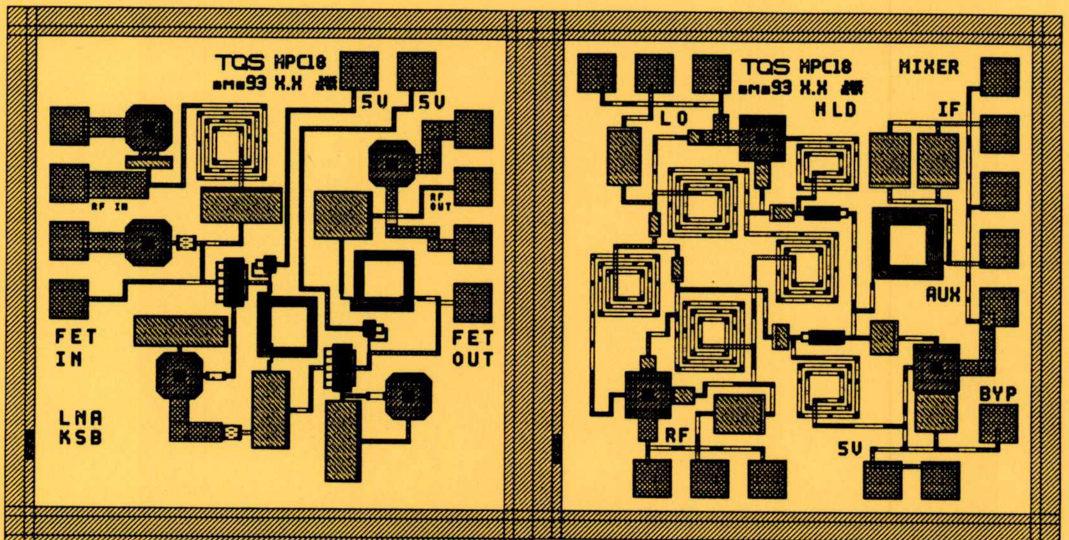
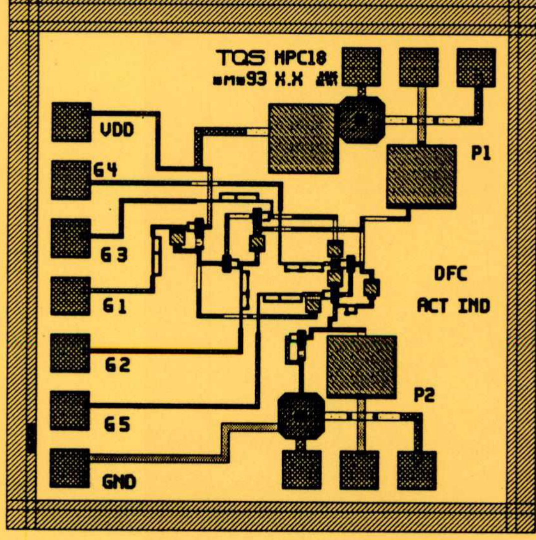
TEST RESULTS of STUDENT MMIC DESIGNS

The Johns Hopkins University EE 787 10/94





MMIC DESIGN EE 787

FALL 1993

STUDENT PROJECTS

ACTIVE INDUCTOR	D. COGHLAN
LOW NOISE AMPLIFIER	K. BONTZOS
BALANCED MIXER	M. DYE

WITH SUPPORT FROM:

HP/EESOF

TRIQUINT

FOREWORD

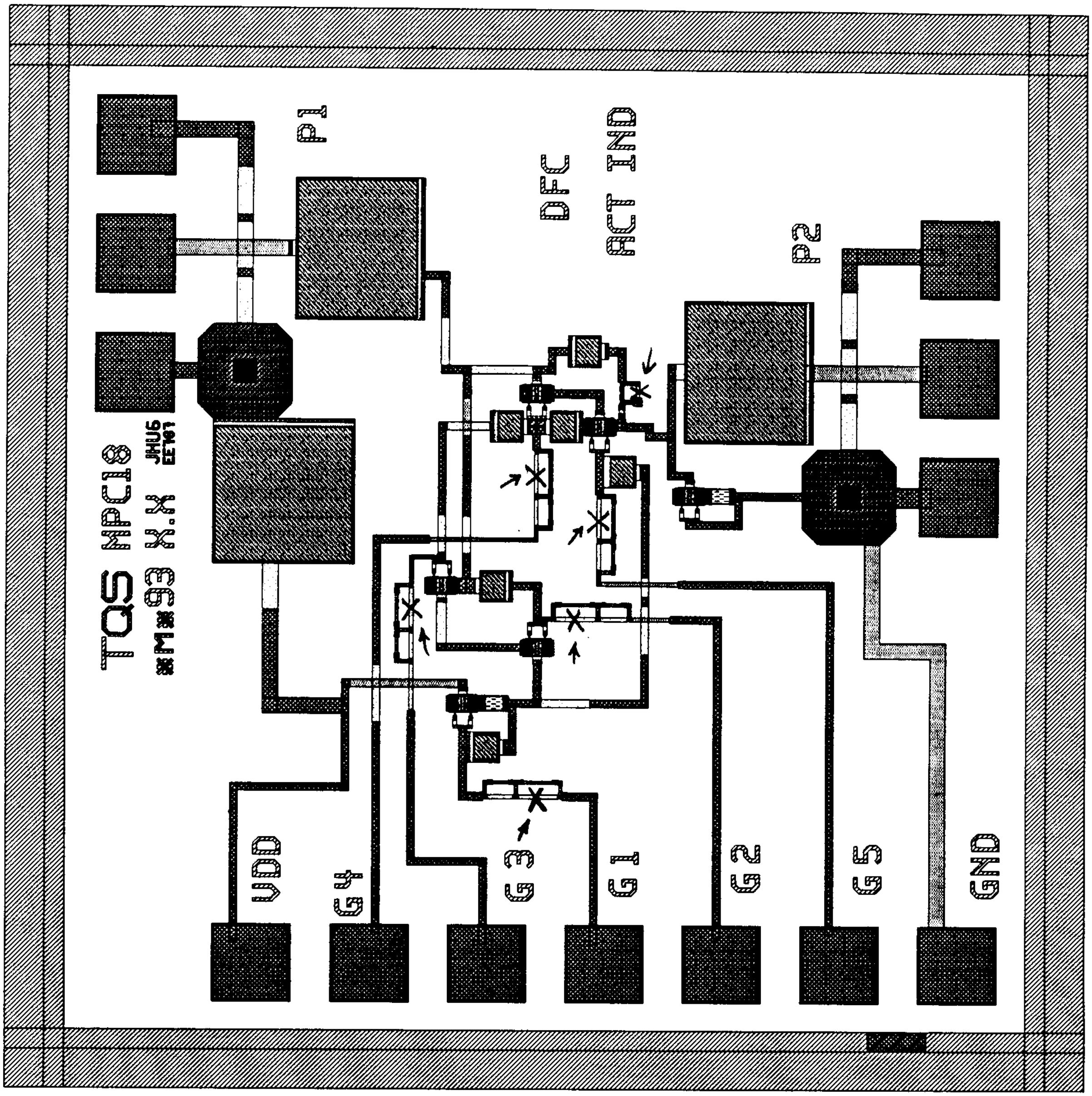
September 23, 1994

This brief report documents the experimental test results obtained by students in the Johns Hopkins University MMIC Design course EE 787 on the chips they designed in the fall of 1993 and which were fabricated by TriQuint Semiconductor in the spring and summer of 1994. These projects represent the work of 3 students over a period of about 8 weeks and include an active inductor, an LNA, and an improved balanced diode mixer. The LNA and mixer are intended to be used in the down converter for a C-Band receiver on the next Amateur Radio satellite (AMSAT). The active inductor would be useful as a high Q tuned circuit in a voltage controlled oscillator. All layouts were generated in ACADEMY 3.5 using the TriQuint SMART Library and analyzed with LIBRA. The resulting Calma files were unstreamed in ICED and checked using ICED's DRC.

