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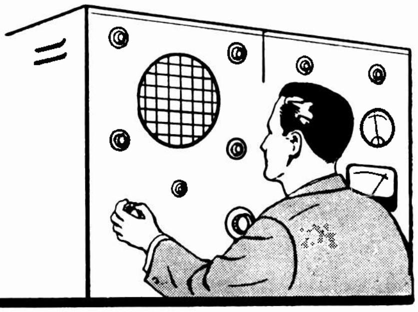

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Frequency-Selective Audio RC Networks: Simplified Design

By the Engineering Department, Aerovox Corporation

Frequency - selective resistance - capacitance networks have the obvious advantage of simplicity and compactness. But they also permit the tuning of amplifiers, oscillators, and filters at frequencies where variable inductors are unavailable for LC circuits, and would be exceedingly bulky if they were obtainable. An attendant advantage, of course, is freedom from hum and other extraneous pickup which result from use of inductors.

Two widely used networks are shown in Figure 1. These are the Wien bridge (A) and parallel-T circuit (B). Both are essentially null circuits; i. e., at some frequency governed by the R and C values, transmission from INPUT to OUTPUT ideally is zero. The performance often is inverted simply by including the RC network in the negative feedback loop of an amplifier. The gain of the amplifier accordingly is cancelled at all frequencies except the null frequency (which is removed by the network), the amplifier transmits this frequency, and the result is a sharply tuned active bandpass system.

SIMPLIFICATION

As is well known, the network is simplified by maintaining a suitable relationship between its R and C elements. Thus in Figure 1 (A), the two "tuning" resistances (R) are equal and so are the two capacitances (C). Furthermore, the ratio arms have a 2:1 relationship (the values of 1000 and 2000 ohms, shown here, are convenient for most applications, but any desired total resistance may be used as long as the 2:1 ratio is preserved. In Figure 1 (B), the two ungrounded resistances are equal, whereas the grounded one is half their value. Similarly, the two ungrounded capacitances are equal, whereas the grounded one is twice their value. When these conditions are satisfied, both circuits have the same balance equation; i. e., the null frequency

(1) $f=1/2\ RC$ Where f is in cycles per second, R in ohms, and C in farads

Therefore:

(2) $R=1/2\ fC$, and

(3) $C=1/2\ fR$

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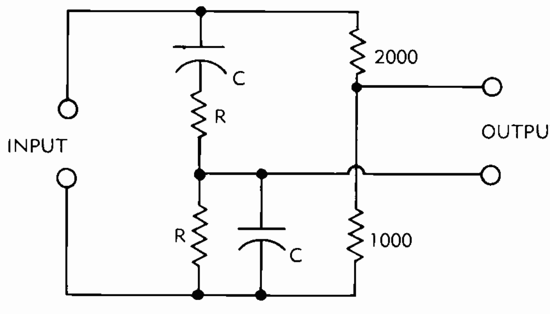
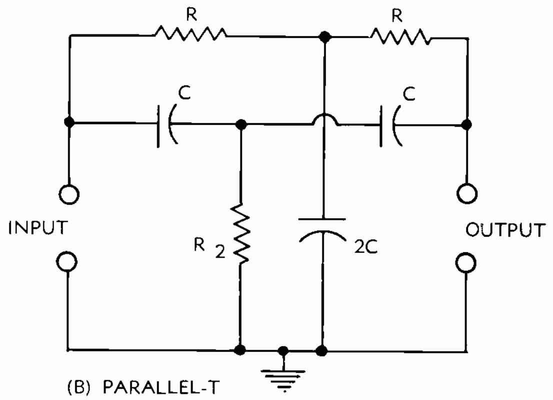


(A) WIEN BRIDGE



(B) PARALLEL-T

TYPICAL FREQUENCY-SELECTIVE RC NETWORKS

Figure 1.

