The AEROVOX Research Worker

Radio Editors of magazines and newspapers are hereby given permission to reprint in whole or in part, with proper credit to the Aerovox Corporation, the contents of this issue of the Aerovox Research Worker.

The Aerovox Research Worker is a monthly house organ of the Aerovox Corporation. It is published to bring to the Radio Experimenter and Engineer authoritative, first hand information on condensers and resistances for radio work.

VOL. 7, No. 2 | FEBRUARY, 1935 | 50c per year in U.S.A. 60c per year in Canada

Methods of Calculating The Current Carrying Capacity of Resistors

By the Engineering Department, Aerovox Corporation

IT is often required to find the maximum safe current for a resistor of given resistance and power rating, such as a voltage divider. This problem can of course be readily solved with well known equations, yet it seems to take more time and trouble then is warranted, probably because of the extraction of a square root; particularly when fractions are involved. In this article the solution by algebraical methods will be reviewed, showing how one can avoid the fractions; a labor saving chart is also presented, which shows the answer at a glance for practically all such questions and with an accuracy which is sufficient for all practical purposes.

CALCULATION OF MAXIMUM CURRENT OR VOLTAGE

The power in a circuit is found by any one of the three well known equations:

$$P = E\ I \quad (1)$$

$$P = I^2\ R \quad (2)$$

$$P = \frac{E^2}{R} \quad (3)$$

depending on which are the given quantities. Here, E is expressed in volts, I in amperes, R in ohms and P in watts. When the power is the required quantity, these equations are to be used, but if the power is one of the given quantities and the voltage or current is required, the equations have to be transposed so as to bring either E or I alone to the left of the equation. This gives:

$$I = \sqrt{\frac{P}{R}} \quad \text{amperes} \quad (4)$$

or,

$$I = \sqrt{\frac{P \times 1{,}000{,}000}{R}} \quad \text{milliamperes} \quad (4a)$$

$$E = \sqrt{P\,R} \quad \text{volts} \quad (5)$$

Before going over to the examples, it is necessary to discuss the voltage divider some more. Such a divider might for instance be rated at 50 watts, allowing a certain maximum current. Now the resistor is divided into sections carrying different amounts of current and consequently dividing the power unequally over the resistor. It should not be thought that since one section is carrying less than its share, that other sections can handle more so as to bring the total up to 50 watts again. That cannot be done; the maximum current is to be determined by supposing that the entire 50 watts is to be divided uniformly and the current found in this way should not be exceeded in any section.

Similarly, the maximum voltage across the resistor may be found by equation (5) again assuming that no current is to be drawn from any tap. If any part of the resistor is to carry less than the allowable maximum current, the maximum allowable voltage is *more* than the value found by equation (5).

MATHEMATICAL METHODS OF CALCULATION

Example 1: What is the maximum allowable current for a resistor of 15000 ohms and 25 watts? Using equation (4a) and substituting values:

$$P = \sqrt{\frac{25 \times 1{,}000{,}000}{15{,}000}} = \sqrt{\frac{5000}{3}} =$$

$$\sqrt{1667} = 40.8 \text{ ma.}$$

Example 2: What is the maximum allowable voltage across a 75000 ohm resistor with a power rating of 10 watts? Use equation (5); substituting values:

$$E = \sqrt{10 \times 75000} =$$

$$\sqrt{750{,}000} = 100\sqrt{75} = 868 \text{ volts}$$

Example 3: A speaker field has a resistance of 1000 ohms and is rated at 6 watts. What is the current required? Use again equation (4a)

$$I = \sqrt{\frac{6 \times 1,000,000}{1000}} =$$

$$\sqrt{6000} = 77.5 \text{ ma.}$$

Eample 4. A resistor of 10,000 ohms is to carry a current of 25 ma., what is the dissipated power? Use equation (2), remembering that I is in amperes:

$$P = .025^2 \times 10,000 = .000625 \times 10,000 = 6.25 \text{ watts}$$

If the squaring of a fraction is inconvenient, the equation can be written:

$$P = \frac{I^2R}{1,000,000} \text{ watts (2a)}$$

where I is in milliamperes. Using the same example:

$$P = \frac{25^2 \times 10,000}{1,000,000} = \frac{625 \times 10,000}{1,000,000} = 6.25 \text{ watts}$$

The table in this article has been prepared for users of standard size resistors. It shows the maximum allowable current for the most common resistors of this kind; the current is given in milliamperes unless otherwise stated.

