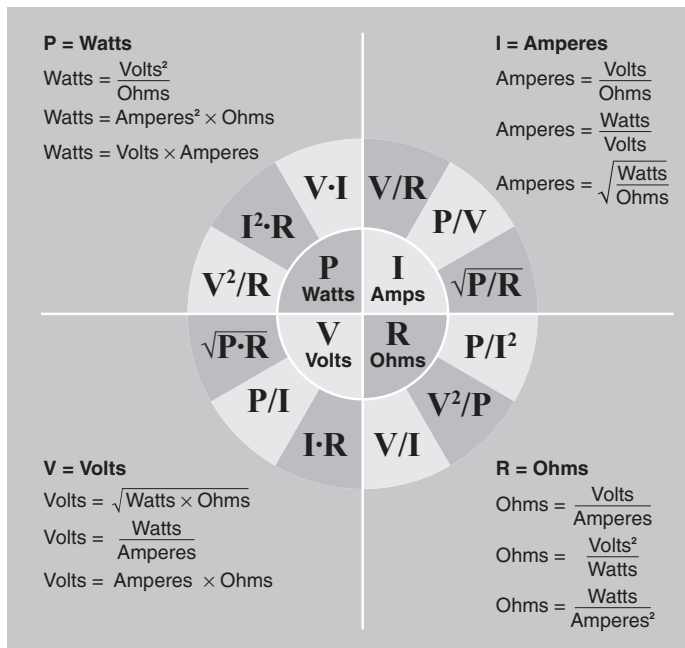


# Application Notes

## Ohm's Law



Ohm's Law defines the relationships between (P) power, (V) voltage, (I) current, and (R) resistance. One ohm is the resistance value through which one volt will maintain a current of one ampere.

**I** Current is what flows on a wire or conductor like water flowing down a river. Current flows from negative to positive on the surface of a conductor. Current is measured in (A) amperes or amps.

**V** Voltage is the difference in electrical potential between two points in a circuit. It's the push or pressure behind current flow through a circuit, and is measured in (V) volts.

**R** Resistance determines how much current will flow through a component. Resistors are used to control voltage and current levels. A very high resistance allows a small amount of current to flow. A very low resistance allows a large amount of current to flow. Resistance is measured in ohms.

**P** Power is the amount of current times the voltage level at a given point measured in wattage or watts.

# Application Notes

## Resistor Terminology

**Adjustable Resistor:** A resistor so constructed that its resistance can be readily changed.\*

**Alternating Current:** A periodic current the average value of which over a period is zero. The equation for alternating current is the same as that for a periodic current except that  $I_0=0$ .\*

**Ambient Temperature:** The temperature of the surrounding coiling medium, such as gas or liquid, which comes into contact with heated parts of the apparatus.\*

**Ampere:** The unit of constant current which, maintained in two parallel rectilinear conductors of infinite length separated by a distance of one meter, produces between these conductors a force equal to  $2 \times 10^{-7}$  mks (meter-kilogram-second) units of force per meter of length.

**Armature Resistor:** A resistor connected in series with the armature of a motor either to limit the inrush current on starting, the gradual short circuiting of which brings the motor to normal speed, or to regulate the speed by armature-voltage control.

**Axiohm<sup>†</sup>:** Centohm<sup>®</sup> Coated axial terminal wire-wound resistor.

**Bracket Terminal Resistor:** A resistor equipped with slotted metal end j brackets that serve as a means of mounting and connecting to the resistor.

**Capacitance:** That property of a system of conductors and dielectrics which permits the storage of electricity when potential differences exist between the conductors. Its value is expressed as the ratio of a quantity of electricity to a potential difference. A capacitance value is always positive.\*

**Capacitor:** A device, the primary purpose of which is to introduce capacitance into an electric circuit. Capacitors are usually classified, according to their dielectrics, as air capacitors, mica capacitors, paper capacitors, etc.\*

**Clearance:** The shortest distance through space between two live parts, between live parts and supports or other objects, or between any live part and grounded part.

**Conduction:** The transmission of heat or electricity through, or by means of, a conductor.

**Conductor:** A body so constructed from conducting material that it may be used as a carrier of electric current.\*

**Continuous Duty:** A requirement of service that demands operation at a substantially constant load for an indefinitely long time.\*

**Continuous-Duty Resistor:** A resistor that is capable of carrying continuously the current for which it is designed without exceeding the specified temperature rise.

