End Mass #2 Damping Electronics 1983 January 18 to 1984 August 1

Society Note Book

The Coop

2739Q

END MASS #2

DAMPING ELECTRONICS

EM2

the coop

1882 — A Century of Service — 1982

Name _____

_____

$1.30

"This book is made with 20lb. paper"

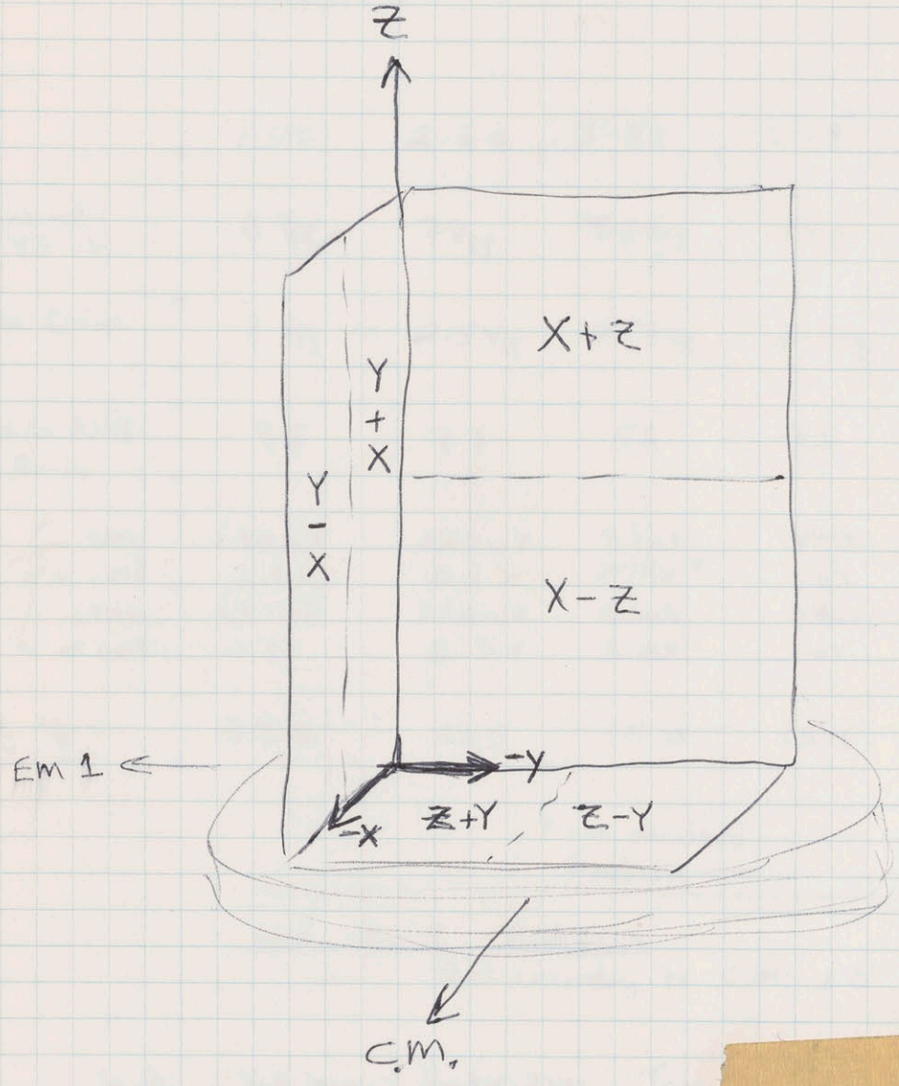
END MASS #2 NIM SLOTS:

1/18/83

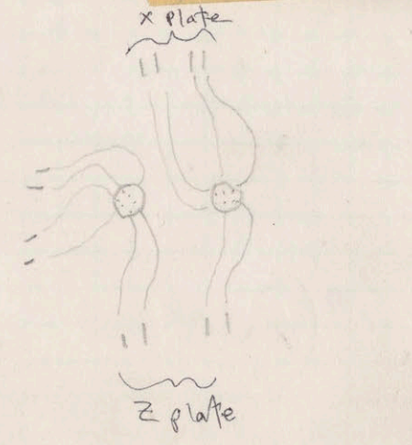
1.00 MHz BRIDGE X-Z	DRIVE
X-Z HV AMP X+Z	DRIVE
2.60 MHz BRIDGE X+Z	DRIVE
3.90 MHz BRIDGE Y+X	MATRIX BOX
Y-X HV AMP Y+X	
5.18 MHz BRIDGE Y-X	
6.31 MHz BRIDGE Z-Y	DRIVE
Z-Y HV AMP Z+Y	DRIVE
7.52 MHz BRIDGE Z+Y	DRIVE

E. M. 2 CAGE PLATE DESIGNATIONS:

1/18/83



EM2



Top view of feedthrough breakout

1/24/83

End Mass IB Driver Boards

Tested and Aligned as in EM Notebook p 4

Results:

	1.00	2.60	3.90	5.18	6.31	7.52
Drive into 47-2	6 V_{pp}	7 V_{pp}	4.5 V_{pp}	7 V_{pp}	7.5 V_{pp}	7 V_{pp}
Mixer Drive	3 V_{pp}	2.5 V_{pp}	2.7 V_{pp}	2.5 V_{pp}	2.5 V_{pp}	2.5 V_{pp}
RF IN to RF TP Gain	95	79	56	83	25	41 ♯
1 V_{pp} @ RF TP to: CMO	130 mV	125 mV	85 mV	60 mV	45 mV	30 mV
C Loop	3.4 V	2.9 V	>14 V *	1.5 V	1.05 V	0.77 V
-CMO	130 mV	120 mV	80 mV	44 mV	45 mV	25 mV
-C Loop	3.3 V	2.9 V	2.2 V	1.0 V	1.1 V	0.70 V
a eqvlv. (C Loop)	38.8	31.0	15.0	15.6	3.5	3.9

* non standard feedback

♯ 27 μH Input Filter L's

HV AMP BOARDS

1/24/83

Test according to C.M. p 5 :

Unit	Vout max	Vin for 2 V_{pp}	Trise	Tfall	Quiescent Current (500 V each output No AC)
Z+Y	8.4 V	7 V_{pp}	6 ms	1.5 ms	7.0 mA
Z-Y	8.0 V	7 V_{pp}	6 ms	2.0 ms	
Y+X	7.8 V	7.5 V_{pp}	6.5 ms	2.5 ms	7.2 mA
Y-X	7.8 V	7.3 V_{pp}	6.5 ms	5.5 ms	
X+Z	8.2 V	6.8 V_{pp}	6.5 ms	2.0 ms	7.0 mA
X-Z	8.2 V	7.0 V_{pp}	6.5 ms	2.0 ms	

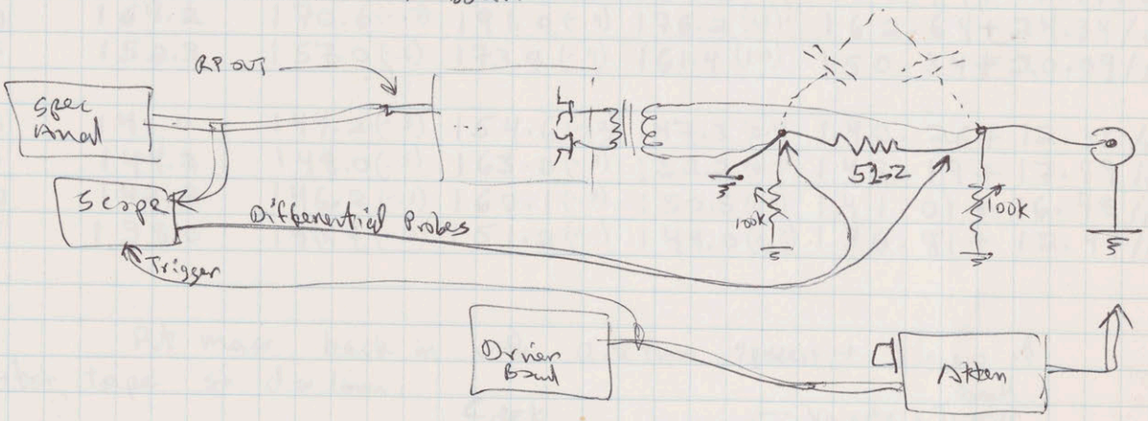
2/10/82

Bridge Boards

- Set 2 Bals as described in CM p6
- All units in 180° FB mode
- Checked Power Supplies
- Set C and Z mon values (+5V, -7V) and check X FB → X MON has gain of -1.

- Set FET bias and ~~GAIN~~ BAL controls so we have -3.5 V on the FET side of 2K's resistors.

- Put 51Ω resistors in boards:



Unit	Diff scope in, mVpp	Into scope only → RF OUT, VIS	G	Noise into 100KHz BW into 50Ω only dBm	nV/√	÷ G/2 → FET ~~GAIN~~ nV/√
1.00	6mV	2.6	433	-66.2	,347	1.60
2.60	6.5mV	2.05	315	-70.5	,201	1.34
3.90	12.5mV	2.3	184	-74.5	,133	1.45
5.19	1.6mV	1.63	1019	-59.5	,750	1.47
6.31	5.5mV	1.2	218	-72.2	,173	1.60
7.50	4.0mV	1.05	262	-72.0	,178	1.36

Install Filters between bridge transformer and first FET stage. Values & components as in CM p13.

