RF BOOK
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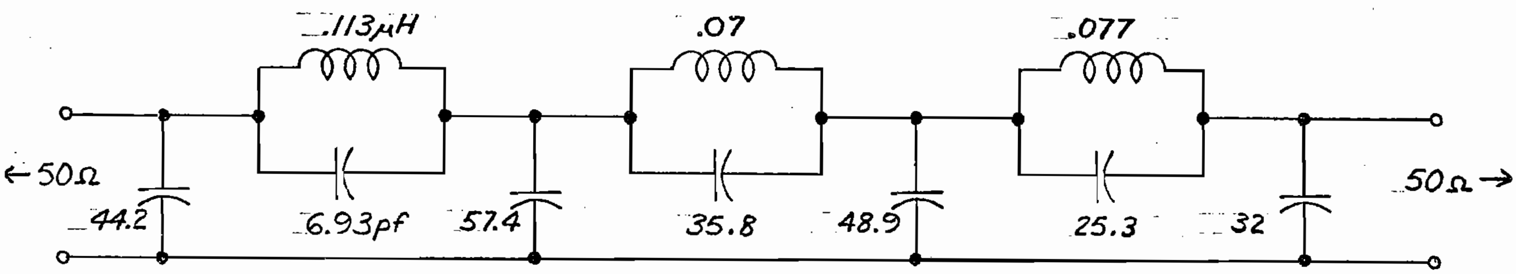
Lo-Pass Filters

As shown in the present block diagram for the frequency synthesizer, 8 identical Lo-Pass filters are required. These filters must pass frequencies of up to ~70 MHz, and block higher components, in particular above ~130 MHz. They must also introduce no phase distortion, in the sense that all have identical phase characteristics.

We originally tested a filter with cut-off around 72 MHz, but soon found it practically impossible to achieve phase characteristics close to theoretical values very near the cut-off frequency. The obvious thing to do, since we had the margin, was to move the cut-off frequency up. With a filter of cut-off frequency 85 MHz, we easily can provide very accurate phase characteristics up to 70 MHz.

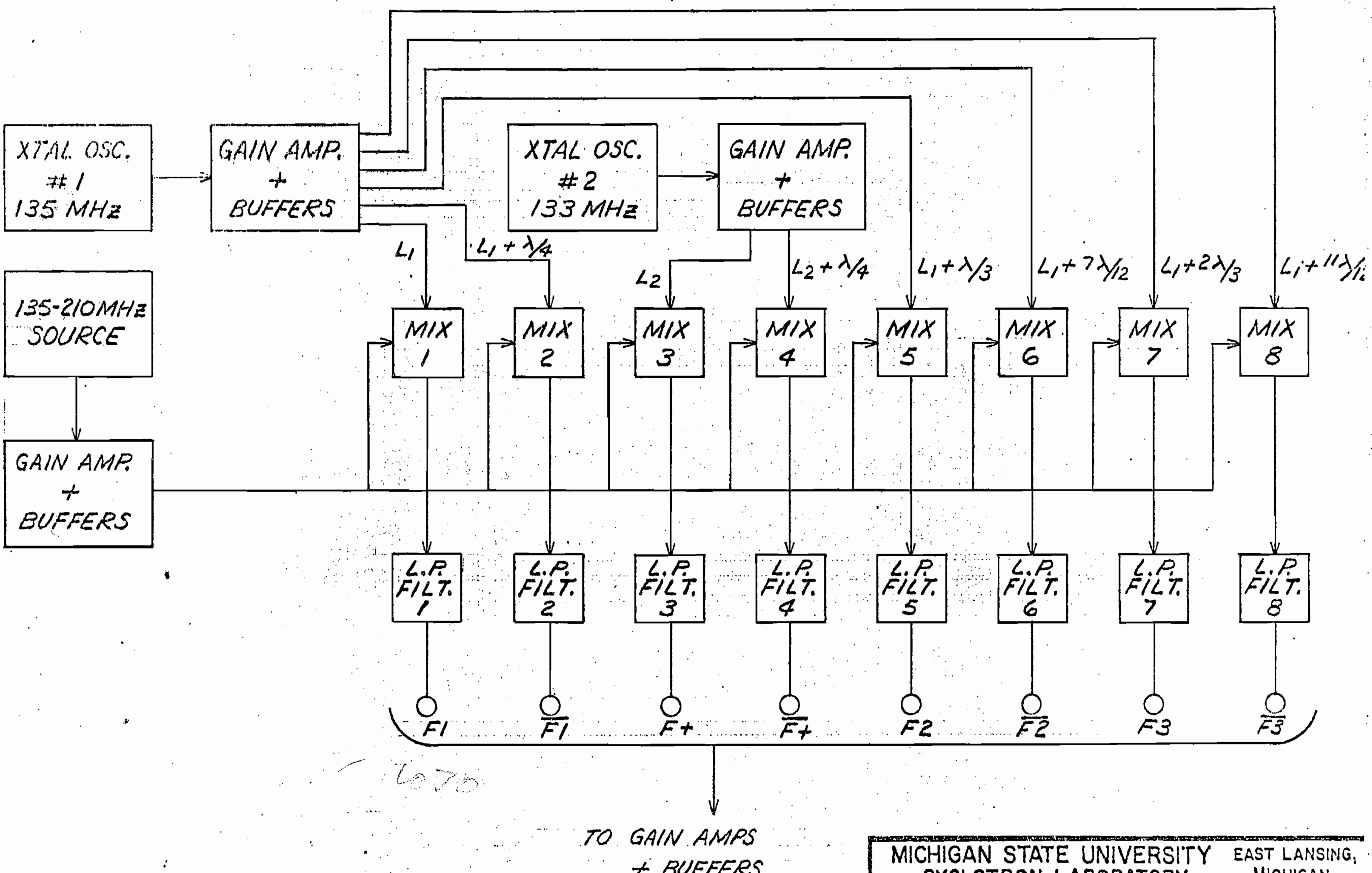
The filter used is the following 10 element elliptic filter, f_c=85 MHz.



