New Folder Name DATA BOOK

FILE: T900002

LIGO 40m PROTOTYPE SERVO SYSTEM DATA BOOK

M. E. ZUCKER

5 DECEMBER 1990

VERSION 1.0

SECTION	CONTENTS
A.	CONTENTS, INTRODUCTORY MATERIAL
B.	LASER LOOP: GENERAL
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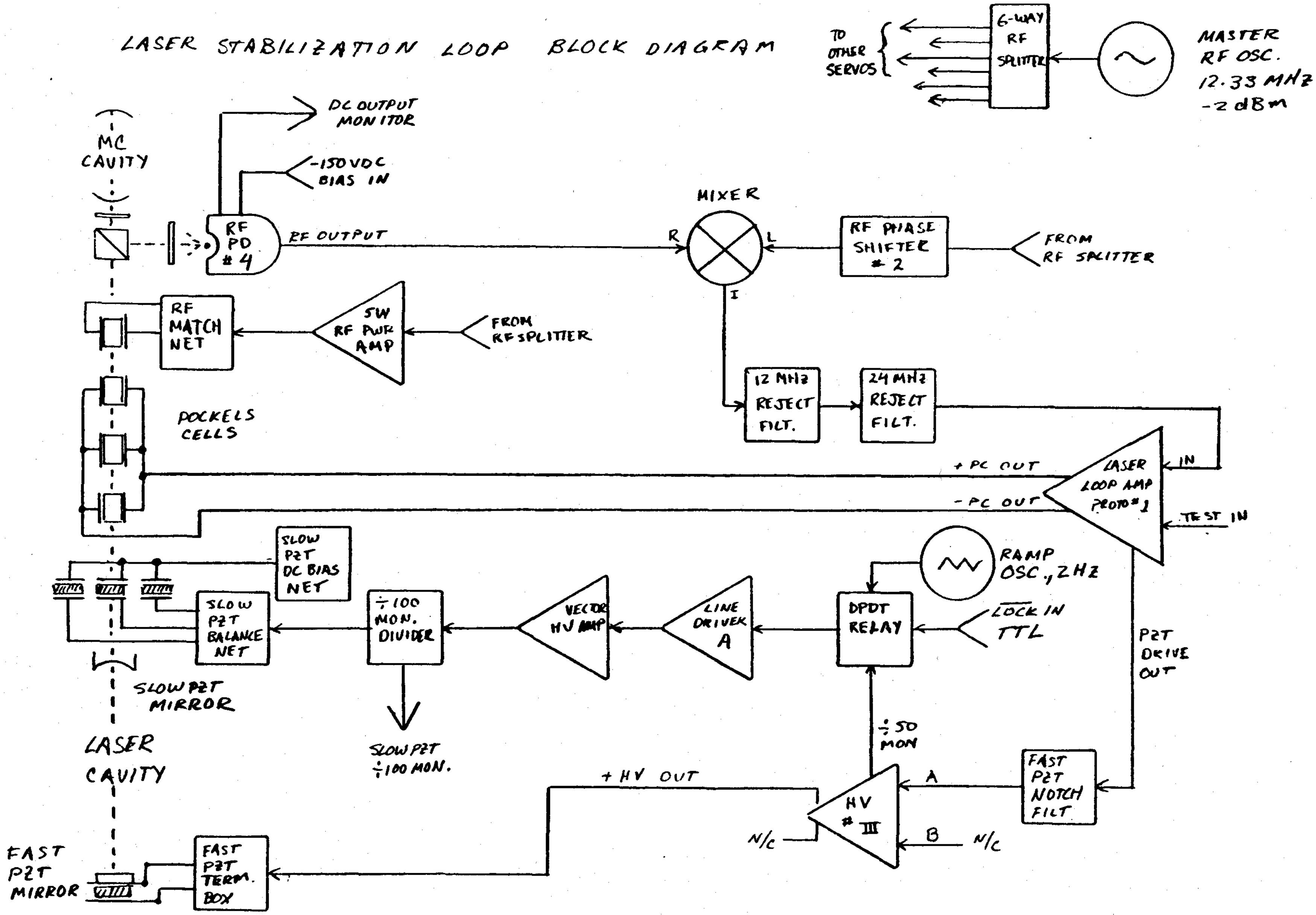
F.	PRIMARY CAVITY LOOP
G.	SECONDARY CAVITY LOOP
H.	PHOTODETECTORS
I.	RF MODULATION
Z.	MISCELLANEOUS

B. LASER LOOP: GENERAL

10/10/90 MEZ

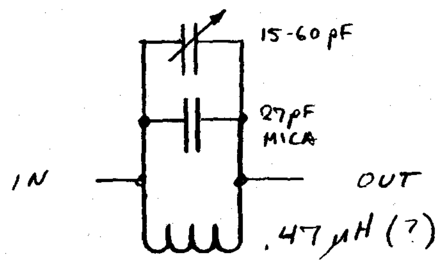
LASER STABILIZATION LOOP BLOCK DIAGRAM



B1

LASER STABILIZATION LOOP

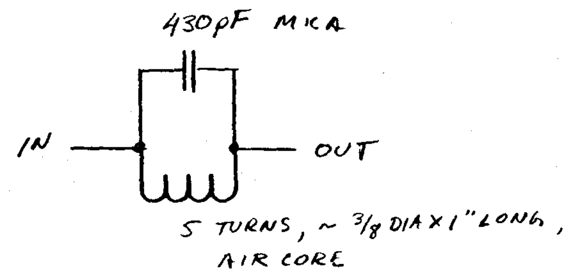
RF REJECTION FILTERS;



12.3 MHz REJECT

-35 dB peak atten

-3dB BW 7MHz - 16MHz



24.6 MHz REJECT

- 17dB peak atten

-3dB BW 23 MHz - 25MHz

TRANSFER FUNCTION OF BOTH IN SERIES
STORED ON HP4195A FLOPPY DISK
DISK LABEL "ZUCKER, START 10/10/90, DISK #1"
FILE NAME "LLNOTCHES1"

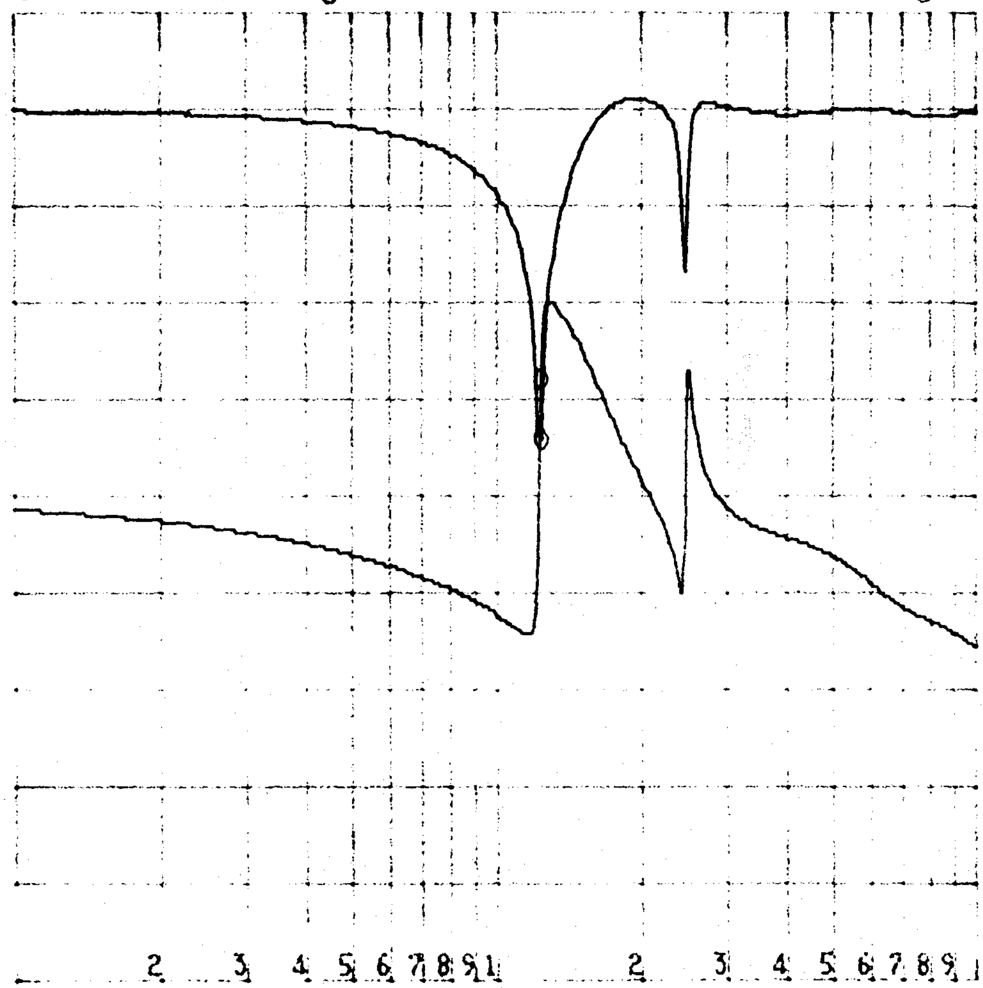
10/10/90 mez

NETWORK

A: REF B: REF 0 MKR 12 302 687.708 Hz

10.00 225.0 T/R -34.1216 dB

[dB][deg] θ 54.4350 deg



DIV DIV START 1 000 000.000 Hz

10.00 45.00 STOP 100 000 000.000 Hz

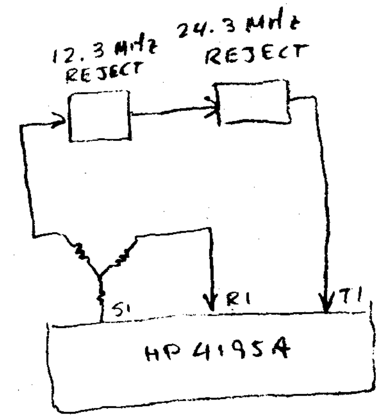
RBW: 1 KHz ST: 4.33 sec RANGE: R= 10, T= 10dBm

TRANSFER FUNCTION,

LASER SERVO LOOP

RF REJECTION

NOTCH FILTERS

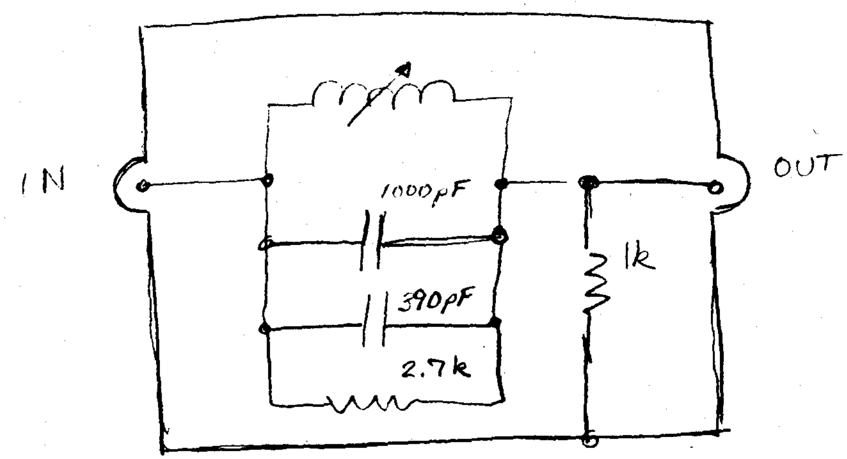


FILE "LLNOTCHES1"

DISK #1, 10/10/90, "ZUCKER"

11/8/90
MEZ

FAST PZT NOTCH FILTER

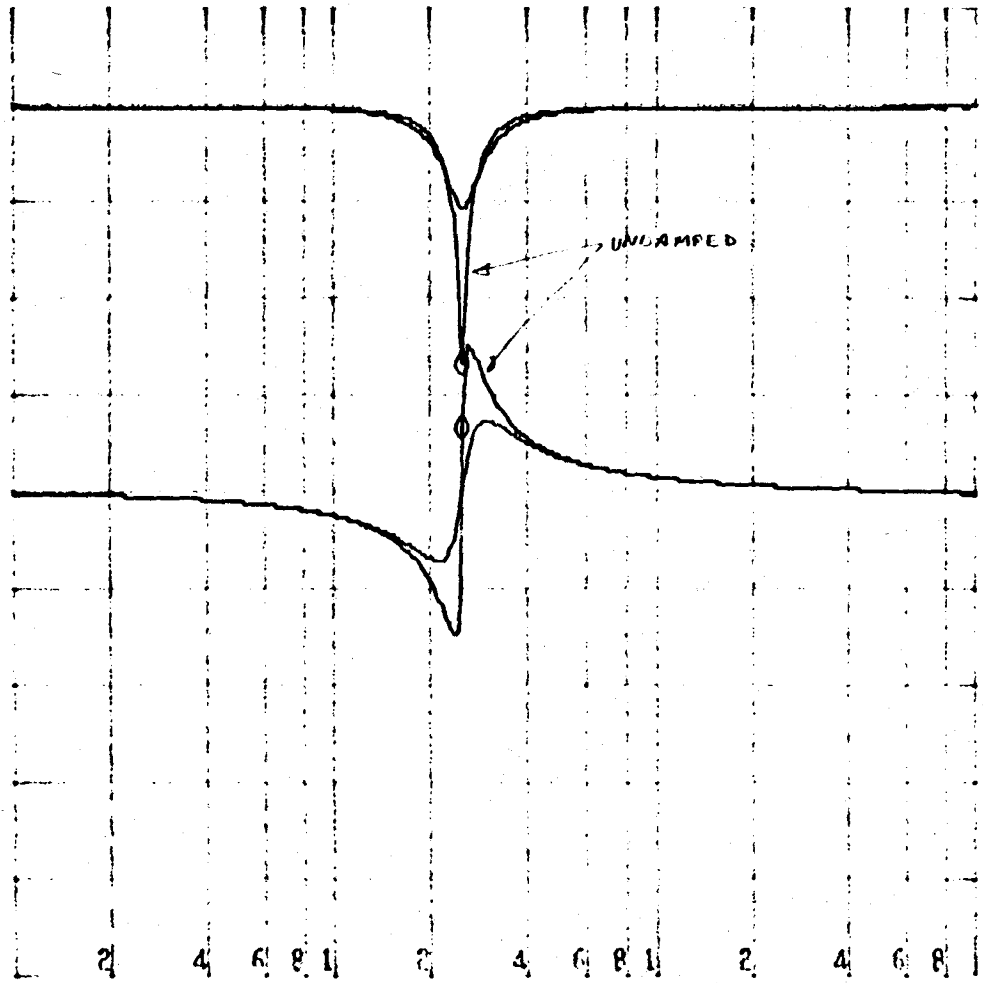


B4

11/6/90 2)

NETWORK Cor

A: REF B: REF 0 MKR 252 638.771 Hz
10.00 225.0 T/R -27.0474 dB
[dB] [deg] θ 28.8915 deg

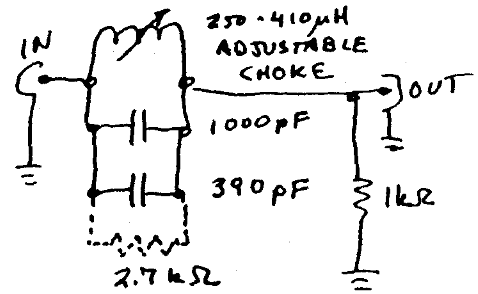


DIV DIV START 10 000.000 Hz
10.00 45.00 STOP 10 000 000.000 Hz
RBW: 300 Hz ST: 13.7 sec RANGE: R= 10, T= 0dBm
REF= 1.00000E+01

XF
FP2T NOTCH FILTER

RED, BLUE:
AS BEFORE,
NO DAMPING SHUNT

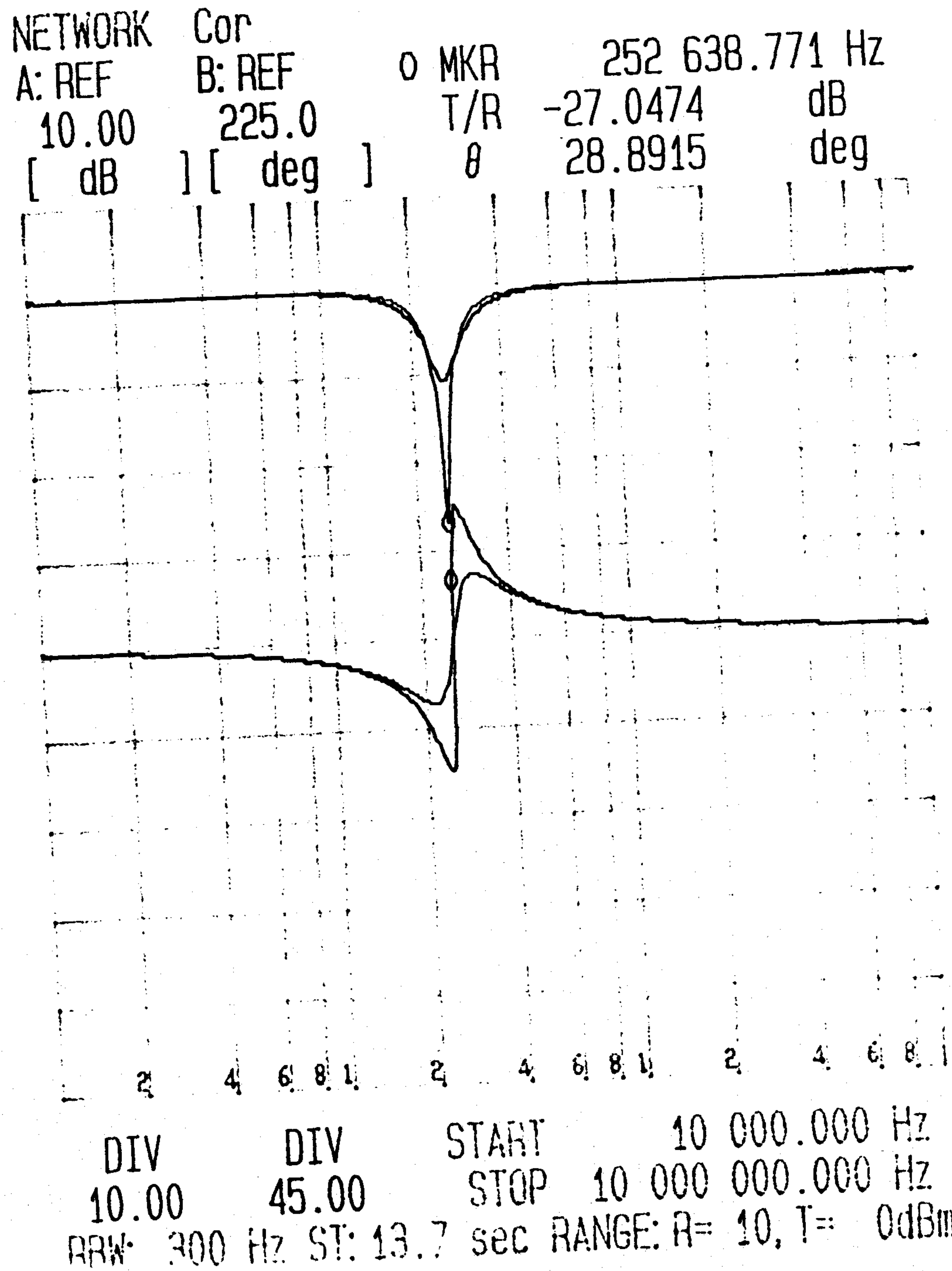
BLACK, PURPLE:
2.7kΩ DAMPING
SHUNT ACROSS LC



(TEST COND: DRIVEN BY
50Ω SOURCE
OF 4195A & SPLITTER)

B5

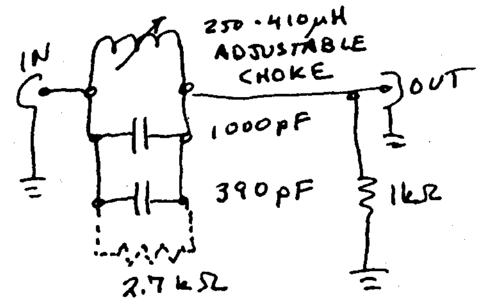
11/6/90 [initials]



XF
FP8T NOTCH FILTER

RED, BLUE:
AS BEFORE,
NO DAMPING SHUNT

BLACK, PURPLE:
2.7kΩ DAMPING
SHUNT ACROSS LC



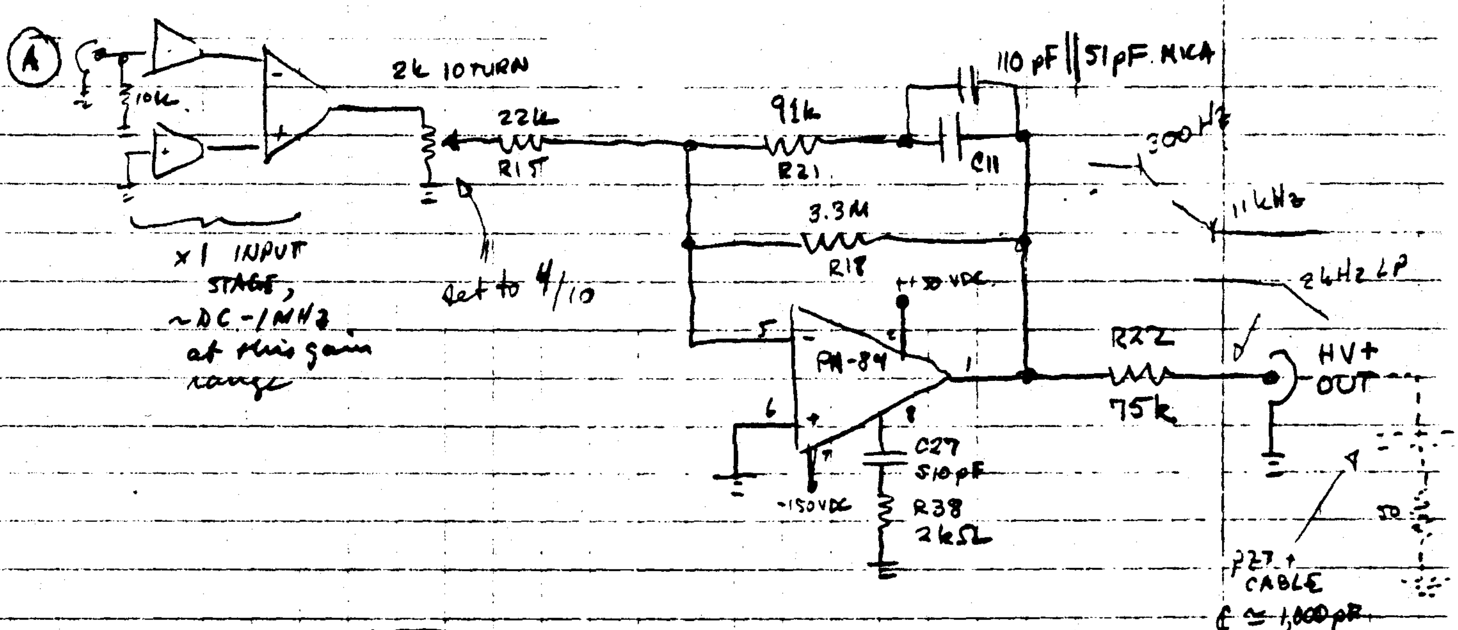
(TEST COND: DRIVEN BY
50Ω SOURCE
OF 4195A + SPLITTER)

10/25/89

Temporarily setting aside the mystery of the loop gain measurement discrepancy, decided to work on improving laser stabilization loop some more.

JH and BT improved on loop gain by improving the PZT drive amplifiers. Previously HV #1 had been used, range x1, vernier + 7/10, ⇒ DC Gain ≈ 6dB, effective single pole (due to Z_{out} ≈ 160kΩ / Z_{PZT} ≈ 800 pF) @ 1 kHz, extra phase shift at 100kHz of about 20° due to strays in amplifier circuit (5pF ∥ 330k ⇒ 100kHz due to strays across FB loop!)

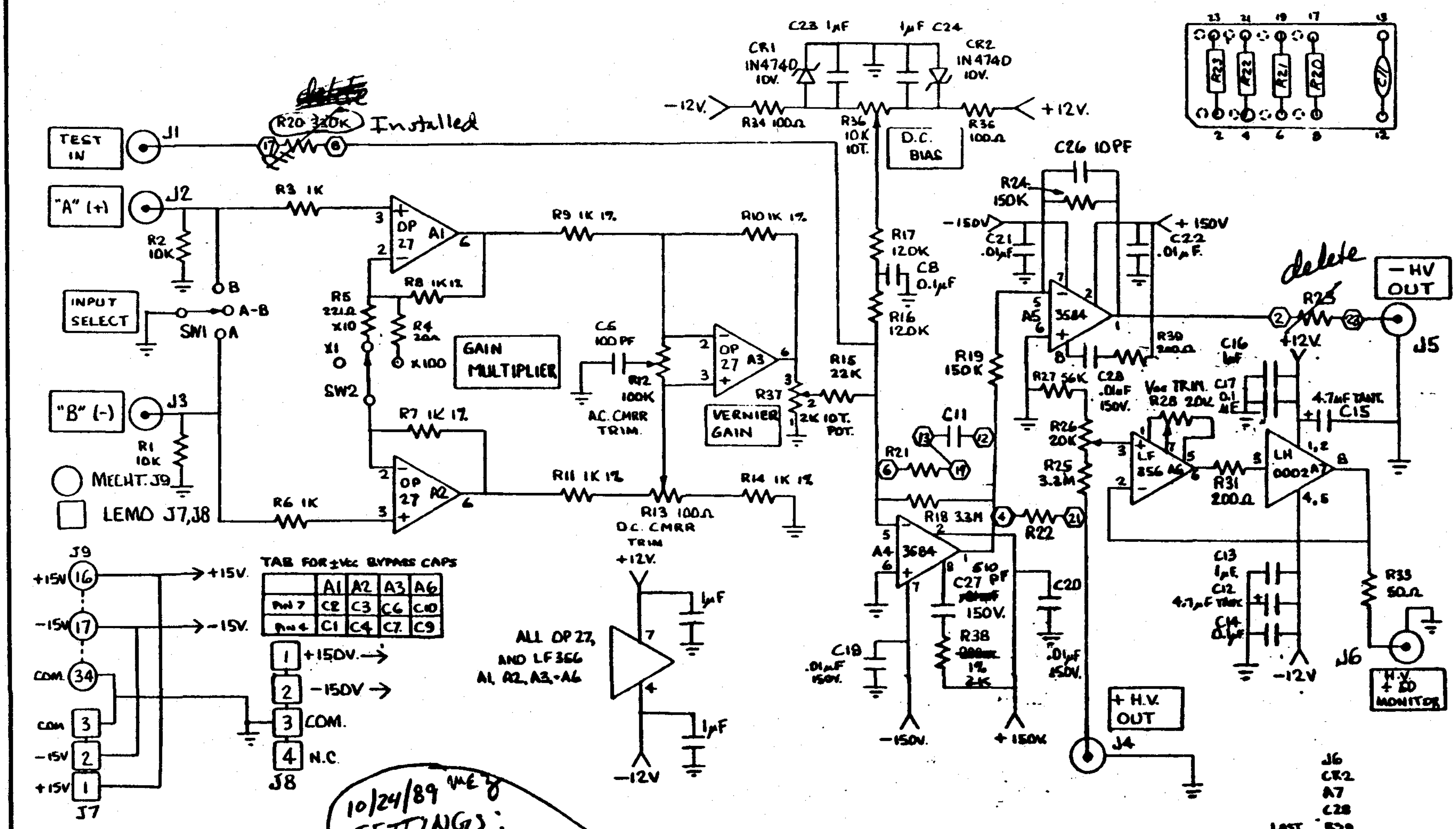
Installed improved circuit (abbreviated diagram below, complete diagram + tfer-function to follow)



HV # III
AS CONFIGURED 10/24/89 FOR SUCCESSFUL LOCKING IN LASER STABILIZATION SERVO LOOP

NB) ÷50 mon. still drives line driver + "Vector" HV amp exactly as before.

HV # III INSTALLED 10/24/89 TO DRIVE FAST PZT MIRROR IN LASER LOOP



	A1	A2	A3	A6
PIN 7	C2	C3	C6	C10
PIN 4	C1	C4	C7	C9

10/24/89 MEZ
SETTINGS;
INPUT → "A"
MULTIPLIER → x1
VERNIER → 4.0/10

NOTES 1. ⌐J¬ INDICATES JUMPER TO SHORT
2. J7, J8, and J9 ARE ALL MOUNTED ~~ON BACK PANEL~~

SMARTWRK FILE C:\SMARTWRK HVAMP.PCB
DRAWN FROM E. LINDELEF OF 9-1-87 PROHVAMP.PL
ADDED COMP CARRIED PIN NO's TO DWG

REPLACES 87-0901-1

LAST: J6, CR2, A7, C28, R39

NO'S SKIPPED: C25, C18, R32, R30, R29

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
HV AMPLIFIER ± 150V.		
DRAWN BY B. TINKER	DATE 3-4-88	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

BISHOP GRAPHICS/ACCUPRESS REORDER NO A38301

88-0304-1

R20 = 330K
C11 = ~~51pF~~ → 150 pF 10/24/89 MEZ
R21 = 91K
R22 = 75K
~~R20~~ R23 } not used

MODIFIED 10-2?-89 B.T.

