RESISTORS

DERATING

The following tables and graphs present the derating requirements for each major resistor style. Because each resistor style is manufactured using different methods and contains different materials, each style is addressed separately. A short discussion of the construction methods and materials is presented to aid the user in determining the most applicable resistor style for a given application. For convenience, derating requirements are also presented in tabular form in Table 1.

Most resistor specifications limit full power operation to a maximum operating temperature, T_S, and then linearly "derate" to an absolute maximum operating temperature, T_{MAX}, at zero power. The same approach is used in this chapter. Depending upon the resistor style and failure characteristics, applied power is derated to between 50 and 70% and then linearly derated to the zero power point.

Additional voltage derating is specified for high voltage with high resistance value applications. The purpose of this additional derating is to assure the maximum continuous working voltage of the resistor is not exceeded. Most of the time, the user does not need to be concerned with this additional derating (e.g., logic circuits are not affected). It only comes into play when dealing with relatively high voltages in combination with high resistance values. For example, up to 500V can be applied across a 1/2W, 50% derated, 1MΩ resistor without exceeding derated power. However, 500V may exceed the maximum continuous working voltage of the resistor, so the user may impose further limits. No specific limits for the maximum continuous working voltage are specified in this manual because they are dependent on the resistor style. Consult the appropriate resistor specification or MIL-SPEC to obtain the correct value. Then, limit power in accordance with Ohm's Law and the derating criteria, or

$$P = D*V^2_{continuous} / R,$$

where:

$V_{continuous}$ = Maximum continuous working voltage and

D = Derating criteria for the resistor in question.

As an example, a 0505 size chip resistor is equivalent to a MIL-R-55342/2 military style and has a maximum continuous working voltage of 40V. The maximum specified resistance for this style is 470 KΩ and rated power is 0.025W. The $V = \sqrt{PR}$ voltage could therefore be as high as 108V. The 40V limit effectively limits voltage and power dissipation of high-value resistors, in this case above 64KΩ.

Additional voltage derating is also specified for high frequency and pulse applications of fixed value styles in the form of a 70% limit on dielectric withstanding voltage (or maximum short term overload voltage, whichever is less).

Some resistor styles are marketed in both commercial and military versions. Although the resistor is physically identical, the part vendor will specify different ratings on the Military style to assure it will function adequately in the extreme environments typical to many Military applications. Some vendors label this “derating.” Such “derating” should be ignored when applying the derating requirements of this manual. This manual assumes the part vendor is the subject matter expert and the most competent authority to set performance requirements at the piece-part level. It further assumes the part vendor considers operation outside the performance parameters to void all warrantees and guarantees.

Table 1. Derating Requirements of Resistors in Tabular Form[1]

Resistor Style	Derating Parameter		
	Power (Max %Rated Electrical Stress)[6]	Max Temperature	Max Voltage
Fixed, Film, Chip			
P_D<1/2W (rated)	70% or 70%*$V^2_{continuous}$/R (whichever is less)	$T_s+0.70(T_{MAX}-T_s)$	
P_D≥1/2W (rated)	55% or 55%*$V^2_{continuous}$/R (whichever is less)	$T_s+0.55(T_{MAX}-T_s)$	
Fixed, Film (General Purpose and Precision)			
MIL-PRF-39017 Styles RL05, RL07 and MIL-PRF-55182 Styles RN50 and RN55	65%	$T_s+0.65(T_{MAX}-T_s)$	70%
All Others	55% or 55%*$V^2_{continuous}$/R (whichever is less)	$T_s+0.55(T_{MAX}-T_s)$	70%
Fixed, Film, Power	55%	$T_s+0.55(T_{MAX}-T_s)$	--
Fixed, Film, Network	55% or 55%*$V^2_{continuous}$/R (whichever is less)	$T_s+0.55(T_{MAX}-T_s)$	70%
Fixed, Wirewound (Accurate)			
Styles MIL-R-39005, MIL-R-93	70% or 70%*$V^2_{continuous}$/R (whichever is less)	T_s	70%
All Others	50% or 50%*$V^2_{continuous}$/R (whichever is less)	T_s	70%
Fixed, Wirewound, Power	60% or 60%*$V^2_{continuous}$/R (whichever is less)	$T_s+0.60(T_{MAX}-T_s)$	70%
Fixed, Wirewound, Chassis Mounted	50% or 50%*$V^2_{continuous}$/R (whichever is less)	$T_s+0.50(T_{MAX}-T_s)$	70%
Variable, Wirewound (General Purpose)	55%	$T_s+0.55(T_{MAX}-T_s)$	--
Variable, Wirewound, Precision and Semi-Precision	55%	$T_s+0.55(T_{MAX}-T_s)$	--
Variable, Wirewound, Power	55%	110°C	--
Variable, Non-wirewound, Composition	50%	$T_s+0.50(T_{MAX}-T_s)$	--
Variable, Non-wirewound, Film	50%	$T_s+0.50(T_{MAX}-T_s)$	--
Variable, Non-wirewound, Precision	55%	$T_s+0.55(T_{MAX}-T_s)$	--

[1] Note: This table is only intended to serve as a convenient summary of the derating requirements for resistors. Figure 1-13 provides more precise information in graphical form.

[6] Italicized text and additional power derating is applicable for high voltage, high resistance values only.

Resistors, Fixed, Film, Chip

This is a small size, film style resistor intended for surface mount applications and thick film hybrid circuits. The resistor is considered ESD-sensitive. Normal purchased values are 2.7Ω to 100MΩ, with power rating ranging from 1/8 W to 2W.