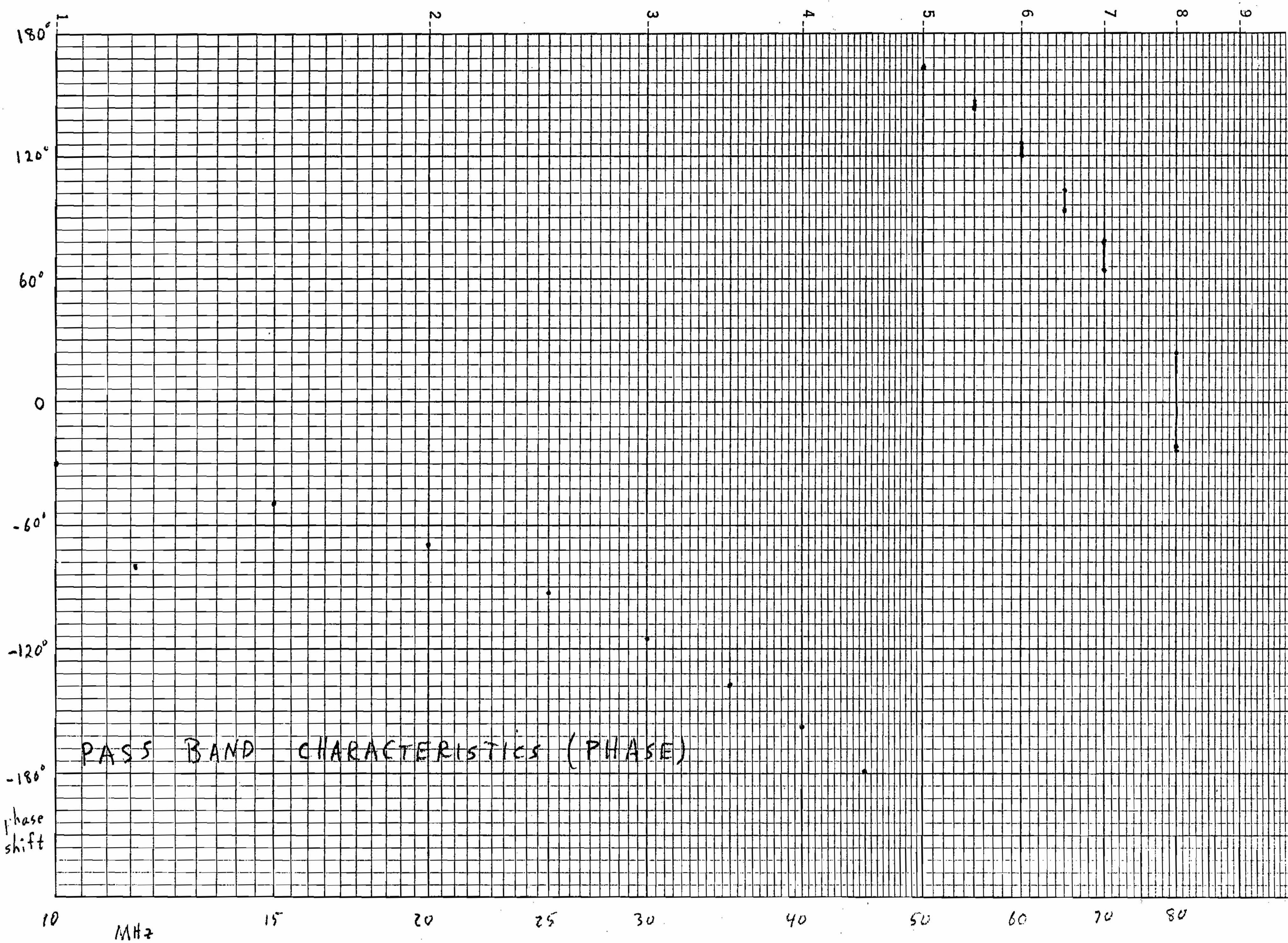
Six filters were built, and frequency data follow. For 70 MHz and below, all filters have phase characteristics within 10°, and below 50 MHz are virtually identical. The pass band amplitude characteristics are flat. At 130 MHz, all filters are at least 60 dB down ($V_{out}=10^{-3}V_{in}$).