	WAS	IS
C27	.01μF	510pF
R38	200Ω	2K 1%

MOD. 1

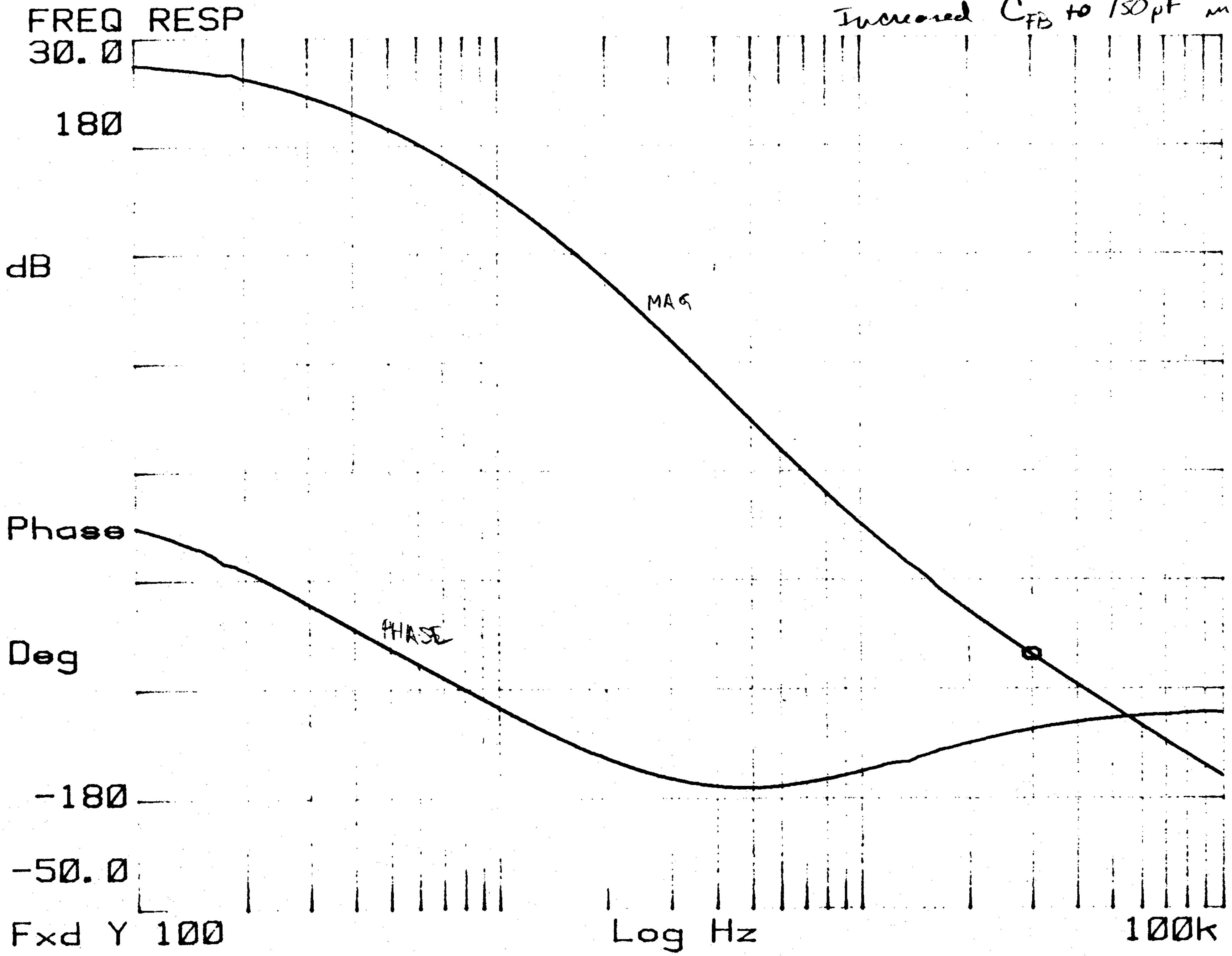
S/N. 3

X=29.854kHz
Ya: 5.758 dB

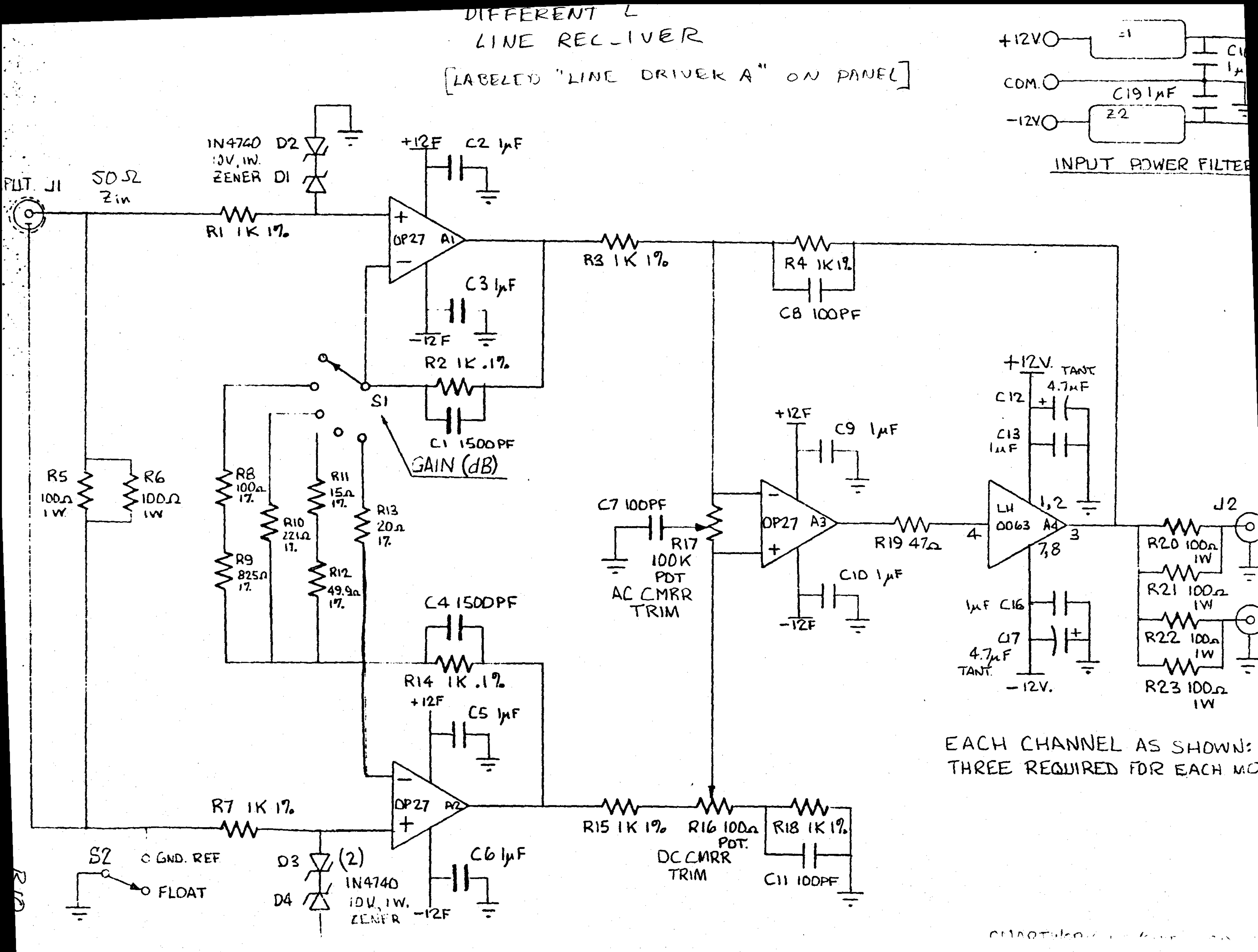
FREQ RESP

(3) 10/24/89 15:41

Modified Freq. Response of HV #III
Increased C_{FB} to 150pF in PA-84 Ckt.

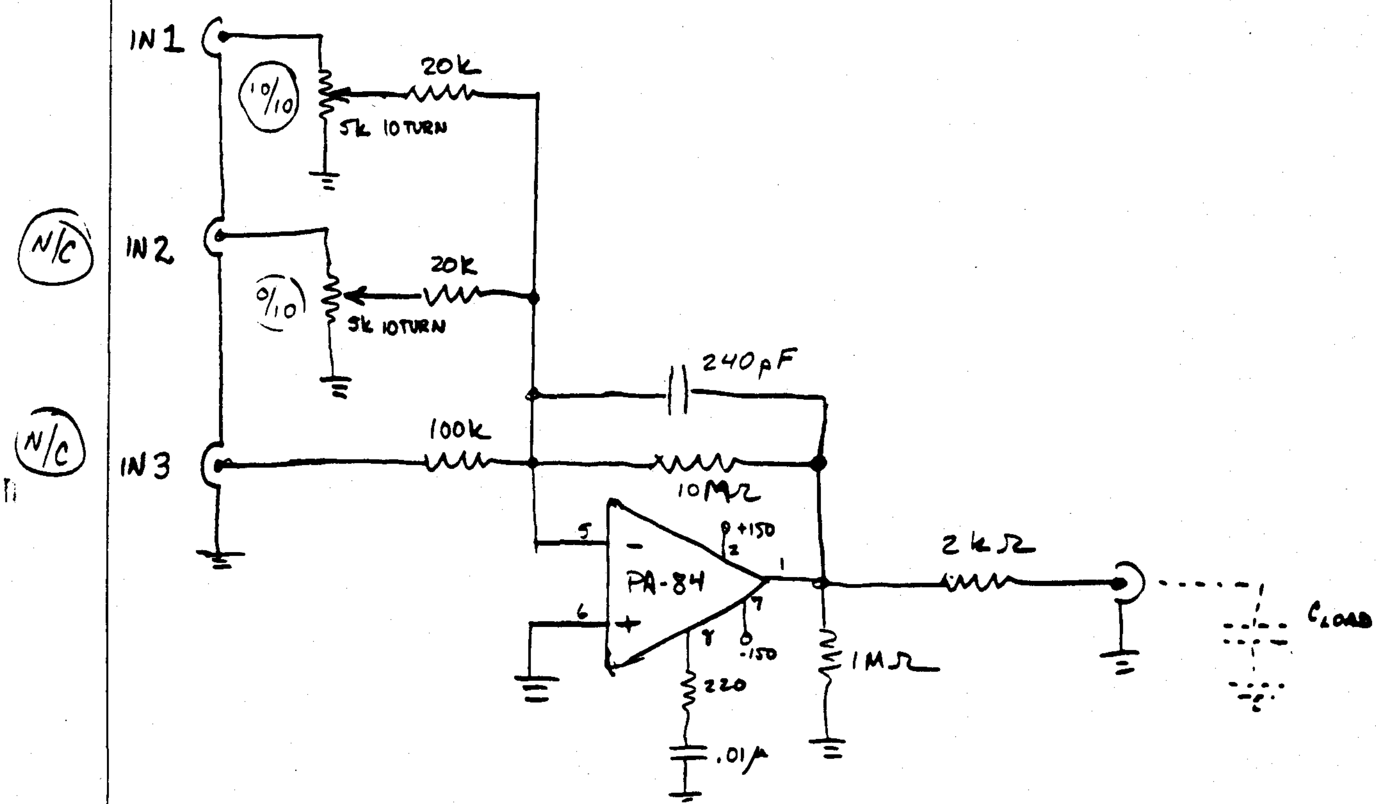


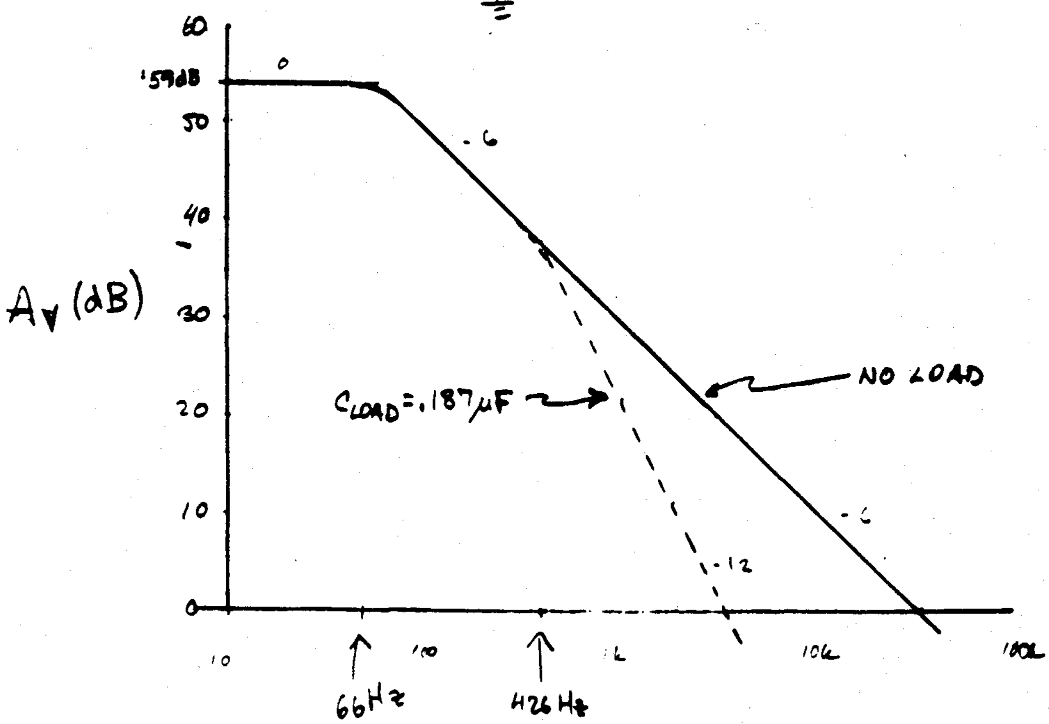
89


DIFFERENT L
LINE REC_IVER
[LABELED "LINE DRIVER A" ON PANEL]
+12V
COM.
-12V
C19 1μF
INPUT POWER FILTER
1N4740 D2
10V, 1W.
ZENER D1
+12F C2 1μF
50Ω
Zin
R1 1K 1%
OP27 A1
R3 1K 1%
R4 1K 1%
C8 100PF
C3 1μF
-12F
R2 1K .1%
S1
C1 1500PF
GAIN (dB)
R5
100Ω
1W
R6
100Ω
1W
R8
100Ω
1%
R9
825Ω
1%
R10
221Ω
1%
R11
15Ω
1%
R12
49.9Ω
1%
R13
20Ω
1%
C7 100PF
R17
100K
POT
AC CMRR
TRIM
+12F
C9 1μF
OP27 A3
C10 1μF
-12F
R19 47Ω
+12V.
TANT
4.7μF
C12
C13
1μF
LH
0063 A4
1,2
3
4
7,8
J2
R20 100Ω
1W
R21 100Ω
1W
R22 100Ω
1W
R23 100Ω
1W
1μF C16
C17
4.7μF
TANT.
-12V.
C4 1500PF
R14 1K .1%
+12F
C5 1μF
OP27 A2
R7 1K 1%
R15 1K 1%
R16 100Ω
POT.
DC CMRR
TRIM
R18 1K 1%
C11 100PF
S2
GND. REF
FLOAT
D3
(2)
1N4740
10V, 1W.
ZENER
D4
-12F
C6 1μF
EACH CHANNEL AS SHOWN:
THREE REQUIRED FOR EACH MO

11/15/88 MEZ

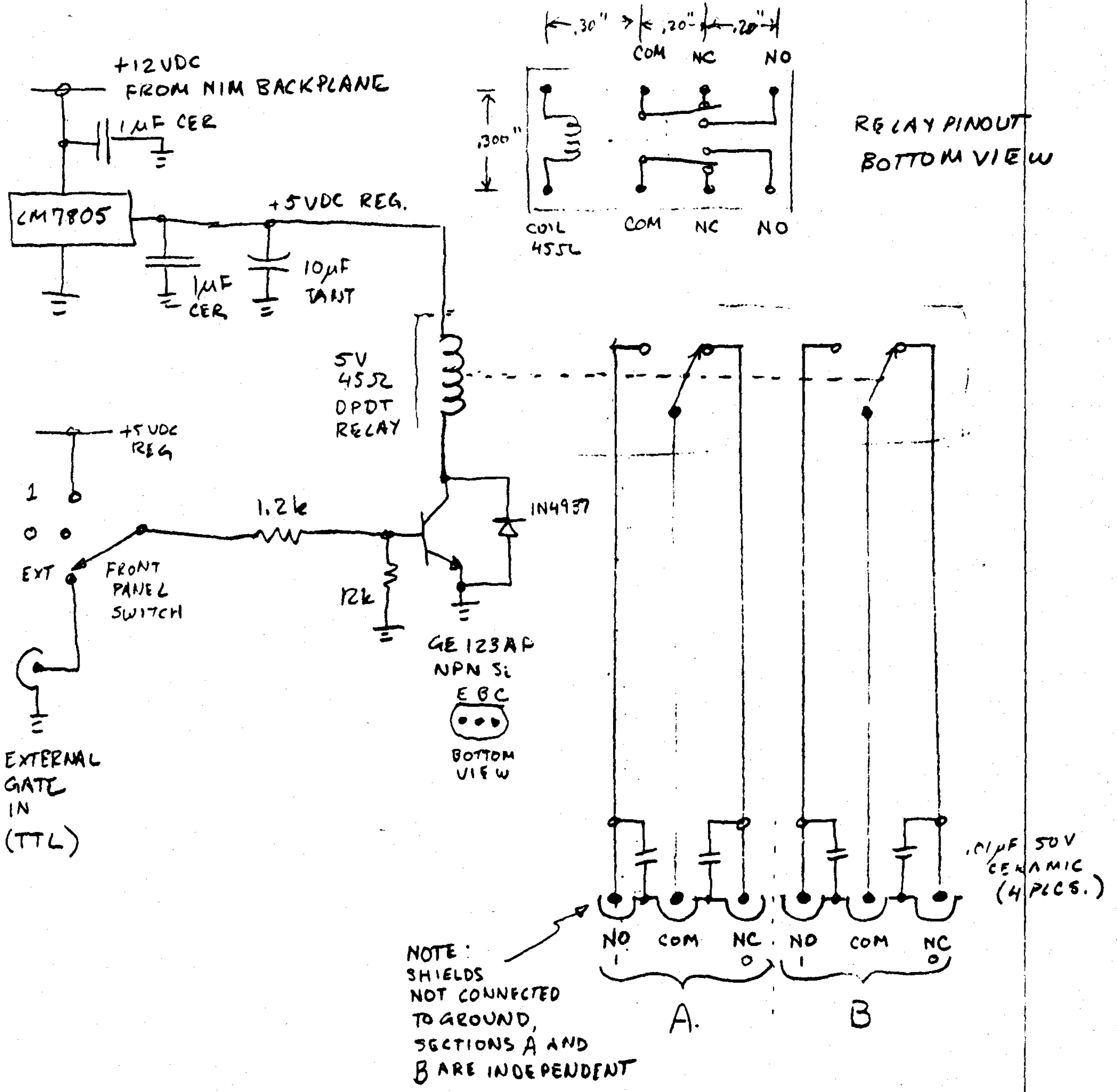
MODE CLEANER SERVOLOOP "VICTOR H.V. AMP"



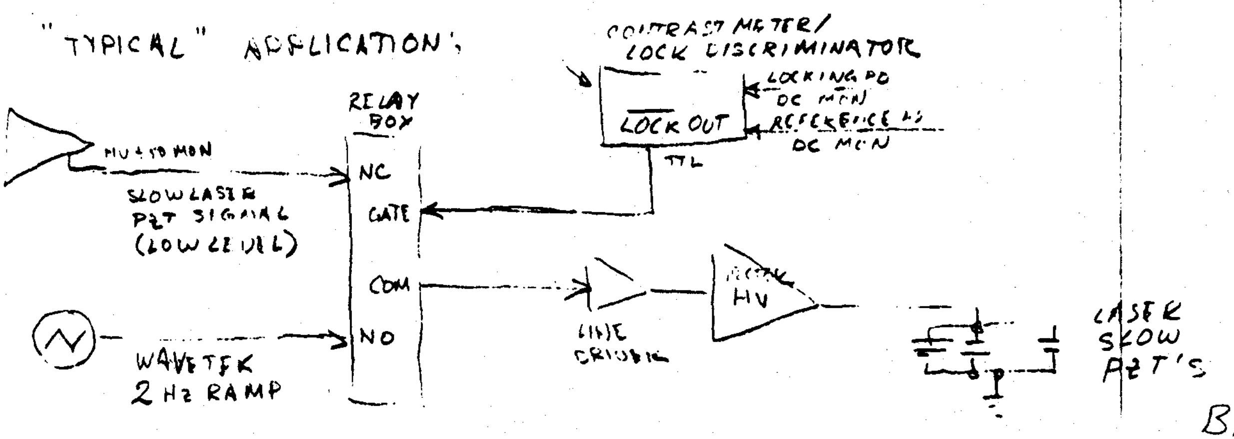


10/31/87 MEG

DPDT RELAY FOR AUTOMATIC LASER RE-LOCK

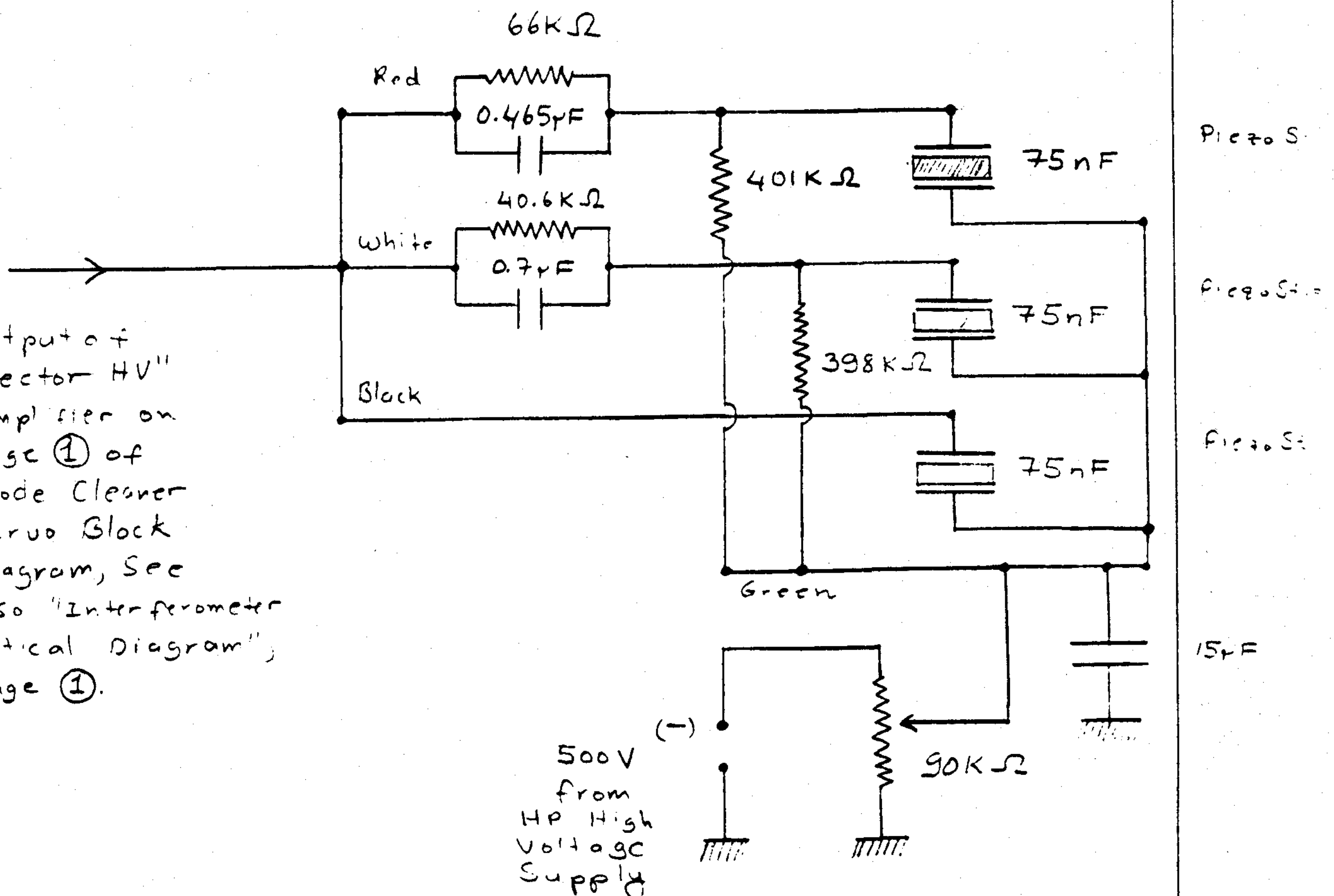


"TYPICAL" APPLICATION:



3 Piezo Stack Balancing Network

(For the Laser "BARNEY")



Output of "Vector HV" Amplifier on page ① of Mode Cleaner Servo Block Diagram, See also "Interferometer Optical Diagram", page ①.

'Also on page ① of "Mode cleaner servo Block Diagram".

July 25, '89 YG

~~[scribbled-out]~~ C. LASER LOOP: SENSORS AND ACTUATORS

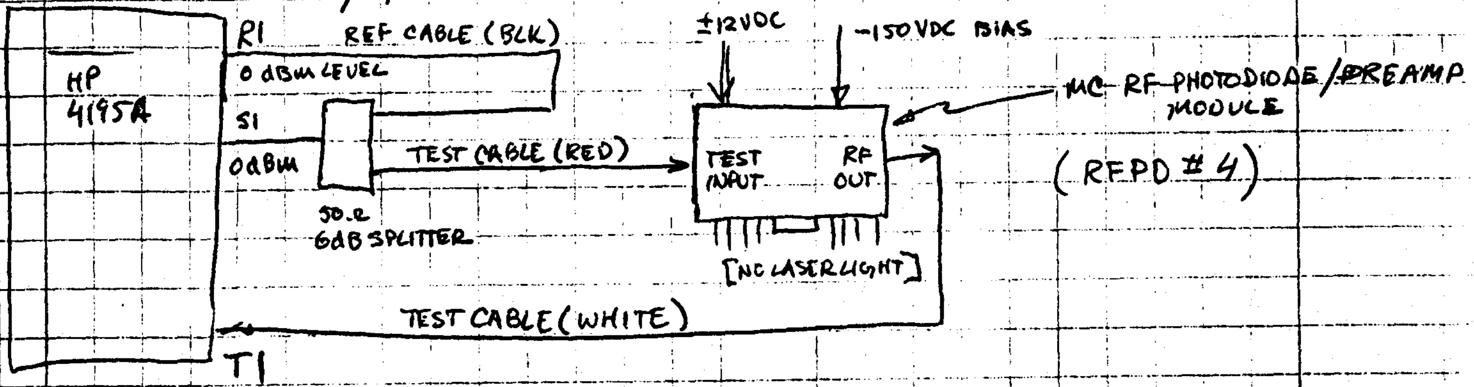
SENSITIVITY OF RF DETECTION SYSTEM + "OPTICAL GAIN"

8/4/89 M.E. Zucker 18:20

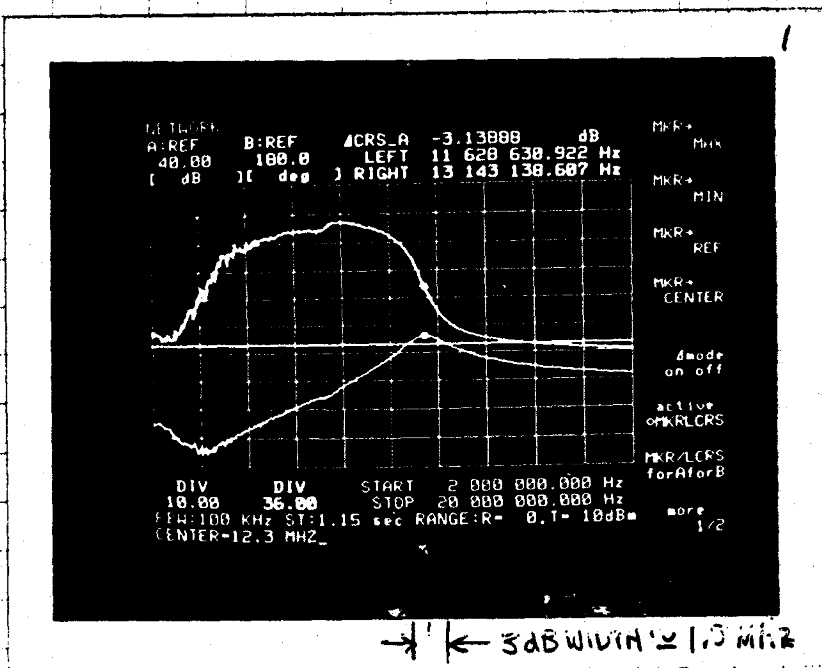
Recording measurements of optical and electronic transfer functions of various key elements of the extralaser-pockels cell laser stabilization loop. (A.K.A. "Mode Cleaner Servo")

① Measured response of mode cleaner RF photodiode / preamp module at RF frequency using HP 4195A network analyzer

Setup:



8/9/89 10:15



UPPER TRACE: ARG(T_1/R_1), DEG

LOWER TRACE: $|T_1/R_1|$, dB

→| |← 3dB WIDTH ≅ 1.5 MHz

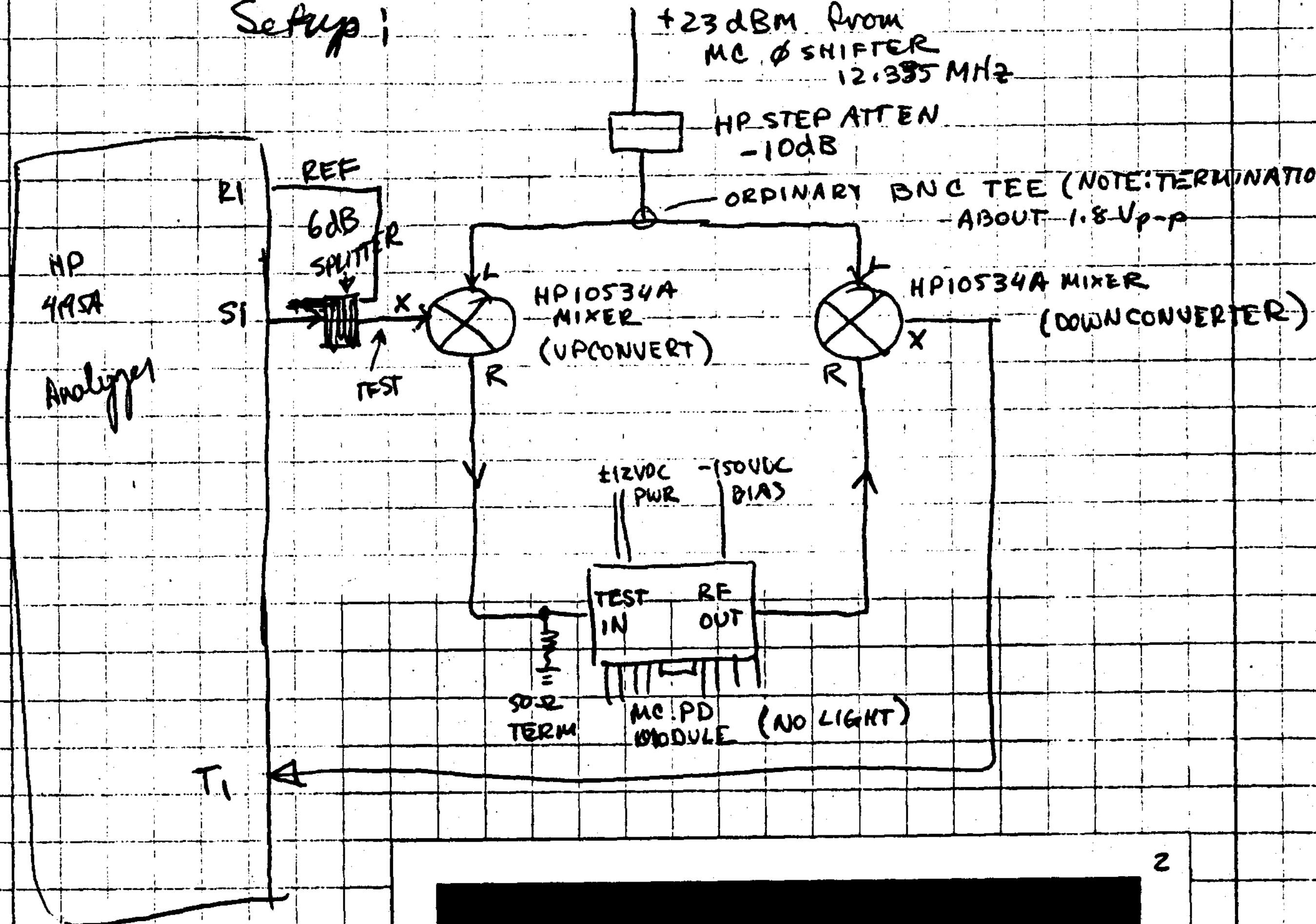
LINEAR FREQUENCY SCALE, 2 MHz → 20 MHz

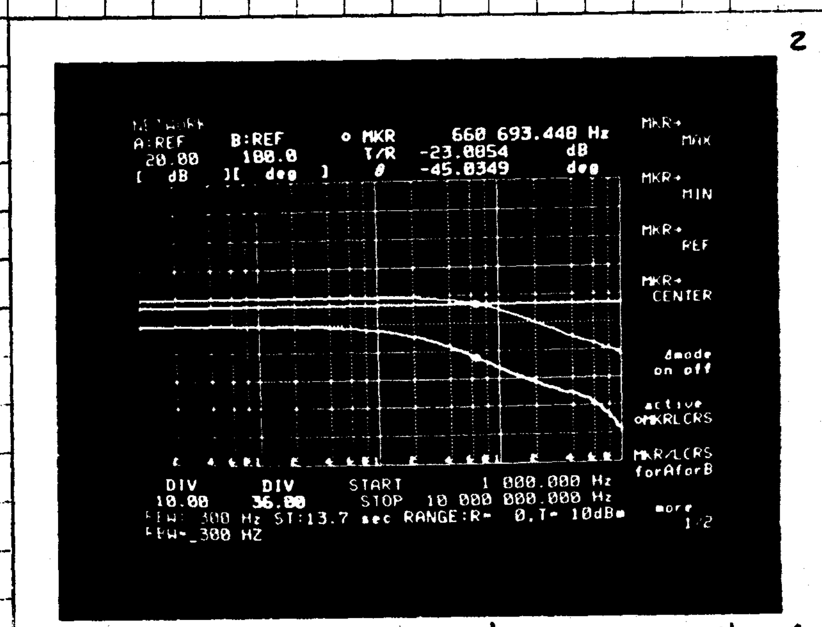
NOTE THAT PHASE IS + 40° AT CENTER FREQUENCY

8/4/89 Cont'd. MEZ

② Measured "equivalent baseband response" of RF photodiode unit by upconverting the network analyzer's sweep to 12.33 MHz (amplitude modulation, suppressed carrier, just like an optical phase error producer).

Setup:





TOP: $\left|\frac{T_1}{R_1}\right|$

BELOW: ARG(

-3dB @ 660 kHz

↑ EFFECTIVE POLE DUE TO PHOTODIODE BANDPASS

8/8/89 Analysis of "Optical transfer function" measurements;

(MEZ) Transfer function on page 004Y must be corrected for

- (a) mis-termination of mixer
- (b) delay in long cable used to excite PC
- (c) the bandpass transfer function of the photodiode.
- (d) the propagation delay in the light path and in the RF cable from the photodiode to the mixer.