Construction

Thick film chip resistors are constructed by screen printing a RuO_2 – family resistive paste to an alumina substrate (similar to hybrid manufacturing techniques). Thin film is constructed by sputtering or vacuum deposition of a metal film. For both thin and thick film types, value is calibrated through trimming of the resistive element.

Derating

Power: For resistors with a rated power dissipation of less than ½W, derate power to 70% of the maximum full rated power below T_S. Above T_S, linearly derate to T_D, as shown in Figure 1, where $T_D = T_S + 0.70(T_{MAX} - T_S)$. For high voltage, high resistance value applications, do not allow power dissipation to exceed P = $0.70 * V^2_{continuous} / R$, where $V_{continuous}$ is the maximum continuous working voltage.

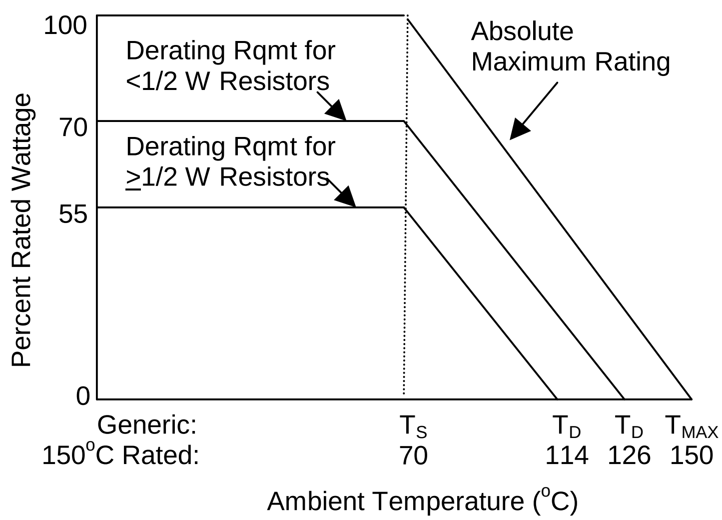

Figure 1. Derating Requirement for Fixed Value, Film, Chip Resistor

For resistors with a rated power dissipation of ½W or greater, derate power to 55% of the maximum full rated power below T_S, and then linearly derate to T_D, as shown in Figure 1, where $T_D = T_S + 0.55(T_{MAX} - T_S)$. For high voltage, high resistance value applications, do not allow power dissipation to exceed P = $0.55 * V^2_{continuous} / R$, where $V_{continuous}$ is the maximum continuous working voltage.

Application Information

Reliability: This is a highly reliable resistor provided it is properly handled and properly mounted to substrate material. It is prone to cyclic fatigue failure of solder joints when the design does not adequately account for thermal expansion mismatch or when the temperature of the resistor increases rapidly in comparison to the underlying board material. Chip stacking is not recommended. The film side of the resistor should be mounted on the up side to reduce thermal stressing. Past reliability problems occurred due to tin plated finishes causing whisker growth. Tin plated finishes are prohibited by the Military performance specification but may be present on commercial styles.

Tolerance/Aging: Normal purchased tolerance is ±5% and is typically available in tolerances between 0.1 and 10%. ESD sensitivity must be taken into account when handling the resistor, especially for tight tolerance values. Improper ESD handling may result in the resistor exceeding its stated tolerance, particularly those with small size, high sheet resistivity values and tight tolerances. Tight tolerance resistors (< ±0.5%) are of the thin film variety.

Frequency Characteristics: The high frequency characteristics of this resistor are considered one of the best of any resistor style, although dependent on amount and pattern of trimming of the resistive element. Thick film resistors have better high frequency and pulse handling capabilities over thin films. Maximum noise level is typically not controlled by specification.

Military Considerations

Figure 1 specifies derating temperature requirements for resistors conforming to MIL-PRF-55342 (Style RM).

Resistors, Fixed, Film (General Purpose And Precision)

This is a small sized, semi-precision style resistor with a cylindrical body. It has the best high frequency performance characteristics of any resistor styles, but is also ESD sensitive. Recommended use is in applications where high stability and close resistance tolerance is required.

Construction

This resistor is constructed by vaporizing a carbon, metal, or thick cermet film onto a ceramic or glass substrate. The element is spiraled to increase available resistance. Resistance is calibrated through trimming of a helical grove in the resistive layer. Terminations are usually a tinned copper wire welded to nickel-plated steel end caps. The body is coated to prevent moisture and contaminate penetration, but coating varies with manufacturer and quality level.

Derating

Power: For MIL-PRF-39017 Styles RL05 and RL07, and for MIL-PRF-55182 Styles RN50 and RN55, derate power to 65% of maximum full rated power below T_S. Above T_S, linearly derate to T_{MAX} as shown in Figure 2. For high voltage, high resistance value applications, do not allow power dissipation to exceed $P = 0.65*V^2_{continuous} / R$, where $V_{continuous}$ is the maximum continuous working voltage.

For all other styles (including commercial), derate power to 55% of maximum full rated power below T_S. Above T_S, linearly derate to T_{MAX} as shown in Figure 2. For high voltage, high resistance value applications, do not allow power dissipation to exceed $P = 0.55*V^2_{continuous} / R$, where $V_{continuous}$ is the maximum continuous working voltage.