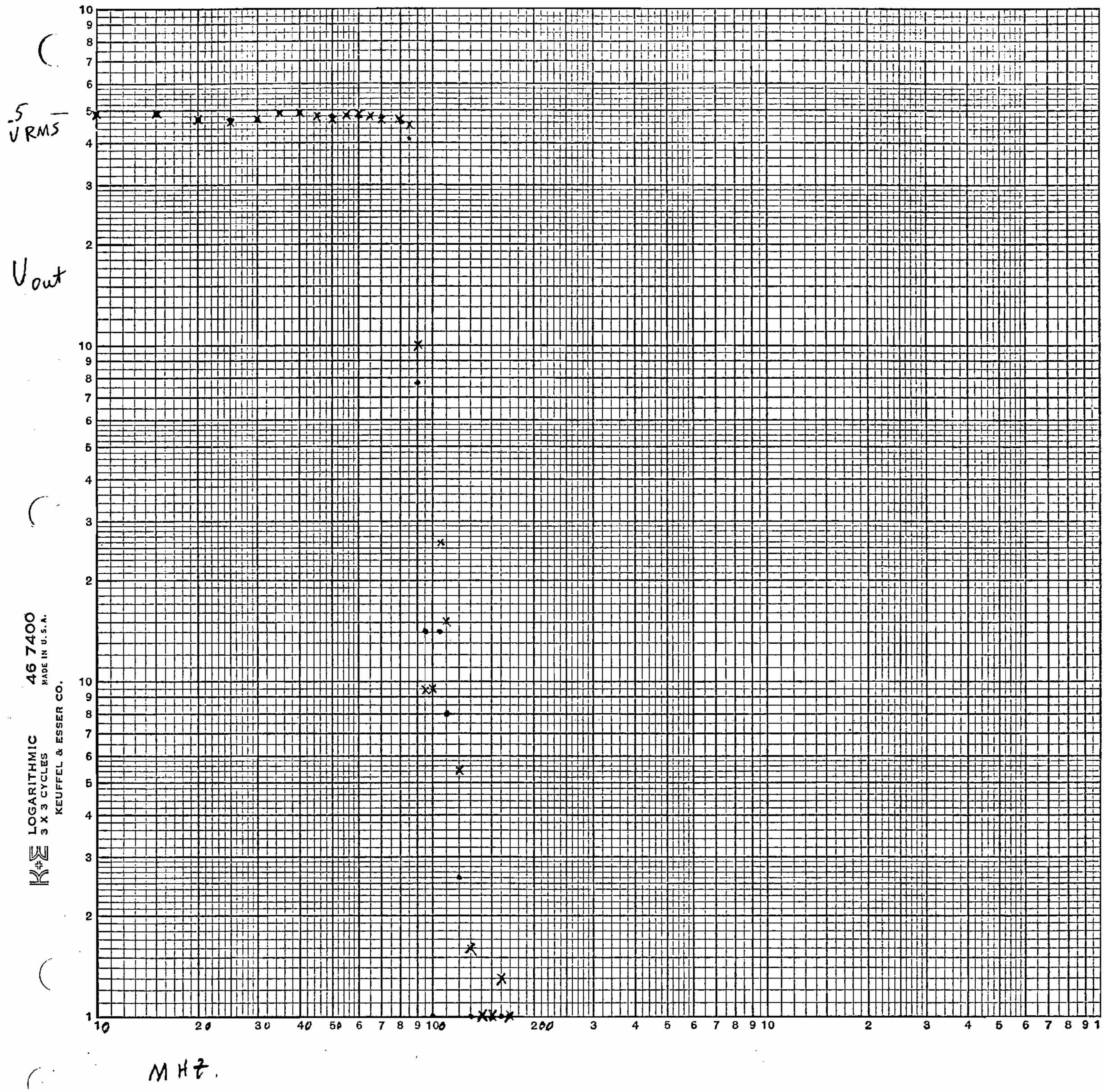
The six filters are mounted in a double width NIM bin, and are shielded for negligible interaction. Inductors are hand wound #16 AWG tinned solid copper (air core) and capacitors are mica in parallel with variable (0-9pf) capacitors. The filters are constructed so that capacitors connected to ground can be measured in situ, and all components were adjusted to within 2% using our Q meter. The components are mounted so that adjustment in operation is possible, however tweaking to improve phase characteristics is accompanied by degradation in the flat amplitude characteristics and in any case does not seem necessary.

