VCO tracks the input signal. The peak to peak deviation of the 612.5MHz IF is 14MHz. The deviation is compressed to 4.4MHz p-p and filtered by the 14MHz wide filter. This filter reduces the noise power and enhances threshold. The limiter discriminator converts this to 0.29V p-p. The loop amplifier provides a DC gain of 2 and Vo = 0.58V p-p to the output buffer amplifier. Vo also FM modulates the VCO producing a deviation of 9.6MHz p-p.

The loop amplifier has a restricted bandwidth to control the loop gain at high frequency to prevent instability. The closed loop response is given in Figure 4.21 and matches CCIR 525 line de-emphasis. The loop tracks the large amplitude low frequency video information for frequencies below 100KHz. Most energy above 100KHz is decreasing in level similar to the de-emphasis curves so that tracking is unnecessary. The output of this demodulator at Vo is already pre-de-emphasized. Therefore, additional de-emphasis is not required.



$$V_0 = \frac{Kd\ Ka}{1 + Kd\,Ka\,Kv} \times \Delta F_1$$

FM FEEDBACK LOOP
DISCRIMINATOR
LEVEL DIAGRAM

FIGURE 4.20

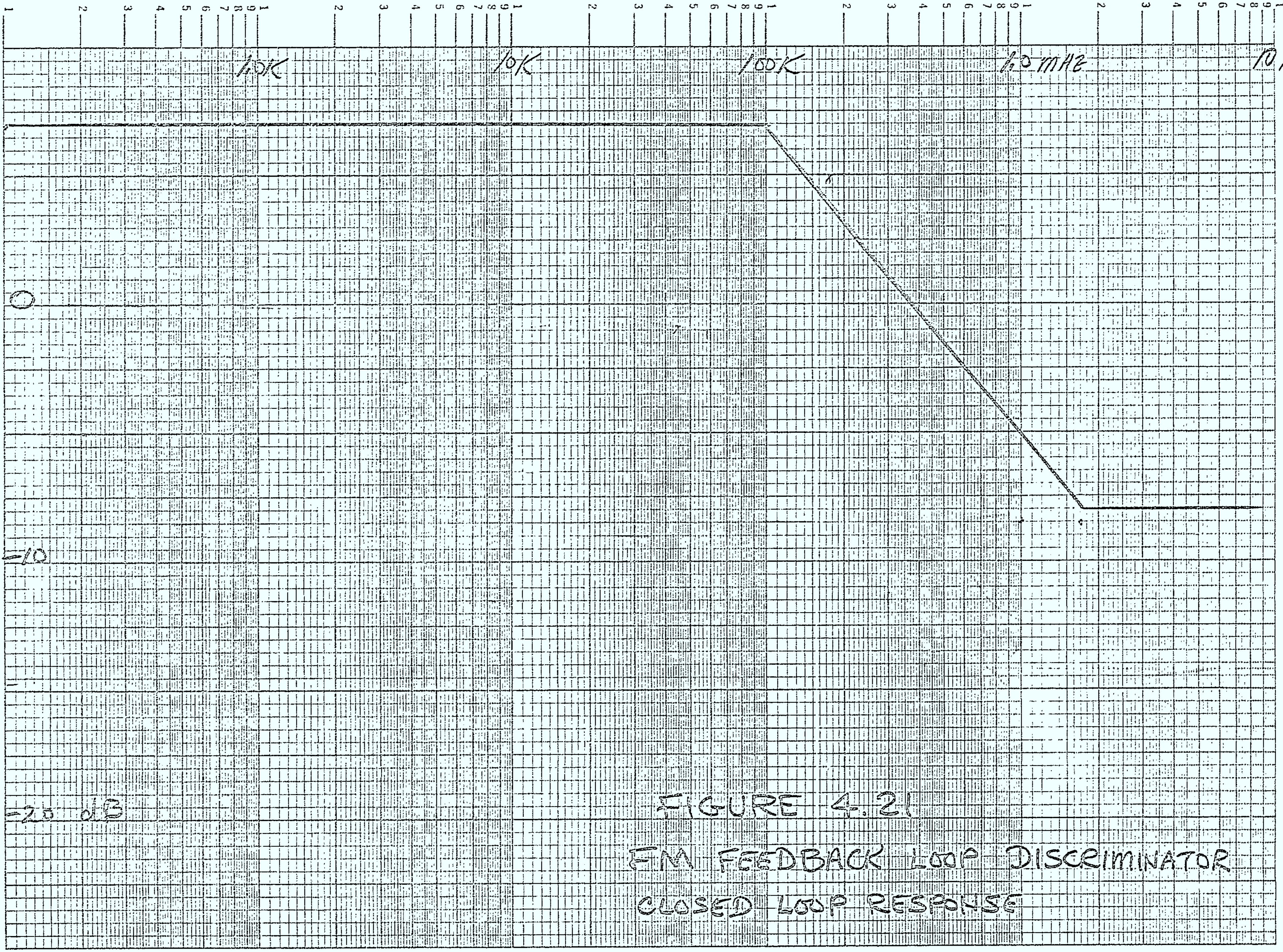


FIGURE 4.21

FM FEEDBACK LOOP DISCRIMINATOR

CLOSED LOOP RESPONSE

4.5 IDU Specifications

1. Input Characteristics

Impedance	75 ohms
Frequency Range	950-1450MHz
Nominal Carrier Level	-45 dBM
Maximum total power level for multiple carriers	-30 dBM
Image rejection	>30 dB
Tuning voltage	2V to 14V (frequency increases with voltage)
2nd IF	612.5MHz
3rd IF	160MHz
1st LO Range	1562.5-2062.5MHz
2nd LO	772.5MHz
Dynamic Range in carrier level	20 dB
Output frequency for AFC	3.0175MHz
Input Noise Figure (SSB)	15 dB max.
2nd IF Frequency including FMFB Demod Tracking ±6MHz change in input frequency	160MHz ± 1%
Equivalent Loop IF Noise Bandwidth	18MHz
Input Impedance	75 ohm (F conn)
Input VSWR	1.3:1
Input Power Level	-35 dBm max.
Input Power Operating Range	-60 dBm to -30 dBm

Differential Phase (10% - 90% APL)	8° max
Differential Gain	15% max
Video signal to noise ratio at C/T = -143.5 dBW/°K (p-p excluding sync. tip to RMS weighted noise CCIR REC. 421-1	>40 dB
Audio signal to noise ratio at C/T = -143.5 dBW/°K (Audio RMS TT/N)	>42 dB
Audio to Video Crosstalk:	
6.2MHz present at video output of receiver	-30 dBm max
-- Energy dispersal of RF carrier	25Hz triangular waveform 1MHz peak
-- Energy dispersal suppression down to	2 IRE max
-- Video hum below 4KHz	2 IRE max
-- Periodic noise at output of receiver 4KHz to 4.2MHz	-40 dBm max
-- Modulated 12.5 T $\sin^2$ pulse test, chrominance to luminance delay	150 nsec max
-- Chrominance to luminance gain inequality	20 IRE max
-- Video response using multiburst test (90 IRE multiburst)	
500 KHz	80 IRE min
3.0, 3.58MHz	70 IRE min
1.5, 2.0, 4.2MHz	60 IRE min
No multiburst to exceed 100 IRE p-p	
-- Short time pulse (2T $\sin^2$ 0.25 μsec) distortion and overshoot	10 IRE max

-- Horizontal line tilt using pulse and bar window test	4 IRE max
-- Vertical field square wave tilt	15 IRE max
-- Sync. pulse distortion 40 IRE normal	±10 IRE max
-- Video gain stability per 24 hrs.	± 5 IRE max
-- Differential gain using modulated staircase waveform 10-90% APL	15% max
-- Differential phase using modulated staircase waveform 10-90% APL	8° max
-- Demodulator -1 dB static threshold* point at 18MHz C/N	TBD

* Static threshold is defined the point of 1.0 dB departure from norminally linear s/n vs c/n characteristic measured in the absence of video modulation.

Video to Audio Crosstalk (75% saturated colour bar test signal) below T.T. level with program weighting and high C/T	-45 dB min
Video bandwidth (nominal)	4.2MHz
Video peak deviation	7MHz
Horizontal Sync. Pulse	Negative
Video Output Level	1V p-p, 75 ohms
Video De-emphasis	CCIR REC. 405-1 (625 line)
Audio Subcarrier Frequency	6.2MHz
Subcarrier peak deviation for 8 dBm T.T.L. at 1KHz	75KHz
Peak deviation of video carrier by audio subcarrier (6.2MHz)	1.4MHz

Audio T.T.L.	+0 dBm (600 ohms balanced 1KHz T.T.)
-- Audio gain stability per 24 hrs.	±1 dB max
-- Harmonic distortion at 1KHz T.T. level: 8 dBm	5% max
0 dBm	2% max
Television standard	625 line PAL-B as per CCIR Report 624-1
Video Modulation	14.2MHz p-p for 1 volt p-p output. Black to white for increasing frequency.
Video Pre-emphasis	CCIR Rec. 405-1 (625 line)
Energy Dispersal	25Hz Triangular waveform up to 1MHz p-p.
Audio Subcarrier	6.2MHz modulating main carrier 2.8MHz p-p. Modulated 150KHz p-p by the audio signal.
Audio Base-Bandwidth	30Hz - 15KHz
Audio Pre-emphasis	50 microsecond
IF Bandwidth	17.5MHz
Audio Subcarrier Noise Bandwidth	190KHz
Tuning	Switch tuning to any frequency in the 12.25 to 12.75 GHz band
Video Modulation	Any deviation between 10 and 20MHz p-p can be used. The bandwidth must be specified at the time of the order.
VHF Television Output	Vision plus sound to Australian PAL-B in 75 ohm Type F connector.
RF Output Frequency	Channel 1 or Channel 6
Output Voltage	2 mVrms max
Spurious Outputs	-40 dB at 5MHz or more from channel limits
Optional Video and Audio	Video and Audio output can be supplied as an option at additional cost.

5.0 Sound Program Add on Unit

Introduction

In addition to television video and audio transmitted on a given transponder there is a need for a radio program service. Two monaural programs are desired plus a third program upgradable to stereo by means of a suitable stereo adaptor. A fourth program is transmitted as a possible source of a pilot reference and L-R stereo difference signal, for use by the stereo adapter. The radio program carriers will be block converted to the commercial 88-108 MHz FM band for reception directly with an FM receiver.

Much system link analysis has already been done by DOC/CRC/SCOPO to determine the feasibility of this kind of service. The analysis here is limited to that required to specify the parameters necessary in order to design the ODU and IDU radio program equipment.

5.1 Audio System Selected

Several schemes are possible to provide two monaural channels and two other channels to enable stereo reception. These are as follows:

1) Digitally multiplexed subcarrier on TV subcarrier
2) Four subcarriers transmitted in addition to the TV sound subcarrier, block conversion of these to the FM band.
3) Separate SCPC carriers transmitted above the TV video RF carrier, block conversion of these to the FM band.

The first one above is unacceptable as it does not permit block conversion, not to mention hardware costs and additional loading of the TV signal.

The second and third alternatives are compared in Table 5.1. The subcarriers provide additional loading on the TV carrier requiring increased IF bandwidth and carrier strength. Also the radio program and TV program are not independently selectable. The third alternative is the most flexible without depending on the video carrier. The only problem presented with the last alternative is in terms of FM noise and frequency stability of oscillators used in the system. The system analysis will concentrate primarily on that.

TABLE 5.1

HACBSS AUDIO SYSTEMS

ITEM	SCPC CARRIERS	AUIO SUB-CARRIERS
TV Rx IF BW	---	Increased BW
Video Threshold	---	Worse
Power Loading & Intermod On Satellite	Worse	----
Sensitive to SHF Osc. Noise and Drift	Yes	No
Block Conversion to FM Band	OK	Easiest
Requires Video Rx	No	Yes
Radio Program Indep. of TV Channel	Yes	No
Uplink From Other Cities	Yes	No
Xtal Osc. Needed in L.O.'s	Yes	No
Spacing of Carrier Highest from Lowest	Up to 20 MHz	Up to 2 MHz (TV Sound Inc.)
Channel Spacing	6 MHz	0.5 MHz
Sub-Carrier Loading on Video BB	1	5

5.2 Oscillator Problems

Currently a Gunn diode oscillator is used in the ODU as the SHF Local Oscillator. This works satisfactorily for video with the FM sound sub-carrier. Due to the nature of this modulation scheme it is tolerant to FM noise and drift of the SHF oscillator.

