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# Design Data for *m*-Derived Type Filters

## PART III

*By the Engineering Department, Aerovox Corporation*

IN the response curve for *m*-derived band-pass filter sections (see Figure 5-A in Part I, Sept.-Oct. 1942 issue), $f_1$ and $f_2$ are respectively the lower and upper cut-off frequencies marking the edges of the pass band, while $f_{1\infty}$ and $f_{2\infty}$ are respectively the lower and upper frequencies of maximum attenuation (minimum transmission). Separation between the $f_1$ frequencies and the $f_2$ frequencies will determine the steepness of the transmission curve at the borders of the pass band.

### BAND WIDTH

Width of the pass band is governed by the separation between $f_1$ and $f_2$ and may be set at a desired value by the designer in accordance with the desired band of frequencies to be transmitted by the filter. The geometric mean of the two cut-off frequencies is the mid-frequency, designated $f_m$, and is equal to the square root of $f_1f_2$. The band-width values given in the tables accompanying this article are obtained from the formula $(f_2-f_1)/f_m$.

### INFINITE-ATTENUATION FREQUENCIES

The frequencies of infinite attenuation, $f_{1\infty}$ and $f_{2\infty}$, have been chosen in the accompanying tables to be spaced 5 percent from the cut-off frequencies, $f_1$ and $f_2$. This placement permits infinite attenuation at frequencies close enough to the cut-off frequencies to raise the transmission characteristic sharply without destroying attenuation at other frequencies. Closer spacing would result in a steeper curve at the cut-off frequencies while sacrificing attenuation of neighboring frequencies.

### VARIATION OF *m*

In *m*-derived band-pass sections, *m* is a complex term which depends upon both cut-off and attenuation frequencies:

$$m = \frac{\sqrt{\left(1-\frac{f_1^2}{f_{2\infty}^2}\right)\left(1-\frac{f_2^2}{f_{2\infty}^2}\right)}}{1-\left(\frac{f_1 f_2}{f_{2\infty}^2}\right)}$$

From this, it is evident that *m* varies with band width. Table I lists *m* values corresponding to the band widths given in the frequency chart, *m* varying from 0.45 to 0.95 for band widths between 0.05 and 0.9. The effect that *m* has upon the values of filter-section components may be seen by inspecting Chart III in Part I.

### FREQUENCY CHART

Chart I in this article gives values of $f_1$, $f_2$, $f_{1\infty}$, $f_{2\infty}$, and $f_m$ for twelve common band widths between 0.05 and 0.9 for both series- and shunt-derived band-pass filters. These frequencies are given in cycles per second, except in the 10-kc. and 100-kc. columns where listings are in kilocycles, and in the 1-Mc. and 10-Mc. columns where listings are in megacycles.

From this chart, all values for frequencies may be taken directly. Thus: a band-pass section with mid-frequency of 2000 and band width of 0.2 is seen to have upper and lower cut-off frequencies of 2220 and 1820 cycles, respectively, and upper and lower infinite attenuation frequencies of 2331 and 1729 cycles, respectively. A section with the same mid-frequency but with band width of 0.5 is observed to have upper and lower cut-off frequencies of 2562 and 1562 cycles, and upper and lower infinite attenuation frequencies of 2690 and 1484 cycles. *m* for the band width of 0.2, from Table I, is found to be 0.72; and for the 0.5 band width, 0.54.

TABLE I

Variation of *m* with Band Width, Band-Pass Filters

| BAND WIDTH | *m* |
|---|---|
| 0.05 | 0.95 |
| 0.1 | 0.84 |
| 0.15 | 0.78 |
| 0.2 | 0.72 |
| 0.25 | 0.71 |
| 0.3 | 0.68 |
| 0.4 | 0.59 |
| 0.5 | 0.54 |
| 0.6 | 0.52 |
| 0.7 | 0.51 |
| 0.8 | 0.45 |
| 0.9 | 0.46 |