The shop is building another identical bin, so we'll have 12 filters to use.



MICHIGAN STATE UNIVERSITY CYCLOTRON LABORATORY			EAST LANSING, MICHIGAN
	SCALE —	DRN BY WS	REV'D
FREQUENCY SYNTHESIZER			
DATE 7-19-78	APPR'D BY	DRAWING NO. 5-REK-1K-1-A	REV 1


PASS BAND CHARACTERISTICS (PHASE)
180°
120°
60°
0
-60°
-120°
-180°
phase shift
10
15
20
25
30
40
50
60
70
80
MHz

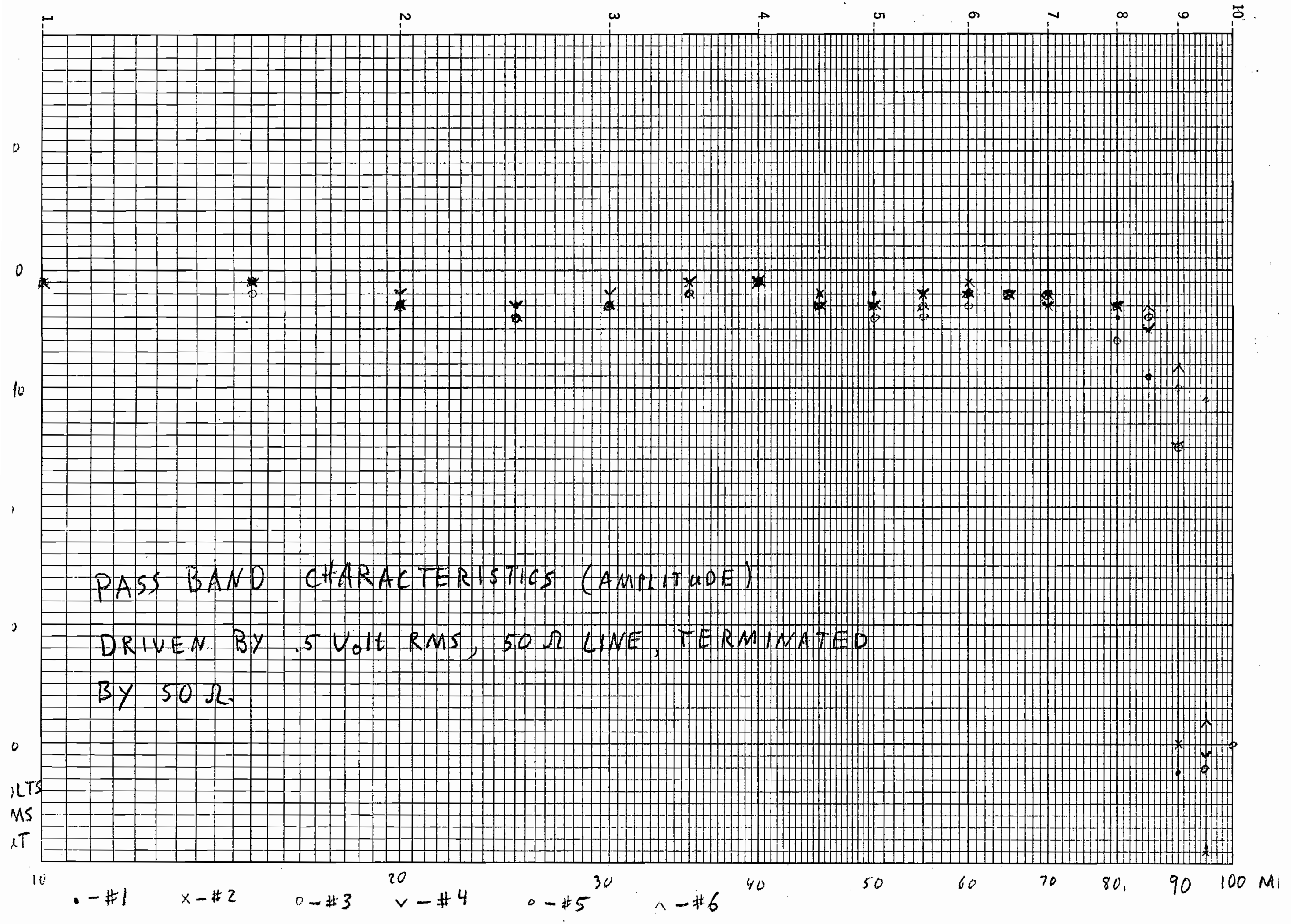


TYPICAL AMPLITUDE CHARACTERISTICS.

V_{in} = .5 V RMS

• - filter #1

x - filter #2


PASS BAND CHARACTERISTICS (AMPLITUDE)
DRIVEN BY .5 Volt RMS, 50 Ω LINE, TERMINATED
BY 50 Ω.
• – #1
x – #2
o – #3
v – #4
o – #5
^ – #6
10
20
30
40
50
60
70
80
90
100 MI

10 Element LP Filters, $f_c = 85$

	1 Black		2 Red, x		Blue 3 o		✓ 4	
10	.49	-30	.49	-30	.49	-30	.49	-30
15	.49	-50	.49	-48	.48	-48	.49	-49
20	.47	-69	.47	-68	.47	-68	.48	-69
25	.47	-93	.46	-92	.46	-93	.47	-94
30	.47	-115	.47	-116	.47	-116	.48	-116
35	.49	-137	.49	-138	.48	-140	.49	-138
40	.49	-158	.49	-158	.49	-159	.49	-157
45	.48	-179	.48	-176	.47	-179	.47	-176
50	.48	163	.47	165	.46	163	.47	165
