IAN-101

PHASE AND AMPLITUDE RESPONSE OF A VARIABLE ELECTRONIC FILTER

DL INSTRUMENTS

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ABSTRACT

The phase and amplitude response of a 4 pole Butterworth low-pass, 4 pole Butterworth high-pass and 4 pole Bessel low-pass filters are provided. Also, the phase and amplitude response of a band-pass filter formed by cascaded 4 pole Butterworth high and low-pass filters are provided for cut-off separations of 0/10, 1/10, 2/10, 3/10 decade. A simple general method is described for obtaining the phase and amplitude response of cascaded 4 pole Butterworth high and low-pass filters for any filter separation in 1/10 decade steps. The –3 dB frequencies, center frequency, –3 dB bandwidth, noise bandwidth and filter gain are tabulated for ITHACO Variable Electronic Filters such that this information can be obtained for any filter setting.

INTRODUCTION

A Variable Electronic Filter as described in this paper is comprised of independently tuned high-pass and low-pass filter sections with provisions to operate as a low-pass, high-pass and band-pass filter. It also may have a transfer function which can be selected according to the application. For normal filtering in the frequency domain four pole Butterworth high-pass and low-pass filters are used. For use in the time domain a four pole Bessel low-pass filter is ideal inasmuch as it has a linear-phase characteristic which perserves the pulse wave shape.

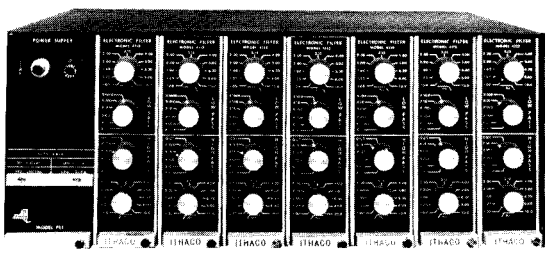
The phase and amplitude response of the Variable Electronic Filter will vary with each filter function (HP, LP, BP), with each filter characteristic (Butterworth, Bessel), and each filter cut-off frequency; so an exhaustive tabulation of amplitude and phase is not practical. However, with tabulation of the phase and amplitude response of a 4 pole Butterworth high-pass filter, a 4 pole Butterworth low-pass filter, and a 4 pole Bessel low-pass filter in 1/20 decade frequency steps, it is possible to obtain the amplitude and phase response for any filter function with cut-off frequencies in 1/10 decade steps. Further, many of the ITHACO Variable Electronic Filters have frequency cut-off steps of 1/10 decade (1/3 octave) so the resultant tabulations are directly applicable.

PHASE & AMPLITUDE RESPONSE OF 4 POLE BUTTERWORTH AND BESSEL FILTERS

The phase and amplitude response for a four pole Butterworth high-pass, 4 pole Butterworth low-pass, and 4 pole Bessel low-pass filter are tabulated in Chart I, II and III respectively. Referring to Chart I, the frequency is tabulated in the first eleven columns – each column corresponding to a 1/10 decade step in cut-off frequency – and the amplitude and phase in the last two columns.

If the filter cut-off frequency is one of the 1/10 decade increments listed at the top of the columns (1.0000, 1.2589, 1.5849, 1.9952, 2.5119, 3.1622, 3.9810, 5.0118, 6.3095, 7.9432, 10.000) or sufficiently close to these numbers such as the internationally preferred set of numbers used on the ITHACO Variable Electronic Filters (1.00, 1.25, 1.60, 2.00, 2.50, 3.15, 4.00, 5.00, 6.30, 8.00, 10.0), the phase and amplitude response can be determined directly from the charts. If the filter cut-off frequency is very different from these listed, the phase and amplitude response can be determined by multiplying each of the frequencies in Column 1 by the cut-off frequency and thereby obtaining a column of frequencies for the phase and amplitude response listed.

The normalized amplitude response for a 4 pole Butterworth high-pass, 4 pole Butterworth low-pass, and 4 pole Bessel low-pass filter is plotted in Figures 1 and 3 respectively and the normalized phase response is plotted in Figures 2 and 4 respectively. To determine the response for a particular cut-off frequency, the normalized frequency scale on the graph is multiplied by the filter cut-off frequency. For example, if the filter cut-off frequency is set to 2KHz, "1" on the normalized frequency scale will indicate 2 KHz, "2" on the normalized frequency scale will indicate 4 KHz, "5" on the normalized frequency scale will indicate 10 KHz, "0.5" on the normalized frequency scale will indicate 1 KHz, etc. In this manner a single curve can specify all filter settings.



TYPICAL ITHACO VARIABLE ELECTRONIC FILTERS

BAND-PASS FILTERS FORMED BY CASCADING HIGH-PASS AND LOW-PASS FILTERS

A band-pass filter can be formed by cascading a high-pass filter with a low-pass filter, and the resultant phase and amplitude response can be obtained from the individual filter responses by adding the amplitude in dB and the phase in degrees at the SAME frequency.

It is the requirement that the phase and amplitude response be added at the same frequency which dictated that the cut-off frequencies and the frequency increments be in compatable logarithmic steps. Referring to Chart I and Chart II, note each column contains the same frequencies (except at the extremes which are least significant). So the phase and amplitude response can be obtained by adding the response in Chart I to that in Chart II for any of the given filter settings.

EXAMPLE: For a Variable Electronic Filter set to:

High-Pass Setting, F_{HP} = 1.2589 KHz

Low-Pass Setting, F_{LP} = 3.1622 KHz

Band-Pass Center Freq., $F_O = \sqrt{(1.2589)\ (3.1622)}$ KHz

= 1.9952 KHz

Refer to Chart I, column 2 for the frequencies for a high-pass filter setting of 1.2589 KHz. Refer to Chart II, column 6 for the frequencies for a low-pass filter setting of 3.1622 KHz. The amplitude and phase information in Chart I is added to the amplitude and phase information in Chart II for the same frequency. Some of the information in Chart I and Chart II are tabulated below. Note, for 1.2589 KHz the high-pass amplitude response is −3.01 dB and the low-pass amplitude response is 0.0 dB so the resulting band-pass filter amplitude response is −3.01 dB. Similarly, for 1.2589 KHz, the high-pass phase response is 180.0 degrees and the low-pass phase response is −58.4 degrees, so the band-pass filter phase response is 121.6 degrees.

Chart IV, for example, is the overall response of a 4 pole Butterworth high-pass and low-pass filter cascaded with equal cut-off frequencies. This chart was obtained by assuming that the cut-off frequency for both filter sections was 1.0000 so the phase and amplitude response for each frequency in column 1 of Chart I was added to the corresponding phase and amplitude response for the same frequency in column 1 of Chart II.

Similarly Chart V is the overall response for a 4 pole Butterworth high-pass cascaded with a 4 pole Butterworth low-pass with the cut-off frequency separated by 1/10 decade. To obtain this tabulation the high-pass filter was assumed to have a cut-off frequency of 1.000 (column 1 of Chart I) and the low-pass filter was assumed to have a cut-off frequency of 1.2589 (column 2 of Chart II) and the resultant tabulation was obtained by looking up the amplitude and phase response for each frequency in column 1 of Chart I and adding it to the corresponding amplitude and phase response for the same frequency in column 2 of Chart II.

Similarly Chart VI and VII where obtained from Chart I and Chart II for 2/10 decade and 3/10 decade separation of the high and low-pass filters.

Figures 5 and 6 show the normalized amplitude and phase response of a band-pass filter formed by cascading 4 pole Butterworth filters for 0/10, 1/10, 2/10, 3/10 decade separation. Figure 7 shows the variation in filter gain (insertion loss) as the cut-off frequency of the high-pass and low-pass filters are separated. Figure 8 shows the normalized amplitude response with the insertion loss removed so the filter characteristics can be compared for different cut-off separations. Note that the filter response for no separation is only slightly different from those with 1/10 and 2/10 decade spearation, but the insertion loss is quite different which suggests that for many applications 2/10 decade separation is preferable. Figures 9 through 12 show families of band-pass filters with 1/10 decade steps in cut-off frequencies.

Chart VIII is an exact tabulation of −3dB frequencies center frequency, bandwidth, noise bandwidth, and filter gain for the internationally preferred set of frequency settings (1.00, 1.25, 1.60, 2.00, 2.50, 3.15, 4.00, 5.00, 6.30, 8.00) used in the ITHACO Variable Electronic Filter. This information is tabulated in a manner which permits it to be used for any combination of filter settings.

HIGH-PASS F_{HP} = 1.2589

CHART I

②	⑫	⑬
FREQ.	AMPLITUDE	PHASE
Hz	dB	DEGREES
1.2589	−3.01	180.0
1.4125	−1.46	153.5
1.5849	− .64	130.6
1.7783	− .27	112.1
1.9952	− .11	97.3
2.2387	− .04	85.1
2.5119	− .02	74.8
2.8183	− .01	66.0
3.1622	.00	58.4

LOW-PASS F_{LP} = 3.1622

CHART II

⑥	⑫	⑬
FREQ.	AMPLITUDE	PHASE
Hz	dB	DEGREES
1.2589	.00	− 58.4
1.4125	− .01	− 66.0
1.5849	− .02	− 74.8
1.7783	− .04	− 85.0
1.9952	− .11	− 97.3
2.2387	− .27	−112.1
2.5119	− .64	−130.6
2.8183	−1.46	−153.5
3.1622	−3.01	−180.0

BAND-PASS F_O = 1.9952

NEW CHART

FREQ.	AMPLITUDE	PHASE
Hz	dB	DEGREES
1.2589	−3.01	121.6
1.4125	−1.47	87.5
1.5849	− .66	55.8
1.7783	− .31	27.1
1.9952	− .22	0.0
2.2387	− .31	− 27.0
2.5119	− .66	− 55.8
2.8183	−1.47	− 87.5
3.1622	−3.01	−121.6