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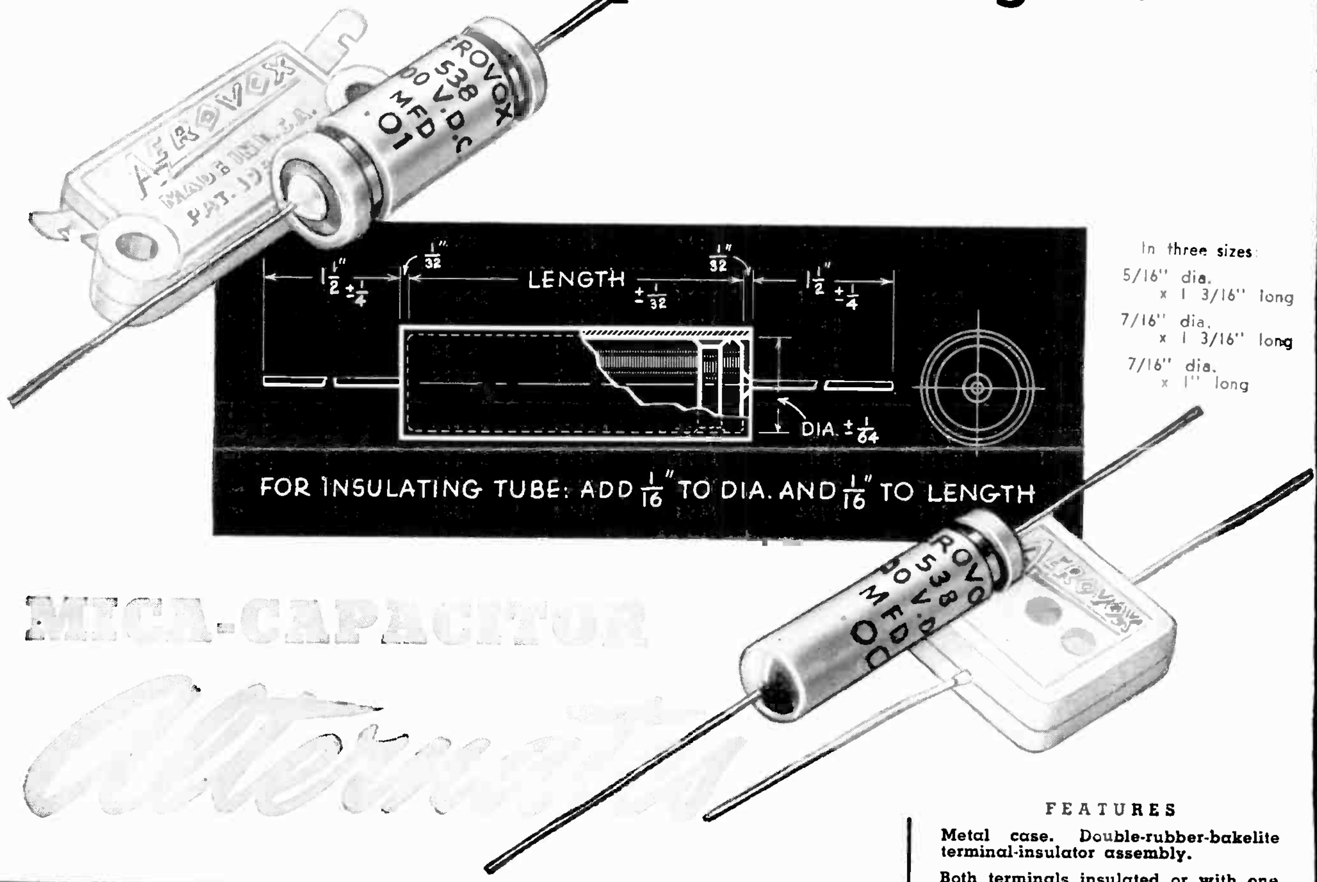
# CHART 1 — Frequency Data, Band-Pass Filters