Differences from CM p13 values:

2.60 : L_V = #18 C_V = 1500pf
6.31 : L_M = #39 C_M = 15pf

2/16/83

Capacities vs. Distance in mm
(includes standard cable) (← 58pf)

PLATE	C(∞)	C(3.36)	C(0.87)	C(1.66)	C(d)
X-ZS	177.0	188.7 (-1.3)	225.0 (-0.7)	198.6 (+2.0)	174.51 + 43.32/d
X+ZD	211.0	224.0 (-0.9)	265.5 (-.5)	236.7 (1.4)	208.44 + 49.23/d
X-ZD	194.5	207.0 (-1.2)	252.0 (-.6)	220.2 (1.8)	189.86 + 53.50/d
X+ZS	192.0	204.0 (-1.0)	240.0 (+0.5)	214.5 (1.5)	190.26 + 42.88/d
Y+XS	154.2	157.9 (-.3)	171.5 (-0.2)	162.0 (0.5)	152.77 + 16.14/d
Y+XD	170.0	175.4 (-.6)	194.0 (-.3)	180.6 (+0.9)	168.19 + 22.17/d
Y-XD	164.2	170.6 (-.7)	191.0 (-.4)	176.2 (1.1)	162.64 + 24.34/d
Y-XS	152.3	157.0 (-.6)	173.8 (-.4)	161.4 (1.0)	150.34 + 20.09/d
Z-YS	141.0	144.2 (-.3)	154.6 (-.2)	147.3 (0.4)	140.26 + 12.35/d
Z+YD	144.3	148.0 (-.5)	163.0 (-.3)	152.2 (0.7)	142.19 + 17.89/d
Z-YD	142.3	146.2 (-.3)	160.1 (-.2)	150.5 (0.4)	141.01 + 16.48/d
Z+YS	138.0	140.7 (-.2)	151.2 (-.1)	144.0 (0.3)	136.81 + 12.44/d

Put mass back in with 0.87mm spacers + 3 layers of scotch tape so d ≈ 1mm.

	PLATE	Theory C(1mm)	Exp. C(1mm)	Cdet Theory − 58pf	← Varactor + small Trimmer −48.6pf	−47pf	extra cap for X units
1.00	X-ZS	217.83	219.0	159.83	111.33	64.33	
	X+ZD	257.67	260.0	199.67			
	X-ZD	243.36	244.5	185.36			
2.60	X+ZS	233.14	234.0	175.14	126.64	79.64	
3.90	Y+XS	168.91	168.5	110.91	62.41		
	Y+XD	190.36	190.6	132.36			
	Y-XD	186.98	187.7	128.98			
5.18	Y-XS	170.43	171.5	112.43	63.93		
6.31	Z-YS	152.61	153.0	94.61	46.11		
	Z+YD	160.08	161.0	102.08			
	Z-YD	157.49	158.2	99.49			
7.52	Z+YS	149.25	150.0	91.25	42.75		

To do to bridge boards:
- Put in 120pf Caps
- Put 47pf Caps in X axis
- Set Trimer Cap 3½ turns out.
- Put in L-Ring - approx as given p8 in CM.
- Put on Fake Cdet and peak Bridge drive
- Peak up input filters - measure VAPERTOUT/Vcmon ... + output Noise

a=1 :

Freqv	V_B^{pp}	C_{det}(mm)	$\frac{dV_{pp}}{dV_{cmon}}$	V_{pp} measured	Theory Gain into 50Ω	Noise into 50Ω	
1.00	(43) 57	159.83	33.1	6.45	195	1290 nV/√	13.0
2.60	(50) 63	175.14	32.9	8.33	253	727 nV/√	5.7
3.90	(31) 40	140.91	34.1	4.00	117	230 nV/√	3.9
5.18	(34) 50 (50)	112.43	42.1	23.08 23.08	548 548	1828 nV/√ 1623	6.9 6.0
6.31	(24) 40	94.61	39.5	5.00	127	408 nV/√	6.4
7.52	(19) 30	91.25	30.6	4.35	142	364 nV/√	5.1

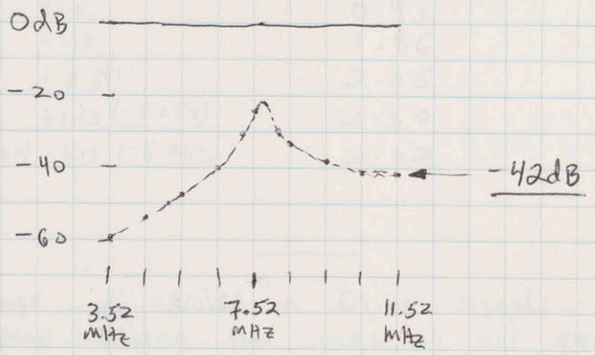
2/23/82 New V_B^{pp} see p 8+9

$$\frac{dV_{pp}^{RFOUT}}{dV_{cmON}} = \frac{V_B^{pp}}{\left(1+\frac{C_{det}}{C_B}\right)(C_B+C_{det})} \cdot \frac{\frac{dC_v}{dV_r}}{\left(1+\frac{C_v}{C_s}\right)^2} \leftarrow \frac{1}{2\text{-}64} \text{ for } \begin{matrix} C_s = 47pf \\ CV1666 @ 5V \end{matrix}$$

$C_B = 120pf$

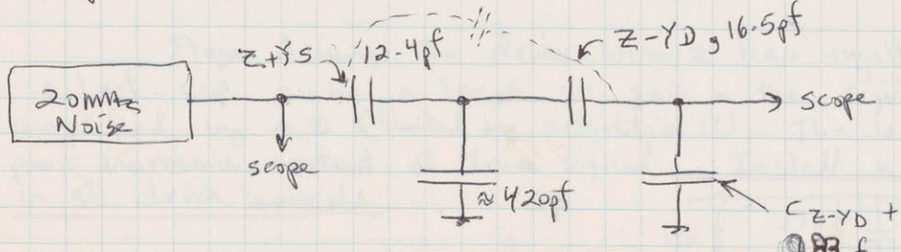
Ground Fake REM through L and R to mimic Rod (mimics Al Rod)

$L_{series} \approx 0.97\mu H$
$R_{series} = 1.5\Omega$
$C_{mass\ to\ gnd} = 430pf$ → 7.8MHz Resonance



Transfer Function from $Z+YS$ to $Z-YD$ with Resonant L and R connected.

Expected assymptotic attenuation:



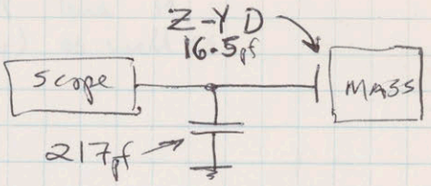
$$\text{atten} \approx \frac{12.4}{420} \cdot \frac{16.5}{\frac{275}{217}} = \begin{matrix} 1.77\times10^{-3} \\ 2.24\times10^{-3} \end{matrix} = \underline{-55dB} \quad (-53dB)$$

(off by factor of 4)

2/21/83

Measure RF voltages on cm:

Drive Unit	Vscope	Vmass
1.00	29 mV	0.41
2.60	27 mV	0.38
3.90	23 mV	0.32
5.18	100 mV	1.41
6.31	130 mV	1.83
7.52	700 mV	9.87



atten = 1/14.1

With RF out connected to RF in measure $\frac{dV_{pp\ RF\ out}}{dV_{cmon}}$

Unit	$\frac{dV_{pp}}{dV_{cmon}}$	$a_{eqriv.}$ × $a_{driver\ board}$ =	Product	÷400 =	Desired $\frac{dV_{pp}}{dV_{cmon}}$ with RF out - RF in
1.00	3.48	105 × 38.8	4077	5.1	0.68
2.60	4.44	135 × 31	4188	5.2	0.85
3.90	2.35	69 × 15	1035	1.3	1.81
5.18	15.38	365 × 15.6	5701	7.1	2.17
6.31	3.51	89 × 3.5	311	.39	–
7.52	2.30	75 × 3.9	293	.37	–

Reduce Bridge board Gains

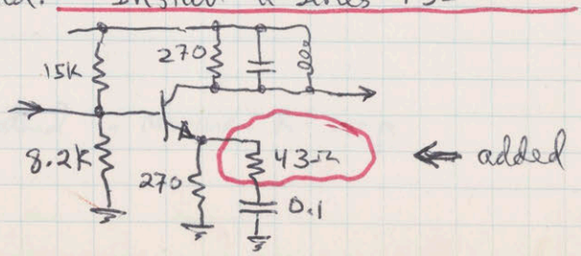
Unit	U431 Biases 1st	U431 Biases 2nd	$\frac{dV_{pp}}{dV_{cmon}}$ with RF-RF
1.00	÷2,	÷2.5,	0.71
2.60	÷2,	÷2.5,	0.93
3.90	÷1.13	÷1.13	1.86
5.18	÷2	÷3.5(?)	2.05
6.31	÷1.13	÷1.13 (-5.25V)	2.50
7.52	÷1.13 (-5.25V)	÷1.13 (-5.25V)	2.02

2/22/83

Discovered wings of noise on Drive signals – most pronounced on high freqrency ones where the mass is not grounded – The 7.52 unit has 4Vpp @ RF TP due to 6.32 units wings!

Found the cause in driver board:

Stage driving the driver LH0002 has emitter grounded through 0.1 µf cap giving a large ac gain – the signal is actually only amplified by ≈ 3 (limited by saturation?!) This leads to noise and poor harmonic content of drive signal. Install a series 43-Ω in all drive boards:



2/22/83

In addition a series LC in the drive out line is installed in the high frequency boards (5 and up) as well as those already in the low. f ones.