NORMALIZED AMPLITUDE RESPONSE OF A 4 POLE BUTTERWORTH FILTER

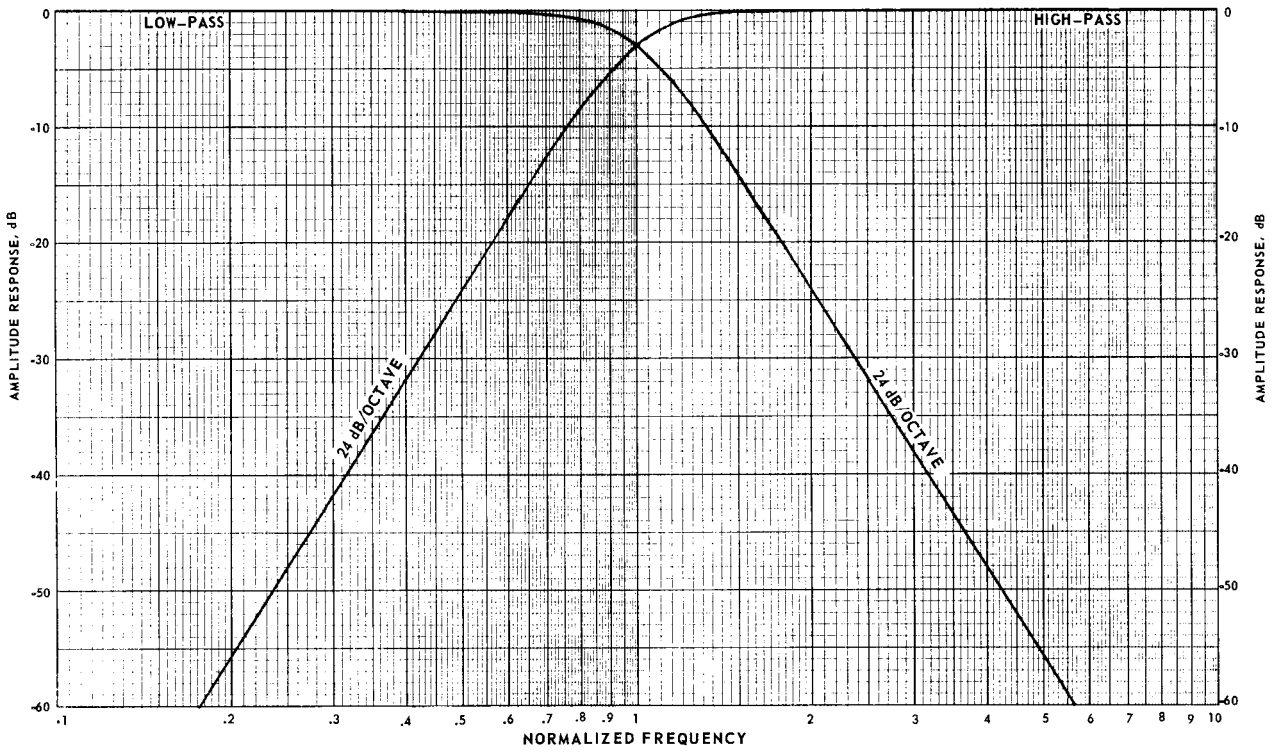


FIGURE 1 AMPLITUDE RESPONSE OF 4 POLE BUTTERWORTH FILTER

NORMALIZED PHASE RESPONSE OF A 4 POLE BUTTERWORTH FILTER

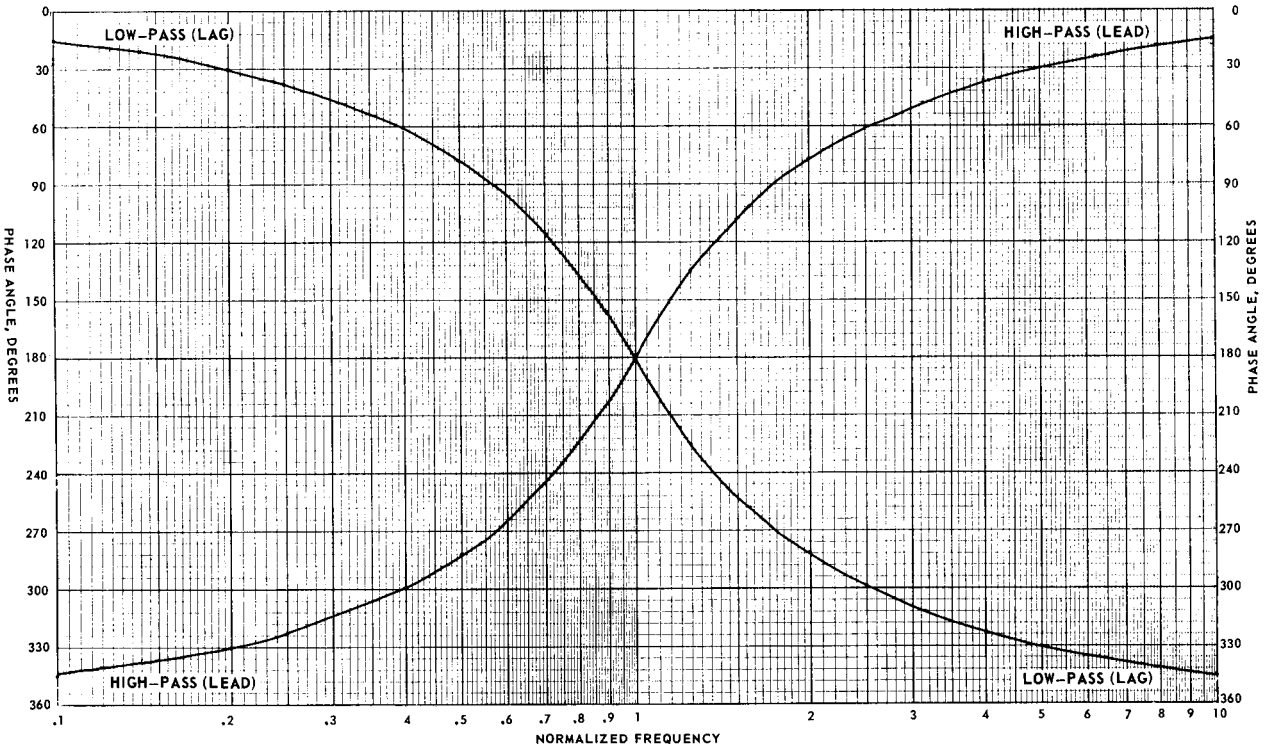


FIGURE 2 PHASE RESPONSE OF 4 POLE BUTTERWORTH FILTER

NORMALIZED AMPLITUDE RESPONSE OF A 4 POLE BESSEL LOW-PASS FILTER

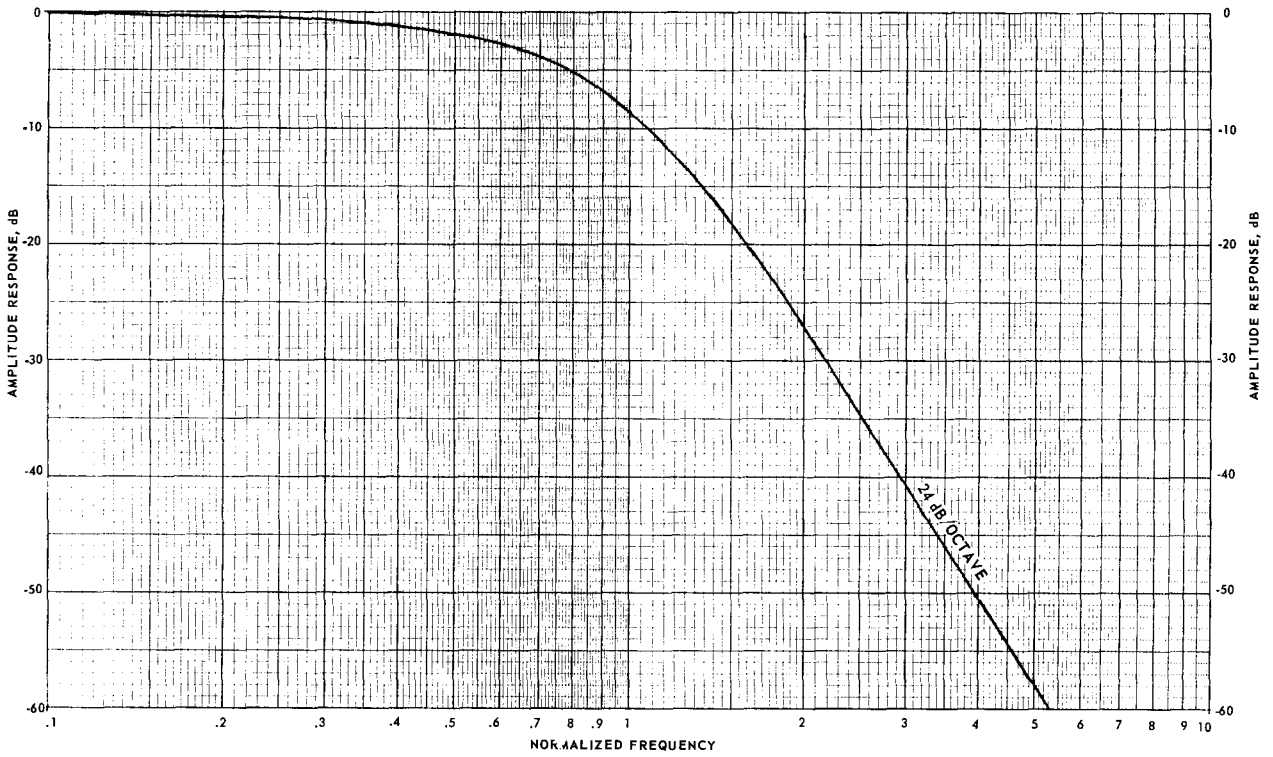


FIGURE 3 AMPLITUDE RESPONSE OF 4 POLE BESSEL FILTER

NORMALIZED PHASE RESPONSE OF A 4 POLE BESSEL LOW-PASS FILTER

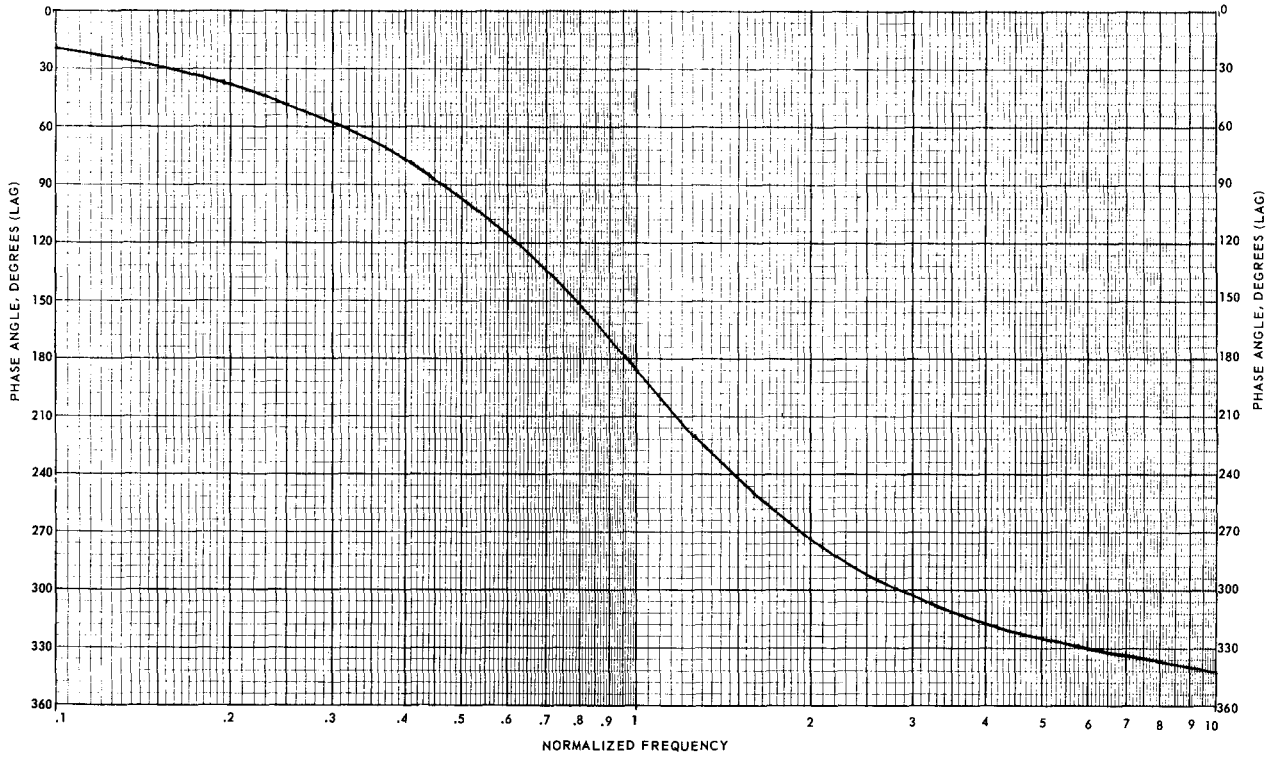


FIGURE 4 PHASE RESPONSE OF 4 POLE BESSEL FILTER

NORMALIZED AMPLITUDE RESPONSE

BAND–PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH LOW–PASS AND HIGH–PASS FILTERS