The results of this analysis (which is attached to subsequent pages for future reference) are summarized as follows;

With; photodiode now in use on MC (700 kHz "pole" due to bandpass)
950mV out of lock, 400mVDC in lock (contrast = 58%)
modulation index ≃ 0.4 ($\frac{P_{SIDEBAND}}{P_{CARRIER}} \simeq 0.04$)

we get; $\frac{\delta V(\text{mixer output, } 50\Omega \text{ term})}{\delta V(\text{ONE GSÄNGER PM-25 POCKELS CELL})} \simeq 5\times10^{-3}\frac{V}{V} \times \left(\frac{1}{1+\frac{jf}{700kHz}}\right)$

Also, from the pockels cell terminals to the mixer output there is a frequency-dependent phase shift which is consistent with a propagation delay of (40 ± 10) nsec; the optical path between pockels cell → cavity → photodiode is about 6.5 m (⇒ 22 nsec), and the cable linking the PD w/ the mixer is 2.3 m (⇒ 11 nsec at 0.7c) for a calculated delay of 33 nsec. There are probably also delays associated with the diode proper, the internal buffer, or the pockels cell itself, but these should not contribute more than 5 nsec total in my estimation.

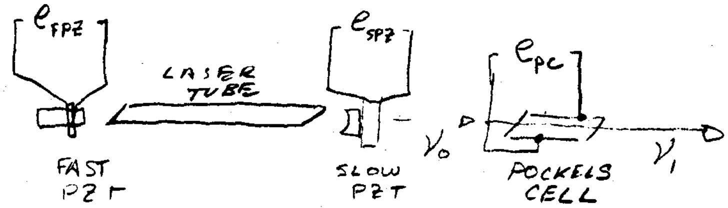
LASER PHASE & FREQUENCY ADJUSTMENT ACTUATORS

MEZ 10/17/90

ν = laser frequency $\simeq 5.8 \times 10^{14}$ Hz or so

ϕ = laser phase

f = audio or video fluctuation frequency



1. Pockels cell;

$$\dot{\phi}_0 = 2\pi \nu_0, \quad \phi_1 = 2\pi \nu_0 t + \frac{2\pi n_{pc} l_{pc}}{\lambda}$$

where l_{pc} = length of Pockels cell, and
n_{pc} = refractive index of cell;

$$n_{pc} = n_0 + \alpha e_{pc}$$

where α = electrooptic coefficient of cell crystal (V^{-1})

so $\nu_1 = \dot{\phi}_1/2\pi = \nu_0 + \frac{\alpha l}{\lambda} \dot{e}_{pc}$

Example: Gränzer PM-25 cell, at $\lambda = 514.5$ nm, has $\alpha l = 0.26$ nm/V *, so for a sinusoidal e_{pc} at frequency f,

$e_{pc} = V_0 \cos(2\pi f t)$, we get an output frequency

$$\nu_1(t) = \nu_0 - \frac{2\pi \alpha l f}{\lambda} e_0 \sin(2\pi f t)$$

$$= \nu_0 - 3.2 \times 10^{-3} \left(\frac{e_0}{1V}\right)\left(\frac{f}{1 Hz}\right) \sin(2\pi f t) \text{ Hz}$$

*corresponding to 1kV/order at this λ.

10/17/90 MEZ

2. Fast PZT mirror;

as long as the laser oscillates in a single longitudinal mode labeled k

$$\nu^k = k\frac{c}{2d}$$

where k is a (large) integer and d is the spacing of the laser cavity (assume $n_{laser} = 1$). The piezo expands or contracts in proportion to e_{FPZ}, so

$d = d_0 + \beta e_{FPZ}$ and

$$\nu^k = \frac{kc}{2(d_0 + \beta e_{FPZ})} \simeq \frac{kc}{2d_0}\left(1 - \frac{\beta e_{FPZ}}{d_0}\right)$$

$$\equiv \nu_0^k\left(1 - \frac{\beta e_{FPZ}}{d_0}\right) \quad \text{for } \beta e_{FPZ} \ll d_0$$

Example; the laser Barney has

$d_0 \simeq 2.3$ m and its fast PZT has

$\beta \simeq \frac{1 \text{ order}}{550 V} \simeq 4.7 \times 10^{-10} \frac{m}{V}$ so

$$\frac{\nu^k - \nu_0^k}{e_{FPZ}} \simeq \frac{\beta \nu_0^k}{d_0} = 120 \frac{kHz}{V}$$

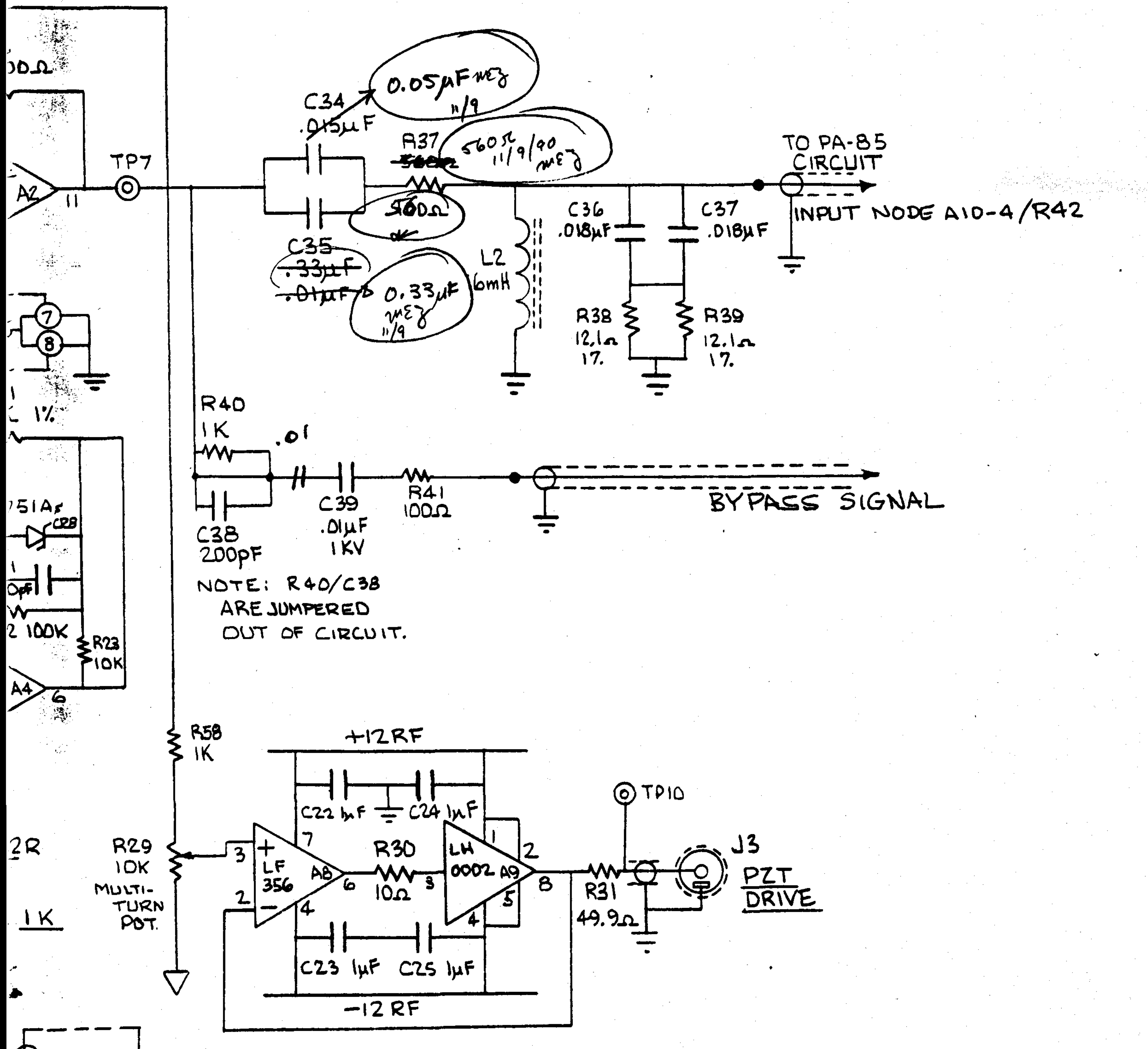
3. Slow PZT mirror; same as fast PZT, different β.

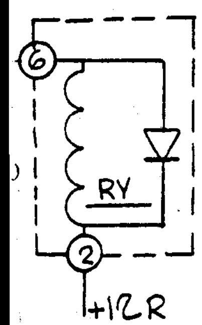
Example; for Barney, $d_0 \simeq 2.3$ m,

$\beta \simeq \frac{1 \text{ order}}{70 V} \Rightarrow$

$$\frac{\nu^k - \nu_0^k}{e_{SPZ}} \simeq 930 \text{ kHz/V}$$

D. LASER LOOP: PROTOTYPE #1





LASER LOOP AMPLIFIER VER. 1 PROTOTYPE 1 VER. 1

ADDED= COMPONENENTS

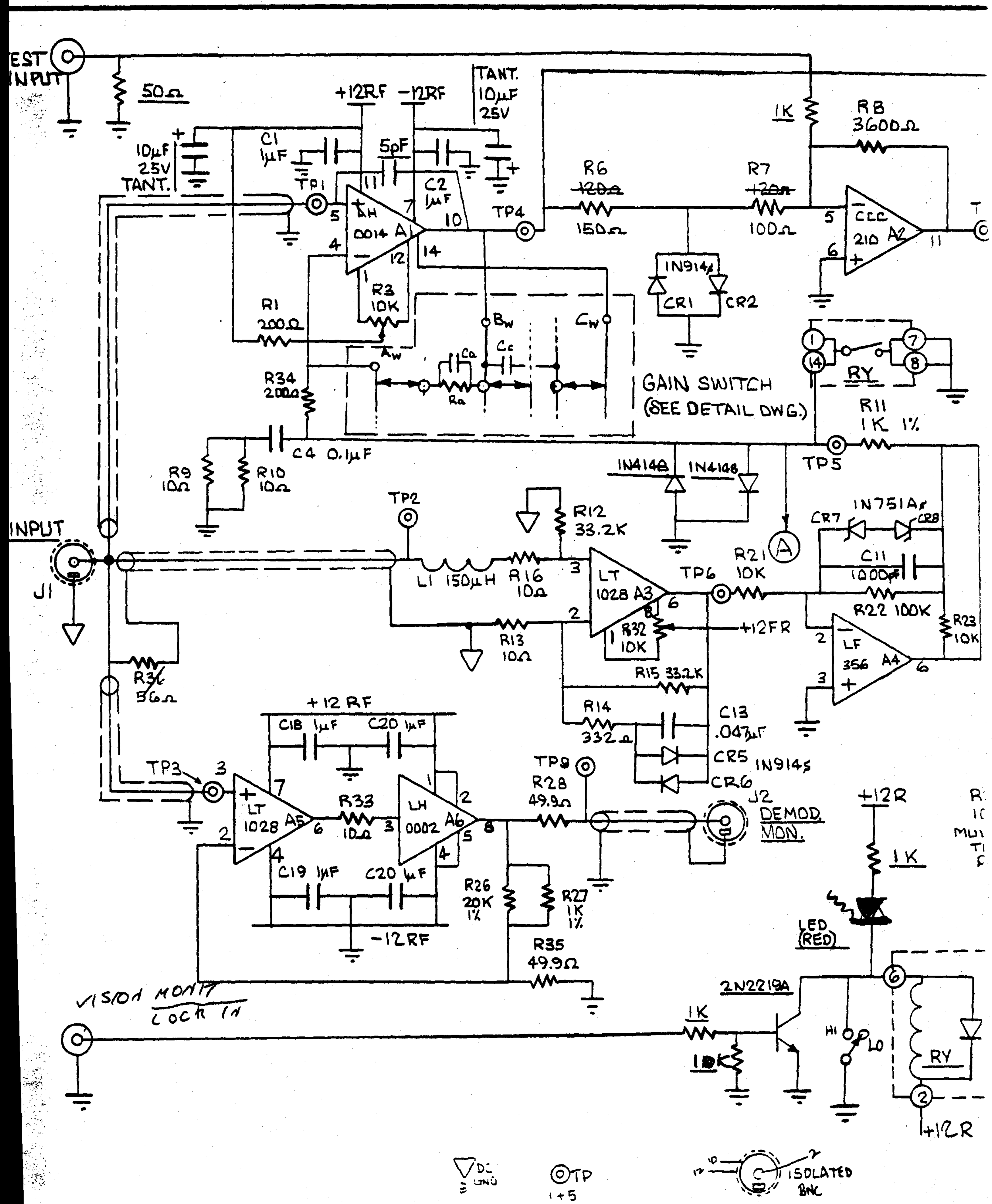
CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS

LASER LOOP AMPLIFIER - SECTION 1

REBUILD 11-8-90 B.T. J.C.

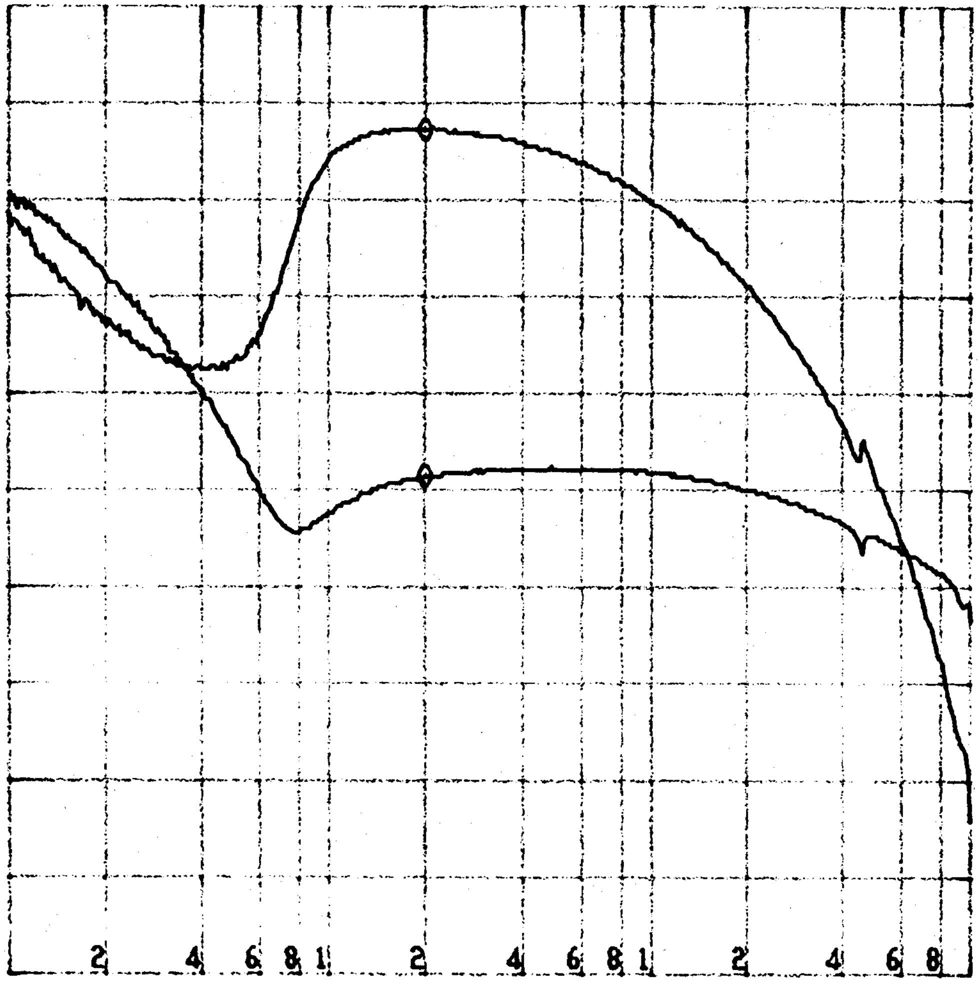
Diagram Revised 11/9/90 MEZ

DRAWN BY B.T.	DATE 10-9-89	DRAWING NO
CHECKED BY	SCALE	
APPROVED BY	W.O.	


TEST INPUT
50Ω
+12RF
-12RF
TANT. 10μF 25V
10μF 25V TANT.
C1 1μF
5pF
C2 1μF
TP1
AH 0014 A1
TP4
R6 120Ω 150Ω
R7 120Ω 100Ω
1K
R8 3600Ω
CLC 210 A2
1N914
CR1
CR2
R1 200Ω
R3 10K
Aw
Bw
Cw
Ca
Cc
Ra
R34 200Ω
GAIN SWITCH
(SEE DETAIL DWG.)
RY
R11 1K 1%
TP5
C4 0.1μF
R9 10Ω
R10 10Ω
1N4148
1N4148
TP2
R12 33.2K
INPUT
J1
L1 150μH
R16 10Ω
LT 1028 A3
R13 10Ω
R32 10K
+12FR
TP6
R21 10K
CR7
1N751A
CR8
C11 1000pF
R22 100K
R23 10K
LF 356 A4
R36 56Ω
R15 33.2K
R14 332Ω
C13 .047μF
CR5
CR6
1N914
+12 RF
C18 1μF
C20 1μF
TP3
LT 1028 A5
R33 10Ω
LH 0002 A6
TP9
R28 49.9Ω
J2
DEMOD. MON.
C19 1μF
C20 1μF
-12RF
R26 20K 1%
R27 1K 1%
R35 49.9Ω
+12R
1K
LED (RED)
2N2219A
VISION MONIT
LOCK IN
1K
10K
HI
LO
RY
+12R
DC GND
TP
ISOLATED BNC

11/14/90
MSY
14:57

NETWORK Cor
A: REF B: REF 0 MKR 198 380.966 Hz
90.00 225.0 T/R 41.3117 dB
[dB][deg] θ 167.567 deg



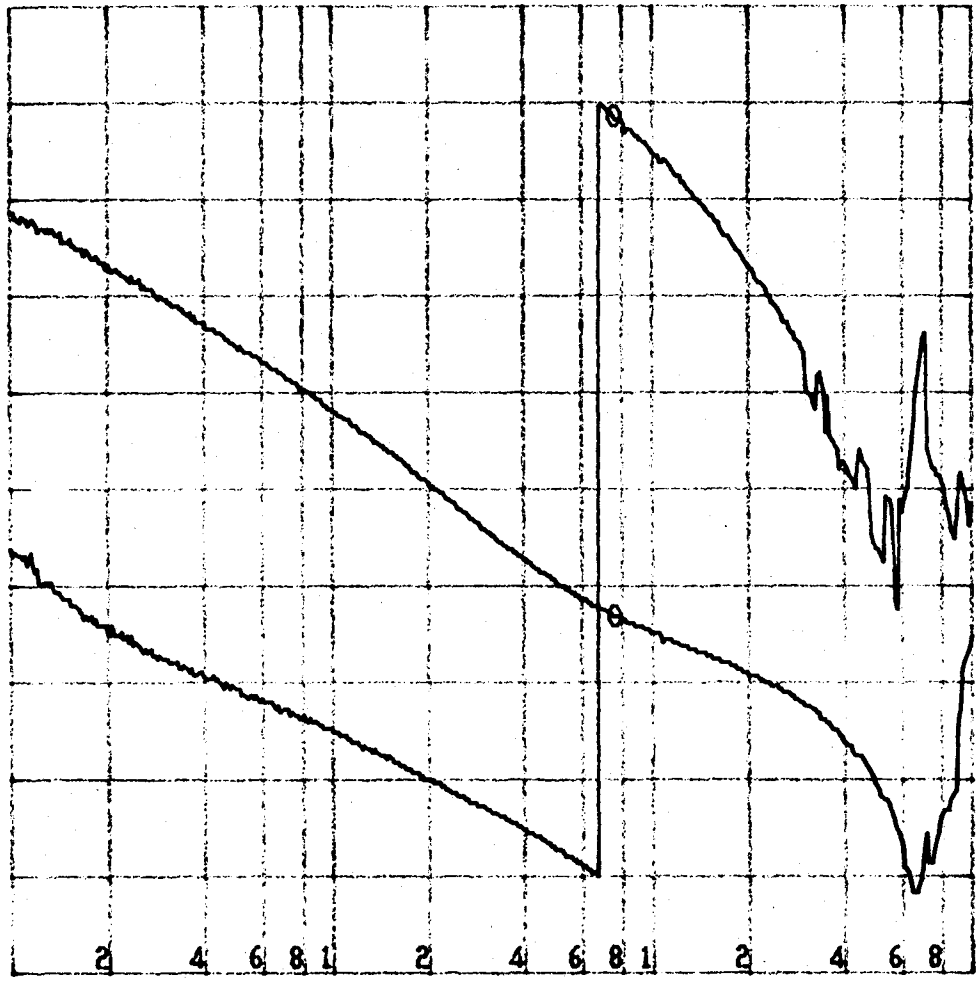
DIV DIV START 10 000.000 Hz
10.00 45.00 STOP 10 000 000.000 Hz
RBW: 100 Hz ST: 40.2 sec RANGE: R= 10, T= 0dBm
ATT1= 10 DB

XF, Laserloop
Proto #1
Demod → A1
PC OUTPUT, END OF CABLE
GAIN "1"
(MIN.)

D3

11/14/90
14:29

NETWORK Cor
A: REF B: REF 0 MKR 762 956.891 Hz
90.00 225.0 T/R 26.8022 dB
[dB] [deg] θ 174.223 deg



DIV DIV START 10 000.000 Hz
10.00 45.00 STOP 10 000 000.000 Hz
RBW: 100 Hz ST: 40.2 sec RANGE: R= 10, T=-10dBm
OSC1= -20.0 DBM

XF*, LASER SERVO PROTO #1

DEMOD IN → A2
PC OUTPUT, AT END OF CABLE (INV.)

GAIN "1" (MIN)