Remeasure Unit	$\frac{dV_{pp}}{dV_{CMON}}$ with RF-RF	: Has been reduced by:		Suspected new V_B^{pp}
1.00	0.54	1.31		43.5
2.60	0.74	1.26	43-2 added	50.0
3.90	1.45	1.28		31.3
5.18	1.40	1.46		34.3
6.31	1.51	1.66	43-2 and series LC added	24.1
7.52	1.27	1.59		18.9

Note: Changing V_B^{pp} changes b – doesn't change a so the RF sectors are still correctly adjusted –

2/23/83

Setting b values:

$$b = \frac{1}{\pi} \frac{V_B^{pp} \cdot A_{CFB}}{\left(1 + \frac{C_{det}}{C_B}\right)(C_{det} + C_B)} \left[\frac{\frac{dC_V}{dV_V}}{\left(1 + \frac{C_V}{C_S}\right)^2}\right] \leftarrow \frac{1}{2.64}\ pf/V$$

Thus

$$A_{CFB} = \frac{\pi\, b}{V_B^{pp}} \left(1 + \frac{C_{det}}{C_B}\right)(C_{det} + C_B) \cdot 2.64\ \frac{V}{pf}$$

we want $b \leq 0.05$

$C_B = 120\ pf$

C_{det}	Unit	V_B^{pp}	A_{CFB} calc.	Feedback ~	so: (CTP→CMON) A_{CFB} measured	"Real b"
159.8	1.00	43.5	6.22	13K 1500pf	6.20	0.050
175.1	2.60	50	6.02	13K 1500pf	5.77	0.048
110.9	3.90	31.3	5.89	13K 1200pf	5.81	0.049
112.4	5.18	34.3	5.44	12K 1200pf	5.89	0.054
94.6	6.31	24.1	6.60	15K 750pf	7.07	0.054
91.3	7.52	18.9	8.16	18K 750pf	8.78	0.054

Also set $w_{RC} \approx 1$ (0.15Hz) by shunting 4M-2 by 360K-2

Leave -2 loop with 56K feedback ~ and 4M x 3μf RC.

Close loops!

← Lowpass capacitor installed to remove RF comp.

3/1/83

V_{HV}	$C_{pf\,drive}$	α	V_B pp	$\frac{dC}{dx}$ pf/cm	C_{dc}	$\frac{dV}{dx}$ V/cm	G_{HV}	M_g	G_F^P	$1+\left(\frac{\omega}{h}\right)^2$	G_F^R	G_P Q=1	G_R Q=5 @5Hz	SYSTEM
450	43.7	1.97	45	360	129	9.98	26.7	15000	112	2	42	1.2	10.5	CM X
450	40.1	1.80	29	369	135	6.29	26.7	15000	64.5	2	24.2	2.1	18.1	Y
450	57.1	2.57	14.7	495	152	3.76	26.7	15000	55.0	2	20.6	— (2.5)	21.4	Z
400	59.3	2.37	45.5	438	143	11.0	23.5	8000	245	1.12	164	0.55	2.7	EM1 X
450	29.1	1.31	29.5	178	101	4.1	22.8	8000	49	3.72	9.9	2.8	44	Y
500	25.0	1.25	22.0	148	86.5	2.92	25	8000	36.5	3.92	6.98	— (3.7)	63	Z
400	51.4	2.05	46.7	430	167	9.31	29	8000	221	1.12	148	0.61	3.0	EM2 X
450	23.3	1.05	32.8	181	111	4.3	27	8000	48.8	3.72	9.8	2.8	45	Y
500	17.2	0.86	21.5	124	93	2.24	28.6	8000	22.0	3.92	4.22	— (6.2)	104	Z

assumed: $C_B = 120$ pf
$a = 800$
$b = 0.05$
$RC = 1$ sec

all parameters are averaged over both systems for a given axis.

Measure ab gain (

Unit	ab of -z loop	ab of C Loop (250Hz)	a	CMO noise @12.6 kHz $\frac{dBV}{\sqrt{}}$	÷ a
7.52	11.7	9.82	181	-105.9	28 nV/√
6.31	3.9	12.3	228	-120.9	3.9
5.18	16.1	27.4	507	-113.3	4.3
3.90	23.2	40.4	825	-107.3	5.2
2.60	30.5	39.6	825	-105.6	6.4
1.00	53.3	34.4	688	-103.8	9.4

2/24/83

	Unit	ab	ACFB	C pf/mm	μm/varac volt	CMO noise μV/√ @12kHz	X equivalent
X-Z	1.00	34.4	6.2	43.32	8.74	6.47	1.02 x10⁻⁹ cm/√
X+Z	2.60	39.6	5.8	42.88	8.93	5.28	0.68
Y+X	3.90	40.4	5.8	16.14	23.5	4.29	1.45
Y-X	5.18	27.4	5.9	20.09	18.9	2.18	0.89
Z-Y	6.31	12.3	7.1	12.35	30.7	0.89	1.58
Z+Y	7.52	9.8	8.8	12.44	30.5	5.07	13.9

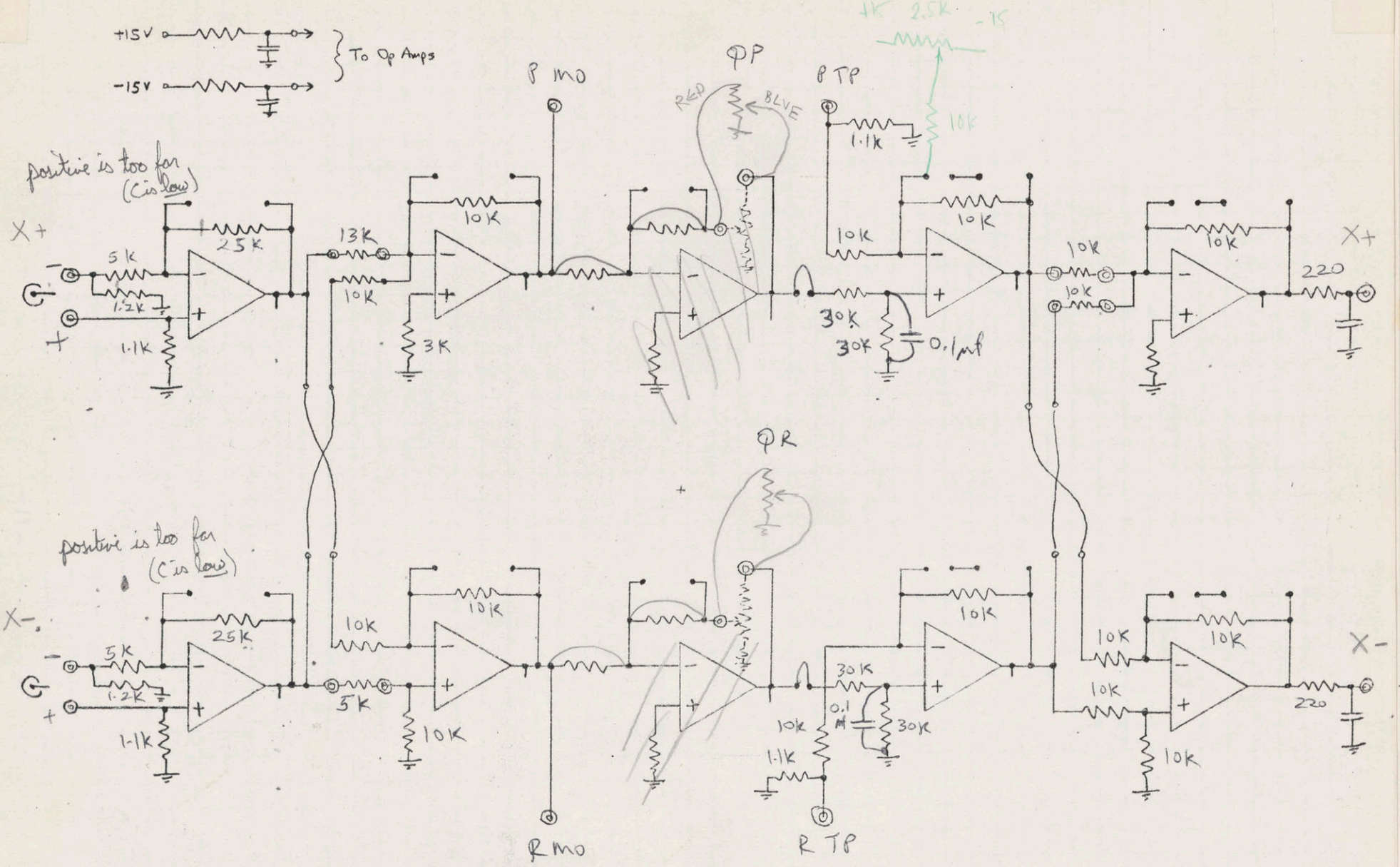
$\frac{10^3}{2.64\ V/pf} \cdot \frac{1}{C_{pf/mm}}$

$X_{eq\ in\ \mu m} = \text{CMO noise} \cdot \frac{ACFB}{\text{ab gain}} \cdot \frac{\mu m}{\text{varac V.}}$

Damping parameters calculated 3/1/83
as in p44-45 in O. Demag #2

modified HV Amps for lower noise 4/26/83

Amp	Gain @ 512 Hz	$\phi = 45°$ Freqy.	atpt noise 512 Hz	atpt noise 25 kHz
X+Z	26.7	26 kHz	-106.2	-116.1
X-Z	27.4	27 kHz	~~-105.5~~ -105.5	-115.5
Y+X	25.6	28 kHz	-105.0	-115.5
Y-X	27.7	28 kHz	-109.9	-116.1
Z+Y	26.5	24 kHz	-92.0	-111.8
Z-Y	27.6	27 kHz	-108.1	-101.3 (?)