55	.48	143	.48	148	.46	145	.48	147
60	.48	120	.49	127	.47	126	.48	125
65	.48	93	.48	103	.48	105	.48	97
70	.48	64	.47	76	.48	83	.47	69
80	.46	-21	.47	-5	.44	27	.47	2
85	.41	-105	.45	-71	.41	-5	.45	-42
90	.077		.1		.40		.35	
95	.014		.0095		.39		.092	
100			.001		.10			
105	.0145		.0265		.0087		.006	
110	.008		.0156		.0053		.0057	
120	.0026		.0055		.0045		.0022	
130	.0002		.0016		.0012		.0002	
140	.0009		.00045		.0011		.001	
150	.001		.001		.0008		.0012	
160	.001		.0013		.0012		.0014	
170	.0007		.001		.001		.0011	

	5	∘	6	^	
10	.49	-30	.49	-30	-30
15	.49	-48	.49	-48	-49
20	.47	-68	.47	-68	-68
25	.46	-90	.46	-91	-92
30	.47	-114	.47	-114	-115
35	.48	-135	.48	-136	
40	.49	-155	.49	-156	
45	.47	-175	.47	-176	
50	.47	166	.47	165	
55	.47	147	.47	147	
60	.48	126	.48	125	
5	.48	100	.48	102	
70	.48	74	.48	76	
80	.47	8	.47	10	
85	.46	-40	.47	-37	
90	.35		.42		
95	.079		.12		
100					
105	.010		.0098		
110	.0073		.0087		
120	.0020		.0037		
130	.00097		.00065		
140	.0017		.00062		
70	.0019		.00094		
160	.0021		.00105		
170	.0017		.0008		