TUNING METHODS

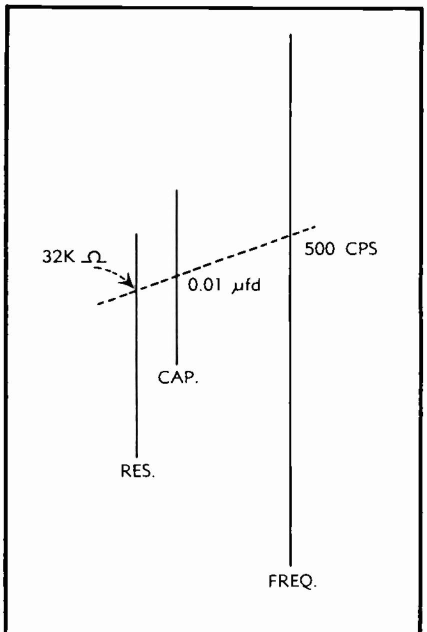
A particular attraction of the selective RC circuit is the comparative ease with which it may be tuned at audio frequencies. This often is accomplished by means of rheostats substituted for the fixed resistors in Figure I. To tune the Wien bridge, either the two resistors (R) *or* the two capacitors (C) must be varied simultaneously and must have equal values at all settings. To tune the parallel-T, either all three resistances *or* all three capacitances must be varied simultaneously and must have equal values at all settings. In practical amplifiers and oscillators in which the RC network is in a feedback loop, a ganged rheostat is used for tuning, and switched capacitors for range selection, or vice versa. Because the Wien bridge is tuned by means of a 2-gang variable unit, it is somewhat simpler and less expensive than the parallel-T which requires a 3-gang unit. But the Wien bridge does not provide the common input-output ground afforded by the parallel-T and thus requires a shielded input transformer, output transformer, or both, in most applications.

When the R and C values are closely maintained, as when close-tolerance capacitors and precision potentiometers are used, a-f frequency-selective networks may be sharply tuned. Frequency rejection, for example, may be 60 db with the parallel-T, and a bandpass amplifier tuned with either of the networks will provide rejection of 40 dc at one octave above and below the pass frequency. Obvious applications are in bandpass and band rejection filters, tuned amplifiers, distortion meters, wave analyzers, noise meters, frequency meters, and telemetering systems.

LABOR-SAVING COMPUTATION

Network calculations will be simplified through use of the nomograph, Figure 3. This alignment chart is based on Equation (1) and has been constructed for frequencies from 1 cps to 20 kc. Capacitance is given from 20 pf to 5 μfd: It has been our observation that lower capacitances than 20 pf often become masked by circuit strays and that higher capacitances than 5 μfd often are difficult to obtain in precision units except at considerable expense. Resistance is given from 5 ohms to 1 megohm. Here again, we have limited the presentation to practical values: These are the limits between which the majority of commercial ganged potentiometers operate.

Figure 2 illustrates use of the nomograph. In this example, the question is answered, "What value of resistance is needed to tune to the null frequency of 500 cps with a capacitance of 0.01 μfd?" For the answer, a line is drawn (real, or simply a straight-edge alignment) from 500 cps on the FREQUENCY scale through 0.01 μfd on the CAPACITANCE scale, and 32,000 ohms in read on the RESISTANCE scale as the required value. The calculated R value, using Equation (2) is 31,847 ohms, indicating a nomograph error of only $+0.48\%$ in this instance. This operation would also give the required C if f and R were stated, and the null frequency if R and C were stated.