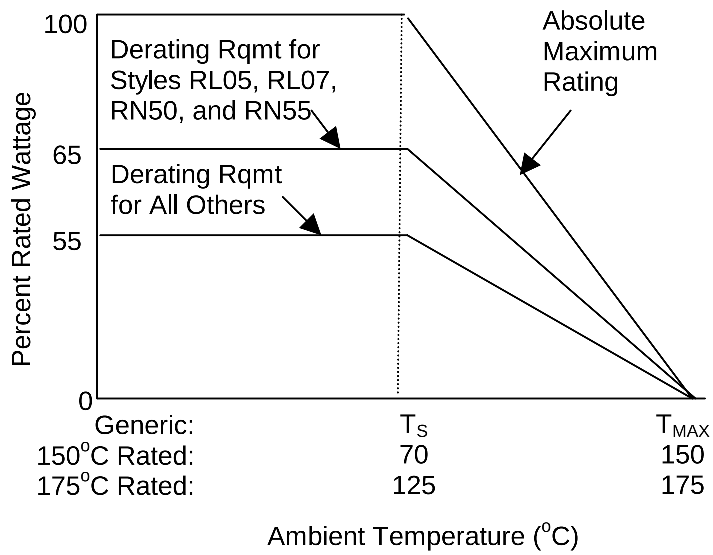

Figure 2. Derating Requirement for Fixed Value, Film Resistor, General Purpose and Precision

Voltage: Under pulse conditions, perform additional derating of voltage to 70% of the dielectric breakdown voltage or the maximum short-term overload voltage, whichever is less.

Application Information

Reliability: The reliability of this style is considered better than that of other resistor styles. The primary failure mode is resistance drift, which is often caused by cracking of the external coating layer and moisture permeation into the resistive element. This resistor is ESD sensitive. Heat dissipation is accomplished through the leads.

Tolerance/Aging: Normal purchased tolerance is ±5%. Resistance is accurately maintained over a broad range of temperatures and for long periods. Designs should tolerate an additional ±2% shift in resistance value during component life. Resistance-temperature characteristics are low for thick film styles (<±500 ppm/°C) and very low for metal film styles (<±25 ppm/°C). Permanent changes in resistance are possible when operating in the presence of extreme temperatures.

Frequency Characteristics: Higher resistance values generally have a greater effect on frequency due to the increased number of spiral cuts in the resistive element. Operation above 10MHz can produce inductive effects on spiral-cut styles. Effective DC resistance remains reasonably constant up to 400MHz for all others. Skin effects are generally negligible below 10 MHz due to the relatively thin film thickness.

Special Considerations: In the construction of film resistors, the trimming of helical grooves tends to be optimized for performance when constructing Military grades and throughput for commercial grades. This means the number and range of grooves may be less for a Military grade than for a commercial grade resistor with the same values, thus giving better frequency performance for the Military grade resistor.

Military Considerations

Figure 2 specifies derating temperature requirements for resistors conforming to MIL-PRF-39017 (Style RLR) and MIL-PRF-55182 (Style RNR, RNC, RNN).

Resistors, Fixed, Film, Power

This is a film style resistor capable of withstanding high power operation for extended periods.

Construction

This resistor is constructed by depositing a metal film on a high-quality ceramic substrate. The element is spiraled to increase available resistance. Resistance is calibrated through trimming of the resistive element. The resistor is coated to provide environmental protection.

Derating

Power: Derate power to 55% of maximum full rated power below T_S. Above T_S, linearly derate to T_{MAX} as shown in Figure 3, where $T_D = T_S + 0.55(T_{MAX} - T_S)$.

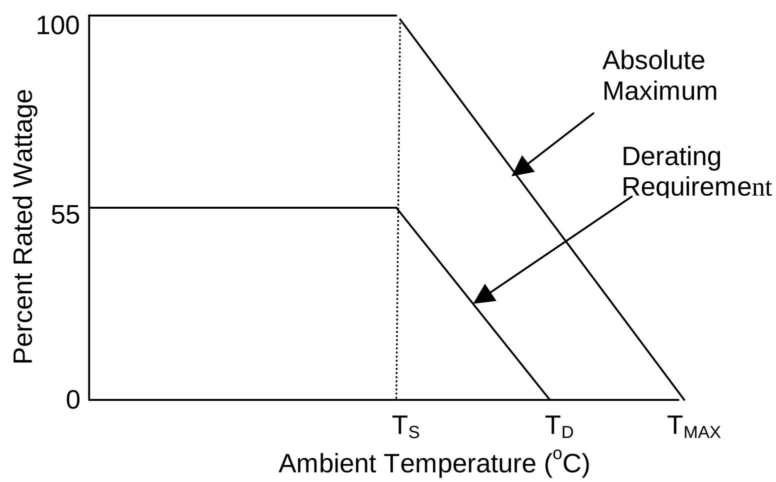

Figure 3. Derating Requirement for Fixed Value, Film, Power Resistor

Application Information

Reliability: This resistor style has comparable reliability to fixed wirewound styles. It is capable of withstanding high humidity, high hotspot temperature, and continuous operation at high wattage.

Tolerance/Aging: Not available with tight tolerances.

Frequency Characteristics: High frequency characteristics are considered good, but are dependent on the number and type of helical grooves cut into the film to increase the resistance value.

Military Considerations

Not Applicable.

Resistors, Fixed, Film, Network

This is a resistor with properties similar to that of fixed film resistors. The primary features are small size and easily assembled.

Construction

Construction is characterized by vaporized metal deposited film or high temperature fired printed metal and glass combination paste on a ceramic substrate. The resistance element is calibrated through trimming of the resistive element. The insulative enclosure normally consists of epoxy or silicone.

Derating

Power: Derate power to 55% of maximum full rated power below T_S. Above T_S, linearly derate to T_D as shown in Figure 4, where $T_D = T_S + 0.55(T_{MAX} - T_S)$. For high voltage, high resistance value applications, do not allow power dissipation to exceed $P = 0.55 * V^2_{continuous} / R$, where $V_{continuous}$ is the maximum continuous working voltage.