For SCPC (single channel per carrier) audio, the Gunn diode oscillator produces as much or more noise at audio as the thermal noise produced normally in the communications channel. This results in a leveling off in the audio S/N versus carrier to noise ratio above threshold. Drift in the Gunn diode oscillator over temperature is at least ± 5 MHz and requires an AFC system in the indoor radio program block converter. A ± 5 MHz drift of the FM channels on the 88 - 108 MHz band would be totally objectional to the user.

The Microwave Dielectric Resonator Oscillator shows good promise in that its close in FM noise is better than the Gunn diode oscillator. The DRO has a frequency drift of less than 0.5 MHz over temperature.

A crystal controlled phase-locked oscillator (PLO) if used in the ODU SHF oscillator provides both low FM noise and minimal temperature drift problems.

In conclusion it is recommended in terms of best system, that for video only a Gunn diode oscillator or Dielectric Resonator oscillator would be satisfactory. For radio program a PLO would be ideal, either as a purchased subsystem or SED developed unit. The second converter 1 GHz to 88 - 108 MHz FM band converter is a low phase noise, phase-locked oscillator locked to its own crystal. The expected conversion accuracy of this system is as follows over nominal temperature changes.

SHF Oscillator 10 X 10^{-6}	
(11 GHz)	± 100 KHz
Second Converter 1 X 10^{-5}	
(800 MHz)	± 8 KHz
Total Converted FM Band Carrier Drift	± 108 KHz

This is well within the AFC range of a commercial FM tuner.

5.3 Description of Possible Systems

Dielectric Resonator Oscillator

This system uses the Dielectric Resonator Oscillator with low phase noise.

The 12 GHz band is converted by the ODU at the antenna to a 250 MHz wide-band 1 GHz high IF. This signal is split both ways to feed a IDU TV receiver unit and is used as a block converter to translate the SCPC radio program carriers to the 88 - 108 MHz commercial FM band. Demodulation is done by a standard consumer FM receiver. A 1 GHz preselector filter FL1 selects the wanted band on the satellite. A mixer M1 converts this to the 88 - 108 MHz band with a low pass filter FL2. A mute switch block the output during the lack of transmitted SCPC carriers. The LO is a UHF VCO divided down and mixed with a Xtal to feed a low frequency phase detector. In addition a low frequency VCO drives the other input of the phase detector and the loop amp provides sufficiently wide loop bandwidth to clean up the inherent FM noise in the UHF VCO. The low frequency VCO permits AFC of the UHF LO.

The fourth SCPC carrier is used for three purposes. Firstly it contains L - R stereo information. Secondly a pilot tone say 19 KHz could be used to identify this carrier from the others. Thirdly this carrier can be used by the AFC system to center other carriers properly within the 88 - 108 MHz. band.

The operation of the AFC works as follows: the UHF VCO is swept with the AFC causing the SCPC carriers after conversion to slide across the 88 - 108 MHz band. An FM receiver as part of the pilor receivers, receives these carriers sequentially. However a 19 KHz pilot subcarrier detector freezes the sweep of the AFC voltage when the SCPC carrier with the 19 KHz pilot is found. At this time lock is acquired and normal AFC is applied to adjust the UHF VCO to compensate for the SHF oscillator drift in the ODU. Also the mute switch is closed permitting the frequency centered carriers to be present and available to an external 88 - 108 MHz tuner. The L - R signal is of no use until a stereo adapter is used. This is discussed later.

5.4 SCPC Radio Program System Cost Comparison

This analysis considers approximate manufacturing costs required to build either the systems of Figure 1 or 3. The TV receive portion and stereo converter is not considered. The costs are based on 1000 quantity and Canadian Funds.

Item		Dielectric Resonator Oscillator Figure 1 $
1.	ODU SHF Oscillator	570
2.	Splitter	30
3.	FL1 Filter	50
4.	M1	25
5.	FL2	5
6.	Mute Switch	20
7.	UHF L.O.	400
Total Costs		$1,100

5.5 Cost Analysis of the Stereo Multiplex Adaptor

This adaptor is a dual FM demodulator made with dual tuners, IF's and discriminators. A matrix amplifier recreates the left and right channels as audio outputs. Quantities are estimated as production costs in Canadian Funds for quantities of 1000.

Item	Quantity	Total Cost To Manufacture $
Packaging	1	30
Power Supply	1	20
Tuner/Converter	2	50
IF/Demod	2	60
Matrix Amp.	1	20
		$180

The manufacturing cost of a stereo adaptor is $180.00

5.6 Operating Specifications, Sound

Sound service is provided by means of an additional unit which is connected to the Television Indoor Unit. This configuration allows the reception of television only, sound only or television and sound. Specifications are as follows:

Sound Broadcast Receiving Band	12.5 - 12.75 GHz
IF Translation Bandwidth	20 MHz
Output Frequency	88 - 108 MHz
Output Impedance	75 ohm
Output Level	1 mv ± 3 dB
Spurious	- 40 dB below unmodulated carrier

The system offered does not require a pilot signal. The SHF local oscillator in the outdoor unit is stable to within 0.25 MHz. The local oscillator for the conversion to 88 - 108 MHz is crystal controlled. With these stable local oscillators, no AFC is required.

The system does not comply with the requirement for a SCPC "Acquired and Locked" monitor.

5.7 Packaging

The prototype HACBSS block converter packaging is shown in figure 5.1. This consists of a 3" high by 8" wide by 8" deep Hammond cabinet, similar to that in section 4.3 The front panel contains a channel selector and a power on-off switch with indicator. The rear panel contains an input F connector for coupling to the LNC. A second bypass F connector is terminated

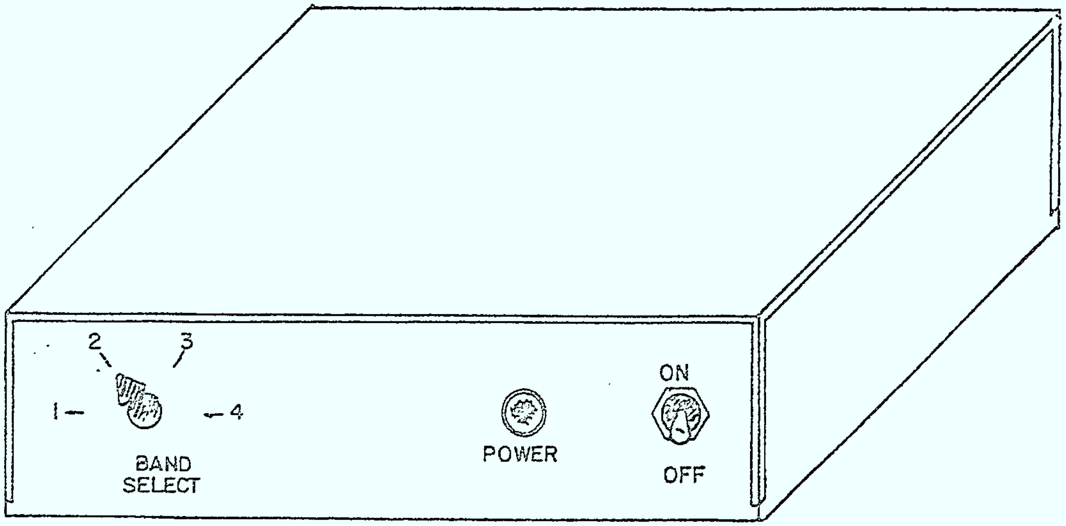


FIGURE : 5.1

OUTLINE DRAWING
INDOOR UNIT

SOUND BROADCAST

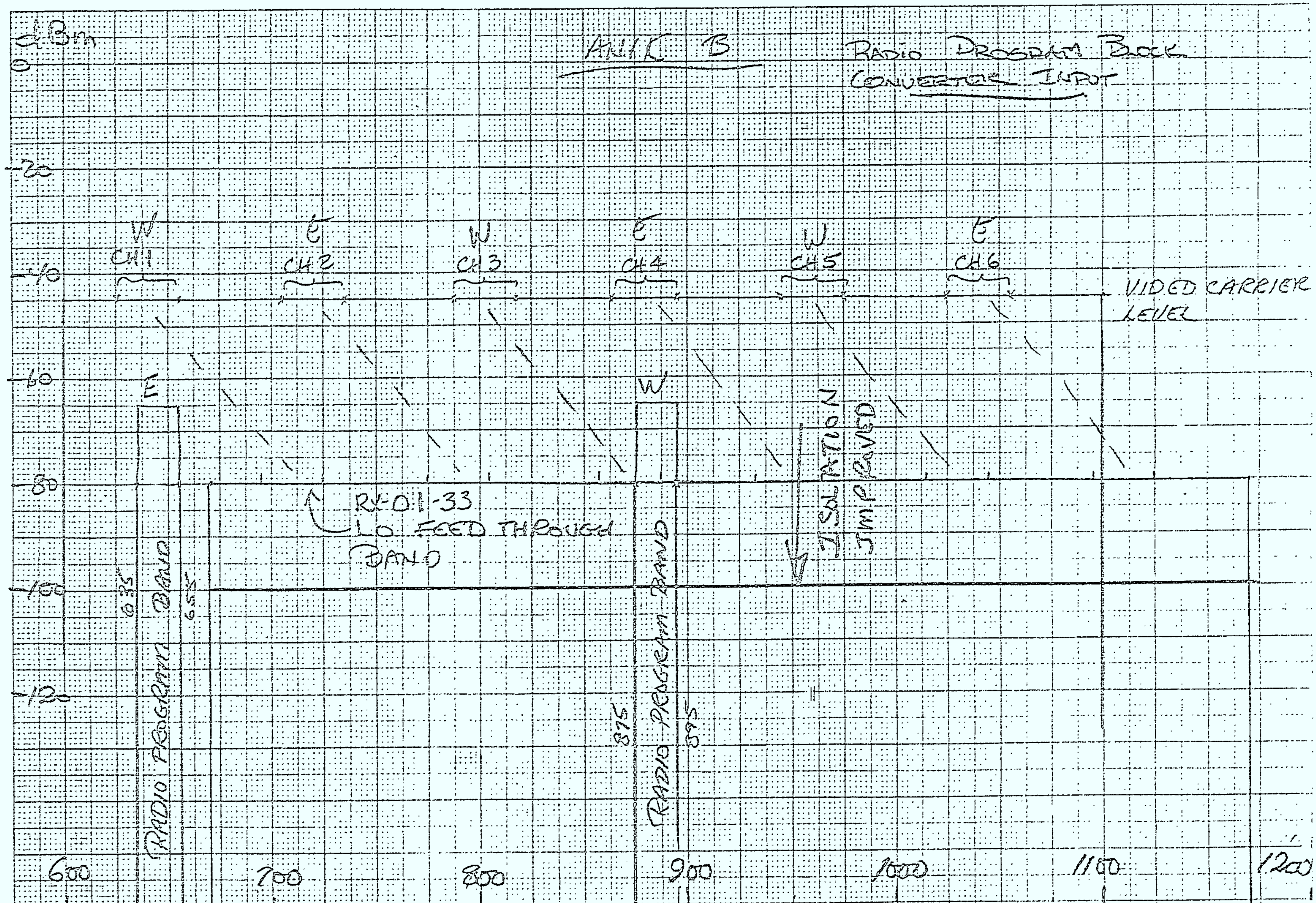
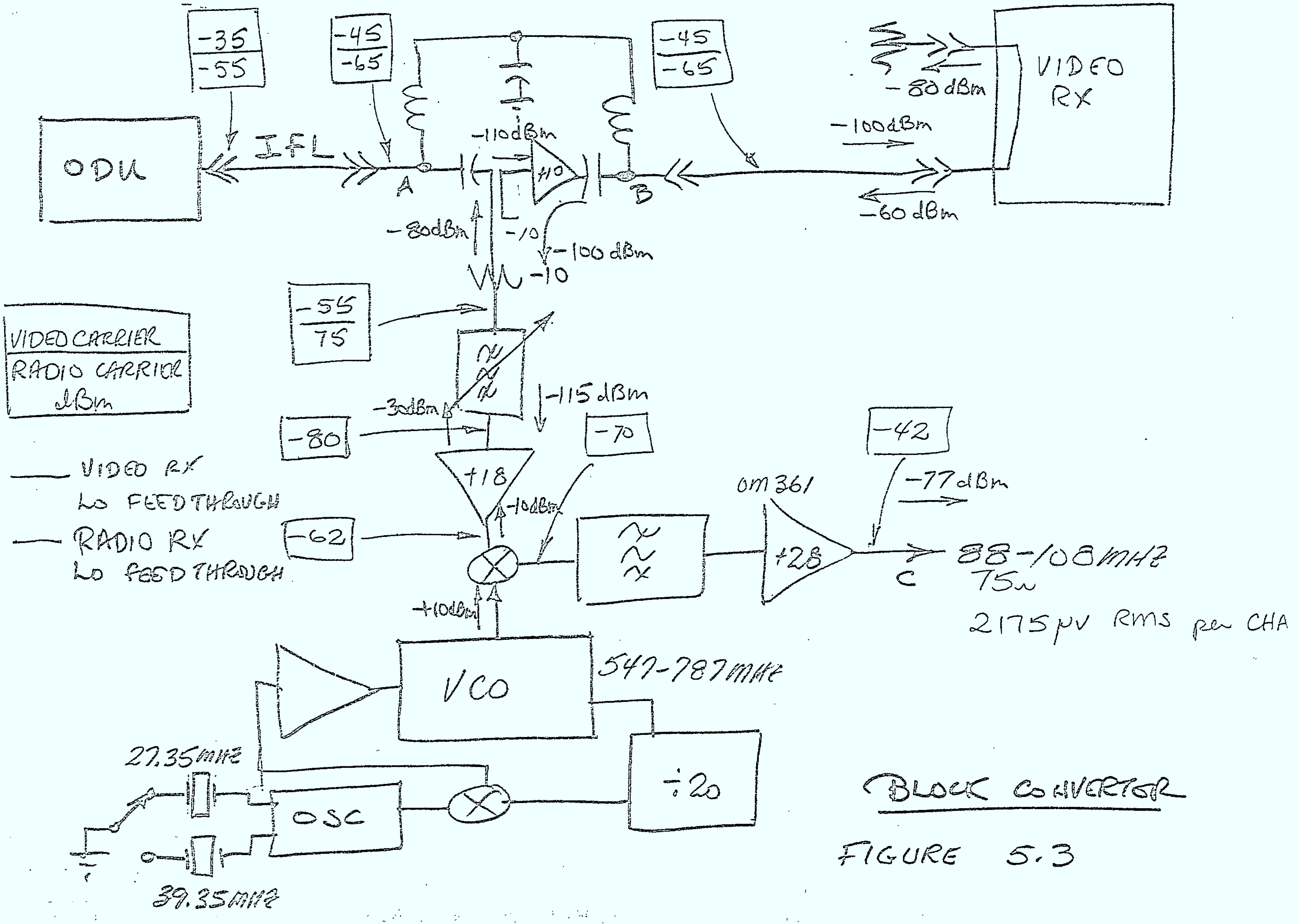