METHOD OF USING THE NOMOGRAPH

Figure 2

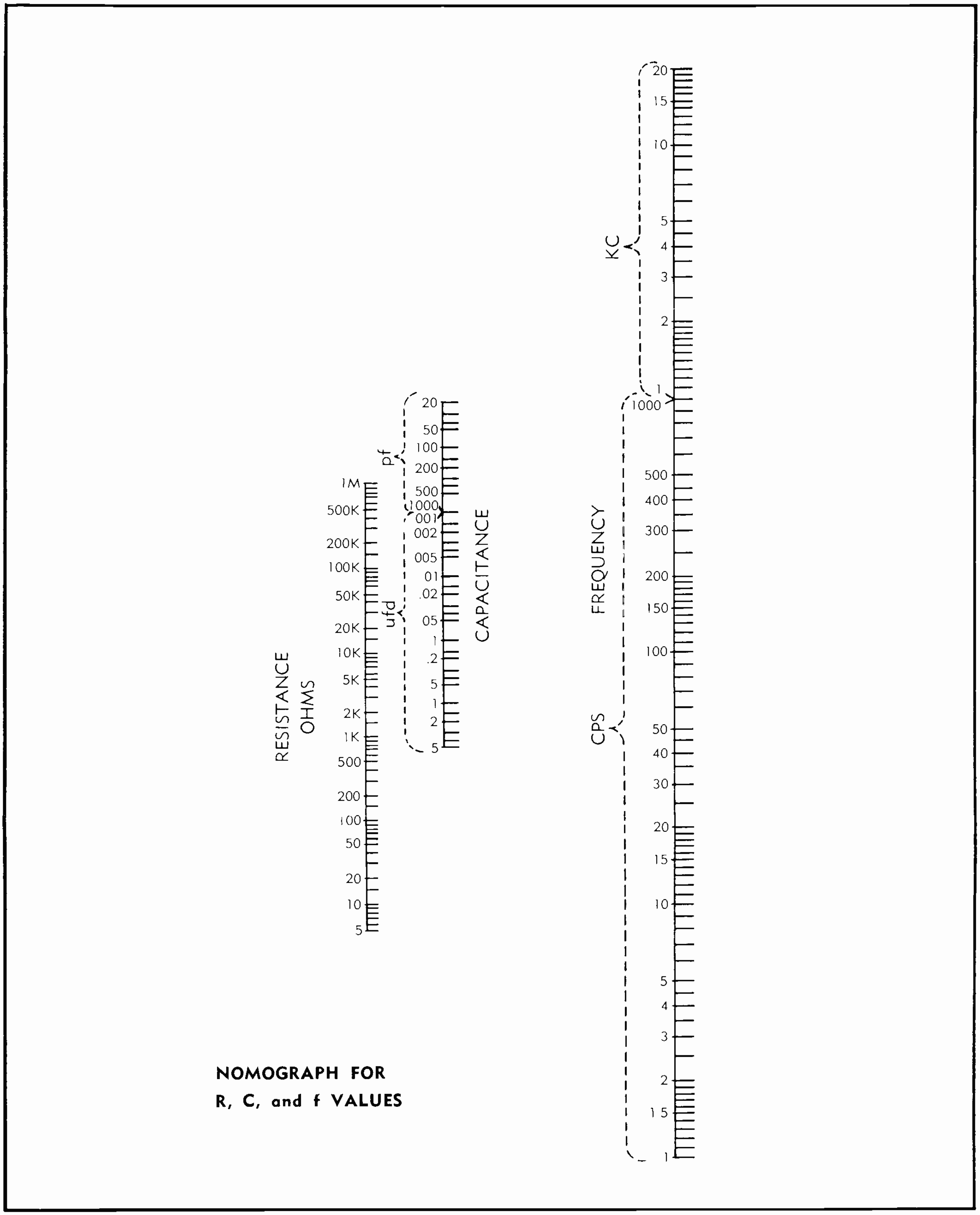
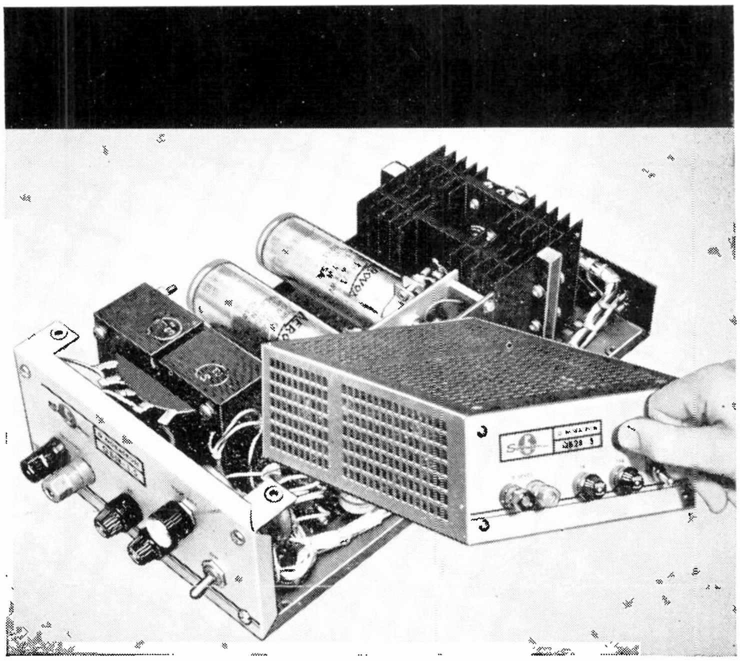
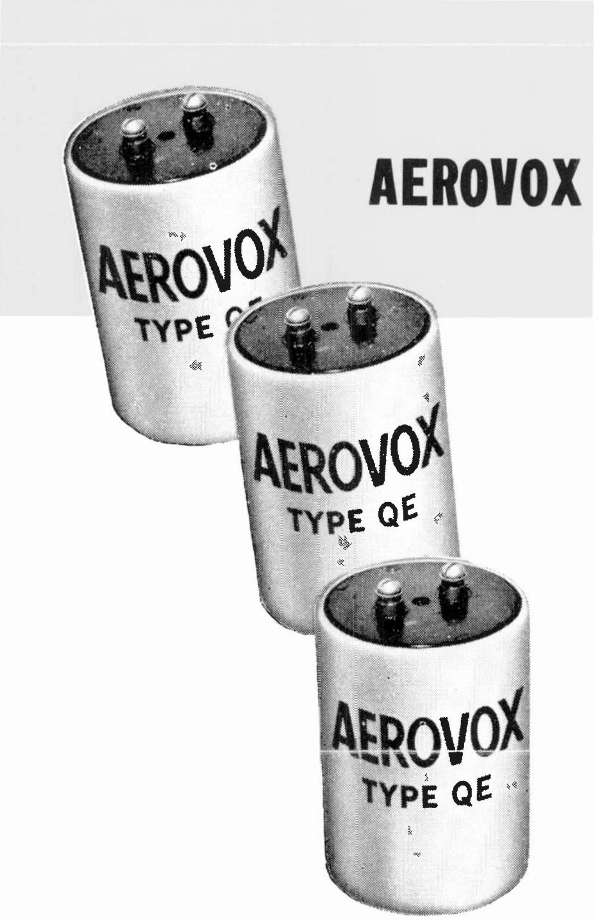