* XF includes 24 + 12 MHz notch filters usually used

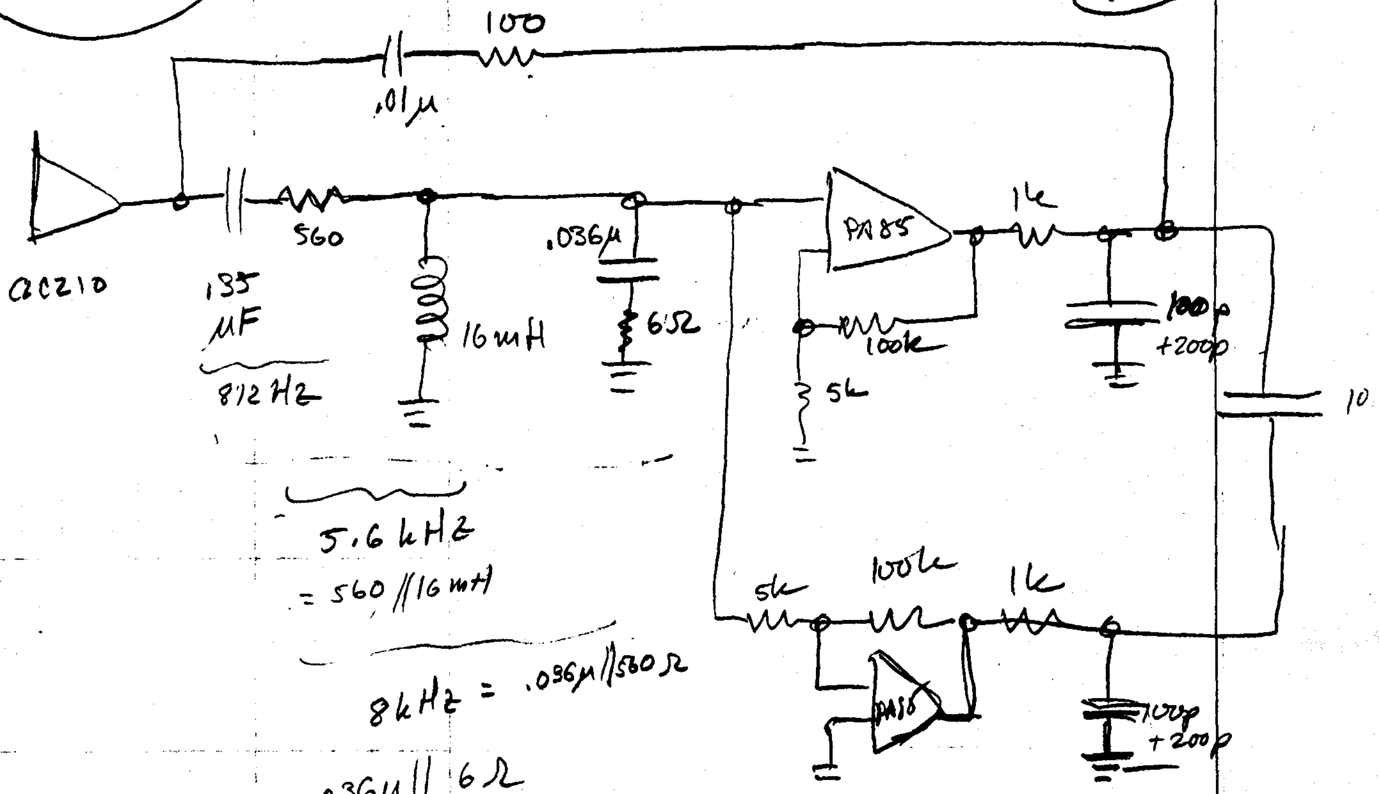
D4

11/6/90 WSG

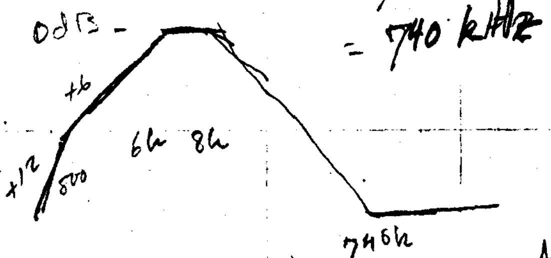
LASER SERVO

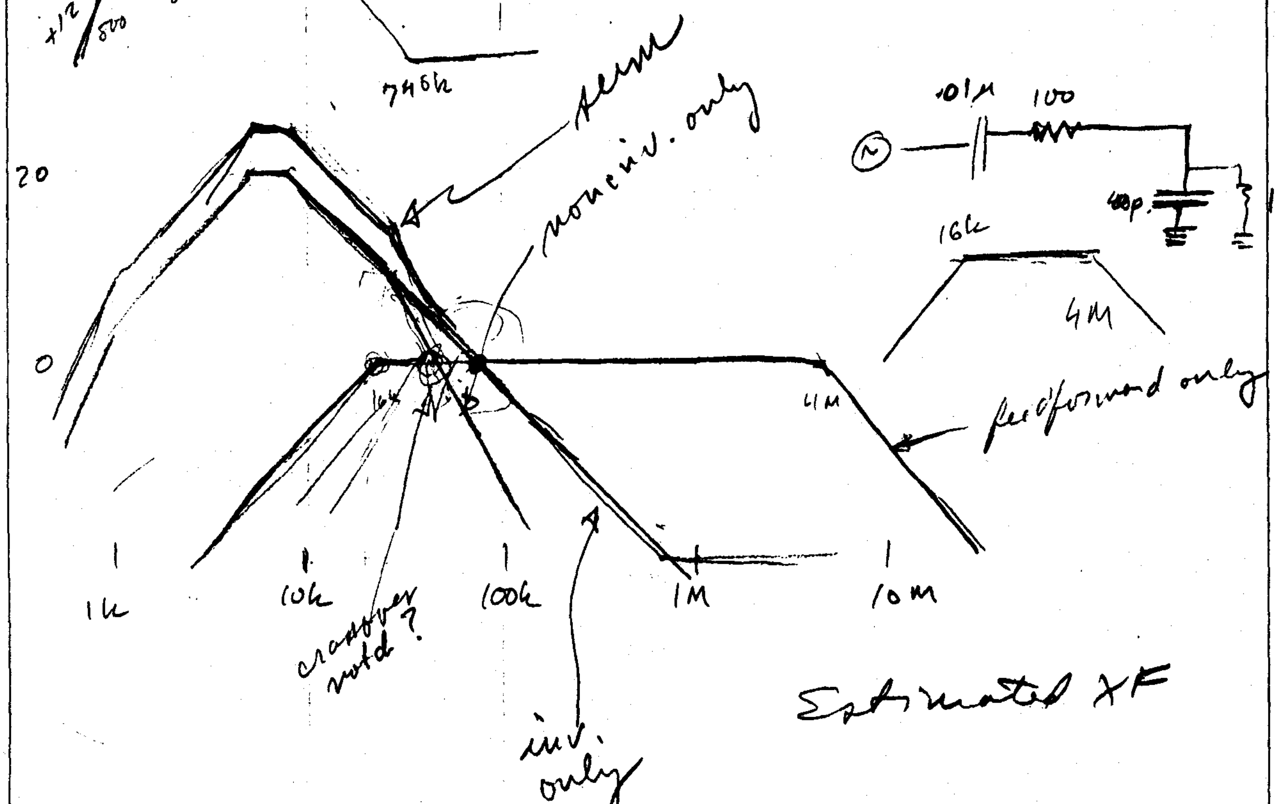
Proto #1

1k || .01μ = 16 kHz

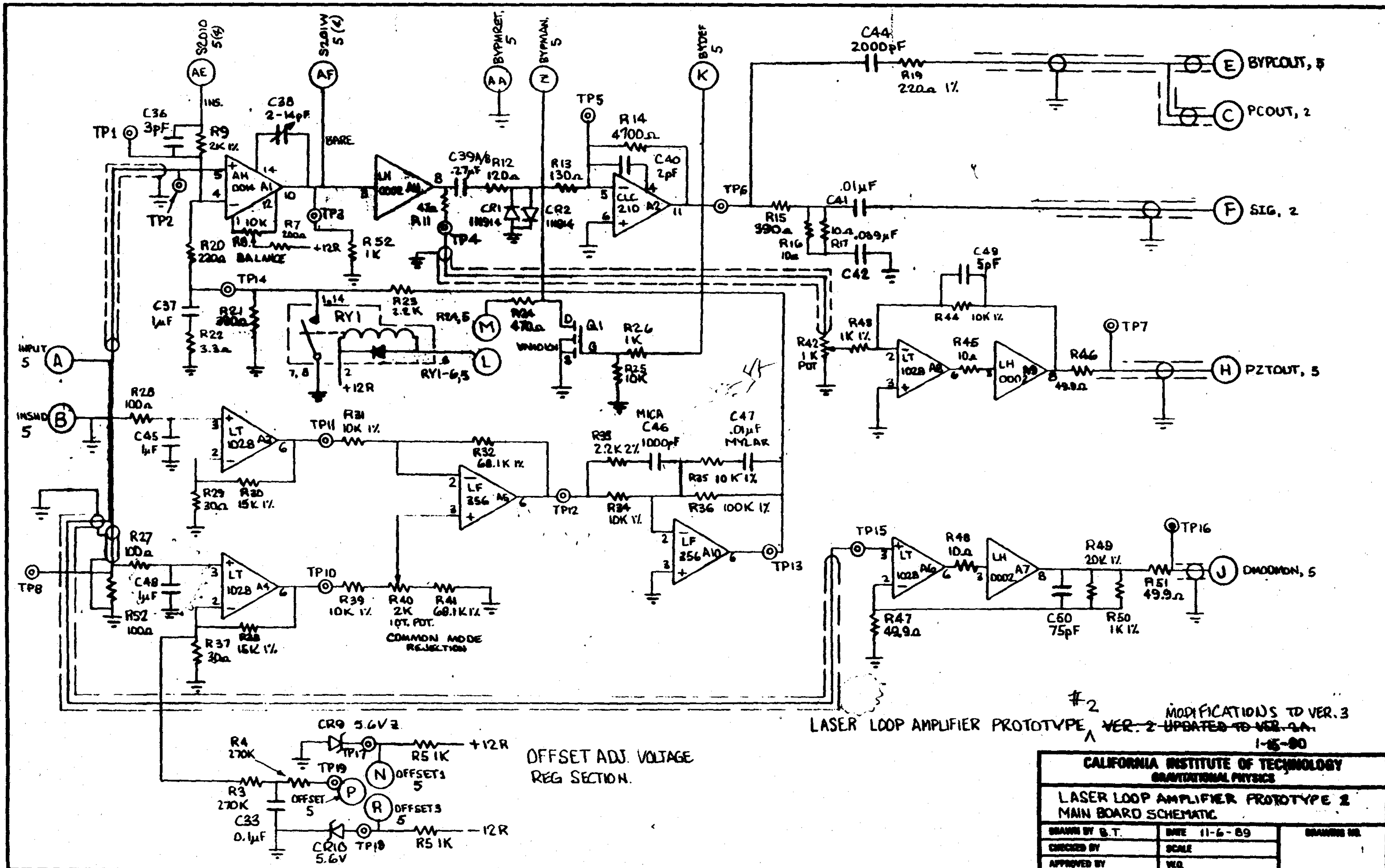


1k || 400pF = 400kHz

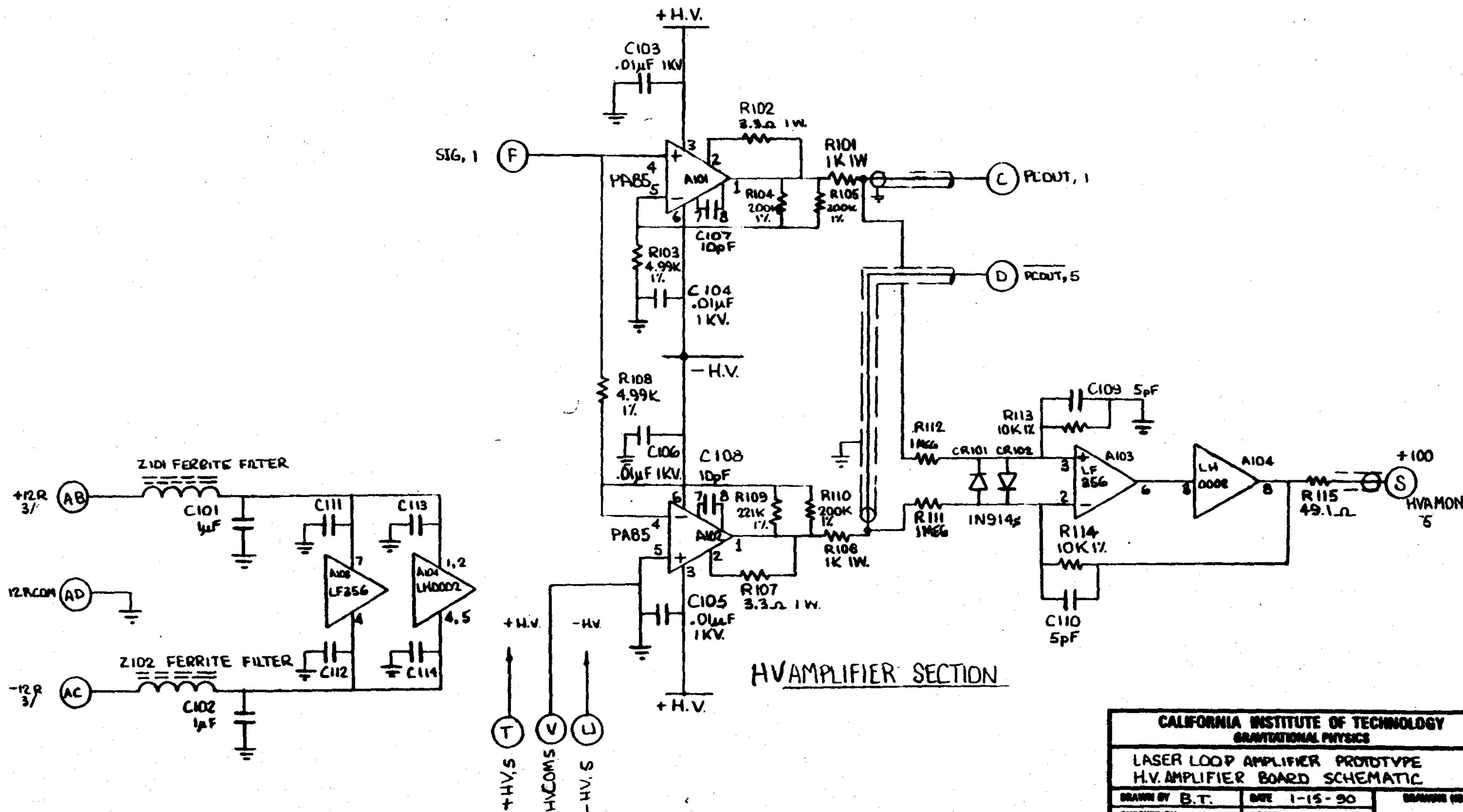




E. LASER LOOP: PROTOTYPE #2



S2010 5(4)
S201W 5(4)
BYPMRET, 5
BYPMAN, 5
BYPDEF 5
AE
AF
AA
Z
K
INS.
BARE
TP1
C36 3pF
R9 2K 1%
C38 2-14pF
AH 0014 A1
LH 0002 A11
C39A/B .27µF
R12 120Ω
R13 130Ω
TP5
R14 4700Ω
C40 2pF
CLC 210 A2
TP2
TP3
TP4
TP6
TP14
R7 200Ω
R8 10K BALANCE
+12R
R52 1K
R11 47Ω
CR1 1N914
CR2 1N914
R20 220Ω
C37 1µF
R21 200Ω
R22 3.3Ω
RY1
R23 2.2K
R24,5
R24 470Ω
M
L
Q1
VN0101
R26 1K
R25 10K
RY1-6,5
7, 8
+12R
C44 2000pF
R19 220Ω 1%
BYPCOUT, 5
PCOUT, 2
E
C
C41 .01µF
R15 390Ω
R16 10Ω
R17 10Ω
.039µF
C42
SIG, 2
F
C49 5pF
R44 10K 1%
TP7
R43 1K 1%
R42 1K POT
LT 1028 A8
R45 10Ω
LH 0002 A9
R46 49.9Ω
PZTOUT, 5
H
INPUT 5
A
INSHD 5
B
R28 100Ω
C45 1µF
LT 1028 A3
TP11
R31 10K 1%
R32 68.1K 1%
R29 30Ω
R30 15K 1%
LF 356 A5
TP12
R33 2.2K 2%
MICA C46 1000pF
C47 .01µF MYLAR
R35 10K 1%
R34 10K 1%
R36 100K 1%
LF 356 A10
TP13
R27 100Ω
C48 1µF
LT 1028 A4
TP8
R52 100Ω
TP10
R39 10K 1%
R40 2K 10T. POT
R41 68.1K 1%
COMMON MODE REJECTION
R37 30Ω
R38 15K 1%
TP15
LT 1028 A6
R48 10Ω
LH 0002 A7
R49 20K 1%
TP16
R51 49.9Ω
DHODMON, 5
J
R47 49.9Ω
C50 75pF
R50 1K 1%
CR9 5.6V Z
TP17
R5 1K
+12R
N
OFFSETS 5
R4 270K
TP19
P
OFFSET 5
R3 270K
C33 0.1µF
R
OFFSETS 5
CR10 5.6V
TP18
R5 1K
-12R
OFFSET ADJ. VOLTAGE REG SECTION.
LASER LOOP AMPLIFIER PROTOTYPE #2 VER. 2 UPDATED TO VER. 2A. MODIFICATIONS TO VER. 3
1-15-90
CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS
LASER LOOP AMPLIFIER PROTOTYPE 2
MAIN BOARD SCHEMATIC
DRAWN BY B.T.
DATE 11-6-89
CHECKED BY
SCALE
APPROVED BY
W.O.
DRAWING NO.
1

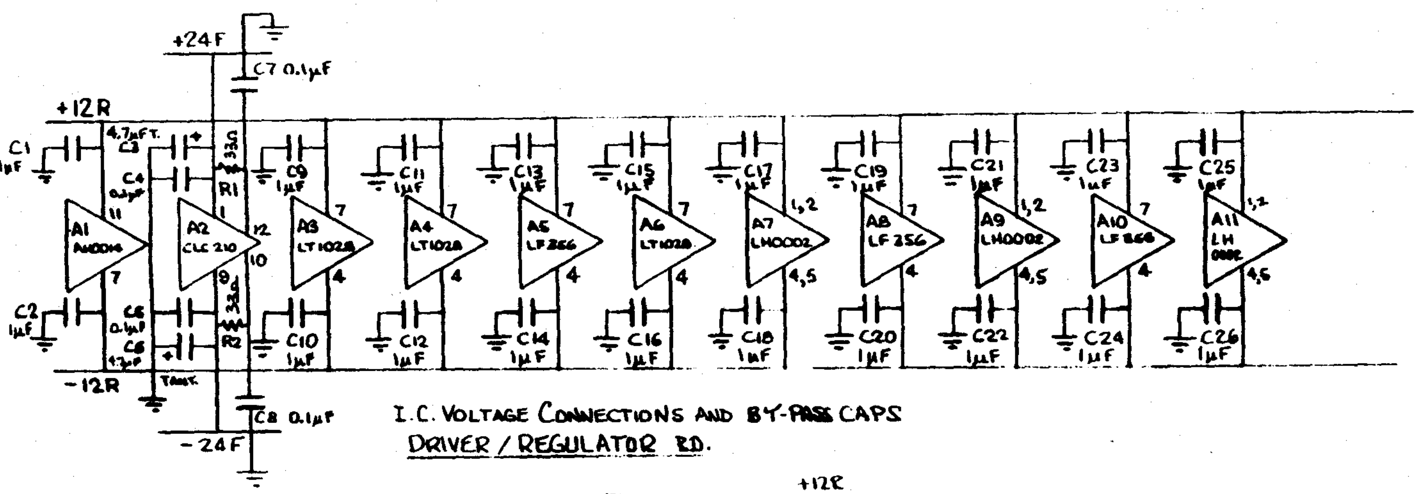


CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS

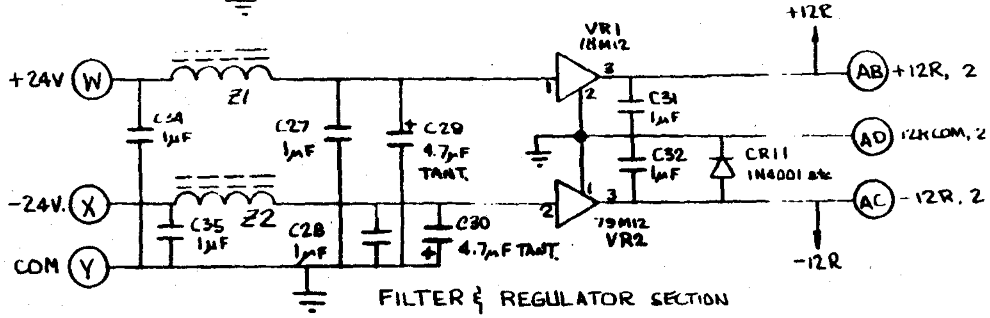
LASER LOOP AMPLIFIER PROTOTYPE
H.V. AMPLIFIER BOARD SCHEMATIC

DRAWN BY B.T.	DATE 1-15-90	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

E2



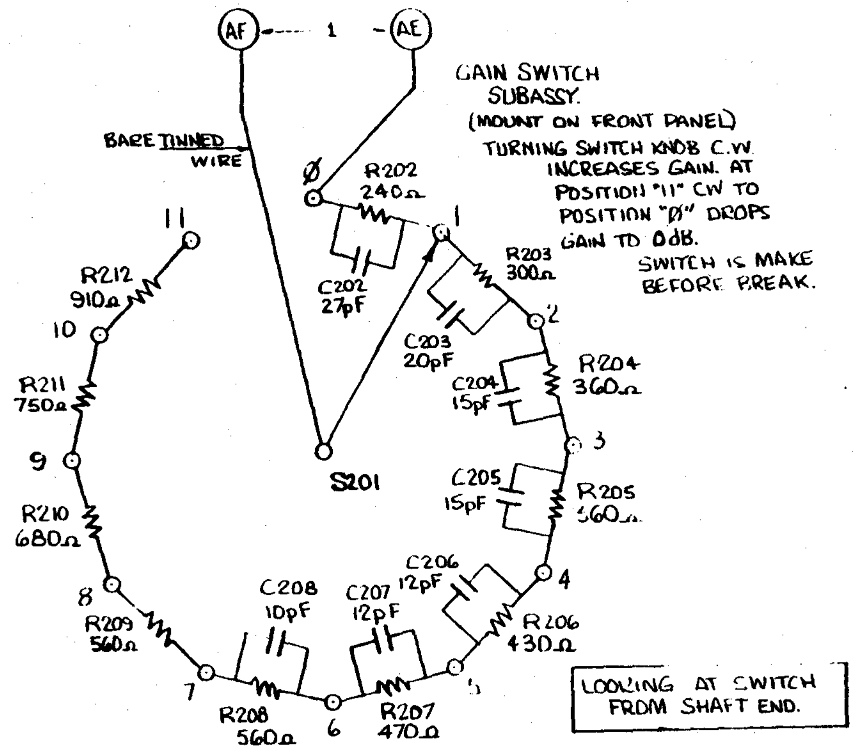
I.C. VOLTAGE CONNECTIONS AND BY-PASS CAPS
DRIVER / REGULATOR BD.



FILTER & REGULATOR SECTION
DRIVER/REGULATOR BD.

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
LASER LOOP AMPLIFIER PROTOTYPE POWER SCHEMATIC		
DRAWN BY B.T.	DATE 1-5-90	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

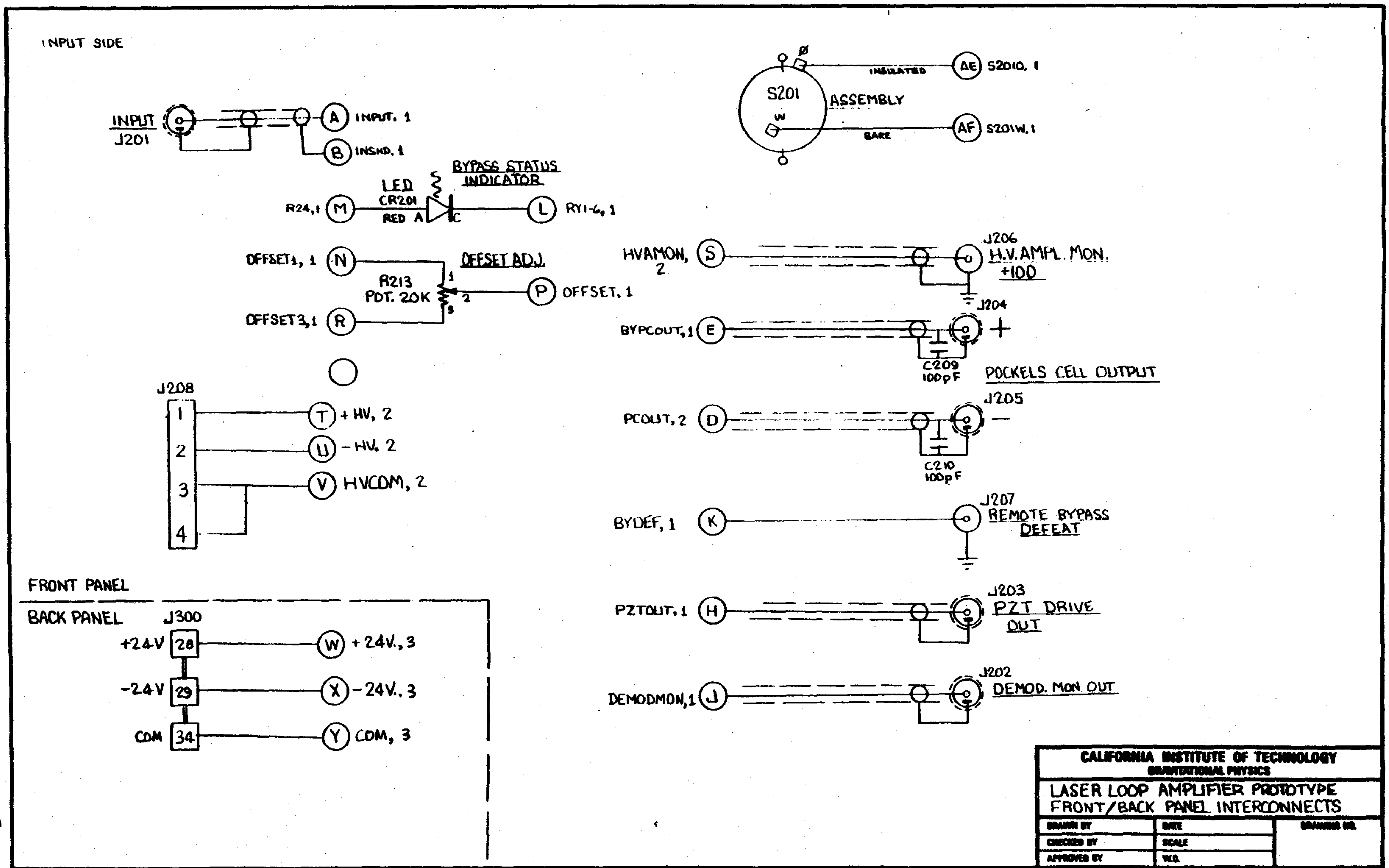
E3



PROTO TYPE: #2

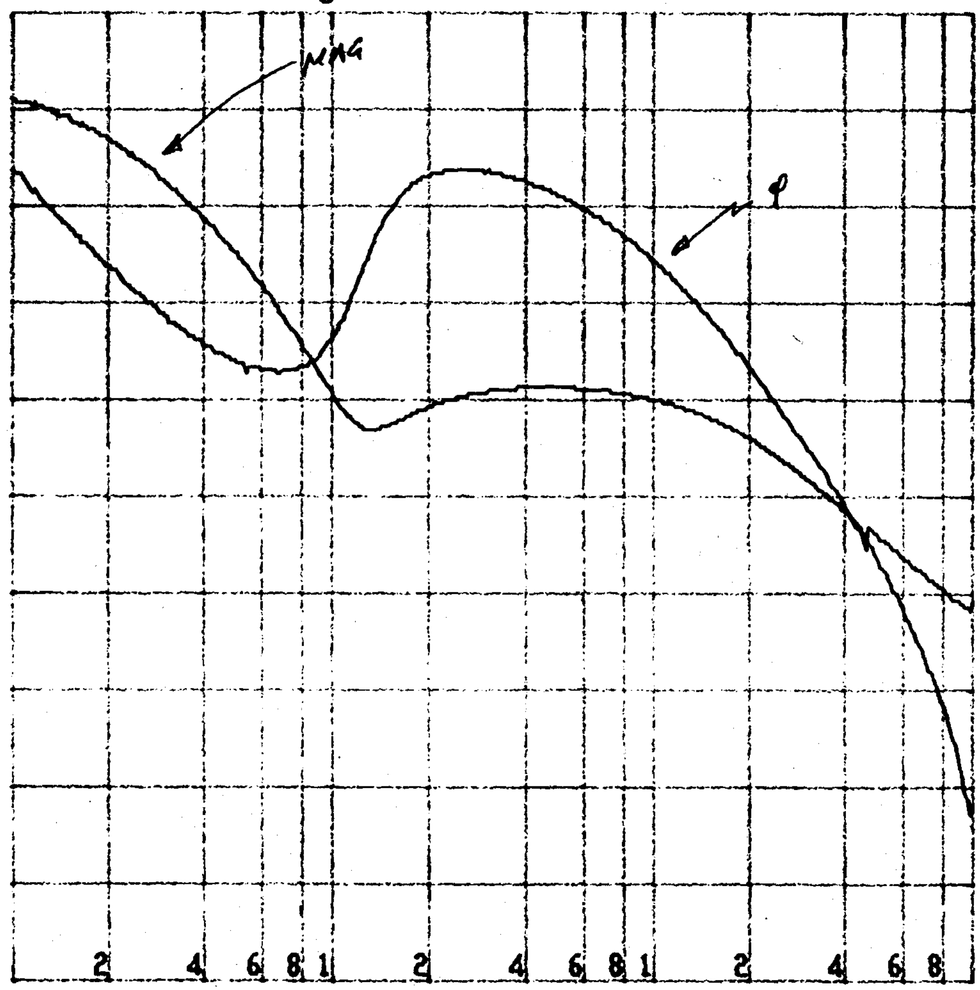
CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
LASER LOOP AMPLIFIER PROTOTYPE VER 2A GAIN SWITCH SCHEMATIC LAYOUT		
DRAWN BY B.T.	DATE 1-5-90	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

E4


INPUT SIDE
INPUT J201
A INPUT. 1
B INSHD. 1
S201 ASSEMBLY
Ø
INSULATED
AE S201Ø, 1
W
BARE
AF S201W, 1
BYPASS STATUS INDICATOR
LED CR201 RED
A
C
R24,1 M
L RY1-6, 1
OFFSET1, 1 N
OFFSET ADJ.
R213 POT. 20K
1
2
3
P OFFSET, 1
OFFSET3,1 R
HVAMON, 2 S
J206 H.V. AMPL. MON. ÷100
BYPCOUT,1 E
J204 +
C209 100pF
POCKELS CELL OUTPUT
PCOUT, 2 D
J205 –
C210 100pF
J208
1
2
3
4
T +HV, 2
U –HV, 2
V HVCOM, 2
BYDEF, 1 K
J207 REMOTE BYPASS DEFEAT
FRONT PANEL
BACK PANEL
J300
+24V 28
W +24V., 3
–24V 29
X –24V., 3
COM 34
Y COM, 3
PZTOUT, 1 H
J203 PZT DRIVE OUT
DEMODMON,1 J
J202 DEMOD. MON. OUT
CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS
LASER LOOP AMPLIFIER PROTOTYPE
FRONT/BACK PANEL INTERCONNECTS
DRAWN BY
DATE
DRAWING NO.
CHECKED BY
SCALE
APPROVED BY
W.O.
BISHOP GRAPHICS/ACCUPRESS

NETWORK Cor
A: REF B: REF
90.00 225.0
[dB][deg]

BP off



DIV DIV START 10 000.000 Hz
10.00 45.00 STOP 10 000 000.000 Hz
RBW: 1 KHz ST: 12.8 sec RANGE: R= 20, T= 0dBm

10/19/90 ... 8

XF, LASER LOOP AMP
PROTO #2,

INPUT → PC "+" OUT
(AT END OF CABLES,
PC INSTALLED, 10 MΩ ‖ 13 pF
PROBE, OPPOSITE SIDE
CONNECTED + DRIVEN
AS OPERATED)

SAME DATA AS 10:45,
LOGBOOK #20, P.039 Y

GAIN = "11" (MAX.)

RF TRAPS
ON INPUT
INCLUDED

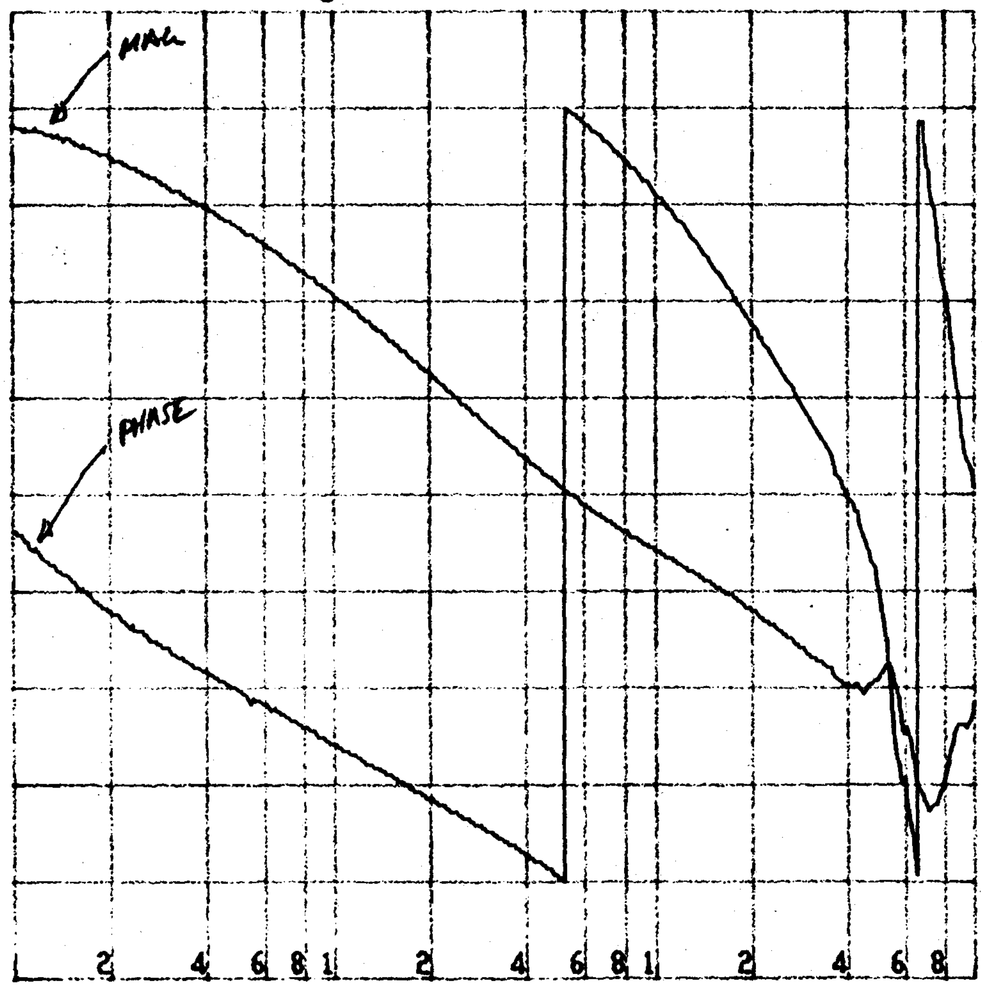
[PROBE SETUP XF
CALIBRATED OUT]

E1
9

10

BP OFF

NETWORK   Cor
A: REF   B: REF
90.00   225.0
[dB][deg]



DIV 10.00   DIV 45.00   START 10 000.000 Hz
STOP 10 000 000.000 Hz
RBW: 1 KHz ST: 12.8 sec RANGE: R= 20, T= 0dBm

XF, LASER LOOP AMP
PROTO #2
INPUT → PC "-" OUT
(SEE 10:50 FOR OTHER INFO)

GAIN = "11" (MAX)

RF TRAPS ON INPUT INCLUDED

[PROBE SETUP XF CALIBRATED OUT]

10/9/90 ME
11:15

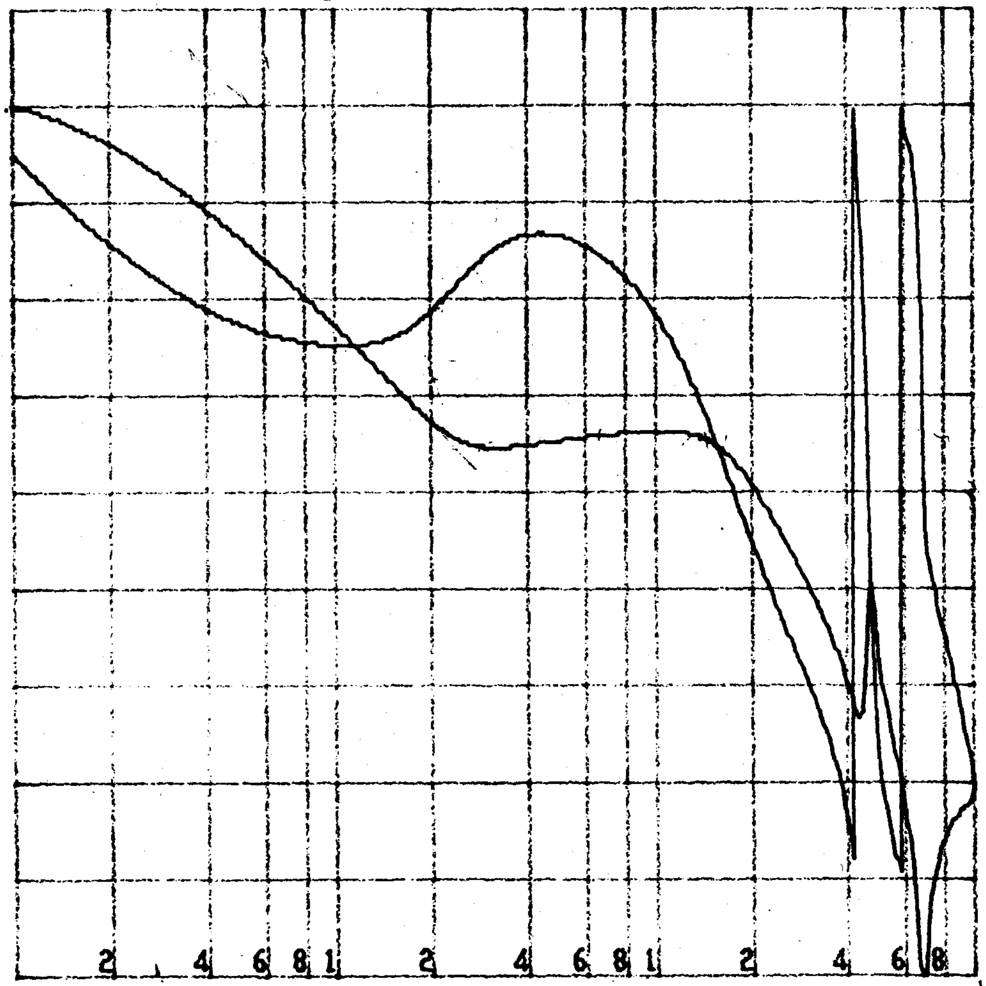
BP OFF

XF, LASERLOOP AMP
PROTO #2

INPUT → PC MON ÷ 100
GAIN = "11" (MAX)
INCL. RF TRAPS AT INPUT

DIRECTLY INTO T1 OF ANALYZER

NETWORK
A: REF B: REF
50.00 225.0
[dB][deg]



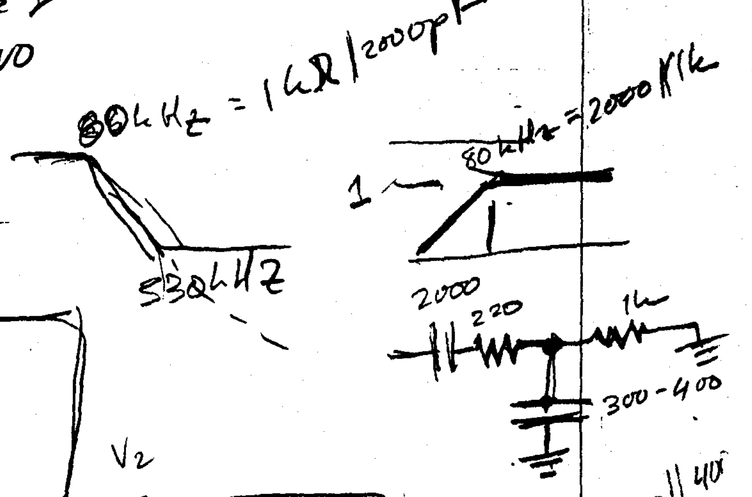
DIV 10.00 DIV 45.00 START 10 000.000 Hz
STOP 10 000 000.000 Hz
RBW: 1 KHz ST: 12.8 sec RANGE: R= 20, T= 10dBm
REF= 5.00000E+01