Voltage: Under pulse conditions, perform additional derating of voltage to 70% of the dielectric breakdown voltage or the maximum short-term overload voltage, whichever is less.

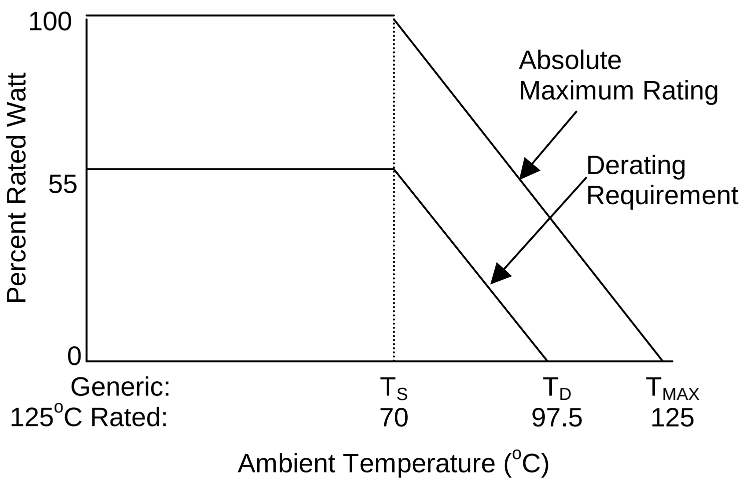

Figure 4. Derating Requirement for Fixed Value, Film, Network Resistor

Application Information

Reliability: Reliability of this resistor is considered better than that of other resistor styles. The primary failure mode is resistance drift, and the secondary mode is open circuit. This resistor is ESD sensitive. Heat dissipation is accomplished through the leads.

Tolerance/Aging: Resistance is accurately maintained over a broad range of temperatures and for long periods. Designs should tolerate an additional ±2% shift in resistance value during component life. Resistance-temperature characteristics are low for thick film styles (<±500 ppm/°C) and very low for metal film styles (<±25 ppm/°C). A permanent change in resistance is possible when operating in the presence of extreme temperatures.

Frequency Characteristics: Higher resistance values generally have a greater effect on frequency. Operation above 100MHz can produce inductive effects on spiral-cut styles. Effective DC resistance remains reasonably constant up to 400MHz for all others.

Military Considerations

Figure 4 specifies derating temperature requirements for resistors conforming to MIL-PRF-83401 (Style RZ).

Resistors, Fixed, Wirewound (Accurate)

This is a high stability, high accuracy resistor with a large size, mass, and cost. It demonstrates relatively poor high frequency performance characteristics due to the inductive effects of helical wound wire.

Construction

This resistor is constructed by winding a precisely measured length of known ohmic value wire around a bobbin or core (usually ceramic). Internal elements are protected by a coating and are enclosed in a moisture-resistant insulating material. Construction materials of military and commercial styles are similar, but Military grades receive additional screening and are rated more conservatively. Type of ohmic value wire used varies and is dependent upon resistance value and power dissipation requirements.

Derating

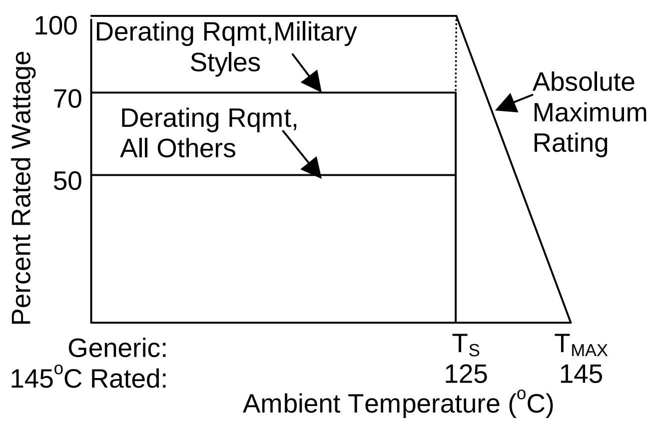

Figure 5. Derating Requirement for Fixed Value, Wirewound Resistor (Accurate)

Power: For resistor styles conforming to MIL-R-39005 and MIL-R-93, derate power to 70% of maximum full rated power and remain below an ambient temperature of T_S, as shown in Figure 5. For all other styles (including commercial), derate power to 50% of maximum full rated power and remain below an ambient temperature of T_S, as shown in Figure 5. For high voltage, high resistance value applications, do not allow power dissipation to exceed $P = 0.70 {*} V^2_{continuous} / R$, where $V_{continuous}$ is the maximum continuous working voltage. Additional derating is recommended for applications demanding tight resistance value tolerances (≈0.1%).

Voltage: Under pulse conditions, perform additional derating of voltage to 70% of the dielectric breakdown voltage or the maximum short-term overload voltage, whichever is less.

Application Information

Reliability: This resistor style has generally comparable (slightly higher) reliability to fixed composition and film styles. It is sensitive to vibration and shock damage due to larger size and mass. The primary mode of heat dissipation is through resistor leads.

Tolerance/Aging: Exhibits the highest accuracy of any resistor style. It is available with tolerances as low as 0.01%, although extreme care must be taken during design and manufacturing process to retain tolerance at this level.

Frequency Characteristics: High frequency operation is generally not recommended, although inductive effects can be minimized by special winding techniques (i.e., reverse pi-winding, bifilar winding, and winding on a flat card). Operation above 50kHz generally produces inductive and intrawinding capacitive effects.

Military Considerations

Figure 5 specifies derating temperature requirements for resistors conforming to MIL-PRF-39005 (Style RBR). Style RBR replaces Style RB (MIL-R-93).