dBm
ANIK B
RADIO PROGRAM BLOCK
CONVERTER INPUT
0
-20
-40
-60
-80
-100
-120
W
CH1
E
CH2
W
CH3
E
CH4
W
CH5
E
CH6
VIDEO CARRIER
LEVEL
E
W
RX-011-33
LO FEED THROUGH
BAND
ISOLATION
IMPROVED
635
RADIO PROGRAM BAND
655
875
RADIO PROGRAM BAND
895
600
700
800
900
1000
1100
1200

FIGURE 5.2



BLOCK CONVERTER

FIGURE 5.3

in 75 ohms unless it is being utilized to feed other video receivers. An F connector is provided for a 75 ohm output, 1000μv minimum level for input to a standard consumer FM tuner. This unit has a self contained power supply.

5.8 Input Frequency Plan

The frequency plan is given in figure 5.2. For the current sale of 3 HACBSS radio program converters to DOC, these units are compatible with the RX-01-33 receiver 600 to 1100 MHz band. The new DBT receiver described in section 4.0 uses the 950 to 1450 MHz band. The inconsistency is due to a change in frequency plans during the contract and timing. This unit blocks converts either the 635 - 655 MHZ band or the 875 - 895 MHz band depending on the operating site, East or West spot beams respectively. The radio carriers are backed off by 19.4 dB below the video.

5.9 Converter Description

The converter (Figure 5.3) takes the wanted 20 MHz wide band of SCPC radio carriers and translates these down to the 88 - 108 MHz band.

The total 600 to 1100 MHz band enters the converter at "A". The video carriers are coupled down by 10 dB and re-amplified to appear at "B". This permits the video carrier bypass. In addition, DC is carried from port B to port A to power up the LNC by the use of the DC blocks and chokes. The coupler and amplifier provide sufficient isolation to block LO feedthrough from the RX-01-33 receiver getting into the radio converter.

Control No. — *N° de réf.* 5342

Date 31-3-82

MATERIEL ISSUE VOUCHER ***REÇU DE REMISE DE FOURNITURE***

Issued to — *Expédié à* D.A. 2049 E. Tsang 0-0696

Issued from — *Expédié de* SED

Via

Date Shipped *Date de l'envoi* 30-3-82

Consignor's Signature — *Signature de l'émetteur* BB

ITEM NO. *ARTICLE (N°)*	DESCRIPTION	Quantity *Quantité*	Unit Cost *Coût L'unité*	Extended Total *Montant*
1	Draft Copy of Final Report	5		Exp.

Posted *Inscription faites*

By — *Par*

Date 1 Apr 82

TOTAL PRICE *COÛT TOTAL*

01 – 43
372

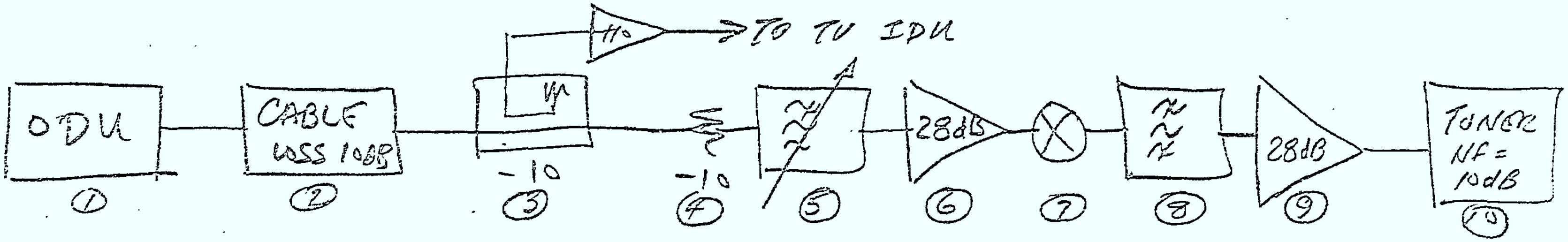
CONSIGNEE'S COPY — COPIE DU DESTINATAIRE

The selected SCPC radio program band is selected by a 20 MHz wide UHF filter. This filter is tuned by piston capacitors and can be tuned by alignment to either 645 MHz or 885 MHz. This is followed by a +18 dB gain amplifier and mixer. A 547 - 787 MHz VCO mixes the band down to 88 - 108 MHz. The SCPC carriers at port C are about 2000μv each. The VCO is prescaled by 20 and phase locked with a MECL phase detector to either of two crystals 27.35 - 39.35 MHz. A 20 KHz loop bandwidth suppresses the close-in noise of the VCO, making it SCPC compatible.

The square boxes denote video carrier and radio SCPC carrier levels from top to bottom. Levels after the filter are for radio SCPC carriers only. The levels shown with the arrows are for the block converter and video receiver inband LO feedthrough levels.

The system was analyzed in figure 5.4 and it was determined that assuming a LNC noise figure of 3 dB and a FM tuner noise figure of 10 dB, the total system noise figure increases to 3.27 dB due to noise contribution in the block converter.

The characteristics of the preselector filter are given in figures 5.5 and 5.6 respectively for 645 MHz and 885 MHz.



CALCULATE SYSTEM NF AS SEEN BY RADIO PROGRAM

UNIT	dB GAIN	L	dB NF	T°K	T°K REL I/P
①	40	1×10^{-4}	3	289	289
②	-10	10	–	261	–
③	0	1	–	–	–
④	-10	10	–	261	–
⑤	-5	3	–	193	2
⑥	28	1.6×10^{-3}	7	1163	35
⑦	-8	6.3	9	2014	–
⑧	-1	1.3	–	67	–
⑨	28	1.6×10^{-3}	7	1163	–
⑩	–	–	10	2610	–
					326°K

3.27dB NF

$$T = 290°K\left(\frac{L-1}{L}\right)$$

$$NF = 10 \log\left(1 + \frac{T}{290°K}\right)$$

DEC. 8, 1981

FIGURE 5.4

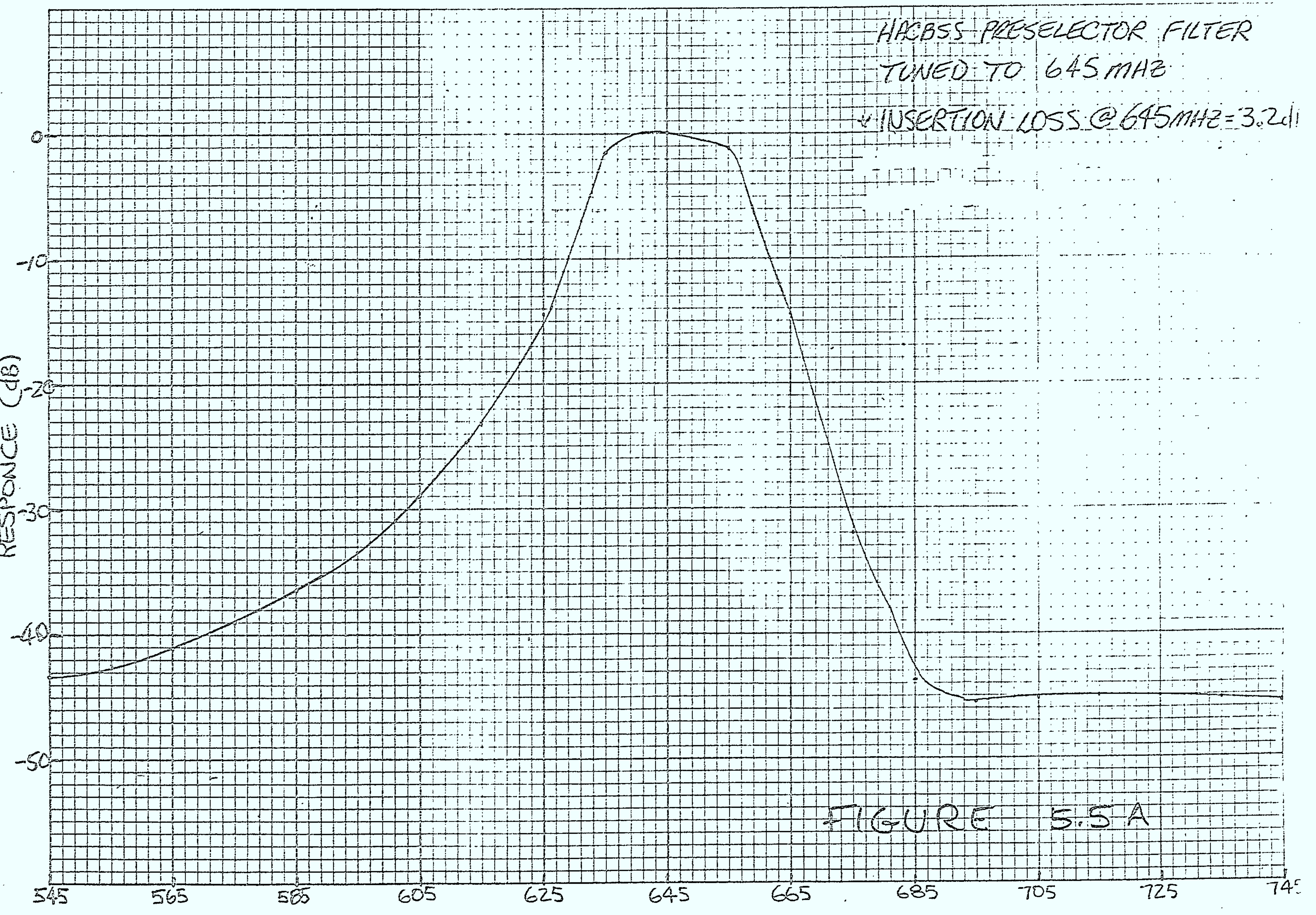

HACBSS PRESELECTOR FILTER
TUNED TO 645 MHZ
INSERTION LOSS @ 645 MHZ = 3.2d
RESPONCE (dB)
0
-10
-20
-30
-40
-50
545
565
585
605
625
645
665
685
705
725
745