E8

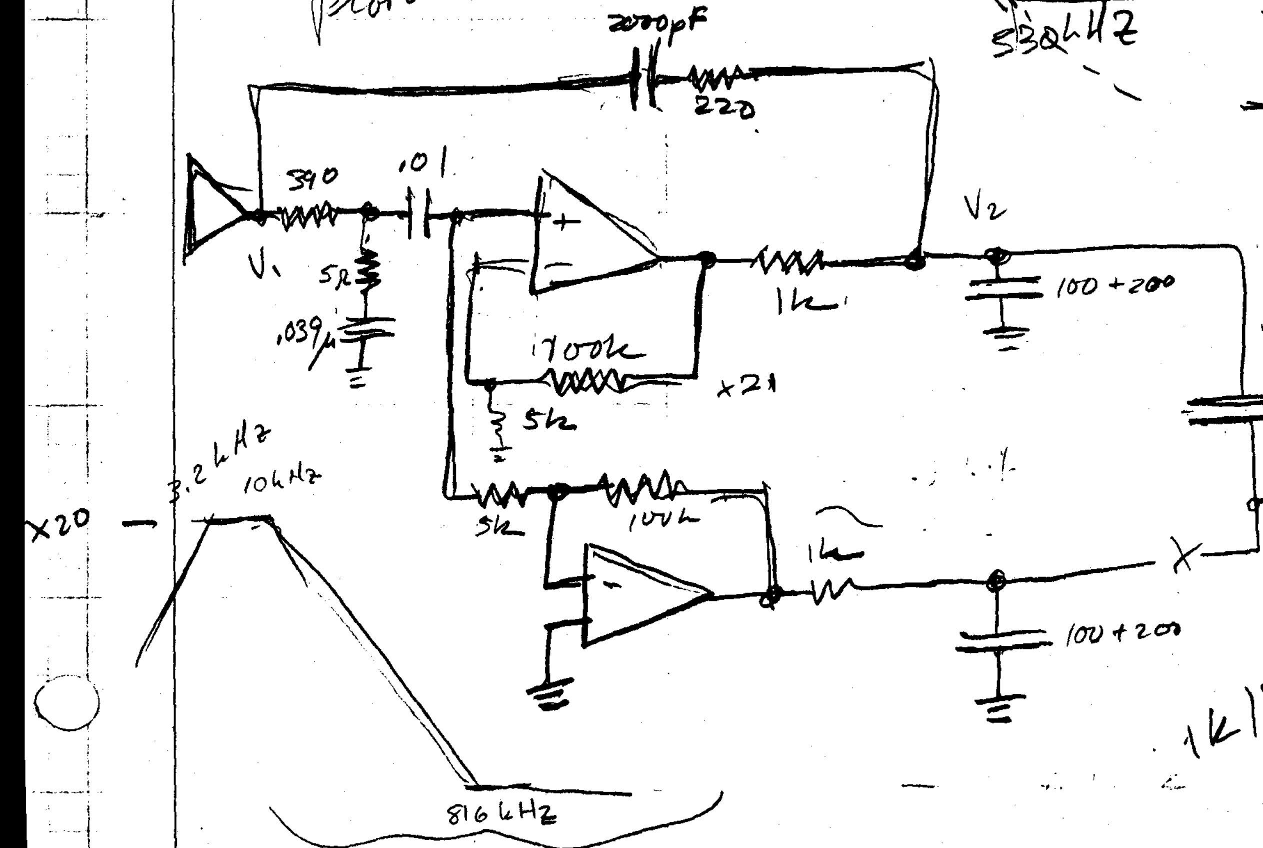
Prototype #2

LASERSERVO

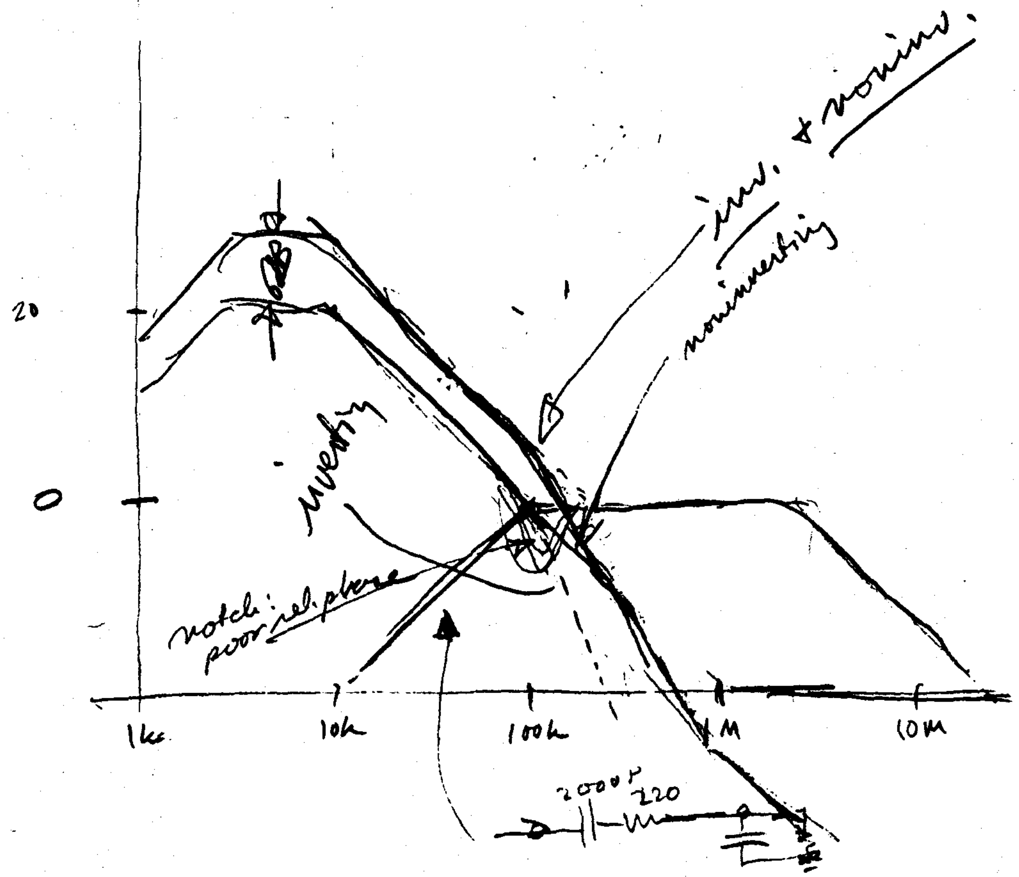
$80kHz = 1k\Omega \| 2000pF$



Proto #2



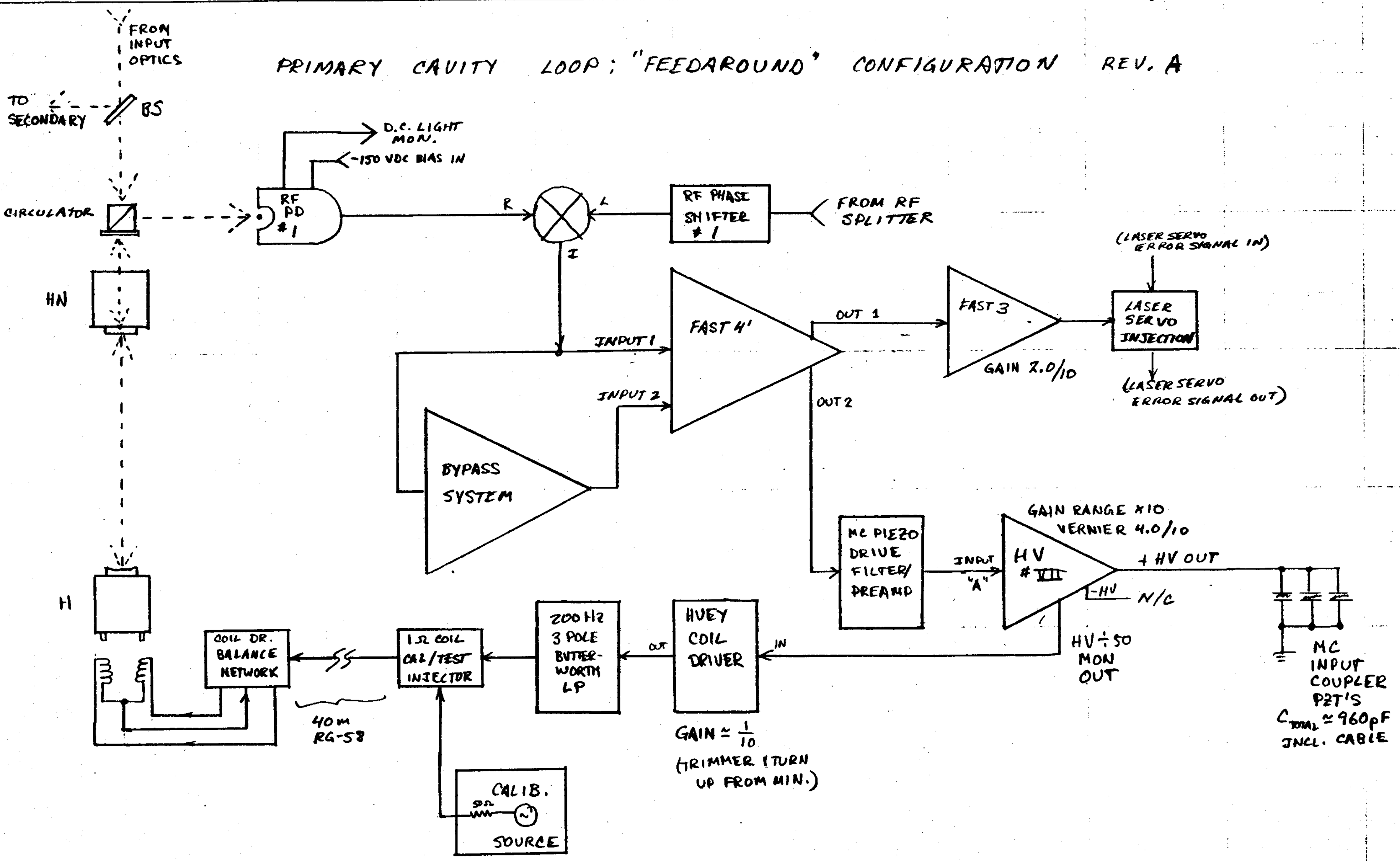
$1k \| 400pF = 400kHz$



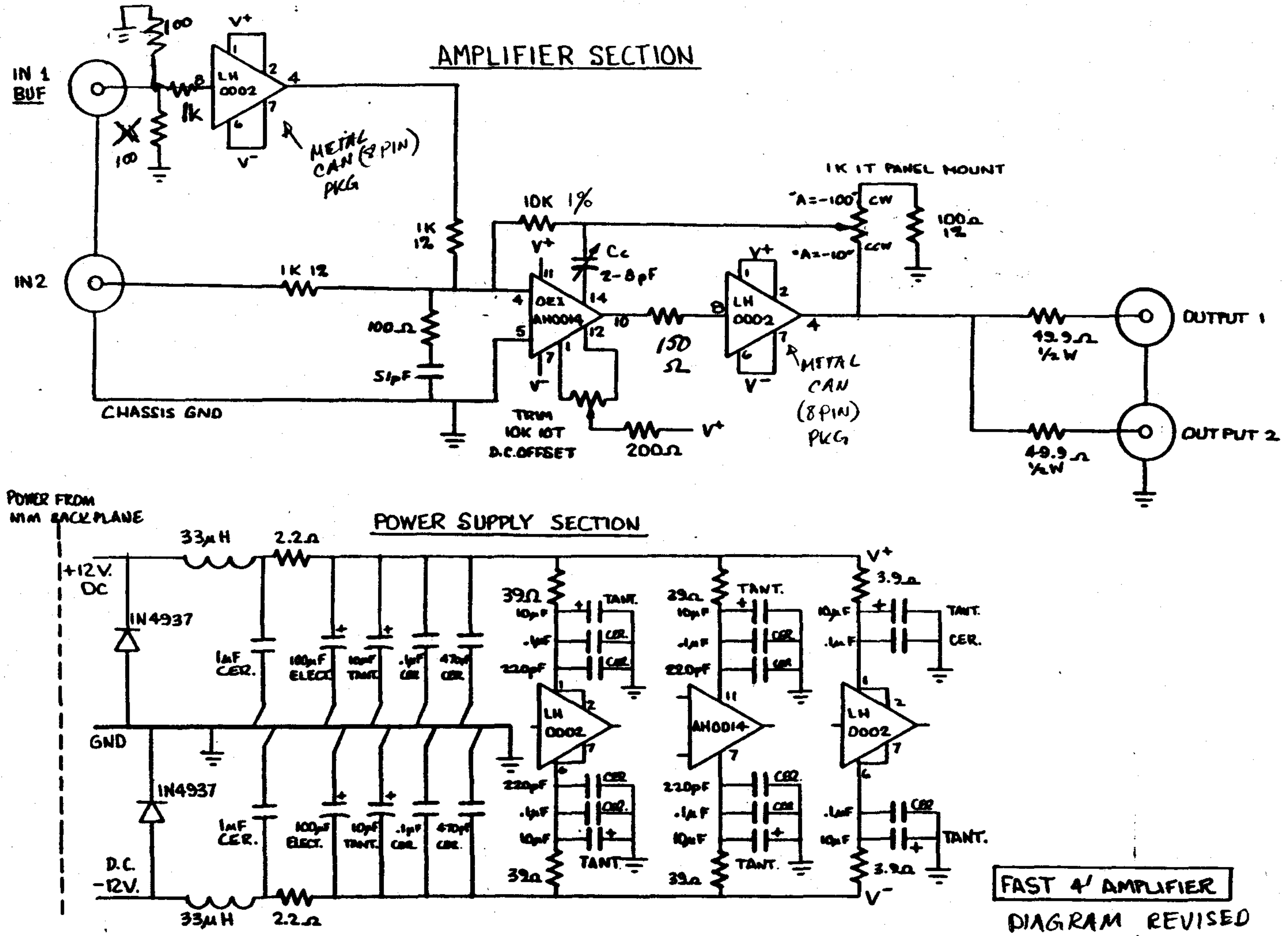
F. PRIMARY CAVITY LOOP

11/20/90 ME

PRIMARY CAVITY LOOP; "FEEDAROUND" CONFIGURATION REV. A



F1



CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS

FAST 4' AMPLIFIER 9-22-88 MEZ

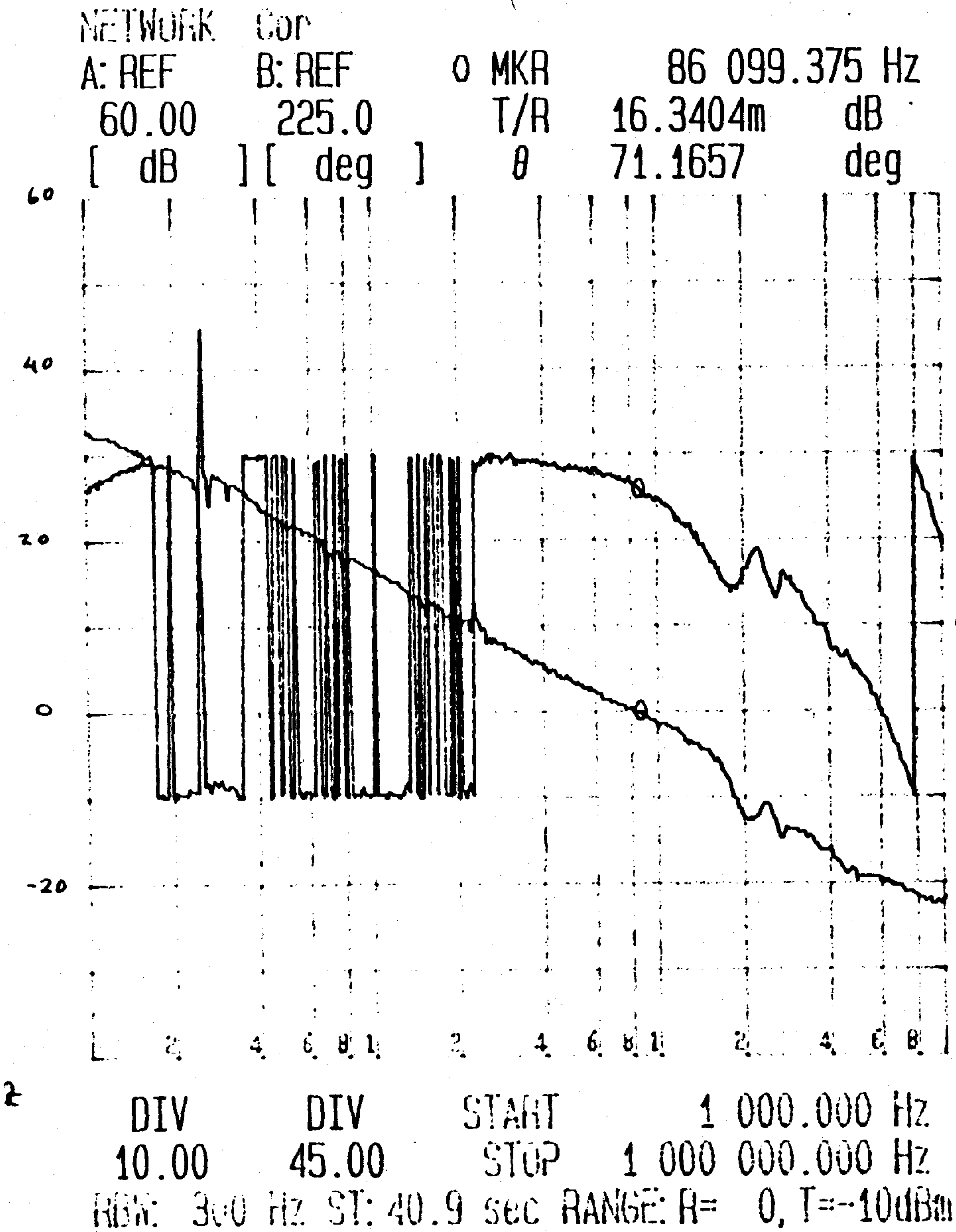
DRAWN BY B.T.	DATE 9-29-88	DRAWING NO.
CHECKED BY	SCALE	
APPROVED BY	W.O.	

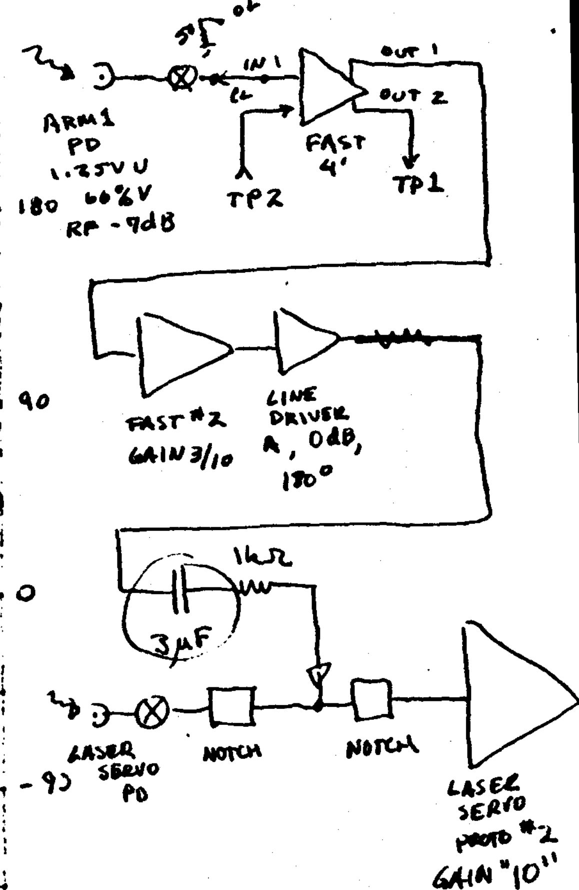
88-0929-1

F2

Loop Gain of Primary Cavity Feedaround Servo (NO PC feedback active)

FILE "A1LGFA2"
DISK # 1
(START 10/10/90)





THIS PLOT DIFFERS FROM 17:00 BECAUSE 3μF AC COUPLING CAP WAS MOVED FROM INPUT OF FAST #2 TO OUTPUT OF LINE DRIVER A

=> HP POLE MOVED DOWN, FROM 3μF || 50Ω = 1kHz TO 3μF || 1kΩ = 50 Hz (better Gain @ 1kHz, probably better xover w/ MCP2T)

TW

THIS PLOT:

$$\left[\frac{\left(\frac{TP_1}{TP_2}\right)_{OL}}{\left(\frac{TP_1}{TP_2}\right)_{CL}} - 1 \right] \equiv G_{OL}$$

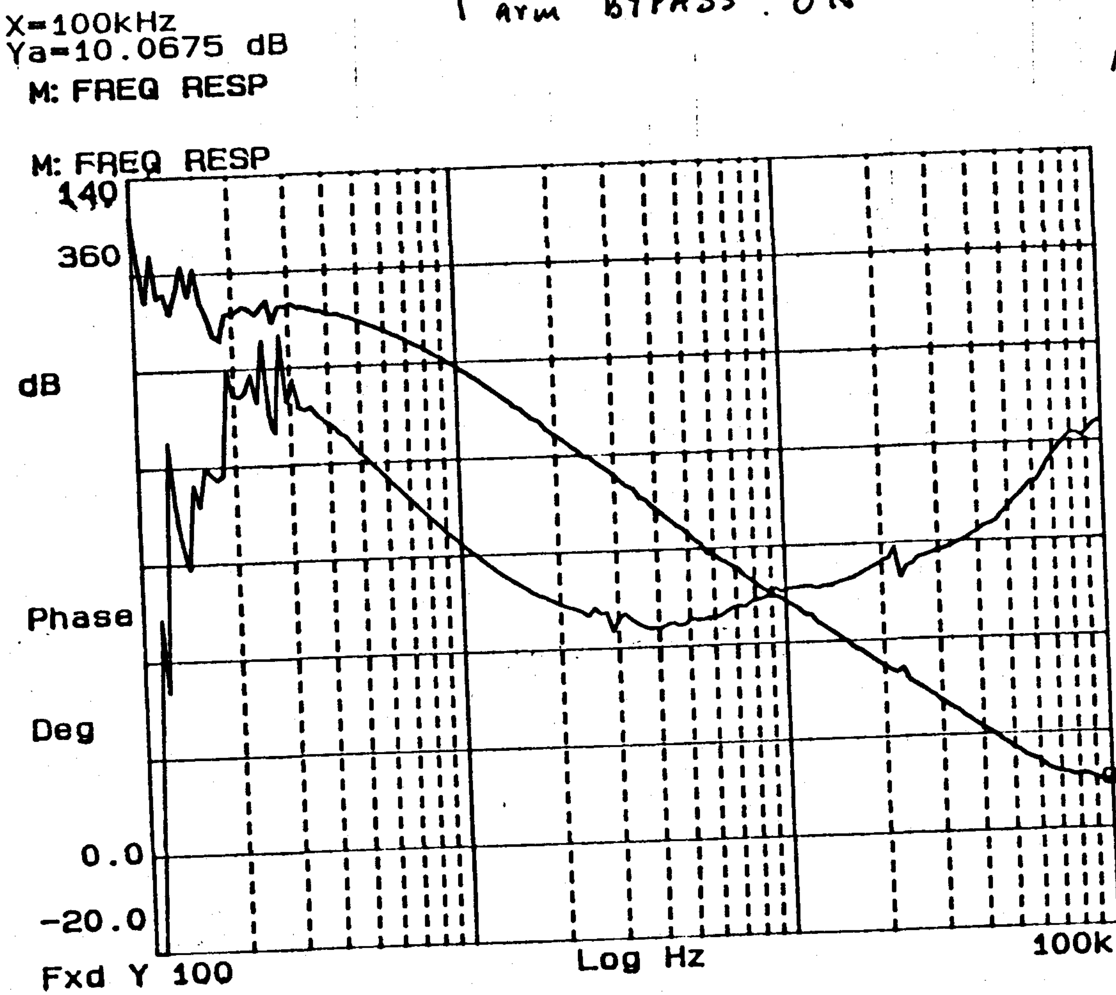
1st a - open loop gain with feed-a sound

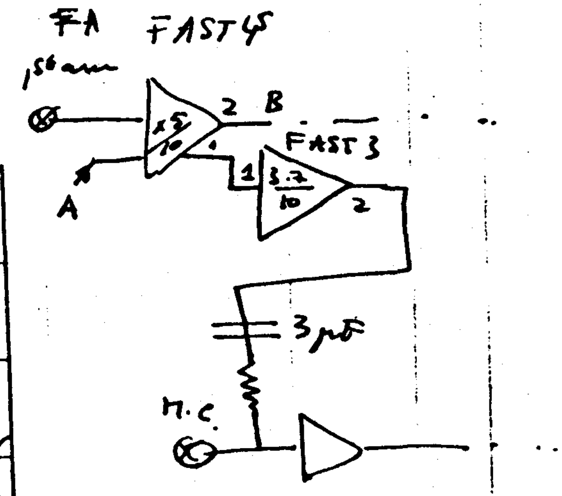
6-NOV-90 17:10

Light levels: 1.4V unlocked.
0.4V locked.

fn: A1FA
DISC B

1st Arm BYPASS : ON





1. Gain without bypass

$$G_{NB} = \frac{\left(\frac{e_B}{e_A}\right)_{\text{open loop}}}{\left(\frac{e_B}{e_A}\right)_{\text{closed loop}}} - 1$$

2. Gain with bypass (show

$G_B = G_{NB} \times (1 +$ Bypass gai

measured previously as "BYPASS".

NOT TO BE TRUSTED BELOW 300 Hz

F4

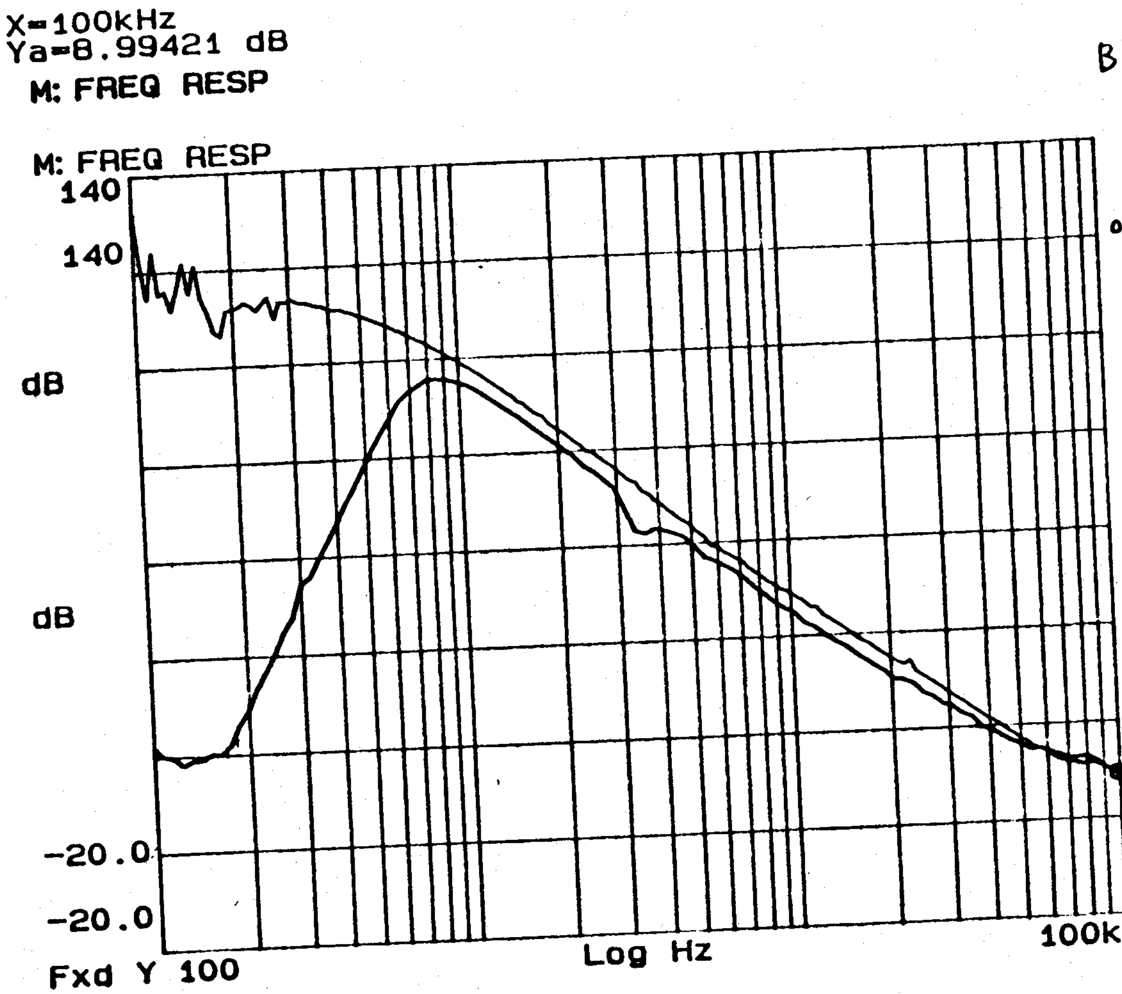
1st arm servo performance, with feed-around

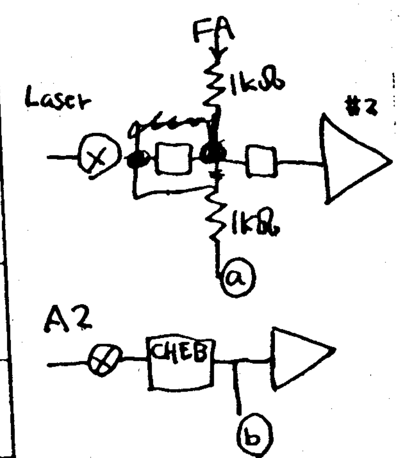
11-6-90 18:

Blue: "Nominal" loop gain of the arm 1 with FA.
(same as 6-NOV-90, 17:10

Black: "Effective" loop gain of the arm 1 with FA
= SUPPRESSION OF ARTIFICIAL Y NOISE AS MEASURED BY SECONDARY CAVITY

- FA set-up same as 17:10





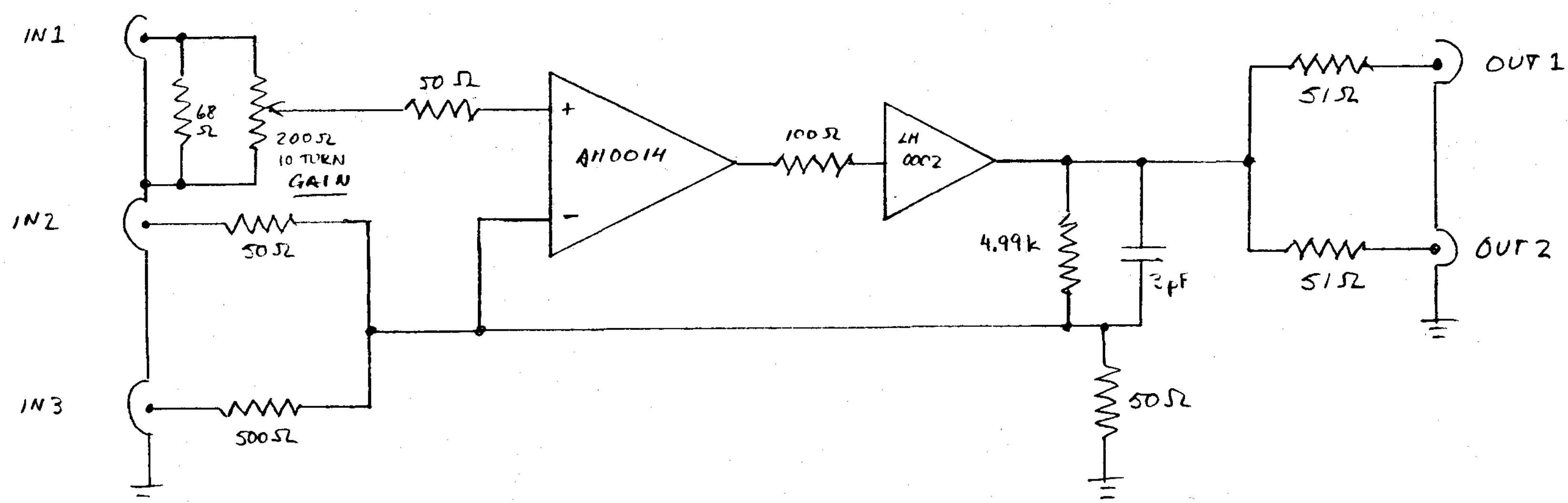
$$\text{"Black"} = \frac{\left(\frac{b}{a}\right)_{\text{no A1}}}{\left(\frac{b}{a}\right)_{\text{w/A1}}}$$

Black : A1FAEFF in Disk B

11/20/90 [initials]

PRIMARY CAVITY SERVO; "FAST #3" AMPLIFIER

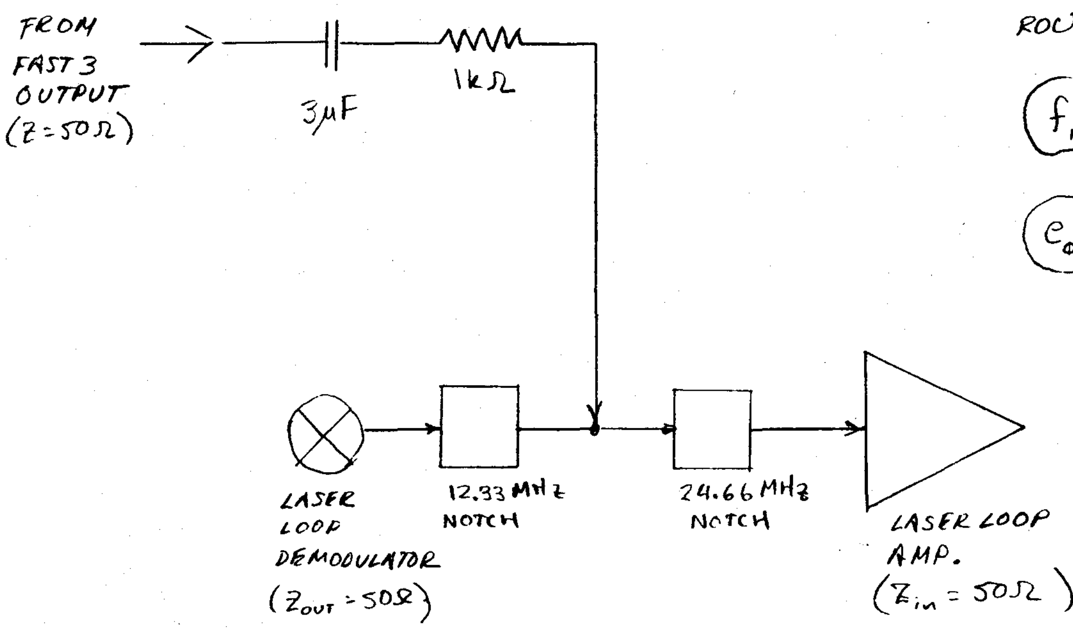
[NOTE: ROUGH CKT. ONLY, COPIED FROM 11/14/88 LASER LOOP DRAWING SET, OLD BLUE "LOCKING SERVO HANDBOOK"]