| Band Width | | $f_m$ = 100 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 | 5500 | 6000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | $f_{2\infty}$ | 107.6 | 1076 | 1615 | 2152 | 2691 | 3230 | 3768 | 4305 | 4844 | 5382 | 5919 | 6459 |
| | $f_2$ | 102.5 | 1025 | 1538 | 2050 | 2563 | 3076 | 3589 | 4100 | 4614 | 5126 | 5637 | 6152 |
| | $f_1$ | 97.5 | 975 | 1463 | 1950 | 2438 | 2926 | 3414 | 3900 | 4389 | 4876 | 5362 | 5852 |
| | $f_{1\infty}$ | 92.6 | 926 | 1390 | 1852 | 2316 | 2780 | 3244 | 3705 | 4170 | 4632 | 5094 | 5560 |
| 0.1 | $f_{2\infty}$ | 110 | 1103 | 1656 | 2207 | 2759 | 3311 | 3862 | 4414 | 4965 | 5519 | 6069 | 6621 |
| | $f_2$ | 105 | 1051 | 1577 | 2102 | 2628 | 3153 | 3678 | 4204 | 4729 | 5256 | 5780 | 6306 |
| | $f_1$ | 95 | 951 | 1427 | 1902 | 2378 | 2853 | 3328 | 3804 | 4279 | 4756 | 5230 | 5706 |
| | $f_{1\infty}$ | 90 | 904 | 1356 | 1807 | 2259 | 2711 | 3162 | 3614 | 4065 | 4518 | 4969 | 5421 |
| 0.15 | $f_{2\infty}$ | 113 | 1132 | 1698 | 2264 | 2829 | 3396 | 3961 | 4527 | 5093 | 5660 | 6225 | 6791 |
| | $f_2$ | 108 | 1078 | 1617 | 2156 | 2694 | 3234 | 3773 | 4312 | 4851 | 5391 | 5929 | 6468 |
| | $f_1$ | 93 | 928 | 1392 | 1856 | 2319 | 2784 | 3248 | 3712 | 4176 | 4641 | 5104 | 5568 |
| | $f_{1\infty}$ | 89 | 882 | 1322 | 1763 | 2203 | 2645 | 3086 | 3527 | 3967 | 4409 | 4849 | 5290 |
| 0.2 | $f_{2\infty}$ | 115 | 1165 | 1743 | 2331 | 2899 | 3496 | 4079 | 4662 | 5245 | 5828 | 6410 | 6993 |
| | $f_2$ | 110 | 1110 | 1660 | 2220 | 2761 | 3330 | 3885 | 4440 | 4995 | 5551 | 6105 | 6660 |
| | $f_1$ | 90 | 910 | 1360 | 1820 | 2261 | 2730 | 3185 | 3640 | 4095 | 4551 | 5005 | 5460 |
| | $f_{1\infty}$ | 86 | 865 | 1292 | 1729 | 2148 | 2594 | 3026 | 3458 | 3890 | 4324 | 4755 | 5187 |
| 0.25 | $f_{2\infty}$ | 119 | 1190 | 1784 | 2379 | 2974 | 3569 | 4163 | 4759 | 5353 | 5949 | 6542 | 7138 |
| | $f_2$ | 113 | 1133 | 1699 | 2266 | 2832 | 3399 | 3965 | 4532 | 5098 | 5666 | 6231 | 6798 |
| | $f_1$ | 88 | 883 | 1324 | 1766 | 2207 | 2649 | 3090 | 3532 | 3973 | 4416 | 4856 | 5298 |
| | $f_{1\infty}$ | 84 | 839 | 1258 | 1678 | 2097 | 2517 | 2936 | 3355 | 3774 | 4195 | 4613 | 5033 |
| 0.3 | $f_{2\infty}$ | 122 | 1220 | 1829 | 2440 | 3051 | 3660 | 4270 | 4880 | 5490 | 6101 | 6710 | 7321 |
| | $f_2$ | 116 | 1162 | 1742 | 2324 | 2906 | 3486 | 4067 | 4648 | 5229 | 5811 | 6391 | 6972 |
| | $f_1$ | 86 | 862 | 1292 | 1724 | 2156 | 2586 | 1050 | 3448 | 3879 | 4311 | 4741 | 5172 |