When tested in July and August of 1994 on a Cascade probe station, these projects were found to be functional but did not perform exactly as simulated 8 months earlier. The measured mixer performance was the closest to predictions, with conversion loss better than simulated by 2.4 dB. The active inductor performance can be closely simulated with lower transistor current or a smaller gate width. The LNA performance was marred by an error in the design submission which caused the output matching network to not be connected to the FET collector. The small gap in the connection to the matching network probably occurred during correction of numerous design rule violations in ICED. Fortunately, the collector was also connected directly to a bond pad to permit use of an external output matching network. Resimulation of the circuit with this "error" introduced and the output taken at the collector bond pad agreed somewhat with the measurements.

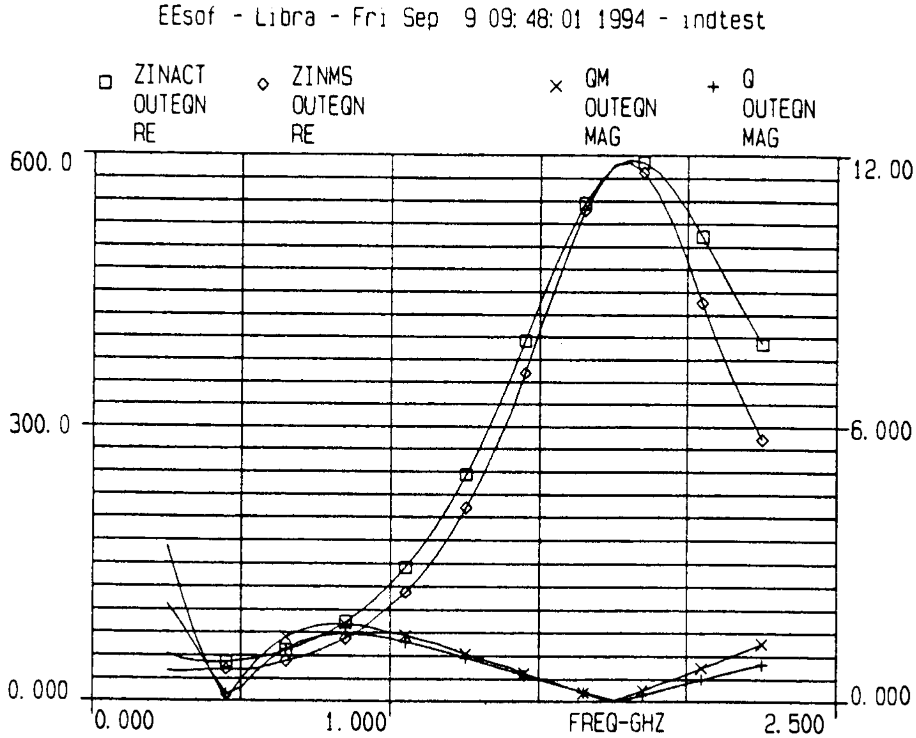
Since these students have graduated and the CAD software has undergone a major revision, it is not feasible to pursue the differences between measurement and simulation of these circuits.

Craig Moore / John Penn



→X denotes airbridges broken for testing.

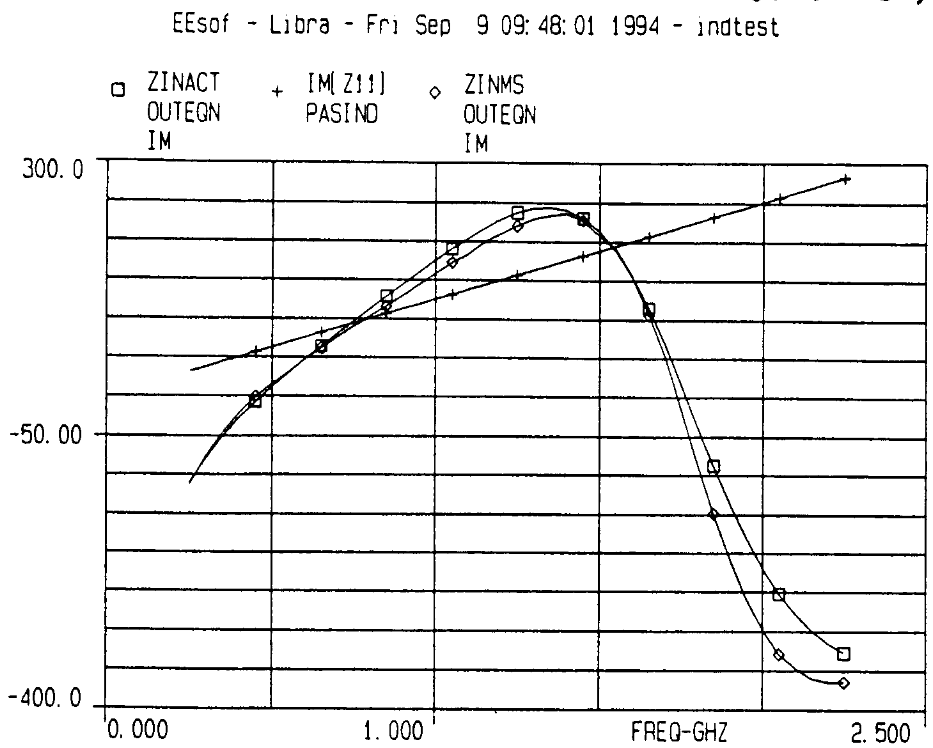
6WiD 20 -> 13



Plot showing measured results versus resimulated "fit" to data. Fit was made by reducing the 2x20 um FETs to 2x13 um FETs in order to match the results.

Key:		
	ZINACT (RE)	Real part of Z11 as Resimulated.
	ZINMS (RE)	Real part of Z11 as Measured.
	QM	Calculated "Q" as Measured.
	Q	Calculated "Q" as Resimulated.