FIGURE 5.5A

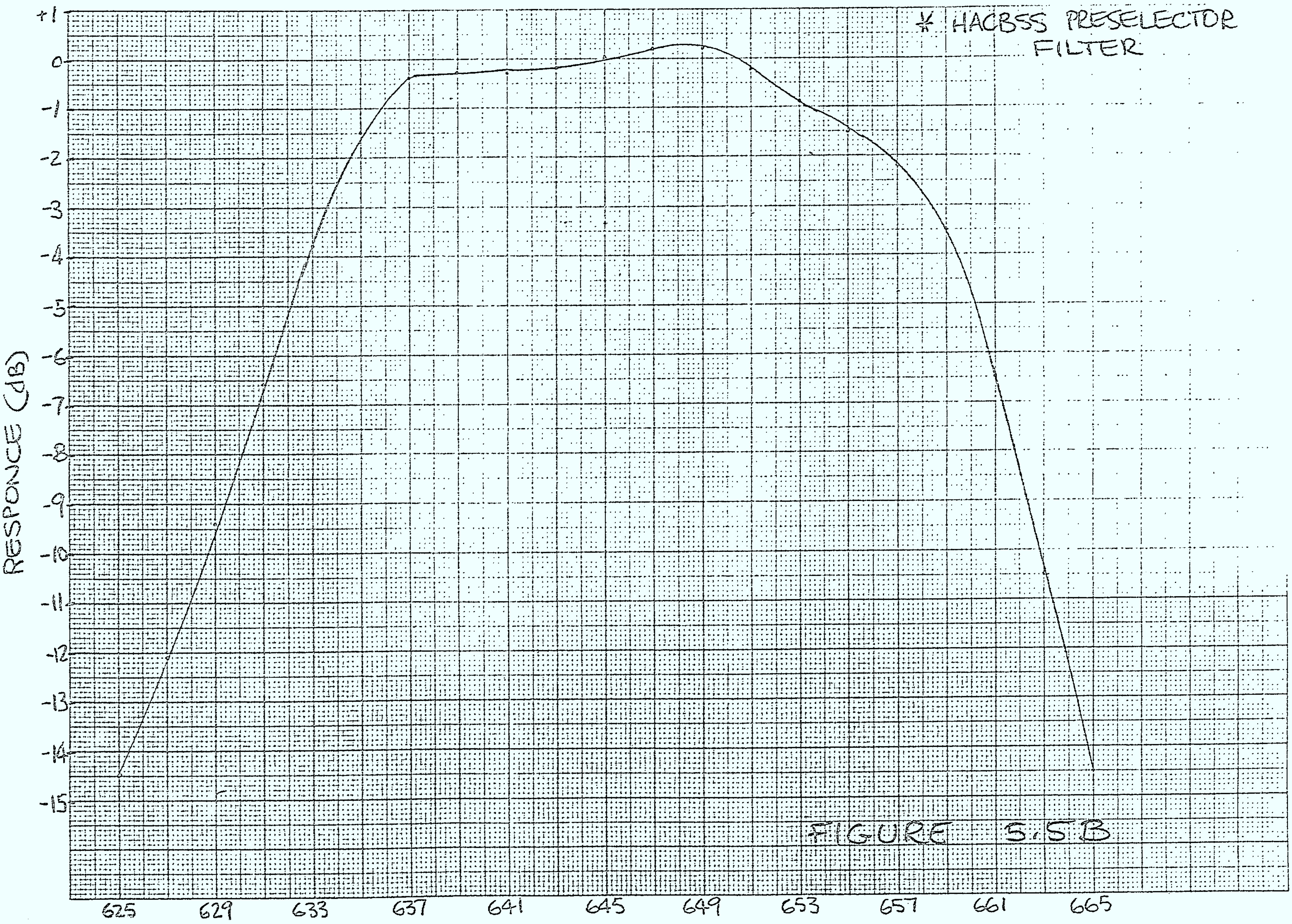

* HACBSS PRESELECTOR FILTER
RESPONCE (dB)
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
625
629
633
637
641
645
649
653
657
661
665

FIGURE 5.5B

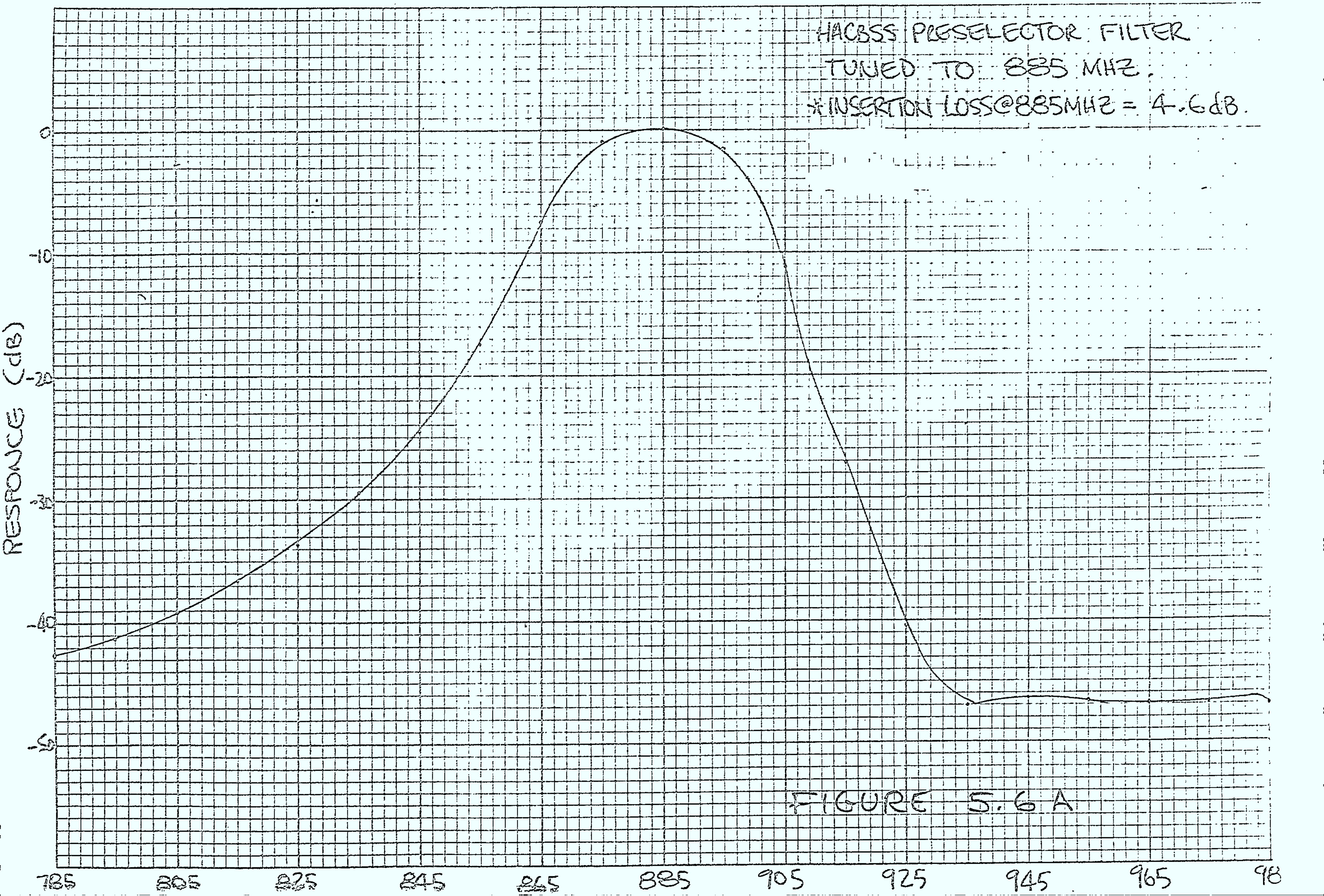

HACBSS PRESELECTOR FILTER
TUNED TO 885 MHZ.
*INSERTION LOSS@885MHZ = 4.6dB.

FIGURE 5.6 A

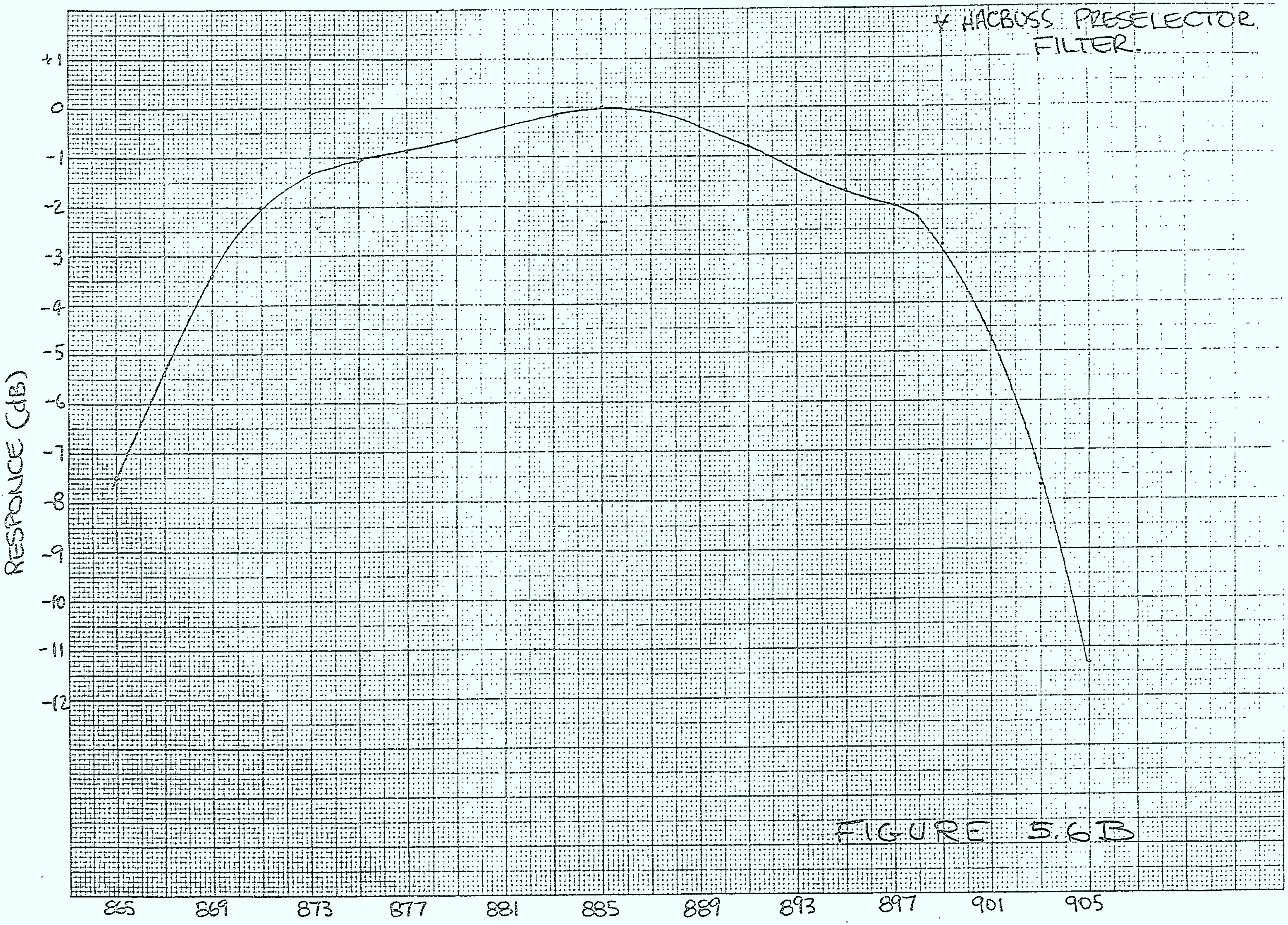

HACBUSS PRESELECTOR FILTER.
RESPONCE (dB)
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
865
869
873
877
881
885
889
893
897
901
905