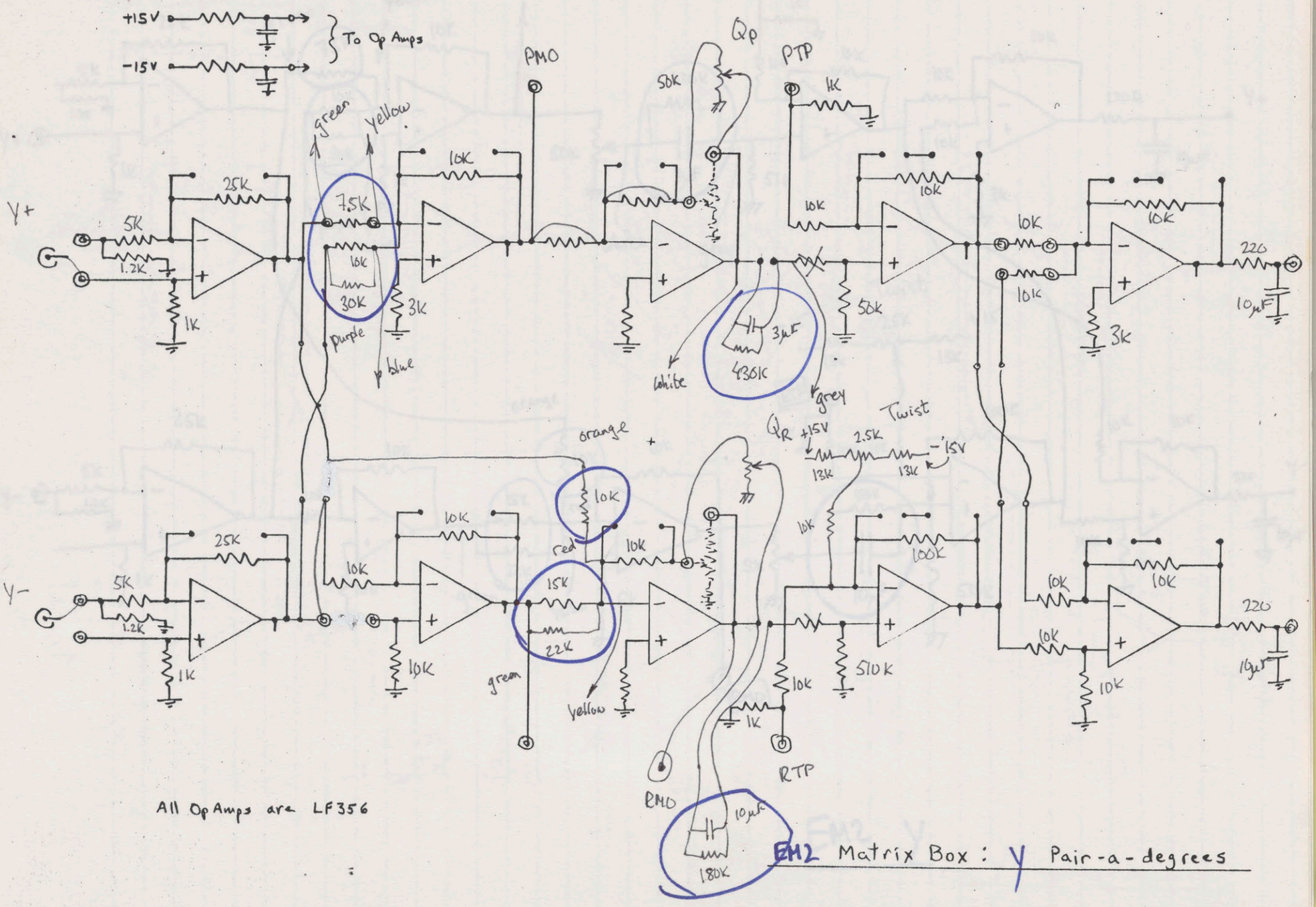


All Op Amps are LF356

EM2 Matrix Box : X Pair-a-degrees

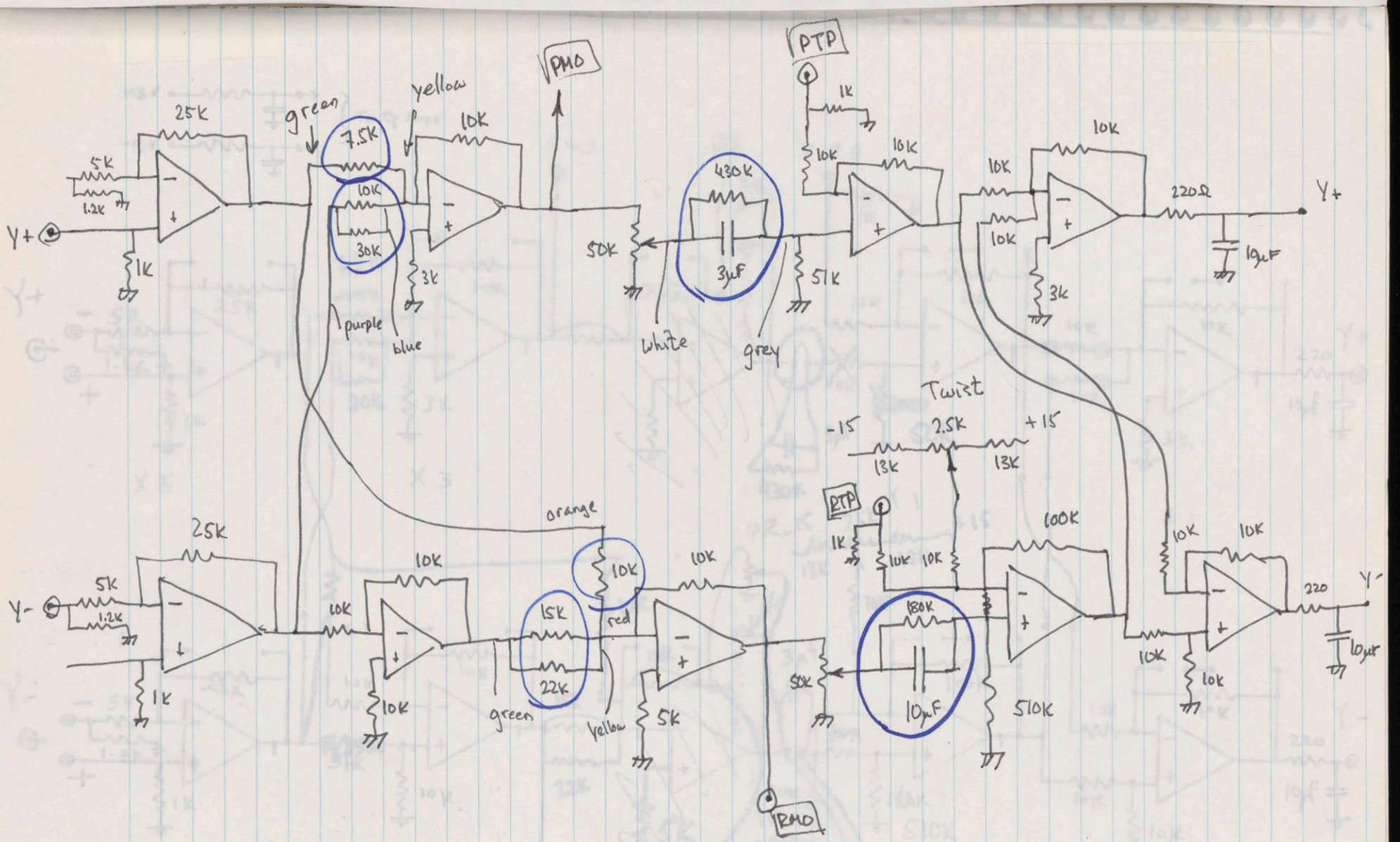
Nominal $G_\varphi = 0.6$

$G_R = 3.0$

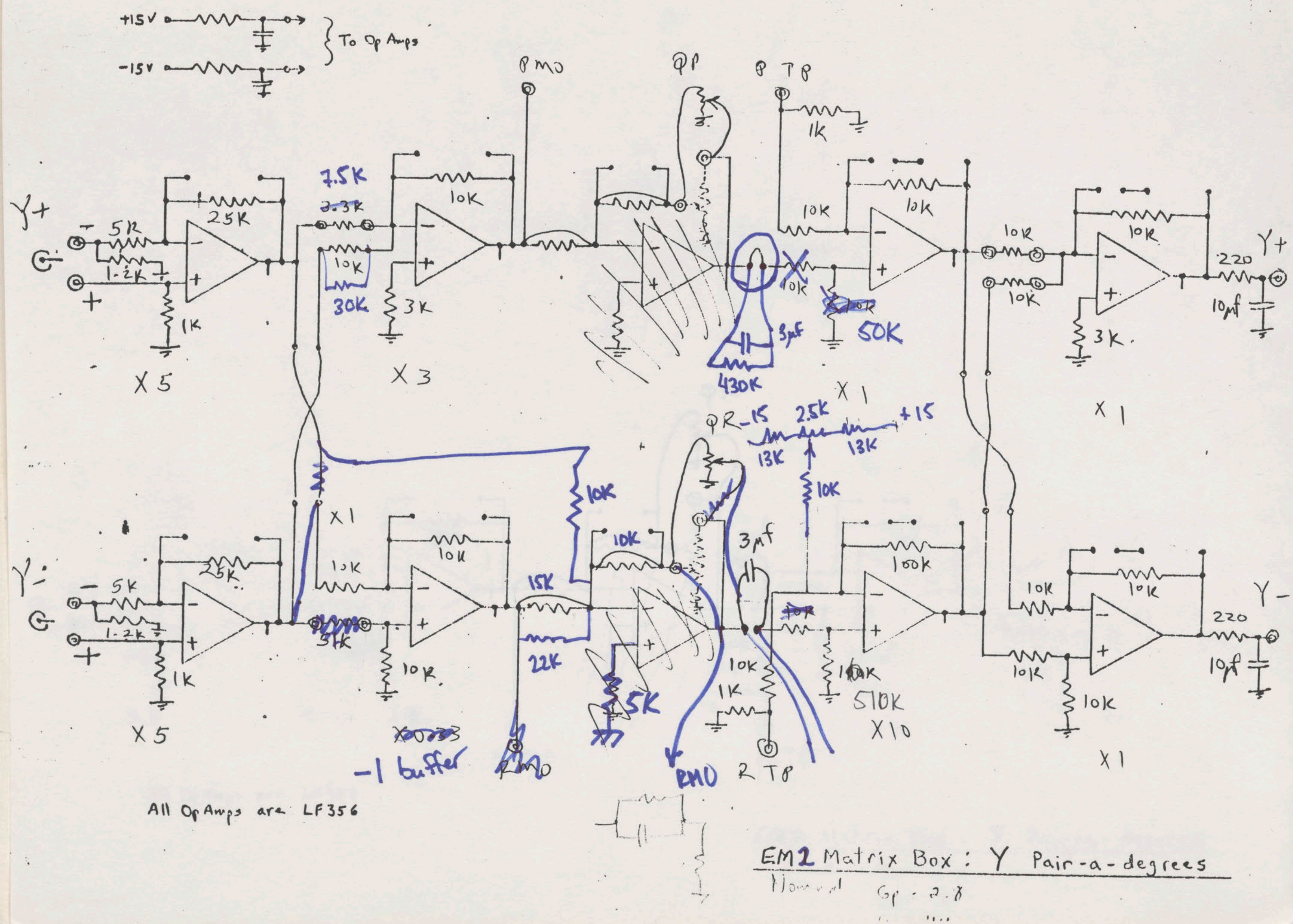


All Op Amps are LF356

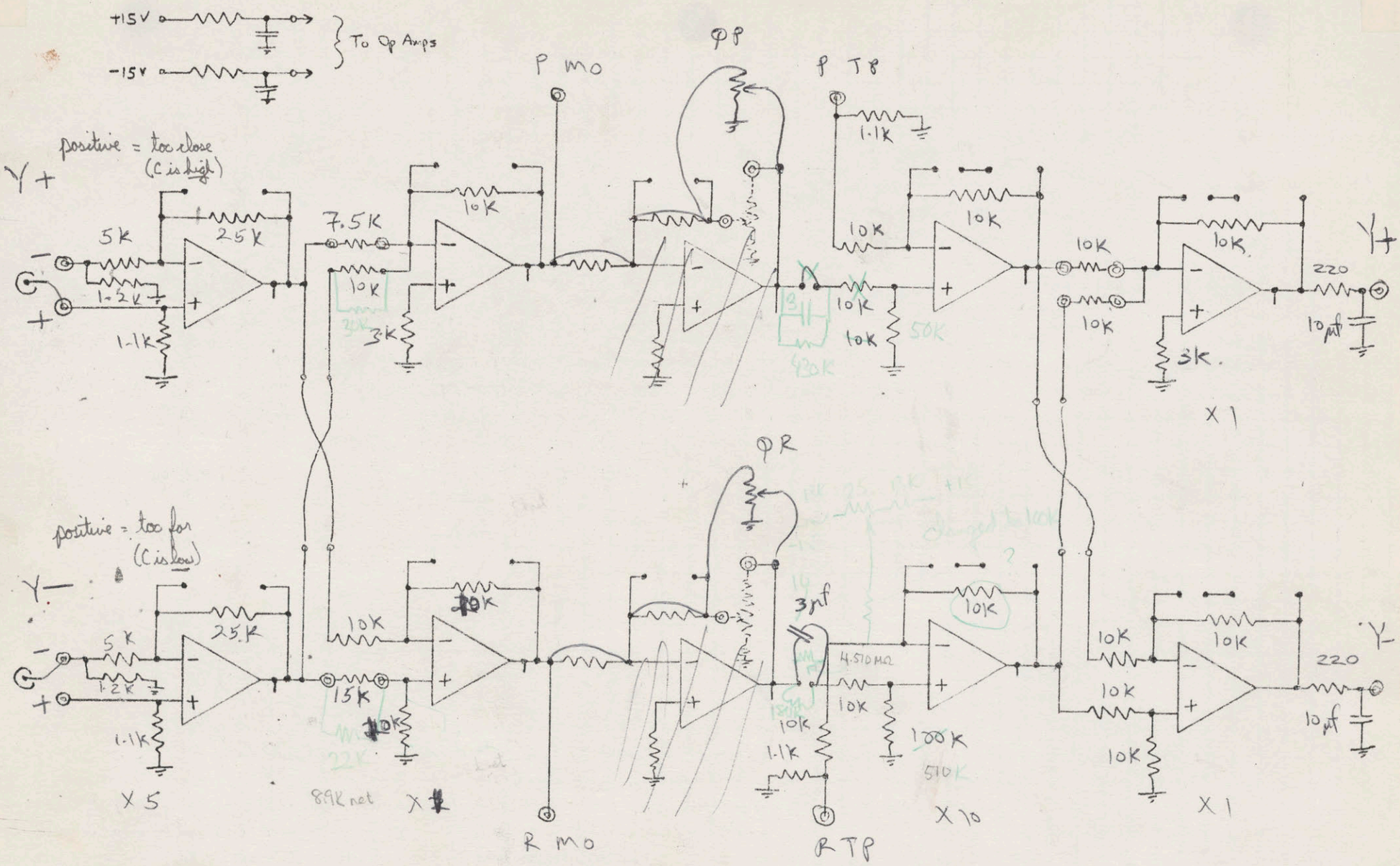
EM2 Matrix Box : Y Pair-a-degrees


Y+
25K
5K
1.2K
1K
green
7.5K
10K
30K
purple
blue
yellow
10K
3K
PMO
50K
430K
3μF
white
grey
51K
PTP
1K
10K
10K
10K
10K
3K
220Ω
10μF
Y+
Twist
-15
2.5K
+15
13K
13K
PTP
1K
10K
10K
100K
510K
10K
10K
10K
220
Y-
10μF
Y-
25K
5K
1.2K
1K
10K
10K
orange
10K
red
15K
22K
green
yellow
10K
5K
50K
180K
10μF
RMO