GWID 20→13



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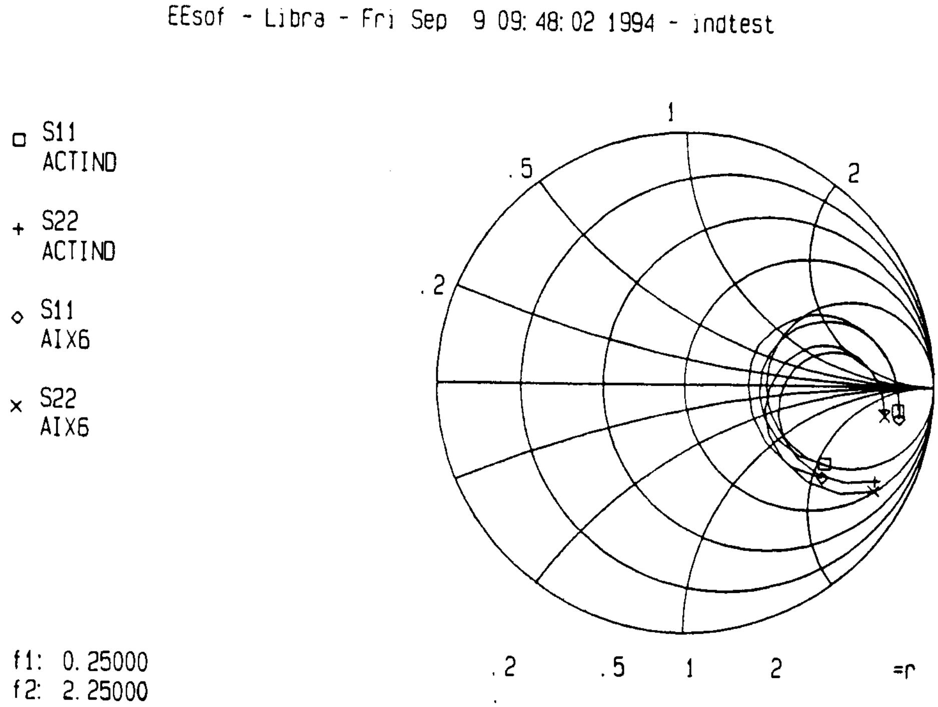
ଟ୍ WID 20 → 13



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Key:	S11 Actind	S11 of active inductor as Resimulated.
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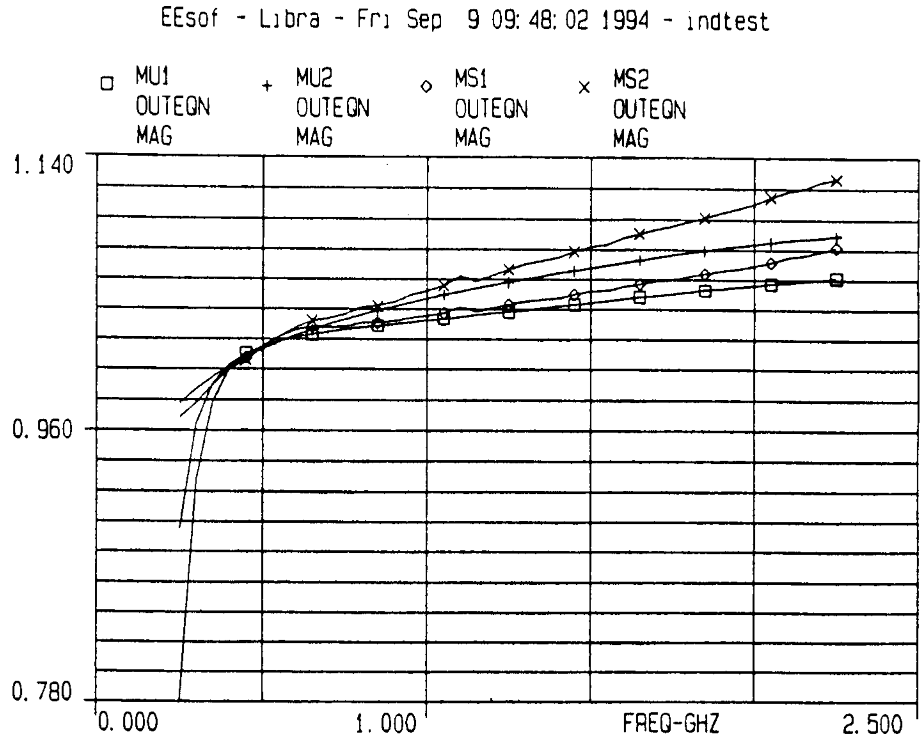
	S11 AIX6	S11 of Measured inductor (6 broken airbrg).
	S22 AIX6	S22 of Measured inductor (6 broken airbrg).

GWID 20→13



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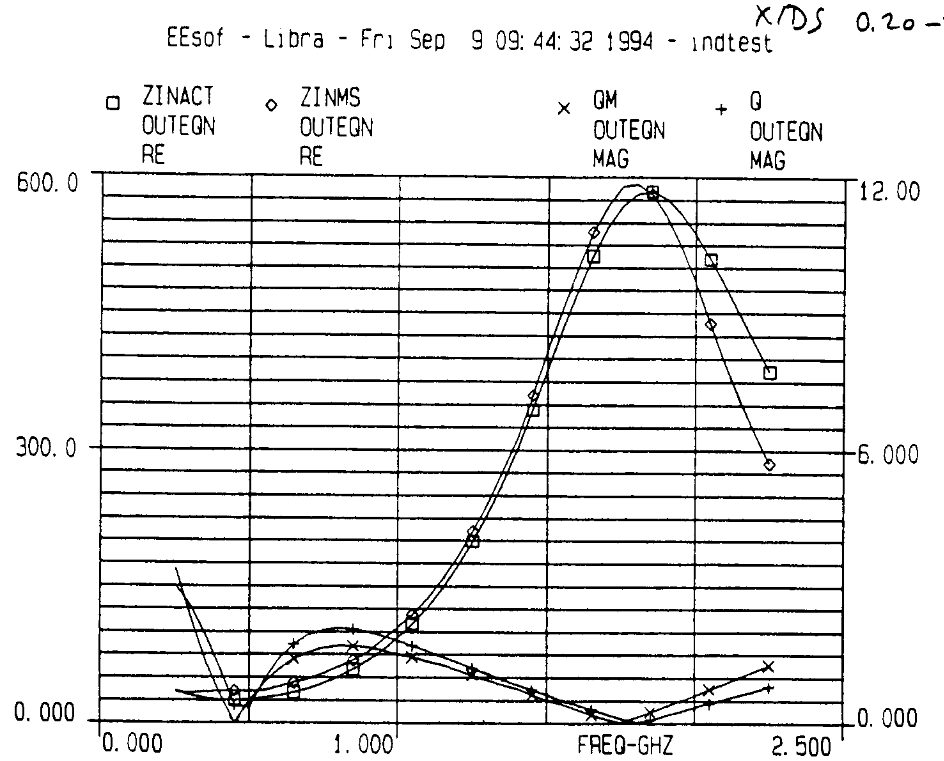
Key:	MU1	Input Stability Function as Resimulated.
	MU2	Output Stability Function as Resimulated.
	MS1	Input Stability Function as Measured.
	MS2	Output Stability Function as Measured.

XDS 0.20 -> 0.06



Plot showing measured results versus resimulated "fit" to data. Fit was made by reducing the drain current of the FETs to 6% IDSS versus the original 20% IDSS in order to match the results. Since the model is not valid below 15% IDSS it is hard to know what "6%" really represents.