**Continuous Rating:** Continuous rating is the rating that defines the load which can be carried for an indefinitely long time.\*

**Convection:** Convection is the motion resulting in a fluid owing to differences of density and the action of gravity.

**Corrib<sup>®</sup>:** A tubular resistor consisting of an alloy resistance ribbon, crimped and edgewound on a ceramic core, the ribbon being securely and permanently fastened to the core by vitreous enamel or cement.

**Creepage Distance:** The shortest distance between conductors of opposite polarity or between a live part and ground as measured over the surface of the supporting material.

**Current-limiting Resistor:** A resistor inserted into an electric circuit to limit the flow of current to some predetermined value. Note: A current-limiting resistor, usually in series with a fuse or circuit breaker, may be employed to limit the flow of circuit or system energy at the time of a fault or short-circuit.\*

**Dielectric Strength:** The dielectric strength of an insulating material is the maximum potential gradient that the material can withstand without rupture.\* It is usually specified in volts per unit thickness.

**Dielectric Test:** A test which consists of the application of a voltage higher than the rated voltage for a specified time for the purpose of determining the adequacy against breakdown of insulating materials and spacings under normal conditions.\*

**Direct Current:** A unidirectional current in which the changes in value are either zero or so small that they may be neglected. A given current would be considered a direct current in some applications, but would not necessarily be so considered in other applications.\*

**Dividohm<sup>®</sup>:** A resistor with a bare side and clamp for adjustment.

**Edgeohm<sup>†</sup>:** A high-current resistor made of an alloy resistance ribbon wound on edge forming an oval-shaped coil supported by grooved insulators which space adjacent turns and insulate them from the support bars. Support bars are secured to steel end pieces forming a sturdy resistor suitable for continuous-and-intermittent-duty applications.

**EIA:** Electronic Industries Alliance.

**Electromotive Force:** The electromotive force is the agency causing the flow of current in a circuit. It is the electrical pressure (or drop) measured in volts.

**Farad:** The unit of capacitance of an electric condenser in which a charge of one coulomb produces a difference of potential of one volt between the poles of the capacitor.

**Ferrule Resistor:** A resistor supplied with ferrule terminals for mounting in standard fuse clips.

**Field Discharge Switch:** A switch usually of the knife blade type having auxiliary contacts for connecting the field of a generator or motor across a resistor (field discharge) at the instant preceding the opening of the switch.

**Fixed Resistor:** A resistor designed to introduce only one set amount of resistance into an electrical circuit.

**Henry:** The unit of inductance of a closed circuit in which an electromotive force of one volt is produced when the electric current traversing the circuit varies uniformly at the rate of one ampere per second.

**Hot Spot:** The point or location of maximum temperature on the external surface of a resistor.

**Inductance:** The (scalar) property of an electric circuit or of two neighboring circuits which determines the electromotive force induced in one of the circuits by a change of current in either of them.\*

**Impedance:** The apparent resistance of an AC circuit, being the combination of both the resistance and reactance. It is equal to the ratio of the value of the EMF between the terminals to the current, there being no source of power

in the portion under consideration. The unit of impedance is the ohm and is represented by Z.

**Intermittent Duty:** A requirement of service that demands operation for alternate intervals of (1) load and no-load; or (2) load and rest; or (3) load, no-load and rest; such alternate intervals being definitely specified.\*

**Intermittent-Duty Resistor:** A resistor capable of carrying for a short period of time the high overload current for which it is designed without exceeding the specified temperature rise.

**Machine-Duty Resistor:** A resistor for use in the armature or rotor circuit of a motor in which the armature current is almost constant.

**Mega Ohm:** A unit of resistance equal to one million ohms.

**MIL Resistor:** A resistor built in accordance with Joint Army-Navy specifications.

**Multi-Section Resistor:** A resistor having two or more electrically independent sections.

**NEC:** The National Electrical Code is the standard of the National Board of Fire Underwriters for electric wiring and apparatus as recommended by the National Fire Protection Association and approved by the American Standards Association.

**NEDA:** National Electronic Distributors Association.

**NEMA:** The National Electrical Manufacturers Association, a non-profit trade association, supported by the manufacturers of electrical apparatus and supplies. NEMA is engaged in standardization to facilitate understanding between the manufacturers and users of electrical products.

**Nominal Diameter:** As applied to tubular resistors, this is the diameter of the ceramic tube expressed in inches and/or fractions thereof.