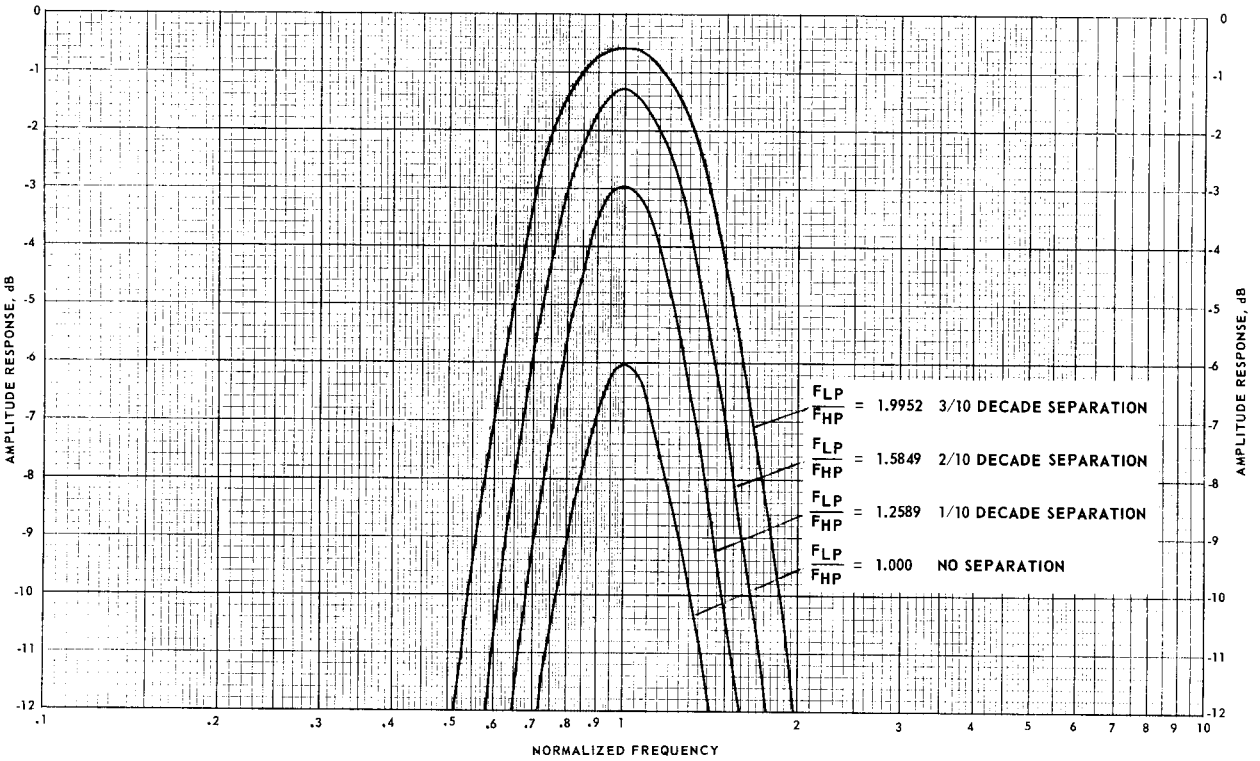


FIGURE 5 AMPLITUDE RESPONSE OF BAND–PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH FILTERS

NORMALIZED PHASE RESPONSE

BAND–PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH LOW&PASS AND HIGH–PASS FILTERS

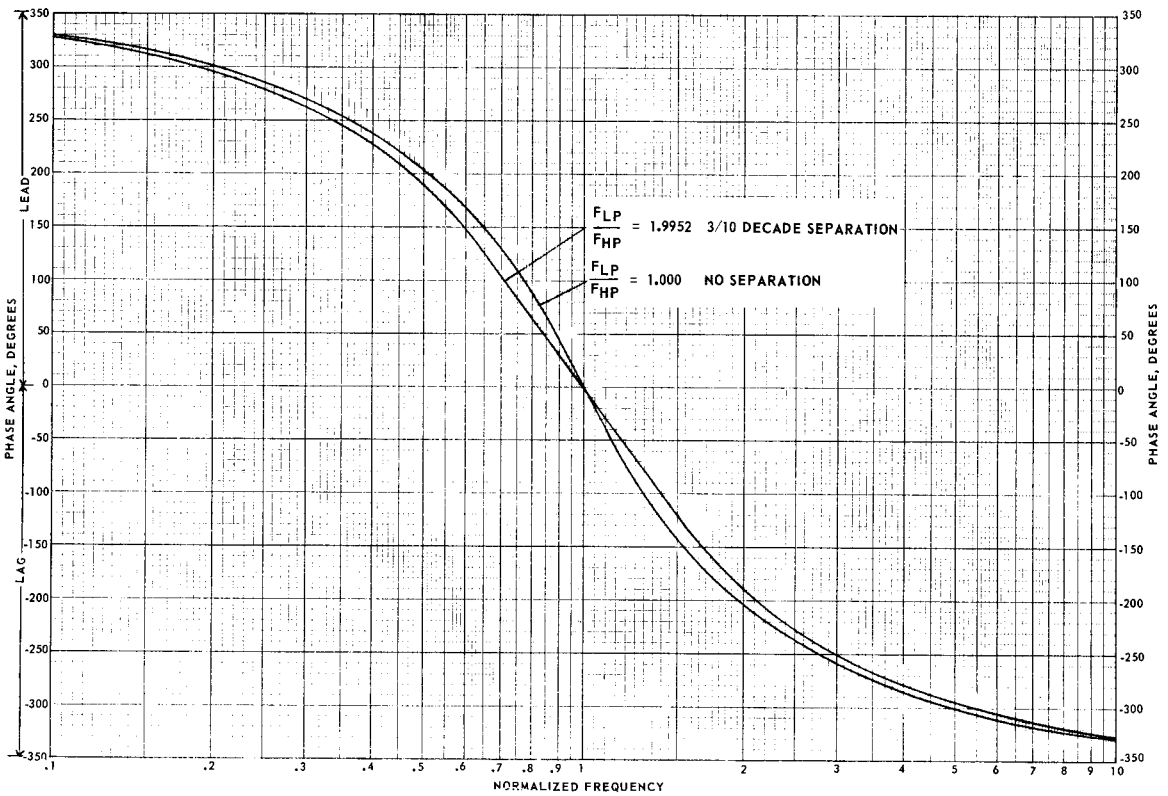


FIGURE 6 PHASE RESPONSE OF BAND-PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH FILTERS

FILTER GAIN VS SEPARATION OF HIGH-PASS & LOW-PASS FILTERS

BAND-PASS FILTER FORMED BY CASCADING 4 POLE BUTTERWORTH LOW-PASS AND HIGH-PASS FILTERS

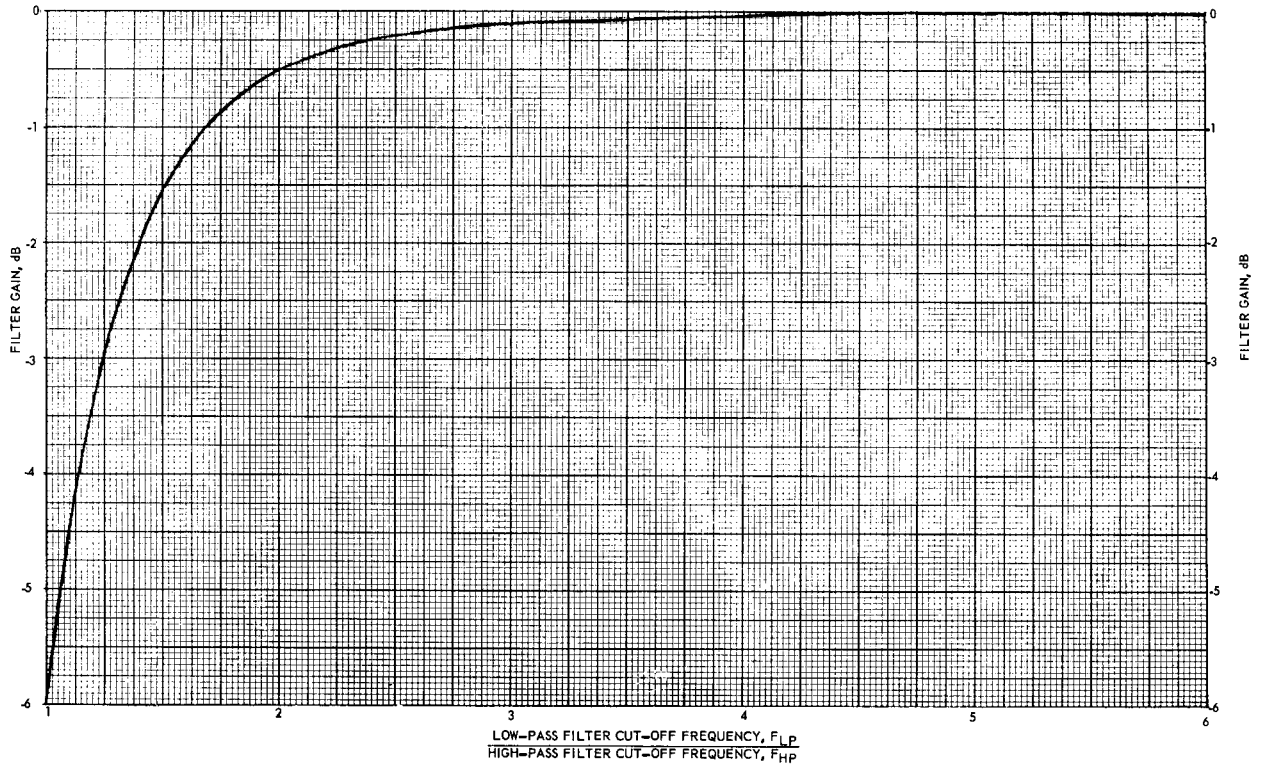


FIGURE 7 BAND-PASS FILTER GAIN VS SEPARATION OF HIGH & LOW-PASS FILTERS

NORMALIZED AMPLITUDE RESPONSE WITHOUT INSERTION LOSS

BAND-PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH LOW-PASS AND HIGH-PASS FILTERS