Resistors, Fixed, Wirewound, Power

This is a resistor capable of handling high power and is intended for low frequency applications. Its two primary drawbacks are large size and weight, as compared to other resistor styles.

Construction

A fixed length of wire or ribbon of known ohmic value is wound around a ceramic core and terminated with axial leads. It is similar to other wirewounds, but specifically designed to handle higher load currents.

Derating

Power: Derate power to 60% of maximum full rated power below T_S. Above T_S, linearly derate to T_D at 10% rated wattage as shown in Figure 6, where $T_D = T_S + 0.60(T_{MAX} - T_S)$. For high voltage, high resistance value applications, do not allow power dissipation to exceed $P = 0.60 * V^2_{continuous} / R$, where $V_{continuous}$ is the maximum continuous working voltage. Do not use above a

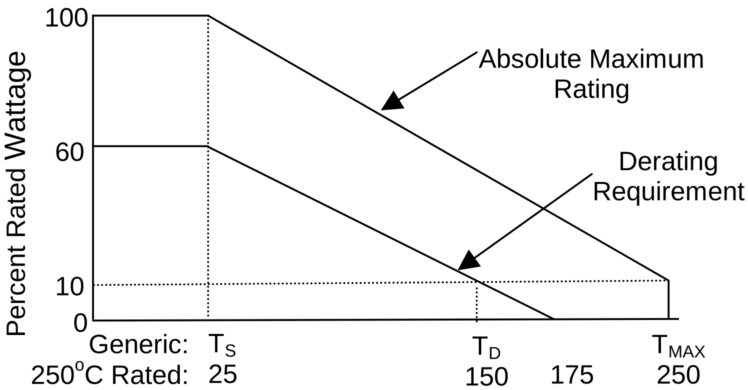

Figure 6. Derating Requirement for Fixed Value, Wirewound, Power Resistor

surface (case) temperature of 200^{o}C.

Voltage: Under pulse conditions, perform additional derating of voltage to 70% of the dielectric breakdown voltage or the maximum short-term overload voltage, whichever is less.

For resistance values higher than those given in MIL-R-39007, derate working voltage to $V = \sqrt{PR}$, where R is the maximum MIL-PRF-39007 resistance value for the given style, and P is the derated power at the applicable temperature.

Application Information

Reliability: For this resistor, reliability is generally the lowest of all fixed resistor styles, but failure rates are highly variable between manufacturers. Special mounting considerations need be taken into account in high vibration environments due to its large size. Heat dissipation is accomplished by both radiation and conduction through the lead materials, with the conduction component highly dependent on thermal conductivity of the resistor core.

Tolerance/Aging: This resistor style is generally not supplied with close tolerances and not intended for tight tolerance applications. Regardless of purchased tolerance, design should tolerate a +1% shift in resistance to assure long life. Temperature coefficients are typically tightly controlled.

Frequency Characteristics: High frequency performance is poor for this resistor style. Recommend against use in applications where AC performance is critical.

Special Considerations: Coating materials used during the fabrication process may be subject to outgassing of volatile materials when operating at surface temperatures above 200^{o}C.

Military Considerations

Figure 6 specifies derating temperature requirements for resistors conforming to MIL-PRF-39007 (Style RWR). RWR80 is recommended over RWR70 in high power applications due to higher thermal conducting core materials.

Resistors, Fixed, Wirewound, Power, Chassis Mounted

This is a high power, low frequency resistor style, intended to be mounted on a heat sink to dissipate power. It exhibits the highest power dissipation capability of any resistor style, but with large size and mass.

Construction

This resistor style features a measured length of known resistance wire or ribbon wound around a ceramic core or tube, enclosed in a finned aluminum housing to aid in heat dissipation.

Derating

Power: Derate power to 50% of maximum full rated power below T_S. Above T_S, linearly derate to T_D, as shown in Figure 7, where $T_D = T_S + 0.50(T_{MAX} - T_S)$. For high voltage, high resistance value applications, do not allow power dissipation to exceed $P = 0.50 * V^2_{continuous} / R$, where $V_{continuous}$ is the maximum continuous working voltage.

Voltage: Under pulse conditions, perform additional derating to 70% of the dielectric withstanding voltage, or the maximum short-term overload voltage, whichever is less.

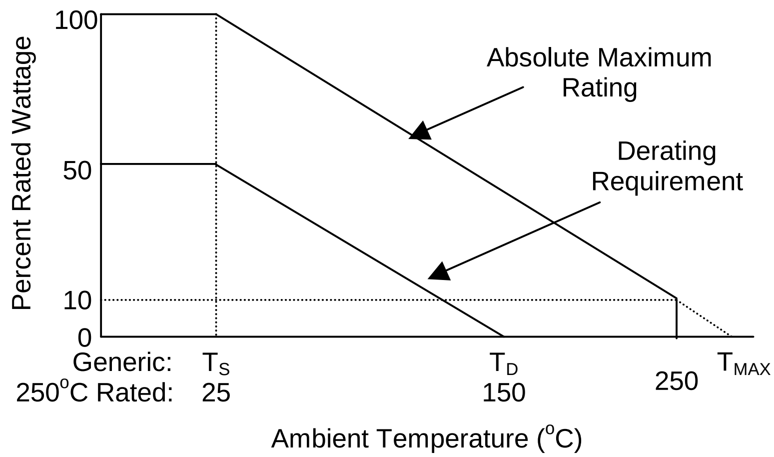

Figure 7. Derating Requirement for Fixed Value, Wirewound, Power, Chassis Mounted Resistor

Application Information

Reliability: High dissipation power causes low reliability. A heat sink should be used to dissipate power.