**Nominal Length:** As applied to tubular resistors, this is the length of the resistor base or core expressed in inches and/or fractions thereof.

**Non-Inductive Resistor:** A non-inductive power resistor is one in which the inductance and distributed capacitance are reduced to an absolute minimum.

**Ohm:** A unit of resistance defined as the resistance at 0°C of a column of mercury of uniform cross-section having a length of 106.3 centimeters and a mass of 14.4 grams.

**Ohmmeter:** An instrument for measuring electrical resistance that is provided with a scale graduated in ohms.

**Periodic Duty:** A type of intermittent duty in which the load conditions are regularly recurrent.\*

**Periodic Rating:** The rating which defines the load which can be carried for the alternate periods of load and rest specified in the rating, the apparatus starting cold and for the total time specified in the rating without causing any of the specified limitations to be exceeded.\*

**Power:** The time rate of transferring or transforming energy; the rate of doing work or expending energy.

**Power Resistor:** A resistor capable of dissipating 5 watts or more.

**Rating:** A designated limit of operating characteristics of a machine, apparatus or device, based on definite conditions.

**Note 1:** Such operating characteristics as load, voltage, frequency, etc., may be given in the rating.

**Note 2:** The rating of control apparatus in general is expressed in volts, amperes, horsepower or kilowatts as may be appropriate, except that resistors are rated in ohms, amperes and class of service.\*

**Reactor:** A device used for introducing reactance into a circuit for purposes such as motor starting, paralleling transformers and control of current.\*

**Rectifier:** A device which converts alternating current to unidirectional current by virtue of a characteristic permitting appreciable flow of current in only one direction.\*

**Resistance:** The (scalar) property of an electric circuit or of any body which may be used as part of an electric circuit which determines for a given current the rate at which electric energy is converted into heat or radiant energy and which has a value such that the product of the resistance and the square of the current gives the rate of conversion of energy. In the general case, resistance is a function of the current, but the term is most commonly used in connection with circuits where the resistance is independent of the current.\*

**Resistance Tolerance:** The resistance tolerance of a power resistor is the extent to which its resistance may be permitted to deviate above or below the specified resistance. Resistance tolerance is usually expressed in percent.

**Resistance Method of Temperature Determination:** This method consists in the determination of temperature by comparison of the resistance of the winding at the temperature to be determined with the resistance at a known temperature.\*\*

**Resistive Conductor:** A resistive conductor is a conductor used primarily because it possesses the property of high electric resistance.\*

**Resistivity:** The resistivity of a material is the resistance of a sample of the material having specified dimensions.

**Resistor:** A device, the primary purpose of which is to introduce resistance into an electric circuit.\*

**Resistor Core:** The resistor core or base of a power resistor is the insulating support on which the resistive conductor is wound.

**Rheostat:** An adjustable resistor so constructed that its resistance may be changed without opening the circuit in which it may be connected.\*

**Screw-Base Resistor:** A power-type resistor equipped with Edison-type screw-base terminals for quick interchangeability.

**Short-Time Rating:** The rating that defines the load which can be carried for a short and definitely specified time, the machine, apparatus or device being at approximately room temperature at the time the load is applied.\*

**Silicone:** A silicone coating meeting MIL-R-26 used on power type wirewound resistors.

**Slim Mox** A flat style resistor Ohmite manufactures. They are available in a variety of sizes and values.

**Single-Wound Resistor:** A resistor that has only one layer of resistance wire or ribbon wound around the insulating base or core.

**Stackohm®†:** A resistor consisting of a hollow ceramic core, oval in shape, about which resistance wire is wound and completely embedded in an insulating and heat conducting coating.

**Still Air:** Still air is considered air having no circulation except that created by the heat of the resistor which is being operated.

**Tapped Resistor:** A resistor with two or more steps.

**Temperature Coefficient of Resistance:** A measure of the increase or decrease in resistance of a resistive conductor due to change in temperature in parts per million (ppm).

$$R_T = R_r + [R_r(\alpha T - \alpha T_r)]$$

Where,

$R_T$  = Resistance of conductor at temperature  $T$

$R_r$  = Resistance of conductor at reference temperature  $T_r$

$\alpha$  = Temperature coefficient of resistance at reference temperature  $T_r$

**Temperature Rise:** Temperature rise is the difference in temperature between the initial and final temperature of a resistor. Temperature rise is expressed in degrees C or F, usually referred to an ambient temperature. Temperature rise equals the hot spot temperature minus the ambient temperature.