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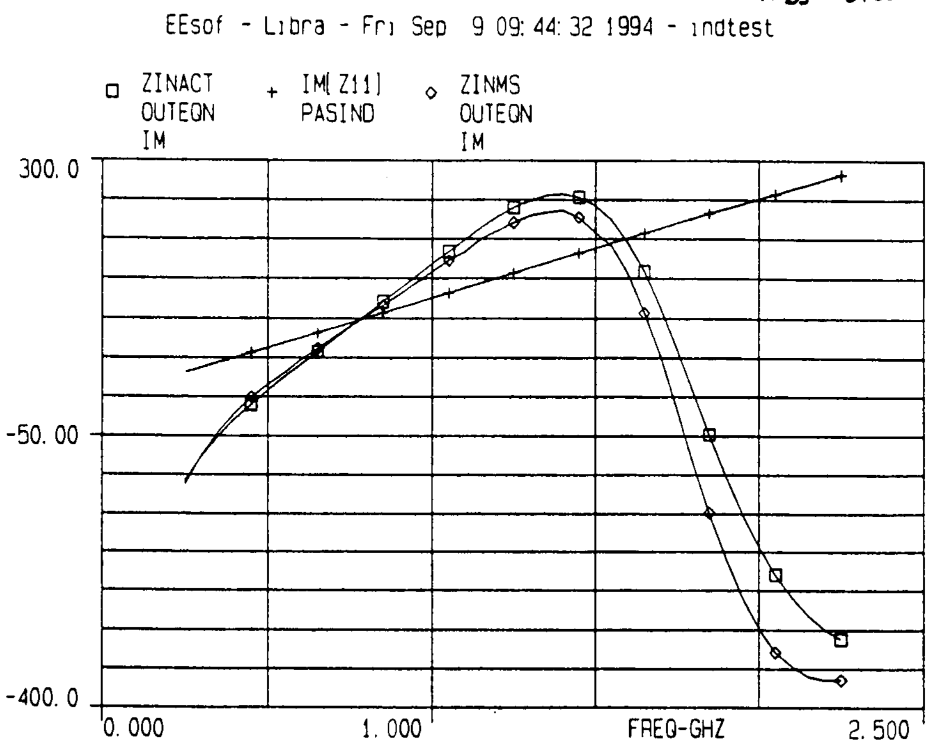
X2DS 0.20 → 0.06



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× IDS 0.20 → 0.06

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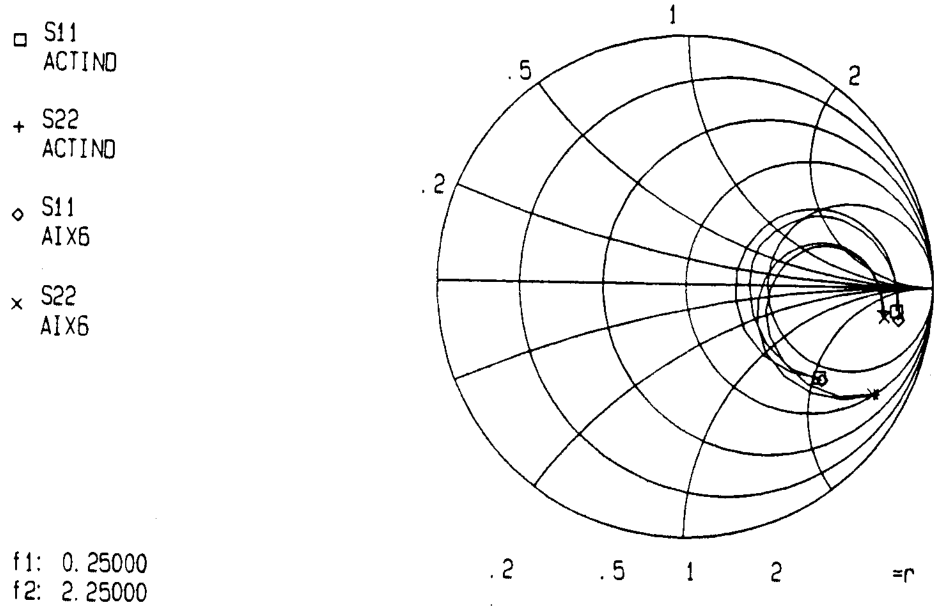

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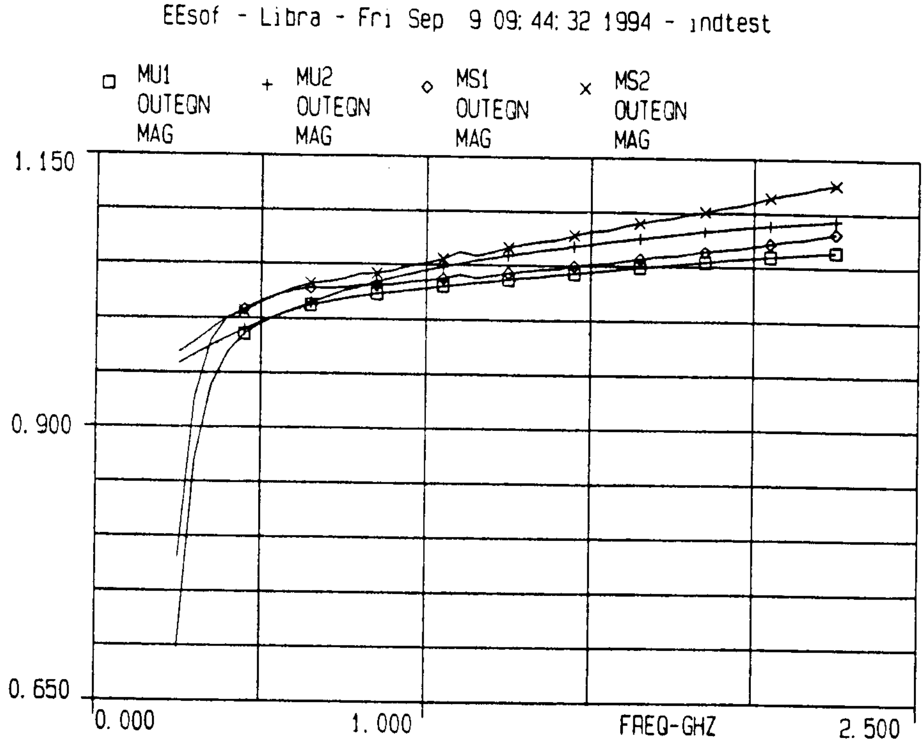