| | $f_{1\infty}$ | 82 | 819 | 1227 | 1638 | 2048 | 2457 | 998 | 3276 | 3685 | 4096 | 4504 | 4913 |
| 0.4 | $f_{2\infty}$ | 128 | 1282 | 1921 | 2564 | 3202 | 3846 | 4487 | 5128 | 5769 | 6411 | 7051 | 7692 |
| | $f_2$ | 122 | 1221 | 1830 | 2442 | 3050 | 3663 | 4273 | 4884 | 5494 | 6106 | 6715 | 7326 |
| | $f_1$ | 82 | 821 | 1230 | 1642 | 2050 | 2463 | 2873 | 3284 | 3694 | 4106 | 4515 | 4926 |
| | $f_{1\infty}$ | 78 | 780 | 1169 | 1560 | 1948 | 2340 | 2729 | 3120 | 3509 | 3901 | 4289 | 4680 |
| 0.5 | $f_{2\infty}$ | 134.4 | 1345 | 2017 | 2690 | 3362 | 4035 | 4707 | 5380 | 6052 | 6726 | 7397 | 8070 |
| | $f_2$ | 128 | 1281 | 1921 | 2562 | 3202 | 3843 | 4483 | 5124 | 5764 | 6406 | 7045 | 7686 |
| | $f_1$ | 78 | 781 | 1171 | 1562 | 1952 | 2343 | 2733 | 3124 | 3514 | 3906 | 4295 | 4686 |
| | $f_{1\infty}$ | 74 | 742 | 1112.5 | 1484 | 1854.4 | 2226.9 | 2596 | 2986 | 3338 | 3711 | 4080 | 4452 |
| 0.6 | $f_{2\infty}$ | 141 | 1411 | 2117 | 2822 | 3528 | 4233 | 4939 | 5645 | 6350 | 7057 | 7762 | 8467 |
| | $f_2$ | 134 | 1344 | 2016 | 2688 | 3360 | 4032 | 4704 | 5376 | 6048 | 6721 | 7392 | 8064 |
| | $f_1$ | 74 | 744 | 1116 | 1488 | 1860 | 2232 | 2604 | 2976 | 3348 | 3721 | 4092 | 4464 |
| | $f_{1\infty}$ | 71 | 707 | 1060 | 1414 | 1767 | 2120 | 2474 | 2827 | 3181 | 3535 | 3887 | 4241 |
| 0.7 | $f_{2\infty}$ | 148 | 1480 | 2220 | 2961 | 3701 | 4441 | 5182 | 5922 | 6662 | 7403 | 8143 | 8883 |
| | $f_2$ | 141 | 1410 | 2114 | 2820 | 3525 | 4230 | 4935 | 5640 | 6345 | 7051 | 7755 | 8460 |
| | $f_1$ | 71 | 710 | 1064 | 1420 | 1775 | 2130 | 2485 | 2840 | 3195 | 3551 | 3905 | 4260 |
| | $f_{1\infty}$ | 68 | 685 | 532 | 1349 | 1686 | 2024 | 2361 | 2698 | 3035 | 3374 | 3710 | 4047 |
| 0.8 | $f_{2\infty}$ | 155 | 1551 | 2327 | 3102 | 3876 | 4652 | 5427 | 6203 | 6978 | 7755 | 8529 | 9305 |
| | $f_2$ | 148 | 1477 | 2216 | 2954 | 3692 | 4431 | 5169 | 5908 | 6646 | 7386 | 8123 | 8862 |
| | $f_1$ | 68 | 677 | 1016 | 1354 | 1692 | 2031 | 2369 | 2708 | 3046 | 3386 | 3723 | 4062 |
| | $f_{1\infty}$ | 65 | 643 | 965 | 1286 | 1607 | 1930 | 2251 | 2573 | 2894 | 3217 | 3537 | 3859 |
| 0.9 | $f_{2\infty}$ | 163 | 1627 | 2436 | 3255 | 4069 | 4882 | 5696 | 6510 | 7324 | 8138 | 8951 | 9765 |
| | $f_2$ | 155 | 1550 | 2320 | 3100 | 3875 | 4650 | 5425 | 6200 | 6975 | 7751 | 8525 | 9300 |
| | $f_1$ | 65 | 650 | 970 | 1300 | 1625 | 1950 | 2275 | 2600 | 2975 | 3251 | 3575 | 3900 |
| | $f_{1\infty}$ | 62 | 618 | 922 | 1235 | 1544 | 1853 | 2161 | 2470 | 2826 | 3089 | 3396 | 3705 |