Tolerance/Aging: Stability over temperature is very good. Resistance tolerance is normally ±1%, but designs should be capable of tolerating an additional ±1.5% shift in resistance value over lifetime.

Frequency Characteristics: Not intended for high frequency applications.

Military Considerations

Figure 7 specifies derating temperature requirements for resistors conforming to MIL-PRF-39009 (Style RER).

Resistors, Variable, Wirewound, General Purpose

This resistor is a low precision variable resistor intended for matching, balancing, and adjusting circuit variables.

Construction

An element of a continuous length wire is wound around a rectangular or arch shaped core, with a sliding contact traversing the element.

Derating

Power: Derate power to 55% of maximum full rated power below T_S. Above T_S, linearly derate to T_D, as shown in Figure 8, where, $T_D = T_S + 0.55(T_{MAX} - T_S)$.

Dielectric Breakdown: N/A.

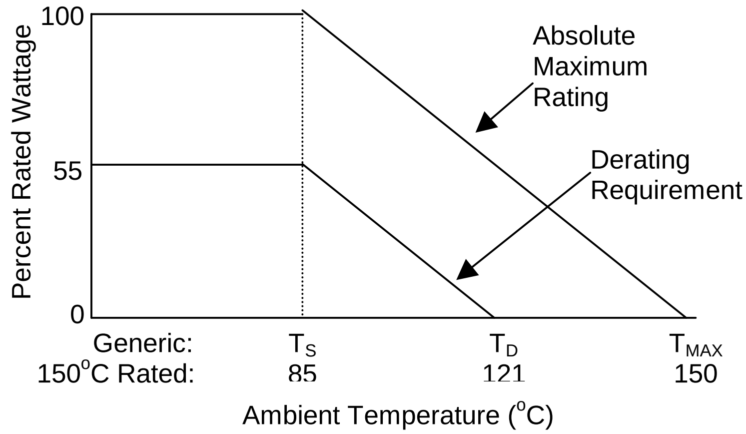

Figure 8. Derating Requirement for Variable, Wirewound (General Purpose) Resistor

Application Information

Reliability: Reliability is best among the variable resistors, but substantially lower than equivalent fixed value styles. Lack of a protective seal makes the resistor sensitive to moisture and contamination (flux, cleaning solvents, etc.) intrusion between the winding elements. Lubrication oil will cause dust or wear particles to concentrate further. A wiper arm locking mechanism is necessary to assure long term reliability, particularly in high vibration/shock applications. Mechanical support should not be done by relying on resistor leads, and brackets may be necessary in some applications. Principal failure mode is open circuit.

Tolerance/Aging: Tolerance normally specified at ±5%, although designs should be able to tolerate ±7% over lifetime. The user should account for change in resistance due to resistance-temperature effects.

Frequency Characteristics: Not recommended for high frequency applications. Noise can be generated while being adjusted due to stepping of contact from wire to wire.

Special Considerations: Heat dissipation is accomplished through a combination of radiation and conduction through the component leads. When only a portion of the resistance element is engaged, the wattage is reduced in directly the same proportion as the resistance.

Military Considerations

Figure 8 specifies temperature-derating requirements for resistors conforming to MIL-PRF-39015 (Style RTR).

Resistors, Variable, Wirewound, Precision And Semi-Precision

This is a precision variable resistor used for servo-mounted applications requiring precise electrical and mechanical output and performance. A heat sink should be used to aid in power dissipation. The output is linear with respect to wiper arm position.

Construction

A wire of known ohmic value is wound around a rectangular or arch shaped core, with a sliding contact traversing the element. The element is enclosed in an environmentally resistant housing and the wiper arm is designed to assure continuos contact during adjustment.

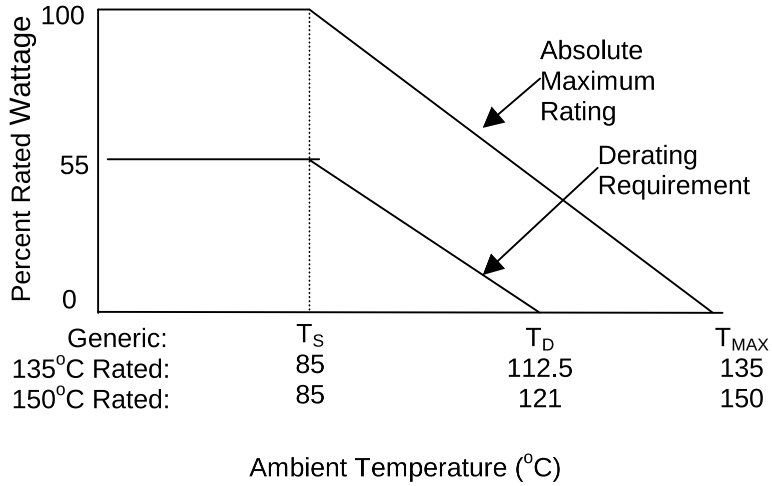

Figure 9. Derating Requirement for Variable, Wirewound, Precision and Semi-Precision, Resistor

Derating

Power: Derate power to 55% of maximum full rated power below T_S. Above T_S, linearly derate to T_D as shown in Figure 9, where, $T_D = T_S + 0.55(T_{MAX} - T_S)$. Ensure power rating will be sufficient to handle the higher current produced when the resistance is reduced. When only a portion of the resistance element is engaged, the wattage is reduced in directly the same proportion as the resistance.