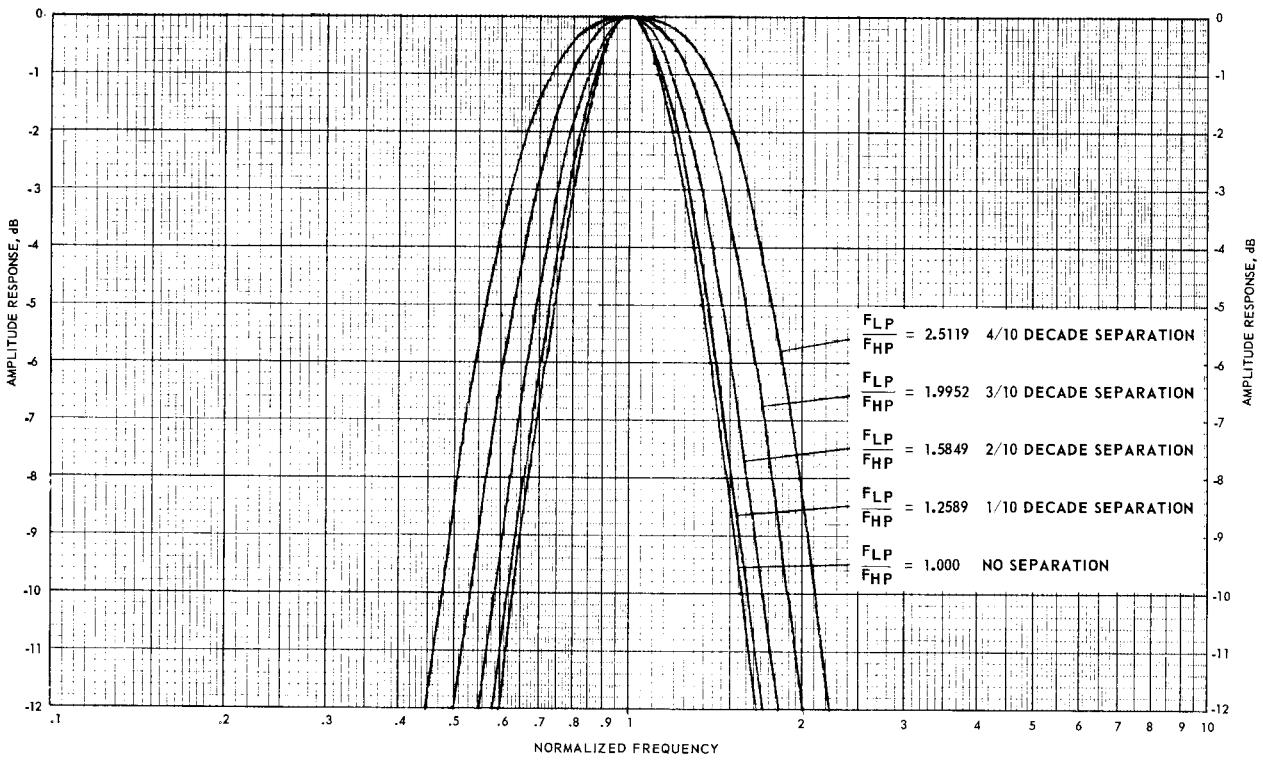


FIGURE 8 AMPLITUDE RESPONSE OF BAND-PASS FILTER WITHOUT INSERTION LOSS

BAND–PASS FILTERS

FAMILY OF BAND–PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH HIGH–PASS AND LOW–PASS FILTERS

NO SEPARATION – $F_{LP} = F_{HP}$ – 0 OCTAVE SEPARATION

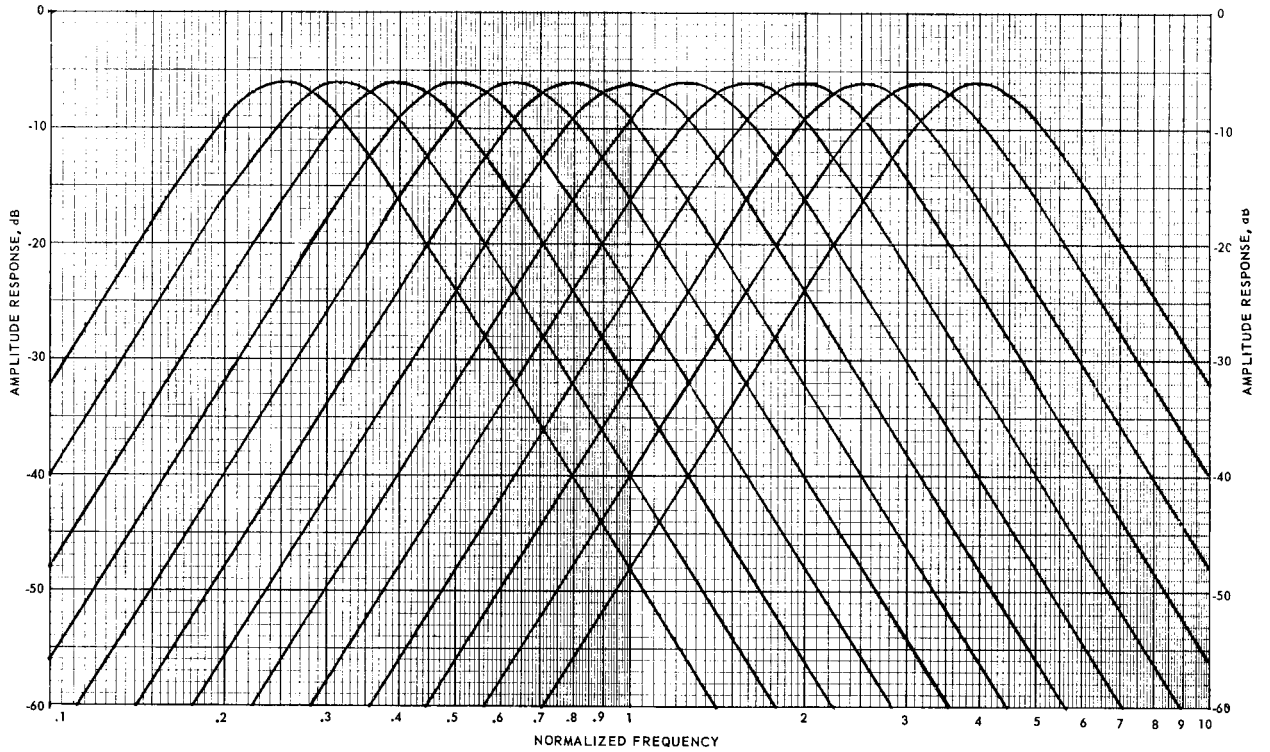


FIGURE 9 FAMILY OF BAND–PASS FILTERS WITH NO SEPARATION

BAND–PASS FILTERS

FAMILY OF BAND–PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH HIGH–PASS AND LOW–PASS FILTERS

1/10 DECADE SEPARATION – $\frac{F_{LP}}{F_{HP}} = 1.2589$ – 1/3 OCTAVE SEPARATION

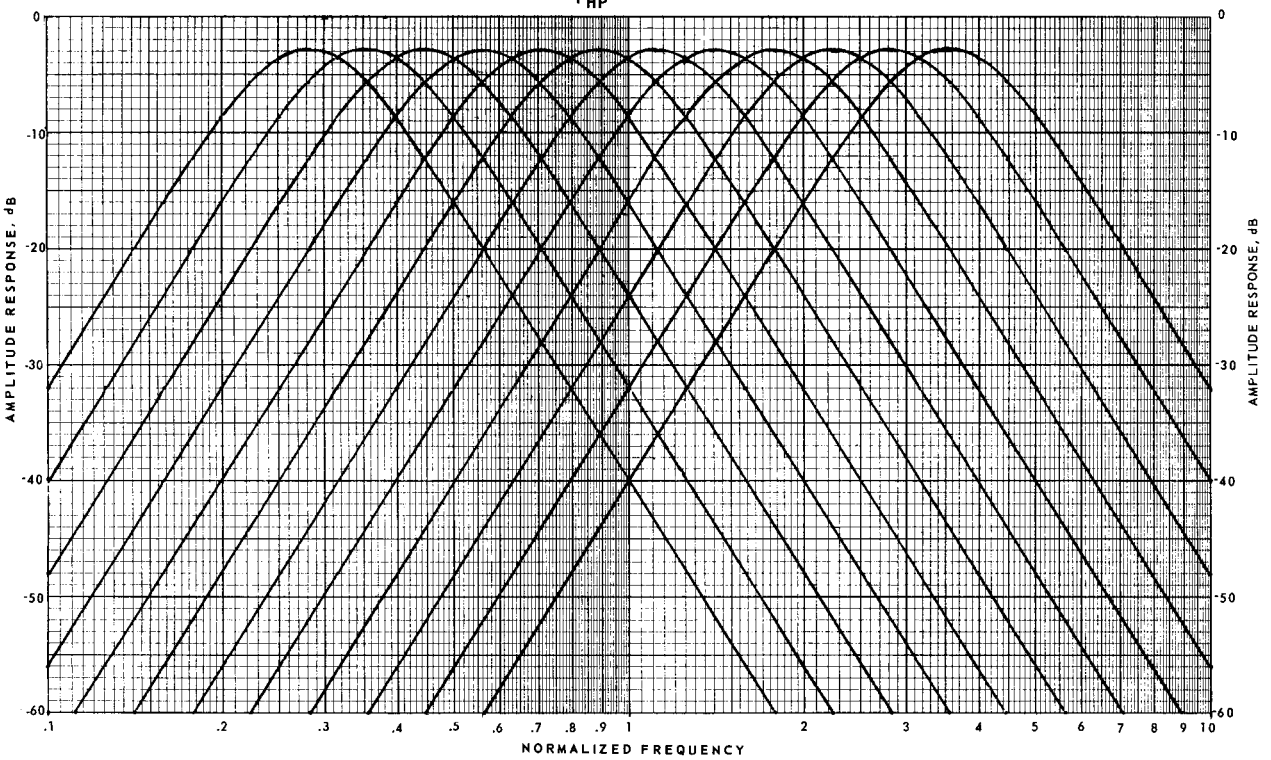


FIGURE 10 FAMILY OF BAND–PASS FILTERS WITH 1/10 DECADE SEPARATION

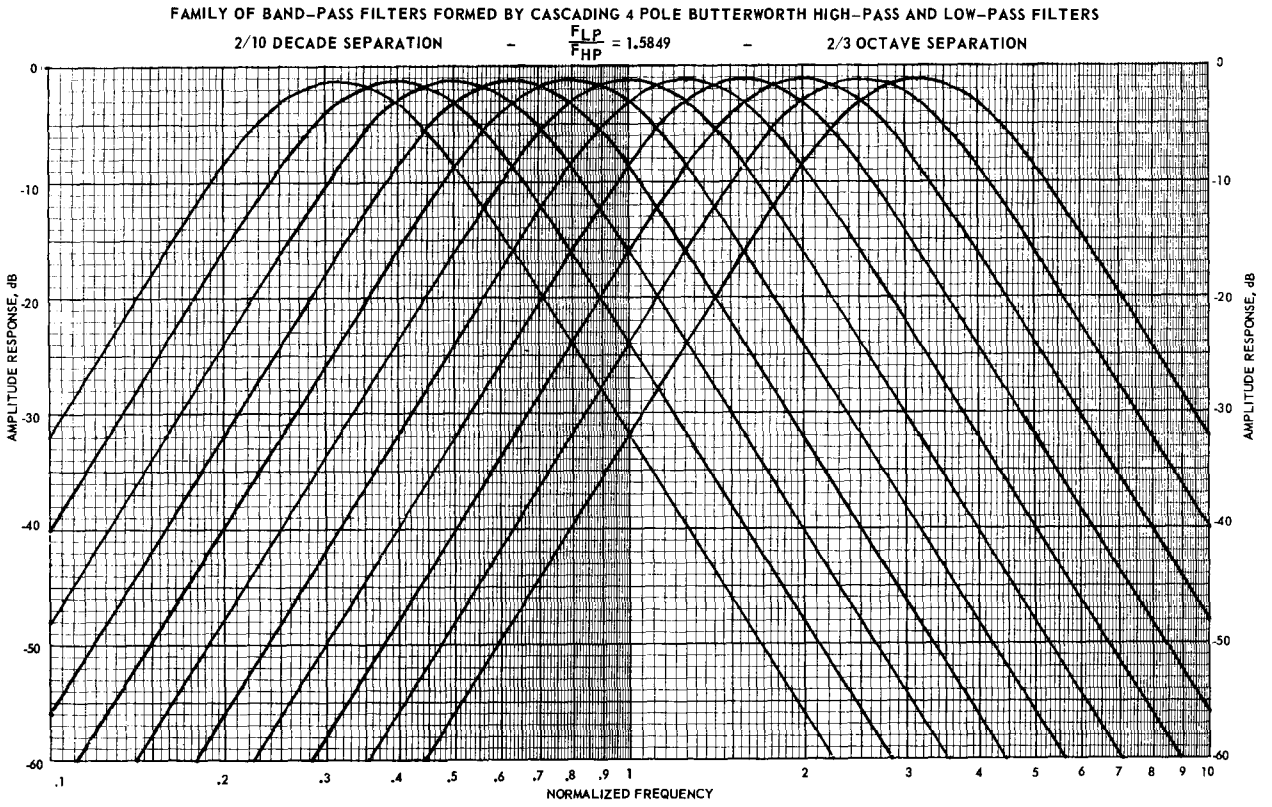


FIGURE 11 FAMILY OF BAND-PASS FILTERS WITH 2/10 DECADE SEPARATION

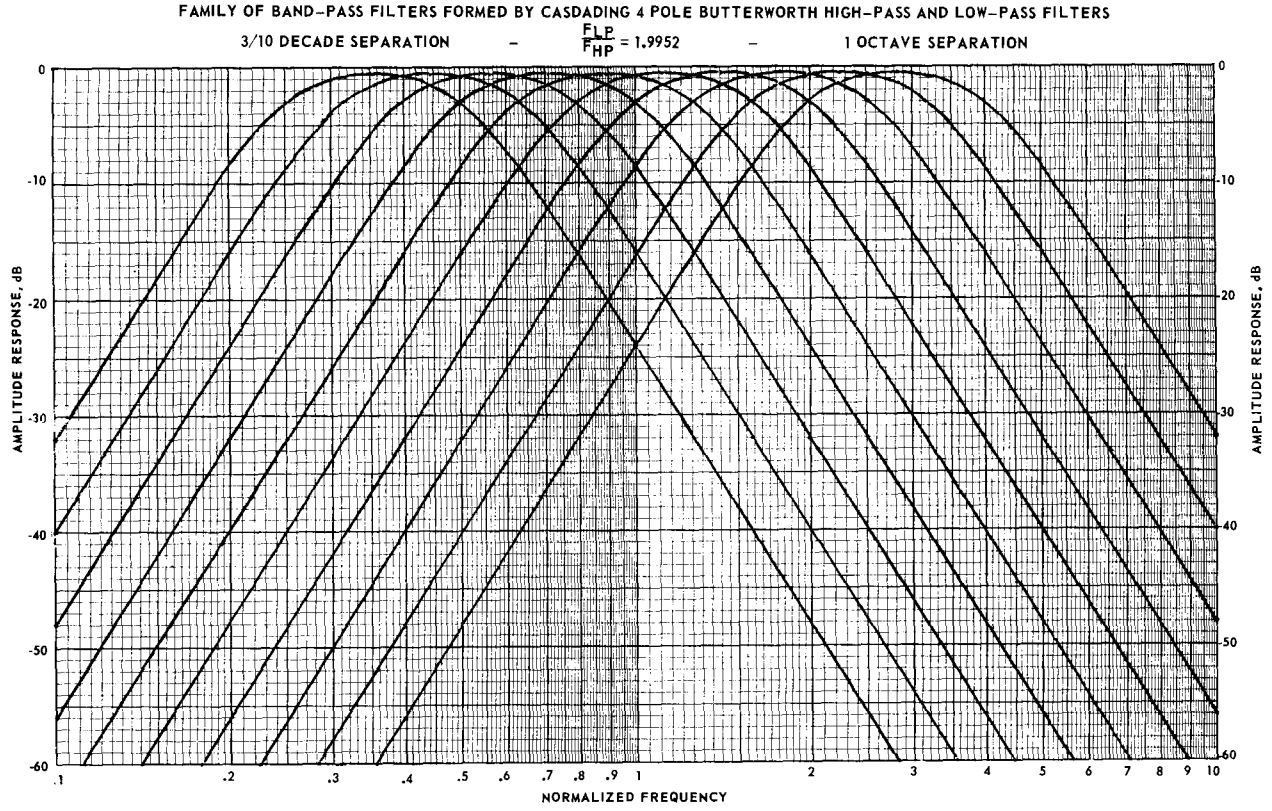


FIGURE 12 FAMILY OF BAND-PASS FILTERS WITH 3/10 DECADE SEPARATION

CHART I

HIGH–PASS FILTER

BUTTERWORTH

PHASE & AMPLITUDE RESPONSE OF A 4 POLE BUTTERWORTH HIGH–PASS FILTER

FREQUENCY SETTING, Hz											AMPLITUDE RESPONSE	PHASE RESPONSE
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000		
FREQUENCY, Hz											dB	DEGREES
.0100	.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	-160.0	358.5
.0112	.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	-156.0	358.3
.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	-152.0	358.1
.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	-148.0	357.9
.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	-144.0	357.6
.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	-140.0	357.3
.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	-136.0	357.0
.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	-132.0	356.6
.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	-128.0	356.2
.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	-124.0	355.8
.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	-120.0	355.3
.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	-116.0	354.7
.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	-112.0	354.0
.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	-108.0	353.3
.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	-104.0	352.5
.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	-100.0	351.6
.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	- 96.0	350.5
.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	- 92.0	349.4
.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	- 88.0	348.1
.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	- 84.0	346.6
.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	- 80.0	345.0
.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	- 76.0	343.2
.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	- 72.0	341.1
.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	- 68.0	338.8
.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	- 64.0	336.2
.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	- 60.0	333.3
.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	- 56.0	330.0
.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	- 52.0	326.2
.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	- 48.0	322.1
.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	- 44.0	317.3
.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	- 40.0	312.0