EM2 Y



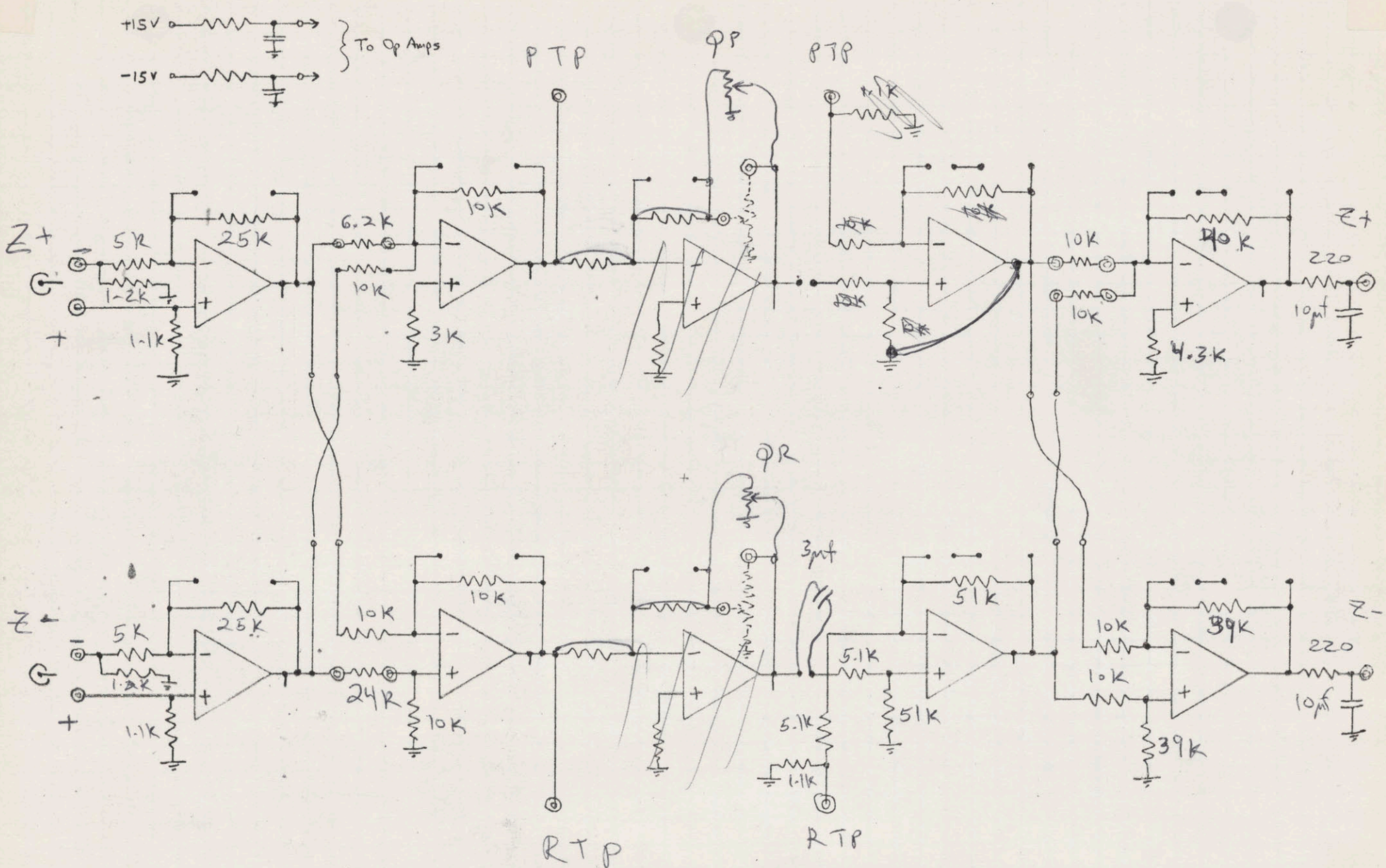
EM2 Matrix Box : Y Pair-a-degrees



EM2 Matrix Box : Y Pair-a-degrees

Nominal $G_P = 2.8$

$G_R = 45$



All Op Amps are LF356

EM2 Matrix Box : Z Pair-a-degrees

Nominal G_P = —

G_R = 104

```
0001          PROGRAM EM2XOC
          C
          C   THIS PROGRAM COMPUTES THE DISTANCE OF PLATE MASS SEPERATION
          C   OF THE END MASS GIVEN CAPACITANCE WITH S.C.
          C
0002          DIMENSION OFF(12)
0003          DIMENSION DCDX(12)
0004          OFF(1)=174.51                    !X-ZS
0005          OFF(2)=208.44                    !X+ZD
0006          OFF(3)=189.86          !X-ZD
0007          OFF(4)=190.26                    !X+ZS
0008          OFF(5)=152.77                    !Y+XS
0009          OFF(6)=168.19                    !Y+XD
0010          OFF(7)=162.64                    !Y-XD
0011          OFF(8)=150.34                    !Y-XS
0012          OFF(9)=140.26                    !Z-YS
0013          OFF(10)=142.19                   !Z+YD
0014          OFF(11)=141.01                   !Z-YD
0015          OFF(12)=136.81                   !Z+YS
0016          DO 5 I=1,12
0017          OFF(I)=OFF(I)+1.4     !EXTRA oF OF NEW STANDARD CABLE
0018      5   CONTINUE
0019          DCDX(1)=43.32
0020          DCDX(2)=49.23
0021          DCDX(3)=53.50
0022          DCDX(4)=42.88
0023          DCDX(5)=16.14
0024          DCDX(6)=22.17
0025          DCDX(7)=24.34
0026          DCDX(8)=20.09
0027          DCDX(9)=12.35
0028          DCDX(10)=17.89
0029          DCDX(11)=16.48
0030          DCDX(12)=12.44
0031     10   CONTINUE
0032          TYPE *,'ENTER PLATE NUMBER, CAPACTANCE (oF) :'
0033          ACCEPT *,NPLATE,C
0034          IF(NPLATE.LE.0) STOP
0036          X=DCDX(NPLATE)/(C-OFF(NPLATE))
0037          TYPE 50,C,X
0038     50   FORMAT(3X,'X(',F4.0,'pF) = ',F5.2,' mm')
0039          GOTO 10
0040          END
```

6/6/83

End mass in cage - Nominal X, Y Position (1mm)
Z is on bumpers

Mass grounded by clip lead

	Plate	C+S.C.	Distance (mm)
(1)	X-ZS	222	0.91
(2)	X+ZD	270	0.80
(3)	X-ZD	248.5	0.91
(4)	X+ZS	244.5	0.79
(5)	Y+XS	177.3	0.66
(6)	Y+XD	201	0.68
(7)	Y-XD	194.8	0.76
(8)	Y-XS	176	0.78
(9)	Z-YS	167.8	0.45
(10)	Z+YD	180.3	0.47
(11)	Z-YD	177	0.46
(12)	Z+YS	166.2	0.42

Using C-meter + New Standard Oct 25 '83

Cable = 59.4 pf

C+S.C.		10/31/83	C	X		
220	0.98	220	217	1.05		
272	0.79	272	259	1.00		
247	0.96	247	241	1.08		
247	0.77	247	235	0.99		
170	1.02	170	158	4.2		
192	0.99	192	176	3.46		
188	1.02	188	171	3.50		
172	0.99	172	158	3.21		
169	0.45	169	169	0.45	169	169
181	0.48	181	180	0.49	180	180
177	0.48	177	178	0.46	178	178
167	0.43	167	166	0.45	167	167

10/31/83 Micrometer readings (measured at 0 of vernier)

Z = 1.963 mm
Y = 8.58
X = 5.08

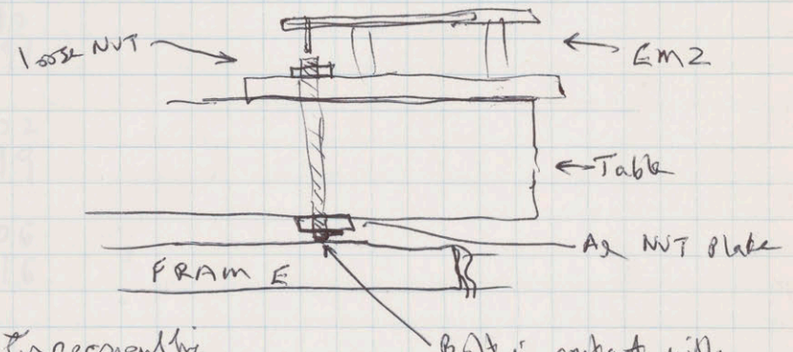
Move Z to 1.46 mm
to 0.96 mm
0.46 mm

2+2 = 51 ppi's rod.

Vp to atmospheric pressure with N_2. Remove + fix mass.

Mass back in cage - rod not grounded - tube down. 11/1/83
mass nominally at bumper distances.
Check capacities to ensure no open before torquing bottom flange.

Note: Hold down bolt (1"dia) near SMA connector block is loose - looks due to table coming down on bottom of bolt:



	C	X mm	After recessenting, before lifting C	After recessenting, before lifting X mm	C	X mm			DESIRED
—	235	0.73	203	1.60	211	1.23	205	1.49	220
+	292	0.60	253	1.14	280	0.7	270	0.82	272
—	263	0.75	232	1.31	237	1.17	230	1.38	247
+	268	0.56	221	1.46	258	0.65	246	0.79	247
+	182	0.58	172	0.91	159	3.34	168	1.17	170
+	207	0.59	191	1.04	177	2.99	189	1.14	192
-	201	0.66	179	1.63	172	3.06	182	1.36	188
-	184	0.62	162	1.96	158	3.21	165	1.52	172
-	167	0.49	169	0.45	159	0.71	155	0.93	~~169~~
+	179	0.51	180	0.49	162	0.97	160	1.09	~~181~~
-	175	0.51	177	0.48	164	0.76	159	0.99	~~177~~
+	166	0.43	167	0.43	151	0.97	150	1.06	~~167~~

These look OK! ↑ Torque bottom flange.

Z = 4.14
Go to Z = 3.64

	C	Xmm	C	X	
—	228	0.83	230	0.80	
+	270	0.82	272	0.79	
—	255	0.84	257.5	0.81	
+	244	0.82	245	0.80	
+	171	0.96	170	1.02	170 1.02
+	194	0.91	192	0.99	192 0.99
—	188	1.02	186	1.19	189 .98
—	170	1.10	169	1.16	172 .99
—	155	0.93	154	1.00	
+	160	1.09	160	1.09	
—	159	0.99	159	0.99	
-15 - +	150	1.06	150	1.06	

RF Stuff! Replace 47pf shunt cap in X-Z bridge by 110pf.

12/1/83

Driver Capacities with 159.4 pf S.C.