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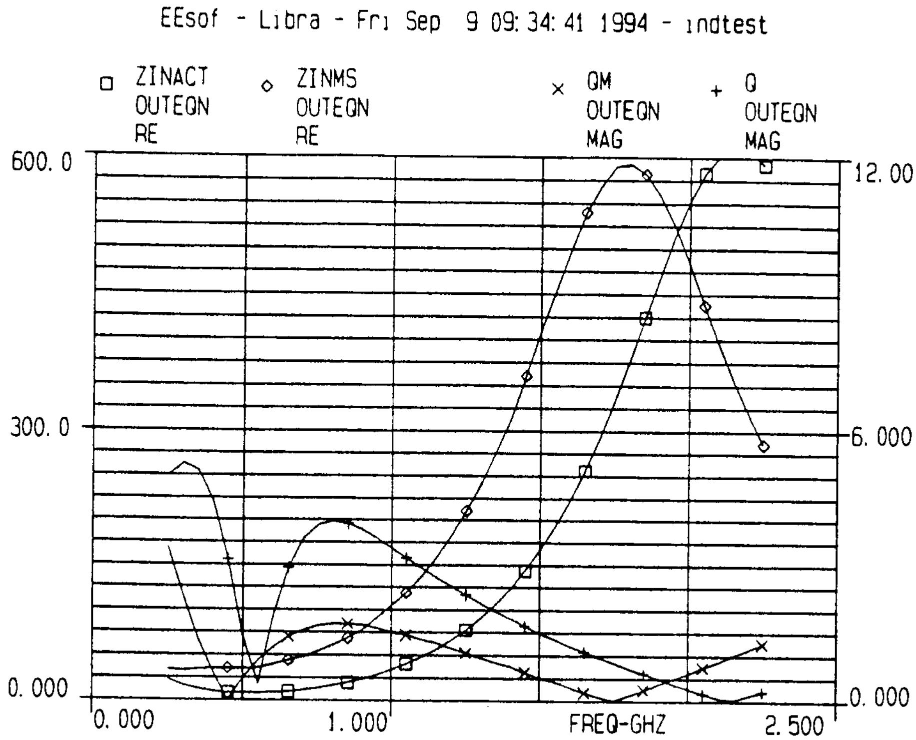
ORIGINAL



Plot showing measured results versus the original circuit adjusted according to the six airbridges broken for the test. The original design expected all airbridges to be broken!

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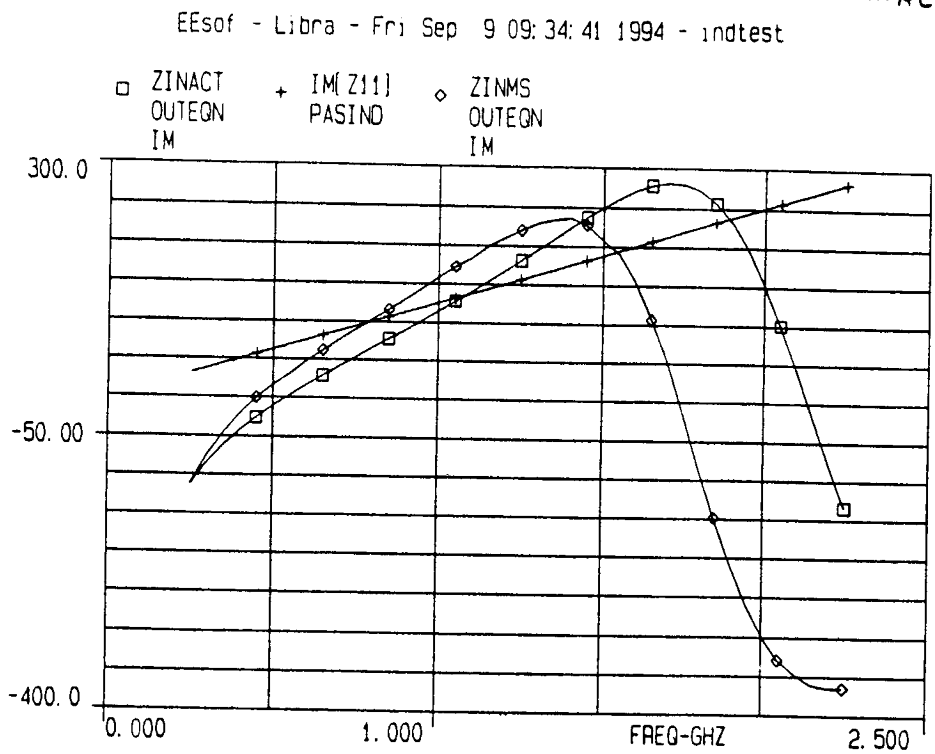

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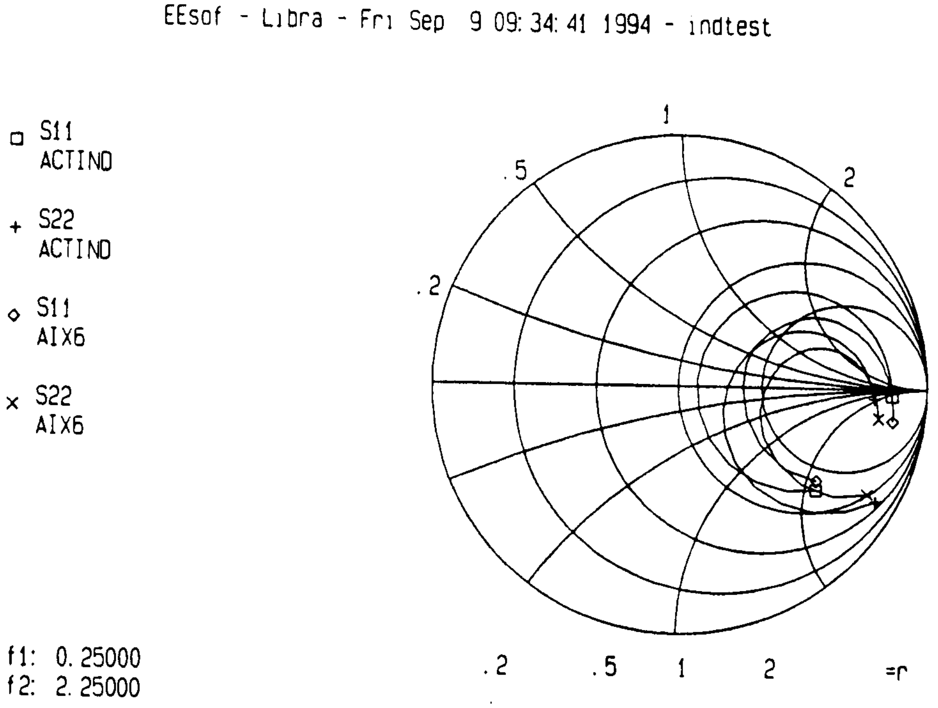