.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	- 36.0	305.9
.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	- 32.00	298.9
.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	- 28.01	291.0
.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	- 24.02	281.8
.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	- 20.04	271.2
.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	- 16.11	258.6
.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	- 12.27	243.5
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	- 8.64	225.4
.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	- 5.46	203.9
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	- 3.01	180.0
1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	- 1.46	156.1
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	- 0.64	134.6
1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	- 0.27	116.5
1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	0.11	101.4
1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	- 0.04	88.8
1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	- 0.02	78.2
2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	- 0.01	69.0
2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	0.00	61.1
2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	0.00	54.1
3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	0.00	48.0
3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	0.00	42.7
3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	0.00	38.0
4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	0.00	33.8
5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	0.00	30.0
5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	0.00	26.7
6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	0.00	23.8
7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	0.00	21.2
7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	0.00	18.9
8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	0.00	16.8
10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	0.00	15.0
11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	0.00	13.4
12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	0.00	11.9
14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	0.00	10.6
15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	0.00	9.4
17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	0.00	8.4
19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	0.00	7.5
22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	0.00	6.7
25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	0.00	6.0
28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	0.00	5.3
31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	0.00	4.7
35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	0.00	4.2
39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	0.00	3.8
44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	0.00	3.4
50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	0.00	3.0
56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	0.00	2.7
63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	0.00	2.4
70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	0.00	2.1
79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	0.00	1.9
89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	891.24	0.00	1.7
100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	1000.0	0.00	1.5