			X_{mm}
(3)	X-	351	0.90
(2)	X+	364	0.91
(7)	Y-	288	1.02
(6)	Y+	292	0.99
(11)	Z-	258	1.06
(10)	Z+	259	1.16

micrometer settings (read correctly)

X = 6.75
Y = 7.16
Z = 2.52

Damping Signs:

X- =
X+ =

Y- —
Y+ +

Z- =
Z+ —

Ratios

$\frac{X-}{X+} \approx -2.5\,dB \rightarrow 0.75$

$\frac{Y-}{Y+} \approx +2.0\,dB \rightarrow 1.26$

$\frac{Z-}{Z+} \approx +4.5\,dB \rightarrow 1.68$

5/8/84 Up to Atmospheric Pressure:

Gravity II #128

Capacities Standard cable = 165 pf 5/8/84

EM2:			X_{mm}
(1)	X-ZS	326	0.97
(2)	X+ZD	365	0.99
(3)	X-ZD	351	0.99
(4)	X+ZS	340	1.00
(5)	Y+XS	276	0.99
(6)	Y+XD	298	0.97
(7)	Y-XD	294	1.00
(8)	Y-XS	277	1.02
(9)	Z-YS	260	0.97
(10)	Z+YD	265	1.13
(11)	Z-YD	264	1.03
(12)	Z+YS	255	1.11

8/1/84

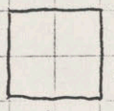
Install series Resistors in

AV Amp Outputs : 100k X plates
1M Y, Z plates

31-Oct-84

Trivial capacities: EM2

		C (pF)	d (mm)
(1)	X-ZS	346	.71
(3)	X+ZD	374	.71
(2)	X+ZD	387	.71
(4)	X+ZS	361	.77
(5)	Y-XS	290	.83
(7)	Y-XD	305	.89
(6)	Y+XD	312	.77
(8)	Y+XS	288	.89
(9)	Z-XS	270	.84
(11)	Z-XD	273	.97
(10)	Z+XD	275	1.00
(12)	Z+XS	266	.86



loops	+	−
X	-18.	10.5
Y	2.2	-4.0
Z	33.8	41.9

from Gravity III, p 115

standard cable = 173 pF

5/5/85

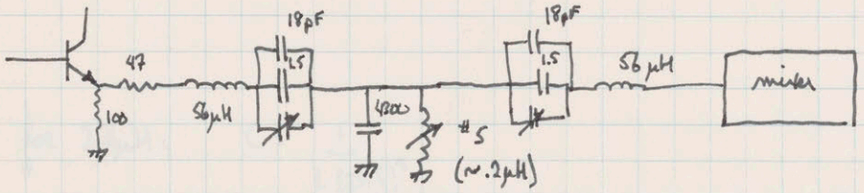
Rai has installed 100KΩ resistors in series with all the HV amp outputs

5/6/85

Replaced all 6 UTB550's in the y HV amp.

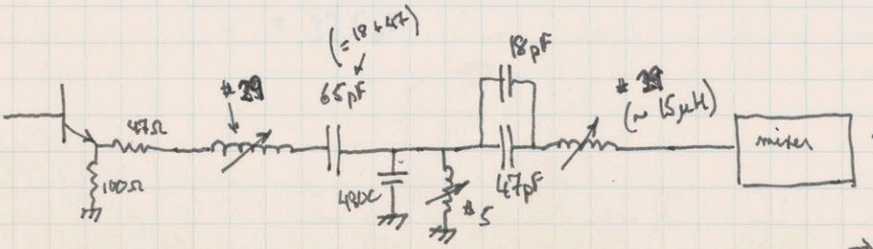
5/25/85

The y-X mixer box (5.18 MHz) had a limited dynamic range: ± .2V. The problem turned out to be the filter after the emitter follower just before the capacitive mixer. Circuit was:



the 56μH inductors were very lossy and prevented the circuit from effectively functioning as a resonant bandpass

New design (implemented on the C loop only – also, mixer was changed)



the mixer was replaced early on to check a suspicions

tuned for a 0° phase response

→ filter has a ~750kHz bandpass instead of 500kHz

More on the Y-X board... 5/26/85

Had to implement the same filter on the Ω balance to get the relative phase of the RF feedback identical on the R and the C mixers. Found also that the sign of the Ω feedback was wrong - flipped the signs on the bridge board, adding a 2k resistor to keep the gains the same. Returned as follows:

① balanced bridge with a fake capacitor - set resistive balance as well.
② unbalanced bridge with capacitive signal only, keeping out of saturation
③ set over-all phase to keep the Ω mixer close to zero
④ rebalanced capacitively
⑤ unbalanced resistively → set relative phase to null the C mixer.

Seems to work O.K. . .

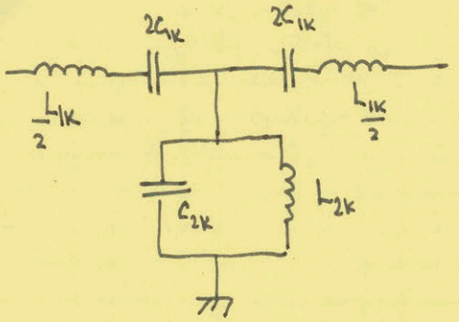
Also: some signs:

Y+X	mixer	capacity increase	⇒	mixer goes up
Y-X	"	capacity increase	⇒	mixer goes down
X-Z	"	capacity increase	⇒	mixer goes down
X+Z	"	capacity increase	⇒	mixer goes down

Radio Amateur's Handbook p.50 (1972 edition)

$\omega^2 = \frac{1}{LC} = (2\pi f)^2$

"Constant-K T section"



$L_{1K} = \frac{R}{\pi(f_2 - f_1)}$

$C_{1K} = \frac{f_2 - f_1}{4\pi f_1 f_2 R}$

$L_{2K} = \frac{(f_2 - f_1)R}{4\pi f_1 f_2}$

$C_{2K} = \frac{1}{\pi(f_2 - f_1)R}$

$L_{2K} C_{2K} = \frac{1}{4\pi^2 f_1 f_2}$

filter actually used

$\frac{L_{1K}}{2} = 15\,\mu H$

$2C_{1K} = 65\,pF$

$C_{2K} = 4300\,pF$

$L_{2K} = .2\,\mu H$

$(f_2 - f_1) = \frac{R}{\pi L_{1K}} = \frac{1}{\pi R C_{2K}}$

$\downarrow$ 530 kHz $\qquad \downarrow$ 1.5 MHz

Using values for $L_{1K} = 30\,\mu H$, $C_{1K} = 32.5\,pF$ (values used) } should have

$C_{2K} = \frac{1}{\pi R (530\,kHz)} = 12{,}000\,pF = .012\,\mu F$

$L_{2K} = \frac{1}{4\pi^2 C_{2K} f_o^2} = .08\,\mu H$

do have $C_{2K} = 4300$

$L_{2K} = .2\,\mu H$

- probably just affects passband ripple or flatness.

for 27 μH: $C = \frac{1}{L(2\pi f)^2}$

$= \frac{1}{(27\times10^{-6})(2\pi\, 5\times10^6)^2}$

$= 37.5\,pF$

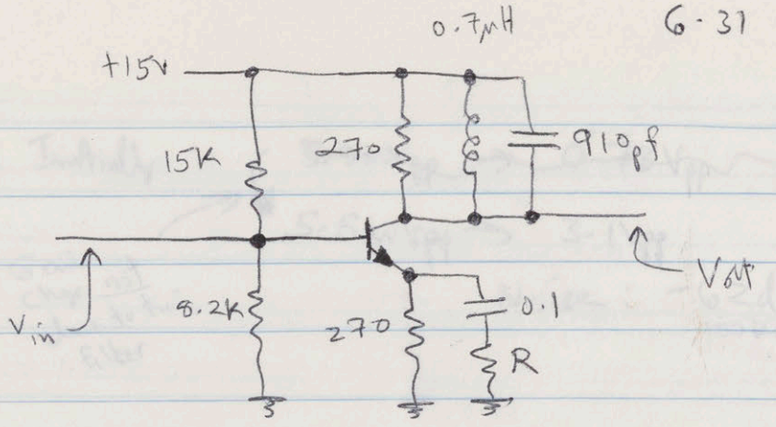
2/22/93

$\sqrt{\frac{L}{C}} = 27.2 \times 60 = 1664\ \Omega$

6.31

2/14/93

??



R	"Theory" Gain	V_{in}^{pp}	V_{out}^{pp}	Gain
0	∞	3.6, -72	14, -65	3.89
27	10	3.8V, -75	11.6, -76	3.05
43	6.3	3.8V, -75	10.8, -76	2.84
86	3.1	3.9V, -75	9.0, -76	2.31

2/14/83

1.00 Initially: 5.8mVpp → 0.73Vpp

5.5mVpp → 3.1Vpp

most Gain change not due to this filter

G: 126 → 563 ??

Noise: −62dBm (100kHz) → 56 nV/√Hz → 2 nV/√Hz

2.60 Initially 6.8mVpp → 2 Vpp

2.0 mVpp → 1.5 Vpp

G = 294 → 2.41 nV/√Hz

G = 750 ?

Noise: −66dBm → 355 nV/√Hz → 0.95 nV/√Hz ?

1.68

3.90 Initially: 12.5mV → 2.25

12mVpp → 3.0

G = 180 → 1.87 nV/√Hz

G = 250 → 168 nV/√Hz → 1.34 nV/√Hz

−72.5dBm (100kHz)

1.26

5.10 Initially 3mV → 1.6V

3mV → 2.1V

G = 533 → 4.2

G = 700

Noise: −56dBm (100kHz) → 1122 nV/√Hz → 3.21

1.50

2/14/03

6.31 Initially: $6.5\,mV_{pp} \rightarrow 1\,V_{pp}$ G = 154

$6.5 \rightarrow 1.05$ G = 161

Noise: $-70\,dBm$ (100 kHz) $\Rightarrow 224\,nV/\sqrt{Hz}$ $\rightarrow 2.8\,nV/\sqrt{Hz}$

1.29

7.5 Initially: $5.7\,mV_{pp} \rightarrow 1\,V_{pp}$ G = 175

" G = "