**Thermal Shock:** Thermal shock consists of a sudden marked change in the temperature of the medium in which the device operates.

**Thermocouple:** A device for converting heat energy into electrical energy consisting of a pair of dissimilar conductors so joined as to produce a thermo-electric effect. It is used with a millivoltmeter to measure temperature rise in apparatus.

**Thermometer Method of Temperature Determination:** This method consists in the determination of the temperature by a mercury or alcohol thermometer, by a resistance thermometer, or by a thermocouple, any of these instruments being applied to the hottest part of the apparatus accessible to a mercury or alcohol thermometer.\*\*

**Tolerance (%)** The tolerance is the allowable deviation from the nominal resistance value.

**Varying Duty:** A requirement of service that demands operation at loads, and for intervals of time, both of which may be subject to wide variation.\*

**Voltage (V or E):** The unit of measure is the volt. A unit of electrical pressure, EMF or potential difference. Ohmite's voltage rating is the voltage that can be applied to the resistor without arcing or degrading the resistor.

**Voltage Coefficient (VCR)** The unit of measure is in parts per million (ppm). Voltage coefficient defines the change in the value of the resistor that occurs as the voltage changes. The resistor is measured at two voltages and the deviation is then calculated. VCR is usually stated as the change per volt (ex. 2ppm/v).

**Watt:** A unit of electric power. It is the power expended when one ampere of direct current flows through a resistor of one ohm.

**Winding Pitch:** The distance from any point on a turn of a resistive conductor to the corresponding point on an adjacent turn measured parallel to the long axis of the winding.

\* ASA Standard

\*\* NEMA Standard

† Ohmite trade name

### RESISTANCE VALUES

#### Abbreviations and Part Numbering Structure

	Part Numbering Structure					Scientific Notation
Prefix	Abbreviation			Numeric Value	Description	
Milli	m	Thousandth	R001	0.001	1 Milli Ohm	1.0 x 10 <sup>-3</sup>
Centi	c	Hundredth	R010	0.01	1 Centi Ohm	1.0 x 10 <sup>-2</sup>
Deci	d	Tenth	R100	0.1	1 Deci Ohm	1.0 x 10 <sup>-1</sup>
—	—	One	1R00	1	1 Ohm	1.0 x 10 <sup>0</sup>
Deca, Deka	da	Ten	10R0	10	1 Deca Ohm	1.0 x 10 <sup>1</sup>
Hecto	h	Hundred	1000*	100	1 Hecto Ohm	1.0 x 10 <sup>2</sup>
Kilo	k	Thousand	1001*	1,000	1 Kilo Ohm	1.0 x 10 <sup>3</sup>
			1002*	10,000	10 Kilo Ohms	1.0 x 10 <sup>4</sup>
			1003*	100,000	100 Kilo Ohms	1.0 x 10 <sup>5</sup>
Mega	M	Million	1004*	1,000,000	1 Mega Ohm	1.0 x 10 <sup>6</sup>
			1504*	1,500,000	1.5 Mega Ohms	1.5 x 10 <sup>6</sup>
			1005*	10,000,000	10 Mega Ohms	1.0 x 10 <sup>7</sup>
			1006*	100,000,000	100 Mega Ohms	1.0 x 10 <sup>8</sup>
			1506*	150,000,000	150 Mega Ohms	1.5 x 10 <sup>8</sup>
Giga	G	Billion	1007	1,000,000,000	1 Giga Ohm	1.0 x 10 <sup>9</sup>
			1507	1,500,000,000	1.5 Giga Ohms	1.5 x 10 <sup>9</sup>
			1008	10,000,000,000	10 Giga Ohms	1.0 x 10 <sup>10</sup>
			1009	100,000,000,000	100 Giga Ohms	1.0 x 10 <sup>11</sup>
			1509	150,000,000,000	150 Giga Ohms	1.5 x 10 <sup>11</sup>
Tera	T	Trillion	100A	1,000,000,000,000	1 Tera Ohm	1.0 x 10 <sup>12</sup>
			150A	1,500,000,000,000	1.5 Tera Ohms	1.5 x 10 <sup>12</sup>
			100B	10,000,000,000,000	10 Tera Ohms	1.0 x 10 <sup>13</sup>

\*Part Numbering Structure may vary by product line