FIGURE 5.6B

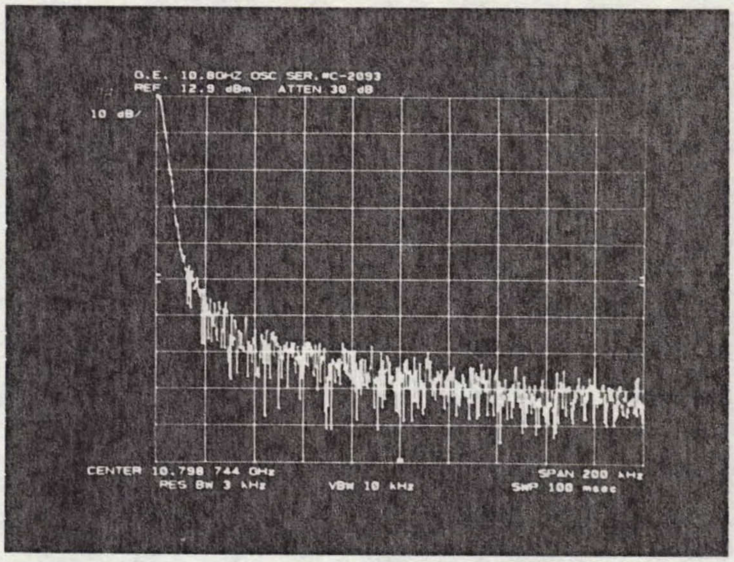
APPENDIX

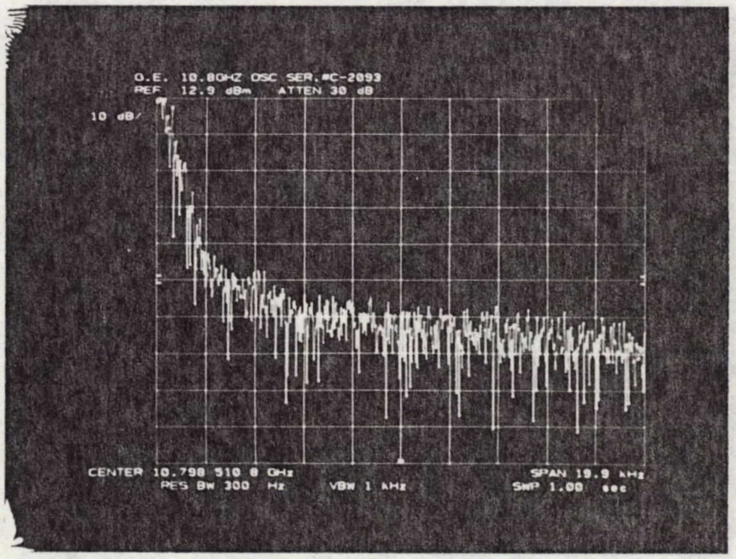
Oscillator Phase Noise Measurement Data

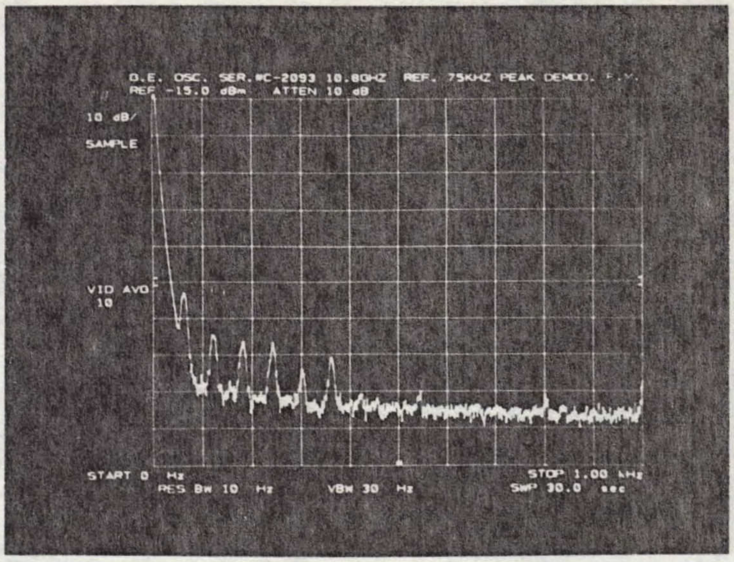
G.E. OSCILLATOR

10.8 GHZ.

SER. # C-2093


G.E. 10.8GHZ OSC SER.#C-2093
REF 12.9 dBm ATTEN 30 dB
10 dB/
CENTER 10.798 744 GHz
SPAN 200 kHz
RES BW 3 kHz
VBW 10 kHz
SWP 100 msec


G.E. 10.8GHZ OSC SER.#C-2093
REF 12.9 dBm ATTEN 30 dB
10 dB/
CENTER 10.798 510 8 GHz
SPAN 19.9 kHz
RES BW 300 Hz
VBW 1 kHz
SWP 1.00 sec



75 KHZ PEAK = 53KHZ RMS
B.W. B = 10HZ

FREQ.	fm	92dB	-20LOG f	+ DBm0	= dBC
50					
	100	92	-40	-80	-28
150					
	200	92	-46	-81	-35
250					
	300	92	-49.5	-82	-39.5
350					
	400	92	-52	-83	-43
450					
	500	92	-54	-84	-46
550					
	600	92	-55.6	-86	-49.6
650					
	700	92	-56.9	-86	-50.9
750					
	800	92	-58	-86	-52
850					
	900	92	-59	-87	-54
950					

NOTE:
DOWN CONVERTING
WITH CMT. PC117N
-1 AND H.P. 8640B
WITH X2 MULT.
AND F.M. DEMOD.
@10.7 MHZ
T.T.L. = 1KHZ AND
0.0 dBM @ 75KHZ
PEAK DEV.

15KHZ FLAT = -51dB
PROG. WTG = -56.4dB

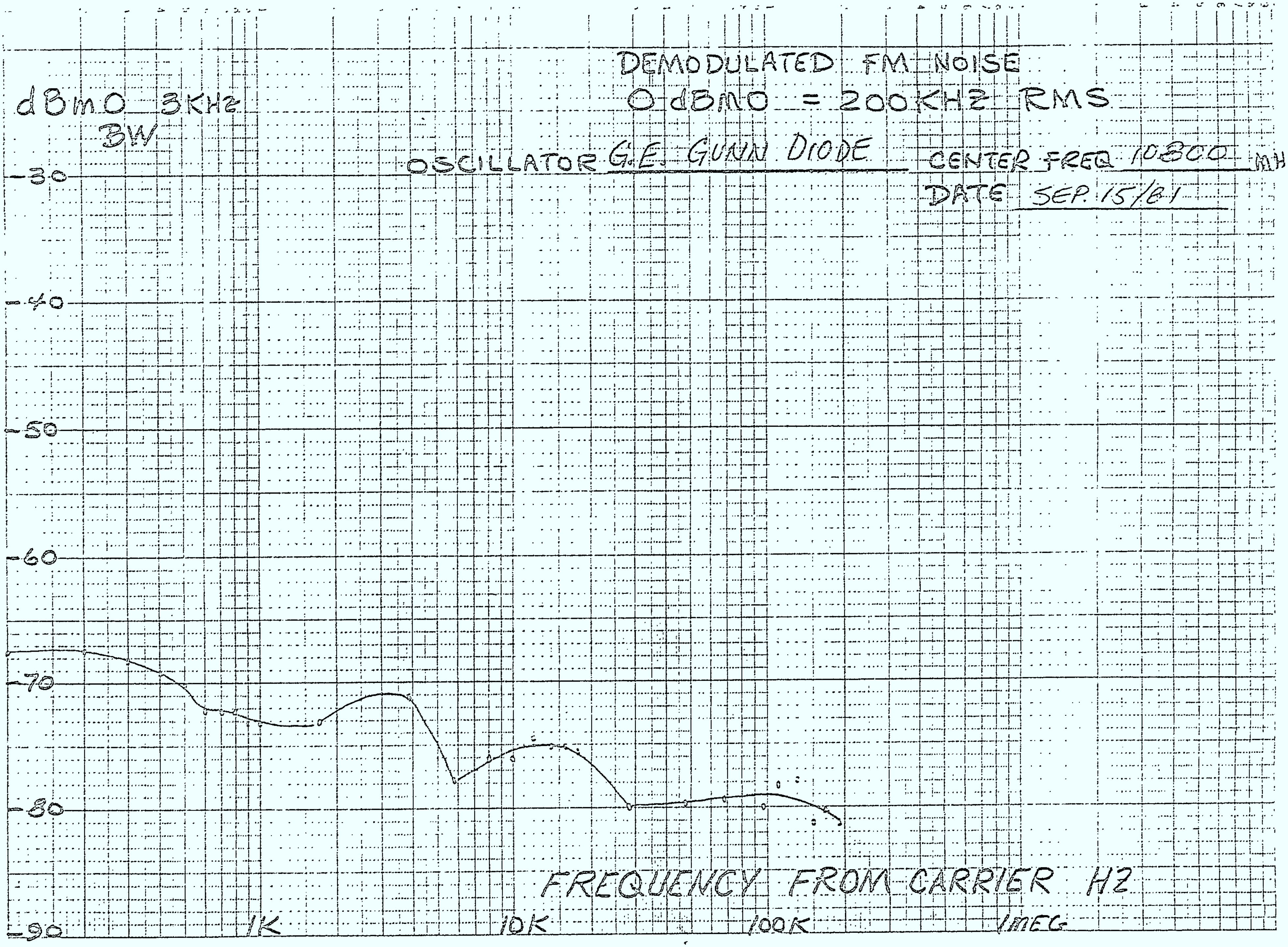
```
  GE OSC SER #C-2029 10.8GHZ  SEPT 81

 FLAG OSCN
  WITH>
  OSCILLATOR INTEGRATED NOISE PROGRAM
  ...................................................
  START FREQ F1 HZ?
 ?50
  STEP SIZE F2 HZ?
 ?100
  STOP FREQ F3 HZ?
 ?1050
  SPECTRUM ANALYSER IF BW B?
 ?10
  TYPE IN SSB NOISE AT GIVEN MEAN
  FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
  MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
  ************  **************  ***********  ****
         86.6
 ?-28
                    1.542        .24E+03    -67.5
        193.6
 ?-35
                    1.540        .24E+03    -67.5
        295.8
 ?-39.5
                    1.401        .20E+03    -68.3
        396.9
 ?-43
                    1.256        .16E+03    -69.3
        497.5
 ?-46
                    1.115        .12E+03    -70.3
        597.9
 ?-49.6
                     .885        .78E+02    -72.3
        698.2
 ?-50.9
                     .890        .79E+02    -72.3
        798.4
 ?-52
                     .897        .80E+02    -72.2
        898.6
 ?-54
                     .802        .64E+02    -73.2
        998.7
 ?-55
                     .794        .63E+02    -73.3
  TYPE 1 TO STOP; 2 TO CONTINUE
 ?1
  RMS NOISE HZ FM
  ................................
      36.317
  *STOP*

 !
```

```
 GE GUNN DIODE OSC IO.8 GHZ


!FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 ---------------------------------------------------------------------
 START FREQ F1 HZ?
?1000
 STEP SIZE F2 HZ?
?2000
 STOP FREQ F3 HZ?
?19000
 SPECTRUM ANALYSER IF BW B?
?300
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
      1732.1
?-45
                       .795        .13E+04    -73.2
      3873.0
?-50
                      1.000        .20E+04    -71.3
      5916.1
?-60
                       .483        .47E+03    -77.6
      7937.3
?-61
                       .578        .67E+03    -76.0
      9949.9
?-63
                       .575        .66E+03    -76.1
     11958.3
?-63
                       .691        .96E+03    -74.5
     13964.2
?-65
                       .641        .82E+03    -75.1
     15968.7
?-67
                       .582        .68E+03    -75.9
     17972.2
?-68
                       .584        .68E+03    -75.9
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ----------------
        90.0
 *STOP*

!
```

```
 GE GUNN DIODE OSC



FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 -----------------------------------
 START FREQ F1 HZ?
?20000
 STEP SIZE F2 HZ?
?20000
 STOP FREQ F3 HZ?
?200000
 SPECTRUM ANALYSER IF BW B?
?3000
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
     28284.3
?-66
                     .366       .27E+04    -80.0
     48989.8
?-70
                     .400       .32E+04    -79.2
     69282.0
?-73
                     .400       .32E+04    -79.2
     89442.7
?-76
                     .366       .27E+04    -80.0
    109544.5
?-76
                     .448       .40E+04    -78.2
    129614.7
?-77
                     .473       .45E+04    -77.8
    149666.2
?-82
                     .307       .19E+04    -81.5
    169705.6
?-82
                     .348       .24E+04    -80.4
    189736.6
?-84
                     .309       .19E+04    -81.4
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ----------------
       162.0
 *STOP*

!
```