# CHART 1 — Frequency Data, Band-Pass Filters

| Band Width | | $f_m$ = 6500 | 7000 | 7500 | 8000 | 8500 | 9000 | 9500 | 10 kc. | 100 kc. | 1 Mc. | 10 Mc. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.05 | $f_{2\infty}$ | 6994 | 7532 | 8070 | 8608 | 9146 | 9684 | 10220 | 10.76 | 107.6 | 1.076 | 10.762 |
| | $f_2$ | 6662 | 7175 | 7687 | 8200 | 8456 | 9225 | 9737 | 10.25 | 102.5 | 1.025 | 10.250 |
| | $f_1$ | 6337 | 6475 | 7312 | 7800 | 8287 | 8775 | 9260 | 9.75 | 97.5 | 0.975 | 9.750 |
| | $f_{1\infty}$ | 6019 | 6482 | 6945 | 7408 | 7871 | 8334 | 8797 | 9.26 | 92.6 | 0.926 | 9.262 |
| 0.1 | $f_{2\infty}$ | 7169 | 7721 | 8272 | 8824 | 9375 | 9927 | 10478 | 11.03 | 110.3 | 1.103 | 11.035 |
| | $f_2$ | 6831 | 7357 | 7882 | 8408 | 8933 | 9459 | 9984 | 10.51 | 105.1 | 1.051 | 10.510 |
| | $f_1$ | 6181 | 6657 | 7132 | 7608 | 8083 | 8559 | 9034 | 9.51 | 95.1 | 0.951 | 9.510 |
| | $f_{1\infty}$ | 5869 | 6321 | 6772 | 7224 | 7675 | 8127 | 8578 | 9.03 | 90.3 | 0.903 | 9.034 |
| 0.15 | $f_{2\infty}$ | 7332 | 7896 | 8460 | 9024 | 9588 | 10152 | 10716 | 11.28 | 112.8 | 1.128 | 11.287 |
| | $f_2$ | 6987 | 7525 | 8062 | 8600 | 9137 | 9675 | 10212 | 10.75 | 107.5 | 1.075 | 10.750 |
| | $f_1$ | 6012 | 6475 | 6937 | 7400 | 7862 | 8325 | 8787 | 9.25 | 92.5 | 0.925 | 9.250 |
| | $f_{1\infty}$ | 5707 | 6146 | 6585 | 7024 | 7463 | 7902 | 8341 | 8.78 | 87.8 | 0.878 | 8.787 |
| 0.2 | $f_{2\infty}$ | 7540 | 8120 | 8700 | 9280 | 9860 | 10440 | 11020 | 11.60 | 116.0 | 1.160 | 11.602 |
| | $f_2$ | 7182 | 7735 | 8287 | 8840 | 9392 | 9945 | 10497 | 11.05 | 110.5 | 1.105 | 11.050 |
| | $f_1$ | 5882 | 6335 | 6787 | 7240 | 7692 | 8145 | 8597 | 9.05 | 90.5 | 0.905 | 9.050 |
| | $f_{1\infty}$ | 5583 | 6013 | 6442 | 6872 | 7201 | 7731 | 8160 | 8.59 | 85.9 | 0.859 | 8.597 |
| 0.25 | $f_{2\infty}$ | 7728 | 8323 | 8917 | 9512 | 10106 | 10701 | 11295 | 11.89 | 118.9 | 1.189 | 11.896 |
| | $f_2$ | 7364 | 7931 | 8497 | 9064 | 9630 | 10197 | 10763 | 11.33 | 113.3 | 1.133 | 11.330 |
| | $f_1$ | 5739 | 6181 | 6625 | 7064 | 7505 | 7947 | 10388 | 8.83 | 88.3 | 0.883 | 8.830 |
| | $f_{1\infty}$ | 5447 | 5866 | 6285 | 6704 | 7123 | 7542 | 7961 | 8.38 | 83.8 | 0.838 | 8.388 |
| 0.3 | $f_{2\infty}$ | 7917 | 8526 | 9135 | 9744 | 10353 | 10962 | 11571 | 12.18 | 121.8 | 1.218 | 12.180 |
| | $f_2$ | 7540 | 8120 | 8700 | 9280 | 9860 | 10440 | 11020 | 11.60 | 116.0 | 1.160 | 11.600 |
| | $f_1$ | 5590 | 6020 | 6450 | 6880 | 7310 | 7740 | 8170 | 8.60 | 86.0 | 0.860 | 8.600 |
| | $f_{1\infty}$ | 5310 | 5719 | 6127 | 6536 | 6944 | 7353 | 7761 | 8.17 | 81.7 | 0.817 | 8.170 |