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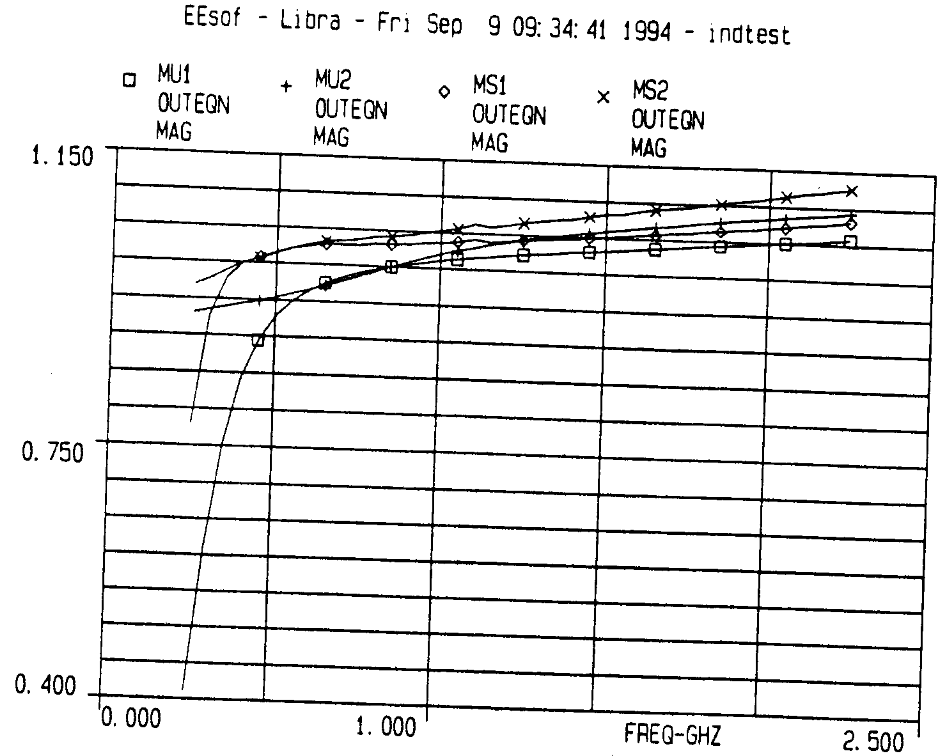

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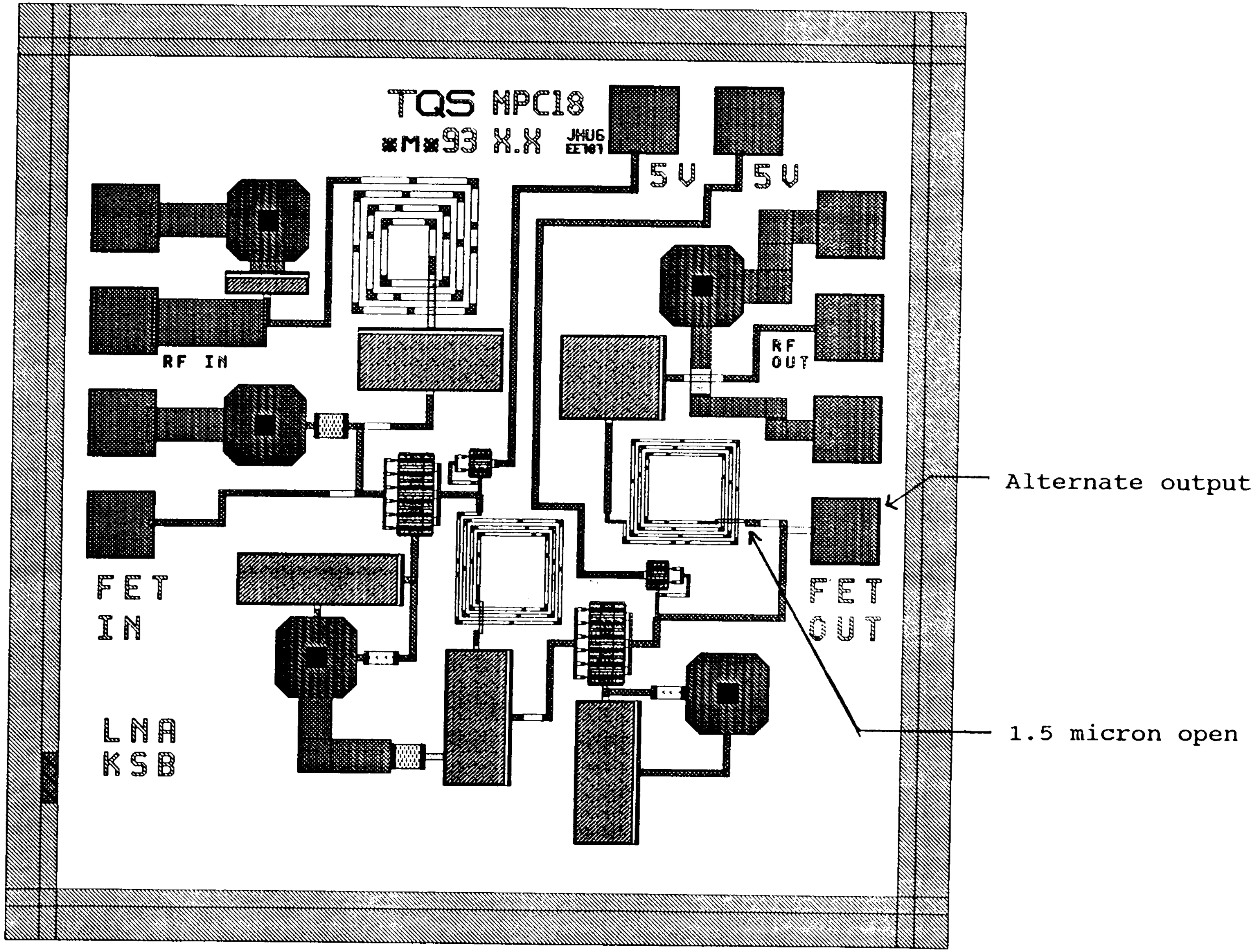
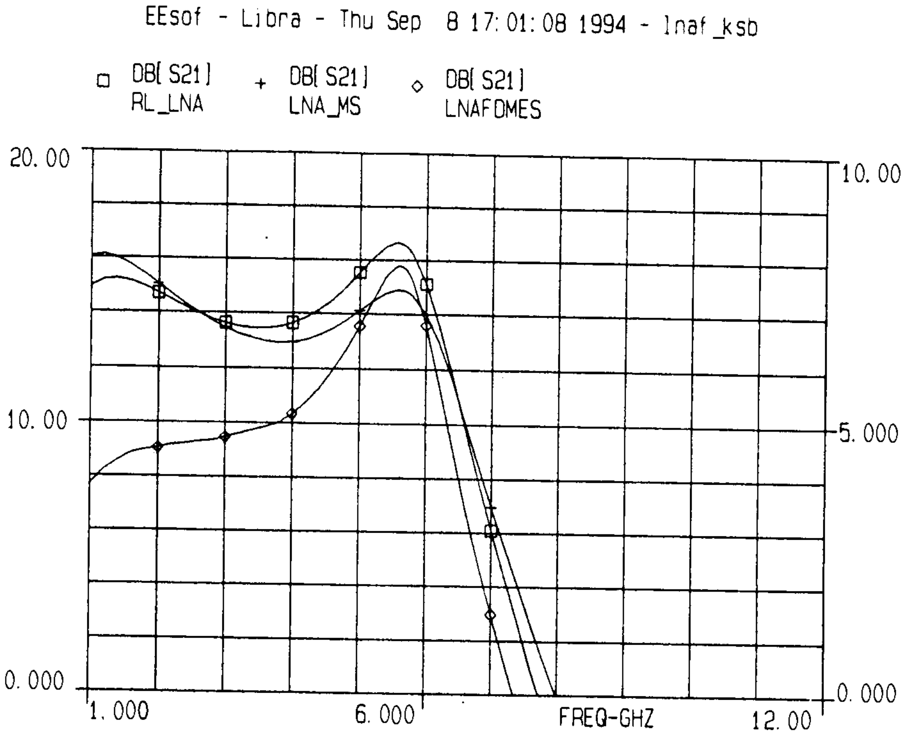

TQS MPC18
*M*93 X.X
JHU6
EE787
5 V
5 V
RF IN
RF OUT
FET IN
FET OUT
LNA KSB
Alternate output
1.5 micron open



Plot showing measured results of the Amplifier versus the original simulated and the resimulated circuit with a bypassed output matching circuit.