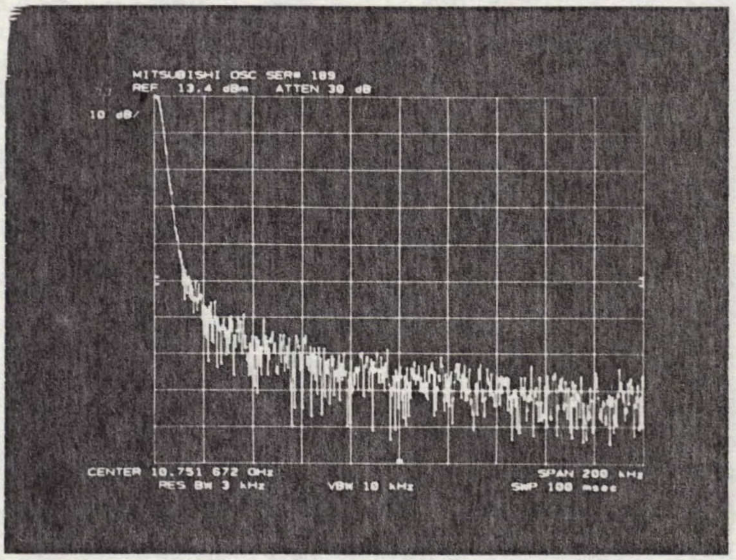
DEMODULATED FM NOISE
0 dBmO = 200KHz RMS

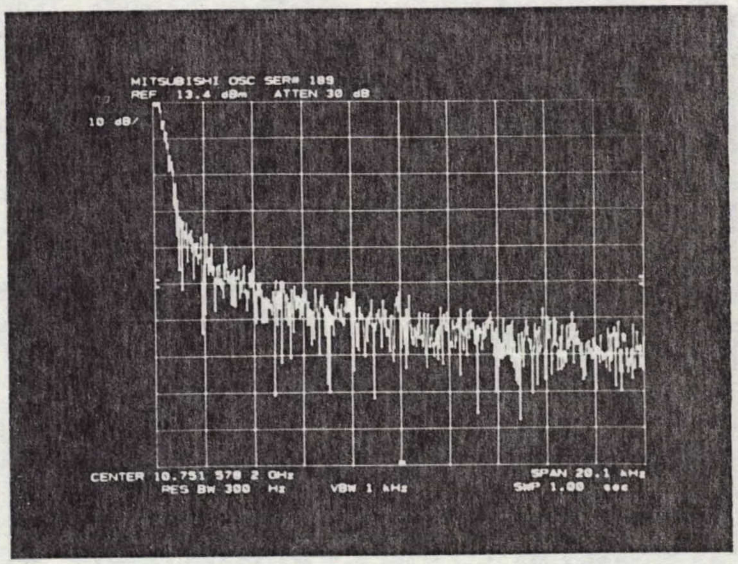
OSCILLATOR G.E. GUNN DIODE
CENTER FREQ 10800 MHz
DATE SEP. 15/81



MITSUBISHI OSC.

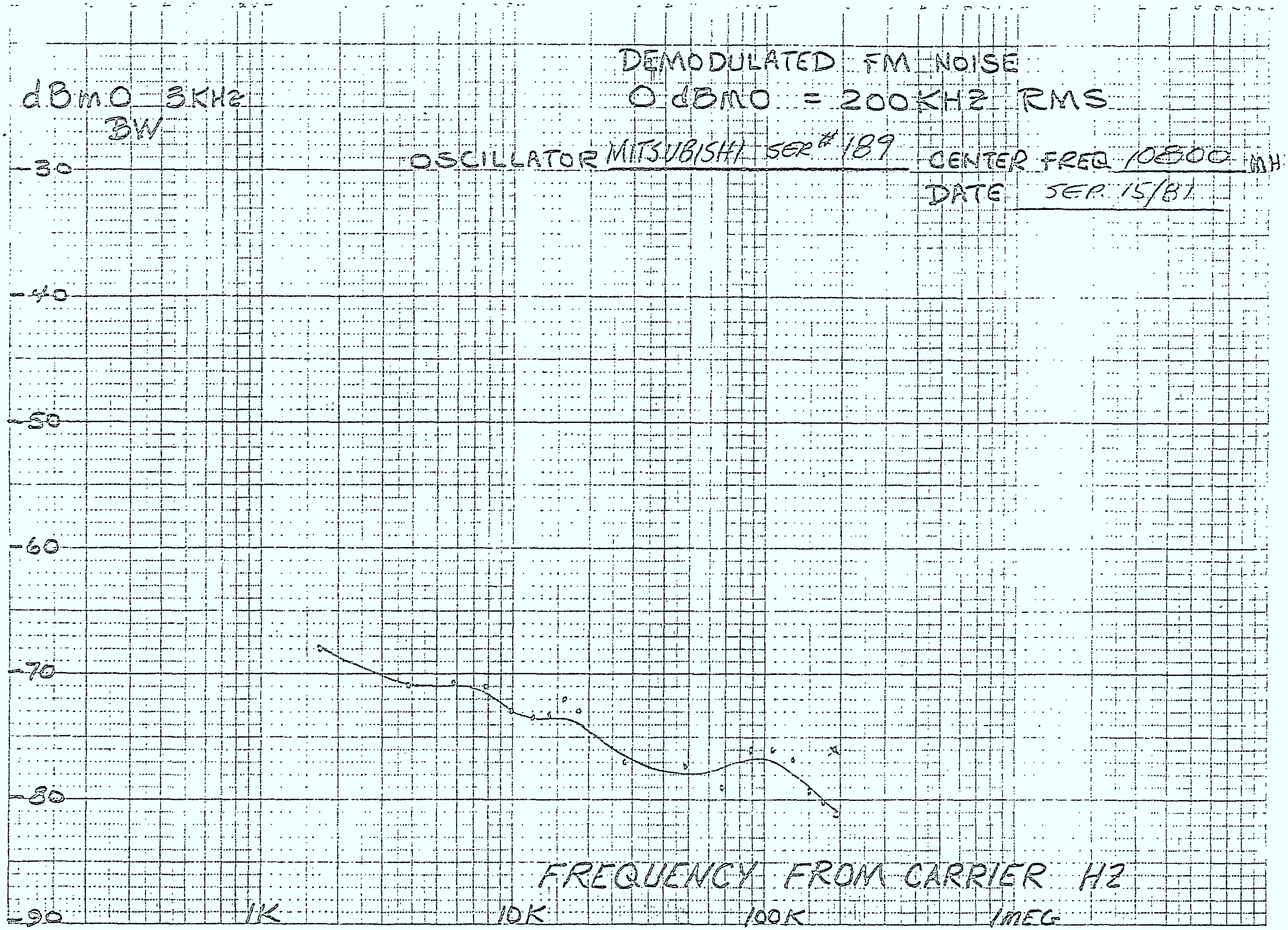
SER.# 189


MITSUBISHI OSC SER# 189
REF 13.4 dBm ATTEN 30 dB
10 dB/
CENTER 10.751 672 GHz
RES BW 3 kHz
VBW 10 kHz
SPAN 200 kHz
SWP 100 msec


MITSUBISHI OSC SER# 189
REF 13.4 dBm ATTEN 30 dB
10 dB/
CENTER 10.751 578 2 GHz
RES BW 300 Hz
VBW 1 kHz
SPAN 20.1 kHz
SWP 1.00 sec

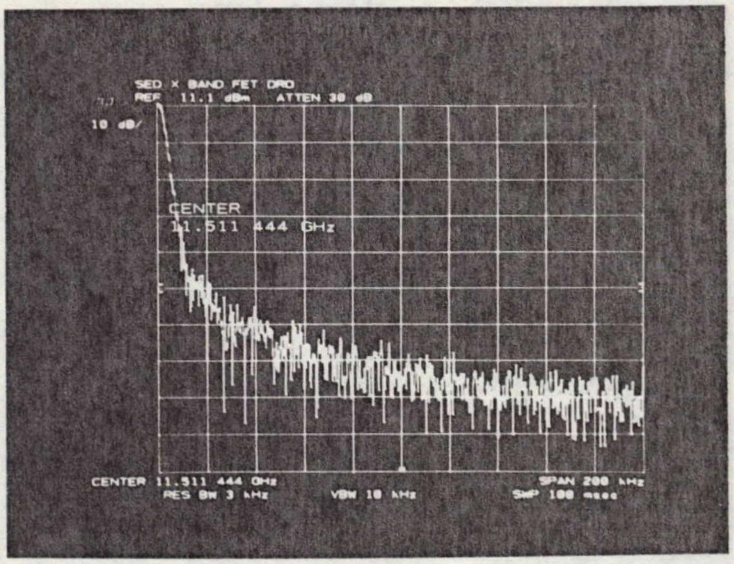
```
  MITSUBISHI OSC SER 189 10.8GHZ


FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM

 START FREQ F1 HZ?
?1000
 STEP SIZE F2 HZ?
?2000
 STOP FREQ F3 HZ?
?19000
 SPECTRUM ANALYSER IF BW B?
?300
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
      1732.1
?-40
                     1.414       .40E+04    -68.2
      3873.0
?-50
                     1.000       .20E+04    -71.3
      5916.1
?-53
                     1.081       .23E+04    -70.6
      7937.3
?-56
                     1.027       .21E+04    -71.0
      9949.9
?-60
                      .812       .13E+04    -73.1
     11958.3
?-62
                      .776       .12E+04    -73.5
     13964.2
?-63
                      .807       .13E+04    -73.1
     15968.7
?-63
                      .923       .17E+04    -71.9
     17972.2
?-65
                      .825       .14E+04    -72.9
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM

       131.0
 *STOP*

!
```

```
MITSUBISHI OSC




!FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 ------------------------------------------------------------
 START FREQ F1 HZ?
?20000
 STEP SIZE F2 HZ?
?20000
 STOP FREQ F3 HZ?
?200000
 SPECTRUM ANALYSER IF BW B?
?3000
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
     28284.3
?-63
                      .517         .53E+04    -77.0
     48989.8
?-67
                      .565         .64E+04    -76.2
     69282.0
?-73
                      .400         .32E+04    -79.2
     89442.7
?-72
                      .580         .67E+04    -76.0
    109544.5
?-73
                      .633         .80E+04    -75.2
    129614.7
?-76.
                      .530         .56E+04    -76.8
    149666.2
?-80
                      .386         .30E+04    -79.5
    169705.6
?-82
                      .348         .24E+04    -80.4
    189736.6
?-84
                      .309         .19E+04    -81.4
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ----------------------------
       206.0
 *STOP*

!
```

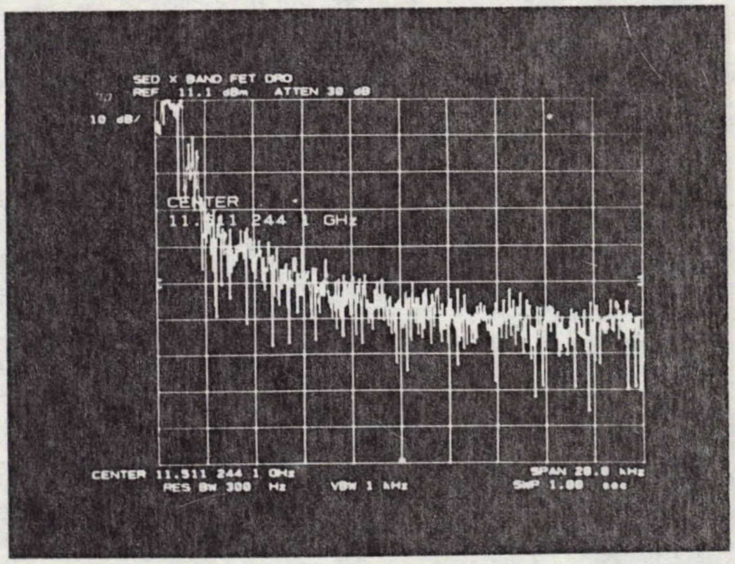

DEMODULATED FM NOISE
0 dBm0 = 200KHz RMS
dBm0 3KHz BW
OSCILLATOR MITSUBISHI SER# 189
CENTER FREQ 10800 MHz
DATE SEP. 15/81
-30
-40
-50
-60
-70
-80
-90
1K
10K
100K
1MEG
FREQUENCY FROM CARRIER Hz