RESISTANCE
OHMS
1M
500K
200K
100K
50K
20K
10K
5K
2K
1K
500
200
100
50
20
10
5
pf
ufd
20
50
100
200
500
1000
.001
.002
.005
.01
.02
.05
.1
.2
.5
1
2
5
CAPACITANCE
FREQUENCY
KC
CPS
20
15
10
5
4
3
2
1
1000
500
400
300
200
150
100
50
40
30
20
15
10
5
4
3
2
1.5
1
NOMOGRAPH FOR
R, C, and f VALUES

Figure 3

TECHNICAL LEADERSHIP—MANUFACTURING EXCELLENCE





AEROVOX COMPUTER GRADE CAPACITORS SELECTED BY SORENSEN FOR NEW COMPACT QB SERIES POWER SUPPLIES

The new QB Series of DC power supplies designed by the Sorensen division of the Raytheon Company offers a unique combination of "custom" specifications, compact size and low price. Engineered for installation in computers and communications equipment, test and instrument applications, and for general laboratory use, the units are fully transistorized. ■ During the early stages of design, Aerovox application engineers were called in to discuss the concept in regard to selecting the most reliable capacitors available to satisfy all criteria. Aerovox Computer Grade Type QE capacitors of low ESR design were selected by Sorensen engineers to meet the exacting circuit requirements. QE capacitors are high-reliability aluminum electrolytics with a life expectancy of better than ten years! They are available in a wide capacitance range at voltages ranging from 5 to 450 VDCW. Once again, this close teamwork provided exactly the right answer in time to meet the delivery deadline! ■ Your local Aerovox sales representative can provide you with full information about the qualified Aerovox application engineering service available for the discussion and analysis of your specific capacitor requirements. Your inquiry may provide a new solution to your present or future designs. Why not call him today?

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Type QE capacitors are also available from Aerovox Industrial Distributors in prototype and small production quantities.