Noise: $-69\,dBm$ $251\,nV/\sqrt{Hz} \rightarrow 2.9\,nV/\sqrt{Hz}$

1.41

1/24/03

End Mass 2

1.00 MHz Drive Bd.

6 V_{pp} into 47 Ω

minus ≈ 3 V

Gain $\frac{1.95}{0.0205} = 95$

1 V_{pp} @ RF TP → 130 mV @ CMO
3.4 V @ C LOOP
130 mV @ −2 CMO
3.3 V @ −2 LOOP

EM #2

2.60 MHz Driver

Drive into 47-2 : 7Vpp

Mixers ≈ 2.5V

RF BN → RF TP Gain: $\frac{1.9}{0.024} = 79$

1Vpp @ RF TP →

CMO	125mV
Cloop	2.90V
-2mo	120mV
-2 Loop	2.90V

1/18/83

EM3

3-90 Driver Bd

Drive into 75Ω: 4.5 V_{pp}

Mirror Drive: 2.7 V_{pp}

RF IN → RF TP Coupling: $\frac{1 V_{pp}}{0.018 V_{pp}} = 56$

1 V_{pp} @ RF TP → 85mV cmo
≥ 1.4V @ closed out
80mV rmo
2.2V @ 2200p out

Cm #2

Drive band: 5.18mA$_{pp}$

7V$_{pp}$ into 47Ω

2.5V min

RF IN → RF TP : $\frac{1.5\,V_{pp}}{0.018\,V_{pp}} = 83$

Input RF TP → R mo : 60mV

R loop : 1.5V

C mo : 44mV

C loop : 1.0V

EM #2

6.31 MHz Drive bd.

V_{pp} into 47 Ω = 7.5 V_{pp}

Mixers 2.5 V_{pp}

RF In → RF TP ; 6 dB = 25 with 47 Ω fixed fixture

$1V_{pp}$ →

R_{mo}	45 mV
R_{loop}	1.05 Ω
C_{mo}	45 mV
C_{loop}	1.1 V

Evil Mess IV

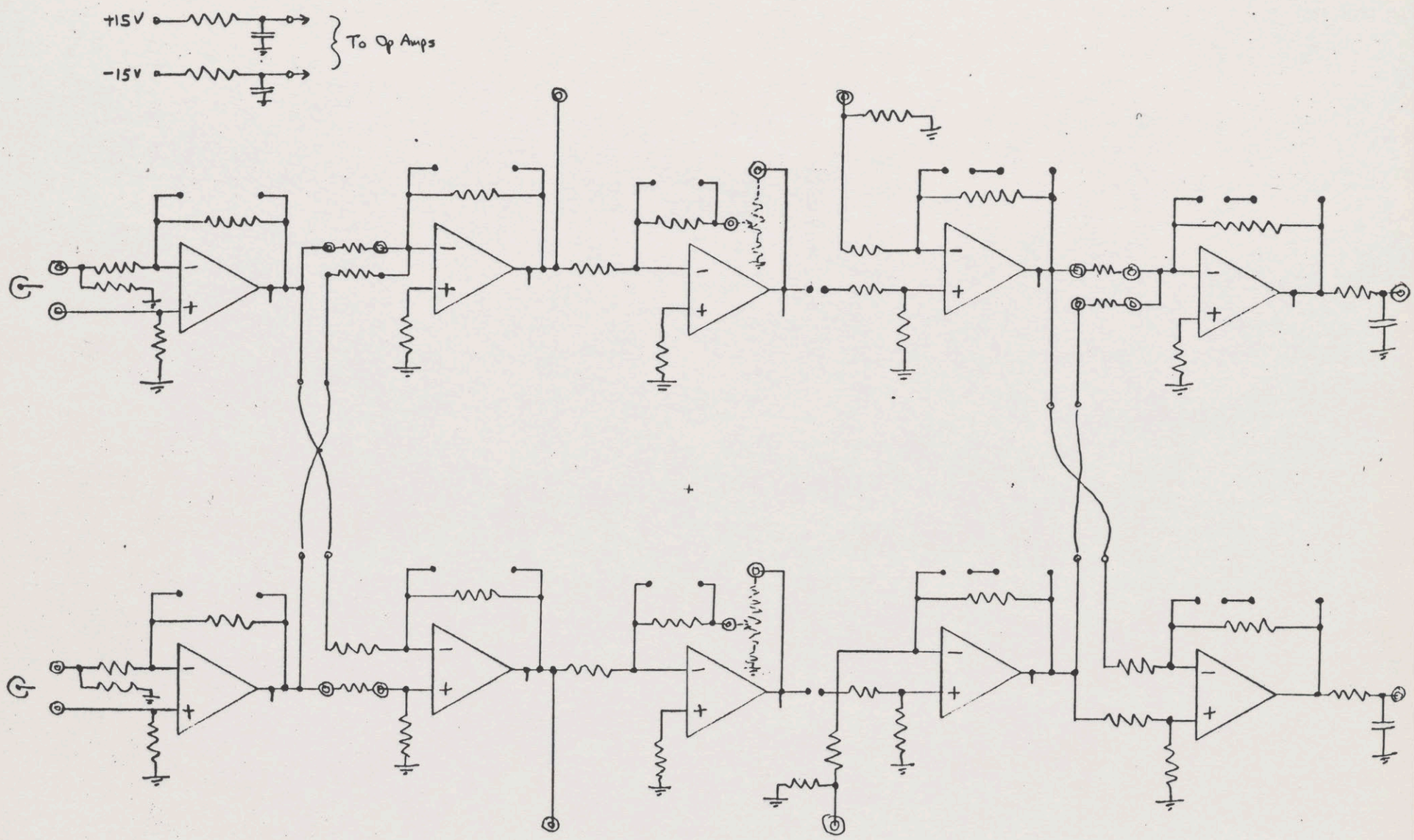
Ornie Board 7.52 MHz

Ornie Op 7 V_{pp} into 47-2

mixers 2-3 V_{pp}

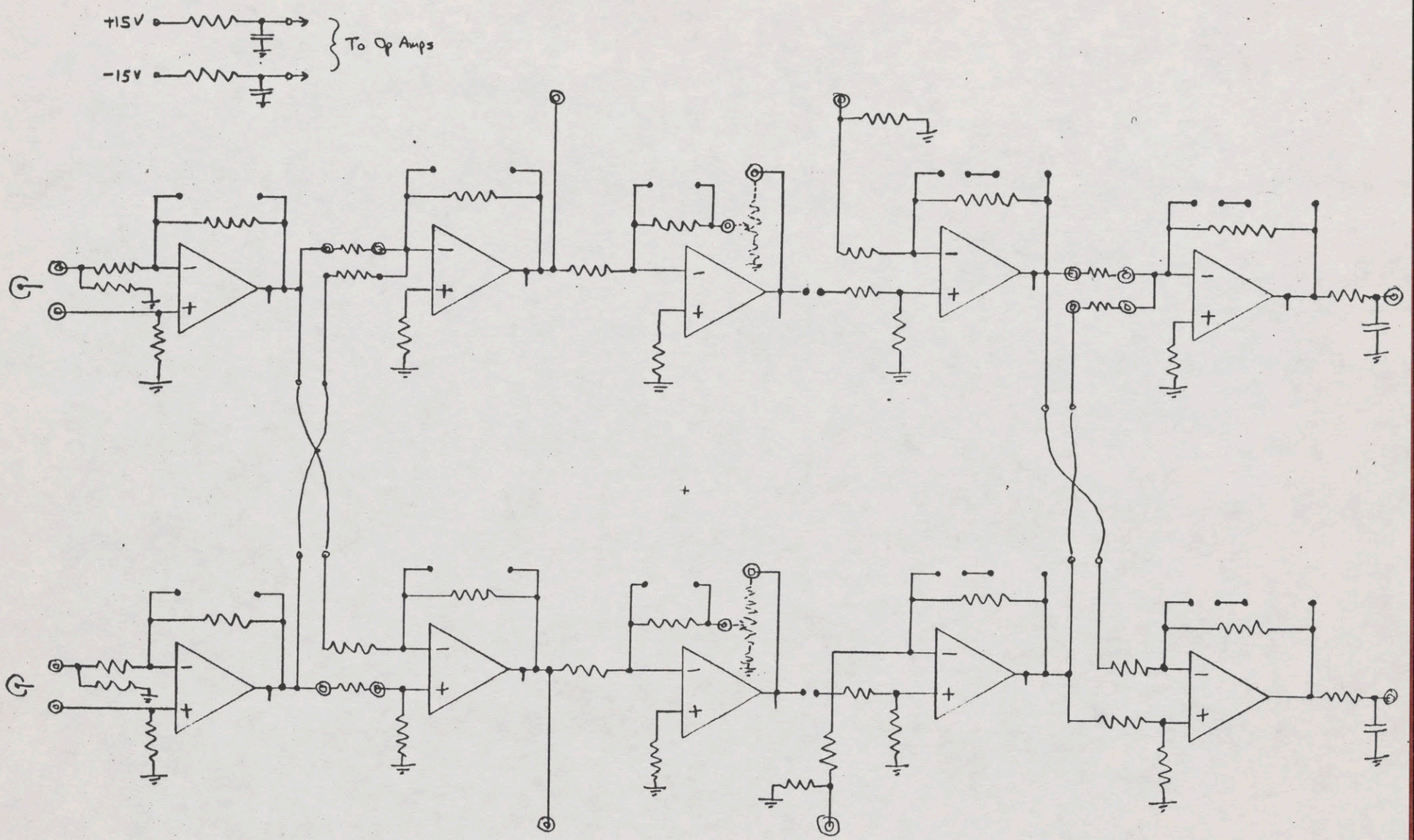
RTW → RF TB gain: $\frac{1.25V}{30mV} = 41.6$

CMO	30mV
C LOOP	470mV
2MO	25mV
2 LOOP	700mV



All Op Amps are LF356

Matrix Box : Pair-a-degrees



All Op Amps are LF356

Matrix Box : Pair-a-degrees