CHART II

LOW-PASS FILTER

BUTTERWORTH

PHASE & AMPLITUDE RESPONSE OF A 4 POLE BUTTERWORTH LOW-PASS FILTER

FREQUENCY SETTING, Hz											AMPLITUDE RESPONSE dB	PHASE RESPONSE DEGREES
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000		
FREQUENCY, Hz												
.0100	.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	0.00	- 1.5
.0112	.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	0.00	- 1.7
.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	0.00	- 1.9
.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	0.00	- 2.1
.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	0.00	- 2.4
.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	0.00	- 2.7
.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	0.00	- 3.0
.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	0.00	- 3.4
.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	0.00	- 3.8
.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	0.00	- 4.2
.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	0.00	- 4.7
.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	0.00	- 5.3
.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	0.00	- 6.0
.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	0.00	- 6.7
.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	0.00	- 7.5
.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	0.00	- 8.4
.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	0.00	- 9.4
.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	0.00	- 10.6
.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	0.00	- 11.9
.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	0.00	- 13.4
.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	0.00	- 15.0
.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	0.00	- 16.8
.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	0.00	- 18.9
.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	0.00	- 21.2
.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	0.00	- 23.8
.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	0.00	- 26.7
.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	0.00	- 30.0
.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	0.00	- 33.8
.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	0.00	- 38.0
.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	0.00	- 42.7
.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	0.00	- 48.0
.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	0.00	- 54.1
.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	0.00	- 61.1
.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	- 0.01	- 69.0
.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	- 0.02	- 78.2
.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	- 0.04	- 88.8
.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	- 0.11	-101.4
.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	- 0.27	-116.5
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	- 0.64	-134.6
.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	- 1.46	-156.1
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	- 3.01	-180.0
1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	- 5.45	-203.9
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	- 8.64	-225.4
1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	- 12.26	-243.5
1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	- 16.11	-258.6
1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	- 20.04	-271.2
1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	- 24.02	-281.8
2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	- 28.01	-291.0
2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	- 32.00	-298.9
2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	- 36.00	-305.9
3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	- 40.00	-312.0
3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	- 44.00	-317.3
3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	- 48.00	-322.1
4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	- 52.00	-326.2
5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	- 56.00	-330.0
5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	- 60.00	-333.3
6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	- 64.00	-336.2
7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	- 68.00	-338.8
7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	- 72.00	-341.1
8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	- 76.00	-343.2
10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	- 80.00	-345.0
11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	- 84.00	-346.6
12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	- 88.00	-348.1
14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	- 92.00	-349.4
15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	- 96.00	-350.5
17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	-100.00	-351.6
19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	-104.00	-352.5
22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	-108.00	-353.3
25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	-112.00	-354.0
28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	-116.00	-354.7
31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	-120.00	-355.3
35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	-124.00	-355.8
39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	-128.00	-356.2
44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	-132.00	-356.6
50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	-136.00	-357.0
56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	-140.00	-357.3
63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	-144.00	-357.6
70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	-148.00	-357.9
79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	-152.00	-358.1
89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	891.24	-156.00	-358.3
100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	1000.0	-160.00	-358.5

LOW–PASS FILTER

BESSEL — LINEAR PHASE — MAXIMAL FLAT TIME DELAY

PHASE & AMPLITUDE RESPONSE OF A 4 POLE BESSEL LOW–PASS FILTER

FREQUENCY SETTING, Hz											AMPLITUDE RESPONSE dB	PHASE RESPONSE DEGREES
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000		
FREQUENCY, Hz												
.0100	.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	0.00	- 1.94
.0112	.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	0.00	- 2.18
.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	0.00	- 2.45
.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	0.00	- 2.74
.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	0.00	- 3.08
.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	0.00	- 3.45
.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	0.00	- 3.88
.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	0.00	- 4.35
.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	0.00	- 4.88
.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	- 0.01	- 5.47
.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	- 0.01	- 6.14
.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	- 0.01	- 6.89
.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	- 0.01	- 7.73
.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	- 0.01	- 8.68
.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	- 0.02	- 9.73
.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	- 0.02	- 10.92
.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	- 0.03	- 12.25
.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	- 0.04	- 13.75
.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	- 0.05	- 15.43
.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	- 0.06	- 17.31
.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	- 0.07	- 19.42
.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	- 0.09	- 21.79
.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	- 0.11	- 24.45
.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	- 0.14	- 27.43
.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	- 0.18	- 30.78
.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	- 0.23	- 34.54
.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	- 0.29	- 38.75
.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	- 0.36	- 43.48
.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	- 0.45	- 48.78
.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	- 0.57	- 54.74
.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	- 0.73	- 61.41
.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	- 0.92	- 68.91
.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	- 1.16	- 77.31
.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	- 1.48	- 86.73
.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	- 1.88	- 97.29
.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	- 2.41	-109.09
.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	- 3.09	-122.23
.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	- 3.98	-136.75
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	- 5.15	-152.57
.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	- 6.67	-169.43
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	- 8.58	-186.80
1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	- 10.91	-204.10
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	- 13.64	-220.65
1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	- 16.69	-235.99
1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	- 20.00	-249.89
1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	- 23.50	-262.31
1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	- 27.13	273.32
2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	- 30.86	-283.06
2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	- 34.66	-291.67
2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	- 38.51	-299.28
3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	- 42.39	-306.01
3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	- 46.30	-311.98
3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	- 50.24	-317.27
4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	- 54.18	-321.96
5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	- 58.14	-326.13
5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	- 62.11	-329.84
6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	- 66.08	-333.14
7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	- 70.06	-336.07
7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	- 74.05	-338.68
8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	- 78.03	-341.01
10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	- 82.02	-343.08
11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	- 86.02	-344.92
12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	- 90.01	-346.56
14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	- 94.00	-348.03
15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	- 98.00	-349.33
17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	-102.00	-350.49
19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	-106.00	-351.52
22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	-109.99	-352.45
25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	-113.99	-353.27
28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	-117.99	-354.00
31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	-121.99	-354.65
35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	-125.99	-355.23
39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	-129.99	-355.75
44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	-133.99	-356.21
50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	-137.99	-356.63
56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	-141.99	-356.99
63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	-145.99	-357.32
70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	-149.99	-357.61
79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	-153.99	-357.87
89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	891.24	-157.99	-358.10
100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	1000.0	-161.99	-358.31

CHART IV

BAND-PASS FILTER

$F_{LP} = F_{HP} = F_O$

BAND-PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH HIGH-PASS & LOW-PASS FILTERS

1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	CENTER FREQ.	
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	L.P. SETTING	
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	H.P. SETTING	
FREQUENCY, Hz											AMPLITUDE dB	PHASE DEGREES
.0100	.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	-160.0	357.0
.0112	.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	-156.0	356.6
.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	-152.0	356.2
.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	-148.0	355.8
.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	-144.0	355.3
.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	-140.0	354.7
.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	-136.0	354.0
.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	-132.0	353.3
.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	-128.0	352.5
.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	-124.0	351.6
.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	-120.0	350.5
.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	-116.0	349.4
.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	-112.0	348.1
.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	-108.0	346.6
.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	-104.0	345.0
.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	-100.0	343.2
.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	- 96.0	341.1
.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	- 92.0	338.8
.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	- 88.0	336.2
.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	- 84.0	333.3
.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	- 80.0	330.0
.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	- 76.0	326.3
.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	- 72.0	322.2
.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	- 68.0	317.6
.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	- 64.0	312.4
.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	- 60.0	306.5
.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	- 56.0	299.9
.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	- 52.0	292.5
.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	- 48.0	284.1
.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	- 44.0	274.6
.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	- 40.0	263.9
.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	- 36.0	251.7
.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	- 32.0	237.9
.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	- 28.02	222.0
.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	- 24.04	203.7
.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	- 20.08	182.3
.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	- 16.22	157.1
.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	- 12.54	127.0
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	- 9.28	90.8
.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	- 6.92	47.8
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	- 6.02	00.0
1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	- 6.92	- 47.8
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	- 9.28	- 90.8
1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	- 12.54	- 127.0
1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	- 16.22	- 157.1
1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	- 20.08	- 182.3
1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	- 24.04	- 203.7
2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	- 28.02	- 202.2
2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	- 32.0	- 237.9
2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	- 36.0	- 251.7
3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	- 40.0	- 263.9
3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	- 44.0	- 274.6
3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	- 48.0	- 284.1
4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	- 52.0	- 292.5
5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	- 56.0	- 299.9
5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	- 60.0	- 306.5
6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	- 64.0	- 312.4
7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	- 68.0	- 317.6
7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	- 72.0	- 322.2
8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	- 76.0	- 326.3
10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	- 80.0	- 330.0
11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	- 84.0	- 333.3
12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	- 88.0	- 336.2
14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	- 92.0	- 338.8
15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	- 96.0	- 341.1
17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	-100.0	- 343.2
19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	-104.0	- 345.0
22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	-108.0	- 346.6
25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	-112.0	- 348.1
28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	-116.0	- 349.4
31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	-120.0	- 350.5
35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	-124.0	- 351.6
39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	-128.0	- 352.5
44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	-132.0	- 353.3
50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	-136.0	- 354.0
56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	-140.0	- 354.7
63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	-144.0	- 355.3
70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	-148.0	- 355.8
79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	-152.0	- 356.2
89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	891.24	-156.0	- 356.6
100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	1000.0	-160.0	- 357.0

CHART V

BAND-PASS FILTER

1/10 DECADE SEPARATION — $\frac{F_{LP}}{F_{HP}} = 1.2589$ — 1/3 OCTAVE SEPARATION

BAND-PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH HIGH-PASS & LOW-PASS FILTERS

1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	CENTER FREQ., F_O	
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	L.P. SETTING, F_{LP}	
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	H.P. SETTING, F_{HP}	
FREQUENCY Hz											AMPLITUDE RESPONSE dB	PHASE RESPONSE DEGREES
.0100	.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	-160.0	357.3
.0112	.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	-156.0	357.0
.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	-152.0	356.6
.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	-148.0	356.2
.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	-144.0	355.7
.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	-140.0	355.2
.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	-136.0	354.6
.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	-132.0	354.0
.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	-128.0	353.3
.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	-124.0	352.4
.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	-120.0	351.5
.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	-116.0	350.5
.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	-112.0	349.3
.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	-108.0	348.0
.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	-104.0	346.5
.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	-100.0	344.9
.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	- 96.00	343.0
.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	- 92.00	341.0
.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	- 88.00	338.6
.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	- 84.00	336.0
.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	- 80.00	333.1
.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	- 76.00	329.8
.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	- 72.00	326.1
.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	- 68.00	322.0
.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	- 64.00	317.3
.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	- 60.00	312.0
.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	- 56.00	306.1
.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	- 52.00	299.5
.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	- 48.00	292.0
.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	- 44.00	283.6
.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	- 40.00	274.0
.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	- 36.00	263.2
.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	- 32.00	250.9
.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	- 28.01	236.9
.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	- 24.02	220.8
.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	- 20.05	202.2
.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	- 16.13	180.4
.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	- 12.30	154.7
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	- 8.75	123.9
.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	- 5.72	87.4
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	- 3.65	45.4
1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	- 2.92	00.0
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	- 3.65	- 45.4
1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	- 5.72	- 87.4
1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	- 8.75	-123.9
1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	- 12.30	-154.7
1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	- 16.13	-180.4
2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	- 20.05	-202.2
2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	- 24.02	-220.8
2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	- 28.01	-236.9
3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	- 32.00	-250.9
3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	- 36.00	-263.2
3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	- 40.00	-274.0
4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	- 44.00	-283.6
5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	- 48.00	-292.0
5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	- 52.00	-299.5
6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	- 56.00	-306.1
7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	- 60.00	-312.0
7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	- 64.00	-317.3
8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	- 68.00	-322.0
10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	- 72.00	-326.1
11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	- 76.00	-329.8
12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	- 80.00	-333.1
14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	- 84.00	-336.0
15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	- 88.00	-338.6
17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	- 92.00	-341.0
19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	- 96.00	-343.0
22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	-100.0	-344.9
25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	-104.0	-346.5
28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	-108.0	-348.0
31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	-112.0	-349.3
35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	-116.0	-350.5
39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	-120.0	-351.5
44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	-124.0	-352.4
50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	-128.0	-353.3
56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	-132.0	-354.0
63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	-136.0	-354.6
70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	-140.0	-355.2
79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	-144.0	-355.7
89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	891.24	-148.0	-356.2
100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	1000.0	-152.0	-356.6