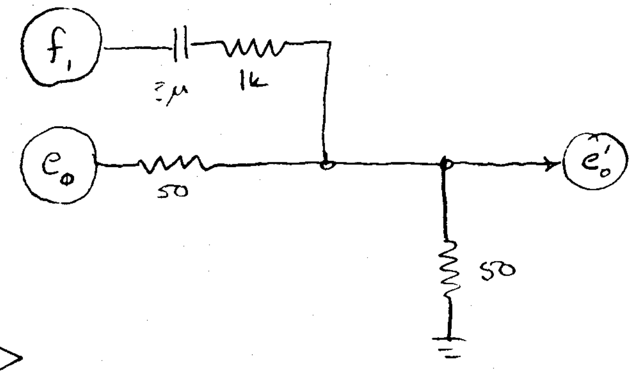
F6

11/20/90 MEZ

PRIMARY CAVITY LOOP; LASER SERVO INJECTION NETWORK



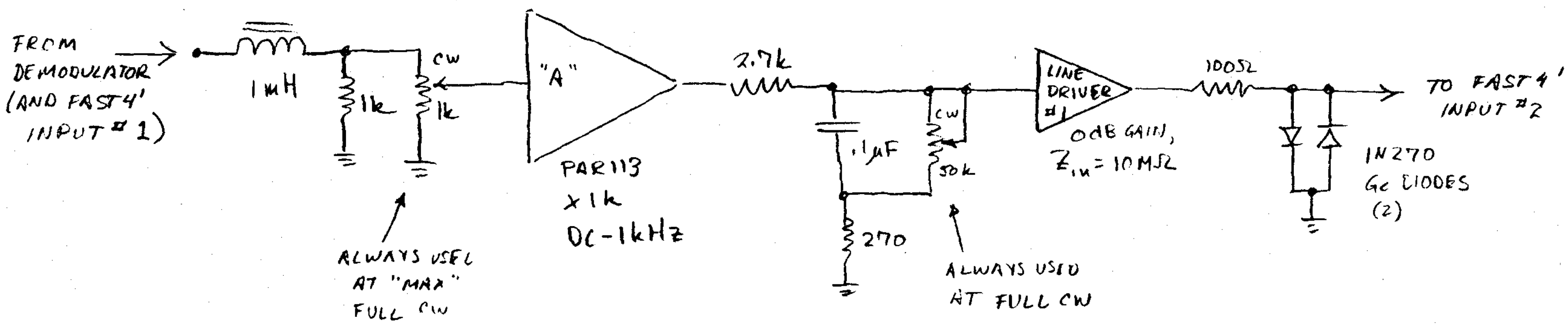
ROUGH EQUIVALENT CIRCUIT;



F7

11/20/90 MEZ

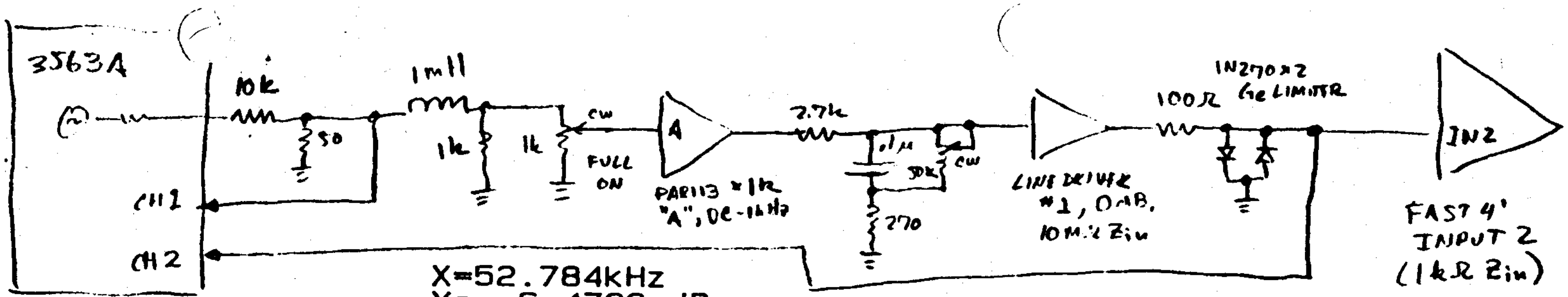
PRIMARY CAVITY LOOP ; BYPASS SYSTEM



600 Hz/6kHz

T1
8

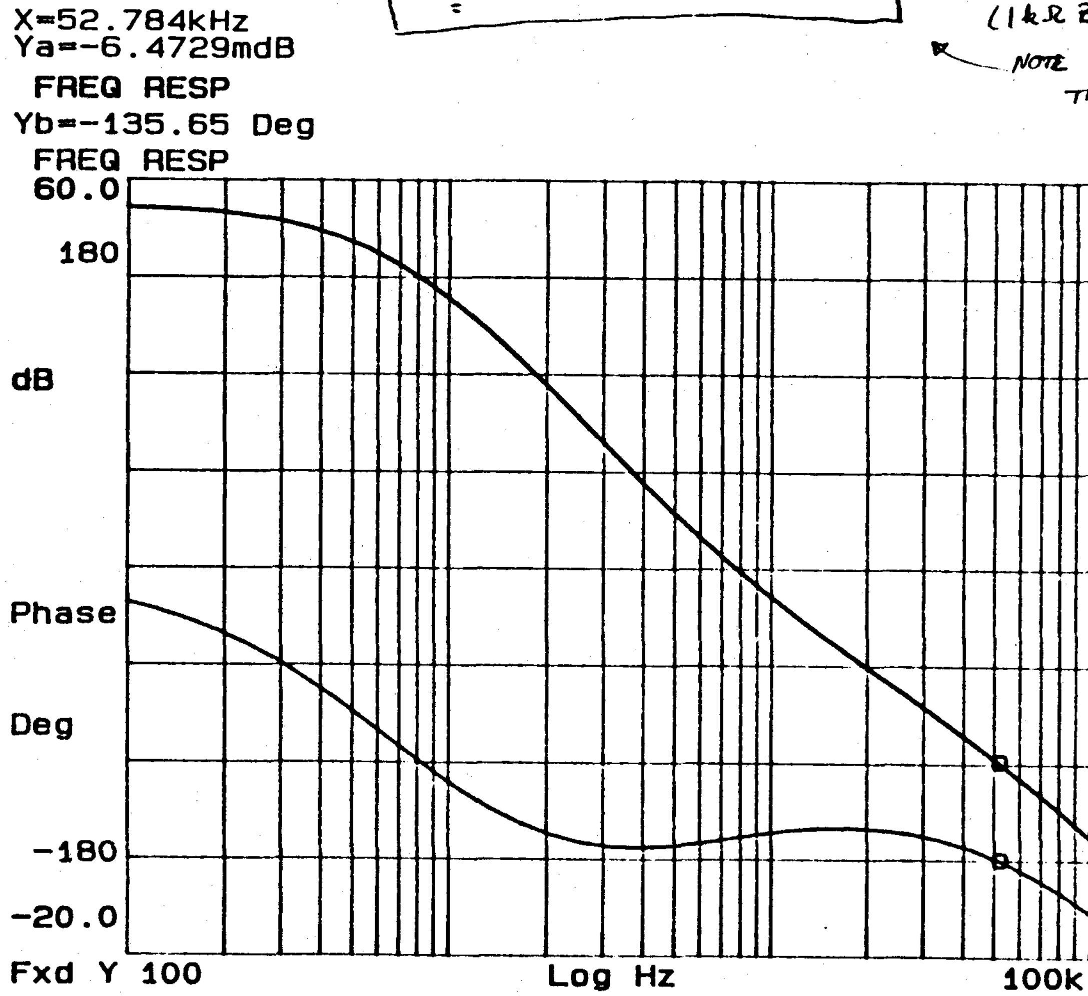
11/1/90 (20)



NOTE PROPER TERMINATION THIS TIME

ARM 1 BYPASS TRANSFER F'N

LOGBOOK #20 p.028W



FILE "BYPASS", DISK B, PAGE 1

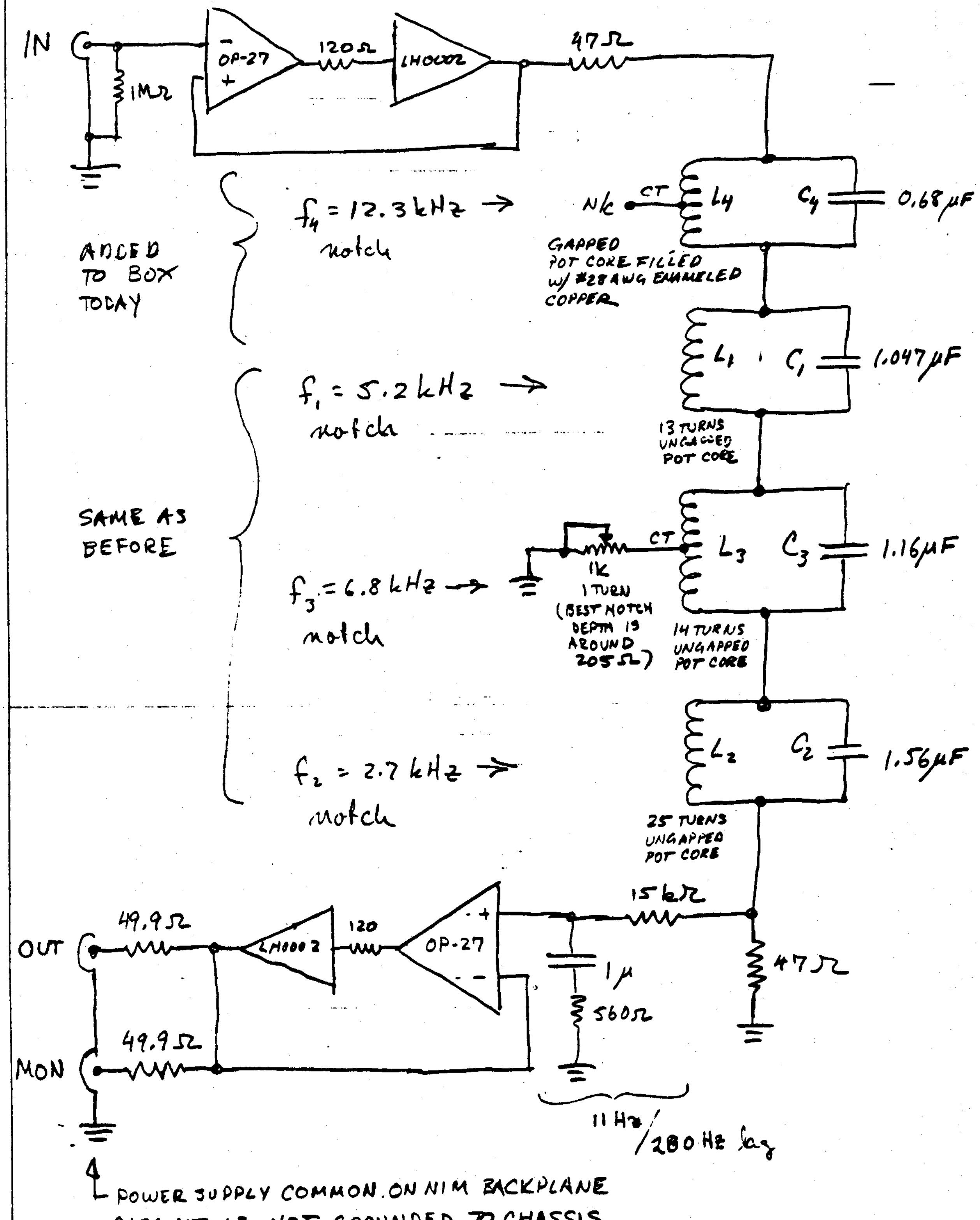
F9

5/15/90 MEZ 16:30

New 12.3 kHz Notch Filter Installed Permanently in

MC PIEZO DRIVE FILTER / PREAMP Box

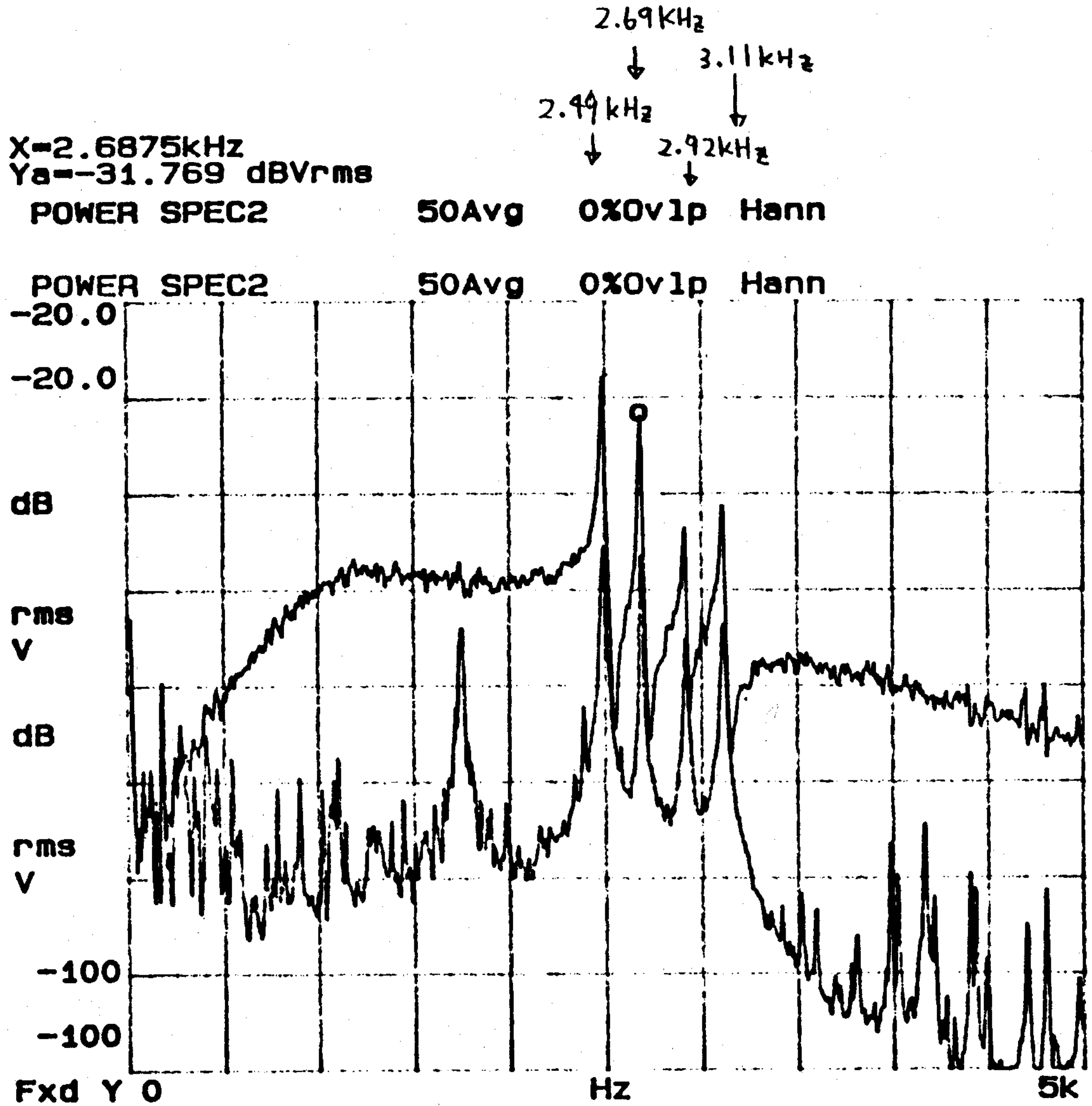
Circuit is now as follows.



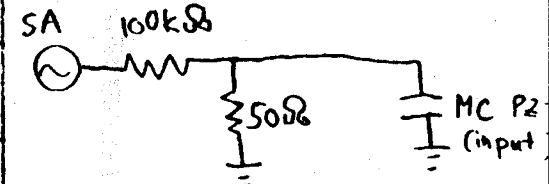
POWER SUPPLY COMMON ON NIM BACKPLANE
CIRCUIT IS NOT GROUNDED TO CHASSIS
(ALL BNC'S ISOLATED)

F10

10-23-90 15:30



Arm 2 error signal with and without white noise applied to MC PZT



Orange: random noise applied (300 mVrms in SA)

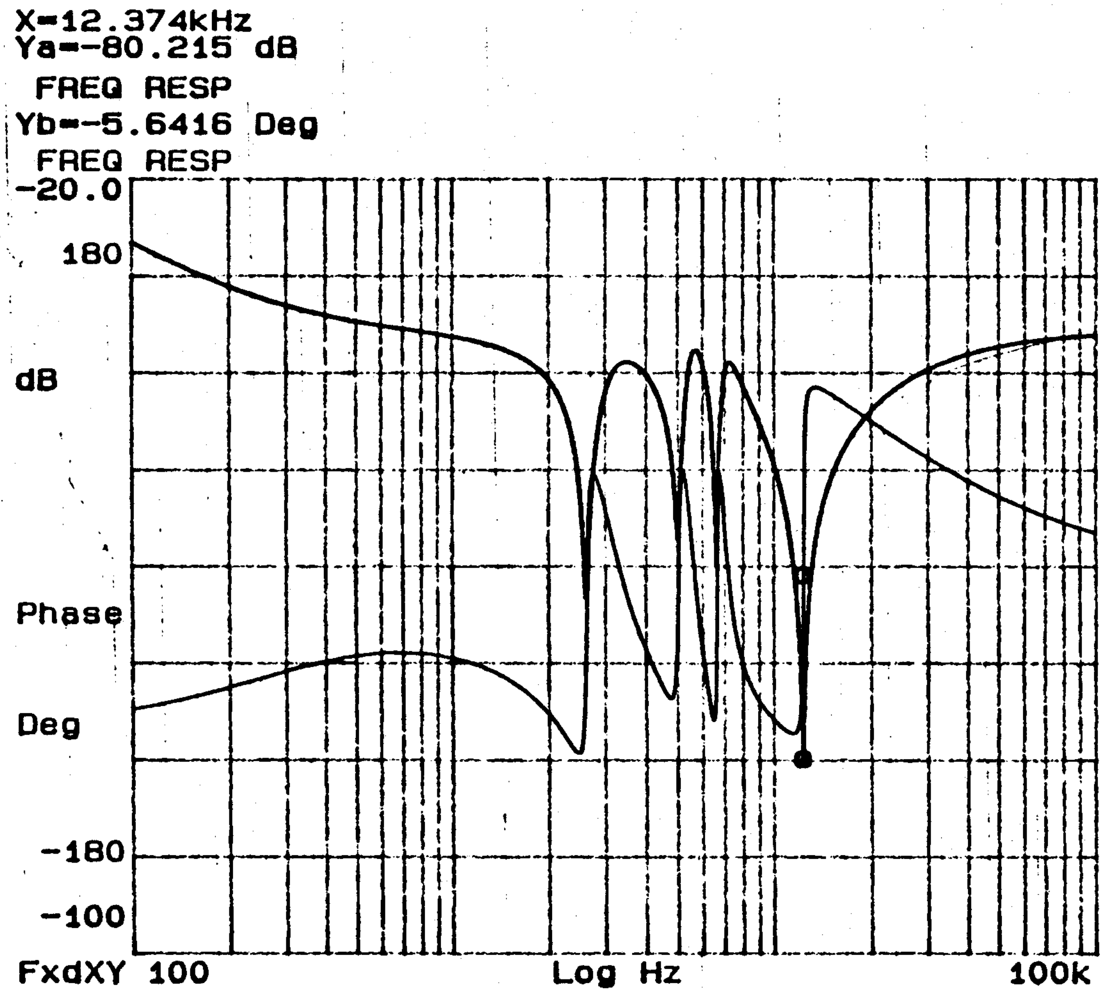
Green: without

The four peaks were identified in (17) 092 Y (opposite)

F//

5/15/[illegible] 17:30
McG

AFTER



TRANSFER FUNCTION OF "MC PIEZO DRIVE FILTER/ PREAMP" MODULE AFTER MODIFICATION [ADDED AN ADDITIONAL NOTCH AT 12.37 kHz INSIDE CIRCUIT]

SUPERCEDES XFER F'N ON P. 077 OF BOOK #17

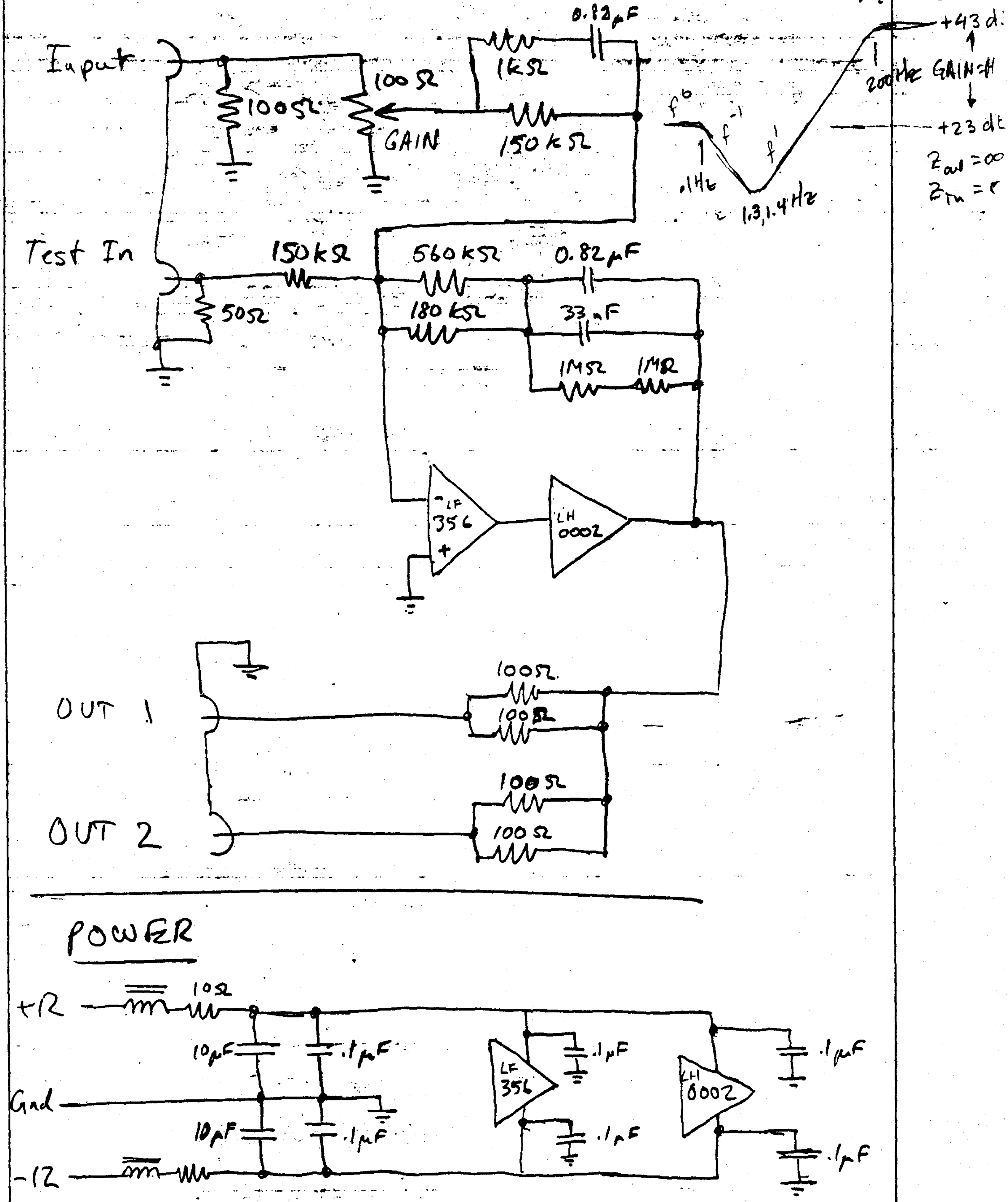
← note 6dB increase, due to placing notch between existing buffers in module rather than outside; compensated by cutting gain of HV #VIII back down.

F12

013

Hueq Coil Driver 891020

MWR

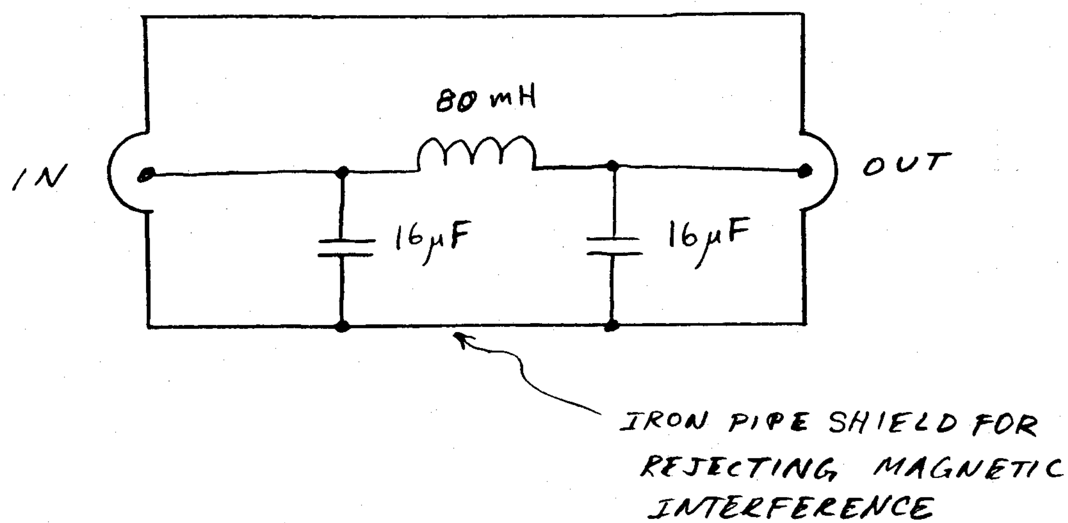


10/10/90 MEZ

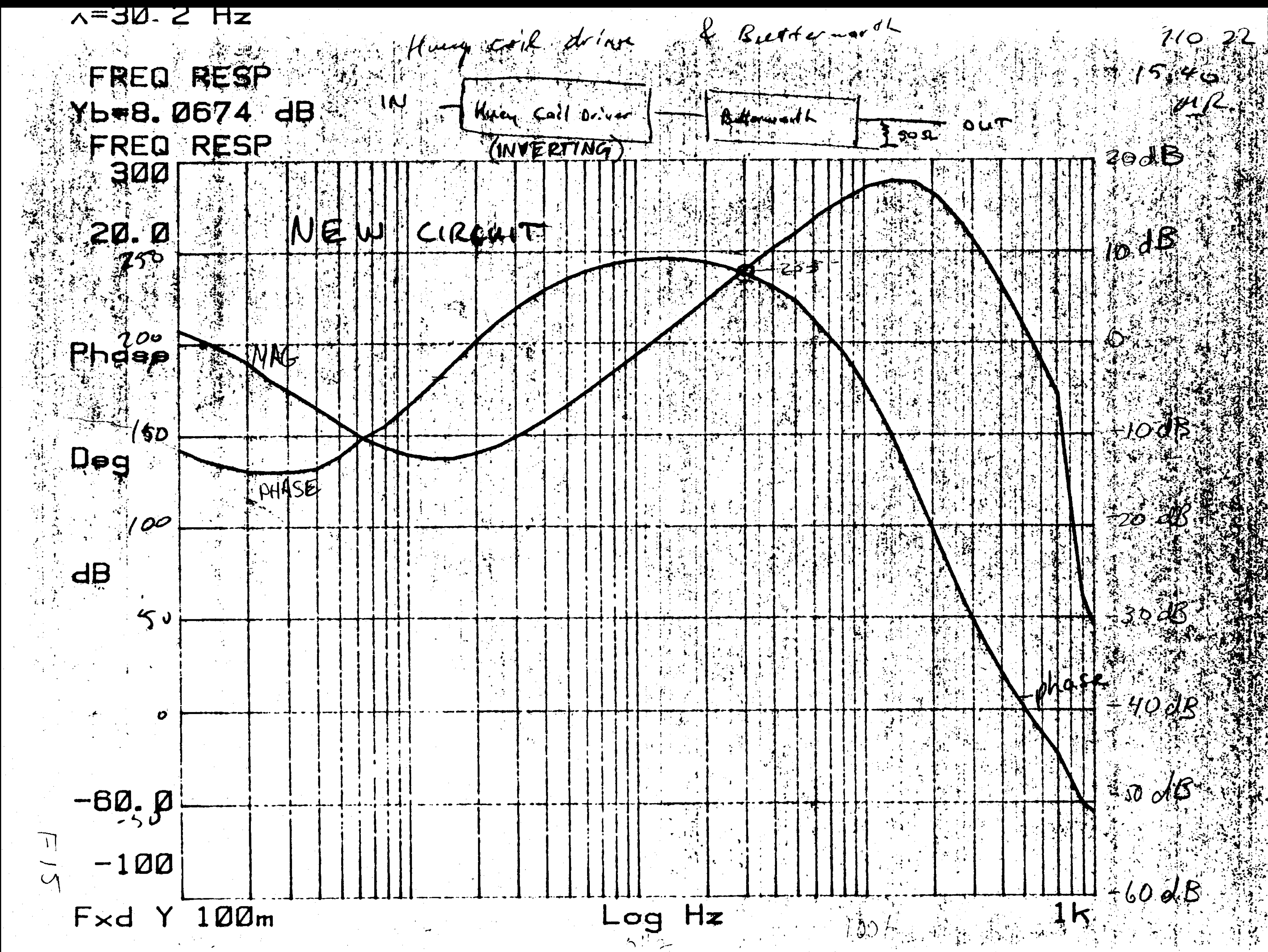
PRIMARY CAVITY SERVO;

200Hz 3-POLE BUTTERWORTH LOWPASS FILTER

$Z_{in} = 50\Omega = Z_{OUT}$



F14

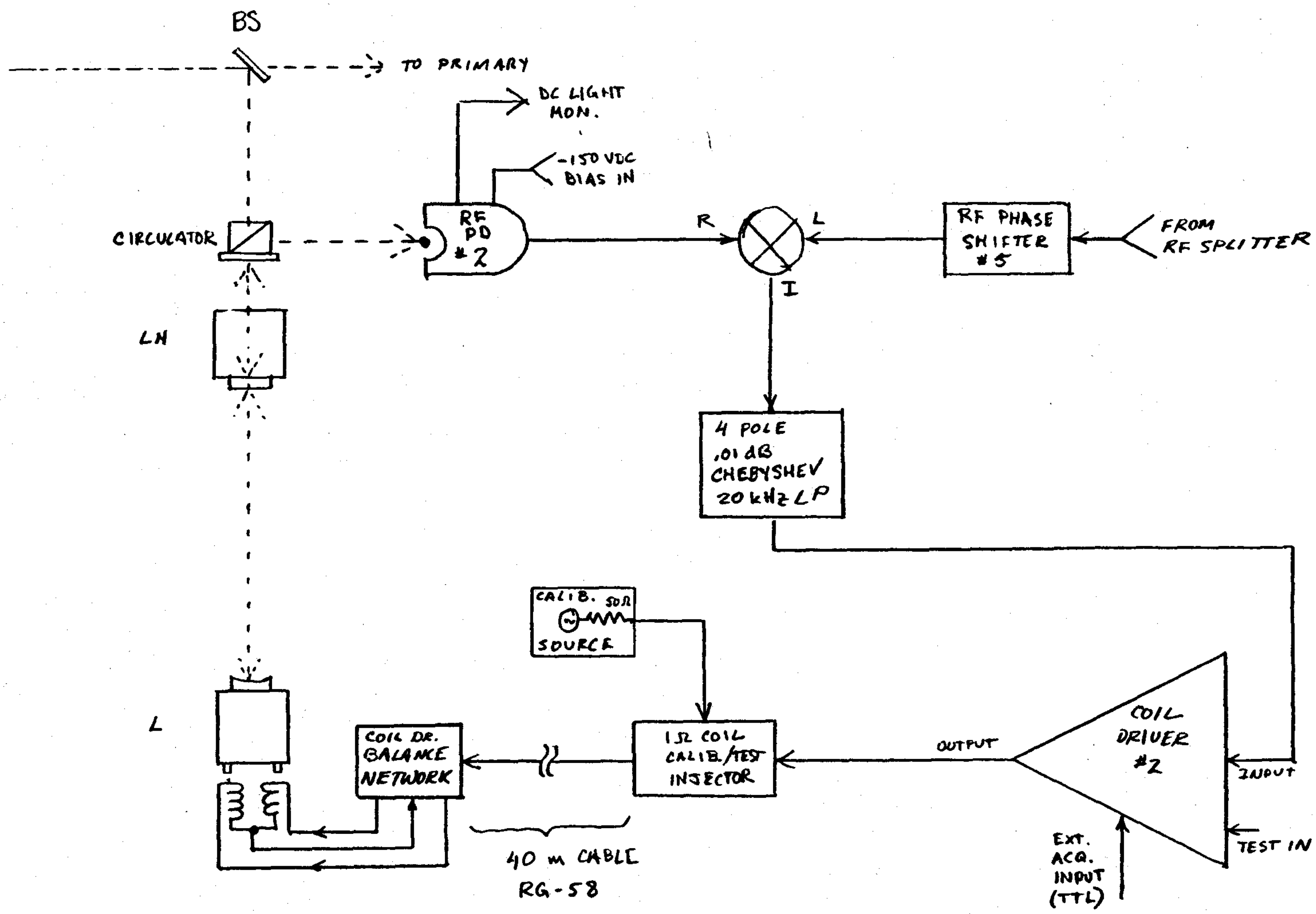


A=30.2 Hz
FREQ RESP
Yb=8.0674 dB
FREQ RESP
300
20.0
Phase
Deg
dB
-60.0
-100
Fxd Y 100m
Log Hz
1k
IN
Hum coil driver
(INVERTING)
Butterworth
OUT
NEW CIRCUIT
MAG
PHASE
phase
20 dB
10 dB
0
-10 dB
-20 dB
-30 dB
-40 dB
-50 dB
-60 dB
250
200
150
100
50
0
-50