SED

X-BAND F.E.T. DRO


SED X BAND FET DRO
REF 11.1 dBm ATTEN 30 dB
10 dB/
CENTER
11.511 444 GHz
CENTER 11.511 444 GHz
SPAN 200 kHz
RES BW 3 kHz
VBW 10 kHz
SWP 100 msec

SER. #1


SED X BAND FET DRO
REF 11.1 dBm ATTEN 30 dB
10 dB/
CENTER
11.511 244 1 GHz
CENTER 11.511 244 1 GHz
SPAN 20.0 kHz
RES BW 300 Hz
VBW 1 kHz
SWP 1.00 sec

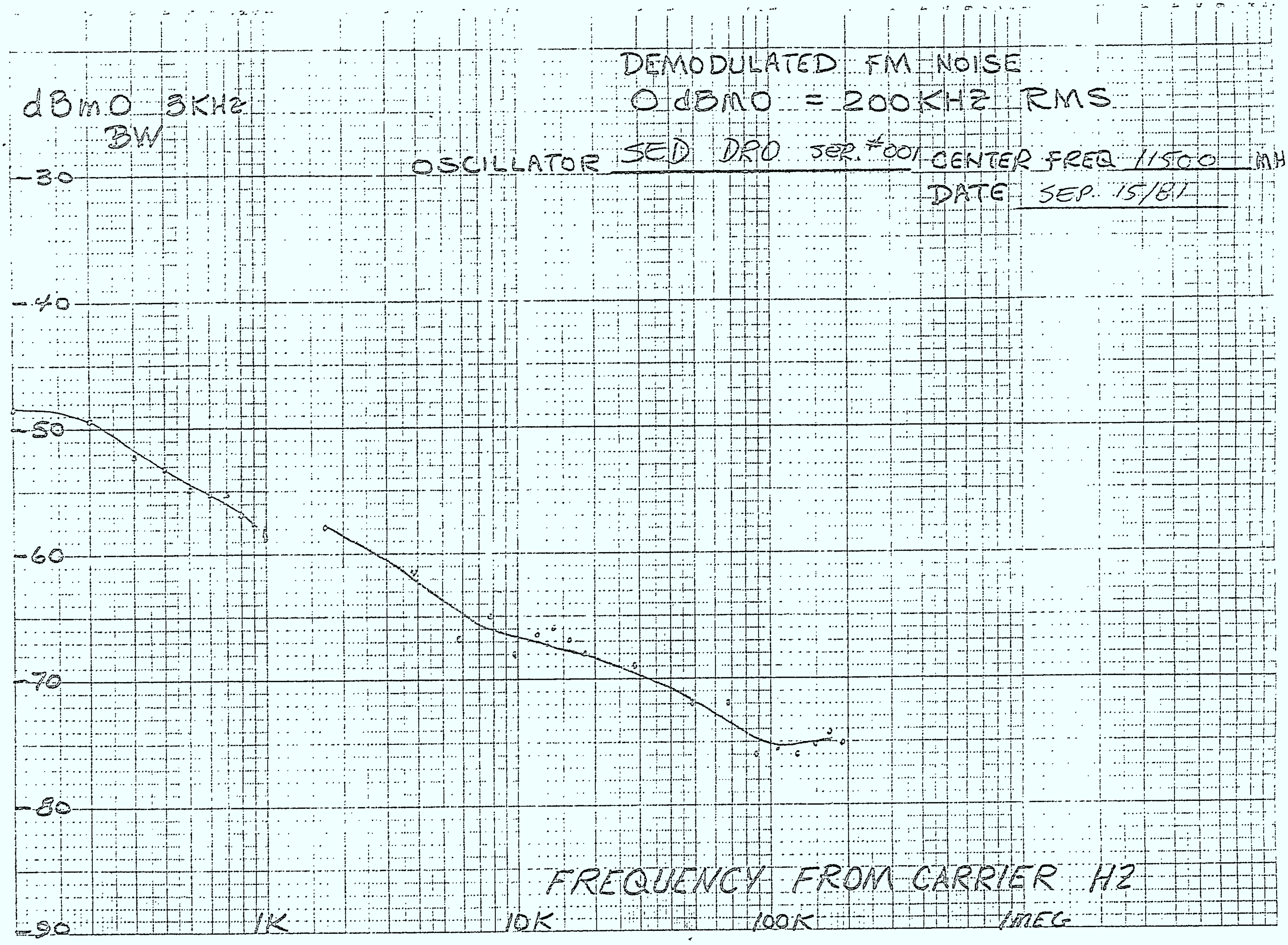
SER. #1

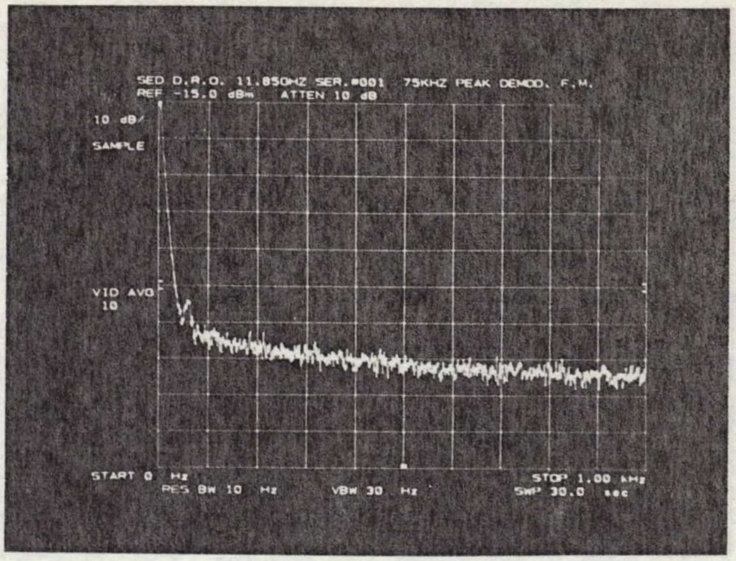
SED DRO SER. #1

```
FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 -----------------------------------
 START FREQ F1 HZ?
?20000
 STEP SIZE F2 HZ?
?20000
 STOP FREQ F3 HZ?
?200000
 SPECTRUM ANALYSER IF BW B?
?3000
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
     28284.3
?-55
                    1.299       .34E+05    -69.0
     48989.8
?-63
                     .895       .16E+05    -72.2
     69282.0
?-66
                     .897       .16E+05    -72.2
     89442.7
?-72
                     .580       .67E+04    -76.0
    109544.5
?-73
                     .633       .80E+04    -75.2
    129614.7
?-75
                     .595       .71E+04    -75.8
    149666.2
?-75
                     .687       .94E+04    -74.5
    169705.6
?-76
                     .694       .96E+04    -74.4
    189736.6
?-78
                     .617       .76E+04    -75.4
 TYPE 1 TO STOP, 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ----------------
       338.0
 *STOP*

!
```

SED DRO 10.8 GHZ SEPT. 81 SER.#001

```
!FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 ----------------------------------------------------------------
 START FREQ F1 HZ?
?1000
 STEP SIZE F2 HZ?
?2000
 STOP FREQ F3 HZ?
?19000
 SPECTRUM ANALYSER IF BW B?
?300
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
      1732.1
?-30
                     4.472        .40E+05    -58.2
      3873.0
?-40
                     3.162        .20E+05    -61.3
      5916.1
?-48
                     1.923        .74E+04    -65.6
      7937.3
?-50
                     2.049        .84E+04    -65.0
      9949.9
?-55
                     1.445        .42E+04    -68.1
     11958.3
?-55
                     1.736        .60E+04    -66.5
     13964.2
?-56
                     1.807        .65E+04    -66.1
     15968.7
?-58
                     1.641        .54E+04    -66.9
     17972.2
?-60
                     1.467        .43E+04    -67.9
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ------------------------
       319.0
 *STOP*

!
```


DEMODULATED FM NOISE
0 dBm0 = 200KHz RMS
dBm0 3KHz BW
OSCILLATOR SED DRO SER. #001
CENTER FREQ 11500 MH
DATE SEP. 15/87
-30
-40
-50
-60
-70
-80
-90
1K
10K
100K
1MEG
FREQUENCY FROM CARRIER Hz



REF. 75KHZ PEAK = 53KHZ RMS

FREQ.	Δf	92dB	- 20LOG f	+ DBMO	= dBC
50 HZ ↓					
	100	92	-40	-61	-9
150					
	200	92	-46	-63	-17
250					
	300	92	-49.5	-66	-23.5
350					
	400	92	-52	-67	-27
450					
	500	92	-54	-69	-31
550					
	600	92	-55.6	-70	-33.6
650					
	700	92	-56.9	-70	-34.9
750					
	800	92	-58	-71	-37
850					
	900	92	-59	-72	-39
950					
	1000	92	-60	-73	-41
1050					

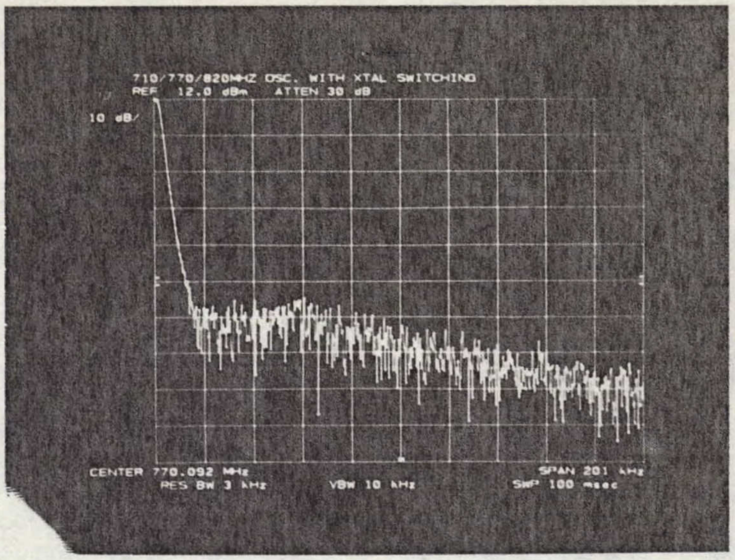
NOTE:
DOWN CONVERTING WITH
CMJ. PC117N-1 AND
H.P. 8640B
AND F.M. DEMOD. @ 10.7 MHZ
T.T.L. = 1KHZ 0.0dBM @ 75
KHZ PEAK DEV.