Application Information

Reliability: Reliability is considered good in comparison to other variable wirewound styles. A wiper arm locking mechanism is necessary to assure long term reliability, particularly in high vibration/shock environments. The principal failure mode of this resistor style is open circuit. The principle mode of heat dissipation is accomplished through conduction to a heat sink.

Tolerance/Aging: Overall stability is considered good, but in tight tolerance applications the user should account for a change in resistance due to resistance-temperature characteristic.

Frequency Characteristics: This resistor is not suitable for high frequency or pulse applications. Noise performance is better than other wirewound resistor styles due to continuous contact feature.

Military Considerations

Figure 9 specifies temperature derating requirements for resistors conforming to MIL-PRF-12934 (Style RR) and MIL-PRF-39002 (Style RK). Ambient temperature ratings of Military resistors assume the resistor will be mounted on a 4-inch square, ¼ inch thick aluminum alloy panel.

Resistors, Variable, Wirewound, Power

This is a high power variable resistor, intended for high voltage, high power applications such as motor speed controls, lamp dimming, heater controls, etc. It is available only in relatively low resistance values (typically <5KΩ). It is designed for mounting on a heat sink.

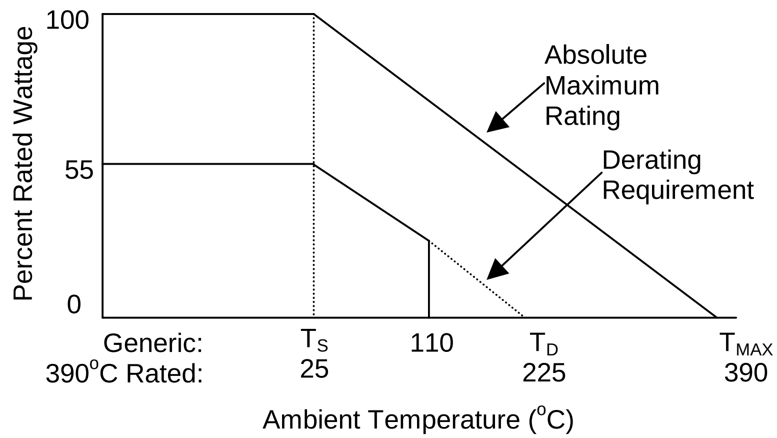

Figure 10. Derating Requirement for Variable, Wirewound, Power Resistor

Construction

A continuous length wire of known ohmic value is wound around a central core, with a sliding contact traversing the element. The wire and core are usually bonded to the base structure by a vitreous enamel. The structure is left unenclosed.

Derating

Power: Derate power to 55% of maximum full rated power below T_S. Above T_S, linearly derate to T_D, as shown in Figure 10, where $T_D = T_S + 0.55(T_{MAX} - T_S)$, or limit maximum operating temperature to 110°C, whichever is less. When only a portion of the resistance element is engaged, the wattage is reduced in directly the same proportion as the resistance.

Dielectric Breakdown: N/A.

Application Information

Heat Dissipation: The primary mode of heat dissipation is accomplished through radiation or conduction to a heat sink, depending on mounting. Ensure power rating will be sufficient to handle the higher current produced when the resistance is reduced.

Reliability: Exhibits very poor reliability, lowest of any resistor style.

Tolerance/Aging: Consult manufacturer's specifications.

Noise: This style is not suitable for high frequency applications.

Military Considerations

Figure 10 specifies derating temperature requirements for resistors conforming to MIL-R-22 (Style RP). Ambient power ratings of MIL-R-22 styles assume mounting on a 12-inch square, 0.063-inch thick metal plate heat sink.

Resistors, Variable, Non-Wirewound, Composition

This resistor is intended for applications where stability and precision are not important and a constant resistance value does not need to be locked into place. Characteristics are similar to variable film resistors, but with lower cost, reliability, and rated operating temperatures.

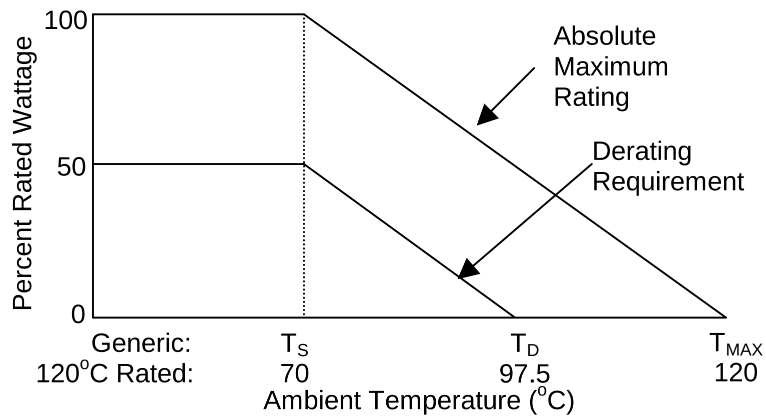

Figure 11. Derating Requirement for Variable, Non-wirewound, Composition Resistor, Military Style RV

Construction

This one-piece molded style contains the resistance material, terminals, faceplate, and busing. Composition film style is a film of carbon resistance material painted onto the surface of a prepared form.

Derating

Power: Derate power to 50% of maximum full rated power below T_S. Above T_S, linearly derate to T_D as shown in Figure 11, where, $T_D = T_S + 0.50(T_{MAX} - T_S)$. When only a portion of the resistance element is engaged, the wattage is reduced in directly the same proportion as the resistance.

Dielectric Breakdown: N/A.

Application Information

Reliability: This style is generally more susceptible to wear than wirewound styles because composition element tends to wear after extended use, leaving behind particles to permeate the mechanism.