CHART VI

2/10 DECADE SEPARATION — $\frac{F_{LP}}{F_{HP}}$ — — 2/3 OCTAVE SEPARATION

BAND-PASS FILTER

BAND-PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH HIGH-PASS & LOW-PASS FILTERS

1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	CENTER FREQ., F_O	
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	L.P. SETTING, F_{LP}	
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	H.P. SETTING, F_{HP}	
FREQUENCY, Hz											AMPLITUDE RESPONSE dB	PHASE RESPONSE DEGREES
.0100	.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	-152.0	356.9
.0112	.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	-148.0	356.6
.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	-144.0	356.1
.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	-140.0	355.7
.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	-136.0	355.1
.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	-132.0	354.5
.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	-128.0	353.9
.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	-124.0	353.1
.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	-120.0	352.3
.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	-116.0	351.3
.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	-112.0	350.3
.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	-108.0	349.1
.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	-104.0	347.8
.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	-100.0	346.3
.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	- 96.0	344.6
.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	- 92.0	342.7
.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	- 88.0	340.6
.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	- 84.0	338.2
.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	- 80.0	335.6
.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	- 76.0	332.6
.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	- 72.0	329.2
.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	- 68.0	325.4
.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	- 64.0	321.2
.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	- 60.0	316.4
.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	- 56.0	311.1
.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	- 52.0	305.0
.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	- 48.0	298.2
.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	- 44.0	290.6
.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	- 40.0	281.9
.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	- 36.0	272.1
.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	- 32.0	261.0
.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	- 28.01	248.3
.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	- 24.02	233.8
.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	- 20.04	217.0
.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	- 16.11	197.5
.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	- 12.28	174.5
.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	- 8.66	147.2
.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	- 5.50	115.1
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	- 3.12	78.6
.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	- 1.73	39.6
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	- 1.28	00.0
1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	- 1.73	- 39.6
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	- 3.12	- 78.6
1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	- 5.50	-115.1
1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	- 8.66	-147.2
1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	- 12.27	-174.5
1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	- 16.11	-197.5
2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	- 20.04	-217.0
2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	- 24.02	-233.8
2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	- 28.01	-248.3
3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	- 32.0	-261.0
3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	- 36.0	-272.1
3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	- 40.0	-281.9
4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	- 44.0	-290.6
5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	- 48.0	-298.2
5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	- 52.0	-305.0
6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	- 56.0	-311.1
7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	- 60.0	-316.4
7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	- 64.0	-321.2
8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	- 68.0	-325.4
10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	- 72.0	-329.2
11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	- 76.0	-332.6
12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	- 80.0	-335.6
14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	- 84.0	-338.2
15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	- 88.0	-340.6
17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	- 92.0	-342.7
19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	- 96.0	-344.6
22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	-100.0	-346.3
25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	-104.0	-347.8
28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	-108.0	-349.1
31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	-112.0	-350.3
35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	-116.0	-351.3
39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	-120.0	-352.3
44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	-124.0	-353.1
50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	-128.0	-353.9
56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	-132.0	-354.5
63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	-136.0	-355.1
70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	-140.0	-355.7
79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	-144.0	-356.1
89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	891.24	-148.0	-356.6
100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	1000.0	-152.0	-356.9

CHART VII

BAND-PASS FILTER

3/10 DECADE SEPARATION — $\frac{F_{LP}}{F_{HP}} = 1.9952$ — 1 OCTAVE SEPARATION

BAND-PASS FILTERS FORMED BY CASCADING 4 POLE BUTTERWORTH HIGH-PASS & LOW-PASS FILTERS

1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	CENTER FREQ., F_O	
1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	L.P. SETTING, F_{LP}	
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	H.P. SETTING, F_{HP}	
FREQUENCY, Hz											AMPLITUDE RESPONSE dB	PHASE RESPONSE DEGREES
.0100	.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	-152.0	357.2
.0112	.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	-148.0	356.8
.0126	.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	-144.0	356.4
.0141	.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	-140.0	356.0
.0158	.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	-136.0	355.5
.0178	.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	-132.0	355.0
.0200	.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	-128.0	354.4
.0224	.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	-124.0	353.7
.0251	.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	-120.0	352.9
.0282	.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	-116.0	352.0
.0316	.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	-112.0	351.1
.0355	.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	-108.0	350.0
.0398	.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	-104.0	348.7
.0447	.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	-100.0	347.4
.0501	.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	- 96.0	345.8
.0562	.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	- 92.0	344.1
.0631	.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	- 88.00	342.1
.0708	.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	- 84.00	340.0
.0794	.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	- 80.00	337.5
.0891	.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	- 76.00	334.7
.1000	.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	- 72.00	331.7
.1122	.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	- 68.00	328.2
.1259	.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	- 64.00	324.3
.1413	.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	- 60.00	319.9
.1585	.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	- 56.00	315.0
.1778	.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	- 52.00	309.4
.1995	.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	- 48.00	303.2
.2239	.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	- 44.00	296.1
.2512	.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	- 40.00	288.1
.2818	.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	- 36.00	279.1
.3162	.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	- 32.00	268.9
.3548	.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	- 28.01	257.2
.3981	.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	- 24.02	243.9
.4467	.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	- 20.04	228.5
.5012	.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	- 16.11	210.5
.5623	.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	- 12.26	189.4
.6310	.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	- 8.64	164.3
.7079	.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	- 5.46	134.9
.7943	1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	- 3.03	101.8
.8912	1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	- 1.50	67.3
1.0000	1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	- 0.75	33.2
1.1220	1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	- 0.54	00.0
1.2589	1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	- 0.75	- 33.2
1.4125	1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	- 1.50	- 67.3
1.5849	1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	- 3.03	-101.8
1.7783	2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	- 5.46	-134.9
1.9952	2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	- 8.64	-164.3
2.2387	2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	- 12.26	-189.4
2.5119	3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	- 16.11	-210.5
2.8183	3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	- 20.04	-228.5
3.1622	3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	- 24.02	-243.9
3.5481	4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	- 28.01	-257.2
3.9810	5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	- 32.00	-268.9
4.4668	5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	- 36.00	-279.1
5.0118	6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	- 40.00	-288.1
5.6233	7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	- 44.00	-296.1
6.3095	7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	- 48.00	-303.2
7.0794	8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	- 52.00	-309.4
7.9432	10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	- 56.00	-315.0
8.9124	11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	- 60.00	-319.9
10.000	12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	- 64.00	-324.3
11.220	14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	- 68.00	-328.2
12.589	15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	- 72.00	-331.7
14.125	17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	- 76.00	-334.7
15.849	19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	- 80.00	-337.5
17.783	22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	- 84.00	-340.0
19.952	25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	- 88.00	-342.1
22.387	28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	- 92.00	-344.1
25.119	31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	-96.00	-345.8
28.183	35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	-100.0	-347.4
31.622	39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	-104.0	-348.7
35.481	44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	-108.0	-350.0
39.810	50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	-112.0	-351.1
44.668	56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	-116.0	-352.0
50.118	63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	-120.0	-352.9
56.233	70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	-124.0	-353.7
63.095	79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	-128.0	-354.4
70.794	89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	-132.0	-355.0
79.432	100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	-136.0	-355.5
89.124	112.20	141.25	177.83	223.87	281.83	354.81	446.68	562.33	707.94	891.24	-140.0	-356.0
100.00	125.89	158.49	199.52	251.19	316.22	398.10	501.18	630.95	794.32	1000.0	-144.0	-356.4

CHART VIII

HIGH-PASS FILTER (LOW-FREQUENCY ROLLOFF)

NORMAL (BUTTERWORTH): −3 dB AND +180° AT THE HIGH-PASS FREQUENCY SETTING
PULSE (BUTTERWORTH): −3 dB AND +180° AT THE HIGH-PASS FREQUENCY SETTING

LOW-PASS FILTER (HIGH-FREQUENCY ROLLOFF)

NORMAL (BUTTERWORTH): −3 dB and −180° AT THE LOW-PASS FREQUENCY SETTING
PULSE (BESSEL): −8.6 dB and −187° AT THE LOW-PASS FREQUENCY SETTING
DC COUPLED: SET HIGH-PASS MULTIPLIER TO OUT

BAND-PASS FILTER (NORMAL MODE ONLY)

WHEN THE LOW-PASS FILTER SETTING, F_{LP} (HIGH FREQUENCY ROLLOFF) DIVIDED BY THE HIGH-PASS FILTER SETTING, F_{HP} (LOW-FREQUENCY ROLLOFF) IS LESS THAN 4, THE CHART BELOW MUST BE CONSULTED FOR BAND-PASS FILTER CHARACTERISTICS. (FOR USERS CONVENIENCE, THE FILTER CHARACTERISTICS HAVE BEEN TABULATED FOR $F_{LP}/F_{HP} \leq 10$)

DIRECTIONS:

$\frac{F_{LP}}{F_{HP}} > 4$

- UPPER −3 dB FREQUENCY = LOW-PASS CUTOFF FREQUENCY
- CENTER FREQUENCY = $\sqrt{F_{HP} \cdot F_{LP}}$
- LOWER −3 dB FREQUENCY = HIGH-PASS CUTOFF FREQUENCY
- −3 dB BANDWIDTH = $F_{LP} - F_{HP}$
- NOISE BANDWIDTH = $1.025 (F_{LP} - F_{HP})$
- FILTER GAIN = 0.0 dB

$\frac{F_{LP}}{F_{HP}} \leq 4$

1. DIVIDE THE CUTOFF FREQUENCY SETTINGS BY HIGH-PASS MULTIPLIER TO OBTAIN NORMALIZED SETTINGS.
2. OBTAIN THE FILTER GAIN AND NORMALIZED FREQUENCIES FROM TABLE USING NORMALIZED SETTINGS.
3. MULTIPLY NORMALIZED FREQUENCIES OBTAINED FROM TABLE BY HIGH-PASS MULTIPLIER.