15KHZ FLAT = -41 dB
PRGM WTNG = -43.5 dB

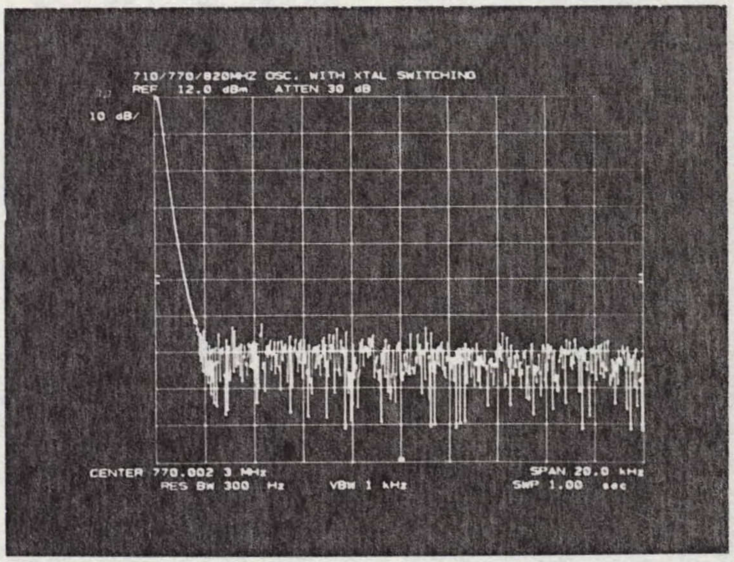
```
FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 -----------------------------------
 START FREQ F1 HZ?
?50
 STEP SIZE F2 HZ?
?100
 STOP FREQ F3 HZ?
?1050
 SPECTRUM ANALYSER IF BW B?
?10
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
        86.6
?-9
                  13.742        .19E+05    -48.5
       193.6
?-17
                  12.233        .15E+05    -49.5
       295.8
?-23.5
                   8.841        .78E+04    -52.3
       396.9
?-27
                   7.928        .63E+04    -53.3
       497.5
?-31
                   6.270        .39E+04    -55.3
       597.9
?-33.6
                   5.587        .31E+04    -56.3
       698.2
?-34.9
                   5.617        .32E+04    -56.3
       798.4
?-37
                   5.044        .25E+04    -57.2
       898.6
?-39
                   4.509        .20E+04    -58.2
       998.7
?-41
                   3.981        .16E+04    -59.3
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ----------------
     253.613
 *STOP*

!BYE

CPU = .0473 CON= 00:07:00 TRD= 43 TWR= 93 CORE= .4725 I/O= 54

NET COST OF SESSION WAS $0.89
```

```
FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 ------------------------------------
 START FREQ F1 HZ?
?50
 STEP SIZE F2 HZ?
?100
 STOP FREQ F3 HZ?
?1050
 SPECTRUM ANALYSER IF BW BT?
?10
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
        86.6
?-11
                   10.915          .12E+05    -50.5
       193.6
?-21
                    7.718          .60E+04    -53.5
       295.8
?-27.5
                    5.578          .31E+04    -56.3
       396.9
?-33
                    3.973          .16E+04    -59.3
       497.5
?-37
                    3.143          .99E+03    -61.3
       597.9
?-38.6
                    3.142          .99E+03    -61.3
       698.2
?-39.9
                    3.159          .10E+04    -61.3
       798.4
?-42
                    2.836          .80E+03    -62.2
       898.6
?-43
                    2.845          .81E+03    -62.2
       998.7
?-44
                    2.818          .79E+03    -62.3
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ----------------
    167.162
 *STOP*

!
```

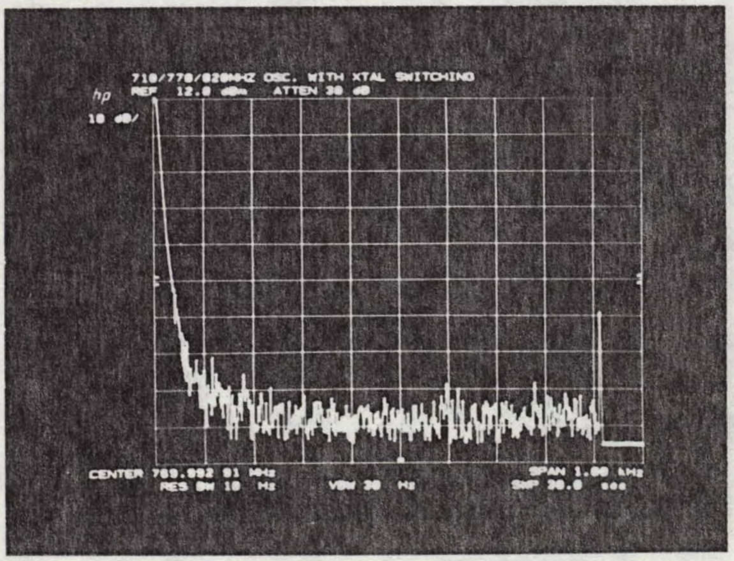
710/770/820 MHZ OSCILLATOR WITH XTAL SWITCHING.



710/770/820MHZ OSC. WITH XTAL SWITCHING
hp
REF 12.0 dBm
ATTEN 30 dB
10 dB/
CENTER 770.092 MHz
SPAN 201 kHz
RES BW 3 kHz
VBW 10 kHz
SWP 100 msec



710/770/820MHZ OSC. WITH XTAL SWITCHING
hp
REF 12.0 dBm
ATTEN 30 dB
10 dB/
CENTER 770.002 3 MHz
SPAN 20.0 kHz
RES BW 300 Hz
VBW 1 kHz
SWP 1.00 sec



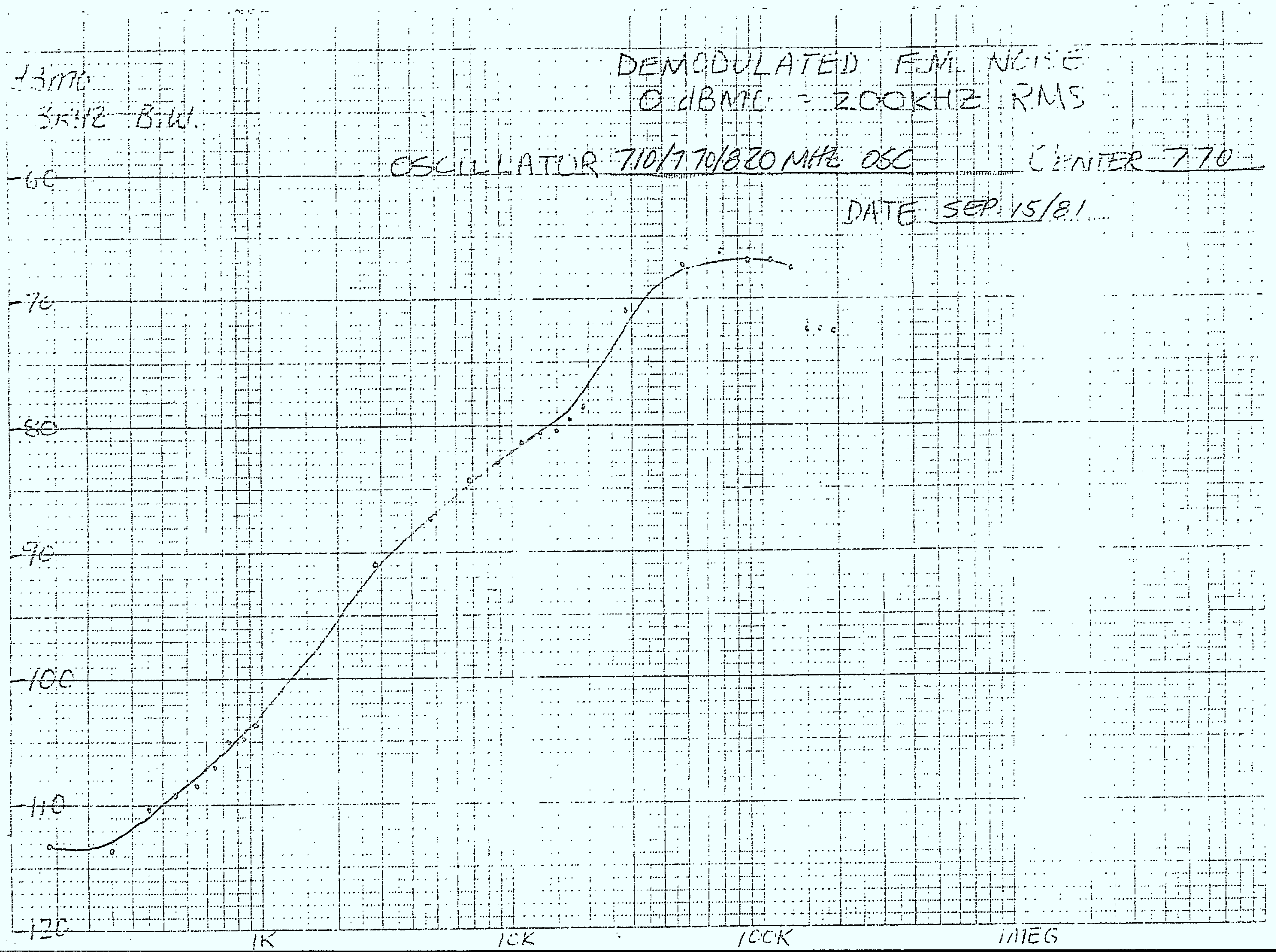
710/770/820MHZ OSC. WITH XTAL SWITCHING
hp
REF 12.0 dBm
ATTEN 30 dB
10 dB/
CENTER 769.992 91 MHz
SPAN 1.00 kHz
RES BW 10 Hz
VBW 30 Hz
SWP 30.0 sec

710/770/820 MHZ OSC. WITH XTAL SWITCHING

```
FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 -----------------------------------
 START FREQ F1 HZ?
?20000
 STEP SIZE F2 HZ?
?20000
 STOP FREQ F3 HZ?
?200000
 SPECTRUM ANALYSER IF BW B?
?3000
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
       28284.3
?-57
 -------                1.032       .21E+05    -71.0
       48989.8
?-58
                        1.592       .51E+05    -67.2
       69282.0
?-60
                        1.789       .64E+05    -66.2
       89442.7
?-63
                        1.635       .53E+05    -67.0
      109544.5
?-65
                        1.591       .51E+05    -67.2
      129614.7
?-67
                        1.495       .45E+05    -67.8
      149666.2
?-73
                         .865       .15E+05    -72.5
      169705.6
?-74
                         .874       .15E+05    -72.4
      189736.6
?-75
                         .871       .15E+05    -72.4
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ------------------
       574.0
 *STOP*
```

```
!FLAG OSCN
 WITH>
 OSCILLATOR INTEGRATED NOISE PROGRAM
 ----------------------------------
 START FREQ F1 HZ?
?2000
 STEP SIZE F2 HZ?
?2000
 STOP FREQ F3 HZ?
?20000
 SPECTRUM ANALYSER IF BW B?
?300
 TYPE IN SSB NOISE AT GIVEN MEAN
 FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
 MEAN FREQ HZ  FM NOISE HZ AV  FM NOISE SQ  DBMO
 ************  **************  ***********  ****
        2828.4
?-67
                        .103        .21E+02    -91.0
        4899.0
?-68
                        .159        .51E+02    -87.2
        6928.2
?-68
                        .225        .10E+03    -84.2
        8944.3
?-69
                        .259        .13E+03    -83.0
       10954.4
?-69
                        .317        .20E+03    -81.2
       12961.5
?-70
                        .335        .22E+03    -80.8
       14966.6
?-71
                        .344        .24E+03    -80.5
       16970.6
?-71
                        .391        .31E+03    -79.4
       18973.7
?-71
                        .437        .38E+03    -78.4
 TYPE 1 TO STOP; 2 TO CONTINUE
?1
 RMS NOISE HZ FM
 ---------------
        40.0
 *STOP*
```

```
         710/770/820 MHZ OSC WITH XTAL SWITCHING

      FLAG OSCN
       WITH>
       OSCILLATOR INTEGRATED NOISE PROGRAM
       ----------------------------------------------------
       START FREQ F1 HZ?
      ?100
       STEP SIZE F2 HZ?
      ?100
       STOP FREQ F3 HZ?
      ?190\\000
       SPECTRUM ANALYSER IF BW B?
      ?10
       TYPE IN SSB NOISE AT GIVEN MEAN
       FREQ HZ DB,DBMO=FM NOISE 3K BW BELOW 200KHZ RMS
       MEAN FREQ HZ   FM NOISE HZ AV   FM NOISE SQ   DBMO
       ************   **************   ***********   ****
             141.4
      ?-78
                                   .008          .63E-02    -113.2
             244.9
      ?-83
                                   .008          .60E-02    -113.5
             346.4
      ?-83
                                   .011          .12E-01    -110.4
             447.2
      ?-84
                                   .013          .16E-01    -109.2
             547.7
      ?-85
                                   .014          .19E-01    -108.5
             648.1
      ?-85
                                   .016          .27E-01    -107.0
             748.3
      ?-85
                                   .019          .35E-01    -105.8
             848.5
      ?-85
                                   .021          .46E-01    -104.7
             948.7
      ?-85
                                   .024          .57E-01    -103.7
       TYPE 1 TO STOP; 2 TO CONTINUE
      ?1
       RMS NOISE HZ FM
       --------------------------------
            .473
       *STOP*
```


DEMODULATED F.M. NOISE
0 dBMC = 200KHZ RMS
OSCILLATOR 710/770/820 MHZ OSC
CENTER 770
DATE SEP 15/81
dBmc
3KHZ B.W.
-60
-70
-80
-90
-100
-110
-120
1K
10K
100K
1MEG