It is of course impossible to give the figure for all possible cases in a table. The nearest approach one can make to such an ideal is to provide a chart and even then it is difficult enough to cover the complete range and to obtain sufficient accuracy to be of any use.

Logarithmic divisions are the only ones which permit the coverage of a wide range keeping the accuracy the same percentage throughout the range. The given problem could be solved either by a chart of the "alignment" type (also called "abac" and "nomograph"), or by the one shown. Both have their advantages. The first one does not have the page so full of lines but it requires a straight-edge to get a solution. The second one does not require this; when two of the quantities: volts, milliamps, ohms or watts, are known the other two can be found immediately.

MAXIMUM CURRENT RATINGS OF STANDARD RESISTORS

Resist. Ohms	10 Watt	25 Watt	50 Watt	75 Watt
1	3.16 amp.			
2	2.24 amp.			
2.5	2.00 amp.			
3	1.83 amp.			
5	1.41 amp.			
10	1.00 amp.			
15	817			
20	707			
25	634			
30	578			
50	448			
100	316	500	707	877
200	224	354	500	613
300	183	292	408	500
400	158	250	354	432
500	141	224	316	388
750	115	183	258	316
800	112	177	250	306
850	108	172	242	297
1,000	100	158	224	274
1,500	82	129	183	224
2,000	70.7	112	158	193
2.500	63.4	100	141	172
3,000	57.8	91.2	129	158
4,000	50.0	79.2	112	137
5,000	44.8	70.7	100	122
6,000	40.8	64.5	91.2	112
7,000	37.8	59.8	84.6	104
7,500	36.6	58.8	81.7	100
8,000	35.4	56.0	79.2	97.0
10,000	31.6	50.0	70.7	87.7
12,000		45.7	62.0	79.2
15,000		40.8	57.8	70.7
20,000		35.4	50.0	61.3
25,000		31.6	44.8	54.8
30,000			40.8	50.0
40,000			35.4	43.4
50,000			31.6	38.8
60,000				35.4
75,000				31.6

Current ratings given above are all in milliamperes except those designated in amperes (amp.). These currents should not be exceeded in any portion of a voltage divider.

This list contains data on the most popular sizes of resistors. For similar information on other sizes, see chart on page 3.

The chart covers a range which should be large enough for all radio work involving receivers and amplifiers. The ranges are from 1 to 1000 volts, from .1 ma to 10 amperes, from .1 ohm to 10 megohms and from .1 milliwatt to 10 kilowatts.

The lines are plotted on regular full logarithmic coordinate paper. Current is measured along the horizontal axis (X-axis) and volts along the vertical (Y- axis). When this is done, the locus of all points representing a given resistance will form a line making an angle of 45 degrees with the X-axis. All these lines are parallel, sloping upwards to the right. All points representing the same power are situated on a straight line which makes an angle of 135 degrees with the horizontal, sloping upwards towards the left. These slanting lines are again spaced in logarithmic proportion, forming the network with quadruple index.

USE OF THE CHART

A few examples will best illustrate the use of the chart. Suppose the e.m.f. in a circuit is 100 volts and the current is 100 ma.; what is the resistance and the power? Beginning with the 100 ma. mark on the horizontal axis, follow the vertical line to the intersection with the horizontal 100 volt line. This is also an intersection of the slanting lines. Following the one going upwards to the left read 10 watts; following the other, towards the right, read 1000 ohms.

A 5000 ohm resistor has a rating of 20 watts; what is the maximum current and corresponding voltage? Following the 5000 ohm line until the 20 watt line is reached. Follow the vertical lines down, and interpolating by estimation read 63 ma. Then follow the horizontal lines towards the left and read 316 volts.