EXAMPLE:
HIGH-PASS CUTOFF FREQUENCY, Hz = 6.30×10^3 (Divide by High-Pass Multiplier) → NORMALIZED HIGH-PASS SETTING = 6.30
LOW-PASS CUTOFF FREQUENCY, Hz = 1.00×10^4 → NORMALIZED LOW-PASS SETTING = 10.0

	NORMALIZED (From Table)		ACTUAL
UPPER −3 dB FREQUENCY, Hz	10.70	(Multiply by High-Pass Multiplier)	1.07×10^4
CENTER FREQUENCY, Hz	7.937		7.937×10^3
LOWER −3 dB FREQUENCY, Hz	5.932		5.932×10^3
−3 dB BANDWIDTH, Hz	4.768		4.768×10^3
NOISE BANDWIDTH, Hz	5.339		5.339×10^3
FILTER GAIN, dB	−1.23	(Gain not normalized)	−1.23

NORMALIZED HIGH-PASS SETTING		NORMALIZED LOW-PASS SETTING																				
		1.00	1.25	1.60	2.00	2.50	3.15	4.00	5.00	6.30	8.00	10.0	12.5	16.0	20.0	25.0	31.5	40.0	50.0	63.0	80.0	100
1.00	UPPER −3 dB FREQ., Hz	1.245	1.418	1.699	2.057	2.530	3.165	4.000	5.000	6.300	8.000	10.00	12.50	16.00	20.00	25.00	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz	1.000	1.118	1.265	1.414	1.581	1.774	2.000	2.236	2.510	2.828	3.162	3.536	4.000	4.472	5.000	5.612	6.325	7.071	7.937	8.944	10.00
	LOWER −3 dB FREQ., Hz	0.803	0.881	0.942	0.972	0.988	0.995	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
	−3 dB BANDWIDTH, Hz	0.442	0.537	0.757	1.085	1.542	2.170	3.002	4.000	5.300	7.000	9.000	11.50	15.00	19.00	24.00	30.50	39.00	49.00	62.00	79.00	99.00
	NOISE BANDWIDTH, Hz	.513	.612	.848	1.163	1.620	2.252	3.105	4.097	5.414	7.178	9.226	11.79	15.38	19.48	24.60	31.26	39.99	50.23	63.53	81.00	101.5
	FILTER GAIN, dB	−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.25	UPPER −3 dB FREQ., Hz		1.556	1.773	2.124	2.571	3.163	3.956	5.000	6.300	8.000	10.00	12.50	16.00	20.00	25.00	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz		1.250	1.414	1.581	1.768	1.984	2.236	2.500	2.806	3.162	3.536	3.953	4.472	5.000	5.590	6.275	7.071	7.906	8.874	10.00	11.18
	LOWER −3 dB FREQ., Hz		1.004	1.101	1.177	1.215	1.235	1.245	1.247	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
	−3 dB BANDWIDTH, Hz		0.552	0.672	0.947	1.356	1.928	2.711	3.753	5.050	6.750	8.750	11.25	14.75	18.75	23.75	30.25	38.75	48.75	61.75	78.75	98.75
	NOISE BANDWIDTH, Hz		.641	.766	1.059	1.454	2.025	2.815	3.877	5.176	6.919	8.974	11.53	15.12	19.21	24.35	31.01	39.72	49.95	63.31	80.72	101.3
	FILTER GAIN, dB		−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.60	UPPER −3 dB FREQ., Hz			1.992	2.269	2.718	3.291	4.048	5.064	6.400	8.000	10.00	12.50	16.00	20.00	25.00	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz			1.600	1.789	2.000	2.245	2.530	2.828	3.175	3.578	4.000	4.472	5.060	5.657	6.325	7.099	8.000	8.944	10.04	11.31	12.65
	LOWER −3 dB FREQ., Hz			1.284	1.410	1.506	1.556	1.581	1.592	1.597	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600
	−3 dB BANDWIDTH, Hz			0.708	0.859	1.212	1.735	2.467	3.472	4.803	6.400	8.400	10.90	14.40	18.40	23.40	29.90	38.40	48.40	61.40	78.40	98.40
	NOISE BANDWIDTH, Hz			.821	.979	1.357	1.860	2.591	3.602	4.966	6.561	8.610	11.17	14.76	18.86	23.99	30.65	39.36	49.60	62.95	80.35	100.8
	FILTER GAIN, dB			−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.00	UPPER −3 dB FREQ., Hz				2.480	2.836	3.398	4.113	5.060	6.330	8.000	10.00	12.50	16.00	20.00	25.00	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz				2.000	2.236	2.510	2.828	3.162	3.550	4.000	4.472	5.000	5.657	6.325	7.071	7.937	8.944	10.00	11.22	12.65	14.14
	LOWER −3 dB FREQ., Hz				1.606	1.762	1.882	1.945	1.976	1.990	1.996	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
	−3 dB BANDWIDTH, Hz				0.874	1.074	1.516	2.168	3.084	4.340	6.004	8.000	10.50	14.00	18.00	23.00	29.50	38.00	48.00	61.00	78.00	98.00
	NOISE BANDWIDTH, Hz				1.026	1.225	1.696	2.325	3.240	4.503	6.209	8.204	10.76	14.35	18.45	23.58	30.23	38.95	49.20	62.52	79.98	100.5
	FILTER GAIN, dB				−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.50	UPPER −3 dB FREQ., Hz					3.113	3.545	4.247	5.142	6.325	7.913	10.00	12.50	16.00	20.00	25.00	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz					2.500	2.806	3.162	3.536	3.969	4.472	5.000	5.590	6.325	7.071	7.906	8.874	10.00	11.18	12.55	14.14	15.81
	LOWER −3 dB FREQ., Hz					2.008	2.203	2.354	2.431	2.470	2.487	2.495	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500
	−3 dB BANDWIDTH, Hz					1.105	1.342	1.893	2.711	3.855	5.426	7.505	10.00	13.50	17.50	22.50	29.00	37.50	47.50	60.50	77.50	97.50
	NOISE BANDWIDTH, Hz					1.282	1.531	2.246	2.907	4.050	5.630	7.754	10.24	13.84	17.95	23.07	29.72	38.46	48.70	62.02	79.43	99.88
	FILTER GAIN, dB					−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.15	UPPER −3 dB FREQ., Hz						3.921	4.467	5.352	6.478	7.970	9.970	12.60	16.00	20.00	25.00	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz						3.150	3.550	3.969	4.455	5.020	5.612	6.275	7.099	7.937	8.874	9.961	11.22	12.55	14.09	15.87	17.75
	LOWER −3 dB FREQ., Hz						2.523	2.775	2.966	3.063	3.144	3.146	3.148	3.150	3.150	3.150	3.150	3.150	3.150	3.150	3.150	3.150
	−3 dB BANDWIDTH, Hz						1.398	1.692	2.386	3.415	4.826	6.824	9.452	12.85	16.85	21.85	28.35	36.85	46.85	59.85	76.85	96.85
	NOISE BANDWIDTH, Hz						1.616	1.930	2.670	3.664	5.105	7.096	9.772	13.17	17.27	22.40	29.07	37.76	48.03	61.38	78.80	99.21
	FILTER GAIN, dB						−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.00	UPPER −3 dB FREQ., Hz							4.980	5.672	6.796	8.226	10.12	12.66	16.00	20.00	25.00	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz							4.000	4.472	5.020	5.657	6.325	7.071	8.000	8.944	10.00	11.22	12.65	14.14	15.87	17.89	20.00
	LOWER −3 dB FREQ., Hz							3.212	3.524	3.766	3.890	3.952	3.980	3.992	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
	−3 dB BANDWIDTH, Hz							1.768	2.148	3.030	4.336	6.168	8.680	12.01	16.00	21.00	27.50	36.00	46.00	59.00	76.00	96.00
	NOISE BANDWIDTH, Hz							2.051	2.449	3.392	4.651	6.479	9.005	12.42	16.41	21.53	28.19	36.90	47.15	60.46	77.89	98.40
	FILTER GAIN, dB							−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.00	UPPER −3 dB FREQ., Hz								6.225	7.090	8.495	10.28	12.65	16.08	20.00	25.00	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz								5.000	5.612	6.325	7.071	7.906	8.944	10.00	11.18	12.55	14.14	15.81	17.75	20.00	22.36
	LOWER −3 dB FREQ., Hz								4.015	4.405	4.708	4.862	4.940	4.975	4.990	5.000	5.000	5.000	5.000	5.000	5.000	5.000
	−3 dB BANDWIDTH, Hz								2.210	2.685	3.787	5.418	7.710	11.11	15.01	20.00	26.50	35.00	45.00	58.00	75.00	95.00
	NOISE BANDWIDTH, Hz								2.564	3.062	4.241	5.814	8.100	11.26	15.51	20.49	27.07	35.89	46.13	59.43	76.91	97.39
	FILTER GAIN, dB								−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.30	UPPER −3 dB FREQ., Hz									7.843	8.933	10.70	12.96	15.94	19.94	25.20	31.50	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz									6.300	7.099	7.937	8.874	10.04	11.22	12.55	14.09	15.87	17.75	19.92	22.45	25.10
	LOWER −3 dB FREQ., Hz									5.059	5.550	5.932	6.126	6.224	6.268	6.287	6.300	6.300	6.300	6.300	6.300	6.300
	−3 dB BANDWIDTH, Hz									2.784	3.383	4.768	6.834	9.716	13.67	18.91	25.20	33.70	43.70	56.70	73.70	93.70
	NOISE BANDWIDTH, Hz									3.232	3.898	5.339	7.328	10.21	14.19	19.54	25.82	34.54	44.79	58.14	75.51	96.05
	FILTER GAIN, dB									−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00	0.00
8.00	UPPER −3 dB FREQ., Hz										9.960	11.34	13.59	16.45	20.24	25.32	32.00	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz										8.000	8.944	10.00	11.31	12.65	14.14	15.87	17.89	20.00	22.45	25.30	28.28
	LOWER −3 dB FREQ., Hz										6.424	7.048	7.533	7.779	7.904	7.960	7.984	8.000	8.000	8.000	8.000	8.000
	−3 dB BANDWIDTH, Hz										3.536	4.292	6.057	8.671	12.34	17.36	24.02	32.00	42.00	55.00	72.00	92.00
	NOISE BANDWIDTH, Hz										4.102	4.898	6.784	9.300	12.96	18.01	24.83	32.81	43.05	56.38	73.79	94.30
	FILTER GAIN, dB										−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00	0.00
10.0	UPPER −3 dB FREQ., Hz											12.45	14.18	16.99	20.57	25.30	31.65	40.00	50.00	63.00	80.00	100.0
	CENTER FREQ., Hz											10.00	11.18	12.65	14.14	15.81	17.75	20.00	22.36	25.10	28.28	31.62
	LOWER −3 dB FREQ., Hz											8.030	8.810	9.416	9.724	9.880	9.950	9.980	10.00	10.00	10.00	10.00
	−3 dB BANDWIDTH, Hz											4.420	5.370	7.574	10.85	15.42	21.70	30.02	40.00	53.00	70.00	90.00
	NOISE BANDWIDTH, Hz											5.129	6.124	8.482	11.63	16.20	27.05	31.05	41.02	54.14	71.78	92.26
	FILTER GAIN, dB											−6.02	−2.98	−1.23	−0.53	−0.22	−0.09	−0.03	0.00	0.00	0.00	0.00

BAND-REJECT FILTER

1. SET THE HIGH-PASS FILTER CUTOFF ABOVE THE LOW-PASS FILTER CUTOFF.
2. SET THE AMPLIFIER GAIN TO 0 dB.

NOTCH FREQUENCY = $\sqrt{F_{HP} \cdot F_{LP}}$
FILTER GAIN = −6 dB
UPPER −3 dB FREQUENCY = F_{HP}
LOWER −3 dB FREQUENCY = F_{LP}