Tolerance/Aging: This resistor style exhibits a large change in resistance value over time and temperature. The initial tolerance is ±10% for most styles, and designs should be capable of withstanding up to ±20% tolerance over intended life.

Frequency Considerations: The noise level is relatively high, although it tends to decrease with age. This resistor is not intended for high frequency applications.

Special Considerations: Power ratings may assume mounting to a heat sink. For potentiometer applications, consider both load and bleeder current in calculating power dissipation.

Military Considerations

Figure 11 specifies derating temperature requirements for resistors conforming to MIL-PRF-94 (Style RV). Ambient power ratings for MIL-R-94 style assumes mounting on a 4 inch square, 16 gage steel plate heat sink.

Resistors, Variable, Non-wirewound, Film

This resistor is intended for rheostat or potentiometer applications where high precision is not required and a constant resistance value does not need to be locked in place.

Construction

The resistive element is a metal-ceramic film fused onto a ceramic substrate (usually in the form of an arch) and housed in an enclosure to provide environmental and mechanical protection.

Derating

Power: Derate power to 50% of maximum full rated power below T_S. Above T_S, linearly derate to T_D, where $T_D = T_S + 0.50(T_{MAX} - T_S)$, as shown in Figure 12. Apply additional derating if the entire element is not used.

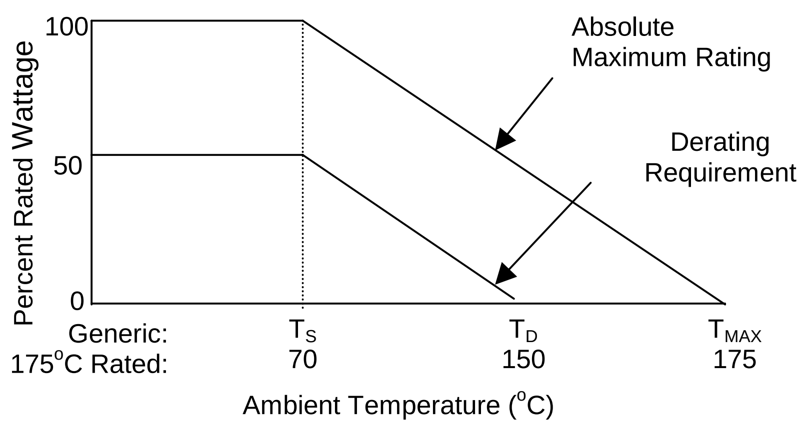

Figure 12. Derating Requirement for Variable, Non-Wirewound, Film Resistor

Application Information

Reliability: Reliability for this style is considered high in comparison to other variable styles. This resistor is typically used in similar applications as variable composition styles, but where increased reliability is required. The resistor is good at withstanding acceleration, shock, and high frequency acceleration.

Tolerance/Aging: Consult manufacturer's specifications.

Frequency Considerations: The noise level is high, but generally is less than other variable styles.

Special Considerations: Power ratings may assume mounting to a heat sink. One must ensure the power rating will be sufficient to handle the higher current produced when the resistance is reduced.

Military Considerations

Figure 12 specifies derating temperature requirements for resistors conforming to MIL-R-23285 (Style RVC). Ambient power ratings of MIL-R-23285 styles assume mounting on a 4 inch square, 16 gage steel plate heat sink.

Resistors, Variable, Precision

This is a high precision variable resistor intended for servo mounted applications requiring precise electrical and mechanical output and performance. The output is linear with respect to the angular position of the operating shaft.

Construction

The resistive element usually consists of carbon, cermet, or conductive plastic deposited on a plastic insulating base. Element is enclosed in an environmentally protective housing.

Derating

Power: Derate power to 55% of maximum full rated power below T_S. Above T_S, linearly derate to T_D as shown in Figure 13, where $T_D = T_S + 0.55(T_{MAX} - T_S)$. Apply additional derating if the entire resistive element is not used.

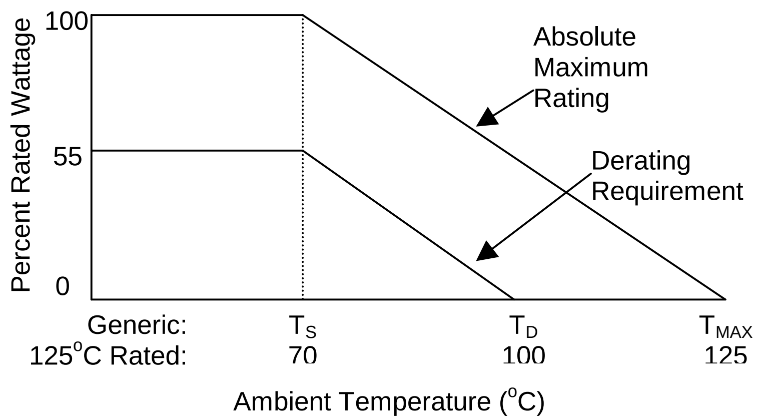

Figure 13. Derating Requirement for Variable, Non-Wirewound, Precision Resistor

Application Information

Reliability: Reliability is considered marginal among variable resistor styles. The primary failure mode is resistance drift, with a secondary failure mode of open circuit.

Tolerance/Aging: This resistor offers increased accuracy over equivalent value composition or film variable styles.

Frequency Considerations: The noise is lower than wirewound styles because wiper arm maintains continuous contact through entire travel.

Special Considerations: Maximum power handling specifications may assume mounting on a heat sink.

Military Considerations

Figure 13 specifies derating temperature requirements for resistors conforming to MIL-PRF-39023 (Style RQ). Ambient power ratings for MIL-R-39023 style assumes mounting on a 4 inch square, 16 gage steel plate heat sink.