| 0.4 | $f_{2\infty}$ | 8313 | 8953 | 9592 | 10332 | 10871 | 11511 | 12240 | 12.79 | 127.9 | 1.279 | 12.799 |
| | $f_2$ | 7923 | 8533 | 9142 | 9752 | 10361 | 10971 | 11580 | 12.19 | 121.9 | 1.219 | 12.190 |
| | $f_1$ | 5323 | 5733 | 6142 | 6552 | 6961 | 7371 | 7780 | 8.19 | 81.9 | 0.819 | 8.190 |
| | $f_{1\infty}$ | 5057 | 5446 | 5835 | 6224 | 6613 | 7002 | 7791 | 7.78 | 77.8 | 0.778 | 7.780 |
| 0.5 | $f_{2\infty}$ | 8736 | 9408 | 10080 | 10752 | 11424 | 12096 | 12768 | 13.44 | 134.4 | 1.344 | 13.440 |
| | $f_2$ | 8320 | 8960 | 9600 | 10240 | 10880 | 11520 | 12160 | 12.80 | 128.0 | 1.280 | 12.800 |
| | $f_1$ | 5070 | 5460 | 5850 | 6240 | 6630 | 7020 | 7410 | 7.80 | 78.0 | 0.780 | 7.800 |
| | $f_{1\infty}$ | 4816 | 5187 | 5557 | 5928 | 6298 | 6669 | 7039 | 7.41 | 74.1 | 0.741 | 7.410 |
| 0.6 | $f_{2\infty}$ | 9171 | 9877 | 10580 | 11288 | 11993 | 12699 | 13404 | 14.11 | 141.1 | 1.411 | 14.112 |
| | $f_2$ | 8736 | 9408 | 10080 | 10752 | 11424 | 12096 | 12768 | 13.44 | 134.4 | 1.344 | 13.440 |
| | $f_1$ | 4836 | 5208 | 5580 | 5952 | 6324 | 6696 | 7068 | 7.44 | 74.4 | 0.744 | 7.440 |
| | $f_{1\infty}$ | 4589 | 4942 | 5295 | 5648 | 6001 | 6354 | 6707 | 7.06 | 70.6 | 0.706 | 7.068 |
| 0.7 | $f_{2\infty}$ | 9613 | 10353 | 11092 | 11832 | 12581 | 13311 | 14050 | 14.79 | 147.9 | 1.479 | 14.794 |
| | $f_2$ | 9158 | 9863 | 10567 | 11272 | 11976 | 12681 | 13385 | 14.09 | 140.9 | 1.409 | 14.090 |
| | $f_1$ | 4608 | 4963 | 5317 | 5672 | 6026 | 6381 | 6735 | 7.09 | 70.9 | 0.709 | 7.090 |
| | $f_{1\infty}$ | 4374 | 4711 | 5047 | 5384 | 5720 | 6057 | 6393 | 6.73 | 67.3 | 0.673 | 6.735 |
| 0.8 | $f_{2\infty}$ | 10075 | 10850 | 11625 | 12400 | 13175 | 13950 | 14725 | 15.50 | 155.0 | 1.550 | 15.503 |
| | $f_2$ | 9594 | 10332 | 11070 | 11808 | 12546 | 13284 | 14020 | 14.76 | 147.6 | 1.476 | 14.765 |
| | $f_1$ | 4392 | 4732 | 5070 | 5408 | 5746 | 6084 | 6422 | 6.76 | 67.6 | 0.676 | 6.765 |
| | $f_{1\infty}$ | 4173 | 4494 | 4815 | 5136 | 5457 | 5778 | 6099 | 6.42 | 64.2 | 0.642 | 6.426 |
| 0.9 | $f_{2\infty}$ | 10556 | 11368 | 12180 | 12992 | 13804 | 14816 | 15428 | 16.24 | 162.4 | 1.624 | 16.243 |
| | $f_2$ | 10055 | 10829 | 11602 | 12376 | 13149 | 13923 | 14696 | 15.47 | 154.7 | 1.547 | 15.470 |
| | $f_1$ | 4205 | 4529 | 4852 | 5176 | 5499 | 5823 | 6146 | 6.47 | 64.7 | 0.647 | 6.470 |
| | $f_{1\infty}$ | 3991 | 4298 | 4605 | 4912 | 5219 | 5526 | 5833 | 6.14 | 61.4 | 0.614 | 6.146 |

# Meeting the mica-capacitor shortage . . .

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