G. SECONDARY CAVITY LOOP

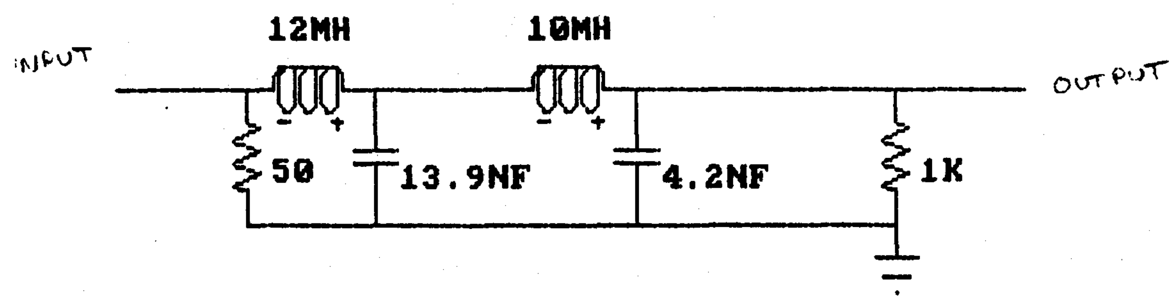
11/20/90 MLZ

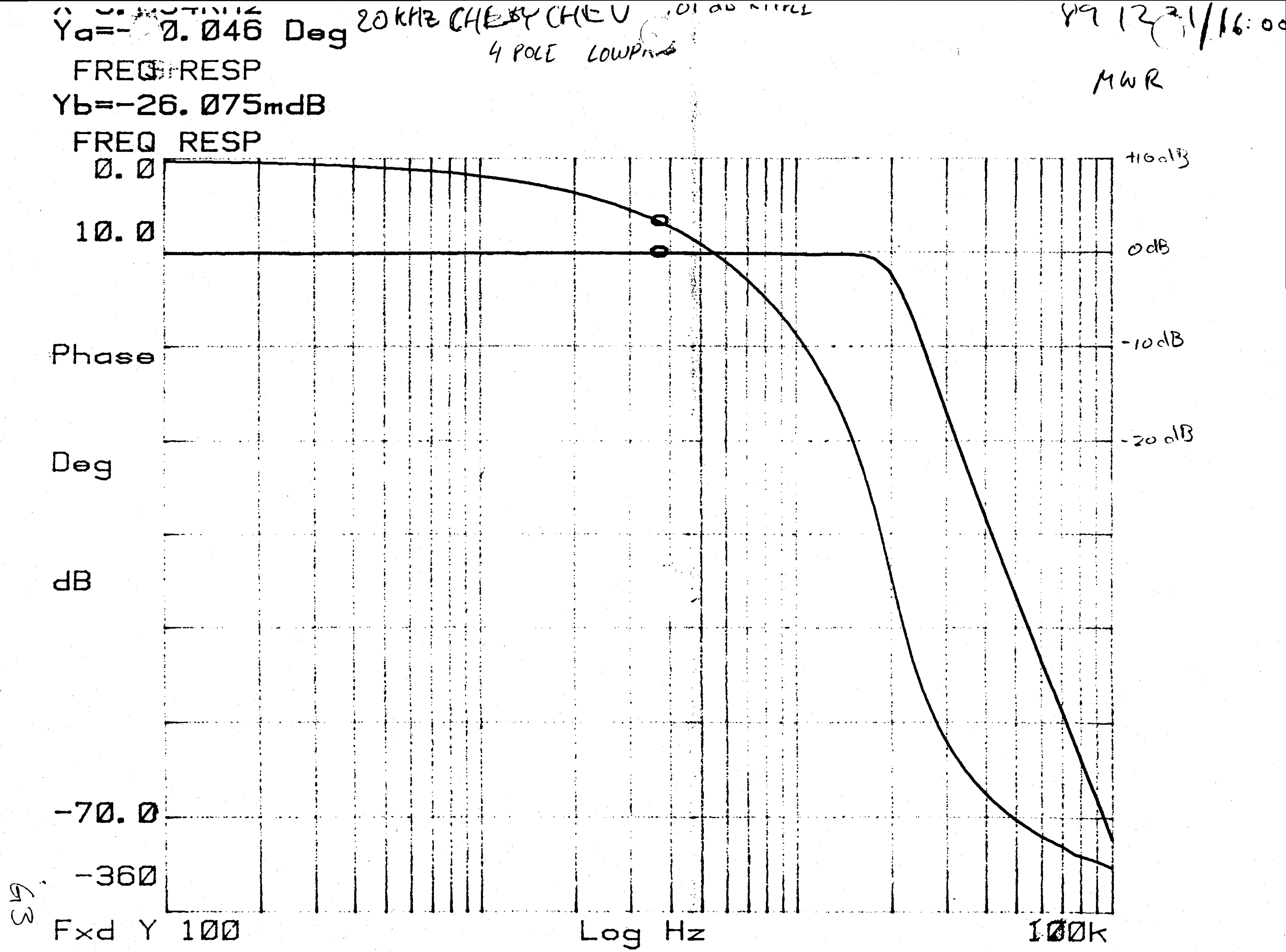
SECONDARY CAVITY LOOP BLOCK DIAGRAM



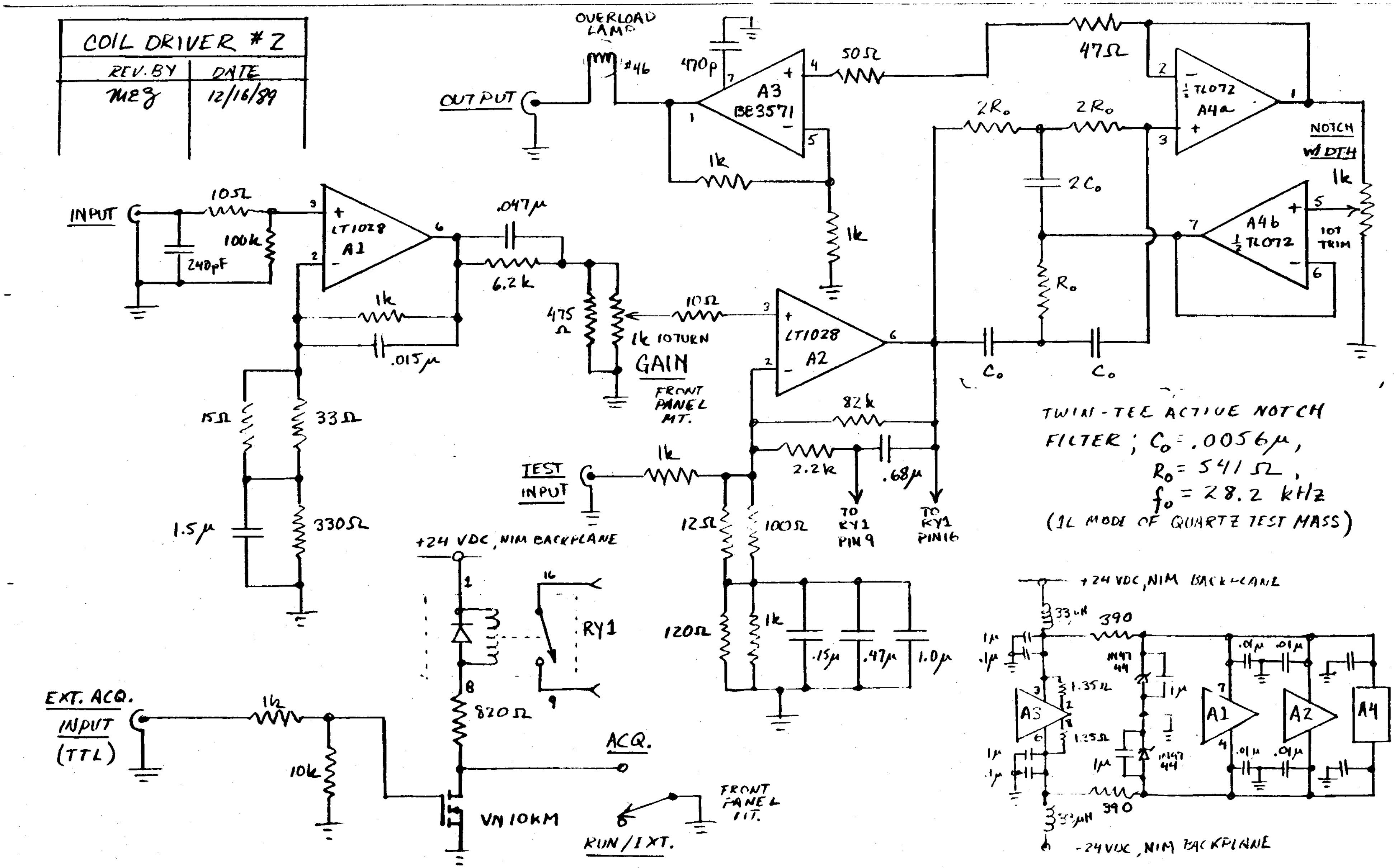
G1

4 POLE CHEBYCHEFF .01 DB 20 KHZ FILTER




Ya=- 0.046 Deg
FREQ RESP
Yb=-26.075mdB
FREQ RESP
20 kHz CHEBYCHEV
4 POLE
MWR
0.0
10.0
Phase
Deg
dB
-70.0
-360
Fxd Y 100
Log Hz
100k
+10dB
0dB
-10dB
-20dB

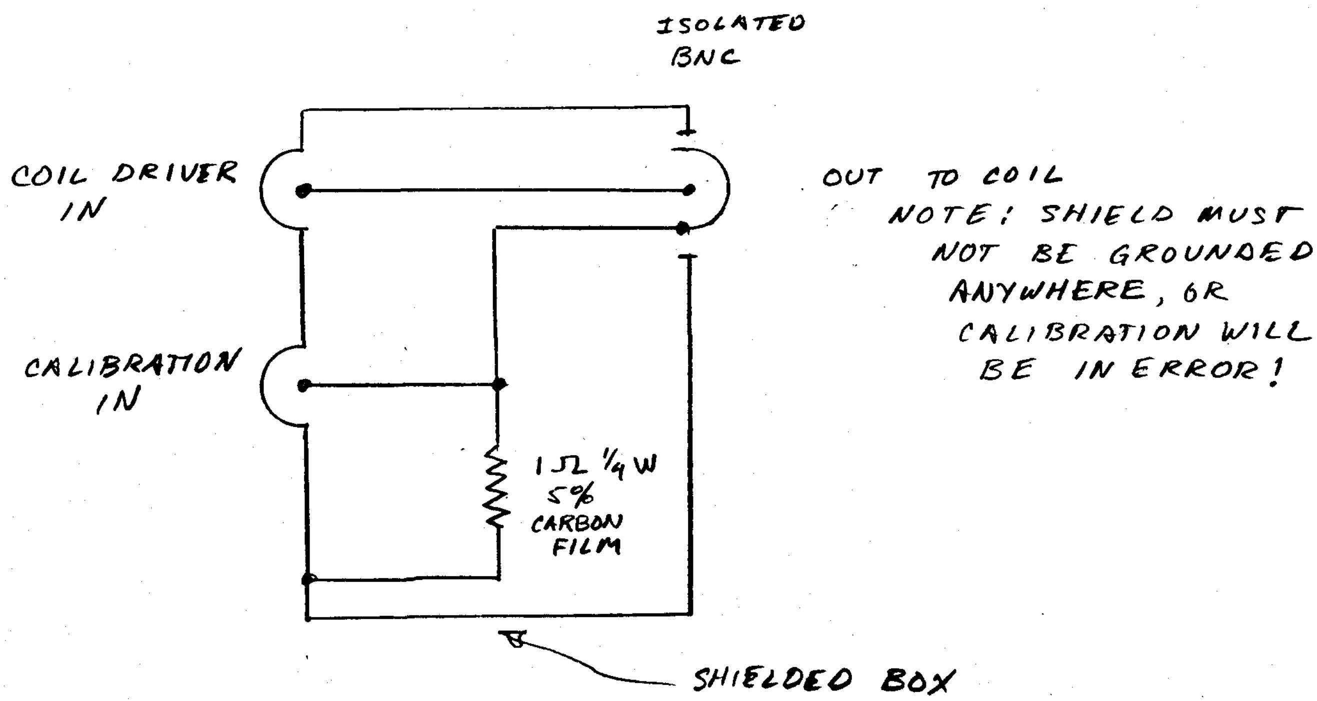
12/16/89 MEJ


COIL DRIVER #2
REV. BY
DATE
MEJ
12/16/89
OVERLOAD LAMP
#46
470p
A3
BE3571
50Ω
47Ω
OUTPUT
1k
1k
½ TL072
A4a
2R₀
2R₀
2C₀
R₀
C₀
C₀
NOTCH WIDTH
1k
A4b
½ TL072
10T TRIM
INPUT
10Ω
240pF
100k
LT1028
A1
.047µ
6.2k
1k
.015µ
15Ω
33Ω
1.5µ
330Ω
475 Ω
1k 10TURN
GAIN
FRONT PANEL MT.
10Ω
LT1028
A2
82k
2.2k
.68µ
TO RY1 PIN 9
TO RY1 PIN 16
TEST INPUT
1k
12Ω
100Ω
120Ω
1k
.15µ
.47µ
1.0µ
TWIN-TEE ACTIVE NOTCH FILTER; C₀ = .0056µ, R₀ = 541Ω, f₀ = 28.2 kHz
(1L MODE OF QUARTZ TEST MASS)
+24 VDC, NIM BACKPLANE
RY1
820Ω
ACQ.
EXT. ACQ. INPUT (TTL)
1k
10k
VN10KM
FRONT PANEL MT.
RUN/EXT.
+24 VDC, NIM BACKPLANE
33µH
390
1.35Ω
1N4744
A3
A1
A2
A4
.01µ
1µ
.1µ
33µH
390
-24VDC, NIM BACKPLANE

10/10/90 MEZ

PRIMARY, SECONDARY CAVITY SERVOS;

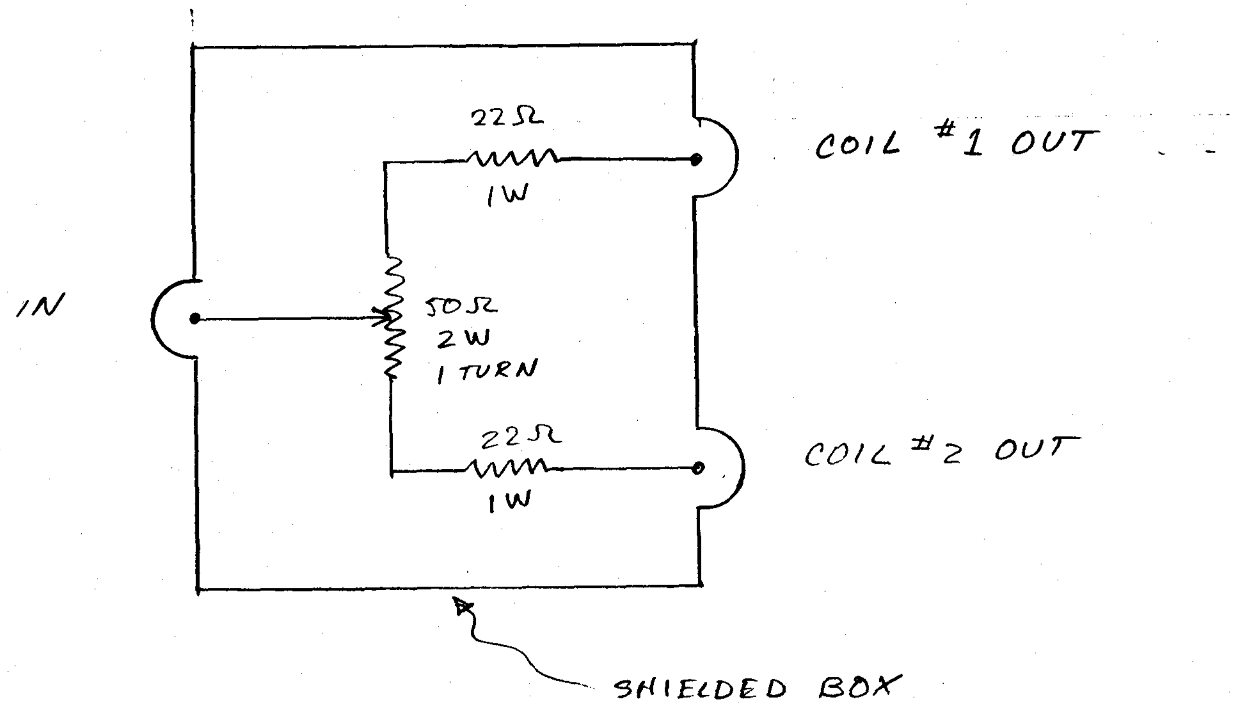
1Ω COIL CALIBRATION/TEST INJECTOR



64

PRIMARY, SECONDARY CAVITY SERVOS;

COIL DRIVE BALANCE NETWORK, END TEST MASS

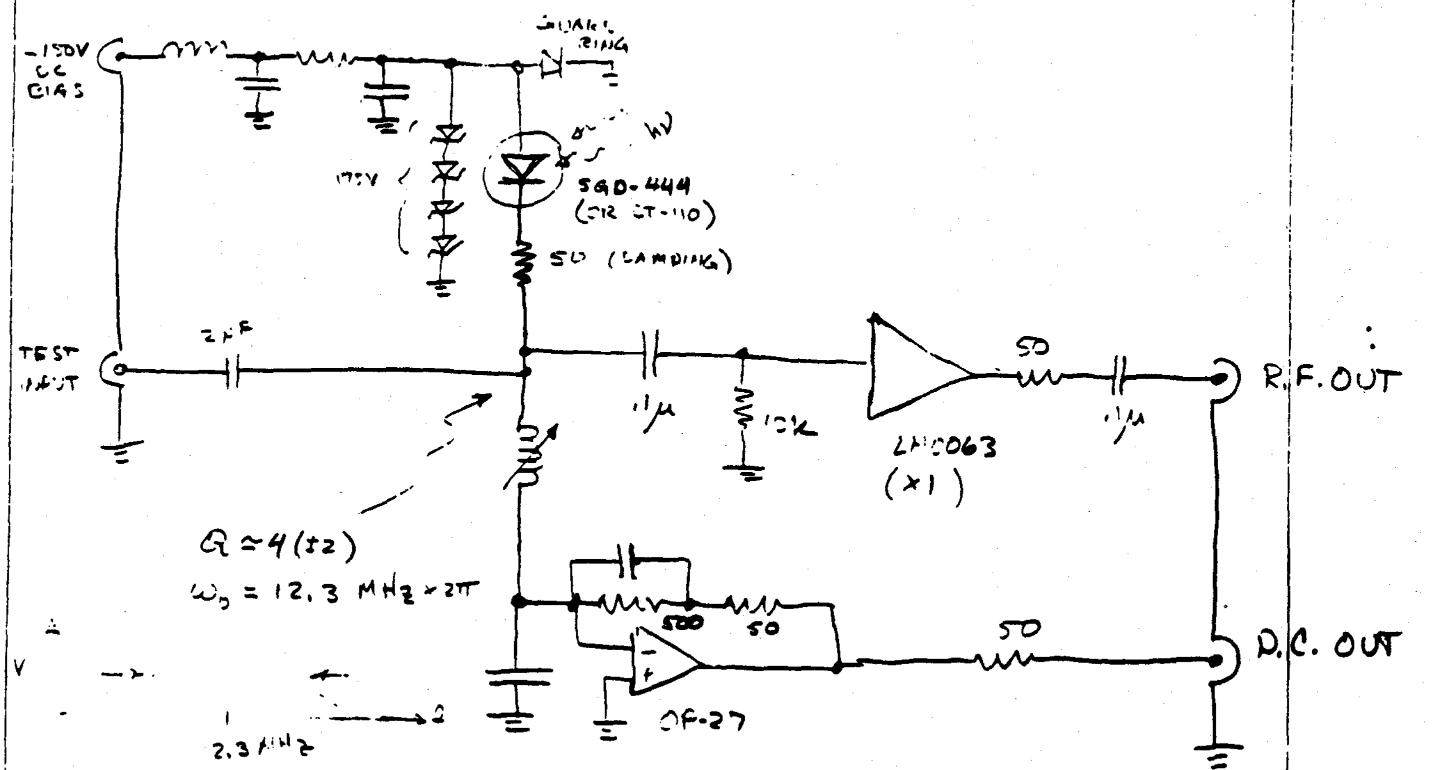


NOTE: SHIELD MUST NOT BE GROUNDED TO ANYTHING

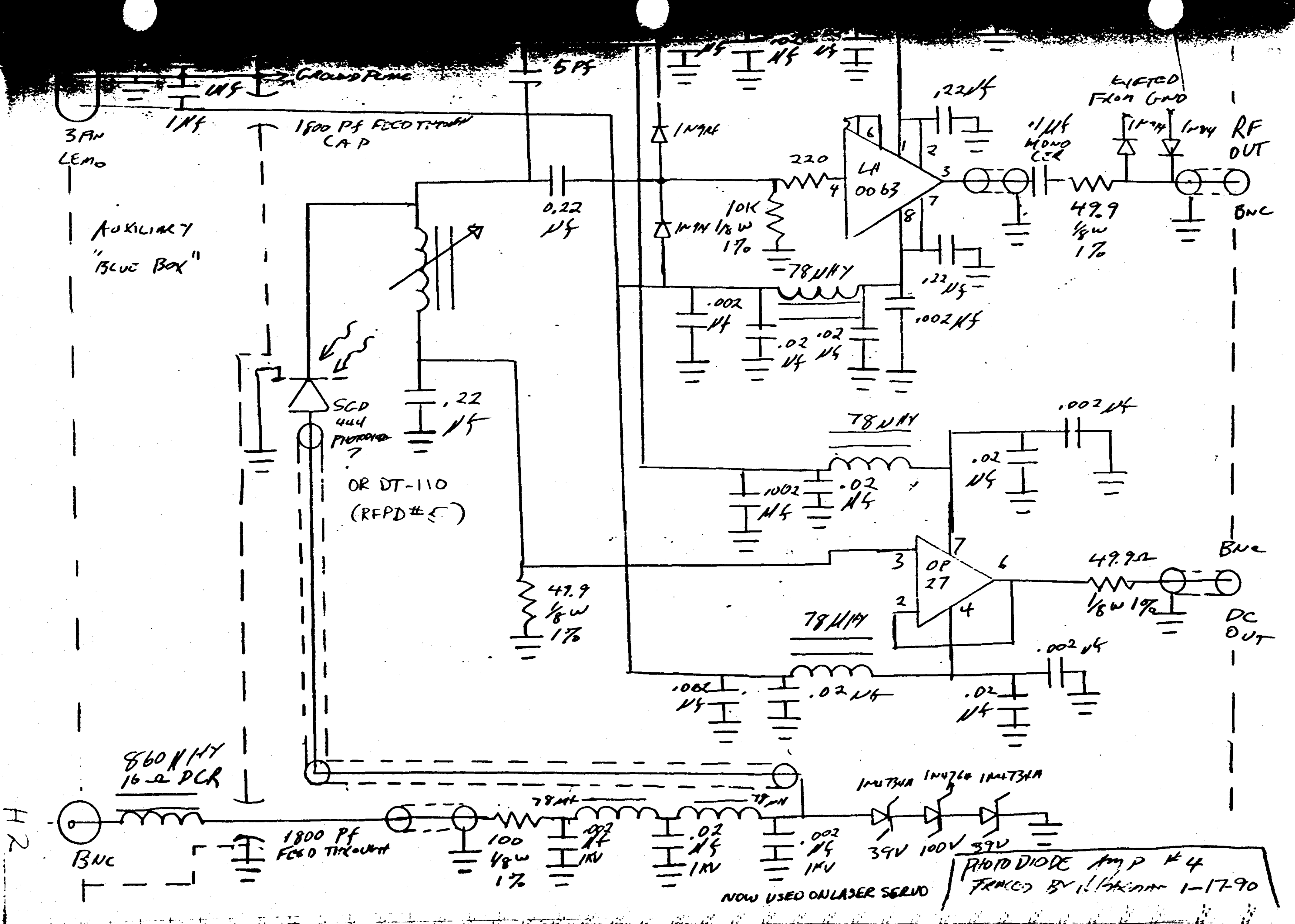
H. PHOTODETECTORS

11/14/88 MEZ

MODE CLEANER SERVO PHOTODIODE / BUFFER
(STANDARD CALTECH FRONT END)



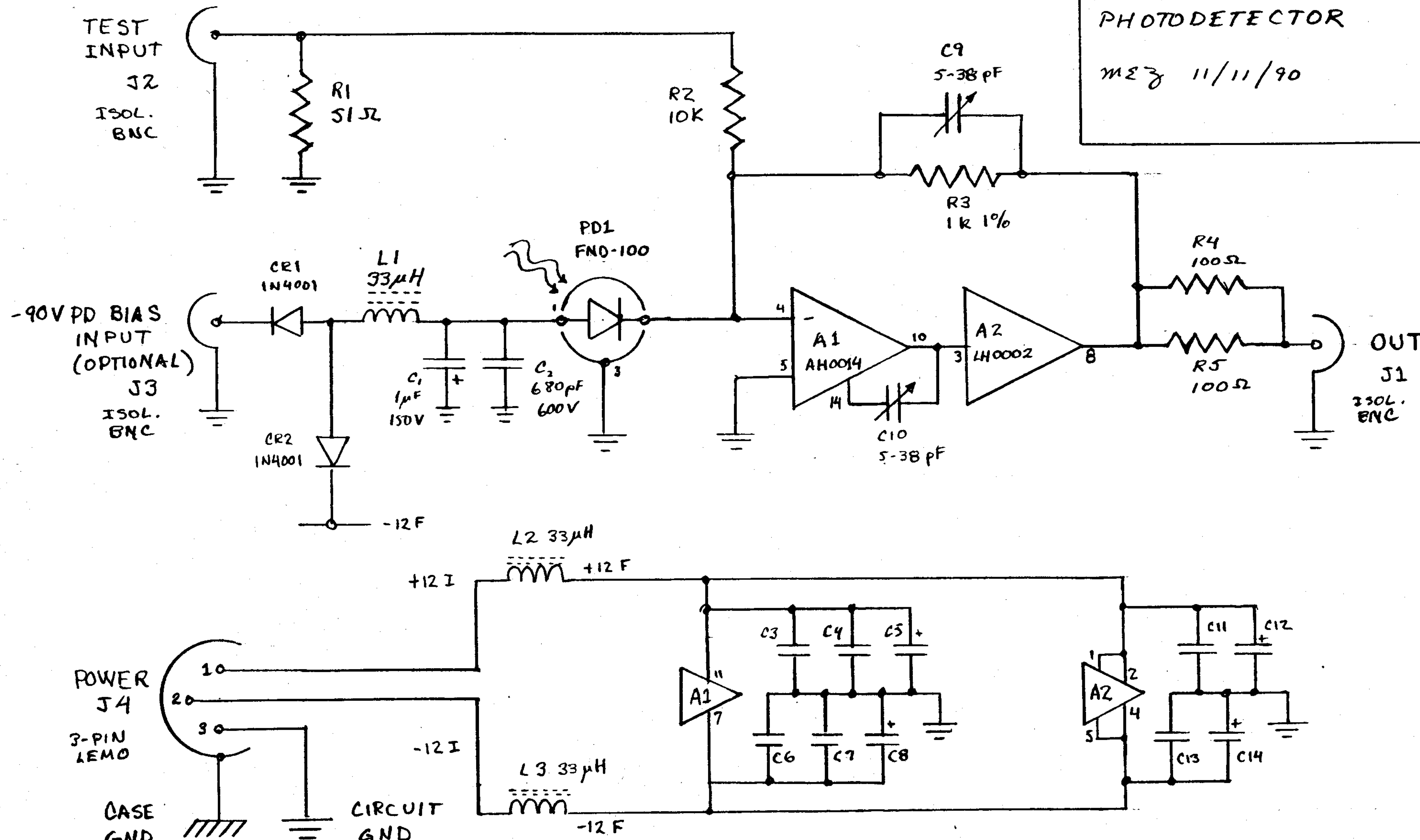
R.F. DARK NOISE ≃ SHOT NOISE AT 1mW, 5145 Å



GROUND PLANE
1 µf
5 pf
.22 µf
3 PIN LEMO
1800 pf FEEDTHROUGH CAP
AUXILIARY "BLUE BOX"
220
LH 0063
.1 µf MONO CER
49.9 1/8W 1%
RF OUT
BNC
10K 1/8W 1%
78 µHY
.002 µf
.02 µf
0.22 µf
SGD 444 PHOTODIODE
OR DT-110 (RFPD #5)
.22 µf
OP 27
49.9Ω 1/8W 1%
DC OUT
49.9 1/8W 1%
860 µHY 16Ω DCR
1800 pf FEED THROUGH
100 1/8W 1%
1KV
39V 100V 39V
NOW USED ON LASER SERVO
PHOTO DIODE AMP #4
1-17-90

RINGDOWN PHOTODETECTOR

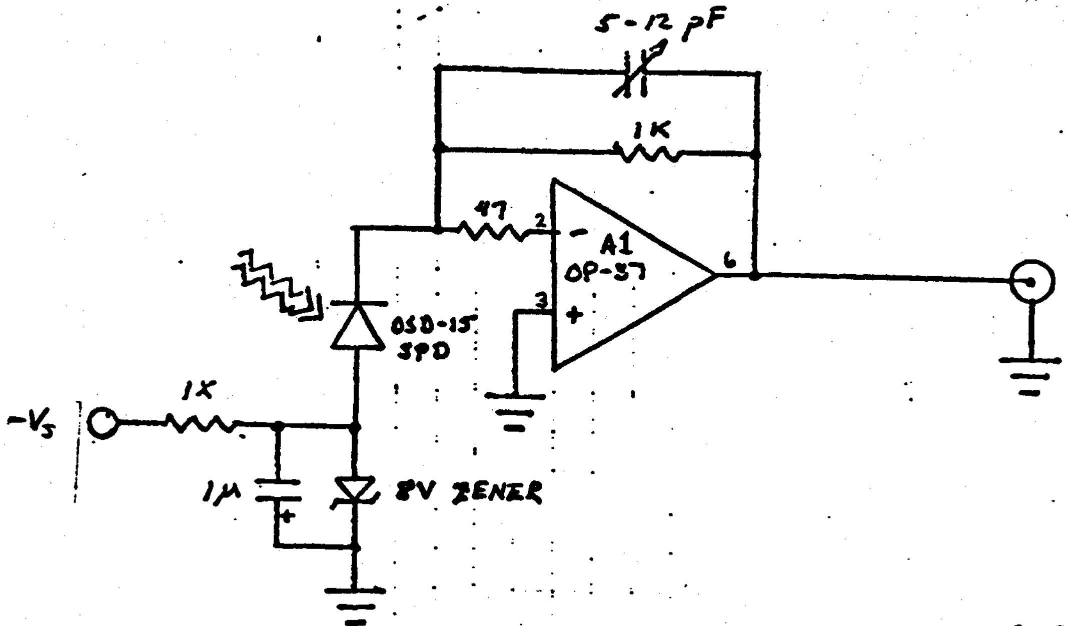
MEZ 11/11/90



C3, C6 = .1µF CERAMIC; C4, C7, C11, C13 = 1µF CERAMIC; C5, C8, C12, C14 = 10µF TANT.

NOISE EATER SENSING DIODE 2/27/85 MEZ

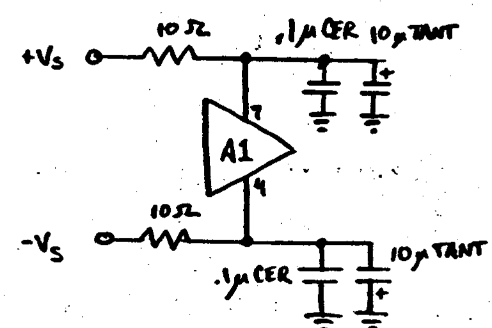
DIODE #73



0.33 V/mW

DARKNOISE ≃ 5 nV/√Hz (TYP.)