Key:

RL_LNA	S21 (dB) of the Original Amp.
LNA_MS	S21 (dB) of the Resimulated Amp (No OMN).
LNAFOMES	S21 (dB) of the Measured Amp.

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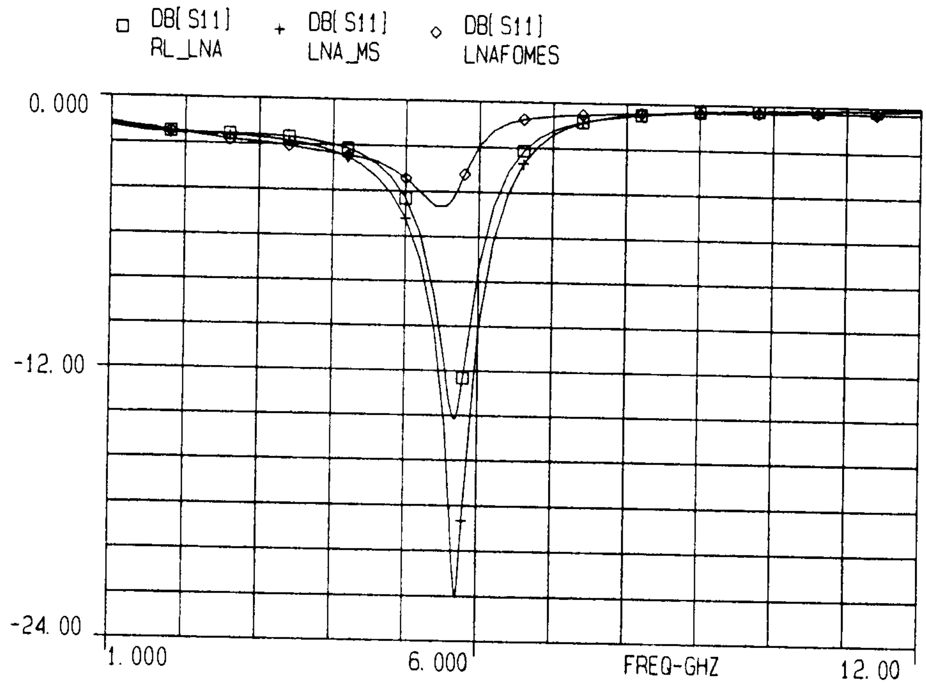

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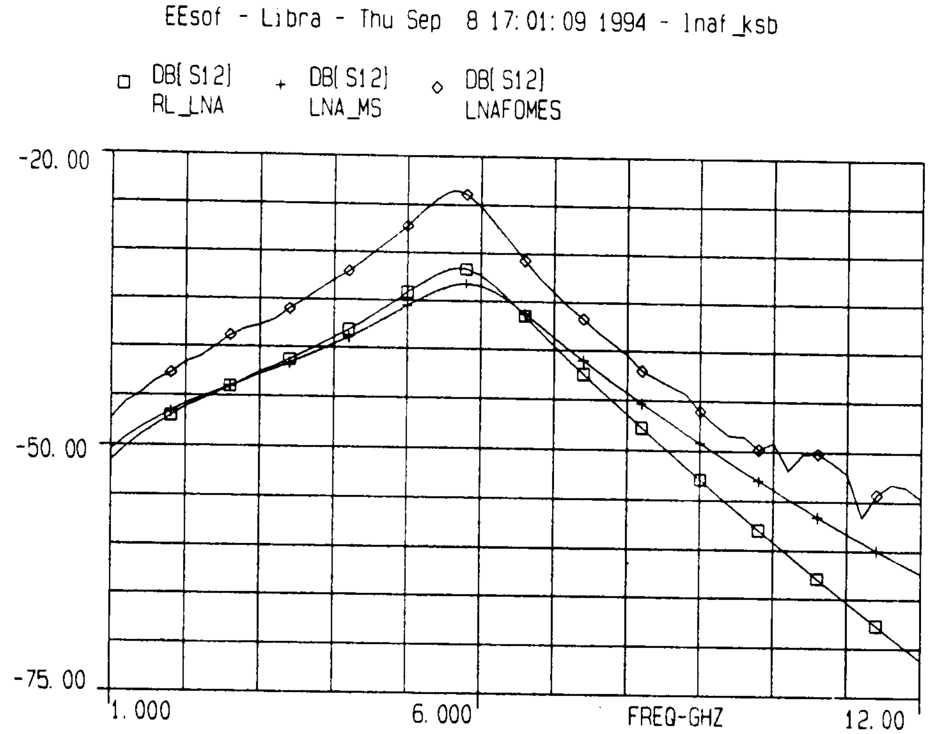

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RL_LNA	S12 (dB) of the Original Amp.
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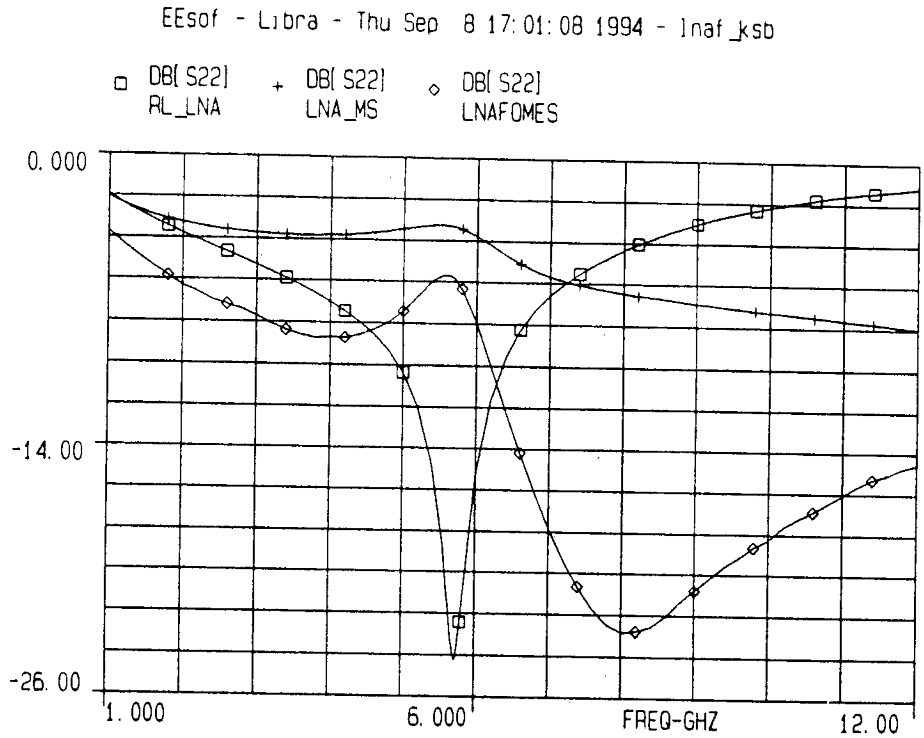

