

# Resistor Selection

## Application Notes

### RESISTOR FACTS AND FACTORS

A resistor is a device connected into an electrical circuit to introduce a specified resistance. The resistance is measured in ohms. As stated by Ohm's Law, the current through the resistor will be directly proportional to the voltage across it and inversely proportional to the resistance.

The passage of current through the resistance produces heat. The heat produces a rise in temperature of the resistor above the ambient temperature. The physical ability of the

resistor to withstand, without deterioration, the temperature attained, limits the operating temperature which can be permitted. Resistors are rated to dissipate a given wattage without exceeding a specified standard "hot spot" temperature and the physical size is made large enough to accomplish this.

Deviations from the standard conditions ("Free Air Watt Rating") affect the temperature rise and therefore affect the wattage at which the resistor may be used in a specific application.

### SELECTION REQUIRES 3 STEPS

Simple short-cut graphs and charts in this catalog permit rapid determination of electrical parameters. Calculation of each parameter is also explained. To select a resistor for a specific application, the following steps are recommended:

1. (a) Determine the Resistance.  
(b) Determine the Watts to be dissipated by the Resistor.
2. Determine the proper "Watt Size" (physical size) as controlled by watts, volts, permissible temperatures, mounting conditions and circuit conditions.
3. Choose the most suitable kind of unit, including type, terminals and mounting.

### STEP 1 DETERMINE RESISTANCE AND WATTS

#### Ohm's Law

$$(a) R = \frac{V}{I} \text{ or } I = \frac{V}{R} \text{ or } V = IR$$

Ohm's Law, shown in formula form above, enables determination of the resistance when the required voltage and current are known. When the current and voltage are unknown, or the best values not decided on, at least two of the three terms in Ohm's Law must be measured in a trial circuit.

$$(b) P = I^2R \text{ or } P = VI \text{ or } P = \frac{V^2}{R}$$

Power in watts, can be determined from the formulas above, which stem from Ohm's Law. R is measured in ohms, V in volts, I in amperes and P in watts.

#### Why Watts Must Be Accurately Known

Stated non-technically, any change in current or voltage produces a much larger change in the wattage (heat to be dissipated by the resistor). Therefore, the effect of apparently small increases in current or voltage must be investigated because the increase in wattage may be large enough to be significant. Mathematically, the wattage varies as the square of the current, or voltage, as stated in the formulas (b). For example, an increase of 20% in current or voltage will increase the wattage 44%. Figure 1 below graphically illustrates the square law relation. Hence, the actual current must be used in figuring the wattage and the increase in wattage due to apparently small changes, then determined in order to select the proper size resistor. Allowance should be made for maximum possible line voltage.

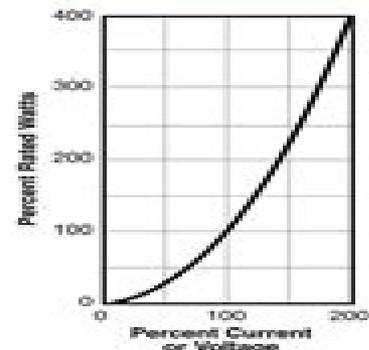


Fig. 1: Rapid increase of wattage with current or voltage.

### STEP 2 POWER RATING OR PHYSICAL SIZE OF RESISTOR

A resistor operated at a constant wattage will attain a steady temperature which is determined largely by the ratio between the size (surface area) and the wattage dissipated. The temperature stabilizes when the sum of the heat loss rates (by radiation, convection and conduction) equals the heat input rate (proportional to wattage). The greater the resistor area per watt to be dissipated, the greater the heat loss rate and therefore the lower the temperature rise. The relation between the losses varies for different resistors.

#### Free Air Watt Rating

The wattage rating of resistors, as established under specified standard conditions, is defined as the "Free Air Rating" ("Full Rating" or "Maximum Power Rating"). Several standard methods of rating are in use based on different service conditions. The method of both

the "National Electrical Manufacturers Association" (NEMA) and the "Underwriters' Laboratories, Inc." (UL) can be described as follows:

The relation of the "Free Air Watt Rating" of tubular type, wire-wound enameled resistors to the physical size, is to be set at such a figure that when operated at their rated watts, the temperature rise of the hottest spot shall not exceed 300°C (540°F) as measured by a thermocouple when the temperature of the surrounding air does not exceed 40°C (104°F). The temperature is to be measured at the hottest point of a two-terminal resistor suspended in free still air space with at least one foot of clearance to the nearest object, and with unrestricted circulation of air.

A slightly different definition of temperature limit used as a basis for wattage rating, and which results in a slightly higher attained temperature, was originally established in military specification MIL-

# Resistor Selection Ohmite

**Jessica J Manson**



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*Electro-technology* Stanley A. Dennis, Leon Irving Thomas, 1960 **Instruments** ,1952 Issues for Nov 1949 Dec 1953 include the Journal of the Southern California Meter Association General Electric Review General Electric Company, 1950 *Electronic Industries & Tele-tech* ,1948 **QST.** ,1915 *Electronics* ,1945-07 June issues 1941 44 and Nov issue 1945 include a buyers guide section The Engineers' Digest ,1945 *Electronic Industries* ,1945 **Radio News** ,1948 Some

issues 1943 July 1948 include separately paged and numbered section called Radio electronic engineering edition called Radionics edition in 1943 Proceedings of the IRE. Institute of Radio Engineers,1959 Electro Technology Newsletter Stanley A. Dennis,Leon Irving Thomas,1942 Electrical Manufacturing Stanley A. Dennis,Leon Irving Thomas,1959

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### **Table of Contents Resistor Selection Ohmite**

1. Understanding the eBook Resistor Selection Ohmite
  - The Rise of Digital Reading Resistor Selection Ohmite
  - Advantages of eBooks Over Traditional Books
2. Identifying Resistor Selection Ohmite
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Resistor Selection Ohmite
  - User-Friendly Interface
4. Exploring eBook Recommendations from Resistor Selection Ohmite
  - Personalized Recommendations
  - Resistor Selection Ohmite User Reviews and Ratings

- Resistor Selection Ohmite and Bestseller Lists
- 5. Accessing Resistor Selection Ohmite Free and Paid eBooks
  - Resistor Selection Ohmite Public Domain eBooks
  - Resistor Selection Ohmite eBook Subscription Services
  - Resistor Selection Ohmite Budget-Friendly Options
- 6. Navigating Resistor Selection Ohmite eBook Formats
  - ePub, PDF, MOBI, and More
  - Resistor Selection Ohmite Compatibility with Devices
  - Resistor Selection Ohmite Enhanced eBook Features
- 7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Resistor Selection Ohmite
  - Highlighting and Note-Taking Resistor Selection Ohmite
  - Interactive Elements Resistor Selection Ohmite
- 8. Staying Engaged with Resistor Selection Ohmite
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Resistor Selection Ohmite
- 9. Balancing eBooks and Physical Books Resistor Selection Ohmite
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Resistor Selection Ohmite
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Resistor Selection Ohmite
  - Setting Reading Goals Resistor Selection Ohmite
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Resistor Selection Ohmite
  - Fact-Checking eBook Content of Resistor Selection Ohmite
  - Distinguishing Credible Sources

- 
13. Promoting Lifelong Learning
    - Utilizing eBooks for Skill Development
    - Exploring Educational eBooks
  14. Embracing eBook Trends
    - Integration of Multimedia Elements
    - Interactive and Gamified eBooks

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