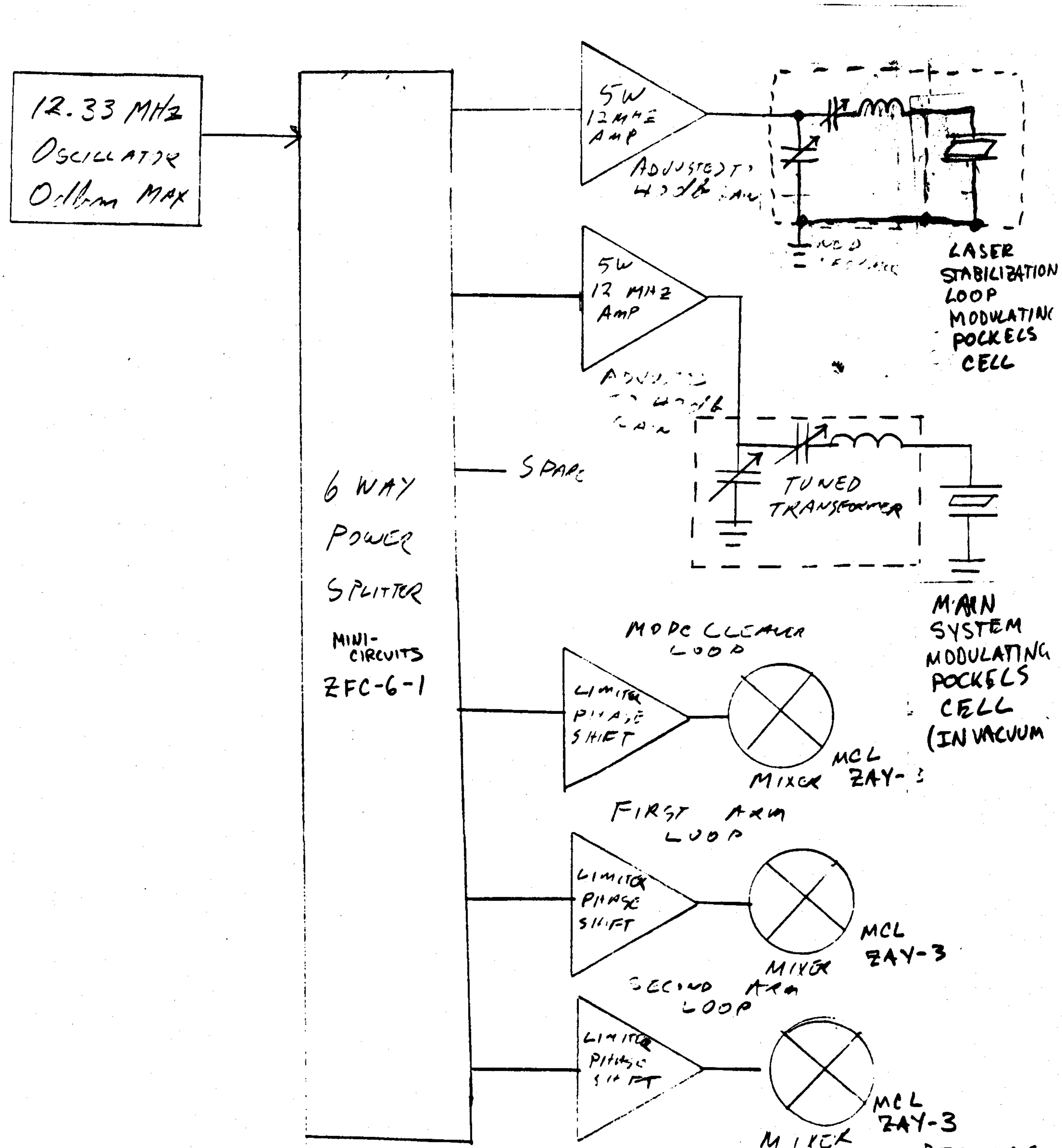
SUPPLY DECOUPLING



I. RF MODULATION

12 MHz RF DISTRIBUTION

REV.
10/10/90 MEZ



DEC 29, ?

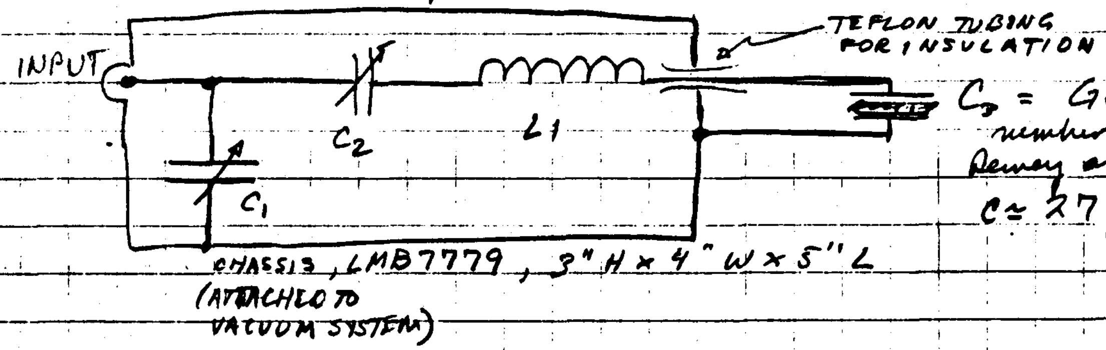
J. H. [illegible]

I1

11/21/89 cont'd

After much effort, arrived at the following ferrite-less design for the RF stepup network

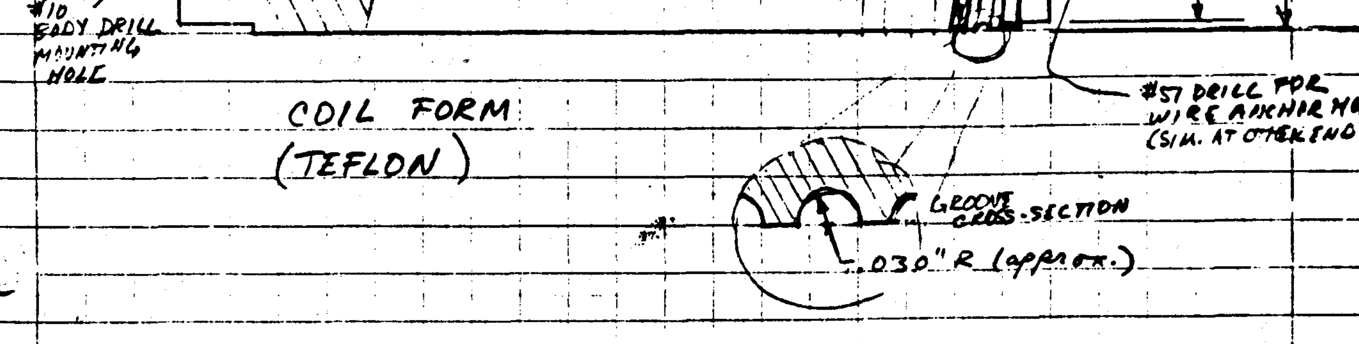
Electronic Diagram of New RF Stepup Network



C_1 = 50-500 pF air variable, 3 gangs in ∥, about 1½" H × 2" W × 3" L (surplus, same as in old circuit but cleaned ultrasonically in strong detergent to remove grease, then in Methanol)

C_2 = 10-120 pF air variable tuning cap, about 1" H × 7/8" W × 1½" L (surplus, also cleaned as above)

L_1 = 20½ turns of a 48-turn coil of #14 gauge bare copper wire (stripped ordinary AC power wire) wound in a .032" deep semicircular cross-section groove cut at a pitch of 12 threads per inch into a 1.25" O.D. Teflon rod 4.5" long;

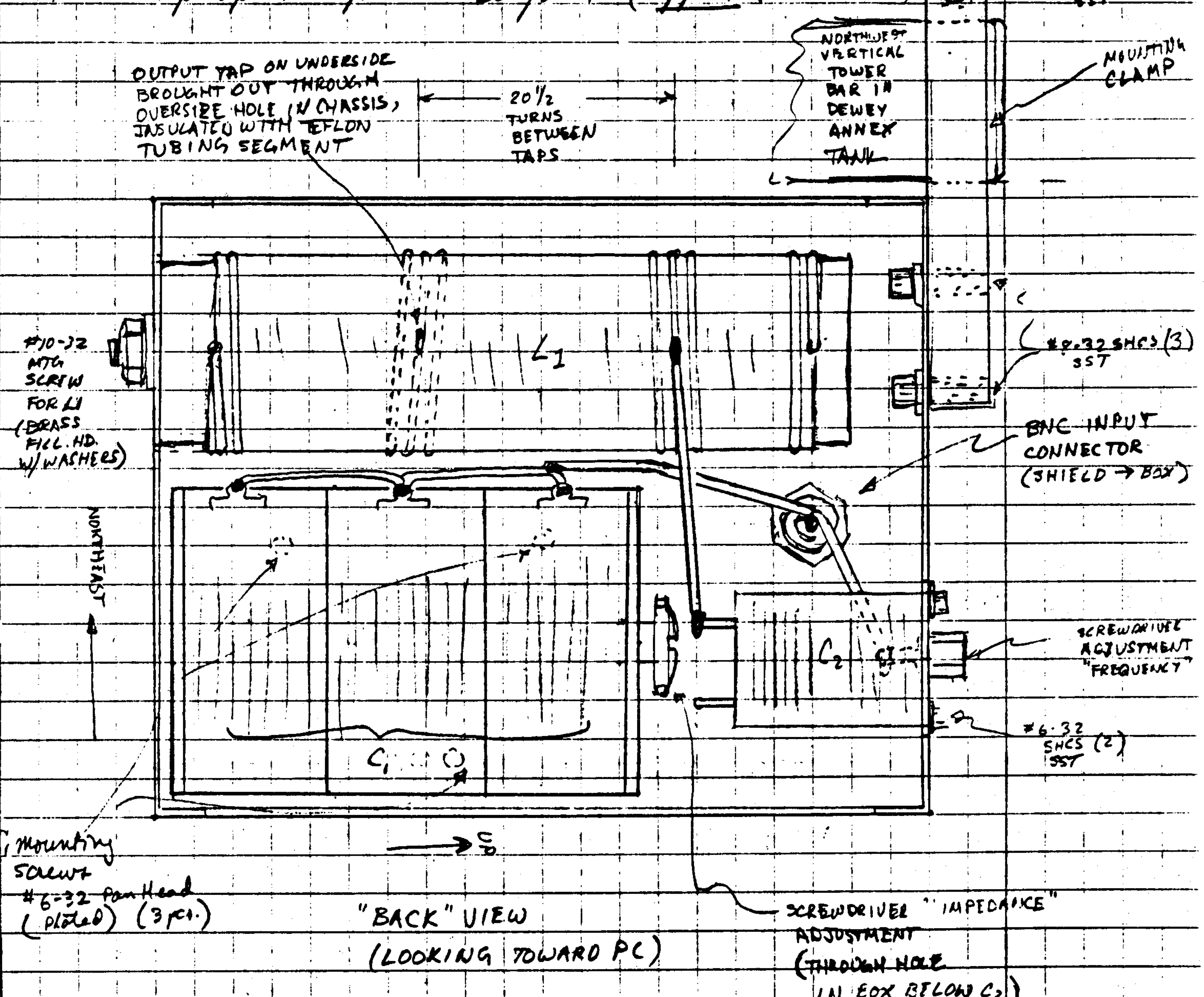


COIL FORM (TEFLON)

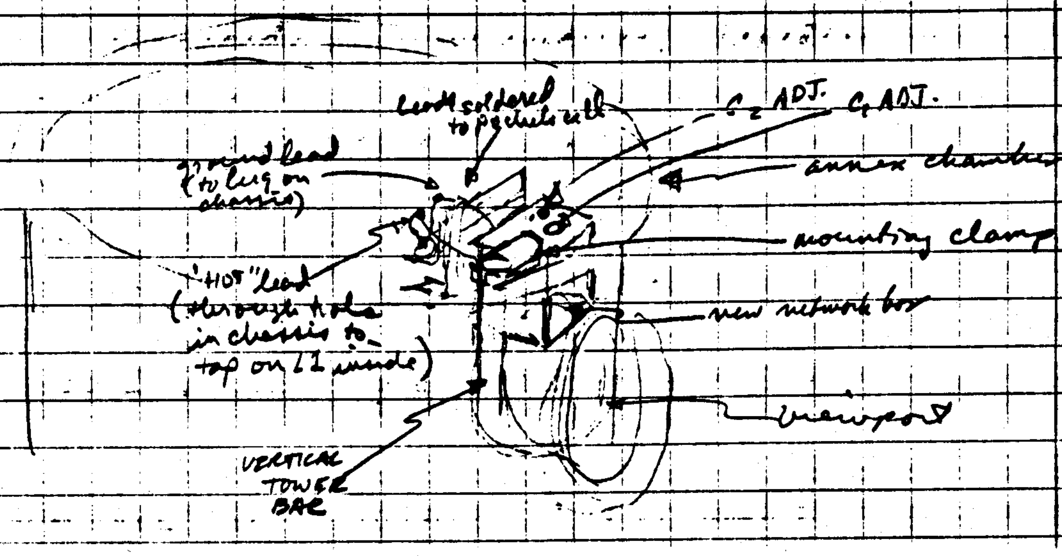
I2

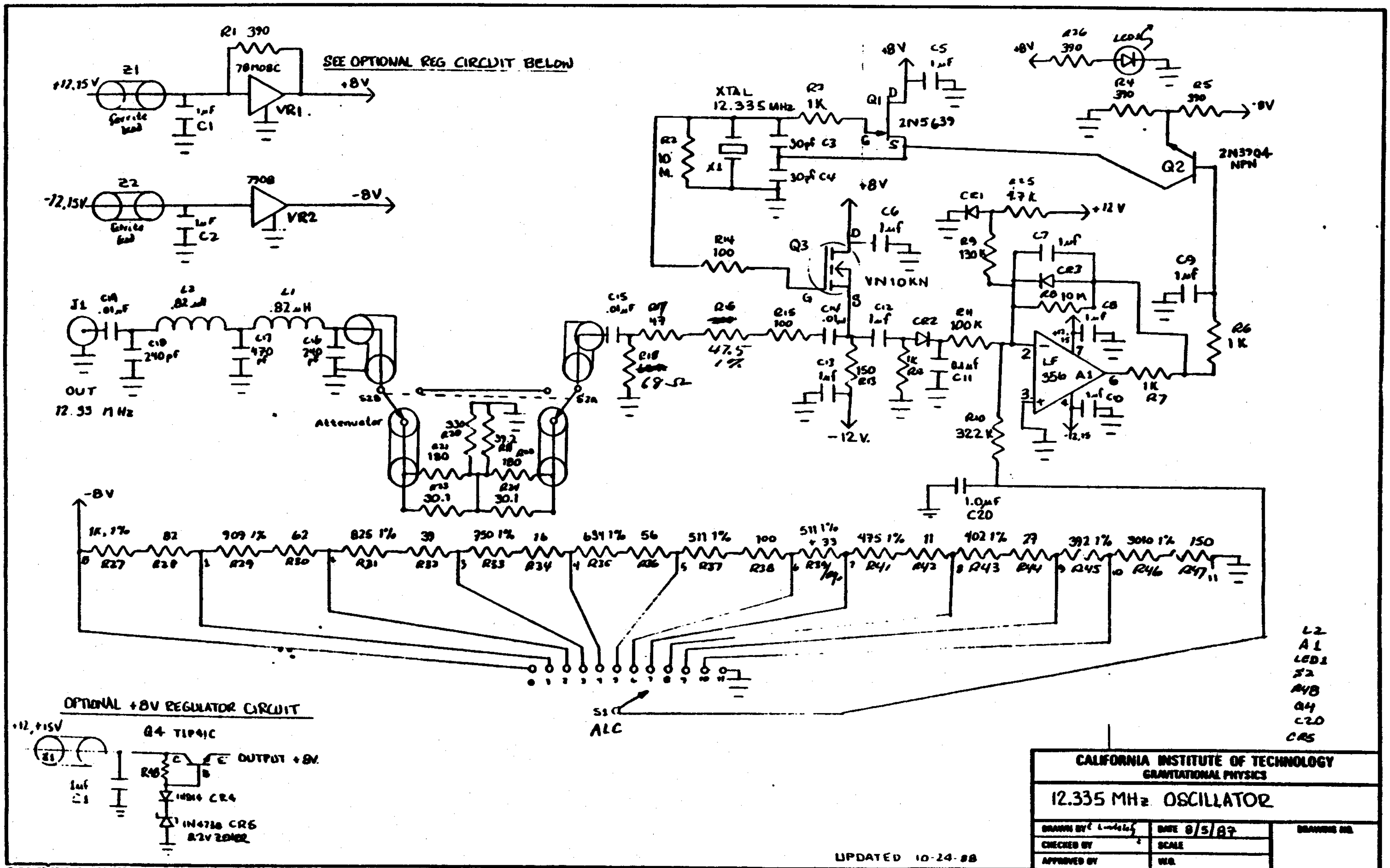
11/21/89

New step-up transformer layout (approx. 1:1 scale)

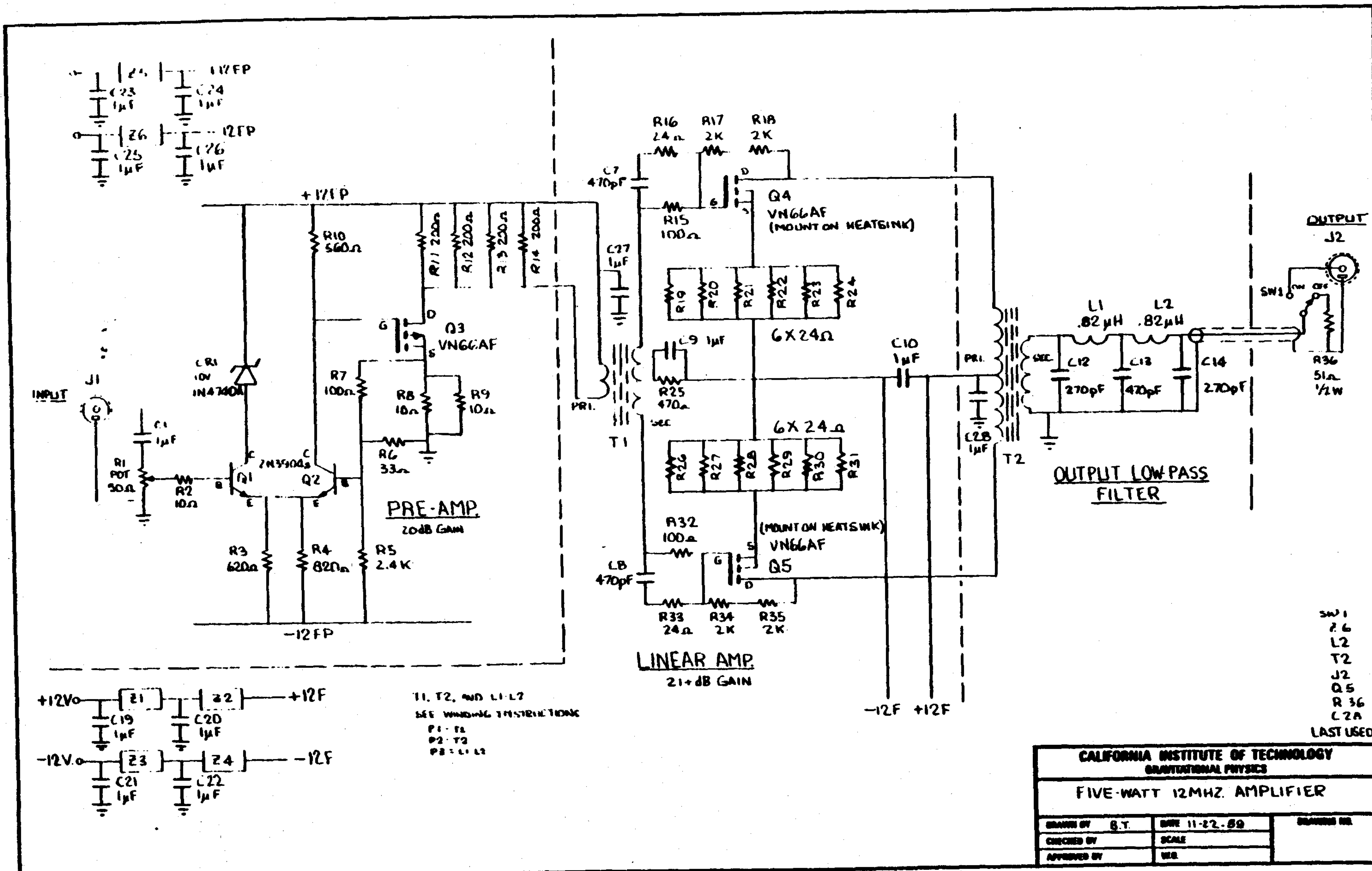


"BACK" VIEW
(LOOKING TOWARD PC)



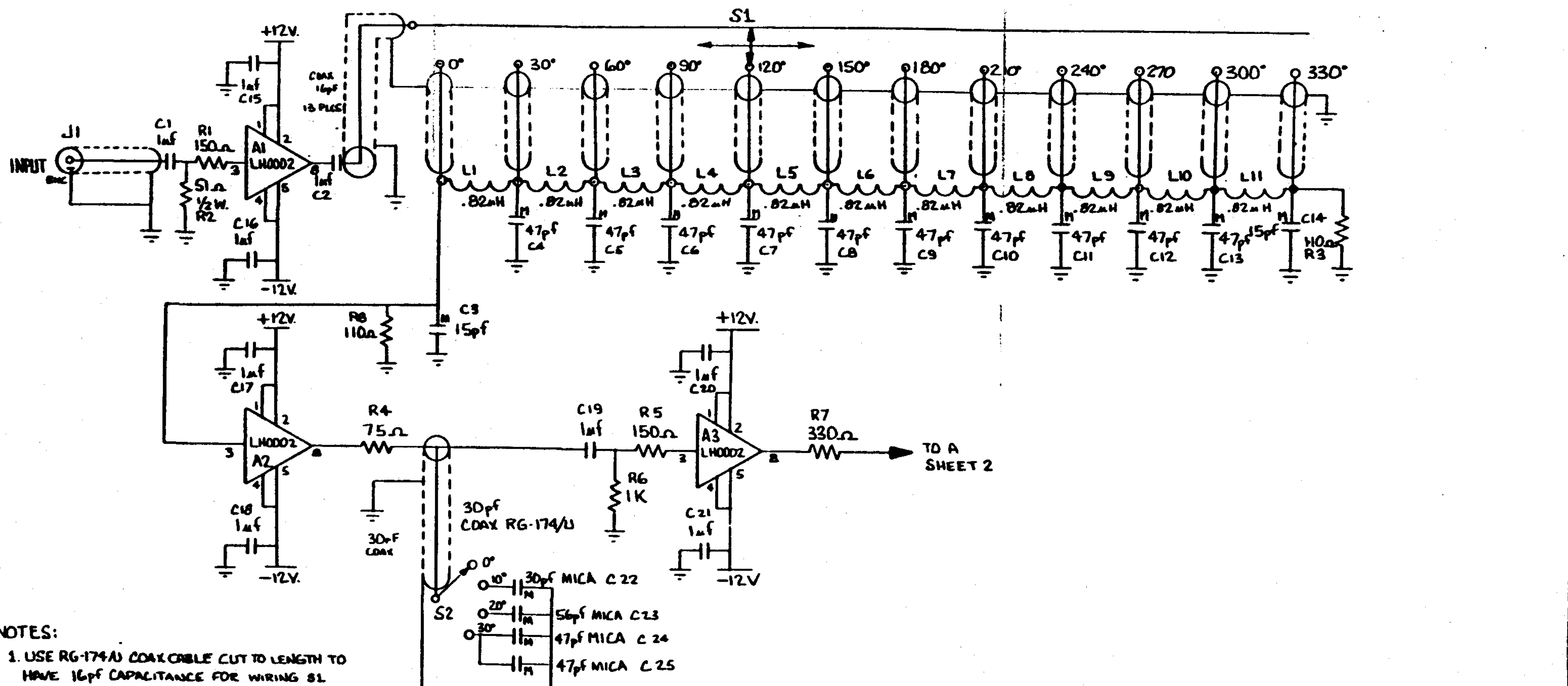

SEE OPTIONAL REG CIRCUIT BELOW
R1 390
78M08C
VR1
+8V
Z1
C1
Z2
C2
7908
VR2
-8V
XTAL
12.335 MHz
R3 1K
Q1
2N5639
C3
C4
R2 10 M
X1
Q2
2N3904 NPN
R4 390
R5 390
R36 390
LED1
Q3
VN10KN
R14 100
C6
CR1
R9 130K
C7
CR3
R8 10M
C8
C9
R6 1K
LF 356 A1
R7 1K
CR2
R11 100K
C11
C10
R10 322K
C20 1.0µF
-12 V.
+12 V
J1
OUT 12.335 MHz
L1 .82µH
L2 .82µH
Attenuator
S2A
S2B
R18 68 Ω
R17 47
R16 47.5 1%
R15 100
R13 150
R27
R28
R29
R30
R31
R32
R33
R34
R35
R36
R37
R38
R39
R41
R42
R43
R44
R45
R46
R47
S1
ALC
OPTIONAL +8V REGULATOR CIRCUIT
Q4 TIP41C
OUTPUT +8V
CR4
1N4738 CR6
8.2V ZENER
UPDATED 10-24-88
CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS
12.335 MHz OSCILLATOR
DRAWN BY
DATE 8/5/87
DRAWING NO.
CHECKED BY
SCALE
APPROVED BY
W.O.

87-0805-1


+12FP
-12FP
C23 1µF
C24 1µF
C25 1µF
C26 1µF
Z6
+12FP
INPUT
J1
C1 1µF
R1 POT 50Ω
R2 10Ω
Q1
Q2
2N3904s
CR1 10V 1N4740A
R10 560Ω
R11 220Ω
R12 220Ω
R13 220Ω
R14 220Ω
Q3 VN66AF
R7 100Ω
R8 10Ω
R9 10Ω
R6 33Ω
R3 620Ω
R4 820Ω
R5 2.4K
PRE-AMP.
20dB GAIN
R16 24Ω
R17 2K
R18 2K
C7 470pF
R15 100Ω
Q4
VN66AF
(MOUNT ON HEATSINK)
C27 1µF
R19
R20
R21
R22
R23
R24
6X24Ω
C9 1µF
R25 470Ω
PRI.
SEC
T1
6X24Ω
R26
R27
R28
R29
R30
R31
R32 100Ω
(MOUNT ON HEATSINK)
VN66AF
Q5
C8 470pF
R33 24Ω
R34 2K
R35 2K
LINEAR AMP.
21+dB GAIN
C10 1µF
-12F
+12F
PRI.
C28 1µF
T2
SEC.
L1 .82µH
L2 .82µH
C12 270pF
C13 470pF
C14 270pF
OUTPUT LOW-PASS FILTER
OUTPUT
J2
SW1
R36 51Ω 1/2W
+12V
Z1
Z2
+12F
C19 1µF
C20 1µF
-12V
Z3
Z4
-12F
C21 1µF
C22 1µF
T1, T2, AND L1-L2
SEE WINDING INSTRUCTIONS
SW1
Z6
L2
T2
J2
Q5
R36
C28
LAST USED
CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS
FIVE-WATT 12MHZ AMPLIFIER
DRAWN BY B.T.
DATE 11-22-89
CHECKED BY
SCALE
APPROVED BY
DRAWING NO.

89-1122-1

45



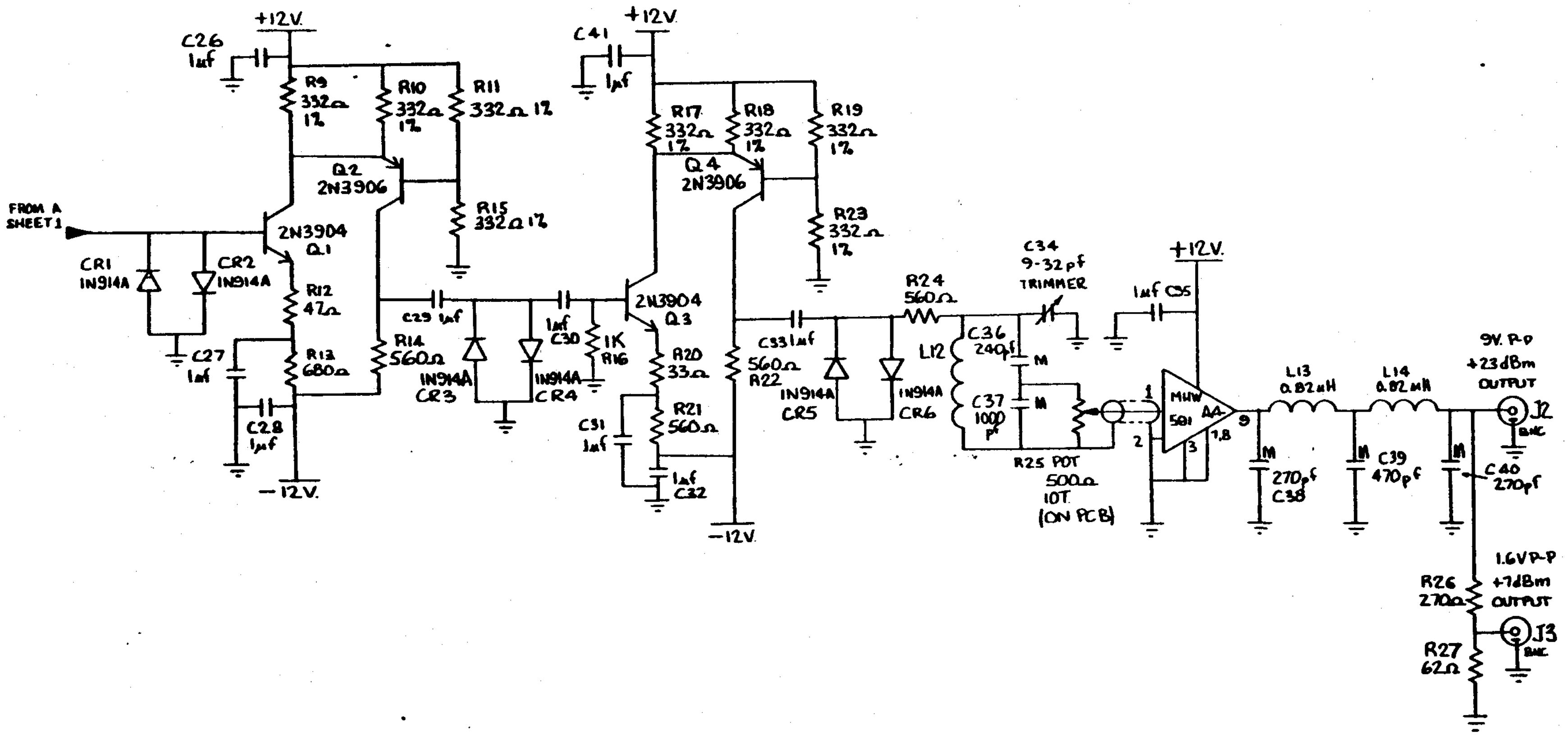
NOTES:

1. USE RG-174/U COAX CABLE CUT TO LENGTH TO HAVE 16pf CAPACITANCE FOR WIRING S1 FROM TERMINALS TO IND. 0.82uH
2. COAX FROM 75Ω/1uf NODE (OUTPUT OF A2) TO S2 WILL BE CUT TO A LENGTH TO HAVE A 30pf CAPACITANCE. DRESS COAX AWAY FROM COMPONENTS ON P.C.B.
3. GND ALL COAX FROM ISO-BNC ON FRONT PANEL TO P.C. CARD GND PLANE.

I6

CALIFORNIA INSTITUTE OF TECHNOLOGY GRAVITATIONAL PHYSICS		
12.33 MHZ. LIMITER PHASE SHIFTER SHEET 1		
DRAWN BY B.T.	DATE 11-6-87	DRAWING NO.
CHECKED BY	SCALE NONE	-1
APPROVED BY	W.O.	

87-1106-1



A4
Q4
J3
L14
CR6
C40
LAST NO. USED R27

CALIFORNIA INSTITUTE OF TECHNOLOGY
GRAVITATIONAL PHYSICS

12.33 MHZ. LIMITER PHASE SHIFTER
SHEET 2

DRAWN BY B.T.	DATE 11-6-87	DRAWING NO.
CHECKED BY	SCALE	-2
APPROVED BY	W.O.	

17

87-1106-2