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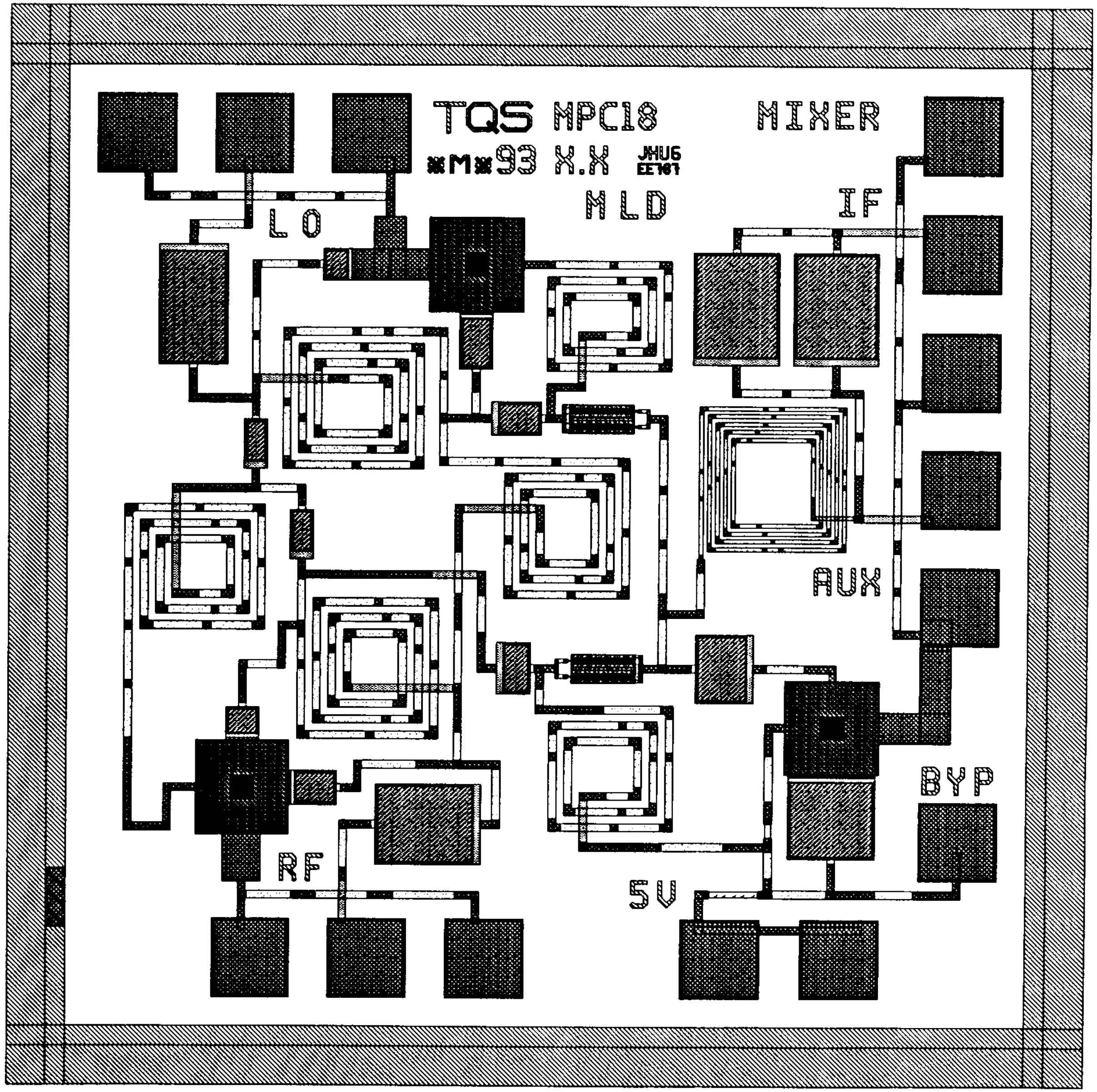
TQS MPC18
MIXER
M 93 X.X
JHU6
EE787
MLD
LO
IF
AUX
BYP
RF
5V

Table 3.1 New MMIC Mixer Compliance Matrix

Parameter	Specification	Goal	Predicted	Meas
RF FREQ	5654 MHZ	-	5654 MHZ	5654 MHz
LO FREQ	6400 MHZ	-	6400 MHZ	6400 MHz
IF FREQ	746 MHZ	-	746 MHZ	746 MHz
BANDWTH	>100 MHZ	-	yes	IF=157 to 1570 MHz (-3dB)
L TO R	10 DB	16 DB	33 DB	
R TO L	10 DB	16 DB	25 DB	
CONV L	15 DB	6 DB	9.5 DB	7.1 dB
SUPPLY	+-5 V	+5 V	+5 V	+5V
RF VSWR	2.5:1	1.5:1	1.3:1	
LO VSWR	2.5:1	1.5:1	1.3:1	
IF VSWR	?	?	<2.5:1	
L TO I	?	?	46 DB	39 dB
R TO I	?	?	23 DB	22 dB
LO PWR	?	?	+10 DBM	+10 dBm

Meas 7/25/94

Lo	Conv. Loss
+12 dBm	-6.8
+10	-7.1
+8	-7.1
+6	-7.3
+4	-7.6
+2	-7.8

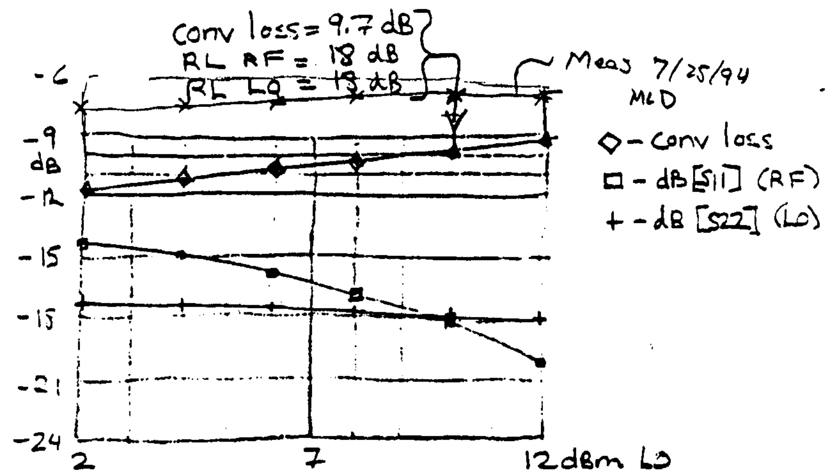

Figure 3.6 Conversion Loss vs LO Drive
Return Loss LO vs "
Return Loss RF vs "